



Land Applications

Carla Barroso, IM

Satellite Image Interpretation and Applications

MONITORING

WEATHER

CLIMATE

SEISMIC ACTIVITY

TO

A SUSTAINABLE DEVELOPMENT AND A SAFER WORLD

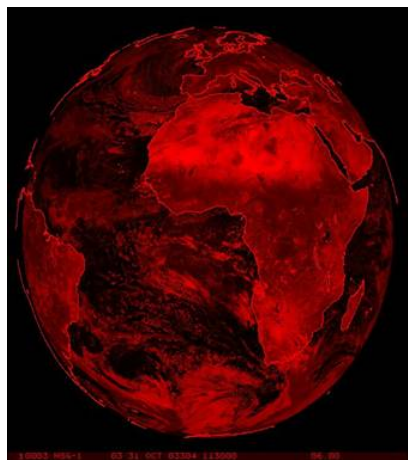


- FRAMEWORK
- VEGETATION
 - APPLICATIONS
- EVAPOTRANSPIRATION
- REFERENCE EVAPOTRANSPIRATION
- LAND SURFACE TEMPERATURE
 - APPLICATIONS

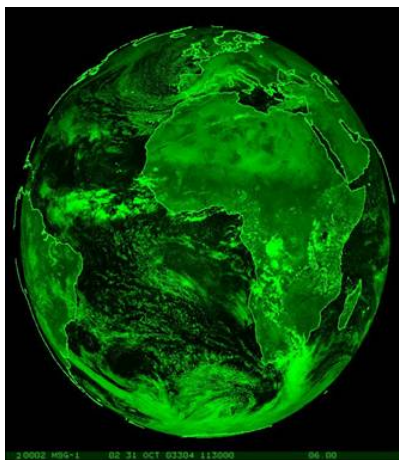


- The new generation of sensors on board meteorological satellites (SEVIRI -MSG, ASCAT- EPS,...) enabled a whole new range of **products** related to the **properties of the surface**.
- There are many applications of such products, including:
 - Vegetation monitoring
 - Wild Fires detection and monitoring
 - Floods monitoring
 - Heat waves monitoring
 - Detection of Urban heat islands
 - Crop water requirements
 - ...

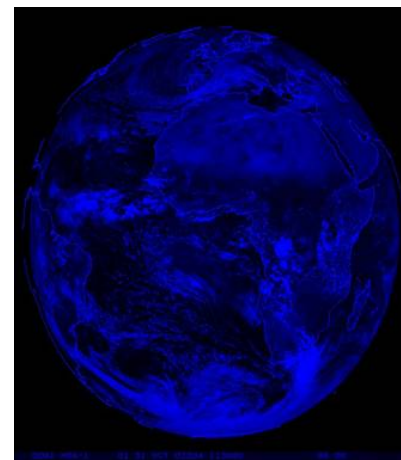
RGB Techniques – works by associating a colour to a particular channel



Red - MSG 1.6 μm

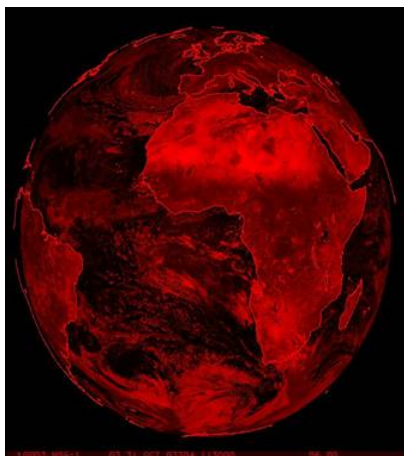


Green - MSG 0.8 μm

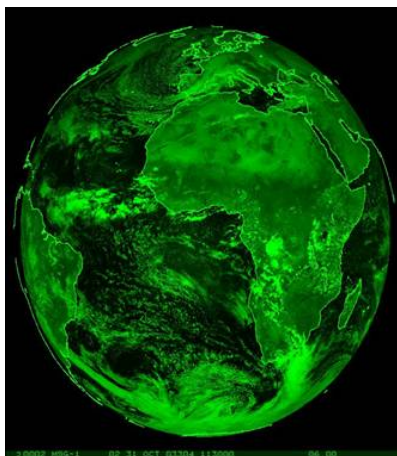


Blue - MSG 0.6 μm

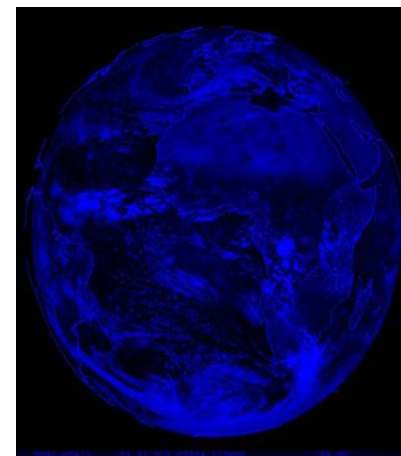
Source: http://www.eumetrain.org/resources/operational_use_rgb.html



Red - MSG 1.6 μm



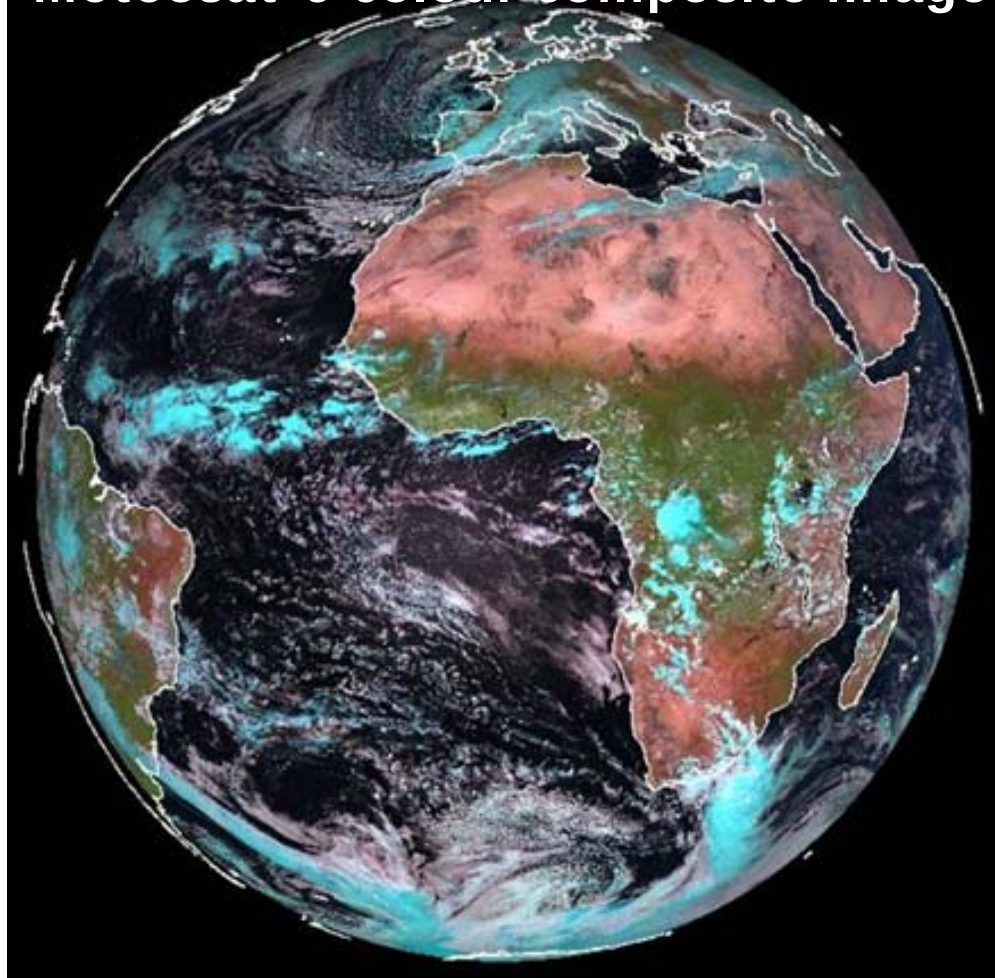
Green - MSG 0.8 μm



Blue - MSG 0.6 μm

Q. Can you remember the name of this RGB?

Meteosat-9 colour composite image



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

Natural colour

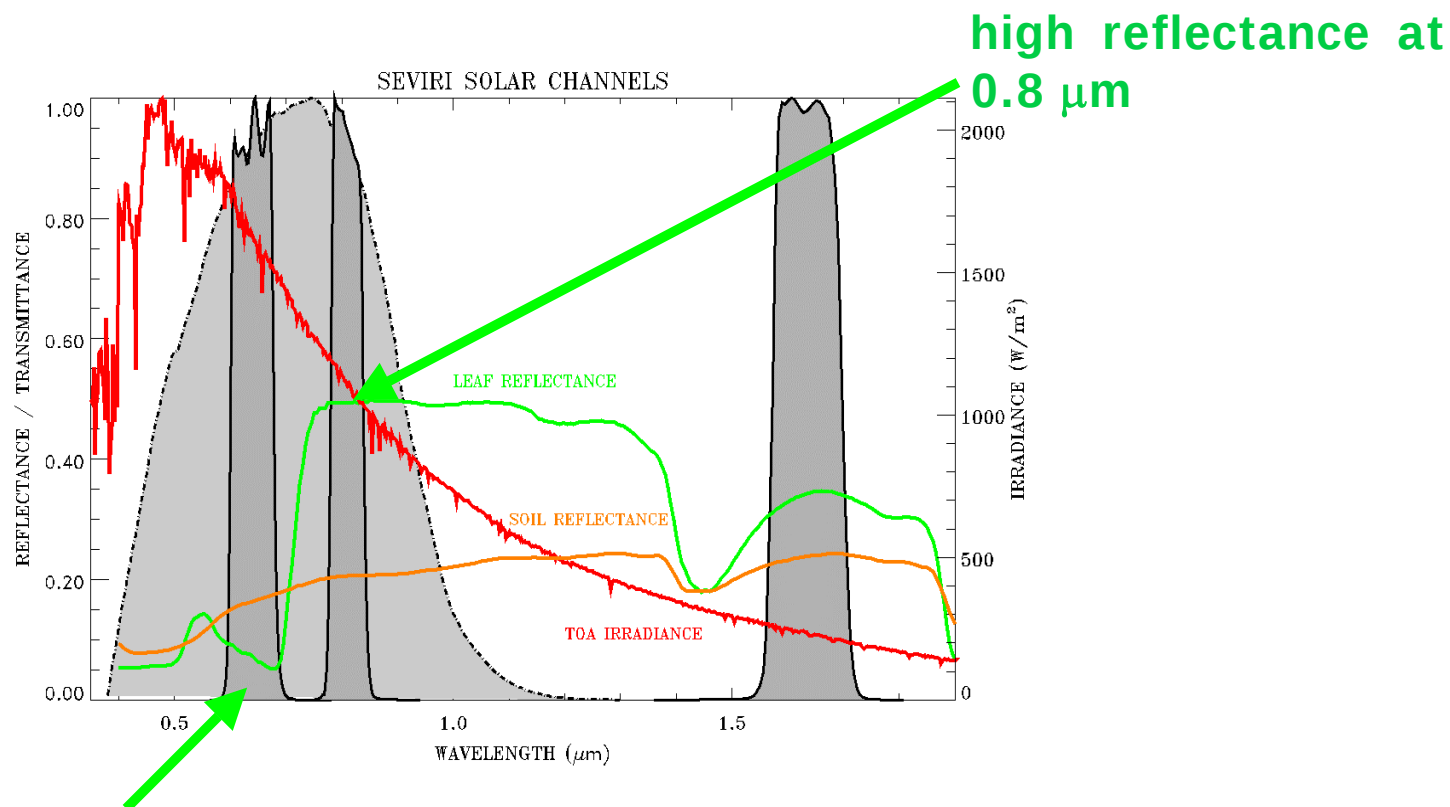
Source: http://www.eumetrain.org/resources/operational_use_rgb.html

Vegetation Indices

- Combine information from different channels to enhance the 'vegetation signal'.
- Have been developed for a wide range of sensors and for different applications.

NDVI – Normalized Difference Vegetation Index

The usage of **NDVI** is based on the characteristics of the reflectance spectrum of vegetation:



Source:

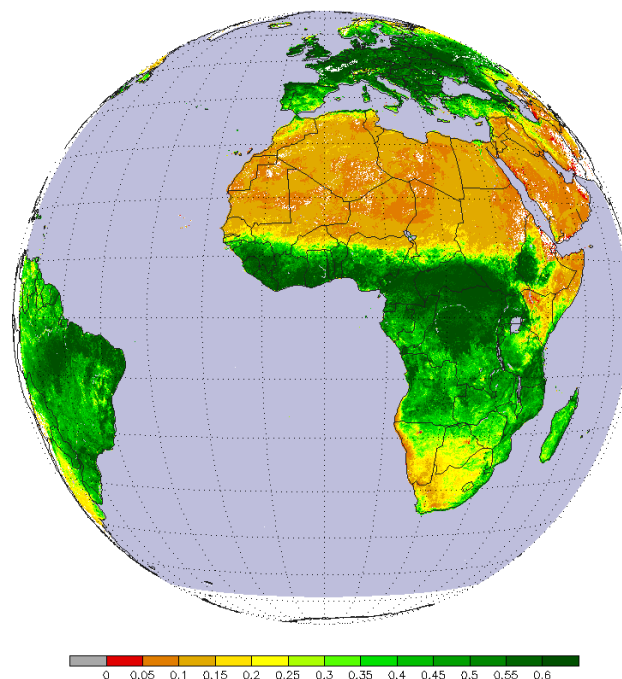
http://www.eumetrain.org/resources/operational_use_rgb.html

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



SEVIRI/MSG Channels 1 e 2 reflectances

NDVI (15 June 2008)



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

NDVI – Normalized Difference Vegetation Index

Advantages

- ✓ Very easy to compute – it is a transformation of reflectance in 2 channels; does not need additional information (like the type of soil/vegetation);
- ✓ Allows the analysis of long time series – using satellite data from NOAA, we can analyze data with more than 20 years.

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Disadvantages

- ✗ Sensitive to fluctuations/noise in the observations (the lighting conditions of the surface, aerosols, contamination by clouds);
- ✗ It saturates in high biomass situations;
- ✗ Does not correspond to any property / physical characteristic of the surface/vegetation.

Parameters that represent the structural characteristics of vegetated surfaces:

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



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

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Parameter directly related with the state (and health) of vegetation:

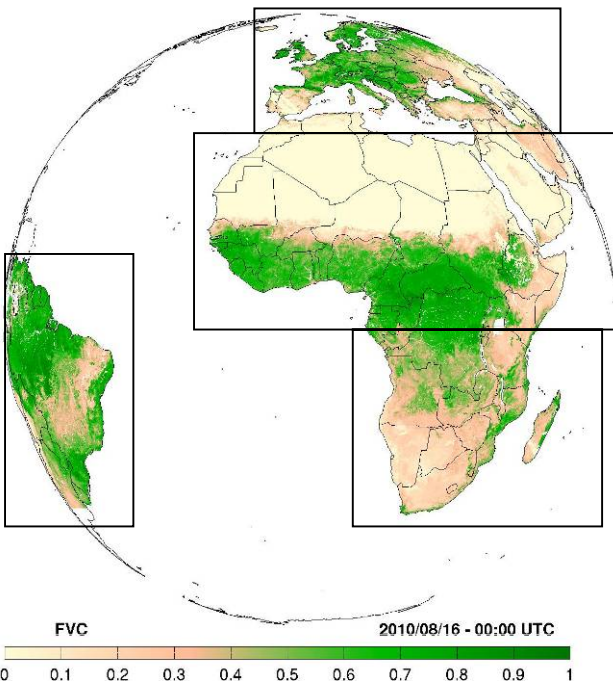
**Fraction of Absorbed
Photosynthetically Active
Radiation:**

part of radiation used for
photosynthesis (0.4 – $0.7\mu\text{m}$)
absorbed by the green parts of the
canopy

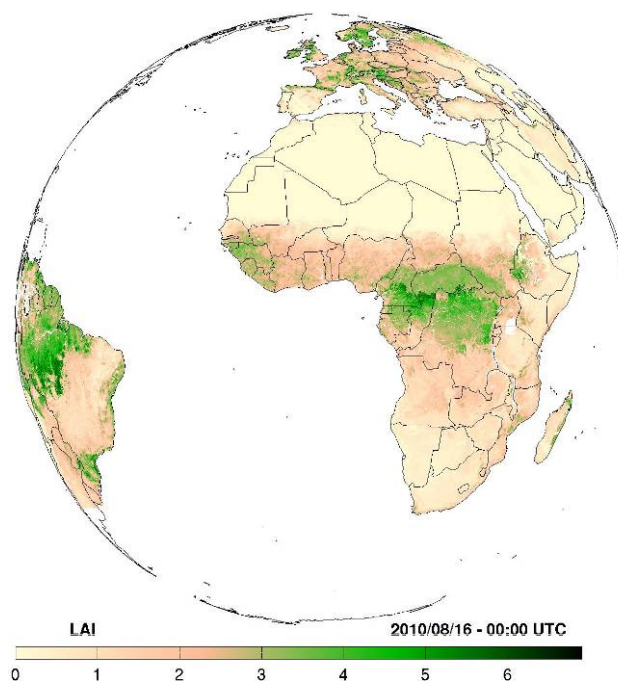
(**FAPAR**)

LSA SAF Products

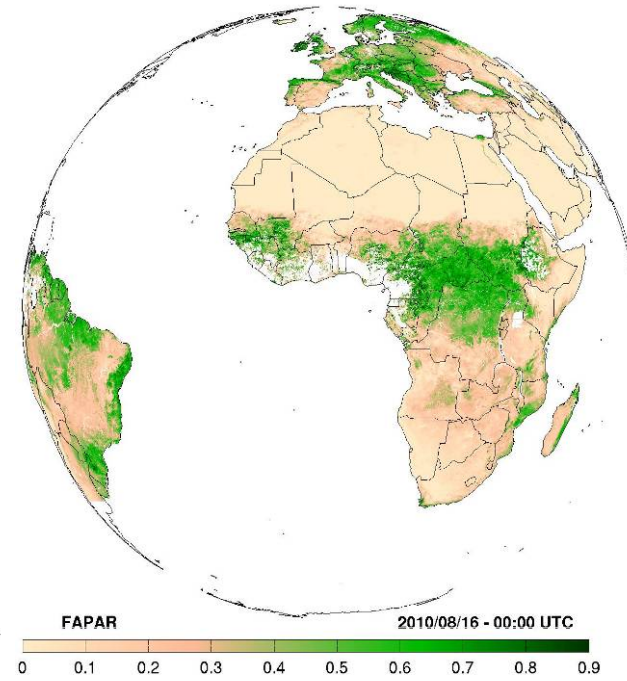
Fractional Vegetation Cover - FVC



Leaf Area Index- LAI



Fraction of Absorbed Photosynthetically Active Radiation - fAPAR



✓ Daily

✓ SEVIRI resolution
(3 x 3 km at sub-
satellite point)

✓ Available freely:

Via Ftp (2006)
Eumetcast (2009)

<http://landsaf.meteo.pt>





LAND SURFACE ANALYSIS SATELLITE APPLICATIONS FACILITY



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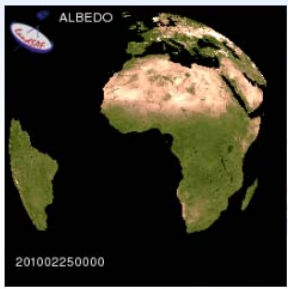
The scope of Land Surface Analysis Satellite Applications Facility (LSA SAF) is to increase benefit from EUMETSAT Satellite (MSG and EPS) data related to:

- Land
- Land-Atmosphere interaction
- Biospheric Applications

The LSA SAF performs:

- R&D Programs.
- Operational Activities

- Generation
- Archiving
- Dissemination



201002250000

[See product colour maps...](#)

of land surface related products.

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...](#)

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 Short-wave 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

Caption

Not Avail. Internal Develop. Demo Pre-Operat. Operat.

LSA SAF is an initiative of:




LSA SAF consortium in COOP (2007-2012):

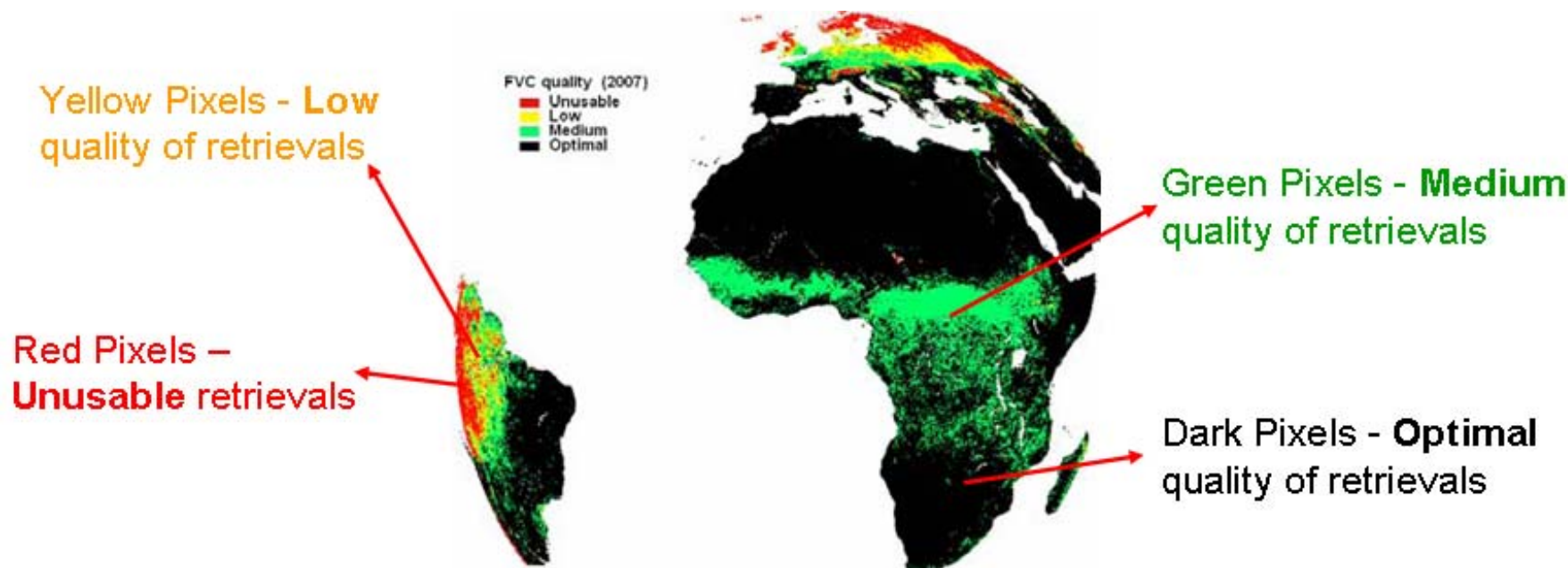








Overall quality of LSA SAF Vegetation Products



Q. Which of the following facts most (•) / do not (×) contribute to the optimal quality the LSA SAF veg products over Afr?

•The temporal sampling of MSG

•The spatial resolution of MSG

•The geometry of acquisition

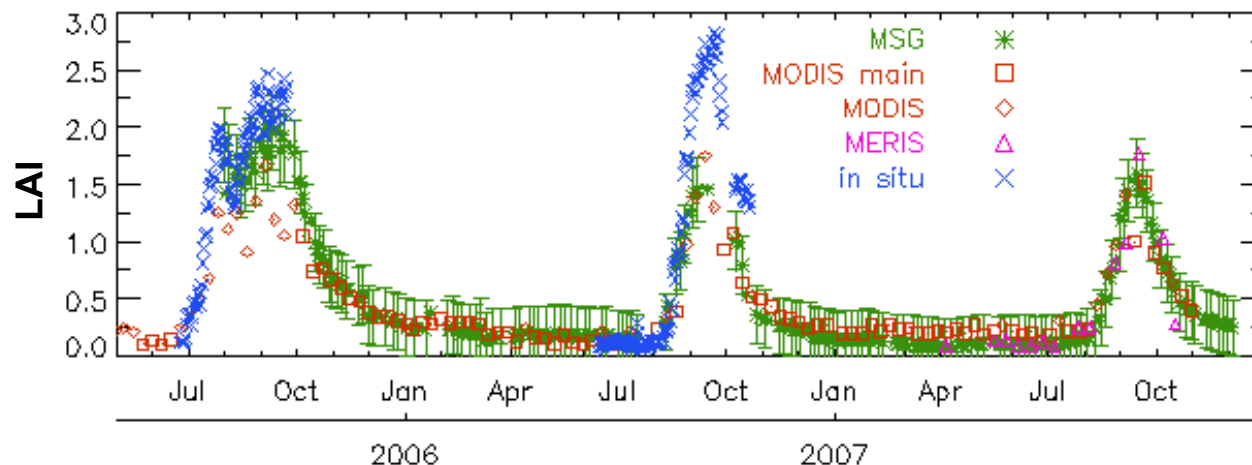
VEGETATION PRODUCTS FROM OTHER SATELLITE PROGRAMS:

- POLDER (Leroy et al. 1997, Roujean and Lacaze 2002);
- MODIS and MISR (Knyazikhin et al. 1999);
- MERIS (Gobron et al. 1999, Bacour et al. 2006, Baret et al. 2007);
- VEGETATION (Baret et al. 2007, Bartholomé et al. 2006);

...

➤ Comparison with in situ measurements

Dahra (Senegal)



Q. Which of the products shows less gaps?

MODIS

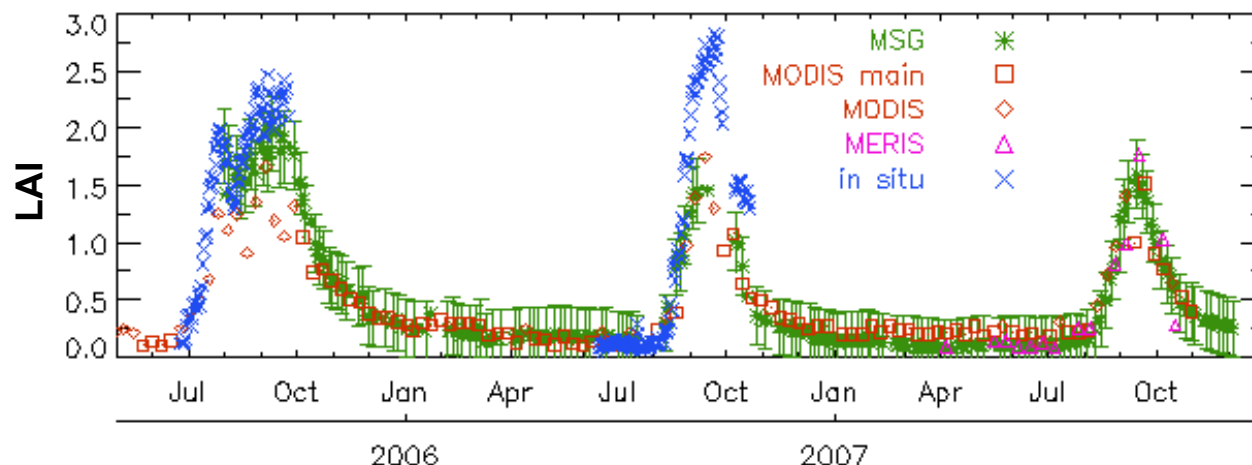
MSG

MERIS

Land-SAF team (F. Camacho, J. Garcia-Haro)

➤ 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;

Land-SAF team (F. Camacho, J. Garcia-Haro)



Comparison to Polar-Orbiter Derived Products

The vegetation products (**FVC**, **LAI**, **FAPAR**) obtained from geostationary satellites (like SEVIRI/MSG), while compared with polar-orbiter derived products (MODIS, VGT):

- ↓ have **coarser spatial resolution**;
- ✓ Reproduce the **seasonal cycle** in a **more realistic** way (without spurious variations; time series show less noise);
- ✓ Have **fewer gaps** in the data

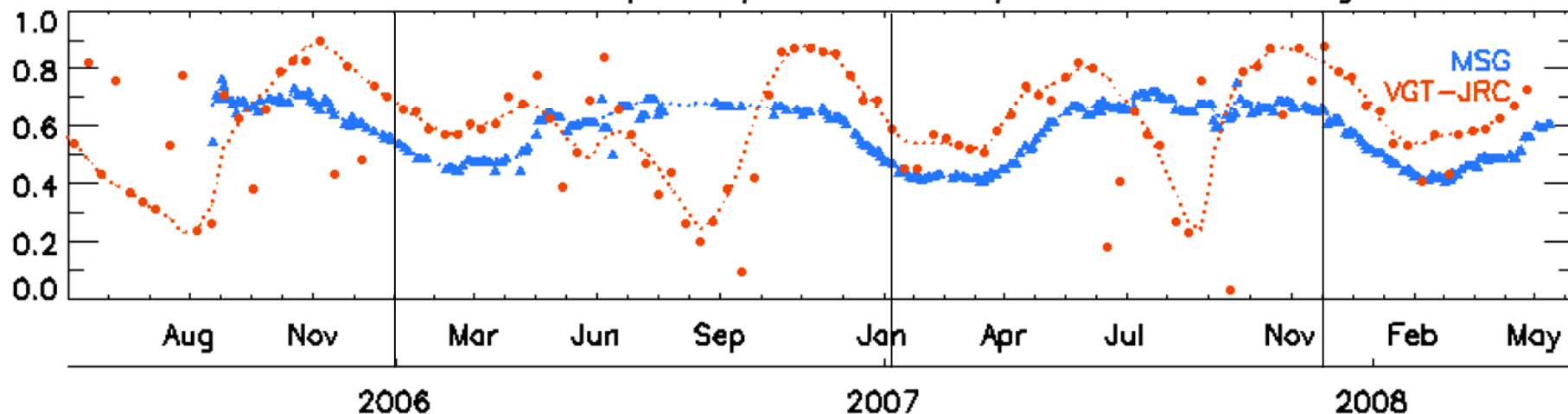
Vegetation products from LSA SAF

- Generate spatially coherent images of **phenological parameters**. E.g:
 - The start, length & amplitude of the growing season;
 - the timing of phenological stages (onset of greenness, maximum development, senescence);

➤ **The date of the SOS** (start of the growing season) 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)

Q. Can you indicate the SOS in 2007?

LSA SAF team (F. Camacho, J. Garcia-Haro)

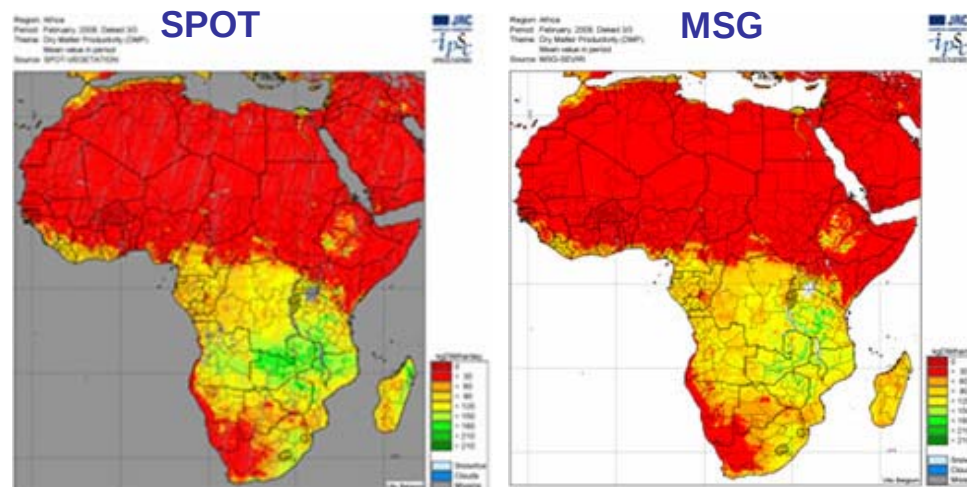
- **Dry Matter Productivity** – represents the increase in dry matter biomass.
- It is a function of (*Monteith, 1972*):
 - ✓ Incoming solar radiation (0.2-3.0 μm);
 - ✓ Surface Temperature;
 - ✓ fAPAR

The Joint Research Center (JRC) is computing this parameter for crop monitoring using meteorological information and the fAPAR product from the LSA SAF (LSA SAF 3rd User Training Workshop).

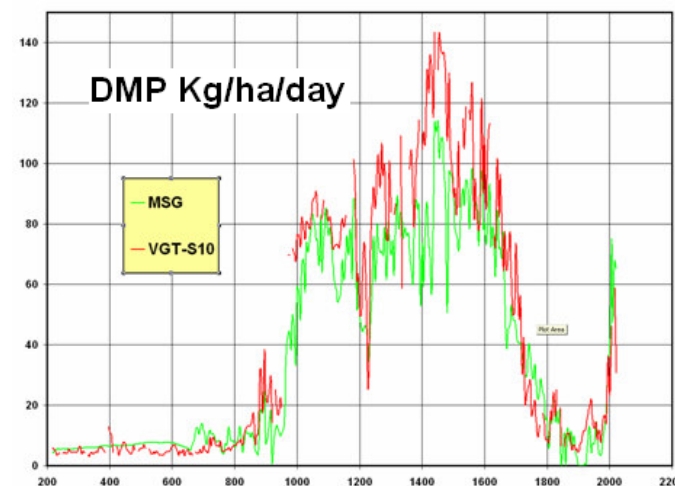
➤ Dry Matter Productivity

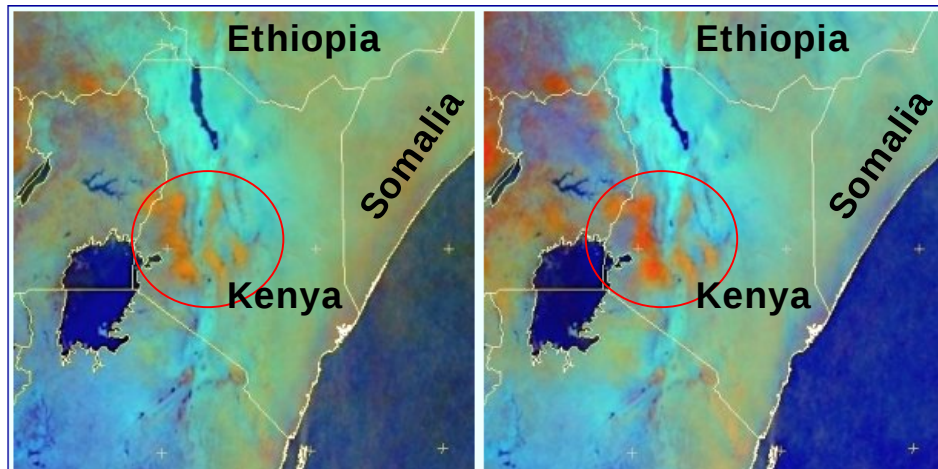
2008, February, Dekad 3 over Africa

➤ Very good spatial consistency;



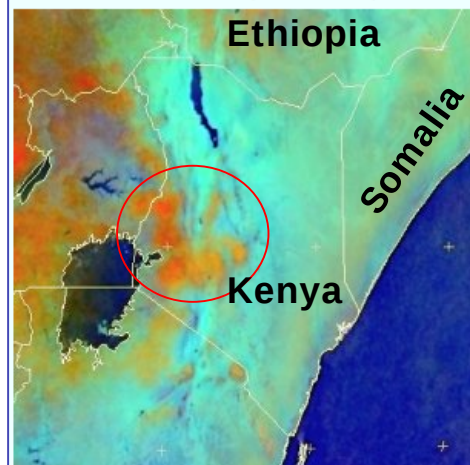
A North-South transect through Africa (from Lybia to Cape Town) also highlights the good correspondence between SPOT and MSG:





July 2009

August 2009



September 2009

Severe Drought in Kenya 2009

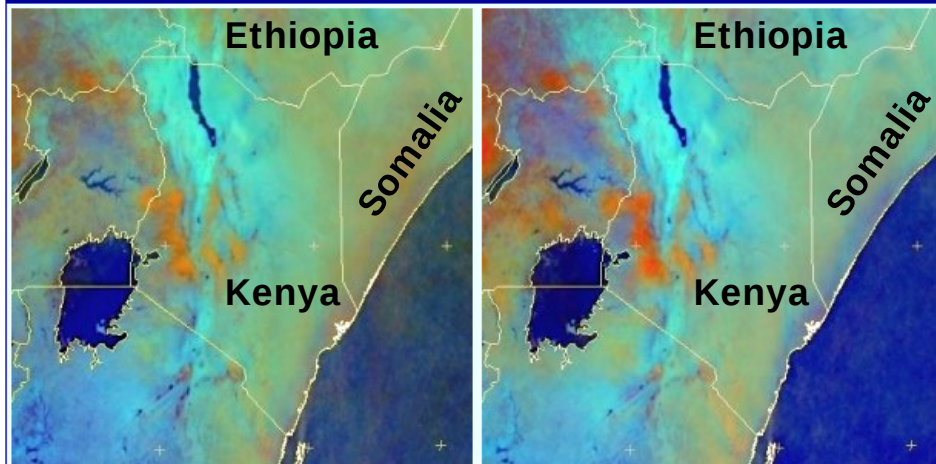
Q. Can you tell the name of this RGB?

Blue colors – cloud free/no rain areas

Red colors – high coverage of cold ice clouds & precipitation

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

Meteosat-9 Day Microphysics RGB Images



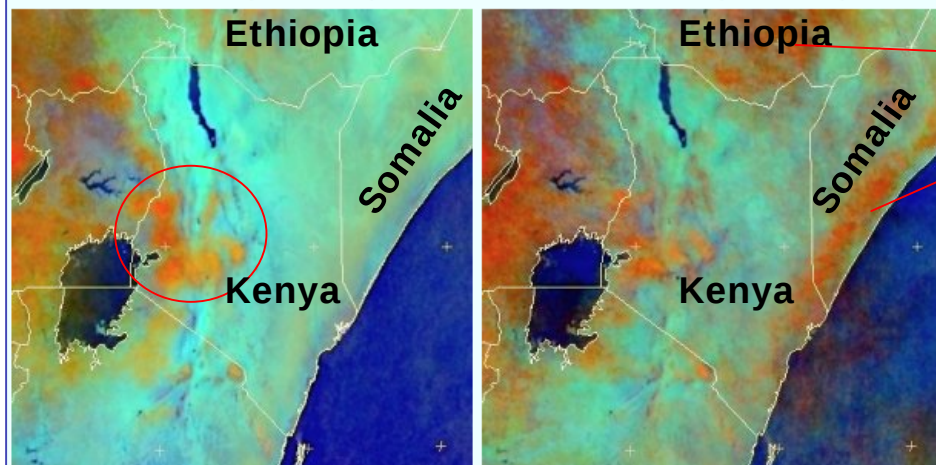
Severe Drought in Kenya 2009

Blue colors – cloud free/no rain areas

Red colors – high coverage of cold ice clouds & precipitation

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)



October

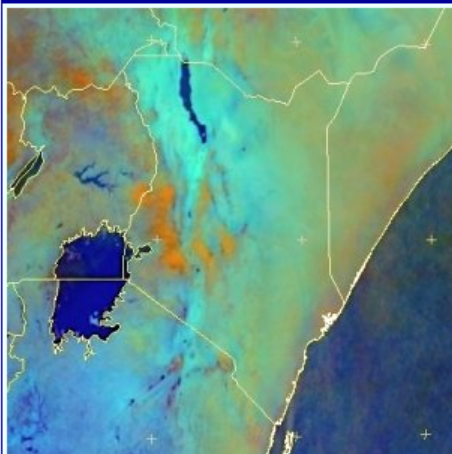
clouds and rains developed also
in Somalia, Ethiopia and the
coastal/central areas of Kenya.

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

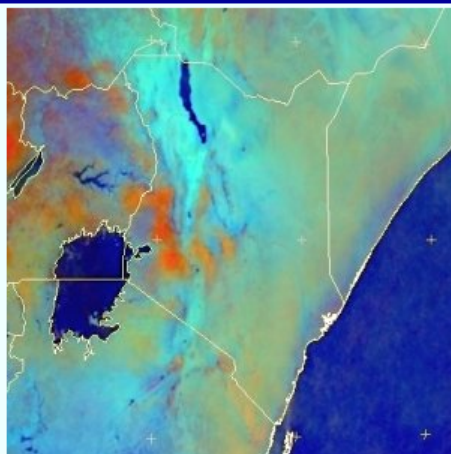
Met-9, September 2009
RGB Day Microphysics
Monthly average (from 12 UTC images)
[Full Resolution](#) (JPG, 128 KB)

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

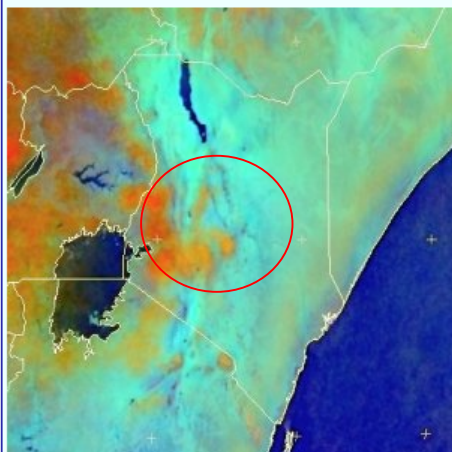
Meteosat-9 Day Microphysics RGB Images



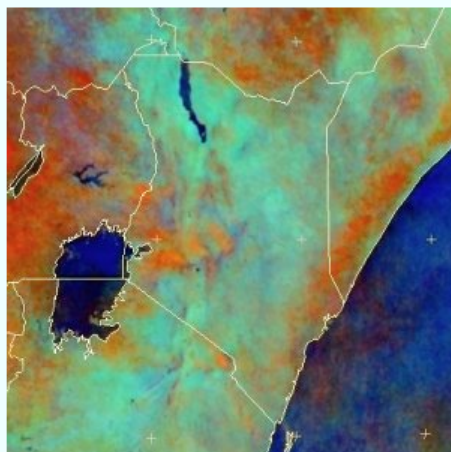
Met-9, July 2009
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[Full Resolution](#) (JPG, 127 KB)



Met-9, August 2009
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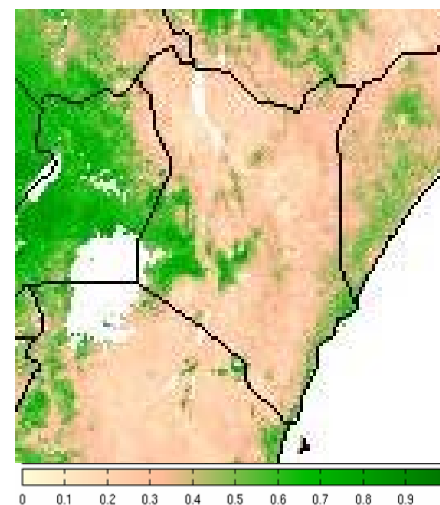


Met-9, September 2009
RGB Day Microphysics
Monthly average (from 12 UTC images)
[Full Resolution](#) (JPG, 128 KB)

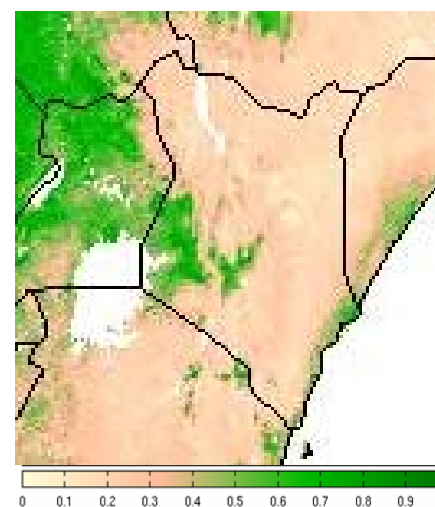


Met-9, October 2009
RGB Day Microphysics
10-26 Oct average (from 12 UTC images)
[Full Resolution](#) (JPG, 135 KB)

Which from bellow is from November 2009?

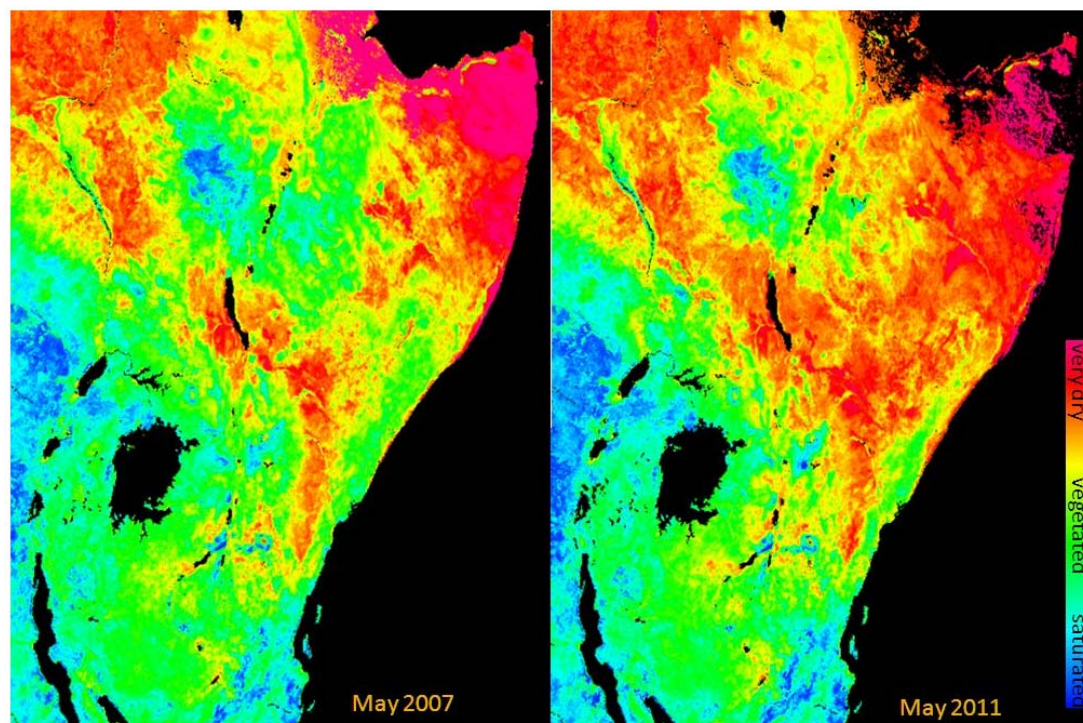


LSA SAF FVC



LSA SAF FVC

Severe Drought continued up to 2011...



source: <http://www.eumetsat.int/Home/Main/News/Features/809364?l=en>

➤ Monitoring of Vegetation: Effects of the Fire Activity

FVC

FVC before fire season of 2007, that mainly affected Italy and Greece



FVC

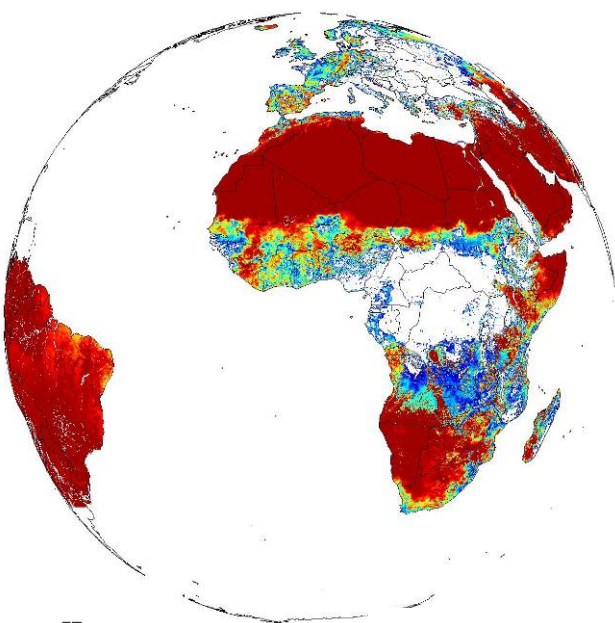
There is a drastic reduction of the vegetation cover to which fires have most likely contributed, besides other reasons as harvested crops or drying out of leaves.



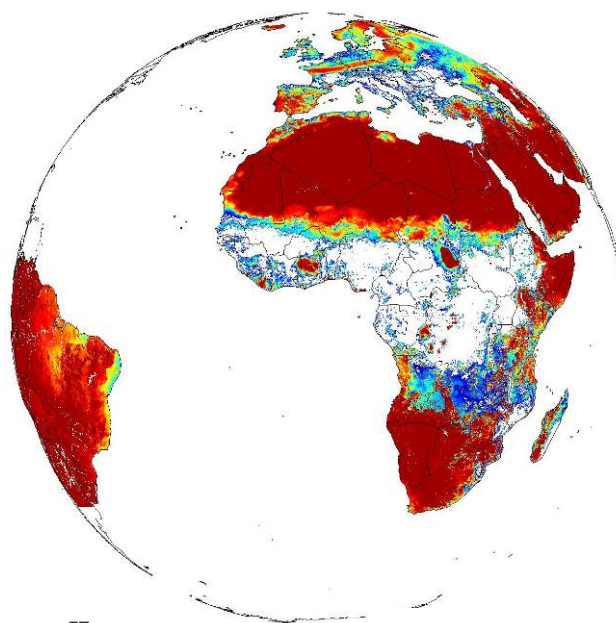
Source: http://www.eumetrain.org/resources/forest_fires.html

➤ Temporal Frequency: 30 min & daily

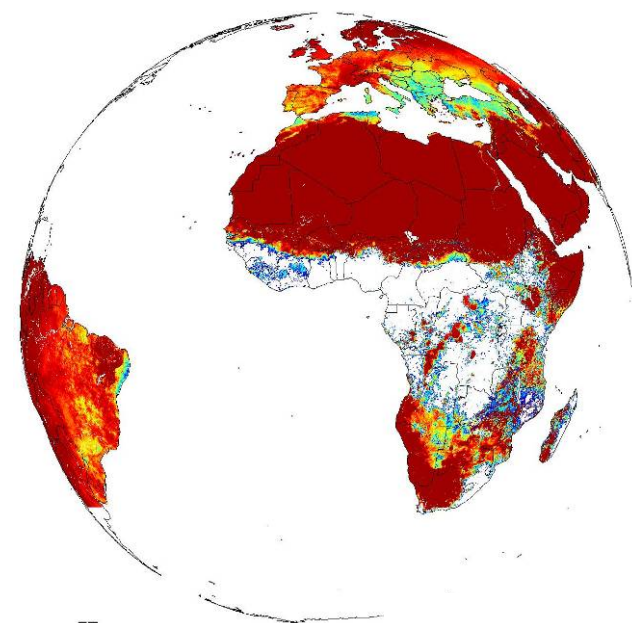
15 July 2010 @10:00UTC



15 Sep 2010 @10:00UTC



15 Nov 2010 @10:00UTC



Evapotranspiration - quantification of the flux of water vapour from the ground surface (soil and canopy) into the atmosphere.

$$ET_c = K_c \cdot ET_0$$

Reference evapotranspiration (equivalent to the evapotranspiration from a well defined surface (FAO))

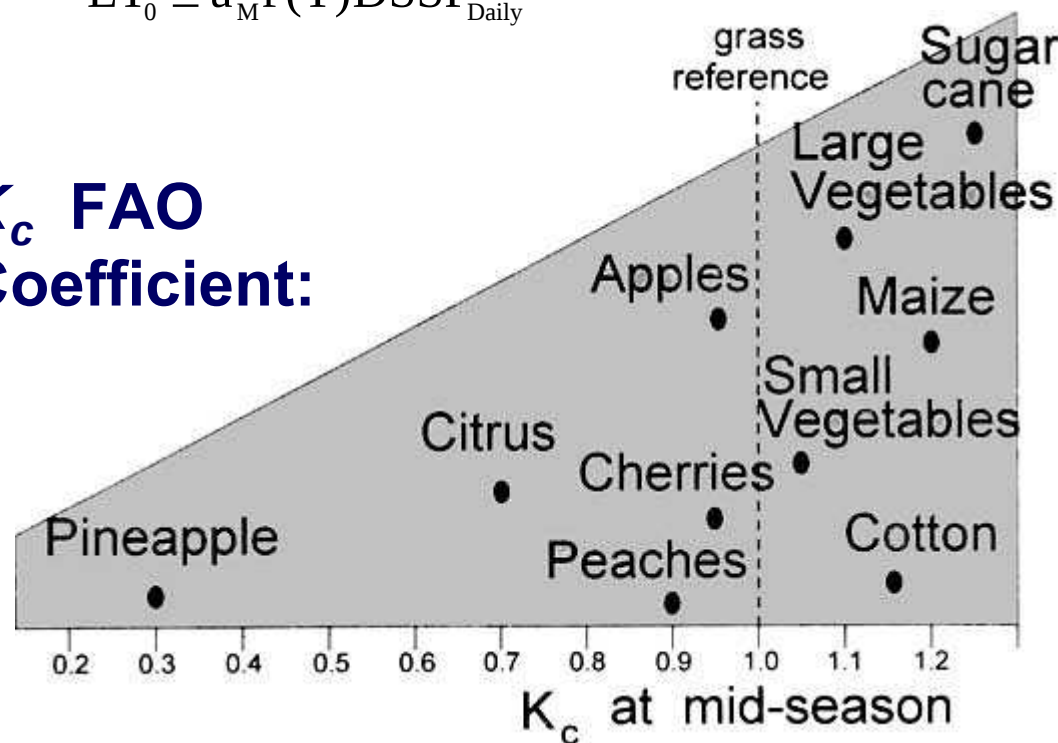
ET_0 is essentially determined by solar irradiance:

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

Crop evaporation
or crop water need

K_c FAO
Coefficient:

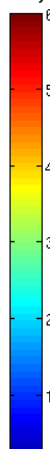
Important in irrigation management, allowing an effective use of soil water reserves on agricultural production.



July 2009

ETO 20090715

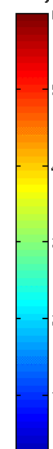
mm/day



September 2009

ETO 20090915

mm/day



November 2009

ETO 20091115

mm/day

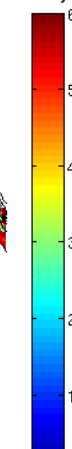


Water requirements for irrigation crops are higher in July and then diminishes towards November.

July 2009

ET₀ 20090715

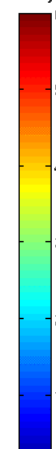
mm/day



September 2009

ET₀ 20090915

mm/day



November 2009

ET₀ 20091115

mm/day

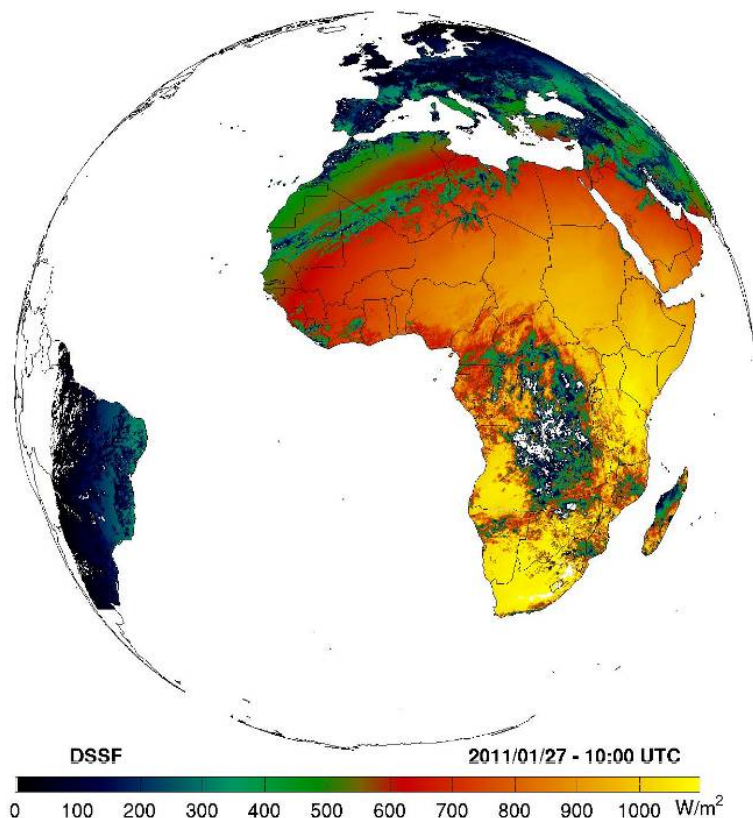


Water requirements for irrigation crops are higher in July and then diminishes towards November.

ET_0 is essentially determined by solar irradiance: $ET_0 \cong a_M f(T) DSSF_{\text{Daily}}$

Solar Radiation Flux in the LSA SAF - MSG/SEVIRI

DSSF



✓ SEVIRI resolution (3 x 3 km at sub-satellite point)

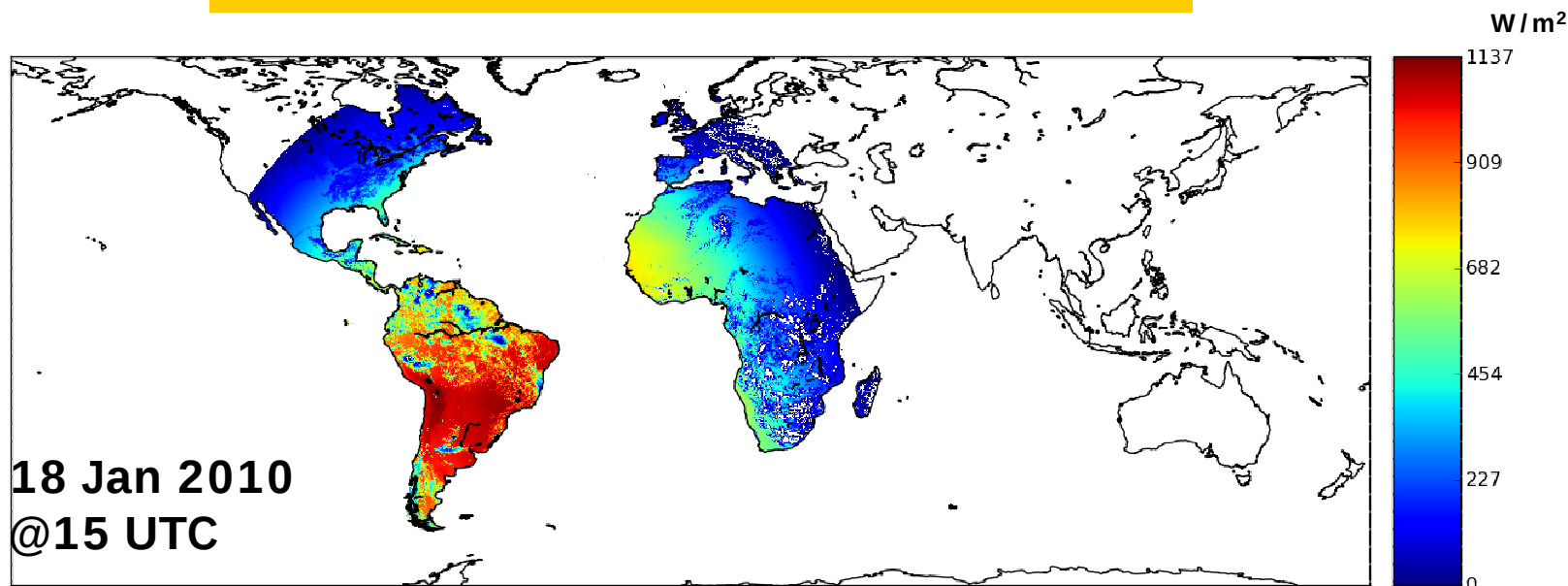
✓ 30 minutes & daily

✓ Land Pixels within SEVIRI field of view, divided in 4 areas: Europe, North Africa, South Africa & South America.

✓ Available since 2005

Solar Radiation Flux

Solar Radiation Flux in Geoland – GMES



✓ Land Pixels within GOES,
SEVIRI & MTSAT field of view

✓ 0.05° Spatial Res
✓ 1h temporal res

✓ Available since Aug 2009

The Portuguese Met Office participates in Geoland 2 project – EU-funded project (GMES*), a joint initiative of European Commission (EC) and European Space Agency (ESA).

* Global Monitoring for Environmental Security

<http://www.gmes-geoland.info/home.html>



Operational Monitoring Services for our Changing Environment

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News

7th geoland Forum - Register Now! [more...](#)
01. July 2011

GMES Masters [more...](#)
27. June 2011

Newsflash
Download the **August Newsflash** [here](#).

Data Portals



The [geoland2 Expert Portal](#) provides expert tools to use and download all geoland2 products. It also provides access to the GMES Earth Observation data-set (Image2009) for registered geoland2 user organisations.

GMES Land Video



geoland2 - Supporting the Monitoring, Protection and Sustainable Management of our Environment

With the ongoing climate change, the pressure on nature, biodiversity and our own living conditions increases steadily. To mitigate these threats by effective adaptation strategies and counter measures a frequent and area-wide monitoring of the environment is crucial.

Benefiting from Earth Observation satellite data, the GMES Land Service provides accurate and cross-border harmonised geo-information at global to local scales. Within GMES the geoland2 project aims to organise a qualified production network, to build, validate and demonstrate operational processing lines and to set-up a user driven product quality assurance process.

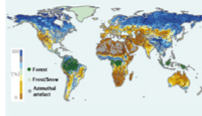
Core Mapping Services

European Land Monitoring



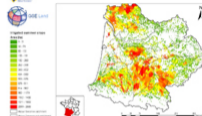
The Service addresses the continental and local component, i.e. high spatial resolution and land cover change. [More](#)

Global Land Monitoring



The Biogeophysical Parameter Service describes the continental vegetation state, the radiation and water cycle. [More](#)

Annual Land Monitoring



The Service provides seasonal / annual coverage of physical properties describing bio-geophysical parameters. [More](#)

Core Information Services

Spatial Planning



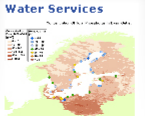
The Service provides Geoinformation Products to describe.

AgriEnvironmental Services



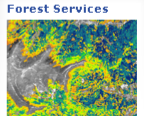
The Service develops and improves agri-

Water Services



The Service provides a pan-European model for

Forest Services



The Service provides highly accurate and spatially detailed



à frente do nosso tempo

Land Surface Temperature

The EUMETSAT
Network of
Satellite Application
Facilities

LSA SAF
Land Surface Analysis

LST in the LSA SAF estimated from MSG/SEVIRI data (LSA SAF)

➤ **SPATIAL RESOLUTION:**

SEVIRI resolution, i.e,
3 x 3 km at sub-satellite point

➤ **TEMPORAL RESOLUTION:**

15 minutes

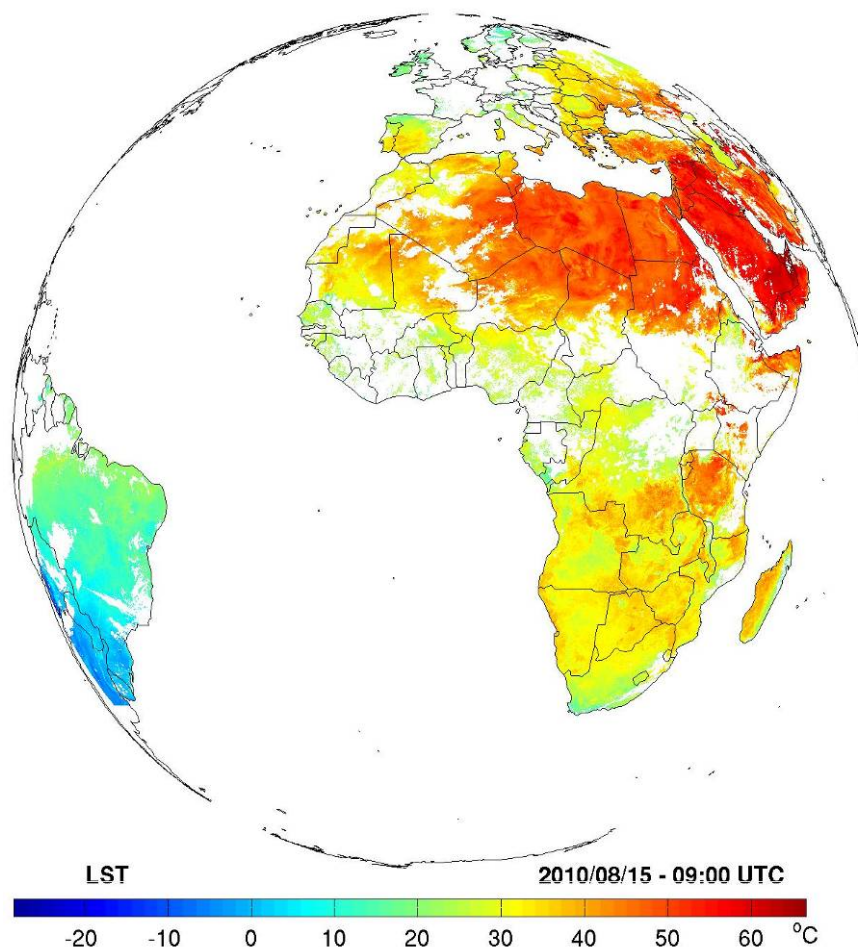
➤ **GEOGRAPHICAL COVERAGE:**

Earth disk within SEVIRI field of view,
divided in 4 areas: Europe, North Africa,
South Africa & South America.

➤ **AVAILABLE SINCE:**

Europe – February 2005

All disk – July 2005





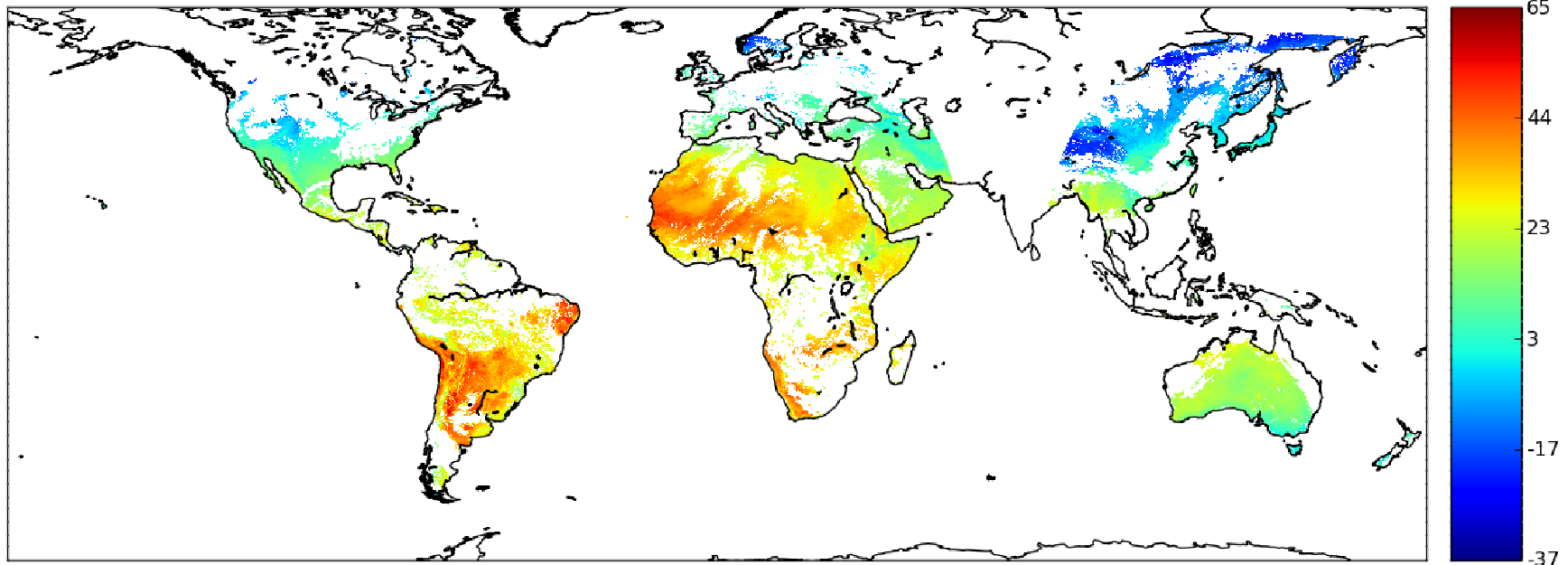
à frente do nosso tempo

Land Surface Temperature

The EUMETSAT
Network of
Satellite Application
Facilities

LSA SAF
Land Surface Analysis

LST estimated from MSG, GOES & MTSAT (GEOLAND 2)



✓ Land Pixels
within GOES,
SEVIRI & MTSAT
field of view

✓ 0.05° Spatial Res

✓ 1h temporal res

✓ Available since Aug 2009

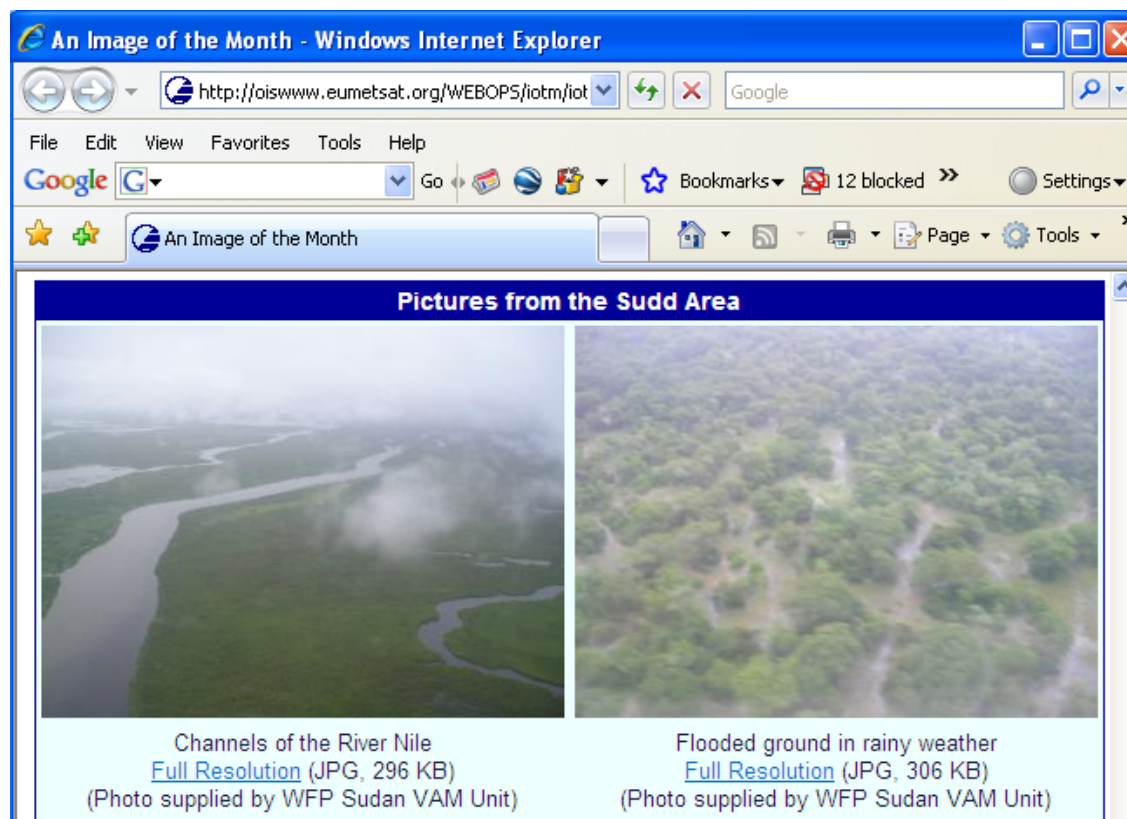
Floods in the Sudd Marshes (Southern Sudan) November 2005 to January 2006

Marshes are defined as wetlands frequently or continually inundated with water*.



*
<http://water.epa.gov/type/wetlands/marsh.cfm>

A marsh typically features herbaceous plants in shallow waters:



Source:

http://oiswww.eumetsat.org/WEBOPS/iotm/iotm/20051202_flood/20051202_flood.html

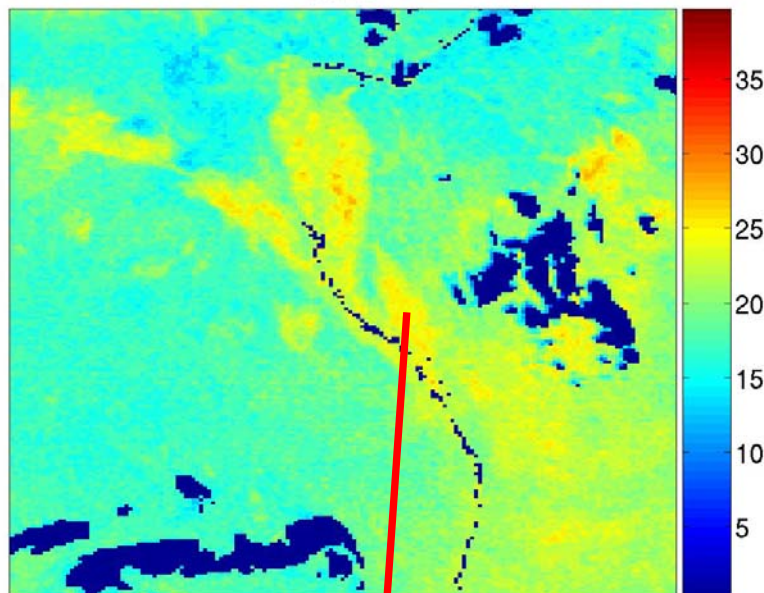
The Sudd Marshes peak extent occurs usually in November-December, (when the ITCZ recedes and the wet weather moves away).[R1]

R1 - http://oiswww.eumetsat.org/WEBOPS/iotm/iotm/20051202_flood/20051202_flood.html

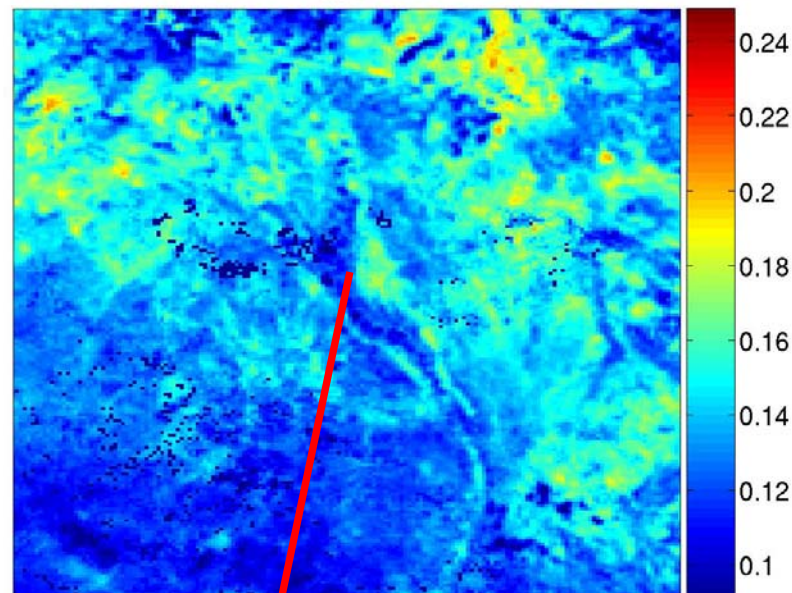
The Sudd Marshes peak extent occurs usually in November-December, (when the ITCZ recedes and the wet weather moves away).[R1]

NOVEMBER 2005:

LST-00UTC



ALBEDO

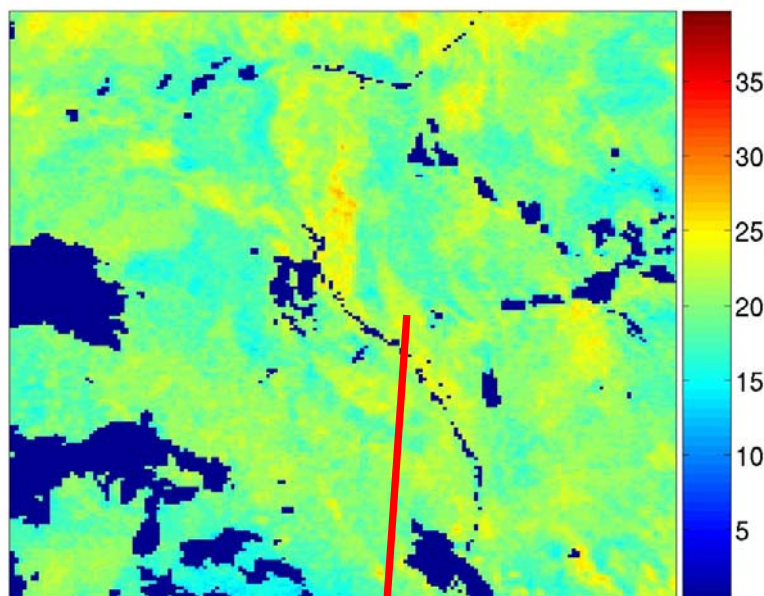


Flooded area
(warmer than the surroundings)

ALBEDO ↓↓ over flooded area

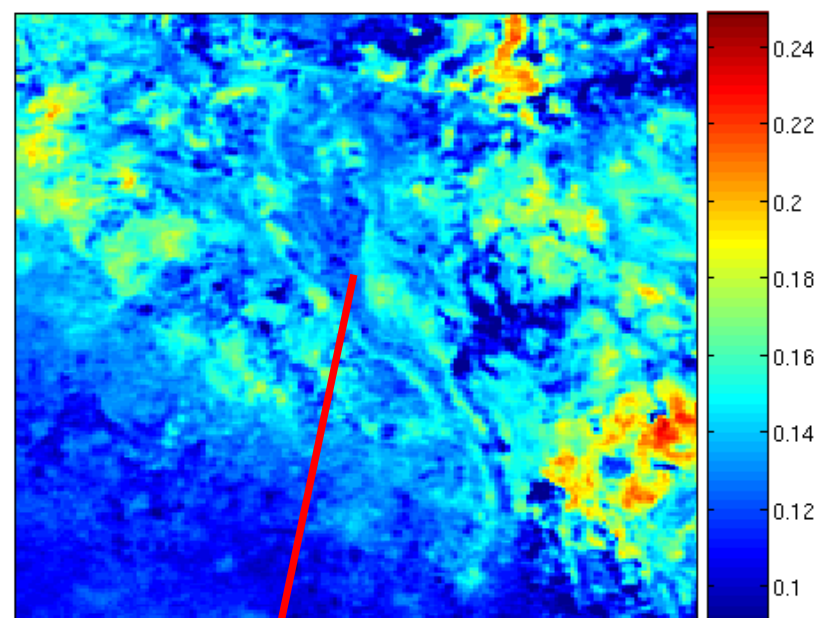
DECEMBER 2005:

LST-00UTC



Flooded area
(warmer than the surroundings)

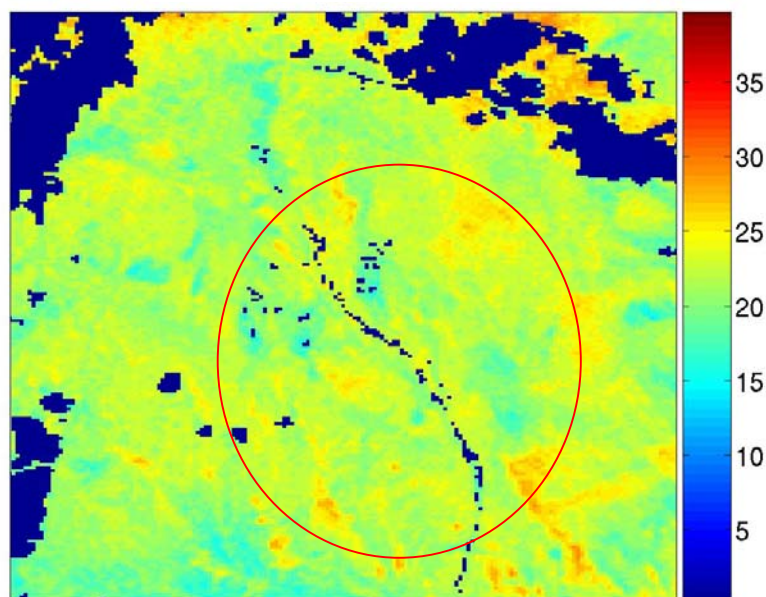
ALBEDO



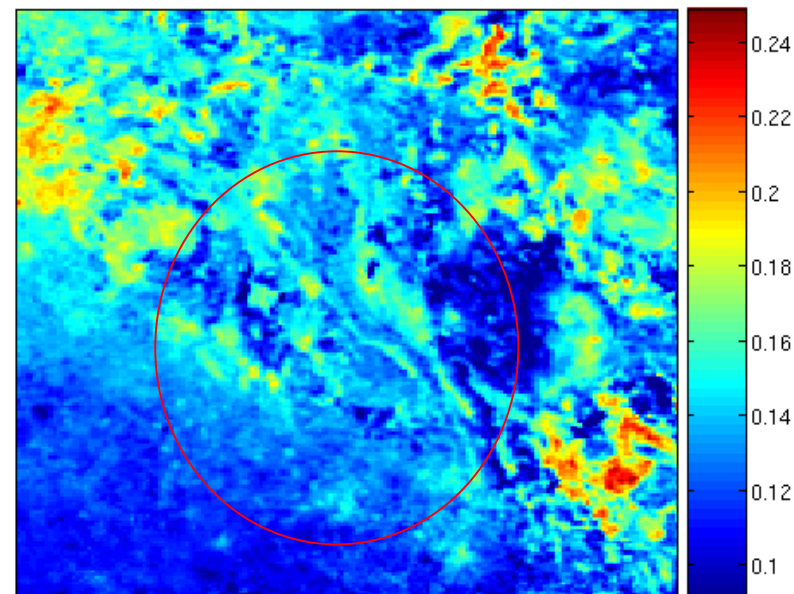
ALBEDO ↓ over flooded area

JANUARY 2006:

LST-00UTC



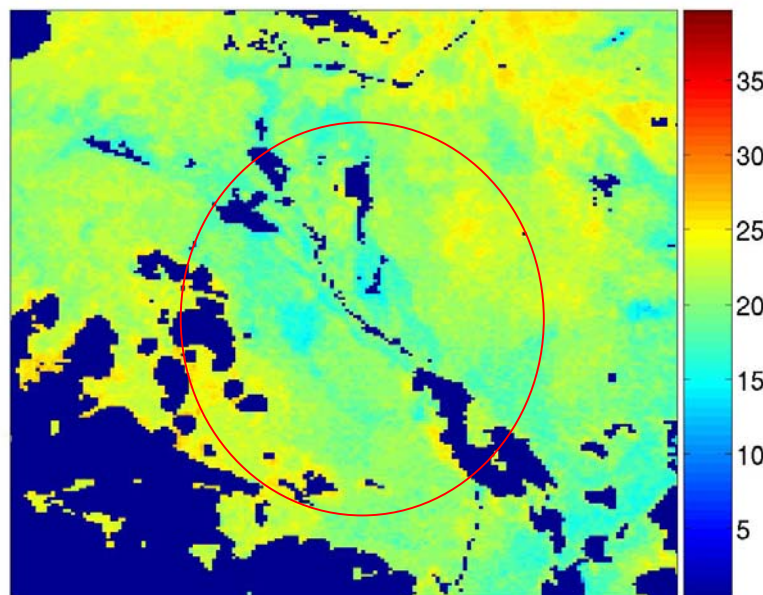
ALBEDO



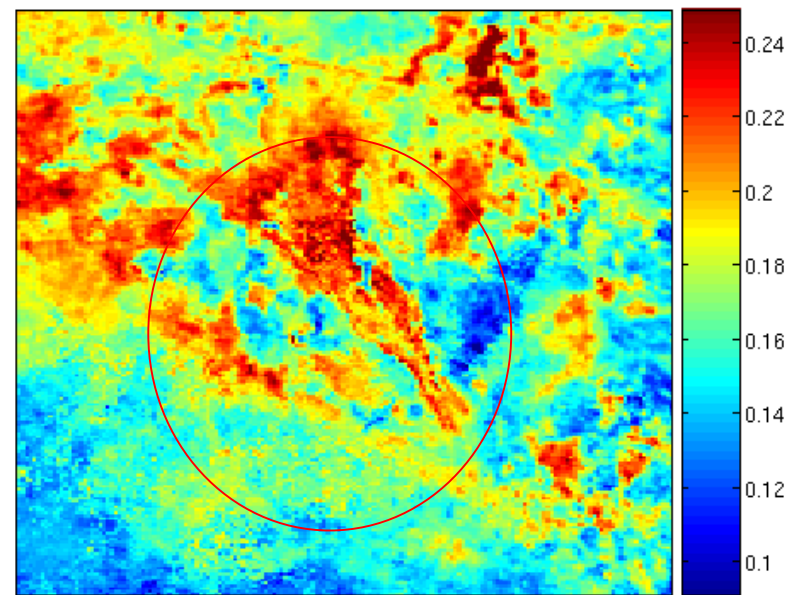
No pattern in LST or in ABEDO that could be associated to a flooded area.

FEBRUARY 2006:

LST-00UTC



ALBEDO



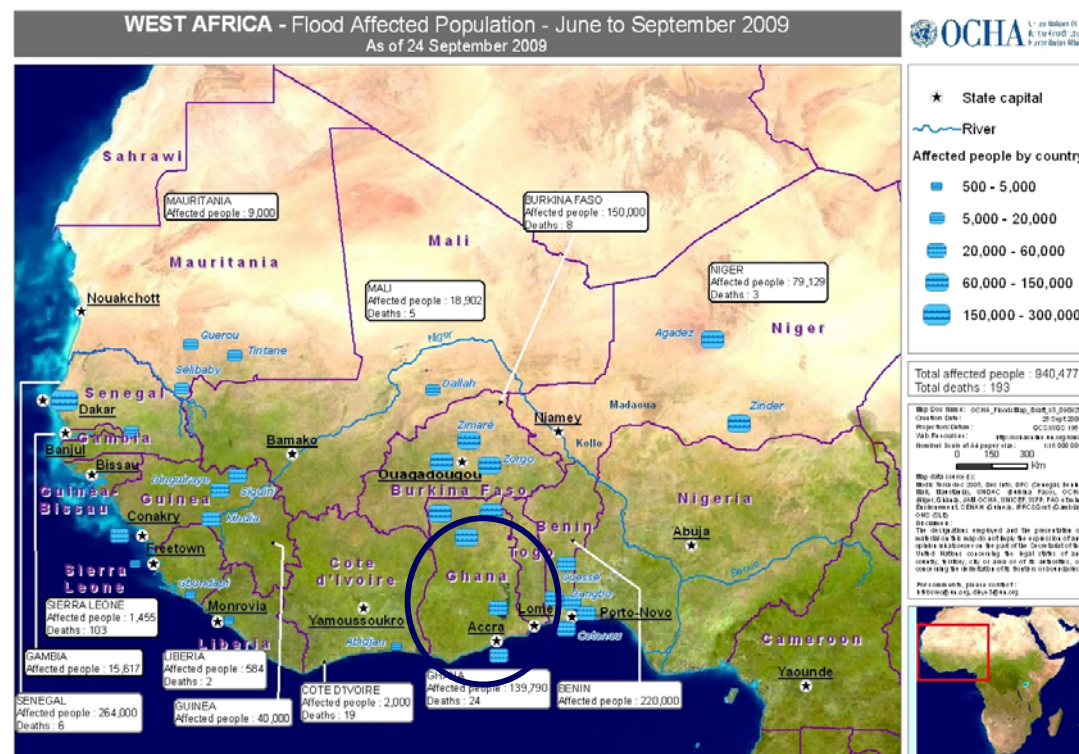
No pattern in LST or in the ALBEDO that could be associated to a flooded area.

West Africa heavy floods 2009

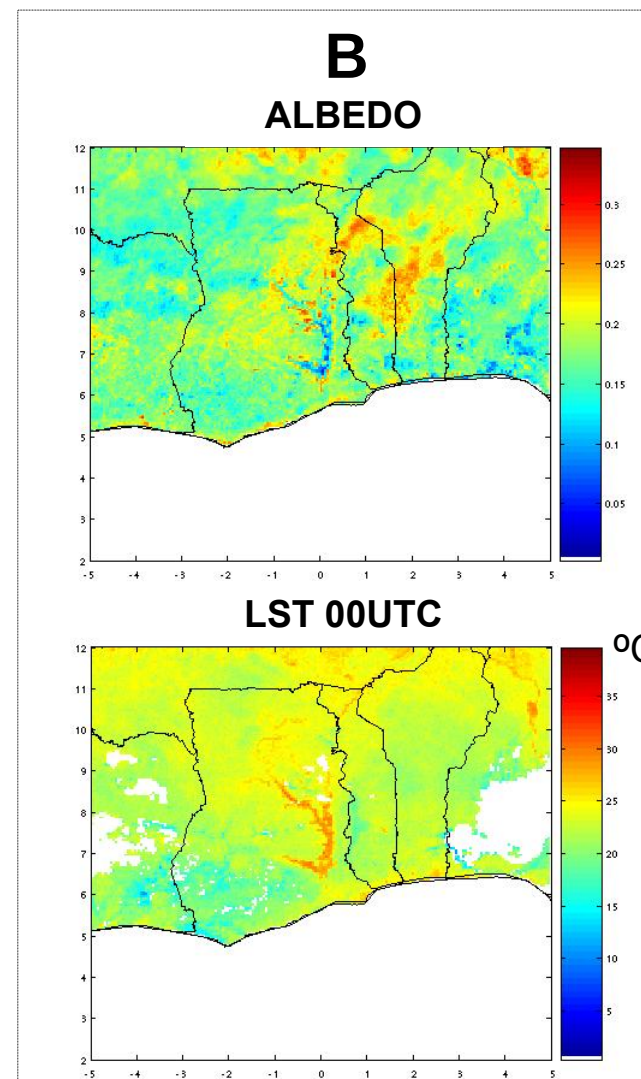
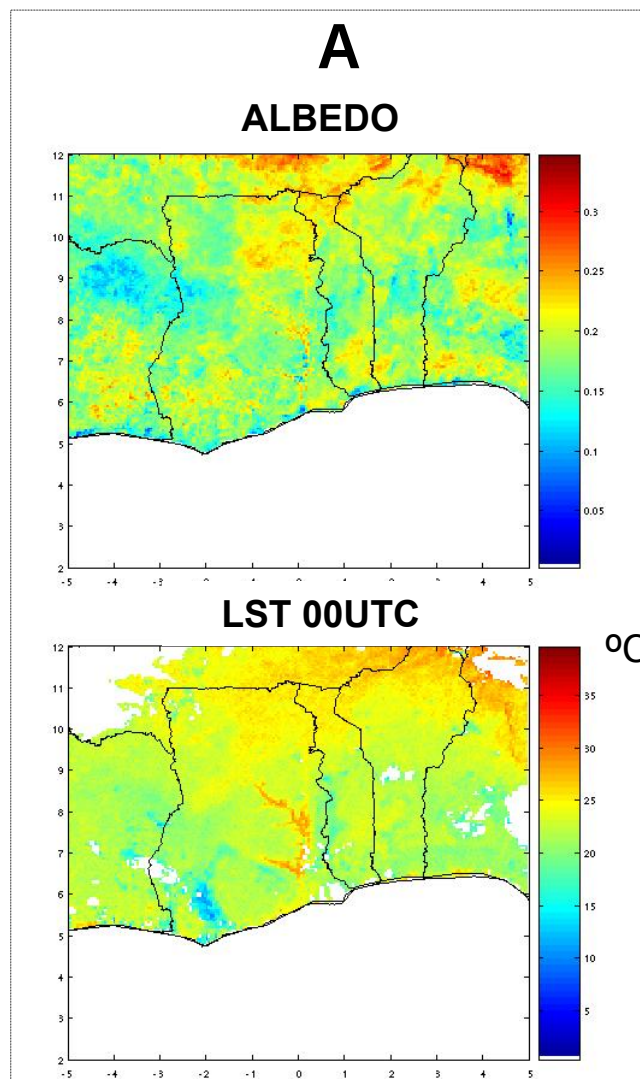


<http://news.bbc.co.uk/2/hi/8239552.stm>

350,000 people affected

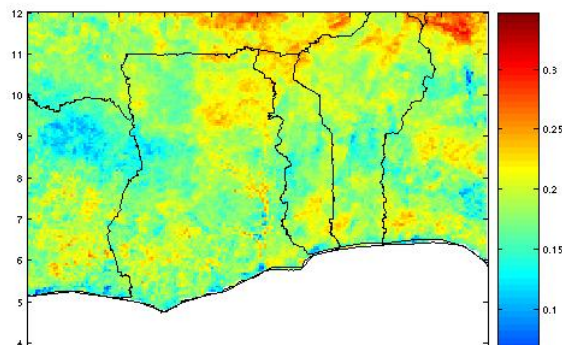


Q. Which group of pictures (A or B) should correspond to October 2009 (end of rainy season)?



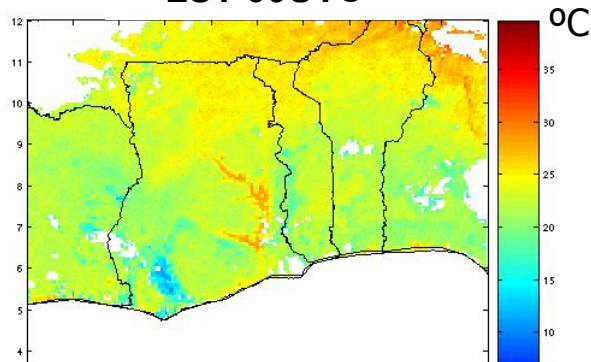
A

ALBEDO



Albedo values similar to neighbour pixels => No flooded areas

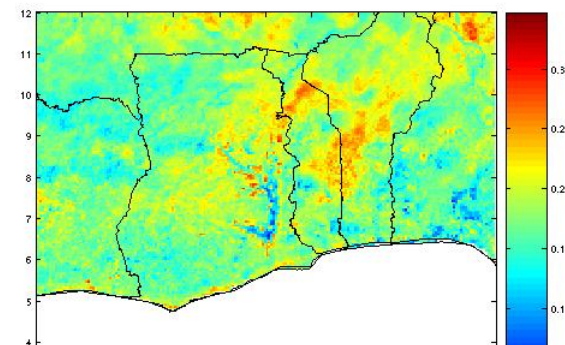
LST 00UTC



LST gradient less evident and relative high values constrained to inland waters => No flooded areas

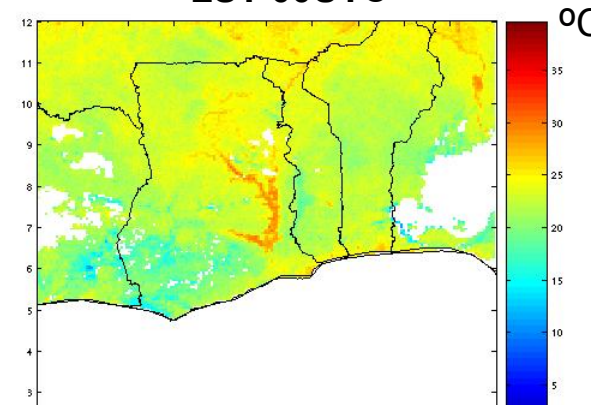
B

ALBEDO



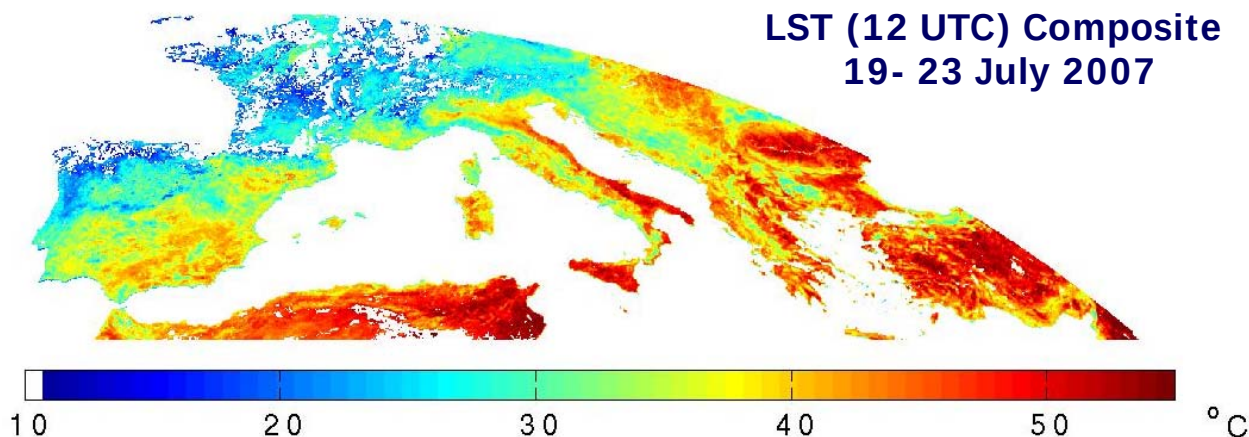
Low Albedo values compared with neighbouring pixels => **water bodies**

LST 00UTC



High LST values (at 00UTC) compared with neighbouring pixels => **water bodies**

THE HEAT WAVE IN CENTRAL AND SOUTHEASTERN EUROPE (JULY 2007)



Land Surface Temperature (LST) over the Mediterranean region showing the high temperatures occurred during the heat wave in July 2007 over Central and South-eastern Europe.



Watch One-Minute World News

Last Updated: Wednesday, 25 July 2007, 12:21 GMT 13:21 UK

E-mail this to a friend Printable version

Europe bakes in summer heatwave

South-eastern Europe is sweltering as a heatwave continues, with fears of further power cuts and forest fires.

The mercury is tipped to hit 40C in Greece, Romania, Bulgaria and Serbia, but temperatures have eased slightly in many areas affected by the heat.

Greece's electricity grid is close to breaking point as demand soars and searing temperatures evaporate rivers used to



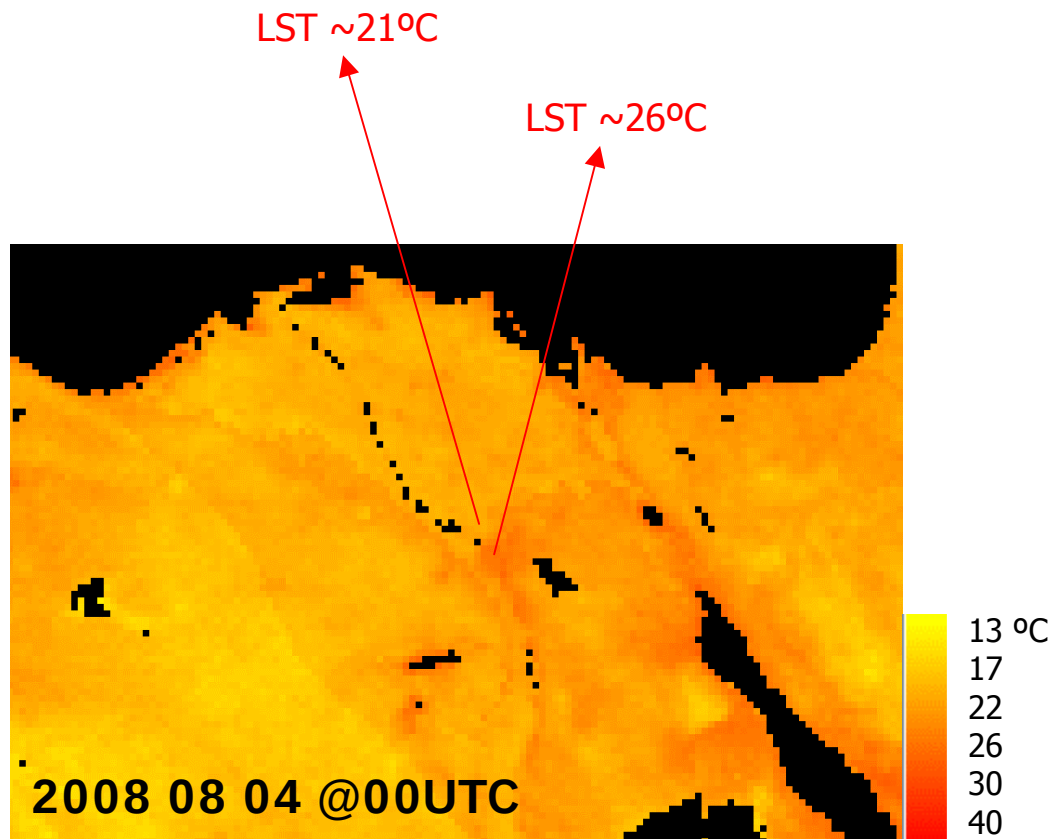
Macedonia's president declared a state of emergency as fires raged by the heat.

News Front Page

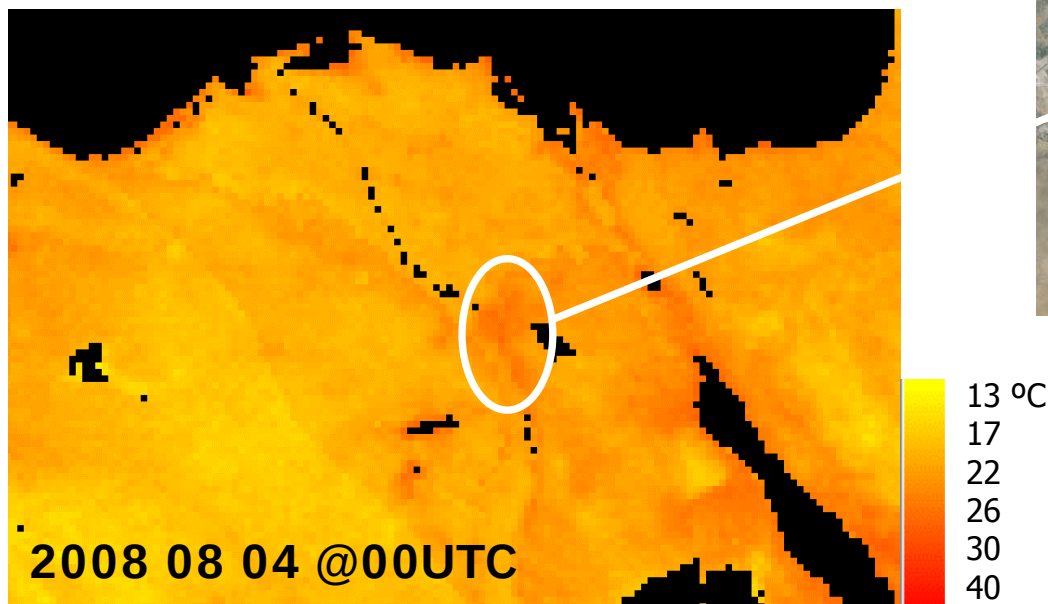
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- Asia-Pacific
- Europe**
- Middle East
- South Asia
- UK
- Business
- Health
- Science & Environment
- Technology
- Entertainment
- Also in the news

Source: <http://news.bbc.co.uk/2/hi/europe/6915157.stm>

Detection of Urban Heat Islands



Detection of Urban Heat Islands



The Portuguese Met Office is developing a frost monitoring product based in the LSA SAF LST;

First step: derive a correspondence between range of land surface temperatures and possibility of frost.

Range of LST	Possibility of Ground Frost	Range of LST	Possibility of Ground Frost
$3 < \text{LST} \leq 4$	1	$-2 < \text{LST} \leq -1$	6
$2 < \text{LST} \leq 3$	2	$-3 < \text{LST} \leq -2$	7
$1 < \text{LST} \leq 2$	3	$-4 < \text{LST} \leq -3$	8
$0 < \text{LST} \leq 1$	4	$-5 < \text{LST} \leq -4$	9
$-1 < \text{LST} \leq 0$	5	$\text{LST} \leq -5$	10



Source:

<http://www.flickr.com/photos/belly-timber/74605196/>

Source:

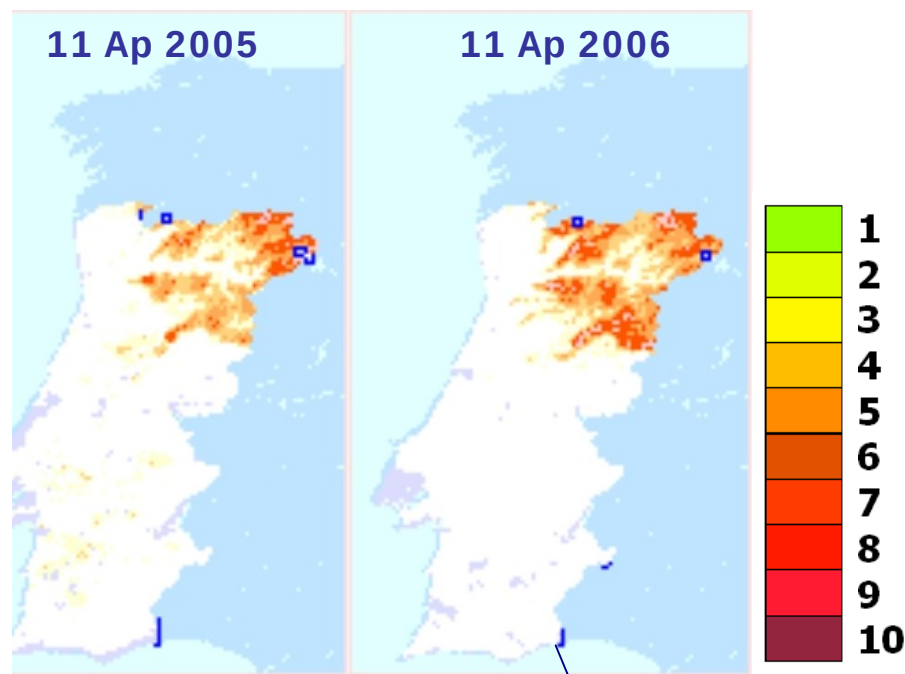
APPLICATIONS OF "LSA SAF PRODUCTS". Lourdes Bugalho¹, Luís Pessanha². Proceeding of the 7^o Simpósio de Meteorologia e Geofísica da APMG. Setubal, Portugal, 2011

¹ Instituto de Meteorologia, Lisboa, lourdes.bugalho@meteo.pt

² Instituto de Meteorologia, Lisboa, luís.pessanha@meteo.pt

Frost conditions:

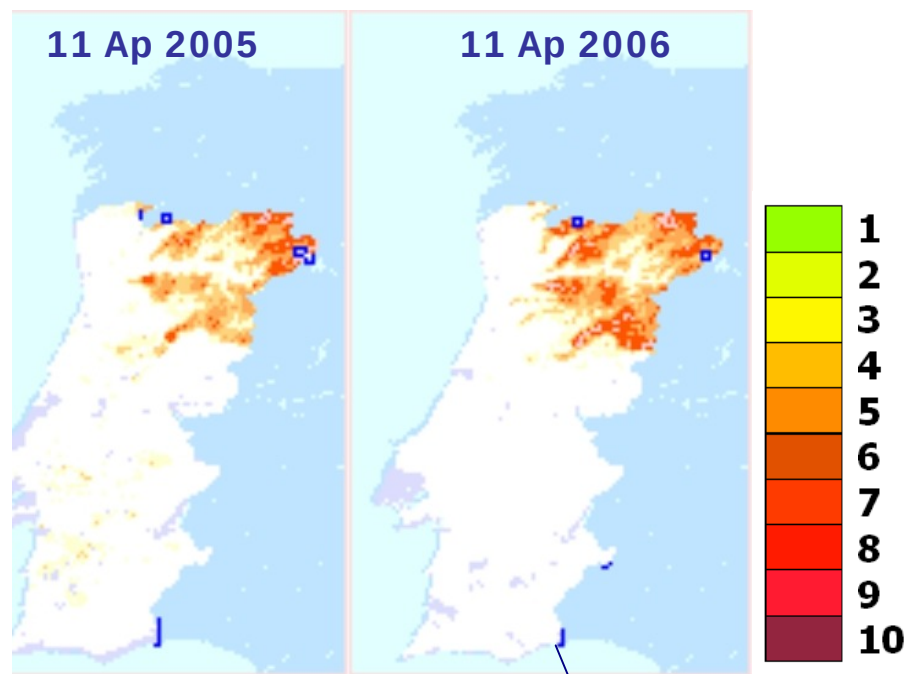
Ground data showed a good agreement with this results.



Degree of possibility for ground ice

Blue coloured pixels = Possible contamination by clouds

Frost conditions:



Degree of possibility for ground ice

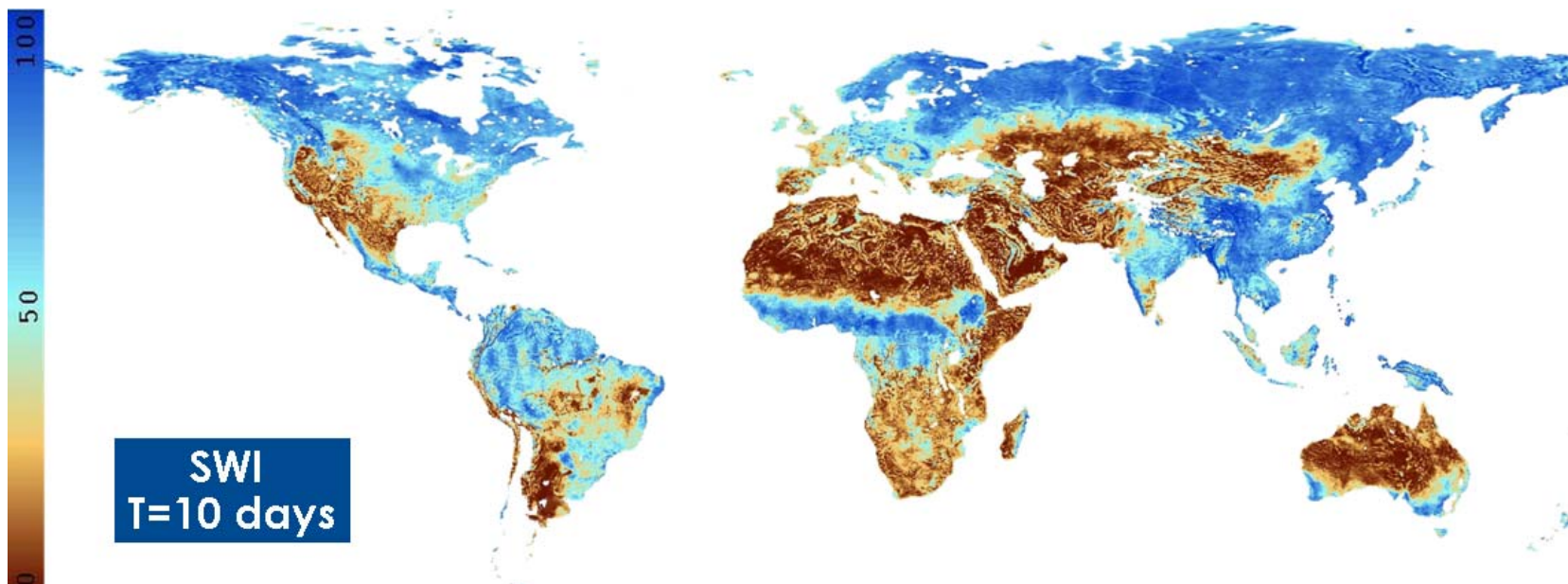
Blue coloured pixels = Possible contamination by clouds

Variables to be included shortly:

- wind
- Soil water content

Soil water index

The **Soil Water Index** is defined as the soil moisture content (in percent) in the soil profile.



Coverage:	Global
Spatial Resolution:	0.1° X 0.1°
Temporal Resolution:	Daily
Projection:	Plate-carré
File Format:	HDF5



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 **LSA SAF**
Low Level Surface Analysis

Questions / Comments?