

Vegetation monitoring in the framework of EUMETSAT Land Surface Analysis SAF (land-SAF/LSA-SAF):

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Based on material provided by:

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Carla Barroso (IPMA, Portugal)**

LSA-SAF MSG Products

Surface Radiation

LST

↓ LongWave Flux

Albedo

↓ 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



Outline

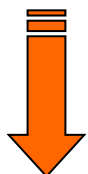
- Basic Principles (Spectral signatures)
- MSG channels for vegetation monitoring
- Land SAF vegetation products (FVC, LAI, fAPAR)
 - Products characteristics
 - Products validation and quality assessment
 - Potential applications

■ Spectral Signatures

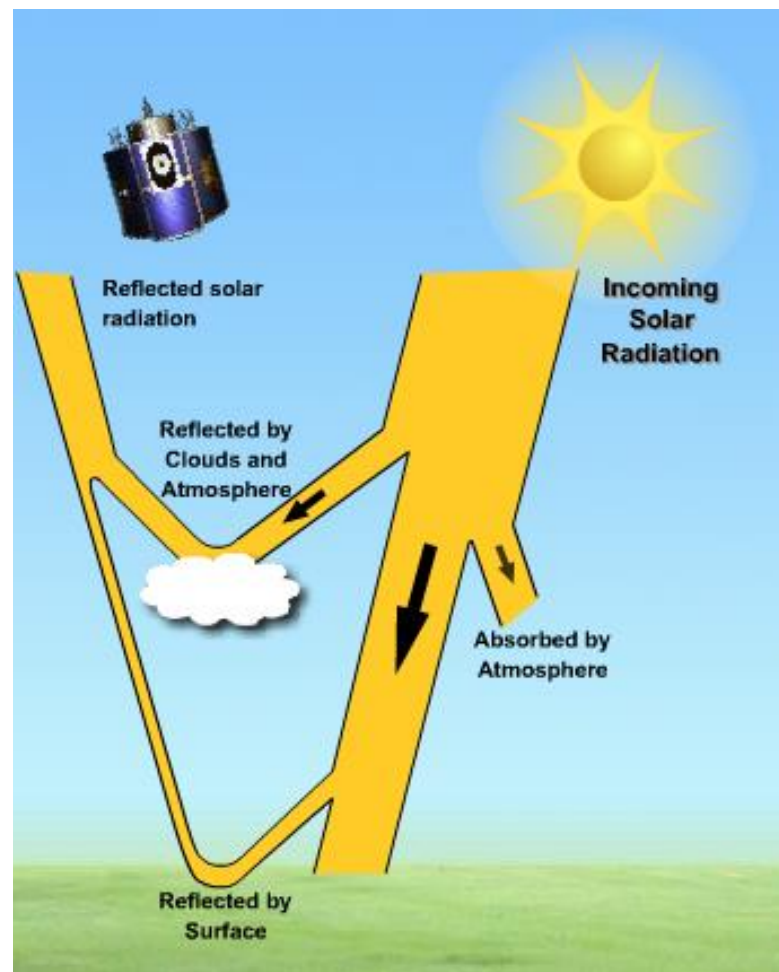
■ Different materials **reflect** and **absorb** differently at different wavelengths.



■ Have different **spectral signatures**.

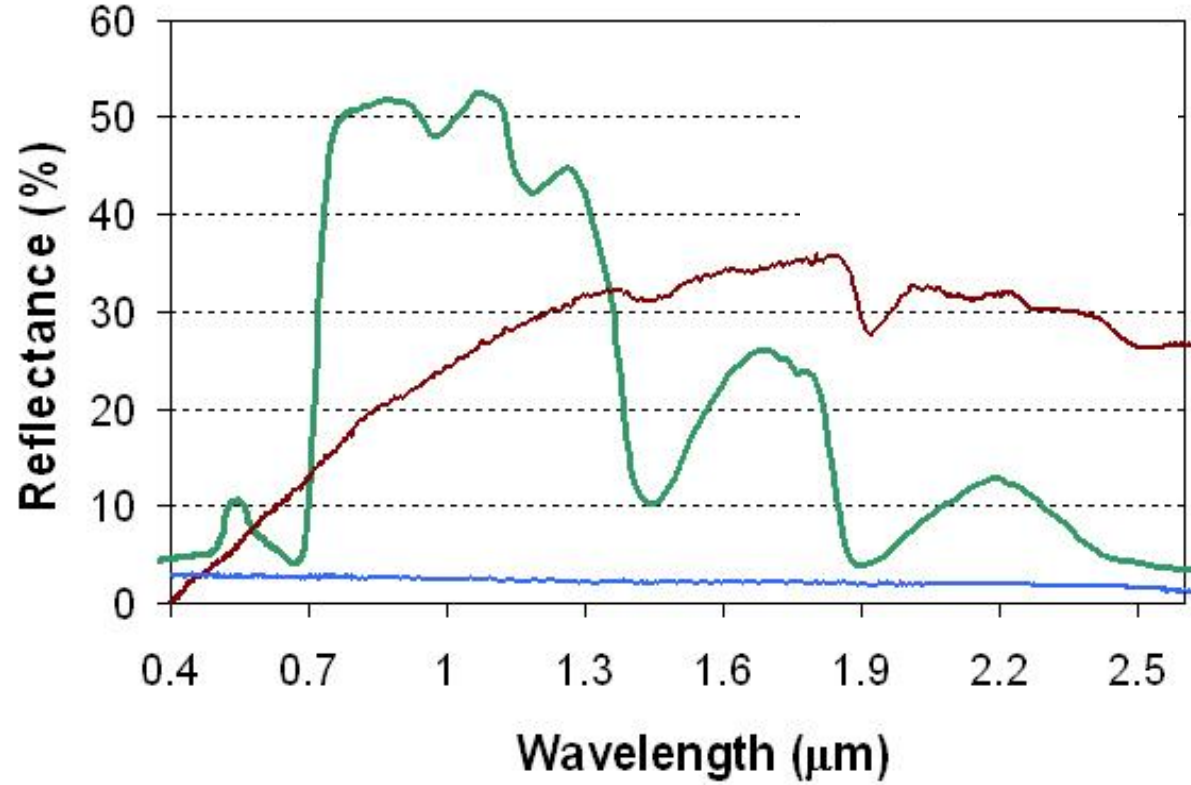


■ Enables to distinguish the different features from remotely sensed data.



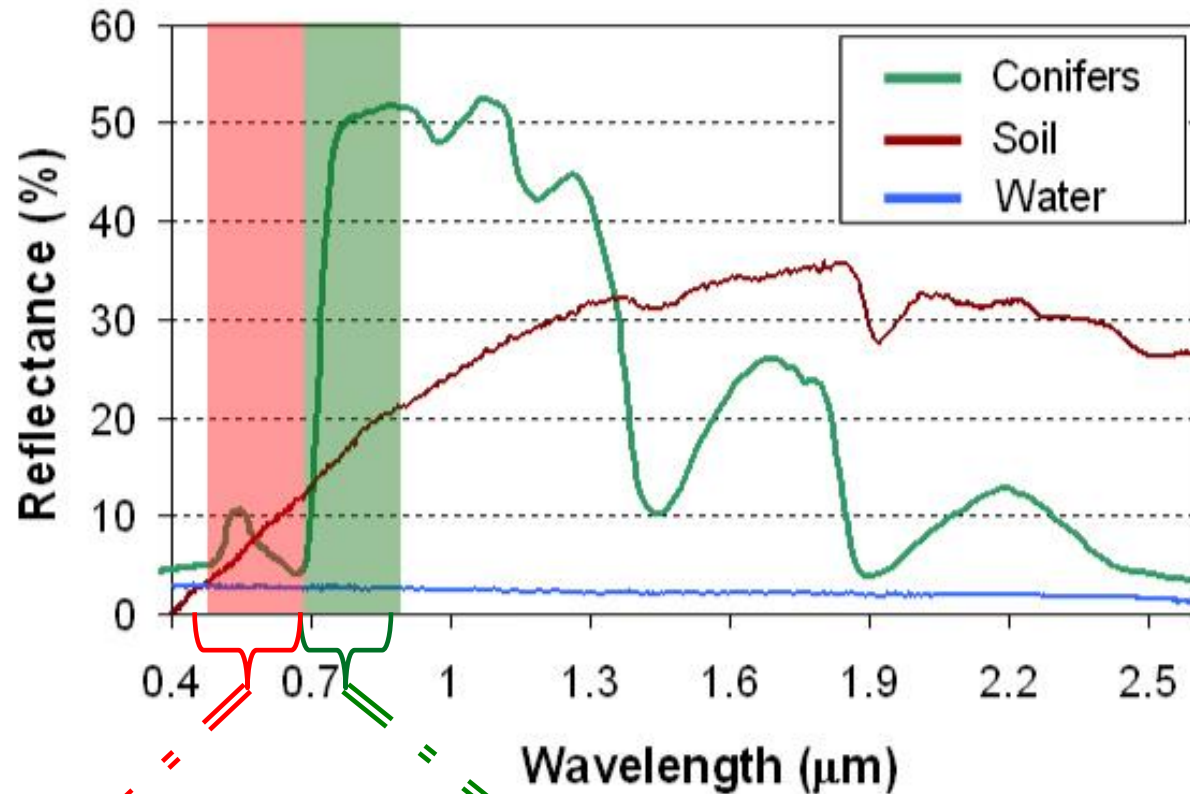
Spectral Signatures

**Spectral Signature
Or
Spectral response curves**



Spectral Signatures

Spectral Signature
Or
Spectral response curves

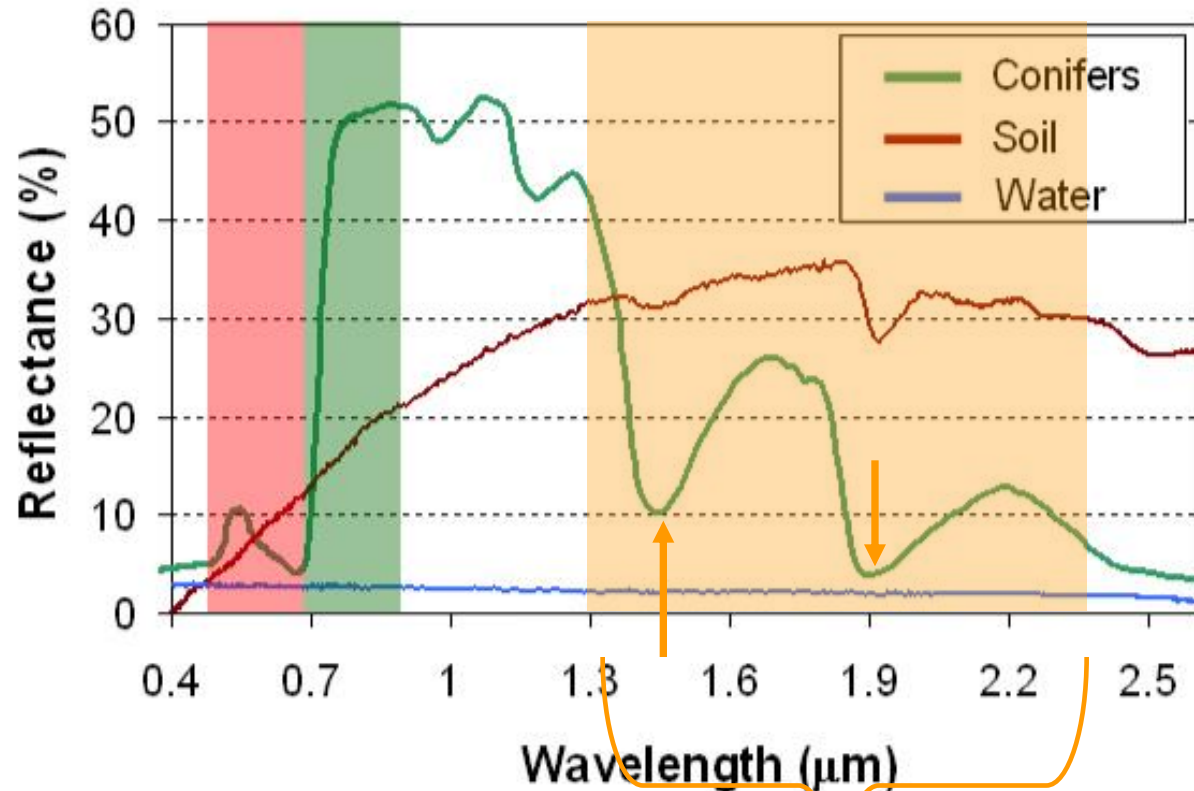


Strong absorption
(reflectance peak at
0.55 μm)

**High reflectance in
the NIR (0.8 μm)**

Spectral Signatures

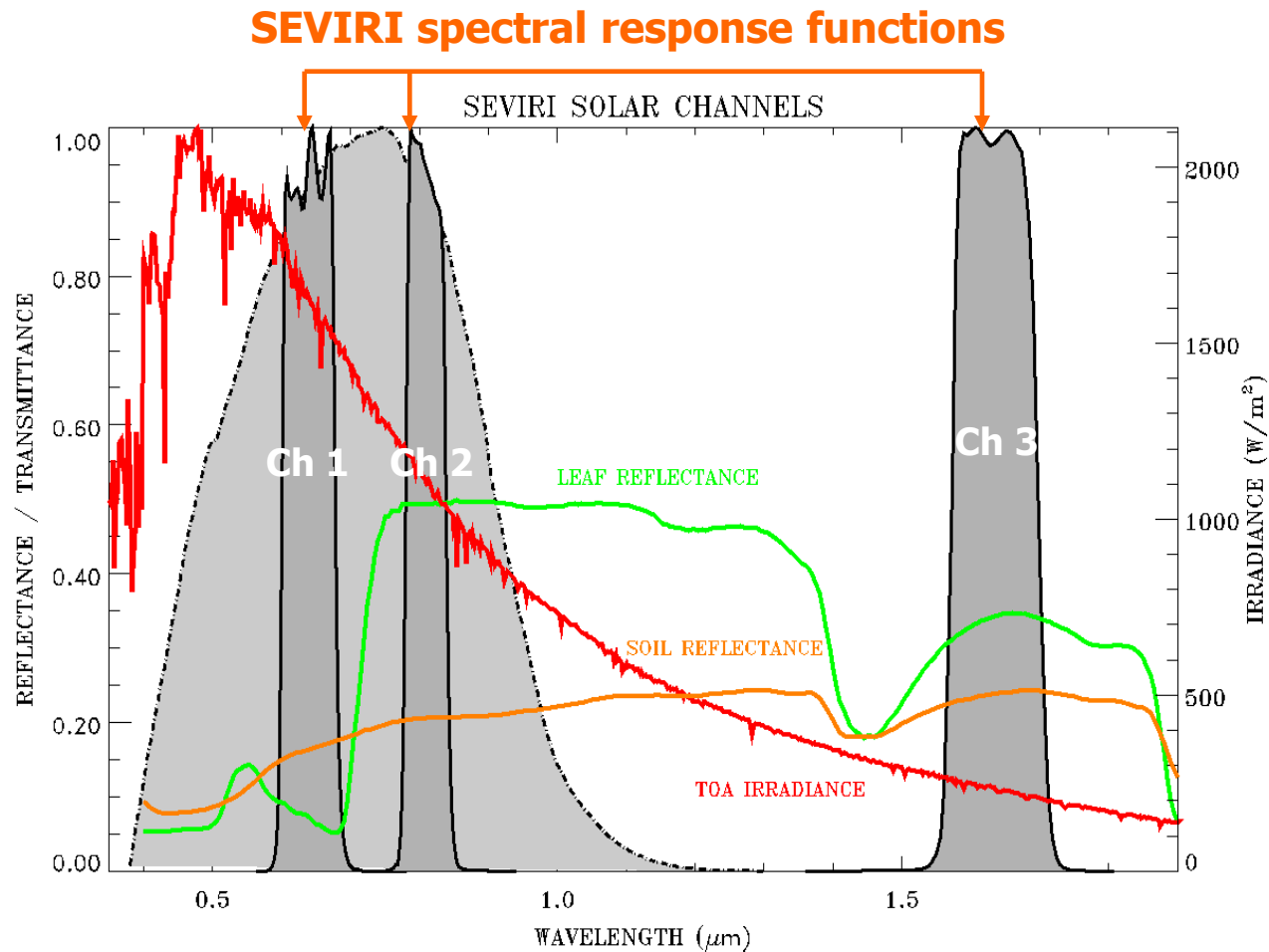
Spectral Signature Or Spectral response curves



**absorption by water,
cellulose and lignin and
several other biochemical
constituents**

To identify the spectral signature of a material, the sensing system need to have enough spectral resolution in order to distinguish its spectrum from those of other materials!

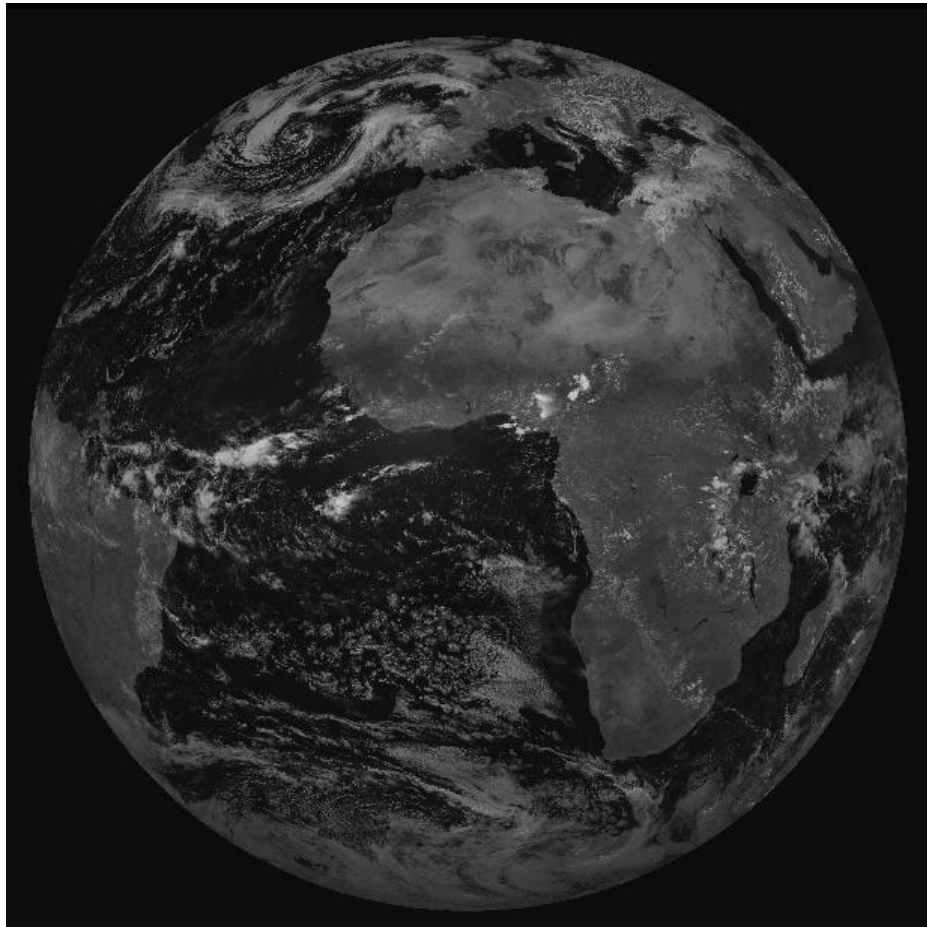
MSG channels for vegetation monitoring



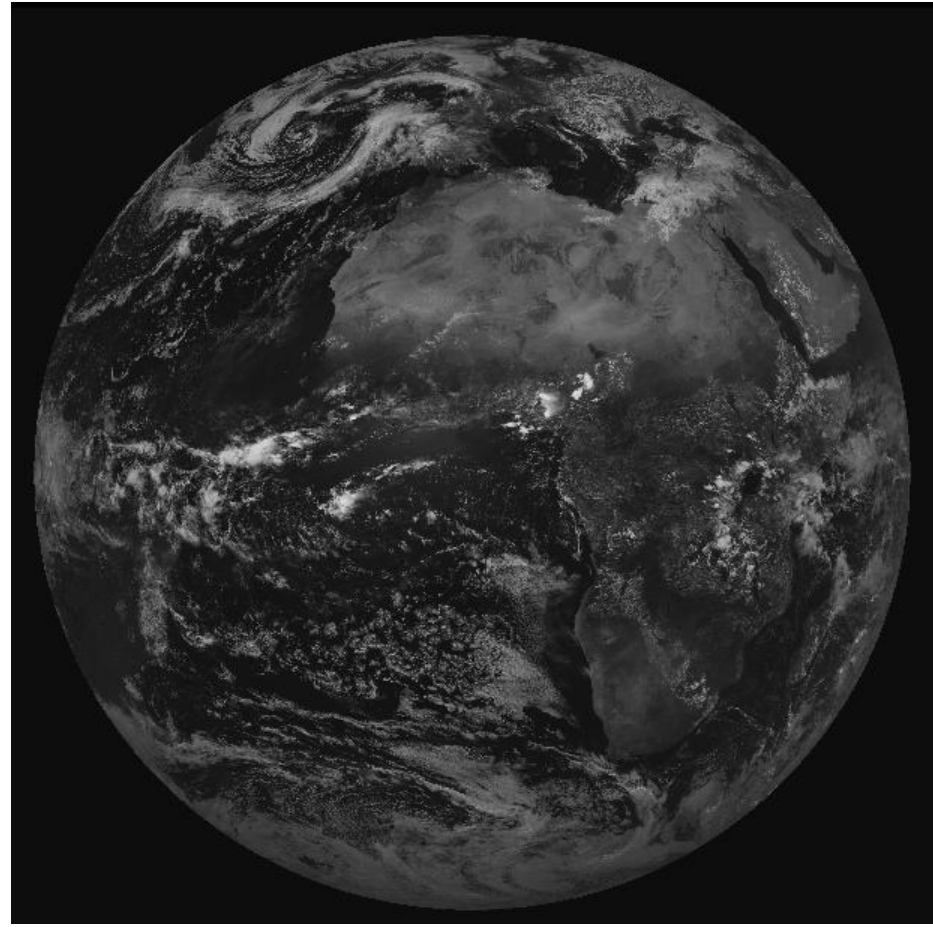
Source: http://www.eumetrain.org/resources/operational_use_rgb.html

MSG channels for vegetation monitoring

Which of the images correspond to MSG 0.8 μm channel?



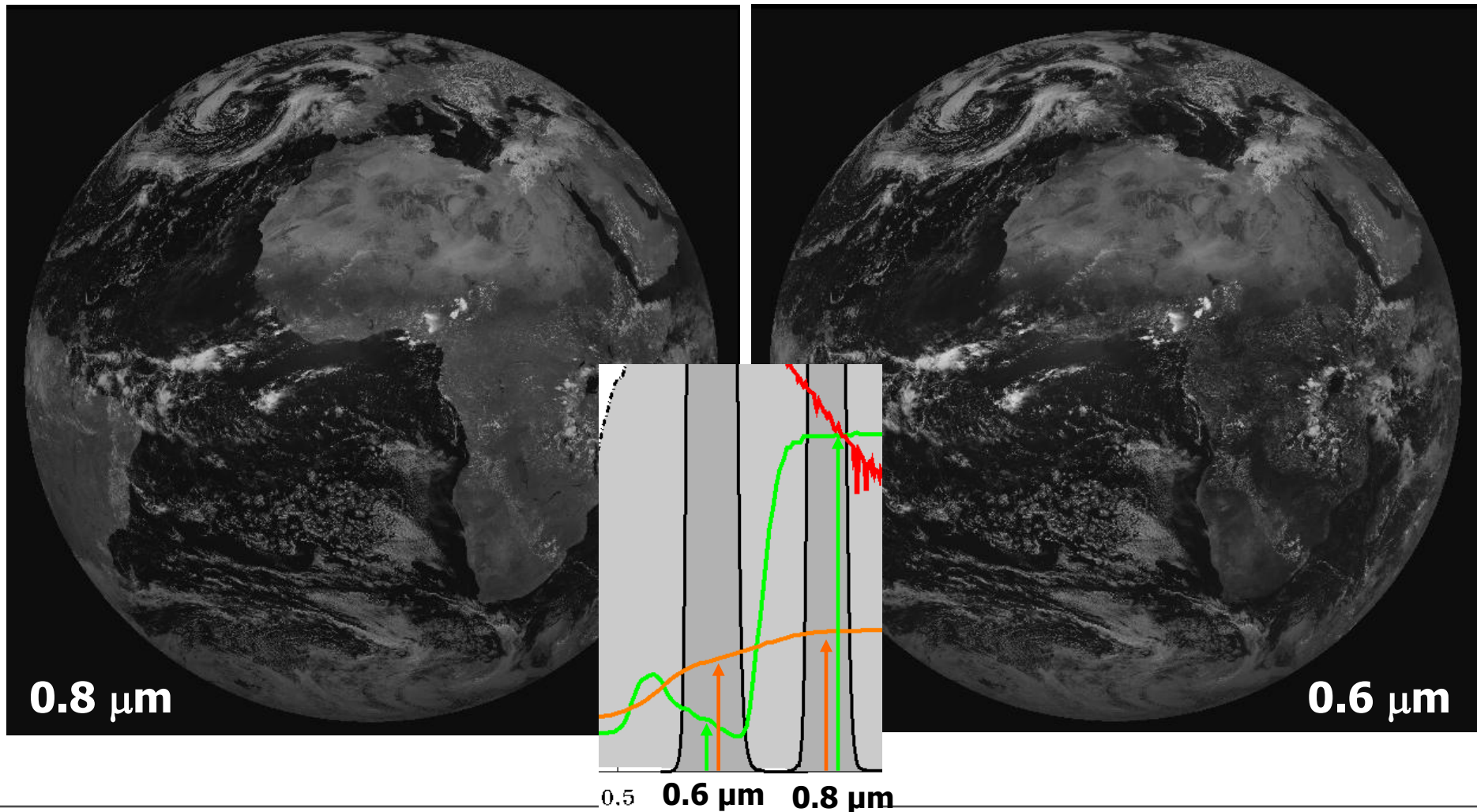
A



B

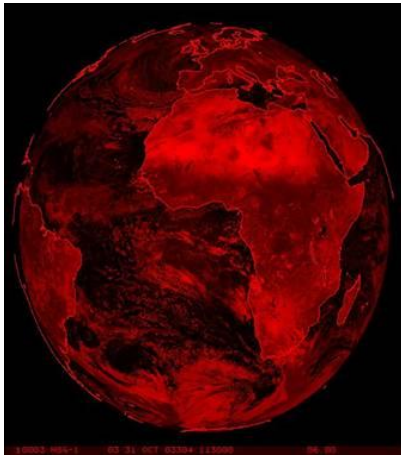
MSG channels for vegetation monitoring

Which of the images correspond to MSG 0.8 μm channel?

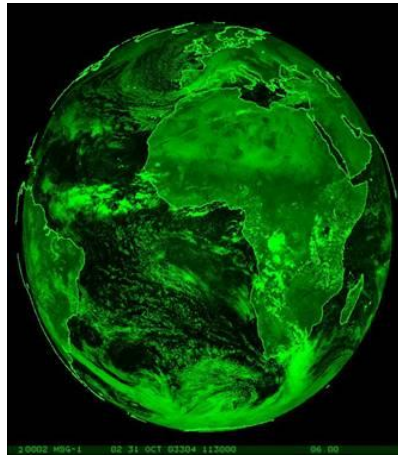


RGB Techniques

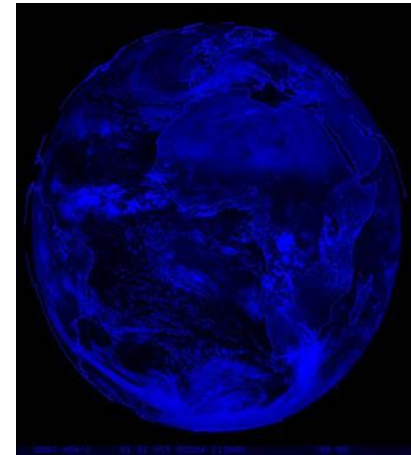
RGB Techniques – works by associating a colour to a particular channel



Red - MSG 1.6 μm



Green - MSG 0.8 μm

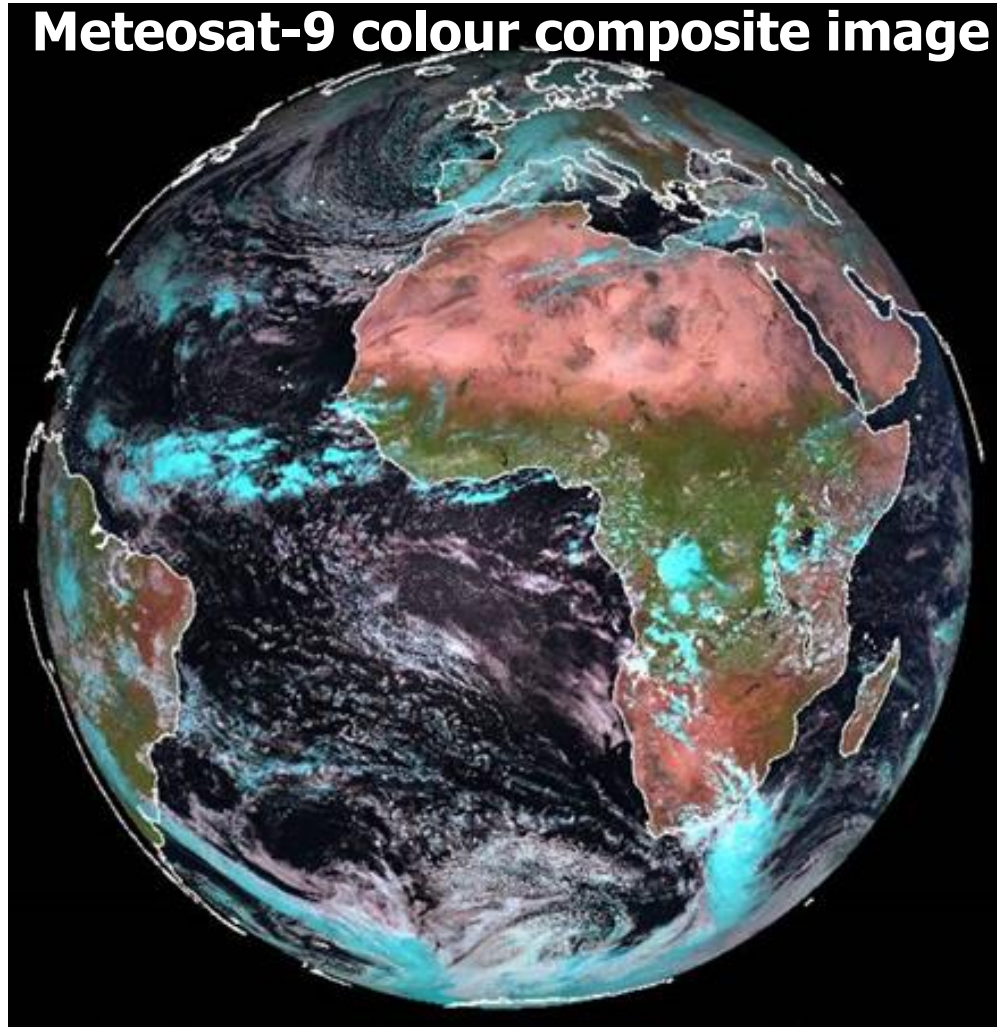


Blue - MSG 0.6 μm

Source: http://www.eumetrain.org/resources/operational_use_rgb.html

RGB Techniques

Meteosat-9 colour composite image



Red - 1.6 μm ;
Green - 0.8 μm ;
Blue - 0.6 μm

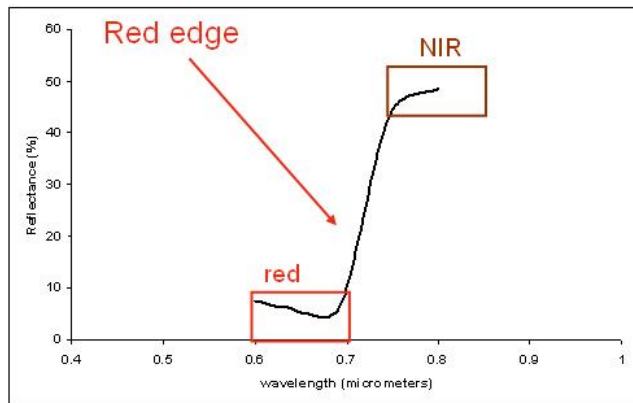
Natural colour

Source: http://www.eumetrain.org/resources/operational_use_rgb.html

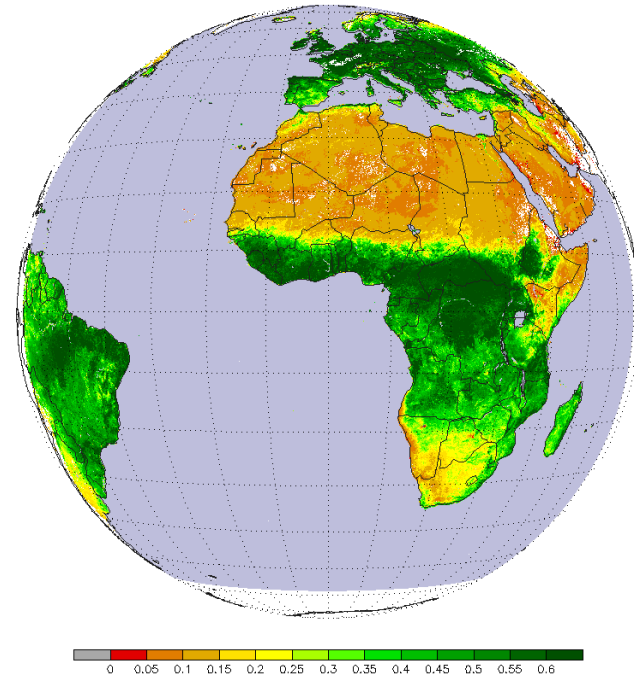
Vegetation Indices

$$NDVI = \frac{\rho_{\text{channel2}} - \rho_{\text{channel1}}}{\rho_{\text{channel1}} + \rho_{\text{channel2}}}$$

SEVIRI/MSG Channels 1 e 2 reflectances



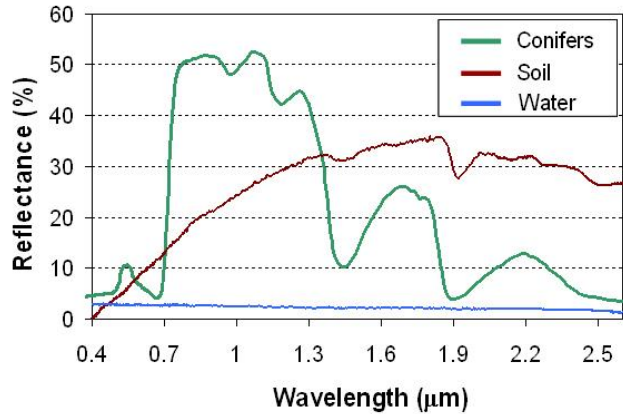
NDVI (15 June 2008)



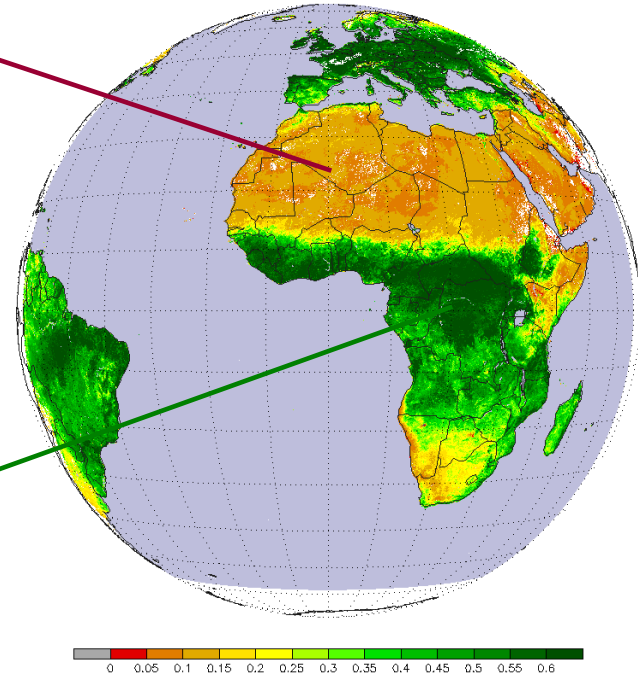
NDVI daily composite of SEVIRI full disk, June 15, 2008 (Source: Yu, Y. et al. Development of Vegetation Products for U.S. GOES-R Satellite Mission, Presented on 4th Global Vegetation Workshop Univ. of Montana, Missoula, June 16-19 2009)

Vegetation Indices

For bare soil NDVI ~ 0



NDVI (15 June 2008)



For **vegetated** areas
NDVI ranges
between 0.2 and 0.6

NDVI daily composite of SEVIRI full disk, June 15, 2008 (Source: Yu, Y. et al. Development of Vegetation Products for U.S. GOES-R Satellite Mission, Presented on 4th Global Vegetation Workshop Univ. of Montana, Missoula, June 16-19 2009)

Biogeophysical Parameters

Parameters related to the structure of vegetated surfaces:

Fraction of Vegetation Cover (FVC): fraction of the surface covered by vegetation [0 – 1] and

Leaf Area Index (LAI): total area occupied by the leaves per unit area [m^2/m^2].

Parameter related with the state of vegetation

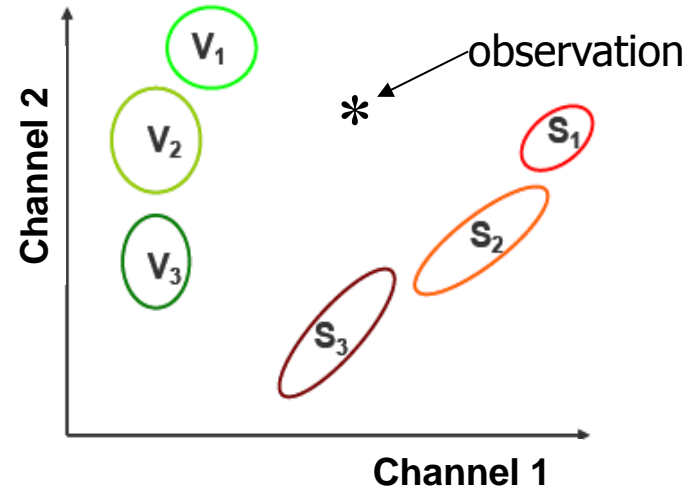
Fraction of Absorbed Photosynthetically Active Radiation (FAPAR): part of radiation used for photosynthesis ($0.4 - 0.7\mu\text{m}$) absorbed by the green parts of the canopy



LSA SAF FVC Algorithm

FVC, LAI, FAPAR are based in the analysis of vegetation signature in the **0.6 μm , 0.8 μm & 1.6 μm channels.**

- For any given observation (*) the algorithm assumes this value can be modelled by the pairs ($\rho_{\text{vegetation}}$, $\rho_{\text{soil subclass}}$)
- The pure types, V_i and S_i for **each pixel** are obtained by the **prevalent Land-cover**
- The distances between (*) and V_i , S_i give the fractions of each vegetation and soil type within the scene



$$FVC = \sum_{i=1}^N fvc_{V_i}$$

Number of vegetation subclasses present in the pixel

Fraction of vegetation cover for vegetation type V_i

Full description at <http://landsaf.meteo.pt>

LAI ESTIMATION

semi-empirical method in which LAI is related to FVC according to:

$$1) \quad LAI = \frac{-1}{b \cdot G(\theta_s = 0) \cdot \Omega} \cdot \frac{\ln(a_0 - FVC)}{a}$$

B, G constants and A_0, Ω coefficients depending on LandCover.

fAPAR ESTIMATION

estimated from a Renormalised Difference Vegetation index

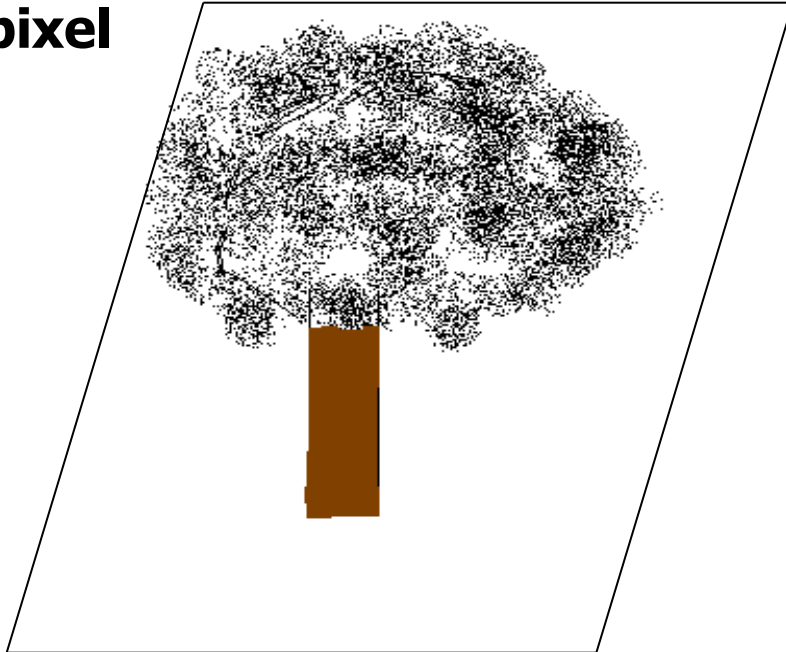
$$2) \quad RDVI = \frac{\rho_{\text{channel2}} - \rho_{\text{channel1}}}{\sqrt{\rho_{\text{channel1}} - \rho_{\text{channel2}}}}$$

View-illumination geometry
may have a large impact on reflectances

$$3) \quad fAPAR = 1.81RDVI_{\text{opt}} - 0.21$$

Biogeophysical Parameters

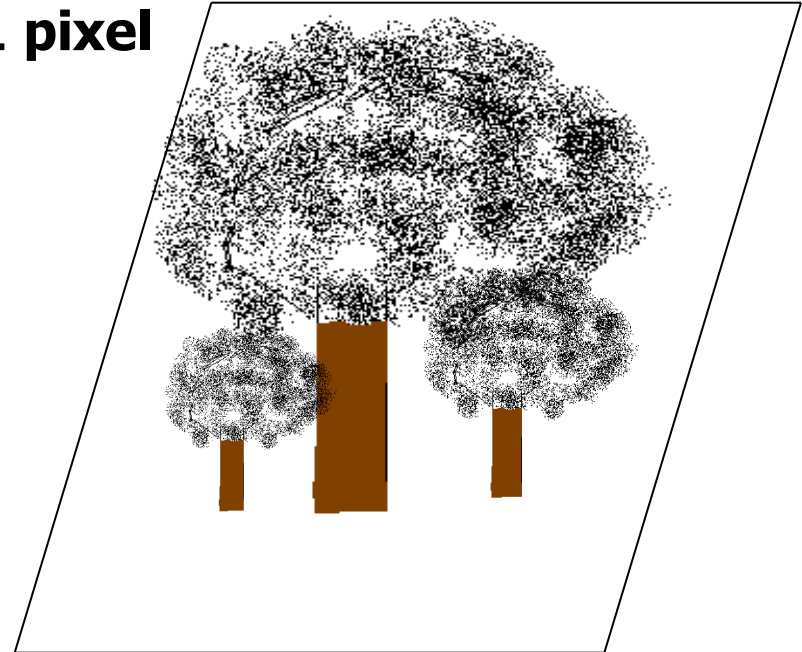
1 pixel



FVC=0.8
LAI= 5

a ..?

1 pixel



FVC=0.8
LAI= 5

b ..?

FVC=0.6
LAI= 5

c ..?

FVC=0.8
LAI= 7

d ..?

LSA SAF Vegetation Products

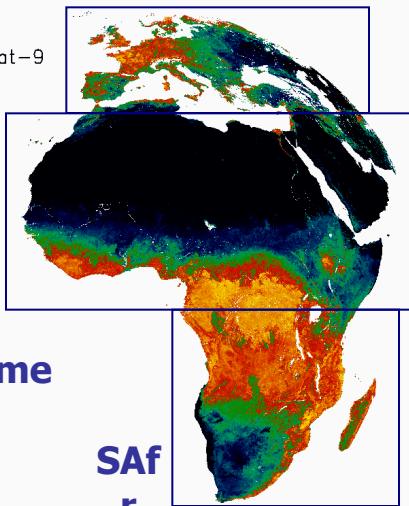
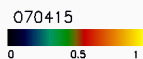
FVC

Euro

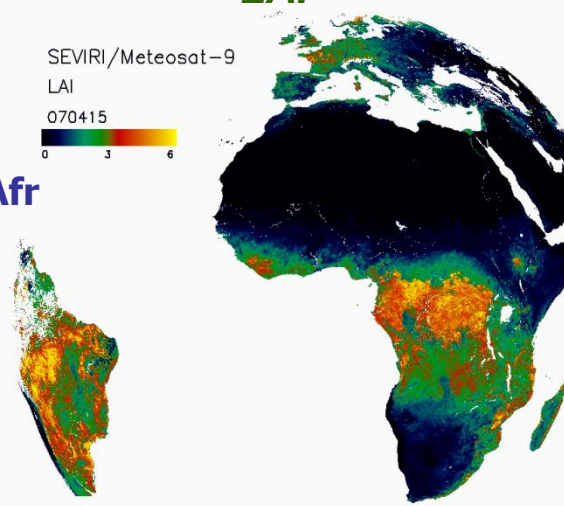
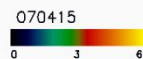
LAI

FAPAR

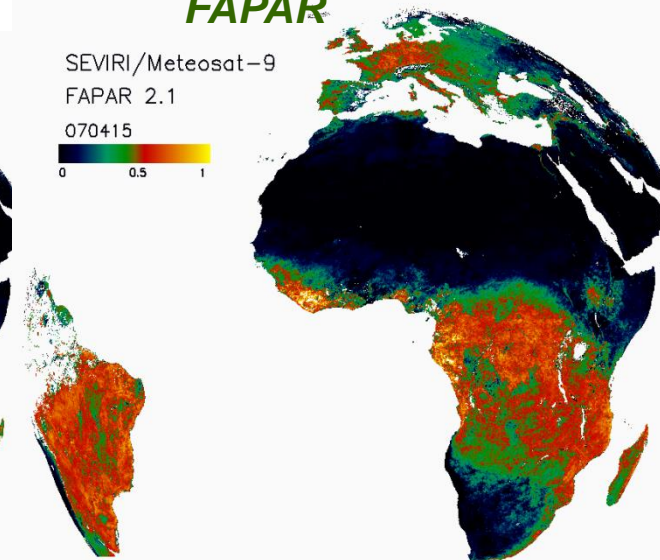
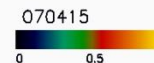
SEVIRI/Meteosat-9
FVC



SEVIRI/Meteosat-9
LAI

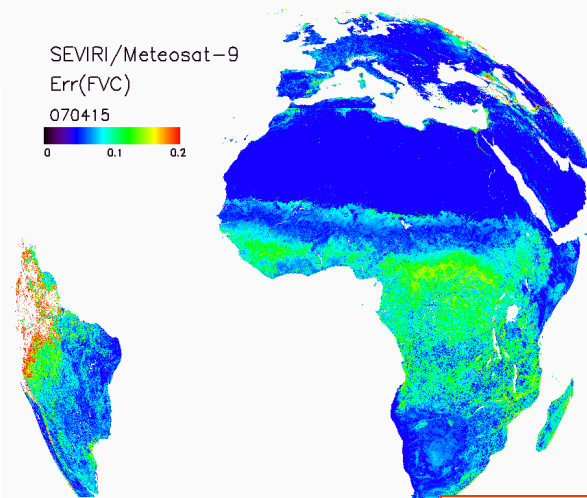
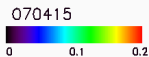


SEVIRI/Meteosat-9
FAPAR 2.1

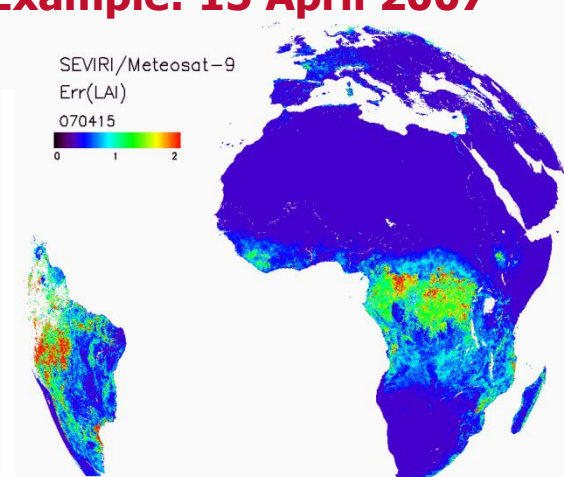


Example: 15 April 2007

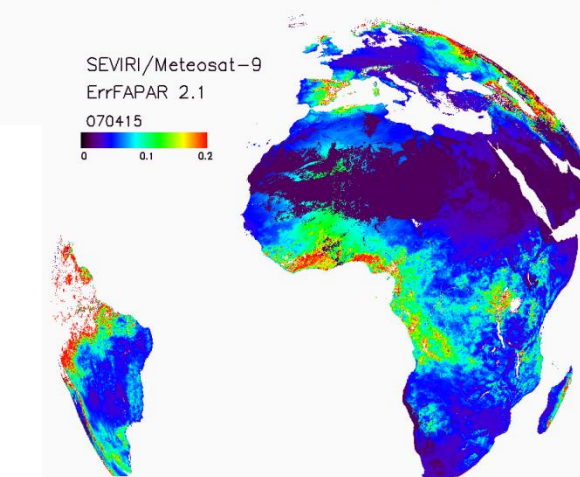
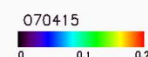
SEVIRI/Meteosat-9
Err(FVC)



SEVIRI/Meteosat-9
Err(LAI)

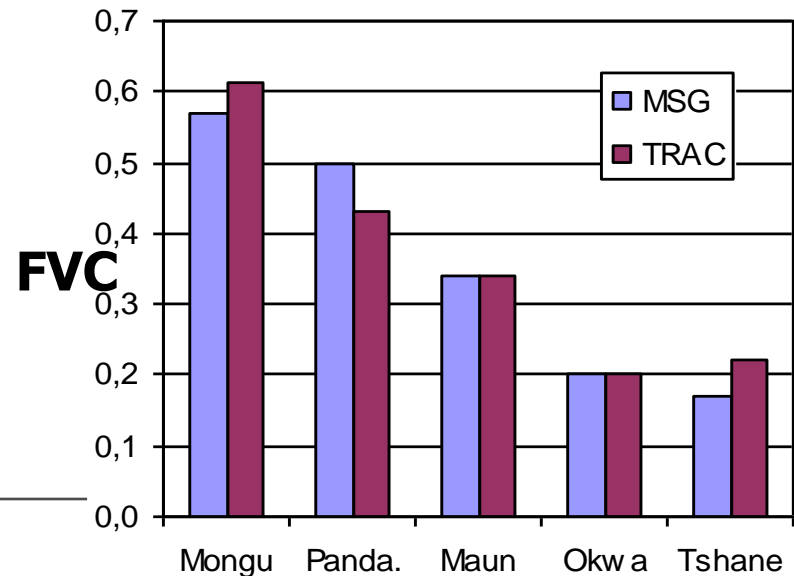
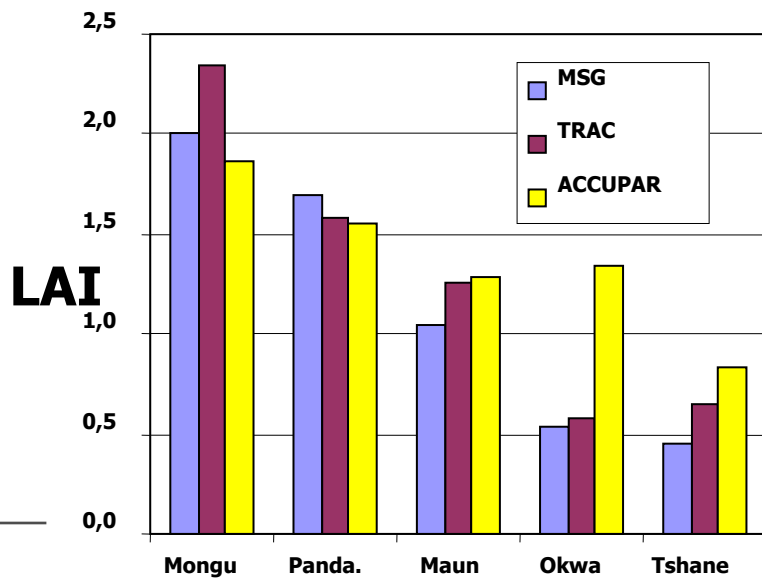
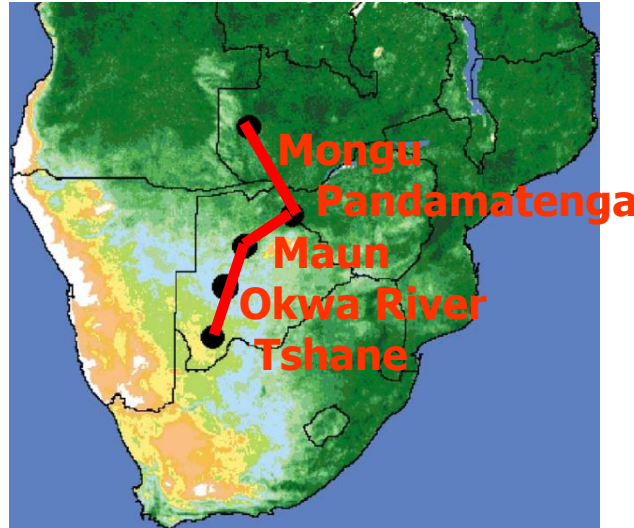


SEVIRI/Meteosat-9
ErrFAPAR 2.1



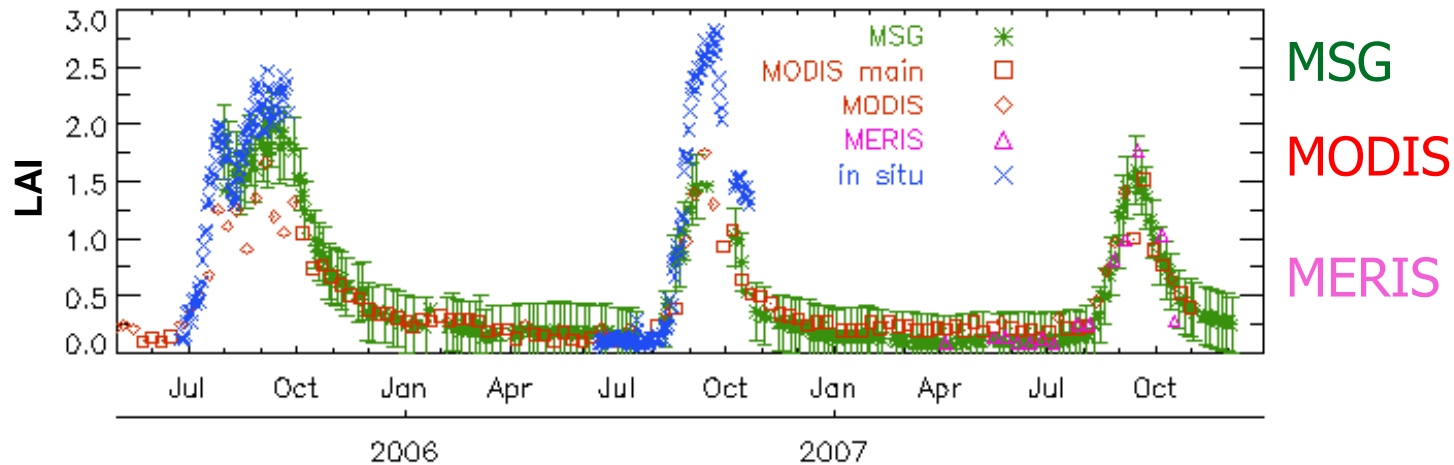
- <http://landsat.meteo.pt>
- **EUMETCAST**

Products Validation



➤ Comparison with in situ measurements

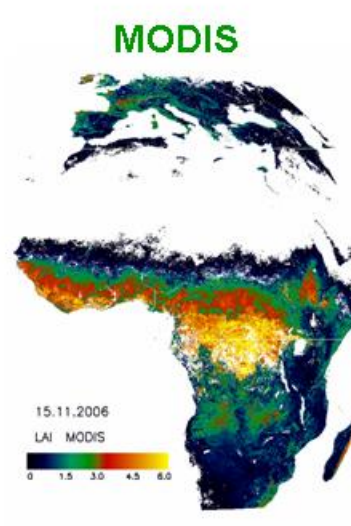
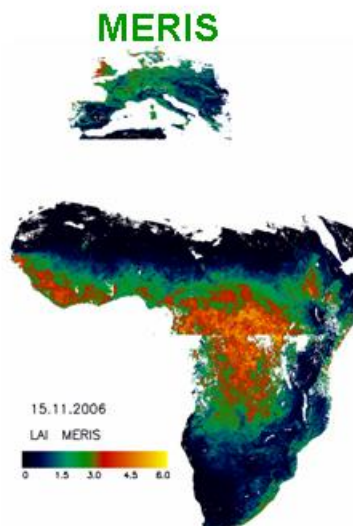
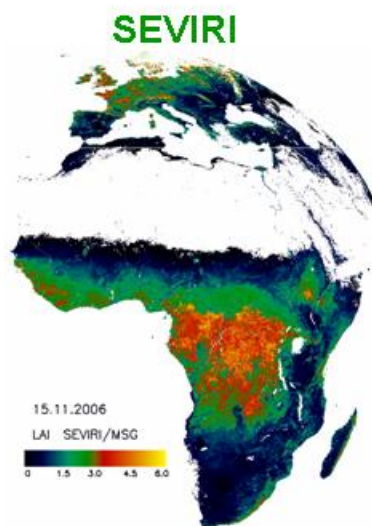
Dahra (Senegal)



- All products are consistent with ground measurements;
- LSA SAF LAI better follows the seasonality of the vegetation activity during 2006 and 2007;
- The peak of the green season is well captured by LSA SAF LAI;

Products Validation

November 2006:

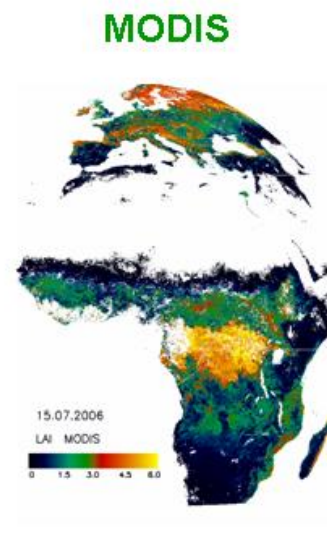
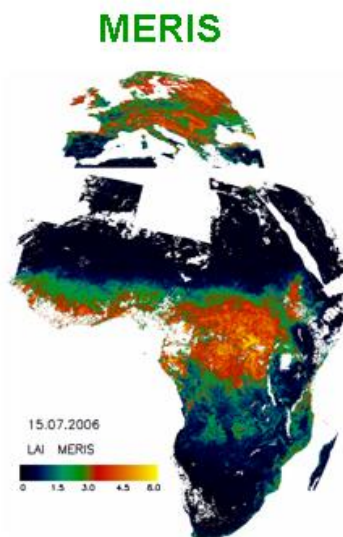
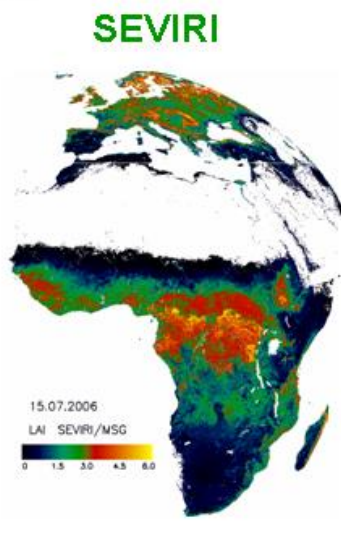


LAI

**SEVIRI/
MERIS/
MODIS**

- High spatial consistency;
- LSA SAF LAI presents less gaps in vegetated areas.

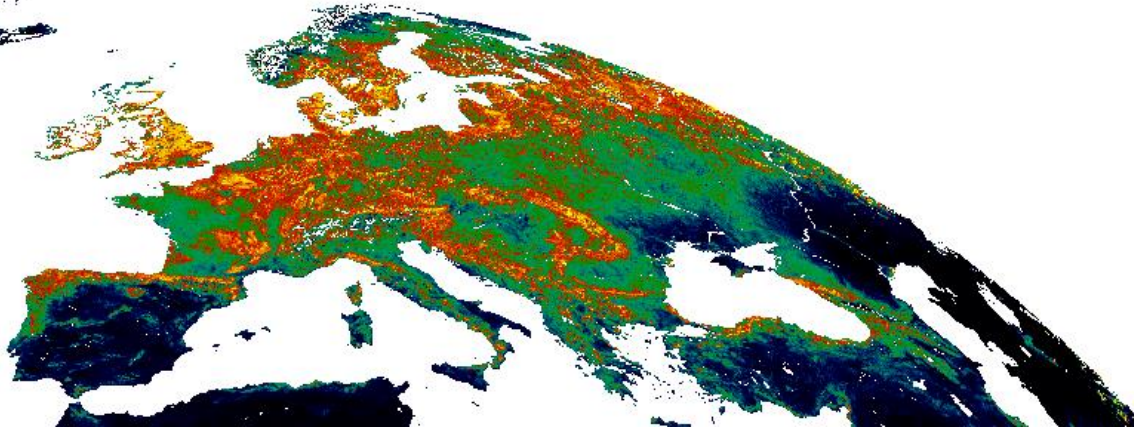
July 2006:



Quality monitoring

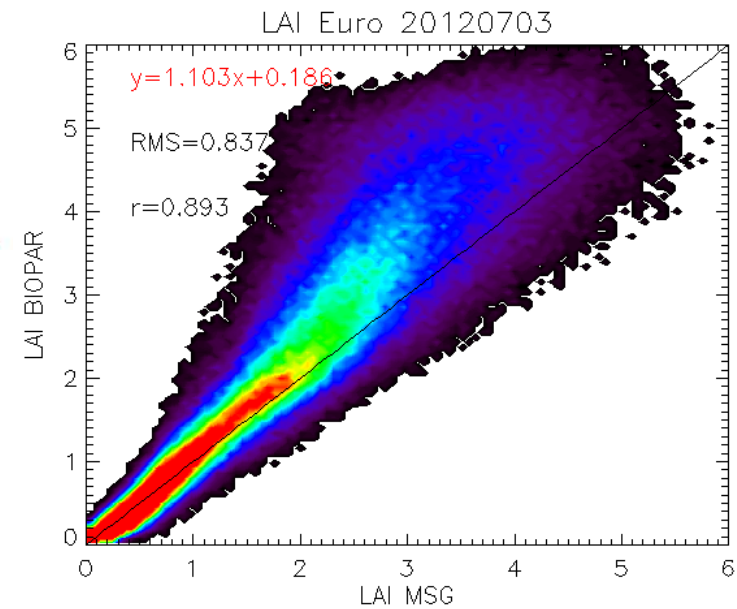
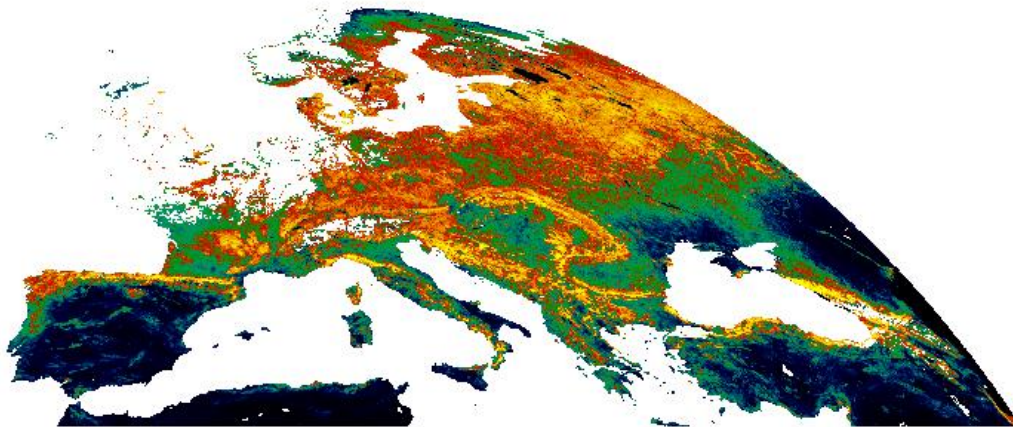
MSG VEGA PRODUCTS

20120703



BIOPAR PRODUCTS

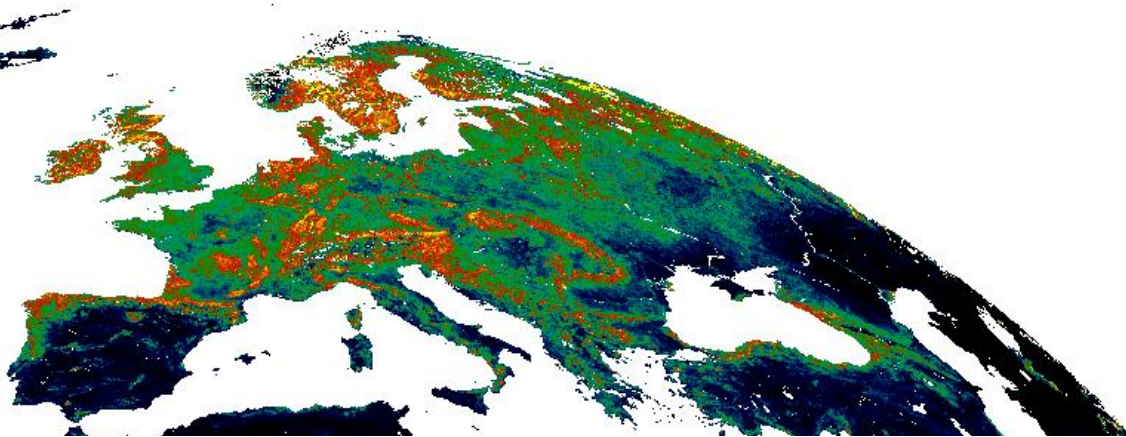
20120703



Quality monitoring

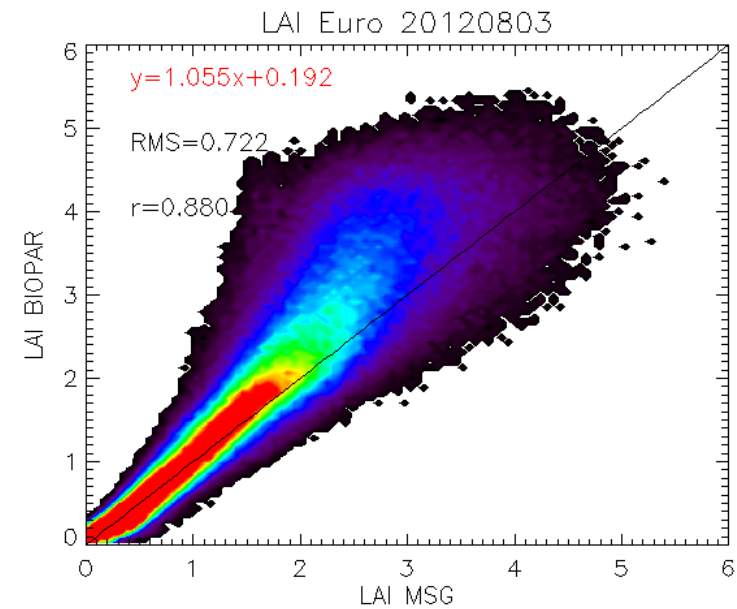
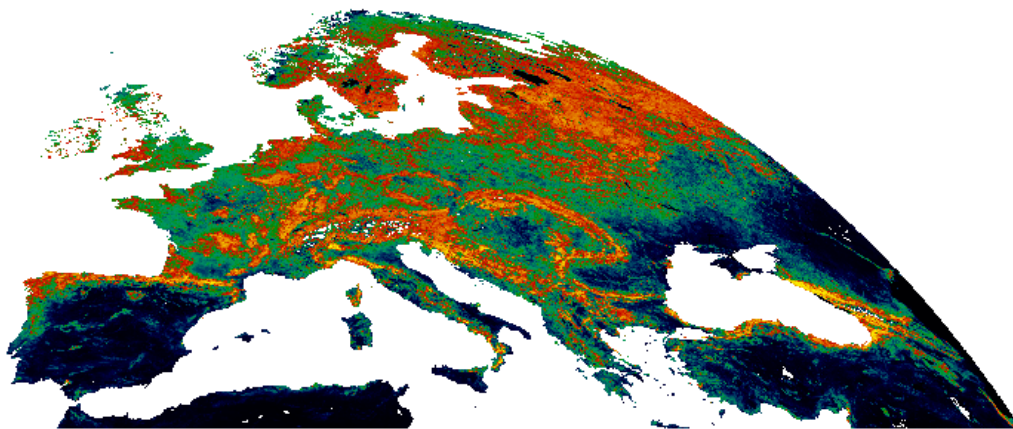
MSG VEGA PRODUCTS

20120803



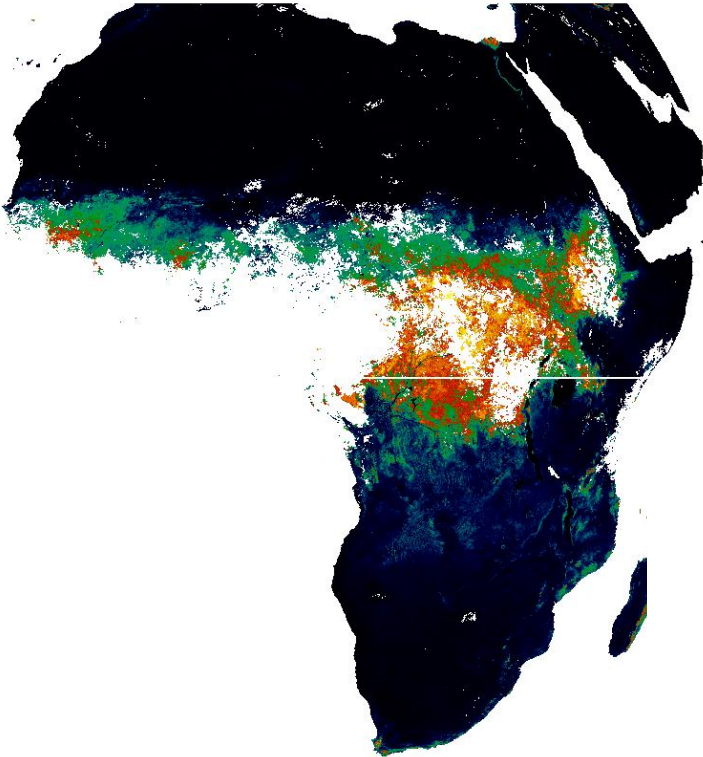
BIOPAR PRODUCTS

20120803

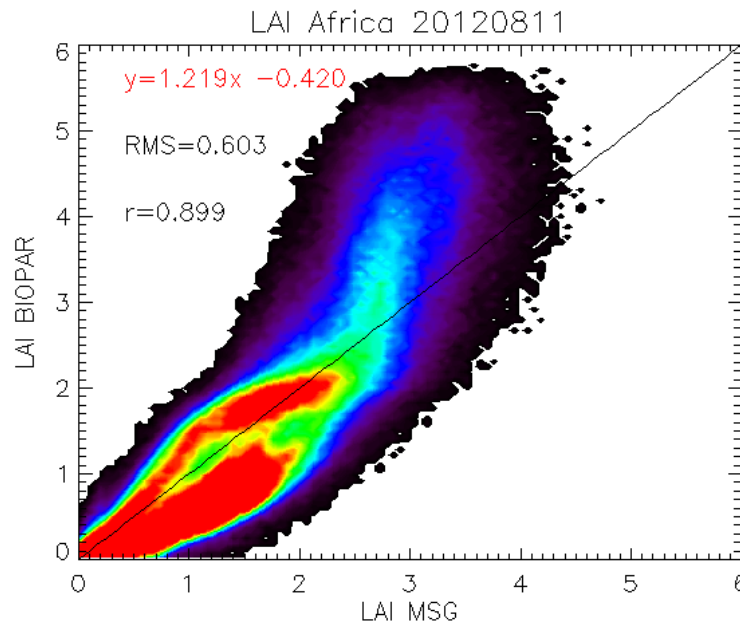
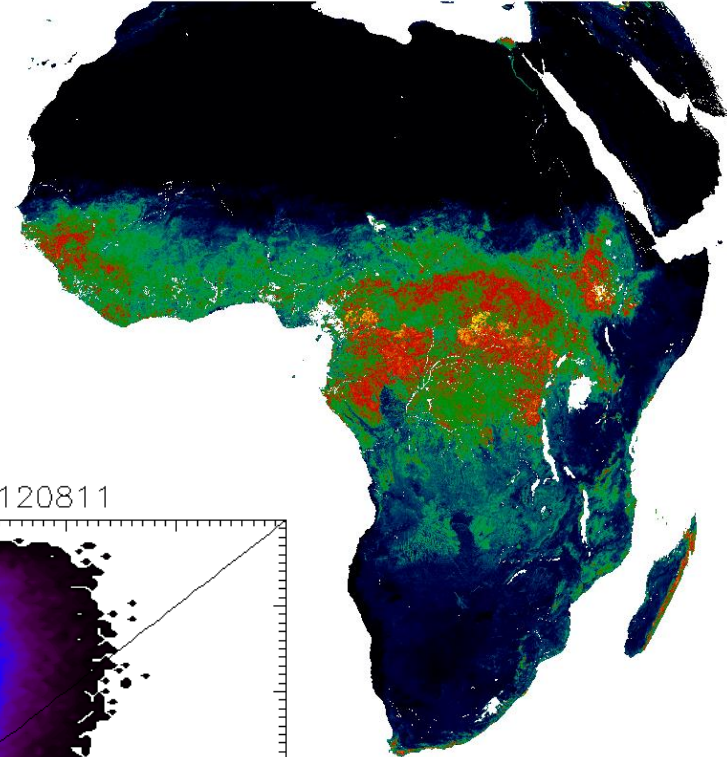


Quality monitoring

BIOPAR PRODUCTS
20120811



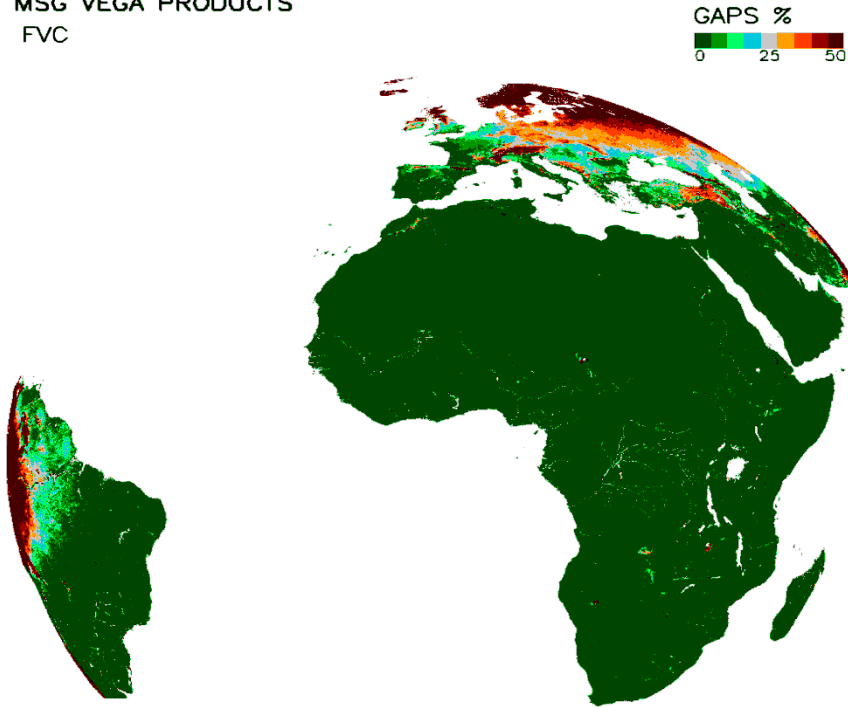
MSG VEGA PRODUCTS
20120811



Overall quality of LSA SAF Vegetation Products

Percentage of gaps over 1 year of data

MSG VEGA PRODUCTS
FVC



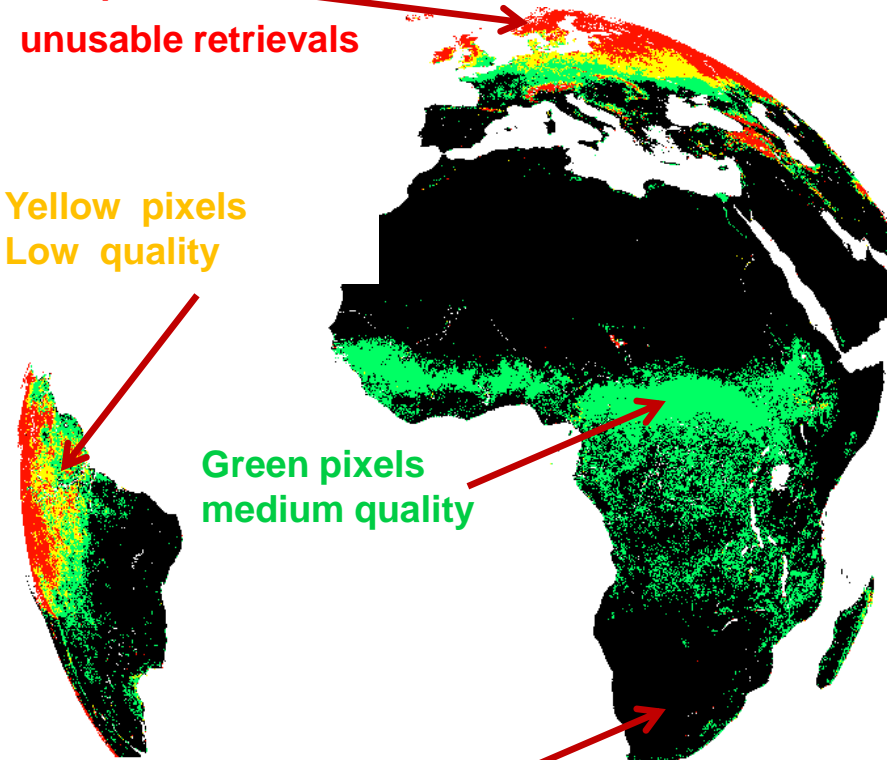
Mean value of the product error along year 2007

Red pixels
unusable retrievals

Yellow pixels
Low quality

Green pixels
medium quality

Black pixels
Optimal quality of retrievals



- ✓ Detect the start, length & amplitude of the growing season
- ✓ Follow the timing of phenological stages (onset of greenness, maximum development, senescence);
- ✓ Monitor Vegetation response to climatic variability
- ✓ Monitoring of vegetation disturbances (droughts, fire, retrospectively analyse the impact of vegetation disturbances)

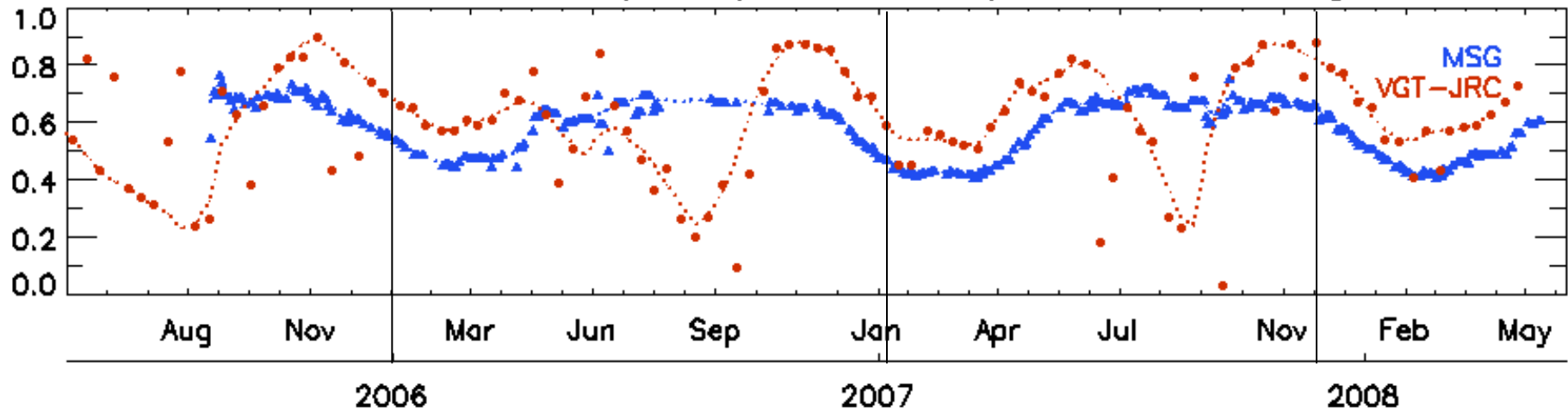
Potential Applications

➤ Reconstruction of seasonal curves

The date of start of the growing season(SOS) is a critical parameter for food security monitoring.

C.Afr – Guinea Gulf

GLC2000 17. Mosaic: Cropland / Tree Cover / Other natural vegetation



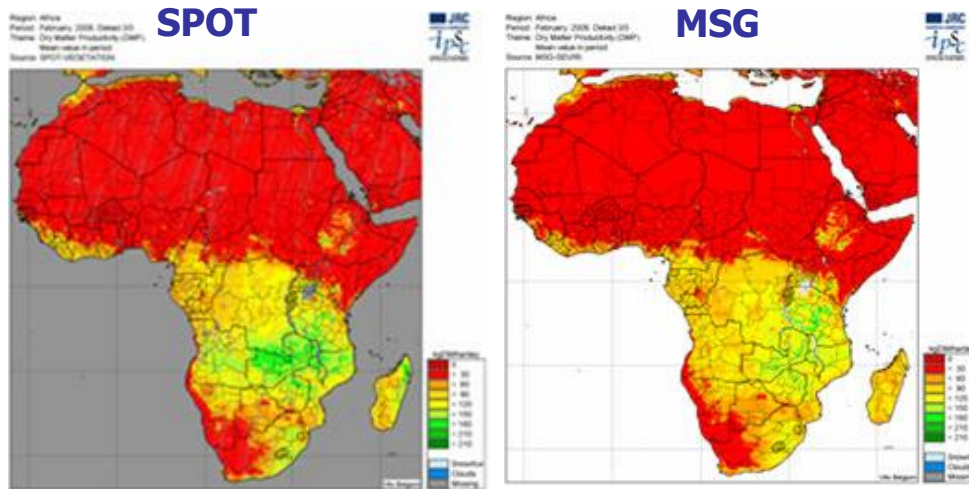
- FVC product from VEGETATION (VGT – JRC)
- FVC product from SEVIRI (LSA SAF)

indicate the SOS in 2007 !!!

Potential Applications

➤ Estimation of Dry Matter Productivity (DMP)

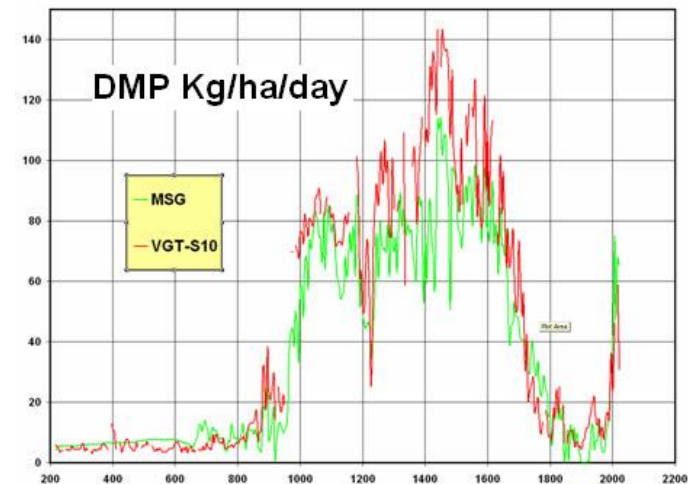
DMP represents the increase in dry matter biomass.



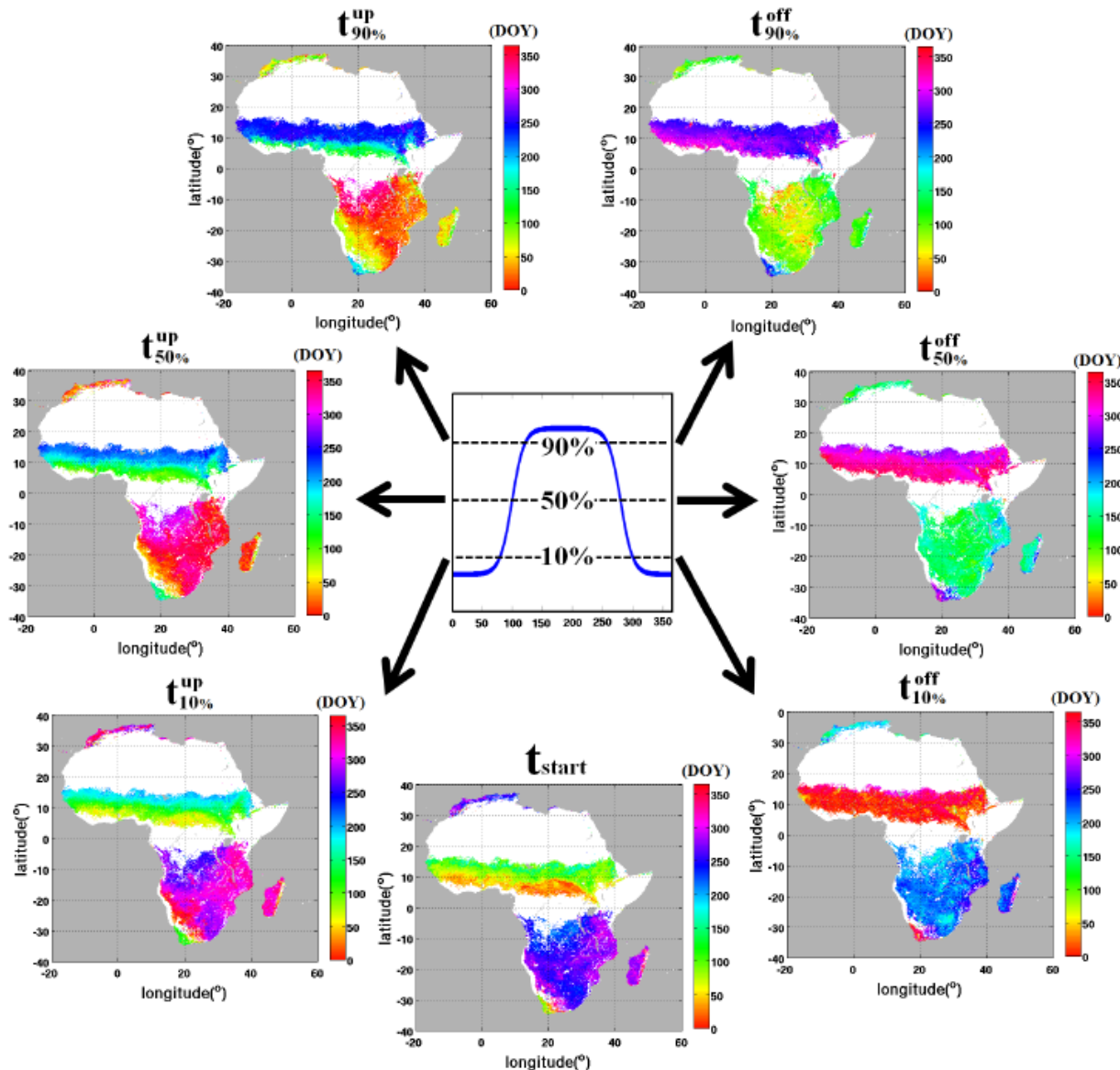
2008, February, Dekad 3 over Africa

➤ Good spatial consistency

A North-South transect through Africa (from Libya to Cape Town) also highlights the good correspondence between SPOT and MSG:



Potential Applications

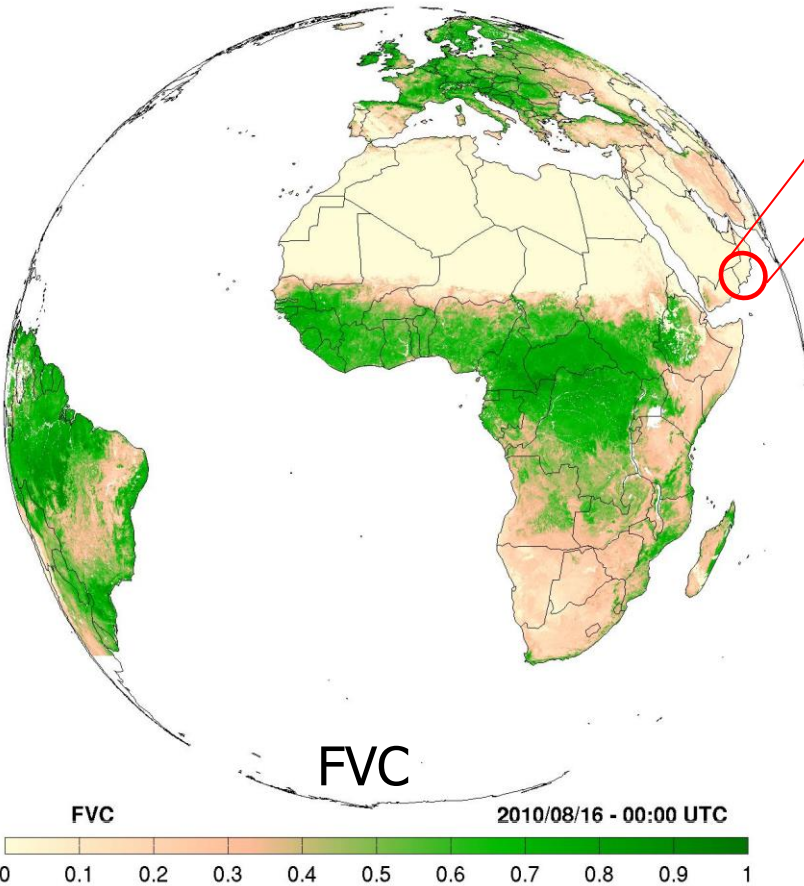


➤ Mean phenological dates of reaching 10%, 50% and 90% of LAI range during green-up and green-off periods

Guan, K., E. F. Wood, D. Medvigy, K. K. Caylor, S. Li and S. J. Jeong, 2012, Derive vegetation phenological time and structure information over Africa using SEVIRI daily LAI, *IEEE transactions on Geoscience and Remote Sensing*, in press.

Applications – Veg Monitoring

➤ Effects of the khareef on vegetation



15 Aug 2010

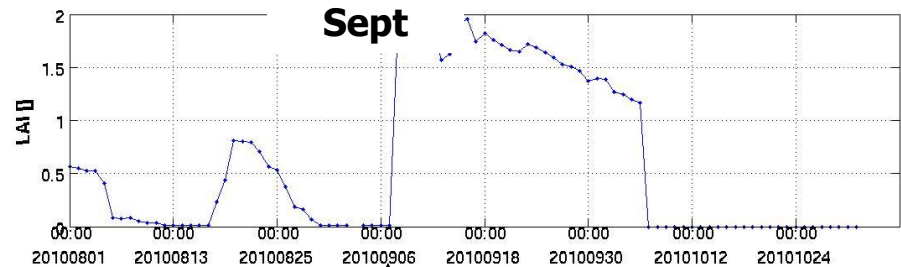
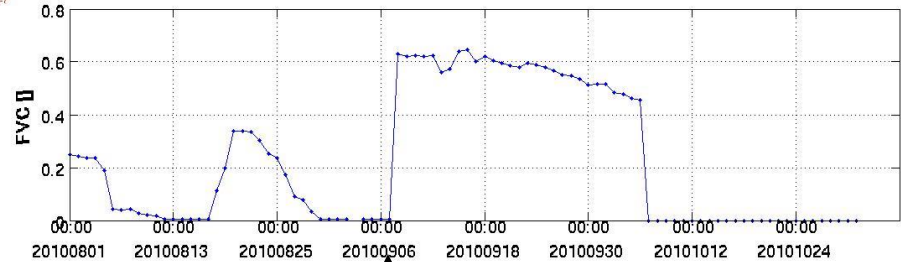
15 Sep 2010

15 Oct 2010

The south east monsoon affects the Dhofar region from about June to early September.

(col:lon)=(2135:902)
(lat:lon)=(17.26:54.09)
Land
IGBP=7

2010/08/01 → 2010/10/31



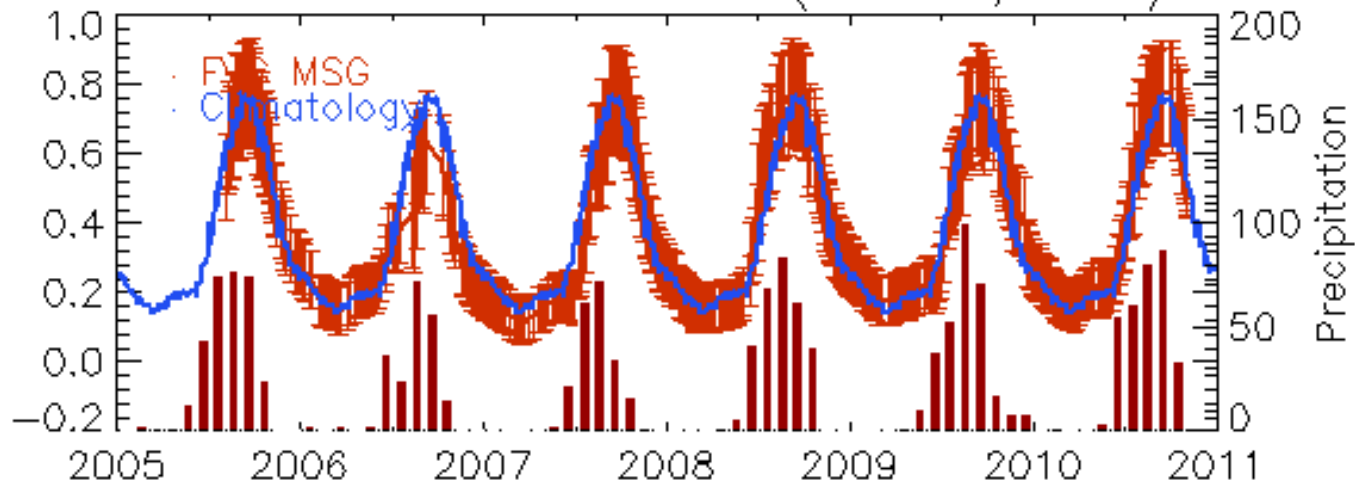
Sept

Sept

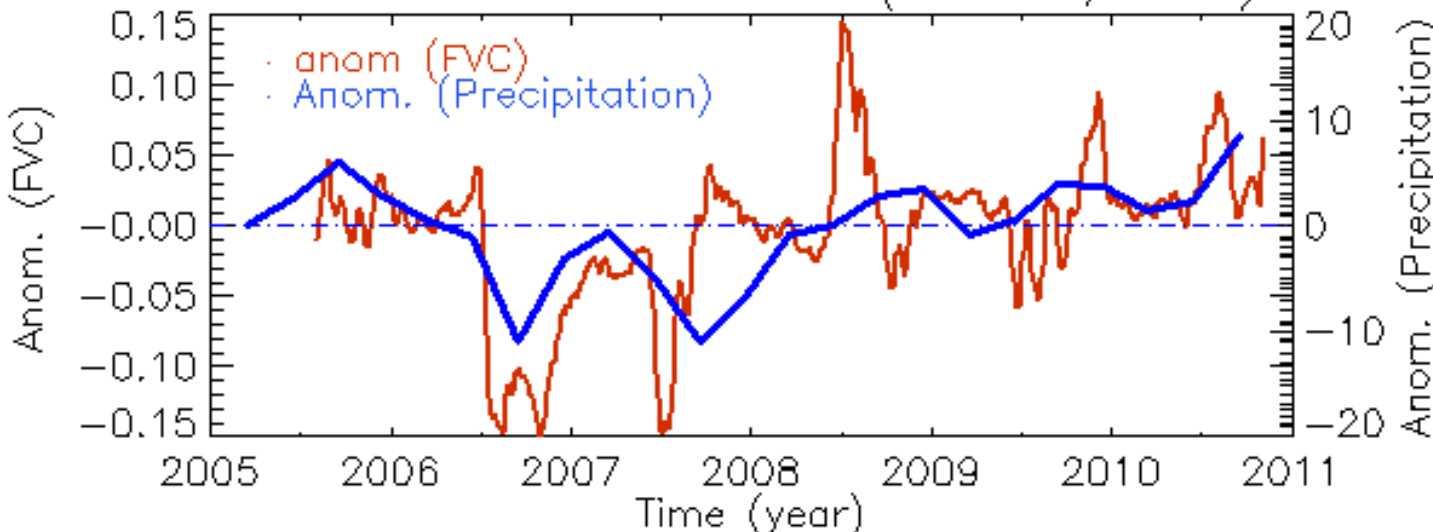
Applications – Veg Monitoring

Vegetation response to climatic variability

GLC12.shrub_deciduous (-13.24,13.79)



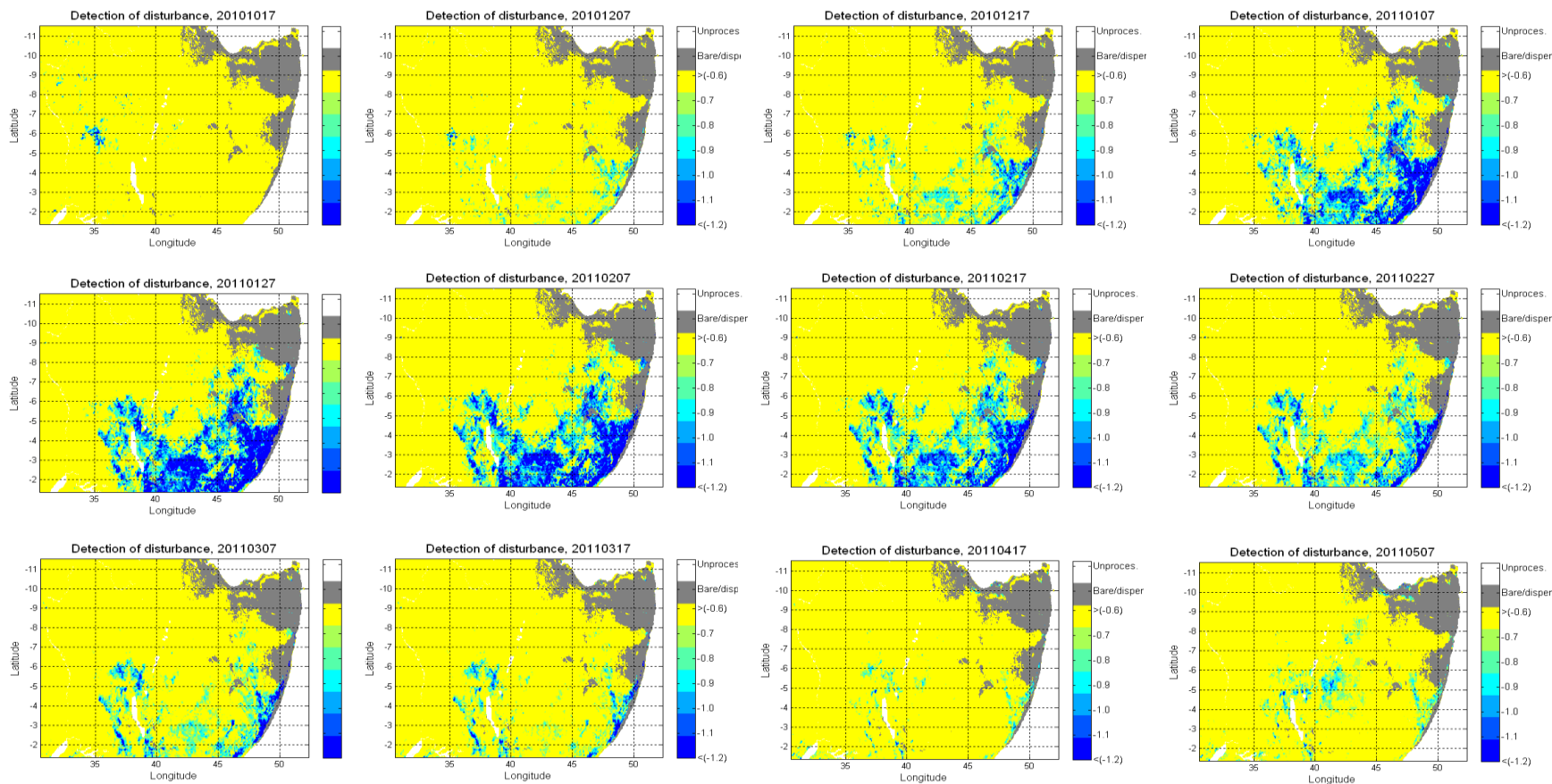
GLC12.shrub_deciduous (-13.24,13.79)



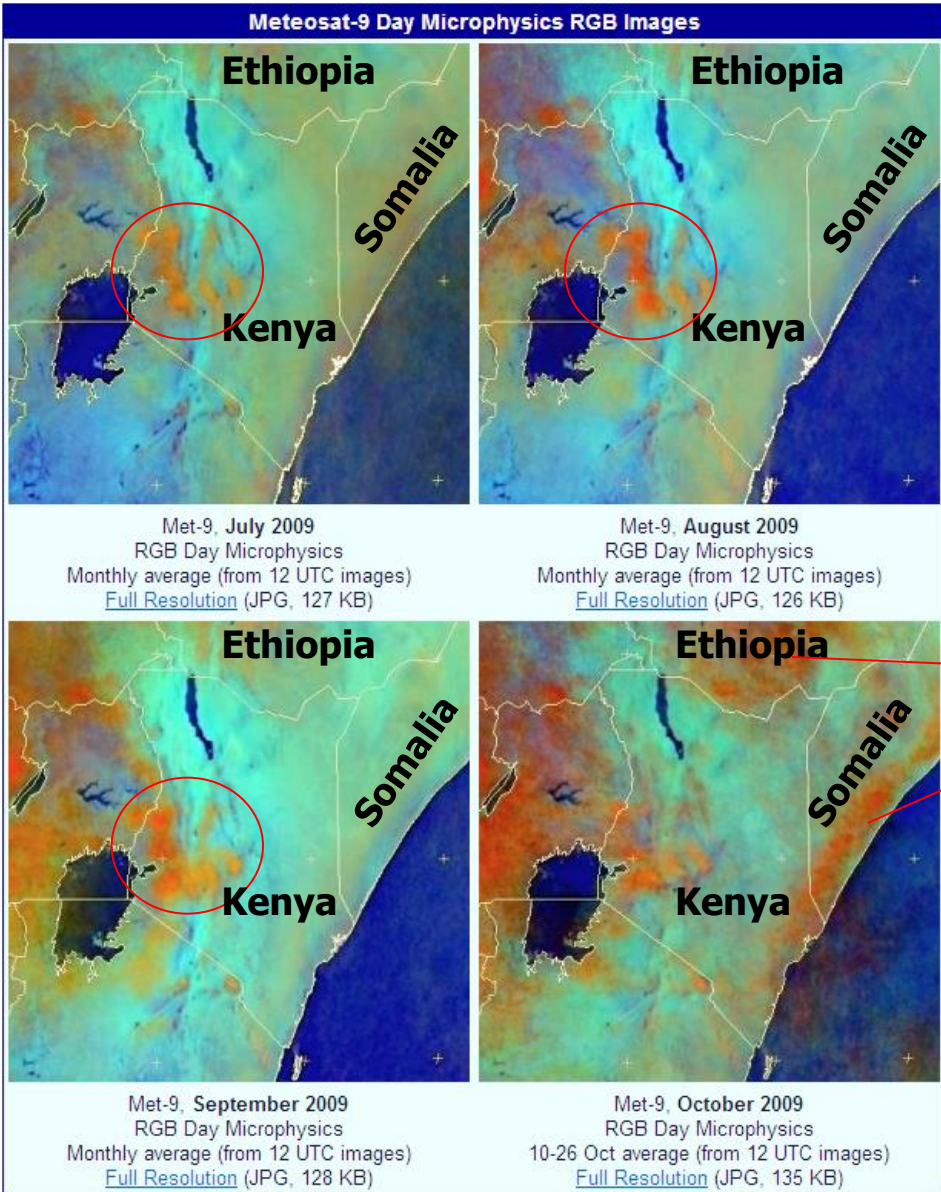
**Climatologies
based on
timeseries of FVC
(SEVIRI/MSG)**

Applications – Veg Monitoring

Drought monitoring Horn of Africa (2011)



Applications – Drought Monitoring



Severe Drought in Kenya 2009

Blue colors – cloud free/no rain areas

Red colors – high coverage of cold ice clouds & precipitation

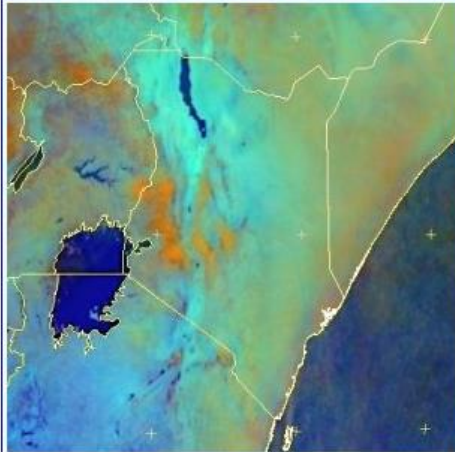
October

clouds and rains developed also in Somalia, Ethiopia and the coastal/central areas of Kenya.

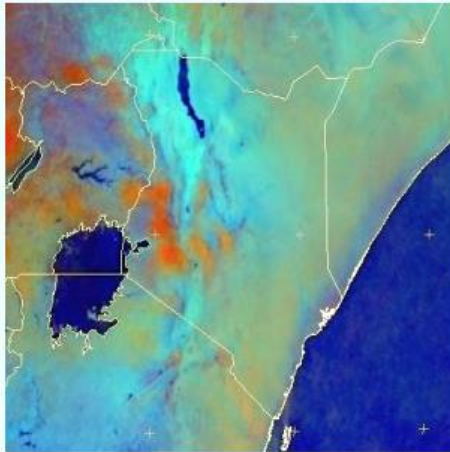
Sequence of images from
http://oiswww.eumetsat.org/WEBOPS/iotm/iotm/20091001_drought/20091001_drought.html

Applications – Drought Monitoring

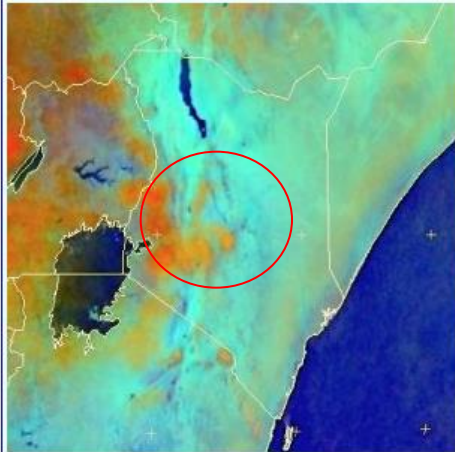
Meteosat-9 Day Microphysics RGB Images



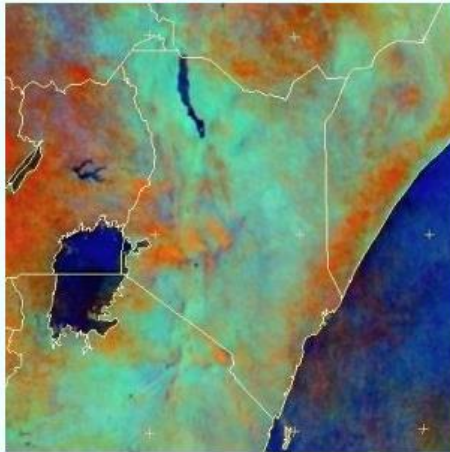
Met-9, July 2009
RGB Day Microphysics
Monthly average (from 12 UTC images)
[Full Resolution](#) (JPG, 127 KB)



Met-9, August 2009
RGB Day Microphysics
Monthly average (from 12 UTC images)
[Full Resolution](#) (JPG, 126 KB)

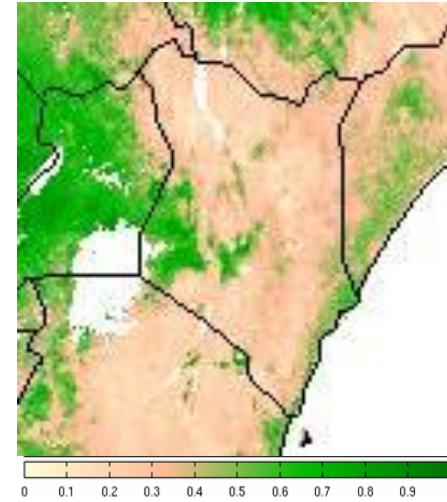


Met-9, September 2009
RGB Day Microphysics
Monthly average (from 12 UTC images)
[Full Resolution](#) (JPG, 128 KB)



Met-9, October 2009
RGB Day Microphysics
10-26 Oct average (from 12 UTC images)
[Full Resolution](#) (JPG, 135 KB)

Which from bellow is from November 2009?



LSA SAF FVC



LSA SAF FVC

LSA SAF Vegetation Products

More information and
data download at:

<http://landsaf.meteo.pt>

The screenshot shows the LSA SAF website home page. At the top, there is a header with the LSA SAF logo and the text "LAND SURFACE ANALYSIS SATELLITE APPLICATIONS FACILITY". Below the header, there is a navigation menu on the left with categories like "About", "Home", "Overview", "Links", "Contacts", "Site Map", "Site Search", "News", "Messages", "Workshops", "Forum", "Products", "Description", "Development Status", "Documents", "List", "Publications", "User Support", "FAQs", "Authentication", "Login", and "Register".

The main content area is titled "Home" and contains the following sections:

- 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
- Product Development Status:**
 - MSG/SEVIRI based products**
 - Wild Fires
 - Fire Radiative Power - PIXEL
 - Fire Radiative Power - GRID
 - Vegetation Parameters
 - Fraction of Vegetation Cover
 - Leaf Area Index
 - Fraction of Absorbed Photosynthetic Active Radiation
 - Snow Cover
 - Snow Cover (daily)
 - Other
 - 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 Shortwave Radiation Flux
 - Down-welling Surface Long-wave Radiation Flux
 - Evapotranspiration
 - Evapotranspiration (30 mins)
 - MetOp/AVHRR based products**
 - Land Surface Temperature
 - EPS - Land Surface Temperature
 - Down-welling Surface Fluxes
 - Down-welling Surface Long-wave Radiation Flux

- Latest News:**
- Important New version of the ET algorithm (ver. 4.0.2) [see more...](#)
- Important New version of the ET algorithm (ver. 4.0.1) [see more...](#)
- Update LSA SAF Database maintenance [see more...](#)
- Warning LSA SAF Database maintenance [see more...](#)
- Important LSA SAF Dissemination resumed [see more...](#)
- Information LSA SAF Dissemination interruption [see more...](#)

At the bottom of the page, there is a caption for the product status colors: Not Avail., Internal, Develop., Demo., Pre-Operat., Operat. Below this, it states "LSA SAF is an initiative of:" followed by logos for EUMETSAT and saf. At the very bottom, it lists the LSA SAF consortium members in CDOP (2007-2012): IM, MF, RMI, IMK, UV, FMI, IDL.