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APPLICATIONS OF NEAR REAL TIME SATELLITE OBSERVATIONS IN THE BALKAN REGION USING THE ILWIS OPEN GEONETCAST TOOLBOX

Abstract: There is a growing availability of earth observation (EO) and *in-situ* data and derived products for use in environmental research and resources management practice. GEONETCast operated by EUMETSAT and the ESA-DDS or the European Space Agency direct data dissemination system are examples of such global real time EO data dissemination systems. Currently, also more and more software packages can be legally downloaded and used with little restrictions, including source code access. The use of ILWIS Open (3.7), an open source geospatial analysis system, is shown with emphasis on hydrological and environmental application. Real time satellite data import and visualization, land surface and digital terrain parameterization, as well as spatially distributed computation of water cycle components, like rainfall and evapotranspiration rates, and water quality is also illustrated.

SATELLITE DATA ACQUISITION AND ACCESS

Real-time satellite observation capabilities have been greatly enhanced in recent years by data infrastructures such as GEONETCast, the global satellite and *in situ* data dissemination system of GEOSS, the emerging Global Earth Observation System of Systems, an initiative led by the Group on Earth Observation [1, 2].

GEONETCast permits open and free data reception through a global network of communication satellites, and provides near real-time earth observation and environmental data and derived products. This DVB-S or digital video broadcasting by satellites is emerging rapidly as a very effective way for persons around the globe to receive satellite and environmental data and geo information instantaneously (Fig. 1).

The EUMETCast dissemination system started off to provide the European and African national meteorological centres with satellite information mainly focussing

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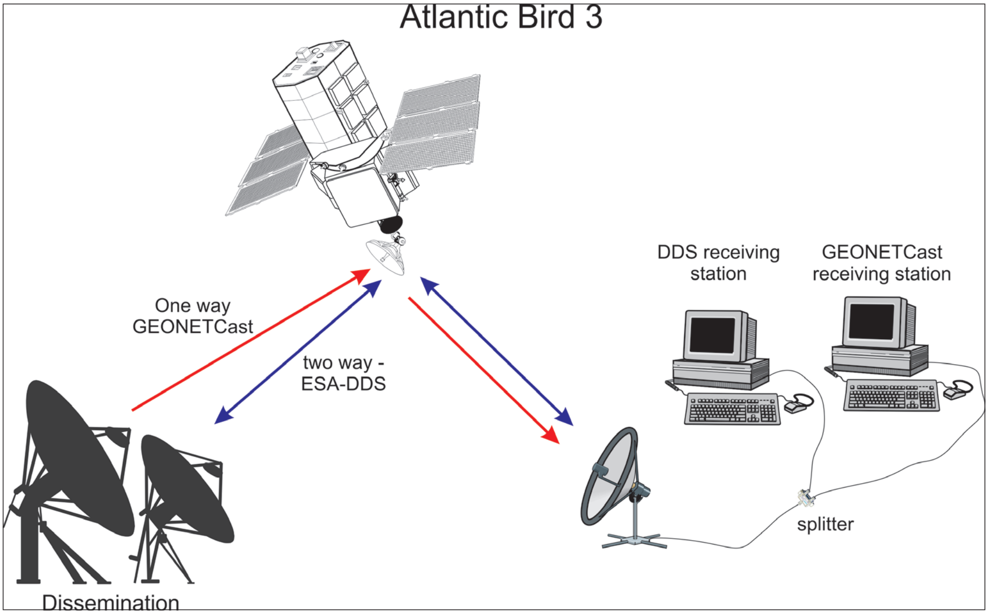

Fig. 1: DVB-S system for environmental and geo informations

on meteorological applications; currently, the system is rapidly expanding and is now disseminating a wide array of environmental data from various third party data providers. More details on images and products can be consulted at the „*Product Navigator*", available at the home page of EUMETSAT (`http://www.eumetsat.int`).

DATA PROCESSING AND ANALYSIS

The Geonetcast Toolbox is open source software plug-in of ILWIS Open [3]. It enables direct import and management of GEONETCast satellite data streams and supports their subsequent processing using ILWIS or other geospatial analysis systems. The software design principles of the toolbox were an easy operability, open source a/o freeware software components and an interface, adaptable by the users to their own selected data streams, data analysis, processing needs and information dissemination requirements, like e. g. web mapping services. The toolbox setup and key features are shown in Figure 2.

The key features of the ITC Geonetcast Toolbox can be described as follows:

▫ *Satellite data reception & archive*
- Data reception via DVB antenna using EUMETCast / GEONETCast (or ftp);
- Global geographical coverage combining EUMETCast & CMACast services;
- Selective archiving according user preferences e. g. satellite, data type, segment selection, time of storage, using an build-in data reception manager;

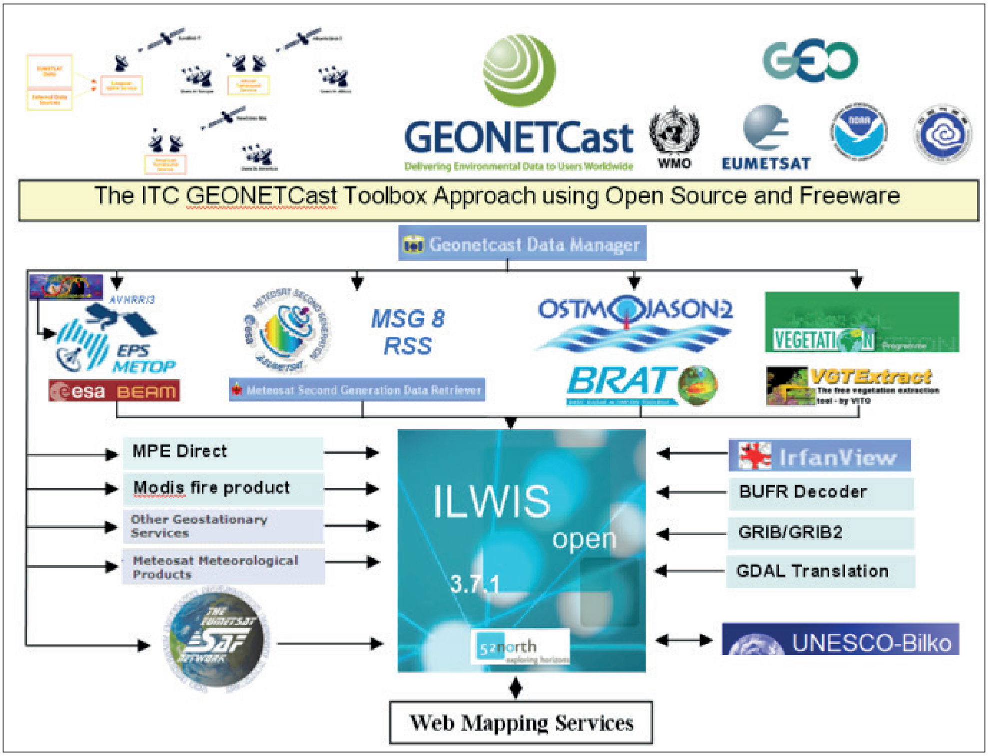

Fig. 2: Geonetcast Toolbox setup and key features

▫ *Near real-time image processing & applications*
- ILWIS Open v. 3.7 with full image analysis – GIS functionality with vector, raster, database, spatial modelling, visualization modules;
- Build-in Meteosat MSG data browser and retriever;
- Multiple data import and format routines (64) i. e. BUFR, GRIB, netCDF, GeoTIFF, NAS, HDF and other formats using Open GDAL geospatial data library libraries routines and freeware tools;
- Toolbox sample library (with processing and example application development routines);

▫ *Visualization and web-based services*
- Web-based client/server model using HTML and XML languages;
- WMS or web mapping services client.

For an overview of the standard ILWIS remote sensing and GIS functionality, we refer to [4] and the 52 north.org (www.52north.org) website for download and information. This geospatial analysis software combines image processing with raster and vector data processing, using a high geo referencing accuracy and contains extended projection and data format exchange libraries. New versions (v. 3.6 and higher) have a modular setup, permitting advanced users to create and add own plug-ins like additional processing capabilities, model couplings, etc.

HYDROLOGICAL AND ENVIRONMENTAL APPLICATION EXAMPLES

Hereunder, we highlight some water resources and environmental examples. ILWIS Open contains hydrological functionality permitting to use satellite observations and data for monitoring and management of water resources. Its geographic data handling permits to combine spatial and hydrological analysis. This permits to address spatial scales ranging from very small regions of interest, to large river basins or global area mapping.

▫ WEATHER AND RAINFALL

An example of direct satellite data import for hydro meteorological purposes are Meteosat second generation (MSG) data and derived weather and hydrological products.

Figures 3 a and 3 b illustrate the processing of MSG data (2011–03–13 1200 UTC) for the Balkan and Black sea region with Fig. 3 a, the HRV high resolution visible 1 km channel and Fig. 3 b, a daytime false colour image after resampling of the 2 VIS and NIR MSG 3 km resolution bands from the geostationary MSG projection to a UTM projection – 1 km resolution using the Ilwis Open GEONETCast Toolbox MSG data retriever (automated processing). Several atmospheric products as well as land surface and land cover products can be obtained from the 12-channel SEVIRI sensor on-board the MSG.

Hydrological products of satellites are for example satellite rainfall estimates, using algorithms which may be combined with ground observations (level 3 products). Figure 4 shows the MSGMPE or multi sensor 24-hour precipitation estimate from MSG, for March, 13. 2011. and derived from the geostationary MSG ther-

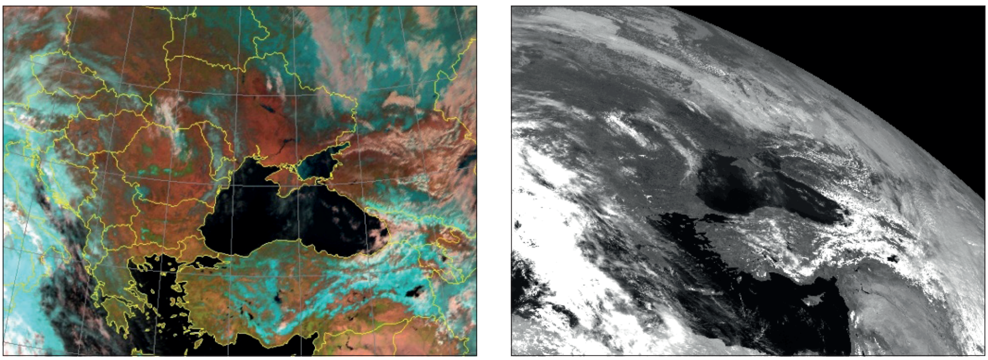

Fig. 3 a and 3 b: MSG images of Balkan and Black Sea region on March, 13. 2011. 1200 UTC

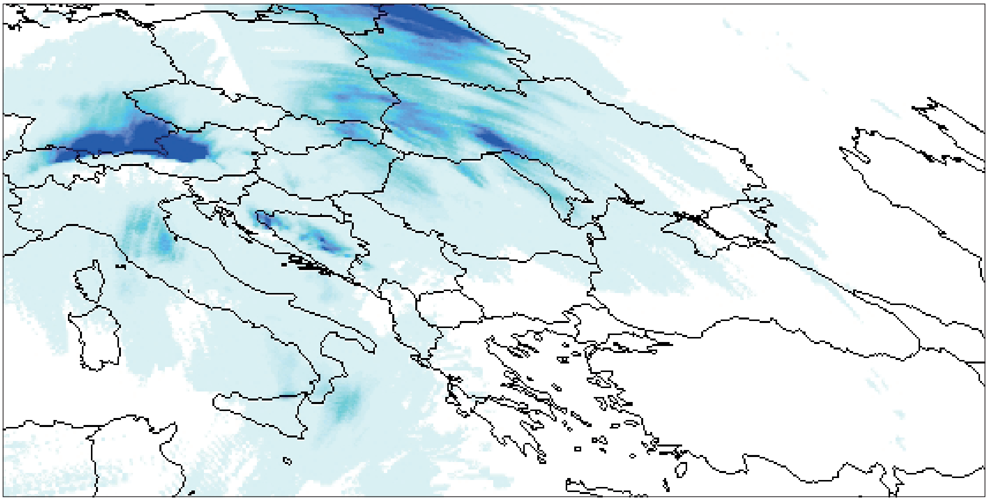

Fig. 4: MSG Multisensor precipitation estimate (24-hour total) of Balkan region for March, 13. 2011, illustrating large rainfall amounts on the northern slopes of the Alps during that day.

mal (10.8 μm) channel in combination with the TMI Microwave imager on-board the DMSP constellation [5].

This satellite precipitation estimate, available at 15-minutes intervals or frequency, permits to monitor well the spatial and temporal distribution of precipitation intensities, as shown by Figure 4, indicating very high rainfall on the northern slopes of the Alps (Swiss, Southern Germany and Austria), a hydro meteorological phenomena with high potential hydrological impacts such as high river discharges and local or regional flooding in e. g. the Danube river basin.

▫ DIGITAL TOPOGRAPHY AND RIVER BASIN GEOMORPHOMETRY

The digital elevation or DEM Hydro-processing module for automated hydrological network analysis and hydrological basin parameterization is available in ILWIS (Fig. 5). The drainage network extraction routine has advanced and multiple options and permits to delineate river networks in very flat floodplain areas or depressions, a known problem issue of concern in much other available software for automated basin delineation [6]. DTM generated basins and parameters can then be coupled to rainfall – runoff models, using geomorphologic information like e. g. GIUH (geomorphic instantaneous unit hydrograph) approaches to generate peak discharges and stream flow estimates at basin outlets [8].

▫ EVAPOTRANSPIRATION USING SURFACE ENERGY EXCHANGES AND BALANCE

Another hydrological feature included in Ilwis Open modular system is the SEBS plug-in, giving users the ability to perform semi-automated satellite-based

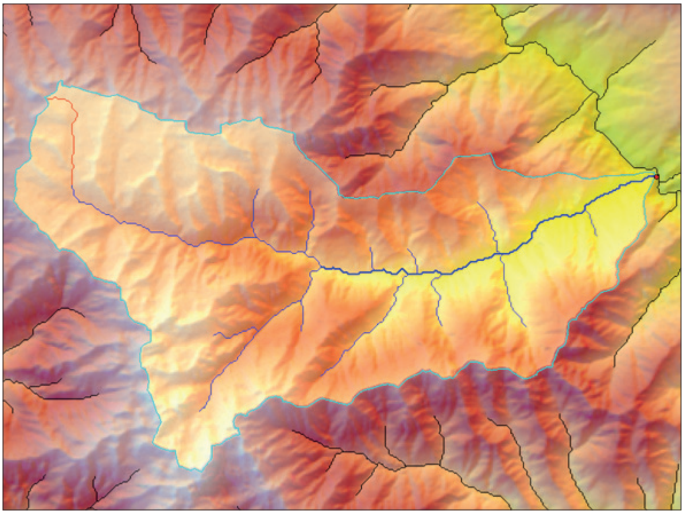

Fig. 5: DEM Hydro-processing module in ILWIS

computations of evapotranspiration using the surface energy balance method [9]. The SEBS algorithm can be implemented, using a variety of satellite source data (e. g. MODIS, ASTER, MSG, NOAA and other), pending on availability, user preference and scale of observation. The modelling system permits to generate daily (or even sub-daily using geostationary orbits) estimates as shown in Figure 6, illustrating the use of MSG and limited ground data to estimate daily evapotranspiration fields (3 km – 24 hr) over the Zambezi river basin [9].

Several more options for retrieval of satellite, in situ data and analysis of hydrological phenomena are available under ILWIS Open. New open plug-ins for cou-

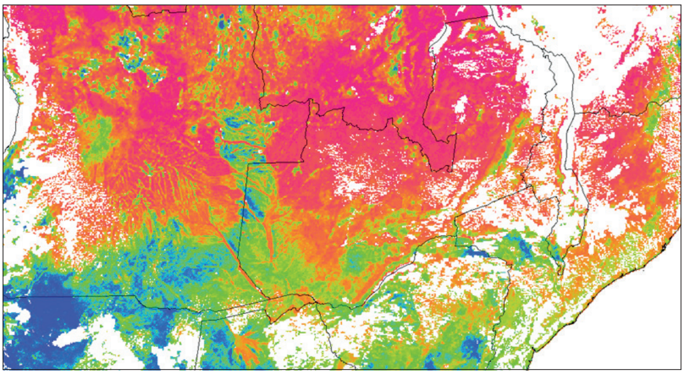

Figure 6: Estimate of daily evapotranspiration fluxes over the Zambezi river basin using Meteosat (MSG) satellite data, standard ground meteorological observations and the SEBS modular plug-in of ILWIS Open

pling of hydrological models to satellite and *in situ* data are under continuous development. As such, the Integrated Land and Water Information System is supporting the water resources community and users to generate and analyse satellite data-driven near real-time scenarios in river basins and forecast or predict changes or environmental risks more soundly.

▫ WATER QUALITY MONITORING AND ASSESSMENT

Water quality monitoring from space platforms today is rapidly becoming a feasible EO service for environmental offices and management. The MERIS sensor onboard ENVISAT, as received by the ESA direct data dissemination system permits near real time (offset approx. 12 hours) monitoring of larger water systems, such as important lakes and coastal waters. Figure 7 illustrates a quick look of the October 06 2011 ENVISAT satellite overpass over the Balkan and central Mediterranean, as received by the ITC DDS. The large Skadar lake between Montenegro and Albania is easily detectable, and could be made subject of more detailed water quality and ecosystem analysis. Several water quality constituents can be retrieved from the imagery when using appropriate and validated image processing algorithms [7].

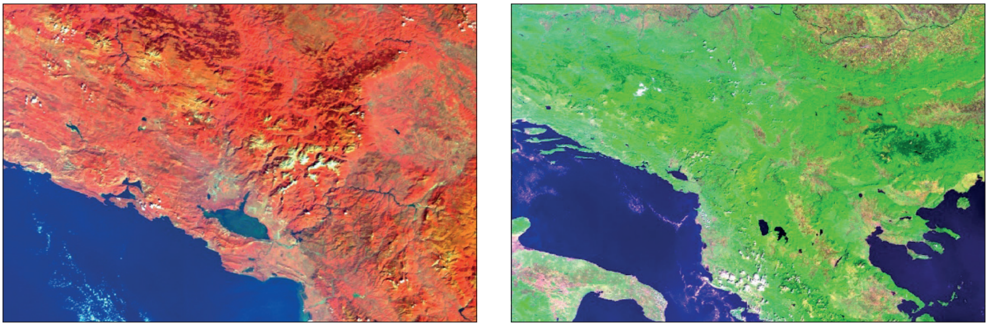

Fig. 7a and 7b: ENVISAT MERIS colour composites of Balkan region on October 06, 2011. showing potential for water quality retrieval and land cover application of Earth Observation data.

▫ LAND COVER MONITORING AND APPLICATIONS

Probably most use of satellites is still made for monitoring land cover and related land surface features. GEONETCast data streams contain multiple data sets, permitting direct mapping and medium resolution monitoring of vegetation cover and agricultural production (e. g. SPOT-VGT instrument), but also hazard and risk assessment and monitoring such as forest fire risk and monitoring using MODIS or MSG data streams. Figure 6 b is illustrative for this, as several land cover features can already directly be recognized on this simple direct MERIS colour composite.

CONCLUSIONS

This short overview of some GEONETCast and ESA-DDS satellite data streams, combined with open source geospatial analysis tools, can illustrate the direct application potentials of the system for research as well as for professional practice. For more information, we refer to other literature and web site [10]. ILWIS and the GEONETCast Toolbox are open source contributions, developed mainly at ITC, and available under 52 north. org, an initiative for Geospatial Open Source of ITC – University of Twente with the University of Munster (Germany) and other partners.

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