EUMETSAT Satellite Applications Facility on Land Surface Analysis (LSA SAF)

Past, Present & Future

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Thanks to:

SALGEE

Satellite **A**pplications in **L**and surface analyses **G**roup for **E**astern **E**urope

LSA-SAF or LAND SAF
Land Surface Analysis Satellite Applications Facility

When I was preparing this presentation I start to think that I don't know who will attend the meeting. This make me to give you maybe a bit more of details, but I hope not so much.

EUMETSAT SAF Network

The SAFs have efficiently exploited EUMETSAT Satellite Observations to monitor, and to improve our understanding:

- Atmosphere
- Ocean & Sea Ice
- Land Surfaces
- Climate
- Interactions among components of the Earth System

Contributing to

- ✓ Improve Weather Surveillance & Forecast
- ✓ Track long-term (Climate) changes

LSA SAF

H SAF

NWC SAF

OSI SAF

CM SAF

AC SAF

ROM SAF

NWP SAF

LSA-SAF

Satellite Applications Facility
on Land Surface Analysis

PAST AND PRESENT

LSA-SAF

- LSA-SAF explores EUMETSAT satellite observations to derive land surface products;

- LSA-SAF involves now a big team;

- LSA-SAF responsible for **development and upgrade of products** (mainly science, to develop and upgrade products including validation);

- LSA-SAF responsible for **operations** (production, distribution and help desk).

LSA-SAF

- Products and datasets, are generated and provided in **NRT** or **off-line** (using EUMETCast or by FTP);

- A **helpdesk** is maintained for user support, together with product documentation. Also important is the promotion of activities, including training events, often carried out in collaboration with other SAFs and/or EUMETSAT.

- The organization of **workshops** and a regular preparation of show cases, is an important goal. Product applications data showing their added value is needed.

LSA-SAF

✓Near Real Time & Off-line production of Land surface Products/ Datasets

✓ Maintain User Support

- Helpdesk

- Product Distribution and Product Documentation

- Promotion: Training, Workshops, Show Cases

10 members from 8 European countries, being led by IPMA
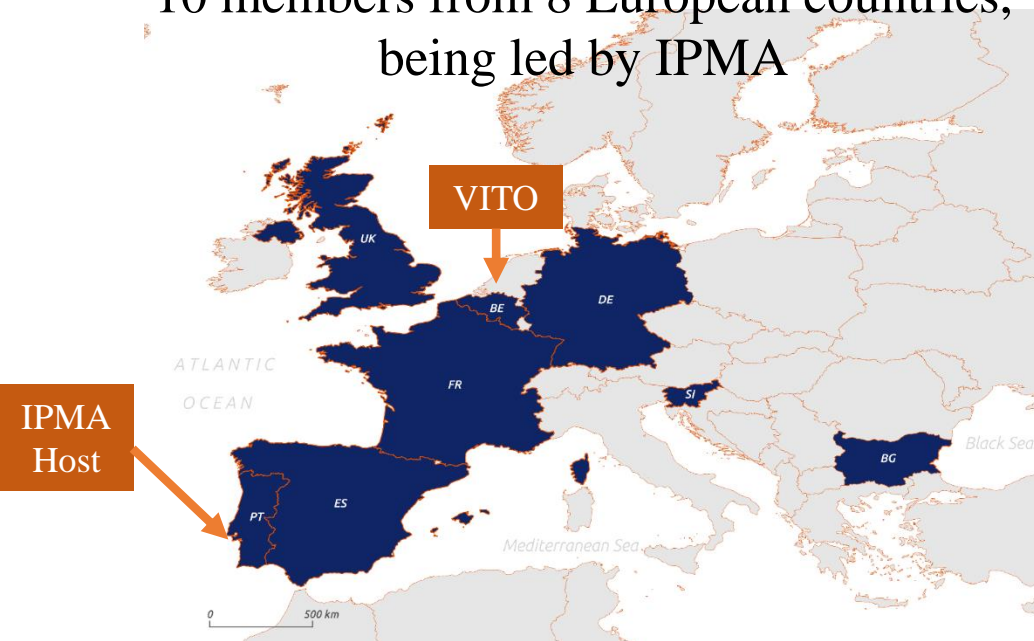
Important Goal
LSA SAF as Reference Centre for Land Surface Remote Sensing

✓Distributed Product Development & Validation & Training
✓Data Production, Archiving & Dissemination: IPMA, VITO

LSA-SAF

Observations from SEVIRI on-board MSG, is being the main source of data for most LSA-SAF products. High frequency observation rate is a particular value.

Data distribution and relation with users is for SAFs very important. Users can get data from different ways:

- EUMETCast - Most of NRT products;
- FTP all products including the ones distributed by EUMETCast and CDR (Climate Data Records) and reprocessed products.

LSA-SAF

![LSA SAF EUMETSAT logo]

Land SAF products that fully characterize the surface

- Evapotranspiration
- Turbulent Fluxes
- All Sky LST

Energy Balance

Radiation

Vegetation
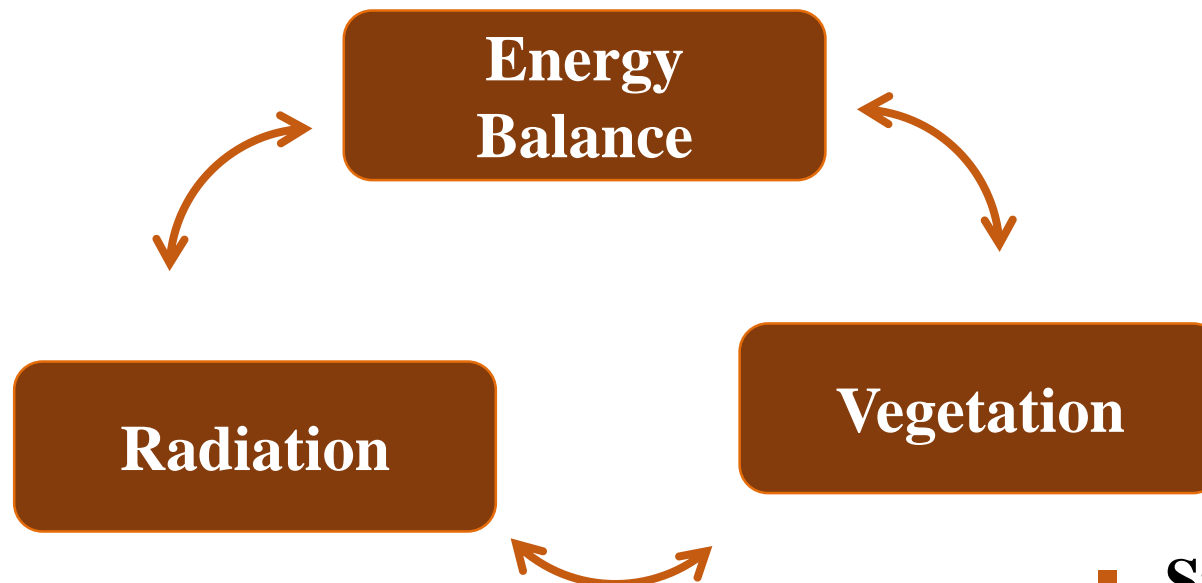
- **SW:** Albedo, Down-welling SW
- **LW:** LST, Emissivity, Down-welling LW

- **State**: LAI, FAPAR, FVC, NDVI
- **Stress**: ET, ETRef
- **Wild-Fires:** FRP, Emissions, Risk

BRDF (Bi-directional Reflectance Distribution Function) is a function of four real variables defining how light is reflected from a surface.

Each direction ($\mathbf{W_i}$ or $\mathbf{W_r}$) is itself parameterized by azimuth angle ϕ and zenith angle θ, therefore the BRDF is a function of 4 variables.

The function takes an incoming light direction, $\mathbf{W_i}$, and outgoing direction, $\mathbf{W_r}$, (in a coordinate system where the surface normal $\mathbf{n}$ is the normal to the plane of the soil).

Returns the ratio between the reflected radiance along $\mathbf{W_r}$ to the irradiance incident on the surface from direction $\mathbf{W_i}$.
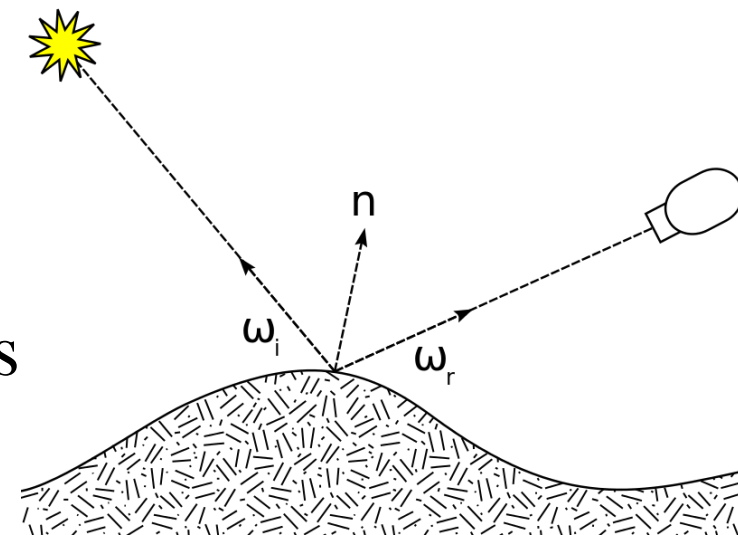
MSG can view different illuminates angles during the day (and the year) but using always the "same" viewing angle.

Using VIS/NIR observations over a full day, i.e., over multiple illumination angles, it is possible to derive the surface BRDF allowing to derive daily surface Albedo.

With BRDF it is possible to estimate a suite of vegetation parameters.

For each single pixel it is computed the amount of reflected radiation for all outgoing directions.

LSA-SAF products
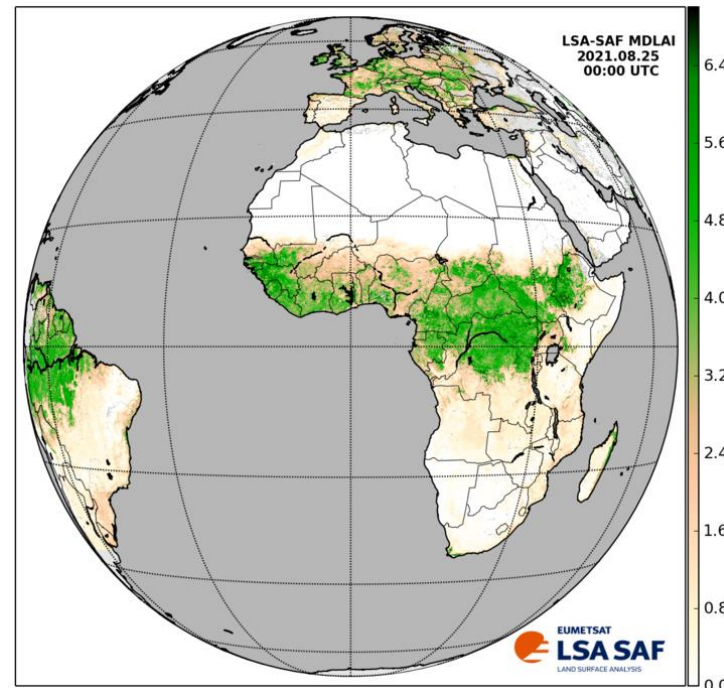
Exploring **15-minute SEVIRI/MSG observations**

Daily Albedo

VIS/NIR/SWIR observations at multiple illumination angles

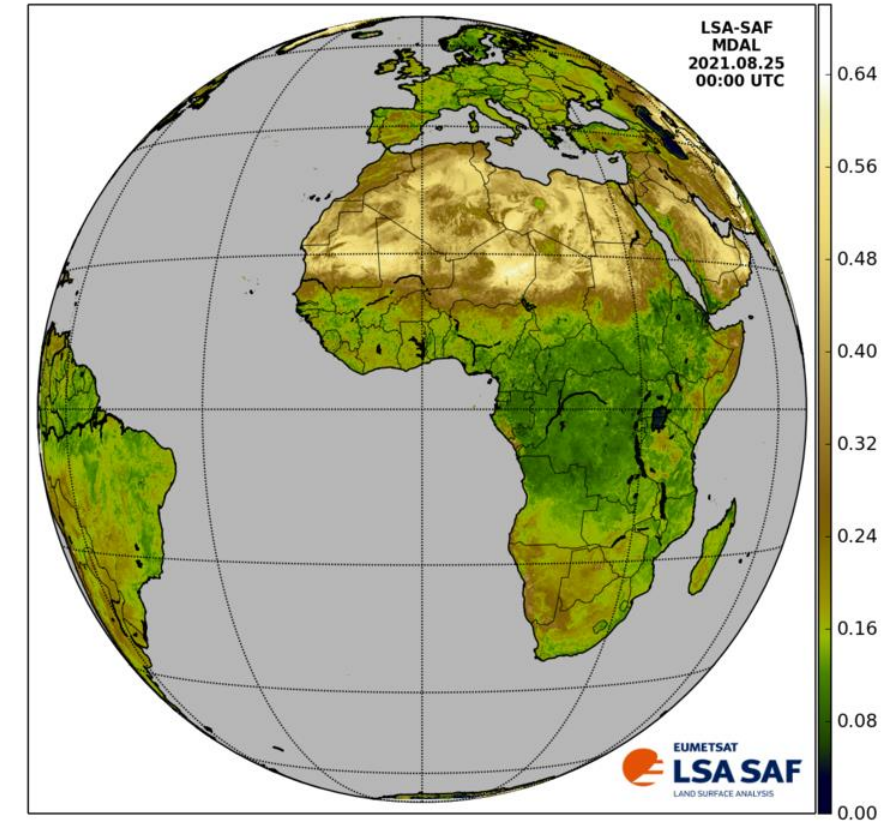Surface **Albedo**

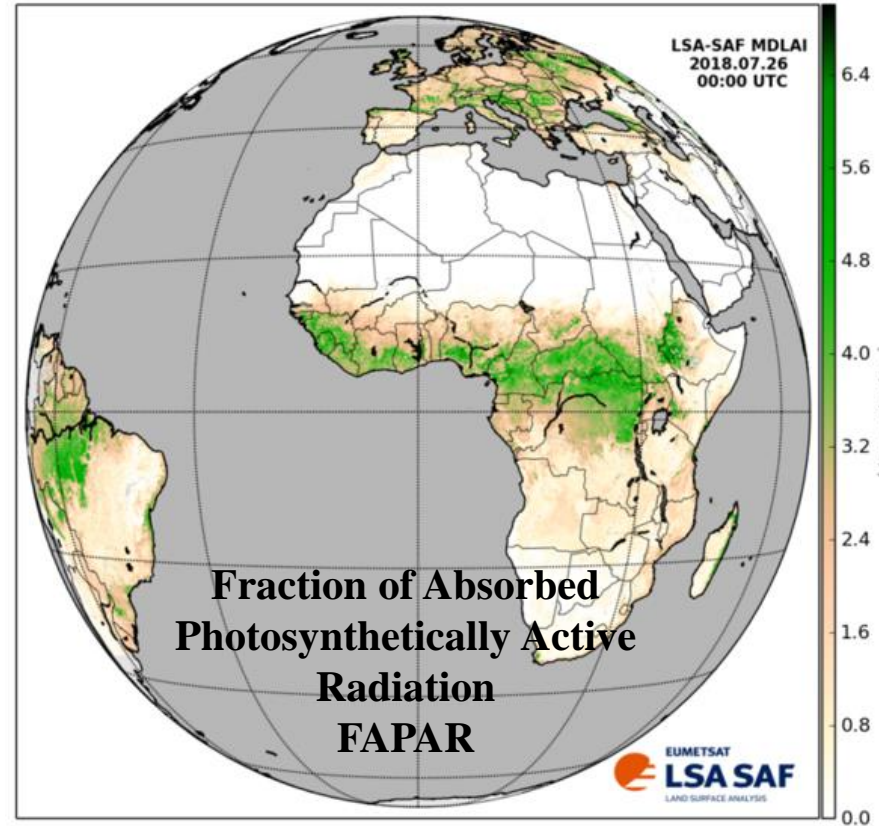Surface BRDF

Vegetation Parameters
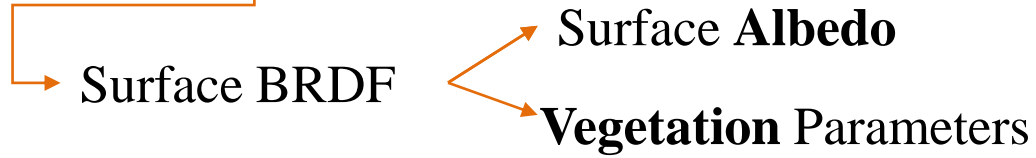
Daily FAPAR
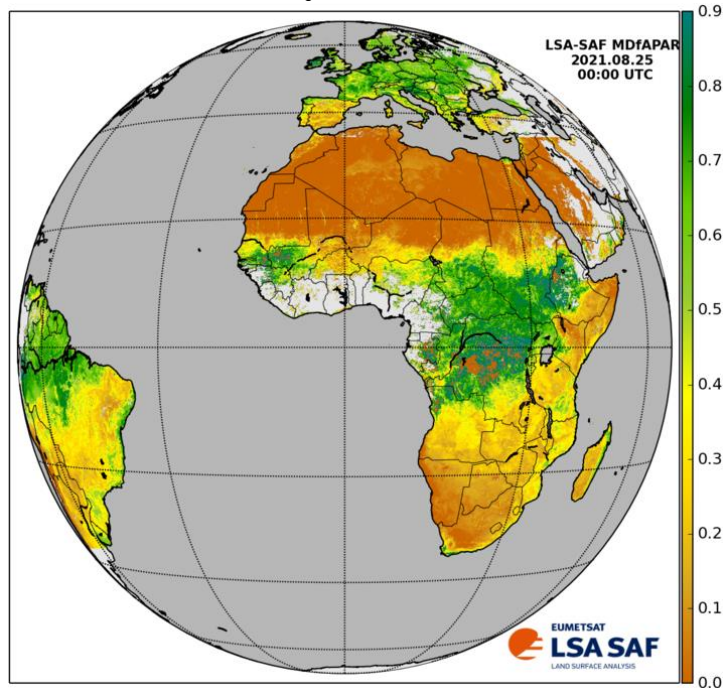
Daily LAI
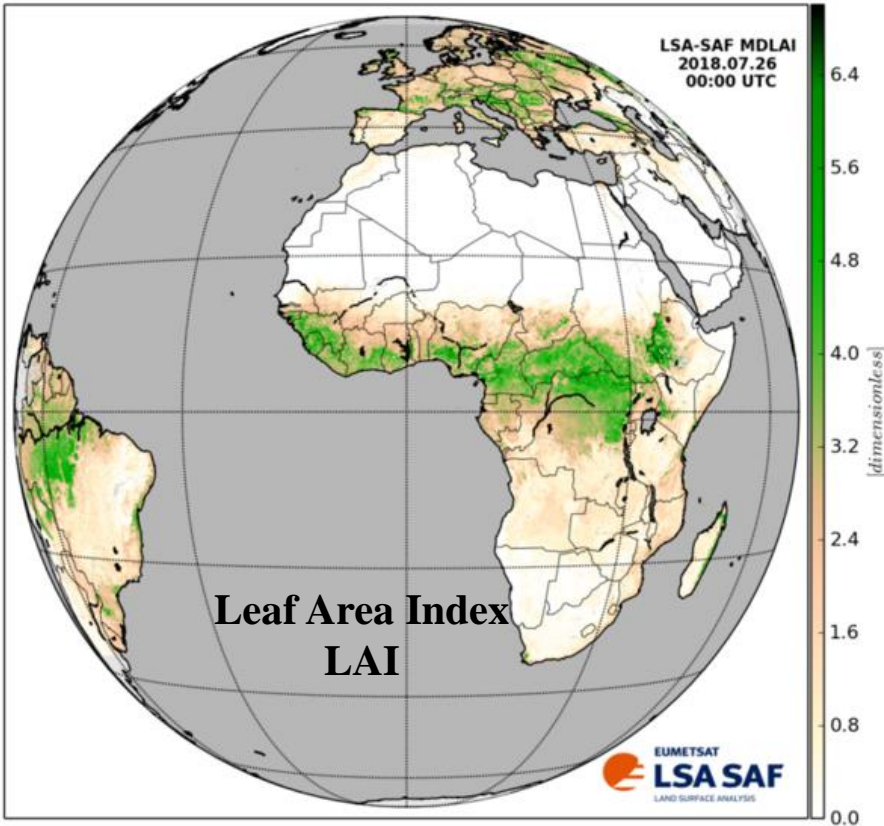

FAPAR - Fraction of Absorbed Photosynthetic Active Radiation

LAI - Leaf Area Index

LSA-SAF products
LAI & FAPAR

Leaf Area Index
LAI

LSA-SAF MDLAI
2018.07.26
00:00 UTC

Fraction of Absorbed
Photosynthetically Active
Radiation
FAPAR

LSA-SAF MDLAI
2018.07.26
00:00 UTC

Together with **FVC**, **LAI** and **FAPAR** provide complementary information on

✓ Vegetation density

✓ Canopy density

✓ Vegetation Health

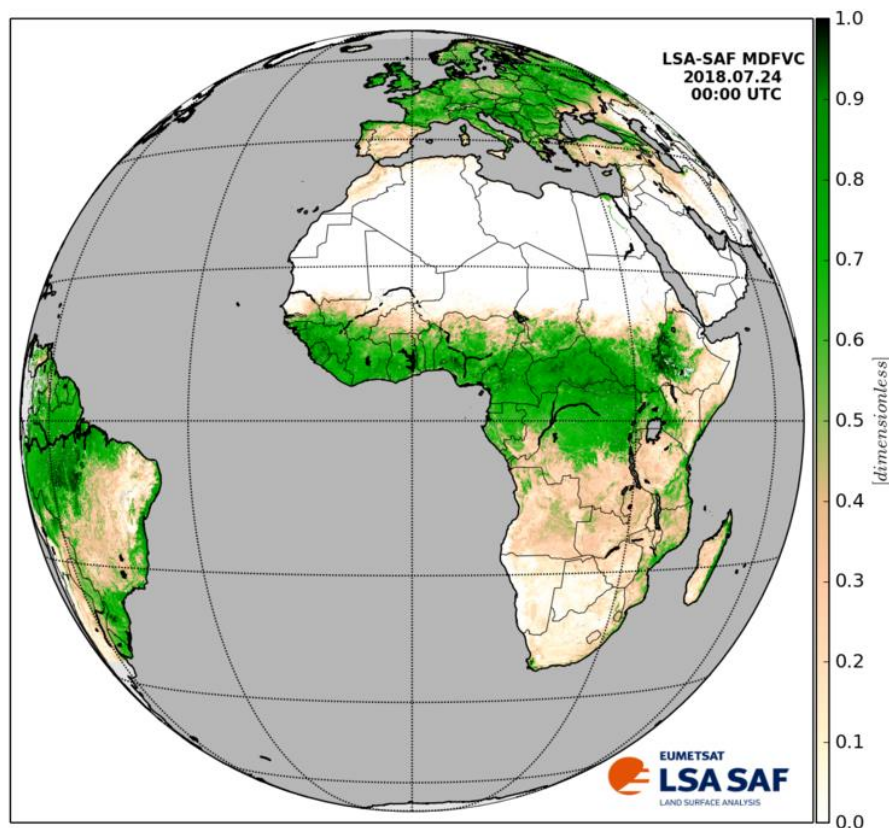Derived from VIS & SWIR SEVIRI channels

Frequency: Daily & 10-days

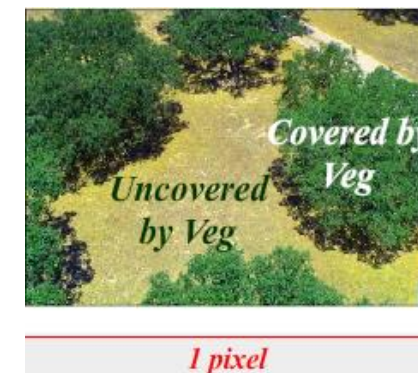**Available ≥ 2004**

To learn more about LAI and FAPAR:

➤ LSA SAF Vegetation Module@eumetrain.org
➤ Applications @eumetrain.org
➤ All information about LSA SAF MSGLAI Product@LSASAFWebsite

LSA-SAF products

Fraction of Vegetation Cover FVC

1 pixel

FVC accounts for the amount of vegetation distributed on a flat background

FVC retrieval – uses surface reflectance information from MSG SEVIRI channels 0.6 μm, 0.8 μm & 1.6 μm

Frequency: Daily & 10-days   **Available ≥ 2004**
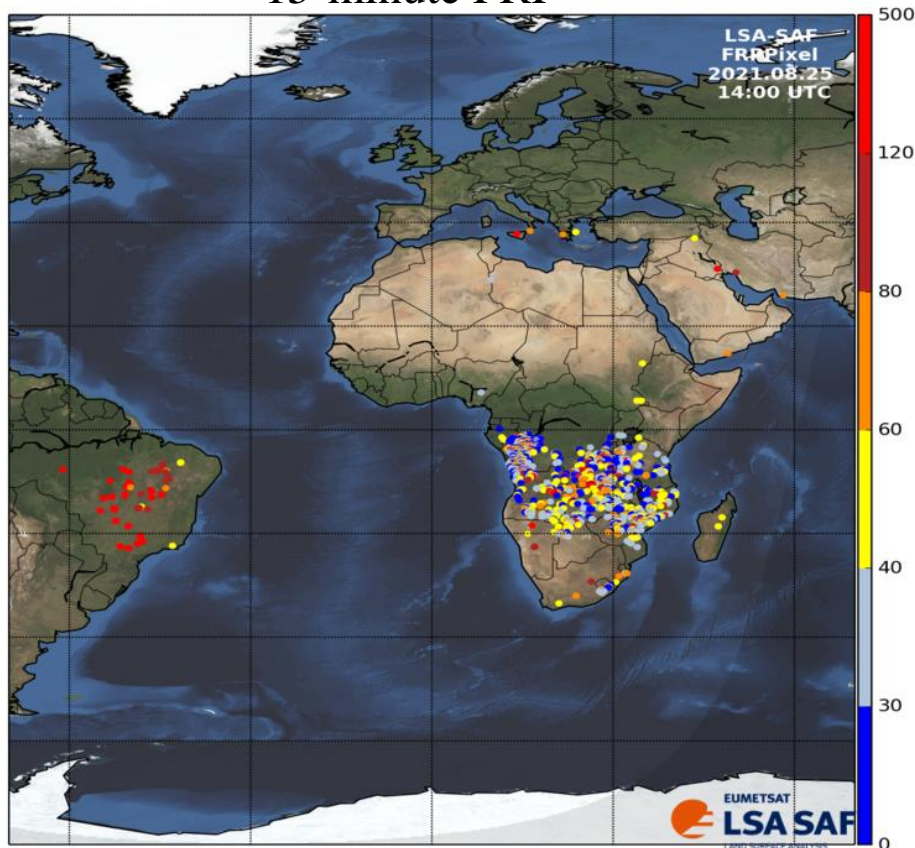
To learn more about FVC:

➤ LSA SAF Vegetation Module@eumetrain.org
➤ Applications @eumetrain.org
➤ All information about LSA SAF MSGFVC Product@LSASAFWebsite

LSA-SAF products

- Using full 15-minute MIR (together with TIR observation) it is possible to identify **wild fires** and get an estimation of their Radiative Emit Power. Such high frequency allows to follow fast evolution of events;

- FRP (**Fire Radiative Power**) it is already estimated over several years, making possible to calibrate **Fire Risk**, converting weather forecasts into a map of fire risk over Mediterranean Europe;

- FRP is also used to derive **Fire Emissions** over the whole MSG disk (in development and to be released soon).

LSA-SAF products

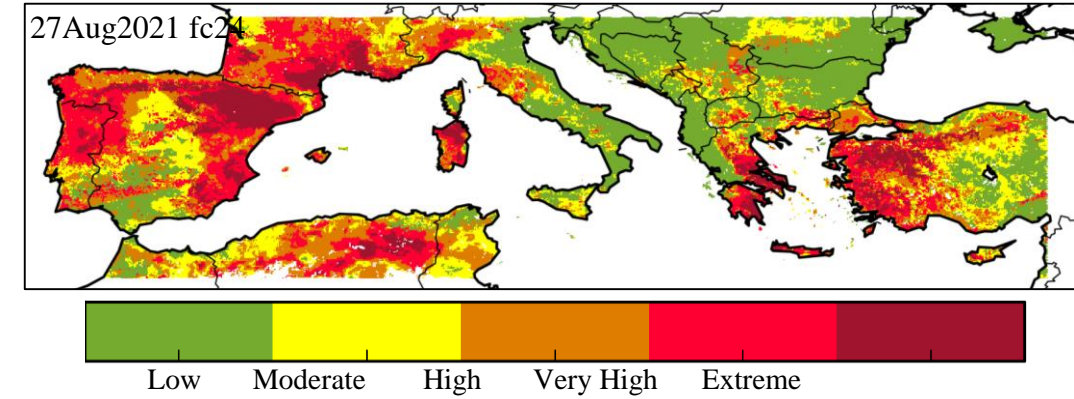MIR (& TIR) observations

High Freq. **Fire Radiative Power**

15-minute FRP

Fire Risk

Fire Emissions

Daily Fire Risk

27Aug2021 fc24

Low   Moderate   High   Very High   Extreme

LSA-SAF
FRPPixel
2021.08.25
14:00 UTC

EUMETSAT
LSA SAF
LAND SURFACE ANALYSIS

Fire Emissions (*In Development*)
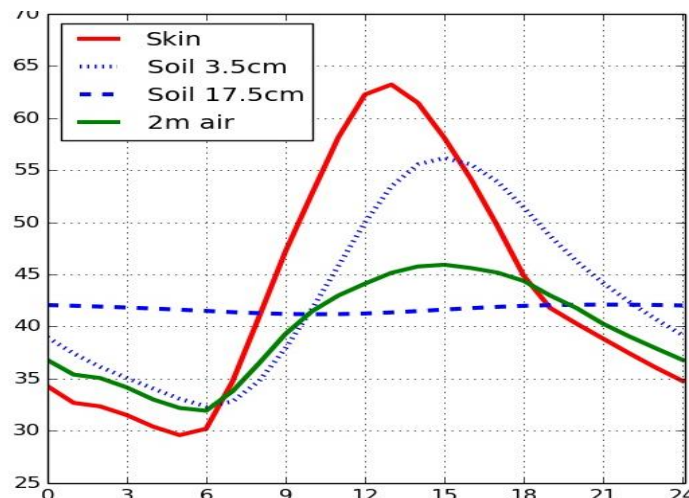

FREMv2

TPM emission density (g m⁻²)
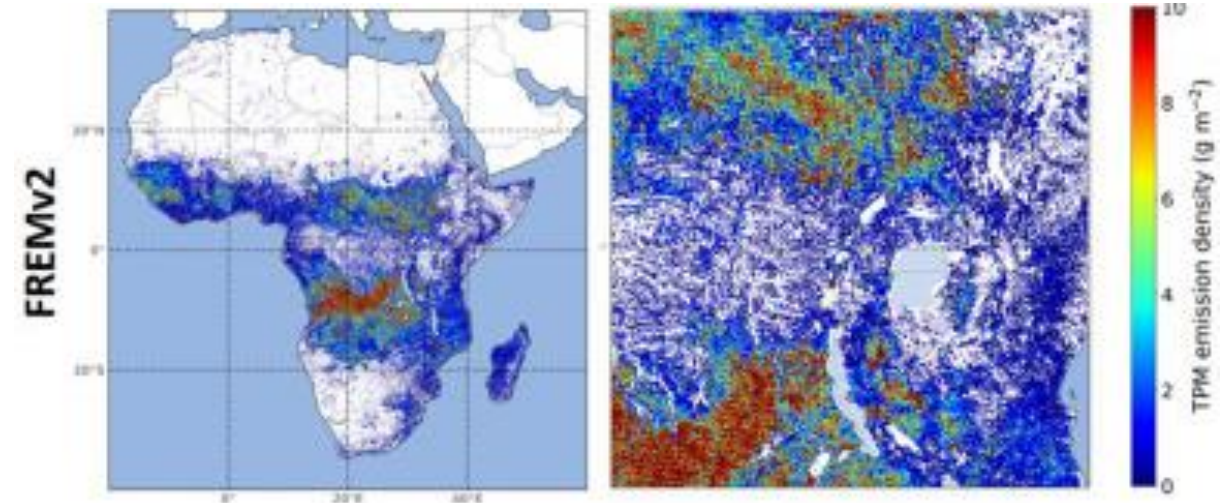
Nguyen and Wooster (2020) in *Remote Sens. Environment*

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

LST ≠ Tair ≠ Tsoil

(but LST & Tair are strongly correlated)

In clear sky areas it is possible to make an estimation of LST.

In cloud areas will not be make a calculation and this means that will be areas without any LST.

However, using radiation at the surface (also a product estimated by the LSA-SAF), Surface Albedo and Vegetation parameters, can be used to solve an Energy Balance equation, filling these gaps and producing all-sky LST.

LST retrieval - based on **clear-sky** measurements from MSG system in the thermal infrared window (MSG/SEVIRI channels IR10.8 and IR12.0)

Available ≥ 2004   **Frequency: 15 min.**
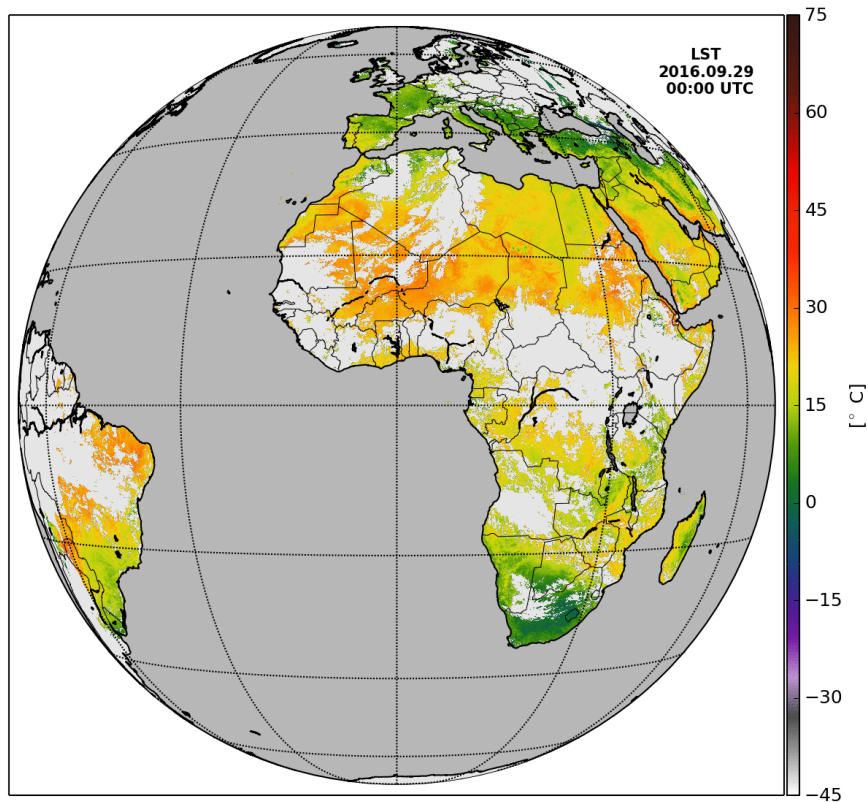
To learn more about LST:

➢ **Introduction to LST Tutorial @eumetrain.org**
➢ **LST Applications @eumetrain.org**
➢ **All information about LSA SAF MSGLST Product@LSASAFWebsite**

LSA-SAF products

TIR observations (& Vegetation Cover)

LSA-SAF Radiation & Vegetation Products

High Freq. **Land Surface Temperature**

All-Sky LST & Energy Fluxes

LST (15-minute)

All-Sky LST (30-minute)

LSA-SAF products

Application: Temperature & Vegetation Anomalies
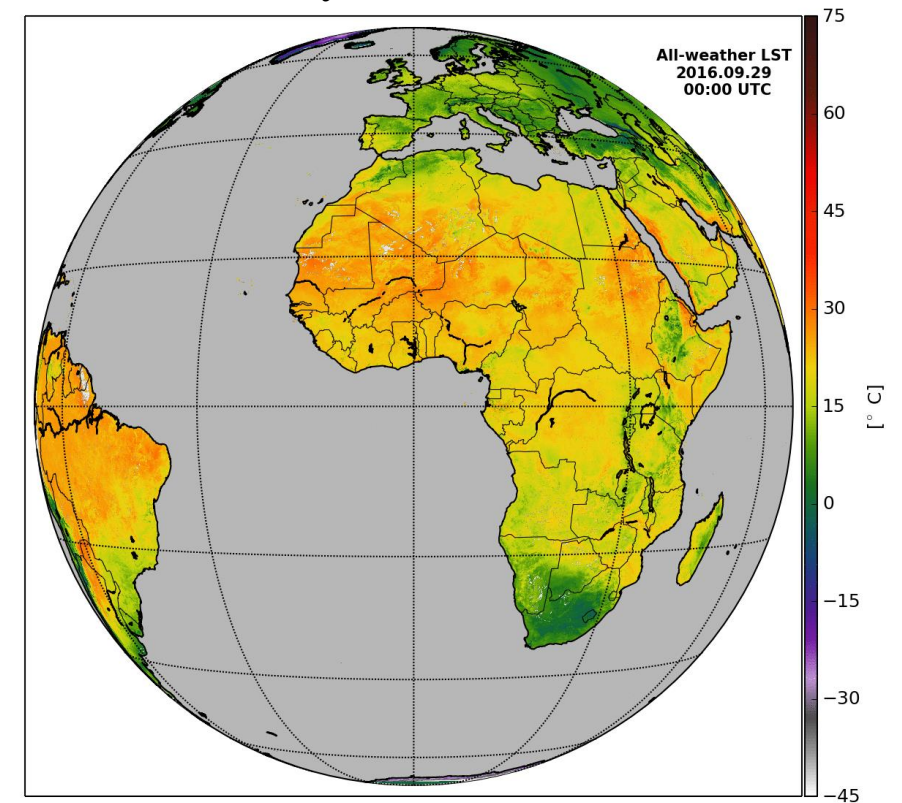
Zooming into Southern Africa
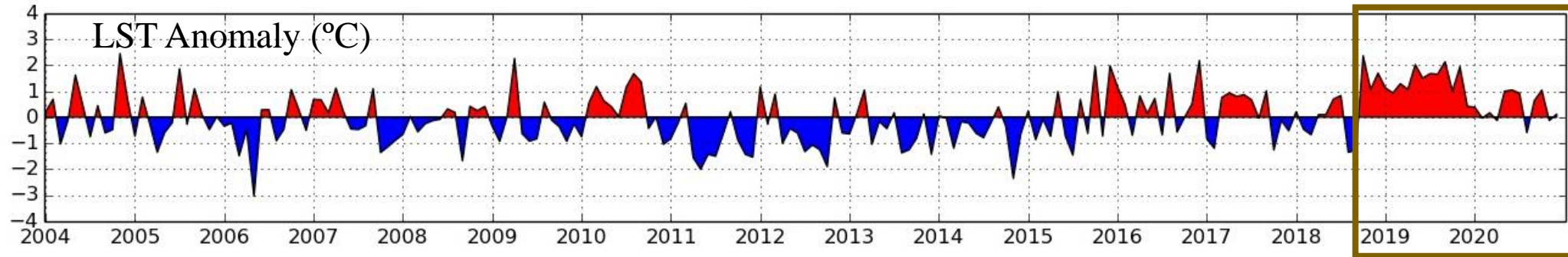
LST Anomaly December 2019
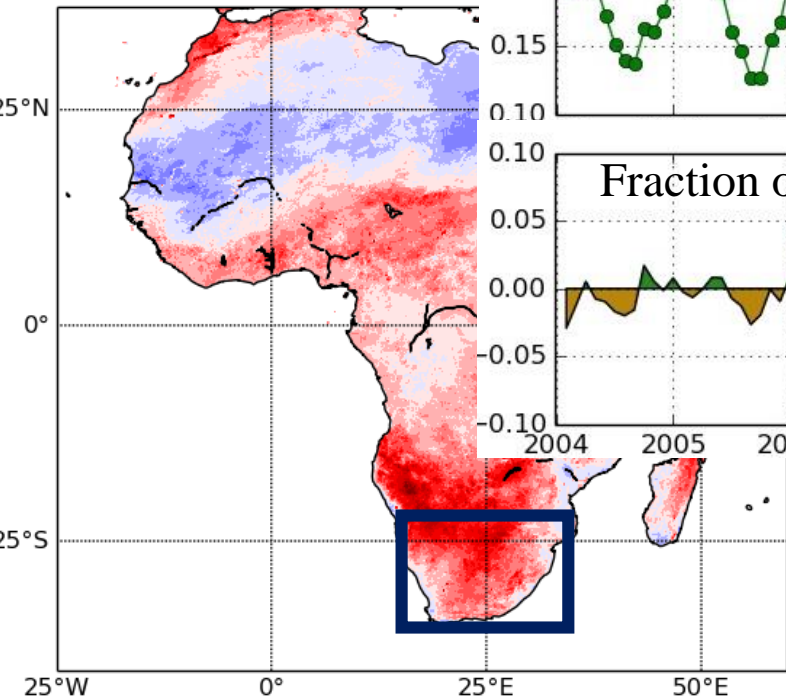
South Africa drought ~Oct 2018 - 2021

LSA-SAF products

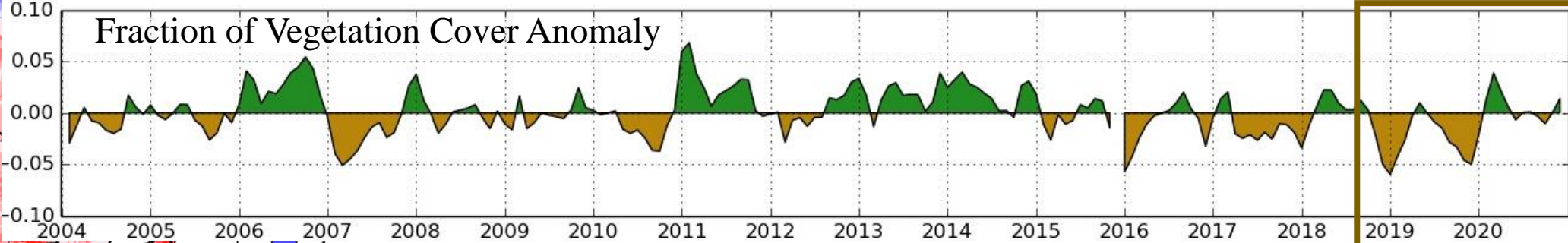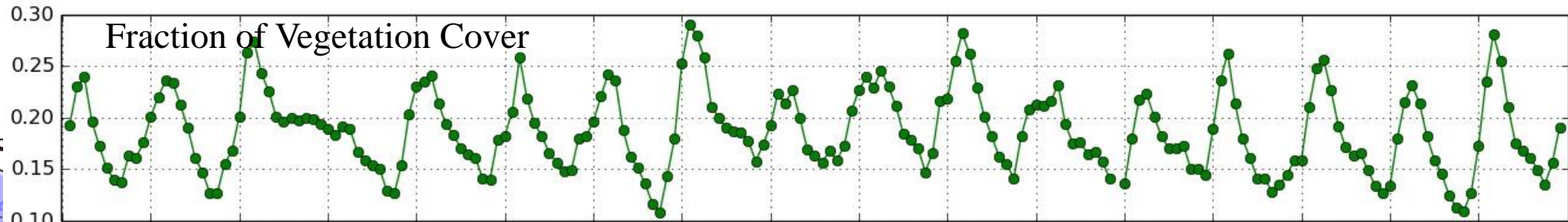Derived from SEVIRI/MSG: Available since 2004; up-dated in Near Real Time

✓ Full spatial resolution (3-km at nadir)
✓ Generation frequencies: 15-minute up to daily and 10-daily
✓ Product Uncertainty and/or Quality Flag

Gross Primary Production

Evapotranspiration

Long-wave Radiation at Surface

Solar (diffuse & direct) Radiation at Surface

LSA-SAF products Energy Balance

Evapotranspiration

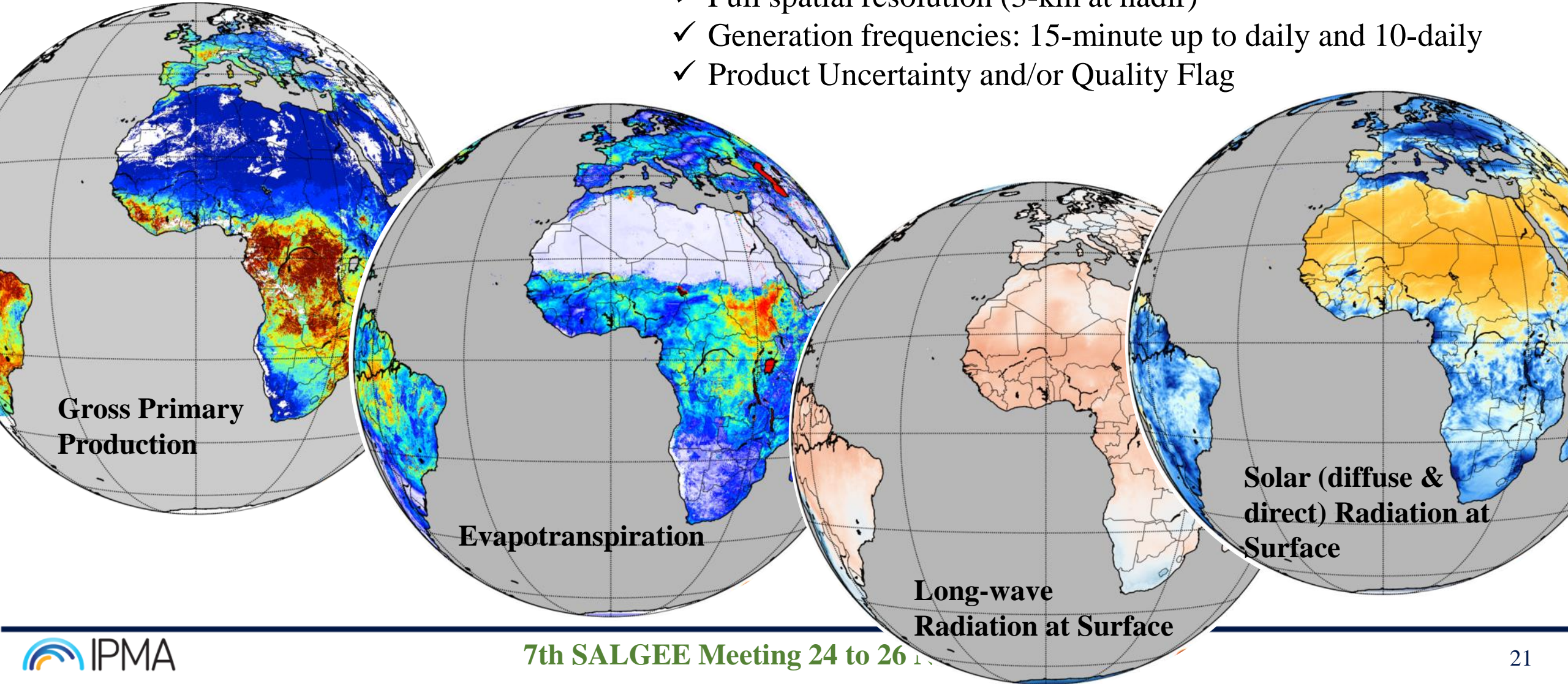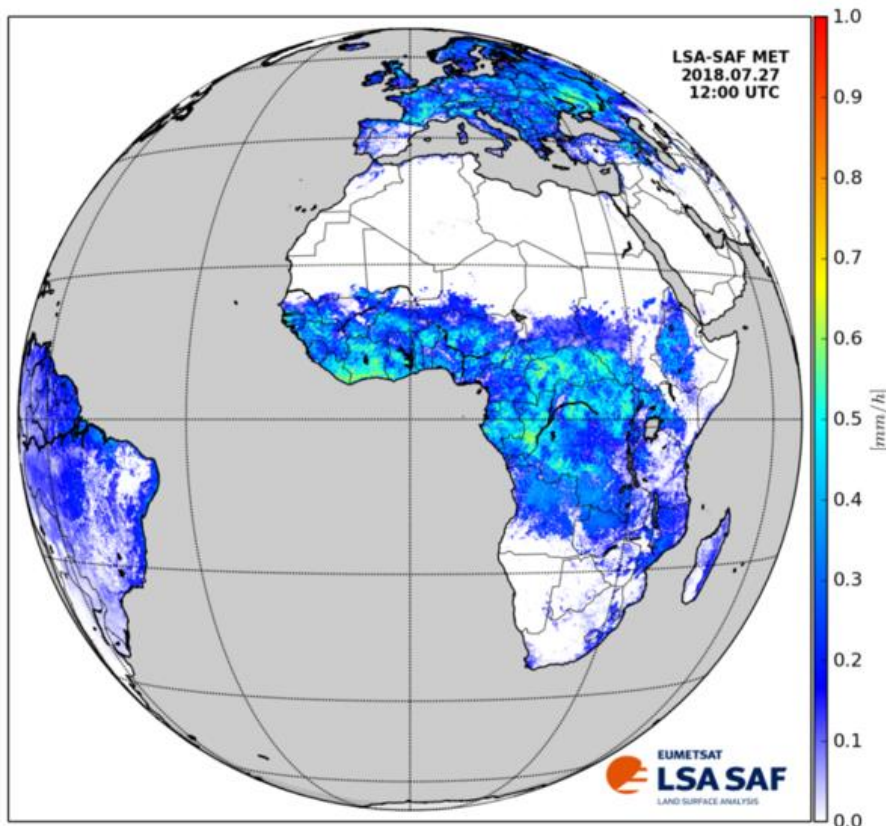**ET** accounts for the flux of water **evaporated** at the Earth-atmosphere interface (soil + vegetation + water bodies) & **transpired** by vegetation through stomata in its leaves.

evapotranspiration = transpiration + evaporation

transpiration
trees   grass

evaporation

runoff

groundwater recharge
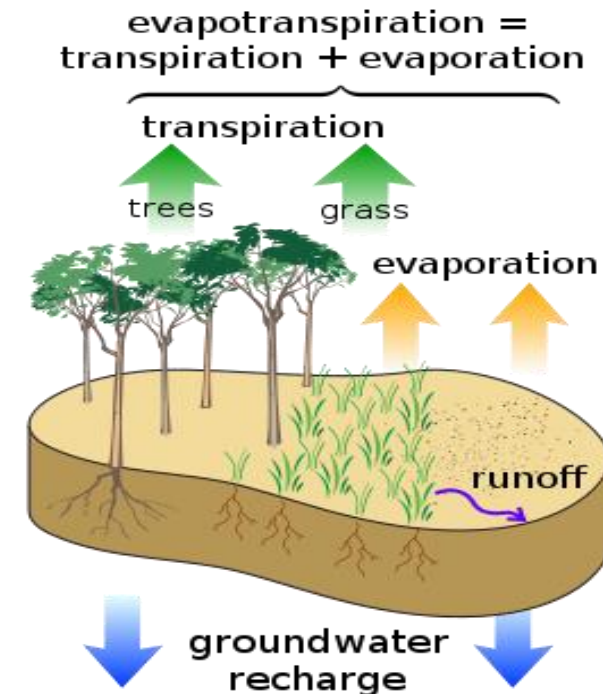
Frequency: 30 min. & Daily

Available from 2010 onwards (30 min.) & ≥ Dec 2010 (Daily)

Back-Processing on-going ≥ 2004

To learn more about ET:
➢ **All information about LSA SAF MSGET Product@LSASAFWebsite**

LSA-SAF products
Reference Evapotranspiration

Reference evapotranspiration, ETREF, is the evapotranspiration rate from a clearly defined reference (extensive green, non-water stressed) surface, evaporative demand of the atmosphere (i.e., crop water needs) independently of crop type, crop development or management practices.
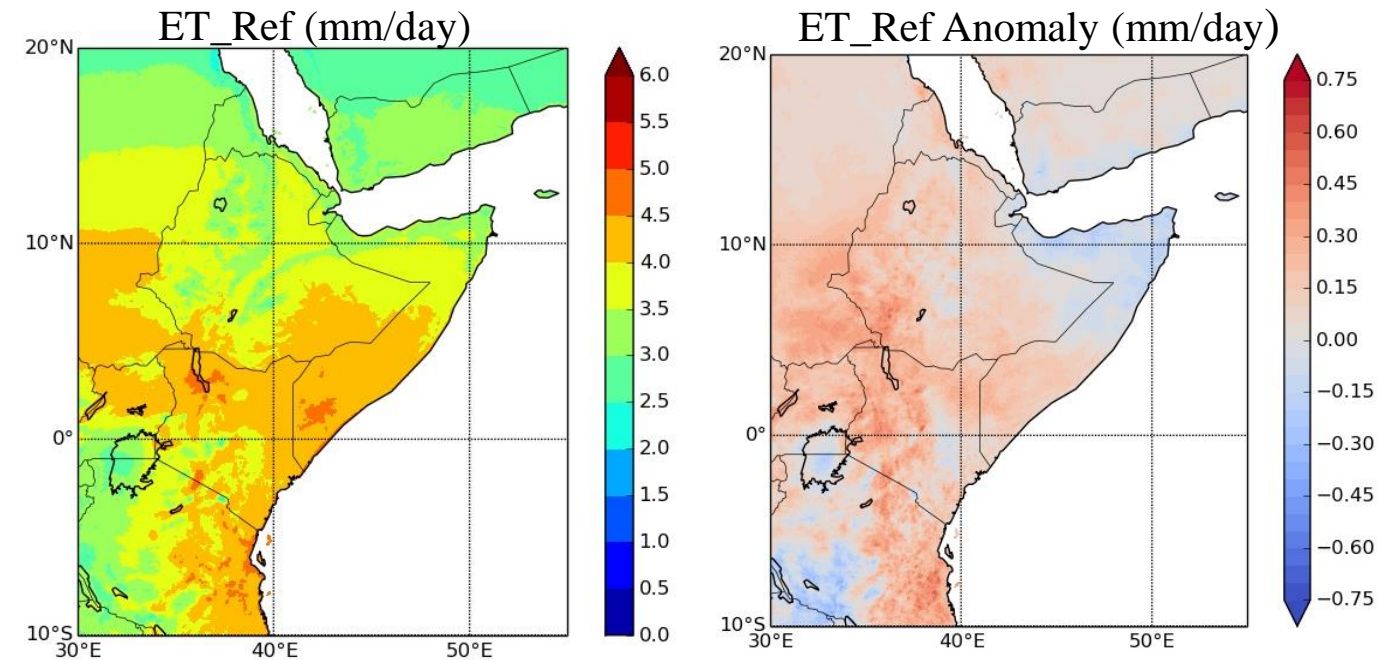

Frequency: Daily

Available ≥ 2004

To learn more about ETREF:

➢ **All information about LSA SAF MSGET Product@LSASAFWebsite**

LSA-SAF products
Application: Evaporative Demand & Vegetation State

Reference Evapotranspiration
(Crop Water Requirements)
December 2020

December 2020 **FAPAR** Anomalies
Vegetation growth **above**/**below** average

Although SEVIRI, on-board MSG, is the basis for most LSA-SAF products, some few other global products are based on AVHRR on board of Metop satellite.

Over several days, various viewing angles over each locations are possible and can be used to derive a 1km global surface BRDF which, in turn, is used to derive albedo and vegetation products every 10-days.
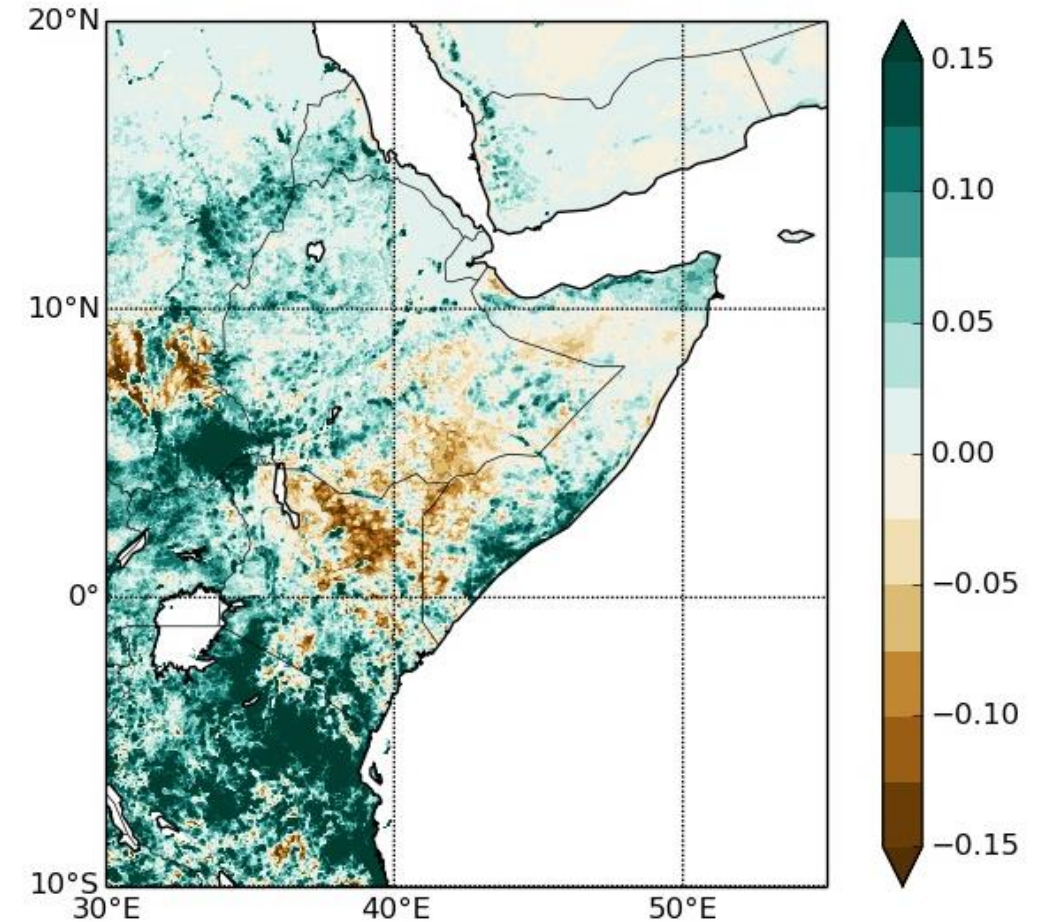
AVHRR/Metop LSA-SAF Products

VIS/NIR observations at multiple viewing angles

TIR observation (& Vegetation Cover)

Surface BRDF

Land Surface Temperature

10-daily Albedo

Daytime

**10-daily Vegetation:
LAI, FAPAR, FCV,
NDVI**
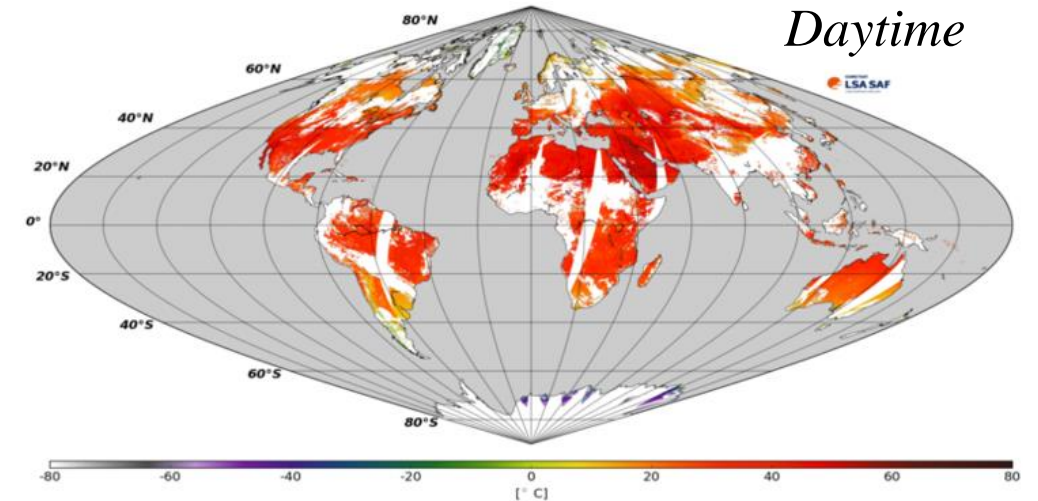
Night-time
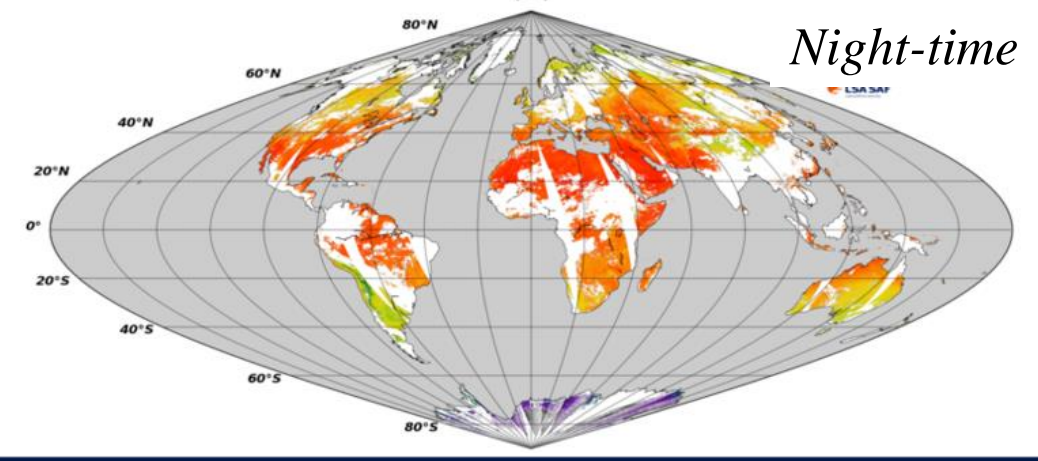
Data Format:

- ✓ HDF5 – products at full spatial resolution
    - MSG: Geostationary projection
    - Metop: (1km) sinusoidal projection
- ✓ NetCDF4 – products on regular grid
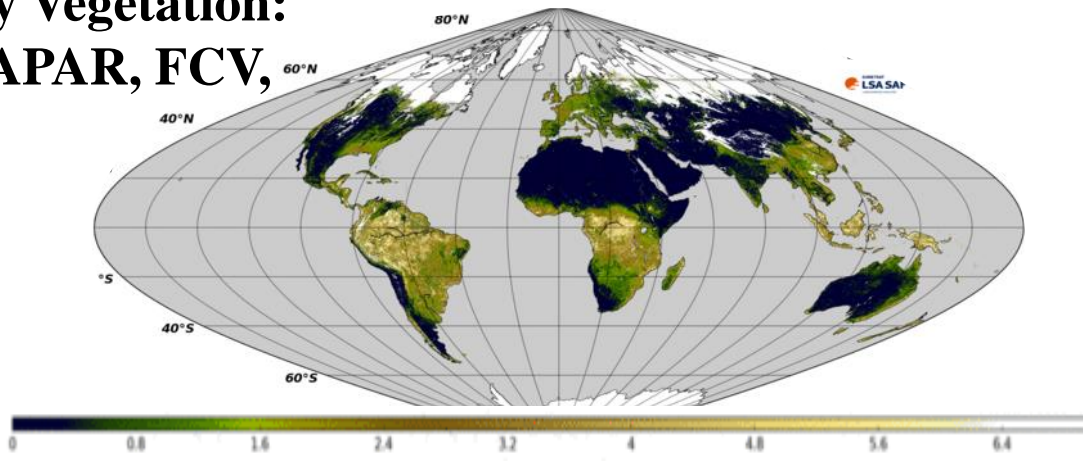   - MSG: 0.05° long. X 0.05° lat. grid
    - Metop: 0.01° long. X 0.01° lat. grid

Data Distribution:

- ✓ EUMETCast – Near Real Time dissemination
    - Only HDF5 format
    - High frequency products (15-minute up to daily)
- ✓ ftp / website (**lsa-saf.eumetsat.int**)
    - HDF5 & NetCDF4
    - All Products
    - Product Temporal Aggregations

Helpdesk – helpdesk.landsaf@ipma.pt

Vegetation: LAI, FAPAR, FCV

Albedo

Surface Temperature
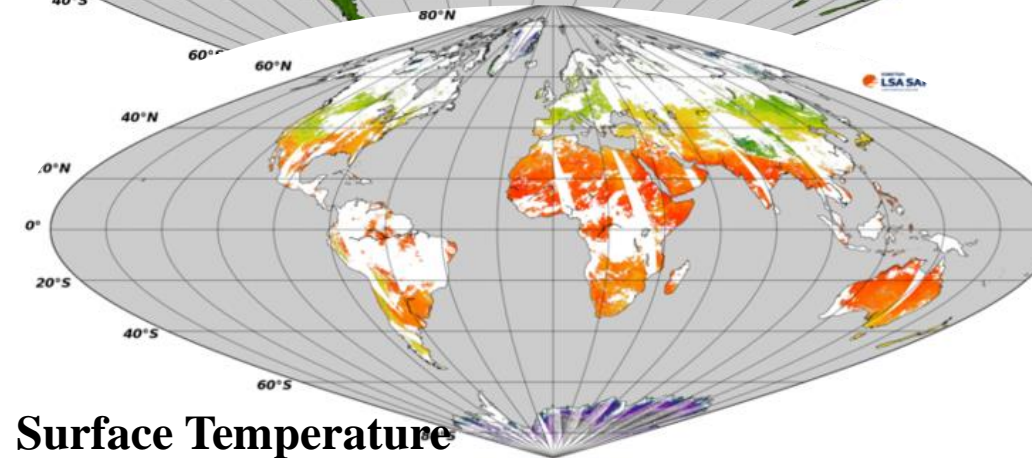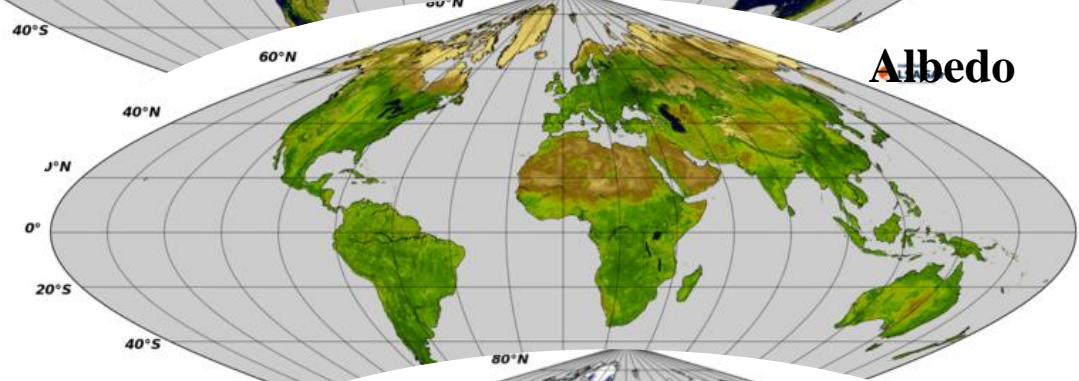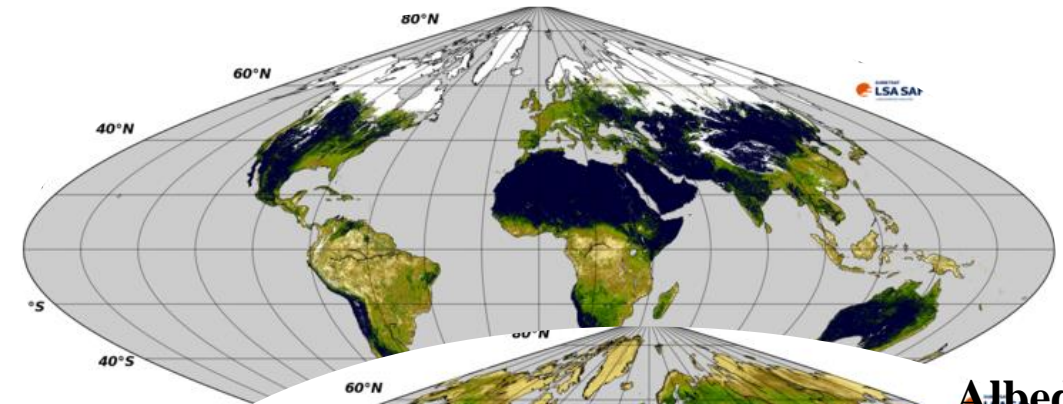
LSA-SAF products validation & quality)

Before releasing each product, a careful validation should be done, using the best available reference data.

It is very useful to assure that products is with the required quality.

Please more product information on the LSA SAF site:

http://lsa-saf.eumetsat.int

An important message to pass is that all these products, form a consistent set being compatible among them.

Most, are already available for the whole SEVIRI data-record, starting in 2004 (and some will be available soon), i.e., we have the full SEVIRI record being continuously up-dated.

FUTURE

NEXT GENERATION OF EUMETSAT SATELLITES

EUMETSAT is planning to **launch a next generation of satellites**, taking advantage of improved technology:

❖ MSG, to be replaced by MTG;

❖ METOP to be replaced by METOP-SG.

FUTURE
MTG

Meteosat Third Generation (MTG)

Looking at the next generation of EUM Satellites is expect that observations from the Flexible Combined Imager on-board MTG, will replace SEVIRI.

As a 1st step, LSA SAF is developing a set of FCI/MTG products to assure continuation of actual products.

Meteosat Third Generation (MTG)

MTG Configuration

Twin Satellite Concept, based on 3-axis platforms

– **Imaging Satellites** (MTG-I)

– **Sounding Satellites** (MTG-S)

❖ **The payload complement of the MTG-I satellite consists of**
- The Flexible Combined Imager (FCI) – replacing SEVIRI;
- The Lightning Imager (LI) - new;
- The Data Collection System (DCS);
- Search and Rescue (GEOSAR).

   ❖ **The payload complement of the MTG-S satellite consists of**
   - The Infrared Sounder (IRS);
   - The Ultra-violet, Visible and Near Infrared Sounder (UVN), provided as GMES Sentinel 4 Instruments.

Meteosat Third Generation (MTG)

FCI/MTG products as follow-up of **SEVIRI/MSG**, taking advantage of:

- Increased temporal (10-minute) & spatial samplings;
- Enhanced spectral information – improving cloud mask/info and atmospheric corrections.

Main Benefits for LSA-SAF Products:

✓ Vegetation & Albedo which can increase the ability to detect changes (e.g., snow, fire scars, harvesting, phenology);

✓ Better spatial information, a permanent require of users;

✓ Land Surface Temperature, improving the representation of the diurnal cycle;

✓ Fire Radiative Power, increasing the capacity to identify and characterize small and very large fires.

✓ …

Flexible Combined Imager
on-board MTG I1

Launch date – end of 2022

Meteosat Third Generation (MTG)

MTG IMAGER	MTG SOUNDER
MTG I1 - Planned launch date: **Late 2022**	MTG S1 - Planned launch date: **Early 2024**
MTG I2 - Planned launch date: **2025**	
MTG I3 - Planned launch date: **Around 10 years after MTG I1**	MTG S2 - Planned launch date: Around **10 years after MTG-S1**
MTG I4 - Planned launch date: **Around 10 years after MTG-I3**	

Meteosat Third Generation (MTG)

In the case of vegetation and albedo, it is expect an improvement of sampling, with increase on the ability to detect rapid changes in the surface;

For LST, increasing spatial details of surface thermal features, will certainly benefit many applications, such as urban heat or islands;

As for FRP, we expect to see an increased capacity to have more fires detect (more fires not detected before) and correct the saturation problem.

FUTURE METOP-SG

METOP-SG

Metop–SG would be the next EUM polar-orbiter is expected to have a significant increase in spectral resolution that we will get from METimage when compared to the current AVHRR.

We also expect to explore observations from the new 3MI instrument.

The nominal EPS-SG system will include a configuration of two satellites (A and B) with different sets of instruments.

Satellite A will carry instruments to fulfil the sounding and optical imaging missions:

METimage is a multi-spectral (visible and IR) imaging passive radiometer, which will provide detailed information on clouds, wind, aerosols and surface properties which are essential for meteorological and climate applications.

IASI-NG, Infrared Atmospheric Sounding Interferometer - New Generation (IASI-NG) is a passive infrared sounder which has the capability to measure the temperature and water vapour profiles of the Earth's atmosphere.

MWS, The Microwave Sounder (MWS) is a total power radiometer which measures the brightness temperature, at various altitudes, and delivers calibrated and geo-located atmospheric temperature and water vapour sounding data.

Sentinel-5 (Copernicus), will provide operational monitoring of trace gas concentrations for atmospheric chemistry and climate applications

3MI, The EPS-SG Multi-Viewing Multi-Channel Multi-Polarisation Imaging (3MI) instrument is a passive optical radiometer dedicated primarily to aerosol characterisation for applications in climate monitoring, atmospheric chemistry, and numerical weather prediction (NWP).

RO The radio occultation (RO) instrument is a passive instrument measuring the time variation of the excess path length of Global Navigation Satellite System (GNSS) signals as they are occulted by the atmosphere.

Satellite B will carry four instruments to fulfil the passive micro-wave and sub-millimetre-wave imaging, scatterometry, and radio occultation sounding missions:

- The **Scatterometry mission (SCA),** provides back-scattered signals to measure ocean-surface vector winds and soil moisture of land surfaces at a spatial resolution of 25 km;
- The **Micro-Wave Imaging mission (MWI),** provides precipitation and cloud imaging in 18 channels (8 of which being dual-polarisation) at a spatial resolution from 10 km (highest frequency) to 50 km (lowest frequency);
- The **Ice Cloud Imaging mission (ICI)** provides ice cloud and snowfall imaging in 11 channels (2 of which being dual-polarisation)
- A second **RO (Radio Occultation)** sounding instrument to complement that on Metop-SG A to provide a higher number of all-weather RO soundings of temperature and water vapour by tracking GPS, Galileo and optionally GLONASS, and Compass-Beidou satellites.
- **Advanced Data Collection System (A-DCS4)** Metop-SG B satellite also carries an instrument for the collection and transmission of observations and data from surface, buoy, ship, balloon or airborne data collection platforms.

METOP-SG

METOP-SG A	METOP-SG B
Metop-SG A1 - Plan Launch date: **Q2 2024**	Metop-SG B1 - Plan Launch date: **Q4 2024**
Metop-SG A2 - Plan Launch date: **2031**	Metop-SG B2 - Plan Launch date: **2032**
Metop-SG A3 - Plan Launch date: **2038**	Metop-SG B3 - Plan Launch date: **2039**

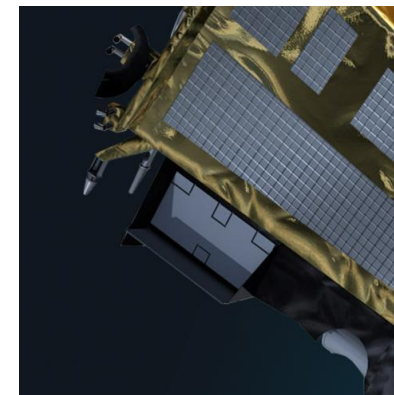# EUM Satellites – Next Generation

Metop – Second Generation
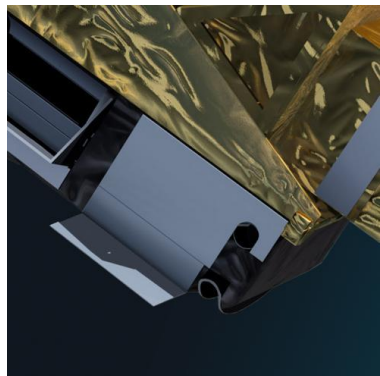
METimage

on-board Metop-SG A1
Launch date – 2024

3MI

METimage products as follow-up of **AVHRR/Metop**

Enhanced spectral information together with increased spatial sampling leading to:

✓ More competitive (albedo, vegetation, LST) products;

✓ New LSA-SAF global products:

- Fire Radiative Power and Emissions
- Burned Scars (shapes and date of burn)

3MI products - NEW instrument

Explore multiple band & multiple angle observations for fast BRDF global updates, i.e.,

✓ Global Albedo

✓ Global Vegetation (FVC, LAI, FAPAR)

The Future: CDOP-4 (2022-2027) and Beyond

Service Continuity

- ✓ SEVIRI/MSG & AVHRR/Metop products throughout the missions' lifetime
- ✓ Maintaining Product/Dataset Quality Assurance

Service Evolution

- ✓ Enhancing existing products with Next Generation
  - ▪ SEVIRI/MSG towards FCI/MTG
  - ▪ AVHRR/Metop towards Metimage/EPS-SG
  - ▪ Ensuring consistency among LSA-SAF products
  - ▪ Seek consistency between missions follow-ups
- ✓ Exploiting New Capabilities & New Sensors (e.g., 3MI)
  - ▪ New Products and Thematic Areas

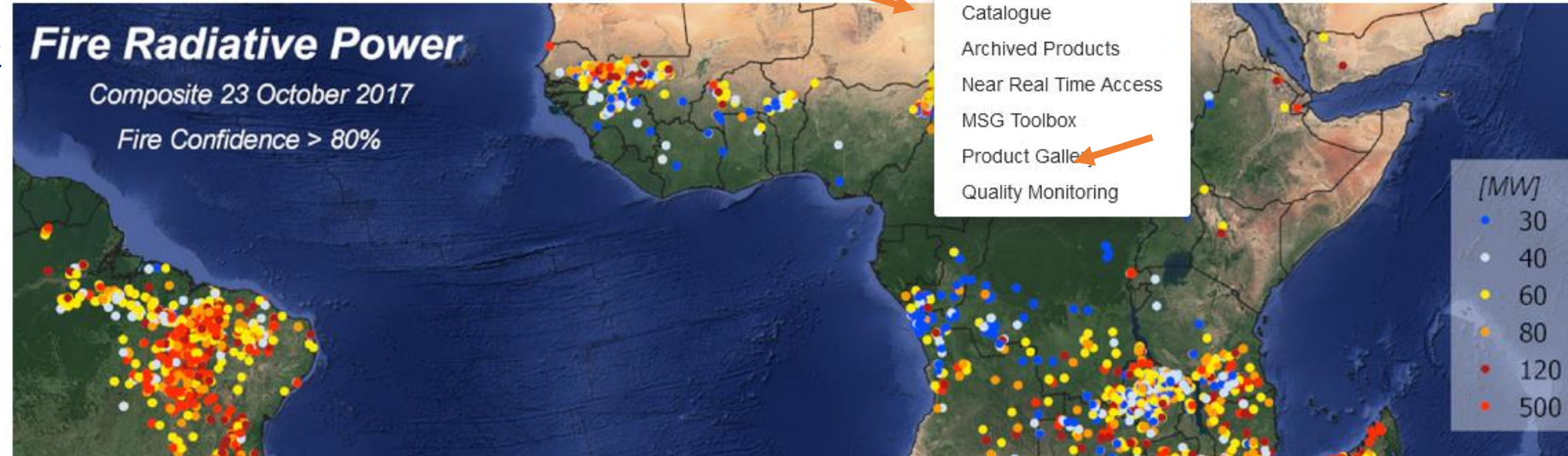## Long Time-Series: Monitoring the Present with an Eye on the Past

- ✓ Promote the Use of LSA-SAF NRT products and data records to follow changes in Land Surfaces

http://lsa-saf.eumetsat.int

See "**Catalogue**" to search for products & Datasets

Register to download data

Send us your feedback or questions to **helpdesk.landsaf@ipma.pt**

THANK YOU TO BE SO PATIENT !!!