



## The LSA-SAF ET product: an operational service of sub-daily estimation of evapotranspiration in near-real time across Europe, Africa and Eastern South America

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# Outline

- What is the LSA-SAF programme?
- The evapotranspiration product
- Take-home messages

# The LSA-SAF programme

# What is the LSA-SAF programme?

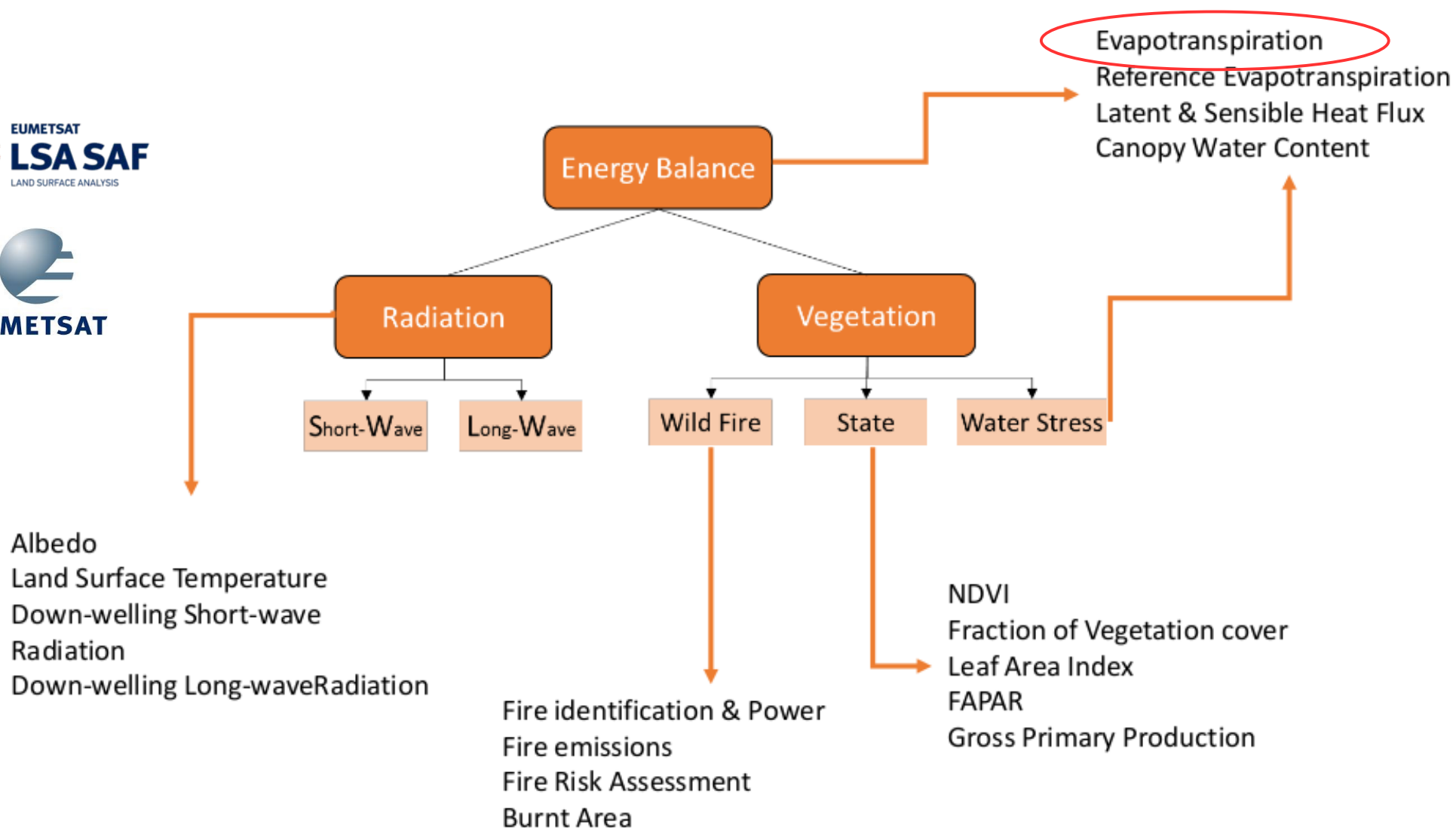


- LSA SAF: A EUMETSAT's programme
- LSA-SAF stands for: Satellite Application Facility on Land Surface Analysis (LSA)
- The aim of the LSA SAF is to take full advantage of data observed from to derive biophysical variables on land, land-atmosphere interactions and biosphere applications.

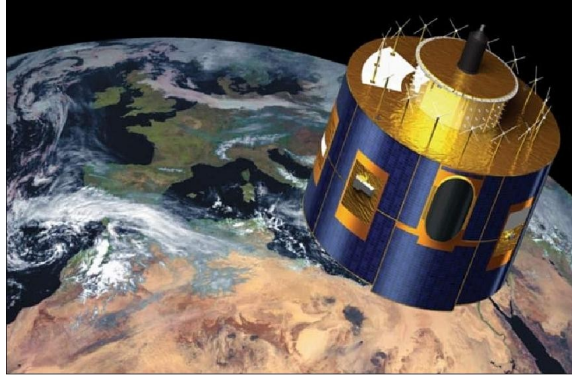
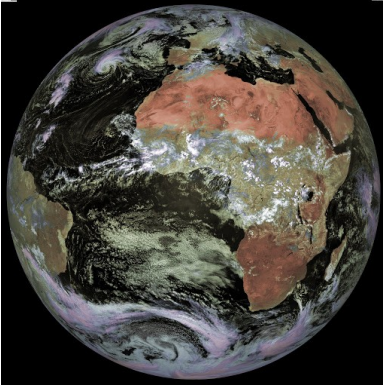
LSA-SAF consortium:



# The LSA-SAF products



# Satellite platforms used in LSA-SAF



## METEOSAT SECOND GENERATION

- Geostationary
- SEVIRI sensor
- 12 spectral channels
- 96 observations set per day
- 3 km spatial resolution at nadir
- FOV: Europe + Africa + Eastern South America



MetOp-AVHRR S10 or 'ENDVI10'

## METOP

- Polar orbit
- Sensor: Advanced Very High Resolution Radiometer (AVHRR)
- 5 spectral channels
- ~2 observations per day
- ~1 km spatial resolution
- FOV: Global

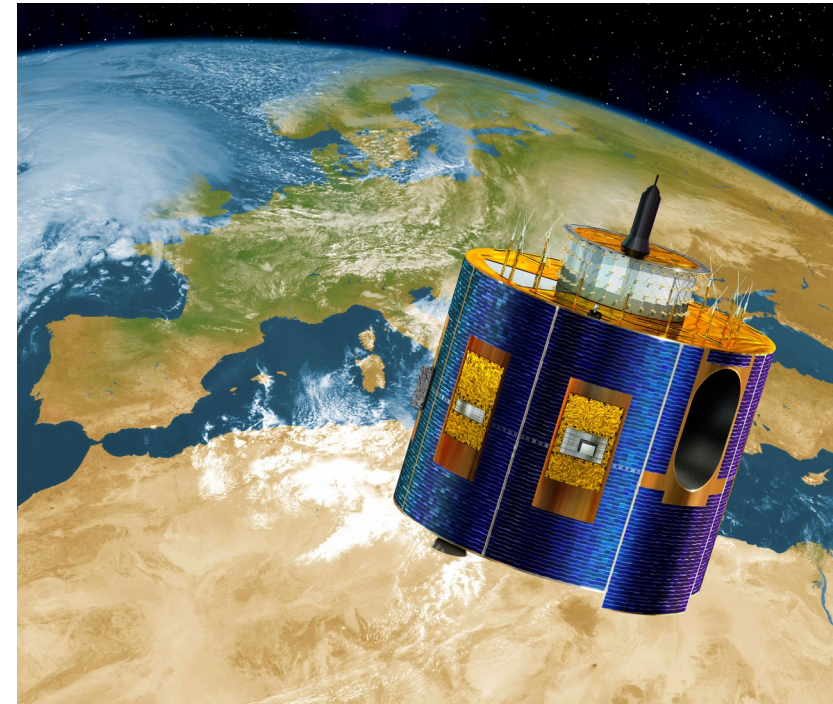


## Details on SEVIRI spectral channel onboard MSG satellite

Cha. No	Channel		Nominal spectral band (μm)	NEΔR or NEΔT	Max Dynamic range *
	Name	Center of λ (μm)			
12	HRV (High Resolution Visible)	Broadband (silicon response, about 0.4-1.1)		1.07 W/(m <sup>2</sup> sr μm) at 1.3 W/(m <sup>2</sup> sr μm)	460 W/(m <sup>2</sup> sr μm)
1	VIS 0.6	0.635	0.56-0.71	0.53 W/(m <sup>2</sup> sr μm) at 5.3 W/(m <sup>2</sup> sr μm)	533 W/(m <sup>2</sup> sr μm)
2	VIS 0.8	0.81	0.74-0.88	0.49 W/(m <sup>2</sup> sr μm) at 3.6 W/(m <sup>2</sup> sr μm)	357 W/(m <sup>2</sup> sr μm)
3	IR 1.6	1.64	1.50-1.78	0.25 W/(m <sup>2</sup> sr μm) at 0.75 W/(m <sup>2</sup> sr μm)	75 W/(m <sup>2</sup> sr μm)
4	IR 3.9	3.90	3.48-4.36	0.35 K at 300 K	335 K
5	WV 6.2	6.25	5.35-7.15	0.75 K at 250 K	300 K
6	WV 7.3	7.35	6.85-7.85	0.75 K at 250 K	300 K
7	IR 8.7	8.70	8.30-9.10	0.28 K at 300 K	300 K
8	IR 9.7	9.66	9.38-9.94	1.5 K at 255 K	310 K
9	IR10.8	10.80	9.80-11.80	0.25 K at 300 K	355 K
10	IR 12.0	12.00	11.00-13.00	0.37 K at 300 K	335 K
11	IR 13.4	13.4	12.40-14.40	1.8 K at 270 K	300 K

The LSA-SAF ET product uses products derived from SEVIRI observations:

- Downwelling Long/short wave radiation
- Leaf Area Index
- Fraction of Vegetation Cover
- Albedo
- Land Surface Temperature



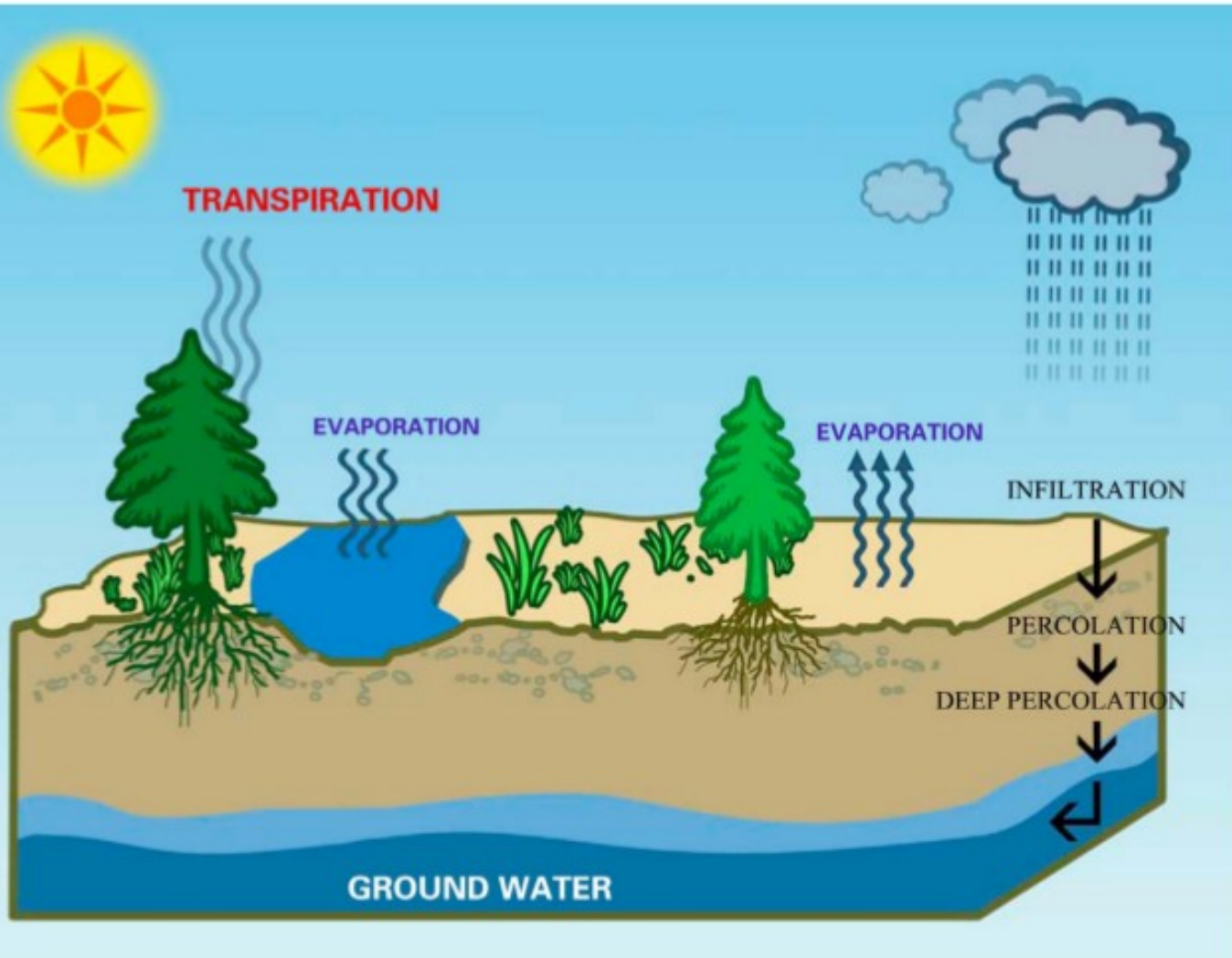
Follow this link for an animation of SEVIRI observations

<https://www.youtube.com/watch?v=LEDo5p3sE3o>

# Evapotranspiration



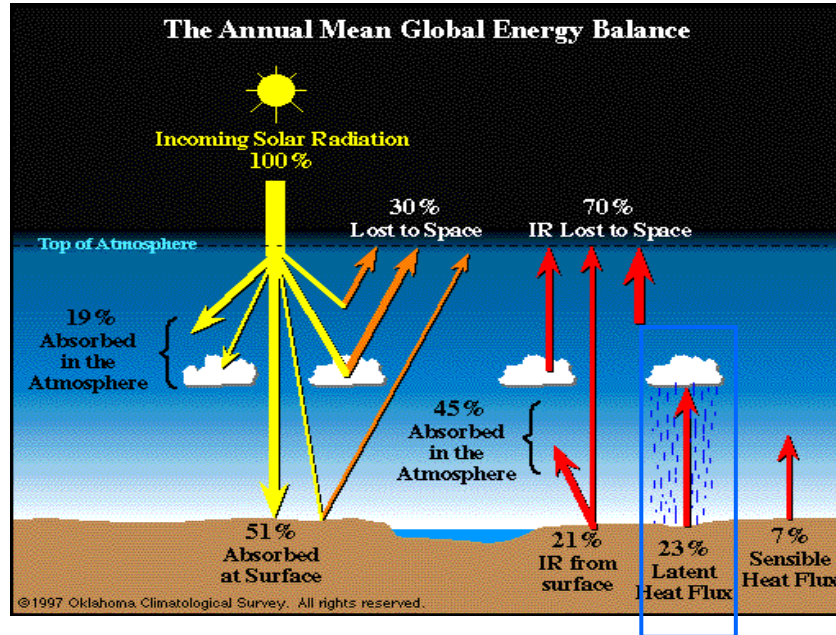
# What is Evapotranspiration?



Various components:

- Transpiration from plants
- Evaporation from water bodies
- Evaporation from upper layers of the soil

# ET: a component of both energy and water balance

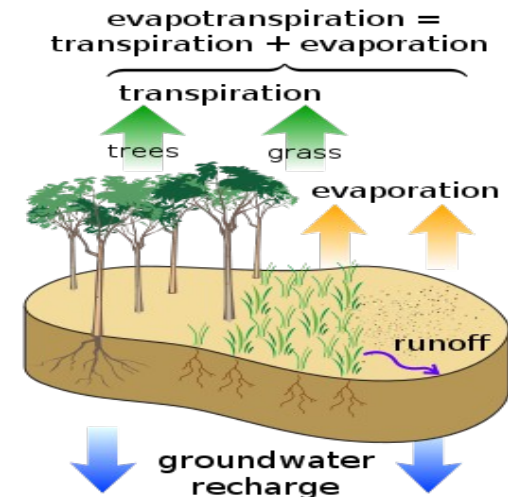


$$\text{Energy balance: } (1-\alpha).S + \epsilon.(L-\sigma.T_{sk}^4) + H + \text{LE} - G = 0$$

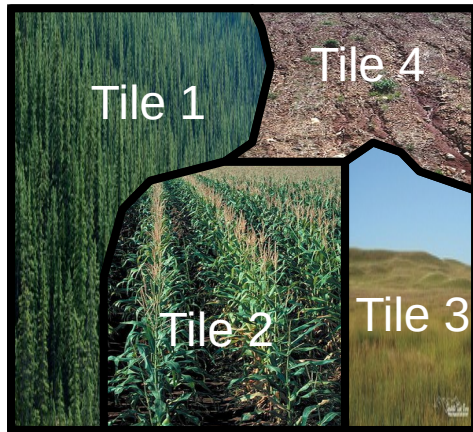
$$\text{Catchment Water balance: } P - Q - \text{ET} - Dw - OF = 0$$

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

OF= flow at the outlet



# The ET algorithm



For each tile  $i$  of cell  $k$

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

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

$$G_i = \beta_i R n_i \quad \beta_i = f(L A I_i)$$

$$R n_i - H_i - LE_i - G_i = 0$$

$$R n_i = (1 - \alpha) S_{\downarrow} + \varepsilon (L_{\downarrow} - \sigma T_{sk,i}^4)$$

Parameterizations  
adapted from  
ECMWF TESSEL  
model (van den  
Hurk et al, 2000;  
Ghilain et al, 2011)

Link between LE and ET:

$$LE = L_v ET$$

$LE$ : latent heat flux [W m<sup>-2</sup>]

$ET$ : evapotranspiration [kg m<sup>-2</sup> s<sup>-1</sup>]

$L_v$ : latent heat of vaporisation

$$L_v \sim 2,5 \cdot 10^6 \text{ J kg}^{-1}$$

For each cell  $k$  in MSG field of view

$$LE_k = \sum_i \xi_i LE_i$$

Evapotranspiration [mm h<sup>-1</sup>]

$$ET_k = 3600 LE_k / L_v$$

Half-hourly  
ET product

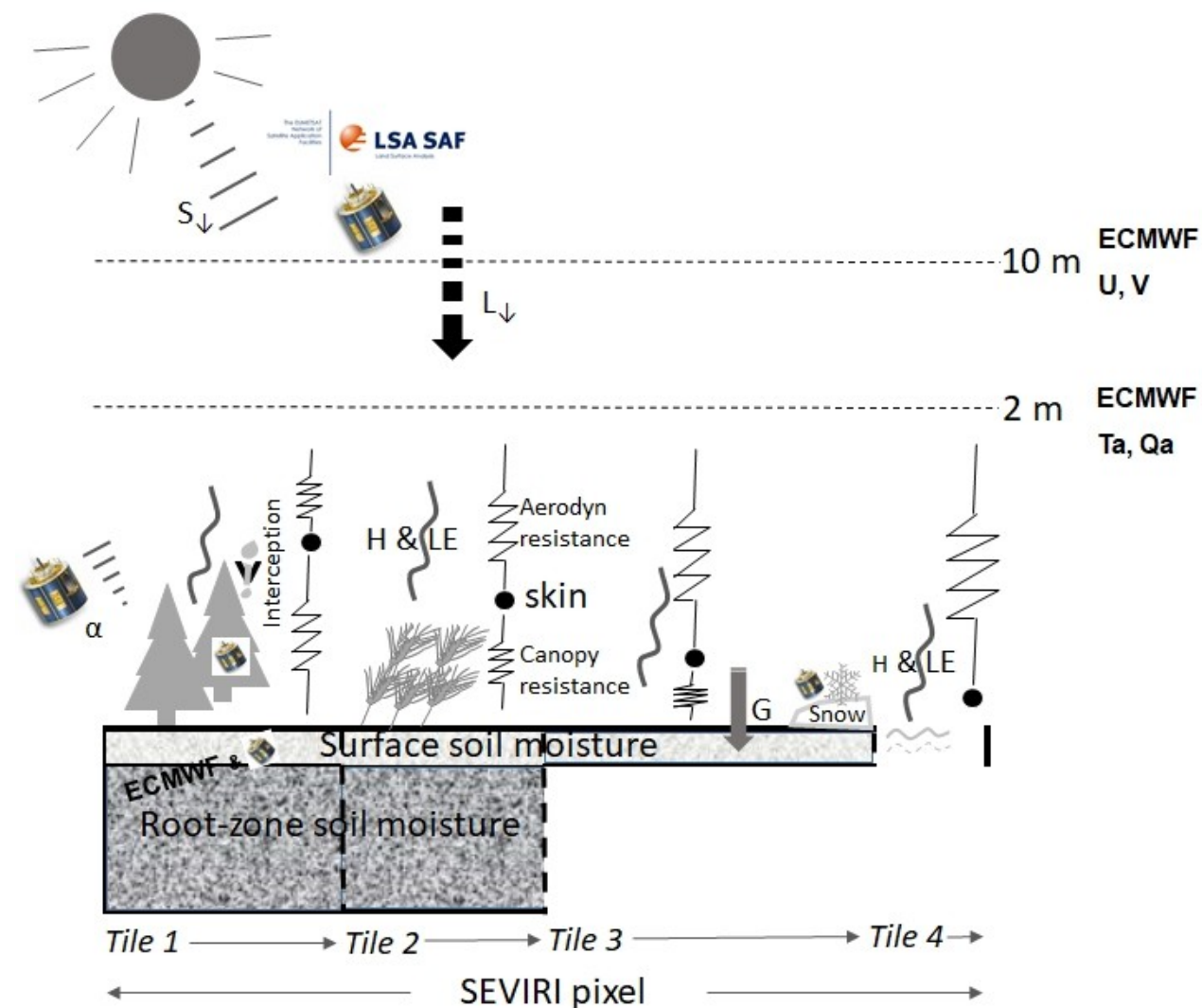
For each pixel of day  $d$

Evapotranspiration [mm d<sup>-1</sup>]

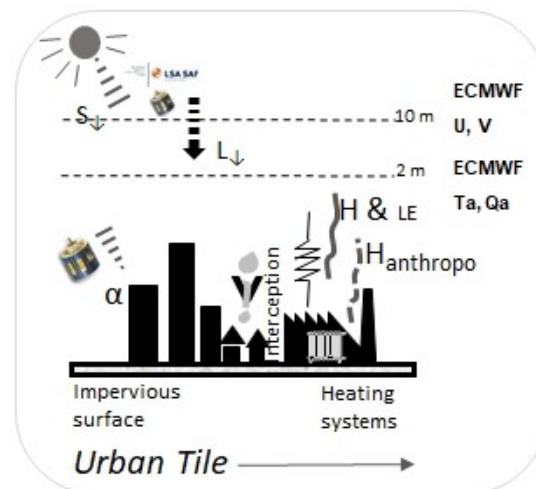
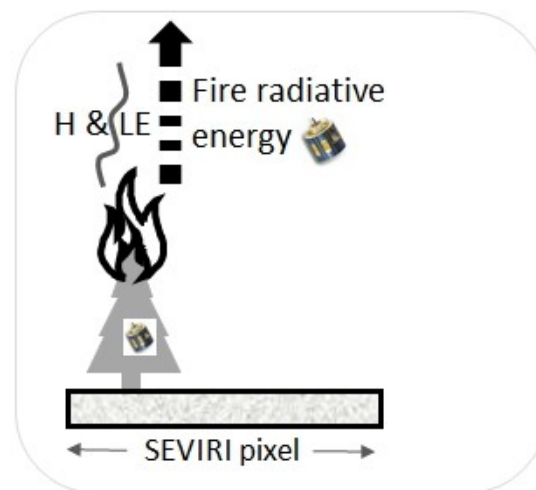
$$ET_d = \sum_k ET_k$$

Daily ET  
product

# The ET algorithm



*In case of wildfire*



# The ET algorithm (summary)

- Generates ET estimates at the spatial resolution of Meteosat Second Generation/SEVIRI imagery: 3 km at sub-satellite point
- Generates ET estimates in near-real time at 30 minute spatial resolution
- Already about 10 years of operations
- Considers up to 4 different land cover types within each cell
- Energy balance is computed for each land cover type (tile) within the cell
- Forcing composed by:
  - ✓ Other LSA-SAF products derived from MSG/SEVIRI (radiation, albedo, vegetation parameters)
  - ✓ ECMWF meteorological forecast
  - ✓ ECOCLIMAP database
  - ✓ More recently: H-SAF soil moisture products and LSA-SAF land surface temperature for estimating soil moisture



# LSA-SAF operational ET product:

- Produced in near-real time
- With a time step of 30 minutes: 48 images per day
- Geographical extent: the FOV of Meteosat Second Generation

## Example of 30 minutes (instantaneous) product:

Instantaneous ET (mm/h) every three hours (UTC) for 2019/05/01

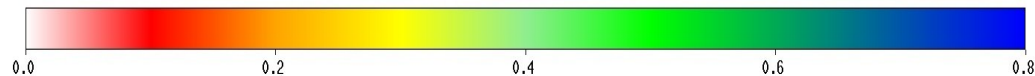
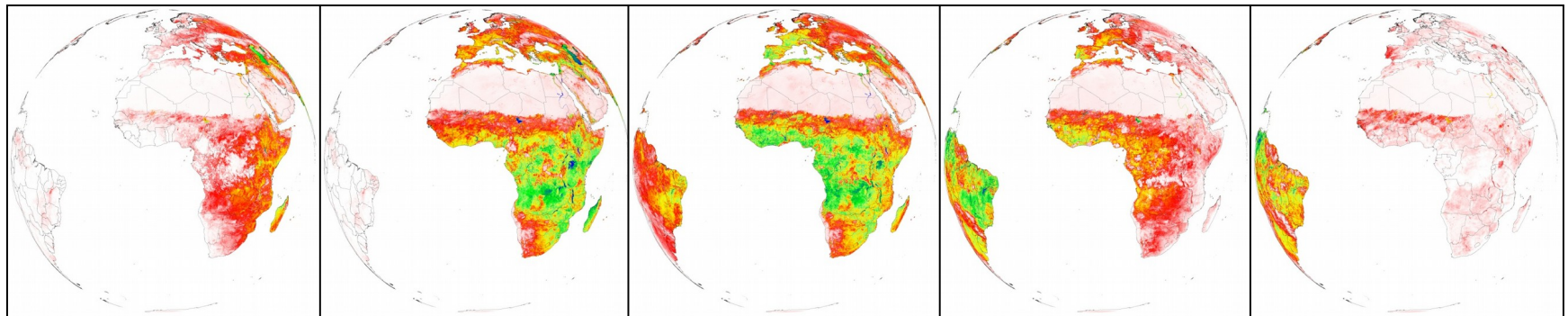
06:00

09:00

12:00

15:00

18:00

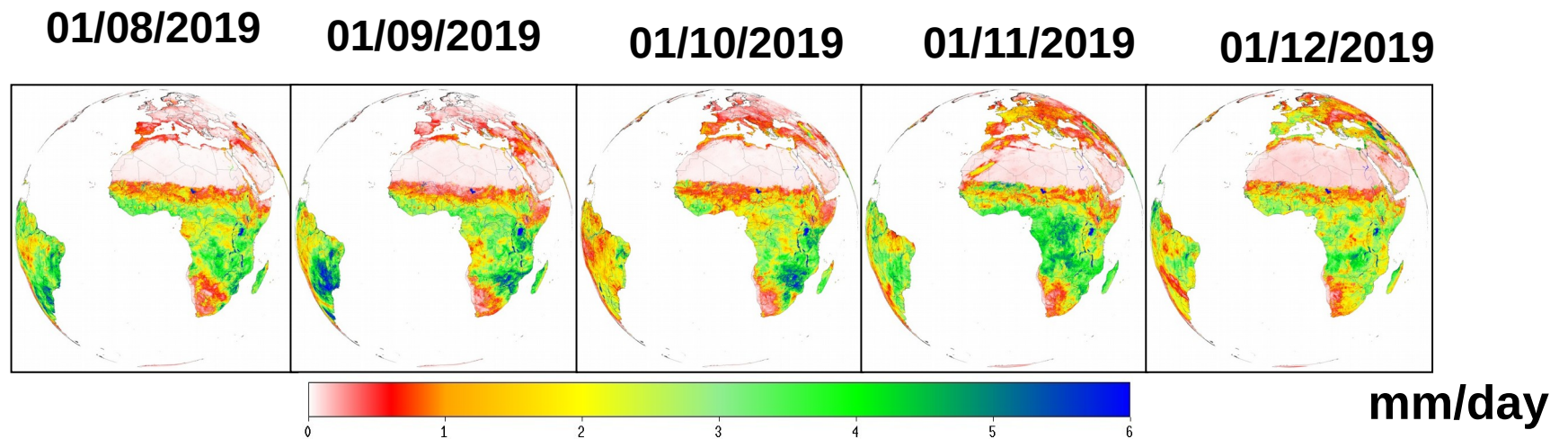


mm/h

# LSA-SAF operational ET product :

- Daily ET
- Built by aggregating the 30 minutes ET estimates
- Daily ET accounting for the diurnal variability

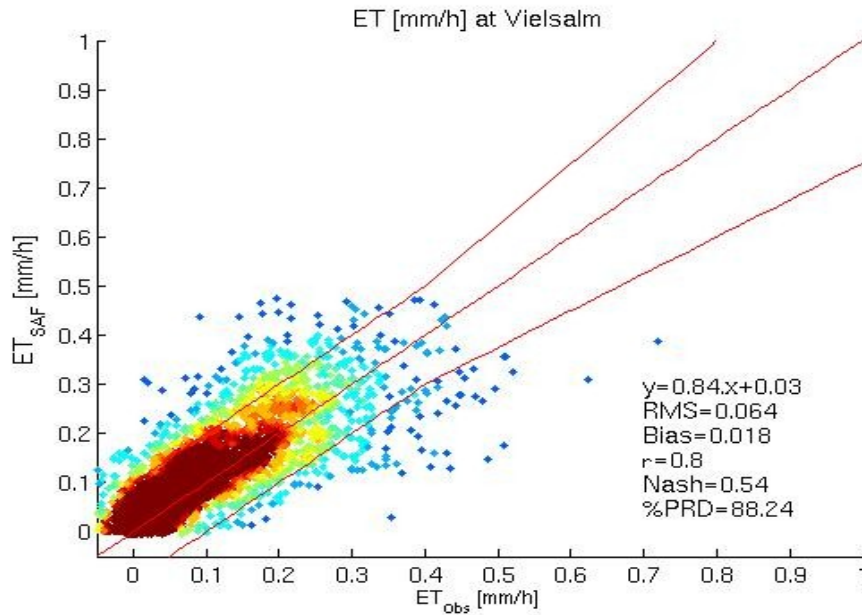
**Example of daily ET product:**





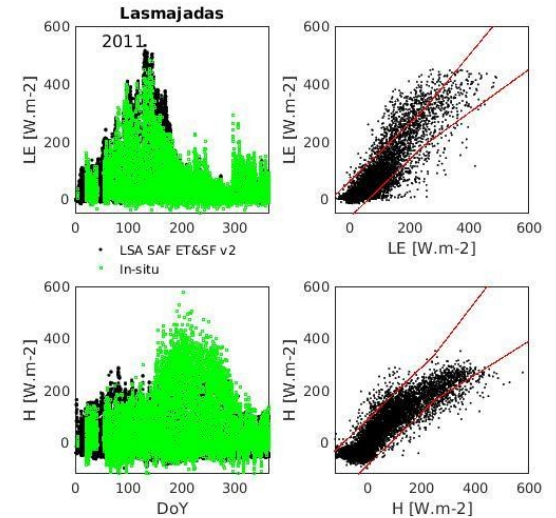
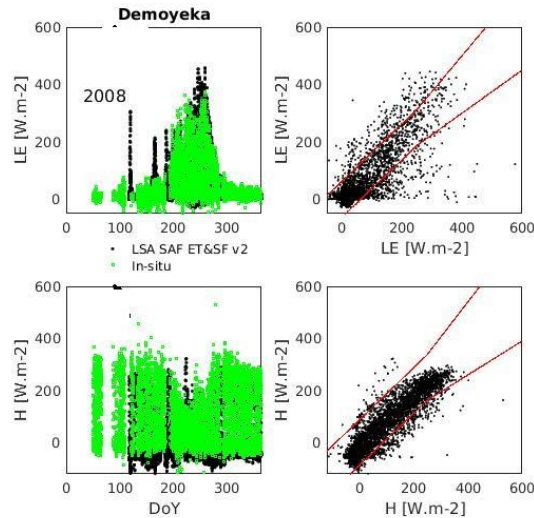
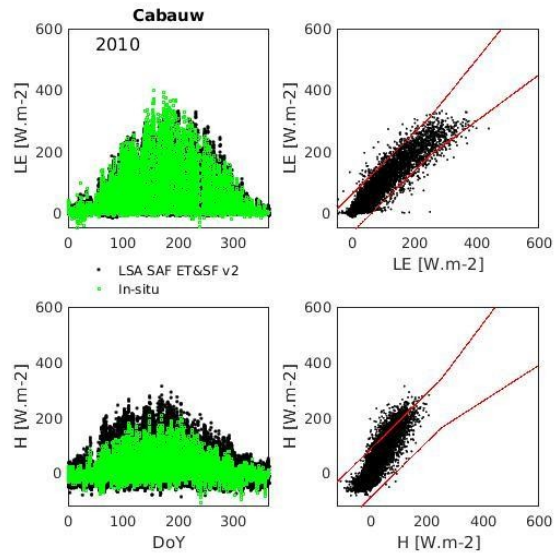
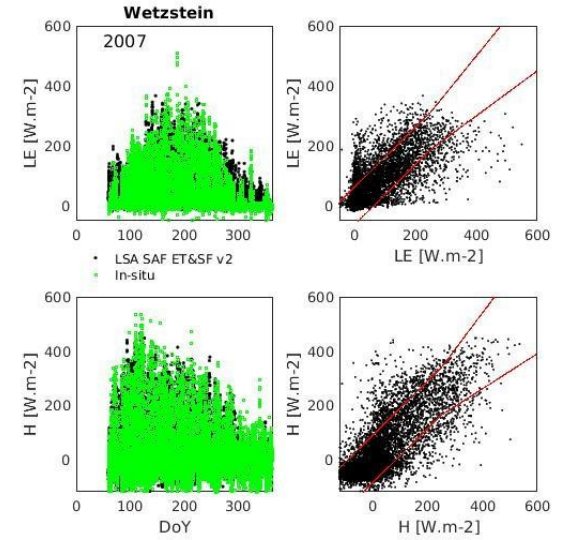
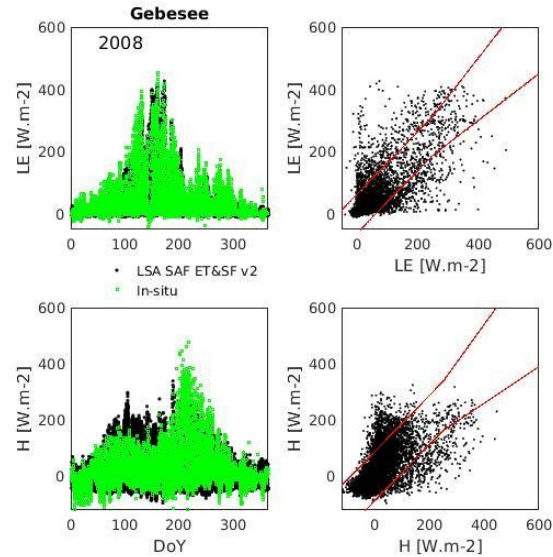
# Validation of the ET product

- Modelled ET is validated with flux measurements at Eddy Covariance stations



- The ET product has proved accuracy in temperate regions. Different plant functional types.
- Some deficiencies in dry areas related to the sensitivity to soil moisture data source

Some of our test sites:



# Use of the ET in research, an example:

## Validation of remotely-sensed evapotranspiration and NDWI using ground measurements at Riverlands, South Africa

Nebo Jovanovic<sup>1\*</sup>, Cesar L Garcia<sup>2,3</sup>, Richard DH Bogan<sup>1</sup>, Ingrid Teich<sup>2,4</sup> and Carlos M Garcia Rodriguez<sup>2,5</sup>

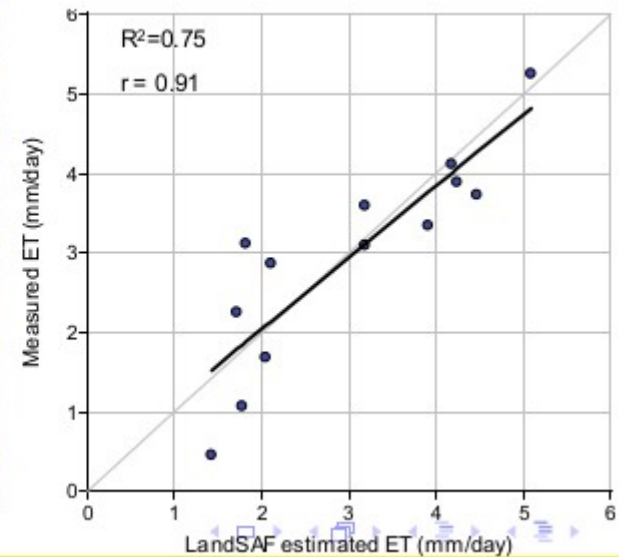
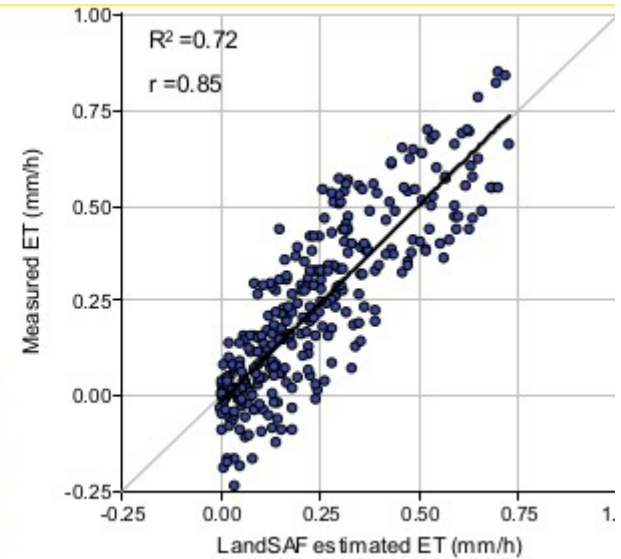
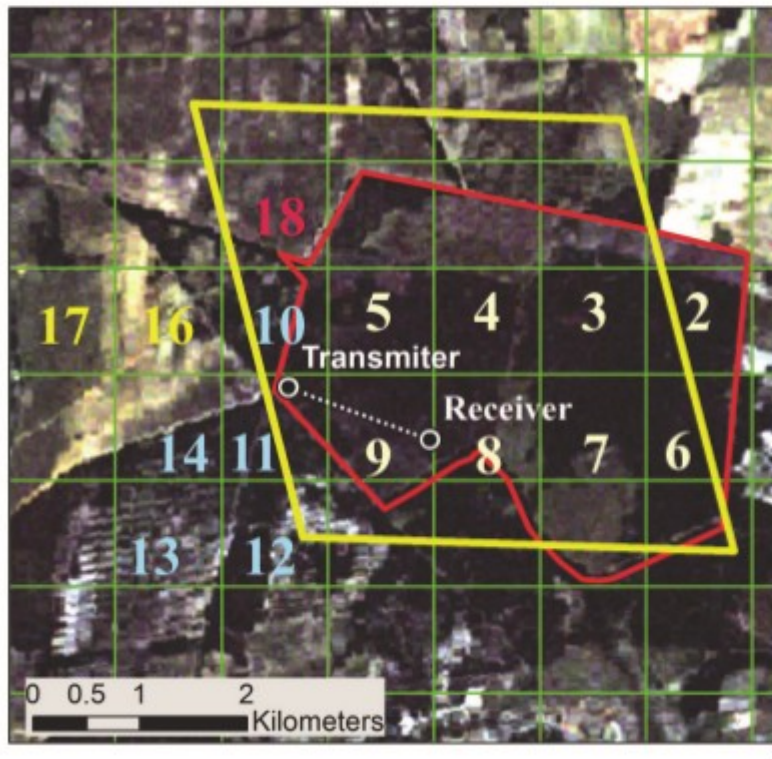
<sup>1</sup>CSIR, Natural Resources and Environment, PO Box 320, Stellenbosch 7590, South Africa

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<sup>4</sup>Estadística y Biometría, Facultad Ciencias Agropecuarias, Av. Valparaíso S/N, Campus Univ. Nacional de Córdoba, C.P.5000, Argentina

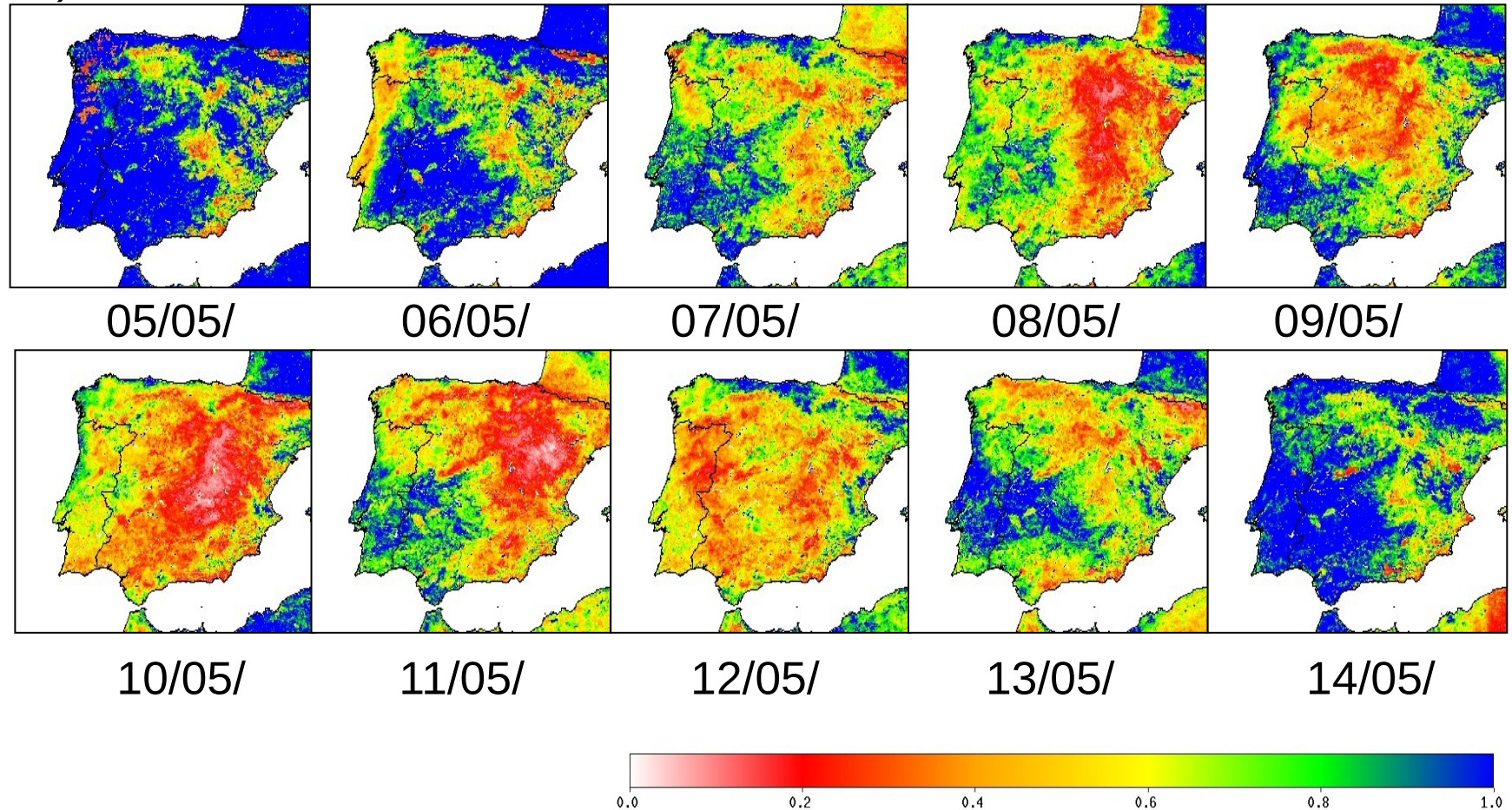
<sup>5</sup>CETA, Facultad de Ciencias Físicas Exactas y Naturales, Av. Filioy S/N, Campus Univ. Nacional de Córdoba, C.P.5000, Argentina





## Potential application, an example: LSA-SAF ET product as support for drought monitoring

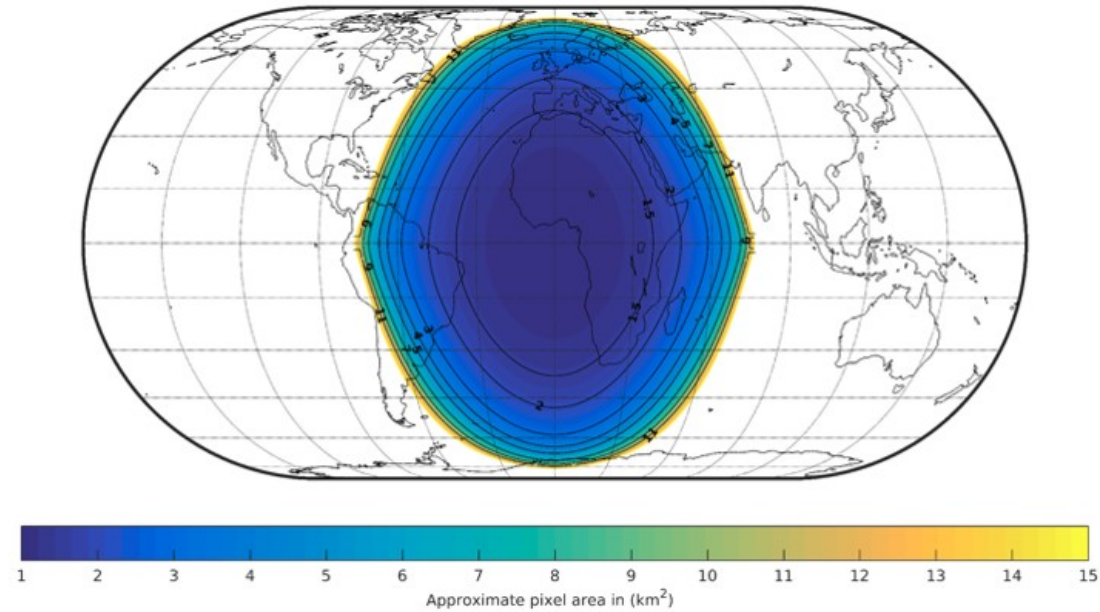
A very basic water stress indicator may be calculated as the ratio between real and potential or real and reference evapotranspiration (another LSA-SAF product).



# The (near) future: Meteosat Third Generation:



- MTG operations= ET will be produced at higher spatial and temporal resolution



Instrument information

CHANNEL	CENTRE WAVELENGTH	SPECTRAL WIDTH	SPATIAL SAMPLING DISTANCE (SSD)
VIS 0.4	0.444 $\mu\text{m}$	0.060 $\mu\text{m}$	1.0 km
VIS 0.5	0.510 $\mu\text{m}$	0.040 $\mu\text{m}$	1.0 km
VIS 0.6	0.640 $\mu\text{m}$	0.050 $\mu\text{m}$	1.0 km; 0.5 km*
VIS 0.8	0.865 $\mu\text{m}$	0.050 $\mu\text{m}$	1.0 km
VIS 0.9	0.914 $\mu\text{m}$	0.020 $\mu\text{m}$	1.0 km
NIR 1.3	1.380 $\mu\text{m}$	0.030 $\mu\text{m}$	1.0 km
NIR 1.6	1.610 $\mu\text{m}$	0.050 $\mu\text{m}$	1.0 km
NIR 2.2	2.250 $\mu\text{m}$	0.050 $\mu\text{m}$	1.0 km; 0.5 km*
IR 3.8 (TIR)	3.800 $\mu\text{m}$	0.400 $\mu\text{m}$	2.0 km; 1.0 km*
WV 6.3	6.300 $\mu\text{m}$	1.000 $\mu\text{m}$	2.0 km
WV 7.3	7.350 $\mu\text{m}$	0.500 $\mu\text{m}$	2.0 km
IR 8.7 (TIR)	8.700 $\mu\text{m}$	0.400 $\mu\text{m}$	2.0 km
IR 9.7 (O <sub>3</sub> )	9.660 $\mu\text{m}$	0.300 $\mu\text{m}$	2.0 km
IR 10.5 (TIR)	10.500 $\mu\text{m}$	0.700 $\mu\text{m}$	2.0 km; 1.0 km*
IR 12.3 (TIR)	12.300 $\mu\text{m}$	0.500 $\mu\text{m}$	2.0 km
IR 13.3 (CO <sub>2</sub> )	13.300 $\mu\text{m}$	0.600 $\mu\text{m}$	2.0 km

## PLANNED LAUNCH DATES

SATELLITE	PLANNED LAUNCH DATE	DETAILS
MTG I1	Q4 2021	Imaging (FCI, LI, DCS, GEO)
MTG S1	Q2 2023	Sounding (IRS, UVN)
MTG I2	Q3 2025	Imaging (FCI, LI)
MTG I3	Q2 2028	Imaging (FCI, LI)
MTG S2	Q4 2030	Sounding (IRS, UVN)
MTG I4	Q4 2032	Imaging (FCI, LI)

# Take-home messages:

1. LSA-SAF: A programme set in operations by EUMETSAT  
Aims at optimally exploiting satellite-based information to study land-atmosphere processes
2. LSA-SAF includes the operational generation of Evapotranspiration estimates in near-real time and high-temporal resolution
3. Validation exercises and independent studies have shown quality of the product
4. Spatial and temporal resolutions of ET product is expected to increase with the advent of Meteosat Third Generation
5. LSA-SAF products are freely available at: <https://landsaf.ipma.pt>



# Thank you for your attention

## Contact:

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More information on LSA-SAF and data access:

<https://landsaf.ipma.pt>



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## *Vegetation Monitoring and Locating Drought Impacted Areas*

Fraction Vegetation Cover indicates the state of vegetation



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