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Use of GEONETCast for Water and Food Security Analysis in Africa

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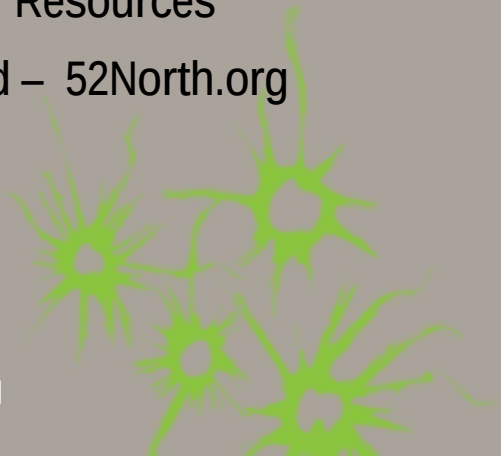


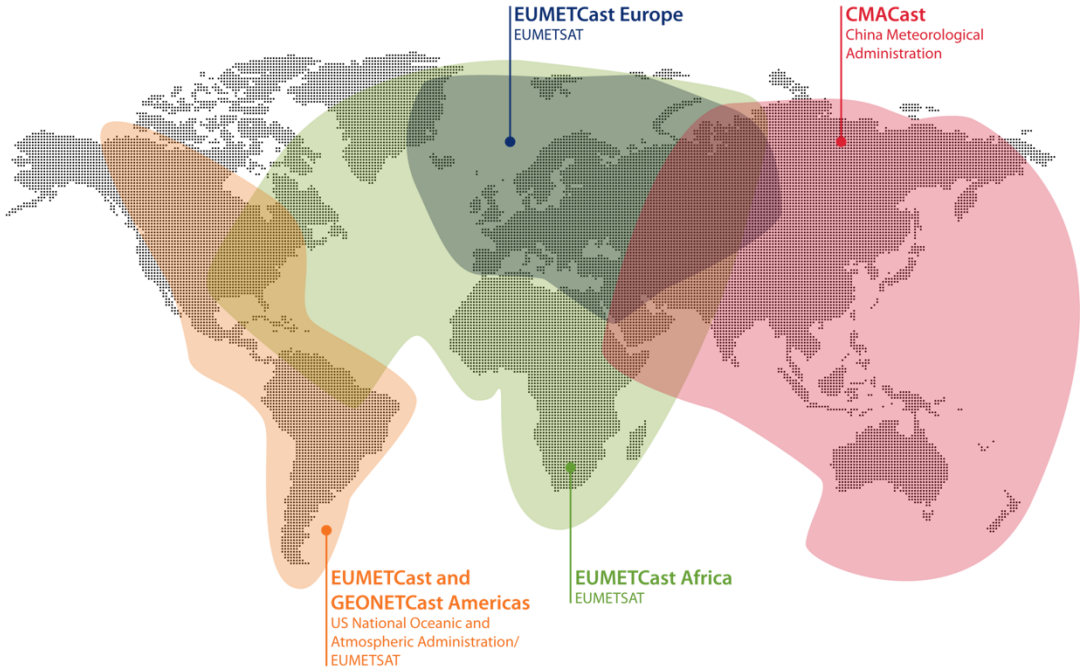
ITC FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

What is needed for effective use of environmental data for Water and Food Security Analysis in Africa?

- Free access to real-time and time series ***data*** -> GEONETCast - Internet
- Free access to ***tools*** -> freeware and open source software
- Linking ***in situ*** *and* ***satellite observations*** and development of tailor made applications through (collaborative) research

Free access to data: GEONETCast

GEONETCast 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



Data Dissemination Systems

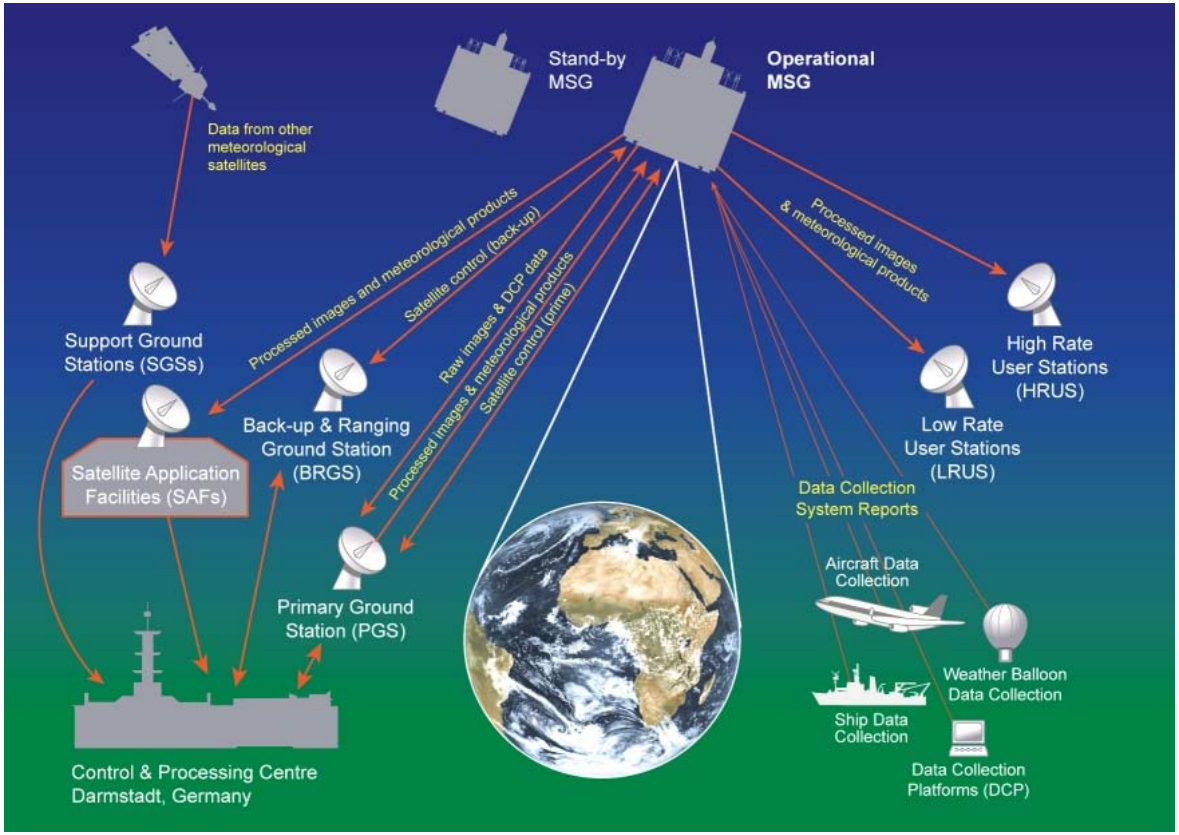
- Large amounts of (near real-time) environmental related information is currently operationally disseminated and can be received without internet connection using GEONETCast;
- Telecommunication based Data Dissemination Systems are new in many parts of the world, especially outside the Meteorological Community;
- A ground receiving station can be established using low cost and off-the-shelf equipment.

NOTE:

- Large number of complementary data resources available for free on internet, especially time series.

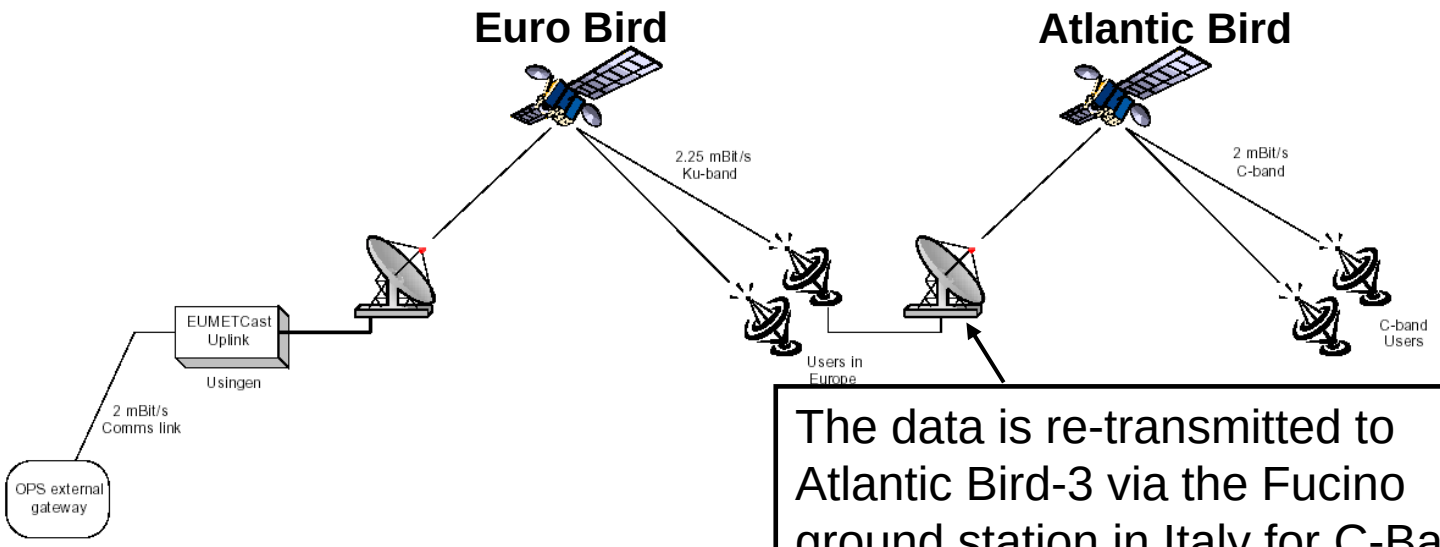
GEONETCast in Europe-Africa

Near real-time satellite image reception using a communication satellite based data distribution system, example MSG



GEONETCast in Europe-Africa

After central ground processing at EUMETSAT, images in full resolution are transmitted in HRIT mode, within five minutes of observation….

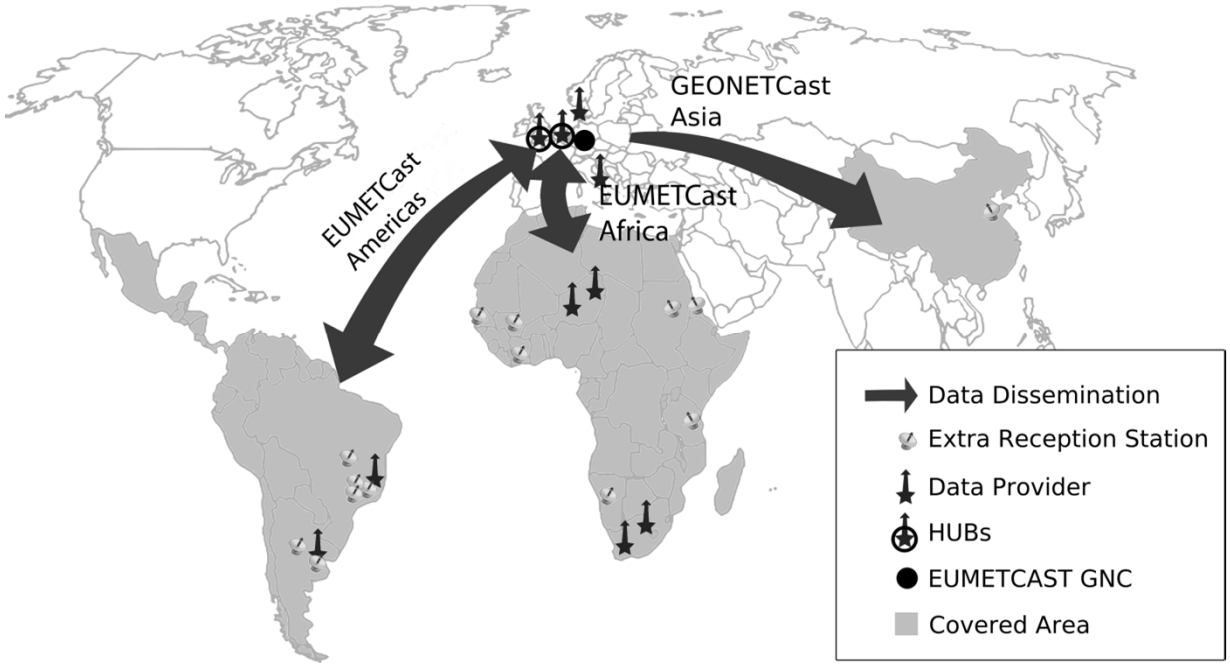


The data is re-transmitted to Atlantic Bird-3 via the Fucino ground station in Italy for C-Band reception for African Users

Before the signal is received at a local ground receiving station it has traveled from MSG -> Darmstadt -> Usingen -> Eurobird-9 -> Fucino -> AtlanticBird-3 -> Local Station (approximate distance is 5 * 36.000 km!!)

Using products and data generated by various organizations

- Data produced by various organizations in Africa and Latin America is also broadcasted and can be received locally.

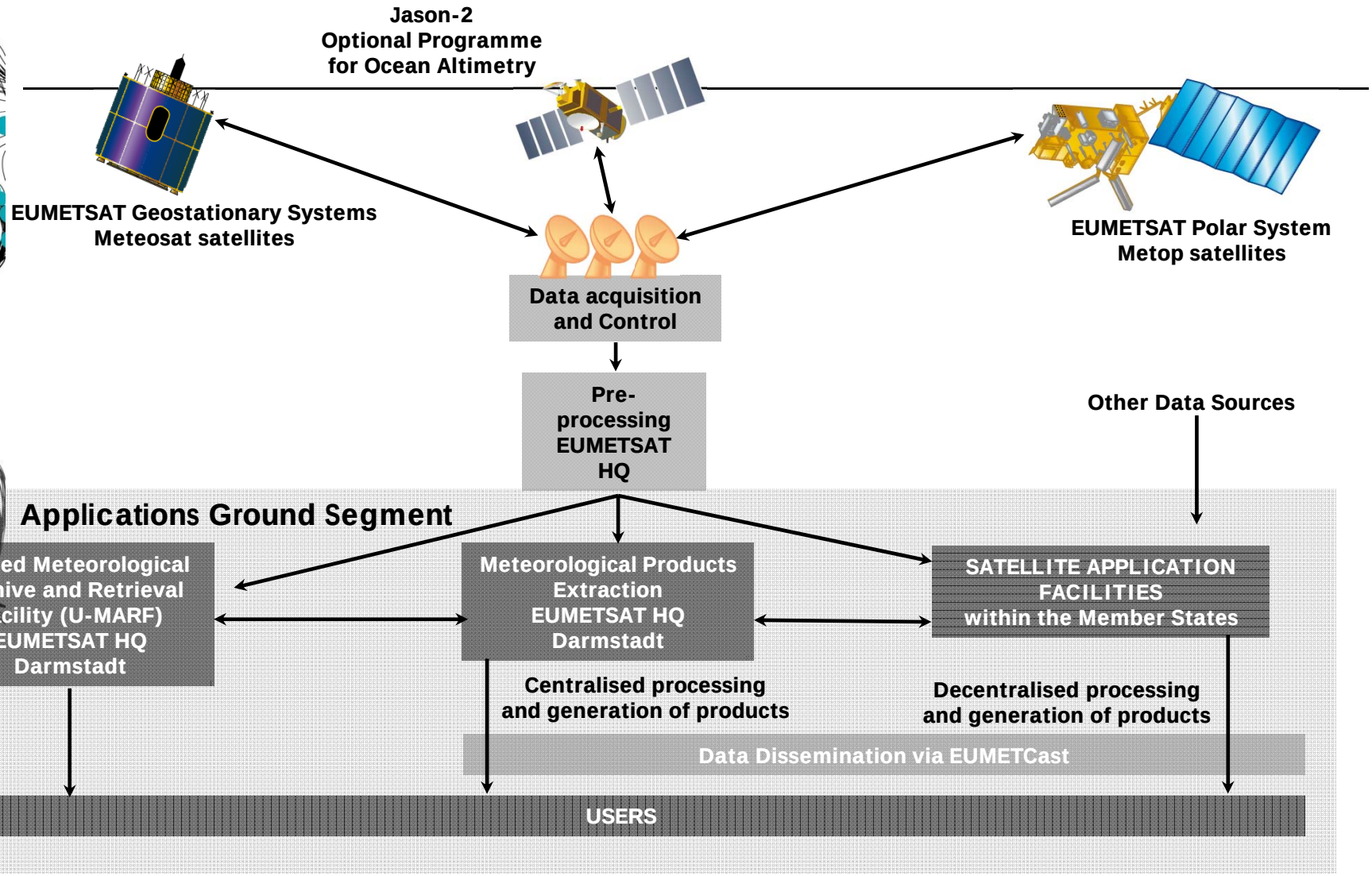


Land hub at VITO and Ocean hub at PML

Key player: EUMETSAT

- Data and Services provided by EUMETSAT (The European Organisation for Exploitation of Meteorological Satellites): Meteosat, Metop & Jason
- Goal: Maintain continuity and develop the operational meteorological and climate data services with adequate satellite and ground infrastructure, and associated user services

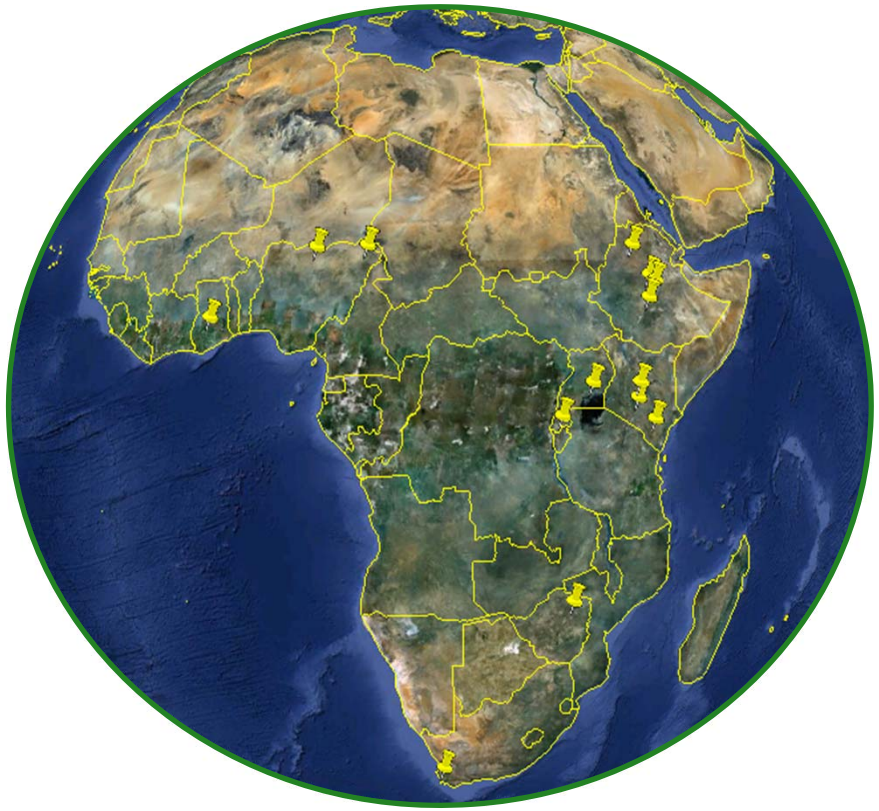
Overview of the EUMETSAT Ground Segment



Low Cost Ground Reception systems

- Keywords:
  - Not only GEONETCast Ku-reception over Europe;
  - Also GEONETCast reception over Africa (C-Band);
  - New reception room developed to offer dedicated training on use of ground reception infrastructure hard - and software;
  - Check new services and develop new routines for relevant data sets;
  - Update "*DataManager*" configuration files for automated storage of (newly arrived) data in structured manner;
  - Registered 52North as software developer at EUMETSAT.

Low cost ground reception infrastructure in place at Universities in sub Sahara Africa using utilities developed (mainly self financed)



More through projects, like EAMNET (Ghana, Namibia, Senegal and Tanzania)

Low cost ground reception infrastructure to be put place in Ethiopia together with NMA - WFP

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National Meteorological Agency of Ethiopia (NMA) is going to equip all regional branch offices

Low cost ground reception systems in Africa

Some of the antenna configuration at various locations in Africa

Satellite Dish installed at Makarere University, Kampala, Uganda

Satellite Dish installed at CGIS-NUR, Butare, Rwanda

Satellite Dish installed at RCMRD, Nairobi, Kenya

Low cost ground reception systems

Temporary setup at Africa-GIS conference in 2009

Ground reception infrastructure @ ITC

Both Ku and C band frequency GEONETCast reception using:

- Science and Education license
- Manufacturer license

Also C-Band reception @ ITC

The ground reception infrastructure facilities at ITC

Ground receiving station used during "Open Days"

- "*Experiment in het Bos" – September 2011*

- Configuration can be used during field campaign!

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Opportunities of the Low-Cost Satellite Image Reception Station

Abeyou Wale, Essayas Kaba, Daniel Fuka, Ben Maathuis, Chris Mannaerts & Tammo Steenhuis

Introduction

In many countries throughout the world, the use of earth observation data for environmental or societal purposes still remains underexplored, in spite increasing earth observation (EO) data provision but sustainable development requires coordinated, comprehensive and sustained Earth observations for early warning and for effective decision making.
In March 2011, in collaboration with Tana Sub-Basin Office and ITC, the Netherlands (the GEONETCast Strategic Initiative) a low-cost GEONETCast satellite image reception station is established at Bahir Dar University (BDU).

Objective

The main objective of this poster is to describe the components and the opportunities of the established reception station, and in addition the received satellite image will be processed to see the spatial and temporal relationships of Normalized Difference Vegetation Index (NDVI) versus areal rainfall and Land Surface Temperature (LST) versus Evapotranspiration (ET) for the Lake Tana Basin.

Study area description

The study area, Lake Tana is the source of the Blue Nile River and has a total drainage area of approximately 15,000 km^2, of which the lake covers 3,060 km^2 at elevation 1,786 m amsl.

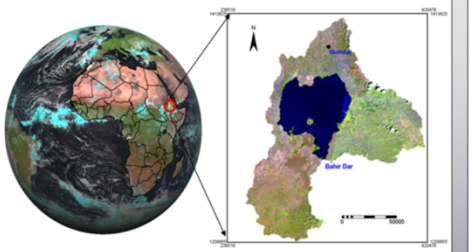


Figure- 1: Location of Lake Tana Basin north-west highlands of Ethiopia
(Left side first MSG satellite image received March 12, 2011 at 09:35 UTC and right Landsat 7 ETM+ satellite image of September 12, 1999)

Figure- 2: Hardware components of the reception station at BDU

System overview and opportunities

System overview

For Africa, the EUMETSAT AtlanticBird-3 carries the dissemination service. The reception station at Bahir Dar University comprises of a standard PC with Digital Video Broadcast (DVB) card inserted and C-band LNB, 2.4 meter diameter parabolic dish antenna. The reception station is fitted, next to the TechniSat SkyStar-2 DVB board, with Tellicast Client Software and the USB EUMETSAT Key Unit (EKU).

DVB card configuration software

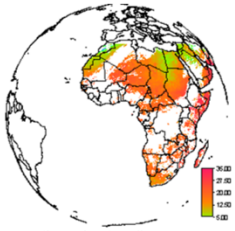
GEONETCast Toolbox plug-in for ILWIS

Opportunities of the reception station

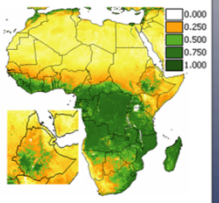
Some of the raw satellite images and processed products received by the GEONETCast ground reception station includes:
Meteosat Second Generation (MSG): Raw unprocessed data received every 15 minutes in 12 spectral bands from visible to infrared channel. All of them have a spatial resolution of 3 km except the high resolution visible which has 1 km resolution.
Satellite Application Facilities (SAFs): The LANDSAF disseminates high-quality geo- and bio-physical products :

Table 1: List of products available from LSA-SAF

SAF products	Spatial Resolution (km)
Albedo (1 per day)	3
Down-welling Short-wave and Long-wave Radiation (0.5 hr)	3
Land Surface Temperature (LST) (0.25 hr)	3
Fraction Vegetation Cover (FVC) (1 per day)	3
Leaf Area Index (LAI) (1 per day)	3
Evapotranspiration (ET) (0.5 hr)	3



Land Surface Temperature LST 2011/03/15 08:00 UTC



SPOT-VGT Normalized Difference Vegetation Index

Meteorological Product Extraction Facility (MPEF): is part of the MSG ground segment; its primary function is disseminating Meteorological Products:

Table-2: List of products available through MPEF

MPEF products	Spatial Resolution (km)
Atmospheric Motion Vectors (AMV) (1 hr)	BUFR file
Cloud Analysis Image (CLAI) (3 hr)	9
Cloud Mask (CLM) (0.25 hr)	3
Cloud Top Height (CTH) (1 hr)	9
Active Fire Monitoring (FIR) (0.25 hr)	Ascii table
Global Instability Index (GII) (0.25 hr)	BUFR file
Precipitation Estimate (MPE) (0.25 hr)	3
Clear Sky Radiance (CSR) (1 hr)	BUFR file
Tropospheric Humidity (TH) (3 hr)	BUFR file
Total Ozone (TOZ) (1 hr)	BUFR file

VGT4Africa: distributes vegetation data to Africa through EUMETCast every 10 day interval with 1 km spatial resolution. Some of the products available from VGT4Africa include Normalized Difference Vegetation Index (NDVI), Albedo (ALBQ), Fraction of surface covered by vegetation (FCOVER), Leaf Area Index (LAI), Normalized Difference Water Index (NDWI) and Vegetation Productivity Index (VPI).

Methodology

The spatial and temporal relationship between vegetation density and rainfall across Lake Tana Basin is captured by the decadal NDVI map collected from VGT4Africa for the year 2005, and daily rainfall data collected from six nearby stations for the same period.

The temporal relationship between LST and ET over the Lake Tana Basin is captured using SAF-data, archived by the reception station at hourly interval for March 15, 2011.

Result

The decadal NDVI map archived from VGT4Africa is aggregated to monthly NDVI using ILWIS software. The monthly areal rainfall of Lake Tana Basin is estimated by Thiessen polygon method using Bahir Dar, Gondar, Dangla, Addis Zemen, Enfranze and Debre Tabor stations. The result indicated a maximum NDVI in September (0.63) and minimum in April (0.23) and maximum and minimum rainfall of 392 mm and zero in July and December respectively for the study period.

Figure- 3: Rainfall Thiessen polygon map of the basin

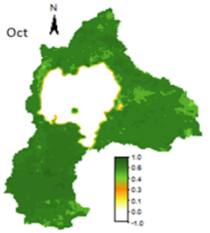
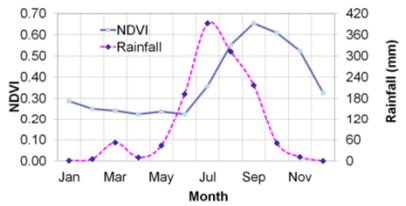
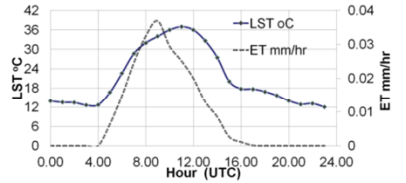


Figure- 3: NDVI map of Lake Tana Oct/2005



The correlation of areal monthly NDVI and rainfall on Lake Tana Basin for year 2005 is poor around 0.1, the analysis showed that for the study period NDVI responded slowly to precipitation by almost two month lag time. Satellite derived precipitation estimate, as provided by the MPE product, should be further explored.

Hourly LST and ET archived from the LSA-SAF for March 15, 2010 through the reception station was analyzed using the ILWIS software.



The analysis shows that, ET and LST are maximum at 9:00 UTC and 11:00 UTC respectively which a lag time of approximately two hours and they have a correlation of 0.8.

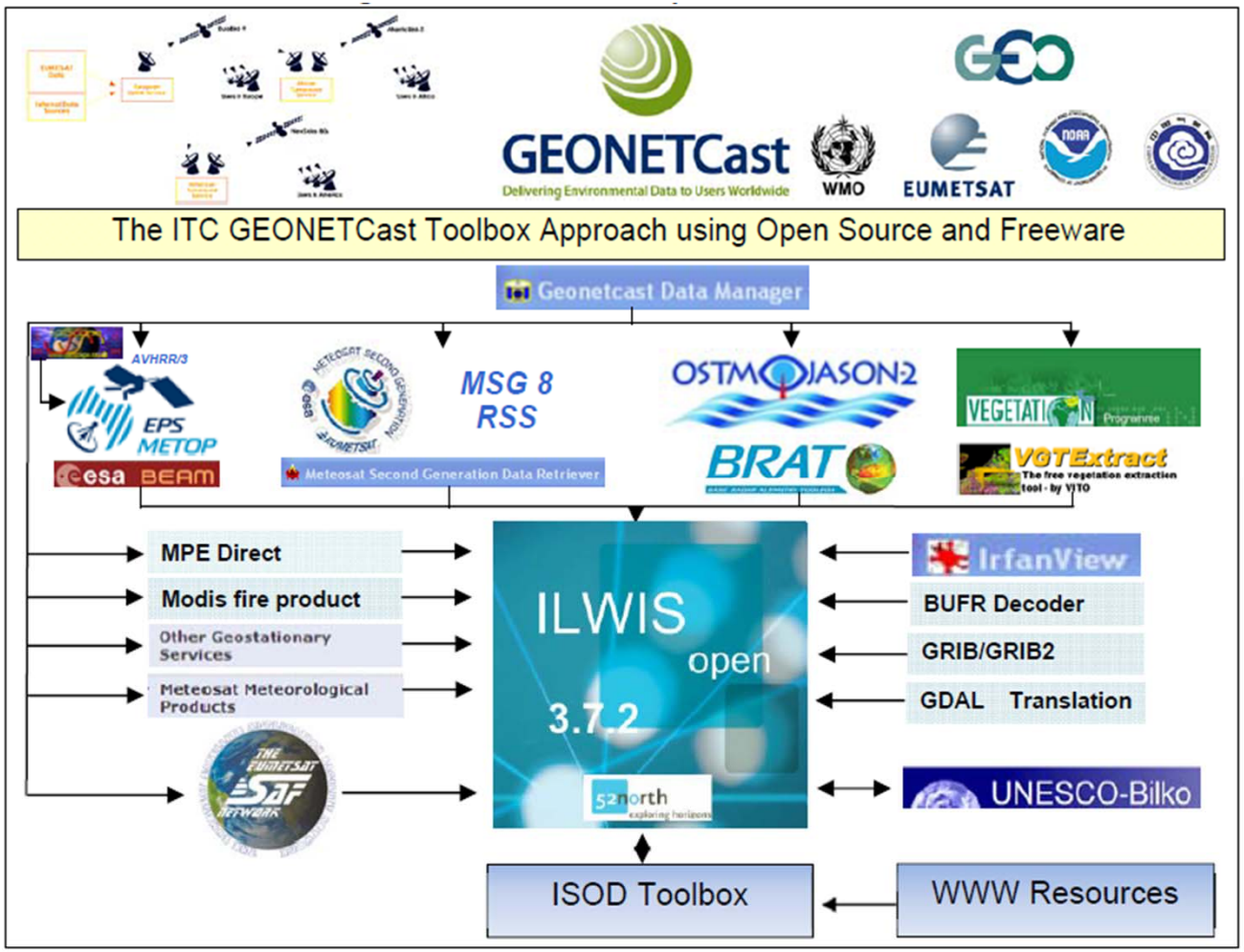
Conclusion

The low-cost GEONETCast ground reception system established at the Bahir Dar University, insures that with a minimum cost the possibility of collecting time series data's relevant for environmental, hydrological and meteorological monitoring. This archived data can be utilized for further research to obtain a better insight in the changing conditions of the environment and to assist the policy making process.

Development of software

- Keywords:
  - Open source / freely available;
  - Easy to modify by user (no need for programming skills);
  - Built on existing ILWIS capability, enhance and add to functionality of ILWIS;
  - There is more than GEONETCast:
    - METOP S10
    - Culture MERIS !
    - GEOLAND (2)
    - A lot of free environmental internet data resources;
  - Use of existing networks for provision / dissemination of utilities (52North) but through the "*EO-Community*";

GNC data in a common GIS/RS environment - ILWIS



GEONETCast and ISOD Toolbox plug-ins (generic plug-ins)

GEONETCast Toolbox 1.3

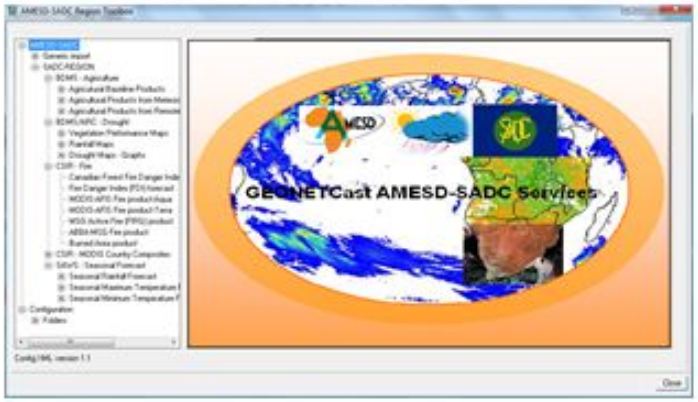
Import routines for various satellites, Meteorological Product Extraction facility (MPEF), Satellite Application Facilities (SAF), Chinese Meteorological Administration and 3rd party data providers such as TAMSAT, DevCoCast, MODIS, SPOT Vegetation, integration of METOP-AVHRR and JASON-2 data, export routines to BILKO and R, calculation of solar and MSG zenith and azimuth angles and real time MSG visualization.

ISOD Toolbox 1.0

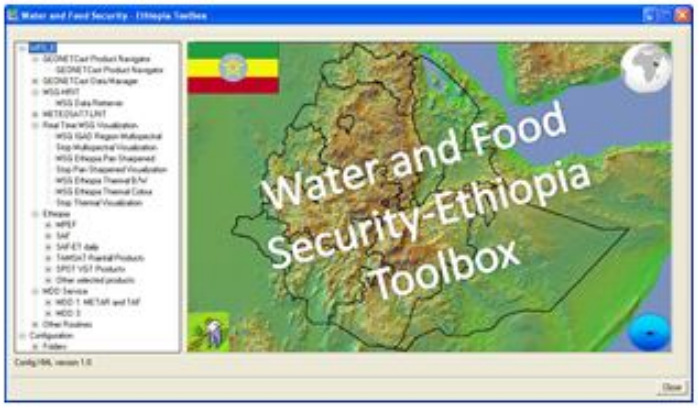
Retrieval and import of (time series) data from free online archives related to *in-situ* climatological observations, gauge and satellite derived rainfall estimates, weather and pressure forecasts, potential evapotranspiration, normalized difference vegetation indices and elevation information.

AMESD-SADC and WFS-Ethiopia Toolbox plug-ins (dedicated plug-ins)

AMESD-SADC Toolbox 1.1
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).

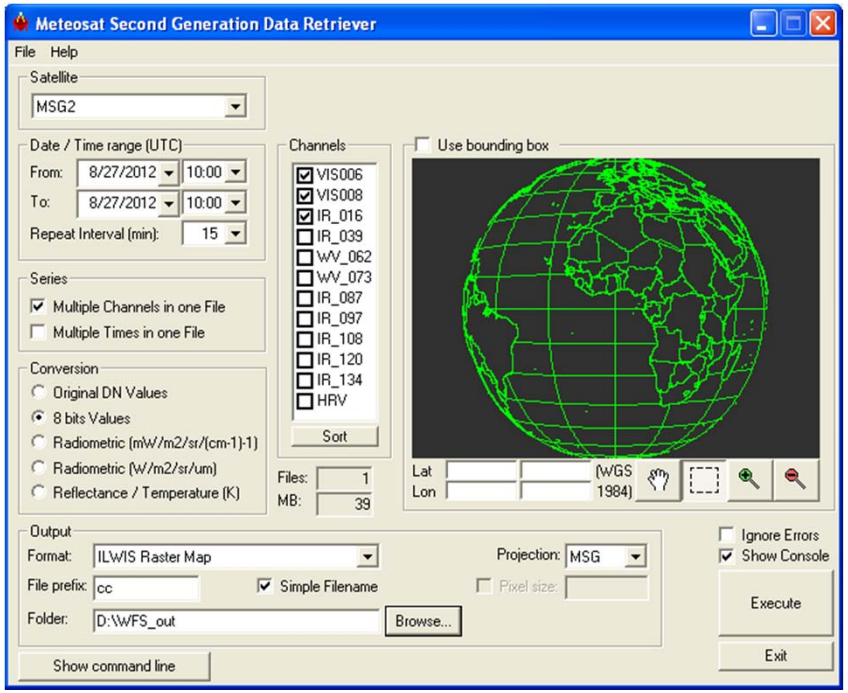


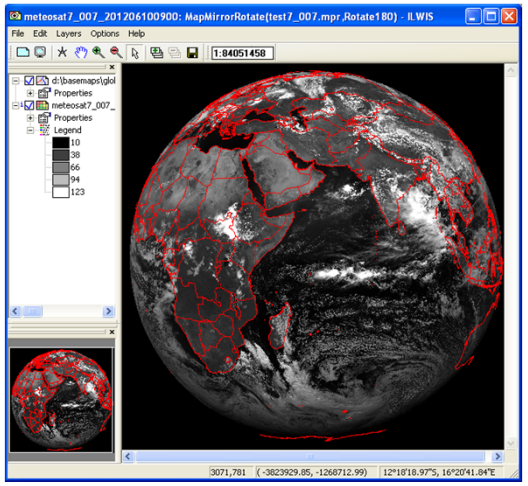
Water and Food Security Ethiopia Toolbox 1.0
Import and processing of selected data from GEONETCast relevant for water and food security monitoring and analysis for Ethiopia, like MPEF, SAF, VGT, TAMSAT and fire products, real time visualization, surface soil moisture and meteorological data dissemination service. Developed together with National Meteorological Agency, Ministry of Agriculture and WFP Ethiopia country office.

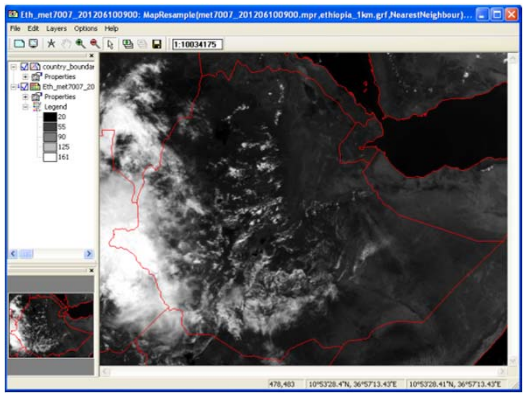


CMACast Toolbox under development (for SE-Asia)

MSG Data Retriever and METEOSAT 7 import

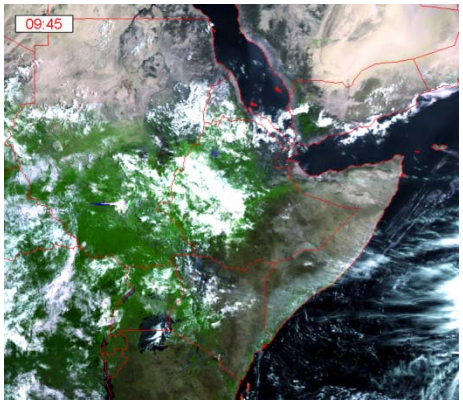


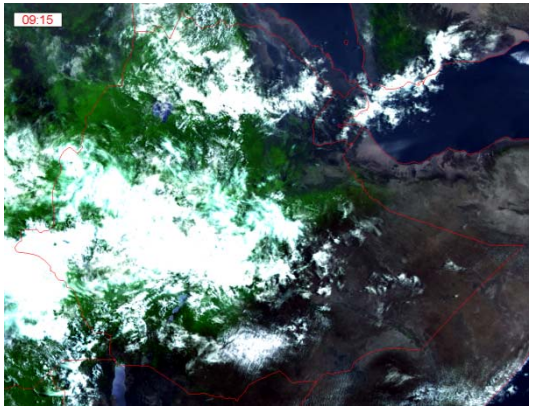




Import of MSG (time series) images according to user needs and import routines for MET-7 for the whole field of view and resampled to the Ethiopia Window.

Real Time MSG Visualization routines

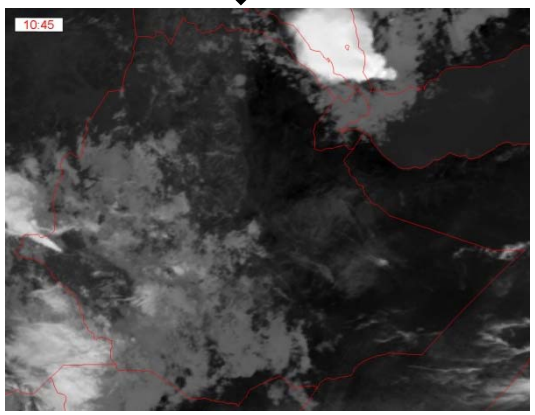


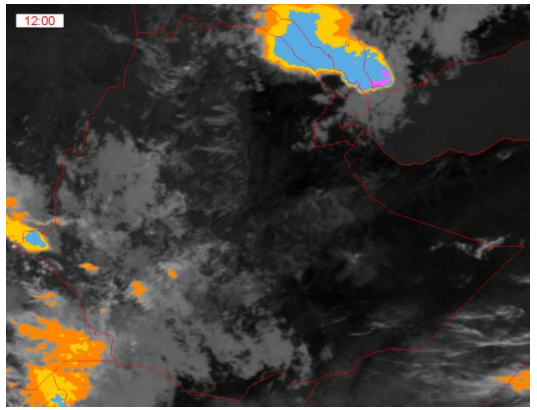


For the IGAD Region and including HRV channel for Ethiopia Window (resolution merge and pseudo natural colour transformation) for more detailed assessment

Automated day time and night time animation capability, every 15 minutes

Thermal channel using inverted gray scale and applying thresholds for colour coding (orange to pink – representing clouds from 235K to less than 190K)

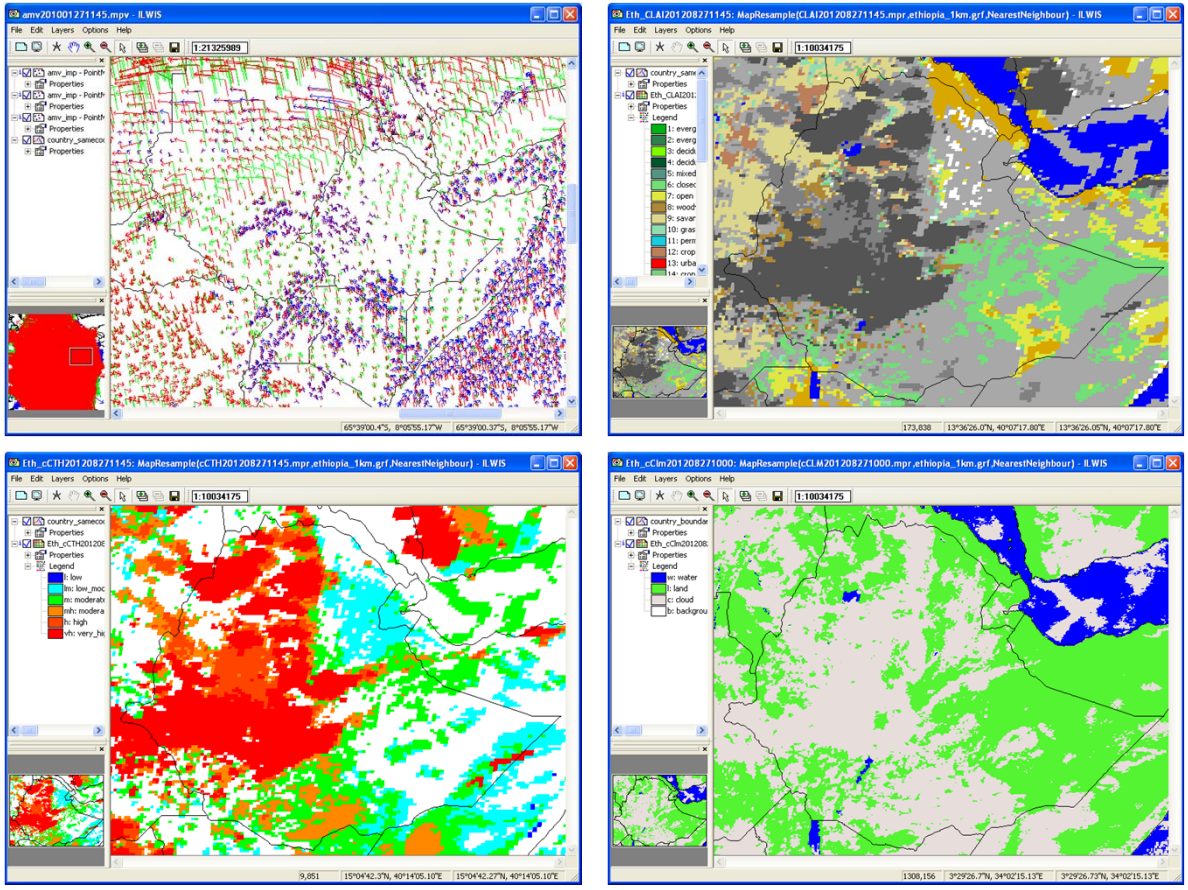




Toolbox routines for the Ethiopian window

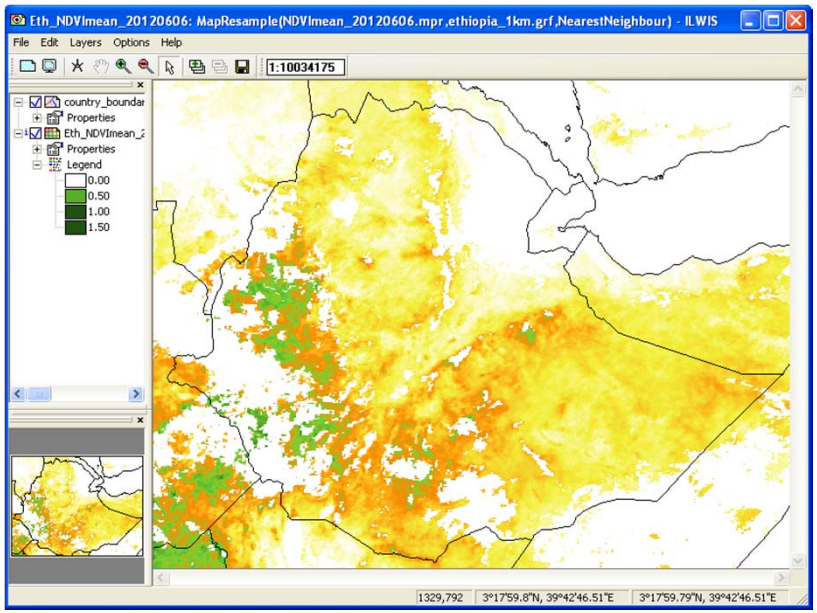
Various products relevant for agriculture, meteorology and fires, most are resampled to LEAP window

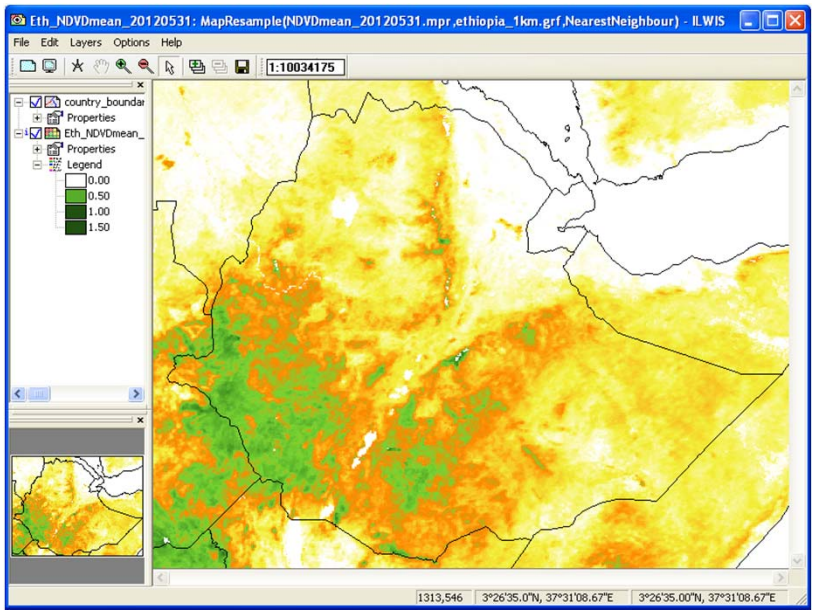
Ethiopian Window: some selected High Resolution MPEF Examples



Atmospheric motion vectors, cloud analysis image, cloud top height and cloud mask

Ethiopian Window: some selected Low Resolution MPEF Examples

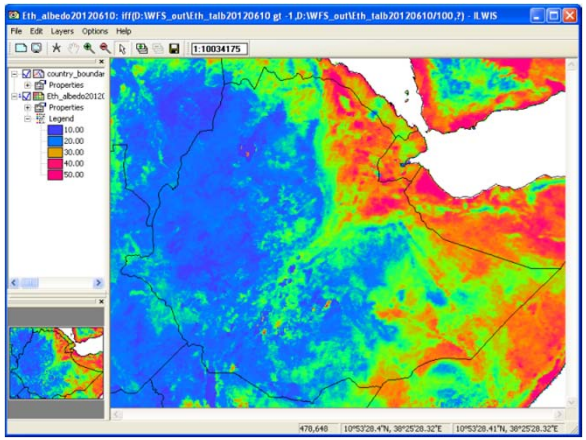


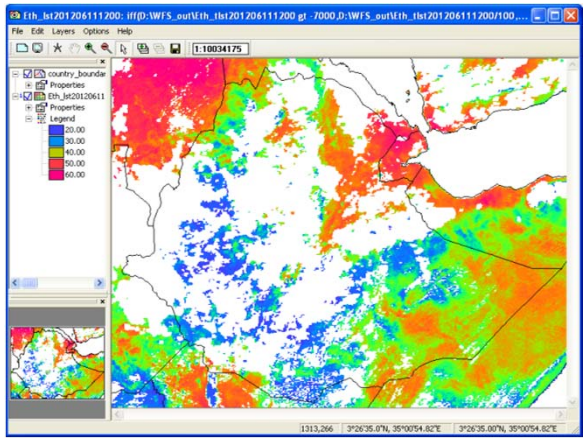


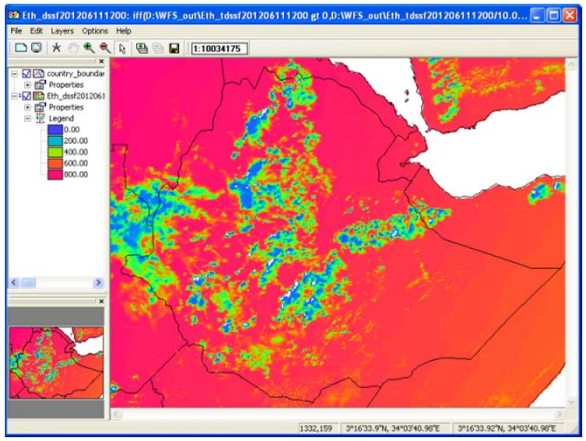
MSG derived Daily and Dekadal Minimum, Maximum and Mean NDVI

Ethiopian Window: some selected SAF Examples

Surface Radiation Budget parameters



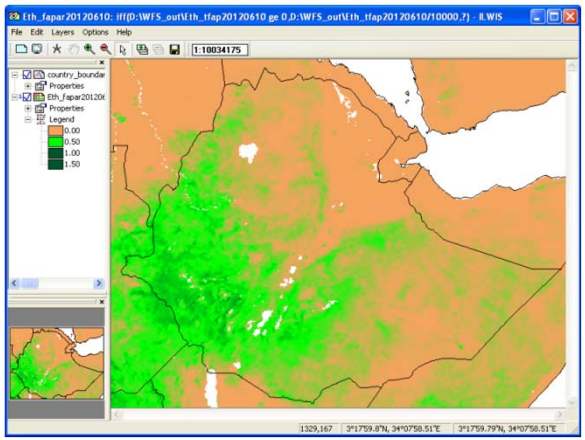


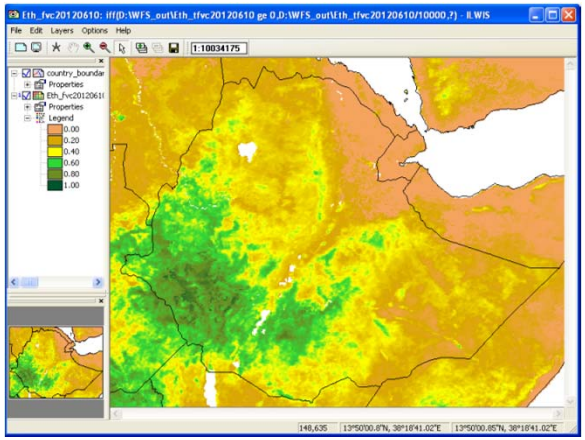


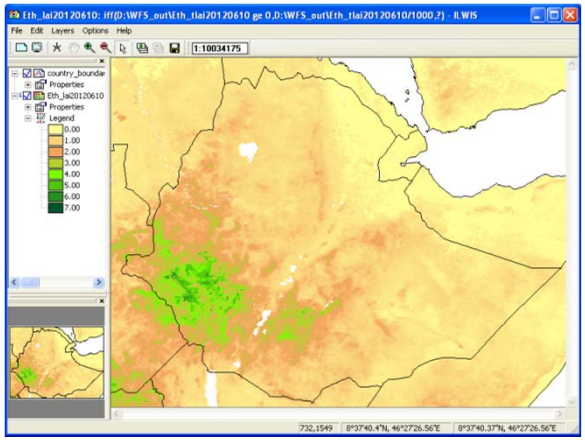
Albedo (daily), Land Surface Temperature (15 minutes) and Down-welling Surface Short-wave Radiation Flux (30 minutes)

Ethiopian Window: some selected SAF Examples

Bio-Geophysical Area parameters

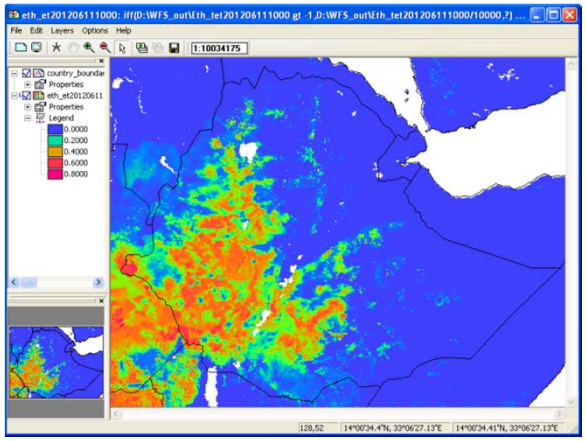


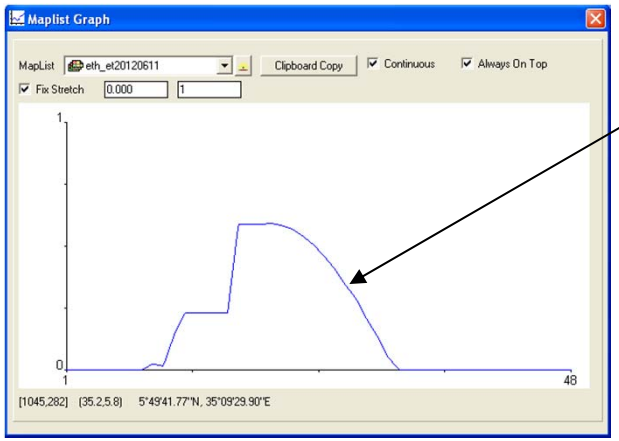




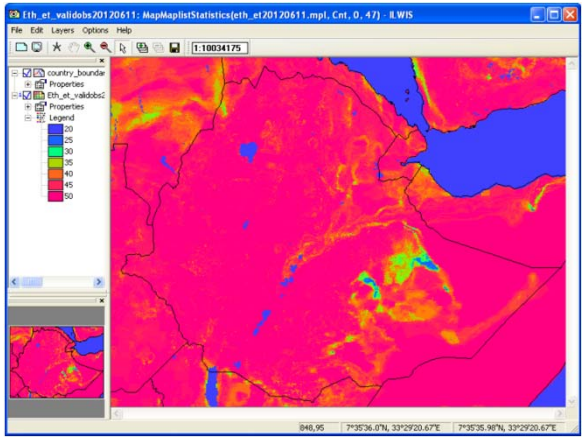
Fraction of Absorbed Photosynthetic Active Radiation (FAPAR), Fraction of Vegetation Cover (FVC) and Leaf Area Index (LAI), all daily products

Ethiopian Window: SAF ET Daily Example



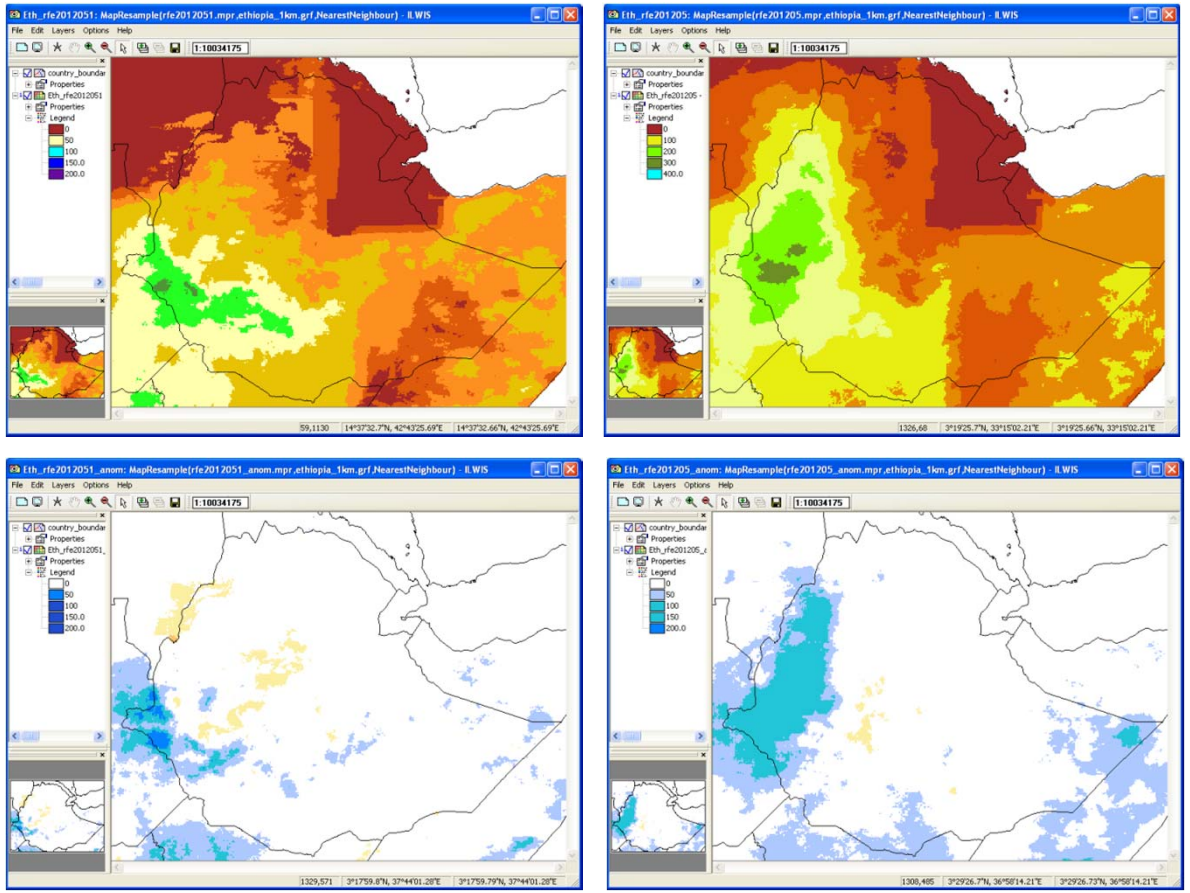


ET distribution over the day – time in UTC



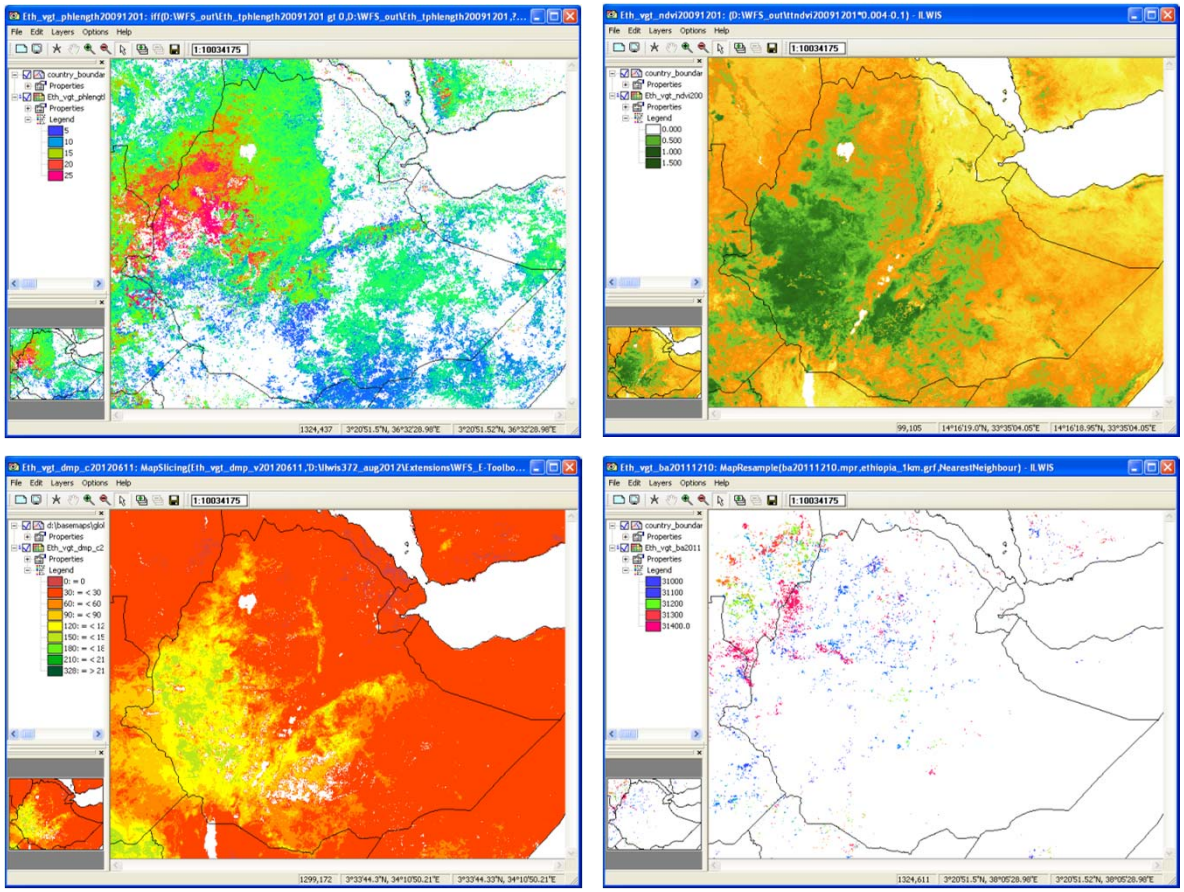
Aggregated Daily ET from 48 half- hourly ET products in an automated manner and creation of status map showing number of valid observation (to evaluate if the aggregated ET might be underestimated due to “no data values” in some of the half hourly products)

Ethiopian Window: some selected TAMSAT Examples



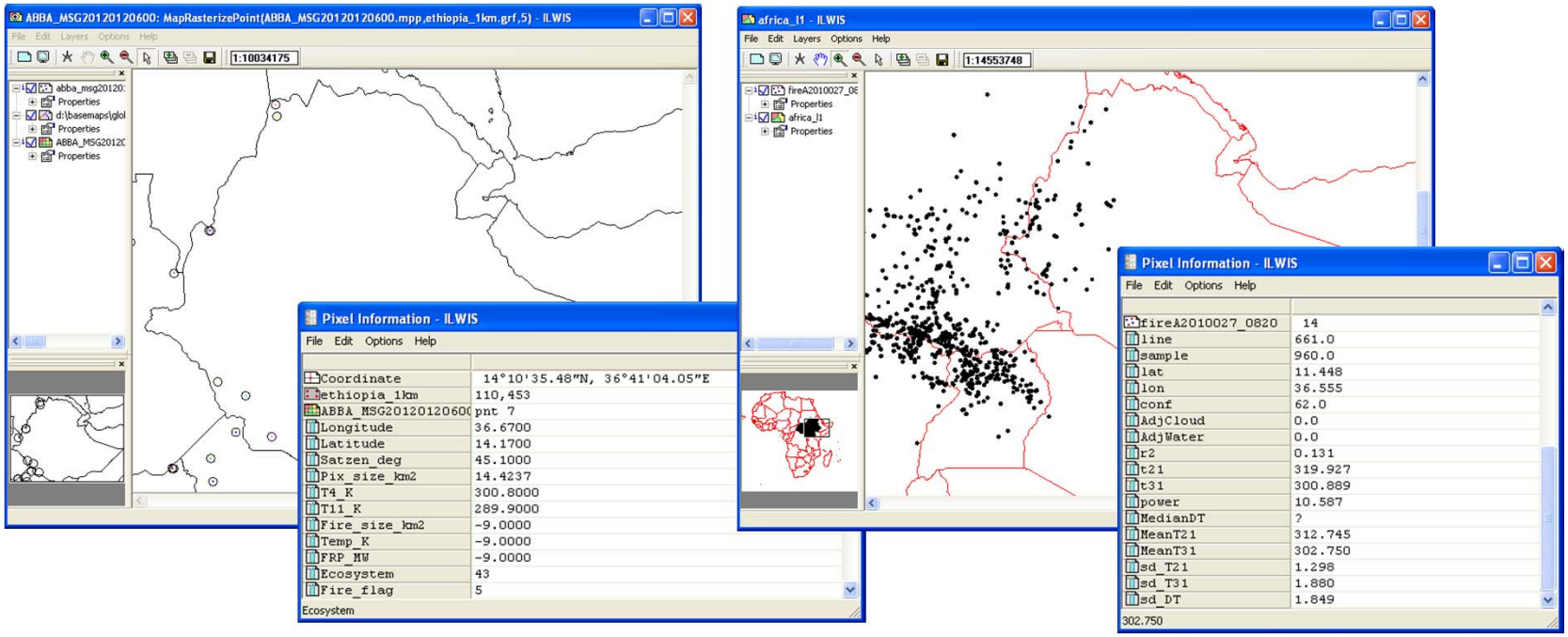
TAMSAT Dekadal and Monthly Rainfall Estimates and Anomalies

Ethiopian Window: some selected SPOT VGT Examples



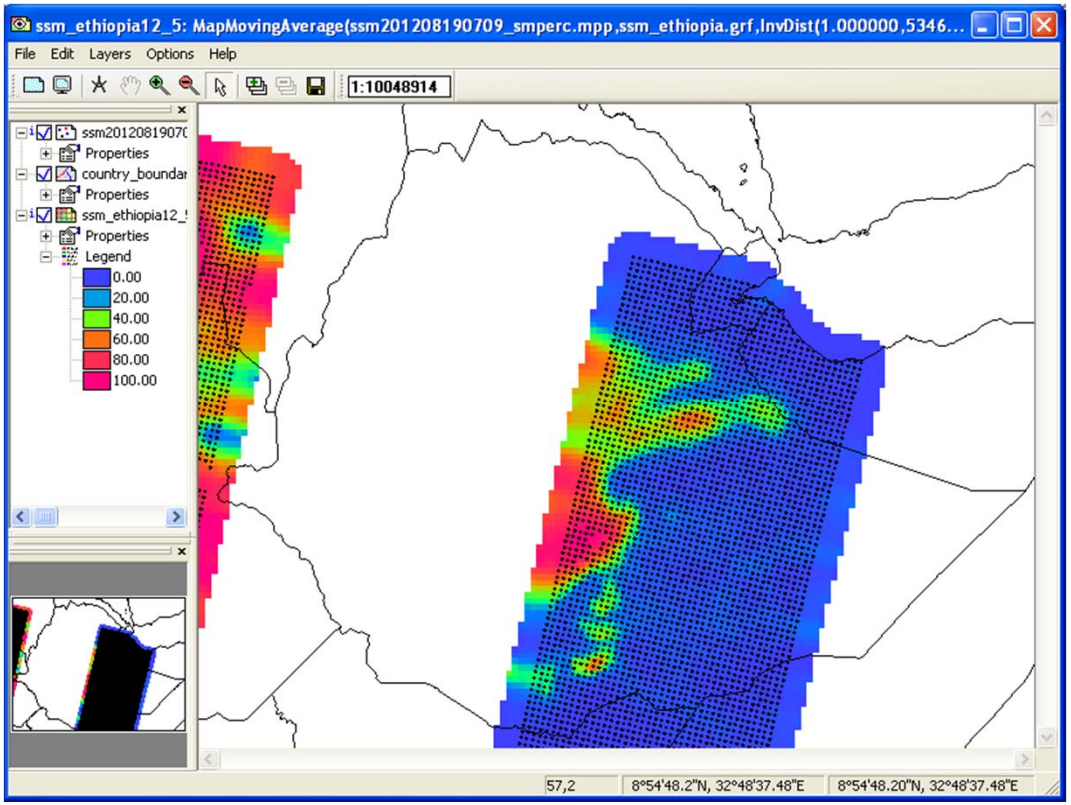
Season length, NDVI, Dry Matter Productivity and Burned Areas

Ethiopian Window: some selected other products



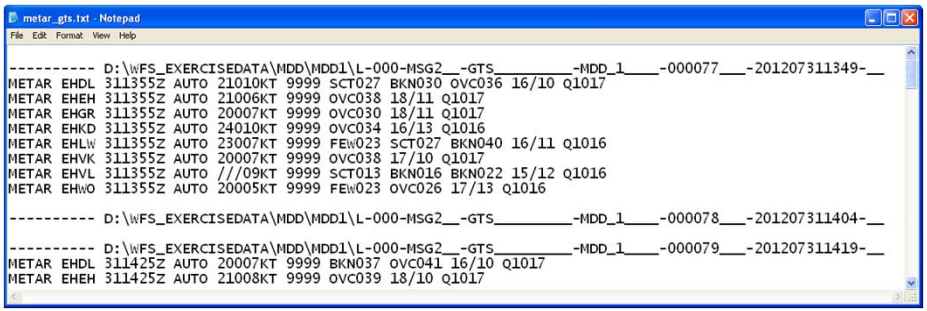
MSG based Automated Burned Biomass Algorithm Fire product and MODIS Aqua – Terra Fire Product with attribute tables

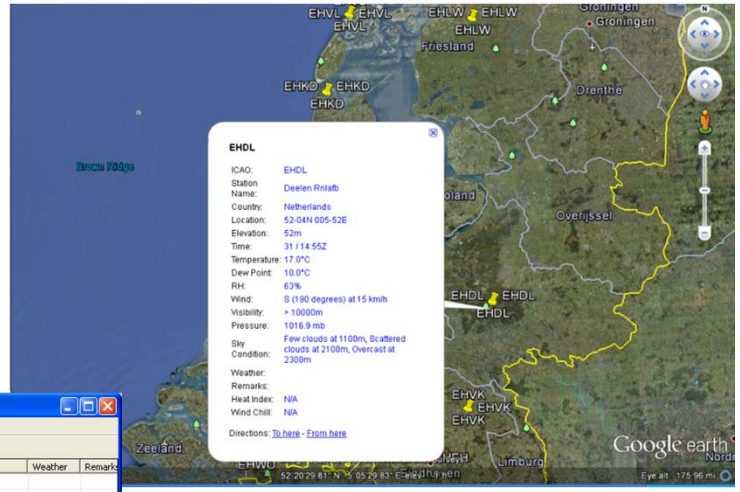
Ethiopian Window: some selected other products



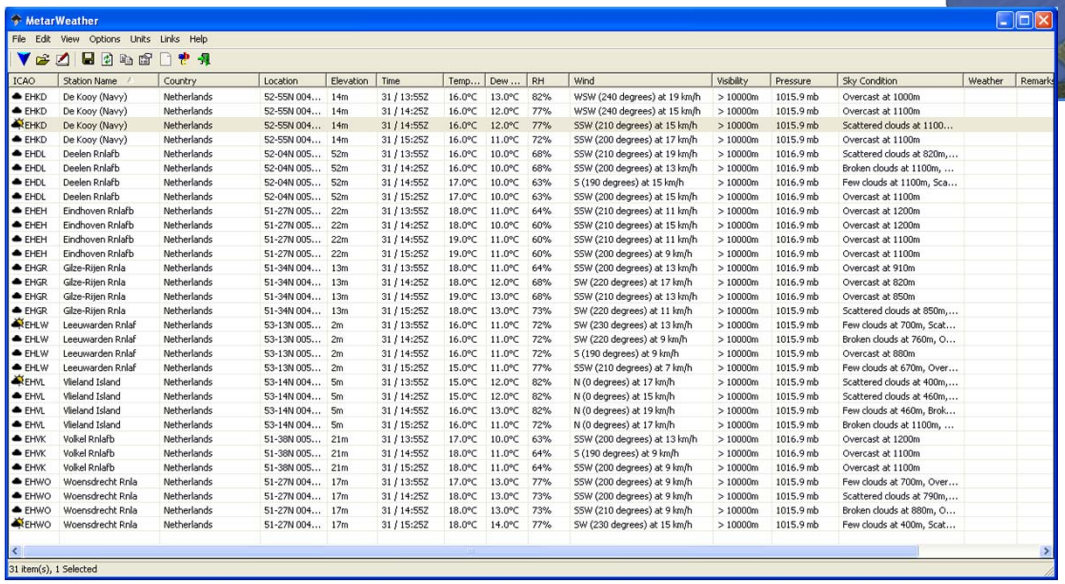
METOP – ASCAT Surface Soil Moisture product, interpolated using other ILWIS functionality

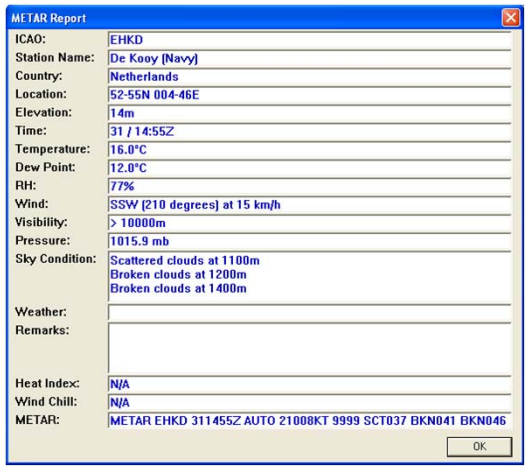
Meteorological Data Dissemination Service: MDD-1





Find Country METAR – TAF Messages





Display results as report or as Google Earth overlay

Meteorological Data Dissemination Service: MDD-1

For TAF Forecast and TAF-AMD Messages Strawberry-Perl scripts used

```
TAF EGWU 311335Z 3115/0109 20008KT 9999 FEW012 BKN018 TEMPO 3115/3118 6000 -RADZ BKN010 BECMG 3119/3122 FEW015 PROB30 TEMPO
3122/0103 SCT008
```

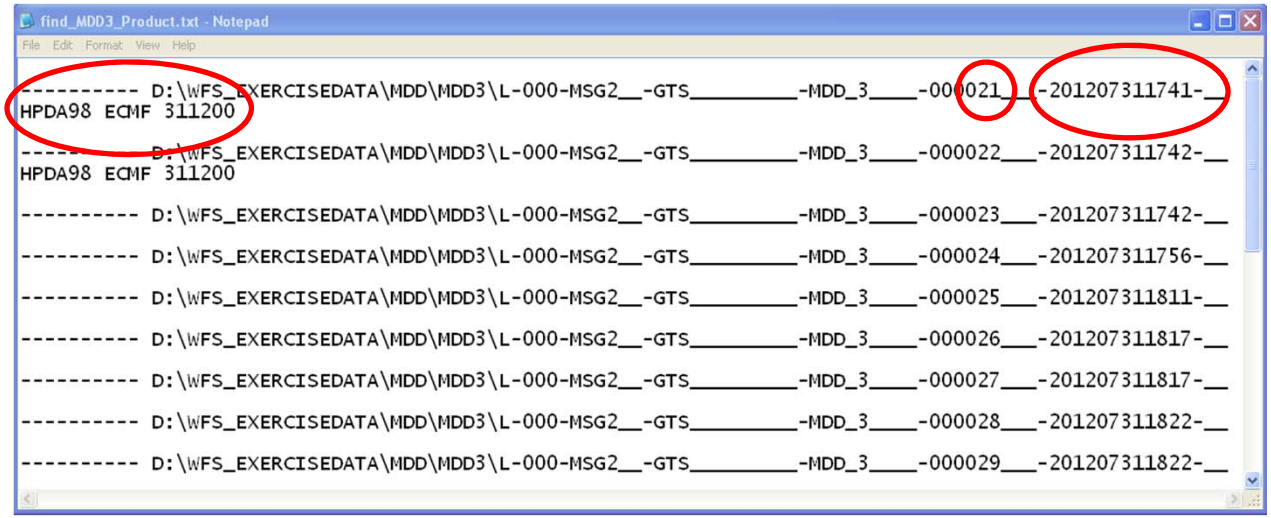
TAF	**18h aerodrome forecast**		
EGWU	station id:	EGWU	
311335Z	Issue time:	on the 31., 13:35 UTC	
3115/0109	Forecast period:	from the 31., 15:00 UTC till the 1., 09:00 UTC	
20008KT	Wind:	from the SSW (200Â° (+4Â°/-5Â°)) at 14.8 km/h	8 kt = 9.2 mph = 4.1 m/s
9999	Visibility:	>=10 km	>=6.2 miles
FEW012 BKN018	ceiling*:	at 1800 ft	550 m
	Sky condition:	few clouds at 1200 ft	370 m
		broken clouds at 1800 ft	550 m
	trend forecast:		
TEMPO 3115/3118	**from the 31., 15:00 UTC till the 31., 18:00 UTC temporarily:**		
6000	Visibility:	6000 (.. <7000) m	3.7 miles
-RADZ	Weather:	light rain with drizzle	
BKN010	ceiling*:	at 1000 ft	300 m
	Sky condition:	broken clouds at 1000 ft	300 m
BECMG 3119/3122	**from the 31., 19:00 UTC till the 31., 22:00 UTC transition to:**		
FEW015	Sky condition:	few clouds at 1500 ft	460 m
PROB30 TEMPO 3122/0103	**with 30 % probability from the 31., 22:00 UTC till the 1., 03:00 UTC temporarily:**		
SCT008	Sky condition:	scattered clouds at 800 ft	240 m

Meteorological Data Dissemination Service: MDD-3

- Based upon requirements from NMA:

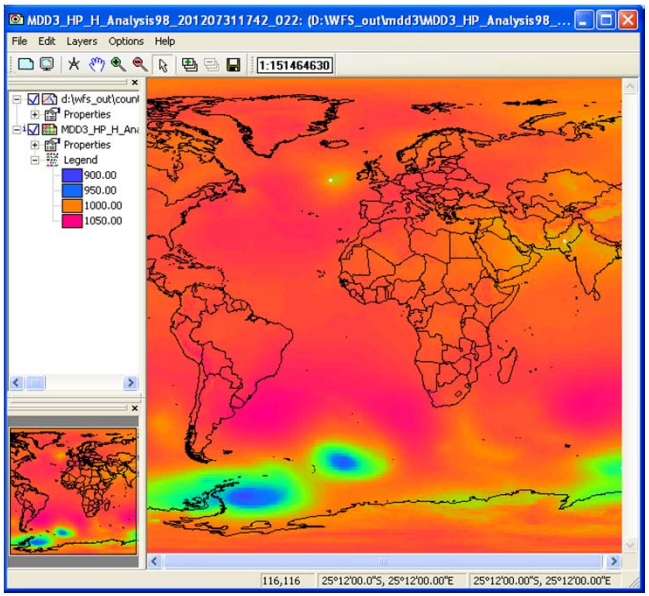
Mean Sea Level Pressure:	HPDA98		
Geopotential Height at 500 hPa:	HHDA50		
Winds at 200 hPa:	HUDA20	or	HVDA20
Winds at 500 hPa:	HUDA50	or	HVDA50
Winds at 700 hPa:	HUDA70	or	HVDA70
Winds at 850 hPa:	HUDA85	or	HVDA85

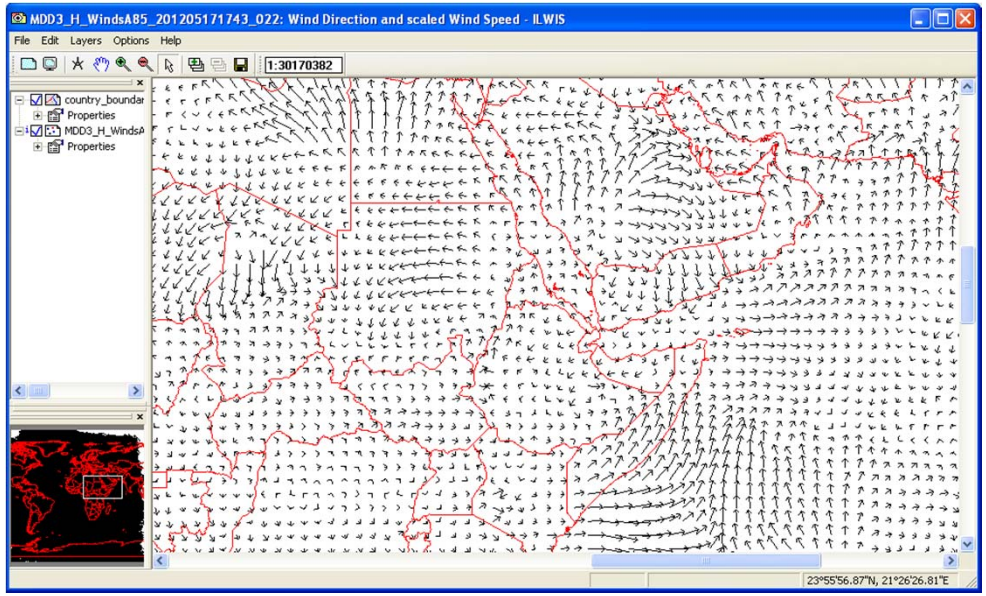
- Find MDD-3 Product codes from messages, example: HPDA98



Meteorological Data Dissemination Service: MDD-3

Mean Sea Level Pressure at 980hPa and Winds at 850hPa

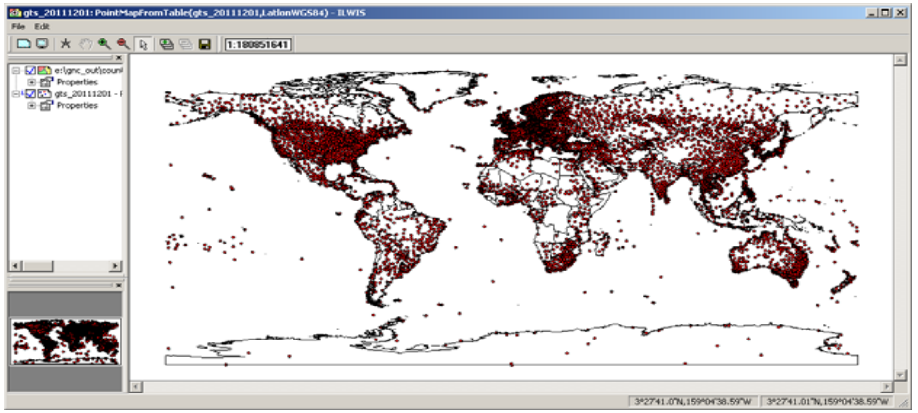


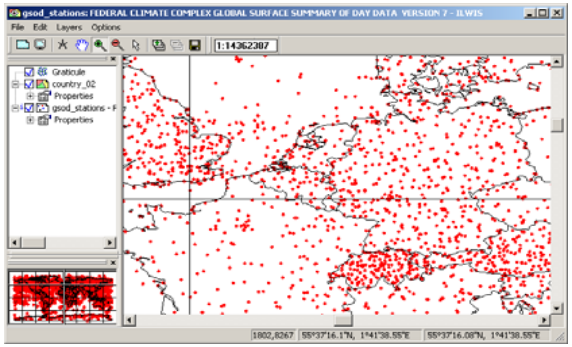


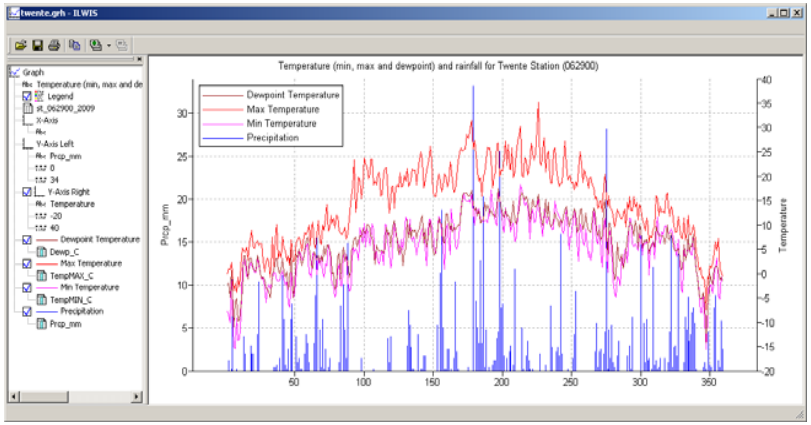
Products are at different resolution (1 and 2.5 degree),
if available both are processed
Currently Tropical Belt products not processed

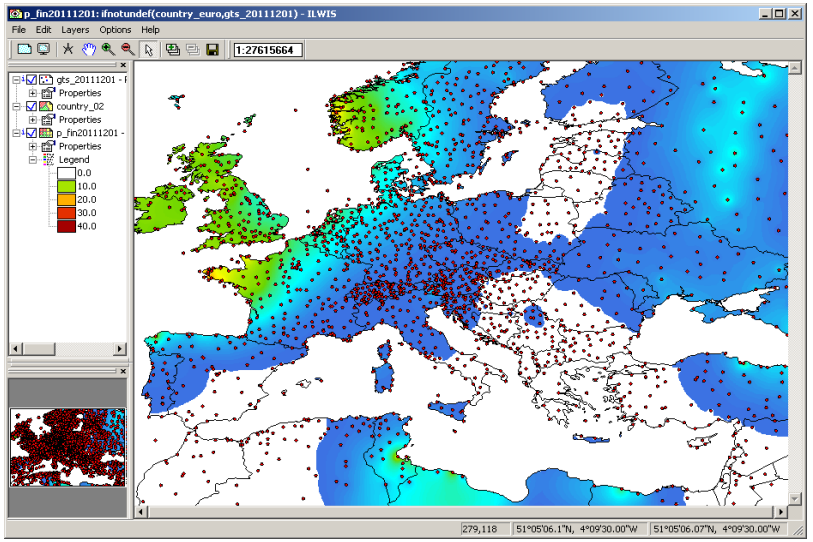
Retrieving online *in situ* and time series data

- ISOD Toolbox: example of GSOD & GTS online data

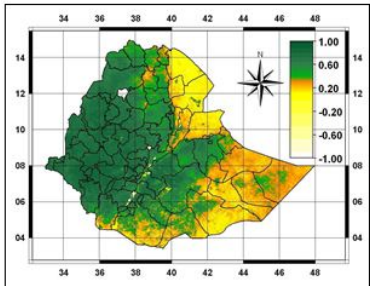






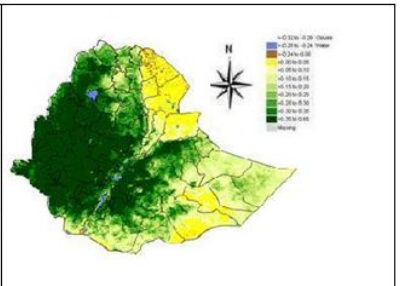


From GEONETCast to other applications - Bulletins



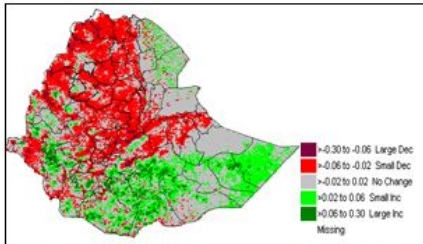
NDVI for the second dekade of October 2012
Source: GEONETCast near real time data from SPOT_VGT
Processed by ILWIS GEONETCast Toolbox at EWRD, DRMFSS

ካርታ 1



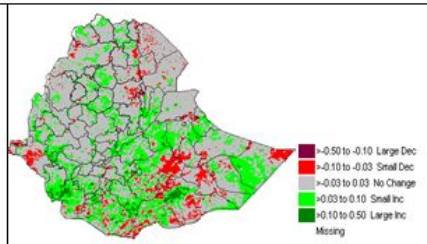
Vegetation Greennes(NDVI) in fraction for the 2nd dekade of October 2012
Source: METEOSAT
Processed by LEAP

ካርታ 2



Deviation NDVI in fraction - 2012 October 2 [compared to the first decade of October 2012), processed by LEAP (Version 2.70)

ካርታ 3



Vegetation Greenness (NDVI) in fraction - 2012 October 2 [Compared to Normal], processed by LEAP (Version 2.70)

ካርታ 4

የ METEOSAT መረጃን በመጠቀም በ Livelihood Early Assessment Protection (LEAP) ሰፍጥዌር የተተነተነው እና የ SPOT_VGT የእፅዋት ሽፋን መረጃ በ ILWIS GEONETCast toolbox የተተነተነው እ.ኤ.አ የኦክቶበር 2012 የሁለተኛው አስር ቀናት የእፅዋት መረጃ ስዕሎች እንደሚያሳዩት የእፅዋት ሽፋኑ በአሁኑ ሰዓት የዝናብ ወቅታቸው በሆነው የአገሪቱ ደቡብ እና ደቡብ ምስራቅ አካባቢዎች ላይ እየተስፋፋ መሆኑን ነው። በመሆኑም ከኦሮሚያ በአብዛኛው ቦረና እና ጉጂ እንዲሁም በባሌ ደቡብ እና በቡብ ምስራቃዊ ከፍሎች የእፅዋት ሽፋኑ ጨምሮ የታየ ሲሆን ከሶማሌ ክልል በአብዛኛው ቀርዴር እና ኮሬሄ በአፍዴር ሰሜናዊ አጋማሽ እንዲሁም በብዛኛው ሲበን ዞን የእፅዋት ሽፋኑ ጨምሮ እና ተስፋፍቶ እንደነበረ ምስሎቹ ይጠቁማሉ (ካርታ 1 እና 2 ይመልከቱ)።

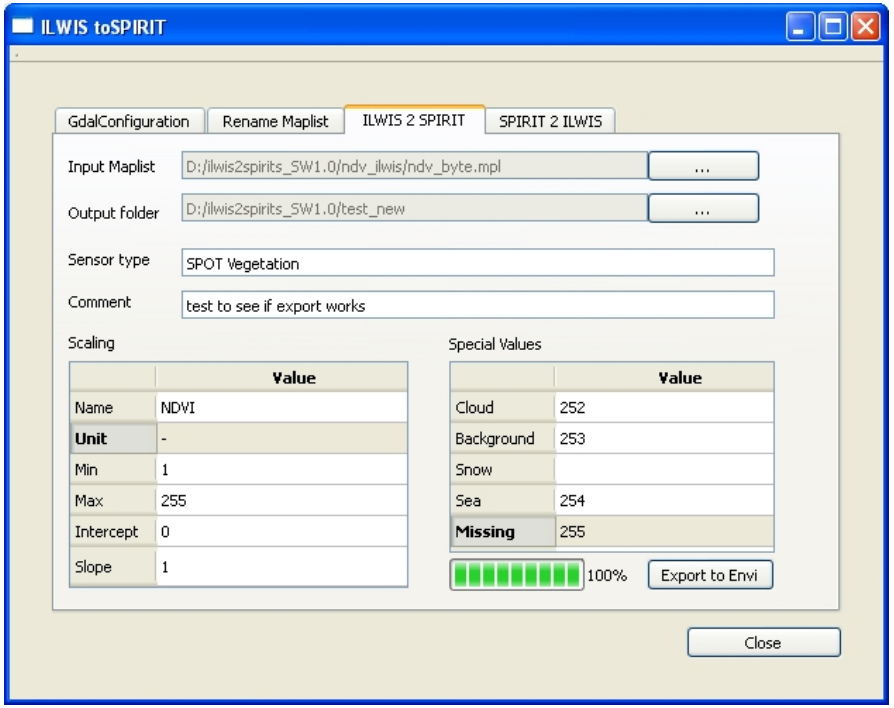
እ.ኤ.አ የኦክቶበር 2012 የመጀመሪያው አስር ቀናት የእፅዋት ሽፋን እ.ኤ.አ ከኦክቶበር 2012 ሁለተኛው አስር ቀናት የእፅዋት ሽፋን ጋር ሲነፃፀር ከአብዛኛው የመኸር አብቃይ አካባቢዎች በፍሬከሽን ከ −0.6 እስከ −0.02 መጠነኛ የእፅዋት ሽፋን መቀነስ ለውጥ አንዳሳየ ከላይ በካርታ 3 የሚታየው ስዕል የሚያመለክት ሲሆን በሴላ በኩል ደግሞ በደቡብ እና ደቡብ ምሥራቅ የአገሪቱ ከፍሎች ማለትም ከኦሮሚያ በአብዛኛው ቦረና፣ ጉጂ እና ባሌ፤ ከደቡብ ብሄር ብሄረሰቦች እና ሕዝቦች በሲዳማ፣ በኔዮ እና በአንዳንድ የገሙ ጎፋ ምስራቃዊ ከፍል እንዲሁም ከሶማሌ ክልል በአብዛኛው ቀርዴር እና ኮሬሄ፣ በአፍዴር ሰሜናዊ አጋማሽ እና አብዛኛው ሲበን ዞንን ጨምሮ ከመጠነኛ እስከ ከፍተኛ (በፍሬከሽን ከ 0.20 እስከ 0.30) የእፅዋት ሽፋን የመጨመር ለውጥ እንደነበር ምስሉ የጠቁማል።

እ.ኤ.አ የኦክቶበር 2012 የሁለተኛው አስር ቀናት የእፅዋት ሽፋን ሁኔታ በመደበኛ ሁኔታ መቸር ከሚገባው የረዥም ጊዜ አማካይ የእፅዋት ሽፋን ሁኔታ ጋር ሲነፃፀር ደግሞ በአብዛኛው የአገሪቱ ከፍሎች መደበኛ እና ከመደበኛ በላይ የሆነ የእፅዋት ሽፋን ለውጥ የታየባቸው ሲሆን ከሶማሌ በአፍዴር መካከለኛው ከፍል እንዲሁም ከደቡብ ብሄር ብሄረሰቦች እና ሕዝቦች ክልል በአንዳንድ የቤንች ማጂ ደቡባዊ ከፍል እና በደቡብ ኦሞ ሰሜን ምዕራብ ከፍል ጎልቶ የታየ ማለትም በፍሬከሽን ከ 0.10 እስከ 0.50 የሆነ የእፅዋት ሽፋን የመጨመር ለውጥ እንደነበር እ.ኤ.አ የኦክቶበር 2012 የሁለተኛው አስር ቀናት ከመደበኛው የእፅዋት ሽፋን ሁኔታ ጋር ያለውን ንጽጽር የሚጠቁመው ምስል ያሳያል (ካርታ 4 ይመልከቱ)።

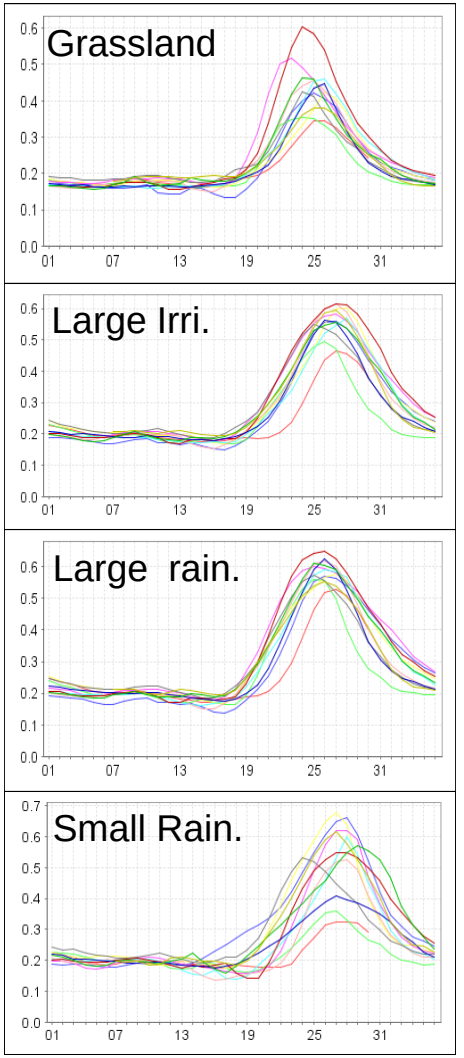
Use of GEONETCast data in the “Livelihood, Early Assessment and Protection (LEAP) software at the Disaster Response Unit (Min. Agriculture Ethiopia)

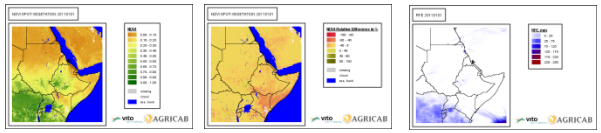
Working with time series raster data: from ILWIS to SPIRITS

- Seamless data transformation:



- From maps to time series graphs: CNDVI for different land covers

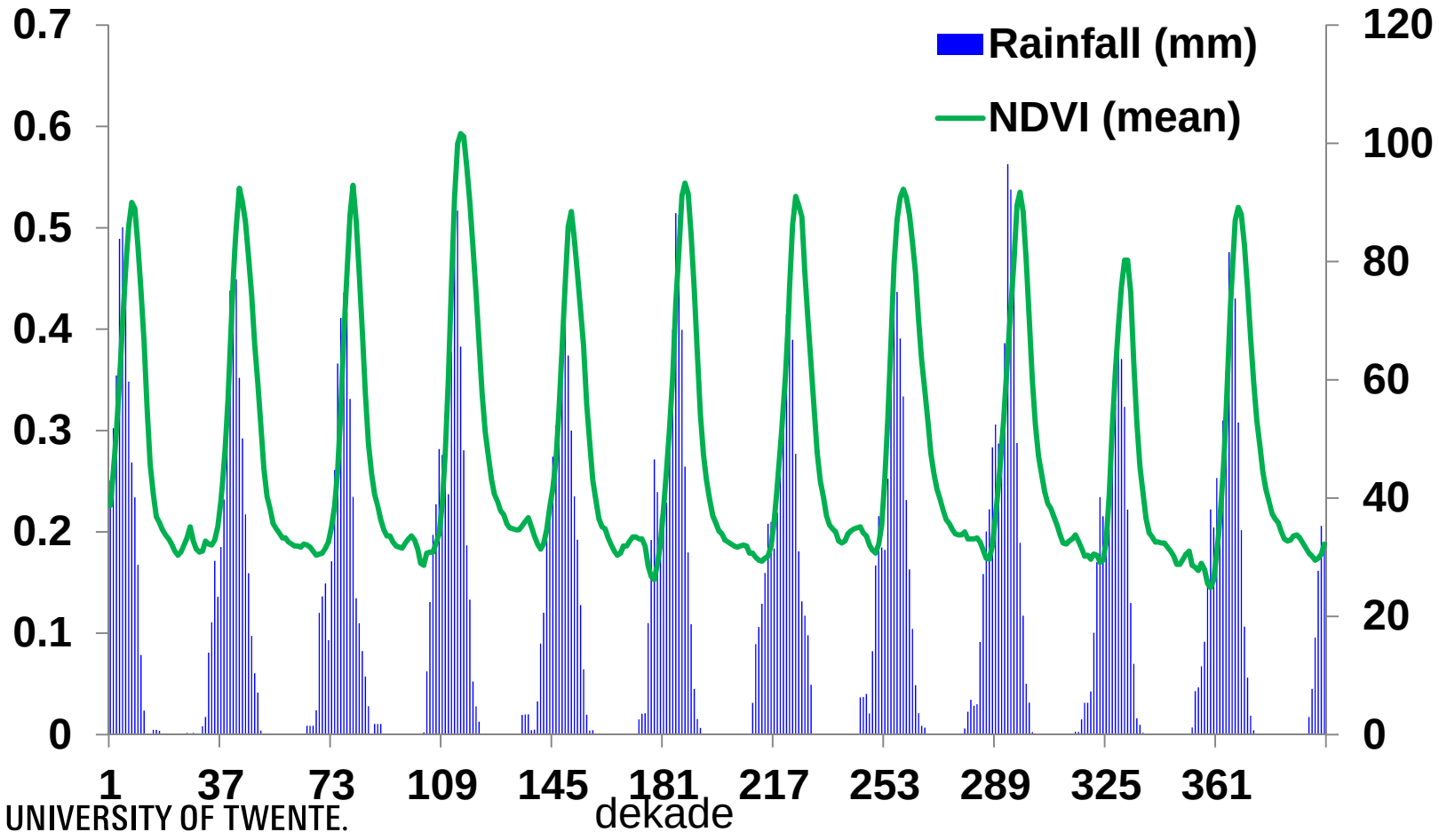




UNIVERSITY OF TWENTE.

Working with time series raster data: from ILWIS to SPIRITS

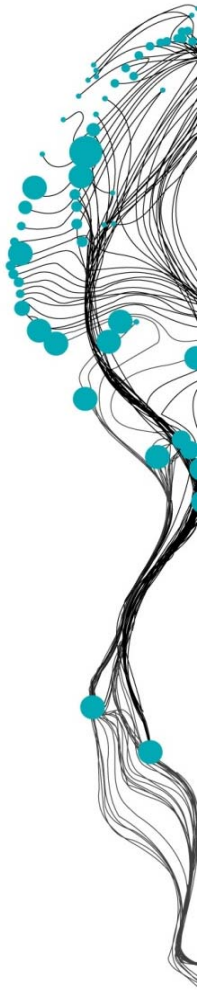
Response of CNDVI for large-scale agricultural land to TAMSAT RFE

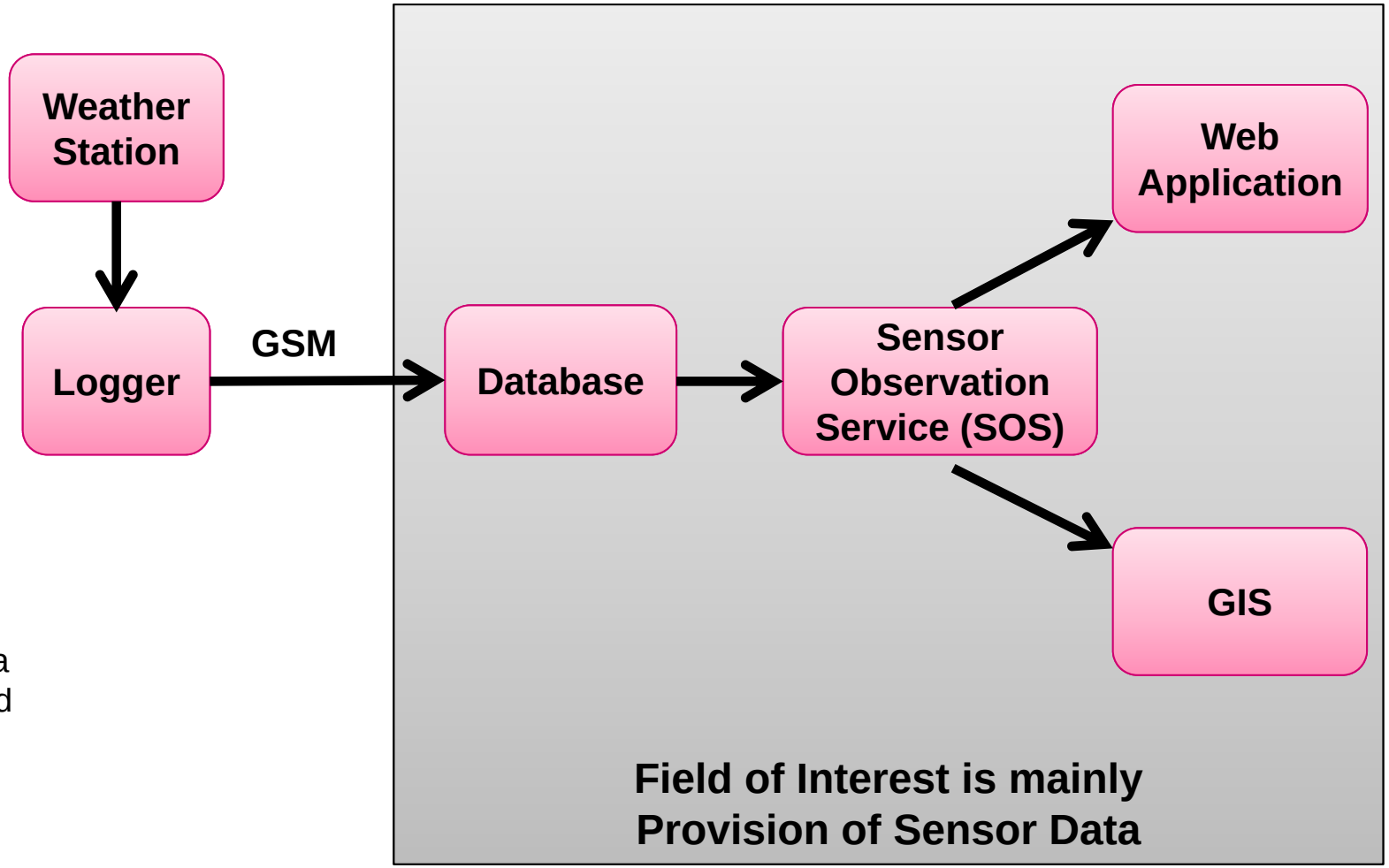


Sensor Web: Integration of sensors and sensor data into spatial data infrastructures, development ideas

- ILWIS as a central tool
- ILWIS Sensor Web toolbox
- Interoperable loading of data
  - Multiple thematic domains
  - Different data providers (e.g. citizens and official measurement networks)
  - Raster as well as in-situ data
- Processing functionality
- Alerting
- For Demo: http://www.sensor-gdi.de/52n-thinsweclient-webapp/

Sensor Web: Integration of sensors and sensor data into spatial data infrastructures – step 1



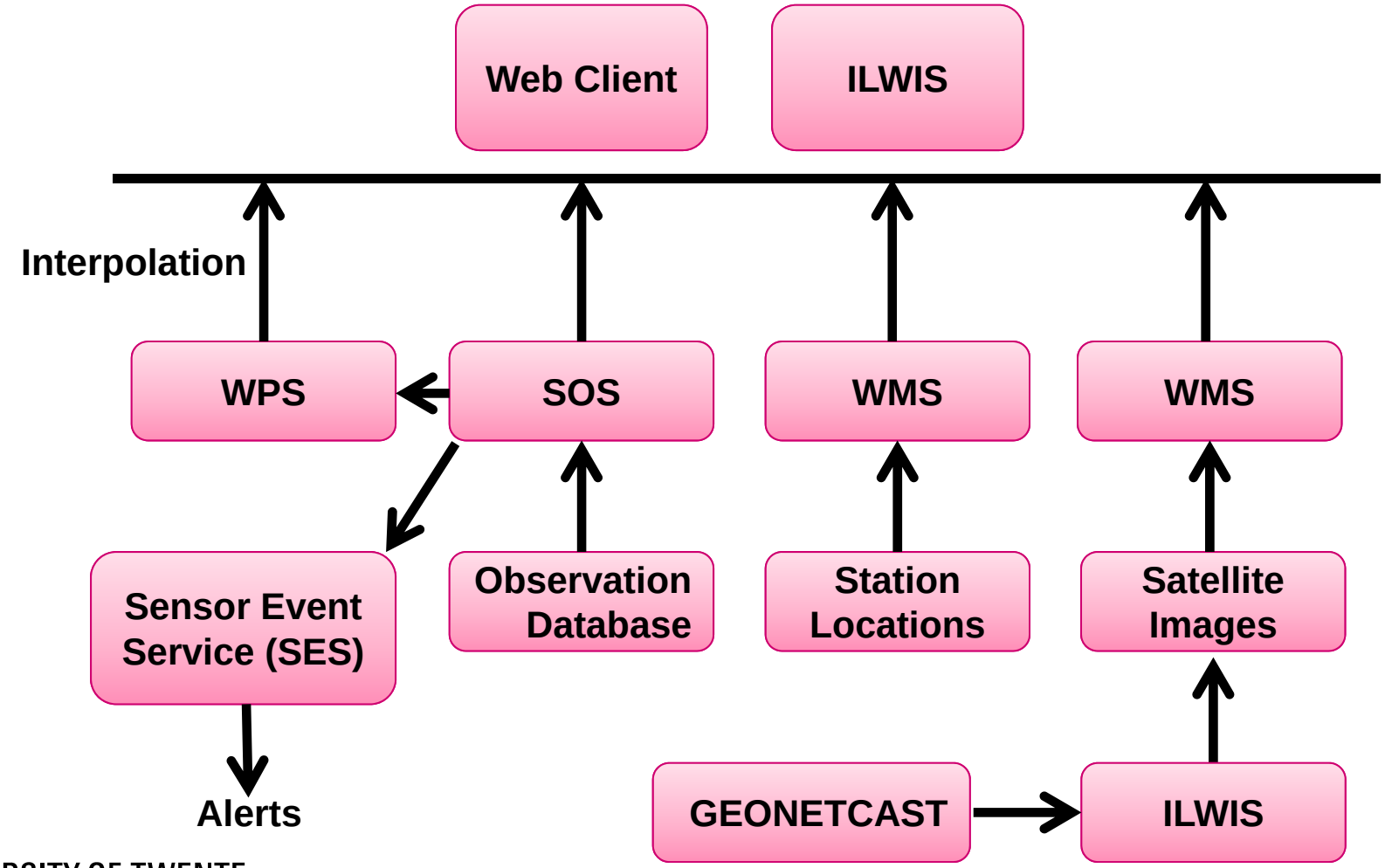


After: Simon Jirka
Sensor Web Lead
(52North.org)

ITC UNIVERSITY OF TWENTE.

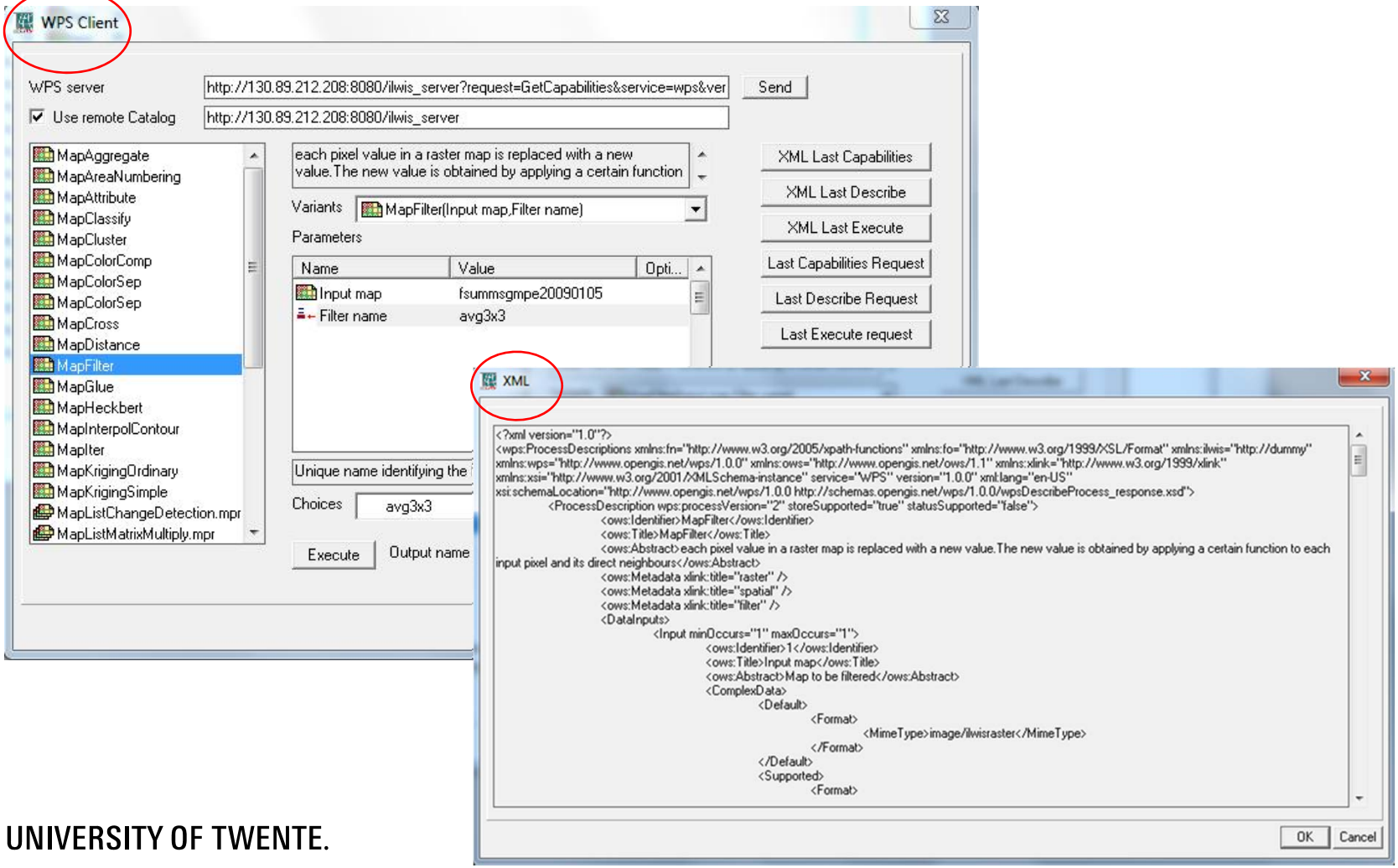
http://52north.org/communities/sensorweb/

Sensor Web: Integration of sensors and sensor data into spatial data infrastructures – step 2



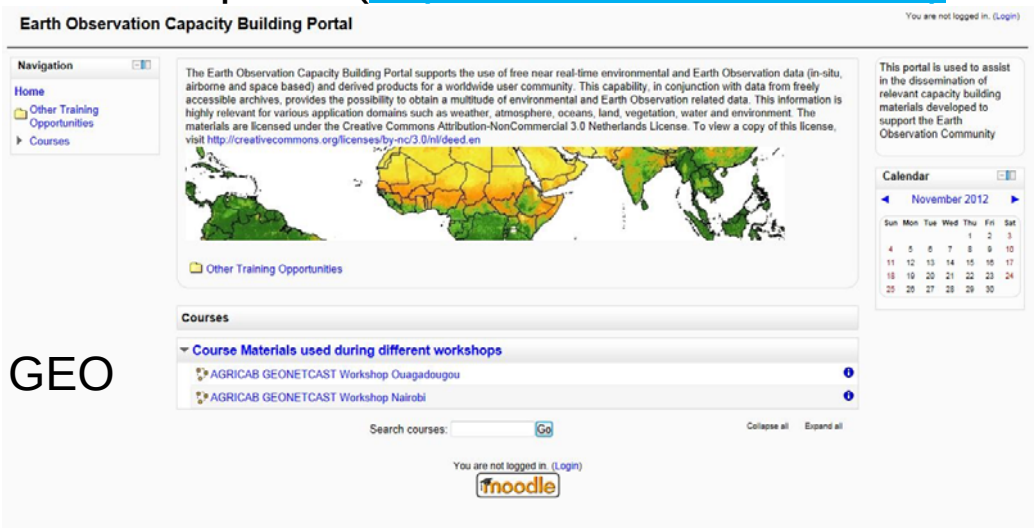
After: Simon Jirka
Sensor Web Lead
(52North.org)

ILWIS as Web Processing Server (WPS) and Client



Free resources available to the interested public

- **Software portal:**
  - Software to handle and process the GEONETCast data received is now freely available through the newly established "*Earth Observation*" community (http://52north.org).
- **Capacity building portal:**
  - Further information, hands on exercises and sample data is now freely available at the ITC "*GNC pages*" (http://www.itc.nl/Pub/WRS/WRS-GEONETCast) or at Moodle EO-CB portal (http://130.89.212.208:100/)



- Registered as contribution to GEO

Concluding remarks

- Free data, software and training - instruction materials are available to utilize environmental data streams for multiple applications;
- Collaboration within various networks spread over Africa very successful, e.g. Universities, Government Agencies and various projects;
- African Universities are encouraged to establish low cost data ground reception infrastructure and use tools for:
  - Teaching these new capabilities in their regular Curricula so new graduates have obtained appropriate knowledge and skills;
  - Provision of external training (workshops, DE courses, etc) to professionals from relevant ministries and other line agencies.
- The ITC/52N-communities can provide the necessary backstopping and continue to develop relevant utilities for processing and analysis of the data streams (CMACast toolbox, WPS and Sensor Web) and (assisting in the) development of societal relevant applications.