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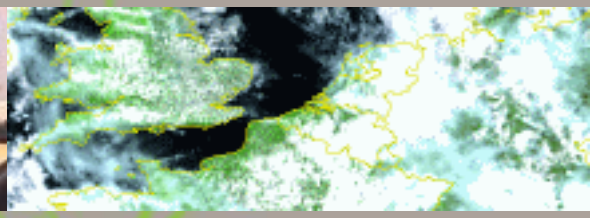
NEAR REAL TIME EARTH OBSERVATION DATA AND OPEN TOOLS FOR CLIMATE OBSERVATION AND EARLY WARNING SYSTEMS

Chris Mannaerts (et al)

ITC - Department of Water Resources

Presentation at UNDP “DRM-Capdev” Workshop,
July, 24-27 2016, Praia, Cape Verde

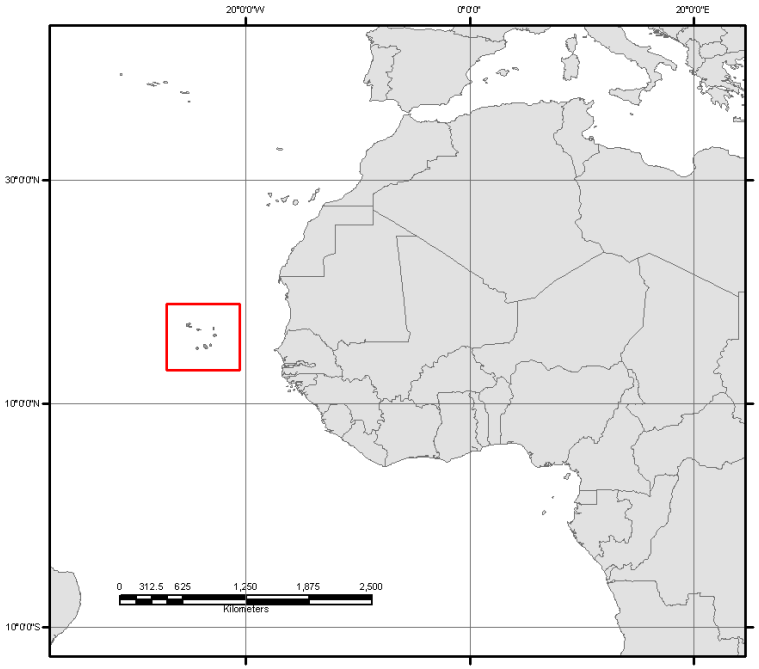


ITC FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

Overview

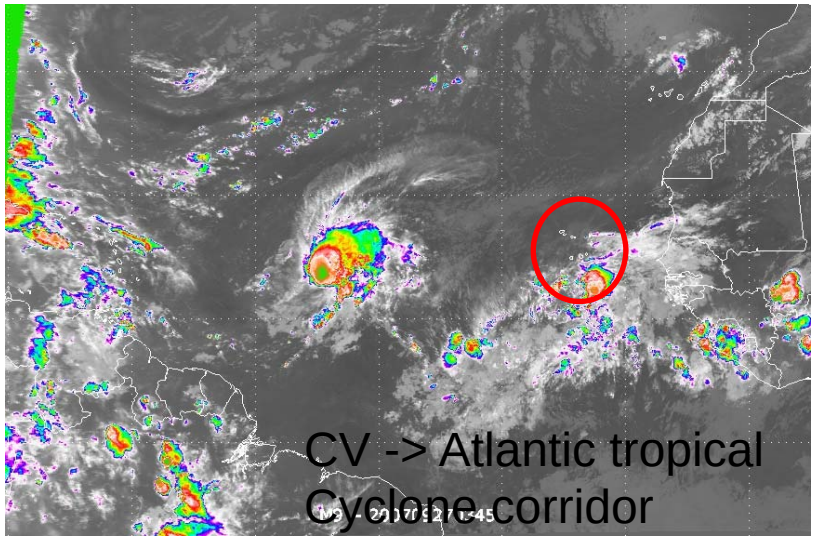
- Climate observation and early warning: importance and need
- Near real time (open) atmospheric, land and ocean data
  - EUMETCast and GEONETCast systems
  - Open Source Tools (ITC GEONETCast Toolboxes)
  - Web-based data
- Data streams for Weather, Climate and Early Warning Systems
- Some project Use Cases
  - GEONETCast 4 EW & Food Security – Ethiopia
  - GIACIS: Geodata for Agricultural Credit Insurance
  - AMESD-SADC Toolbox for Drought, Agriculture, and Fire Hazard risk monitoring
- Closing remarks

CAPE VERDE 1



Dry season: relatively less sudden onset potential disaster events: but many environmental challenges, winds, drought, haze, dust, “bruma seca”, health, disease vector spreading, water resources availability, seismic and volcanic activity (permanent)..

CAPE VERDE 2

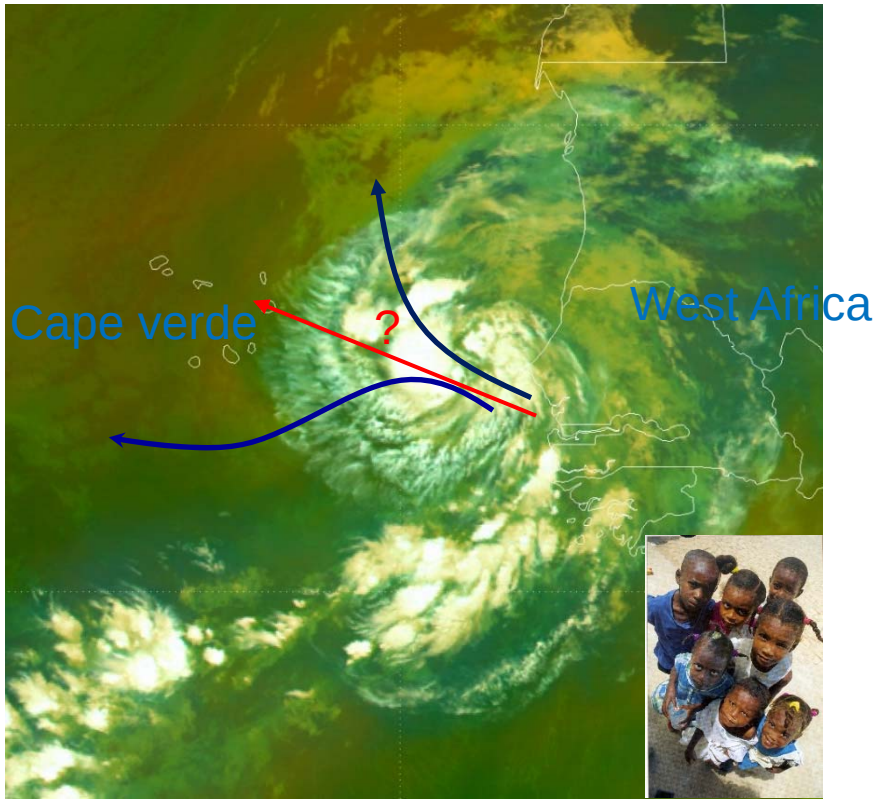


Rainy season (august - october)
More sudden onset potential “disaster” events: extreme weather & rainfall, flash floods, rock fall, land slides, sediment lows, roads,..emergencies

EARLY WARNING GEOSPATIAL DATA AND INFORMATION PRODUCTION

SATELLITE & IN-SITU BASED

Tropical depression 15-08-08, cyclone L1, activity, direction, path ..?



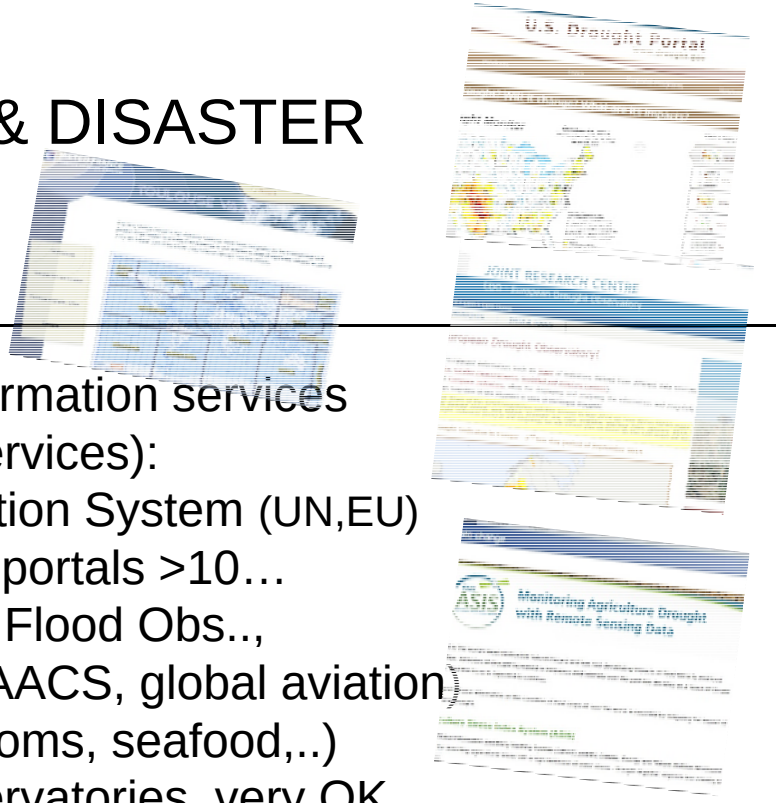
Solutions:

- Buy-in 3td party information (many “global” sources, web servers…)
- Develop own capacities to generate and disseminate EW; This needs “know-how” development in raw data access, processing, risk analysis and dissemination to public

Local populations @ risk

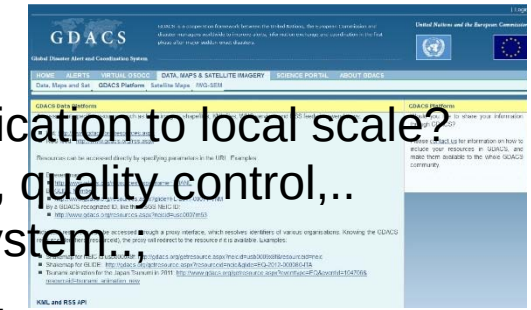
EARLY WARNING WEBSITES & DISASTER RISK OBSERVATORIES

MANY CHOICES…



Today (2016), numerous websites with information services i.e. WMS or web mapping or processing services):

- GDACS Global Disaster Alert & Coordination System (UN,EU)
- Drought monitoring - food security (many portals >10…
- Flood alert observatories: e.g. Dartmouth Flood Obs..,
- Volcano watch (eruptions, ash clouds): VAACS, global aviation)
- Water quality – health risks (e.g. algal blooms, seafood,..)
- And many more of these web-based observatories, very OK



But some issues remain:

- usually global or regional observation systems: application to local scale?
- Ingesting information from 3th parties, data sources, quality control,..
- no ownership over operations and functionality of system …,
- financial cost for non-public (commercial) systems…

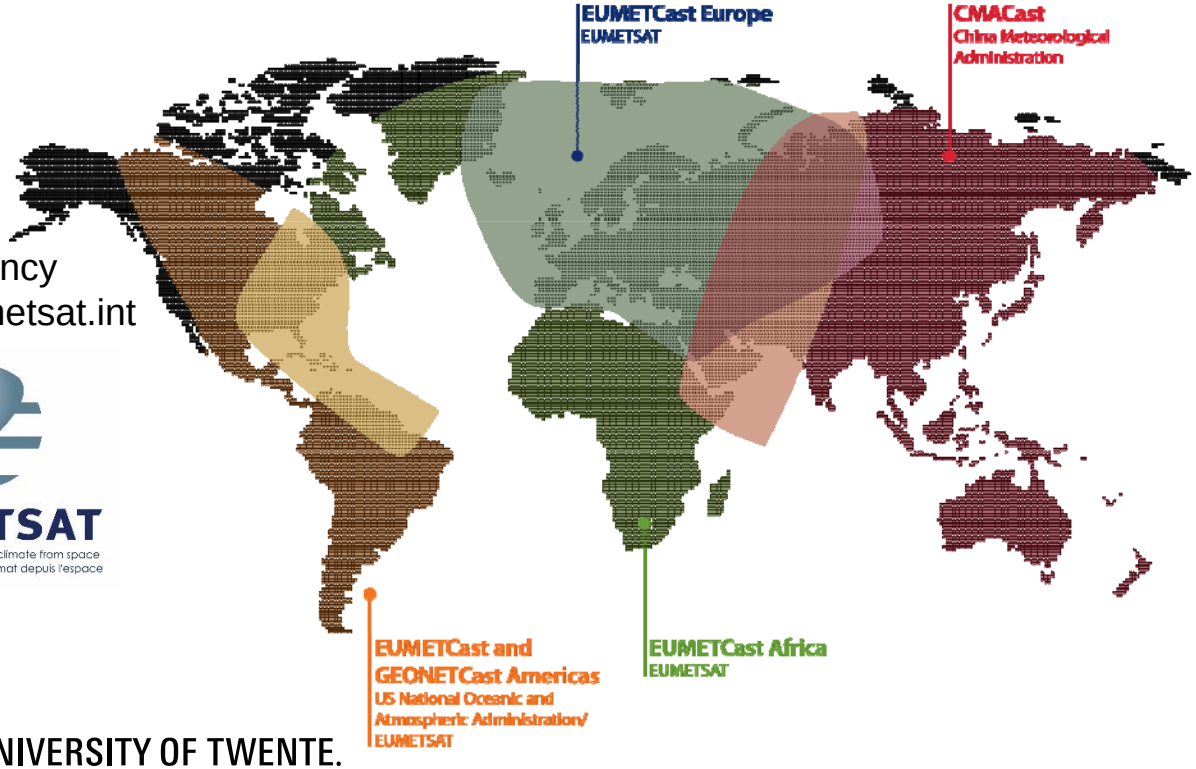
Our solution: Develop own capacities and ownership (& more independence),..
Some ITC examples: **GEONETCast Open ToolBoxes** (OTB)

GEONETCAST

DELIVERING OPERATIONAL SERVICES TO USERS

GROUP ON EARTH OBSERVATIONS

- GEONETCast is the global data dissemination system of GEO
- It provides free near real-time environmental and Earth observation data and derived products to a worldwide user community using a telecommunication satellite based data distribution system



Lead agency
www.eumetsat.int

EUMETSAT
Monitoring weather and climate from space
Surveiller le temps et le climat depuis l'espace

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ITC reception control

GEONETCAST DATA RECEIVING INFRASTRUCTURE: HARDWARE COMPONENTS (5 PIECES)

FROM LOW COST TO HIGH TECH SYSTEMS

Dish antenna
PC (or 2)
DVB-S i/o card
Data storage
USB key

Temporary setups at:
AfricaGis Conf. 2009, Kampala
Utwente, Open days Sep, 2012
(schoolchildren take a look)

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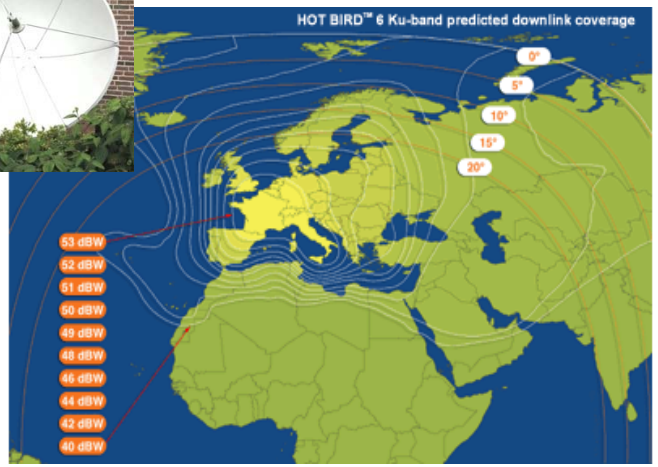
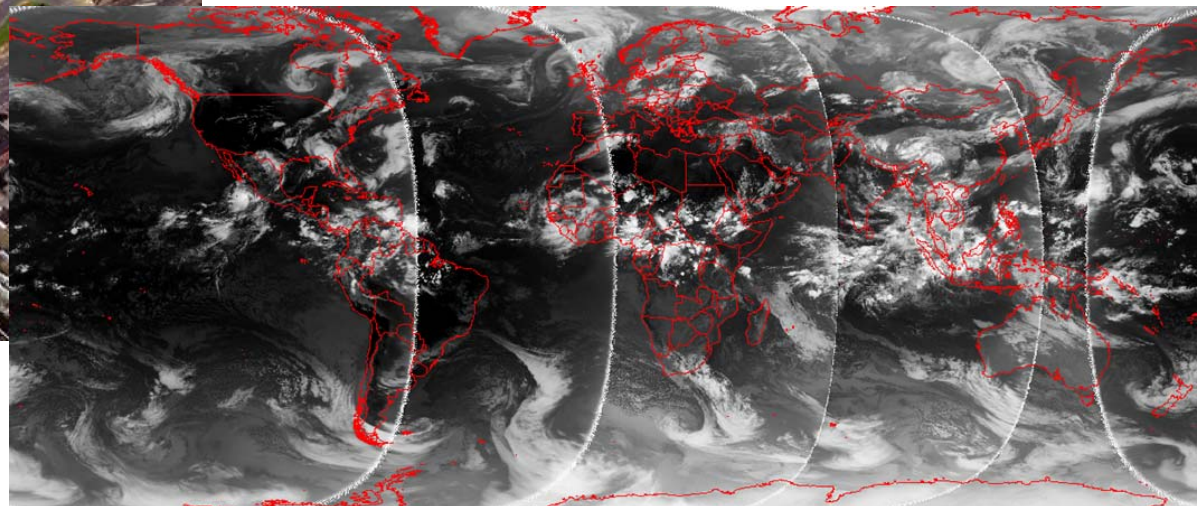
GEONETCast data reception over Europe & North Africa:-> EUTELSAT DTV satellites (example ITC)

- EUMETCast license (Science - Education)
- EUTELSAT 10A Ku band & C-band (Africa system)
- 88 cm satellite dish (DTV for Europe reception)
- Low cost
- Global near real time data reception



ITC Enschede, NL

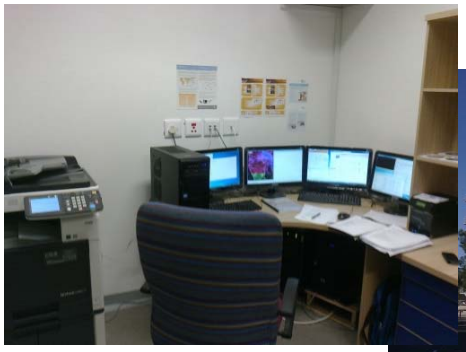
Global NRT TIR composite from geostationary orbits: GOES W/E, MSG, MET-7, FY-2E/MTSAT



GEONETCast data reception in Africa and Latin America using C-band dish antennas -> research & training

- GEONETCast Africa & Americas services

EUTELSAT 5 WEST C-band dBW footprint



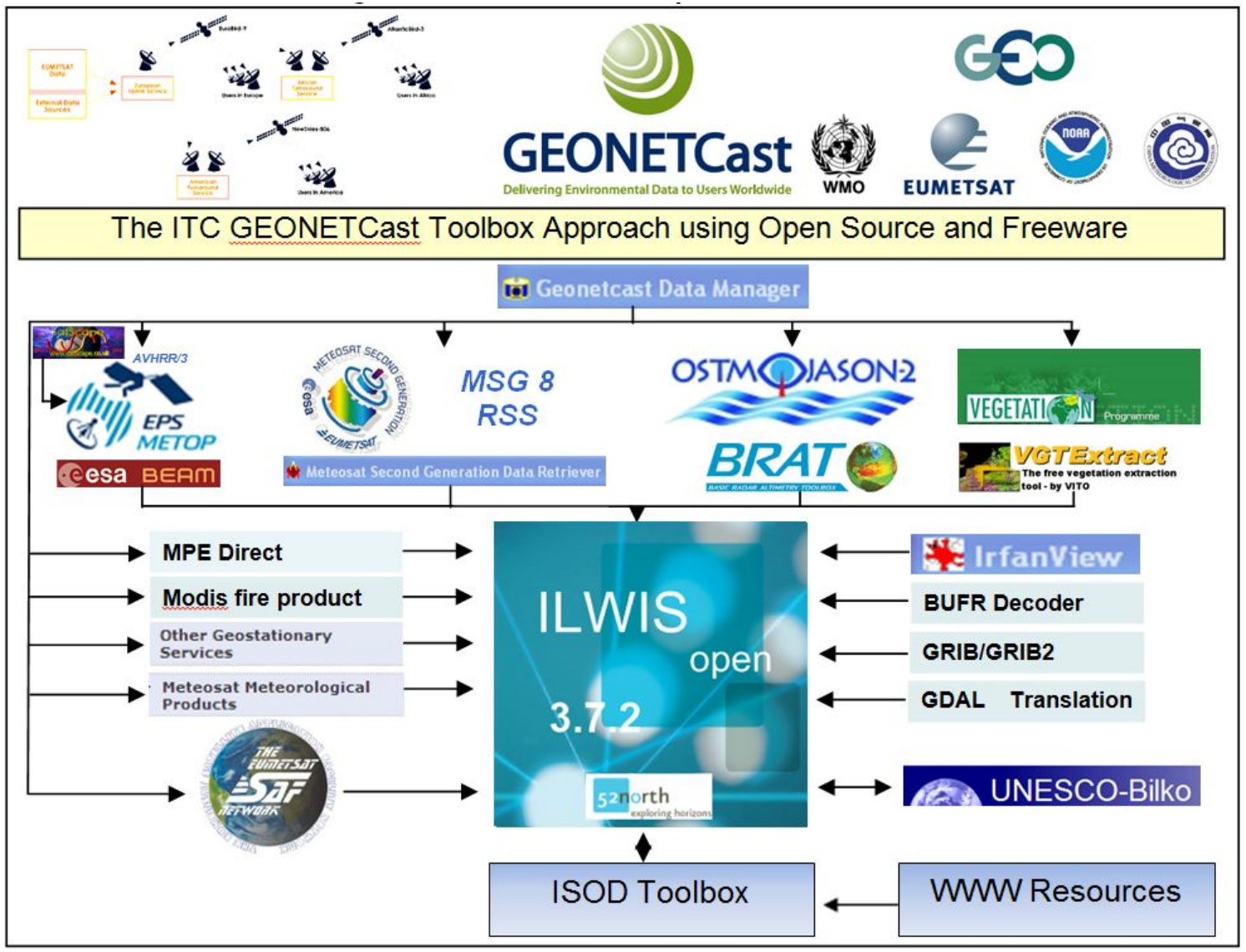
GNC reception room at UWC Bellville campus, Cape Town, SA 2012

Dish at CGIS-NUR Rwanda First ITC system setup

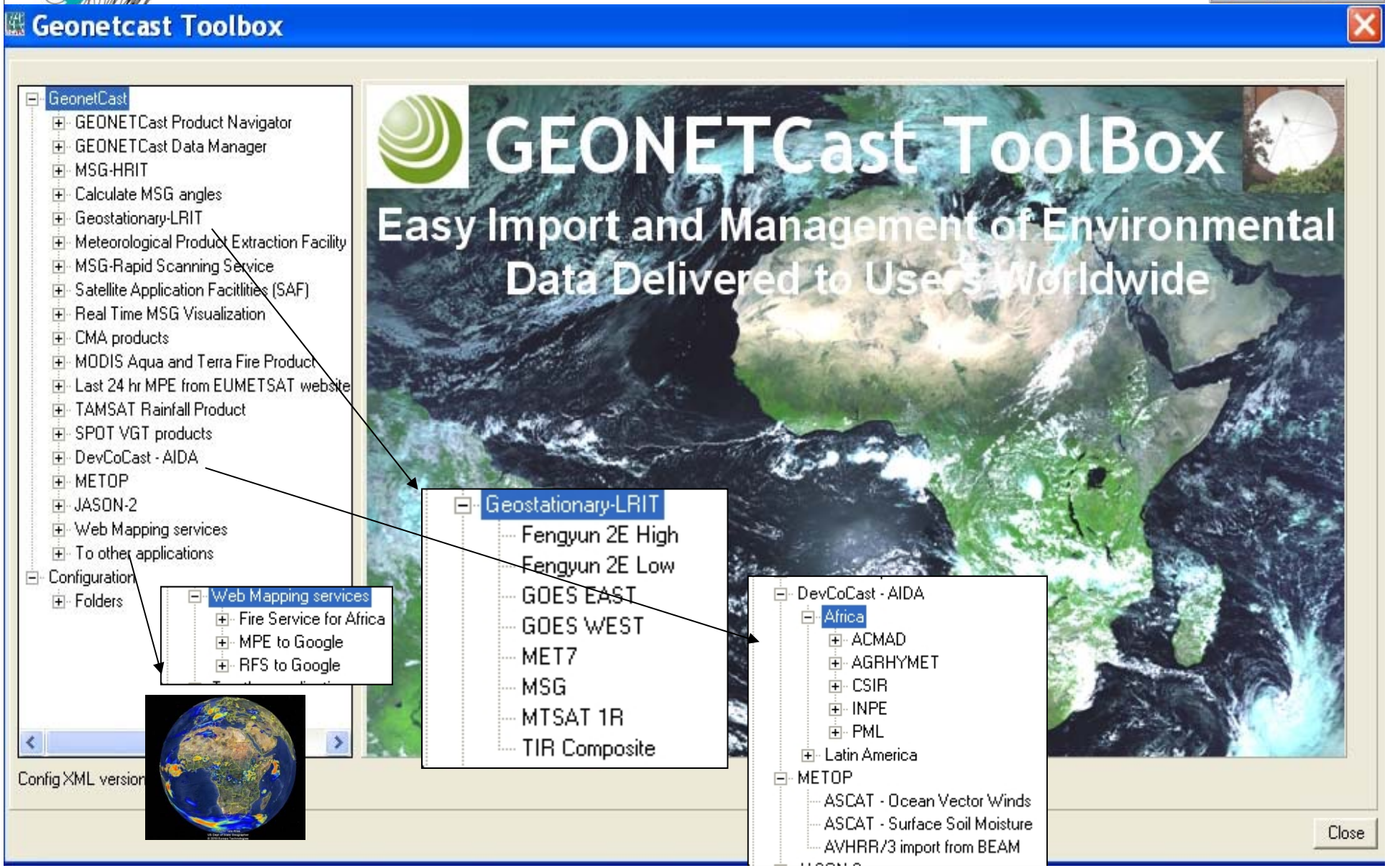
Setup for a training course in Ouagadougo Nov, 2013 using laptop

Satellite Dish installed at RCMRD, Nairobi

ITC: OPEN DATA AND TOOLBOX APPROACH

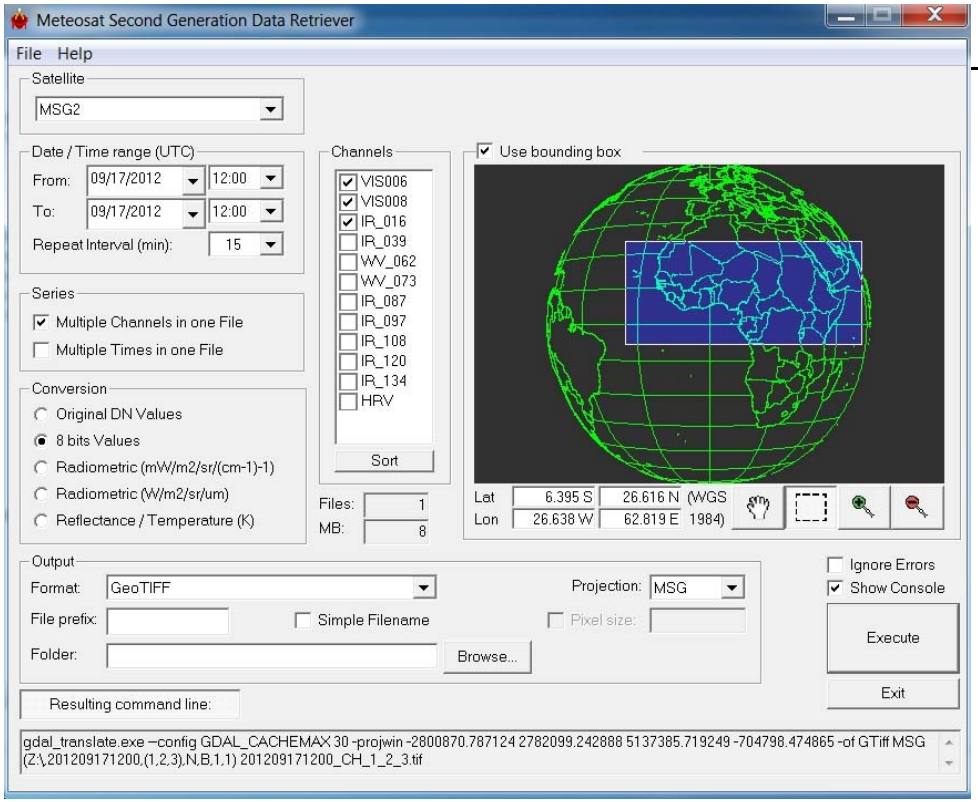


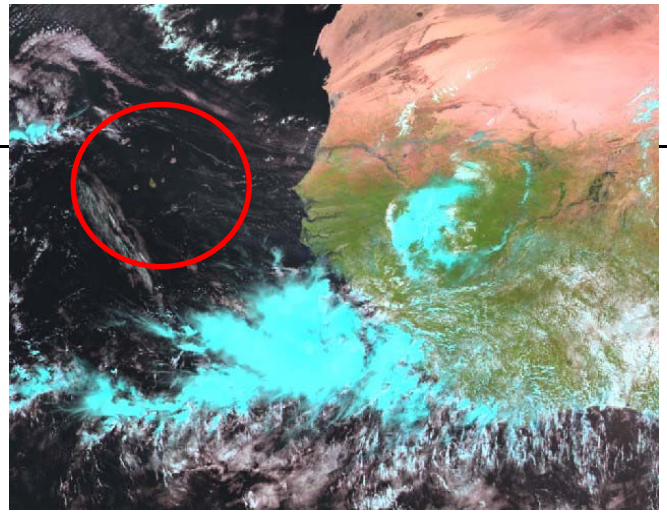
ILWIS Open GEONETCast TOOLBOX v.3.72

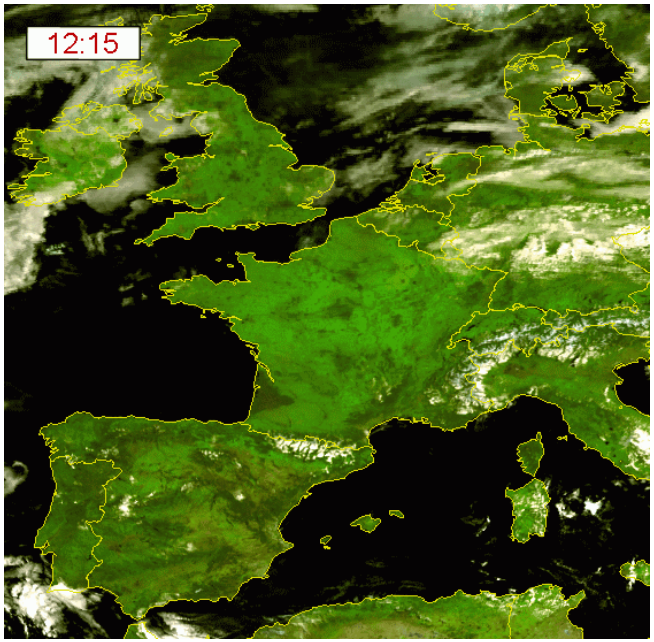


More than visualization: working with scientific sat data

EXAMPLE: MSG DATA RETRIEVER







- Rapid SEVIRI channel import, user-defined windowing
- Optional resampling, (re)projection to MSG, Lat-Lon, UTM
- Extraction of time series or channel composites in one file,
- Various output formats: byte, radiances, reflectance, BT,..
- Open code access (GDAL), choice output formats

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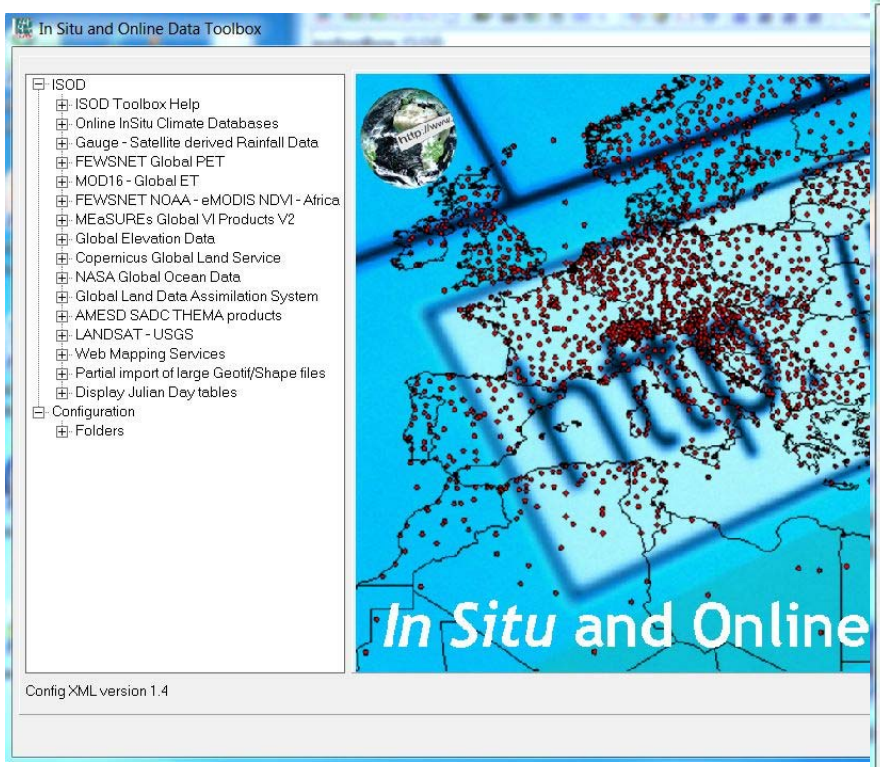
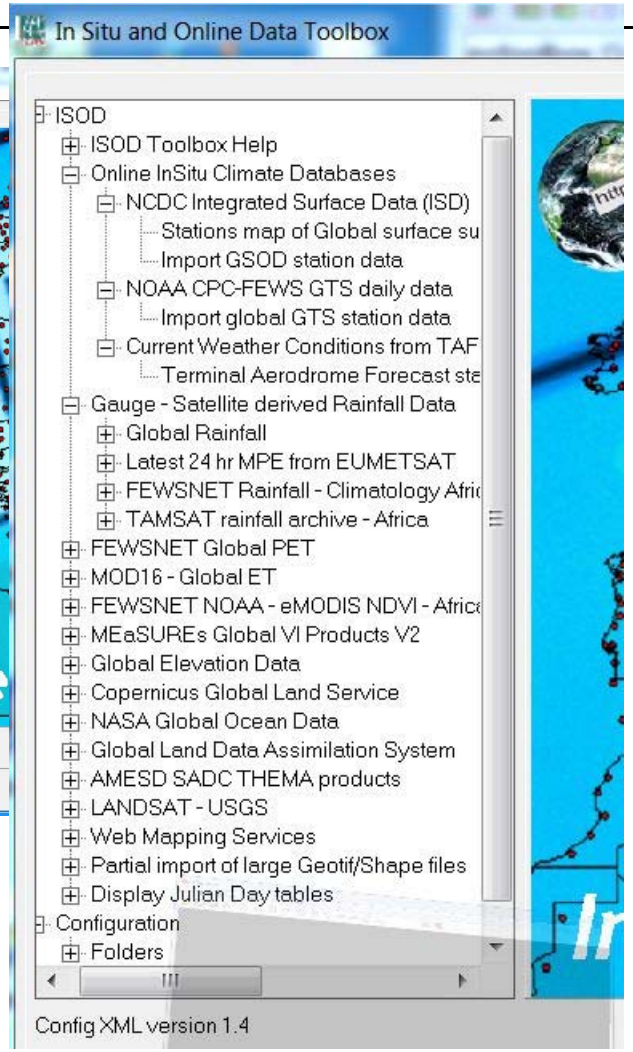
IN-SITU AND ON-LINE DATA TOOLBOX

NEAR REAL TIME SURFACE OBSERVATIONS DATA: LAND & OCEAN





AND TIME SERIES OF WEB-BASED EO DATASETS (OPEN ACCESS) using ftp or http transfer

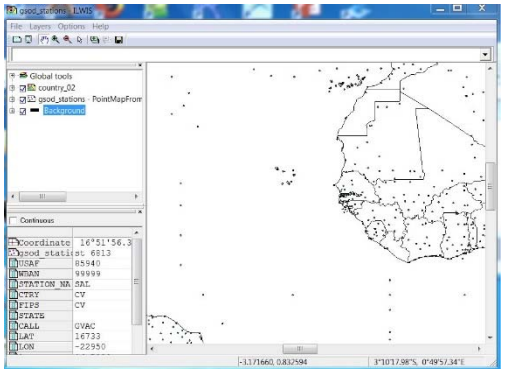
EXAMPLE ROUTINE

On-line Weather & Climate Data -> laptop

Retrieval from Data bases and (pre-)processing to Ilwis open data

Various in-situ online climatological data resources:

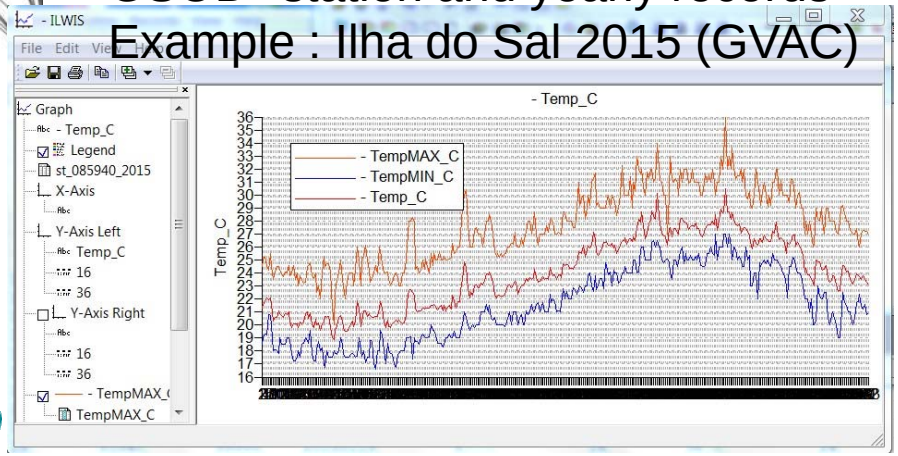
- SYNOP, *GSOD, METAR, TAF,..

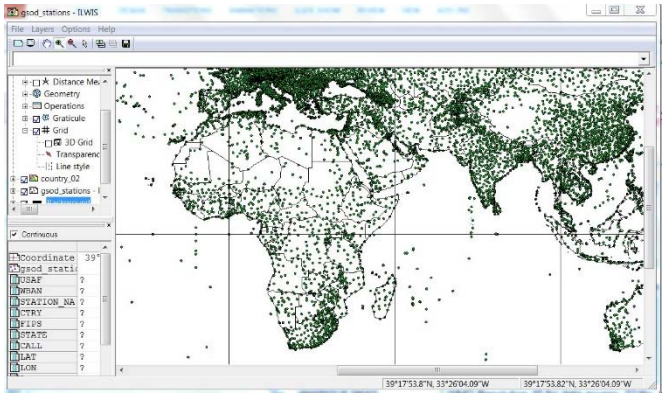


Coordinate	16°41'06.23"N,
gsod_stati	st 6813
USAF	85940
WBAN	99999
STATION_NA	SAL
CTRY	CV
FIPS	CV
STATE	
CALL	GVAC
LAT	16733
LON	-22950
lat_new	16.7330
lon_new	-22.9500
elevation_r	53
country_02	
Area	

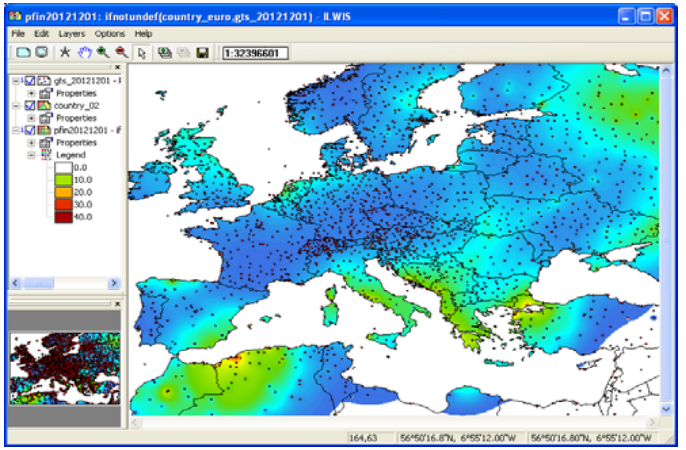
GSOD* station and yearly records

Example : Ilha do Sal 2015 (GVAC)





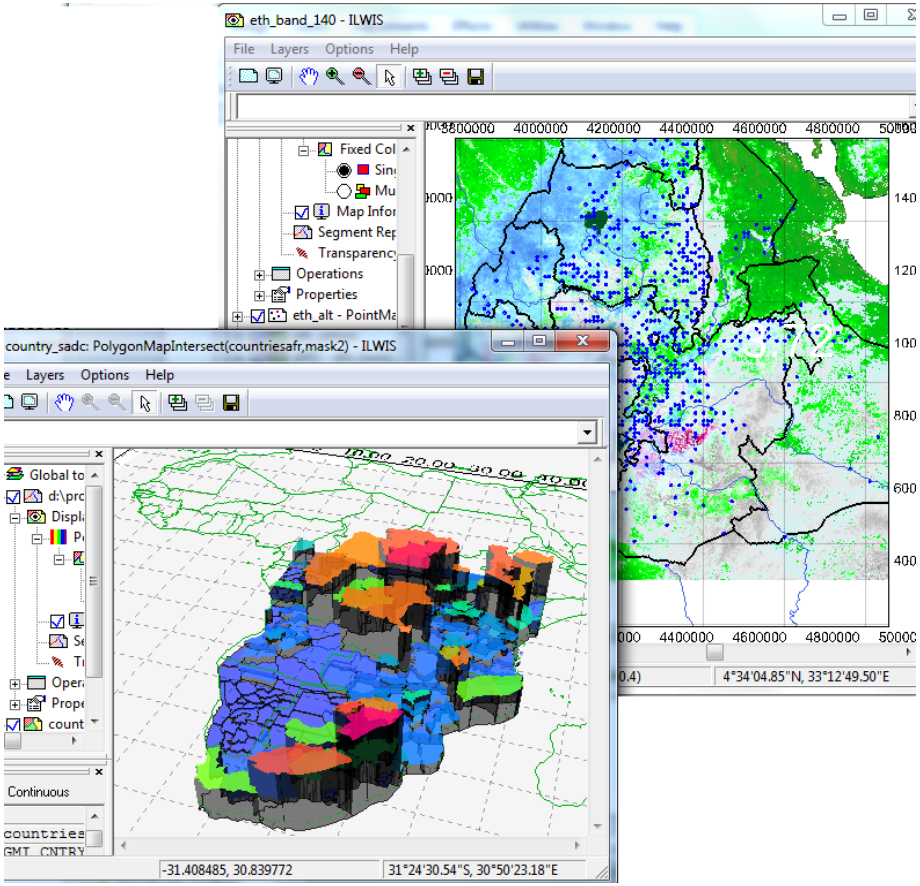
GTS stations and precipitation



* WMO Resolution 40 for data access -024hr

ILWIS OPEN

OPEN SOURCE EO & GEOSPATIAL DATA ANALYSIS (CORE)



Key features:

- integrated raster and vector design
- import - export of widely used geospatial data formats
- on-screen digitizing
- comprehensive image processing tools
- orthophoto, image georeferencing, transformation and mosaicking
- advanced modeling and spatial data analysis
- 3D visualization & animation (optional 3D)
- auto resampling of different spatial geometries
- rich projection and coordinate system library
- geo-statistical analyses & interpolators
- Spatial Multiple Criteria Evaluation
- Web Mapping & Processing Services
- Hydrological digital terrain modeling
- Surface Energy Balances (SEBS) functionality
- Application Plug-in architecture (Toolboxes)

Compact main package: 25 MB only!

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GEONETCAST and *in-situ* data streams for CLIMATE OBSERVATION & EARLY WARNING SYSTEMS

- The Global Meteorological satellite constellation is data backbone with geostationary and polar orbiters, but also many 3th party providers (VITO, INPE,...) and other satellite data & products

WATER

Precipitation

- MSGMPE NRT
- TAMSAT 10-D
- GPM NRT
- FY-2D/E (ASIA)
- INPE (LAm)

ET (evapotrans..)

- LST, DWSF...
- AET-LSASAF

SM (soil moisture

- METOP SSM/I
- SENTINEL-1A
- Other

ENERGY

SOLAR Radiation

- DWSF, DWLF, PAR
- LST, SST

WIND Energy

- MSG Atm.motion.vecs
- Metop ASCAT winds

****GTS METEO MODEL outputs -> Forecasts***

(*MetService distribution) -> Weather model but also *Agricultural and Hydrological forecasting*

FOOD SECURITY

LULC: Land Use – Land Cover

- MSG NDVI, LST, FVC,…
- SPOT-VGT, PROBA-V
- METOP a/b, NPP

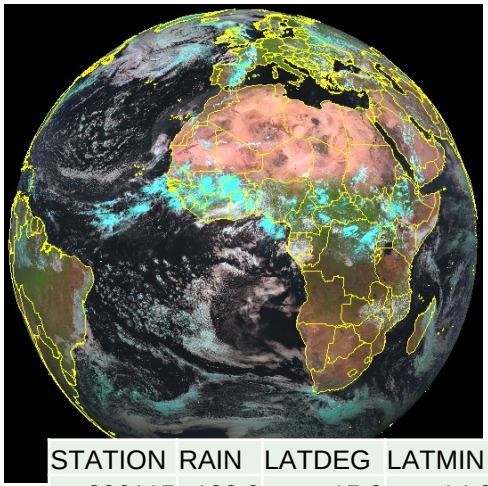
Many other via on-line retrieval (e.g. ***ISOD OTB***)

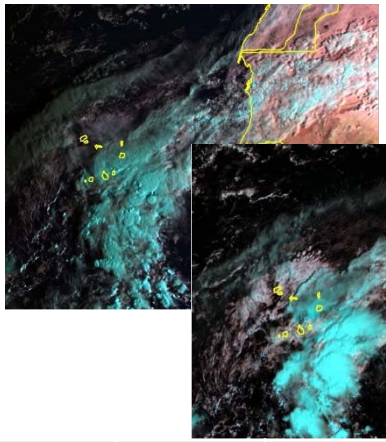
- ***LDAAC***: e.g. MODIS,…
- ***USGS***: LANDSAT-8
- ***ESA***: **SENTINEL-2** (& 3)
- ***INPE (Br)***: CBERS collection
- ….

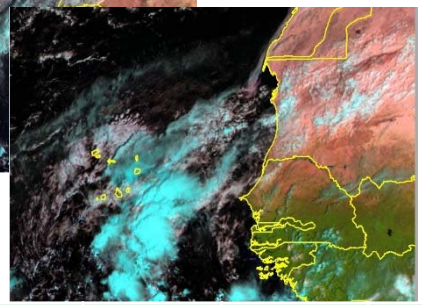
Some GNC data snapshots ->

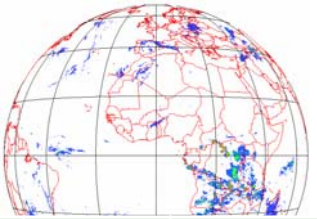
[1] MSG Real time weather and rainfall monitoring over Europe & Africa: ->ex. Cape Verde, 2007-Oct-14

Event shown: 14 Oct 2007 (2007-10-14) 0800 1200 UTC view and accumulated 24hr MSGMP









STATION	RAIN	LATDEG	LATMIN	LATSEC	LONGDEG	LONGMIN	LONGSEC	HEIGHT	N	E	ELEVATION
806115	109.0	15.0	14.0	35.3	-23.0	42.0	20.3	290.0	1687024.47	209361.21	318.0
806095	17.0	15.0	6.0	0.0	-23.0	40.0	0.0	0.0	1671125.82	213357.07	562.0
806096	3.0	15.0	4.0	40.2	-23.0	37.0	40.5	454.0	1668621.60	217495.59	463.0
806013	63.4	15.0	16.0	0.0	-23.0	46.0	0.0	0.0	1689711.90	204000.00	13.0
806103	28.0	15.0	1.0	50.1	-23.0	36.0	32.8	820.0	1663366.72	219456.52	857.0
806078	136.4	15.0	2.0	54.7	-23.0	36.0	38.4	369.0	1665355.24	219312.66	402.0
806074	80.0	15.0	3.0	52.5	-23.0	35.0	53.8	230.0	1667116.91	220666.41	232.0
806087	20.0	15.0	8.0	15.6	-23.0	35.0	22.5	40.0	1675196.49	221697.01	146.0
806107	3.6	15.0	0.0	0.0	-23.0	32.0	0.0	0.0	1659886.19	227570.37	314.0
806126	0.0	15.0	6.0	27.5	-23.0	42.0	12.9	400.0	1672020.08	209396.72	445.0
806080	16.7	15.0	1.0	8.9	-23.0	32.0	57.2	235.0	1662024.52	225885.16	307.0
806009	0.0	14.0	59.0	1.3	-23.0	29.0	26.6	90.0	1658029.16	232134.92	99.0
806012	11.5	15.0	3.0	9.1	-23.0	36.0	17.7	310.0	1665790.74	219936.48	310.0
806082	74.0	15.0	11.0	1.0	-23.0	41.0	25.3	765.0	1680413.64	210922.13	808.0
806072	0.0	15.0	3.0	16.5	-23.0	34.0	42.6	241.0	1665984.87	222780.96	255.0
806105	15.2	15.0	3.0	48.1	-23.0	36.0	48.0	321.0	1667000.77	219045.25	343.0

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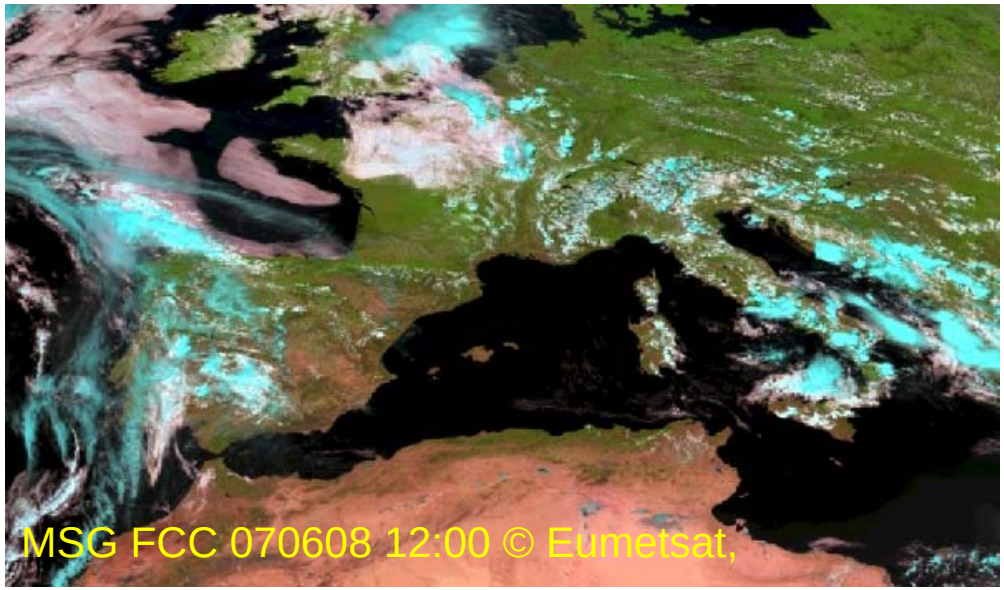
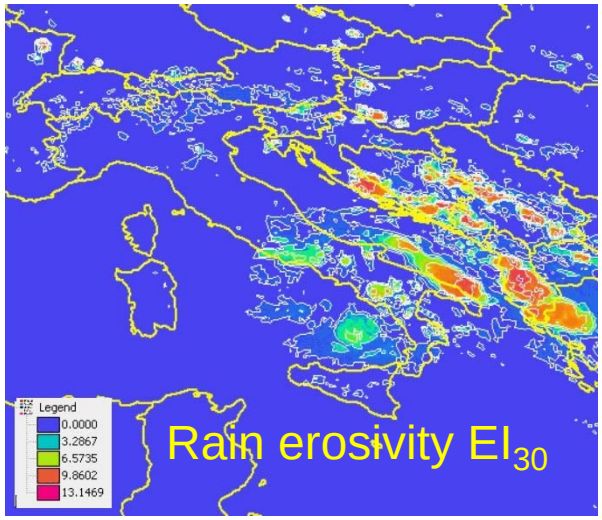
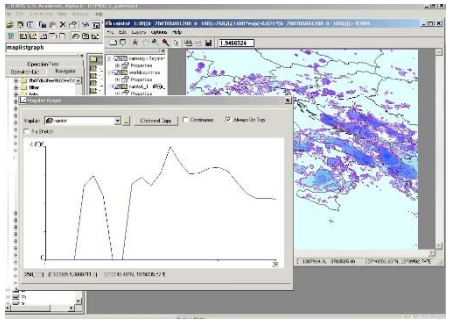
RAINFALL EROSIVITY FROM WEATHER SATELLITES

APPLICATION DOMAIN: LAND DEGRADATION – SOIL EROSION

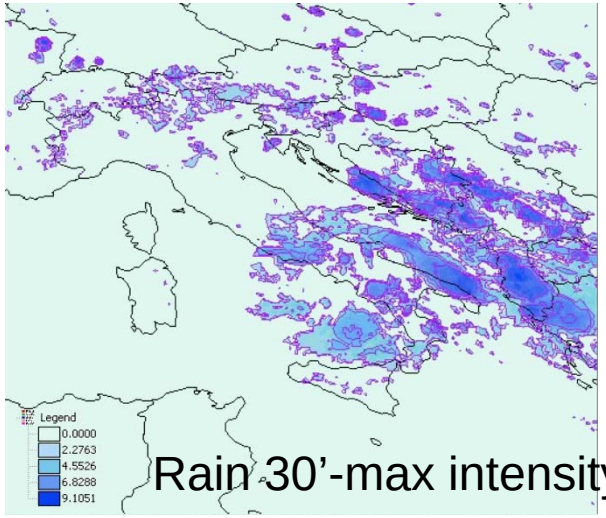




Application domain:
land degradation studies
-> Long term environmental Challenge for Food Security
e.g. see also Cape Verde Research Desire project FP6



Methodology test
By C.Mannaerts



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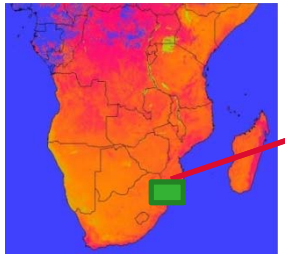
[6] VEGETATION & LAND USE MONITORING: FROM COARSE 3K, 1K TO MEDIUM HIGH RES. 10M

SATS: METEOSAT- METOP – SPOTVGT – MODIS & LANDSAT (FTP) - CBERS

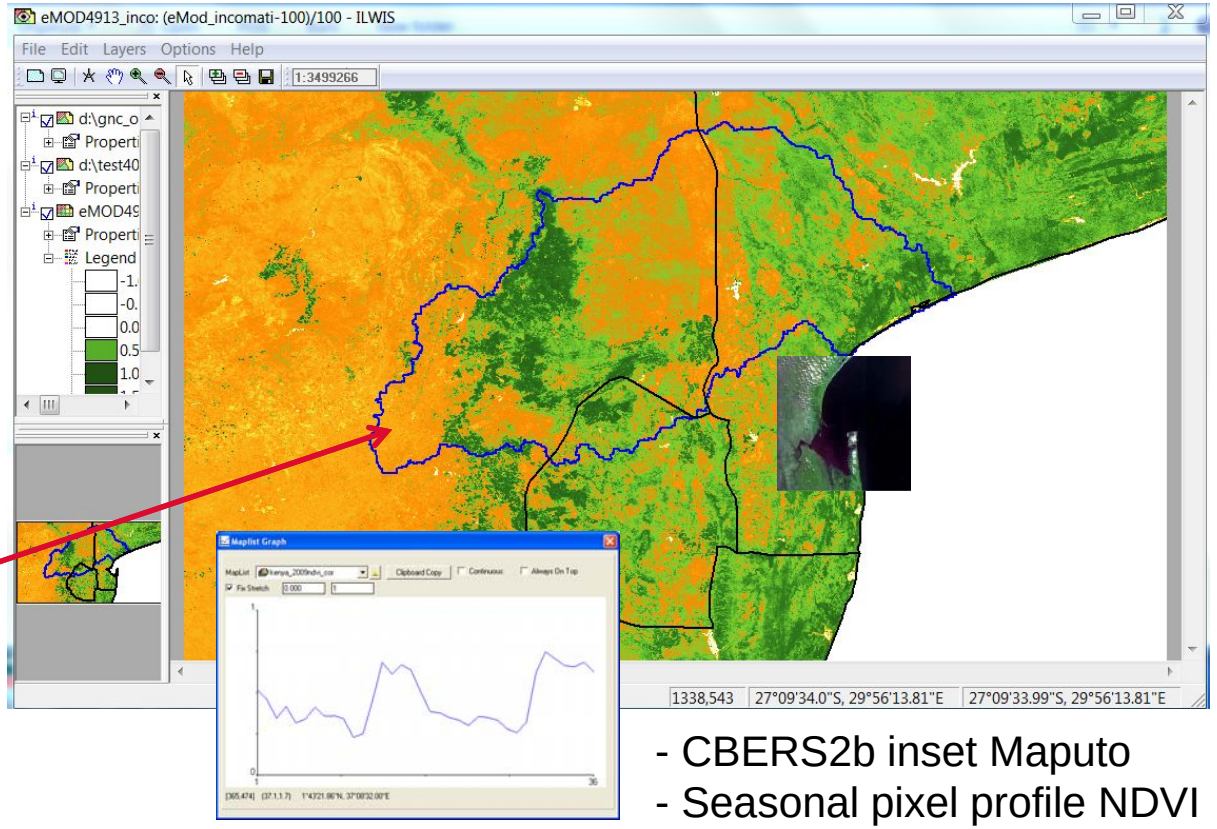
Several indicators of land cover, vegetation status, crops can be observed via GEONETCast data streams (or via ISOD). From simple vegetation indices to biomass productivity, land surface temps, areal coverage and so on.

Choice of satellites:

- MSG 3k – 30'
- METOP 1k – 24h
- SPOT-VGT 1k – 10d
- PROBA-V 1k/300m – 10d
- eMODIS 250/500m – 5/10d
- LANDSAT8 30m – +-21d
- CBERS2B 20m – 10m



Data source: NDVI Africa



- CBERS2b inset Maputo
- Seasonal pixel profile NDVI

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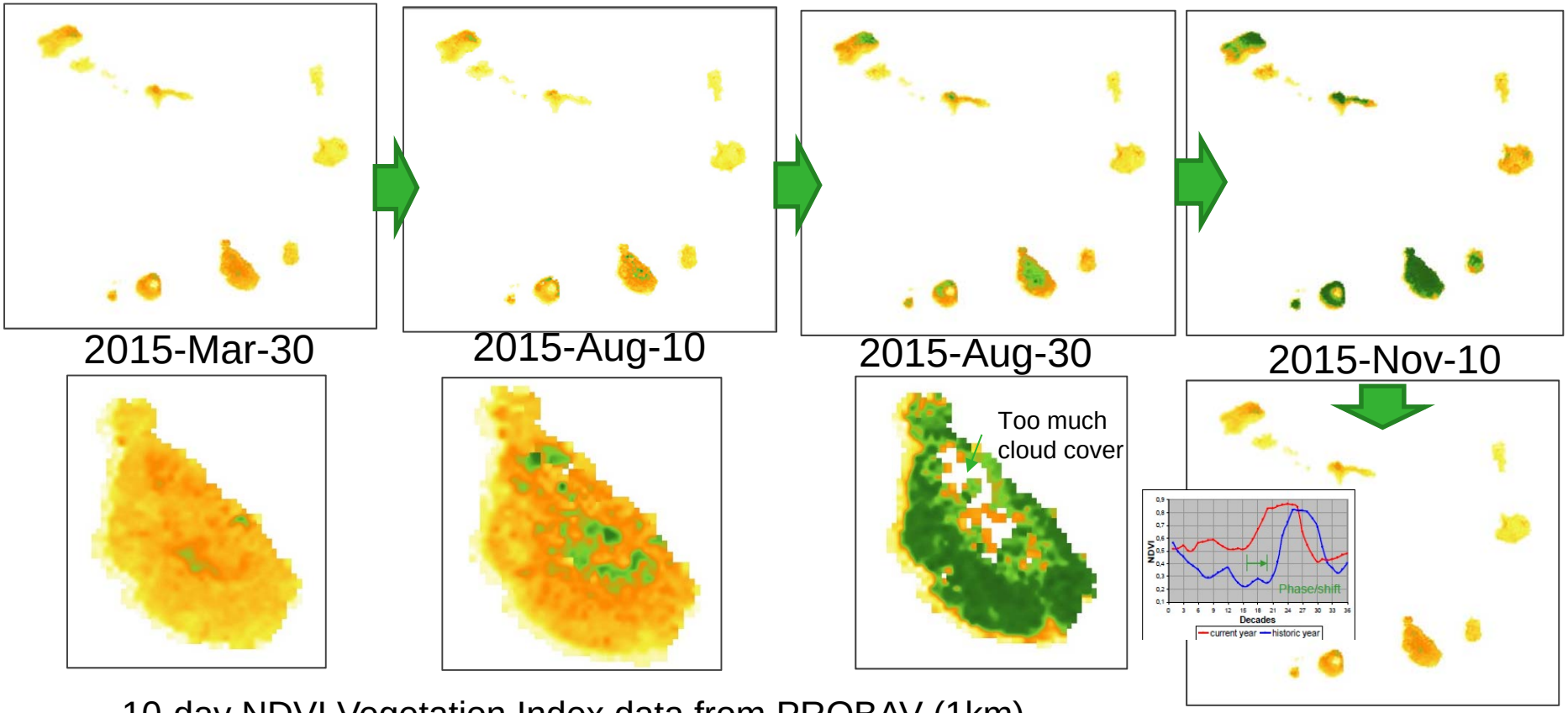
VEGETATION TIME SERIES MONITORING: USING PROBAV SATELLITE S10 NDVI

APPLICATION DOMAIN: AGRIC. DROUGHT AND FOOD SECURITY



10-day NDVI Vegetation Index data from PROBAV (1km)

A generic monitoring system for ***agricultural production monitoring***, ***drought and food security analysis*** (ref. our WFP, G4AW projects in Ethiopia)

Now, also 300m and 250m available ….

MEDIUM TO HIGH RESOLUTION LAND COVER - LAND USE IMAGE DATA

LANDSAT8, SENTINEL-2,…-> SPOT5,6,7, GEOEYE, PLEIADES,…

SPOT 4 XS FCC composite

More detailed LULC monitoring requires higher spatial resolution data.

Open (free) satellite data such as:

LANDSAT8 (30-15m) (NASA/USGS)

ESA SENTINEL-2 (10, 20, 60m)

or commercial satellite data:

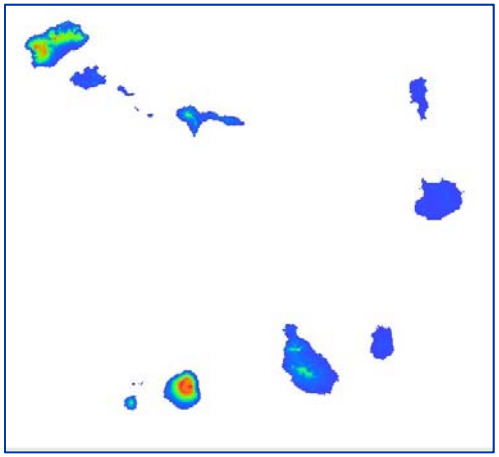
SPOT 6-7 (6m; 1.5m); GeoEye

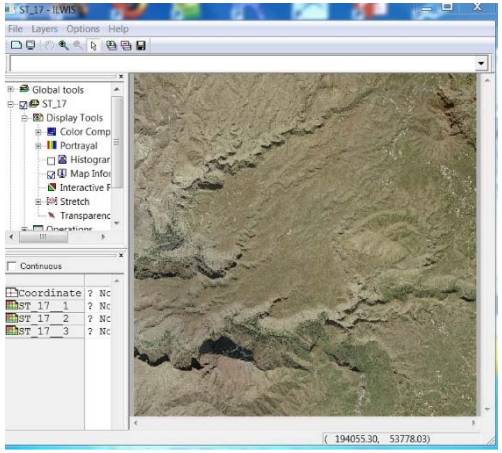
And techniques to combine the high time frequency of the low resolution images (e.g. PROBA, MODIS,,) with these higher spatial resolution data

DIGITAL TERRAIN (ELEVATION) MODELS

ESSENTIAL DATA IN DISASTER RISK ANALYSIS AND MORE

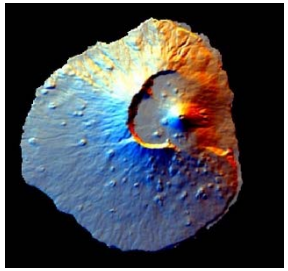
Current digital elevation data from satellites and airborne (aerial photogrammetry, Lidar, etc.) From coarse scale 10km-> 1km->90m->30m->10-> <1m

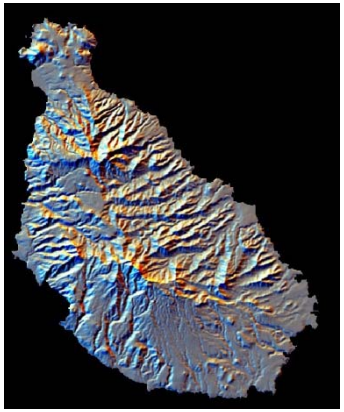


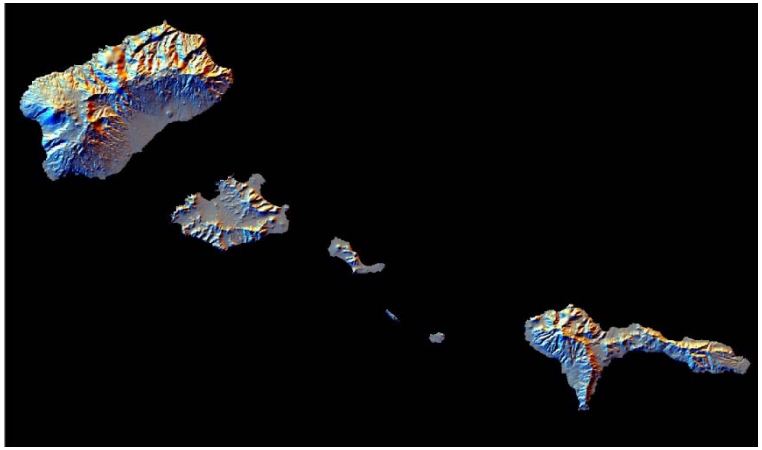


Digital orthophoto 0.5m in Ilwis

SRTM 90m v4 also 30m







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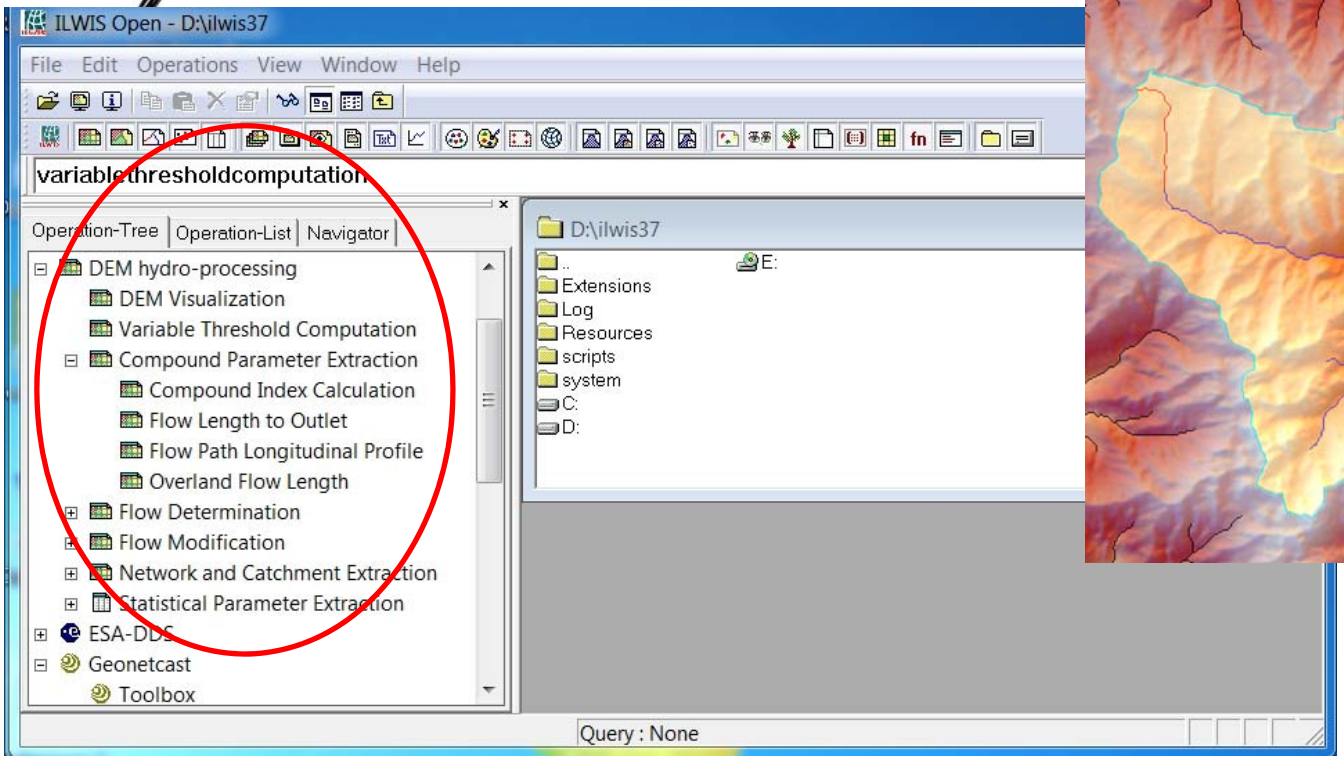
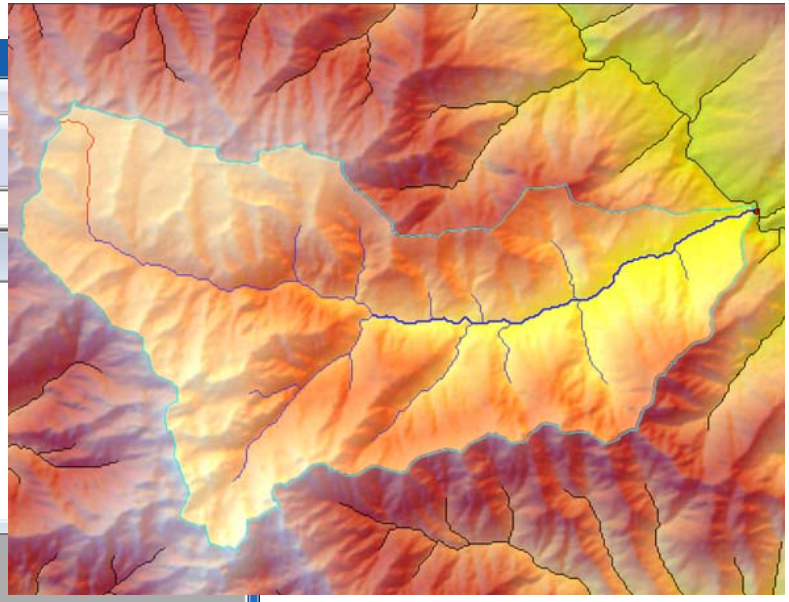
[8] RIVER BASIN GEOMORPHOMETRY & HYDROLOGICAL BASIN DATA GENERATION IN ILWIS OPEN ->VIP IN DISASTER STUDIES

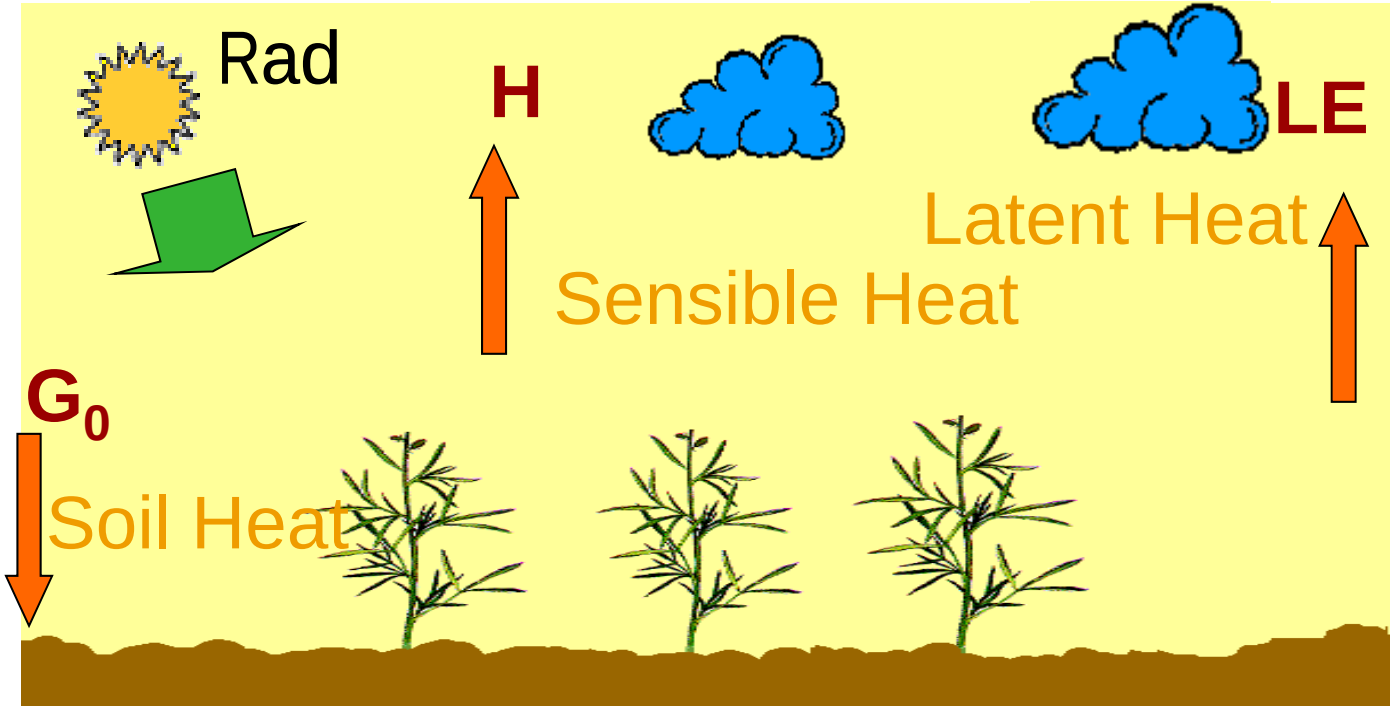
Besides satellite data analysis tools, Ilwis Open contains an extensive toolbox for automated river basin delineation and geomorphological data generation and statistical analysis
- Easy model couplings e.g. GUIH type





[2] Evapotranspiration (using satellites) and applications in water and agriculture

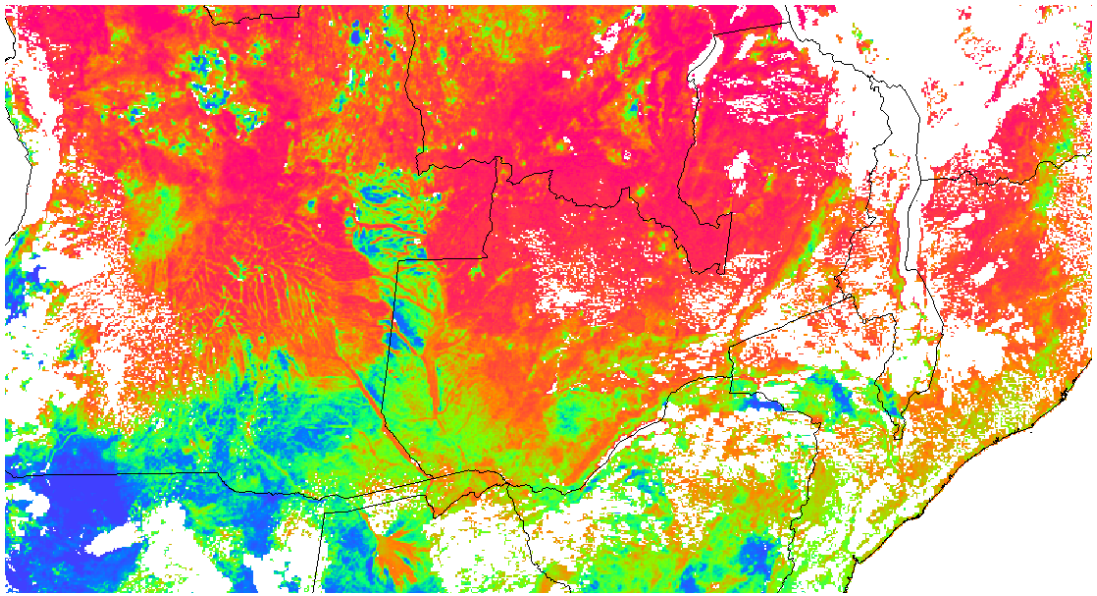
Theoretical basis: surface energy balance model & fluxes using thermal (TIR) band (land surface temp.) & vegetation RS and meteorological data

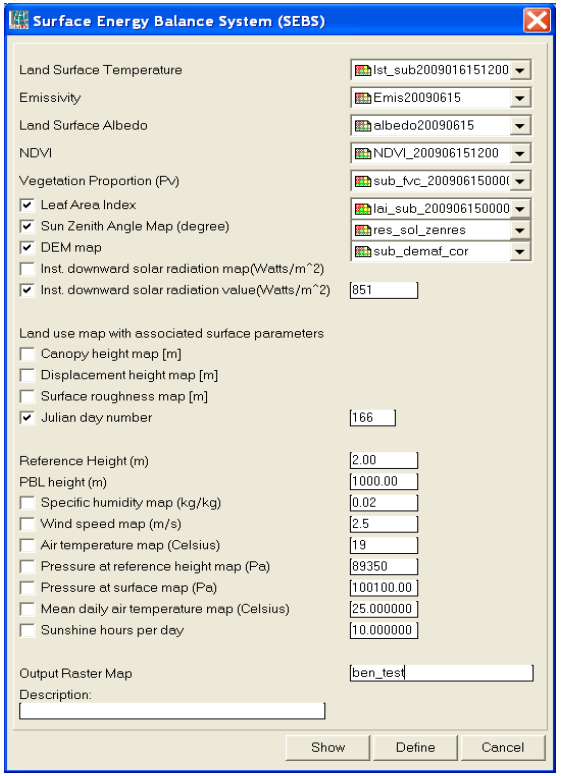


$$R_n = G_0 + H + LE$$

[2] Satellite ET: Monitoring of ET component of water cycle over large areas at med. spatial & high temporal frequency (e.g. 1km, daily to sub-daily)

ET: Evapotranspiration (example below)





Daily ET estimate - Zambezi basin – region using SEBS - SURFACE ENERGY BALANCE SYSTEM – ILWIS Open Plug-in

Ps. most of the EO and *in situ* meteorological data can be obtained from GNC DVB-S, ECMWF server

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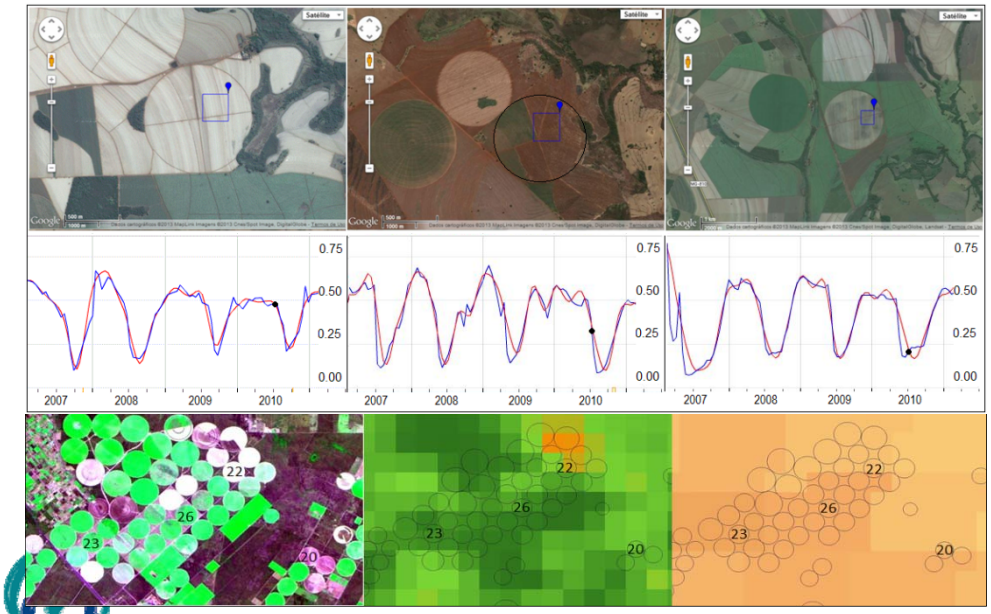
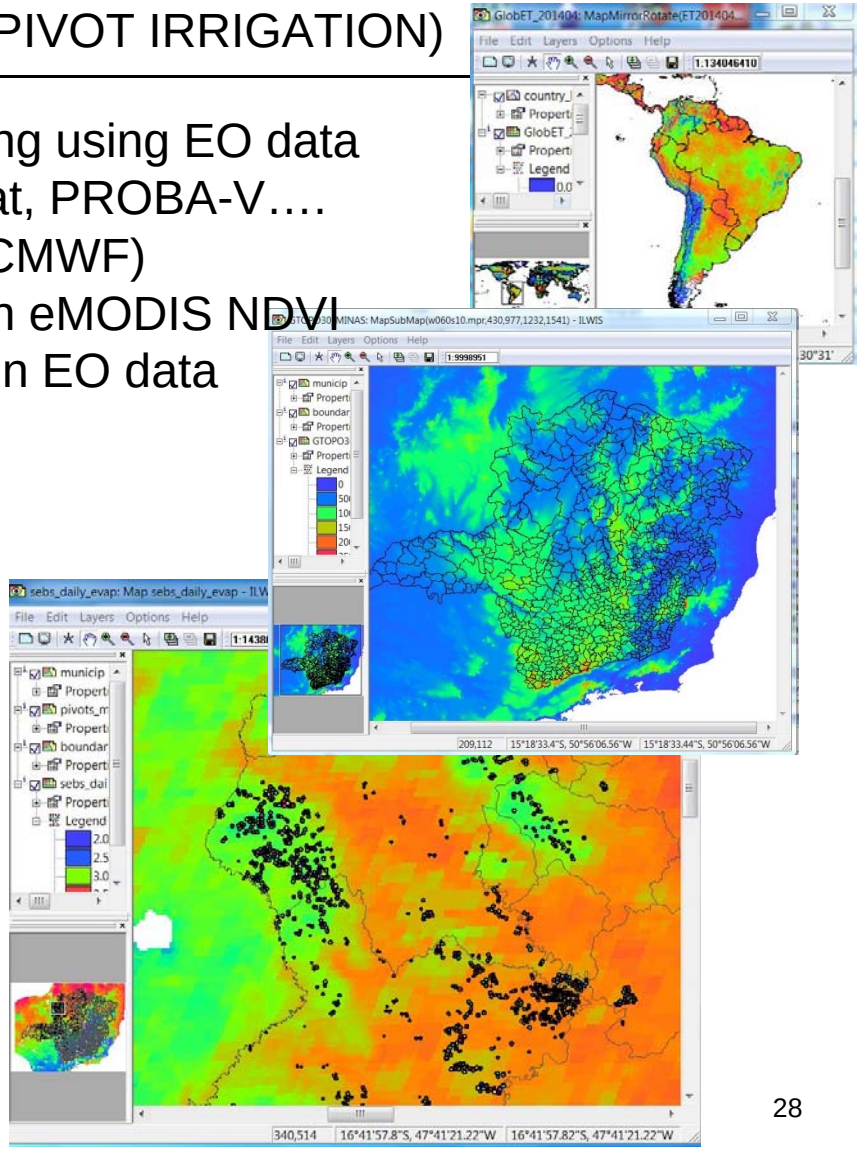
[2C] ET MAPPING IN AGRICULTURE
LAVRAS (BRASIL) EXAMPLE: SUGARCANE
MONITORING SUGARCANE UNDER PIVOT IRRIGATION)

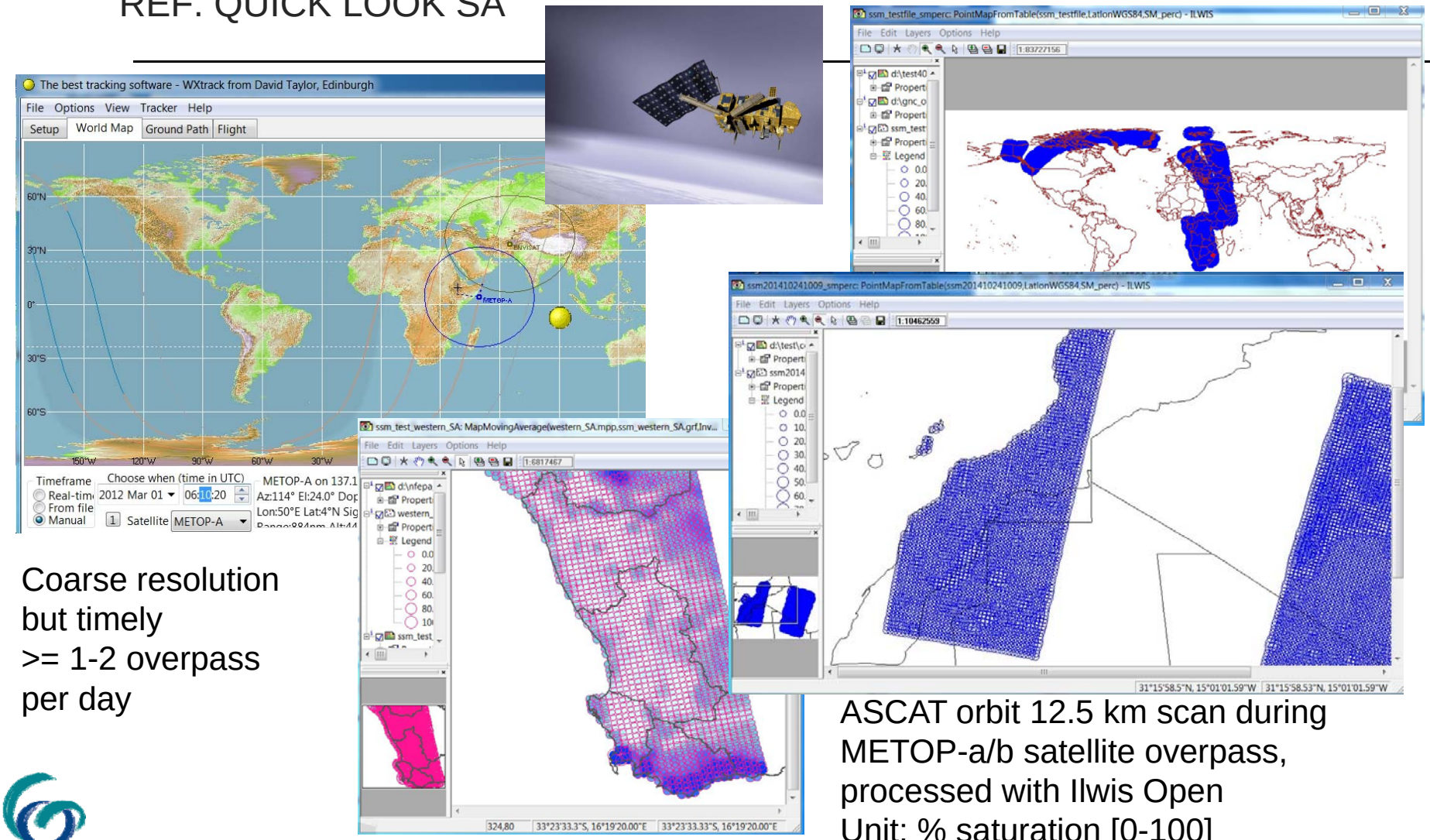
Sugarcane water consumption monitoring using EO data
ET modelling with SEBS; MSG Meteosat, PROBA-V….
Meteorological data (from stations or ECMWF)
Crop growth period and status validation eMODIS NDVI
Ground validation using higher resolution EO data





[3] SOIL MOISTURE ESTIMATES FROM SATELLITES: METOP / ASCAT SURFACE SOIL MOISTURE INDEX

REF. QUICK LOOK SA



Coarse resolution
but timely
>= 1-2 overpass
per day

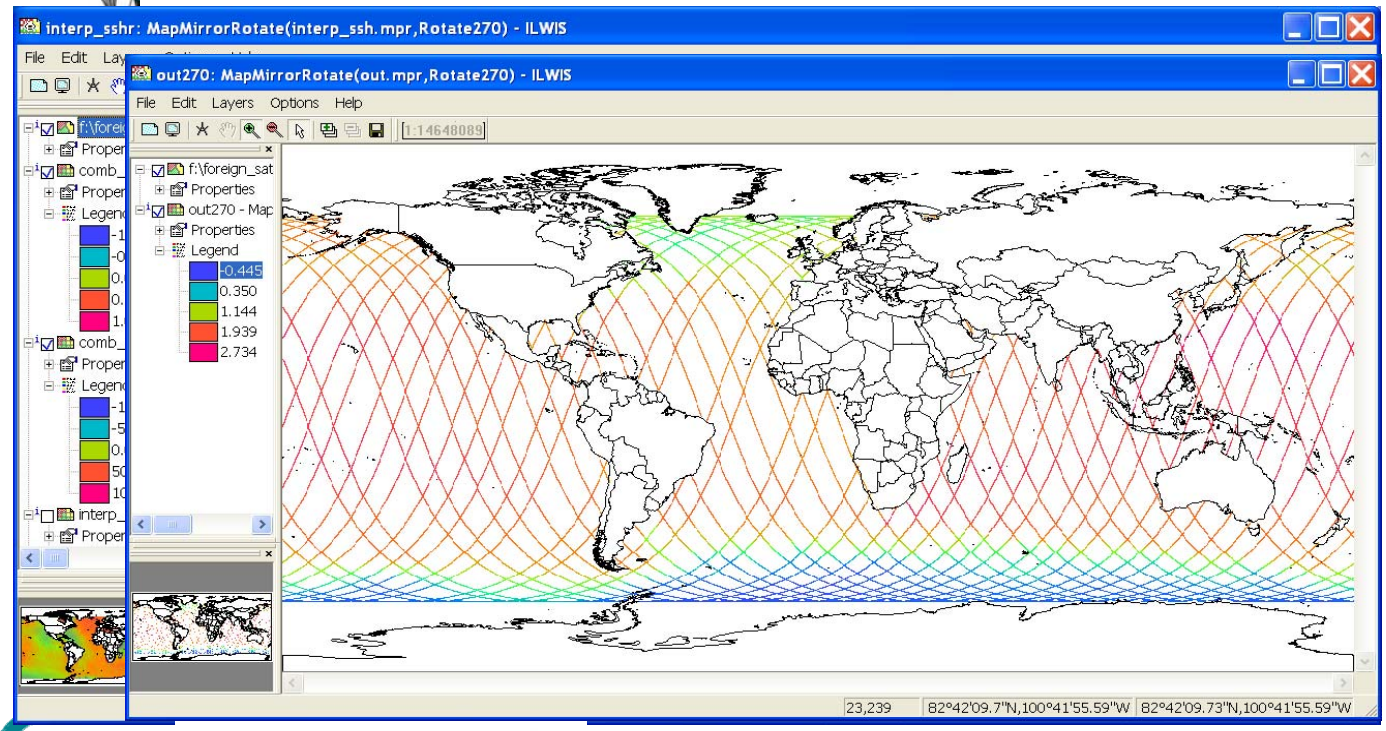
ASCAT orbit 12.5 km scan during METOP-a/b satellite overpass, processed with Ilwis Open
Unit: % saturation [0-100]

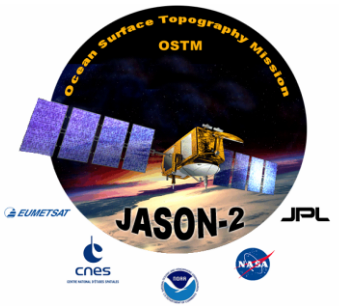
METOP 2011-05-02 1839UTC

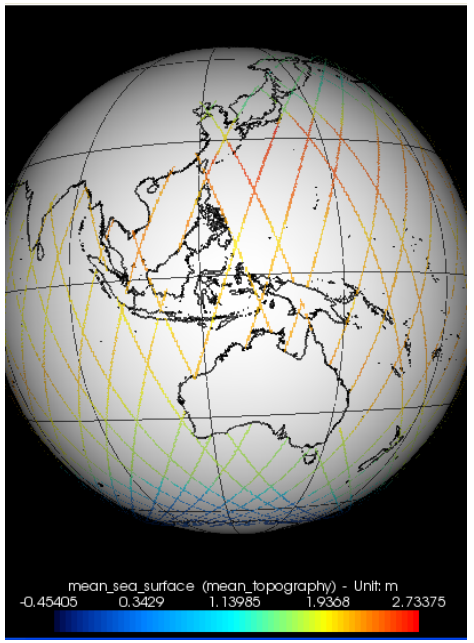
[5] EO of Water levels using radar altimetry example using Jason-2 Satellite altimetry data for SSH (sea surface height) and SLA (sea l. anomalies)

- Altitude = 1336 km, non sun synchronous orbit, inclined 66 degrees, 10 day repeat cycle.

  Jason-2 near real time altimetry products are disseminated by EUMETSAT and NOAA within 3 hours from acquisition, using GEONETCast.







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BRAT BASIC RADAR ALTIMETRY TOOLBOX

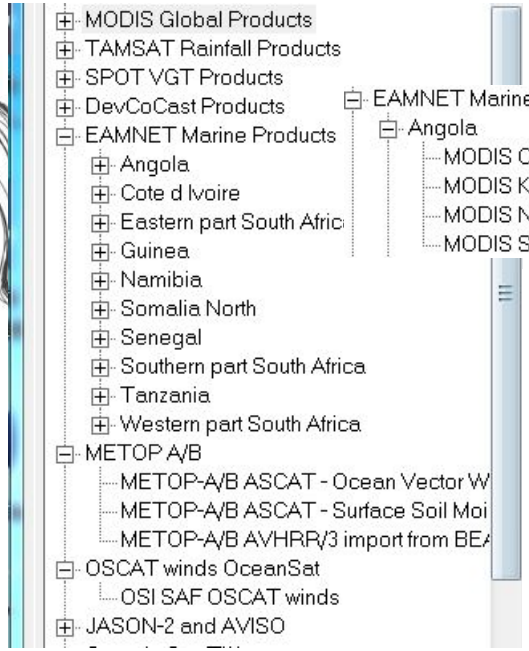
Using BRAT as preprocessor

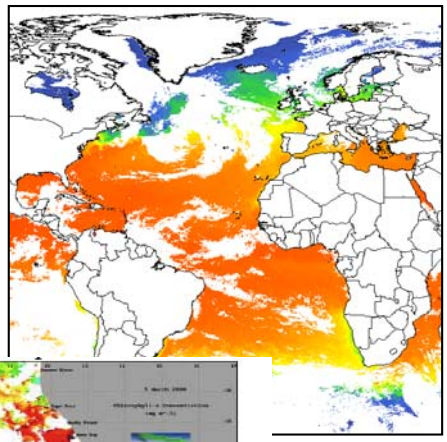
[6A] WATER QUALITY MONITORING USING SATELLITES

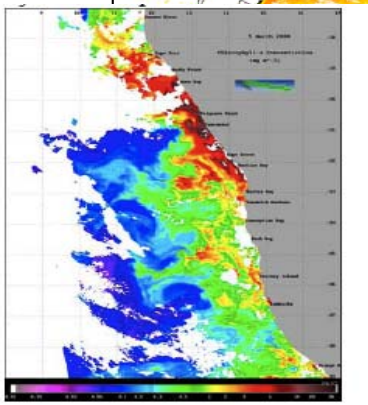
OCEAN, COASTAL AND INLAND WATERS -> FISHERIES

- WQ parameters linked to eutrophication (e.g. algal pigments), sediment flows (turbidity, optical depth), temperature and also water body extend, etc. can be monitored from RS
- Near real Water Quality EO data (mostly from MODIS but also MSG, GOES, METOP) for coastal and marine monitoring are available from GEONETCast

Water Quality on GEONETCast



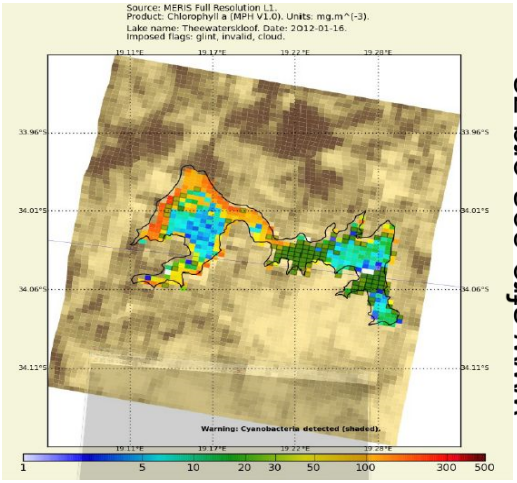




SST from MSG-GOES, METOP,..

Harmful Algal blooms, Namibia

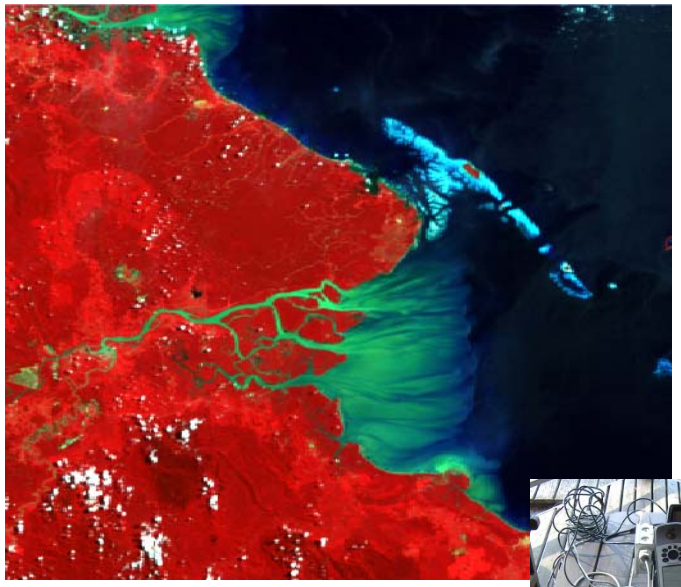
Good results for ***inland Water Quality*** were available with MERIS (on ENVISAT) and future ***ESA Sentinel-2,3***



www.afro-sea.org.za

[6B] EO of water quality and Coastal systems: data acquisition and analysis using Ilwis Open TOOLBOXES

ILWIS Open contains also Toolbox Plug-ins which permits to download near real time Ocean and Coastal Water Quality imagery from MODIS and other sensors (MSG, GOES..)

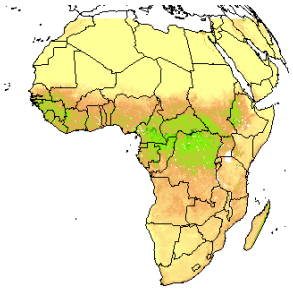


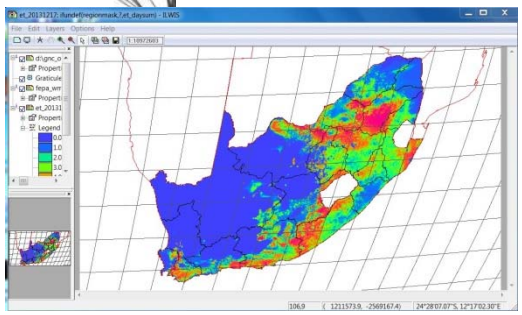
Example © MERIS Full Resolution May 2007 Berau research, East Kalimantan, WOTRO/ITC/WRS research project (ref. Mannaerts - Ambarwulan)

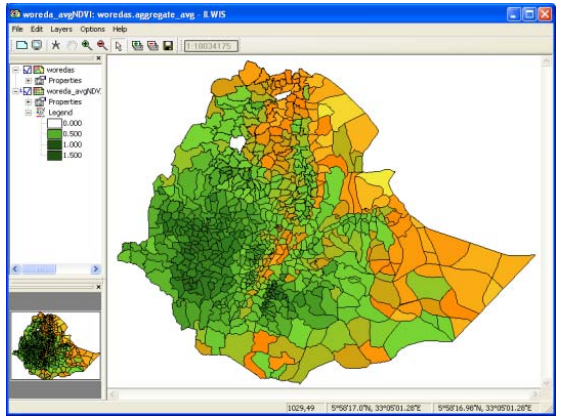
SOME PROJECT CASES QUICK LOOKS OF OPEN TOOLBOXES FOR WATER & FOOD SECURITY

-

- Water & Food Security – Ethiopia Toolbox
  - Assessing numbers of people at risk (UN-WFP 2011-13)
- GIACIS project: GeoData for Innovative Agricultural Credit Insurance Systems (2014-2017)
- AMESD – SADC Toolbox (dedicated to SADC region)







GEONETCAST SERVICES FOR FOOD SECURITY EARLY WARNING - ETHIOPIA

- ITC cooperation with Government of Ethiopia and WFP: Early Warning for Food Security to support their Livelihood Early Assessment & Protection program
- Use of GEONETCast satellite and *in-situ* data reception and analysis systems and GNC Toolbox open source software technologies
- Focus: capacity development (training) & research
- Partners:

GEONETCast
Delivering Environmental Data to Users Worldwide

MOArD/DRMFSS Disaster Risk Management Food Security Sector Agency

NMA | National Meteorological Agency
Federal Democratic Republic of ETHIOPIA

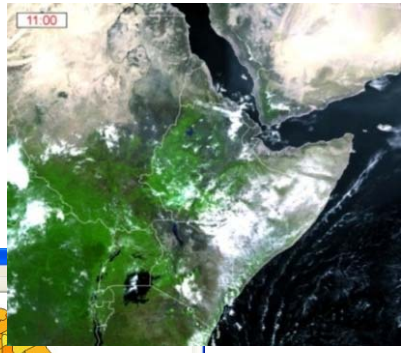
WFP
wfp.org

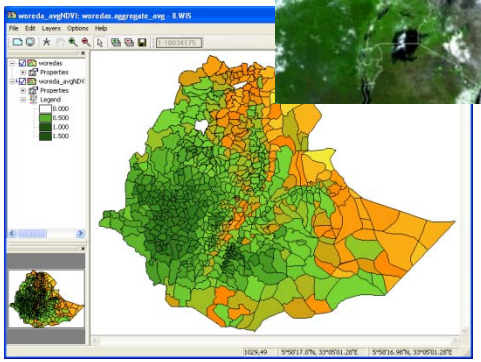
UN World Food Program
Country Office Ethiopia

ITC

Department of Water Resources

Faculty of Geo-Information Science and Earth Observation



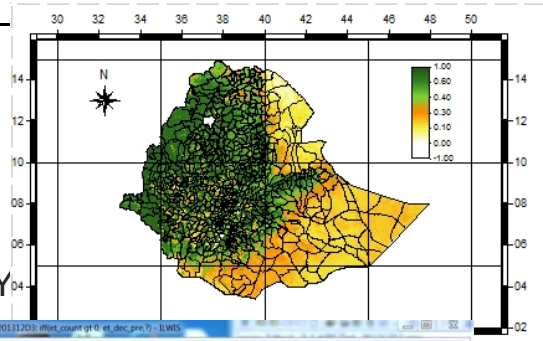


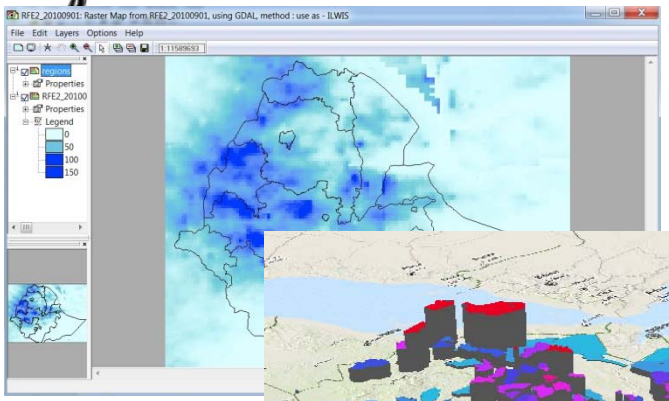
World Food Programme of the United Nations
The World Bank
The Federal Government of Ethiopia
The Livelihoods Integration Unit (LIU) supported by USAID

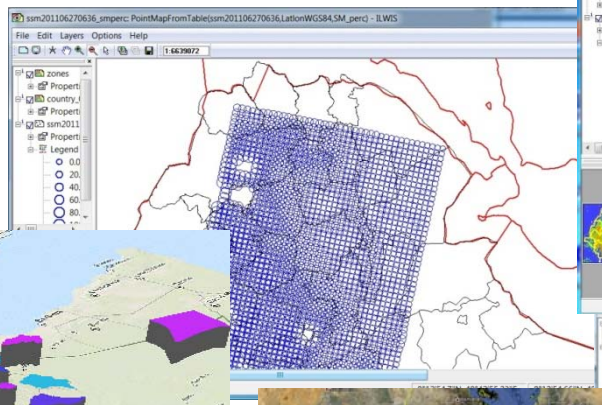
SOME WFS - ETHIOPIA PROJECT OUTPUTS : GEONETCAST & *IN-SITU* DATA FOR FOOD SECURITY EARLY WARNING

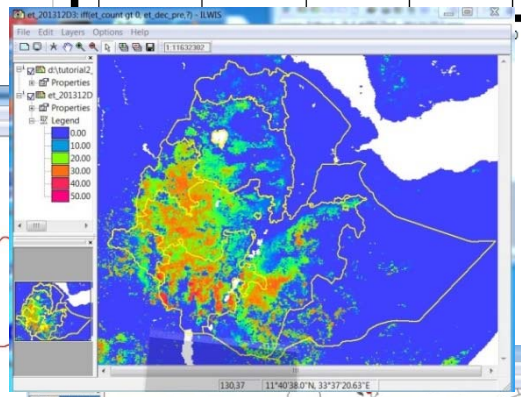
GEONETCAST4WFS PROJECT OUTPUTS (ITC-DRMFSS-NMA-WFP)

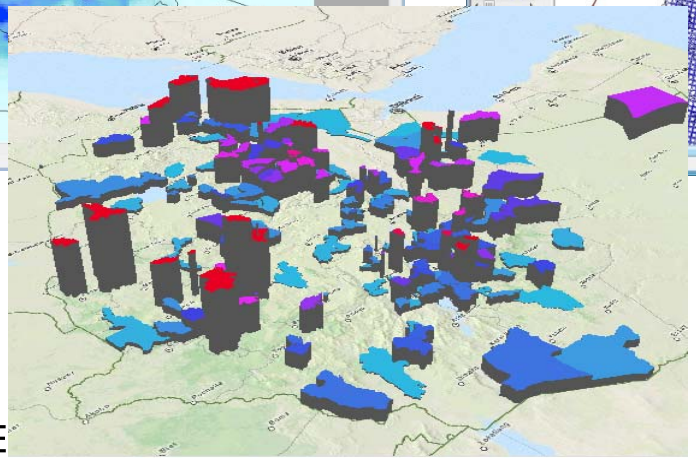
- Satellite rainfall MSGMPE, TAMSAT,
- Surface soil moisture indices e.g. Metop/ASCAT
- actual evapotranspiration estimates (LSA-SAF AET) & in-situ NMA
- vegetation indices (e.g. NDVI SPOTVGT, MSG, FVC)
- To compute crop water requirement WRSI & crop yield reduction (Y
- affected population # early warning at district level scale (LEAP)

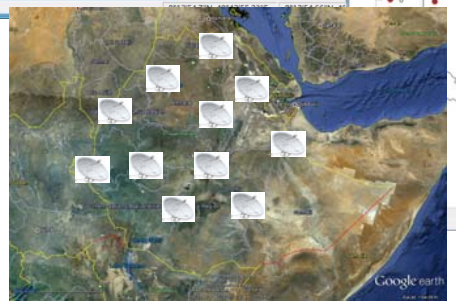


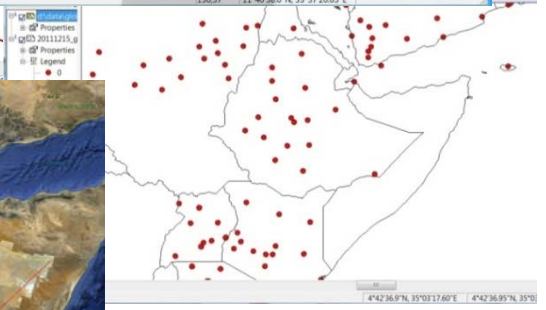








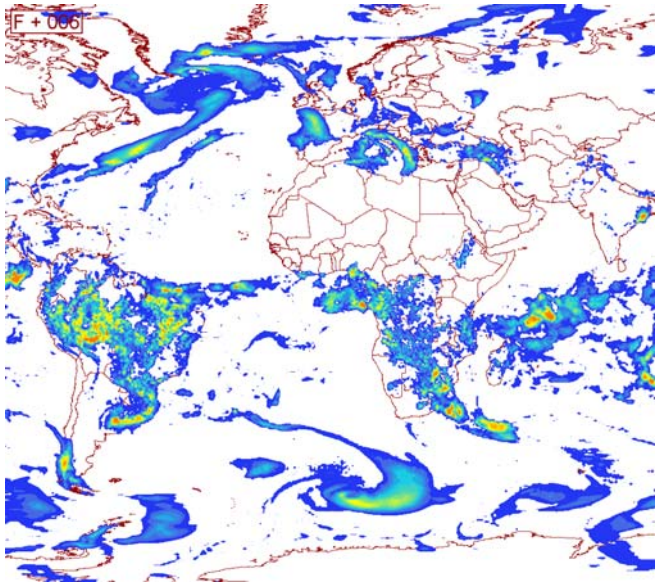


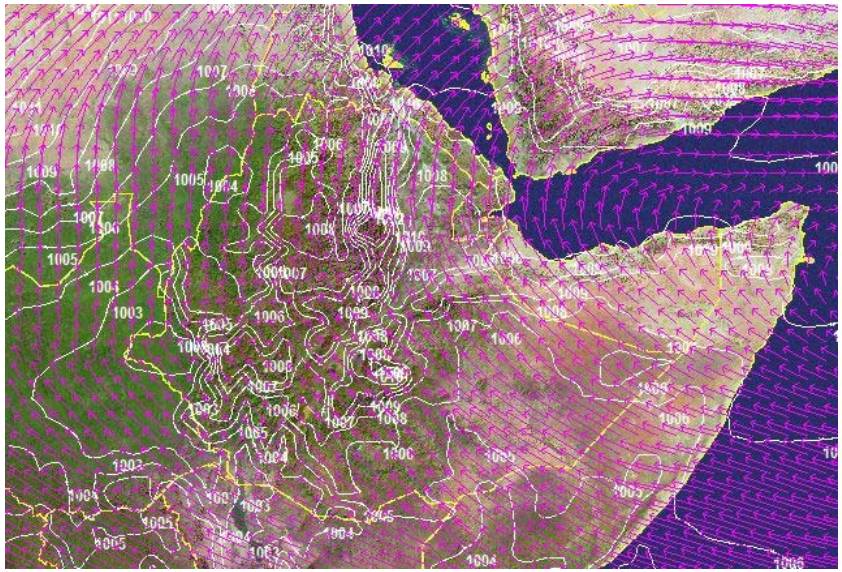


CURRENT DEVELOPMENTS -> GIACIS PROJECT (WITH ETHIOPIA)

GEODATA FOR INNOVATIVE AGRICULTURAL CREDIT INSURANCE SYSTEMS

- Increase weather-based risk and agricultural forecasting capacity (in cooperation with Ethiopian actors (public private p.): NMA, ATA, Kifya Insurance, ITC
- Data readers and visualizations for GEONETCast disseminated GTS forecast data; GFS, FS (Global and Integrated Forecasting Systems (of NOAA/NWS/NCEP, ECMWF, MeteoFrance Arpege, UK MetOffice UMD)
- Development of spatial insurance model (applicable to small holders, farmers)



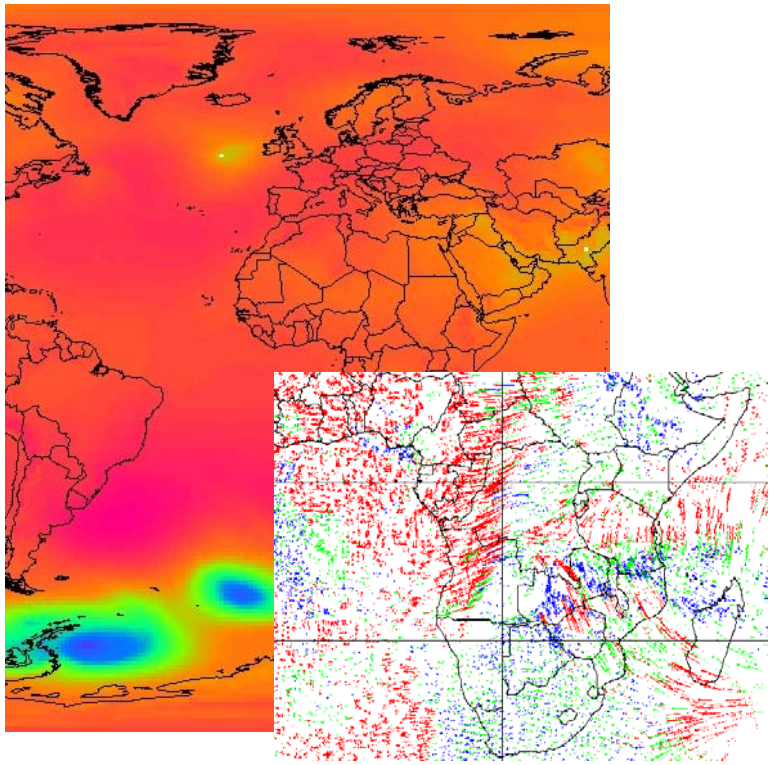


Ps. All made and processed using Ilwis Open

NEW DEVELOPMENTS: METEO SERVICE TOOLS

DEDICATED TOOLS FOR WMO GTS MDD USERS -> FORECASTS

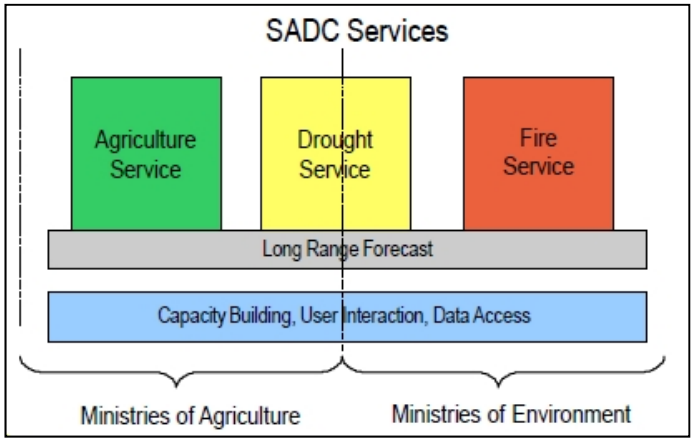
Examples: MDD3 MSL H98 and
wind fields (u,v-vectors) at diff. GP heights



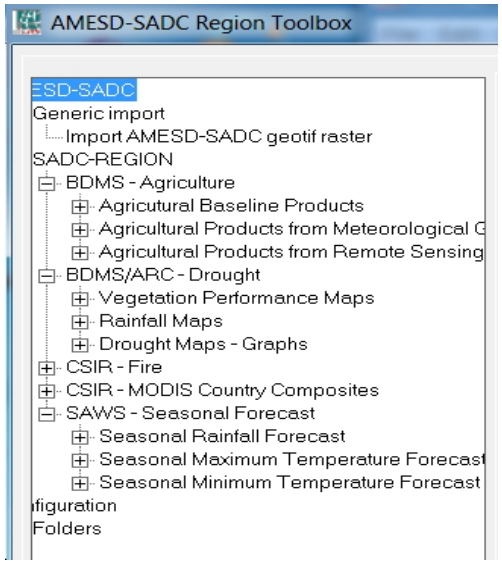
- Dedicated Toolbox for NMHS & agencies
- Full meteorological satellite data stream and products access:
  - MSG-2, MET-7, MET-8 (RSS),
  - Foreign satellites: GOES, MTSAT, FY-2D/E
  - EPS: Metop-A, JASON-2,…
  - MPEF and SAF data and products
- Third party GNC data
  - SPOT-VGT, CPTEC/INPE,…
- GTS – MDD text message and data visualization
  - SYNOPS, METAR, TAF…
  - Imports (Under testing): MDD1,MDD3,…
- 3D visualizations (4D using Ilwis 3.8 update early 2013)

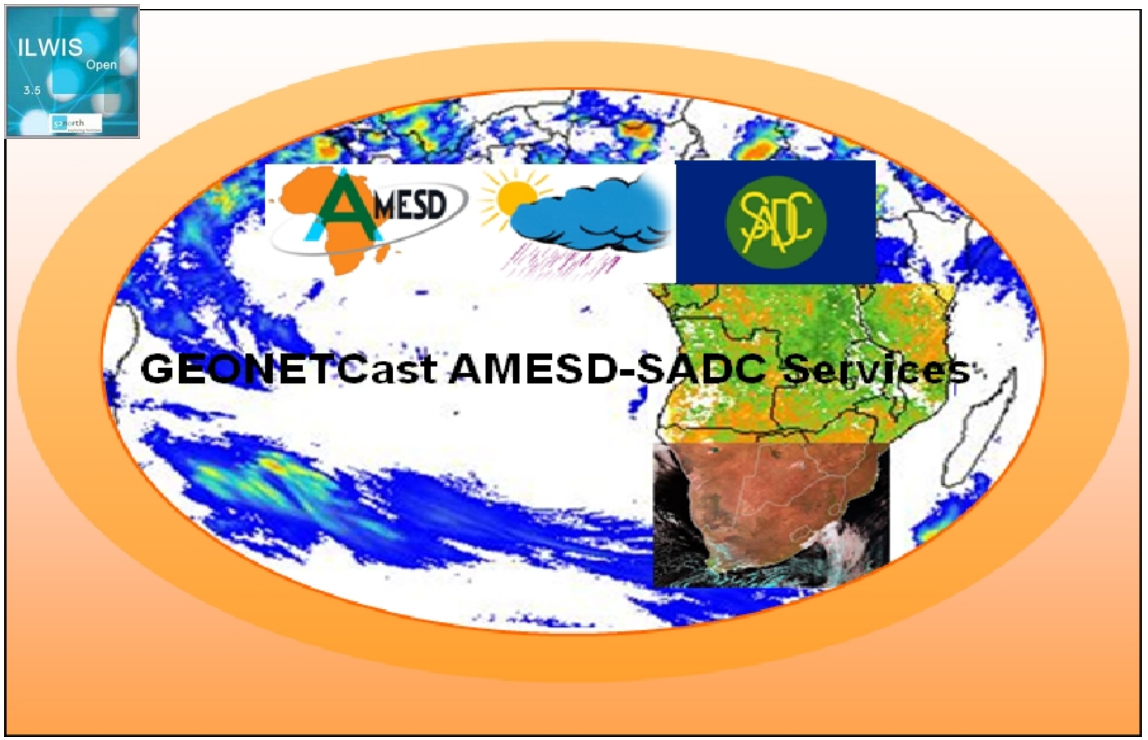
** Used in WFS-Ethiopia project Toolbox by NMA, Ethiopia*

African Monitoring of the Environment for Sustainable Development (AMESD)



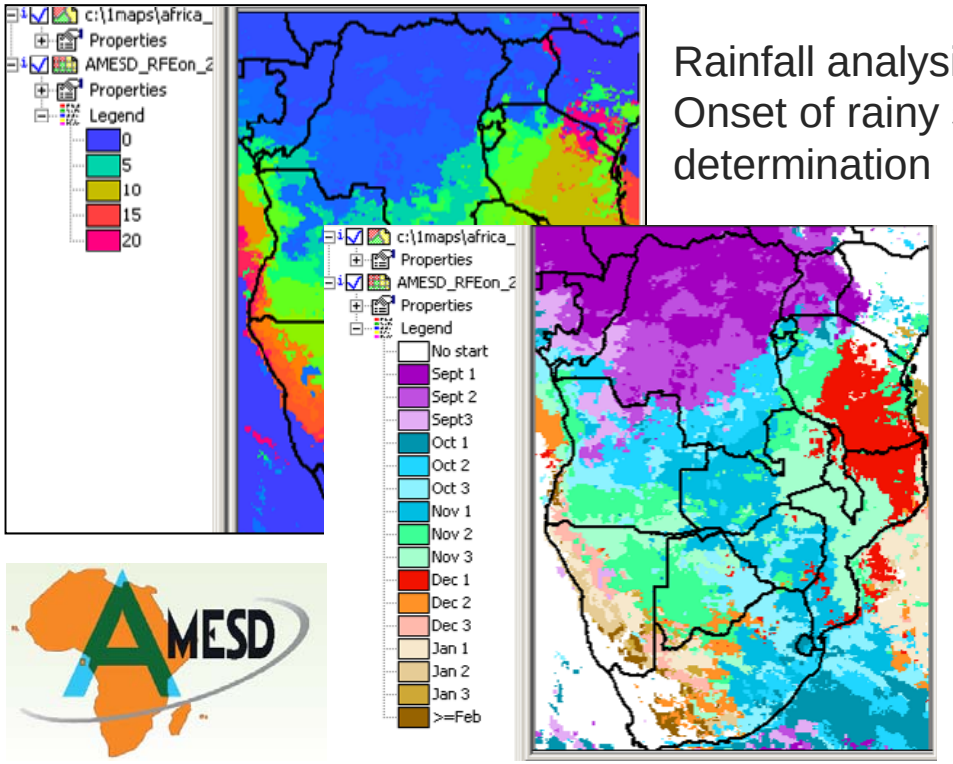
- Dedicated GEONETCast Toolbox for SADC Earth Observation Services in ILWIS Open
- Developed by SADC project & education partners: BDMS, CSIR, ARC, UZ, UB, BCA, ITC
- Data products disseminated via EUMETCast



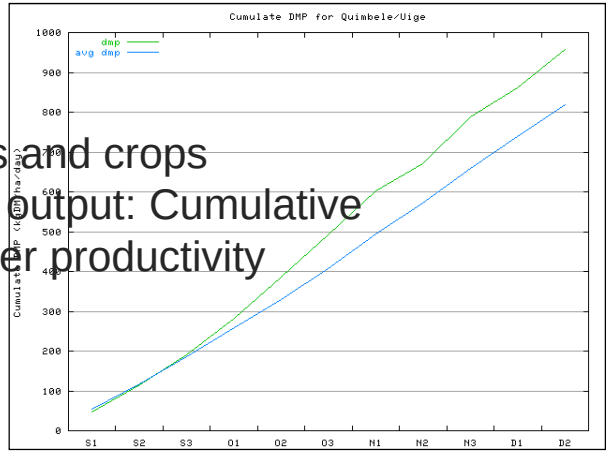


AMESD-SADC GNC TOOLBOX: SNAPSHOTS

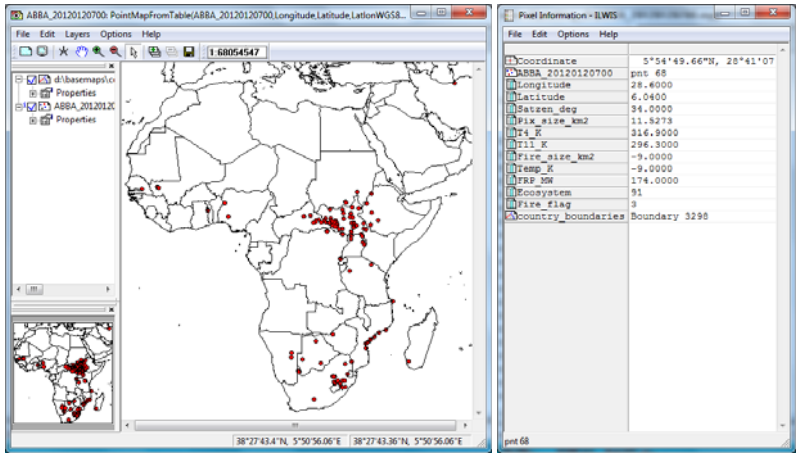
AN ILWIS OPEN V.3.72 PLUG-IN



Rainfall analysis and Onset of rainy season determination



Biomass and crops
Graphic output: Cumulative dry matter productivity



ABBA-MSG fire incidence

Automated Biomass Burning 3-band Algorithm

Training opportunities (in 2013) using Distance Education by our SADC partners UZ, UB & BCA using the ITC digital BB environment

ITC

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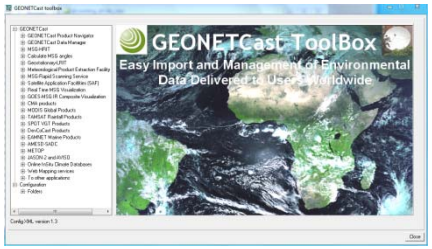
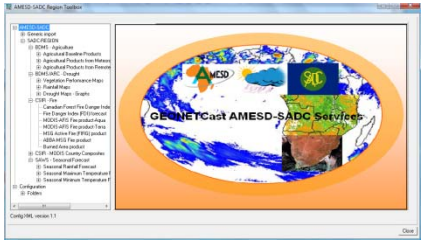
DEVELOP YOUR OWN EARTH OBSERVATORY APPLICATION

OPEN DATA & DESIGN PERMITS TO CREATE YOUR OWN DEDICATED OTB

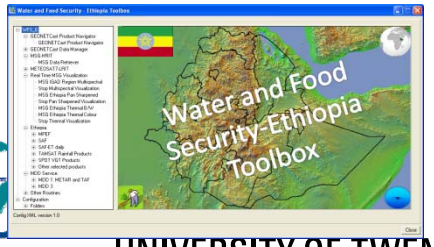


Standard GEONETCast Toolbox v.1.3 -> generic & global application
Import of Geostationary Constellation: MSG-1,2, MET-7, GOES-E/W, FY-2D/E, MTSAT
Import of Polar Orbiting satellites: EPS/METOP-a, NOAA -series, JASON-2,..
EUMETSAT MPEF and Satellite Application Facilities (SAF) data e.g. LSA-SAF
3th party Data: NOAA, CMA , INPE-CPTEC, MODIS products, SPOT Vegetation, DevCoCast
Real time MSG visualization. calculation of solar and MSG zenith and azimuth angles,…

In-situ & Online Data Toolbox v.1.0 -> generic & global data
Direct import of data from *internet* online archives related to *in-situ* climatological observations, gauge and satellite derived rainfall estimates, weather forecasts, normalized difference vegetation indices and elevation information. Examples: GSOD, GLDAS, ERA-I, GPR, CMORPH, FEWSNET,..



AMESD SADC project Toolbox -> regional Southern African countries
Import and pre-processing of all products disseminated by the AMESD-SADC program related to agriculture, drought, fire and long range forecasting.
Developed together with AMESD-SADC Regional Implementation Centre, Botswana Department of Meteorological Services (BDMS).

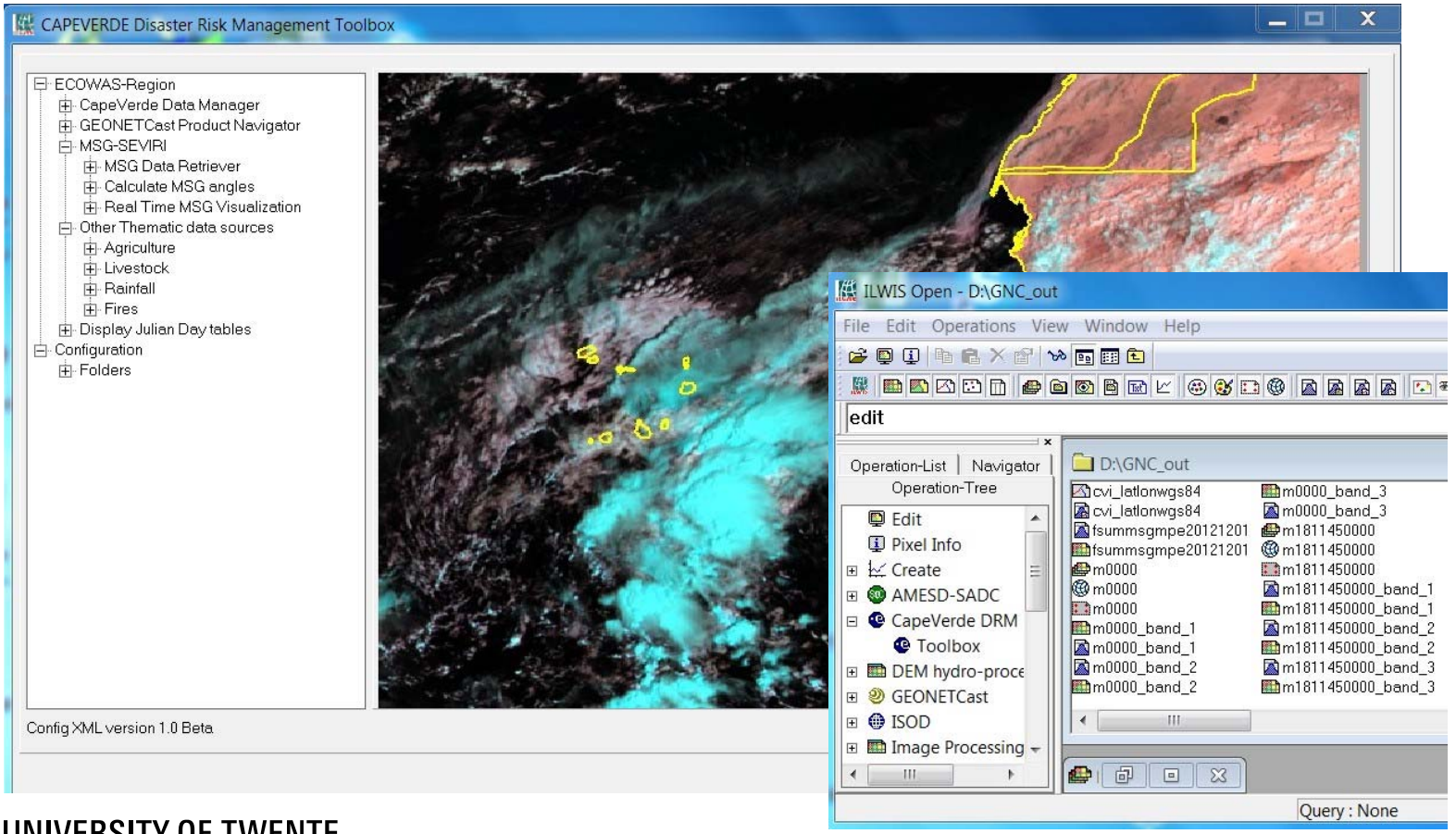


Early Warning for Water & Food Security -> project Toolbox for country
Import and processing of data from GEONETCast for water and food security monitoring in Ethiopia, like MPEF, SAF, VGT, TAMSAT and fire products, real time visualization, surface soil moisture and WMO GTS MDD service. Developed together with National Meteorological Agency, Ministry of Agriculture and UN-WFP Ethiopia.

PROPOSAL: EARLY WARNING DATA ACQUISITION FOR DISASTER RISK MANAGEMENT TOOLBOX - CABO VERDE

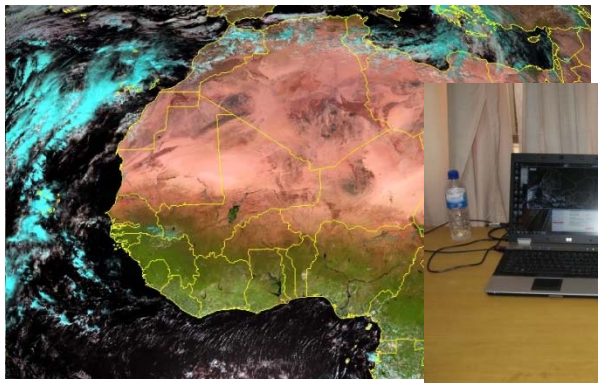
MADE JOINTLY BY CABOVERDE - ITC

Uses open source plug-in concept in ILWIS software…



CONCLUDING REMARKS (1): ROAD AHEAD

- The GEONETCast data dissemination system (backbone meteorological satellite constellation and data) contains and can provide important geo-information for weather and climate monitoring & early warning
- Weather, hydrological and agriculture related satellite data are available
- Fast and open access to satellite and *in-situ* data, combined with Open Source Tools foster rapid uptake of remote sensing concepts and design of own satellite applications for climate information provision to the public
- Fast development of human resources and capacities and more knowledge & ownership of early warning for disaster risk management instruments

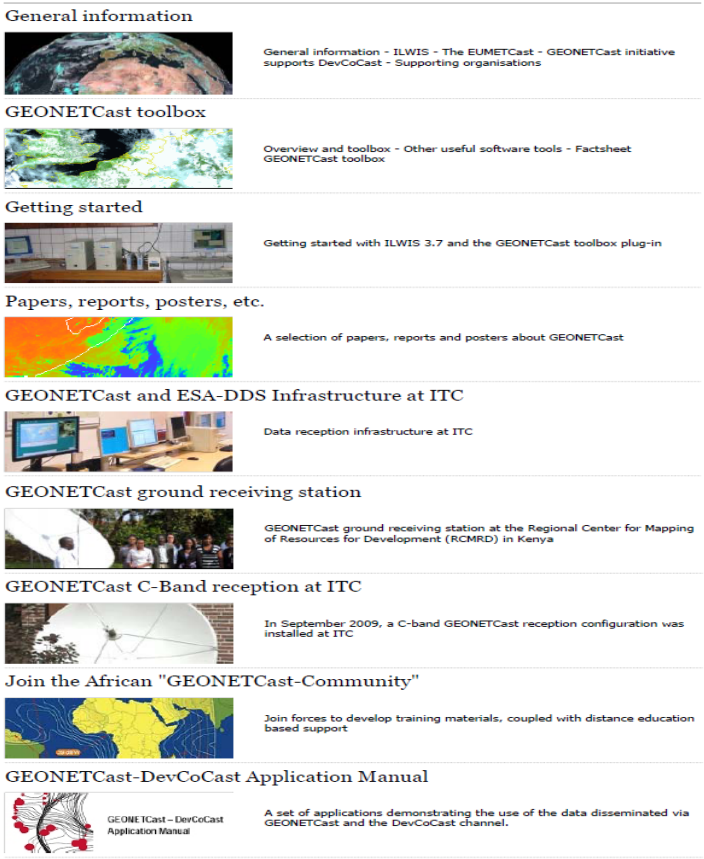


OPEN ACCESS to our OTB (OS TOOLBOXES) Capacity Development & Research @

- **Software portal**: @ 52NORTH (OS consortium partner)
  - Software to handle and process the EUMETCast and GEONETCast data received is freely available through the ***Earth Observation*** **Community** @ (**http://52north.org**).
- **Capacity development portal**: @ ITC
  - Further information, hands on exercises, sample data

  http://www.itc.nl/Pub/WRS/WRS-GEONETCast)
- Registered components of **GEO**

  -> GEOSS Common Infrastructure



UNIVERSITY OF TWENTE.

Thank you and for further information, contact us @ www.itc.nl or UTwente

The ITC GEOSS – GEONETCast team

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ITC FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION