EUMETSAT LSA-SAF EVAPOTRANSPIRATION PRODUCTS STATUS AND PERSPECTIVES

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ABSTRACT
Evapotranspiration (ET) defined as the flux of water between the surface (soil + vegetation) and the atmosphere is one of the main components of the terrestrial water budget. Its continuous monitoring at large spatial scales arouses particular interest in disciplines like water management, agriculture, hydrology, ecology and climate monitoring. The instantaneous (MET) and daily (DMET) evapotranspiration products developed in the framework of EUMETSAT’s Land Surface Analysis Satellite Application Facility (LSA-SAF) are generated by a physical based algorithm, forced with radiative data from MSG satellites and auxiliary sources (Ghilain et al., 2011). The MET and DMET products are in operational status since August 2009 and November 2010 respectively. More and more users start using these products on regular basis. The MET and DMET products has been satisfactorily validated in different climates and environments, showing very good performances for well-watered conditions prevailing notably in Europe. At the same time, some deficiencies in dry areas were revealed. Research has been pursued in order to improve model performances on those areas by including new satellite-derived products that can better depict the real state of vegetation, soil and environment.

INTRODUCTION
Accurate measurements of evaporation rates at large spatial scales are crucial to understanding land and atmosphere interactions in the context of climate change. The temperature change effects on ET are perhaps already there but lack of regular ET measurements at global scales do not allow for clearly depicting the phenomenon. In last years, many efforts have been done to develop models allowing the quantification of the flux of water released from the ground surface at different spatial and temporal scales. Satellite remote sensing is seen as the most suited technology given its current accessibility and relatively low acquisition costs. In the framework of EUMETSAT’s SAF network, The LSA-SAF has taken in charge the development of techniques to retrieve parameters related to land, land-atmosphere interactions and biosphere applications, by using data from MSG satellites. One of the products developed in LSA-SAF is the land evaporation and transpiration from vegetation “evapotranspiration” MET. The method follows a physical approach and the model is forced with radiative data derived from MSG satellites combined with information on land-cover characteristics and ancillary meteorological data from NWP. The model shares available energy at the surface into the latent (LE), sensible (H) and ground (G) heat fluxes, depending on land-cover type characteristics and meteorological conditions (humidity, temperature, pressure). This method is one of the firsts to derive ET operationally over large areas. The LSA-SAF ET product can be used for hydrological modelling specially for medium size and large hydrological basins, for continuous (in near real time) ET monitoring, for long-term studies directed towards possible change detection and by combination with potential evapotranspiration it can be used for drought monitoring and desertification studies.

THE LSA-SAF ET PRODUCTS (MET/DMET)
As described in Ghilain et. al (2011), the MET product is derived with a SVAT scheme forced with MSG-SEVIRI derived data, and external information about vegetation coverage and characteristics, which depend essentially on the state of development of considered vegetation. The main advantage of the method is that it uses instantaneous fluxes observed in near real time which accounts for the
real cloud coverage and position, producing more accurate results when compared with method that uses for instance information from only one satellite overpass and integrates this information over the whole day. A complete description of the method has been presented in Ghilain et al 2011, and is also available on LSA-SAF ET documentation (site [http://landsaf.meteo.pt/]). In the proposed model, the net radiation reaching the surface is decomposed into latent, sensible, and soil heat fluxes. The instantaneous evapotranspiration is obtained from the LE and the latent heat of vaporisation which is function of air temperature. In optimal conditions (no missing forcing data), one ET image is generated every 30 minutes. Each image is stored on an HDF5 file, containing also information about the quality of generated output. In Figure 1, an example of the MET product (a) and the accompanying information on quality of the estimation (b) is presented for 29th October 2010 over the full MSG disk. Quality flags reflect the quality of input data and assumptions done to work out the results (red colour corresponds to the best quality). A detailed description of algorithm output can be found in the MET Product User Manual (‘PUM’)

![Figure 1](image)

**Figure 1**, LSA-SAF instantaneous evapotranspiration product (a) and associated quality flag (b) for 2010/10/29 at 12:00 UTC over full MSG disk

Figure 2 depicts instantaneous ET estimations over Europe and Africa for 3 different hours (09:00, 12:00, and 15:00) of the day 20120903 and in Figure 3, the corresponding daily image over the full MSG FOV is shown. Daily product is generated with a lag time of one day. Figure 4 represents an example of a possible application of the ET product. In this figure, the monthly evapotranspiration over the Vistula river basin in Poland is presented. This type of applications can be useful for hydrological modelling and water management. The picture shows the evolution of the evapotranspiration rates throughout the year 2011, starting from low rates from November to February, medium values for March, April, September and October to highest rates from May to August.
Figure 2, Instantaneous ET (mm/h) for the day 20120903 over Europe and Africa (Nafr, SAfr) at three different hours: 09:00 (left column), 12:00 (medium) and 15:00 (right column)

Figure 3, Daily ET product (mm), for 20120903 over full MSG FOV
VALIDATION

The products have been validated by comparing the instantaneous and daily-cumulated ET values to evapotranspiration derived from measurements at selected locations and by comparing the algorithm output to the output from other models. Detailed information about validation approach and results can be found in the product validation report, available from the LSA-SAF web site (http://landsaf.meteo.pt/) and in Ghilain et. al (2011). Figure 5 is an example of comparison between simulations and observations, at a mixed forest site (Vielsalm) in Belgium, for the year 2007.

Figure 5, density scatter plot of 30 minutes simulated vs observed ET (left panel) and ten days sliding averages with a scatter plot of daily simulations vs. observations and a Taylor diagram summarising the statistics of the comparison (on the right panel)
FURTHER MODEL IMPROVEMENTS

As already presented on Arboleda et al (2011), two axes are pursued to improve the quality of MET/DMET products. On the first one, LSA-SAF leaf area index (LAI) and fractional vegetation cover (FVC) products combined with ECOCLIMAP database (Masson et al., 2003) are used to a closer monitoring of the vegetation state. The methodology has been tested in offline mode and will be implemented on the operational chain in coming months. As it can be seen from Figure 6, the use of LSA-SAF vegetation products (FVC and LAI) pulls the statistical indicators (correlation coefficient and RMS error) toward improved values. The second axe is dedicated to better knowledge on soil moisture status. For this purpose, preliminary tests with SM-DAS-II root zone soil moisture and LSA-SAF LST products have been undertaken. For example, the preliminary results with LST are encouraging given that they confirm that there exists a correlation between SM indicator derived from LST with in-situ SM observations and also with ECMWF estimation (Figure 7).

*Figure 6. Comparison of latent heat flux generated by the operational MET algorithm at selected stations (top), to latent heat flux generated by the same model after implementation of proposed modifications (bottom) at the same locations.*
DISCUSSION

The MET and DMET evapotranspiration products developed in the framework of the LSA-SAF project have been presented. The products are generated with a physically based approach that uses main radiative forcing from Meteosat Second Generation (MSG) geostationary satellites together with land-cover information from ECOCLIMAP and ancillary meteorological data from ECMWF. This is one of the first evapotranspiration products to be proposed operationally over large areas. The product is suitable for continuous (in near real time) ET monitoring for different applications and when long-term series will be available for studies directed towards possible change detection. Research is pursued towards a closer monitoring the state of vegetation by including more and more input derived directly from satellite observations. In particular the emphasis is put towards a better estimation of soil water content in order to improve the model estimates in dry areas.

REFERENCES


