Potential of the EUMETSAT LSA-SAF Evapotranspiration for drought monitoring in Europe; a study developed in the framework of the European Drought Observatory.

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Eumetrain Event on Droughts, Floods and Landslides

1/12/2014

1. Some concepts about Drought
2. European Drought Observatory (EDO)
3. LSA-SAF ET for drought monitoring
4. Potential of other LSA-SAF for drought monitoring

River Rhine, November 2011

Key Terms

(1) Drought

- ✓ Complex phenomena with as much definitions as impacts (meteorological, hydrological, socioeconomic drought…)
- ✓ Significant negative deviation of rainfall amounts from the climatic average
- ✓ Is a natural phenomenon occurring in all climates
- ✓ It is not possible to control the occurrence of droughts although the resulting impacts
- ✓ may be mitigated to a certain degree (e.g., appropriate surveillance and management strategies; Drought Management Plans)

(2) Water Scarcity

- ✓ Water demand exceeds the water resources exploitable under sustainable conditions
- ✓ Refers to a long-term water imbalance between availability and demand.

Economic Impacts:

- Agricultural drought can have severe economic and social consequences, especially in regions with limited water resources or with imbalances between water demand and natural supply capacity.

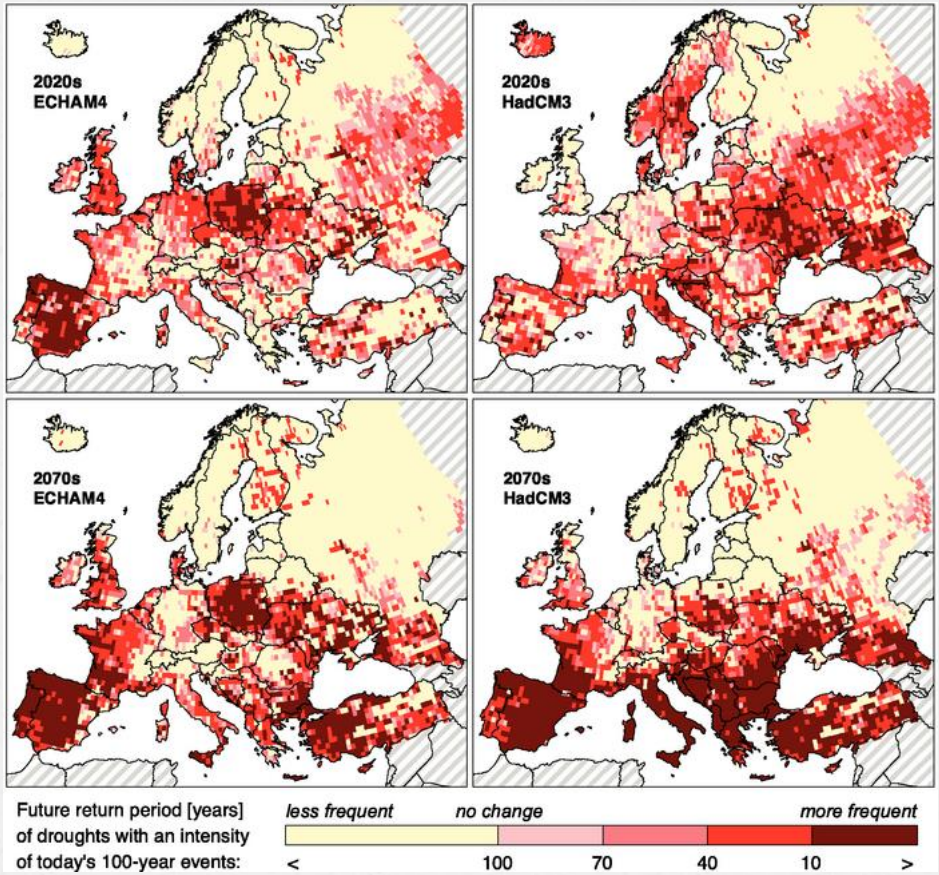
- For example, the 2005 drought event in Spain led to a 40% loss of cereal production, and the estimated non-irrigated crop and pasture losses reached 2,500 million euros (European Commission, 2006).

Environmental Impacts:

- Drought can cause serious long-term environmental impacts (e.g., water quality, salinization, desiccation of wetlands, soil erosion, desertification, …)
- These impacts are difficult to quantify and data are generally lacking

Expected Change in Drought Return Periods

Expected Change in Return Periods of Today's 100-years Events

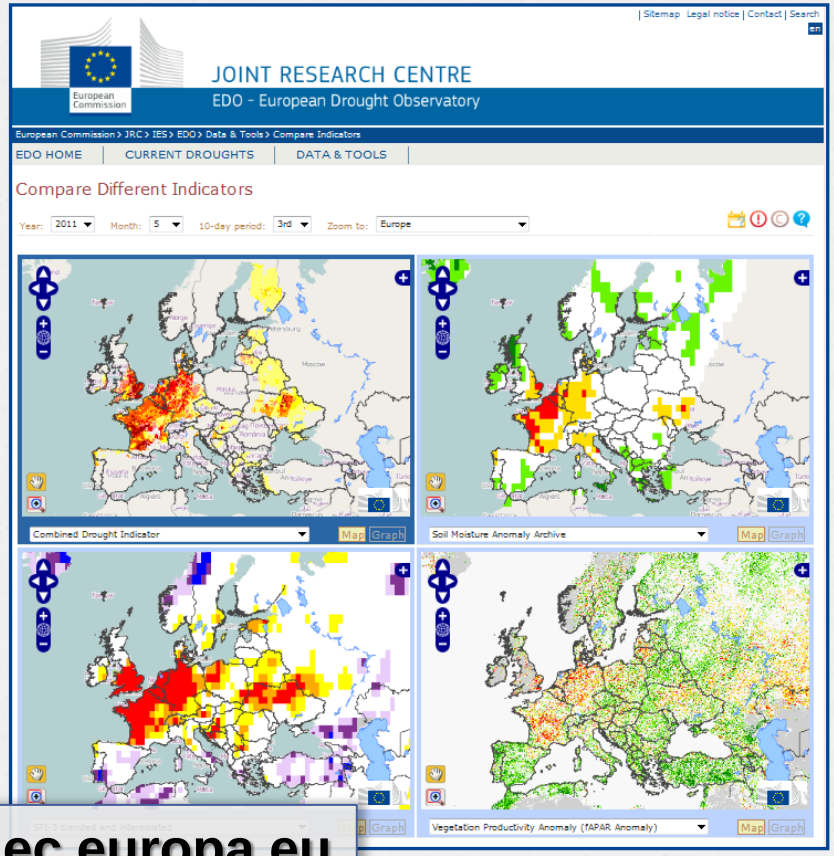


2020s

2070s

Lehner, B. *et al*., 2006: Estimating the impact of global change on flood and drought risks in Europe: A continental integrated assessment. *Climatic Change*, 75, 273-299

European Drought Observatory (EDO)

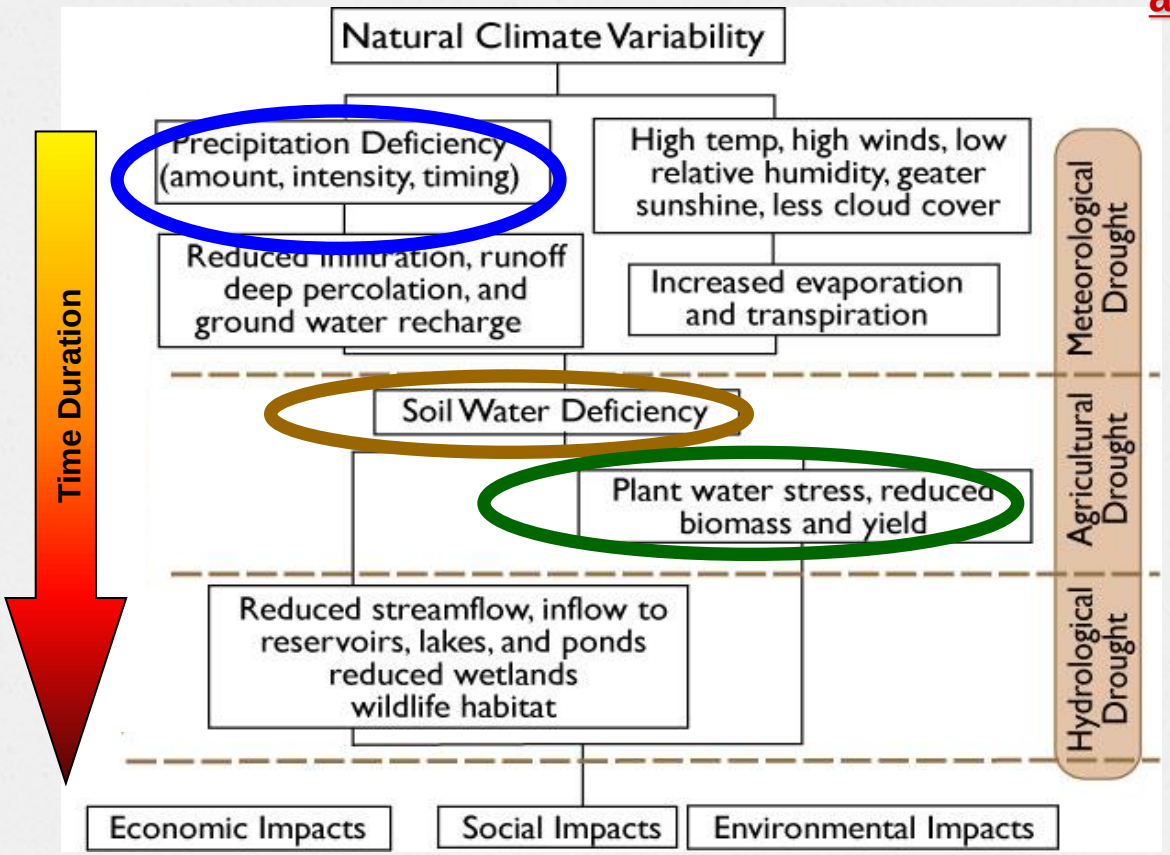


http://edo/jrc.ec.europa.eu

Information, data and tools to monitor and assess drought events across Europe

Multi-Indicator Approach

at continental scale



Standardized Precipitation Index

Soil Moisture Anomaly

Vegetation Response

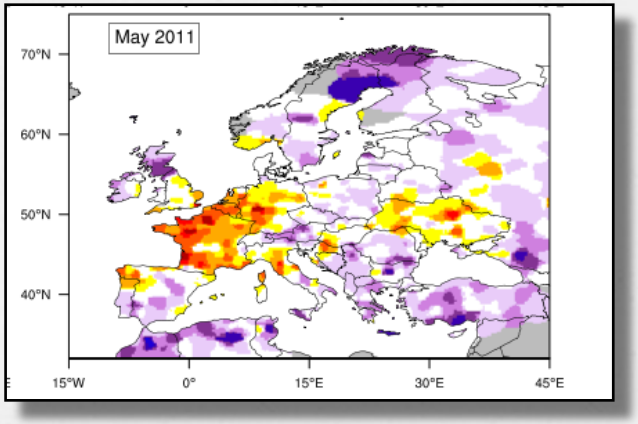
Source: National Drought Mitigation Center, University of Nebraska-Lincoln, USA

Precipitation Analysis

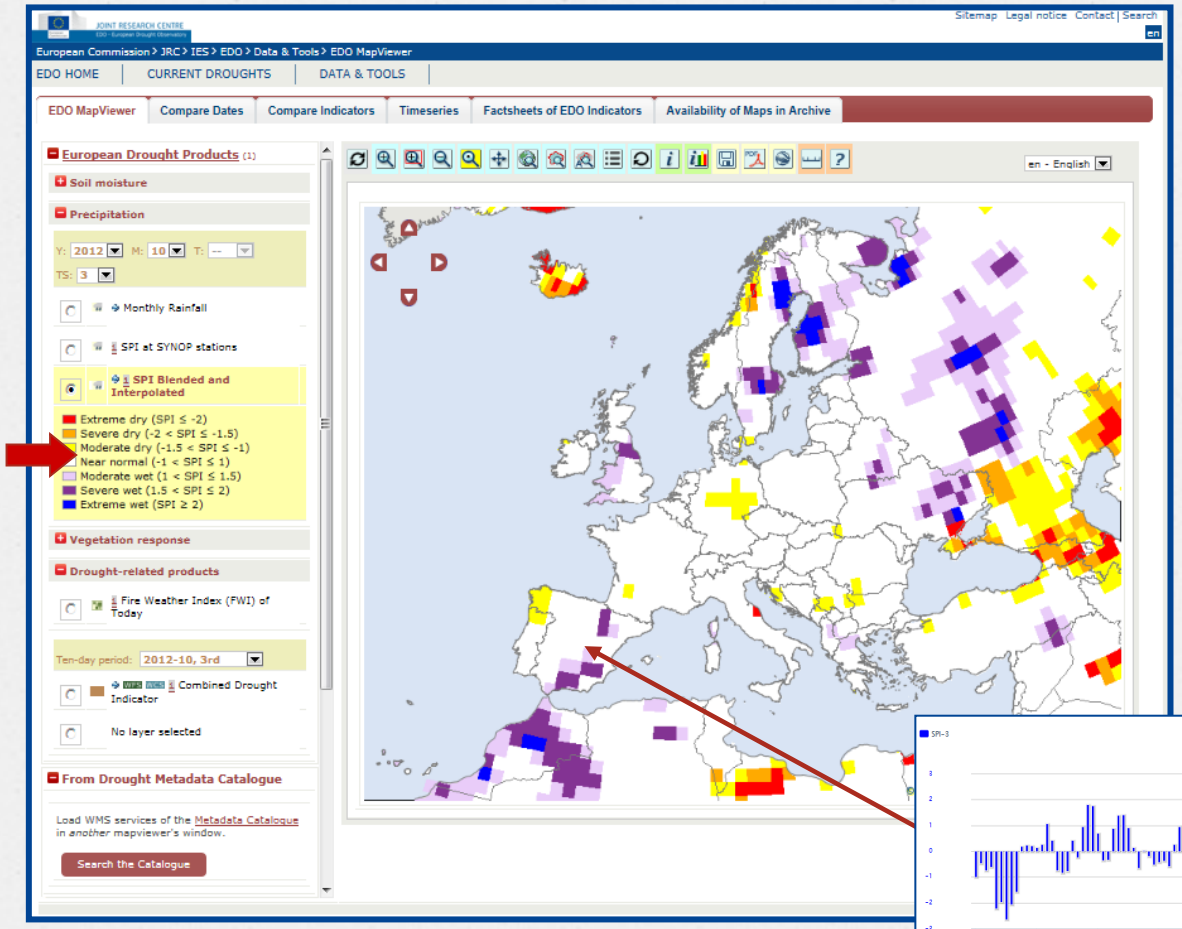
Standardized Precipitation Index (SPI):

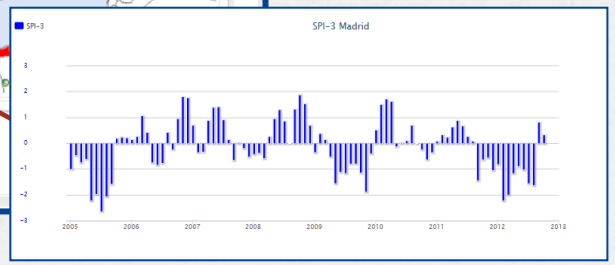
- is a **statistical indicator** comparing the total precipitation received during a period of time with the long-term rainfall distribution for the same period of time
- is based on a transformation into a **standard normal variable** with zero mean and variance equal to one
- is given in units of **standard deviation** from the long-term mean of the standardized distribution
- Allows for the **statistical comparison** of wetter and drier climates
- reflects the statistically **expected frequency** (i.e. probability) of a given event
- is a **probabilistic measure of the severity** of a wet or dry event
- is calculated over **different rainfall accumulation periods**
- **Reference Period**: 1971 - 2010

SPI Values	Category	Probability [%]
SPI ≥ 2.00	Extremely wet	2.3%
1.50 < SPI ≤ 2.00	Severely wet	4.4%
1.00 < SPI ≤ 1.50	Moderately wet	9.2%
-1.00 < SPI ≤ 1.00	Near normal	68.2%
-1.50 < SPI ≤ -1.00	Moderately dry	9.2%
-2.00 < SPI ≤ -1.50	Severely dry	4.4%
SPI < -2.00	Extremely dry	2.3%



EDO: Standardized Precipitation Index





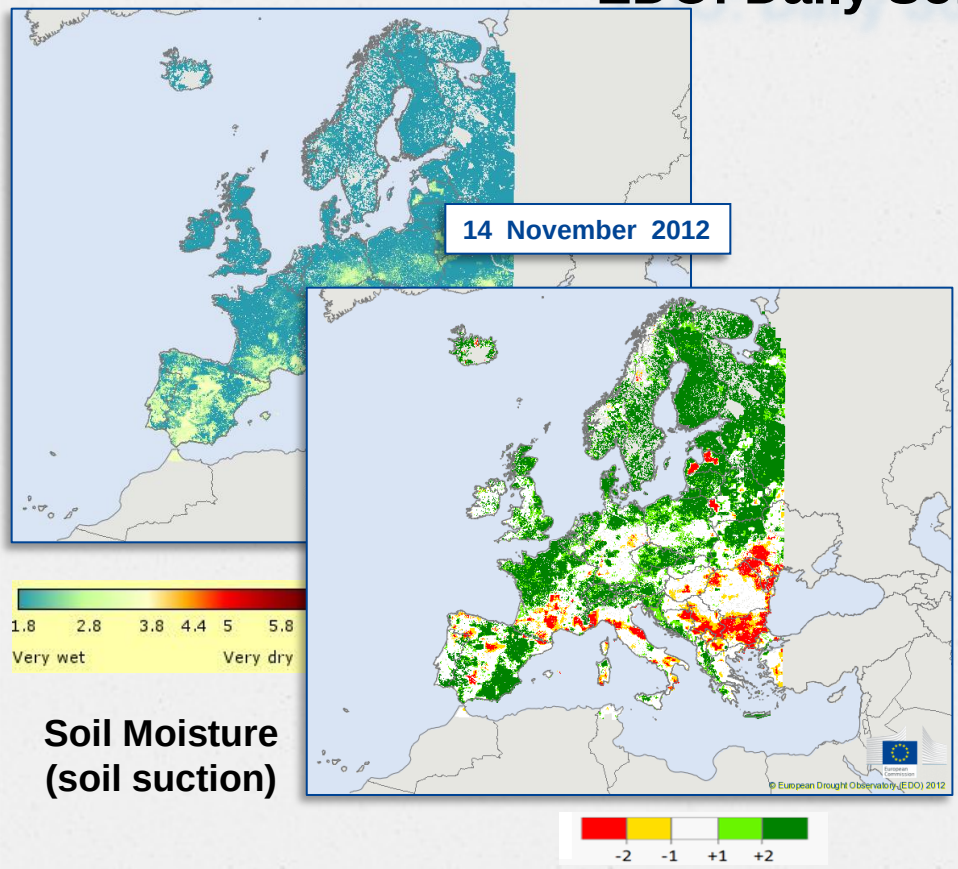
SPI-3

3-month Standardized Precipitation Index
August to October 2012

Madrid (ES)

http://edo.jrc.ec.europa.eu/

EDO: Daily Soil Moisture Information



Soil Moisture (soil suction)

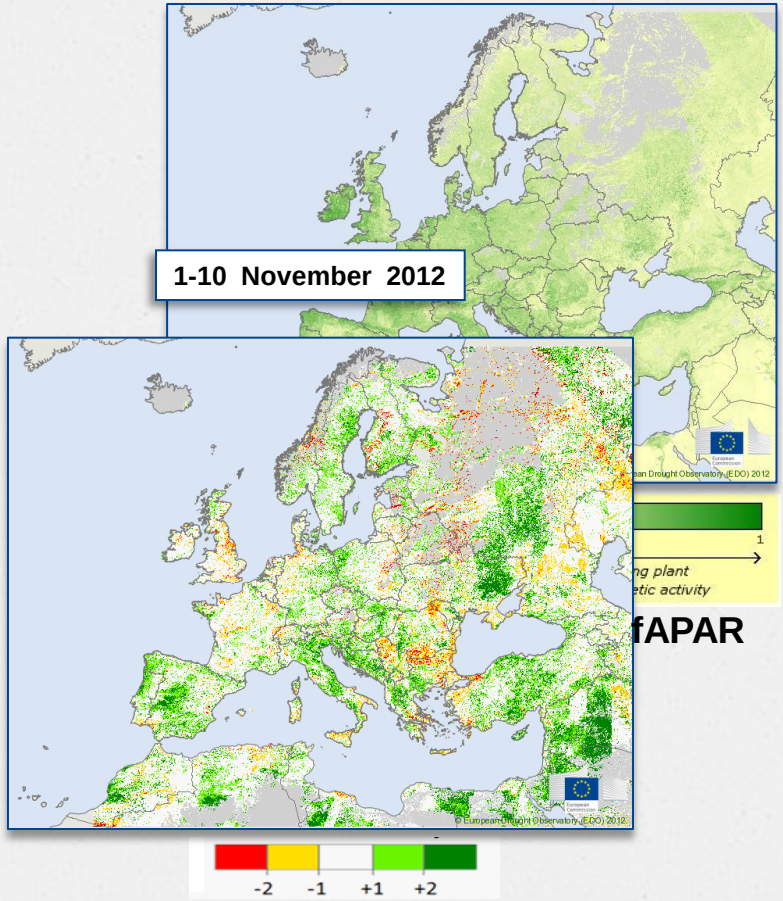
Soil Moisture Anomaly

- It is obtained daily with the an adapted version of the hydrological model LISFLOOD.
- Grid 5x5km
- The meteorological input information is derived from observed **meteorological point data**
- It is presented as **anomalies** (statistical deviation from the long-term mean)
- **reference period:** 1990-2010

EDO: Analysis of Vegetation Vigor

Fraction of Absorbed Photosynthetically Active Radiation (fAPAR):

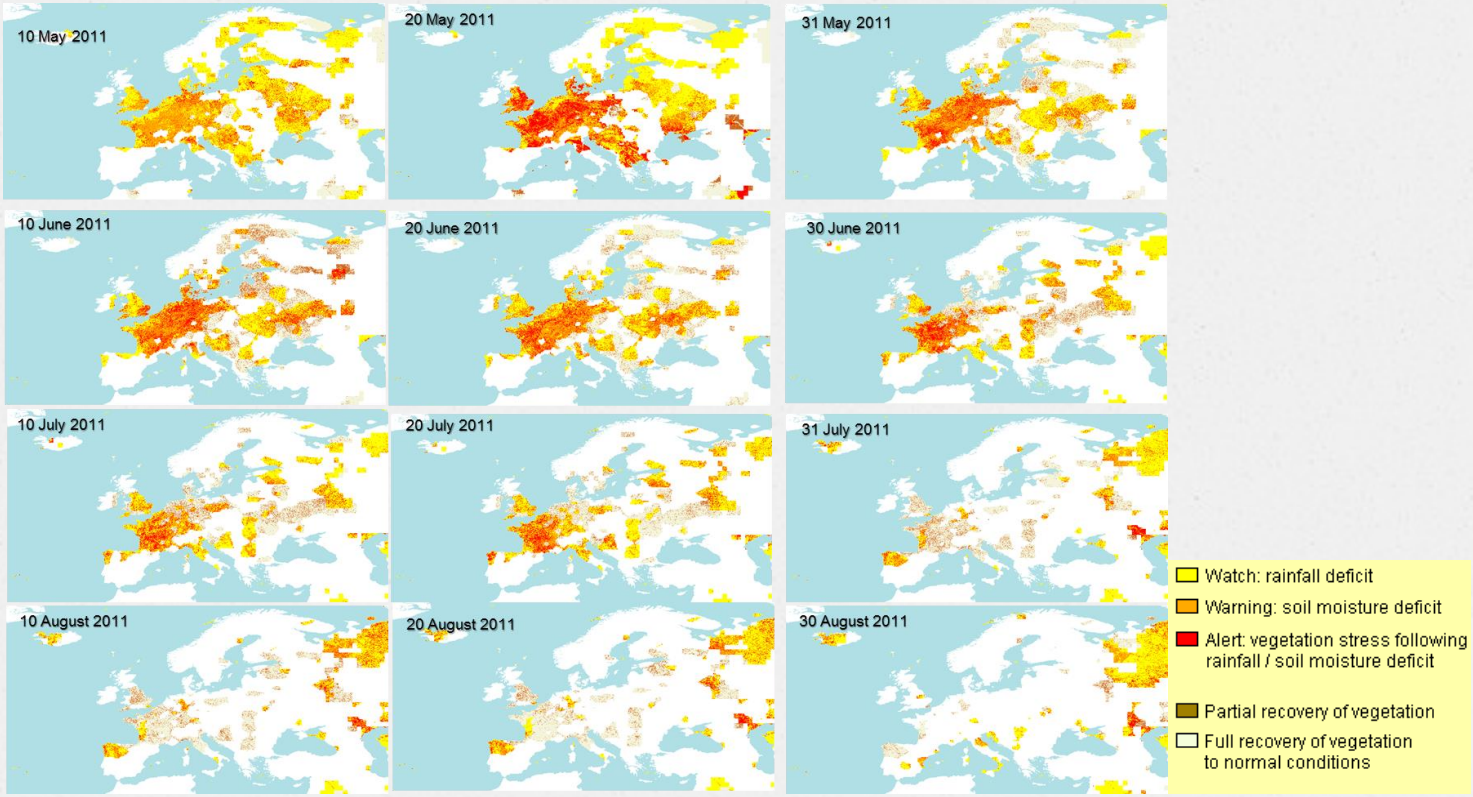
- represents the **fraction of the solar energy which is absorbed** by the vegetation canopy
- is a **biophysical variable** directly correlated with the primary productivity of the vegetation
- is **sensitive to vegetation stress** that causes changes in the solar interception of the plant or its light use efficiency
- is **remote sensing derived** indicator available every 10 days (SPOT-VEG)
- Is presented as **anomalies** (statistical deviation from the long-term mean)
- the available **time-series** is still short (from 1999)

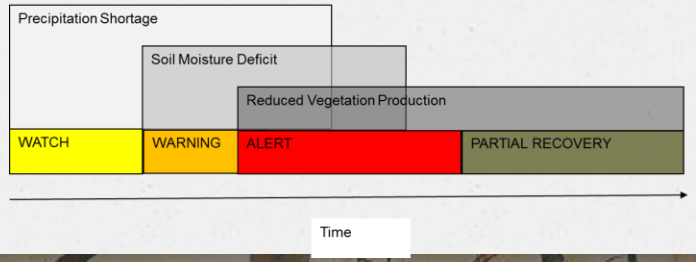


fAPAR

fAPAR anomaly

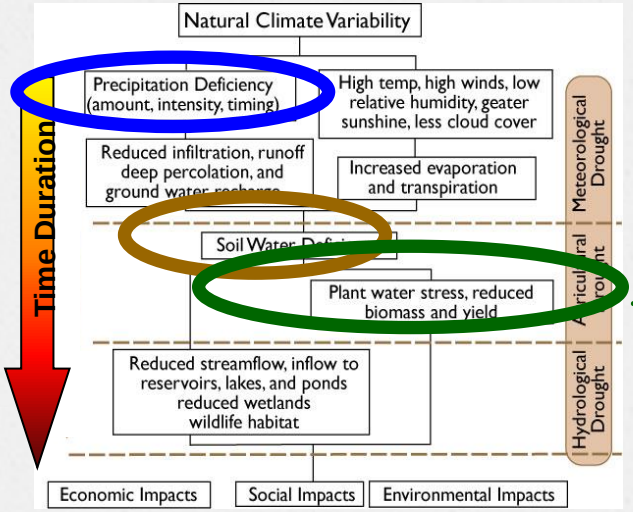
Combined Drought Indicator





21-31/03/2011 1-10/04/2011 11-20/04/2011

LSA-SAF ET for drought monitoring



Source: National Drought Mitigation Center, University of Nebraska-Lincoln, USA

Vegetation water stress → Physiological processes affected → Decrease in the vegetation production

↓

Stomata closure to avoid loss of water

↓

Reduction of the evaporative cooling

LSA-SAF ET for drought monitoring

Index assessed :
ET/ETo

- ***LSA SAF ET product***
- ***ETo from* FAO Penman-Monteith using ECMWF**

Assessment:
case studies 2007, 2011

- ***Comparison with drought indices based in meteorological data (SPI, SPEI, Sc-PDSI)***

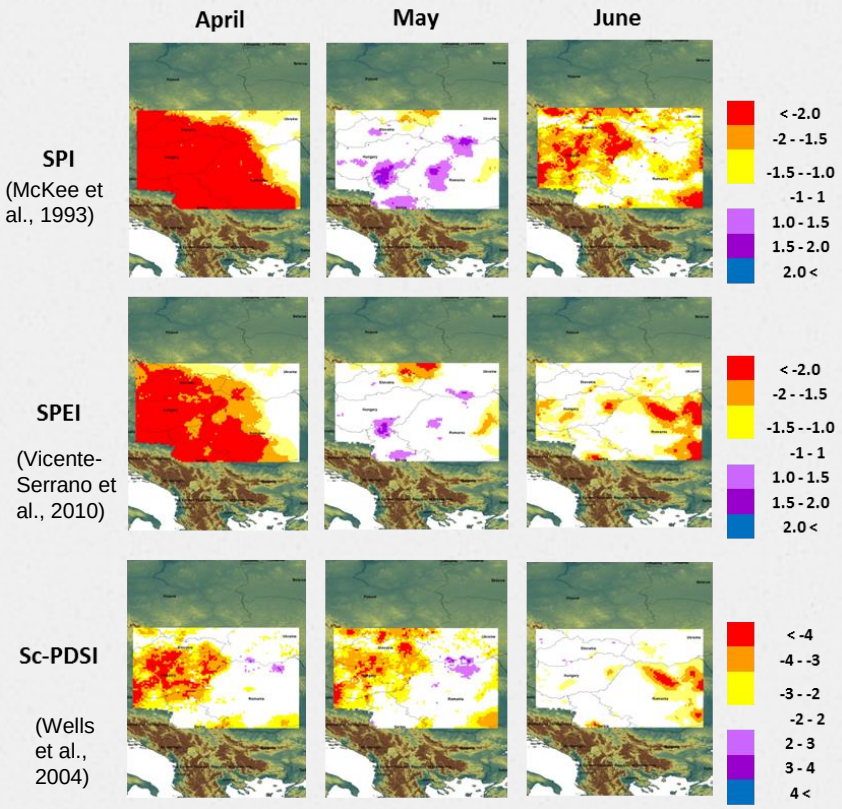
http://edo/jrc.ec.europa.eu
http://www.carpatclim-eu.org

- ***Comparison with fAPAR coming from RS***
- ***Analysis at rain gauge station***

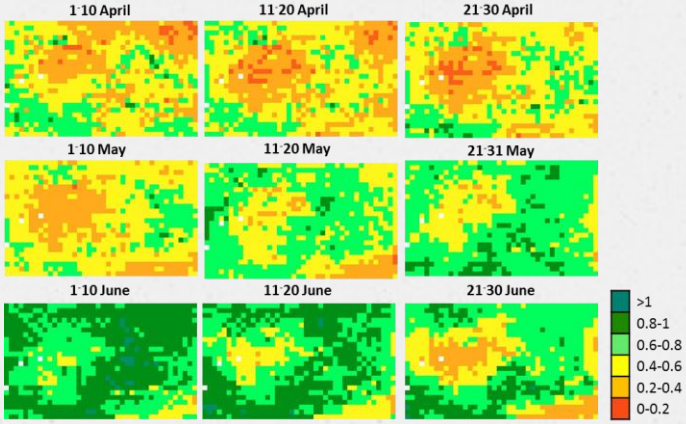
http://eca.knmi.nl/

Case study 2007 Carpathians

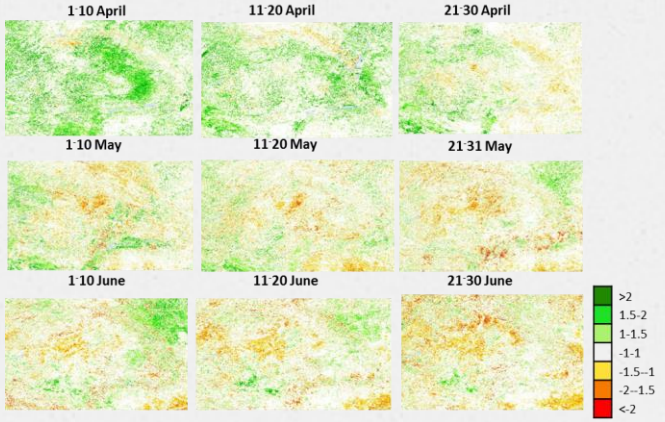
Meteorological indices



ET/ETo



ΔfAPAR



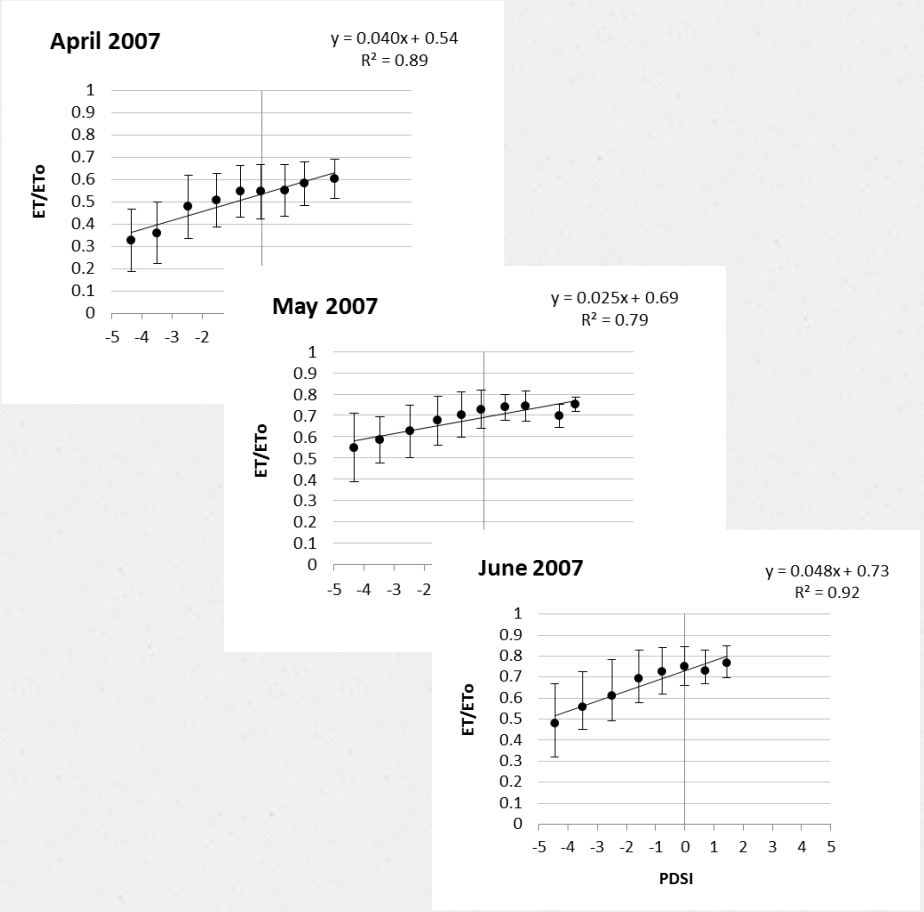
LSA-SAF ET for drought monitoring

Relationships between ET/ETo and drought indices based in meteorological data

	ET/ETo		
R (n=960)	**April**	**May**	**June**
SPI	0.25	0.11	--
SPEI	0.24	0.11	0.20
Sc-PDSI	0.50	0.44	0.45

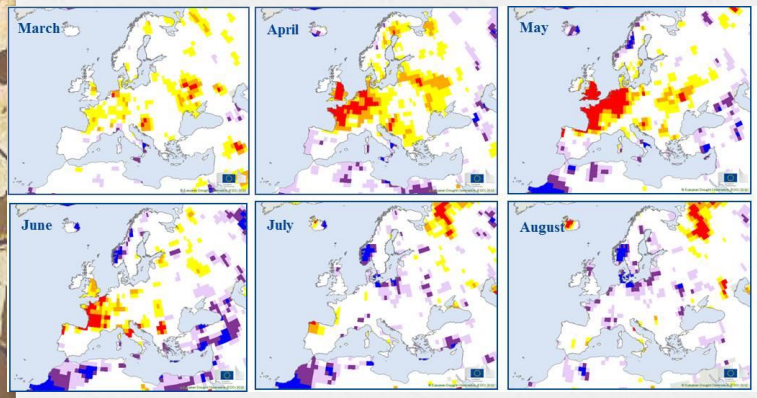
Sc-PDSI classification

4.0 or more	extremely wet
3.0 to 3.99	very wet
2.0 to 2.99	moderately wet
1.0 to 1.99	slightly wet
0.5 to 0.99	incipient wet spell
0.49 to -0.49	near normal
-0.5 to -0.99	incipient dry spell
-1.0 to -1.99	mild drought
-2.0 to -2.99	moderate drought
-3.0 to -3.99	severe drought
-4.0 or less	extreme drought

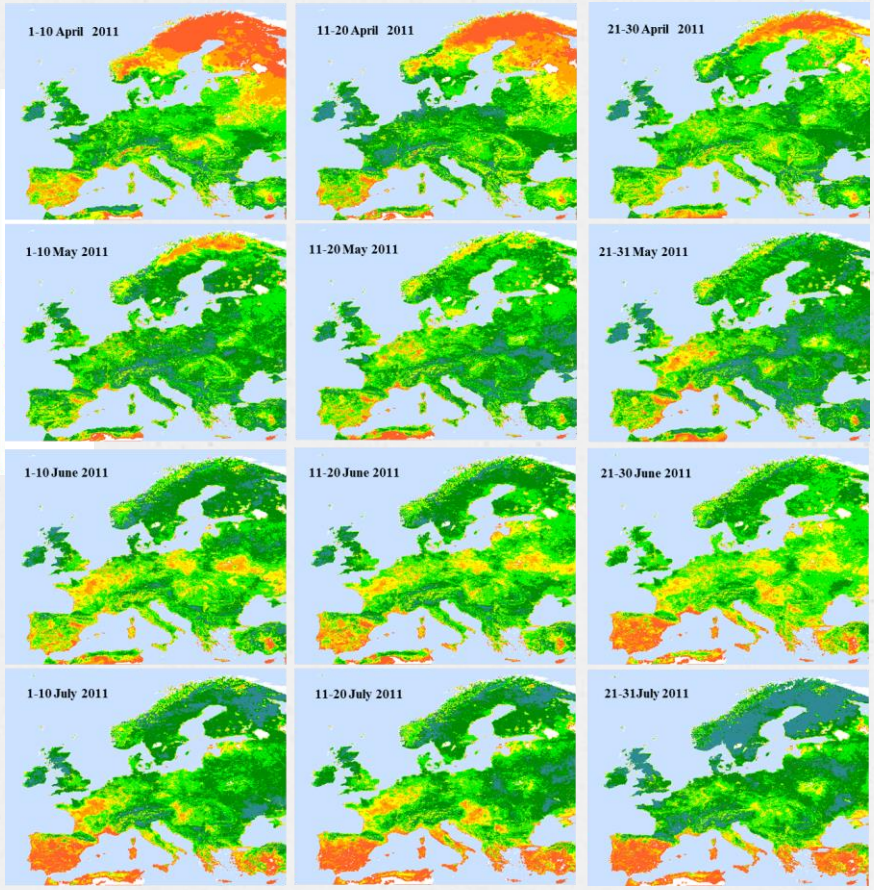


Case study 2011 Europe

SPI-3

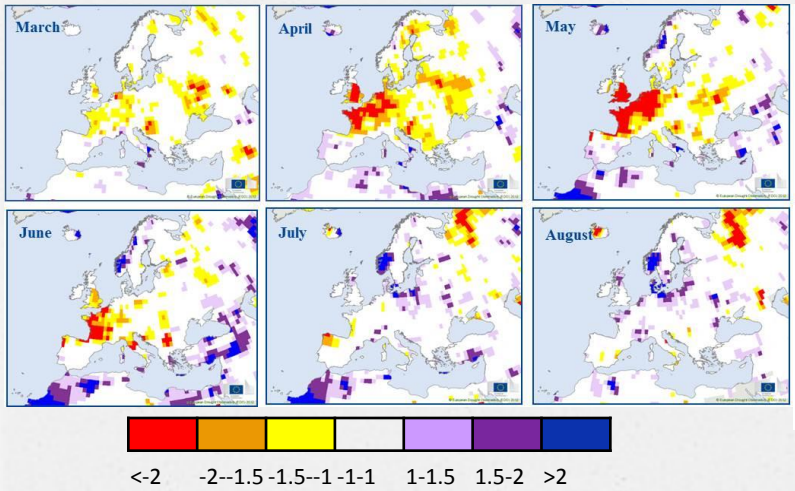


ET/ETo

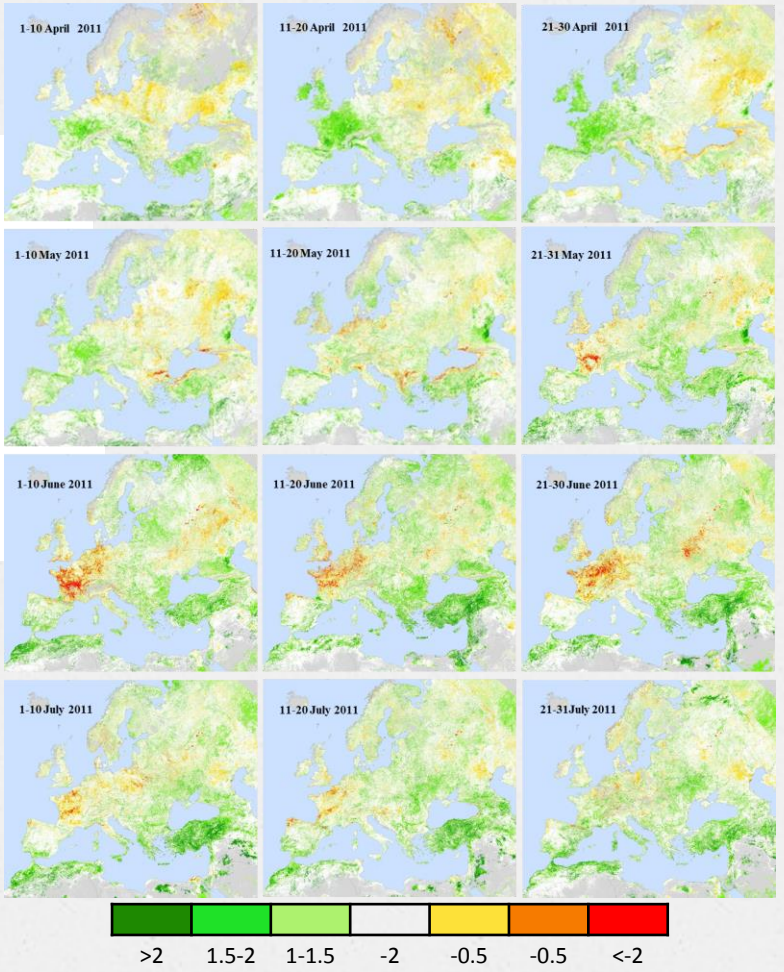


Case study 2011 Europe

SPI-3



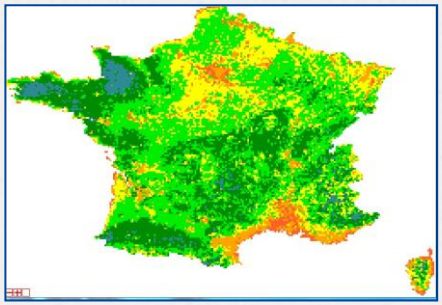
ΔfAPAR



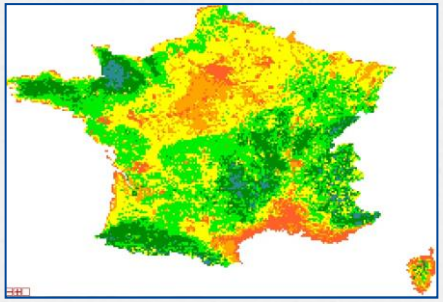
LSA-SAF ET for drought monitoring

ET/ETo in France

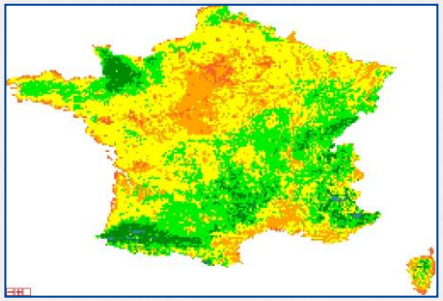
11-20/05/2011



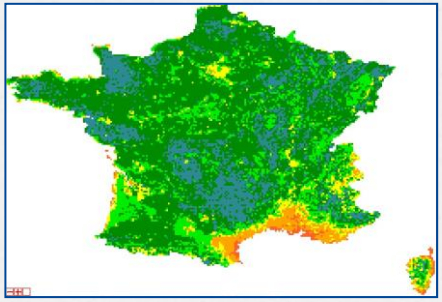
21-31/05/2011



1-10/06/2011



11-20/05/2012



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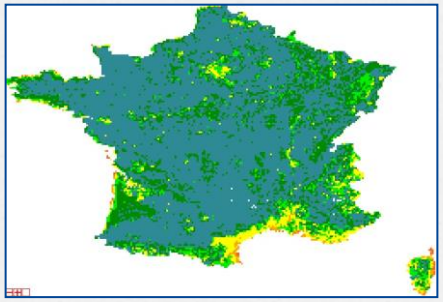

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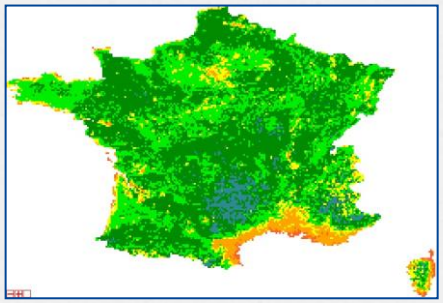
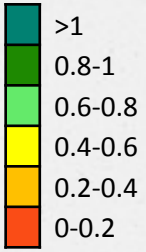
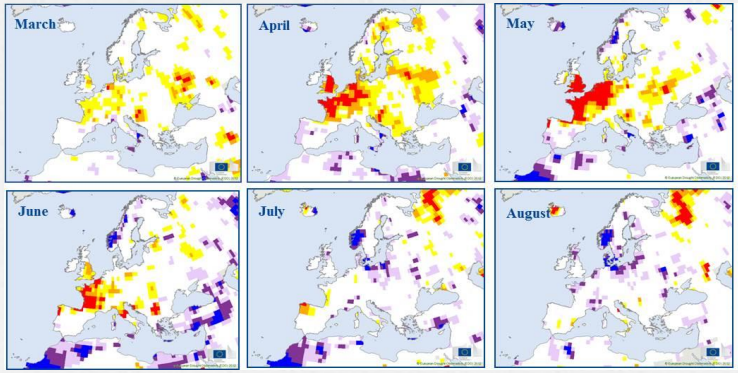


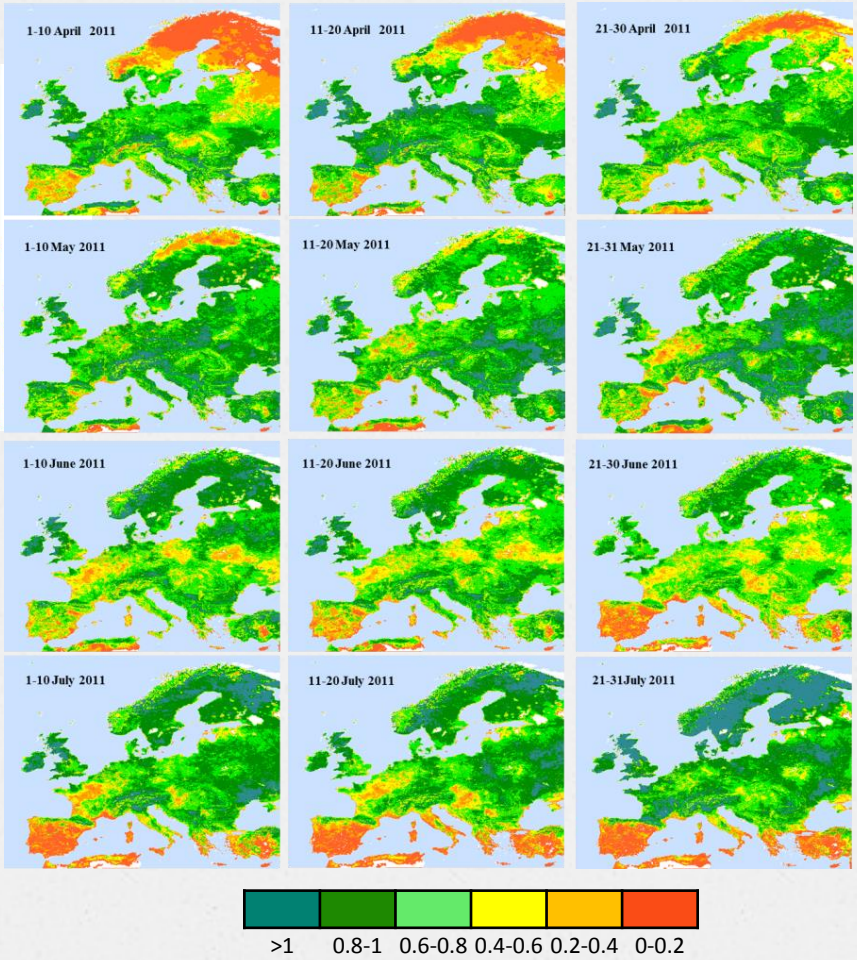


LSA-SAF ET for drought monitoring

SPI-3

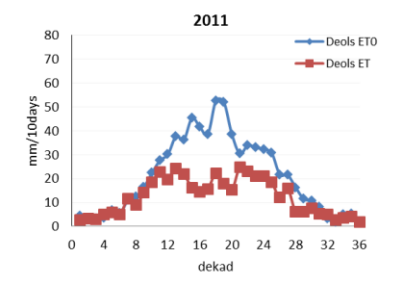


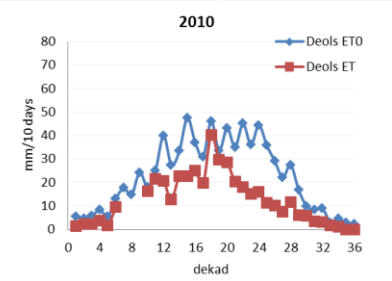
ET/ETo

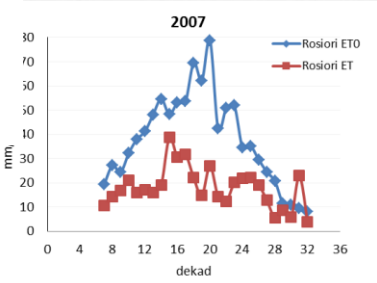


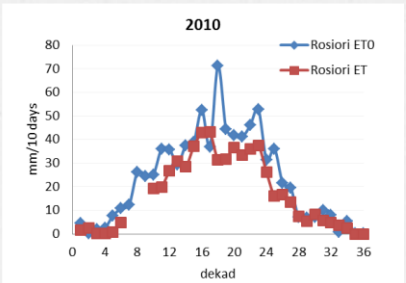
LSA-SAF ET for drought monitoring

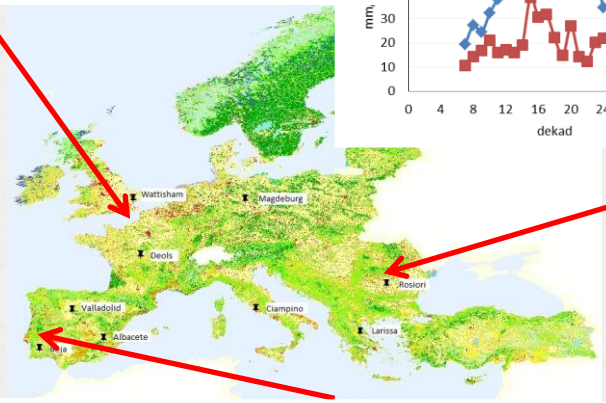
ET and ETo in agricultural areas

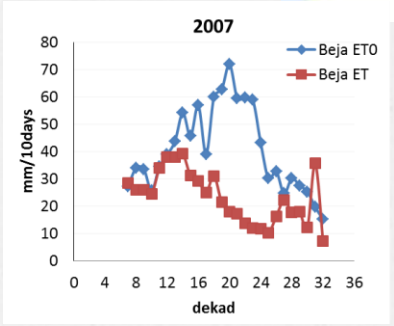


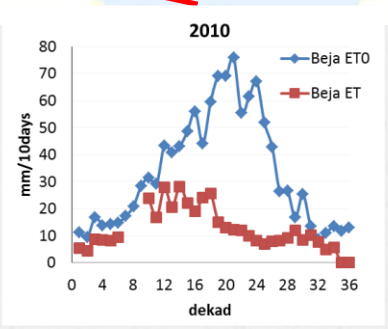


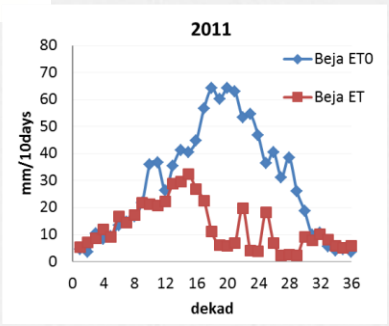








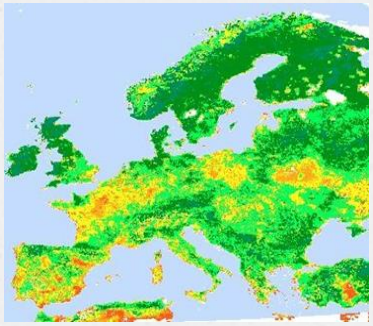


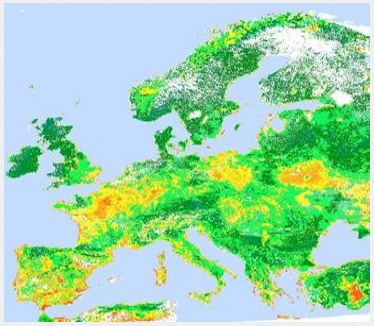


LSA-SAF ET for drought monitoring

Example ET/ETo of 1-10 June 2011 after applying different filters

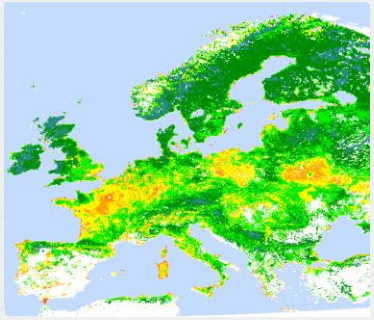
Phenology filter

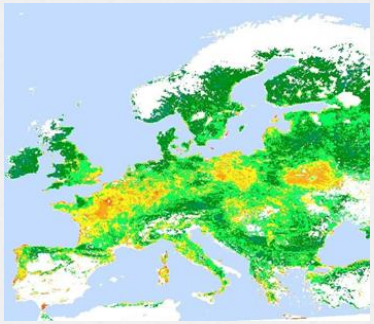




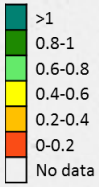
Mean fAPAR filter

ECOCLIMAP filter



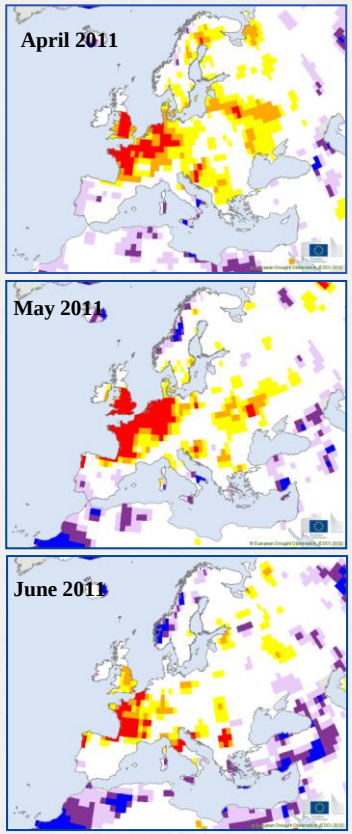


50% FVC

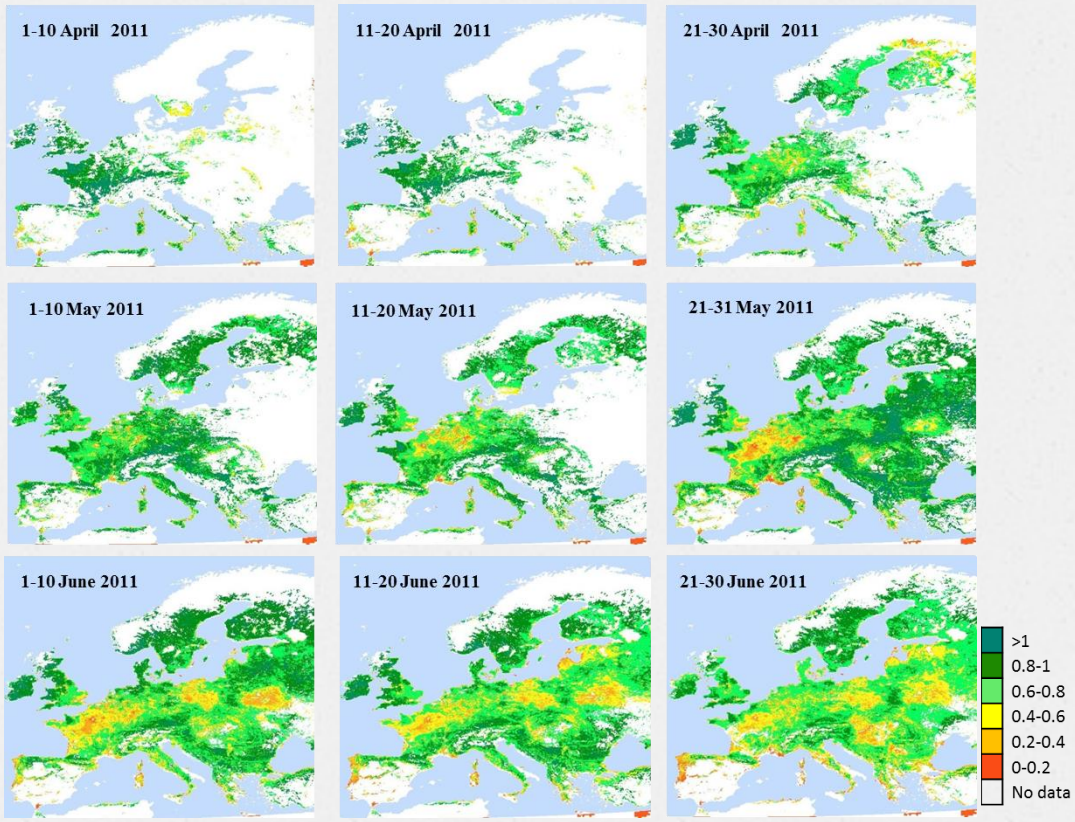


LSA-SAF ET for drought monitoring

SPI-3

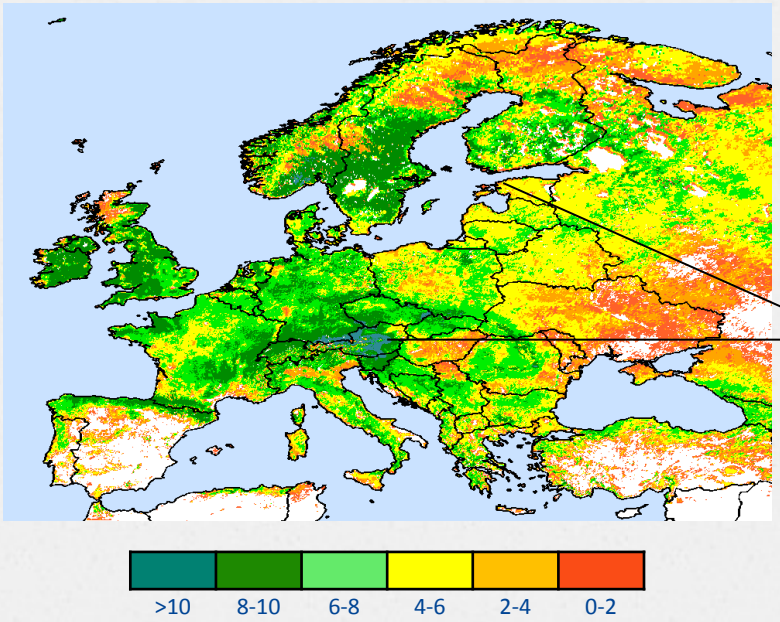


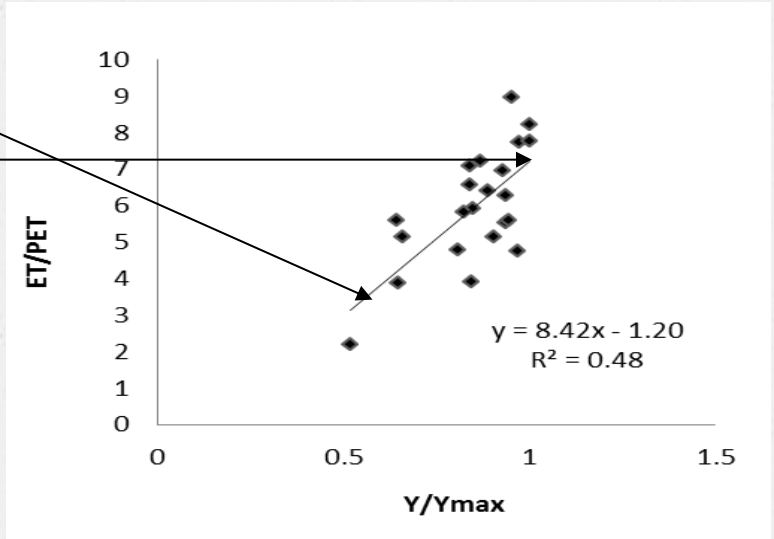
ET/ETo filtering areas with FVC < 50%



LSA-SAF ET for drought monitoring

2011 accumulated ET/PET vs Winter wheat Yield (Kg/ha)/Yield$_{max}$





Some conclusions

- ET is an important parameter that gives information about the water and energy exchange between soil, plant and atmosphere. Moreover, it integrates environmental factors like meteorological conditions and soil moisture status. The ratio between evapotranspiration and potential evapotranspiration reflects the climatic demand in relation to the soil water supply.

- In absence of time series of data long enough to characterize the normal conditions of the area, ET/ETo is giving relevant information for drought monitoring except in areas of low vegetation cover.

- ET/ETo showed to give additional information to those given by SPI and fAPAR.

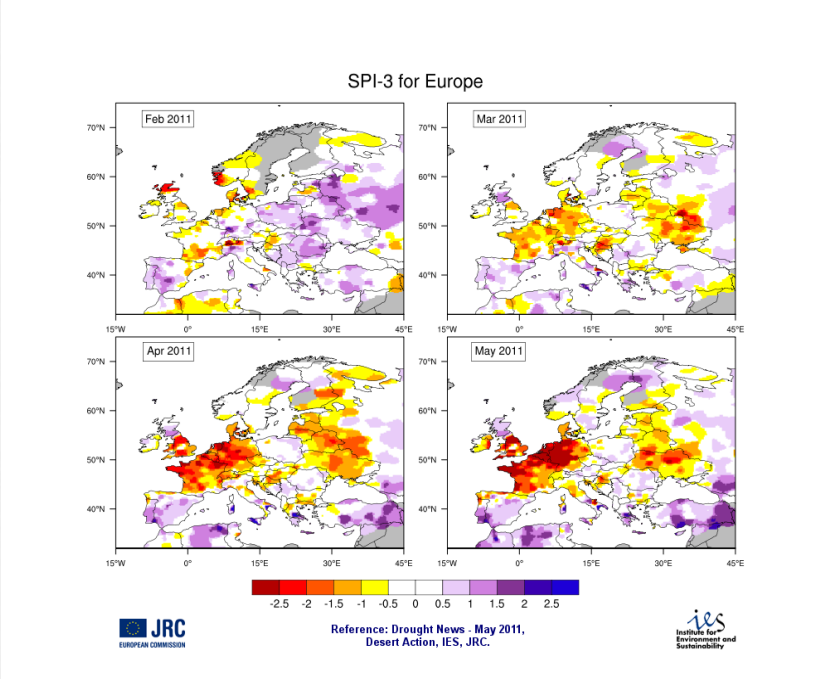
- Filtering taking into account the beginning and the end of the growing period or the percentage of vegetation cover was tested, eliminating the areas where high values of the ratio did not corresponded to drought conditions.

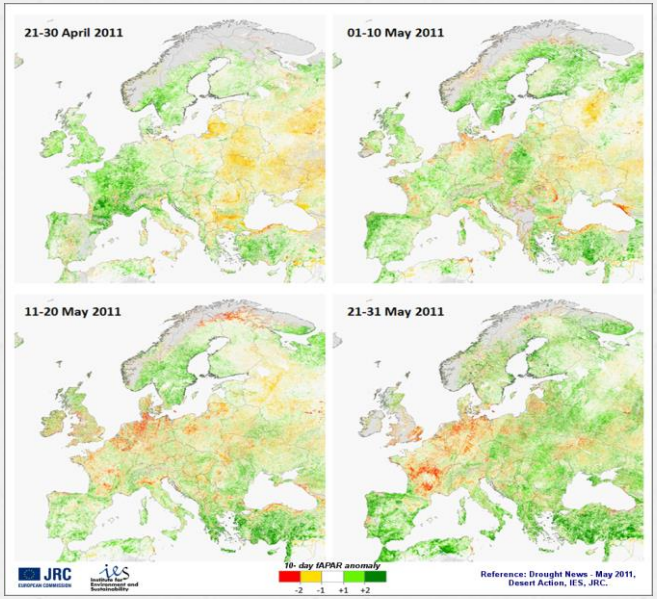
- ET/ETo can be produced operationally as it is based in three products already operational and freely distributed, ET and FVC distributed by LSA-SAF and ETo by the MARS-JRC.

- In addition, the SVAT model used to obtain ET, can be modified to obtain PET and therefore it would be possible to produce the ratio ET/PET as new product. This ratio has important applications in global agricultural monitoring.

Potential of LSA-SAF for drought monitoring: fAPAR

http://edo.jrc.ec.europa.eu drought news may 2011

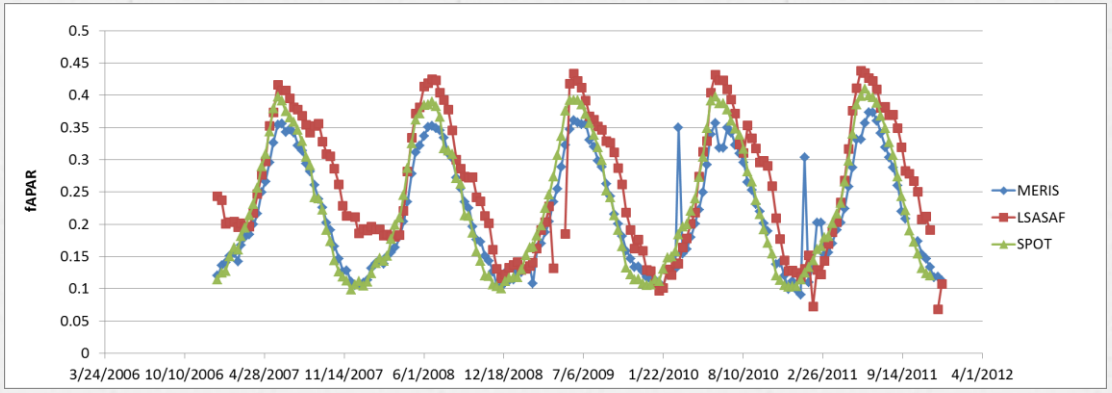


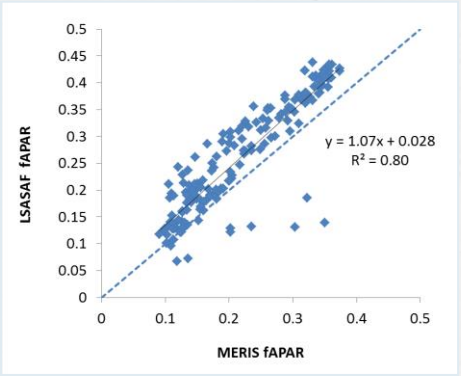


Potential of LSA-SAF for drought monitoring: fAPAR

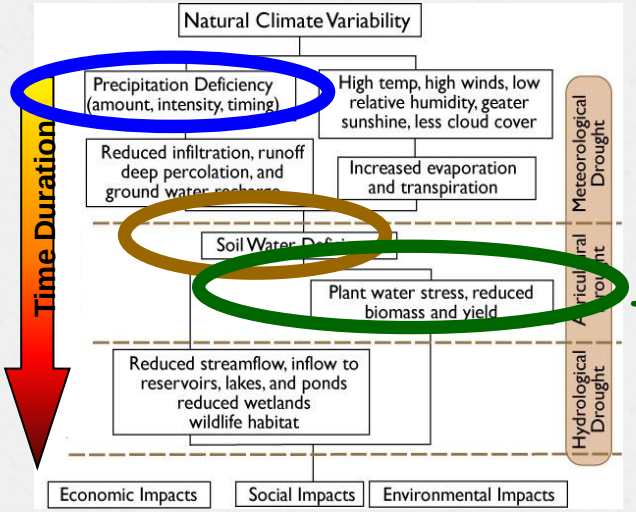
Comparison between fAPAR MODIS and fAPAR LSA-SAF

Spatial correlation coef=0.80





Potential of LSA-SAF for drought monitoring: LST



Source: National Drought Mitigation Center, University of Nebraska-Lincoln, USA

Vegetation water stress → Physiological processes affected → Decrease in the vegetation production

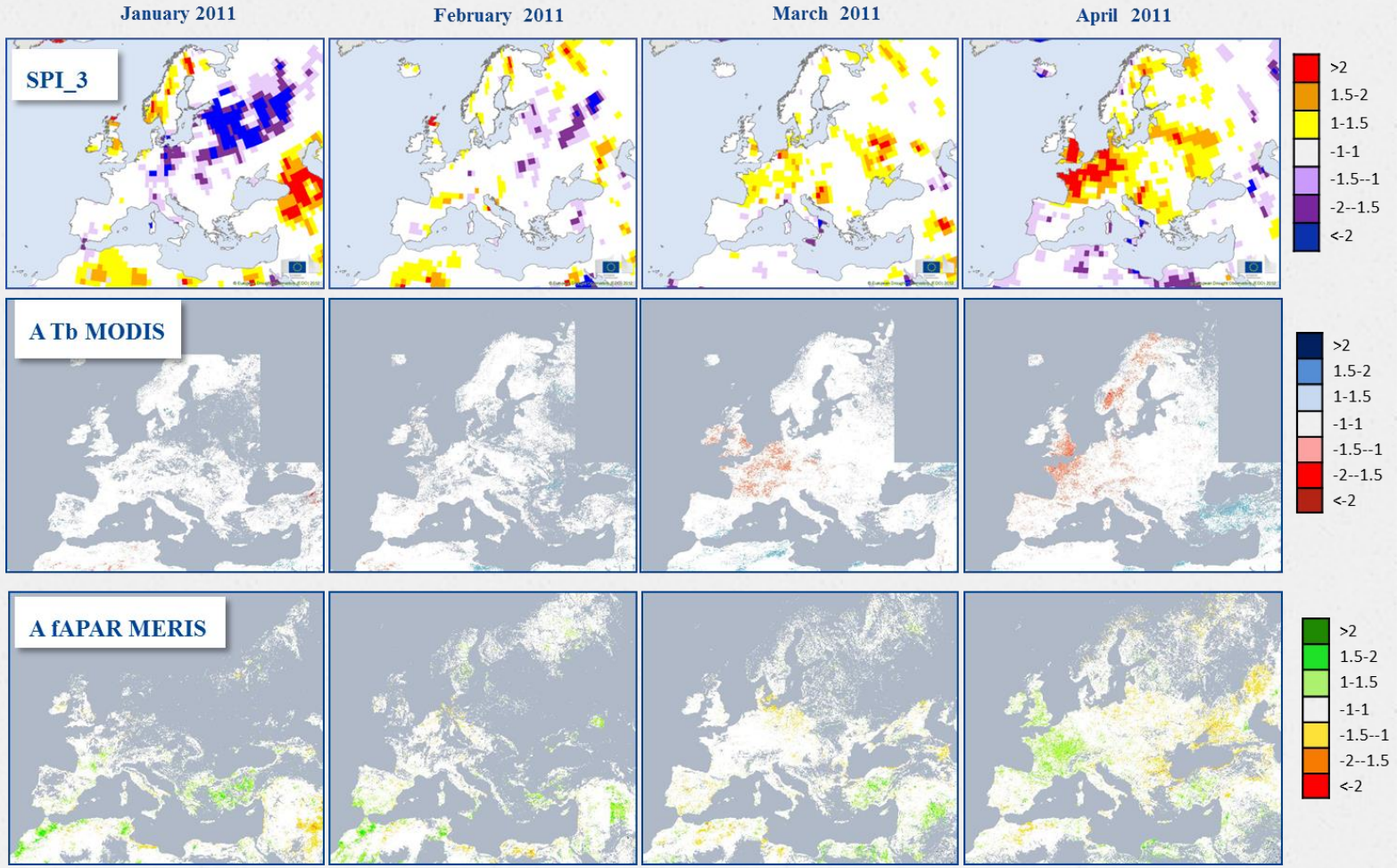
↓

Stomata closure to avoid loss of water

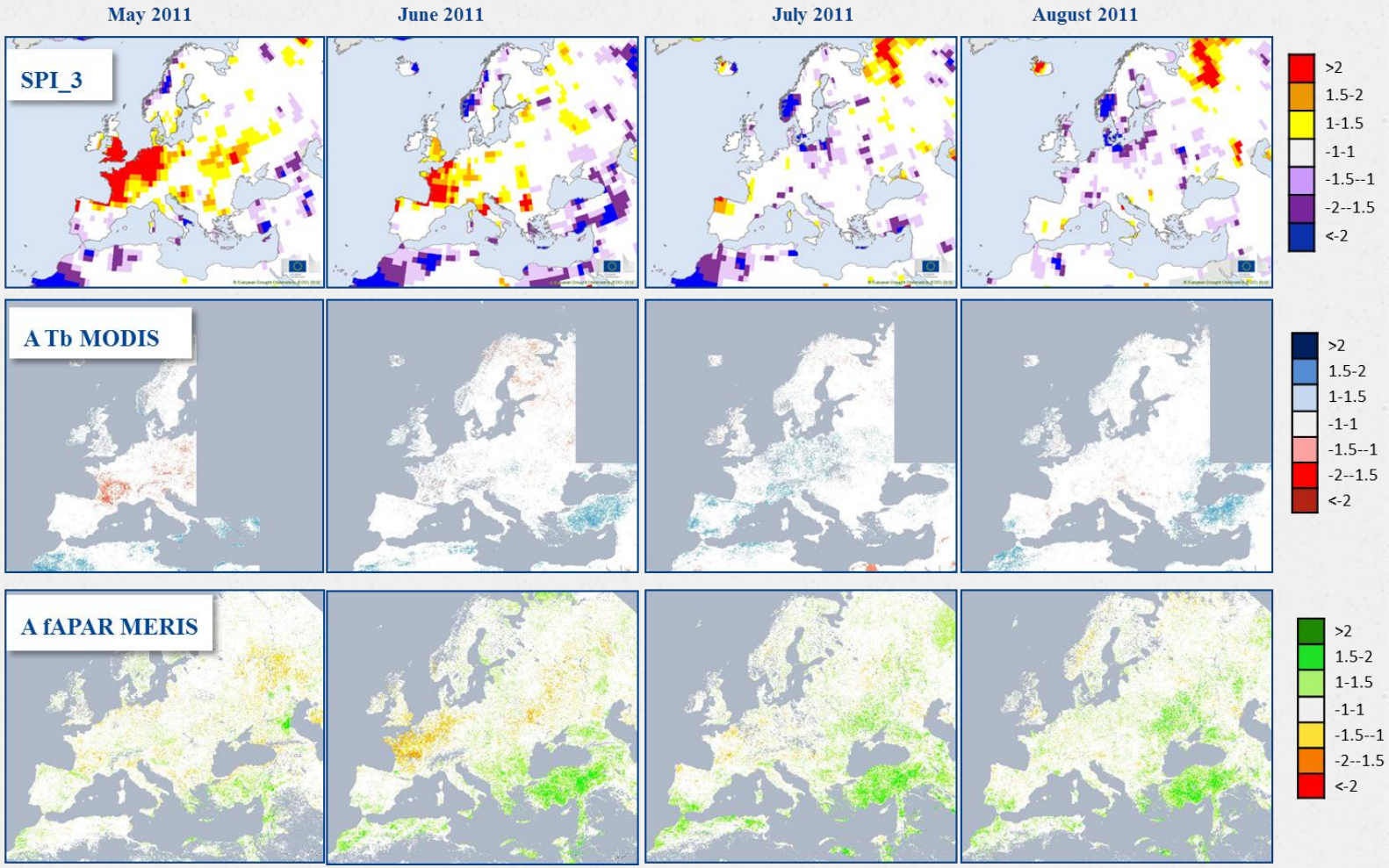
↓

Reduction of the evaporative cooling → **Increase of canopy temperature**

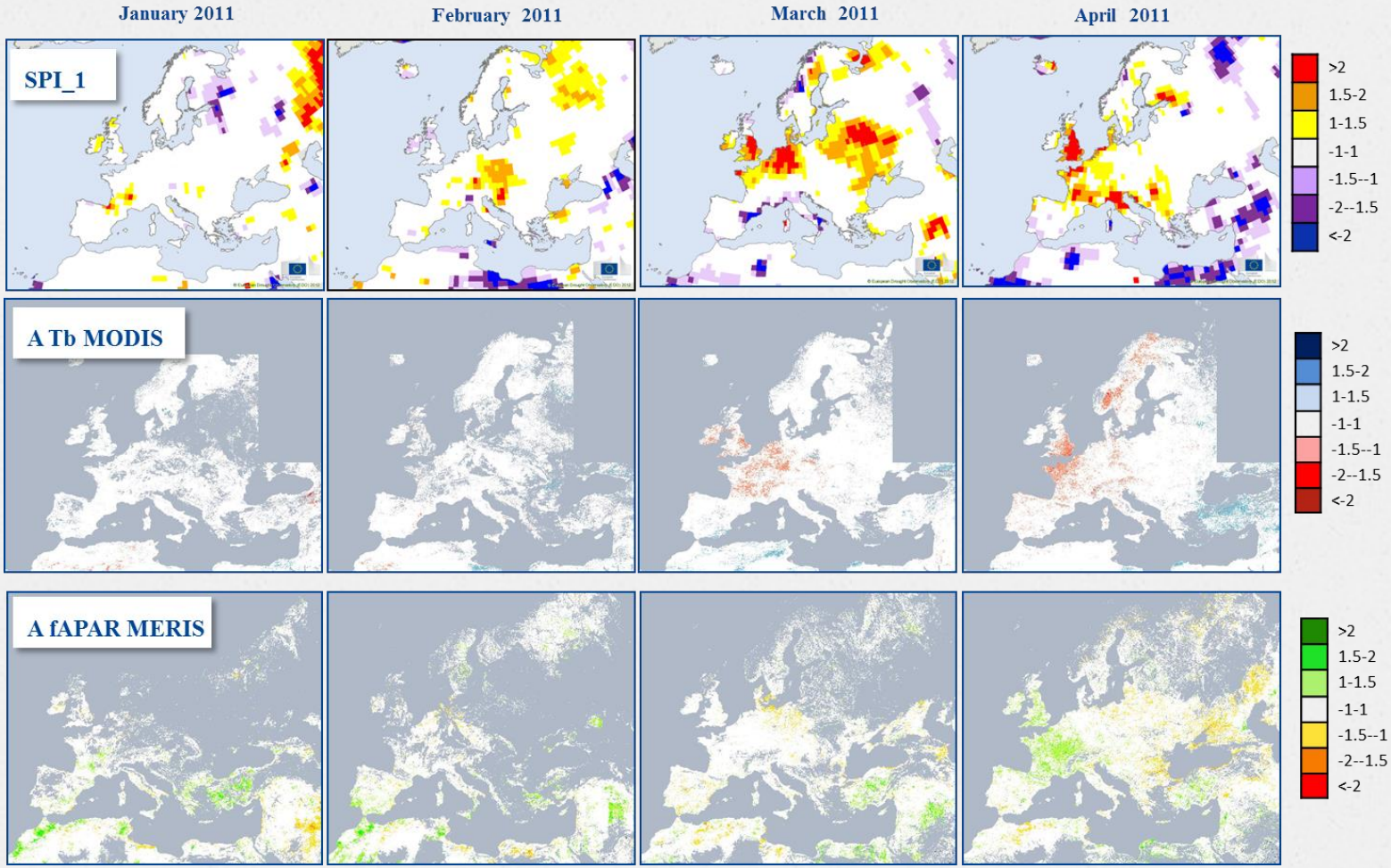
Potential of LSA-SAF for drought monitoring: LST



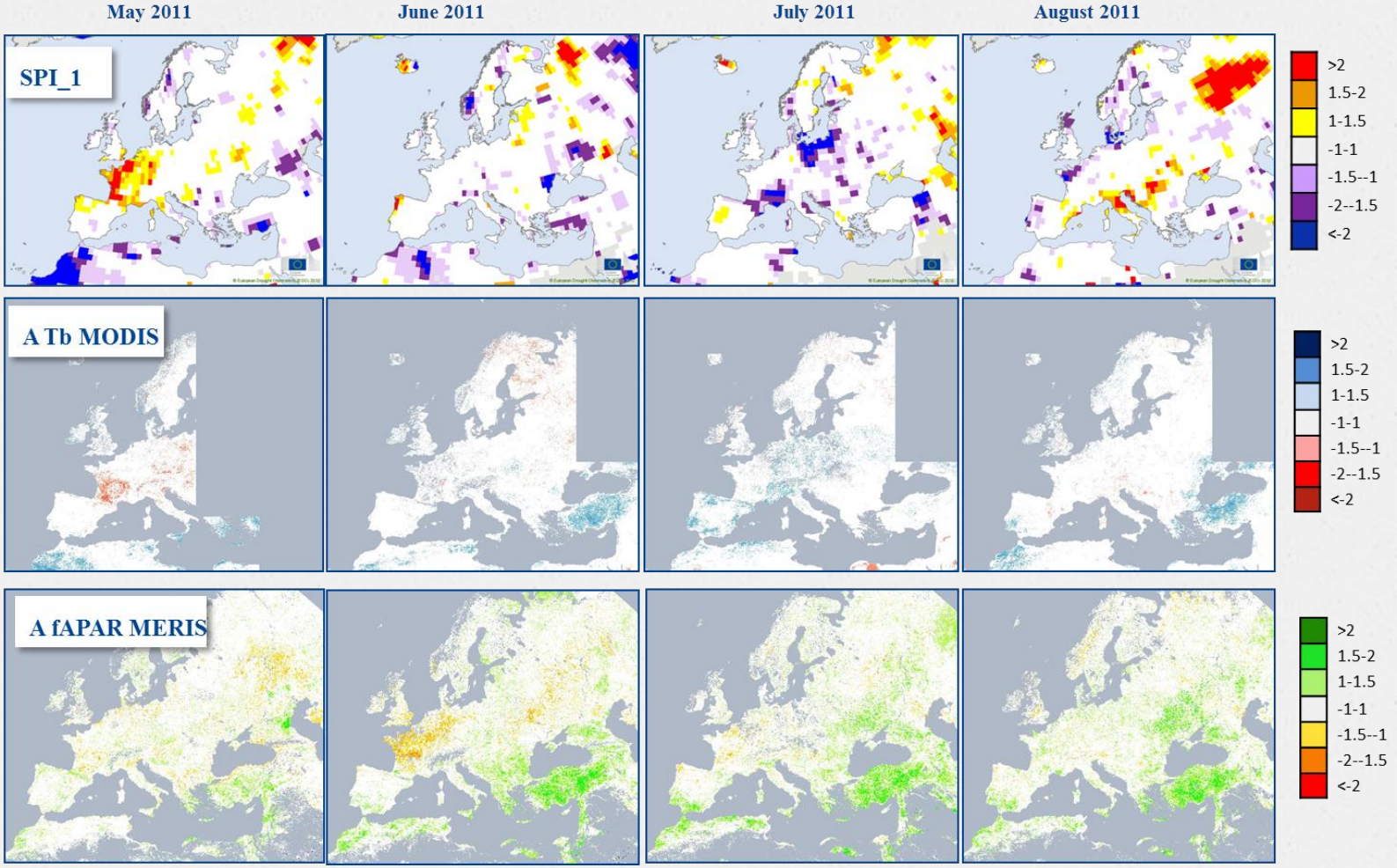
Potential of LSA-SAF for drought monitoring: LST



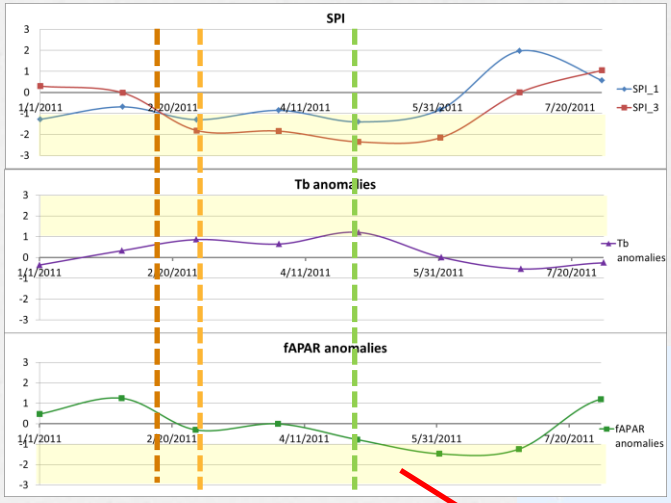
Potential of LSA-SAF for drought monitoring: LST

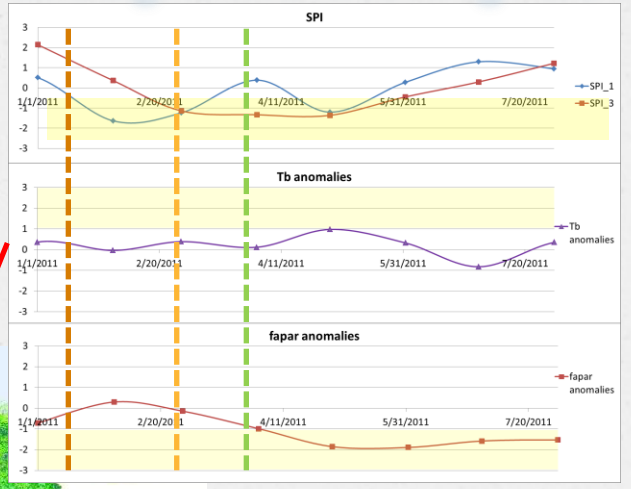


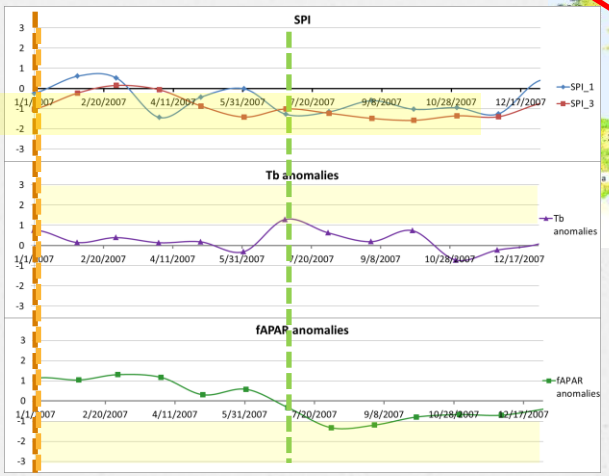
Potential of LSA-SAF for drought monitoring: LST

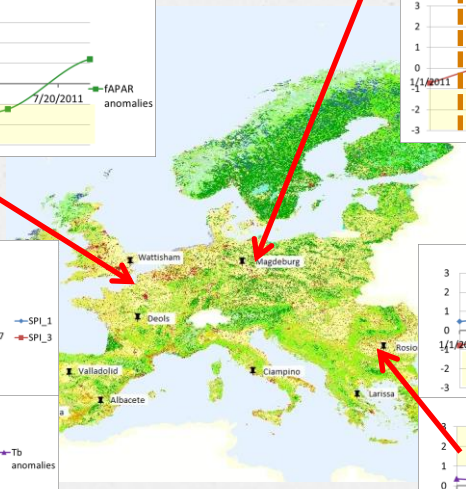


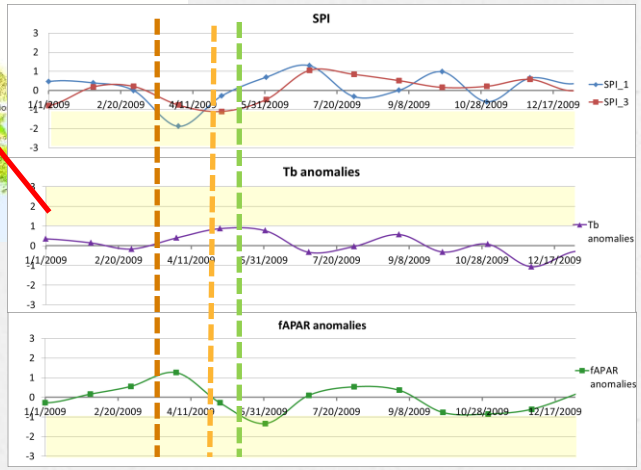
Potential of LSA-SAF for drought monitoring: LST





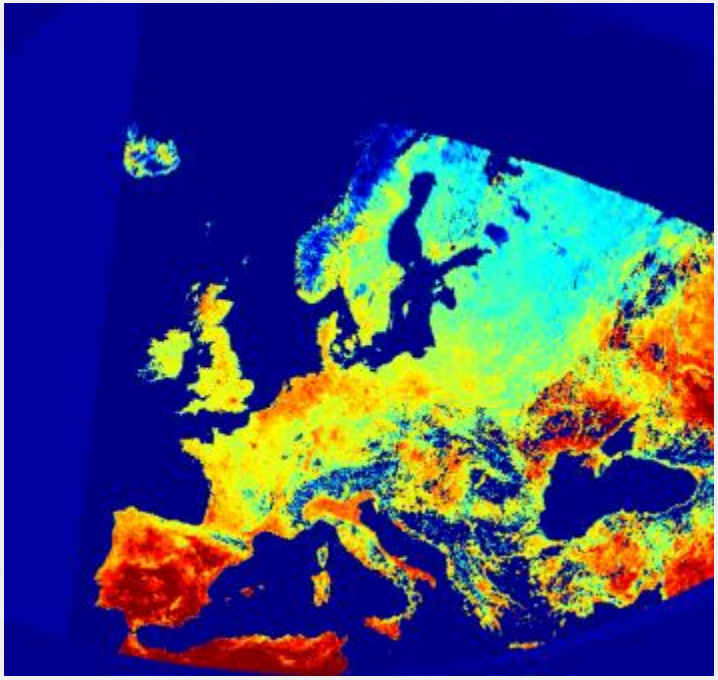






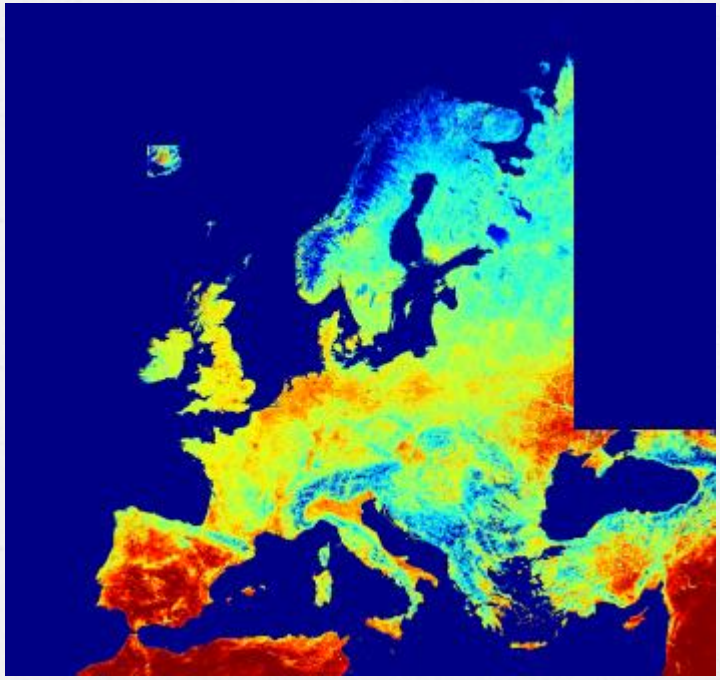
Potential of LSA-SAF for drought monitoring: LST

10 days composite (21-31/05/2012)
of **LSA-SAF LST** at 12:00



-5 55ºC

10 days composite (21-31/05/2012)
of **MODIS/AQUA TB**



0 32 ºC

More info

http://edo.jrc.ec.europa.eu

Sepulcre-Cantó, G., J. Vogt, A. Arboleda, T. Antofie. (2014) Assessment of the EUMETSAT LSA-SAF Evaporation Product for Drought Monitoring in Europe. *Int. Journal of Applied Earth Observation and Geoinformation*, 30:190–202.

Guadalupe Sepulcre-Cantó, S. Horion, A. Singleton, H. Carrao, J. Vogt (2012). Development of a Combined Drought Indicator to detect agricultural drought in Europe. *Natural Hazards and Earth System Sciences,* 12, 3519–3531.