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Climate data record of evapotranspiration and surface heat fluxes: a feasibility study based on joint LSA-SAF and CM-SAF capabilities

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Abstract

Land surface heat and water vapour fluxes are key elements in our climate system: they materialize the feedback the land gives in return to atmosphere. In order to better apprehend the changes of this feedback over the years, a long record of data is necessary. The exploitation of the observations from EUMETSAT METEOSAT suite of satellites could be valuable in that perspective as it provide information for a period in time of about 30 years. The Climate Monitoring (CM) Satellite Application Facility (SAF) has already issued climate data records based on METEOSAT satellites, providing for example different components of the Earth's energy budget. The Land Surface Analysis (LSA) SAF is issuing products for the near-real time applications based on the same platforms: most components of the land surface energy budget are issued, including the instantaneous and daily evapotranspiration rate. In this contribution, we show the result of a feasibility study to combine expertise in both SAFs to provide in the future a climate data record of surface heat fluxes based on METEOSAT satellites.

INTRODUCTION

- The climate community is looking for datasets of evapotranspiration and surface heat fluxes over land and oceans.
- EUMETSAT geostationary satellites provide observations from space back to 1983 that could be used for an evapotranspiration dataset.
- CM-SAF possesses the expertise of creating climate data records of most energy and water component near the Earth surface,
- LSA-SAF has developed an land evapotranspiration algorithm for NRT monitoring.
- LSA-SAF ET (V2), reprocessed locally as in CM SAF context, reveals the gain of accuracy by using Meteosat, especially over Africa.

JOINT EXPERTISE & CAPABILITIES OF TWO EUMETSAT SATELLITE APPLICATION FACILITIES (SAF)

EUMETSAT's Satellite Application Facility on Climate Monitoring (CM SAF) is dedicated to the long-term monitoring of the climate system's state and variability. It generates and archives satellite-derived near-real time climate monitoring products on a continuous basis as well as high-quality validated, homogeneous and consistent time-series. CM-SAF develops, produces, archives and disseminates satellite-data-based products in support to climate monitoring. The product suite mainly covers parameters related to the energy & water cycle and addresses many of the Essential Climate Variables as defined by GCOS (GCOS 138). Several sensors are used to derive operational climate monitoring products and homogeneized datasets: sensors aboard polar orbiters (eg SSM/I, AVHRR, ATOVS, …) or/and geostationary satellites (SEVIRI, MVIRI, GERB). Among different climate monitoring products and datasets, several products on the energy and water components at the surface are already available, eg surface incoming shortwave radiation, surface albedo and surface incoming longwave radiation. In addition, the datasets HOAPS derived from SSM/I include evaporation, latent and sensible heat flux, globally over the oceans only. Such components over land would be crucial for climate scientists to complement the HOAPS dataset, and therefore merge the land and oceans components in the future.

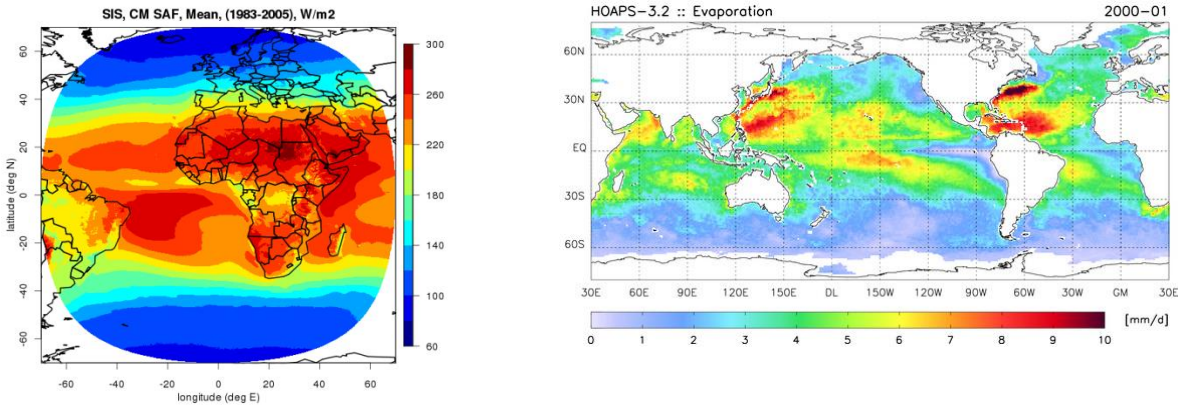

Figure 1: Example of the operational dataset (1983-2005) CM-SAF surface incoming shortwave radiation based on Meteosat MVIRI (image from www.cmsaf.eu) (left). Example of the HOAPS dataset (1987-2008) evaporation based on SSM/I (image from www.cmsaf.eu). (right)

LSA-SAF develops, produces in NRT and delivers maps of variables related to land surface derived from Meteosat and MetOp satellites (Trigo et al, 2011). Actual evapotranspiration (ET) is produced every 30 min, and integrated daily (Ghilain et al, 2011, Arboleda et al, 2012). This product is operational since 2010.

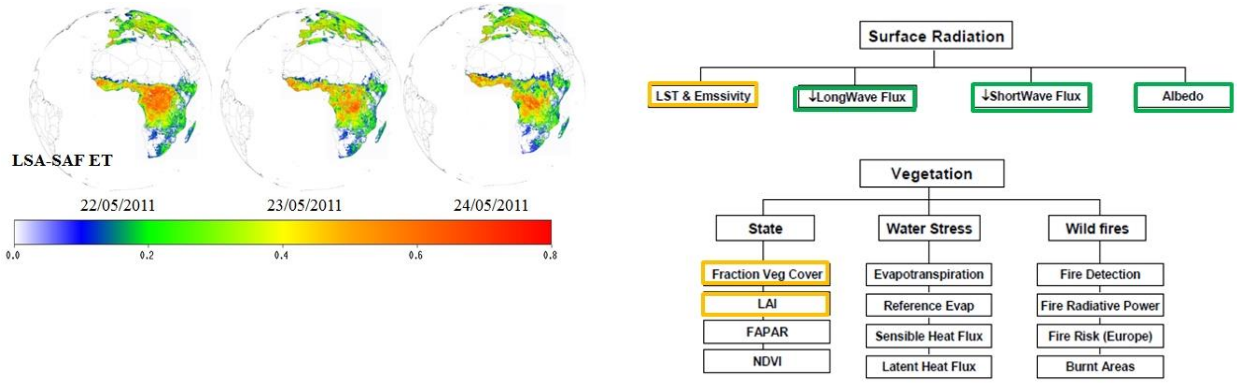

Figure 2: **Example of the LSA-SAF ET product generated operationally since 2009 (left). Portoflio of LSA-SAF products and variables used by the operational algorithm in green and by the new prototype (v2) in yellow (right).**

The ET algorithm uses radiation components derived from Meteosat (green). A new version (v2) to be delivered soon relies even more on Meteosat data (yellow): vegetation state variables, snow cover and land surface temperature products further constrain the ET algorithm to represent daily and inter-annual variations even more realistically over data sparse regions. In LSA-SAF ET v2 (Ghilain et al, 2015a), daily soil moisture is assessed using the LSA-SAF LST products in semi-arid zones. The representation is well adapted in the Sahel: better agreement with ground observations (Ghilain et al, 2015b). In addition to ET, the algorithm also produces maps of latent and sensible heat fluxes, requested by the climate community.

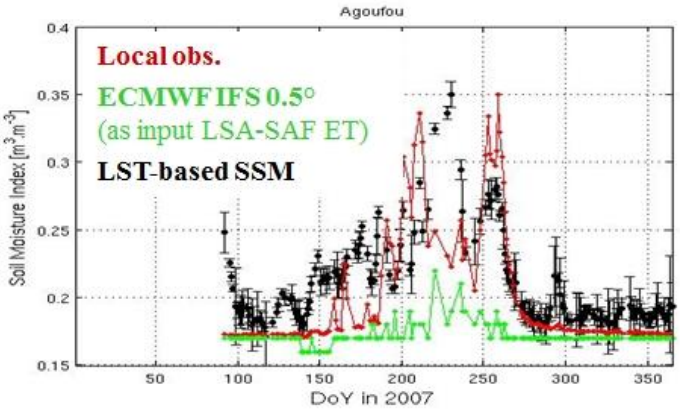

Figure 3: **In Sahel, the new soil moisture input (black) is more realistic than previous version (green).**

FEASIBILITY STUDY: PRELIMINARY PREPARATION A 30+ YEARS DATASET USING GEOSTATIONARY SATELLITES

Concept: ET algorithm is used in CM-SAF (almost) as in LSA-SAF (LSA-SAF ET v2). The forcing radiation variables are derived in CM-SAF using Meteosat data (MVIRI, SEVIRI). The meteorological forcing comes from ECMWF ERA-Interim dataset.
Set-up: The ET algorithm is re-processed over 1-4 years (2007-2010) over selected sites. The sites (30) located in Europe and Africa sample representative ecosystems. The output consists of heat fluxes (30 min) and evapotranspiration (daily) time series.

ASSESSMENT OF THE ADDED-VALUE

The time series of the fluxes and daily evapotranspiration are compared to:

- In-situ data from the FLUXNET and CarboAfrica networks (eddy covariance technique).
- ERA-Interim/Land - a NWP reanalysis forced by ERA-Interim (1° resolution, 6 hours time step)
- GLEAM v2A - a climate data record of daily evapotranspiration based on satellites data and ERA-Interim (1° resolution, daily time step) (Miralles et al, 2011).

Results for temperate regions are quite similar among products and in agreement with local observations. However, a better match is observed between LSA/CM-ET and observations due to more appropriate spatial resolution of MSG for in-situ comparison (Ex. Germany).

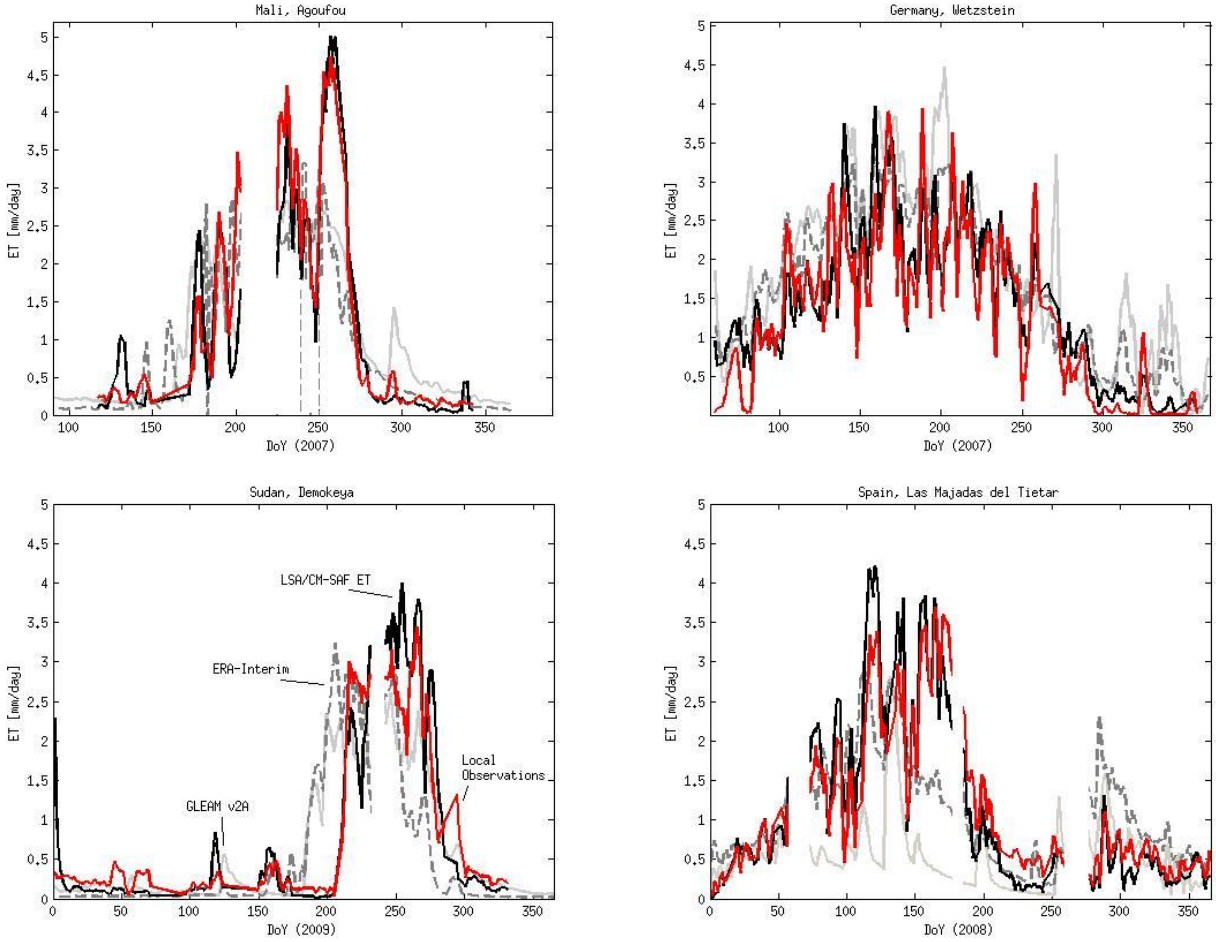

Figure 4: **Validation and comparison of the proposed algorithm for the retrieval of energy surface fluxes and evapotranspiration in the context of CM-SAF based on LSA-SAF algorithm v2 (black). Validation is presented over 4 contrasted sites over Africa (savannahs) and Europe (coniferous forest, open shrubland). Models compared are ERA-Interim, a long-term reference re-analysis (dashed grey), and GLEAM v2A, a dataset of global land evapotranspiration based on several satellite data (light grey).**

For the other sites, there is a clear gain in accuracy with LSA/CM-SAF ET compared to observations. Again, this is partly imputable to a more appropriate spatial resolution of MSG, but also a better constrain using MSG observations like LST and LAI.

CONCLUSIONS

A climate data record based on LSA-SAF algorithm relying on Meteosat satellites data seems to provide an added-value to the current available climate datasets:

- More spatial details thanks to the close monitoring in time (30 min, 1 h) and space (3-5 km);
- A slightly improved accuracy in temperate areas of Europe;
- A largely better accuracy in semi-arid areas of Africa, eg Sahel.

We still have to extend our analysis to other climate datasets available (eg GLDAS v2 Noah) and better discriminate the effect of spatial resolution and model performances.

PERSPECTIVES

We expect to prepare more in details the generation of a climate data record of evapotranspiration and surface heat fluxes to complement the CM-SAF portfolio of energy and water budget component on land. Re-processing with MVIRI and SEVIRI is proposed within a future joint CM-SAF and LSA-SAF activity. In addition, we could in the future extend the methodology to the other continents by exploiting geostationary satellites from other space agencies.

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