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Geoland2 / BIOPAR

Towards GMES Land Monitoring Services

F. Camacho (EOLAB) on behalf of the geoland2/BioPar team

geoland2 is a Collaborative Project (2008-2012) funded by the European Union under the 7th Framework Programme (project number 218795)

GMES overview

- **Global Monitoring for Environment and Security** (**GMES**) aims to provide, on a sustained basis, **reliable and timely geo-information services** related to environmental and security issues in support of public policy makers' needs
- **GMES** is an EU-led initiative, in which ESA implements the space component and the European Commission manages actions for developing services, relying on both in-situ and space-borne remote sensing data.
- **GMES Services** address six thematic areas:. They support a wide range of applications, including environment protection, management of urban areas, regional and local planning, agriculture, forestry, fisheries, health, climate change, sustainable development, civil protection…:
  - Land, → geoland2 → GIO Land Service
  - Marine,
  - Atmosphere,
  - Climate Change,
  - Emergency management
  - Security

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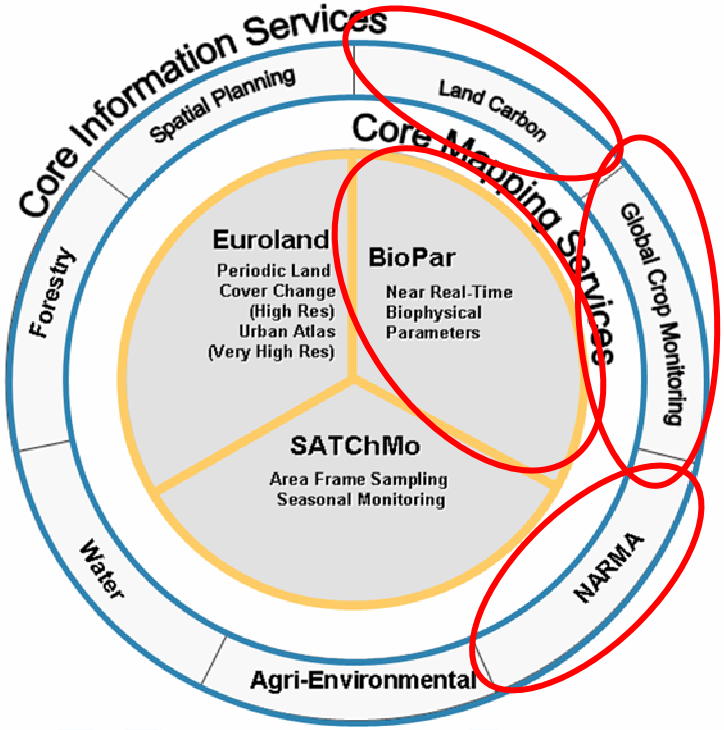
- **Some figures:**
  - 50 partners
  - 11 thematic tasks
    - 3 Core Mapping Services
    - 7 Core Information Services
    - 1 task on Spatial Data Infrastructure
  - 4 years duration (50 months)
    - From September 2008 to October 2012
    - 2 months extension (December 2012)



- **Objectives:**
  - to prepare, validate and demonstrate pre-operational service chains and products, and
  - to propose and demonstrate a concrete functional Land Service.
- **Global component: BioPar CMS + Land Carbon, NARMA and Global Crop Monitoring CIS.**

Integrated approach

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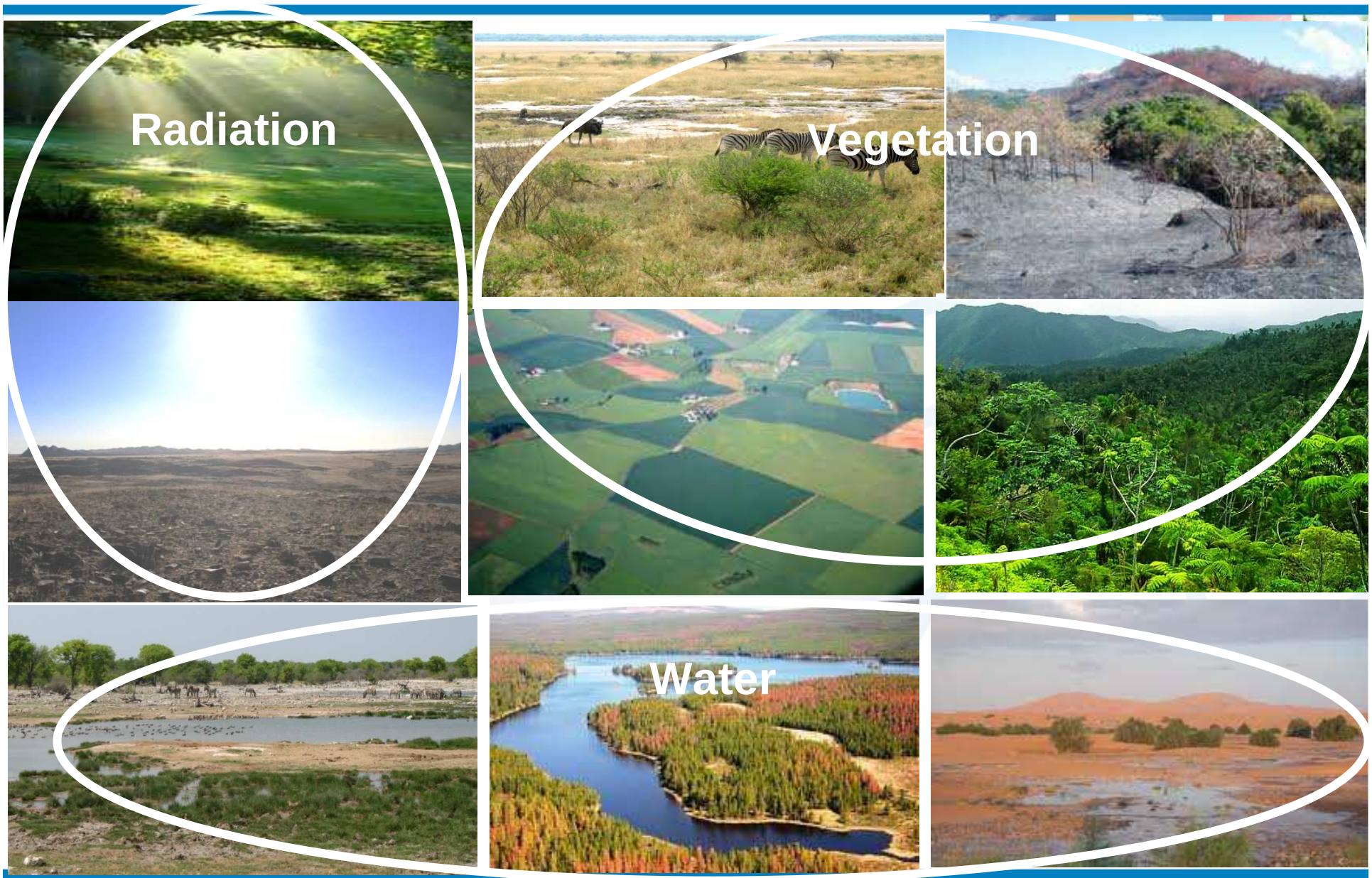

BioPar CMS Portfolio

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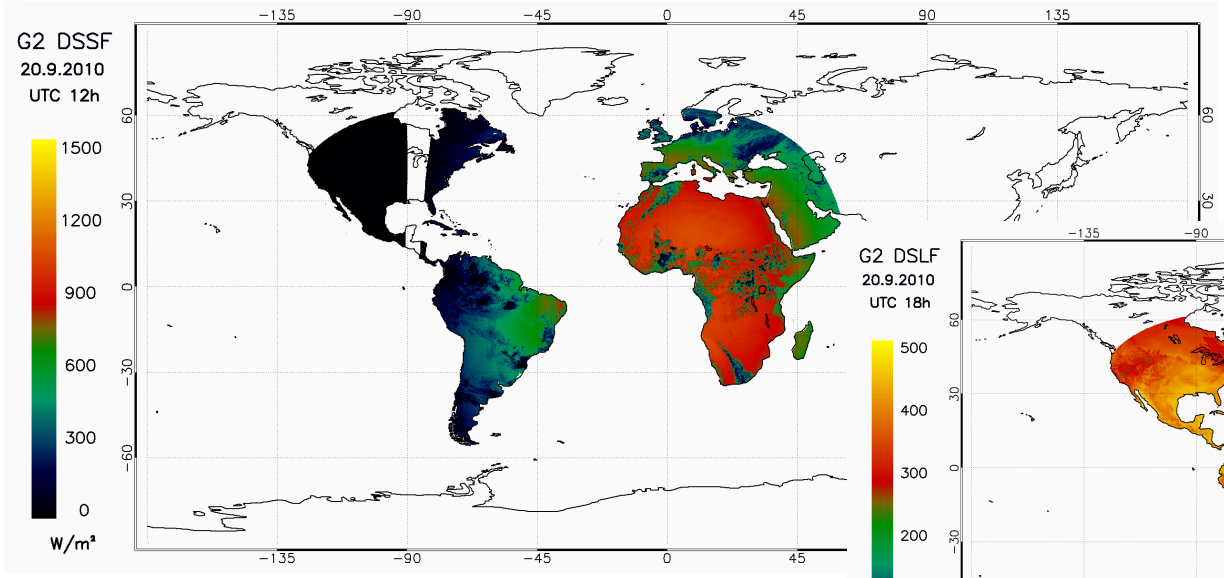
Product	NRT / Off-line	Spatial Resolution	Spatial coverage	Temporal Resolution	Sensor (back-up)
Land Surface Temperature (*)	NRT	~ 5 km	Global	3 hours	ΣGEO + AVHRR
Downwelling Shortwave Radiation, Downwelling Longwave Radiation	NRT	~ 5 km	Global	3 hours	ΣGEO + AVHRR
Surface Albedo – GEO	NRT	~ 5 km	Global	10-days	ΣGEO + AVHRR
Surface Albedo – VGT (*) (**)	NRT	1 km	Global	10-days	VGT
LAI, fCover, fAPAR, DMP, NDVI (*)	NRT	1 km	Global	10-days	VGT (MODIS)
Burnt areas + seasonality (*)	NRT	1 km	Global	Daily	VGT
MERIS FR biophysical products	NRT	300 m	Test Areas	10-days	MERIS
HR biophysical products	Off-line	< 50m	Pilot Areas	2-3 months	SPOT
Long time series of vegetation products + Climatology	Off-line	4 km	Global	10-days	AVHRR + VGT
Water Bodies + seasonality (*)	NRT	1 km	Africa	10-days	VGT
Soil Moisture + Freeze/Thaw (*)	NRT	25 km	Global	Daily	ASCAT
Time series of soil moisture products	Off-line	25 km	Global	Dailly	ERS1&2 Scatt

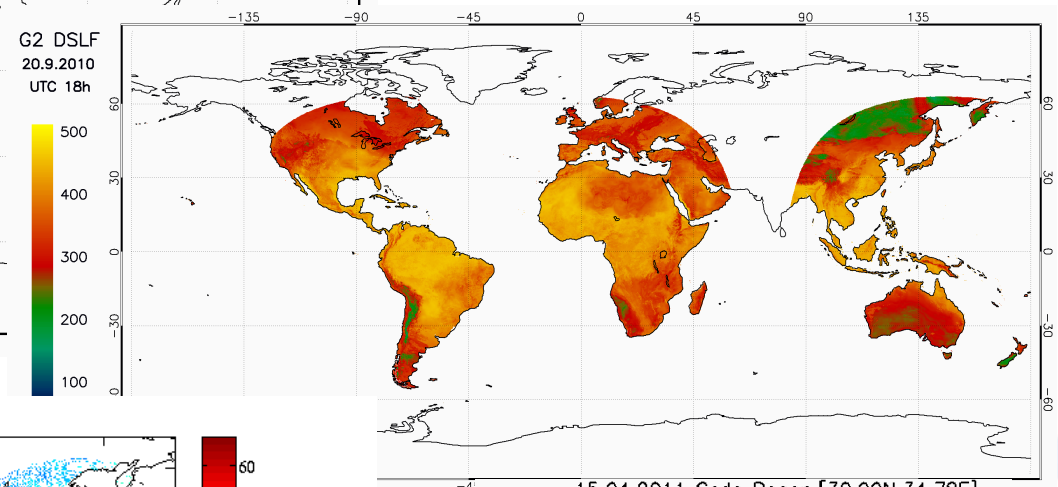
(*) With continuty in GIO Global Land (**) TOC Reflectances will be also delivered

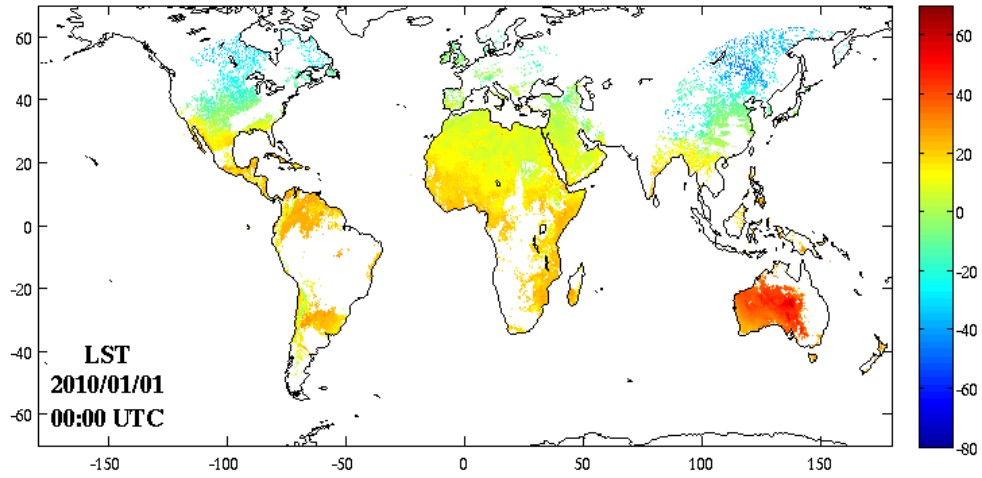
Radiation variables (DSSF, DSLF, LST)

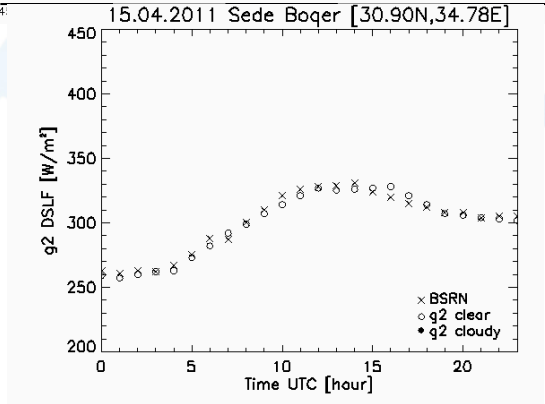
- **They are needed:**
  - Components of surface radiation budget (ECV)
  - main source of energy for surface processes
- **Global hourly products from ΣGEO data**
  - Daily cycle
  - Estimates of integrated values are more reliable since they use higher frequency data
- **Complementary with Eumetsat LSA SAF products**
- **LST selected for the GIO Global Land**
- **Applications:**
  - Atmospheric forcing of surface models
  - Essential to monitor vegetation state, forecast yields and productivity, carbon modeling and carbon surface budget
  - Energy sector (solar)

DSSF, DSLF, LST



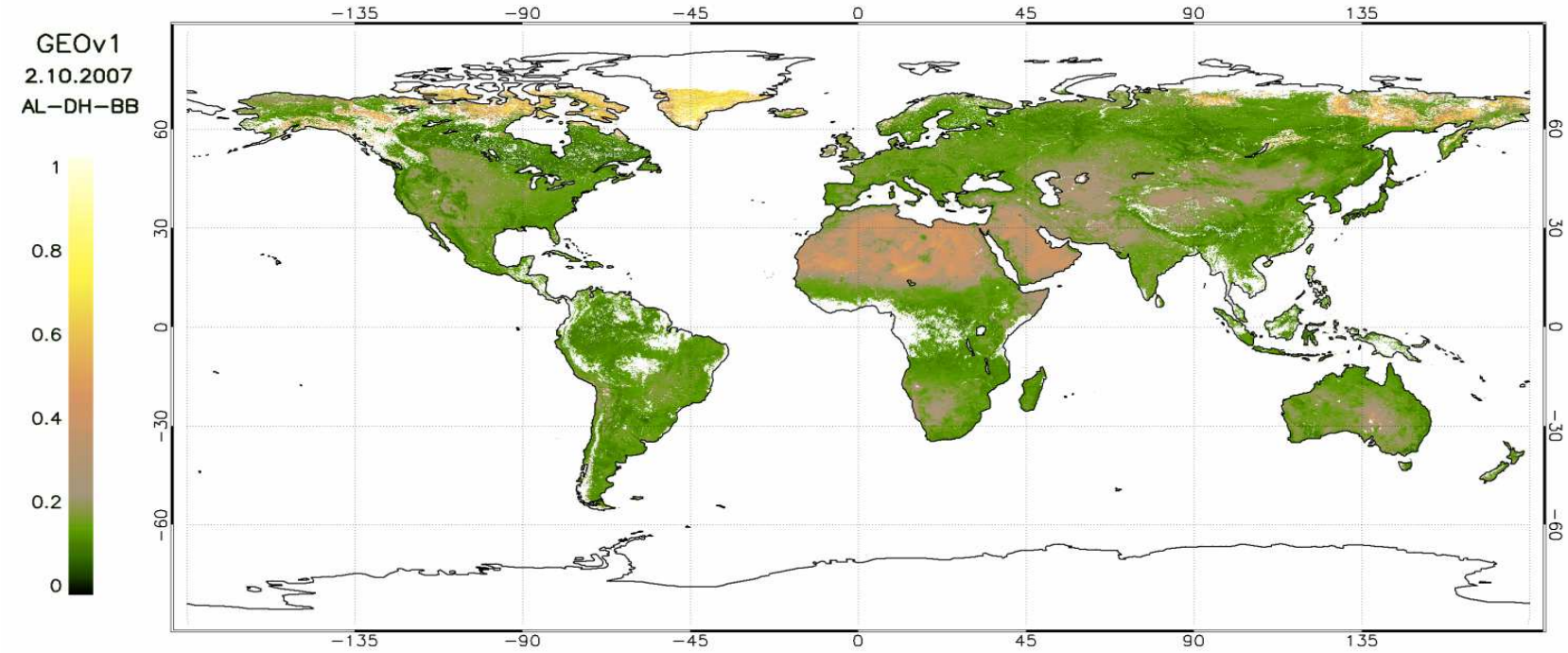






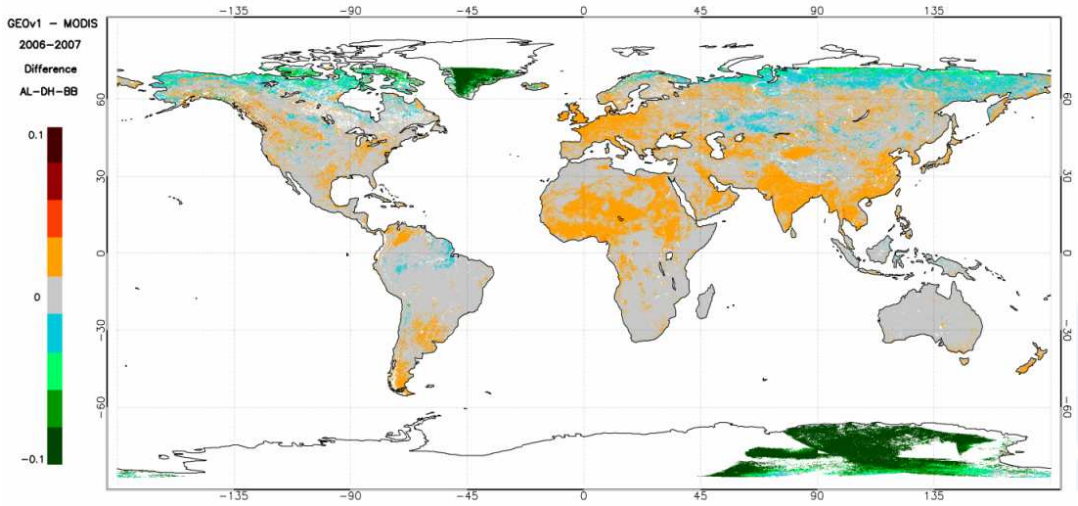
ALBEDO

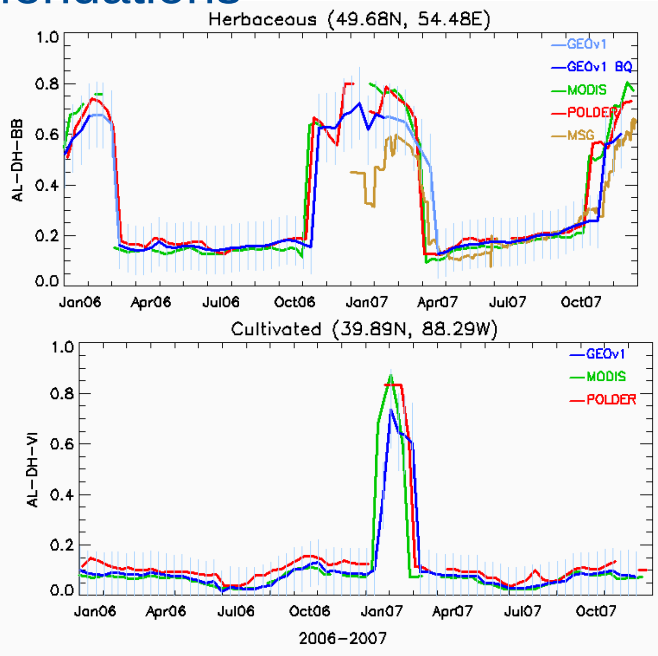
- **SPOT/VGT Albedo V1**
  - Directional-hemispherical reflectance (DH-AL)
  - Bi-hemispherical reflectance (BH-AL)
    - VIS: [0.4, 0.7 µm]; NIR: [0.7, 4 µm]; BB: [0.3, 4 µm]
  - Error field, Quality Flag, Number of observations, Land-Sea Mask
  - NRT & long-time series since 1999

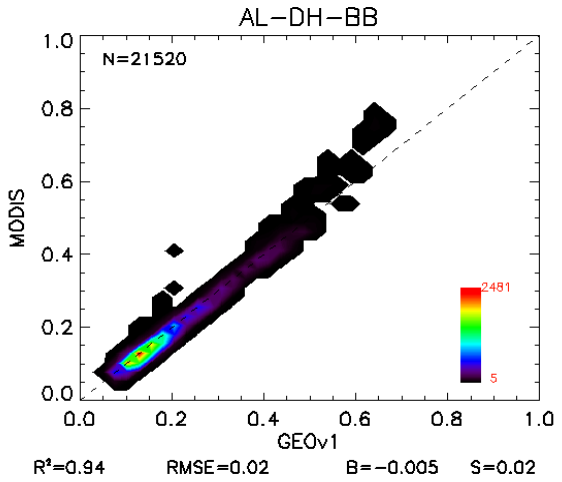


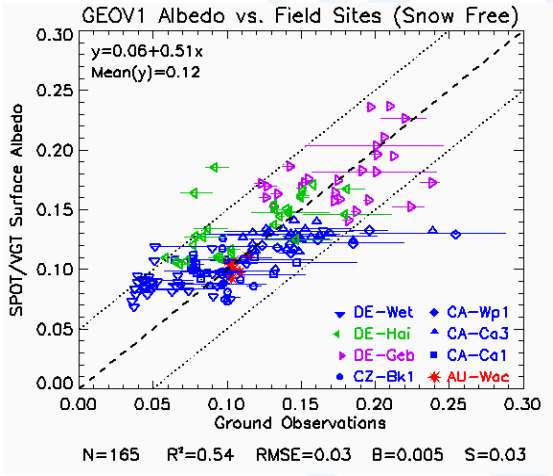
Albedo: Validation

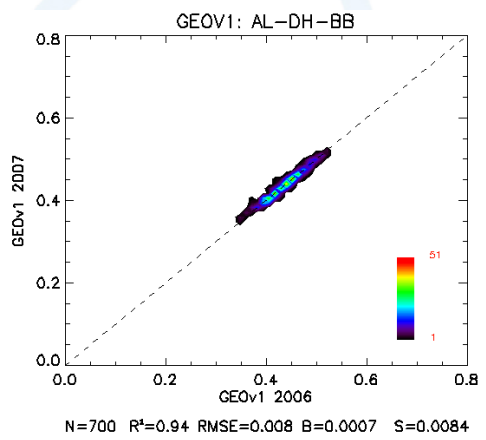
- Validated according to CEOS/LPV recommendations





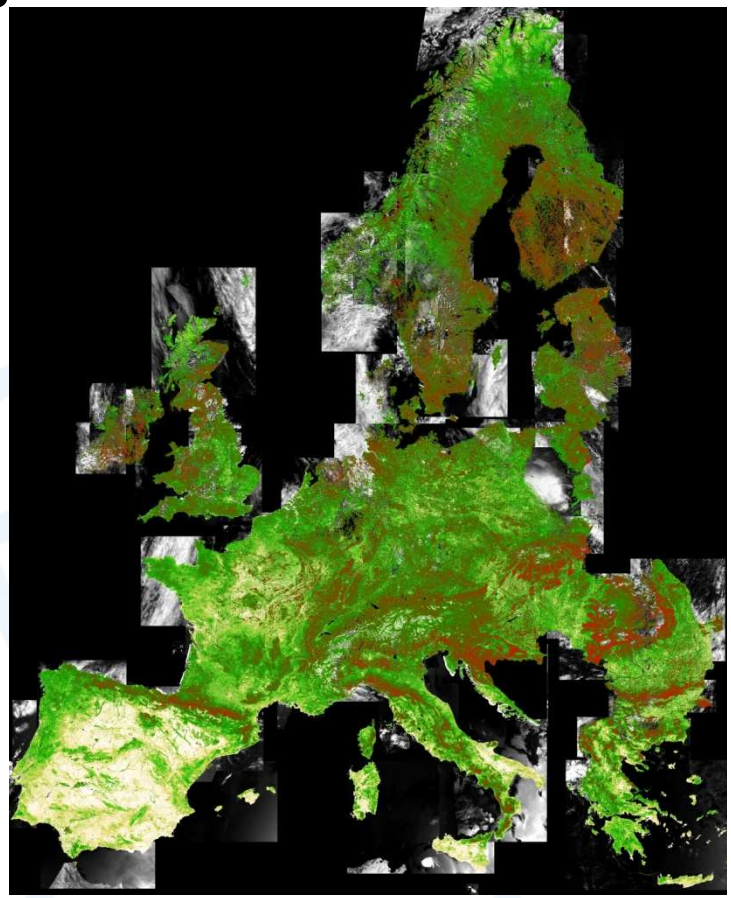




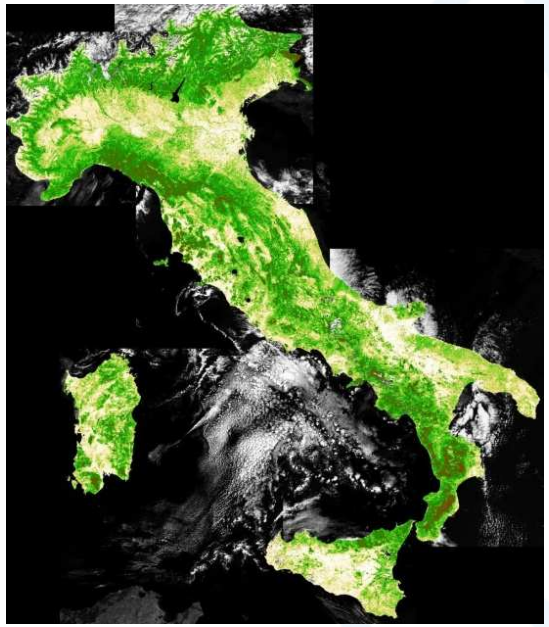


Vegetation variables - MERIS

- **NRT MERIS full resolution products over Europe**
  - ‘basic’ parameters: LAI, FAPAR, fCover
  - 'advanced' parameters: Chlorophyll, fBrown, Canopy Shade Factor
  - From March 2011-March 2012

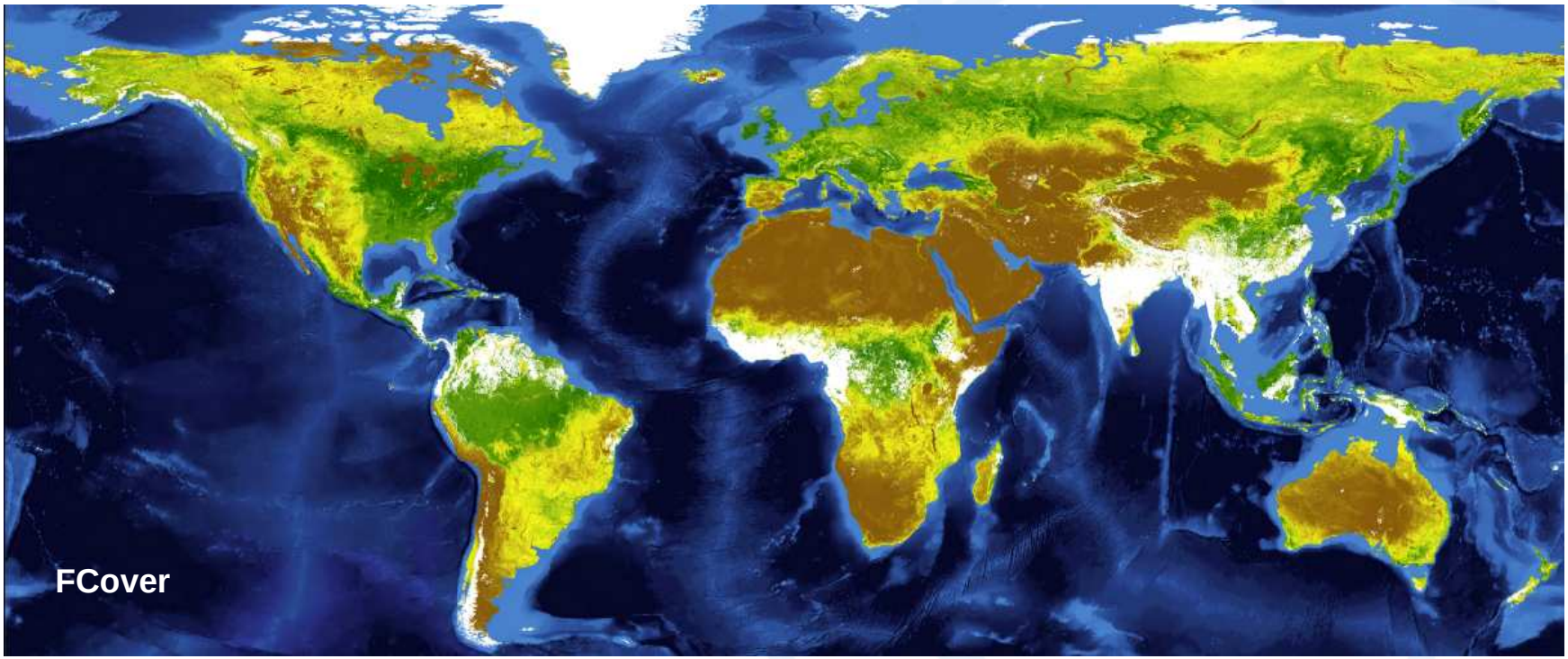


- **Expandable to other world regions having MERIS systematic acquisition**



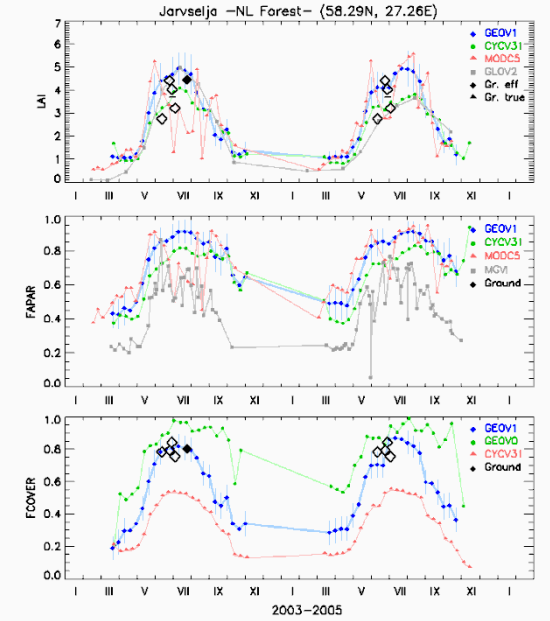
Vegetation variables – SPOT/VGT

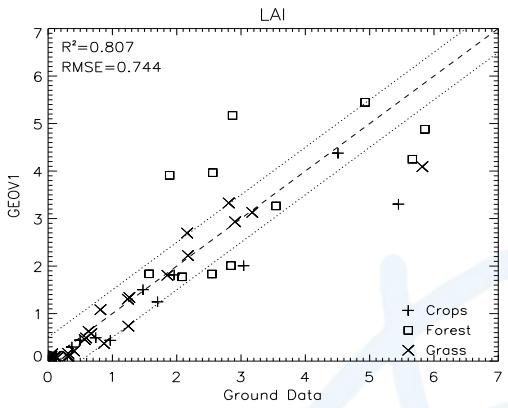
- **LAI, FAPAR (terrestrial ECV) + FCover and NDVI**
- **Global products from SPOT/VGT, since 1999 and NRT**
- **Long heritage since 2002 (FP5/Cyclopes, FP6/geoland)**
- **Complemented (from 1982) by AVHRR/NOAA time series**
- **Validated according to CEOS/LPV criteria:**
  - Best products on the market according to CEOS/LPV criteria

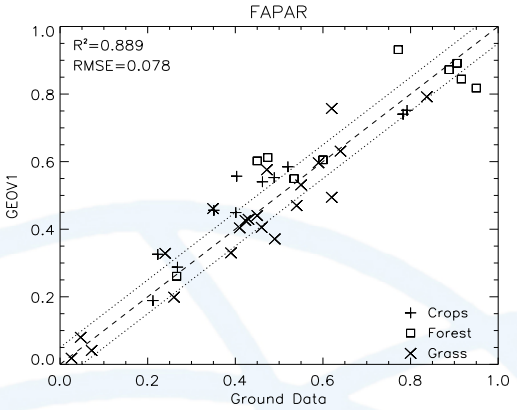


Vegetation variables – SPOT/VGT

- **Validation shows that GEOV1 is the best global product**





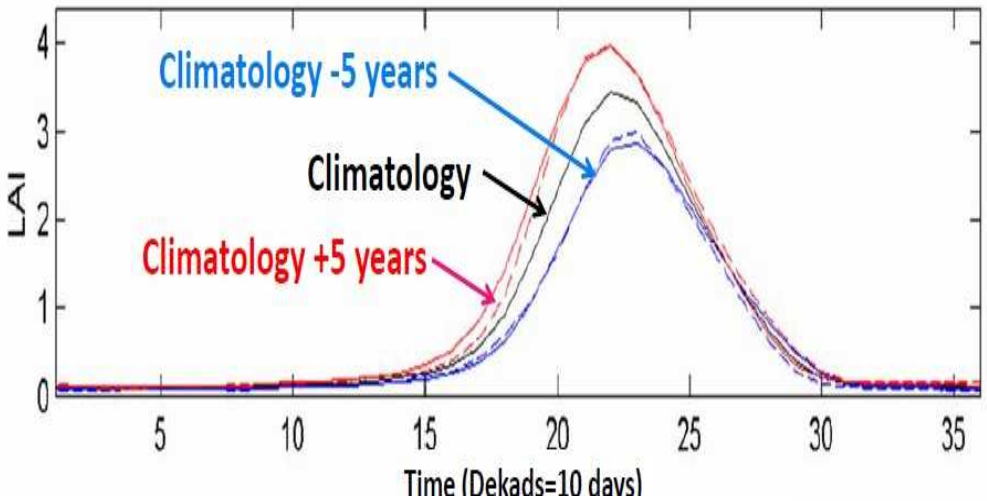


Summary of Product Evaluation

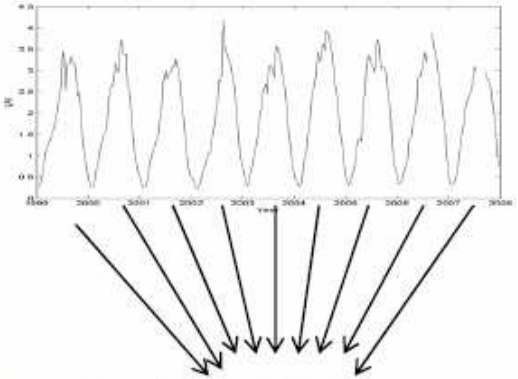
	GEOV1	MODIS	CYCLOPES	GLOBCARBON	JRC FAPAR
Continuity (Missing Values)	-	-	-	-	-
Magnitude High Values	+	+	-	+	-
Magnitude Low Values	+	-	+	+	+
Temporal Consistency (Precision)	+	+	+	-	+
Direct Validation (Accuracy)	+	+	+	-	-
Smoothness	+	-	+	monthly (+)	daily (-)

Vegetation variables – Climatology

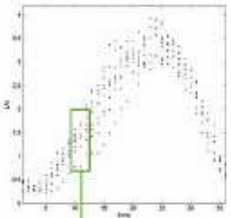
- **LAI, FAPAR (terrestrial ECV) + Fcover**
  - Based on SPOT/VGT products (1999-201
  - Useful for:
    - Trend Analysis
    - Gap Filling



Time series

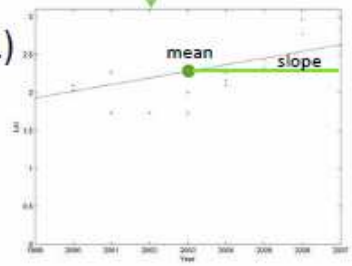


Compilation of all years over the 36 dekads



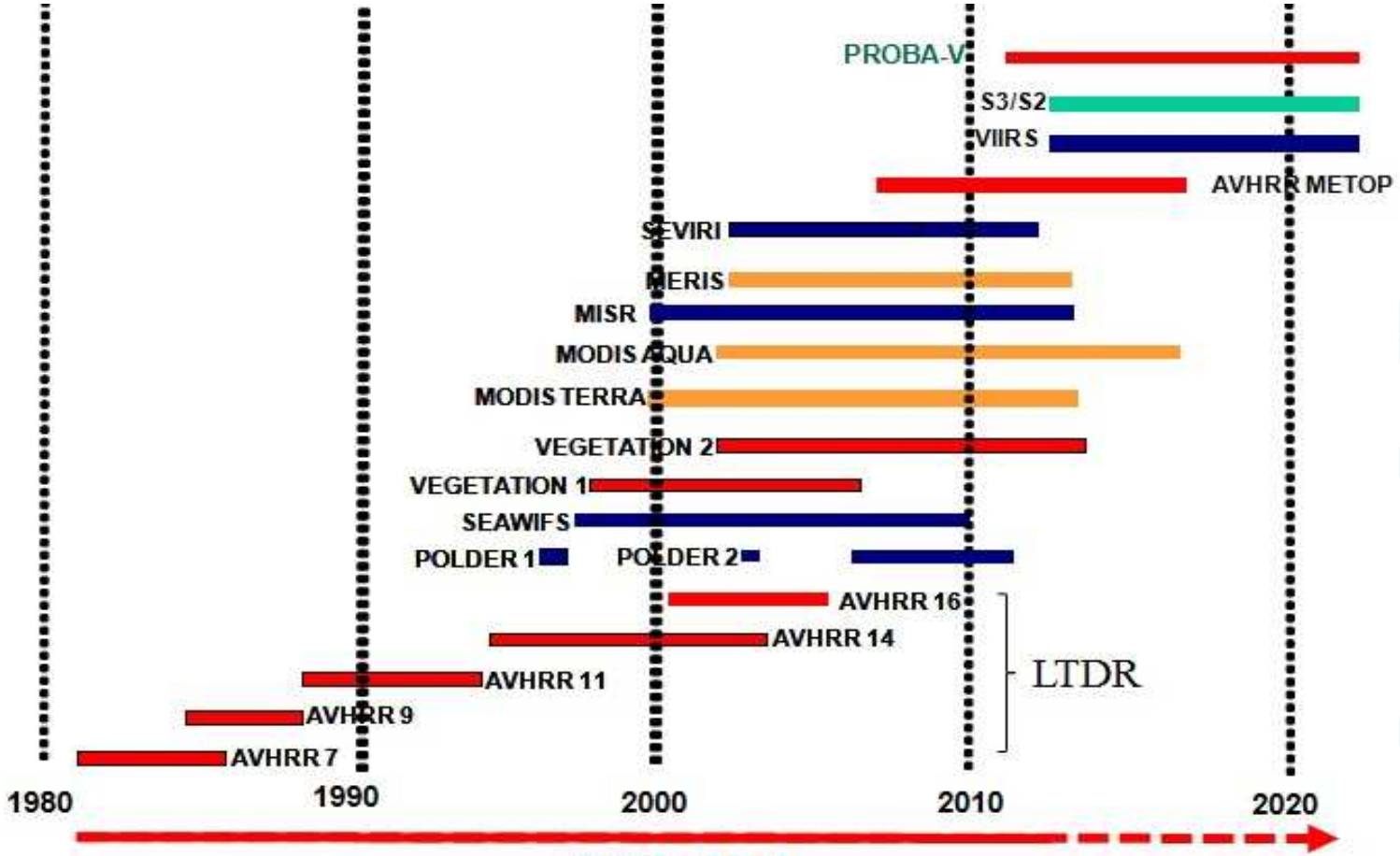
Extraction of 3 consecutive dekads

For each dekad (d-1, d, d+1)
- Average
- Standard deviation
- Number of obs.
- Trend
- Probability



Vegetation variables – Long-time series

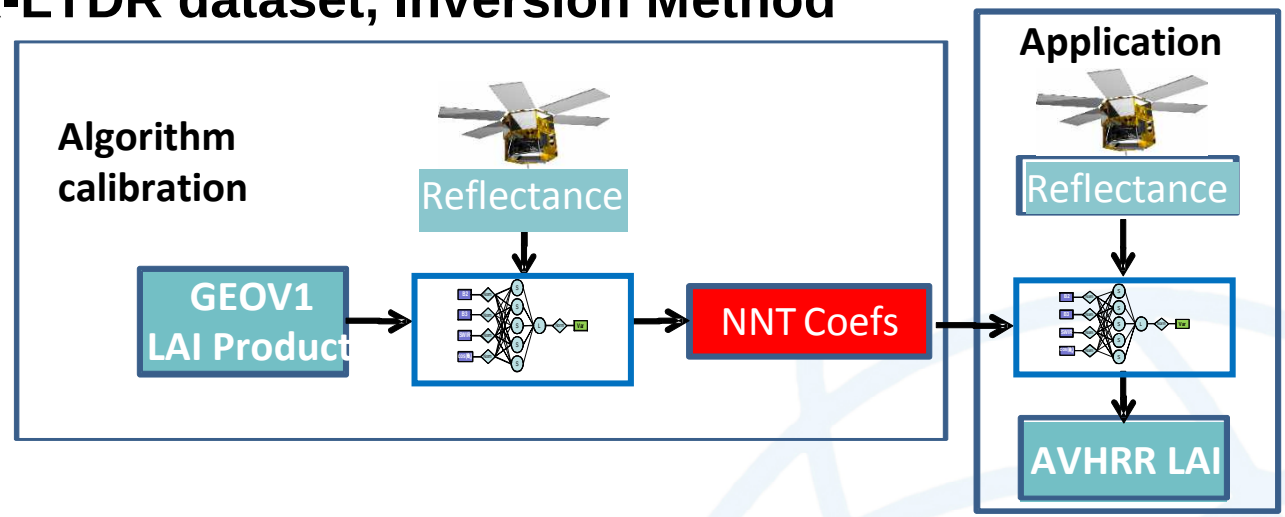
- **AVHRR-LTDR dataset, fully compatible with SPOT/VGT**

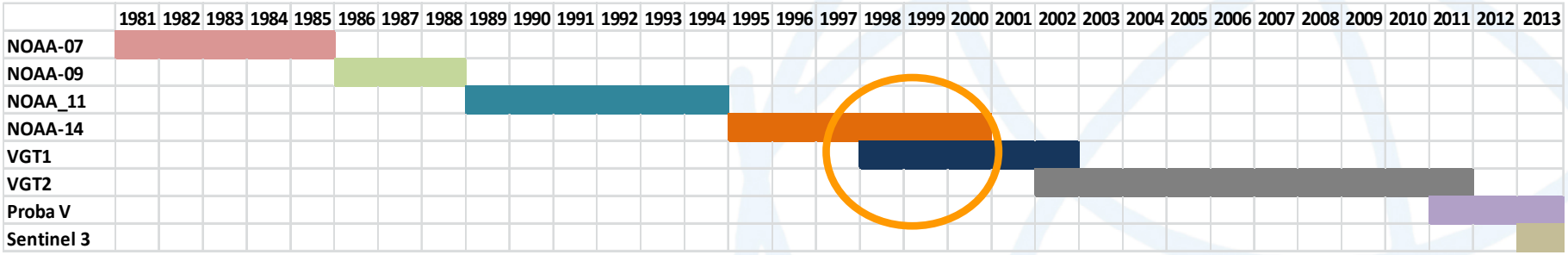


For many (most) applications, continuity (& consistency) with past observations (AVHRR/VEGETATION/MODIS/SEAWIFS) mandatory

Vegetation variables – Long-time series

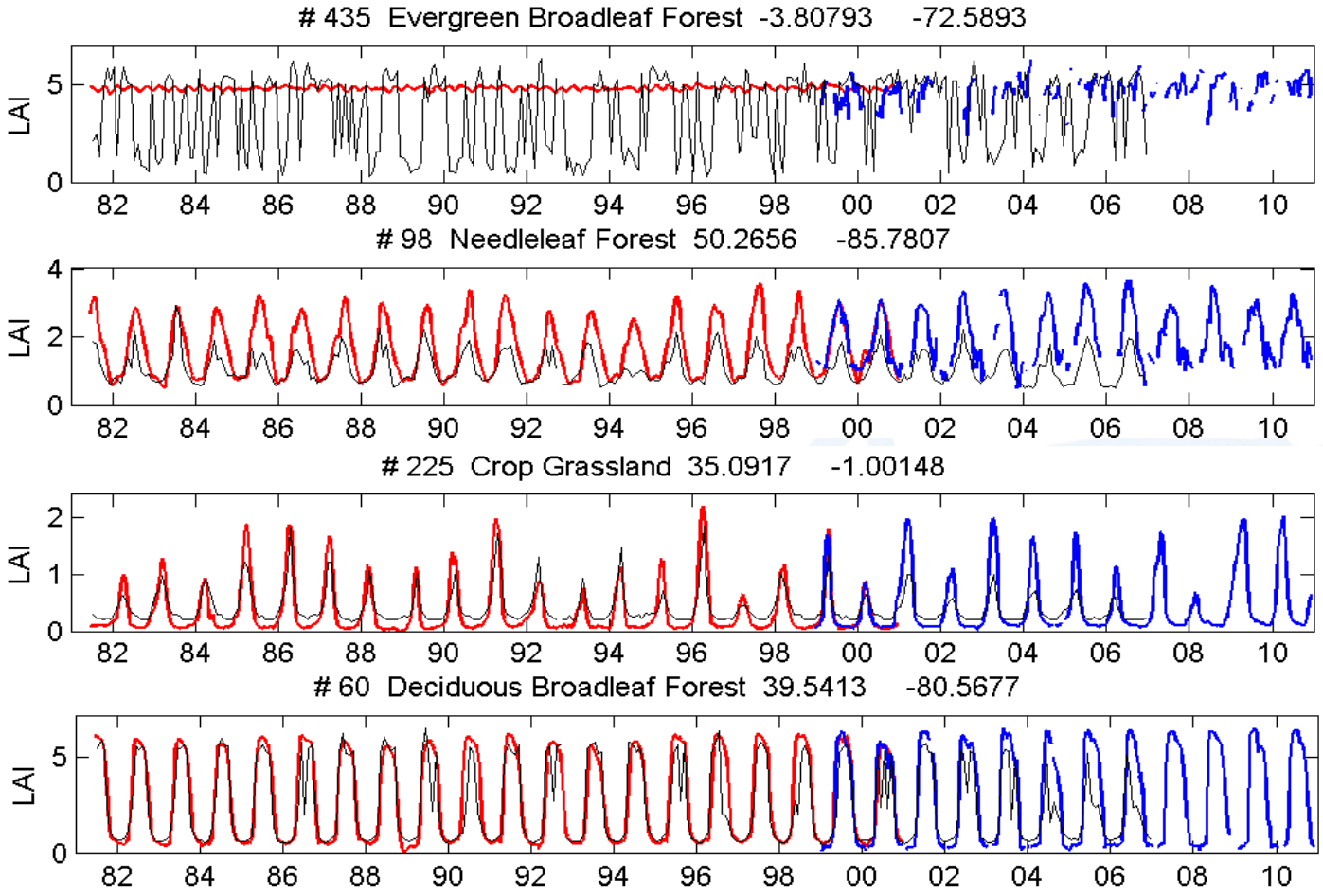
- **AVHRR-LTDR dataset, Inversion Method**





- Neural networks trained on GEO-V1 products (decade), using daily LTDR AVHRR (NOAA14) reflectance data as inputs on the overlapping period 1999-2000 on BELMANIP sites (Verger et al., 2008)

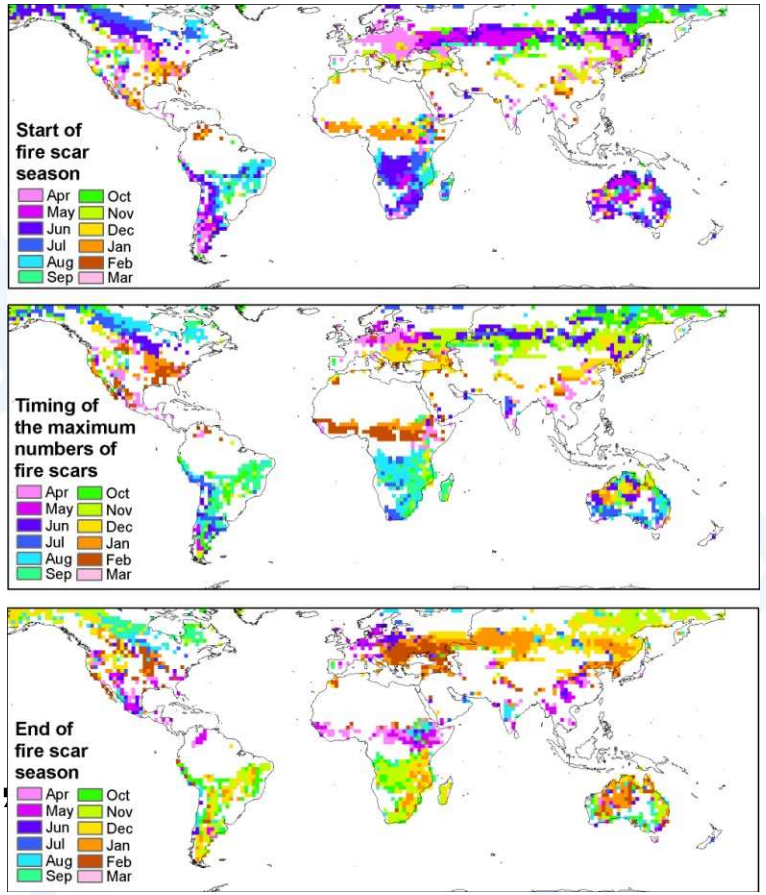
Vegetation variables – Long-time series



BU_AVHRR GEOV1_AVHRR GEOV1_VGT

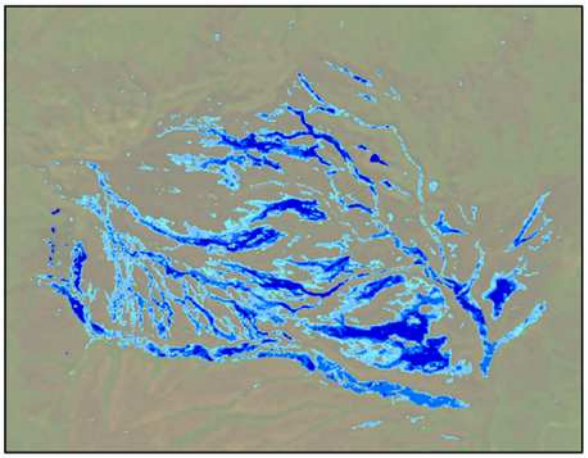
Burnt Areas

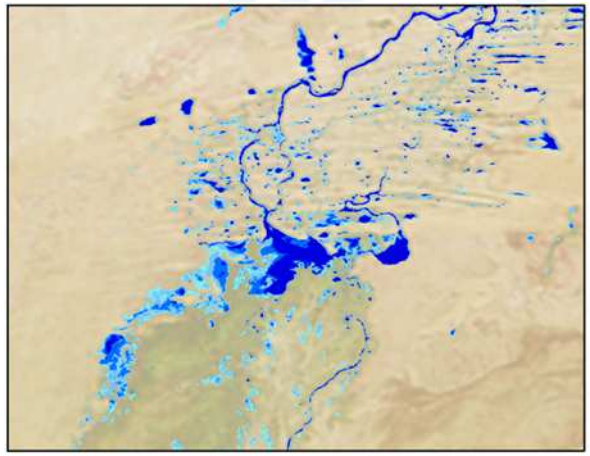
- **International recognition around the importance of fire**
  - GOFC-GOLD Fire Implementation Team
  - Burnt Areas is a terrestrial ECV
- **global Burnt Area from SPOT/VGT**
  - Contains seasonality information, made operational for the first time
  - Consistent with other variables as FAPAR and land use
  - May be selected as being the best algorithm presented for the ESA-CCI round-robin exercise.
- **Fires and burning will continue to be an issue related to emissions, degradation, deforestation and human well-being**

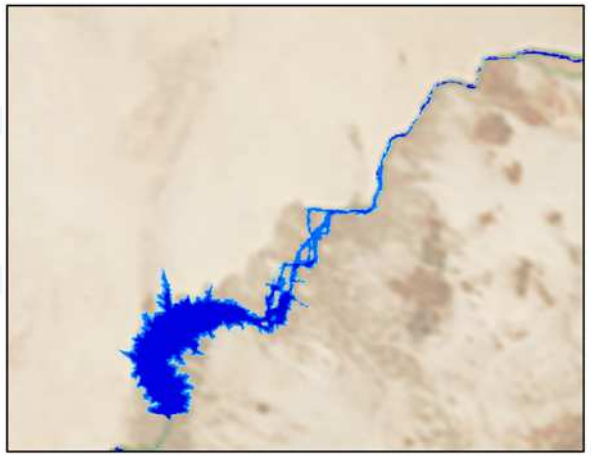


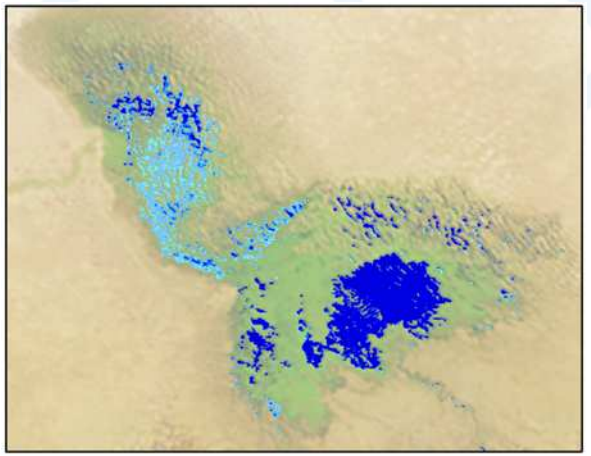
Water Bodies

- **Major interest for applications in Africa**
- **Demonstration done at continental scale but generic algorithm can be applied at global scale**
- **Mapping and seasonality information**
- **2 versions of products**
  - From SPOT/VGT 1km
  - From MODIS 250m





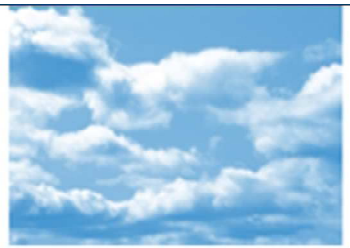




Soil Moisture – Soil Water Index

- **Soil moisture is needed**
  - by all GEO Social Benefit Areas and was ranked the second top priority parameter (behind precipitation) in a year 2010 GEO report on „Critical Earth Observation Priorities“
- **Geoland 2 ASCAT Soil Water Index**
  - Level 3 product based on EUMETSAT’s Level 2 product, the only global NRT soil moisture service worldwide
  - Estimate of the profile soil moisture content: easier to use & more relevant in terms of the applications
- **Long heritage since 1999**
  - Widely validated by independent research teams
  - SWI algorithm now also used with other soil moisture products (AMSR-E, SMOS, etc.)





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Applications of BIOPAR products



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geoland2 project

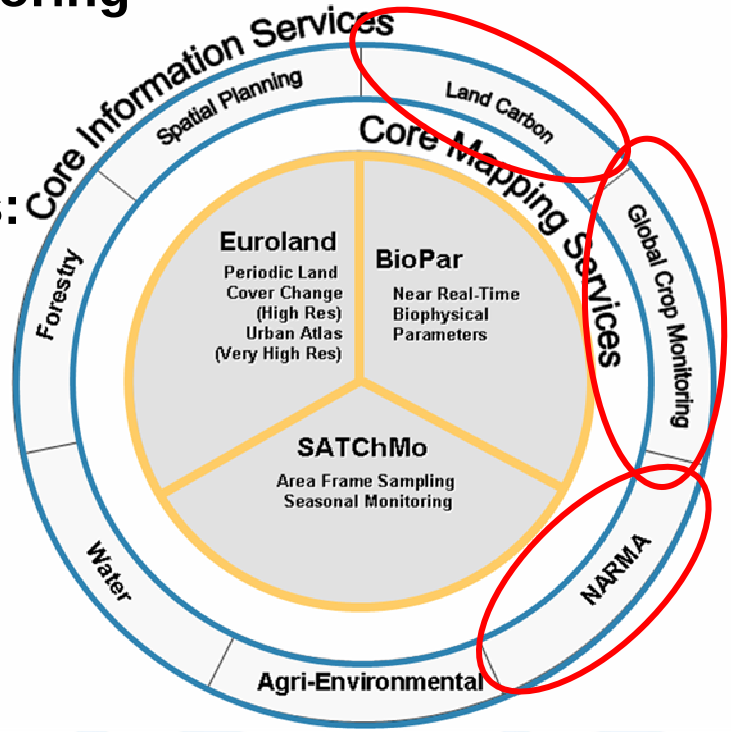
- **There are many potential applications mainly related to agriculture, environmental monitoring and land-atmosphere interactions**

- **Withing geoland2 there are three key users:**
  - ECMWF, Land Carbon CIS

    Provides global and regional variables related to the terrestrial carbon cycle, in near-real-time
  - JRC/ MARS - Global Crop CIS

    Crop assessment and yield forecasts in support of EC Policies
  - JRC/ GEM- NARMA (Natural Resources Monitoring in Africa) CIS

    Environmental monitoring capacity over African countries for the benefits of the EC and its regional and continental partners in Africa.

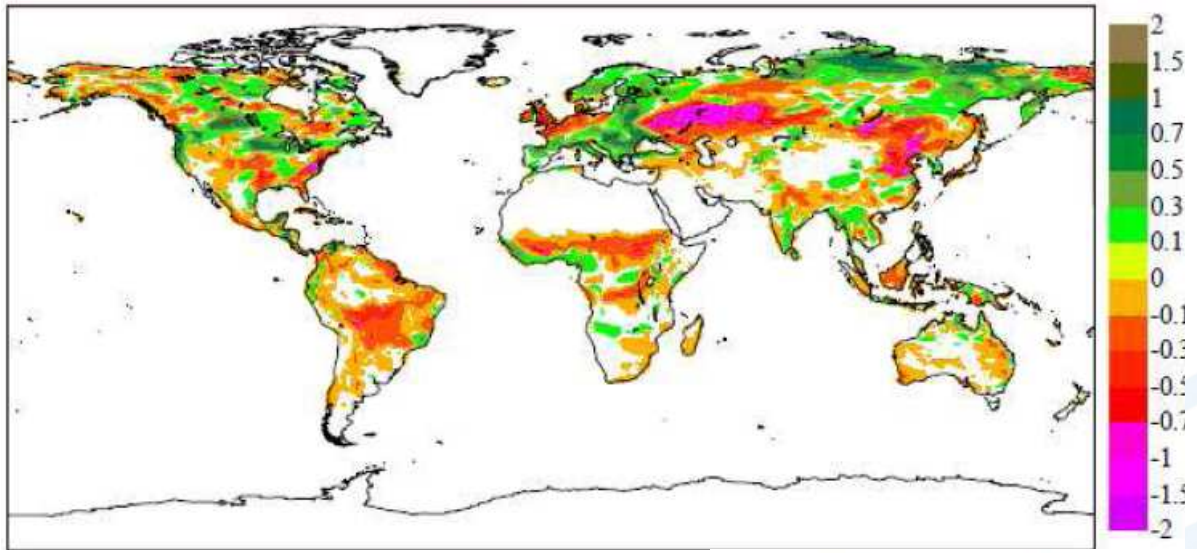


Land Carbon

- **A pre-operation global land carbon fluxes monitoring service at ECMWF**
- **Modelling platform**
  - based on the CTESSEL land surface model
  - built upon the physics of the Meteo-France model
- **Interactive vegetation modelling allowing the**
  - Assimilation of LAI & SM satellite products running in NRT
  - Assessment of the impact of climatic extremes that have large societal impact
- **Product status**
  - Carbon fluxes are already pre-operational (since 17 November 2011)

Land Carbon

CTESSEL Leaf Area Index anomaly from 1979-2010 mean [m2/m2] for 201007



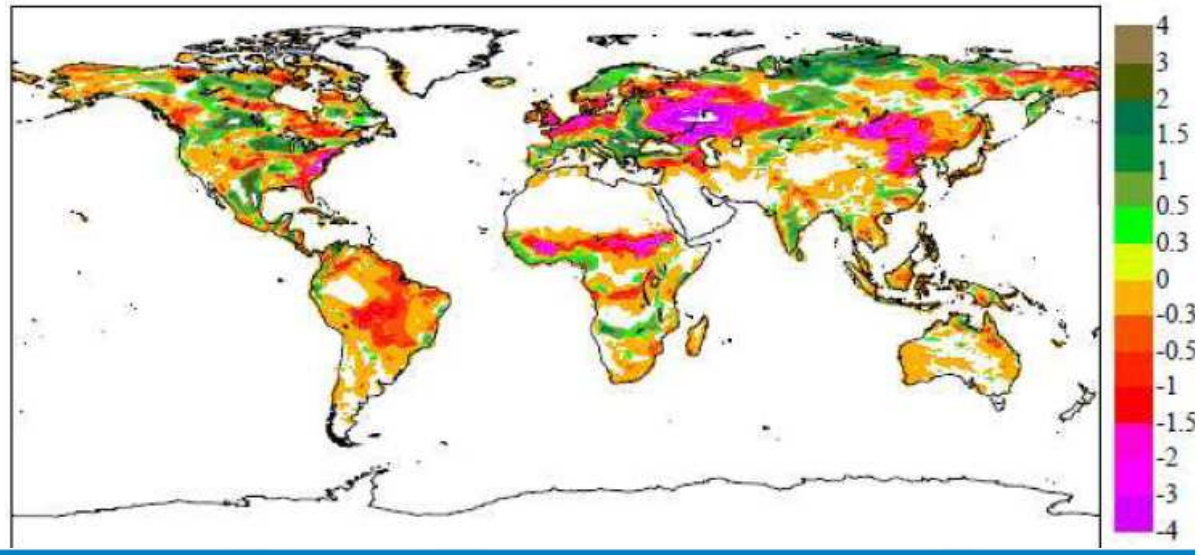
Impact of climate anomalies on:

LAI

CO_2 fluxes

The summer 2010 Russian case

CTESSEL Net Ecosystem Exchange anomaly from 1979-2010 mean [micomoles/m2/s] for 201007

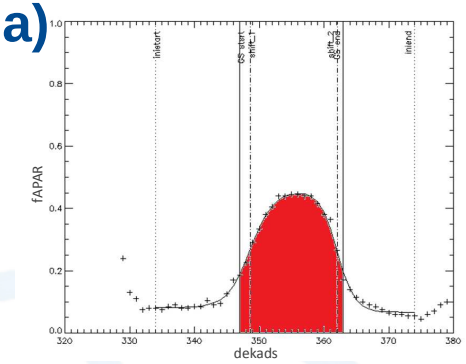


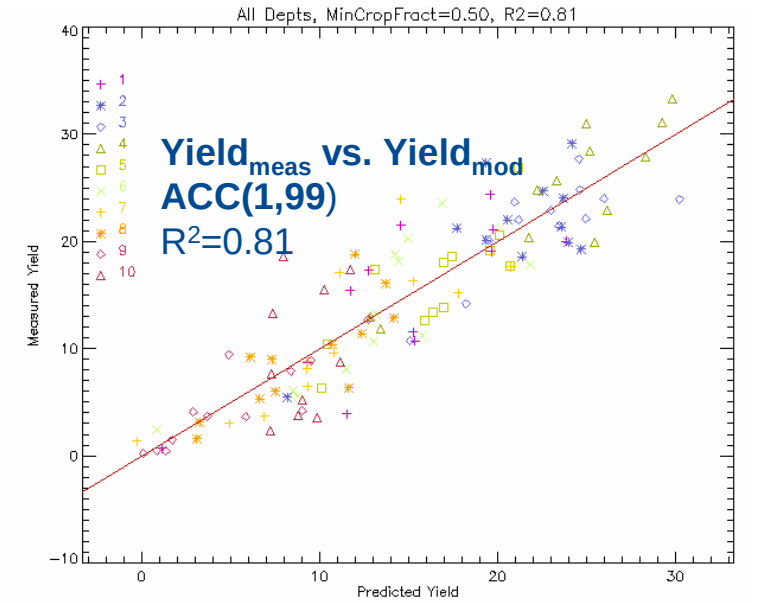
The summer 2010 Russian case

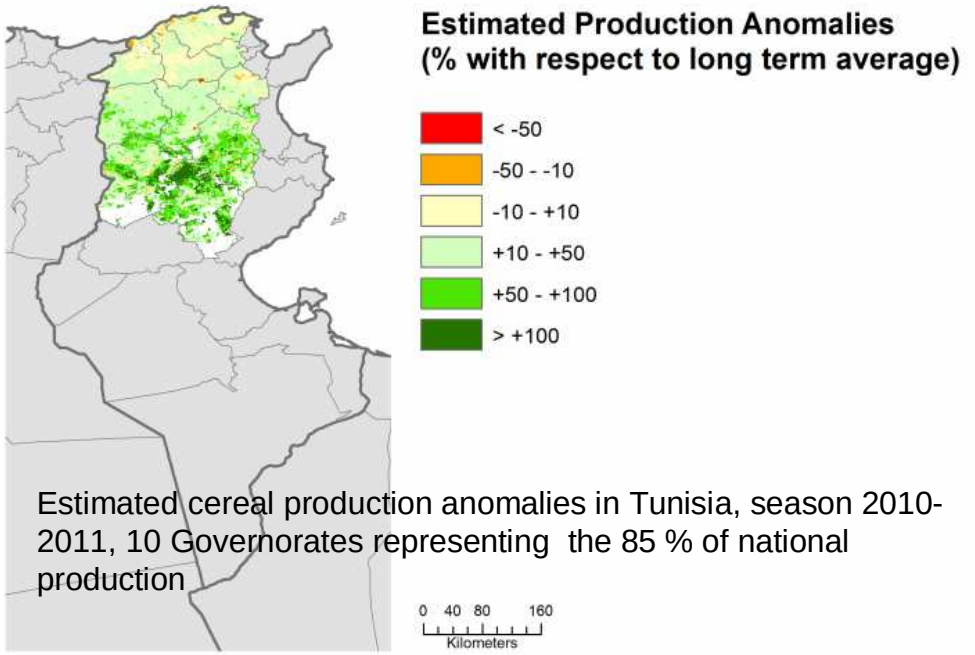
Crop & Yield monitoring (Case study: Tunisia)

- Yield is modelled as cumulative fAPAR between key phenological dates (SOS and EOS, extracted from VGT time series), proportional to GPP

$$\text{Yield} \approx \int_{sos}^{eos} fAPAR\, dt \approx \int_{sos}^{eos} \varepsilon * PAR * fAPAR\, dt$$



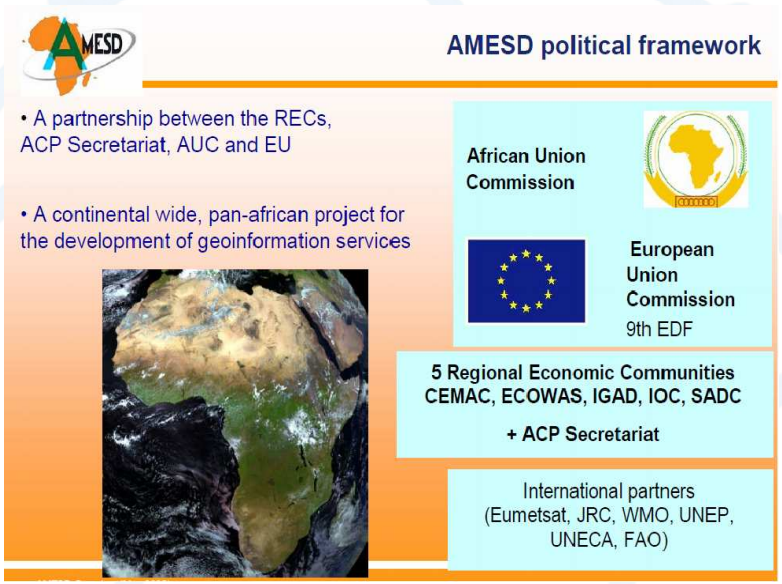




Estimated cereal production anomalies in Tunisia, season 2010-2011, 10 Governorates representing the 85 % of national production

NARMA

- **NARMA service is allocated in the AMESD e-Station platform**
  - automates the final steps of data post-processing adjustable to the specific geographic and thematic areas to be covered, and provides a multi-user web-based reporting environment
- **Key Users of NARMA: AMESD (African Monitoring for Environment and Sustenaible Development) THEMAS (THEMatic ApplicationS)**
  - CEMAC (Regional Economic Community)
    Management Water Resources (THEMA)
  - ECOWAS
    Water Management for Cropland and Rangeland Management
  - IGAD
    Land Degradation Mitigation and Natural Habitat Conservation
  - IOC
    Coastal and Marine Management
  - SADAC
    Agricultural and Environmental Resource Management



AMESD e-Station platform and BIOPAR products support ECOWAS services

ECOWAS : Water Management for Cropland and Rangeland Management

Associated countries

- Mauritanie / Sénégal / Gambie / Cap Vert / Guinée Bissau / Guinée Conakry / Sierra Léone / Libéria / Cote d'Ivoire / Ghana / Togo / Bénin / Nigeria / Tchad / Niger / Burkina Faso / Mali

Regional Implementation Centre (RIC)

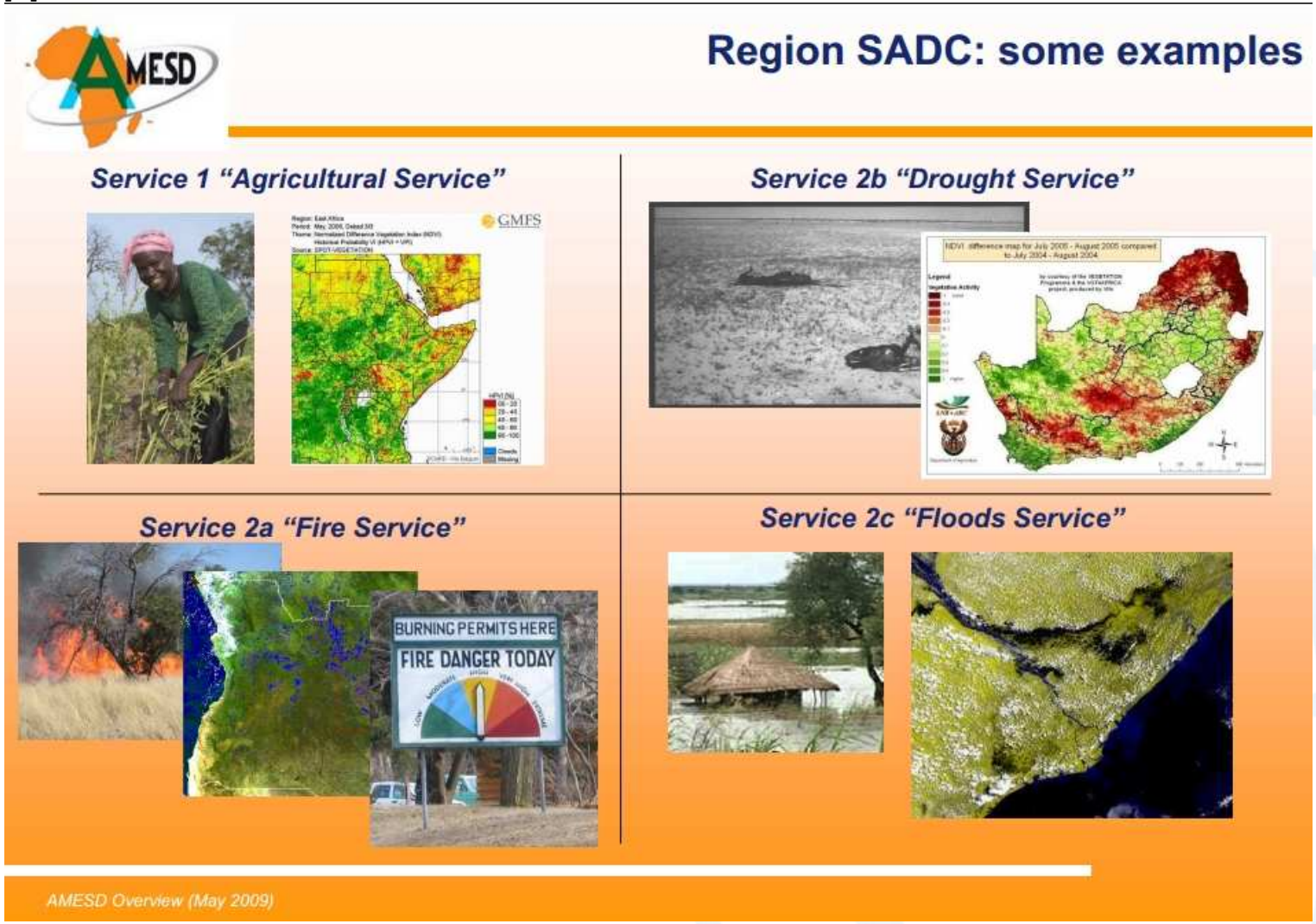
- Centre Régional Agrhymet (CRA)

Service « Production and Distribution of indicators for 4 environmental themes chosen by the users »:

- estimation of yields of cultural and pastural land
- dryland areas and drought risks
- filling levels of small water bodies to support livestock management
- savannah fires

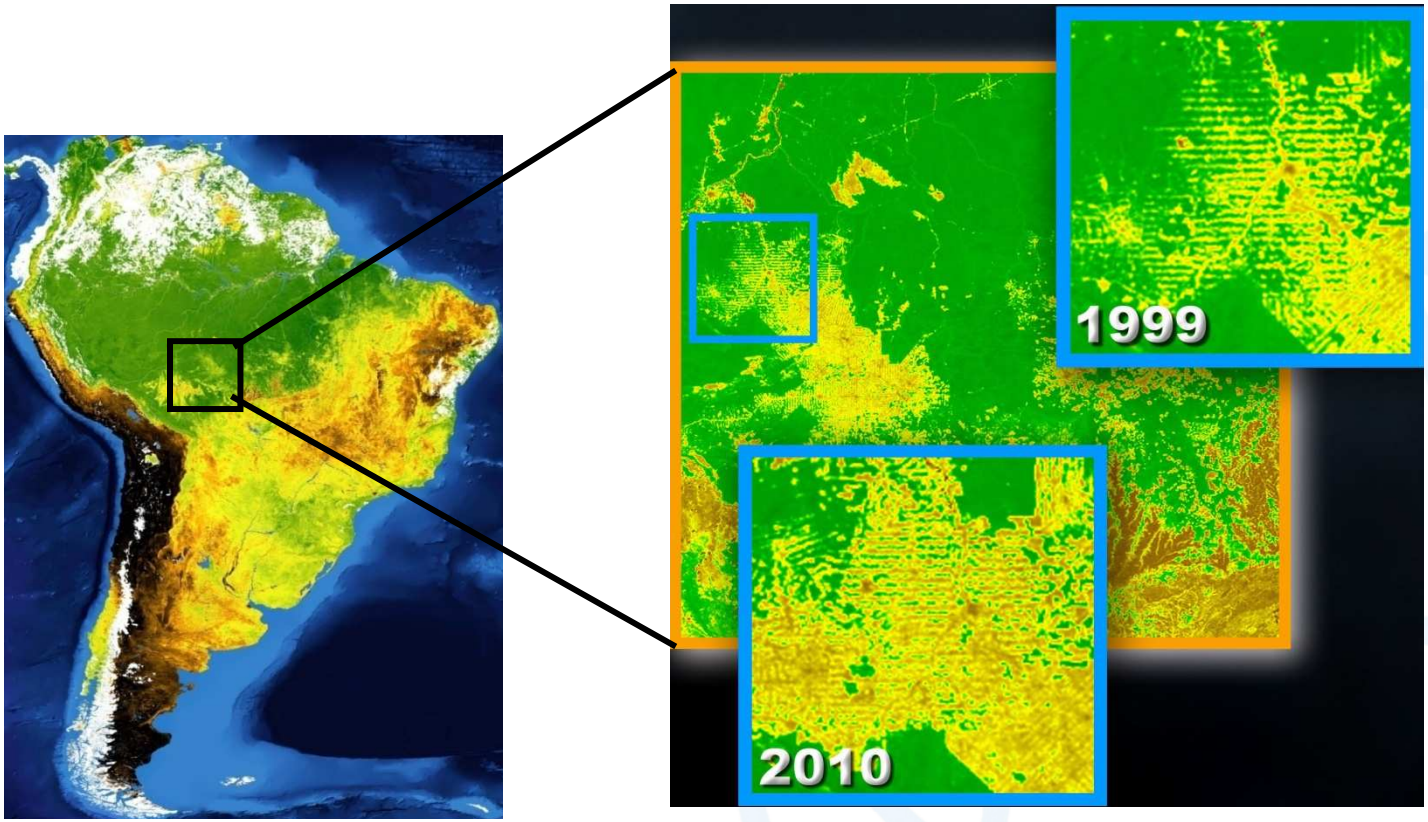
- Key products : Vegetation state, Dry matter productivity, Phenology, Fraction cover, small water bodies, active fires, burnt areas
- Distributed in near real time by EUMETCast and internet
- Key users : ECOWAS, CILSS, International and regional organisations, national authorities

AMESD e-Station platform and BIOPAR products supports SADC services



Vegetation variables

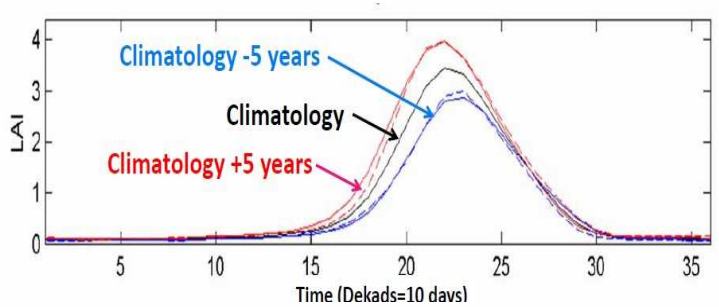
- **applications:**
  - forest and natural resources monitoring, crop monitoring
  - climate change, biodiversity, etc…

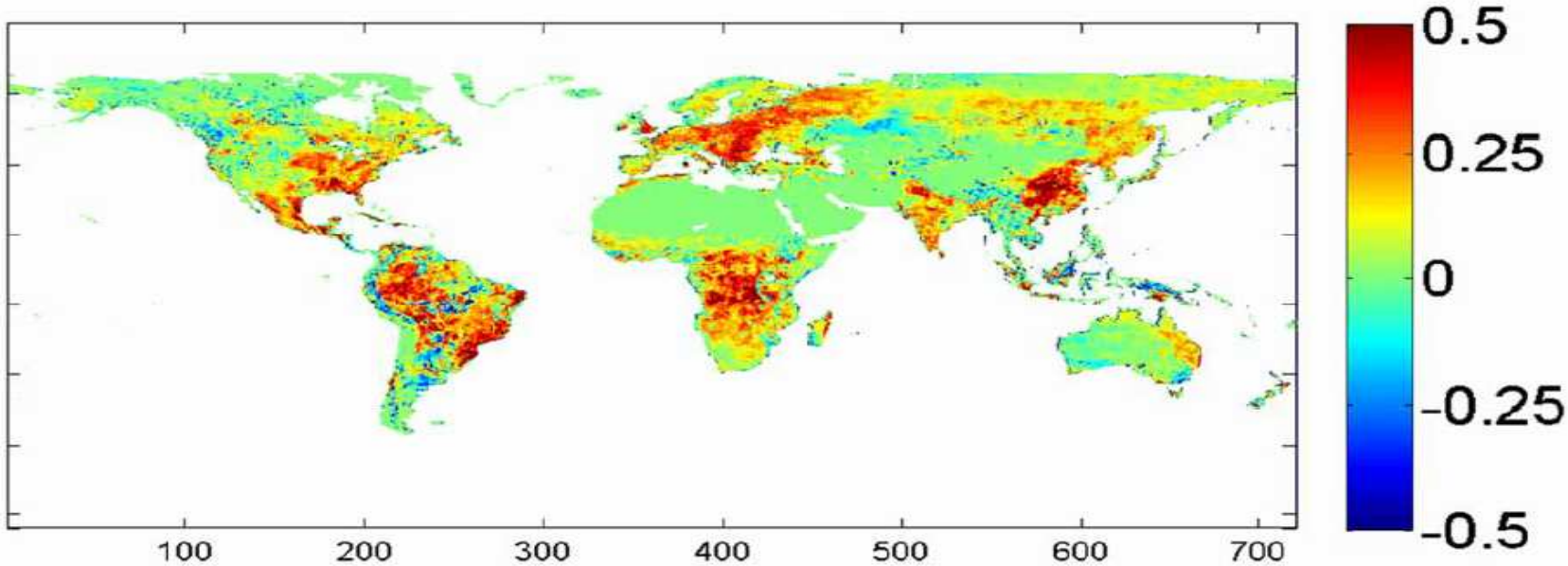


Vegetation variables

- **Applications:**
  - Anomalies, change detection

: Change in LAI magnitude

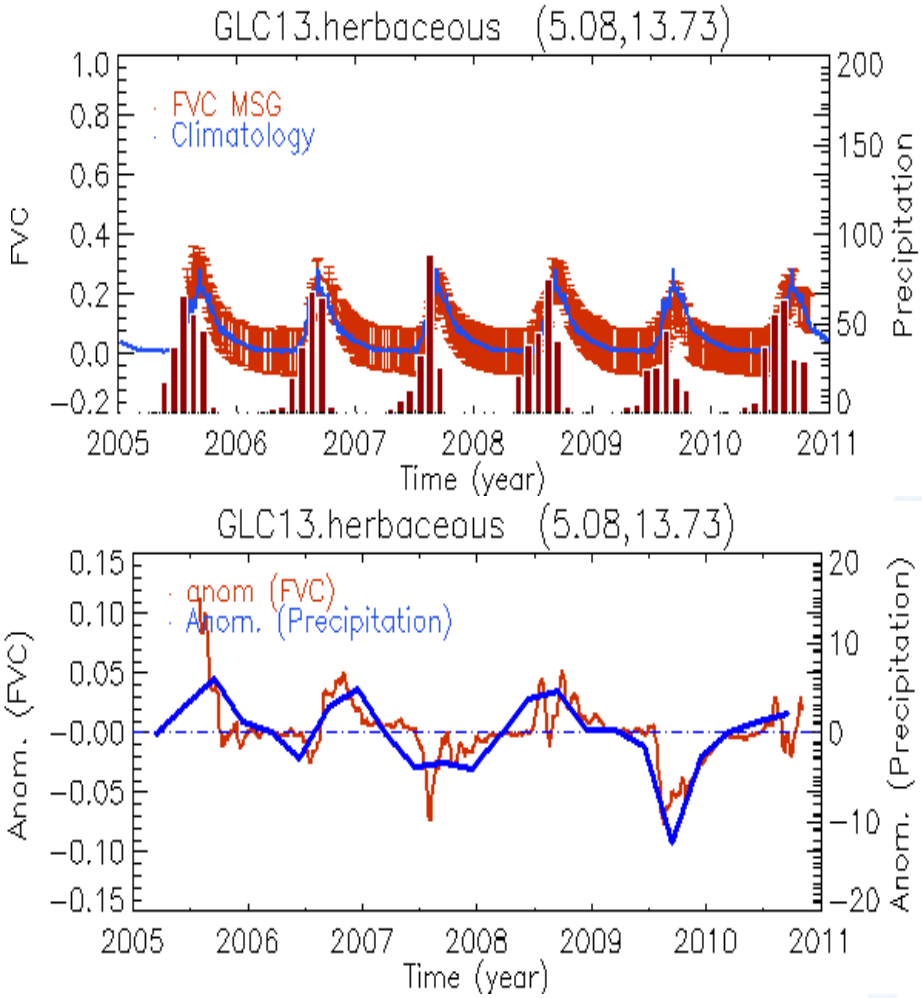


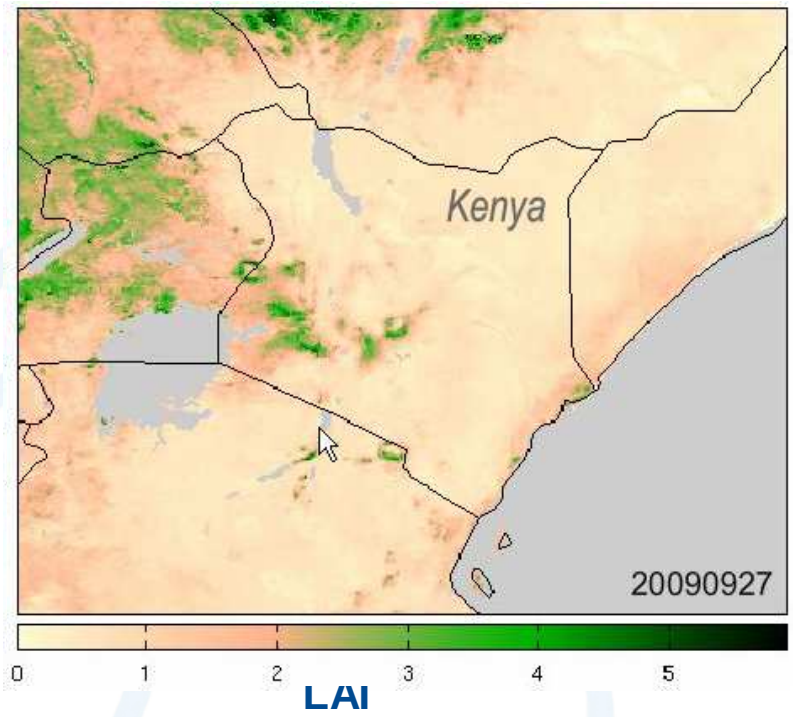


Vegetation variables

- **Applications:**
  - Drought monitoring

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

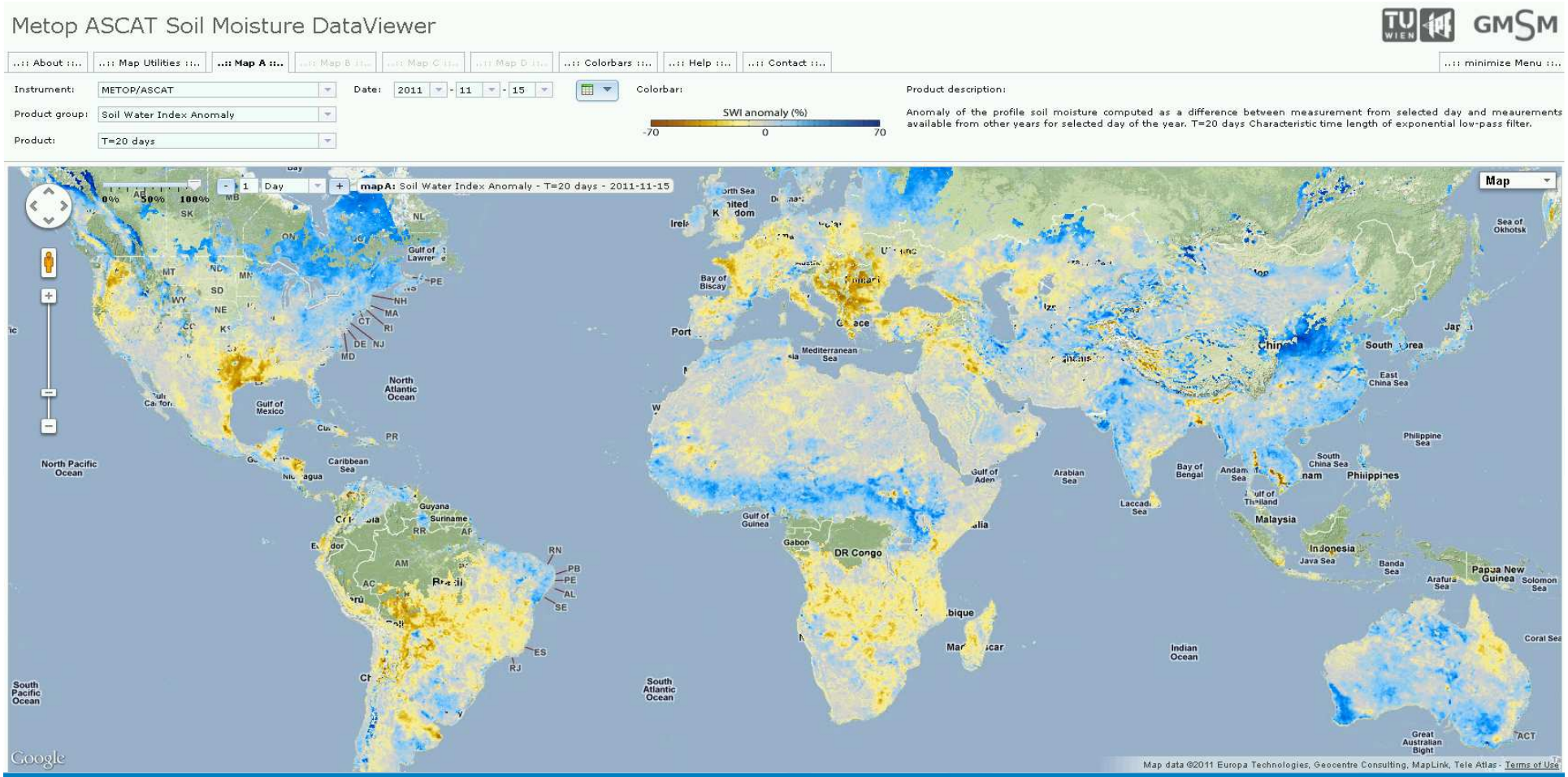




by Isabel Monteiro (EUMETRAIN)

Soil Moisture – Soil Water Index

- **Applications**
  - Prediction of next month‘s vegetation status, improved runoff prediction, drought monitoring etc.



Dissemination

- **Biophysical variables**
  - Accessible through the geoland2 Expert Portal hosted by VITO
    - http://www.geoland2.eu
    - Discovering, viewing, ordering, subscription for NRT products
    - Free access after registration
  - SPOT/VGT products also disseminated via Eumetcast to African and South American users (DevCoCast project)
  - Documentation, including Validation reports, and tools available
- **Global CO_2 fluxes**
  - Available on MARS (Meteorological Archive and Retrieval System) at ECMWF

Conclusions

- **Good progress of geo-biophysical variables and assimilation activities.**
  - NRT production and time series available
  - Validation performed according to CEOS/LPV. BioPar products outperforms for different criteria the quality of existing products
- **A number of production lines are ready for operational production in the GIO Global Land**
- **R&D activities will continue in IMAGINES for developing PROBA-V and Sentinel data processing lines**

ID	Name	EO sensor	Temporal resolution	Spatial resolution	Spatial coverage
01	LAI, FAPAR, FCover	S3 + PROBA-V	10 days	300 m	Global
02	Albedo	S3 + PROBA-V	10 days	300 m	Global
03	Biomass	S3 + PROBA-V	10 days	16 km (8 km)	Global (Fr,Hu)
04	Drought indicators	S3 + PROBA-V + ASCAT	10 days	16 km (8 km)	Global (Fr,Hu)
05	Carbon fluxes (GPP, RE, NEE) and evapotranspiration	N/A	10 days	16 km (8 km)	Global (Fr,Hu)
06	FAPAR per class	S3 + PROBA-V	10 days	16 km (8 km)	Demo sites
07	Surface reflectance	S2	Instantaneous[1]	10 m	Demo sites
08	FAPAR	S2 + S3 + PROBA-V	10 days	10 m	Demo sites
09	Biomass	S2 + S3 + PROBA-V	10 days	10 m	Demo sites
10	Crop map	S1 + S2 + S3	Continuous update [2]	10 m	Demo sites

Table 1.2-2: Detailed IMAGINES products. [1]: for each Sentinel-2 image; [2]: when a new acquisition is available.


Thank you for your attention!