The EUMETSAT Network of Satellite Application Facilities

LSA SAF
Land Surface Analysis

Monitoring of vegetation properties. Products overview and applications: Drought assessment

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- Derivation of seasonal information
- Drought applications
  - Response of vegetation to rainfall deficit
  - Capabilities of VEGA products for real time detection/monitoring of drought related disturbances

Introduction

Vegetation as indicator of land condition

- A complete integrator of the physical variables (moisture condition)
- Satellite observations of biophysical parameters: spatial and temporally consistent indicators of vegetation structure and condition at a regional scale

Time series of vegetation

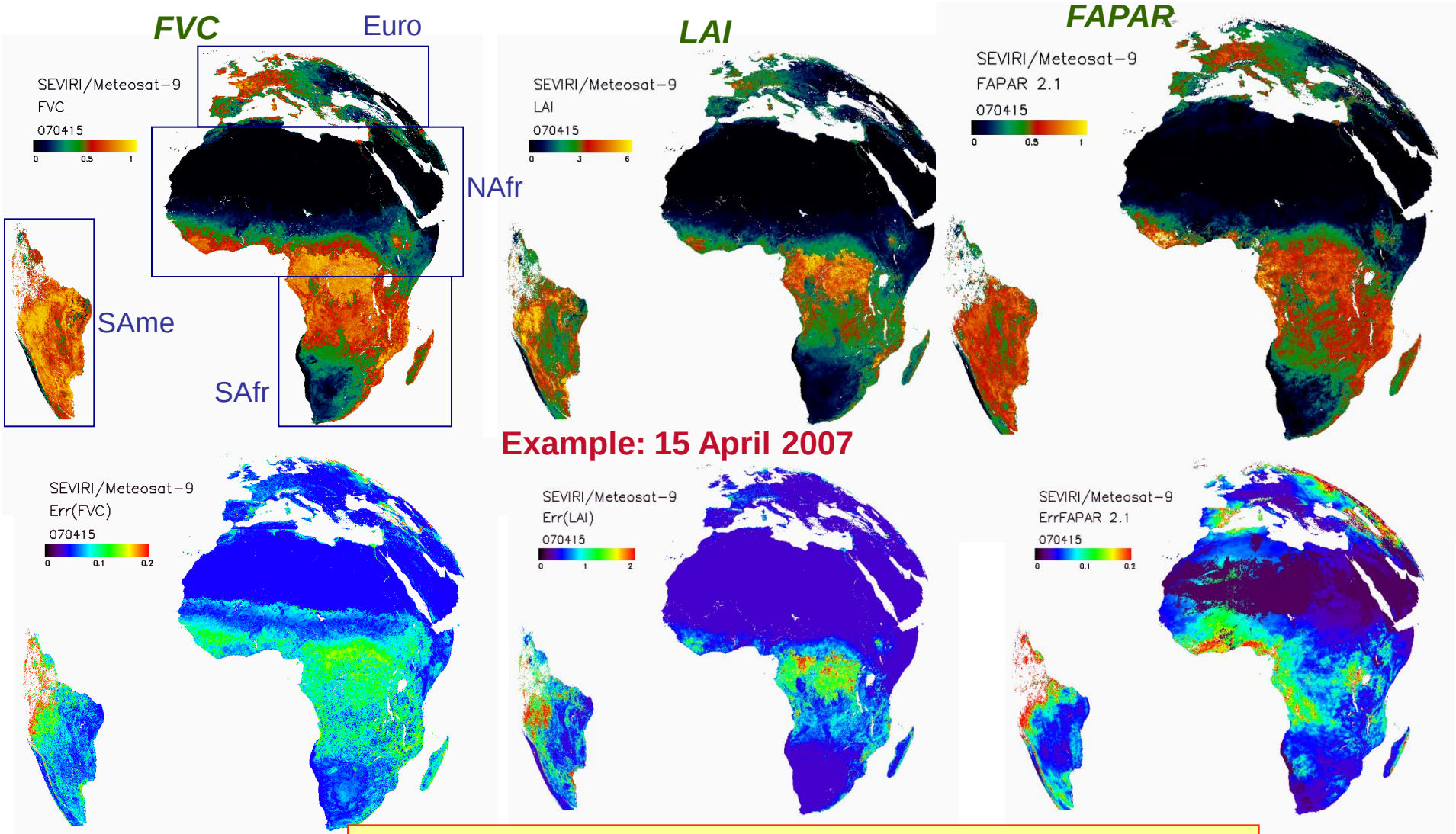
- An important data source for monitoring disturbances (drought, fire) and trends (degradation, deforestation, LC changes)
- Applications: crop & yield monitoring, early warning systems, Carbon sequestration, resources management, etc.

Drought monitoring

- Vegetation activity is closely related to rainfall dynamics in water limited ecosystems
  - Africa, Southern Europe (e.g. Iberian Peninsula)

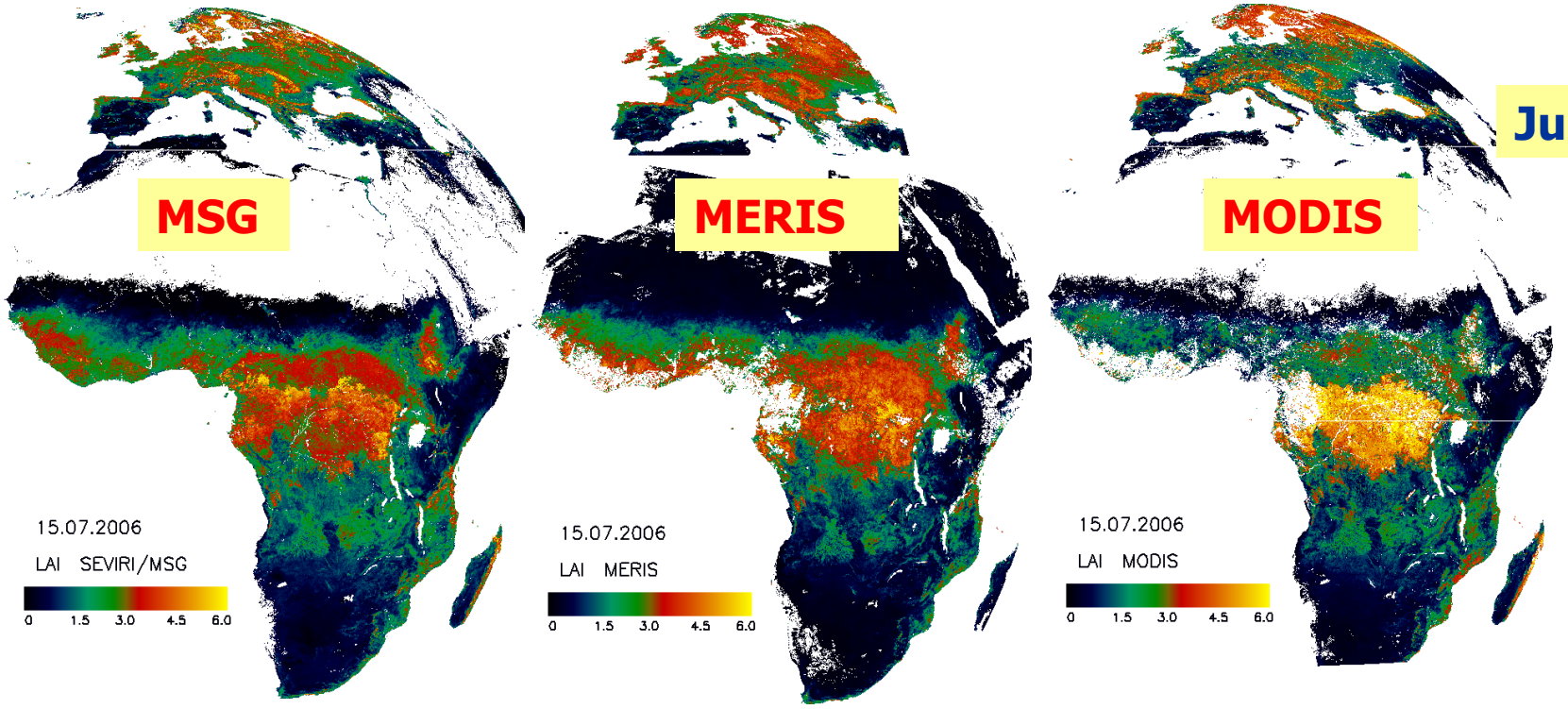
PRODUCT CONTENT

SEVIRI "VEGA": daily products



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

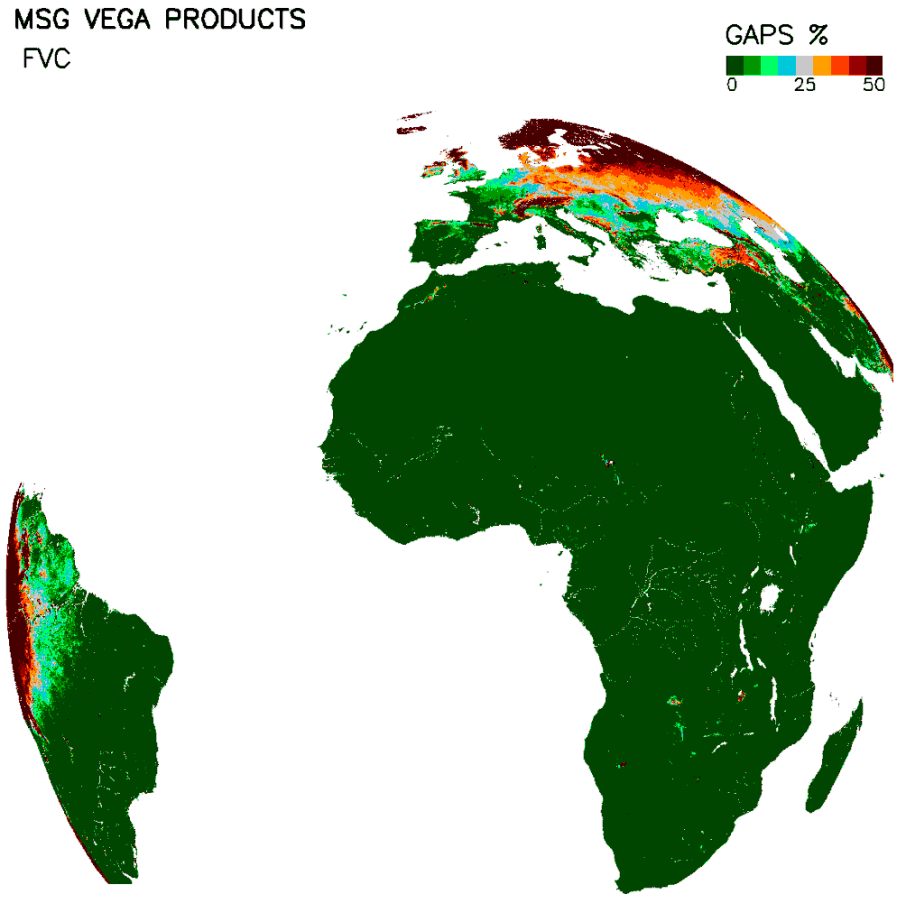
PRODUCT VALIDATION



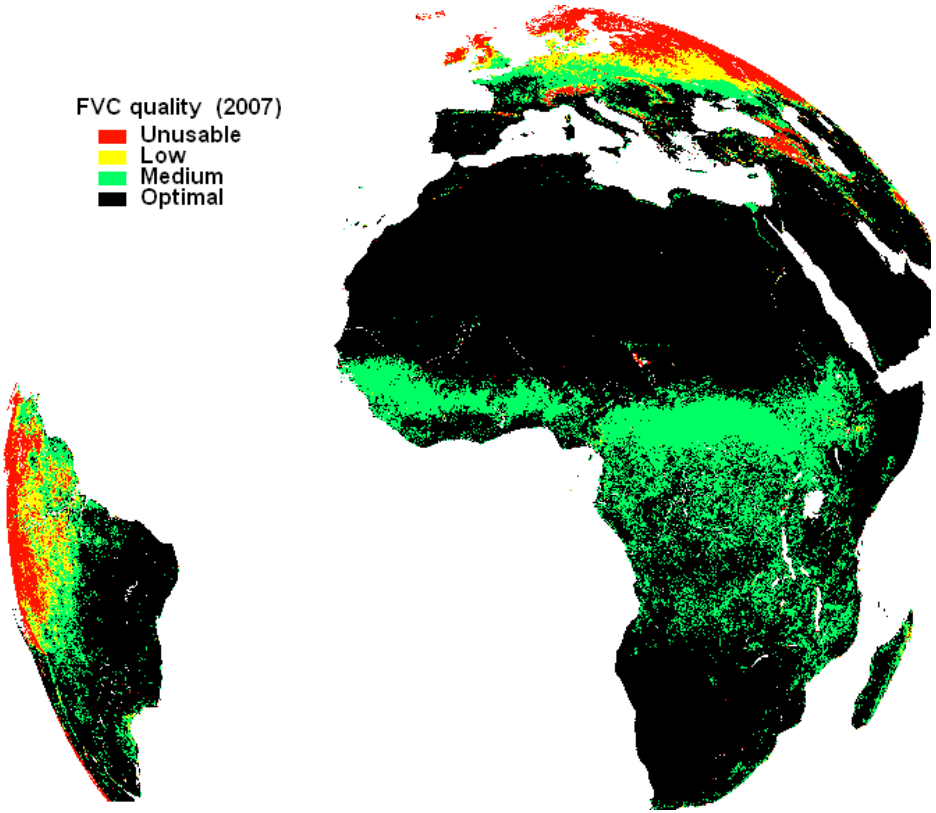
- Algorithms robust, validated against common literature methods
- Continuosly evaluated since 2006 against satellite products (CYCLOPES, POLDER, MERIS (TOAVEG & MGVI), JRC-SAHEL, SEAWIFS, VGT4Africa, MODIS, GMES) and ground-truth (VALERI, SAFARI, FP7 IMAGINES).
- Products include pixel-level information (error estimate, QF) and fit well with the existing satellite and ground truth within the error bars
  - FVC: 0.10-0.15
  - LAI: 0.5-1.0
  - FAPAR: 0.10-0.15 (MSG), 0.20 (other products)

PRODUCT DESCRIPTION

Percentage of gaps over 1 year of data



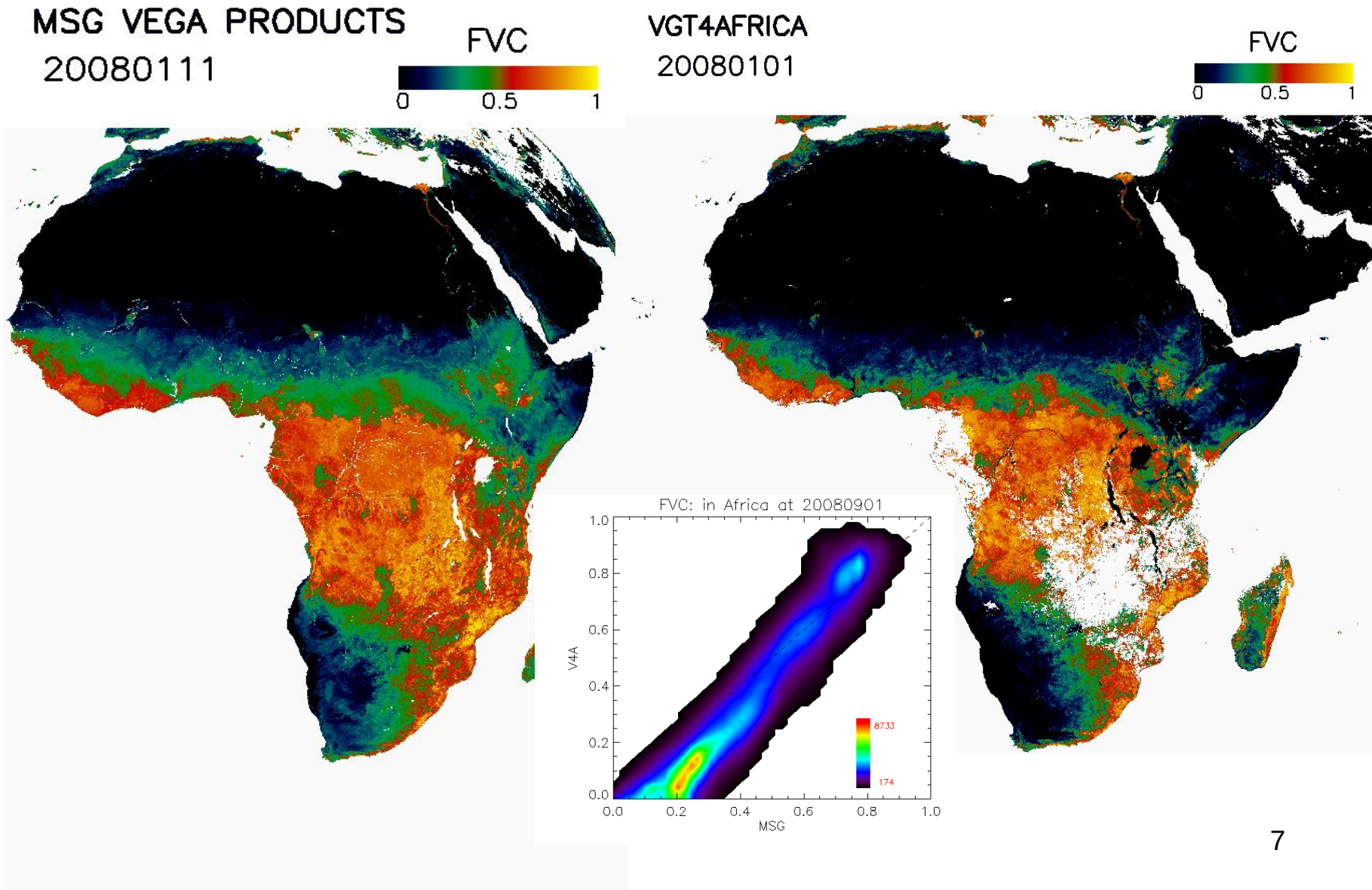
Compliance with the URD



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 DESCRIPTION

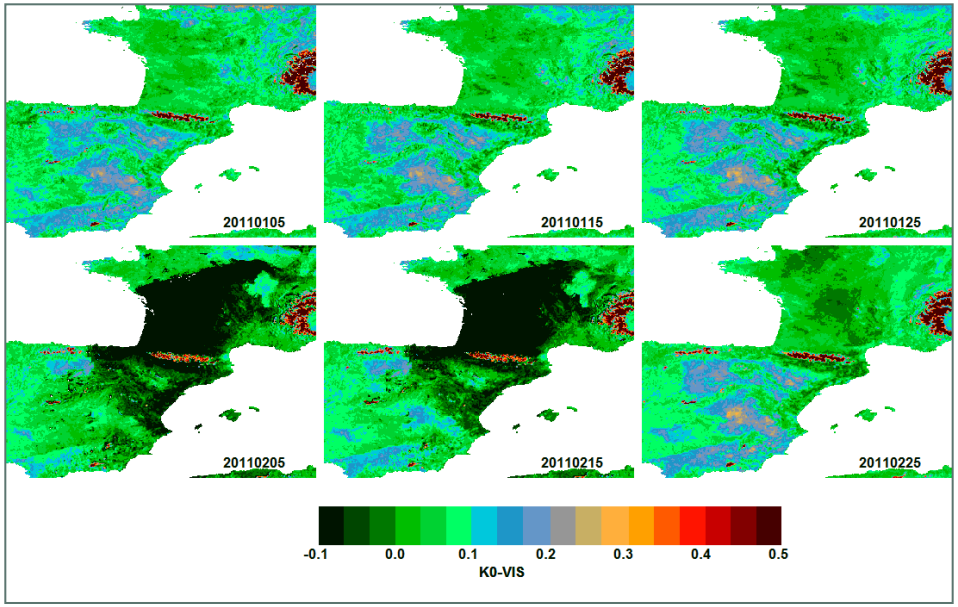
Comparison with VGT4SAFRICA FVC



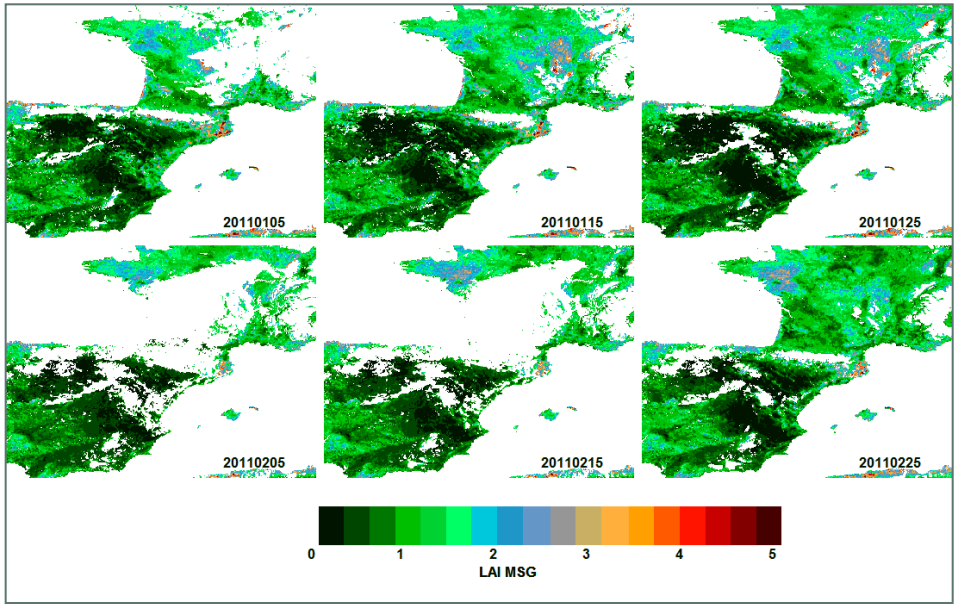
PRODUCT DESCRIPTION

Identified artefacts

Input (BRDF K0)



LAI



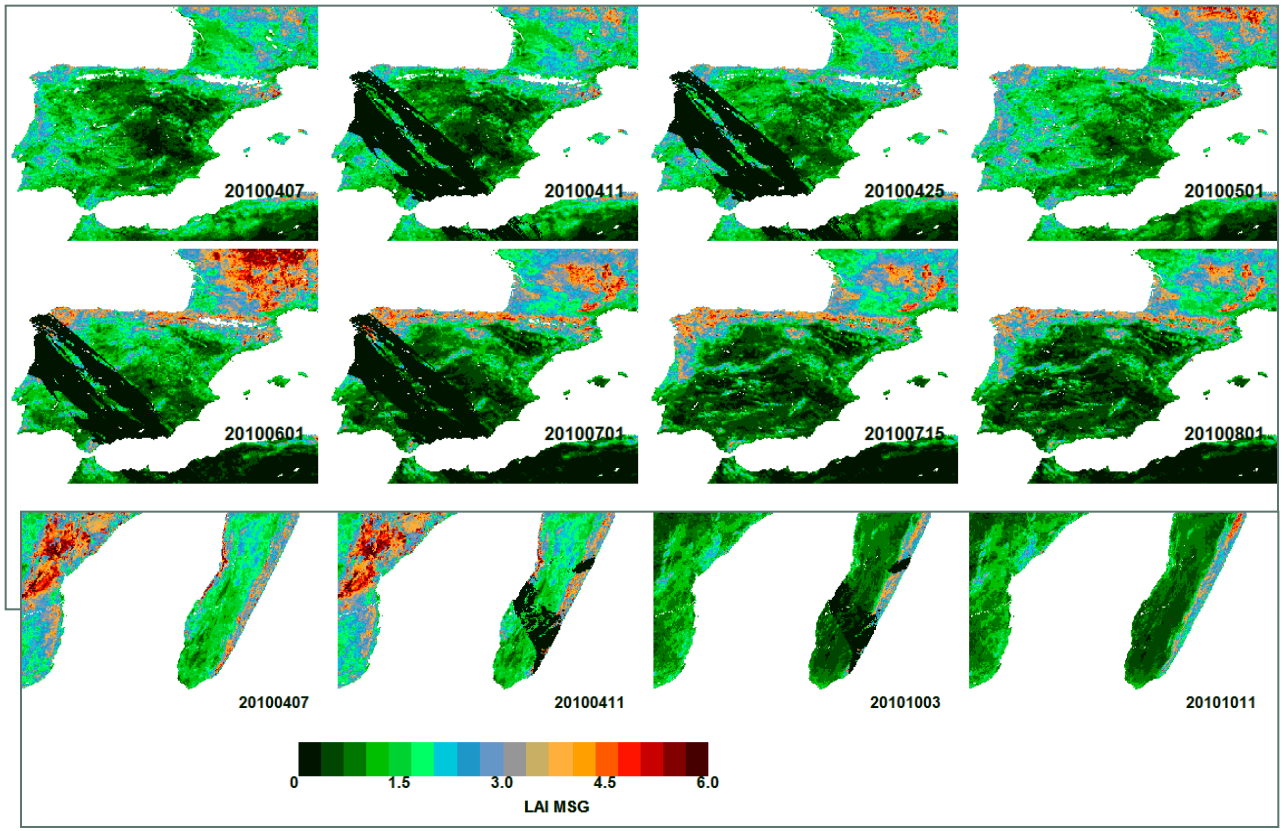
Artefacts during late winter 2011

- 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

PRODUCT DESCRIPTION

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

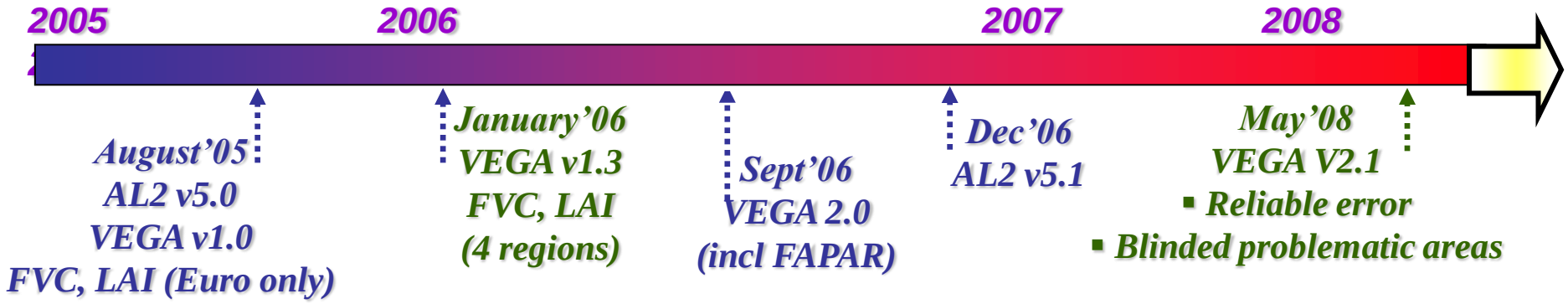
PRODUCT DESCRIPTION

Known Limitations

- Usability of VEGA products is only limited for high view zenith angles
- FVC, LAI are land cover dependent (GLC-2000), which may introduce some spatial artefact
- Take care about a possible over-estimation of FVC for low values (semi-arid areas).
- FAPAR temporal profiles present some noise introduced for the k_2 BRDF parameter.

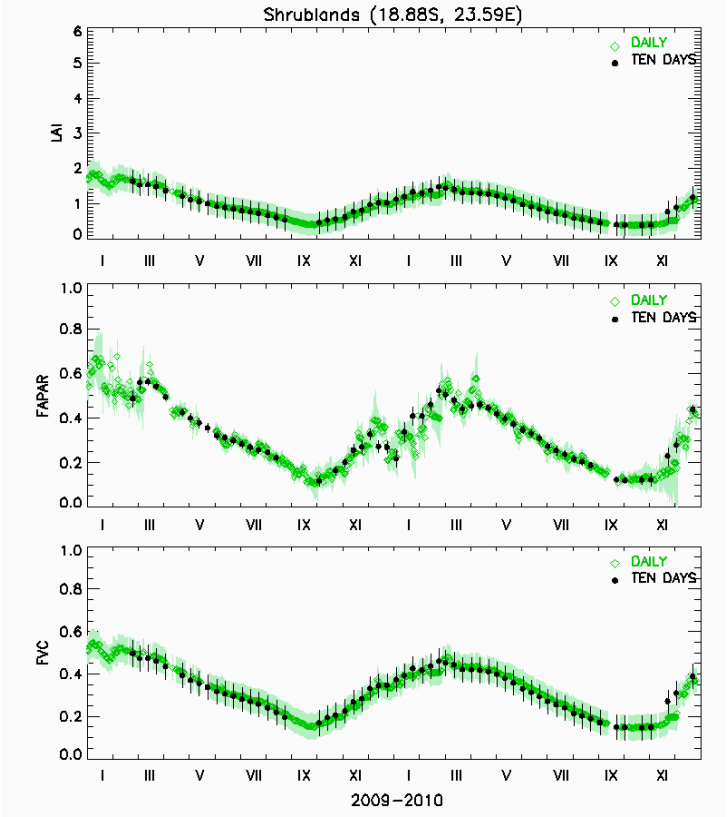
Time series

- Changes in the algorithm could introduce changes in products – No back-processing (so far)
- ~15% Missing dates (e.g. system stops)

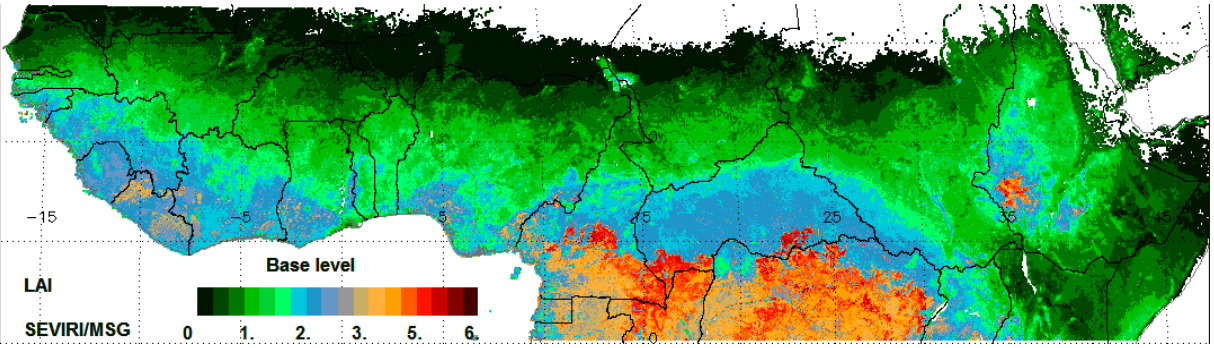


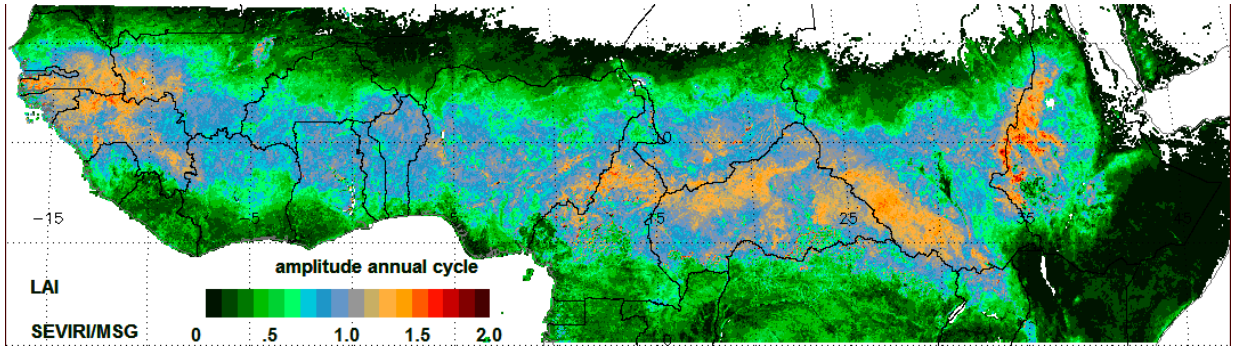
FUTURE PRODUCTS

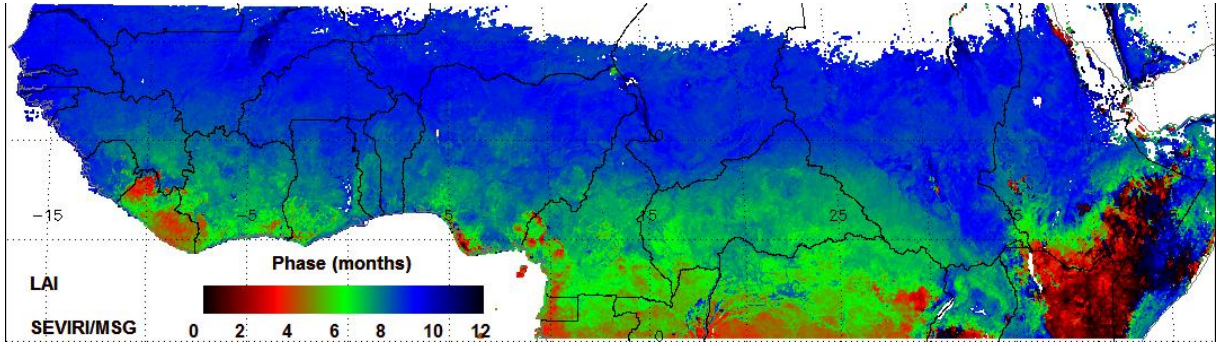
- 10-day VEGA (MTVEGA)
- *AVHRR-EPS* vegetation products (ETVEGA)
- New products
  - Vegetation Primary Production: NPP – Net Primary Production, GPP – Gross Primary Production
  - Water content: equivalent Water thickness (kg/m2), fuel Moisture Content (%)
  - Prototyped using MODIS data



Deriving phenologic attributes





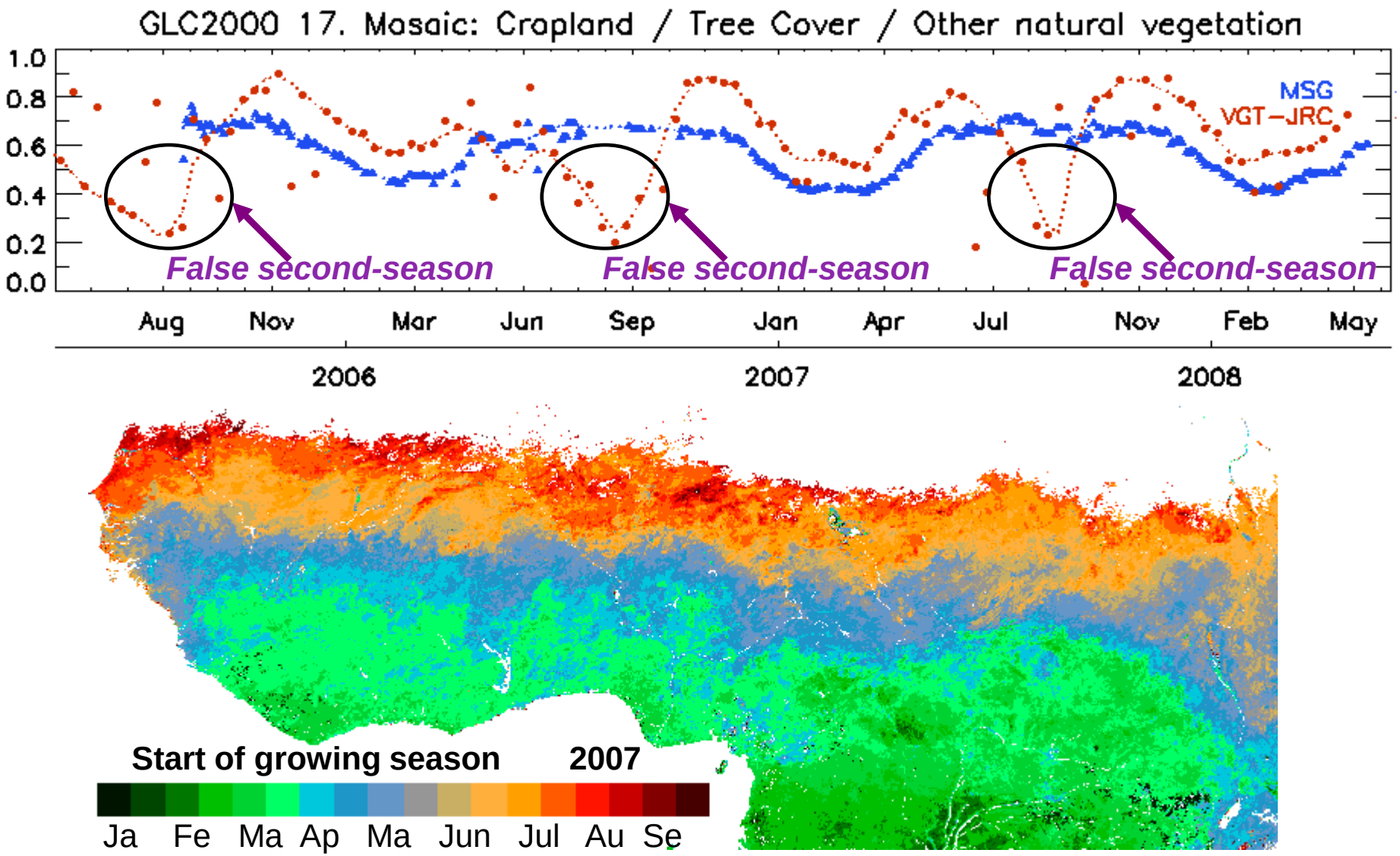


Seasonal metrics

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

Reconstruction of seasonal curves

Potential applications

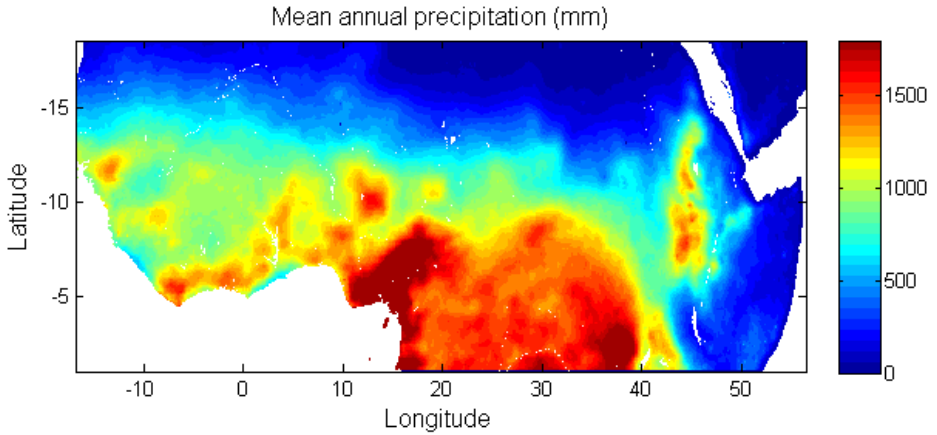


- Africa is a consolidated region: no gaps, temporal continuity, improving the capabilities of polar orbiters to characterise the phenology

Meterological data

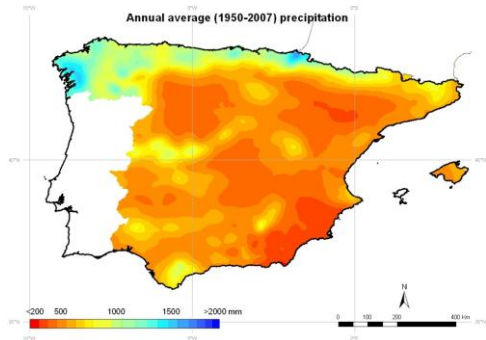
AFRICA

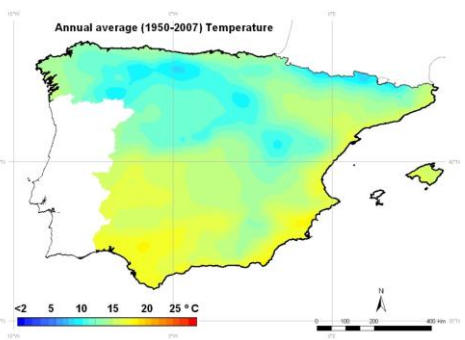
- 10-day rainfall estimates (RFE 2.0) for Africa from the NOAA Climate Prediction Center (NOAA/CPC) at a spatial resolution of 8-km
- monthly and 3-montly accumulated



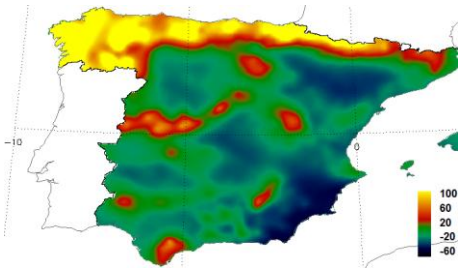
SPAIN

- 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)

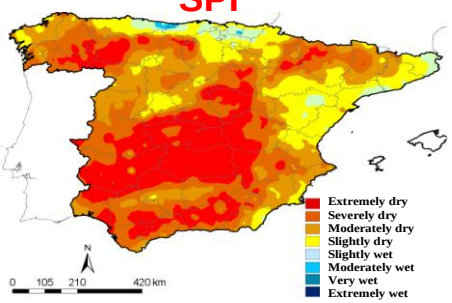




Moisture index

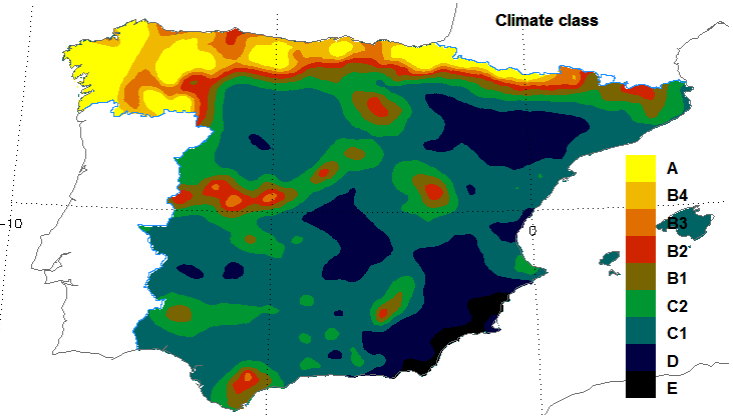


SPI

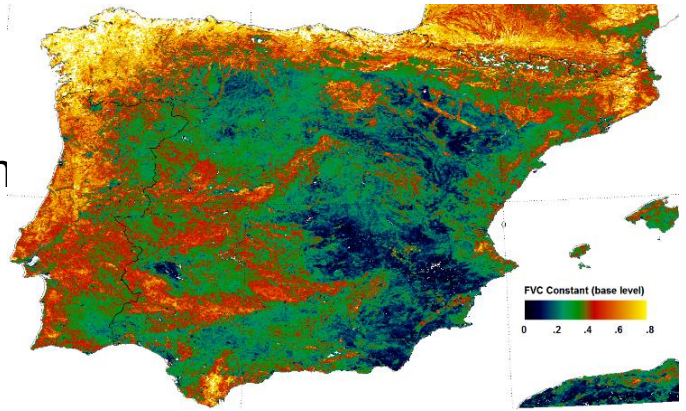


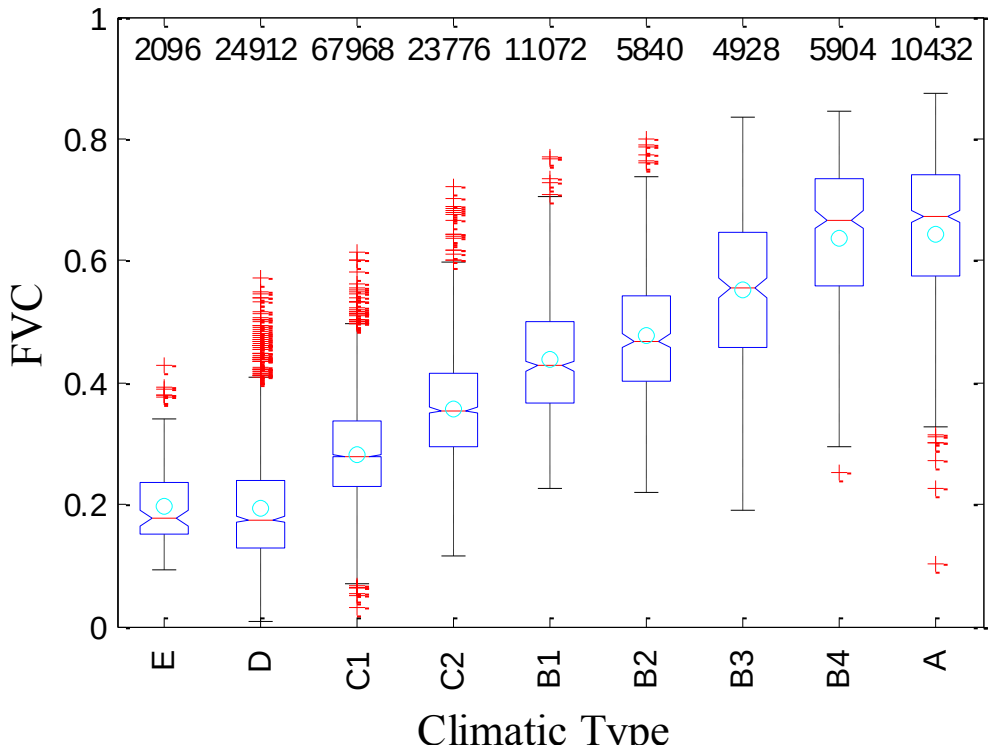
INTERRELATION CLIMATE-VEGETATION

Spatial distribution



relationships between water availability and vegetation coverage in Spain

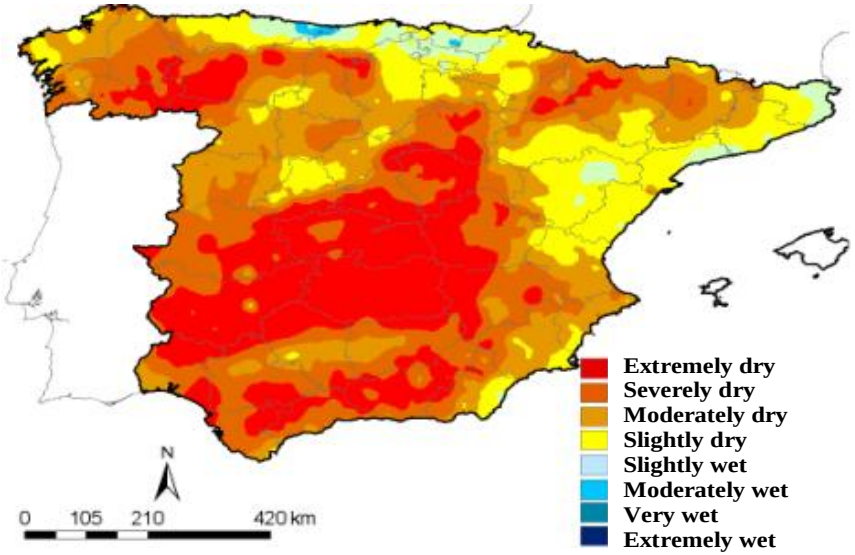




Climatic Type		Moisture Index
A	Very humid	≥ 100
B_4	Humid	80 to100
B_3	Humid	60 to 80
B_2	Humid	40 to 60
B_1	Humid	20 to 40
C_2	Moist subhumid	0 to 20
C_1	Dry subhumid	-20 to 0
D	Semiarid	-40 to -20
E	Arid	-60 to -40

FEEDBACKS CLIMATE-VEGETATION

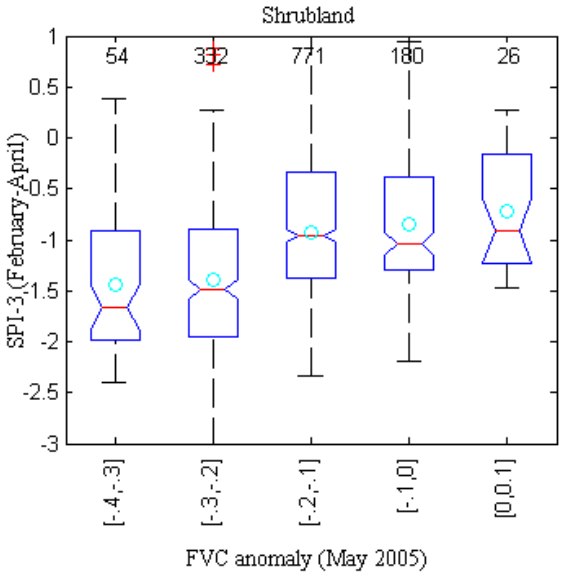
Impact of 2004-06 drought in Spain

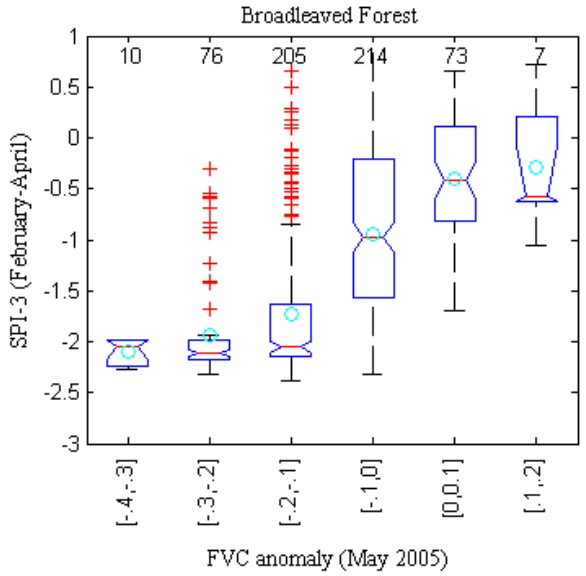


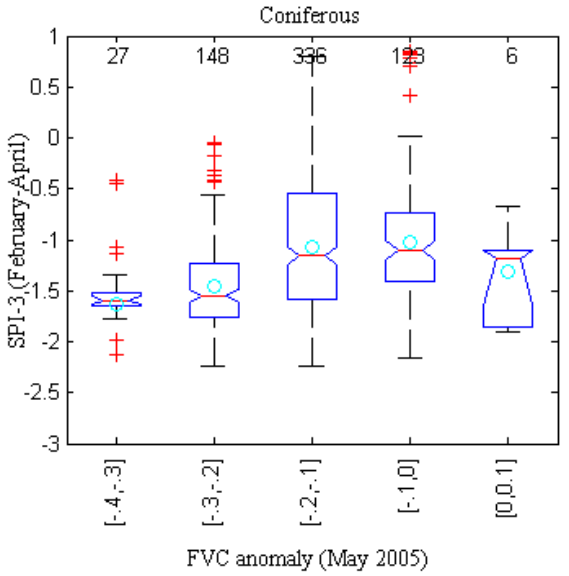
FVC/MSG anomaly (3 June'05) vs. SPI-3 (March-May)

- Shrub, herbaceous and broadleaved are sensitive to drought

***SPI-12* (August'04 – July'05)**

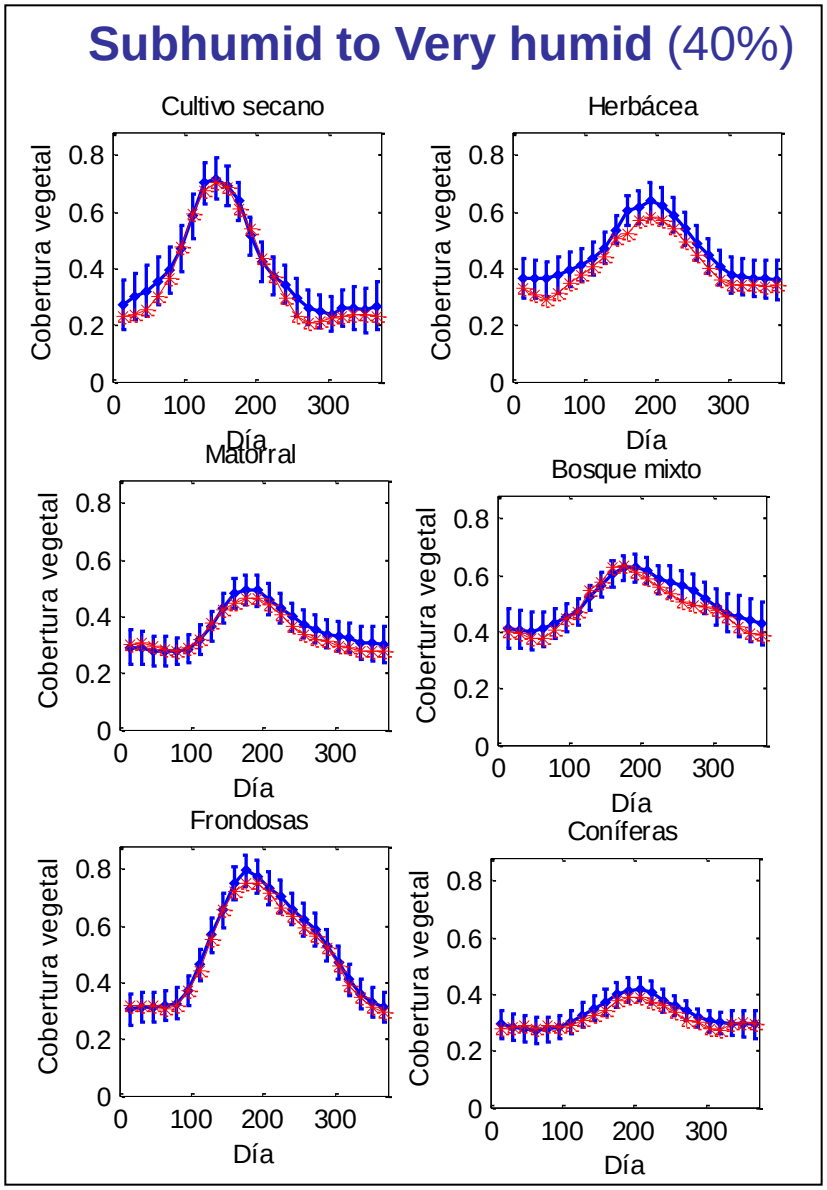


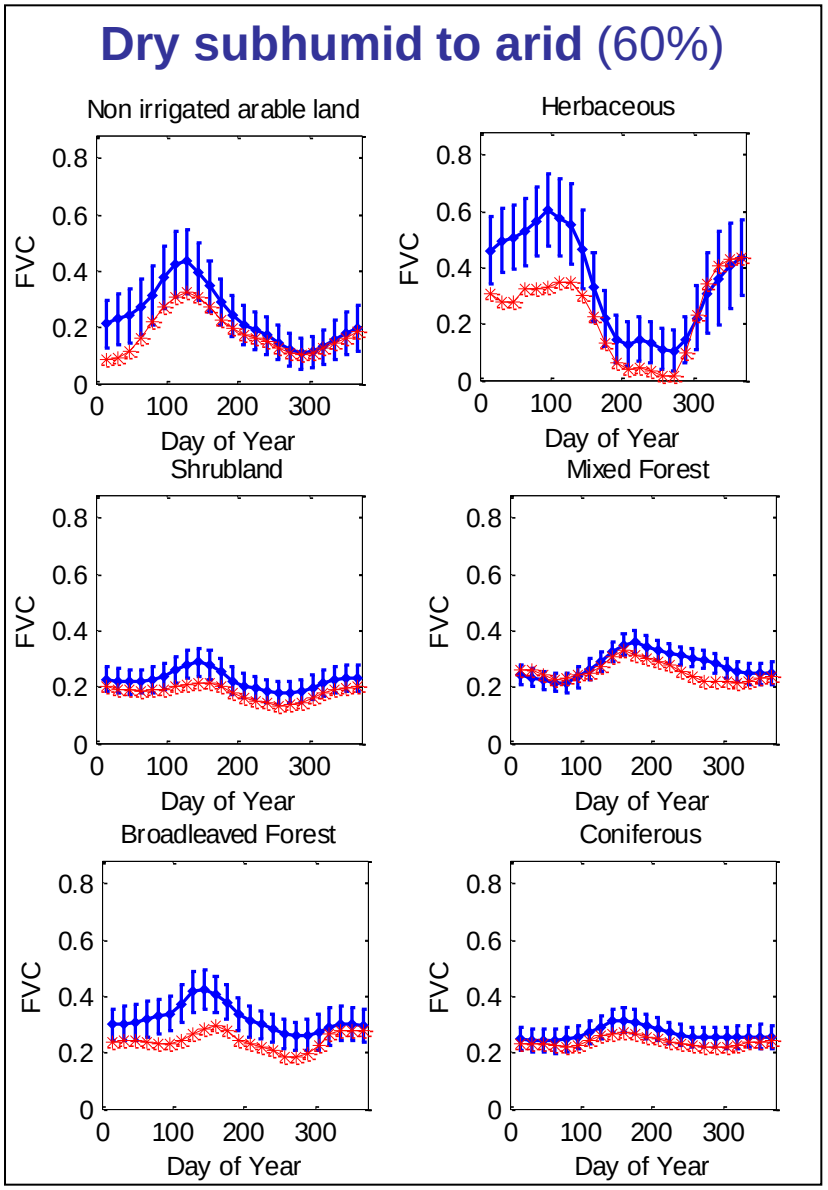




FEEDBACKS CLIMATE-VEGETATION

Impact of 2004-06 drought in Spain

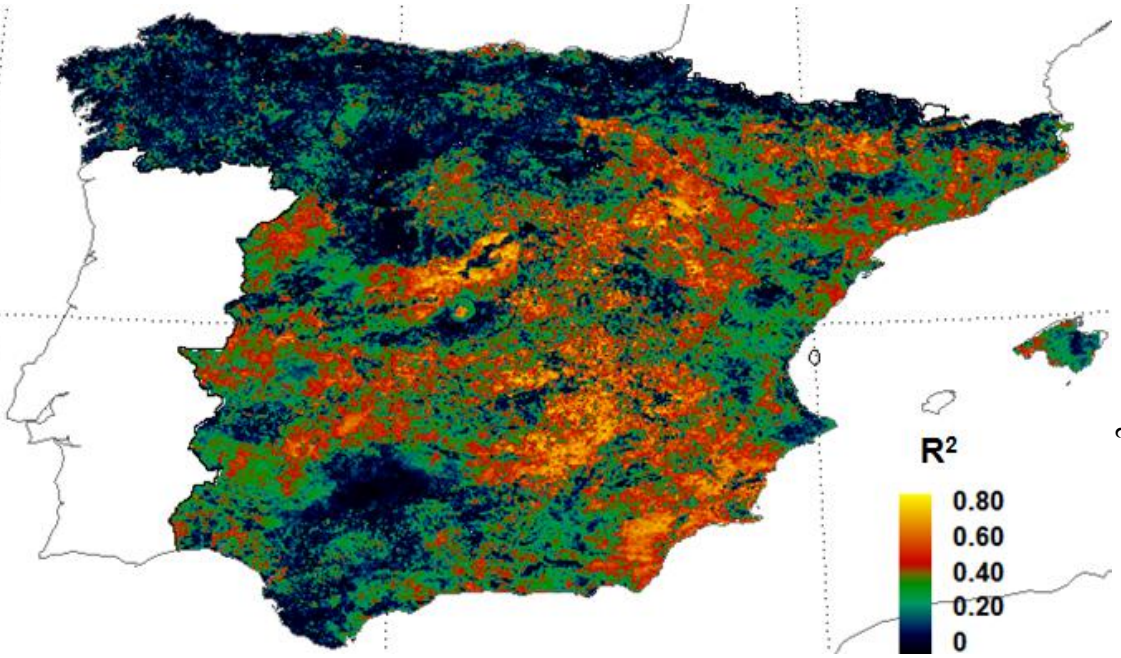


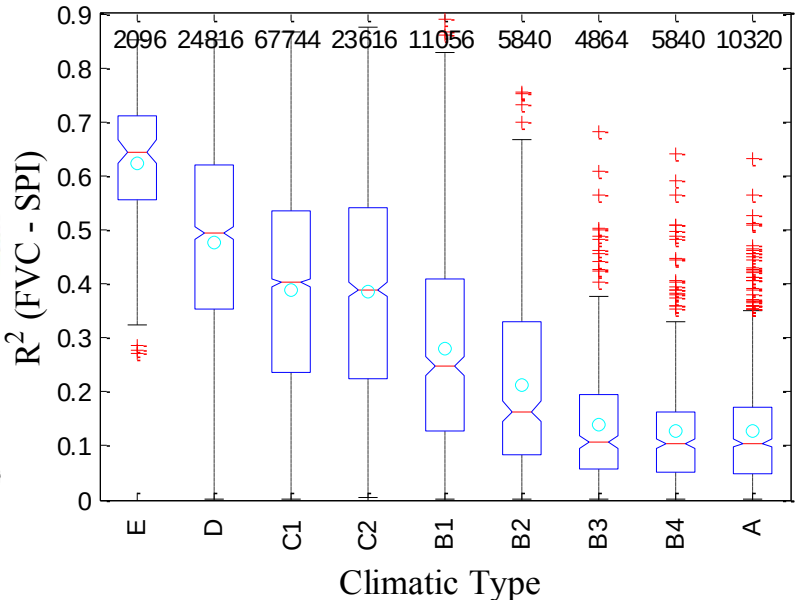


- Vulnerability is controlled by climatic conditions (e.g. aridity), veg. types (herbaceous, shrub, broadleaved) and seasonality (e.g. middle of growing-season)

FEEDBACKS CLIMATE-VEGETATION

Vulnerability of natural ecosystems



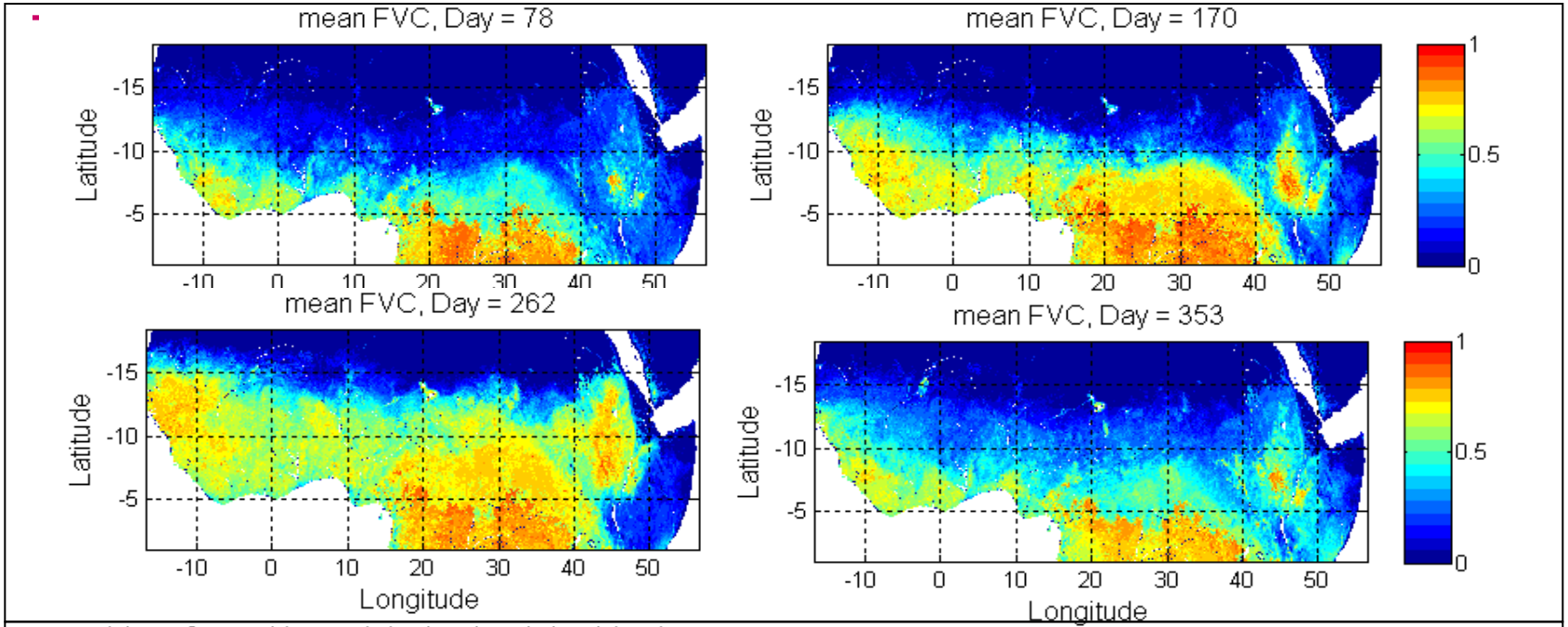


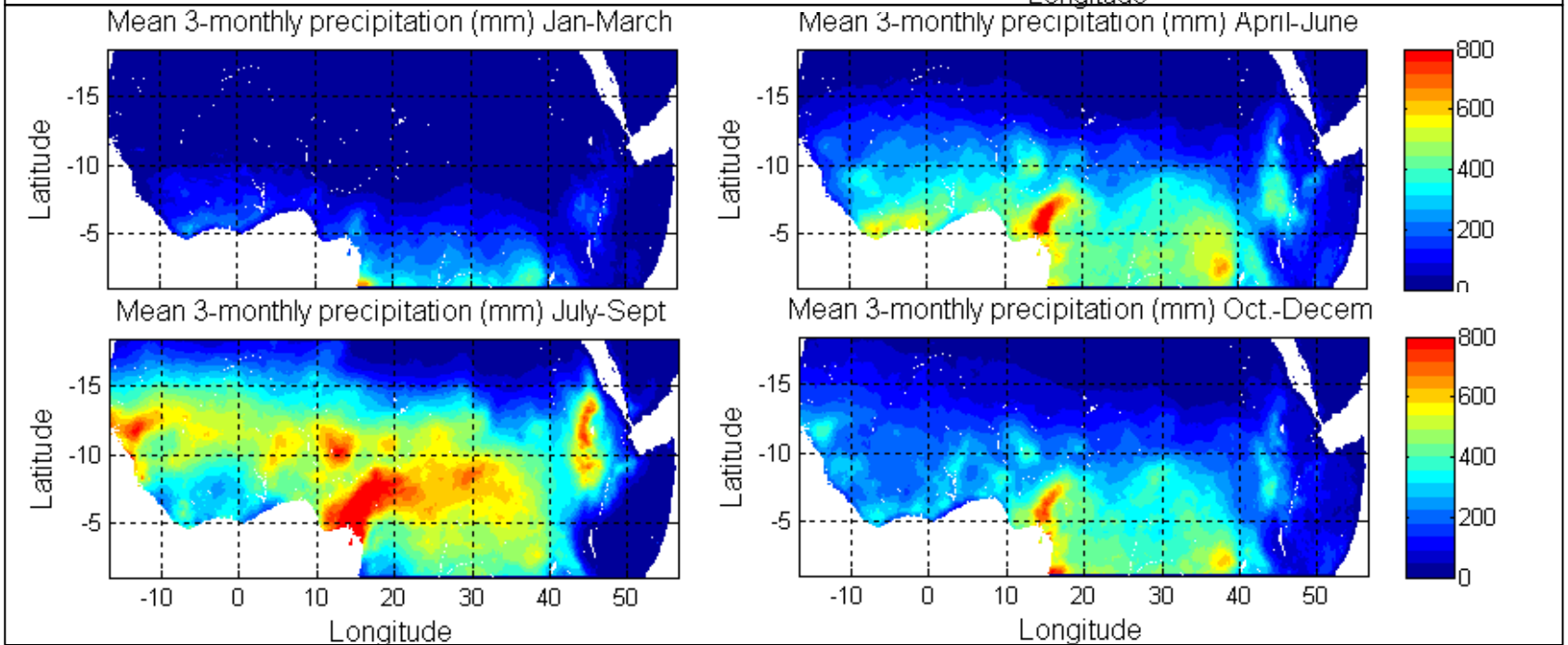
R^2 of Dummy-Variable Model between SPI (1 month lagged) and FVC anomaly during April-August

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

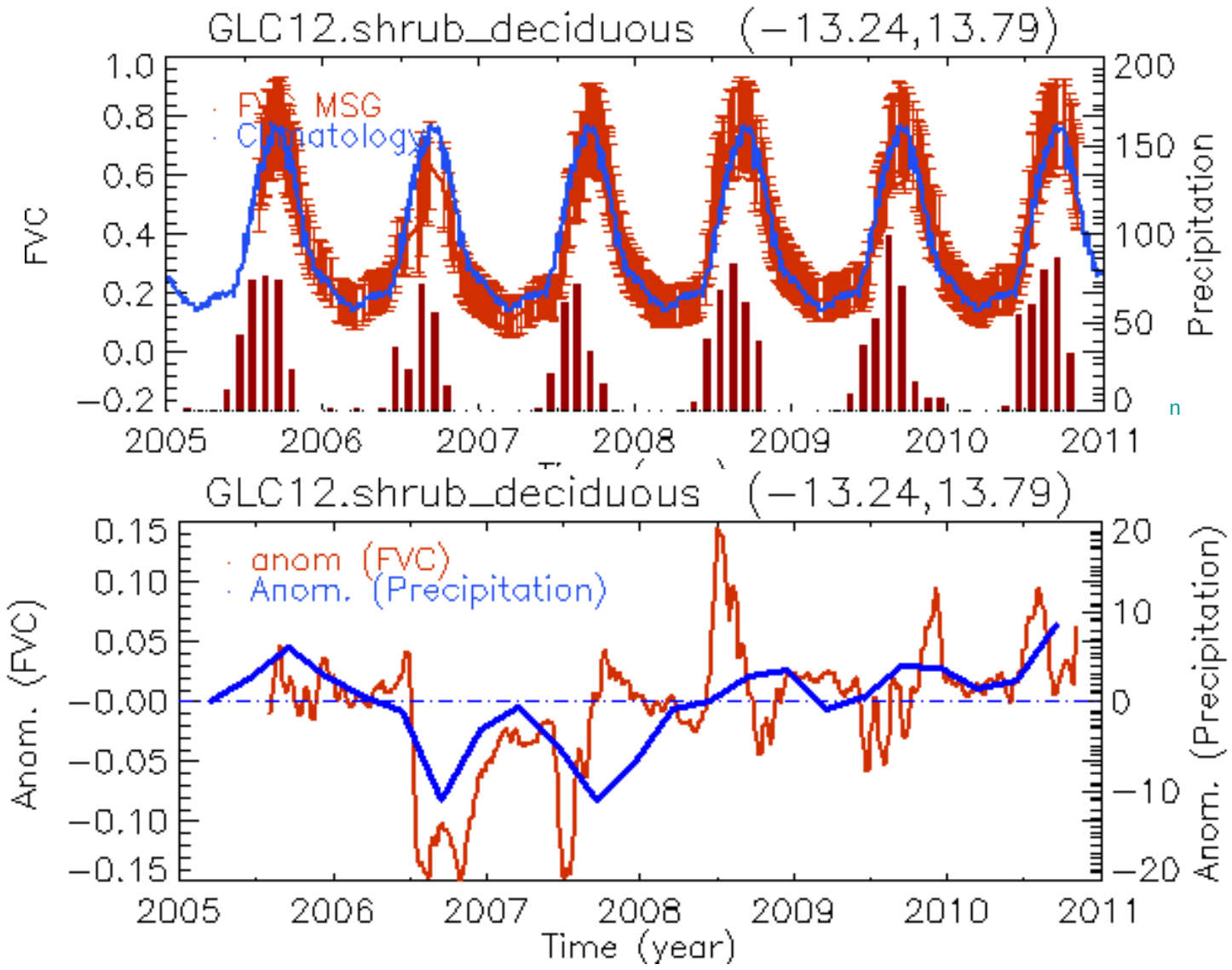
FEEDBACKS CLIMATE-VEGETATION

Africa





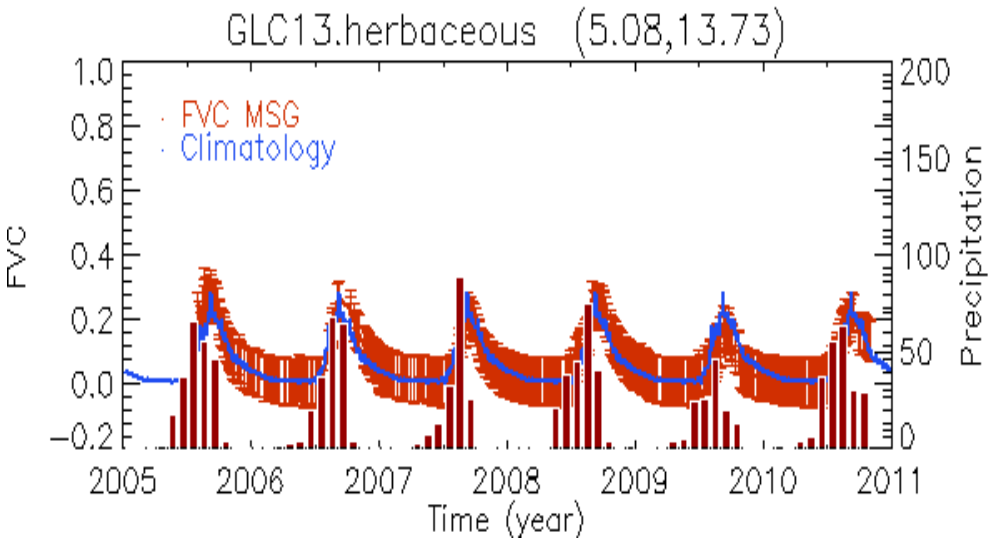
Vegetation response to climatic variability

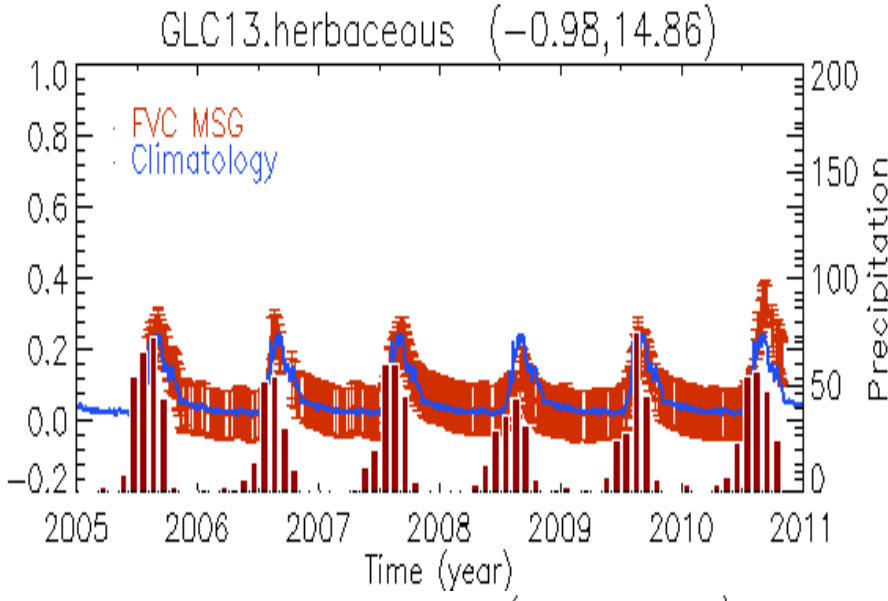


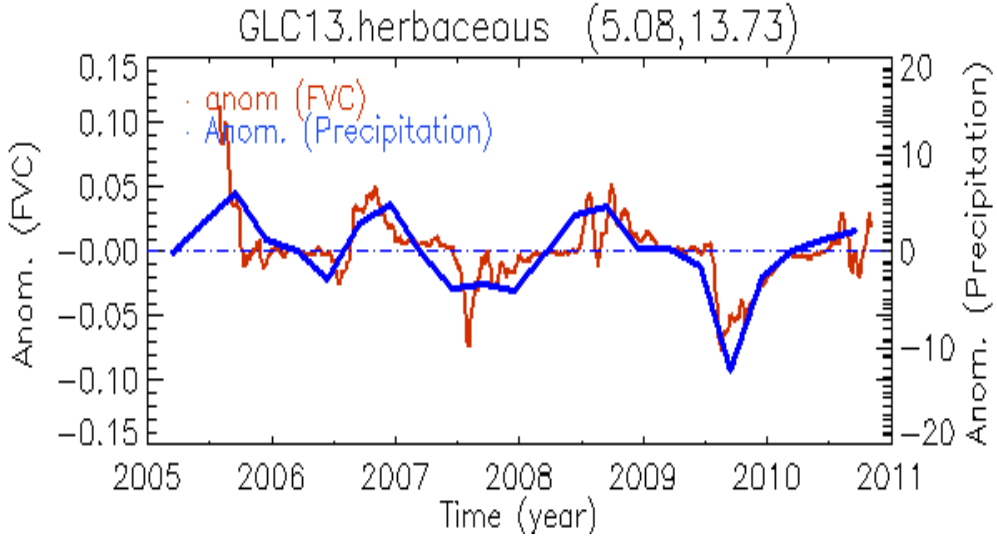
Climatologies based on timeseries of FVC (SEVIRI/MSG)

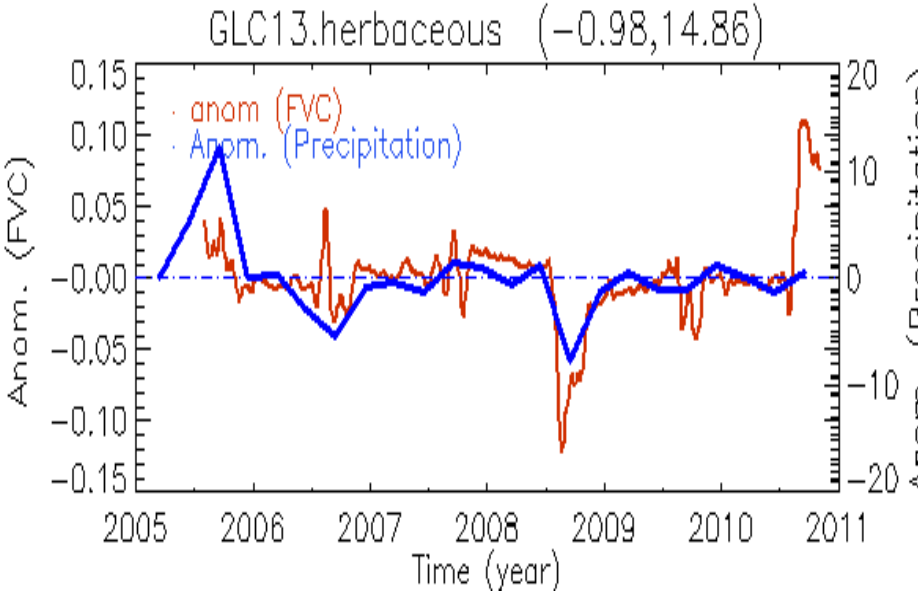
Vegetation response to climatic variability

Sahelian semi-arid environments





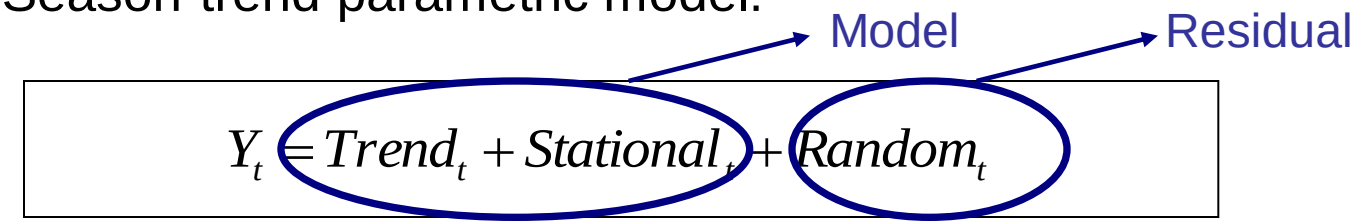




Automated monitoring of vegetation disturbance

Modeling the dynamics of vegetation

- Season-trend parametric model:



Example: Time series of SEVIRI FVC

- Seasonal: Amplitudes (A_k) and Phases (φ_k) of 3 harmonics: cycles of frequency annual, semi-annual and 4-monthly.
- Liner trend

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

- Estimation of model parameters: robust and fast (weigthed OLS), may incorporate errors (even gaps) of FVC values.

Automated monitoring of vegetation disturbance

STEPS:

- 1. Estimate model parameters (Normal behaviour)
- 2. Residual (= Observed - Normal)
- 3. Accumulated residual of the current day (t) and precedent (t-1, t-2,…t-n), ej. moving average $\Rightarrow$ Very negative values represent severe disturbance
- 4. ¿How to express a meaningful magnitude of disturbance?
  - Normalize accumulated residual by a measure of the expected variability (e.g. $\sigma_{inter\text{-}annual(t)}$, σ_y, $\sigma_{residual}$)

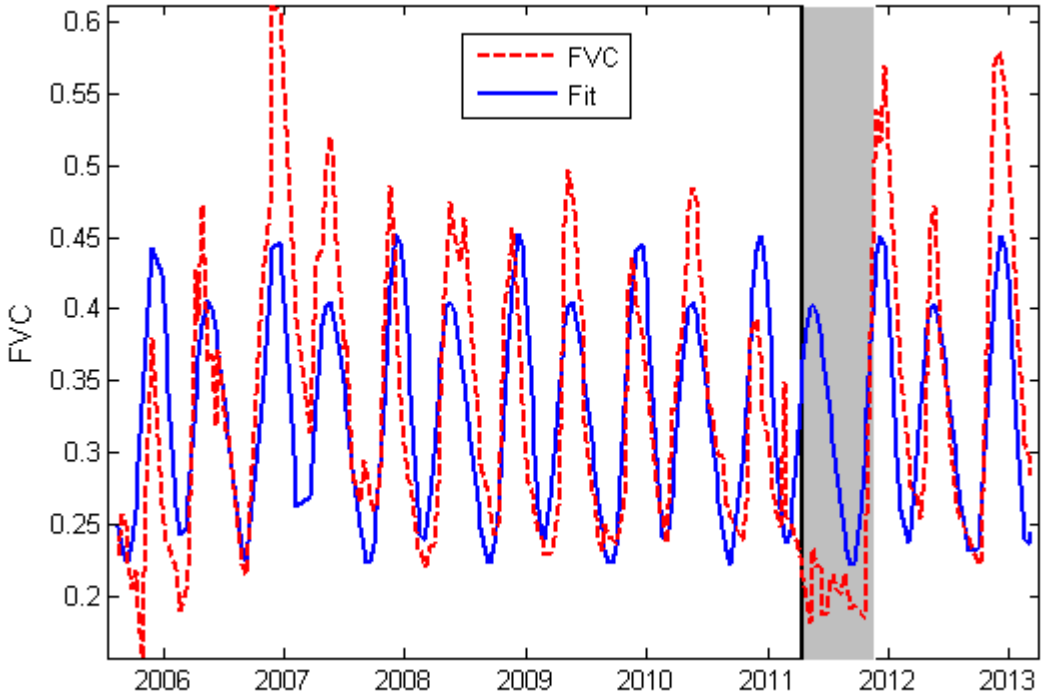
Example: Disturbance measure

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

APPLICATIONS:

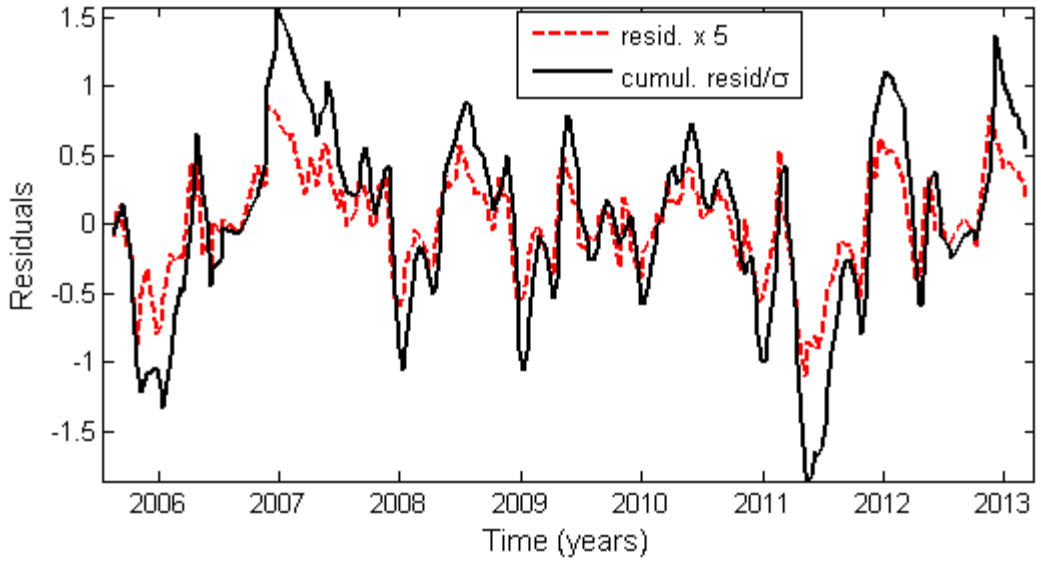
- Real time detection (drought, fire): Disturbance refer to deviation from a (stable?) history period (>1 years).
- Retrospectively monitoring the impact of disturbances: A single fit to the full series is a reasonable.
  - Period of recovery can be estimated (e.g. *std_resid* pass from -1 to 0)

Automated monitoring of vegetation disturbance



Example: Drought in Somalia (2011)

- FVC/MSG time series (Somalia)
- Savanna, 2 growing seasons
- Fully automated: Only disturbances with *std_resid*<-1 are detected



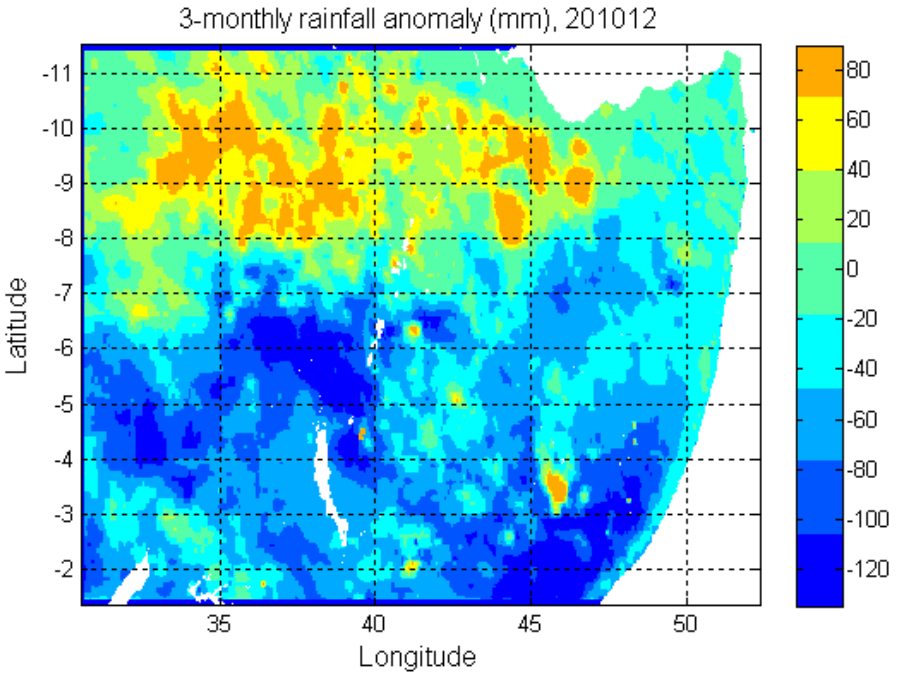
SEVIRI Capabilities (VEGA)

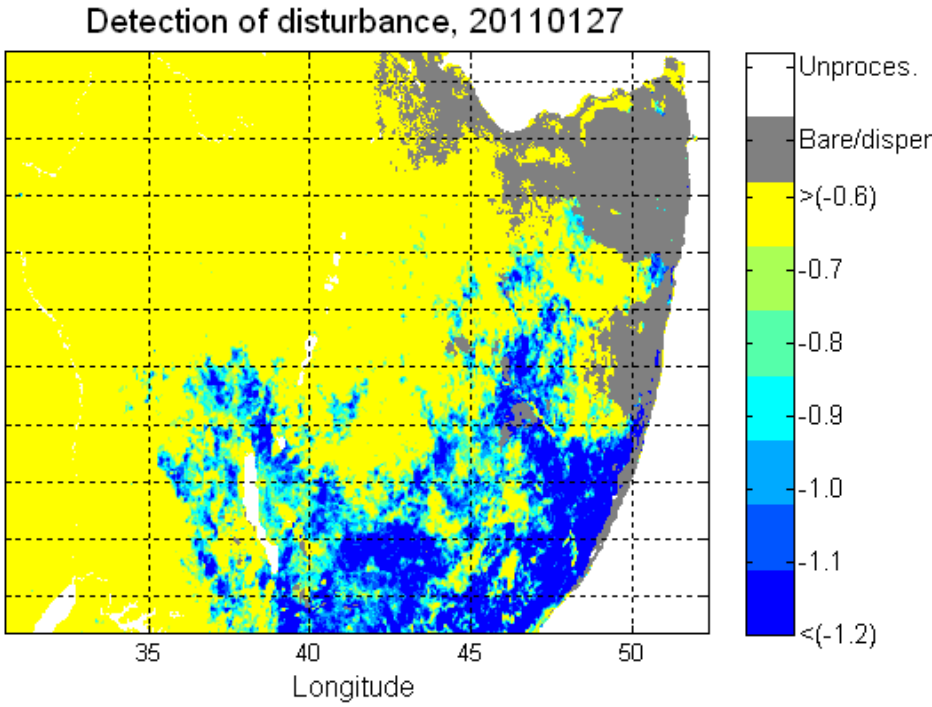
- High frequency and continuity
- Normal season-trend can be usually captured from a single year

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

Severe drought in Horn of Africa (2011):

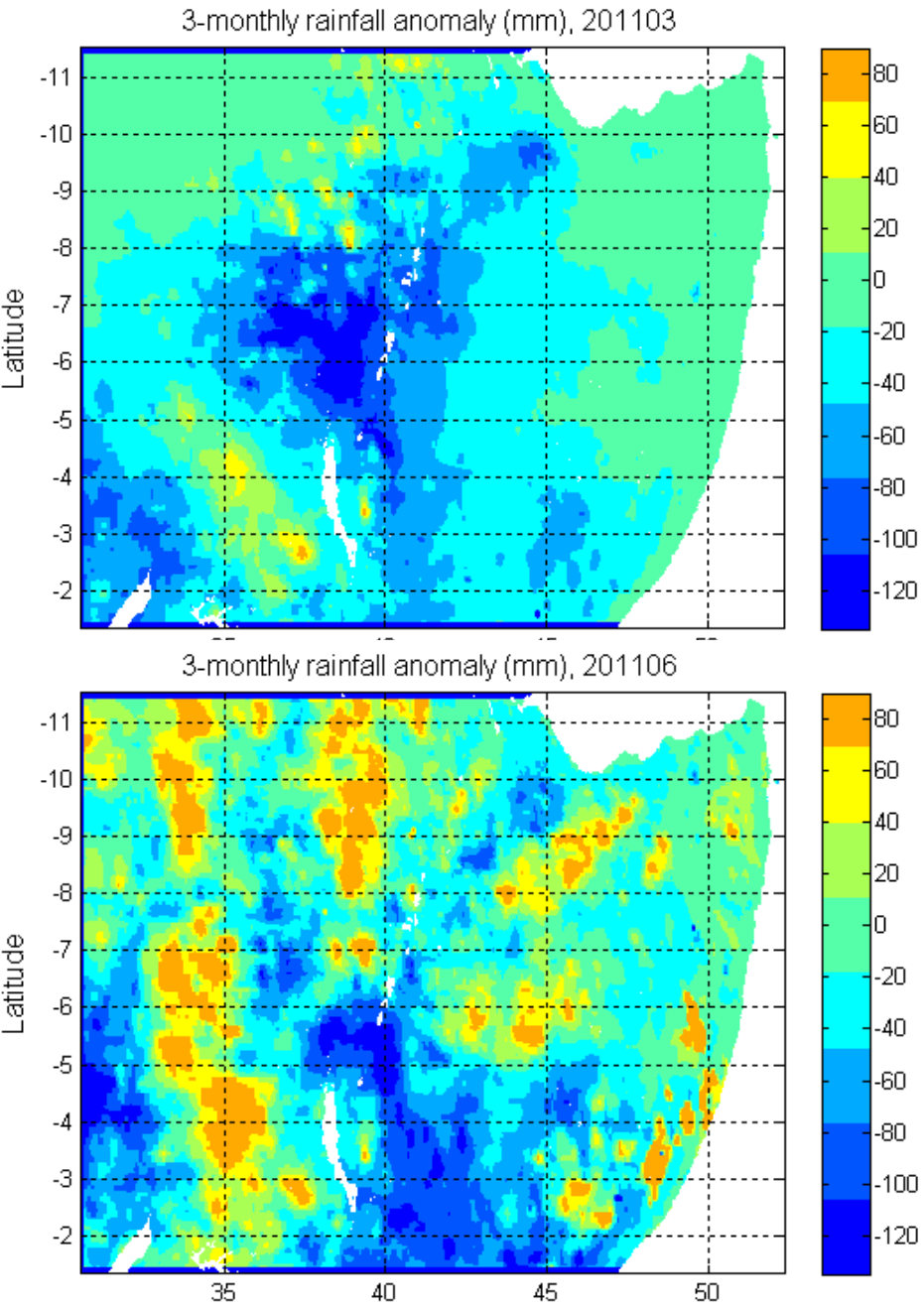
- Shortage of rain in the two rainy seasons (autumn and spring)

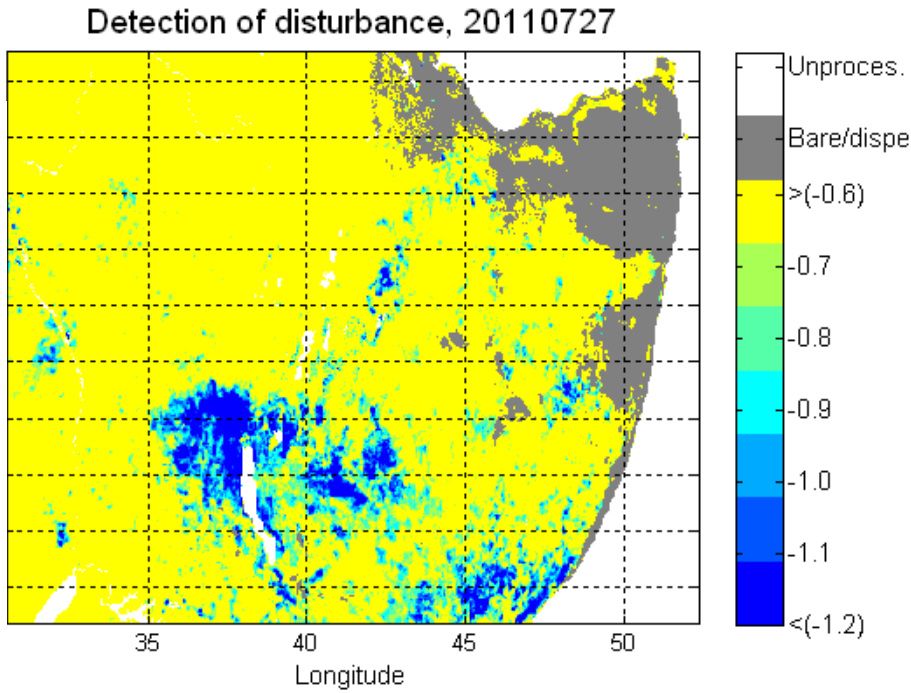




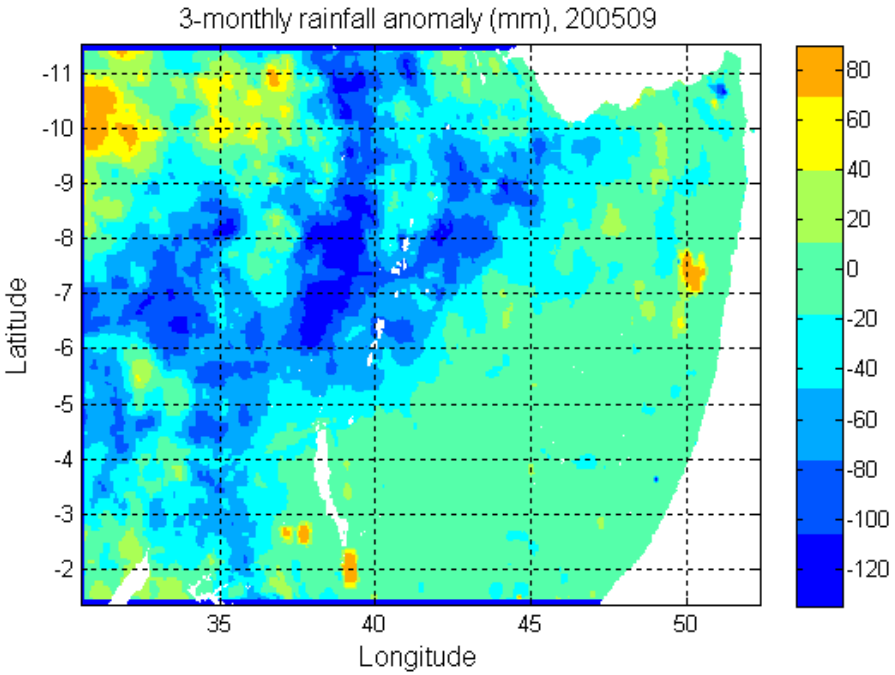
Drought monitoring

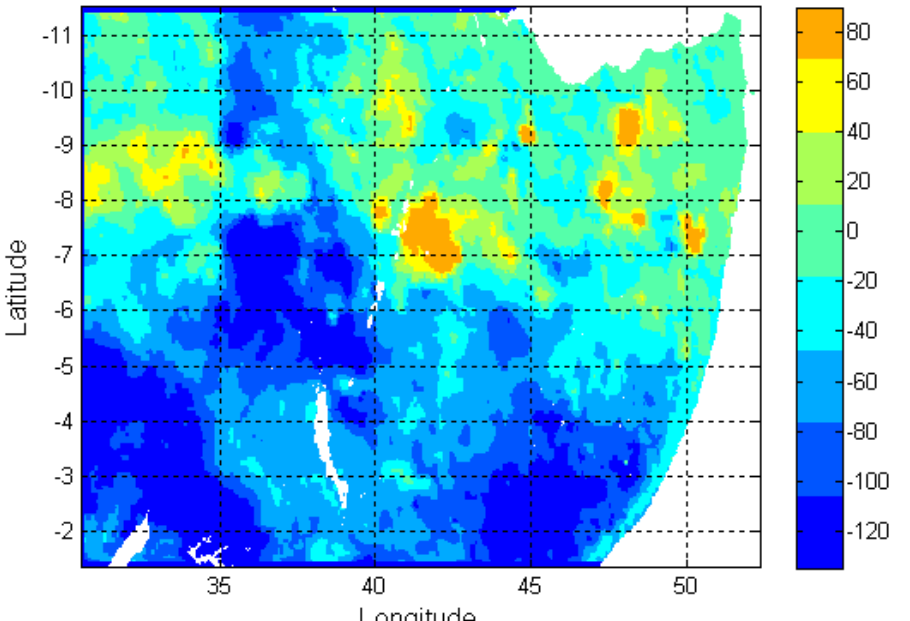
Horn of Africa (2011)





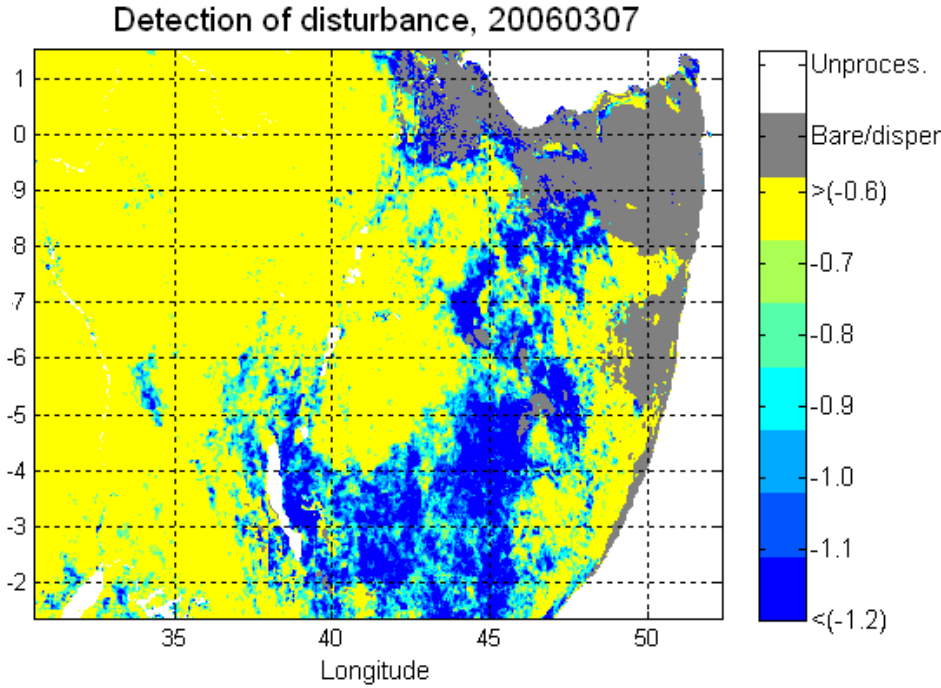
Drought monitoring





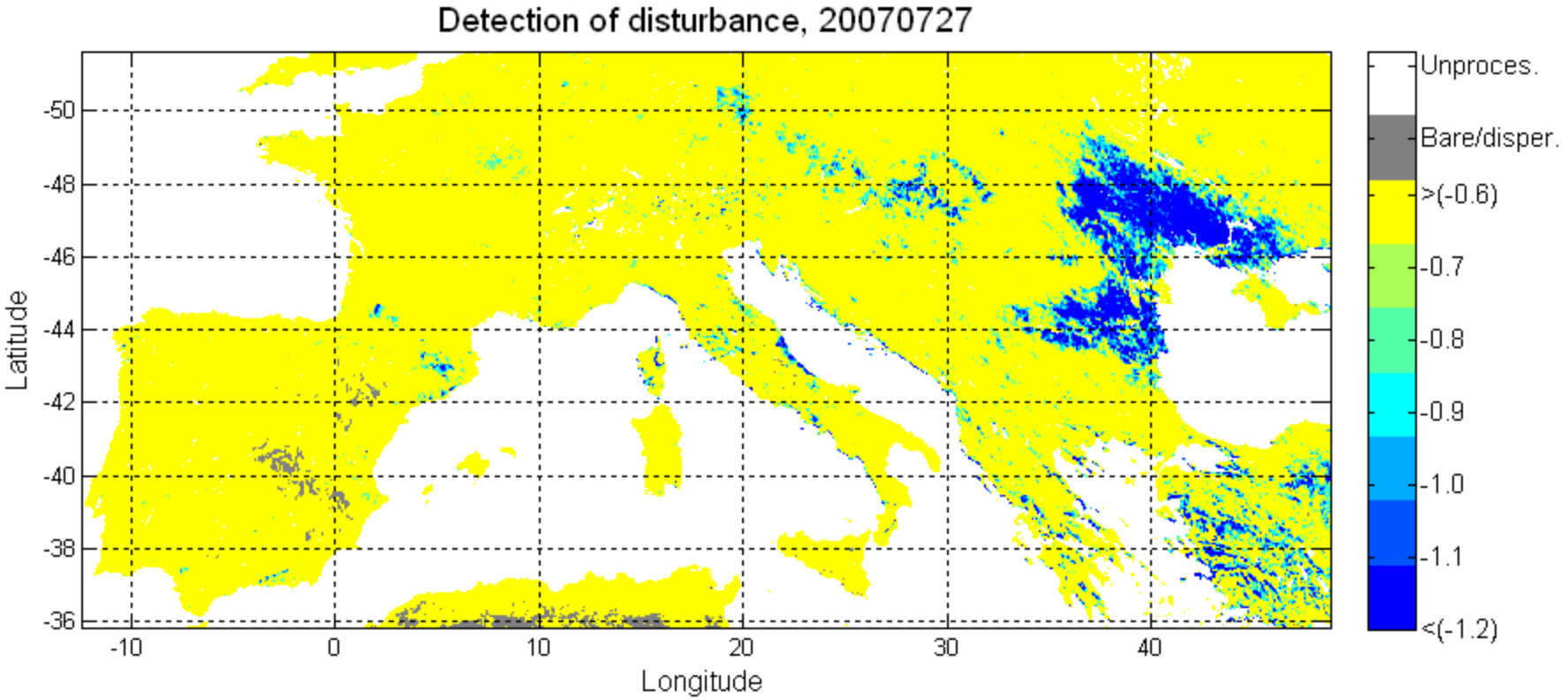
A similar example

- Drought in 2006



Drought monitoring

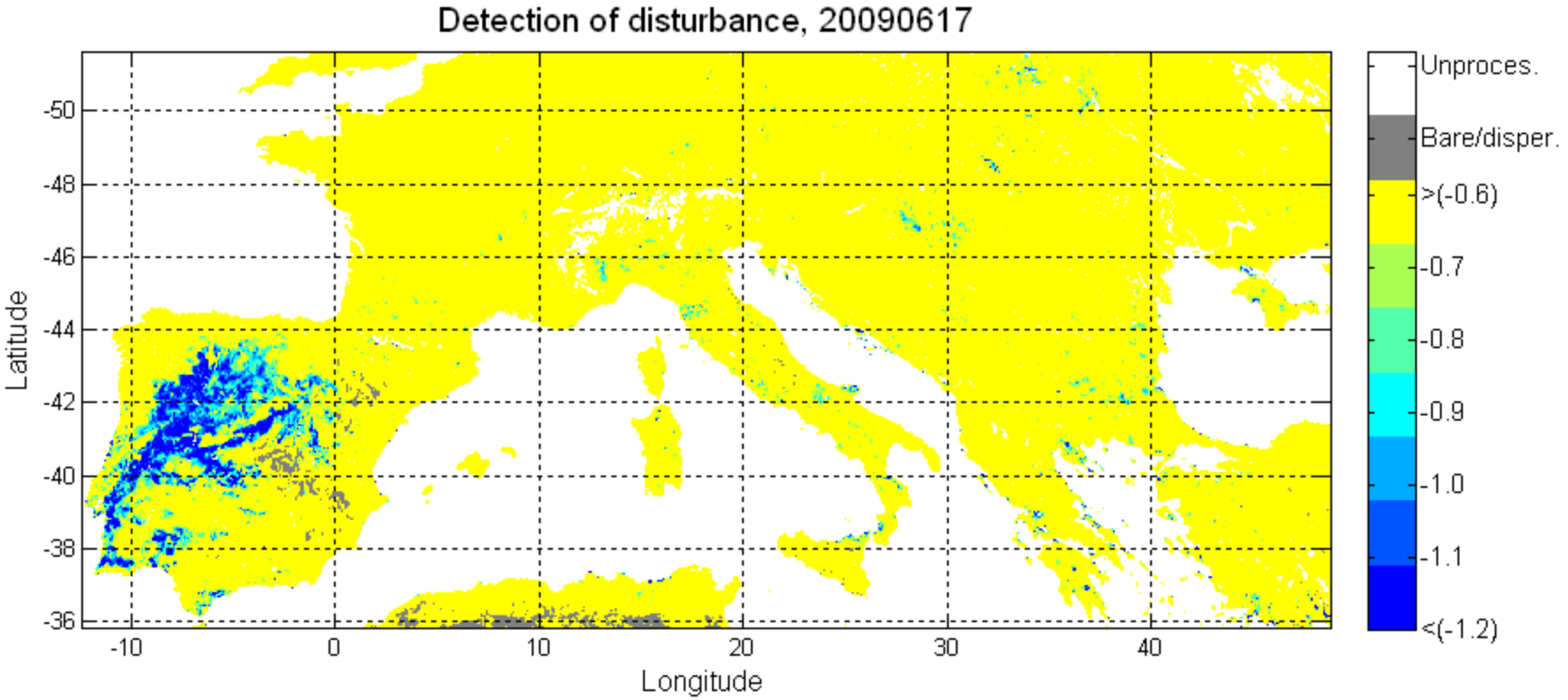
Southern Europe



Western Europe (summer, 2007)

Drought monitoring

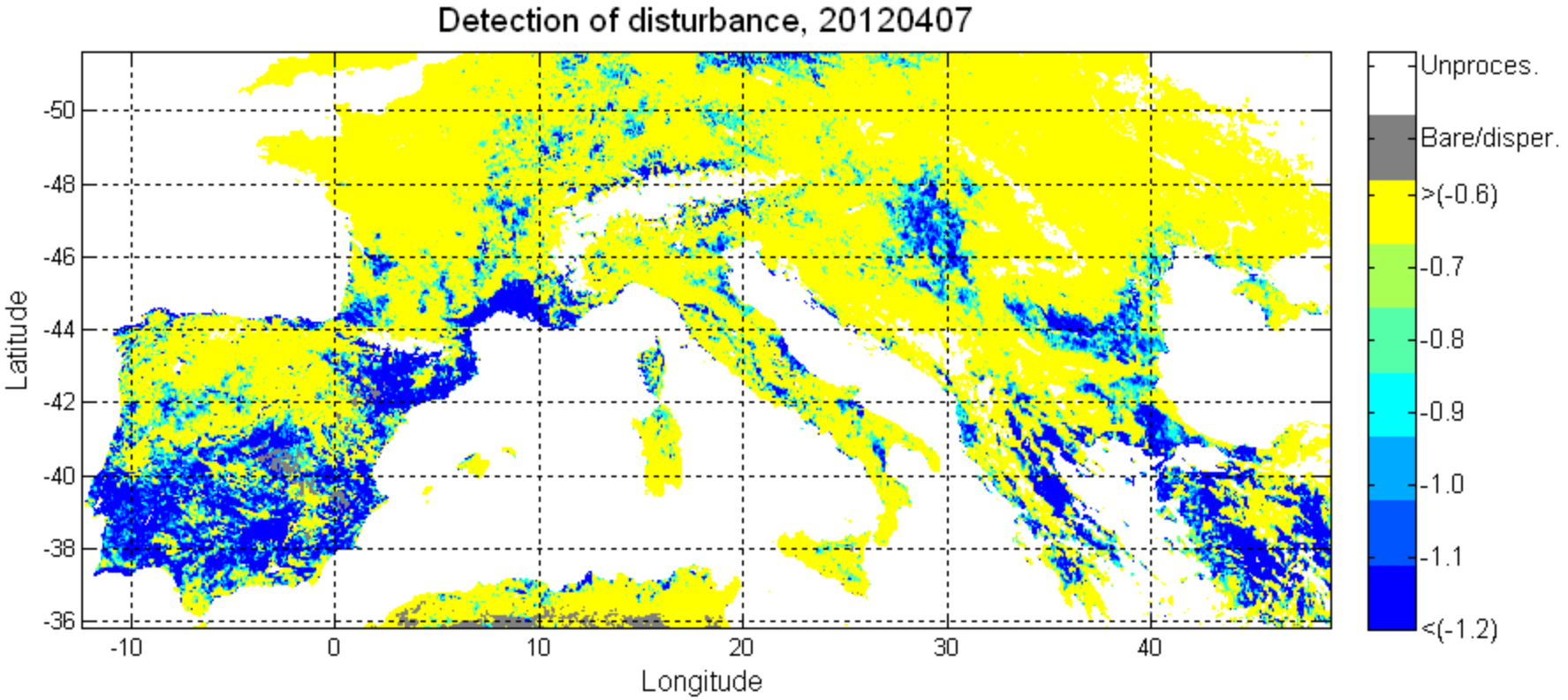
Southern Europe



Iberian Peninsula (spring, 2009)

Drought monitoring

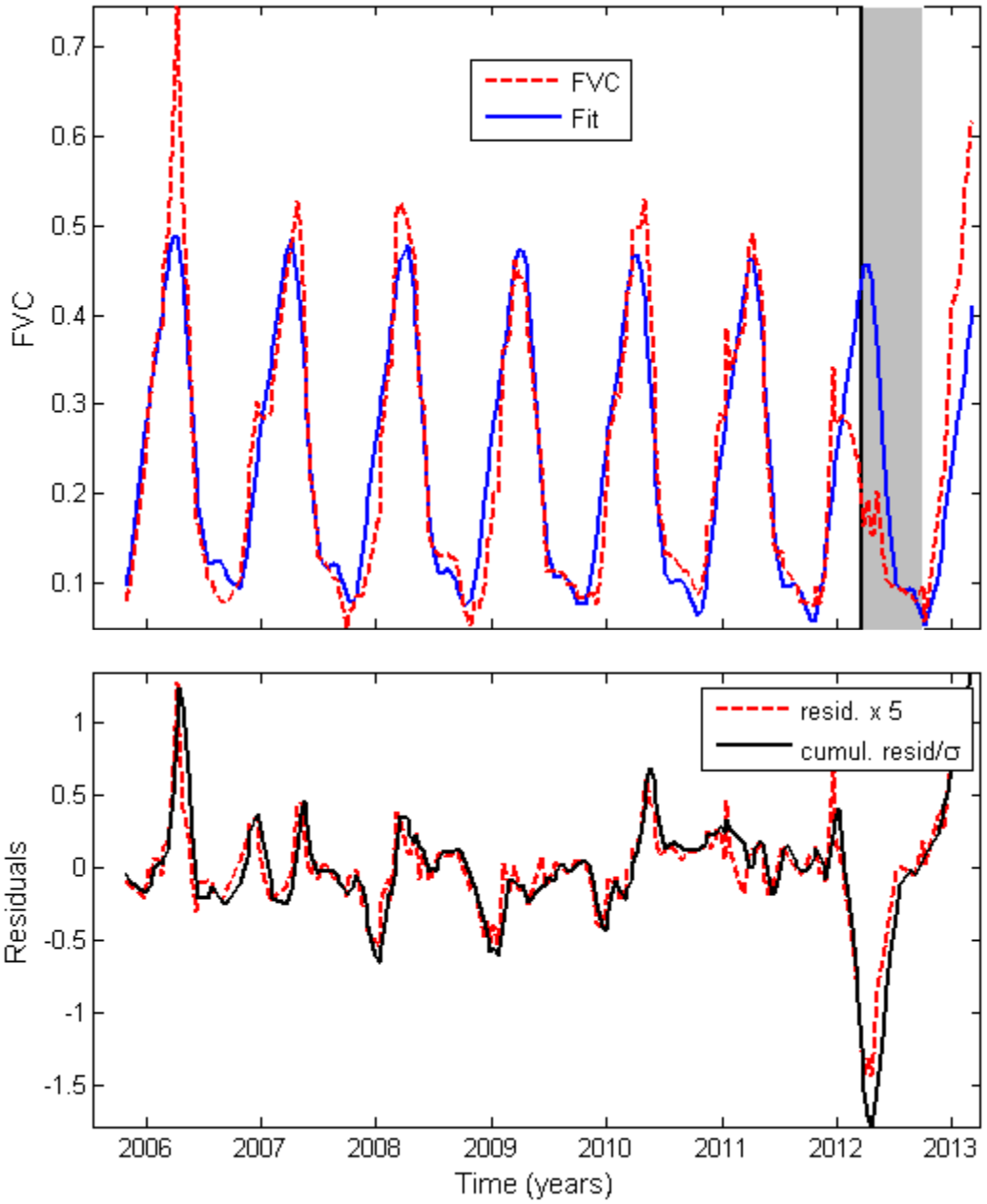
Southern Europe



Mediterranean countries (spring, 2012)

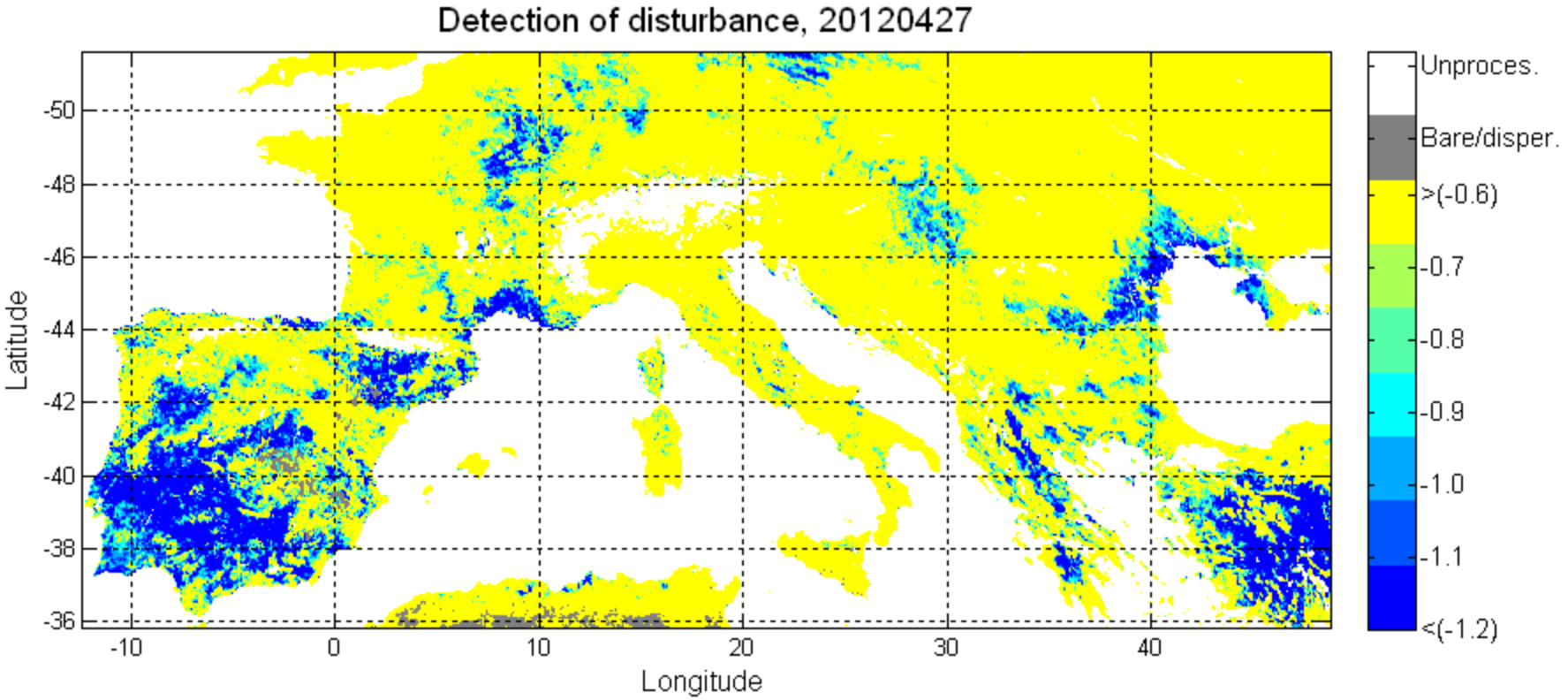
Drought monitoring

Iberian Peninsula Drougth (2012)



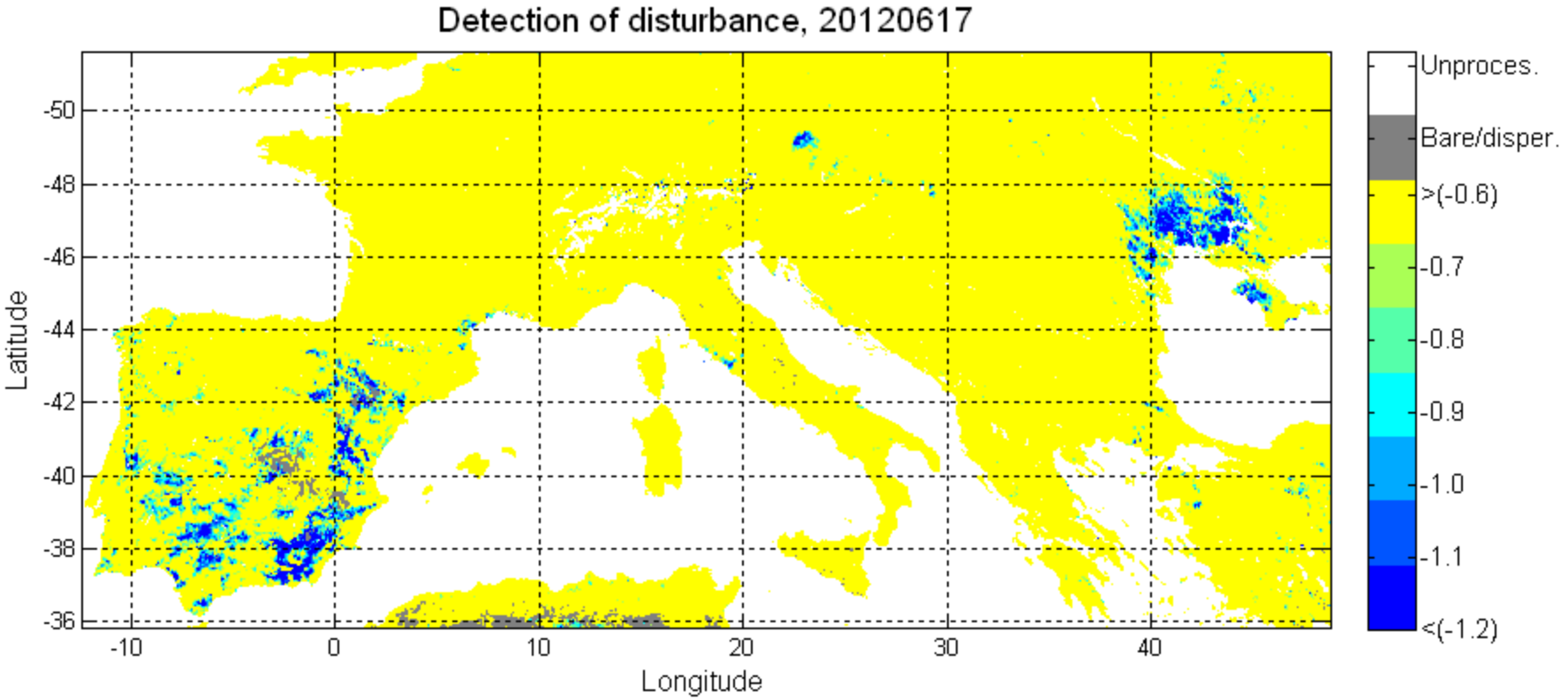
Drought monitoring

Southern Europe

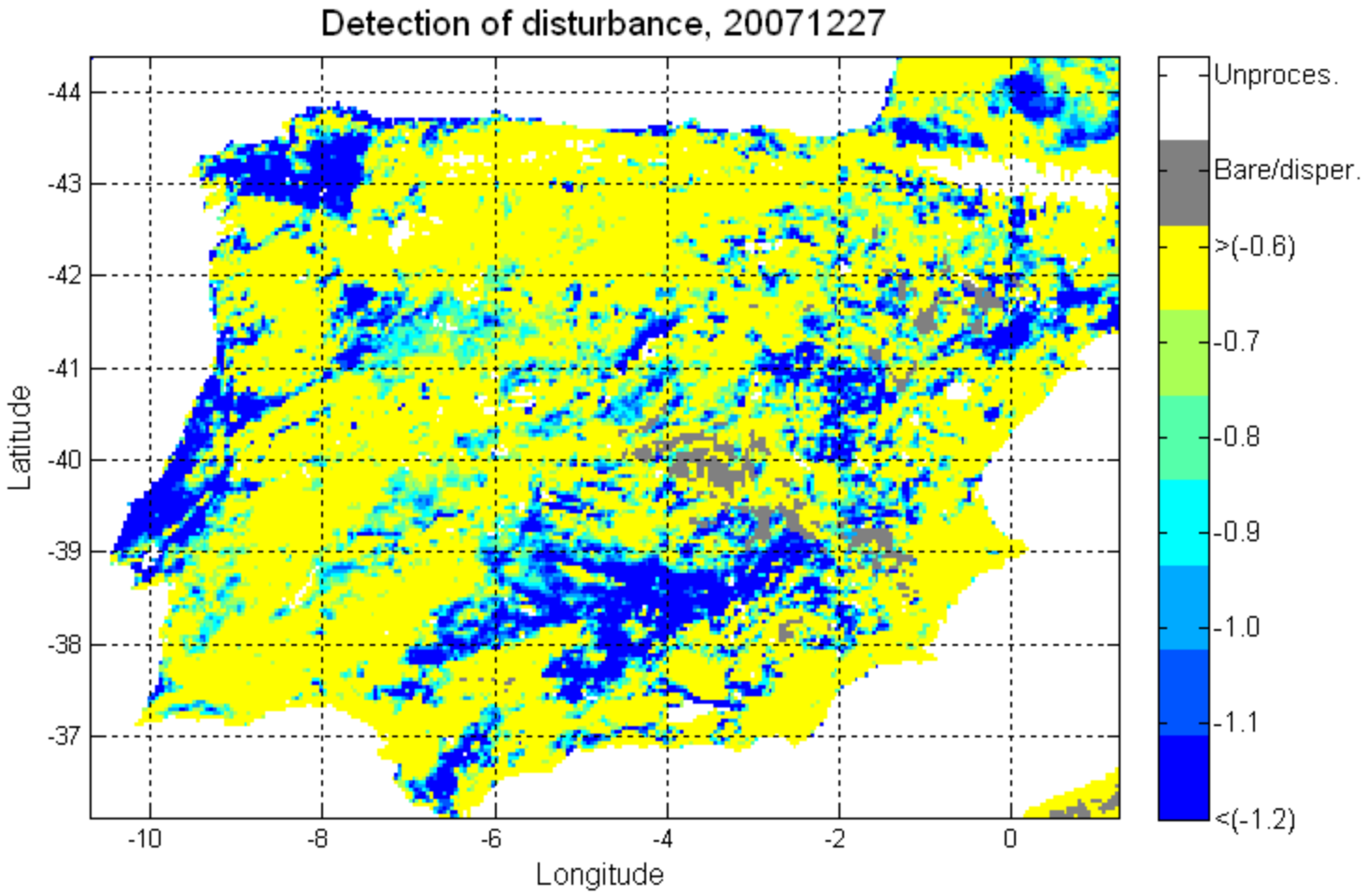


Mediterranean countries (spring, 2012)

Drought monitoring

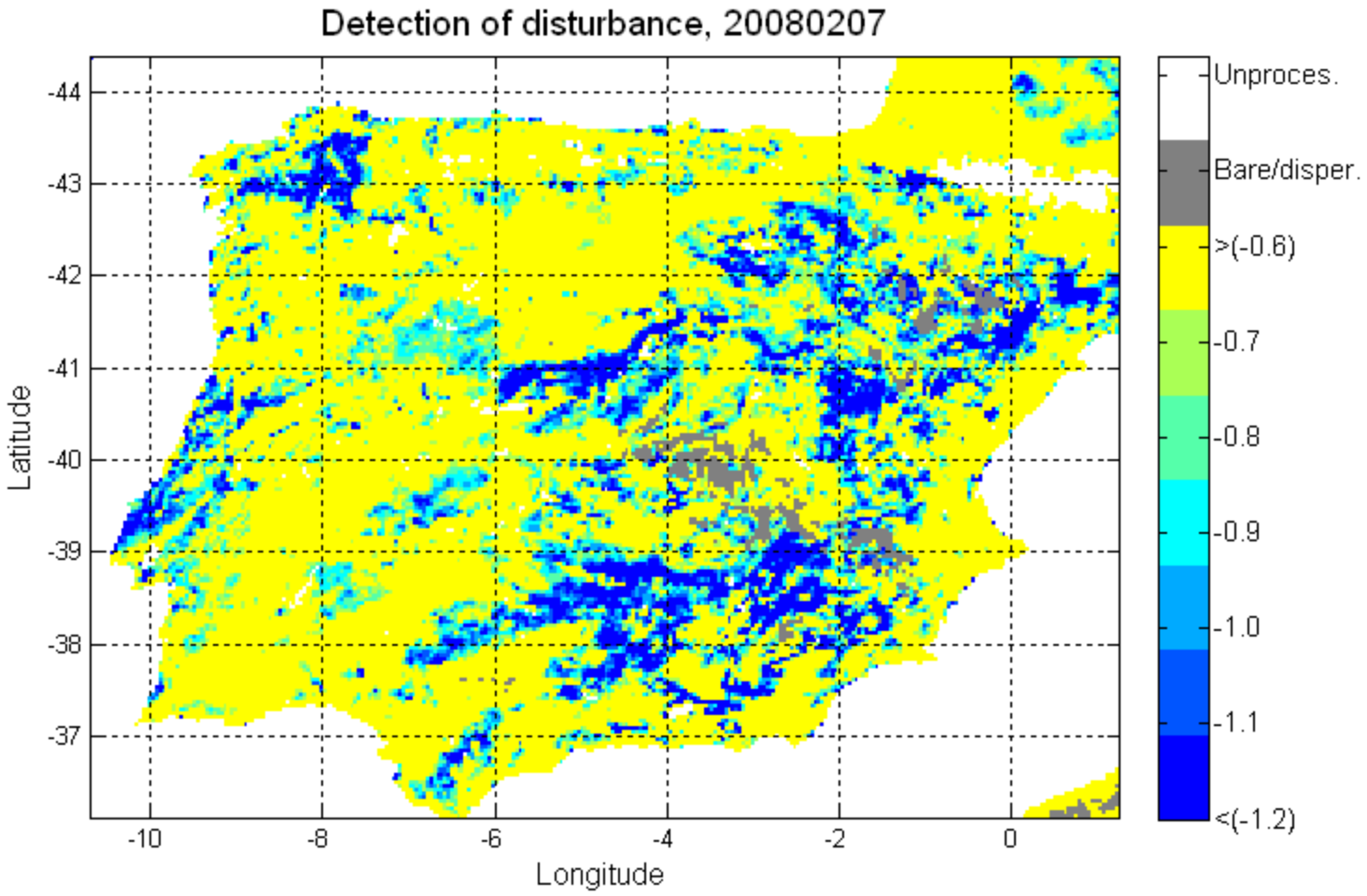


Drought monitoring



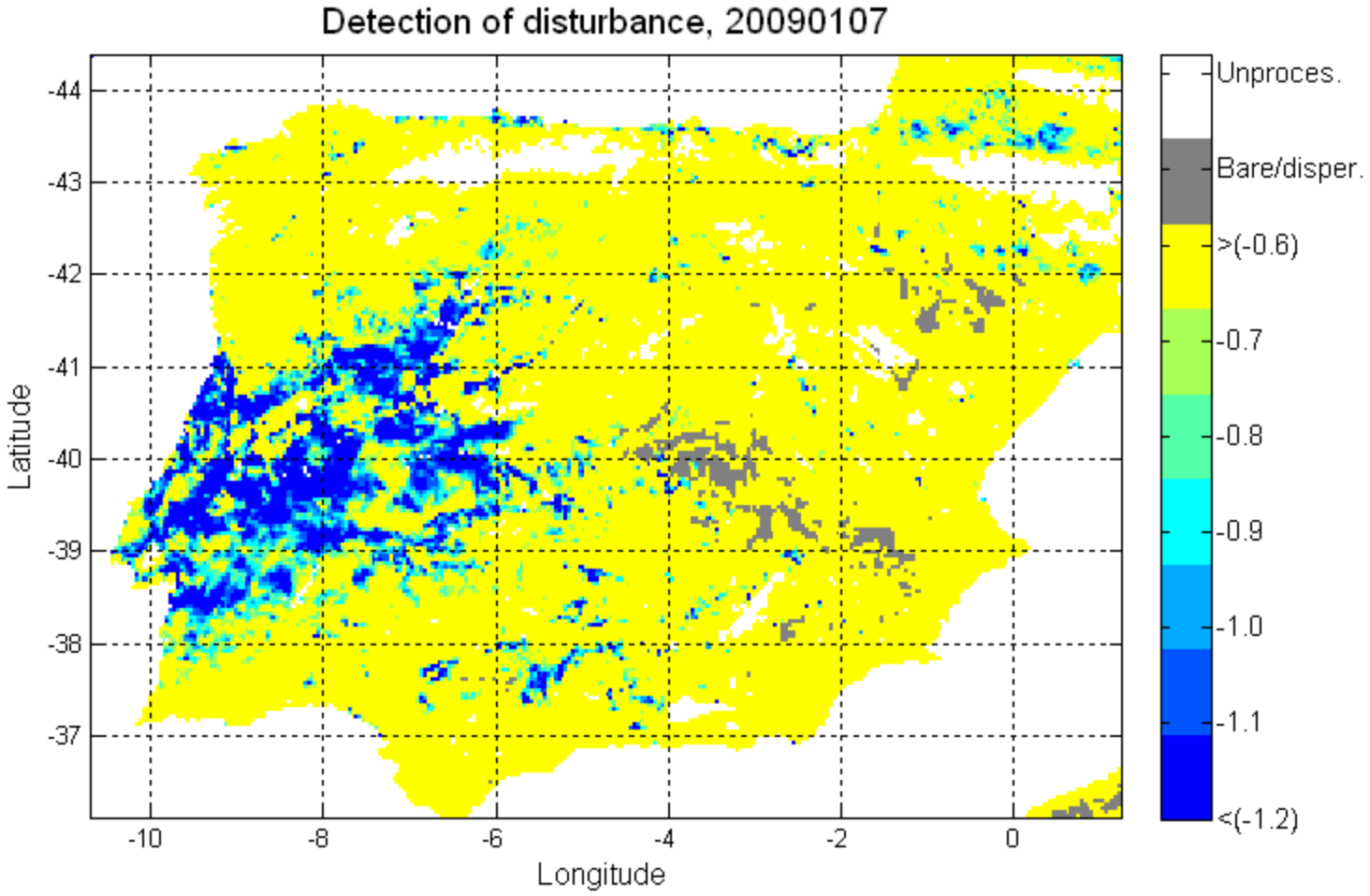
Iberian Peninsula (spring, 2008)

Drought monitoring



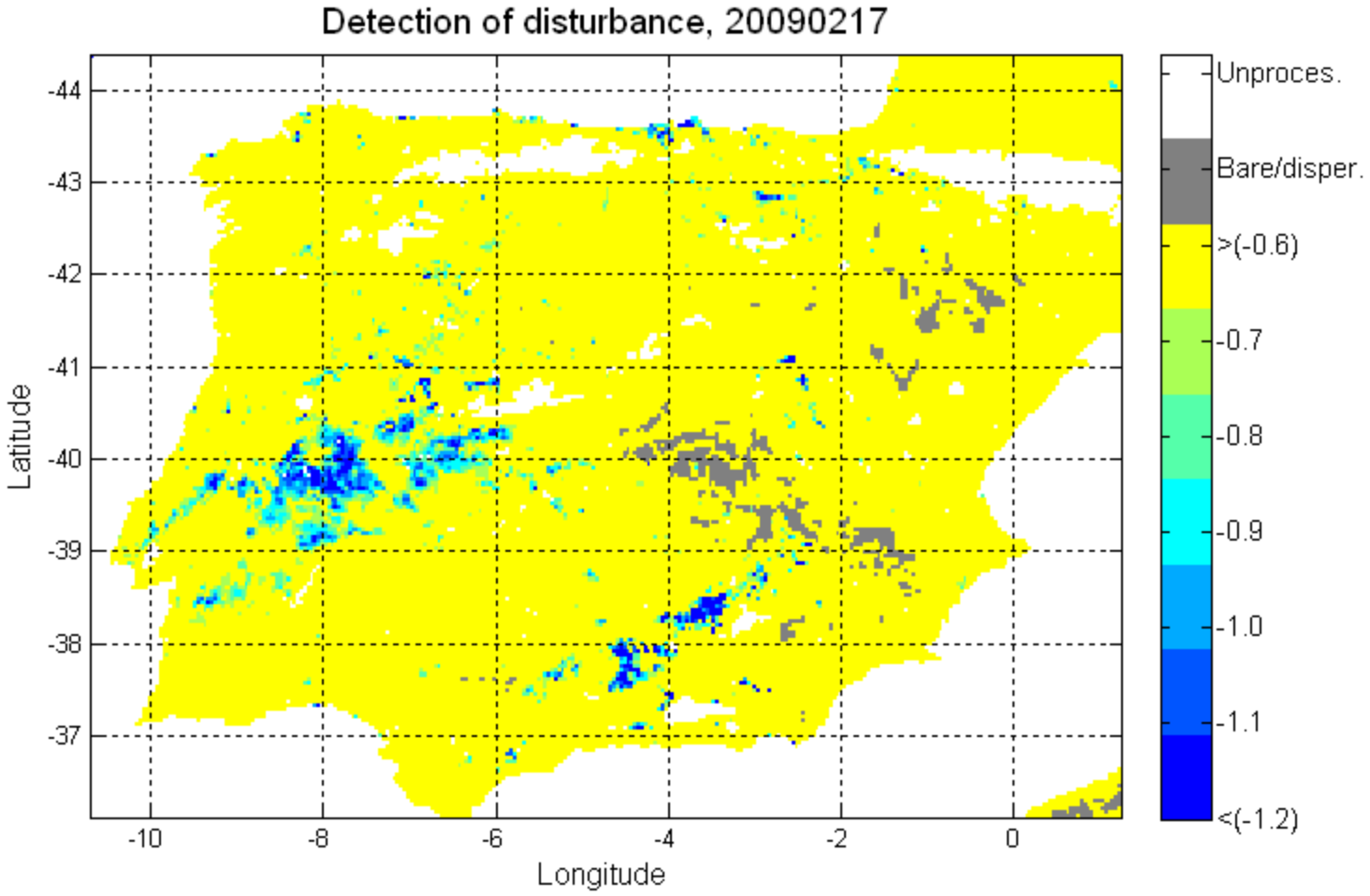
Iberian Peninsula (spring, 2008)

Drought monitoring



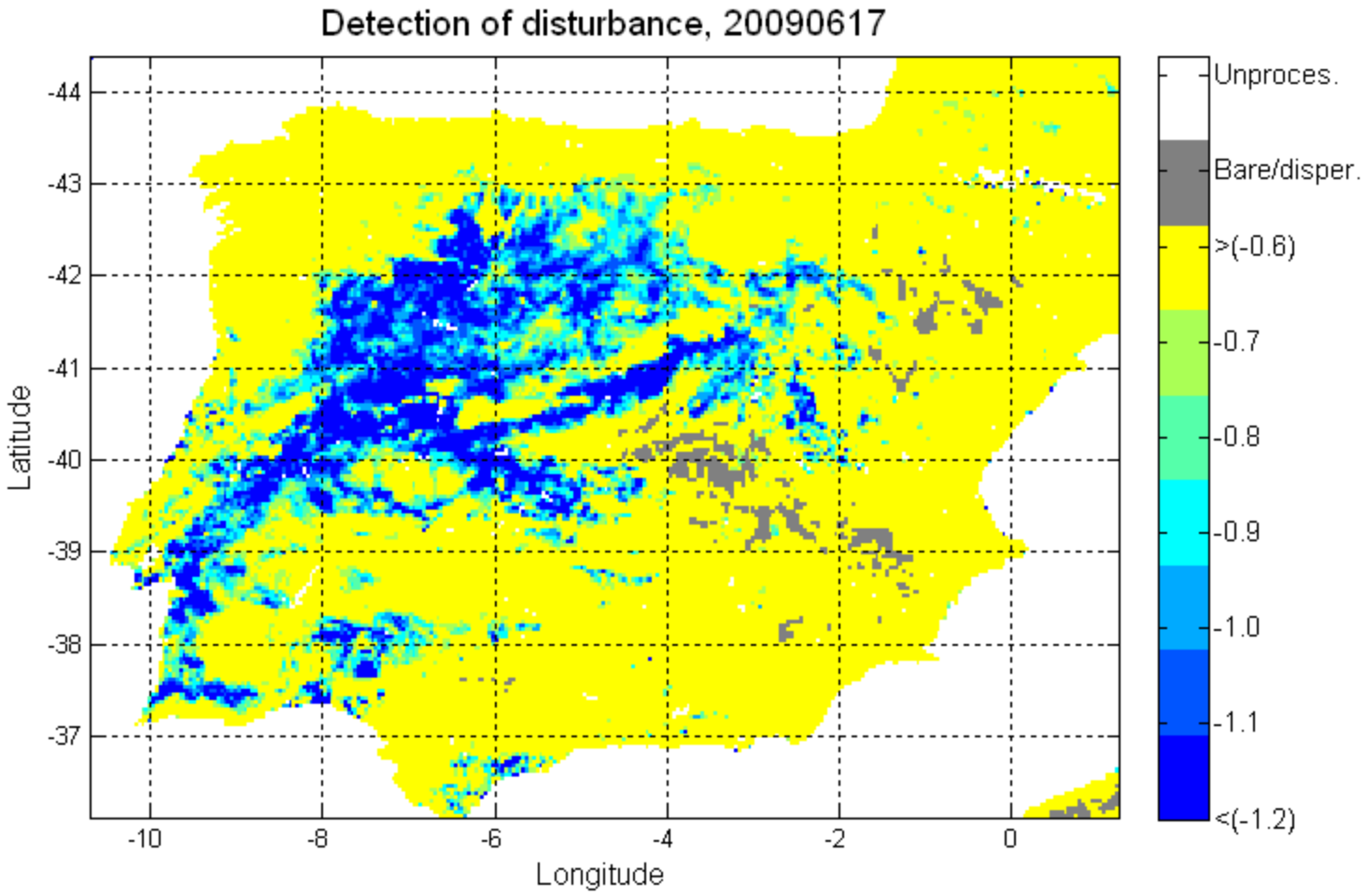
Iberian Peninsula (spring-summer, 2009)

Drought monitoring



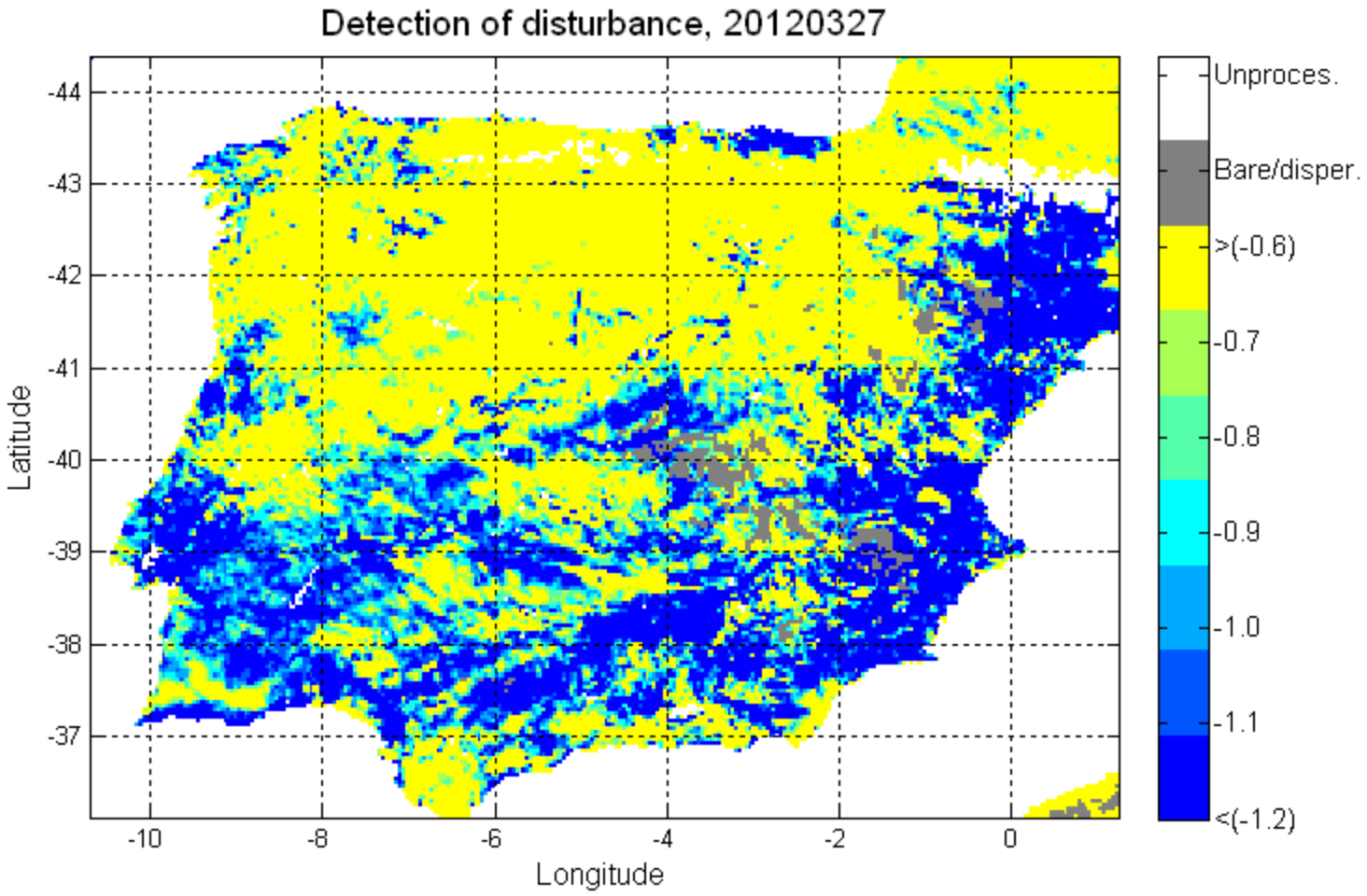
Iberian Peninsula (spring-summer, 2009)

Drought monitoring



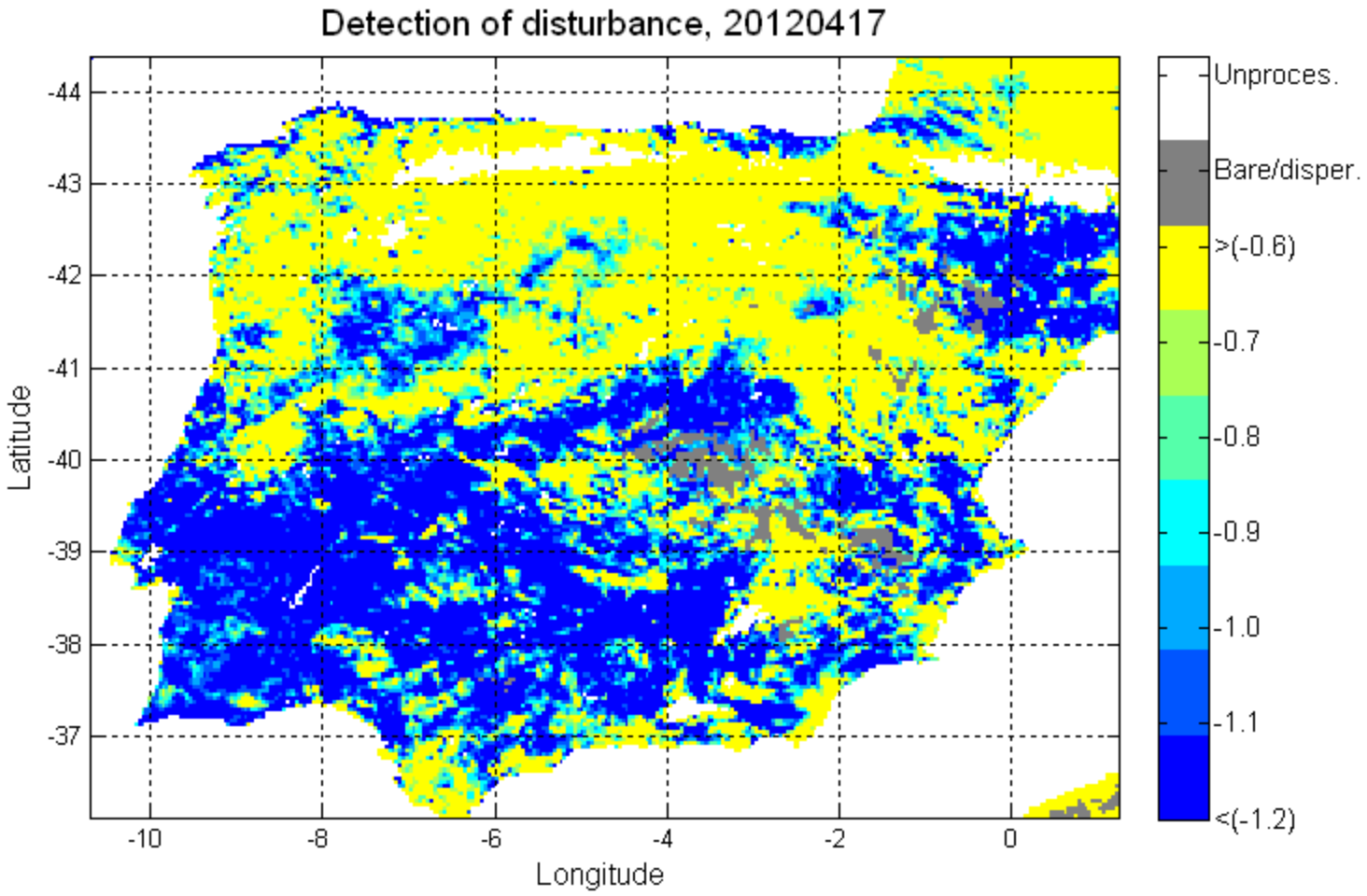
Iberian Peninsula (spring-summer, 2009)

Drought monitoring



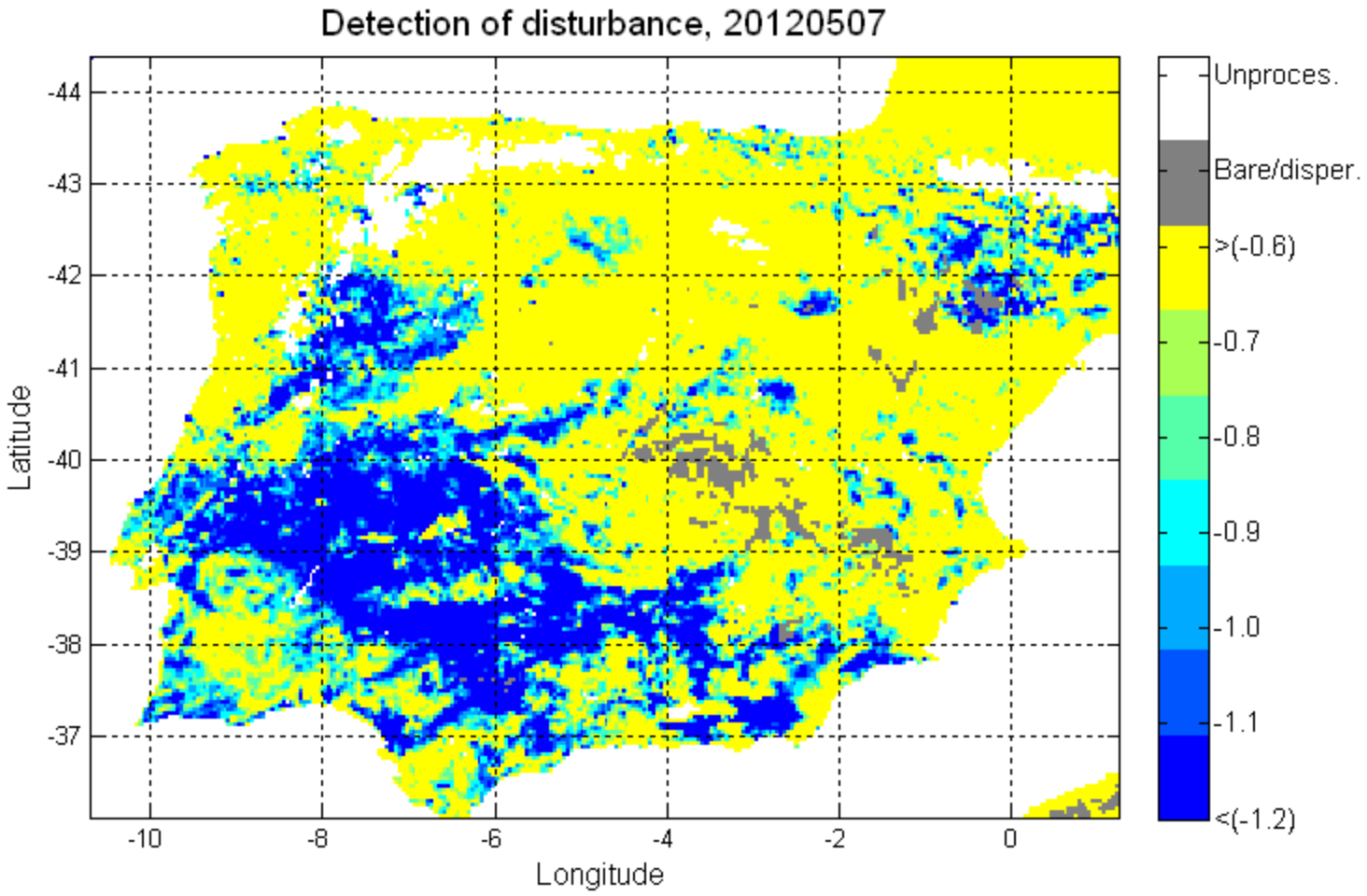
Iberian Peninsula (spring, 2012)

Drought monitoring



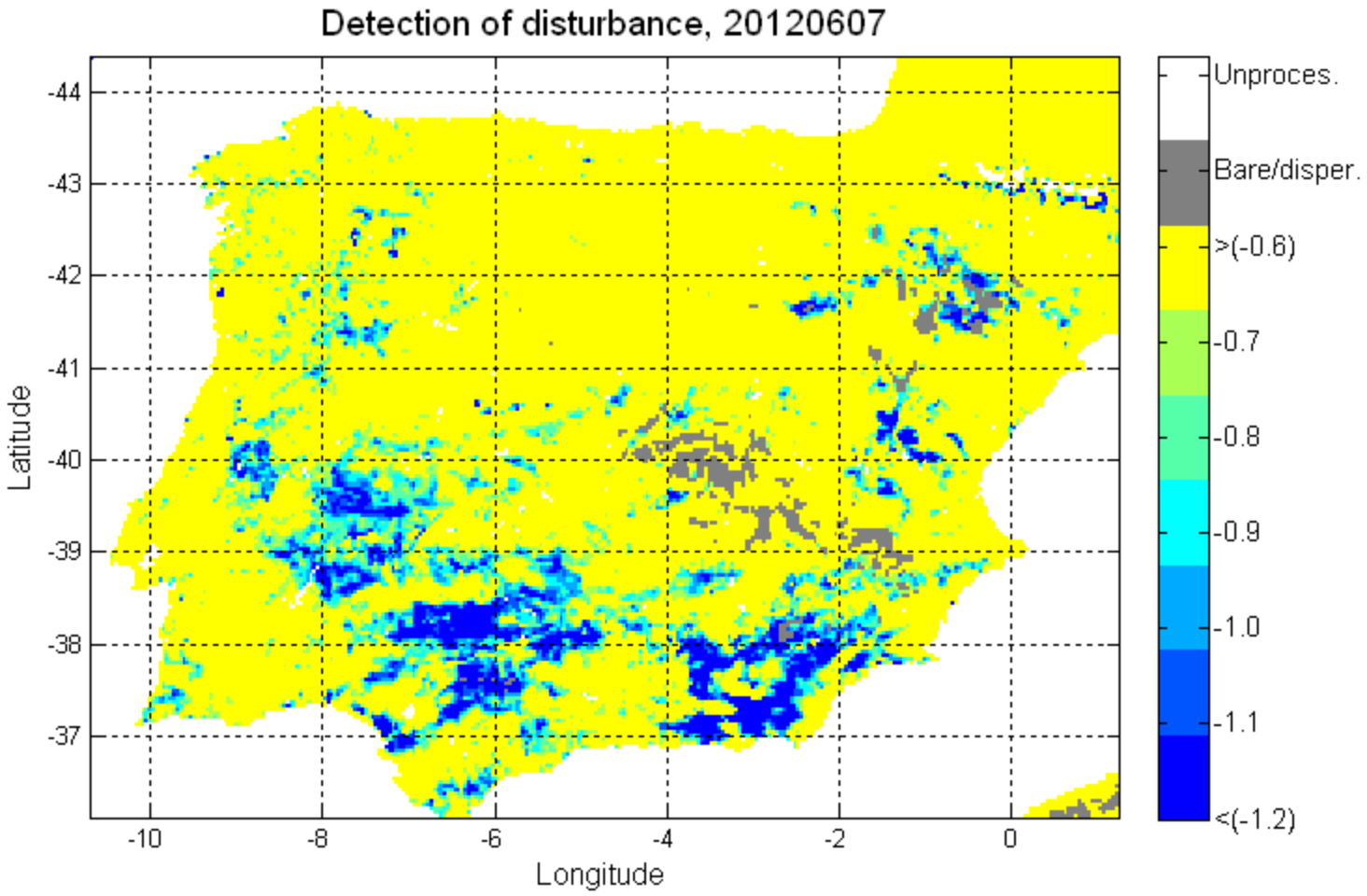
Iberian Peninsula (spring, 2012)

Drought monitoring

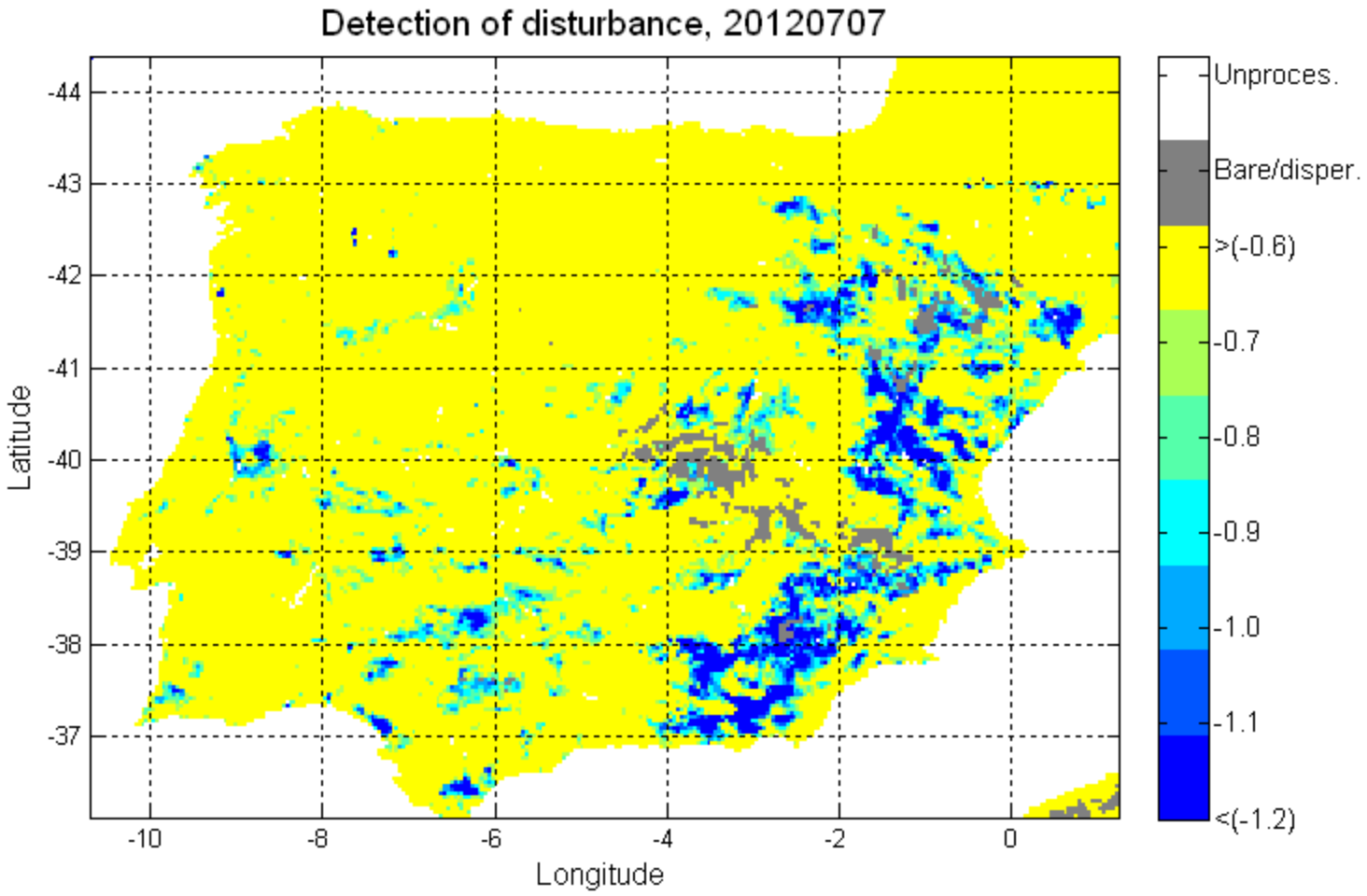


Iberian Peninsula (spring, 2012)

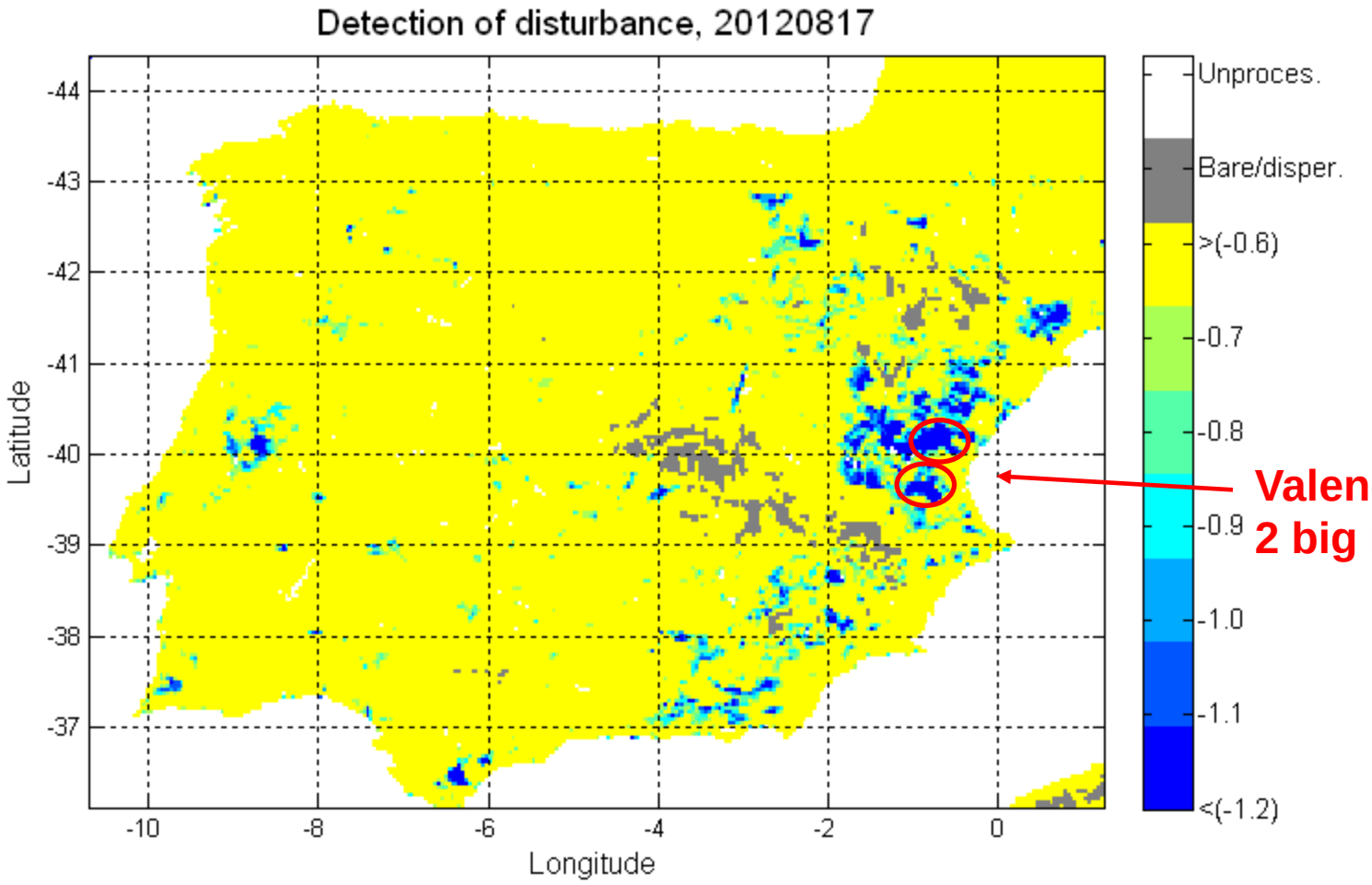
Drought monitoring



Drought monitoring



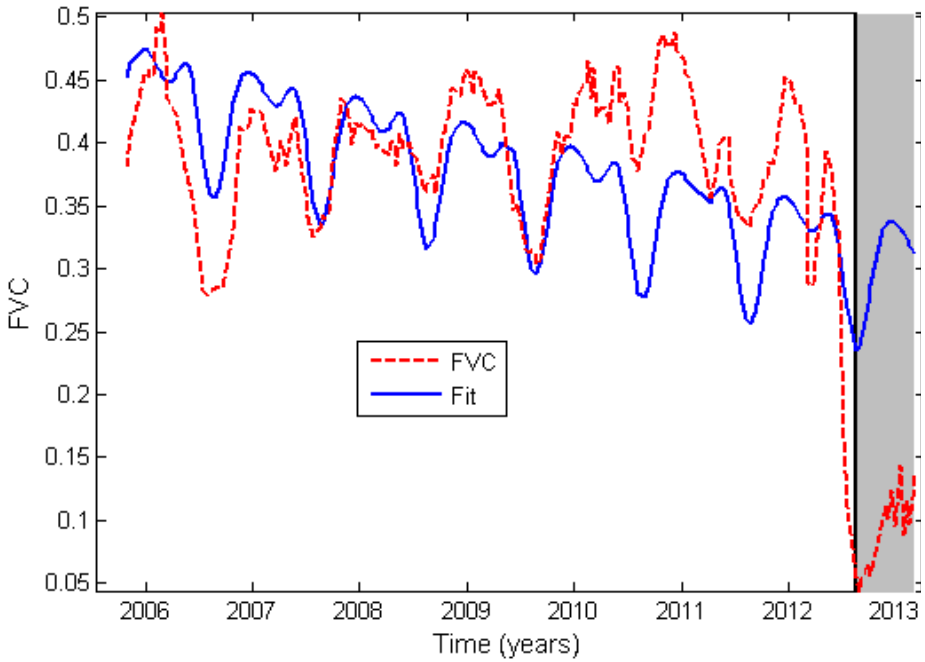
Drought monitoring

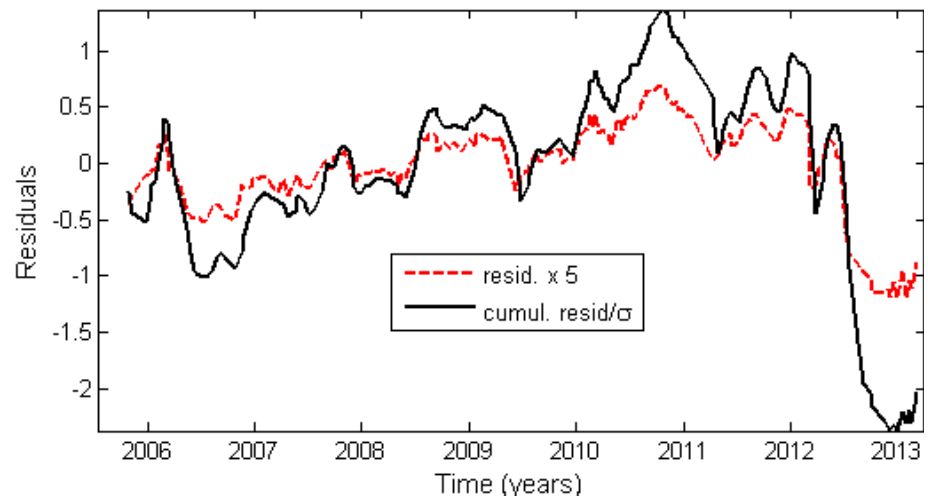


Drought monitoring

Fire related disturbances

Valencia, July 2012





Greece 31-August 2007