Deliverable D4.6 (report supplement)

Description of the Demonstration Package for Monitoring and Forecasting Water & Climate using a Triple Sensor approach

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Abstract of deliverable	AfriAlliance is a five year project funded under H2020 by the European Commission. The overall objective of the project is to establish mechanisms for African and European stakeholders to work together in the areas of water innovation, research, policy and capacity development in order to enhance the preparedness of Africa for future Climate Change challenges. This report describes the demonstration package for improved water resources monitoring and forecasting using a triple sensor approach.

Versions and Contribution History

Version	Date	Modified by	Modification details
v.00	17-Aug- 2018	ITC (CM)	First zero draft; idea report template and ToC
v.0.1	15_Oct	ITC(CM)	First draft texts
v.0.2	25-Oct	ITC(CM)	Second draft update

Table of contents

List of figures

List of tables

No table of figures entries found.

Acronym List

AKVO	AKVO Foundation (The Netherlands)
AMCOMET	African Ministerial Conference on Meteorology
AMCOW	African Ministerial Conference on Water
AU	African Union
BOM	Australian Bureau of Meteorology
CPTEC	Centro de Previsão do Tempo e Estudos Climáticos (Brasil)
ECMWF	European Centre for Midrange Weather Forecasting (Reading, UK)
ECOWAS	UN Economic Commission – Western Africa
EIP	European Innovation Partnership
ESA	European Space Agency
EUMETSAT	European Agency for Meteorological Satellites
FAO	Food & Agricultural Organization of the UN
GCOS	WMO - Global Climate Observing System
GEOSS	Global Earth Observation System of Systems
GFCS	Global Framework of Climate Services
GMES	Global Monitoring & Environmental Security
GPRS	General Packet Radio Service for GSM (Global System for Mobile phones)
ICOLD	Int'l Commission on Large Dams
IHE	UN - Institute for Water Education (Delft, NL)
IPCC	Intergovernemental Panel on Climate Change
ITC	Faculty of Geo-information Sciences & Earth Observation – Univ. of Twente (NL)
JAES	Joint Africa-EU Strategy
KS	Knowledge Sharing
M&F	Monitoring and Forecasting
MOOC	Massive Open Online Course
MoU	Memorandum of Understanding
NASA	National Aeronautics & Space Administration (USA)
NCDC	National Climate Date Centre(s) / NOAA
NOAA	National Oceanic and Atmopsheric Adminsitration – US.Department of Commerce
NCEP	National Centres for Environmental Prediction / NOAA
RBO	River basin organization
RCOF	Regional Climate Outlook Forum
SDG	Sustainable Development Goals
ToR	Terms of Reference
UNECA	UN Economic Commission of Africa
W&C	Water and Climate
WATER JPI	Joint Programming Initiative on Water
WMO	World Meteorological Organization

1 Introduction and background

1.1 Background

The AfriAlliance project aims to prepare Africa for future climate change challenges by creating the opportunity for African and European stakeholders to work together in the areas of water innovation, research, policy, and capacity development.

Rather than creating new networks, the 16 EU and African partners in this project are consolidating existing ones, consisting of scientists, decision makers, practitioners, citizens and other key stakeholders, into an effective, problem-focused knowledge sharing mechanism. This will be coordinated by means of an innovation platform: the Africa-EU Innovation Alliance for Water and Climate.

AfriAlliance will support the existing networks in identifying appropriate social innovation and technological solutions for key water and climate change challenges. It will capitalise on the knowledge and innovation base and the potential in Africa and the EU. The project will support effective means of knowledge sharing and technology transfer within Africa and between Africa and the EU, with the aim of increasing African preparedness to address the vulnerability of water and climate change-related challenges. The project makes extensive use of existing/emerging communication channels and events (EU/African platforms, conferences and social media) to streamline climate change issues into water-related networks, thereby raising awareness about their impacts and to propose adaptation measures

1.2 Use of multiple Sensors for improving Water Resource Monitoring & Forecasting

One of the innovative aspects of AfriAlliance and more specifically of WP4 is the multiple information source gathering approach. The inventory is based on a triple-sensor approach, looking into the capacity and efforts on *human sensors* (citizens, geo-crowdsourcing and communications), *physical in-situ sensors* (like weather station-based meteorological and ground-based water resource and hydrological networks such as stream gauging, groundwater, etc.) and *space-based satellite sensor*s.

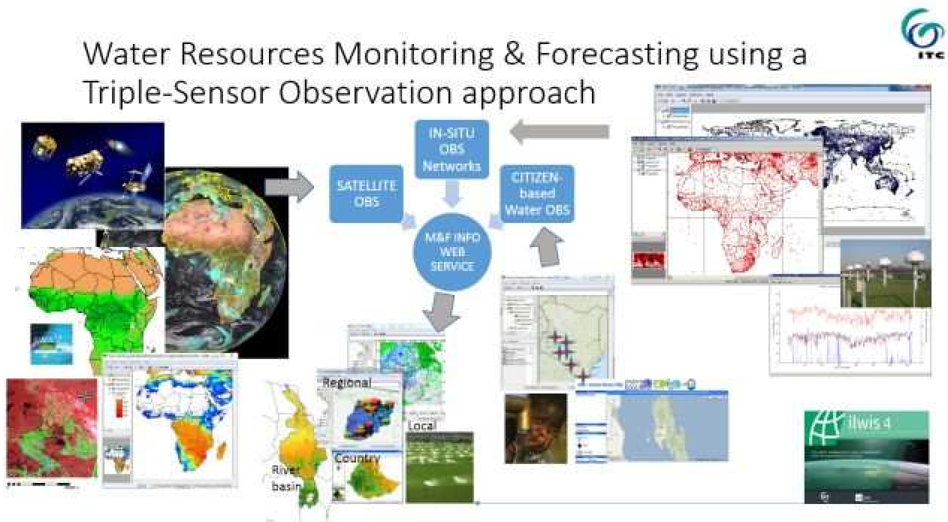

Figure 1 The AfriAlliance Triple Sensor approach for improved water resources Monitoring & Forecasting

A major challenge in climate and water information analysis for decision-making at different spatial levels and stakeholders (i.e. ranging from governments at country level to local populations at village level) lies in the accessibility of the information sources, as well as the reliability and accuracy associated with the different data. Some people may rely heavily (or solely) on rain gauge network information, whereas others typically use satellite observations. Yet others, and especially local communities, may find crowdsourcing and citizen observatories the best choice.

In AfriAlliance, an information merging or collocation approach is proposed to support African stakeholders in their analysis of climate and weather challenges related to water resources management. This approach is derived from the principle that a single observation (e.g. on weather or water availability) at a certain location and time will be much more reliable and generally accepted if it is compared to other independent observation data sources (of the same location and time period). And as typically done in the weather forecasting and prediction world (who were the first do adopt this technique), to merge data sources and derive optimal estimates and information. This triple sensor approach launched by AA is under development within WP4, and some more information is given in later sections of this report. After the inventories of constraints and opportunities of the three different sensor approaches (in-situ, citizen and satellites) in sections 3, 4, and 5, the current barriers and opportunities of collocating the three data and information sources using the triple sensor approach will also be investigated (Chapter 6). It is acknowledged that triple collocation of data sources is also subject to constraints, and these will be visited in Section 6. Section 7 draws conclusions and the way forward.

1.3 Purpose and structure of the Report

This report describes the Demonstration package for applying a triple sensor collocation approach to 3 different information sources. The software tool (formal deliverable) represents a full fledged open source geospatial data and image analysis software, and contains a specific Afrialliance toolbox for analysing and collocating Triple sensor data in Africa. Next to this geospatial software, also a web-based AA triple sensor collocation demo was developed by ITC and it's use is also described in this accompagning report.

The ILWIS Afrialliance Triple Sensor Demo toolbox contained in the software is for users with preliminary knowledge of geodata and basic skills in GIS analysis and preferably remote sensing. Use of the toolbox needs a prior quick installation (unzip) of the software on a laptop or PC system (Windows-based). The web-based Triple collocation demo is for all (incl. novice users) gremia, and demonstrates the principle of the triple sensor collocation approach. This is a zero-install web application and can be run from any browser on most platforms i.e. laptop, iPad, smartphone.

The introductory section 1, generally describes the AA project goals related to Monitoring & Forecasting Climate and Water Challenges in Africa, and introduces the novel AA 3-S approach. In Section 2, the triple sensor approach is described in some more details. In Section 3, the data sets used in the demonstration of the triple sensor approach are visited in brief. In Section 4, a hands-on guided demonstration is worked out, explaining first user show to use the software, acquire the data and perform the data analysis. Section 5 described the web-based application. This report supplement to the demonstration package (toolbox) and triple collocation web-application refers extensively to the main Afrialliance report deliverable (D4.4) on Constraints and Opportunities for Water Resources Monitoring using a Triple Sensor approach available on-line (www.afrialliance.org project portal > Knowledge section Tab).

2 Triple sensor collocation

2.1 Short history and current novel use

Triple Sensor Collocation can be used to validate 3 independent observations at a location, when the error-free true value is not known. With this you can judge, which water or climate observation, i.e. your citizen observation, conventional station data or a remotely sensed satellite look-up is most reliable.

The origins of the triple collocation of data sources originate from meteorology (e.g. Stoffelen, 1998; Roebeling et al, 2012). The technique has arisen from the need to jointly analyze e.g. ground station measurements of meteorological variables (e.g. wind speed) with weather model- or satellite-based predictions of meteorological variables. The main idea behind triple collocation (in meteorology) is to verify and/or to increase the accuracies of global weather forecast modelling output, needed and used in our daily weather bulletins, as well as for global aviation, maritime transportation, and early warning of weather hazards. The method is closely linked to other mathematical data merging approaches such as data assimilation, where typically meteorological station observations are ingested in weather forecast models to improve predictions ad forecasts (Bengtsson et al, 1981).

Currently, and due to the enormous increase in data sources and information provision in all societal domains, data validation and quality control of information is becoming a necessary „must do“ step in any information gathering, analysis, interpretation and use process. Triple collocation and other control techniques are therefore receiving more attention today as a methods for data validation, and applications to other data types and sources (beyond meteorology) are getting developed (Zwiebach, 2012; McColl et al, 2016). In Afrialliance, a similar methodology for mapping the three independent information sources (sensors) for water resource monitoring has been proposed. It can be typically applied to:

- Mapping which of the information sources are available in a certain region or physical area of interest;
- Verify the agreement (in a statistical sense) among the three sensor data sources.

In the statistical sense, triple collocation is a technique for estimating the variance of the error (noise error) and correlation coefficients of the measurement systems (e.g. satellite, in-situ and citizen-based products), wth respect to the unknown true value of the variable being observed (e.g. soil moisture, wind speed, rainfall, surface water occurence, groundwater levels, etc.).

The three independent data sources in AA are: a) in-situ hydro meteorological or water resource ground station observations e.g. soil moisture, surface and shallow ground water levels, etc. b) satellite-based estimates of hydrological variables and c) citizen-based observations on water resources.

Where the basic idea behind this triple sensor collocation is seemingly simple and has certainly opportunities, the method is also subject to several constraints and challenges. In order to derive the constraints with the triple sensor (collocation approach), we first summarize some more important constraints and opportunities of the 3 (independent) monitoring & forecasting techniques in Table 10. This permits to better formulate the constraints of the triple sensor approach. Table 10 summarizes a number of Constraints and Opportunities of the three monitoring approaches and data sources.

2.2 Short description of algorithms and triple collocation procedure

We will not detail the advanced statistical concepts used for triple collocation of spatial and temporal data. This is beyond scope of this document, aiming at wider audience. We give here a basic explanation of the procedure applied in this project context and supply the scientific references for readers with a more advanced scientific algorithm interests.

Triple Collocation of satellite, in-situ station and citizen data" „How it works"?

The Triple Sensor Collocation can be used to validate 3 independent observations at a location, when the error-free true value is not known. With this you can judge, which water or climate observation, i.e. your citizen observation, conventional station data or a remotely sensed satellite look-up is most reliable.

The method is based on statistical covariance analysis on three independent data sources and yields the errors (RMSE) and correlations and permits to rank the dataset reliability.

The method references used for the TC are:

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The TC algorithms from McColl et al (2014; 2016) were coded in R-code for initial testing by CM (C.Mannaerts) and further implemented in Python and VisualC++ for full integration in ILWIS by VR (V.Retsios).

3 Description of data sets

A limited number of data sets (and used in the demo exercise Chapter 4) were added to this Triple sensor Toolbox for demonstration purposes. For more extensive data resources (including acquisition routines), we refer to 2 other ILWIS toolboxes (i.e. GEONETCast and ISOD), which can be plugged-in in this software package. We refer to the Help section and "About" for more information.

3.1 *In-situ* station Data

In-situ station data represent all near surface data collected in conventional and new ground stations, by official authorities, e.g. hydro- & meteorolgical services, regional monitoring and research programs and projects. We refer to the scheme on Social Actors involved in data acquisition for Monitoring & Forecasting (pages 13-14) in the AA D4.4 report on Constraints and Opportunities for Water Resources Monitoring using a Triple Sensor approach available on-line (www.afrialliance.org project portal > Knowledge section Tab).

3.1.1 WMO-GTS GSOD (Global Summary of Day) Meteorological station Data

GSOD or Global Summary of Day data are daily summaries of the 6-hourly (00.00;06.00;12:00;18:00 UTC) reported data of high level synoptic station (e.g. at airports,...) from countries to the WMO (World Meteorological Org) and using their WMO-GTS Global Telecommunication system. The global meteorological station data summaries provided are based on data exchanged under the World Meteorological Organization (WMO) World Weather Watch Program according to WMO Resolution 40. This allows WMO member countries to place restrictions on the use or re-export of their data for commercial purposes outside of the receiving country. Data for selected countries may, at times, not be available through this system.

Those countries' data summaries and products which are available here are intended for free and unrestricted use in research, education and other non-commercial activities. The data are available via http://www.ncdc.noaa.gov/cgi-bin/res40.pl?page=gsod.html and ftp://ftp.ncdc.noaa.gov/pub/data/gsod.

The input data used in building these daily summaries are the Integrated Surface Data (ISD), which includes global data obtained from the USAF Climatology Centre. The latest daily summary data are normally available 1-2 days after the date-time of the observations used in the daily summaries. A few historcal online station data files begin already in year 1929, and over 9000 stations' data are typically available.

The daily elements included in the dataset (available for each station) are: mean temperature, mean dew point, mean sea level pressure, mean station pressure, mean visibility, mean wind speed, maximum sustained wind speed, maximum wind gust, maximum temperature, minimum temperature, precipitation amount, snow depth and indicator for the occurrence of: fog, rain or drizzle, snow or ice pellets, hail, thunder and tornado/funnel cloud. Upon import the data is converted to SI units.

We also refer to Afrialliance report D4.4 paragraph 3.2.1 (pages 27-28) for more information on these synoptic surface observations. [link]

The AfriAlliance project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 689162. - www.afrialliance.org

3.1.2 NOAA CPC-FEWS global WMO-GTS daily Data

One important source of in-situ observed climate information used by NOAA Climate Prediction Center (CPC) and many other meteorological agencies for weather and climate applications are the gauge-observed precipitation and temperature reports transmitted through the WMO Global Telecommunications System (GTS). Together with station reports from other national and international sources, the GTS gauge data are used to monitor and assess the climate at station locations and as inputs to define analyzed fields of global and regional precipitation and surface (station) temperature.

The Global Telecommunication System (GTS) is the coordinated global system of telecommunication facilities and arrangements for the rapid collection, exchange, and distribution of observed and processed meteorological information within the framework of the World Weather Watch (WWW). Station reports of precipitation, together with those of many other physical variables, are exchanged routinely among the World Meteorological Organization (WMO) member countries through the GTS network. At NOAA / CPC, these precipitation reports are received and processed to form a database of GTS gauge-based daily precipitation. Starting from October 1977, the GTS daily gauge database is updated on a real-time basis. On average, daily reports are available from about 6000 GTS stations. The GTS gauge network is relatively dense over United States, Western Europe, and east coasts of Australia and China, while it is very sparse over several regions including equatorial Africa and Amazon (source: Quality Control of Daily Precipitation Reports at NOAA/CPC by Mingyue Chen, Pingping Xie and CPC Quality Control Working Group, Climate Prediction Center, CPC/NCEP/ NOAA, available at http://ams.confex.com/ams/pdfpapers/131381.pdf).

The rainfall and temperature (minimum and maximum) up to a year before present can be obtained online from ftp://ftp.cpc.ncep.noaa.gov/fews/gts.

3.1.3 CPC Gauge-Based analysis of Global Daily Precipitation

This data set is a first product of the CPC Unified Precipitation Project that is underway at NOAA Climate Prediction Centre (CPC). The primary goal of the project is to create a suite of unified precipitation products with consistent quantity and improved quality by combining all information sources available at CPC and by taking advantage of the optimal interpolation (OI) objective analysis technique. The coverage is global (land only) at 0.5 degree spatial resolution. The temporal resolution is daily and the data is available from the 1st of January 1979 – Present:

1979 – 2005:	Retrospective Version (30K+ gauges)
	ftp://ftp.cpc.ncep.noaa.gov/precip/CPC_UNI_PRCP/GAUGE_GLB/V1.0/
2006 - Present:	Real-time version (~17K gauges)
	ftp://ftp.cpc.ncep.noaa.gov/precip/CPC_UNI_PRCP/GAUGE_GLB/RT/

Other relevant background documents are:

- On the Interpolation algorithm:
  Xie, P., A. Yatagai, M. Chen, T. Hayasaka, Y. Fukushima, C. Liu and S. Yang (2007): A gauge-based analysis of daily precipitation over East Asia, J. Hydrometeorol., 8, 607. 626. ftp://ftp.cpc.ncep.noaa.gov/precip/CPC_UNI_PRCP/GAUGE_GLB/DOCU/Xie_et_al_2007_JHM_EAG.pdf
- On the Gauge Algorithm Evaluation:

Chen, M., W. Shi, P. Xie, V. B. S. Silva, V E. Kousky, R. Wayne Higgins and J. E. Janowiak (2008): Assessing objective techniques for gauge-based analyses of global daily precipitation, J. Geophys. Res., 113, D04110, doi:10.1029/2007JD009132. ftp://ftp.cpc.ncep.noaa.gov/precip/CPC_UNI_PRCP /GAUGE_GLB/DOCU /Chen_et_al_2008_JGR_Gauge_Algo.pdf

- On the Construction of the Daily Gauge Analysis: Chen, M., P. Xie, and Co-authors (2008), CPC Unified Gauge-based Analysis of Global Daily Precipiation, Western Pacific Geophysics Meeting, Cairns, Australia, 29 July - 1 August, 2008. ftp://ftp.cpc.ncep.noaa.gov/precip/CPC_UNI_PRCP/GAUGE_GLB/DOCU/Chen_et_al_2008

Hereunder are some examples of (research) boundary organizations co-producing secondary surface weather and climate observations and they complement the global high-level synoptic WMO-GTS station network for real time data applications.

3.1.4 SASSCAL WeatherNet

The SASSCAL or Southern Africa Science Service Centre for Climate Change and Adaptive Land Management program, covering a number of countries in the SADC or Southern Africa region, maintains a number of AWS, directly coupled (by GPRS) to the EUMETSAT Data Uplink and Retransmission service or to local GSM providers. This data communication technique permits rapid near real time (NRT) data and weather information acquisition by end-users and the public (see Figure 9).

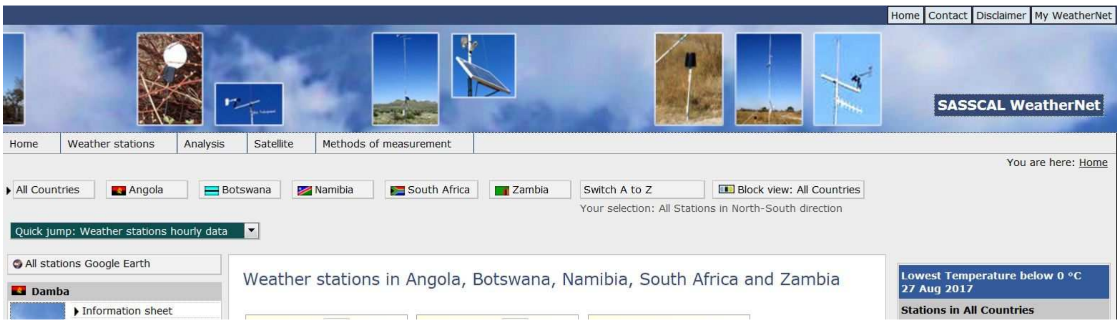


Figure 2 Example of the Southern Africa SASSCAL near real-time weather data (web-based) access

The SASSCAL weathernet presents a recent initiative to increase meteorological surface observations and data collection over a number of SADC countries (Angola, Botswana, Namibia, South Africa and Zambia). The data can be accessed through the webpage www.sasscalweathernet.org. Data collected in Excel (csv) format can be read in ILWIS or other software for further use. No automatic import routines are currently available in the AA Toolbox, but the generic File>Import>Ilwis>Table (for csv-format) or .>Import >ADO>Excel in case of an Excel xls format works for people having some experience with Ilwis.

The AfriAlliance project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 689162. - www.afrialliance.org

3.1.5 WASCAL Data Portal

The Afrialliance consortium partner, WASCAL (West African Science Service Center on Climate Change and Adapted Land Use) is a large-scale research-focused Climate Service Center designed to help tackle this challenge and thereby enhance the resilience of human and environmental systems to climate change and increased variability. It does so by strengthening the research infrastructure and capacity in West Africa related to climate change and by pooling the expertise of ten West African countries and Germany. Funded by the German Federal Ministry of Education and Research (BMBF), WASCAL is implemented in a collaborative effort by West African and German partners.

It's data portal also guides people to research data collections across Western Africa. However, a user log-in name is required for data access. Otherwise, some metadata can be browsed only. For th Afrialliance Triple sensor collocation web-based demo, short rainfall data series from 5 WASCAL meteorological stations in the small Dano catchment (South west Burkina Faso) were used. These data were obtained through direct exchange with Wascal research staff, and used for demonstration purposes.

3.1.6 TAHMO - Trans-African Hydro Meteorological Observatory

The Trans-African Hydro Meteorological Observatory (TAHMO) aims to develop a vast network of weather stations across Africa.

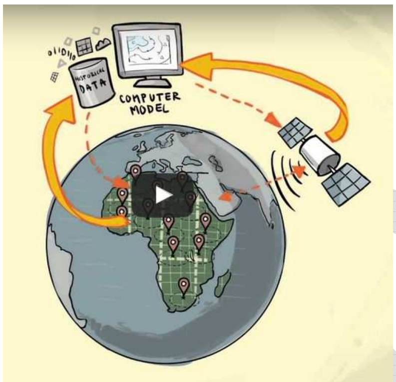


Figure 3 TAHMO network © TAHMO http://tahmo.org/about-tahmo-2/

The idea behind this project is to develop a dense network of hydro-meteorological monitoring stations in sub-Saharan Africa – one every 30 kilometres. This entails the installation of 20,000 stations across the continent. By applying innovative sensor technology and ICT, TAHMO stations are both inexpensive and robust. Stations are placed at schools and integrated in educational programs, adding richness to the curriculum and helping foster a new generation of scientists. Local weather data will be combined with models and satellite observations to obtain insight into the distribution of water and energy stocks and fluxes. Currently, no automatic import routines are available in the toolbox, but authorised (registered) users, can access stations in near real time, and download data (e.g. in csv formats). Users should be authorized (cooperating or registered) members of the TAHMO network.

We refer further to the Afrialliance report deliverable (D4.4) on Constraints and Opportunities for Water Resources Monitoring using a Triple Sensor approach available on-line (www.afrialliance.org project portal > Knowledge section Tab).

3.2 Earth Observation satellite data

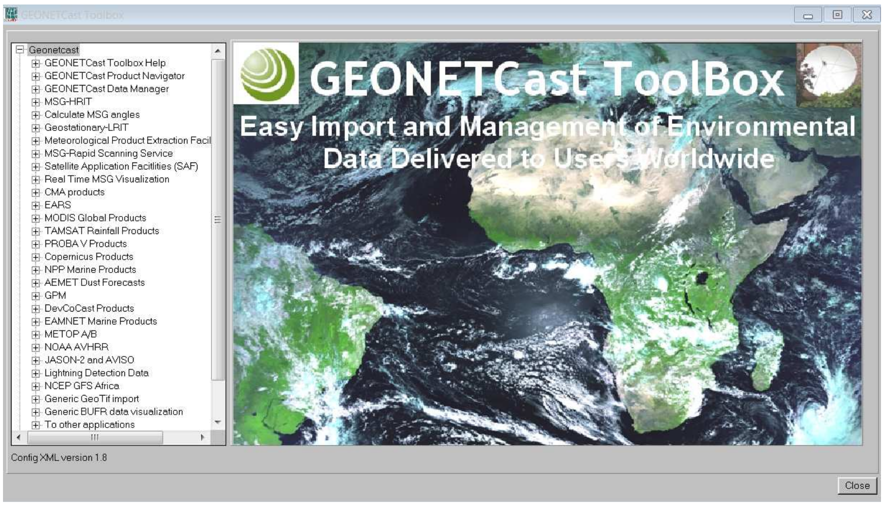
The amount of available satellite data (raw, processed and derived products) from Earth Observation platforms available today is enormous. A quick browse of the OSCAR or Observing Systems and Capability Review Tool of the WMO at https://www.wmo-sat.info/oscar/satellites shows the large number of geostationary and polar or lower equatorial orbiting satellite systems. Detailed description of these multiple data sources is way beyond scope of this document.

3.2.1 GEONETCast and ftp-based EO data dissemination and access

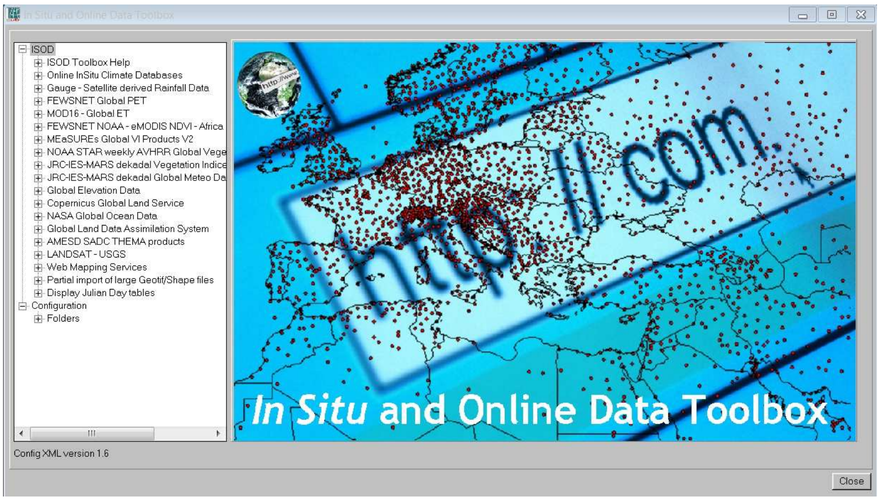
We refer here to two other ILWIS GEONETCast and ISOD Toolboxe plug-ins available (for this software) with more information on free and open access satellite data available through the EUMETCast near real time dissemination system (GNC Toolbox) and satellite data available from open accessible http- or ftp data servers globally (ISOD toolbox). Pls. see their Install & User Guides in the Help Tab.

The User Manuals, available in the Toolbox Help Tabs (shown below), contain valuable data descriptions and also guided exercise to acquire (import) the data to your geospatial analysis software.

EUMETCAST near real time satellite data import library (toolbox)



Ftp- (or http) based on-line satellite and *in-situ* data acquisition (ISOD toolbox)



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Next to these build-in Satellite and in-situ Data access toolboxes, several http- and FTP-based satellite data web portals are today widely used. We can mention the:

3.2.2 EU Copernicus Program and other large int'l EO data portals

The Copernicus program currently delivers operational data and information services openly and freely in a wide range of application areas, including thematic product/data streams of Copernicus services on Land, Ocean, Atmosphere and Climate as well as near real-time and archive images acquired by the various dedicated Sentinel satellites. The observations from Copernicus Contribution Missions should also be mentioned in this respect (http://www.copernicus.eu/main/contributing-missions). All these contribute to operational services in the domain of Land, Marine, Atmosphere, monitoring, as well as security, emergency management and climate change services.

Access to COPERNICUS products is through online portals, for the global land service GIO2 is through:

- http://land.copernicus.eu/global/products.

Free access to near real time and archived data from the ESA Sentinels 1,2 is currently provided through the European Space Agency or ESA "Science Hub":

- https://scihub.copernicus.eu/

the "Copernicus Online Data Access" Portal at EUMETSAT (Darmstadt) for ESA Sentinel-3:

- https://coda.eumetsat.int

Pls. see also the EUMETView direct ftp-access of S-3 (available in the Toolbox EO Menu).

and for Sentinel-1 and S-2 also via the French CNES mirror portal (Toulouse):

- https://peps.cnes.fr/rocket/#/home

or the USGS portal:

- https://landsatlook.usgs.gov/sentinel2/viewer.html

Examples of other large int'l archives for other medium to medium high resolution satellites are:

- USGS Earth Explorer at https://earthexplorer.usgs.gov/
- NASA Giovanni at https://giovanni.gsfc.nasa.gov/giovanni/
- GOOGLE Earth Engine: https://earthengine.google.com/ (ps. also Sentinel data)
- SPOT: https://www.theia-land.fr/en/products/spot-world-heritage
- LANDSAT: https://landsatlook.usgs.gov/viewer.html
- ASTER: https://lpdaac.usgs.gov/dataset_discovery/aster
- CBERS: http://www.dgi.inpe.br/siteDgi/english/index_eng.php

The Group on Earth Observations (GEO), through its global earth observation system of systems (GEOSS) portal (http://www.geoportal.org/) is offering information and links to many EO resources including other data and websites (e.g. other producers, e.g., JAXA, JMA, CMA, SANSA, etc.).

Hereunder, we will only succintly describe the data sets used in the Triple sensing collocation demo.

3.2.3 EUMETSAT - EUMETView

EUMETView is a new and rapid way to visualise EUMETSAT satellite data, in near real time. Typically the Geostationary MSG Meteosat Second Generation satellites (Atlantic main service and the IODC Indian Ocean service) are used to monitor the weather, atmosphere, land surface and oceans. Next to the MSG satellites, also the ESA Sentinel-3 polar orbiter(s) are available from EUMETVIEW. For more information, pls. Visit https://www.eumetsat.int/website/home/Images/EUMETView/index.html

„EUMETView is a visualisation service that allows users to view EUMETSAT imagery in an interactive way. It is currently a pilot service (EUMETSAT, 2018)“. Users can opt to download te data in „picture view“ e.g. jpg format, but also in geospatial data formats like GeoTIFF or NetCDF. This permits import and further use and processing of the data in the ILWIS software (or any other e.g. QGIS) using the standard File>Import>GDAL libraries.

EUMETVIEW is a nice web-based alternative to users not having access to an EUMETCAst dish antenna receiving and data processing system. Those who have such a reception system, can use the ILWIS GEONETCast Toolbox, which contains all tools and import libraries for the HRIT and LRIT formats (standard data dissemination formats for near real time Level 1.5 MSG data). The internet-based EUMETVIEW cannot compete with the fast download speeds (20-45 Mbits/sec) typical for EUMETCast receiving systems using DVB-S2 based data transmission. We refer to the ILWIS GEONETCast Toolbox, available from http://52north.org/communities/earth-observation/ for more information. EUMETVIEW will function well if one has a good internet connection.

3.2.4 CHIRPS – Rainfall (Global)

Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) is a 30+ year length of record quasi-global rainfall dataset. Spanning 50°S–50°N (and all longitudes), starting in 1981 to near-present,

CHIRPS incorporates 0.05° resolution satellite imagery with in-situ station data to create gridded rainfall time series for trend analysis and seasonal drought monitoring. As of May 1st, 2014 version 1.8 of CHIRPS is complete and available (source: http://chg.geog.ucsb.edu/data/chirps/). Data is retrieved from ftp://chg-ftpout.geog.ucsb.edu/pub/org/chg/products/CHIRP/ and is available in pentad and monthly temporal intervals. Each pentad is consisting of 5 days, 6 pentads per month.

More detailed information can be obtained from USGS report:

Funk, C.C., Peterson, P.J., Landsfeld, M.F., Pedreros, D.H., Verdin, J.P., Rowland, J.D., Romero, B.E., Husak, G.J., Michaelsen, J.C., and Verdin, A.P., 2014, A quasi-global precipitation time series for drought monitoring: U.S. Geological Survey Data Series 832, 4 p., http://dx.doi.org/110.3133/ds832. Available at: http://pubs.usgs.gov/ds/832/pdf/ds832.pdf.

and the home website of the CHIRPS data producers at http://chg.geog.ucsb.edu/data/chirps/.

The CHIRPS data were used as an example for satellite-based rainfall data in the Triple Collocatin demonstration exercise (Chapter 4). We refer to the ISOD Toolbox for acquisition other global (or regional) rainfall data.

The AfriAlliance project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 689162. - www.afrialliance.org

3.2.5 CMORPH – Rainfall - Global

CMORPH (CPC MORPHing technique) produces global precipitation analyses at very high spatial and temporal resolution. This technique uses precipitation estimates that have been derived from low orbiter satellite microwave observations exclusively, and whose features are transported via spatial propagation information that is obtained entirely from geostationary satellite IR data. At present it is incorporating precipitation estimates derived from the passive microwaves aboard the DMSP 13, 14 & 15 (SSM/I), the NOAA-15, 16, 17 & 18 (AMSU-B), and AMSR-E and TMI aboard NASA's Aqua and TRMM spacecraft, respectively. These estimates are generated by algorithms of Ferraro (1997) for SSM/I, Ferraro et al. (2000) for AMSU-B and Kummerow et al. (2001) for TMI. Note that this technique is not a precipitation estimation algorithm but a means by which estimates from existing microwave rainfall algorithms can be combined. Therefore, this method is extremely flexible such that any precipitation estimates from any microwave satellite source can be incorporated. With regard to spatial resolution, although the precipitation estimates are available on a grid with a spacing of 8 km (at the equator), the resolution of the individual satellite-derived estimates is coarser than that - more on the order of 12 x 15 km or so. The finer "resolution" is obtained via interpolation. In effect, IR data are used as a means to transport the microwave-derived precipitation features during periods when microwave data are not available at a location. Propagation vector matrices are produced by computing spatial lag correlations on successive images of geostationary satellite IR which are then used to propagate the microwave derived precipitation estimates. This process governs the movement of the precipitation features only. At a given location, the shape and intensity of the precipitation features in the intervening half hour periods between microwave scans are determined by performing a time-weighting interpolation between microwave-derived features that have been propagated forward in time from the previous microwave observation and those that have been propagated backward in time from the following microwave scan. This latter step is referred to as "morphing" of the features

(source: http://www.cpc.ncep.noaa.gov/products/janowiak/cmorph_description.html).

The 8-km 30 minute, 0.25 degree 3 hourly and daily CMORPH data sets can be found on the ftp.cpc.ncep.noaa.gov/precip server in the “CMORPH_V1.0/CRT” directory. CPC has been performing a reprocessing of the CMORPH using a fixed algorithm and inputs of the same versions. The reprocessed CMORPH is called Version 1.0. The previous version “0.x” of CMORPH that CPC has been generating since CMORPH became operational in December 2002 is now replaced by version 1.0. Data is available from 1998 onwards. The major differences between Version 0.x and Version 1.0 are:

- The Version 1.0 covers the entire TRMM/GPM era from Jan.1998 to the present, while the Version 0.x started from Dec.2002;
- The Version 1.0 is generated using a fixed algorithm and inputs of fixed versions to ensure best possible homogeneity, while the Version 0.x has been produced using an evolving algorithm and inputs of changing versions and therefore presents substantial inhomogeneity especially over the earlier yearof its operations (2003-2006);
- The Version 1.0 include the raw, satellite only precipitation estimates as well as bias corrected and gauge-satellite blended precipitation products; while the Version 0.x only has the satellite only products. Currently for the 8-km 30 minute, 0.25 degree 3 hourly and daily CMORPH data sets version 1 is used, the recent daily and weekly CMORPH rainfall estimates is retrieved from another location

and issatellite estimate only (ftp://ftp.cpc.ncep.noaa.gov/fews/CMORPH/GIS/), units are mm per time step (day or week). A routine is available to aggregate the 30 minutes rainfall to 1 hour time steps.

3.2.6 Vegetation cover - Africa

As an example of satellite vegetation monitoring data, we have opted here to highlight some readily downloadable medium high resolution vegetation index data based on the old-workhorses, the MODIS sensors on-board the AQUA and TERRA platforms (2000+ - present). Pls. note that MODIS sensor is phasing out soon and is being replaced by the NASA - VIIRS sensor and also the ESA Sentinel-3 systems. As we are not linked to an EUMETCast receiving system or data server, we will use a secure web download for this most widely used vegetation index over Africa, i.e., the FEWSNET NOAA eMODIS 250m NDVI, but obtained from the European EU-JRC-MARS download site. In eMODIS, the 250-m resolution and decadal products present very valuable land cover information, for a wide variety of applications.

For those not familiar with EO-based vegetation monitoring, just a ***a short note on NDVI:***

The Normalized Difference Vegetation Index (NDVI) provides a measure of the amount and vigour of vegetation at the land surface. The magnitude of NDVI is related to the level of photosynthetic activity in the observed vegetation. In general, higher values of NDVI indicate greater vigour and amounts of vegetation. NDVI is and can be derived from many satellite sensors and platforms. The NDVI shown here is derived from data collected by the US National Oceanic and Atmospheric Administration (NOAA) satellites, and processed by the Global Inventory Monitoring and Modelling Studies group (GIMMS) at the National Aeronautical and Space Administration (NASA). The NDVI is calculated from two wavelength channels of the AVHRR sensor, the near-infrared (NIR) and visible (VIS) wavelengths, using the following algorithm:

NDVI = (NIR - VIS)/(NIR + VIS)

NDVI is a nonlinear function that varies between -1 and +1 (undefined when NIR and VIS are zero). Values of NDVI for vegetated land generally range from about 0.1 to 0.7, with values greater than 0.5 indicating dense vegetation. Since the late 1980's, the Famine Early Warning System (FEWS) has used AVHRR data to produce dekadal (10-day) composite NDVI images of Africa and has built a valuable archive of these data from mid-1981 to present. This can be used e.g. to monitor long term (and short term) trends in vegetation cover, and can also be linked to causal factors such as climate, land use and human impacts. SPOT-Vegetation data and it’s follow-up PROBAV sensor and currently also ESA Sentinel-3 can also be used, but the data record starts in the ‘90s. NDVI’s can be produced by many more satellite sensors at different resolutions.

3.3 Citizen-based data

At this stage, we did not inventorize and gather large citizen-based data sets from Africa. Instead, we opted here to view and use (as an example), the Water Point Data Exchange database, available on internet. We request interested persons to do however and communicate with the developers, on open accessible water resources related (or other) citizen observations.

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3.3.1 WPDx Water Point Database

The Water Point Data Exchange is governed by a diverse group of WASH experts, interested in monitoring water and sanitation issues and progress across the world. Citizen-based data collection methods are used to gather information and report on status of water supply points, water availability, etc. The WPDx database can be accessed freely on https://www.waterpointdata.org/water-point-data and data points + information can be retrieved on a country basis. In this Demo Package, we used a dataset from Burkina Faso, retrieved mid-May or 2018-05-23 from the website.

More citizen-based monitoring data will and can be added in the future, or by the user of this software and/or by the developers. As the Toolbox setup is open source, an intermediate to advanced ILWIS user can add new data entries and processing routines to the system.

3.4 Forecast and NWP model-based data

Forecasting of weather can be done at very short time interval (see e.g. METAR-TAF), but usually it is done at 6, 12 24-hr to 10-day (240-hr) time scale by the large Global Circulation model or Numerical Weather Prediction (NWP) Models and weather forecasting centers (e.g. US-NCEP, EU-ECMWF, Brazil-CPTEC, Australia-BOM, China-CMA and some more). Several countries have own facilities and models for weather forecasting e.g. UK (UKMET), France (Arpege), SAWS (South Africa). Most countries adopt regional and/or higher resolution versions of these larger global or regional weather forecast models.

Large amounts of historical (re-analysis data such as the US-MERRA and EU ERA-interim) and current forecast data are available from servers like the European ECMWF and US-based NCEP/NOAA and more. Besides atmospheric data, also land surface variables (e.g. soil moisture,..) and other parameters are disponible from several large model outputs. We include here only 2 examples of data (based on global which are useful for agriculture, water, weather and climate resources monitoring. First, a very short term weather forecast from the WMO (and ICAO) affiliated Meteo services (not model but observation based) is shown.

3.4.1 6-hourly Weather forecasts from METAR & TAF

This very short term forecasts present reports, derived from airport station observations and made by aviation meteorologists and forecasters (and not from global models). Reports from actual weather (and 6-hourly forecast) of all ICAO (Int'l Civil Aviation Organization) registered (and operational) airports are contained in 6-hourly METAR (i.e. 06.00 UTC; 12.00UTC, etc.) or Meteorological Airport Reports, and in 6-hourly Terminal Aerodrome Forecasts (TAF), respectively one hour ahead of METAR. These informations, typically used by airline pilots and other navigators is accessible through several telecom channels, but info is typically coded. A code reader - converter is therefore required. The following two web portals can be used to see what METAR and TAF is all about, incl. downloading. [http://en.allmetsat.com/metar-taf/ ; https://www.aviationweather.gov/metar/gis]. Pls. see the ISOD Toolbox for retrieval. The ISOD toolbox can be used for retrieval of these short term 6-hourly weather forecasts from ICAO coded airports.

3.4.2 US – NOAA - GFS-based Global weather Forecasts (present to 10-day)

The US - NOAA's CPC or Climate Prediction Centre (i.e. one of the National Centers for Environmental Predicition or NCEP) is providing forecasts on Weather and Climate Parameters for Africa, like Precipitation, Temperature, Winds, Heights, MSLP, Relative Vorticity, SST, etc. using their NWP Model (available at http://www.cpc.ncep.noaa.gov/products/ african_desk/cpc_intl/). 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.

3.4.3 EU – ECMWF – IFS model based Data

Most of the ECMWF IFS or data derived from their "Integrated Forecasting System" global model data are available from the ECMWF data servers.

The EU-JRC-IES is using these data to provide interesting data for monitoring agricultural production and food security. The Monitoring Agricultural ResourceS (MARS) Unit (http://mars.jrc.ec.europa.eu/mars/) is focusing on crop production, agricultural activities and rural development. The MARS Unit provides timely forecasts, early assessments and the scientific underpinning for efficient monitoring and control systems. Data needed for this purpose is based on various ECMWF including the ERA-Interim and the OPE (operational deterministic ECMWF model). Long time series of dekadal rainfall (from 1989 onwards at 0.25 degree spatial resolution) is made available online through JRC's SPIRITS webpage (http://spirits.jrc.ec.europa.eu/?page_id=184). The routine provided here is merging the various windows into a global precipitation map (in mm / dekad), both for the Interim as well as the operational data. For further information also consult the MARS Crop Yield Forecasting System wiki, available at: http://marswiki.jrc.ec.europa.eu/agri4castwiki /index.php/Main_Page

The MARS ECMWF-based meteorological database is a daily weather data base based on various European Centre for Medium-Range Weather Forecasts (ECMWF) sources. The MARS ECMWF data set includes ERA-INTERIM (from 1989 to March 2013) and OPE (operational deterministic ECMWF model) data currently covering the period April 2013-April 2014. The ERA-INTERIM data set is a reanalysis of the global atmosphere. Due to this reanalysis system, ERA-INTERIM has proven to have better performance compared to previous reanalysis data sets such as ERA-40, see also 3.16.8. The following variables are available: mean temperature (C), maximum temperature (C), minimum temperature (C), ET0 (in mm, according to Penman-Monteith, based on dew point, daily radiation sum, wind speed, and temperature) and rainfall (mm). A number of pre-processing steps were developed in the MARS project, to prepare the data as input to the crop models. For instance x-hourly data are aggregated to daily time steps and a downscaling method was developed consisting of an inverse distance weight interpolation (IDW) from the 0.75 degree ERA-INTERIM grid to the 0.25 degree OPE grid and of a bias correction between the IDW-interpolated ERA-INTERIM model and the OPE model (not applied to rainfall). The dataset has a global coverage and the time series is from 1989 onwards, but from April 2014 there is currently an interruption of the service reported. Temporal resolution is daily although only the dekadal product is presently distributed by JRC. The spatial resolution: 0.25 degrees (http://marswiki.jrc.ec.europa.eu/datadownload/index.php and http://spirits.jrc.ec.europa.eu/). Dekadal format expected by the routine is yyyymmdekdek, e.g. 20101201, for the first dekad of December.

4 Guided demonstration exercise(s)

The USB stick supplied (or available for copy), contains 4 directories:

- .\software\.
- .\sampledata\.
- .\documents
- .\other

4.1 Installing ILWIS Open

We use the ILWIS v3.8.5.1s version in the workshop (software directory) D:\waternet\software\ILWIS. This version, contains the first version of the Afrilaalliance Toolbox v1.0. If for any reason, you have already an ILWIS installation, you will still need to copy this version and put aside your other. Ps. ILWIS is not a large software (30MB) and Toolbox (+- 90 MB), so not storage space hungry, Ps. de sampledata may be more voluminous. Check your system first pls.

Plug-in the USB in your laptop.

Copy and Unzip the Ilwis385s.zip to a working drive e.g. c:\ or d:\.. or similar. Pls. do NOT unzip the ILWIS385.zip to your D:\Program Files or Program Files (x86) Windows directories, or to your Desktop!! These directories are usually "write protected" and the Toolboxes need read/write access to their software subdirectories. The desktop location has a very long Windows "path" which does not work with all Toolbox routines. Pls. make your life simple, and unzip to an open drive e.g. C:\, D:\. E:..

Browse to your newly created drivename:\ILWIS385x directory and create a "Shortcut to Desktop" of the ILWIS.exe application, you can find in the newly created D:\ILWIS385 directory. See workshop.

You can also just open Ilwis by just double-clicking on the Ilwis.exe (executable application). Easier is however to use the Desktop Icon to launch Ilwis.

Create a working or output directory somewhere on the root of a drive. Pls. use a short directory name e.g. .\Afrialliance or .\ilwisout..... (your own choice).

Open ILWIS and browse to the working directory (your Ilwis data catalog). Get some look and feel of the GUI. Ps. if you now close and open ILWIS again, it will open with your working catalog active (visible).

4.2 Retrieve and Explore some example data sets using ILWIS

Let’s explore some data sets described briefly in Chapter 3. In order to do the data and tool explorations, users should be linked to a good internet connection (with sufficient download speed). Downloads represent typically compressed data files ranging from 1MB to 100 MB (the maximum here for eMODIS NDVI SA).

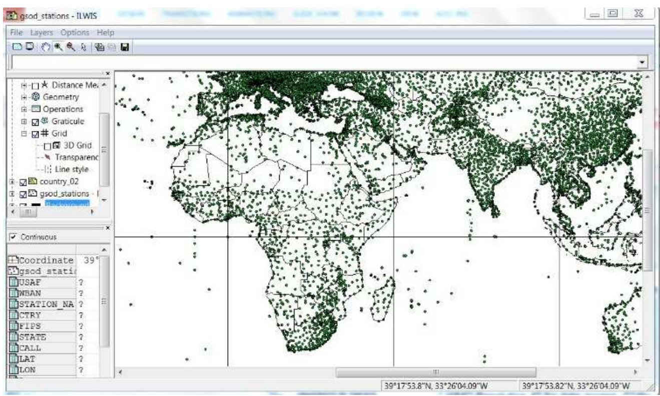
Get your ILWIS Ready

Start ILWIS385 (e.g. from your desktop Icon) and open the “AFRIALLIANCE” > “Toolbox” from the left hand Menu tree. Inspect the menu of the Toolbox and open the item “Configuration” > “Folders”. Note that here the assumption is made that you have created on your local system (i.e. drive “C or D, E..”), a directory called “\Ilwisout” or any other own name. For the all the Folder items under GSOD,… specify the appropriate directory and press “Save” to store the ‘drive:\directory’ settings. Close the Toolbox and use the ILWIS Navigator to move to the directory “D:\Ilwisout”. Close ILWIS and start ILWIS again, ensure that the location of your data catalogue is now “D:\Ilwisout”. Select from the menu the “AFRIALLIANCE” and “Toolbox” options and you are ready to start the exercises. Note that if you have changed working directory during an active ILWIS session, it is advised to close ILWIS and start it again. The catalogue should now open in the correct working directory.

4.2.1 Retrieval of WMO-GTS GSOD synoptic meteo station data

Within the AFRIALLIANCE toolbox utilities are available to incorporate the archive maintained and updated by the NCDC, providing a „Global surface Summary Of Day“ or GSOD data on various meteorolgical station variables. First a map will be visualized showing the global locations and the station numbers of the climatological stations (over 27750 records).

From the “AFRIALLIANCE” and “Toolbox” main menu select the “Online InSitu Climate Database” > “NCDC Integrated Surface Data (ISD)” > “Stations map of Global surface summary of day product produced by the NCDC” sub menu. Note that the “Output Directory” here is “D:\Ilwisout” and press “Import”.



After import a map view will be shown, indicating the locations of the stations. Moving the mouse over the active map window, keeping the left mouse button pressed is providing information on the station number. To get additional information, select from the menu of the active map window the option “File” and “Open Pixel Information”. Zoom into the area of interest and move the mouse over a station. In the Pixel Information window additional details are shown,

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such as station name, USAF number, coordinates and elevation. The USAF number should be noted as this is used during the subsequent extraction of the daily summary data.

To extract the station data, from the “AFRIALLIANCE” and “Toolbox” main menu select the “Online InSitu Climate Database” > “NCDC Integrated Surface Data (ISD)” > “Import GSOD station data” sub menu. Specify the “Year”, USAF “Station”, check the settings for the “Output Directory” and press “Import”. Here use is made of the station “Ilha do Sal”, year is “2015” and USAF station number is “085940”. Note that a 6 digit station code is required; in case the station has only a 5 digit code the station number coding should always precede with a zero (0). The station code for Praia is “…. ”. Here Sal station is used for further explanation, but you can freely substitute it with ‘Praia’. (Ps. Praia has now 2 USAF codes; only one is operational; old aerodrome and new airport locations).

Additional information on the data is provided when selecting the “Metadata” option. When using the import routine the data will be extracted and processed, additional columns are calculated providing the data in SI units, like temperature (also minimum and maximum), dew point, visibility, wind speed and maximum wind speed, precipitation. Note that if during import an error message appear that ILWIS cannot find table, close ILWIS, start ILWIS again and repeat the import. This error occurs due to the fact that you changed to another output directory during an active ILWIS session.

Refresh you catalogue, selecting from the ILWIS menu the options “Window” > “Refresh”. To visualize the imported station data, open the imported table, starting with “st_USAFno_year”, in this case “st_084940_2015”. Inspect the table content. In the menu of the active table window, select the graph icon, in the subsequent popup window, don’t select an X-axis, for the Y-axis select the attribute to be visualized, here “Prcp_mm” and press “OK”.

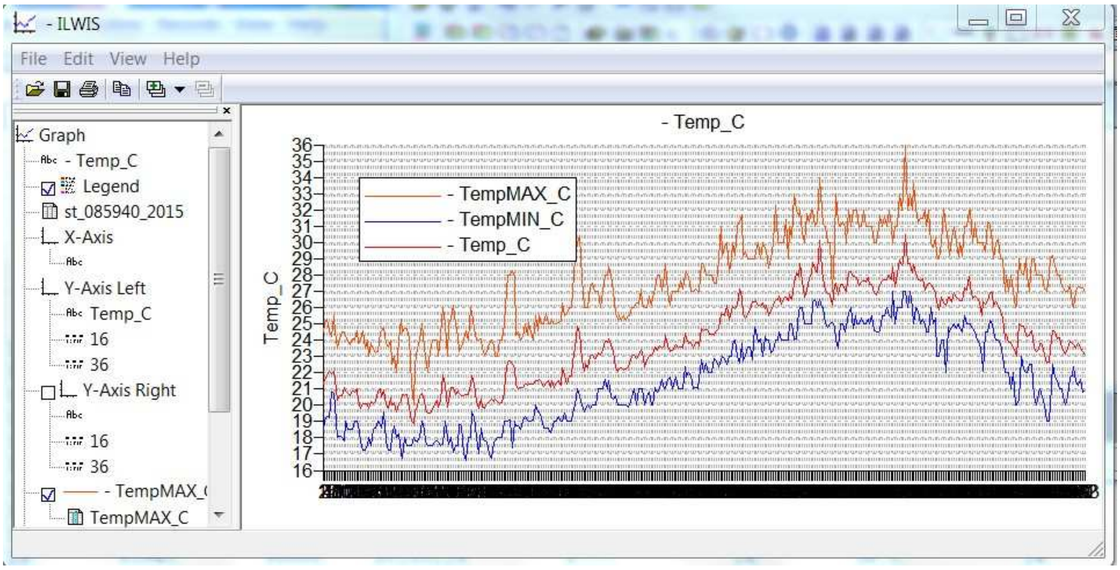
Now from the left hand graph menu the visualization properties can be changed. Double click the layer “Prcp_mm”. In the Graph options, change the name to “Precipitation”, select a “Needle” representation, instead of a point, and eventually change the colour to “Blue” and press “OK”.

Now select from the graph menu the option “Edit” > “Add Graph” > “from Columns” and select for the Y-Axis the table attribute “TempMIN_C” and press “OK”. Double click the layer “TempMIN_C”. In the Graph options, change the name to “Minimum Temperature”, select a “Line” representation, instead of a point, and eventually change the colour to “Magenta”. Now select “Use Y-Axis” the “Right” Axis, and press “OK”.

From the graph menu, select the option “Y-Axis Right” , as Axis Text “Temperature” and set the Min-Max Interval to “-10” and “50” respectively and press “OK”. Uncheck the option “Show Grid”. Note that the data range required can be obtained from the statistics pane from the (bottom) of the table!

Repeat the procedure for the attribute “tempMAX_C” and “Dewp_C”, call these “Maximum Temperature” and “Dewpoint Temperature” respectively, select as representation “line” and select appropriate colours. Ensure that the Y-Axis Right is used! In the graph window itself the title can be modified. Double click on the title in the Graph and consult figure 2.3.1 for a sample title.

Figure 2.3.1 Daily Air Temperatures for Ilha do Sal airport (2015), USAF station number 085940



4.2.2 CPC-FEWS global WMO-GTS daily Data

This routine will – in contrast to the previous GSOD import routine - import for 1-day all globally available station temperature (min, max) and rainfall data. A large table willbe generated by ILWIS with collums with several thousands (+- 8000) of records of station ID data, latitute – longitude and temperature and rainfall data. By using the Table to Pointmap option in ILWIS, e.g. a global daily station-based rainfall map can be created. This global point data can be further interpolated to a gridded field (after carefull selection of the spatial interpolation routine of course). We however recommend persons to use the CPC Gauge-based Analysis data set, which has been already carefully interpolated, and is available from the next In-Situ data Exploration Entry.

- See practical for more information.

4.2.3 CPC Gauge-Based analysis of Global Daily Precipitation

This gridded data set in fact contains the interpolated station data from the WMO-GTS and CPC-FEWS (see above). Pls. Use these data if you require gridded fields (e.g. full contry coverage) of daily station-based rainfall data.

See practical for more information.

4.2.4 SASSCAL WeatherNet, WASCAL an TAHMO data imports

The data from these in-situ stations, collected by these organizations, can (at this moment) not be directly imported in this Toolbox. The user has to access and browse the respective websites and download data e.g. as an Excel or .csv data files. These files can be imported as Table in ILWIS from the File>Import>ILWIS>Table Menu. Pls. See the example given by the Citizen Data Import (use case Dano, Burkina Faso).

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4.2.5 Explore the current weather over Africa with EUMETSAT - EUMETView

From Earth Observation Satellite Data, open the EUMETView MSG / Sentinel-3 Tab, and hold-on until the application is launched. This depends on your internet speed. You can now browse a variety of MSG image data (i.e. wavelength bands), but also derived visualized MSG products. Also Sentinel-3 is available.

First explore some Imagery > Meteosat MSG wavelength bands TIR10.8, WV6.7, IR3.9 and VIS0.6. For example, the Thermal Infrared 10.8 µm channel permits to view cloud cover [day and night], whereas the Visible solar 0.6 µm channel will illustrate the typical day-night observation cycle.

Then Go to Visualized Products and explore near realtime MPE rainfall fields (e.g. the MSG MultiSensor Precipitation Estimate). This tells where it is raining at this moment and also the intensity of rainfall (last 15-min) over Africa (based on the MSGMPE algorithm).

From RGB composites, also explore a DayTime Natural Color Composite. You can download an image (of choice) using the GeoTIFF (full resolution) option (under download). You can then try to import the data in ILWIS using File Menu > Import> GDAL >Raster > GeoTIFF.

Open the file Maplist then in Ilwis and invert the Color Scheme (RGB 1,2,3 to BGR 3,2,1) to display the same color composite but using real data.

4.2.6 Import CHIRPS rainfall data

To import CHIRPS precipitation data for Africa, select from the "*AFRIALLIANCE*" > "*Toolbox*"

main menu the item *Earth Observation Satellite Data* and further to the >"*CHIRPS – Rainfall - AfricaI*"

sub menu. In this case only the "Date" field and the "Output Directory" need to be specified. Pls. work in your data catalog, as specified in the Toolbox configuration for CHIRPS. The CHIRPS v2.0 data are delayed (+-2 months), due to merging with stations.

Go to CHIRPS V2.0 Dekad (10-day) and select a Date stamp select e.g. "*2010081*" and press "*Import*". This is the first dekad (day 01-10) of August 2018. After the import has been completed, display the newly created map "*chirps_201008d1*", using as Representation "*Pseudo*" (see Display Tools). Add the country boundaries (no Info, boundaries only) and use pixel information to inspect the values. If you use the PSEUDO Color Look-up table, you better apply a color Stretch (reduce the max. value) for a better view (from the Display Menu). You can also use a rainfall MPE-sum Representation for a nicer look. Change this using the Portrayal – Representation settings from the Display Tools Menu.

To import the data from the CHIRPS pentad precipitation data (aggregated to 5 days)

"*CHIRPS V2.0 pentad*" sub menu. There are 6 pentatd per month, so use 1 to 6 after the year-month data stamp, e.g. Date stamp select "*2018076*" (for the last pentad of July 2018) and press "*Import*". After the import has been completed, display the newly created map "*chirps_201007p6*", using as Representation "*MPE-sum*". Add the country boundaries (no Info, boundaries only) and use pixel information to inspect the values. Compare both rainfall maps and close them when ready.

Pls. note that for multiple imports, i.e. time series, other ILWIS-based routines (automated) exist. See also Triple Collocation Menu and/or the GEONETCast Toolbox User Guide v.1.6 (par.4.1 p.125-128) or contact the developers.

4.2.7 Import CMORPH global rainfall data

Using the CMORP Tab will permit you to import a range of global satellite precipitation data based on the CMORPH algorithms. Procedure is similar to CHIRPS. Pls. get first familiar with the several data sets available (see Chapter 3) and also the information websites and references supplied.

4.2.8 Import a Vegetation index (NDVI) for Africa

This import routine will permit you to import FEWS eMODIS 250-m NDVI vegetation index data. As a 250-m resolution yields rather large filesize, the import is done per four quadrants of Africa North, East, South and West.

Pls. for Zambia, Go to Dekadal NDVI – Southern Africa – last 3 dekads and perform an import. Pls. note that import will take a while (e.g. >60 seconds or more on slow systems, due to large +100MB data size). You need to find of course the dekad equivalent number [0-36 dekads in a year] and specify this after the year-dekad number. E.g. The dekads of January have numbers: 01,02,03 and June have numbers: 16,17,18 and so on.

4.2.9 Import Citizen WPDx (WaterPointData Exchange) locations

As an example for importing citizen-based observations, we show here the import of a dataset of Burkina Faso (used later under 4.3) , downboaded from the WPDx WaterPointData exchange database or

https://www.waterpointdata.org/water-point-data. Just select a country and proceed to download as excel.csv formatted file. Ps. For sake (of speed and practice), the datafile is supplied with the demo in the sub-directory .\sampledata.

- Table File Import (to describe here); Dano Citizen data table.

4.2.10 Import and View 6-hourly (current) weather forecast at airport locations

Decoded METAR or TAF reports from civil airports (using a ICAO-ID code) are requested in this routine from the https://aviationweather.gov/.. , an US-NOAA-NWS National Weather Service linked website. Other download sites and options are possible, but this site delivers continuous up-to-date (present time) data.

Run the application which goes to the Aviation Weather Service website. Browse (move and scroll) the global map to your Region of Interest (ROI) and check for available (actively reporting airport stations). A coded METAR report will be shown when pointing (clicking) on a station. To get the decoded report (readible data by non-aviation meteorologists), request the decoded METAR a/o including TAF report

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(issued 1-hour ahead of the 6-hourly METAR. To do so, first Look-up the IDs or ICAO code (e.g. GVAC is Sal Island, Cape Verde; EHAM for Schiphol airport, etc.), and request the METAR report (See data entry on webpage under station map). You can also find ICAO airport codes on the internet (Tabular information).

The METAR report will give you the current (assumed valid for 6-hours ahead) air temperature, dew temperature, air pressure, Rel. Humidity %, wind speed and direction, rainfall including type, cloud base and ceiling, and octets (i.e. cloud cover), and more information supplied to aviation pilots etc. Also the TAF report can be included.

4.2.11 NOAA - GFS Global Forecasting System (present to 10-day) weather Forecasts

You can import and derive (from present to max. 240-hours ahead or 10-day), forecasts of the global weather e.g. temperature and rainfall for the whole world from the US-based - NCEP - CPC Numerical Weather Prediction model(s). ILWIS downloads, imports and creates own maps, which can be used later, and also displayed as a Slide show animation (e.g.), using the maplist View Menu. Pls. See practical demo.

- See demo during practical

4.2.12 Explore JRC-IES-MARS archive dekadal global agrometeo data

Check the output directory (when starting a new data import, it is wise to do this small check).

Open the “AFRIALLIANCE” > “Toolbox” options from the left hand menu tree and open the item “Configuration” > “Folders”. For the Folder item under “JRC_IES” specify your appropriate Ilwis output directory (e.g. d:\Ilwisout) and press “Save” to store the drive:\directory settings. Move to the working directory using the ILWIS Navigator. Close ILWIS and open it again.

Import an ECMWF-based MARS Operational Agrometeorological data product of Africa.

From the “*AFRIALLIANCE*” > “*Toolbox*” main menu select the Forecasts – Model-based Data sub Menu. And the option “EU-ECMWF-IFS based Data” and then "*JRC-IES-MARS AgroMeteo Operational*" > And then “*10-day Temperature – Average (C)”*. Note that the routine expects a year-month dekad input, e.g. specify for last dekade January 2017 the following time stamp: “*20170121*”. Note the dekades are number 01, 11 and 21, for the 1st, 2nd and last dekade of the month respectively. Check the output folder and press “*Import*”. After the import has been completed display the new map created: “*int_africa_tav_20170121*”, use as Representation “*Pseudo*” and press “*OK*”, add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values. Note the unit is in degree Celsius.

If other products are imported note the file name conventions; the prefixes used are ‘int’ and ‘ope’, indicating the Interim and Operational products, region names are self-explanatory and product variables are defined as: rain, evpt, rad, tav, tmax and tmin for the rainfall, evapotranspiration, global radiation sum, average temperature, maximum temperature and minimum temperature. When importing multiple time steps of the same variable for the same region, note that the time step can also be changed in the ILWIS command line and the routine can be executed by pressing <enter>.

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4.3 Triple Collocation demo exercise

4.3.1 Running the web-based Afrialliance Triple Collocation Demo

The Afrialliance web-demo illustrates the technique for rainfall observations (July 2015) near Dano in Southwest Burkina Faso, a research area of West African Afrialliance partner WASCAL. Citizen locations were extracted from the Open access WPDx or Water Point Database. Citizen names were adapted (privacy) and rain data were simulated for demo purposes. Observed meteorological station data were obtained from WASCAL.org and CHIRPS2 was used as open access satellite precipitation. Pls. Go to the following web-address to open the demo: http://afrialliance.itc.utwente.nl/triplesensor/

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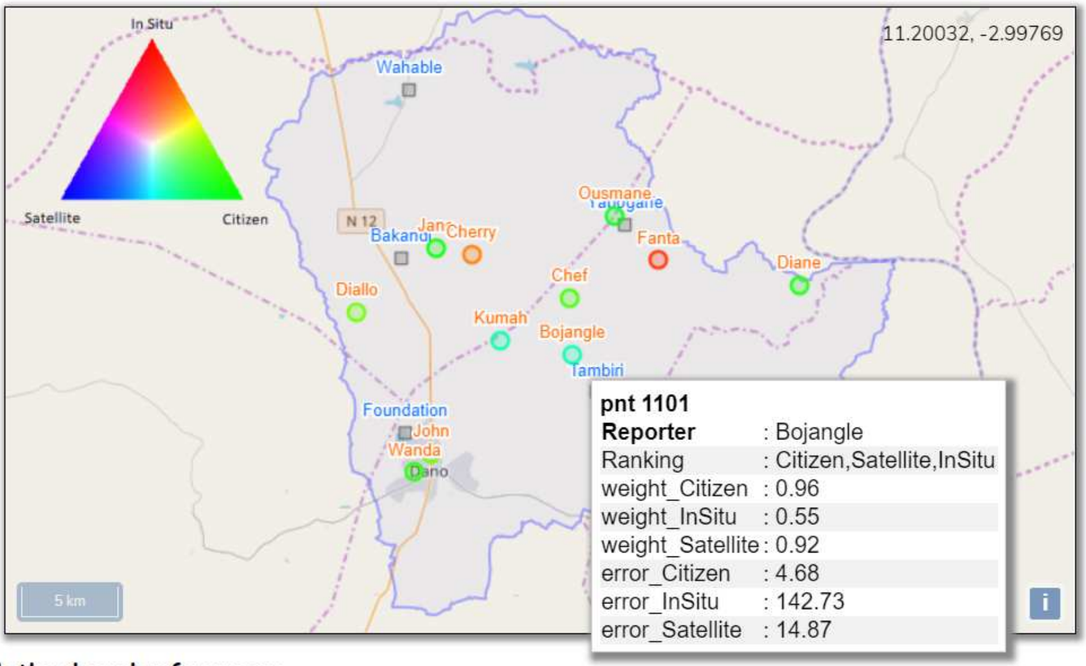
Run the Demo

Change the observation period and view which data source is most reliable in that period (compare the color of the symbols to the color triangle legend). Scroll map and move mouse pointer over Citizen location(s) for evaluation statistics.

all data | july 1-14 | july 7-21 | july 15-31



Method and references

The method is based on statistical covariance analysis on three independent data sources and yields the errors (RMSE) and correlations and permits to rank the dataset reliability.

The references of the current Triple Collocation method applied can be found in:

McColl, K. & Vogelzang, J., Konings, A., Entekhabi, D., Piles, M. & Stoffelen, A. (2014). Extended Triple Collocation: estimating errors and correlation coefficients with respect to an unknown target. Geophysical Research Letters. 10.1002/2014GL061322. [link]

Mannaerts, C.M., Maathuis, B., Wehn, U., Gerrets, T., Riedstra, H., Becht, R. and Lemmens, R. (2017) - Afrialliance Project Report Deliverable 4.4: Constraints and Opportunities for Water Resources Monitoring & Forecasting using the Triple Sensor approach. Available here [link]

The data sources used in the web-demo are from Wascal (2018) http://www.wascal.org ; Chirps (2018) http://chg.geog.ucsb.edu/data/ and WPDx (2018) http://www.waterpointdata.org (see this Toolbox).

4.3.2 Performing Triple Collocation using the ILWIS Afrialliance Triple Sensor Toolbox

We hereafter describe the procedure to perform the same Triple Collocation exercise as shown in the Web-based application. However, here the user is “in command” of his datasets, and also eventually other Triple Collocations can be done, in a different geographic Region of Interest (ROI) or study area, and also with other satellite, station and citizen source data.

Pls. follow the next steps to run a TC with the Toolbox….

Using sampledata supplied

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Using own downloads! (fast internet connected).

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5 References

6 Appendixes

6.1 APPENDIX 1

Some small but important ILWIS tips and tricks

- [STARTING ILWIS OPEN]: When you start working with Ilwis Open and Toolboxes (which doesn't need to be officially installed, just unzipped), open Ilwis, first navigate to your working directory, close and re-open Ilwis. Ilwis is now registered in Windows memory - registry, and remembers it's program locations and the data catalog (directory) path.
- [COPY and DELETE Ilwis FILES]: You can best delete Ilwis files using the Edit Menu > Delete option. This removes all (hidden, non-displayed ancillary files) from your system. Also always copy Ilwis files (to other disks or directories) using the Edit Menu > Copy Object to … option, in order to copy the object dependencies also.
- [REFRESH MEMORY]: Pls. use the Refresh (or F5) from the Window Menu, if you do not find a filename of something you just created. This is a refresh Memory operation in Ilwis.
- [RESTORE DEFAULTS]: If you worked much on data and e.g. did overwrite filenames or tried operations which are not possible or allowed etc. and if Ilwis is getting slow (or seems to hang), you can refresh (clean) the entire *Ilwis memory* by File > preferences > Advanced > Restore Defaults. This resets Ilwis. You will need to navigate back to your work directory for the first time again, after resetting Ilwis.
- [CLOSE APPLICATION]: *Kill Ilwis* in case of "hanging". By some not allowed operations, Ilwis Open might not work further. In worst case, pls. use the Windows Task Manager from the Windows Task Bar to "End Task" -> Ilwis run operations. This is "brute" Windows forced close program, but efficient if really needed. Just Re-open Ilwis again.
- [FILE DEPENDENCIES]: GIS files in general (e.g. also ArcGIS) have much earlier created file dependencies and heritages or lineages, which can sometimes be cut, but sometimes also may not be removed. The Ilwis Properties button is an important info source to see the dependencies of your Ilwis object. Especially earlier Georeferences used to create the (sub)object are important file heritages or lineages in Ilwis.
- [DISPLAY SETTINGS]: Sometimes your Defaults Display settings for e.g. Raster maps looks not good (e.g. gtdmax). This raster representation is not nice (in the Ilwis default settings) and should by preference be set to *Pseudo* (colour Look-up). Use File > Preferences > Map Window> Display > Default Representations to adapt.
- [SERVICE OBJECTS]: Pls. remember that in ILWIS, the Domain (-> data type) and georeference, coordinate systems are most important Service Objects to take care off. They basically determine what you can do on an object. If a certain RS/GIS operation does not work (or you cannot activate it), pls. first check the domain type, georeference and dependencies of the objects you are working with (or combining, etc.)…

Appendix 2:

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