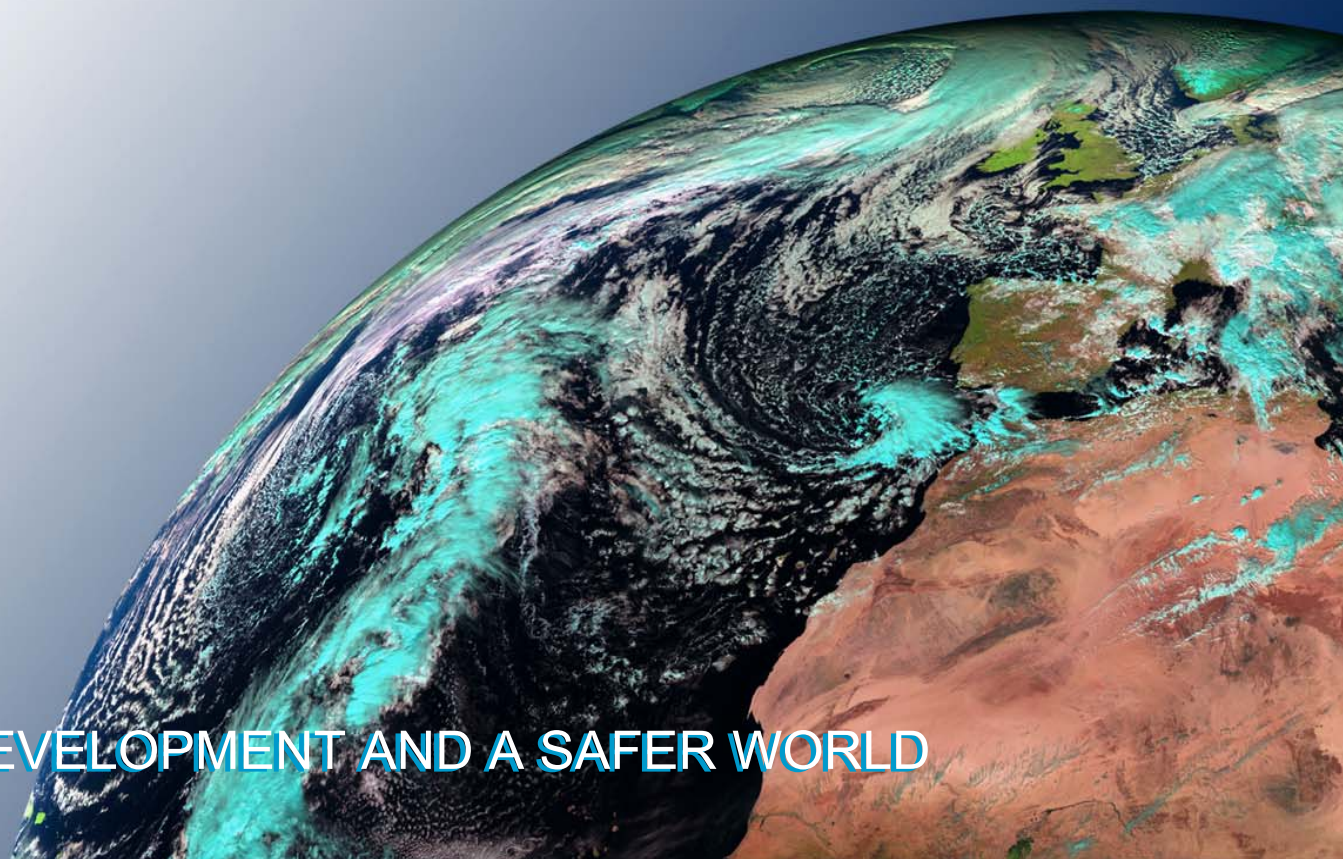
Land Applications

Carla Barroso, IM

Satellite Image Interpretation and Applications



MONITORING

WEATHER
CLIMATE
SEISMIC ACTIVITY

TO

A SUSTAINABLE DEVELOPMENT AND A SAFER WORLD

Outline

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

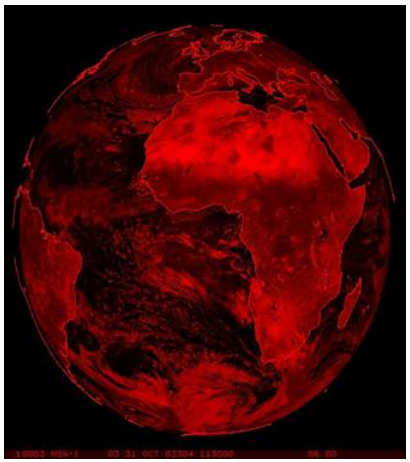
Framework

- 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**.

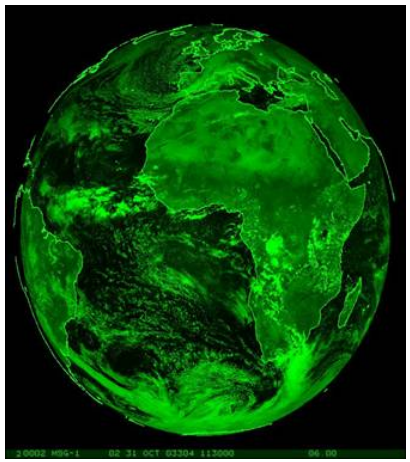
- There are many applications of such products, including:
  - Vegetation monitoring
  - Wild Fires detection and monitoring
  - Floods monitoring
  - Heat waves monitoring
  - Detection of Urban heat islands
  - Crop water requirements
  - …

Vegetation

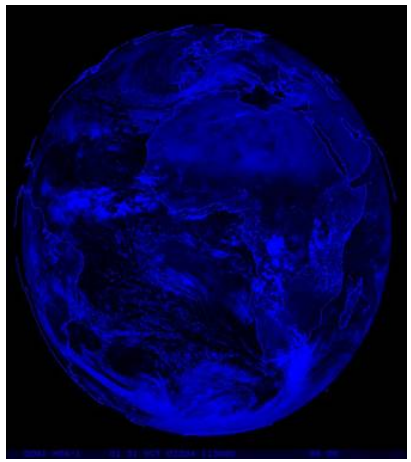
RGB Techniques – works by associating a colour to a particular channel



Red - MSG 1.6 μm



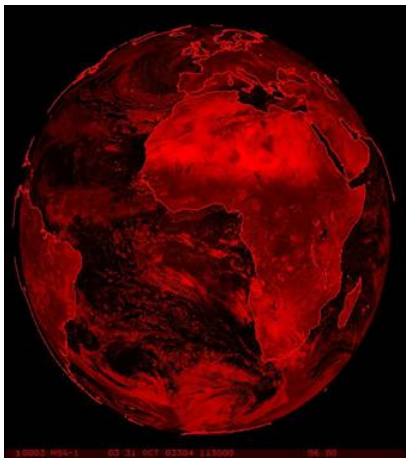
Green - MSG 0.8 μm

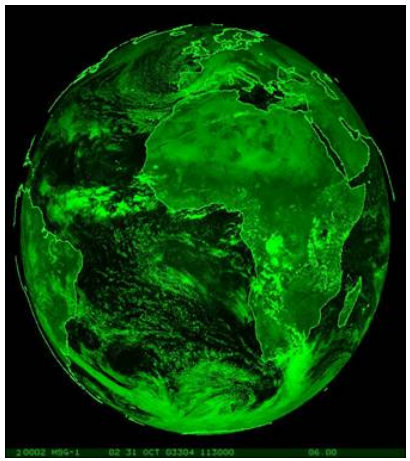


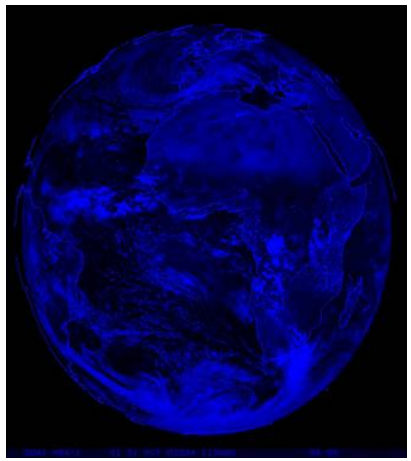
Blue - MSG 0.6 μm

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

Vegetation





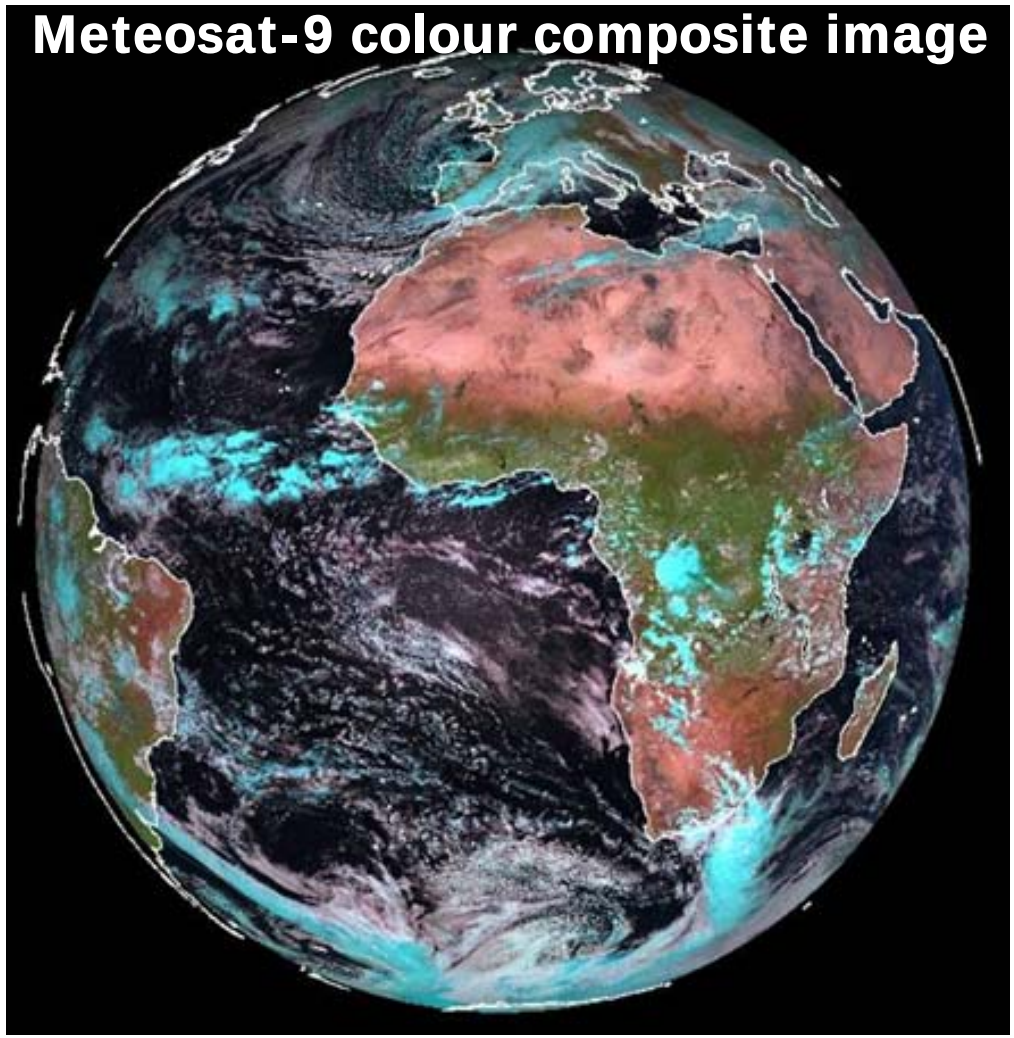


Red - MSG 1.6 μm Green - MSG 0.8 μm Blue - MSG 0.6 μm

Q. Can you remember the name of this RGB?

Vegetation

Natural colour



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

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

Vegetation Indices

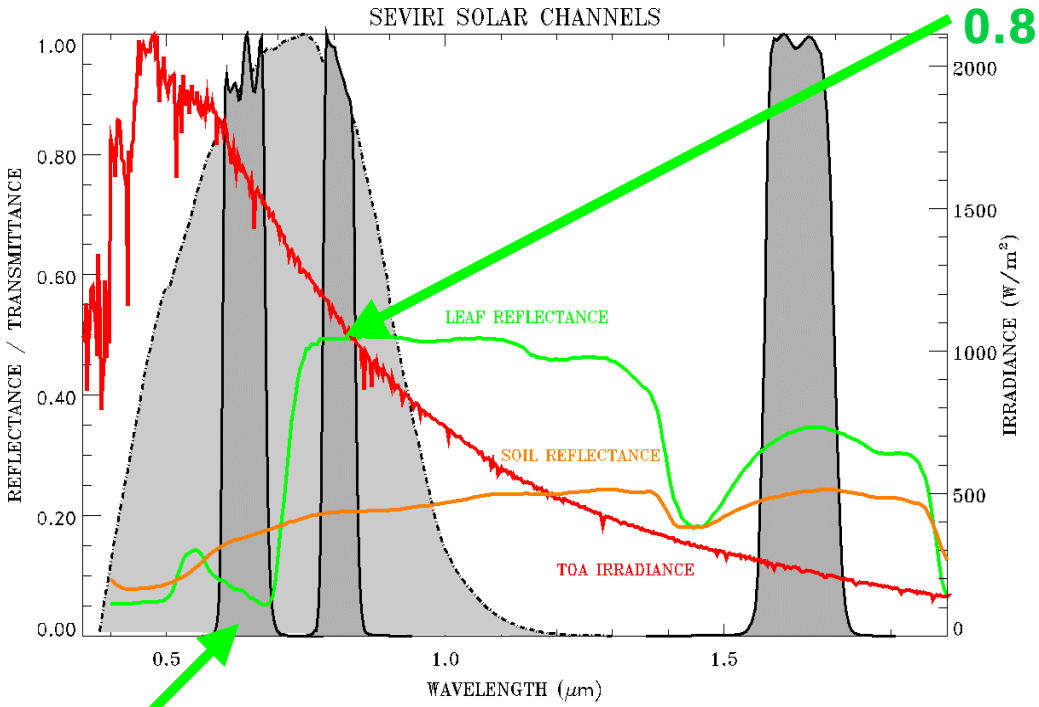
- Combine information from different channels to enhance the 'vegetation signal'.
- Have been developed for a wide range of sensors and for different applications.

Vegetation

NDVI – Normalized Difference Vegetation Index

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

high reflectance at 0.8 μm



strong absorption at the 0.6 μm

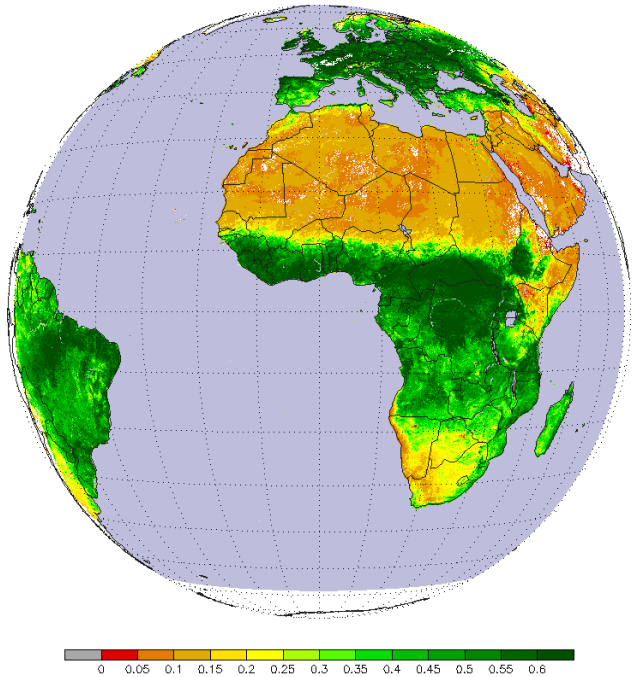
***Source**:*
http://www.eumetrain.org/resources/operational_use_rgb.html

Vegetation

$$NDVI = \frac{\rho_{\text{channel}2} - \rho_{\text{channel}1}}{\rho_{\text{channel}1} + \rho_{\text{channel}2}}$$

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.

Vegetation

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Disadvantages

× Sensitive to fluctuations/noise in the observations (the lighting conditions of the surface, aerosols, contamination by clouds);

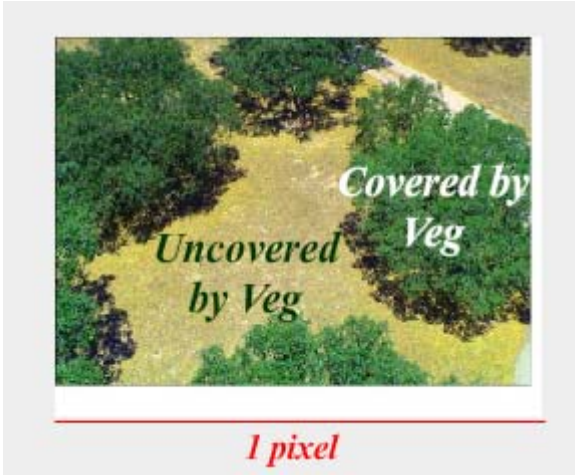
× It saturates in high biomass situations;

× Does not correspond to any property / physical characteristic of the surface/vegetation.

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**)

Vegetation

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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**)

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

Fraction of Absorbed Photosynthetically Active Radiation:

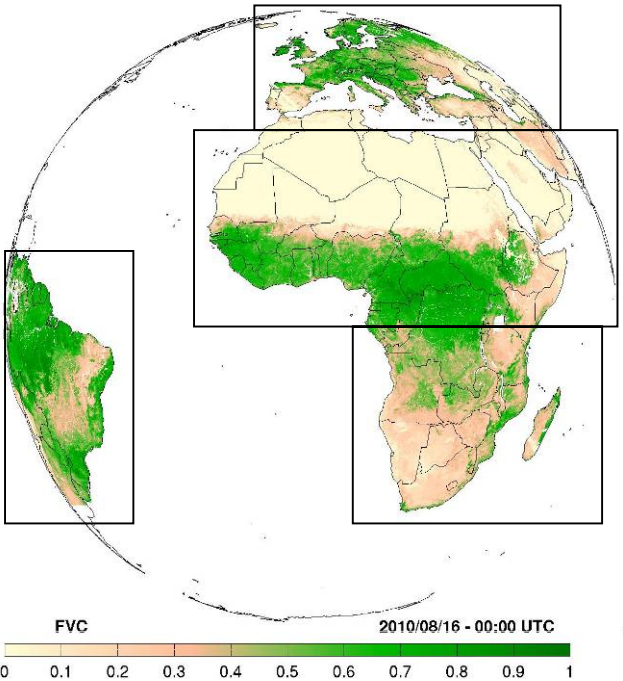
part of radiation used for photosynthesis (0.4 – 0.7μm) absorbed by the green parts of the canopy

(**FAPAR**)

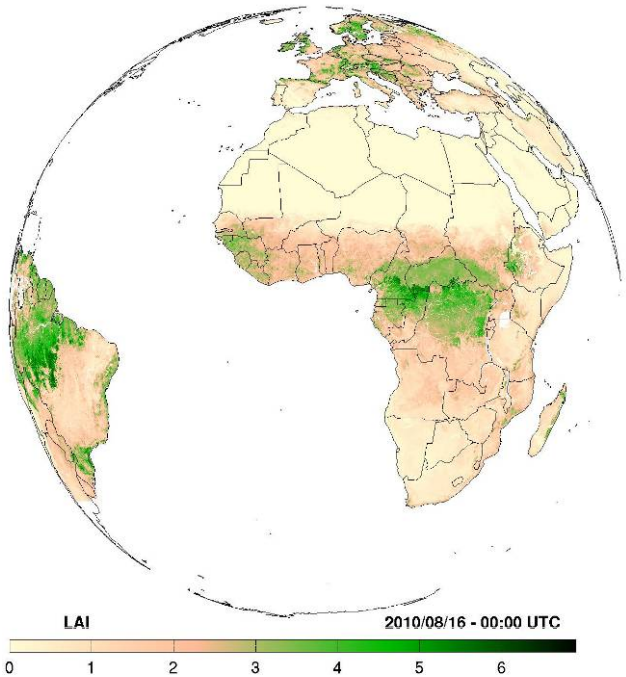
Vegetation

LSA SAF Products

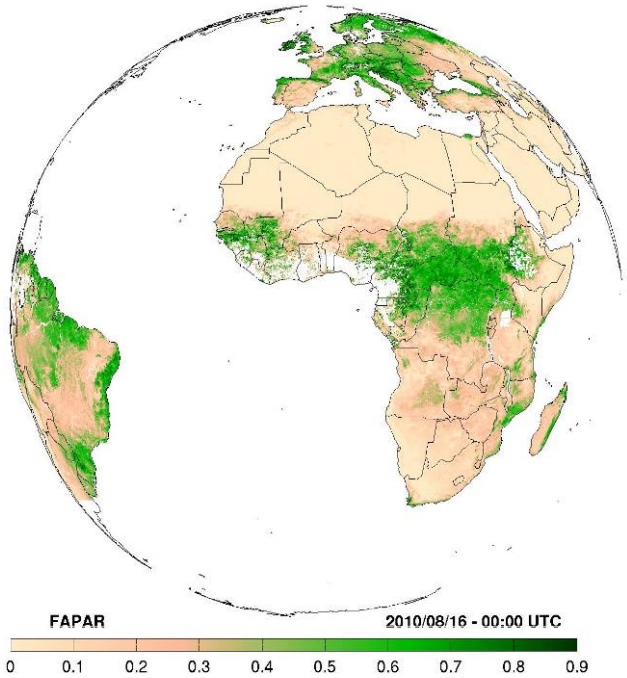
Fractional Vegetation Cover - FVC



Leaf Area Index- LAI



Fraction of Absorbed Photosynthetically Active Radiation - fAPAR



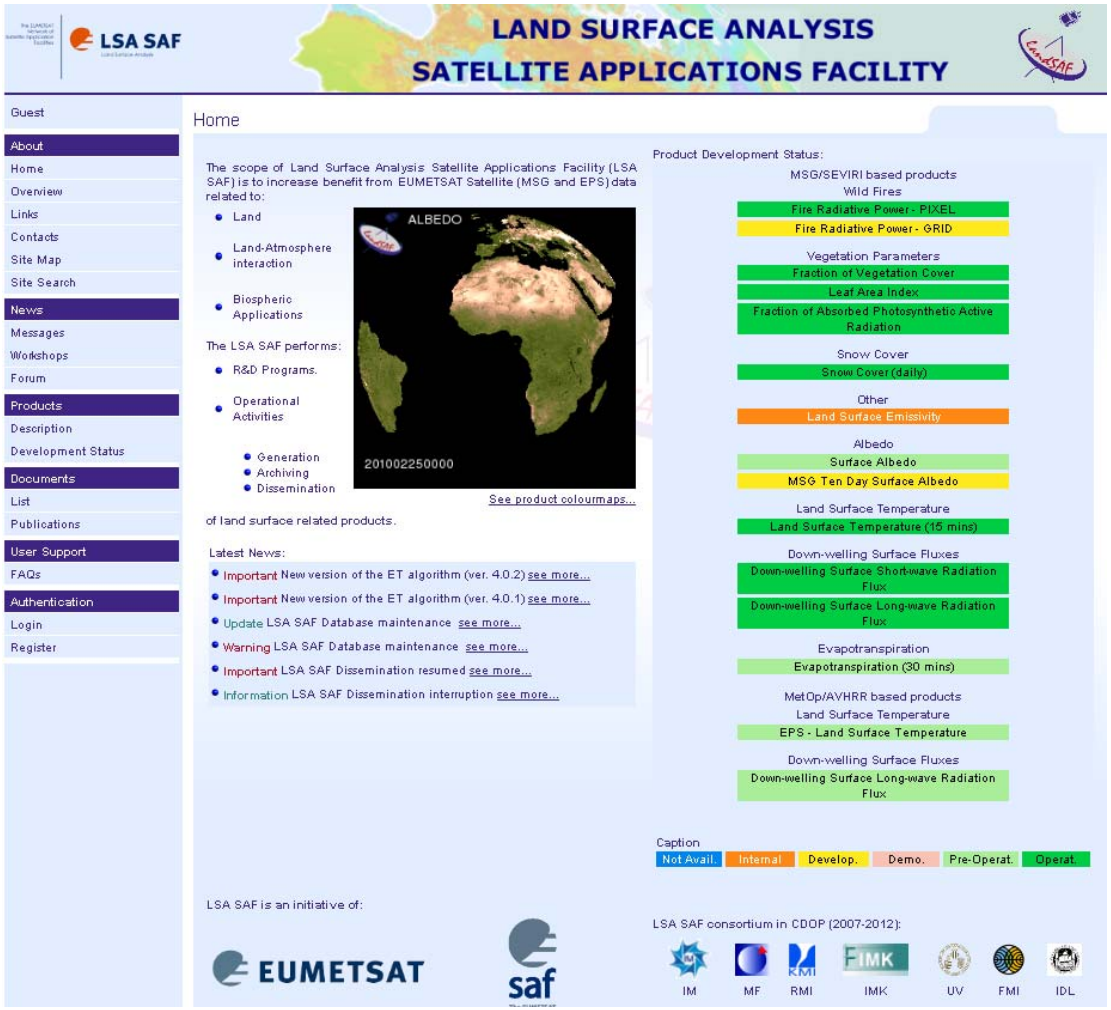
√ Daily

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

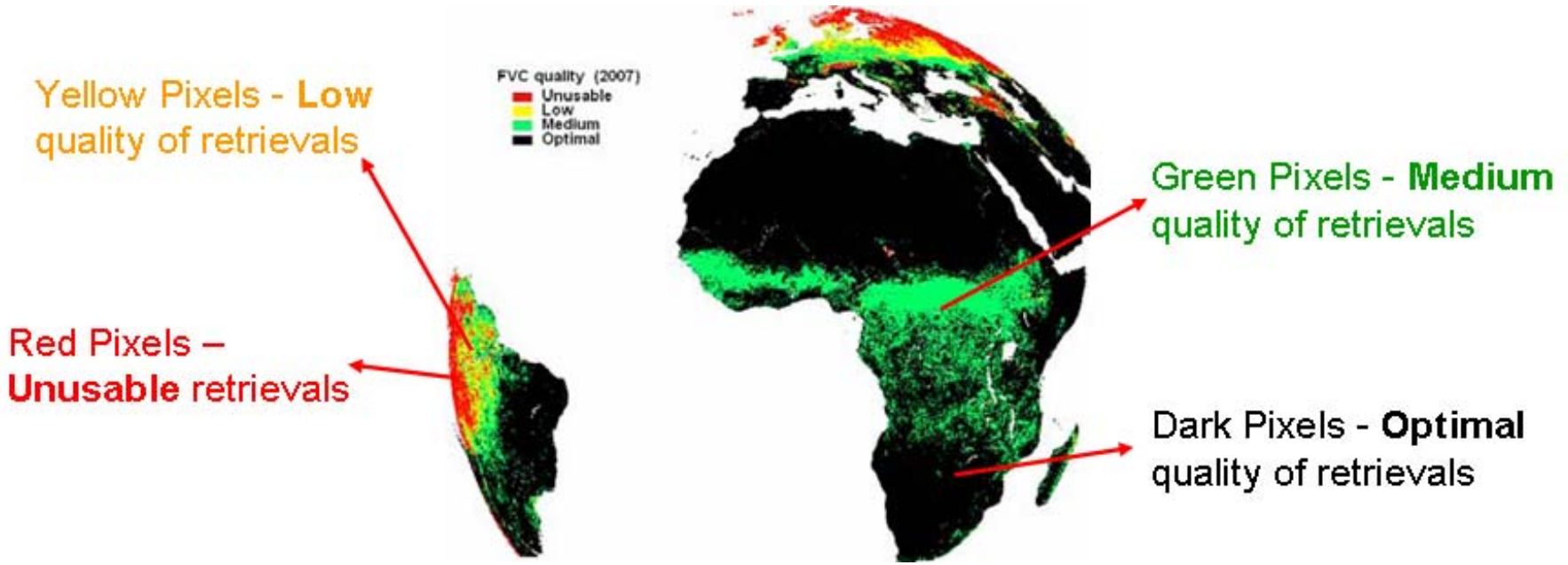
√ Available freely: Via Ftp (2006)
Eumetcast (2009)

LSA SAF

http://landsaf.meteo.pt



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

VEGETATION PRODUCTS FROM OTHER SATELLITE PROGRAMS:

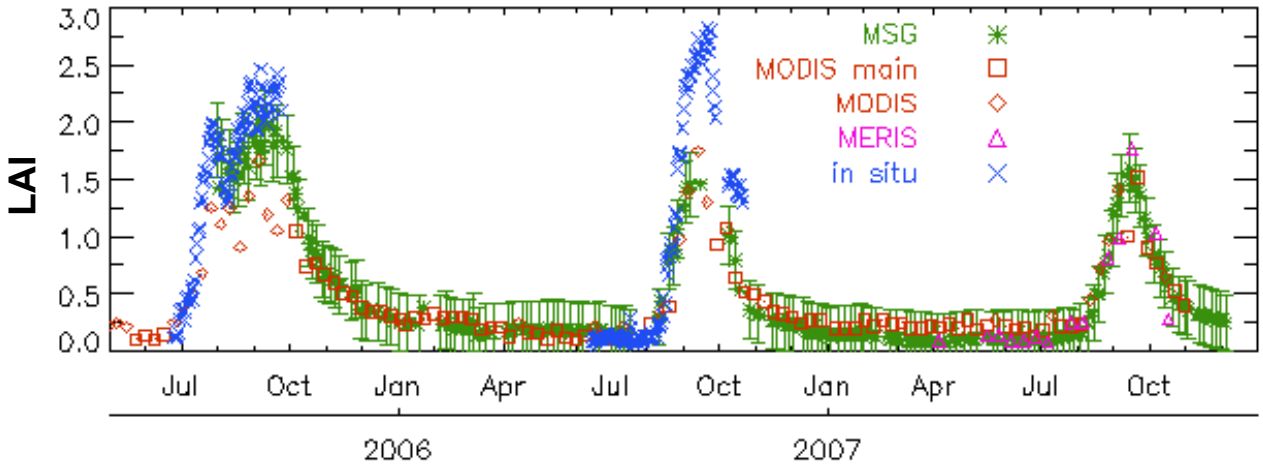
- POLDER (Leroy et al. 1997, Roujean and Lacaze 2002);
- MODIS and MISR (Knyazikhin et al. 1999);
- MERIS (Gobron et al. 1999, Bacour et al. 2006, Baret et al. 2007);
- VEGETATION (Baret et al. 2007, Bartholomé et al. 2006);

...

Vegetation

➢Comparison with in situ measurements

Dahra (Senegal)



Q. Which of the products shows less gaps?

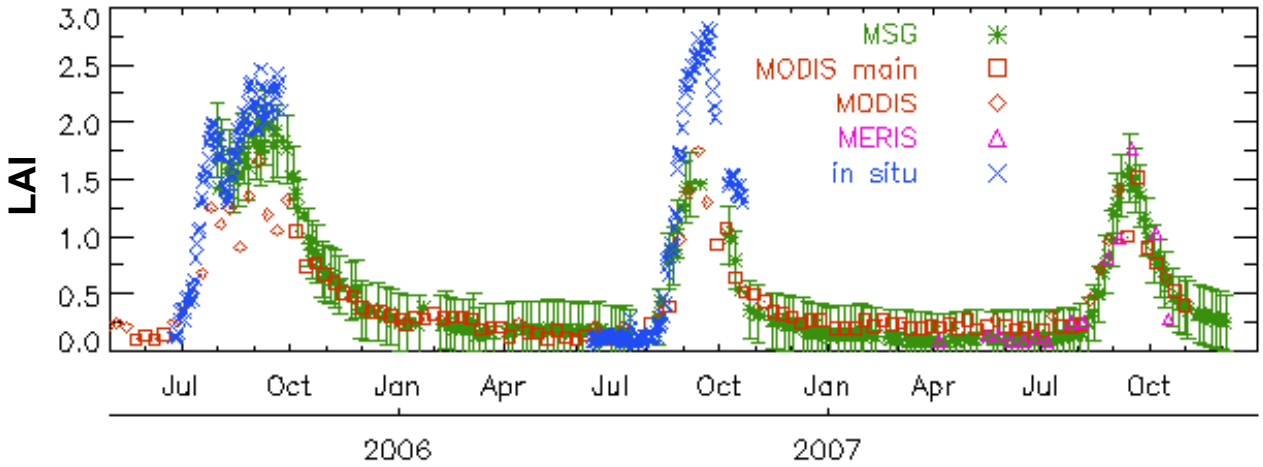
MODIS MSG MERIS

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

Vegetation

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

Applications - Phenological parameters

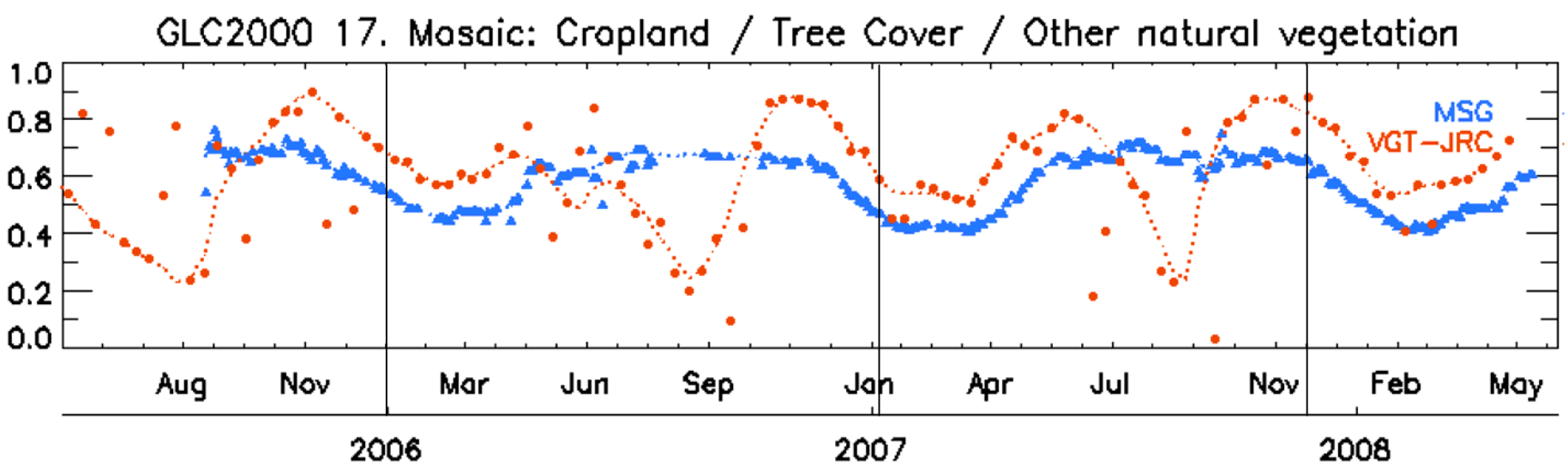
Vegetation products from **LSA SAF**

- 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);

Applications - Phenological parameters

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

C.Afr – Guinea Gulf



- 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)

Applications - DMP

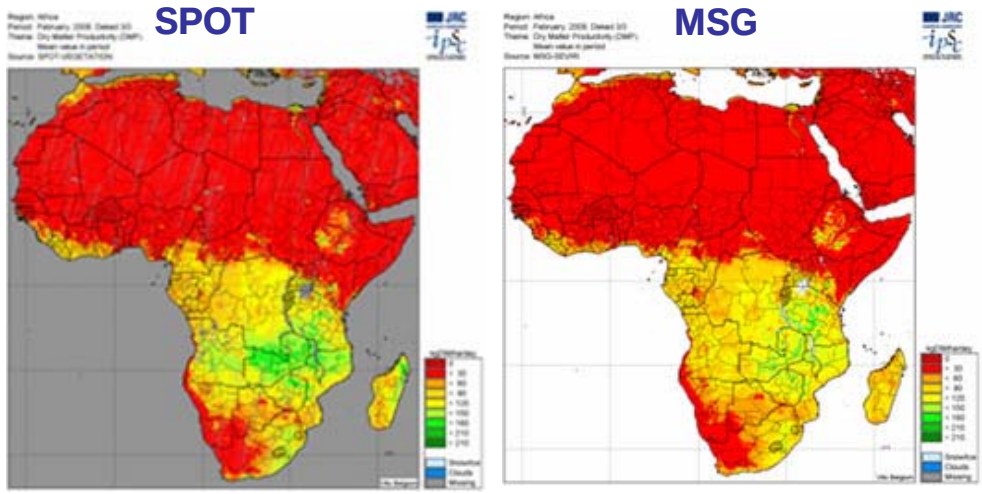
- **Dry Matter Productivity –** represents the increase in dry matter biomass.
  - It is a function of (*Monteith, 1972*):
    - ✓Incoming solar radiation (0.2-3.0 µm);
    - ✓Surface Temperature;
    - ✓fAPAR

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).

Applications - DMP

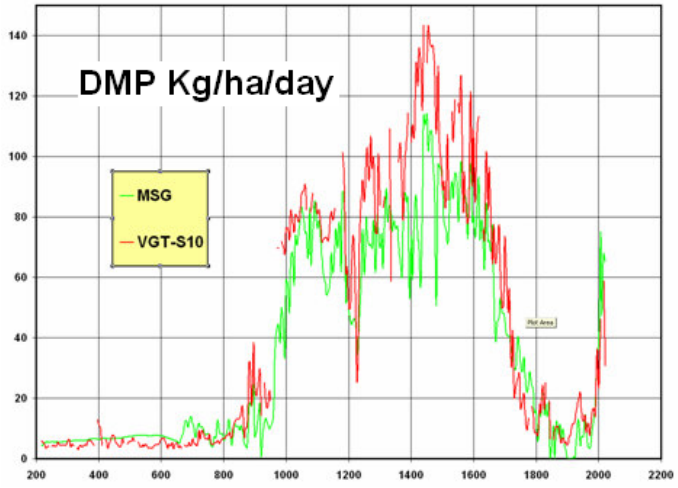
➢ Dry Matter Productivity

2008, February, Dekad 3 over Africa

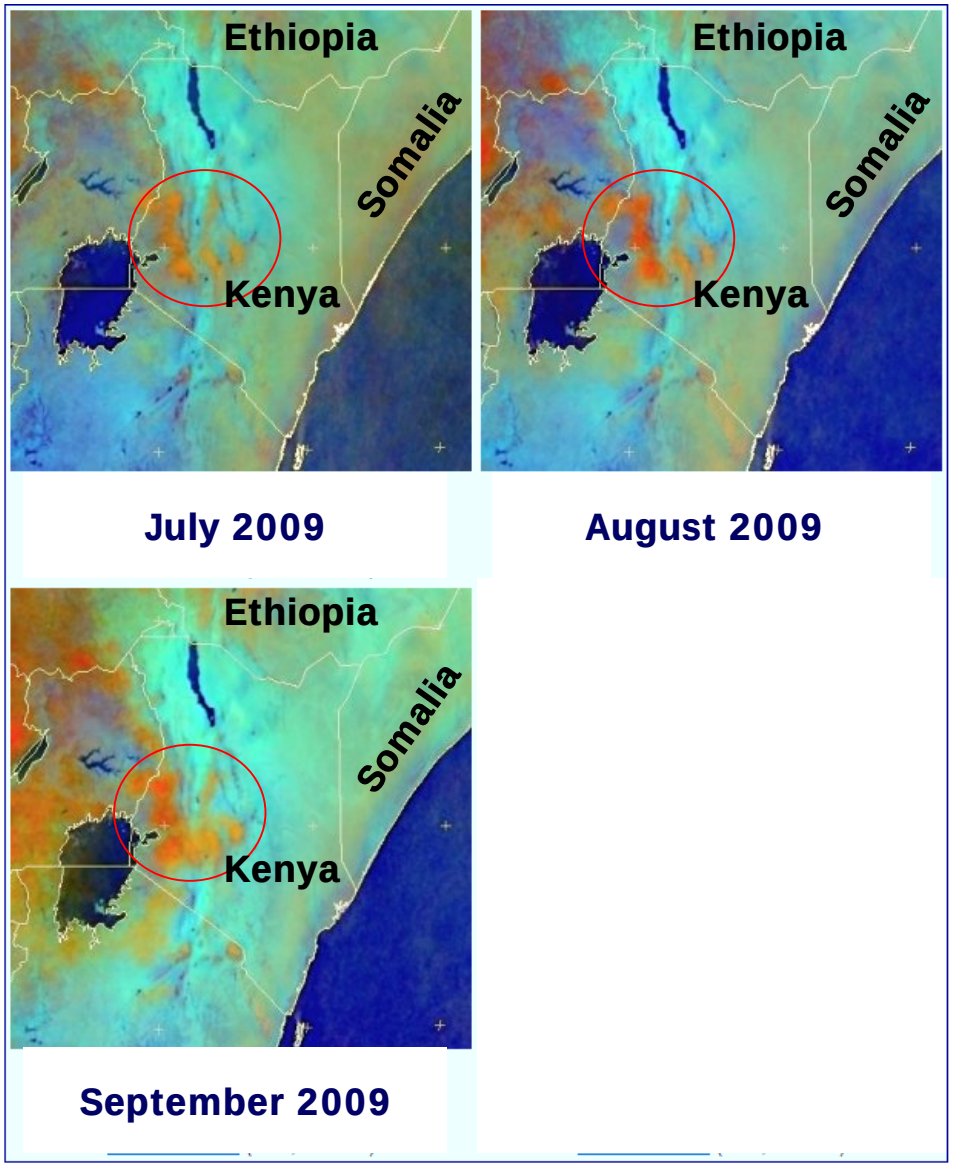


➢Very good spatial consistency;

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



Applications – Drought Monitoring



Severe Drought in Kenya 2009

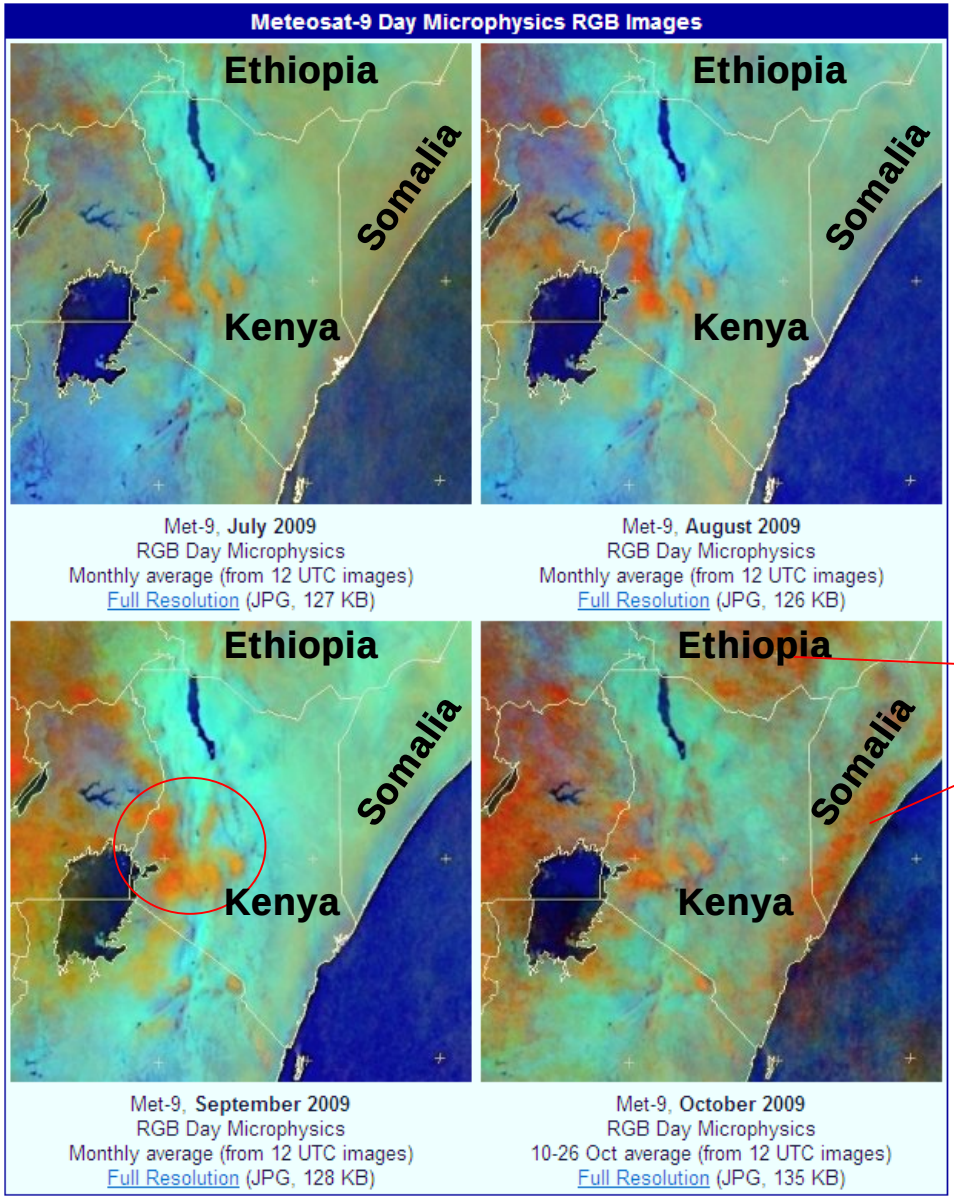
Q. Can you tell the name of this RGB?

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

Applications – Drought Monitoring



Severe Drought in Kenya 2009

Blue colors – cloud free/no rain areas

Red colors – high coverage of cold ice clouds & precipitation

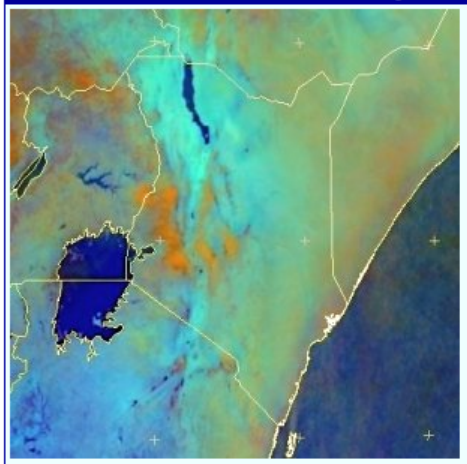
October

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

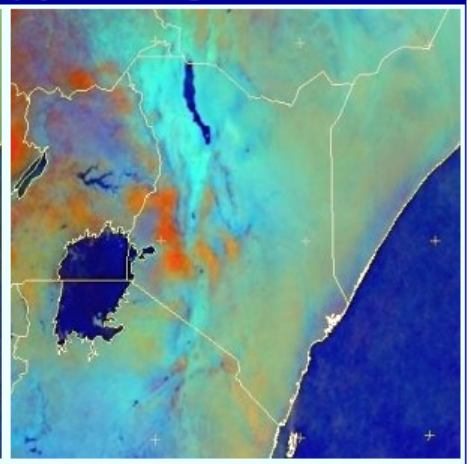
Sequence of images from http://oiswww.eumetsat.org/WEBOPS/iotm/iotm/20091001_drought/20091001_drought.html

Applications – Drought Monitoring

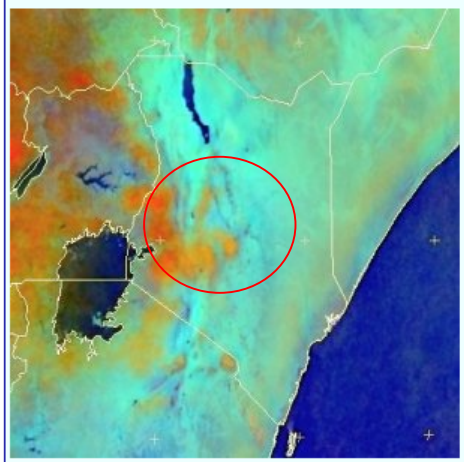
Meteosat-9 Day Microphysics RGB Images



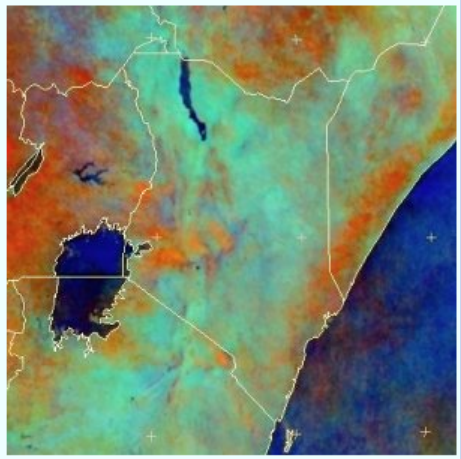
Met-9, **July 2009**
RGB Day Microphysics
Monthly average (from 12 UTC images)
Full Resolution (JPG, 127 KB)



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

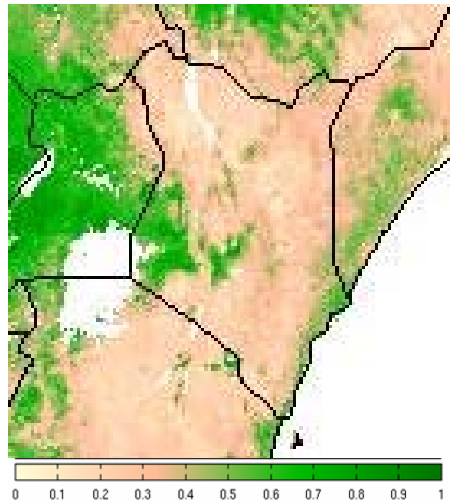


Met-9, **September 2009**
RGB Day Microphysics
Monthly average (from 12 UTC images)
Full Resolution (JPG, 128 KB)

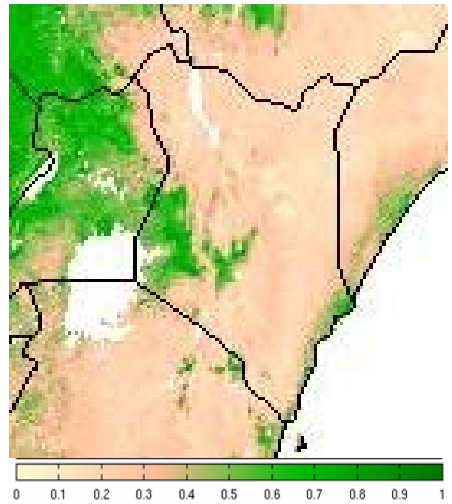


Met-9, **October 2009**
RGB Day Microphysics
10-26 Oct average (from 12 UTC images)
Full Resolution (JPG, 135 KB)

Which from bellow is from November 2009?



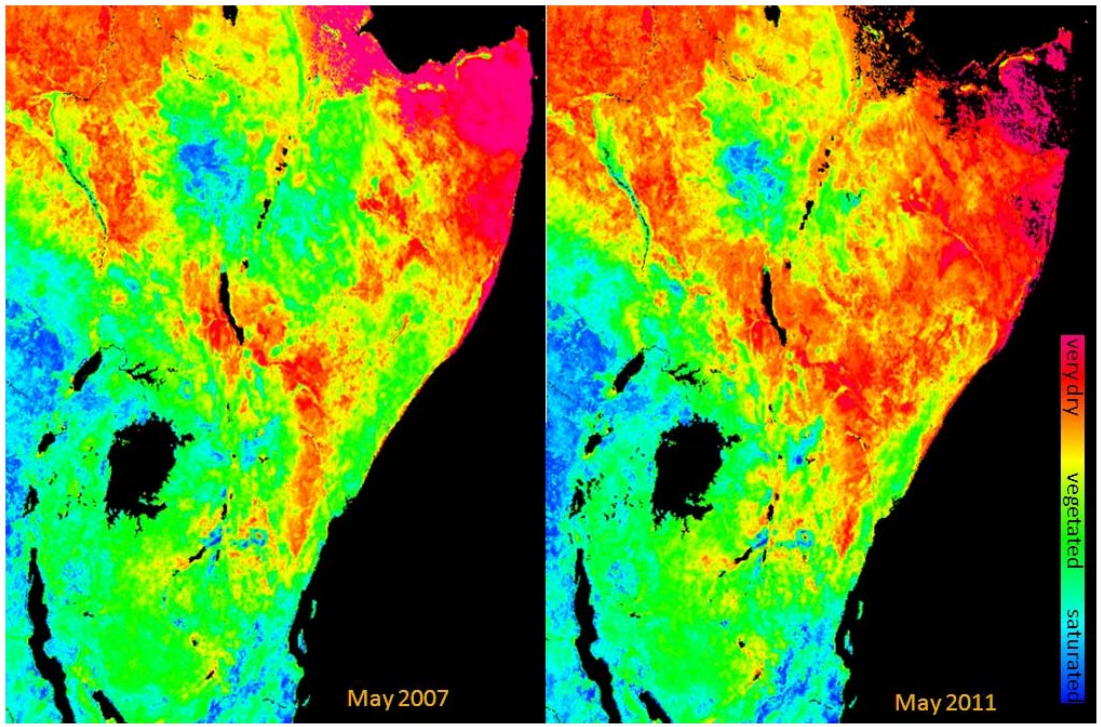
LSA SAF FVC



LSA SAF FVC

Applications – Drought Monitoring

Severe Drought continued up to 2011...



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

Applications - Fire Effects

➢Monitoring of Vegetation: Effects of the Fire Activity

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.

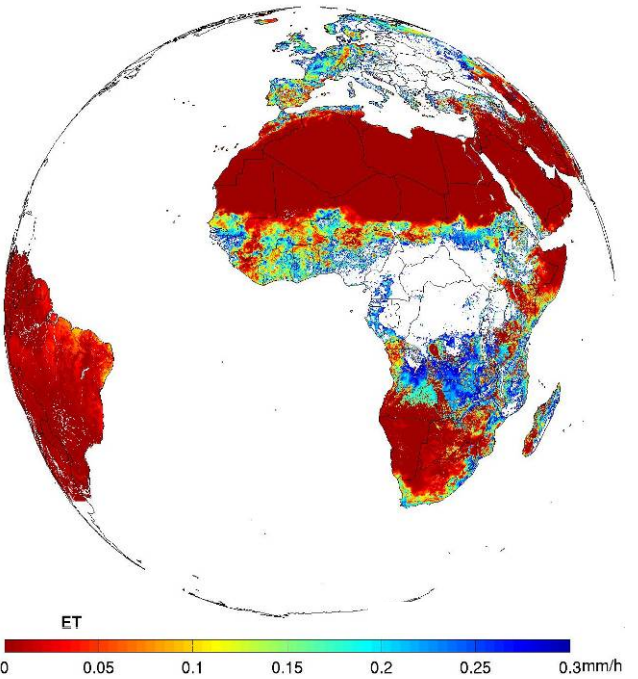
FVC

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

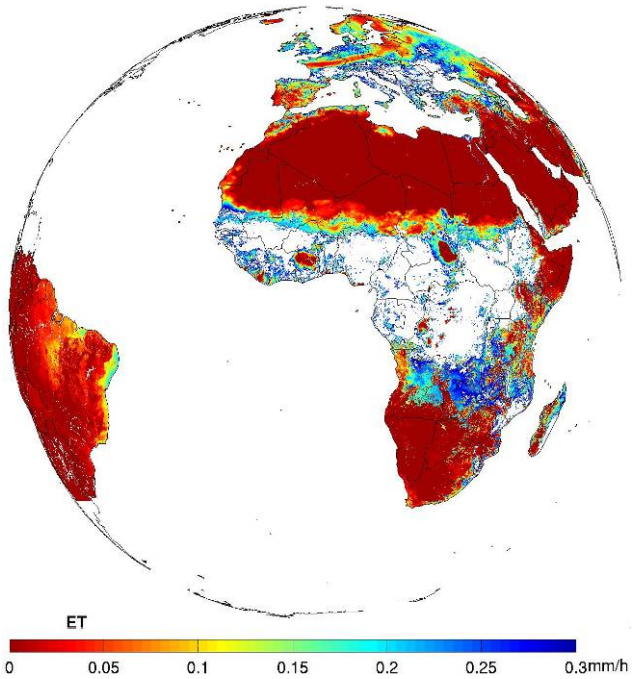
Evapotranspiration

➢ ***Temporal Frequency: 30 min & daily***

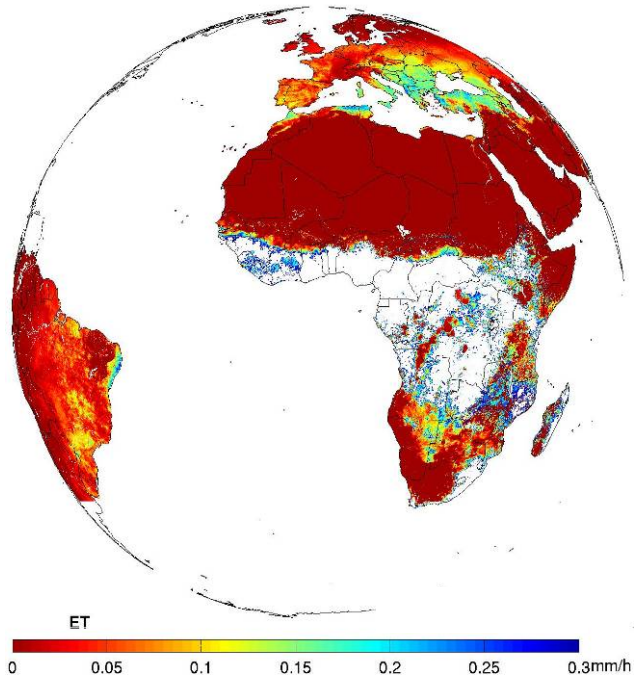
15 July 2010 @10:00UTC



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.

Reference Evapotranspiration

$$ET_c = K_c \cdot ET_0$$

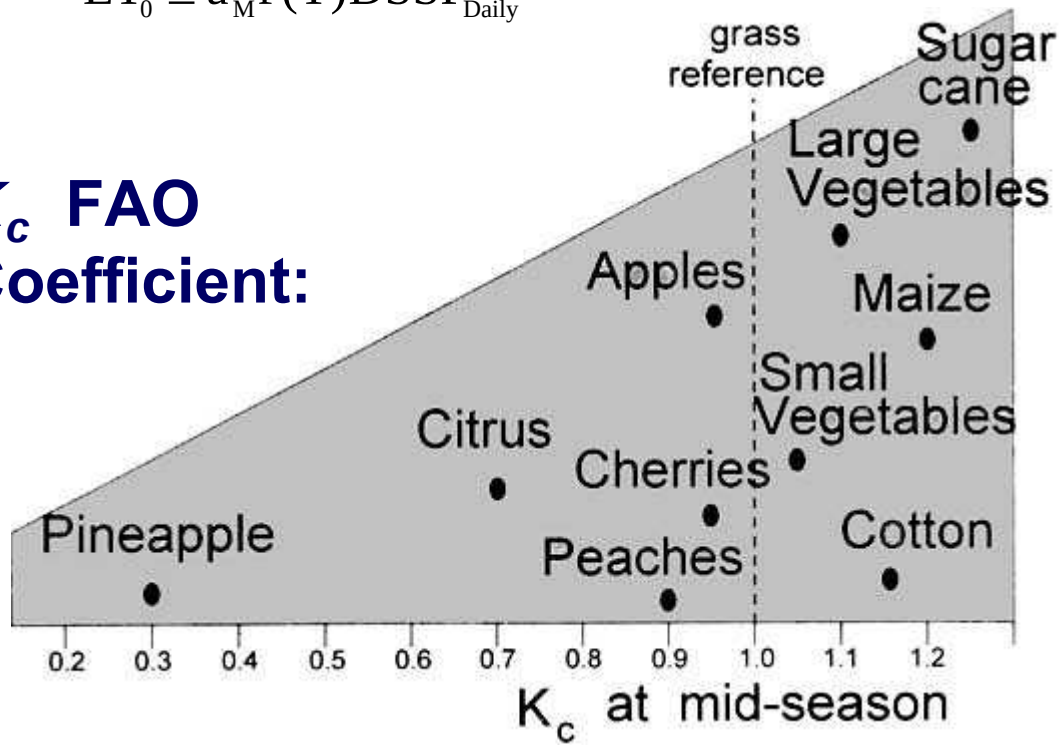
Crop evaporation or crop water need

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

ET_0 is essentially determined by solar irradiance:

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

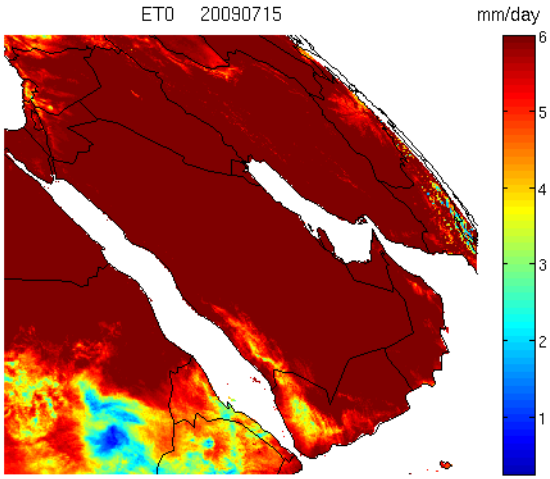
K_c FAO Coefficient:



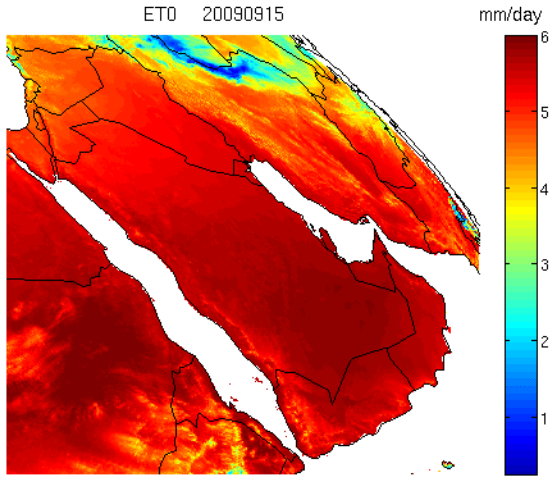
Important in irrigation management, allowing an effective use of soil water reserves on agricultural production.

Reference Evapotranspiration

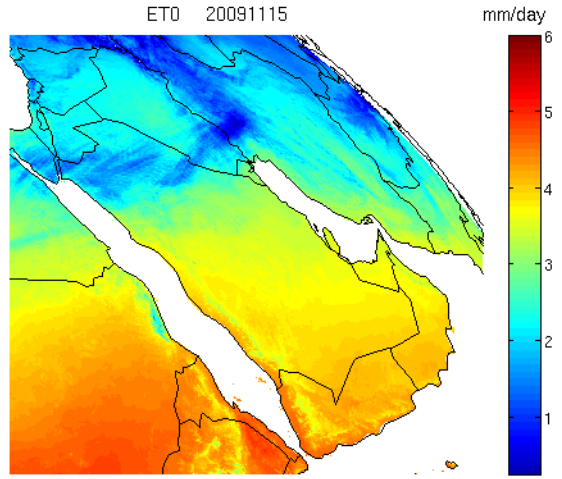
July 2009



September 2009



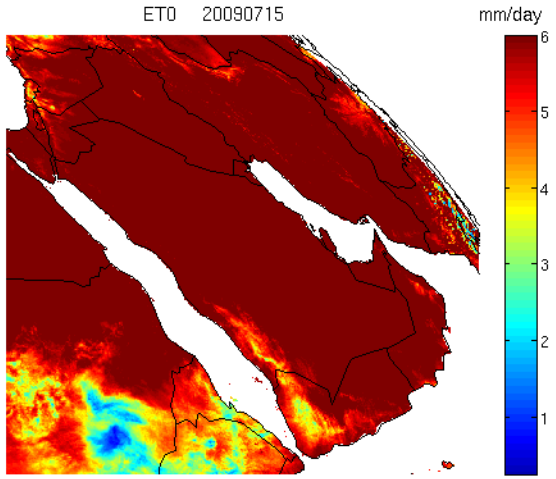
November 2009



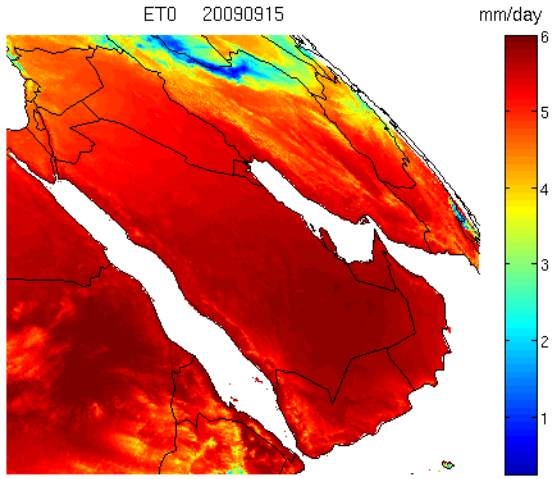
Water requirements for irrigation crops are higher in July and then diminishes towards November.

Reference Evapotranspiration

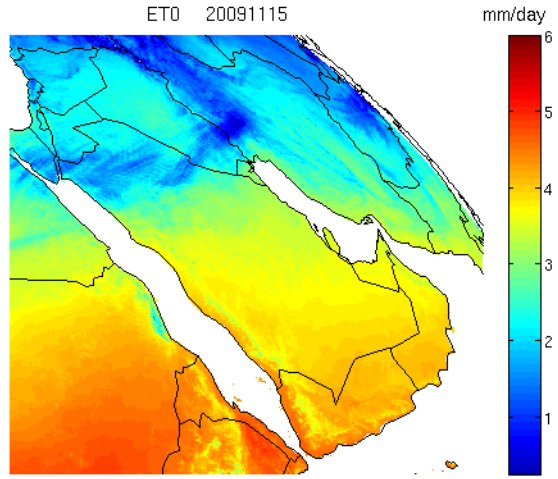
July 2009



September 2009



November 2009



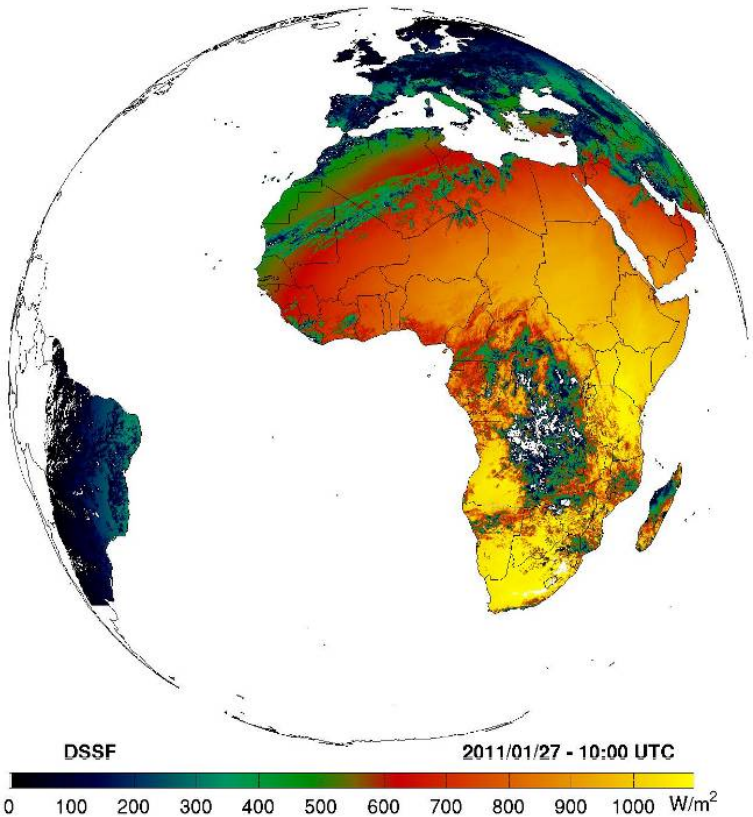
Water requirements for irrigation crops are higher in July and then diminishes towards November.

ET_0 is essentially determined by solar irradiance: $\mathrm{ET}_0 \cong \mathrm{a}_\mathrm{M}\mathrm{f}(\mathrm{T})\mathrm{DSSF}_{\mathrm{Daily}}$

Solar Radiation Flux

Solar Radiation Flux in the LSA SAF - MSG/SEVIRI

DSSF



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

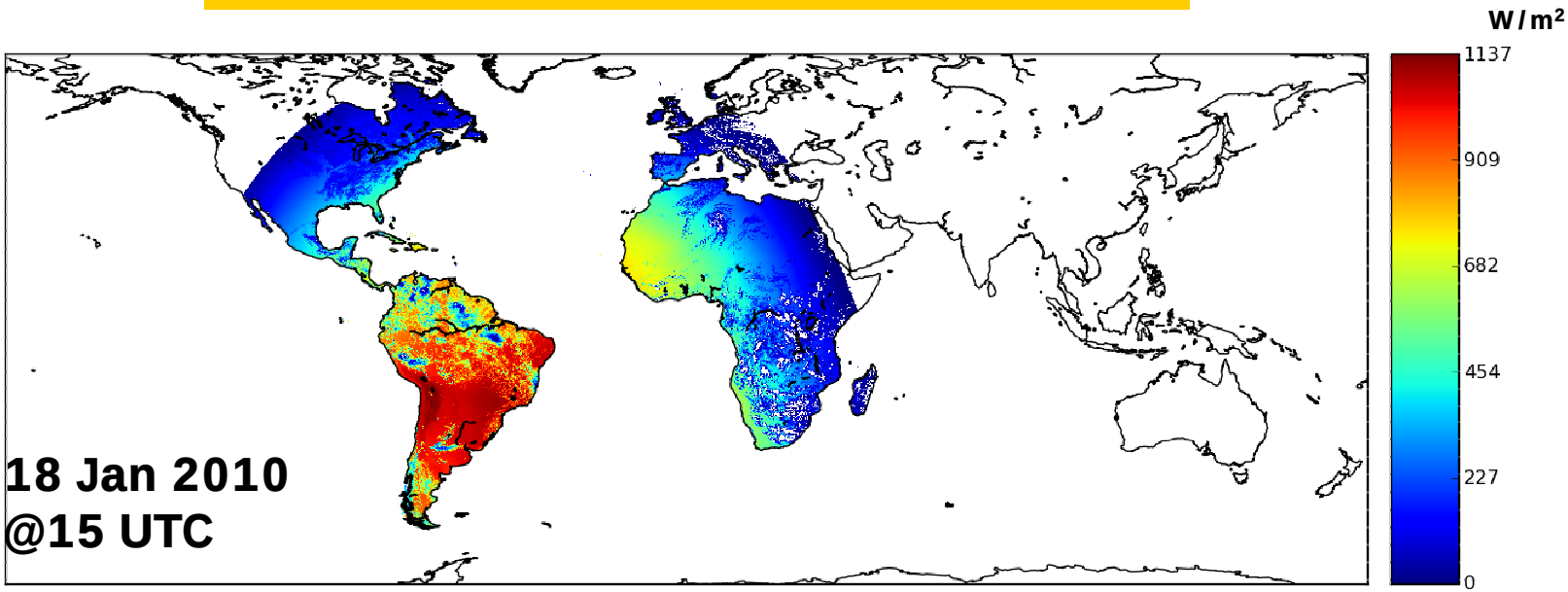
√ 30 minutes & daily

√ 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

√ 0.05^0 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

Land Surface Temperature

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:***

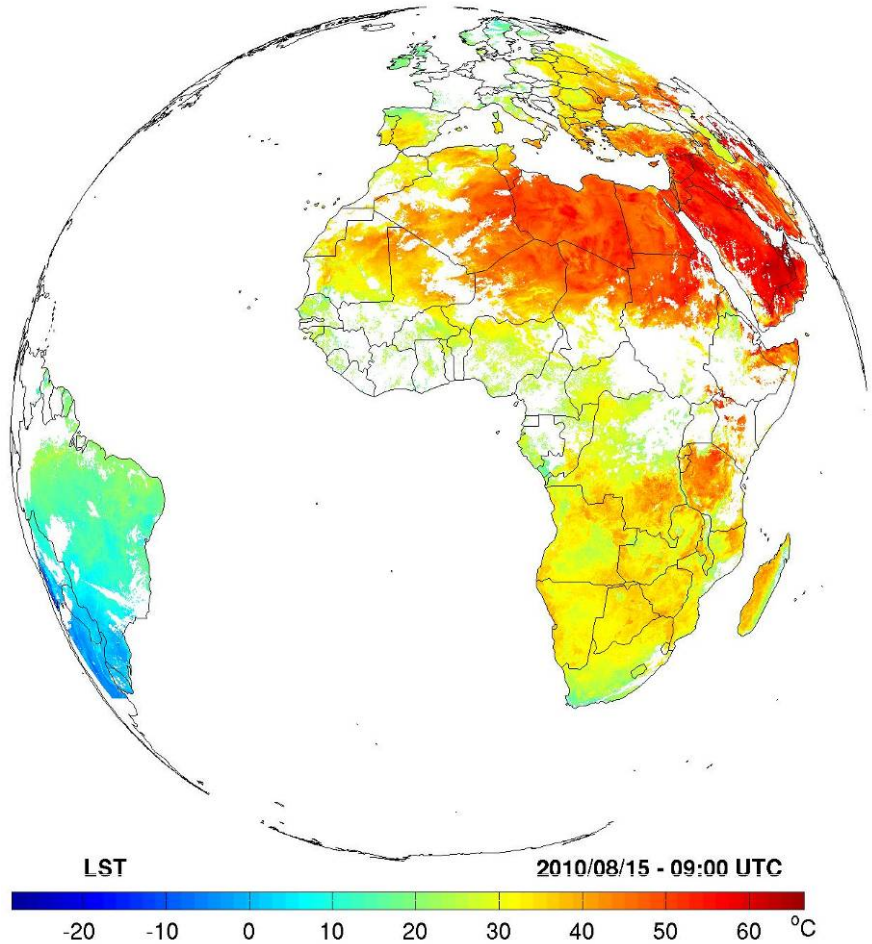
15 minutes

- ***GEOGRAPHICAL COVERAGE:***

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

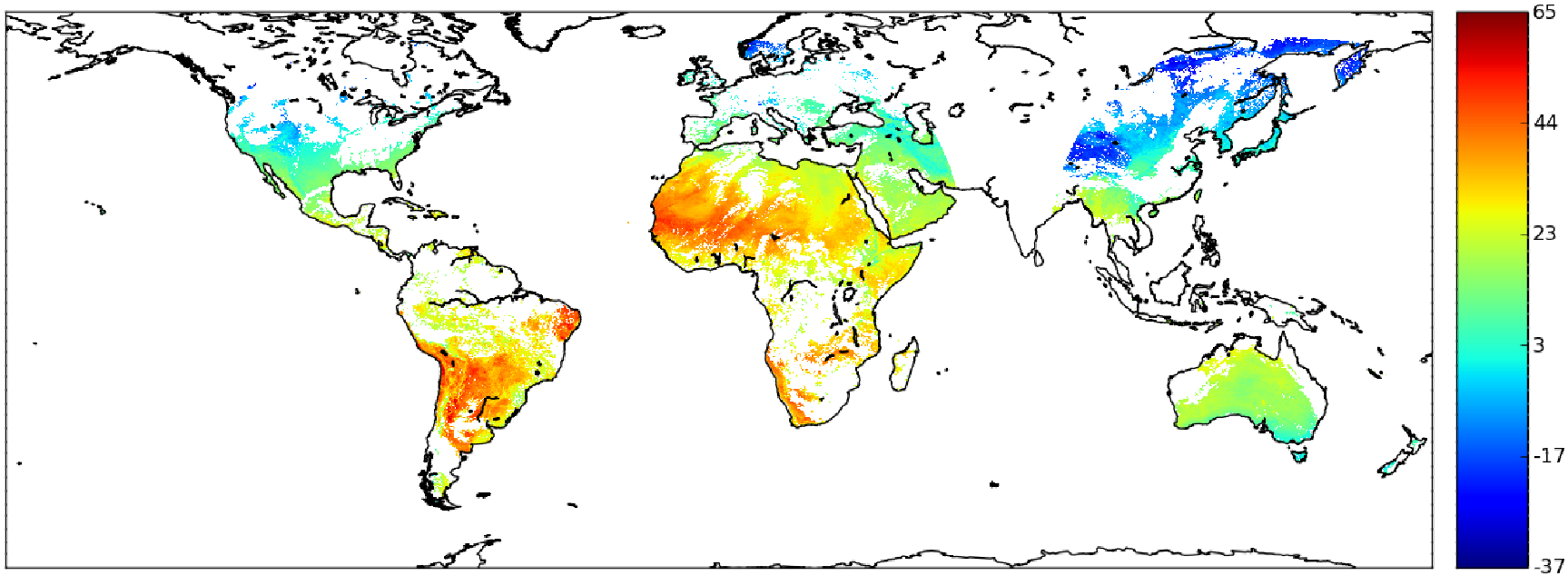
- ***AVAILABLE SINCE:***

Europe – February 2005
All disk – July 2005



Land Surface Temperature

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



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

√ 0.05^0 Spatial Res

√ 1h temporal res

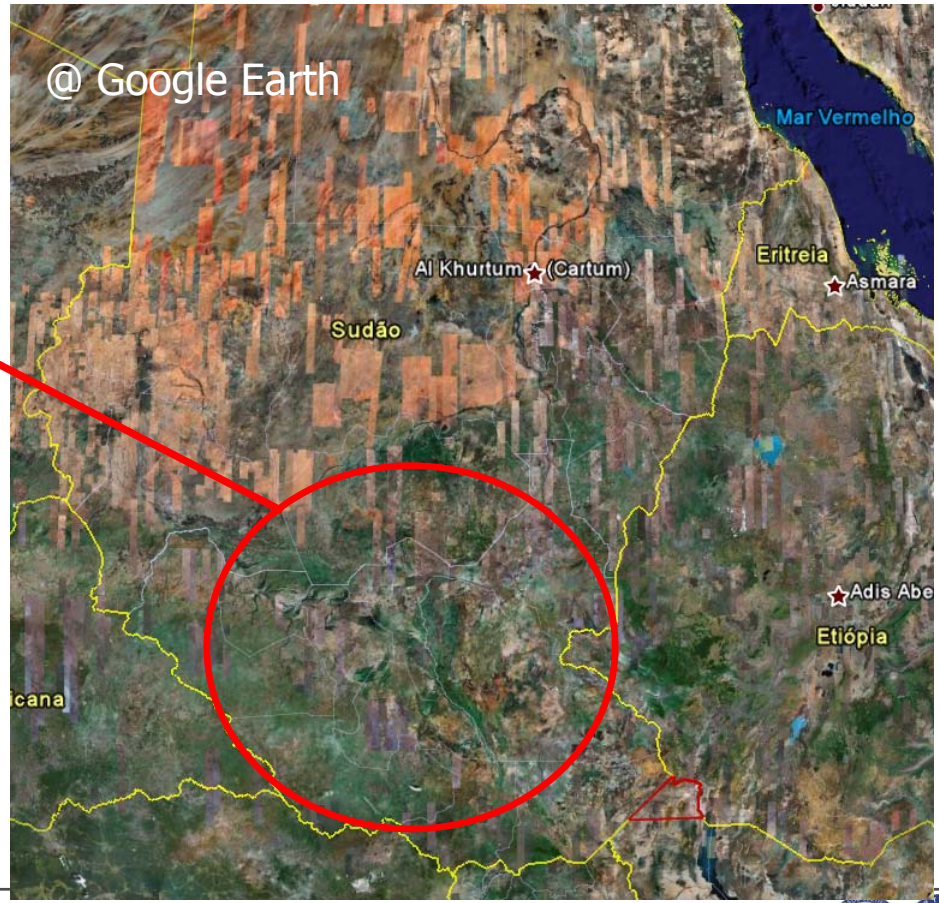
√ Available since Aug 2009

Applications - Floods Monitoring

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

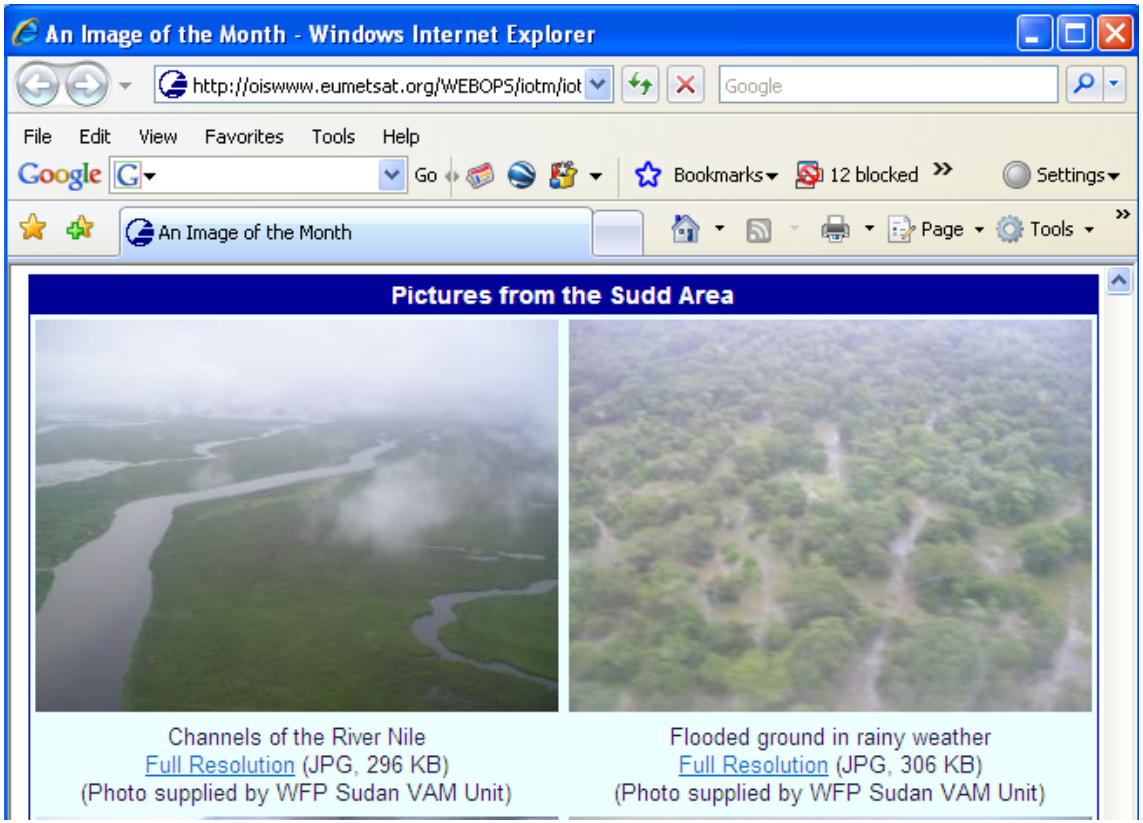
Marshes are defined as wetlands frequently or continually inundated with water*.

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



Applications - Floods Monitoring

A marsh typically features herbaceous plants in shallow waters:



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

Applications - Floods Monitoring

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

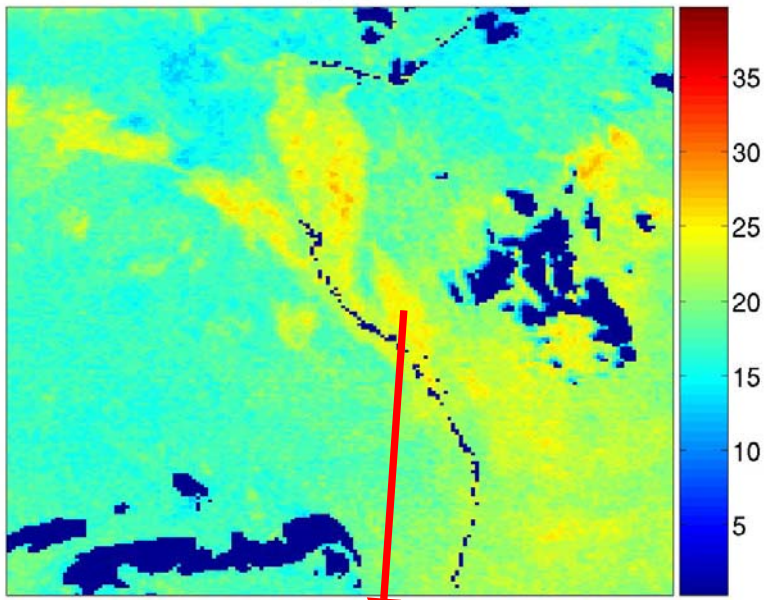
R1 - http://oiswww.eumetsat.org/WEBOPS/iotm/iotm/20051202_flood/20051202_flood.html

Applications - Floods Monitoring

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

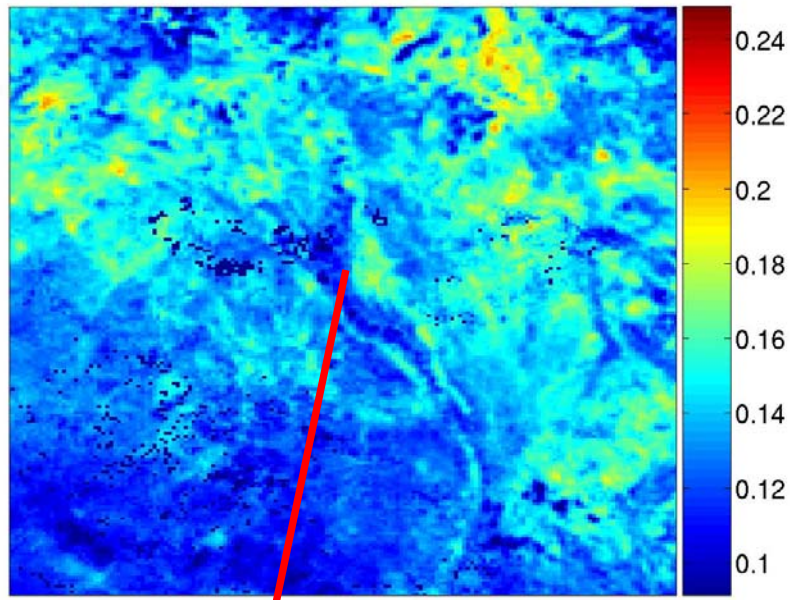
NOVEMBER 2005:

LST-00UTC



Flooded area
(warmer than the surroundings)

ALBEDO

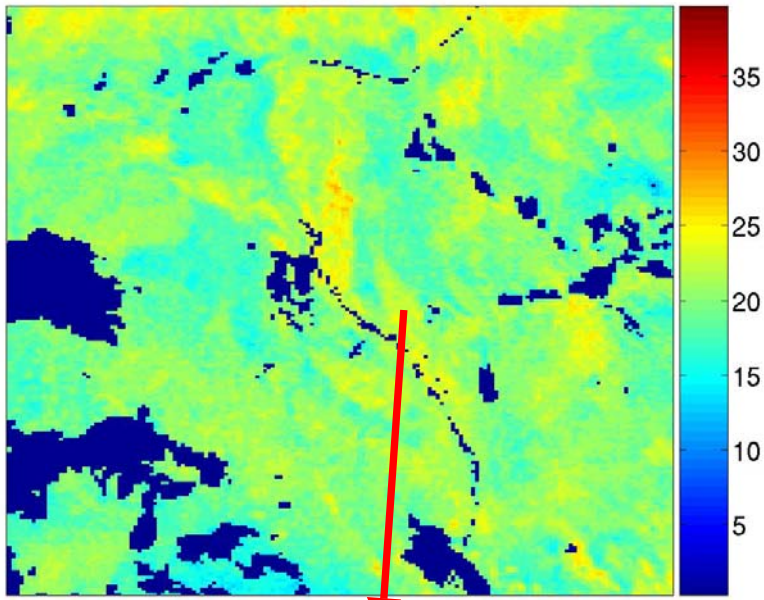


ALBEDO ↓↓ over flooded area

Applications - Floods Monitoring

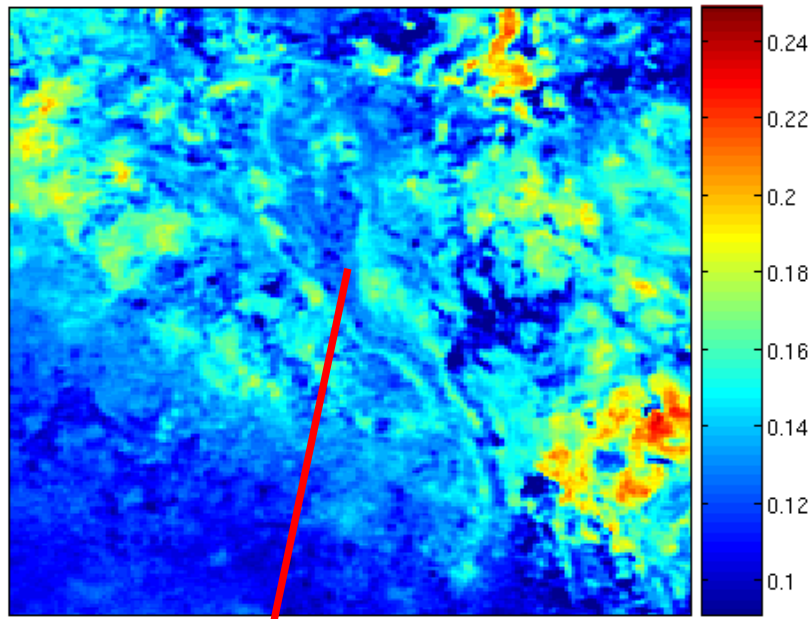
DECEMBER 2005:

LST-00UTC



Flooded area
(warmer than the surroundings)

ALBEDO

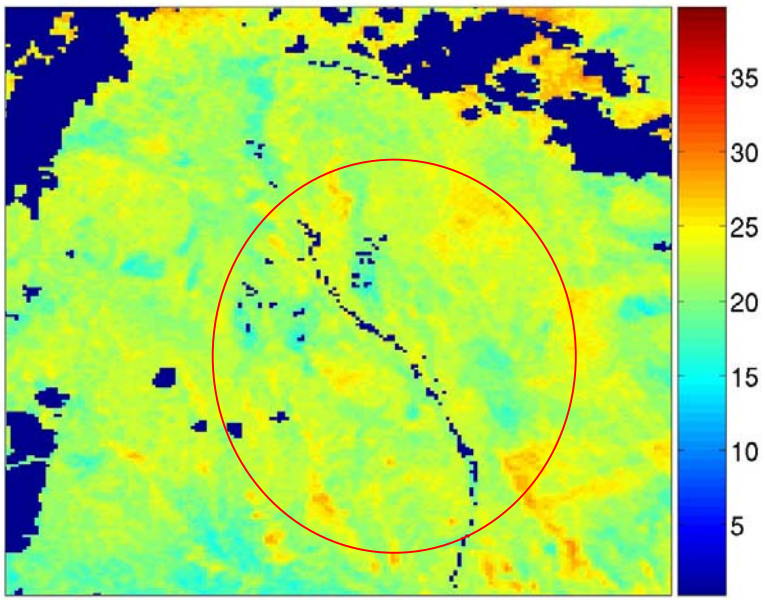


ALBEDO ↓ over flooded area

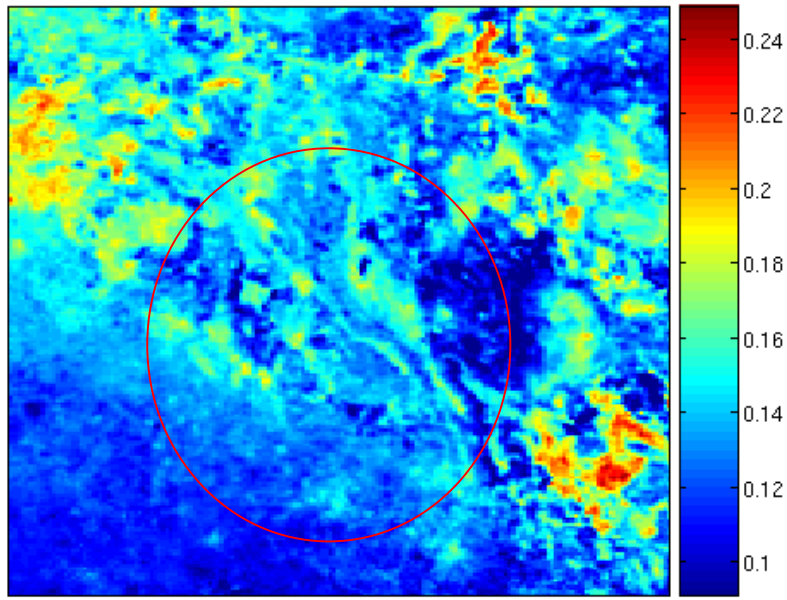
Applications - Floods Monitoring

JANUARY 2006:

LST-00UTC



ALBEDO

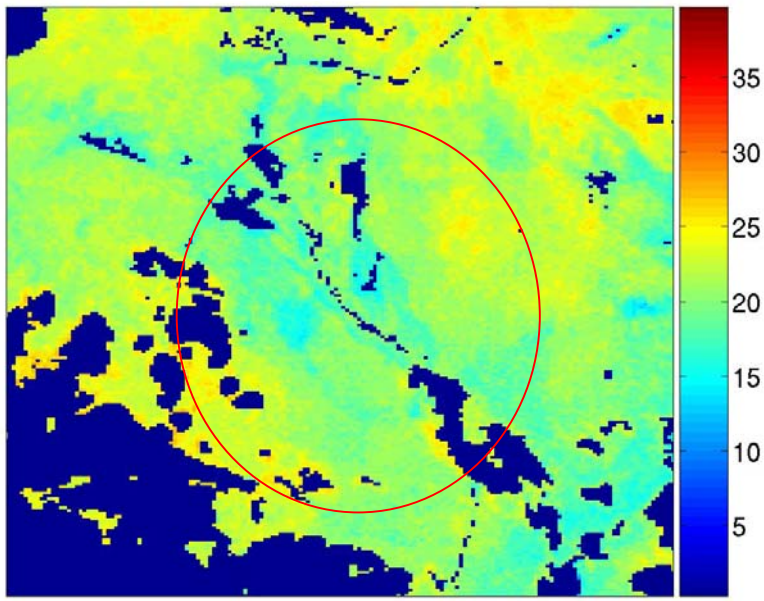


No pattern in LST or in ABEDO that could be associated to a flooded area.

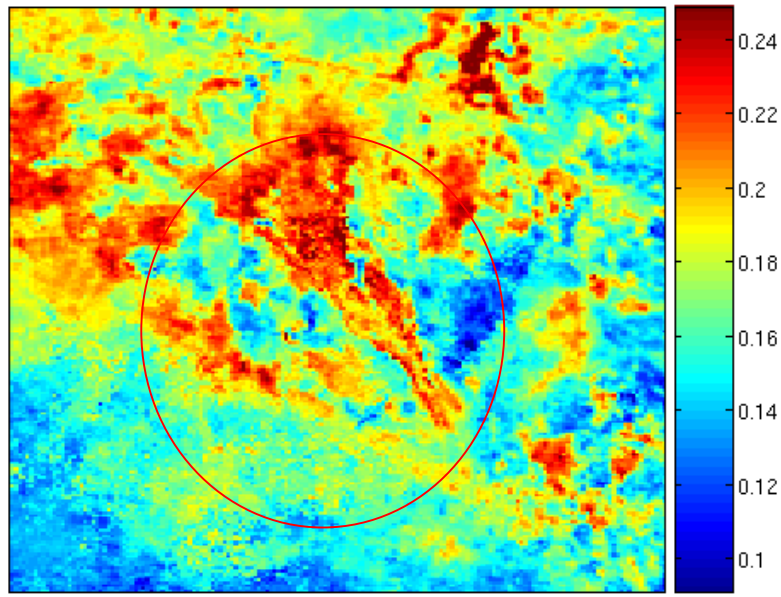
Applications - Floods Monitoring

FEBRUARY 2006:

LST-00UTC



ALBEDO



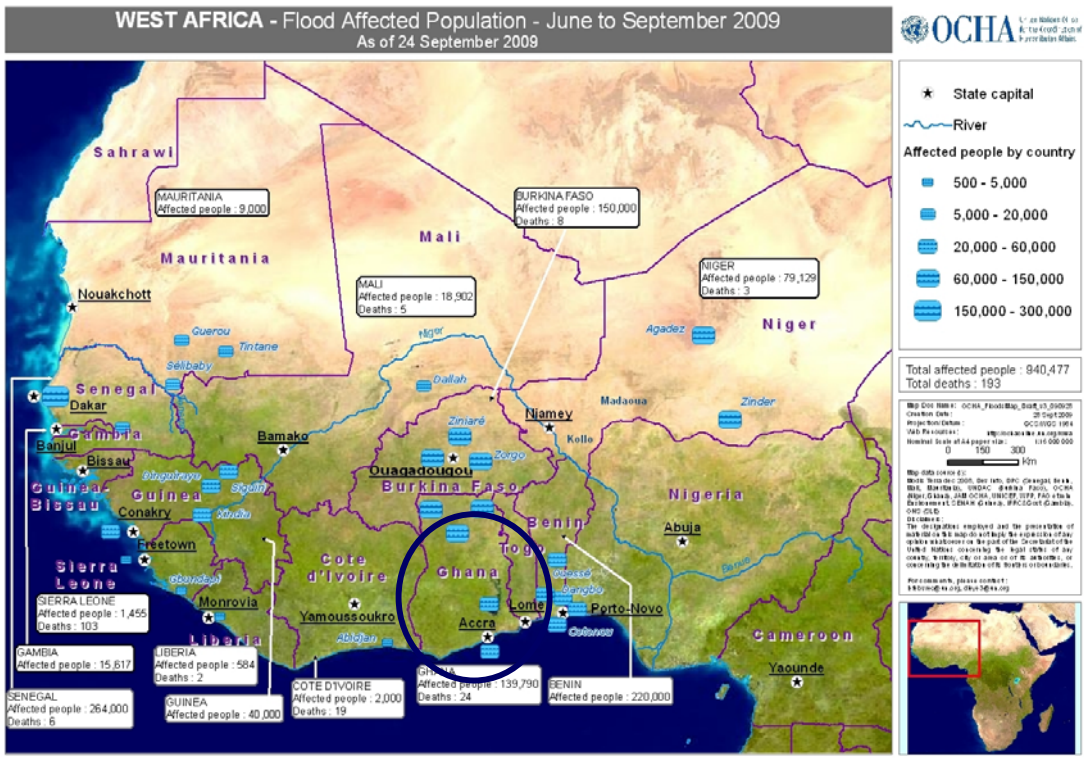
No pattern in LST or in the ALBEDO that could be associated to a flooded area.

Applications - Floods Monitoring

West Africa heavy floods 2009

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

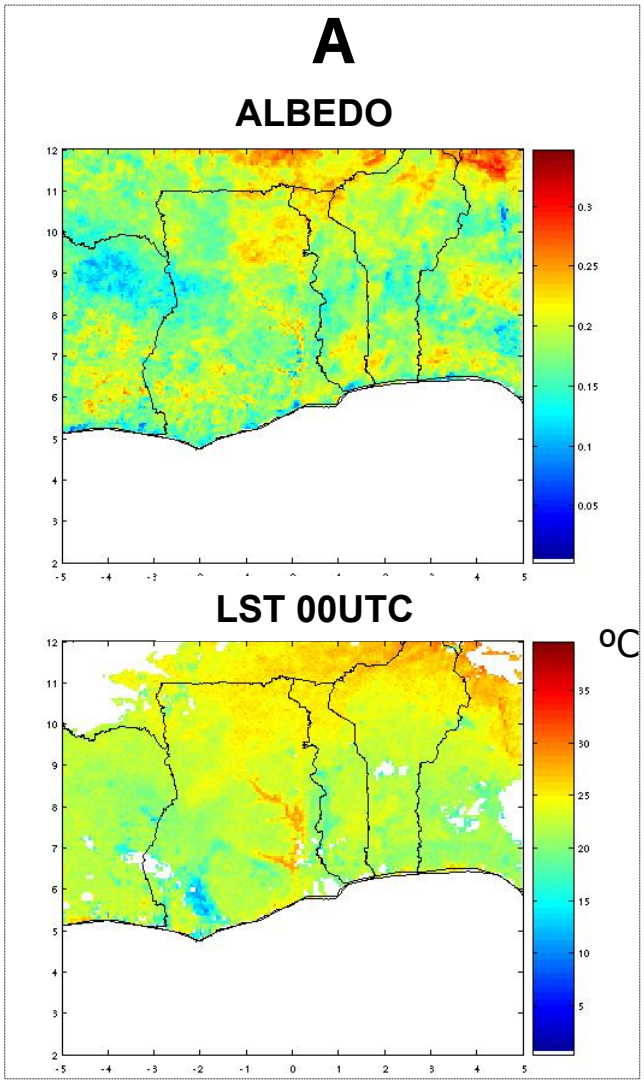
350,000 people affected



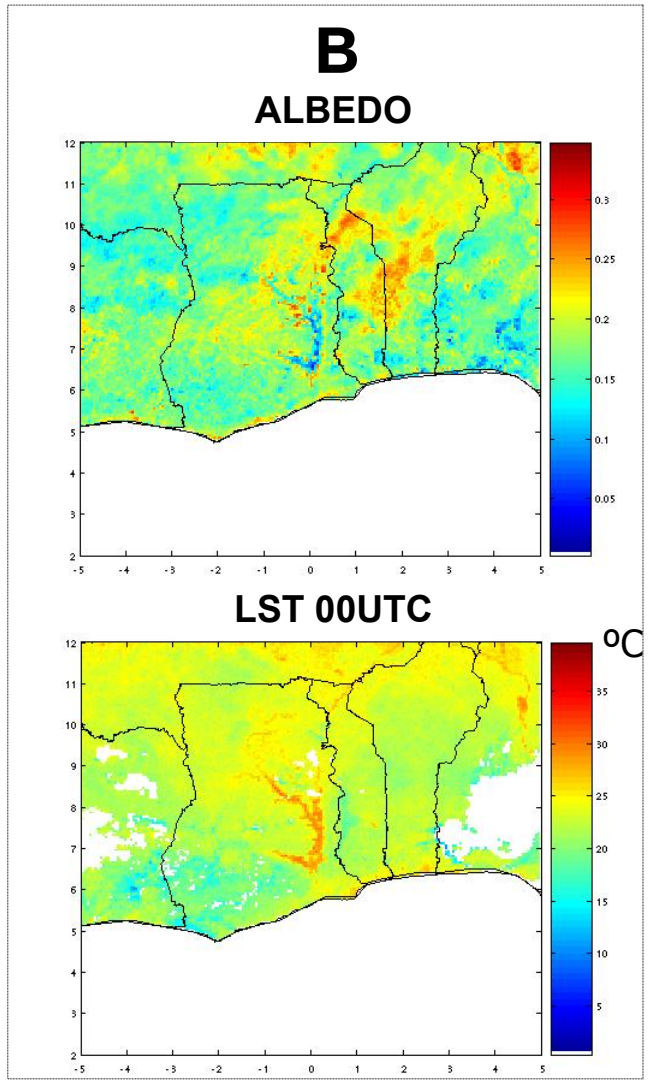
Applications - Floods Monitoring

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

A



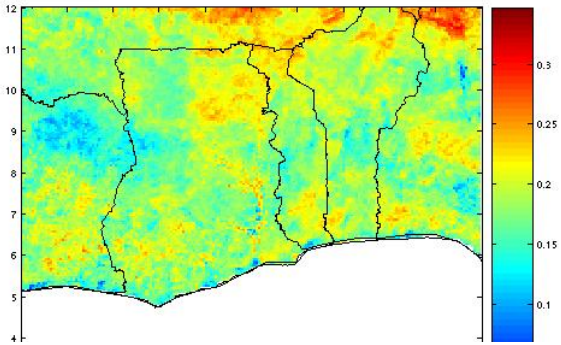
B



Applications - Floods Monitoring

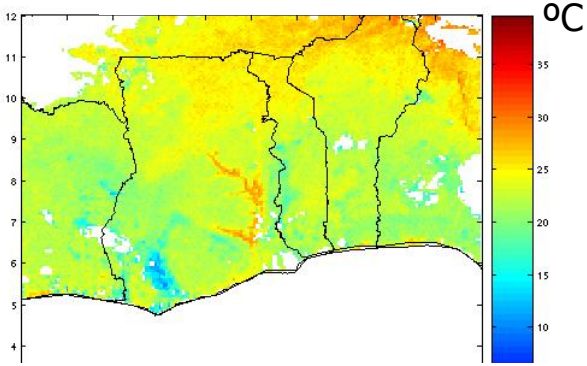
A

ALBEDO



Albedo values similar to neighbour pixels = > No flooded areas

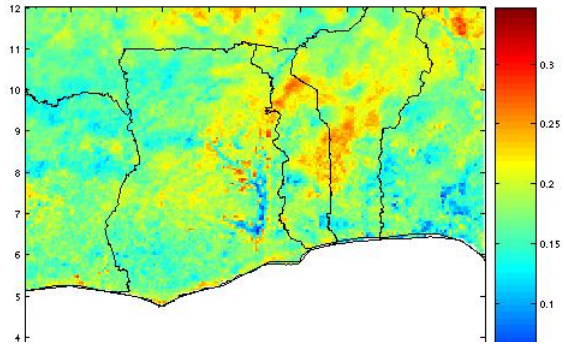
LST 00UTC



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

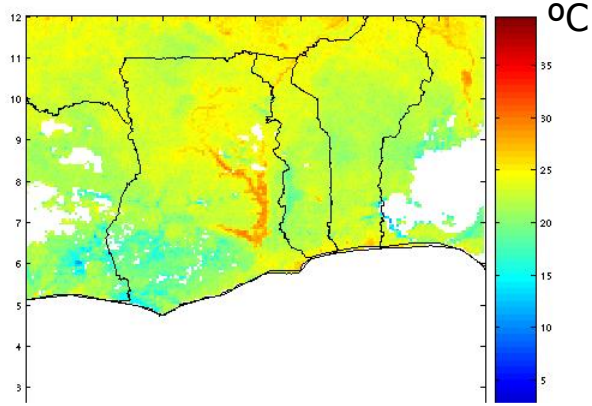
B

ALBEDO



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

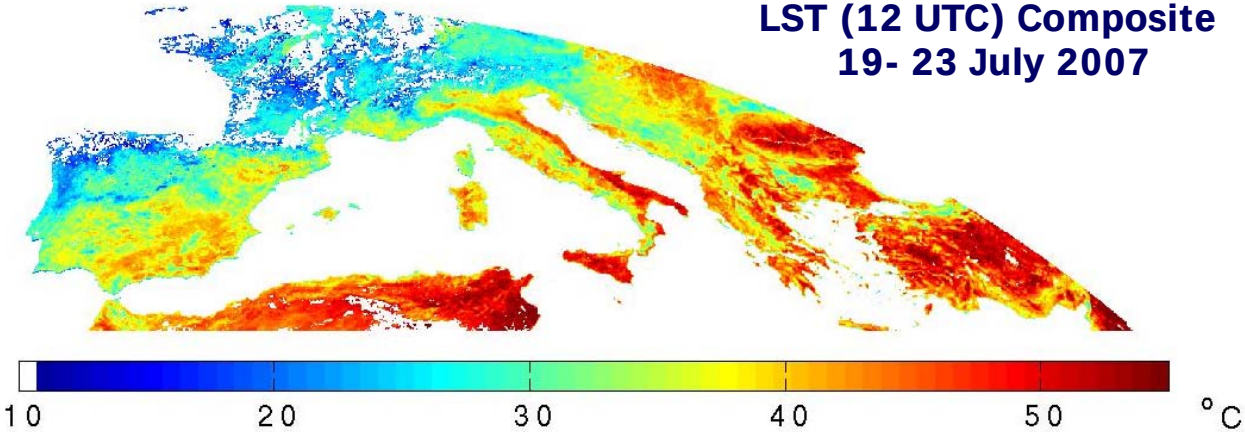
LST 00UTC



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

Applications - Heat Waves Monitoring

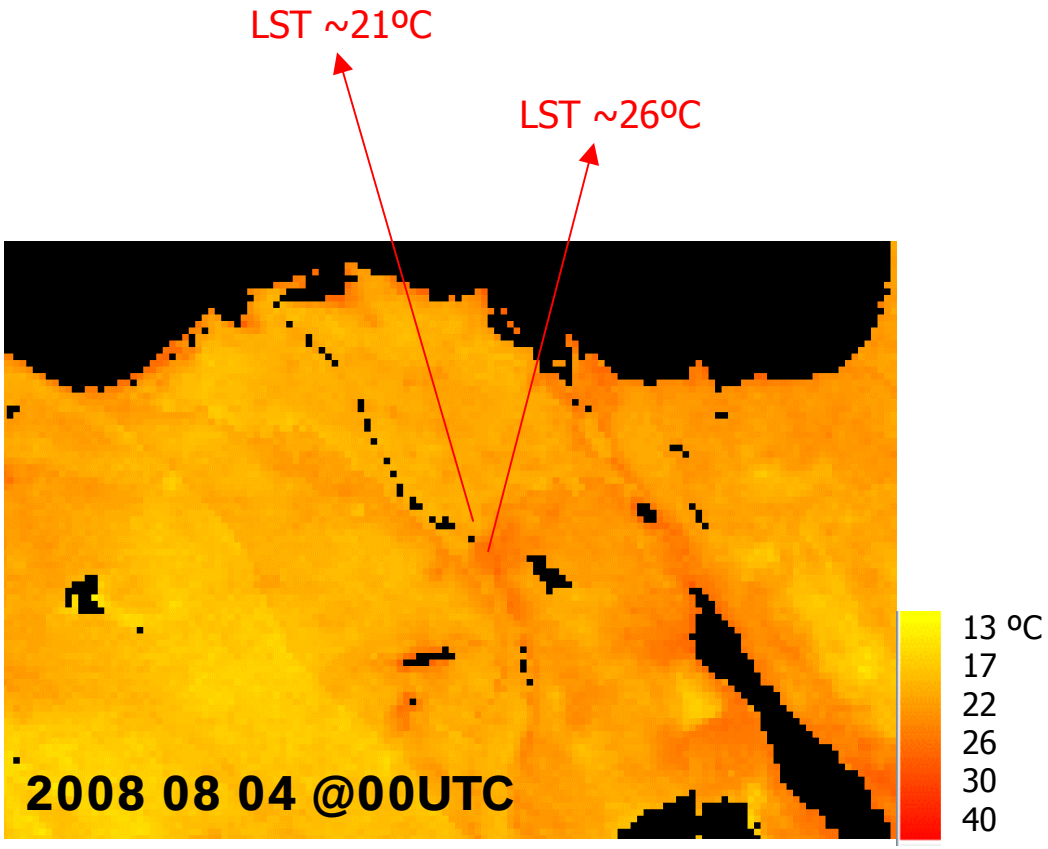
THE HEAT WAVE IN CENTRAL AND SOUTHEASTERN EUROPE (JULY 2007)



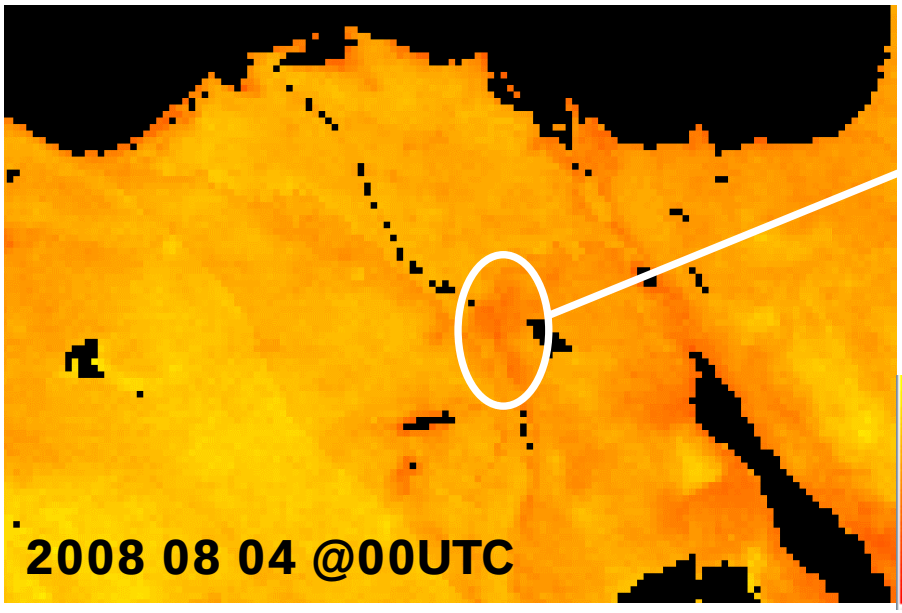
Land Surface Temperature (LST) over the Mediterranean region showing the high temperatures occurred during the heat wave in July 2007 over Central and South-eastern Europe.

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

Detection of Urban Heat Islands



Detection of Urban Heat Islands



Applications - Frost Monitoring

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 < LST <= 4	1	-2 < LST <= -1	6
2 < LST <= 3	2	-3 < LST <= -2	7
1 < LST <= 2	3	-4 < LST <= -3	8
0 < LST <=1	4	-5 < LST <= -4	9
-1 < LST <= 0	5	LST<= -5	10

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

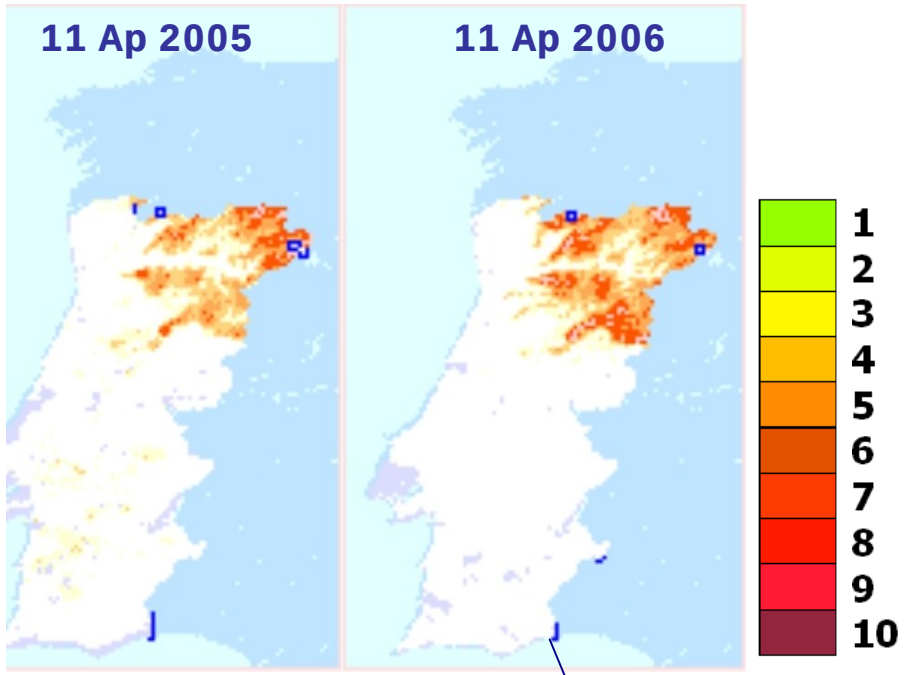
Source:
APPLICATIONS OF "LSA SAF PRODUCTS". Lourdes Bugalho[1], Luís Pessanha[2]. Proceeding of the 7º Simpósio de Meteorologia e Geofísica da APMG. Setubal, Portugal, 2011

[1] Instituto de Meteorologia, Lisboa, lourdes.bugalho@meteo.pt
[2] Instituto de Meteorologia, Lisboa, luís.pessanha@meteo.pt

Applications - Frost Monitoring

Frost conditions:

Ground data showed a good agreement with this results.

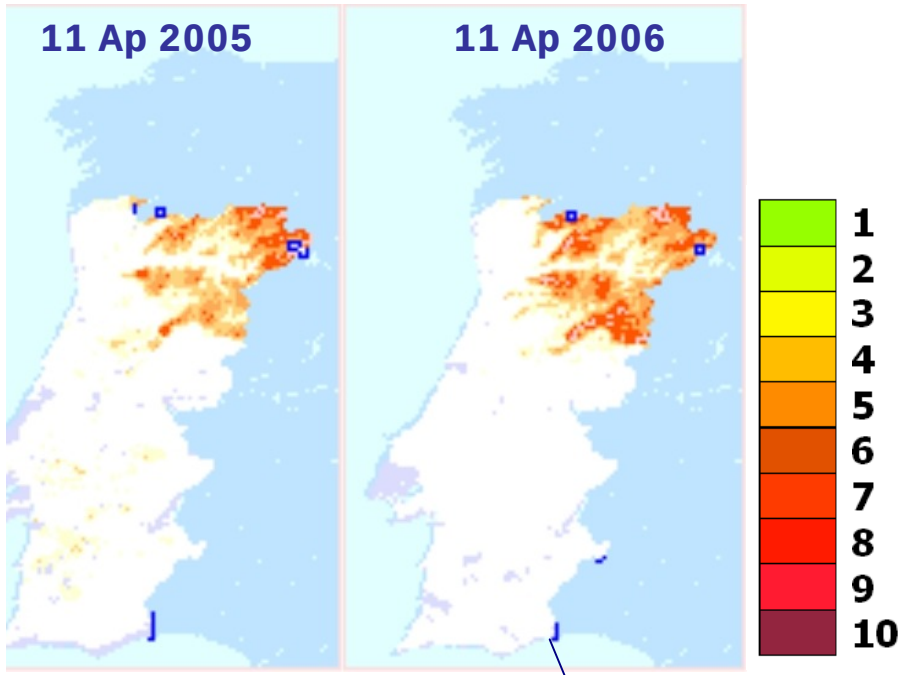


Degree of possibility for ground ice

Blue coloured pixels = Possible contamination by clouds

Applications - Frost Monitoring

Frost conditions:



Degree of possibility for ground ice

Blue coloured pixels = Possible contamination by clouds

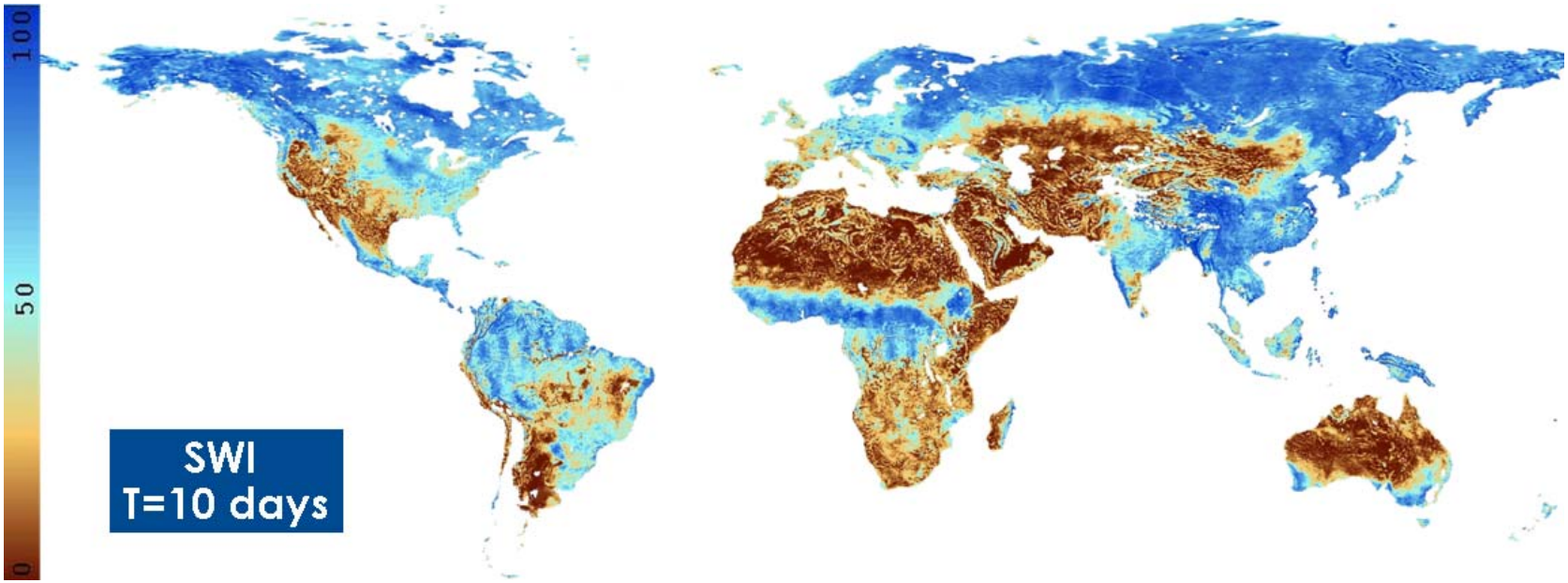
Variables to be included shortly:

- wind
- Soil water content

Applications - Frost Monitoring

Soil water index

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



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

Questions / Comments?