FACULTY OF GEO-INFORMATION SCIENCE
AND EARTH OBSERVATION

ITC

WATER AND FOOD SECURITY-ETHIOPIA TOOLBOX

INSTALLATION, CONFIGURATION AND USER GUIDE OF THE WFS - ETHIOPIA TOOLBOX PLUG-IN FOR ILWIS 3.7.2

XML version 2.0

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Acknowledgement

After the announcement by EUMETSAT in 2004 that data from the SEVIRI instrument (on-board of the Meteosat 2nd generation or MSG satellite) would become freely available for education and research, an initiative was launched at ITC, to enable reception and processing of the data from this instrument in near real time for use in education and capacity building worldwide. Also through the efforts of the Group on Earth Observation (GEO), many more datasets became rapidly available on a global earth observation data dissemination system – "EUMETCast / GEONETCast", used by several space agencies (like EUMETSAT, ESA, NOAA, CMA) as a global data distribution system.

The GEONETCast data dissemination system is used to receive, without internet connection, a variety of meteorological and environmental data in near real time. Within the framework of a dedicated project on early warning for food security in the Horn of East Africa and Ethiopia in particular, a dedicated toolbox, called the "*Water and Food Security-Ethiopia Toolbox*", was developed as a plug-in of the generic remote sensing and GIS freeware and open source package "*ILWIS*" and various applications have been developed.

The ILWIS open source software community as well as the more recently established "*Earth Observation Community*" are hosted by our cooperation partner "*52North.org*". All software and toolbox utilities can be freely obtained and 52North is thanked for their continuing support. Furthermore these developments would not have been possible without the support from various organizations. EUMETSAT's support has been instrumental. Technical or logistical questions, requests for trial data or questions to various data providers where handled promptly and efficiently. Utilities developed by EUMETSAT could be used, such as the "*Product Navigator*". User Services and 'ops@eumetsat.int' were instrumental in providing licenses to new users in Ethiopia, specifically for the regional offices of the National Meteorological Agency (NMA), Early Warning and Response Directorate of the Ministry of Agriculture (DRMFSS), the World Food Programme (WFP) – Ethiopia country office and a number of Ethiopian Universities, enabling them to receive the data disseminated by "GEONETCast" in conjunction with ILWIS Open Source RS and GIS technology.

The ITC Directorate has also been instrumental in supporting this development throughout the years. Next to their continuing support to the Capacity Building component of GEO, they allocated resources for this capacity development initiative, including setting up antennas, providing data storage capacity and day to day management of the data receiving centre established at ITC-UTwente. Together with Ethiopian Universities currently the EENSAT project is executed (see: https://www.eensat.org/) to ensure that these technologies are becoming part of routine higher education in support of the agricultural transformation initiative of the Ethiopian government.

The collaboration within different projects and partners from Ethiopia was instrumental. The inputs from the NMA, DRMFSS, WFP and various Ethiopian Universities have been taken as a guide for the development of the various routines available in this dedicated toolbox. The experiences gained during training activities and short capacity building workshops conducted has been used to ensure that the utilities developed can be easily implemented by the growing Ethiopian User Community.

An important driver behind the development of Version 2.0 of this WFS-Ethiopia toolbox is the subsequent use of processed GEONETCast data, for further analysis by the NMA, within the framework of the "*GIACIS*" and "*ClimDev*" projects with the overall objective to increase food security among the most vulnerable communities in Ethiopia. We especially would like to express our gratitude to Mr. Tsegaye Ketema Haile, Director for Development Meteorology Services Directorate, National Meteorology Agency of Ethiopia, for the long term collaboration and his input and comments on different issues and his scientific knowledge in this domain.

List of acronyms and abbreviations

52North	52°North Initiative for Geospatial Open Source Software
AMESD	African Monitoring of the Environment for Sustainable Development
AMV	Atmospheric Motion Vector
AVHRR	Advanced Very High Resolution Radiometer
BDMS	Botswana Department of Meteorological Services
BEAM	Basic ERS and ENVISAT AATSR and MERIS Toolbox
BILKO	Software package for learning and teaching remote sensing image analysis skills
BRAT	Basic Radar Altimetry Toolbox
BUFR	Binary Universal Form for the Representation of meteorological data
CBERS	Chinese Brazilian Earth Resources Satellite
CCD	Charge Coupled Device
CHC	CBERS CCD and HRC composite product
CLAI	Cloud Analysis Image
CMA	Chinese Meteorological Agency
CSIR	Council for Scientific and Industrial Research, South Africa
CTH	Cloud Top Height
DDS	Data Dissemination System
DevCoCast	GEONETCast for and by Developing Countries
DMP	Dry Matter Productivity
DN	Digital Number
DOS	Disk Operating System
DRMFSS	Disaster Risk Management and Food Security Sector
DSLF	Down welling Surface Long-wave radiation Flux
DSSF	Down welling Surface Short-wave radiation Flux
DVB	Digital Video Broadcast
EAMNET	European African Marine Network
ECMWF	European Centre for Medium-Range Weather Forecasts
ENVISAT	Environmental Satellite
ESA	European Space Agency
ET	Evapotranspiration
EUMETCast	A satellite based data dissemination of various (mainly satellite based) data covering Europe and Africa
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
FAPAR	Fraction of Absorbed Photosynthetically Active Radiation
FTP	File Transfer Protocol
FVC-FCOVER	Fraction of Vegetation Cover
GDAL	Geospatial Data Abstraction Library
GEO	Group on Earth Observation
GEONETCast	A global network of satellite based data dissemination systems
GEOSS	Global Earth Observation System of Systems
GIACIS	Geodata for Innovative Agricultural Credit Insurance Systems
GNC	GEONETCast
GRIB	Gridded Binary data format
GTS	Global Telecommunication System
GUI	Graphical User Interface
HRIT	High Rate Image Transmission
HRV	High Resolution Visible
ICAO	International Civil Aviation Organization
ILWIS	Integrated Land and Water Information System
INPE	Instituto Nacional de Pesquisas Espaciais, Brazil
ITC-UT	Faculty of Geo-Information Science and Earth Observation, University of Twente
IR	Infra-Red
LAI	Leaf Area Index
LEAP	Livelihood, Early Assessment, Protection

LSA	Land Surface Analysis
LST	Land Surface Temperature
MDD	Meteorological Data Dissemination
METAR	Meteorological Aerodrome Report (amongst others!)
METOP	Meteorological Operational satellite programme
MODIS	Moderate Resolution Imaging Spectrometer
MPE	Multi sensor Precipitation Estimate
MPEF	Meteorological Product Extraction Facility
MSG	Meteosat Second Generation
NDVI	Normalized Difference Vegetation Index
NDWI	Normalized Difference Water Index
NIR	Near Infra-Red
NMA	National Meteorological Agency
NOAA	National Oceanic and Atmospheric Administration
PML	Plymouth Marine Laboratory
PHENOKS	Phenology Key Stages
PROBA-V	Project for On-Board Autonomy - Vegetation
R	A language and environment for statistical computing and graphics
RFS	Rainfall Satellite
RGB	Red – Green – Blue colour assignment
RSS	Rapid Scanning Service
SADC	Southern African Development Community
SAF	Satellite Application Facilities
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SPOT	Système Probatoire d'Observation de la Terre ou Satellite Pour l'Observation de la Terre
SWB	Small Water Bodies
TAF	Terminal Aerodrome Forecast
TAMSAT	Tropical Applications of Meteorology using Satellite data and ground-based observations
TIR	Thermal Infra-Red
VGT-instrument	Vegetation instrument onboard of SPOT
VIS	Visible
VITO	Flemish Institute for Scientific Research
VPI	Vegetation Production Indicator
UTC	Universal Time Coordinated
WFP	World Food Programme
WFS-E	Water and Food Security – Ethiopia
WMO	World Meteorological Organization
WV	Water Vapour
XML	Extensible Markup Language

RELEASE NOTES

Following comments have to be taken into consideration with respect to the release of this Water and Food Security – Ethiopia Toolbox, XML version 2.0:

1. This is an updated release and currently used by the Ethiopian User Community. Utmost care was taken to ensure appropriate operation of the routines developed but at this stage some defects might still be included and should be reported to the corresponding author to be included in a new release;
2. No liability can be accepted for use of the WFS-Ethiopia Toolbox by the toolbox developers;
3. In order to maintain a concise toolbox structure a selected number of products can be processed. The type and number of products for which processing routines have been developed are resulting from discussions between ITC and the Ethiopian stakeholders: National Meteorological Agency (NMA), Early Warning and Response Directorate of the Ministry of Agriculture (DRMFSS), the World Food Programme (WFP) – Ethiopia country office and requirements from the Ethiopian Universities participating in the EENSAT project. Consult also the 'GEONETCast Toolbox' plug-in if looking for additional functionality to access other data and products disseminated via GEONETCast – EUMETCast;
4. Toolbox Version 2.0 has been updated to include new relevant data and products for the target Ethiopian User Community. However some routines are based on data which is restricted and is only available to National Meteorological Services and their Partner Organizations. Within this version obsolete routines have been removed, due to the fact that satellites are not operationally used (like Meteosat-7 / Vegetation instrument on the SPOT series of satellites) or products are no longer disseminated. The change log can be consulted and if older products need to be processed, a previous version of the toolbox can be used;
5. When using the WFS-Ethiopia Toolbox you agree and comply with the conditions of the software utilities used as well as the terms and conditions stipulated by EUMETSAT for the use of the data delivered by means of GEONETCast and EUMETCast and the other utilities integrated within this toolbox release.
6. Further license notes are described in the files '52N_EO_license.txt' and 'Readme.txt', situated in the root folder of the WFS-Ethiopia toolbox.

REFERENCES

As the toolbox is applied by users within their own working environment and might not be affiliated with ITC – University of Twente or do not have access to resources provided by ITC, within this manual use is made (as much as possible) to provide links to free online references, web portals and other online resources. These are included within the body text when describing e.g. the various products or contain valuable information for further reference. These resources can be used for further independent review. Given the transient nature of the internet some of the links might not be active after some time. During the moment of writing all links have been checked and proved to be active / correct.

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GENERAL INSTALLATION AND CONFIGURATION INSTRUCTIONS

1.1 INTRODUCTION

Follow the instructions provided below to install ILWIS Version 3.7.2, the WFS-Ethiopia Toolbox and a number of other free software utilities, in order to work with the data provided via EUMETCast - GEONETCast. Read the instructions provided below carefully and proceed with the installation of the various utilities. In case you want to use the WFS-Ethiopia Toolbox, be aware that at this moment it is not running under LINUX-Ubuntu. Furthermore this WFS-Ethiopia Toolbox version is not downwards compatible; you need to use at least the latest ILWIS Version 3.7.2. Although ILWIS works on a 32 bits OS, other utilities might require a 64 bits OS, it is therefore recommended to work on a system using a 64 bits OS.

1.1.1 *ILWIS*

Available from: http://52north.org/

From this location select the navigation tab: "*Software*" > "*Github*" > *"ILWIS3Downloads"* or directly select "https://github.com/52North/Ilwis3Downloads". Select the latest (multiple file) ILWIS372 version ("*ILWIS 3.07.02*") and download the ZIP file(s), save the file(s) in a temporary directory on your hard disk. Unzip the file and run the ILWIS setup. When you intend to use the WFS-Ethiopia Toolbox **do not install ILWIS372 under the default installation directory "C:\Program Files"** as this might cause problems with respect to administration rights when creating temporary files and because the toolbox is utilizing DOS batch routines, which can be affected by the space in the directory name "*Program Files*". Select as your installation "*drive:\directory*" a location where you have the proper administrative rights (e.g. "*D:\ILWIS372*"). In the "*ILWIS372*" directory a shortcut to the "*ILWIS.exe*" can be created, you can copy this shortcut to the desktop of your system.

Please take into consideration, straight from the start, the following golden rules when using ILWIS:

- ***Don't use spaces in (sub-) directory or file names, instead use underscores;***
- ***Do not only use numbers as file names;***
- ***Do not work in multiple output directories;***
- ***Start ILWIS, navigate to your working directory and close ILWIS. Open ILWIS again to ensure that your current working directory is also the actual ILWIS working directory.***

1.1.2 *WFS-Ethiopia Toolbox*

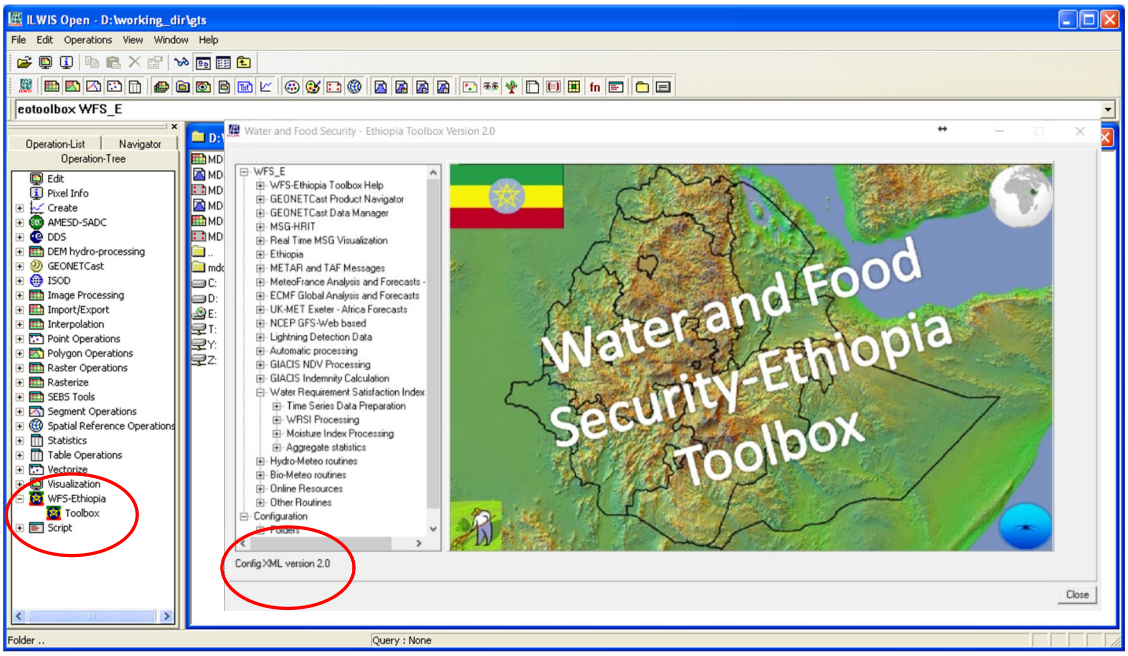
Available from: https://52north.org/software/software-projects/ilwis-toolboxes/

To download the *WFS-Ethiopia Toolbox* from the 52North website: Select from the 52north.org website the navigation tab: "*WFS-E Toolbox*". Additional information is provided over there as well as the link to the download area. You can also directly download the Toolbox from https://github.com/52North/WFS-E-Toolbox, select "*V2.0.0*". Download the Zip file: "*52n-eo-WFS-E-toolbox-2.0*" available over there and store it in a temporary directory. Eventually download other resources provided over there.

After the download is completed, copy this ZIP file in the ILWIS sub-directory "\Extensions". *There is no need to unzip the file! ILWIS automatically detects the ZIP file in this directory then unzips the file and installs the plug-in when a new instance of ILWIS is started. Afterwards the ZIP file is deleted in this sub-directory!*

Start ILWIS and in the Operation-Tree of ILWIS the “WFS-Ethiopia” tab will appear (see also figure 1.1). Double click the “WFS-Ethiopia” tab and the subsequent “Toolbox” tab and various (sub) menu items are now at your disposal. These options can be used to import several image and data sources disseminated via EUMETCast-GEONETCast, a system that uses digital video broadcast (DVB-S2) to deliver environmental data worldwide. Over 150 image and product processing routines, relevant for Water and Food Security Analysis for Ethiopia, including near real time visualization procedures, are currently supported. As the GEONETCast dissemination system is constantly developing, keep checking the ITC website (https://www.itc.nl/about-itc/organization/scientific-departments/water-resources/geonetcast/) or the “*Earth Observation*” community webpage at https://52north.org/research/rd-communities/earth-observation/, for new (toolbox) developments. Modifications and added functionality for the WFS-Ethiopia Toolbox are made available here on an ad hoc basis, so check if you are working with the latest version. The XML configuration number, currently 2.0 is given on the lower left hand portion of the WFS-Ethiopia Toolbox opening screen.

Figure 1.1: The WFS-Ethiopia Toolbox V2.0 main and sub menu structure under ILWIS372



Close ILWIS as you might need to install additional utilities. Check if you have already installed the Java runtime environment, IrfanView, BUFRdisplay and BUFRextract, MSG-Toolbox, Ilwis-Open, Grep, Gifsicle, Panoply, Wget, 7Gif and METAR-Weather. If this is not or partially the case, use the links below and follow the additional installation instructions. Minimum requirement is that IrfanView, BUFRextract, Grep, Gifsicle, Wget and for the GIACIS NDVI processing routines also Ilwis-Open should be available.

1.1.3 *Java*

Available from: http://www.java.com/en/download/index.jsp

Some WFS-Ethiopia Toolbox routines make use of JAVA. If your system does not have JAVA installed already, move to the website indicated above, select the “Free Java Download” button and install it. Accept the License Agreement to start and complete the installation (using default settings). It is advised to use a recent Java version.

1.1.4 *IrfanView*

Available from: http://www.irfanview.com/

For some data visualizations that do not require import into an ILWIS data format, use is made of IrfanView. Download the setup executable and save it in a temporary directory on your hard disk.

After the download has been completed run the setup, there is no need to create shortcuts, use the option: “For all users” and select the default Installation folder. Click “Next” three times, just use the default settings, “Don’t install Google Desktop Search”, click “Next” two times and after the installation has been completed, press “Done”.

An instance of IrfanView can be started to check if the installation has been successful, the program can stopped.

1.1.5 *BUFRdisplay and BUFRextract*

Available from: http://www.elnath.org.uk/

On this webpage, under “BUFR File Support Software”, select “*BUFRdisplay*” and download the latest Windows version of the BUFRdisplay utility and eventually also the User Guide. Store the BUFRdisplay_v???.zip file in a local temporary directory. Copy the zipped file into your ILWIS directory under “\Extensions\WFS_E-Toolbox\util\bufrdisplay” and unzip the BUFRdisplay_v???.zip in this sub-directory (without creating another sub-directory!). This utility facilitates quick visualization of (multiple) EUMETCast-GEONETCast disseminated BUFR encoded files for various products.

The BUFRextract is used to import selected BUFR encoded data into ILWIS format using command line syntax, for subsequent analysis. Download the latest Windows version of the BUFRextract utility and eventually also the User Guide. Store the BUFRextract_v???.zip file in a local temporary directory. Copy the zipped file into your ILWIS directory under “\Extensions\WFS_E-Toolbox\util\bufrextract” and unzip the BUFRextract_v???.zip in this sub-directory (without creating another sub-directory!).

Using the software tools means that you agree and comply to the conditions of use of the software. Note that currently only 64-bit Windows versions are supported only!

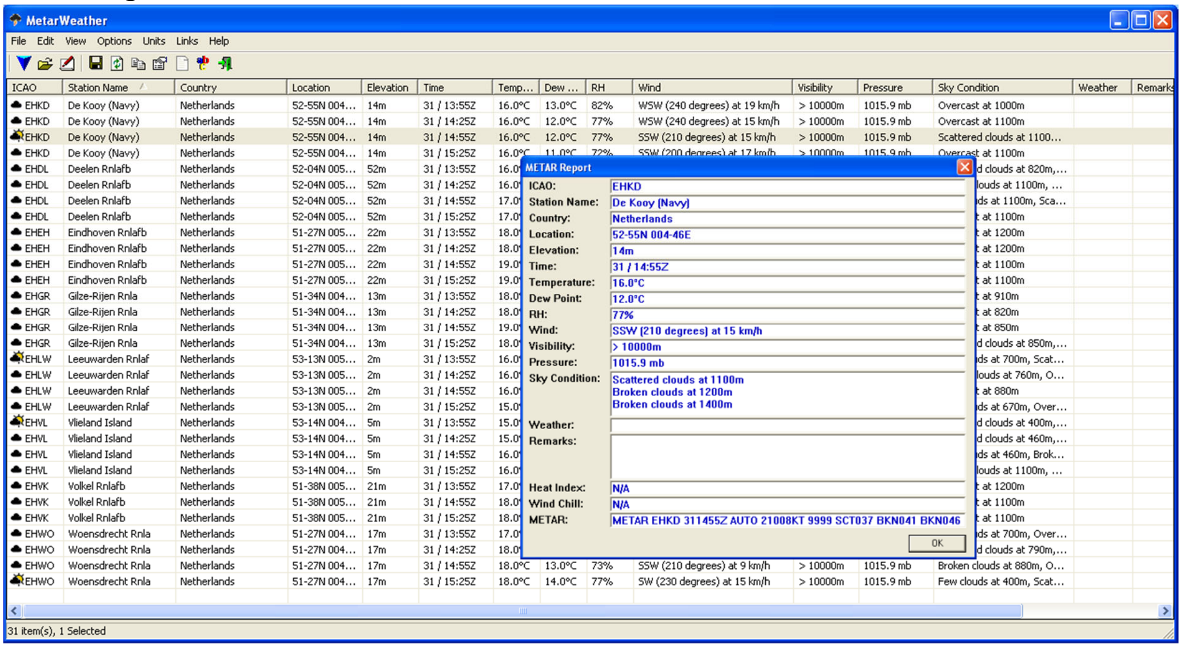
1.1.6 *METAR-Weather*

Available from: http://www.nirsoft.net/utils/mweather.html

To quickly visualize METAR and TAF information use is made of a freeware tool called “METAR-Weather” (currently use is made of MetarWeather Decoder version 1.75, Copyright (c) 2003 - 2017 by Nir Sofer). The Metar-Weather utility decodes METAR and TAF weather reports from around the world, and displays them in a simple weather report table. You can save the weather report into text, HTML or KML files. Metar-Weather can decode METAR reports from a text file, or download the latest reports directly from the Internet. Within the Toolbox the utility is used to display the METAR and TAF messages (for TAF only the first line of the message) disseminated through the GTS System, a restricted service of GEONETCast, see also figure 1.2.

At the bottom of the webpage indicated above use the link: “*Download MetarWeather in Zip File*”. Save the utility to your local disk unzip the file and copy the utility “Mweather.exe” into your ILWIS sub-directory: “Extensions\WFS_E-Toolbox\util\mweather”. You can double click on “*mweather.exe*” to see if the application works, subsequently close it.

Figure 1.2: The METAR Weather Viewer with TAF data from the Netherlands



1.1.7 *GREP*

Available from: http://gnuwin32.sourceforge.net/packages/grep.htm

Grep searches one or more input files for lines containing a match to a specified pattern. This utility is used e.g. to look for specific string sections in the various Meteorological product messages to find specific GRIB files contained within these messages.

On the web link provided above, under the 'Download" section, select the link to 'Setup Program' and download the 'Grep setup.exe' in a temporary directory. Activate the Grep-setup executable and install the 'Binaries', you can use the same temporary directory for the installation, activate the option "Don't create a Start Menu folder" and no need to "Download Sources". After the installation is completed, copy the files contained in the sub-directory '\bin' in a new folder under the ILWIS sub-directory \Extensions\WFS_E-Toolbox\util\grep. Note that the 3 executables and 4 dlls should be copied directly under "\Extensions\WFS_E-Toolbox\util\grep".

1.1.8 *GIFSICLE*

Available from: http://www.lcdf.org/gifsicle/

Gifsicle is a command-line tool for creating, editing, and getting information about GIF images and animations. This utility is used to create animated gifs from time series data.

On the web link provided above, under the section 'Windows port (maintained by Jernej Simončič): gifsicle_1.89.win.zip (32-bit Windows), gifsicle_1.89.win64.zip (64-bit Windows)' select and download the appropriate version for your system. Download the zip file to a temporary directory and unzip the file. Copy the file "gifsicle.exe" in a new folder under the ILWIS sub-directory \Extensions\WFS_E-Toolbox\util\gifsicle. Note that the executable should be copied directly under "\Extensions\WFS_E-Toolbox\util\gifsicle".

1.1.9 ***MSG-Toolbox***

Available from: https://landsaf.ipma.pt/en/getdata/msg-toolbox/

The Meteosat Second Generation Toolbox (under development by LSA SAF and VITO) brings together a set of software utilities to help with the further processing and analysis of Earth Observation products that are operationally produced and disseminated by the Land Surface Analysis Satellite Application Facility (LSA-SAF), as part of the EUMETSAT SAF network. Its main functions include daily and n-day temporal compositing, spatial subsetting and remapping while combining the four LSA-SAF product regions (NAFR, SAFR, EURO and SAME) and filtering on provided product quality layers (source: MSGToolbox Manual: Introduction).

Once downloaded to a temporary directory run “lsasaf_msgtoolbox_v20.exe”, the package is self-extracting. After completion copy the package content (from within the extracted folder “\MSGToolbox”) into the folder \Extensions\WFS_E-Toolbox\util\MSGToolbox as well as the manual. File name convention for the pdf manual is “MSGToolbox_Manual.pdf”. Note that the utility requires a recent version of Java, see chapter 1.1.3.

1.1.10 ***Panoply***

Available from: http://www.giss.nasa.gov/tools/panoply/

Currently data retrieved from ECMWF are visualized using Panoply, developed by Robert B. Schmunk, NASA Goddard Institute for Space Studies. The Panoply package for Windows comes as a zipped archive. Manually extract this archive in the ILWIS sub-directory “\Extensions\WFS_E-Toolbox\util\Panoply”. This sub-directory, after decompression, should include the following items: Panoply.exe (application), application code files in a folder called "jars", colour tables in a folder called "colorbars", continent masks and outlines in a folder called "overlays". You can check to run Panoply by double-clicking on the Panoply.exe application.

1.1.11 ***Wget***

Available from: https://www.gnu.org/software/wget/faq.html#download

In this toolbox version also a number of online utilities are provided. This utility is used for automatic retrieval of the respective data sets from online resources. Download the ‘wget-*.zip’ file, unzip the file to a temporary directory and copy the content from this directory to the folder “\Extensions\WFS_E-Toolbox\util\wget”.

1.1.12 ***7GIF***

Available from: http://www.xtreme-lab.net/7gif/en/index.html

The GIACIS indemnity calculation routines produce an animation of the indemnity situation in Ethiopia. To facilitate user interaction during visualization of the animation use is made of 7GIF.

Use the option: “Download the stand alone package as a zip file”. Unzip the file in a temporary directory and copy the content into the folder “\Extensions\WFS_E-Toolbox\util\7GIF”. Note that already a number of files and a sub directory is existing within this folder which are used to create the animated background making use of 7GIF.

1.1.13 *ILWIS Open*

Available from: ftp://ftp.itc.nl/pub/52n/WFS-EthiopiaTB2/

In this toolbox version also a number of utilities are provided which are used within the GIACIS NDVI and Indemnity calculation processing routines and these routines have been developed using ILWIS Open. Download the ILWIS_O.zip file, unzip the file to a temporary directory and copy the content from this directory to "\Extensions\WFS_E-Toolbox\util\ILWIS_O". The version used of Ilwis Open is a command line version.

Note that this Ilwis-Open version is not publicly released and therefore only available via the ftp address provided here.

1.1.14 *GIACIS supporting data*

Available from: proprietary / request from main author

Within the folder under "\Extensions\WFS_E-Toolbox\util\maps" a zip file is expected called "Indemnity.zip". This zip file is used within the GIACIS indemnity processing routines. This file is not freely distributed and should be requested from the main author of this toolbox as the intended use is solely by NMA, as local service provider within the GIACIS project.

1.1.15 *Concluding remarks*

With ILWIS, the *Water and Food Security - Ethiopia* Toolbox plug-in and the other necessary utility-software installed you first need to configure the EUMETCast / GEONETCast reception settings. These are further described in the next section, providing further details on how to configure the automated data management system. If a reliable reception is available near real time data will be received which can be further processed using the toolbox utilities provided.

Chapter 2 is giving further background information on the overall open toolbox design, chapter 3 is providing further background information on the data and products received and those selected which can be processed using the toolbox utilities available. Chapter 4 is consisting of exercises applying the data received and applications developed.

Note that also use can be made of other freeware utilities for pre or post processing of the data, such as BILKO, BRAT, satellite tracking software, SNAP, etc. Links to these resources are provided in appendix 1. For other "EO" community freeware utilities developed, like the "GEONETCast Toolbox" or the "*In Situ* and Online Data Toolbox", see also the references provided in the appendix 5. Using the various software utilities means that you agree and comply with the conditions of use of these software tools. See also the information provided in the *license.txt* and *readme.txt* in the toolbox source folder.

1.2 CONFIGURATION OF THE DATA STREAM USING THE GEONETCAST DATA MANAGER

1.2.1 *Introduction*

Once having installed and configured a local GEONETCast ground receiving station the satellite and environmental data that is (re-) broadcasted via communication satellites can be received and stored on a storage device (server), see also figure 2.14 below. As the data is received on a 24 hr – 7 days a week basis, the “GEONETCast Data Manager”, a data management system, has been developed that can be easily configured using a simple ascii text file. How to prepare or modify this ascii configuration file and to run the Data Manager is described below. This section is of special relevance to the system administrator operating the ground receiving station. On the 52north.org website (https://github.com/52North/GEONETCast-DataManager”) also a recent ascii “GEONETCast Data Manager” configuration file is available, so new users don’t need to start from scratch constructing the ascii file. Within the WFS-Ethiopia toolbox an ascii configuration file, fine-tuned for Ethiopia, is also available. Within this toolbox an updated Data Manager (version 2) has been included, offering an auto-start and copy option. Check also the updated “*Installation – User Manual*”, available from the menu (see below).

1.2.2 *General design considerations for development of the GEONETCast Data Manager*

The GEONETCast Data Manager is a software application for Windows / Linux written in Java that - in short – examines computer files, and transfers them to a proper location, based on filename-patterns. It was developed at ITC (http://www.itc.nl).

The primary purpose for developing this application is to organize the large amount of data files received on a GEONETCast receiving station (a computer with a Digital Video Broadcast (DVB-S2) device connected to a satellite dish, configured to receive the EUMETCast – GEONETCast data. The data that is received on the EUMETCast - GEONETCast receiving station must be transferred to computer storage that is independent of the receiving station's disk storage before users can access it. Users are not allowed to work directly with the data on the receiving station, because it should perform its primary task undisturbed, which is to be available all the time for storing the files captured by the (DVB-S2) device.

Main objectives of the GEONETCast Data Manager application:

- To organize all files in the "Received" folder of the EUMETCast – GEONETCast receiving station, according to “rules” defined by the local system administrator.
- To detect and log "missing files". The application can be fed with knowledge about the files that are expected from a certain category (e.g. for MSG-HRV this would be 24 segments every 15 minutes). The "missing files" log is very helpful when users need to check data consistency prior to time-series analysis.
- Be extremely reliable to work continuously, 24 hours per day, 7 days per week, preferably unattended for several months, because if the application stops working unexpectedly (and nobody is available to solve the problem), after a couple of days, the files accumulated in the "Received" folder on the EUMETCast - GEONETCast receiving station is likely to reach the maximum available disk capacity.
- Cause as little as possible disturbance to the EUMETCast – GEONETCast receiving station (lightweight activity), or otherwise the station will be too busy and occasionally miss the reception of files (fail to store some of the files captured by the DVB-S2 device).
- It must be easy to restore the configuration of the GEONETCast Data Manager after a software or hardware crash or a power failure, even by non-experts, as the local system administrator may not be available at all times.
- The GEONETCast Data Manager must be able to process a large number of files in a single folder at one time. Therefore it must be able to handle all files that have been

accumulated in the "Received" folder in case the application has not worked for a couple of days. This can be more than a million files!

- The type of files that the GEONETCast Data Manager can process must not be fixed to a specific type (e.g. satellite images). Therefore the application will only depend on the fact that EUMETCast files have specific filename-patterns. With this, the process of detecting a file's category can be kept lightweight, as the file does not need to be opened.
- The “rules” with which files are organized are kept simple in the initial implementation (transfer files to a new location, delete after a certain time period, delete immediately or keep forever, ignore specific files, etc.), which is sufficient for the primary objective of the application. However, it is not difficult to extend their capability if such demand exists.
- The system administrator must be able to easily adapt the configuration file, so that new data that is broadcasted can be easily handled, as the EUMETCast-GEONETCast system is further developing and it is expected that in the future more data will be broadcasted.
- The system manager should be able to fine-tune the storage of the data that is received to be tailored for a specific organization. Given the data load it is impossible to store all of the data. Each organization will have its own specific data storage requirements!

The GEONETCast Data Manager can run without problems on the EUMETCast-GEONETCast receiving station, but can also run on another computer, as long as all necessary folders can be accessed through the network connection. Note that the (sub-) directories assigned to store the various data files can be created manually prior to starting the Data Manager or can be automatically generated according to the directory names specified in the ascii configuration file.

An upgraded Data Manager version is used within this toolbox. This new version described here has a few added advantages, such as an automatic start option after system re-start and a copy option, leaving the data in the source folder of the ground receiving station to be available by other applications. This allows the construction of time series even if the other software routines running on the ground reception station are deleting the data from the source folder after some time. For further details also check the ‘Installation and User Manual’ from the available from the GEONETCast Data Manager toolbox menu.

1.2.3 *The GEONETCast Data Manager - “Rules”*

The local EUMETCast-GEONETCast system administrator creates the file-processing rules. This is initially done by editing a text-file (the configuration file that is used by the GEONETCast Data Manager). At a later stage, the rules are fine-tuned in the user-interface of the GEONETCast Data Manager. This was done to keep the user-interface simple and understandable. For example, file patterns or expected frequency of a category of files must be changed in the configuration file, using a text-editor. However, the destination location or the duration of storage of a category of files is changed in the user-interface, because it is considered a "last-minute" change: the administrator may frequently change his mind about this.

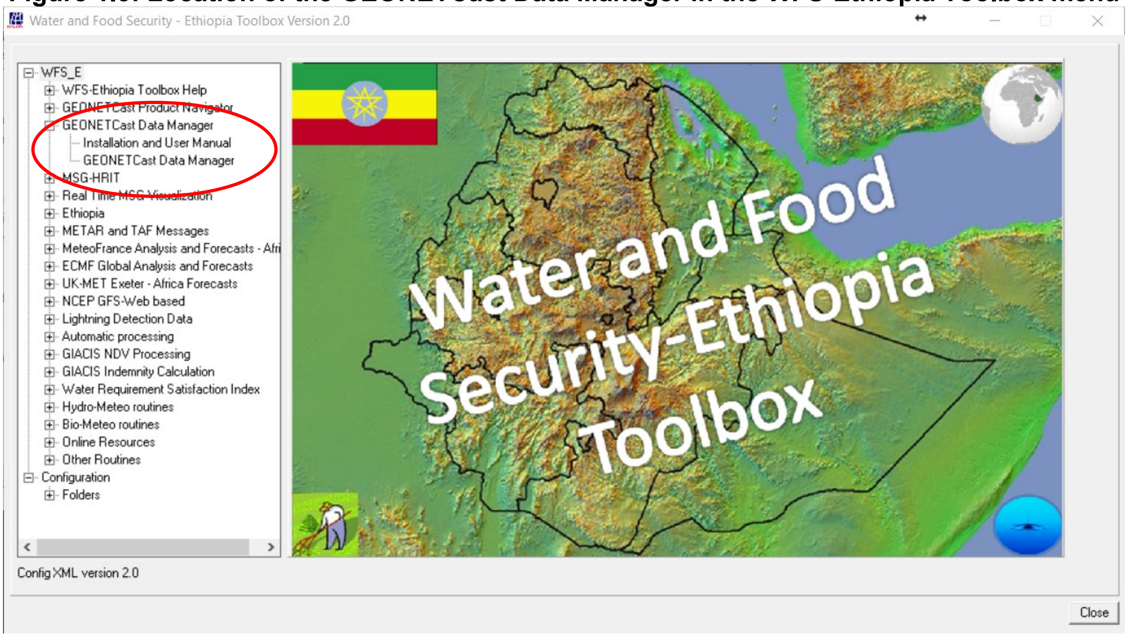
The user-interface of the GEONETCast Data Manager adapts itself to the rules that are defined. Rules are organized in “groups” and “items”. Each group becomes a tab, and each item becomes a box within a tab.

1.2.4 *Configuring the GEONETCast Data Manager Version 2*

Open ILWIS and from the Operation-Tree select the “*WFS-Ethiopia*” and the “*Toolbox*” tab. Subsequently select the option “GEONETCast Data Manager” (see also the figure 1.3 below) and start the “Data Manager” by pressing the “*Start Data Manager*” button. Note that also a ‘Installation and User Manual’ is provided. This document can be retrieved using the menu options “GEONETCast Data Manager”, “Installation and User Manual” and subsequently press “Import”.

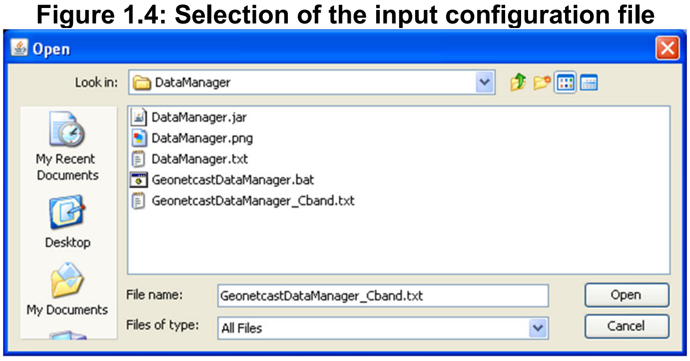
Once the GEONETCast Data Manager is activated an input configuration file needs to be specified as indicated in figure 1.4. A sample configuration file that is used at ITC for the C-Band EUMETCast broadcasting is provided. Select the file “*GeonetcastDataManager_Cband.txt*” and a menu will appear on the screen. A menu sample is shown in figure 1.5.

Figure 1.3: Location of the GEONETCast Data Manager in the WFS-Ethiopia Toolbox menu



Note that this utility only needs to be configured by the system manager-administrator to ensure that the data which is required by the organization – institute is properly stored and can be accessed by the other users within the organization – institute. There is no need to start the application as an instance of the GEONETCast Data Manager might already be running by the system administrator.

Figure 1.4: Selection of the input configuration file



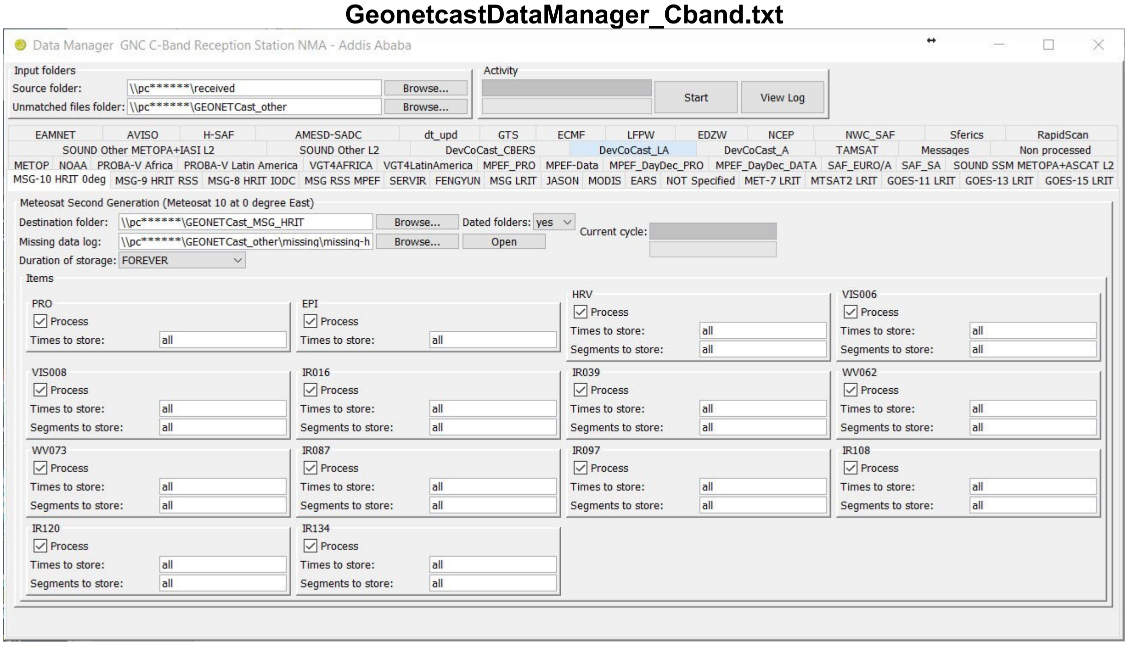
The menu that subsequently appears is based upon the settings that are provided in the “GeonetcastDataManager_Cband.txt” file. Examine the various tabs (“groups”) and look at the “items” within each of these groups (once more: don’t start the application!).

The User Interface allows the system administrator to define the “Source folder”, the directory where the newly received data arrive on the ground reception station; the “Destination folder” is used to store the newly arrived data on the archiving system.

A location for the “Missing Data log” can be specified if for each “Item” the number of “Times per day” is specified (see also figure 1.6). Also “Duration of storage” can be interactively defined and how the data is stored, e.g. by a date formatted folder structure, activating the “Dated folders” option.

This configuration file can also be opened using a text editor and can be modified according to the specific need of the user. The Data Manager can be closed by clicking the closing button in the top-right corner.

Figure 1.5: The GEONETCast Data Manager, showing the menu as defined by the ascii file GeonetcastDataManager_Cband.txt



Use the Windows Explorer, move to the ILWIS directory and move to the following sub-directory: \Extensions\WFS_E-Toolbox\DataManager.

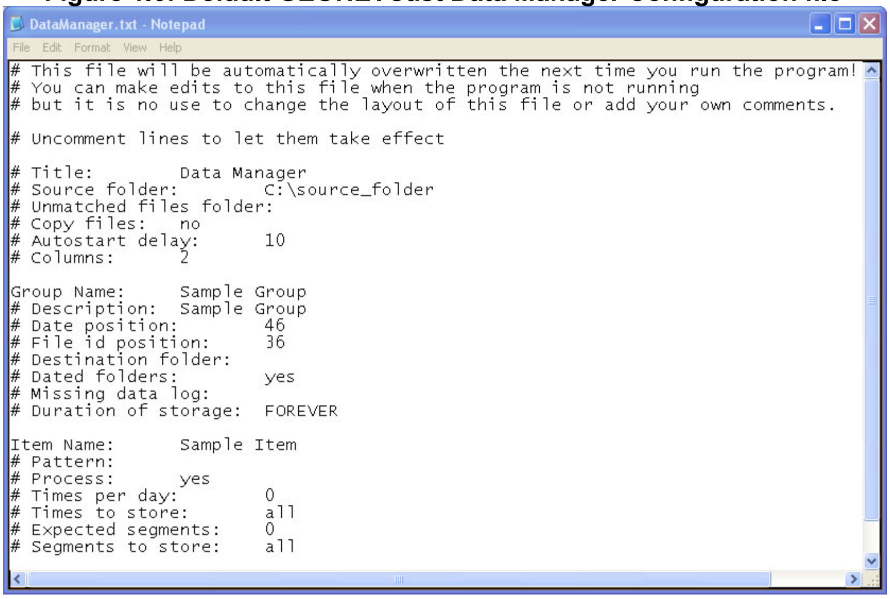
Select the file “DataManager.txt”, double click the file to open it using Notepad. This file is the default file that can be used to build your own data storage configuration file (see also figure 1.6).

As indicated in the application description before (chapter 1.2.3 GEONETCast Data Manager - “Rules”) you are able by adapting the “Group Name” and “Item Name” to modify the menu that will be generated subsequently when starting the application using the modified configuration file, which should be saved using a different name (else it will be overwritten when a new instance of the Data Manager is started using the default “DataManager.txt” file). To ensure that the changes are implemented when a new event of the Data Manager is started the lines should be uncommented to let them take effect.

The GEONETCast Data Manager can also be used as a stand-alone application. All required files are situated in the ILWIS sub-directory \Extensions\WFS_E-Toolbox\DataManager. This sub-directory can be copied to the appropriate system with JAVA installed and the “DataManager.jar” can be directly started from there as well, also using LINUX.

Having the capability to easily adapt the menu and therefore also the storage of the incoming data stream any new modifications resulting from adaptations of the EUMETCast-GEONETCast system can be easily incorporated without the need to wait for software updates. This is important as the system will further develop and broadcast more / different types of satellite and environmental data. Using simple copy and paste options the text file can be configured according to the need of the user, the system manager-administrator does not need to have any programming experience to do these types of manipulations.

Figure 1.6: Default GEONETCast Data Manager Configuration file



```
DataManager.txt - Notepad
File  Edit  Format  View  Help
# This file will be automatically overwritten the next time you run the program!
# You can make edits to this file when the program is not running
# but it is no use to change the layout of this file or add your own comments.

# Uncomment lines to let them take effect

# Title:          Data Manager
# Source folder:          C:\source_folder
# Unmatched files folder:
# Copy files:     no
# Autostart delay:        10
# Columns:        2

Group Name:       Sample Group
# Description:    Sample Group
# Date position:          46
# File id position:       36
# Destination folder:
# Dated folders:          yes
# Missing data log:
# Duration of storage:    FOREVER

Item Name:        Sample Item
# Pattern:
# Process:        yes
# Times per day:          0
# Times to store:         all
# Expected segments:      0
# Segments to store:      all
```

Note that any data which is not assigned by the rules specified is stored in the Directory assigned under the “Unmatched File Folder”. If this Directory is regularly checked the new data that has arrived can be easily captured in a set of new “rules” and stored if required relevant or deleted.

Carefully check the content of the text file “*GeonetcastDataManager_Cband.txt*” using Notepad to see how at ITC (for C-band reception) the full range of data broadcasted via GEONETCast is configured / handled and which data is stored (for various durations). Check also the various “Group” and “Item” names, “Pattern” and “Source” and “Destination” folders used.

In the WFS-Ethiopia toolbox XML version 2.0 wildcard characters * and ? are allowed in the filename pattern (thus not full regular expressions). Expected pattern examples are:

H-000-MSG?__-MSG?_________-HRV______-
*,METOPA+MHS_C_EUMP_*   or   A_H*_C_ECMF_*_grib2.bin

Note that new GEONETCast users can use this configuration file to get them going and adapt it to their local circumstances (using copy, paste and delete!). On https://github.com/52North/GEONETCast-DataManager also a recent ascii “GEONETCast Data Manager” configuration file is available, which can be downloaded and used/modified.

Check the Data Manager Version 2 Installation and User Manual for more details. This guide is available from the toolbox menu, under the tab “GEONETCast Data Manager” or from the ILWIS folder \Extensions\WFS_E-Toolbox\util\manuals (provided the toolbox has been installed!).

1.2.5 *Making the GEONETCast data available within the organisation*

The data that is received via EUMETCast-GEONETCast is commonly stored on a file server that can be accessed by all users within the organization according to the Data Manager settings described above. When using the “GeonetcastDataManager_Cband.txt” configuration file, two directories are relevant:

- GEONETCast_MSG_HRIT; a year, month, day formatted directory structure, which is storing the High Rate Image Transmitted data of Meteosat Second Generation (full spatial, spectral and temporal resolution data of MSG), also for MSG situated at 41.5 degree East;
- GEONETCast_other; including a number of sub-directories as well as (undefined) data that might reside in the root of this directory, which still needs to be defined by new "rules".

The directory "GEONETCast_other" is configured to contain all the other data, except the MSG HRIT data from the receiving computer, using the settings as specified by the GEONETCast Data Manager's configuration file and is stored in various sub-directories in this archiving folder. Some relevant sub-directories in this folder are:

- LRIT: Low Rate Image Transmitted satellite image data from Geostationary satellites (such as GOES);
- METOP: Data from the various instruments on-board of METOP, like the ASCAT instrument;
- MPEF (also IODC): Secondary Meteorological Products with high temporal resolution (AMV, GII, CLM, CLAI), note that the directory is "date-formatted";
- MPEF_DayDek: Secondary Meteorological Products with low temporal resolution (daily NDVI and decadal NDVI products from MSG);
- SAF (various): Satellite Application Facility data (e.g. surface radiation budget, bio-geophysical parameters, sea surface temperature);
- MODIS: MODIS global products like fires and chlorophyll;
- Proba Vegetation: Dekadal processed data derived from Proba Vegetation Instrument, like NDVI, NDWI, DMP, etc, for Africa;
- DevCoCast: Products produced by the DevCoCast-AGRICAB partners (CSIR, PML, INPE) for Africa;
- EAMNET: Various marine products for several regions in Africa;
- TAMSAT: Dekadal and monthly rainfall and rainfall anomaly products over the African continent;
- AMESD-SADC: Products for the Southern African Region related to Agriculture, Drought, Fires and Long Range Forecasting. This service also contains the ABBA-MSG fire product;
- Copernicus: provision of global products like Soil Water Index;

Restricted services, available only to National Meteorological Services and their Partner Organizations:

- ECMF: Analysis and forecasts from the ECMWF Integrated Forecast system and UK Met – Exeter, the UMD model data for Africa;
- LFPW: Analysis and forecasts from the Meteo France Arpege model for Africa;
- Meteorological data (see also https://www.ecmwf.int/en/forecasts/datasets/wmo-and-acmad-datasets) :
  - GTS METAR and TAF reports;
  - ECMF analysis and forecasts;
  - selected ECMWF products for ACMAD;
- NCEP: Global Forecasting System (NWP-model);
- SAFNWC: Nowcasting products from the NWC SAF.

To get easy access to the data, as it is stored on a "distant" file server, it is convenient to map these directories as a Network Drive using the Windows File Explorer Tools option.

Open Windows File Explorer and from the left hand menu, right click with the mouse on the icon “Network” and select from the context sensitive menu the option: “Map Network Drive..”, and select the shared network folder from Windows and browse to the target folder. If you have configured your system using the “GeonetcastDataManager_Cband.txt” file, specify two network mappings, one for the folder “GEONETCast_MSG_HRIT” (e.g. as drive Z:\) and one for the folder “GEONETCast_other” (e.g. drive Y:\).

These settings will vary for different locations. You have to consult the system manager to get the details of how the data is stored in the archive. Note that there are differences with respect to the type of data disseminated by Ku and C-Band services and a certain organization might not have requested all the services that are disseminated by EUMETCast-GEONETCast.

1.2.6 *Product information and other services*

To get an idea of what is currently disseminated using the various services, browse to the Product Navigator from EUMETSAT, available at: http://navigator.eumetsat.int/. From here type: “*Africa*”. Under “What are you looking for?” and press <Enter>. Also the total number of products that are operationally broadcasted is indicated and further details on the products can be obtained by exploring the individual product links provided.

To ensure that the (new) products are also received at the ground reception station the registration details have to be checked using the EO Portal operated at EUMETSAT. Login in to this portal at https://eoportal.eumetsat.int/userMgmt/login.faces using the appropriate User ID and password. Check your “Service Subscription” and the “Service Types” currently activated for your registration - station, eventually update the services by activating these like the new ‘Copernicus Sentinel services’, providing e.g. the Ocean products derived from Sentinel 3. Note that to receive the ABBA-MSG fire data, which is also used within the WFS-Ethiopia Toolbox, the AMESD-SADC service needs to be activated as well.

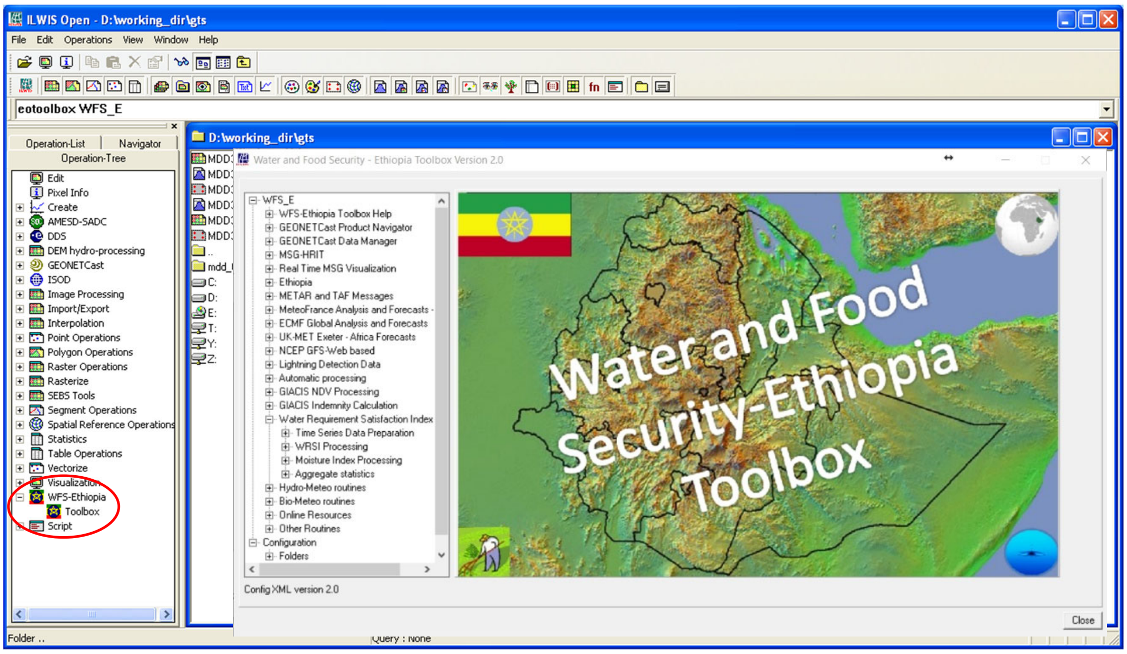
2. OVERVIEW OF THE WFS-ETHIOPIA TOOLBOX ARCHITECTURE

2.1 INTRODUCTION

This is an updated version of the Water and Food Security - Ethiopia Toolbox (see appendix 6 for changes incorporated). It is developed as a plug-in under ILWIS 3.7.2 but can also be used as a plug-in under ILWIS 3.8, provided that the appropriate EO-Toolbox.dll is loaded. The general installation instructions are described before. Note that this Toolbox version is not ILWIS downward compatible; in such a case download the latest ILWIS 3.7.2 version from https://github.com/52North/Ilwis3Downloads.

The main objective of the Toolbox is to allow the user, who operates a EUMETCast – GEONETCast ground receiving station to easily manage the incoming data stream and to import the data into a common freeware GIS-RS environment for further analysis, in this case using the functionality of ILWIS version 3.7.2 or higher. This toolbox version allows import of various data sources relevant for water and food security analysis for Ethiopia through a Graphical User Interface (GUI). Here the toolbox architecture is described into more detail. Once the toolbox is installed and ILWIS is newly started the "WFS-Ethiopia Toolbox" should appear as a menu item under the ILWIS Operation Tree (see figure 2.1).

Figure 2.1: The WFS-Ethiopia Toolbox Version 2.0 plug-in Graphical User Interface



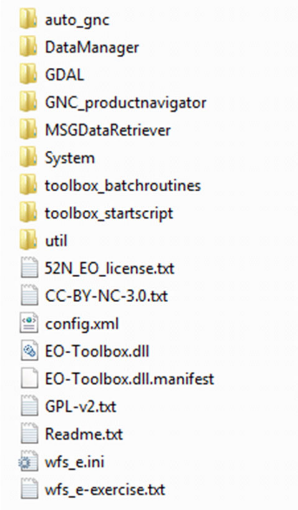
2.2 STRUCTURE OF THE WFS-ETHIOPIA TOOLBOX

To operate the WFS-Ethiopia Toolbox, the file ""*52n-eo-WFS-E-toolbox-2.0*.zip" is copied under the ILWIS sub-directory \Extensions. Once a new event of ILWIS372 is started this ZIP file is extracted and the content is stored in the sub-directory \WFS_E-Toolbox within the same \Extensions sub-directory. Within the WFS_E–Toolbox sub-directory a number of other sub-directories appear (see figure 2.2).

The folder *DataManager* contains the "GEONETCast Data Manager", a utility that allows automated archiving of the newly incoming data. This application requires the Java Runtime

Environment. It is advised to run this utility as a stand-alone application if operated on a ground receiving station as it should be operated continuous. This utility is described in chapter 1.2 and also operates under LINUX.

Figure 2.2: Toolbox sub-directory structure



The folder *GDAL* (Geospatial Data Abstraction Library) contains a translator library for raster geospatial data formats that is released under an X/MIT style Open Source license by the Open Source Geospatial Foundation (http://www.gdal.org).

The folder *GNC_productnavigator* contains the utilities to open the GNC Product Navigator disseminated via EUMETCast-GEONETCast. Here a Product Navigator version is provided as of the release of this toolbox version. The GEONETCast Product Navigator is also available in the "*Received*" folder on the 'Ground Receiving Station'. This folder can be copied to the archiving system to ensure you are working with a recent version. As the Product Navigator is regularly updated it is advised to update it frequently so the end user is using the latest version. To ensure that the latest information is at your disposal also a link to an online version is provided, using as link: http://navigator.eumetsat.int.

In order to automate the updating procedure of the 'Product Navigator' disseminated through EUMETCast, a "Scheduled Task" can be created in Windows by the system administrator. This task is executed automatically at the given system clock time, preferably to be invoked once a day. This task subsequently runs a batch file, which should have the following command lines:

```
@echo off
xcopy /s /i /r /y \\pc\received\product-navigator y:\product-navigator
```

where:

\\pc\received\product-navigator	the receiving computer \ directory
y:\product-navigator	the output directory on the archive

The folder *MSGDataRetriever* contains the utility that allows import of the HRIT MSG Level 1.5 data of MSG at 0 and 41.5 degrees, but also of the MSG satellite providing the Rapid Scan Service (RSS). This utility can also be used as stand-alone. Further information is provided in chapter 2.5.

The folder *System* is storing the ILWIS service objects. Service objects are used by data objects; they contain accessories required by data objects besides the data itself. Upon installation of the toolbox, these objects are copied to the main ILWIS directory \System.

The folder *Toolbox_startscript* is having various sub-directories containing ILWIS scripts. Upon selection of an import routine, from the WFS-Ethiopia toolbox User Interface (GUI) a script is called and this script subsequently calls a batch file which executes the operation. The scripts can also be opened and modified using ILWIS. Further information is provided in chapter 2.6.

The folder *Toolbox_batchroutines* provides the batch files that are used to execute most of the actual operations. These files can be opened and modified using a text editor. Currently over 150 routines are available for accessing (in near real time) the various images and data products in the EUMETCast-GEONETCast data stream relevant for water and food security analysis for Ethiopia. Further information is provided in chapter 2.7.

The folder *auto_gnc* contains the routines and within the sub directories the templates and background maps needed for the automatic visualizations of the latest MSG images and Nowcasting products, as well as the MSG infrared enhanced animation. This directory contains a utility called "*DDEClient.exe*". This is used for display of a map or mapview from the command prompt. It should be noted that ILWIS needs to be active! Further information is provided in chapter 3.2.13.

In the root of the *Util* folder ILWIS service objects are stored, like lookup tables, georeferences, domains, etc. Furthermore a number of executables are stored here as well which are used by various toolbox batch routines. Next to this, the folder is containing a number of sub-directories:

- The sub-directory *Maps* is containing various segment maps of Ethiopia and a segment-polygon file of all countries of the world and for Africa, a land mask for Africa (zipped) as well as a number of map views.
- The sub-directories *MSG_time* contain the time stamps needed for the MSG real time visualization.
- The sub-directory \Bufrdisplay and \Bufrextract are used to store the "Bufrdisplay" and "Bufrextract" executables (bufrdisplay.exe and bufrextract.exe), see also chapter 1.1.5. The utility should be downloaded yourself and copied into this folder. The program can be accessed from the menu under the option "*Other Routines*" >> "*Generic BUFR data visualization*". Bufrextract is a command line utility, directly called from within the batch routines.
- The folder \Julian_Day contains two tables showing the Julian day number for normal and leap years and the actual calendar date. The tables can be accessed from the menu under the option "*Other Routines*" >> "*Display Julian Day tables*".
- The folder \MWeather is used to store "MWeather.exe" (see also chapter 1.1.6), a utility to quickly decode METAR and TAF messages. The program can be accessed from the menu under the option "*METAR and TAF Messages*". After creation of a METAR-TAF file for a certain country the "*Display METAR TAF data*" option is used to start MWeather.exe and the information contained in the file created can be displayed.
- The sub-directory \Grep should contain the Grep tool, see chapter 1.1.7 for further details. This utility is directly used from within batch routines.
- The sub-directory \Gifsicle should contain the Animated Gif creation tool "gifsicle.exe", see chapter 1.1.8 for further details. This utility is directly used from within batch routines.
- The sub-directory \MSGToolbox should contain the MSGToolbox, see chapter 1.1.9 for further details. The toolbox can be accessed from the menu under the option "*Other Routines*" >> "*Generic LSA-SAF Processing*".
- The sub-directory \PanoplyWin should contain the Panoply.exe, see chapter 1.1.10 for further details. The utility can be accessed from the menu under the option "*Other Routines*" >> "*Generic NetCDF_GRIB_HDF data Visualization*".
- The sub-directory \Wget should contain the Wget.exe, see chapter 1.1.11 for further details. This utility is directly used from within batch routines to download data from online

resources without user interaction. The system is assumed to be connected to the internet.

- The sub-directory \7GIF should contain the utility 7GIF.exe used to create the animation for the GIACIS Indemnity maps, see chapter 1.1.12 for further details. This utility is directly used from within batch routines to create the animated GIFs, for visualization afterwards, use the link from the menu under the option "*Other Routines*" >> "*View Animated GIF*".
- The folder \ilwis_O should contain ILWIS Open, see chapter 1.1.13 for further details. This utility is directly used from within batch routines.
- The sub-directory \Timeseries_transform contains the time series transformation and map list rename utility. The utility can be accessed from the menu under the option "*Other Routines*" >> "*Time series Data Transform*".
- The sub-directory \manuals contains a number of installation and user manuals and a change log description. From the various sub-menus links are provided to the relevant documents (in PDF format). A PDF reader is assumed to be available on the system of the user.

The file "*config.xml*" contains the WFS-Ethiopia Toolbox GUI menu structure. This file can be edited using a text editor. In case the user wants to add new routines, this XML file can be adapted and modified. The resulting GUI menu will be adapted accordingly when a new instance of the Toolbox is started. This allows users that do not have programming experiences to adapt the toolbox to their own preferences. A more detailed description is provided below in chapter 2.3.

The file "*wfs_e.ini*" contains the settings of the input and output directories for each "folderid" that is defined in the "config.xml". This file is storing the settings as defined from the Toolbox menu options: "*Configuration*" >> "*Folders*". Further information on the input and output folder settings is provided in chapter 2.4. An additional "*ini*" file is available, called "*wfs_E_exercises.txt"*. This file can be renamed to wfs_e.ini to obtain the appropriate directory settings as expected for the exercises provided in chapter 4. The "xml" and "ini" files can be opened and edited with Notepad or Wordpad. Before modifying or overwriting these files first make a backup!

The file "*EO-Toolbox.dll*" contains the layout of the User Interface of the WFS-Ethiopia Toolbox and generates the full ILWIS command string that executes the script, batch file and defines and passes the parameters that are used, like the time stamp, input drive, input directory, output drive, output directory, ILWIS directory, etc. Up to 9 parameters are used to execute a Toolbox operation.

Note that for ILWIS38 another EO-Toolbox.dll has to be used, this DLL can be downloaded from the ITC FTP (ftp://ftp.itc.nl/pub/52n/ILWIS385_DDL/) and copied into the ILWIS sub-directory \Extensions\WFS_E-Toolbox. The existing DLL can be replaced.

The file "*EO-Toolbox.dll.manifest*" is used by the operating system for certification of the appropriate DLL.

Furthermore included are a 'Readme.txt' and the '52N_EO_license.txt', which can be opened using a text editor. These files provide relevant license and additional information on this toolbox release. The files 'CC-BY-NC-3.0.txt' and 'GLP-v2.txt' provide further details on the Creative Commons and GNU General Public License information applicable respectively.

2.3 STRUCTURE OF THE CONFIG.XML

One of the main criteria during the development of this utility was to make the toolbox as open as possible, allowing persons with no programming background to make modifications in case new sensor data - products become available as the EUMETCast-GEONETCast data stream will further evolve-change. As indicated before, all scripts and batch routines used can be adapted by the user. Next to this, the user can also modify the menu of the Toolbox GUI. The file that generates the user interface, “config.xml”, can be opened using a text editor.

The structure of the file is kept as simple as possible. The “Level” is defining the main (Level1) and sub menu structure (Level2 – Level”*N*”). For the “Level value=” a menu name can be defined. Within a certain level a “Product value=” can be specified, which will generate the name of the respective (sub) menu.

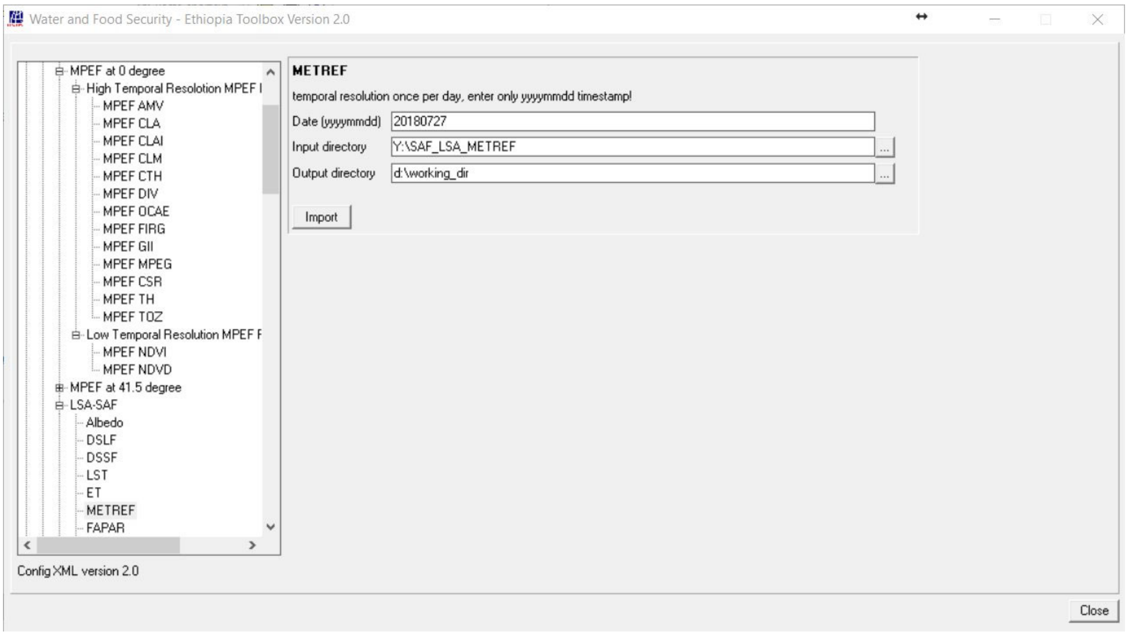
The string starting with “Product value=” contains mostly a number of other items, like “*script*”, “*format*”, “*type*”, “*folderid*” and “*comment*”.

- ***Script***: The item script defines the sub-directory were the respective ILWIS script is located and the name of the script that should be executed;
- ***Format***: The text string that can be entered here will appear in the popup window when importing a certain image or product. It is used to ensure that e.g. the appropriate “time stamp” is entered on the user interface (see the “Date” on figure 2.3). For the various images and products these can have a different formats, in the example of figure 2.3 the “Date” stamp expected should have the format “yyyymmddhhmm” (y=year, m=month, d=day, h=hour and m=minute);
- ***Type:*** This is the only part of the toolbox that does not allow user modification without programming experiences. Various forms, that generate the pop-up windows are available within the “EO-Toolbox.dll” and are called by their specific names given. These forms generate the appearance of the popup windows when importing a specific product. The popup menu that is given in figure 2.3 is generated from a “type” called: “ymdhm”. In case another pop-up window is required don’t hesitate to send an email to the corresponding author;
- ***Folderid***: This item generates a folder item in the “wfs_e.ini” file. From the main Toolbox menu, Configuration and Folders option, this Folder item is now available and can now be further specified by defining the appropriate input and output directories. As example a “folderid” of “MPEF-highres” is given. When opening the “wfs_e.ini” file, using a text editor, an item [MPEF-highres] is added and the input and output folders can now be specified here as well by providing the relevant directory names, like:

  [MPEF-highres]
  InputFolder=D:\WFS_Ethiopia_TrainingData\MPEF\HighRes
  OutputFolder=D:\WFS_out

  Make use of a text editor (using find and replace) to quickly change the output directory for all “OutputFolder” settings in the “wfs_e.ini”;
- ***Comment:*** Additional information (one line of text) can be provided in the popup menu to notify the user on any specific information that might be relevant. In figure 2.3 a comment string is added showing the temporal resolution of the METREF data and temporal resolution of the data. If the data is having a higher temporal resolution also the starting time stamp of the images in UTC per day is provided;
- ***Id:*** This item is currently under development; here you can specify keywords that can be used for a search.

Figure 2.3: Popup menu for import, example LSA-SAF METREF import, Ethiopia window



The first few lines of the config.xml are:

1: <WFS_E>
2: <Version id="2.0" finder="false"/>
3: <UIInfo icon="ethiopia" menu="WFS-Ethiopia..Toolbox" title="Water and Food Security - Ethiopia Toolbox Version 2.0"/>
4: <Path value="Extensions\WFS_E-Toolbox" inifile="wfs_e.ini"/>

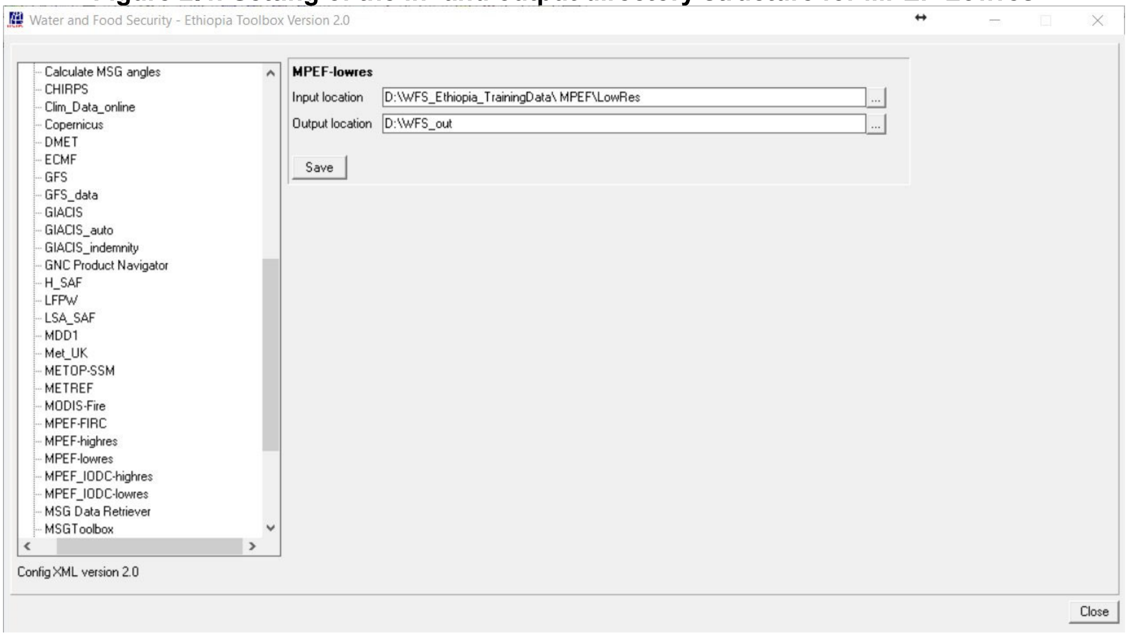
Line 1 provides the link to the plug-in and the menu name, note that this is also the last line of the XML. Line 2 provides the opportunity to indicate a version number, useful if modifications are done to the original XML. The version number is also shown in the main WFS-Ethiopia Toolbox menu, in the lower left hand corner (see also figure 2.3). The "*Finder*" is a utility under development, allowing a search using keywords. The "*UIInfo Icon*" in line 3 refers to the toolbox logo used in the ILWIS Operation Tree, the "*menu*" provides the name, the ".." indicates that the menu consists of two levels, and the heading used in the toolbox user interface is defined by the "*title*". In Line 4 the "*path*" defines the location of the toolbox in ILWIS and the "*inifile*" here refers to the "wfs_e.*ini*" file, which provides the links to the input and output directories. Note that between lines 3 and 4 there can be an entry "RemoteServer…". This is an internal (ITC) item at this moment.

After changes are made to the config.xml the file should be saved and a new instance of the Toolbox should be started, showing the adaptations. Before modifying the file first make a backup!

2.4 General GEONETCast Toolbox Configuration - Folder settings

For you to conveniently work with the WFS-Ethiopia Toolbox the data sources (on your local area network) and the local system output (working) directories need to be defined. From the main WFS-Ethiopia Toolbox menu, select "*Configuration*" and the sub-menu "*Folders*". In figure 2.4 below the in- and output directory settings used to conduct the exercises described in chapter 4 for the MPEF low temporal resolution data is used as example. "*D:\WFS_Ethiopia_TrainingData\MPEF\LowRes*" is the "local GEONETCast data directory" and "*D:\WFS_out*" is the local system hard disk, storing the results of the processing routine. Note that use can be made of a "Network Mapping" as described in chapter 1.2.5. Furthermore note that some input folders can be date formatted according to the specifications of the local system administrator. These directories are also having a year, month and day structure.

Figure 2.4: Setting of the in- and output directory structure for MPEF-Lowres



Configure the input directory "Folders" according to the settings given by the local system configuration. Note that if your system administrator has provided you with an updated configuration file used for the GEONETCast Data Manager, all relevant settings can be obtained from there! It might not be necessary to specify all folders as some of the data services are not received by the local ground reception infrastructure. There is a "Special locations" folder to select the location and programme-executable. Currently the location of "IrfanView" and "i_view32.exe" (or newer version) needs to be specified, as this freeware utility is used for visualization of pictures that are not transformed into an ILWIS data format. Make sure that this folder and executable are always correctly specified.

2.5 Configuring the data source of the MSG Data Retriever

The data source folder for the MSG Data Retriever can be specified from the main WFS-Ethiopia Toolbox menu, select "*Configuration*" and the sub-menu "*Folders*". Select the Folder "*MSG Data Retriever*" and specify the input location and press "*Save*".

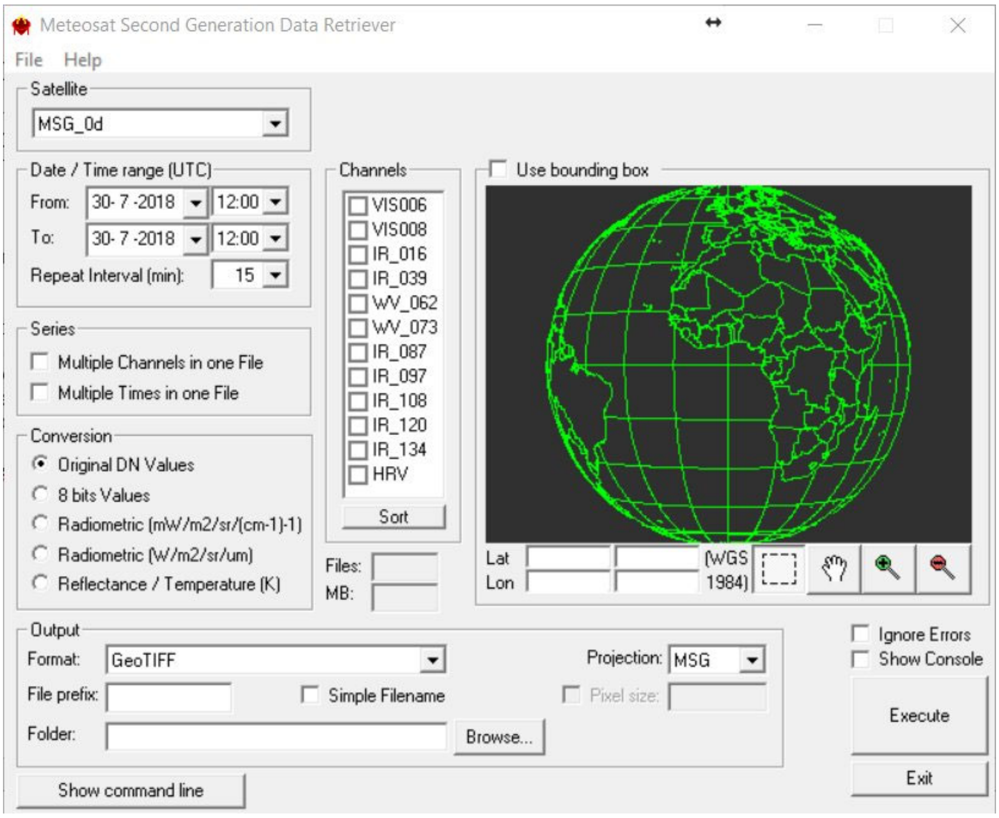
For advanced data source(s) configuration settings open the "*MSG HRIT*" tab and activate the "*MSG Data Retriever*" option in the WFS-Ethiopia Toolbox. The Meteosat Second Generation

Data Retriever (MSG Data Retriever) window appears. This utility is a tool for converting raw Meteosat Second Generation (MSG) SERVIRI Level 1.5 files into a known raster-GIS or raster image file format. The MSG Data Retriever is used to extract the HRIT data recorded by the MSG 8, 9 10 and 11 (also referred to as MSG1, MSG2, MSG3 and MSG4 respectively prior to being declared operational). In geostationary orbit 36,000 km above the equator, the Meteosat satellites operate over part of Southern America, the Atlantic Ocean, Europe, Africa, the Indian Ocean towards South East Asia. In the Satellite dropdown list, situated in the top left portion of the MSG Data Retriever window MSG at 0 degree, MSG at 41.5 degree and MSG-RSS can be selected:

- Meteosat-11 is the prime operational geostationary satellite, positioned at 0 degrees and providing full disc imagery every 15 minutes. It also provides Search and Rescue monitoring and Data Collection Platform relay service;
- Meteosat-10 provides the Rapid Scanning Service, delivering more frequent images every five minutes over parts of Europe, Northern Africa and adjacent seas. It also provides Search and Rescue monitoring;
- Meteosat-9 provides a backup service to Meteosat-11 Full Earth scanning and a gap filling service to Meteosat-10 Rapid Scanning;
- Meteosat-8 operates over the Indian Ocean performing Full Earth scanning. It also provides Search and Rescue monitoring and Data Collection Platform relay service (which includes relay of Tsunami warnings).

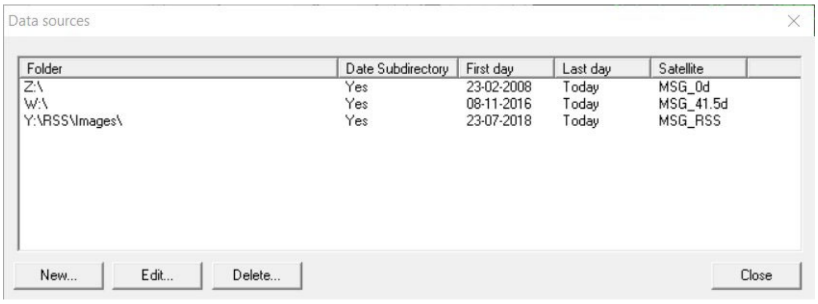
The MSG-HRIT data is licensed and therefore parts of MSG Data Retriever are licensed. Using the software means that you agree and comply to the conditions of use of the software as specified in the document provided under the main menu "*Help*" function. See here: "*Limitation of use of MSG Data Retriever*". See also figure 2.5 below.

Figure 2.5: Meteosat Second Generation Data Retriever at 0 Degree



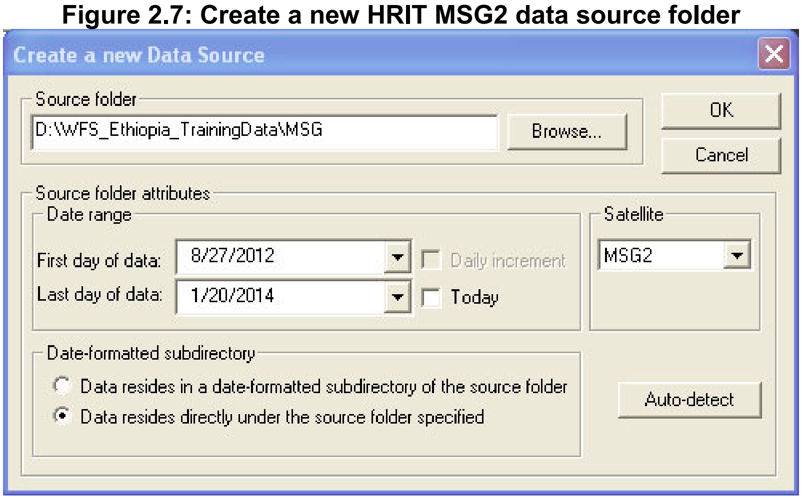
The advanced settings of the data sources of this HRIT data stream have to be configured separately. To configure the appropriate data source for the various MSG satellites (note that use can be made of more data sources, e.g. for each of the satellites), select from the top left menu, the "*File*" Option and open the "*Data Sources*" menu.

Figure 2.6: Data Sources Menu



In this submenu you can delete any folder that might appear, subsequently select "*New*". In the "*Create a new data source*" menu, browse to your "*drive:\folder*" that contains the raw MSG_0d HRIT data (see also figure 2.7). See also the description given in chapter 1.2.5 if a new network mapping has to be created, here the settings for the exercises as of chapter 4.1 are used.

Figure 2.7: Create a new HRIT MSG2 data source folder



When the source folder is provided, the "*First day of data*" and "*Last day of data*" should be specified. These can be obtained using the option "*Auto-detect*" situated at the lower right portion of the "Create a new Data Source" Window. When using the "*Auto-detect*" option these settings are automatically detected. If "Last day of data" equals the current day it will automatically keep updating the "Last day of data" to be the present date.

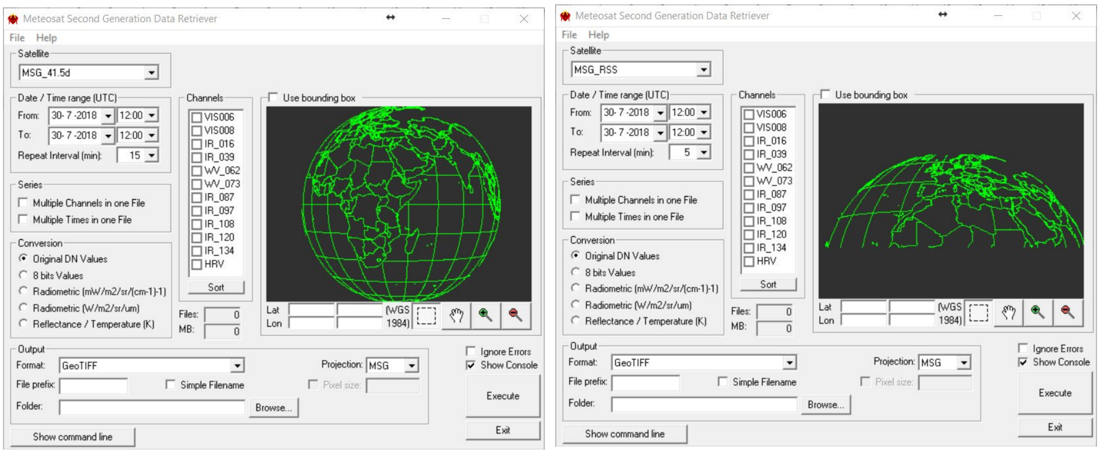
If the data source is correctly specified the settings can be accepted by pressing "OK". Note that when using the settings of the GeonetcastDataManager_Cband.txt (as discussed in chapter 1.2.4) use is made of a date-formatted sub-directory structure (each day a new sub directory is created storing the MSG-HRIT data of that specific day). In this case the option "Data resides in a date-formatted subdirectory of the source folder" is activated. In case all the MSG-HRIT data is situated directly under a source folder the other option can be activated ("Data is situated directly under a source folder specified"). Note that this option is selected in the example provided here.

In a similar way also the source folder for the "MSG_41.5d" (Indian Ocean Data Coverage) and "MSG_RSS" satellite (Rapid Scanning Service) can be specified. The help function in the main

MSG Data Retriever Window is providing additional information on the functionality offered by this utility. Note that RSS data is not provided via C-band reception (in Africa).

When selecting another satellite also the map view is changing. The figure below provides the map layout for MSG at 41.5 Degree and MSG- RSS. The map view allows interactive selection of the area of interest.

Figure 2.8: MSG Data Retriever 41.5 Degree and RSS screen layout



From the “Meteosat Second Generation Data Retriever” the “Help” menu has been updated as well.

2.6 STRUCTURE OF THE ILWIS GEONETCAST TOOLBOX SCRIPTS

Most of the ILWIS scripts, situated within various sub-directories in the folder *Toolbox_startscript*, contain a single line which is mostly identical. You can open ILWIS, use the "Navigator" to move to the sub-directory \Toolbox_startscript\Ethiopia\MPEF and double click with the mouse on a script to open it. You can close the script editor. Below an example is given of an Atmospheric Motion Vector (AMV) import routine (situated in the same sub-directory *toolbox_startscript\ Ethiopia\MPEF*):

!%7\Extensions\WFS_E-Toolbox\toolbox_batchroutines\MPEF_eth_amv_import.bat %1 %2 %3 %4 %5 %6 %7 %8

The command line starts with: ! This syntax (!) instructs ILWIS to start an external application. The application that should be started is situated in *"%7\Extensions\WFS_E-Toolbox\toolbox_batchroutines\"* and called "*MPEF_eth_amv_import.bat*". This is a DOS batch routine which should be executed. The parameters required to execute the batch routine are given as %1 to %8:

%1	Longfilename	remark: the time stamp entered for the specific product
%2	InputDrive	remark: input data drive, can also be a network mapping
%3	InputDir	remark: input data directory
%4	OutputDrive	remark: output data drive
%5	OutputDir	remark: output data directory
%6	GdalDir	remark: location of GDAL directory within toolbox
%7	IlwDir	remark: location of the ILWIS directory
%8	UtilDir	remark: location of the Util directory within toolbox

A number of these parameters are generated by the "EO-Toolbox.dll", such as "GdalDir", "IlwDir" and "UtilDir" as these are fixed locations within the toolbox. Other parameters require user interaction, such as "longfilename", "InputDrive", "InputDir", "OutputDrive", "OutputDir", as these change based on the user preferences. These parameters can be interactively provided in the popup menu when importing an image or product, see e.g. figure 2.3 above and the Date field provides the "Longfilename", input and output directory for the "InputDrive", "InputDir", "OutputDrive" and "OutputDir" respectively.

When pressing the "Import" button of the popup menu (see again figure 2.3) a command line is generated which is executed by ILWIS. Using the script example above to import an Atmospheric Motion Vector (AMV) map, the following command line is generated and executed:

!C:\ilwis372\Extensions\WFS_E-Toolbox\toolbox_batchroutines\MPEF_eth_amv_import.bat 201207021145 Y: MPEF\2012\07\02 D: GNC_out C:\ilwis372\Extensions\WFS_E-Toolbox \GDAL\bin C:\ilwis372 C:\ilwis372\Extensions\WFS_E-Toolbox\util

The parameters are now defined as follows:

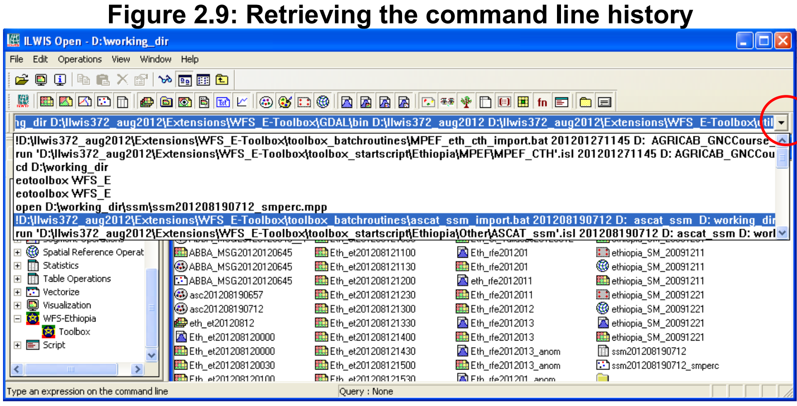
%1	Longfilename	201207021145
%2	InputDrive	Y:
%3	InputDir	MPEF\2012\07\02
%4	OutputDrive	D:
%5	OutputDir	GNC_out
%6	GdalDir	C:\ilwis372\Extensions\WFS_E-Toolbox\GDAL\bin
%7	IlwDir	C:\ilwis372
%8	UtilDir	C:\ilwis372\Extensions\WFS_E-Toolbox\util

Now with all parameters set the batch file "*MPEF_eth_amv_import.bat*", situated in the ILWIS sub-directory \Extensions\WFS_E-Toolbox\toolbox_batchroutines\ can be executed. Starting the command with the !, ILWIS knows it has to execute an external command, given the fact that the extension is ".bat", the Windows Command Line Interpreter (CMD.exe) knows it has to execute this file using the Batch command line processor.

For a number of visualization routines "IrfanView" is used. In these cases an additional parameter is defined as %9, called "IrfanViewDir". This parameter defines the location of the IrfanView directory and executable. It can be specified under the "Configuration", "Folders" and "Special locations" options from the WFS-Ethiopia Toolbox User Interface. Sometimes (e.g. for the MODIS global fire products) %9 is used for the Julian day or for the METOP A/B Soil Moisture %9 is used for the orbit number.

The command line history can be retrieved pressing the drop down arrow at the right hand part of the command line in the main ILWIS menu. Note that the history length can be specified from the ILWIS main menu, select "File" >> "Preferences" and modify the command line "History entries".

Figure 2.9: Retrieving the command line history



2.7 STRUCTURE OF THE ILWIS WFS-ETHIOPIA TOOLBOX BATCH ROUTINES

As is the case with the ILWIS scripts, also most of the batch files follow a similar structure. These files are located in the sub-directory \Extensions\WFS_E-Toolbox\toolbox_batchroutines. As an example a MPEF Cloud Top Height import routine (MPEF_eth_cth_import.bat) is given below.

The first 9 lines (see line numbers) are giving some remarks. Lines start with the "echo" command, which allows, or turns off (echo off) the display of messages in the command line window, see also figure 2.10. Note that an "echo." creates an empty line in the command line window. From line 10 to line 18 in the batch file, the parameters are passed, originating from the ILWIS script, to the batch file using the "SET" command. This command displays, sets, or removes Windows Environment Variables. Once these parameters are known the actual import routine can start. Special attention should be given to lines 10 and 11. The time stamp is defined as longfilename1 and is set in line 10. In line 11 this time stamp is used, starting from position 0, for 12 characters. In this case if a time stamp is used, like 201007021145 (as yyyymmddhhmm), the whole time stamp will be set as "shortfilename1", as this has a length of 12 characters. This allows flexibility in selections of portions of strings, but does not have any influence for this specific import routine, here longfilename and shortfilename1 are the same.

Lines 19 to 21 ensure that the application moves to the appropriate output directory. Line 22 displays the selected output directory in the command line window (see again figure 2.10). The items "echo." in line 23 and creates an empty line in the command line window (see again figure 2.10). Line 24 (using the command "echo off") sets the display of subsequent messages off.

From lines 25 to 29 a test is being conducted which MSG satellite is being used. At the moment operationally MSG4 is being used at 0 degree. Previously this was MSG 2 and MSG 3. Still MSG

2 is being used as backup for MSG 4. As a convention the MSG satellite number is always used in the file name string and this number can change when another satellite is operated at a given location or used as temporary backup. To ensure that all satellites can be used during import this check is required. If within the filename string a certain “MSG_number” is given, the procedure continues to the position indicated by “START1”, in this case line 30.

In line 32 a check is performed if the input file exists, if this file does not exist the batch routine jumps to the section starting with “:MESSAGE”. If the input file exists line 33 is displayed in the command line window, followed by 2 empty lines and then jumps to the start of the actual import routine, which begins at the “:START” section (line 36).

If the input file does not exist (in line 32) the batch routine jumps to line 37 “:MESSAGE”, the section below (lines 38 to 42) are displayed, see also figure 2.10. In line 43 a “pause” command is used and the user has to press <enter> in order to continue. Once this is done the “GOTO END” command in line 44 causes the routine to jump to line 63.

If the data is located in the specified input drive-directory, line 46 copies the requested input data, using the appropriate time stamp, note %shortfilename1%. Images and products can consist of more than one file / segment. In line 46 note the portion of the file name string “__-00000?__”. Using the “?” allows copying all segments of the same time stamp. To reconstruct the image or product the various segments have to be merged. This is done in line 47 (using the utility “joinmsg.exe”) and a new output file is created, file format is GRIB. This file is renamed in line 48, to obtain a shorter filename and is imported into ILWIS format in line 49, using GDAL_translate.exe.

Once the file is in ILWIS format, ILWIS is executed from the command prompt in lines 50 to 53 (ilwis.exe –C) and a number of operations, such as map calculations (line 50), slicing (line 51) and map resampling to the Ethiopian window (lines 52 and 53) are performed. Lines 55 – 62 are deleting the files that have become obsolete.

Line 63 marks the “:END” section. With or without the required input data line 64 is always executed, this line closes instances of ILWIS which have started using this batch routine.

Start of batch file listing: MPEF_eth_cth_import.bat

```
------------------------------------------------------------------------------------------------------------------------------------------
1:@echo off
2: echo Cloud Top Height import routine
3: echo The output-prefix: Eth_v  is a value map
4: echo The output prefix: Eth_c  is a class map, using elevclass.dom
5: echo The value map can be displayed using a PSEUDO Representation
6: echo Data is resampled to cover the Ethiopian region
7: echo Use is made of the Ethiopia 1km Lat-Lon projection
8: echo.
9: echo.

10: set longfilename=%1
11: set shortfilename1=%longfilename:~0,12%
12: set InputDrive=%2
13: set InputDir=%3
14: set OutputDrive=%4
15: set OutputDir=%5
16: set gdalDir=%6
17: set IlwDir=%7
18: set UtilDir=%8

19: cd\
20: %OutputDrive%
21: cd %OutputDir%
```

```
22: echo your current working directory = %OutputDrive%\%OutputDir%
23: echo.
24: echo off

25: set MSG_number=2
26: if exist %InputDrive%\%InputDir%\"L-000-MSG2__-MPEF________-CTH______-00000?___-
    %shortfilename1%-__*.*" goto START1
27: set MSG_number=3
28: if exist %InputDrive%\%InputDir%\"L-000-MSG3__-MPEF________-CTH______-00000?___-
    %shortfilename1%-__*.*" GOTO START1
29: set MSG_number=4

30: :START1
31: echo off
32:  if not exist %InputDrive%\%InputDir%\"L-000-MSG%MSG_number:~0,1%__-MPEF________-
      CTH______-00000?___-%shortfilename1%-__*.*" goto MESSAGE
33: echo The file(s) %InputDrive%\%InputDir%\"L-000-MSG%MSG_number:~0,1%__-MPEF________-
      CTH______-00000?___-%shortfilename1%-__*.*" will be copied to your current working directory
34: echo.
35: echo.

36: GOTO START

37: :MESSAGE
38: echo The input file was not found.
39: echo Check your directory and date stamp settings
40: echo Your current date stamp used is %shortfilename1%
41: echo Check also if the data exists on your input directory - archive
42: echo Note the temporal resolution of your data

43: pause

44: GOTO END

45: :START


46: copy %InputDrive%\%InputDir%\"L-000-MSG%MSG_number:~0,1%__-MPEF________-CTH______-
    00000?___-%shortfilename1%-__*.*"

47: "%UtilDir%\joinmsg.exe" "L-000-MSG%MSG_number:~0,1%__-MPEF________-CTH______-
      000001___-%shortfilename1%-__" %OutputDrive%\%OutputDir%\

48: rename "l-000-MSG%MSG_number:~0,1%__-mpef________-cth______-000001___-
      %shortfilename1%-__.grib" CTH%shortfilename1%.grib

49: "%gdalDir%\gdal_translate" -of ILWIS CTH%shortfilename1%.grib tCTH%shortfilename1%

50: "%IlwDir%\ilwis.exe" -C %OutputDrive%\%OutputDir%\vCTH%shortfilename1%.mpr{dom=value;vr=-
      100000.00:1000000.00:0.01}:=iff(%OutputDrive%\%OutputDir%\tCTH%shortfilename1%_band_1 ne
      9999,%OutputDrive%\%OutputDir%\tCTH%shortfilename1%_band_1,?);

51: "%IlwDir%\ilwis.exe" -C %OutputDrive%\%OutputDir%\cCTH%shortfilename1%.mpr{dom='%UtilDir%\
      elevclass'}:=MapSlicing(%OutputDrive%\%OutputDir%\vCTH%shortfilename1%.mpr,'%UtilDir%\elevcl
      ass');

52: "%IlwDir%\ilwis.exe" -C OutputDrive%\%OutputDir%\Eth_vCTH%shortfilename1%.mpr{dom=value;vr=-
      100000.00:1000000.00:0.01}:=MapResample(%OutputDrive%\%OutputDir%\vCTH%shortfilename1%,
      ethiopia_1km.grf,nearest)
```

```
"%IlwDir%\ilwis.exe" -C OutputDrive%\%OutputDir%\Eth_cCTH%shortfilename1%.mpr{dom='%UtilDir%\clai'}:=MapResample(%OutputDrive%\%OutputDir%\cCTH%shortfilename1%,ethiopia_1km.grf,nearest)
del "tCTH%shortfilename1%".mp*
del "tCTH%shortfilename1%".csy
del "tCTH%shortfilename1%".grf
del tCTH%shortfilename1%.aux.xml
del "tCTH%shortfilename1%_band*".mp*
del CTH%shortfilename1%.grib
del "L-000-MSG%MSG_number:~0,1%__-MPEF________-CTH______-00000?___-%shortfilename1%-__*.*"
del cCTH%shortfilename1%.mp*
del vCTH%shortfilename1%.mp*

:END
"%IlwDir%\ilwis.exe" -C closeall
```

End of Batch file listing.

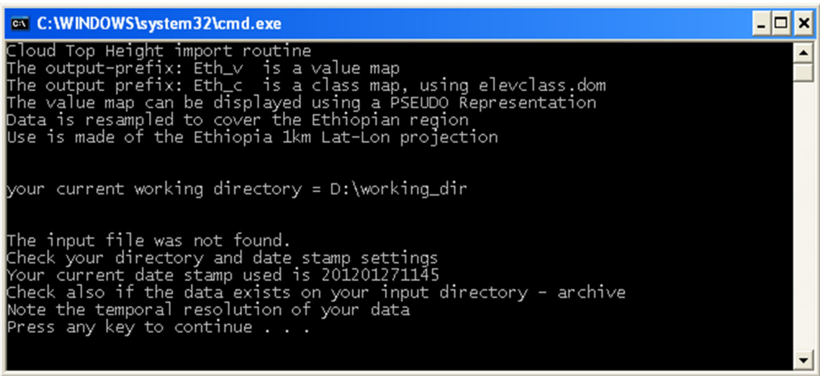
Although the content of the batch files can vary significantly, the sequence of activities is mostly the same:

- Some remarks are given at the start of the batch file
- Setting of the environment variables, passing over the parameters from the ILWIS scripts
- Check if input data is available, if not go to the end of the batch routine
- Copy the original data to a local disk
- Import of the data into ILWIS format
- Execute various ILWIS routines from the command prompt
- Delete obsolete files
- Close ILWIS tasks created by the batch routine

Note that all batch routines show a command line window. Relevant information is contained in these windows. It is advised that the content of these windows is critically checked while waiting for the batch routine to finish. The batch files can be opened using a text editor. The name of the batch file executed can be obtained from the ILWIS command line string as given in chapter 2.6 and figure 2.10.

In the example given in the batch file listing a date stamp should have been entered as “201001271145”. The actual time stamp used is “201201271145” which is resulting in the fact that the input data cannot be found and the routine, after pressing <enter> is aborted. Carefully inspect the date stamp and directory settings as indicated in the command line interpreter window as given in the figure below.

Figure 2.10: Resulting message when entering wrong date-time stamp



When appropriate, “quotation marks” are used to specify the location of a ‘directory\executable’ as well as for the input GEONETCast original file names to ensure that batch routines keep working if encountered spaces in (sub-) directory names and to copy input files with complex file names. To ensure proper operation of the batch routines it is strongly advised to stick to the golden rules as given in chapter 1.1.1.

As can be seen from the batch file listing provided above, the toolbox routines are executing a new instance of ILWIS from the command line starting with the command: “ilwis.exe –C”, see batch file listing lines 50 - 53. When opening the ‘Windows Task Manager’, and opening the tab “Processes”, eventually pressing the option “Image Name” the two ILWIS processes and their CPU and Memory Usage can be observed.

2.8 CHANGES AND MODIFICATIONS

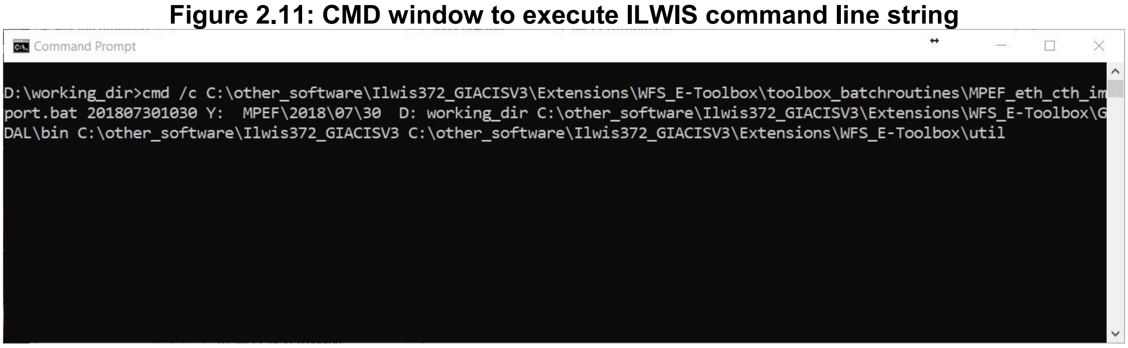
As the EUMETCast-GEONETCast data stream is continuously changing-evolving the user has the capability to easily modify or create new import routines and subsequently change the graphical user interface. For all these actions no programming experiences are required. New lines can be added in the “config.xml” file, and using the option “folderid” a new entry is created in the “wfs_e.ini” file. When opening a new instance of the WFS-Ethiopia Toolbox GUI, these changes are incorporated and using the option “Configuration” and “Folders” the appropriate input and output directories can be specified. A new script can be prepared, which in turn is executing a new batch file, to be created by the user. There are over 150 batch files already and portions of these files can be used as example to create new ones.

It is advised to keep track of the changes using the XML version number. This version number can be modified in the “config.xml” file as well. The version number used for creation of this document is config.xml version 2.0.

2.9 ADVANCED USE

If certain operations have to be repeated on a continuous basis, e.g. import of a certain data type, e.g. for which basically only the time stamp has to be modified, it is advised to copy the command line string that is generated through the graphical user interface, available from the command line, in the main menu of ILWIS (see also figure 2.9), to the WINDOWS command line interpreter (CMD.exe). Move to your working directory; paste the command line string in the command line interpreter window. Delete the “!” from the start of the string and, type “cmd /c” in front of the string and press <enter> execute the expression. Within the string the date stamp (here: 201807301030) can easily be modified to import another instance of the same product.

Figure 2.11: CMD window to execute ILWIS command line string



Also from the main menu of ILWIS, the command line history can be checked (see figure 2.9). Select the appropriate string generated through the graphical user interface, modify the time stamp and execute the expression again.

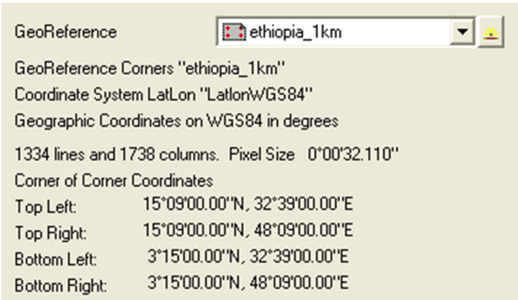
2.10 THE REGION OF INTEREST: ETHIOPIA

2.10.1 *Latitude and Longitude*

Given the dimensions of Ethiopia various UTM zones do exist in the country and therefore the data for the Ethiopia ROI routines, available from the WFS-Ethiopia Toolbox under the sub menu “Ethiopia” are resampled to Latitude-Longitude, using the WGS84 Ellipsoid and Datum. The georeference used is “ethiopia_1km.grf” and is available in the “Util” sub-directory. Coordinates of the selected window correspond with those from LEAP and are (in Degree.Decimals): MinX=32.65, MinY=3.25, MaxX=48.15 and MaxY=15.15. The corner of the corner pixel is used (not the centre!). For resampling use is made of a nearest neighbour resampling method.

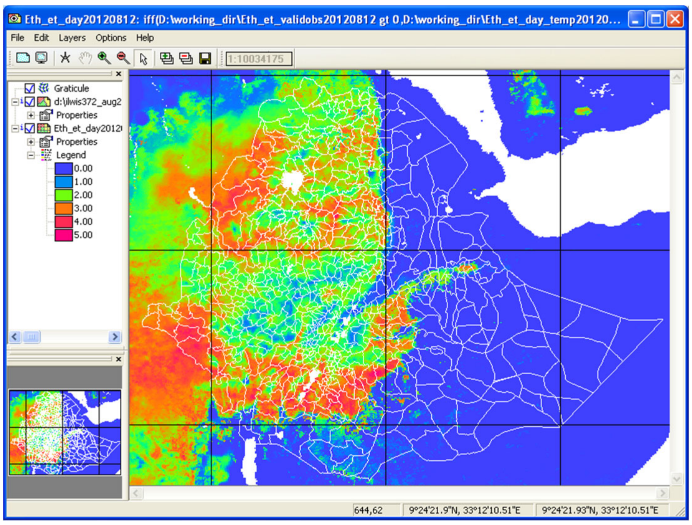
Given the fact that at the equator one degree can be approximated by 112 km (1/112), a pixel size of 0.008928571429 degree or 0º0’32.14’’ represents 1 km. Here a pixel size of 0.00891829689 degree (X or Longitude, approximately 998.849 metres) and 0.00892053973 degree (Y or Latitude, approximately 999.101 metres) or 0º0’32.11’’ is used. A pixel therefore approximately represents 0.998km^2. Further details are presented in figure 2.12 and a map example is given in figure 2.13.

Figure 2.12: Region of Interest details for Ethiopia



If another projection is required (e.g. UTM), the user can create one using the generic ILWIS functionality and transforms the map using the command “MapResample” (see batch file listing, lines 52 and 53 of chapter 2.7) and replace “Ethiopia_1km.grf” with the new target georeference.

Figure 2.13: Ethiopia ROI showing 24 hour accumulated ET, woreda boundaries and 5 degree interval graticule



2.10.2 ***Metric coordinate system***

For the GIACIS and WRSI calculation routines another common used georeference and coordinate projection is "*giacisV2_proba_eth*" which is based on the projection of the Proba-Vegetation product for continental Africa. As only a small portion out of the continental Africa Proba Vegetation NDVI product is required, after import of the full image (initial georeference used is Plate Carree – WGS84), the map is resampled (using a nearest neighbor resampling, so basically a subset is created) and the Ethiopian window is extracted. The subset window, projection and georeference (window bounding coordinate) details for the selected Ethiopian window are given below.

The map consists of 1715 columns x 1345 lines, total of 2306675 pixels. The pixels size is 993.924 meters (in both X,Y direction – equal area), approximately 987885 m2/pixel. Bounding coordinates of corners are: MinX=3650185.977537530, MinY=356320.54841828, MaxX=5354767.22380949 and MaxY=1693149.57246247. Further details are provided in the table below.

Table 2.1: Projection details of the giacisV2_proba_eth

Projection	Plate Carree
Datum	WGS 1984
Ellipsoid	WGS 84
Ellipsoid parameters:	
a	6378137.000
1/f	298.257223563
False Eastings	0.000
False Northings	0.000
Central Meridian	0 degree 0 minutes 0.00 seconds Eastings

2.11 CONCLUDING REMARK

With all the configuration settings provided you are now ready to utilize the Water and Food Security-Ethiopia Toolbox and explore the selected (real time) data that is delivered via DVB-S2 broadcast. The WFS-Ethiopia Toolbox under ILWIS is able to import and process a multitude of data types delivered via EUMETCast-GEONETCast, but it depends on the service channels activated which data is actually received at the various ground receiving stations. Furthermore the National Meteorological Agency has access to the meteorological data services, which is restricted for non meteo users. Check the services actually received by contacting the local ground receiving system administrator and the details with respect to data storage on and access to the local archiving system.

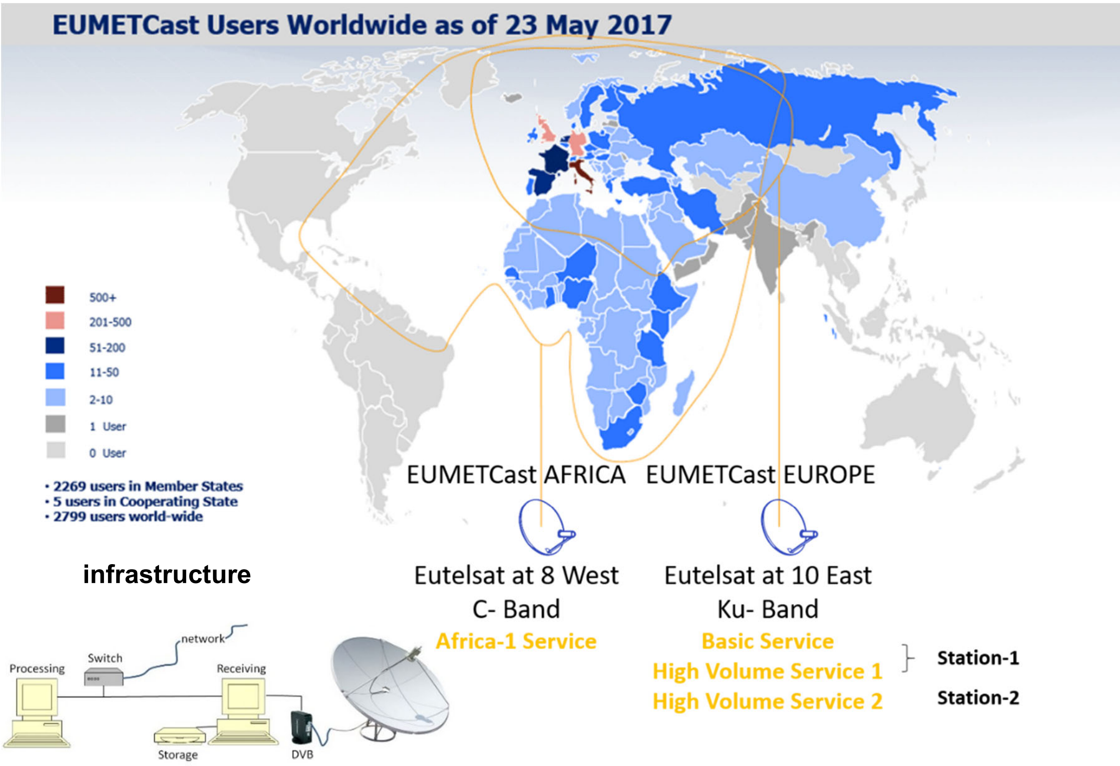
Further information can also be found on the EO-portal at EUMETSAT (https://eoportal.eumetsat.int). Your system administrator has access to the services received and can login to this portal using the provided username and password. Using the "Edit/View Service Subscriptions" tab it is possible to apply for new services. Your system administrator should check the account of your organization on a regular basis to see if new services offered are of interest, in such case these services can be requested – activated and these will be received at the ground receiving station after the application has been processed by EUMETSAT. Check the services actually received by contacting the local ground receiving system administrator, eventually check the PID settings applied for the 'Data Services' from the DVB software settings used. In case you observe new products described in the 'Product Navigator' and having activated the service but these products are not supported by the WFS-

Ethiopia Toolbox, check if routines are available in the GEONETCast Toolbox, see https://52north.org/software/software-projects/ilwis-toolboxes/.

Further general information on the data delivered can also be found at EUMETSAT at http://www.eumetsat.int/website/home/Data/DataDelivery/index.html and also check the PIDs http://www.eumetsat.int/website/home/Data/DataDelivery/EUMETCast/ReceptionStationSetup/ChannelsandPIDs/index.html.

All regional meteorological branch offices from the NMA are equipped with a low cost EUMETCast - GEONETCast reception facility (see figure 2.14) and are receiving the EUMETCast Africa Service. Services indicated in light brown below are received at ITC.

Figure 2.14: EUMETCast - GEONETCast system layout and low cost ground reception



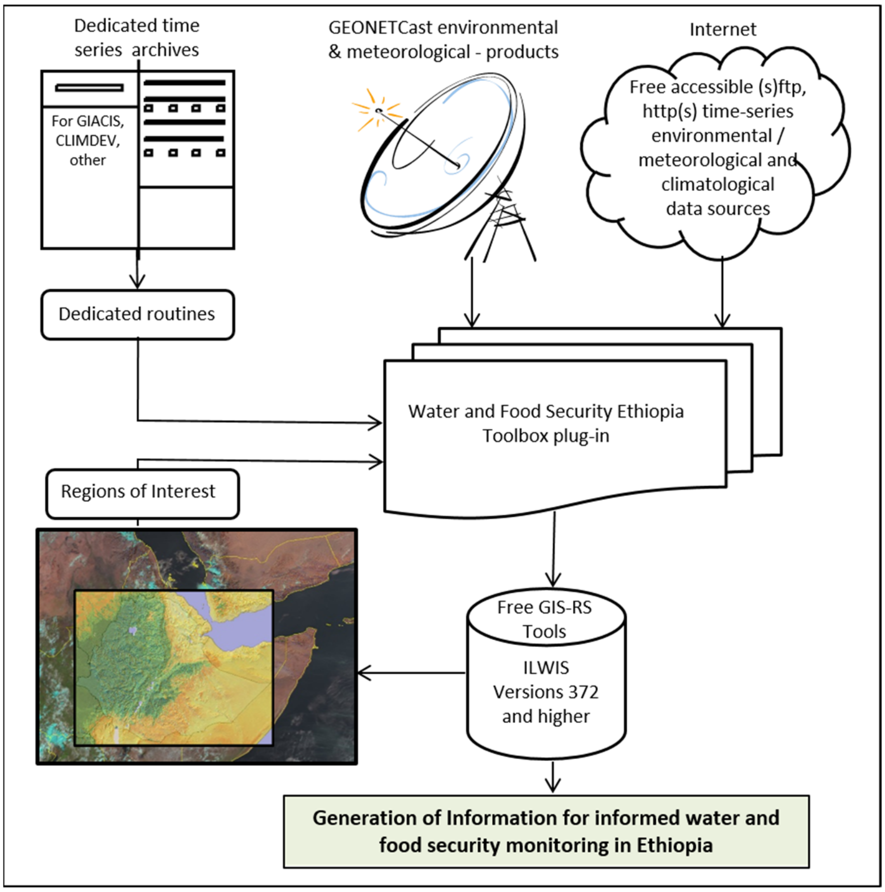
Currently the new Africa Service is including near real time MSG observations, from 0 and 41.5 degree, MPEF and SAF products, 3rd party (environmental) data, Sentinel 3 (ocean) data-various instruments, WMO RA-1 data (restricted access) and Copernicus data amongst others. See also: https://www.eumetsat.int/website/home/TechnicalBulletins/EUMETCast/DAT_3589215.html.

3. EXPLORING THE GEONETCAST DATA STREAM USING THE WATER AND FOOD SECURITY-ETHIOPIA TOOLBOX

3.1 INTRODUCTION

The WFS-Ethiopia Toolbox provides an open and flexible integrated solution to manage the EUMETCast-GEONETCast data stream, data derived from internet resources, etc. and import of the various image types and data products and bring them together in a common GIS and RS environment for further processing. This approach is further elaborated upon in figure 3.1.

Figure 3.1: Overall concept of the WFS-Ethiopia Toolbox (version 2)



The data disseminated by EUMETCast-GEONETCast is consisting of various formats. Over time a number of utilities have been developed at ITC to be able to import these data types. Also other existing freeware utilities are used and have been integrated in the toolbox, such as BUFR and GRIB (2) decoders. Also use can be made of other available software routines, such as Panoply, for data visualization. Furthermore attention was given to use data that is made freely available through the World Wide Web. A number of routines are available to incorporate relevant environmental, long term climatological and forecasting information in this manner, extending the functionality beyond the EUMETCast-GEONETCast direct reception. To be able to use these routines internet connectivity is required. The data is automatically retrieved and pre-processed.

To access some free archives credentials have to be provided. Once this is done the user can freely download the required (time series) data and routines are available for further processing.

3.2 THE WFS-ETHIOPIA TOOLBOX FUNCTIONALITY (CONFIG XML VERSION 2.0)

Below a short description with instructions to import the data / run a utility is provided of the main menu items that are available in the WFS-Ethiopia Toolbox, XML version 2.0. The sequence followed is identical to the menu structure as given in figure 2.1.

3.2.1 *WFS-Ethiopia Toolbox Help*

Under this menu item the change log for this XML version can be consulted as well as the 'Installation and User Manual'. These files require availability of a PDF Reader on your system. The PDF files are situated in the ILWIS sub-directory '\Extensions\WFS_E-Toolbox\util\manuals'.

3.2.2 *GEONETCast Product Navigator*

The Product Navigator is developed and maintained by EUMETSAT. Updates are disseminated via EUMETCast-GEONETCast and can be found at the \Received data folder on the ground receiving station. A regular windows scheduled task should be created to copy the files from this directory to a central archive, so users always work with the latest version. The location of this utility should be specified and saved using the options "Configuration" >> "Folders" >>"GNC Product-Navigator". If this is done the button "Start GNC Product Navigator", under the main toolbox menu item "GEONETCast Product Navigator" can be pressed and a web browser is opened showing the details of the GEONETCast data stream. All kind of selection criteria can be applied to find the data that might be of interest to the various users as well as further meta-data details and links to relevant online resources. This is a good starting point to familiarize yourself with the data currently disseminated through the African dissemination service.

Also a routine is provided to access the Product Navigator online at the EUMETSAT web portal which can be useful if you are not able to locally access a recent version disseminated through EUMETCast.

3.2.3 *GEONETCast Data Manager*

This utility allows the system administrator to transfer the newly incoming data on the ground receiving station to a central archive based on all kind of rules and decisions. This utility generates a menu based on an ascii text file. This file can be modified and adapted using a text editor if new data has arrived or if the organization wants to maintain only a certain portion of the full data stream. This utility is described into more detail in chapter 1.2 as well as in a separate manual. Note that Java is required to run this application.

Having selected from the menu the "Geonetcast Data Manager" the utility can be activated by pressing the "Start Data Manager" button and subsequently select the appropriate text file (*.txt) and the menu will appear. As indicated before it is advised to run this utility as a stand-alone, only to be operated by the local system administrator. It has to be stressed that appropriate data management is the key to successful application of this toolbox

3.2.4 *MSG-HRIT, MSG Data Retriever*

MSG-1 was launched on the 28th of August 2002 and after a testing period commenced routine operations on the 29th of January 2004. Then the satellite was renamed to Meteosat-8. On the 21st of December 2005, as a backup of Meteosat-8, MSG-2 was successfully launched and renamed MSG-9. On 05 July 2012 MSG 3 was launched and was moved to the 0 degree position on 21 January 2013. On 15 July 2015, MSG-4, the last in the MSG series of geostationary satellites, was successfully launched.

In 2017 Meteosat-8 was relocated to 41.5 degree East as the successor of Meteosat-7, the last of the first generation meteorological satellites. During the beginning of 2018, EUMETSAT completed a two-month-long series of maneuvers involving its geostationary fleet of satellites. The changes affected three of EUMETSAT's Meteosat Second Generation (MSG) satellites, Meteosat-9, -10 and -11, and included bringing the newest of these, Meteosat-11, out of in-orbit storage and into active service. The rearrangement, along with mission swaps among the fleet, ensures the best possible use of this satellite technology and greater availability of data, as disruption to services during scheduled maintenance or anomalies will be minimised.

As from the beginning of 2018 the positions of the operational Meteosat fleet are:

- Meteosat-11 at 0° longitude, providing the Full Earth Scan service. This service provides an image of the full disc, or hemisphere, every 15 minutes.
- Meteosat-10 at 9.5°E, providing the Rapid Scan Service. The RSS provides an image of Europe and Northern Africa only every five minutes, scanning the northern 1/3 portion compared the Full Earth Scan.
- Meteosat-9 at 3.5°E, between the other two satellites, as back-up spacecraft.
- The fourth member of the MSG fleet, Meteosat-8, is at 41.5°E, as part of an international Indian Ocean Data Coverage service.

Meteosat 11 is now the prime geostationary satellite at 0 degree and Meteosat 8 at 41.5 degree, both are providing full disc imagery every 15 minutes. This will ensure continuous satellite observations for the next couple of years. The advanced SEVIRI radiometer on board the MSG series of geostationary satellites enables the Earth to be scanned in 12 spectral channels from visible to thermal infrared (including water vapour, ozone and carbon dioxide channels). The specifications of SEVIRI have been chosen carefully to match operational requirements. Each of the 12 channels (table 3.1) has one or more specific applications in mind, either when used alone or in conjunction with data from other channels. Each has a well-established heritage, ensuring that their characteristics are well understood so that the data can be used on an operational basis.

The actual instrument includes a primary mirror with a diameter of 51 cm and infrared detectors. The raw images are generated through a combination of an east-west scan obtained from the spinning of the entire satellite at 100 revolutions per minute, together with a stepping of a telescope mirror from south to north after each scan line. The spatial resolution of the SEVIRI instrument has been slightly increased (at intervals of 3 km) compared to its predecessors, the High Resolution Visible (HVR) channel even has a sampling distance interval of just 1 km.

Table 3.1: SEVIRI channels and their applications

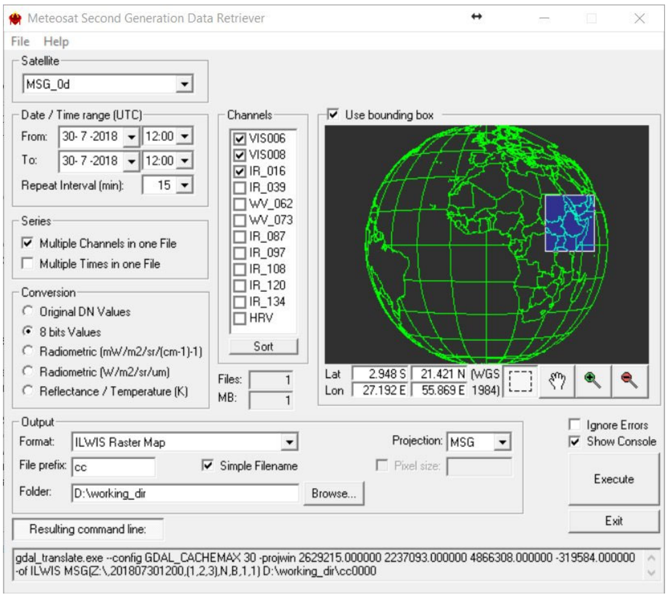
Band	Center	Min	Max	Nadir Res	Row x Cols	Repetition	Application
1	0.635	0.56	0.71	3000	3712 x 3712	15	Surface, clouds, windfield
2	0.81	0.74	0.88	3000	3712 x 3712	15	Surface, clouds, windfield
3	1.64	1.5	1.78	3000	3712 x 3712	15	Surface, cloud phase
4	3.9	3.48	4.36	3000	3712 x 3712	15	Surface, clouds, windfield
5	6.25	5.35	7.15	3000	3712 x 3712	15	Water vapor, high level clouds, atmospheric instability
6	7.35	6.85	7.85	3000	3712 x 3712	15	Water vapor, atmospheric instability
7	8.7	8.3	9.1	3000	3712 x 3712	15	Surface, clouds, atmospheric instability
8	9.66	9.38	9.94	3000	3712 x 3712	15	Ozone
9	10.8	9.8	11.8	3000	3712 x 3712	15	Surface, clouds, windfield, atmospheric instability
10	12	1100	13	3000	3712 x 3712	15	Surface, clouds, atmospheric instability
11	13.4	12.4	14.4	3000	3712 x 3712	15	Cirrus cloud heights, atmospheric instability
12	-	0.4	1.1	1000	11136 x 7700	15	Surface, clouds

The problem with the MSG data is that the file format is not standard. None of the commonly used remote sensing packages is able to open or process the raw compressed images. Therefore a driver was developed for reading the images in the Geospatial Data Abstraction Library (GDAL, http://www.gdal.org). GDAL is a translation library for raster geospatial data formats that is released under an MIT style Open Source license. All source code is in C++, and great effort is put into keeping the code platform-independent. Drivers for writing files in popular RS formats (e.g. ENVI, ERDAS, ILWIS, GeoTiff) but also picture formats like JPEG, GIF and BMP have already been implemented by the community, so appending a driver for reading MSG image files to this driver was seen as the most appropriate solution.

An algorithm developed is correctly re-composing the images from the multiple compressed data files / segments. According to the provided documentation the algorithm must take care of scan direction, image compression, bit-depth, image size and proper alignment of the image strips of the high resolution band. A second algorithm developed performs the radiometric calibration using the relevant header / footer (PRO / EPI) parameters and applying appropriate formulas that calculate the resulting pixel values into the required unit. A third algorithm determines the geo-location of each pixel. Automatic geo-location has the advantage that no manual steps are needed to transform the images to a known projection. This utility can be used to import the recordings from the Rapid Scanning Service as well as those covering the whole footprint at 0 and 41.5 degree.

The command-line utilities that come with GDAL facilitate the use of the library to transform MSG images into widely applied RS data formats. The GDAL version used supports various output formats in its library. In-house experiences with these command-line utilities revealed that composing such a command-line string is an error-prone process (given the many options available). Therefore a Microsoft Windows based user-interface was developed that generates the necessary command-line syntax (figure 3.2). The user only needs to express the “query” by making appropriate choices using checkboxes, radio buttons, list boxes, selection of area of interest, etc. Through the user interface all relevant parameters can be adjusted and a time series can be easily constructed. The user interface facilitates retrieval of original DN values (10 bit-depth), compressed DN values to 8 bit-depth, Top of Atmosphere radiances in 2 different units (W/m2/sr/um or mW/m2/sr/cm-1)-1), computation of Top of Atmosphere reflectance for the visible channels or Top of Atmosphere temperature (in Kelvin) for the thermal channels. The geometric precision is within a pixel for the low resolution bands and Geographic coordinates and UTM projection conversion is possible (a pixel size dimension has to be entered).

Figure 3.2: The MSG Data Retriever



For more flexibility, with the option “Show Command Line” the corresponding command-line string for performing a certain import is revealed. This string can then be copied into a batch file which can be executed or called from within an ILWIS script in order to perform similar imports multiple times in a semi-automated manner. The GDAL-driver and windows based Data Retriever interface facilitate easy geometric and radiometric calibrated data retrieval of MSG into e.g. ILWIS format.

The MSG Data Retriever can be invoked when pressing the button "Start MSG Data Retriever" Using the option "File", "Data Sources" the linkage can be established to the central archive, where the data is stored. Multiple data sources can be configured. More details on the configuration of the data sources can be found in chapter 2.5. Under the "Satellite" option the current selection of the EUMETSAT operational geostationary fleet can be specified: MSG at 0 degree, MSG at 41.5 degree and the MSG Rapid Scanning Service.

3.2.5 *Real Time MSG Visualization*

Utilities are developed to automatically import a number of spectral channels (and band combinations) derived from the SEVIRI instrument. Once a real time visualization routine is selected and the appropriate input and output directories are specified, the utility automatically starts at a given system clock time, scheduled in such a way to ensure that the last recorded images have arrived at the ground reception station. The task is automatically repeated every 15 minutes, in sync with the temporal resolution of MSG. The current real time applications available are "IGAD Region Multispectral", "MSG Ethiopia Pan Sharpened", "MSG Ethiopia Thermal B/W" and "MSG Ethiopia Thermal Colour".

The utility starts a Windows Scheduled Task event. Once this is done, ILWIS can be closed as it will automatically run from the command prompt. To stop (and remove the Scheduled Task), the option "Stop …… Visualization" ('…..' stands for "Multispectral", "Pan Sharpened" or "Thermal") and subsequently the "Stop" button can be selected.

The procedure for automatic visualization is further explained below using as example the "MSG IGAD Region Multispectral" option from the toolbox menu. Note that the other visualization routines work in a similar manner. When starting the routine "MSG IGAD Region Multispectral" a batch file "ini_IGAD.bat" is executed, situated within the ILWIS sub directory \Extensions\WFS_E-Toolbox\toolbox_ startscript\RealtimeMSGVisualization\AfricaIGADWindow. This batch file sets a number of input parameters (like the in- and output drive\directory and the directory location of executables needed). It furthermore creates a Scheduled Task. In this example when a new event of a Scheduled Task is started a new file "st_msgIGAD.bat" is created. This file is stored in the same ILWIS sub-directory and the syntax line creating the Scheduled Task is given below:

schtasks /create /sc minute /mo 15 /st 08:01:00 /tn "MSG_visual" /tr %4Extensions\WFS_E-Toolbox\toolbox_startscript\RealtimeMSGVisualization\AfricaIGADWindow\st_msgIGAD.bat

where:

schtasks	Windows Scheduled Tasks application (schtasks /? is the help function)
/create	Create a scheduled task
/sc	Specifies the schedule frequency
/mo	Modifier, for more refined task tuning, as "/sc" is defined as "Minute", "/mo" provides a repeat interval of 15 minutes
/st	Starting time, note this is your system time
/tn	Name that uniquely identifies the task
/tr	Task name, the batch file which is subsequently executed, containing the full path (here %4 defines the ILWIS directory)

The result is that a new Scheduled Task, named "MSG_visual" is created, which now executes a batch file ("st_msgIGAD.bat") every 15 minutes, starting from 08:01 hr (local time).Note that the file "ini_IGAD.bat" can be modified if e.g. another starting time is required.

The applications access the newly arrived raw MSG data (at the end of the each scan) which is stored on a network resource. A dated folder structure is assumed here (see also chapter 2.5 and figures 2.6 and 2.7).

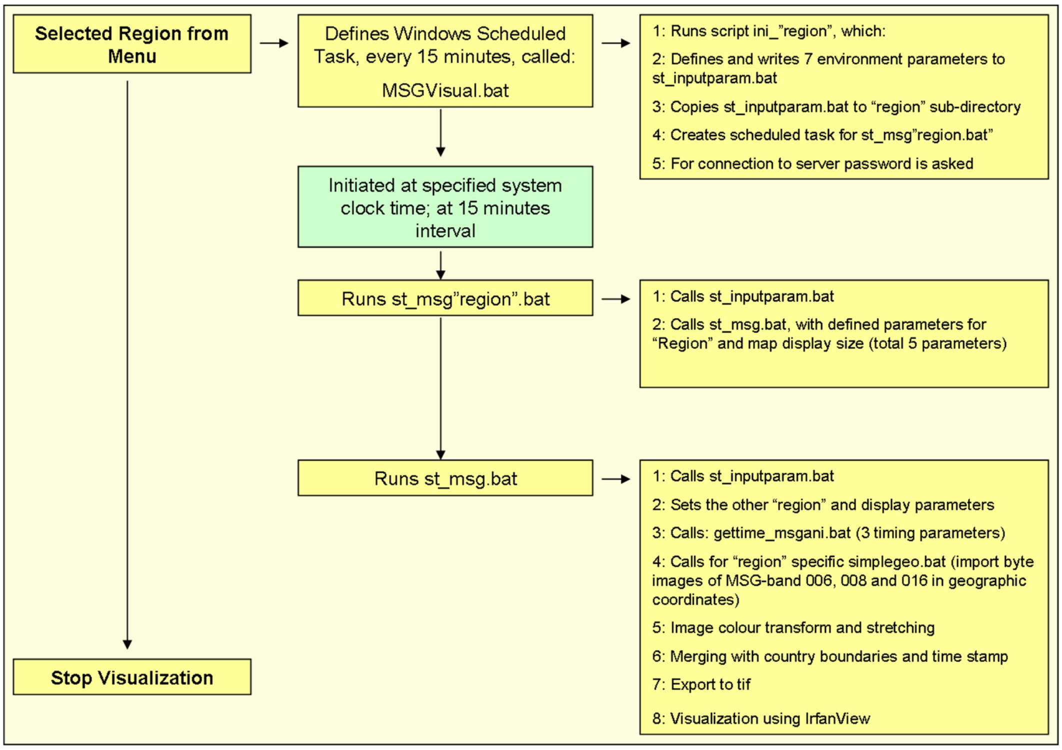
Each of the utilities run a (similar) sequence of batch files for each routine selected, which are located in the ILWIS sub-directory "\Extensions\WFP_E-Toolbox\toolbox_startscript\Realtime MSGVisualization". The sequence of batch routines is specified into more detail in figure 3.3. In this example "Region" refers to the IGAD window.

The final image shown on the screen is visualized using IrfanView. The link to the IrfanView directory\executable has to be properly specified in the main WFS-Ethiopia Toolbox menu, using the options "Configuration", "Folders" and "Special locations". Once a number of import sequences have passed the user can click with the left mouse button on the last displayed image (to activate the image display window) and use the scroll bar on the mouse to interactively move to the previous images and back to the last imported time interval.

The time stamp displayed on the upper left hand portion of the image is referring to the end of scan time for the whole field of view of MSG-9. The actual time when the northern most part of the Ethiopian window is scanned by MSG is approximately 07:30 minutes after the start of scan time. So from the equator till about 15 degree north latitude the actual time when the region is recorded is about 06:00 to 07:30 minutes after start of scan time respectively.

To get the appropriate end of scan time stamp in local time (but still applicable for the whole field of view of MSG) the system "date and time settings" should adhere to the appropriate time zone setting. It is advised to configure your system time stamp in a "HH:mm:ss" format, check your system "Region and Language" settings. The screen resolution to display the images should preferably be 1280 by 1024 pixels.

Figure 3.3: Layout of the various components for Real Time MSG visualization



Currently four automated visualization routines are supported. The “IGAD Region Multispectral” option displays a natural colour transformed composite covering the IGAD region, using the VIS006, VIS008 and IR_016 channels of the SEVIRI instrument. This visualization is only suitable for daytime conditions. The option “MSG Ethiopia Pan Sharpened” shows the Ethiopian window, resampled to approximately 1 km^2 pixel resolution. Next to the VIS006, VIS008 and IR_016 channels of the SEVIRI instrument also the HRV channel is incorporated and a pan sharpening approach is included after which a natural colour transformation is performed. Again this visualization is only relevant for daytime conditions. Using the HRV channel shows greater details, especially with respect to cloud occurrences. The HRV channel is moving according to the position of the sun, therefore after 14:00 UTC this routine starts showing a HRV gap, starting from the east!

The “MSG Ethiopia Thermal B/W” imports and resamples the SEVIRI IR_108 channel over the Ethiopian region. The data is imported as Temperature (Kelvin). The output image is using an inversed ‘grey-scale’ lookup table (using the routine “st_msg_thermal_bw.bat”). The “MSG Ethiopia Thermal Colour” (using the routine “st_msg_thermal_c.bat”) is displaying the colder clouds in a colour scheme.

For both the thermal channel visualization routines, the imported data is transformed into Temperature. To obtain an inverse representation a coefficient of 400 is used from which the actual imported pixel values are subtracted (400-actual). Assume a non-clouded pixel with a Top of Atmosphere (ToA) temperature of 310 Kelvin (K) this algorithm will result in an output pixel value of 90. Now assume a cloud pixel with a top of the cloud temperature of 190 K, this will result in an output pixel value of 210. The resulting data range is mostly in the range of 0-255 (byte range), and if an inverted grey scale lookup table is used the white toned pixels now represent the cold clouds and the dark grey areas represent the non-clouded land and water surfaces. No stretch function is applied!

The same approach (using also a coefficient of 400) has been used for the coloured thermal image visualization routine. Thresholds are defined and the pixels falling in these threshold ranges are subsequently colour coded. The threshold actual temperature range and colour coding is given in table 3.2.

Table 3.2: Thermal thresholds applied for temperature ranges and colour coding used

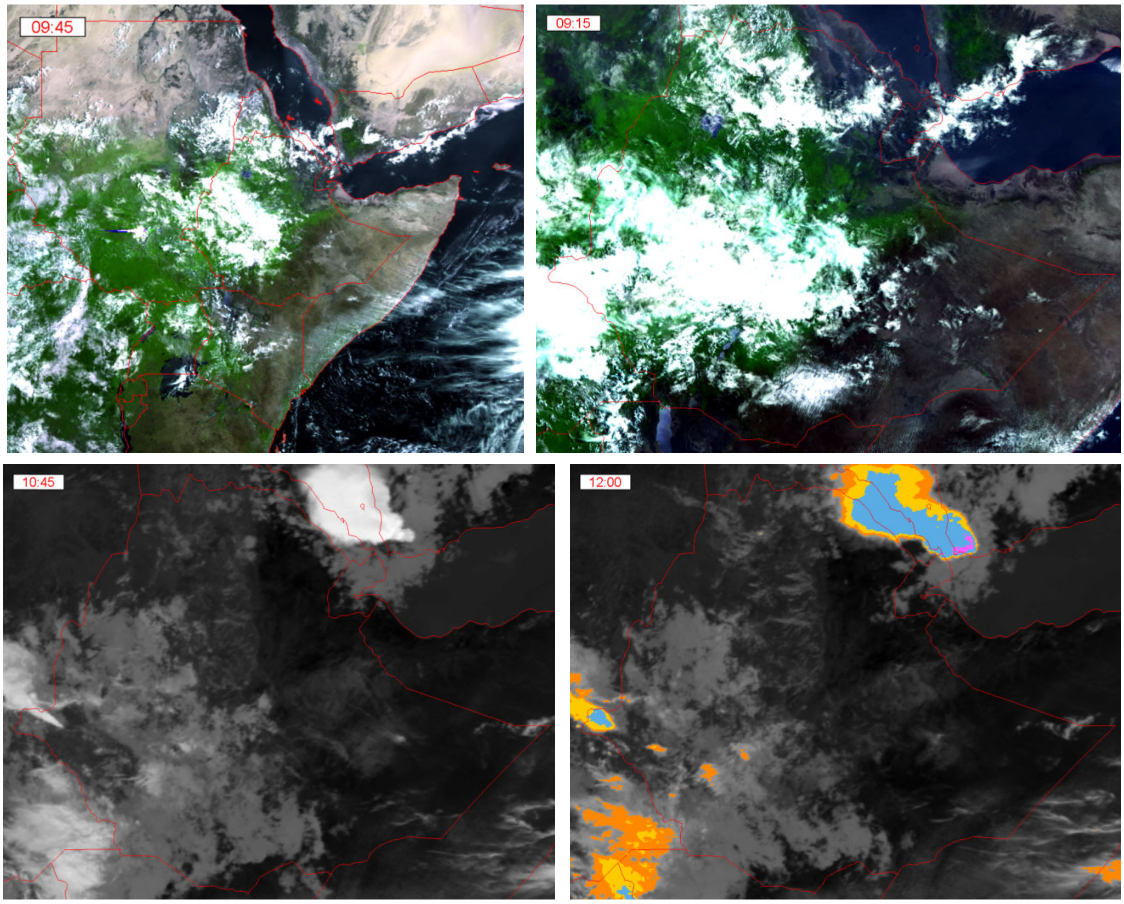
Thresholds (Kelvin)	Grey scale values	Colour code (R,G,B)	Resulting colour
> 235	Inverted Grey scaling is applied for values less than 165		
220 - 235	165 - 180	255,136,0	orange
205 - 220	180 - 195	255,203,1	yellow
190 - 205	195 - 210	89,173,228	blue
< 190	> 210	255,93,255	pink

Within the batch file “st_msg_thermal_c.bat” an ILWIS MAPCALC “color” operation is executed to create the output map “ccTOA_Tinverse%workingtime%.mpr”, assigning the class ranges to the specified output colours. If more classes or different colour are required this expression can be modified to suit the need of the user.

If at a given moment required input files cannot be retrieved (from the archive) due to whatever reason the application stops the import of that given time event. A command box will appear on the screen. To continue press <enter> and check what the problem could be why you are not able to import the latest images!

From the main WFS-Ethiopia Toolbox menu, using the options “Configuration” and “Folders”, the input “Real Time MSG VIS” and output directories can be specified. Also check the input folder settings for the folder “MSG Data Retriever”.

Figure 3.4: MSG-IGAD, MSG Pan Sharpened and MSG Thermal visualization examples



It is always possible to fine-tune the scheduled task if you create one yourself. If this is done it is advised to first create a scheduled task from the toolbox menu (to ensure that an appropriate inputparam.bat and st_msg*.bat file is created in the ILWIS sub-directories contained in \Extensions\WFS_E-Toolbox\toolbox_startscript\RealtimeMSGVisualization\. Check the scheduled task which is created to determine which batch file is executed (look at the properties). The task can be deleted and you can create one yourself specifying the appropriate batch file when defining a "New Action". For purpose of downward compatibility (e.g. with older version of Windows only limited Scheduled Tasks functionality has been used when creating the Visualization tasks. If working with Windows 7 or later version a "/du" option (specifying the duration) can be included and the time (in hh:mm) the visualization should be running can be included in the "schtasks /create" example as given above. To get further information on the various options type "schtasks /?" or "schtasks /change /?" in the command line interpreter window (cmd.exe).

The output images are stored within the specified output drive\directory. The file name format is "ccyyyymmddhhmmhhmm.tif". The first "hhmm" instance refers to the start of scan time in UTC, the second "hhmm" represents the local end of scan time (of the whole field of view of MSG) in hours and minutes, using a 24 hour format. Using IrfanView, and selecting the appropriate series of images, an animation can be easily created and can be saved as an executable (*.exe). The created slideshow can be visualized just by double clicking the file using your mouse.

3.2.6 ***Ethiopia***

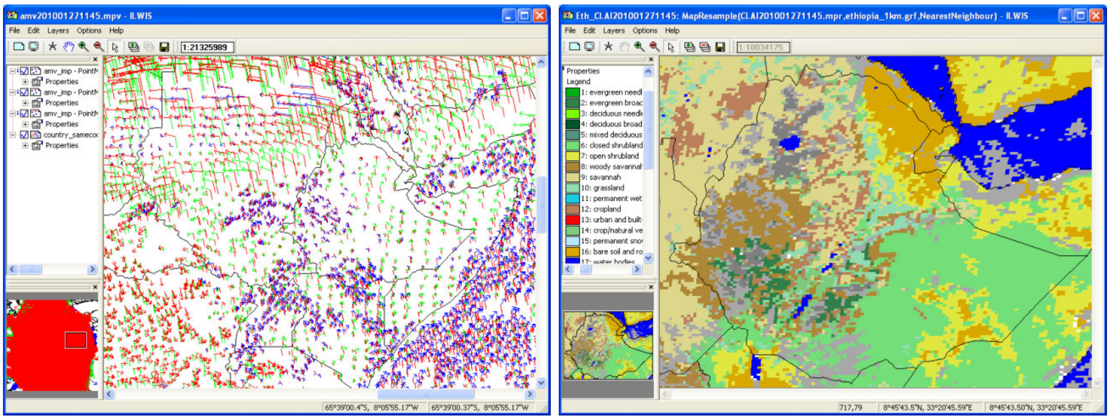
The majority of the import routines under this menu option extract the data for the Ethiopian window. Details on the map resampling procedure and georeference are provided in chapter 2.10.1.

3.2.6.1 Meteorological Product Extraction Facility (MPEF)

The MPEF is a part of the MSG Ground Segment; its primary function is the generation of Meteorological Products from the Level 1.5 SEVIRI image data supplied by the Image Processing Facility (IMPF). The products are then quality controlled and encoded prior to being passed to the Data Acquisition and Dissemination Facility (DADF) for delivery to users. MPEF products generated from MSG at 0 and 41.5 degree (Indian Ocean Data Coverage – IODC) are supported.

Under these heading a number of routines are available to import the various products that are generated by the MPEF at EUMETSAT. For the “High Temporal Resolution MPEF Products” the time stamp required here should adhere to: yearmonthdayhourminute (12 digits). The temporal resolution changes for the various products; it is indicated in the comment line of the menu as well as the time of the first product generated on a given day. From the main WFS-Ethiopia Toolbox menu, using the options “Configuration” and “Folders”, the input “MPEF_IODC_highres” or “MPEF_highres” and output directories can be specified. These products are generated using the full disk of MSG, currently METEOSAT 11 at 0 degree and METEOSAT-8 at 41.5 degree. Import of the following products is supported: Atmospheric Motion Vectors (AMV), Cloud Analysis (CLA), Cloud Analysis Image (CLAI), Cloud Mask (CLM), Cloud Top Height (CTH), Divergence (DIV), Optimum Cloud Analysis (OCA), Fire-Grid (FIRG), Global Instability Index (GII), Multi Sensor Precipitation Estimate – Geostationary (MPEG), Clear Sky Radiances (CSR), Tropospheric Humidity (TH) and Total Ozone (TOZ). Note that some of the import routines create multiple output files, like the GII which creates the following output maps: K-Index, Parcel Lifted Index (to 500 hPa), Precipitable Water (kg m-2), KO-Index and Maximum Buoyancy. Some example import results for the AMV and CLAI are given in figure 3.5.

Figure 3.5: MPEF Atmospheric Motion Vectors and Cloud Analysis Image products



Also data with lower temporal resolution are generated by MPEF, such as a daily and dekadal NDVI. Import routines are available to process this information; the routines are situated under the sub menu “Low Temporal Resolution MPEF Products”, the input data directory is specified as “MPEF_lowres” or “MPEF_IODC_lowres”, using the options “Configuration” and “Folders”. Only the “yyyymmdd” timestamp is required as for these products the “hhmm” timestamp is always “1200”. For the NDVD the day timestamp is 10, 20 or last day of the month, for each of the respective dekades. For both NDVI and NDVD the maximum, minimum and mean is extracted, use can be made of the Representation “NDVI1” for visualization.

All batch routines can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\ toolbox_batchroutines and the batch filename convention used for the products is *MPEF_eth_"abbreviation"_import.bat* or *MPEF_eth_"abbreviation"_IODC_import.bat* (where "*abbreviation"* stand for product type) for the products from 0 and 41.5 degree respectively.

3.2.6.2 LSA-SAF

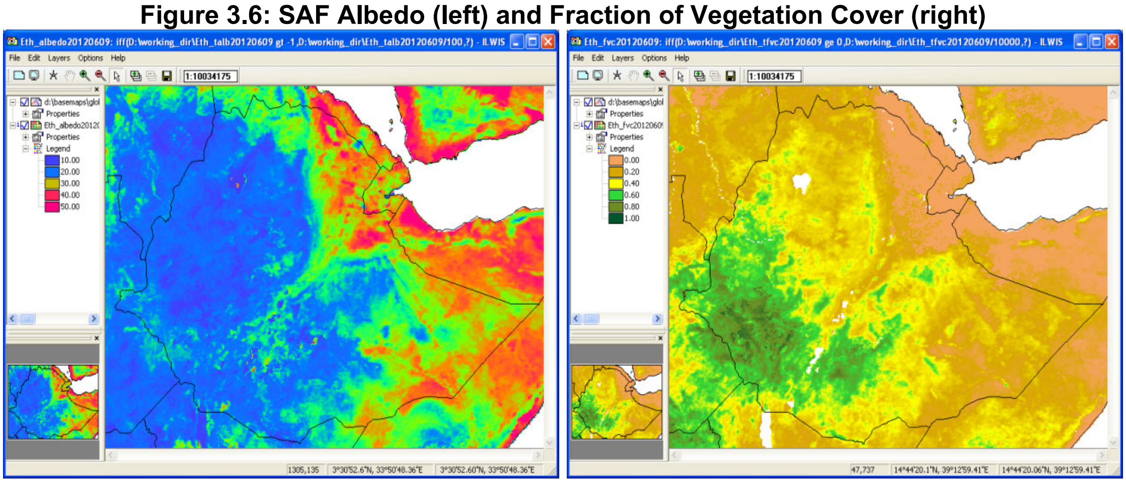
Satellite Application Facilities (SAFs) are specialised development and processing centres within the EUMETSAT Applications Ground Segment. Utilising specialised expertise in Member States, they complement the production of standard meteorological products derived from satellite data at EUMETSATs Central Facilities.

The routines available here allow the user to ingest the data produced by the Satellite Application Facility (SAF) on Land Surface Analysis (LSA) (https://landsaf.ipma.pt/en/). The following products are supported: Albedo, Down-welling Surface Long-wave Radiation Flux (DSLF), Down-welling Surface Short-wave Radiation Flux (DSSF), Land Surface Temperature (LST), Evapotranspiration (ET), Reference Evapotranspiration (METREF), Fraction of Absorbed Photosynthetically Active Radiation (FAPAR), Fraction of Vegetation Cover (FVC) and Leaf Area Index (LAI).

The import routines available allow import of the various products. The time stamp required here should adhere to: yearmonthday (8 digits) or yearmonthdayhourminutes (12 digits) as the temporal resolution changes for the various products; it is indicated in the comment line of the menu as well as the time of the first product generated on a given day in case of multiple products on a daily basis. From the main WFS-Ethiopia Toolbox menu, using the options "Configuration" and "Folders", the input and output directories can be specified. Some product examples are given in figure 3.6. For visualization of the imported products standard look-up tables are available as "Representations" (lai, fapar, fvc, pseudo, etc).

All batch routines can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\ toolbox_batchroutines and the batch filename convention used for the products is *LSASAF_eth_"abbreviation"import.bat* (where "*abbreviation"* stand for product type).

Figure 3.6: SAF Albedo (left) and Fraction of Vegetation Cover (right)



3.2.6.3 *LSA-SAF Evapotranspiration Daily*

In order to obtain a daily total Evapotranspiration map, the 48 half hourly events of the SAF ET product are imported using a batch looping procedure. After all events are processed, the sum is calculated for each input pixel and a total ET in mm over a 24 hour period is obtained. Another map calculated is showing the number of valid observations, for some events during the day the ET cannot be derived and a no-data or undefined is returned. This map is useful to see if the sum ET is underestimated for some of the pixels!

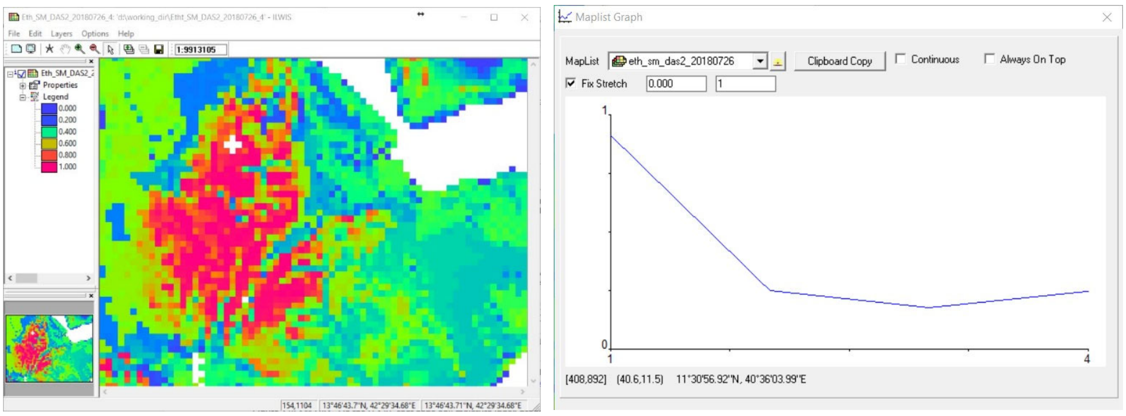
The routine first checks if all 48 events are copied to your local system, if this is not the case a message is given and the missing files should be created (e.g. by coping and pasting previous or next time stamp event). The routine continues only if 48 events are available. An example of the result of this routine is given in figure 2.13.

The batch routines can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\toolbox_batchroutines and the batch filename convention used for this routine is "*LSASAF_eth_ET_sta.bat"* and *"LSASAF_eth_ET_loop.bat".* The *sta.bat starts the procedure and executes for all 48 events the *loop.bat. If all 48 products are processed the *sta.bat creates an ILWIS maplist and performs the required calculations.

3.2.6.4 *H-SAF*

H-SAF is the SAF on Support to Operational Hydrology and Water Management (http://hsaf.meteoam.it/). SM-DAS-2 is the H-SAF root zone soil moisture index product, retrieved by scatterometer assimilation in the ECMWF Land Data Assimilation System. In the soil moisture assimilation system, the surface observation from ASCAT is propagated towards the roots region down to 2.89 m below surface, providing estimates for 4 layers (thicknesses 0.07, 0.21, 0.72 and 1.89 m). The ECMWF model generates soil moisture profile information according to the Hydrology Tiled ECMWF Scheme for Surface Exchanges over Land (HTESSEL). SM-DAS-2 is available at a 24-hour time step, with a global daily coverage at 00:00 UTC. SM-DAS-2 is produced in a continuous way in order to ensure the time series consistency of the product (and also to provide values when there is no satellite data, from the model propagation). The SM-DAS-2 product is the first global product of consistent surface and root zone soil moisture available NRT for the NWP, climate and hydrological communities (source: https://software.ecmwf.int/wiki/pages/viewpage.action?pageId=29328616).

Figure 3.7: Layer 4 of SM-DAS-2 root zone soil moisture index product and graph showing values of a pixel for all 4 layers



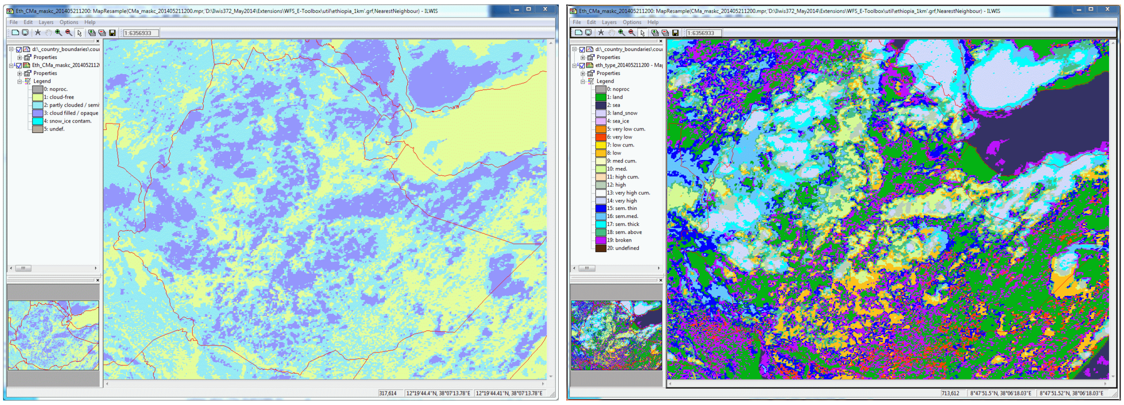
The import routine available allows import of the Soil Moisture index product. The time stamp required here should adhere to: yearmonthday (8 digits). From the main WFS-Ethiopia Toolbox menu, using the options “Configuration” and “Folders”, the H_SAF input and output directories can be specified. The batch routines can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\ toolbox_batchroutines and the batch filename convention used for the products is “*HSAF_eth_sm_das2_import.bat*”.

3.2.6.5 NWC-SAF

The products disseminated by the SAF on NowCasting (http://www.nwcsaf.org) fall under the category ‘Restricted Services’ and is therefore only available to National Meteorological Services and their Partner Organizations. Import routines have been developed for a number of products currently operationally disseminated such as: cloud mask (also for dust and volcanic plumes), type, phase, height, temperature, pressure and cloudiness. These products are produced at full MSG spatial and temporal resolution and made available at very short time delay. For further information consult the product description provided on their website (see address above).

The import routines available allow import of the various products. The time stamp required here should adhere to a yearmonthdayhourminutes (12 digits) time stamp convention. From the main WFS-Ethiopia Toolbox menu, using the options “Configuration” and “Folders”, the NWC_SAF input and output directories can be specified. Some product examples are given in figure 3.8. For visualization of the imported products standard look-up tables are available as “Representations” (nwc_cma, nwc_dust_vol, nwc_ctg, pseudo, etc).

Figure 3.8: NWC-SAF cloud mask (left) and type (right) products



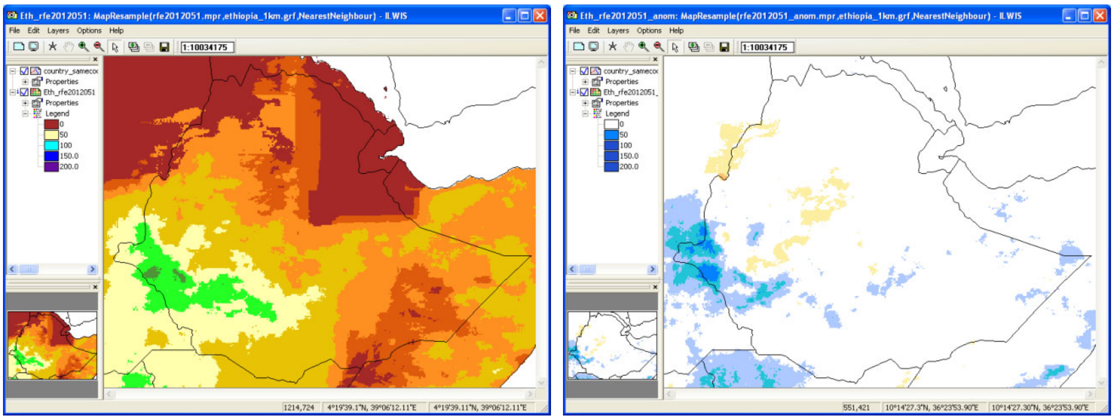
The batch routines can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\ toolbox_batchroutines and the batch filename convention used for the products is “*NWCSAF_eth_ ***_import.bat*”, where *** is referring to the specific product.

3.2.6.6 TAMSAT Rainfall Products

Within the GEONETCast data stream also non-meteorological organizations contribute. An example is the rainfall product for Africa, produced by the TAMSAT group from the University of Reading (UK) which are producing ten-daily (dekadal) and monthly rainfall estimates and anomalies derived from Meteosat Thermal Infra-Red (TIR) channels based on the recognition of storm clouds and calibration against ground-based rain gauge data (see also: https://www.tamsat.org.uk/about). Using this set of import routines the 10 day accumulated RFE rainfall product can be imported as well as a monthly accumulated rainfall product, which is the sum of the 3 dekadal rainfall products for a given month. Furthermore a dekadal anomaly and monthly anomaly rainfall product can be imported. Note that the “Date” stamp required format is: yyyymmdek (which stands for yearmonthdekade), dekades are number 1 to 3 for the dekadal products and yyyymm (which stands for yearmonth) for the monthly products. As from the 1st dekade of March 2011 the file format has changed, the import routines developed for import of the various TAMSAT rainfall (and anomaly) products can be applied to process the post March 2011 products. If older data is required check the routines available from the ISOD Toolbox.

From the main WFS-Ethiopia Toolbox menu, using the options "Configuration" and "Folders", the input TAMSAT and output directories can be specified. Standard representations for the various TAMSAT products for visualization are available, their names are starting with "rfe_*. An example is provided in figure 3.9.

Figure 3.9: Dekadal TAMSAT rainfall and rainfall anomaly (using climatology from 2000 - 2009) maps from 1st dekade of May 2012



All batch routines can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\ toolbox_batchroutines and the batch filename convention used for the products is *TAMSATRFE_eth_"abbreviation".bat* (where "*abbreviation"* stand for product type).

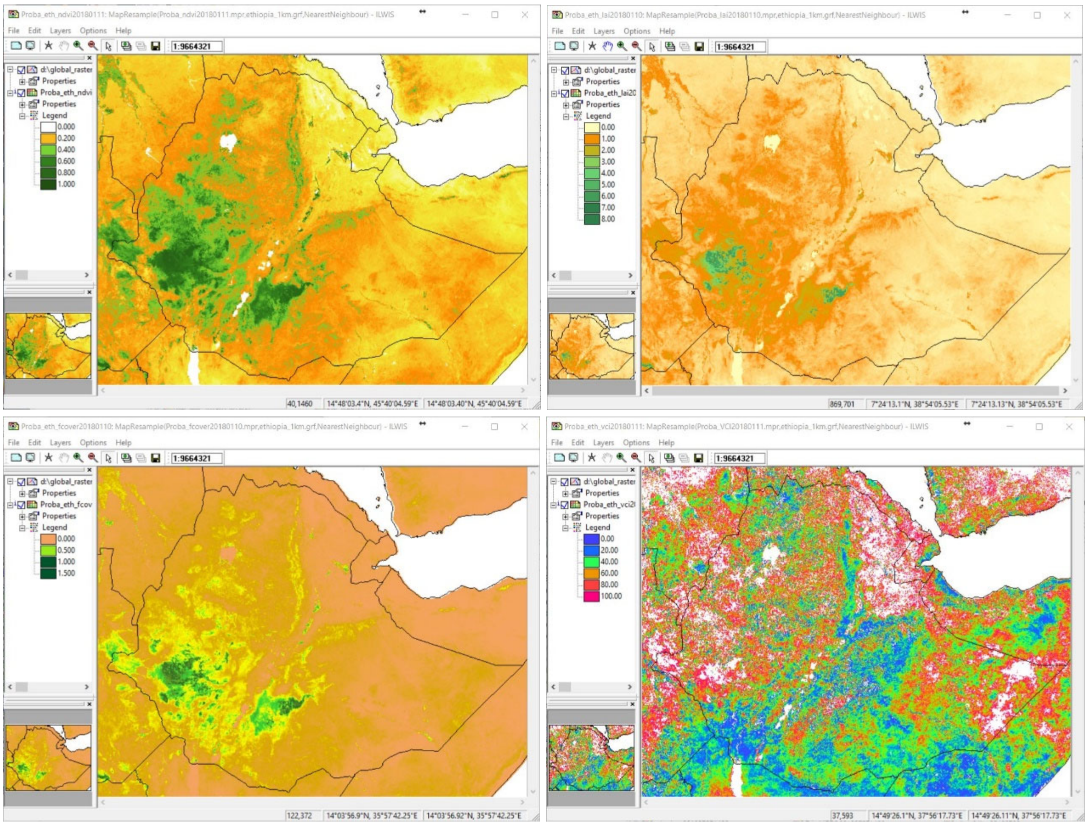
3.2.6.7 PROBA-Vegetation

As from June 2014 the Proba-Vegetation instrument took over the task of the SPOT-VGT instrument. See the Proba website for further instrument and mission details (http://proba-v.vgt.vito.be/en/about/proba-v-satellite-mission). Based on the data recorded by Proba, currently a number of derived products for Africa are disseminated through GEONETCast to continue the legacy of its predecessor. Routines to import the products currently available have been included in this toolbox release, applying the calibration coefficients for the various products. As the product versions keep changing versions, due to improvements of the product processing routines, for each of the products the expected file name and product version is given at the comment line in the main import window .

The following products and versions are currently supported: Burned Area (V1.1.1), Dry Matter Productivity (V1.0), Fraction of Absorbed Photosynthetically Active Radiation (V2.0.1), Fraction of Vegetation cover (V2.0.1), Leaf Area Index (V2.0.1), Normalized Difference Vegetation Index (V2.2.1), Vegetation Condition Index (V1.0), Vegetation Production Indicator (V1.0), Water Body (V2.0.1).

All batch routines can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\toolbox_batchroutines and the batch filename convention used for the products from Africa is: *ProbaV_eth_"abbreviation"import.bat*. Note that the abbreviation refers to the product names, like 'ndvi', 'lai' and 'fcover'. All products are resampled to the Ethiopian window and some product examples are provided in the figure below.

Figure 3.10: Proba Vegetation product examples



From top right to bottom left: NDVI, LAI, FCover and VPI.

For further information on the products, see: https://land.copernicus.eu/global/themes/vegetation. It should be noted that the near real time provision of the VPI product is discontinued. The Burnt Area import routine is currently supporting the 300 meter BA product. An area covering Ethiopia is extracted, the product is not resampled and at 300 meter (0.0029761905 degree) spatial resolution. The layer extracted is the first date of burn in the dekade. The BA reference year is 1980 and the other 3 digits of the BA map value are representing the day of year, e.g. "38031" represents 2018, day 31, or 31 January 2018.

3.2.6.8 Other selected products

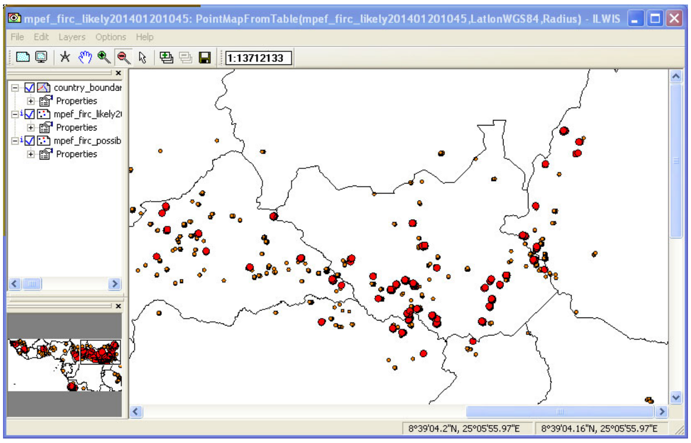
3.2.6.8.1 MPEF FIRC

The active fire monitoring product is a fire detection product indicating the presence of fire within a pixel. The underlying concept of the algorithm takes advantage of the fact that SEVIRI channel IR3.9 is very sensitive to hot spots which are caused by fires. The algorithm distinguishes between potential fire and active fire (source: http://navigator.eumetsat.int/). The ASCII version of this product has been superseded by the Active Fire Monitoring (Common Alert Protocol) version, which is currently implemented. For further information on CAP, see also http://en.wikipedia.org/wiki/Common_Alerting_Protocol.

Before starting to import the FIRC product available in the GEONETCast data stream verify the settings of the directory containing the raw data. In order to do so, select from the main menu the option "Configuration" and "Folder" and select "MPEF-FIRC" and specify the appropriate folders.

As input string a “yyyymmddhhmm” timestamp is expected. After import two point maps are created and fires are extracted for the whole MSG field of view. The point map ‘MPEF_FIRC_Possible’ contains fires having a probability of less or equal 50 percent. The point map ‘MPEF_FIRC_Likely’ contains the fires having a probability greater than 50 percent, see also figure 3.11. In the associated tables the fire radius is given for each location.

Figure 3.11: MPEF FIRC Possible (orange) and Likely (red) fires



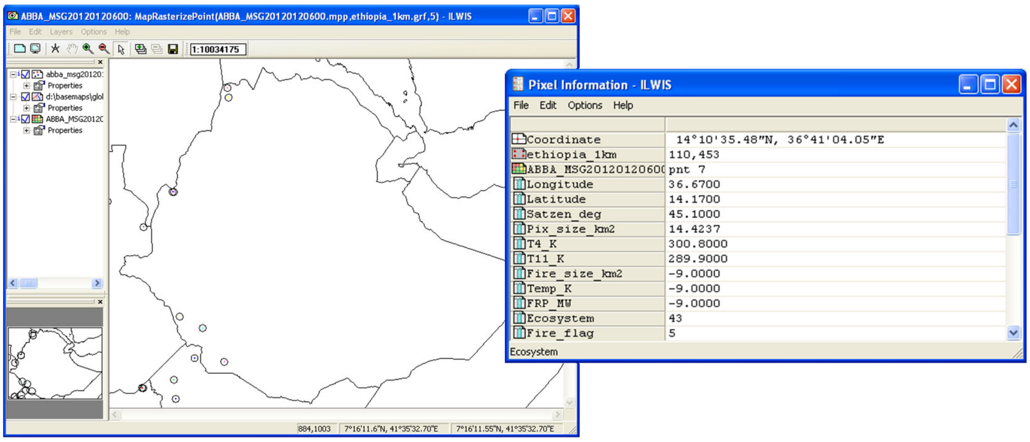
The batch routine can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\toolbox_batchroutines and the batch filename convention used for this product is: *MPEF_eth_firc_import.bat*.

3.2.6.8.2 ABBA-MSG Fire Product

The Automated Biomass Burning Algorithm (ABBA) is using SEVIRI MSG, in full temporal resolution to capture active fires for the whole African continent. Further information of the processing routines is available at: http://cimss.ssec.wisc.edu/goes/burn/wfabba.html.

The input data directory is specified as “ABBA_MSG” and can be set using the options “Configuration” and “Folders”. As input string a “yyyyjjjhhmm” timestamp is expected, note that “jjj” stand for Julian Day. After import of the file a point map is created and this map is resampled to the Ethiopian window. Both the raster map and point map can be displayed; additional information on the fires detected is stored in the attribute table. As example see figure 3.12.

Figure 3.12: ABBA-MSG fire product and associated attribute table



The batch routine can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\toolbox_batchroutines and the batch filename convention used for this product is: *ABBA_MSG_import.bat*.

3.2.6.8.3 MODIS Aqua and Terra Fire product for a Julian Day

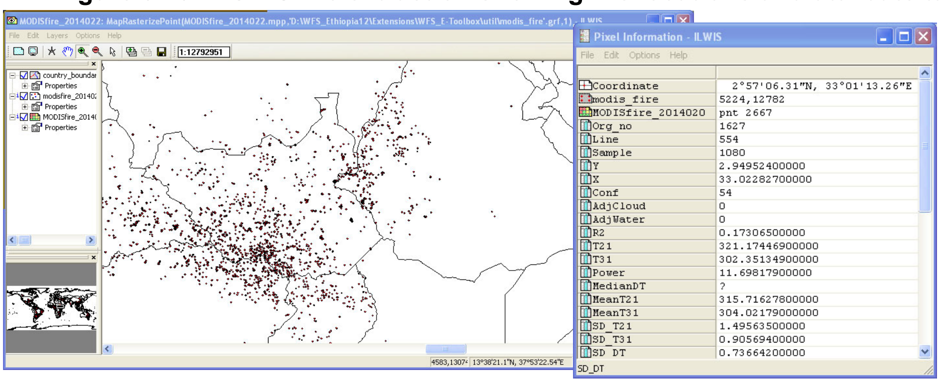
This is the most basic fire product in which active fires and other thermal anomalies, such as volcanoes, are identified using the Aqua and Terra instruments on the MODIS series of satellites. The product is covering an area of approximately 2340 by 2030 km in the across- and along-track directions, respectively (per file!).

All the imported files are accompanied by a fire-pixel table which provides radiometric and internal-algorithm information about each fire pixel detected within a granule (source: http://navigator.eumetsat.int/). On a daily basis 288 files for the Aqua and Terra each, are disseminated and each file contains 5 minutes of observations. The import routine expects the year and Julian day number to be entered.

It is possible to first determine the overpass time of the instruments over the Region of Interest (RoI). This can be done by using a Satellite Orbit Tracking software package. See the appendices for freeware utilities available. Once a selection has been made of the time of overpass over the RoI all the required files need to be copied into a dedicated input folder, as the routine retrieves all the files of both Terra and Aqua and starts the processing, using a looping procedure. If there are occurrences of fires, the information is extracted and point maps and associated tables are created. Subsequently all fire tables are exported to a text delimited format and are combined into a single file. This overall fire file is imported and a new table is created as well as derived point and raster maps. For a good visualisation of the raster map, showing the affected (single) pixels, it is advised to display the point file over the raster map. If no RoI is selected all fire files of the specified Julian Day are processed, both of Terra as well as Aqua. Given the huge number of files the procedure takes some time to complete and will generate a global fire map for the specified date. An example is provided in figure 3.13 showing a global import of MODIS fires displayed over Eastern Africa, zooming in on South Sudan and Ethiopia. The table includes a column on confidence (in percentage). This column (see figure 3.13, the column 'conf') can be used to retrieve only those fires having a high confidence.

From the main WFS-Ethiopia Toolbox menu, using the options "Configuration" and "Folders", under "MODIS-Fire" the input MODIS and output directories can be specified. The batch files used for the import of the MODIS fire product from Aqua and Terra all start with modis* and are situated in the ILWIS sub-directory \Extensions\WFS_E-Toolbox\toolbox_batchroutines. The routine is first initiated by the batch file called "modis_firestart.bat" and from within this batch file other routines are executed to retrieve and process the Aqua and Terra files and import these in ILWIS format.

Figure 3.13: MODIS fire extraction showing fire locations and attribute table



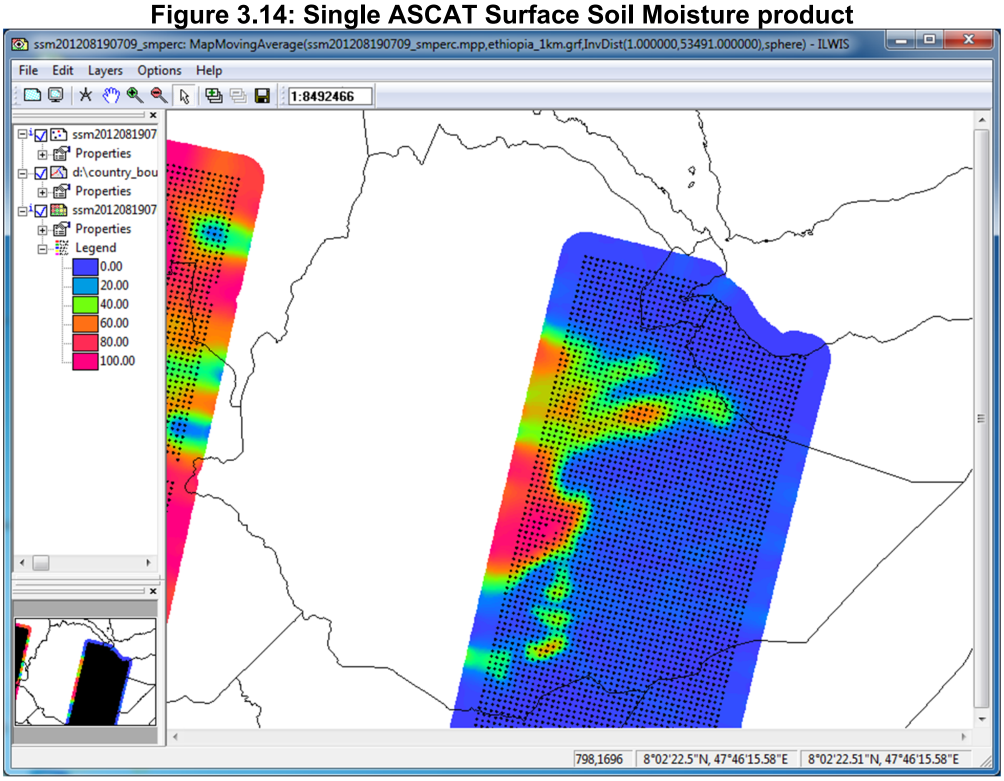
3.2.6.8.4 *ASCAT Surface Soil Moisture*

The METOP A/B instruments are carrying various sensors. The products derived from the ASCAT instrument, the surface soil moisture and the ocean vector winds, are disseminated both via Ku and C band reception. For the Surface Soil Moisture product, with 12.5 km resolution, an import routine is available. For import of this product, next to the 12 digits time stamp (format=yyyymmddhhmm) also the orbit number is required. It is advised to check the raw data that is situated in the respective input directory to obtain the appropriate “Date” and “Orbit” stamp as it is related to the overpass time and orbit number. The link to this directory has to be specified in the main WFS-Ethiopia Toolbox menu, using the options “Configuration” and “Folders”, under “METOP-SSM”.

To select from the input directory the appropriate image for a specific region of interest, use can be made of Satellite Orbit Tracking freeware utilities (see Appendix 1 for some links). These utilities provide the possibility to retrieve the time of overpass of a given (polar) orbiting satellite. The filename convention for the METOP data indicates the start time of the recording; each file contains 3 minutes of observations.

Upon completion of the product import a point file and associated attribute table are created, the point map shows the surface soil moisture in percentage. An example is presented in figure 3.14, showing also the results of a moving average interpolation procedure.

Figure 3.14: Single ASCAT Surface Soil Moisture product



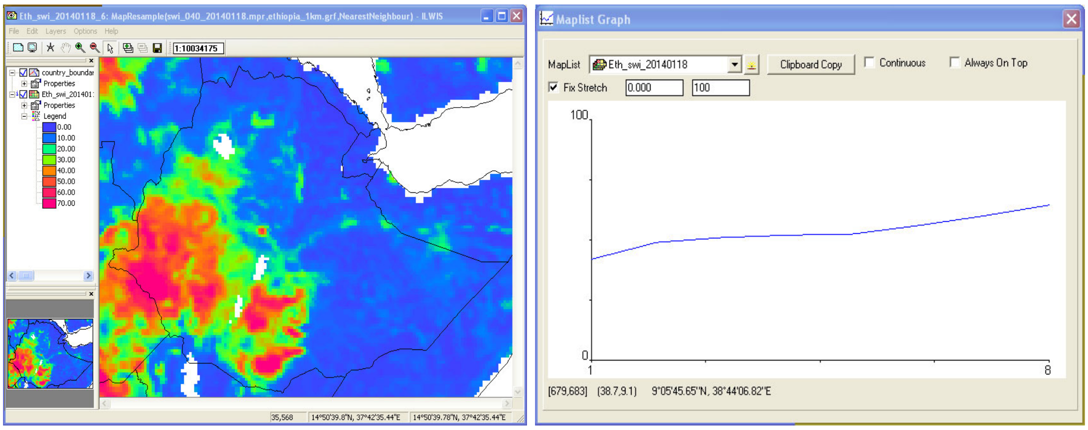
The batch routine can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\toolbox_batchroutines and the batch filename convention used for this product is: *ASCAT_ssm_import.bat*.

3.2.6.8.5 *Copernicus Global Daily Soil Water Index*

The Soil Water index (SWI) product provides global daily information about moisture conditions in different soil layers. SWI daily images are produced from EUMETSAT ASCAT-25km SSM product in orbit format and include a quality flag indicating the availability of SSM measurements for SWI calculations. Soil moisture is a key parameter in numerous environmental studies including hydrology, meteorology and agriculture. In addition to Surface Soil Moisture (SSM), information on the moisture condition within the underlying soil profile is of interest for different applications. Soil moisture in plant root zone can be estimated by an infiltration model using information on surface soil moisture and soil characteristics (source: http://navigator.eumetsat.int/). The Soil Water Index quantifies the moisture condition, also within the underlying soil profile in 8 different characteristic time lengths - T (where T is 1, 5, 10, 15, 20, 40, 60 and 100) (http://land.copernicus.eu/global/index.html).

Before starting to import the SWI product available in the GEONETCast data stream verify the settings of the directory containing the raw data. In order to do so, select from the main menu the option "Configuration" and "Folder" and select "Copernicus". As input string a "yyyymmdd" timestamp is expected. After import of the file a map list is created containing the 8 different characteristic time lengths (T), numbered from 1 to 8 (where T is 1, 5, 10, 15, 20, 40, 60 and 100 respectively). The maps are resampled to the Ethiopian window.

Figure 3.15: Soil Water Index for the T=1 layer and SWI graph for all T-values (1=1 and 8=100) at a pixel over Central Ethiopia (for 2014)



The batch routine can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\toolbox_batchroutines and the batch filename convention used for this product is: *Copernicus_SWI.bat*.

3.2.7 ***METAR and TAF Messages***

On a continuous basis GTS message files are disseminated. A single file contains multiple METAR and TAF messages (see also: https://en.wikipedia.org/wiki/METAR). To extract only the messages for a specific country from a large collection of GTS message files the option "Create METAR-TAF for a country" has to be used. This operation filters all message files in the input directory specified and extracts the messages only for the country specified. To operate the routine the 2 digit ICAO Location Indicator, specifying the country code (in capitals) has to be entered. Once the operation is completed a number of ascii files are created and displayed, called "find_MDD1_METAR_**.txt", "find_MDD1_TAF_AMD_**.txt" and "find_MDD1_TAF_**.txt" (by default ** is the country code used). The information contained within the various messages for the selected country is now merged into this single output file and might contain several half hourly weather reports of the main airports situated within the country.

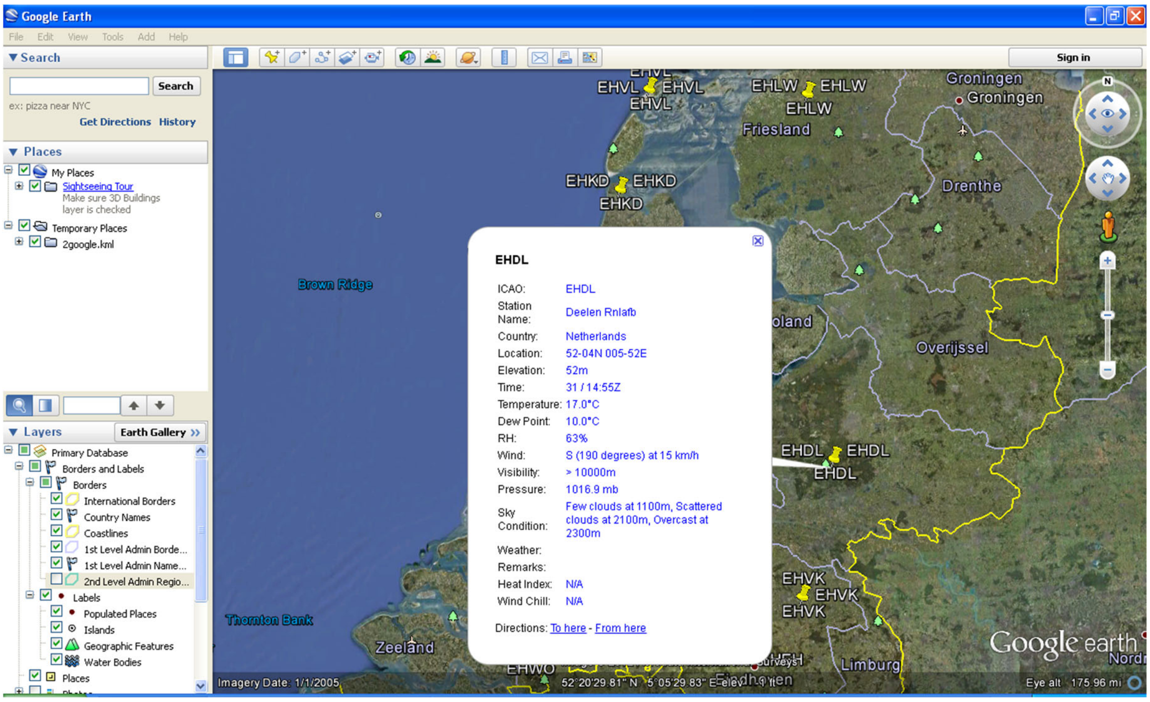
From the main WFS-Ethiopia Toolbox menu, using the options “Configuration” and “Folders”, under “Metar_Taf” the input GTS METAR and TAF messages directory and output directory can be specified and this is also the location where the “METAR – TAF - AMD.txt” files for the specified country to be created will be stored. Once the total file list of GTS messages is reviewed the asci files created are automatically displayed. The user can inspect the content of the files and subsequently close it. These files can be opened with a text editor at a later stage as well. Note that at this moment for the TAF messages only the first part of the message is retrieved, forecasting information is not extracted.

The files created can be used as input for the second routine: “Display METAR-TAF data” and press import. The freeware utility “MetarWeather” is appearing on your screen. From the menu, select “File” >> “Load METARs From File” and select the file “find_MDD1_METAR_**.txt” (for the country code here EH is used, being the ICAO code for the Netherlands) and press “Open”. All messages now appear as a table; by double clicking on a record a METAR report form is shown. If all records in the table are selected (selected records turn blue), and the right mouse button is pressed, the context sensitive option “Save selected Items” and “Save as Type” “KML File – For Google Earth (*.kml)” can be selected, an appropriate output file name can be specified and the file can be saved.

Move to the output directory and double click with the mouse on the *.klm file created. Google Earth will start and zooms to the geographic extent covered by the kml file. A location displayed on the map can be selected and when clicking on a place mark the METAR report is shown. An example is presented in figure 3.16. Note that for the same location multiple METAR reports are available, each 30 minutes. For further details see also figure 1.2 which shows the MetarWeather table and report of the same GTS messages processed.

The batch routines can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\toolbox_batchroutines and the batch filename convention used for this product is: *MDD1_find_METAR_TAF.bat and Metar_weather_start.bat respectively*.

Figure 3.16: MDD-1 METAR-TAF reports in Google Earth



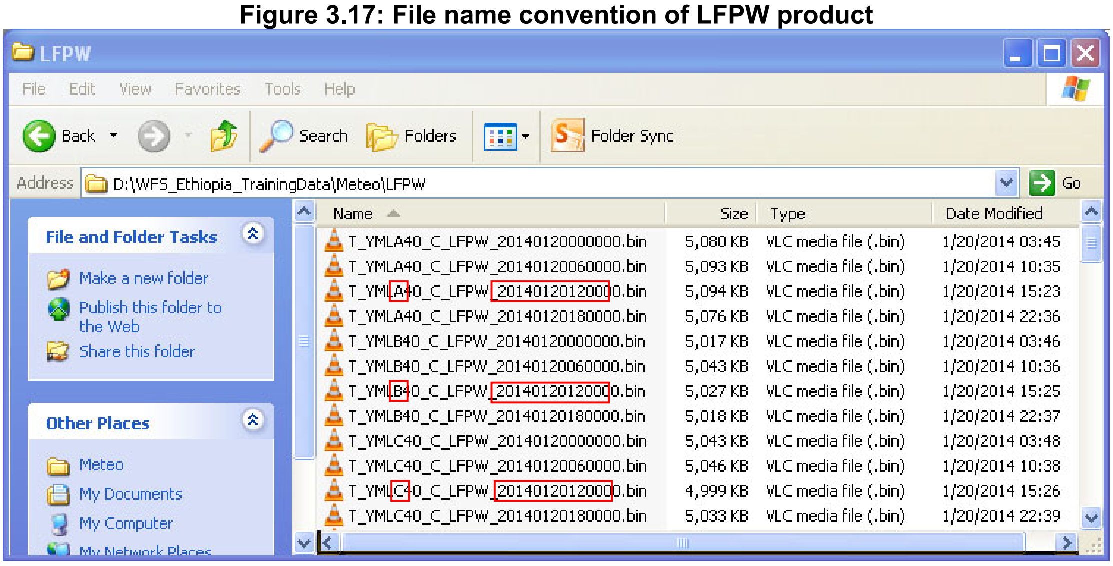
3.2.8 *MeteoFrance Analysis and Forecasts - Africa*

The numerical model ARPEGE is a global and spectral general circulation model. It has been developed for operational numerical weather forecast by Météo-France in collaboration with ECMWF (Reading, U.K.). Further information on the model can be obtained from http://www.umr-cnrm.fr/spip.php?article121&lang=en. The products disseminated through GEONETCast are composed of 9 fields on 15 isobaric levels plus surface pressure, convective available potential energy (CAPE), precipitations, 2m and 10m temperature-humidity-wind. The model starts the product generation at 00:00 UTC for the up-to-96 hour/4 day forecast and at 12:00UTC for the up-to-72-hour/3 day forecast (forecast step 6hr). The products generated at 06:00UTC and 18:00UTC are exclusively analysis. The ARPEGE model is used to generate these products (source: http://navigator.eumetsat.int/). The spatial resolution is 0.5 degree.

From the main WFS-Ethiopia Toolbox menu, using the options “Configuration” and “Folders”, under “LFPW” the input and output directories can be specified.

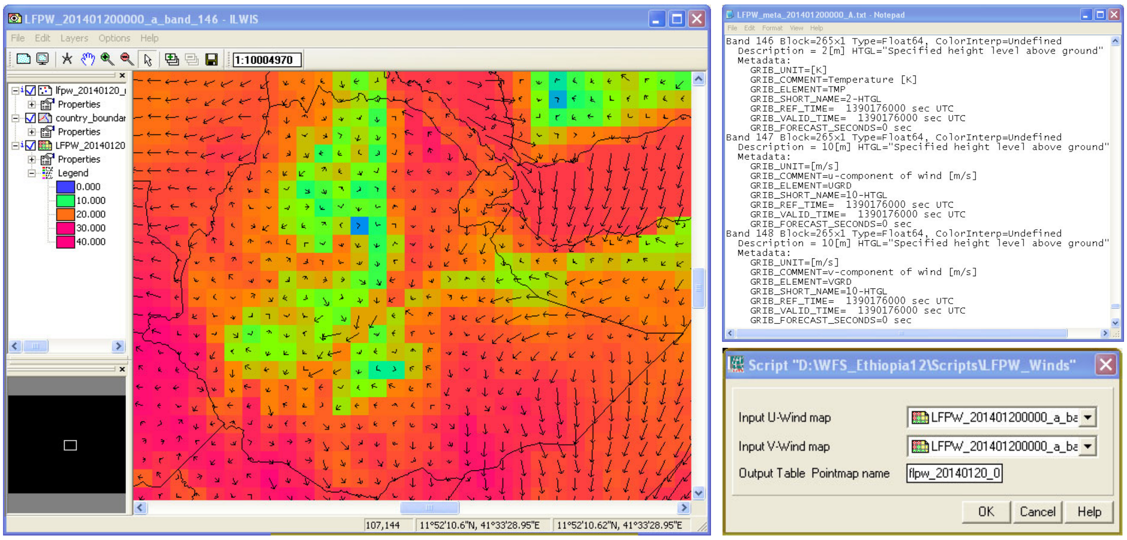
In order to process the data from this model first the meta data needs to be retrieved. The routine expects as input a ‘date string_Product character’, see also the figure below. The date string is consisting of 12 digits, ‘yyyymmddhhmm’. There are 4 temporal intervals, 00:00, 06:00, 12:00 and 18:00. The product string is from A to Y, A being the analysis and B to Y, the forecast, e.g. B is the 3 hr forecast, C is the 6 hr forecast, etc. Y is the 96 hr forecast. This file is also stored and available in the output directory for later consultation; the file name convention used is “LFPW_meta_date_Product.txt”. The file can be opened with Notepad or WordPad.

Figure 3.17: File name convention of LFPW product



Once the “Date_Product character” is entered the meta data file is retrieved, showing the details of the layers in the file, see also the left hand meta data listing of figure 3.18. Subsequently the file (using the same “Date_Product character”) can be imported using the routine “LFPW-Arpege import”. For the analysis a map list consisting of 153 layers is extracted and the forecast is consisting 154 layers.

Figure 3.18: Import of Temperature at 2 HTGL and processed U/V winds at 10 HGTL using an ILWIS script



Additionally a dedicated ILWIS script has been developed to process the U and V wind field layer, to derive the wind direction and wind speed vectors. The derived point map and associated table can be plotted over the other layers; a wind speed scaling column for visualization purposes is also calculated. The zip file, called 'LFPW_winds.zip", containing the script, service objects needed and description can be downloaded from ftp://ftp.itc.nl/pub/52n/ilwis_scripts/. For the script example and the results see also the figure above.

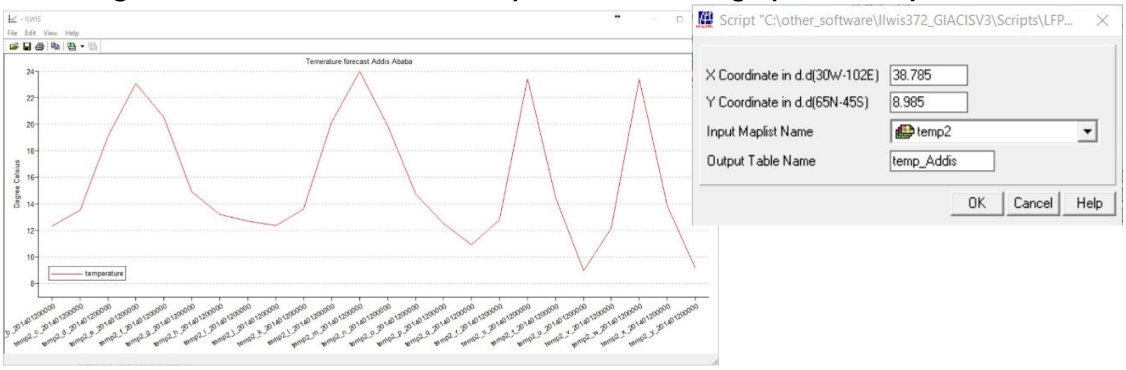
The batch routines can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\toolbox_batchroutines and the batch filename convention used for this product is *LFPW_meta.bat* and *LFPW_import.bat*.

This XML version also allows import of time series forecast parameters like 2 mtr temperature, and relative humidity, 10 mtr and mean sea level surface pressure, large scale and convective water precipitation, total cloud cover and convective available potential energy (CAPE), 10 mtr wind speed and direction. The relevant forecasted parameter is extracted from all files of a certain issue time. See once more figure 3.17 and note the forecasting time is denoted by the 'characters' B to Y. The time range from B to Q is having 3 hourly time steps, Q therefore is the issue time +48 hours (2 days) and thereafter the time steps become 6 hours, R is +54 hours and Y is +96 hours (4 days) with respect to the issue time.

The batch routine can be found under the ILWIS directory '\Extensions\WFS_E-Toolbox\toolbox_batchroutines' and the batch filename convention used for this product is 'LFPW_f_'parameter'_import.bat' which subsequently calls the batch file 'LFPW_f_'parameter'_ layer_extract_loop.bat' to import the various time steps for the selected 'parameter'.

Additionally a dedicated ILWIS script has been developed to retrieve the time series values for a certain parameter. The user has to manually create a maplist of the imported parameter and has to provide the X,Y location and output table name. The derived table contains the values of the parameter for the specified location. Additional columns can be calculated for appropriate graphical representation. The zip file, called 'LFPW_location.zip', containing the script, service objects needed and description which can be downloaded from ftp://ftp.itc.nl/pub/52n/ilwis_scripts/. For a script dialog example and the results see also the figure below.

Figure 3.19: LFPW time series temperature forecast graph and script window



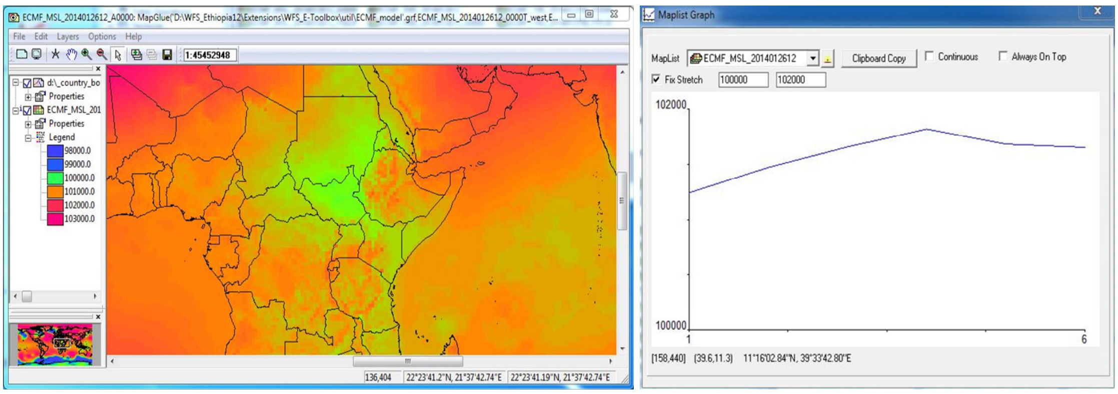
3.2.9 *ECMF Global Analysis and Forecasts*

Global surface and pressure level parameters from ECMWF Integrated Forecast System (ISF) are produced twice a day for 00 and 12 UTC, containing global analysis and forecast, and are disseminated through GEONETCast at approximate 06:30 and 18:30 respectively (up to the 120 hr forecast). See for further information on the ISF NWP used https://www.ecmwf.int/en/forecasts/documentation-and-support.

The routines prepared ingest the NWP model results for the following parameters: Temperature at 850 hPa (degree Celsius), Geopotential Height at 500 hPa (gpm), Mean Sea Level Pressure (pa), Relative Humidity at 700 and 850 hPa (in %). Upon import, the routine extracts the analysis and the forecasts for +24, +48, +72, +96 and +120 hrs. A map list is constructed and the analysis and forecasts can be shown as an animated sequence. Both the 00 and 12 UTC products can be imported and processed, see also figure 3.20.

From the main WFS-Ethiopia Toolbox menu, using the options “Configuration” and “Folders”, under “ECMF” the input and output directories can be specified.

Figure 3.20: Import of Mean Sea Level Pressure and time series graph showing analysis and forecasts



The batch routine can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\toolbox_batchroutines and the batch filename convention used for this product is *ECMF_’product’_’time’.bat* (where ‘product’ is the ECMF product type and ‘time’ is the UTC product time stamp, 00 or 12).

Additionally a dedicated ILWIS script has been developed to process the U and V wind field layer, to derive the wind direction and wind speed vectors. The derived point map and associated table can be plotted over the other layers; a wind speed scaling column for visualization purposes is also calculated. The zip file, called ‘ECMF_winds.zip’, containing the script, service objects needed and description can be downloaded from ftp://ftp.itc.nl/pub/52n/ilwis_scripts/.

3.2.10 *UK-Met Exeter Africa Forecasts*

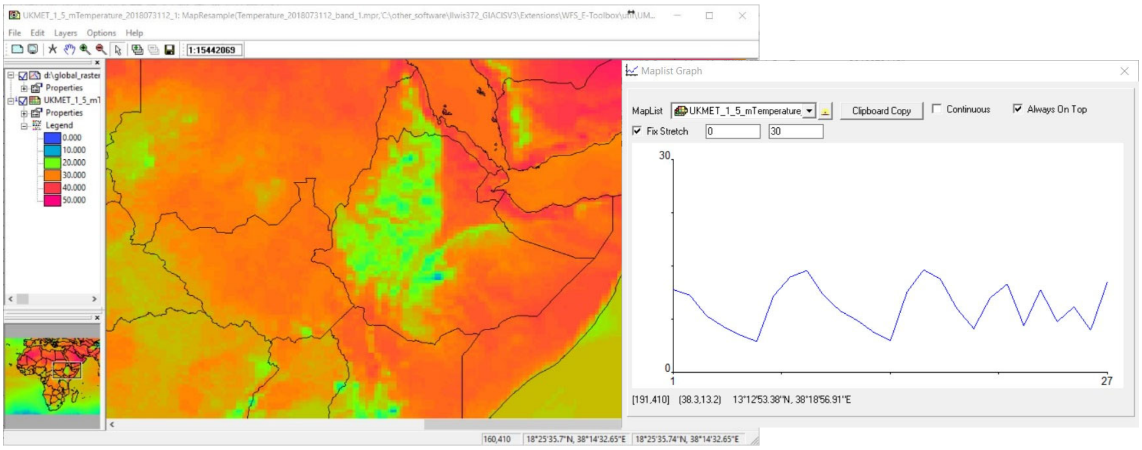
The Unified Model (UM) is a numerical model of the atmosphere used for both weather and climate applications (https://www.metoffice.gov.uk/research/modelling-systems/unified-model). The Met Office NWP Unified Model data (17km resolution) is used by the African National Meteorological & Hydrological Services to carry out their activities.

From this Unified Model (144 hr forecast for Africa only) the following data layers are extracted:

- Atmospheric forecasts: Convective clouds, Total (accumulated) precipitation, Long wave radiation (outgoing);
- Agro-meteorological forecasts (at 1.5 mtr above ground level): dew point, relative and specific humidity as well as temperature;
- Geo-potential heights: at 850, 700, 500 and 250 hPa;

After import of the products various map lists are created, containing 27 time steps each, from 0 to 48 hrs with 3 hr interval, then to 72 hrs with 6 hour interval, then from 72 to 144 hrs with 12 hrs interval. Time of issue is at 00:00 and 12:00 (UTC) and available on EUMETCast 2 times per day just prior to 04:00 and 16:00 (UTC). Within each of the Map list, layers 1 to 17 are representing the 0 to 48 hrs forecast, time step of 3 hours, layers 18 to 21 are giving the 48 to 72 hrs forecast, time step of 6 hours and finally layers 22 to 27 are providing the 72 to 144 hrs forecast, time step of 12 hours.

Figure 3.21: Temperature forecast (1.5 m above ground) and graph showing 144 hr forecast of pixel taken in the Simien mountains



Note that within the graphical representation the x axis is not corrected for the change in temporal resolution!

From the main WFS-Ethiopia Toolbox menu, using the options “Configuration” and “Folders”, under “Met_UK” the input and output directories can be specified. The batch routines can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\toolbox_batchroutines and the batch filename convention used for this product is UMD_*’products’.bat* (where ‘product’ are the atmospheric, geopotential height and agrometeorological products types indicated above.

3.2.11 ***NCEP GFS***

From NOAA's Climate Prediction Centre is providing forecasts on Weather and Climate Parameters for Africa, like Precipitation, Temperature, Winds, Heights, MSLP, Relative Vorticity, SST, etc. using a NWP Model.

The Global Forecast System (GFS) is a weather forecast model produced by the National Centres for Environmental Prediction (NCEP). Dozens of atmospheric and land-soil variables are available through this dataset, from temperatures, winds, and precipitation to soil moisture and atmospheric ozone concentration. The entire globe is covered by the GFS at a base horizontal resolution of 18 miles (28 kilometres) between grid points, which is used by the operational forecasters who predict weather out to 16 days in the future. Horizontal resolution drops to 44 miles (70 kilometres) between grid point for forecasts between one week and two weeks. The GFS model is a coupled model, composed of four separate models (an atmosphere model, an ocean model, a land/soil model, and a sea ice model), which work together to provide an accurate picture of weather conditions (source: http://www.ncdc.noaa.gov/data-access/model-data/model-datasets/global-forcast-system-gfs).

The GFS forecasts for the African continent are online available, with a daily update frequency, at http://www.cpc.ncep.noaa.gov/products/ international/africa/africa.shtml. From the main WFS-Ethiopia Toolbox menu, using the options "NCEP GFS-Web based" >> "NCEP GFS Forecasts" the link is provided to the web portal. Figure 3.22 is showing the main menu template for Africa displayed when running the import routine. This main menu template provides the links to all the other product items. The batch routine can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\toolbox_batchroutines and the batch filename convention used for this product is "*NCEP_CPC_intl.bat".*

Other online resources related to NCEP GFS derived precipitation and 850 Mb temperature, relative humidity and streamlines, precipitable water and convective available potential energy (CAPE) and sea level pressure are provided as well, produced by the Centre for Ocean-Land-Atmosphere Studies, George Mason University. The batch routines can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\toolbox_batchroutines and the batch filename convention used for this product is "*GFS_wxmaps_*.bat" (* for the various parameter).* The 6 day forecasting data at 24, 48, 72, 96, 120 and 144 hrs. time steps are retrieved from http://wxmaps.org/. From the main WFS-Ethiopia Toolbox menu, using the options "Configuration" and "Folders", under "GFS" the output directory can be specified.

With respect to the interpretation of the animations a guide is provided by the Centre for Ocean-Land-Atmosphere Studies, George Mason University (source: http://wxmaps.org/ fcstkey.php):

Precipitation animation:

- 24 hour accumulated precipitation, measured in millimetres. The total is the amount of rainfall forecast during the 24 hours immediately preceding the verification time in the lower left-hand corner of the map

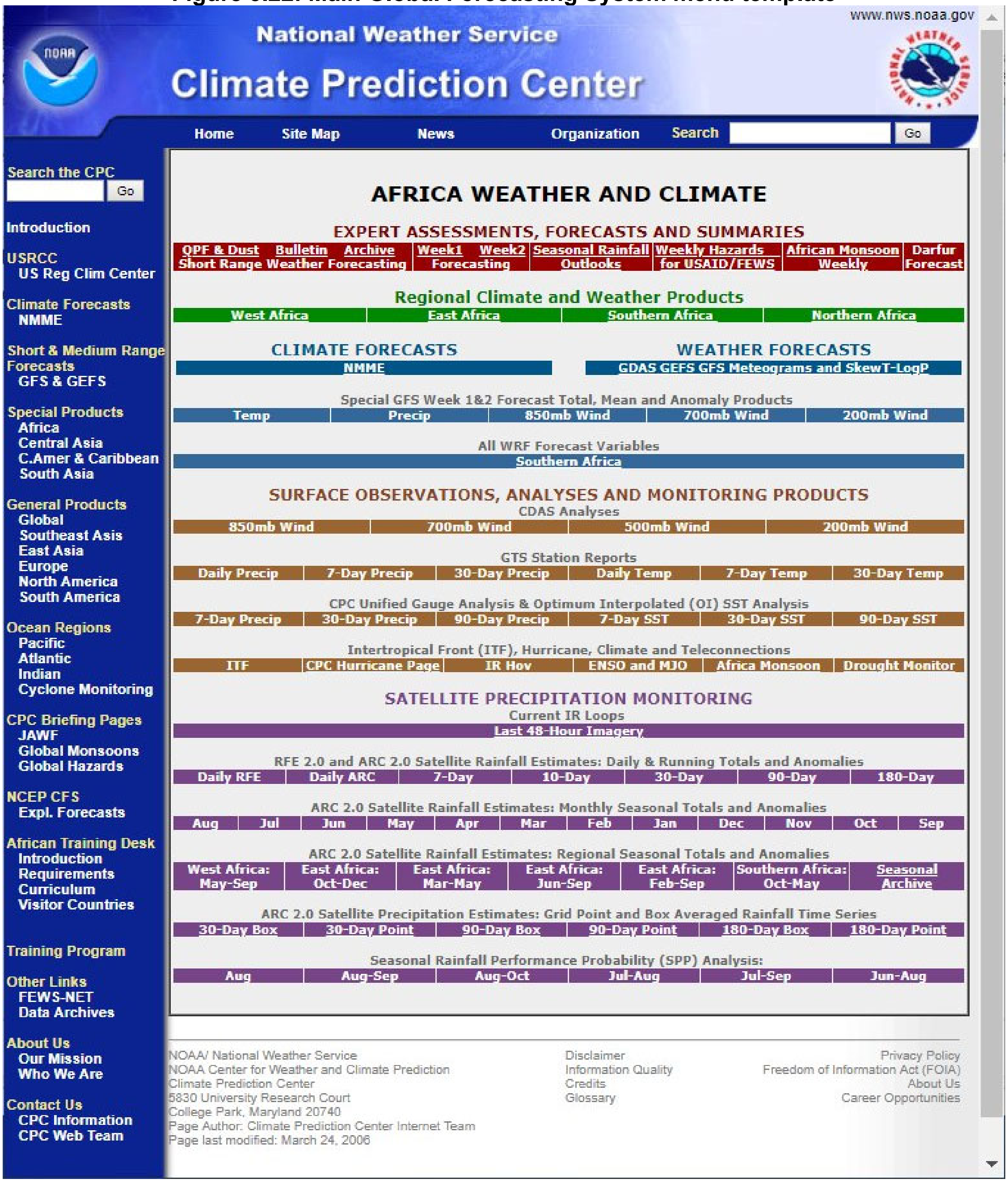
850mb temperature, humidity and winds animation:

- Coloured contour lines indicate the air temperature at the 850 millibar level, in degrees Celsius. The 0 °C contour is highlighted, as this is also often used as a divider between rain and snow.

- The green shading indicates the relative humidity percentage at the 850 millibar level. High values indicate the availability of moisture. When areas of large upward vertical velocity are co-located with high moisture availability, heavy rainfall will likely occur.

- The streamlines indicate the wind flow. Advection of moisture by the wind can be inferred by noticing the direction and rate at which moist areas appear to be blown. Similarly, temperature advection can be inferred by noticing whether the wind is blowing cold air toward a warm region, or warm air toward a cold region.

Figure 3.22: Main Global Forecasting System menu template



Precipitable water and convective available potential energy (CAPE) animation:

- The shaded contours indicate total precipitable water in the atmosphere. Precipitable water is the total depth of liquid water that would result if all water vapour contained in a vertical column of air could be "wrung out", leaving the air completely dry. It indicates the total humidity of the air above a location, and is a good indicator of the amount of moisture potentially available to supply rainfall.

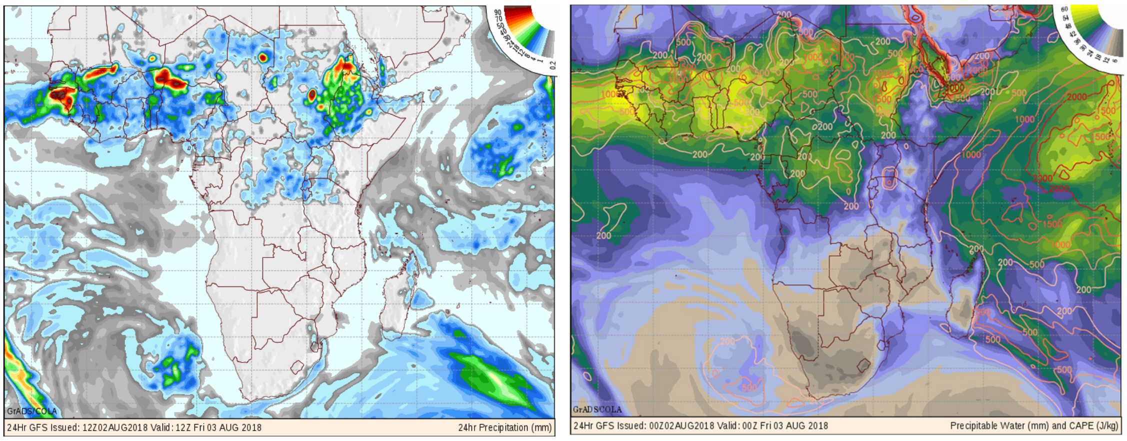
- Convective available potential energy is a good indicator of the potential for strong thunderstorms and severe weather. High values of CAPE indicate that most (but not necessarily all) conditions exist for strong thunderstorms. CAPE is drawn in red-coloured contour lines overlaid on top of the precipitable water shaded contours in most panels. For the weather maps for the Tropics, CAPE is drawn as shaded contours with sea level pressure contours overlaid in black.

Sea level pressure and 1000-500mb thickness animation:

- The coloured contour lines indicate sea level pressure in millibars. High pressure is red, low pressure in green or blue. Only the last 2 digits shown -- sea level pressure is usually around 1000 millibars, so add 1000 to values in the range of 00-50, and add 900 to values in the range of 50-98. Low sea level pressure indicates cyclones or storms near the surface of the earth. High sea level pressure indicates calm weather.

- The shaded contours indicate the vertical distance, or thickness, between the 1000 millibar surface and the 500 millibar surface, measured in tens of meters. Since air behaves nearly as an ideal gas, and vertical distance is proportional to volume over a specified surface area, the thickness between two pressure levels is proportional to the mean temperature of the air between those levels. Thus, low values of thickness mean relatively cold air. The 540 line is highlighted in black, since this line is often used as a rule of thumb to indicate the division between rain and snow for low terrain. When there is precipitation where the thickness is below 540dam, it is generally snow. If the thickness is above 540dam, it is usually rain (or sleet if the air next to the surface is below freezing).

Figure 3.23: GFS derived rainfall (left), precipitable water and CAPE example (right)



All routines extracts the latest forecasts (up to 6 days / daily interval) to the provided output directory, transform the *.png files to *.gif and creates and animated GIF which is subsequently displayed using 7GIF. The animated gif is stored in the output directory under the name "*wxmaps_p_ani_time*", "*wxmaps_850mb_ani_time*", "*wxmaps_slp_ani_time*" and "*wxmaps_pcape_ani_time*" (where time is local time from system clock time at start time execution of the routine). Within the toolbox, under "Other Routines" >> "View animated GIF" >> "Display animated GIF using 7GIF" the animations created can be visualized as well.

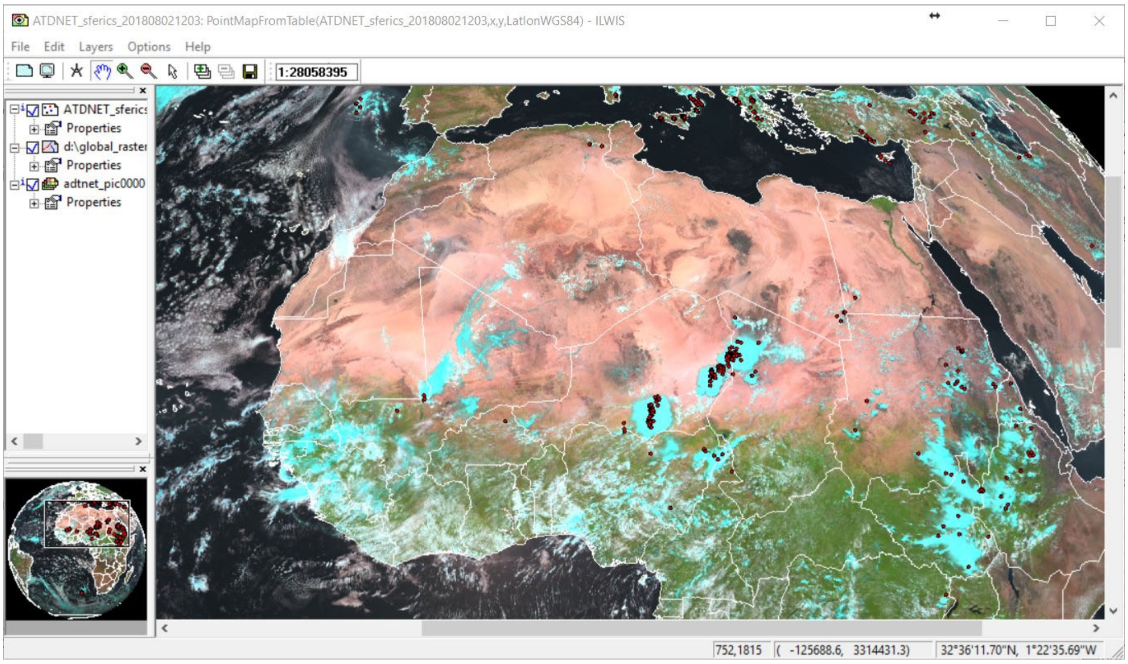
3.2.12 ***Lighting Detection Data***

The ATDnet system is an automatic lightning location network capable of sensing lightning flashes over a wide and variable geographical area. The system locates lightning by timing the arrival of unique very low frequency radio waves (known as atmospherics, or simply 'sferics') generated by individual lightning strikes at the ATDnet outstations. The differences in the arrival times of these strokes at the outstations are used to calculate the lightning's location. Data are collected every minute and BUFR encoded using the 'Universal BUFR template for lightning data' with 15 minutes of data combined into one file which is then sent to EUMETSAT (source: http://navigator.eumetsat.int/).

Before starting to import the Sferics product available in the GEONETCast data stream verify the settings of the directory containing the raw data. In order to do so, select from the main menu the option "Configuration" and "Folder" and select "ATDNET". As input string a "yyyymmddhhmm" timestamp is expected, note the temporal resolution of 15 minutes and the product is available with a timing offset of 3 minutes. After import of the file a point map and table is created using as file name convention "ATDNET_sferics_yyyymmddhhmm".

The Sferics can be retrieved from the main WFS-Ethiopia Toolbox menu, using the options "Lightning Detection Data" >> "ATDNET Sferics". The batch routine can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\toolbox_batchroutines and the batch filename convention used for this product is "*ATDNET_import.bat".*

Figure 3.24: ATDNET 15 minutes BUFR file plotted over MSG for the same time step



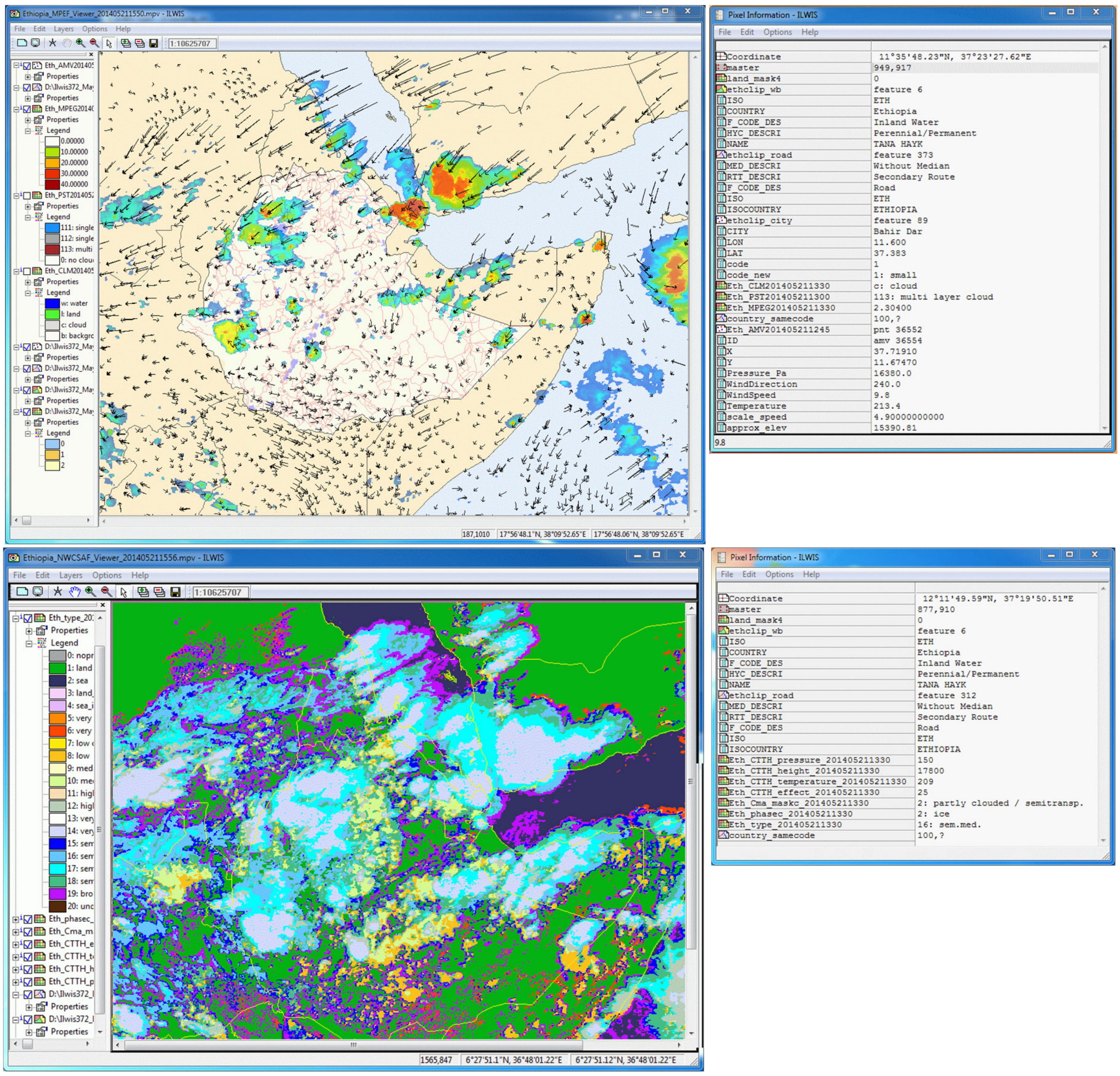
The relationship between strong convective processes (cumulonimbus clouds) and occurrences of lighting can be clearly observed from the figure above. For further information see also https://www.metoffice.gov.uk/learning/storms/thunder-and-lightning/lightning.

3.2.13 ***Automatic processing***

To facilitate operational weather services a number of routines have been developed requiring minimal user interaction to retrieve and display in a mapview a selected number of most recent MSG images and standard SEVIRI RGB composites as well as derived products. Figure 3.25 is showing the MPEF and NWCSAF viewers and figure 3.26 is showing the MSG-Day viewer. After the processing has been completed a mapview is displayed showing the results over a standard background. The only user interaction required is to switch layers 'on' and 'off'. Full GIS functionality is however provided, like zooming, panning, setting layers transparent, adding other layers, retrieving the image or product (pixel) values, etc. For image visualizations and RGB compositing the EUMETSAT 'best practices' are applied (http://oiswww.eumetsat.int/~idds/html/doc/best_practices.pdf). Table 3.3 provides details on the products / images retrieved.

The routine determines for the selected images / products those which have been most recently received, retrieves the appropriate files, performs the processing, is creating and visualizing a mapview. The date-time stamp attached to the mapview is the (local) time when the routine started. For all products and images the actual file date-time stamp (in UTC) is used.

Figure 3.25: MPEF and NWCSAF automatic generated mapviews



From the main WFS-Ethiopia Toolbox menu, using the options “Configuration” and “Folders”, under “MPEF-highres”, “NWCSAF” and “MSG Data Manager” the input and output directories can be specified for the different viewers. The batch routine can be found under the ILWIS directory ‘\Extensions\WFS_E-Toolbox\auto_gnc’ and the batch filename convention used for this product is “*begin_*.bat”* which subsequently calls another batch routine “*start_*_visualization.bat*” (* is used for the different product visualizations). The routine determines automatically if a dated folder structure is used and if this is the case, based on the actual system clock date-time, the appropriate year\month\day is determined. The routines can also be operated as a “Windows Scheduled Task”, fully automating the whole processing.

Figure 3.26: Example of MSG-Day-Viewer showing Day Convective Storms visualization

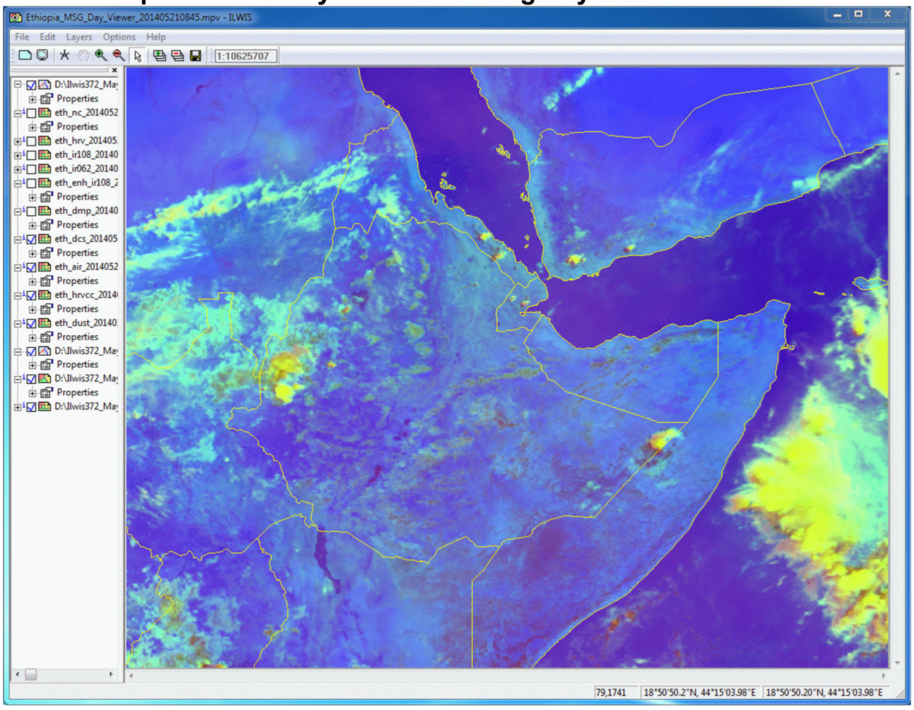


Table 3.3: Automatic processed data layers

Viewer	MSG-Day	MSG-Night	MPEF	NWC-SAF
Image/products imported	All MSG SEVIRI channels, converted to reflectance and temperature. Images are stretched and gamma function is applied.	All IR MSG SEVIRI channels, converted to temperature. Images are stretched and gamma function is applied.	Cloud Mask (CLM), Multi Sensor Precipitation Estimate (MPEG), Atmospheric Motion Vectors (AMV), Optimal Cloud Analysis (OCAE)	Cloud Mask (CMa), Cloud Type (CT), Cloud Temperature-Height (CTTH)
Layers added to MapView visualization	IR_10.8 (K) WV_6.2 (K) Enhanced IR_10.8 Airmass RGB Dust RGB Microphysics RGB Severe Storm RGB Natural RGB HighRes RGB	IR_10.8 (K) WV_6.2 (K) Enhanced IR_10.8 Airmass RGB Dust RGB Microphysics RGB	CLM Cloud Mask MPEG Precipitation (mm/hr) OCAE Pixel Scene Type AMV Direction, Speed, Pressure, Temperature, approx. Elevation, Scaling for speed	CMa Cloud Mask CT Cloud Type and Phase CTTH Cloudiness (%), Temperature (K), Pressure (hPa), Height (m)
Background layers used / at disposal	Layers used: land/water mask, water bodies and main roads Ethiopia, country boundaries, Other layers available: (colour shaded) DEM and satellite image background, Ethiopia (admin) regions and cities			

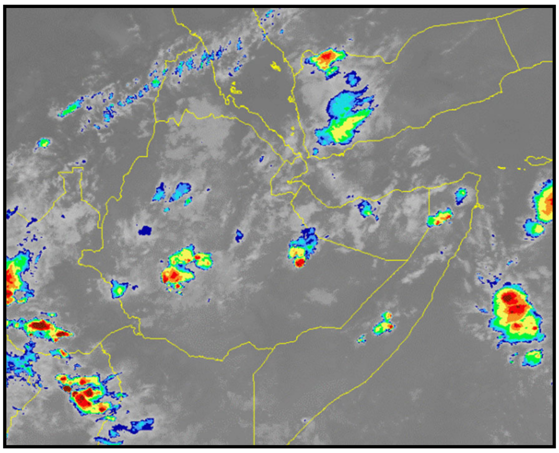
For the Enhanced IR visualization an inverse grey scale is applied for the pixels having temperatures above 240 Kelvin. For the pixels below 240 K a colour scheme is adopted in 5 degree class intervals as given in the table below.

Table 3.4: Temperature classes adopted for enhanced IR visualizations

Temperature class (K)	Colour
>240	Inverted grey scale
240-235	Dark blue
234-230	Blue
229-225	Cyan
224-220	Green
219-215	Yellow
214-210	Orange
209-205	Red
< 205	Brown

A routine has been added to create from the most recent 2 hr MSG IR_10.8 images received at the reception station an animated gif. An enhanced IR colour visualization is created, using the class intervals as given in table 3.4. An example of such an animation is given in the figure below. Upon creating the gif is automatically displayed and is stored in the working directory. The file name convention used is anim_tir_last2hrs_yyyymmddhhmm.gif, where the date-time stamp refers to the start of the routine, local time! The animation shows clearly the development – dissipation and movement of the colder clouds over the preceding 2 hours in 8 time steps.

Figure 3.27: Single time step of Enhanced IR_10.8 animation



Also a routine has been added for quick retrieval of certain layers from the latest Analysis NWP output (of 00:00, 06:00, 12:00 and 18:00) of the MeteoFrance Arpege model. Layers retrieved are: CAPE [J/kg], total cloud cover [%], MSL Pressure [Pa], Relative Humidity [%] at 2 mtr, Temperature [K] at 2 mtr, Wind Speed [m/s] and Direction [Degree] at 2 mtr and Geo Potential Height [(m^2)/(s^2)] at 500 hPa. All layers are added to a MapView.

It is anticipated that more automated visualization routines will be added based upon the requirements of the Ethiopian National Meteorological Agency, especially to assist day to day operations by the staff of the regional branch offices.

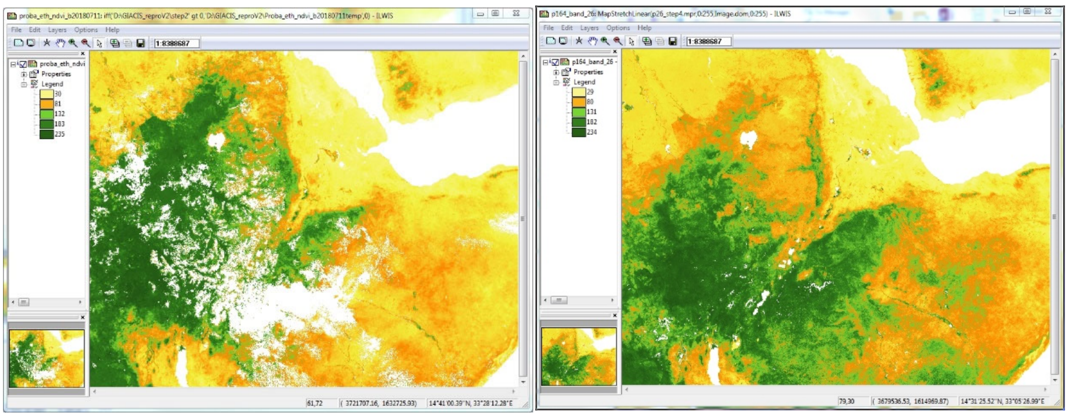
3.2.14 *GIACIS NDV Processing*

Additional functionality was developed for processing of PROBA-Vegetation NDVI time series for the purpose of Geodata for Innovative Agricultural Credit Insurance Schemes (GIACIS). The majority of farmers in Ethiopia have less than 0.5 ha of land. These subsistence farmers are very vulnerable to climate-based risks such as agricultural drought. Trying to avoid unnecessary risks they are not inclined to invest and adopt recommended management changes, although a basic insurance would go a long way to get them out of this poverty trap. The GIACIS project has developed the required insurance instrument. It reduces the impact of drought related shocks in income of smallholder farmers, especially when they made extra investments using credit or own capital. ITC developed the method, algorithms and tools to interpret satellite imagery to monitor the status of the green vegetation. Every ten days this information is used to calculate the severity of drought by crop production zone and to determine the indemnity payments due. The target is that farmers are automatically insured against drought, indirectly when using credit to buy agricultural inputs, or directly when purchasing those inputs. Implementation relies on low-cost branchless banking technology using apps for mobile devices, and on scalable financial inclusion that can reach the majority of rural areas. GIACIS is a public-private partnership between ITC, Kifiya Financial Technology, the Agricultural Transformation Agency (ATA) and the National Meteorology Agency (NMA) of Ethiopia (source: https://www.itc.nl/global-impact/itc-major-projects/!/giacis).

In support of GIACIS, under the WFS-Ethiopia Toolbox, additional functionality was developed to allow easy ingestion and processing of the PROBA-Vegetation NDVI and subsequent time series (re-) processing like temporal filtering. From the WFS-Ethiopia toolbox menu, select the menu options “GIACIS NDV Processing” >> “GIACIS NDVI calc HELP” to obtain access to additional documentation describing the routines provided into more detail.

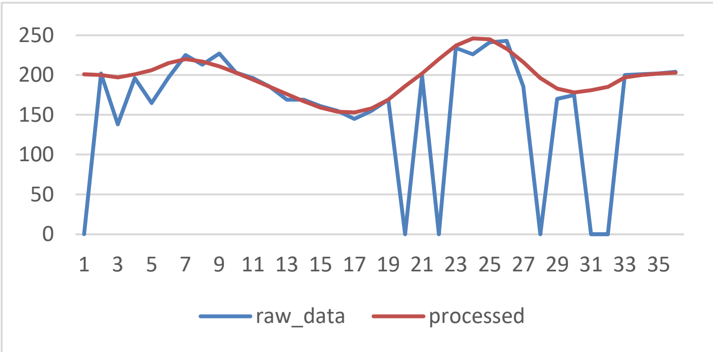
One of the most important elements of the set of routines developed is the temporal filtering application. Once a Proba-Vegetation NDVI dekadal product is made available through GEONETCast, the routine supports the import of this product and is performing some initial corrections (calibration against SPOT Vegetation derived NDVI data per agro-ecological zone). The “TimeSat” application developed allows temporal filtering using a time series of NDVI images and climatology NDVI images of future time steps. Subsequently after the processing masks are applied for water bodies and areas that have persistent cloud coverage. This application results in a reduction of noise in the time series data using a modified adaptive Savitzky-Golay filter, forcing an upper envelope. See the figures below.

Figure 3.28: TimeSat filtering – original NDVI product and after filtering



From the figure above it can be seen that the initial NDVI has many pixels which have been affected by clouds and therefore do not contain valid observations. The filtering procedure replaces these occurrences with 'best guess' data based on observations from a number of previous and future time steps. The future time steps are based on long term NDVI climatology.

Figure 3.29: Graphical presentation of filter effectiveness



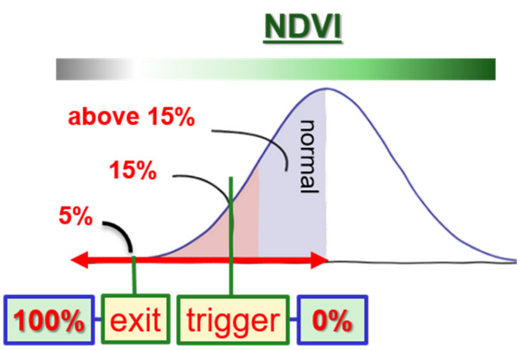
Within the GIACIS project on a 10 day basis the routines are applied and the NDVI data is provided (as a table) for further insurance processing, e.g. calculation of indemnities.

3.2.15 *GIACIS Indemnity Calculation*

Under the WFS-Ethiopia Toolbox extension in ILWIS, additional functionality was developed to calculate the indemnity based on processed time series of the PROBA-Vegetation NDVI images. From the WFS-Ethiopia toolbox menu, select the menu options "GIACIS Indemnity Calculation" >> "GIACIS Indemnity calc HELP" to obtain access to additional documentation describing the routines provided into more detail.

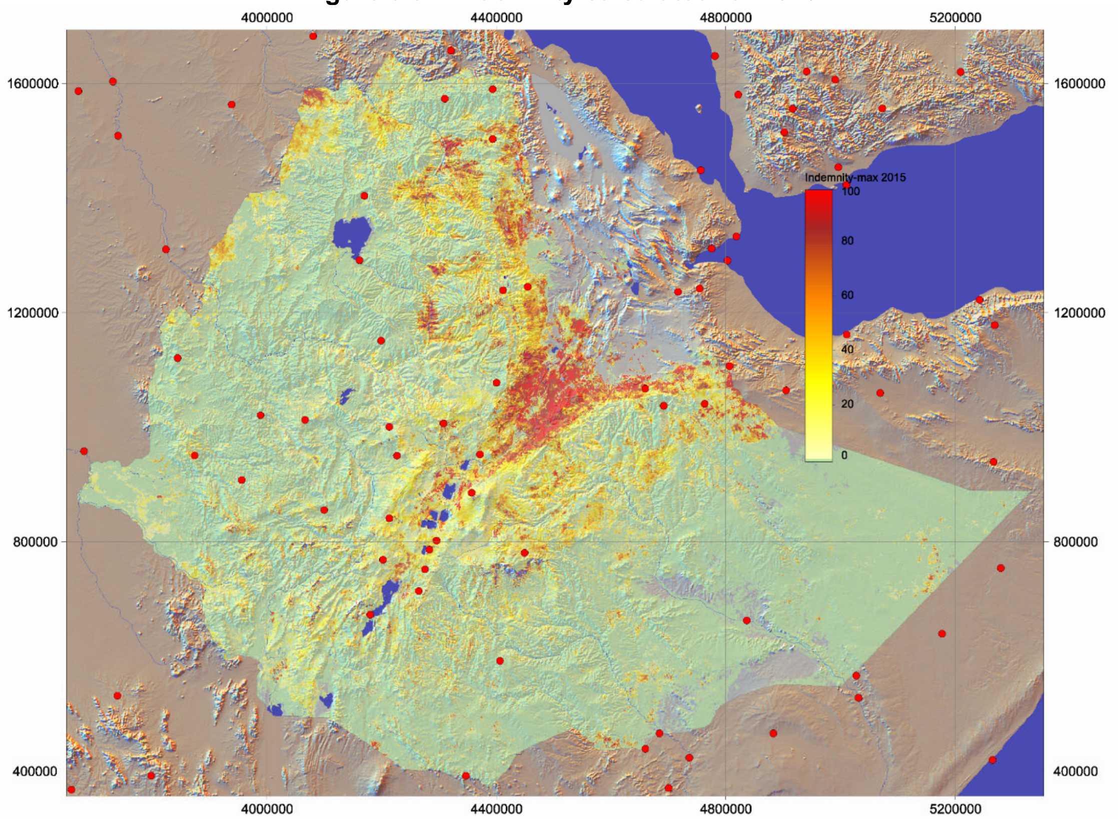
These routines calculate, based on NDVI thresholds defined per agro ecological zone, if the actual or seasonal NDVI value of the respective pixel drops below the lower 15% threshold defined for that specific agro ecological zone. Once the NDVI value is in the lower range from 15 to 5 % the indemnity increases from 0 to 100 % (total crop loss), see also the figure below.

Figure 3.30: NDVI based trigger for indemnity calculation as applied in GIACIS



Indemnity calculations are available to calculate the indemnity for a whole (previous) season or for a current season, which is not completed. Average indemnity is calculated taking into account length of growing season. The figure below shows the situation for 2015. Per season the maximum indemnity is given to get an impression of the overall indemnity for a specific year.

Figure 3.31: Indemnity calculated for 2015



3.2.16 *Water Requirement Satisfaction Index*

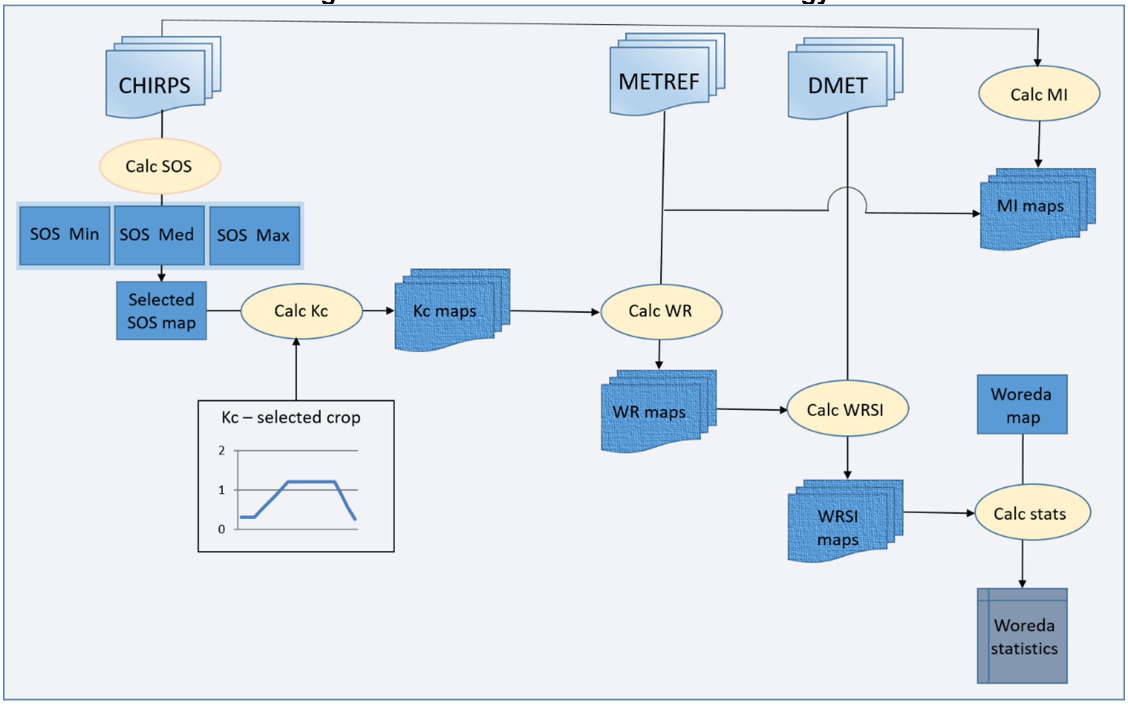
Within this version of the WFS-Ethiopia toolbox ILWIS scripts routines have been added to calculate an energy balance based Water Requirement Satisfaction Index (WRSI). The overall procedure is given in the figure below.

The WRSI is calculated on a 10 day basis. As input 3 data sources are required, yearly dekadal precipitation, yearly dekadal Reference Evapotranspiration (METREF) and yearly dekadal Actual Evapotranspiration (DMET). From the LSA SAF archive the daily METREF and DMET products can be obtained (https://landsaf.ipma.pt/en/ >> Get Data). The daily rainfall used is from CHIRPS: ftp://chg-ftpout.geog.ucsb.edu/pub/org/chg/products/CHIRPS-2.0/africa_daily/tifs/p05, and select the appropriate year.

The data is freely available at daily temporal resolution but should be downloaded by yourself, the LSA SAF requires registration. Once the data is locally available (as daily zipped files), to facilitate efficient data pre-processing a looping routine is available to process a full year of daily products from CHIRPS, DMET and METREF. The daily data have to be aggregated to dekadal time steps using the statistical aggregation function 'SUM' available within ILWIS.

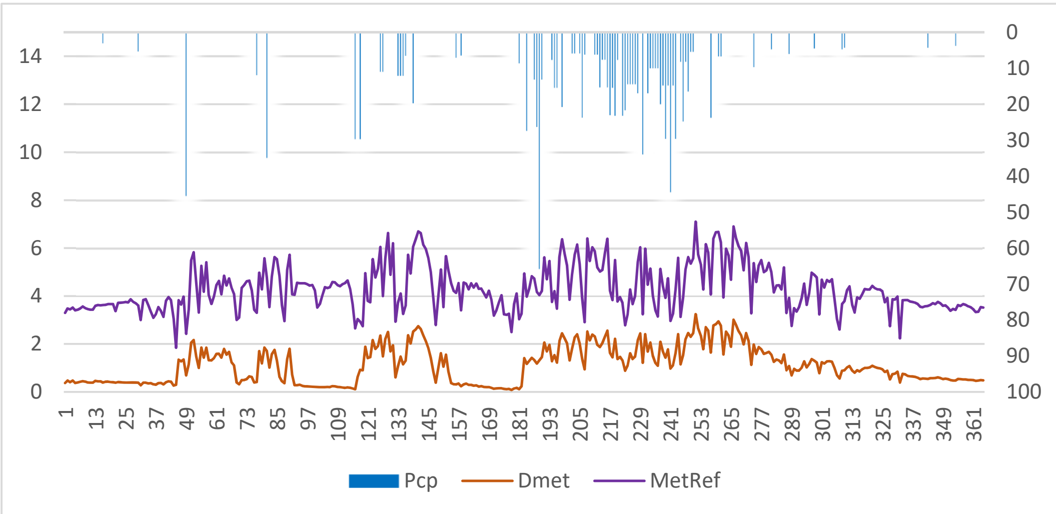
Further documentation on the products can be obtained from the LSA SAF website indicated above and for CHRIPS from the Climate Hazards Group (http://chg.geog.ucsb.edu/data/chirps/).

Figure 3.32: WRSI calculation methodology



Once all 3 time series layers (pcp, dmet and metref) are imported in Iilwis and 3 map lists are created, using map list graph for a single pixel the data from the 3 layers can be copied (clipboard copy) to Excel for further data quality control, see also the figure below.

Figure 3.33: Representative pixel located at highlands Ethiopia, year 2017



It should be noted that the DMET product has areas with missing observations, these need to be corrected, here use is made of a majority undefined filter. This initial procedure applied might need to be further refined. Once the input data is ready a number of scripts can be applied to derive the WRSI and the Moisture Index. The following steps are performed, see also figure 3.32:

1. Calculate Start or Onset of Season (SoS):
   Input is dekade based rainfall, time series required for the full year (36 maps). As antecedent rainfall for 3 dekades is used, the output time series maps created are from 021 to 123 (33 maps). Rainfall thresholds applied are provided by NMA. The output are 3 SoS map series, using different thresholds and maps created and are having as prefix: SOS_Max, SOS_Med and SOS_Min.

2. Calculate Kc:
   Kc is distributed in time according to the SoS time series selected. Kc values are used for teff, wheat and barley, Kc values have been taken from NMA. Kc maps start calculations from 021 to 123 (33 maps).

3. Calculate ETo or Water Requirement (WR), defined as: METREF * Kc (per time step).

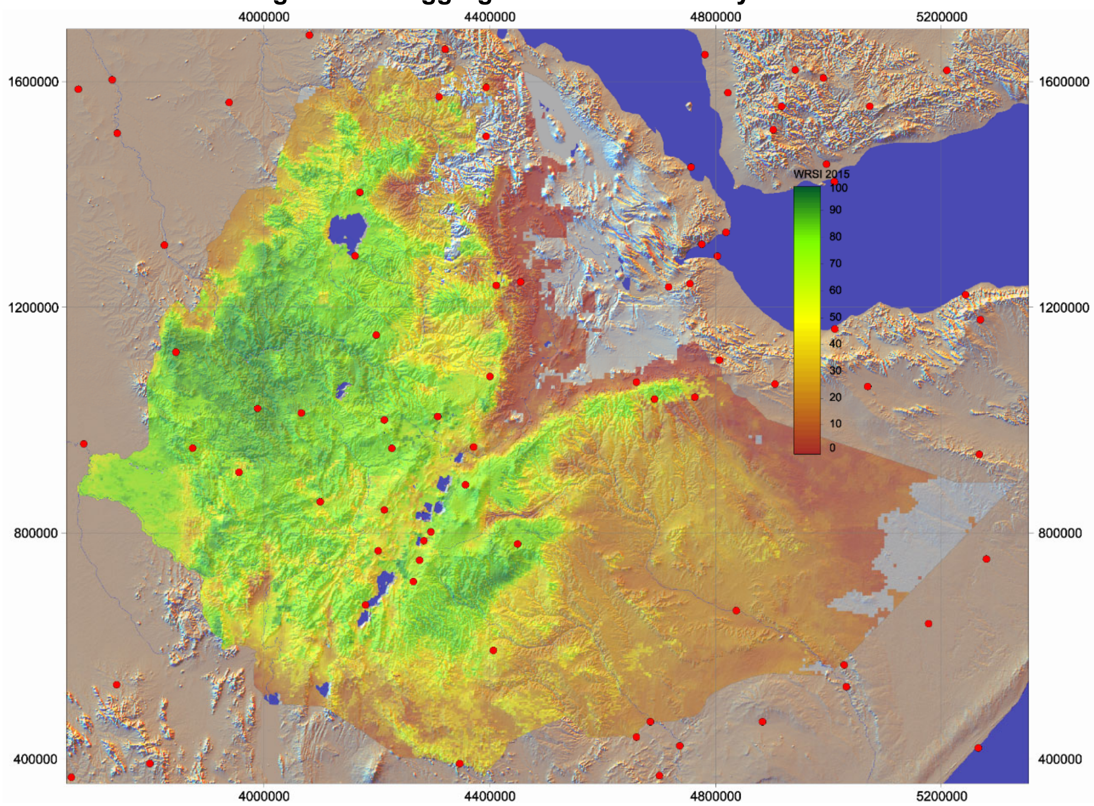
4. Calculate WRSI, defined as (DMET/WR)*100 (per time step). The average of all time steps over the year (when Kc > 0.0) can be computed as well.

5. Calculate the Moisture Index (MI), defined as (PCP/METREF).

6. Calculate Woreda based statistics, like calculation of the average WRSI per Woreda.

Resulting aggregated WRSI calculated for teff, wheat and barley for the 2015 season is shown in the figure below. It should be noted that no crop mask has been applied! Per time step the WRSI is available and can be animated.

Figure 3.34: Aggregated WRSI over the year 2015



3.2.17 ***Hydro-Meteo Routines***

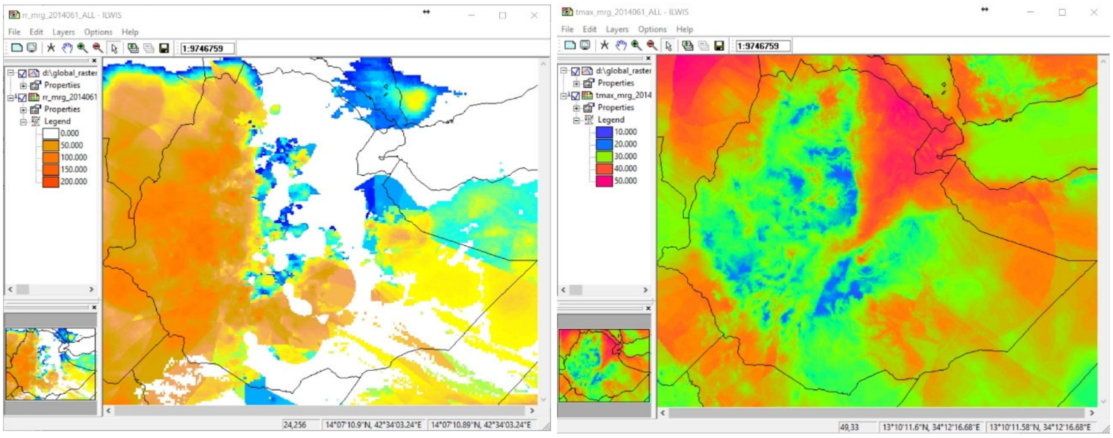
Before starting to create the Hydro-Meteo products verify the settings of the working directory. In order to do so, select from the main menu the option "*Configuration*" and "*Folder*" and select "*HydroMet*". Note that the ENACT data required is available upon request from NMA, so in order to perform these routines the data has to be locally available. As input string a "yyyymmdek" timestamp is expected as "2018101".

The other Hydro-Meteo routines expect monthly data on (mean) mean monthly temperature and precipitation. As input the ENACT products can be used, but also the routines described under the "Online Resources" below, can be applied first to retrieve the required monthly time series data. All routines expect a yearly time series with monthly time steps. The script routines can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\toolbox_startscript\HydroMet and the scripts are transferred to the working directory when the routines are executed, so the user can review the calculation procedures implemented.

3.2.17.1 ENACTS Products

At NMA dekadal data on temperature and precipitation are generated serve decision makers in climate sensitive sectors, particularly agriculture, water, and public health. These are merged products, using in-situ observations together with various satellite derived products. (see also: http://www.climate-services.org/wp-content/uploads/2015/09/ENACTS_Case_Study.pdf). Upon the request from NMA import routines of the 10 day precipitation, maximum and minimum temperatures have been added to the toolbox. The initial products are in NetCDF format and are not resampled to the have a spatial resolution (in decimal degree) of 2.25 degree. Units are in mm and degree Celsius respectively. The figure below provides a sample of the first dekade of June 2014 of precipitation and maximum temperature.

Figure 3.35: ENACTS dekadal precipitation (left) and maximum temperature (right)



3.2.17.2 Various precipitation versus temperature indices

In order to quantify the degree of exposure to aridity in Ethiopia a number of aridity indices and a rainfall distribution / concentration index have been integrated. These indices are all based on monthly mean temperature and monthly total precipitation. For an overview see http://indico.ictp.it/event/a06222/material/4/2.pdf and https://pdfs.semanticscholar.org/cd50/d8f1e43abbaf9a1dc867107ef90fc9d3e79a.pdf . The following indices are implemented:

- Aridity Index according to De Martonne
- Precipitation-Effectiveness Index or UNEP aridity index (P/ETP)

- Gaussen-Bagnouls classification

The 'De Martonne' Aridity index ($Index_{DM}$) defines aridity as the ratio of precipitation to mean temperature according to the equation below:

$$Index_{DM} = \frac{P}{t + 10}$$

Where:

P = annual average precipitation (mm)
t = annual average temperature in degree Celsius

The Precipitation Effectiveness Index, or UNEP Aridity Index is using the monthly mean temperature (℃) to empirically derive the potential evapotranspiration (ETo). The following formulas are applied:

$$ETo = 16 \times Nm\,((10 \times Tm)/\,I)^{a}$$

Where:

Tm = mean monthly temperature (for month 1, 2, …, 12)
Nm = adjustment factor related to hours of daylight (for month 1, 2, …, 12)
a = 0.49 + (0.0179 * I) - (0.0000771 * I^2) + (0.000000675 * I^3)
Heat Index or I =

$$I = \sum_{1}^{12} (Tm/5)^{1.514}$$

During the final step the monthly rainfall (in mm) rainfall is divided by the ETo, subsequently multiplied by 100. The index obtained is classified according to the following thresholds:

< than 16	= Dry
16 – 31	= Semi-dry
32 – 63	= Sub-humid
64 – 128	= Humid
> than 128	= Wet

The Gaussen-Bagnouls classification method compares the average monthly temperature and the total rainfall for the month according to the following thresholds:

P > 3T	= Humid
3T > P > 2T	= Semi-humid
P < 2T	= Arid

Also a precipitation concentration index is available to evaluate the rainfall distribution and rain concentration, according to the method described by Michiels, Gabriels and Hartmann (1992) (https://www.sciencedirect.com/science/article/pii/0341816292900165). The higher the PCI, the more irregular and greater the precipitation variability. To estimate this variability the input required is the monthly precipitation for a given year in mm/month. A yearly monthly precipitation map list is required to execute the calculations. The index applied firstly determines the coefficient of variation (CV):

$$CV = 100 \times \frac{s}{\overline{Pi}}$$

Where:

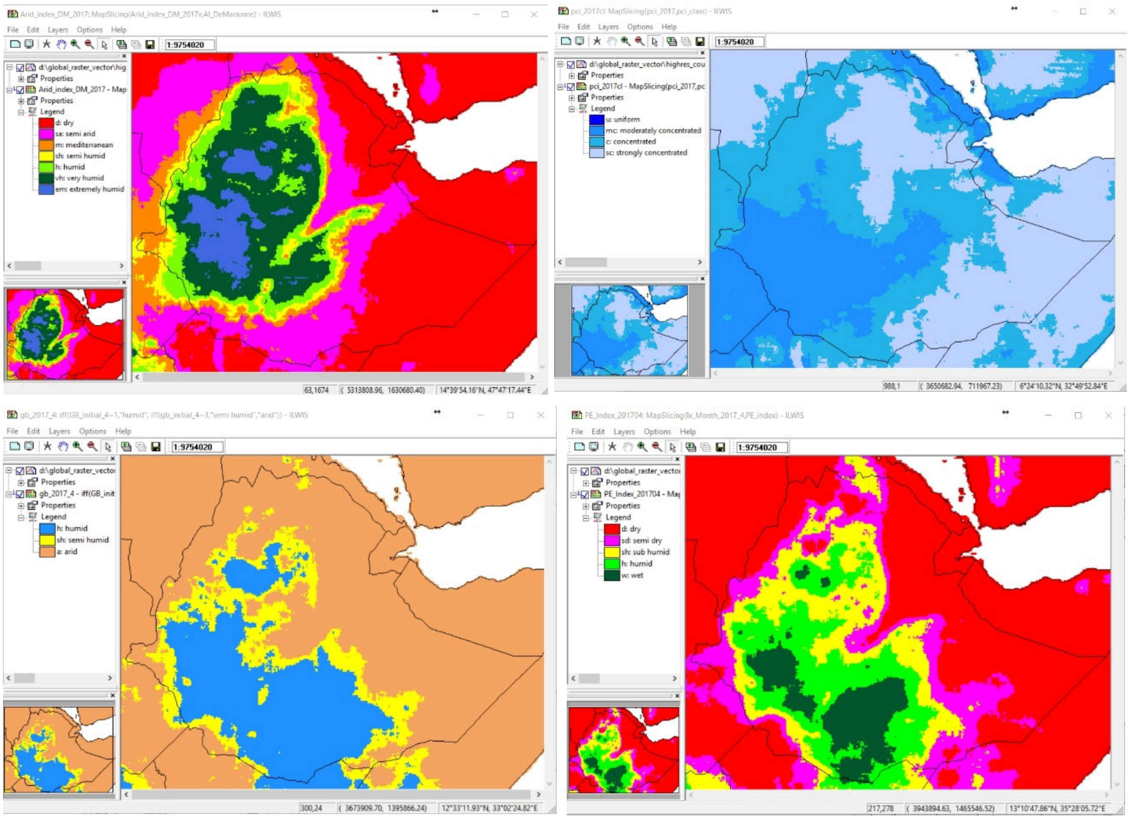
$\overline{Pi}$ = the arithmetic mean of the monthly rainfall per year
s = standard deviation of the data set sampled from the population

Subsequently the Precipitation Concentration Index (PCI) is related to the coefficient of variation (CV) using the following equation:

$$PCI = \frac{100}{12} \times \left[1 + \left(\frac{CV}{100}\right)^2\right]$$

In the figure below results are provided for the various indices based on the CAMS monthly air temperature products that are available from the IRI/LDEO Climate Data Library (https://iridl.ldeo.columbia.edu/) and the aggregated monthly precipitation data (from daily time steps) from CHIRPS (http://chg.geog.ucsb.edu/data/chirps/).

Figure 3.36: Aridity indices for (April) 2017



From top left to bottom right: The De Martonne Index for 2017, the PCI for 2017, the Aridity Index classification according to the Gaussen-Bagnouls classification method for April 2017 and the Precipitation-Effectiveness Index or UNEP aridity index for April 2017.

3.2.18 ***Bio-Meteo Routines***

Before starting to create the Bio-Metric products verify the settings of the working directory. In order to do so, select from the main menu the option “Configuration” and “Folder” and select “BioMet”. Note that the GFS based forecasting data required is available from the ITC FTP, so in order to perform these routines the system has to be online. As input string a “yyyymmdd” timestamp is expected

The Bio-Meteo products, on Malaria habitat suitability and Temperature-Humidity can be retrieved from the main WFS-Ethiopia Toolbox menu, using the options “*Bio_Meteo Routines*”. The script routines can be found under the ILWIS directory \Extensions\WFS_E-Toolbox\ toolbox_startscript\BioMet and the scripts are transferred to the working directory when the routines are executed, so the user can review the calculation procedures implemented.

3.2.18.1 Mosquito comfortable anticipated conditions suitability mapping

Some of the most dangerous infections are sensitive to climatological conditions. Temperature, precipitation and humidity are known to strongly influence the reproduction, survival and biting rates of mosquitoes, which in turn can transmit deceases like malaria and dengue. Malaria in Ethiopia is endemic to almost the whole country and therefore having a monitoring system in place the assist in predicting the suitable environmental conditions to inform the public and other stakeholders is a must.

In order to derive the locations having suitable conditions, also called the comfortable anticipated conditions for infectious agents, the following method has been developed:

- Based on the forecasts produced by the Global Forecasting Model, the 10 day 6 hourly forecasts are processed and daily forecasts are produced (using automated processing routines at ITC) for:
    - Temperature, both Minimum and Maximum Temperatures (℃)
    - Rainfall (mm)
    - Humidity (%)

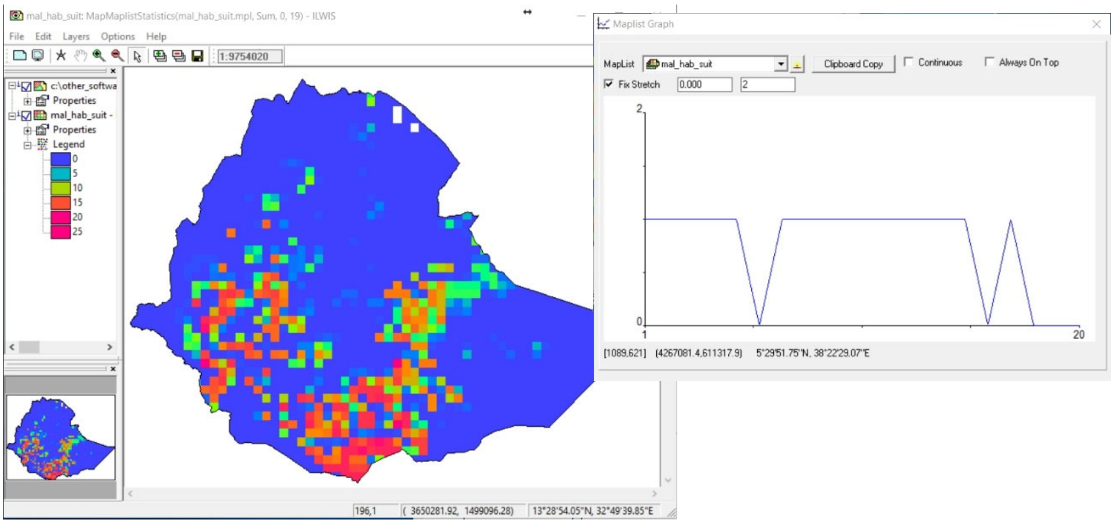
In order to obtain a Dynamic Mosquito Monitoring and Forecasting System the following calculations are performed based on 10 day weather conditions derived from the GFS Forecast:

- Rainfall: threshold used is more than 30 mm over the 10 day forecasting period
- Minimum and Maximum Temperature: thresholds defined are mean temperature over the 10 day period between 18 to 32 degree Celsius respectively
- Relative Humidity: average humidity over the 10 day period should be equal or greater than 60 %

In order to derive the final comfortable anticipated conditions suitability map each of the 3 conditions have to be fulfilled and the final map is resampled to the Ethiopian Projection used. The areas meeting the 3 criteria receive a value of 1 and those not meeting (one of) the 3 criteria are classified as 0.

Each day a comfortable anticipated conditions suitability map can be produced and by adding the maps, for each pixel in the map the period for which all conditions are favorable will show the highest map values. In the figure below the previous 20 days are processed, together with the last day of the GFS forecasting data. This map shows (values from 0 to 20) which areas are having previous and next 10 day suitable conditions for the malaria mosquito to reproduce and survive. The actual conditions over time can be evaluated looking at the MapList Graph, here suitable events are indicated by the value of 1 and when one of the above indicated thresholds are not fulfilled a value of 0 is returned in the graph, on a daily basis.

Figure 3.37: Mosquito comfortable anticipated conditions suitability map



3.2.18.2 Temperature Humidity Index Forecast

This index expresses the comfortability of (dairy) livestock by thermal stress of weather based on a combination of temperature and humidity. The *THI* is a useful and easy way to assess and predict the risk of heat stress. The standard *THI* value for dairy livestock is calculated as follows:

$THI = 1.8Ta - (1 - (RH/100))\,(Ta - 14.3) + 32$ (source: NMA-Addis Ababa, Ethiopia)

Where:

RH = Relative Humidity (in percentage)

Ta = Ambient Temperature (℃)

The results of the equation above are in accordance to those provided by the Veterinary Handbook, chapter 14.1 (http://www.veterinaryhandbook.com.au). Similar index thresholds are provided by the Washington State University (Livestock Heat Stress: Recognition, Response, and Prevention Extension Fact Sheet - FS157E, http://cru.cahe.wsu.edu/CEPublications/FS157E/FS157E.pdf). Their *THI* classification, as given in the table below, is used.

Table 3.5: Degree of heat stress with corresponding Temperature Humidity Index value for dairy cattle and non-dairy cattle livestock

Degree of heat stress	THI, non-dairy cattle livestock	THI, dairy livestock
No significant heat stress	≤69	≤67
Stress threshold; monitor livestock and be alert for problems	70–74	68–71
Mild—signs of heat stress widely evident but most animals coping	75–78	72–79
Moderate—danger zone; some animals will be significantly affected	79–83	80–89
Severe—emergency situation; most animals severely heat stressed and struggling	84–90	90–98
Extreme—fatalities expected	≥91	≥99

For this index, the GFS forecast is being used for the next 24 hour forecast only, the forecast is issued at 00:00 UTC. For the day under consideration the average temperature is calculated. Then the formula as provided above is being applied to derive the current day THI. The map is resampled to the Ethiopia projection and is classified using the thresholds provided above.

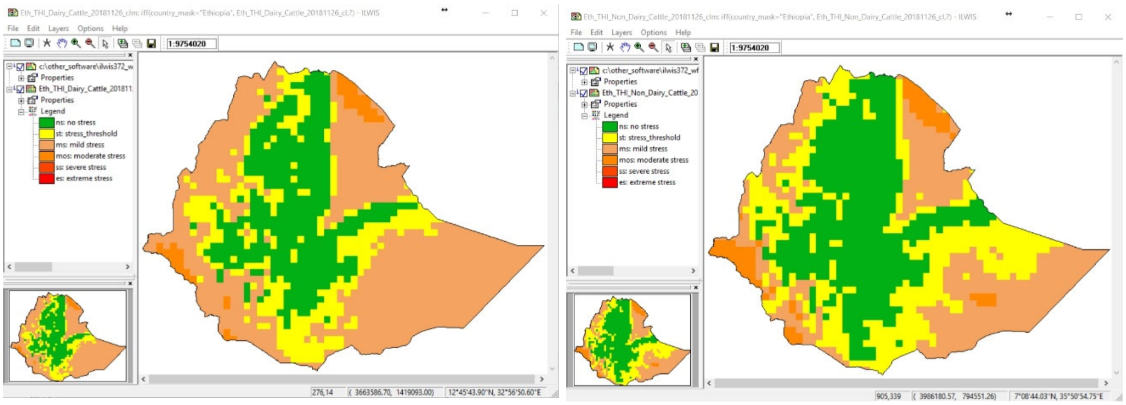
Although the formula provided by NMA is slightly different from the one provided in the Veterinary Handbook (THI is: 0.8*T + RH*(T-14.4) + 46.4), results are almost identical.

The THI thresholds for Humans used are derived from Abdel Galeil A Hassan and Kassem Kh. O, https://dx.doi.org/10.22161/ijaers/3.11.38. THI threshold values used are provided in the table below.

Table 3.6: Temperature Humidity values applicable to Humans

THI value	Human feeling
> 80	100% are not comfortable
75 – 80	50% are not comfortable due to hot and humid weather
65 – 75	100%are quite comfortable
60 – 65	50% are partially comfortable
< 60	Almost 100% are comfortable due to cold and dry weather

Figure 3.38: Temperature-Humidity Index for Dairy (left) and non-Dairy Livestock 20181126



3.2.19 *Online Resources*

A number of online resources useful for climatological analysis / seasonal forecasts are included as well. Important parameters used within this type of analysis are long term historical time series, like monthly air and sea surface temperatures and precipitation. To evaluate the state of the climate in Africa, ACMAD (http://www.acmad.net/new) is using amongst others long term monthly time series prepared by the International Research Institute for Climate and Society, Earth Institute, Colombia University (https://iri.columbia.edu/). A number of time series products like air temperature and precipitation can be retrieved from their data portal. Routines are prepared for automatic retrieval and import into ILWIS. More information is provided at http://iridl.ldeo.columbia.edu/maproom/Global/.

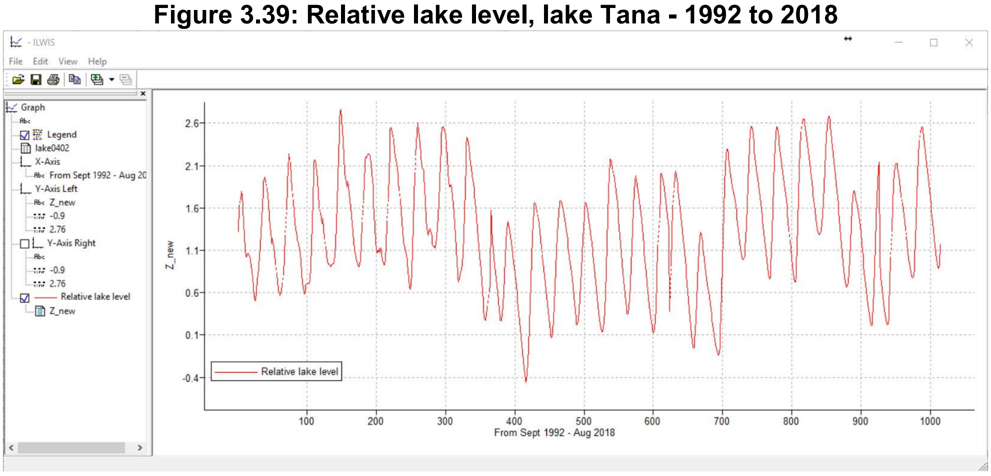
Also use is made of the CPC Merged Analysis of Precipitation (CMAP) data. Also long term monthly precipitation data, starting from January 1979, can be downloaded and imported. For further information see also the description provided in ‘cmap_mon_v1807.doc’, available at ftp://ftp.cpc.ncep.noaa.gov/precip/cmap/ monthly/.

A number of long term monthly sea surface temperatures for the globe do exist, used to derive the progress of various oscillations (like the ENSO or the Indian Ocean Dipole) and associated teleconnections. The first source is the Reynolds and Smith optimum interpolation (OI) sea surface temperature (SST) analysis sea surface temperature dataset, see http://iridl.ldeo.columbia.edu/maproom/Global/Ocean_Temp/Monthly_Temp.html. Next to this the Extended Reconstructed Sea Surface Temperature (ERSST) dataset can be retrieved. This is a global monthly sea surface temperature analysis derived from the International Comprehensive Ocean–Atmosphere Dataset with missing data filled in by statistical methods. This monthly analysis begins in January 1854 (see also https://www.ncdc.noaa.gov/data-access/marineocean-data/extended-reconstructed-sea-surface-temperature-ersst-v5).

Last but not least altimetry observations over lakes can be retrieved, see https://www.pecad.fas.usda.gov/cropexplorer/global_reservoir/, which is especially relevant to see if the region is affected by hydrological drought. Relative lake height variations are computed from TOPEX/POSEIDON (T/P) and the Jason series of altimeters. Data for Ethiopia is provided for Lake Ziway; Jason-2/Jason-3 July 2008-present (lake0349), Lake Tana; Topex/Poseidon/ Jason-1/Jason-2/Jason-3 Sept 1992-present (lake0402) and Lake Turkana Kenya Reservoir; Topex/Poseidon/Jason-1/Jason-2/Jason-3 Sept 1992-present (lake0093)

The figure below shows the fluctuations over time for Lake Tana, filtered lake height variation with respect to Jason-2 reference pass level (unit is meters, no observations for visualization purposes are represented by dashed line.

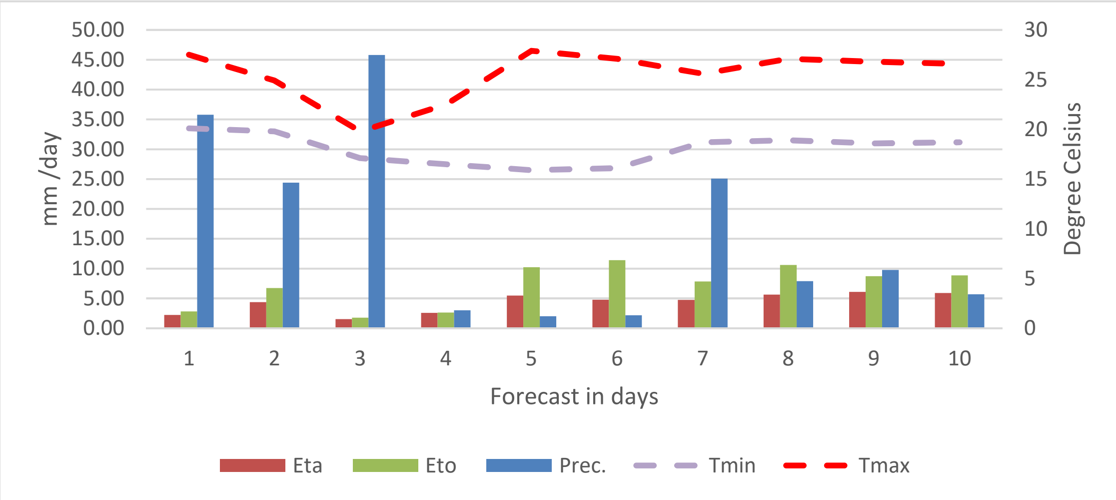
Figure 3.39: Relative lake level, lake Tana - 1992 to 2018



To assist the agro-meteorological section of the meteorological agency procedures have been developed utilizing the GFS-10 day forecasts. Routines have been developed to link the precipitation forecast to the GIACIS area - insurance codes. Within GIACIS all areas in Ethiopia, above 700 meters have received a unique identifier. The precipitation forecast is linked to this identifier, so the next 10 day rainfall forecast can be provided to the farmer having taken an insurance policy and is having his farming area within a given uniquely coded area.

In a more general sense, an additional routine extracts next to the 10 day forecasted precipitation also the minimum and maximum temperatures, the actual and potential evapotranspiration. The GFS forecasts are pre-processed at ITC, given the large volume of data involved. Automatic routines download the respective GFS GRIB files and transform the selected layers into an Ilwis format. Subsequently the data is aggregated to have a daily temporal resolution. Once this is done the data is zipped and transferred to FTP. The routines automatically download the data from this ftp location and import these and the various map lists, containing the daily data can be visualized as an animation. An example of the 10 day GFS combined agrometeorological forecast is given below over a pixel selected and providing the forecasts for the various parameters.

Figure 3.40: GFS-10 forecast, issued 20180206 at 00:00Z



The data is provided as zip files on a daily basis at ftp://ftp.itc.nl/pub/mpe/ within the sub-directories “gfs” and “gfs_5p”.

The routines are available from the main WFS-Ethiopia toolbox menu under “Online Resources” >> “GFS 10-day Forecast”.

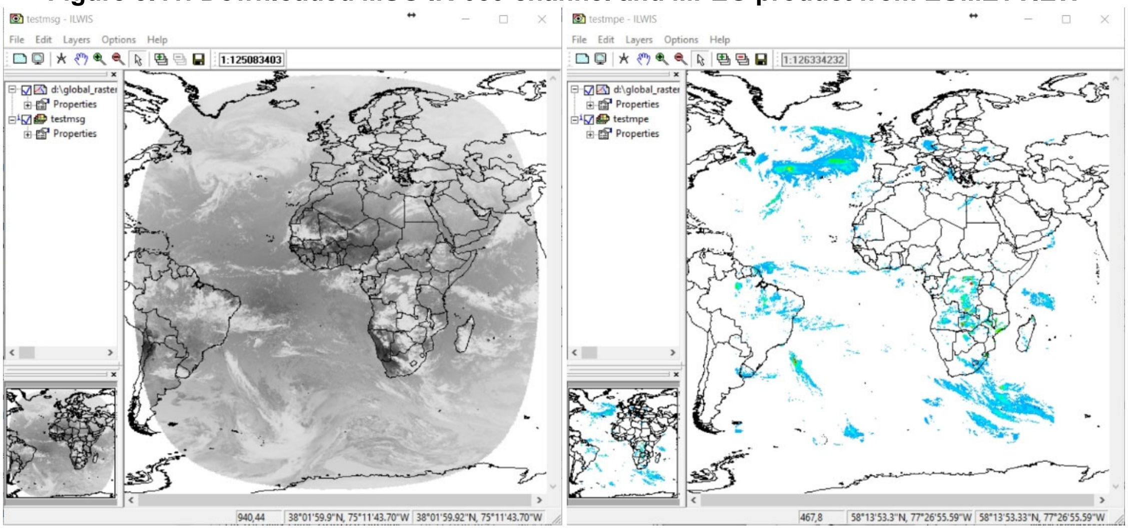
3.2.20 ***Other routines***

3.2.20.1 EUMETVIEW

EUMETView is a visualisation service that allows users to view EUMETSAT imagery in a more interactive way through an online map viewer or Web Map Service (WMS). From the “WFS-E” and “Toolbox” main menu select the option “Other Routines” >> “EUMETVIEW” and “Latest EUMETSAT Images-Products” sub menu items. Press “Import” and a Web Browser is opened at the following address https://eumetview.eumetsat.int/mapviewer/. Images from MSG at 0 and 41.5 degree and associated products can be visualized. Products can also be downloaded.

When downloading, select the options “GEOTiff” and “Full Resolution”. The routine “Import downloaded Images - Products” can be used to visualize the data in ILWIS. Subsequently in ILWIS display the downloaded product or image by selecting the map list created and assign the RGB colours to the appropriate bands. An example of the IR-039 channel and the MPEG product is provided in the figure below. If the EUMETCast reception station can’t be operated, this is a good resource to continue providing services.

Figure 3.41: Downloaded MSG IR-039 channel and MPEG product from EUMETVIEW



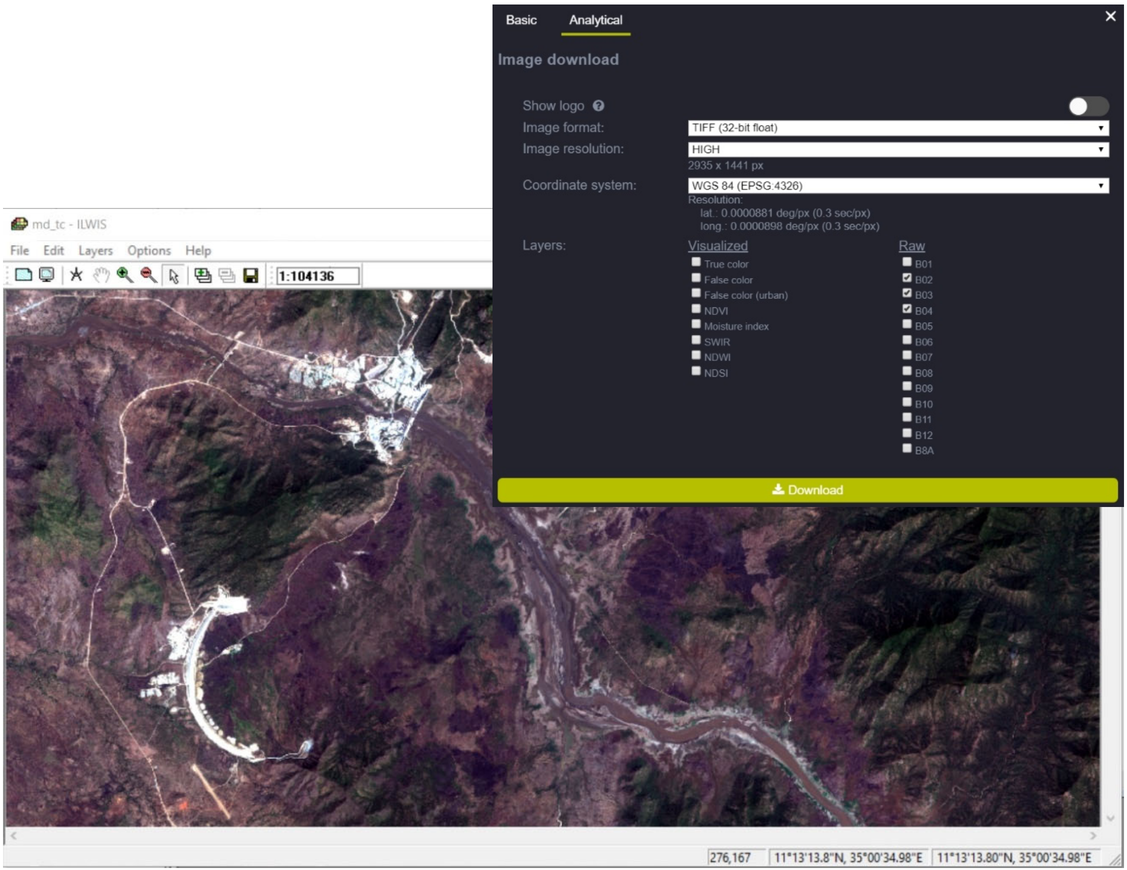
3.2.20.2 Sentinel EO-Browser

The EO-Browser is a recent developed utility to view using a web browser data from Sentinel (1, 2, 3 and 5P) as well as Landsat. The portal is continuously updated and various selection criteria can be applied, like time range and cloud coverage. From the “WFS-E” and “Toolbox” main menu select the option “Other Routines” >> “Sentinel EO Browser” and “Sentinel, Landsat, etc. Images-Products” sub menu items. Press “”Import and a Web Browser is opened at the following address https://apps.sentinel-hub.com/eo-browser/.

Once the browser is opened, first navigate to your area of interest. To make full use of the utility a free registration is required. After the selected image is visualized the view can be exported. The import routine of the downloaded data “Import downloaded Images-Products” can be used to visualize the data in ILWIS.

The preferred settings to download a true colour image are given in the figure below as well as a recent Sentinel 2 level 1C image (2018-11-21) over the Millennium dam under construction in the Blue Nile, western part of Ethiopia using geographic coordinates.

Figure 3.42: Sentinel data download settings and downloaded Sentinel 2 L1C True Colour image over the Millennium Dam



3.2.20.3 *Display Julian Day Tables*

As a number of products contained in the EUMETCast-GEONETCast data stream use the Julian Day convention two tables, one for a normal and one for a leap year, can be retrieved under this menu option. Select the appropriate “Show Julian Day table” option, press “Import” and the conversion table from Julian to Calendar day is given. This table can be closed and the operation is stopped.

3.2.20.4 *Generic NetCDF-GRIB-HDF data visualization*

Panoply (source: https://www.giss.nasa.gov/tools/panoply/) plots geo-referenced and other arrays from netCDF, HDF, GRIB, and other datasets. Panoply allows, without further import into ILWIS, quick visualization of:

- Slice and plot geo-referenced latitude-longitude, latitude-vertical, longitude-vertical, time-latitude or time-vertical arrays from larger multidimensional variables;
- Slice and plot "generic" 2D arrays from larger multidimensional variables;
- Slice 1D arrays from larger multidimensional variables and create line plots;
- Combine two geo-referenced arrays in one plot by differencing, summing or averaging;

- Plot lon-lat data on a global or regional map using any of over 100 map projections or make a zonal average line plot;
- Overlay continent outlines or masks on lon-lat map plots;
- Use any of numerous color tables for the scale colour bar;
- Save plots to disk GIF, JPEG, PNG or TIFF bitmap images or as PDF or PostScript graphics files;
- Export lon-lat map plots in KMZ format;
- Export animations as MP4 video or as a collection of individual frame images.

From the toolbox menu, select the option “Other Routines” >> “Generic NetCDF-GRIB-HDF data visualization” >> “Start Panoply”. It should be noted that the routine requires Java, the batch file starting Panoply can be found under “Extensions\WFS_E-Toolbox\toolbox_batchroutines” and is called “panoply_start.bat”.

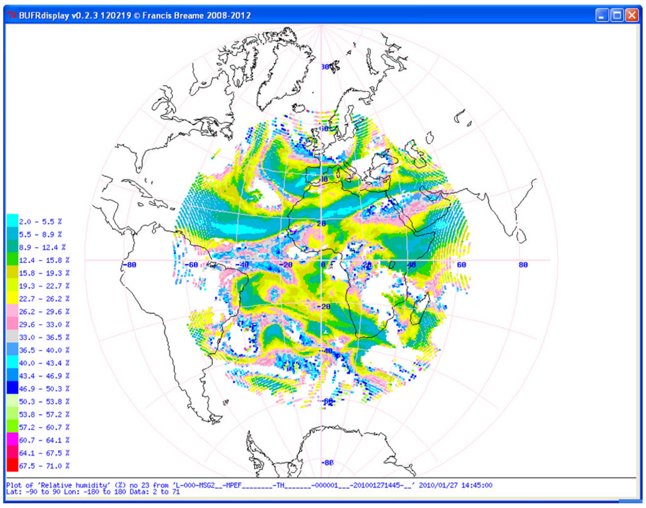
3.2.20.5 Generic BUFR data visualization

To visualize the various BUFR formatted products that are available in the EUMETCast-GEONETCast data stream you need to install the BUFRdisplay utility. See for installation instructions also chapter 1.1.6. From the main WFS-Ethiopia Toolbox menu, using the options “Configuration” and “Folders”, select “Bufrdisplay”. Browse to the appropriate data output directory and press “Save” to store the settings. Note that Bufrdisplay is storing some temporary program files in the output directory, so ensure that you have the proper administration rights.

From the “WFS-E” and “Toolbox” main menu select the option “Other Routines” >> “Generic BUFR data Visualization” and “Show BUFR data using BUFRdisplay” sub menu items and if the output directory is properly assigned, press “Import”. In the Command Line Interpreter (CMD.exe) window, acknowledge the copyright of Francis Breame by pressing <enter> and the BUFRdisplay utility is opened. From the BUFRdisplay window select “File” and “Open”, navigate to the input data folder and select the appropriate file and press “Open”. Under the “Data Selection” window the required attributes need to be specified, like latitude, longitude and the data field. Once this is done activate the option “Input/decode data” and subsequently “Generate map”.

An example of a map showing the Tropospheric Humidity, in a stereographic projection is given in figure 3.43. Note that this utility is only used for visualization of (multiple) BUFR encoded products. Other routines within the toolbox can be used to convert the selected files into ILWIS data format.

Figure 3.43: Display of BUFR encoded data using BUFRDisplay



3.2.20.6 Generic LSA-SAF processing

The MSGToolbox user guide provides a comprehensive description of the functionality. From the main WFS-Ethiopia Toolbox menu, using the options “Configuration” and “Folders”, select “MSGToolbox”. Browse to the appropriate data output directory and press “Save” to store the settings. Note that the MSGToolbox is retrieving and storing the data according to those specified within the utility, it is advised that the output directory is identical to the WFS-Ethiopia toolbox output directory specified.

From the “WFS-E” and “Toolbox” main menu select the option “Other Routines” >> “Generic LSA SAF processing” and “Installation and User Manual” sub menu items to retrieve the manual, or “Import using MSG Toolbox” and if the output directory is properly assigned, pressing “Import”.

3.2.20.7 Generic GeoTif import

To conveniently import some of the data in Geotif format this routine allows you to quickly transform the data format from TIF into ILWIS.

3.2.20.8 View Animated GIF

GIF Viewer is a lightweight Windows application used to open and view (interactively) the contents stored within GIF files. The application has a simple layout and offers only a few configuration settings, e.g. like selection of the file to be viewed.

As soon as you run the program, you are required to select the GIF file to be opened. The utility lets you add items. GIF Viewer gives you the possibility to choose the quality (low or high), make file associations, and switch to a full screen mode for a better focus on a selected portion of the image or animation.

Furthermore the application is able to open both animated and non-animated GIF files, and lets you play or stop the current files, seek for a position in the video frame, as well view the frame rate displayed in the primary panel.

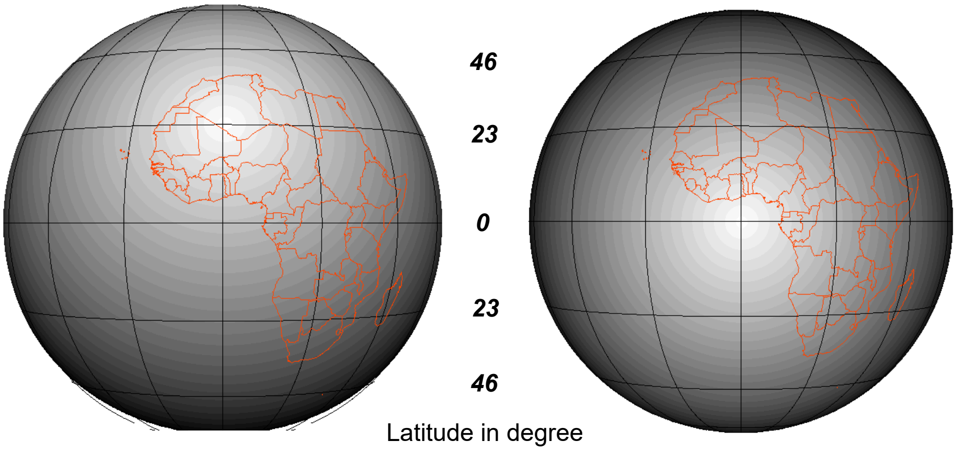
3.2.20.9 Calculate MSG angles

For many applications corrections to the pixels have to be applied based on satellite or sun azimuth and zenith angles. A Java applet has been created which allows computation of MSG satellite and sun azimuth and zenith angles based on date and time. This routine is called by an ILWIS script that allows the user to calculate the solar and MSG satellite solar / zenith angles for a certain time for the MSG field of view using a simple user interface. Note that the minutes are expressed in decimals, e.g. 30 minutes is 0.5.

This utility is using ILWIS scripts which are situated in the ILWIS sub-directory \Extensions\WFS_E-Toolbox\toolbox_startscript\angle. For the solar zenith angles also the sun elevation is calculated and the illumination conditions, as defined using thresholds from Meteo-France. The content of the scripts can be seen using ILWIS, using the Navigator option and move to the respective sub-directory. To open a script, double click the script using the left mouse button.

Once the Year, Month, Day and Time of day (in UTC) and output directory are specified the script can be started by pressing the “Create” button.

Figure 3.44: Example of Sun (for 21 June 2006, 12.00 UTC) and MSG satellite zenith angles (for 0°N latitude and 0°E longitude, left and right hand picture respectively)



3.2.20.10 METOP AVHRR Retriever

Although AVHRR images from METOP A and B are not disseminated through the EUMETCast Africa Service, the images can be obtained from the Data Archive at EUMETSAT. A routine has been developed to import the Level 1B data, which performs the radiometric conversion to radiance, reflectance and temperature of the respective channels. Next to this the geometry is retrieved to enable visualization of the entire image, compensating for the panoramic distortions. The routine requires a recent version of ILWIS as the geometry created is not supported by ILWIS372. An example is provided in the additional exercises, see chapter 4.17.8.

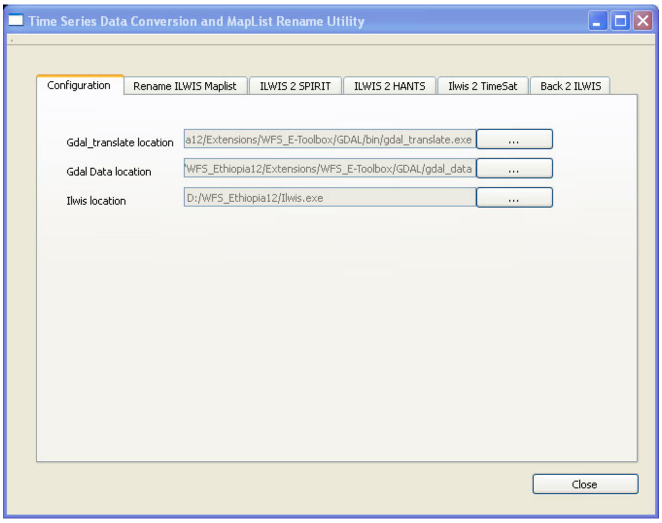
3.2.20.11 Time Series Convert Utility

It was noted over and over again that a lot of time is actually spend on preparation of time series data. Once the time series is constructed multiple freeware tools are available to allow further processing of the data. Conversion between the packages is again a tedious process and consuming a lot of time. In order to efficiently transformation the data from one application to another, and make full use of the capabilities offered by various packages, this tool has been developed. Further information is also provided in the 'Time Series Conversion Installation and User manual'.

The utility developed is based on the data translation library offered by GDAL, also available within the WFS-Ethiopia Toolbox. It facilitates renaming of a map list which has been constructed in ILWIS, by adding temporal information to the name of the layers within a time series. After completion of this process the data can be exported to other free time series data analysis tools, like HANTS, SPIRITS and TIMESAT. The output - result of the analysis in these packages can then be transformed back into an ILWIS format for ingestion into other processing or visualization routines.

From the main WFS-E Toolbox menu, using the options "Configuration" and "Folders", select "Timeseries_transform". Browse to the appropriate data output directory and press "Save" to store the settings. The application can be used as stand-alone, but when operating the WFS-E Toolbox, the following "Configuration" settings can be applied: for GDAL-translate select the ILWIS sub-directory \Extensions\WFS_E-Toolbox\GDAL\bin\ and select GDAL-translate.exe, for the link to the Data directory select \Extensions\ WFS_E -Toolbox\GDAL\gdal_data. For the link to ILWIS, select “ILWIS.exe” from your ILWIS directory. See also figure 3.45 showing the “Configuration” Tab.

Figure 3.45: Time series conversion tool configuration settings under WFS_E Toolbox



3.2.21 ***Configuration and folder settings***

For you to conveniently work with the GEONETCast toolbox the data sources (on your local area network) and the local system output (working) directories need to be defined. From the main Water and Food Security-Ethiopia Toolbox menu, select “Configuration” and the sub-menu “Folders”. Further details have already been described in chapter 2.4. It is important to note that a “Folders” item can be set in the “config.xml”, using the “folderid” option.

In general the input and output folders are set over here and are subsequently used in the various import routines to pre-set the input and output folders over there. This prevents the need to specify the folder specifications time and again! Note that external executables can be defined, using the folder “*Special locations*”.

3.3 CONCLUDING REMARKS

The description provided is showing the capabilities of the various routines that are currently implemented under the WFS-Ethiopia Toolbox config XML version 2.0.

In case products or data is disseminated for which no import routines are available in this toolbox, chapter 2 is providing the necessary background information to add additional routines yourself. When you need assistance in building these scripts and batch routines don’t hesitate to contact the corresponding author.

Chapter 4 contains a number of exercises to demonstrate the use of the data disseminated through GEONETCast. The Water and Food Security-Ethiopia Toolbox supports a number of import routines that have been selected as being most relevant. Other toolbox plug-ins can also be used if required. These can be obtained from http://52north.github.io/#. More information is also provided on the “EO” community pages at https://52north.org/research/rd-communities/earth-observation/.

Appendix 1 is providing links to other freeware utilities that can be used in conjunction with ILWIS. Having an operational ground receiving station, together with these utilities, allows you to process a multitude of environmental information, delivered near real time and free of charge. You can also register for licensed services like AVISO at the EUMETSAT Earth Observation Portal.

Note that Appendix 2 is providing a description of how the sample and exercise data should be copied to / stored on your local system. Note that the sample and exercise data can also be downloaded from: ftp://ftp.itc.nl/pub/52n/wfs_exercisedata. Appendix 3 is providing further information to configure the data source(s) for the MSG Data Retriever. Appendix 4 provides additional information on the other freeware tools that can be downloaded from the "Earth Observation" community. In Appendix 5 some links are provided to other instruction and capacity building materials which have been developed over time and can be downloaded as well.

With all these free tools, utilities, manuals and sample data available new users should be able to become acquainted with the information currently delivered through satellite based communication systems as well as freely available relevant information which can be retrieved from internet resources.

This chapter provided further details on the capabilities and functionality of the Water and Food Security-Ethiopia Toolbox. The next chapter is focussing more on the use of the data, ensure that before you continue you download or copy the sample data to your local system (see also appendix 2 for further details). It is strongly advised to copy the directories directly on your system drive, don't hide it under a complex (sub-) directory structure as you will need to inspect the sub-directories containing the various data sources on a frequent basis! Success when conducting the exercises described below.

4. EXERCISES USING DATA FROM GEONETCAST, APPLYING ILWIS AND THE WFS-ETHIOPIA TOOLBOX

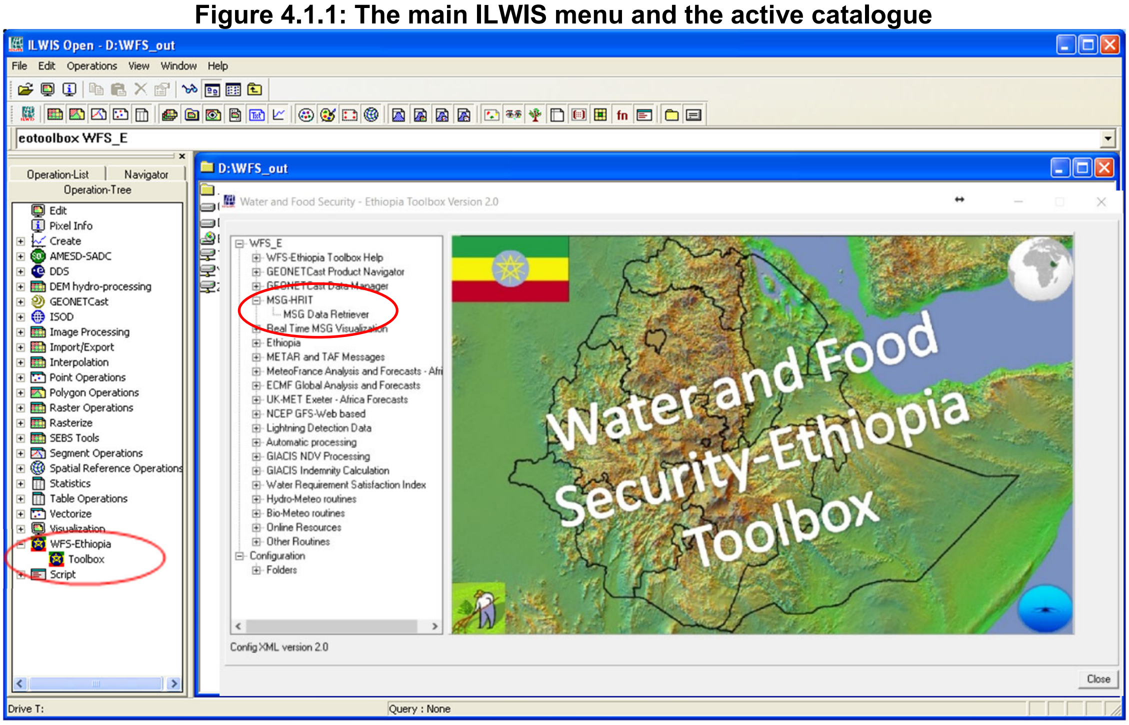
4.1 IMPORT AND VISUALIZATION MSG AT 0 AND 41.5 DEGREE

Download the sample data directory obtained from the ITC FTP site (ftp://ftp.itc.nl/ pub/52n/ wfs_exercisedata/) to your hard disk or copy them from the DVD(s). Preferably use the sub-directory structure as indicated in Appendix 2. Copy the folder "*WFS_out*" on your D:\ drive. In case you are not familiar with ILWIS and want to practice some before you continue with these exercises, download from ftp://ftp.itc.nl/pub/52n/intro_exercises the exercise descriptions and exercise data, unzip the files and conduct the exercises as instructed. Here it is assumed that you have a basic Remote Sensing and GIS background.

4.1.1 *Data import and visualization from Meteosat Second Generation (MSG).*

Open ILWIS and use the Navigator to select the working directory. See also the ellipse indicated in the figure below pointing to the main menu items that will be used during this exercise. Note that in this figure the active working directory is "*D:\WFS_out*". Some ancillary files needed during the exercises are already located in this directory. Close ILWIS and open ILWIS again. It should now open in your working directory (D:\WFS_out). Please read once more (and adhere to) the golden rules when working with ILWIS as given in chapter 1.1.1.

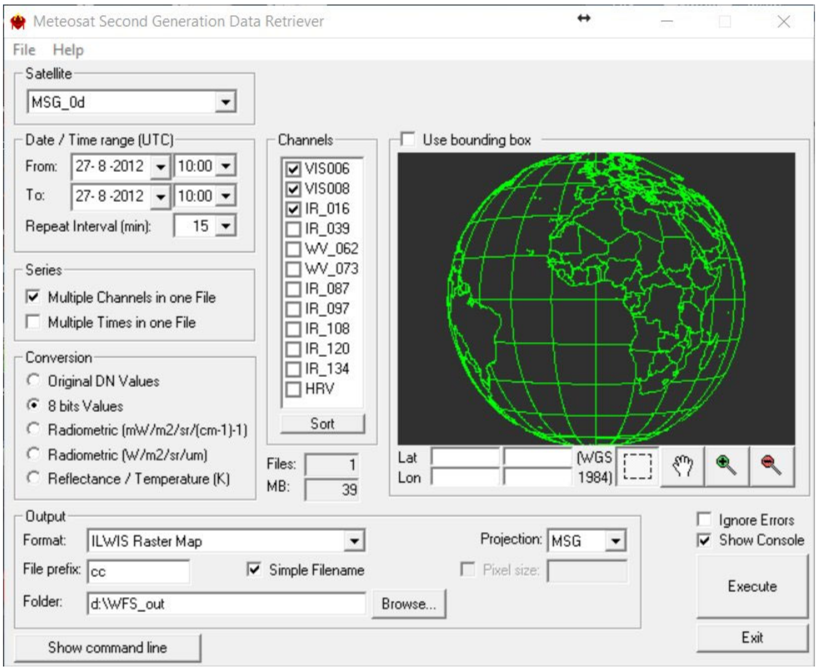
Figure 4.1.1: The main ILWIS menu and the active catalogue



In order to import data from MSG open the "*WFS-Ethiopia*" and "*Toolbox*" tabs from the main-menu and select "*MSG-HRIT*" and "*MSG Data Retriever*". The so-called MSG Data Retriever window will be activated which can be used to import the data recorded by MSG (currently MSG 8, 9, 10 and 11). Specify the settings as indicated in figure 4.1.2, to import the 10:00 UTC image.

If you did not configure the "*Data Sources*" of the MSG Data Retriever consult chapter 2.5 as well as Appendix 3.

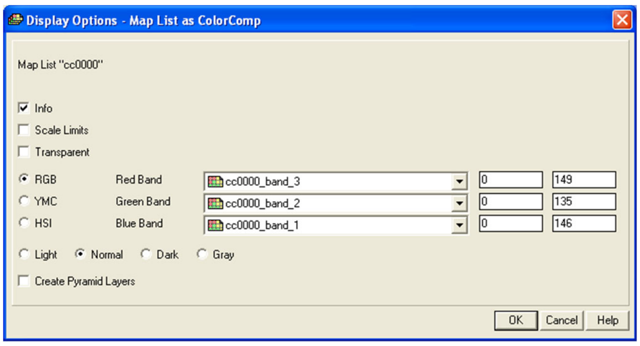
Figure 4.1.2: Selection and import of MSG channels using the Data Retriever



Note the following from these import settings: the "*Satellite*" selected is MSG_0d, which refers to Meteosat Second Generation – 11 (currently!). The "*Date / Time Range*" is 8/27/2012 and 10:00 UTC respectively. The three channels that have been selected are often used to generate a Daytime Standard Colour Scheme composite. The multiple imported channels, converted to 8 bits, are stored as "*Multiple Channels in one File*" with a "*File Prefix*" cc and the option "*Simple Filename*" is activated. As output format an ILWIS Raster Map is selected and the appropriate "*Folder*" is selected to store the output data generated. The "*Projection*" MSG allows you to look at the data from a geostationary perspective and in this case the whole disk as recorded by MSG is selected.

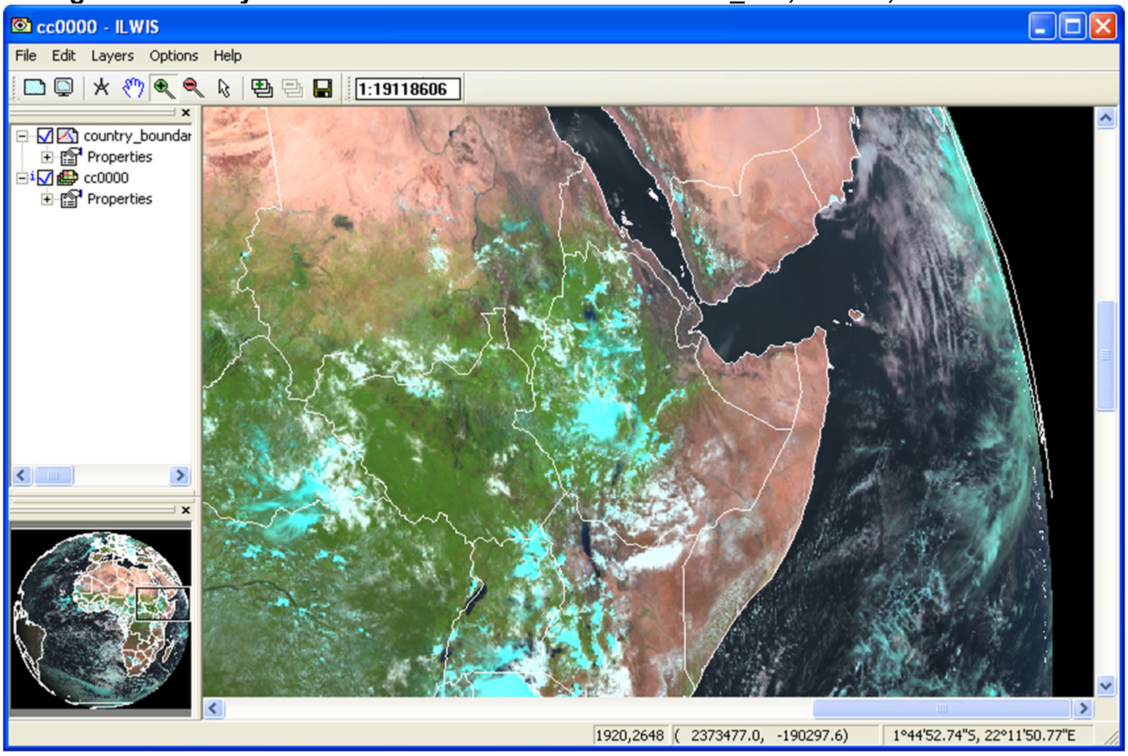
After you have specified the appropriate settings, press "*Execute*" to conduct the import. Close the WFS-Ethiopia Toolbox window, note that in the tray bar the Meteosat Second Generation Data Retriever is still active, keep it as such as you will need during the next set of exercises. Upon completion of the import, select from the ILWIS main menu, the option "*Window*" and from the drop down menu "*Refresh F5*". To display the image double click the map list icon "*cc0000*" and in the Map List "cc0000" menu select the "*Open as ColorComposite*" option . Display the bands according to the assignment in the figure 4.1.3 below.

Figure 4.1.3: Band assignment for visualization



Note that using the "*Simple Filename*" option during import band_1 now represents VIS006, band_2 is VIS008 and band_3 is the IR_016 channel (see also figure 4.1.2). The default stretch function for each of the channels can be used and press "OK" to show the image. Figure 4.1.4 is showing a portion of the MSG disk over the Horn of Africa, using a similar colour assignment, for 8/27/2012 at 10:00 UTC. Note your local time!

Figure 4.1.4: Day time standard colour scheme MSG: IR_016, VIS008, VIS006 in RGB



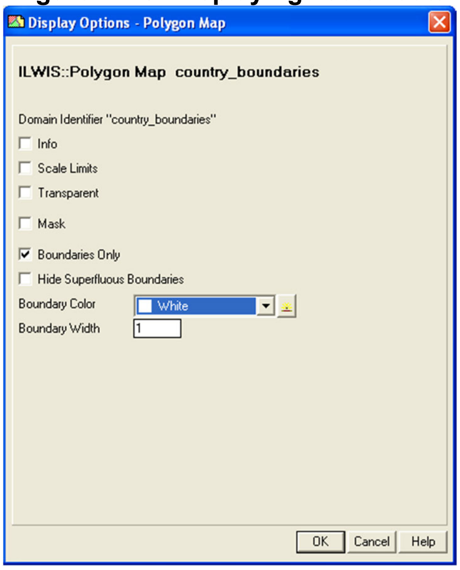
Check the features on the image, e.g. the water, (bare) land – vegetated surfaces and (various) clouds. Add to this image view also the country boundaries. In order to do so, select from the active map display window menu, the option "*Layers*", and "*Add Layer*", select an available segment or polygon map layer, e.g. "*country_boundaries*". Note that when displaying a Polygon map, set the "*info*" option off, and to display only the boundaries, activate the option "*Boundaries Only*", you can also specify the "*Boundary Color*", select a white colour. See also figure 4.1.5.

With the vector layer active you can zoom to your area of interest, check the colour composite. Activate the "*Normal*" option from the active map display window. When you move the mouse cursor over the image and simultaneously press the left mouse button you can also see the values (note the unit: 8 bits values, see also the "*Conversion*" option as of figure 4.1.2) for RGB respectively.

Close all active layers when you have finished browsing through the colour composite.

Additionally import the MSG image for the same spectral channels for 20140120 at 10:00 UTC, display the resulting colour composite in a similar manner as described above.

Figure 4.1.5: Displaying vector data



Further online information about MSG can be obtained from:

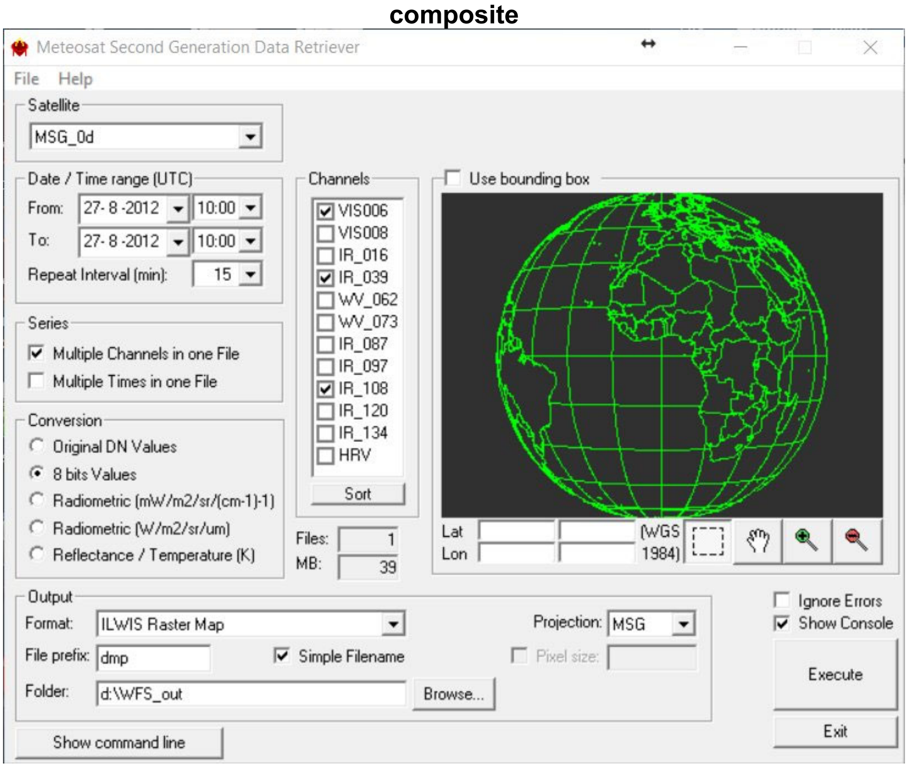
J. Schmetz, P. Pili, S Tjemkes, D. Just, J. Kerkmann, S. Rota, and A. Ratier (2002): An introduction to Meteosat Second Generation (MSG), available at:
http://journals.ametsoc.org/doi/pdf/10.1175/1520-0477%282002%29083%3C0977%3AAITMSG%3E2.3.CO%3B2

J. Schmid: The SEVIRI Instrument, available at:
http://www.eumetsat.int/groups/ops/documents/document/pdf_ten_msg_seviri_instrument.pdf

4.1.2 ***Construct a Daytime Microphysical (DMP) Colour Scheme composite***

Activate once more the “*Meteosat Second Generation Data Retriever*”. Now specify for the “*Date / Time range UTC*” the same date as used for the previous exercise (20120827 at 10:00 UTC). The other settings are indicated in figure 4.1.6.

Figure 4.1.6: Import settings to construct Daytime Microphysical Colour Scheme composite



Upon completion of the import, select from the ILWIS main menu, the option “*Window*” and from the drop down menu “*Refresh F5*”. To display the new map list created, double click the map list called “*dmp0000*”, display band 1 (VIS006) as Red, band 2 (IR_039) as Green and Band 3 (IR_108) as Blue, use the default stretch options. Also display the country boundaries (info off and boundaries only) and zoom in as well. Figure 4.1.7 is showing this visualization (for the 10:00 UTC – part of MGS disk) of this MSG channel combination.

Note that this band combination can be used to determine in a qualitative manner some of the cloud properties. The VIS006 can be used to derive information about the optical thickness and the amount of cloud water and ice of the clouds, IR_039 can be used to get an idea of the particle size and the phase of the clouds (e.g. consisting of water vapour, small ice, large ice) and the IR_108 channel records the cloud top temperature.

Table 4.1 is showing the daytime convective development stages (I to IV) of clouds and the associated colouration that can be observed on a colour composite. When using this colour scheme for the respective MSG channels, note that an increasing Red colour contribution is an indication of larger visible reflectance; an increased Green colour contribution indicates smaller cloud top particles and with an increased Blue colour contribution the cloud tops are warmer.

Figure 4.1.7: Day Time Microphysical Colour Scheme, VIS006, IR_039 and IR_108 in RGB

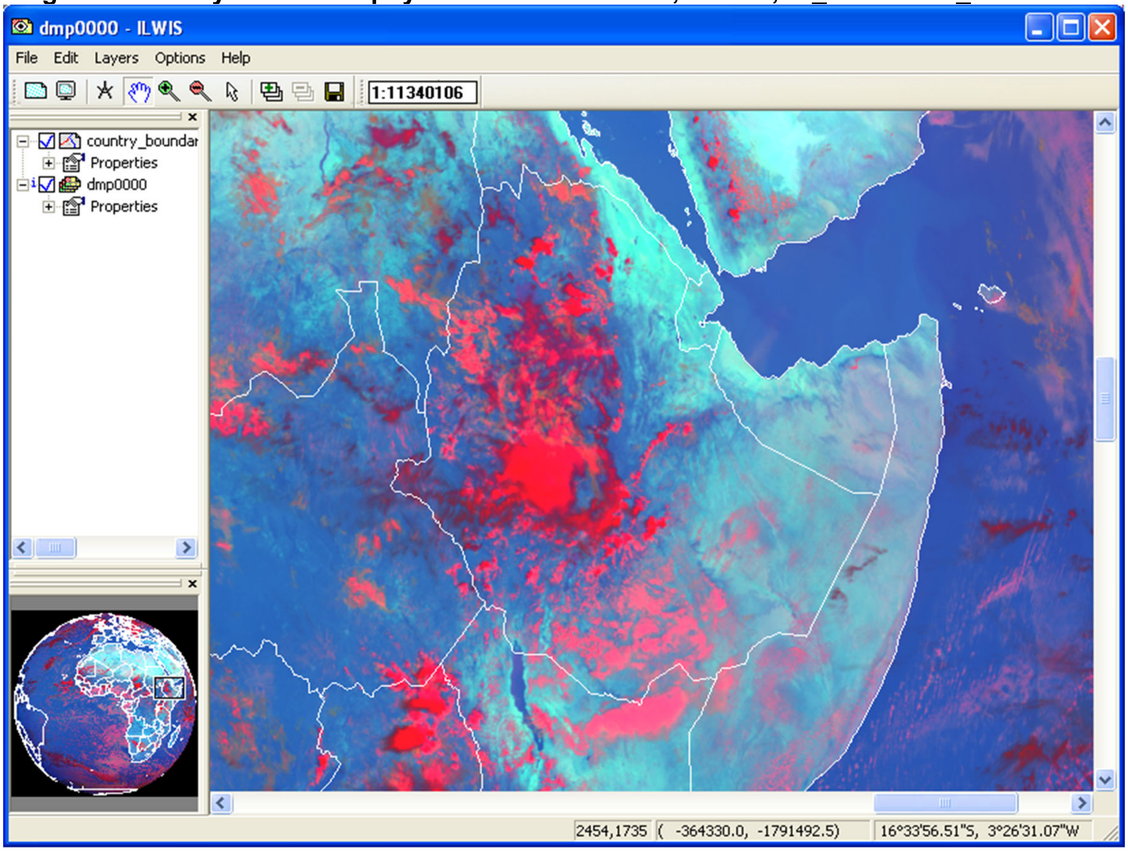
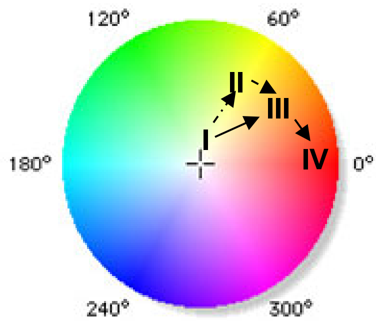


Table 4.1: Typical daytime convective development of clouds and related colour scheme

<table>
<tr><th></th><th>VIS006 (Red)</th><th>NIR016</th><th>IR_039 (Green)</th><th>IR_108 (Blue)</th><th></th></tr>
<tr><td>I. Very early stage
(low, warm water cloud)</td><td>White
opt thick</td><td>White
water</td><td>White
water</td><td>Light Grey
warm</td><td rowspan="4">
Related colour scheme for various stages of convective development

Cb = Cumulonimbus</td></tr>
<tr><td>II. First convection
(first convective towers)</td><td>White
opt thick</td><td>White
super cooled water</td><td>White
super cooled water</td><td>Dark Grey
cold</td></tr>
<tr><td>III. First icing
(transformation into Cb)</td><td>White
opt thick</td><td>Light Grey
small ice</td><td>Grey
small ice</td><td>Black
very cold</td></tr>
<tr><td>IV. Large icing
(Cb anvils)</td><td>White
opt thick</td><td>Dark Grey
large ice</td><td>Black
large ice</td><td>Black
very cold</td></tr>
</table>

Interaction of the solar radiation with clouds is presented in figures 4.1.8 and 4.1.9 for the various parts of the Electromagnetic Spectrum (EM). Figure 4.1.8 shows that at 1.6 µm (NIR) much more solar radiation is absorbed by the clouds than in the visible (VIS) part of the EM, ice absorbs even more strongly than water in the NIR. At 3.9 µm even more solar radiation is absorbed and here also ice is a stronger absorber compared to water. Figure 4.1.9 indicates the changes in reflectivity of snow clouds in the VIS and NIR part of the EM.

Figure 4.1.8: Absorption of water and ice by clouds for the various MSG channels (from: Daniel Rosenfeld, The Hebrew University of Jerusalem, HUJ)

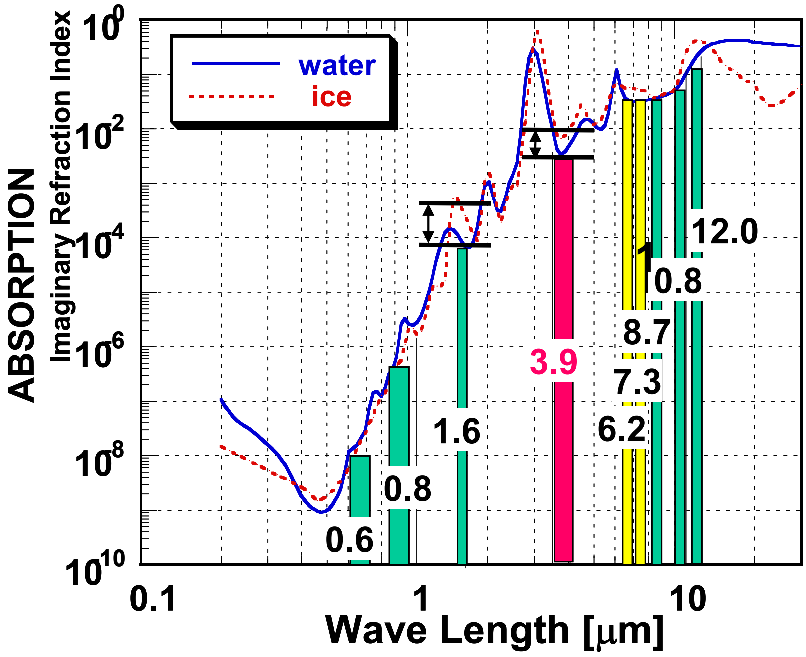
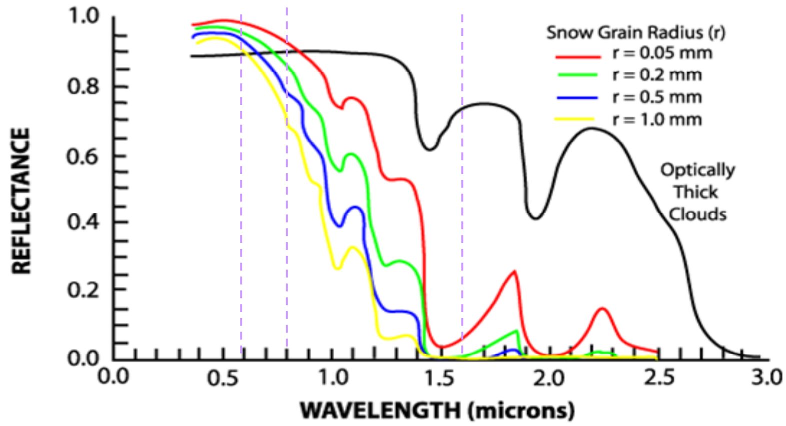


Figure 4.1.9: Different reflectivity of snow clouds at 0.6, 0.8 and 1.6 microns (from Rob Roebeling: Royal Netherlands Meteorological Institute, KNMI)

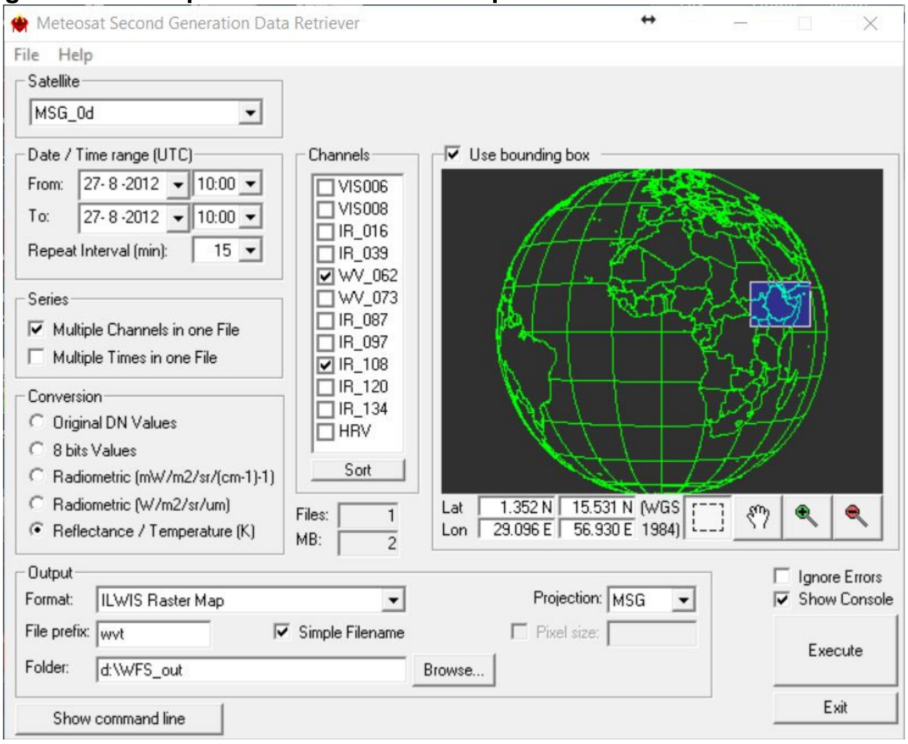


Explain using figures 4.1.8 and 4.1.9 why a daytime standard colour scheme (displayed as a colour composite, using as band assignments: IR_016, VIS008 and VIS006 in RGB) snow and ice clouds will have a cyan appearance and water clouds will be white (see also figure 4.1.4).

4.1.3 *The MSG water vapour (WV_062) and the Thermal (IR_108) channels*

MSG is recording the Visible to the Infrared region of the electromagnetic spectrum into a number of discrete channels. Import the WV_062 and the IR_108 channels for the same date / time as for the previous exercises and specify the other import options according to the specification given in figure 4.1.10.

Figure 4.1.10: Import of the MSG water vapour and thermal infrared channels



Note that the "*Conversion*" option used now is converting the WV and IR channels to Top of Atmosphere (TOA) brightness temperatures. The data is now converted to Kelvin; note the offset with Celsius of approximately 273. Also the window over Ethiopia has been added to select only a dedicated area. After the import is completed, refresh the catalogue, press with the left mouse button on the catalogue and press F5.

Right-click with the mouse on the map name "*wvt0000_band_1*" and select the option "Properties". Select the option "Change Value Range" and as 'Precision' enter "0.01" and press "OK" twice (sorry for this small bug in ILWIS!). Repeat this procedure for the map "*wvt0000_band_2*".

Display the imported image; from the ILWIS catalogue select the imported water vapour channel raster layer directly by double clicking on the file: "*wvt0000_band_1*", using as Representation "*Inverse*", and use default stretch values (note the minimum and maximum units of this image). Also put a vector layer showing the country boundaries on top (info off, boundaries only and boundary colour in red). The image should be comparable with the left image of figure 4.1.11.

Check the values of the image and also check the patterns. What can you observe? Do you see any features from the Earth surface on this water vapour image? What do the white toned areas represent (note also the Representation used)?

Also display the image “*wvt0000_band_2*” using an “*Inverse*” Representation. This is the thermal IR image and add also the country boundaries, in an identical manner as done for the previous image. The IR_108 image is also given in figure 4.1.11 on the right side. Also compare the values of this image and note especially the differences between the clouded (the bright white toned pixels on both images) and the non-clouded areas, like those over the eastern part of the Horn of Africa.

Figure 4.1.11: Imported WV channel (left) and TIR channel (right) for the same timestamp

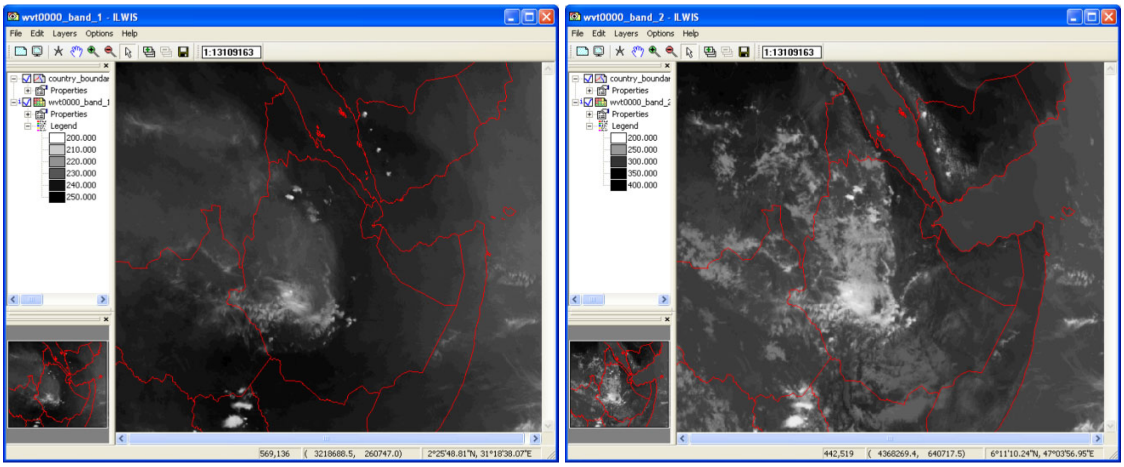
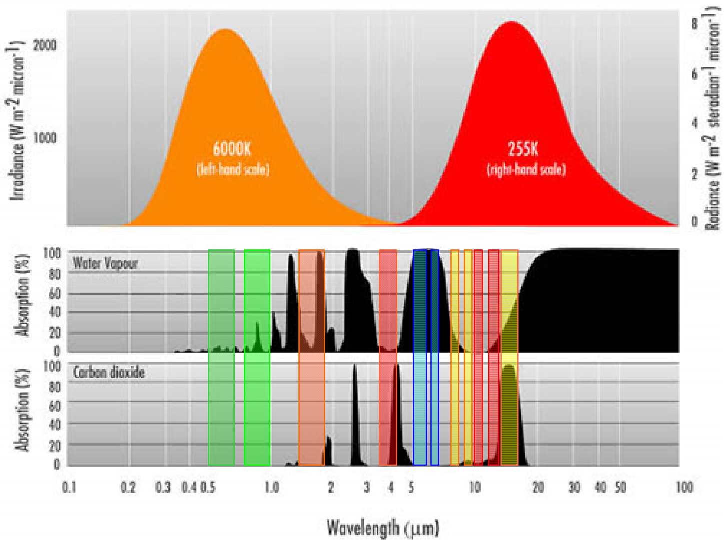
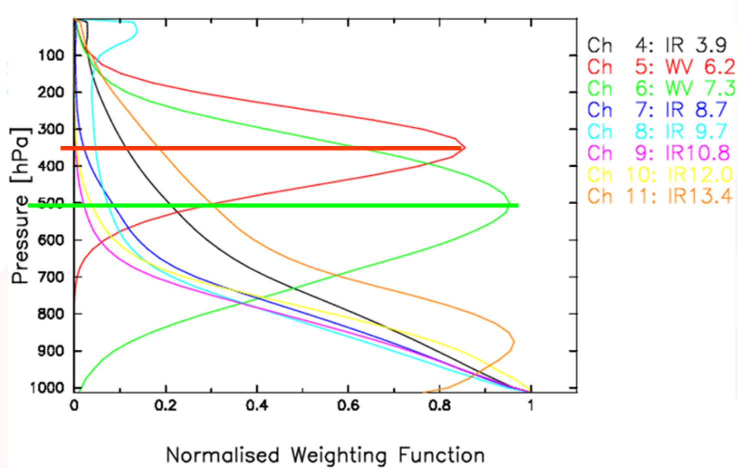


Figure 4.1.12: Irradiance and absorption for the various MSG channels (from: Rob Roebeling, Royal Netherlands Meteorological Institute, KNMI)



Note from figure 4.1.12 that the Water Vapour channels are strongly affected by absorption of the water vapour in the lower troposphere and therefore all radiation from the Earth itself is absorbed. The channels record the radiation that is emitted from certain layers within the troposphere. Therefore the water vapour channels are indicative of the water vapour content in the upper part of the troposphere. The maximum signal from WV_062 is at 350 hPa, and for WV_073 at 500 hPa (assuming normal pressure at sea level approximate elevation is at 8980 m and 5965 m amsl respectively), see also figure 4.1.13. If there would be no water vapour in the troposphere, radiation from far below can reach the satellite (source: Veronika Zwatz-Meise, ZAMG, available at: http://oiswww.eumetsat.org/WEBOPS/msg_interpretation/PowerPoints/Channels/WVguide.ppt#283,1,Introduction into the Absorption Channels). The IR_108 channel has its maximum contribution from the ground surface. Note the effect of the carbon dioxide absorption in the IR_134 channel.

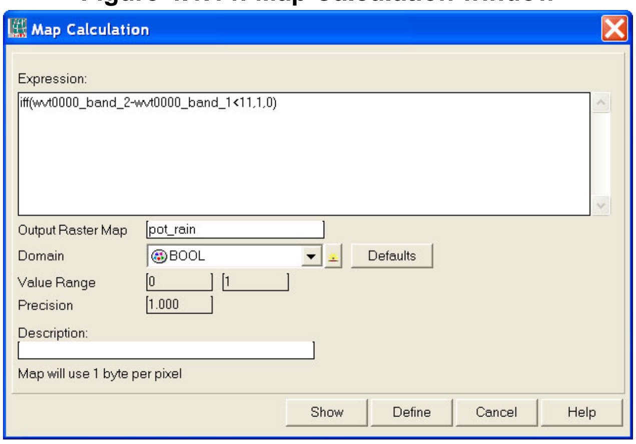
Figure 4.1.13: Contributions to Water Vapour and IR channels



The thermal channel records the emitted energy from the Earth surface itself. Based on a classification using MSG channel 108 and 062, applying a threshold on the temperature difference of less than 11 Kelvin (an empirically determined threshold by Kidder, et al, 2005) an approximation of the clouds that have a high likelihood of precipitation can be obtained (see also: Kidder, S., Kankiewicz, J.A., Eis, K. (2005): Meteosat Second Generation cloud algorithms for use in AFWA. In: BACIMO 2005, Monterey, CA.).

To calculate the potential precipitating clouds select from the ILWIS main menu the option "*Raster Operations*" and from the drop down menu "*Map Calculation*". Type the indicated algorithm as indicated in figure 4.1.14 in the Expression window, specify an output map, select as Domain "*Bool*" and execute the command by pressing "*Show*".

Figure 4.1.14: Map Calculation window



Display the map "*pot_rain*" calculated, for the "*True Color*" select "*Blue*" and for the "*False Color*" select "*White*". Also add the country boundary layer, using the options, no info, boundaries only and as boundary colour black.

Open in a new map window the map list showing the Daytime Microphysical Colour Scheme (dmp0000) and display band 1 (VIS006) as Red, band 2 (IR_039) as Green and Band 3 (IR_108) as Blue, use the default stretch options. Zoom in to cover approximately the same area. When you compare both maps what can you conclude?

Finally create a ‘Dust’ colour composite. Dust is an RGB composite based upon infrared channel data from the Meteosat Second Generation satellite. It is designed to monitor the evolution of dust storms during both day and night. The Dust RGB is composed from data from a combination of the SEVIRI IR8.7, IR10.8 and IR12.0 channels. This colour composite has been designed to monitor the evolution of dust storms over deserts. The combination does allow however the further (24 hour) tracking of dust clouds as they spread over the sea. In practice, during the daytime the use of visible channels (in particular the HRV channel) is preferable for the tracking of dust over the sea.

Dust appears pink or magenta in this RGB combination. Dry land looks pale blue (daytime) to pale green (night time). Thick, high-level clouds have red-brown tones and thin high-level clouds appear very dark (nearly black). The RGB combination exploits the difference in emissivity of dust and desert surfaces seen in the IR channels. In addition, and during daytime, it exploits the temperature difference between the hot desert surface and the cooler dust cloud.

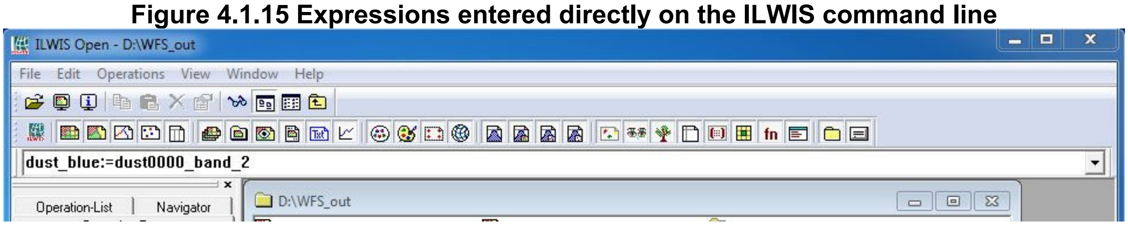
The RGB composite is using the following MSG channels/features: IR12.0-IR10.8 (on red), IR10.8-IR8.7 (on green) and IR10.8 (on blue).

In the Data Retriever also select the IR_087, IR10.8 and the IR_120 channels, as file prefix use “dust”, see also figure 4.1.16 for the settings. Press “*Execute*” to import the channels. Note that these are converted to temperature (in Kelvin).

After the import is completed type the following expressions directly on the ILWIS command line and press <enter> and “*OK*” to execute the calculation using default settings (see also figure 4.1.15):

Dust_blue:=dust0000_band_2
Dust_green:= dust0000_band_2- dust0000_band_1
Dust_red:= dust0000_band_3- dust0000_band_2

Figure 4.1.15 Expressions entered directly on the ILWIS command line

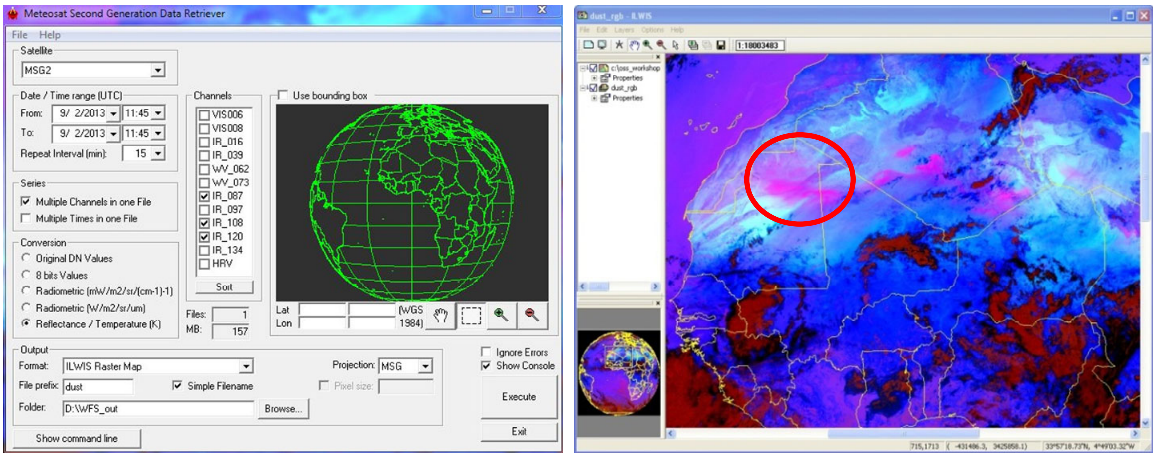


Now from the main ILWIS menu, select the option “File” > “Create > “Map List” and select the image called “*Dust_blue*”, press the > sign in the middle of the window to move this layer to the right hand side. Repeat this procedure for the “*Dust_green*” and “*Dust_red*” images. Specify an appropriate Map List file name, e.g. “*Dust_RGB*”. Press “*OK*” to store this map list. In the ILWIS catalogue double click the map list icon “*Dust_RGB*”, select the option “Open as ColorComposite” and select the appropriate bands for the colour assignment. Use the stretch values as given below for the appropriate channels:

Colour	Channel	Layer Name	Stretch Range: Min … Max
Red	IR12.0 - IR10.8	Dust_red	-4 K … +2 K
Green	IR10.8 - IR8.7	Dust_green	0 K … +15 K
Blue	IR10.8	Dust_blue	261 K … 289 K

Press “*OK*” to see the image. Also put a vector layer showing the country boundaries on top (info off, boundaries only and boundary colours in yellow or black). Your results should represent those of figure 4.1.16 showing a portion of the central Sahara, see the dust in red circle!.

Figure 4.1.16 MSG Data Retriever settings and Dust image created



4.1.4 ***Multi temporal data import, processing and analysis***

Within ILWIS 3.7.2 additional tools are at your disposal to perform dedicated analysis using time series of e.g. Meteosat-9 data. To deal with multi temporal image files ILWIS utilizes the concept of a map list, identical to the way a colour composite is handled. This list provides the temporal reference to a sequence of individual files in a time series. An algorithm can be entered through the command line and is executed for all of the maps in the map list. This map list can be created if in the Data Retriever the option: “*multiple times in one file*” is selected to create the co-registered image stack.

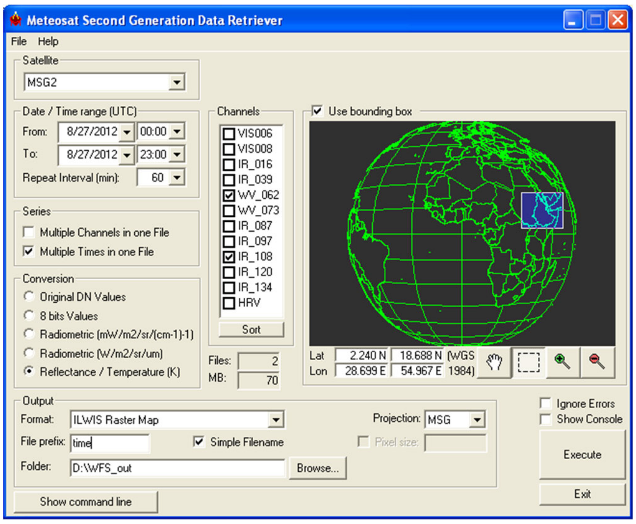
The map list can be visualized using an animation, by right clicking the map list icon, Visualization / as Slide Show; the user can define the image refresh rate and select a suitable colour representation and stretch in the Display Options.

Most of the regular Map calculation statements can be applied to map lists as well, making this a very powerful tool for time series data analysis.

In order to import a time series of data from MSG open the “*WFS-Ethiopia”* and *“Toolbox*” tabs from the main-menu and select “*MSG-HRIT*” and “*MSG Data Retriever*”. You are now going to import the same bands as used before, but now an image for each hour. Specify the import settings as given in the figure below and execute the import. Given the time needed for import otherwise, here a subset of the field of view is selected; also try to select a subset, covering e.g. the Horn of Africa region. Note the “*Date / Time Range*” and “*Repeat Interval*” settings! Carefully check the settings of figure 4.1.17.

Upon completion of the import, select from the ILWIS main menu, the option “*Window*” and from the drop down menu “*Refresh F5*”. To display the map list as an animated sequence double click the map list icon “*time0000*” and in the Map List “*time0000*” menu select the “*Open as SlideShow*” option. Use as Representation “*Inverse*”, the other display options can be kept default, press “*OK*” twice. Note that the map list is containing 24 maps; each map represents one hour starting from 08/27/2012 at 00:00hr to 23:00hr. Furthermore, note that the map list "*time0000*" represents the WV_062 channel and the map list "*time0001*" represents the IR_108 channel.

Figure 4.1.17: Import time series of MSG images, transformed into temperature

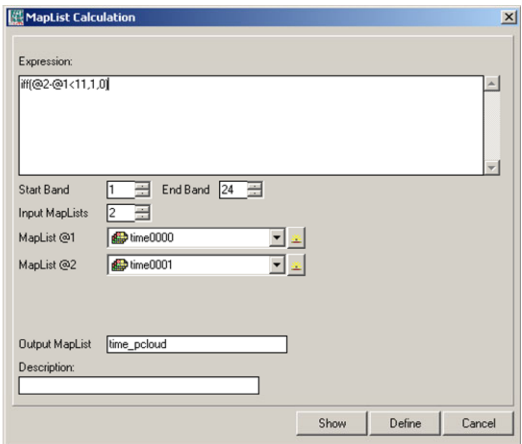


Press the left mouse button over the active map window to see the values of the image, note that you look here at the temperature (unit in Kelvin). Also put a vector layer showing the country boundaries on top (info off, boundaries only and boundary colour in red).

Also display the map list "*time0001*" as an animated sequence to see for example the development of the clouds during this 24 hr period, with one hour intervals. Also put a vector layer showing the country boundaries on top (info off, boundaries only and boundary colour in red).

To calculate the potential precipitating clouds from this map list, select from the ILWIS main menu the option "*Raster Operations*" and from the drop down menu "*Map List Calculation*". Type the algorithm as indicated in figure 4.1.18: "*iff(@2-@1<11,1,0)*", in the Expression window, specify the appropriate Map Lists (time0000 is the WV; time0001 is the IR, as @1 and @2 respectively) and specify an output map list. Execute the command by pressing "*Show*".

Figure 4.1.18: MapList Calculation window



Note that a map list is defined by the "@" symbol. The syntax of the expression is the same as that of figure 4.1.14!

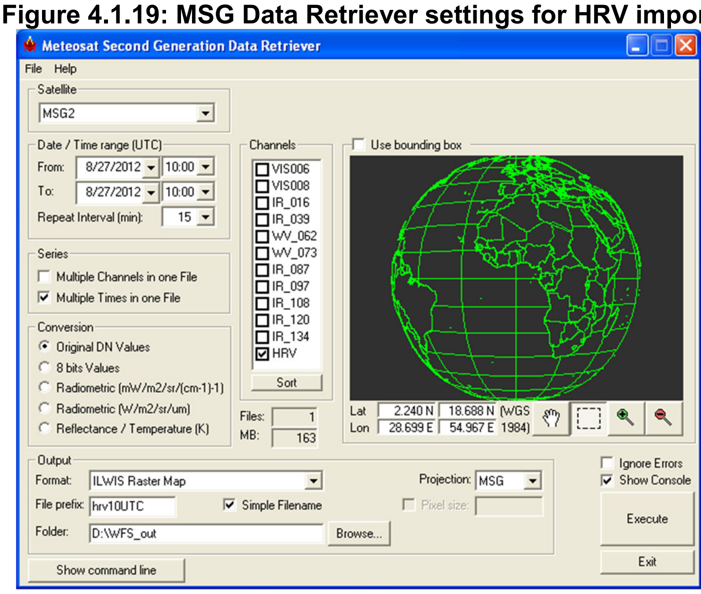
Upon completion of the calculation display the map list "*time_pcloud*" using an "*Inverse*" Representation. Also put a vector layer showing the country boundaries on top (info off, boundaries only and boundary colour in red). Note that the potential precipitating clouds have been assigned 1 and the background is 0.

4.1.5 ***Import of the HRV channel***

One of the channels on MSG is the so-called High Resolution Visible channel. This is a broadband channel, recording the electromagnetic spectrum from 0.4 – 1.1 µm, with a sub-satellite spatial resolution of 1 km. Its primary use is with respect to surface and clouds (see also table 3.1).

In order to import a HRV image from MSG open the "*WFS-Ethiopia" and "Toolbox*" tabs from the main-menu and select "*MSG-HRIT*" and "*MSG Data Retriever*". Specify the settings as given in the figure below. Note that the data is now imported as 10 bit, data range from 0 to 1023.

Figure 4.1.19: MSG Data Retriever settings for HRV import

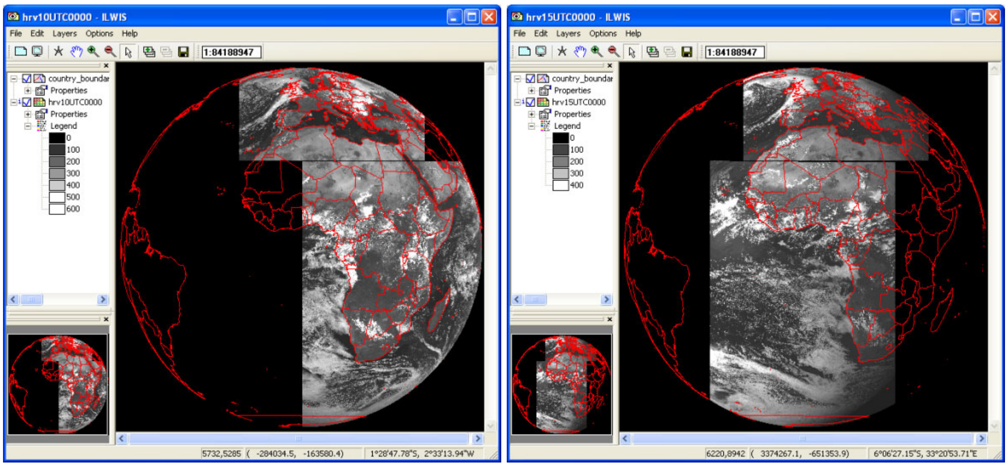


Upon Completion of the import double click the imported image "*hrv10UTC0000*", as Representation use "Gray" and press "Show" to see the image. Also put a vector layer showing the country boundaries on top (info off, boundaries only and boundary colour in red). Note that the image does not completely cover Africa and there is no coverage of western Africa at this UTC time selected. Zoom to the African region: from the active map window, select "Options" and "No Zoom" to see the image in the full resolution. Note that when another time is selected the southern part of the HRV image will move westward. Specify as Date / Time Range "*15:00*", use as File prefix "*hrv15UTC*" and conduct the import again. Your results should resemble those given in figure 4.1.20

Why can we use a "Gray" Representation here instead of an "Inverse" Representation?

As a general remark: Always consider carefully how to represent your images or data retrieved from GEONETCast (or in general), a wrong Representation can be misleading!

Figure 4.1.20: Imported HRV image at 10:00 UTC (left) and 15:00 UTC (right)



Note that till 13:45 UTC the eastern part of Africa is still fully covered, at 14:00 the eastern most part of the Horn of Africa is excluded and subsequently the southern MSG window moves over to cover the western part of Africa at 15:00 UTC.

In chapter 4.12.1 an additional exercise, using data from MSG, is presented. As this exercise can only be conducted when operating a real time reception system it cannot be provided as a generic exercise here. It might however be useful to browse through the exercise description though to note the functionality of the "*Real Time MSG Visualization*" options available from the WFS-Ethiopia Toolbox menu.

4.1.6 *Import MSG-IODC*

As Meteosat 8 is now the operational satellite situated at 41.5 degree, the satellite is perfectly located to record Ethiopia, as recordings are nearly sub-satellite. MSG data from Meteosat 8 is available under the folder \WFS_Ethiopia_TrainingData\MSG_IODC for '201808060900' for the VIS-006, VIS-008 and IR-016 channels. These allow you to create a colour composite.

In order to import data from MSG open the "*WFS-Ethiopia"* and *"Toolbox*" tabs from the main-menu and select "*MSG-HRIT*" and "*MSG Data Retriever*". If you did not configure the "*Data Sources*" of the MSG Data Retriever consult chapter 2.5 as well as Appendix 3.

Note the following from these import settings: the "*Satellite*" selected is MSG_41.5d, which refers to Meteosat Second Generation – 8 (IODC). The "*Date / Time Range*" is 6/8/2018 and 09:00 UTC respectively. The three channels that have been selected are used to generate a Daytime Standard Colour Scheme composite. The multiple imported channels, converted to 8 bits, are stored as "*Multiple Channels in one File*" with a "*File Prefix*" 'cc_IODC' and the option "*Simple Filename*" is activated. As output format an ILWIS Raster Map is selected and the appropriate "*Folder*" is selected to store the output data generated. The "*Projection*" MSG allows you to look at the data from a geostationary perspective and in this case the whole disk as recorded by MSG is selected.

After you have specified the appropriate settings, press "*Execute*" to conduct the import, see also the figure below. After the import has been completed open the map list "cc_IODC0000", open the map list as colour composite and use the default display settings, add the country boundaries as well. See also the figures below and note the difference in area covered from MSG at 41.5 degree compared to MSG at 0 degree (see also figure 4.1.4). As the satellite sensor design

(SEVIRI) is identical, all procedures as described before are applicable also to the MSG satellite at 41.5 degree.

Figure 4.1.21: MSG data import from MSG at 41.5 degree

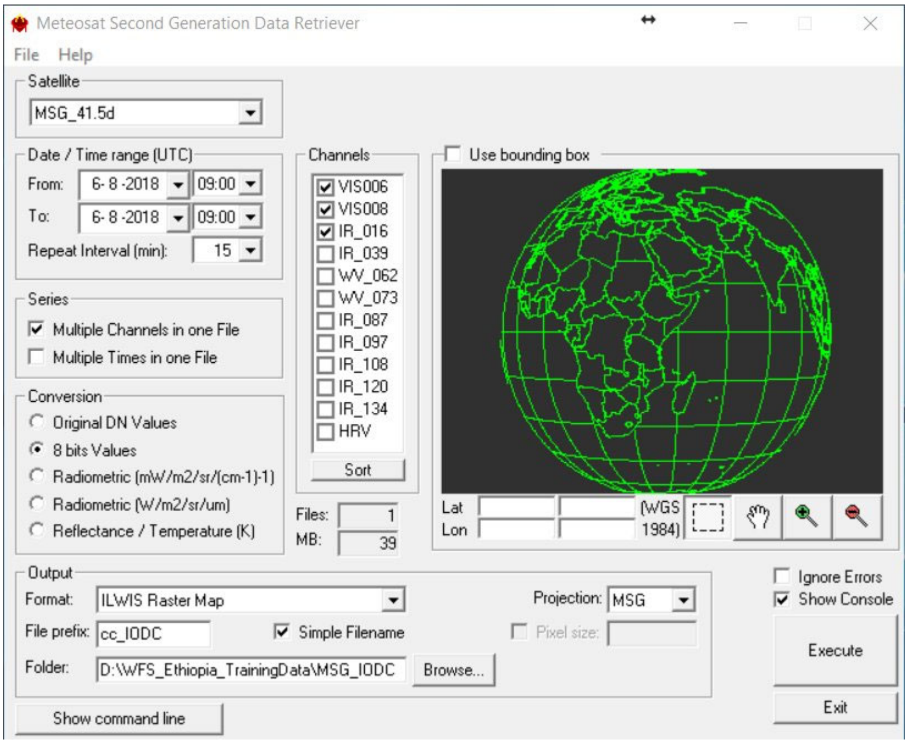
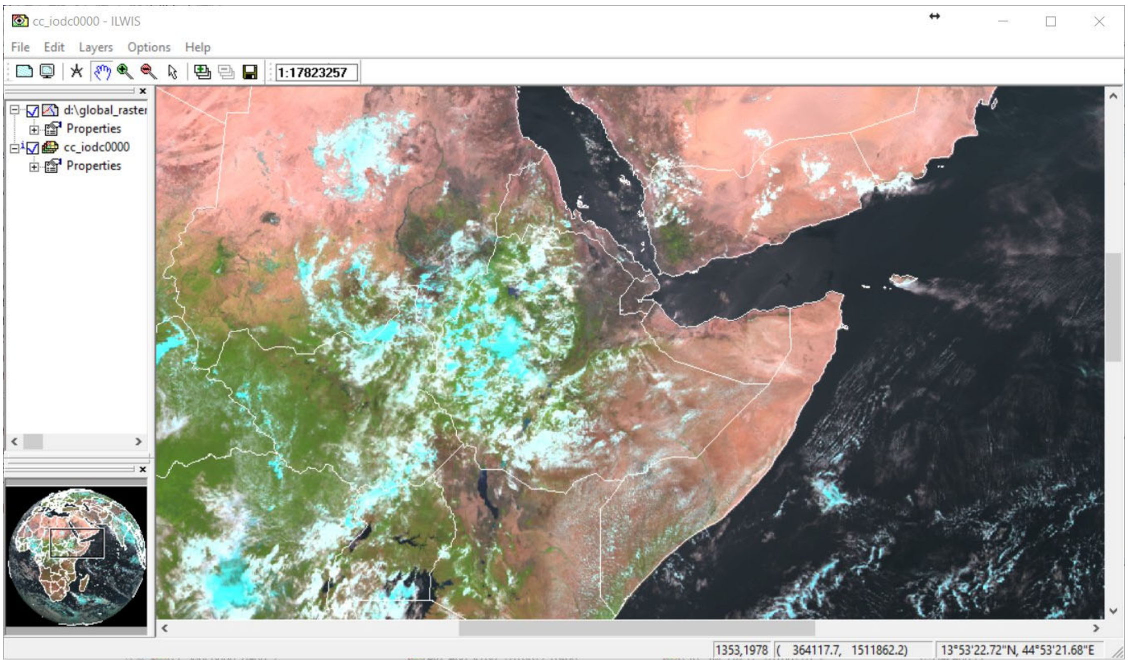


Figure 4.1.22: Resulting MSG colour composite of MSG at 41.5 degree

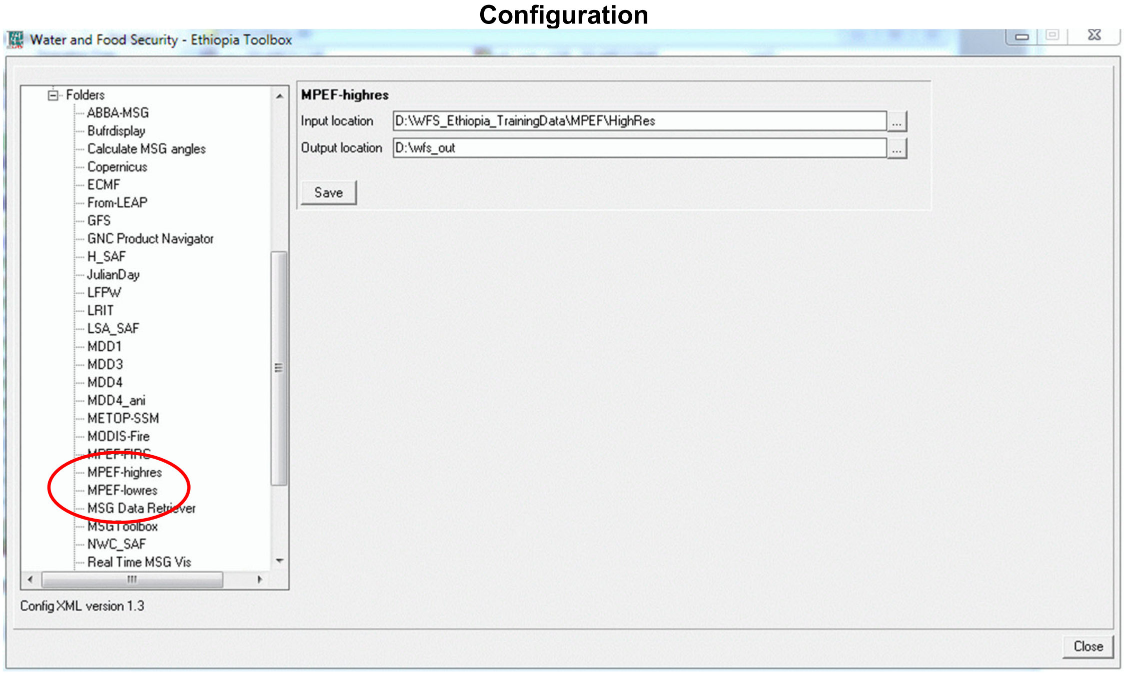


4.2 ETHIOPIA - IMPORT PRODUCTS FROM THE METEOROLOGICAL PRODUCT EXTRACTION FACILITY (MPEF) AT 0 AND 41.5 DEGREE

4.2.1 *Import and processing of MPEF high temporal resolution data*

Before starting to import the various other data types that are available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*MPEF_highres*". Browse to the appropriate data input and output locations (here "*D:\WFS_Ethiopia_TrainingData\MPEF\HighRes"*, where "*D:*" is the designated hard disk drive location). Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings. See also the figure below.

Figure 4.2.1: Input and output directory specification using the Toolbox Folder Configuration

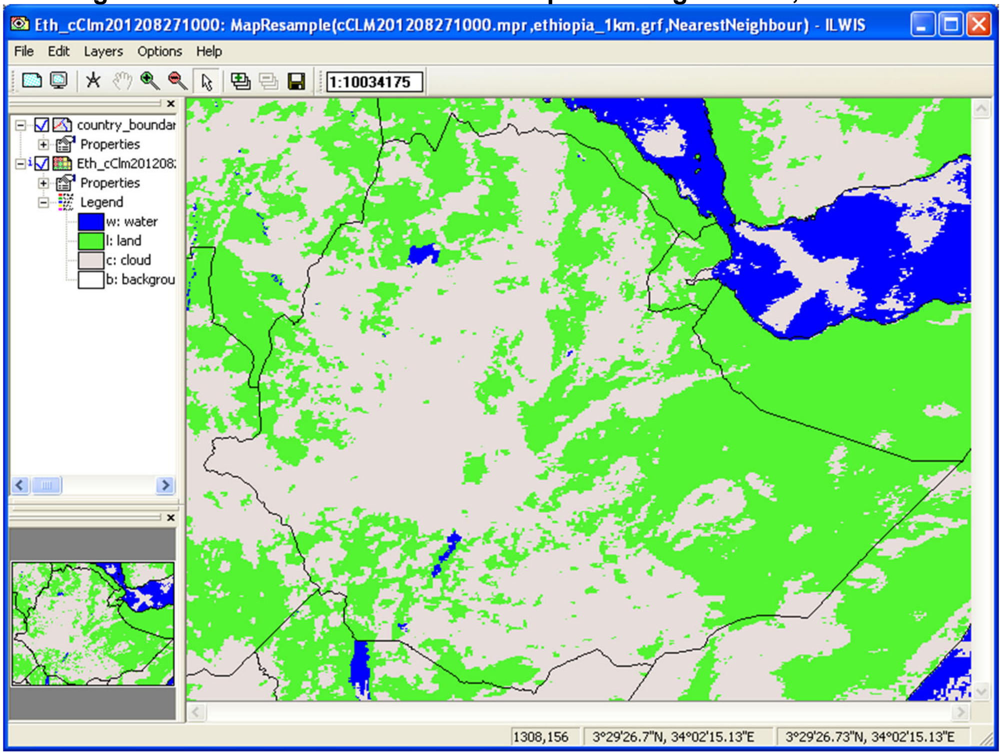


From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select "*Ethiopia*" >> "*MPEF at 0 degree*" >> "*High Temporal Resolution MPEF Products*" >> "*MPEF CLM*" to import the Cloud Mask (CLM). Select for the "*Date*" the identical time as used when importing the MSG images, in this case 201208271000. Specify this time stamp according to the format required in the "*Date*" field ("*yyyymmddhhmm*" is in this case "*201208271000*"). Press "*Import*" to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

As is the case with most routines under the menu item "Ethiopia" the data is resampled to the Ethiopian Region of Interest. Note that details of the RoI are given in chapter 2.10.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select "*Window*" and "*Refresh F5"*) and note that two new files have been created: "*Eth_cCLM*"* and "*Eth_vCLM*"* (*=yyyymmddhhmm), a classified cloud mask map and a value respectively. Open both maps and check their values or class names. A cloud mask class map is also given in figure 4.2.2.

Figure 4.2.2: Classified cloud mask map of 27 August 2012, 10:00 UTC



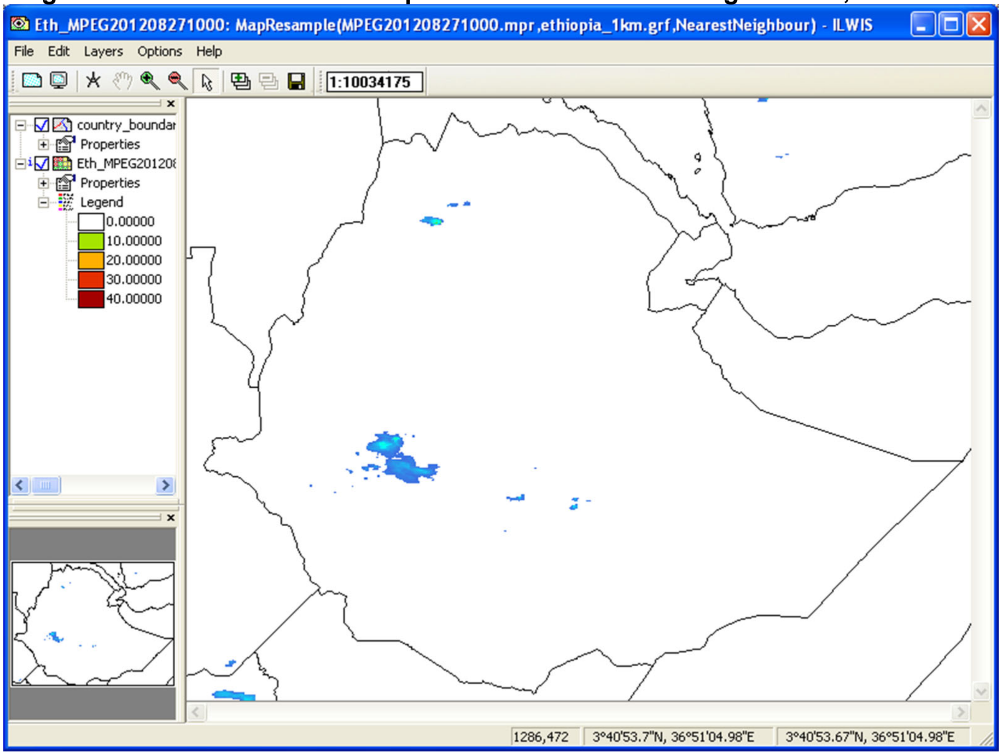
Close all active layers before you continue.

The Multi-Sensor Precipitation Estimate (MPE) product consists of the near-real-time rain rates in mm/hr for each Meteosat image in original pixel resolution. The algorithm is based on the combination of polar orbiting microwave measurements and thermal images recorded by the Meteosat IR-108 channel by a so-called blending technique. The MPE is most suitable for convective precipitation (source: http://www.eumetsat.int/Home/Main/DataProducts/ProductNavigator/index.htm?l=en).

From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select "*Ethiopia*" >> "*MPEF at 0 degree*" >> "*High Temporal Resolution MPEF Products*" >> "*MPEF MPEG*" to import the Multi-sensor Precipitation Estimate (MPEG) product. Select for the "*Date*" the identical time as used when importing the Cloud Mask: "*201208271000*". Specify this time stamp according to the format required in the "*Date*" field. Also check if the input directory (note that this can be date specific!) and output directory are correctly defined. Press "*Import*" to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select "*Window*" and "*Refresh F5"*) and note the file that has been created: Eth_MPEG* (*=yyyymmddhhmm). Display this map, using as Representation "*mpe_single*", also add the country boundaries (no info, boundaries only using a black colour). Check the values obtained, note that these are in mm/hr. The results obtained should resemble those of figure 4.2.3.

Figure 4.2.3: Multi Sensor Precipitation Estimate of 27 August 2012, 10:00 UTC

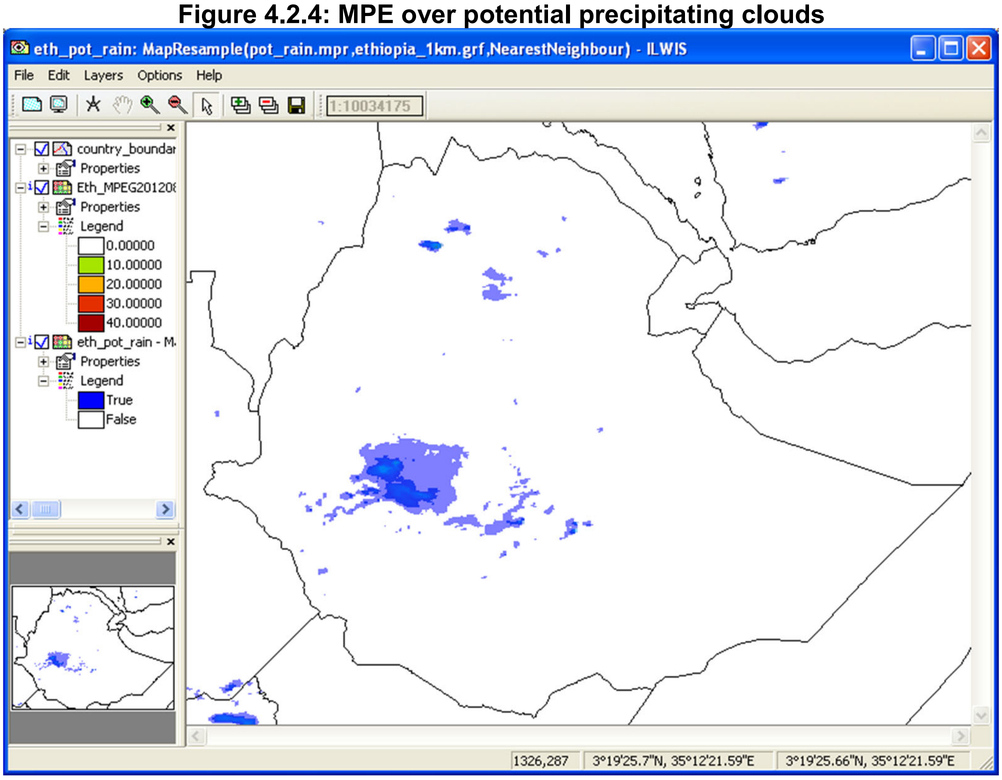


Display also the map that you calculated before showing the potential rainfall areas, called "*pot_rain*" and the cloud mask created before. What can you observe when comparing the maps?

The map "pot_rain" is based upon the MSG projection and shows a different geometry, check the country boundaries. In order to make a better comparison the map "pot_rain" can be resampled. From the main ILWIS menu, select the option "*Operations*" >> "*Spatial Reference Operations*" >> "*Raster*" >> "*Resample*", use as input raster map "*pot_rain*", specify as output map "*eth_pot_rain*" and as Georeference select "*ethiopia_1km*", press "*Show*". Display the map using as True Color "*blue*" and as False Color "*white*". From the map window press the "*Add Layer*" icon and add the map "*Eth_MPEG201208271000",* in the display options of this raster map, activate the option "*Transparent*", use default transparency, as Representation use "*mpe_single*" and press "*OK*". The results should look like in Figure 4.2.4 (note that the transparency does not always work, depending on your graphic board). Move the mouse cursor over the screen while keeping the left mouse button pressed. Note the rainfall intensities.

Note that for resampling use is made of the nearest neighbour resampling method, actual map values have not changed, only their "geographic" position! It can be noted that the threshold used to calculate the potential rain field is resulting in an overestimation. Modifying the threshold could yield better "regional" results. You can try to calculate the potential rain field once more using a smaller threshold using a similar methodology is described above (see figure 4.1.14).

Figure 4.2.4: MPE over potential precipitating clouds



From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select "*Ethiopia*" >> "*MPEF at 0 degree*" >> "*High Temporal Resolution MPEF Products*" >> "*MPEF CLAI*" to import the Cloud Analysis product. Select for the "*Date*" the appropriate time stamp, here use is made of the data for 27 August 2012 and as time step 1145 UTC is entered. Specify the time stamp according to the format required in the "*Date*" field. Also note if the input directory (this can be date specific!) and output directory is correctly defined. Press "*Import*" to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select "*Window*" and "*Refresh F5*") and note the file that has been created: "*Eth_CLAI**" (*=yyyymmddhhmm). Display this map, using the default "*Representation*" "*CLAI*", also add the country boundaries (no info, boundaries only using a black colour). Check the classes obtained, note that these are obtained from the CLAI product description. Furthermore you will observe a more 'blocky' appearance of the pixels; this is due to the fact that the initial resolution of this product is 3 by 3 MSG pixels! Your results should resemble those of figure 4.2.5A (left), close the map when finished.

Note that for 27 August 2012 more MPEF products are available, you can check this MPEF sub-directory. You can import a number of these products. In order to import them, select the appropriate time stamp according to the format required in the "*Date*" field (e.g. for AMV: "*201208271145*", for CTH: "*201208271145*"; note that a value and a class map is generated, for FIRG: "*201208271145"*). In order to visualize the AMV products, select the so called map view icon for the respective imported products e.g. "*amv201208271145*". To display the CTH value map a "*Pseudo*" representation can be used, for other maps use the default representation. Your results should resemble those of figure 4.2.5A (right) and 4.2.5B, close all active maps when finished. For the FIRG visualization add also the point map created (having the same name), use a point size of 3.

Figure 4.2.5A: Imported products from MPEF: CLAI (left) and CTH (right)

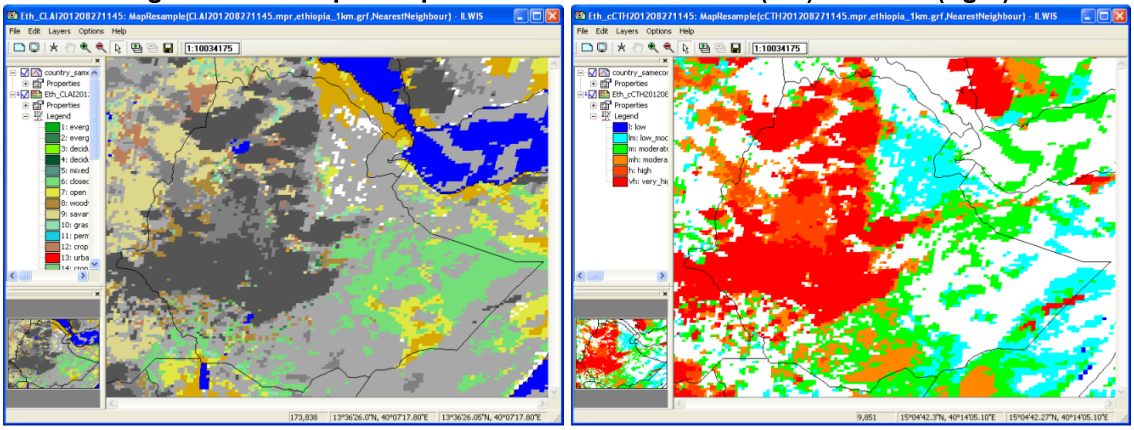
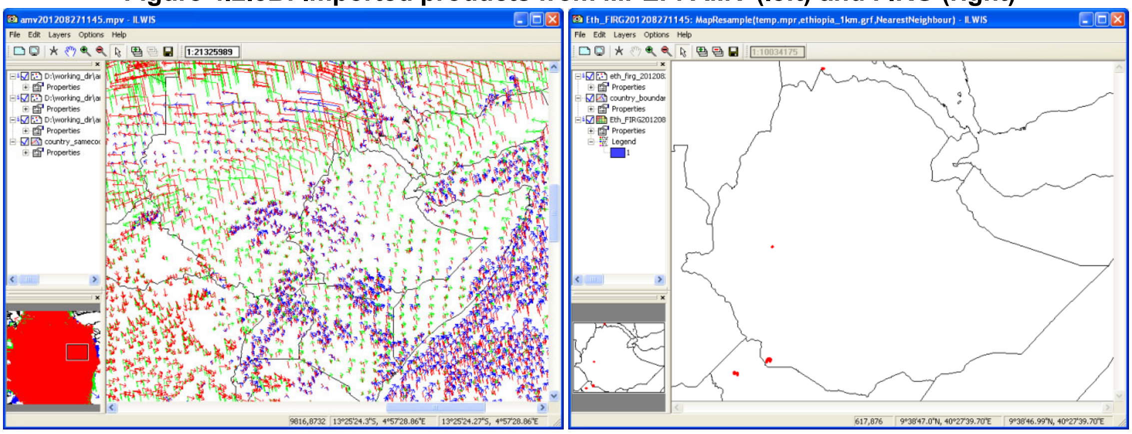


Figure 4.2.5B: Imported products from MPEF: AMV (left) and FIRG (right)



Another recent MPEF product is the 'Optimum Cloud Analysis'. To import this product select the option "MPEF OCA" from the MPEF High Temporal Resolution toolbox menu, specify as date stamp "201401211200", as the temporal resolution of this product is 1 hr. After the import is completed open the maplist "OCA_201401211200_undef" and display layer 1 and use as Representation "Pseudo". For the legend of this product see table 4.2.1.

Table 4.2.1 Optimum Cloud Analysis Code Table for each map layer

Number	Parameter Name		Unit
Layer-1	Pixel Scene Type:		-
	Number	**Parameter Name**	
	111	Single Layer Water Cloud	
	112	Single Layer Ice Cloud	
	113	Multi-Layer Cloud	
Layer-2	Measurement Cost		-
Layer-3	Upper Layer Cloud Optical Thickness		-
Layer-4	Upper Layer Cloud Top Pressure		Pa
Layer-5	Upper Layer Cloud Effective Radius		m
Layer-6	Error in Upper Layer Cloud Optical Thickness		-
Layer-7	Error in Upper Layer Cloud Top Pressure		Pa
Layer-8	Error in Upper Layer Cloud Effective Radius		m
Layer-9	Lower Layer Cloud Optical Thickness		-
Layer-10	Lower Layer Cloud Top Pressure		Pa
Layer-11	Error in Lower Layer Cloud Optical Thickness		-
Layer-12	Error in Lower Layer Cloud Top Pressure		Pa

After the import is completed open the map list “*Eth_OCA_201401211200*” and select the layer “*Eth_OCA_201401211200_1*”, using a “*Pseudo*” Representation. Move the cursor with the left mouse button pressed over the map and inspect the values, see also the numbers in the table above for their respective meaning. From the active map window select from the menu the option “File” and “Open Pixel Information”. From the Pixel Information Window, select “File” and “Add Map”, now select the map list “*Eth_OCA_201401211200”.* Move the mouse cursor over the map and inspect the values from the pixel information window, note the units as given in table 4.2.1. Eventually display a few other map layers of this product.

4.2.2 *Import and processing of MPEF low temporal resolution data*

From the “*WFS-Ethiopia”* and *“Toolbox*” main menu select the option “*Configuration*” and “*Folder*” and select “*MPEF_lowres*”. Browse to the appropriate data input and output locations and in case of MPEF_lowres note that the data is not stored in a year-month-day specific directory (here “*D:\WFS_Ethiopia_TrainingData\MPEF\LowRes”*, where “*D:*” is the designated hard disk drive location). Here as output location “*D:\WFS_out*” is used. Press “*Save*” to store the settings.

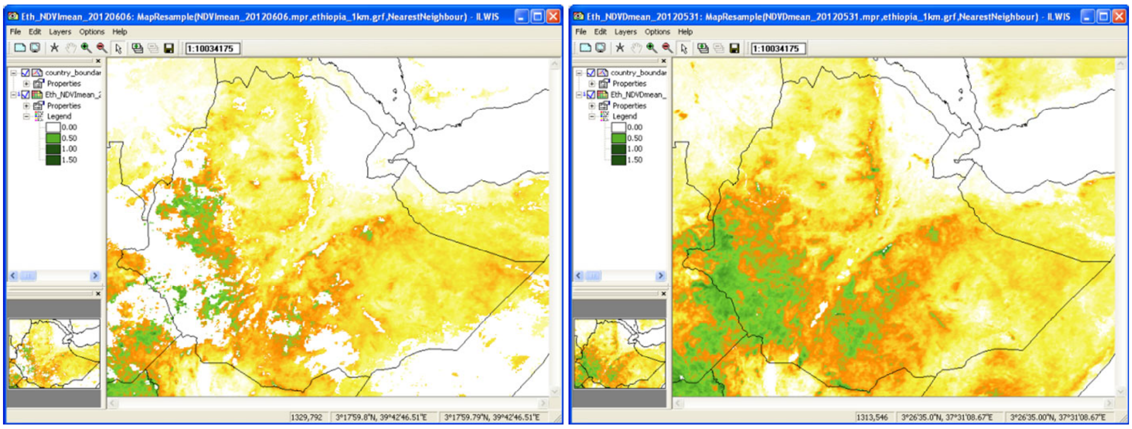
From the “*WFS-Ethiopia”* and *“Toolbox*” main menu select “*Ethiopia*” >> “*MPEF at 0 degree*” >> “*Low Temporal Resolution MPEF Products*” >> “*MPEF NDVI*” to import the Daily NDVI based on MSG. Specify for the “*Date*” field a yyyymmdd timestamp like “*20120606*”. Note that there is 1 product on a daily basis, the hhmm is always 1200 and is therefore not used. Press “*Import*” to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select “*Window*” and “*Refresh F5”*) and note that three new files have been created: Eth_NDVImax_*, Eth_NDVImean_* and Eth_NDVImin* (*=yyyymmdd), the daily maximum, mean and minimum NDVI of the various MGS observations respectively. Open the maps, using as Representation “*NDVI1*” and check their values. The daily NDVImean map of 20120606 is also given in figure 4.2.6 (left).

From the “*WFS-Ethiopia”* and *“Toolbox*” main menu select “*Ethiopia*” >> “*MPEF*” >> “*Low Temporal Resolution MPEF Products*” >> “*MPEF NDVD*” to import the Dekadal NDVI based on MSG. Select to import the last dekade of May 2012 as the “*Date*” stamp “20120531” (note for the 1st and second dekade of each month this is always 10 and 20 respectively, for the last dekade of the month this is always the last day of the respective month!). Specify this time stamp according to the format required in the “*Date*” field (“*yyyymmdd)* and in this case is “*20120531*”. Note that there are 3 products per month, the hhmm is always 1200 and is not used. Press “*Import*” to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select “*Window*” and “*Refresh F5”*) and note that three new files have been created: Eth_NDVDmax_*, Eth_NDVDmean_* and Eth_NDVDmin_* (*=yyyymmdd), the dekadal maximum, mean and minimum NDVI of the various daily MGS NDVI observations for that specific dekade. Open the maps, using as Representation “*NDVI1*” and check their values. The NDVDmean map of the last dekade of May 2012 is also given in figure 4.2.6 (right). Note the reduction of cloud contamination when comparing the daily and dekadal NDVI.

Figure 4.2.6: MPEF NDVI day and dekadal map



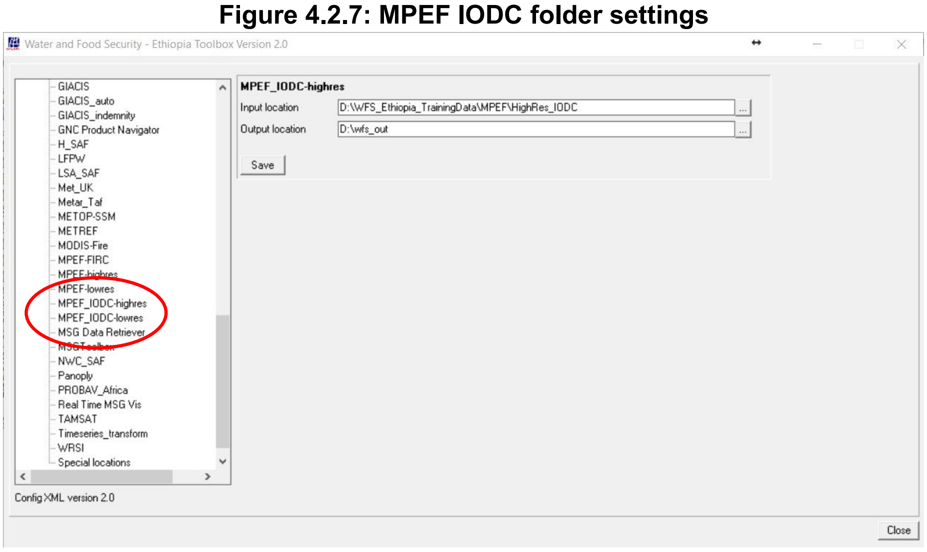
More information on MPEF and the algorithms used can be found in the document: *"MSG Meteorological Products Extraction Facility Algorithm Specification Document" (*EUM/MSG/SPE/ 022)*,* available at: www.eumetsat.int/groups/ops/documents/document/PDF_TEN_SPE_04022_MSG_MPEF.pdf

4.2.3 *MPEF at 41.5 degree*

All MPEF routines described above are also applicable to the products produced from MG at 41.5 degree. Within the provided processing routines, all products are resampled to the Ethiopian Window, so the user will not note directly if the data originated from a different satellite.

Some sample data to work with MPEF products from 41.5 degree are provided as well. Before starting to import the various IODC MPEF data types that are available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the "*WFS-Ethiopia" and "Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*MPEF_IODC_highres*". Browse to the appropriate data input and output locations (here "*D:\WFS_Ethiopia_TrainingData\MPEF\HighRes_IODC"*, where "*D:*" is the designated hard disk drive location). Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings. See also the figure below. For the low temporal resolution MPEF IODC products, note the input source data folder can be specified under the folder option "*MPEF_IODC_lowres*"

Figure 4.2.7: MPEF IODC folder settings

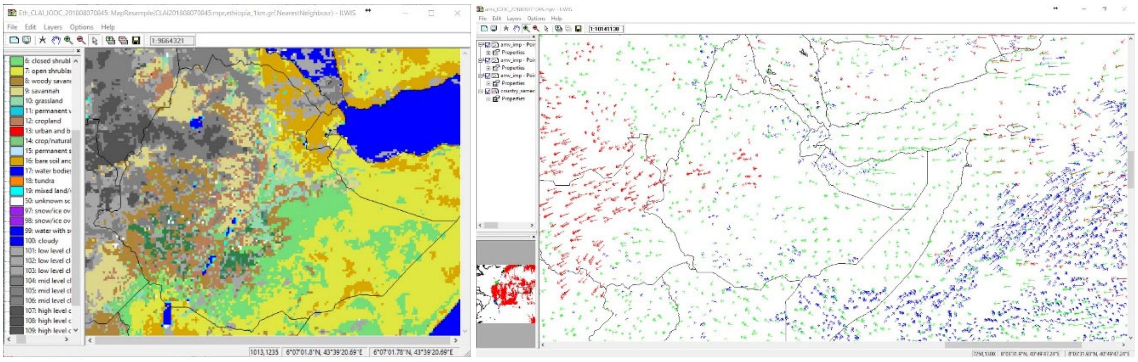


From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select "*Ethiopia*" >> "*MPEF at 41.5 degree*" >> "*High Temporal Resolution MPEF Products*" >> "*MPEF CLAI*" to import the Cloud Analysis product. Select for the "*Date*" the appropriate time stamp, here use is made of the data for 07 August 2018 and as time step 0845 UTC is entered. Specify the time stamp according to the format required in the "*Date*" field. Also note if the input directory (this can be date specific!) and output directory is correctly defined. Press "*Import*" to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select "*Window*" and "*Refresh F5"*) and note the file that has been created: "*Eth_CLAI_IODC*" (*=yyyymmddhhmm). Display this map, using the default "*Representation*" "*CLAI*", also add the country boundaries (no info, boundaries only using a black colour).

Note that for 07 August 2018 more MPEF products are available, you can check this MPEF\highres_IODC sub-directory. You can import a number of these products. In order to import them, select the appropriate time stamp according to the format required in the "*Date*" field (e.g. for AMV: "*201808071045*"), see also some of the results below.

Figure 4.2.8: Import of some MPEF IODC products (CLAI and AMV)



For the low temporal resolution data from MPEF at 41.4 degree, from the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*MPEF_IODC-lowres*". Browse to the appropriate data input and output locations and in case of MPEF_lowres note that the data is not stored in a year-month-day specific directory (here "*D:\WFS_Ethiopia_TrainingData\MPEF\LowRes_IODC"*, where "*D:*" is the designated hard disk drive location). Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select "*Ethiopia*" >> "*MPEF at 41.5 degree*" >> "*Low Temporal Resolution MPEF Products*" >> "*MPEF NDVI*" to import the Daily NDVI based on MSG. Specify for the "*Date*" field a yyyymmdd timestamp like "*20180214*". Note that there is 1 product on a daily basis, the hhmm is always 1200 and is therefore not used. Press "*Import*" to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select "*Window*" and "*Refresh F5"*) and note that three new files have been created: Eth_NDVImax_IODC_*, Eth_NDVImean_IODC_* and Eth_NDVImin_IODC_* (*=yyyymmdd), the daily maximum, mean and minimum NDVI of the various MGS observations respectively. Open the maps, using as Representation "*NDVI1*" and check their values.

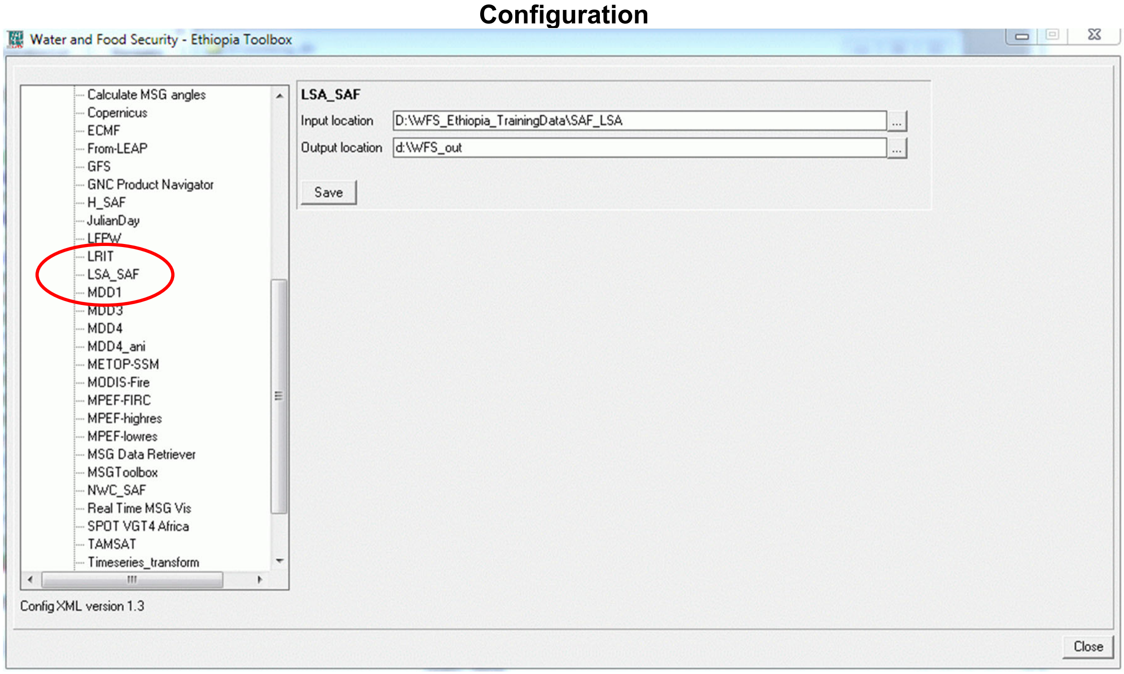
As a file naming convention for the MPEF at 41.5 degree always the suffix "IODC" is applied, so the user always knows the source of the satellite.

4.3 ETHIOPIA - IMPORT PRODUCTS FROM THE LSA SAF

4.3.1 *Import and processing of LSA SAF data for Ethiopia*

Before starting to import the various other data types that are available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the "*WFS_Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*LSA_SAF*". Browse to the appropriate data input and output locations and in this case the SAF data is stored in the directory: "*D:\WFS_Ethiopia_TrainingData\SAF_LSA*" (where "*D:*" is the designated hard disk drive location). Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings. See also the figure below.

Figure 4.3.1: Input and output directory specification using the Toolbox Folder Configuration



4.3.2 *Surface Albedo (Albedo)*

Land surface albedo is a key variable for characterising the energy balance in the coupled soil-vegetation-atmosphere system. The albedo quantifies the part of the energy that is absorbed and transformed into heat and latent fluxes. Owing to strong feedback effects the knowledge of albedo is important for determining weather conditions at the atmospheric boundary layer. Climate sensitivity studies with Global Circulation Models have confirmed the unsteady nature of the energy balance with respect to small changes in surface albedo. Other domains of applications are in hydro-meteorology, agro-meteorology and environment related studies (source: http://landsaf.meteo.pt/).

From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select "*Ethiopia*" >> "*LSA-SAF*" >> "*Albedo*" to import the Surface Albedo product. Select for the "*Date*" the appropriate time stamp, here use is made of the data for 10 June 2012. Specify the time stamp according to the format required in the "*Date*" field (e.g. "*20120610*"). Press "*Import*" to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select "*Window*" and "*Refresh F5*") and note the file that has been created: "*Eth_albedo**"

(*=yyyymmdd). Display this map, using as Representation “*Pseudo*”, also add the country boundaries (no info, boundaries only using a black colour). Check the values obtained, note that these are in percentage. Your results should resemble those of figure 4.3.2A (left), close the map when finished.

4.3.3 *Down-welling surface short-wave and long-wave radiation fluxes*

The down-welling surface short-wave radiation flux (DSSF) refers to the radiative energy in the wavelength interval [0.3µm, 4.0µm] reaching the Earth's surface per time and surface unit. It essentially depends on the solar zenith angle, on cloud coverage, and to a lesser extent on atmospheric absorption and surface albedo. DSSF fields are crucial for a wide number of applications involving scientific domains like weather forecast, hydrology, climate, agriculture and environment-related studies. In numerical weather prediction and general circulation models of the atmosphere, satellite-derived DSSF estimates can either be used as a control variable or as a substitute to surface radiation measurement networks. Down-welling Surface Long-wave Radiation Flux (DSLF) is the result of atmospheric absorption, emission and scattering within the entire atmospheric column and may be defined as the thermal irradiance reaching the surface in the thermal infrared spectrum (4-100µm). In clear sky situations DSLF depends on the vertical profiles of temperature and gaseous absorbers (primarily the water-vapour followed by CO2, and others of smaller importance like O3, CH4, N2O and CFCs). However, DSLF is determined by the radiation that originates from a shallow layer close to the surface (about one third being emitted by the lowest 10 meters and 80% by the 500-meter layer). The cloud contribution mainly occurs in the atmospheric window (8-13µm) and mainly depends on cloud base properties (height, temperature and emissivity). DSLF is directly related to the greenhouse effect and its monitoring has an important role in climate change studies. Other applications include meteorology (land applications) and Hydrology (source: http://landsaf.meteo.pt/).

As an example of these fluxes, from the “*WFS-Ethiopia*” and “*Toolbox*” main menu select “*Ethiopia*” >> “*LSA_SAF*” and “*DSSF*” to import the down-welling surface short-wave radiation flux product. Select for the “*Date*” the appropriate time stamp, here use is made of the data for 11 June 2012 and as time step “*1200*” UTC is entered. Specify the time stamp according to the format required in the “*Date*” field (e.g. “*201206111200*”). Also note if the input directory and output directory is correctly defined. Press “*Import*” to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select “*Window*” and “*Refresh F5*”) and note the file that has been created: “*Eth_dssf**” (*=yyyymmddhhmm). Display this map, using as Representation “*Pseudo*”, also add the country boundaries (no info, boundaries only using a black colour). Check the values obtained, note that the map unit is W/m^2. Your results should resemble those of figure 4.3.2A (right), close the map when finished.

4.3.4 *Land Surface Temperature (LST)*

Land Surface Temperature (LST) is the radiative skin temperature over land. LST plays an important role in the physics of land surface as it is involved in the processes of energy and water exchange with the atmosphere. LST is useful for the scientific community, namely for those dealing with meteorological and climate models. Accurate values of LST are also of special interest in a wide range of areas related to land surface processes, including meteorology, hydrology, agro meteorology, climatology and environmental studies (source: http://landsaf.meteo.pt/).

From the “*WFS-Ethiopia*” and “*Toolbox*” main menu select “*Ethiopia*” >> “*LSA-SAF*” >> “*LST*” to import the Land Surface Temperature product. Select for the “*Date*” the appropriate time stamp, here use is made of the data for 11 June 2012 and as time step “*1200*” UTC is entered. Specify the time stamp according to the format required in the “*Date*” field (e.g. “*201206111200*”). Also note if the input directory and output directory is correctly defined. Press "*Import*" to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select "*Window*" and "*Refresh F5"*) and note the file that has been created: "*Eth_lst*"* (*=yyyymmddhhmm). Display this map, using as Representation "*Pseudo*", also add the country boundaries (no info, boundaries only using a black colour). Check the values obtained, note that the temperature is in Celsius. Your results should resemble those of figure 4.3.2B (left), close the map when finished.

4.3.5 *Evapotranspiration (ET)*

Evapotranspiration (ET) accounts for the flux of water evaporated at the Earth-atmosphere interface (from soil, water bodies and interception) and transpired by vegetation through stomata in its leaves as a consequence of photosynthetic processes. ET is an important component of the water cycle and it is associated with the latent heat flux (LE), a key link between the energy and water cycles. In other words, LE represents the energy needed for the ET process. Evaluating energy fluxes at the Earth surface is of great importance in many disciplines like weather forecasting, global climate monitoring, water management, agriculture and ecology. This product currently is in an operational status (source: http://landsaf.meteo.pt/). From the LSA SAF archive also a daily ET product can be obtained.

From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select "*Ethiopia*" >> "*LSA-SAF*" >> "*ET*" to import the Evapotranspiration product. Select for the "*Date*" the appropriate time stamp, here use is made of the data for 11 June 2012 and as time step "*1200*" UTC is entered. Specify the time stamp according to the format required in the "*Date*" field (e.g. "*201206111200*"). Press "*Import*" to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select "*Window*" and "*Refresh F5"*) and note the file that has been created: "*Eth_et*"* (*=yyyymmddhhmm). Display this map, using as Representation "*Pseudo*", also add the country boundaries (no info, boundaries only using a black colour). Check the values obtained, note that the ET is in mm/hr. Your results should resemble those of figure 4.3.2B (right), close the map when finished.

Figure 4.3.2A: Imported products from the LSA SAF: Albedo (left) and DSSF (right)

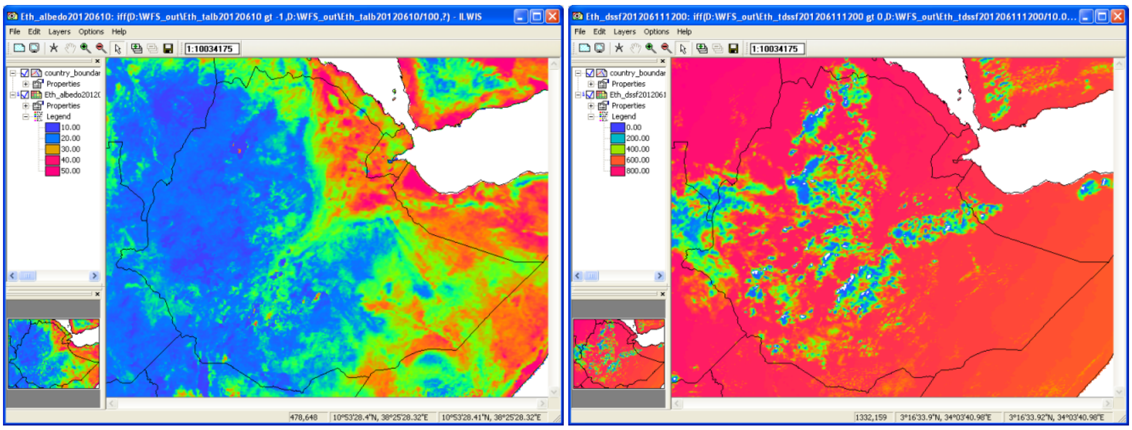
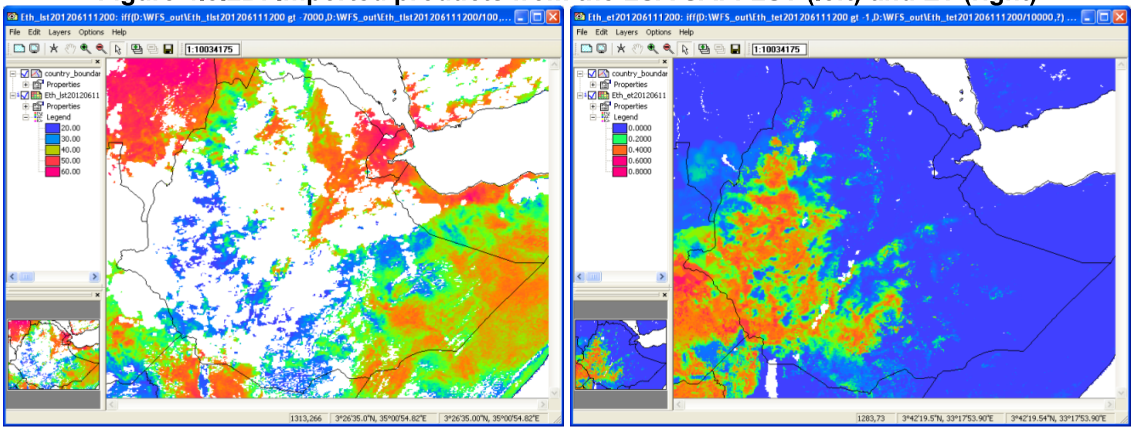


Figure 4.3.2B: Imported products from the LSA SAF: LST (left) and ET (right)



4.3.6 *Reference Evapotranspiration (METREF)*

A product that became operational at a later stage (from 2015 onwards) is the so called Meteosat Reference Evapotranspiration. Reference evapotranspiration is the evapotranspiration rate from a clearly defined reference surface. The concept was introduced to allow the estimation of the evaporative demand of the atmosphere independently of crop type, crop development or management practices. ETo corresponds to the evapotranspiration from a hypothetical extensive well-watered field covered with 12 cm height green grass having an albedo of 0.23 would experience under the given down-welling short-wave radiation.

The LSA SAF METREF provides daily ETo [mm/day] estimated from daily global radiation derived from SEVIRI/MSG, as this is the main driver of evapotranspiration over the extensive reference surface. The algorithm is described in the LSA SAF documents (source: https://landsaf.ipma.pt/en/products/evapotranspiration/metref/).

The characteristics of land surfaces impact the radiation budget and influence the atmosphere boundary layer. The LSA METREF product, however, does not use atmospheric humidity and only presents a slight dependency on near surface air temperature. LSA SAF METREF is not affected by local effects, such as surface aridity or local advection.

From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select "*Ethiopia*" >> "“*LSA-SAF*" >> "*METREF*" to import the Evapotranspiration product. Select for the "*Date*" the appropriate time stamp, here use is made of the data for 01 July 2017. Specify the time stamp according to the format required in the "*Date*" field (e.g. "*20170701*"). Press "*Import*" to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select "*Window*" and "*Refresh F5*") and note the file that has been created: "*Eth_metref**" (*=yyyymmdd). Display this map, using as Representation "*Pseudo*", also add the country boundaries (no info, boundaries only using a black colour). Check the values obtained, note that the ETo is in mm/day.

You will now continue to import a number of Vegetation Parameters that are generated once a day by the LSA SAF, using the data collected by the SEVIRI instrument on board of MSG.

4.3.7 ***Fraction of Vegetation Cover (FVC)***

The FVC product is currently generated daily at the full spatial resolution of the MSG-SEVIRI instrument, and will be later provided on a 10-days and monthly basis. The product is based on the three short-wave channels (VIS 0.6µm, NIR 0.8µm, SWIR 1.6µm) using as input the k0 parameter of a parametric BRDF (Bi-directional Reflectance Distribution Function) model (Roujean et al. 1992). The k0 parameter (normalized reflectance) provides cloud-free observations over the SEVIRI disk based on an iterative scheme with a characteristic time scale of five days. The FVC product is expressed in the range from 0 % to 100 %. It is corrected from uncertainty derived of the view/sun angles and also the anisotropy effects of surface's reflectance in the SEVIRI image. The FVC product includes routine quality check and error estimates. The product will be validated in order to define the product uncertainties over a range of global conditions studies (source: http://landsaf.meteo.pt/).

From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select "*Ethiopia*" >> "*LSA-SAF*" >> "*FVC*" to import the Fraction of Vegetation Cover product. Select for the "*Date*" the appropriate time stamp, here use is made of the data for 10 June 2012. The "hhmm" time step (always 0000 UTC) is not required as the product is generated once a day. Specify the time stamp according to the format required in the "*Date*" field (e.g. "*20120610*"). Press "*Import*" to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select "*Window*" and "*Refresh F5"*) and note the file that has been created: "*Eth_fvc**" (*=yyyymmdd). Display this map, using as Representation "*fvc*", also add the country boundaries (no info, boundaries only using a black colour). Check the values obtained, note that these are in percentage (0 to 1 represents 0 to 100 percent). Your results should resemble those of figure 4.3.3A, close the map when finished.

4.3.8 ***Leaf Area Index (LAI)***

Leaf Area Index (LAI) is a dimensionless variable [m2/m2], which defines an important structural property of a plant canopy. LAI is defined as one half the total leaf area per unit ground area (Chen and Black, 1992). It provides complementary information to the FVC, accounting for the surface of leaves contained in a vertical column normalized by its cross-sectional area. It defines thus the area of green vegetation that interacts with solar radiation determining the remote sensing signal, and represents the size of the interface between the vegetation canopy and the atmosphere for energy and mass exchanges. LAI is thus a necessary input for Numerical Weather Prediction (NWP), regional and global climate modelling, weather forecasting and global change monitoring. Besides, the LAI is relevant for Land Biosphere Applications such as agriculture and forestry, environmental management and land use, hydrology, natural hazards monitoring and management, vegetation-soil dynamics monitoring and drought conditions studies (source: http://landsaf.meteo.pt/).

From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select "*Ethiopia*" >> "*LSA-SAF*" >> "*LAI*" to import the Leaf Area Index product. Select for the "*Date*" the appropriate time stamp, note that the product is generated once a day. Specify the time stamp according to the format required in the "*Date*" field (e.g. "*20120610*"). Press "*Import*" to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select "*Window*" and "*Refresh F5"*) and note the file that has been created: "*Eth_lai**" (*=yyyymmdd). Display this map, using as Representation "*lai_saf*", also add the country boundaries (no info, boundaries only using a black colour). Check the values obtained, note these are m^2/m^2. Your results should resemble those of figure 4.3.3B, close the map when finished.

4.3.9 *Fraction of Absorbed Photosynthetically Active Radiation (FAPAR)*

Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) defines the fraction of PAR (400-700 nm) absorbed by the green parts of the canopy, and thus expresses the canopy's energy absorption capacity. FAPAR depends both on canopy structure, leaf and soil optical properties and irradiance conditions. FAPAR has been recognized as one of the fundamental terrestrial state variables in the context of the global change sciences (Steering Committee for GCOS, 2003; Gobron et al., 2006). It is a key variable in models assessing vegetation primary productivity and, more generally, in carbon cycle models implementing up-to-date land surfaces process schemes. Besides, FAPAR is an indicator of the health of vegetation. FAPAR is generally well correlated with the LAI, the more for healthy fully developed vegetation canopies studies (source: http://landsaf.meteo.pt/).

From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select "*Ethiopia*" >> "*LSA-SAF*" >> "*FAPAR*" to import the Fraction of Absorbed Photosynthetically Active Radiation product. Select for the "*Date*" the appropriate time stamp, here use is made of the data for 10 June 2012, note that the product is generated once a day. Specify the time stamp according to the format required in the "*Date*" field (e.g. "*20120610*"). Press "*Import*" to start the import. Check during import the command window which is activated and also have a look at information displayed in this window.

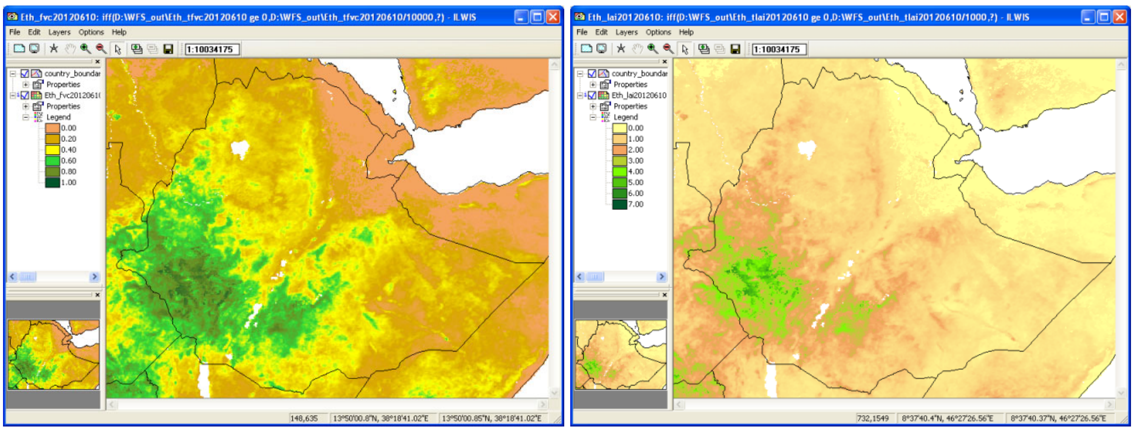
After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select "*Window*" and "*Refresh F5"*) and note the file that has been created: "*Eth_fapar**" (*=yyyymmdd). Display this map, using as Representation "*fapar*", also add the country boundaries (no info, boundaries only using a black colour). Check the values obtained, note that the FAPAR unit is in percentage, 0 to 1, 1=100 percent. Your results should resemble those of figure 4.3.3C, close all open maps when finished.

Before you continue, close all active map windows. Eventually close ILWIS to continue with the other exercises at a later stage.

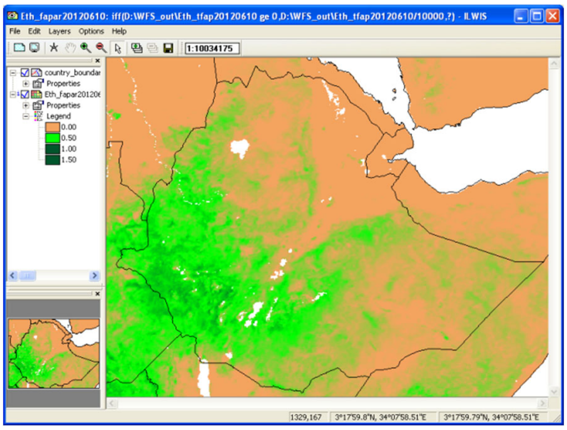
Note that a lot of additional online information is provided with respect to the products that are used here, check the LSA-SAF webpages, available at: http://landsaf.meteo.pt/.

Figure 4.3.3: LSA SAF vegetation products Fraction of Vegetation Cover (FVC), Leaf Area Index (LAI) and (Fraction of Absorbed Photosynthetically Active Radiation FAPAR)

A: FVC B: LAI



C: FAPAR



4.4 ETHIOPIA – CREATE DAILY ET MAP

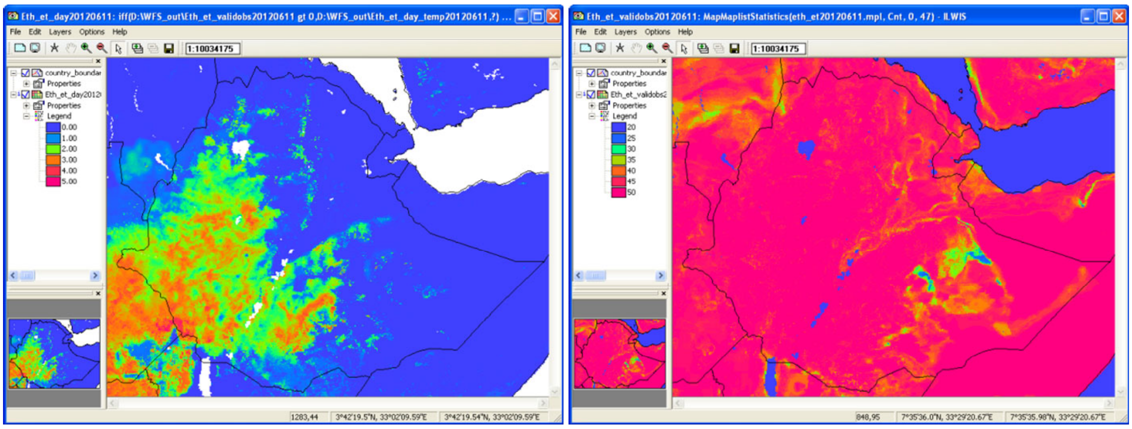
As could be noted from the previous exercise when importing the SAF data, some products are aggregated at daily level and other products are produced at 15 or 30 minutes temporal intervals. This is also the case with the Evapotranspiration (ET) product. To obtain a daily product for the ET all 30 minutes products over a 24 hour period (from 00:00 to 23:30 UTC) can be summed and the total ET can be calculated. To optimize this routine a batch looping procedure is used which copies all ET products for a certain day (48 products) and subsequently imports the data, creates an ILWIS map list and performs a number of map list statistics functions, like sum (to obtain the total ET) and count (to obtain the number of valid observations).

Before you continue, check the settings of the directories that contain the raw data. From the "*WFS_Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*LSA_SAF*". Browse to the appropriate data input and output locations and in this case the SAF ET data is stored in directory: "*D:\WFS_Ethiopia_TrainingData\SAF_LSA*" (where "*D:*" is the designated hard disk drive location). Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

From the WFS-Ethiopia Toolbox menu, select "*Ethiopia*" >> *"LSA-SAF ET daily*" >> "*SAF_ET daily*", specify the appropriate Date stamp (in yyyymmdd format), here you can enter "*20120611*" and press import. After import has started a command line interpreter windows shows the progress of the import routine, note the time stamp. After import of all 48 events is completed ILWIS calculates the required aggregate statistics. Wait until the routine has finished and then open the newly created map ""*Eth_et_day20120611*", use a "*Pseudo*" Representation. Browse with the mouse, keeping the left mouse button pressed over the map display to see the ET values.

Right click with the mouse on the map "*Eth_et_validobs20120611*" and from the context sensitive menu select the option "*Statistics*" >> "*Histogram*" and press "*Show*". As can be seen from this histogram more than 85 % of the region has 40 or more valid observations, about 10 % has 0 valid observations (these are open water bodies or the ocean), so about 5 % of the observations are having a risk of underestimation of the ET. Close the histogram and display the map "*Eth_et_validobs20120611*" using a "*Pseudo*" Representation, stretch the map from 22 (min) to 48 (max) to see the spatial distribution. Your results should resemble those given in figure 4.4.1.

Figure 4.4.1: Daily ET and number of valid observations for 20120611



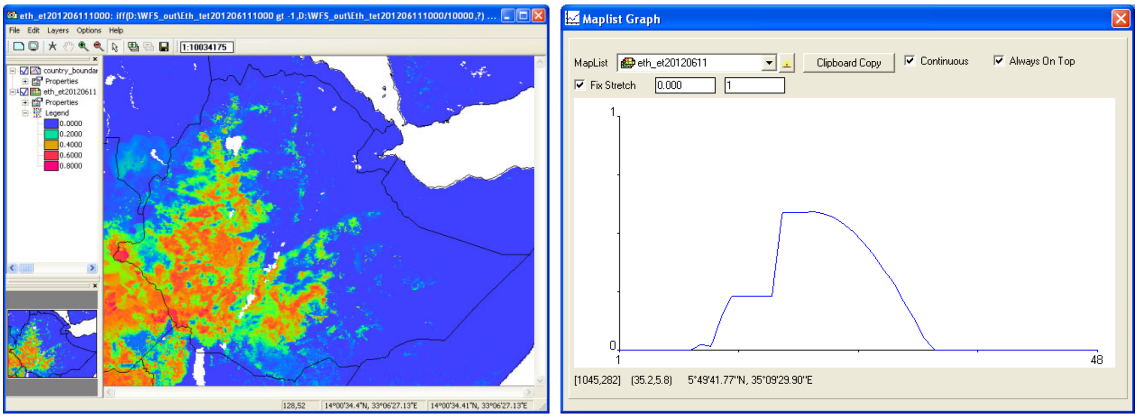
Note that all maps that have been imported and the map list are also available. Open the Map List "*eth_et20120611*" by double clicking with the left mouse button on the file name, note once more the different icon , belonging to a map list. Note the content of the map list, ET maps from 1 to 48 represent the 48 half hourly events of 11 June 2012. To display the map list, select as visualization option "*Open as Slide Show*", by clicking on the icon in the map list display window. For the "*Display Options*" select as Representation "*Pseudo*" and press "*OK*", for the new window showing more "*Display Options*", like "*Refresh rate*", the defaults can be accepted, continue by pressing OK.

Visually inspect the changes that have occurred over the day, also note the occurrence of the "not a value"/ undefined pixels. After you have inspected the map list, close the map list display window.

Open the map list "*eth_et20120611*" once more and now select the layer "*eth_et201206111000*", double click on this layer with the left mouse button and as Representation select "*Pseudo*", press "*OK*" to display the map showing the ET at 10:00 UTC. Now from the ILWIS main menu, select: "*Operations*" >> "*Statistics*" >> "*MapList*" >> "*MapList Graph*". Select as "*MapList*" "*eth_et20120611*". Activate the option: "Fix Stretch", select as minimum "*0"* and as maximum "*1"*. Also activate the options "*Continuous*" and "*Always On Top*". Note that the X-axis of the graph represents the time, here the time steps from 00:00 to 23:30 UTC and the Y axis is the ET, in mm/hr! Move the mouse cursor over the map "*eth_et201206111000*" (it might have disappeared under the main ILWIS window!) and check the corresponding ET values in the graph for a given pixel over the daily time range, in this case for 11 June 2012. Your results should resemble those of figure 4.4.2. Undefined pixels (not having a value) are represented by a dashed red line.

Note that with the "*Clipboard Copy*" option the time stack for a certain pixel can be copied to clipboard to be pasted into a spread sheet. In order to do so it is necessary to uncheck the option "*Continuous*" and click in the map on the desired location. The coordinate information / row-column number is provided in the Map List Graph window in the lower left hand corner.

Figure 4.4.2: ET map of 20120611 at 10:00 UTC (left) and the map list graph for the whole day for a selected pixel location (right)



Close all active map windows before you continue and open once more the map "*eth_et20120611*" using a *"Pseudo"* Representation. From the menu of the map "*eth_et20120611*", select "*Layer*", "*Add Layer*" and select the point map "*my_observations*", press "*OK*" twice to display the point map over the ET map. Check the location of the points.

From the main ILWIS menu, select "*Operations*" >> "*Point Operations*" >> "*Pointmap cross*". As Pointmap use "*my_observations*", as Map List use "*eth_et20120611*" and as Output Point Map specify: "*ET_locations*". A new point file "*ET_locations*" is created, but more important is the new table created. Open the table "*ET_locations*" and check the content. Note that for every point location you have the ET values for each of the 48 events in the map list. This can be very handy if you want to link your data with ground based observations. When you right click with the mouse on the table "*ET_locations*", select "Table Operations" >> "Transpose Table" and specify a new table name. After the operation has completed open this new table and check the content once more and take note of the record order in the transposed table!

Before you continue close all active windows, apart from the main ILWIS window. Eventually you can delete some of the obsolete files that have been created during previous exercises. Note that daily products can be obtained from LSA-SAF directly. Check the link below: https://landsaf.ipma.pt/en/products/evapotranspiration/.

4.5 ETHIOPIA – IMPORT SOIL MOISTURE INDEX MAP OF HYDROLOGY SAF

The first global product of consistent surface and root zone soil moisture available NRT for the NWP, climate and hydrological communities, it is based on ASCAT surface soil moisture data assimilation in the ECMWF Land Data Assimilation System. In the soil moisture assimilation system, the surface observation from ASCAT is propagated towards the roots region down to 2.89 m below surface, providing estimates for 4 layers (thicknesses 0.07, 0.21, 0.72 and 1.89 m). The ECMWF model generates soil moisture profile information according to the Hydrology Tiled ECMWF Scheme for Surface Exchanges over Land (HTESSEL) (source: http://navigator.eumetsat.int/). On a daily basis a file is currently disseminated via GEONETCast.

From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*H_SAF*". Browse to the appropriate data input and output locations and in the case of the SM-DAS-V2 global soil moisture products note that the data is stored in "*D:\WFS_Ethiopia_TrainingData\H_SAF"*, where "*D:*" is the designated hard disk drive location. Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

In order to import the H-SAF Soil Moisture products, from the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Ethiopia*" >> "*H-SAF*" >> "*SM-DAS-V2*". Import a soil moisture index map for the following Date (yyyymmdd): "20140520". Note that during import 4 layers are extracted representing the various root zones. After import is double click on the mapview icon "*eth_sm_das2_20140520*" and use as display option "Open as slide show", as Representation use "*Pseudo*" and click "*OK*" twice. Add the country boundary vector file "*country_boundaries*", no info and boundaries only, use a black colour for the boundaries.

4.6 Ethiopia – Import cloud parameters from the NWC SAF

The Nowcasting SAF is producing, using their NWC-SAF Geo Software Package, a number of Geostationary Nowcasting cloud products derived from MSG are produced, like cloud top temperature, height, pressure, cloudiness, cloud mask (including dust and volcanic ash flags), cloud phase and cloud classification. The products are disseminated at full MSG spatial and temporal resolution (source: http://navigator.eumetsat.int/). Note that this service is restricted to the national meteorological agencies and their partner organizations. Some sample data is available in the 'training data' directory.

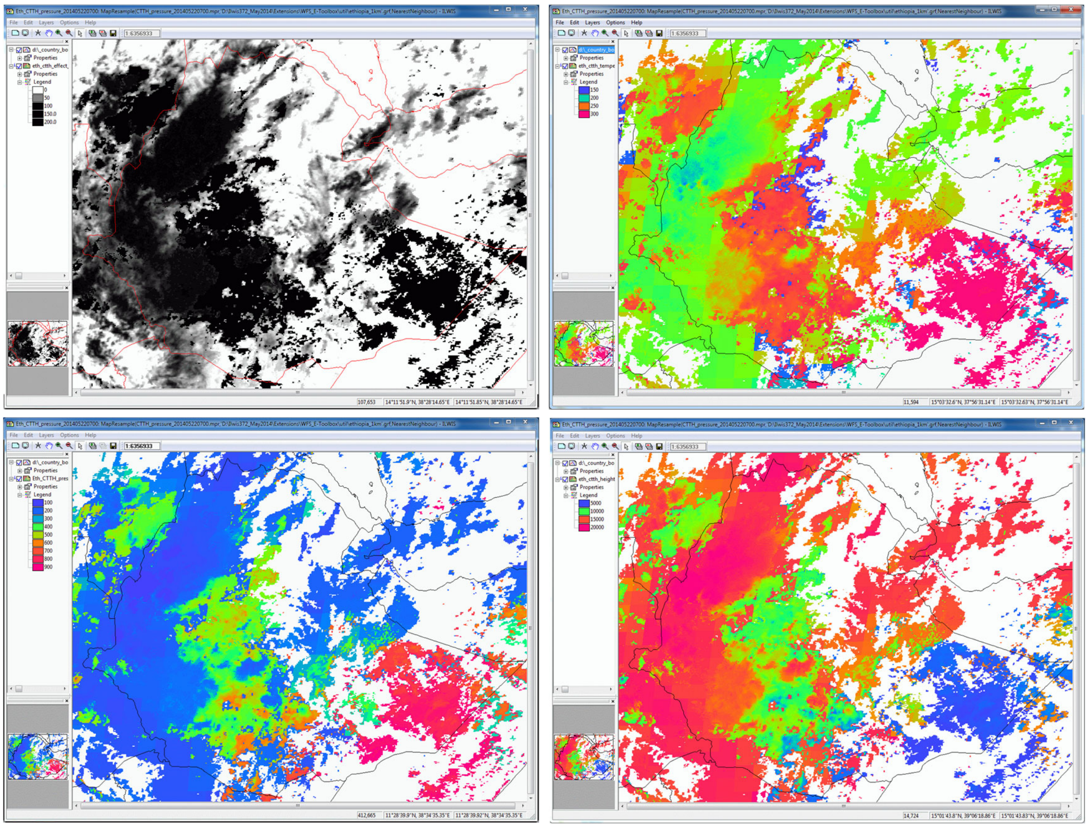
From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*NWC_SAF*". Browse to the appropriate data input and output locations and in the case of the Nowcasting products note that the data is stored in "*D:\WFS_Ethiopia_TrainingData\NWC_SAF*", where "*D:*" is the designated hard disk drive location. Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

In order to import the NWC-SAF Cloud Type product, from the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Ethiopia*" >> "NWC-*SAF*" >> "*Cloud Type*". Import a cloud classification map for the following Date (yyyymmddhhmm): "*201405220700*". Upon import two files are created, the cloud type and cloud phase.

After the import is completed, select the map "*eth_type_201405220700*", use the default Representation "*nwc_ctg*" and press "OK". Also add the country boundary vector file "*country_boundaries*", no info and boundaries only, use a black colour for the boundaries. Move the mouse cursor over the map keeping the left mouse button pressed and check the cloud classification. Also display the map "*Eth_phasec_201405220700*", now use as default Representation "*nwc_phase*" and press "*OK*", add the country boundary vector file and move the mouse cursor once more over the map keeping the left mouse button pressed and check the cloud phase.

In order to import the NWC-SAF Cloud Height/Temperature product, from the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Ethiopia*" >> "NWC-*SAF*" >> "*Cloud Height\Temperature*". Import this cloud product for the following Date (yyyymmddhhmm): "*201405220700*". Upon import four files are created, the cloudiness, temperature, pressure and height. Display the map "*Eth_CTTH_effect_201405220700*", using as Representation "*Inverse*", note the unit is percentage. Display also the layers "*Eth_CTTH_height_201405220700", "Eth_CTTH_pressure_ 201405220700"* and *"Eth_CTTH_temperature_201405220700",* using as Representation "*Pseudo*", the unit is meters (for the height), hPa (for the pressure) and Kelvin (for temperature). Your results should resemble those of figure 4.6.1. Close all open map layers.

Figure 4.6.1: Nowcasting Cloudiness, Temperature, Pressure and Height



4.7 ETHIOPIA - TAMSAT 10 DAY AND MONTHLY RAINFALL PRODUCT

The TAMSAT *R*ain*F*all *E*stimate (RFE) for Africa are ten-daily (dekadal) and monthly rainfall estimates and anomalies derived from Meteosat Thermal Infra-Red (TIR) channels based on the recognition of storm clouds and calibration against ground-based rain gauge data are currently disseminated via GEONETCast.

From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*TAMSAT*". Browse to the appropriate data input and output locations and in the case of the TAMSAT rainfall products note that the data is stored in "*D:\WFS_Ethiopia_TrainingData\TAMSAT"*, where "*D:*" is the designated hard disk drive location. Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

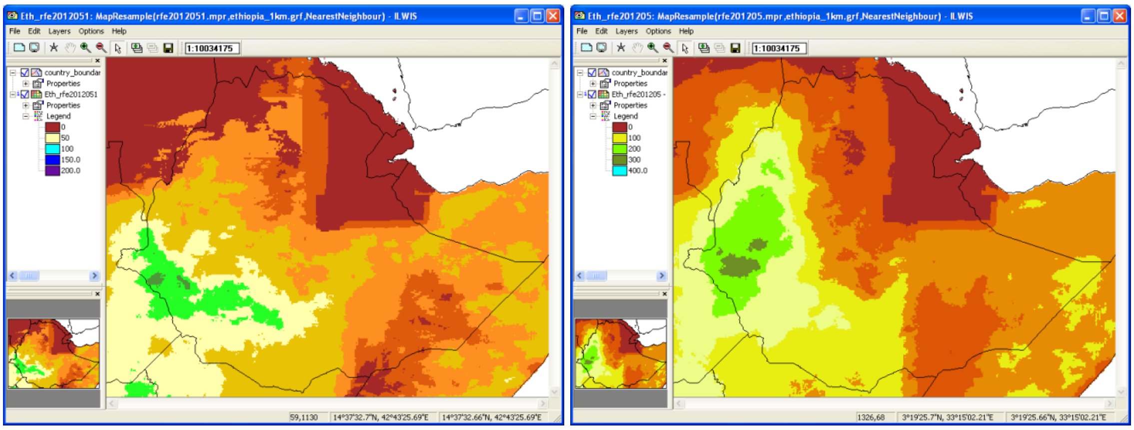
In order to import the dekadal RFE, from the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Ethiopia*" >> "*TAMSAT Rainfall Products*" >> "*TAMSAT 10 day Accumulated Rainfall Ethiopia*".

Import the dekadal rainfall map for the first dekade of May 2012, enter "*2012051*". Note the format that is required for the Date stamp (yyyymmdek).

After the import is completed open the file "*Eth_rfe2012051"*, use as Representation "*rfe_dec*". Add the country boundary vector file "*country_boundaries*", no info and boundaries only, use a black colour for the boundaries.

Conduct the import of the other 2 dekades of May 2012 ("*2012052*" and "*2012053*") and optionally calculate the total monthly precipitation by adding the three dekadal maps to obtain the total monthly precipitation (in mm!). Display this map using as Representation "*rfe_month*". Browse with the left mouse button pressed over the map and note the values. Note that you can also use the "*TAMSAT monthly Accumulated Rainfall Ethiopia*" import option available under "*Ethiopia*" >> "*TAMSAT Rainfall Products*". As "*Date*" format yyyymm is expected, so enter for Date: "*201205"*. Conduct the import and display the map "*Eth_rfe20125*" using as Representation "*rfe_month*". The RFE map of the first dekade of May 2012 (right) and of the month of May 2012 (left) is also given in figure 4.7.1.

Figure 4.7.1: RFE map of the first dekade of May 2012 and of the month of May 2012



Compare your own calculated monthly RFE with the TAMSAT monthly RFE product; you can calculate the difference by subtracting the monthly precipitation maps.

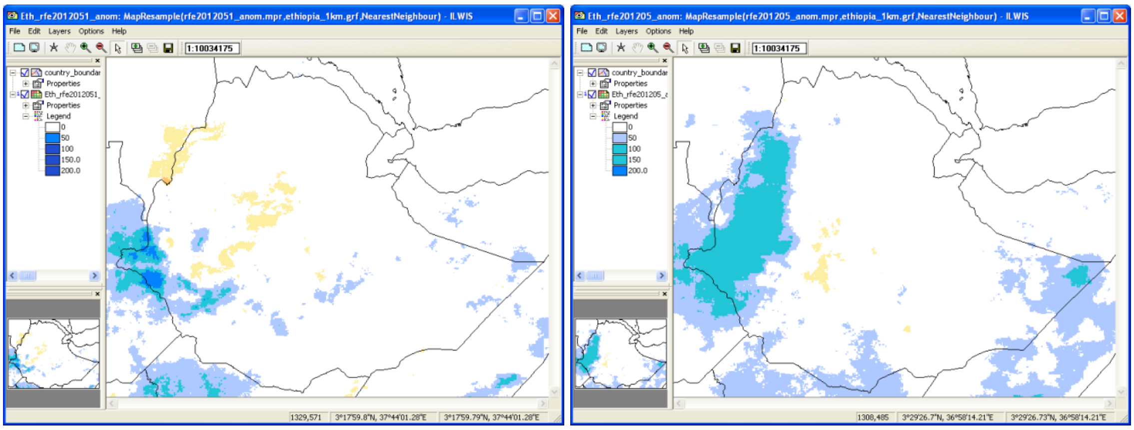
TAMSAT is also providing anomaly maps, using a climatology (from 1983-2012). In order to import the anomaly RFE for the 1st dekade of May 2012, select from the "*WFS-Ethiopia*" and "*Toolbox*" main menu the option under "*Ethiopia*" >> "*TAMSAT Rainfall Products*" >> "*TAMSAT 10 day accumulated rainfall anomaly Ethiopia*".

Import the dekadal anomaly rainfall map for the first dekade of May 2012, enter "*2012051*". Note the format that is required for the Date stamp (yyyymmdek).

After the import is completed open the file "*Eth_rfe2012051_anom"*, use as Representation "*rfe_anom_dec*". Add the country boundary vector file "*country_boundaries*", no info and boundaries only, use a black colour for the boundaries.

Repeat above procedure, but now select the import option "*TAMSAT monthly accumulated rainfall anomaly Ethiopia*" and as Date stamp specify "*201205*" and press "*Import*". After the import is completed open the file "*Eth_rfe201205_anom"*, use as Representation "*rfe_anom_month*". Add the country boundary vector file "*country_boundaries*", no info and boundaries only, use a black colour for the boundaries. Your results should be identical to those given in figure 4.7.2.

Figure 4.7.2: RFE anomaly map for 1st dekade May 2012 (left) and the month of May 2012 (right)



As a general remark note that the legend classes in the left hand ILWIS map window do not properly reflect - represent your data range. It is advised to always check the map values using the mouse, keeping the left mouse button pressed. You can also consult the histogram.

4.8 ETHIOPIA - IMPORT PROBA-V PRODUCTS

Proba-Vegetation derived products are being disseminated through GEONETCast for Africa and Latin America as a follow-up of the SPOT Vegetation instrument. First the NDVI product for Ethiopia will be retrieved. Further information can be obtained from http://land.copernicus.eu/global/products/NDVI. Product user manuals are available from http://land.copernicus.eu/global/sites/default/files/products/GIO-GL1_PUM_NDVIV1_I1.00.pdf and http://land.copernicus.eu/global/sites/default/files/products/ GIOGL1-ProductUserManual-NDVI-V2-I1.31.pdf.

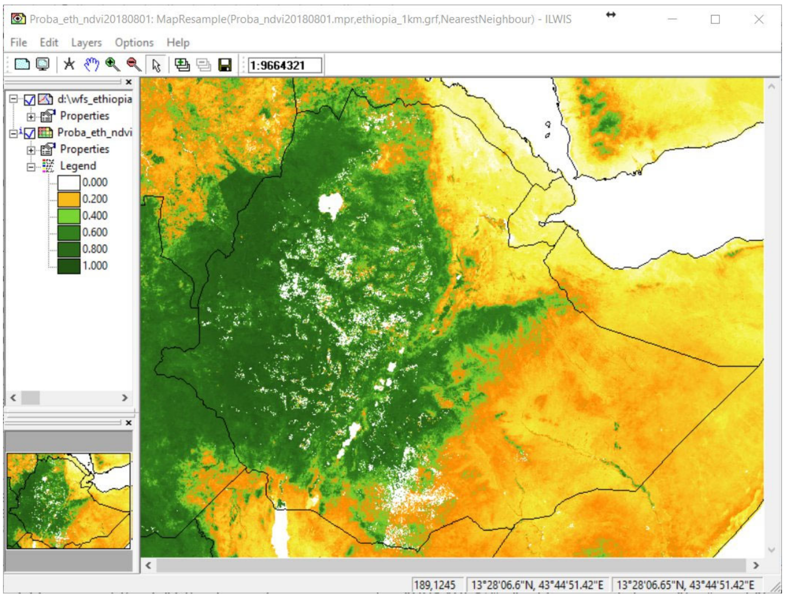
From the "*WFS-Ethiopia" and "Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*PROBA V Africa*". Browse to the appropriate data input and output locations and in the case of PROBA note that the data is stored in "*D:\WFS_Ethiopia_TrainingData\ProbaV"*, where "*D:*" is the designated hard disk drive location. Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

In order to import the dekadal Proba-V NDVI, from the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Ethiopia*", "*PROBA V Products*", "*PROBA V Africa*" and "*NDVI*".

Import the dekadal NDVI map for the first dekade of August 2018, enter "*20180801* ". Note the format that is required for the Date stamp (yyyymmdekdek).

After import the import is completed open the file "*Proba_ndvi20180801"*, use as "*Representation*" "*NDVI1*". Add the country boundary vector file "*country_boundaries*", no info and boundaries only, use a black colour for the boundaries.

Figure 4.8.1: Proba-V NDVI of 20180801 for Ethiopian window



In a similar manner also the PROBA ‘FCover’ and ‘LAI’ products can be retrieved. Note that for the FCover and the LAI the time stamp required is “*20180810*”. Note the file name / date convention from the command line of the import dialog box. As Representations “*fvc*” and “*lai*” can be used respectively. Add the country boundary vector file “*country_boundaries*”, no info and boundaries only, use a black colour for the boundaries.

To import the dekadal Proba-V 300 meter Burnt Area product, from the “*WFS-Ethiopia*” and “*Toolbox*” main menu select the option “*Ethiopia*”, “*PROBA V Products*”, “*PROBA V Africa*” and “*BA 300m*”.

Import the dekadal Burnt Area map for the last dekade of October 2018, enter “*20181031* “. Note the format that is required for the Date stamp (yyyymmdekdek).

After import the import is completed open the file “*Proba_eth_BA20181031”*, use as “*Representation*” “*Pseudo*”. Add the country boundary vector file “*country_boundaries*”, no info and boundaries only, use a black colour for the boundaries. Zoom in, check the data values (also from the left hand legend), note that the first two digits, represent the year, in this case 38, represents the year 2018, (reference year is 1980 + 38). The last 3 digits are referring to the day within the year.

Open from the toolbox menu the options “*Other Routines*” >> “*Display Julian Day tables*” >> “*Show Julian day table, normal year*”, check the date for the value “*294*”, this is 21 October! The value “*304*” represents 31 October. Note that the layer extracted for the Burnt Area product is the FDOB, which is the ‘first date of burn’.

The product is extracted over Ethiopia, as the spatial resolution is 300 meter, it is not resampled to 1 km as this might modify the original product!

4.9 ETHIOPIA - IMPORT OF OTHER SELECTED PRODUCTS.

Within the GEONETCast-EUMETCast data stream, various other near real time products are produced. In collaboration with the National Meteorological Agency, Ministry of Agriculture (Early Warning and Response Directorate) and the World Food Programme, Ethiopia office a few products have been selected and import routines have been developed. Here attention is given to fire products which also cover Ethiopia (from MSG and MODIS) and surface soil moisture derived from the ASCAT instrument on board of METOP. The exercises below elaborate into more detail how this data can be incorporated.

4.9.1 *Import MPEF-FIRC*

Next to the FIRG (see the routine under Ethiopia >> MPEF at 0 degree >> High Temporal Resolution MPEF Products), also a Fire Ascii product is created, following the XML conventions as defined for the Common Alert Protocol. You can open a FIRC file using e.g. notepad and you will observe two listings of coordinates, one classified as 'Likely' and the other classified as 'Possible'.

Before starting to import the FIRC fire product that is available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*MPEF-FIRC*". Browse to the appropriate data input and output locations and in the case of these fire products note that the data is stored in the directory "*D:\WFS_Ethiopia_TrainingData\Fire\MPEF"*, where "*D:*" is the designated hard disk drive location. Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

In order to import this type of fire information, from the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Ethiopia*" >> "*Other selected products*" >> "*MPEF FIRC*". To import a fire product for 201401201045, enter "*201401201045* "on the Date stamp and press "*Import*".

Upon completion of the import, open the point map "*mpef_firc_likely201401201045*", from the Display Options, select "*Symbol*" and uncheck the option "*Stretch*", as point size use "*4*" and as Fill Color select "*Red*" and press "*OK*" (twice). Now from the menu of the active point map window, select "*Layers*" and Add Layer, and select the layer "*mpef_firc_possible201401201045*". From the Display Options, select "Symbol" and uncheck the option "*Stretch*", as point size use "*2*" and as Fill Color select "*Orange*" and press "*OK*" (twice). Add the country boundary vector file "*country_boundaries*", no info and boundaries only, use a black colour for the boundaries. From the menu of the active map display, select "*File*" >> "*Open Pixel Information*" and move your cursor over a fire pixel and note the content of the pixel information window over that fire location. Eventually zoom in on a fire location.

The point map 'MPEF_FIRC_Possible201401201045' contains fires having a probability of less or equal 50 percent. The point map 'MPEF_FIRC_Likely201401201045' contains the fires having a probability greater than 50 percent, see also figure 3.11. In the associated tables the fire radius is given for each location.

4.9.2 *Import ABBA – MSG fire product*

Currently within the AMESD-SADC service on GEONETCast there is a fire product, the so called Automated Biomass Burning Algorithm (ABBA) product, showing the MSG Active Fires captured for whole Africa. Further information can be obtained from http://cimss.ssec.wisc.edu/goes/burn/wfabba.html. Fire locations are provided as well as additional fire characteristics, like instantaneous fire size, fire temperature and fire radiative power. Upon extraction of the product it is provided as tabular information.

Before starting to import the ABBA fire product that is available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*ABBA-MSG*". Browse to the appropriate data input and output locations and in the case of these fire products note that the data is stored in the directory "*D:\WFS_Ethiopia_TrainingData\Fire\ABBA"*, where "*D:*" is the designated hard disk drive location. Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

In order to import this type of fire information, from the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Ethiopia*" >> "*Other selected products*" >> "*ABBA-MSG Fire product*". To import a fire product for 20120120715, enter "*20120120715* "on the Date stamp and press "*Import*". Note the format that is required for the Date stamp as here Julian Day is used (yyyyjjjhhmm).

After the import is completed open the raster map "*ABBA_MSG20120120715"*, use the default Representation. Add the country boundary vector file "*country_boundaries*", no info and boundaries only, use a black colour for the boundaries. Also add the point map having the same name, using the default display settings. From the menu of the active map display, select "*File*" >> "*Open Pixel Information*" and move your cursor over a fire pixel and note the content of the pixel information window over that fire location. Eventually zoom in on the map, as example see also figure 3.12.

4.9.3 *Import multiple MODIS Aqua and Terra Fire Products*

This is the most basic fire product in which active fires and other thermal anomalies, such as volcanoes, are identified. The Level 2 product is defined in the MODIS orbit geometry covering (per image) an area of approximately 2340 by 2030 km in the across- and along-track directions, respectively. It is used to generate all of the higher-level fire products, and contains the following components:

- an active fire mask that flags fires and other relevant pixels (e.g. cloud);
- a pixel-level quality assurance (QA) image that includes 19 bits of QA information about each pixel;
- a fire-pixel table which provides 19 separate pieces of radiometric and internal-algorithm information about each fire pixel detected within a granule;
- extensive mandatory and product-specific metadata;
- a grid-related data layer to simplify production of the Climate Modeling Grid (CMG) fire product.

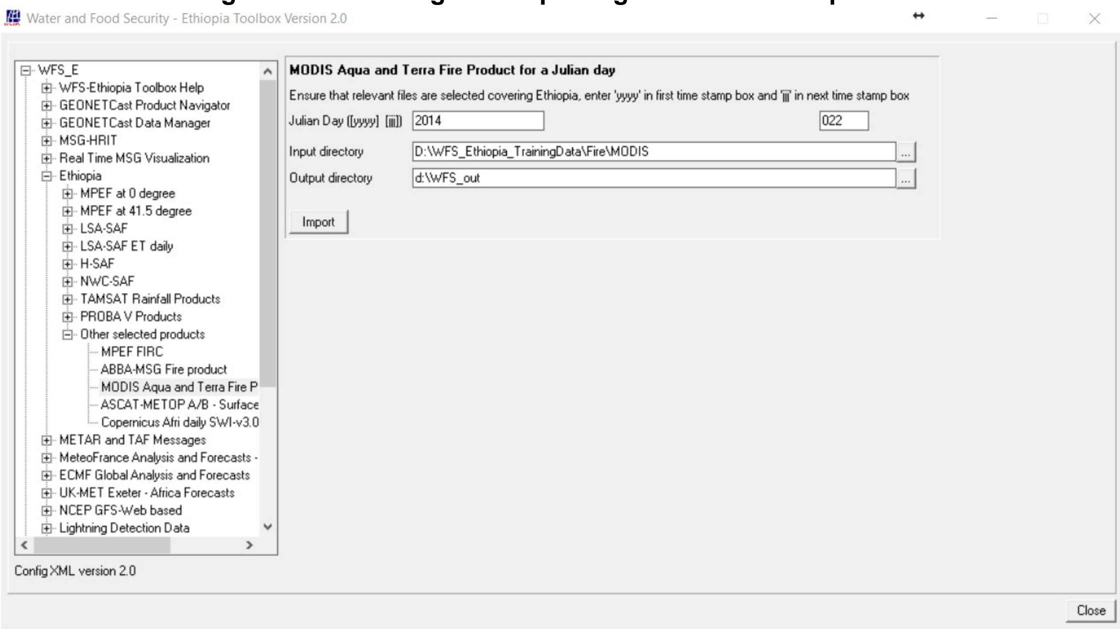
Product-specific metadata within the Level 2 fire product includes the number of cloud, water, non-fire, fire, unknown, and other pixels occurring within a granule to simplify identification of granules containing fire activity (source: Geonetcast Product Navigator).

Keep in mind that the MODIS Terra is passing over the equator during the morning and evening, the Aqua is having an afternoon and night time overpass (local time). As this MODIS Fire Product is a global product 2 * 288 files are generated which need to be processed on a daily basis to cover the whole globe. If you only want to select a certain area and therefore only those MODIS Terra and Aqua fire products that are recorded over Ethiopia for a certain Julian day use can be made of Satellite Orbit Tracking software utilities, see also Appendix 1. In such a case the selected files need to be copied into a specific directory. By default the routine processes the data for a given Julian day, so potentially 576 files are retrieved and if containing fires these are further processed.

Before starting to import the MODIS fire products that are available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select “*MODIS-Fire*”. Browse to the appropriate data input and output locations and in the case of these MODIS products note that the data is stored in the directory “*D:\WFS_Ethiopia_TrainingData\Fire\MODIS”*, where “*D:*” is the designated hard disk drive location. Here as output location “*D:\WFS_out*” is used. Press “*Save*” to store the settings.

In the “*WFS-Ethiopia*” and “*Toolbox*” main menu select the option “Ethiopia” >> “Other selected products” >> “*MODIS Aqua and Terra Fire Product for a Julian Day*”. Having relevant files covering Ethiopia in the input sub-directory (here the sub-directory “*MODIS*” is used), you can start the import of the multiple MODIS fire files. Specify the appropriate year (“*2014*”) and Julian day number (“*022*”) and press “*Import*”. See also the figure below. The import will start and processes all files, for those that contain fires, the vector files will be retrieved and transformed into a point map with associated table. Also check the command line window information during the import. Wait until the import has finished and refresh the catalogue of your working directory.

Figure 4.9.1: Settings for importing the MODIS Fire product



After the import has been completed open the raster map “*MODISfire_2014022*” using default display settings. Don’t feel disappointed when you think you have an empty map! Select the option “*Layers*” and “*Add Layers*” from the active map menu, select the point map “*MODISfire_2014022*”, press “*OK*” and press the option “*Symbol*”, as Size specify “*2*” and as Fill Color use “*Red*”, press “*OK*” twice.

Add the country boundary vector file “*country_boundaries*”, no info and boundaries only, use a black colour for the boundaries. Also add the point map having the same name, using the default display settings. From the menu of the active map display, select “*File*” >> “*Open Pixel Information*” and move your cursor over a fire pixel and note the content of the pixel information window for the attributes given over that fire location. Eventually zoom in on the map, as example see also figure 3.13.

To retrieve only the fires having a confidence of higher than e.g. 50 % use the following procedure. Double click with the mouse on the table “*MODISfire_2014022*”. In the table command line type the following expression:

conf_new:=iff(conf>=50,conf,?)

and press “*OK*”. Check the newly created column “conf_cl50”. Close the table. Select the table “*MODISfire_2014022*” and press the right hand mouse button, from the context sensitive menu, select “*Table Operations*" and “*Table to Point Map*", as Coordinate System select “*LatLonWGS84*” and as Domain of Output map use the option “*Use Attribute Column*” and as Attribute select “*Conf_cl50*” and as output raster map specify “modisfire_2014022_cl50” and press “Show”. As Display options now use for Fill Color “Red”, uncheck the Stretch option, and as point size use “4”, press “OK” twice.

Add the country boundary vector file “*country_boundaries*”, no info and boundaries only, use a black colour for the boundaries. From the menu of the active map display, select “*File*” >> “*Open Pixel Information*” and move your cursor over a fire pixel and note the content of the pixel information window for the attributes given over a fire location and check the confidence value.

4.9.4 ***ASCAT Surface Soil Moisture processing***

The Surface Soil Moisture L2 product is derived from the Advanced SCATterometer (ASCAT) data and given in swath geometry. This product provides an estimate of the water saturation of the 5 cm topsoil layer, in relative units between 0 and 100 [%]. The algorithm used to derive this parameter is based on a linear relationship of soil moisture and scatterometer backscatter and uses change detection techniques to eliminate the contributions of vegetation, land cover and surface topography, considered invariant from year to year. Seasonal vegetation effects are modeled by exploiting the multiple viewing capabilities of ASCAT. The processor has been developed by the Institute of Photogrammetry and Remote Sensing of the Vienna University of Technology (source: GEONETCast Product Navigator). The import routine available here supports the import of the product that is available in 12.5 km point sampling distance. Further information is provided in the ASCAT Product Guide, available at: http://oiswww.eumetsat.org/WEBOPS/eps-pg/ASCAT/ASCAT-PG-index.htm.

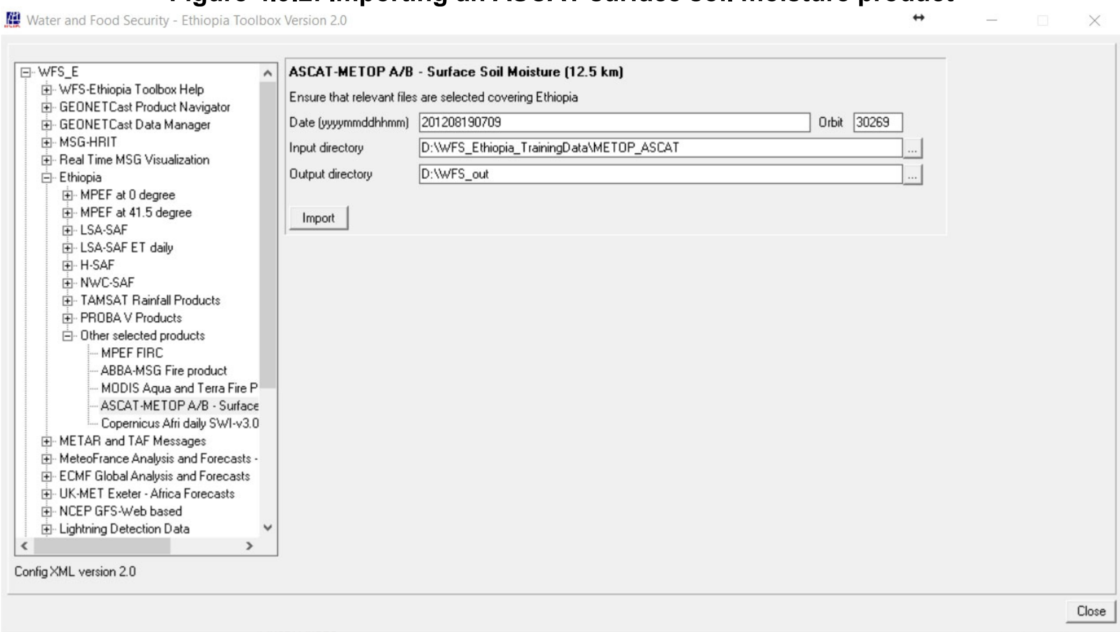
Before starting to import the ASCAT surface soil moisture products that are available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the “*WFS-Ethiopia”* and *“Toolbox*” main menu select the option “*Configuration*” and “*Folder*” and select “*METOP-SSM*”. Browse to the appropriate data input and output locations and in the case of these ASCAT products note that the data is stored in the directory “*D:\WFS_Ethiopia_TrainingData\METOP_ASCAT”*, where “*D:*” is the designated hard disk drive location. Here as output location “*D:\WFS_out*” is used. Press “*Save*” to store the settings.

It should be noted that nearly 500 products are available on a daily basis as it is a global product. Starting point of the process is to make a selection of the relevant products covering the area of interest. Use can be made of Satellite Orbit Tracking software utilities, see Appendix 1.

In the “*WFS-Ethiopia*” and “*Toolbox*” main menu select the option “Ethiopia” >> “Other selected products” >> “*ASCAT - Surface Soil Moisture (12.5 km)*”. Note the specifications from figure 4.9.2 below and conduct the import, by pressing “*Import*”.

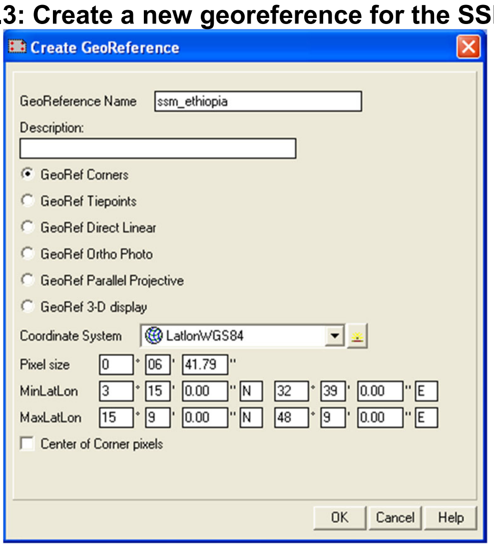
After the import has been completed, refresh the ILWIS catalogue. Note that two new files have been created, a point map “*ssm201208190709_smperc*” and the associated table “*ssm201208190709*”. First open the table “*ssm201208190709*” and inspect the content. Note that the column “SM_Perc” has been used to create the point map, close the table when finished. Display the point map “*ssm201208190709_smperc*” using the default display settings and press “*OK*”. Display also the “*country_boundaries*” and use a red boundary colour. Zoom in over one of the recorded strips, e.g. over the central-eastern part of Ethiopia and keep the left mouse button pressed to check the point values. From the active map display window activate the option “Measure Distance”, by clicking on the icon and check yourself the distance between the centers of the sampling points, both along and across track.

Figure 4.9.2: Importing an ASCAT surface soil moisture product



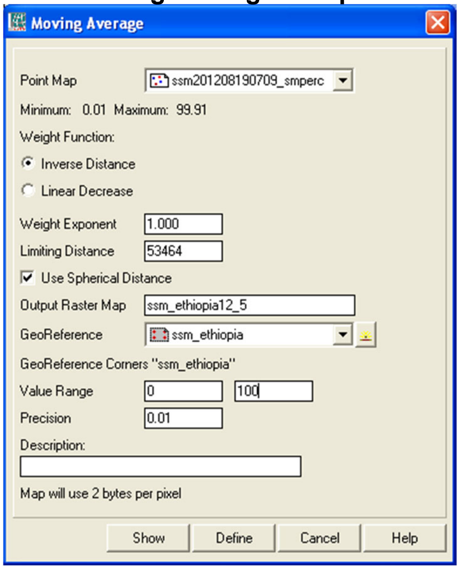
This point map can be used for interpolation. As the point sampling distance of the product is 12.5 km it does not make sense to resample it to 1 km using the "Ethiopia_1km" georeference. A new georeference can be created which can be used for the purpose of interpolation. Assuming that 1 degree at the equator is 112 km, 12.5 km represents 0.111607142 decimal degree or 0º6'41.79''. From the main ILWIS menu, select the options "*File*" >> "*Create*" >> "*Georeference*" and specify the settings as given in figure 4.9.3. Here we are using the coordinate boundaries for the "Ethiopia" window, but apply a different pixel size (which is more in line with the product resolution!). Press "*OK*" when all parameters are entered to create this new georeference.

Figure 4.9.3: Create a new georeference for the SSM product



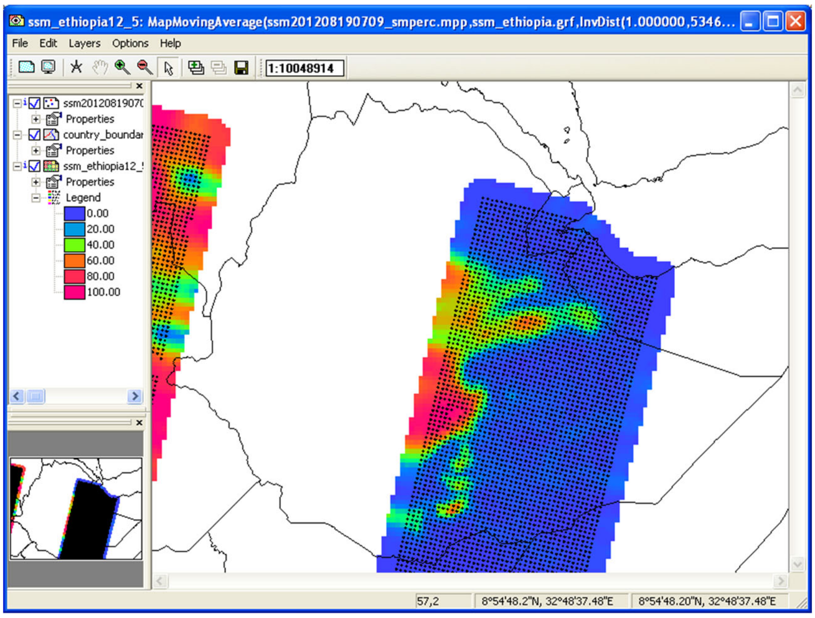
Now from the main ILWIS menu, select the options "*Operations*" >> "*Interpolation*" >> "*Point Interpolation*" >> "*Moving Average*". Specify the settings as given in figure 4.9.4 and press "*Show*".

Figure 4.9.4: Moving Average Interpolation settings



Wait until the interpolation procedure has finished and display the resulting raster map, here specified as "*ssm_ethiopia12_5*", using as Representation "*Pseudo*" and add the "*country_boundaries*". Note that for the interpolation a Spherical Distance is used as here the georeference used is having geographic coordinates. Also add the point map, in the point map display window use the button "*Symbol*", now uncheck the "*Stretch*" option, as point size use 2 and as fill colour select "*Black*". Press "*OK*" to show this point map. Check the values of the map using Pixel Information. Your results should resemble those given in figure 4.9.5.

Figure 4.9.5: Interpolated Surface Soil Moisture Map, using a moving average method



4.9.5 *Copernicus global daily Soil Water Index*

The Copernicus global Soil Water Index product provides global daily information about moisture conditions in different soil layers. SWI daily images are produced from EUMETSAT ASCAT-25km SSM product in orbit format and include a quality flag indicating the availability of SSM measurements for SWI calculations. Soil moisture is a key parameter in numerous environmental studies including hydrology, meteorology and agriculture. In addition to Surface Soil Moisture (SSM), information on the moisture condition within the underlying soil profile is of interest for different applications. Soil moisture in plant root zone can be estimated by an infiltration model using information on surface soil moisture and soil characteristics (source: http://navigator.eumetsat.int).

The SWI algorithm uses an infiltration model describing the relation between surface soil moisture and profile soil moisture as a function of time. The algorithm is based on a two-layer water balance model proposed by Wagner et al. (1999) to estimate profile soil moisture from SSM retrieved from scatterometer data. A computational adaption of SWI algorithm has been made based on a recursive formulation proposed by Albergel (2008). The SWI retrieval method does not account for soil texture, which determines the relation between the characteristic time (T) value and the soil depth. Therefore 8 T values (T=1, 5, 10, 15, 20, 40, 60 and 100) are provided to give more possibility to the users for selecting the best matching data (source: http://land.copernicus.eu/global//products/SWI).

Before starting to import the SWI product available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*Copernicus*". Browse to the appropriate data input and output locations and in the case of the SWI products note that the data is stored in the directory "*D:\WFS_Ethiopia_TrainingData\Copernicus"*, where "*D:*" is the designated hard disk drive location. Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

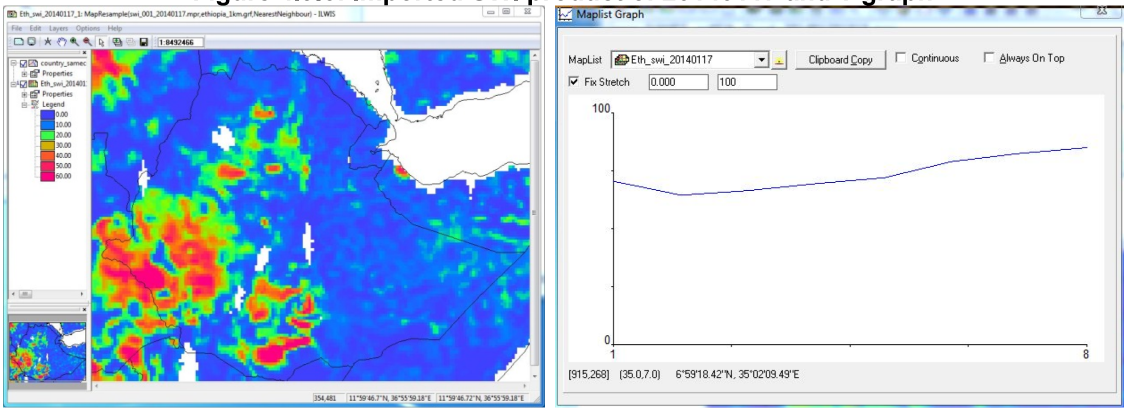
In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "Ethiopia" >> "Other selected products" >> "*Copernicus Global daily SWI-v2*". Note the specifications for the 'Date' stamp and specify here "*20140117*", conduct the import by pressing "*Import*". Note that the product is extracted for the Ethiopian window only.

After the import is completed open the map list "*Eth_swi_20140117*" and from this map list select the layer "*Eth_swi_20140117_1*", representing time step '1', select as Representation "Pseudo" and display the map. Browse with the mouse, keeping the left mouse button pressed over the map and inspect the values (in percentage).

Now from the ILWIS main menu, select: "*Operations*" >> "*Statistics*" >> "*MapList*" >> "*MapList Graph*". Select as "*MapList*" "*Eth_swi_20140117*". Activate the option: "Fix Stretch", select as minimum "*0"* and as maximum "*100"*. Also activate the options "*Continuous*" and "*Always On Top*". Note that the X-axis of the graph represents the time, here the time steps from T1 to T 100 and the Y axis is the WSI, in percentage. Move the mouse cursor over the map "*Eth_swi_20140117_1*" (it might have disappeared under the main ILWIS window!) and check the corresponding WSI values in the graph for a given pixel over the characteristic time range, in this case for 17 January 2014. Your results should resemble those of figure 4.9.6. Undefined pixels (not having a value) are represented by a dashed red line.

Note that with the "*Clipboard Copy*" option the time stack for a certain pixel can be copied to clipboard to be pasted into a spread sheet. In order to do so it is necessary to uncheck the option "*Continuous*" and click in the map on the desired location. The coordinate information / row-column number is provided in the Map List Graph window in the lower left hand corner.

Figure 4.9.6: Imported SWI product of 20140117 and T graph



4.10 METEOROLOGICAL DATA SERVICES

As stated already in chapter 3, the data disseminated by these services are restricted to National Meteorological Services and their Partner Organizations. Import routines have been developed in collaboration with the National Meteorological Agency (NMA) of Ethiopia to allow visualization of these products, especially for the regional NMA offices. Based on their preferences a number of import routines are developed and these are further elaborated upon below.

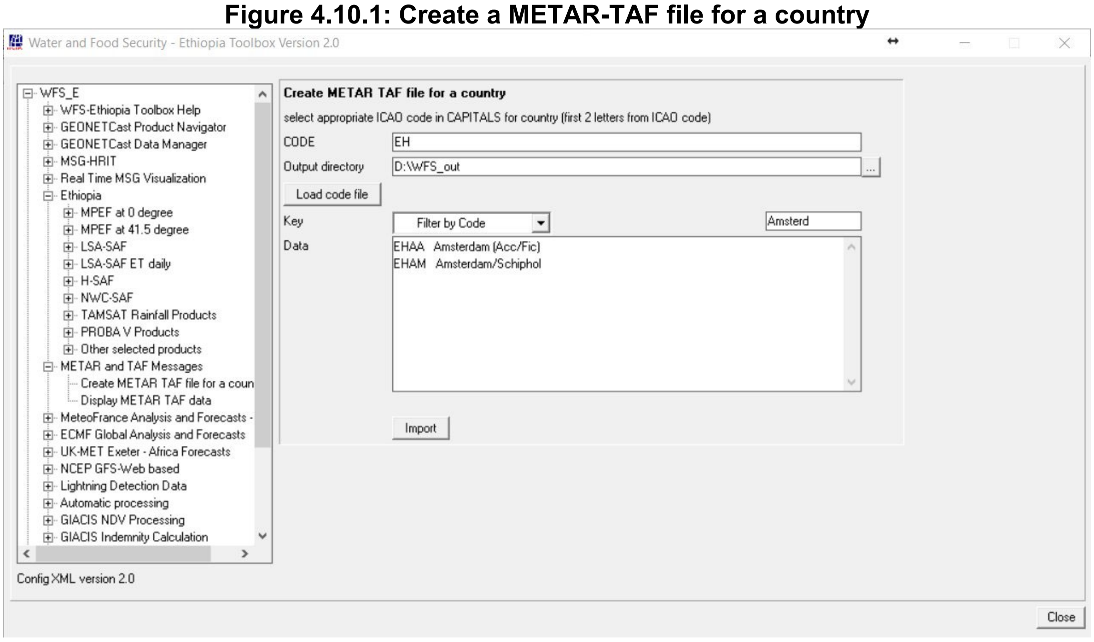
4.10.1 *GTS Service METAR and TAF*

The GTS messages provide METAR and TAF messages for the major airports in the world. On a continuous basis these coded messages are received and use is made here of a freeware utility, called "MetarWeather", for decoding and report generation. The procedure adopted is consisting of two steps. First from all messages that have been received, those messages covering a country are retrieved and the messages are stored in a new file in the specified output directory. Once this file is available these messages are loaded in "MetarWeather" for visualization of the content and generation of the reports.

Before starting to import the METAR and TAF products that are available in the GEONETCast data stream derived from the Meteorological Data Dissemination Service you need to check the settings of the directories that contain the raw data. From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*METAR-TAF*". Browse to the appropriate data input and output locations and in the case of the GFS Messages note that the data is stored in the directory "*D:\WFS_Ethiopia_TrainingData\Meteo\GTS_Messages"*, where "*D:*" is the designated hard disk drive location. Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

In order to import the GTS messages, from the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*METAR and TAF messages*" >> "*Create METAR TAF file for a country*". In the subsequent menu the country code needs to be specified according to the ICAO naming convention. The option "*Load code file*" can be used to get country codes by typing the name of a city / airport for the respective country, see figure 4.10.1 as an example for the Netherlands. The country code here is "*EH*" and should be entered under the CODE field.

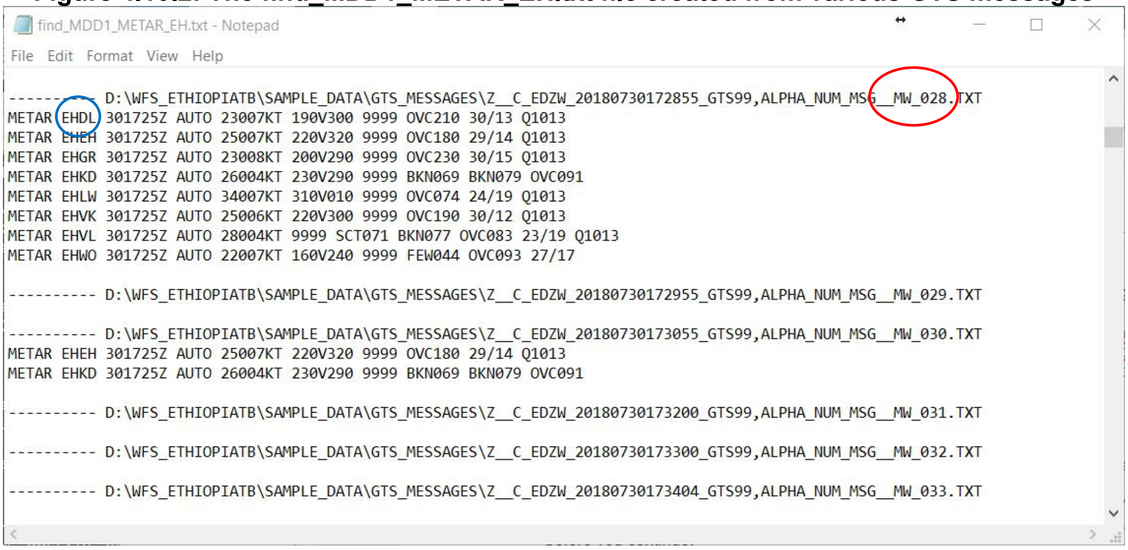
Figure 4.10.1: Create a METAR-TAF file for a country



After the appropriate code has been obtained (note it should be provided in Capitals), the routine checks the content of all GTS messages stored in the specified input directory and creates a new file in the specified output directory, called “*find_MDD1_METAR_EH.txt*”, which is displayed using notepad. Two other files are created as well, “*find_MDD1_TAF_EH.txt*” and “*find_MDD1_TAF_AMD_EH.txt*” and displayed as well, also check their content. If only the input directory\filename is displayed, without any messages, the file is not containing relevant information with respect to the country code specified.

Press “*Import*” and after the routine has finished the file “*find_MDD1_METAR_EH.txt*” is displayed and take note of the content. An example of such a file is provided in figure 4.10.2.

Figure 4.10.2: The find_MDD1_METAR_EH.txt file created from various GTS messages



```
find_MDD1_METAR_EH.txt - Notepad
File  Edit  Format  View  Help

---------- D:\WFS_ETHIOPIATB\SAMPLE_DATA\GTS_MESSAGES\Z__C_EDZW_20180730172855_GTS99,ALPHA_NUM_MSG__MW_028.TXT
METAR EHDL 301725Z AUTO 23007KT 190V300 9999 OVC210 30/13 Q1013
METAR EHEH 301725Z AUTO 25007KT 220V320 9999 OVC180 29/14 Q1013
METAR EHGR 301725Z AUTO 23008KT 200V290 9999 OVC230 30/15 Q1013
METAR EHKD 301725Z AUTO 26004KT 230V290 9999 BKN069 BKN079 OVC091
METAR EHLW 301725Z AUTO 34007KT 310V010 9999 OVC074 24/19 Q1013
METAR EHVK 301725Z AUTO 25006KT 220V300 9999 OVC190 30/12 Q1013
METAR EHVL 301725Z AUTO 28004KT 9999 SCT071 BKN077 OVC083 23/19 Q1013
METAR EHWO 301725Z AUTO 22007KT 160V240 9999 FEW044 OVC093 27/17

---------- D:\WFS_ETHIOPIATB\SAMPLE_DATA\GTS_MESSAGES\Z__C_EDZW_20180730172955_GTS99,ALPHA_NUM_MSG__MW_029.TXT

---------- D:\WFS_ETHIOPIATB\SAMPLE_DATA\GTS_MESSAGES\Z__C_EDZW_20180730173055_GTS99,ALPHA_NUM_MSG__MW_030.TXT
METAR EHEH 301725Z AUTO 25007KT 220V320 9999 OVC180 29/14 Q1013
METAR EHKD 301725Z AUTO 26004KT 230V290 9999 BKN069 BKN079 OVC091

---------- D:\WFS_ETHIOPIATB\SAMPLE_DATA\GTS_MESSAGES\Z__C_EDZW_20180730173200_GTS99,ALPHA_NUM_MSG__MW_031.TXT

---------- D:\WFS_ETHIOPIATB\SAMPLE_DATA\GTS_MESSAGES\Z__C_EDZW_20180730173300_GTS99,ALPHA_NUM_MSG__MW_032.TXT

---------- D:\WFS_ETHIOPIATB\SAMPLE_DATA\GTS_MESSAGES\Z__C_EDZW_20180730173404_GTS99,ALPHA_NUM_MSG__MW_033.TXT
```

As can be seen from this file, GTS message number 28 (see red ellipse) is containing messages for the ICAO code used (see blue circle), message number 29 is not containing valid information and message 30 has again relevant reports, etc. Close also the other two asci files created if the content has been reviewed.

For transformation of the METAR and TAF coding used into a more ‘readable’ output use is made of MetarWeather. From the “*WFS-Ethiopia*” and “*Toolbox*” main menu select the option “*METAR and TAF Messages*” >> “*Display METAR TAF data*”. When pressing “Import” the utility is opened. Select from the menu “*File*” >> “*Load METARs From File*”, browse to your output directory and select the file “*find_MDD1_METAR_EH.txt*” and press “*Open*”. A table containing the data is now provided; double clicking on a record shows the METAR Report for that specific location. As example see also figure 1.2. Close the “MetarWeather” application before you continue.

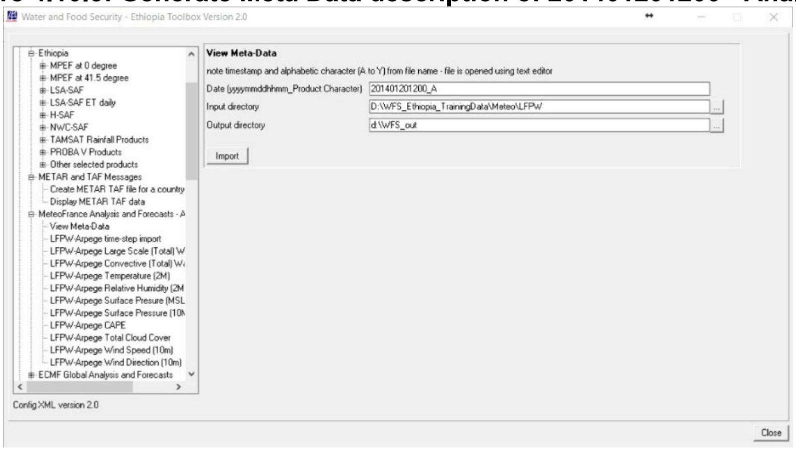
4.10.2 *MeteoFrance Analysis and Forecasts for Africa*

Data delivered from this Numerical Weather prediction model is consisting of the analysis and the forecasts and is available at 4 temporal intervals. Before importing the data first a meta data file can be extracted.

Before starting to import the Meteo France NWP products that are available in the GEONETCast data stream derived you need to check the settings of the directories that contain the raw data. From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*LFPW*". Browse to the appropriate data input and output locations and in the case of the Meteo France products note that the data is stored in the directory "*D:\WFS_Ethiopia_TrainingData\Meteo\LFPW*", where "*D:*" is the designated hard disk drive location. Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

Now from the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*MeteoFrance Analysis and Forecasts - Africa*" >> "*View Meta-Data*". Specify your settings according to the figure 4.10.3 below. Note that you have to enter the selected product time stamp (in a yyyymmddhhmm_Product Character format). Press "*Import*" to execute the routine. The meta data are generated for the 12:00 hrs analysis product for 20140120, product characters like B or C, etc. are providing the forecasts!

Figure 4.10.3: Generate Meta Data description of 201401201200 - Analysis



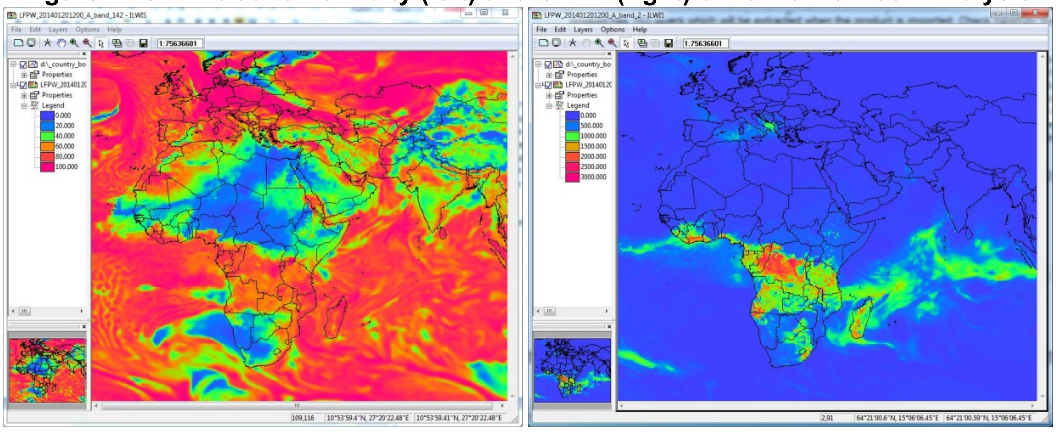
In Notepad the file "*LWPF_meta_201401201200_A.txt*" (also available in your working directory, can be used for later consultation!) a listing of the data file is presented. Note that the Analysis product has 153 layers which will be extracted when the product is imported. Check carefully the descriptions provided for 'Grib_Unit', 'Grib_Comment' and 'Grib_Forecast'.

From the same sub menu select the option "*LFPW-Arpege time-step import*" and use "*2014011200_A*" as Date _Product Character stamp and press "*Import*". After the import routine has completed, open the new map list created called "*LWPF_201401201200_A".* Note that the map list has 153 bands, identical to the description of the meta-data file. Display layer – band "*142*", representing the 'Relative Humidity at 900 hPa', as representation use "Pseudo" and press "*OK*". Display also the "*country_boundaries*" and use a black boundary colour. Zoom in over the map, e.g. over the central-eastern part of Ethiopia and keep the left mouse button pressed to check the map values and note the 'Grib_Unit'. Your results should resemble those given in figure 4.10.4. Display in a similar manner some other layers like Convective Available Potential Energy - CAPE (layer 2) or Pressure at MSL (layer 152), Use a "*Pseudo*" Representation.

In order to process the winds from this product dedicated ILWIS scripts are prepared. These scripts are situated within the 'ILWIS main directory\Scripts' and are called "*LFPW_winds*". From the ILWIS main menu, select the option "*Operations*" >> "*Script*" and activate the script

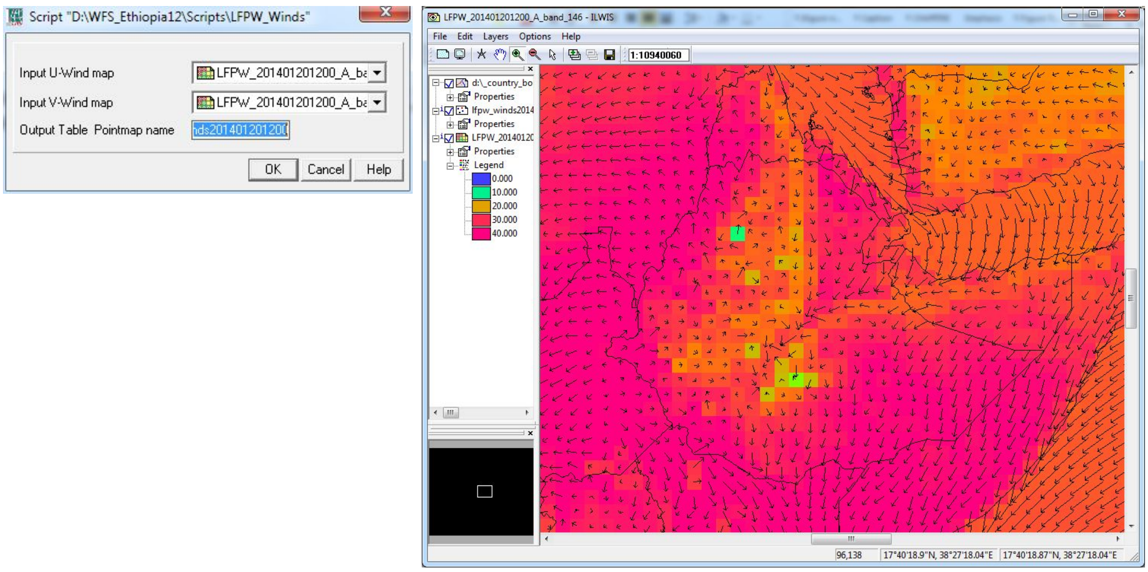
“*LFPW_winds*”. Now specify the appropriate Input U and V Wind Maps, e.g. bands “*147*” and “*148*” respectively and as output table - point map specify “*LFPW_winds201401201200*” and press “*OK*” to execute the script; see also figure 4.10.5.

Figure 4.10.4: Relative Humidity (left) and CAPE (right) of 201401201200 - Analysis



When the script has finished open from the map list “*LWPF_201401201200_A”* layer – band “*146*”, Temperature (at 2 mtr above ground level), using a “*Pseudo*” Representation”, eventually stretch the map values from “*0*” to “*35*” and press “*OK*” to display the map. From the active map window, select from the menu the option “*Layers*” and “*Add Layer*” and select the point map “*LFPW_winds201401201200*”. From the Point Map Display Options menu, select the option “*Symbols as Arrows*” and from the “*Details*” option check - activate the “*Length*” option and select as parameter from the table the column “*Windspeed*” or “*Scale_speed*” (last one used for better representation of strong winds, e.g. at lower pressure levels!) and for Direction use the column “*Winddirection*”, Press “*OK*” twice. Also display also the “*country_boundaries*” and use a black boundary colour. Zoom in over the map to your region of interest, your results should resemble those of the figure below.

Figure 4.10.5: Script and Temperature (at 2 mtr) and winds (at 10 mtr) of 201401201200 - Analysis



To easily facilitate import of the LFPW Arpege forecast from “B” to “Y” (96 hr forecast, consisting of 24 files) for a number of selected products a number of routines are available and can be selected from the menu. The table below provides some of the specifications of the products selected as provided within the Arpege – LFPW source files.

Table 4.10.1: Extracted layers of LFPW forecasts (B to Y)

Routine from menu	**Abbreviation**	**Band nr. in forecast GRIB file (B to Y)**	**Unit**
Convective available potential energy	CAPE	1	J/kg
Total cloud cover	TCC	2	%
Convective water precipitation (3_Hour Average)	CWP	3	kg.m-2
Large scale water precipitation (non-convective) (3_Hour Average)	LSWP	4	kg.m-2
Temperature (2m - Specified height level above ground HTGL)	T-2m	149	K
U-component of wind (10m -HTGL) *(1)	U-10m	150	m/s
V-component of wind (10-HTGL) *(1)	V-10m	151	m/s
Relative humidity (2-HTGL)	RH-2m	152	%
Pressure (0-MSL)	SP-MSL	153	Pa
Pressure (10 - Ground or water surface SFC)	SP-10m	154	Pa

*(1) Both U and V components of winds are required to calculated the wind direction and the wind speed (see also: http://colaweb.gmu.edu/dev/clim301/lectures/wind/wind-uv)

From the “*WFS-Ethiopia*” and “*Toolbox*” main menu select once more the option “*MeteoFrance Analysis and Forecasts - Africa*” >> “*View Meta-Data*”. Specify your settings as “*201401200000_B*”. Note that you have to enter the selected product time stamp (in a yyyymmddhhmm_Product Character format) for a forecast and not the Analysis (denoted by the suffix ‘*_A’). Press “*Import*” to execute the routine. The meta data are generated for the 00:00 hrs forecast product for 20140120, product characters is B, representing the 3 hr forecast. Note from the table given above the band numbers and check the meta data description displayed, especially for Band number 152. Close the file before you continue.

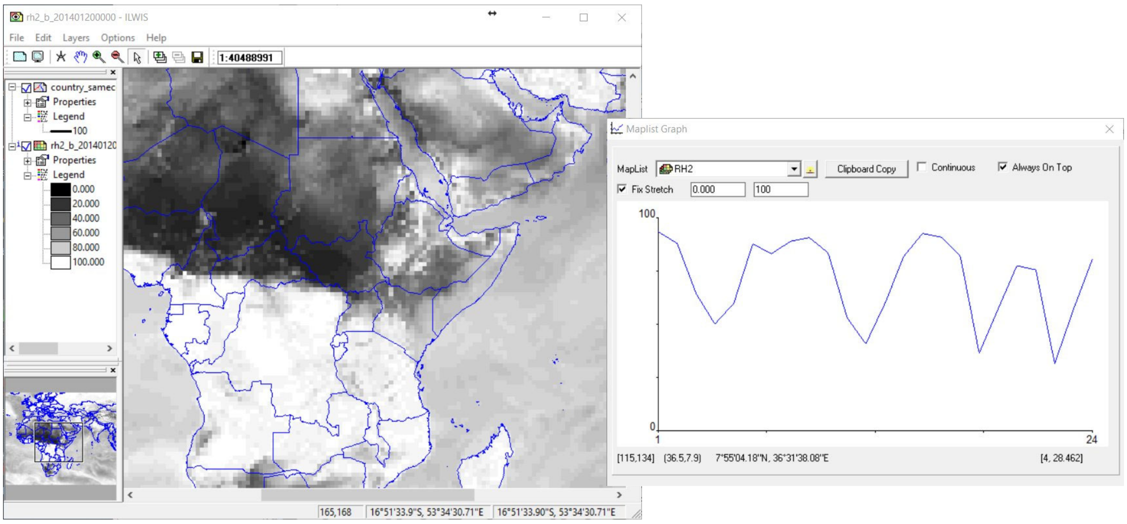
From the “*WFS-Ethiopia*” and “*Toolbox*” main menu select once more the option “*MeteoFrance Analysis and Forecasts - Africa*” >> “*LFPW-Arpege Relative Humidity (2m)*”. Specify your date settings as “*201401200000*”. Press “*Import*” to execute the routine.

Once the routine is completed 24 new raster maps have been created, named “RH2_B_201401200000” to “RH2_Y_201401200000”. From the main ILWIS menu, select the option “*File*” > “*Create*” > “*Map List*”, in the left hand file listing catalogue select all files “*RH2_*_201401200000*” (note * represents ‘B’ to ’Y’), press the “>” sign in the centre and all selected files move to the right hand file listing. Enter a Map List name, e.g. “*RH2*” and press “OK”.

In the main ILWIS catalogue select the Map List “*RH2*”, select the layer “*rh2_b_201401200000*”, representing the first 3 hour time step, select as Representation “*Gray*” and display the map. Browse with the mouse, keeping the left mouse button pressed over the map and inspect the values (in percentage).

Now from the ILWIS main menu, select: “*Operations*” >> “*Statistics*” >> “*MapList*” >> “*MapList Graph*”. Select as MapList “*RH2*”. Activate the option: “*Fix Stretch*”, select as minimum “*0”* and as maximum “*100”*. Also activate the options “*Continuous*” and “*Always On Top*”. Note that the X-axis of the graph (1 to 24) represents the time, here the time steps from B to Y (from 3 to 96 hrs, note that the temporal interval is hanging from 3 to 6 hrs, see chapter 3.2.8) and the Y axis is the Relative Humidity, in percentage. Move the mouse cursor over the map “*rh2_b_201401200000*” (it might have disappeared under the main ILWIS window!) and check the corresponding RH values in the graph for a given pixel over the forecasting time range. Your results should resemble those below. Note that here a representative pixel was selected of the south western highlands in Ethiopia. Have a look at the diurnal cycle of relative humidity and also check the Somaliland region or Afar and note the lower RH values over there.

Figure 4.10.6: LFPW Arpege Relative Humidity forecast



The other LFPW Arpege import routines work in a similar manner, you can try a few yourself as well. See once more also figures 3.18 and 3.19 as examples.

4.10.3 *ECMF Global Analysis and Forecasts*

NWP model output from the ECMWF is also available. Routines are prepared to process a few of these global products at 0.5 degree spatial resolution, like temperature at 850 hPa, geopotential height at 500 hPa, mean sea level pressure and relative humidity at 700 and 850 hPa. Products are disseminated through GEONETCast, the 00:00 time step data is locally available after 06:30 UTC and the 12:00 time step is available after 18:30 UTC. The routine imports the analysis and forecasts (+24, +48, +72, +96 and +120) and is creating a map list, which can be displayed as an animated sequence or a map list graph can be used to show the analysis and forecast over a selected pixel.

Before starting to import the ECMF NWP products that are available in the GEONETCast data stream derived you need to check the settings of the directories that contain the raw data. From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*ECMF*". Browse to the appropriate data input and output locations and in the case of the ECMWF Integrated Forecast System products note that the data is stored in the directory "*D:\WFS_Ethiopia_TrainingData\Meteo\ECMF*", where "*D:*" is the designated hard disk drive location. Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

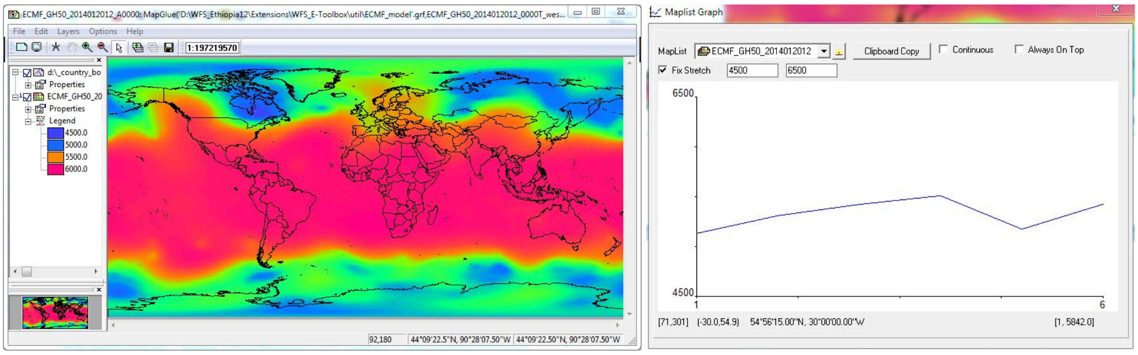
Now from the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*ECMF Global Analysis and Forecasts*" >> "*Temperature at 850 hPa at 00:00*". Note that you have to enter the selected product time stamp in a yyyymmddhh format, select here "*2014012000*" (the product from 00:00 UTC!). Press "*Import*" to execute the routine. After the import has finished open the map list "*ECMF_T85_2014012000*", check the content - naming conventions used and display the maps as an animated sequence using a "Pseudo" Representation and use the default Display Options. Also display also the "*country_boundaries*" and use a black boundary colour. Close the animated visualization.

Now from the “WFS-Ethiopia” and “Toolbox” main menu select the option “*ECMF Global Analysis and Forecasts*” >> “*Geopotential Height at 500 hPa at 12:00*”. Note that you have to enter the selected product time stamp in a yyyymmddhh format, select here “*2014012012*” (the product from 12:00 UTC!). Press “*Import*” to execute the routine. After the import has finished open the map list “*ECMF_GH50_2014012012*”, check the content - naming conventions used and display the maps as an animated sequence using a “*Pseudo*” Representation and use the default Display Options. Also display also the “*country_boundaries*” and use a black boundary colour. Close the animated visualization.

Open the map list “*ECMF_GH50_2014012012*” once more and display the layer “*ECMF_GH50_2014012012_A0000*”, add the vector file “*country_boundaries*” and use a black boundary colour. Now from the ILWIS main menu, select: “*Operations*” >> “*Statistics*” >> “*MapList*” >> “*MapList Graph*”. Select as “*MapList*” “*ECMF_GH50_2014012012*”. Activate the option: “Fix Stretch”, select as minimum “*4500”* and as maximum “*6500”*. Also activate the options “*Continuous*” and “*Always On Top*”. Note that the X-axis of the graph represents the time, here the time steps from *20140120 at 12:00 UTC* to +120 hrs (layer 6) and the Y axis is the height, in metres (gpm)! Move the mouse cursor over the map “ECMF_GH50_2014012012_A0000” (it might have disappeared under the main ILWIS window!) and check the corresponding values in the graph for a given pixel over the daily time range, in this case for 20 January 2014 at 12 UTC and the next 5 days (at 12:00 UTC). Your results should resemble those of figure 4.10.7.

Note that with the “*Clipboard Copy*” option the time stack for a certain pixel can be copied to clipboard to be pasted into a spread sheet. In order to do so it is necessary to uncheck the option “*Continuous*” and click in the map on the desired location. The coordinate information / row-column number is provided in the Map List Graph window in the lower left hand corner. Having imported more map lists you can easy change the map list in the “Maplist Graph window” and select other (map list) values for the same pixel, note that you might have to adapt the Y-scaling!

Figure 4.10.7: ECMF Geopotential height and map list graph for certain pixel location



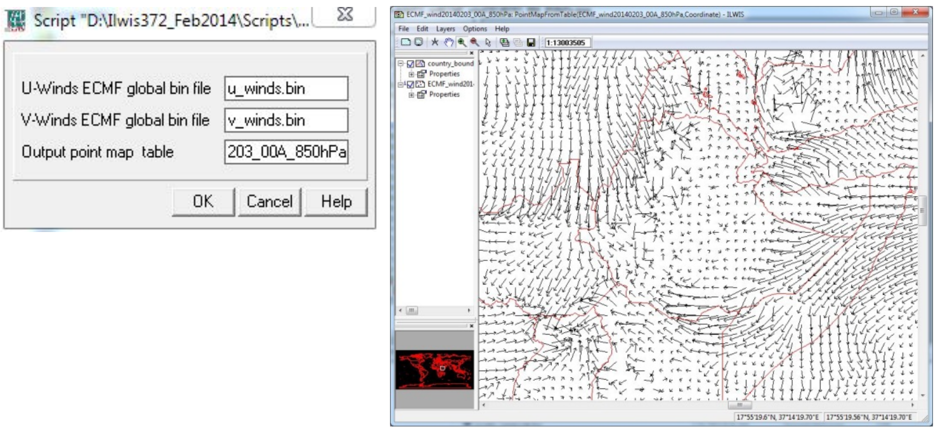
In order to process the winds from this product dedicated ILWIS scripts are prepared. These scripts are situated within the ‘ILWIS main directory\Scripts’ and are called “*ECMF_winds*”. From the ILWIS main menu, select the option “*Operations*” >> “*Script*” and activate the script “*ECMF_winds*”. Now specify the appropriate Input U and V Wind Maps and output table - point map. Note as input the full file name has to be provided for the U and V winds respectively. Navigate with your explorer to the meteo data \ECMF sub-directory and copy the files:

‘*A_HVXA85ECMF030000_C_ECMF_20140203000000_an_u_850hPa_global_0p5deg_grib2.bin*’
and:
‘*A_HVXA85ECMF030000_C_ECMF_20140203000000_an_v_850hPa_global_0p5deg_grib2.bin*’

to your active working directory. Rename the files, e.g. into “*u_winds.bin*” and “*v_winds.bin*” respectively. Specify the appropriate input files in the script under ‘U-Winds ECMF global bin file’ and ‘U-Winds ECMF global bin file’ and specify “*ECMF_wind20140203_00A_850hPa*” as ‘Output point map and table' and press "*OK*" to execute the script. Wait till the routine is ready and then open the point map "*ECMF_wind20140203_00A_850hPa*"

From the Point Map Display Options menu, select the option "*Symbols as Arrows*" and from the "*Details*" option check - activate the "*Length*" option and select as parameter from the table the column "*Windspeed*" or "*Scale_speed*" (last one used for better representation of strong winds, e.g. at lower pressure levels!) and for Direction use the column "*Winddirection*", Press "*OK*" twice. Also display also the "*country_boundaries*" and use a red boundary colour. Zoom in over the map to your region of interest, your results should resemble those of the figure below.

Figure 4.10.8: ECMF winds at 850 hPA, analysis for 20140203 for 00:00 UTC



4.10.4 *UK-Met Exeter Africa Forecasts*

The flagship numerical weather prediction (NWP) model developed and used at the Met Office is called the Unified Model (UM). Unlike most other NWP centres, the same model is used for both weather and climate prediction. For weather forecasting the Met Office runs several configurations of the UM as part of its operational NWP suite. A global configuration provides the large-scale weather forecast and also supports the nested higher resolution regional models with boundary data.

Data delivered from this Numerical Weather prediction model is consisting of the analysis and the forecasts and is available at 2 temporal intervals (issue time at 00 and 12 UTC) and at an approximate spatial resolution of 17 km. The products retrieved are: Convective cloud cover [%] range 0 - 1, Net long wave radiation flux (surface) [W/m^2], Total precipitation [kg/m^2], Dew point temperature [C], Relative humidity [%], Specific humidity [kg/kg], Temperature [C], Geo Potential Heights (GPH): geopotential meter [gpm] for 850, 750, 500 and 250 hPa.

Before starting to visualize the selected Unified Model NWP products that are available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*Met_UK*". Browse to the appropriate data input and output locations and in the case of the Unified Model products note that the data is stored in the directory "*D:\WFS_Ethiopia_TrainingData\Meteo\MET_UK*", where "D:\" is the designated hard disk drive location. Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

To import the selected surface level forecasts, from the "WFS-Ethiopia" and "Toolbox" main menu select the option "*MET-UK Exeter Africa Forecasts*" >> "*AgroMet 1.5m HGLH Forecasts*". Note that you have to enter the selected product time stamp in a yyyymmddhh format, select here "*2018080700*". Note that you are retrieving the 00:00 UTC time of issue, the hour time stamp can also be 12 for the 12:00 UTC time of issue. Press "Import" to execute the routine.

The routine produces 4 map lists (dew point, relative and specific humidity and temperature), e.g. in a format "UKMET_*_2018080700" (* = product type), containing the 27 time steps each, map layer 1 is from the time of issue, the other layer are the subsequent 3, 6 and 12 hourly forecasts (see also chapter 3.2.10). A single layer can be displayed, or the map list can be shown as an animated sequence. As all data is of a "value" format, a "*Pseudo*" Representation can be used.

In a similar manner the other 2 routines can be applied, use the identical date "*2018080700*" to import selected atmospheric product forecasts and geo potential heights. Note that the 'Total Accumulated Precipitation' is consisting of 26 time steps.

4.10.5 *NCEP GFS – Web based*

Although NWP model output from the NOAA Climate Prediction Centre is currently being disseminated on EUMETCast, when using this data source a number of internal links did not work properly. Therefore the existing routine has been adapted and the GFS Africa forecasts are now directly retrieved from the source at CPC-NCEP NOAA (http://www.cpc.ncep.noaa.gov/products/international/africa/africa.shtml). This routine assumes that your system is connected to the internet.

Now from the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*NCEP GFS – Web based*" >> "*NCEP GFS Forecasts*" and press "*Import*". A web-page linking to all kinds of forecasting products is now at your disposal, identical to figure 3.22.

Some of the forecasting products, like precipitation and pressure, are used by the Centre for Ocean-Land-Atmosphere Studies (see chapter 3.2.11) and standardized pictures of these forecasts are created on a daily basis. Routines prepared automatically extract the latest available forecasts at a daily temporal resolution for the next 6 days (144 hrs).

Before you start retrieving these products, from the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*GFS*". Browse to the appropriate data output location and in this case the output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings. Here the downloaded data will be temporally stored and an animated GIF is being created. Once this procedure is completed the animated GIF will be shown on your screen. The GIF created has a system time stamp, so each visualization of a product will result in a specific file name suffix with the time, so you are able to see when the animation was created. The individual files downloaded are deleted once the animated GIF is created.

From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*NCEP GFS Web based*" >> "Latest NCEP *GFS Precipitation Forecasts*" and press "*Import*" to execute the routine. Note that an interpretation guide for the various products is provided, given in chapter 3.2.11. Also use the routines available for the other products, e.g. 850 Mb Forecast, Precipitable Water/CAPE forecast and the Sea Level Pressure forecast. All routines work in an identical manner.

4.10.6 ***Lighting detection - Sferics processing***

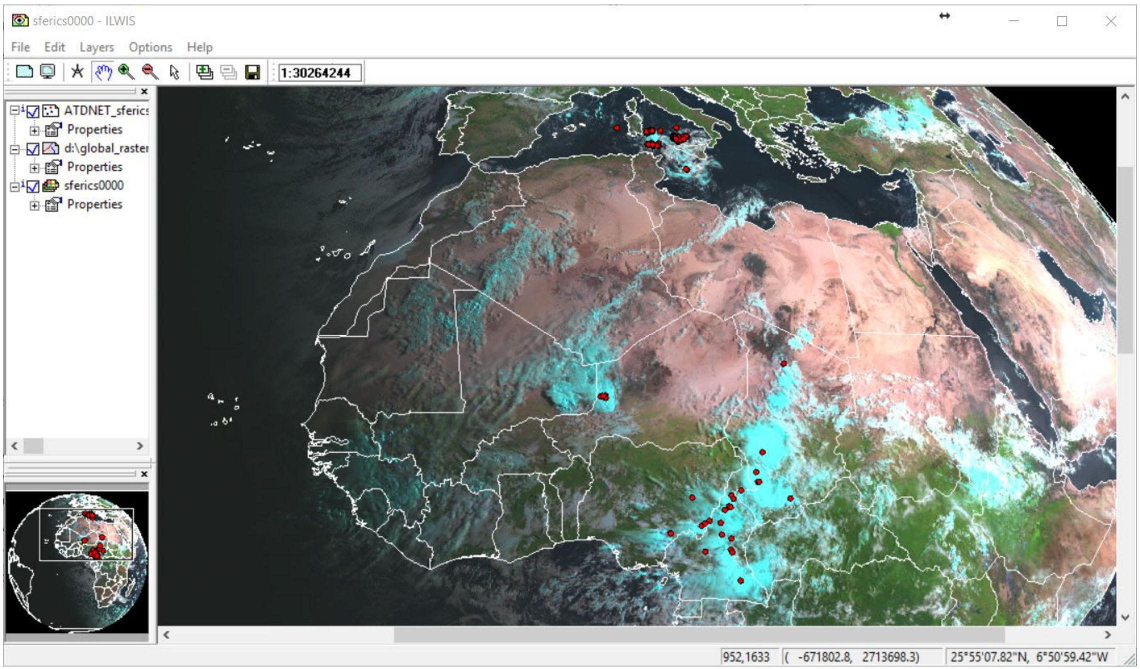
Before starting to visualize the UK MetOffice Sferics Africa 15 minute concatenation products that are available in the GEONETCast data stream derived you need to check the settings of the directories that contain the raw data. From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*ATDNET*". Browse to the appropriate data input and output locations and in the case of the Sferics lighting (BUFR-encoded) products note that the data is stored in the directory "*D:\WFS_Ethiopia_TrainingData\Meteo\Sferics*", where "D:\" is the designated hard disk drive location. Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

To import the selected Sferics product, from the "WFS-Ethiopia" and "Toolbox" main menu select the option "*Lighting Detection Data*" >> "*ATDNET Sferics*". Note that you have to enter the selected product time stamp in a yyyymmddhhmm format, select here "*201808080703*". Note that you are retrieving the concatenated data of the previous 15 minutes, in this case from 06:45 to 07:00 UTC. Press "Import" to execute the routine. Note the offset of 3 minutes with respect to the time stamp.

From the ILWIS catalogue open the table created "*ATDNET_sferics_201808080703*" and check the content showing the locations for the lighting events detected. Now open the corresponding point map created "*ATDNET_sferics_201808080703*" using the default display settings , also add the "country_boundary" vector file. The locations should represent those given in the figure below.

Note that being able to detect the location of thunderstorms is of great importance as it is not only the lightning strike that is dangerous, but many other factors linked to thunderstorms. These include intense rain and tornadoes. The relationship with convective cloud occurrences, not the shapes of the cloud formations, in the figure below is obvious.

Figure 4.10.9: Sferics detected plotted over MSG



4.11 TEMPORAL FILTERING APPLYING ROUTINES DEVELOPED UNDER GIACIS

A very useful routine developed under ILWIS-Open is the possibility to conduct a filtering procedure through a time series. Given the fact that during some temporal intervals data for a certain pixel might not be available, e.g. being flagged / removed due to cloud cover, therefore gaps occur in the time series. To remove these data voids, observations during previous time steps and next consecutive time steps might be used to "cosmetically" reconstruct the missing data. Also in the case of partial cloud cover, when looking at NDVI time series, the value provided is biased towards a lower value. To remove no data and to reduce the noise in time series data such as NDVI a modified adaptive Savitzky-Golay filter forcing an upper envelope is applied. The input data is expected as byte values (domain IMAGE, data range from 0 to 255); the output data will also be byte data (domain IMAGE for ILWIS 3 output). The filter assumes 10 day data (36 images per year). For proper operation at least one year of data is recommended.

Additional information is presented in the "*GIACIS NDVI Processing Routines Manual*", available in from the "*WFS-Ethiopia*" and "*Toolbox*" main menu and select the option "*GIACIS NDVI calc HELP*", have a look at chapter 4.2.4 and read it before you continue.

The sample data prepared here is for 'run 140' and is consisting of the raw Proba V ndvi dekadal data from 20170101 to 2017111 as well as climatology from 1121 to 1221, in total 36 time steps. Run 140 assumes that the latest ndvi product available is from 20171111, the future time steps are represented here by the long term climatology prepared, also on dekadal basis.

From the sample data directory '\WFS_Ethiopia_TrainingData' copy the folder '\GIACIS_TS' to the root of your C:\ or D:\ drive. It should be noted that this step is critical else you will get an error message at a later stage. From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*GIACIS*". Browse to the appropriate data input and output locations and in the case of the GIACIS filtering sample data note that the time series (Run 140) is stored in the directory "*D:\GIACIS_TS*", where "D:\" is the designated hard disk drive location. Here as output location "*D:\GIACIS_TS*" is used. Press "*Save*" to store the settings. Note that you can also set the input and output folders to "*C:\GIACIS_TS*", as long as the folder is situated directly on the root!

In ILWIS navigate to the data folder '*\GIACIS_TS'*. Close ILWIS and open ILWIS again. ILWIS should now open is the designated directory. Open the map list "*r140*", display the NDVI map having the time stamp of "*20171111*", use as Representation "*ndv_byte*". Check the map for data voids, the white areas having a 'value' of '0', note water bodies are assigned "0" on a continuous basis. Now from the ILWIS main menu, select: "*Operations*" >> "*Statistics*" >> "*MapList*" >> "*MapList Graph*". Select as "*MapList*" "*r140*". Activate the option: "Fix Stretch", select as minimum "*0"* and as maximum "*255"*. Also activate the options "*Continuous*" and "*Always On Top*". Note that the X-axis of the graph represents the time, here the time steps from *20170101 to 20171221* and the Y axis is the ndvi value. Move the mouse cursor over the map "*proba_eth_ndvi_b20171111*" (it might have disappeared under the main ILWIS window!) and check the corresponding values in the graph for a given pixel over the yearly time range, in this case for 2017 having actual data up to 2017111 and climatology representing the time steps from 20171121 to 20171221. When moving the cursor over the map you will note a large number of events with data voids. This time series, containing the raw data is actually not very useful for further processing!

From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*GIACIS NDV Processing*" >> "*NDVI Temporal Filtering*", provide the name of the map list (on the Date stamp), here "*r140*", check the input and output folders, here "*D:\GIACIS_TS*" and press "*Import*" to execute the routine.

Once the routine has started (temporal filtering and post processing including spatial filtering to remove eventual single pixels assigned 'not a number data' and transformation of the data back into byte range) take some time to check the filtering schedule applied for the GIACIS project. This information is presented in the "*Filtering Schedule 2016-2017*", available from the "*WFS-Ethiopia*" and "*Toolbox*" main menu and select the option "*GIACIS NDVI calc HELP*". Within the table check the details for Run 140. You will note from here that the output created is called "p140", short for 'processed140'. Note that in the filtering routine 4 iterations are used and within the GIACIS project, once data has become available for a new time step, the filtering procedure is repeated, now using actual data instead of climatology. The green column denotes the date when no modifications to the ndvi value are expected given the iterative filtering procedure.

After processing is completed open the map list "*p140*" and display the map "*p140_band_31*", using as Representation "*ndv_byte*". Note this time step is equivalent to 20171111! Now from the ILWIS main menu, select: "*Operations*" >> "*Statistics*" >> "*MapList*" >> "*MapList Graph*". Select as "*MapList*" "*p140*". Activate the option: "Fix Stretch", select as minimum "*0*" and as maximum "*255*". Also activate the option "*Always On Top*". Note that the X-axis of the graph represents the time, here the time steps from *20170101 to 20171221* and the Y axis is the filtered ndvi value. Move the mouse cursor over the map "*p140_band_31*" (it might have disappeared under the main ILWIS window!) and check the corresponding values in the graph for a given pixel. Note that the curve has become much more smooth. From the map list graph window, under 'MapList', select from the drop down menu the map list "*r140*" and note the changes in values! Repeat this procedure for a number of locations to see the impact of the temporal filter. An example over a certain pixel has been provided in figure 3.29 for your reference.

Close the graph and map window. Now open the map list "*r140*" and use as display option "*Open as Slide Show*", select as Representation "*ndv_byte*", press "*OK*", other display options can be used as default and press "*OK*" once more to see the ndvi now as an animation. Note the impact of the data voids. Once finished reviewing the animation, close the map window and repeat this procedure, but now select "*p140*". Note that a few pixels are continuously undefined, these have very persistent cloud cover and therefore removed from further analysis within the GIACIS processing routines, as well as the permanent water bodies.

4.12 CALCULATION OF THE WATER REQUIREMENT SATISFACTION INDEX

4.12.1 *Prepare time series input for WRSI calculations*

Once more review section 3.2.16 providing the overall approach developed to calculate the WRSI for Ethiopia. From the sample data directory '\WFS_Ethiopia_TrainingData' copy the folder '\WRSI' to the root of your C:\ or D:\ drive.

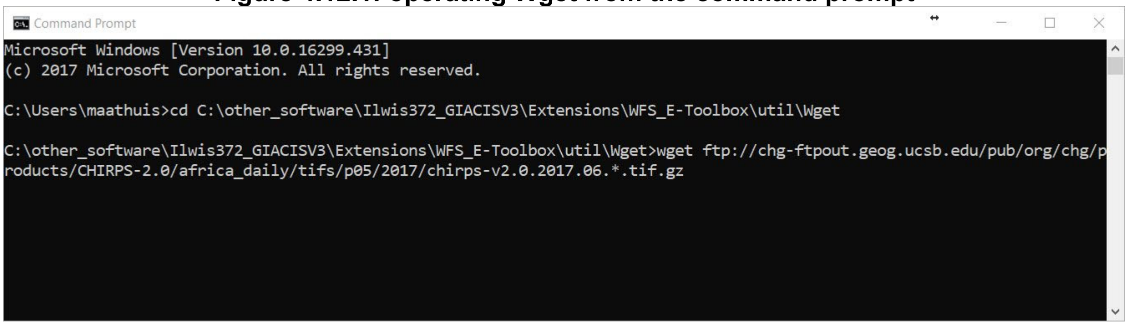
This folder is already containing all the time series data input required for 2017. In order to demonstrate the data preparation required, below a short exercise is given to retrieve one month of daily data from the CHIRPS ftp site for June 2017 and some further processing will be done to prepare the 3 dekadal rainfall input maps required. Note that for the DMET and METREF data the daily data can be requested from the LSA-SAF.

To retrieve the daily CHIRPS data for Africa for July 2017, open a command prompt window, e.g. from the 'Windows 10 - Start' menu type "CMD". Navigate to the folder in the Ilwis directory '\Extensions\WFS_E-Toolbox\util\Wget' and type the following expression and press <enter>:

> wget ftp://chg-ftpout.geog.ucsb.edu/pub/org/chg/products/CHIRPS-2.0/africa_daily/tifs/p05/2017/chirps-v2.0.2017.06.*.tif.gz

See also the figure below, note that the expression to be executed by Wget is a single line statement! The data for June 2017 is now transferred to the Wget directory. Once all data is transferred, copy / cut the data and copy these into the folder *'\WRSI\chirps_pcp062017'*. Note that also all data for 2017 can be retrieve, by replacing the “06” portion of the file name string by “*”.

Figure 4.12.1: operating Wget from the command prompt



Open ILWIS and navigate to the folder ‘\WRSI\chirps_pcp062017’. From the “*WFS-Ethiopia*” and “*Toolbox*” main menu select the option “*Configuration*” and “*Folder*” and select “*CHIRPS*”. Browse to the appropriate data input and output locations and in the case of the Chirps rainfall pre-processing example note that the time series input data is stored in the directory “*D:\wrsi\chirps_pcp062017*”, where “D:\” is the designated hard disk drive location. Here as output location “*D:\wrsi\chirps_pcp062017*” is used. Press “*Save*” to store the settings. Note that to conduct the same type of pre-processing the folders assigned for DMET and METREF can be configured accordingly.

To import the retrieved daily precipitation for the month of June 2017, from the “*WFS-Ethiopia*” and “*Toolbox*” main menu select the option “*Water Requirement Satisfaction Index*” >> “*Time Series Data Preparation*” >> “*CHIRPS time series*”. Provide the year stamp, in this case “*2017*” and after checking if the input and output folder assignment is correct, press “*OK*”. All the Chirps rainfall data downloaded is now converted into an ILWIS format and resampled to the appropriate georeference used for the WRSI computations. After computations are finished, close the Toolbox menu. From the main ILWIS menu select the option “*Window*” >> “*Refresh*” and now you should see the 30 maps created for the month of June 2017, having a daily interval.

Display a few maps and check the values. To adhere to the temporal resolution, the data needs to be aggregated to a dekadal time step. In order to do this first create a map list. From the main ILWIS menu, select the option “*File*” > “*Create*” > “*Map List*”, in the left hand file listing catalogue select the precipitation maps from 20170601 to 20170610, press the “>” sign in the centre and all selected files move to the right hand file listing. Enter a Map List name, e.g. “*eth_pcpdek2017061*” and press “OK”. Repeat this procedure for the rainfall maps from 20170611 to 20170620 and 20170621 to 20170630, and create maps lists “*eth_pcpdek2017062*” and “*eth_pcpdek2017063*” respectively.

To obtain the total rainfall over each of the dekades, from the main ILWIS menu, select the options “*Operations*” >> “*Statistics*” >> “*MapList*” >> “*MapList Statistics*”, as map list select “*eth_pcpdek2017061*”, as Statistical Function select “Sum” and as output map specify “*eth_pcpdek2017061_sum*”. Repeat the procedure also for the other 2 map lists and call these “*eth_pcpdek2017062_sum*” and “*eth_pcpdek2017063_sum*” respectively.

An alternative method is to use the drop down button on the right hand side of the ILWIS command line. Here an example is given of the first dekade statistical aggregation using the sum function:

```
eth_pcpdek2017061_sum.mpr = MapMaplistStatistics(D:\wrsi\chirps_pcp062017\eth_pcpdek2017061.mpl,Sum)
```

Now modify this line as given below and press <enter>:

eth_pcpdek2017062_sum.mpr:=MapMaplistStatistics(D:\wrsi\chirps_pcp062017\eth_pcpdek2017062.mpl,Sum);

Once the syntax is created on the command line, only the output map date stamp and the input map list date stamp need to be modified, followed by <enter>. In this way yearly dekadal maps can be very quickly aggregated, as only the time stamps of the in- and output layers need to be modified. Classification, as defined for dekadal precipitation by NMA, is: 0-5=very dry, 5-25=dry, 25-50=moderately dry, 50-100=moist, 100-200=humid, >200=very humid), units in mm.

This example shows the procedure for the CHIRPS rainfall import and pre-processing required as input to the WRSI calculations. The procedure for the full year as well as those for the other 2 products required, the DMET and the METREF products from the LSA-SAF (see also chapters 3.2.6.2 and 4.3 for further details), are identical.

4.12.2 *Calculate the start of season*

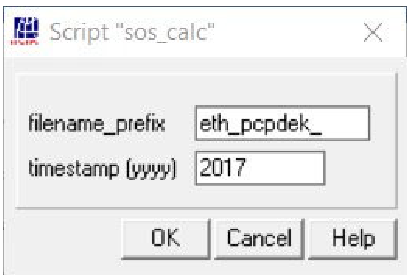
Use the "*Navigate*" from the ILWIS main menu and select the main directory, here 'D:\WRSI'. Note that you have copied from the folder 'WFS_Ethiopia_TrainingData\WRSI' the file 'pcp_dmet_metref2017.zip' and that the file is unzipped in this folder. Here as working directory "*D:\WRSI*" is assumed and should contain 3 map lists. The dekadal precipitation from Chirps has 36 layers, representing dekade 011 to 123, the dekadal Metref and Dmet have 33 layers each, representing the time steps from 021 to 123 respectively. Furthermore a crop mask with likely occurrence of teff, wheat and barley over 700 meters is provided, called "allcrop_mask". Review the source data before you continue, the unit of the pcp, dmet and metref is in mm / time step.

From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*WRSI*". Browse to the appropriate data input and output locations and in the case of the WRSI working directory note that the time series input data is stored in the directory "*D:\wrsi*", where "D:\" is the designated hard disk drive location. Here as output location "*D:\wrsi*" is also used. Press "*Save*" to store the settings.

Review the flow chart presented in chapter 3.2.16 showing the overall WRSI calculation methodology. From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Water Requirement Satisfaction Index*" >> "*WRSI Processing*" four ILWIS script routines are available, select the routine >> "*SOS Calculation*". Note the 'Output Directory' settings and press "*Import*".

Check the remarks provided at the beginning of the script and the observations noted on the replaceable parameters used in this script, namely the file name prefix and the year. Press the "Run Script" Icon from the Script main menu and the Script dialog box is shown, enter the appropriate parameter settings, see also the figure below.

Figure 4.12.2: Script settings for the calculation of the Start of Season



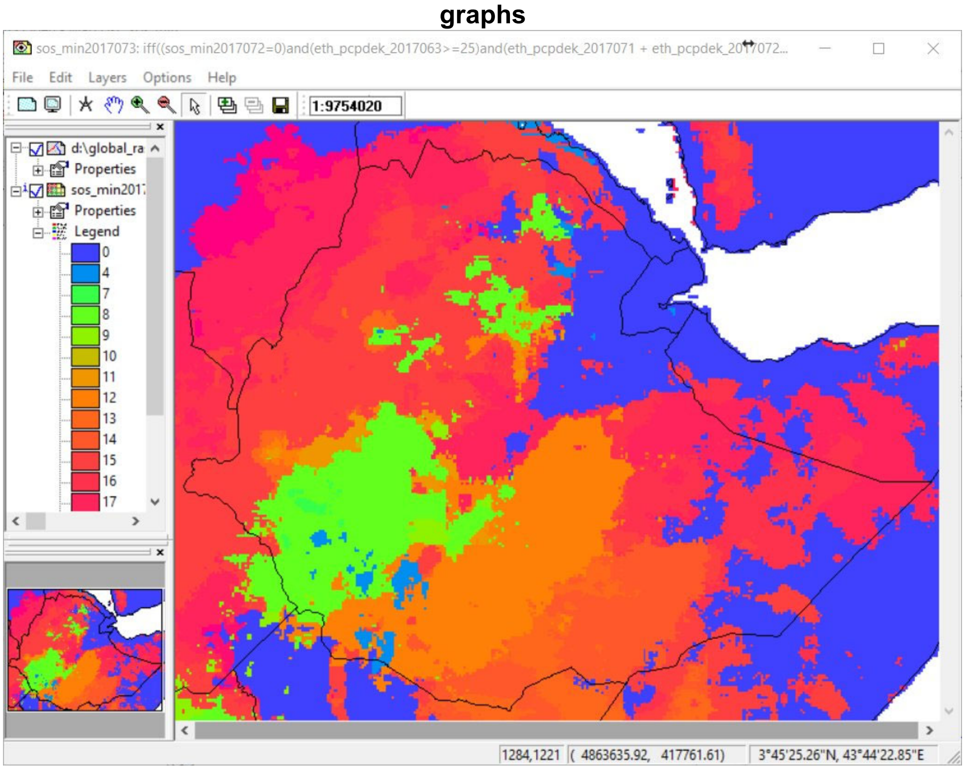
Press "OK" to start the calculations and wait until the calculations are finalized. You have now obtained 3 times 33 maps defining the 'Start of Season', called "sos_min*", "sos_med*" and "sos_max*". Create 3 map lists called "sos_min", "sos_med" and "sos_max". From the main ILWIS menu, select the option "*File*" > "*Create*" > "*Map List*", in the left hand file listing catalogue select the sos_max maps from 2017021 to 2017123, press the ">" sign in the centre and all selected files move to the right hand file listing. Enter a Map List name, e.g. "*sos_max*" and press "OK". Repeat this procedure for the other sos maps and provide as output map list name "*sos_med*" and "*sos_min*" respectively. Note that the sos calculation require a certain minimum rainfall during the preceding 3 dekades – depending on the thresholds used, dekades 011 to 013 are required to derive if this minimum amount is available and therefore these dekades are not used during further crop cycle calculations! The output sos map lists are having 33 layers, representing the time period from 021 to 123. See also Appendix 4 which showing a manual worksheet example of the whole WRSI calculation procedure.

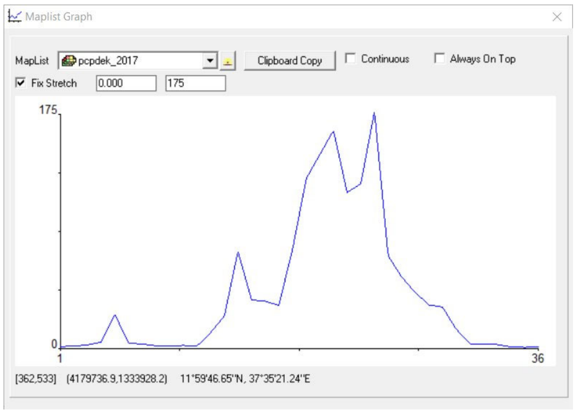
As the Start of Season is the basis of the WRSI computation, open the sos map lists created as slideshow, use a "*Pseudo*" Representation and set the maximum Stretch value to "*25"* and press *"OK"* twice. In the animated display you can see the progress of the Start of Season according to the antecedent precipitation (obtained from the Chirps rainfall data).

The script used to compute the SoS is also transferred to the working directory and can be consulted any time to check the computations performed. For novice users additional information is provided from the ILWIS main menu, under the option "*Help*" >> "*Map and Table Calculation*" >> "*Creating and running scripts*".

The figure below is showing the map "sos_min2017073" and when using the option map list graph and selecting as map list "sos_min" the Start of Season can be seen for each of the regions in the map. Note that the map value is presenting the dekade when the threshold for the antecedent moisture has been realized, to evaluate this change the map list in the map graph window and select "pcpdek_2017", see also the figure below.

Figure 4.12.3: SOS_min map of 2017073 and corresponding SOS and rainfall map list graphs





In this example at time step 17 (dekade 062) the season starts, during the 3 previous dekades rainfall was 72, 36 and 35 mm respectively (at time step 14, 15 and 16). The threshold defined for sos_min for the previous 3 dekades is: dek1=25, dek2 +dek3 >20 and this condition is fulfilled. During the two dekades before (at time step 12 and 13) the rainfall was 12 and 24 mm respectively and the condition was therefore not fulfilled (as well as those of the preceding dekades.

Once the Start of Season is initiated the areas are assigned the time step value for the year, from 1 to 36, although values higher than 25 (representing dekade 083) are not realistic, as growing season is too short for the crops used here (teff, barley and wheat), therefore after time step 21 (dekade 073) it is assumed none of these crops are planted anymore. Some areas receive very little rainfall and do not meet the Start of Season criteria at all, these are mostly in the lower elevated areas and because of the low rainfall these are excluded from further calculations.

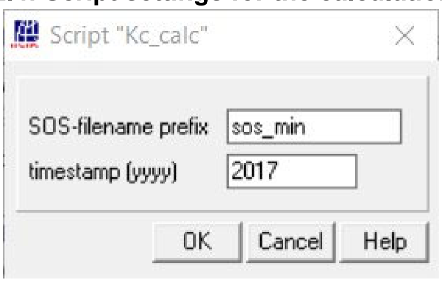
4.12.3 *Calculate the Crop Coefficient (Kc) time series*

Kc values are obtained from the National Meteorological Agency and are applicable to teff, barley and wheat, growing season length defined is 180 days (18 dekades from SOS). Once the calculations are completed the Kc values are given for each dekade during the crop season (based on the sos). Kc maps start calculations from dekade 021.

From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Water Requirement Satisfaction Index*" >> "*WRSI Processing*" and select the routine >> "*Kc Calculation*". Note the 'Output Directory' settings and press "*Import*".

Check the remarks provided at the beginning of the script and the observations noted on the replaceable parameters used in this script, namely the file name prefix and the year. Press the "Run Script" Icon from the Script main menu and the Script dialog box is shown, enter the appropriate parameter settings, see also the figure below.

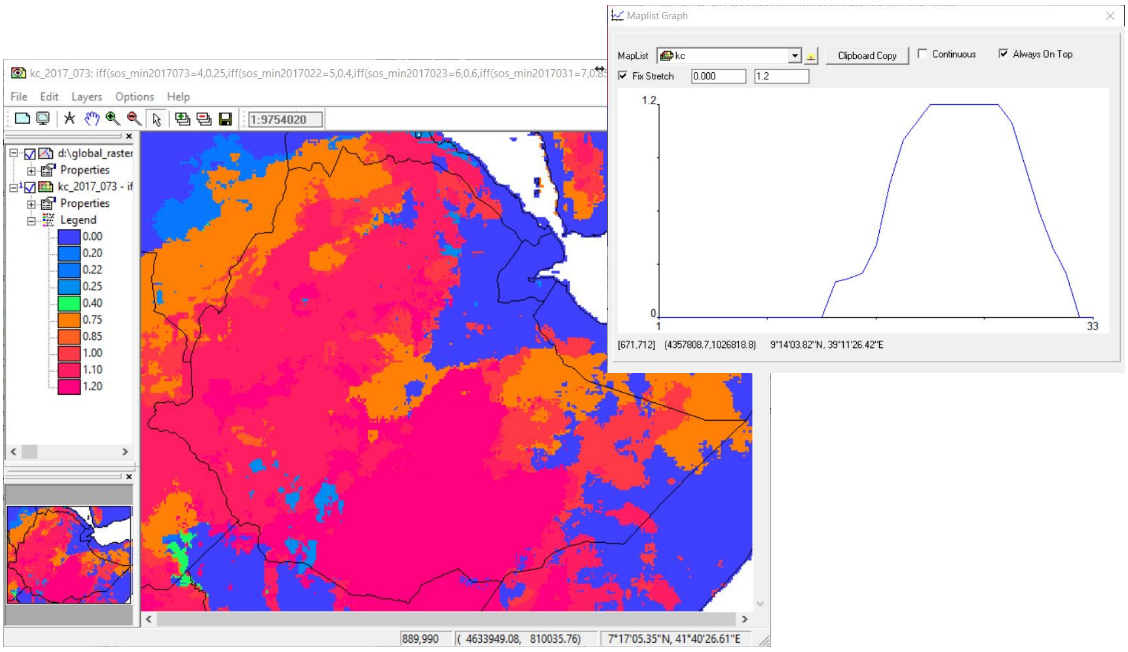
Figure 4.12.4: Script settings for the calculation of the Kc



Once the computations are completed manually create the Kc map list of the 33 Kc maps calculated. From the main ILWIS menu, select the option "*File*" > "*Create*" > "*Map List*", in the left hand file listing catalogue select the Kc maps (kc_2017_021 to kc_2017_123), press the ">" sign in the centre and all selected files move to the right hand file listing. Enter a Map List name, e.g. "*Kc*" and press "*OK*".

Display the map list "*Kc*" as an animated slide show, use a "*Pseudo*" Representation and set the maximum Stretch value to "*1.2*" and press "*OK*" twice. In the animated display you can see the progress of the Kc values once the season has started (based on the sos selected, here sos_min).

Figure 4.12.5: Spatial and temporal distributed Kc maps



For the same area as defined by the Start of Season before, see the figure above, starting at dekade 2017073, here the resulting Kc values over the growing season are shown. Display the map "*kc_2017_073*", contained within the map list "*Kc*", select the option map list graph and selecting as map list "*Kc*". Move the cursor over the map and evaluate the change of Kc values for this time stamp, reflecting the progress of the crops (as defined by the Kc values used) over the country. Again, note the script is available in your working directory, called "*Kc_calc*" which can be consulted to review the calculation procedures applied.

4.12.4 *Calculate the Water Requirement Satisfaction Index*

From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Water Requirement Satisfaction Index*" >> "*WRSI Processing*" and select the routine >> "*WRSI Calculation*". Note the 'Output Directory' settings and press "*Import*".

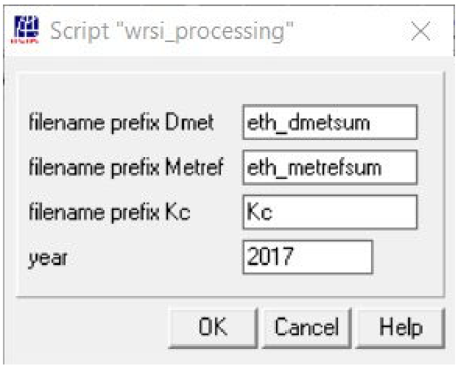
Within this script a number of steps are performed:

- Calculate ETo or Water Requirement (WR), defined as: METREF * Kc (per time step);
- Calculate WRSI, defined as (DMET/WR)*100 (per time step);

- Calculate classified WRSI map (slicing operation, using defined thresholds, according to NMA, domain required is “*wrsi_Eth.dom*” and “*wrsi_Eth.rpr*” and should be available in the ILWIS system sub directory or within the local working directory;

Check the content of the script and provide the parameters is the wrsi-processing dialog box as indicated in the figure below.

Figure 4.12.6: Settings to run the WRSI processing script



To execute the script, press “*OK*” and wait until computations are finished. Manually create map lists for the following time series calculated: “*wr*”, “*wrsi*”, “*wrsi_cl*” and “*wrsi_clcm*”. The suffix used here is ‘*cl*’: classified and ‘*cm*’: crop mask.

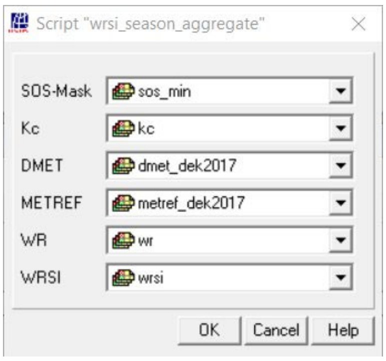
Display the 4 map lists created as animated sequences, showing the developments per time step over the year. Also use the option of map list graph to see the wrsi values computed on a pixel basis.

4.12.5 *Derive the crop season aggregated WRSI*

From the “*WFS-Ethiopia*” and “*Toolbox*” main menu select the option “*Water Requirement Satisfaction Index*” >> “*WRSI Processing*” and select the routine >> “*WRSI Season Calculation*”. Note the ‘Output Directory’ settings and press “*Import*”.

This script calculates season aggregated WRSI values. It uses the SOS to derive the season distribution over the country. It subsequently crosses the Kc map list with the various parameter maps (metref, dmet, wr and wrsi), if the individual Kc map is greater than 0. Check the content of the script and provide the parameters is the wrsi-processing dialog box as indicated in the figure below.

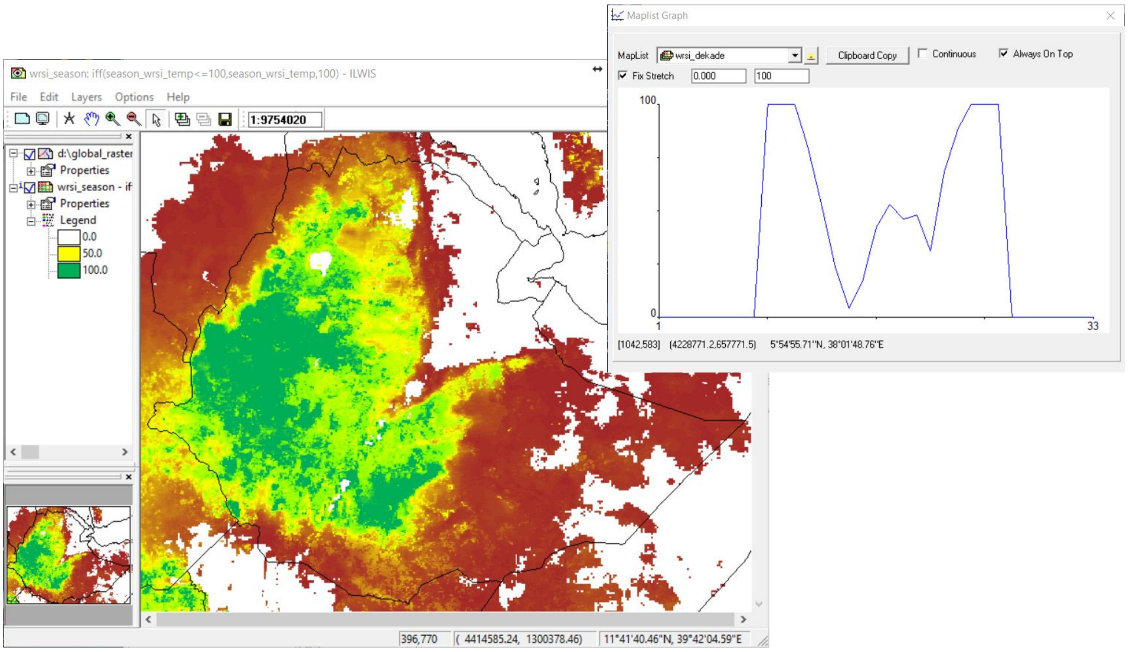
Figure 4.12.7: Settings to run the WRSI Season processing script



To execute the script, press "*OK*" and wait until computations are finished. Display first the map "*sos_season*". This map shows the start of season time step. Also display the maps "*dmet_aggregate*", "*metref_aggregate*", "*wr_aggregate*". These maps show the aggregated values if the Kc is greater than '0', so for the crop season only!

Display the map "*wrsi_season*" using as Representation "*wrsi_season*", also display the country boundaries. This map shows the aggregated water requirement satisfaction index over the crop growing season. Note that to create this map the 'wrsi' is corrected to ensure that if the result of the computation: (dmet/wr)*100 is > 100, the maximum value is set then to 100 %. Especially during the onset and towards the end of the season, due to the fact that the Kc values are very low, the water requirement is minimal and the actual ET can exceed the water requirement which results in values over 100 %. As map list graph select "*wrsi_dekade*" and use a fixed stretch from 0 to 100. Now select a few pixels having a different wrsi over the season and see the temporal developments. These should represent the results given in the figure below.

Figure 4.12.8: Crop season aggregated WRSI map and WRSI dekadal graph



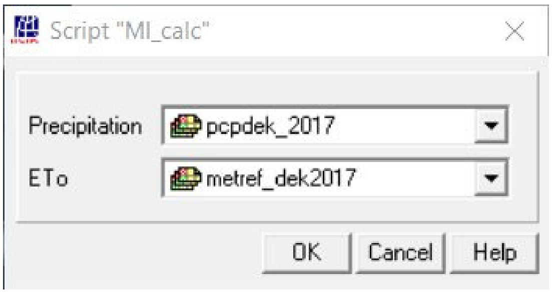
4.12.6 ***Moisture index calculation***

From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Water Requirement Satisfaction Index*" >> "*Moisture Index Processing*" and select the routine >> "*Moisture Index Calculation*". Note the 'Output Directory' settings and press "*Import*".

In order to run the script note that the Precipitation and ETo - METREF map list should contain the identical number and timing of dekades. As likely the precipitation map list has 36 layers, remove from the map list the dekades representing January. Open the map list "*pcpdek_2017*", select the map "*eth_pcpdek_2017011*" and press the 'remove map from map list icon (-), available from the Map List menu. Repeat this procedure for the maps "*eth_pcpdek_2017012*" and "*eth_pcpdek_2017013*". Note these maps are not deleted, only removed from the map list 'container', they can be added at a later stage if required. Now also check the content of the map list "*metref_dek2017*" and note the number of layers and the temporal sequence.

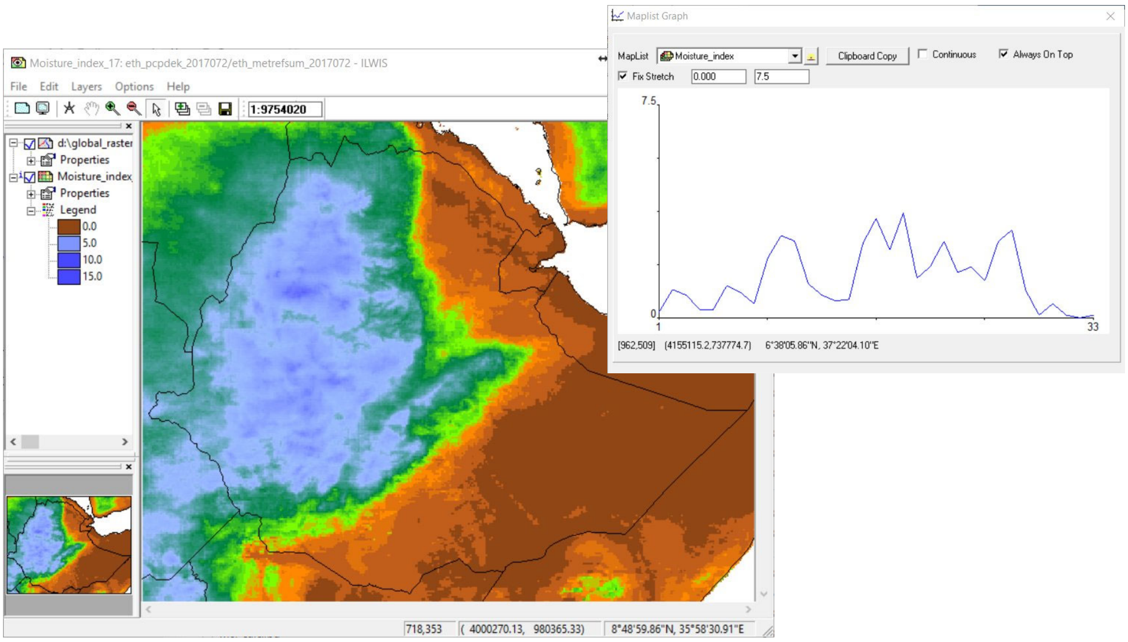
This script calculates the moisture index, defined as the ratio of precipitation over METREF or WR for each time step in the map lists. It uses as input the precipitation and ETo (Wr) – Metref. Check the content of the script and provide the parameters is the wrsi-processing dialog box as indicated in the figure below and press "*OK*".

Figure 4.12.9: Settings to run the Moisture Index script



After computations are completed, open the map list "*moisture_index*" and display one of the layers, using as Representation "*moisture_index*". Note that index layer 1 represents here 2017021 and layer 33 is 2017123. As map list graph select "*moisture_index*" and use a fixed stretch from 0 to 7.5. See also the figure below. Note that NMA classification for the moisture index is: 0-0.1=very dry, 0.11-0.25=dry, 0.26-0.50=moderately dry, 0.51-1.0=moist, 1.1-2.5=humid, >2.5=hyper humid.

Figure 4.12.10: Moisture index time step 17 (2017062) and dekadal graph



Also review the moisture index displaying the map list as an animated sequence, also use as Representation "moisture_index".

Repeat the moisture index calculation, now use as ETo map the map list "*WR*". Check these results as well.

4.12.7 ***Aggregate statistics***

It is important to represent the findings in a format which can be reported to other agencies. Often data is presented in maps and tables having an administrative nature. Here use is made of the Woreda level. If other administrative units are preferred, the script can be easily modified if the administrative map is available.

From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Water Requirement Satisfaction Index*" >> "*Aggregate statistics*" and select the routine >> "*Aggregate at Woreda level*". Note the 'Output Directory' settings and press "*Import*".

Check the content of the script, next to the local availability of the 'woreda' map it is assumed that Excel is available on your system. In the script dialog box provide the name to the map to be aggregated at woreda level, here the map "*wrsi_season*" is used and press "*OK*". An instance of Excel is opened and the table created is displayed showing the average seasonal wrsi value for each of the woredas. This table can be saved for further reporting.

In the ILWIS catalog open the new table created "*wrsi_season_avg*", you will see two columns, 'woredaname' and 'avg'. Now open the table associated with the polygon file "*Woredas*". In this table there is also a colum called 'woredaname'. From the main table menu, in the table "*woredas*" select the options "*Columns*" >> "*Join*", as table select "*wrsi_season_avg*" and as Column "*Avg*", press "*Next*", as output column in current table specify "*avg2017*" and press "*Finish*" and "*OK*".

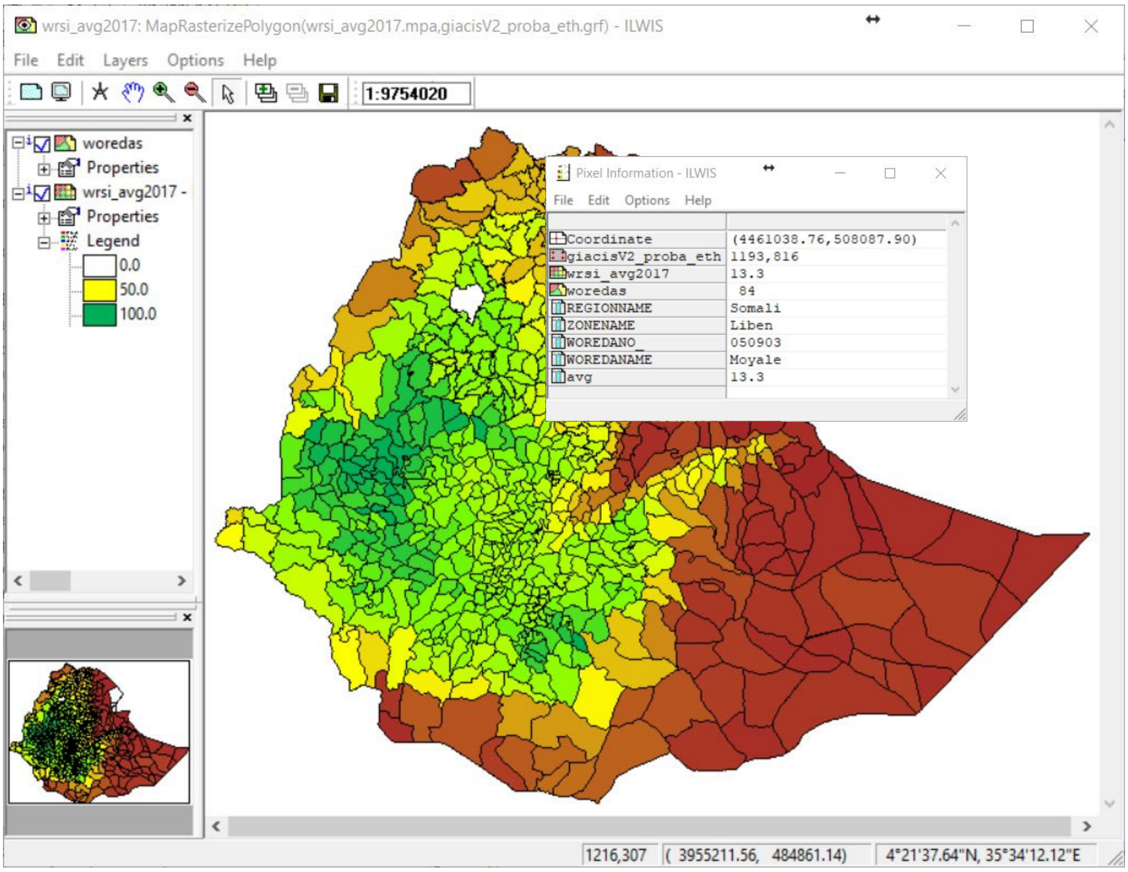
Now the column is added to the 'Woreda' table, you can check if the avg2017 values correspond to those in the table 'wrsi_season_avg'. Close both tables. Right click with the mouse on the polygon map "*Woredas*", select the option for the context sensitive menu "*Polygon Operations*" >> "*Attribute Map*". From the Attribute of Polygon Map dialog box note that the attribute (to be) selected is the column "*avg2017*" (from the table!), specify as output polygon map "*wrsi_avg2017*" and press "*Show*". You can display this polygon map.

Now right click with the mouse on the newly created polygon map "*wrsi_avg2017*", from the context sensitive menu select the option "Polygon to Raster" and specify as georeference "*giacisV2_proba_eth*" and press "*Show*". Now display the raster map "wrsi_avg2017", use as Representation "*wrsi_season*". Add the polygon map "*woredas*", activate the option "Boundaries Only" and press "*OK*".

From the main ILWIS menu, select the option "*File*" >> "Open *Pixel Information*", move the cursor over the map and check the values in the pixel information window. See also the figure below.

As it is known by government agencies for each woreda if teff, wheat and barley is cultivated the table used can be updated and a map showing only the average wrsi for woredas growing these type of crops can be prepared in an identical manner.

Figure 4.12.11: Average WRSI aggregated per Woreda and pixel information



4.12.8 *Concluding remarks*

Based on freely available products the Water Requirement Satisfaction Index and Moisture Index can be obtained. Import routines offer quick pre-processing facilities. It should be noted that the DMET product contains pixels with no data. An additional pre-processing step is required to fill these areas, e.g. using an Majority Undefined filter. The 'majundef' filter is a standard majority filter which works in a 3x3 environment. Of each 9 pixels considered, the predominant value of the other 8 pixels is assigned to the center pixel in the output map, only if the center pixel in the input map is undefined. If the central pixel in the input map is not undefined, the value remains the same in the output map.

Before starting the WRSI calculations it is important that the 3 required dekadal map lists, Precipitation, Reference Evapotranspiration and Actual Evapotranspiration are properly checked.

An example of the whole WRSI calculation over a single pixel (copying the data from the respective map lists) is provided in Appendix 4 and can be used to check the procedure applied over here.

4.13 HYDRO-METEO ROUTINES

Within NMA's MapRoom a link is provided to data produced under the ENACTS program, providing dekadal data on rainfall, minimum and maximum temperature.

Before starting to process the ENACTS data available for 2014 you need to check the settings of the directories that will contain the downloaded and processed data. From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*ENACT*". Browse to the appropriate data input location, here for the rainfall product specify "*D:\WFS_Ethiopia_TrainingData\Hydro_met\ENACTS\Rainfall*". Also specify the output location and in the case of these products note that as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

Here as example the import procedure for ENACTS dekadal rainfall is given, for the temperature import procedures, note that the source data is residing in a different folder. In order to import these products the source folder settings have to be adapted.

In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Hydro-Meteo Routines*" >> "*ENACT Products*" "*10 day precipitation*". Note the output directory specification and enter the appropriate time stamp, here "*2014101*" (in yyyymmdek format) is used, to conduct the import press "*Import*".

Once the processing is completed, open the map "*rr_mrg_2014101_ALL*", as Representation use "*mpe_sum*" and check the map values. Also add the "*country_boundaries*". Eventually import also the minimum and maximum temperature products from ENACTS, note that these are situated in different source folders!

To quickly assess the rainfall and temperature conditions a number of aridity indices can be applied. All are based on (mean) temperature and rainfall. These data sources have been obtained from CHIRPS (for rainfall), see chapter 4.12.1 and CAMS (for air temperature), see chapter 4.15.1. Once more review section 3.2.17 providing the overall approach developed to derive the various indices for Ethiopia. From the sample data directory '\WFS_Ethiopia_TrainingData\HydroMet' copy the folder '\Hydro_index' to the root of your C:\ or D:\ drive.

This folder is already containing all the time series data input required for 2017 for precipitation and mean monthly temperature. The data preparation required for the CAMS air temperature product the conversion from Kelvin to Celsius and resampling to the Ethiopia georeference. The CHIRPS rainfall was aggregated from daily to monthly time step and subsequently resampled to the same georeference.

Before you start, first check the two map lists available, "*eth_pcpm2017*" contains the monthly precipitation for 2017, in mm/month. The map list "*eth_Tm2017*" contains the mean monthly temperature in degree Celsius.

From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*HydroMet*". Browse to the appropriate data input location, here for the 'Input Location' specify "*D:\Hydro_index*", use the same folder for the output locations settings. Press "*Save*" to store the settings.

In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Hydro-Meteo Routines*" >> "*Aridity Index De Martonne*". Note the output directory specification and press "*Import*". As script, called "*AI_DM_index*" is retrieved. Study the content of the script and press the "Run Script" icon available from the menu bar. Three parameters are required and for the 'Monthly_Mean_Temperature' select "*eth_Tm2017*", for the 'Monthly_sum_rainfall' select "*eth_pcpm2017*" and as 'Year' specify "*2017*" and press "*OK*" to execute the script.

Wait till the computations are finished and open the map "*Arid_index_DM_2017v*" using a default 'Pseudo' Representation. Check the values. Note that the thresholds in the table below have been used to obtain the classified map "*Arid_index_DM_2017*". Also display this map using the default Representation.

Table 4.13.1 Aridity classification according the *De Martonne*

Climate type	Aridity Index
Arid	0 - 10
Semi-arid	10 – 20
Mediterranean	20 - 24
Semi-humid	24 - 28
Humid	28 - 35
Very humid	35 - 55
Extremely humid	> 55

Close the maps before you continue.

In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Hydro-Meteo Routines*" >> "*Precipitation-Effectiveness Index*". Note the output directory specification and press "*Import*". As script, called "*PE_index*" is retrieved. Study the content of the script and press the "Run Script" icon available from the menu bar. Three parameters are required and for the 'Monthly_Mean_Temperature' select "*eth_Tm2017*", for the 'Monthly_sum_rainfall' select "*eth_pcpm2017*" and as 'Year' specify "*2017*" and press "*OK*" to execute the script.

Open the map list "PE_Index_2017" and display the map list as an animation, using the default representation. The table below indicates the thresholds being used during the classification procedure.

Table 4.13.2 PE-Index classification

Climate type	Aridity Index
Arid	< 16
Semi-arid	16 - 31
Sub-humid	32 - 63
Humid	64 - 127
Wet	> 128

Stop the animation and close all the maps before you continue.

In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Hydro-Meteo Routines*" >> "*Gaussen-Bagnouls classification*". Note the output directory specification and press "*Import*". As script, called "*GB_index*" is retrieved. Study the content of the script and press the "Run Script" icon available from the menu bar. Three parameters are required and for the 'Monthly precipitation' select "*eth_pcpm2017*"for the 'Monthly mean temperature' select "*eth_Tm2017*", and as 'Year' specify "*2017*" and press "*OK*" to execute the script.

Open the map list "*GB_2017*" and display the map list as an animation, using the default representation. The table below indicates the thresholds being used during the classification procedure.

Table 4.13.3 Gaussen - Bagnouls classification

Climate type	Aridity Index
Arid	P < 2T
Semi-humid	T3 > P > 2T
Humid	P > 3T

The final procedure available is the Precipitation Concentration Index (PCI). In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Hydro-Meteo Routines*" >> "*Precipitation Concentration Index*". Note the output directory specification and press "*Import*". As script, called "*PCI_calc*" is retrieved. Study the content of the script and press the "Run Script" icon available from the menu bar. Two parameters are required, for the 'Monthly precipitation (mm)' select "*eth_pcpm2017*" and as 'Year' specify "*2017*" and press "*OK*" to execute the script.

Wait till the computations are finished and open the map "*PCI_2017v*" using a default 'Pseudo' Representation. Check the values. Note that the thresholds in the table below have been used to obtain the classified map "*PCI_2017cl*". Also display this map using the default Representation.

Table 4.13.4 PCI-classification

PCI Temporal Concentration	PCI Index
Uniform	< 10
Moderately concentrated	11 - 15
Concentrated	16 - 20
Strongly concentrated	> 20

Note that examples of these processing routines are given in Chapter 3.2.17 using the sample data provided.

4.14 BIO-METEO ROUTINES

To evaluate the meteorological conditions suitable for development, reproduction and survival of mosquitoes the GFS forecasts produced by NCEP are used. On a daily basis the forecasts for the next 10 days are processed for a number of parameters, like rainfall, temperature (minimum and maximum) as well as relative humidity. These maps are used to derive the locations which are suitable for mosquitoes to mature based on the thresholds provided by NMA, adapted from monthly to 10 day intervals. The data is made available on the FTP at ITC (ftp://ftp.itc.nl/pub/mpe/gfs_5p/). The routines developed, automatically retrieve the zipped files from this location, based on the time stamp provided and conduct the processing using ILWIS scripts.

Before starting to process the malaria comfortable anticipated condition suitability map available from the ITC FTP you need to check if your system has internet access. Subsequently check the settings of the directories that will contain the downloaded and processed data. From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*BioMet*". Browse to the appropriate data output location and in the case of these products note that as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Bio-Meteo routines*" >> "*Mosquito Habitat Suitability Monitoring*". Note the output directory specification and enter the appropriate time stamp, here 20181001 (in yyyymmdd format) is used, to conduct the import press "*Import*".

Once the processing is completed, open the map "*eth_malaria_suitability_20181001*" and check the map value. Note that the value "1" represents that all the conditions for mosquito development are suitable. Also display the script "*malaria_suitability*" and check the content, so you know how the suitability conditions are derived. Note that the map represents the average conditions for the next 10 days! Also a map is create called "*Eth_malaria_suitability_20181001m*", using the mask of Ethiopia to clip only the area within the country.

Run the routine for the period of 20181002 to 20181015. Create a maplist of these 15 maps, select the maps using the full extent or only those for Ethiopia (having the suffix "*m*". The use the maplist statistics function "Sum" and create a new output map "*Mosq_sum*". Evaluate for this map which areas are suitable, note also the lead time! Also use the MapList Graph function, see as example also figure 3.37.

In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Bio-Meteo routines*" >> "*Temperature-Humidity Index Cattle*". Note the output directory specification and enter the appropriate time stamp, here 20181001 (in yyyymmdd format) is used, to conduct the import press "*Import*".

Upon completion of the routine, check the script "*THI_Cattle*", so you know how the calculations have been performed. Six output maps have been created. Display the map "*Eth_THI_Dairy_Cattle_20181001*" using the default display settings, navigate with the cursor over the map, keeping the right mouse button pressed and check the values. Display the map "*Eth_THI_Dairy_Cattle_20181001_cl*", using the provided Representation "*THI_dairy_cattle*". Now also display the map "*Eth_THI_Dairy_Cattle_20181001_clm*", using the provided Representation "*THI_dairy_cattle*", note that this map is clipped to the Ethiopian country boundary.

Display the map "*Eth_THI_non_dairy_Cattle_20181001*" using the default display settings, navigate with the cursor over the map, keeping the right mouse button pressed and check the values. Display the map "*Eth_THI_non_dairy_Cattle_20181001_cl*", using the provided Representation "*THI_non_dairy_cattle*". Now also display the map "*Eth_THI_non_dairy_Cattle_ 20181001_clm*", using the provided Representation "*THI_non_dairy_cattle*", note that this map is clipped to the Ethiopian country boundary.

Compare the THI maps for dairy and non-dairy cattle. Eventually select another date and repeat the processing.

In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Bio-Meteo routines*" >> "*Temperature-Humidity Index Human*". Note the output directory specification and enter the appropriate time stamp, here 20181001 (in yyyymmdd format) is used, to conduct the import press "*Import*".

Upon completion of the routine, check the script "*THI_Human*", so you know how the calculations have been performed. Three output maps have been created. Display the map "*Eth_THI_Human_20181001*" using the default display settings, navigate with the cursor over the map, keeping the right mouse button pressed and check the values. Display the map "*Eth_THI_Human_20181001_cl*", using the provided Representation "*THI_Human*". Now also display the map "*Eth_THI_Human_20181001_clm*", using the provided Representation "*THI_Human*", note that this map is clipped to the Ethiopian country boundary.

All thresholds used are described in tables 3.5 and 3.6.

4.15 RETRIEVAL OF ONLINE TIME SERIES RESOURCES

In order to evaluate climate variability / change, long term climatological records are required, preferably over 25 years. Climatologists use past weather patterns to predict future trends. To do this they use amongst others, analog years, in which the weather patterns were similar to those expected during the coming season. At NMA a procedure has been put in place for seasonal weather forecast also making use of the concept of analog years. This procedure requires access to long term climatological records, of sea surface temperatures, rainfall and air temperature. To facilitate this process, additional routines have been prepared making use of long term monthly climatological records.

4.15.1 *Retrieval of online monthly air temperature data*

To evaluate the state of the climate in Africa, the ACMAD centre is using data retrieved from the Climate Anomaly Monitoring System (CAMS) prepared by CPC-NCEP-NOAA, and available in the IRI/LDEO Climate Data Library (see also https://iridl.ldeo.columbia.edu/).

The CPC Monthly Global Surface Air Temperature Data Set is available at 0.5 degree spatial resolution from 1948-present. The unit for the temperature is (K), averaged monthly in GRIB format. The data sets is routinely updated around 8th of each month.

Before starting to import the CAMS monthly air temperature products that are available from the IRI/LDEO Climate Data Library you need to check the settings of the directories that will contain the downloaded and processed data. From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*Clim_Data_Online*". Browse to the appropriate data output location and in the case of these long term climatological products note that as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Online Resources*" >> "Basic Historical Time Series Products" >> "*CAMS Air Temperature*". Note the output directory specification and enter the appropriate time stamp, here 201501 (in yyyymm format) is used, to conduct the import press "*Import*".

Once the data is retrieved, display the map "*CAMS_AT201501*", you can use the default display settings. Also display the vector file country_boundaries. Note the unit of the map, in Kelvin. From the ILWIS main menu, press the drop-down button on the right hand side of the command line. Check the string that has executed the import routine. Change the date stamp, now to "*201502*" and press <enter>, to import a new map, now for February 2015. By changing the date stamp quickly time series can be retrieved. After the import is completed, press "*F5*" to refresh the ILWIS catalog and display the map "*CAMS_AT201502*".

4.15.2 *Retrieval of online monthly precipitation data*

Here two online data sources are at your disposal, the CAMS OPI and the CMAP. For information on the CAMS_OPI, see also: ftp://ftp.cpc.ncep.noaa.gov/precip/data-req/cams_opi_v0208/. The "CAMS_OPI" data are 2.5 degree lat/lon spatial means of monthly mean precipitation derived from station gauges and satellite estimates.

The "CAMS_OPI" (Climate Anomaly Monitoring System - "CAMS") and OLR Precipitation Index ("OPI") is a precipitation estimation technique which produces real-time monthly analyses of global precipitation. To do this, observations from rain gauges ("CAMS" data) are merged with precipitation estimates from a satellite algorithm ("OPI"). The analyses are on a 2.5 x 2.5 degree latitude/longitude grid, are updated each month, and extend back to 1979. This data set is intended primarily for real-time monitoring (source: http://www.cpc.ncep.noaa.gov/products/global_precip/html/wpage.cams_opi.html). The units are "mm/day".

In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Online Resources*" >> "*Basic Historical Time Series Products*" >> "*CAMS OPI Precipitation (v0208)*". Note the output directory specification and enter the appropriate time stamp, here "*201501"* (in yyyymm format) is used, to conduct the import press "*Import*".

Once the data is retrieved, display the map "*CAMS_OPI_201501*", you can use the default display settings. Also display the vector file country_boundaries. Note the unit of the map, the mean in mm/day. From the Ilwis main menu, press the drop-down button on the right hand side of the command line. Check the string that has executed the import routine. Change the date stamp, now to "*201502*" and press <enter>, to import a new map, now for February 2015. By changing the date stamp quickly time series can be retrieved. After the import is completed, press "*F5*" to refresh the ILWIS catalog and display the map "*CAMS_OPI_201502*".

For research purposes, NOAA refer users to the CMAP (CPC Merged Analysis of Precipitation) products which are more quality-controlled and use both IR and microwave-based satellite estimates of precipitation. ftp://ftp.cpc.ncep.noaa.gov/precip/cmap/monthly/. This data set consists of monthly averaged precipitation rate values (mm/day), available from 1979 onwards to near present, also at 2.5 degree spatial resolution.

In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Online Resources*" >> "*Basic Historical Time Series Products*" >> "*CMAP Precipitation (v1803)*". Note the output directory specification and enter the appropriate time stamp, here "*201501"* (in yyyymm format) is used, to conduct the import press "*Import*".

Once the data is retrieved, display the map "*CMAP_201501*", you can use the default display settings. Also display the vector file country_boundaries. Note the unit of the map, the mean in mm/day. From the Ilwis main menu, press the drop-down button on the right hand side of the command line. Check the string that has executed the import routine. Change the date stamp, now to "*201502*" and press <enter>, to import a new map, now for February 2015. By changing the date stamp quickly time series can be retrieved. After the import is completed, press "*F5*" to refresh the ILWIS catalog and display the map "*CMAP_201502*".

4.15.3 ***Retrieval of online Sea Surface Temperature data***

Long term Sea Surface Temperature analysis show that at irregular intervals (roughly every 3-6 years), the sea surface temperatures in various oceans along the equator become warmer or cooler than normal and are affecting to overall circulations patterns. For Ethiopia the impact of the Oceanic Niño Index (ONI) and the Indian Ocean based Dipole Mode Index (DMI) have been described in literature as important teleconnections affecting the weather behavior and thus needs to be considered for seasonal forecasting .

The first source of average monthly sea surface temperatures are from the Reynolds and Smith OISST version 2 sea surface temperature dataset. The monthly average sea surface temperature is in (C) for the month indicated on a 1.0 degree lat/lon grid, available from 196001. See also: https://www.esrl.noaa.gov/psd/data/gridded/data.noaa.oisst.v2.html.

In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Online Resources*" >> "*Basic Historical Time Series Products*" >> "SST *OI (v2)*". Note the output directory specification and enter the appropriate time stamp, here "*201501"* (in yyyymm format) is used, to conduct the import press "*Import*".

Once the data is retrieved, display the map "*SST_OI_201501*", you can use the default display settings. Also display the vector file country_boundaries. Note the unit of the map, the mean monthly temperature in degree C. From the Ilwis main menu, press the drop-down button on the right hand side of the command line. Check the string that has executed the import routine.

Change the date stamp, now to “*201502*” and press <enter>, to import a new map, now for February 2015. By changing the date stamp quickly time series can be retrieved. After the import is completed, press “*F5*” to refresh the ILWIS catalog and display the map “*SST_OI_201502*”.

The other SST source is the Extended Reconstructed Sea Surface Temperature (ER SST) dataset (see also: https://www.ncdc.noaa.gov/data-access/marineocean-data/extended-reconstructed-sea-surface-temperature-ersst-v5).

In the “*WFS-Ethiopia*” and “*Toolbox*” main menu select the option “*Online Resources*” >> “*Basic Historical Time Series Products*” >> “*Relative Lake Levels*”. Note the output directory specification and enter the appropriate time stamp, here “*201501”* (in yyyymm format) is used, to conduct the import press “*Import*”.

Once the data is retrieved, display the map “*SST_ER201501*”, you can use the default display settings. Also display the vector file country_boundaries. Note the unit of the map, the mean monthly temperature in degree C. From the Ilwis main menu, press the drop-down button on the right hand side of the command line. Check the string that has executed the import routine. Change the date stamp, now to “*201502*” and press <enter>, to import a new map, now for February 2015. By changing the date stamp quickly time series can be retrieved. After the import is completed, press “*F5*” to refresh the ILWIS catalog and display the map “*SST_ER201501*”.

4.15.4 *Relative lake level information from Altimeters*

Altimeters have been around for quite a while and if all observations are combined from the various altimeters, quite long time series can already be obtained over larger lakes (note the footprint of the altimeter). Using these observations it is possible to get an idea of the changes in lake levels over time, which might give additional information, e.g. with respect to a hydrological drought / recharge. Relative lake height variations are derived from TOPEX/POSEIDON (T/P), Jason-1 and Jason-2/OSTM altimetry observations, with respect to a datum that is based on a single fly-over date of the Jason-2/OSTM mission.

For more information see also: https://ipad.fas.usda.gov/cropexplorer/global_reservoir/ and for the lakes recorded, see: https://ipad.fas.usda.gov/lakes/images/GREALM.Table.Jan2018.htm.

In the “*WFS-Ethiopia*” and “*Toolbox*” main menu select the option “*Online Resources*” >> “*Basic Historical Time Series Products*” >> “*ER-SST OI (v5)*”. Note the output directory specification and enter the appropriate LakeNumber, here “*lake0349”* for lake Ziway. See details from the table using the link above. To continue the import, press “*Import*”.

After import is completed, note the table created “*lake0349*”, open the table. Check the various columns and the last one “*Z_new*” has been calculated for visualization purposes. All no-data have been reassigned “?”. From the table menu, select the icon “*Graph*”, from the graph dialog box, uncheck the option “X-axis” and select the column “*Z_new*” for the Y axis and press “*OK*”. In the graph window double click on the legend for the attribute “*Z_new*” and from the ‘Graph Options’ dialog box select as display option “*Line*” (instead of point), eventually change the name and press “*OK*”.

4.15.5 *GFS 10 day forecasts*

The Global Forecast System (GFS) is a weather forecast model produced by the National Centers for Environmental Prediction (NCEP). Dozens of atmospheric and land-soil variables are available through this dataset, from temperatures, winds, and precipitation to soil moisture and atmospheric ozone concentration (source: https://www.ncdc.noaa.gov/data-access/model-data/model-datasets/global-forcast-system-gfs) and for further information on the products provided see: http://www.nco.ncep.noaa.gov/pmb/products/gfs/#GFS.

The first routine implemented allows the extraction of the 10 day – daily precipitation forecast only for Africa. Daily forecasts are retrieved (pre-processed at ITC and provided in ILWIS format) from the ITC FTP. New forecasts are available at approximately 07:00 UTC each day. Processed data available at: ftp://ftp.itc.nl/pub/mpe/gfs/. File name convention used: gfs_10d_yyyymmdd.zip (like gfs_10d_20170921.zip).

Once the routine is started the 10 day forecast map list as available on the ITC FTP is retrieved. This has a global coverage and the map list is resampled to the GIACIS grid-id map, using the georeference and coordinate system of the GIACIS grid-id map. Resampling is done using a nearest neighbor resampling method. Next the individual daily rainfall forecast maps are crossed with the GIACIS grid-id map and 10 cross tables are created. Subsequently these individual cross tables for time step 2 to 10 are appended to the cross table of the 1st time step. This cross table is providing per GIACIS grid-id the subsequent 10 day rainfall forecast. An additional 'Help' document is available.

Before starting to import the GFS rainfall forecast products that are available from the ITC FTP you need to check the settings of the directories that will contain the downloaded and processed data. From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*GFS_data*". Browse to the appropriate data output location and in the case of these forecasting products note that as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Online Resources*" >> "*GFS 10 day Forecast*" >> "*GFS Import Help)*". Note the output directory specification and to view the 'Help' file press "*Import*".

This document is describing the GFS 10 Day GIACIS-linked Precipitation Forecast routine. To operate the routine, select the option from the menu "*GFS 10 day GIACIS-linked precipitation forecast*" and provide the time stamp (after 01-09-2016). The data is retrieved and processed. Note that this routine is only relevant to those using a GIACIS grid-id as their reference.

Better at this stage to continue with the other routine provided, the "*GFS 10 day P_ET_T forecast*". Here the relevant agro-meteorological information of rainfall, temperature potential and actual ET forecasted for the next 10 days is retrieved and imported.

For the daily automated pre-processing at ITC (at 08:00 UTC) the GFS source data (40 GRIB files) is retrieved from: ftp://ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/gfs.YYYYMMDDCC, note that YYYYMMDD is the Year, Month and Day and CC is the model cycle runtime (i.e. 00, 06, 12, 18), here only '00' is used. Files extracted are: 'gfs.t00z.pgrb2.0p25.f*', where * is forecasting time, e.g. 006 to 240 (having 6 hour intervals). Data provided are converted and changed to represent a daily temporal resolution. Further details from the GFS forecast layers extracted are:

- APCP - layer 293. Total Precipitation [kg /(m^2)] per 6 hours interval - APCP06 (from 24/07/2017 this layer has replaced layer 292), the four time steps (6 hours) are summed;
- PEVPR - layer 280. Potential Evaporation Rate [W/(m^2)], converted to mm/day;
- TMAX - layer 286. Maximum temperature [C] 2-HTGL, aggregated over the day using the ILWIS statistical function 'Max';
- TMIN - layer 287. Minimum temperature [C] 2-HTGL, aggregated over the day using the ILWIS statistical function 'Min';
- LHTFL - layer 300. Latent heat net flux [W/(m^2)], converted to mm/day and represents Actual ET.

To operate the routine, from the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Online Resources*" >> "*GFS 10 day Forecast*" >> "*GFS 10 day P_ET_T forecast)*". Note the output directory specification, enter an appropriate time stamp (after 09-02-2018) in a yyyymmdd format, here "*20180701*" is used and press "*Import*".

Note that the data is retrieved and resampled to the Ethiopian georeference used. Wait until processing is completed and refresh the Ilwis catalog (press "*F5*"). Within the catalog you have now 5 new map lists: "*apcp_10day_fcs_eth_**", "*lhfl_10day_fcs_eth_**", "*pevpr_10day_fcs_eth_**", "*tmax_10day_fcs_eth_**" and "*tmin_10day_fcs_eth_**" (where * = date in yyyymmdd format). The suffix 1 to 10 for each of the maps in the map list denote the forecasting days.

Display all map lists as animated sequences, use a "*Pseudo*" Representation. Next, display from the map list "*apcp_10day_fcs_eth_20180701*" the layer "*apcp_10day_fcs_eth_20180701_1*", representing the accumulated precipitation forecast for the first day.

Now from the ILWIS main menu, select: "*Operations*" >> "*Statistics*" >> "*MapList*" >> "*MapList Graph*". Select as MapList "*apcp_10day_fcs_eth_20180701*". Activate the option: "Fix Stretch", select as minimum "*0*" and as maximum "*100*". Also activate the option "*Always On Top*". Note that the X-axis of the graph represents the time, here the time steps from *20180701* till *201807011* and the Y axis is the rainfall value. Move the mouse cursor over the map "*apcp_10day_fcs_eth_20180701*" (it might have disappeared under the main ILWIS window!) and check the corresponding values in the graph for a given pixel. From the map list graph window, under 'MapList', select from the drop down menu the other map list and note the values obtained! You might need to adapt the maximum stretching value. See as reference also figure 3.33 prepared using the option "Clipboard Copy" and pasted into Excel over a pixel for the various map lists and subsequently creating a graph.

4.16 SOME SELECTED OTHER ROUTINES

As the 'MSG toolbox' and the 'Time Series Convert Utility' are well explained by their respective user manuals. Below 2 tools are highlighted which are very useful to inspect source data in the GEONETCast and EUMETCast data stream, as within the data stream various file formats are used which can be handled by these utilities and provide a convenient way to visualize some of these source data sets. Additional information on how to calculate the MSG solar and zenith angles is provided in chapter 4.15.6: "Additional Exercises". The display of the Julian day tables, use of 7GIF and the GeoTif import routines are self-explanatory.

4.16.1 *Generic NetCDF-GRIB-HDF data visualization*

Panoply is a Java application that allows the user to make plots of data from netCDF, HDF, and GRIB datasets. Although its strength is in making longitude-latitude (map) plots, it can also make other types of georeferenced plots, including keograms and Hovmoeller diagrams; general 2D color plots; and line plots. Data arrays may be "sliced" from larger multidimensional arrays. A large selection of global map projections is available for lon-lat figures. Plot images may be saved to disk in bitmap graphic formats or in PDF.

Before starting to visualize the various NetCDF-GRIB and HDF formatted products that are available in the EUMETCast-GEONETCast data stream you need to install the Panoply utility. See for installation instructions also chapter 1.1.10.

From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*Panoply*". Browse to the appropriate data output directory. Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings. Note that Panoply is storing some temporary program files in the output directory, so ensure that you have the proper administration rights.

From the “*WFS-Ethiopia”* and *“Toolbox*” main menu select the option “*Other Routines*” >> “*Generic NetCDF-GRIB-HDF data visualization*” and “*Start Panoply*” sub menu items and if the output directory is properly assigned, press “*Import*”. In the Command Line Interpreter (CMD.exe) window, acknowledge the use of Panoply, developed by Robert B. Schmunk, NASA by pressing <*enter*> and the Panoply utility is opened.

From the main menu of Panoply, select the options “*File*” >> “*Open*”, navigate to your training data folder *“\WFS_Ethiopia_TrainingData\Meteo\LFPW*”, under ‘File name’ provide the syntax “*”, so all entries in the folder are displayed, and now select the file “*T_YMLA40_C_LFPW_20140120000000.bin*”. From the left hand legend, note the information provided under ‘Name’, ‘Long name’ and ‘Type’. Select the layer "*Convective_available_potential _energy_surface*", check the right hand meta data. Note that this file is having as ‘Type’ ‘Geo2D’, now press the option “*Create Plot*” and *“Create a georeferenced Lat-Lon plot*”, press “*Create*”.

Close this data set and open the file “*W_GB-MetOffice-Exeter,MODEL,_C_EGRR_20180807161929_2018080712_Africa17km_total_cloud_fraction_000144.bin*” available from the folder *“\WFS_Ethiopia_TrainingData\Meteo\MET_UK*”. Once more check in detail the meta data provided. Visualize the data set by selecting the layer “*Total_cloud_cover_surface*” and *“Create a georeferenced Lat-Lon plot*”, press “*Create*”.

In this way quickly different data types can be visualized which are provided within the EUMETCast data stream. For additional information on the use of Panoply, see also the help utilities available at: https://www.giss.nasa.gov/tools/panoply/help/.

4.16.2 *Generic BUFR data visualization*

Before starting to visualize the various BUFR formatted products that are available in the EUMETCast-GEONETCast data stream you need to install the BUFRdisplay utility. See for installation instructions also chapter 1.1.6.

From the “*WFS-Ethiopia”* and *“Toolbox*” main menu select the option “*Configuration*” and “*Folder*” and select “*Bufrdisplay*”. Browse to the appropriate data output directory. Here as output location “*D:\WFS_out*” is used. Press “*Save*” to store the settings. Note that BUFRdisplay is storing some temporary program files in the output directory, so ensure that you have the proper administration rights.

From the “*WFS-Ethiopia”* and *“Toolbox*” main menu select the option “*Other Routines*” >> “*Generic BUFR data Visualization*” and “*BUFRdisplay User Guide V3.0*” sub menu items and press “*Import*”. This ‘Help’ document provides additional information on BUFR encoded data, so if you are not familiar with this data type, consult the document carefully before you continue.

From the “*WFS-Ethiopia”* and *“Toolbox*” main menu select the option “*Other Routines*” >> “*Generic BUFR data Visualization*” and “*Show BUFR data using BUFRdisplay*” sub menu items and if the output directory is properly assigned, press “*Import*”. In the Command Line Interpreter (CMD.exe) window, acknowledge the copyright of Francis Breame by pressing <*enter*> and the BUFRdisplay utility is opened.

From the BUFRdisplay window select “*File*” and “*Open*”, navigate to the training data folder *“\WFS_Ethiopia_TrainingData\MPEF\HighRes*” and select the file: “*L-000-MSG2__-MPEF________-AMV______-000001___-201208270045-__*“ and press “*Open*”. Check the various attributes that are contained within this Atmospheric Motion Vector (AMV) BUFR file under the “*Data Selection*” window. Note that to display the AMV data the following attributes need to be specified:

for the Latitude field:	12 Latitude (high accuracy)
for the Longitude field:	13 Longitude (high accuracy)

for Data field: 18 Wind Speed

Make sure that under the "*Options*" section the option: "*Plot Vector Mode*" is activated

now for Vector Direction field: 17 Wind Direction

Now enter these values for the respective fields situated directly below the Data Attribute window: for Latitude field type "*12*", for the Longitude field type "*13*", for Data field type "*18*" and for Vector Direction field type "*17*" respectively. Note the values and the time stamp given. When the appropriate attributes are provided, press under "Actions" the option "*Input/decode data*" (situated on the mid-right hand side of the BUFRdisplay window). See also figure 4.16.1. After the data is decoded select again from the "Actions" the option "*Generate Map*" and the map window with the AMV's are displayed. Close the map and from the lower right hand part of the BUFRdisplay window select the option "*Zoom*" and enlarge the zoom factor to "*5*" by moving the slide bar to the right hand side using the mouse and activate the option "*Show countries*". Press the option "*Generate Map*" again. Now use the slide bars at the right hand side and lower part of the map display window to navigate over the map. Close the map once more.

Select from the lower left hand part of the BUFRdisplay window the option "*Projection*" and now specify as projection "*Stereographic*", and press the option "*Generate Map*" again. Your results should resemble those presented in figure 4.16.2.

After visualization close the map and to close BUFRdisplay, select from the menu "*File*" and "*Exit*". Repeat the procedure and use as input the Tropospheric Humidity data, available from the same directory. Select as input file: "*L-000-MSG2__-MPEF________-TH________-000001___-201001270245-__*" and as for Latitude field type "*14*", for the Longitude field type "*15*", for Data field type "*31*". Press under "Actions" the option "*Input/decode data*" and "*Generate Map*" respectively. Note the map displayed. Close BUFRdisplay. Also consult the BUFRdisplay user guide for a more detailed description of the functionality of this utility.

Figure 4.16.1: BUFRdisplay main window using the settings to display AMV data

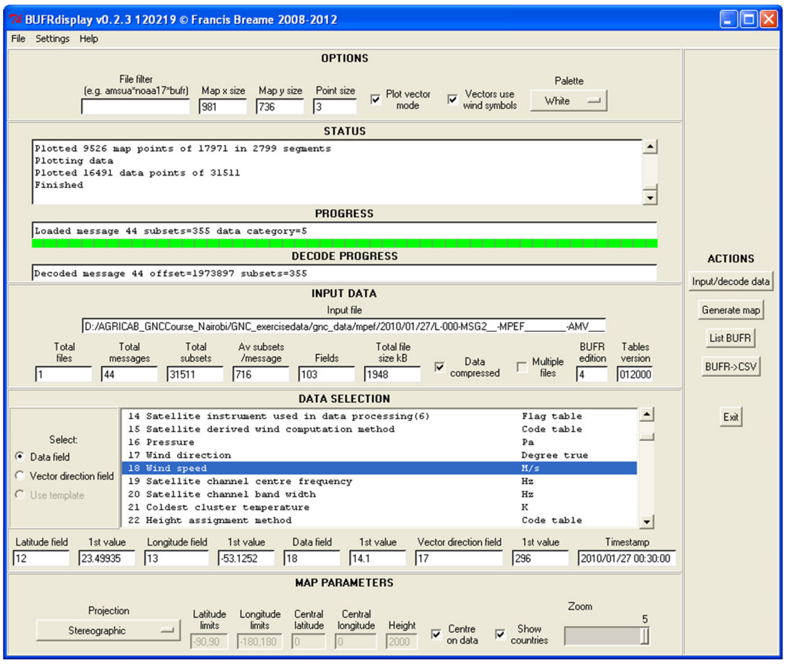
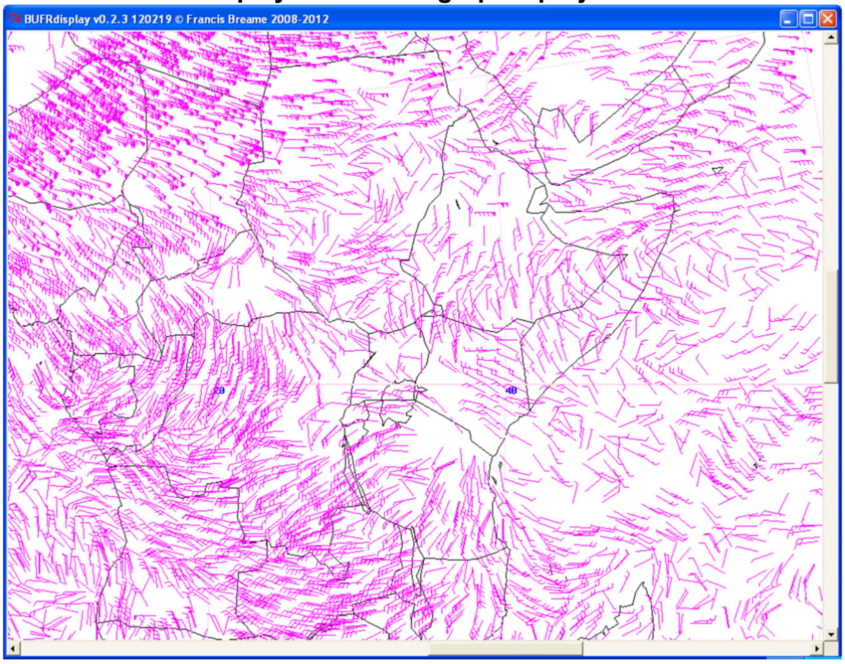


Figure 4.16.2: AMV's displayed in Stereographic projection over Eastern Africa



After visualization close the map and to close BUFRdisplay, select from the menu "*File*" and "*Exit*". Repeat the procedure and use as input the Tropospheric Humidity data, available from the same directory. Select as input file: "*L-000-MSG2__-MPEF________-TH_______-000001___-201001270245-__*" and as for Latitude field type "*14*", for the Longitude field type "*15*", for Data field type "*31*". Press under "Actions" the option "*Input/decode data*" and "*Generate Map*" respectively. Note the map displayed. Close BUFRdisplay.

4.17 ADDITIONAL EXERCISES

4.17.1 ***Data retrieval from EUMETView and the Sentinel EO Browser***

4.17.1.1 EUMETView

Assure you have internet access and subsequently from the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the options "*Other Routines*" >> "*EUMETView*" >> "*Latest EUMETSAT Images-Products*". Check the available near real time images and products. As time in UTC, specify 12:00, as RGB composite select the option 'Natural Colour' and press the download button. As format select "GeoTIFF" and as extent the "full resolution product". Uncheck the option "Overlay". Download the image.

From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" >> "*Folder*" and specify the folder settings for "*EUMETView*". Here the data is downloaded into a folder "*D:\WMS*" and this folder is also used to store the output, so both input and output folders are identical. Press "Save" to store the settings. Once the image is downloaded copy it into the designated folder and check the file name.

In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Other Routines*" >> "*EUMETView*" >> "*Import downloaded Images-Products*". Note the output directory specification and press "*Import*". A script, called "*EUMETView_import*" is retrieved. Study the content of the script and press the "Run Script" icon available from the menu bar. Two parameters are required and for the 'input band name' select the name of the downloaded file, including the extension. For the 'output file name' specify an appropriate name, e.g. "*MSG_TC*", and press "*OK*" to execute the script.

Double click the map list icon "*MSG_TC*", and show the map list as colour composite, "*MSG_TC_band_1*" as Red, "*MSG_TC_band_2*" as Green and "*MSG_TC_band_3*" as Blue. Note the coordinates and add the country boundaries. From the map window menu, select "*Options*" >> "*No Zoom*".

4.17.1.2 Sentinel EO Browser

Assure you have internet access and subsequently from the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the options "*Other Routines*" >> "*Sentinel EO Browser*" >> "*Sentinel – Landsat, etc. Images-Products*". Press the option "*Start Exploring*" and navigate to your Area of Interest, select the appropriate satellite. Also other settings can be applied like cloud cover, time range, etc. Press the "*Search*" button. Check the available near real time images and products and make a selection of an image / product. The top left "Show Info" button provides access to the 'Tutorial'.

Once logged in, the image / product can be downloaded, by pressing the "Download Image" button. Here a Sentinel 2 L1C image is selected. Use the options "*Analytical*", Uncheck the option "*Show Logo*", as image format select "*TIFF (32-bit float)*", image resolution is "*High*", Coordinate System is "*WGS 84 (EPSG:4326)*", as Layers, select from those listed under "*Raw*" the following layers: "*B02*", "*B03*" and "*B04*". If all these criteria are correctly specified, press the "*Download*" button.

Once the image is downloaded, likely in your system 'Downloads' folder a file is available, called "*EO_Browser_images.zip".* Copy this file to your output folder, here 'D:\WMS' and unzip the file in this folder.

It is assumed that the same in and output folders can be used. From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" >> "*Folder*" and specify the folder settings for "*EO_browser*". Here "*D:\WMS*" is used for input and output folders. To store these settings press "*Save*".

In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Other Routines*" >> "*Sentinel EO-Browser*" >> "*Import downloaded Images-Products*". Note the output directory specification and press "*Import*". A script, called "*EO_Browser_import*" is retrieved. Study the content of the script and press the "Run Script" icon available from the menu bar. Two parameters are required and for the 'input band name' select the name of the downloaded spectral band, including the extension. For the 'output file name' specify an appropriate name, e.g. "*Sent2_L1C_B2*" (for band 2), and press "*OK*" to execute the script. Repeat the procedure for the other 2 spectral channels.

Double click the map "*Sent2_L1C_B2*", and display the image using as Representation "*Gray*". Move the cursor over the image and inspect the values. Note that the values represent 'radiances'. Close the map window. In order to create an appropriate visualization, right click with the mouse button on the image "*Sent2_L1C_B2*" and from the context sensitive menu select the options "*Image Processing*" >> "*Stretch*", as Output Raster Map specify "*Sent2_L1C_B2s*", the other options can be kept using their default settings. Repeat above procedure for the other 2 spectral channels.

From the main ILWIS menu, select "*File*" >> "*Create*" and select "*Map List*". Select the 3 stretched images in the left hand column and press ">" to move them to the right hand column. Note their sequence; band2, band 3 and band 4 from top to bottom respectively. Specify an appropriate output map list name, e.g. "*S2L1C*". Double click on the newly created map list and use the "*Open a ColorComposite*" option, select B4 as Red, B3 as Green and B2 as Blue" and press "*OK*". From the map window menu, select "*Options*" >> "*No Zoom*". Measure the pixel size to get an idea of the spatial resolution of the image. To do this use the "*Measure Distance*" icon from the map window menu bar. Also note the coordinates in the lower right hand map display window.

4.17.2 ***Real Time MSG Visualization***

Given the timing and amount of data required to perform these routines they can only be done when having access to the HRIT MSG data stream using a ground receiving station. Have once more a careful look at Chapter 3.2.5 and study the sequence of routines which are executed as described in figure 3.3.

The real time visualization routines expect access to the archive; this can best be achieved by making a network mapping to where the new arriving MSG-HRIT data is stored. Note that given the large amount of MSG files disseminated on a daily basis to effectively store all the data a Year-Month-Day directory structure is commonly used. This structure is expected to run the visualization routines and is automatically recognized and does not need to be defined and therefore only the main directory, containing this dated folder structure has to be specified as a mapped network drive. From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*Real Time MSG Vis*". Browse to the appropriate data input directory and select your mapped network drive. Here as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings. Note that use is made of IrfanView to display the final image created, check once more from the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Configuration*" >> "*Folder*" >> "*Special locations*" if the location of IrfanView directory and executable is correctly specified.

From the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Real Time MSG Visualization*" >> "*MSG IGAD Region Multispectral*". Check the input and output directories and press "Import". If working under XP enter your password, this is not required when working under Windows-7. In principle you can now close ILWIS as all operations are now executed from a scheduled task created and will automatically start (every 15 minutes –in sync with the temporal resolution of MSG) at a given system clock time (1 minute after the end of scan time). The scheduled task created will execute the newly created file "*st_MSGIGAD.bat*", stored in the ILWIS sub-directory: '\Extensions\WFS_E-Toolbox\toolbox_startscript\RealtimeMSGVisualization\AfricaIGADWindow'.

The batch file listing of "*st_MSGIGAD.bat" is given below.*

Start of listing

```
------------------------------------------------------------------------------------------------------------------------
set st_inputdrive=Z:
set st_outputdrive=D:
set st_outputpath=WFS_out
set st_ilwdir=D:\Ilwis372\
set st_utildir=D:\Ilwis372\Extensions\WFS_E-Toolbox\util
set st_irfanviewdir="C:\Program Files\IrfanView\i_view32.exe"


call "%st_ilwdir%Extensions\WFS_E-Toolbox\toolbox_startscript\RealtimeMSGVisualization\st_msg.bat"
AfricaIGADWindow 452 50 100 100
-----------------------------------------------------------------------------------------------------------------------------------
```

End of listing

Every time this batch file is executed, first the relevant parameters are set so the subsequent utilities can make use of these settings. At the end another batch file "*st_msg.bat*" is executed having 5 parameters. The first one, "AfricaIGADWindow" is referring to the sub-directory containing other batch files which are required for this routine, the other 4 parameters are used by IrfanView to display the final image on the screen: 452 and 50 are the starting column and line on the screen respectively, 100 and 100 are used to resize the image, in this case the image is displayed with a resize factor of 100 %, so no resizing is applied in this case! These parameters are subsequently applied in the batch file "*st_msg.bat*" which is executing the actual import using a number of other batch routines. You can check the content of the file "*st_msg.bat*" situated in the ILWIS sub-directory 'Extensions\WFS_E-Toolbox\toolbox_startscript\RealtimeMSG Visualization'. Use your Windows Explorer, navigate to this sub-directory, right click with the mouse on the file and select "*Edit*" from the context sensitive menu.

The whole procedure is quite complex, take some time to study the various files used to create this automated image visualization.

There are more routines for automated visualization. Before you start a new one, Stop the "*MSG IGAD Region Multispectral*" scheduled task which is running by using the option from the menu "*Stop Multispectral Visualization*".

4.17.3 *Automatic processing routines*

In line with the routines described above, operational meteorologists require easy access to a multitude of information. The routines prepared under the option "*Automatic Processing Routines*" facilitate automatic retrieval of a number of recent received images and products when operating a ground reception system. Once more read carefully chapter 3.2.18 and review table 3.3 for the images / products processed. For MPEF visualization it is up to the user to select the option with or without the 'Optimum Cloud Analysis' product. Note that also a routine has been added to retrieve a number of layers from the 'Arpege' NWP model as provided by the most recent Analysis. Ensure that before you continue you check where the data required is stored and which network mappings are used to retrieve the data.

Before starting to import the most recently received images and products that are available from the EUMETCast data feed you need to check the settings of the directories that contain the received data sources required and provide the folder details for the processed data. From the

"*WFS-Ethiopia"* and *"Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*MPEF-highres*", "*NWC_SAF*", "*MSG Data Retriever*" and "*LFPW*". Note that some folders can have a 'dated' folder structure! Ensure the folder storing the data received for the current date is used. Specify the appropriate input folders and browse to the appropriate data output location and in the case of all of the automatic processing routines as output location "*D:\WFS_out*" is used. Press "*Save*" to store the settings.

In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Automatic Processing Routines*" >> "*Most recent Day-time MSG images*", in case you are executing this routine during the day else select the option "*Most recent Night-time MSG images*". To conduct the automated processing press "*Import*". Check the CMD box, which is containing information on the execution of the import and processing of the data retrieved. Note that the way the composites are generated is described under "*Automatic Processing Routines*" >> "*Colour scheme processing details*", according to the best practices as specified by EUMETSAT.

Automatically a map view is shown on the screen after the processing is completed. You only need to switch on / off the layers in the left hand legend. If you close the map view, note that the file name convention used here in case of the MSG day viewer, is "Ethiopia_MSG_Day_Viewer_**", where '**' is the time of the latest MSG image acquired in 'yyyymmddhhmm' format in UTC – start of scan time. Note that the routine works both with MSG images acquired at 0 degree and 41.5 degree (IODC).

In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Automatic Processing Routines*" >> "*Most recent MPEF products-all*" and press "*Import*" to execute the routine. Note that the routine expects MPEF products based on recordings from MSG data at 0 degree. The user can select also the routine "*Most recent MPEF products-no OCA*", then only the CLM, AMV and MPEG data is retrieved and processed.

Automatically a map view is shown on the screen after the processing is completed. You only need to switch on / off the layers in the left hand legend. If you close the map view, note that the file name convention used here in case of the MSG day viewer, is "Ethiopia_MPEF_Viewer_**", where '**' is the time of the latest MSG image acquired in 'yyyymmddhhmm' format in UTC – start of scan time.

To display the most recent NWC-SAF products, in the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Automatic Processing Routines*" >> "*Most recent NWC products*" and press "*Import*" to execute the routine. For further description of the products see http://www.nwcsaf.org/. The routine automatically retrieves the cloud type and cloud phase (CT), cloud mask (CLM), , cloudiness, cloud temperature, cloud pressure and cloud height (CTTH) products.

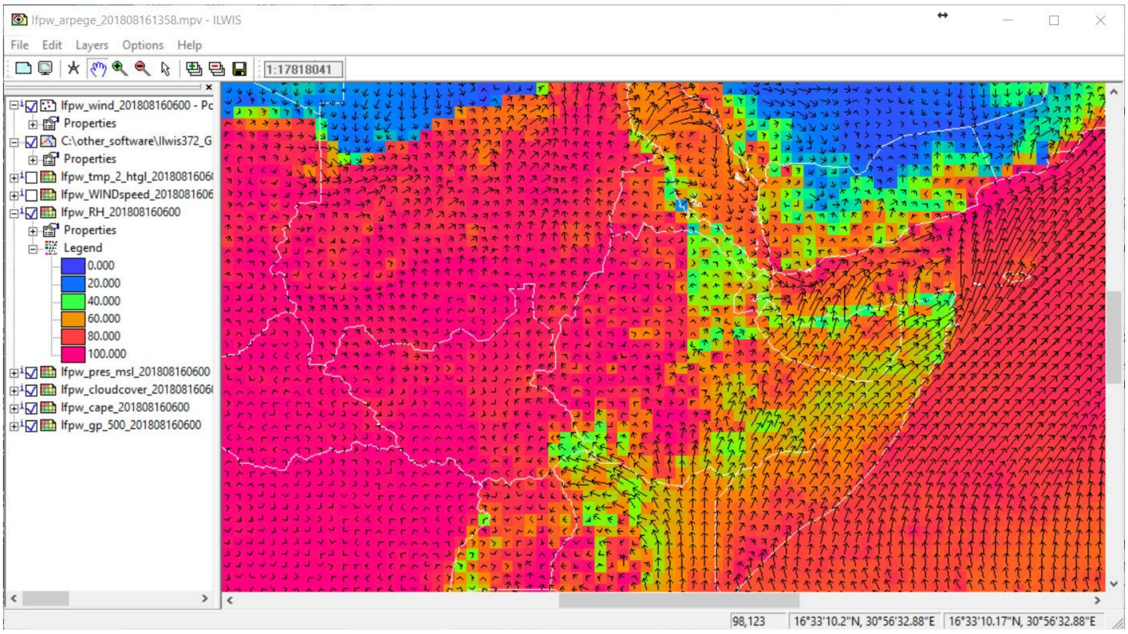
Upon completion of the import, automatically a map view is shown on the. You only need to switch on / off the layers in the left hand legend. If you close the map view, note that the file name convention used here in case of the NWC SAF viewer, is "Ethiopia_NWCSAF_Viewer_**", where '**' is the time of the latest NWC SAF products acquired in 'yyyymmddhhmm' format in UTC.

Finally a routine is provided showing products contained in the latest forecasts from the Arpege Numerical Weather Prediction model, created by Meteo France from Toulouse (LFPW). In the "*WFS-Ethiopia*" and "*Toolbox*" main menu select the option "*Automatic Processing Routines*" >> "*Most recent Arpege Analysis*" and press "*Import*" to execute the routine. Note that this routine can only be used if registered to restricted services on EUMETCast. Data can be obtained if license in the EO-portal for WMO Region 1 (RA1 = Africa) has been activated.

Automatically a map view is shown on the screen after the processing is completed. You only need to switch on / off the layers in the left hand legend. If you close the map view, note that the file name convention used here in case of the MSG day viewer, is "lfpw_arpege_**", where '**' is the time of the latest Analysis forecast acquired in ‘yyyymmddhhmm’ format in UTC. Data for the whole coverage are extracted allowing the meteorologist to view the African region.

Data layers for further review at disposal are CAPE, cloud cover, mean sea level pressure, relative humidity, wind vectors, temperature at 2m, geo potential height at 500Mb.

Figure 4.17.1: Resulting map view of the latest Arpege NWP model Analysis



4.17.4 *Cross in-situ with satellite derived time series observations*

Before satellite time series can be used as a proxy with respect to ground measurements, the satellite derived estimates should be checked against (independent) ground station measurements. Here long term ETo data from NMA, calculated using the Penmann-Monteith method based on variables collected by their ground station network. The ETo computed is used and will be compared against a new satellite derived product, called Reference Evapotranspiration (METREF). See also https://landsaf.ipma.pt/en/products/evapotranspiration/ and consult the METREF product description for further information. The METREF product is relatively new so only the average could be computed for 3 years (2015-2017). It should be noted that the mean ETo data from NMA is calculated based on a longer time period. Furthermore it should be noted that not all station location data could be verified.

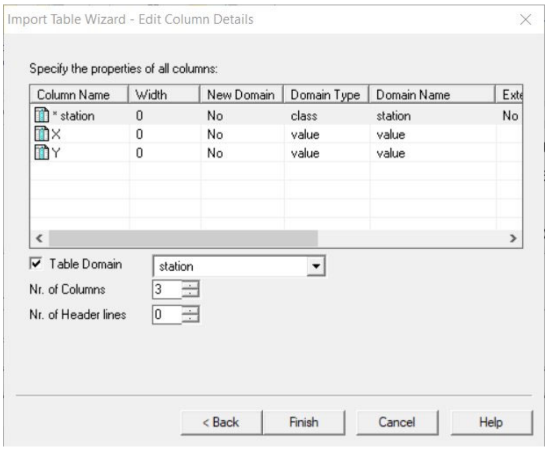
Navigate with your browser to the folder “*D:\WFS_out\Insitu*” and open the worksheet “*NMA_ETo_mean.xlsx*” and navigate to the sheet “*station_only*”, note that the other sheet “Dek_ETo” is providing the mean dekadal ETo per station. The worksheet “*station_only*” has to be saved as a CSV file, to do this ensure that the sheet “*station_only*” is the active sheet. From the Excel main menu select the options “*File*” >> “*Save as*”, browse to the output directory, here “*D:\WFS_out\Insitu*” and select the option “*Save as Type*” ‘CSV (MS DOS)(*.csv)’ and press “*Save*” and save only the active sheet, press “*OK*” and “*Yes*”. Close the worksheet.

Using the explorer, browse to the folder, here “*D:\WFS_out\Insitu*” and open the file with notepad or notepad++ and check the content. Replace “;” by “,”, to do so in notepad ++ from the main menu select the options “Search” >> “Replace” and in the ‘Find what’ field enter “;” and in the ‘Replace with’ field enter “,” and now select the option “Replace all”. Also delete the first line containing the string: 'Station, Lon, Lat'. The first line should now contain the string:"Abobo,34.43,7.85", the last line (78) should contain the string "YETNORA,38.15,10.20". Save the modified file (you can overwrite the file if the replacement is correctly executed.

Open ILWIS 385 and navigate to the working folder, here "*D:\WFS_out\Insitu"*. Once close and open Ilwis again. It should now open in your designated working directory. From the Ilwis main menu select the options "*File*" >> "*Import*" and from the 'Import' menu the options "*ILWIS*" >> "*Table*" >> "*Comma delimited*", now select as input file "*NMA_ETo_mean.csv*" and press "*Open*". Select the "Options.." button, check the content of the input table, press "*Next*", modify the Column name for Column1 to "*Station*", for Column2 to "*X*" and Column3 to "*Y*" and press "*Finish*" and "*OK*". Open the table "*NMA_ETo_mean*". Right click on the column name "*Station*", open the "*Properties*", select the option "*Create new Domain from Strings in column*" and press "OK". Now a new domain is created containing all station names. Close the table and open the new domain created "station". Close also the domain. Now you are going to create a new table, not using record numbers but station names for the records. Delete the table "NMA_ETo_mean".

From the Ilwis main menu select the options "*File*" >> "*Import*" and from the 'Import' menu the options "*ILWIS*" >> "*Table*" >> "*Comma delimited*", now select as input file "*NMA_ETo_mean.csv*" and press "*Open*". Select the "Options.." button, check the content of the input table, press "*Next*", modify the Column name for Column1 to "*Station*", for Column2 to "*X*" and Column3 to "*Y*". Now modify as column properties for the column 'station' the Domain type and change this from 'string' to "class". Under domain name, select from the drop down listing the domain "Station" (created during the previous step) and now activate the option "Table Domain" and once more select from the drop down list "Station", see also the figure below. Press "*Finish*" and "*OK*" to import the table and check the content the new table "*NMA_ETo_mean*". Note that the records are now given the name of the station (and not a record number as was the case during the previous table import).

Figure 4.17.2: Import of the station data into an Ilwis table



Note that the accuracy of the X and Y coordinates provided is maximum 2 decimals (in degree.decimal) as latitude - longitude coordinates. Close the table. Right click the table once more, select the options "Table Operations" >>" "*Table to Point Map*" from the context sensitive menu. In the 'Table to Point Map dialog box' the X and Y Columns are already correctly specified, as coordinate system select "*LatlonWGS84*" and specify as output point map "*station*" and press "*Show*".

As the map list 'eth_metref_sum_avg' is having a different projection, right click the point map "station" and select the options "*Spatial Reference Operations*" >> "*Transform Points*", as output map specify "*station_NMA*" and as coordinate system "*giacisV2_proba_eth*" and press "*Show*".

Now from the main ILWIS menu select the options "*Operations*" >> "*Point Operations*" >> "*Cross*". As point map select "*station_NMA*", as maplist "*eth_metref_sum_avg*", as output point map "*station_NMA_cross*" and press "*Show*". You can close the point map and open the table "*station_NMA_cross*". Now per station the dekadal average METREF is given for the 36 dekades (the columns appended from the map list eth_metrefsum_avg011 - eth_metrefsum_avg123).

You can close the table. From the main ILWIS menu select the options "*File*" >> "*Export*" and select the table "*station_NMA_cross*", export as Format "*Delimited text.txt*", note the output file name and press "*OK*". You can close ILWIS as the other processing is done using Excel.

Before you start with Excel, using the explorer, browse to the folder, here "*d:\insitu*" and open the file "*station_NMA_cross.txt*" with notepad or notepad++ and check the content. At the beginning of the file, on line 1, enter "station,". The first line should now read: 'station,"X","Y","eth_metrefsum_avg011",…. continues for the other dekades'. Save the file and open the sheet "*NMA_ETo_mean.xlsx*" in Excel. Create a new worksheet. From the main menu of Excel, select the option "Data" >> "From Text" and select the file "*station_NMA_cross.txt*", press "*Import*">> "*Next*" >> as Delimiter use "*Comma*". Press "*Finish*" and "*OK*" to complete the import. Rename this new sheet as "*METREF*".

Now the new sheet imported should have the same layout as the sheet "*Dek_ETo*". Check both sheets. Copy the column "Total" from the sheet "*Dek_ETo*" into a new sheet and paste as values! Rename the column name into "*NMA_ETo_sum*" and the sheet as "*ETo_year*".
In the sheet "METREF" create a new column at the end, called "*METREF_sum*" and calculated the sum of all dekades for each station (see procedure applied in sheet Dek_ETo) and also paste these values in the new sheet "*ETo_year*". Number of decimals used can be set to "0".

Calculate a new column 'Dif' which is the difference defined as (NMA_ETo_sum-Metref_sum) and determine the average difference (here a bias of 81 mm/year is noted). Calculate a new column Metref_addbias, adding the bias calculated to the Metref (Metref_sum+81) as in general the Metref product is slightly under estimating the ETo, compared the the ETo as derived from station measurements. Finally create some graphics using the columns "NMA_Eto_sum" and "Metref-addbias", using a 2-D line graph and a scatter plot. Your results should resemble those provided below.

Figure 4.17.3: Line graph of long term mean yearly station ETo and 3 year mean METREF

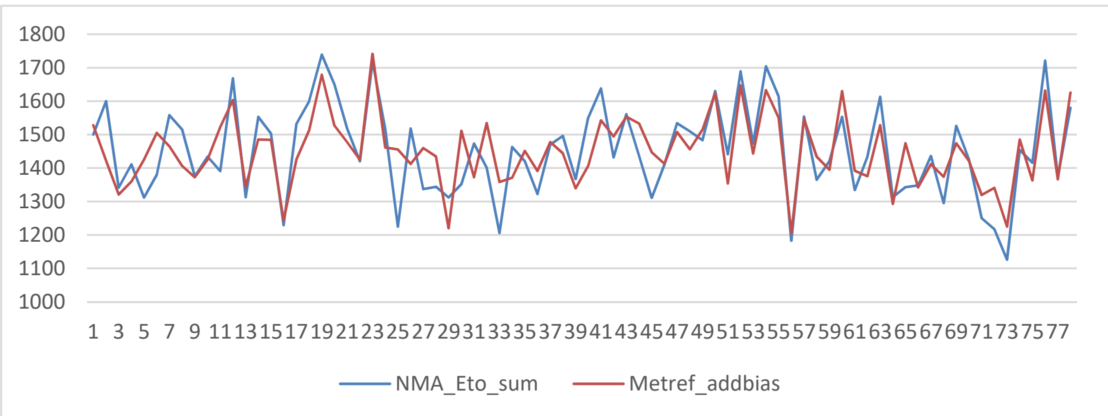
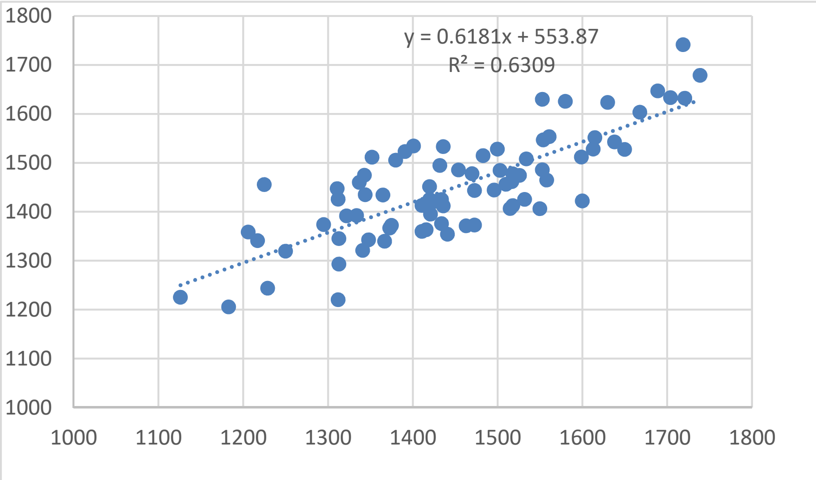


Figure 4.17.4: Scatter plot of long term mean yearly station ETo and 3 year mean METREF



From the analysis it is clear that the METREF satellite product has a reasonable correlation with the longer term mean ETo, calculated using the Penmann-Monteith method by NMA. It seems that the METREF is slightly under estimating and a bias correction of 80 mm / year was introduced, which given the overall yearly mean ETo as provided by NMA is in the order of 4 to 7 % and are in line with the observations presented in the METREF Validation report (available at: https://landsaf.ipma.pt/en/products/evapotranspiration/metref/).

4.17.5 *Multi temporal data import using a batch looping procedure*

To import all necessary data to do a time series analysis using the WFS-Ethiopia Toolbox menu can be cumbersome. Check the content of the sub-directory "*D:\WFS_out\multi_ET*" using your Windows Explorer. This sub-directory is consisting of 2 batch files, multi_ET_start.bat and multi_ET_loop.bat. The content of these batch files is also provided in figure 4.17.5 and 4.17.6.

Figure 4.17.5: Batch file 1, starting the multi temporal import routine

multi_ET_start.bat - Notepad

File Edit Format View Help

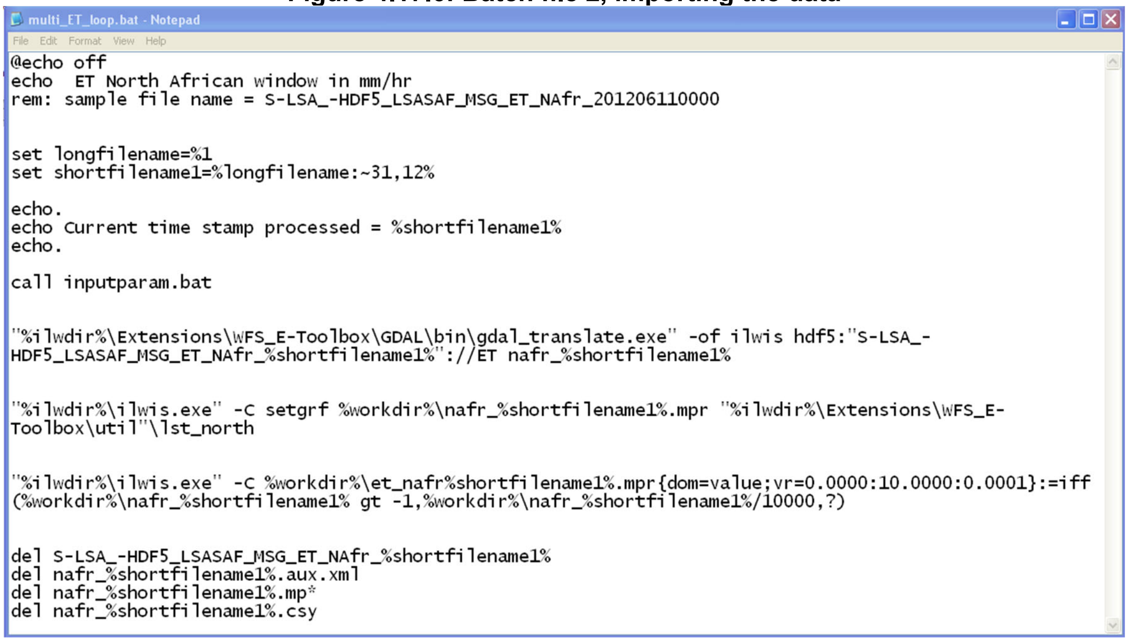
```
@echo off
rem from command line = multi_ET_start.bat data_dir ilwis_dir working_dir

echo set ilwdir=%2>inputparam.bat
echo set workdir=%3>>inputparam.bat

copy "%1\S-LSA_-HDF5_LSASAF_MSG_ET_NAfr_*"

for %%j in (*S-LSA_-HDF5_LSASAF_MSG_ET_NAfr_*) do "%2\Extensions\WFS_E-Toolbox\util\7z.exe" e %%j

del S-LSA_-HDF5_LSASAF_MSG_ET_NAfr_*.bz2


for %%j in (*S-LSA_-HDF5_LSASAF_MSG_ET_NAfr_*) do cmd /c multi_ET_loop.bat %%j

echo.
echo.
echo You have succesfully completed this multi temporal import
echo It is better to devote some time to construction of these import routines
echo as they can save a lot of time on data pre-processing
echo THIS TIME CAN BE USED FOR OTHER SOCIAL ACTIVITIES!
```

This batch routine provides at the beginning, after the rem (remark) in line 2 how the batch file should be executed. It is expecting 3 parameters to execute the batch file: the data directory, the ILWIS directory and the working directory. Parameter 2 and 3 are stored in a new batch file that is created (parameter.bat). Subsequently the required input data is copied from the data directory specified. Next all data is unzipped using 7Z.exe (note the "for" and "do" expression) and the original zipped files are being deleted in the next command line. After this all remaining unzipped files are used as input for the second batch file (multi_ET_loop.bat) which is executed. The "cmd /c" is included to ensure that after all computations are finalized by the second batch file the process continues in the starting batch file. At the end a number of lines are displayed and the content is provided here.

The second batch file is given in figure 4.17.6. Note that for visualization purpose use is made here of the option "Word Wrap" of Notepad, actually if you edit this batch file using Notepad you will see the expressions as single lines!

For each event which is meeting the file string criteria from the start_batch file the loop_batch file is executed. As we are working here with ET images having a 30 minutes temporal resolution and when processing a full day of data, the loop_batch should be executed 48 times. Each ET input file is processed. From the file name the timestamp is extracted (having 12 digits), it is set as shortfilename1 and is displayed in the command line window. Then the parameter file, created by the batch_start, which defines the ILWIS directory and Working directory is called and the directories are set. These are needed by the next three lines. Here the actual import of the data is done. Gdal_translate extracts the ET layer from the HDF file and transforms it into an ILWIS format, the next line sets the georeference, taken from the Toolbox \Util subdirectory and finally a map calculation is performed to transform the data into the appropriate unit (here mm/hr). The obsolete files are then being deleted. Note that ILWIS is executed from the command prompt!

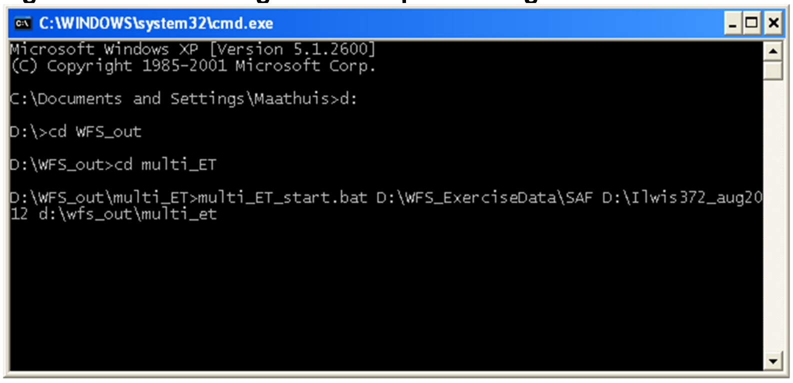
Figure 4.17.6: Batch file 2, importing the data



```
@echo off
echo  ET North African window in mm/hr
rem: sample file name = S-LSA_-HDF5_LSASAF_MSG_ET_NAfr_201206110000


set longfilename=%1
set shortfilename1=%longfilename:~31,12%

echo.
echo Current time stamp processed = %shortfilename1%
echo.

call inputparam.bat


"%ilwdir%\Extensions\WFS_E-Toolbox\GDAL\bin\gdal_translate.exe" -of ilwis hdf5:"S-LSA_-
HDF5_LSASAF_MSG_ET_NAfr_%shortfilename1%"://ET nafr_%shortfilename1%


"%ilwdir%\ilwis.exe" -C setgrf %workdir%\nafr_%shortfilename1%.mpr "%ilwdir%\Extensions\WFS_E-
Toolbox\util"\lst_north


"%ilwdir%\ilwis.exe" -C %workdir%\et_nafr%shortfilename1%.mpr{dom=value;vr=0.0000:10.0000:0.0001}:=iff
(%workdir%\nafr_%shortfilename1% gt -1,%workdir%\nafr_%shortfilename1%/10000,?)


del S-LSA_-HDF5_LSASAF_MSG_ET_NAfr_%shortfilename1%
del nafr_%shortfilename1%.aux.xml
del nafr_%shortfilename1%.mp*
del nafr_%shortfilename1%.csy
```

Now activate the Windows "*Start*" menu and select "*Run*". You are going to use the Windows "command.exe" utility to run the batch files and in order to activate this type "*cmd*" and press "*OK*". In the new command window that appears navigate to your active working directory, here D:\WFS_out\multi_ET is assumed and execute the ET import by typing the name of the start_batch and the three parameters on the command line (see also figure 4.17.7) and press enter. Note that the settings on your system most likely are different; substitute these with the correct (sub-) directory names. For the commands (followed by <enter>) to navigate to your working directory and other DOS command syntax, see also figure 4.17.7. Note the space between the batch file and the parameters!

Figure 4.17.7: Starting the batch processing from a CMD window



```
Microsoft Windows XP [Version 5.1.2600]
(C) Copyright 1985-2001 Microsoft Corp.

C:\Documents and Settings\Maathuis>d:

D:\>cd WFS_out

D:\WFS_out>cd multi_ET

D:\WFS_out\multi_ET>multi_ET_start.bat D:\WFS_ExerciseData\SAF D:\Ilwis372_aug20
12 d:\wfs_out\multi_et
```

After the batch routines have started, keep following the messages displayed in the command line window, each time you will be notified that a new time step is being processed. When the batch routine has finished, navigate ILWIS to the "*\multi_ET*" sub-directory. You will note that all 48 files are now available as raster maps. From the main ILWIS menu, select "*File*", "*Create*" and select "*Map List*". Select all 48 files in the left hand column and press ">" to move them to the right hand column. Specify an appropriate out map list name, e.g. "*et20120611*". Double click on the newly created map list and use the "*Display as Slide Show*" option, select as "*Representation*" "*Pseudo*" and press "*OK*" twice to start the display of the animated sequence.

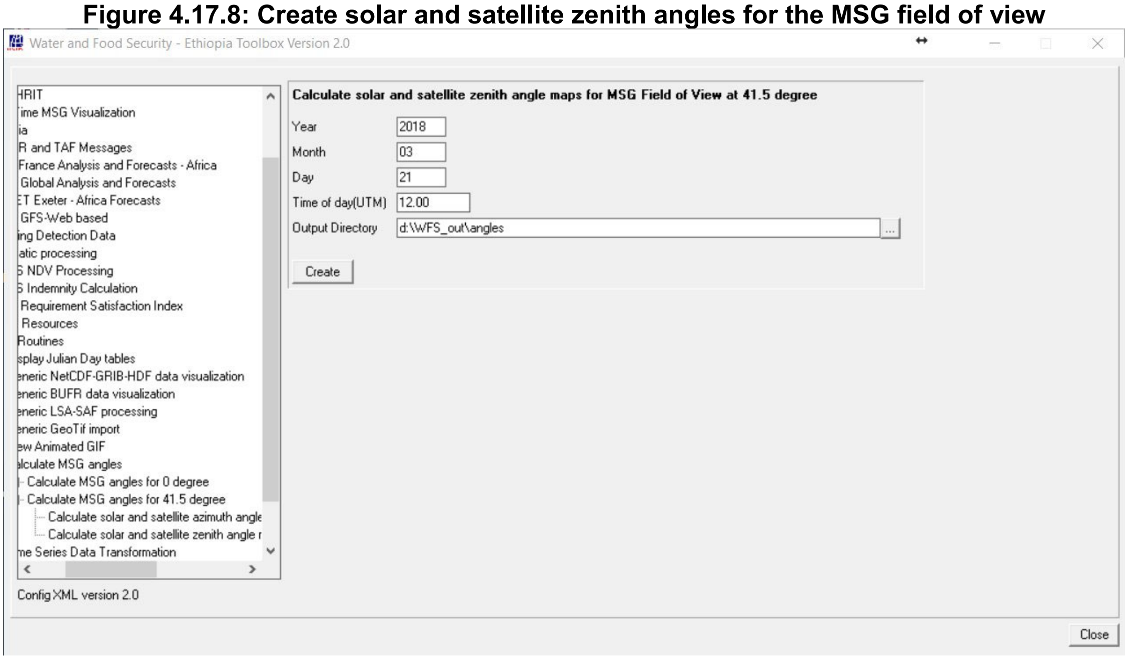
You have noted that the images cover the full northern African continent. In order to select only your region of interest, right click with the mouse the map list "et20120611", select the option "*Spatial Reference Operations*" >> "*Resample*". In the Resample Map window specify as resampling method "*nearest neighbour*", as output raster map "*et_res20120611*" and select as GeoReference "*Ethiopia_1km*", leave the other options as default and press "*Show*". Wait until the resampling process is completed and display the newly created map list as an animated sequence. Navigate back to the main working directory, here "*D:\WFS_out*", before you continue.

4.17.6 *Calculate MSG and solar zenith – azimuth angles for Ethiopia*

In order to derive the satellite viewing and solar angles select from the "*WFS-Ethiopia"* and *"Toolbox*" main menu the option "*Configuration*" and "*Folder*" and select "*Calculate MSG angles*". Browse to the appropriate data output directory. Here as output location "*D:\WFS_out\angles*" is used. Press "*Save*" to store the settings. Use the ILWIS Navigator to move to this sub-directory.

From the "*WFS-Ethiopia"* and *"Toolbox*" main menu select the option "*Other Routines*" >> "*Calculate MSG angles*" >> "*Calculate MSG angles for 41.5 degree*" >> "*Calculate solar and satellite zenith angle maps for the MSG Field of View*" and specify the settings as given in the figure below for 21 March 2018 at 12:00 UTC, when the sun is above the equator and press "*Create*".

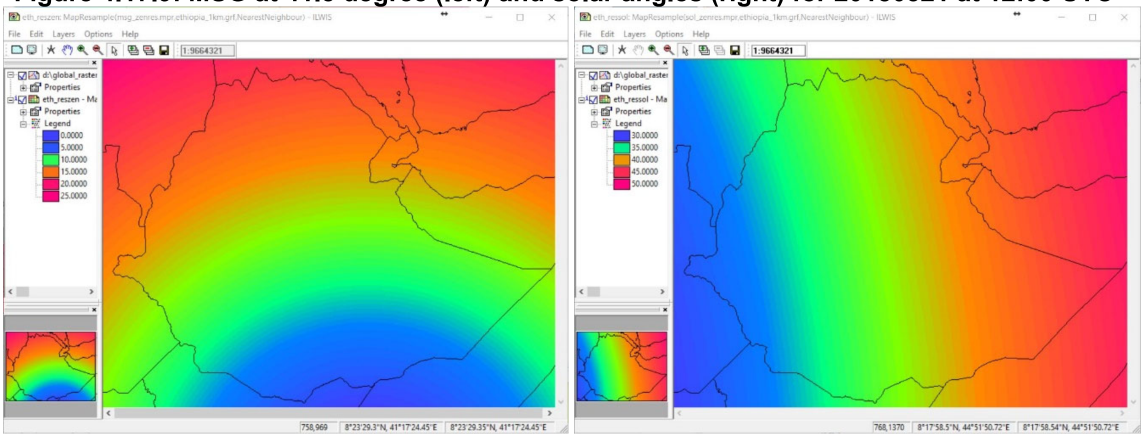
Figure 4.17.8: Create solar and satellite zenith angles for the MSG field of view



When the operation has completed, open the maps "*msg_zenres*" and "*sol_zenres*". Note that also other maps are being created like "*illum_condition*" and "*sun_elev*". Most maps can be displayed using a "*Pseudo*" Representation, as the "*illum_condition*" is a classified map, use the default Representation. From the active map window select the option "Layers" >> "Add Graticule" you can keep using a default Graticule distance of 20 degree and press "OK", also add the country boundaries. Move the mouse, keeping the left mouse button pressed, over the map and inspect the values representing the respective angles. Also the secant of the MSG and sun angle are calculated, open the files "*sec_msgzen*" and "*sec_solzen*", use again a "*Pseudo*" Representation.

In order to obtain the angles for the Ethiopia region of interest, select for example the map "*msg_zenres*", right click with the mouse on the map name and from the context sensitive menu select the option "*Spatial Reference Operations*" >> "*Resample*". As resampling method select "*Nearest Neighbour*", as output map "*Eth_MSGzenres*" and as Georeference "*Ethiopia_1km*", leave the rest as default, press "*Show*" and press "*OK*" to display the map, using a "*Pseudo*" Representation. Add the country boundaries and inspect the values. Repeat the procedure and use as input "*sol_zenres*", to resample the solar zenith angle to the same Ethiopia georeference. Your results should resemble those of figure 4.17.9. Note that also the azimuth angles of the sun and satellite can be derived using the other option from the menu.

Figure 4.17.9: MSG at 41.5 degree (left) and solar angles (right) for 20180321 at 12:00 UTC



MSG is situated over the equator at 41.5 degree and at this given moment the sun is also situated over the equator given a 12:00 UTC time stamp used.

4.17.7 *Retrieving statistical information for basin management*

For basin management it is important to transform the information derived from satellites in such a way that it can be used as input for models or to provide statistical information for further assessment. The unit at which the data will be presented is likely related to watershed units, as this forms the most important boundary condition. Here an assessment will be conducted utilizing the total precipitation derived from CHIRPS of 2017 and the data will be aggregated to present the rainfall statistics for the main catchments / basins for Ethiopia. Open ILWIS and navigate to the folder "*D:\WFS_out\Basins*". Once close and open ILWIS again, it should now open in the appropriate folder.

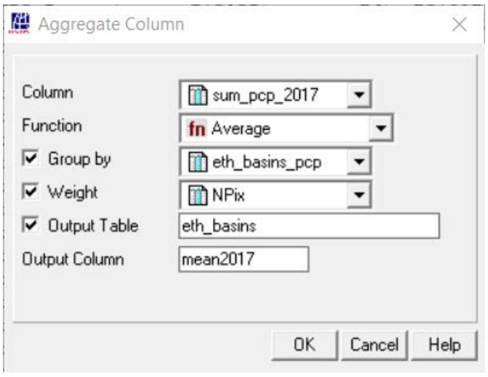
Display the map "*sum_pcp_2017".* This map is created by means of map list statistics, using the daily precipitation for 2017. The statistical aggregation function used is 'Sum'. Now add to this map the polygon map "*eth_basins*". To do so open from the active map display window menu the option "*Layers*" and from the context sensitive menu "*Add Layer*" and display "*Boundaries only*". Activate the "*Pixel Info*" option from the active map display window, from the main menu select the options "*File*" >> "*Pixel Information*". When you move the mouse cursor over the polygon map you can see the values provided in the table, here the 'eth_basin' information from the polygon layer.

The next step is to convert the Polygon map "eth_basins" to a Raster format, using the georeference of the Precipitation map used. Open from the main ILWIS menu "*Operations*", subsequently "*Rasterize*" and "*Polygon to Raster*". Select as polygon map: "*eth_basins*" and as output map you can specify the same name: "*eth_basin_pcp*" (a new raster layer will be obtained) and select the georeference that belongs to the precipitation map, in this case: "*giacisV2_proba_et*". When the polygon to raster conversion is completed, press "*OK"* to show the raster map "*eth_basins_pcp*". Move the mouse cursor over the map and check the values. Once more open from the active map display window the menu item "*File*" and from the drop down menu select "*Open Pixel Information*". Check the relationship between the map and the table.

Now you can cross both maps. Open from the main ILWIS menu "*Operations*", subsequently "*Raster Operations*" and "*Cross*". Specify as first map: "*eth_basins_pcp*" and as second map the precipitation map: "*sum_pcp_2017*". Specify as output cross table: "*basin_pcp2017*", all other options can be left as default, like "*Ignore Undefined*" and don't "*Create an Output Map*". Execute the map crossing by pressing "*Show*". After the crossing is completed the cross table will appear on your screen.

Check the content of the table. Select from the Table menu the option: "*Columns*" and from the drop down menu: "*Aggregation*". Specify other settings according to figure 4.17.10 and press "*OK*" to calculate the average precipitation per basin. Note that in the table "*eth_basins"* a new column: "*mean2017*" is being created by this operation.

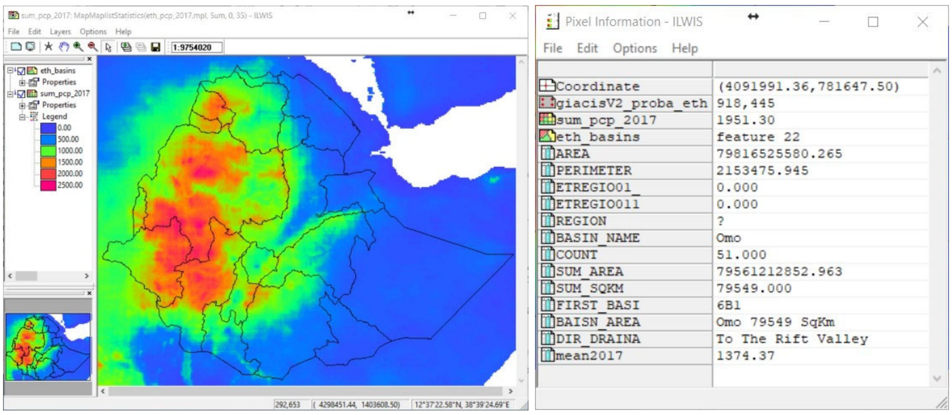
Figure 4.17.10: Create new output column in table with aggregated statistics, grouped per basin, using the function average for the 2017 pcp



Repeat the procedure above and calculate new columns in the table '*eth_basins*', using the aggregation functions 'maximum', 'minimum' and 'Std Deviation' and call these columns the "*Maximum2017*", "*Minimum2017*" and "*Std2017*" respectively.

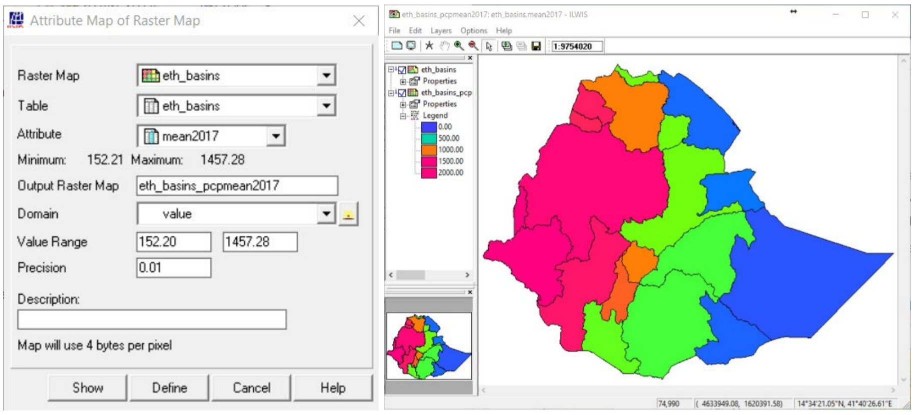
Close the cross table "*basin_pcp2017*" and open the table called: "*eth_basins*", and check all the values in this table. Now you have obtained various statistics for each of the basins. Display the map "*sum_pcp_2017*" and add the polygon layer "*eth_basin*", select boundaries only. Open from the active map display window "*File*" and "*Open Pixel Information*". Inspect your results. They should resemble those of Figure 4.17.11 for the 'mean' precipitation of 2017.

Figure 4.17.11: PCP map of Ethiopia and aggregated statistics appended to map table



The eth_basins raster map can now be reclassified to see the spatial distribution of the average precipitation for each basin. Right click with the mouse on the raster map "*eth_basins*", select from the context sensitive menu "*Raster Operations*" >> "*Attribute Map*", provide the information as given in the left hand figure below and press "*Show*" to execute the operation. Display the new map created "*eth_basins_pcpmean2017*", using as Representation "*Pseudo*". Your results should resemble those of figure 4.17.12. Also display the vector basin boundaries, lakes and rivers.

Figure 4.17.12: Average precipitation per basin in Ethiopia, for 2017



Repeat the procedure above using the attributes "*Maximum*", "*Minimum*" and "*Std*". What can be concluded with respect to the rainfall occurrence in 2017?

The operations conducted above might require further analysis of the data in a spread sheet, like in Microsoft Excel. The table "*eth_basins*" can be manually exported to 'Delimited TXT' format and used in Excel. From the main ILWIS menu select the options "*File*" > "*Export*" and select the table to be exported and provide an appropriate output file name for the text file to be created.

4.17.8 ***Import of METOP AVHRR/3***

The images collected by the AVHRR/3 sensor on METOP is not disseminated via the GEONETCast C-band turn around services (e.g. to Africa or Latin America). It can be obtained from the archive at EUMETSAT (http://archive.eumetsat.int/umarf/, you can continue as Guest and Login). To get an idea of the images an example is included here. The table below shows the spectral channels of the AVHRR/3 sensor on METOP. It has six channels (three visible and three infra-red) but only five channels are used at a given time. Channel 3A is recording the NIR during daytime and the short wave infra-red (channel 3B) at night time.

Table 4.17.1: AVHRR/3 spectral channel details and their primary use

Channel	**Spectral Bandpass (micrometers)**	**Primary Use**
1 (Visible)	0.580 - 0.68	Daytime cloud/surface mapping
2 (Near IR)	0.725 - 1.00	Surface water delineation, ice and snow melt
3A (Near IR)	*1.580 - 1.64*	*Snow / ice discrimination*
3B (IR-Window)	*3.550 - 3.93*	*Sea surface temperature, night time cloud mapping*
4 (IR-Window)	10.300 - 11.3	Sea surface temperature, day and night cloud mapping
5 (IR-Window)	11.500 - 12.5	Sea surface temperature, day and night cloud mapping

An import and pre-processing utility, called “AVHRR_Importer.jar” is developed for allowing to process the METOP Level 1B data as disseminated through EUMETCast. Within the Water and Food Security Ethiopia Toolbox, select the menu options: “*METOP Reader*” >> “*METOP AVHRR Retriever*”. In order to cope with the panoramic distortions towards the end of the swath a new coordinate transformation procedure was implemented, therefore the display of the imported METOP AVHRR data after import can be done using a recent ILWIS 385 version. Here a re-projection can be performed, so the data with the appropriate coordinates (and resampling) can be used in other ILWIS versions.

Navigate, using your browser, to the sub-directory “D:\WFS_Ethiopia_TrainingData\METOP_AVHR” and check the file name conventions used for the METOP AVHRR data. Note the timing from the filename. Create a new folder, here “*D:\Metop*” is used.

From the “*WFS-Ethiopia”* and *“Toolbox*” tabs select the menu item “*Configuration*” >> “*Folders*” >> “*Metop_Retriever*”. Specify as Input Directory “*D:\WFS_Ethiopia_TrainingData\METOP_AVHR*” and as Output Directory “*D:\Metop*”. Within the Water and Food Security Ethiopia Toolbox, select the menu options: “*Other Routines*” >> “*METOP Reader*” >> “*METOP AVHRR Retriever*” and specify the input file name, here the file “*AVHR_xxx_1B_M02_20120608065803Z_20120608070103Z_N_O_20120608073751Z*” is used and press “*Import*”. Check the import message box, while the image is imported. Refresh your ILWIS catalogue after the import is completed.

For correct interpretation one needs to know if it is a day or night time image given the fact that the recording using channel 3 differs during day or night. This can be derived from the file name, as the recording time in UTC is given; see the year-month-day-hour-minutes-seconds notation. This imported image was recorded, starting from “*201206080658*” to “*201206080701*”. Being a day time image, band 3A, recording the NIR, is the channel used. Therefore in the imported images the “radiance_3b” is not imported! Note the files created, check their suffix.

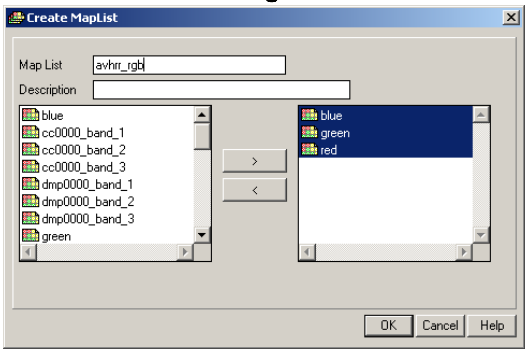
To create a colour composite open (at least) ***ILWIS Version 385T***. First create a map list containing the 3 radiance channels, band1 to band3a having the suffix “Radiance”, save the map list as “*AVHRR_Rad*”. Double click the map list icon of “*AVHRR_Rad*”, in the map list select the option “*Open as ColorComposite*” and select for Red: “*band_3a*”, for Green: “*band_2*” and for Blue: “*band_1*”. Leave the default stretch values; note that the data values represent radiances, inspect the pixel values! Press “*OK*” to see the image. Also put the vector layer showing the “*country_boundaries*” on top (info off, boundaries only and boundary colour in white).

Repeat this procedure for the 3 reflective bands, create a map list “*AVHRR_Refl*” and display the map list as a colour composite, using “*reflectance_3a*” as Red, “*reflectance_2*” as green and “*reflectance_1*” as blue. Also inspect the pixel values. Also put the vector layer showing the “*country_boundaries*” on top (info off, boundaries only and boundary colour in white).

In order to create a better quality colour composite the selected bands need to be stretched. From the ILWIS catalogue, right click using the mouse the “*reflectance_3a*” image, from the context sensitive menu, select “*Image Processing*” and “*Stretch*”, specify as Output Raster Map: “*Red*”, all other options can be kept as default. Press “*Show”*, note that the data is now transformed into a byte image. Close the image once you have inspected the results. Repeat the same procedure for the bands “*reflectance_2*” and “*reflectance_1*” and specify “*Green*” and “*Blue*” as output maps respectively.

Now create a new map list of the 3 newly created images, Red, Green and Blue respectively. In order to do so, select from the ILWIS main menu, the option “*File*” >> “*Create*” >> “*Map List*” and select the image called “*Blue*”, press the > sign in the middle of the window to move this layer to the right hand side. Repeat this procedure for the “Green” and “Red” images. Specify an appropriate Map List file name, e.g. “*avhrr_RGB*” (see also the figure below).

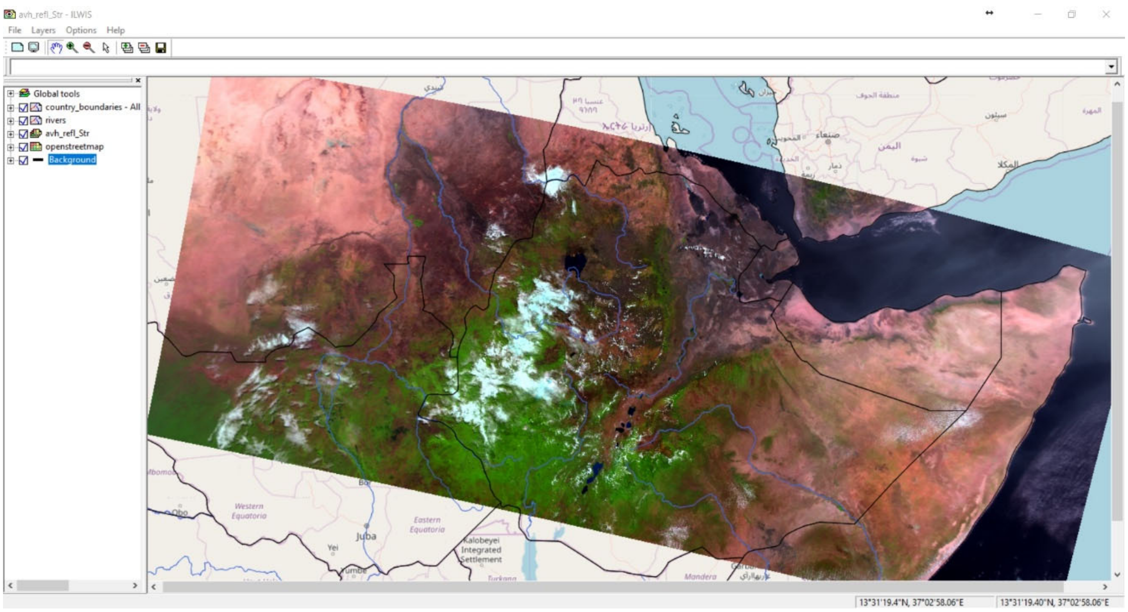
Figure 4.17.13: Create Map List of the visible and NIR channels, transformed to byte images



Press "*OK*" to store this map list. In the ILWIS catalogue double click the map list icon "*avhrr_RGB*", select the option "*Open as ColorComposite*" and select the appropriate bands for the colour assignment. Press "*OK*" to see the image. Also put the vector layer showing the country boundaries on top (info off, boundaries only and boundary colour in black). Your results should represent those of figure 4.17.14 showing a portion of the Horn of Africa.

Display also a thermal channel (e.g. band "*temp_5*", using as Representation "*Inverse*" and keep the default stretch limits. In the active map window, roam the mouse over the map and keep the left mouse button pressed. What do the values indicate and which channel of the AVHRR instrument is now displayed?

Figure 4.17.14: AVHRR/3 image (morning overpass) of 08 June 2012

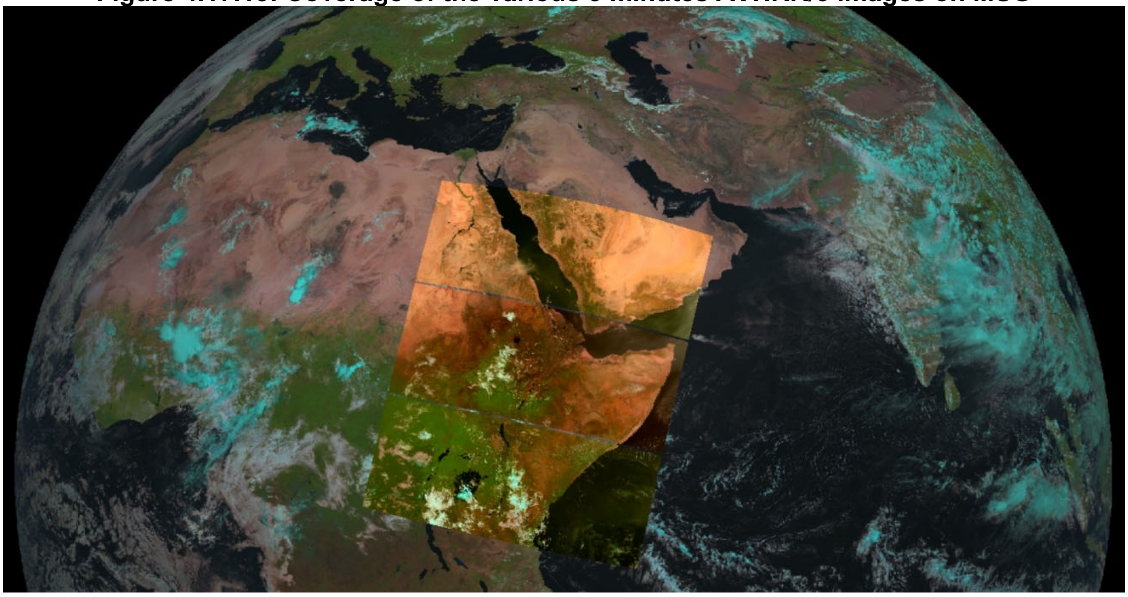


Also display the cloud flags image, use a pseudo representation, stretch the image from 100 to 750, check the clouds flags together with the colour composite.

The other images in the sub-directory \METOP_Africa are also recorded over Africa. Each of the images covers a recording time of 3 minutes. If interested you can import these as well and have a look at it. Note that the AVHRR instrument covers most of the Central and Eastern regions of

Africa in 2 overpasses of 15 to 18 minutes of scanning each. METOP records the morning and evening overpasses (local time!). The coverage of the available images is given below.

Figure 4.17.15: Coverage of the various 3 minutes AVHRR/3 images on MSG



APPENDICES

Appendix 1: Other freeware utilities that can be used in conjunction with ILWIS3.7.2

For Altimetry Data:
Basic Radar Altimetry Toolbox is available at: http://www.altimetry.info/toolbox/

For Satellite Position Prediction software:

Various software tools:
https://celestrak.com/software/satellite/sat-trak.php

SATSCAPE is a satellite tracking program for Windows
https://satscape.jaleco.com/

WXTRACK: developed by David Taylor:
http://www.satsignal.eu/software/wxtrack.htm#DownloadWXtrack

For more Marine Applications and Processing:
BILKO, supported by UNESCO, BILKO is available from homepage:
http://www.noc.soton.ac.uk/bilko/

For visualization and export of BUFR encoded data:
For quick visualization of (multiple) BUFR encoded files in the GEONETCast data stream, developed by Francis Breame
http://www.elnath.org.uk/

For statistical computing:
R is a language and environment for statistical computing and graphics and is available from the R-Project homepage.
http://www.r-project.org/

For Sentinel and other satellite data:

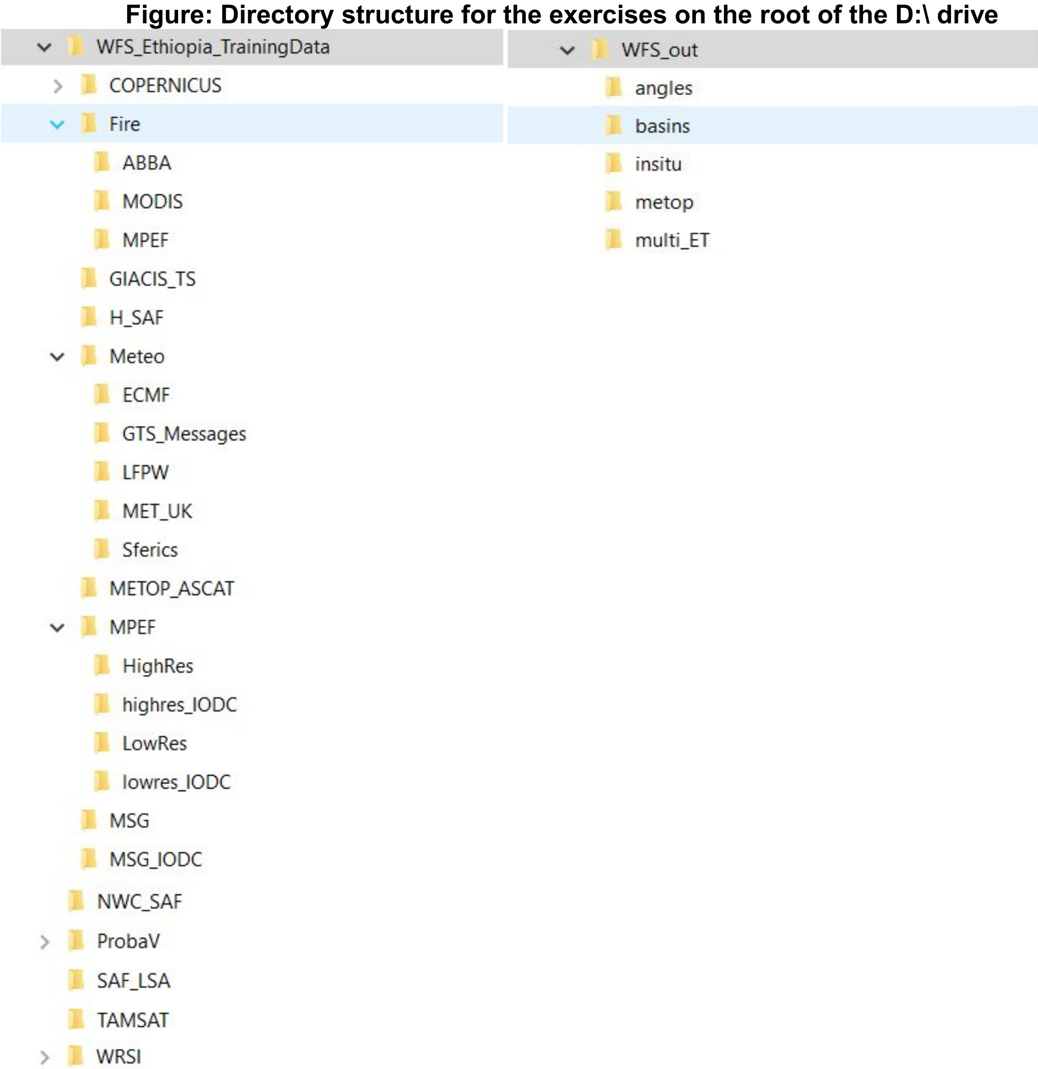
SNAP: http://step.esa.int/main/download/

EO4SD toolbox, import and pre-processing of S1, S2 and S3 data into ILWIS, available from the main author

Appendix 2: Structure of the sample data on DVD and from the ITC FTP site

In the figure below the directory structure is provided to execute the exercises. In the exercise description provided in chapter 4 the "*WFS_Ethiopia_TrainingData*" directory is assumed to be available on the "*D:*" drive of your local system. Unzip and copy the data accordingly. The working directory used for the exercise is "*WFS_out*", this directory and appropriate data should also be copied onto your local system "*D:*" drive.

Figure: Directory structure for the exercises on the root of the D:\ drive



From the ITC FTP site (ftp://ftp.itc.nl/pub/52n/wfs_exercisedata) the data can also be obtained, see also the "installation_readme.txt". Download the files and ensure that the same directory structure is obtained as indicated above. Note that some zipped files are large; you need appropriate bandwidth to download the files. If this is not the case you can request a set of DVD's by sending an email to the corresponding author.

Note the golden rules when working with ILWIS and the toolbox plug-in as given in chapter 1.1.1 and take these into consideration if you want to deviate from the default directory installation instructions provided over here.

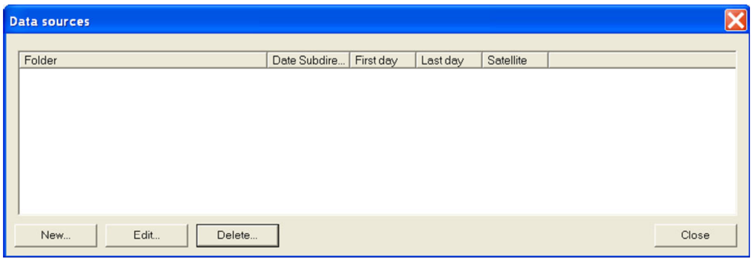
__Appendix 3: MSG Data Retriever settings for exercise 4.1__

Follow the steps to set the appropriate source folder location for the MSG sample data provided for exercise 4.1.

Open from the WFS-Ethiopia and Toolbox menu the MSG-HRIT and MSG Data Retriever options. Click the button "*Start MSG Data Retriever*".

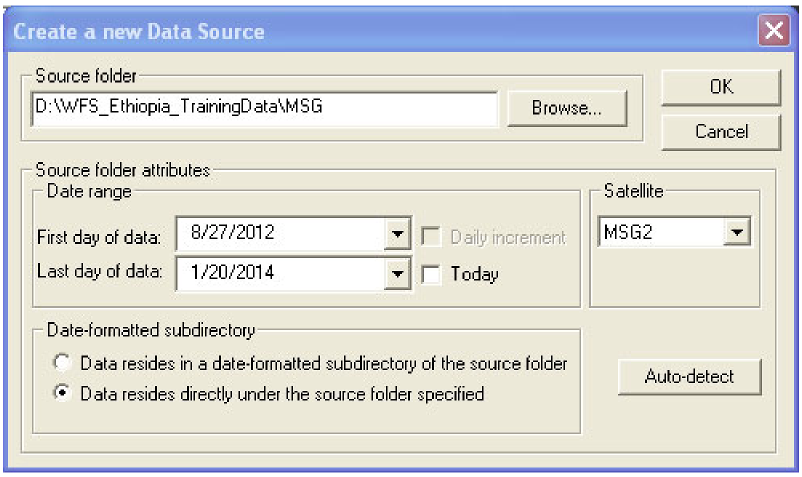
From the Data Retriever Menu, select the option "*File*" and from the popup menu the option "*Data Sources..*" The data sources menu is opened; see also figure 1. In case there are already data source folders specified delete these, using the "*Delete*" button.

Figure 1: Data source folder specification



To define the appropriate data source for the MSG-HRIT sample data provided, press the "*Create*" button, to create a new data source. Use the browse button and move to the appropriate folder. Enter the specifications as given in figure 2.

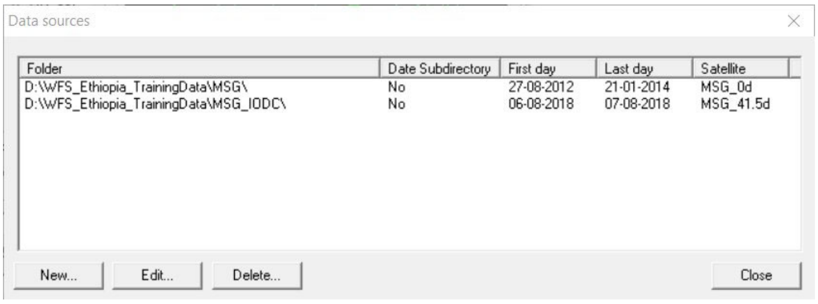
Figure 2: Create a new source folder to specify the location of the MSG-HRIT sample data



Please note that the data is directly residing under the source folder, not in a date formatted structure. Only a few sample images are provided. When pressing the "*Auto-detect*" button, the "*Last day of data*" will be assigned as: 1/20/2014.

Create a new data source, now select as data source directory the folder "*D:\WFS_Ethiopia_TrainingData\MSG_IODC*", press "Auto-detect", check the data source settings. These should now correspond to those provided in the figure below.

Figure 3: MSG Data Retriever Data Source settings for the exercises provided in chapter 4.1

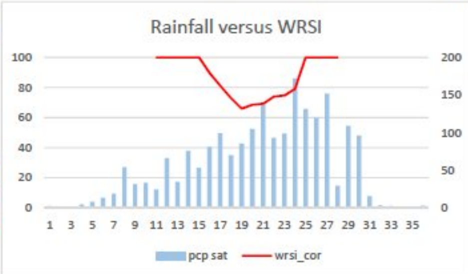


Appendix 4: WRSI calculation procedure over a single pixel

dekade	pcp sat	pcp_acc 3 dekades	sos_max nma	kc_stage nma	kc_value nma	metref sat	dmet sat	wr (metref*kc)	wrsi (dmet/wr)*100	wrsi_cor	start_sos time step	start_year time step	wrsi_cor	pcp sat
11	2.34											1		2.34
12	1.84											2		1.84
13	1.84											3		1.84
21	4.65	6.02	0		0	37.45	19.21	0.00			1	4		4.65
22	8.29	8.33	0		0	30.54	15.69	0.00			2	5		8.29
23	13.53	14.78	0		0	30	18.82	0.00			3	6		13.53
31	18.84	26.47	0		0	43.21	22.02	0.00			4	7		18.84
32	54.37	40.66	0		0	38.73	16.82	0.00			5	8		54.37
33	31.82	86.74	0		0	45.1	21.05	0.00			6	9		31.82
41	33.6	105.03	0		0	39.88	21.25	0.00			7	10		33.6
42	24.74	119.79	11		0.2	40.13	26.61	8.03	331.55	100.00	8	11	100	24.74
43	65.85	90.16	11	i	0.22	32.54	23.22	7.16	324.35	100.00	9	12	100	65.85
51	34.74	124.19	11	i	0.25	33.5	30.55	8.38	364.78	100.00	10	13	100	34.74
52	75.65	125.33	11	i	0.4	32.12	28.07	12.85	218.48	100.00	11	14	100	75.65
53	53.35	176.24	11	v	0.75	35.15	31.4	26.36	119.11	100.00	12	15	100	53.35
61	81.24	163.74	11	v	1	33.12	29.65	33.12	89.52	89.52	13	16	89.523	81.24
62	99.34	210.24	11	v	1.1	32.2	28.78	35.42	81.25	81.25	14	17	81.254	99.34
63	69.8	233.93	11	v	1.2	32.5	28.52	39.00	73.13	73.13	15	18	73.128	69.8
71	85.46	250.38	11	v	1.2	25.54	20.25	30.65	66.07	66.07	16	19	66.073	85.46
62	104.72	254.6	11	f	1.2	26.27	21.6	31.52	68.52	68.52	17	20	68.519	104.72
73	140.32	259.98	11	f	1.2	28.57	23.71	34.28	69.16	69.16	18	21	69.158	140.32
81	93.25	330.5	11	f	1.2	27.31	24.23	32.77	73.94	73.94	19	22	73.935	93.25
82	98.58	338.29	11	f	1.2	27.89	24.98	33.47	74.64	74.64	20	23	74.638	98.58
83	171.71	332.15	11	f	1.1	31.41	27.4	34.55	79.30	79.30	21	24	79.303	171.71
91	131.36	363.54	11	f	0.85	28.5	25.07	24.23	103.49	100.00	22	25	100	131.36
92	119.52	401.65	11	f	0.6	31.8	28.54	19.08	149.58	100.00	23	26	100	119.52
93	151.8	422.59	11	r	0.4	34.7	32.7	13.88	235.59	100.00	24	27	100	151.8
101	29.37	402.68	11	r	0.25	31.56	30.55	7.89	387.20	100.00	25	28	100	29.37
102	108.92	300.69	11	r	0	29.82	27.3	0.00			26	29		108.92
103	96.16	290.09	11		0	33.4	33.31	0.00			27	30		96.16
111	15.77	234.45	11		0	29.81	28.24	0.00			28	31		15.77
112	3.53	220.85	11		0	33.7	32.89	0.00			29	32		3.53
113	2.36	115.46	11		0	31.72	26.3	0.00			30	33		2.36
121	1.48	21.66	11		0	33.48	19.9	0.00			31	34		1.48
122	1.93	7.37	11		0	34.92	14.4	0.00			32	35		1.93
123	2.68	5.77	11		0	39.47	15.3	0.00			33	36		2.68
	2034.8					1096.04	818.33	432.63						

sos max = 25+25+25

		pcp	metref	dmet	wr	wrsi	wrsi_cor
season 2017		1714.98	564.81	485.83	432.63		
daily		9.53	3.14	2.70	2.40		
initial	i		106.17	80.38	23.56	341.17	100.00
vegetative	v		165.09	146.42	146.75	99.78	99.78
flowering	f		195.49	167.24	221.47	75.51	75.51
ripening	r		98.06	91.79	40.85	224.70	100.00
			564.81	485.83	432.63		93.82



Appendix 5: Other utilities available at the EO Community web pages at 52North.org

ILWIS plug-ins to handle free Environmental data sources

Various other software utilities have been developed over time are released via the 52North.org web portal, through the Earth Observation Community, available at: https://52north.org/research/rd-communities/earth-observation/. A short overview of the freely available ILWIS plug-ins is presented below. Also dedicated ILWIS scripts are available to import the Culture MERIS, MERIS Reduced Resolution S10 and METOP AVHRR-S10 data as well as various documents and useful links.

Current data dissemination systems, like GEONETCast provide free, near real-time Environmental and Earth Observation data together with derived products to a worldwide user community. The environmental data is delivered on a global scale via communication satellites. Next to this, a multitude of environmental relevant data is residing in online archives. To easily integrate this information toolbox plug-ins have been developed. Based on user requests more dedicated toolboxes have also been developed, handling dedicated topics and specific geographic regions, like the AMESD-SADC Toolbox and the Water and Food Security Toolbox for Ethiopia.

The toolbox plug-ins, coupled with the existing ILWIS processing utilities, facilitate easy integration of large amounts of environmental data into various applications related to weather, atmosphere, oceans, land, vegetation, water and environment.

To check the ILWIS scripts library navigate to ftp://ftp.itc.nl/pub/52n/ilwis_scripts/. Here newly developed scripts are made available.

There are new plug-ins under development. These will be posted on the EO Community pages at 52North.org when ready.

General Key Features:

- open design and easy user configuration

Features GEONETCast Toolbox Version 1.8

- Updated GEONETCast data management system for dedicated storage of data
- import routines for various satellites, Meteorological Product Extraction facility (MPEF), Satellite Application Facilities (SAF's), Chinese Meteorological Administration and 3rd party data providers such as TAMSAT, DevCoCast, MODIS, SPOT Vegetation
- integration of METOP-AVHRR and JASON-2 data
- (time series) export routines to BILKO, HANTS, R, SPIRITS and TIMESAT
- calculation of solar and MSG zenith and azimuth angles
- real time METEOSAT Second Generation visualization

Features Water & Food Security-Ethiopia Toolbox Version 2.0

- processing selected GEONETCast data relevant for water and food security monitoring and analysis for Ethiopia, including Meteorological Data Dissemination Service routines

Features ISOD Toolbox Version 1.6

- retrieval and import of data from various free online archives related to in situ climatological observations, gauge and satellite derived rainfall estimates, weather and pressure forecasts, potential evapotranspiration, normalized difference vegetation indices, ocean and elevation information, soil moisture, processing of GLDAS-Noah model and visualization of Era-Interim from ECMWF

Features MESA-SADC Toolbox Version 1.0

- import and pre-processing of all products disseminated by the AMESD-SADC program for southern Africa, related to agriculture, drought, fire and long range forecasts

Appendix 6: Capacity Building utilities available at the ITC GEONETCast web pages

For access to other CB utilities use can be made of the information and documents posted on: https://www.itc.nl/about-itc/organization/scientific-departments/water-resources/geonetcast/. Various documents are presented here providing further information on data dissemination systems providing a multitude of free environmental information, without the need for internet access but using a local ground receiving station for reception of the data.

For more advanced use of the environmental information in ILWIS use can be made of the so-called "GEONETCast-DevCoCast Application manual", providing various exercises, including description, exercise data and power point presentation.

Also other training materials are available from the ILWIS community at https://52north.org/software/software-projects/ilwis and from https://www.itc.nl/ilwis/users-guide/, check the left hand "*Documentation*" and "*Applications*" tabs.

Appendix 7: Change log and update history WFS-Ethiopia Toolbox

WFS-Ethiopia Toolbox XML config version 2

Change log November 2018.

Removed from menu (data no longer available):

- Meteosat-7 LRIT and MPEF routines, satellite obsolete
- SPOT VGT products, SPOT Vegetation instrument obsolete
- Import VGT Products Ethiopia, products obsolete. If older VGT products are required, older version of Toolbox needs to be used
- Dependency on BUFRTool is removed, software obsolete
- UK Met – Exeter, Africa-MidEast 48 hrs forecast, products obsolete
- LEAP model import and export
- MDD3 and MDD4 removed, data obsolete

Routines modified:

- GDAL, updated version is added (GDAL 111 and 221)
- BUFRExtract and BUFRDisplay, updated versions
- MSG Data Retriever, now also import and retrieval of MSG-IODC (MSG_0d and MSG_41.5d)
- Copernicus WSI, Africa only
- All Proba-V products, according to the last version provided on EUMETCast, for Fapar, Fcover, NDVI, WB and LAI. BA 300 meter product now supported extracted for window covering Ethiopia
- Automated processing routines for MSG adapted to allow for processing of MSG_0d and MSG_41.5d (IODC)
- Mapviews and routines updated for “Automated Processing” routines to allow for retrieval of MSG4
- All MPEF products updated to allow for retrieval of MSG4 and remove dependency of BUFRTool (for BUFR products)
- All NWSAF products updated to allow for retrieval of MSG4
- MWeather, updated version
- MDD-1 now separate menu item, under METAR and TAF Messages
- XML Menu, now version 2
- Installation and user guide updated

Routines added:

- Generic visualization of HDF, NetCDF and Grib formatted data using Panoply, using latest version
- Under MPEF: Added Divergence product and isoline creation having an interval of 25 and 50
- Under LSA-SAF: Added METREF product
- Added online climatological resources:
    - Monthly mean time series products like air temperature, precipitation sea surface temperature and lake levels, for Ethiopia lakes are monitored like Turkana, Ziway and Tana
    - GFS forecasting products like precipitation, actual ET, potential ET minimum temperature and maximum temperature, 10 day forecast
- Unified Model Data, UK-Met Exeter, Africa 17 km model (144 hr forecast for Africa only) for:
    - Convective clouds, Total (accumulated) precipitation, Long wave radiation (outgoing)

    - Agro-meteorological forecasts (at 1.5 mtr above ground level), like dew point, relative and specific humidity and temperature
    - Geo-potential heights (850, 700, 500 and 250 hPa)
- MPEF Indian Ocean Cover, replacement of MSG1 (Meteosat-8) at 41.5 degree over equator
- MPEF products from IODC coverage
- Sferics: lightning detection using ADNET - automatic lightning location network
- Online access to EUMETCast – GEONETCast Product Navigator
- Processing routines for NDVI index based crop insurance and indemnity calculation
- Water Requirement Satisfaction Index based calculation routines
- Various Hydro-meteo and Bio-meteo processing routines to import ENACTS data, calculate various aridity indices, Temperature Humidity Indices and Mosquito habitat suitability monitoring
- Online basic (climate) historical data sets to retrieve air temperature, rainfall, etc.
- GFS Forecasts of selected parameters, like rainfall, temperature (min, max), relative humidity, ETa and ETo
- EUMETView and subsequent data import routine
- Sentinel EO-Browser and subsequent data import routine
- METOP AVHRR Level 1b Reader
- In manual added various exercises and sample data updated

WFS-Ethiopia Toolbox version 1.3

The WFS-Ethiopia toolbox XML version 1.3 menu structure has been slightly modified to reflect the changes due to the availability new data disseminated through EUMETCast-GEONETCast.

Changes

In the XML version 1.3 of the WFS-E toolbox import routines of a number of products have been modified to reflect the changes in the data as provided on EUMETCast-GEONETCast as well as the provision of relevant new data.

The major changes incorporated are:

- New routines to import the MDD-4 ACMAD data for rainfall and 2 mtr temperature and create animated gifs;

- New routines to import the time series forecast data from MeteoFrance (LFPW), routines added are: 2 mtr temperature and relative humidity, 10 mtr and mean sea level surface pressure, large scale and convective water precipitation, total cloud cover and convective available potential energy, 10 mtr wind speed and direction;

- Added routines to import the data from the NCEP GFS Numerical Weather Prediction model;

- Added routines to import the data from the Nowcasting SAF and the H-SAF soil moisture products;

- Added routines for automated processing, which retrieve the latest MSG images and is performing various image visualizations (both for day and night time conditions) as well as the latest nowcasting products. The data is automatically retrieved and processed and a mapview is created and displayed. Also a routine has been added to create an animation of the most recent 2 hours MSG 10.8 micron channel colour enhanced 15 minutes images;

- A routine has been added to start the LSA SAF ‘MSG-Toolbox’.

A new release of the toolbox manual and user guide has been prepared.

WFS-Ethiopia Toolbox version 1.2

The WFS-Ethiopia toolbox XML version 1.2 menu structure has been slightly modified to reflect the changes due to the availability of the Copernicus Soil Water Index, the OceanSat Oscat wind product and the EUMETSAT MPEF Advanced Cloud Analysis product and a time series conversion tool as well as those for the meteorological services.

Changes

In the XML version 1.2 of the WFS-E toolbox import routines of a number of products have been modified to reflect the changes in the data as provided on EUMETCast-GEONETCast as well as the provision of relevant new data.

The major changes incorporated are:

- New routine to import the Soil Water Index, resampled to the Ethiopia window;
- New routine to process the Advanced Cloud Analysis product, provided through MPEF, resampled to the Ethiopia window;
- New routine to process the wind derived from the OSCAT instrument;
- New routines to import the NWP analysis and forecasts from the ECMF (global) and Meteo France (Africa);
- Adapted routine for MODIS Terra and Aqua fire processing, retrieval of single map (point – raster) showing all fires for a specified Julian Day globally;
- Adapted routines for the MDD1 and 3 retrieval, downwards compatible (use of MSG2 and MSG3);
- Including help menu, providing changelog and manual – user guide;
- Including a newly developed tool for time series map list renaming and efficient import and export of the time series to other freeware processing tool.

All routines have been checked to ensure proper operation with the GEONETCast-EUMETCast data stream as provided from the release of this toolbox version.

Toolbox manual and exercises are updated, when reflecting new developments the manual has been adapted, additional exercises added demonstrating the use of new routines added. Recent data sets have been added to the exercise data directory and are mentioned for further practice in the exercise sections of the user guide. A new release of the toolbox manual and user guide has been prepared.

WFS-Ethiopia Toolbox version 1.1

The WFS-Ethiopia toolbox XML version 1.1 menu structure has been slightly modified to reflect the changes due to the availability of the METOP A and B Surface Soil Moisture product.

Changes

In the XML version 1.1 of the WFS-E toolbox import routines of a number of products have been modified to reflect the changes in satellite sensor acquisition configuration, especially of those operated by EUMETSAT due to:

- Change of primary service to MSG10 (MSG3):
    - Combined use of METOP A and B
- Satellite sensor acquisition configuration, especially of those operated by EUMETSAT due to:
    - Change of primary service to MSG10 (MSG3)
    - Combined use of METOP A and B

The following routines have been updated:

- MDD1 and MDD3 have been modified; now work with data from MSG3, not downward compatible. If older MDD data needs to be imported use the previous XML (1.0) version.
- METOP A and B can be used both to retrieve the Surface Soil Moisture product.
- MPEF high and low temporal resolution products. Routines have been adapted and can both process older (MSG2) as well as the new MSG3-data. This change is applicable for the following MPEF high temporal resolution routines: AMV, CLA, CLAI, CLM, CSR, CTH, FIRG, FIRC, GII, MPEG, TH, TOZ, and the following MPEF low temporal resolution routines; NDVI and NDVD. It should be noted that the processing of the GII and the TOZ require a lot of time due to the large number of records retrieved when importing the Bufr files.

The following routine has been replaced:

- The Data Manager has been upgraded to a new version with new functionality like copy and auto-start options. Also the ascii configuration file has been updated. Additional description is provided on the EO Community pages.
- A new version of BUFRTool (version 5.4) has been used for testing Bufr import, especially to import the MPEF-TOZ data.

Note that use of MSG10 as instrument for primary service has not affected the MSG Data Retriever for the HRIT data. When selecting as satellite MSG2 also the MSG3 HRIT data can be retrieved.

Note that given only minor menu changes the WFS-Ethiopia Toolbox user manual has not been modified. It should be noted that all routines, apart from the MDD will work with old or new data provided. New MDD sample data for MSG3 MDD messages (MDD1_3_MSG3.zip) is available from: ftp://ftp.itc.nl/pub/52n/wfs_exercisedata/. The routines works in a similar manner as described in the User Guide for XML version 1.0.