The EUMETSAT Network of Satellite Application Facilities

LSA SAF
Land Surface Analysis

List of Abstracts

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Status of the Land Surface Product Development for U.S. GOES-R Satellite Mission

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The U.S. GOES-R satellites, which has a first satellite planned launch-ready in 2015, is a new generation of geostationary-orbiting satellite. On-board the GOES-R, the Advanced Baseline Imager (ABI) will provide a best-ever opportunity for measuring land surface parameters from geostationary orbit over America. Comparing to the current generation of the GOES Imagers, ABI sensor has three major advantages for the land surface measurement: high horizontal resolution (2 km at nadir), more frequent refresh rate (e.g., 5 minutes for full disk mode) , and lower sensor noise level. It is expected that products generated from the GOES-R satellite will be significantly better than the current GOES Imager products. In 2010, Land team of the GOES-R Algorithm Working Group (AWG) reached its peak time of algorithm developments. There are six land surface products that are under development: land surface temperature (LST), fire detection and characterization (FDC), normalized difference vegetation index (NDVI), green vegetation fraction (GVF), land surface albedo (LSA), and flood/standing water (FSW). Among those, LST and FDC are required as baseline products of the GOES-R mission and NDVI, GVF, LSA, FSW are required as option 2 products. All the land products are generated from the ABI measurements, with some ancillary data needs. Currently, 100% readiness algorithm theoretical bases documents (ATBDs) and delivered algorithm packages (DAPs) for LST, FDC and NDVI have been delivered to the GOES-R program office (GPO), and are in mplementation/installation process by vender. 80% readiness ATBDs and DAPs for GVF, LSA and FSW have been delivered also to GPO, and are under investigation by the vender; 100% readiness ATBDs and DAPs for GVF, LSA and FSW will be delivered in 2011. Meanwhile, all the ATBDs are sent to external reviewers, who are pointed by the GOES-R algorithm development executive board (ADEB), for the independent verification and validation (IV & V) process. Starting from late 2010, comprehensive validation process for the GOES-R land surface products have been activated for providing high quality validation datasets and tools.

Capability of SEVIRI/MSG for large-scale monitoring of vegetation condition

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Keywords: SEVIRI/MSG, vegetation products, vegetation monitoring, Land-SAF, environmental applications

The Land-SAF products, classified as “essential” by EUMETSAT, are available on a free and unrestricted basis. The Land-SAF SEVIRI vegetation (VEGA) products include the fractional vegetation cover (FVC), the leaf area index (LAI) and the fraction of Absorbed Photosynthetically Active Radiation (FAPAR). The data may be requested and downloaded off-line from the Land-SAF website, while near real time users are encouraged to use EUMETCast, i.e., the primary distribution means for EUMETSAT image data and derived products.

This work presents the current status of the VEGA products and explores some advantages and potential applications. The products are spatially and temporally consistent and present practically no missing data except for areas, which are usually covered by snow. Temporal trajectories of VEGA products are suitable to derive key phenological parameters related with annual vegetation production and monitoring inter-annual variations of ecosystems linked with land use/cover change, drought conditions, deforestation and fires. The increase in spatial coverage, temporal continuity and stability of the VEGA products is complementary of polar orbit based products (e.g. VGT, MODIS), which in turn provide a finer spatial resolution. The capability of the products for large-scale monitoring of vegetation in a range of environmental and climatologic applications such as carbon fluxes, numerical weather prediction, crop forecast and environmental monitoring is an active research issue in Land-SAF.

LAI remote sensing products and simulated LAI: an intercomparison over France

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The Leaf Area Index (LAI) is an important characteristic of the vegetation. It is a good measure of the amount of active vegetation and is linked to the canopy resistance, the water and carbon fluxes between the atmosphere and the vegetation. In this study, we compare 4 different estimates of LAI over France: two LAI products derived from visible remote sensing and simulated LAI from two land surface models. The simulated LAI originates from two land surface models, the ISBA-A-gs model (developed by CNRM) and the ORCHIDEE model (developed by IPSL). The atmospheric forcing for the models is the high resolution (8-km) SAFRAN atmospheric reanalysis over France, and the vegetation map is the ECOCLIMAP2 dataset. The LAI remote sensing products are derived from the MODIS and SPOT/VGT sensors: the MODIS Collection 5 product and the CYCLOPES product. In the framework of the CARBOFRANCE and GEOLAND2 projects, these products were reprojected on the grid used by the models, and an intercomparison was performed.

The study period ranges from 2000 to 2007 and allows studying the average seasonal cycle as well as the interannual variation of LAI. We analyse monthly values of LAI over the period. The average seasonnal cycle over the seven years starts earlier in the ORCHIDEE simulations than in the ISBA-A-gs ones. ORCHIDEE simulates a strong maximum of interannual variablity at springtime (and a small variability at summertime), whereas in the ISBA-A-gs simulations the maximum variability occurs at summertime (with a small variability at springtime). These differences can be explained by the differences in model formulations. The interannual variability of both satellite products is more complex, with a weaker seasonal cycle and contrasted spatial patterns. Finally, the simulations are compared with the LSA-SAF LAI and LST products.

Keywords : LAI products ; Leaf area index; land surface models;

The operational MSG/SEVIRI fire radiative power products generated at the Land-SAF

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Biomass burning is globally significant source of trace gases and aerosols and a major mechanism controlling both land-cover change and exchanges of carbon between the land and atmosphere. Quantitative estimates of biomass burning emissions are required for many applications, including studies of the carbon cycle and for operational forecasting of atmospheric state, where such data are required in close to real-time. This is possible only via a satellite remote sensing approach, ideally utilising the high temporal frequency available from geostationary orbit. This presentation describes the Meteosat SEVIRI Fire Radiative Power products that have been developed to meet these requirements, which include both repetitive detection of actively burning fires at 15 minute intervals (thus allowing analysis of the complete biomass burning diurnal cycle) and quantification of the fires radiative power output (which has been shown to relate closely to the rate of fuel consumption and thus trace gas, carbon and aerosol emission). The products are derived from multi-spectral observations provided by Meteosat SEVIRI, including all fire-affected regions of Africa, Europe and part of eastern South America. Two product versions are to be delivered operationally to users by the Land Surface Analysis Satellite Applications Facility (LSA SAF; http://landsaf.meteo.pt/), a pixel-level product made available at the full spatio-temporal resolution of the original SEVIRI observations, and a gridded "integrated" product available at hourly time-steps at a reduced spatial scale. This work details examples of the information content, performance characteristics and accuracy of both product types, and provides examples of their use in delineating major biomass burning events and patterns in the main fire-affected areas covered. It is anticipated that these products will provide valuable input to a variety of earth science applications, including real-time forecast models linking pollutant emissions from fires to models of atmospheric chemistry and transport.

Global Fire Emission Monitoring with Fire Radiative Power in the MACC Project

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This presentation gives an overview of the global fire emission products that are being developed in the EU-funded project MACC "Monitoring Atmospheric Composition and Climate". The products are available either in real time with a time lag of about six hours or retrospectively starting in 2003. The real time products are based on space-borne fire radiative power (FRP) observations that are routinely available. The FRP products from the geostationary SEVIRI observations, which are produced at the EUMETSAT LandSAF, resolve the diurnal variation of open fires in Africa and Southern Europe. The FRP products derived by MACC from geostationary GOES observations do the same for the Americas. The FRP products derived by NASA/NOAA from the polar orbiting MODIS observations provide complementary global coverage in roughly one day and serve as transfer standard between the different geostationary observations. All FRP products are merged to provide a consistent global map of fire activity, from which emission rates of various species are derived. The emission rates are subsequently used as boundary conditions in the MACC services that provide monitoring and forecasting of the atmospheric distributions of aerosols, reactive gases and greenhouse gases. The services monitor and forecast the atmospheric composition and air quality by assimilating observations into global and regional models of the atmospheric aerosol, reactive gas and greenhouse gas abundances. This consistent description of, amongst others, the occurrence, transport and composition of large biomass burning plumes depends on accurate bottom-up fire emission input on the one hand and, on the other hand, yields complementary information on the global fire distribution and behavior in a top-down approach. The MACC services are developed in preparation for operational GMES services. All products are available to the public.

Monitoring of gas flares with MSG active fire data – A new application of the LandSAF FRP Pixel product

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Gas flaring is a commonly used practice for the disposing of natural gas in the petroleum production industry, especially in oil-rich regions where it is not needed or where the necessary distributive infrastructure is deficient. According to the Global Gas Flaring Reduction initiative of the Worldbank, an estimated volume of 150 - 170 billion cubic meters of gas, worldwide, has been flared annually over the past 14 years (Elvidge et al. 2007). This practice is an enormous waste of energy and has a highly negative environmental impact, including local problems like air pollution, a decrease in living standards, and global effects on climate in terms GHG emissions, caused by the unnecessary combustion of a fossil fuel. International and national policies have become increasingly aware of the problem, and initial regulations on gas flaring have been or are currently being introduced in some of the major oil producing countries (e.g. the USA, the Russian Federation, and Nigeria). However, current reporting practices on the gas amounts flared are mostly based on estimates by the oil producers only, while quantitative measurements of the gas flaring are rarely carried out due to missing measurement equipment on the majority of oil production facilities and lacking regulations.

Earth observation data has enormous potential for monitoring fire and other thermal anomalies on a global scale. Various low and moderate resolution satellite based sensor instruments have been used (AVHRR, MODIS, BIRD, ATSR, Meteosat SEVIRI) and a variety of algorithms for fire detections have been developed (Kaufmann et al. 1998, Giglio et al. 2003). However, most sensors are optimized for the detection of fires from biomass burning, such as forest fires and wildfires. Detailed investigations on the potential of the different fire sensors for gas flare monitoring are rare to date (Elvidge et al. 2007, Gallegos et al. 2007, Casadio & Arino 2009). Major limitations in previous studies were found in the temporal resolution of the system used, image accessibility, and the detection potential in general.

This study examines the suitability of the Meteosat Second Generation (MSG) LandSAF Fire Radiative Power Pixel Product (Govaerts et al. 2009) in comparison to two other modern and freely available EO based active fire products for the monitoring gas flares: the MODIS Active Fire Product (Giglio et al. 2003) and the ESA World Fire Atlas (WFA) (Arino et al. 2001). The study was carried out in two differing environmental scenarios (tropics and desert) in the major oil producing regions of Nigeria and the Persian Gulf, and is based on fire product data from 2008 through July 2010. Reference data on flare locations, extracted from high resolution remote sensing data (Landsat-5 TM & Landsat-7 ETM+, GoogleEarth) was used to analyze the detection potential of the three datasets.

The results revealed the high potential of the LandSAF FRP Pixel product for the long-term monitoring of gas flaring on multiple spatial and temporal scales. While smaller individual flares showed a lower detection rate, at the site level, in the FRP Pixel product than in the higher resolution MODIS Active Fire product, larger oil producing facilities with large, or even multiple flares, could be monitored throughout the year with a very high temporal resolution. At the study area level, the data was used successfully to assess differences in annual and multi-annual gas flare detections. The dataset can thus serve as a valuable independent information source for monitoring the implementation of gas flare reduction programs in oil producing countries.

USE OF SATELLITE LAND SURFACE PRODUCTS FOR ASSESSMENT OF VEGETATION FIRE CONDITIONS OVER BULGARIA

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Since 2007, NIMH of Bulgaria has been working on implementation of MSG data and products, which provide insight into different land surface processes responsible for thermal anomalies over the region of South Eastern Europe. The problem of drought vulnerable forests as a source of fire-carbon in Bulgaria has been considered.

The paper presented is focused on the use of coupled satellite data and modeling in assessing the vegetation water status as a pre-fire condition as well as thermal anomalies detection. The information content of LSA Land Surface Temperature (LST) and MPEF active fire monitoring (FIR) products regarding two aspects of vegetation, weather and climate interrelations in fire conditions is studied, as follows:

1. Considering that drought is a complex phenomenon, which is formed as a result of vegetation and atmosphere interface, an integrated approach in its study and assessment is evolved using both:

- Modeling, through development of a Bulgarian Soil-Vegetation-Atmosphere Transfer (SVAT) model ('SVAT_bg') based on ground meteorological data. A soil moisture index, introduced on the basis of a threshold scheme for accounting the moisture availability of soil-vegetation continuum is proposed. The scheme is applied for two types of field land covers for the whole territory of Bulgaria in the form of color-coded maps on a daily operational mode.

- Remote sensing, by using MSG LST product as a measure of forest-and field-vegetation water stress.

For that purpose, comparisons of soil moisture measurements and satellite LST values (averaged around a 5x5 MSG pixels) with 'SVAT_bg'-model derived soil moisture and LST, at the same points are performed. The use the MSG LST product as a forest fire risk diagnostic tool is confirmed and discussed.

2. For validation of the MPEF FIR product third edition, two cross-comparisons (2009 and 2010) are performed:

- firstly, by comparing with consistent ground observations of vegetation fire datasets;

- secondly, by comparison with a remote sensing product for thermal anomalies detection, based on MODIS sensor of Aqua/Terra satellites (with a higher resolution and a of known level of accuracy).

Remote sensing derived evapotranspiration and comparisons to observations and models over selected hydrological basins.

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In the framework of EUMETSAT's Satellite Application Facility on Land Surface Analysis (LSA-SAF), a method to monitor the instantaneous flux of water (evapotranspiration -ET-) between the land surface and the atmosphere has been developed. This method combines information derived from satellite remote sensing with the ability of SVAT models to describe physical and physiological process occurring in vegetation. The algorithm has been implemented in the LSA-SAF system and is currently producing, in near real time, instantaneous ET estimates over four regions defined in the MSG FOV (Europe, Africa and the West of South America), at MSG spatial resolution (3 km at sub satellite point) and a temporal time step of 30 minutes. The requirements of the product had been assessed by external reviewers and on these bases, the product has reached the pre-operational status what means that the product satisfies the majority of defined requirements and is suitable for distribution to users. By a temporal integration of instantaneous values, a daily product has been developed. Validation of the method at different spatial scales has shown the ability of the model to reproduce the evolution of evapotranspiration with accuracy similar to the accuracy of observations. In this contribution we will present results at local and regional scales, instantaneous and cumulated at different time intervals (daily, monthly, and seasonally) with emphasis on selected hydrological river basins in Africa.

Mapping Daily Evapotranspiration at Field to Global Scales using Geostationary and Polar Orbiting Satellite Imagery

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Thermal infrared (TIR) remote sensing of land-surface temperature (LST) provides valuable information about the sub-surface moisture status required for estimating evapotranspiration (ET) and detecting the onset and severity of drought. While empirical indices measuring anomalies in LST and vegetation amount (e.g., as quantified by the Normalized Difference Vegetation Index; NDVI) have demonstrated utility in monitoring ET and drought conditions over large areas, they may provide ambiguous results when other factors (soil moisture, advection, air temperature) are affecting plant stress. A more physically based interpretation of LST and NDVI and their relationship to sub-surface moisture conditions can be obtained with a surface energy balance model driven by TIR remote sensing. The Atmosphere-Land Exchange Inverse (ALEXI) model is a multi-sensor TIR approach to ET mapping, coupling a two-source (soil+canopy) land-surface model with an atmospheric boundary layer model in time- differencing mode to routinely and robustly map daily fluxes at continental scales and 5-10 km resolution using thermal band imagery and insolation estimates from geostationary satellites. A related algorithm (DisALEXI), spatially disaggregates ALEXI fluxes down to finer spatial scales using moderate resolution TIR imagery from polar orbiting satellites. An overview of this modeling approach will be presented, along with strategies for fusing information from multiple satellite platforms and wavebands to map daily ET down to resolutions of 30 m. The ALEXI/DisALEXI model has potential for global applications by integrating data from multiple geostationary meteorological satellite systems, such as the U.S. Geostationary Operational Environmental Satellites, the European Meteosat satellites, the Chinese Fen-yung 2B series, and the Japanese Geostationary Meteorological Satellites. Work is underway to further evaluate multi-scale ALEXI implementations over the U.S., Europe and Africa and other continents with geostationary satellite coverage.

Monitoring soil and vegetation fluxes of carbon and water at the global scale: towards a GMES service

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GMES (Global Monitoring for Environment and Security) is a European initiative for the implementation of information services dealing with environment and security (http://www.gmes.info). GMES is based on observation data received from Earth Observation satellites and ground based information. These data will be coordinated, analyzed and prepared for end-users. The vegetation / land component of GMES (http://www.land.eu) is called “Land Monitoring Core service” (LMCS). The geoland2 project (2008-2012), co-funded by the European Commission, is a demonstrator of the evolution of the LMCS, including the consolidation of prototype services and the test of their operational capacity. In particular, the perimeter of the LMCS is extended, with a global component (biogeophysical parameters), and thematic core information services. The main mission of the land carbon core information service (LC-CIS) of geoland2 is to assess the impact of weather and climate variability on terrestrial biospheric carbon fluxes, in the context of international conventions, and to build an interface between the land and the atmosphere GMES activities. Based on the long experience of meteorological services in land surface modelling and soil moisture analysis, upgrades of existing modelling and land data assimilation system infrastructures are proposed, in order to monitor the terrestrial biospheric fluxes of carbon and water at the global scale. The LC-CIS aims at monitoring the global terrestrial carbon fluxes (e.g. to support reporting obligations in the course of the Kyoto Protocol) and setting-up preoperational infrastructures for providing global products, both in near real time and off-line mode. A global multi-model carbon accounting system is developed, coupled with EO data assimilation schemes. Emphasis is put on validation (in-situ data), with downscaling on reference European countries (France, the Netherlands, Hungary). The C-TESSEL (Voogt et al. 2006, http://www.ecmwf.int/research/EU_projects/GEOLAND/CTESSEL/index.html) and SURFEX (http://www.cnrm.meteo.fr/surfex/) modelling platforms (of ECMWF and Météo-France, respectively) are used for production. The ORCHIDEE modelling platform (LSCE) is used for benchmarking and validation purposes. The ECWMF reanalysis (ERA-Interim) are used to build a global 20-y climatology of carbon and water fluxes, LAI and vegetation biomass, in order to rank the near-real time simulations. Gradually, EO data will be integrated in the modelling platforms, in order to improve the atmospheric constraint on the model (e.g. downwelling solar radiation from METEOSAT), analyze soil moisture and vegetation biomass (e.g. assimilate the EUMETSAT’s ASCAT soil moisture product and SPOT/VGT and/or MODIS LAI estimates). Finally, EO data will be used for model verification (e.g. land surface temperature). Addressing the weather, seasonal, and interannual climate variability of the fluxes will be the primary added value of the service. In a second stage, it is expected that adaptations of the system will be needed in order to account for crop and forest harvest/fires.

Regional evapotranspiration based on MSG-SEVIRI and polar orbiting satellite data

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Geostationary Earth Observation carries a large potential for assessment of surface state variables. Not the least the European Meteosat Second Generation platform with its SEVIRI sensor is well suited for studies of the dynamics of land surfaces due to its high temporal frequency (15 minutes).

We present here a method to estimate regional evaporative fraction EF based on land surface temperature (LST) and vegetation indices (NDVI) derived from SEVIRI data over West Africa. The high temporal frequency of image acquisitions with the SEVIRI sensor means that not only information on diurnal variations in LST can be derived, but also that the information related to surface moisture conditions and water stress contained in the morning rise in LST can be exploited fully. The Priestly-Taylor parameter is interpolated in the LST/NDVI space that contraints the LST for given evapotranspiration rate. Once the parmeter is estimated, the calculation of EF is straightforward and hence also actual evapotranspiration can be estimated. The method is simple, requires no ancillary data and the results show good agreement with in situ measurements. The potential for application in drought monitoring systems, early warning systems and in agriculture is there for large.

For some applications the spatial resolution of geostationary data is too coarse. By combining and properly scaling the coarse resolution MSG-SEVIRI data with data from sensors aboard polar orbiting platforms, like METOP AVHRR or MODIS, the best from two worlds can be exploited.

Here we illustrate a method to derive evaporative fraction (EF) on a nerscale by using a combination of SEVIRI LST data with MODIS NDVI data (spatial resolution of 250m). A hierarchical, deterministic scaling method has been applied to the data, and results are compared to existing deterministic downscaling methods based on LST and NDVI.

First results of the LAND-SAF project on reference crop evapotranspiration

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Among others, the scope of the Land Surface Analysis Satellite Applications Facility (LSA SAF) is to increase benefit from the EUMETSAT geostationary Satellites MSG data related to land, land-atmosphere interactions and biophysical applications. This is achieved by developing techniques, products and algorithms that will allow a effective use of MSG data, if needed, combined with products of the European Centre for Medium-Range Weather Forecasts (ECMWF). Although directly designed to improve the observation of meteorological systems, the spectral characteristics, time resolution and area coverage offered by MSG allow for their use in a broad spectrum of other applications, for instance in agro- and hydrometeorology. The objective of this study is to investigate whether reliable estimates of the so-called Reference Crop Evapotranspiration (ET_0) can be derived from the existing LSF SAF products. This hypothetical quantity is introduced in FAO Irrigation and Drainage report 56 (FAO56) and it is used to determine water requirements of agricultural crops in irrigated regions. ET_0 is evaluated with a special version of the Penman-Monteith equation using data of a weather station installed over non-stressed grass. Such stations are expensive and very labor consuming. Our study concerns an attempt to develop an approximate method using LSA SAF products as input for semi-arid regions where appropriate weather stations needed for FAO56 ET_0 are missing. In first instance, we will focus on radiation-based approximations, similar to the Makkink formula, requiring down-welling surface short-wave radiation (DSSR) at the surface and air temperature only. The DSSR is already an operational LAND-SAF product. The air temperature at 2m (T2m) is obtained from forecasts provided by the European Centre for Medium-range Weather Forecasts (ECMWF) model. The initial 3-hourly T2m forecasts (steps between 12h and 36h) at a resolution of about 25 km, are linearly interpolated in time to hourly, and bi-linearly interpolated in space to the SEVIRI/MSG resolution. In the developing phase of the ET_0-project we will use different high-quality micrometeorological datasets collected in Spain. Independent validations with a similar dataset gathered at Cordoba will be presented as well as. a comparison between MSG LSA-SAF estimates of ET_0 and the ground truth values for this location.

In addition, experimental validations will be shown for
a) a site in the Ethiopian highland at an elevation of about 1800m:
b) two sites in the Jordan Valley located about 250m below sea level.
For the Ethiopian site we will consider the uncertainties in the LAND-SAF T2m obtained from ECMWF fields having a resolution of 25 km in a region with fast varying orography. The interesting feature of the Jordan Valley sites is the effects of their locations below sea level on solar radiation and air temperature. Because most formulas for ET_0 include the psychrometric constant propositional to air pressure, we will also discuss air pressure effects.

The AMESD Drought Monitoring System

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The Agricultural Research Council is in the process of developing a Drought Monitoring System for SADC countries. The system is being developed in Open Source as part of the AMESD Project by adjusting and extending what was developed during the PUMA Project. The system (to be availed free of charge to participating countries) is a decision support tool that can be used for drought monitoring at national and provincial levels by providing an overview of 'current' rainfall conditions and responses of vegetation to changes in weather/climate conditions. The system can be used to derive drought products from NDVI and rainfall data, guide decision making and enhance the compilation of support reports. Output products of the system will include raw data, different GIS products consisting of user-friendly drought-monitoring maps and graphs that capture spatial and temporal variations in the distributions of rainfall and vegetation. Overall, the long-term objective of this initiative is to enable users to create their own products by capacitating them through demonstration and direct involvement in the project at different stages of the system's continued development and improvement.

OPPORTUNITE DE L'UTILISATION DES DONNEES MSG POUR UN DEVELOPPEMENT DURABLE EN C I

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Situation antérieure

Dans le but d'aider le gouvernement ivoirien à conduire des études sur des phénomènes environnementaux nécessitant l'utilisation de données météosat (suivi de la végétation, détermination de la biomasse, suivi de l'agriculture, Suivi de la saison sèche, suivi des feux de brousse, détermination des zones maritimes favorables à la pêche), le CNTIG a acquis une station de réception METEOSAT et une station NOAA en 1997.
Dans ce cadre des études ont été réalisées sur les centres d'intérêt suivants :

- La conception et la réalisation d'un système de détection des feux de brousse.
- La détermination et le suivi de zones maritimes favorables à la pêche afin de rationnaliser cette activité
- Le suivi de l'agriculture et la détermination de la biomasse dans la moitié nord de la Côte d'Ivoire
- Le suivi de la progression du désert au nord et de la déforestation au sud de la Côte d'Ivoire
- L'application de la Télédétection à l'énergie solaire : contribution à l'estimation de l'irradiation solaire journalière à partir de traitement d'un mois d'images VIS PDUS de METEOSAT en Côte d'Ivoire (projet **S**ystème d'**I**nformation **M**ultimédia pour l'**E**nvironnement **S**ubsaharien / Projet SIMES)

Malheureusement, des difficultés politiques et économiques ont freiné la poursuite de ce travail par le CNTIG.

Situation actuelle

Aujourd'hui, le pays sort de la crise, et l'objectif qui avait conduit à se lancer dans ce travail reste d'actualité. Il s'agit donc de relancer le travail ; mais compte tenu de la caducité des stations de réception d'image METEOSAT et des évolutions technologiques connues dans le domaine depuis une dizaine d'années, il est impératif de conduire une étude exploratoire sur l'état de l'art concernant les nouvelles méthodes d'acquisition, de traitement d'images et de données MSG et les matériels nécessaires.

Importance de l'atelier

Nous pensons que notre participation à cet atelier pourrait nous donner suffisamment d'informations pour réaliser ces études qui sont vitales dans le développement de la Côte d'Ivoire et pour notre structure en ce sens qu'il nous offrira l'opportunité

- d'évaluer le coût des équipements, déterminer les besoins de renforcement de capacités,
- déterminer la nature de la collaboration entre les potentiels utilisateurs tant au niveau national que international des données MSG
- proposer à la tutelle (Cabinet du Premier Ministre) la remise sur pied de la cellule traitant des données MSG.

Perspectives

La remise sur pied de la cellule de traitement des données METEOSAT du CNTIG va réactiver la coopération entre les différentes structures nationales, des organismes africains et occidentaux et relancer de nombreux projets nécessitant l'utilisation des données MSG qui sont en attente. Par ailleurs le pays est confronté ces dernières années aux phénomènes récurrents d'inondation et de glissement de terrain pour lesquels l'utilisation des données MSG peut s'avérer très utile (la cellule de gestion des catastrophes, plan **ORSEC**). Une des perspectives à moyen terme est la mise en place d'équipes pluridisciplinaires pour créer et vulgariser des bulletins agro-météorologiques

ECOCLIMAP-II/ Africa : a twofold database at 1 km resolution of ecosystems and land surface parameters for meteorological applications

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ECOCLIMAP-II database is a twofold physiographic product, which encompasses an ecosystem classification and several maps of biophysical parameters (albedo, LAI, fraction of vegetation).
Ecosystems classification is the process of allocating vegetation types into groups so that individuals in the same class are similar according to their physiological and phenological characteristics to another one. Over large areas, the only suitable technique to obtain frequent and repetitive data acquisitions over such large areas is the use of observations recorded by sensors of moderate resolution. In order to minimize the role of the analyst and to improve the accuracy of the results, innovative and efficiency approaches for the classification of ecosystems continue to appear in the literature. This research developed and implemented a new hybrid unsupervised classification approach to derive ecosystems using pluriannual time series by combining hierarchical and partitioning clustering principles. The latter approach is applied on 8-years time series (2000-2007) of 10-day composite Normalized Difference Vegetation Index (NDVI) recorded by SPOT/VEGETATION. After, the first segmentation of the mainland obtained by grouping pixels in bioclimatic ecoregions using the Fast Fourier Transform (FFT), successive k-nearest neighbour (k-NN) clustering enhance the discrimination of ecosystems and yields to the production of the ECOCLIMAP-II classification for the African continent. The classification nomenclature relied on three levels of vegetation structural categories based on the Land Cover Classification System (LCCS). On the basis of validated continental and national maps, a pixel-by-pixel analysis is conducted to assess the accuracy of the ECOCLIMAP-II classification and the one obtained by only the means of a k-NN classifier using the same NDVI datasets. The hybrid clustering facilitates the identification/labelling process. The obtained results, which should provide key information needed for management and monitoring of natural resources, biodiversity conservation and biogeochemical studies may also deserve vegetation, cover modelling at regional and local scale.
Albedo and LAI products in ECOCLIMAP-II rely essentially on an analysis of time series of MODIS products. The consistency of these parameters is reinforced through the classification. A comparison of these ECOCLIMAP-II surface parameters is performed against Land SAF products.

Keywords: Ecosystems, unsupervised classification, Africa, NDVI, SPOT-VEGETATION.

An application of the LAND-SAF datasets within the AMMA Land surface Model Intercomparison Project (ALMIP) Phase 2

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A high priority of African Monsoon Multidisciplinary Analysis (AMMA) project is to better understand and model the influence of the spatial and temporal variability of surface processes on the atmospheric circulation patterns and the regional scale water and energy cycles. This is being addressed through the AMMA Land surface Model Intercomparison Project (ALMIP) which uses a multi-scale modeling approach encompassing an ensemble of land surface models (LSMs) which rely on dedicated satellite-based forcing and land surface parameter products, and data from the AMMA observational field campaigns. In the recently completed Phase 1 of ALMIP, an ensemble of LSMs from the international community performed multi-year offline simulations for the period of 2002-2007 over West Africa. The LSMs used the LAND-SAF downwelling radiative products as input forcing from July 2005 onward. The resulting LSM simulations have been used extensively by the international community for hydrological modeling, regional scale water budget estimates, mesoscale atmospheric case studies, regional atmospheric chemistry modeling, and the evaluation of regional and global scale atmospheric models.

In ALMIP Phase 2, LSMs will be evaluated using observational data from three heavily instrumented super-sites from the AMMA-Couplage de l'Atmosphère Tropicale et du Cycle Hydrologique (CATCH) observing system. The AMMA-CATCH window covers a north-south transect encompassing a large eco-climatic gradient. The first experiment will be performed over 3 mesoscale domains (each covering approximately 10^4 km^2) using a grid resolution of approximately 5 km and a time step of 30 minutes, covering the period from 2005-2008. A key aspect is the atmospheric forcing data, and the LAND-SAF radiative product is being used (together with an observation-based precipitation dataset and meteorological state variables from numerical weather prediction models) to drive land surface, vegetation and hydrological models. In addition, it is anticipated that the LAND SAF brightness temperature (LST) and vegetation products will be used to evaluate LSM simulations. The results will be used in conjunction with those from ALMIP-1 in an effort to evaluate the effect of scale change on the representation of the most important processes from the local to the regional scale.

In this talk, we will give an overview of the ALMIP2 project, some examples of the SAF products compared to field campaign measurements, an example of first results using the ISBA model together with a new river routing scheme, and perspectives for the project in 2011. The development and results of ALMIP-2 will be supported and advised by the Global Energy and Water cycle Experiment (GEWEX) Global Land Atmosphere System Study (GLASS).

Assessing the use of LSA SAF VEGA data for environmental monitoring in Africa: Fractional cover and natural vegetation condition assessment

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LSA SAF provides on a daily basis a number of biophysical parameters that are distributed to the user community through the EUMETCast data distribution system operated by EUMETSat. At the Joint Research Centre the “Global Environment Monitoring” Unit has developed the eStation, an open-source based system aimed at ensuring the post-processing and analysis by environmental experts. The eStation is being installed in each African country south of the Sahara in the framework of the AMESD project funded by the European Development Fund and implemented by the African Commission in partnership with the ACP secretariat, Regional Economic Communities, Regional Implementation Centres in Africa and National partners.

The purpose of the study is to assess the adequacy from a user point (service assessment as well as utility assessment) of view in particular of FVC, the Fraction of Vegetation Cover product for non meteorological applications where qualitative interpretation of data is the most frequent approach. The analysis looks in particular at the post-processing procedures needed for the specific range of above-mentioned applications, I. a. data remapping, time syntheses, usability of historical time series for inter-annual comparison purposes.

The data are then assessed in terms of usability for the main biomes and key ecosystems from deserts to equatorial rainforest. This analysis is carried out over a series of reference sites for which mainly static environmental documentation was collated. The product is also evaluated by comparison with other similar products, such as biophysical parameters generated by the geoland2 project (BioPar component) from higher resolution instruments, but with a lower acquisition frequency.

Finally conclusions are drawn regarding possible improvements of the product.

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Comparison of MSG-SEVIRI and SPOT-VEGETATION data for Fraction of Vegetation Cover (FVC) monitoring over Africa

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Fractional Vegetation Cover (FVC) defines an important structural property of a plant canopy, which can be monitored from coarse resolution satellite multitemporal data, and validated from high spatial resolution images or ground measurements. Two sources of data are compared here :

- MSG-SEVIRI daily values of FVC, as delivered by LSA-SAF, following the methodology elaborated at University of Valencia, Spain (cf. PUM VEGA, 2008; Verger et al., 2009);
- SPOT-VEGETATION dekadal data : FVC are recalibrated from NDVI 10-days composites using a simple approach (Carlson & Ripley, 1997; Bartholomé et al., 2002).

Data are resampled at 0.025 degree resolution over the whole continent of Africa. Comparison are made between temporal profiles for the period March to December 2007, using Region of Interests (ROIs) defined from global land cover map GLOBCOVER v2.2 (2008) based on ENVISAT MERIS data at full resolution (300m) from December 2004 to June 2006.
Results indicate a rather good correlation between FVC estimates. Using dekadal data, MSG-SEVIRI data appear more reliable than VEGETATION data during the rainy season, providing images with less cloud contamination. The use of daily MSG-SEVIRI data is not recommended, as there are in some areas very large unexpected day to day variations in FVC estimates.

DETECTING CANOPY WATER STRESS USING SHORTWAVE INFRARED GEOSTATIONARY MSG-SEVIRI DATA.

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Water scarcity limits vegetation growth over 40 per cent of Earth's vegetated surfaces and water is the single most important limiting factor for global vegetation growth. In the 1970s and 80s the semi-arid zone of Africa suffered from a severe prolonged drought and in first 5 years of the new millennium a second severe drought period has hit the East African part of the Sahelian region. In perspective of global climate change, climate variability is projected to increase and drought conditions to be more frequent and severe. Given the relevance of limited water resources, it is of outmost importance to develop capacities for improved drought monitoring. Earth Observation (EO) remains the only viable means for systematically monitoring the different aspects of vegetation water stress on a regional, continental or global scale and is thus a critical component of famine and drought early warning systems. However, the use of conventional polar orbiting environmental satellite-based (POES) information is limited owing to the low temporal sampling frequency of the EO systems. Together with persistent cloud cover especially during the critical crop growing season for instance in the semi-arid zone of Africa this often results in data gaps and spurious short-term variability in vegetation time-series. With the launch of the geostationary Meteosat Second Generation (MSG) satellite with its Spinning Enhanced Visible and Infrared Imager (SEVIRI), unprecedented data for scientific exploration of natural resources including vegetation drought stress are now available. SEVIRI measures every 15 minutes radiation in 12 spectral wavebands whereof three are specifically suited for vegetation studies: the red, the near-infrared (NIR) and shortwave-infrared (SWIR) bands centered at 635, 810 and 1640 nm, respectively. GOES-R ABI with similar spectral bands should be launched in 2014 enabling geostationary-based vegetation monitoring of the continents of N. &S. America.

The aim of this study is to assess the potentials of using high temporal resolution geostationary MSG-SEVIRI data for drought related vegetation stress monitoring. Numerous studies have shown that changes in water content in plant tissues have a large effect on the leaf and canopy reflectance in the SWIR (1300–2500 nm) spectral region whereas the NIR range (700–1300) is mainly affected by structural characteristics. Algorithms and indices based on these spectral regions are therefore potentially useful to monitor water stress in vegetation, but the signal from POES data have shown to be influenced by day-to-day variations in the sensor view angle. It is therefore expected that the fixed viewing geometry from MSG-SEVIRI combined with the possibility of studying the diurnal behavior of surface reflectances and stress indices will provide an interesting alternative to conventional POES based drought monitoring. Daily stress indices based on SEVIRI NIR and SWIR reflectances are compared with time series of in situ measurements for the growing season of the Dahra test site located in the semi-arid northern part of Senegal 2008 (15 minutes sampling interval). Measurements of surface reflectances, energy fluxes (Qe), rainfall and soil moisture conducted at the Dahra field site were used as a reference and indicator of water stress.

With the very high temporal data sampling frequency and consequently an increased probability of producing cloud free data for a short time composite period, it is expected to substantially improve various applications of satellite based natural resource management with MSG-SEVIRI observations, including crop condition monitoring, vulnerability assessment and food security monitoring in near real-time.

Land Surface Temperature, Emissivity and Long-wave Downward Fluxes from MSG Observations: Current Status and way forward

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The LSA SAF is generating on an operational basis, a set of parameters that described the thermal component of the surface radiation budget. These are primarily obtained from SEVIRI/MSG data and include Land Surface Temperature (LST), which along with infrared emissivity (EM) controls the upward thermal radiation, and the Downwelling Surface Long-wave radiative Flux (DSLF).

The LSA SAF adapted a generalized split-window algorithm to derive LST from SEVIRI/Meteosat TOA clear sky brightness temperatures measured by the channels centred at 10.8 μm and 12.0 μm. Channel emissivity (EM) is derived from LSA SAF estimations of the Fraction of Vegetation Cover (FVC) and a priori knowledge of the dominant vegetation and ground types within each pixel. Along with the LST fields, the LSA SAF disseminates an estimation of the product uncertainty, computed on a pixel-by-pixel basis taking into account the retrieval conditions (viewing geometry and atmospheric water vapour), along with the propagation of input errors.

LST validation is carried out through the comparison of retrievals from different sensors (e.g., SEVIRI LST versus MODIS LST), and with ground measurements. Such validation exercises show that LST discrepancies are generally within estimated error bars. However, a systematic comparison of SEVIRI and MODIS products puts into evidence the directional character of remotely sensed LST, particularly over highly heterogeneous surfaces. Such effects should be corrected in order to provide an ensemble radiometric temperature of all surface elements within the sensor FOV.

Downwelling Surface Long-wave radiative Flux (DSLF) is defined as the irradiance reaching the surface in the thermal infrared part of the spectrum (4-100 μm). The LSA SAF generates, archives and disseminates DSLF from SEVIRI/MSG data over land pixels (including inland water bodies), at the original spatial resolution and projection, as 30-minute instantaneous fluxes and as daily (0-24 UTC) accumulated fluxes. The method is based on a bulk parameterization, which merges the signature of clouds on MSG with information on atmosphere water content and near surface air temperature available from Numerical Weather Prediction (NWP) fields.

DSLF performance, along with that of ECMWF flux forecasts and surface fluxes obtained from the Clouds and the Earth's Radiant Energy System (CERES), are assessed against independent ground observations. It is shown that the DSLF parameterization scheme performs well when compared to other methods, with root mean square errors within 20 Wm^{-2}. The overall good matching between parameterized values and in situ data suggests a good performance of a relatively simple bulk scheme, and also of the use of MSG-based cloud identification.

Assessment of Met Office Forecasting Models Using SEVIRI Land Surface Temperatures

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Synoptic observations of near-surface air temperature are routinely assimilated into the Met Office's numerical weather prediction system, but suffer from problems of representativity and uneven spatial coverage. With their high temporal resolution and more homogeneous spatial coverage satellite observations of land surface temperature (LST) offer complementary information for assessing the performance of current forecasting models and may have future applications in data assimilation.

As an initial study of the potential value of land surface temperatures, comparisons have been made between land surface temperatures retrieved from SEVIRI and those obtained from numerical weather forecasts. To avoid complications introduced by clouds, cases have been selected where clouds were neither observed nor forecast. Parallel comparisons are made between the forecast near-surface air temperatures and synoptic observations. The simultaneous use of both surface and near-surface air temperatures highlights the importance of ensuring that temperature gradients near the surface are represented realistically in forecasting models. Consequently, plans to make use of land surface temperatures in assimilation should be based on an integrated approach that takes model physics into account.

Assimilation of low-level SEVIRI IR observations over land to better constrain atmospheric analyses in meso scale models

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This work aims to improve the assimilation of low-level SEVIRI (Spinning Enhanced Visible and Infra Red Imager) IR (Infra-red) observations over land to better constrain atmospheric analyses in meso scale models operating at Météo-France. To date, only high-peaking Water Vapour channels are operationally assimilated over land and IR channels are entirely rejected over land surfaces. The assimilation of IR observations over land is possible only if several limitations are accounted for: a reliable description of the surface emissivity, a more accurate estimation of the surface temperature and an effective bias correction scheme.

Some feasibility studies have been undertaken in order to assimilate more SEVIRI observations in the ALADIN French system. The land surface emissivity was described using climatologies from the EUMETSAT Land-SAF (Satellite Application Facilities). The use of these climatologies was found very helpful in improving the RTTOV performances when simulating SEVIRI brightness temperatures (Tb) over Europe. The land surface emissivity and SEVIRI Tb were also used as input parameter in the radiative transfer model to retrieve the surface temperature (Ts) over Europe. The retrieved Ts was compared with independent Ts estimates (MODIS, Land-SAF products, …) and was then used within the assimilation process to constrain the analysis of surface temperature.

A description of the methods for emissivity/temperature retrievals will be given. An evaluation of the retrieved Ts against independent measurements will be also presented. Finally, we will give an overview of assimilation and forecast experiment results when SEVIRI IR observations are assimilated over Europe.

SNOW COVER MAPPING USING METOP/AVHRR DATA

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Weather and meteorological processes are affected by the varying snow cover. Snow areal extent is essential information for weather forecasting and nowcasting. Successful snow detection is possible using data from geostationary satellites (e.g. LSA SAF snow cover product based on MSG/SEVIRI data). However these products have limited resolution especially in polar regions. Polar orbiting satellites offer some advantages which might be used to improve snow cover products in these areas.

Operational LSA SAF snow cover product for MSG/SEVIRI has been available some years. The methods used for the development of the MSG/SEVIRI algorithm have been modified and applied to the development of the LSA SAF MetOP/AVHRR snow cover algorithm. We present the MSG/SEVIRI product and some preliminary examples of the MetOP/AVHRR product.

Operational derivation of surface albedo and downwelling short-wave radiation based on MSG observations

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After ten years (1999-2009) of research, development, and progressive operational activities, a summary of the surface albedo and down-welling short-wave radiation product characteristics, and performances are presented. The albedo product is delivered on a daily basis in order to capture rapid changes such as ones caused by snowfalls. The basic algorithm concept comprises an atmospheric correction scheme, the inversion of a linear semi-empirical model of the bidirectional reflectance distribution function, the angular integration of the bidirectional reflectance distribution function to obtain spectral albedo, and the application of suitable conversion relations to derive broadband albedo estimates. These latter were evaluated against similar MODIS albedo fields and ground networks over Europe and North Africa regions. The results indicate a relative accuracy of 10% compared to MODIS products with the exception of the visible broadband albedo. The down-welling short-wave radiation is calculated at 30 minutes interval based on a every second SEVIRI imagery. It essentially depends on solar geometry and cloud cover. The validation studies with BSRN (Baseline Surface Radiation Network) stations show in general a good agreement between the satellite estimates and in-situ measurements. Over Africa there is an overestimation of the radiation in clear sky situations potentially due to aerosol effects. The main objective of the current phase (the Continuous Development and Operational Phase, 2007-2012) is presented: to provide a new product generation by means of merging data between the polar satellite MetOp (Meteorological Operational, launched in October 2006) and the MSG-2 geostationary satellite data. The LSA SAF program provides a great opportunity to monitor and identify human-induced climate change as a consistent production of surface albedo guaranteed until at least 2019 with the forthcoming MSG-3 mission.

MODIS Albedo and Reflectance Anisotropy: The First Decade

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and a large number of other dedicated researchers over the years.

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Land surface albedo is identified as an Essential Climate Variable (ECV) by GCOS and is required globally by climate, biogeochemical, hydrological, and weather forecast models at a variety of spatial and temporal scales. The MODIS albedo, reflectance anisotropy, nadir view-angle-corrected reflectance products have been available since early 2000 and have utilized both Terra and Aqua acquisitions since mid-2002 (Schaaf et al., 2002; Lucht et al., 2000). The operational MODIS BRDF/Albedo algorithm makes use of a kernel-driven, linear model of the Bidirectional Reflectance Distribution Function (BRDF) that relies on the weighted sum of an isotropic parameter and two functions (or kernels) of viewing and illumination geometry (Roujean et al., 1992). One kernel is derived from radiative transfer models (Ross, 1981) and the other is based on surface scattering and geometric shadow casting theory (Li and Strahler, 1992). The kernel weights selected are those that best fit the cloud-cleared, atmospherically-corrected surface reflectances available for each location over a 16 day period. Once an appropriate anisotropy model has been retrieved, integration over all view angles results in a directional-hemispherical reflectance (DHR) or a black-sky albedo, at any desired solar angle and a further integration over all illumination angles results in a bihemispherical reflectance (BHR) under isotropic illumination, or a white-sky albedo. The standard product is produced at a gridded 500m resolution in sinusoidal 10 degree tiles. Although averaged products are also available in global geographic projections. Using temporal phenological fits of the available high quality reflectance anisotropy retrievals, a snow-free, gap-filled 30 arc second global product has also recently been prepared for modeling applications. Furthermore, while archive limitations have resulted in the current operational retrieval only being attempted every 8 days, this product has always been envisioned as a daily product. Therefore, a daily rolling version of the algorithm has been implemented for the Direct Broadcast community, whereas the BRDF is informed by multi-date data with the most recent observation being emphasized most heavily. An overview of the validation efforts over the past decade will also be provided.

ESA GlobAlbedo – Preliminary products

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Albedo is the proportion of the incident radiation reflected by the land surface, integrated over the whole viewing directions. The albedo can be calculated for bi-hemispherical reflectance under isotropic illumination conditions integrating over all illuminations directions, known as white-sky albedo or considering a directional-hemispherical reflectance for a given sun zenith angle, black-sky albedo. Additionally, spectral albedo can be estimated, for each narrow band of the sensor, or broadband albedo, integrated over the solar spectrum, generally split into two spectral components, visible (VIS) and near infrared (NIR).

Remote sensing optical sensors measure only the reflectance from the earth-atmosphere in narrow spectral bands, solid angles and fixed time. In order to derive Albedo using these measurements, it is necessary to estimate the total reflected flux integrated over the broadband, over all viewing angles and finally over time using all possible remotely-sensed observations.

The GlobAlbedo project will develop a broadband albedo map of the entire Earth's land surface (snow and snow-free), which is required for use in climate modelling and research. The final albedo products will include both black and white sky albedo over the entire globe with at least monthly frequency over the 1995-2010 time period, including uncertainty estimates, and be integrated in three spectral broadband ranges, namely the solar spectrum (400-3000nm), the visible (400-700nm) and the near- and shortwave infrared (700-3000nm).

With the aim of deriving independent estimates making the best use of operational European satellites, GlobAlbedo sets out to create a 15-year time series by employing ATSR2, SPOT4-VEGETATION and SPOT5-VEGETATION2 as well as AATSR and MERIS. Albedo retrieval will use an optimal estimation approach, as well as a novel system for gap-filling.

Assimilation of LandSAF albedo product in limited area NWP model

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The EUMETSAT Satellite Application Facility for Land Surface Analysis operationally provides albedo estimates for the entire disc seen from a geostationary satellite positioned at 0 degrees longitude. The spatial resolution of such data is of the scale of a few kilometres and is comparable to most NWP models ran operationally in many European countries. As such it presents an original source of information that could be used to improve surface representativness in an NWP model. A simple Kalman filter based assimilation technique was used for assimilation of these data in ALADIN model. Results show a non-negligible positive impact on surface parameters, in particular the 2m temperatures. The highest impact is observed in spring months whilst there is no significant improvement in summer.

The EUMETSAT Network of Satellite Application Facilities

LSA SAF
Land Surface Analysis

List of Abstracts

POSTER PRESENTATIONS

4th User Workshop

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The Satellite Application Facility on Land Surface Analysis

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Information on land surface properties finds applications in a range of domains related to weather forecast, environmental research, hazard management, and climate monitoring. Remotely sensed observations yield the only means to supply land surface information with adequate time sampling and ensuring a wide spatial coverage. The scope of the Satellite Application Facility on Land Surface Analysis (LSA SAF) is to take full advantage of remotely sensed data to support land, land-atmosphere interactions and biosphere applications; a strong emphasis is put on developing and implementing algorithms that will allow an operational use of data from EUMETSAT satellites. This poster provides an overview of the LSA SAF, with brief descriptions of products. The set of parameters currently estimated and disseminated by the LSA SAF consist of three main groups: (i) surface radiation budget, including albedo, land surface temperature, and downward short- and long-wave fluxes; (ii) surface water budget (snow cover and evapotranspiration); and (iii) vegetation and wild fire parameters.

A MULTI-SENSOR APPROACH TO LAND SURFACE TEMPERATURE

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Land Surface Temperature (LST) presents high variability in space and time, essentially due to the low thermal inertia of land surfaces and to the sensitivity of the skin temperature to local effects (such as terrain characteristics, land cover, vegetation state). The use of remotely sensed data is the only means to achieve both a large spatial coverage and its daily cycle. The latter aspect, along with an increased probability of obtaining a significant number of (clear sky) retrievals per day, constitute the main advantage of LST fields retrieved from sensors onboard geostationary satellites, when compared with those obtained from polar-orbiters. Here we will present LST product which is the combination of retrievals from a constellation of geostationary satellites.

LST is obtained from MSG, GOES and MTSAT. Such multi-sensor LST makes use of different retrieval algorithms designed for each sensor, using brightness temperatures from infrared window channels (split-window channels in the case of MSG and MTSAT; 10.7 μm and 3.9 μm in the case of GOES). The calibration (and verification) of the different algorithms relies on radiative transfer simulations of top-of-atmosphere brightness temperatures for the relevant channels. The simulations are performed for the database of global profiles of temperature, moisture, and ozone compiled by Borbas et al. (2005) for clear sky conditions. The database compiles over 15,700 profiles from other datasets, such as NOAA88, TIGR-like, and TIGR, to be representative of a wide range of atmospheric (clear sky) conditions over the whole globe. In addition, surface parameters such as skin temperatures (Tskin) and a landcover classification within the International Geosphere-Biosphere Programme ecosystem categories (IGBP) are assigned to each profile. In this study, we assume that each profile corresponds to one given pixel within the geostationary disks. Thus, for radiative simulation purposes, a satellite zenith angle chosen randomly within the 0^o - 80^o range is assigned to each profile, except for cases with (i) Tskin below 270 K, which are constrained to angles above 30^o; and (ii) Tskin < 240 K, which are allowed to be observed by a geostationary satellite with a zenith angle within 60^o and 80^o.

The simulated data are split into two sets – one for algorithm calibration and another for the assessment of algorithm uncertainties. This also allows the quantification of the uncertainty of LST estimations, which take into account (i) error statistics of the retrieval algorithms under different conditions; (ii) sensor noise; (iii) and a careful characterization of the uncertainty of input data, particularly the surface emissivity and forecasts of the total water vapour content. Such analysis is the basis for the assignment of error bars to estimate LST uncertainty. Finally, LST retrievals from different geostationary satellites are merged into a single field. In overlapping areas, the final LST value is a weighted average, taking into account the error bars of each LST estimation.

This work was carried out within the framework of Geoland-2 project.

Assimilation of CYCLOPES Leaf Area Index into the ISBA-A-gs land surface model over France

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The GEOLAND2 European project (FP7, 2008-2012) is a major step of the evolution of the Land Monitoring Core Service (LMCS), the vegetation/land component of GMES. The C-TESSEL and SURFEX modelling platforms (of ECMWF and Météo-France, respectively) are used for describing the continental vegetation state, surface fluxes and soil moisture. Gradually, EO data are integrated in the modelling platforms in order to improve the analysis of soil moisture and vegetation biomass. Several studies demonstrated the benefit of assimilating satellite derived LAI within land surface models.
In our study the SURFEX modelling platform is used in the off-line mode. It consists of the land surface model ISBA-A-gs that simulates photosynthesis and plant growth. The vegetation biomass and Leaf Area Index (LAI) evolve dynamically in response to weather and climate conditions. The ECOCLIMAP database provides detailed information about the land cover at a resolution of 1 km. For this study we have used the version 2 of the ECOCLIMAP data set that describes about 300 ecosystems and contains rules to aggregate these ecosystem types in 12 covers (patches). Over the France domain, the most present ecosystem types are grassland (32%), C3 crops (24%), deciduous forest (20%), bare soil (11%), and C4 crops (8%).
A version of the Extended Kalman Filter scheme is used for the assimilation of CYCLOPES LAI product derived from the SPOT4/VEGETATION sensor within the ISBA-A-gs model. The LAI data is incorporated into the model every 10 days to analyse its impact on vegetation biomass. The study period ranges from April to July 2007.
The experiment is performed over France at a spatial resolution of 8 km. A model grid box is divided in a number of patches each having its own set of prognostic variables. The filter algorithm is designed to provide the analysis for each patch independently by using one observation per grid box. When needed, the updated values are aggregated by computing a weighted average.

In this study we demonstrate that the assimilation scheme works effectively within the 12-patches version of our model. An important reduction of the LAI bias between the model and measurements is achieved. Validation procedure is performed by using the LAI in situ data for the SMOSREX site.

Daily NDVI Product Derived from MSG SEVIRI

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Normalized Difference Vegetation Index (NDVI) is a crucial land surface characteristic derived from satellite data. NDVI derived from AVHRR/NOAA is now the most widely used in medium to large scale studies to determine vegetation-climate interactions. Experiments with MSG (METEOSAT 8/9) SEVIRI data have demonstrated a good potential for new generation imaging instruments onboard geostationary satellites to provide routine monitoring of the vegetation state through NDVI.
In this study, we present pre-operational daily NDVI products derived from MSG SEVIRI data. Full disc MSG coverage red and near infrared bands are processed and the products are masked using the derived Cloud Mask products. Validation is performed against Land SAF fractional vegetation cover (FVC) products. Additionally, MSG NDVI products are compared with METOP AVHRR and MODIS based NDVI products. Temporal stability analysis is also performed.

Key words: Vegetation monitoring, NDVI, MSG SEVIRI

Estimation of downward longwave radiation flux LW using MSG/SEVIRI data

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In this presentation we would like to show the possibility of applying information concerning cloudiness to estimate downward longwave radiation flux LW using MSG/SEVIRI data for the southern Baltic region. In clear situations LW depends on the vertical profiles of temperature, water vapour and other greenhouse gases. However, the largest radiation modulators in the atmosphere still remain clouds. Cloudy conditions dominate the area for approximately 2/3 of the year. We have tested cloudiness for two different ways. The first one was based on height characteristics, analyzing (i.a.) capacity of water vapor in atmosphere [Tokuno 1994] and the second one using climate temperatures data in threshold relations [EUMETSAT 2007]. We have tabulated these cloud cover parameters with empirical data to compile functions for both of the methods. LW has been calculated on the basis of the formula [Zapadka et al. 2007] taking into account the new cloudiness fun ctions in which the parameters from the methods [Tokuno 1994 and EUMETSAT 2007] have been used. The obtained results from the two methods have been compared and an empirical verification has been carried out. The values of the LW have been determined for the new applications with statistical error less than 26 Wm-2. Additional cloud classification from low through mid to high level has improved the accuracy of estimated LW by several Wm-2. Both statistical and systematical errors have been decreased. Some further research has been done which has shown the possible causes of the errors. This empirical material was collected during cruises in the southern Baltic region between January 2008 and May 2010.

Land Surface Temperature – Towards the Ideal Dataset

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Land Surface Temperature (LST) is a vital parameter in Earth climate science, driving long-wave radiation exchanges that control the surface energy budget and carbon fluxes, both of which are important factors in monitoring climate change. Satellites offer a convenient way to observe LST consistently and regularly over large areas. A number of space born platforms provide data from which LST is estimated using a number of different retrieval techniques. Here, we present a comparison of LST retrieval methods employed by two sensors over selected sites in Europe and Africa: the Advanced Along Track Scanning Radiometer (AATSR), which is in polar-orbit on board ENVISAT, and the Spinning Enhanced Visible and InfraRed Imager (SEVIRI), which is in geostationary orbit on board Meteosat Second Generation (MSG). Both sensors offer differing benefits. AATSR offers high precision, 1 km2 measurements, globally but given its sun-synchronous platform only observes at one of two local times, ~10am and ~10pm. SEVIRI provides the high-temporal resolution (every 15 minutes) required for observing diurnal variability of surface temperatures but given its geostationary platform has a poorer resolution, 3km at nadir, which declines rapidly at higher latitudes. The validation sites have been selected such that the retrieval response to a range of surface types and viewing angles can be fully examined.

In large, the significance of LST lies in daily temperature extremes, e.g. for estimating permafrost thawing depth or risk of crop damage due to frost, hence the ideal dataset would use a combination of observations. This comparison acts as a preliminary step in constructing a combined retrieval mechanismwhich adequately accounts for surface and atmospheric factors and the extreme directional effects associated with geostationary satellites. Such advancements will lead to a retrieval that can be applied to all remotely sensed thermal infrared data such that a consistent global dataset, spanning the last 30 years, can be studied. Ultimately giving a much better impression of the long-term variability of LSTs, the response and effects it has the climate in large and empirical evidence in regards to climate change.

Detecting drought related stress with field spectroradiometric measurements of natural grass savanna

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Water is the single most important limiting factor for global vegetation growth. Given the importance of limited water resources in many parts of the world, it is of outmost importance to develop capacities for improved drought monitoring. Earth Observation (EO) remains the only viable means for systematically monitoring the different aspects of vegetation water stress on a regional, continental or global scale and is thus a critical component of famine and drought early warning systems. However, the use of conventional polar orbiting environmental satellite-based (POES) information is limited owing to the temporal sampling frequency of the EO systems together with persistent cloud cover especially during the critical crop growing season in the semi-arid zone of Africa. For improved temporal resolution, the SEVIRI sensor onboard the MSG satellite is predestined since it measures every 15 minutes radiation in 12 spectral bands, one of them centered at 1640 nm in the shortwave-infrared (SWIR) spectral region.

Numerous studies have shown that changes in water content in plant tissues have a large effect on the leaf and canopy reflectance in the NIR (750–1300 nm) and SWIR (1300–2500 nm) spectral regions. Algorithms and indices based on these spectral regions are therefore very useful to monitor water stress in vegetation. For instance, the Shortwave Infrared Water Stress Index (SIWSI) based on MODIS data proved to be sensitive to variations in leaf water content and enabled an improved quality of primary production estimates in the African Sahel. On the other hand, using geostationary MSG data for plant water stress poses new challenges as compared to POES data due to diurnal variations in the solar zenith angle, which must be accounted for. Therefore we conducted a study with field spectrodirectional measurements of natural grass savanna to evaluate the impact of varying sun-target geometry on water stress indices. The measurements were taken at the Dahra study site located in the semi-arid northern part of Senegal (15.33°N, 15.48°W) with an Analytical Spectral Devices (ASD) FieldSpec spectroradiometer that covers the 350–1800 nm spectral range. The ASD fieldspec is mounted on a 12.5 meter high mast and records every 15 minutes (corresponding to the MSG-SEVIRI acquisition times) an averaged spectral measurement at nadir, ±15°, ±30º and ±45° off-nadir viewing directions in the solar principal plane, daily between 7 a.m. and 7 p.m. These measurements allow us to gain information on the amplitude and shape of the diurnal variation of plant water stress indices, on the sensitivity of such indices to changing illumination geometry and finally to validate SEVIRI-based drought information at a later stage with in situ data.

Assessment of Land-SAF FVC and LAI products over Africa

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Keywords: FVC, LAI, Land-SAF, VGT4Africa, Geoland-2, MODIS, Africa

Fraction of Vegetation Cover (FVC) and Leaf Area Index (LAI) are key biophysical parameters for a wide range of environmental applications (agriculture, forestry, environmental management, food security).
Operational programs are currently running to provide geo-biophysical variables to key users in Africa such as the AMESD (African Monitoring of the Environment for Sustainable Development) and the geoland-2 NARMA (Natural Resource Management of Africa) Core Information Service programs. African users need long and consistent time series of vegetation variables.
The Land-SAF program of EUMETSAT is providing in near real time daily estimates of vegetation variables based on geostationary SEVIRI/MSG data covering Europe, Africa and part of South America. Land-SAF SEVIRI vegetation products present a high spatial and temporal coverage over Africa thanks to the sampling capabilities of geostationary sensors with a spatial resolution of 3 km over Equator. On the other hand, the VGT4Africa EC project was aimed to produce, in near real time, geo-biophysical variables over Africa each 10-day based on SPOT/VEGETATION data at 1 km resolution. The Geoland-2 project, a major step forward in the implementation of the GMES Land Monitoring Core Service (LMCS), provides temporal continuity to VGT4Africa product extending the production over the globe. The initial version of geoland-2 FVC and LAI products are based on the same VGT4Africa algorithms. Furthermore, NASA is providing global fields of LAI based on MODIS/Terra composited every 8 days at 1-kilometer resolution on a sinusoidal projection since 2000.
The goal of this paper is to assess the LSA SAF MSG FVC and LAI products as compared with existing operational VGT4Africa/Geoland-2 and MODIS vegetation products. The analysis is mainly focused on key points from the user perspective: product assumptions, spatial and temporal continuity, smoothness, statistical consistency, product availability and packaging.

Application of LSA SAF vegetation parameters to improve the spatial and temporal resolution of ECOCLIMAP over Africa

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Keywords: LSA SAF, ECOCLIMAP, leaf area index, land cover, synergy, Africa
Presentation preference: Poster

Vegetation variables and land cover maps are essential input information required for modeling surface processes in meteorology, climate and environmental applications. The EUMETSAT Satellite Application Facility for Land Surface Analysis (LSA SAF) operationally delivers daily estimates of vegetation products including fractional vegetation cover (FVC) and leaf area index (LAI) generated on a pixel-by pixel basis at the SEVIRI/MSG resolution on a near real time. ECOCLIMAP provides a detailed 1-km land cover classification and a class specific coherent set of biophysical variables, amongst which are the surface albedo, FVC and LAI based on historical series. The aim of this paper is to develop a synergic approach for combining ECOCLIMAP with coarser resolution LSA SAF SEVIRI- vegetation products to take advantage of its spatial and temporal information.

A decomposition approach has been used to describe the spatial and temporal variability of LAI in Africa from time series of MODIS and SEVIRI products. Results show that the subdivision of the entire region into the main ECOCLIMAP classes retains the major part of the overall variance. This means that the ECOCLIMAP representation of African continent is adequate for the capture of main LAI variability in this region. In order to reduce errors due to the intra-ecosystem variability, an unsupervised fuzzy k-means clustering of the LSA SAF LAI annual cycle was applied to identify substructures within the original set of within ECOCLIMAP classes. An optimal number of clusters has been chosen to maximize the partition density and the ratio between inter-cluster and intra-cluster distance. The approach has been automated for its application on near real-time SEVIRI products for analysis of African continent. The approach offers daily estimates of LAI and FVC at the original ECOCLIMAP resolution. The FVC and LAI fields capture the inter-annual variability and show the temporal continuity (e.g. gradual variations and no missing data) required for climate and environmental applications.

EARTH RADIATIVE FLUXES EVALUATION AT A REGIONAL SCALE

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Evapotranspiration is one of the most important hydrological components and plays a key role in the energy exchange processes between land surface and the atmosphere, significantly affecting regional and global climates. It is also of great importance in the evaluation of groundwater and surface water resources and crop yield as well as in land use planning. However, the estimation of evapotranspiration with an acceptable level of accuracy has been limited in the past by the lack of data at high temporal and spatial resolution, that are available today thanks to the development of remote sensing technology.

In this work SEBS (Surface Energy Balance System) model for actual evapotranspiration estimate was developed and applied to a wide area, including the two Italian southern regions Basilicata and Calabria. For this purpose ground data, measured at the meteorological stations distributed on the territory of both regions, were integrated with remote sensing data obtained from AATSR (Advanced Along Track Scanning Radiometer) on board Envisat (Environmental Satellite). The ground measured parameters are essentially pressure, air temperature and humidity and wind speed at a given height, while solar radiation and vegetation height input parameters can be derived directly or indirectly, from satellite measurements. Model results were then compared with net radiation, soil heat, sensible heat and instantaneous and daily evapotranspiration fluxes measured at the two eddy covariance stations of Terra Montonata (MT) in Basilicata and Paglialonga (CS) in Calabria (South Italy).

As SEBS was originally developed and applied by Su (2001) to the Chinese territory, two changes were made to the model in this work, the first based on CORINE Land Cover thematic map, to take into account the vegetation cover and land use characteristics of the study areas, and the second based on a split window algorithm for land surface temperature estimation.

Overall, this work shows that SEBS model is a useful tool for estimating actual evapotranspiration; in particular, instantaneous and daily evapotranspiration distribution is in accord with the vegetation cover of the study areas. Furthermore, it can be concluded that SEBS model can be applied to different sites and in different situations of atmospheric stability, while maintaining the same parameterization. This could be important for large scale applications, where the information on site characteristics is not sufficiently detailed or where the system of local atmospheric stability is not reliable.

Evaluating the effectiveness of producing BRDF models from SEVIRI surface reflectance data.

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Remotely sensed surface reflectances are strongly variable as a function of the scene geometry under which the reflectances were recorded, meaning that they display anisotropic reflectance. The high temporal resolution of the SEVIRI aboard Meteosat Second Generation means that its surface reflectance measurements will display a strong diurnal variation as the sun moves across the sky. By acquiring surface reflectances over a four day period it is possible to normalise many of the anisotropic effects present in SEVIRI data, thereby producing a Nadir BRDF Adjusted Reflectance (NBAR) in which each pixel in a scene is simulated to be produced by a nadir sensor and low sun angle through the use of a Bidirectional Reflectance Distribution Function (BRDF) model.

Here we present results demonstrating the application of the MODIS BRDF algorithm to MSG data in an attempt to generate NBARs. We show that under many conditions this algorithm is capable of producing high quality BRDF models, and therefore accurate surface reflectances, in which the majority of anisotropic effects are removed. Compared to the MODIS BRDF product (MCD43) the relative difference is typically less than 10%.

Some conditions do exist in which the NBAR is of less than optimal quality, however, and these are most frequently in very cloud prone areas such as central Africa. But by adapting the cloudmask usage it is possible to increase the quality of the BRDF model, even in severely cloud affected regions. Additionally, quality can be compromised in the cross principal plane (the area directly north of the sensor) in which angular sampling is low - and this can be partially overcome by the addition of other sources of reflectance data, such as that from MSG 1 located at a longitude of 9.5E.

Land cover and Land use Monitoring using Remote Sensing and GIS from parts of south India: Implications to Natural resources assessment

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Over the past few decades there has been raising concerns from the researchers and planners about the increasing anthropogenic influence on Forest resources. Anthropogenic changes in forests are being increasingly recognized as critical factors influencing global change. Land use is often shaped by human , socio-economic and political influences on the land. Remote Sensing (RS) , integrated with Geographic Information System (GIS) , provides an effective tool for analysis of land use and land cover changes at a regional level. The techniques have been used extensively in the tropics for generating valuable information on forest cover , vegetation type and land use changes. Therefore, we have used RS and GIS to study land in Rajampet –Pullampet area. The inputs used in the study area are geocoded imagery 57N04 (IRS P6), Survey Of India, toposheet 57N04, tracing sheet, GIS Software etc. With this in view, the present work has been taken up to study and assess some of the Forest resources monitoring and environmental potential of study area. A total of three thematic maps such as land use and land cover ,drainage and slope maps were prepared based on image interpretation studies with limited checks. The land use-land cover pattern fall under the broad categories of agricultural land, forest land and waste land. Further the forest land has been classified into reserve forest and waste land vegetation. . Forest land represents areas that have a tree grown aerial density of 30 percent or more, are stocked with trees capable of producing timber or other wood products and exert an influence on the climate or water regime. In the study area land is classified into two levels.Fairly dense forest land covered with the hills which are in trending NW-SSE adjacent to Seshachalam Extension Reserved Forest (RF), Cheyyeru Extension RF,Tippayapalle RF, NE part of the Chitveli RF and central part of the Vattaluru RF. Sparse forest land located on undulating terrain , up lands, and slopes of the hills. The villages nearer to the sparse forest land are Tippayapalle, Bramhanapalle, Anantasamudram, Poli, Pulapathuru, Vattaluru ect. Social forestry program include plantations and development of pasture land, arrest of soil erosion by afforestration has been suggested. In the study area , most of the land (60%) is unused for neither cultivation nor settlements so the land can be suggested for industrialized and urban planning.

Directional Effects on Land Surface Temperature Estimation from MSG-SEVIRI

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A main source of error in Land Surface Temperature (LST) estimates is its dependency on vegetation structure and viewing and illumination geometry. These effects are typically not considered in current operational LST products from neither polar-orbiting nor geostationary satellites.

Here we present results from a simulation study of the angular effect that can be expected when estimating LST with the viewing geometry of the geostationary MSG Spinning Enhanced Visible and InfraRed Imager (SEVIRI) sensor across the African Continent. We use the Modified Geometric Projection model (MPG), that estimates the scene thermal infrared radiance from different land covers. The results show that the sun-target-sensor geometry plays a significant role in the estimated temperature, in some cases with variations of more than 3 deg K strictly due to the angular configuration. On continental scale, the average error is small except for at hot-spot conditions, but large variations occur both geographically and temporally. The sun zenith angle, the amount of vegetation, and the vegetation structure are all shown to a□ect the magnitude of the errors.

Directional effects for a specific savanna site in West Africa are investigated in more detail. The MGP model assumes that the surface consists of four components: shaded and sunlit tree canopy and shaded and sunlit background. The brightness temperatures of these four surface components are provided by in-situ measurements at the validation site and emissivities are taken from the LSA-SAF project.

The findings highlight the need for taking the angular effects into account when applying LST estimates in models and when comparing LST estimates from different sensors or from different times, both on daily and seasonal scale.

Land surface albedo and down-welling short-wave radiation retrievals: toward merged products between MSG geostationary satellite and the polar system Metop

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The European Meteorological Satellite Organization (EUMETSAT) maintains a number of decentralized processing centers dedicated to different scientific themes. The Satellite Application Facility on Land Surface Analysis (LSA-SAF) is hosted by the Portuguese Meteorological Institute. Its objective is to provide value added products for the meteorological and environmental science communities with main applications in the fields of climate modeling, environmental management, natural hazards management, and climate change detection. Since 2005 data from Meteosat Second Generation satellite are routinely processed in near real time by the Land-SAF operational system in Lisbon. The delivered operational products comprise land surface albedo and temperature, short-wave and long-wave downwelling radiation fluxes, and snow cover. They have a spatial resolution of 3 km at the sub-satellite point and around 5 km over Europe. The product files are generated in HDF5 format with projection and spatial resolution corresponding to the characteristics of MSG/SEVIRI instrument. Products are distributed in near-real time by Eumetcast via satellite. They can also be ordered on the project website *http://landsaf.meteo.pt*. After ten years (1999-2009) of research, development, and progressive operational activities, a summary of the surface albedo and down-welling short-wave radiation product characteristics, and performances are presented. The albedo product is delivered on a daily basis in order to capture rapid changes such as ones caused by snowfalls. The basic algorithm concept comprises an atmospheric correction scheme, the inversion of a linear semi-empirical model of the bidirectional reflectance distribution function, the angular integration of the bidirectional reflectance distribution function to obtain spectral albedo, and the application of suitable conversion relations to derive broadband albedo estimates. These latter were evaluated against similar MODIS albedo fields and ground networks over Europe and North Africa regions. The results indicate a relative accuracy of 10% compared to MODIS products with the exception of the visible broadband albedo. The down-welling short-wave radiation is calculated at 30 minutes interval based on a every second SEVIRI imagery. It essentially depends on solar geometry and cloud cover. The validation studies with BSRN (Baseline Surface Radiation Network) stations show in general a good agreement between the satellite estimates and in-situ measurements. Over Africa there is an overestimation of the radiation in clear sky situations potentially due to aerosol effects. The main objective of the current phase (the Continuous Development and Operational Phase, 2007-2012) is presented: to provide a new product generation by means of merging data between the polar satellite MetOp (Meteorological Operational, launched in October 2006) and the MSG-2 geostationary satellite data. Preliminary evaluation study of the beta-merged products shows that the additional information is particularly beneficial for high latitudes during winter. The LSA SAF program provides a great opportunity to monitor and identify human-induced climate change as a consistent production of data sets until at least 2019 with forthcoming MSG-3 mission.

ECOCLIMAP-II : A Characterization of land surface parameters for Meteorological and Climate models based on SPOT/VEGETATION

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The ECOCLIMAP initiative has been specifically implemented to answer the needs of the meteorological community in investigating natural and managed ecosystems in connection with weather forecasting and climate change modelling.

It is presented a new land cover map ECOCLIMAP-II, developed in using recent data from the SPOT/VEGETATION instrument over a 7-year period (1999-2005), along with a classification method based on the k-means algorithm. Combining satellite-derived land cover maps and climate information, with the aid of a supervised analysis, ECOCLIMAP-II initiative is performing the discrimination of the latter ecosystems.

The contents of ecosystems is described through their expression as a linear combination of 4 main surface types or tiles: sea, inland water bodies, human built up areas and natural land areas. This description of the surface is well adapted to the tile approach used by atmospheric models to calculate the energy, water, and carbon fluxes at the surface.

The tile ‘natural land areas’ is composed of 12 functional types: bare land, bare rock, permanent snow and ice, deciduous broadleaf forest, evergreen broadleaf forest, needle-leaved forest, C3 crops, C4 crops, irrigated crops, C3 herbaceous, C4 herbaceous, wetlands. In order to provide all parameters needed by land surface models, ECOCLIMAP-II provides for each functional type of a cover a 10-day annual LAI profile, a root depth, a total soil depth and a height of trees (if appropriate). Other surface parameters (fraction of vegetation, vegetation albedos, roughness length notably) are defined only by functional type, independently of the cover. They are set with constant values or with formulas relying on LAI, soil depths or heights of trees. The surface energy, water and carbon fluxes are calculated separately for each tile. Average fluxes over the entire grid cell are returned to the atmospheric model and are used as the lower boundary condition.

Adaptation of LSA SAF products for crop monitoring

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Since 2004, VITO systematically collects all the MSG-derived information distributed by the Land Surface Analysis Satellite Application Facility (LSA SAF) at the Instituto de Meteorologia in Lisbon, Portugal. All the data (temperatures, radiation, evapotranspiration, vegetation parameters,...) are spatially re-organised, temporally composited and converted to easier formats. In practice, daily and dekadal images are generated in flat binary format for the two entire continents: Africa in the Geographic Lon/Lat system with a resolution of 4°/112 (about 4 km) and Europe in the Lambert Azimuthal Equal-Area projection with pixels of 5 km. In this way, the MSG-derived data are congruent and compatible with the imagery collected from other sensors such as SPOT-VEGETATION, NOAA-AVHRR and TERRA-MODIS.

The following topics will be presented:

- Basic processing
- Comparison of the MSG-parameters with other data sources (FAPAR from SPOT-VEGETATION, DSSF and ET from ECMWF,…)
- Extraction of derived information (smoothed time series, DMP, databases)
- Further use of the data, especially for crop monitoring by the MARS project of the EC-JRC in Ispra, Italy.

Canopy resistance retrieval using Land SAF LST and Net Radiation in view to the LSA- SAF ET improvement in drought areas.

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The Land SAF Evapotranspiration product is obtained using an SVAT model that uses the Land SAF DSSF, DSLF and ALBEDO products, ECMWF data and the ECOCLIMAP database to characterize the vegetation. The model solves the energy balance equation, obtaining in addition to the evapotranspiration the surface fluxes and the skin temperature as outputs.

This product has pre-operational status and has been extensively validated by comparison with Fluxnet ground measurements over Europe and Africa. Although the existing LSA-SAF algorithm has a good performance in most conditions in Europe, the results in dry conditions are susceptible to be improved. One source of error that is critical in the evapotranspiration estimation in these areas is the soil moisture. The presented study is focused on the use of the LSA-SAF Land Surface Temperature (LST) product to attempt avoiding this problem.
In a first step, a first order model $Rn(t)=(T(t)-To)/R + C\, dT(t)/dt$ is chosen, consisting of a thermal capacity C in parallel with a thermal resistor R connecting T(t) to an equilibrium temperature To. This model aims to give a mathematical description of the relation between net radiation (Rn) and LST. The equation is solved for clear sky days.
In a second step, the first order model is linked to the ET SVAT model by means of the canopy resistance. The canopy resistance (rc) is obtained by inversion, choosing the rc value that provides the diurnal net radiation and skin temperature giving the first order coefficients closest to those obtained in the first step. Finally, this value of rc is used as an input of the evapotranspiration model, eliminating the dependency of the model to the ECMWF soil moisture values.
Maps of the different coefficients will be shown for all the MSG disk domain, as well as maps of the least square error of the Rn estimation, showing the correlations between 1/R and To with evaporative fraction and the minimum temperature of the day respectively. The first evapotranspiration results obtained using this methodology will be compared with those obtained with the pre-operational model and those measured at different Fluxnet stations, discussing the potential of using this methodology at operational level.

CEOS Working Group on Calibration and Validation: Land Product Validation Subgroup

C.Schaaf (schaaf@bu.edu)
and a large number of other dedicated researchers over the years.

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The Land Product Validation (LPV) sub-group of the CEOS Working Group on Calibration and Validation (WGCV) aims to address the challenges associated with global land product validation. The mission of the LPV sub-group is to foster and coordinate international validation activities for satellite-derived land products, to develop international validation protocols, conduct land product inter-comparisons, promote data sharing, and to ensure that data and results are available to the user community. LPV sub-group activities initially focused on land cover and fire products, in collaboration with GOFC-GOLD, as well as surface radiation and biophysical products. The recent emphasis on the independent and systematic evaluation and validation of terrestrial ECVs has prompted the sub-group to expand the LPV product focus areas to seven, each with internationally independent co-chairs who have been actively involved in validation activities and are respected community members. This structure allows for a stronger task force (working group) with a closer proximity to the corresponding land communities, and enhances feedback and collaborative efforts in relation to global independent validation and product inter-comparison, as well as increasing ground network and measurement databases.

Characterisation of permanent LST validation sites with field surveys and an unmanned aerial vehicle (UAV)

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Land surface temperature (LST) is an important quantity for the energy exchange between surface and atmosphere and is an operational product of the Land Surface Analysis – Satellite Application Facility (LSA-SAF). In order to validate LST products, KIT operates four permanent stations; these are the only long term LST validation stations within the field of view of the METEOSAT satellites. The validation work is carried out within the scope of LSA-SAF and is co-funded by EUMETSAT. Here, results from a field survey performed with a mobile radiometer and a feasibility study of validation with a mini UAV are presented. The UAV is based on the open source project “Paparazzi”, which allows robotic aerial surveys at very low cost. The surveys were performed in 2010 in Namibia in order to capture small scale spatial variations of LST around the desert station “Gobabeb” (gravel plain, 405 m asl) and the semi-desert station “RMZ” (Kalahari semi desert, 1500 m asl). Results are presented on the poster “Validation results for Land-Surface-Temperature”.

The validation stations core instrument is the “Heitronics KT 15.85 IIP” IR radiometer; additionally, long- and short-wave components of the energy balance as well as wind speed & direction and air temperature & moisture are measured. The KT 15.85 IIP is a chopped radiometer with high long term stability. The standard deviation of the difference between in-situ LST at Gobabeb and MSG / SEVIRI LST was shown to be generally less than 1.5℃, often with negligible bi as. In order to further increase the quality of these results, it has to be ensured that the areas observed by the stations radiometers (a few m^2) are representative of the corresponding MSG / SEVIRI pixels (about 25km^2). Gobabeb LST validation station is located on large (several thousand km^2) and highly homogeneous gravel plains. The plains consist mainly of gravel and sand with some patches of desiccated grass, wadis, and rock outcrops. This leads to a certain amount of spatial LST variation and may cause time dependent biases between station LST and satellite LST. In order to improve comparisons between the two LSTs, the underlying assumptions about homogeneity are validated with field surveys. Results obtained with a mobile radiometer and the UAV are presented and the effect of the within pixel LST variation are discussed.

Validation results for Land-Surface-Temperature

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Land surface temperature (LST) is an operational product of the Land Surface Analysis – Satellite Application Facility (LSA-SAF). In order to validate LST products, KIT operates four permanent stations - the only long term LST validation stations within the field of view of the METEOSAT satellites. The validation work is carried out within the scope of LSA-SAF and is co-funded by EUMETSAT. Here, mainly validation results from 2008 to 2010 from the KIT-Station Gobabeb, Namibia, are presented. The desert station “Gobabeb” is located on the gravel plains of the Namib Desert at 405 m asl. A quality assessment and details of the validation station are presented on the poster “Characterisation of permanent LST validation sites with field surveys and an unmanned aerial vehicle (UAV)”.

With the exception of Jul-Aug 2008 and Dec 2009, the data from June 2008 until July 2010 from Gobabeb are available. The LST at the station was determined from ground observing radiometers, a sky view radiometer, and the emissivity used operationally. Thus emissivity errors are not considered in this validation study. The datasets from sunrise to noon (“morning”), noon to sunset (“afternoon”), and between sunset and sunrise (“night”) were analyzed separately.
First we compared the station data with LSA-SAF LST from operations, i.e. it is an assessment of the quality of the data disseminated to the users. The main result is the proof of the excellent quality of the delivered LST data for most months. In summer (Jan, Feb) the scatter is higher (RMS of 4.9℃ and 2.9℃) than for the rest of the year (RMS generally less than 2.1℃).
Cold outliers of SAF-LST are very likely due to undetected clouds and can be identified at first glance. These outliers were removed with the “Hampel identifier”. This algorithm uses the median and the absolute deviation from median instead of the commonly used mean and standard deviation, and therefore, it is more robust. The dataset without cloudy outliers allows a better validation of the LST retrieval algorithm. In summer (Jan, Feb) the scatter of the filtered data generally has an RMS of about 3.3℃ and 2.2℃, respectively, and during the rest of the year it is less than 1.5℃. The bias of the cloud filtered dataset is below 1℃, the slope of the linear regression varies between 0.97 and 1.1. The low bias is somewhat less consistent when separating the data set into “morning”, “afternoon”, and “night”. However, generally we find positive slopes and negative offsets. In particular at high temperatures (best seen around noon in summer) MSG-LSTs are warmer than the in-situ LST. Similar investigations in Evora show that the findings in Gobabeb are not unique to the desert location.

Geoland2 - Towards an operational GMES Land Monitoring Core Service: Monitoring the Land Surface at global scale

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The European GMES (Global Monitoring for Environment and Security) initiative provides a political framework for future implementations of Services Centres in charge of products and services related to environmental applications (http://www.gmes.info). The project geoland2 (2008-2012), co-funded by the European Commission (EC), 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 prepare, validate and demonstrate pre-operational service chains and products that will underpin the LMCS, and to propose and demonstrate a concrete functional organisation of the LMCS. The architecture of geoland2 is made of two layers, the Core Mapping Services (CMS) and the Core Information Services (CIS). The CMS produces “basic” land state products covering a wide variety of thematic content, spatial scales from local to global, and update frequency from 1 day to several years. The CIS are a set of thematic elements from CMS products and other data sources to generate “elaborated” information products addressing specific European policies.

The Biogeophysical Parameter (BioPar) CMS aims at setting-up pre-operational infrastructures for providing regional, continental, and global variables describing the vegetation state, the radiation budget at the surface, and the water cycle, both in near real time and off-line mode. It takes a further step towards the visible integration of European operational services (Eumetsat/LSA SAF, FP6/VGT4Africa, MARS Food), and R&D projects (ESA/Globcarbon, FP5/Cyclopes, ESA/Globcover), and of national initiatives. The BioPar CMS is a user-driven service whose portfolio has been designed to suit the needs of institutional users, future downstream services, and the international science community involved in agri-environmental activities, natural resources monitoring, the crop production, water management, and carbon cycle modelling.

Three Core Information Services (CIS) are involved in global land applications. The main mission of the Land Carbon (LC) CIS is to assess the impact of weather and climate variability on terrestrial biospheric carbon fluxes, in the context of international conventions. The LC-CIS aims at monitoring the global terrestrial carbon fluxes (e.g. to support reporting obligations in the course of the Kyoto Protocol) and setting-up pre-operational infrastructures for providing global products, both in near real time and off-line mode. The objective of the Natural Resources Monitoring in Africa (NARMA) CIS is to develop an environmental monitoring capacity over African countries for the needs of the European Commission services and for regional and continental EC partners in African countries. NARMA CIS focuses on data analysis processes to identify the surface conditions for rangeland and water management, and to set-up environmental indicators about the climate variability and human impacts on forest, agricultural and pastureland areas. The mission of the Global Crop Monitoring (GCM) CIS is to provide objective, near real-time crop assessment and yield forecasts in support to EC policies in the field Agriculture and Food security. GCM CIS contributes to the development of pre-operational techniques for the timely assessment of regional crop yield, crop area and crop production at a global scale. The presentation will present the concept, the objectives, the structure, and the activities of research, development, and production of geoland2, of the BioPar CMS, and of the global CIS in the European GMES context.

Using the MSG Fire Radiative Power PIXEL Product to monitor gas flaring

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Gas flaring is a commonly used practice for disposing of natural gas in the petroleum production industry, especially in oil-rich regions where it is not needed or where the necessary distributive infrastructure is deficient. According to the Global Gas Flaring Reduction initiative of the Worldbank, an estimated volume of 150 - 170 billion cubic meters of gas has been flared annually worldwide over the past 14 years. This practice is an enormous waste of energy and has an highly negative environmental impact. This includes local problems like air pollution and a decrease in living standards of the local population, and global effects on climate in terms GHG emissions caused by the unnecessary combustions of a fossil fuel. International and national policies have become increasingly aware of the problem, and initial regulations on gas flaring have been or are currently being introduced in some of the major oil producing countries (e.g. the USA, the Russian Federation, and Nigeria).

Earth observation data has a long tradition as a tool for monitoring fire and other thermal anomalies on a global scale. Various low and moderate resolution satellite based sensor instruments have been used (AVHRR, MODIS, BIRD, ATSR, Meteosat SEVIRI) and a variety of algorithms for fire detections have been developed. However, most sensors are optimized for the detection of fires from biomass burning, such as forest fires and wildfires. Detailed investigations on the potential of the different fire sensors for gas flare monitoring are rare to date (GGFR, NRL, Elvidge, Arino 2010). Major limitations in previous studies were found in the temporal resolution of the system used, image accessibility, and the detection potential in general. Gas flare monitoring on a large-scale (regional to global) requires high temporal resolution EO data to be successful.

This study analyzes the potential of the Meteosat Second Generation (MSG) Fire Radiative Power Pixel Product (distributed by LandSAF) in comparison to two other modern and freely available EO based active fire products for monitoring gas flares: the MODIS Active Fire Product (University of Maryland) and the ESA World Fire Atlas (WFA). The study was carried out in three differing environmental scenarios (tropics, desert, sub-polar) in the major oil producing regions of Nigeria, the Persian Gulf and Siberia and examined fire product data from 2008 through July 2010.

Influence of algorithm and angular configuration on LAI, FVC and FAPAR estimates from SEVIRI/Meteosat

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The EUMETSAT Land-SAF program delivers operationally Leaf area index (LAI), Fraction of green Vegetation Cover (FVC) and Fraction of Absorbed Photosynthetically Active Radiation (fAPAR) products from the observations provided by the Spinning Enhanced Visible and Infrared Imager (SEVIRI) instrument onboard the Meteosat Second Generation satellite.

The inputs of the Land-SAF algorithm for the estimation of vegetation products are atmospherically corrected cloud-screened TOC bidirectional reflectances in three SEVIRI channels: red, near infrared and middle infrared. A kernel-driven bidirectional reflectance distribution function (BRDF) model is used for the correction of directional effects and the adjustment of satellite reflectances to common conditions. LAI and FVC are estimated from reflectances normalized at nadir sun-view geometry. This geometry leads to a minimum contribution of the shadow proportion and physically coincides with the complement to unity of the gap fraction at nadir direction. However some studies indicate that nadir-view reflectance is more susceptible to noise when extrapolated to nadir solar zenith angle than at the median solar zenith angle of the observations. Further at this geometry the contribution of illuminated soil background is significant, constituting thus a source of noise that has long been recognized as major problem in remote sensing of vegetation. Inputs for retrieving FAPAR are reflectances in an optimal angular geometry established close to the backscattering direction (solar zenith angle of qs=45º, view zenith angle of qv=60º and relative azimuth angle of f=0º). This geometry was proposed in order to reduce the soil contribution to the canopy reflectance. However, other algorithms have been developed based on alternative principles and geometrical configurations.

This investigation focuses on the influence of the retrieval algorithm and the angular configuration of reflectance data in the estimation of LAI, FVC and FAPAR from SEVIRI/Meteosat. A comparative analysis of the neural network model inversion algorithm used operationally in ESA/MERIS and FP5/CYCLOPES and the statistical approach implemented in EUMETSAT/LandSAF is performed. To assess the influence of input data, neural networks trained over radiative transfer simulations were applied to reflectance data for different observation and illumination geometries. The study focused over problematic areas with large BRDF uncertainties in Europe.

Keywords: LSA SAF, vegetation products, algorithm influence, BRDF input data

Remote Sensing of the Annual Heat Storage Change in Lake Tana, Ethiopia

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Lake Tana is the largest lake Ethiopia has and is the source of the Blue Nile. The lake water resources support the livelihoods of over 3 million people living around and have local and global economic and political significance. It is vital to establish a water resources management scheme to ensure sustainable development. For this reason a sound understanding of the lake's hydrological processes and energy balance is a key factor.

It is possible to evaluate the annual heat storage changes and the resulting effect on lake evaporation through retrieving the lake surface temperature from satellite data. First the available methods of water surface temperature retrieval algorithms have been identified. Two split window techniques including the Sun-Pinker and Becker-Li methods were selected for further validation and calibration. The lake surface temperature was retrieved with both methods and results have been checked against ground observations.

The algorithm developed by Sun and Pinker for night-time temperature retrieval did not yield acceptable values. Upward temperature jumps in the order of 2 K occurred at sunset, while the reverse happened at sunrise. For this reason the night-time algorithm had to be modified. The lake water surface temperature (WST) has been retrieved with the modified algorithm and the diurnal cycle was analyzed.

A final objective of the first part of this study was to identify the most suitable model in terms of input parameters and computational efficiency. A two channel algorithm developed by Becker and Li was found to meet the requirements. However, the coefficients of the model were developed for the AVHRR sensor originally, and needed to be adjusted for the MSG satellite data. This was accomplished by linear regression against the modified Sun-Pinker method.

METEOSAT Second Generation Data for Assessment of Daily Vegetation Condition Status over the Brazilian Amazon

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Frequent monitoring of the vegetation dynamics at regional scale is important in ecosystem variability studies and in understanding the interactions between the climate variability and terrestrial ecosystem carbon exchange. One of the greatest challenges in the monitoring of changing detection of terrestrial biomes is how to disentangle the effects of climate and human-induced land degradation impact on vegetation dynamics. There have been limited investigations on the operational utilization of satellite-derived vegetation indices to daily monitor the spatial and temporal patterns of vegetation activity at regional scale. Part of this problem concerns the causing diurnal variations for cloud contamination, illumination and viewing geometry. The METEOSAT SEVIRI instrument posses all spectral channels to characterize daily the changes of the Earth's vegetation. One of the most popular approaches to monitor the state of vegetation is the application of the Normalized

Difference Vegetation Index (NDVI) derived from space-based remote sensing data as a good proxy for plant productivity. Therefore, the monitoring of the state of vegetation in terrestrial biomes, particularly in high-frequency observations, is of great importance. With this respect, in this study we present first results on daily composite NDVI image deriving from level 1.5 SEVIRI data received via EUMETCast covering the Brazilian Amazon. To be able to preliminary generate of daily composite NDVI image, cloud masked surface reflectance in the red and near infrared channels for each image and followed by maximum of the images from 10 am to 2 pm local solar time were computed. Our preliminary results show the daily maximum-composite METEOSAT NDVI track vegetation dynamics over the Brazilian Amazon and provide new opportunities for integrative studies of carbon/land use activities. This work is in progress and awaits the comparisons between time series of our SEVIRI NDVI analysis and LAND SAF fractional Vegetation Cover (FVC) product.