Satellite Application Facility on Land Surface Analysis (LSA-SAF/Land SAF):

Products and applications

by:

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Acknowledgments:

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LSA SAF consortium

Layout

- What is the LSA-SAF and what we do
- Where we are where we go
- Proposed products
- Products characteristics and applications

EUMETSAT SAF NETWORK

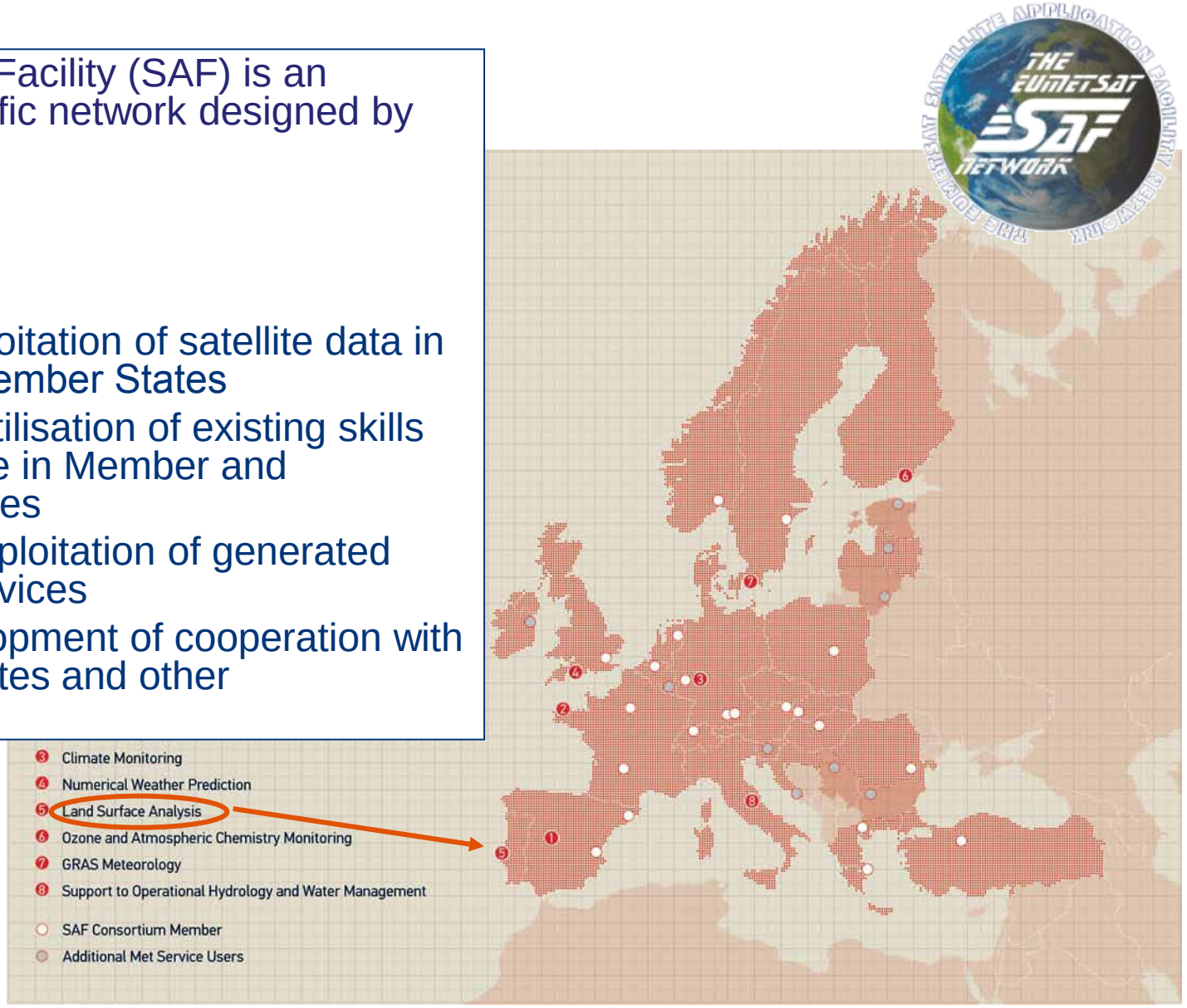
The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

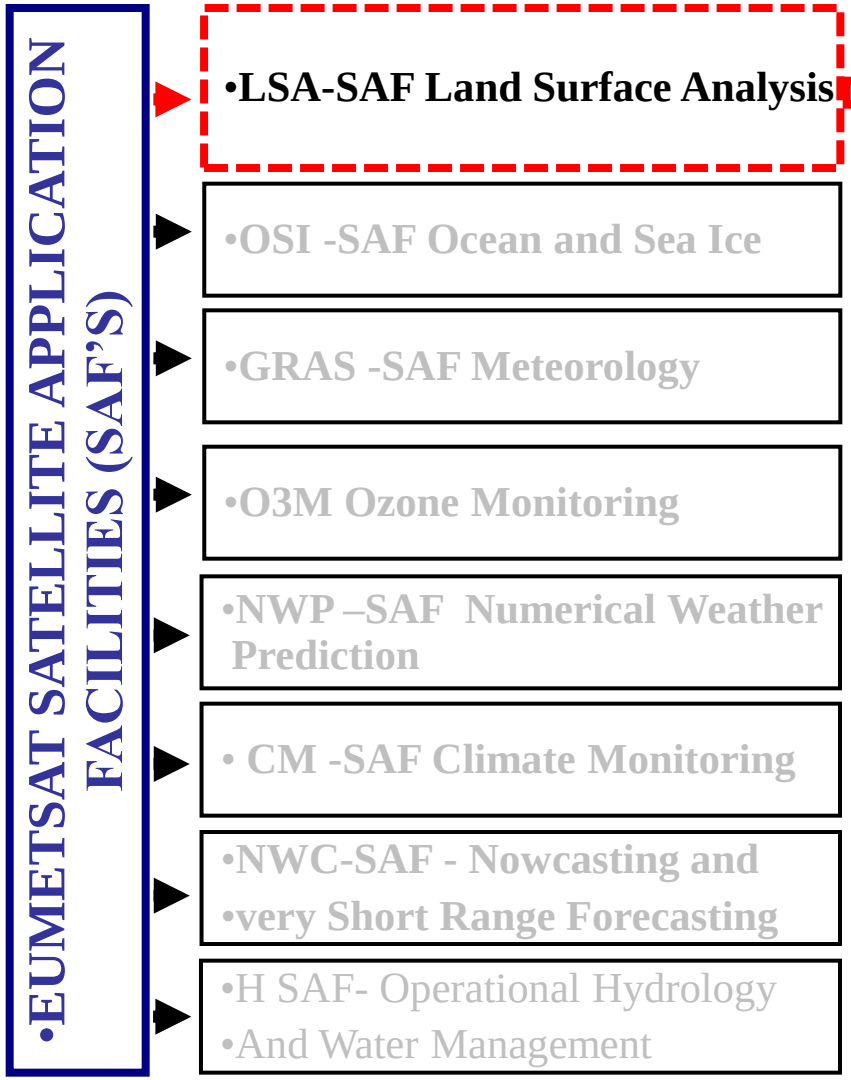
Satellite Application Facility (SAF) is an European scientific network designed by EUMETSAT.

Objectives

- Improve the exploitation of satellite data in EUMETSAT's Member States
- Encourage the utilisation of existing skills and infrastructure in Member and Cooperating States
- Cost-effective exploitation of generated products and services
- Foster the development of cooperation with non-Member States and other organisations



Land Surface Analysis SAF (LSA-SAF/land-SAF)



OBJECTIVES

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

Concretely:

- **Algorithm development**
- **Algorithm validation**
- **Generate the products pperationally in near real time (~1 hour after observation)**
- **Products reprocessing**
- **Provide products and support to user**
- **Participate to products review made by external reviewers**

The Land SAF Consortium

The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

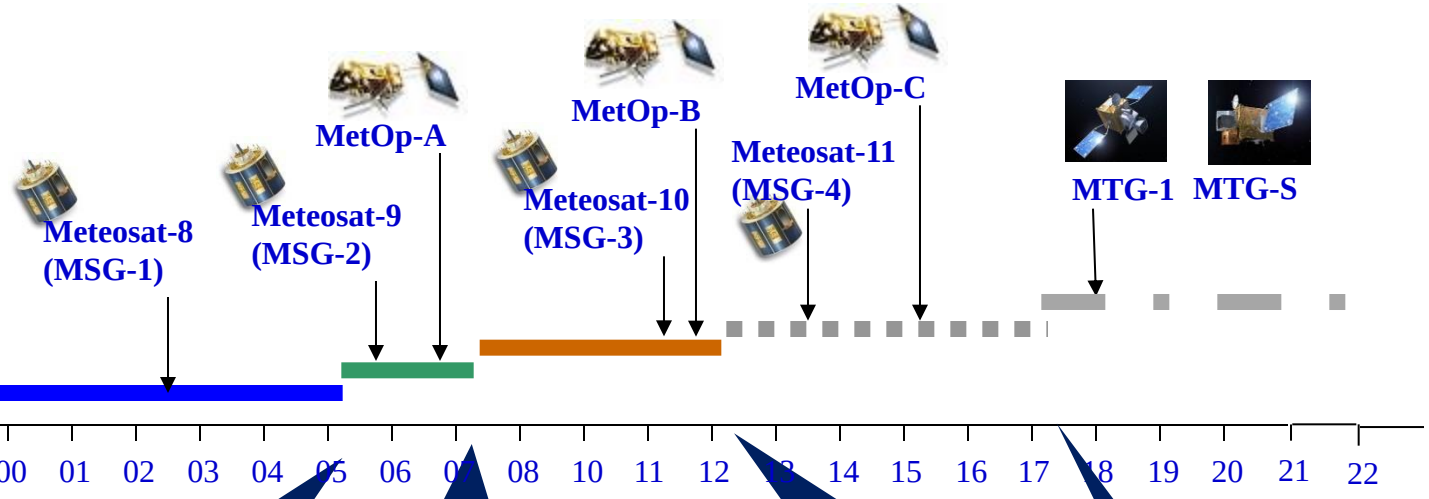
A consortium of 9 Institutions in 7 countries

- Instituto de Meteorologia (IPMA), Portugal
- Meteo-France (MF), France
- Royal Meteorological Institute (RMI), Belgium
- [Finnish Meteorological Institute (FMI), Finland]
- IMK, University of Karlsruhe
- IDL, University of Lisbon
- UV, University of Valencia
- KCL, UK
- VITO, Belgium
- CDOP-3 new members:

Organisation principles:

- ✓ Algorithms developed at one of the participating Institutios
- ✓ Algorithms handed over to IPMA for integration and production

LSA-SAF chronogram of activities



Dev. Phase: Sep 1999

Initial Operations Phase: Feb 2005

Continuous Development & Operations Phase: Mar 2007

Continuous Development & Operations Phase 2: Mar 2012

Continuous Developmen & Operation Phase 3: Mar 2017

LSA-SAF MSG Products

Surface Radiation

- LST
- Albedo
- ↓LongWave Flux
- ↓ShortWave Flux

Surface Water Balance

- Snow Cover
- Evapotranspiration

Vegetation

- Fraction Veg Cover
- LAI
- FAPAR
- NDVI from Metop

Wild fires

- Fire Risk Mapping(Europe)
- Fire Radiative Power
- Fire Detection & Monitoring

Development | Pre. Operat. | Operational

Increased level of maturity

Common Products Characteristics

The EUMETSAT Network of Satellite Application Facilities

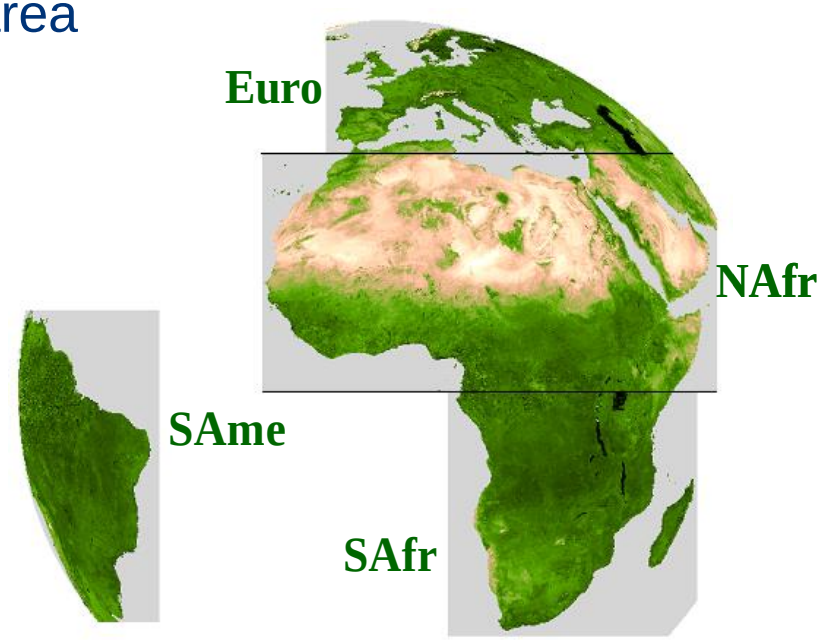
LSA SAF Land Surface Analysis

All products have a quality flag and/or error bar associated

Detailed documentation (Product User Manual, Validation Report, Algorithm theoretical Basis Document)

Products generated for the same area

- Europe
- Northern Africa
- Southern Africa
- Southern America
- MSG-Disk (since 11/2015)



SEVIRI resolution

Variable time resolution

-15 min to 10 days

EPS products generation for a subset of variables(LST, DSLF, NDVI)

LSA-SAF MSG Products

The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

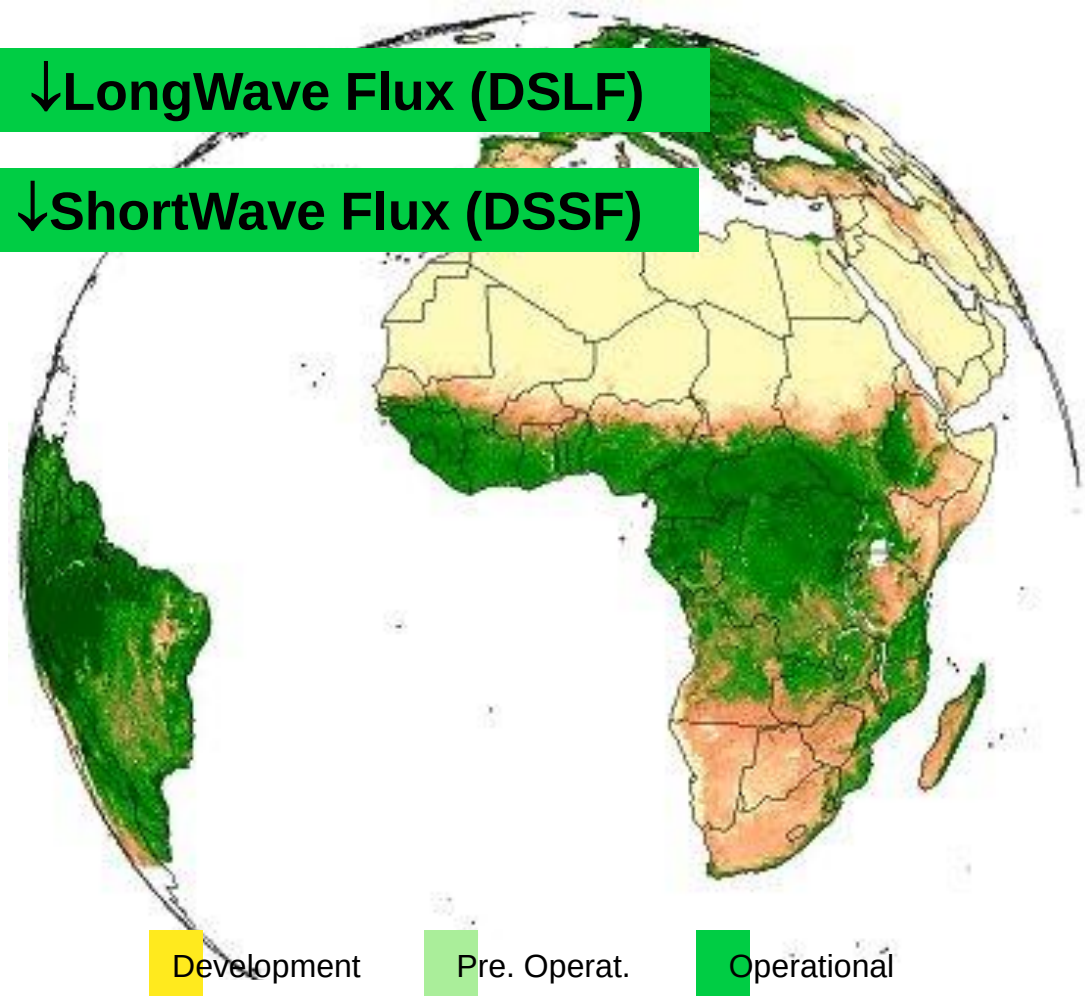
Surface Radiation

LST

Albedo

↓LongWave Flux (DSLF)

↓ShortWave Flux (DSSF)



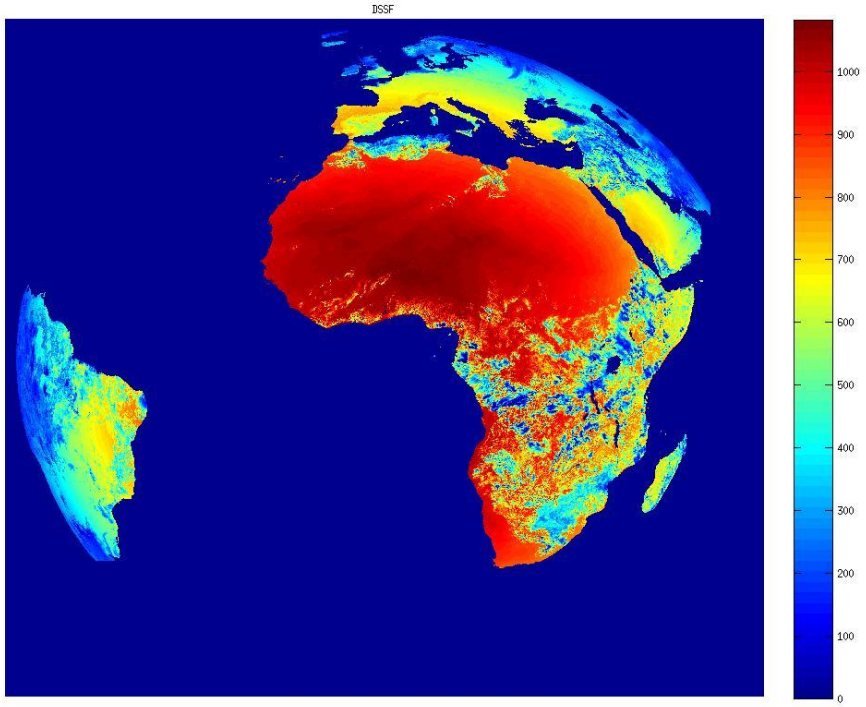
Development | Pre. Operat. | Operational

Increased level of maturity

Radiation Products - DSSF

Downwelling Surface Shortwave Flux

Radiative energy flux in the wavelength interval [0.3µm, 4.0µm] reaching the Earth's surface per time and surface unit.



LSA SAF method (Geiger et al., 2008)

Input data:

- 0.6, 0.8 and 1.6 μm SEVIRI channels
- TCWV from ECMWF
- Cloud mask from NWCSAF

Radiation Products - DSSF

Methodology

$$DSSF \approx S_0 \nu(t) \cos\theta_{sun} T_{effective}$$

- S_0: Solar Constant
- $\nu(t)$: Distance sun-earth (jday)
- $\cos\theta_{sun}$: Solar zenith angle
- $T_{effective}$: Effective transmittance

$$T_{effective} = T_{atm} \frac{1}{1 - A_{surf} A_{atm}}$$

Atmosphere transmittance

The effective transmittance of the atmosphere is a funtion of atmospheric constituents

$$T_{effective} = T_{atm} \frac{T_{cloud}}{1 - T_{atm\_below\_cloud} A_{surf} A_{cloud}}$$

Cloud transmittance

Surface albedo

Cloud albedo

Simplified physical description of the radiation transfer in the cloud-atmosphere-surface system

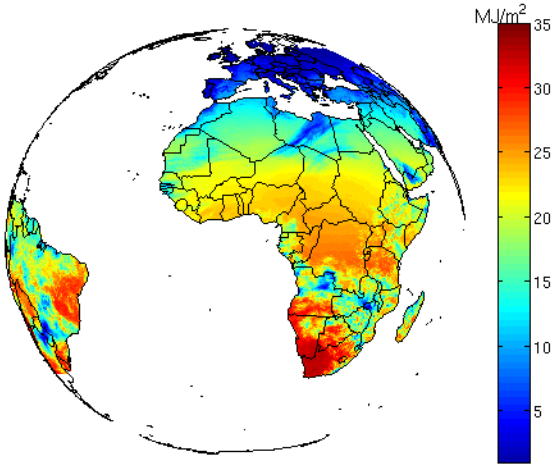
Radiation Products - DSSF

The EUMETSAT Network of Satellite Application Facilities

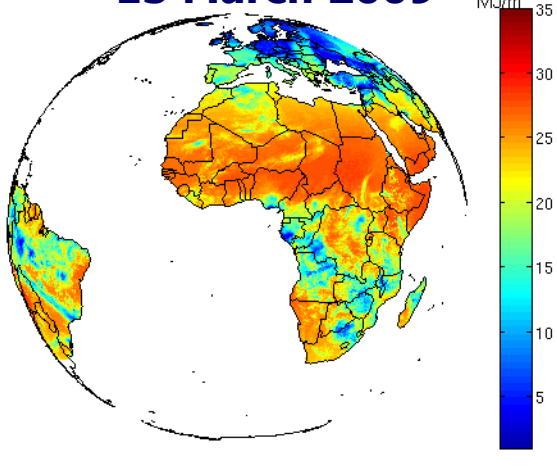
LSA SAF Land Surface Analysis

Monthly variation of daily accumulated Solar Radiation

15 Jan 2009



15 March 2009



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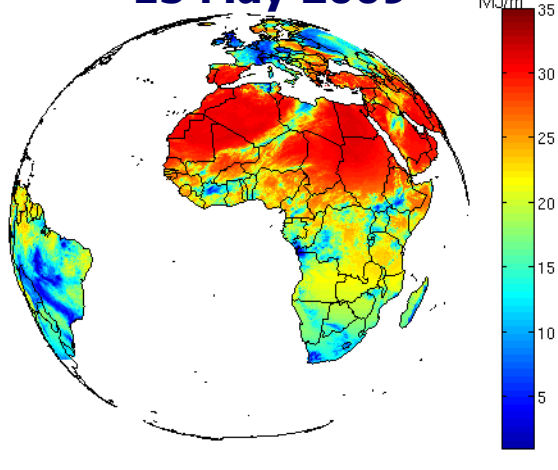
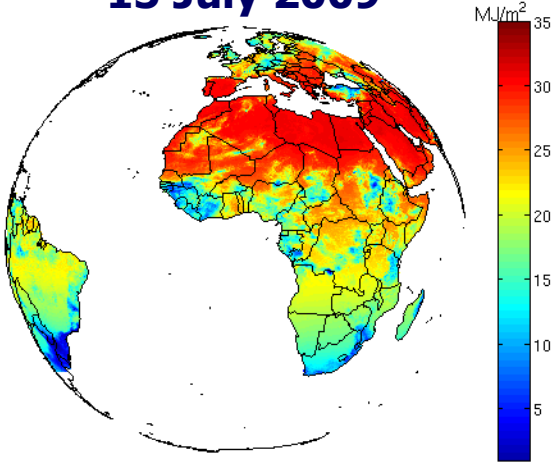


15 July 2009



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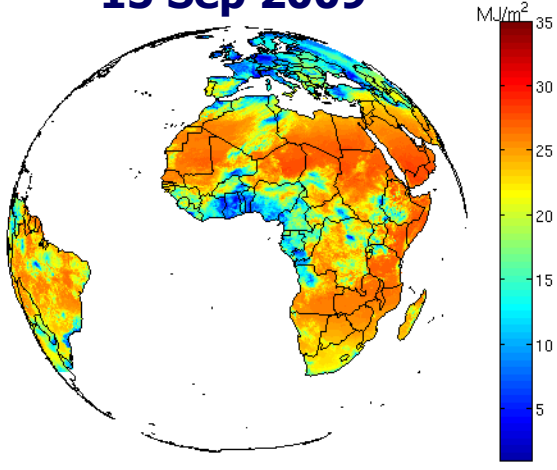

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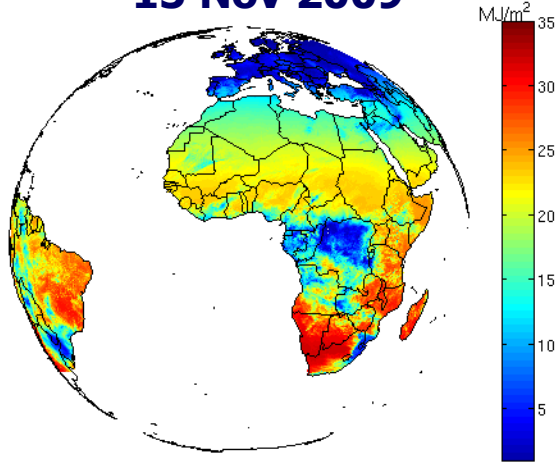
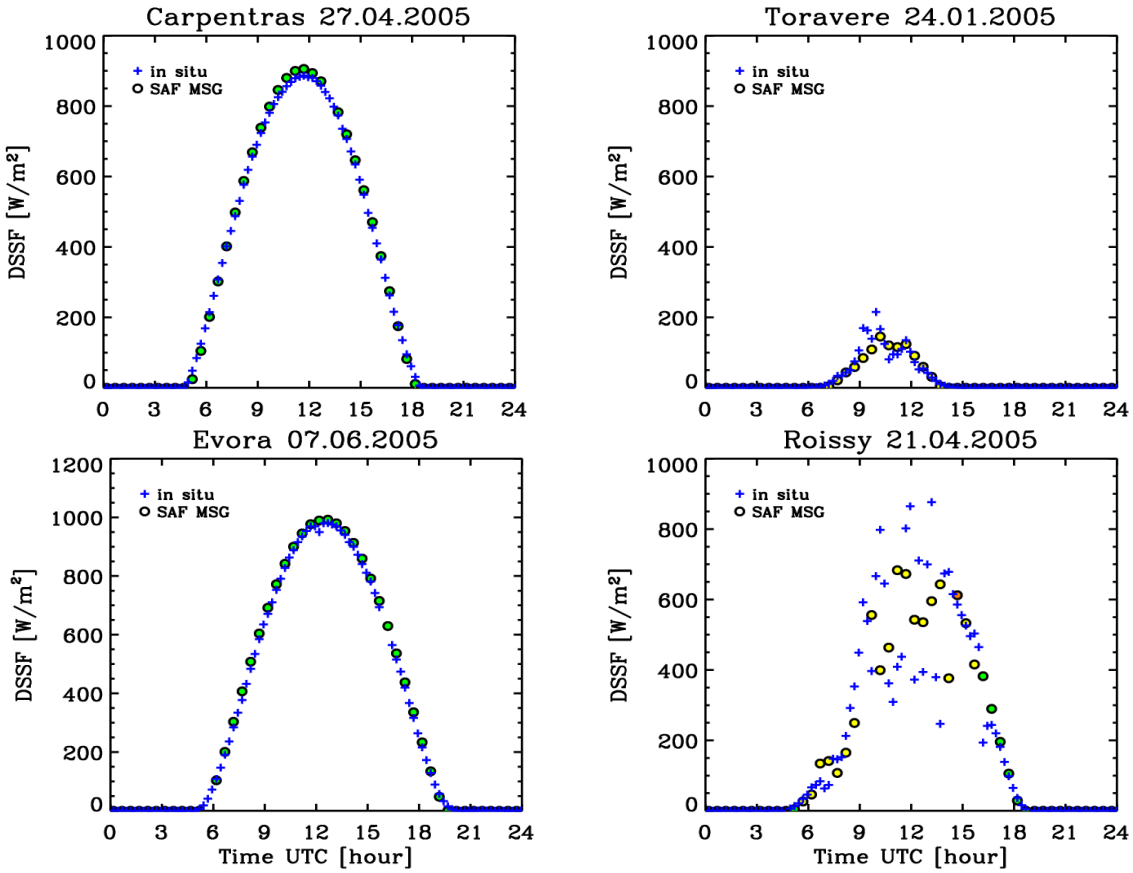


Radiation Products - DSSF

Validation



Validation at measurement sites

Radiation Products - Albedo

Albedo: Fraction of incident radiation reflected by the surface

Albedo Seasonal Cycle:

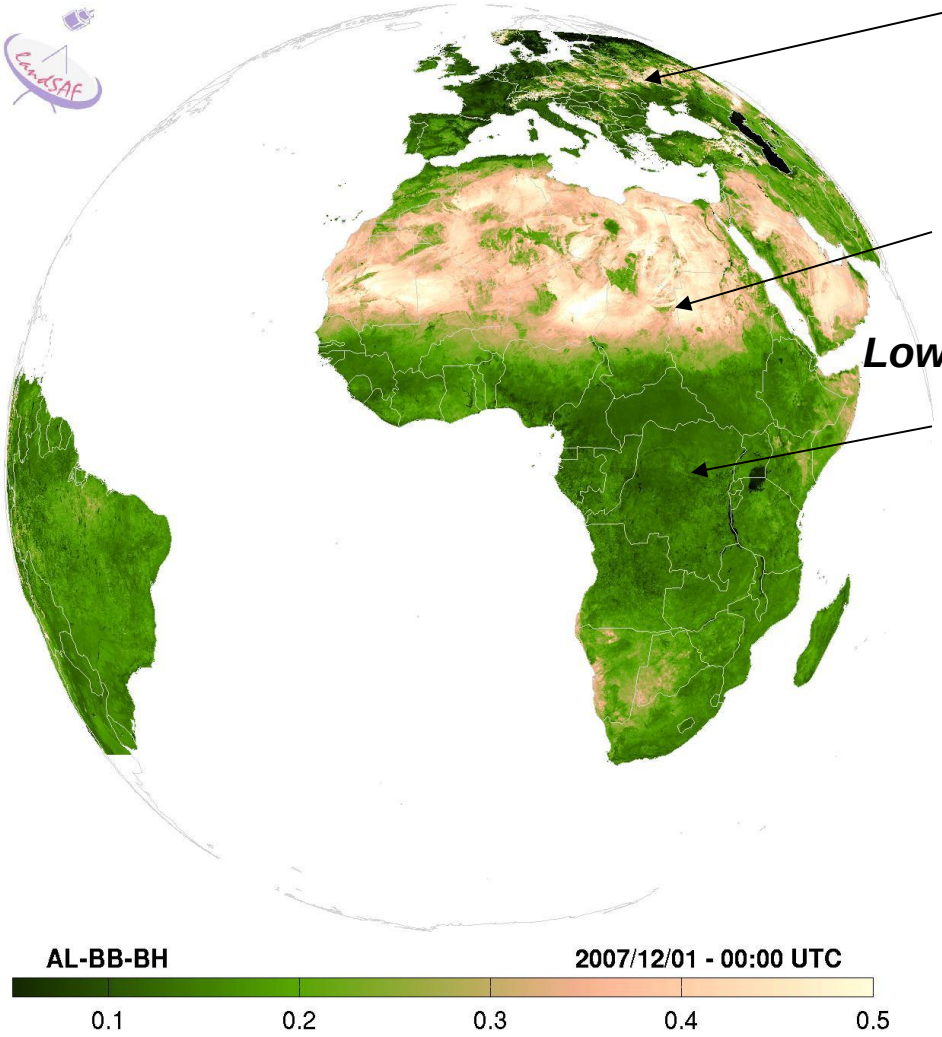
Primarily driven by Vegetation & Snow

High Albedo Values over Snow

and

Deserts

Low Albedo Values over vegetated areas



Input data:

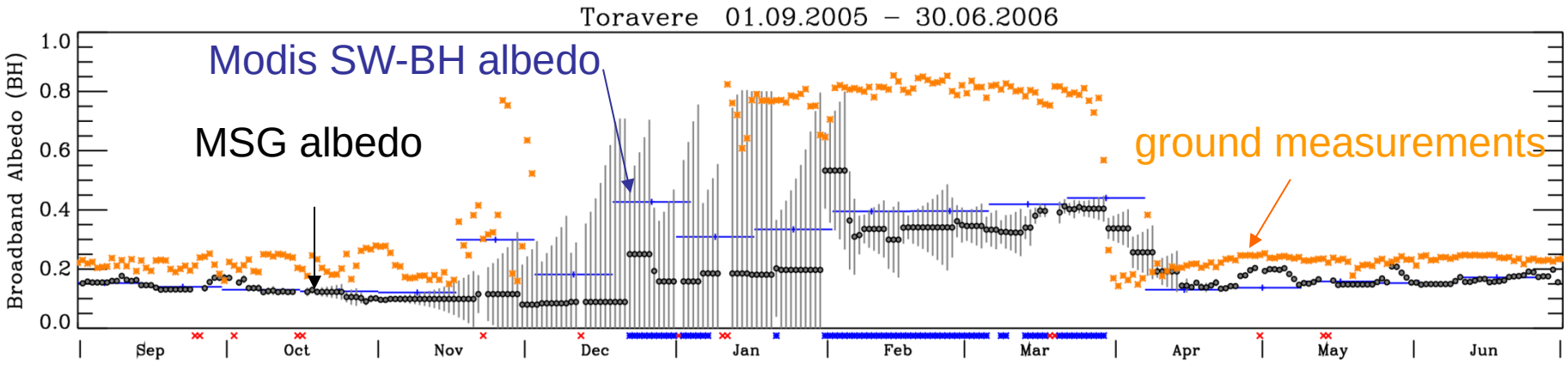
0.6µm, 0.8µm, 1.6µm SEVIRI channels

- Solar and View Angles
- Land/Sea Mask
- **Cloud Mask (SAF-NWC software)**
- Total Column Water Vapour, and Pressure (ECMWF)
- Ozone Content (Climatology)
- Aerosol Optical Thickness (Climatology)

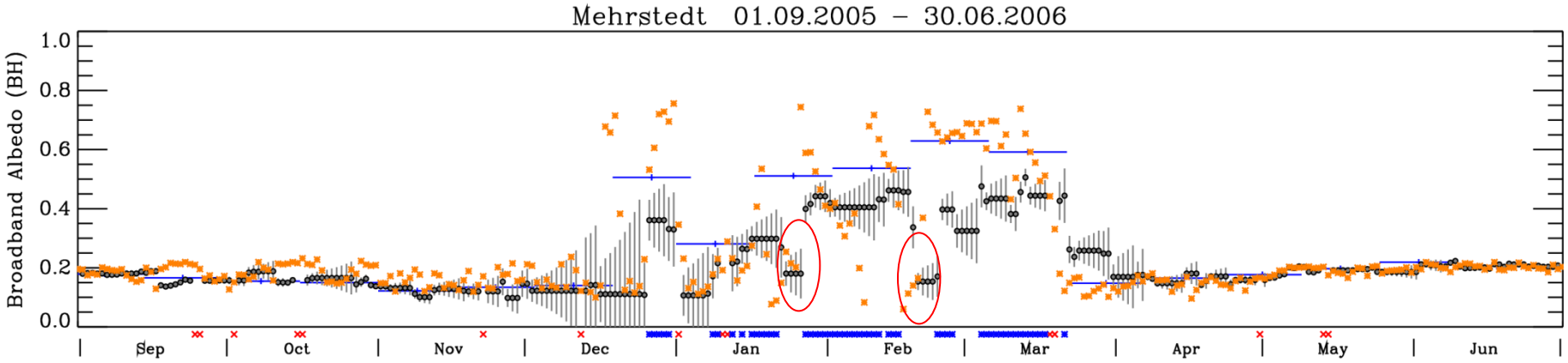
Radiation Products - Albedo

Validation

boreal forest

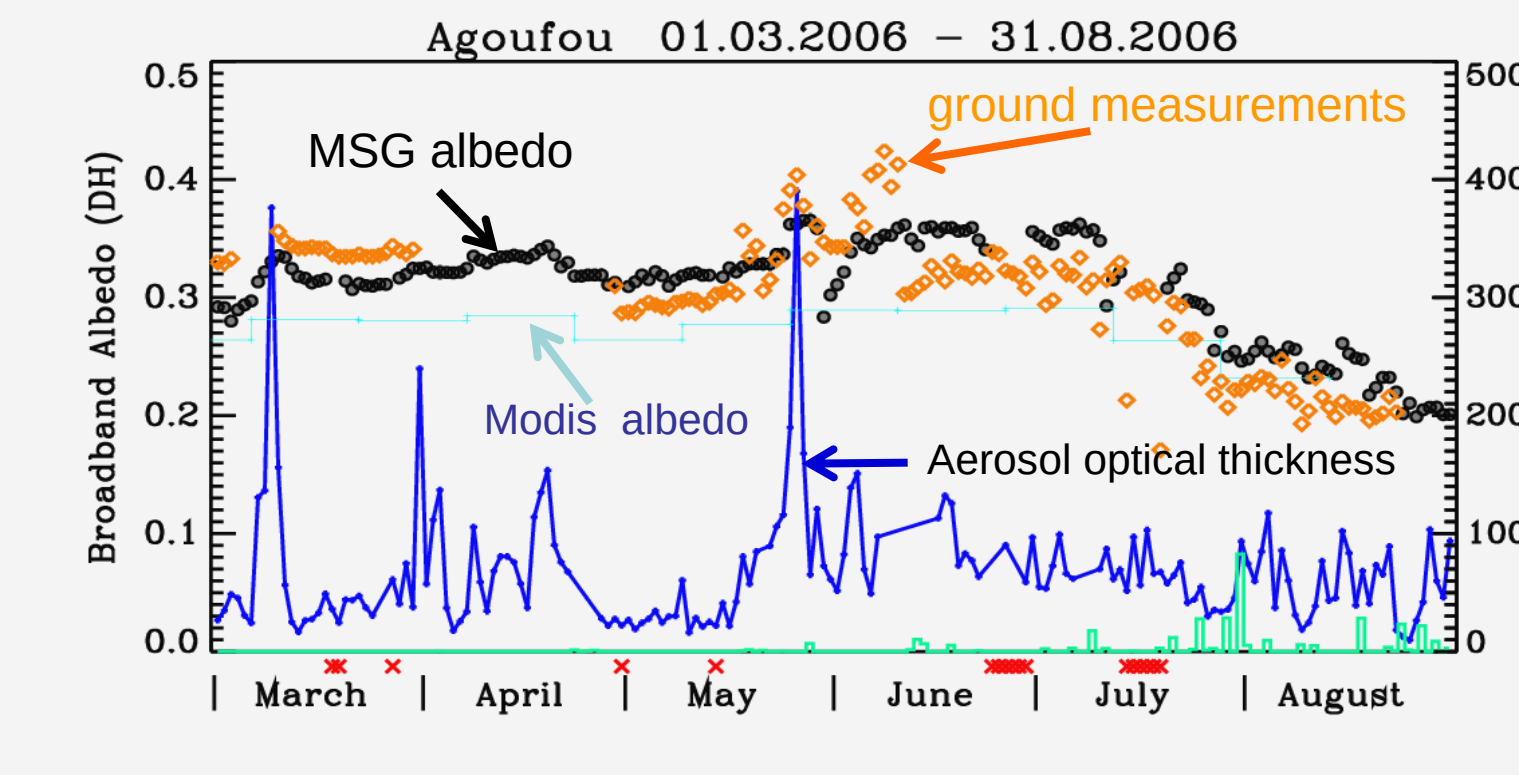


mixed shrub/tree



Radiation Products - Albedo

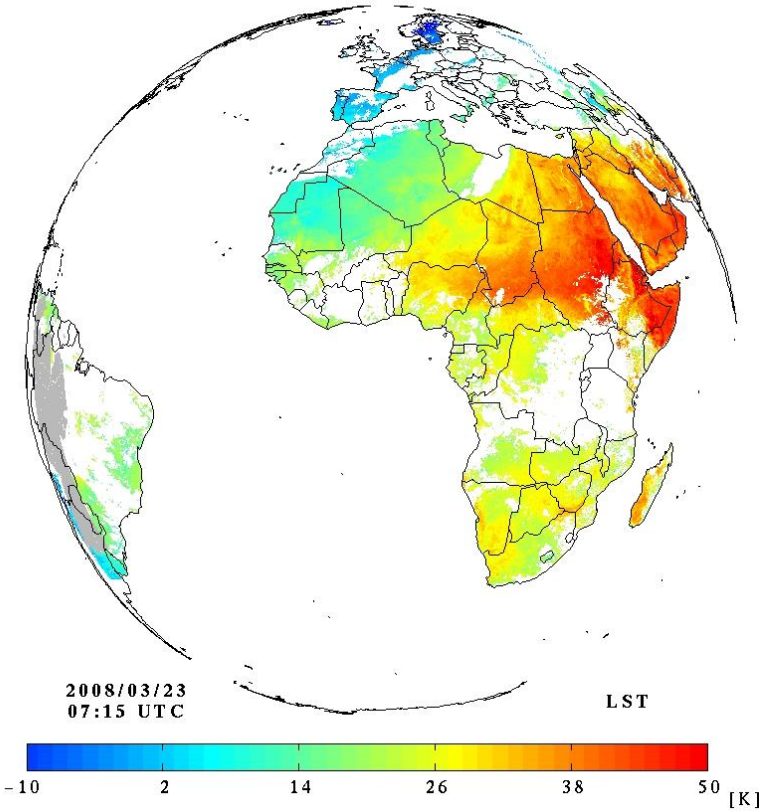
Validation



- Temporal evolution of the albedo estimate is influenced by rainfall.
- 'Spurious' fluctuations appear to be caused by aerosol effects.

Radiation Products - LST

LST



Land Surface Temperature (LST) is the radiative skin temperature over land.

- ✓Generation Frequency - 15 min
- ✓clear sky pixels ...
- ✓ over land ...
- ✓ where estimated errors < 4K
- ✓ Available since 2005

Radiation Products - LST

Methodology: generalised Split-Windows (Wan and Dozier 1996, adapted to SEVIRI: Trigo et al., 2008a), based on TOA Clear sky brightness temperature at 10.8μm and 12.0μm (**SEVIRI)**

$$LST = (A_1 + A_2\frac{1-\varepsilon}{\varepsilon} + A_3\frac{\Delta\varepsilon}{\varepsilon^2})\frac{T_{10.8}+T_{12.0}}{2} + (B_1 + B_2\frac{1-\varepsilon}{\varepsilon} + B_3\frac{\Delta\varepsilon}{\varepsilon^2})\frac{T_{10.8}-T_{12.0}}{2} + C$$

GSW parameters depend on:

1. total column of water vapour
2. satellite viewing angle

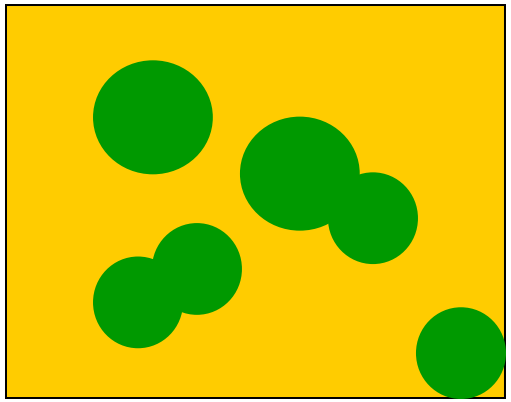
ε = average
$\Delta\varepsilon$ = difference
} of channel emissivities

Radiation Products - LST

Methodology

Channel Emissivity → From fraction of Vegetation Cover

Pixel MSG



$$\varepsilon = \varepsilon_{veg} FVC + \varepsilon_{ground} (1\text{-}FVC)$$

LSA SAF Product

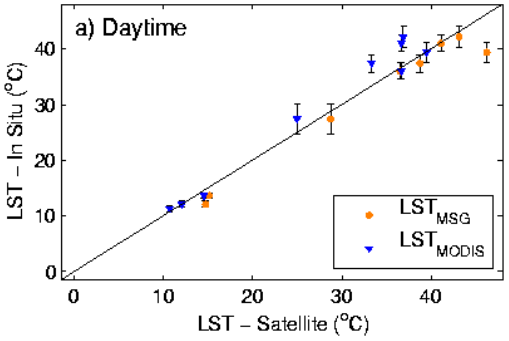
Emissivity is estimated as a weighted average of that of bare ground and vegetation elements within the pixel

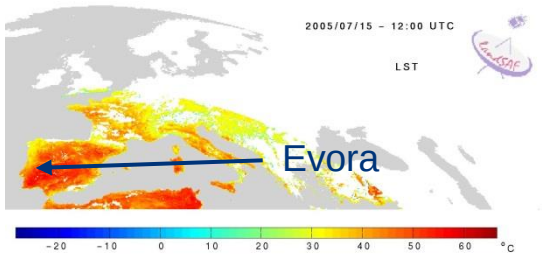
Radiation Products - LST

Validation at Evora (Pt)

Day time

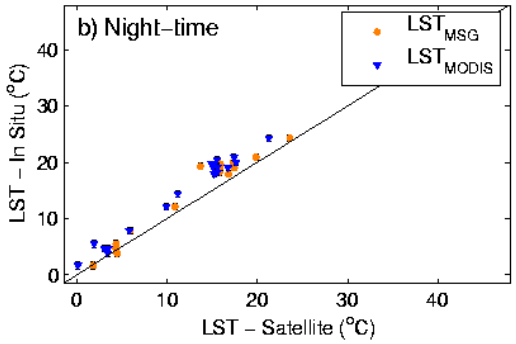
(ºC)	BIAS	RMSD
SEVIRI	**+1.9**	**2.2**
MODIS	**-1.8**	**2.6**





Night time

(ºC)	BIAS	RMSD
SEVIRI	**-1.7**	**2.1**
MODIS	**-2.6**	**2.7**

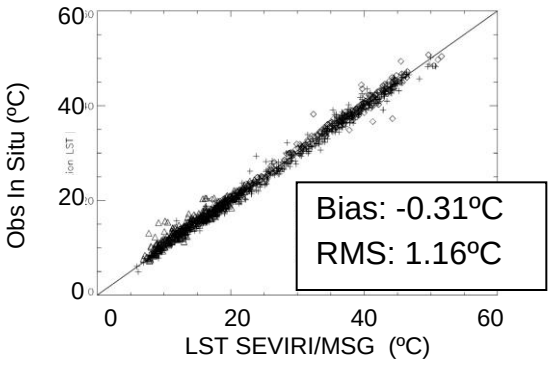


Trigo, I. F., I. T. Monteiro, F. Olesen, and E. Kabsch, (2008) *in* J. Geophys. Res., 113

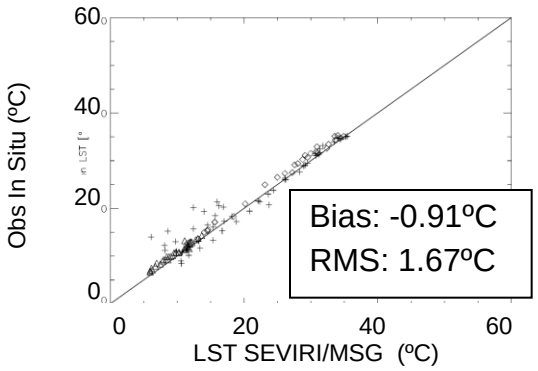
Radiation Products - LST

Validation at Gobabeb (Na.)

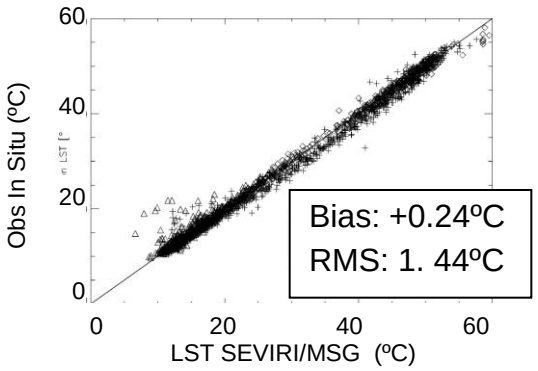
May 2008



Jul 2008



Nov 2008

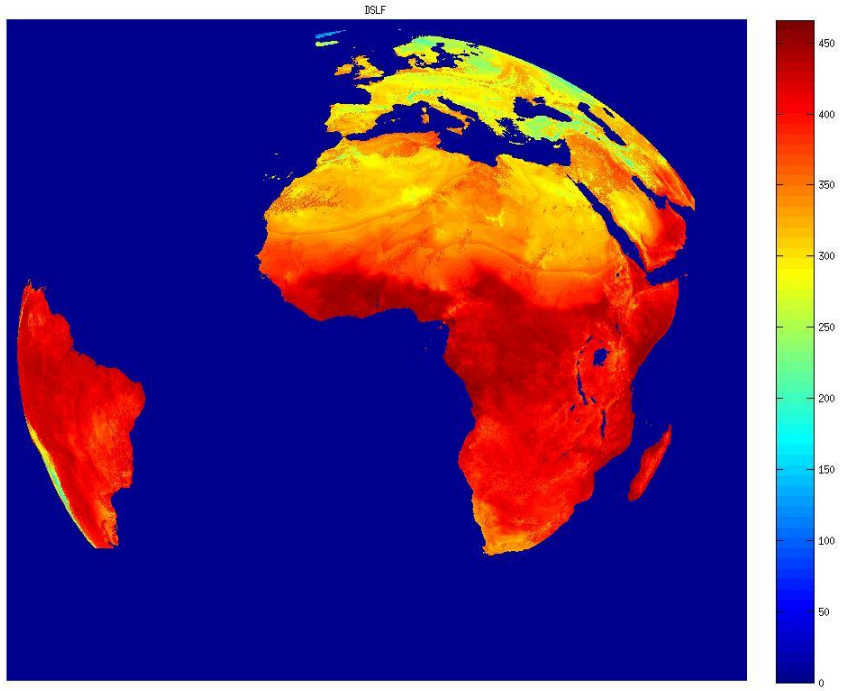


Freitas, S. C., I. F. Trigo, J. M. Bioucas-Dias, F.M. Goettche, 2010 in IEEE TGRS

Radiation Products - DSLF

Down welling Surface Long-wave Flux (DSLF):

Total irradiance within infrared part of the spectrum [4µm,100µm].



Generation Frequency - 30 min

Long-wave Radiation reaching the Surface:

Essentially emitted by the lowest **100 m** of the atmosphere

✓ It is controlled by

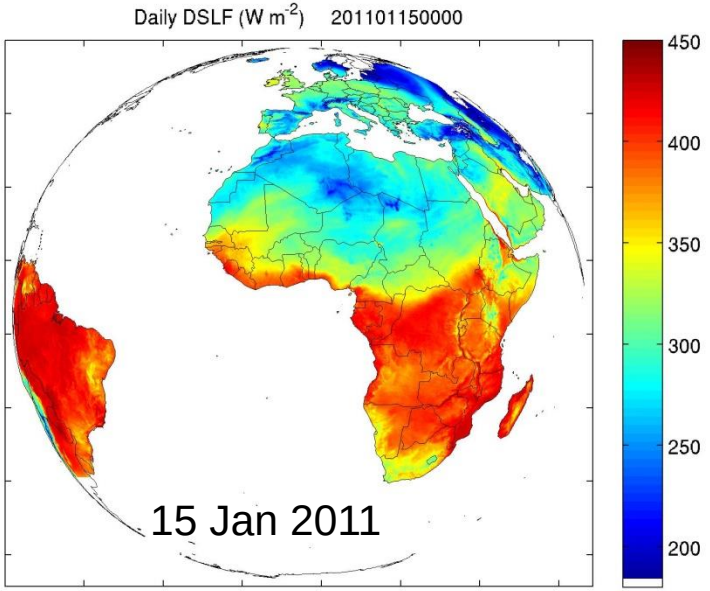
- ➢ concentration of absorbing gases

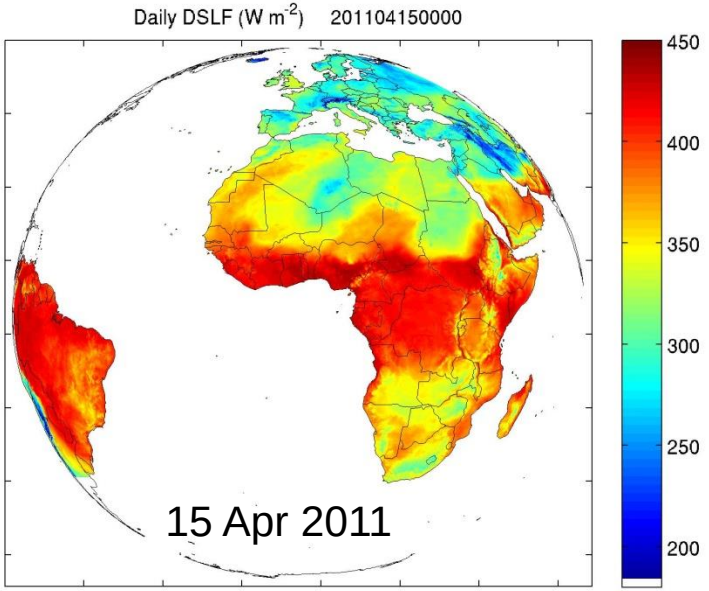
  CO_2, CH_4, H_2O, ...

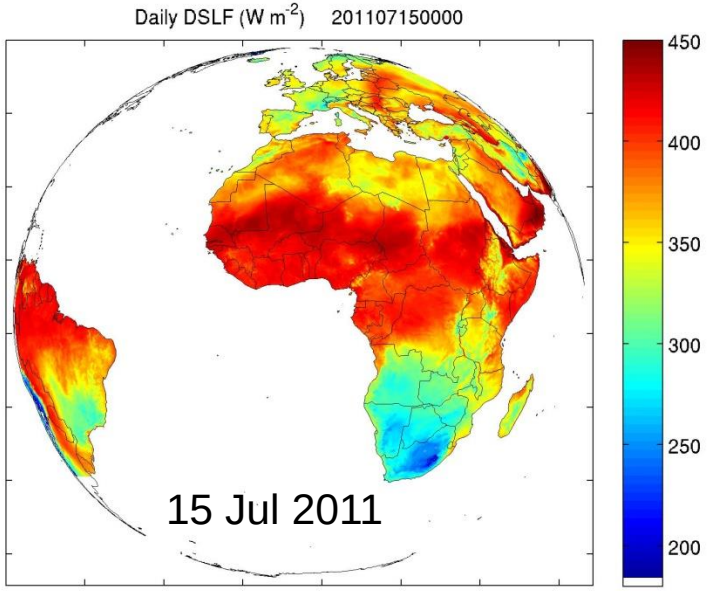
- ➢ presence of clouds, clouds phase
- ➢ temperature profile & temperature of cloud base

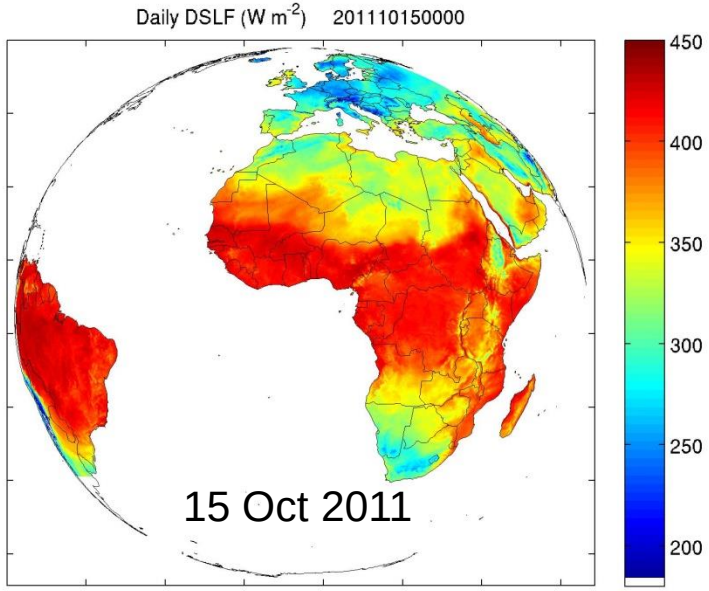
....

Radiation Products - DSLF



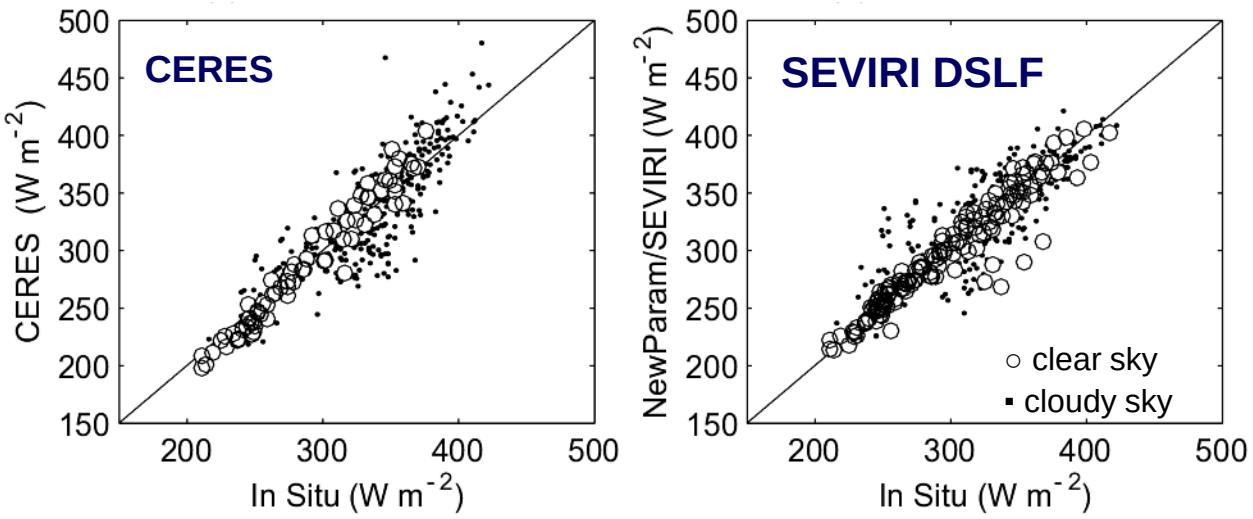






Radiation Products - DSLF

Validation: Central Europe station



Period

Jan 2006 - Apr 2007

Stations

Palaiseau, France
Payerne, CH
Carpentras, France

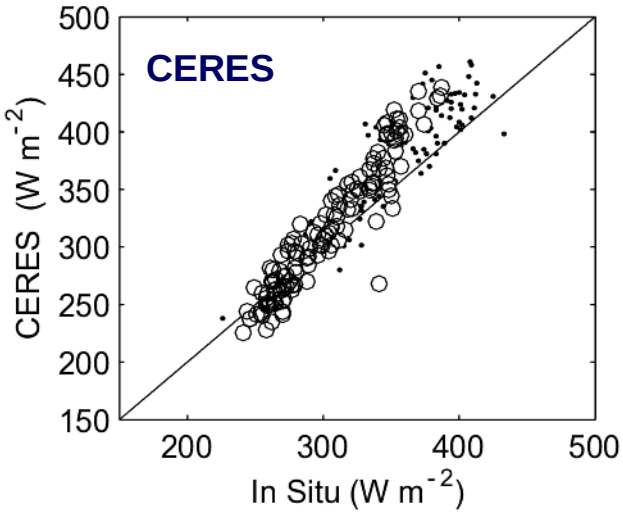
	CERES		SEVIRI DSLF	
	Bias	**RMSE**	**Bias**	**RMSE**
Clear Sky	-0.9	13.4	0.8	14.5
All Sky	-1.4	22.7	1.6	22.5

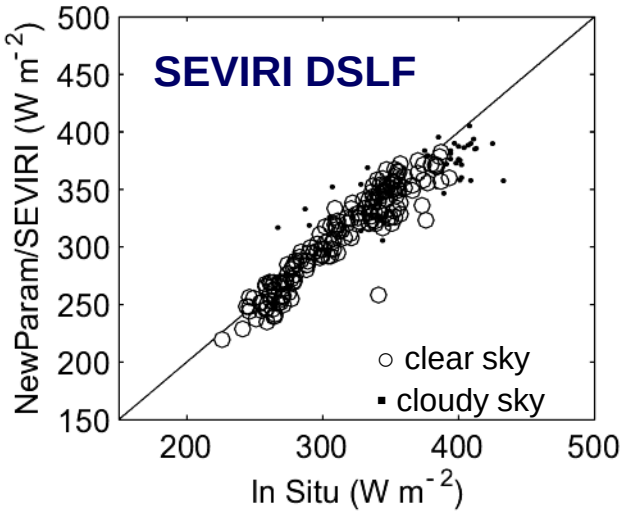
Problems:

- temperature inversions

Radiation Products - DSLF

Validation: Semi-arid and desert stations





Period

Jan 2006 - Apr 2007

Stations

Tamanrasset, Algeria
Sde Boqer, Israel
Niamey, Niger

	CERES		SEVIRI DSLF	
	Bias	**RMSE**	**Bias**	**RMSE**
Clear Sky	13.0	26.8	-4.4	14.1
All Sky	17.5	29.6	-5.4	16.9

Problems:

- Impact of high aerosol loads

LSA-SAF MSG Products

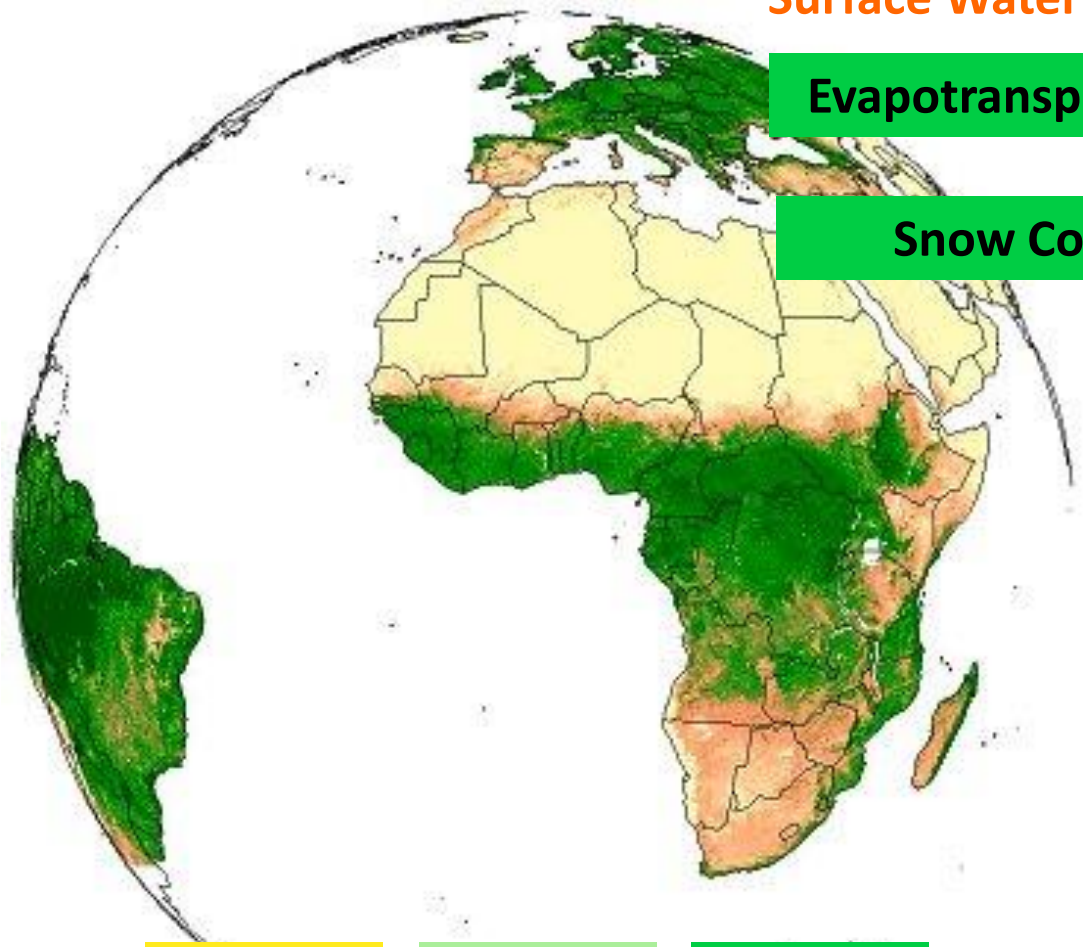
The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

Surface Water Balance

Evapotranspiration

Snow Cover

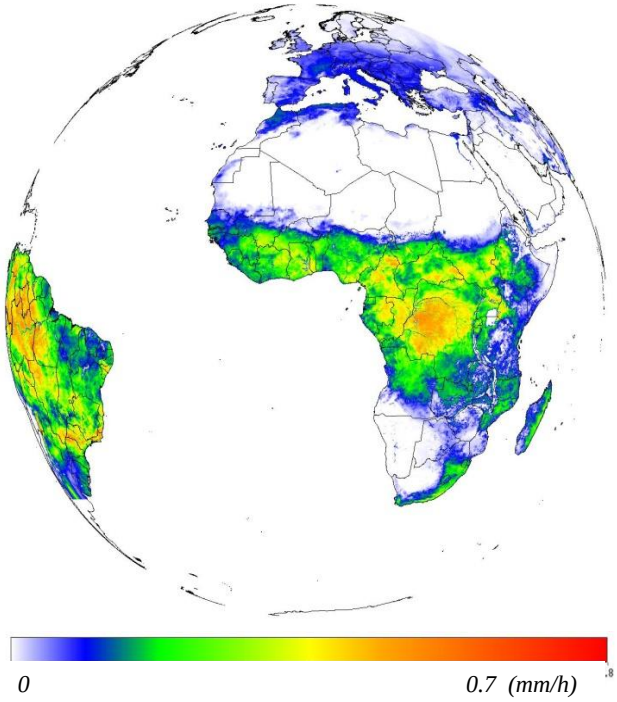


Development | Pre. Operat. | Operational

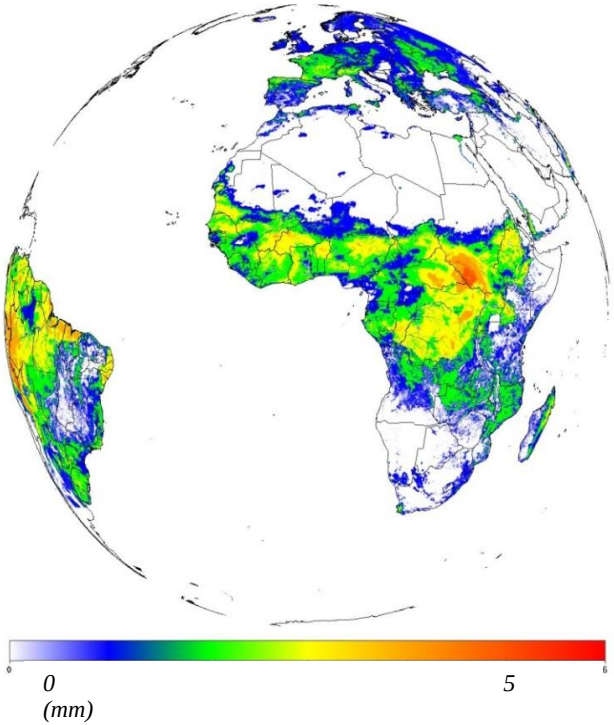
Increased level of maturity

Water balance products
Evapotranspiration (ET)

ET: Flux of water vapour between ground surface and the atmosphere.



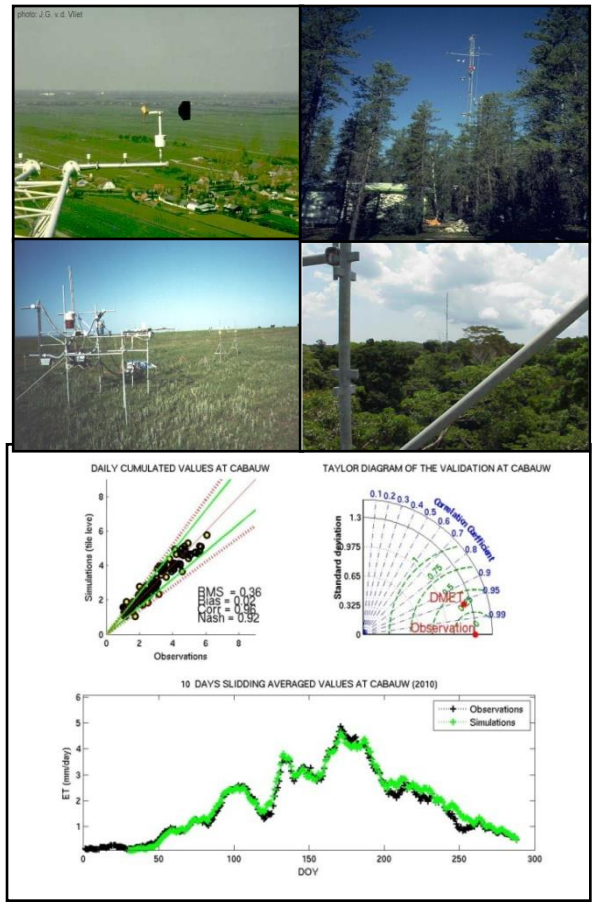
Instantaneous ET, one image every 30 minutes



Daily cumulated ET (DMET)

Water balance products
Evapotranspiration (ET)

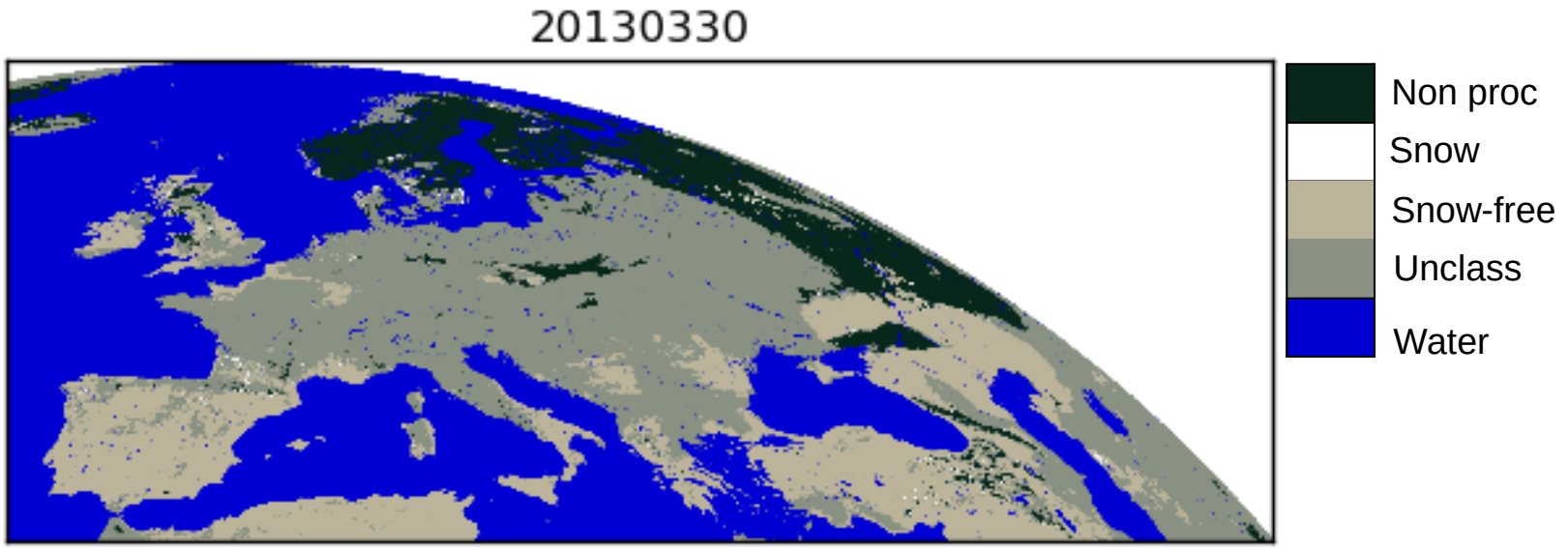
Validation



- ✓ Comparison to observations in different climatic and environmental conditions
- ✓Comparison to output from other models
- ✓Good agreement between simulations and observations ; the best agreement is observed in areas dominated by grasslands and mixed forests

Water balance products
Snow Cover (SC)

Different signatures of snow, ice, and clouds on 0.6, 0.8 & 1.6 μm channels reflectances.



A thresholding technique is applied to distinguish surfaces covered with snow or ice from clouds and snow-free pixels.

LSA-SAF MSG Products

Vegetation

- Fraction Veg Cover
- LAI
- FAPAR
- NDVI from Metop

Wild Fires

- Fire Risk Mapping(Europe)
- Fire Radiative Power
- Fire Detection & Monitoring

Development | Pre. Operat. | Operational

Increased level of maturity

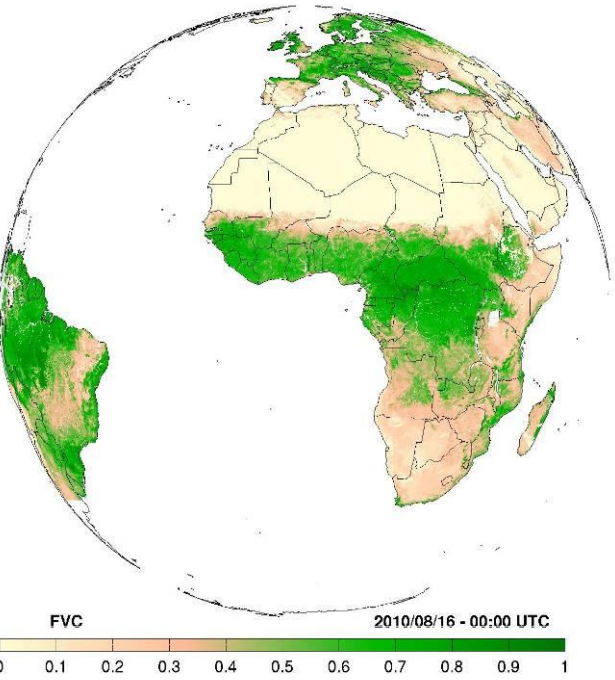
Vegetation Products

The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

FVC

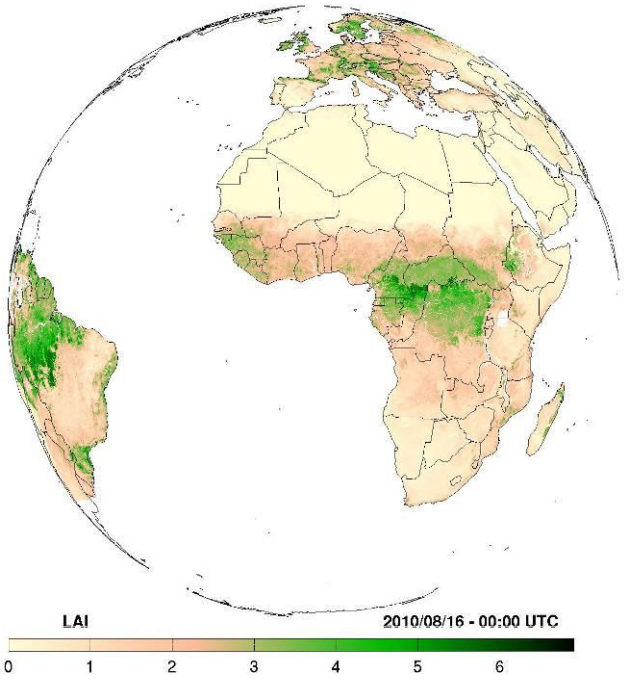
Fractional Vegetation Cover



Fraction of vegetation on a flat background.

LAI

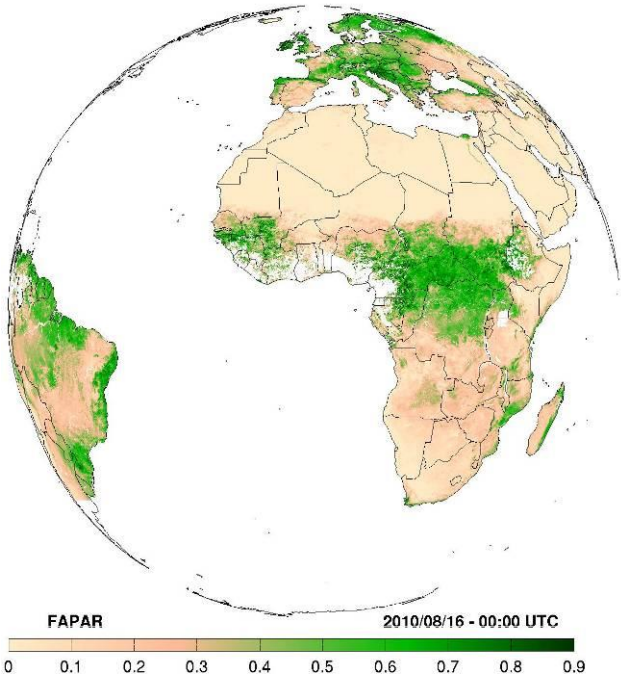
Leaf Area Index



Accounts for the surface of leaves contained in a vertical column normalized by its cross-sectioanl area.

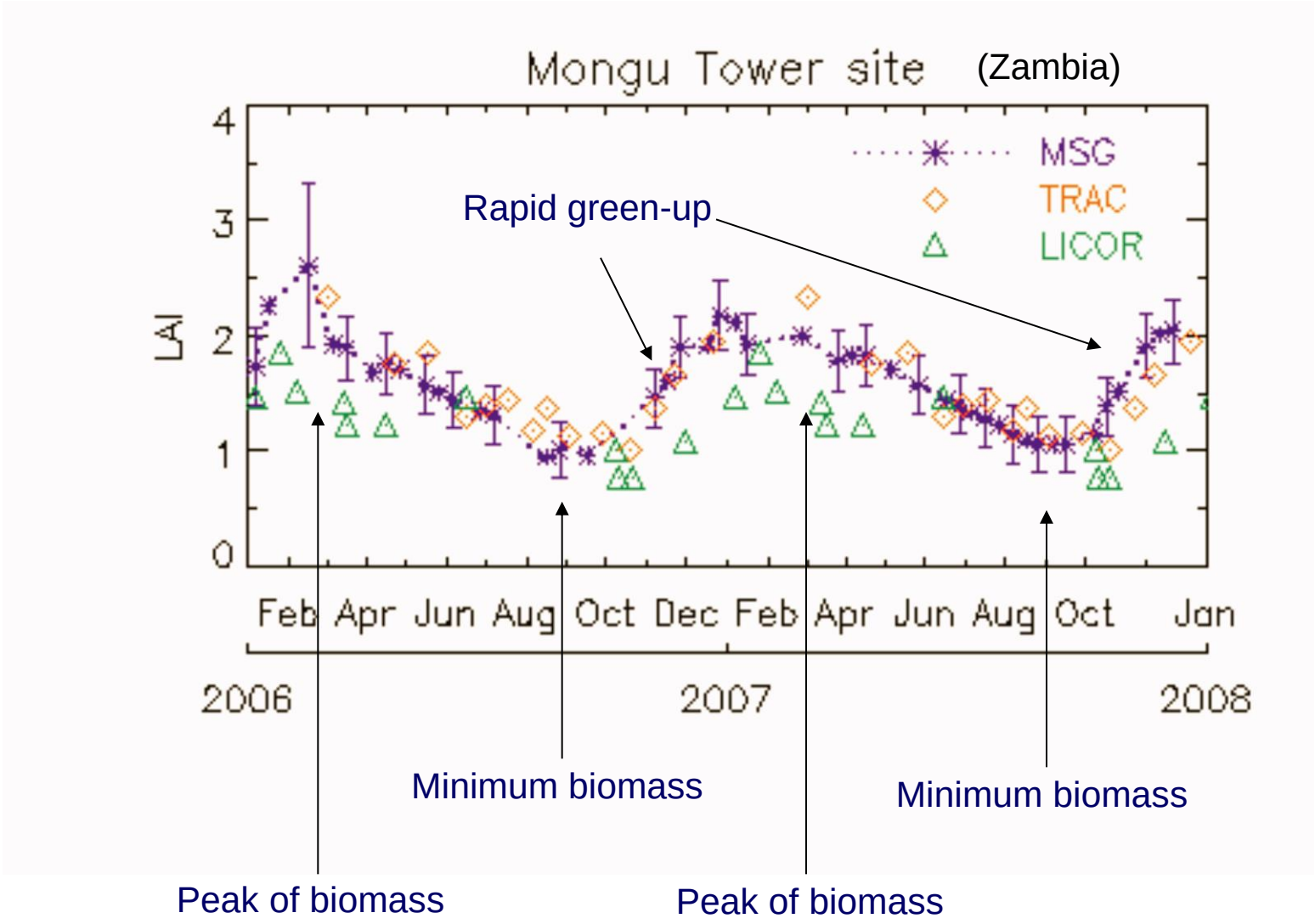
fAPAR

Fraction of Absorbed Photosynthetically Active Radiation



Indicator of the health (productivity) of vegetation.

Validation results



NDVI from Metop

Near-global, 10-daily composite images (synthesized from the "best available" observations registered in the course of every "dekad" by the orbiting earth observation system Metop-AVHRR)

http://www.metops10.vito.be

Fire Radiative Power

FIRE RADIATIVE POWER (FRP) - The Fire Radiative Power (FRP) is the amount of **radiant energy** emitted **per unit time** during a vegetation fire. FRP is related to the rate at which fuel is being consumed

Daily/15 min
(since 2008)

The FRP product is derived using a Fire Thermal Anomaly (FTA) algorithm. Ii works mainly on statistics derived from the 3.9 µm and 11.0 µm brightness temperatures, and their differences

Fire Radiative Power

FRP product allows to:

- ✓**Detect an active vegetation fire**
- ✓**Compute the radiant energy per unit time for the detected fire**
- ✓**Estimate trace gas emissions from the fire**
- ✓ **By integrating FRP during the lifetime of a vegetation fire we get the total combusted biomass(Kg)**

LSA SAF webpage

http://landsaf.meteo.pt