

LAND SURFACE EVAPOTRANSPIRATION AS SEEN FROM METEOSAT SECOND GENERATION SATELLITES: LSA-SAF DEVELOPMENTS AND PERSPECTIVES.

Gellens-Meulenberghs, F., Ghilain, N. and Arboleda, A.

Royal Meteorological Institute (RMI) of Belgium, Avenue Circulaire, 3. B-1180 Brussels, Belgium.

ABSTRACT

The ‘Land-Surface-Analysis’ SAF (LSA-SAF, <http://landsaf.meteo.pt/>), is dedicated to the operational monitoring of land surface. For this purpose, it develops algorithms to obtain near real time data products. The evapotranspiration (ET), cannot be observed directly by remote sensing and is assessed indirectly through modelling. The ET algorithm uses Meteosat Second Generation (MSG) derived data. It produces in near real time ET estimates at the SEVIRI instrument spatial resolution each 30 minutes. Validation already carried out attests the robustness of the proposed algorithm, notably over Europe. Nevertheless, research will be pursued during coming years, looking for additional validation sites and evolving towards an improved combination of remote sensed observations and models.

Index Terms— Meteorology, land surface, hydrology, water resources, remote monitoring.

1. INTRODUCTION

The solar radiation is reflected, diffused, absorbed and re-emitted under the combined effect of the atmosphere, aerosols, clouds, vegetation and ground surface. These processes exhibit very large spatial and temporal variability. The challenge addressed by the LSA-SAF (<http://landsaf.meteo.pt/>) is to model the involved fluxes at the land surface by exploiting data of operational meteorological satellites and to output a series of products within the area covered by the MSG disk or by METOP with the spatial and temporal resolution of respectively SEVIRI and AVHRR sensors.

In the LSA-SAF, the RMI team is responsible for the development of the evapotranspiration (ET), a process linked to the energy released to the atmosphere as latent heat LE through the relationship $ET = LE/L_v$ (L_v , the latent heat of vaporization).

When aiming at quantitative estimates of LE and ET for large scales (regional, continental, global), it is not possible to obtain measurements from a dense network of ground based stations; therefore, computing these fluxes from satellite remote sensing (SRS) data is very attractive as it

enables a widespread area coverage and a high temporal repetition rate. However, a major difficulty is that satellites do not measure ET and turbulent surface fluxes directly, but that they only provide information about the way processes involving these variables do develop. ET has then to be indirectly assessed, taking advantage of information gained through the satellite itself about surface variables and also making use of ancillary meteorological data.

Many approaches have been developed to estimate ET and turbulent surface fluxes, ranging from simple empirical relationships to the most complex models. They have been applied to a variety of spatial scales, from local and regional to global scales. Common methods used to estimate these fluxes at regional scale by using SRS are reviewed in [1], [5] and [6].

Most models based on SRS data uses polar satellites and focuses on clear skies areas which are used to achieve composite images over several days. In the LSA-SAF, cloud covered pixels are taken into account to correctly estimate instantaneous energy fluxes and a fine time step (30 minutes) is used to compute adequately mean values over the longer periods required for environmental applications.

In this contribution, we will give an overview of developments made about LSA-SAF ET and present current results. Information will also be provided about products description and availability to users. Perspective for new activities will be given in-fine.

2. METHODOLOGY

The RMI algorithm has been adapted from the ECMWF SVAT scheme “TESSEL” [8], [9]. A full description of the methodology is given in [3]. In short, ET is obtained by solving an implicit system of equations containing the surface energy budget and classical bulk relationships to parameterize the surface fluxes. The ECOCLIMAP data base [7] is used to identify the land cover types.

The equations associated with the physical description of the energy fluxes at the surface-atmosphere interface are solved iteratively for every land cover types (tiles), including bare soil and several vegetation types, within each SEVIRI pixel; the ET value of the pixel is therefore obtained by the aggregation of the ET calculated separately for each tile. The input data of the ET algorithm comes mainly from two sources: 1) LSA-SAF products (e.g. DSSF

(downward surface shortwave flux), DSLF (downward surface longwave flux), AL (albedo)), and 2) ECMWF analysis and forecasts (air temperature and humidity, wind speed, surface pressure, soil moisture and temperature). The cloudy pixels are also processed as the main input is available whatever the cloud cover. An automatic quality control is performed, reflecting the quality of the input data and a confidence level for the ET output.

During the Continuous Development and Operation Phase (CDOP, 3/2007 – 2/2012), the RMI team has extended the LSA-SAF evapotranspiration (ET) product from European area to the full MSG disk (thus including Africa and a part of South America). Validation material has been searched (from in-situ observations and from global models) and comparisons have been done between LSA-SAF ET and the validation datasets [3].

3. RESULTS

Two products have become fully operational during CDOP: the instantaneous ET derived from MSG (MET product) since mid-2009, and daily cumulated values (DMET product) available since end of 2010. They are freely available to users in near real time through the LSA-SAF web-site (<http://landsaf.meteo.pt/>) or via the EUMETCast. Figures 1a (full disk) and b (Europe) show MET at noon in Europe for a day in May 2012.

Evapotranspiration over FULL MSG DISK for 20120526 at 12:00UTC

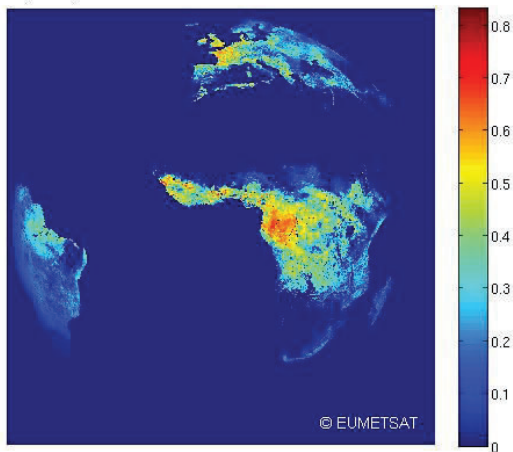


Figure 1a: LSA-SAF ET (mm h^{-1}) as seen from MSG on 28th May 2012 at 12:00 UTC (MET product).

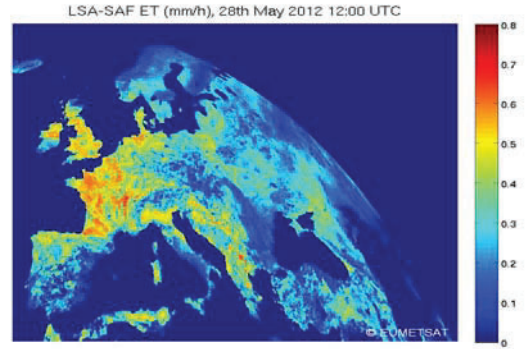


Figure 1b: LSA-SAF ET (mm h^{-1}) over Europe on 28th May 2012 at 12:00 UTC (MET product).

The validation of the ET products is done by comparison with in-situ observations and with comparable output from operational models. (Table 1).

Table 1: Stations used for validation of MET product.

Station	Abb.*	Vegetation Type**	Source***
Amplero	Amp	G	FLUXNET
Buzenol	Buz	G	RMI
Cabauw	Cab	G	KNMI
Humain	Hum	G	RMI
Monte Bondone	MBo	G	FLUXNET
Tojal	Toj	G	FLUXNET
Lonzée	Lon	C	RMI
Hesse	Hes	DBF	FLUXNET
Roccarespampani	Roc	DBF	FLUXNET
Loobos	Loo	ENF	FLUXNET
Wetzstein	Wet	ENF	FLUXNET
Sodankylä	Sod	ENF	FLUXNET
Las Majadas	LMa	EMF	FLUXNET
Puéchabon	Pue	EMF	FLUXNET
Vielsalm	Vie	MF	RMI
Kaamanen	Kaa	B	FLUXNET

*Abb.: Abbreviations of stations names;

**Vegetation Type: Grassland (G), Deciduous Broadleaved Forest (DBF), Evergreen Needle Forest (ENF), Crops (C), Mixed Forest (MF), Evergreen Mediterranean Forest (EMF);

***Source (data provider): FLUXNET, Royal Meteorological Institute of Belgium (RMI) and Koninklijk Nederlands Meteorologisch Instituut (KNMI).

Figure 2 and 3 show statistics obtained from the comparison with a set of observations for the vegetation season (from March to November) in 2007. Correlations coefficients are high, above 0.7, for most of the stations. Biases are low (less than 0.05 mm h^{-1}) and RMS values remain in the uncertainty range of observations (around 20% of mean values).

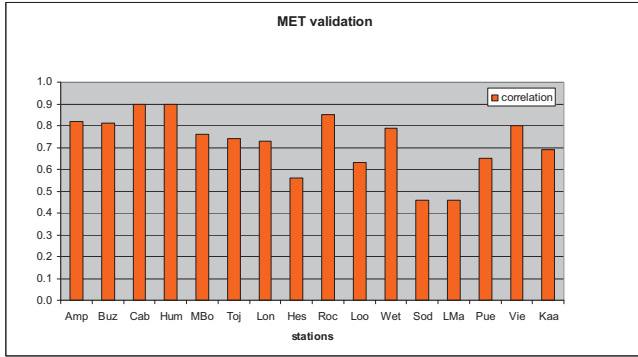


Figure 2. Correlation coefficient between 30 minutes MET results in 2007 and in-situ observations at a set of flux stations (see text and Table 1 for abbreviations of stations names).

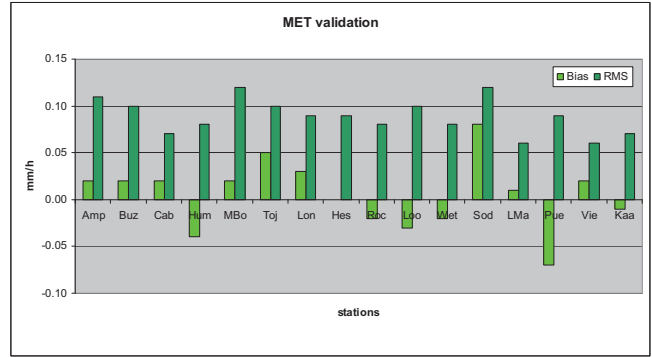


Figure 3. Bias and RMS for the same dataset as in Figure 2.

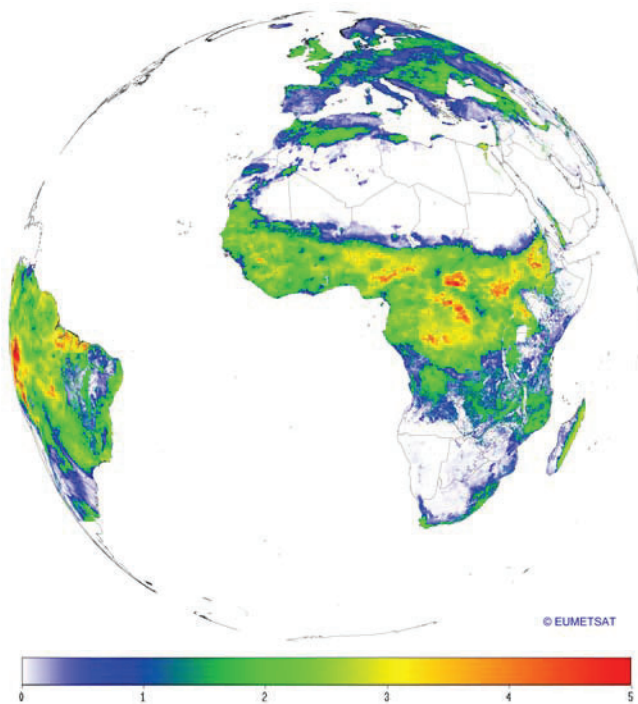


Figure 4. Example of LSA-SAF daily evapotranspiration product, DMET (mm d^{-1}) for a day in September (12/9/2009).

Figure 4 shows an example of the DMET product. Again, validation is done by comparison with data from flux stations. Results of the comparisons give excellent, good or satisfactory results following the considered stations (not shown). Largest differences occur for some periods in stations located in arid or semi-arid areas. Figure 5 illustrates a case where some of the fluctuations are not perfectly reproduced by the model showing that there is still room for improvements.

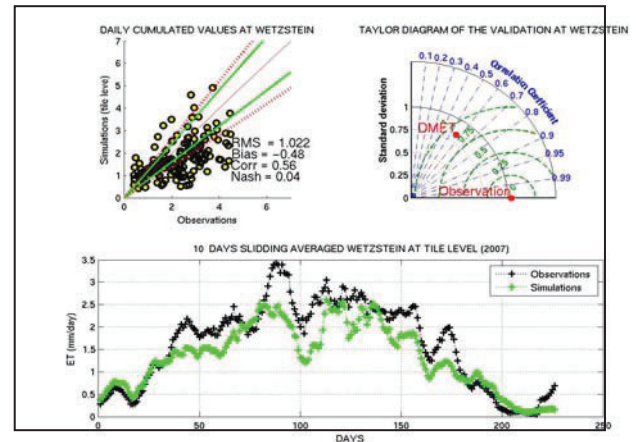


Figure 5: Validation of daily ET at the Wetzstein station. Scatter plot (top left), Taylor diagram (top right) and annual cycle (bottom).

4. FUTURE ACTIVITIES

In parallel to operational production, research is pursued to integrate into the model an increased number of SRS data. Recently, special attention has been given to the integration into the model of vegetation indices derived from MSG-SEVIRI, FVC (fraction of vegetation cover), LAI (leaf area index) [4]. Further research will focus on the verification of bare soil evaporation parameterization and improvement of soil moisture in the model.

In the future, the LSA-SAF ET team will extend its investigations to a second important surface flux: the sensible heat flux H . The LE and H fluxes are the most important components of the surface energy budget and are thus the key elements needed to characterize the surface energy partitioning. In addition, RMI will support LSA-SAF leading entity in implementing a new reference evapotranspiration (ET_{ref}) product [2]. This product will have a great interest for a set of applications in the field of agronomy.

5. CONCLUSIONS

Today, two MSG derived ET products are available from the LSA-SAF. Users can access the data through the LSA-SAF web-site (<http://landsaf.meteo.pt/>) or via the EUMETCast system of data acquisition. Validation results show that the accuracy is in the uncertainty range of flux observations and model intercomparisons studies [3]. In particular good results are obtained over most parts of Europe. However, a few validation stations located in arid or semi-arid areas seems to indicate that the results should be further investigated and possibly improved for areas submitted to this kind of climate. In the future, validation activities will be pursued and model will be improved as necessary.

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