DEVCOCAST IN SUPPORT OF ENVIRONMENTAL MANAGEMENT AND SUSTAINABLE DEVELOPMENT IN AFRICA.

T. Jacobs[1], G. Borstlap[1], E. Bartholomé[2] and B. Maathuis[3]

1: VITO, Mol, Belgium
2: JRC, Ispra, Italy
3: ITC, Enschede, The Netherlands

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ABSTRACT:

The recently initiated project "GEONETCast for and by Developing Countries" (DevCoCast) project, supported by the 7th Framework Programme (FP7) of the European Community, will bring together many disparate sources of environmental information and improve the involvement of Developing Countries in the GEONETCast component of the global GEO System of Systems (GEOSS). Many Developing Countries are exposed to serious environmental risks and their need for adequate information is high. Unfortunately, reliable and continuous access to real time environmental information is often lacking. The GEONETCast concept overcomes existing data delivery limitations and is able to provide reliable and fast access to (near real-time) environmental information. The main objectives of the DevCoCast project are to disseminate existing environmental added-value datasets (both in-situ and satellite based) from various sources in Africa, South- and Central America and Europe in (near) real time and at no cost via GEONETCast to a broad range of user communities in Developing Countries. It furthermore promotes and supports the use of the GEONETCast system. By utilizing the existing EUMETCast dissemination system, supporting its expansion to the global scale, and taking direct benefit from the operational infrastructures as well as from well developed user bases in Africa and South-America, the main focus is directed towards the actual use of the data and building-maintaining capacity in Developing Countries.

1. INTRODUCTION

The operational production, distribution and the effective use of environmental, remote sensing and Earth Observation (EO) data is of enormous benefit to the African people and sustainable development. The European Commission (EC) intends to further promote the involvement of the developing countries in the Global Monitoring for Environment and Security (GMES) initiative, by ensuring their access to and use of EO data, especially from satellite measurement networks. The "Distribution of SPOT-VEGETATION data in Africa through EUMETCast" (VGT4Africa) project responded to this EC intention by setting up and maintaining an operational capacity for production as well as timely and free delivery of VEGETATION data from the SPOT satellites and high-level derived products to EO-experts in all African countries. Those experts were also given basic tools and support to extract valuable information from this data which helps their local policy makers in their decision making processes. To accomplish this, VGT4Africa built on a number of national, EC and ESA funded research projects, such as Cyclopes, Geoland, MARS-FOOD, GMFS and GLC2000 to name a few, and the success of the PUMA project, supported by the European Development Fund (EDF), that shared Meteosat Second Generation (MSG) data via the EUMETCast satellite-based broadcasting system operated by EUMETSAT. The African user community originally consisted of the national meteorological services in Africa that participated to the PUMA network. This user community expanded in VGT4Africa to include many national, regional and international institutions in over 20 African countries, all responsible for environmental monitoring and research and continues to grow further.

The main objectives of the VGT4Africa project were not only to provide environmental EO data to African experts, but also to enable them to work with the provided environmental information. This service is an important step to help African authorities and institutions in fulfilling their environmental monitoring and reporting obligations and in improving the management of their natural resources. The African users are achieving this by developing their own operational environmental monitoring services based on the exploitation of the data delivered through the above-mentioned system. For the production and delivery of the EO data products, selected from a catalogue of potential products by a user committee in 2005, a dedicated processing system was set up at VITO, Belgium. Using this system, two products, NDVI (Normalized Difference Vegetation Index) and NDWI (Normalized Difference Water Index), were operationally produced and delivered to the users via the EUMETCast satellite broadcasting system in the first year. Several other products, 9 in total with the 10th planned to be further integrated in late 2008 or early 2009, were added to the service in 2006, 2007 and early 2008 by VITO, the Joint Research Centre and MEDIAS-France, the 3 project partners. A comprehensive manual was written, covering all aspects from the Space platform down to the retrieval and use of the products (Bartholomé et al, 2006). As a fall-back scenario for the EUMETCast dissemination system, users can download products freely from the project website (http://www.vgt4africa.org) or request sets of historical data on DVD. To assist the African users in easily converting the data into the format they require and in clipping the geographical region of interest, VITO developed the VGTExtract software and provides it as freeware on the website. An increase in product usage and downloads by African organizations was observed over the last couple of years (Jacobs, 2008).

Several activities carry on where VGT4Africa left off. An example is the VGT@Work project that further trains African EO experts in the CILSS and SADC regions. It helps them to use the data in their applications and further bridges the gap between the African EO experts, targeted by VGT4Africa, and the African policy makers (figure 1). Geoland, the GMES Land Monitoring Core Service, will continue the data production, taking it to the global scale, and enhance the data. DevCoCast continues the distribution and capacity building, opening the system to Developing Countries in Asia and South America and, through EUMETCast, strengthening the build up of GEONETCast, one of the early achievements of the Global Earth Observation System of Systems (GEOSS). The African Union's African Monitoring of the Environment for Sustainable Development (AMESD) project, supported by EDF, will for instance maintain the existing EUMETCast receivers in Africa and install several more. The Joint Research Centre's "Africa, Caribbean and Pacific (ACP) Observatory for Sustainable Development" will work together with AMESD to enhance the decision support in Africa and Europe, through thematic analysis of VGT4Africa/Geoland and related data.

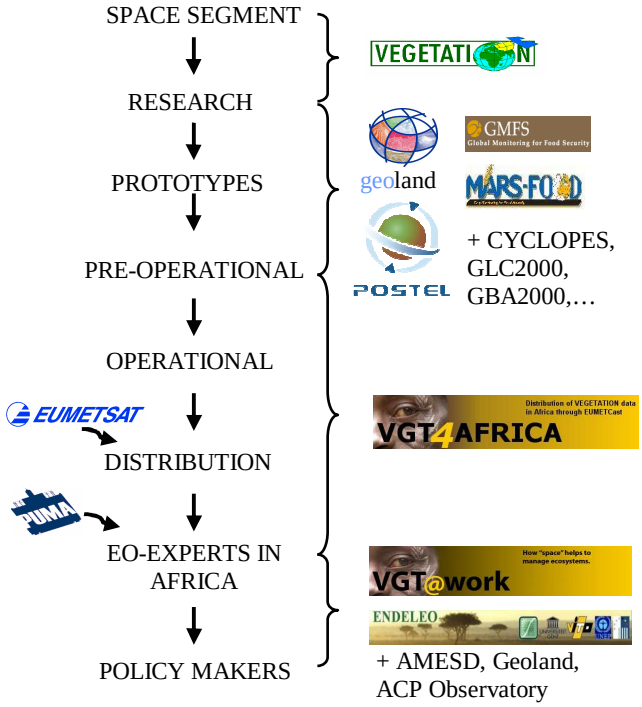

Figure 1: The VGT4Africa concept

2. GEONETCAST

Sustainable development requires coordinated, comprehensive and sustained Earth Observation for early warning, informed policies and effective decision making. In support of this objective the Group on Earth Observation (GEO) is leading a worldwide effort to build a Global Earth Observation System of Systems (GEOSS), providing Earth Observations from a multitude of instruments worldwide. These Earth Observation data (in-situ, air and space borne) and derived products are (re-) distributed via GEONETCast to a broad range of user communities. Satellite, in-situ data and products are transmitted via GEONETCast to users through communication satellites using a multicast, access controlled, broadband capability (http://www.earthobservations.org/geonetcast.shtml).

Therefore GEONETCast, bringing together the many disparate sources of environmental information, has a significant potential to enhance access to a wide range of information to users who may not previously have had access to these resources. This low cost, global, environmental information delivery system currently operates the European, African and American services through EUMETCast (operated by EUMETSAT) and successful tests have been conducted to cover the Asia-Pacific region recently by means of FengYunCast (operated by the Chinese Meteorological Agency). A new system for the Americas, operated by NOAA, is being tested as well.

This GEONETCast effort will ensure global coverage in the near future. The data stream transmitted by these communication satellites can be received using a simple and cheap ground reception infrastructure. The distributed data and images now not only serve the Meteorological community (as in PUMA) and the environmental land-application community (as in VGT4Africa and AMESD), but are becoming an important data source to a wide variety of users from various communities, including also marine, atmosphere and climate, that deal with environmental analysis. Sensor improvements, especially spatial and temporal resolutions, the (favourable) data distribution policy and the way the data are obtained by the user community are to be attributed in this respect. With the ongoing development of GEONETCast, broadcasting (globally) a multitude of satellite observations and associated products in conjunction with cheap ground receiving infrastructure, the data is now at the doorstep of the user community anywhere in the world, even in areas with limited to no internet access.

More organizations are going to provide data and services to GEONETCast, e.g. China (FengYun 1D/FengYun 2C) and Russia (by means of MITRA). Primarily satellite based meteorological data will be provided, but both countries anticipate that in the future next to satellite observations also airborne and in-situ data will be disseminated. Currently NOAA is actively developing the GEONETCast-Americas capability. Next to ongoing and continued provision of environmental products like those from Vegetation for Africa initiative, it is also expected that more data and product providers will join in the near future, e.g. the CBERS initiative (http://www.cbers.inpe.br) to provide medium resolution satellite data for Africa as announced at the GEO-IV and Ministerial Summit in Cape Town (November 2007) and data processed by SERVIR (http://www.servir.net) for Central America, just to name a few. The data distributed are highly relevant with respect to e.g. environmental monitoring and provide meaningful information to assess flood, drought and agricultural conditions, all of which are currently major challenges in many regions around the world, especially in Africa.

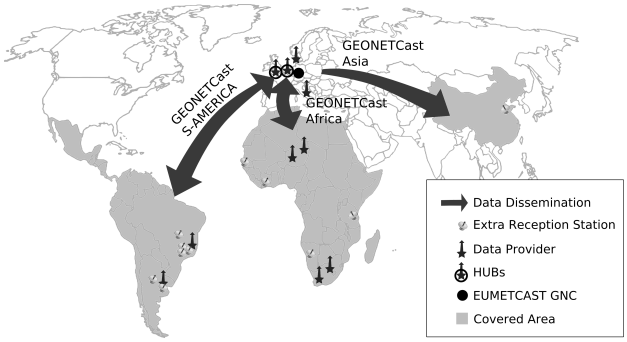

Figure 2: Overview of DevCoCast

3. DEVCOCAST

The recently initiated, 3-year "GEONETCast for and by Developing Countries" project (DevCoCast, 7th Framework Programme) will supply existing, added value environmental data sets from various sources in Africa, South America, and Europe to a broad user community in Developing Countries using EUMETCast. It will help build up GEONETCast GEONETCast through a pilot for data-exchange between EUMETCast and FengYunCast over Asia and by building up additional satellite receivers in Africa (3), South America (6) and China (1), effectively extending the impact and user community. It will open up GEONETCast to additional data providers, even in Developing Countries, through central GEONETCast access nodes for land and marine application data. These access nodes will prioritize the provided data before sending it to the central GEONETCast Networking Centre operated by EUMETSAT, for the satellite dissemination. Figure 2 gives an overview of the different DevCoCast components.

3.1 Provided data

Over 50 different data products, from at least 10 different providers, are to be disseminated, that cover many environmental themes and all of the GEO societal benefit areas. For this reason, an effort is made to assess the quality of the various provided data products and to encourage harmonization efforts, following international interoperability standards. At the same time the costs are kept at a minimum by re-using and extending existing EUMETCast and data production infrastructure, improving existing training materials and relying on existing projects and partnerships such as VGT4Africa, GEOLAND, ChloroGIN, MERSEA, GOOS and YEOS. The ultimate goal is to introduce and embed the information spread via GEONETCast in a systematic way into research, planning and decision making processes and environmental monitoring systems, to improve sustainable development and management of natural resources.

3.2 Capacity building

Even more so than in VGT4Africa, strong focus is put on outreach, direct user support and building human and technical capacity to use GEONETCast. Examples are the organization of 9 international training sessions, including 4 workshops on land applications (at regional centres) and 2 workshops on marine applications (together with at least 3 Large Marine Ecosystem Monitoring services), all in Africa, and a 2 week in depth training at ITC. These trainings are provided by institutions with significant training experience and will be linked to existing training networks, including those from EUMETSAT and AMESD, for cross-fertilization.

A central help desk, linking to the help desks of the various data providers, and stand-alone, on-distance training packages will be provided to support users in the installation of additional receivers and in the integration of the provided data into their everyday applications and in local networking and training activities. More so, several user organizations are participating in the project and are thus directly supported to not only build up a receiving station, but to also take up the data into their already existing applications and decision support systems and to share their experiences in their local networks.

3.3 GEONETCast toolbox - a first effort

The EUMETCast and future GEONETCast data streams already offers a multitude of data from different providers and intended for different user communities and societal benefit areas, each facing their own challenges. With the advent of additional products and users, the challenge to efficiently handle this data variety becomes even more pressing. To address this challenge, the providers are engaging in harmonization activities, but this is not enough. The users also require a set of, preferably free or open source, tools which transform the data stream into information which in turn can support the local, national and regional decision making processes and various other research applications.

Apart from the before mentioned VGTExtract program, part of VITO's open source Vegetation Image Processing (VIP) toolbox (http://www.vgt.vito.be/VIPToolbox/index.htm), and other programs such as the Joint Research Centre's Spada application, a more comprehensive GEONETCast toolbox development effort was initiated at ITC. This GEONETCast toolbox is to provide an overall low-cost and flexible alternative to retrieve regular data and products relevant to a broad range of environmental and hydrological applications by non-meteorological organizations in less developed countries dealing with geo-spatial temporal data analysis. Bartholomé et al (2006) and Jacobs et al (2007) describe how to configure a EUMETCast or PUMA receiver for reception of VGT4Africa data and how to use the VGTExtract software and both documents are to be updated as part of DevCoCast activities. Maathuis et al (2006) provides a description to setup and operate a low-cost EUMETCast ground receiving station, using a C-band configuration, relevant for Africa, as well as an initial set of software tools developed that originally focused on Meteosat Second Generation HRIT data, but was later extended to handle also the VGT4Africa data.

A new GEONETCast Data Manager tool was developed which is capable of effectively handling the large volume of incoming data and stores the various data types in a structured way using an interface that can be easily adapted by the user. Data can be deleted upon reception, stored for a user defined period (e.g. one day or continuous), only retaining selected data segments or times per day. Figure 3 gives an example of a menu covering the full range of EUMETCast data and products. New products or data can be easily added as shown by the DevCoCast and Jason-2 tabs, making the tool suitable for the handling the future GEONETCast data stream as well.

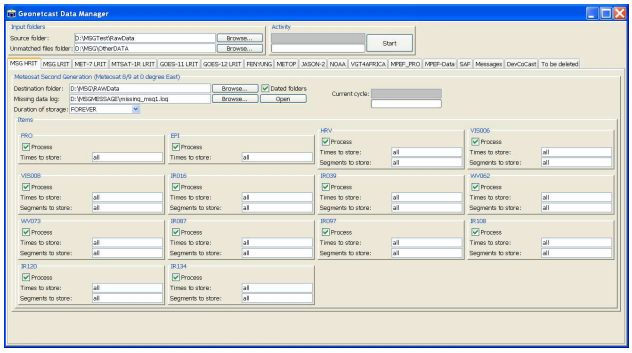

Figure 3: GEONETCast Data Manager

Having stored the relevant data for the user, the toolbox functionality further provides new import and processing routines (Maathuis et al 2008A/B) to incorporate a variety of basic environmental data of various formats for further spatial and temporal analysis into a Geographic Information System software (GIS). The supported data formats include most of those currently used in the EUMETCast data stream, including high and low rate MSG data formats, the GRIB format of the Meteorological Product Extraction Facility (MPEF) data, the HDF5 format of the Satellite Application Facilities (SAF) data and the HDF4 format of the VGT4Africa products (see also figure 4).

- Geonetcast Toolbox
  - DevCoCast Products
    - Land Products
    - Ocean Products
  - Geonetcast Data Manager
    - Geonetcast Data Manager
  - Geostationary
    - MSG HRIT
    - LRIT Fenyung
    - LRIT GOES EAST
    - LRIT GOES WEST
    - LRIT MET7
    - LRIT MSG
    - LRIT MTSAT-1R
    - LRIT TIR Composite
  - Jason-2
  - MPE Direct
    - MET7-based
    - MSG-based
  - MPEF
    - MPEF AMV
    - MPEF CLAI
    - MPEF CLM
    - MPEF CTH
    - MPEF FIRA
    - MPEF GII
    - MPEF MPEG
  - MSG Satellite and Solar Zenith / Azimuth Angles
    - Satellite and Solar Zenith / Azimuth Angles
  - Polar Orbitting
    - Polar Orbitting METOP AVHRR/3
    - Polar Orbitting NOAA AVHRR/3 GAC
  - Real Time MSG Visualization and Animation
  - SAF
    - SAF Albedo
    - SAF LST
    - SAF SST MSG-GOES Combined
  - SPOT Vegetation
    - SPOT Vegetation DMP
    - SPOT Vegetation NDVI
    - SPOT Vegetation NDWI
    - SPOT Vegetation PHENOKS
    - SPOT Vegetation PHENOMAX
    - SPOT Vegetation SWB
    - SPOT Vegetation VPI
  - Toolbox Settings and Export

Figure 4: GEONETCast Toolbox Menu in ILWIS 3.5 Open

The MSG HRIT Data Retriever uses the MSG Level 1.5 data product format and can therefore also be used in conjunction with data obtained directly from the EUMETSAT Archive. In the menu of the MSG Data Retriever different options can be selected to handle the pre-processing and radiometric - geometric conversions. Low Rate Image Transmission data (LRIT) in the GEONETCast data stream, for instance from GOES-West, GOES-East, MSG, Meteosat-7 and MTSAT-1R, can be imported as well. The radiometry of GOES is handled in order to convert the respective spectral channels to albedo and temperature. First the data is decompressed, the segments of the images are glued together and the 10 bit data of GOES is transformed to 16 bit prior to import. Importing, stretching and re-sampling of the LRIT Thermal Infrared bands of the geostationary satellites allows to create and visualize a global, thermal composite image.

A GRIB/GRIB2 decoder was added to the Geospatial Data Abstraction Library (GDAL) (http://www.gdal.org), an open source translation library for raster geospatial data formats also used for HRIT data format exchange - import routines described above. Simple batch routines have been developed to import common products such as the Cloud Mask, Cloud Top Height, Cloud Analysis Image, all imported from their original GRIB format. The individual data segments of these products received via GEONETCast are first merged together to obtain a single file (using a tool called joinMSG) and are subsequently imported. The MPEF GRIB based products are re-assigned to their respective class or value.

Cipher BUFR decoding (http://www.northern-lighthouse.com) is used to handle the BUFR encoded products, such as the various Global Instability Indices (K-index, KO-index, Lifted index and amount of Precipitable Water) and Atmospheric Motion Vectors.
The 15-minute Fire Product (FIR-A, available as an plain text table) can also be imported in ILWIS, by deleting the original header lines to generate a plain text (ASCII) file consisting only of space delimited columns.

HDF4 and HDF5 import routines are available to import some of the VGT4Africa and Satellite Application Facility products, e.g. Albedo and Land Surface Temperature from Land Surface Application SAF (LSA-SAF). For these SAF data, the two African windows are imported and glued to cover the whole continent, while dealing with geometry and data conversion into appropriate unit during the import.

For these procedures, the Integrated Land and Water Information System (ILWIS) software, available as open source, is operated from the command prompt using the ILWISClient utility. This allows users to create batch routines that can loop over the received data and can be scheduled to run at regular intervals to handle import, (pre-)processing and, if desired, (near real time) visualization, in an automated manner. For the visualization, several geographical windows can be selected, eventually fusing the MSG-HRV channel with the low resolution channels (VIS006, VIS008 and IR_016). Having efficiently imported and (pre-)processed the data, further analysis is possible using the generic GIS, Remote Sensing and (time-series) calculation capability of ILWIS 3.5 Open for their different applications. This new ILWIS version furthermore includes additional, improved tools to assist in multi temporal data analysis and for the computation of solar and MSG satellite azimuth / zenith angles.

After further testing the GEONETCast toolbox will become available as a plug-in of the new ILWIS 3.5 Open release. As more data-information will become available through EUMETCast and GEONETCast, it is anticipated that more import and pre-processing routines will be developed in due course (METOP, NOAA GAC, etc) and released.

4. CONCLUSIONS

Within the DevCoCast project, further expansion of the EUMETCast and GEONETCast receiving capability in Developing Countries is foreseen by (i) supporting the build up of additional receivers in Africa and South America, (ii) the production and dissemination of several, relevant land and ocean products by the partners involved in the project (also from Developing Countries themselves) and (iii) testing the data-exchange between EUMETCast and FengYunCast.

A lot of effort will also go towards building the human capacity, by further supporting the actual use of the provided data through several training workshops, outreach and distance education training material, developments of free tools and a central help desk. Some partners will also integrate the received data into their applications and share their experiences through local capacity building and networking.

The ambitions of the project are (i) to further expand the user community, (ii) to strengthen GEONETCast and in particular the involvement of Developing Countries therein and (iii) to have relevant, environmental information, broadcasted through EUMETCast and GEONETCast, embedded in a systematic manner into reporting systems in support of research, planning and decision making processes. This effort will enable authorities in Developing Countries in fulfilling their increasing monitoring and reporting obligations and help them to better manage their natural resources through their sustainable development policies.

Using off-the-shelf equipment to set up a receiving station, in conjunction with large amounts of provided data and the free tools described above, provides a low-cost, essential, sustainable basis for actual use of the data in Developing Countries.

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Remark: all web addresses presented in the article have been accessed during the last week of June 2008.