geoland2 – Towards an operational GMES Land Monitoring Core Service: the Biogeophysical Parameter Core Mapping Service

R. Lacaze [a], F. Baret [b], F. Camacho [c], R. d'Andrimont [d], S. C. Freitas [e], P. Pacholczyk [f], H. Poilvé [g], B. Smets [h], K. Tansey [i], W. Wagner [j], J.-C. Calvet [k], G. Balsamo [l], R. Kidd [j], H. Makhmara [f], M. Weiss [b], A. Bradley [i]

[a] HYGEOS, Cesbio Bpi 2108,18 avenue E. Belin, 31401 Toulouse Cedex 9, France - rl@hygeos.com
[b] INRA, EMMAH UMR1114, site Agroparc, 84914 Avignon, France – (baret, weiss)@avignon.inra.fr
[c] EOLAB, G.V. Marques del Turia, 20-9, 46 005 Valencia, Spain – camacho@eolab.es
[d] Université Catholique de Louvain, 2/16 Croix du sud, B1348 Louvain-la-Neuve, Belgium – raphael.dandrimont@uclouvain.be
[e] IM Portugal, Rua Cao Aeroporto de Lisboa, 1749-077 Lisboa, Portugal – sandra.coelho@meteo.pt
[f] CNES, 18 av. E. Belin, 31 401 Toulouse Cedex, France- (hassan.makhmara, philippe.pacholczyk)@cnes.fr
[g] SpotImage SA, 15 avenue de l'Europe, 31 522 Ramonville Ste-Agne, France – herve.poilve@infoterra.fr
[h] VITO, Boeretang 200, 2400 Mol, Belgium – Bruno.smets@vito.be
[i] University of Leicester, LE1 7RH, Leicester, United Kingdom – kevin.tansey@le.ac.uk
[j] Vienna University of Technology, Gusshausstrass 27-29/122, 1040 Vienna, Austria – (rk, ww)@ipf.tuwien.ac.at
[k] CNRM/Météo-France, 42 avenue G. Coriolis, 31057 Toulouse Cedex, France – calvet@meteo.fr
[l] ECMWF, Shinfield Park, Reading, Berks, United Kingdom – balsamo@ecmwf.int

Abstract - The European GMES initiative provides a political framework for future implementation of Service Centres related to environmental applications. The FP7/geoland2 project is the last brick towards the implementation of fully mature GMES Land Services, consisting of Core Mapping Services (CMS) and Core Information Services (CIS). Its goal is to build, validate and demonstrate operational processing lines and products on a user-driven basis. The Bio-geophysical Parameter (BioPar) CMS aims at setting-up operational infrastructures for providing regional, continental, and global Essential Climate Variables. The research, development, production, and validation activities of the BioPar CMS are presented with a special focus on the biophysical products available to the institutional users, and to the scientific community.

Keywords: Environment, Monitoring, Land, Parameters, Services, Production, Near-real-time, Global

1. INTRODUCTION

The geoland2 project of the 7th Framework Program constitutes a major step forward in the implementation of the GMES Land Monitoring Core Service (LMCS), and addresses the 3 components (local, continental, and global) of the LMCS. The goal of geoland2 is to build, validate and demonstrate operational processing lines and products on a user-driven basis.
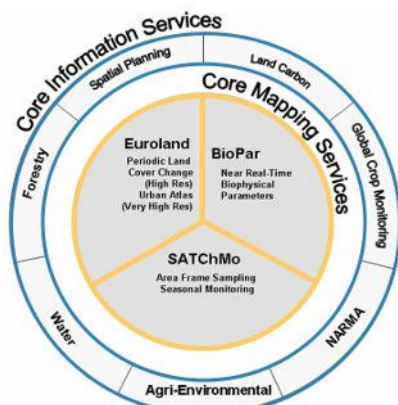

Figure 1. The geoland2 structure

Built upon the results of preceding projects funded by the European Commission and the European Space Agency, geoland2 consists of Core Mapping Services (CMS) and Core Information Services (CIS) (Figure 1). The CMS produces "basic" geo-information on the land state covering a wide variety of thematic content, spatial scales from local to global, and update frequency from 1 day to several years, on the basis of Earth observation data. Besides being a valuable information source by their own, the mapping products are input for the CIS focusing on water quality, spatial planning, forest management, agri-environmental issues, food security, carbon cycle analysis. These CIS offer specific information for European environmental policies and international treaties on climate change, food security, and sustainable development.

The *Biogeophysical Parameter Core Service*, named in short BioPar, is a joint venture of 13 partners: HYGEOS, CNES, Infoterra France, INRA, and Météo-France (France), Université Catholique de Louvain (UCL), and VITO (Belgium), Institute of Meteorology (Portugal), Vienna University of Technology (Austria), EOLAB (Spain), University of Leicester, and ECMWF (United Kingdom), and Igik (Poland).

Product	NRT / Off-line	Spatial Resolution	Spatial coverage	Temporal Resolution	Sensor
Continental Vegetation					
LAI, FCover, FAPAR, DMP, NDVI, Phenology	NRT	1 km	Global	10-days	VGT
Times series of vegetation products	Off-line	4 km	Global	10-days	AVHRR + VGT
Burnt areas + seasonality	NRT	1 km	global	Daily	VGT
MERIS FR biophysical variables	NRT	300 m	Europe	10-days	MERIS
HR biophysical products	Off-line	10 m	Pilot Areas	4 times/year	SPOT
Energy Budget					
Downwelling Shortwave Surface Flux Downwelling Longwave Surface Flux	NRT	~5 km	Global	hourly	ΣGEO + AVHRR
Land Surface Temperature	NRT	~5 km	Global	hourly, daily, 10-days	ΣGEO + AVHRR
Surface Albedo	NRT	1 km	Global	10-days	VGT
Surface Albedo	NRT	~5 km	Global	10-days	ΣGEO + AVHRR
Water cycle					
Water bodies + seasonality	NRT	1km, 250m	Africa	10-days	VGT, MODIS
Soil Moisture + Freeze/Thaw	NRT	0.1°	Global	Daily	ASCAT
Time series of soil moisture products	Off-line	25 km	Global	Daily	ERS-1&2 Scatt

Table 1. BioPar CMS Portfolio

BioPar aims at setting-up validated operational infrastructure able to provide bio-geophysical variables describing the

vegetation state, the radiation budget at the surface, and the water cycle at any scale of interest (regional, continental, and global), both in near real time and off-line mode. The BioPar CMS is a strongly user-driven service. The CMS portfolio has been designed from a careful analysis of the needs of CIS and other CMS, considered as good proxys of a large community of users including institutional users, future downstream services and the international science community. The BioPar portfolio includes Essential Climates Variables (ECV) like Leaf Area Index (LAI), Fraction of Absorbed PAR, Albedo, Burnt Areas, Soil Moisture as well as Land Surface Temperature,. The detailed portfolio is given in Table 1.

Most of the products are delivered in NRT in the sense of few days (less than one week), as requested by the final users who need to know the surface conditions within a few days of delay in order to react appropriately in case of anomaly, and to anticipate and manage the potential resulting problems. Detecting anomalies by comparing the current observation with a reference requires having consistent long time series. BioPar provides such time series for some Essential Climate Variables (LAI, FAPAR, soil moisture) taking advantage of existing EO data archive, and developing sensor-independent methodologies.

2. BIOGEOPHYSICAL PRODUCTS

2.1 LAI, FCover, FAPAR, NDVI derived from SPOT/VEGETATION sensor data

The leaf area index (LAI) is defined as half the total green area per unit of horizontal ground surface. The FCover is the fraction of ground unit covered by green vegetation (Figure 2). The FAPAR is defined as the daily fraction of photosynthetically active radiation absorbed by green vegetation considering clear sky conditions . The Normalized Difference Vegetation Index (NDVI) corresponding to the SPOT-5/VEGETATION-2 sensor characteristics for its Red (B2) and NIR (B3) bands is also provided.
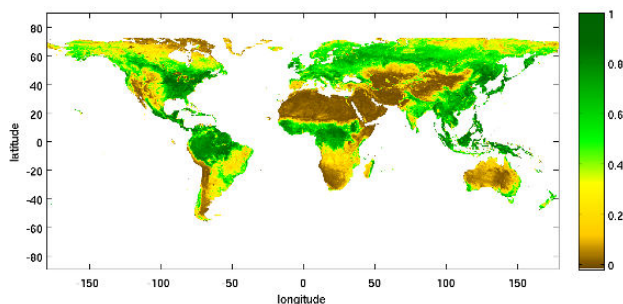

Figure 2. FCover derived from SPOT/VGT, August 2004

The algorithm is based on already existing LAI, FAPAR, and FCover products. Following the published literature on products validation (Weiss, et al. 2007; Garrigues, et al. 2008), the best performing products were selected and combined to take advantage of their specific performances while limiting the situations where products show deficiencies. The detailed description of the methodology, based upon neural network calibrated over the BELMANIP2 set of sites (Baret, et al. 2006) to relate the fused products to the corresponding atmospherically-corrected and directionally-normalized top of canopy SPOT/VEGETATION reflectances, is given in Baret, et al. (2010).

The methodology has been defined by INRA, the processing line has been set-up by CNES, and runs in NRT at VITO. These

vegetation products have been validated by EOLAB according to the protocol defined by the Land Product Validation (LPV) group of CEOS (Morissette et al., 2006). The methodology is adapted to the historical AVHRR surface reflectances made available by the LTDR (Long Term Data Record) project (Pedelty et al., 2007). The archive from 1981 will be processed to get a 30-years time series of vegetation variables fully consistent with the SPOT/VGT products.

2.2 The set of biophysical variables derived from MERIS and HR sensors data.

The MERIS Full Resolution (FR) biophysical products, and the High Resolution (HR) biophysical products, contain a set of variables including estimates of the green, brown & soil cover fractions, the LAI, the FAPAR, the chlorophyll content, a canopy shadow factor, and the water & snow cover fractions.
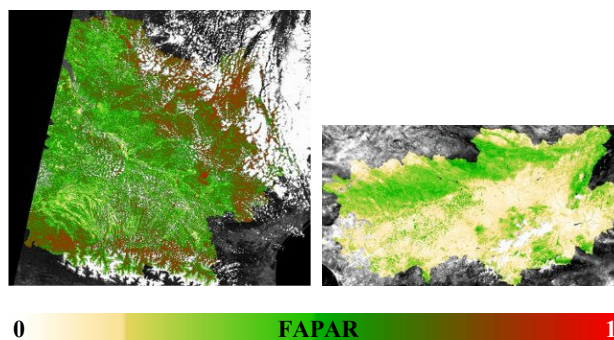

Figure 3. FAPAR over the Adour-Garonne river Basin for May 2008 (left) and over the Guadalquivir river basin for May 2006 (right) derived from MERIS FR data.

The baseline vegetation model developed for processing the MERIS and HR SPOT data uses the SAIL/PROSPECT model as core component (Verhoef, 1984; Jacquemoud et Baret, 1990). This model was upgraded and completed in order to include the contribution of brown vegetation, the modelling of "rough" canopies, the computation of vegetation cover fractions in reference directional conditions, and the computation of FAPAR from the SAIL model. Then, to restore the heterogeneous nature of the MERIS pixels, a further modelling step is applied consisting in having a composite (green + brown) canopy model. The soil modelling is performed through a physical model of soil variability, accounting for the soil shading and surface humidity effects. This scene model is then coupled with a model of the atmospheric transmission from Earth surface level to the sensor (Verhoef and Bach, 2003). The detection of water and snow covers is done through additional modelling of the corresponding surfaces which are combined, as linear mixture, with the standard land model.

SpotImage SA has elaborated the methodology above, developed the processing line, and runs it in NRT over the whole Europe. These products have been validated by EOLAB, jointly with the products derived from SPOT/VGT data. High resolution products have also been generated from SPOT and Rapid-Eye data acquired in 2009 and 2010 at different stages of the vegetation development over some high risk areas.

2.3 Soil Water Index (SWI) derived from ASCAT/Metop sensor data

The Soil Water Index is defined as the soil moisture content (in percent) in the soil profile. The retrieval algorithm uses an infiltration model describing the relation between Surface Soil Moisture (SSM) and profile soil moisture as a function of time

(T). The algorithm is based on a two-layer water balance model (Wagner et al., 1999) to estimate profile soil moisture from SSM retrieved from scatterometer data. A computational adaptation of the original SWI algorithm has been made based on a recursive formulation proposed by Albergel (2008). In this method, a gain factor is introduced that relates the past SWI measurements to the current measurements. The SWI processing algorithm uses ASCAT-25km SSM product as input to generate daily global SWI images, calculated for five different T values (1, 5, 10, 15, 20, 40, 60, 100) together with the respective quality flags.
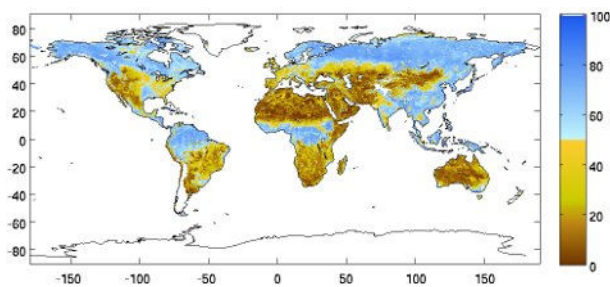

Figure 4. Global SWI (%) derived from ASCAT/Metop data for T=10 on 15th July 2007.

The retrieval algorithm is defined by Vienna University of Technology, the processing line is developed by CNES, and run in near real time at the Institute of Meteorology of Portugal. The SWI products are being validated by Météo-France and ECMWF using in-situ observations, and operational, analyzed products from models running at global and regional scale. A second version of the product is planned in the project life, including a more accurate detection of the freeze and thaw conditions of the surface.

2.4 The Surface Albedo derived from the SPOT/VEGETATION sensor data
The albedo is the fraction of the incoming solar radiation reflected by the land surface, integrated over the whole viewing directions. The BioPar albedo products include the directional albedo calculated for the local solar noon, and the hemispheric albedo, integrated over the whole illumination directions for 3 broad bands: visible [0.4, 0.7µm], near-infrared [0.7, 4µm], and the whole solar spectrum [0.3, 4µm]. The coefficients resulting from the inversion of a 3-kernels linear bidirectional reflectance model on the atmospherically-corrected SPOT/VGT reflectances (Baret, et al. 2007) acquired during a period of 30 days are then combined with the pre-computed values of the directional kernels integrated over angular domains to estimate albedos. Finally, the broadband albedos are derived by linear relationships of spectral quantities.

This algorithm and the processing line have been previously set-up in the framework of the FP5/CYCLOPES project, by CNRM, and Medias-France, respectively. CNES has adapted the existing chain to the geoland2/BioPar specifications. The processing line is running in NRT at VITO. These SPOT/VGT albedo products are being validated by EOLAB according to the protocol defined by the Land Product Validation (LPV) group of CEOS.

2.5 Downwelling Surface Fluxes and Land Surface Temperature from geostationary sensors
The Downwelling Shortwave Surface Flux (DSSF), Downwelling Longwave Surface Flux (DSLF), and Land Surface Temperature (LST) are generated by the fusion of geostationary and polar sensor data. The DSSF represents the short-wave fraction of the solar irradiance (0.3-4 µm) reaching the soil background. The DSLF is defined as the irradiance reaching the surface in the thermal infrared part of the spectrum (4-100 µm). The LST is the radiative skin temperature of land surface. The Institute of Meteorology of Portugal has defined the algorithm, developed the processing lines, and runs them in near real time. These radiation variables correspond to an extension of those currently produced on an operational basis by the Satellite Application Facility on Land Surface Analysis (Trigo et al., 2010). While the latter are restricted to EUMETSAT sensors, Geoland-2 products make use of non-European geostationary satellites to increase area coverage (Freitas et al., 2010). The global DSLF, DSSF, and LST are produced in near real time since August 2009 (Figure 5).
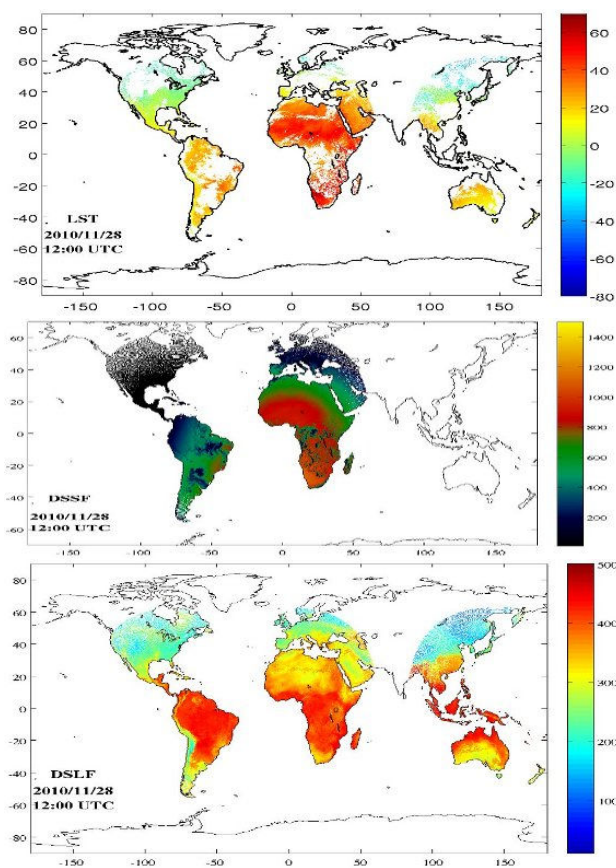

Figure 5. LST (°K), DSSF and DSLF (W.m⁻²) from merging GOES, MSG, and MTSAT data.

2.6 Burnt Areas & Water Bodies products
The burnt areas products are running in NRT at VITO since April 2010. A new product is available every 10 days. The University of Leicester is working on the extension to the global scale, and on the improvement of the algorithm developed previously for the L3JRC project (Tansey et al., 2008). In particular, seasonality metrics (start, end and timing of maximum burning) will be added. Further, in the project life, the methodology will be adapted to AATSR sensor data.

The small water bodies product results from the fusion of two existing algorithms: the first one (Gond et al., 2004) was developed in the framework of VGT4AFRICA by the Joint Research Centre and is suited to arid and semi arid condition; the second one was developed for GlobalWatch project and was further developed in the context of Desert Locust prevention

FAO product (Pekel, 2009). The product includes also information about the seasonality, i.e. the date of filling and the date of drying. The Université Catholique de Louvain has defined the methodology, whereas VITO has set-up the processing line and will run it in NRT. The detection algorithm is being adapted to MODIS data (250m resolution) to identify smaller ponds (D'Andrimont et al., 2010).

3. CONCLUSION

At mid-term of the project life, BioPar has provided demonstration products evaluated by the users of the CIS, and other CMS, by independent thematic validation team, and by external experts of the scientific community. Progressively, the pre-operational implementation of services starts, the NRT products become accessible freely through the SDI Expert Portal with their associated documentation, including validation reports (http://www.geoland2.eu/core-mapping-services/biopar.html). The reprocessing of available EO data archives begins to get consistent long time series.

These efforts are focused on the implementation of the GMES Land Monitoring Core Service, and BioPar CMS intends to bring a main brick to build the Global component of the LMCS. Through a global systematic monitoring service, the Global component of the LMCS aims to provide near real time bio-geophysical parameters at global scale, addressing primarily the terrestrial ECVs, and describing the vegetation state and dynamic. The principal scope of the Global component of the LMCS is to deliver information products and services on the status and evolution of land surfaces to feed a range of downstream services applications set-up to support specific EU policies at international level and European commitments under international treaties and conventions.

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QUESTIONS

For any information on BioPar services and products, please contact R. Lacaze, BioPar Task Manager, at rl@hygeos.com.