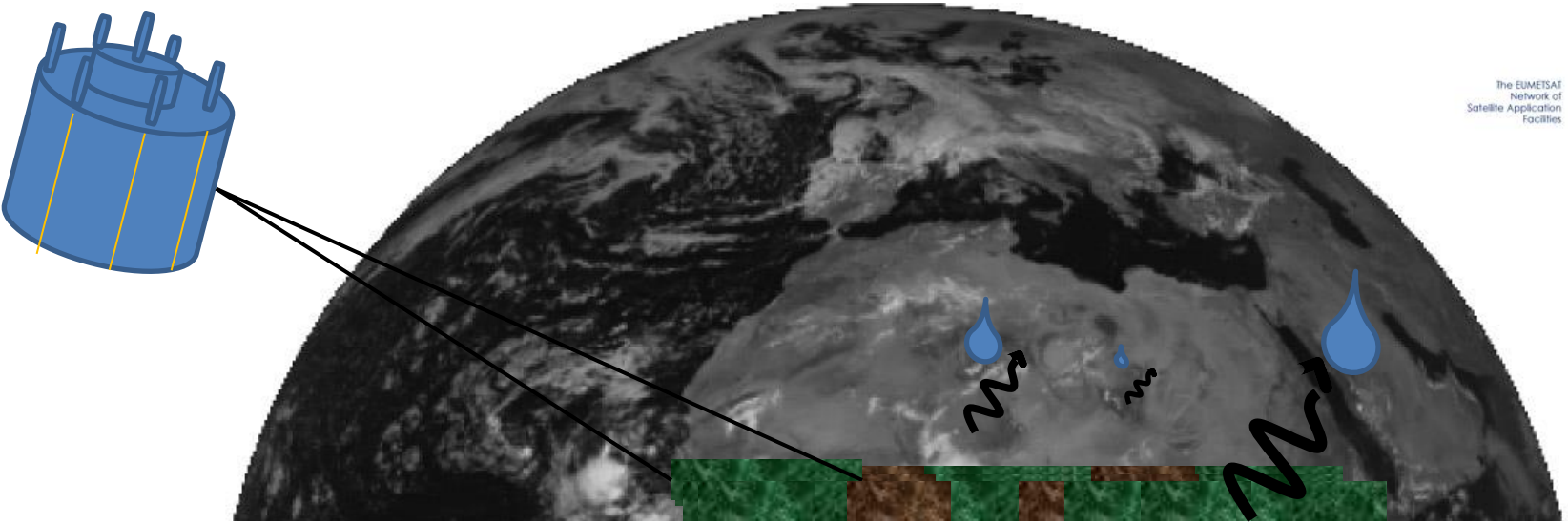


Evapotranspiration monitoring with Meteosat Second Generation satellites: method, products and utility in drought detection.

Nicolas Ghilain
Royal Meteorological Institute
Belgium

EUMeTrain Event week on drought, floods & landslides, 1-5 December 2014

Evapotranspiration

Plants do transpire.

Credit: Ming Kei College, Hong Kong

Corn field (100x100 m^2): ??

150 liters in 1 day

1 500 liters in 1 day

15 000 liters in 1 day

Plants do transpire a lot.

large oak tree:

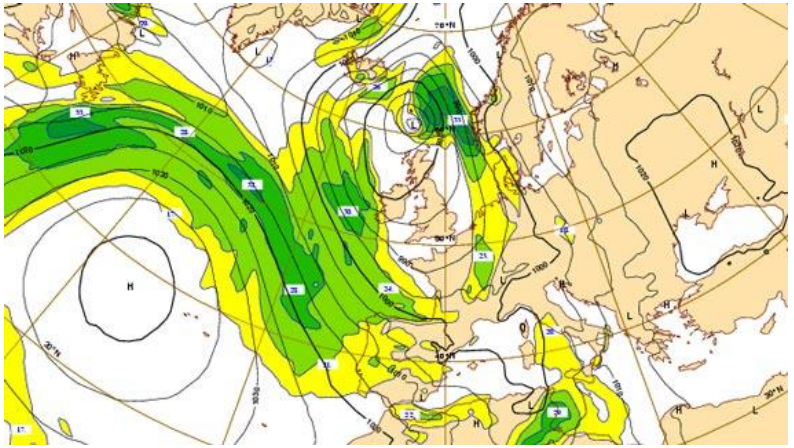
151 000 liters in 1 year

With plausible large consequences

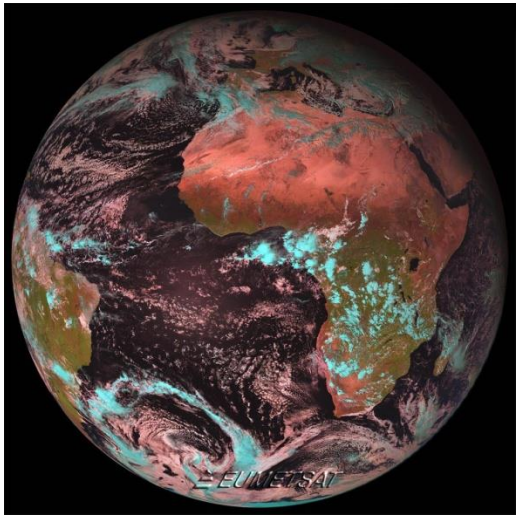
Evapotranspiration monitoring can be essential for drought detection.

Evapotranspiration can be measured !
Indirectly, though …

Models compute evapotranspiration



Satellite observation complement models !

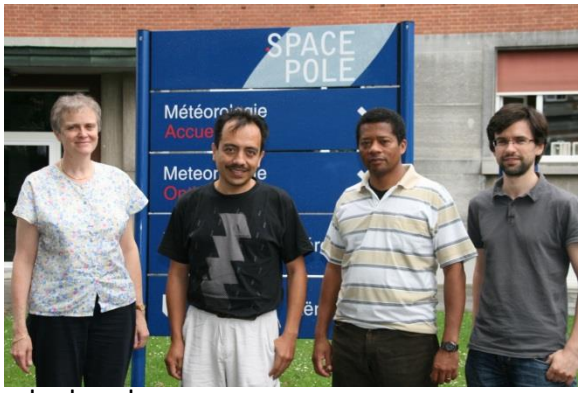


Royal Meteorological Institute of Belgium

"… services supported by research and long term standardised meteorological, climatological and geophysical observations …" (http://www.meteo.be)

"Reliable public service realised by empowered staff and based on research, innovation and continuity."

HydroMeteorology group on modelling& remote sensing



F. Meulenberghs

A. Arboleda

J.M. Barrios

Where are you ?

Who are you ?

I’m a researcher

I work for governmental decision planning

Other:

Who are you ?

- I plan to use EUMETSAT products
- I am here for general interest
- I’m already a EUMETSAT user
- I’m already using remote sensing products from other agencies
- I’m prospecting for satellite products
- Other:

Outline

1. What is evapotranspiration (ET) ?
2. The role of satellites for ET monitoring
3. LSA-SAF ET: algorithm & product
4. Utility of ET in drought monitoring

Outline

1. **What is evapotranspiration (ET) ?**
2. The role of satellites for ET monitoring
3. LSA-SAF ET: algorithm & product
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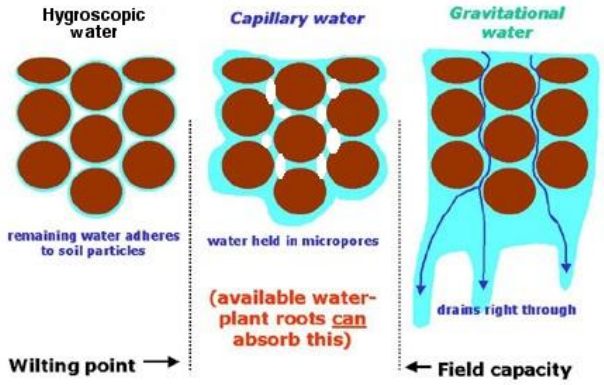
The transpiration process

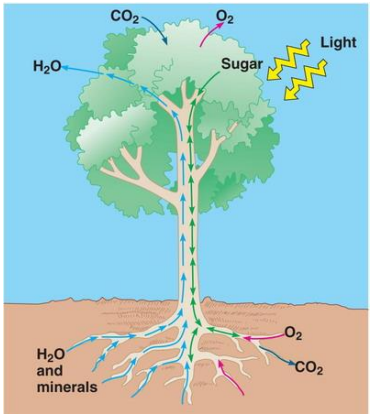
Plant « Breathing » and the Transpiration Process

1. Root-zone water



For transpiration to occur, there must be water available !

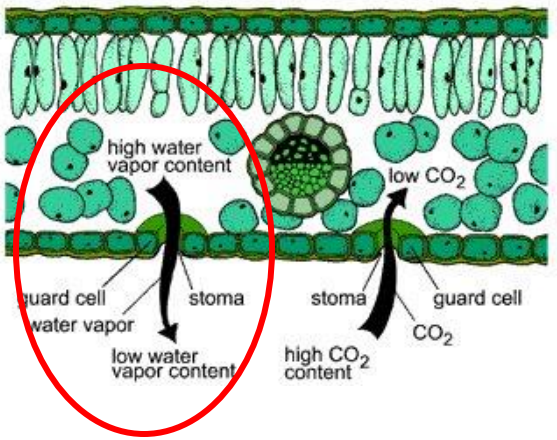
2. Root water uptake



-Water taken to leaves through roots

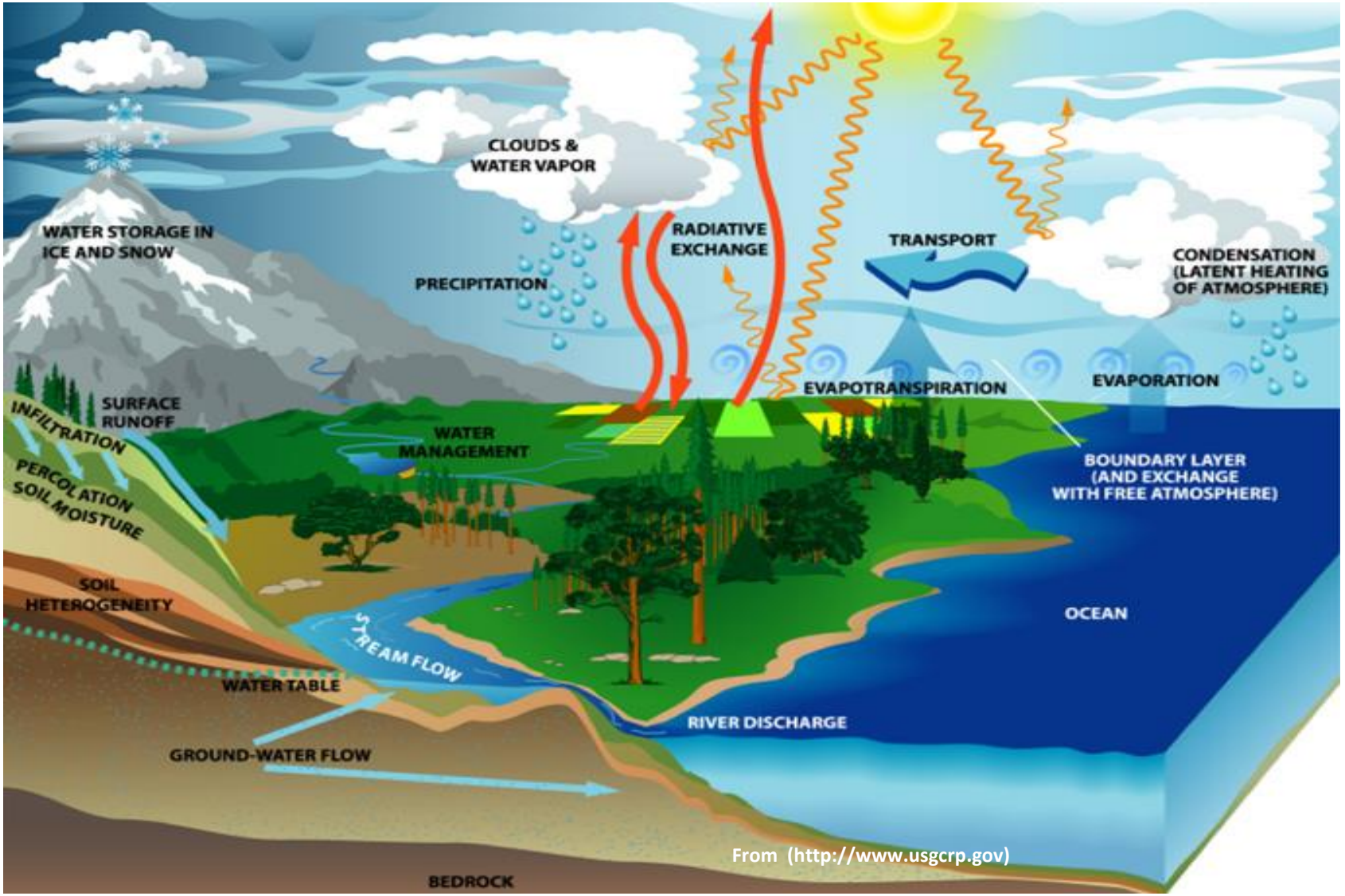
-Light is necessary

3. Exchange plant-atmosphere



Water vapour is released into the air through leaves stomata

The water cycle

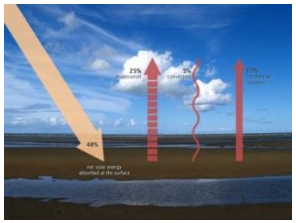


On land, ET returns 58% of precipitation !

Evapotranspiration: List of ingredients

Energy

Surface net radiation



Interface

Soil occupation

Plant type & characteristics

Water

Soil moisture

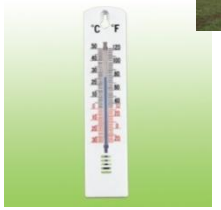
Ambiant atmosphere

Wind

Air movement

Air humidity

Air temperature



Outline

1. What is evapotranspiration (ET) ?
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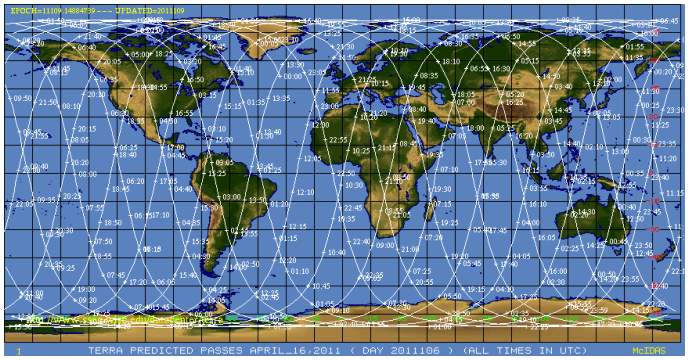
Remote Sensing Opportunities

Orbits preferred for earth monitoring

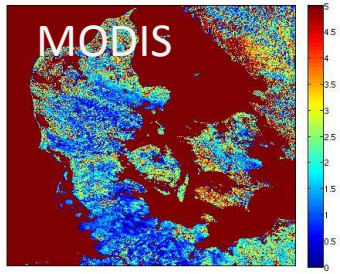


1. (Near-) Polar orbiter, sun-synchronous

-low orbit (~1000 km)
-earth revolution in ~100 min

Need of several ground receivers for the data flow

Polar orbiters: Terra, Aqua, METOP, …

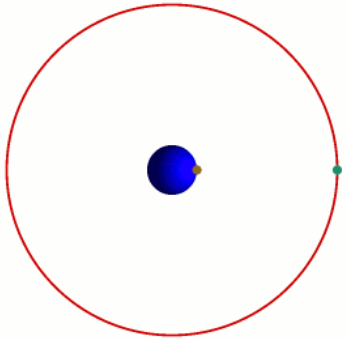


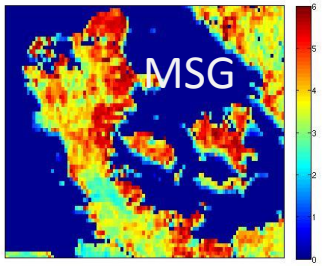
2. Geostationary (geo-synchronous)

-altitude (~36000 km)
-over equator

Depending on longitude, need to correct longitudinal drift

Geostationary satellites: Meteosat, GOES, …

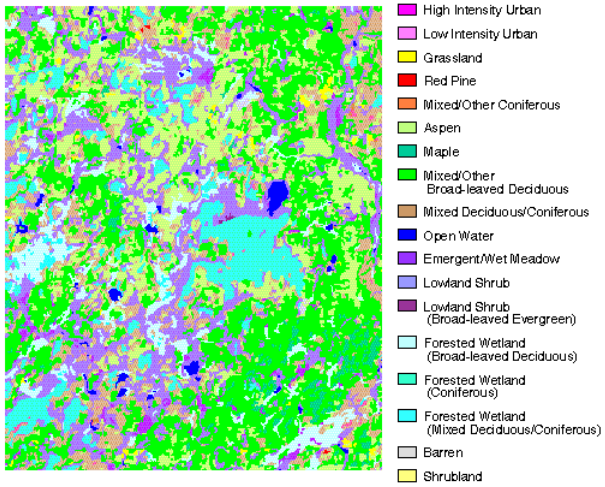




What useful variables derived from remote sensing ?

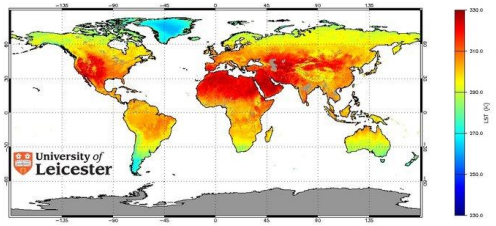
1. Describe surface properties

Land cover

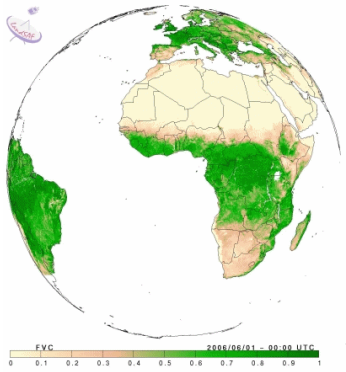


2. Surface variables

Surface temperature



Greeness of vegetation



3. Atmosphere

Cloudiness

Snow cover

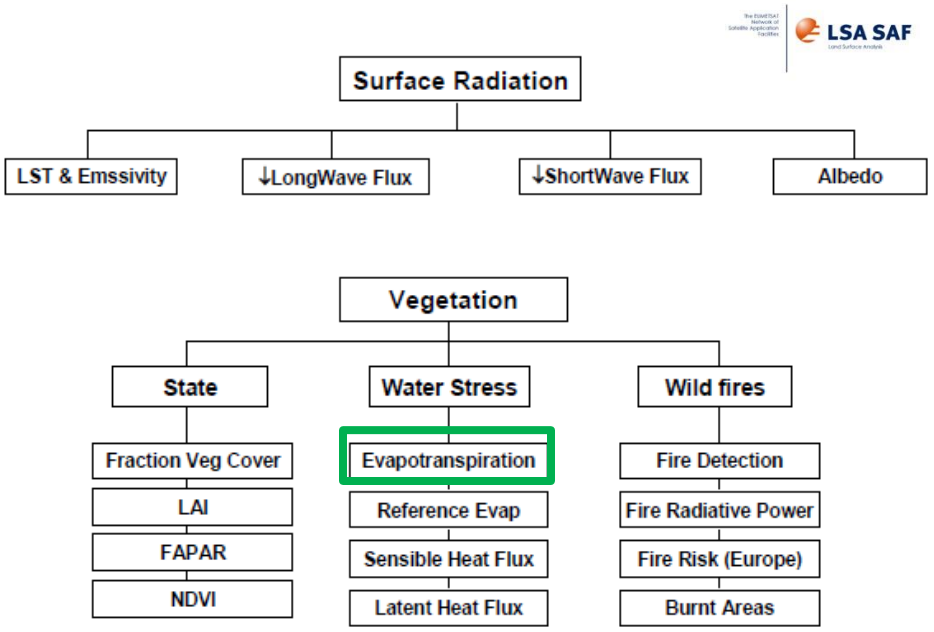
EUMETSAT SAF on Land Surface Analysis

EUMETSAT SATELLITE APPLICATION FACILITIES (SAF'S)

- **LSA -SAF Land Surface Analysis**
- **OSI -SAF Ocean and Sea Ice**
- **GRAS -SAF Meteorology**
- **O3M Ozone Monitoring**
- **NWP –SAF Numerical Weather Prediction**
- **CM -SAF Climate Monitoring**
- **NWC-SAF - Nowcasting and very Short Range Forecasting**

LSA -SAF OBJECTIVES

Develop techniques to retrieve parameters related to land, land-atmosphere interactions and biospheric applications, by using data from MSG and EPS satellites



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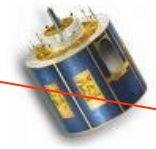
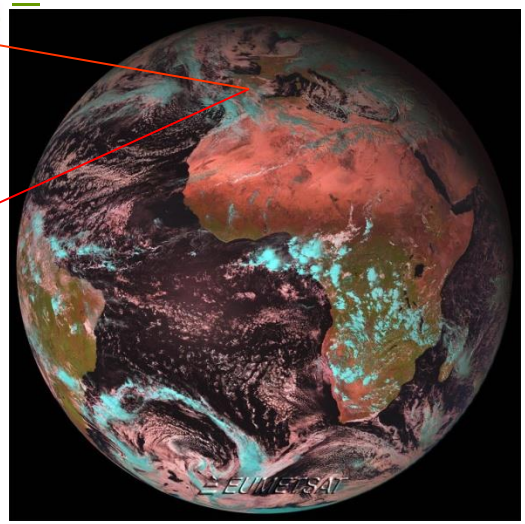
The LSA-SAF evapotranspiration model

MSG/SEVIRI pixel



Meteosat Second Generation



Energy balance: $(1-\alpha).S + \varepsilon.(L-\sigma.T_{sk,i}^4) + H_i + LE_i - G_i = 0$

$ET \sim \Sigma\, LE_i$ (Land Cover, LAI, Wind, T_{air}, Q_{air}, Soil Moist)

ECOCLIMAP-I

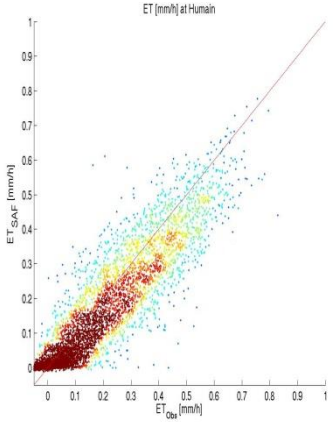
ECMWF weather forecasts

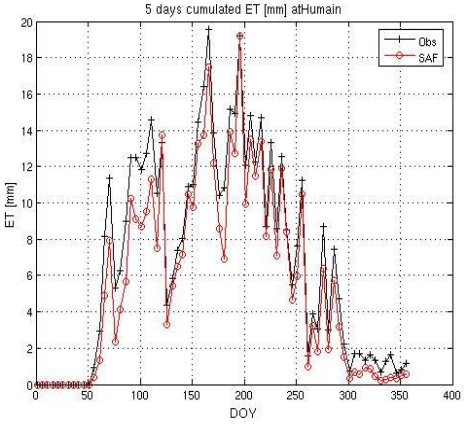
(Ghilain N., Arboleda A., Gellens-Meulenberghs F., 2011, Hydrol. Earth Syst. Sci.)

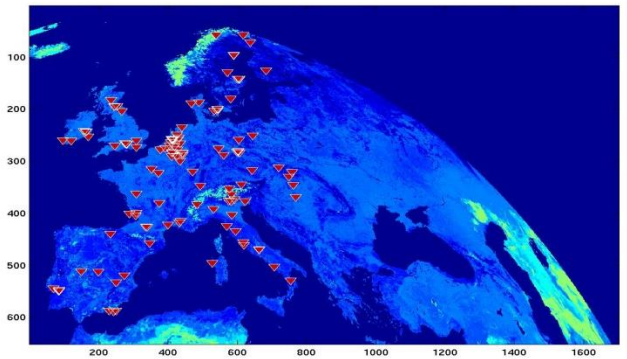
The LSA-SAF evapotranspiration model

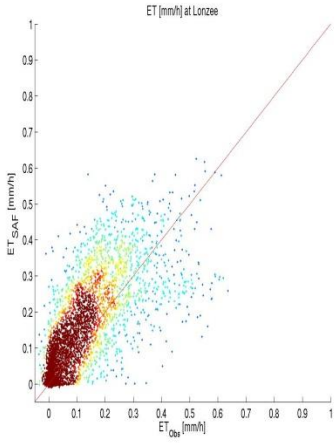
Examples validation LSA-SAF MET product

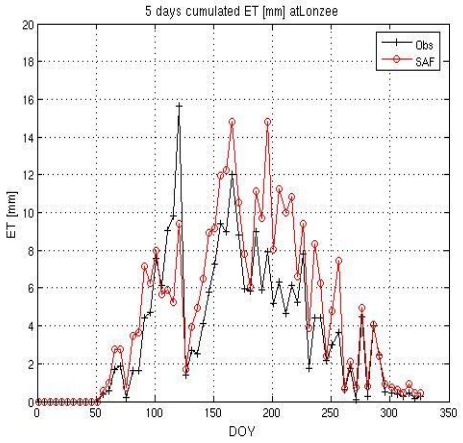
Dataset: 2007

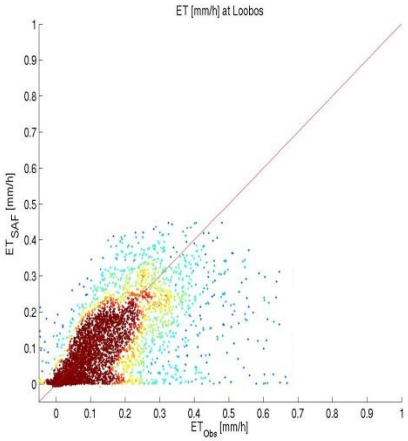


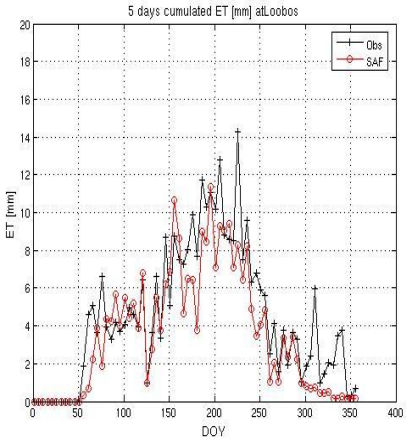










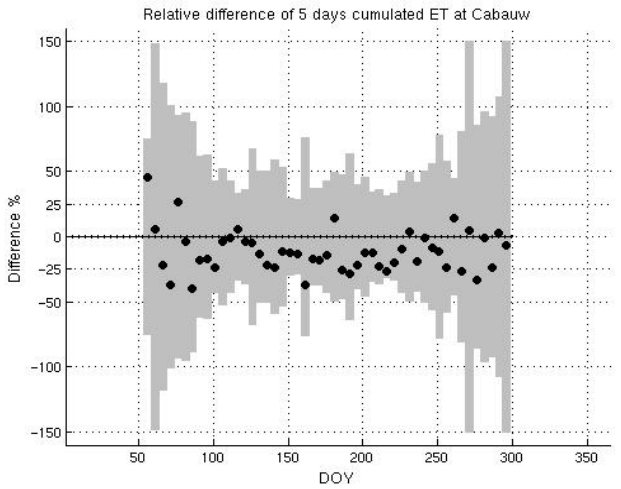


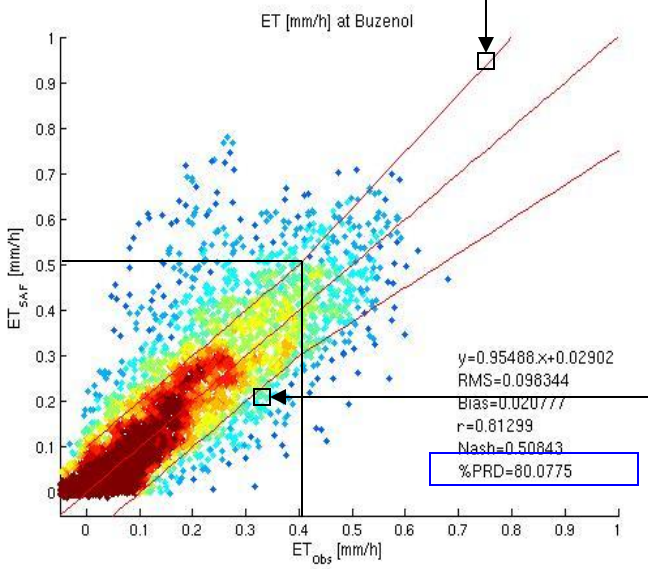
The LSA-SAF evapotranspiration model

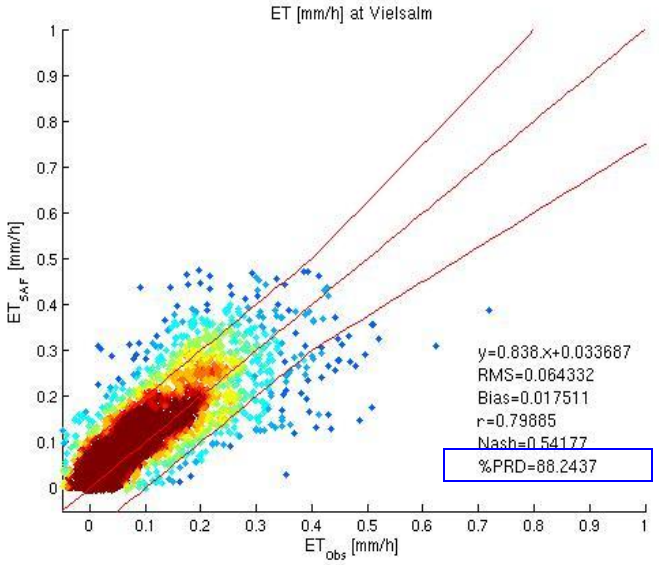
Product Required Accuracy (LSA-SAF MET)

if ET > 0.4 mm h^{-1} ⟶ Error < 25%

if ET < 0.4 mm h^{-1} ⟶ Error < 0.1 mm h^{-1}

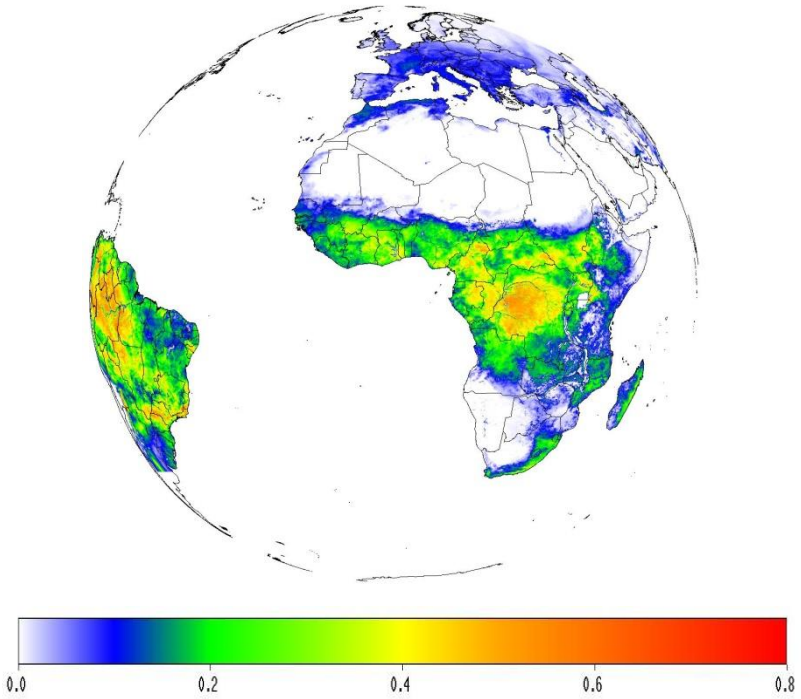




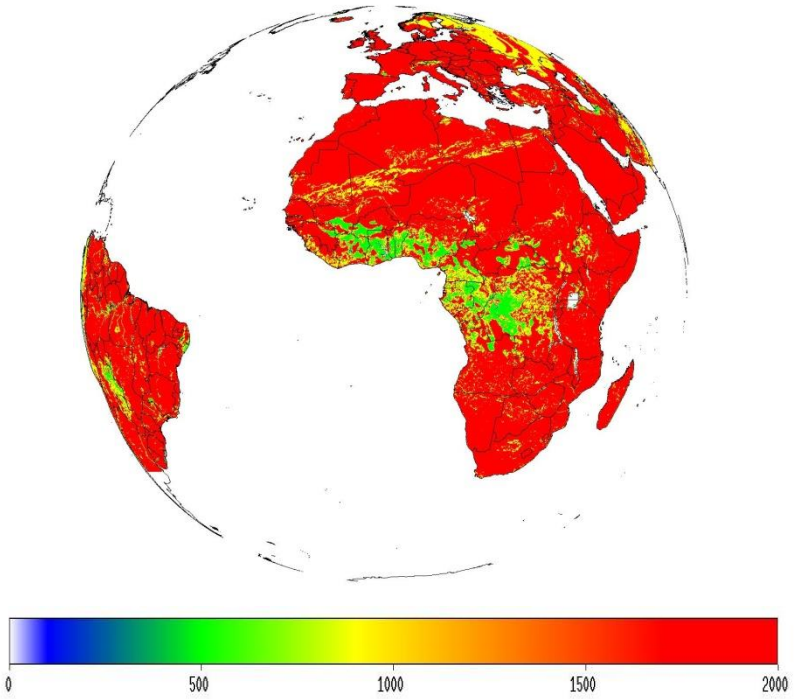


The LSA-SAF evapotranspiration products

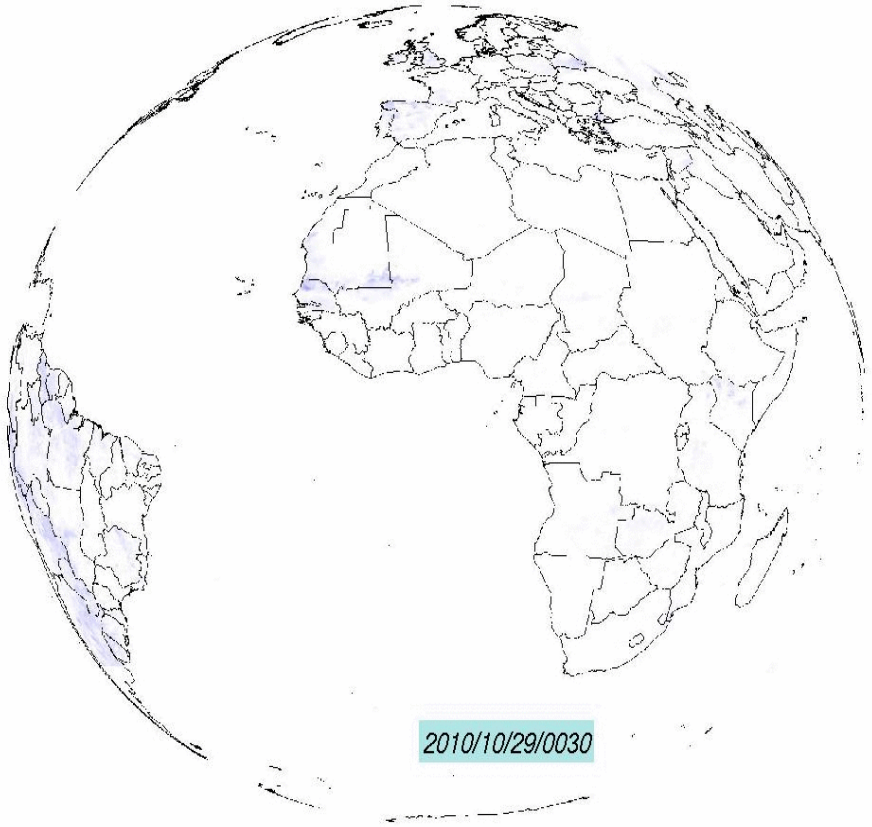
Two images are generated: the first one contains instantaneous ET estimates in mm/h while the second one is the quality flag image, provides information on the quality of estimates pixel by pixel



ET (mm/h) for 2010/10/29 at 12:00 UTC



Associated quality flag (-)


2010/10/29/0030

Instantaneous ET
LSA-SAF MET

Surface type

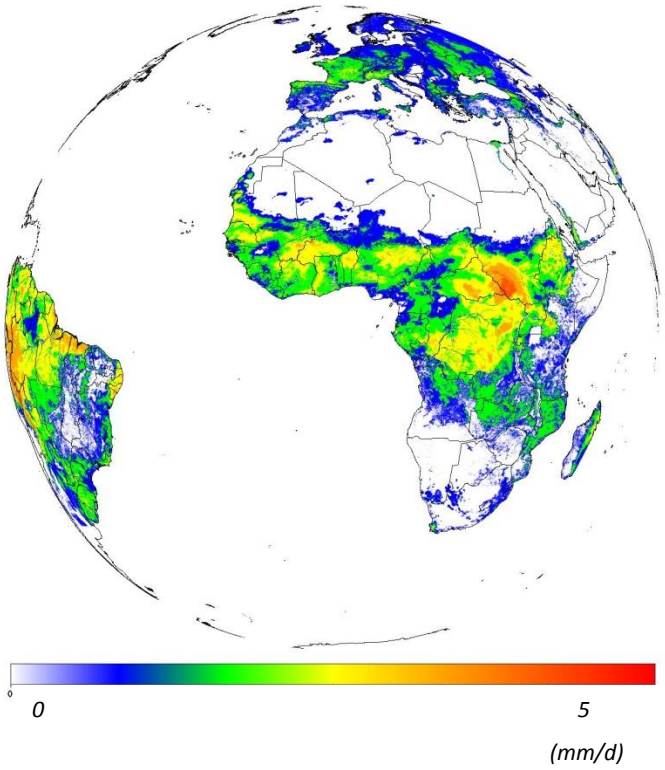
Quality input data

Overall quality

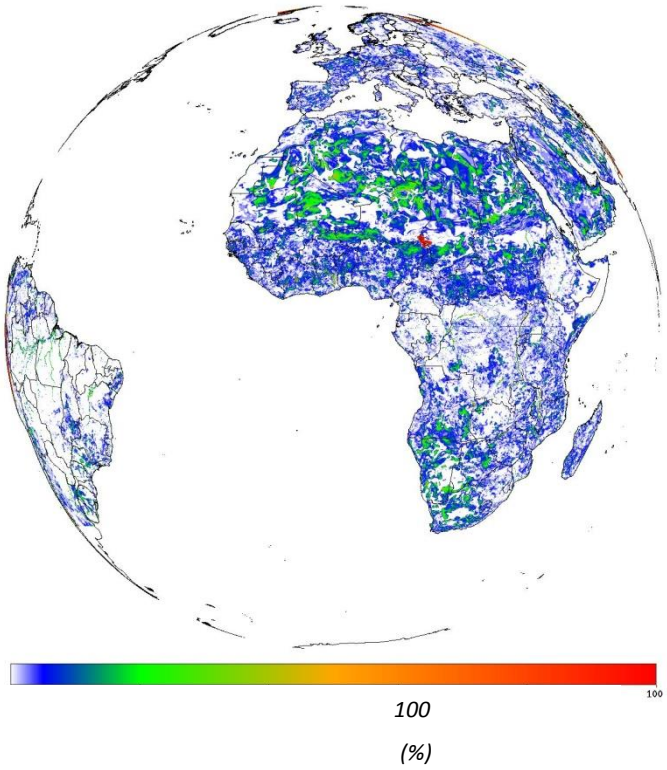
Bit	Field	Category	Binary code	Description
00-00	Land/Sea	Sea	0	
		Land	1	
01-01	Land cover			
			0	IGBP
			1	ECOCLIMAP
02-02	Cloud cover			
			0	Covered
			1	Clear / partially covered
03-04	Snow cover			
			00	Not processed
			01	Snow covered
			10	Partially covered
			11	Snow-free
05-06	SM			
			00	Corrupted / not processed
			01	SM from LSAF-SAF
			10	SM from other source (ECMWF)
07-07	AL			
			0	Albedo from data base
			1	Albedo from AL product
08-09	LST			
			00	Not used by now
			00	
			00	
10-11	DLSF			
			00	Corrupted / not processed
			01	Below nominal
			10	Nominal
			11	Above nominal
12-13	DSSF			
			00	Corrupted / not processed
			01	Below specified angle of view
			10	Cloudy sky method
			11	Clear sky method
14-15	ET confidence			
			00	Corrupted / not processed
			01	Poor quality
			10	Below nominal
			11	Nominal

The LSA-SAF evapotranspiration products

a) DMET (mm/day)

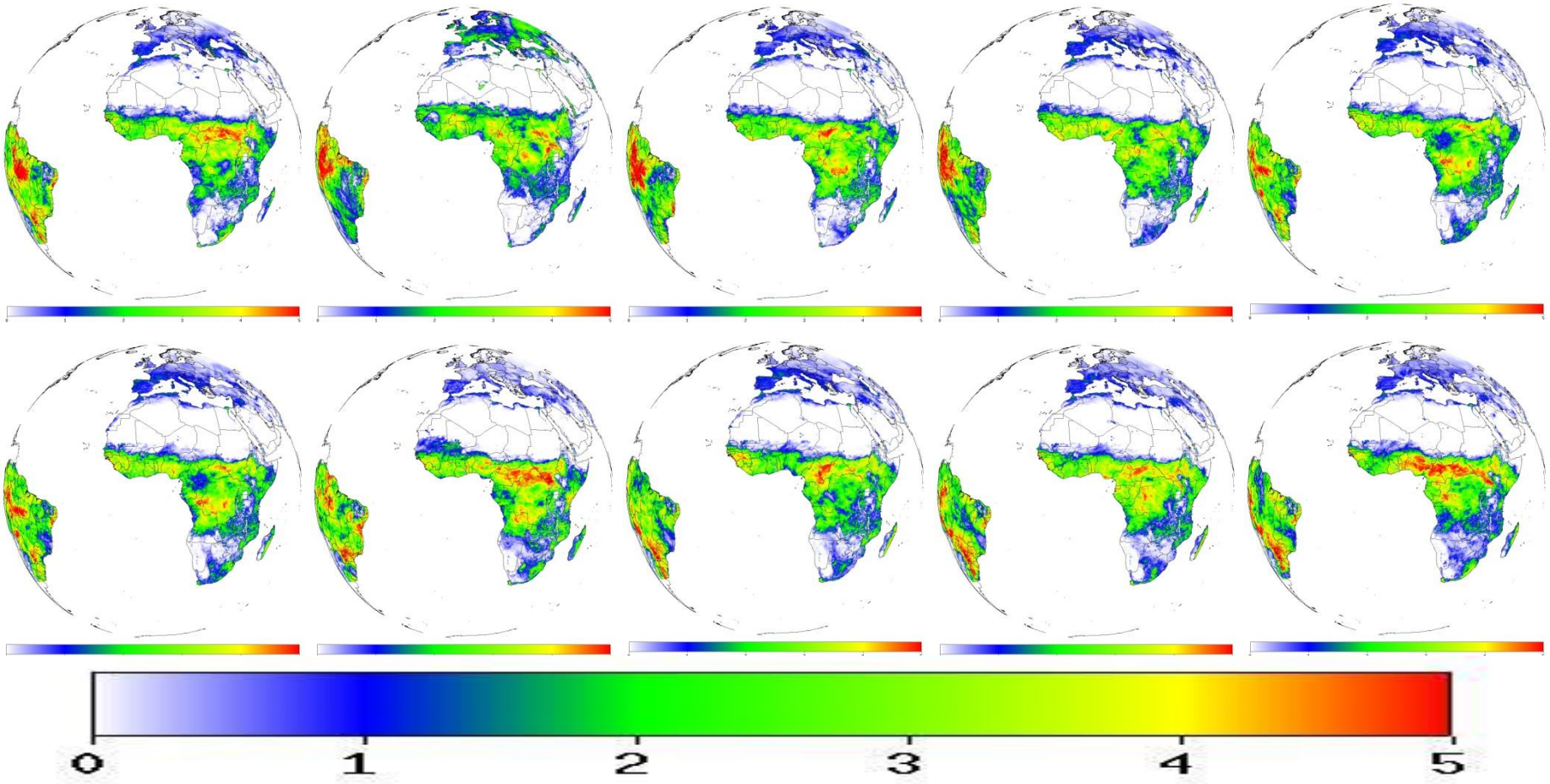


b) Percent of missing values for every pixel



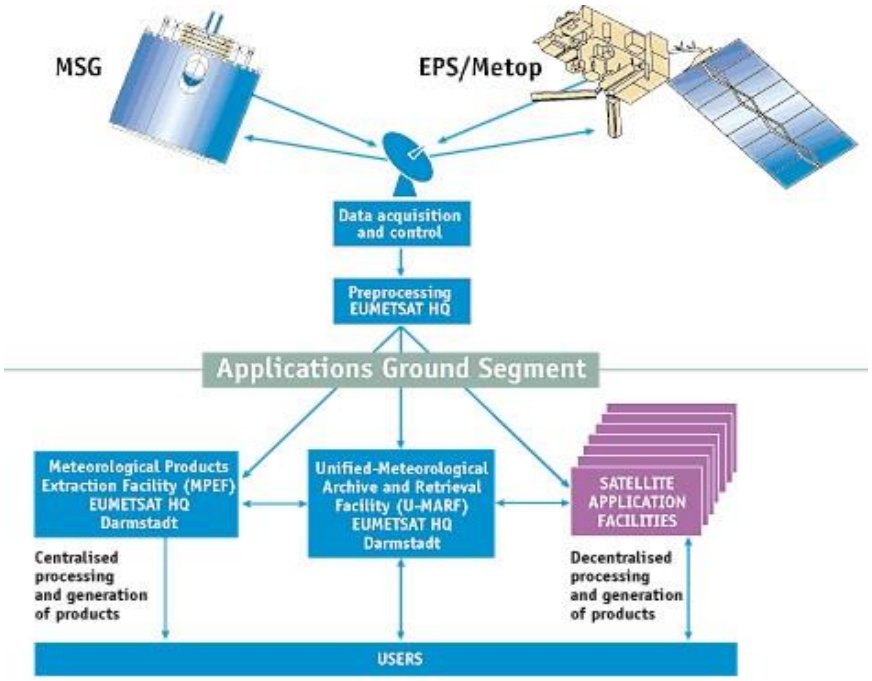
The LSA-SAF evapotranspiration products

DMET images from 06/09 to 15/09 2009



ET [mm/day]

Near-real time production: how it works



1.Acquisition of MSG/SEVIRI corrected radiances and Clouds mapping (from EUMETSAT, Darmstadt, Germany)

2.Computation of radiation components (Land SAF computing facility)

3. Acquisition of the global weather forecasts (ECMWF), reproject and interpolate

4. Computation of ET over 4 areas (Europe, North/South Africa and South America)

5. Compute a quality index

6. Creation HDF5 files

7. Distribution through web or satellite to users

8. Distribution of regular update of User Manual and Validation Reports

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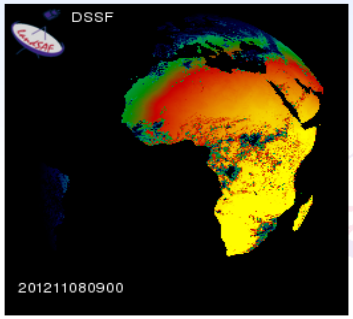
The scope of Land Surface Analysis Satellite Applications Facility (LSA SAF) is to increase benefit from EUMETSAT Satellite (MSG and EPS) data related to:

- Land
- Land-Atmosphere interaction
- Biospheric Applications

The LSA SAF performs:

- R&D Programs.
- Operational Activities
  - Generation
  - Archiving
  - Dissemination

of land surface related products.



See colour legends...

Latest News:

- **Important** Change in LSA SAF lead NMS name see more...
- **Important** LSA SAF Products web dissemination service resumed. see more...
- **Warning** LSA SAF Products WEB Dissemination service stopped see more...
- **Information** LSA SAF Products web dissemination service resumed. see more...
- **Update** LSA SAF Products web dissemination service stopped. see more...
- **Information** Fire Risk Map see more...

Product Development Status:

MSG/SEVIRI based products

Wild Fires
- Fire Radiative Power - PIXEL
- Fire Radiative Power - GRID
- Fire Risk Map
- Fire Detection and Monitoring

Vegetation Parameters
- Fraction of Vegetation Cover
- Leaf Area Index
- Fraction of Absorbed Photosynthetic Active Radiation

Snow Cover
- Snow Cover (daily)
- Snow Cover (15 mins)

Other
- Bi-Directional Reflectance Factor
- Land Surface Emissivity

Albedo
- Surface Albedo
- MSG Ten Day Surface Albedo

Land Surface Temperature
- Land Surface Temperature (15 mins)

Down-welling Surface Fluxes
- Down-welling Surface Short-wave Radiation Flux
- Down-welling Surface Long-wave Radiation Flux
- Daily Downward Surface Shortwave Flux
- Daily Downward Surface Longwave Flux

Evapotranspiration
- Evapotranspiration (30 mins)
- Daily Evapotranspiration

MetOp/AVHRR based products

Land Surface Temperature
- EPS - Land Surface Temperature

Down-welling Surface Fluxes
- Down-welling Surface Long-wave Radiation Flux

Caption

Internal | Develop. | Demo. | Pre-Operat. | Operat.

LSA SAF is an initiative of:

EUMETSAT

saf

LSA SAF consortium in CDOP (2007-2012):

IM MF RMI IMK UV FMI IDL

Outline

1. What is evapotranspiration (ET) ?
2. The role of satellites for ET monitoring
3. LSA-SAF ET: algorithm & product
4. **Utility of ET in drought monitoring**

Clarification of concepts

Natural Evapotranspiration (ET)
= Actual evapotranspiration (AET)
= Real evapotranspiration (ETR)

Evaporation of natural surfaces + plant transpiration

Potential Evapotranspiration (PET)

Maximum evapotranspiration for a given climate and continuous vegetated surface (no hydric stress)

Reference Evapotranspiration (ET0)

Used for agricultural irrigation management (FAO standard).
Evapotranspiration (can be potential) of a well-watered grass patch.

Crop Evapotranspiration (ETc)

Optimum evapotranspiration of a given crop (productivity not affected by hydric stress).

Clarification of concepts

Natural Evapotranspirat
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Evapotranspiration (can ual) of a well-watered grass patch.

Crop Evapotran (ETc)

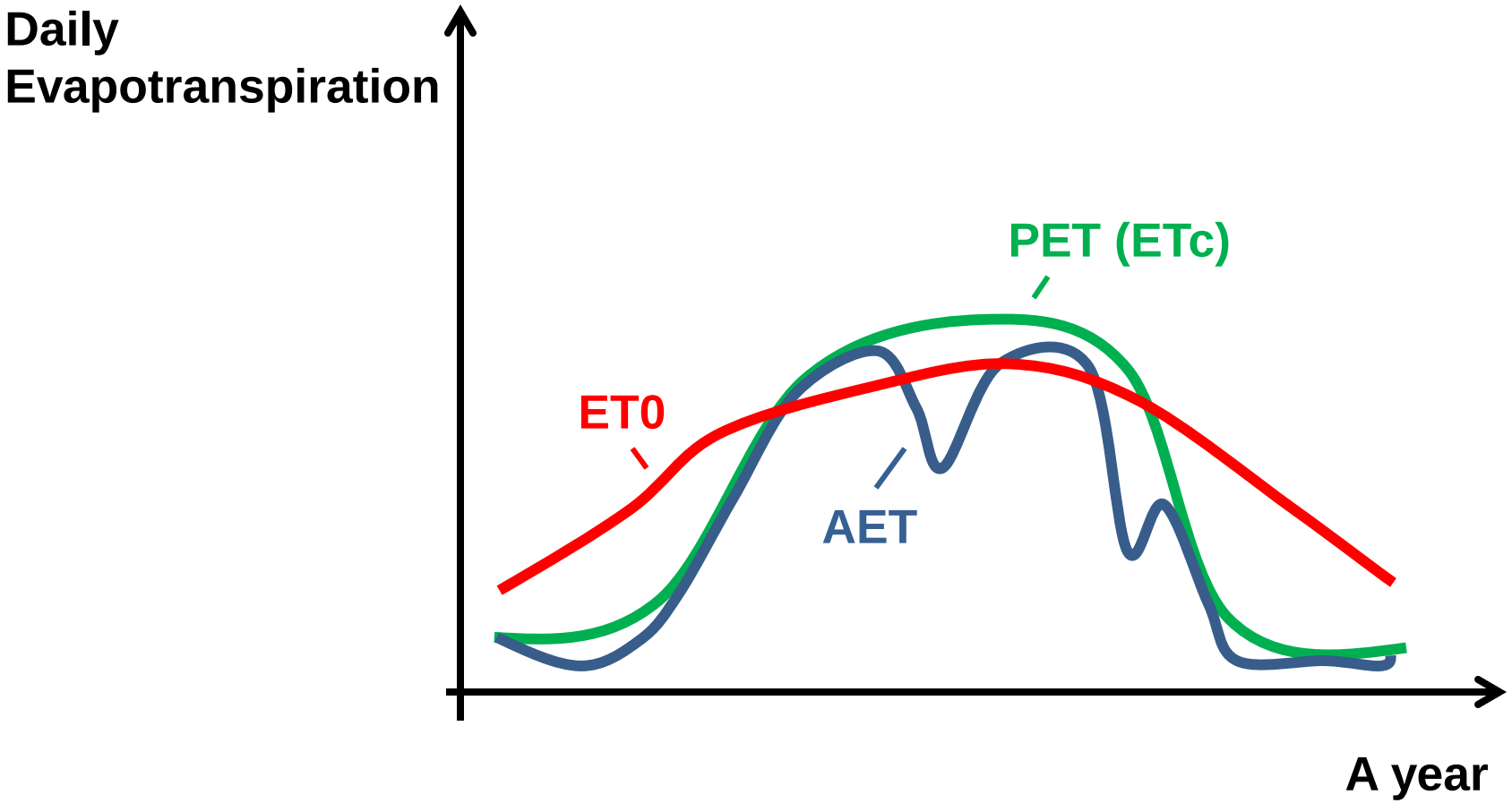
Optimum evapotra piration of a given crop (productivity not affected by hydric stress).

All surfaces

Only crops

Clarification of concepts

For crops

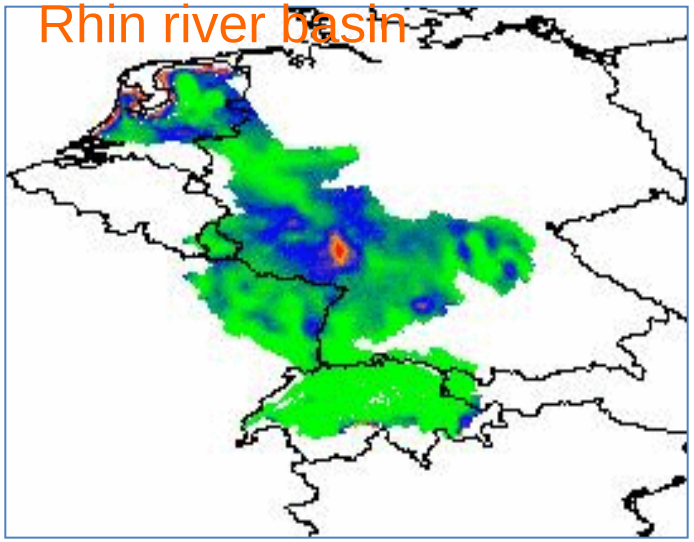


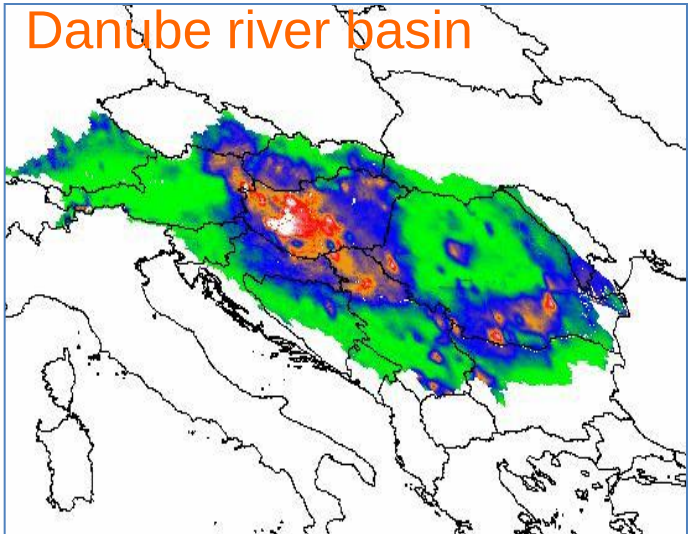
For a given crop: **ETc = Kc x ET0**

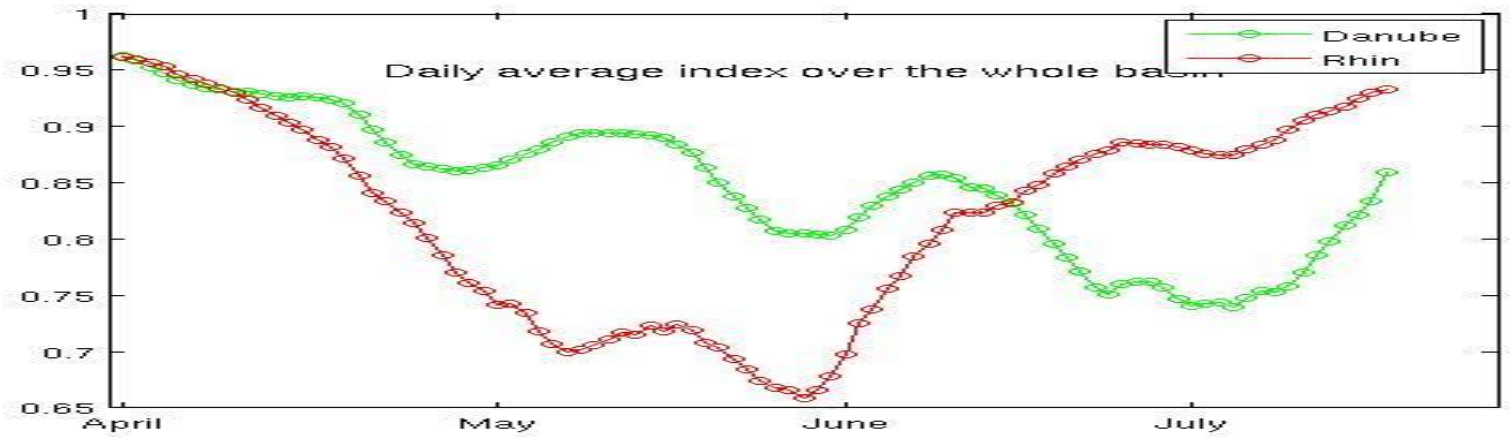
Application perspectives

Meteorological drought
Europe, Spring 2011

$$\text{Drought index (\%)} = \frac{\text{AET}}{\text{PET}}$$

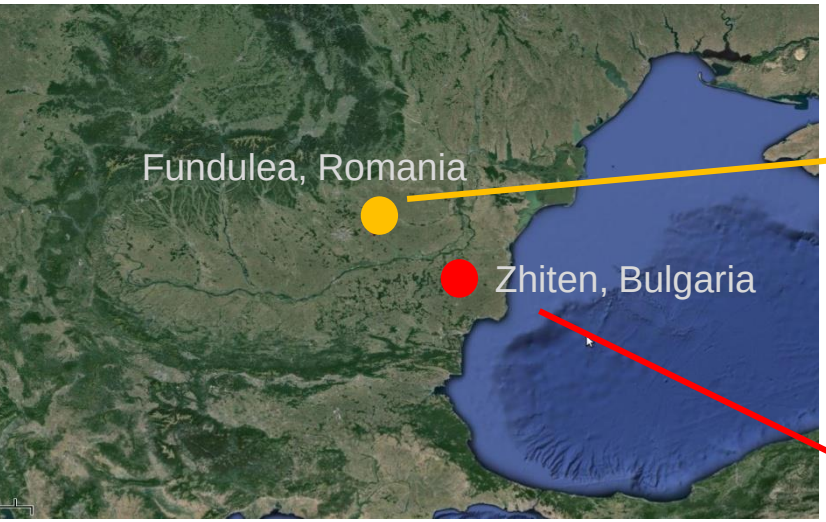


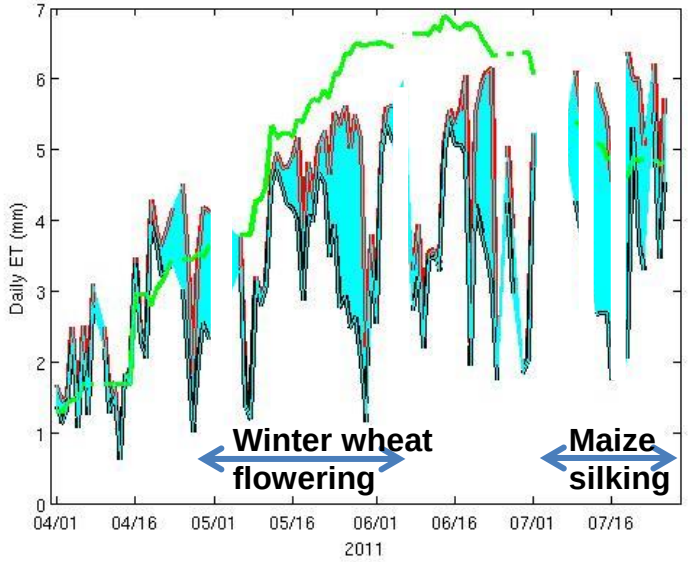


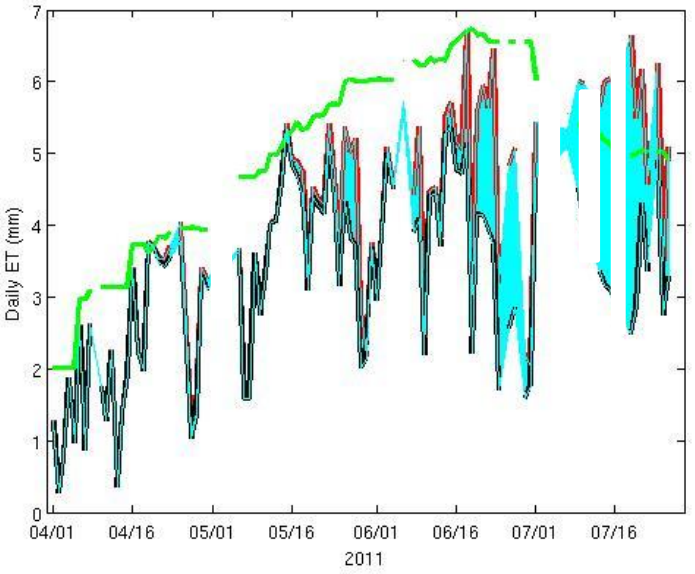


Application perspectives

Agricultural drought
Europe, Spring 2011







PET - AET = Water deficit

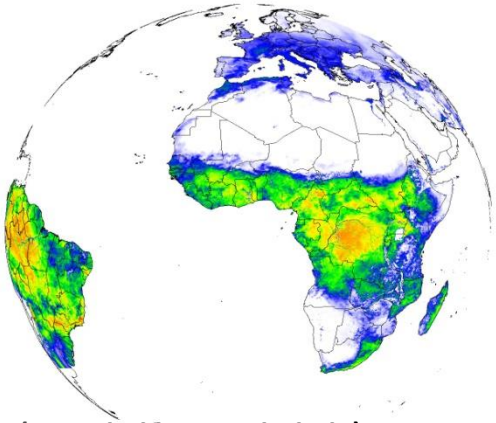
Summary

Operational production in near-real time:

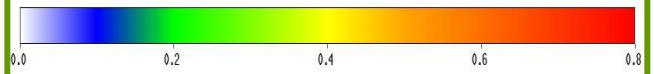
every 30 min & daily

3 km sub-satellite

(http://landsaf.meteo.pt)



(Provided by A. Arboleda)



ET [mm/h] for 2010/10/29 at 12:00 UTC

- Evapotranspiration estimation
  over **wide** and **remote areas**
  in **near-real time**,
  thanks to remote sensing.
- LSA-SAF evapotranspiration products **monitor quantitatively the water loss** from the surface into the atmosphere.
- **Available products have been checked** and show good comparison with in-situ observations (at least) over Europe.
- **LSA-SAF ET products could be a useful tool for drought monitoring.**

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