



**SWF – GEOGLAM – International Meeting on
Food Security, Earth Observations and Agricultural Monitoring**
November 21, 2013, Brussels

Session 3 : Global and regional initiatives
**MARS, the EU Crop monitoring and Yield
Forecasting Systems**

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EC Joint Research Centre
H04 MARS Unit

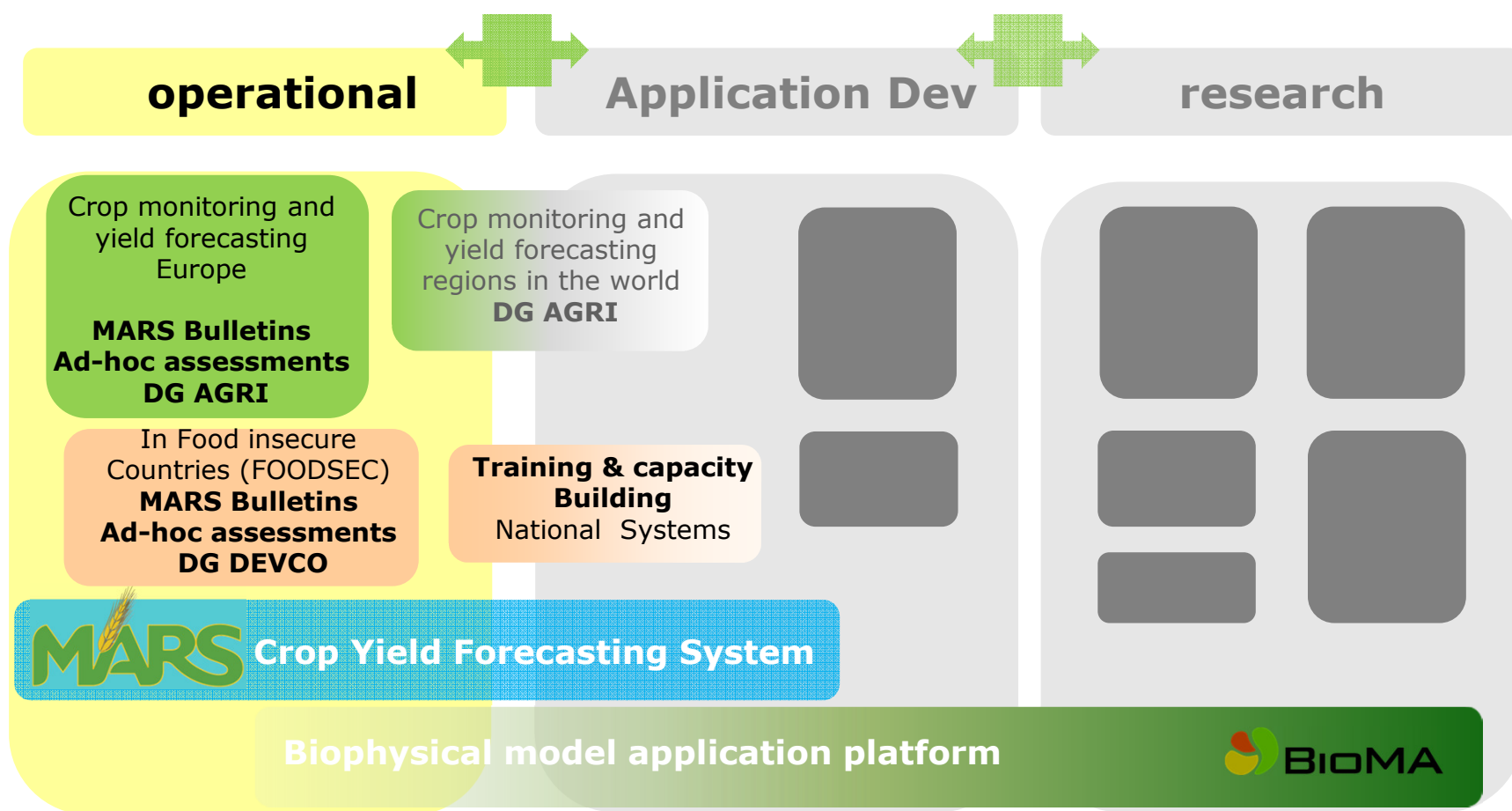




Content

- **Short presentation of MARS Crop Monitoring Yield Forecasting System**
 - **Its current application for Agriculture and Food Security**
- **future prospects and contributions for GEOGLAM**
- **Conclusions Challenges for GEOGLAM**

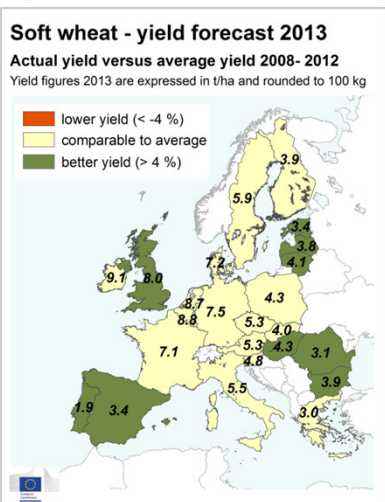
MARS Crop monitoring activities



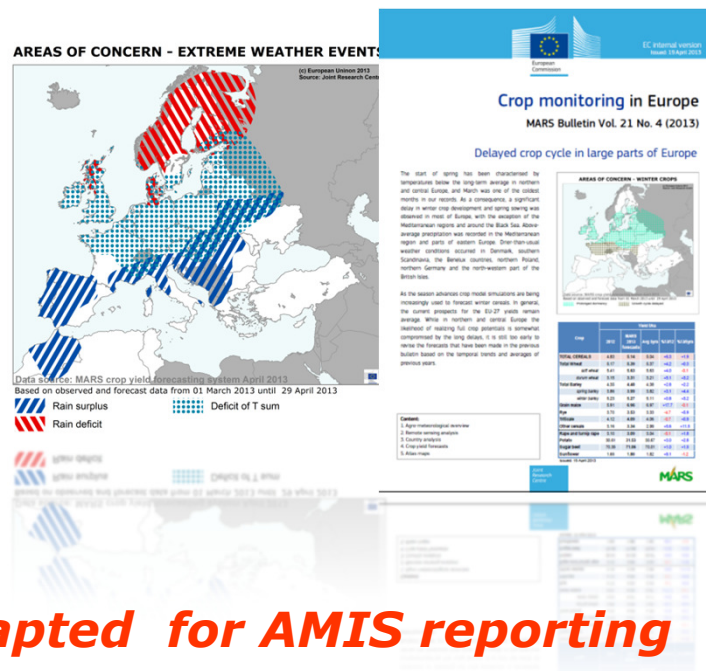
Operational deliverable since 21 years

A quantitative yield forecast at national level for all major crops

Crop	Yield t/ha				
	2012	MARS 2013 forecasts	Avg 5yrs	%13/12	%13/5yrs
TOTAL CEREALS	4.83	5.14	5.04	+6.3	+1.9
Total Wheat	5.17	5.39	5.37	+4.2	
soft wheat	5.41	5.63	5.63	+4.0	
durum wheat	3.15	3.31	3.21	+5.1	
Total Barley	4.35	4.48	4.38	+2.8	
spring barley	3.86	3.99	3.82	+3.1	
winter barley	5.23	5.27	5.11	+0.8	
Grain maize	5.91	6.96	6.97	+17.7	
Rye	3.70	3.53	3.33	-4.7	
Triticale	4.12	4.09	4.06	-0.7	
Other cereals	3.16	3.34	2.99	+5.6	
Rape and turnip rape	3.10	3.09	3.04	-0.1	
Potato	30.61	31.53	30.67	+3.0	
Sugar beet	70.35	71.06	70.01	+1.0	
Sunflower	1.65	1.80	1.82	+9.1	

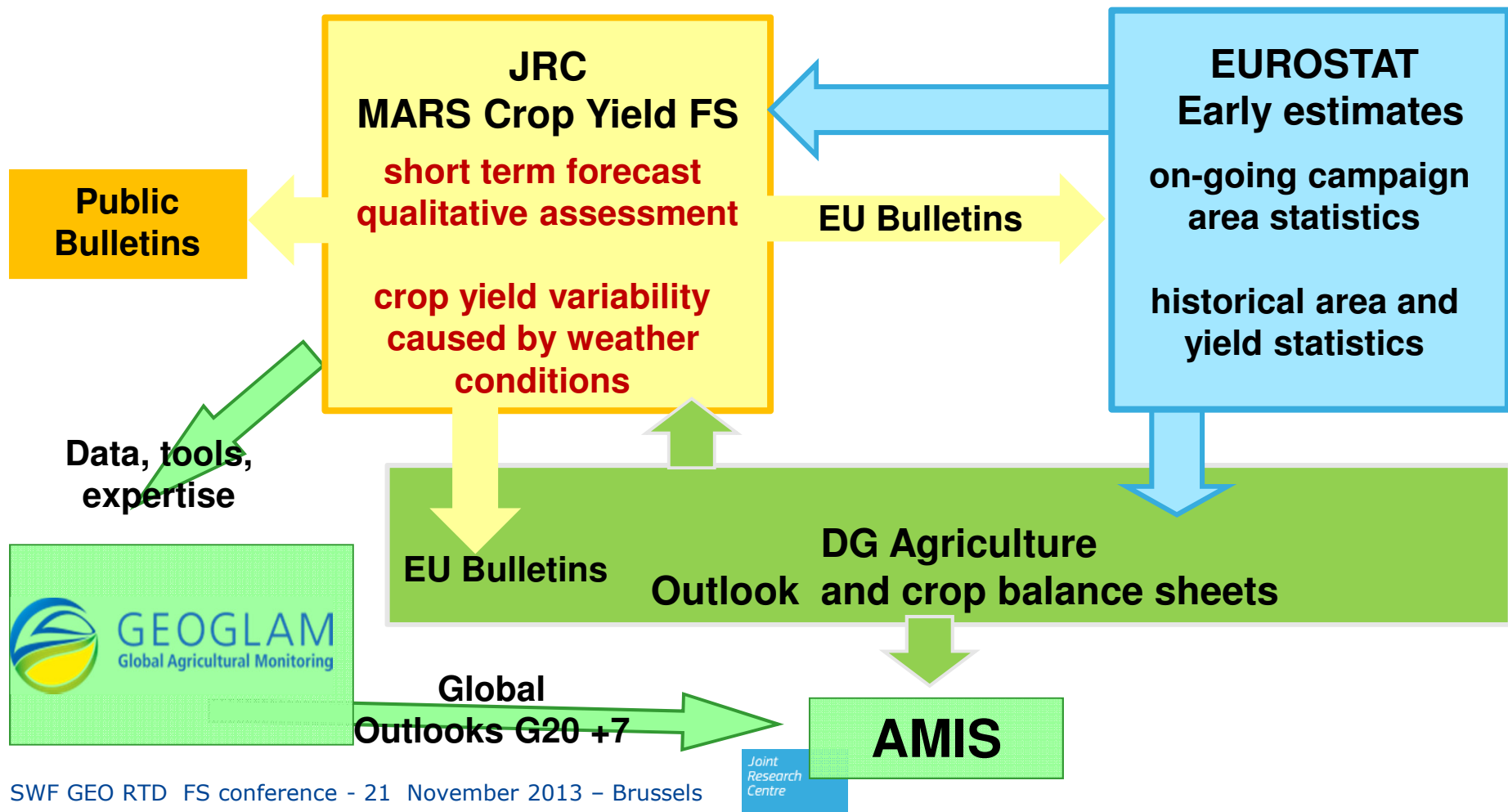


A detailed bulletin/report of current and future agromet conditions (EU level) and a detailed analysis for major crops (at national level)



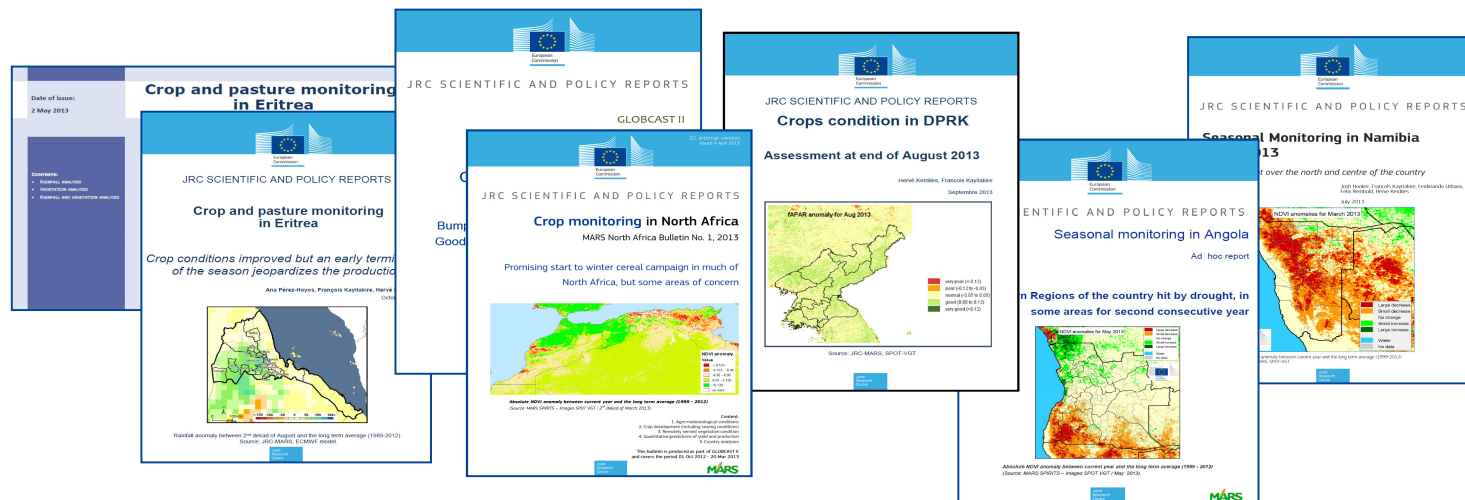
Since 2 years, monthly calendar adapted for AMIS reporting

actors of the process (EU Bulletins)



MARS FoodSec: Early warning & Crop Assessment in Food insecure countries

- In support to **EU Food Security Policies (DEVCO ECHO , EEAS)**
Partly co-funded by Food Security Thematic Program



- Since 1-2 years, Ad-hoc seasonal analysis more than regular EWS bull.
- Scientific evidence based inputs to IPC
- + New focuses on Vulnerability and Risk management



User requirements

independent, timely, scientific and traceable crop yield forecasts for all EU Member States and EU neighbouring countries

Main purposes:

- 1) Input for the monthly crop balance sheets (link to AMIS);
 - 2) Input for the Early Estimate System of Eurostat
 - 3) Ad Hoc Assessment of climatic conditions and potential impacts of particular weather events in Member States or regions
 - 4) Monitoring of crop conditions and forecasting in third countries.
-
- 1) Early warning in Countries at risks

***EU activities are covered by the European Regulation 78/2008
co funded by the DG AGRI (outsourced services) and JRC (staff)***

***Early Warning in Food insecure Third countries
are co funded by DG DEVCO***

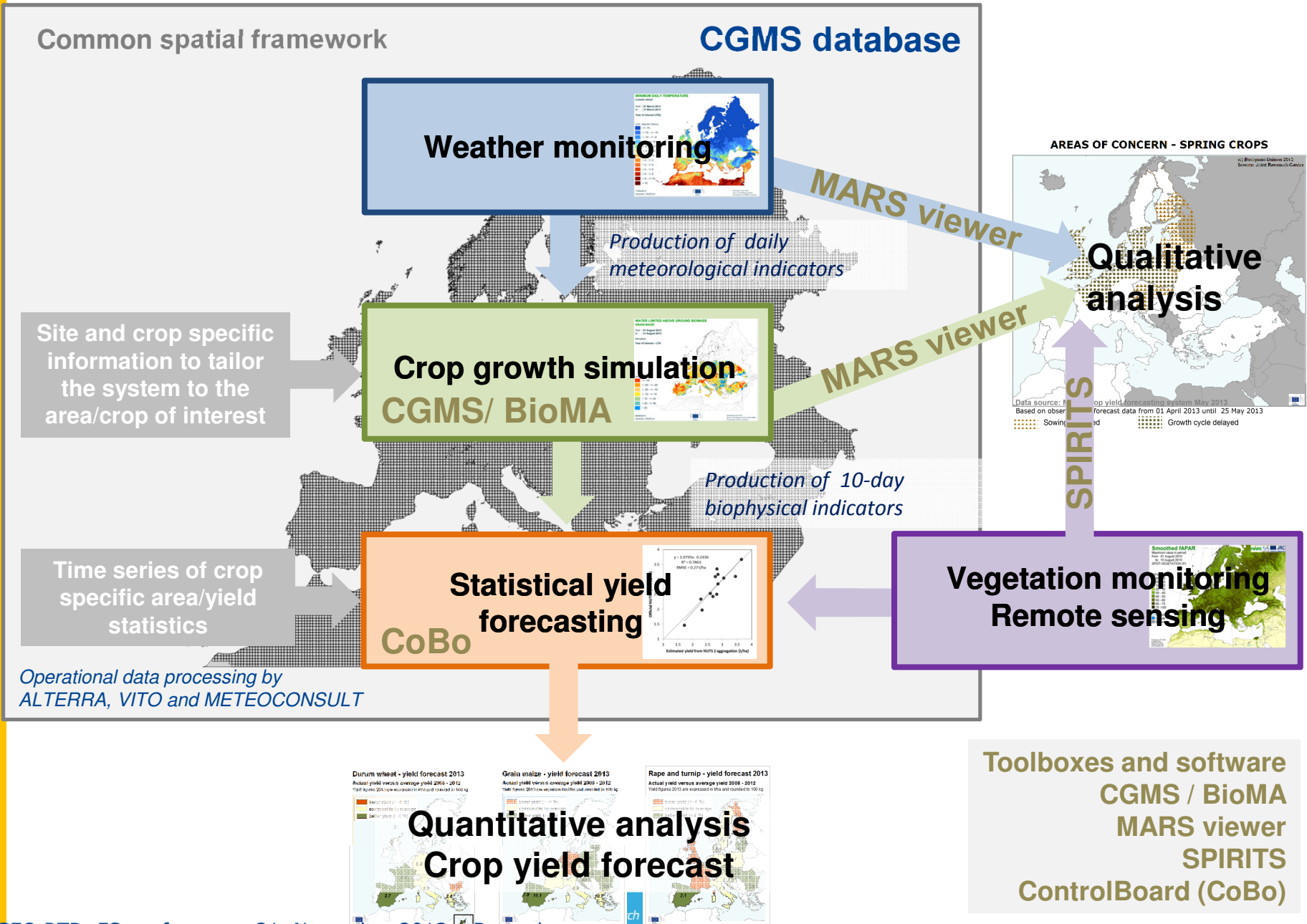
.....translate into system requirements

The user requirements translated into the following system requirements

- 1) Enlarged European window covering neighbouring countries and complete coverage
- 2) Information availability in near real time
- 3) Comprehensive and common spatial framework
- 4) No single source system that may miss key events but use of different sources and methodologies
- 5) Redundancy and synergies between methodologies
- 6) Traceability and accepted procedures to allow for staff turn-over

MCYFS - a model and data driven decision support system

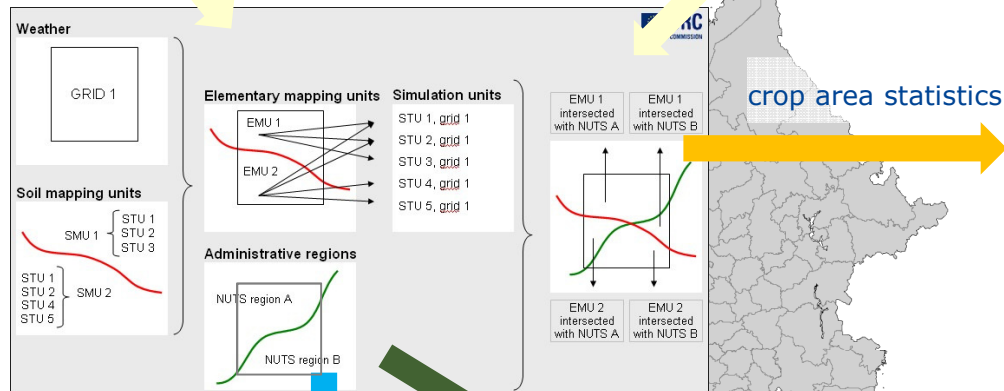
Expert decisions along all steps of the process



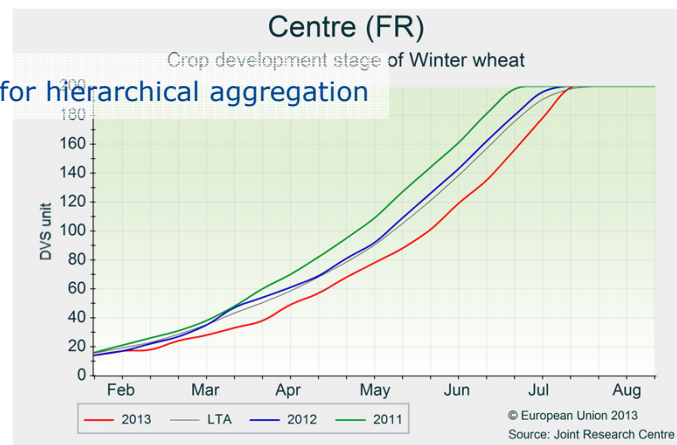
Simulation units - aggregation of results

Intersections to construct the simulation units

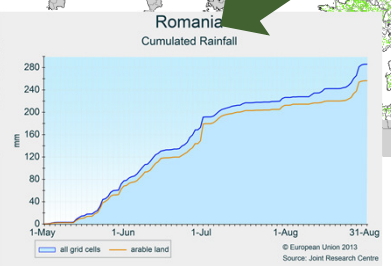
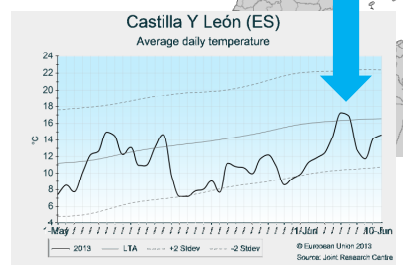
Intersections with administrative boundaries



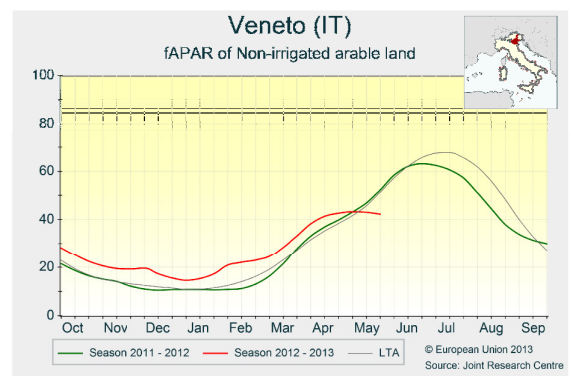
crop area statistics for hierarchical aggregation



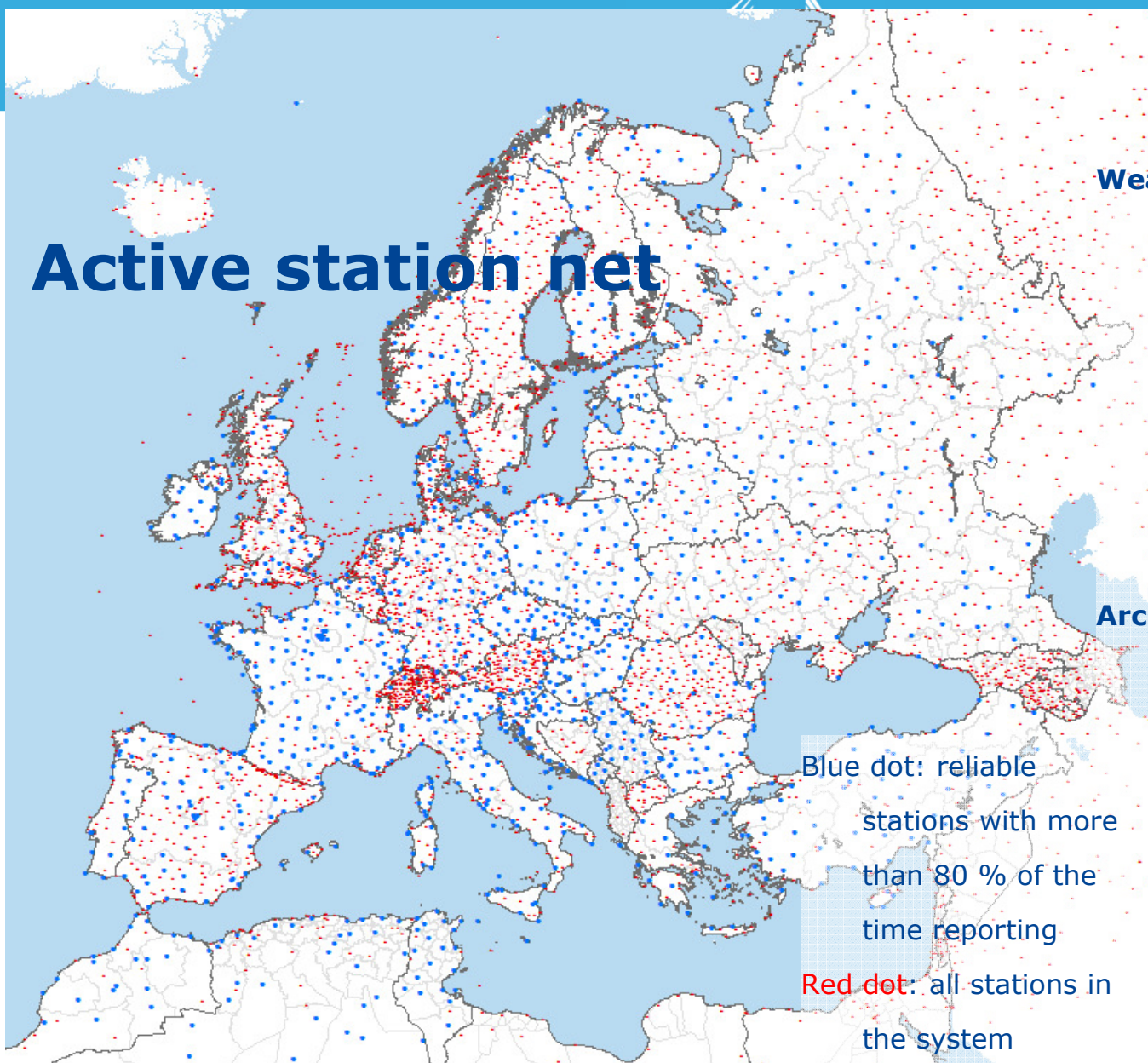
Grids cells belonging to...



Land cover data



Active station net



Weather stations

reporting in near real time to the MARS meteorological infrastructure for the main meteorological variables

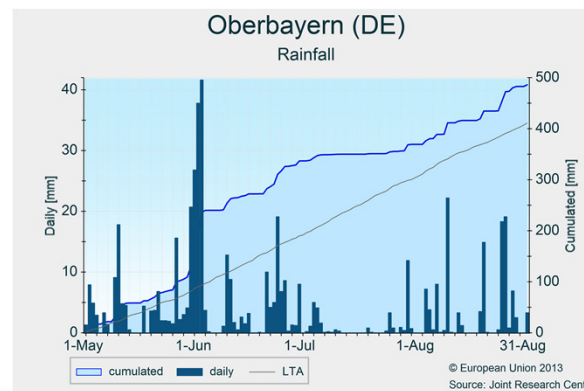
Archive data since 1933, interpolated to the MARS grid for data since 1975

Blue dot: reliable stations with more than 80 % of the time reporting

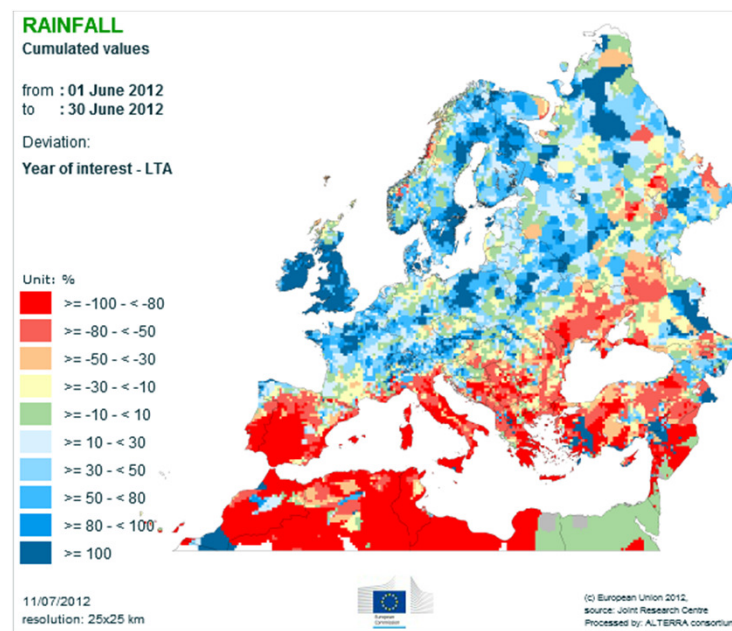
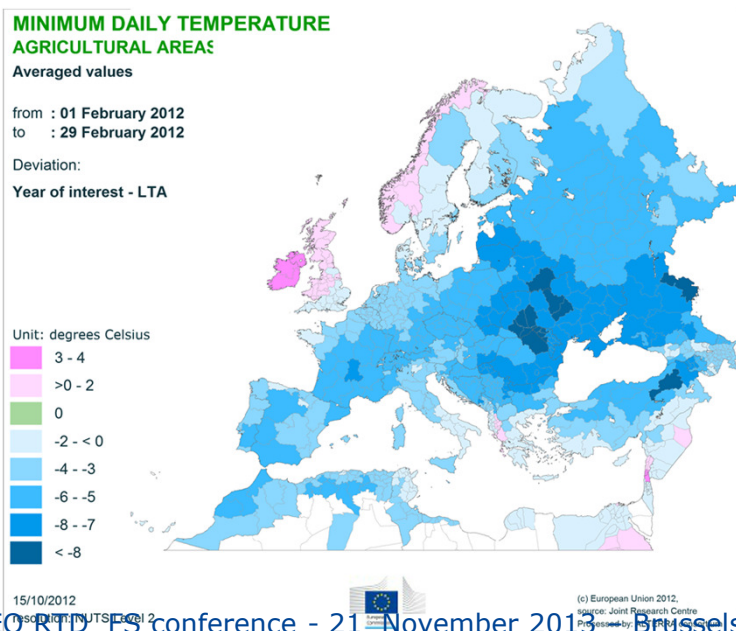
Red dot: all stations in the system

Meteorological analysis

- Overall weather regime
- Extreme events
- Crop reaction



Against long term average (climatology), against particular years from daily values at grid levels to values aggregated over time and space



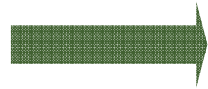
Crop reaction / Meteorological information combined with phenological stages



excess of rain at sowing



frosts at emergence



droughts during vegetative growth



dry spells at grain filling



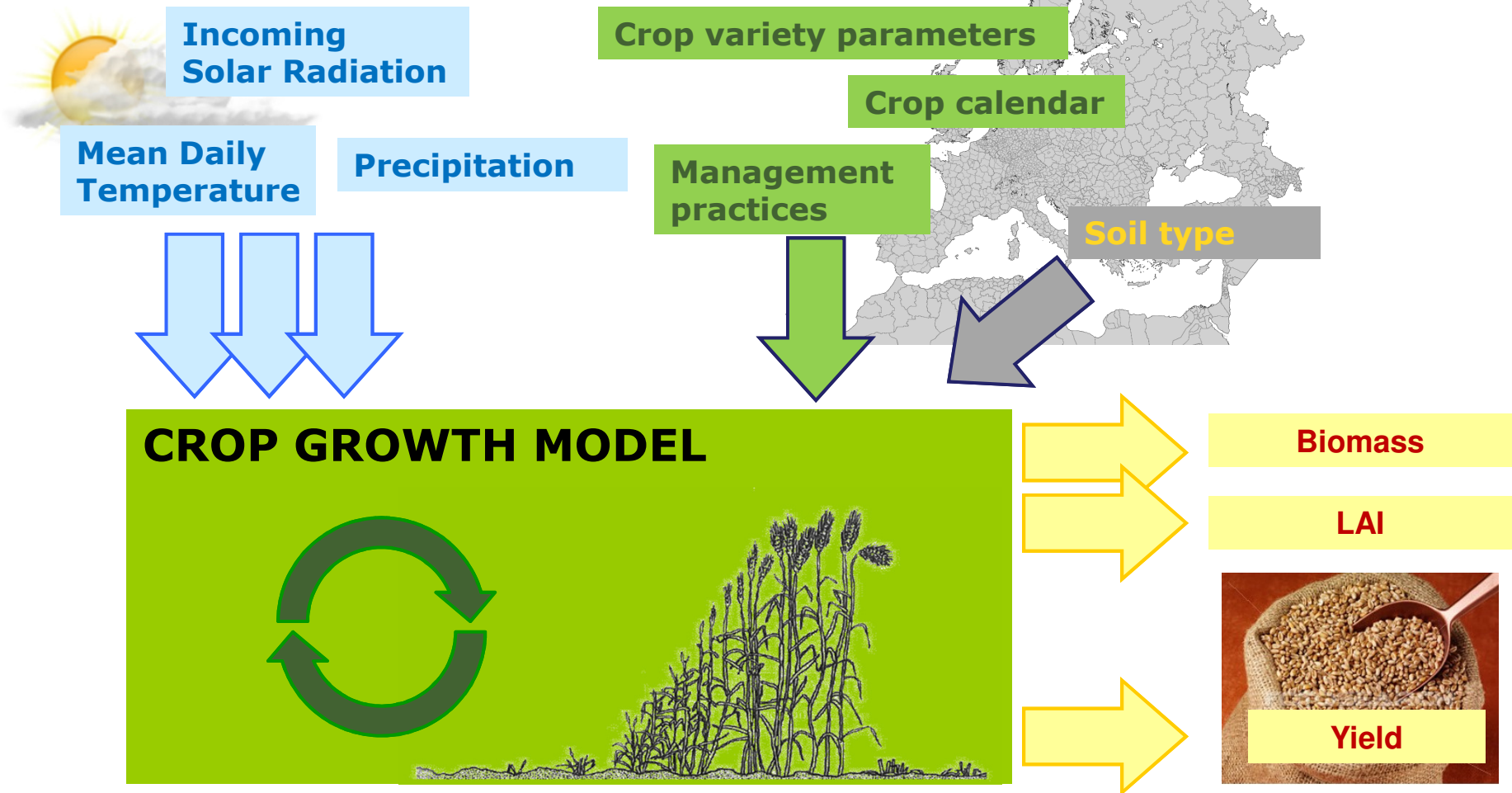
heath stresses before maturity



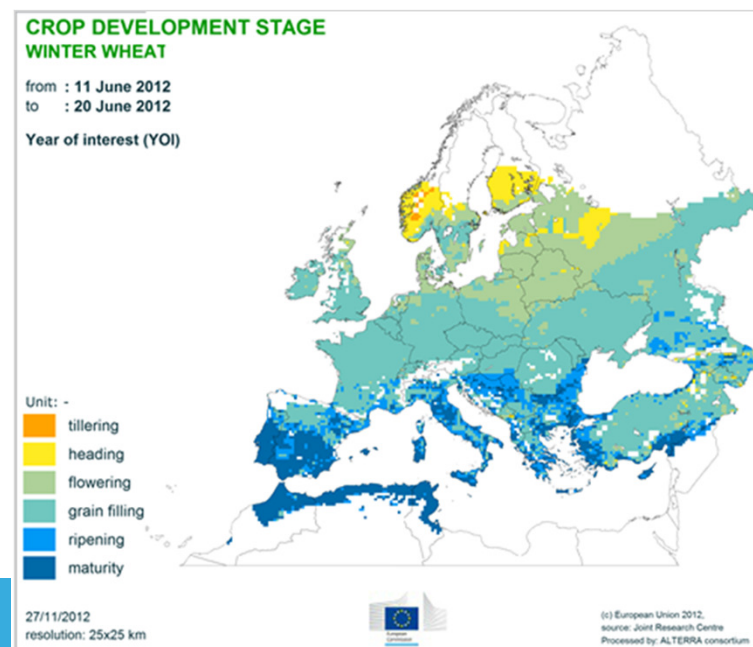
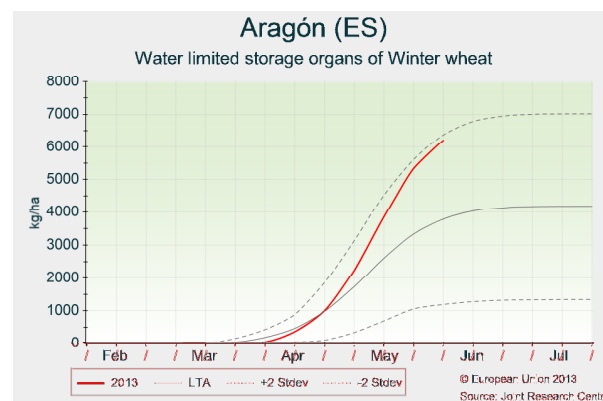
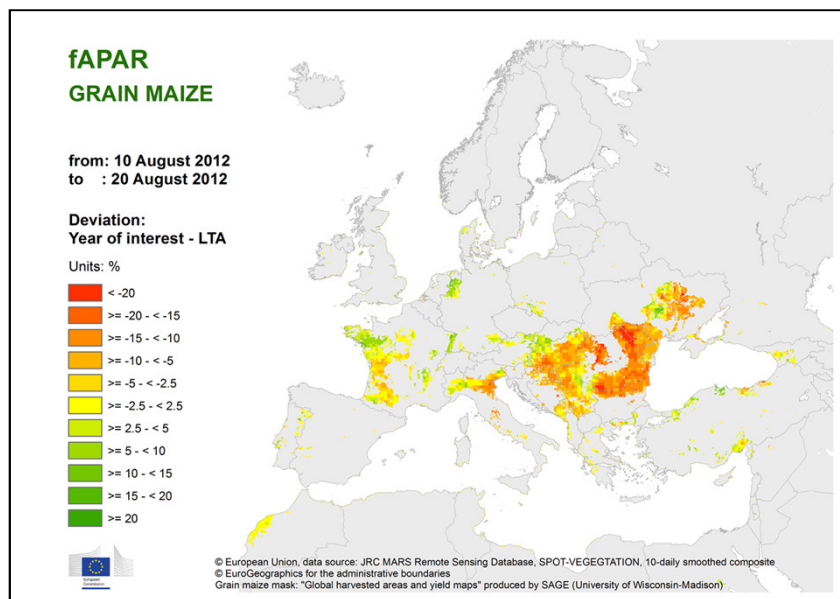
rain at harvest

**are reducing factors of plant productions
and are monitored by our indicators**

Crop Development model



Outputs from the crop models



MARS remote sensing infrastructure

European
Commission

Sensor

MSG
since 2005

NOAA AVHRR
since 1981

METOP AVHRR
from 2008

SPOT VGT
since 1998

MODIS TERRA
since 2000

Processing

Pan-European
Daily, 10- daily, monthly,
long term average

**MARS RS DB
image repository**

- original bands
- atmospheric correction
- geometric correction
- quality flag

- compositing
- interpolation
- smoothing
- indicator computation
- Information products

Indicators

Land surface temp.
Radiation (DSSF)
Sunshine duration
Snow cover

NDVI
fAPAR

NDVI
fAPAR

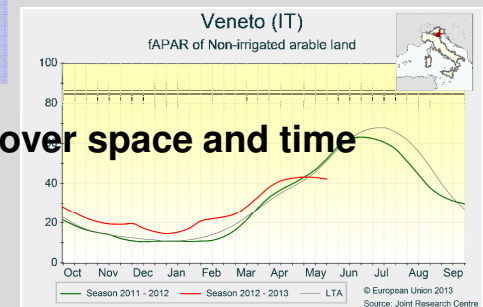
Info extraction over space and time

Difference analysis
Time profile analysis
Cluster analysis
Similarity analysis
Rank analysis
Probability analysis
Scenario analysis

Qualitative /
quantitative
analysis

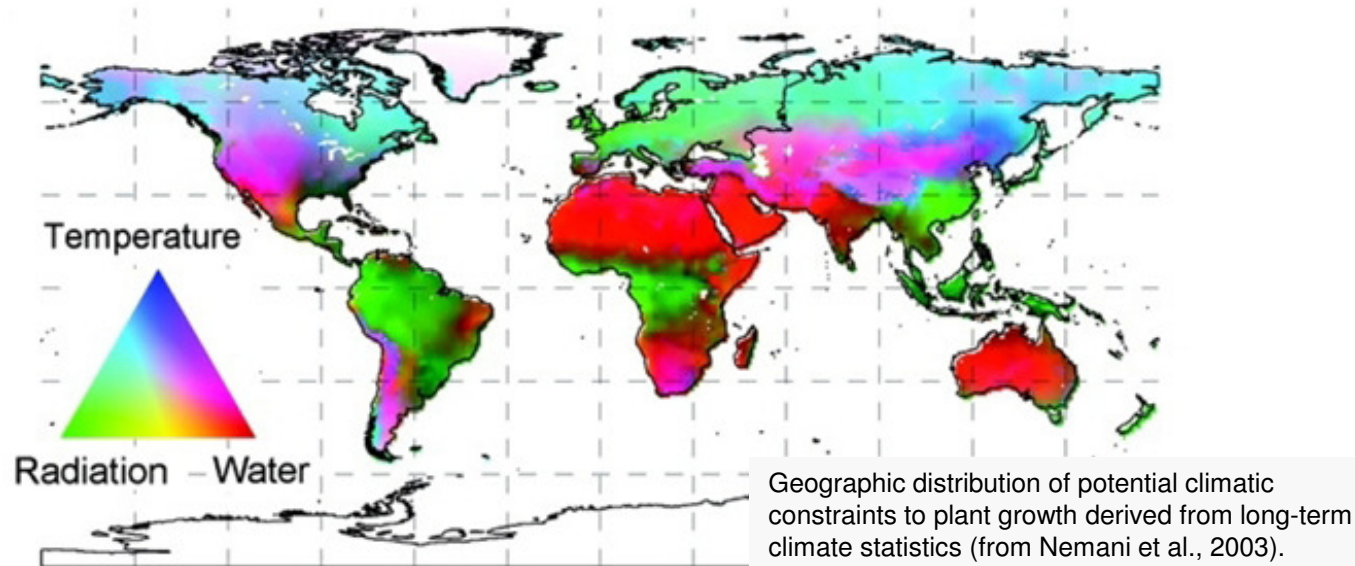
Aggregation over space and time

Administrative unit
Agri-ecological zonation
Grid (25 km * 25 km)



Key Remote Sensing contributions

- Independent analysis for crops and pastures – **qualitative**
 - Independent source of measured biomass/ Convergence of evidence
- Improvements meteorological infrastructure – **quantitative**
 - Snow cover
 - Radiation / MSG / station coefficients
- Independent analysis for crops – **quantitative**
 - Crop yield forecasts (regional) based on RS derived vegetation state parameters only



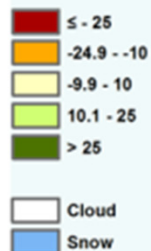
Calibration of solar radiation models for Europe using Meteosat Second Generation and weather station data / Jędrzej Bojanowski

- Solar radiation is the most difficult parameter to obtain / few stations that measure
- Empirical solar radiation models / station co-efficients
- MSG provides continuous source used to calibrate the empirical models at station level

Smoothed fAPAR

Current year - LTA
 from: 1 April 2012
 to: 10 April 2012
 SPOT - VEGETATION (P)

Relative Differences [%]

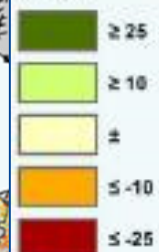


Mask: Arable land mask based on CLC 2000 / Snow mask
 Data source: MARS remote sensing database / SPOT -

Relative Difference of fAPAR

Current year - Long term average (LTA)
 Considered period: 01 April 2013 - 10 April 2013

Relative differences (%) compared to LTA

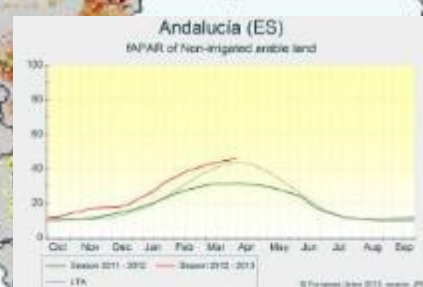


Snow coverage since 20 March

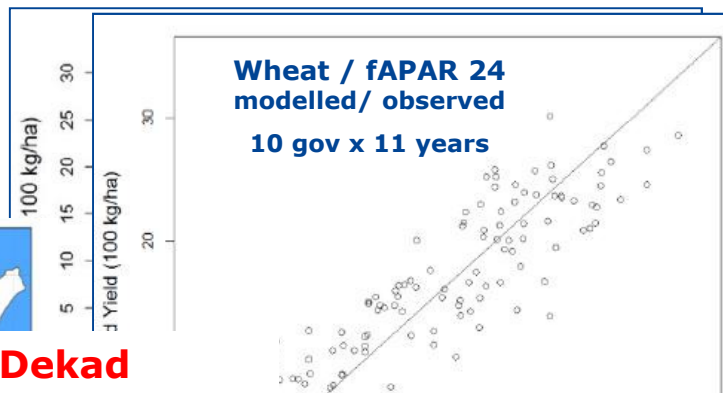
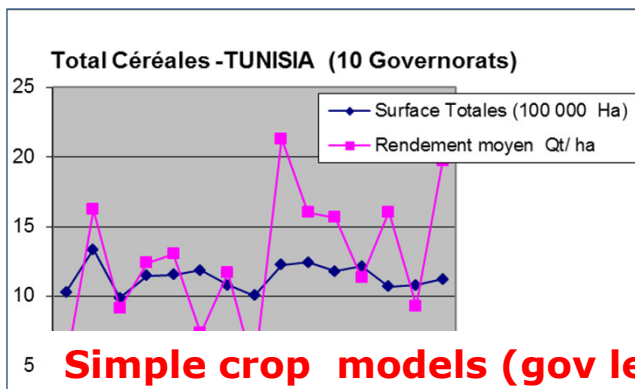


Mask: based on CLC 2000
 Data source: MARS remote sensing database / SPOT-VGT, MSG - SEVIRI

Same date in 2013

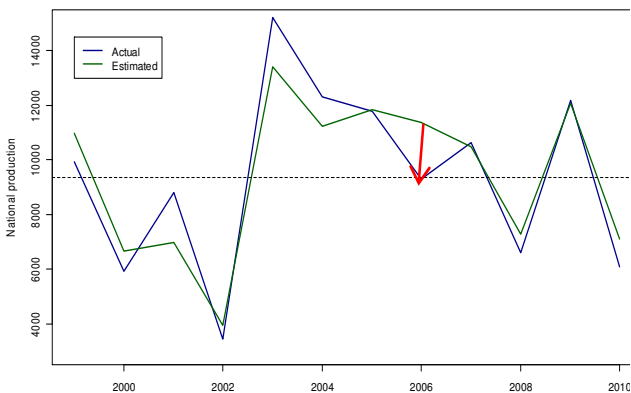


EO direct forecasting models in Maghreb countries

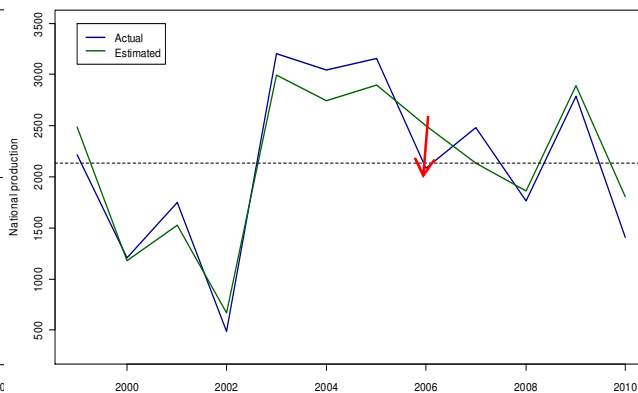


Simple crop models (gov level) based on 3rd April Dekad

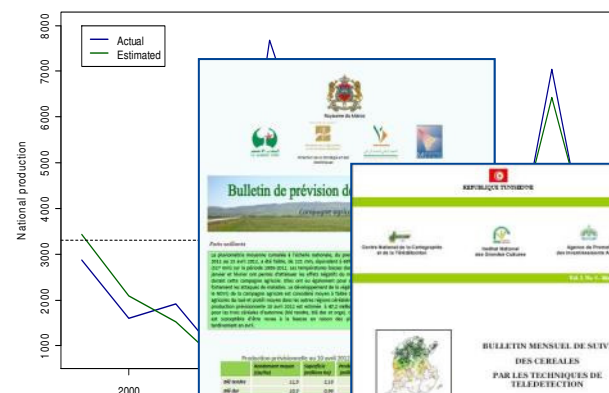
Durum Wheat Durum Wheat



Soft Wheat Soft Wheat



Barley Barley



Morocco and Tunisia use EO for Annual forecasts/ Bulletins
MARS MCYFS implemented in Morocco.
Promising results in ALGERIA (semi operational 2013)



Statistical Infrastructure

- Proposes different type of trends
 - Residuals are correlated to weather impact

Yield forecast are made either by regression

- Best indicators (from the 3 components) selected as predictor
- Or **scenario analysis**
 - Identifying most similar years

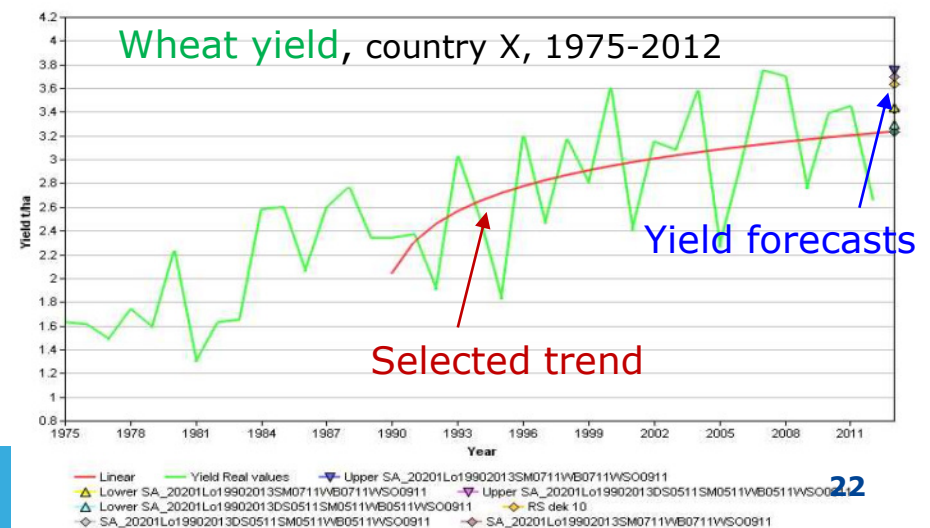
- An analyst friendly interface (**COBO Control Board**)

Record the different options tested /
choice retained each month

Trace the monitoring progress

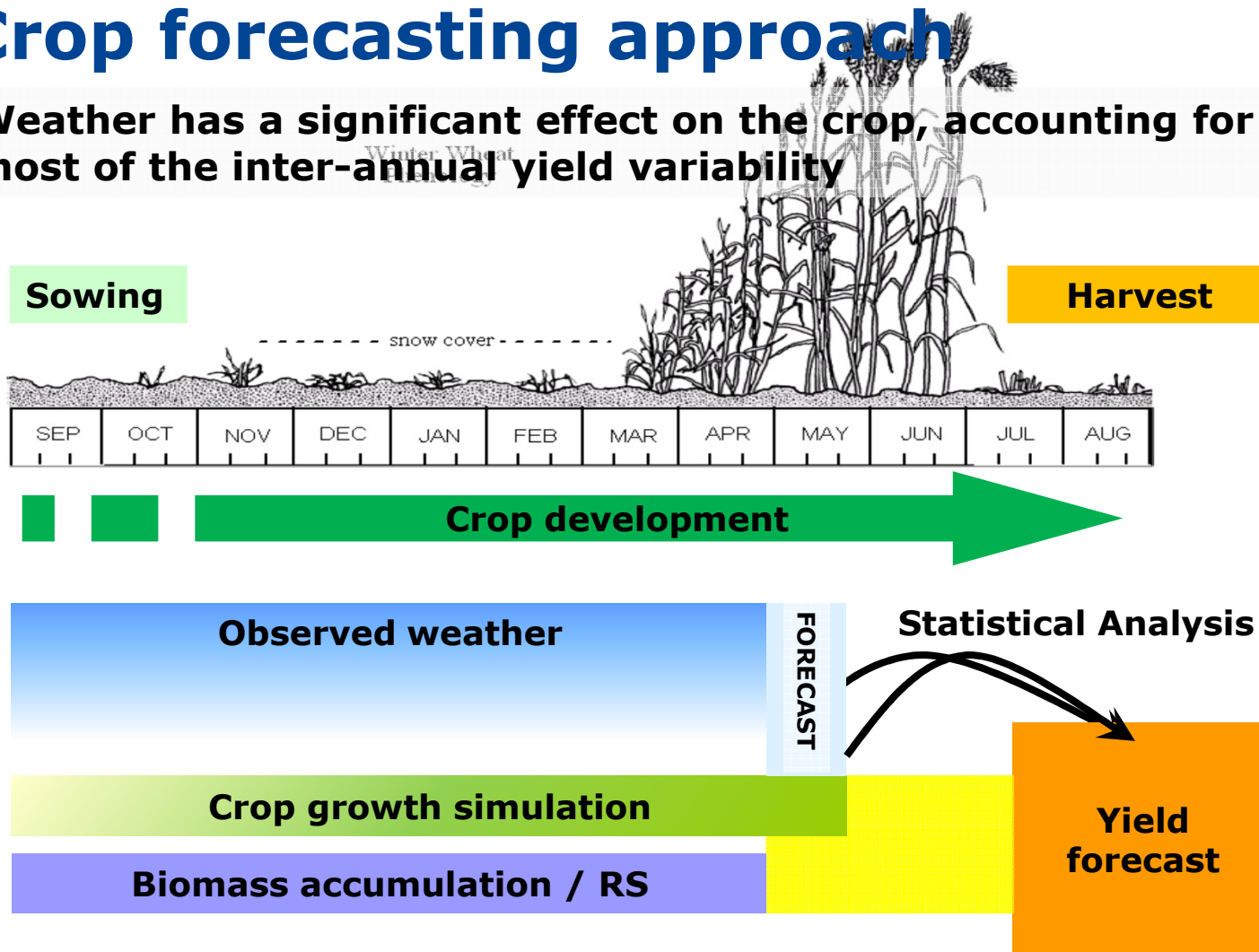
End of Year review

Support team analysis and Learning process



Crop forecasting approach

Weather has a significant effect on the crop, accounting for most of the inter-annual yield variability




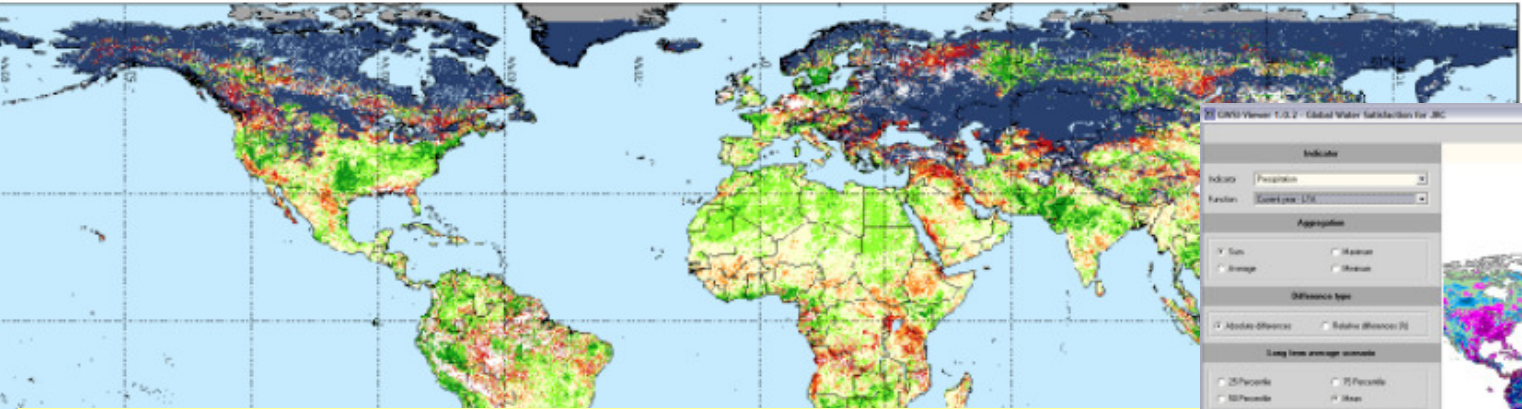
MARS: an EU global data infrastructure & Modelling platform

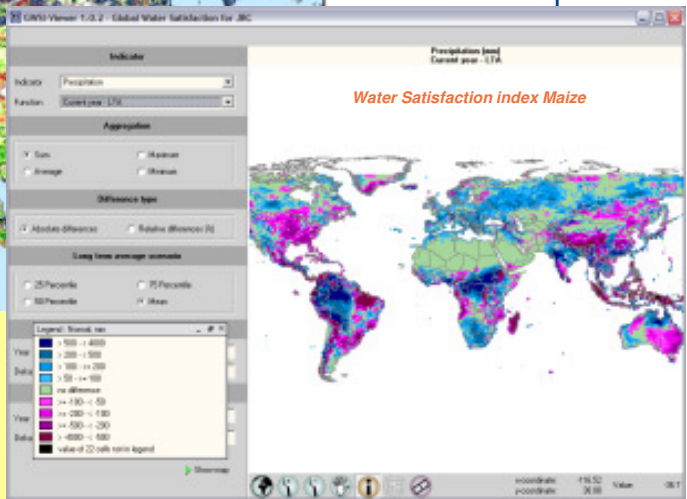
- **Extended globally for a number of datasets / products**
 - **SPOT VGT Biopar Indicators (1km, 13 years)**
 - **ECMWF Weather datasets (ERA 40 Interim, 25 Km)**
- **Multi purpose**
 - **Studies and modelling of CC impact on Agriculture**
 - **Modelling pest and diseases development and impact on Yield Etc..**
- **A Public good , shared with other EU users and globally in the frame of GEOGLAM**

MARS datasets & tools provided to UN FAO (GIEWS) and WFP


Region: The GLOBE
 Period: February, 2012, Dated 3x3
 Theme: Normalized Difference Vegetation index (NDVI)
 Relative difference w.r.t historical mean: $100\% \times (\text{Act.} - \text{Hist.}) / \text{Hist.}$
 Source: SPOT-VEGETATION








*MARS Global datasets used since 2 years by 10 FAO GIEWS analysts through **MARS VIEWER**. Similar collaboration with UN WFP. MARS Indicators derived from SPOT VCT, ECMWF and global Water Satisfaction index provided to GEOGLAM Crop Monitor*





Food and Agriculture Organization of the United Nations

MARS Crop growth Modeling (CGMS – MCYFS and BIOMA)

CGMS Morocco operational since 2011-12

- **Use for CC Modelling impact in EU (Avemac Study 12)**
- **CUBA (2012-13), for UNDP reporting in Makedonia (13) etc**
- **Recent training in BRAZIL (Sept 2013, 24 persons CONAB, SIPAM, INMET, SIMEPAR, INPE)**
- **6th CGMS user Workshop (ISPRA 11-10 Nov 2013)**

Release of a e-learning course on Crop monitoring for Remote sensing for EWS (FAO-JRC Dec 13)



A Software for Processing & Interpreting Remote Sensing Image Time Series

- An innovative and efficient tools for Crop Monitoring (analysis and EWS)
- Developed by VITO for the JRC MARS
- Used by UN FAO and WFP. Total circa 200 users in EU and Africa.
- A downstream application for AMESD-MESA EC programs: Dissemination of Copernicus products through EUMETCast and E-stations in 50 African countries

<http://spirits.jrc.ec.europa.eu/>

Joint
Research
Centre



Future prospects and trends

MARS operational continuity in 2015-2016

- **Main evolutions**
 - **AGROMET:** Move from CGMS to BioMA
 - **EO:** Shift to COPERNICUS services
 - **Geographic extension:** **EU Neighbourhood countries (NA, Black sea Region) + build/maintain a Global capacity Ad Hoc analysis**
- **EWS/ Food Security:** **Focus on Sub Saharan Africa**

R&D axis

- Use of RS derived indicators in crop Models
- Future of Sentinel 2: Crop Specific BioPar (Imagines), area estimates,
- FS: New components on Vulnerability, resilience and Nutrition.



Future GEOGLAM opportunities

in CONFERENCES & CAPACITY BUILDING

- **4th CRAM (Crop and Rangeland Monitoring) Conference**
JRC -FEWSNET-FAO - Addis Ababa **17-20 June 2014 (Tbc)**
Under AU 2014 Flagship "Year for Agriculture and Food Security"
- **MARS EUROMED Crop monitoring and yield forecasting workshop**
- **(North & South Mediterranean countries) Oct 2014 Rabat (Tbc)**
-
- **MARS Towards Global Monitoring? May 2015 Brussels (Tbc)**

MILANO 2015 Exp "Feed the Planet, energy for the life" ???



MILANO
NOURRIR LA PLANETE
ENERGIE POUR LA VIE

Challenges for GEOGLAM

- Inventing a ***System of Systems...*** i.e translating a very general concept into some concrete reality...

Rely on existing robust Systems

- Global/Regional FAO GIEWS, USDA FAS, USAID FEWSNet, CN CROPWATCH, EC MARS
- National Systems

+ focus on the added value functions of the System (*of System*)

Pass from a voluntarily based Community-of-practice to a sustainable operational running

- with sufficient budgeting and staffing
- GEO Sec incubator for the first years , then ?

A complex ***innovation process***, which cannot be simply technological push or only driven by Research

Some crucial ***enabling factors*** allowing users to buy-in

- Avoid confusion or over promising (EO doesn't substitute ground data; crop monitoring doesn't substitute Agricultural Statistics)
- "Capacity building"
- Manage different product/ service maturity (*R&D chain*)
- and different operational/ integration level (*between countries*)
- **Build trust and transparency in a multi-lateral context**

Thanks for your attention !

Olivier.Leo@jrc.ec.europa.eu



- ***To know more about MARS ?***
 - ***MARS AGRI4CAST WIKI***
http://marswiki.jrc.ec.europa.eu/agri4castwiki/index.php/Main_Page
 - ***Download MARS Bulletins*** **<http://mars.jrc.ec.europa.eu>**
 - ***To access MARS data and tools*** **<http://www.marsop.info/marsop3/>**



MarsViewerAir

Orientation Window - E Maize crops: Grain maize Longest heat wave around crop development stage Year of interest (YOI) 150 - 2012 ...

Graph window: Europe

Sud-Est (RO)

Maximum daily temperature

— 2012
— Average
- - +2Stdev
- · -2Stdev

(c) European Union 2012, source: Joint Research Centre

Refresh map

Resolution: show outline

25x25 km

Indicator Legend Advanced

Theme (available years 1975 - 2012):
Crop indicators (simulated) - CGMS, based on station observations

Crop / Landcover:
Maize crops: Grain maize

Indicator:
Longest heat wave around crop development stage

Function:
Year of interest (YOI)

Development stage:
 Flowering Ripening Maturity Harvesting Custom
150 (75% progress)

Year of interest:
2012

Offset (days):
-11

Duration (days):
21

LONGEST HEAT WAVE AROUND RIPENING GRAIN MAIZE

≥ 2 consecutive days where $T_{max} > 30^{\circ}C$

Deviation:
Year of interest - LTA
Year of interest: 2012
Offset (days): -11
Duration (days): 21

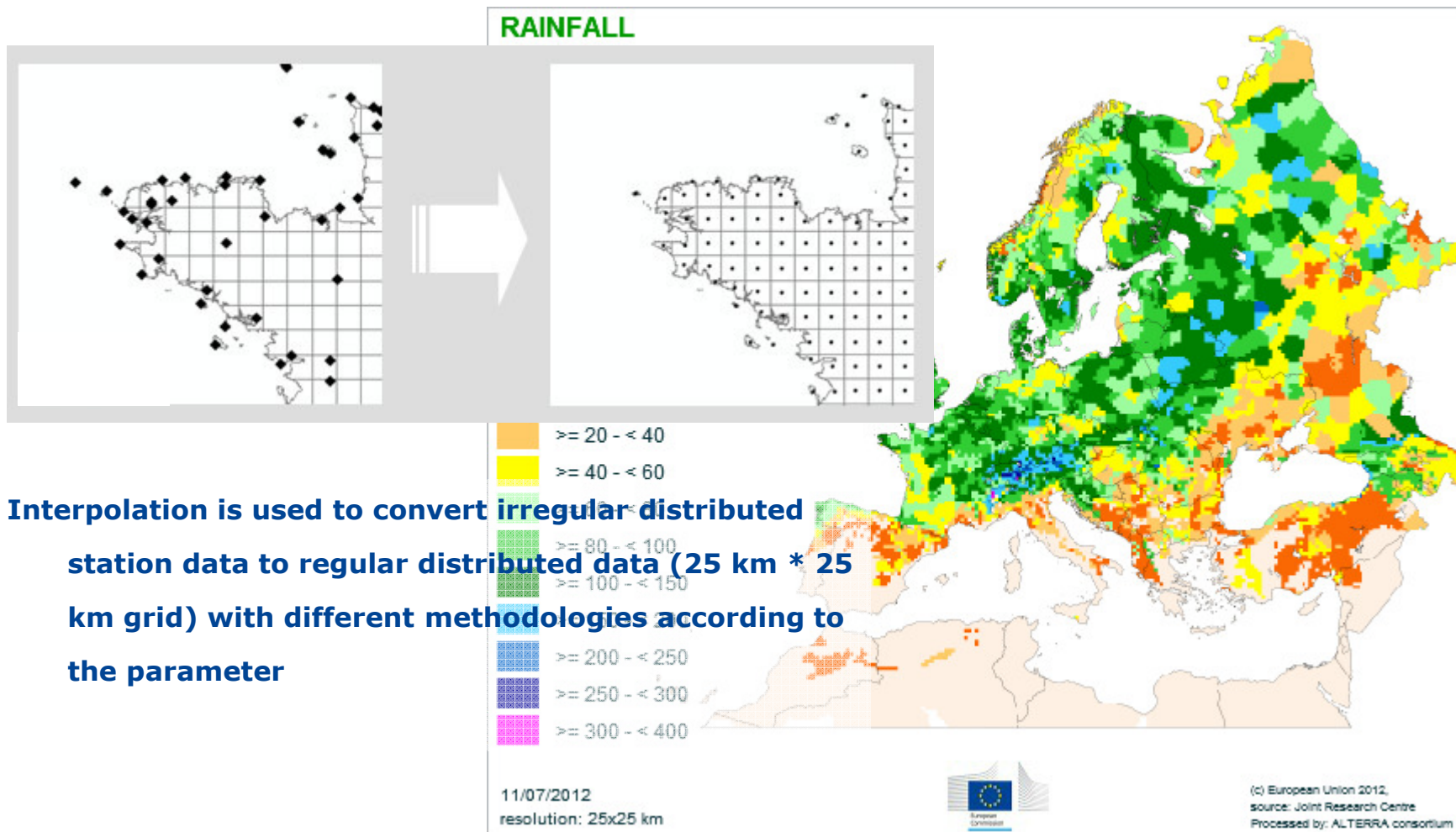
Unit: no. of events

- ≤ -20
- $> -20 - \le -15$
- $> -15 - \le -10$
- $> -10 - \le -5$
- $> -5 - \le 0$
- $> 0 - \le 5$
- $> 5 - \le 10$
- $> 10 - \le 15$
- $> 15 - \le 20$
- > 20

15/10/2012
resolution: 25x25 km

(c) European Union 2012, source: Joint Research Centre, Processed by ALTERNIA consortium

Meteteo station - interpolation MARS grid





European

Crop model infrastructure

Input data

Static data

Crop parameters
Soil parameters
Administrative units
25 km x 25 km grid

Meteorological infrastructure

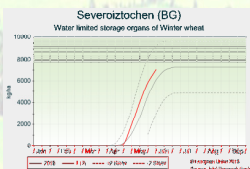
Observed interpolated weather data

Downscaled forecast data

Crop growth simulation

Pan-European
10-daily
long term average
CGMS DB

Crop growth models
in CGMS / BioMA
WOFOST
WARM



Simulated crops
Winter Wheat, Spring
Barley, Grain Maize,
Rice, Rye, Sunflower
Rapeseed, Sugar Beet
Potato

Indicators

Water limited and potential per crop:

Above ground biomass
Storage organs
Leaf area index
Development stage
Relative soil moisture
Crop water requirements
Crop water consumption

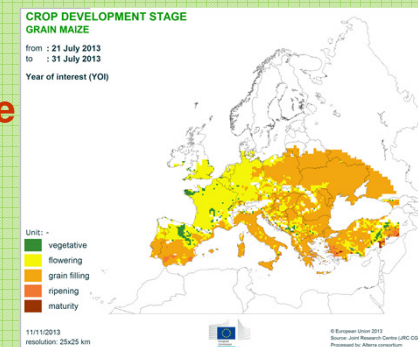
Ingestion into
statistical infrastructure

Meteorological events
in relation to crop
development stage

Info extraction over space and time

Difference analysis
Time profile analysis
Similarity analysis
Rank analysis

Aggregation over
space & time



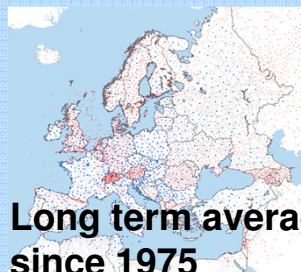
Meteorological infrastructure

European Commission

Meteorological Input data

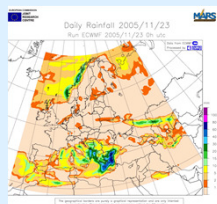
Meteorological Stations

Ca. 3000 active stations
Daily data - NRT



Long term average since 1975

European Centre for Medium-Range Weather Forecasts



10-daily, monthly, seasonal
Since 2002
Archive ERA interim

Database creation

Pan-European
Daily, 10- daily, monthly, seasonal, long term average
METEO DB

- station interpolation
- downscaling forecast data
- calculation of parameters
- grid size 25 km * 25 km
- quality checking

Indicators

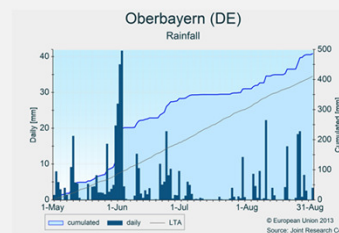
Temperature
Rainfall
Radiation
Vapour pressure
Windspeed
Evaporation
Evapotranspiration
Climatic water balance
Snow depth

Ingestion into crop growth models

Info extraction over space and time

Weather regime
Extreme events
Crop reaction

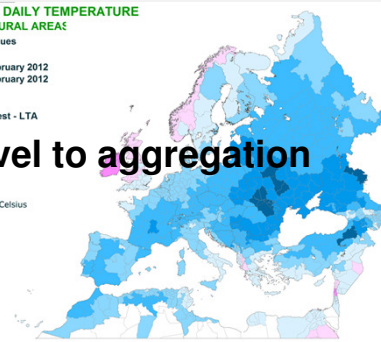
Against LTA, against particular years



From daily values at grid level to aggregation over space and time
Administrative unit
Agri-ecological zonation
Grid (25 km * 25 km)

MINIMUM DAILY TEMPERATURE AGRICULTURAL AREAS

Averaged values
from : 01 February 2012
to : 29 February 2012
Deviation:
Year of interest - LTA

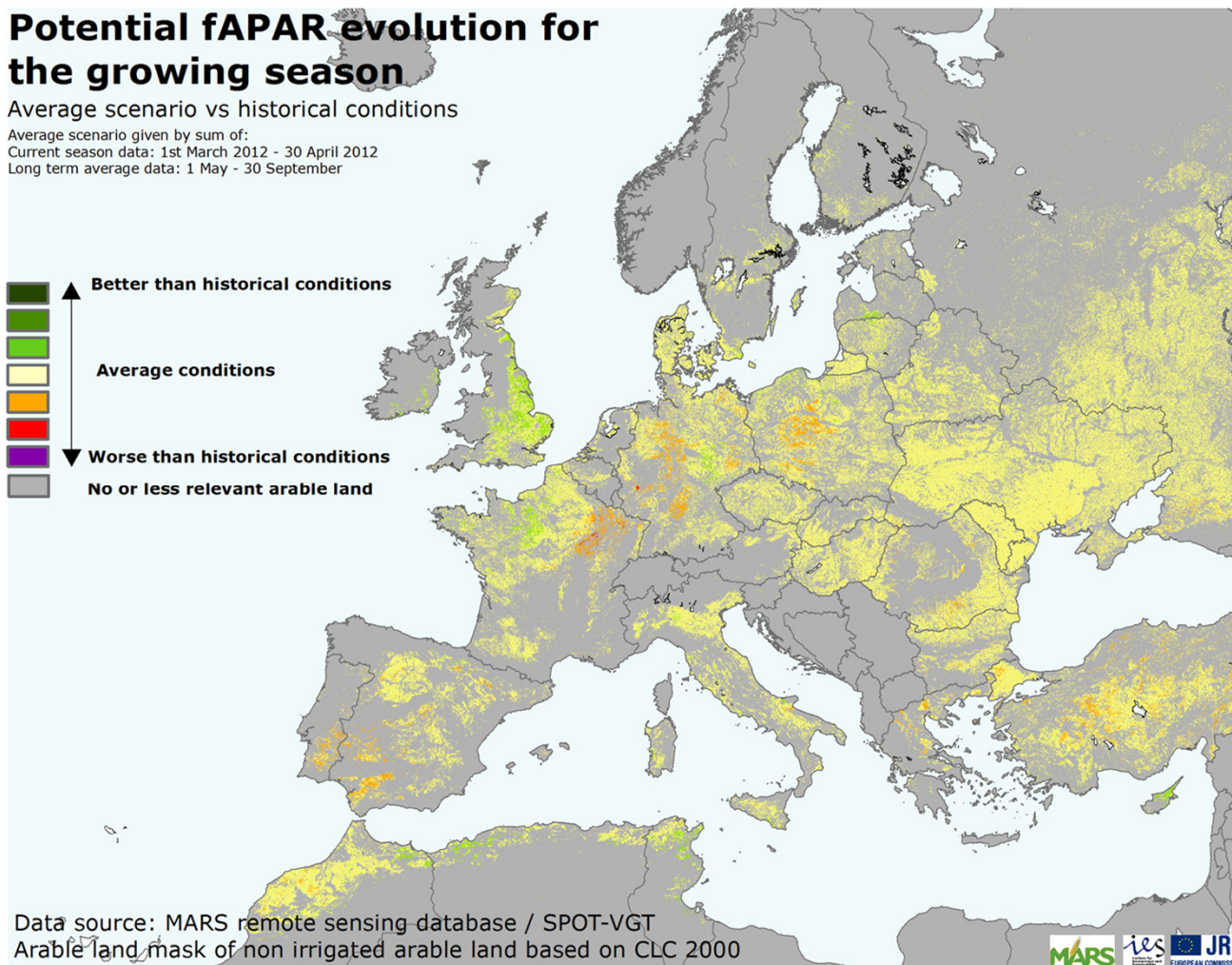
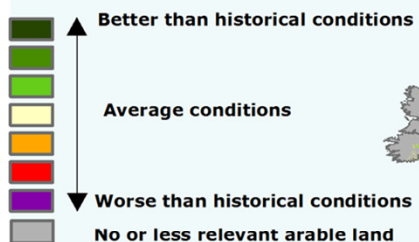


Scenario analysis – potential development

Potential fAPAR evolution for the growing season

Average scenario vs historical conditions

Average scenario given by sum of:
Current season data: 1st March 2012 - 30 April 2012
Long term average data: 1 May - 30 September



Outputs from the crop models

CLIMATIC WATER BALANCE

GRAIN MAIZE

Cumulated values

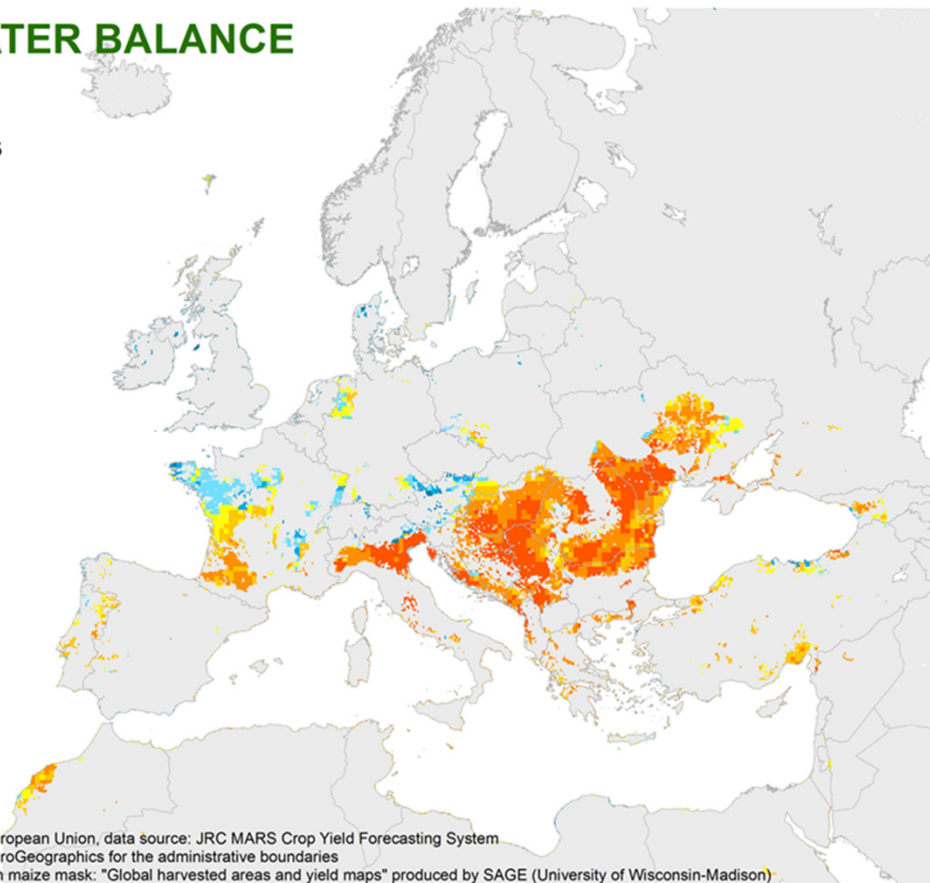
from: 01 June 2012
to : 28 August 2012

Deviation:
Year of interest - LTA

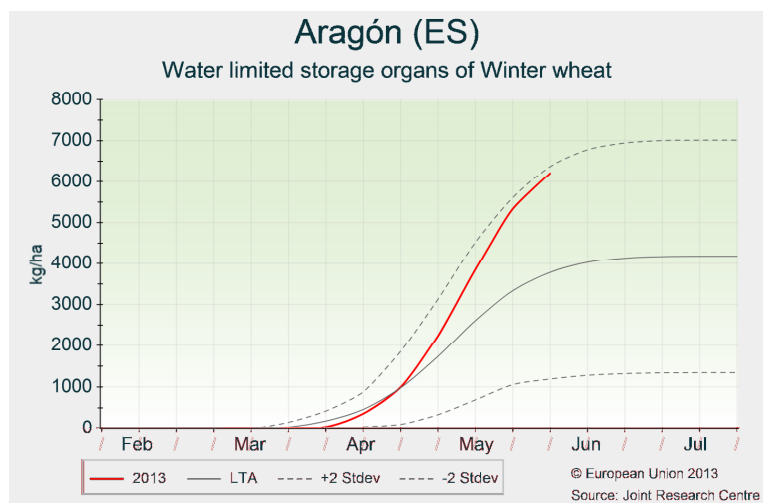
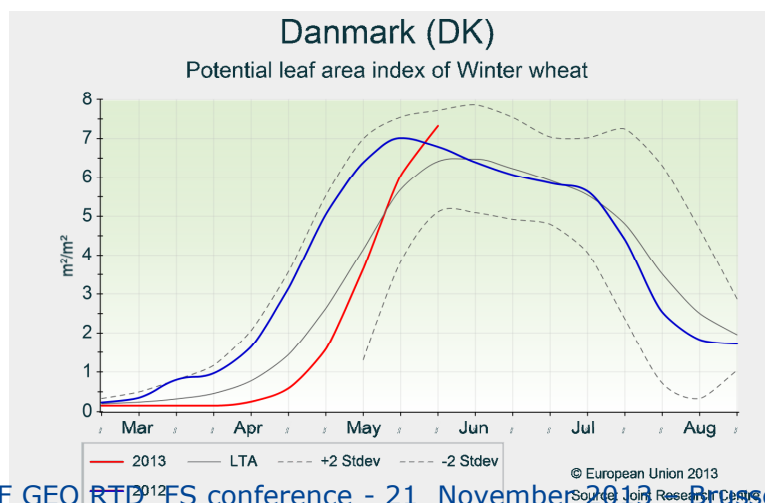
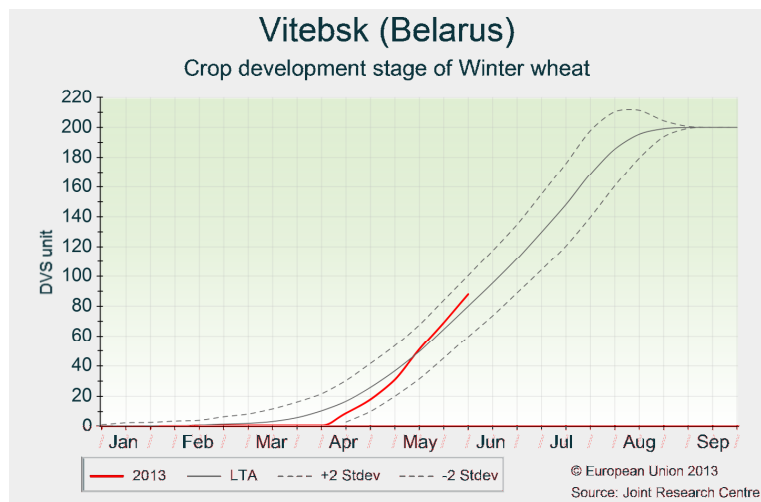
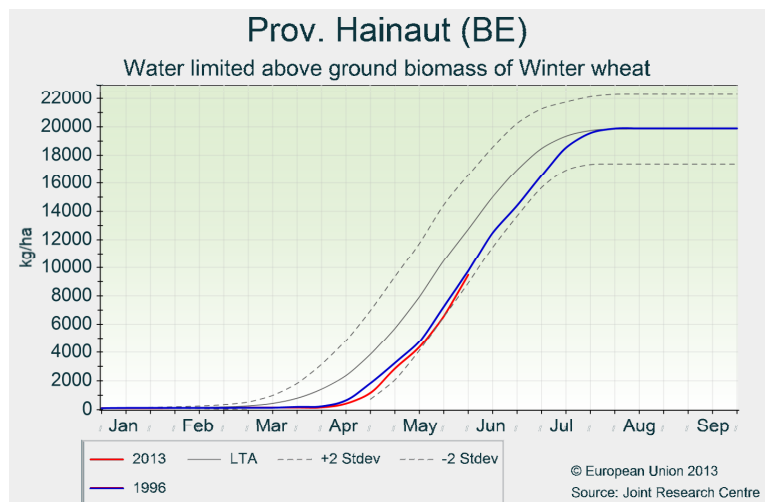
Units: mm



© European Union, data source: JRC MARS Crop Yield Forecasting System
© EuroGeographics for the administrative boundaries
Grain maize mask: "Global harvested areas and yield maps" produced by SAGE (University of Wisconsin-Madison)



Outputs from the crop models



Anomaly detection over the season

Seasonal cumulated NDVI

Current season data vs historical data
Current season data: 1st Oct 2009 - 30 Sep 2010
Historical data: 1 Oct - 30 Sep

