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

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Based on material provided by:
F. Javier García-Haro (University of Valencia, Spain) and Carla Barroso (IPMA, Portugal)
Satellite products for drought monitoring and agro-meteorological applications. Budapest 24-28 April 2017
Alirio Arboleda.

LSA-SAF MSG Products

**Surface Radiation**
- LST
- Albedo
- LongWave Flux
- ShortWave Flux

**Surface Water Balance**
- Snow Cover
- Evapotranspiration

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

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

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
High reflectance in the NIR (0.8 μm)

Spectral Signatures

Spectral Signature
Or
Spectral response curves

Strong absorption (reflectance peak at 0.55 μm)

High reflectance in the NIR (0.8 μm)
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

SEVIRI spectral response functions

Source: http://www.eumetrain.org/resources/operational_use_rgb.html
Which of the images correspond to MSG 0.8μm channel?
MSG channels for vegetation monitoring

Which of the images correspond to MSG 0.8\(\mu\)m 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.eumettrain.org/resources/operational_use_rgb.html
RGB Techniques

Meteosat-9 colour composite image

Natural colour

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

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

SEVIRI/MSG Channels 1 e 2 reflectances

For bare soil NDVI $\sim 0$

For vegetated areas NDVI ranges between 0.2 and 0.6

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 \((0.4 – 0.7 \mu m)\) 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 (pvegetation, psoils subclass)
- The pure types, Vi and Si for each pixel are obtained by the prevalent Land cover
- The distances between (*) and Vi, Si give the fractions of each vegetation and soil type within the scene

\[ \text{FVC} = \sum_{i=1}^{N} fvc_{Vi} \]

Number of vegetation subclasses present in the pixel

Fraction of vegetation cover for vegetation type Vi

Full description at http://landsaf.meteo.pt
**LAI ESTIMATION**

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

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

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

**fAPAR ESTIMATION**

estimated from a Renormalised Difference Vegetation index

$$\text{RDVI} = \frac{\rho_{\text{channel}_2} - \rho_{\text{channel}_1}}{\sqrt{\rho_{\text{channel}_1} - \rho_{\text{channel}_2}}}$$

**View-illumination geometry** may have a large impact on reflectances

$$\text{fAPAR} = 1.81 \text{RDVI}_{\text{opt}} - 0.21$$
Biogeophysical Parameters

1 pixel

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<td>a</td>
<td>..?</td>
<td>b ..?</td>
<td>c ..?</td>
<td>d ..?</td>
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LSA SAF Vegetation Products

Example: 15 April 2007

- http://landsat.meteo.pt
- EUMETCAST
Products Validation

[Map and graphs showing vegetation indices (LAI and FVC) for Mongu, Panda, Maun, Okwa, and Tshane, comparing MSG, TRAC, and ACCUPAR datasets.]
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;

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

November 2006:

- SEVIRI
- MERIS
- MODIS

LAI

SEVIRI/ MERIS/ MODIS

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

July 2006:

- SEVIRI
- MERIS
- MODIS
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

LAI

y=1.219x -0.420
RMS=0.603
r=0.899
Overall quality of LSA SAF Vegetation Products

Percentage of gaps over 1 year of data

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
Potential Applications of LSA SAF vegetation products

- 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)
Reconstruction of seasonal curves

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

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

indicate the SOS in 2007 !!!

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

- **Estimation of Dry Matter Productivity (DMP)**
  DMP represents the increase in dry matter biomass.

- Good spatial consistency

2008, February, Dekad 3 over Africa

A North-South transect through Africa (from Lybia 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.

Applications – Veg Monitoring

- Effects of the khareef on vegetation

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

- 15 Aug 2010
- 15 Sep 2010
- 15 Oct 2010
Applications – Veg Monitoring

Vegetation response to climatic variability

Climatologies based on timeseries of FVC (SEVIRI/MSG)
Applications – Veg Monitoring

Drought monitoring in the Iberian peninsula
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
Which from below is from November 2009?

- LSA SAF FVC

Applications – Drought Monitoring
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More information and data download at:

http://landsaf.meteo.pt