The EUMETSAT Network of Satellite Application Facilities

LSA SAF
Land Surface Analysis

Land SAF LSA-SAF Evapotranspiration (ET) Product

Alirio Arboleda

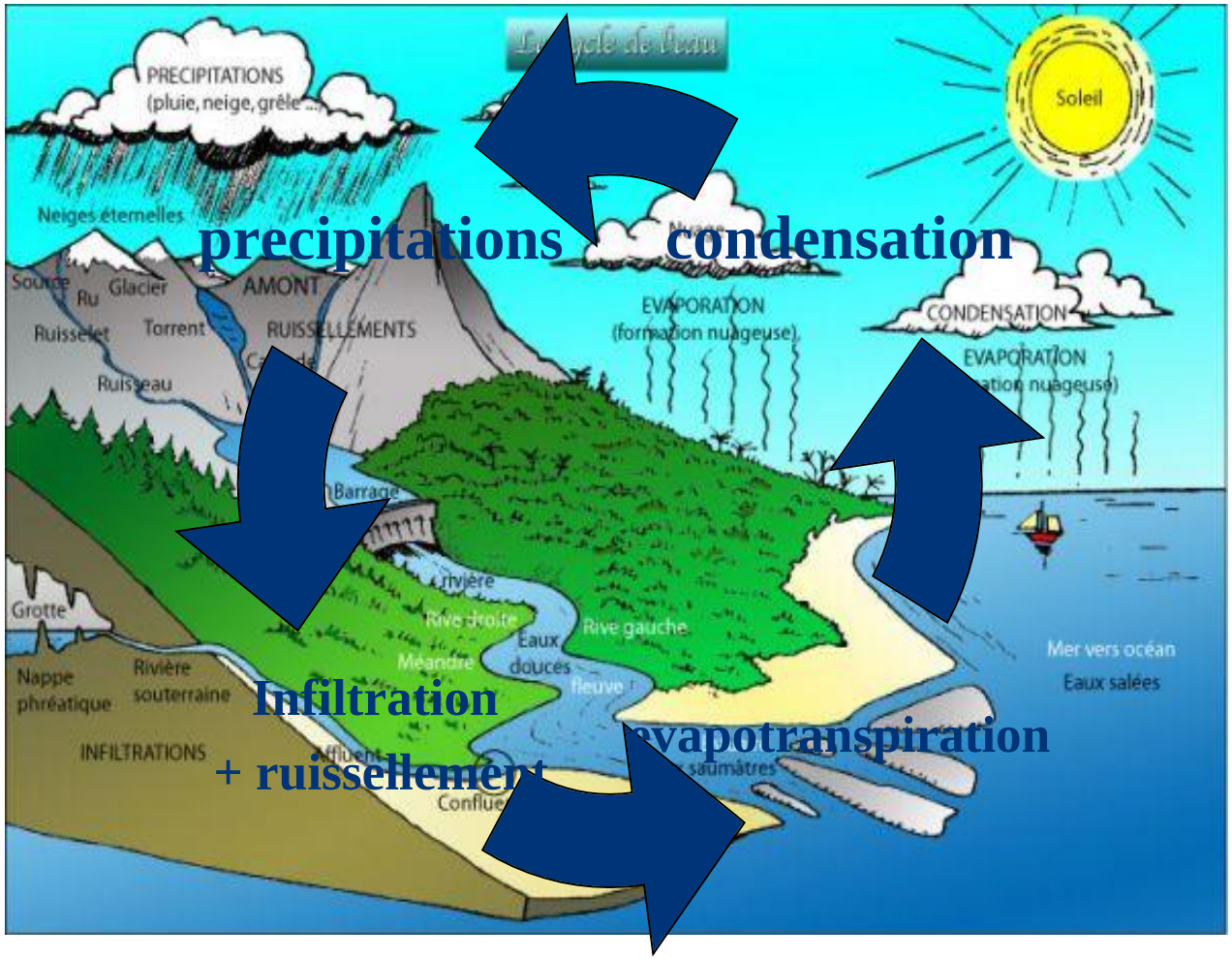
Budapest 25 April 2017

In collaboration with:
Nicolas Ghilain and Françoise Gellens-Meulenberghs
Royal Météorological Institute of Belgium

Layout

- The ET process
- Factors affecting the ET process
- The LSA-SAF ET product
- Possible applications of the ET product
- Data access

The water cycle

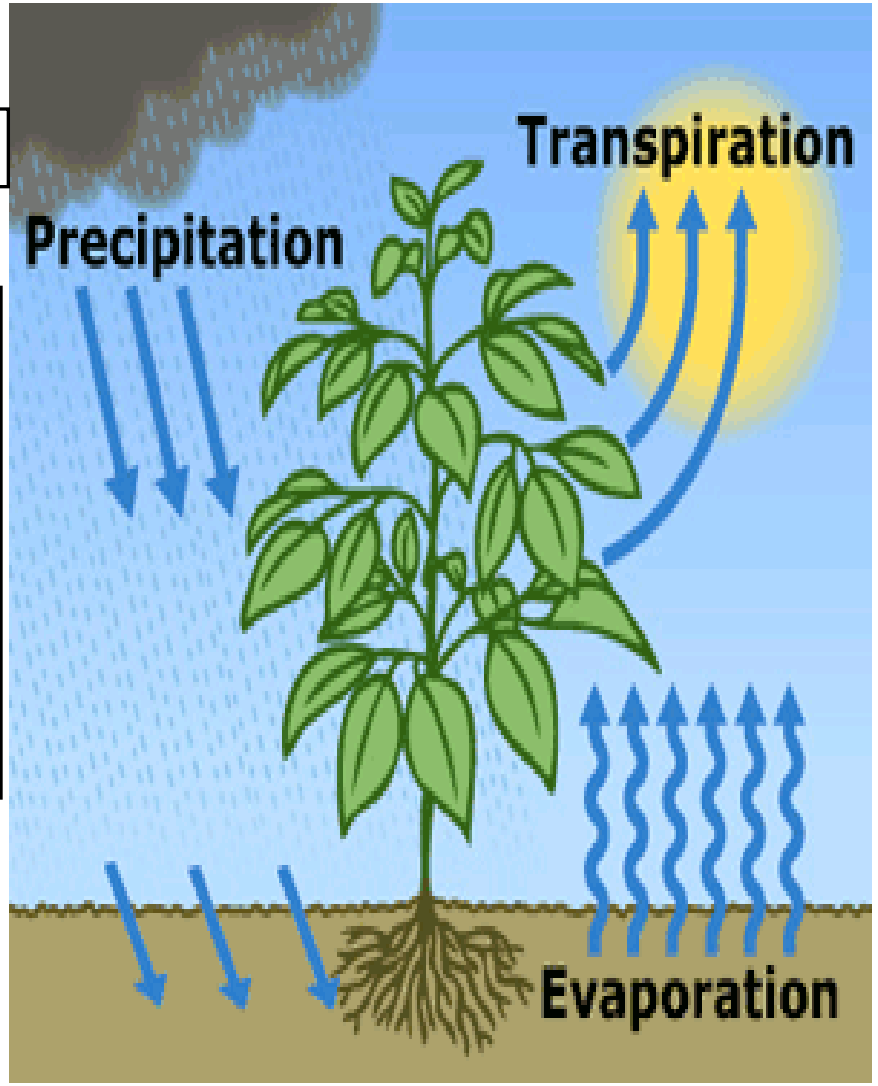


Evapotranspiration (ET)

What is ET and why it matters ?

ET = Evaporation + Transpiration

- Evaporation: Process where liquid water is converted to water vapor (from soil surface , open water,.)
- Transpiration: Vaporization of liquid water in plant tissues and vapor removal to the atmosphere (from vegetation canopy)



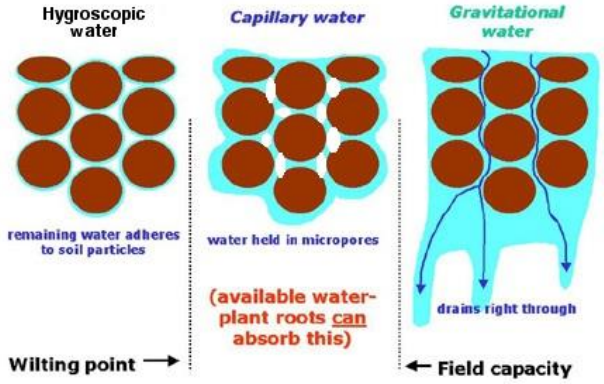
The transpiration process

The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

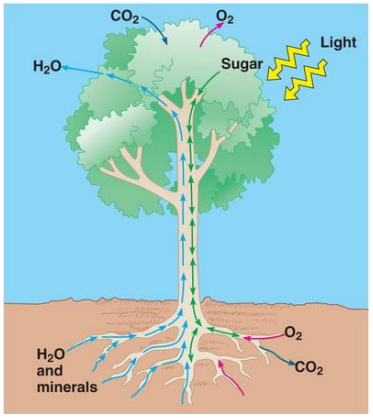
•Plant « Breathing » and the Transpiration Process

1. Root-zone water



For transpiration to occur, there must be water available !

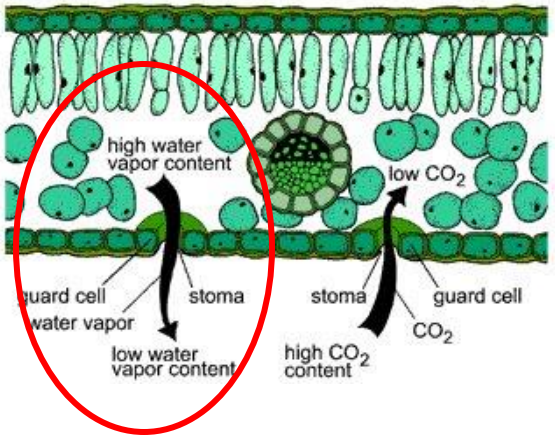
2. Root water uptake



-Water taken to leaves through roots

-Light is necessary

3. Exchange plant-atmosphere

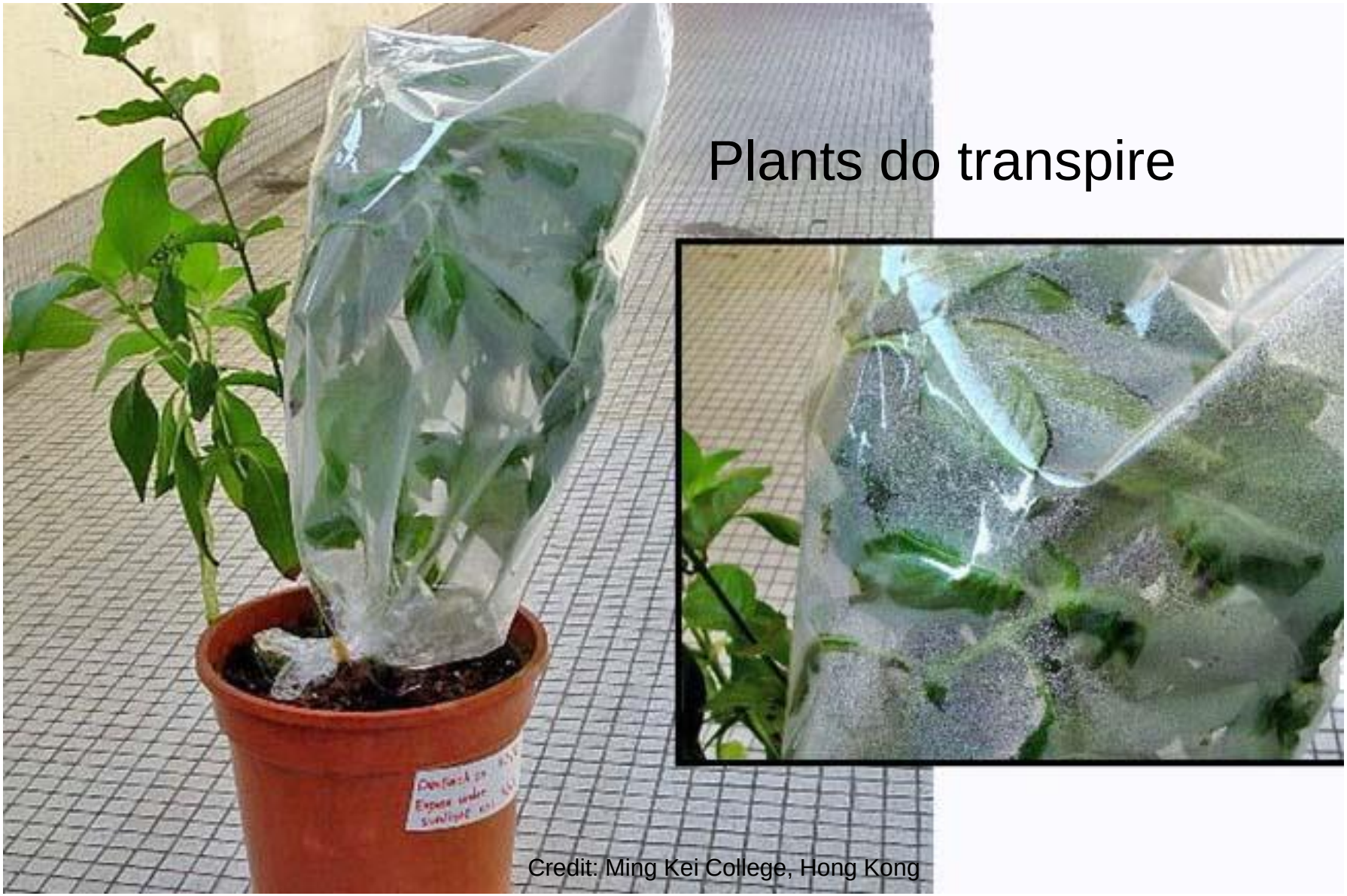


Water vapour is released into the air through leaves stomata

Evapotranspiration means loss of water

The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis



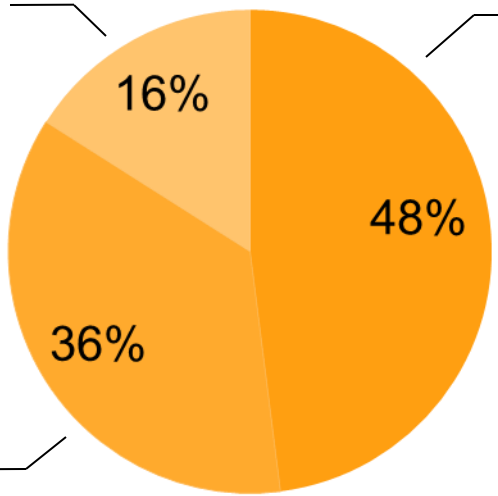
Evapotranspiration means loss of water

The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

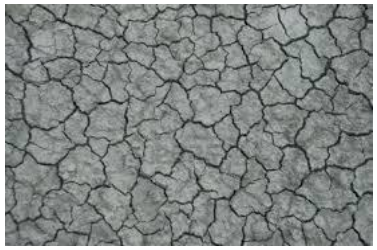
•On land, ET returns 58% of precipitation !

•Evaporation of intercepted water



•transpiration

•Evaporation
•from soil



•Evapotranspiration means loss of water

What amount of water can a large oak tree transpire during one year?

A) 1000 liters ?

B) 100000 liters ?

C) 150000 liters ?

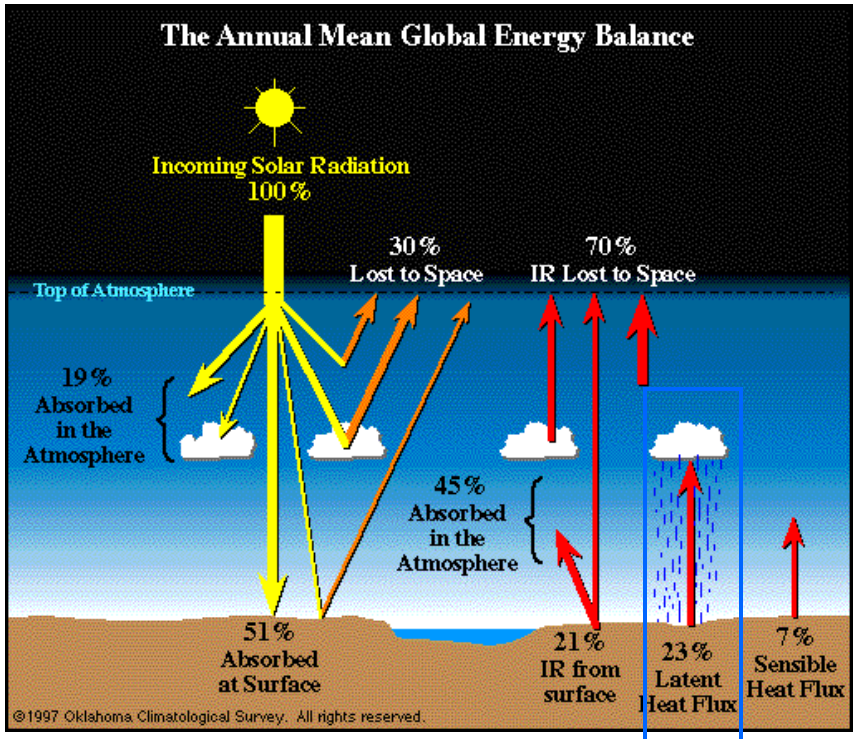
And what amount for a 100 m x100 m maize field in one day at ET rate of 1mm/day?

A) 1000 liters ?

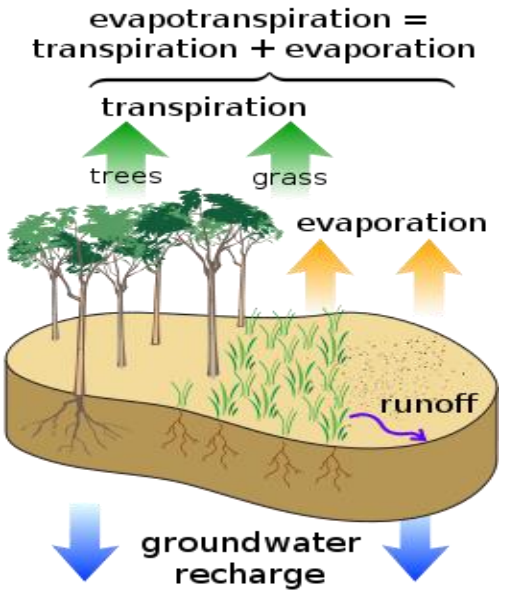
B) 10000 liters ?

C) 20000 liters

Water and energy cycles



Energy balance: $(1-\alpha).S + \varepsilon.(L-\sigma.T_{sk}^4) + H + LE - G = 0$



Catchment Water balance: $P - Q - ET - Dw - OF = 0$

P=Precipitation; Q=Discharge; Dw=stock variation;

OF= flow at the outlet

Evapotranspiration – some definitions

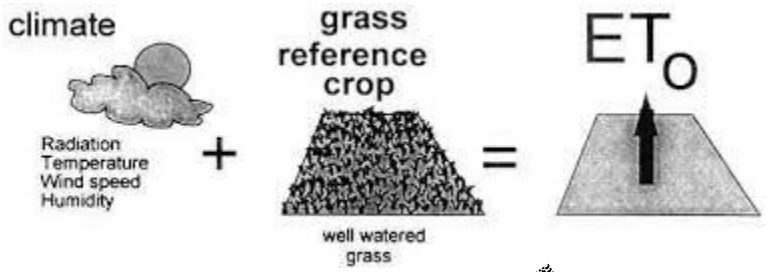
- Potential Evapotranspiration (PET): Maximum value of ET for a given climate depending on the available energy and dynamic features of the atmosphere (enough water to meet the evaporative demand)

- Actual Evapotranspiration (AET): Effective water vapor loss suffered by a canopy/soil system. Less than the PET due to resistance to the flow of water (soil-plant) and the diffusion of water vapor (leafy atmosphere)

- Reference Evapotranspiration (ETref/**ET0**): ET rate from a reference vegetative surface, actively growing, not short of water (The FAO Penman-Monteith method is recommended as the standard method for calculating ET0)

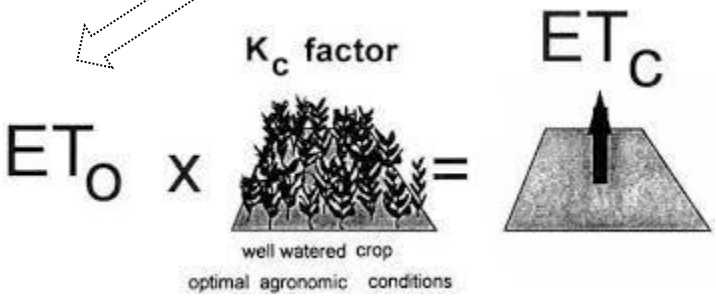
- Crop Evapotranspiration (Etc): Is the evapotranspiration from disease-free, well-fertilized crops, grown in large fields, under optimum soil water conditions, and achieving full production under the given climatic conditions.

Reference evapotranspiration



$$ET_0 \cong a_M \, f(T) DSSF_{Daily}$$

ET rate from reference surface it is essentially determined by solar irradiance



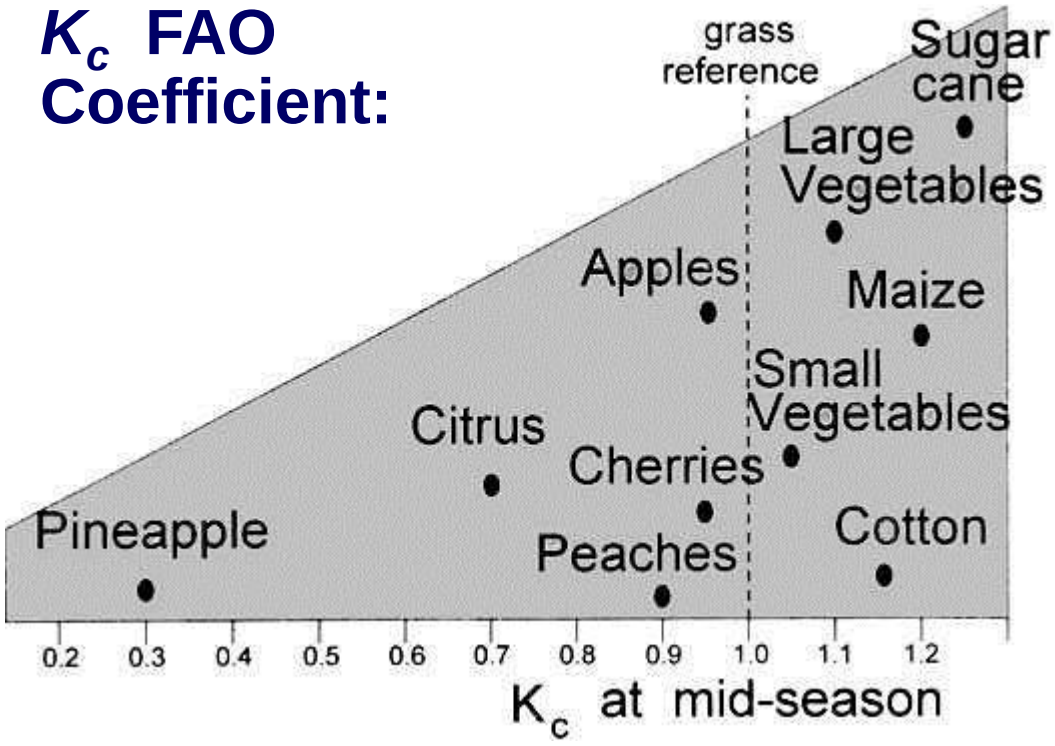
$$ET_c = K_c ET_0$$

Crop evaporation or crop water need

Reference evapotranspiration

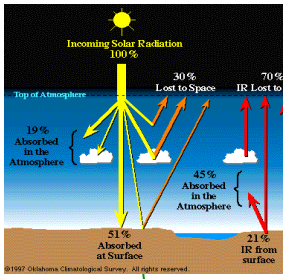
Important in irrigation management, allowing an effective use of soil water reserves on agricultural production.

K_c FAO Coefficient:



Main factors affecting evapotranspiration

Meteorological factors



Solar radiation

Air température (Ta)

Rn ↗ → ET ?

Ta ↗ → ET → ?

Evapotranspiration

Wind speed (Ua)

Air humidité (Ha)

Ua ↗ → ET → ?

Ha ↗ → ET → ?

Type and characteristics of vegetation

- type and variety
  - Height, stomatal control, ground cover, roots depth
  - Stage of development

Grassland

Broadleaf forest

Crops

Management practices

Irrigation management and methods

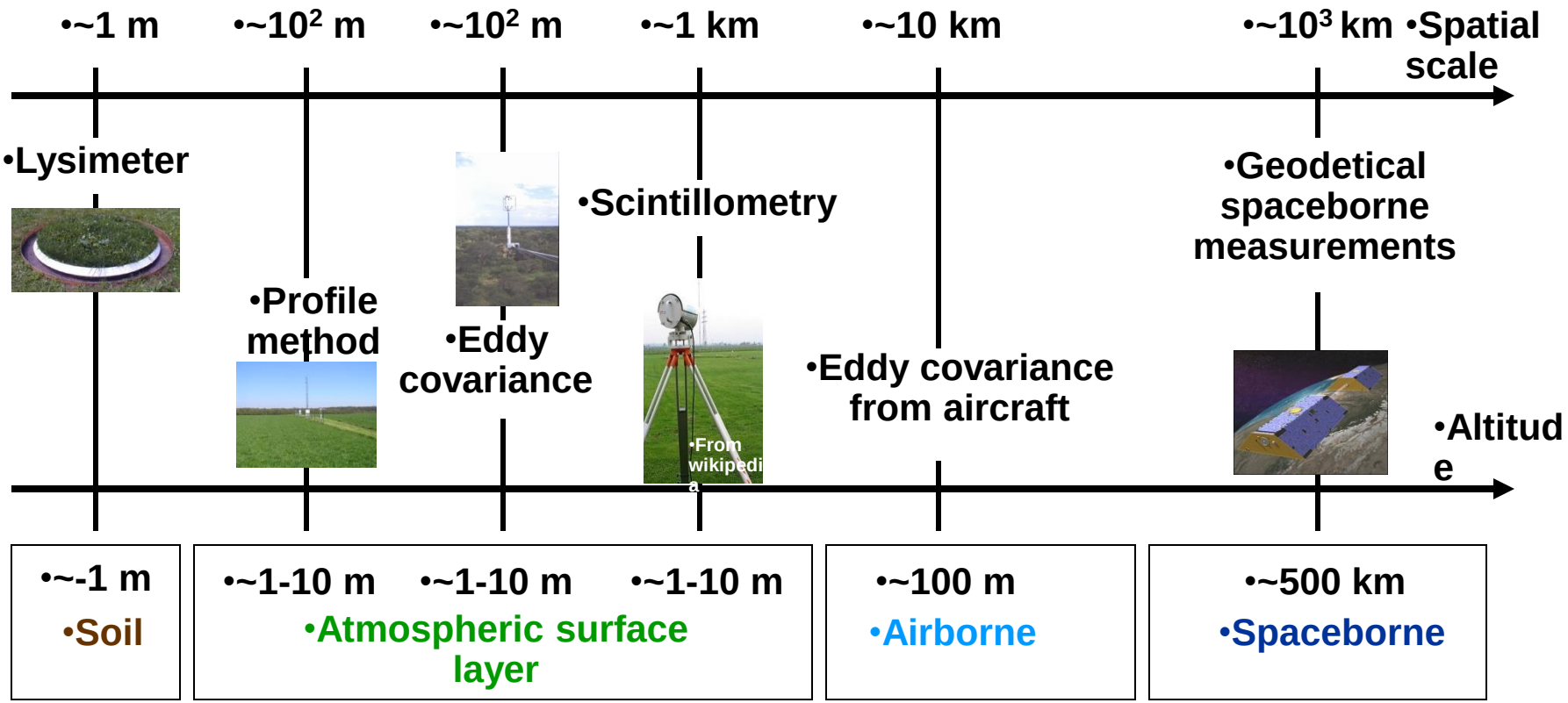
Diseases control and prevention

Environmental conditions

- Soil type and texture, water content, water-holding capacity

Soil depth, fertility, exposure

Estimating ET at different scales



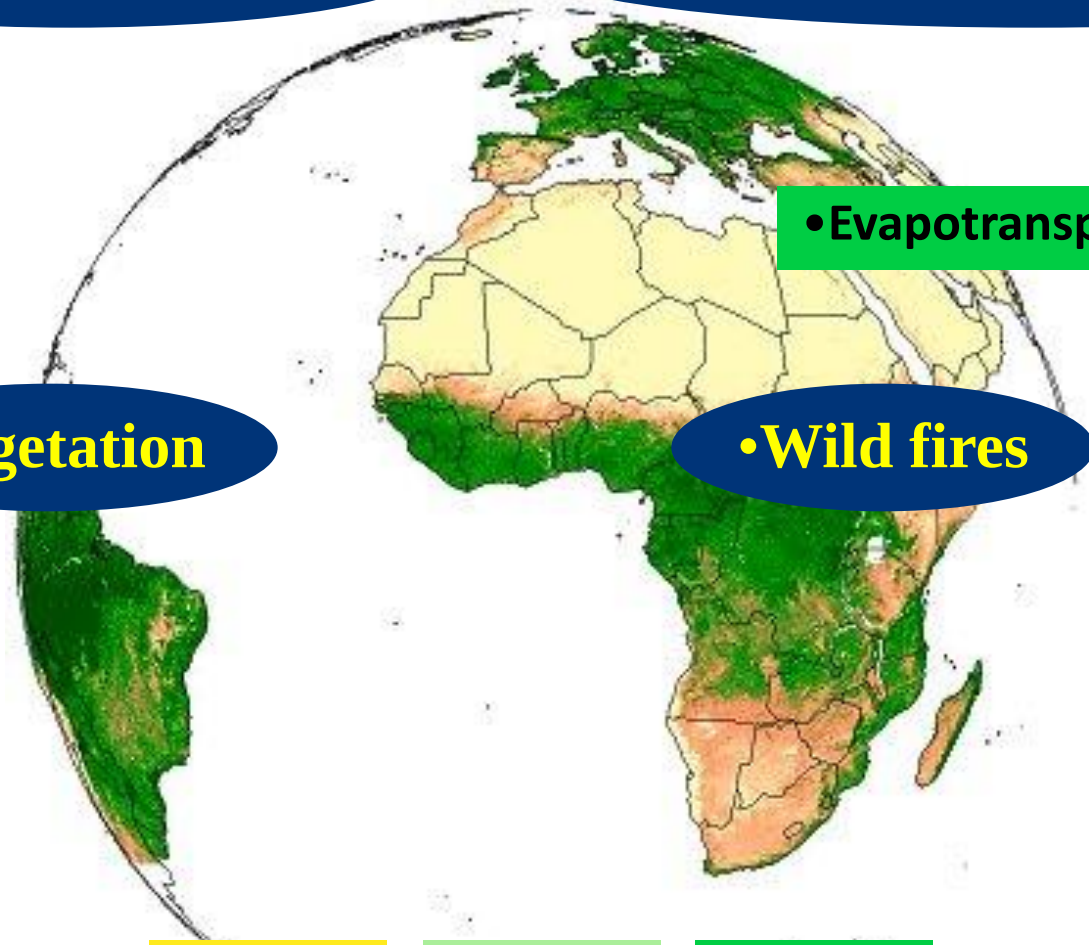
LSA-SAF products

The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

•Surface Radiation

•Surface Water Balance



•Evapotranspiration

•Vegetation

•Wild fires

•Development

•Pre. Operat.

•Operational

•Increased level of maturity

The LSA-SAF ET model

MSG pixel

Tiles:

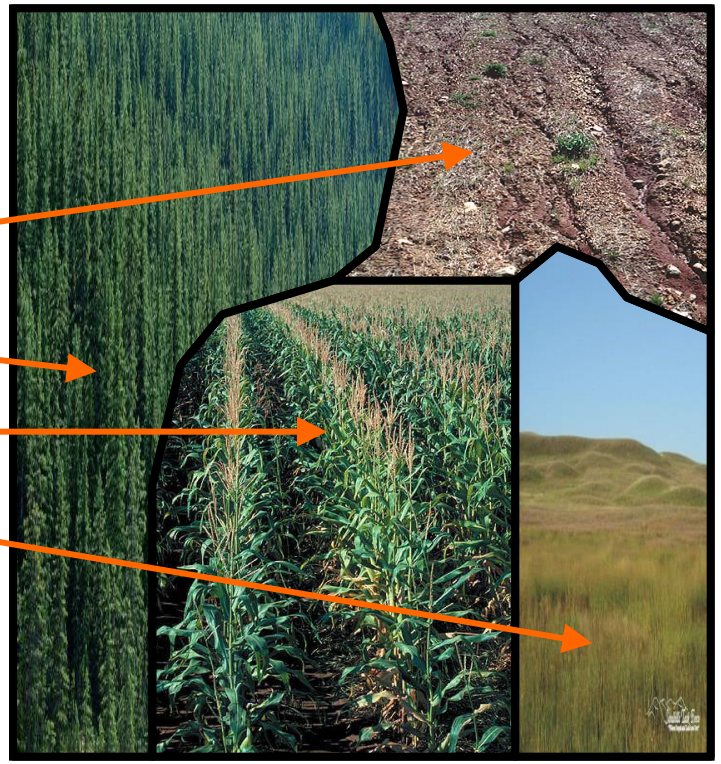
% Bare soil

% Forest

% Crops

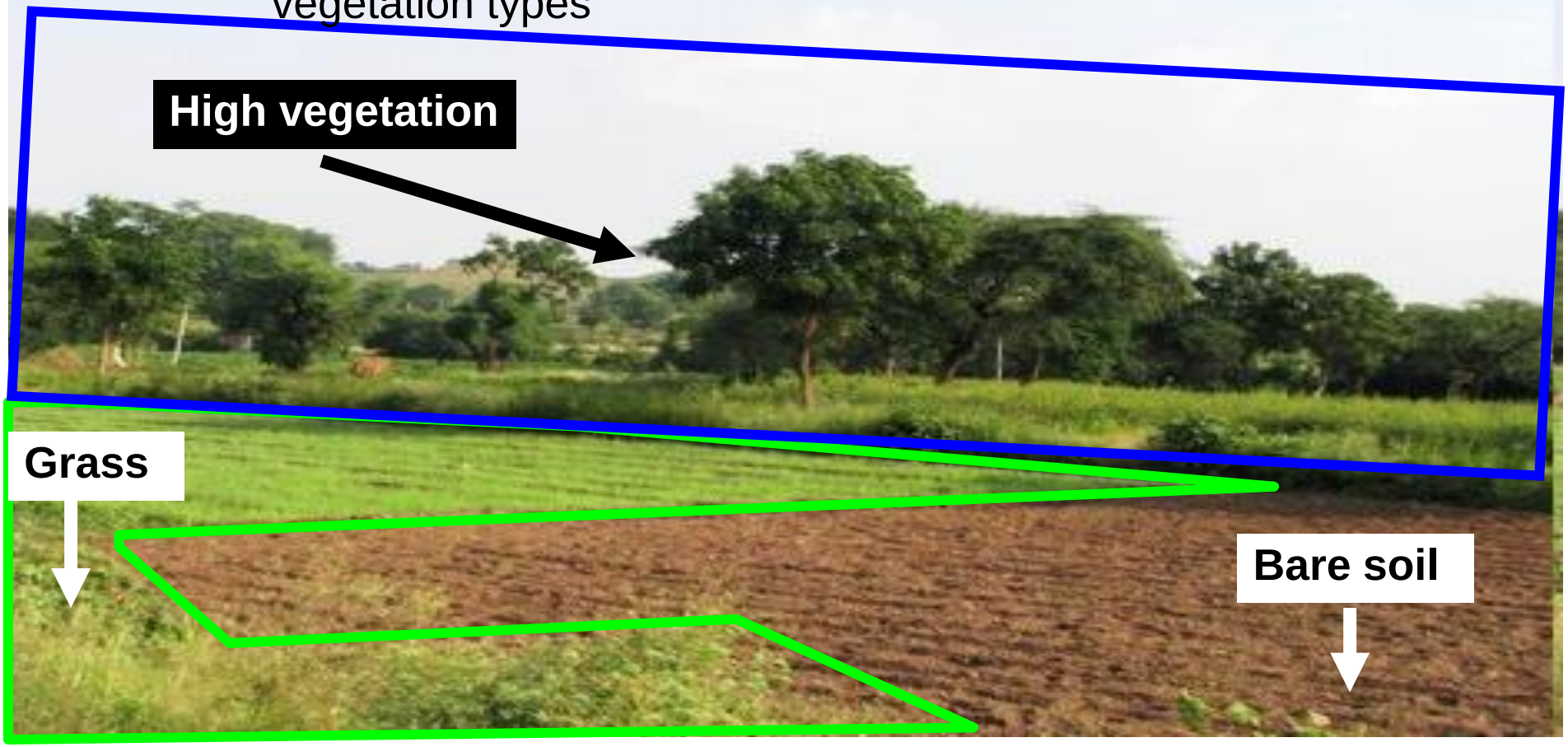
% Grassland

•…



The LSA-SAF ET model

The tile approach: The energy exchanges between the surface and the atmosphere is modelled using a resistance scheme. Each pixel in the image is divided into 'tiles' of homogeneous vegetation types

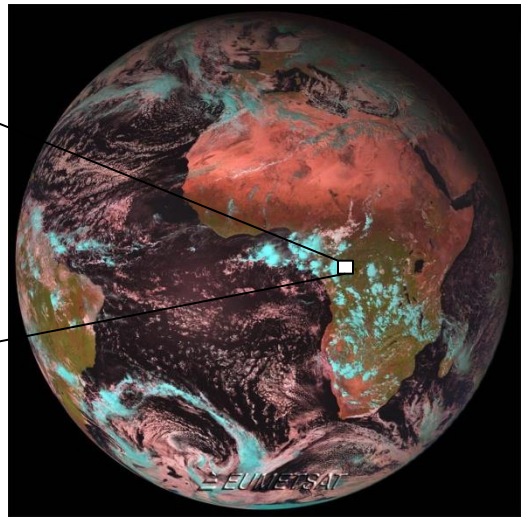


The LSA-SAF ET model

MSG SEVIRI pixel

Tiles:

- Bare soil
- Forest
- Crops
- Grassland
- …



Link between LE and ET:

$LE = L_v\, ET$

LE: latent heat flux [W m^{-2}]

ET: evapotranspiration [kg m^{-2} s^{-1}]

L_v : latent heat of vaporisation

- At tile level

$$(1-\alpha)S_{\downarrow} + \varepsilon(L_{\downarrow} - \sigma T_{sk,i}^4) + H_i + LE_i - G_i = 0$$

$$LE_i = \frac{L_v \rho_a}{(r_{a_i} + r_{c_i})}\left[q_{sat}(T_{sk,i}) - q_a(T_a)\right]$$

$$H_i = \frac{\rho_a}{r_{ai}}\left[c_p(T_{sk,i} - T_a) - g z_a\right]$$

$$G_i = \beta_i\, Rn_i \quad with \quad \beta_i = f(LAI_i)$$

- Pixel value

Evapotranspiration [mm h^{-1}]

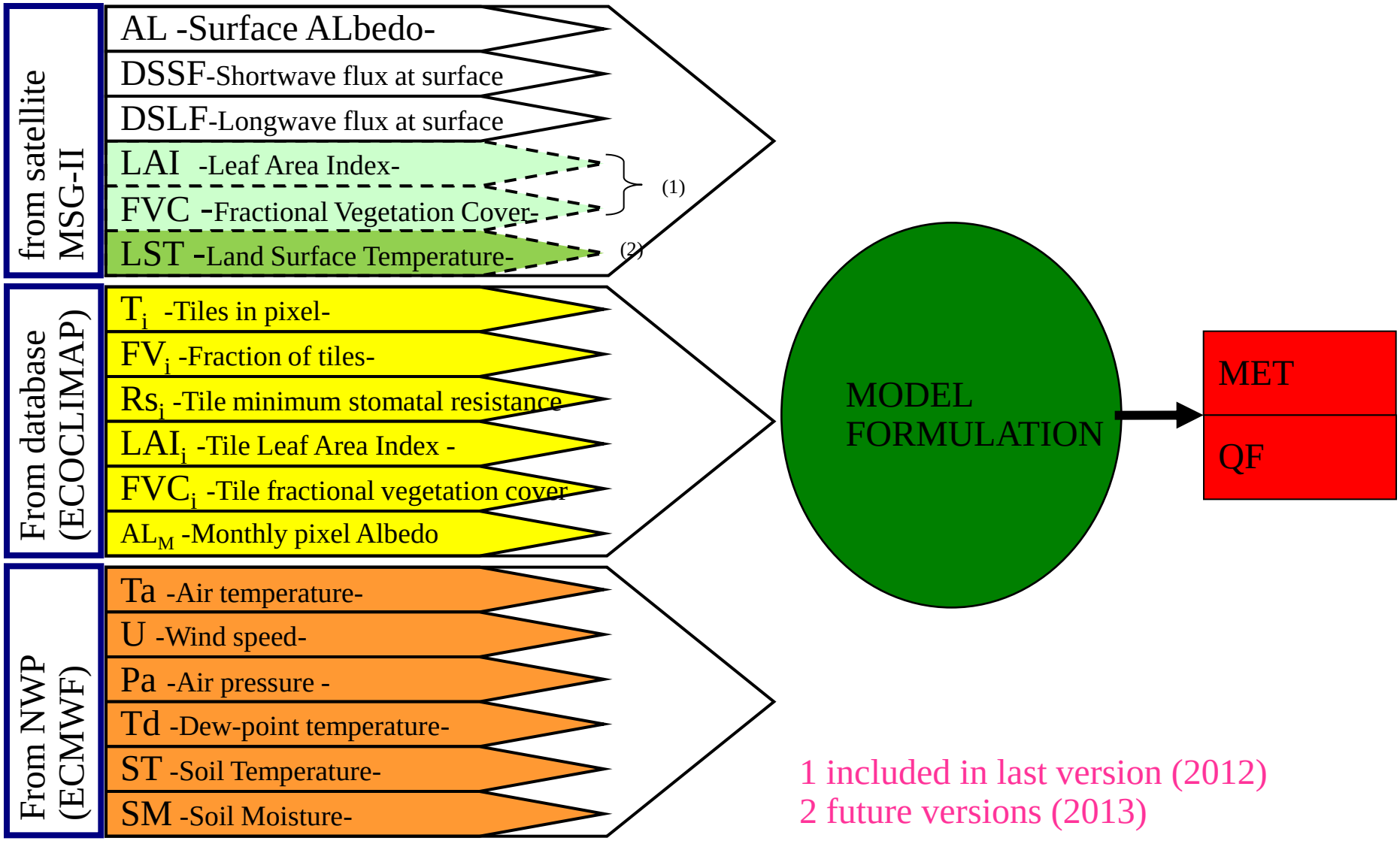
$ET = 3600\ LE/L_v$

For each pixel of day d

Evapotranspiration [mm d^{-1}]

$ET_d = \Sigma\, ET_k$

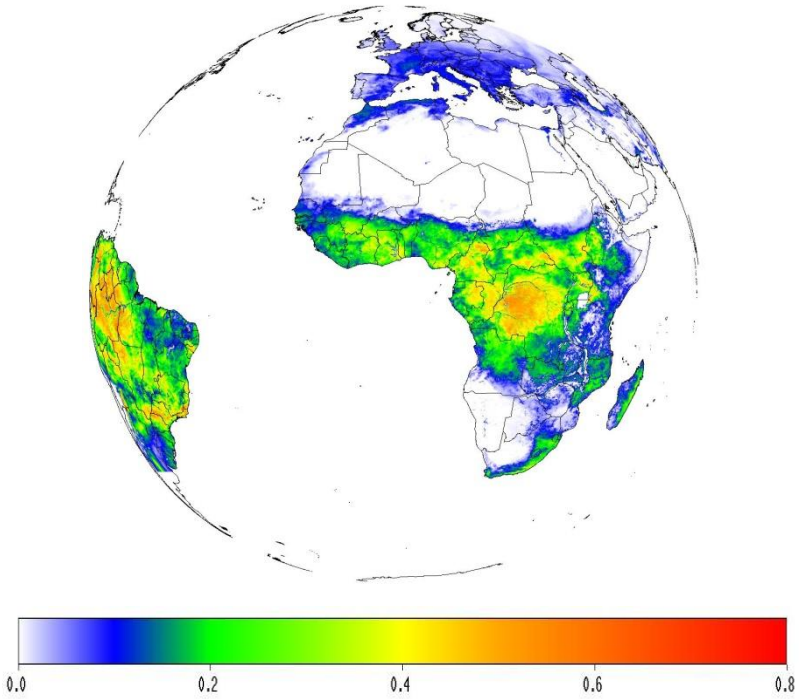
The LSA-SAF ET model (input data)



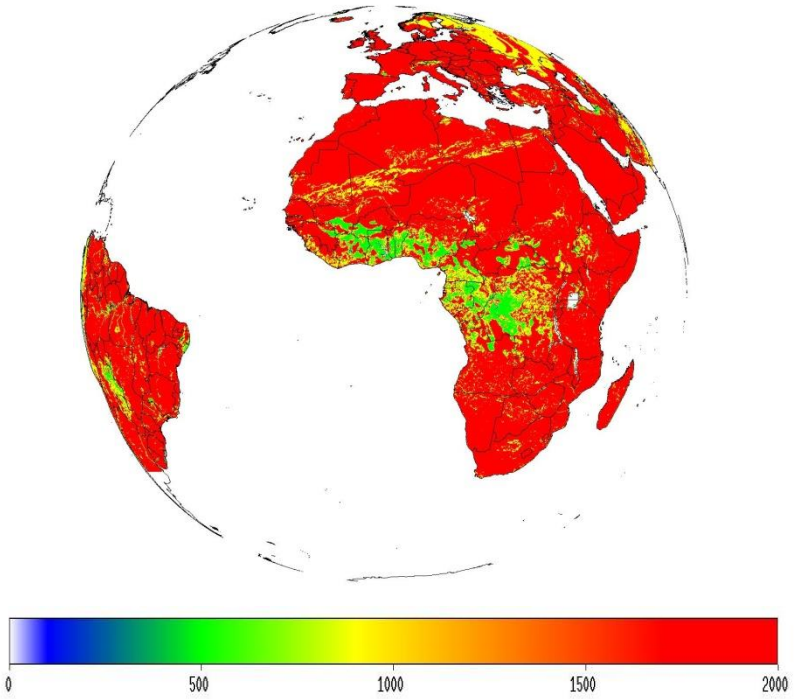
1 included in last version (2012)
2 future versions (2013)

The LSA-SAF ET Algorithm output

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

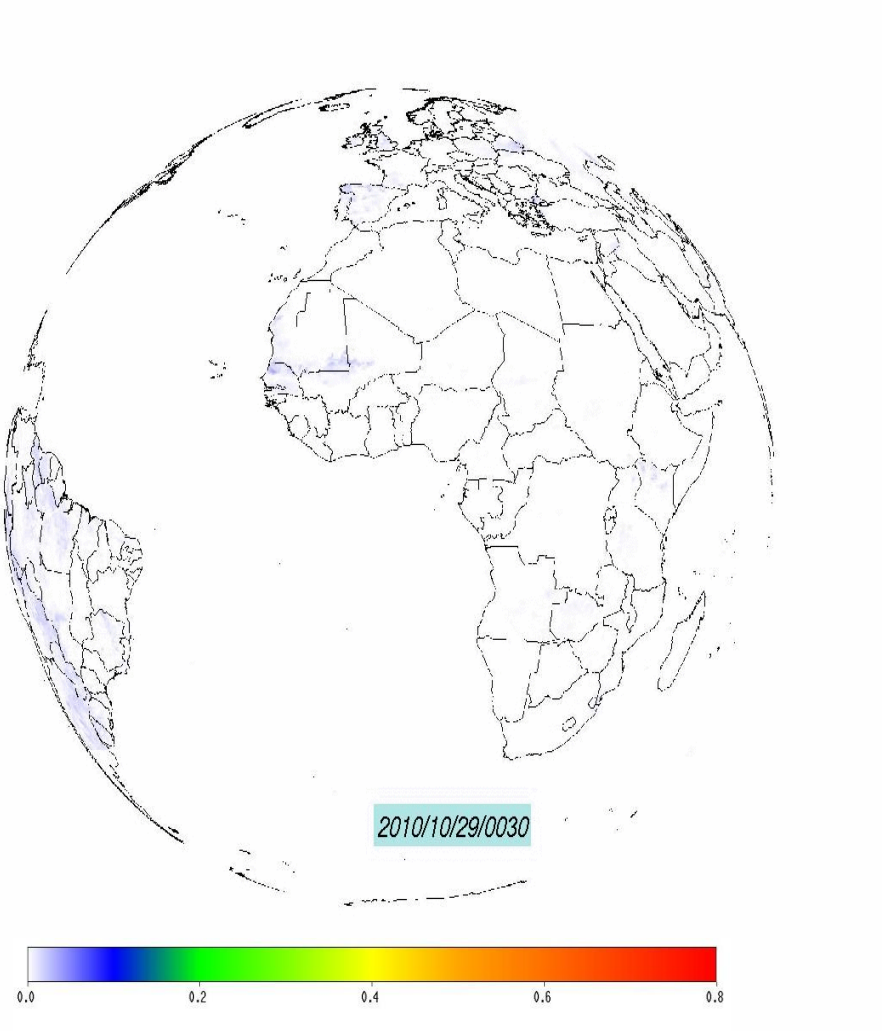


ET (mm/h) for 2010/10/29 at 12:00 UTC



Associated quality flag (-)

The LSA-SAF ET Algorithm output



Instantaneous ET (mm/h) over the MSG disk For 2010/10/29

Daily evapotranspiration product (DMET)

$$DMET = \sum_{t1=1}^{t2=48} MET_i$$

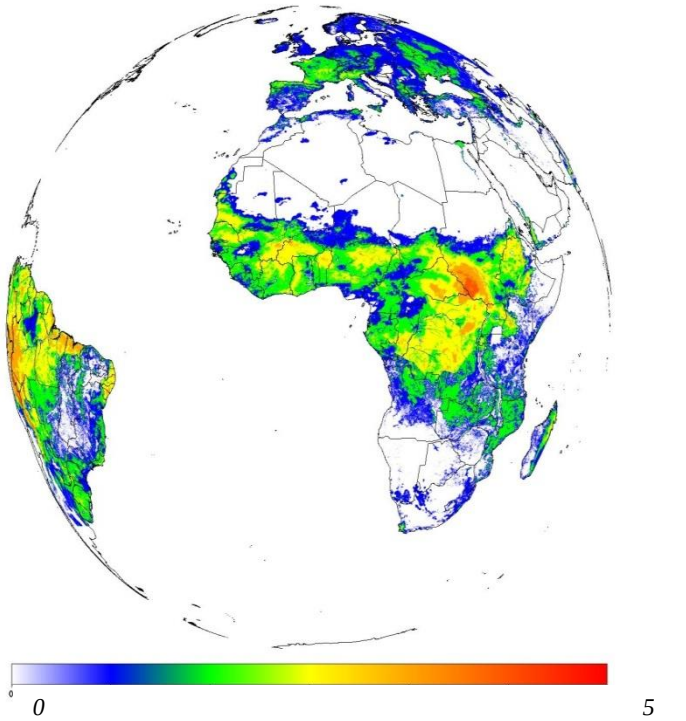
-Daily evapotranspiration product (DMET): temporal integration of instantaneous (MET_i) product.

- MET_i : instantaneous evapotranspiration for i time-step between 00:30 UTC and 24:00 UTC.

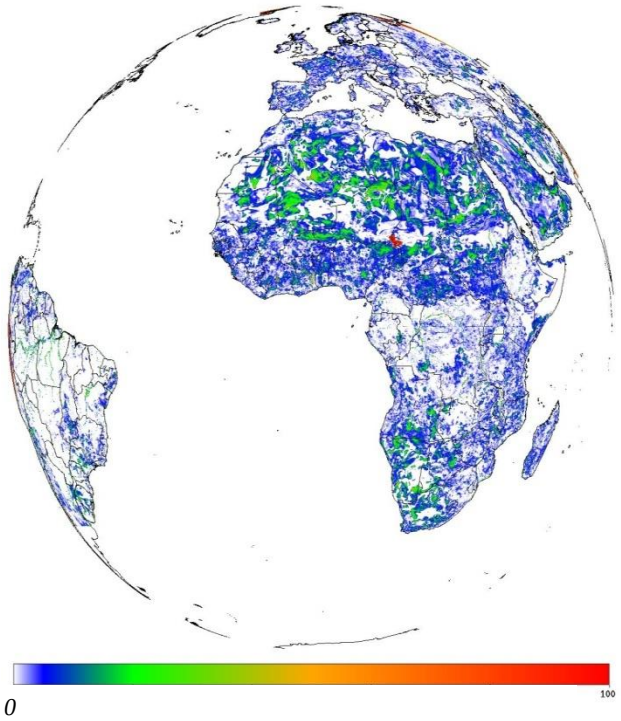
- In optimal conditions (no missing slots) 48 images are integrated for a given day.

Daily evapotranspiration product output

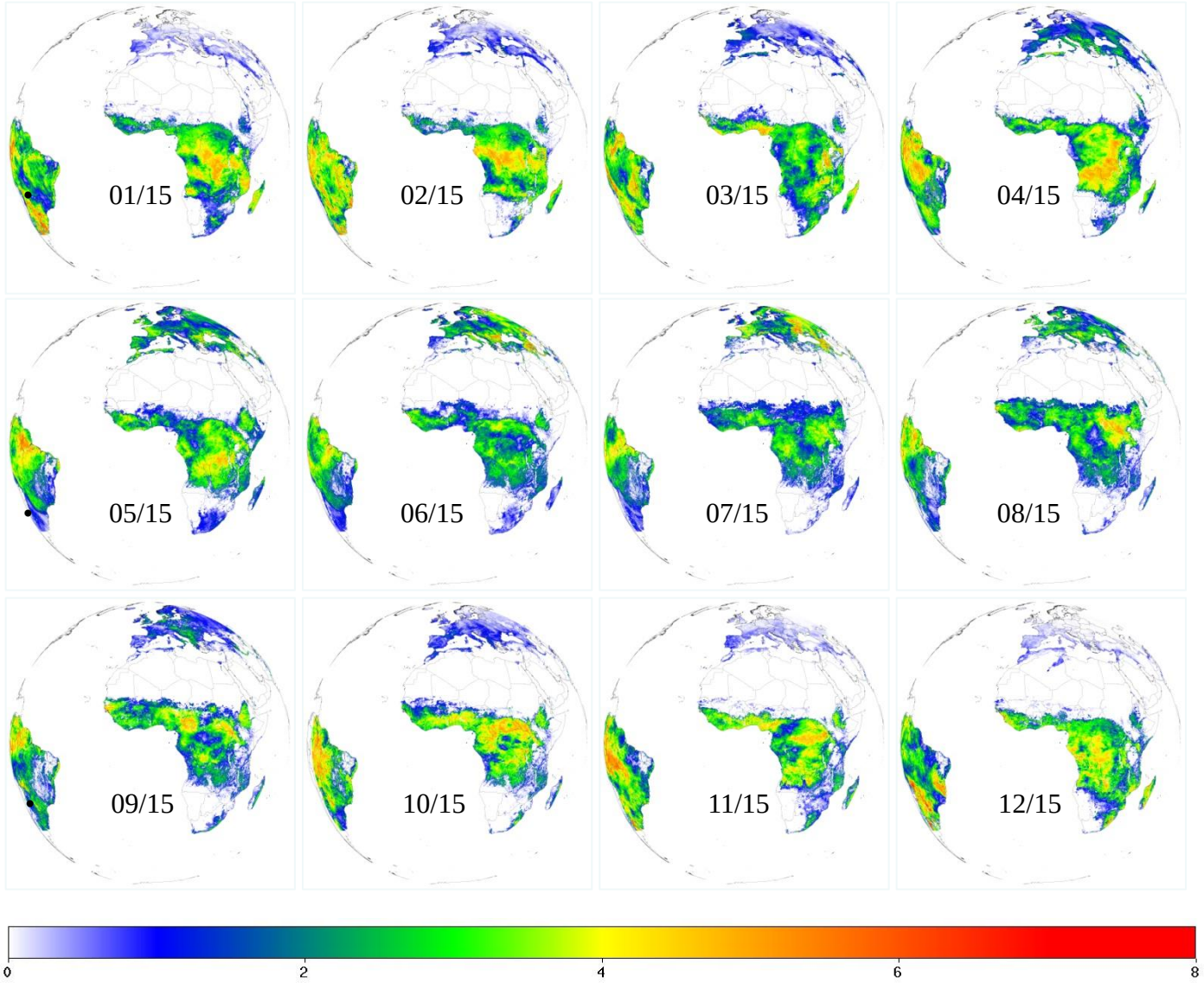
a) DMET (mm/day) every pixel



b) Percent of missing values for



Daily evapotranspiration product output



•ET (mm/day)

Daily cumulated ET for the 15th of Each month, over MSG FOV for the year 2016

Products validation

The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

Validation Approaches

a) Comparison to in-situ measured/computed fluxes (LE, ET)

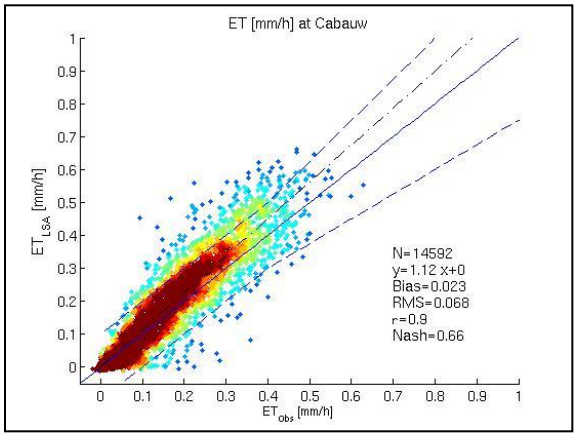
b) Comparison to models generating fluxes at large scale (region, continent)

Products validation (instantaneous ET)

The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

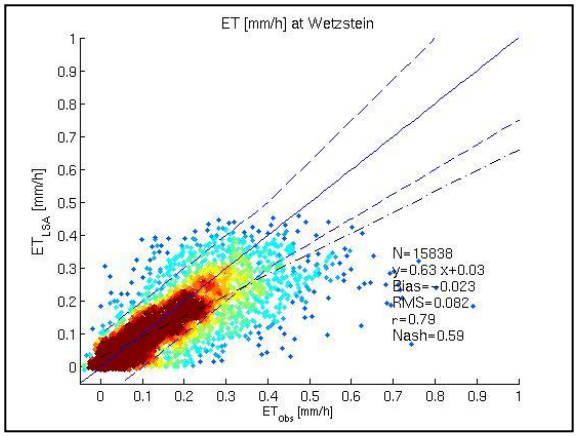
Cabauw (NL) - grassland



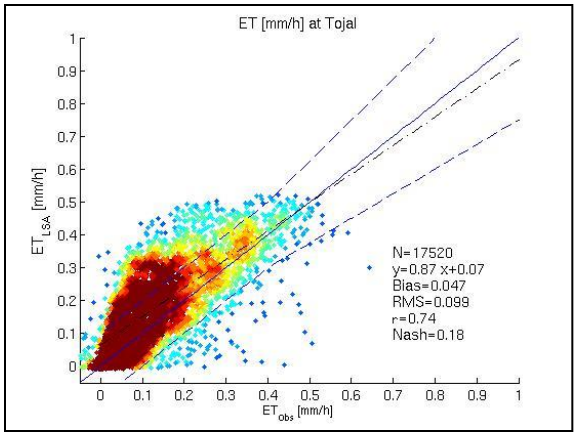
March – Nov

2007

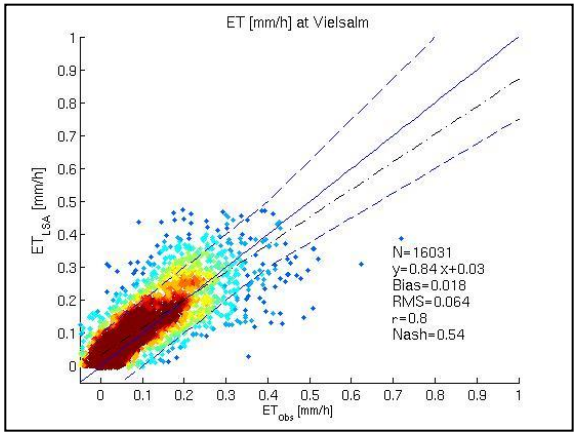
Wetzstein (GE) - coniferous forest



Tojal (PT) - grassland



Vielsalm (BE) - mixed forest

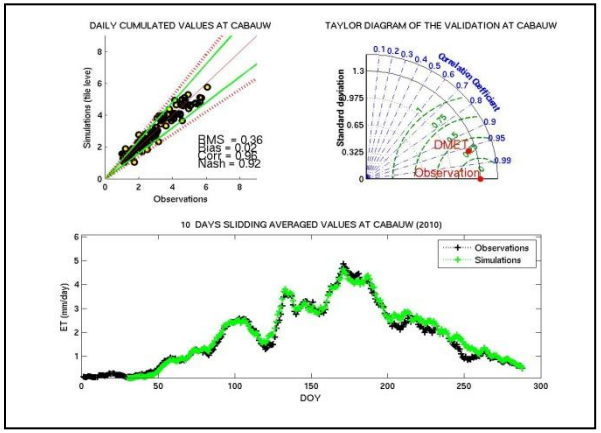


Products validation (daily ET)

The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

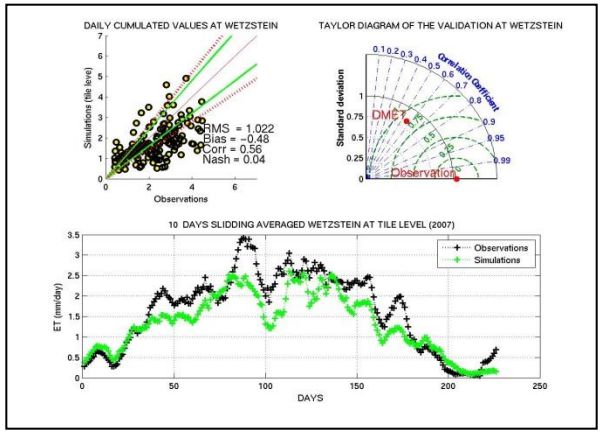
Cabauw (NL) - grassland



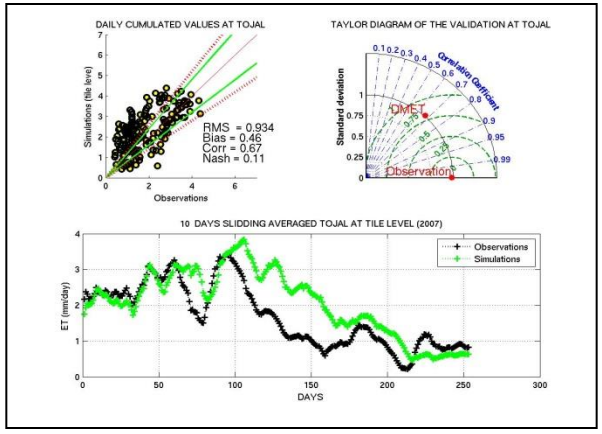
March – Nov

2007

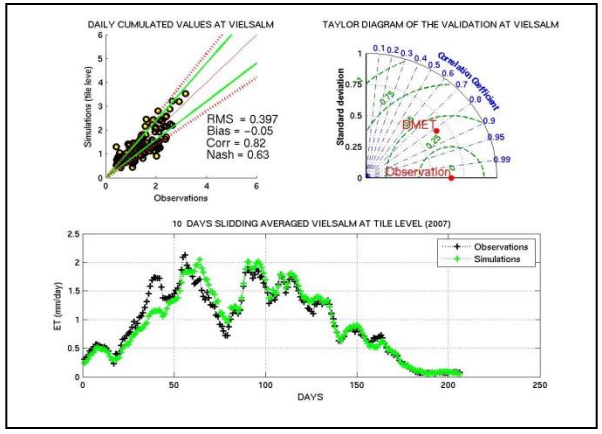
Wetzstein (GE) - coniferous forest



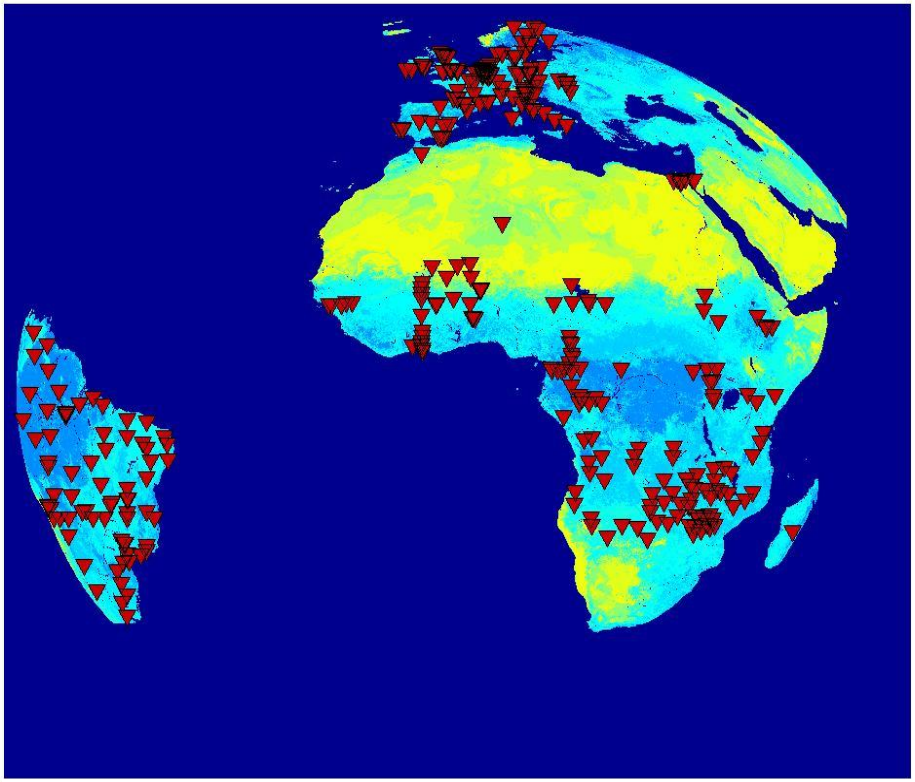
Tojal (PT) - grassland



Vielsalm (BE) - mixed forest



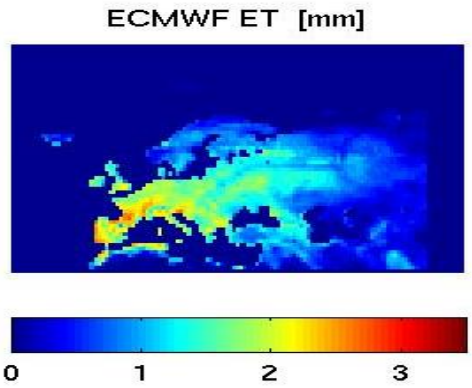
Products validation

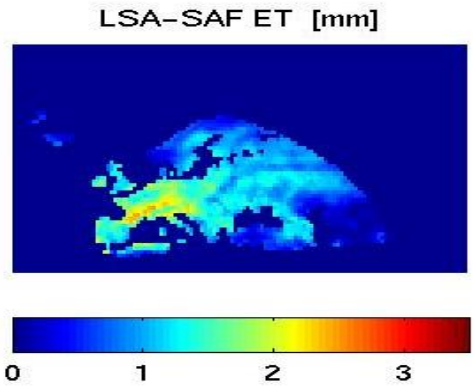


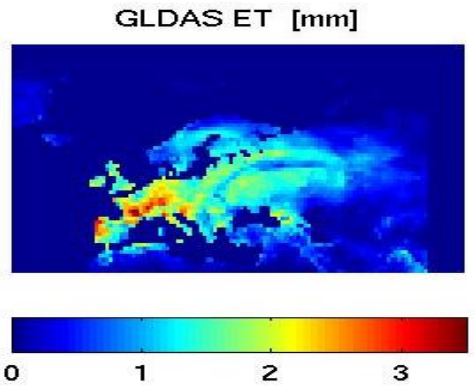
Compare the output of the operational model to in-situ observations at predefined locations

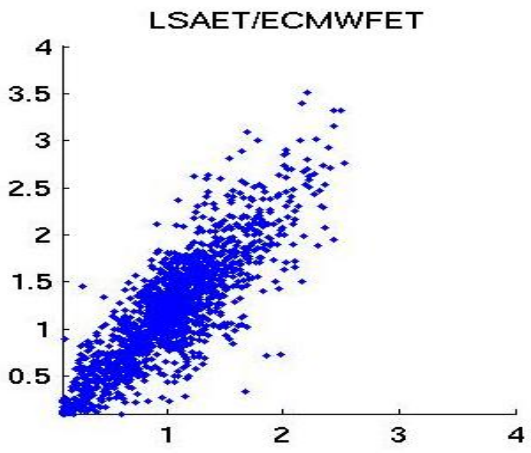
Products validation (Models intercomparison)

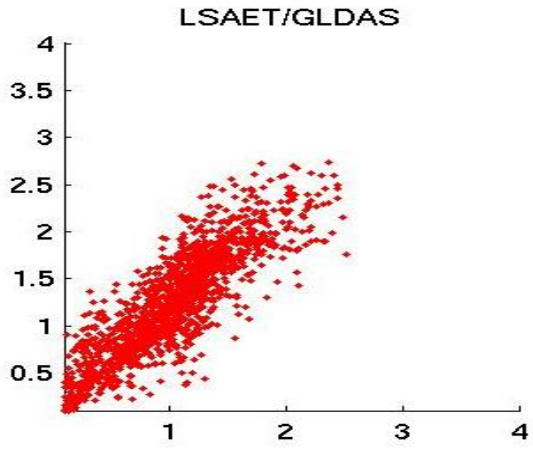
Cumulated (12:00 to 18:00 UTC) Evapotranspiration from LSA-SAF ET, ECMWF and GLDAS for the day 15.08.2007



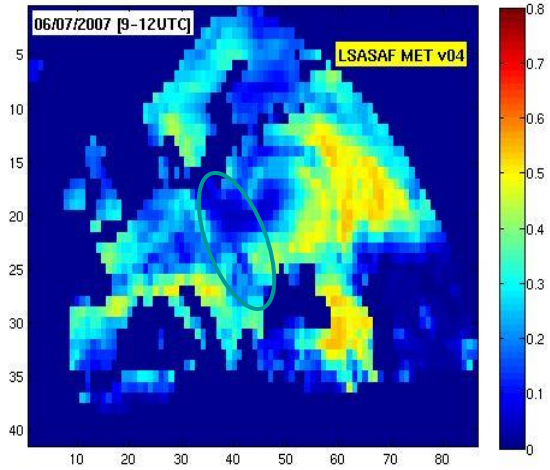


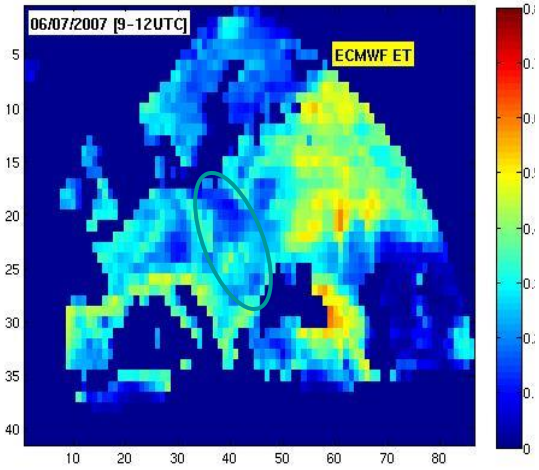


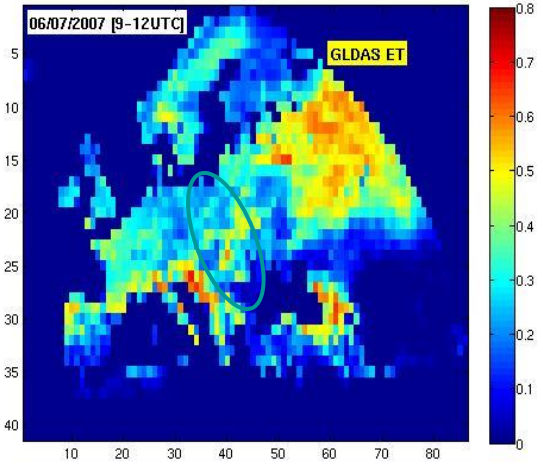




Products validation (Models intercomparison)







Comparison at 3 hours at 1°x1° (06/07/2007 from 9-12 UTC

Differences between models are due mainly to used radiative forcing and soil humidity

Potential applications

The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

- Hydrology

- Crop modelling

- Drought monitoring and desertification

- Water management

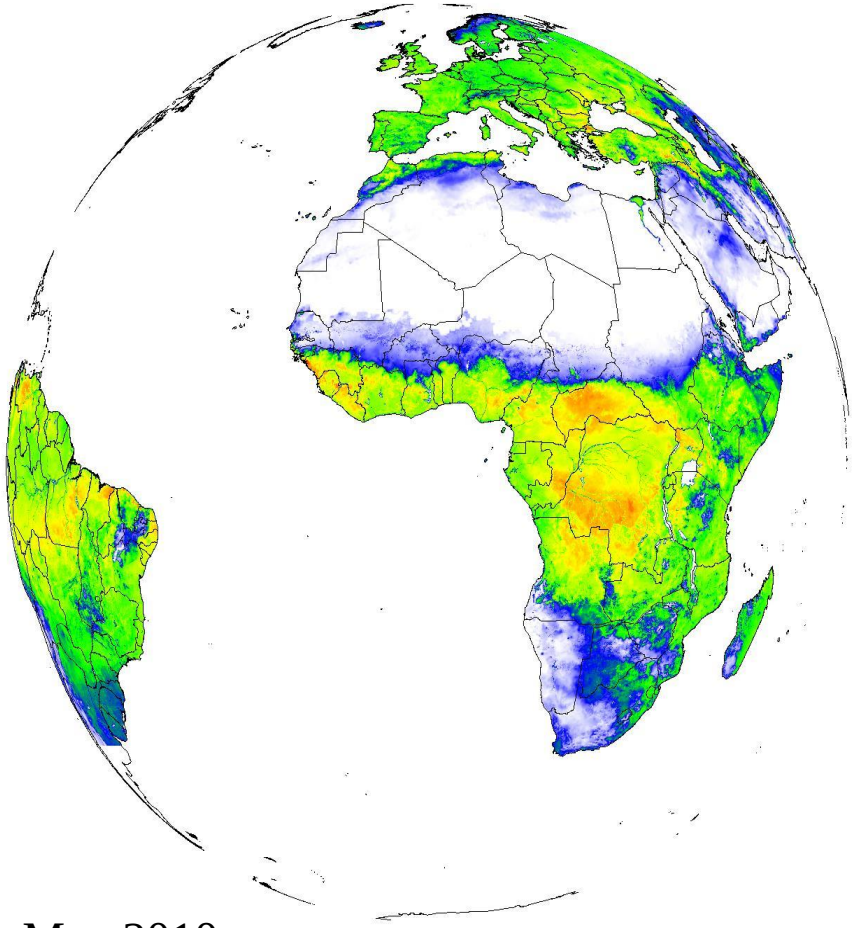
- Climate change studies

Applications in hydrology

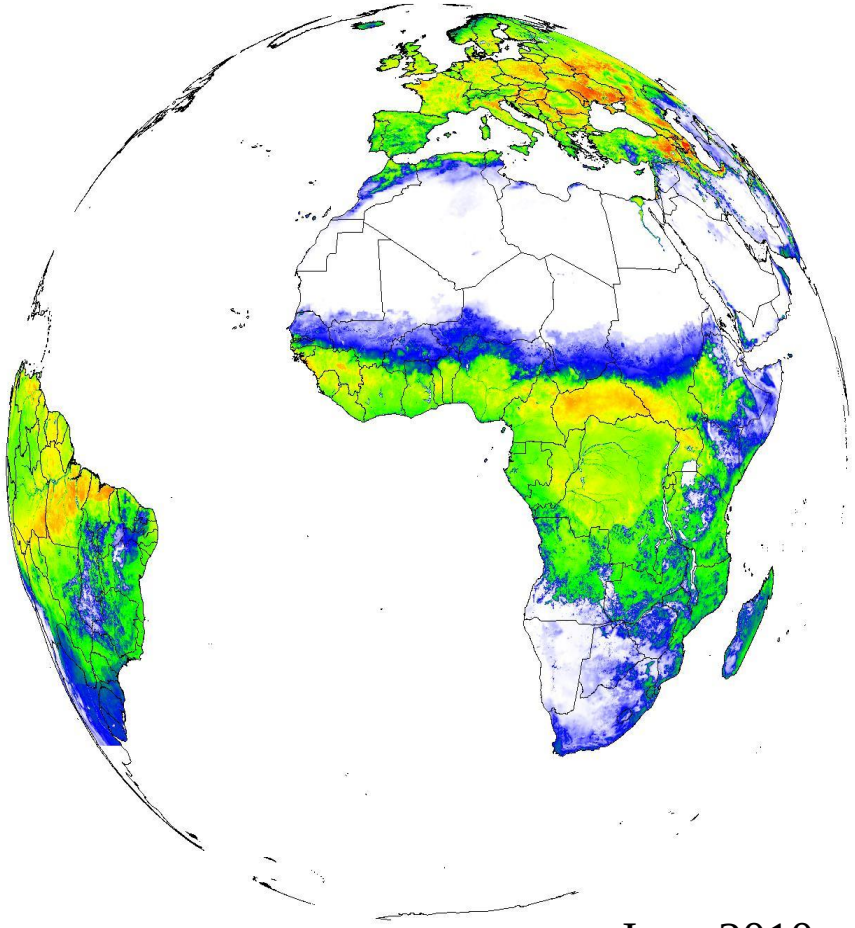
The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

Generate Monthly/seasonal/yearly averages and cumulated ET at regional and continental scales



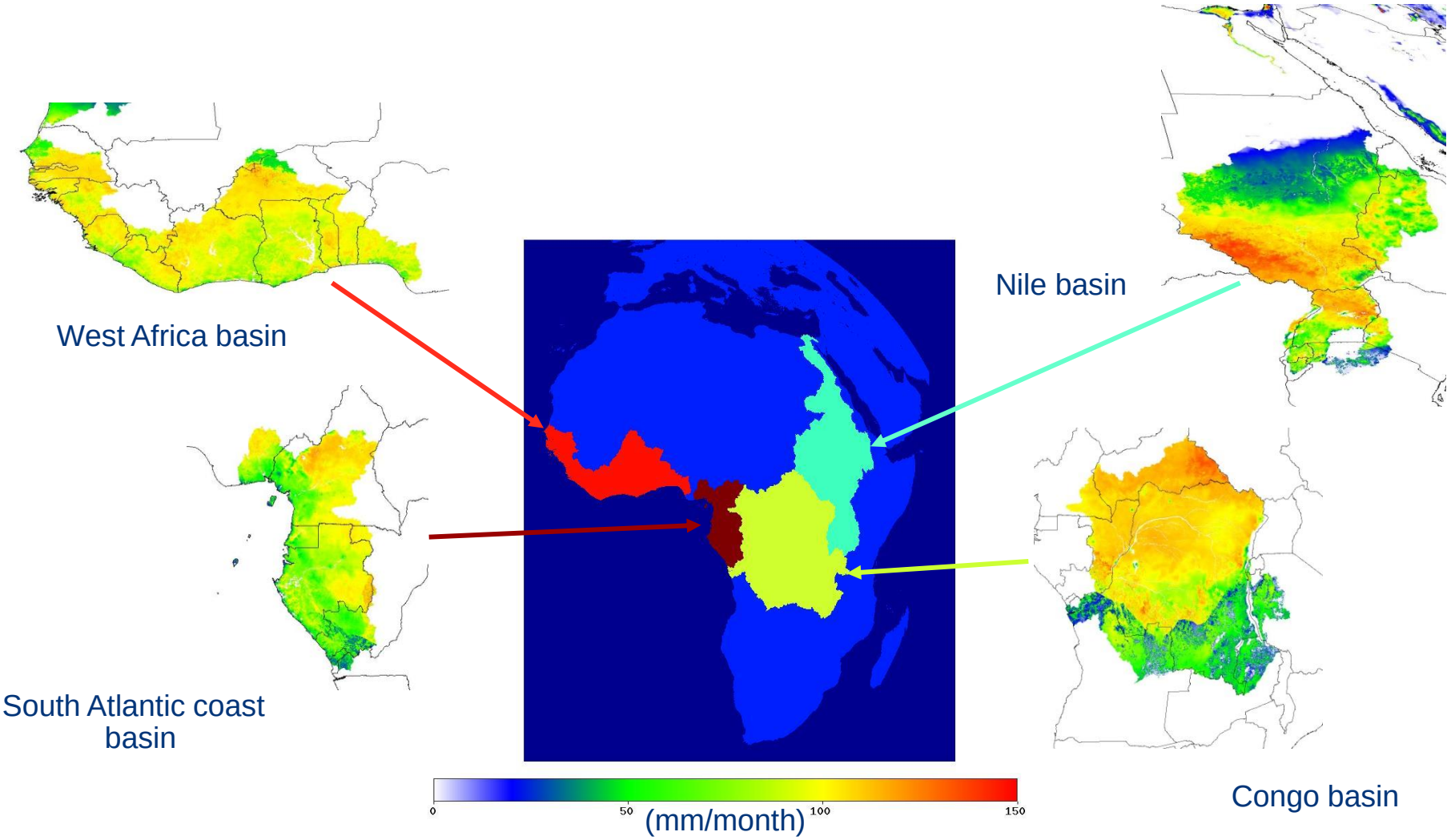
May 2010



June 2010

Applications in hydrology

Generate Monthly/seasonal/yearly average and cumulated ET over hydrological basins



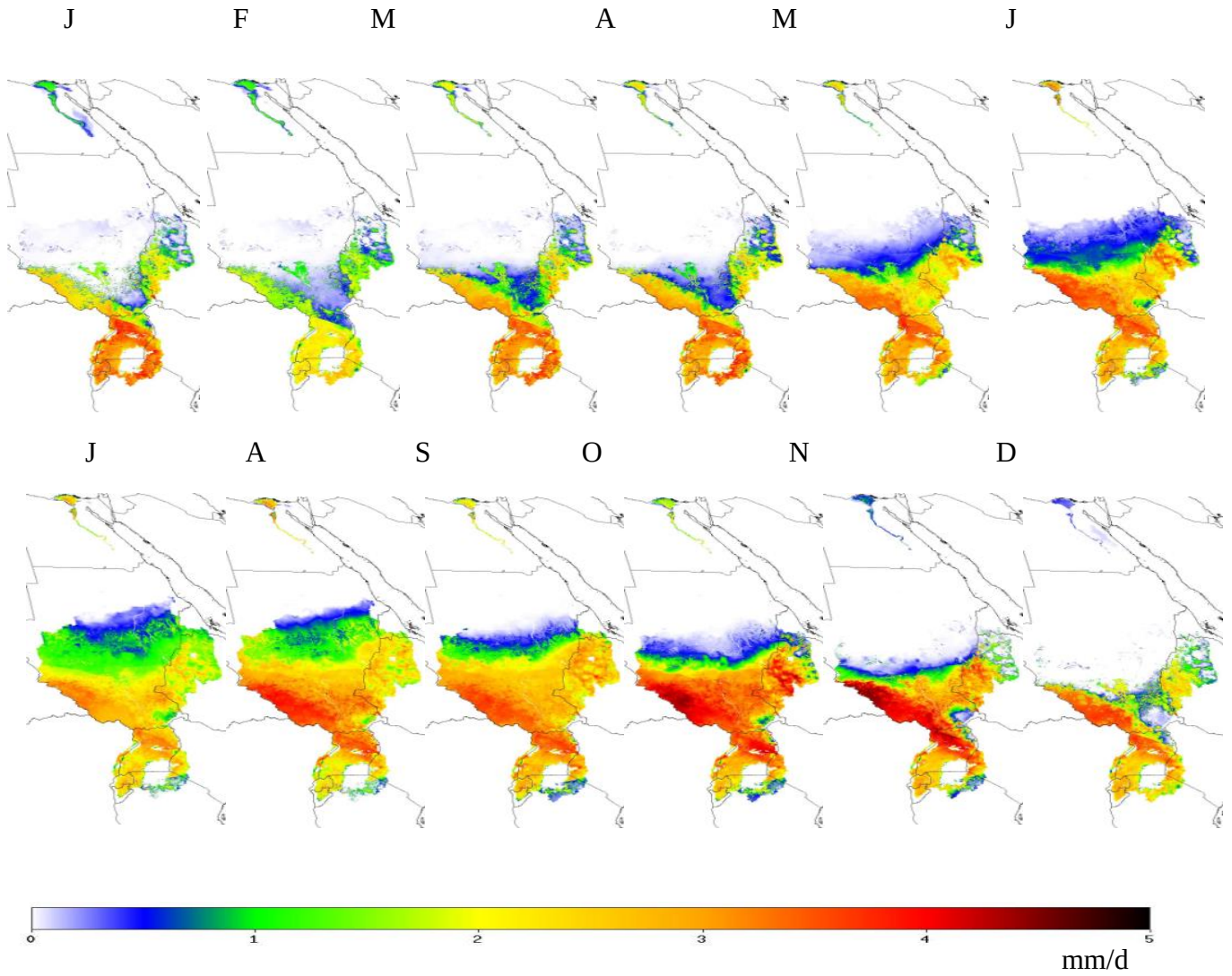
Cumulated ET over selected hydrological basins in Africa November 2009

Applications in hydrology

The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

Month by month daily average ET over the Nile river basin for 2010

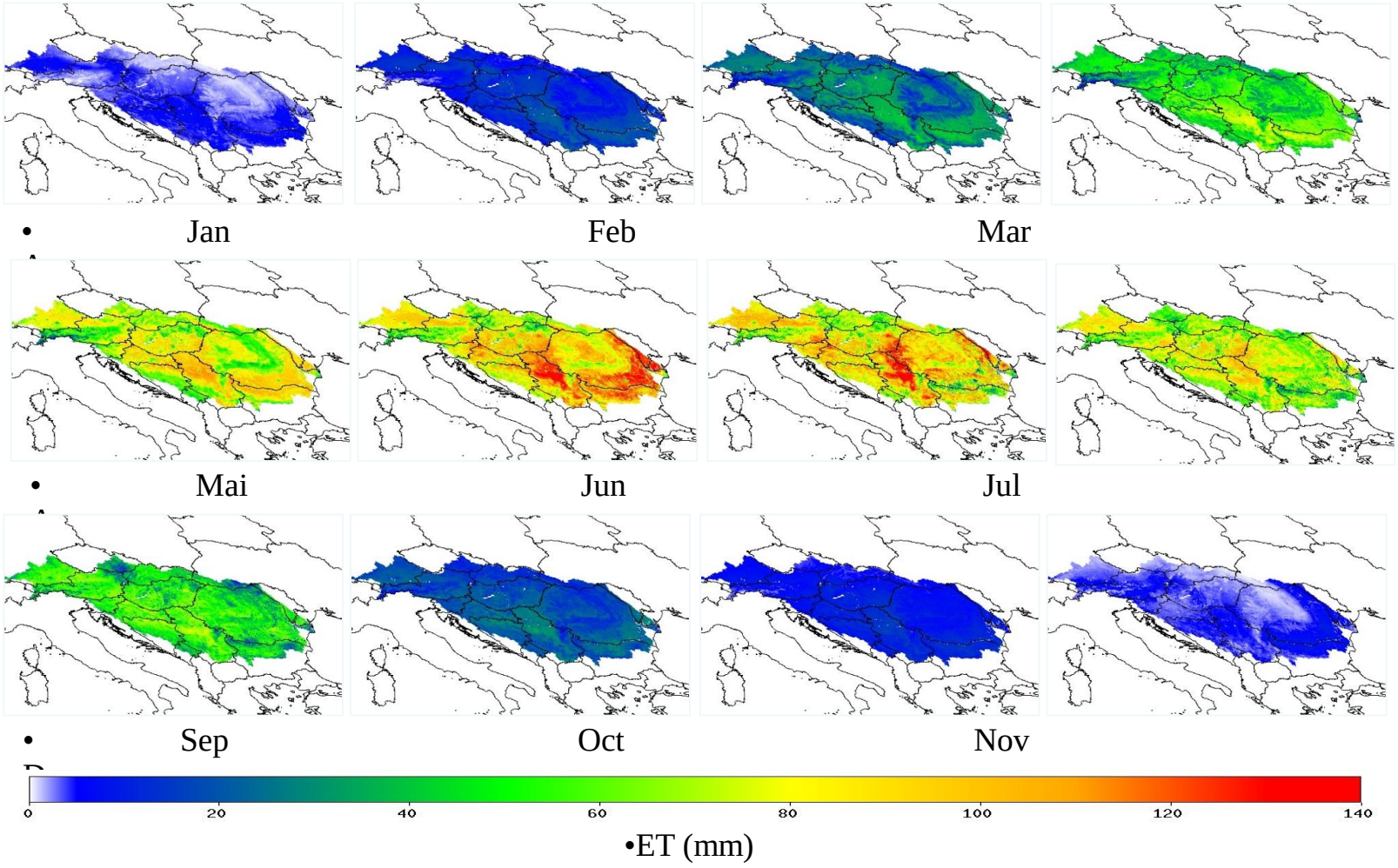


Applications in hydrology

The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

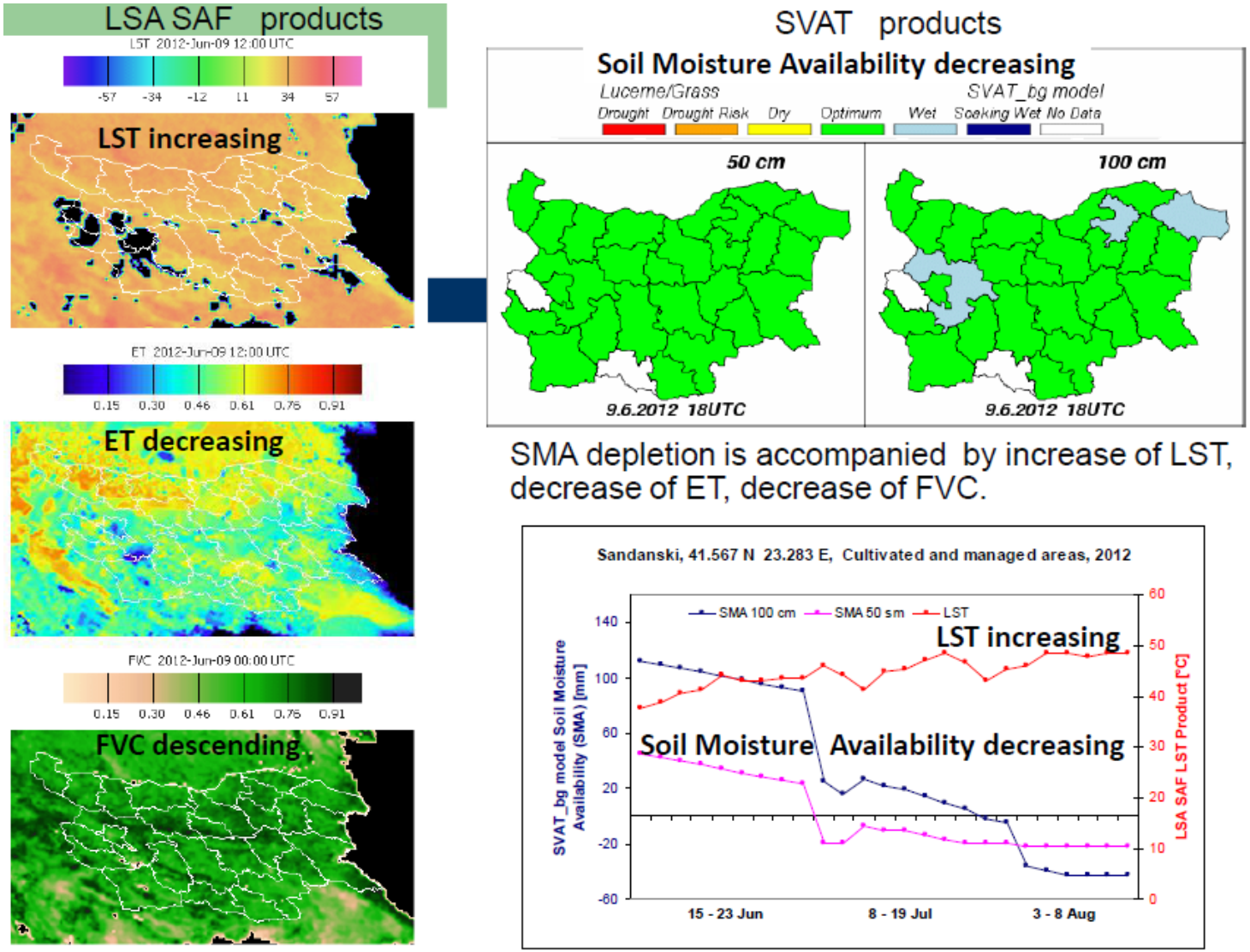
•Monthly cumulated evapotranspiration over the Danube River Basin for the year 2016



Applications in drought monitoring

Evapotranspiration monitoring is essential for drought detection.

Applications in drought monitoring



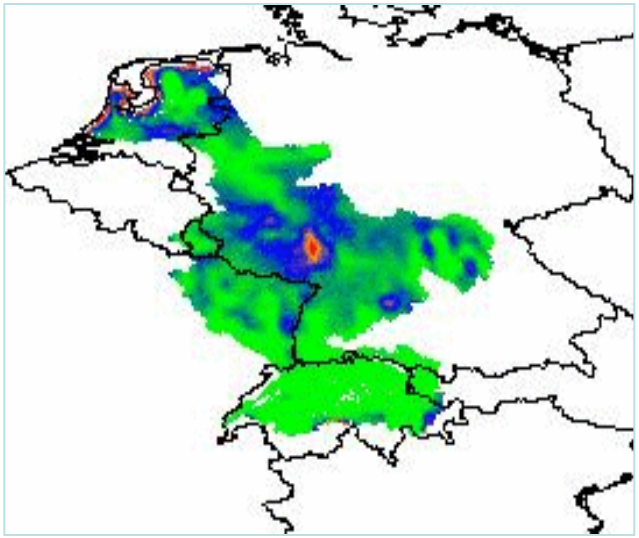
From Julia Stoyanova (Bulgarian National Institute of Meteorology and Hydrology)

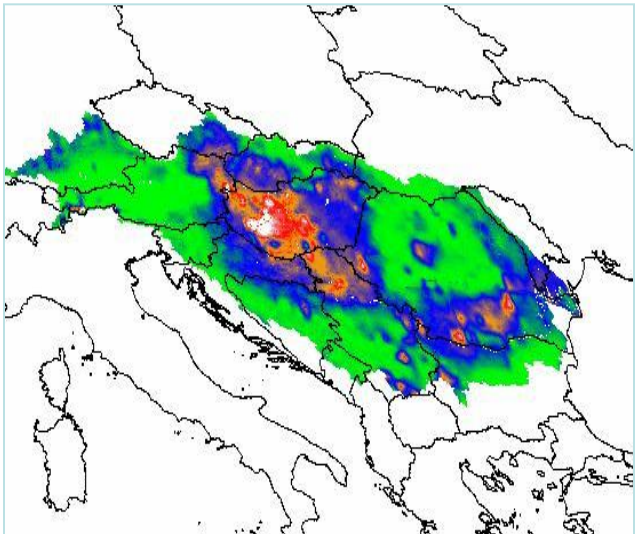
Applications in drought monitoring

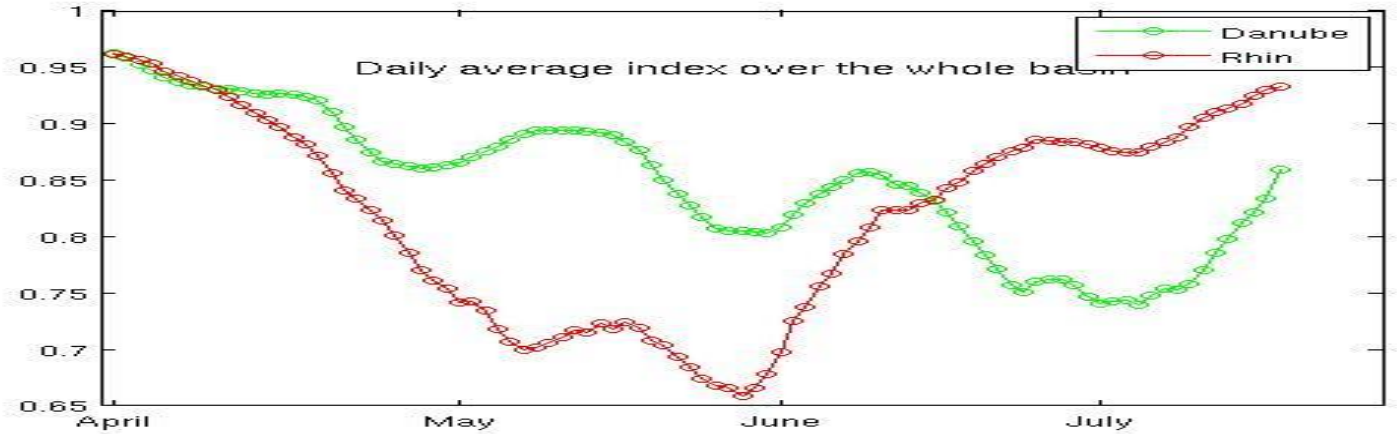
The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

- Rhin river basin
- Danube river basin







Summary

- ET is key component of the water cycle important to determine water requirements
- Most direct methods have limited practical application
- Many factors affect ET(Weather, Crop type, Management, environmental conditions)
- The LSA SAF ET Product suitable for applications in:
  - ✓ Hydrology
  - ✓ Drought monitoring
  - ✓ Crop modelling
  - ✓ Water management
  - ✓ Climate studies
- The LSA SAF ET Product free for registered users

LSA-SAF data & info

The EUMETSAT Network of Satellite Application Facilities | LSA SAF Land Surface Analysis

http://landsaf.ipma.pt

Publications

Download Data

Documentation (User Manuals, Validation Reports)

Helpdesk