The EUMETSAT Network of Satellite Application Facilities

LSA SAF
Land Surface Analysis

The LSA SAF vegetation products and applications: drought monitoring

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UV ERS

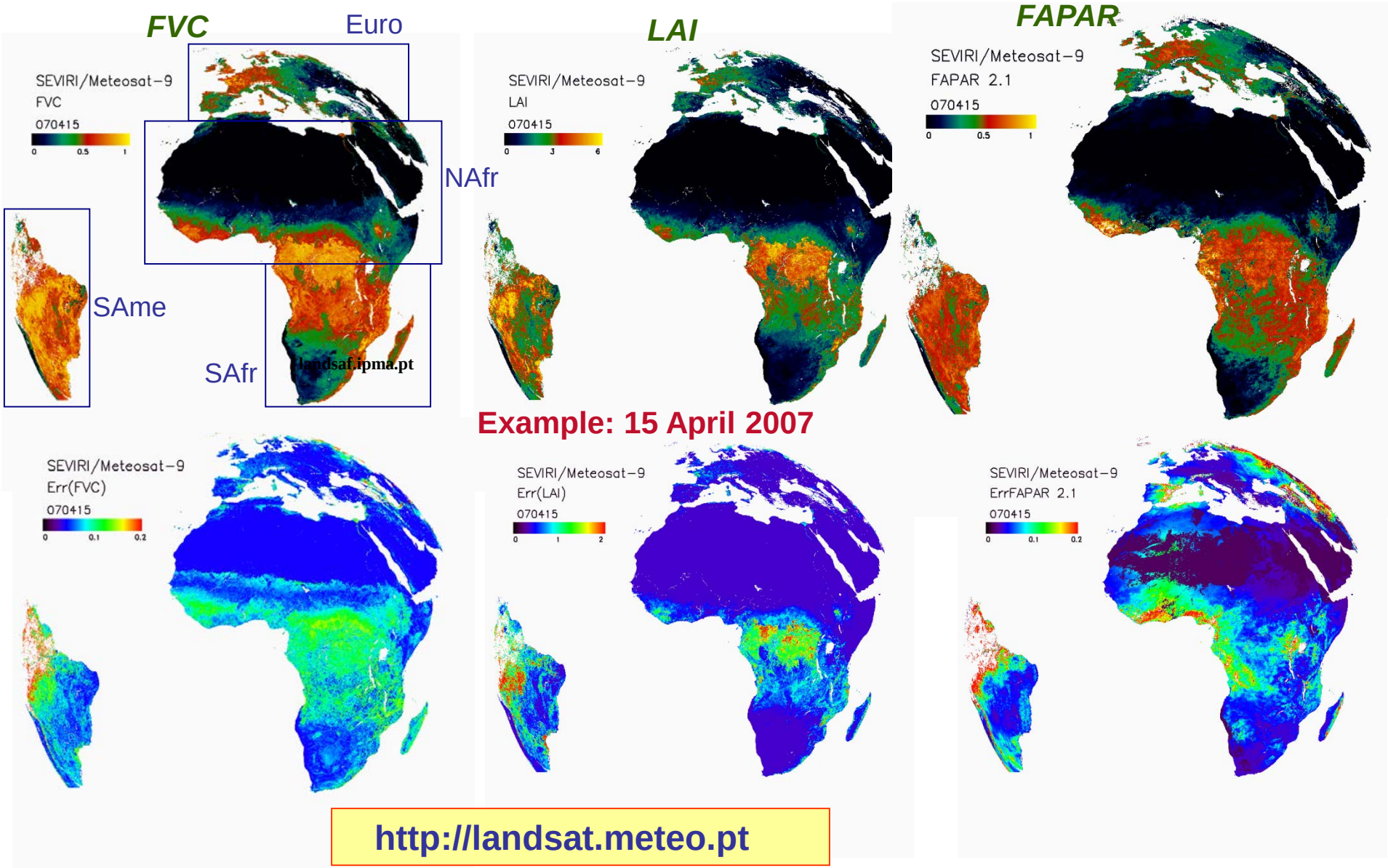
VNIVERSITAT DE VALÈNCIA

INDEX

- LSA SAF vegetation products
- Expert knowledge: advantages and limitations
- Some applications
  - Derivation of phenological information
  - Response of vegetation to rainfall deficit
  - Near real time detection/monitoring of drought related disturbances

LSA SAF VEGA SEVIRI daily products

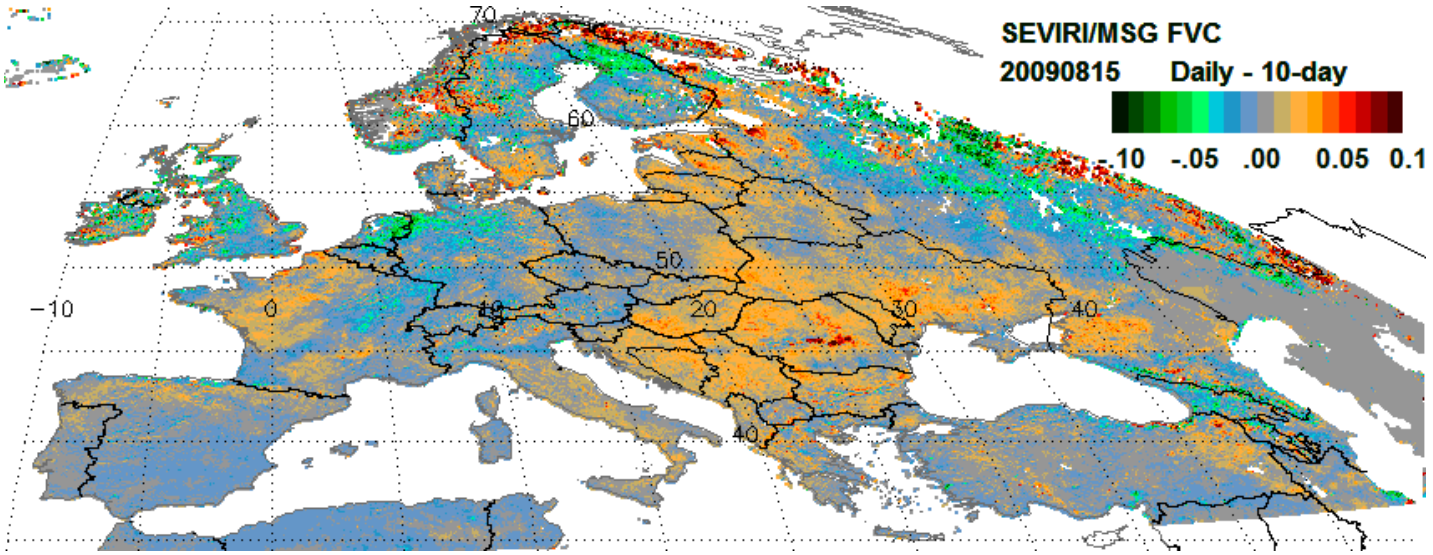
- **SEVIRI "VEGA": daily products**

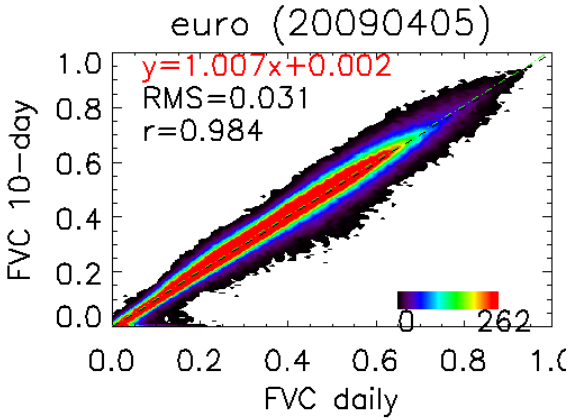


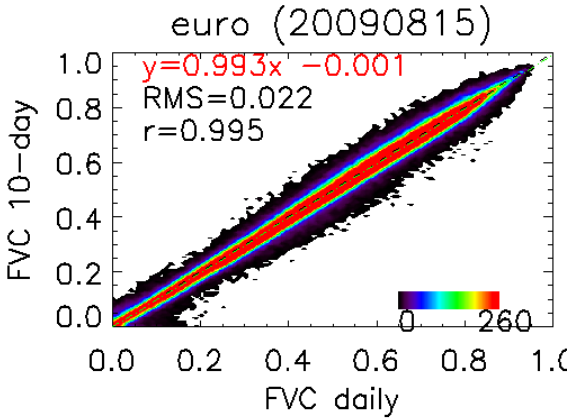
http://landsat.meteo.pt

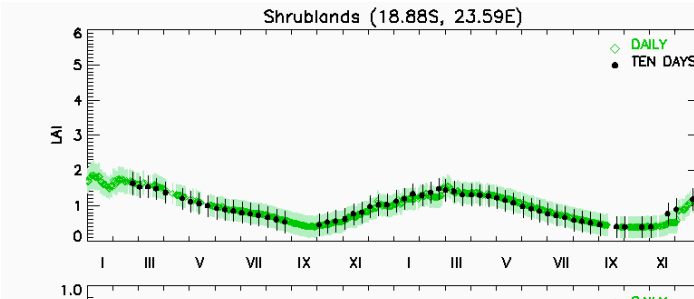
VEGA: Daily (MDVEGA) and 10-day (MTVEGA)

- 10-day VEGA (MTVEGA) based on AL3 (time scale of 30-day)
- Daily and 10-day are spatially and temporally consistent



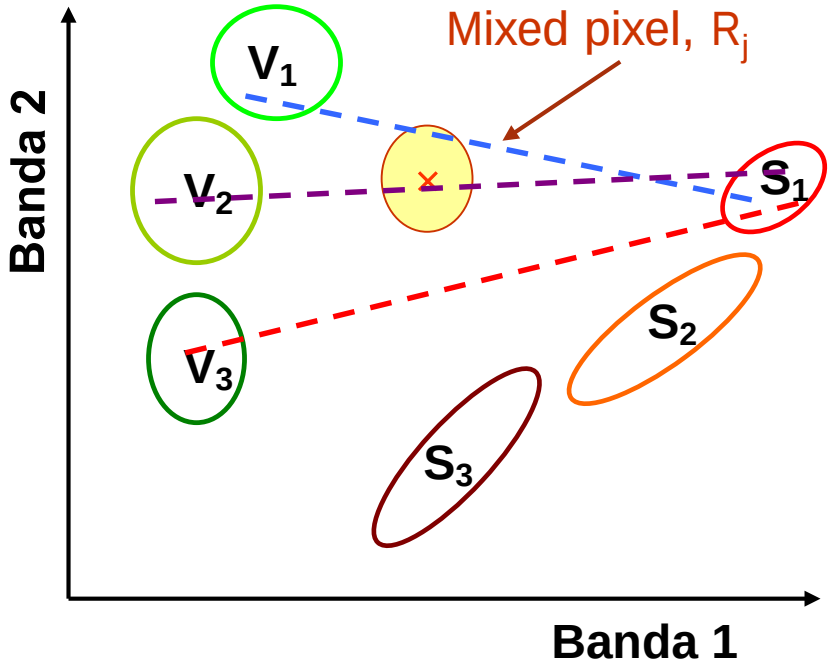






Algorithms description

- **Fraction of ‘ green’ Vegetation Cover (FVC)**



⇒ **Probabilistic Spectral Mixture Analysis**

- 2 components (veg,soil): $R = R_v f_v + R_s f_s$
- Each component: mixture of gaussians

$$\sum_{k=1}^{G_j} \tau_k \phi_k(\mu_{jk}, \Sigma_{jk})$$

Bayesian Theory $$p(M_K \mid r_j) = \frac{p(r_j \mid M_K)\pi(M_K)}{\sum_{i=1}^{N} p(r_j \mid M_i)\pi(M_i)}$$

- **‘True’ Leaf Area Index (LAI)**

Pragmatic approach of Roujean and Lacaze, (2002) based on a modified Beer’s law:

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

b=0.97, G=0.5, clumping (Ω) from a GLC-2000 lookup table (Chen et al. 2005).

Algorithms description

- **'Daily' Fraction of Absorbed PAR (FAPAR)**

  Statistical relationship established between a vegetation index (RDVI) in an optimal geometry and daily integrated FAPAR by using RT simulations with PROSPECT+SAIL model (Roujean and Breon, 1995).

$$RDVI = (NDVI \cdot DVI)^{1/2} = \frac{NIR - R}{\sqrt{NIR + R}}$$

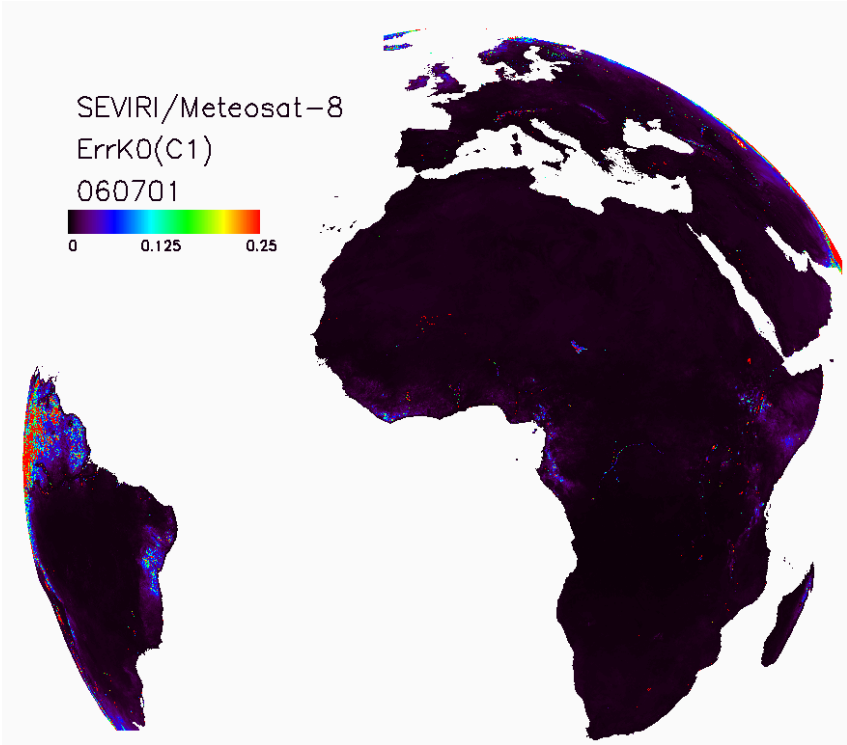
FAPAR=1.81*(RDVI)opt - 0.21

Minimum dispersion FAPAR-RDVI was found in the Principal Plane, VZA=45º and SZA=60º.

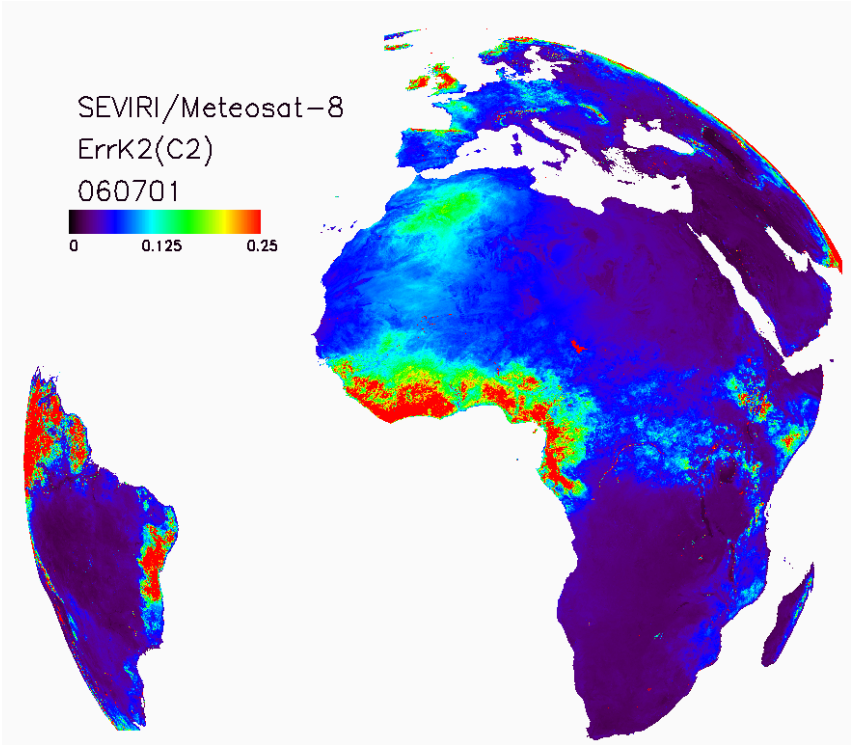
$R_{opt}(\lambda)$= k0(λ) - 0.240*k1(λ) + 0.202*k2(λ)

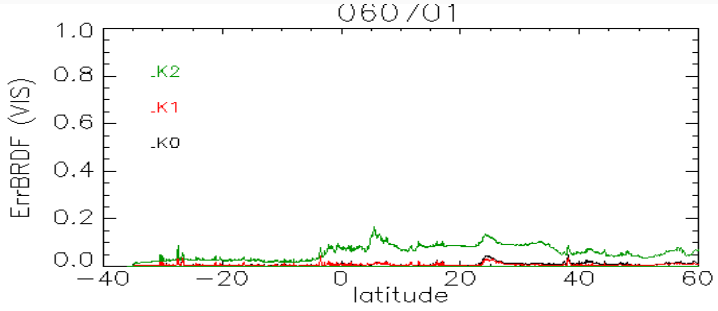
Sources of uncertainty: input errors

Error k0



Error k2





- **BRDF parameters (Roujean et al,. 1992)**
  k0 (RED, NIR, SWIR) for FVC → LAI
  k0,k1,k2 (RED,NIR) for FAPAR

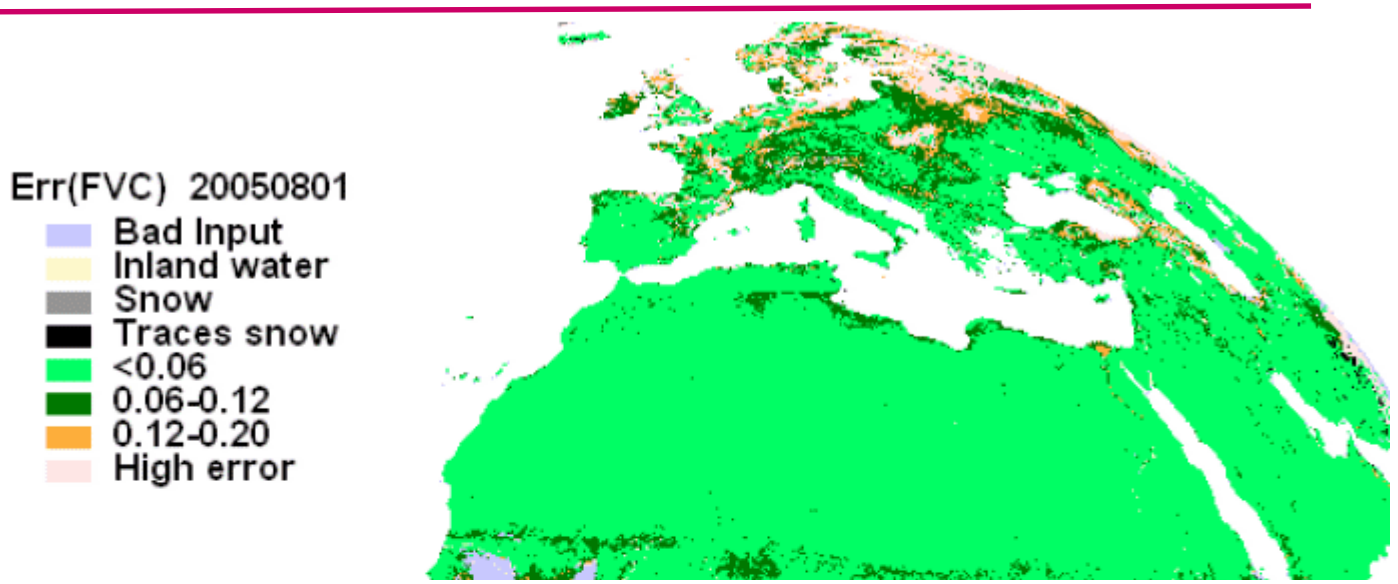
Product content: QF information

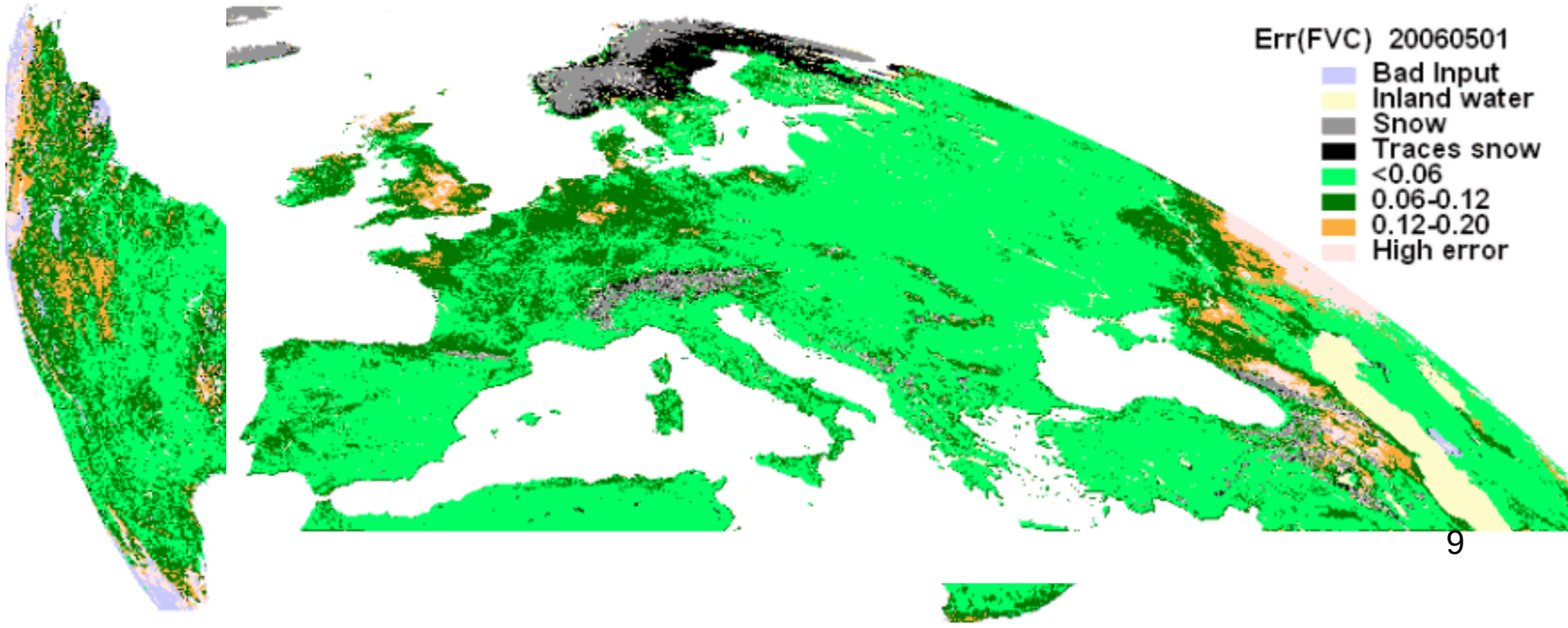
Bit		Binary Code	Description	Products are processed
Bits 0-1	Land Sea Mask(*)	00	Ocean	No
		01	Land	Yes
		10	Space (Outside of MSG disk)	No
		11	Continental water	No
Bit 2	MSG(*)	0	No MSG Observations	Yes
		1	Include MSG Observations	Yes
Bit 3	Traces of inland water	0	No	Yes
		1	High Probability	Yes
Bit 4	Traces of snow cover	0	No	Yes
		1	High Probability	No(errors set to -31)
Bit 5	Snow(*)	0	No Snow	Yes
		1	Snow	No (errors set to -30)
Bit 6	Unrealistic Input ranges	0	Reliable	Yes
		1	Unreliable	No(errors set to -40)
Bit 7	Failure(*)	0	Input Normally Processed	Yes
		1	Input Algorithm Failed	No

See related documents (PUM, VR)

Error Map (Sept'05-Sept'07)

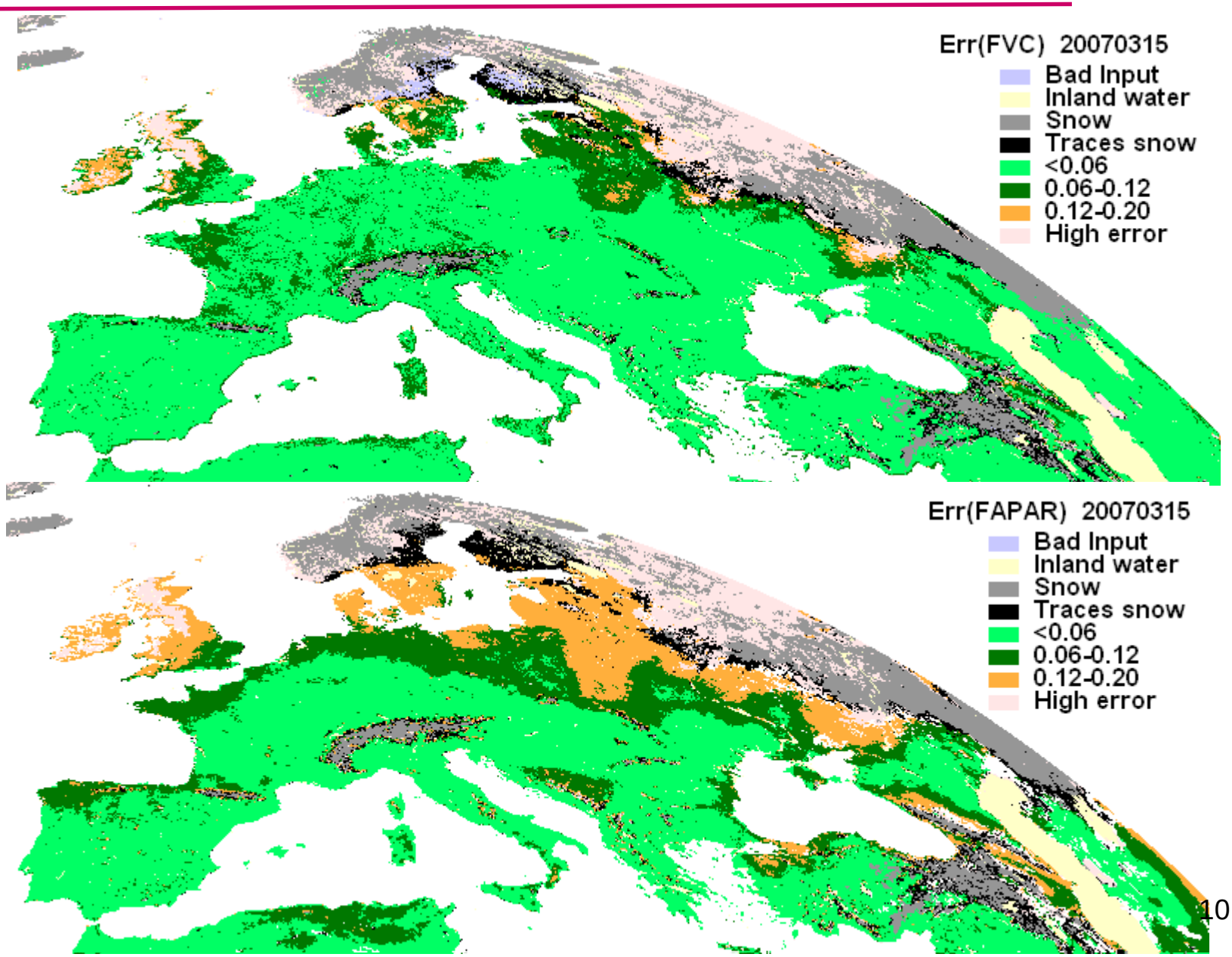
FVC v2.1





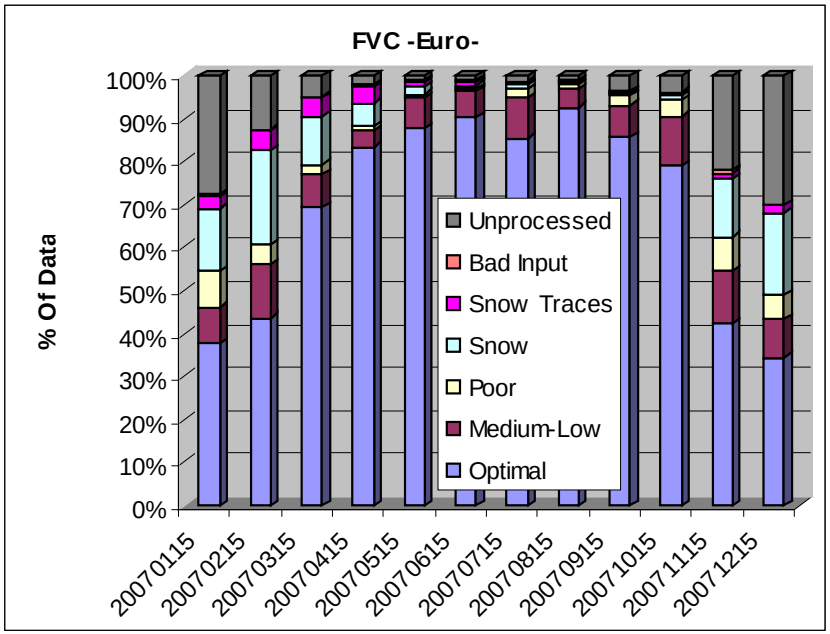
Error Map consistency between products

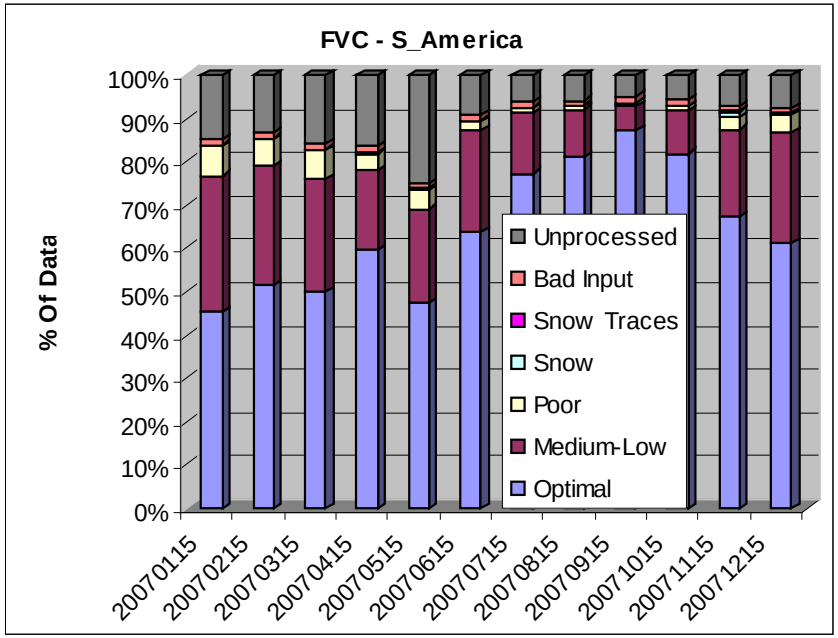
Europe

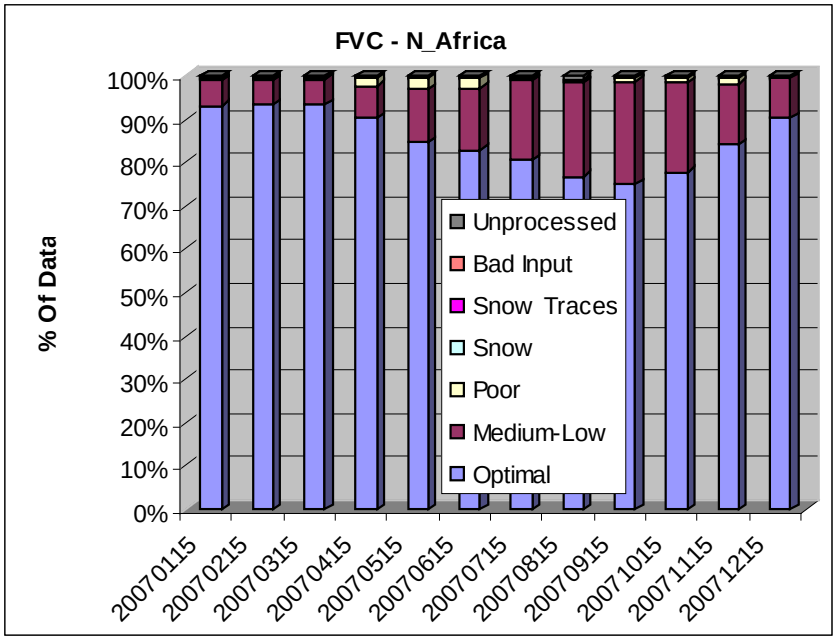


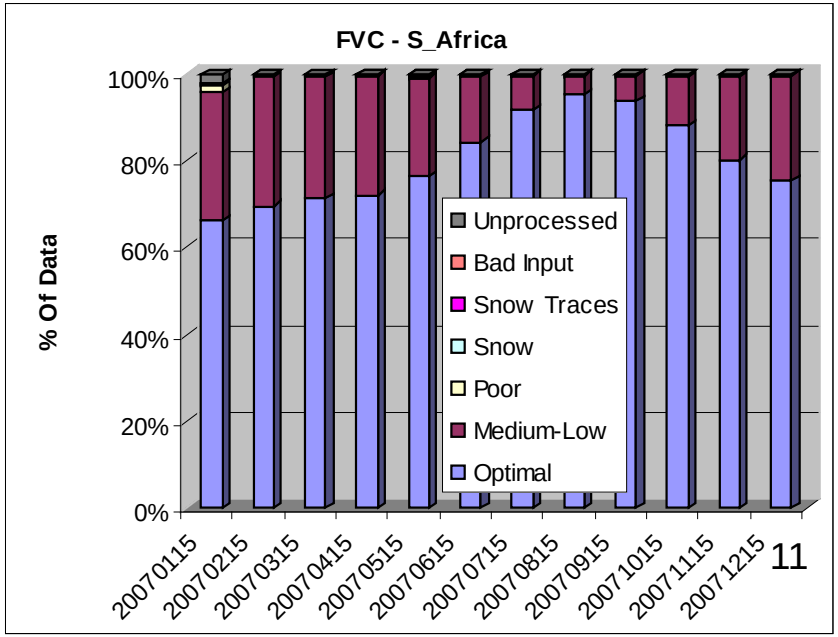
Quality and coverage

Mean values over 2007



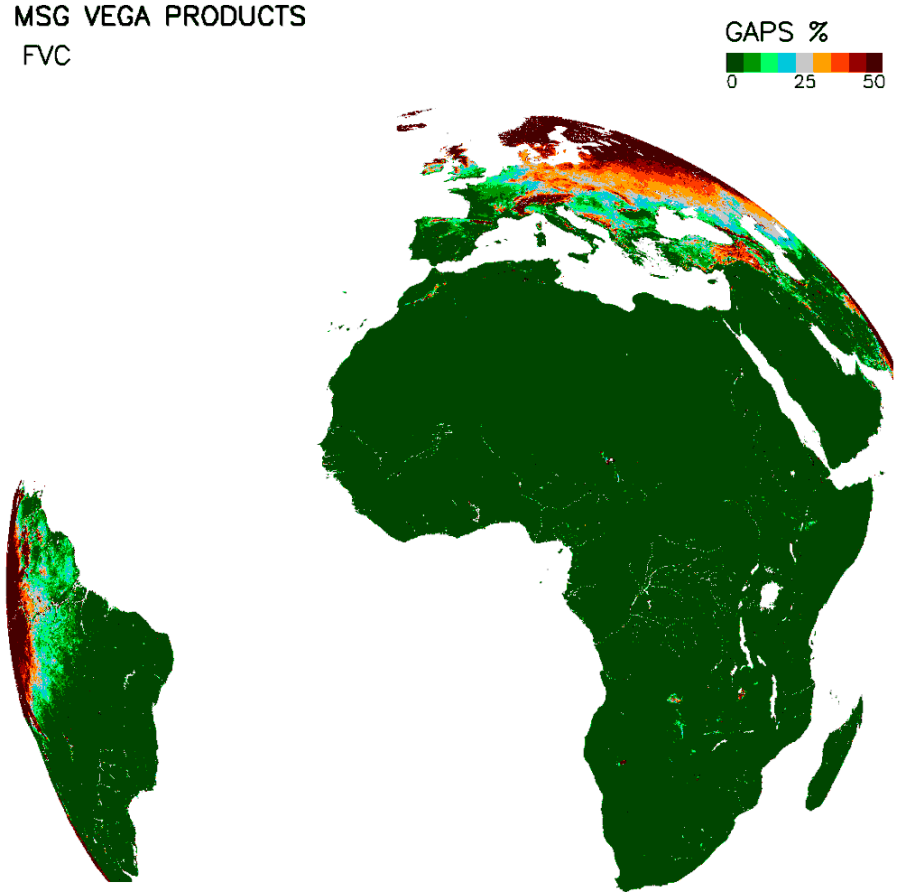


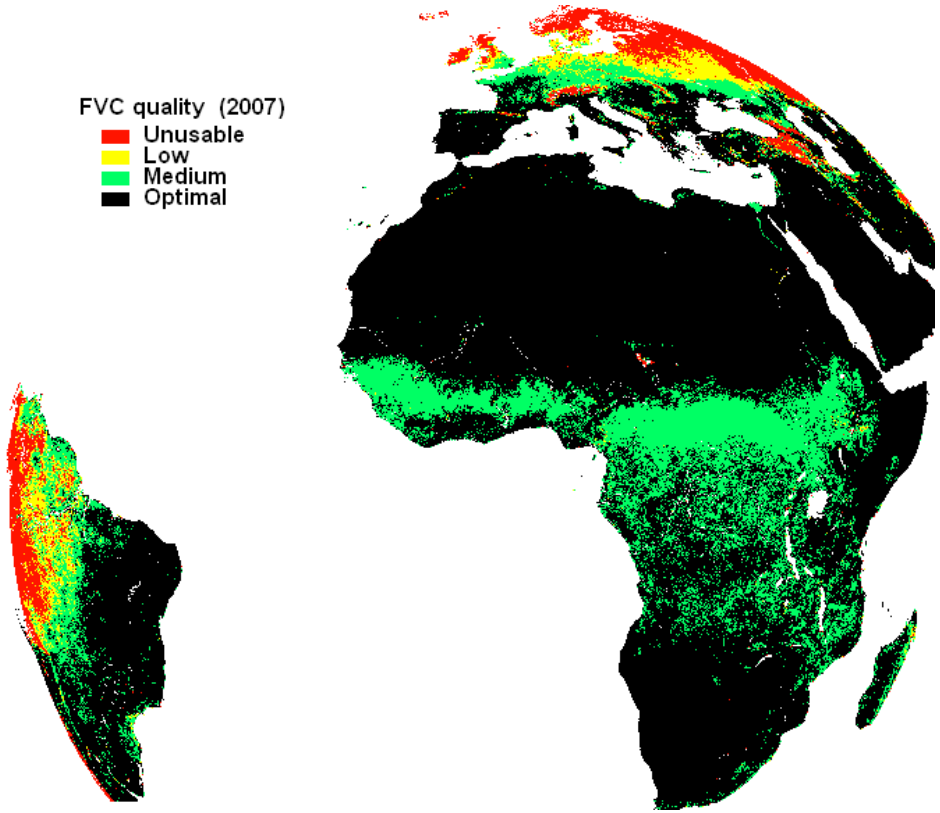




Quality and coverage

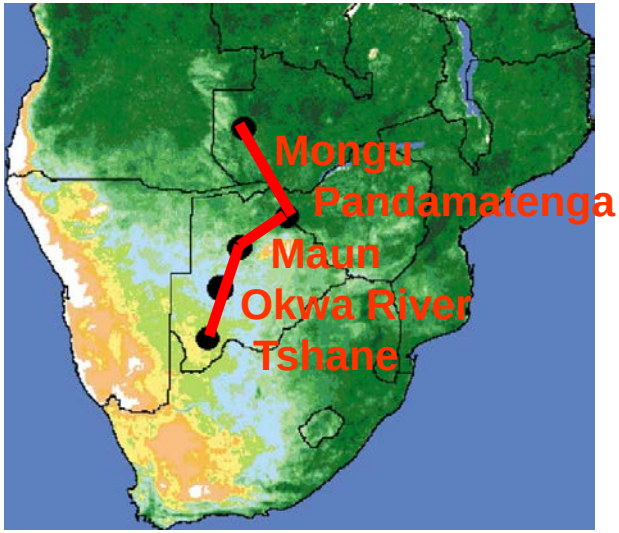
Percentage of gaps over 1 year of data

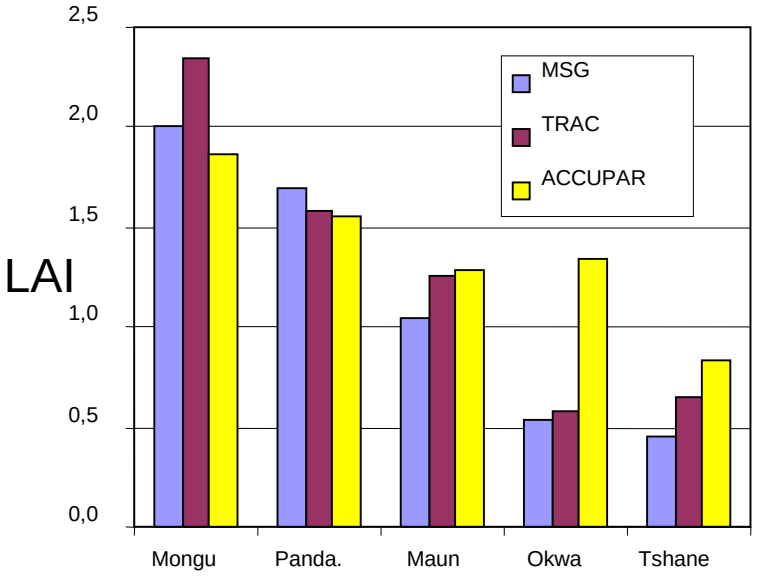


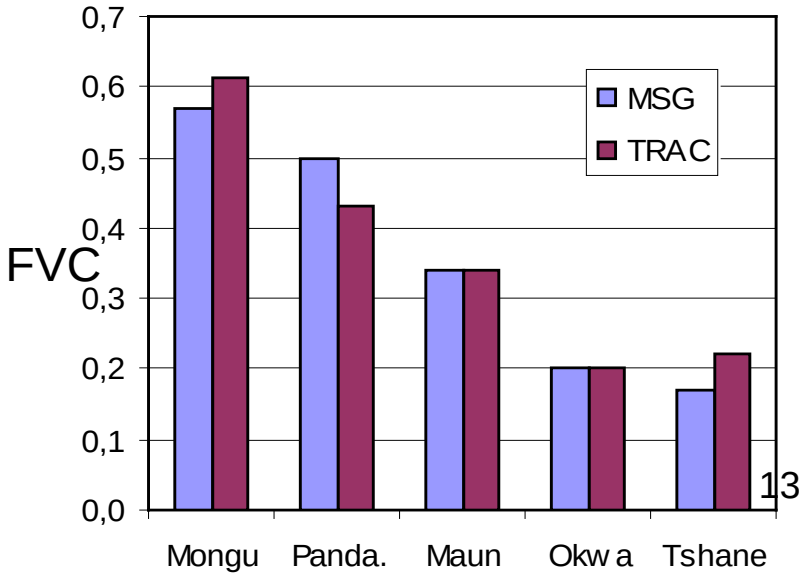


Optimal:	**Err(FVC)<0.10**
Medium:	**0.10<Err(FVC)<0.15**
Low:	**0.15<Err(FVC)<0.20**
Unusable	**Err(FVC)>0.20**

Product Validation

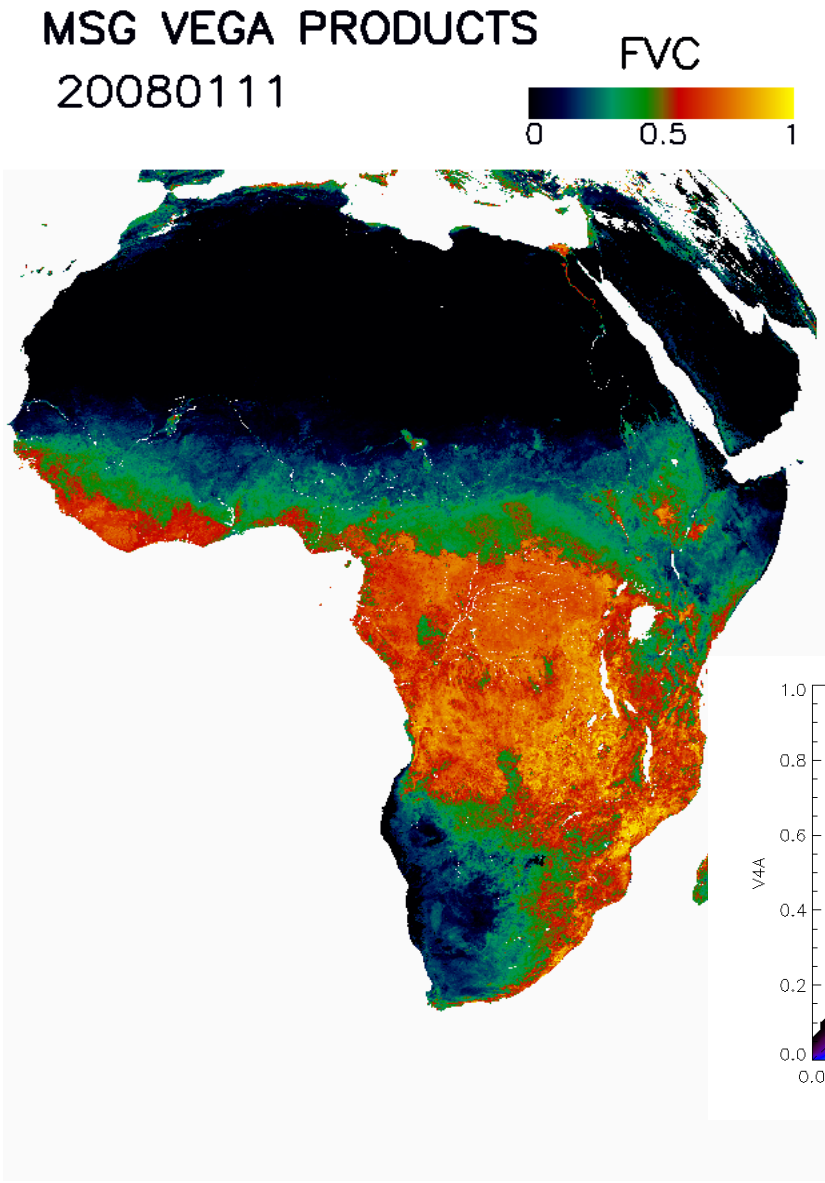


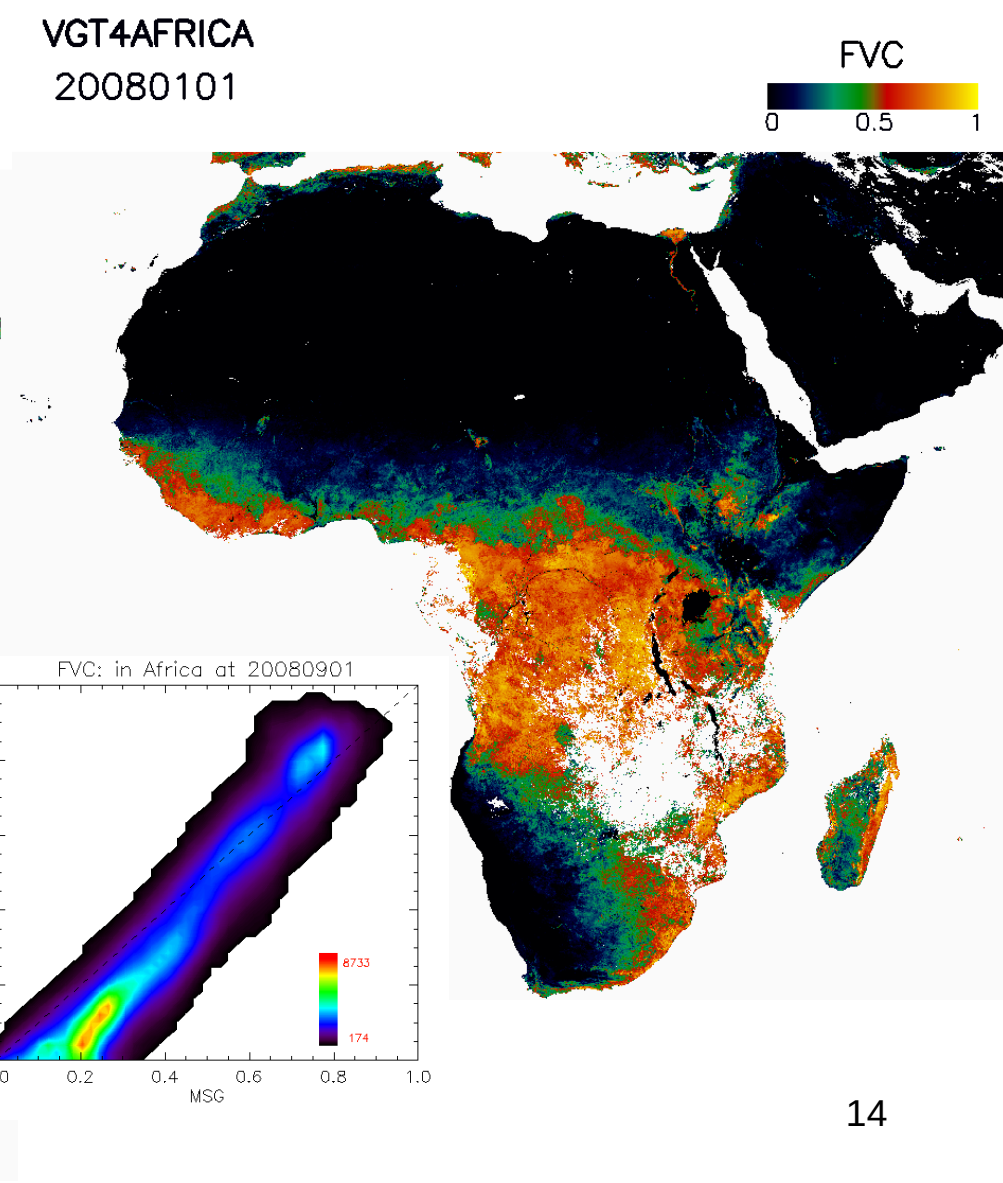




Product validation

Comparison with VGT4SAFRICA FVC



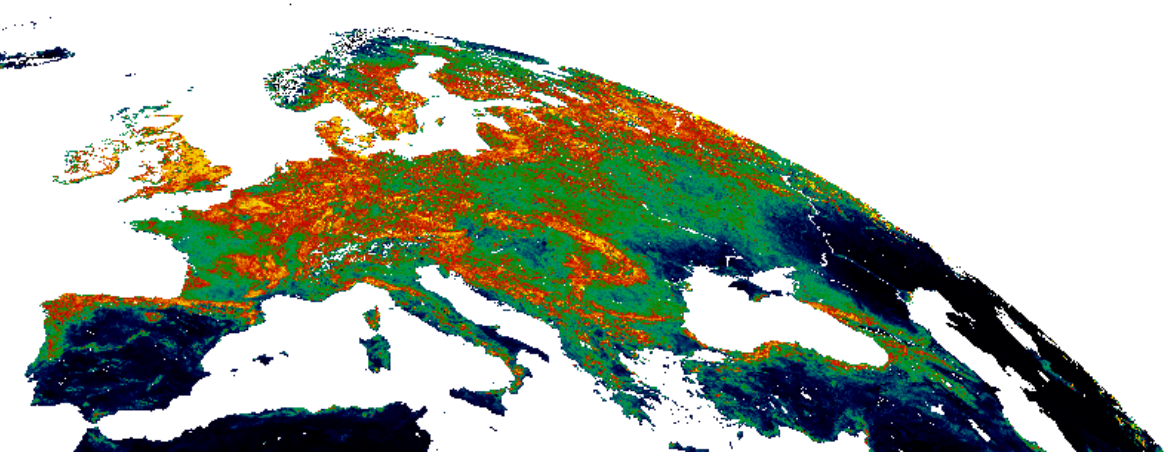


Quality monitoring

Consistency LSASAF and Copernicus Global Land

MSG VEGA PRODUCTS

20120703



BIOPAR PRODUCTS

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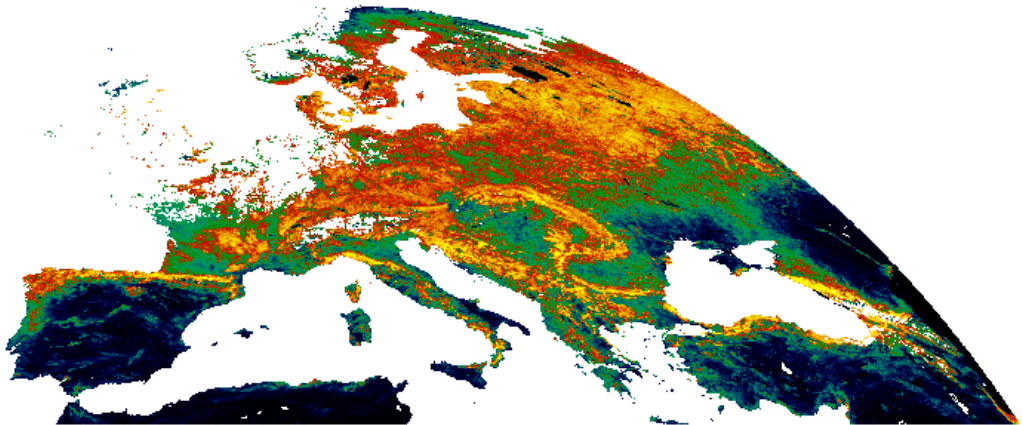
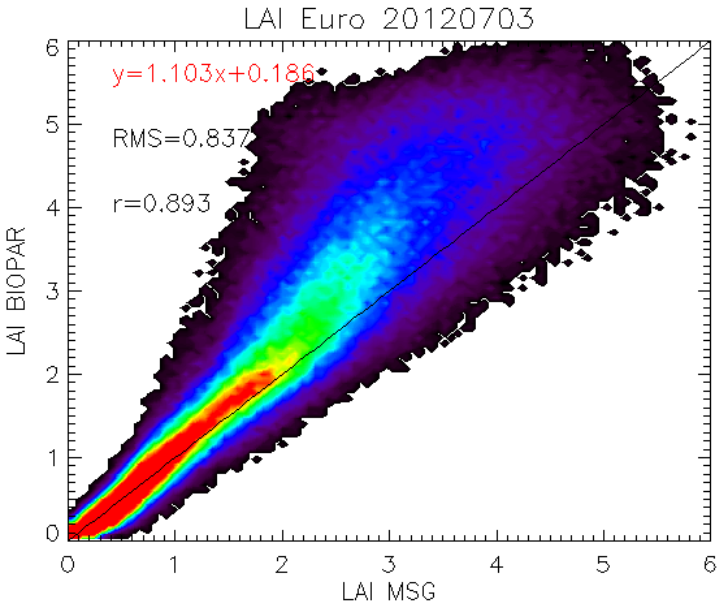


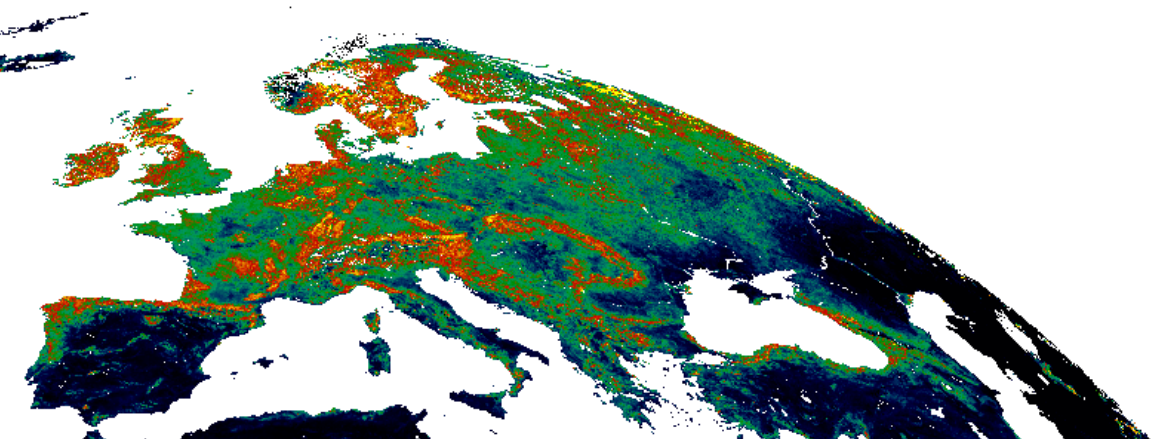


Quality monitoring

Consistency LSASAF and Copernicus Global Land

MSG VEGA PRODUCTS

20120803



BIOPAR PRODUCTS

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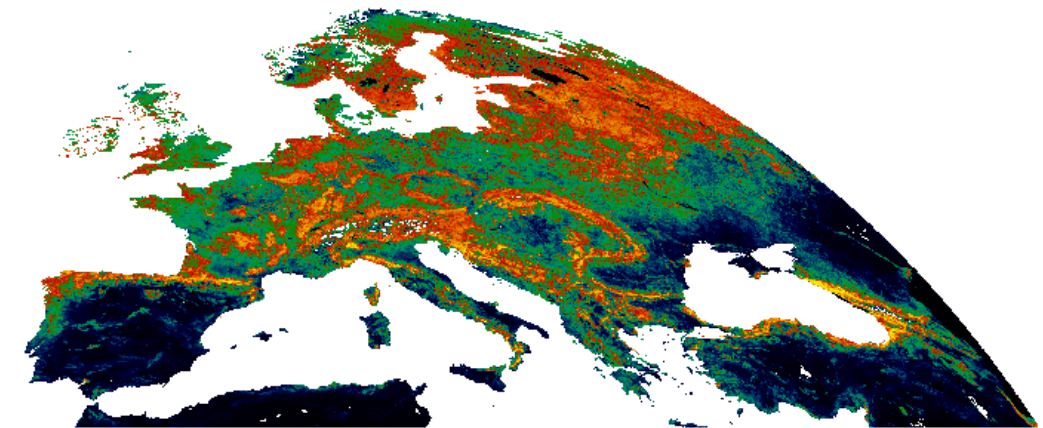

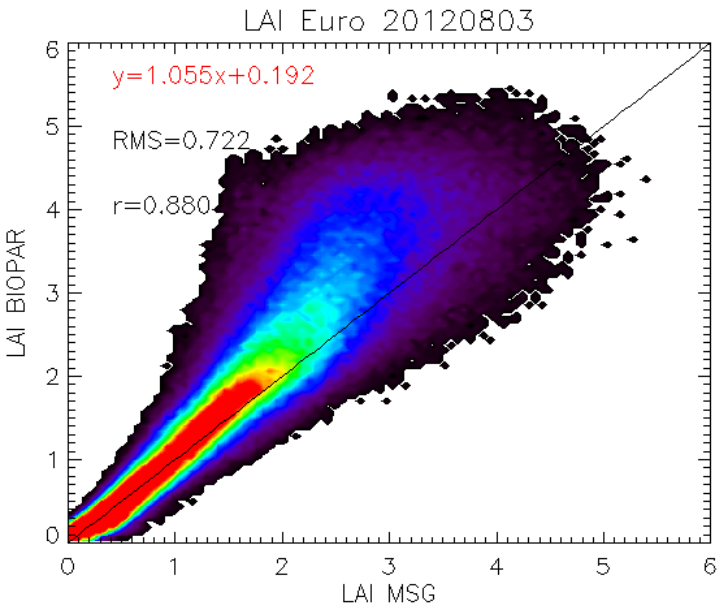

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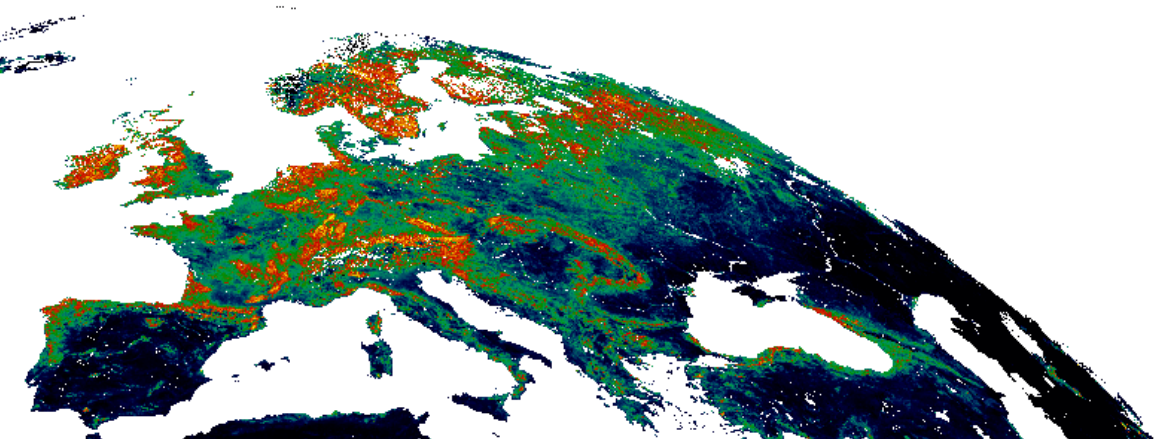

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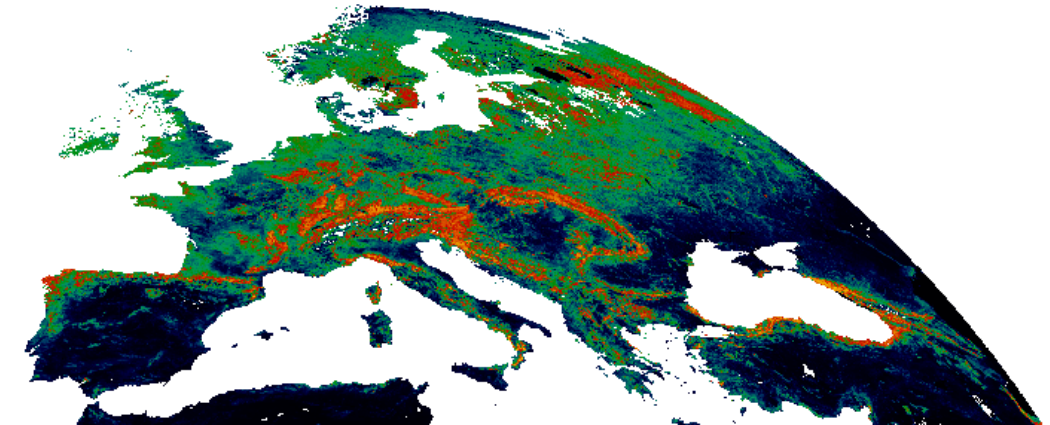
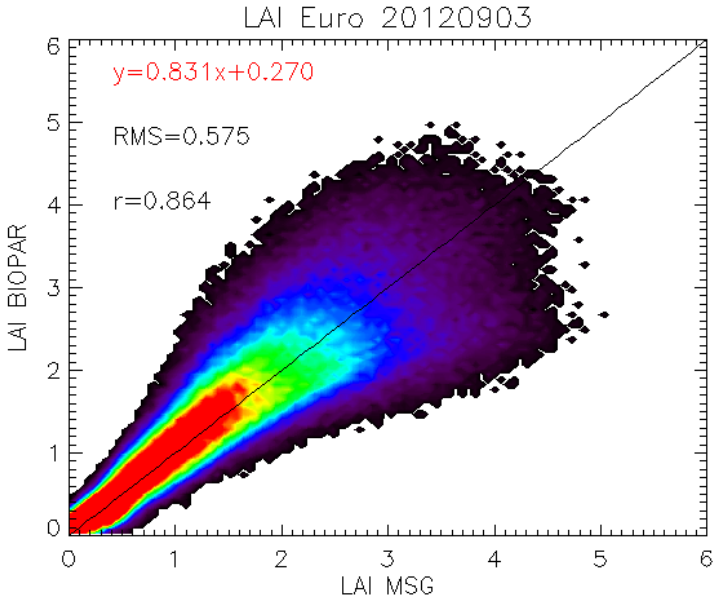
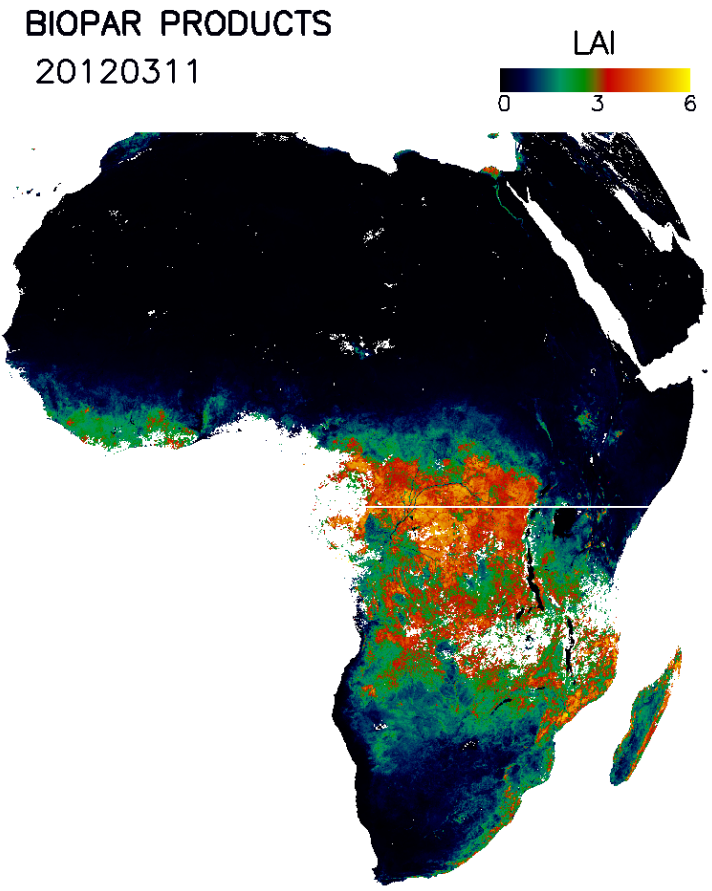
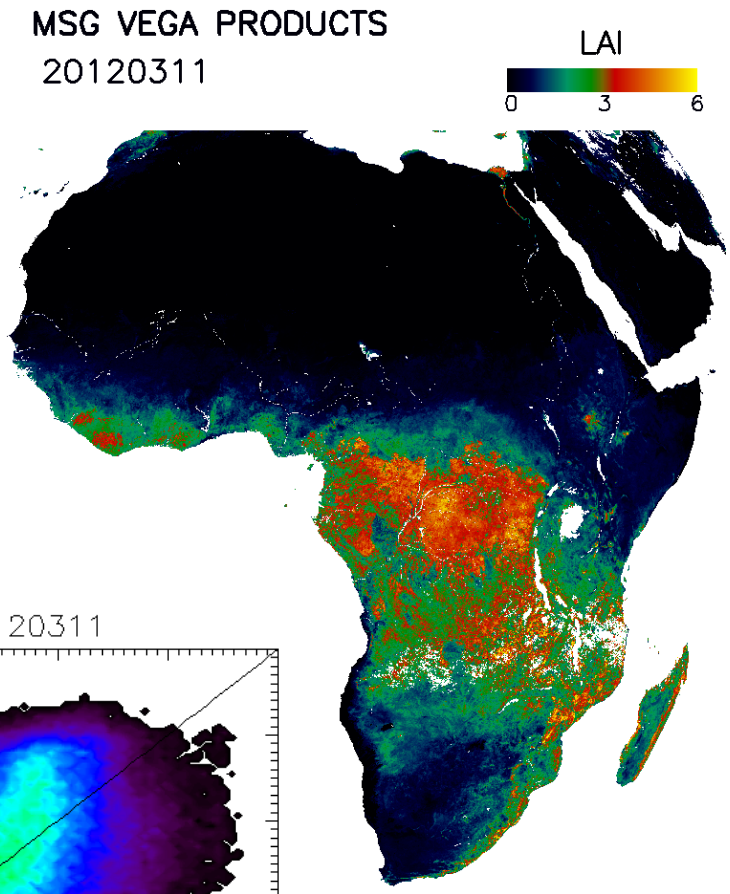


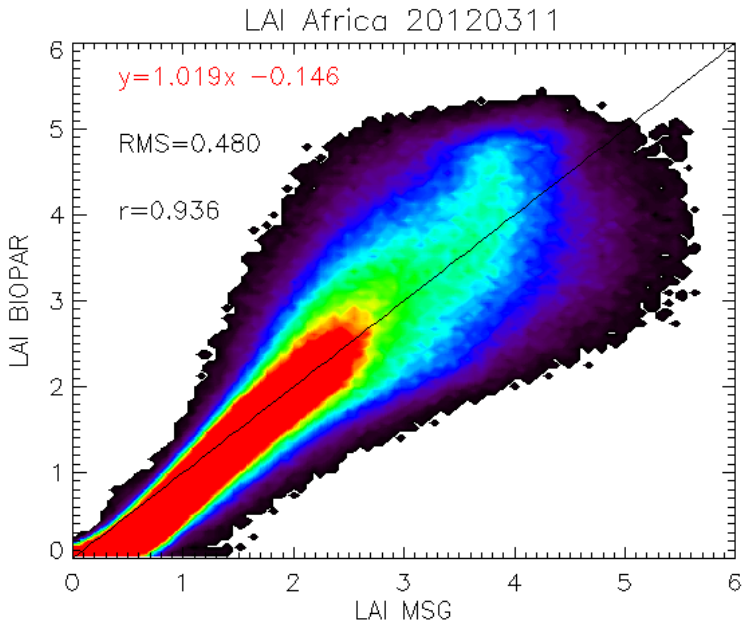


Quality monitoring

Consistency LSASAF and Copernicus Global Land

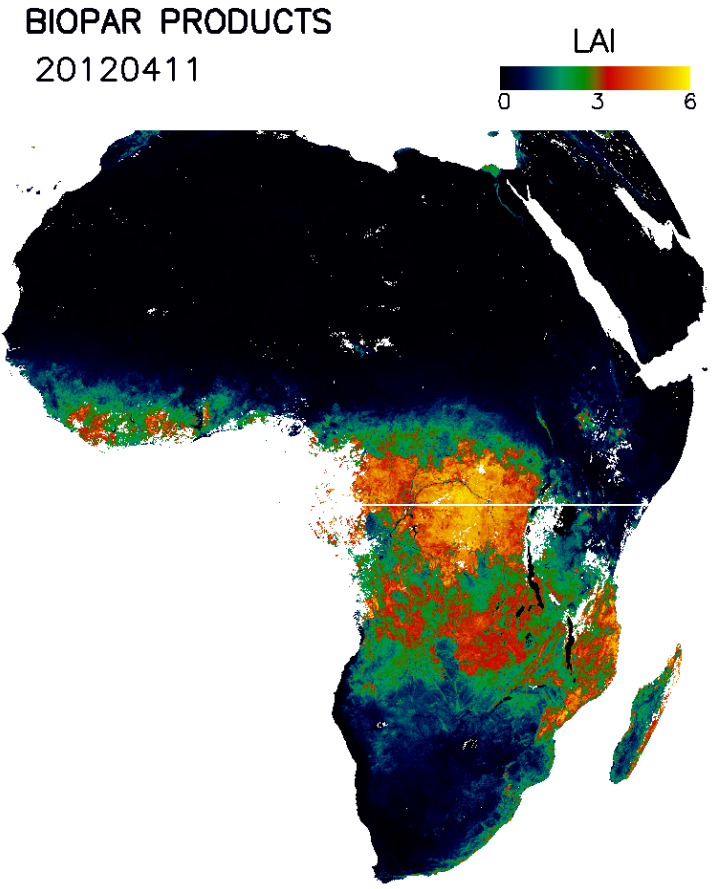


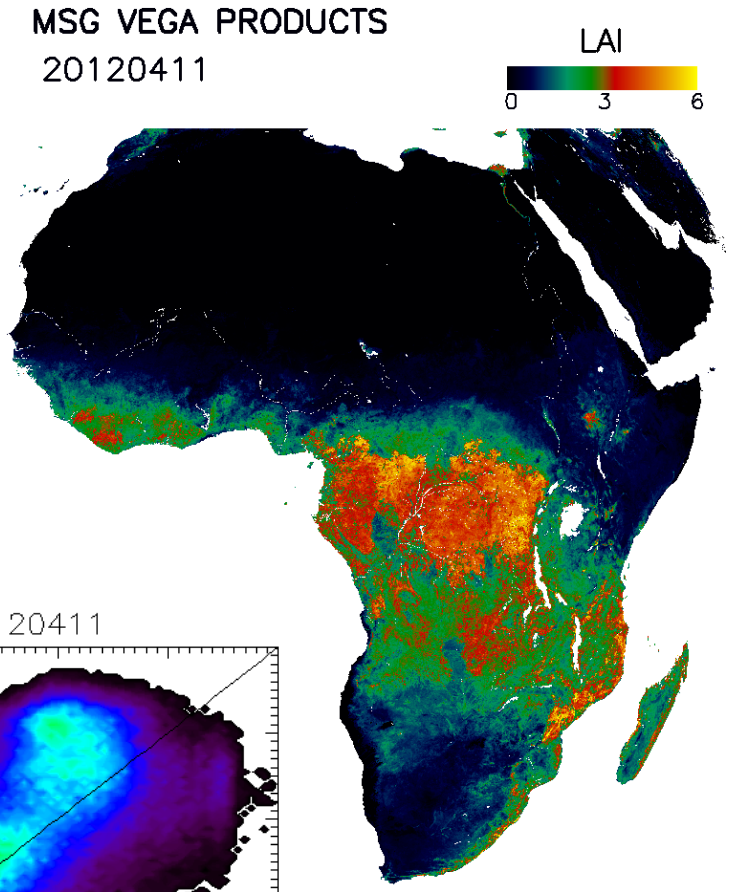


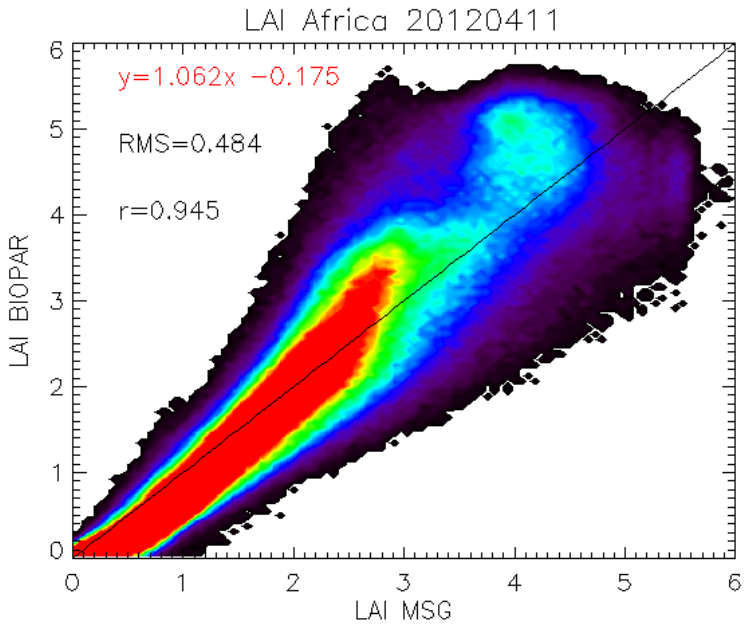


Quality monitoring

Consistency LSASAF and Copernicus Global Land

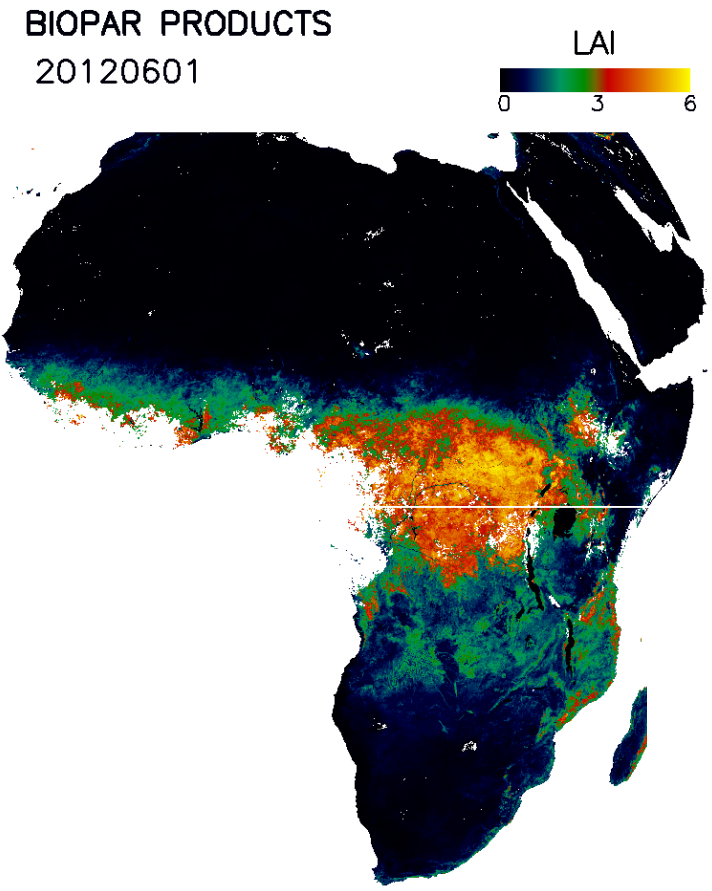


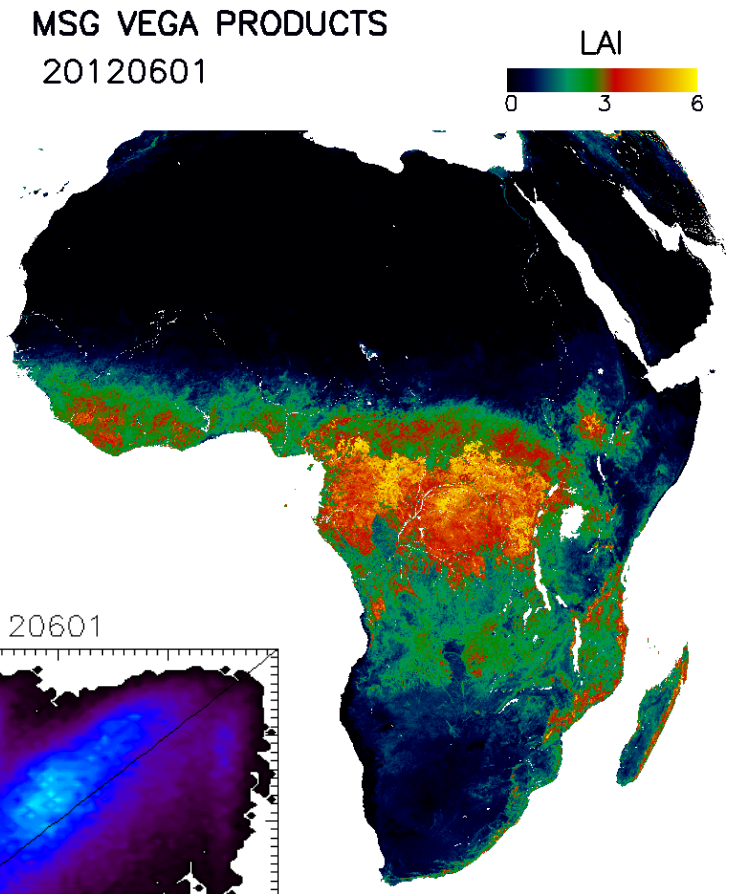


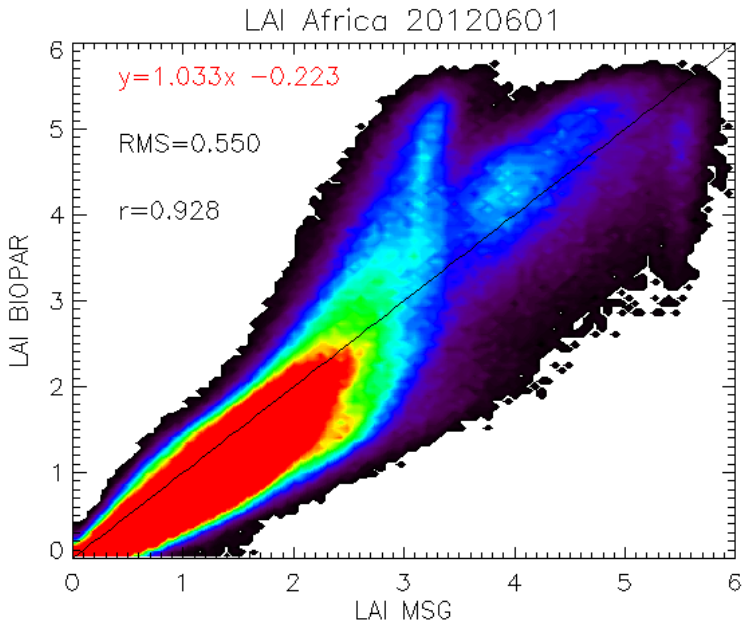


Quality monitoring

Consistency LSASAF and Copernicus Global Land

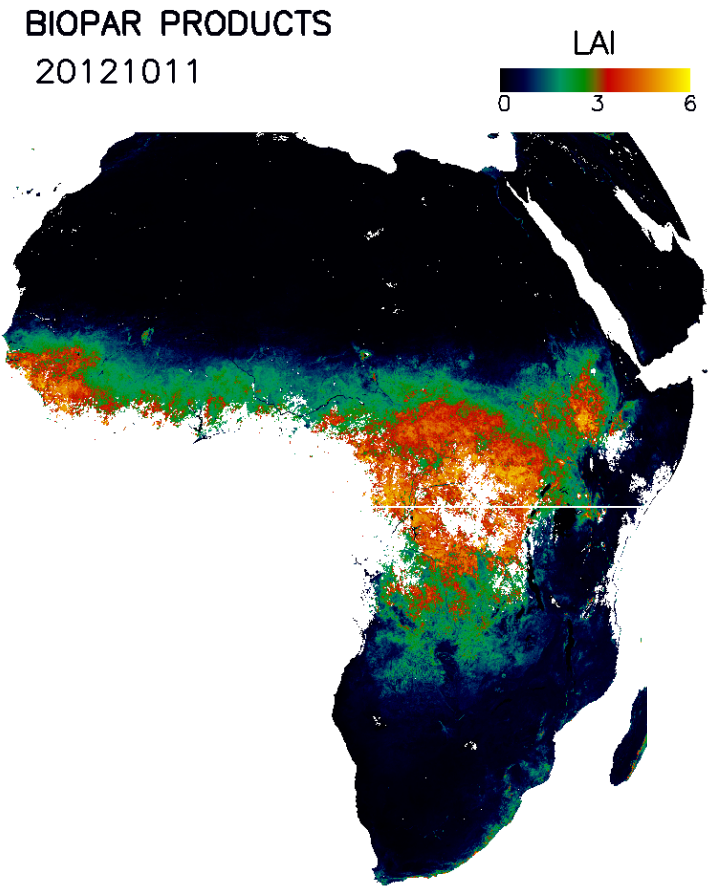


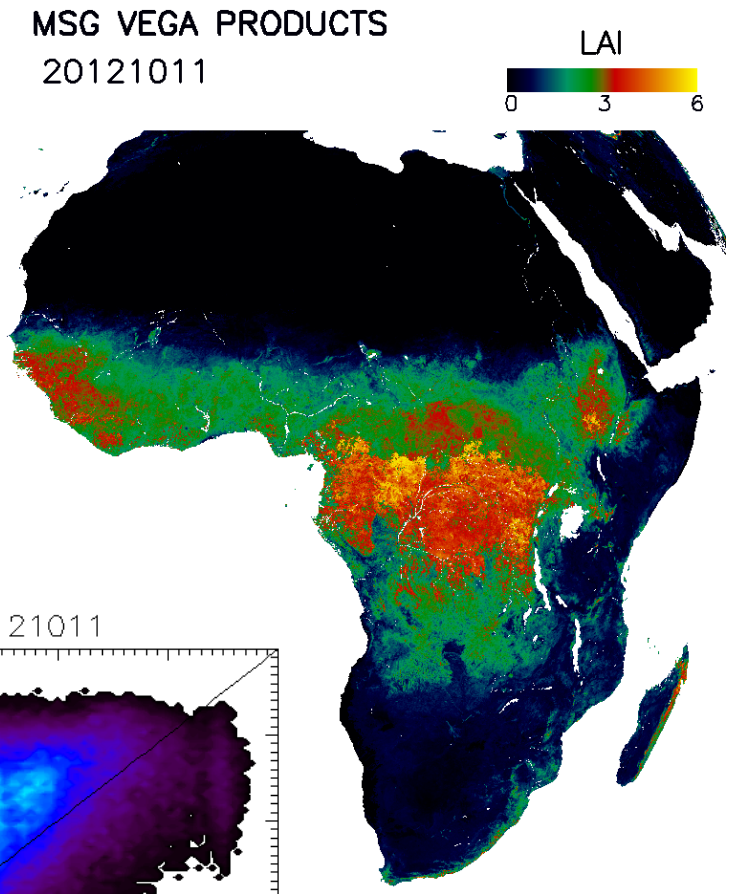


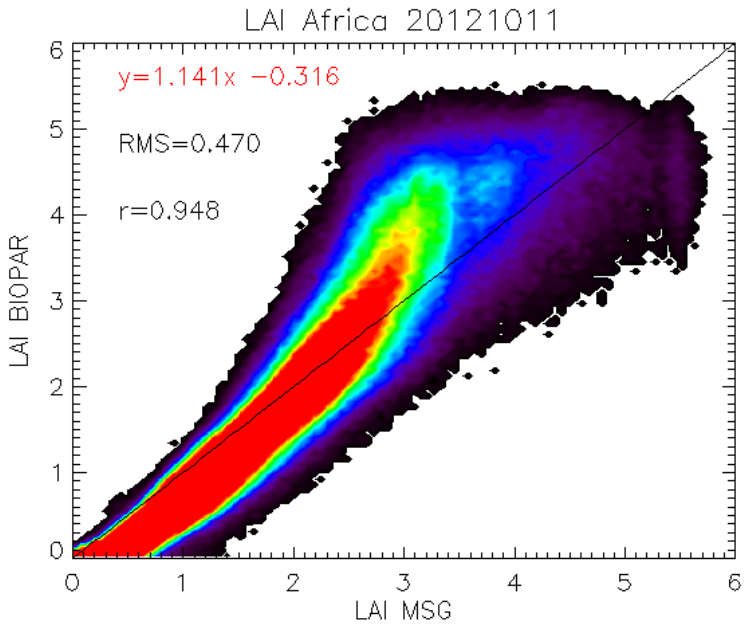


Quality monitoring

Consistency LSASAF and Copernicus Global Land

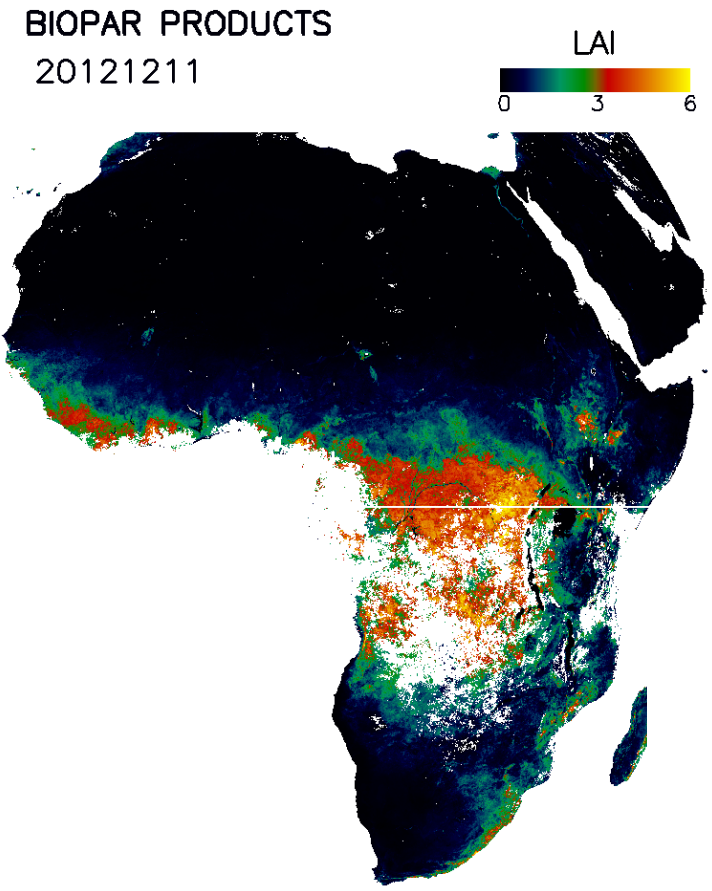


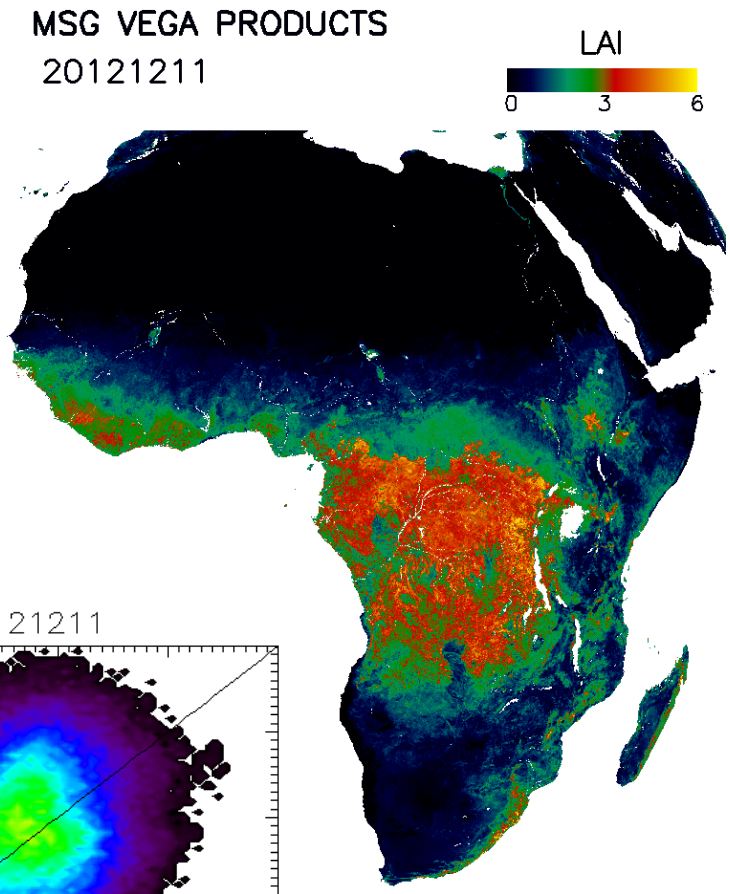


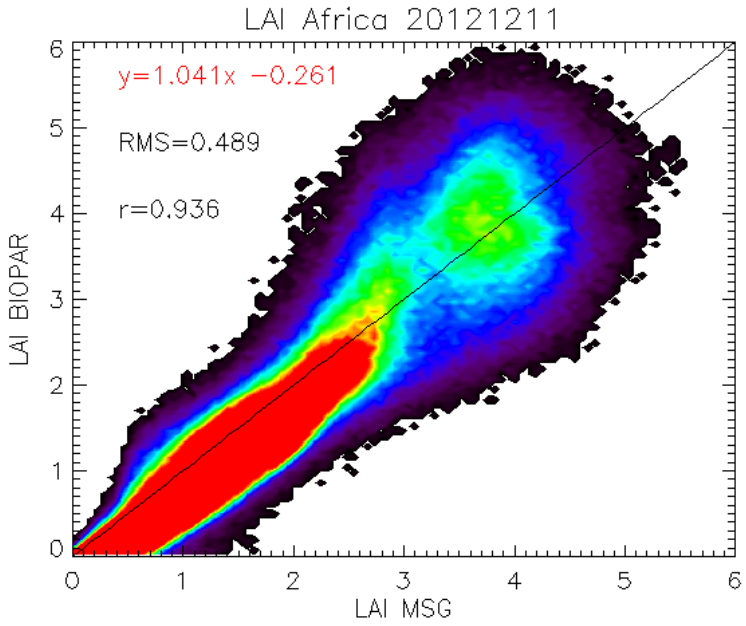


Quality monitoring

Consistency LSASAF and Copernicus Global Land

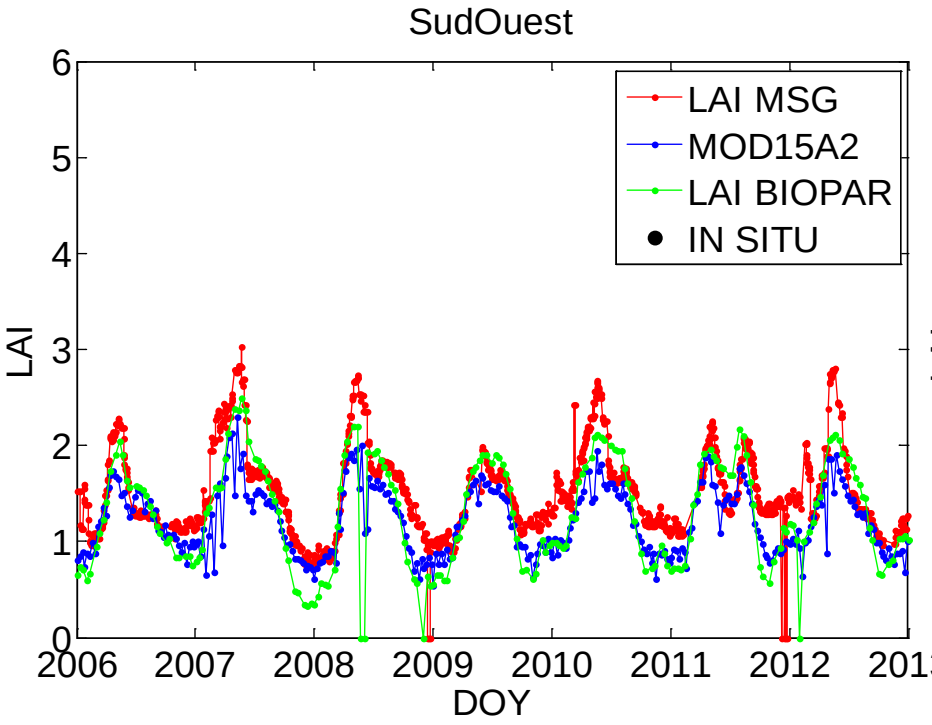


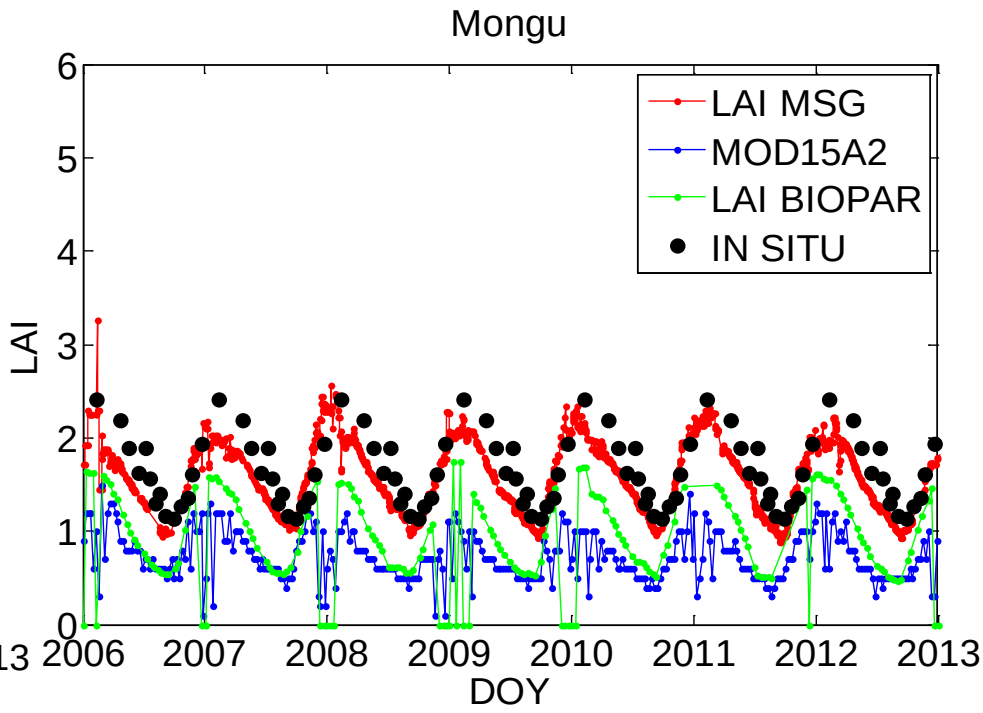




Quality monitoring

Temporal consistency

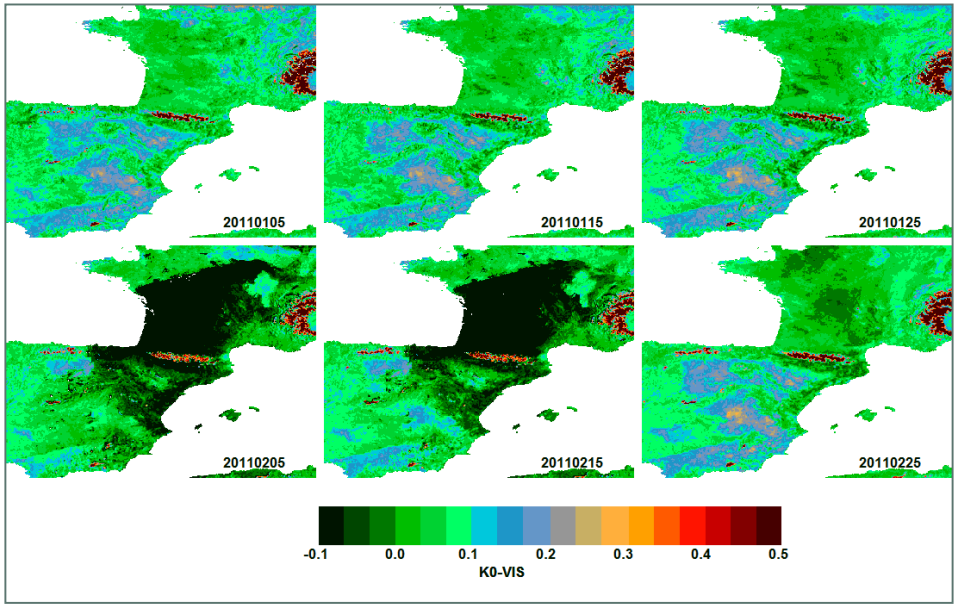




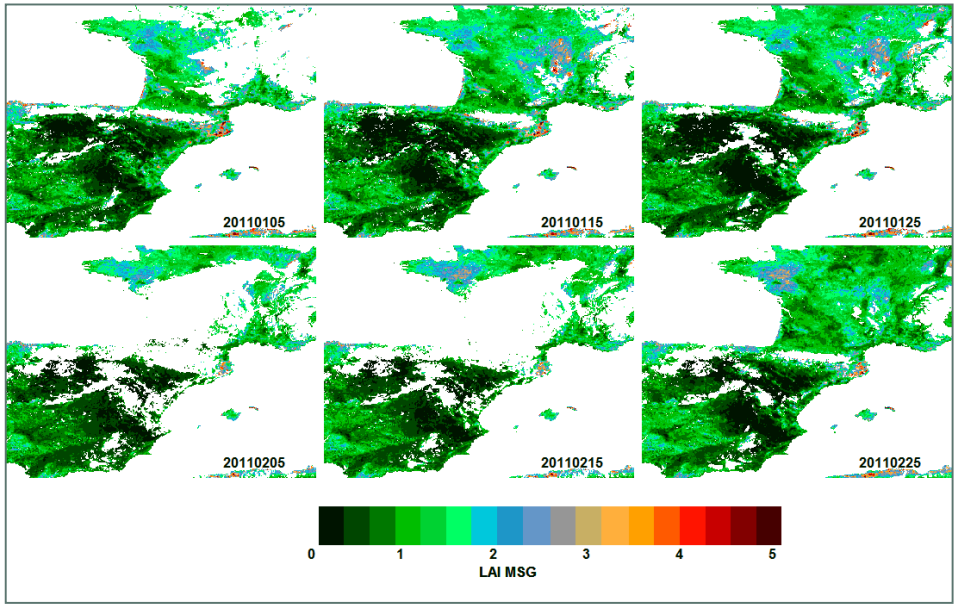
Quality monitoring

Identified artefacts

Input (BRDF K0)



LAI



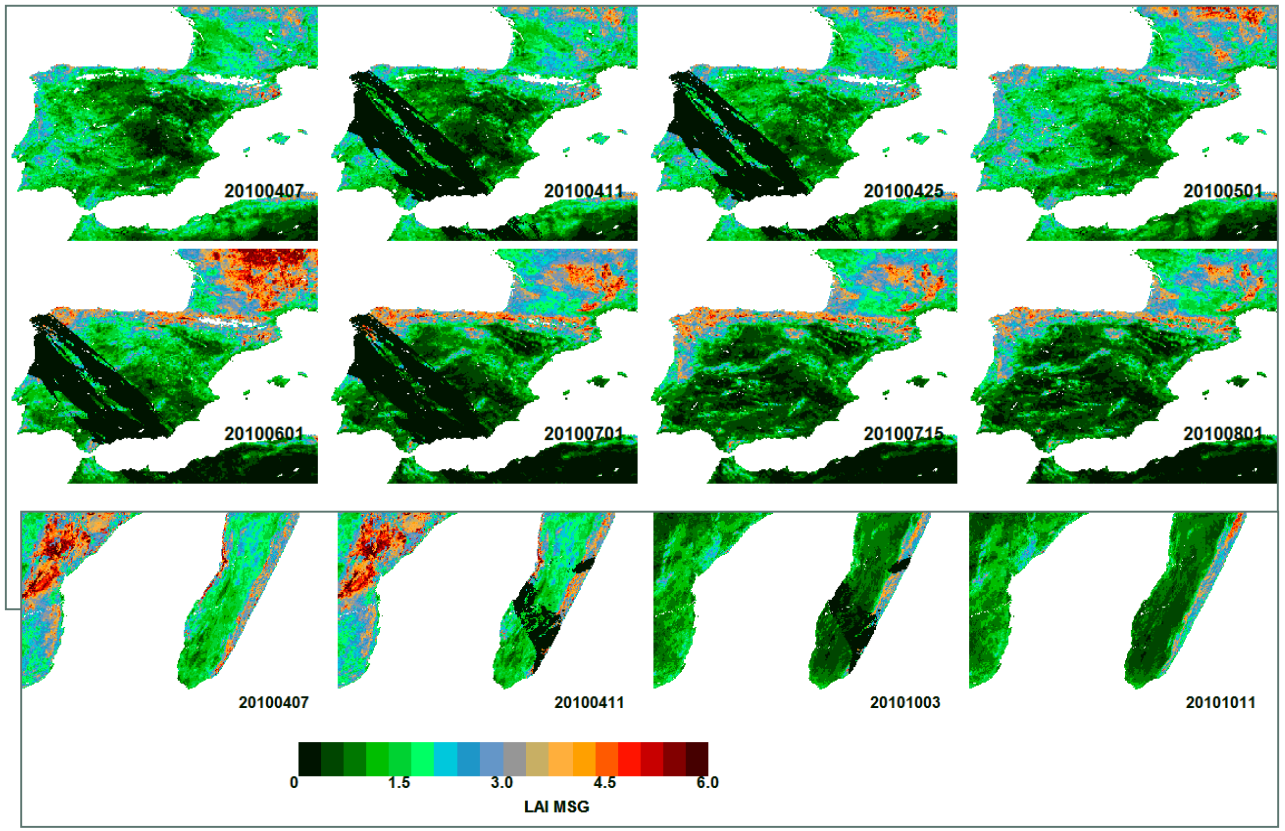
Artefacts during late winter 2011

- at some specific locations in the four SEVIRI regions.
- Caused by a sharp decrease in the BRDF bands, unadressed by quality flag

Documented in Updated Validation Report

Quality monitoring

Identified artefacts



Iberian Peninsula

Madagascar

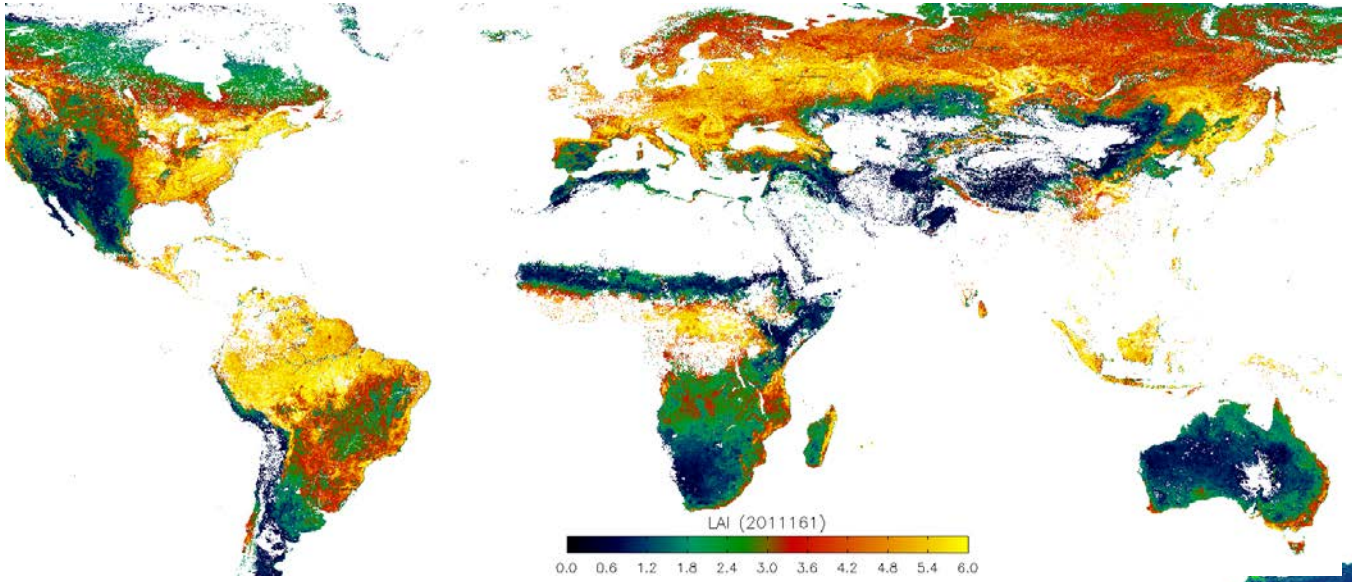
Strips in FVC and LAI at some periods of year 2010

- Assigned an erroneous value of 0
- Unaddressed by quality flag

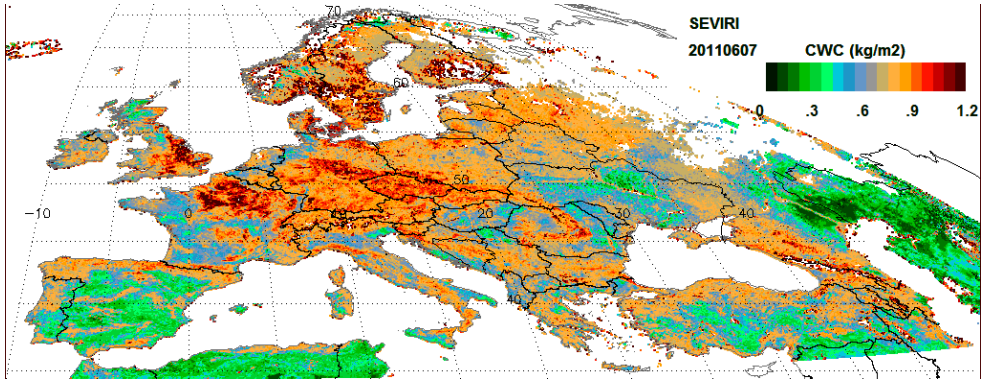
Documented in Updated Validation Report
This justifies the reprocessing (foreseen for March 2015)

Products under develpment

Global FVC, LAI, FAPAR from AVHRR/Metop

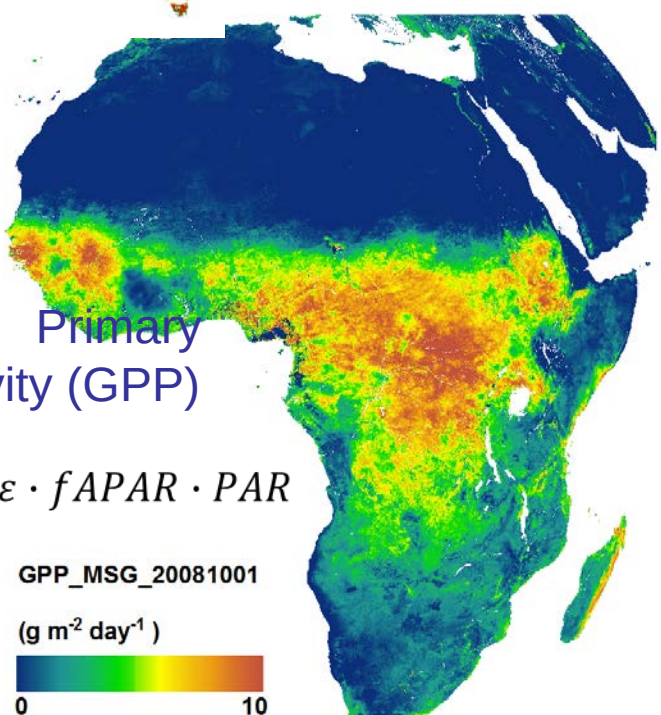


Canopy Water Content (CWC)



Gross Primary Productivity (GPP)

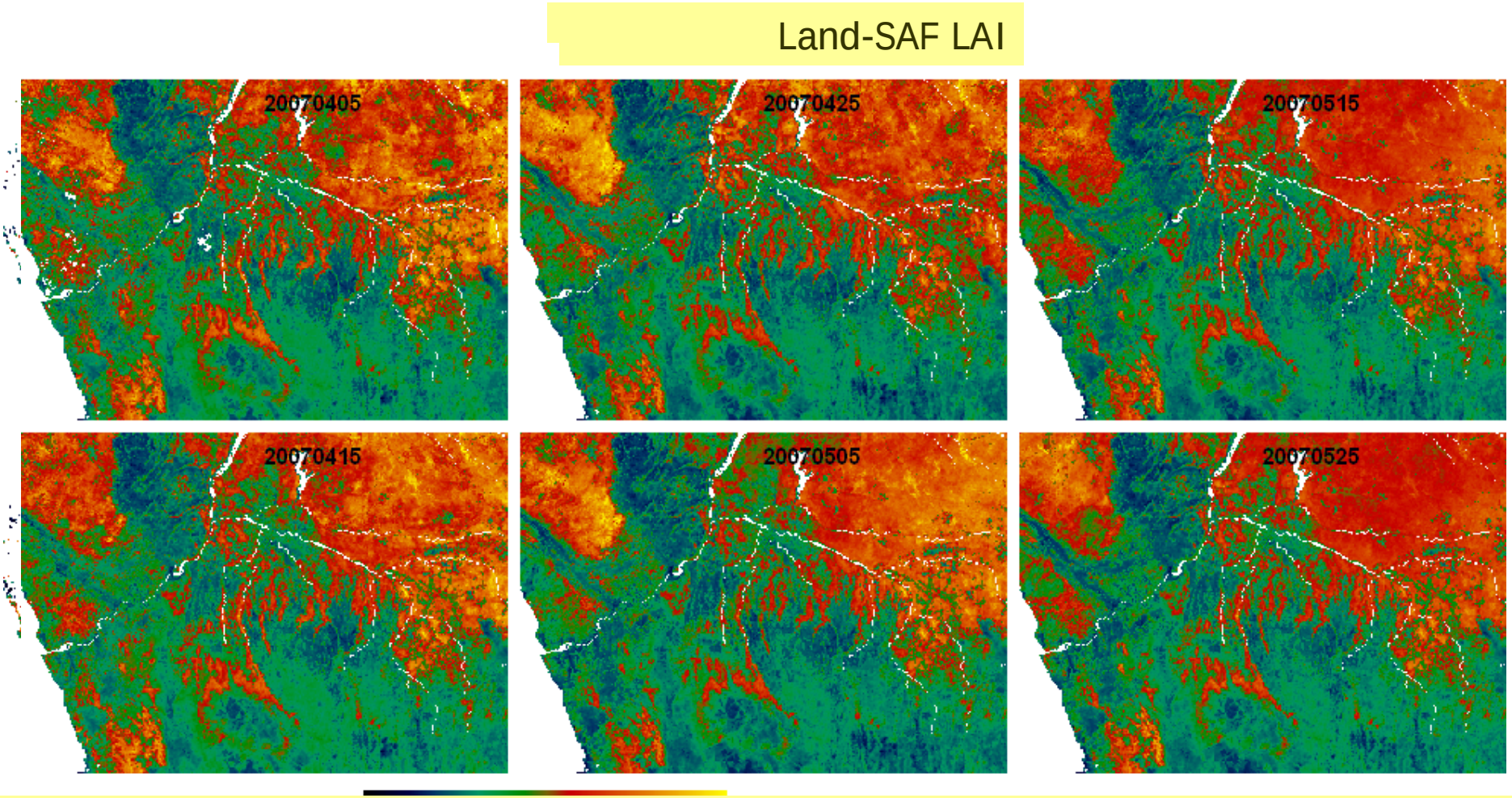
$$GPP = \varepsilon \cdot fAPAR \cdot PAR$$



Added value with regard to similar products

Expert knowledge

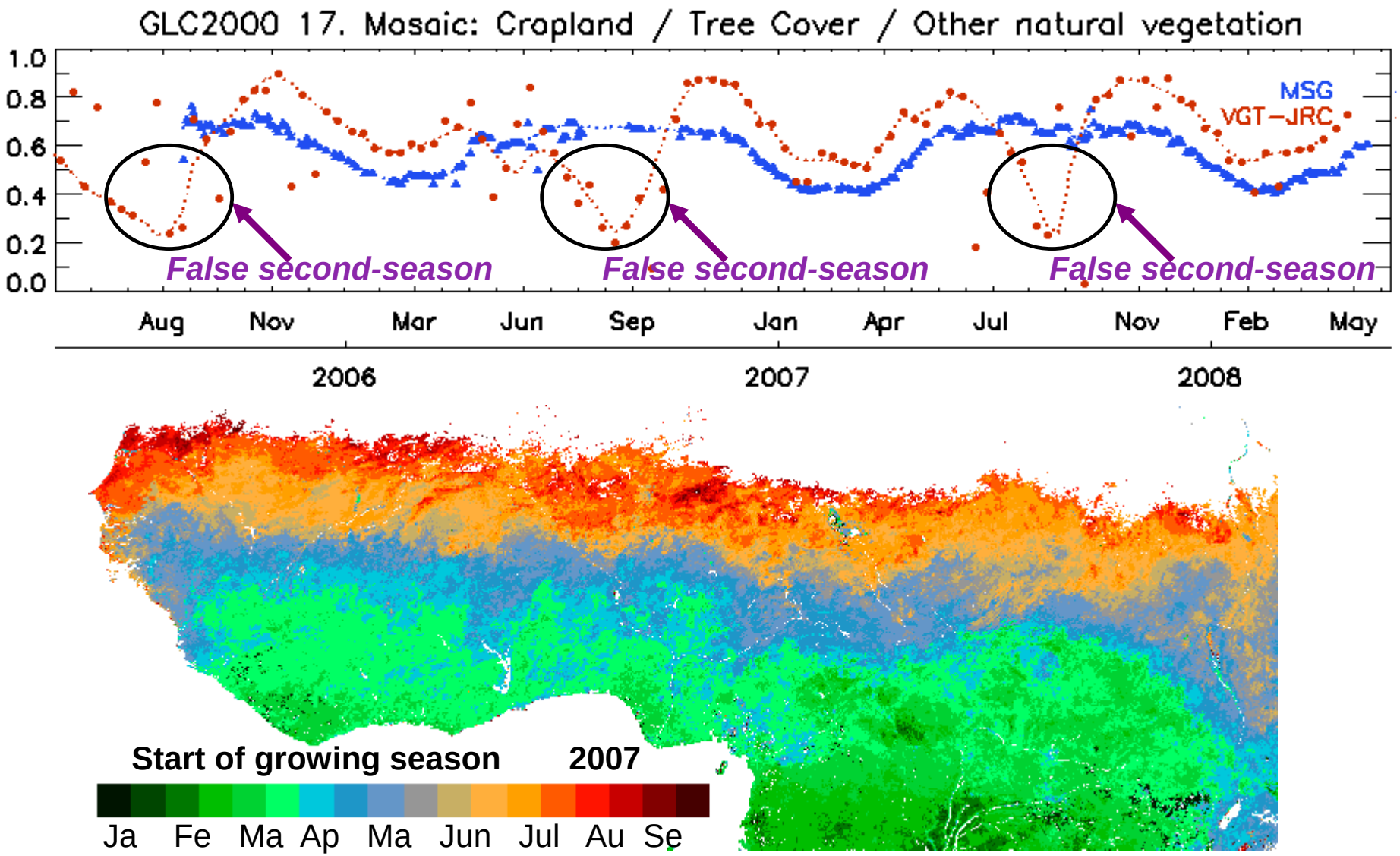
Sequence of products over a 50-day period, S_Africa (0º S, 11.2º E – 8.3ºS, 23.2ºE).



The temporal continuity and stability of LAI MSG product clearly outperforms that of MODIS product.

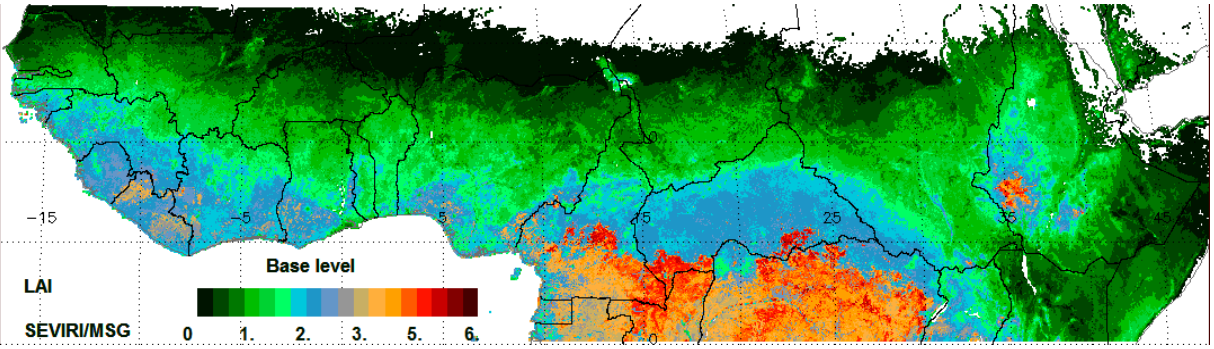
Reconstruction of seasonal curves

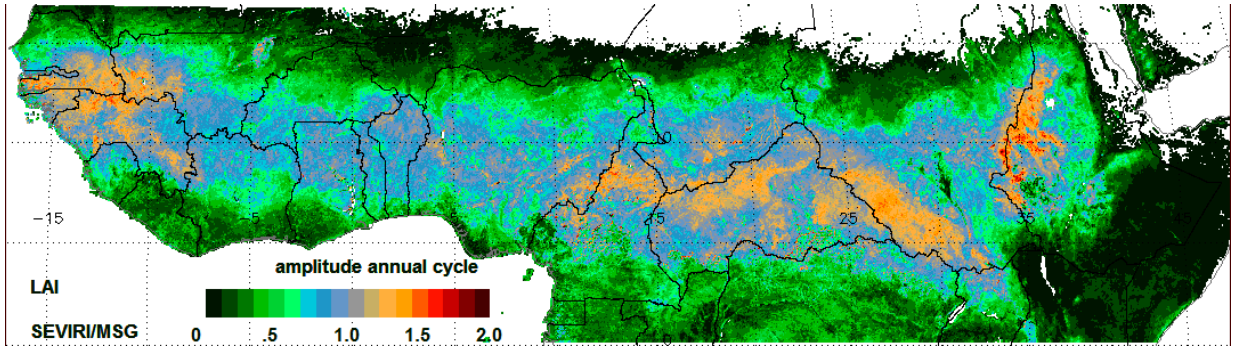
Potential applications

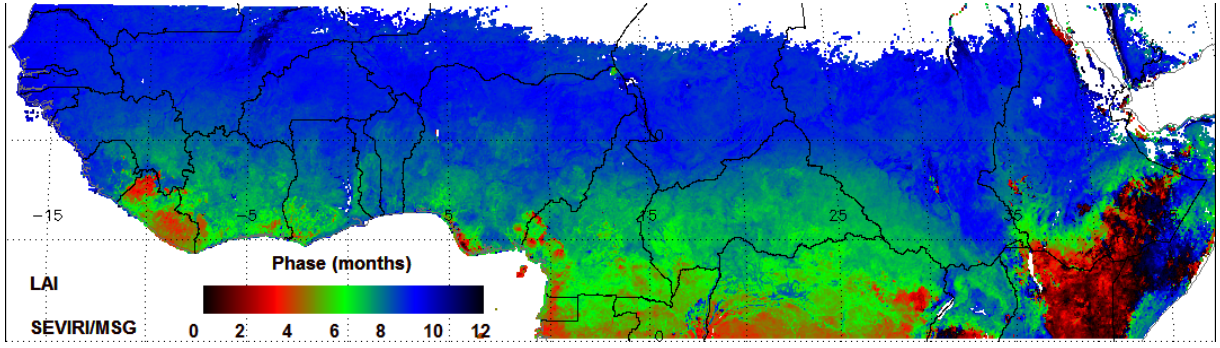


- Africa is a consolidated region: no gaps, temporal continuity, improving the capabilities of polar orbiters to characterise the phenology

Deriving phenologic attributes





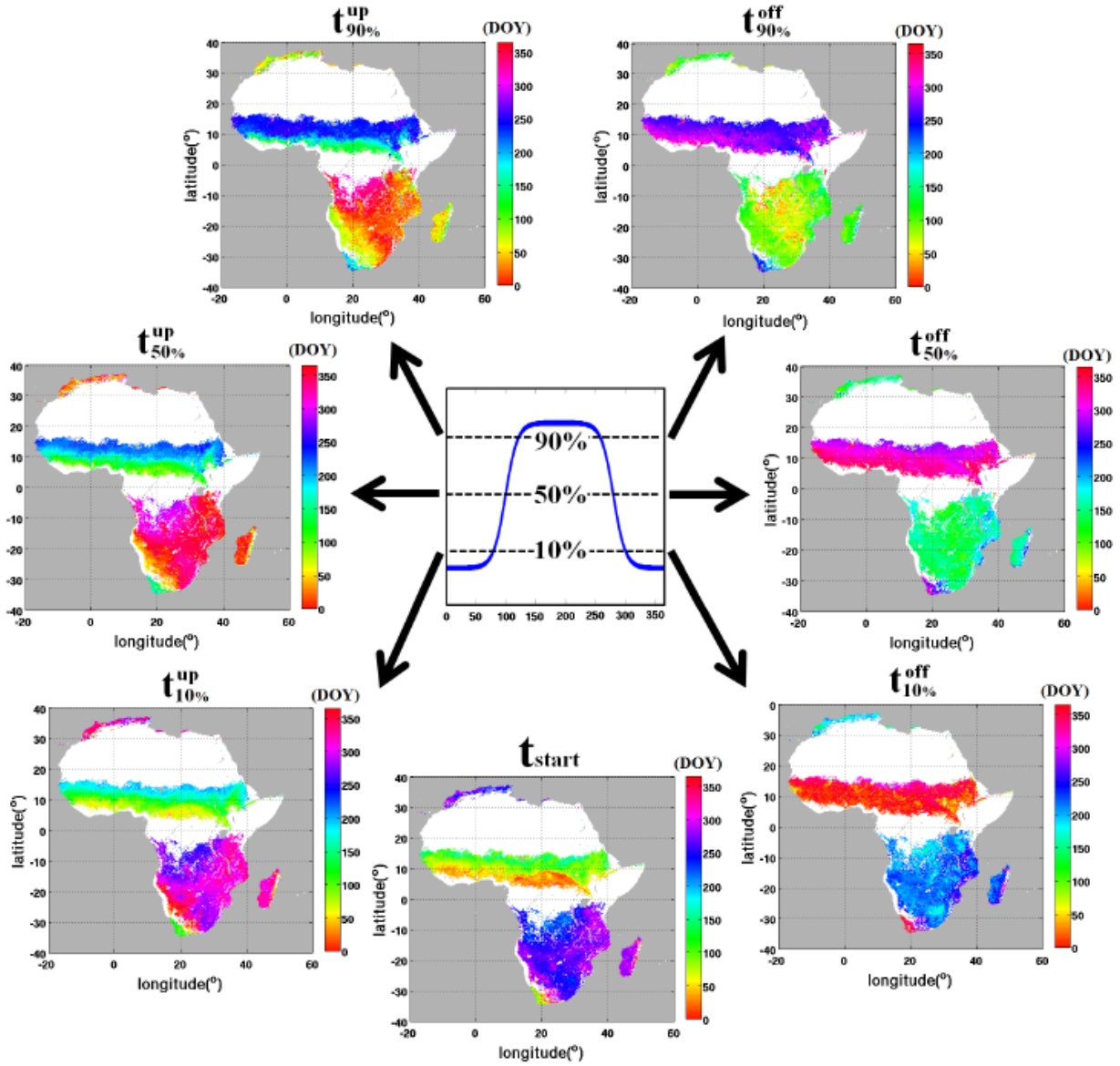


Seasonal metrics

- Base level, amplitude, phase
- indicators of productivity, and timing.
- More reliable than (MODIS, VGT) derived

Deriving phenologic attributes

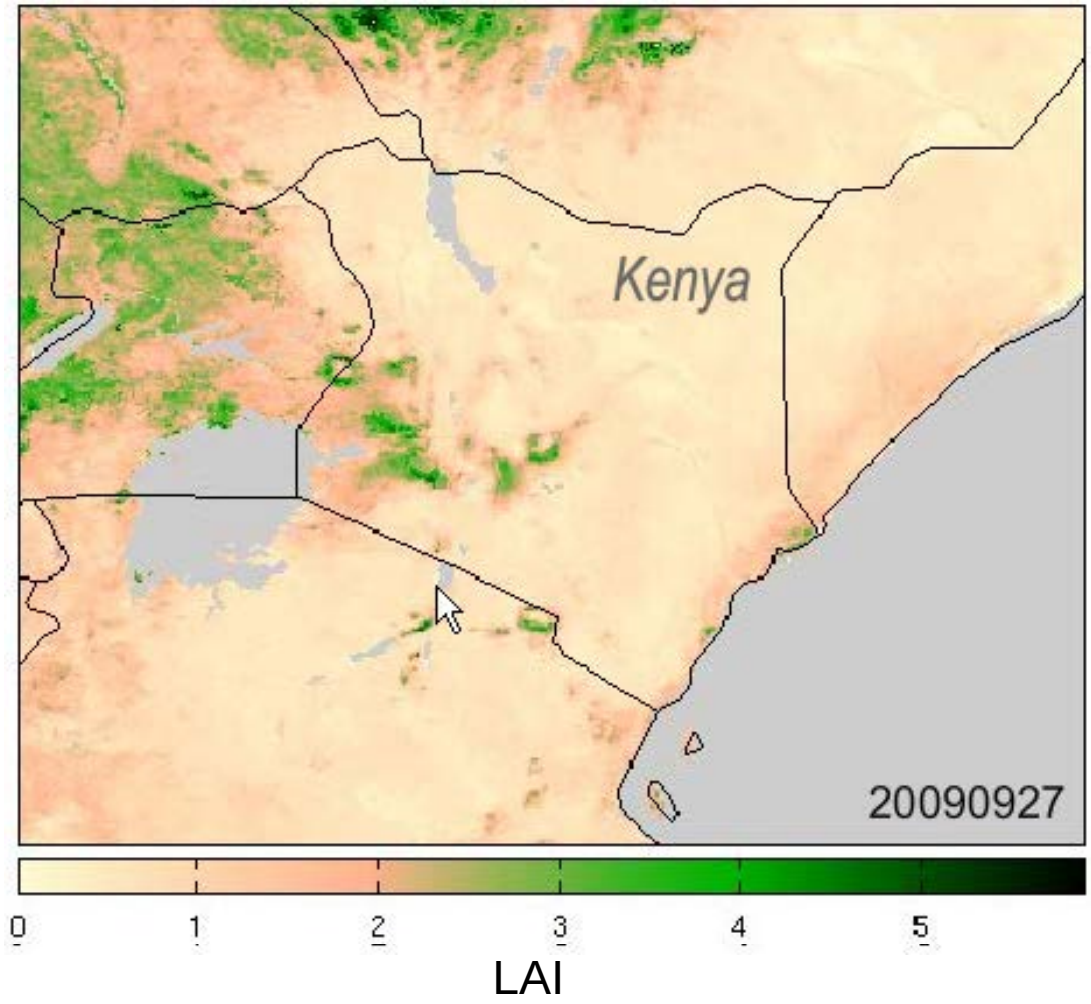
Potential applications



Guan, K., E. F. Wood, D. Medvigy, K. K. Caylor, S. Li and S. J. Jeong, (2013), Derive vegetation phenological time and structure information over Africa using SEVIRI daily LAI, IEEE transactions on Geoscience and Remote Sensing, 52:1113-1130.

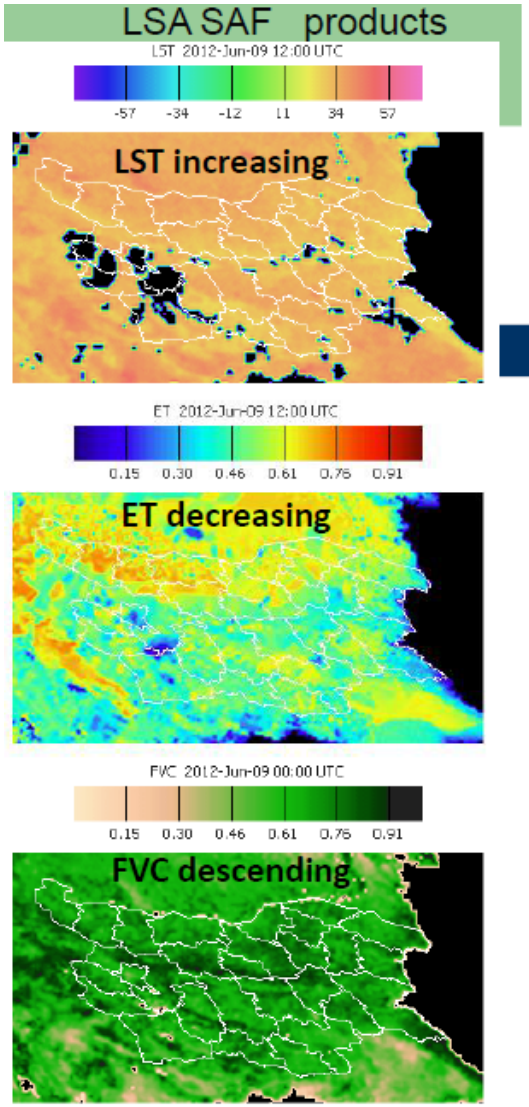
Drought monitoring

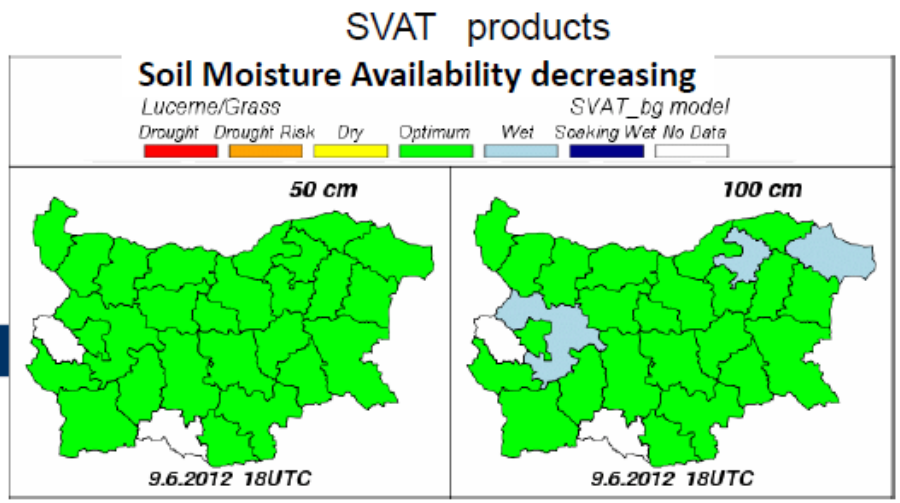
SEVERE DROUGHT OVER EAST AFRICA: 10 million people afected (state of emergency)



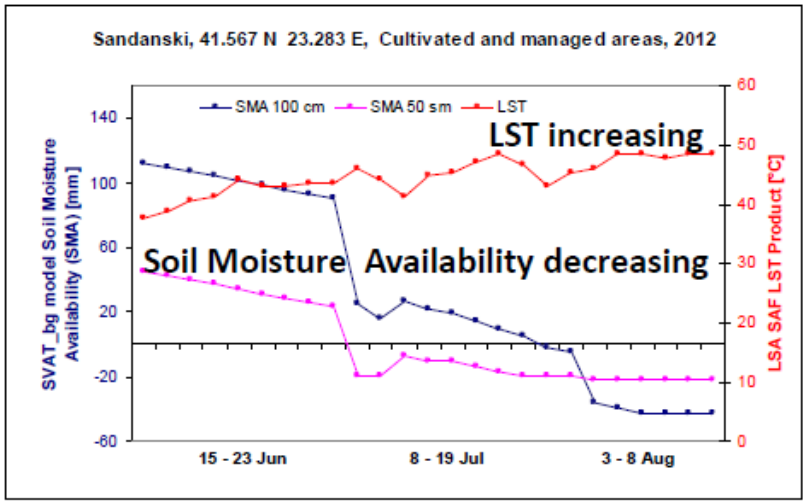
by Isabel Monteiro (**EUMETRAIN**: Monitoring Vegetation from space)
http://www.satreponline.org/landsaf/

Drought monitoring from LSA SAF products





SMA depletion is accompanied by increase of LST, decrease of ET, decrease of FVC.

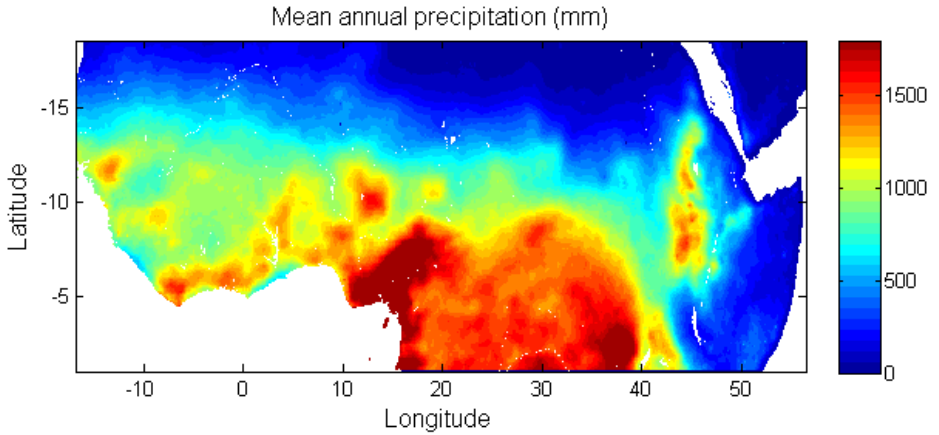


- From Julia Stoyanova (Bulgarian National Institute of Meteorology and Hydrology)

Meterological data

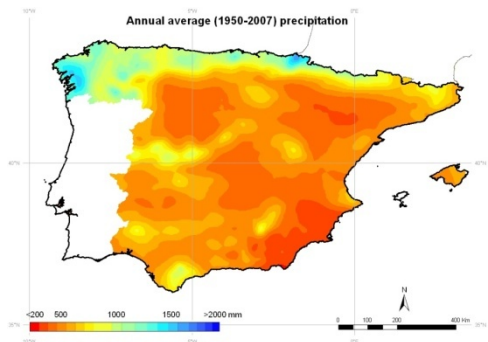
AFRICA

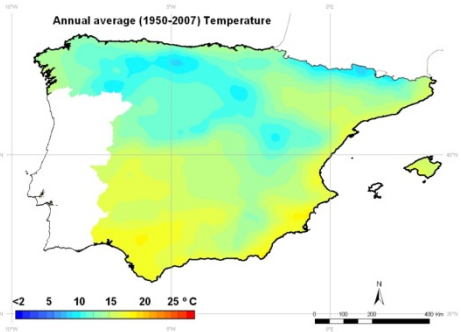
- 10-day rainfall estimates (RFE 2.0) for Africa from the NOAA Climate Prediction Center (NOAA/CPC) at a spatial resolution of 8-km
- monthly and 3-montly accumulated



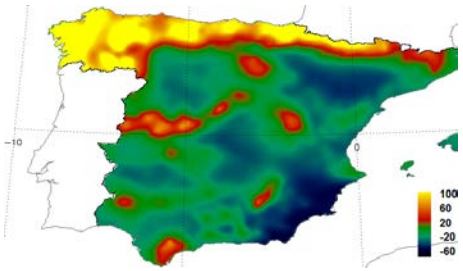
SPAIN

- Monthly P,T records from all AEMET (Spanish Agency of Meteorology) stations.
- Images of climatic variables were interpolated (2-km)
- Thornthwaite Moisture index ⇒ climatic classification
- Standardised Precipitation index (SPI-i) at i-month scales (i=1,3,6,12)

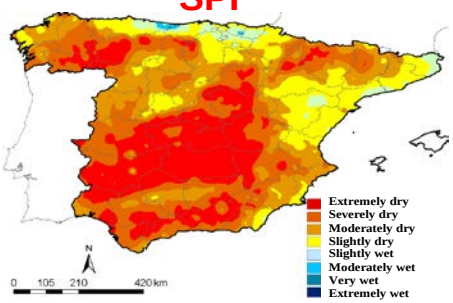




Moisture index

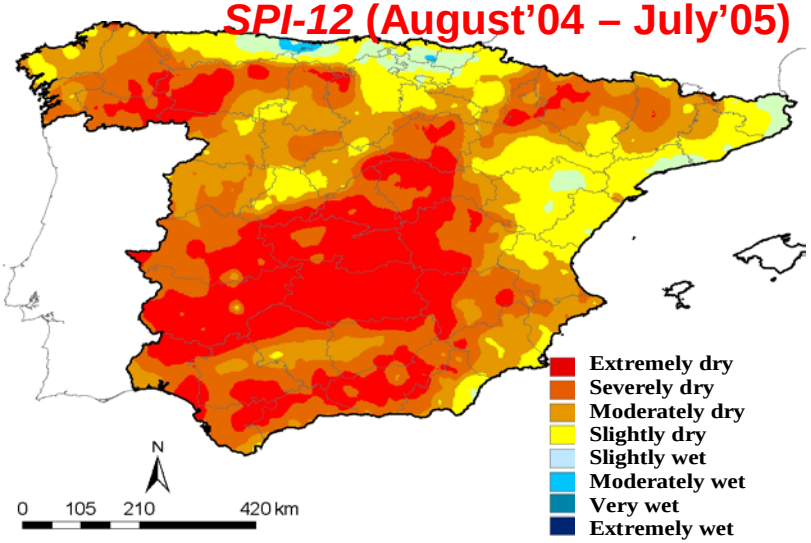


SPI



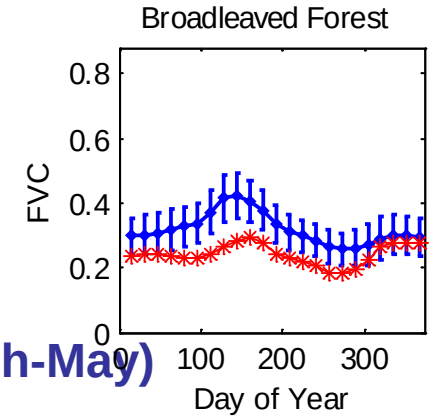
FEEDBACKS CLIMATE-VEGETATION

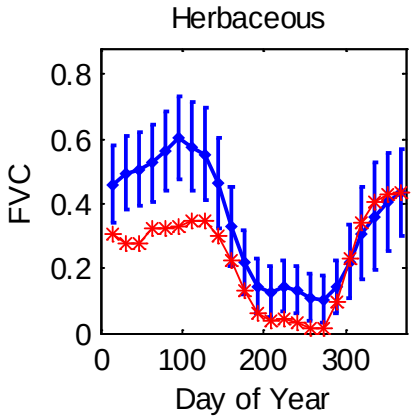
Impact of 2004-06 drought in Spain



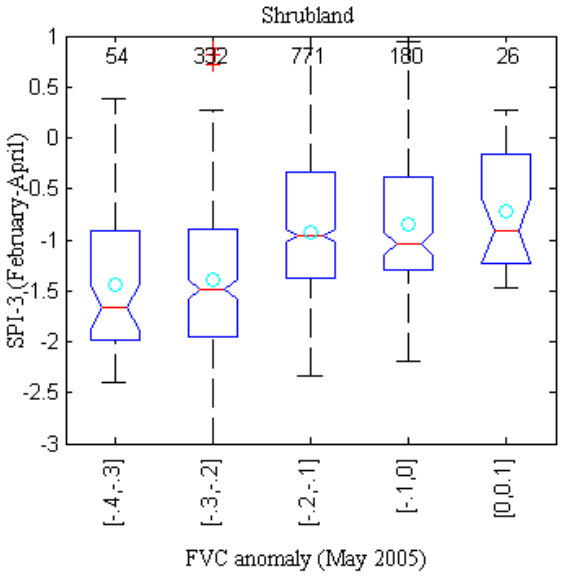
FVC shows large deviation for certains classes/periods in water-limited areas

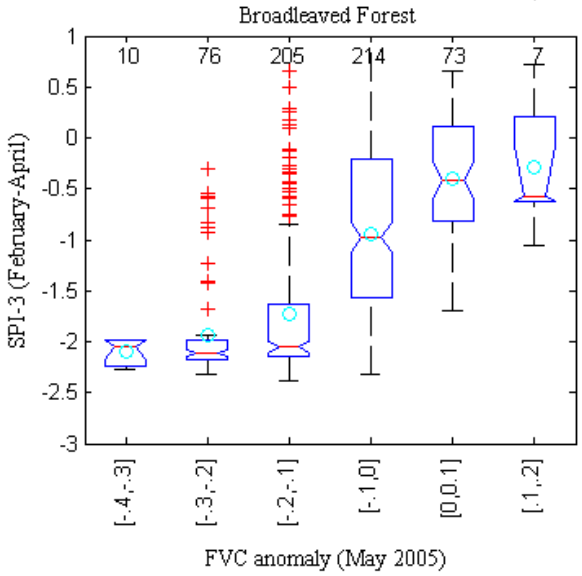
- Shrub, herbaceous and broadleaved are very sensitive to drought

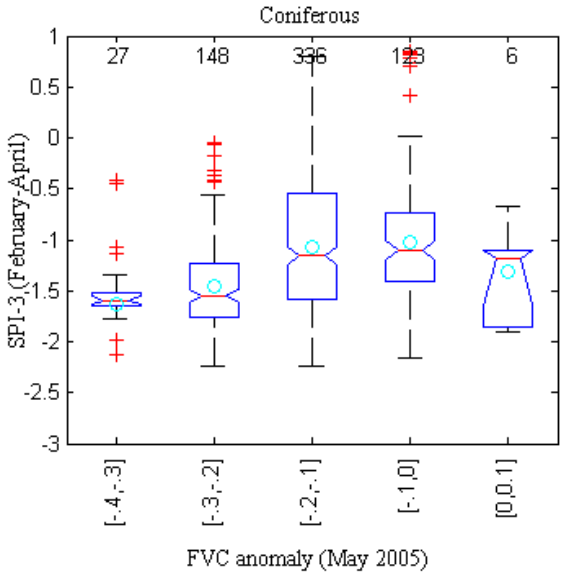




FVC anomaly (June'05) vs SPI-3 (March-May)

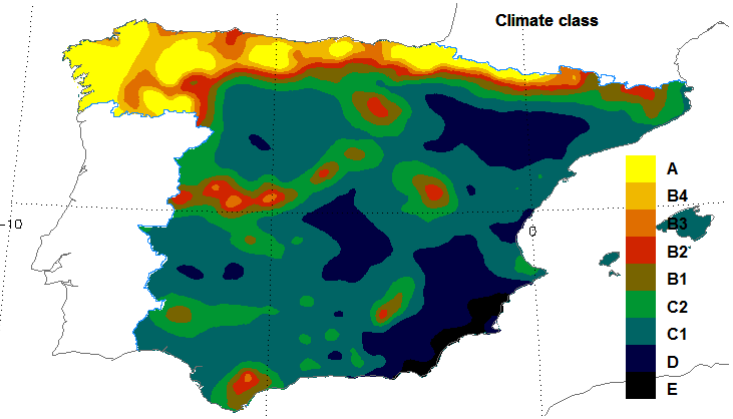




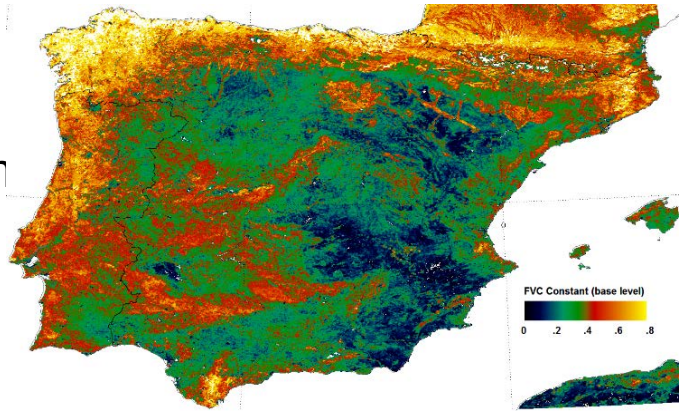


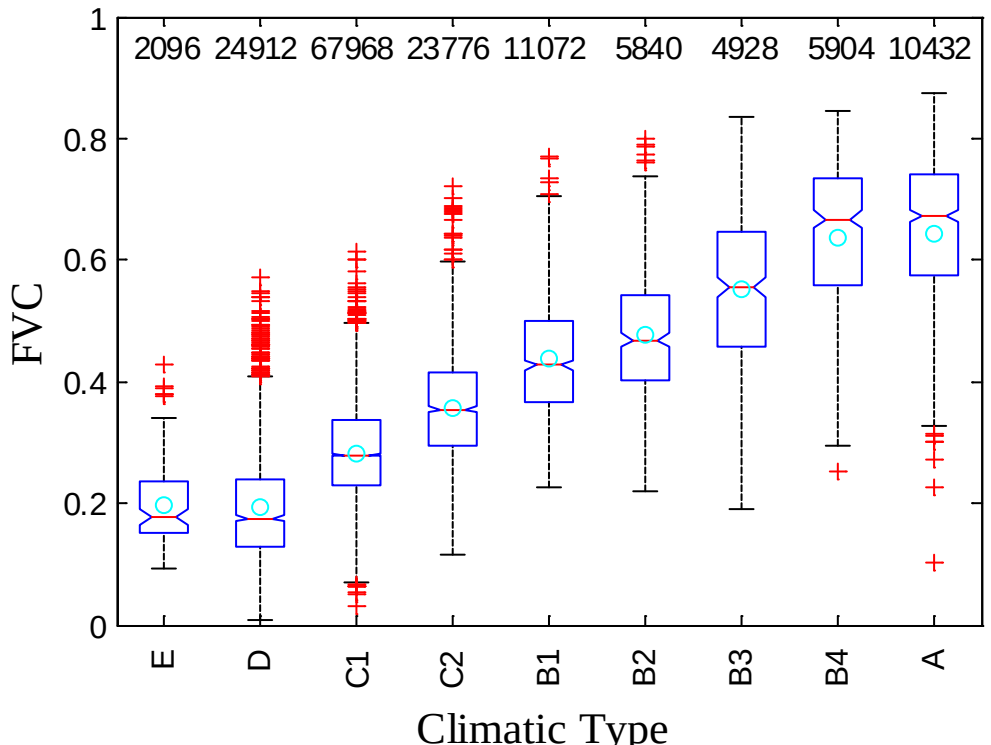
INTERRELATION CLIMATE-VEGETATION

Spatial distribution



relationships between water availability and vegetation coverage in Spain

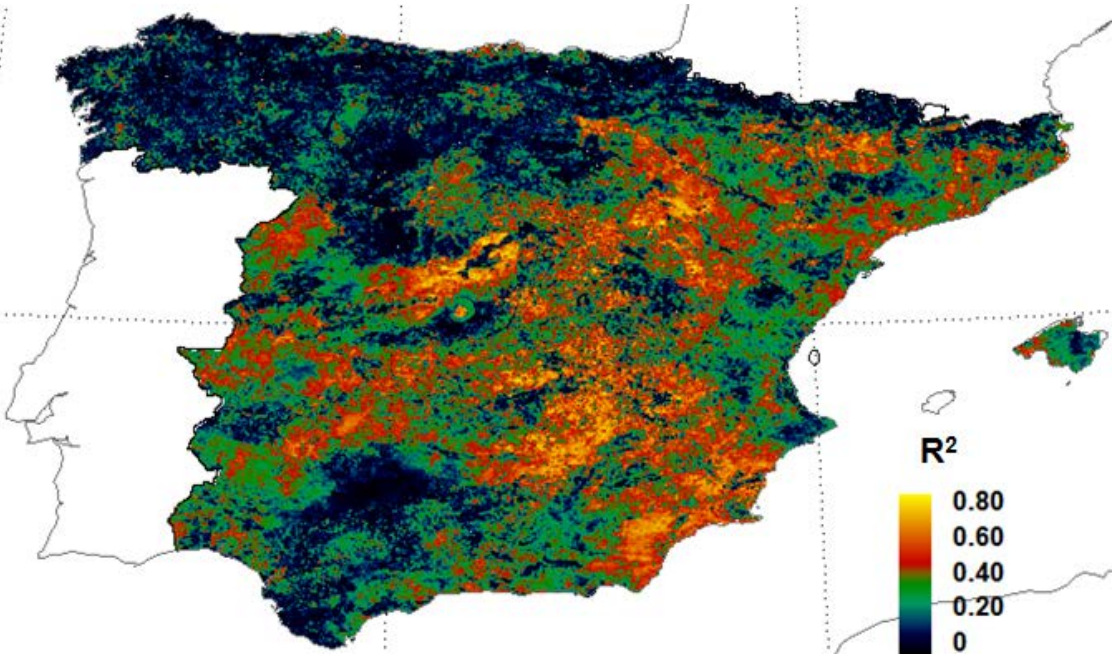


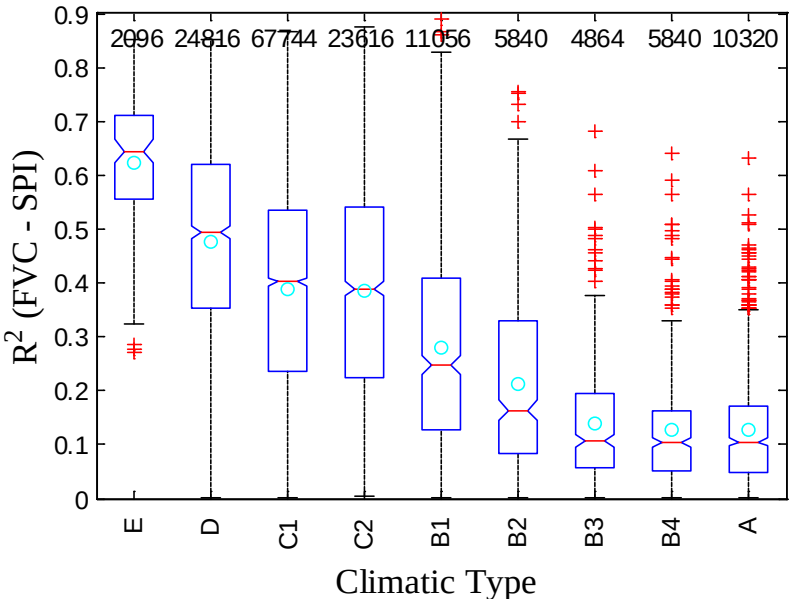


Climatic Type		Moisture Index
A	Very humid	≥ 100
B_4	Humid	80 to100
B_3	Humid	60 to 80
B_2	Humid	40 to 60
B_1	Humid	20 to 40
C_2	Moist subhumid	0 to 20
C_1	Dry subhumid	-20 to 0
D	Semiarid	-40 to -20
E	Arid	-60 to -40

FEEDBACKS CLIMATE-VEGETATION

Vulnerability of natural ecosystems





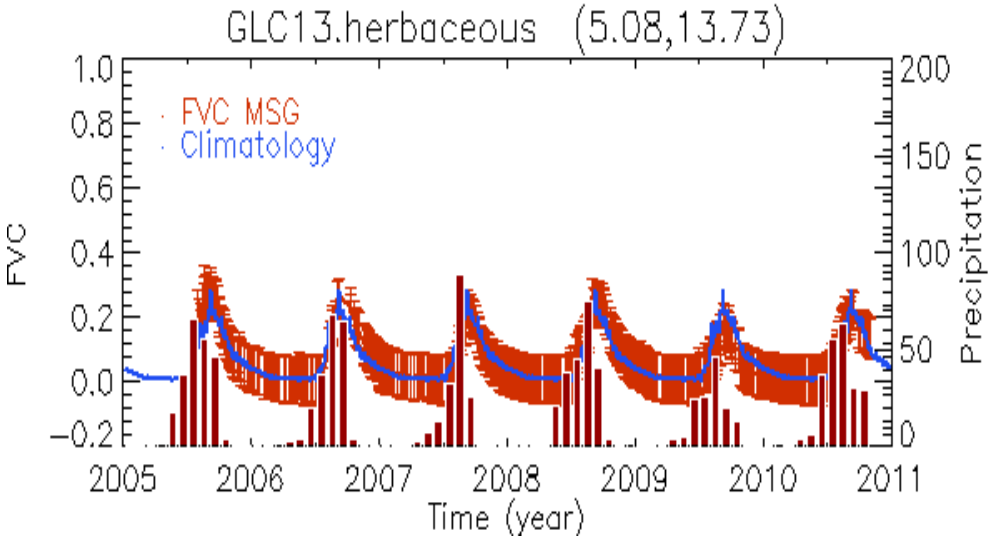
R^2 of Dummy-Variable Model between SPI (1 month lagged) and FVC anomaly during April-August

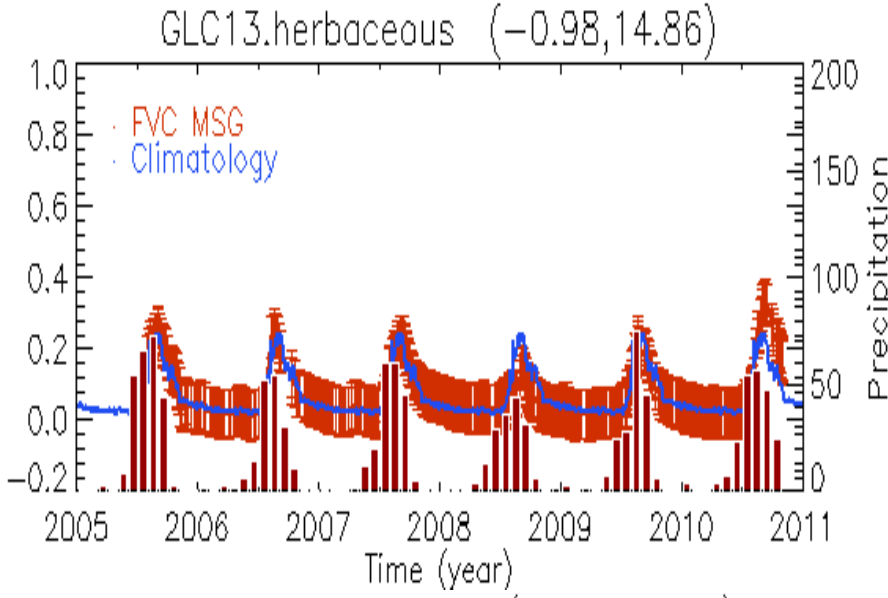
- Strong relationships during March-June in dry regions
  - $\Rightarrow$ water stress limits vegetation growth

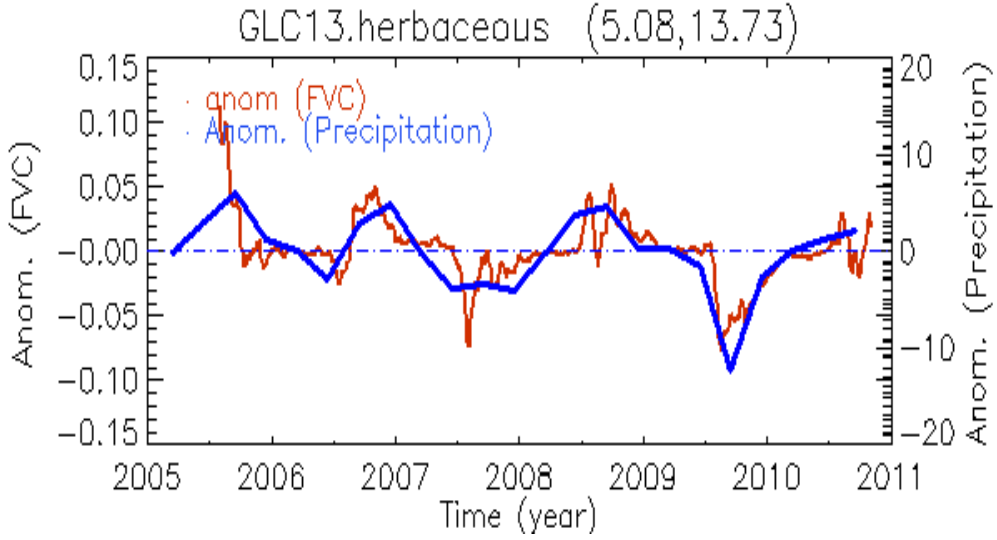
Vegetation response to climatic variability

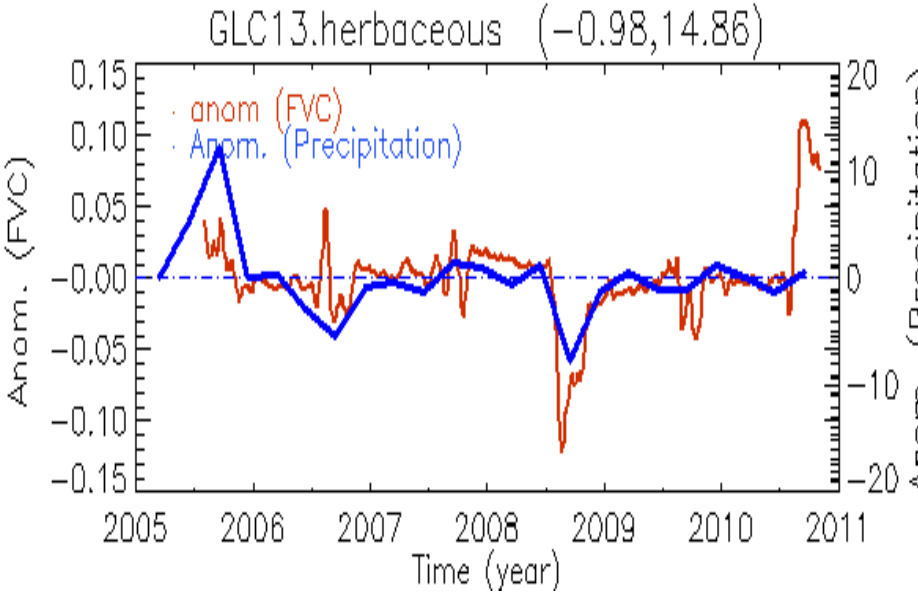
Potential applications

Sahelian semi-arid environments









Automated monitoring of vegetation disturbance

Modeling the dynamics of vegetation

- Season-trend parametric model:

Model → $Y_t = Trend_t + Stational_t$; Residual → $+ Random_t$

Example: Time series of SEVIRI FVC

$$FVC(t) = a_0 + a_1 t + \sum_{k=1}^{3} A_k \sin\left(kwt + \varphi_k\right)$$

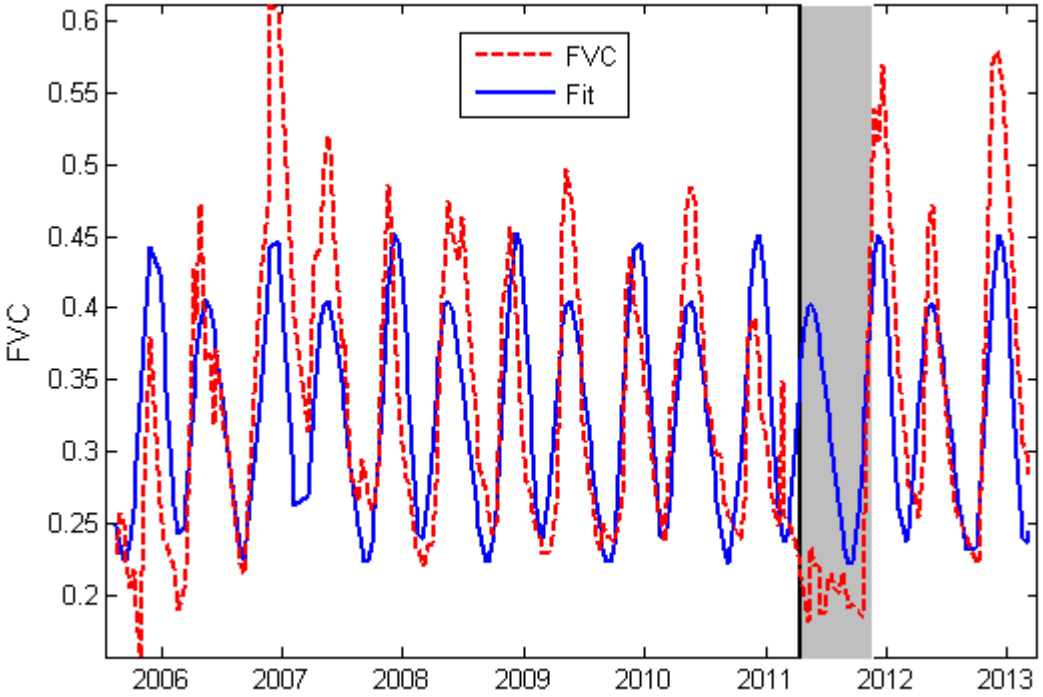
Example: Disturbance measure

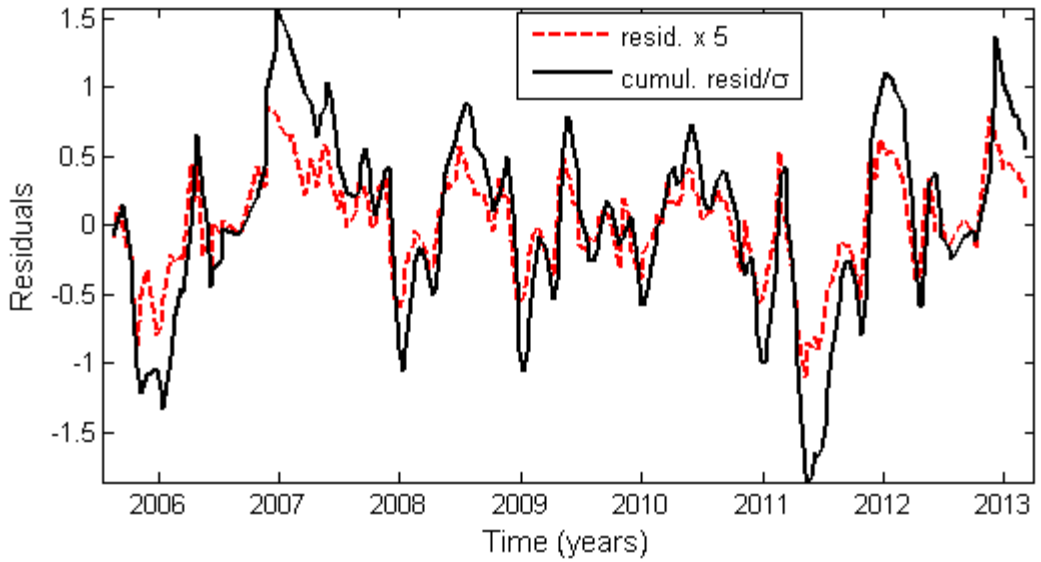
$$std\_resid(t) = \frac{\left\langle Y_t - \hat{Y} \right\rangle}{\sigma_y}$$

APPLICATIONS:

- Real time detection (drought, fire):
- Retrospectively monitoring of disturbances
  - Extent, severity, duration (start, period of recovery)

Automated monitoring of vegetation disturbance





Example: Drought in Somalia (2011)

- FVC/MSG time series
- Savanna, 2 growing seasons

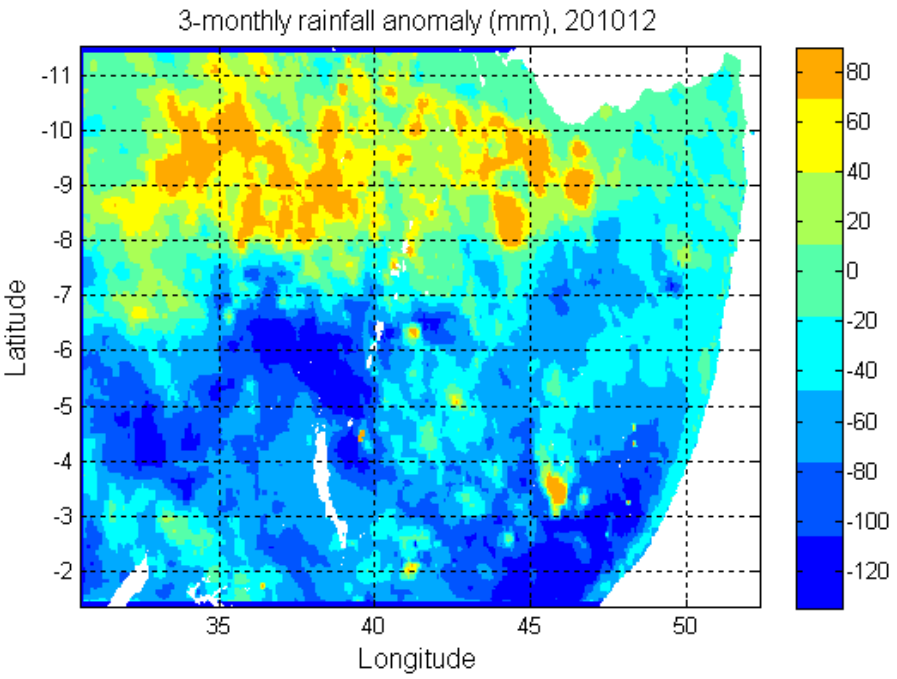
SEVIRI Capabilities (VEGA)

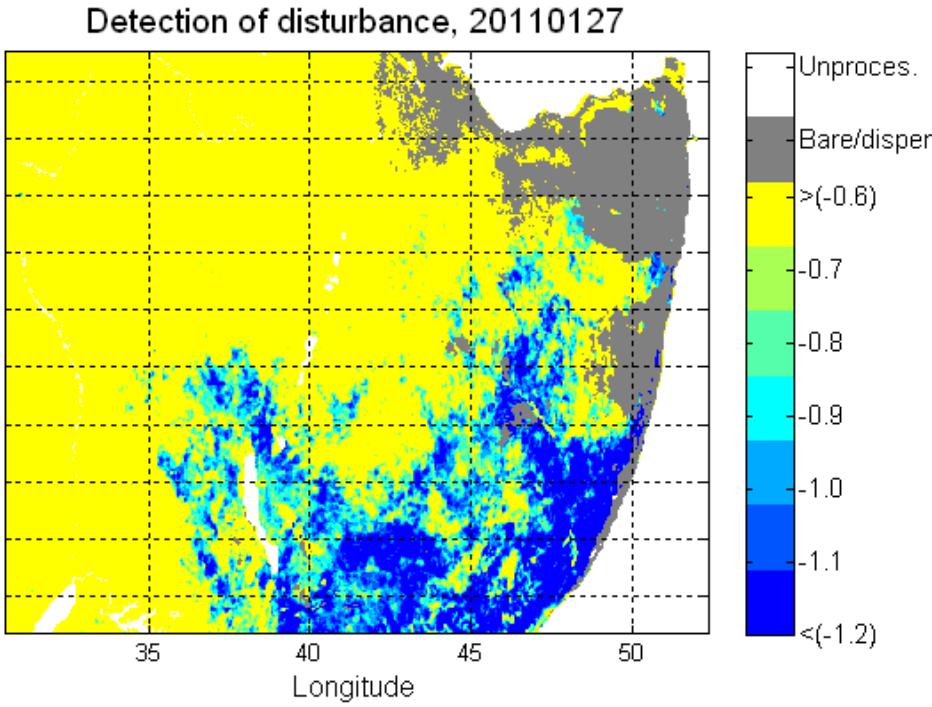
- High frequency and continuity
- Normal season-trend can be usually captured from a single year

⇒ VEGA is specially suited for very rapid detection (e.g. < 1 month)

Severe drought in Horn of Africa (2011):

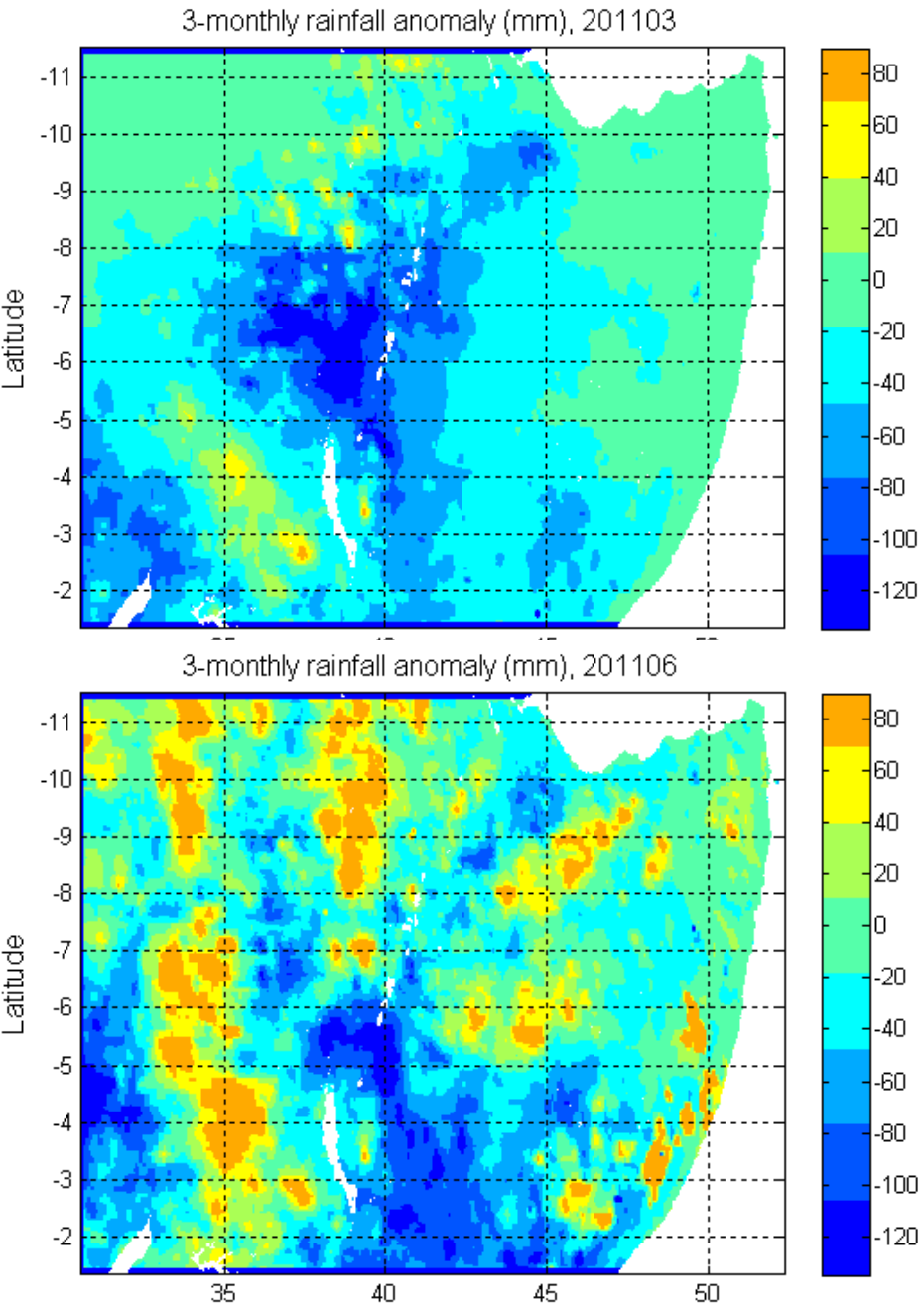
- Shortage of rain in the two rainy seasons (autumn and spring)

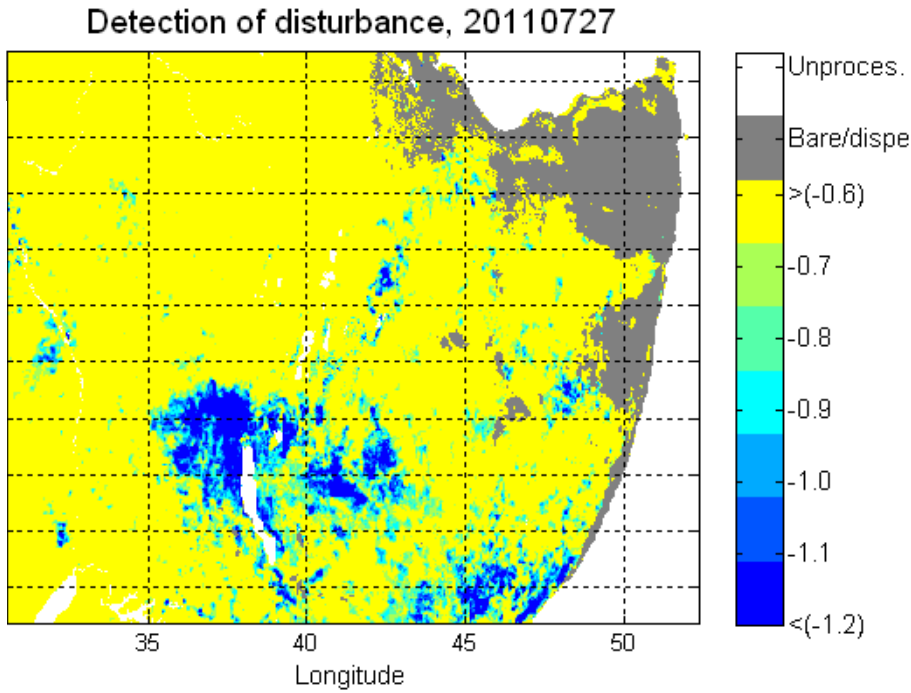




Drought monitoring

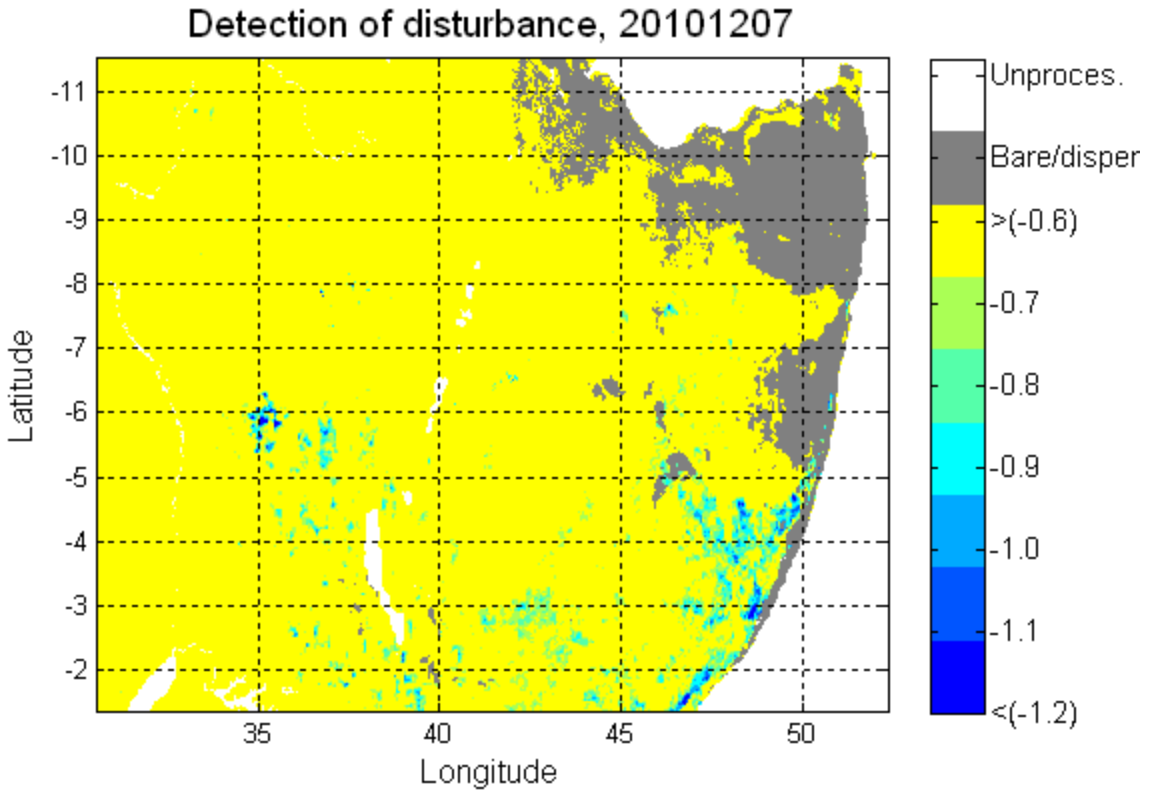
Horn of Africa (2011)





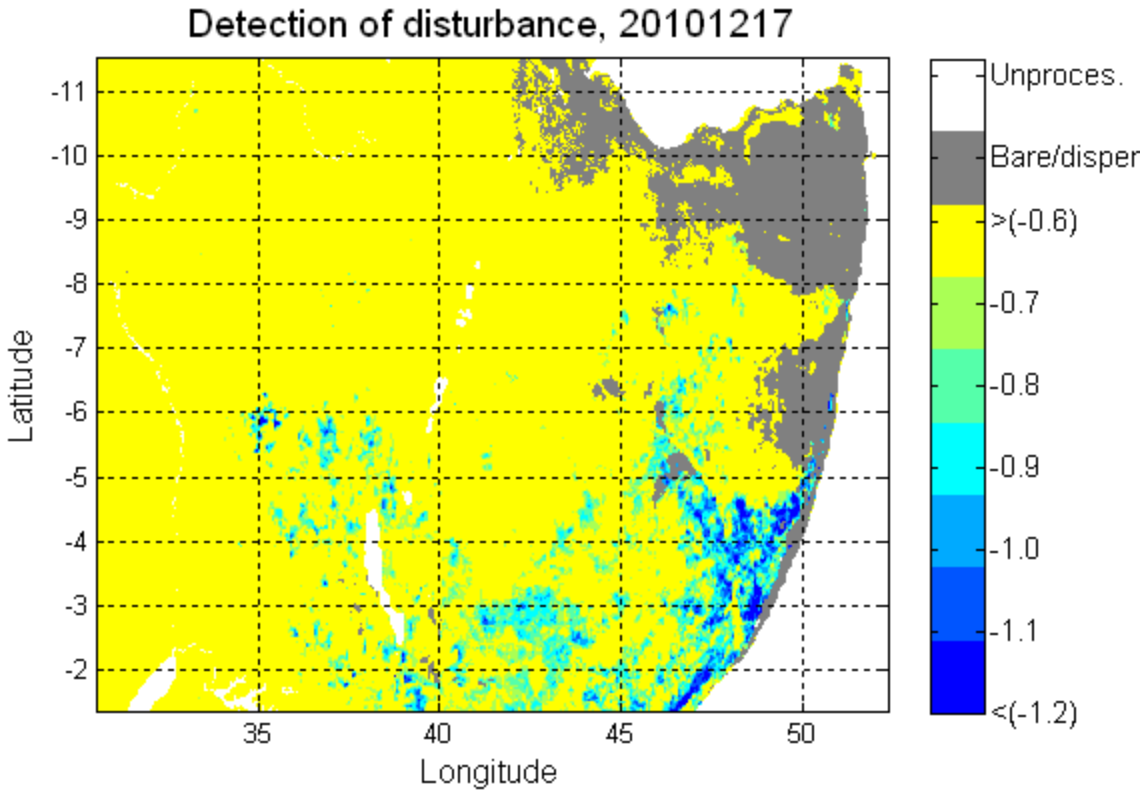
Drought monitoring

Horn of Africa (2011)



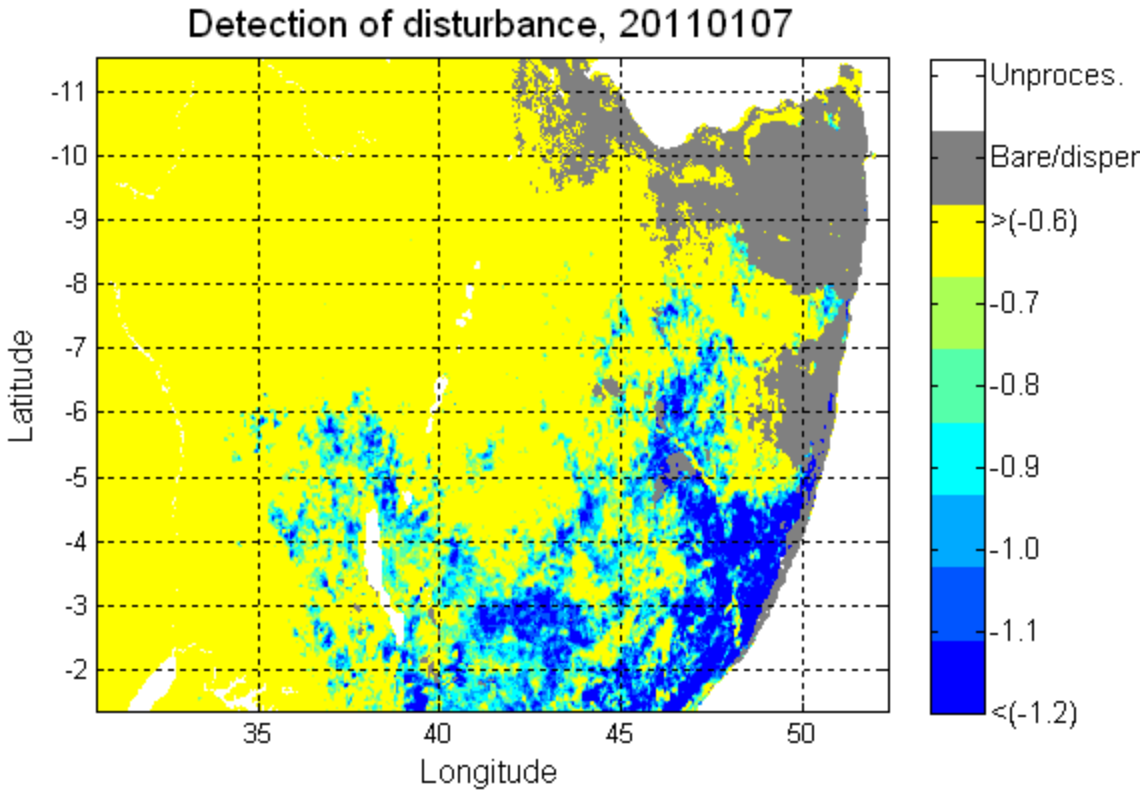
Drought monitoring

Horn of Africa (2011)



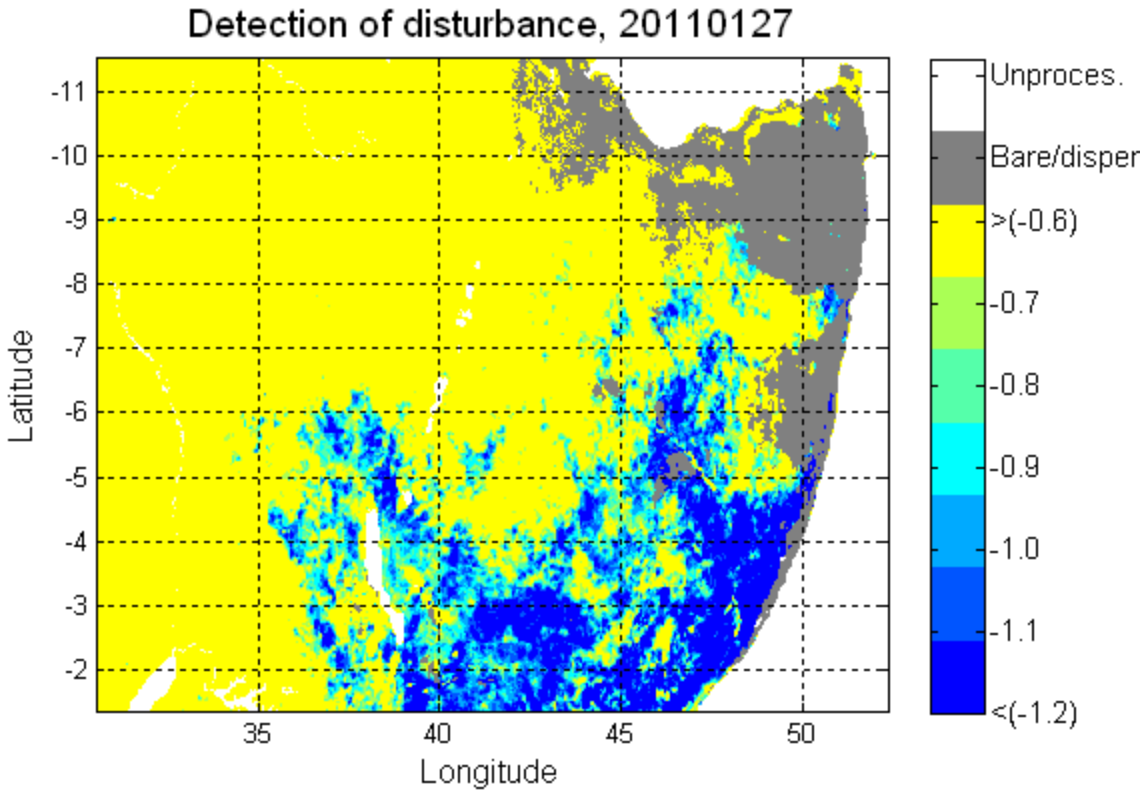
Drought monitoring

Horn of Africa (2011)



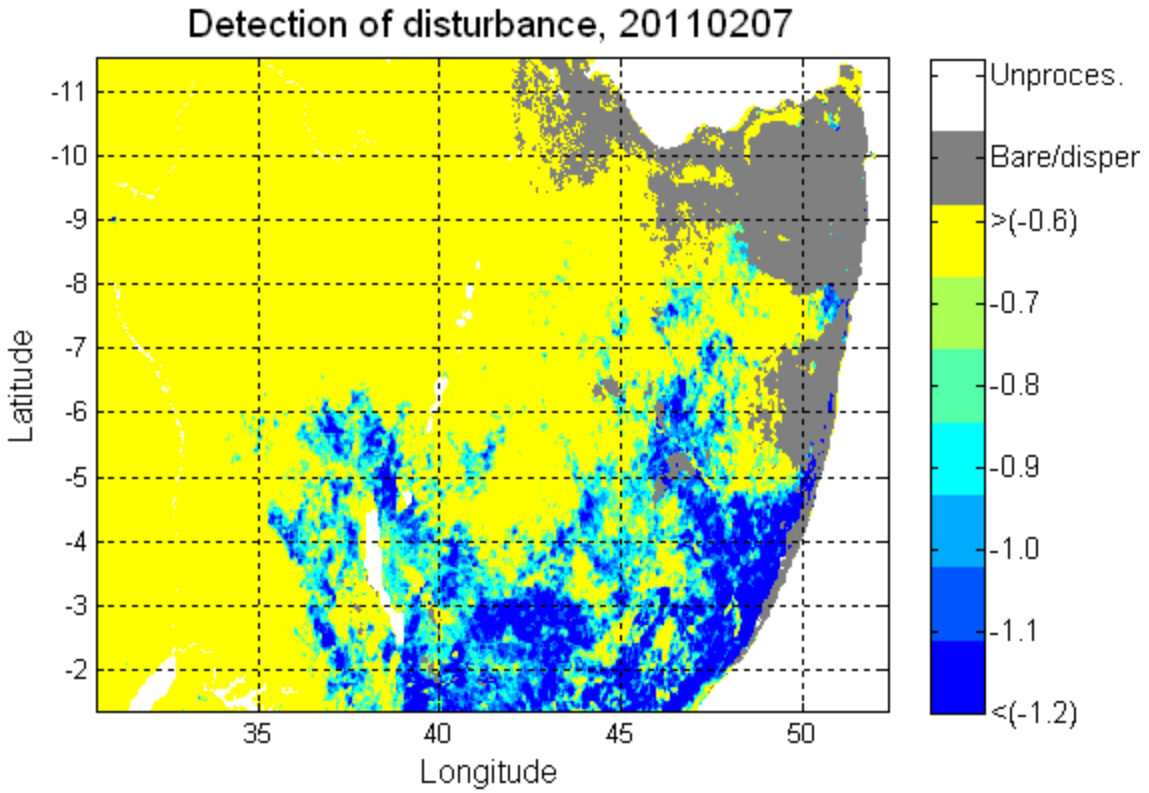
Drought monitoring

Horn of Africa (2011)



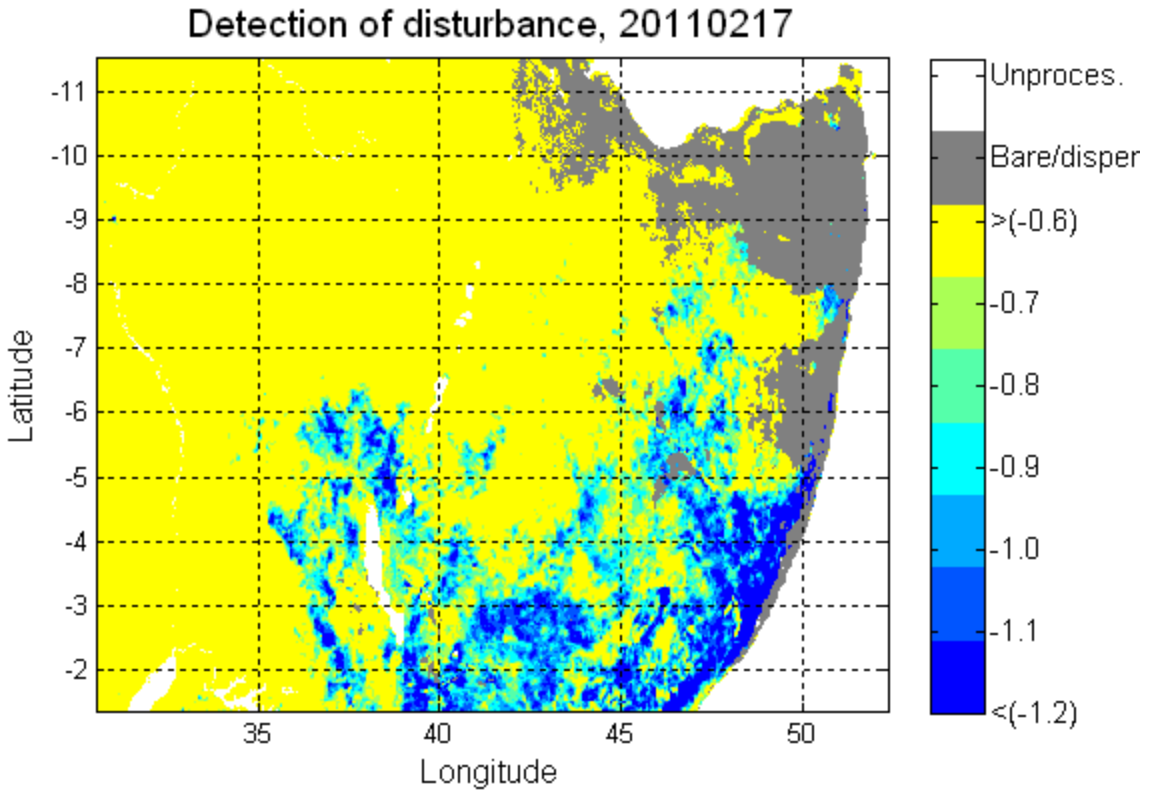
Drought monitoring

Horn of Africa (2011)



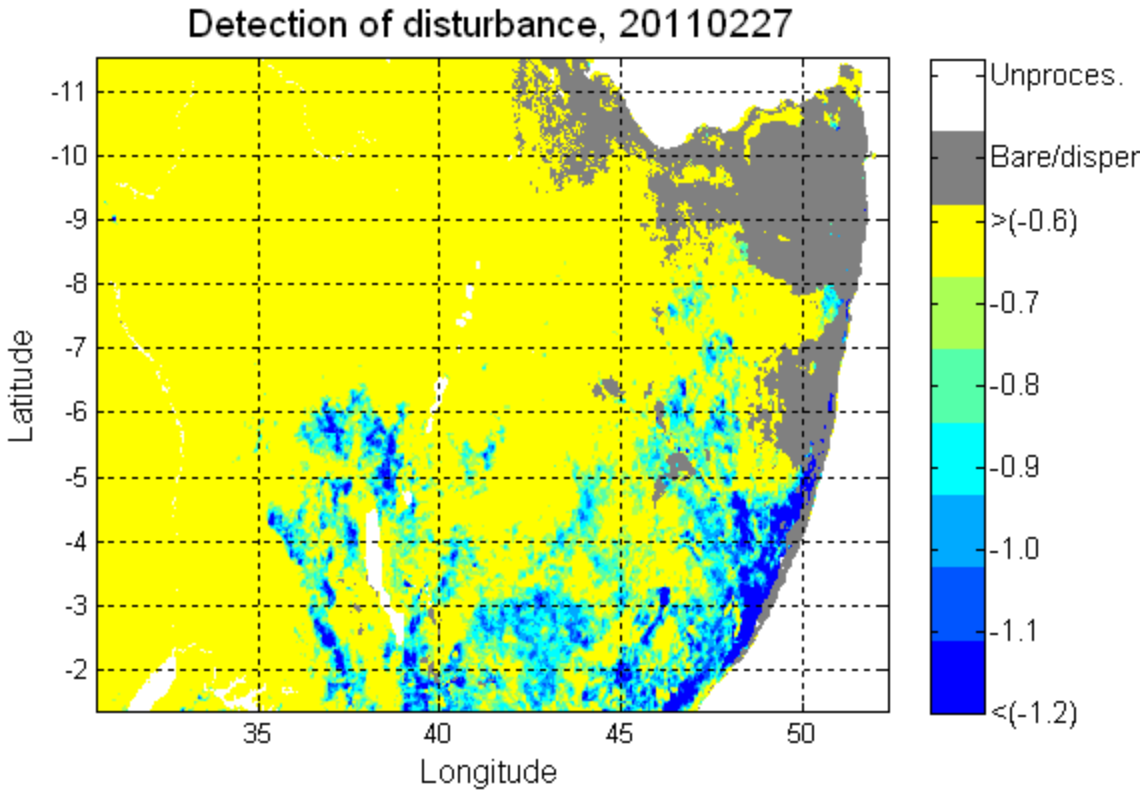
Drought monitoring

Horn of Africa (2011)



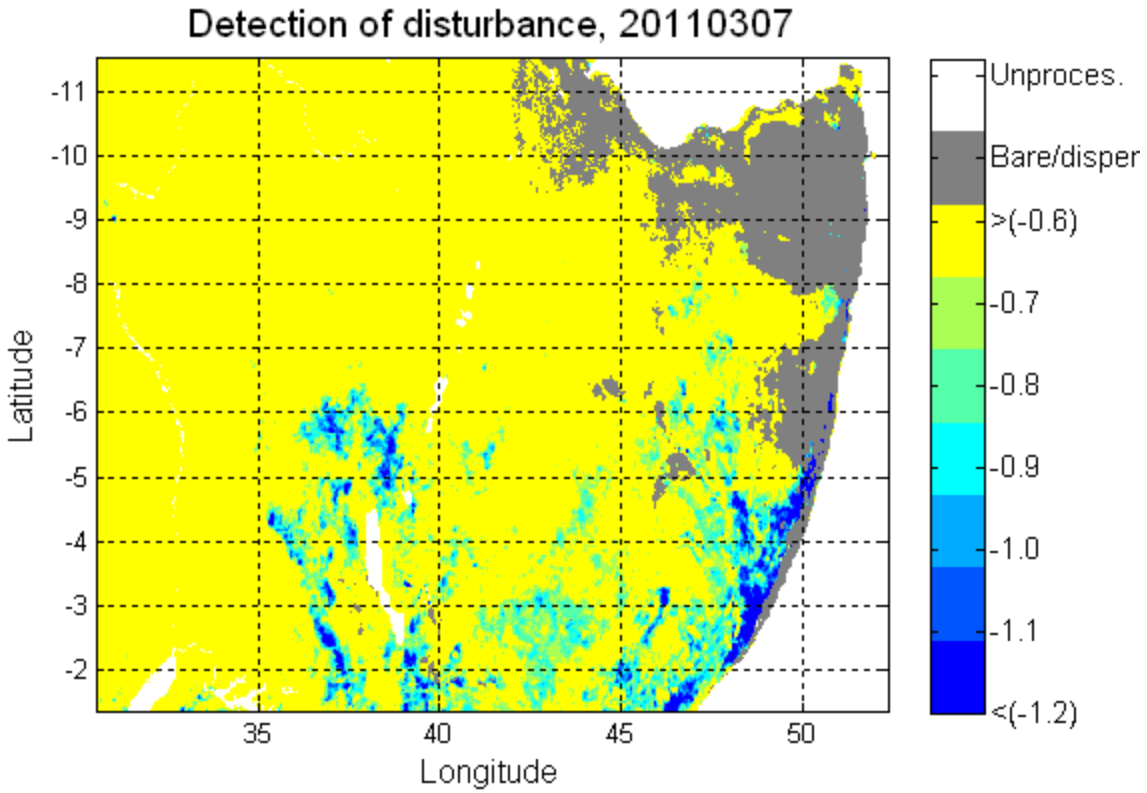
Drought monitoring

Horn of Africa (2011)



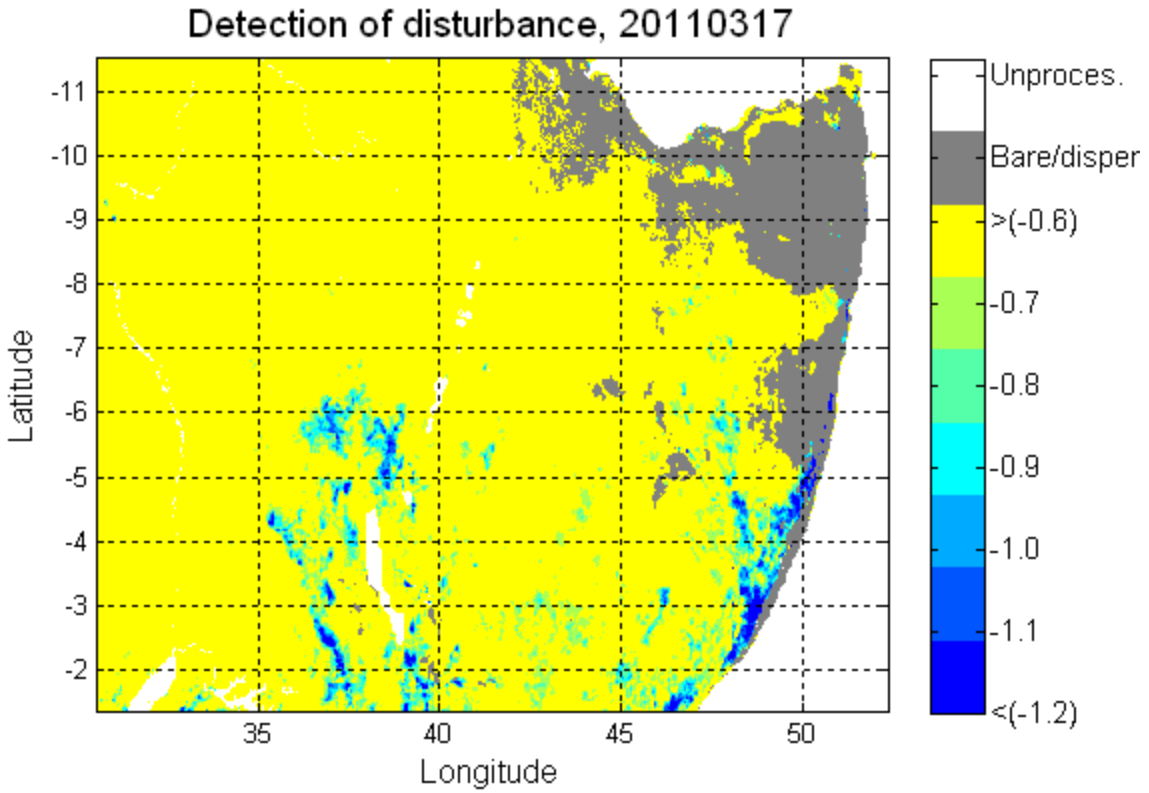
Drought monitoring

Horn of Africa (2011)



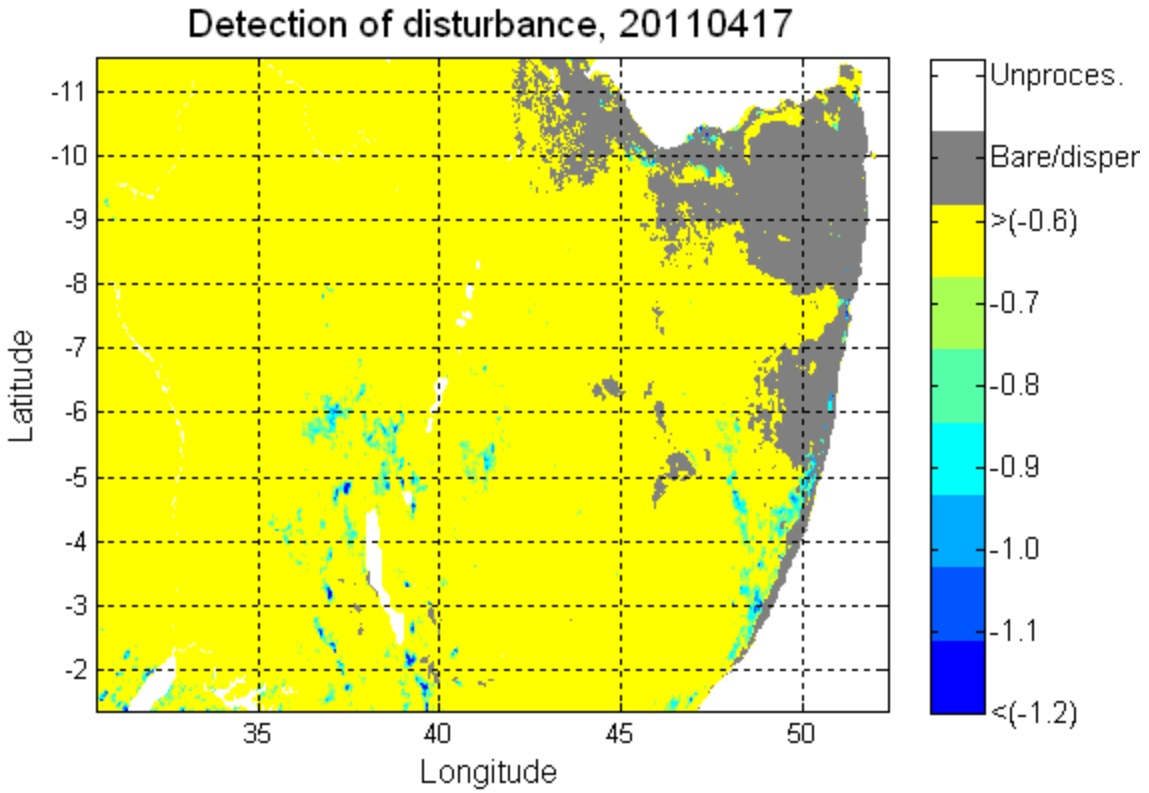
Drought monitoring

Horn of Africa (2011)



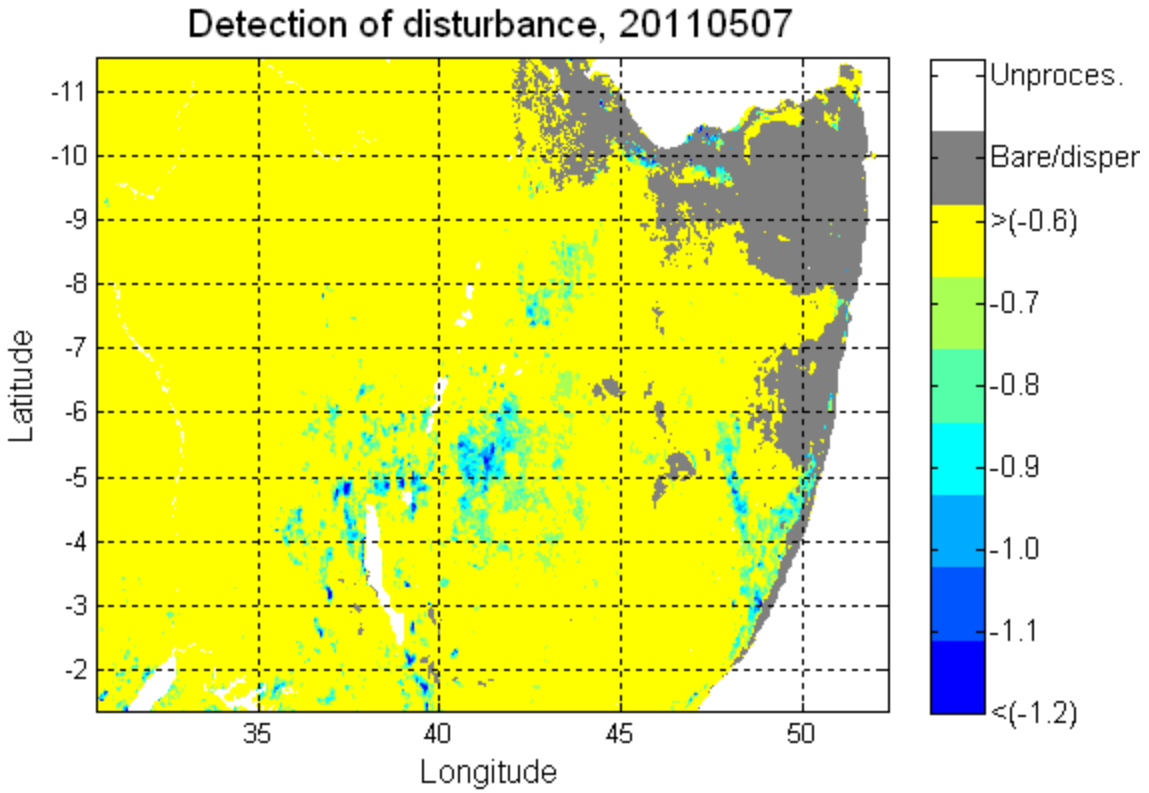
Drought monitoring

Horn of Africa (2011)



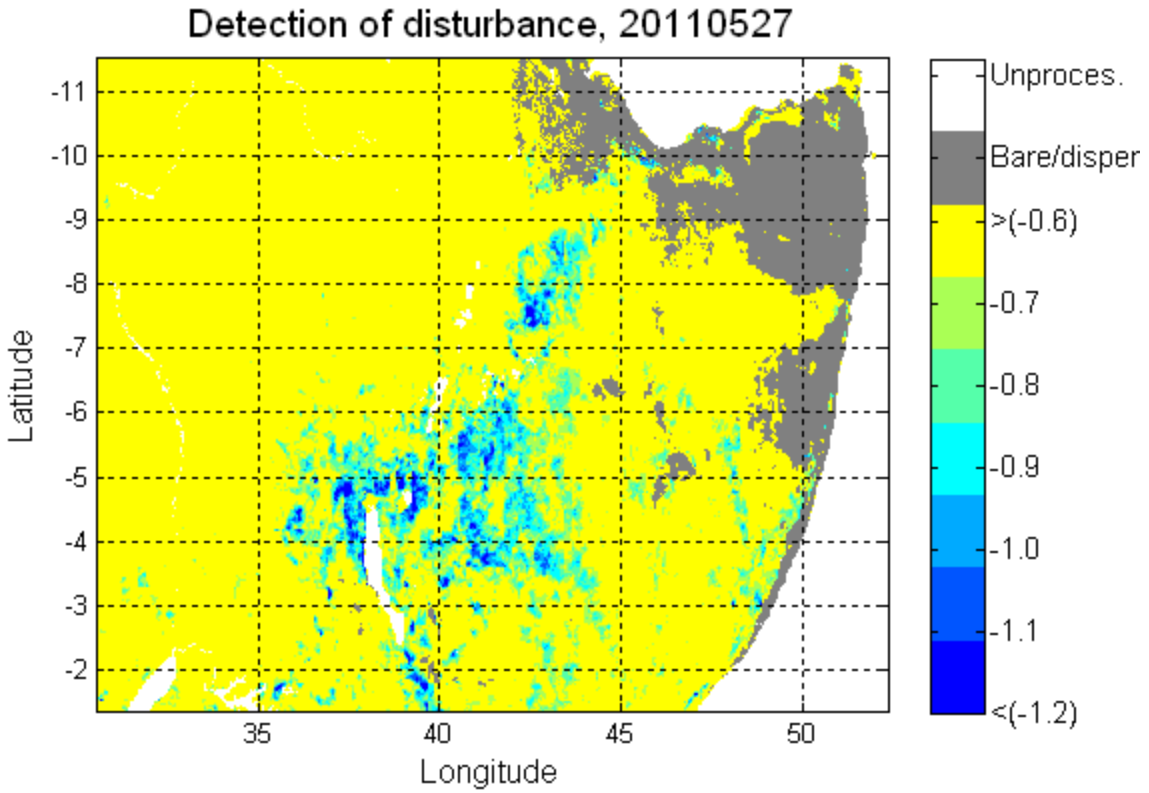
Drought monitoring

Horn of Africa (2011)



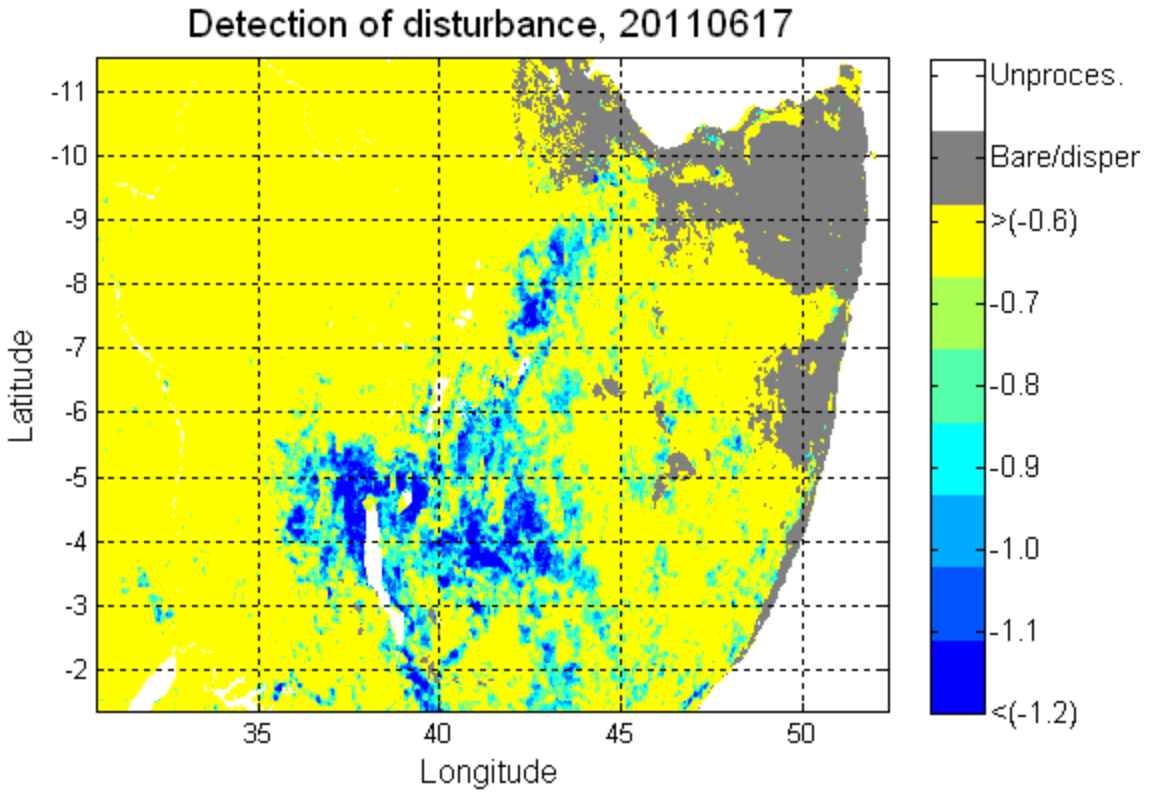
Drought monitoring

Horn of Africa (2011)



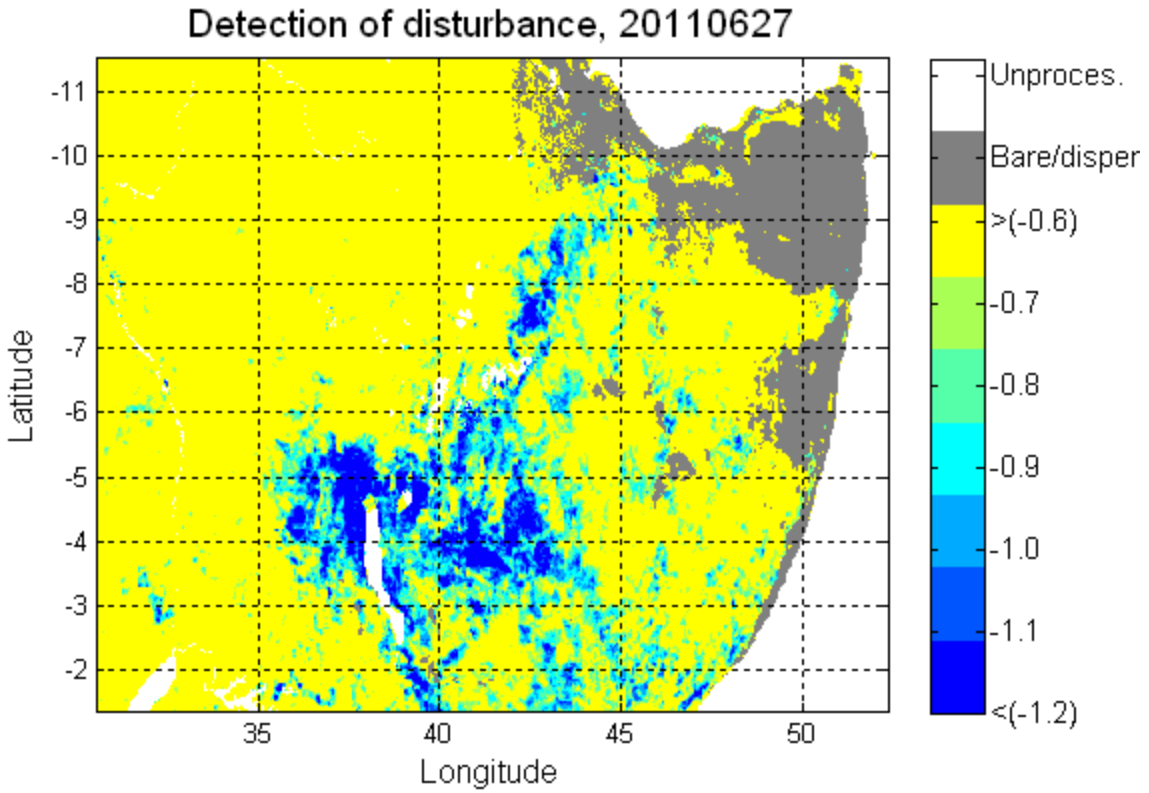
Drought monitoring

Horn of Africa (2011)



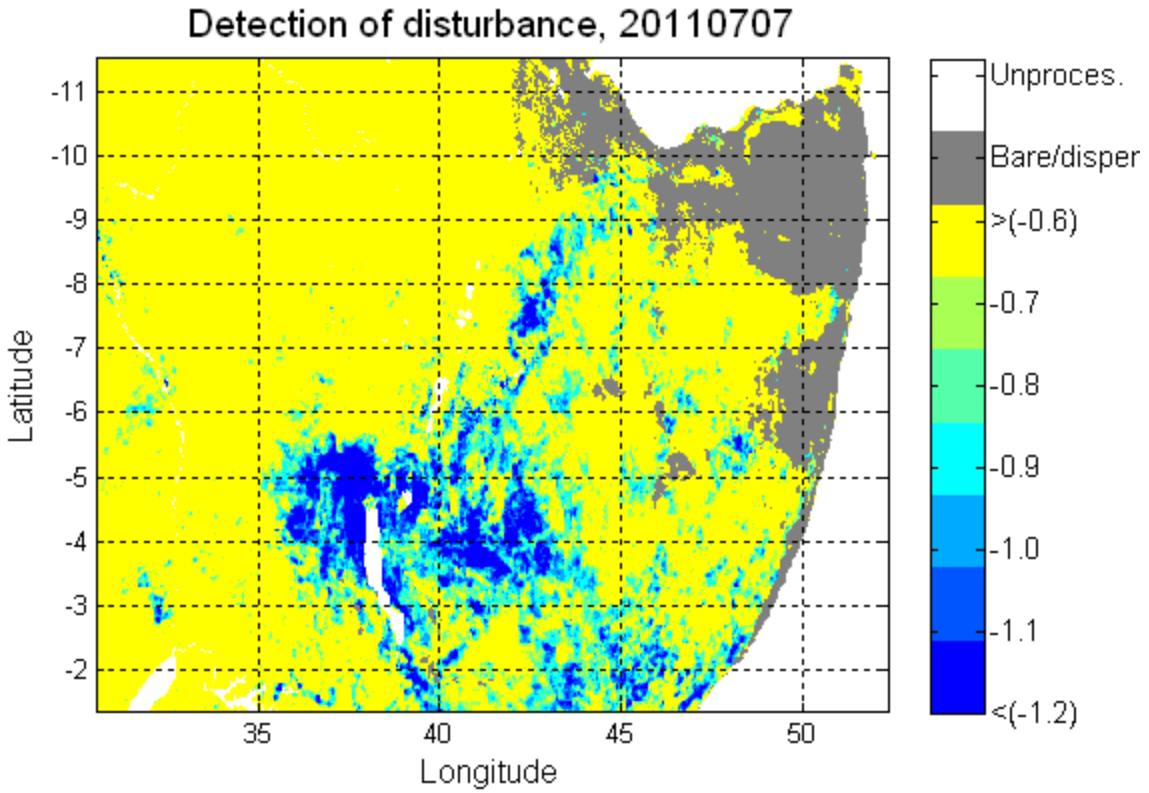
Drought monitoring

Horn of Africa (2011)



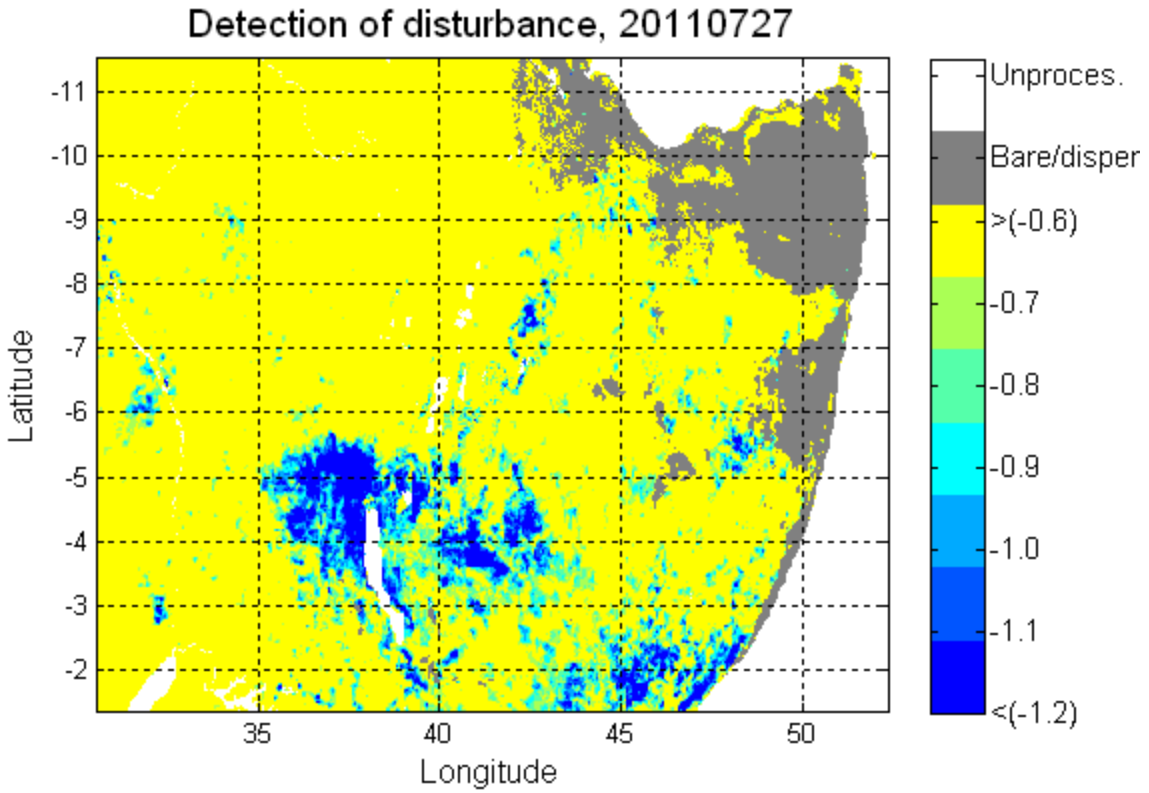
Drought monitoring

Horn of Africa (2011)



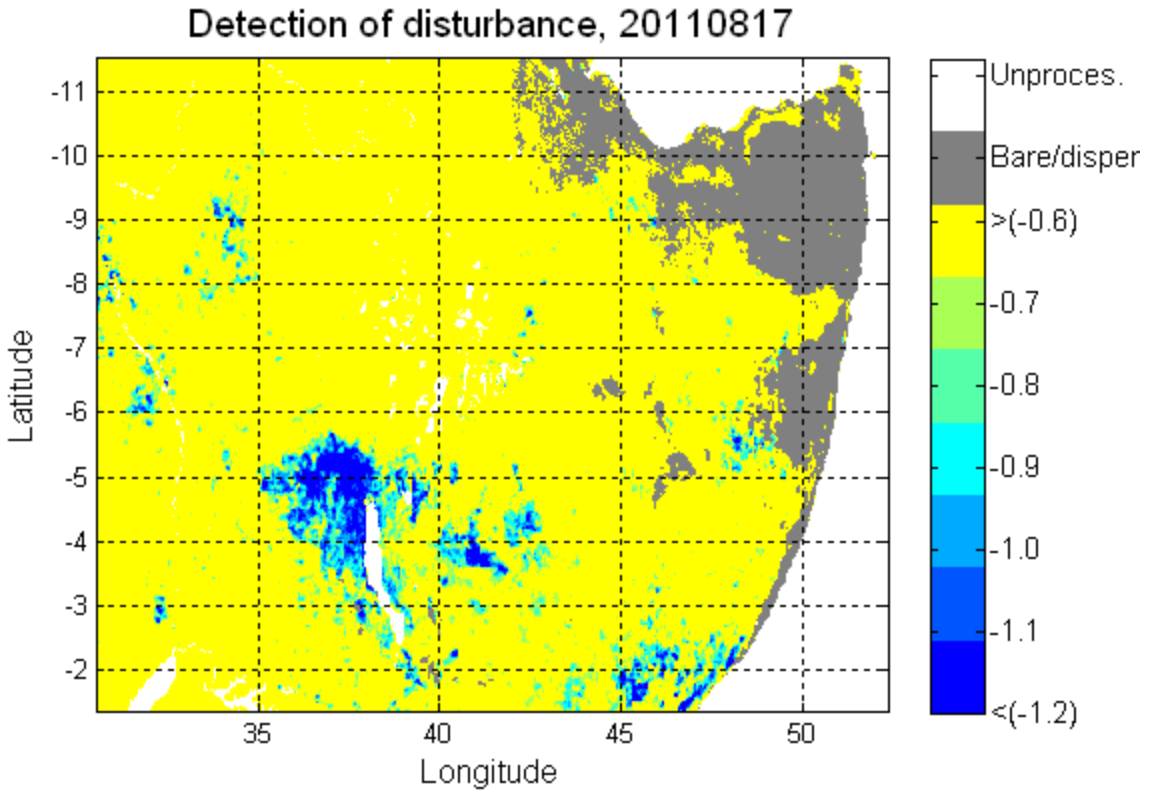
Drought monitoring

Horn of Africa (2011)



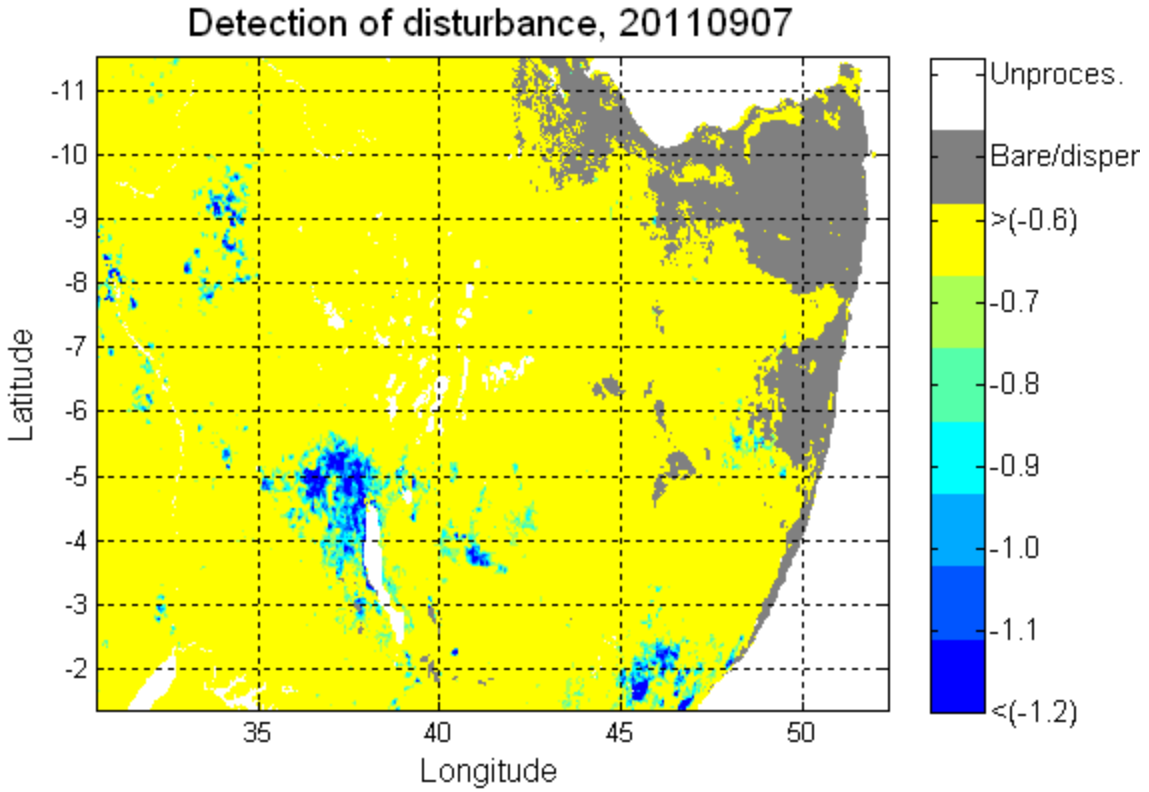
Drought monitoring

Horn of Africa (2011)



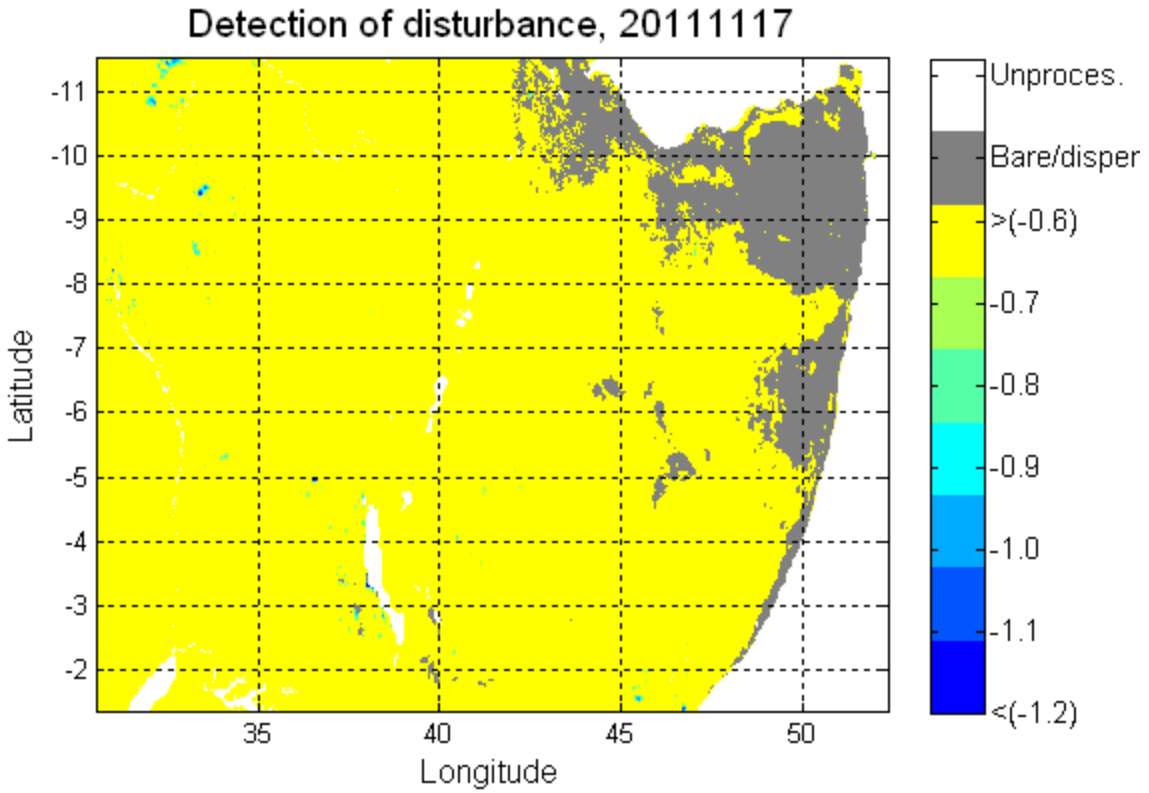
Drought monitoring

Horn of Africa (2011)

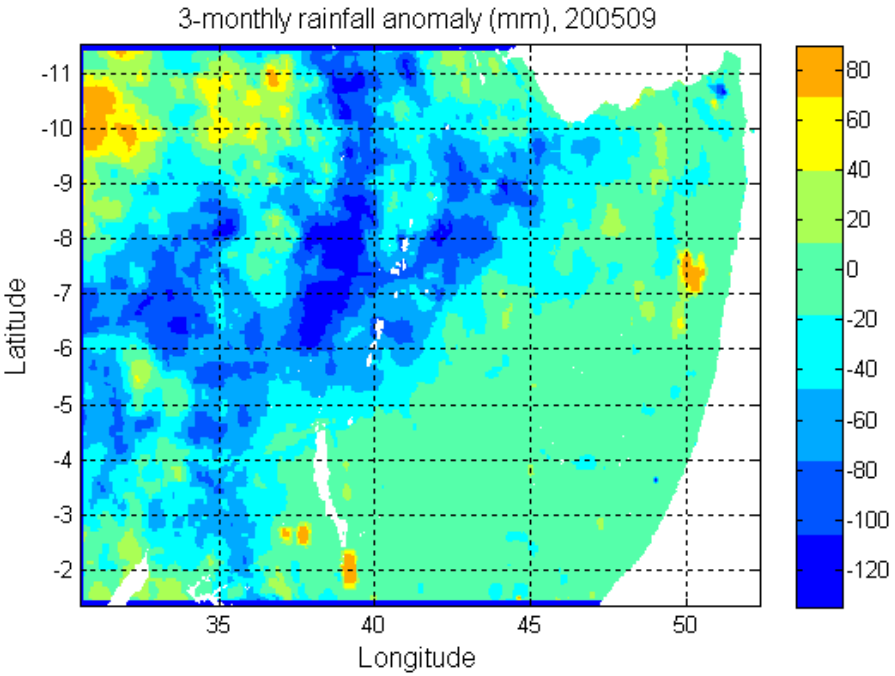


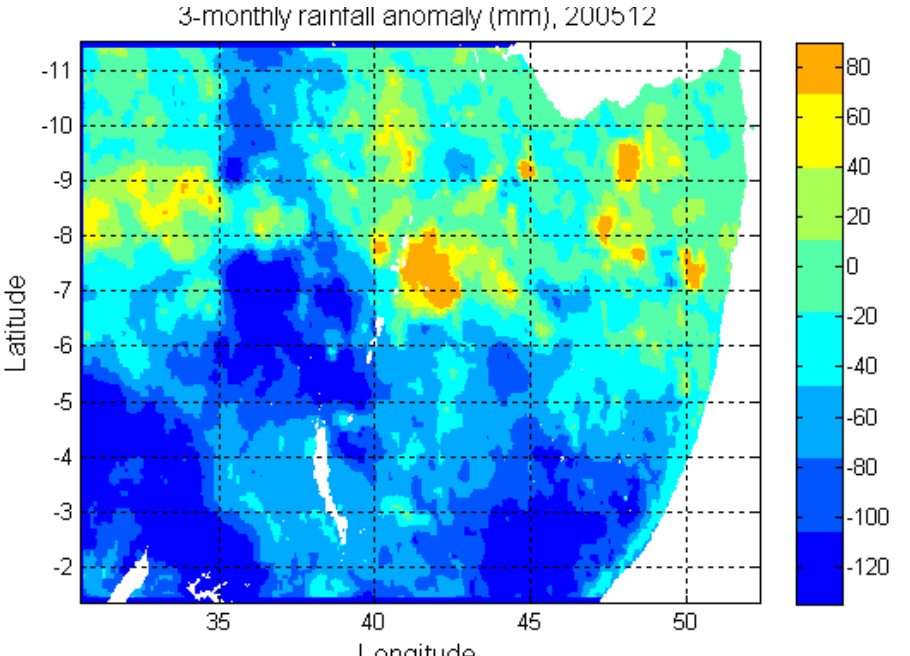
Drought monitoring

Horn of Africa (2011)



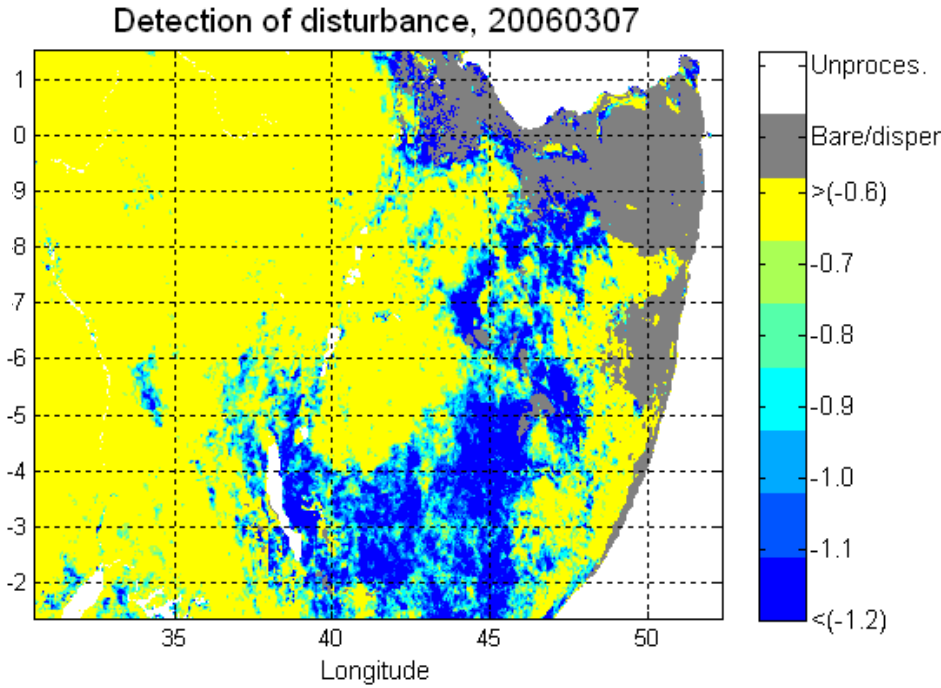
Drought monitoring





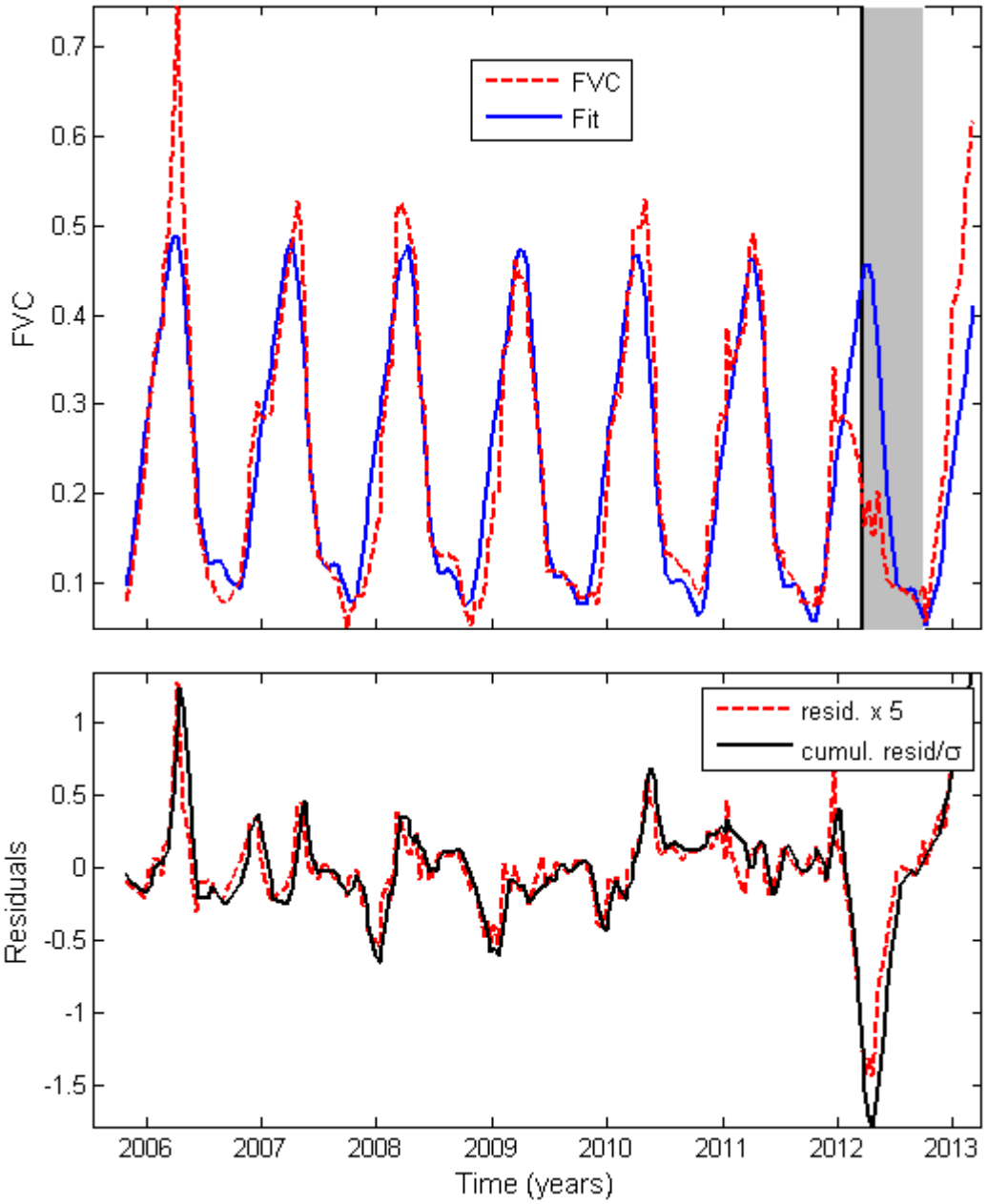
A similar example

- Drought in 2006



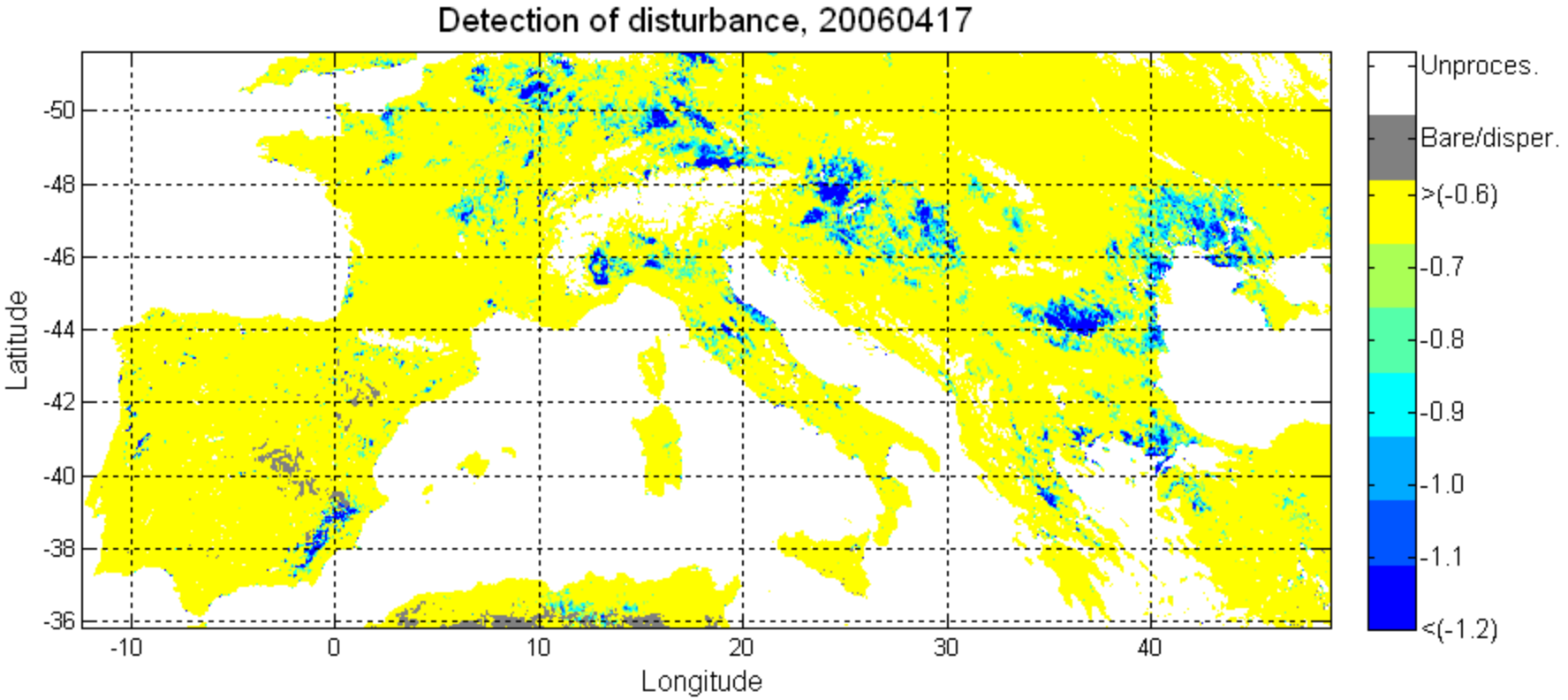
Drought monitoring

Southern Europe



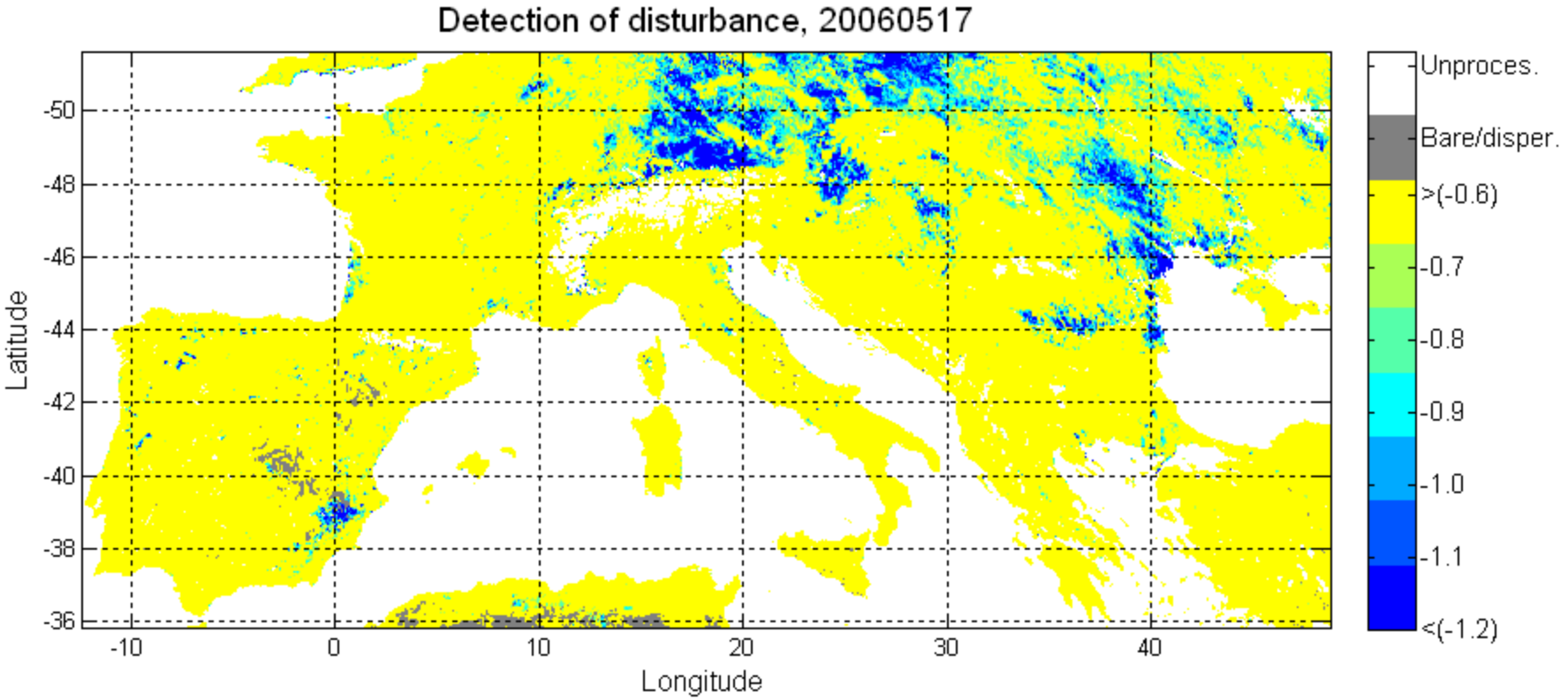
Drought monitoring

Southern Europe



Drought monitoring

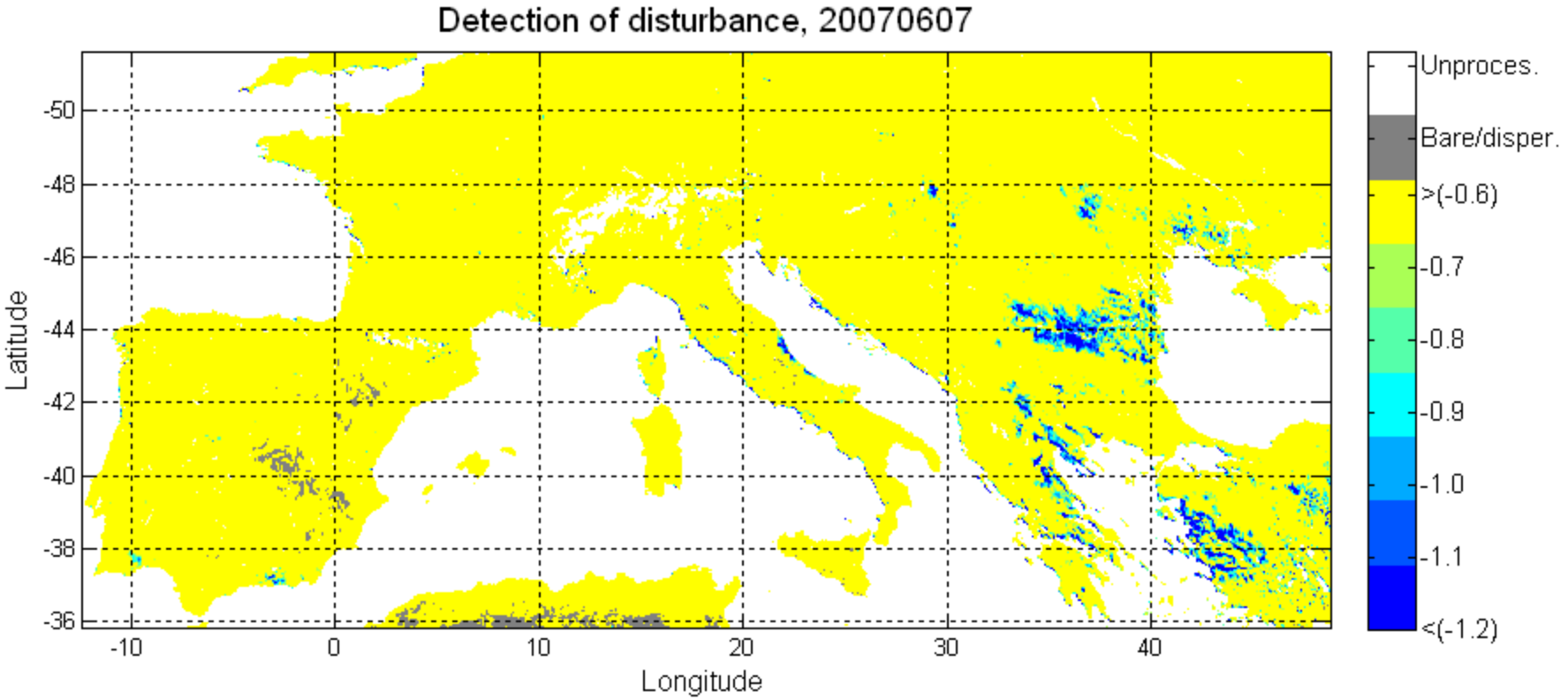
Southern Europe



Central Europe (May, 2006)

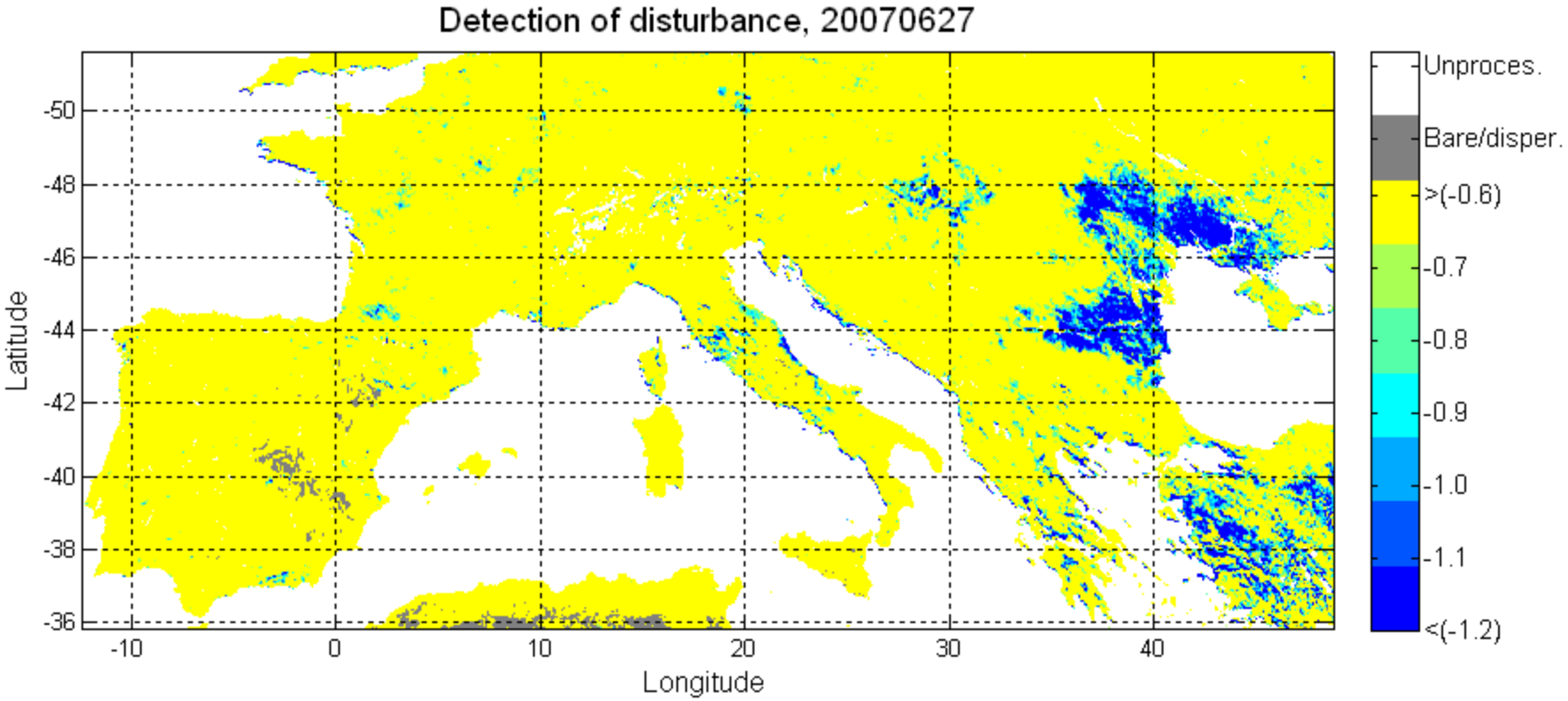
Drought monitoring

Southern Europe



Drought monitoring

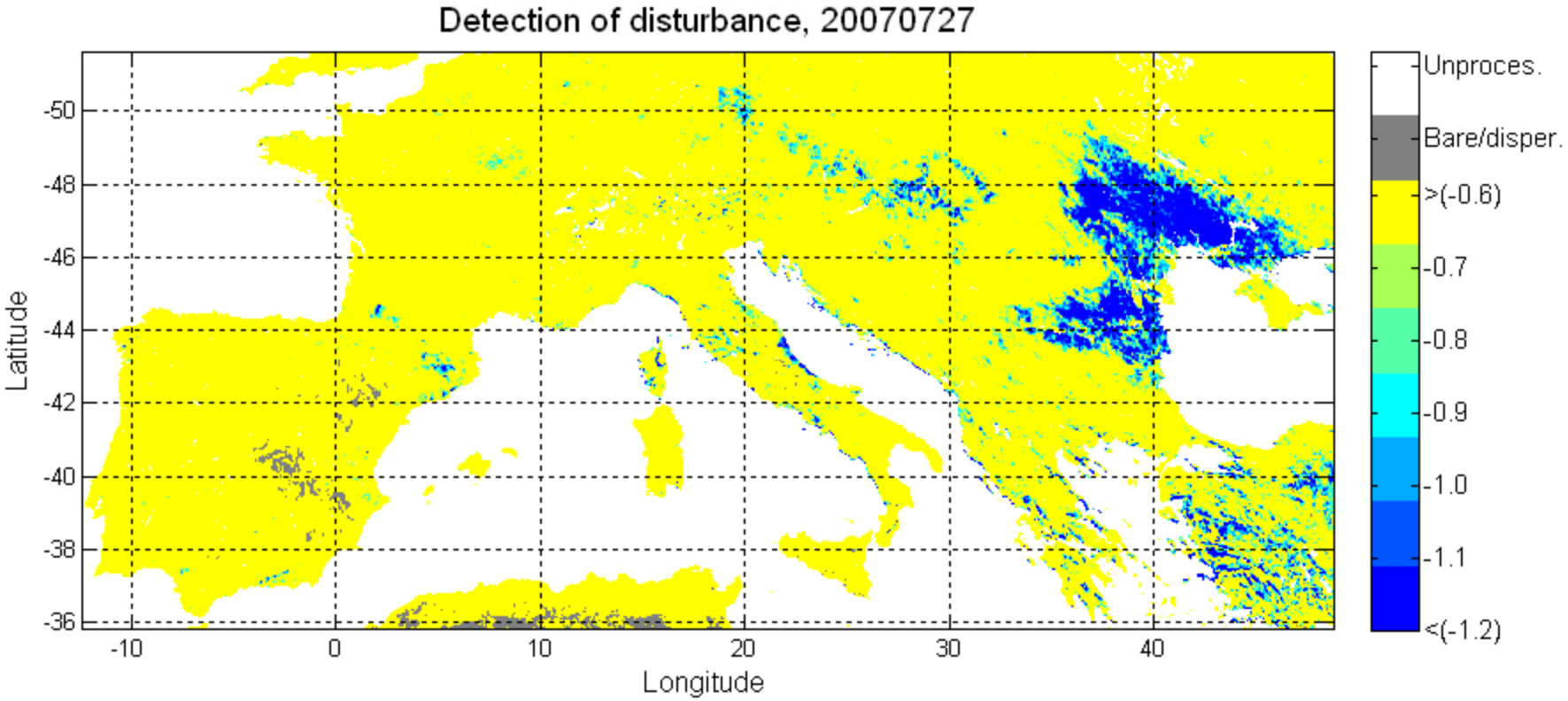
Southern Europe



Eastern Europe (summer, 2007)

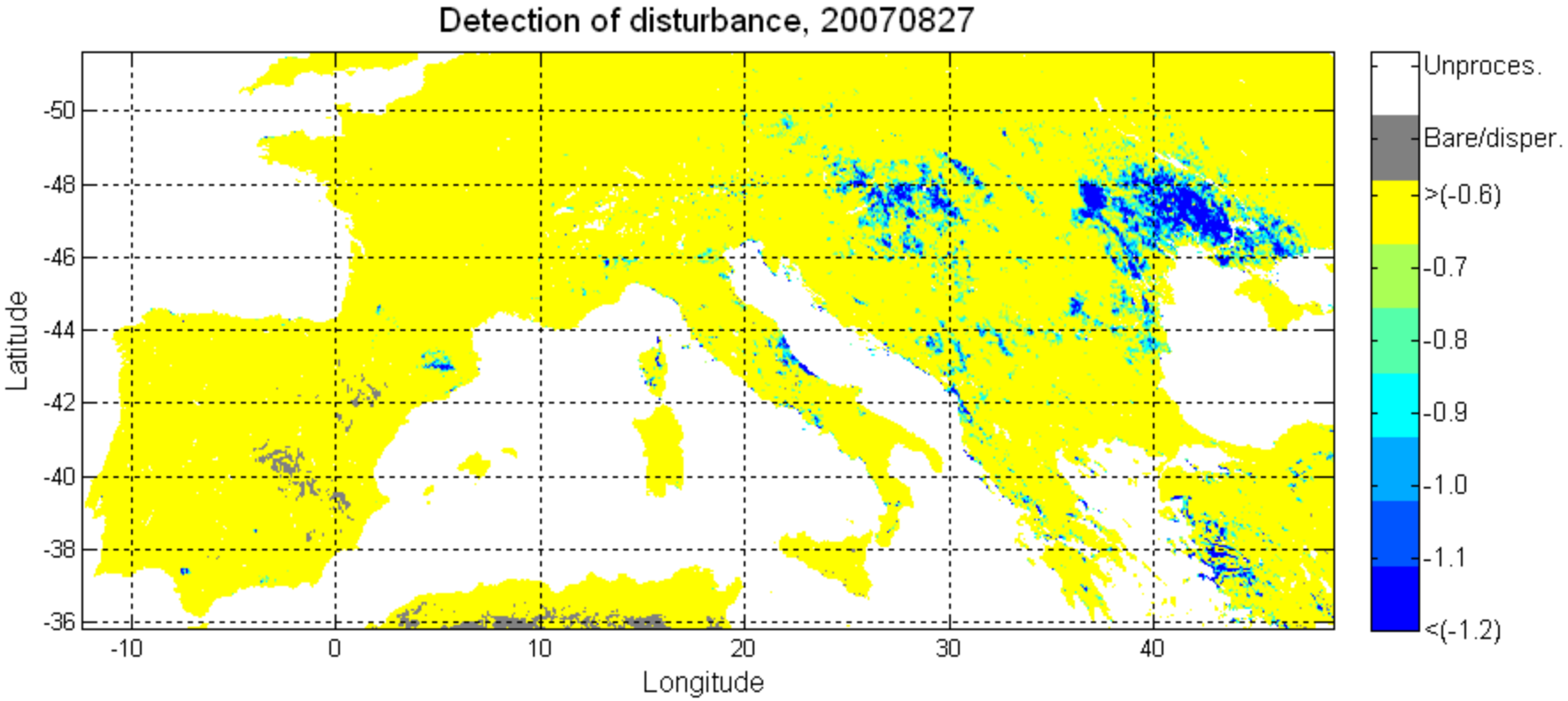
Drought monitoring

Southern Europe



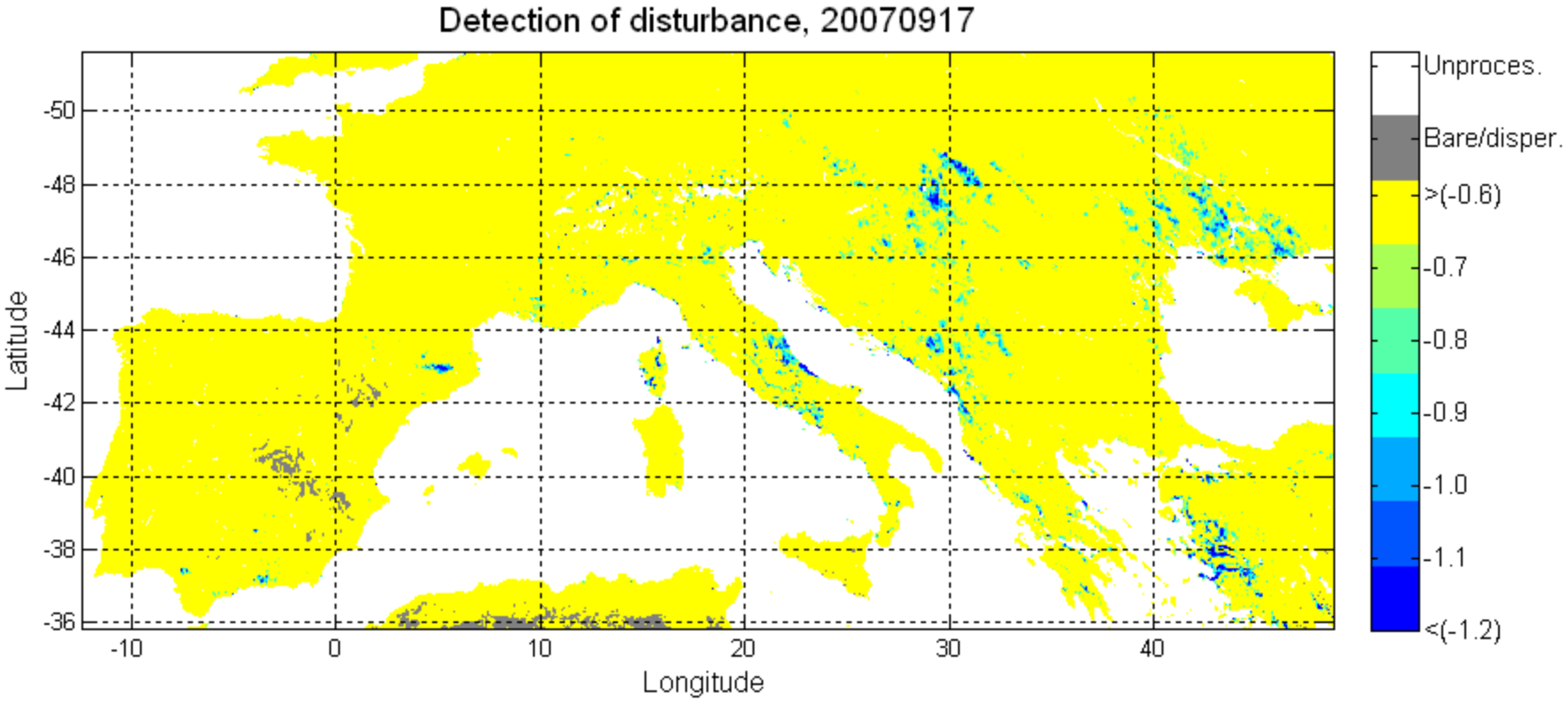
Drought monitoring

Southern Europe



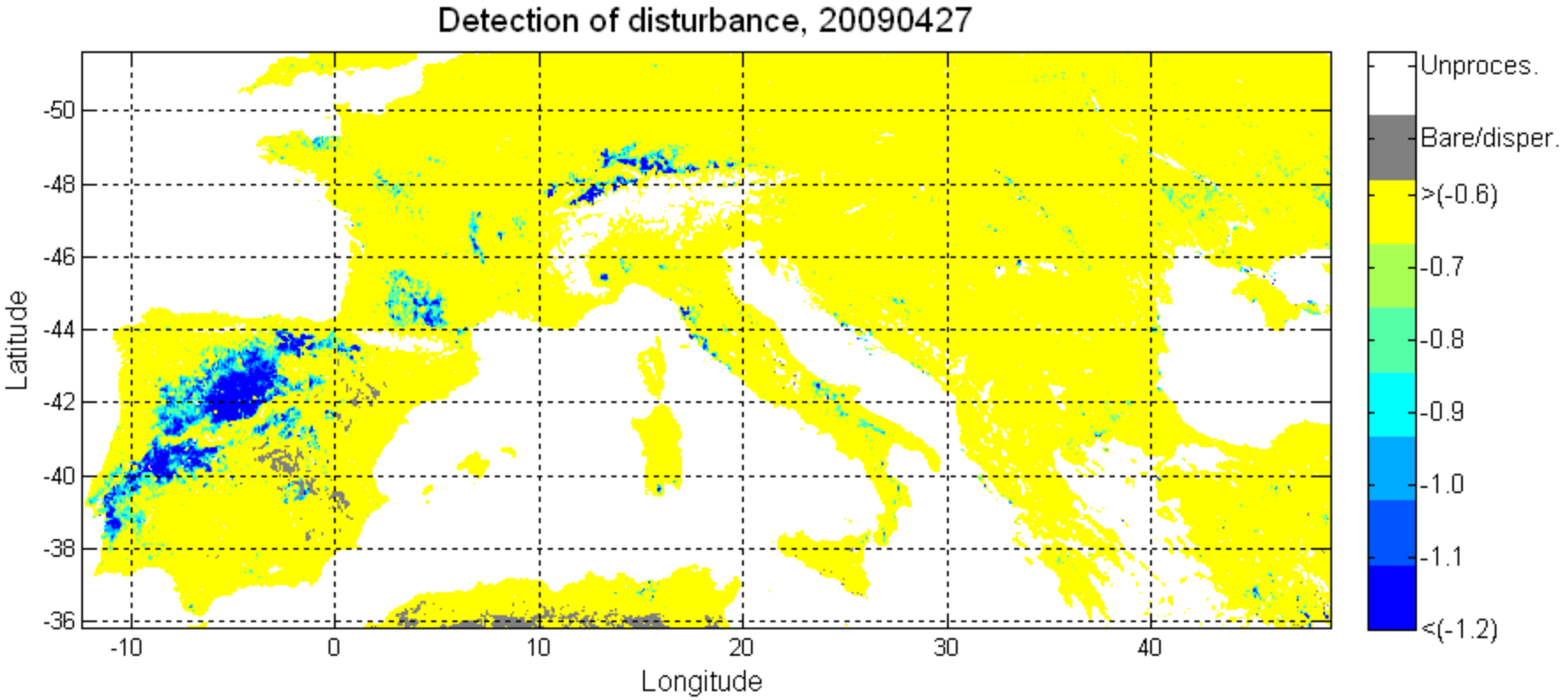
Drought monitoring

Southern Europe



Drought monitoring

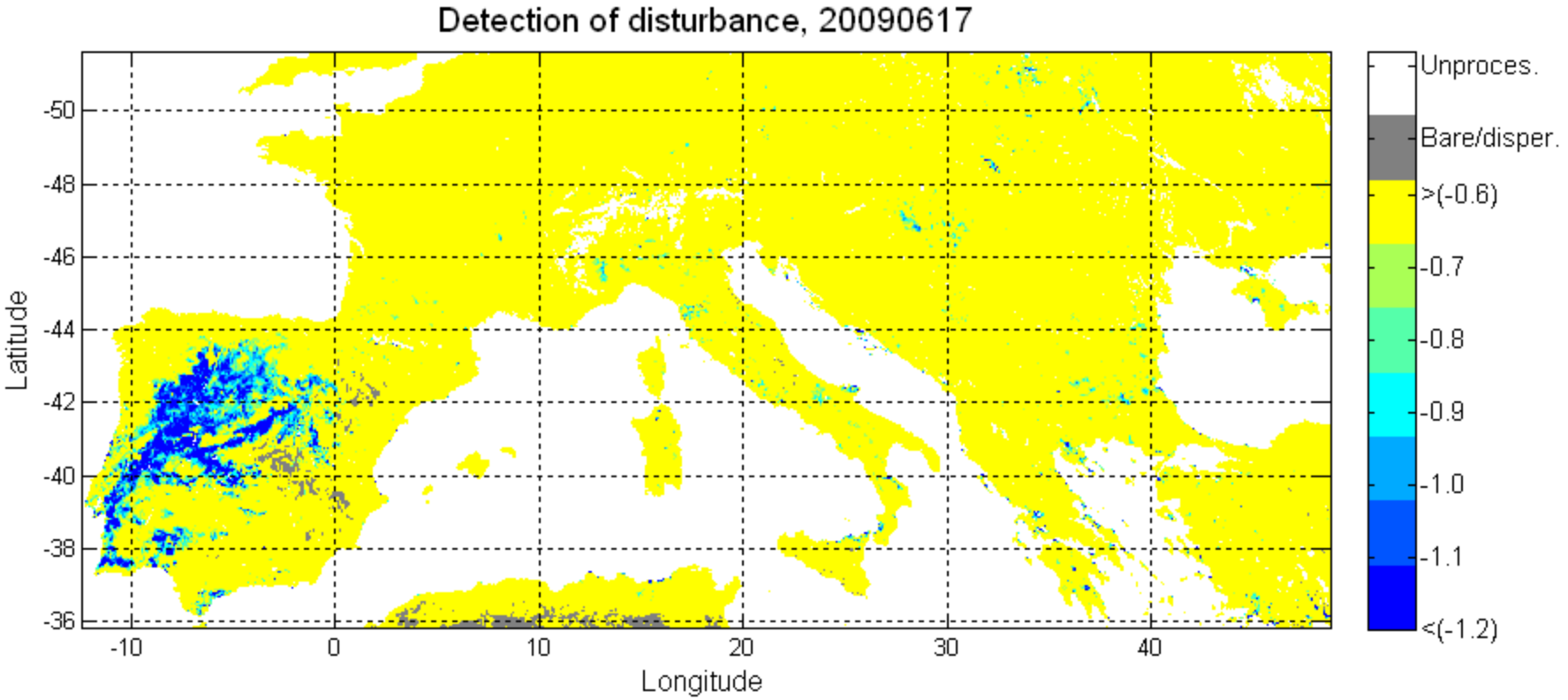
Southern Europe



Iberian Peninsula (spring, 2009)

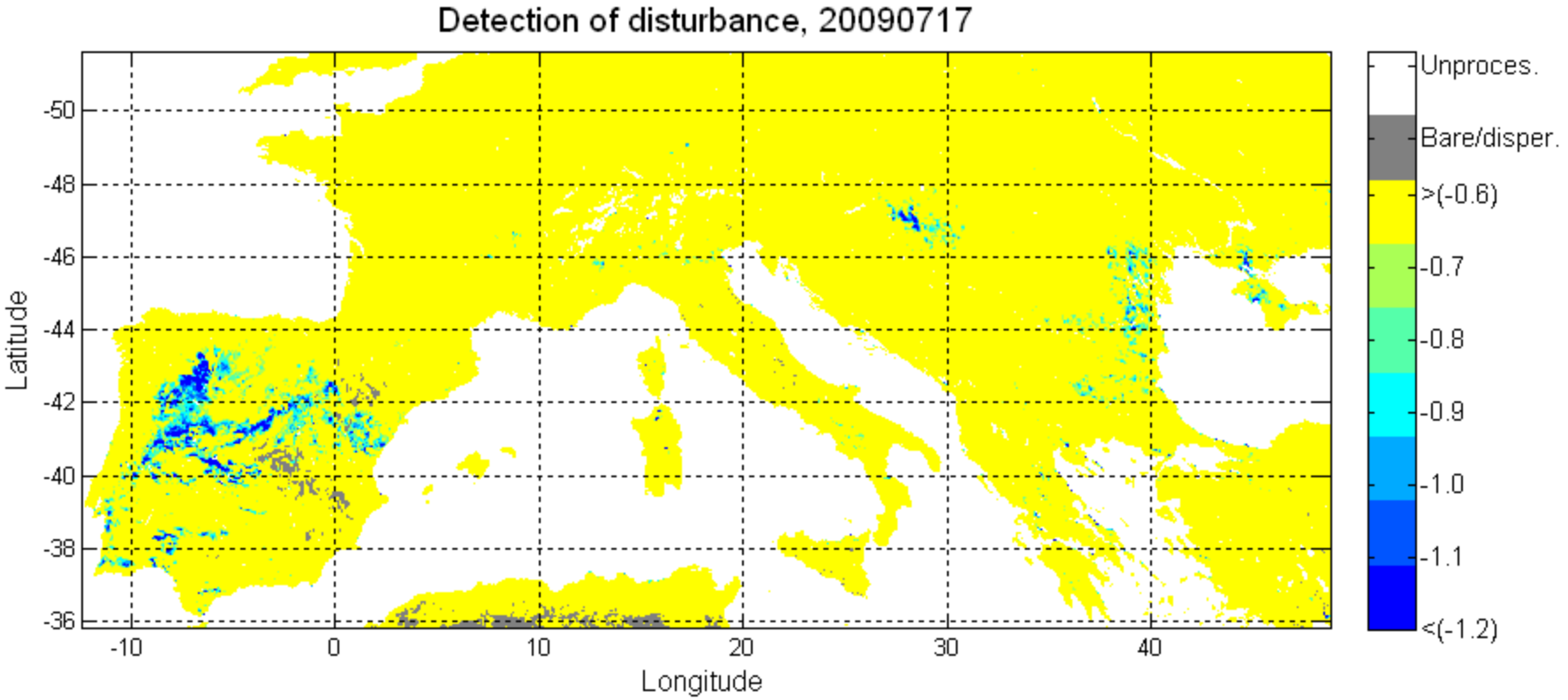
Drought monitoring

Southern Europe



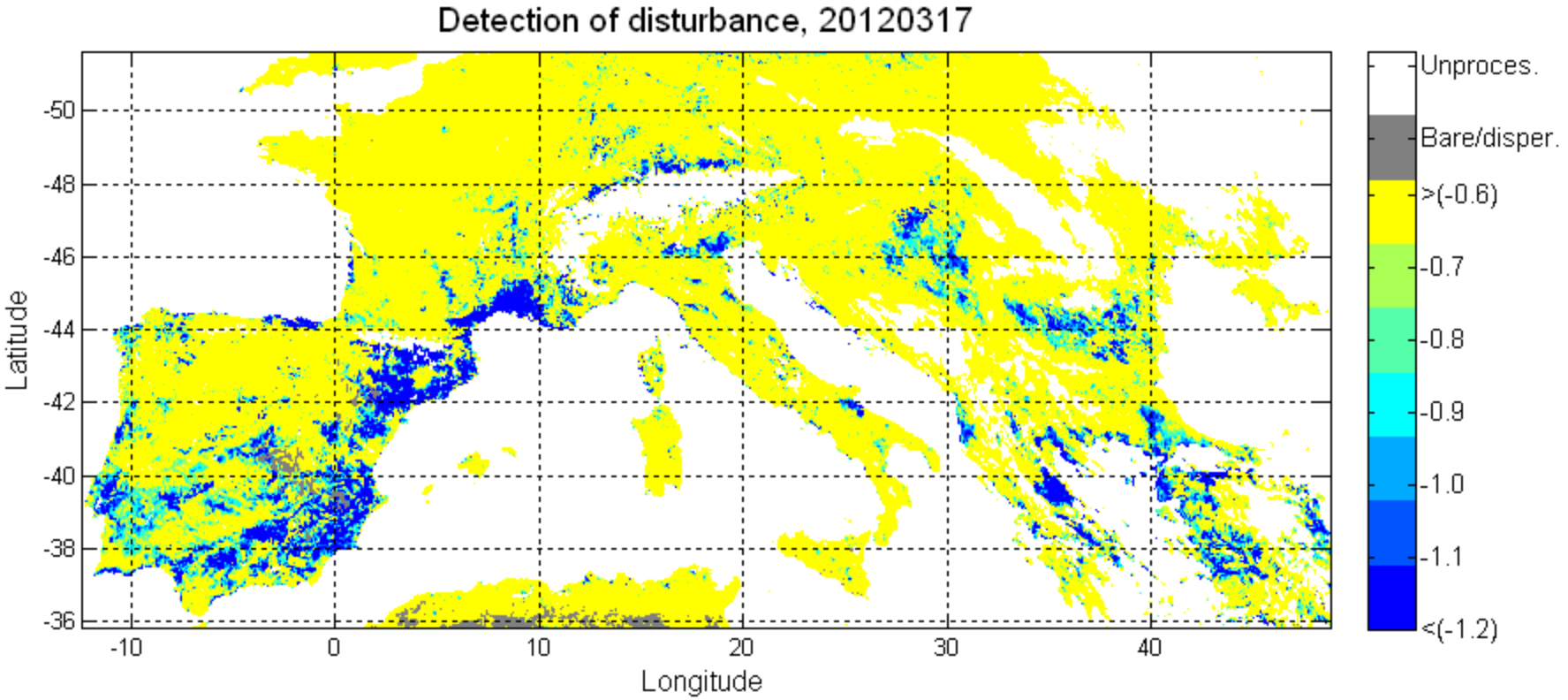
Drought monitoring

Southern Europe



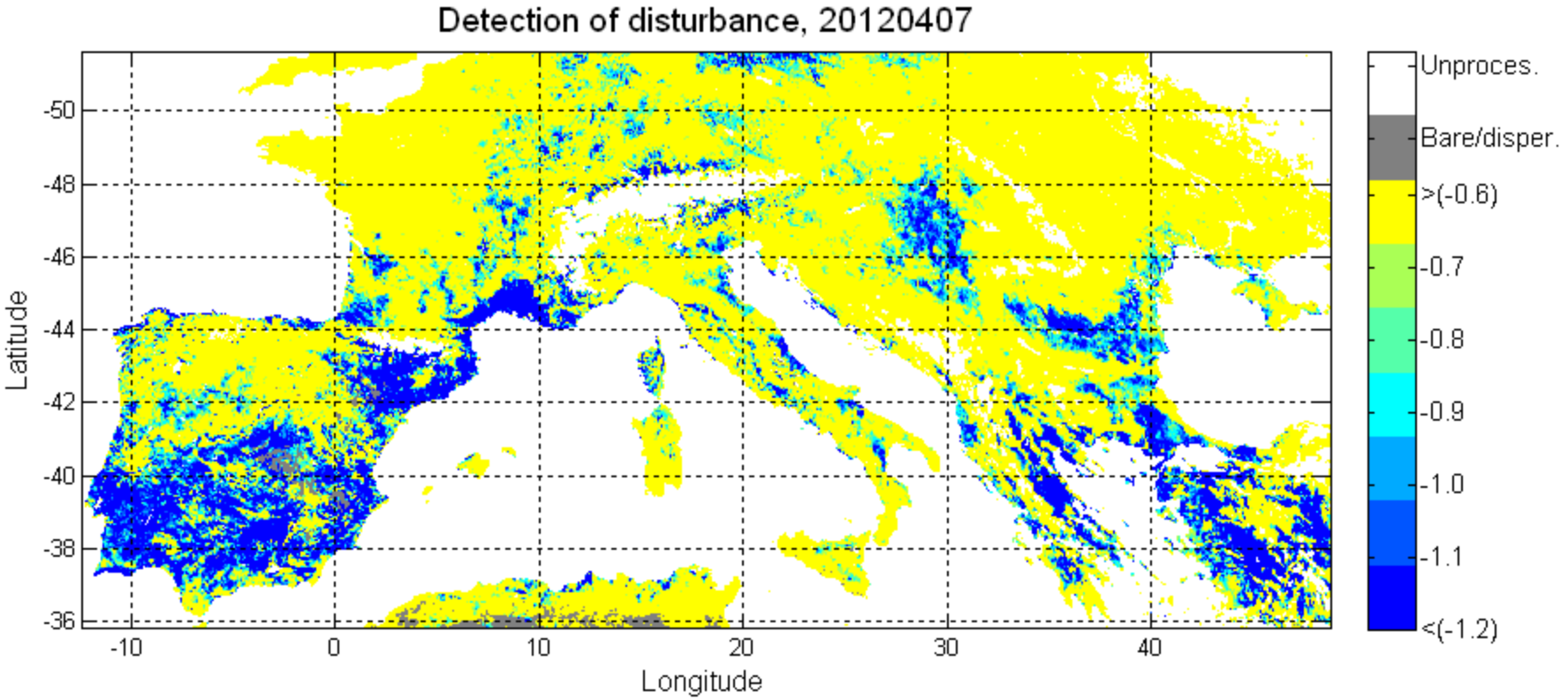
Drought monitoring

Southern Europe



Drought monitoring

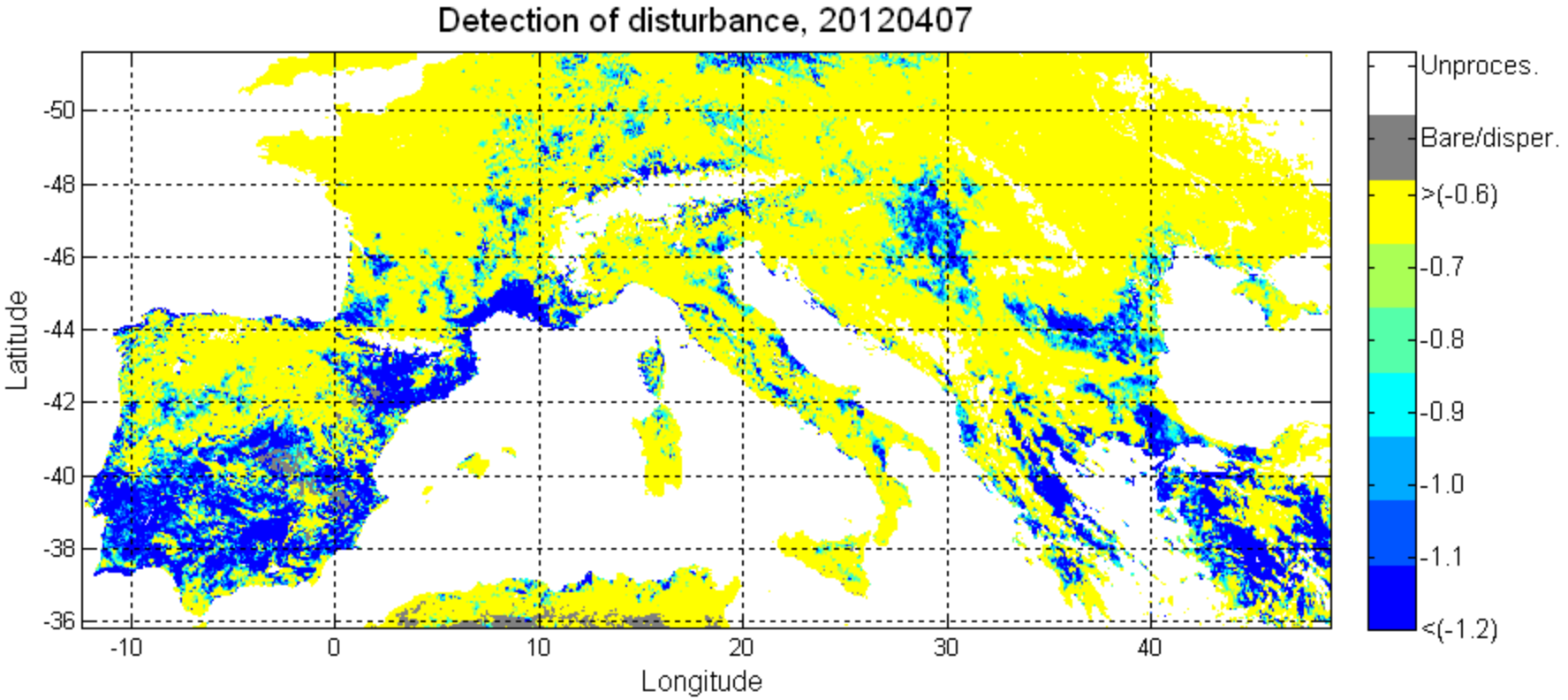
Southern Europe



Mediterranean countries (spring, 2012)

Drought monitoring

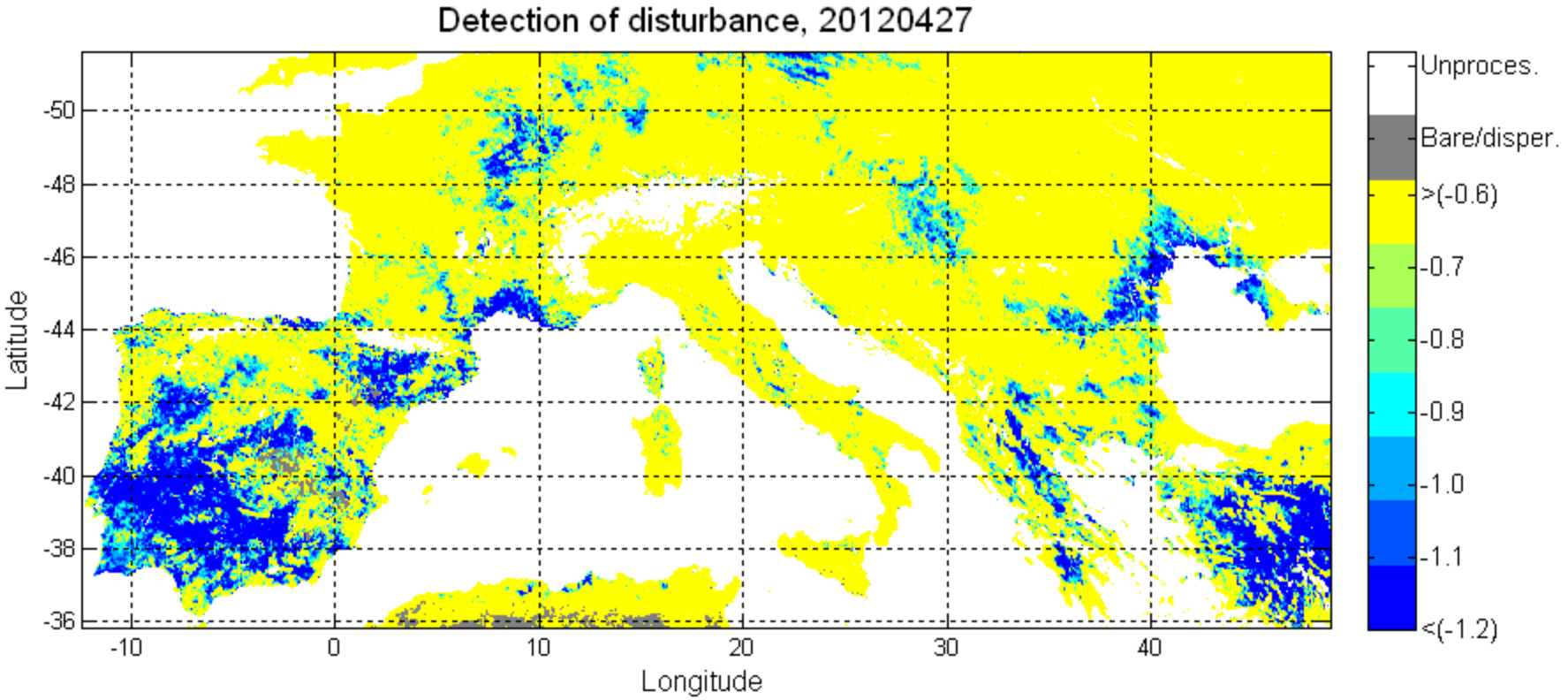
Southern Europe



Mediterranean countries (spring, 2012)

Drought monitoring

Southern Europe



Mediterranean countries (spring, 2012)

Summary

Vegetation estimates from satellite

- A complete integrator of the physical variables (moisture condition)
- closely related to rainfall dynamics in water limited ecosystems

LSA SAF VEGA products (FVC, LAI, FAPAR)

- spatial and temporally consistent indicators of vegetation structure and condition over wide
- FVC time series are suited for near real time drought monitoring
- Use of several LSA SAF products (ET, LST, FVC, FAPAR) to monitoring initiation of water stress and propagation of drought

Contact

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