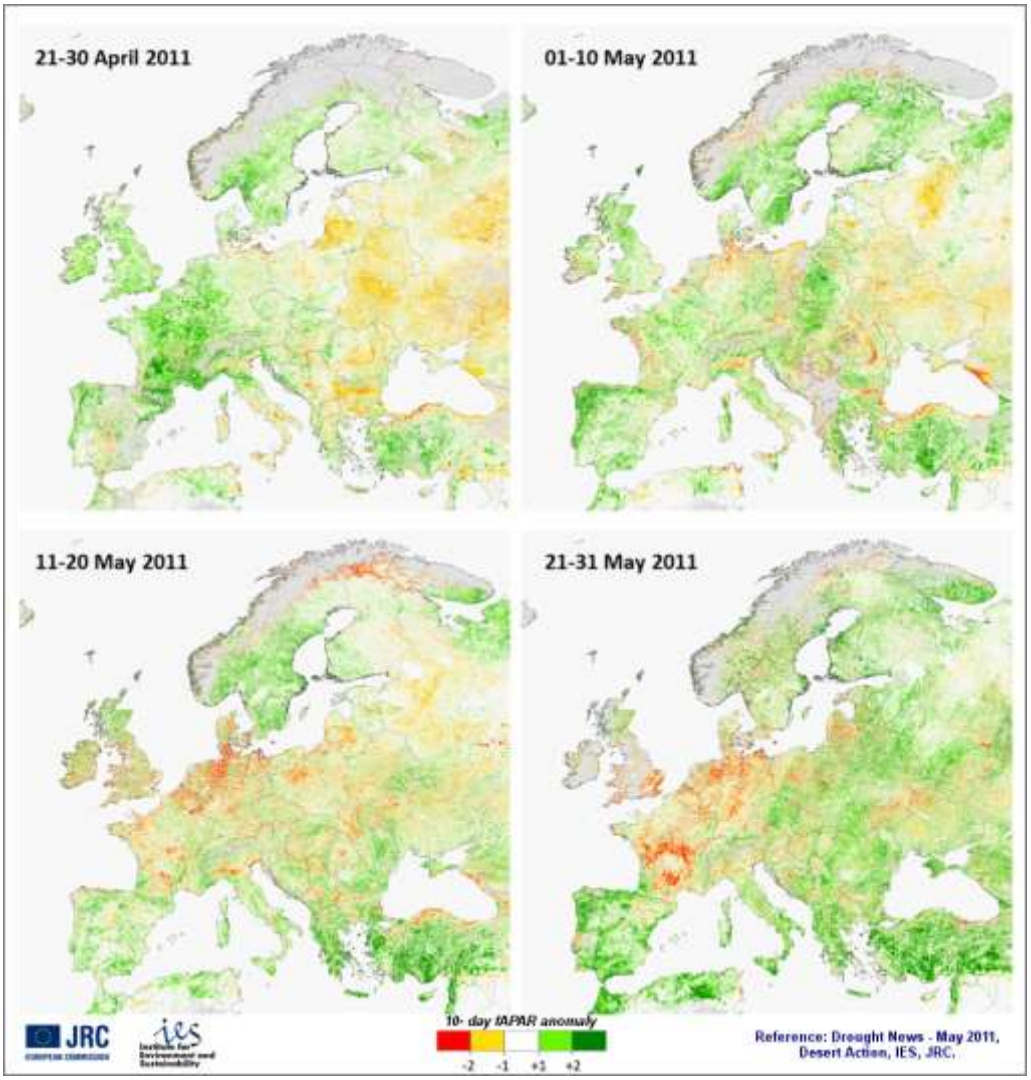
FAPAR anomaly: Anomaly of Fraction of Absorbed Photosynthetically Active Radiation

Type	Temporal scale	Spatial scale	Geo. coverage
Vegetation response	10-day product	1 km	Europe



Key message

Droughts affect the vegetation canopy and specifically its capacity to intercept solar radiation. The Fraction of Absorbed Photosynthetic Solar Radiation (fAPAR) is known to be strongly related to water stress. fAPAR and fAPAR anomalies (the deviation from the long term mean for a certain period of time) are considered good indicators **to detect and assess drought impacts on vegetation canopies** (e.g., agricultural canopies, natural vegetation). Therefore it can provide stakeholders with **information potentially useable for water and agricultural management**.

Relevance of the Product to drought monitoring

The Fraction of Absorbed Photosynthetically Active Radiation (fAPAR) represents the **fraction of the solar energy which is absorbed by the vegetation**. fAPAR is a biophysical variable directly correlated with the primary productivity of the vegetation, since the intercepted PAR is the energy (carried by photons) underlying the biochemical productivity processes of plants. fAPAR is one of the Essential Climate Variables recognized by the UN Global Climate Observing System (GCOS) and by the FAO Global Terrestrial Observing System (GTOS) as of great potential to characterize the climate of the Earth.

Due to its sensitivity to vegetation stress, fAPAR has been proposed as a drought indicator (Gobron et al. 2005 and 2007). Indeed droughts **can cause a reduction in the vegetation growth rate**, which is affected by changes either in the solar interception of the plant or in the light use efficiency.

Technical Information

1. Product

The MERIS Global Vegetation Index (MGVI) is a remote sensing derived index estimating fAPAR at canopy level. Till 2011, the index was derived from ENVISAT-MERIS images. From 2012, the fAPAR estimations are the result of applying the MGVI algorithm to SPOT-VEGETATION images.

- **Geographic coverage**: available for Europe
- **Spatial scale**: 1.2km (from 1/1/2002 to 2011), 1 Km (from 2012)
- **Temporal scale**: every 10 days aligned on the first day of each month, which corresponds to 3 images per month (day 1-10, day 11-20, day 21-last day of month).
- **Data source**:

  Till 2011, MGVI data was delivered as a subscription service within the Service Support Environment (SSE) of the European Space Agency. This service is called "MGVI Catalogue Search and Download" and can be access via this link: http://services.eoportal.org/portal/service/ShowServiceInfo.do?serviceId=7180CB90&categoryId=89802980. From 2012, fAPAR data is accessed through the JRC's Community Image Data (CID) portal (http://cidportal.jrc.ec.europa.eu). The JRC provider of the fAPAR data is the Flemish institute for technological research (VITO).
- **Frequency of data collection:** every 10 days

2. Methodology

2.1 Calculation of fAPAR

fAPAR is difficult to measure directly but can be inferred from models describing the transfer of solar radiation in plant canopies, using Earth Observation information as input data. fAPAR estimates are retrieved using EO information by numerically inverting physically-based models. The fAPAR estimates used within the DESERT Action were operationally produced by the European Space Agency (ESA) till 2011. They were derived from the multispectral images acquired by the **Medium Resolution Imaging Spectrometer (MERIS)** onboard ENVISAT by means of the MERIS Global Vegetation Index (MGVI) algorithm, developed at the JRC (Gobron et al. 2004). From 2012, fAPAR images used are the result of applying the same algorithm to the images acquired by the **VEGETATION** sensor onboard SPOT. These images are produced by the Flemish institute for technological research (VITO).

MGVI is a physically based index which transforms the calibrated multispectral directional reflectance into a single numerical value while minimizing possible disturbing factors. It is constrained by means of an optimization procedure to provide an estimate of the fAPAR of a plant canopy. The objective of the algorithm is to reach the maximum sensitivity to the presence and changes in healthy live green vegetation while at the same time minimizing the sensitivity to atmospheric scattering and absorption effects, to soil color and brightness effects, and to temporal and spatial variations in the geometry of illumination and observation.

The MGVI level-3 aggregation processor has been developed and is maintained by the European Commission Joint Research Centre (JRC). More information on the algorithm can be found in Pinty B. et al. (2002) and Gobron N. et al. (2004).

2.2 Calculation of fAPAR anomaly

- **Data acquisition:** Till 2011, 10-day fAPAR estimates were regularly produced by the European Space Agency (ESA) as **MGVI Level-3 Aggregated Products** following the approach by Aussedat et al. (2007). From 2012, the 10-day fAPAR estimates used are those provided regularly by the Flemish institute for technological research (VITO).

- **Anomaly estimation**: fAPAR anomalies are produced for every 10-day period as followed:

$$fAPAR\ anomaly_t = \frac{X_t - \bar{X}}{\delta}$$

  where X_t is the fAPAR of the 10-day period t of the current year and, $\bar{X}$ is the long-term average fAPAR and δ is the standard deviation, both calculated for the same 10-day period t using the available time series (see baseline statistics).

- **Baseline statistics**: Till 2012, the archive of MGVI covered the period from June 2002 to this date. In Europe, the archive was extended backward to mid-1997 using fAPAR estimations obtained from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) (Gobron et al. 2002). From 2012, the archive of SPOT-VEGETATION fAPAR covers the period from October 1998 till today. Long-term 10-day average and standard deviations are calculated for every pixel whereas at least 6 years of data are available.

Use of the product for drought and/or land degradation monitoring

fAPAR and fAPAR anomalies can be presented in the form of **maps** and **graphs**, providing information both on the spatial distribution of the vegetation activity and the temporal evolution over longer time periods. Gridded data can easily be aggregated over administrative or natural entities such as hydrological watersheds. This allows for the qualitative and quantitative comparison of the intensity and duration of the fAPAR anomalies with recorded impacts such as yield reductions, low flows, lowering of groundwater levels, to cite but a few.

The EDO Mapserver displays the latest available fAPAR 10-day composite image and the fAPAR anomaly image calculated by comparing this image to the historical series in the same 10-day period.

The **fAPAR product** is dimensionless. It is ranging from 0 to 1 in terms of real values, and from yellow to green on the map, with 1 corresponding to a maximum of vegetation activity. The **fAPAR anomaly product** is given in standard deviation units. It is commonly ranging from -4 to +4 and from red to green, red showing negative anomalies.

Both products are easy to read. The interpretation must take into account the fact that this indicator is showing a variation in the vegetation health and/or cover. This variation can be a consequence of a rainfall / soil moisture deficit but can also be due to other factors.

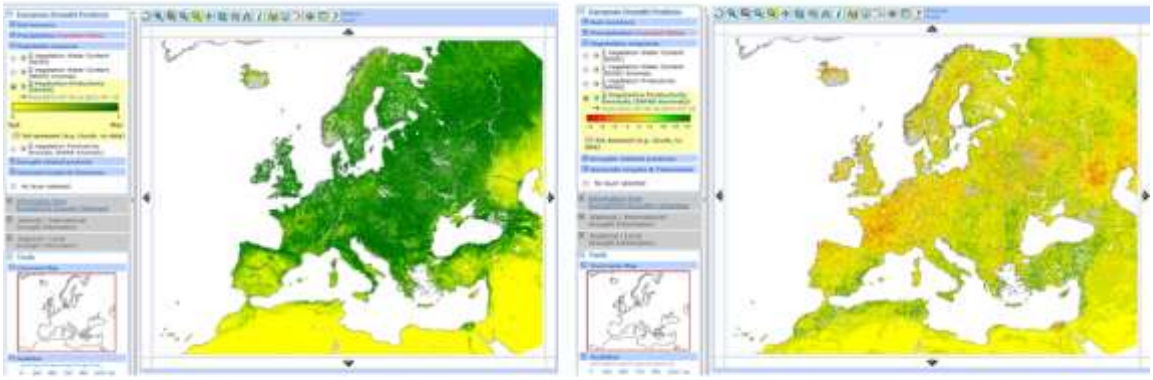


Figure 1: fAPAR (left) and fAPAR anomaly (right) images produced by the processing chain within EDO for the decade 1-11 July 2011

Quality Information

1. Strength & weaknesses

[+] Every ten days, the MGVI gives a spatially continuous picture of the vegetation status/health at a high spatial resolution (~1km) for the entire Europe.

[-] Drought and water stress are not the only factors that can cause a decrease of MGVI values/anomalies. Change in land covers or pests and diseases can also be responsible for such

variation of the signal. Therefore this indicator must be used jointly with other indicators giving information on the deficit of rainfall /soil moisture in order to determine if the variation in the vegetation response (signal) is linked with a drought event or not.

[-] Anomalies are dependent of the time series available to calculate the mean values and the standard deviations. This period should be long enough to characterize the area where the index is calculated. In these terms, anomalies depend on the length of the time series used to calculate the long-term average.

2. Performance of the indicator (reference to literature, reports)

MGVI has been used successfully to assess the impact of the 2003 drought on plant productivity in Europe (Gobron et al. 2005). Moreover Rossi et al. (2008) highlighted the potential of this indicator for drought detection and monitoring by comparing it to other drought indicators such as the Standardized Precipitation Index (SPI). Recently, fAPAR has been used to monitor the drought situation in Europe (Spring 2011) and in the Horn of Africa (November 2010 – now) (http://desert.jrc.ec.europa.eu/action/php/index.php?action=view&id=121).

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