

POSTEL, an initiative to develop biogeophysical geocoded products

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Abstract

Researchers need tailored data which would save them time-consuming and costly pre-processing. POSTEL is a tentative answer in the field of biogeophysical geocoded information derived from space observation. Here are described the context of this initiative, the POSTEL structure, the projects involved, and the products and services it offers.

Key Words

Earth observation – biogeophysical data – geocoded data – land surfaces – remote sensing

Scope

All over the world, researchers and scientists rely on a considerable amount of information to lead their work. They often face the issue of having to pre-process raw data, which, besides being time-consuming and expensive, is definitely not their job. What they actually require are tailored, ready-to-use data.

POSTEL is a tentative answer in the domain of biogeophysical geocoded information at global and regional scales. This programme is meant to provide scientists with relevant products and information, while saving as much time and manpower as possible regarding data handling and pre-processing irrelevant to their scope of research. The goal of this project is to derive, from wide-swath satellites, various biophysical parameters related to surface lands. Using several space-based systems allows to reasonably eradicate instrumental biases due to the specific viewing modes, while benefiting by the extensive range of observations currently available.

POSTEL is therefore fit to supply the scientific and operational communities with products duly referenced in terms of description and accuracy.

Background

In 1998, a Working Group involving the French Space Agency (CNES) and scientific research centres was created to define a medium-term framework for the management of geoscience-related data and information. Its report issued in 1999 brought key recommendations, namely:

- To initiate a close cooperation between the Space Agency and scientific organisations,
- To set up “thematic excellence units” to serve the national and international scientific community.

The aim of these units is to federate scientific expertise and to pool the means to be implemented in order to generate enhanced products derived from satellite data. Within these centres, study results are bound to be developed and adapted to be made operational to users by creating prototypes of services. These thematic units will thus become the precursor elements of the future services of the GMES (Global Monitoring for the Environment and Security) European programme by 2008-2010.

They are expected to fulfil a dual mission:

- Comprehensively processing and managing data (including collecting, receiving, processing – and if need be, re-processing – raw data; archiving and distributing data and products; providing, updating and maintaining software);
- Bringing scientific expertise, by defining products and algorithms, validating and calibrating processing chains, and exploiting information from a scientific standpoint (modelling, assimilating...).

Four core thematic excellence units are under development:

- ETHER, regarding atmospheric chemistry,
- ICARE, regarding aerosols,
- SALTO and CORIOLIS, regarding dynamic oceanography, and
- POSTEL, regarding continental surfaces, which is the subject of the present article.

POSTEL objectives: a challenge

Regarding the “Continental surfaces” theme, POSTEL (Pôle d’Observation des Surfaces continentales par TELédétection¹) is the French enterprise to be integrated into the future GMES services that are being defined through projects financed by the European Space Agency and the European Commission. POSTEL develops, validates, produces and distributes biogeophysical products related to land surfaces and acquired through space observation. It aims at servicing the whole relevant international community with products from regional to global scales, on a long-term timescale (depending on data availability).

Let us recall that Earth observation from space hinges on observational conditions: atmospheric effects, viewing angles, local time, bandwidth, etc... Signals as well are heavily dependent on ground conditions. Interactions between heterogeneous grounds and electromagnetic wavelengths are indeed a complex issue, and lots of parameters mix up before we are able to extract biophysical information of interest from remotely sensed data. Accurate and reliable scientific results cannot be obtained without accurate and reliable retrieval techniques. POSTEL is therefore a scientific challenge in itself; its worth towards “downstream” users relies on the great number of sources it uses and the many independent peer expertises it involves.

POSTEL structure

The thematic expertise unit brings into play three types of bodies:

- a Core Service for biogeophysical Parameters (CSP). Its mission consists in supplying a set of technical assistance and mutual services allowing the users’ community to make the most of the data and products collected by space missions and related to the “Continental surfaces” theme.

¹ Observation of continental surfaces through remote sensing.

- upstream from the CSP, Scientific Expertise Centres. Expertise Centres are laboratories or research organisations that contribute to define space missions and to design and validate derived products. Such Expertise Centres manage all the scientific activities related to the thematic unit.
- downstream from the CSP, the users' community worldwide, namely scientists engaged in multidisciplinary studies on continental surfaces and on the role of these surfaces in the carbon, water and energy cycles. Specific GMES operational services tackle the carbon cycle and climate, food security management, and the monitoring of land use change.

The CSP fulfils two functions:

- a developing function, i.e. setting up scientific processing chains and software for the analysis of remotely sensed data, in accordance with the specifications defined and validated by the relevant scientific Expertise Centres;
- an operating function, i.e. generating, archiving and circulating products derived from space missions.

At the beginning of 2002, the MEDIAS-France public organisation was commissioned to design and implement a prototype of CSP and its upstream and downstream interfaces.

The bodies acknowledged as Expertise Centres are laboratories or public organisations that are engaged in the development of products delivered by the CSP. They supply algorithm specifications and/or data allowing to validate the products, within the scope of opportunity projects named "precursor projects".

POSTEL project portfolio

It should first be remembered that POSTEL is a work in progress. This paper presents the 'state-of-art' beginning of 2005. Other products may and should follow, depending both upon the users' demand and the sponsoring processes from various stakeholders.

The projects in which POSTEL is committed belong to three categories; they are accordingly briefly described hereunder:

R&D projects

CYCLOPES (2003-2005)

CYCLOPES (**C**arbon **c**Ycle and **C**hange in **L**and **O**bservational **P**roducts from an **E**nsemble of **S**atellites) is a project led by INRA Avignon (France), which is co-funded by the Directorate-General for Research of the European Commission (within the 5th Framework Programme), the Terre & Espace network, the Midi-Pyrenees Region and the French Space Agency (CNES).

The aim of CYCLOPES is to develop and validate biophysical products (albedo, LAI, FAPAR, vegetation cover) derived from wide-swath sensors (AVHRR, VEGETATION, POLDER, MERIS). The algorithms used merge the available simultaneous observations; they are designed to supply continuous long-term series.

CYCLOPES products are the global fields of these variables and their associated uncertainties over the period 1997-2003, with a 1-8 km and 10-day spatio-temporal resolution. The use of these products is demonstrated within the framework of two important applications related to climate change:

- detecting and categorising land use changes,

- assessing carbon fluxes in order to improve the description and understanding of vegetation-atmosphere interactions.
- A production cycle is planned every six months, each cycle improving the algorithms and spatio-temporal coverage of the variables obtained.

AMMA (2004-2009)

The AMMA (African Monsoon Multi-disciplinary Analyses) integrated project lies within the scope of the EU 6th Framework Programme. Its consortium gathers a number of European and African institutes and organisations.

Its purpose is to describe surface evolution over the last 50 years while distinguishing between anthropogenic and climatic forcing, and to study the possible impact of this evolution on monsoon. It will especially improve knowledge on the West African Monsoon and its variability from daily to inter-annual timescales.

POSTEL serves as a gateway to the AMMA project and its AMMASAT component, regarding low-resolution continental surface products at the West African and whole African scales, over the period 2004-2007 and beyond. Its products, that are derived from EUMETSAT/SAF, are intended to hydrologists, ecology experts, and atmosphere scientists.

VALERI (2002-2007)

The VALERI (VALidation of Land European Remote sensing Instrument) project is funded by the French Space Agency (CNES); it involves various universities and research institutes worldwide (Bolivia, Finland, France, Mexico, Spain, etc...).

The objectives of the project are to assess the absolute accuracy of biophysical products (LAI, FAPAR, FCOVER) acquired from wide-swath sensors (e.g. AVHRR, POLDER, VEGETATION, etc...) using a range of possible algorithms, and to inter-compare the products derived from different sensors and algorithms. Validation is performed *in-situ* through a network of sites distributed over the Earth surface.

By combining algorithms, data concurrently collected from various sensors, and ground-level measurements, VALERI allows to obtain enhanced biophysical products (LAI, FCOVER) with improved performances and reliability.

GMES pre-operational projects

Geoland (2004-2006)

The Geoland project, launched within the scope of the 6th Framework Programme, is the backbone of GMES-related operational services. The Geoland/CSP activity that started at the beginning of 2004 is jointly led by CNRM (France), NOVELTIS (France), Institute of Meteorology (Portugal), the University of Karlsruhe (Germany), VITO (Belgium), EARS (Netherlands), the Technical University of Vienna (Austria), the University of Bonn (Germany) and MEDIAS-France. Geoland gathers 56 partners from 15 European countries.

It plans to prove the pre-operational capacities of two Core Services (the first one on land cover, the second one on biogeophysical parameters) and of six downstream services (Observatories). The latter are divided into three regional (European) services and three global services. Geoland activities also include proposing scenarios for the implementation of operational services to be distributed over Europe after 2008.

The first two Core Services provide downstream services with the basic information they need. Land cover maps are designed at regional and national scales in the “Generic Land Cover” Core Service. These maps are used as reference for the activities of the three regional services whose goal is to support the application of European guidelines at the regional scale.

Global services concern natural carbon fluxes, crop monitoring and food security, land cover and forest global change. They aim at supporting the European policies and international conventions that require a continental to global scale environmental monitoring.

Geoland products include LAI, vegetation cover, water bodies, FAPAR, albedo, incoming radiance, land surface temperature and moisture, burnt areas, rainfall. Various optical and micro-wave sensors are used to that effect: VEGETATION, MERIS, METEOSAT, POLDER, AVHRR, ATSR, ERS/Scatt and AMSR.

As mentioned above, GEOLAND is an unique opportunity to make the POSTEL products on of the components of the future GMES Service Elements (GSE), a major initiative led by the European Commission and the ESA to supply the European and worldwide community of users with operational products for Environment and Security, thus strongly consolidating the framework in which they are developed, produced and distributed.

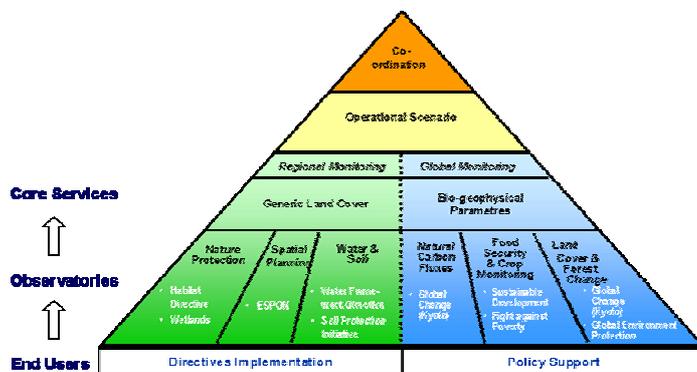


Fig. 1 - GEOLAND/POSTEL within the European GMES initiative

VGT4AFRICA (2005-2007)

This project of the EU 6th Framework Programme is exclusively focused on Africa.

It is intended to distribute data derived from the VEGETATION instrument onboard SPOT satellites. This is to be implemented through the PUMA network of meteorological stations that are being built up all over this continent. Satellite-broadcasting will use EUMETCast, the EUMETSAT telecommunication system.

Standard data as well as high-level products related to environmental monitoring are to be produced and timely delivered to end users in Africa. By the end of the project, a bunch of products should be disseminated over Africa.

Globcover (2005-2006)

The Globcover initiative falls within the scope of ESA Data User Element, i.e. the set of programmes for the development of Earth Observation applications led by the European Agency. Globcover is conducted by an international network of partners, including among others JRC, FAO, UNEP, IGBP, etc...

The aim of this project is to produce a global land-cover map by 2005, using as a main source fine resolution (300 m) data from the MERIS sensor onboard the ENVISAT satellite.

This new map will update and complement other existing global products of the same purpose, in particular thanks to its finer resolution (300 m versus 1 km).

Spatial projects

POLDER (2002-2007)

POLDER (**POL**arisation and **D**irectionality of the **E**arth **R**eflectances) instruments are wide-swath visible & near-infrared radiometers developed by the French Space Agency (CNES). These instruments were operated on the ADEOS-1 Japanese platform from November 1996 to June 1997, and on ADEOS-2 from April 2003 to October 2003. A third instrument is now flying on board the PARASOL micro-satellite.

The level-3 “Land Surface” processing chain reproduces the characteristics of continental surfaces based on data proceeding from POLDER sensors. The algorithm employed uses the Bi-directional Reflectance Distribution Function measured by POLDER to generate biophysical products such as albedo, LAI, and vegetation cover.

POSTEL tasks consist in setting up the operational configuration of the land surface level-3 algorithm chain, to deliver it to the POLDER Production Centre, to ensure computer and algorithmic servicing, and to check the products before distributing them to users. POLDER-derived products are described in the following section.

POSTEL products

POSTEL products originate from the projects in which POSTEL is committed. Consequently, their degree of availability depends on the progress of each individual project.

At the time being, POLDER-derived products are already at the disposal of the international scientific community, while CYCLOPES- and Geoland-derived products are available to the partners of their respective consortiums and should be made accessible to the international scientific community in July 2005 for the former, and by the end of 2006 for the latter.

Currently available products

The “Land surfaces” biophysical parameters derived from POLDER-1 data are the first components of the catalogue of POSTEL products. They include directional albedo, NDVI (Normalised Difference Vegetation Index), LAI (Leaf Area Index), FVC (Fraction of Vegetation Cover), FAPAR (Fraction of Absorbed Photosynthetically Active Radiation), with a 6-km / 10-day spatio-temporal resolution. The Bi-directional Reflectance Distribution Function (BRDF) is another product specific to POLDER which is now available.

Such products meet the needs of specific users. For instance, the BRDF database concerns those involved in measurement physics as it helps generate increasingly effective radiative transfer models. Albedo, LAI, FVC and FAPAR are essential for the modelling of water, energy and carbon exchanges at the ground-vegetation-atmosphere interface. They are aimed at scientists and institutes developing operational methods in hydrology, meteorology, climatology, carbon cycle, land use changes, food security and agricultural production.

BRDF database

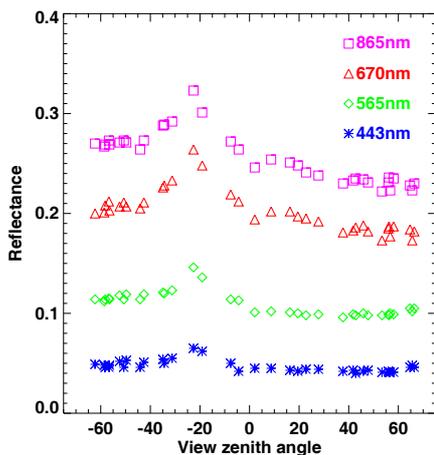


Fig. 2 - Section of a BRDF in the main plane

The Bi-directional Reflectance Distribution Function describes how the surface reflects the sun radiation according to the directions of light and observation. The main BRDF features are a peak of reflectance for back-scattering when the solar and viewing angles coincide, and a minimum reflectance for forward-scattering. POLDER-1 collected 22594 BRDF from November 1996 to June 1997. This database provides exclusive information on the anisotropy of the main continental biomes and their natural variability. It is consequently an exceptional product for many environmental studies, and a remarkable tool to test the performance of radiative transfer models.

Directional albedo and NDVI

The directional albedo shows the reflective power of the surface integrated on the set of zenithal and azimuthal viewing directions. It stems from the inversion of a BRDF linear semi-empirical model on the spectral bi-directional reflectances measured during the 30-day synthesis period. The short-wave directional albedo represents the wide band (250nm, 2500nm). It is computed by a linear combination of spectral directional albedos at 443nm, 670nm, 765nm and 865nm. The Normalised Difference Vegetation Index derived from the spectral directional albedos at 670nm and 865nm is thus corrected from angular effects. Its temporal evolution is then linked only to changes in the surface state.

LAI, FVC and FAPAR

The Leaf Area Index represents the quantity of leaves that intercept the sun radiation while the Fraction of Vegetation Cover quantifies the share of surface covered with vegetation. These parameters proceed from the inversion of a model of radiative transfer through neural network. The daily Fraction of Absorbed Photosynthetically Active Radiation is assessed by a linear relation with a vegetation index computed in the optimum angular configuration to minimise ground contribution.

Albedo, NDVI, LAI, FVC and FAPAR evidence the different continental biomes, their area, their transitions and their spatial heterogeneity. The temporal evolution of parameters at a 10-day resolution shows for instance natural seasonal variations, the consequences of extreme climatic events, or man-induced damage suffered by ecosystems.

The table hereunder lists POSTEL products according to their field of interest:

Product	Parameter	Space Coverage	Time Coverage	Space Resolution	Time Resolution	Sensor
Vegetation	LAI	Continent to Global	1998 - 2003	1 km	1 day	VEGETATION POLDER AVHRR MERIS
	Fcover			to	to	
	FAPAR			to	to	
	Burnt Area			to	to	
	Surface Reflectance			to	to	
	BRDF	to	to			
	Land Cover	Global	2005	300 m		MERIS
Radiation	Surface Albedo	Continent	1998 - 2003	1 km	½ hour	METEOSAT GOES - GMS VEGETATION AVHRR
	Downwelling Shortwave radiation	To		to	to	
	Downwelling Longwave Radiation	Global		to	to	
	Land Surface Temperature	Global		50 km	10 days	
Water	Precipitation	Continent	1992 - 2004	1 km	1 day	METEOSAT ERS/Scatt AMSR VEGETATION
	Soil Moisture	To		to	to	
	Evapotranspiration	Global		to	to	
	Water Bodies	Global		1°	10 days	

Table 1- POSTEL products.

POSTEL tools and services

POSTEL also aims at providing tools that make the use of its products easier. Developments are performed in co-operation with Expertise Centres and have to meet the requirements expressed by users. A practical application of this concept is for instance the availability on the POSTEL website of a tool designed to display BRDF and allow model inversion and comparison of results with measurements.

Assistance to users is materialised in concrete terms by the implementation of specific actions, such as the extraction of BRDF in selected sites to be used as references in studies on radiative transfer, or the formatting of biophysical parameters (change of projection and of spatial resolution, extraction of areas) to meet particular specifications.

Conclusion

By its extent, its various features, and the wide range of issues it faces, Northern Eurasia requires extensive scientific studies and monitoring. Among them, the Siberia Integrated Regional Study (SIRS) and the Northern Eurasia Integrated Regional Study (NEIRS) initiatives will contribute to enhance research on this part of the world.

These studies have to resort to remote sensing, as a unique tool providing timely access to information. However, raw data need to be processed in a scientifically assessed way to deliver useful information at the required scales. Thanks to its validated processed products, POSTEL brings most of the relevant answers, and could thus be profitably used within the scope of the above mentioned research.

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