MCYFS - MARS Crop Yield Forecasting System

Resources and opportunities for pest risk assessment

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Monitoring Agricultural Resources Unit
Joint Research Centre

Content

- MARS crop yield forecasting system
  - Meteorological infrastructure
  - Crop model infrastructure
  - Remote Sensing infrastructure
  - Statistical infrastructure

- Pest risk assessment support
  - Collaboration with EFSA
  - ClimPest
  - MYMICS

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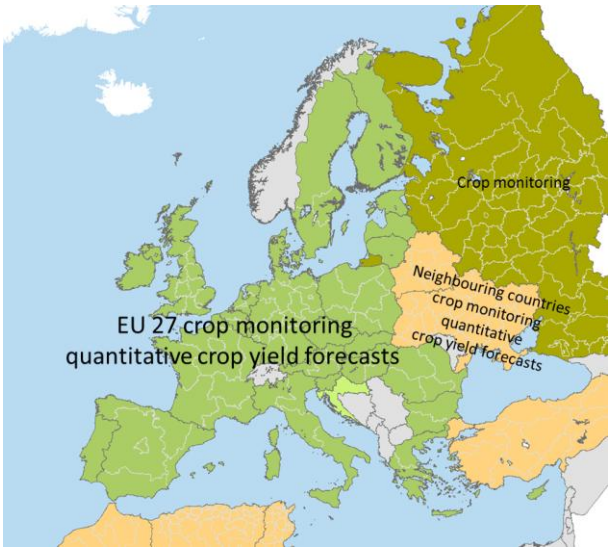
European Commission

Crop monitoring in Europe since 20 years

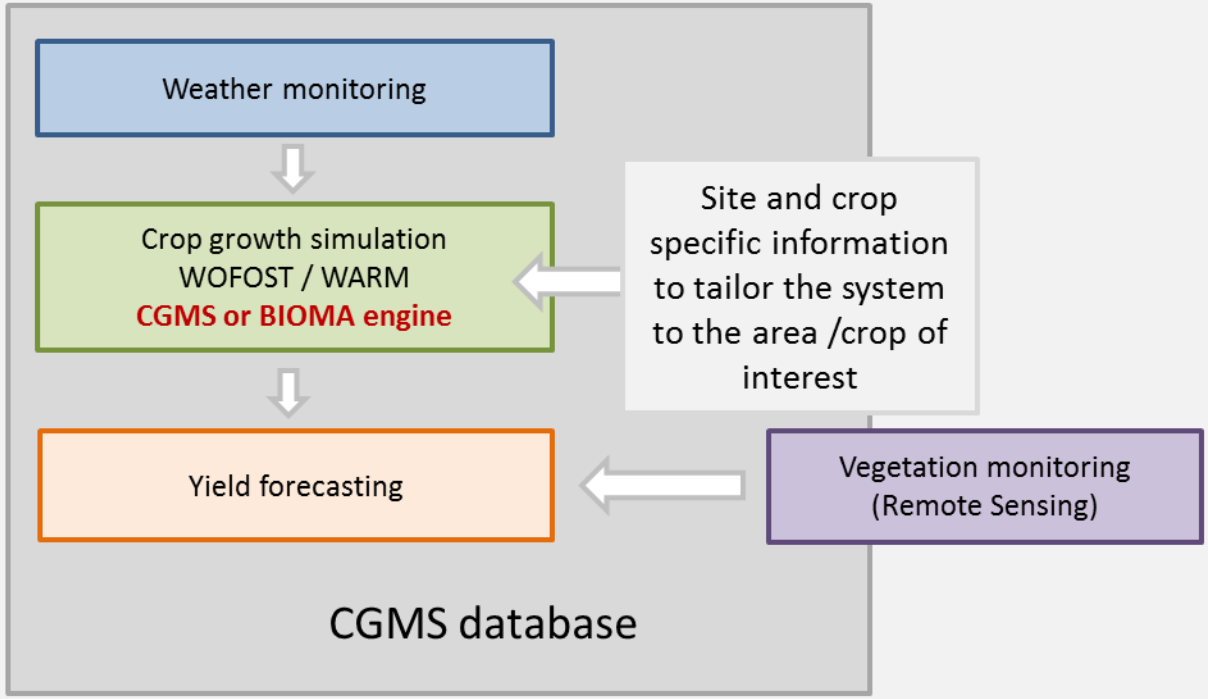


MARS CROP YIELD FORECASTING SYSTEM - MCYFS

Regulation 78/200

ensure agro-economic monitoring of agricultural land and of the condition of crops, to enable estimates to be made, in particular as regards yields and agricultural production;

- CROP GROWTH MONITORING SYSTEM - CGMS

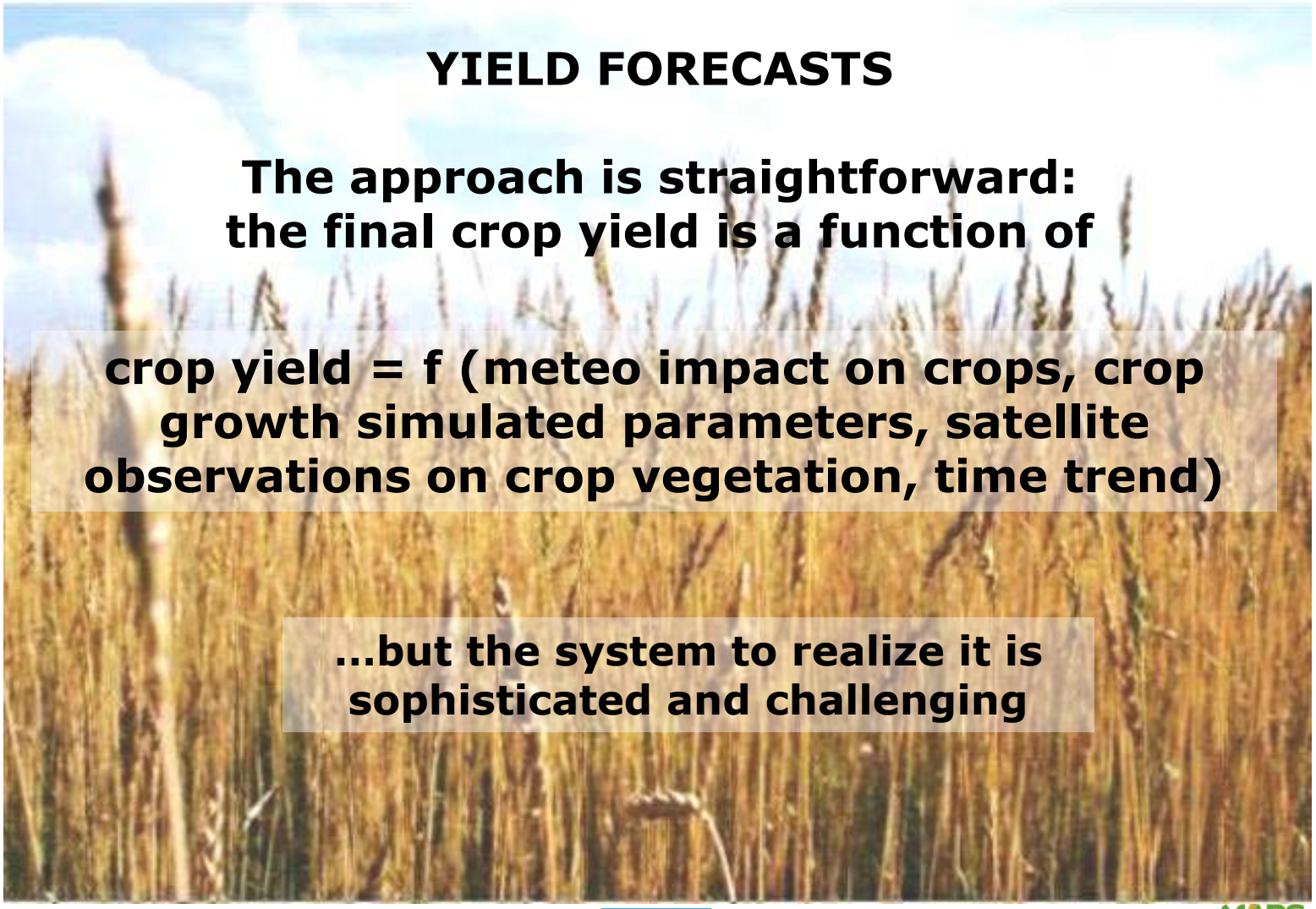


promote access to the estimates referred to in point

- CROP MONITORING BULLETINS, WEB TOOLS

ensure technological follow-up of the agro-meteorological system.

- SW improvement and development, technical supervision of contractors



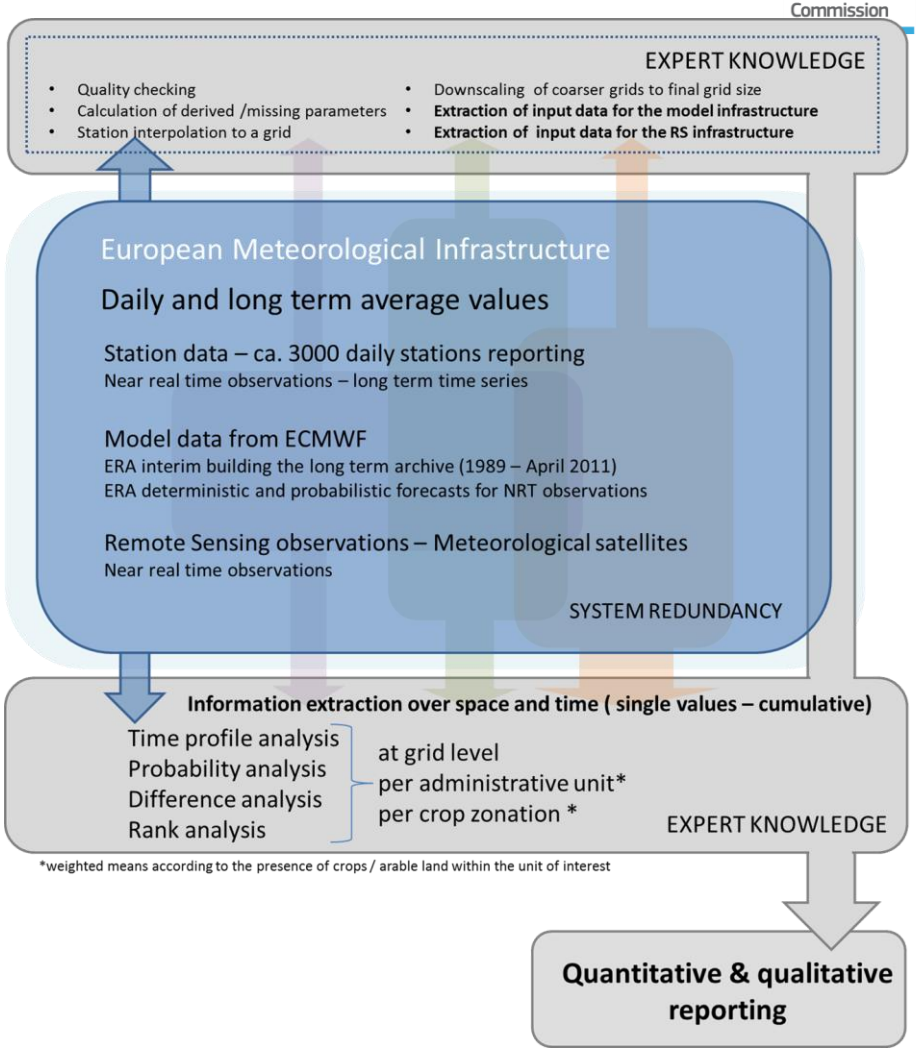
YIELD FORECASTS

The approach is straightforward: the final crop yield is a function of

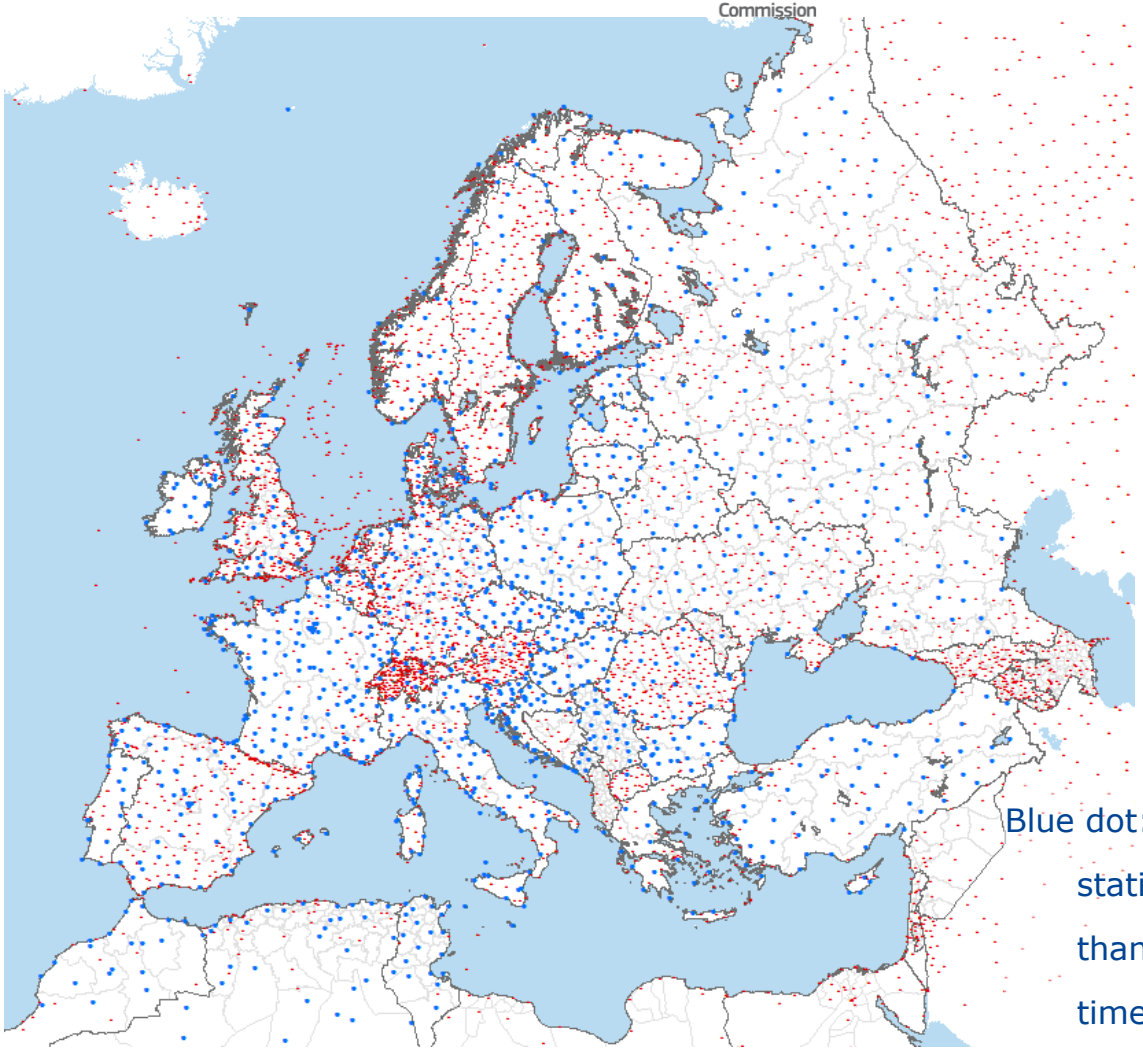
crop yield = f (meteo impact on crops, crop growth simulated parameters, satellite observations on crop vegetation, time trend)

…but the system to realize it is sophisticated and challenging

European meteorological infrastructure



Active station net



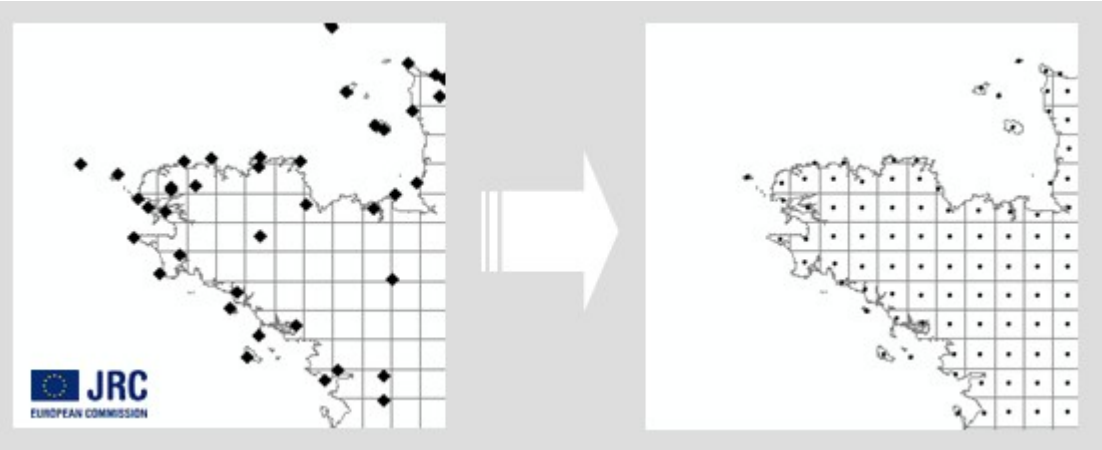
Weather stations reporting in near real time to the MARS meteorological infrastructure for the main meteorological variables

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

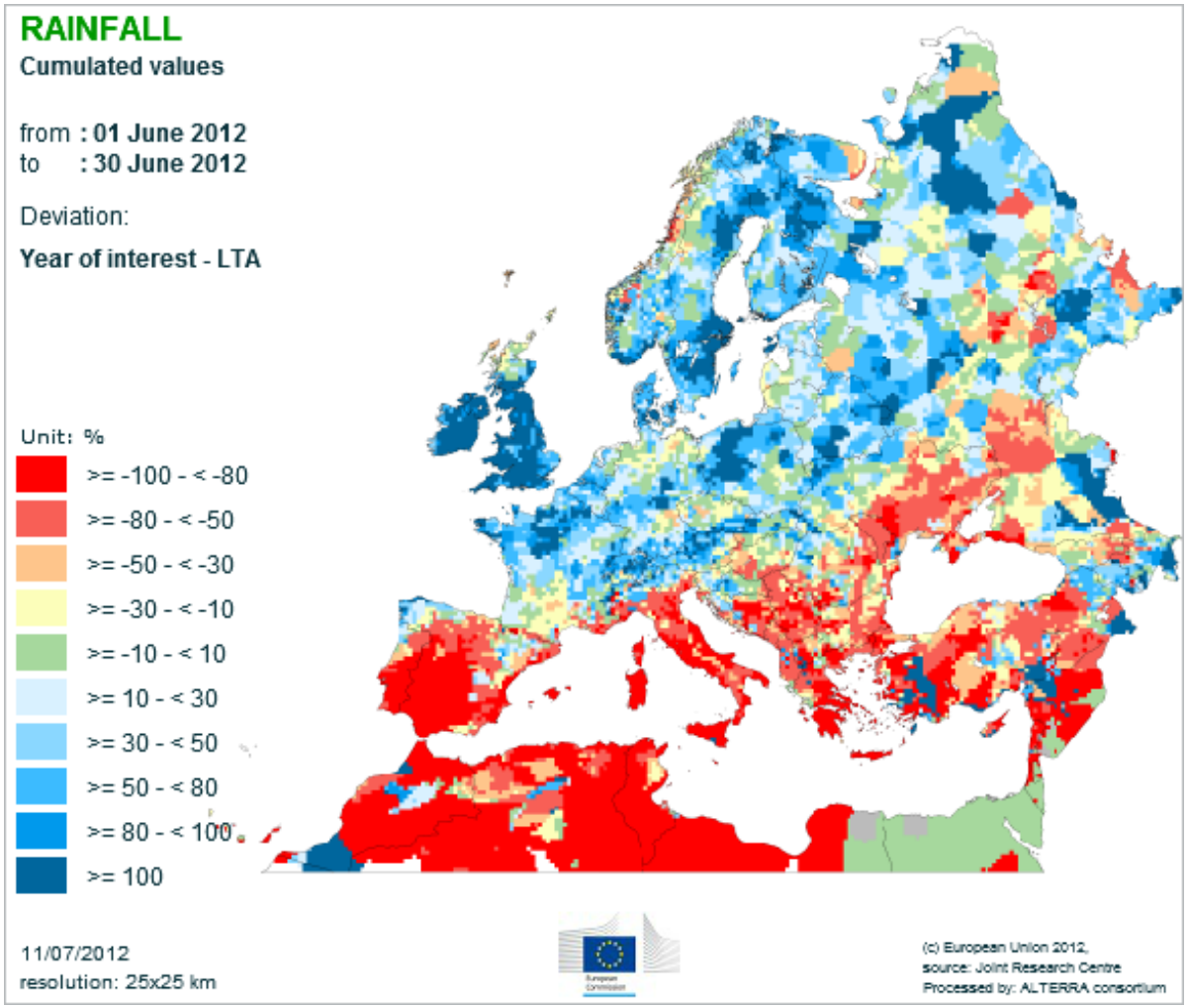
Blue dot: reliable stations with more than 80 % of the time reporting

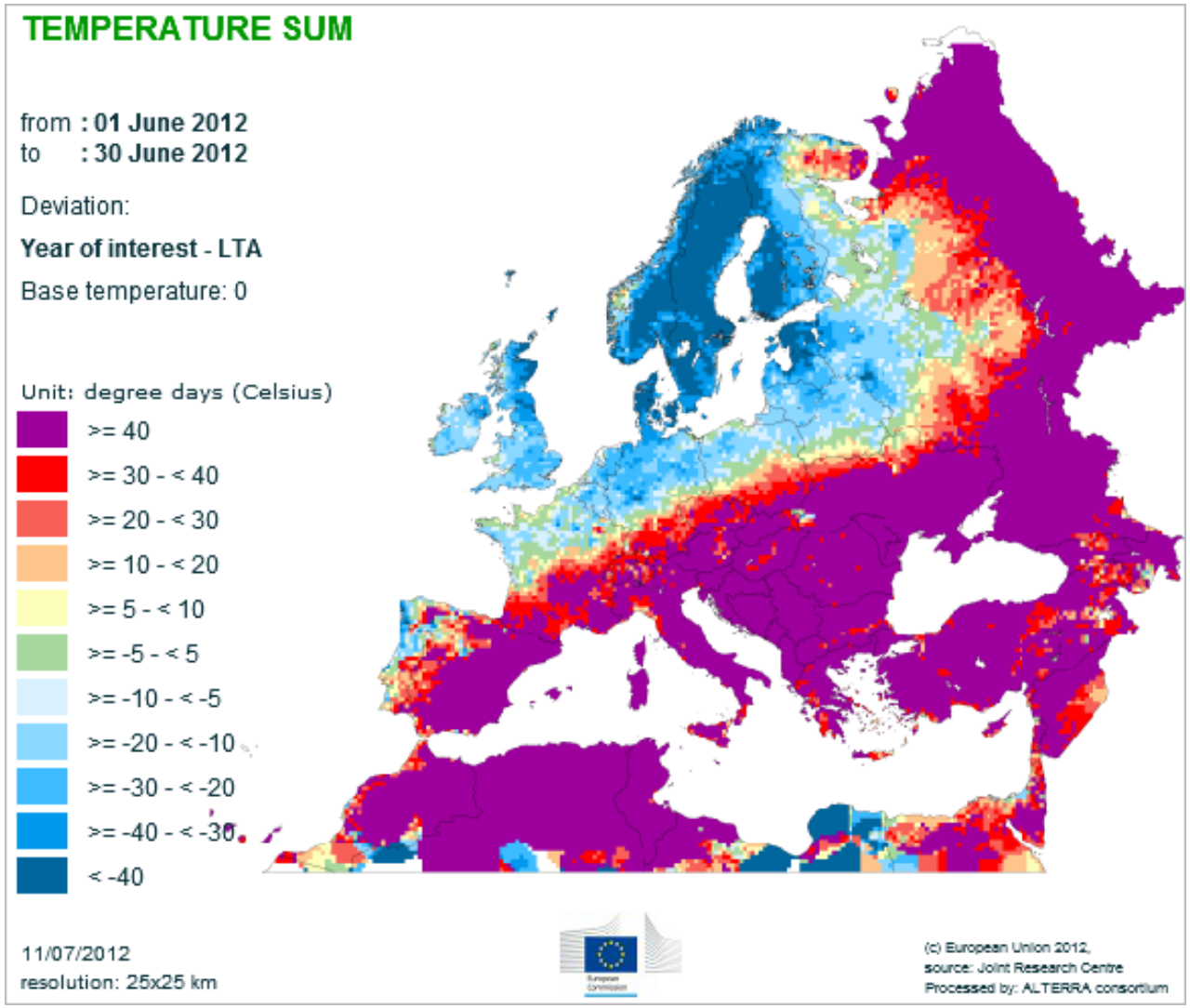
Red dot: all stations in the system

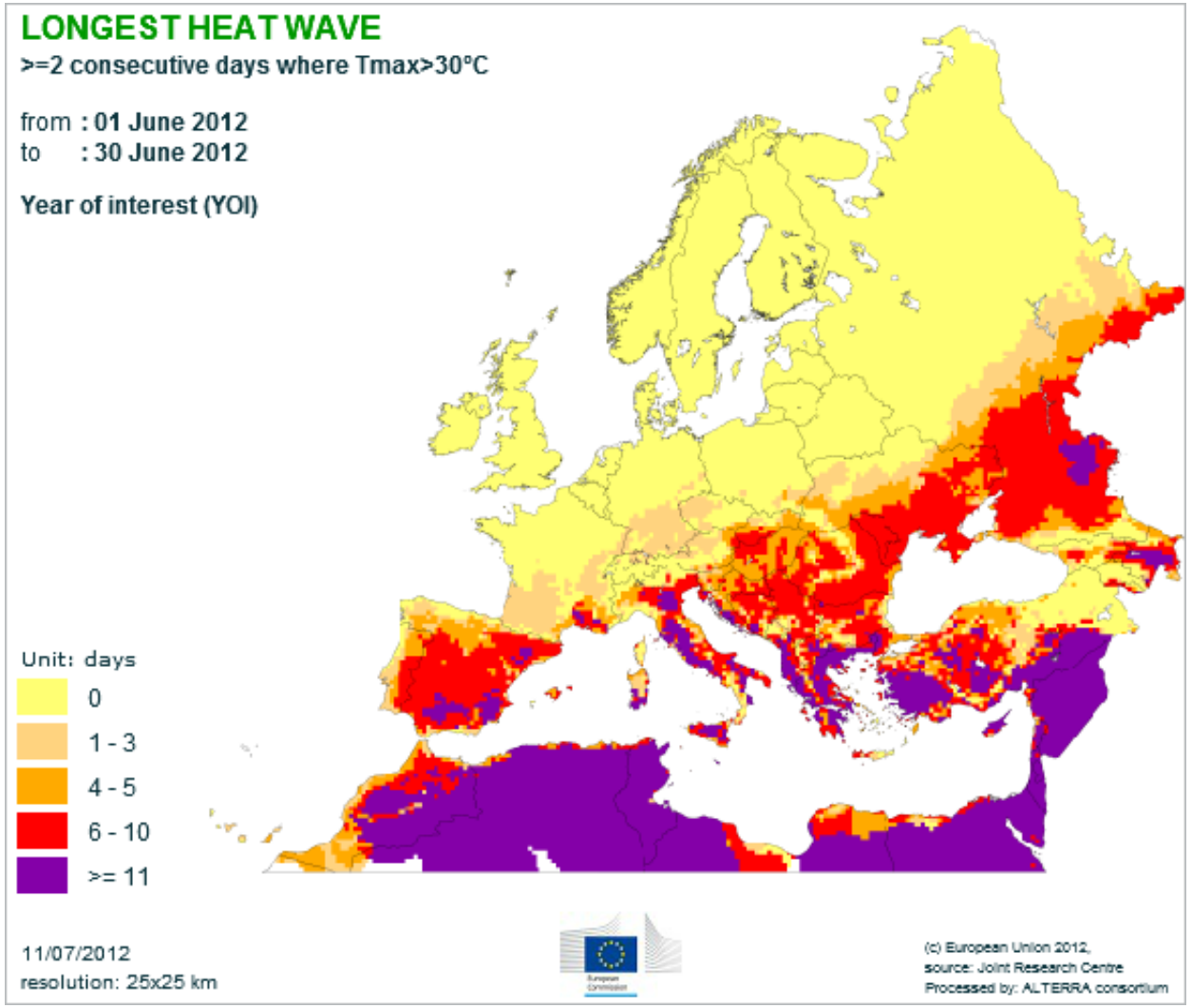
Interpolation to the MARS grid

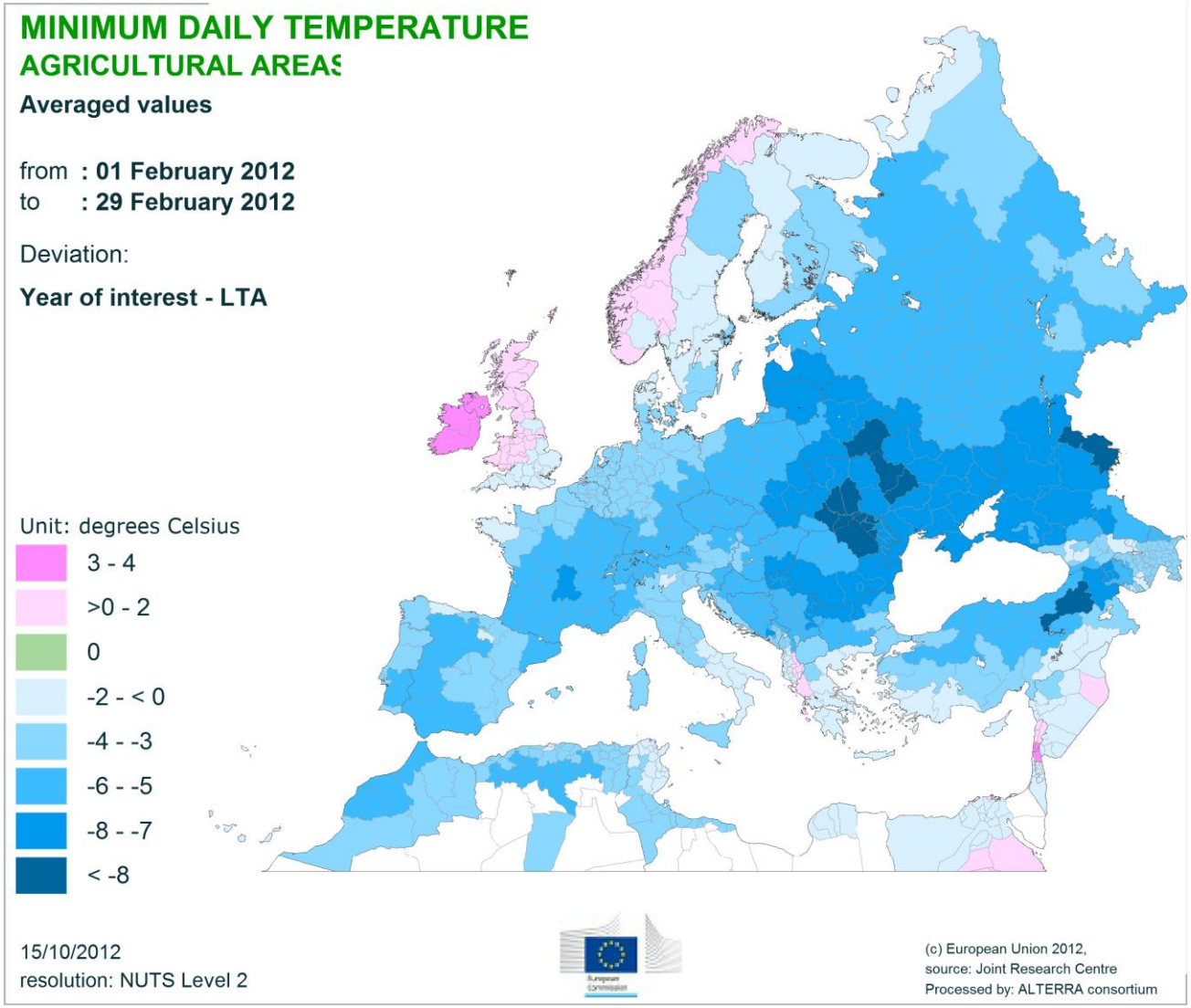


Interpolation is used to convert irregular distributed station data to regular distributed data (25 km * 25 km grid) with different methodologies according to the parameter

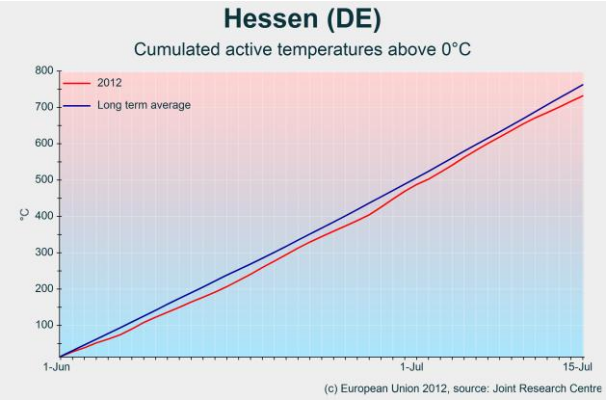

RAINFALL
Cumulated values
from : 01 June 2012
to : 30 June 2012
Deviation:
Year of interest - LTA
Unit: %
>= -100 - < -80
>= -80 - < -50
>= -50 - < -30
>= -30 - < -10
>= -10 - < 10
>= 10 - < 30
>= 30 - < 50
>= 50 - < 80
>= 80 - < 100
>= 100
11/07/2012
resolution: 25x25 km
(c) European Union 2012,
source: Joint Research Centre
Processed by: ALTERRA consortium

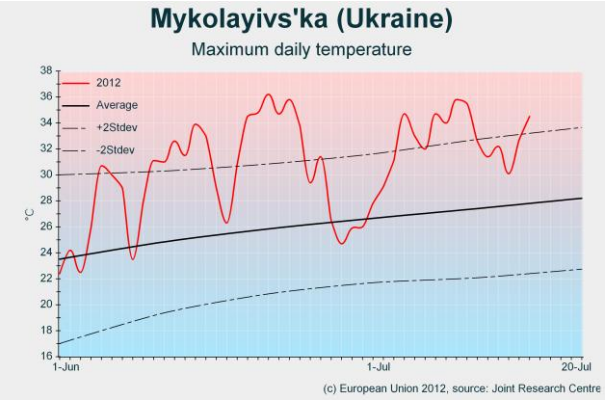

TEMPERATURE SUM
from : 01 June 2012
to : 30 June 2012
Deviation:
Year of interest - LTA
Base temperature: 0
Unit: degree days (Celsius)
>= 40
>= 30 - < 40
>= 20 - < 30
>= 10 - < 20
>= 5 - < 10
>= -5 - < 5
>= -10 - < -5
>= -20 - < -10
>= -30 - < -20
>= -40 - < -30
< -40
11/07/2012
resolution: 25x25 km
(c) European Union 2012,
source: Joint Research Centre
Processed by: ALTERRA consortium

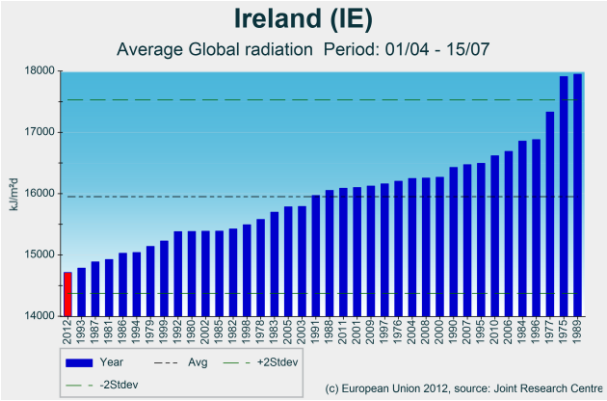

LONGEST HEAT WAVE
>=2 consecutive days where Tmax>30°C
from : 01 June 2012
to : 30 June 2012
Year of interest (YOI)
Unit: days
0
1 - 3
4 - 5
6 - 10
>= 11
11/07/2012
resolution: 25x25 km
(c) European Union 2012,
source: Joint Research Centre
Processed by: ALTERRA consortium

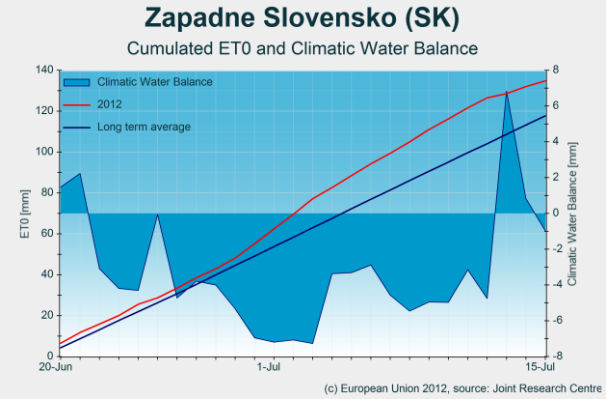

MINIMUM DAILY TEMPERATURE
AGRICULTURAL AREAS
Averaged values
from : 01 February 2012
to : 29 February 2012
Deviation:
Year of interest - LTA
Unit: degrees Celsius
3 - 4
>0 - 2
0
-2 - < 0
-4 - -3
-6 - -5
-8 - -7
< -8
15/10/2012
resolution: NUTS Level 2
(c) European Union 2012,
source: Joint Research Centre
Processed by: ALTERRA consortium

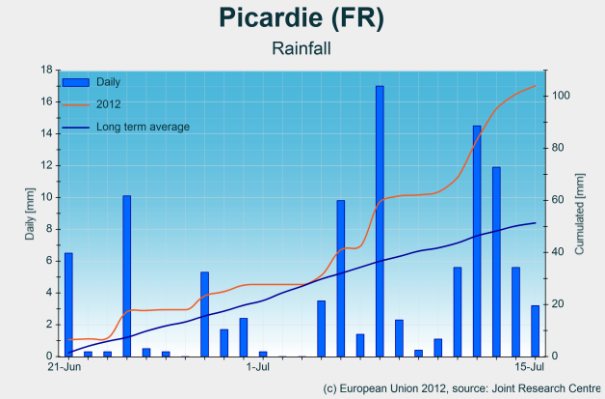
Aggregated results over time

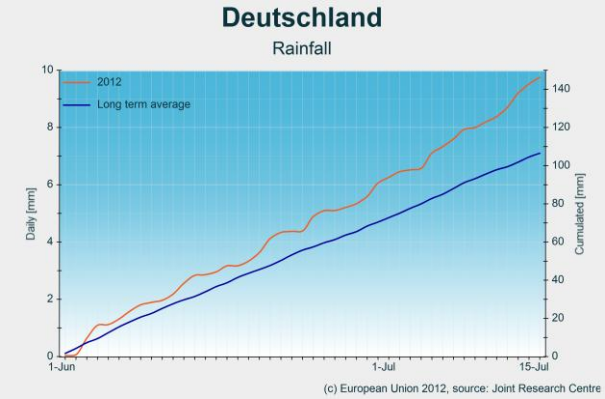




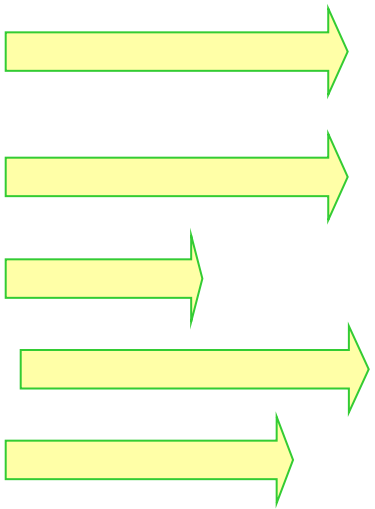








Meteorological information combined with phenological stages



excess of rain at sowing

frosts at emergence

droughts during vegetative growth

dry spells at grain filling

heath stresses before maturity

are reducing factors of plant productions and are taken into account by indicators

LONGEST HEAT WAVE AROUND RIPENING
GRAIN MAIZE

>=2 consecutive days where Tmax>30°C

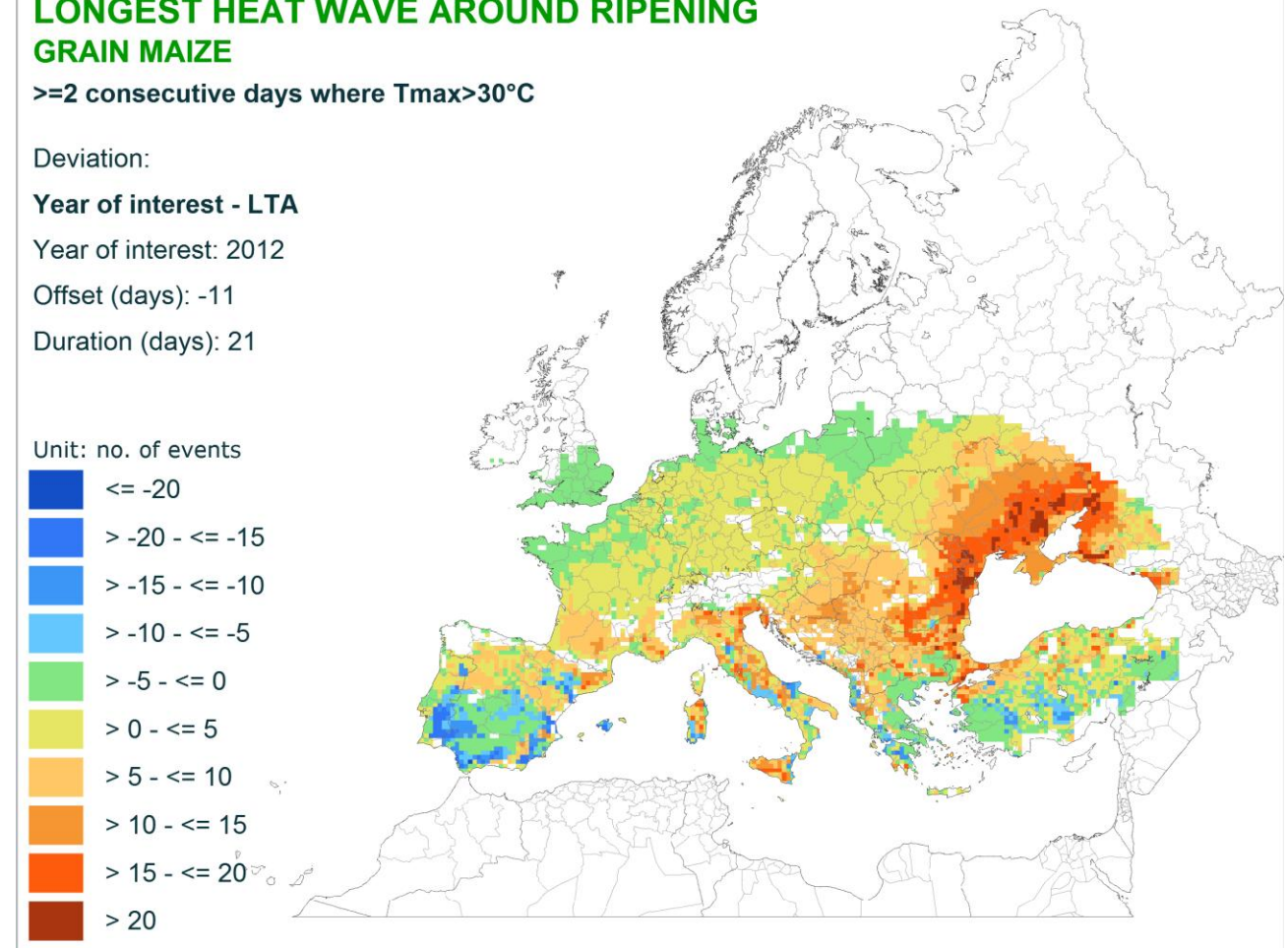
Deviation:

Year of interest - LTA

Year of interest: 2012

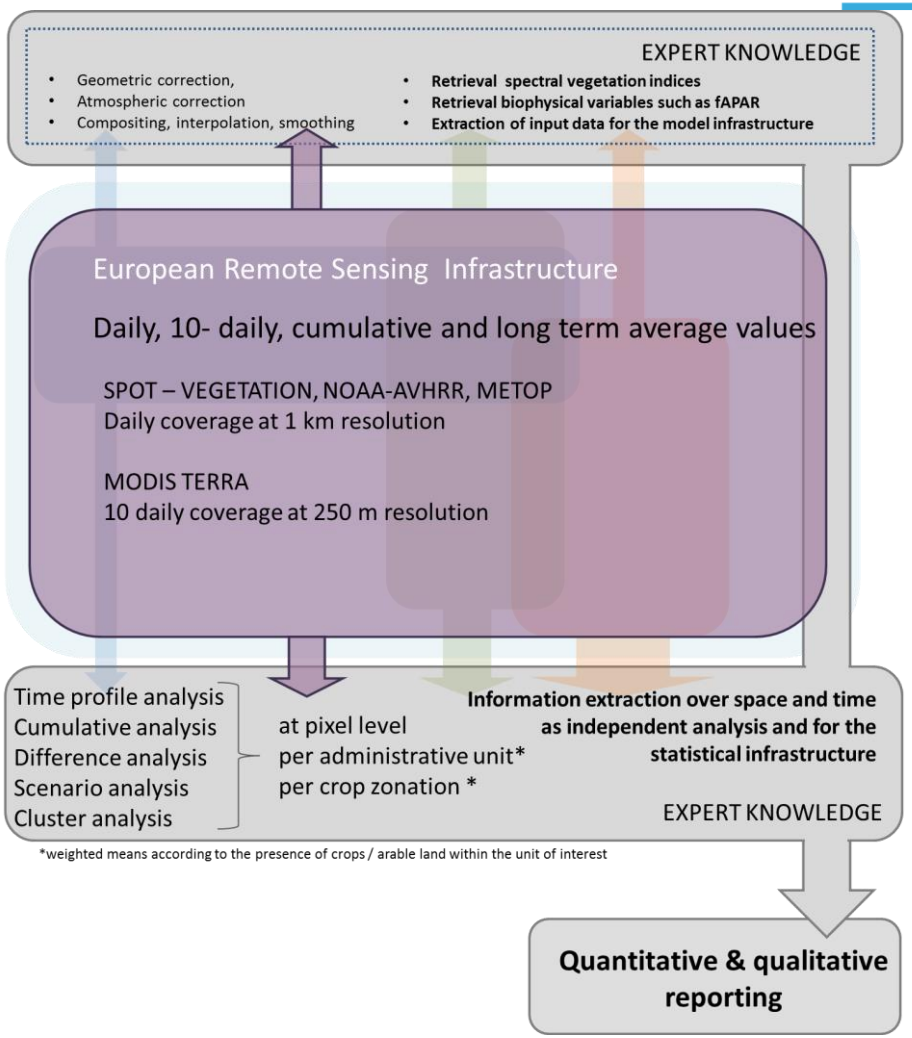
Offset (days): -11

Duration (days): 21



15/10/2012
resolution: 25x25 km

European remote sensing infrastructure



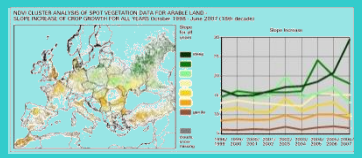
Remote Sensing contributions

Approaches followed:

- Independent analysis for crops and pastures - qualitative
- Independent analysis for crops – quantitative
- Merged analysis with meteo and crop simulation results – quantitative

European Commission

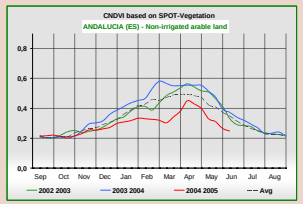
Sensor	Preprocessing	Indicators	Info extraction over space and time
MSG since 2005	Pan-European Daily, 10- daily, monthly, long term average - original bands - atmospheric correction - geometric correction - quality flag - compositing (MVC, avg) - interpolation - smoothing	Land surface temp. Radiation (DSSF) Sunshine duration Snow cover	Difference analysis Time profile analysis Cluster analysis Similarity analysis Rank analysis Probability analysis
NOAA AVHRR since 1981 METOP AVHRR from 2008 SPOT VGT since 1998		NDVI fAPAR DMP	
MODIS TERRA since 2000		NDVI fAPAR DMP	Intra annual & full series



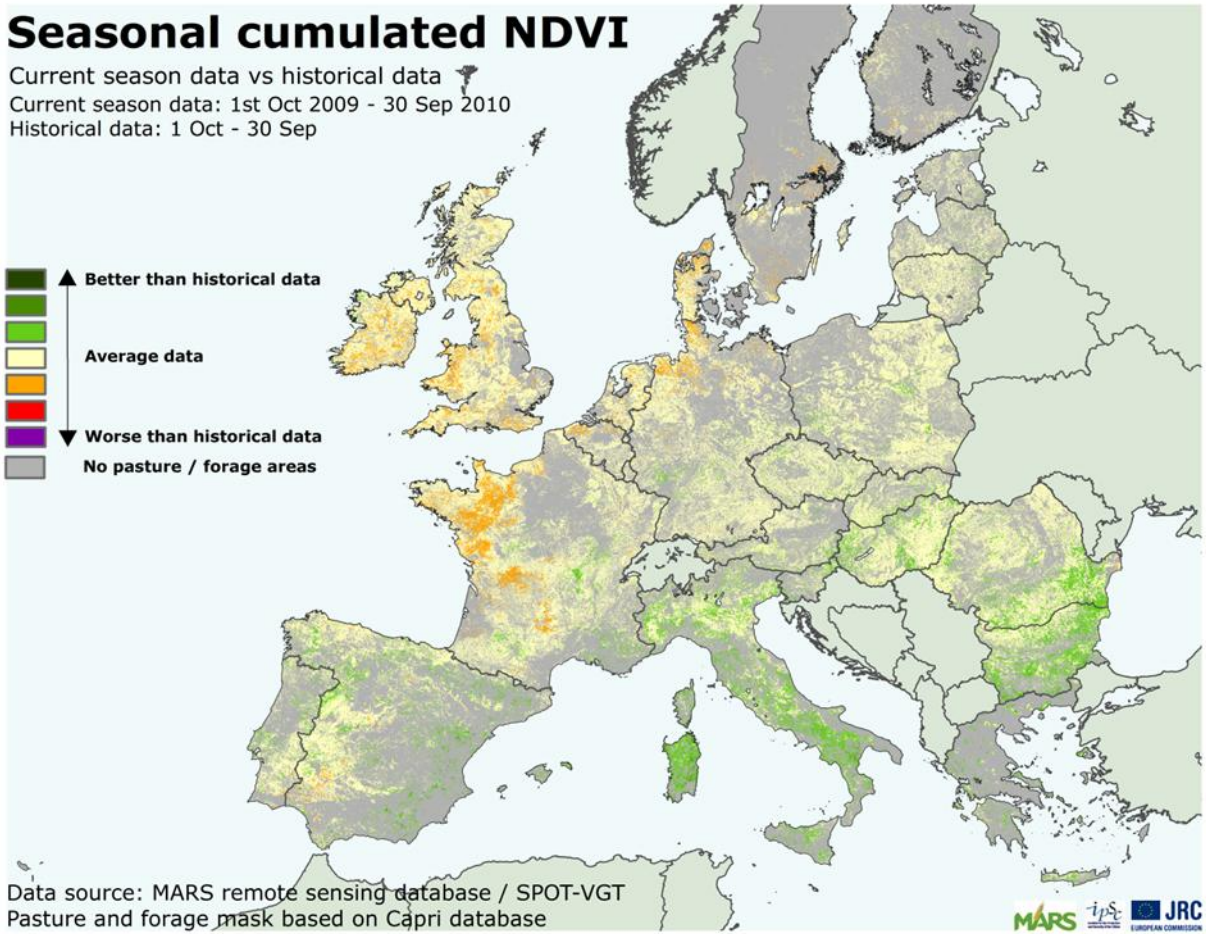
C- indicator

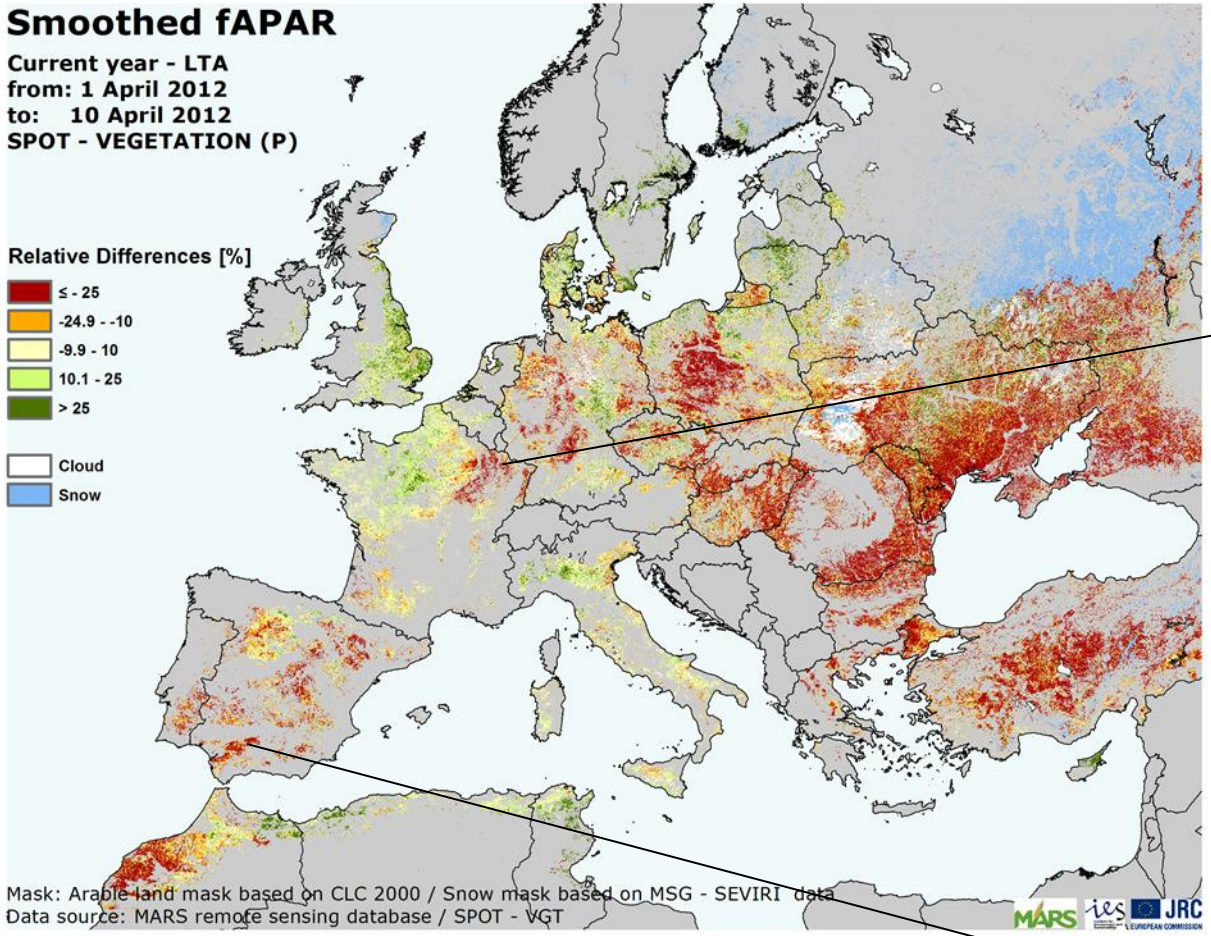
Weighted mean according to land use within the unit of interest

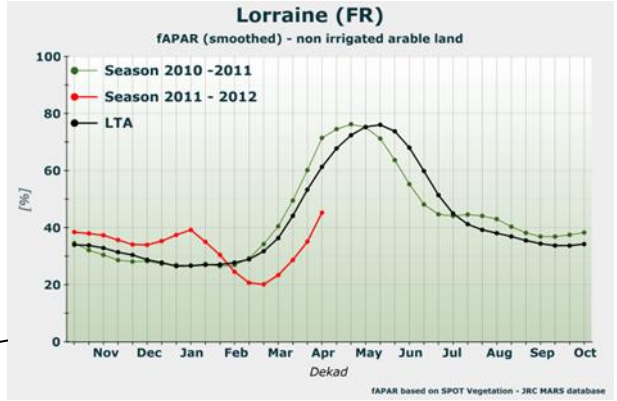
Administrative unit
Agri-ecological zonation
Grid (25 km * 25 km)

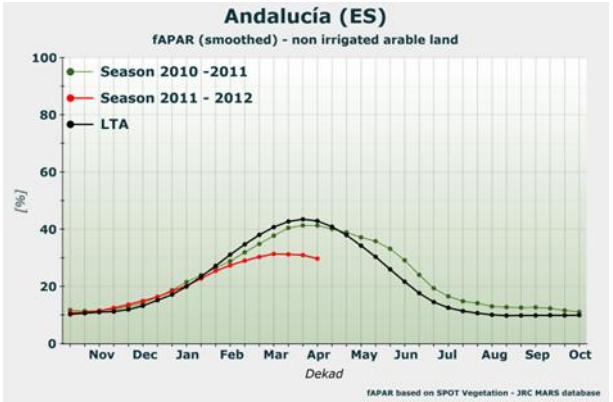


Joint Research Centre


Seasonal cumulated NDVI
Current season data vs historical data
Current season data: 1st Oct 2009 - 30 Sep 2010
Historical data: 1 Oct - 30 Sep
Better than historical data
Average data
Worse than historical data
No pasture / forage areas
Data source: MARS remote sensing database / SPOT-VGT
Pasture and forage mask based on Capri database
MARS
JRC

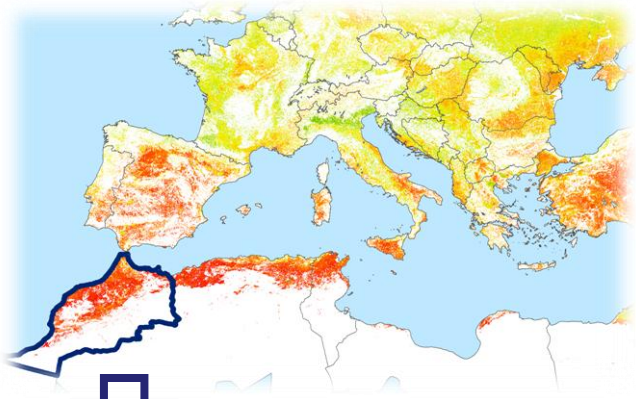

Smoothed fAPAR
Current year - LTA
from: 1 April 2012
to: 10 April 2012
SPOT - VEGETATION (P)
Relative Differences [%]
≤ - 25
-24.9 - -10
-9.9 - 10
10.1 - 25
> 25
Cloud
Snow
Mask: Arable land mask based on CLC 2000 / Snow mask based on MSG - SEVIRI data
Data source: MARS remote sensing database / SPOT - VGT
MARS
ies
JRC

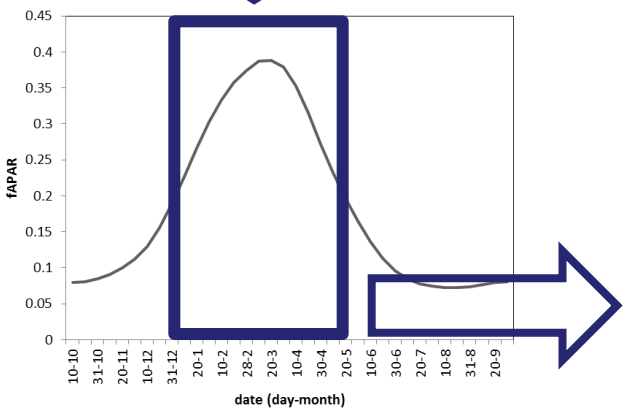

Lorraine (FR)
fAPAR (smoothed) - non irrigated arable land
Season 2010 -2011
Season 2011 - 2012
LTA
[%]
100
80
60
40
20
0
Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct
Dekad
fAPAR based on SPOT Vegetation - JRC MARS database


Andalucía (ES)
fAPAR (smoothed) - non irrigated arable land
Season 2010 -2011
Season 2011 - 2012
LTA
[%]
100
80
60
40
20
0
Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct
Dekad
fAPAR based on SPOT Vegetation - JRC MARS database

Remote sensing approach to quantitative yield estimation

Crop yields related to cumulated fAPAR at regional / national level





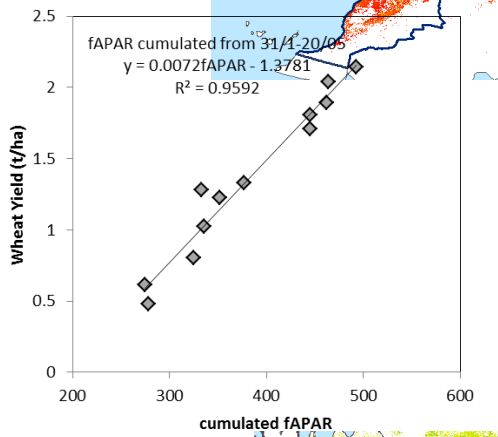
Assumptions:

- The inter-annual **variability of** crop **yield** can be **explained by** crop **photosynthetic activity** along the season (water limited areas)
- The analysis is valid for **predominant crops** (typ. wheat/barley)
- Statistically-based (**reliable** yield **statistics are required**)
- **Crop acreage** is, more or less, **stable** (winter Vs summer cereals)

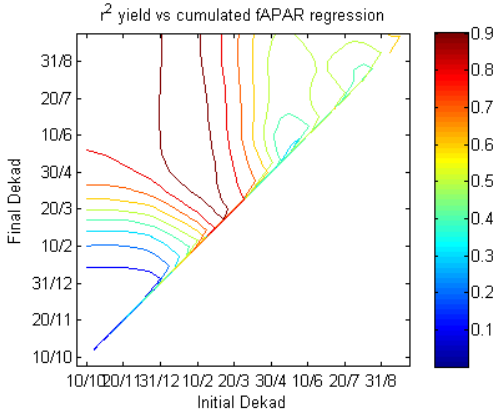
Integration period is optimized through a **regression between yield** figures and **fAPAR** with historical data

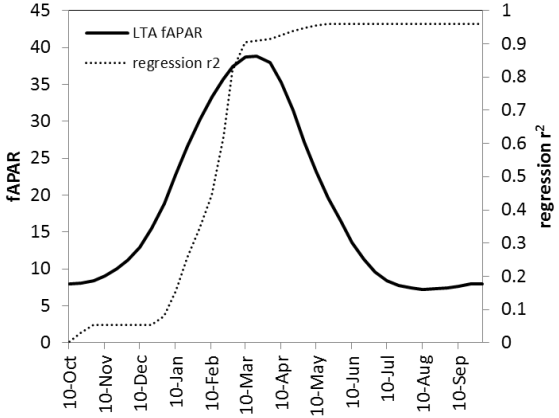
Some examples (1999-2011):

Morocco (Wheat)

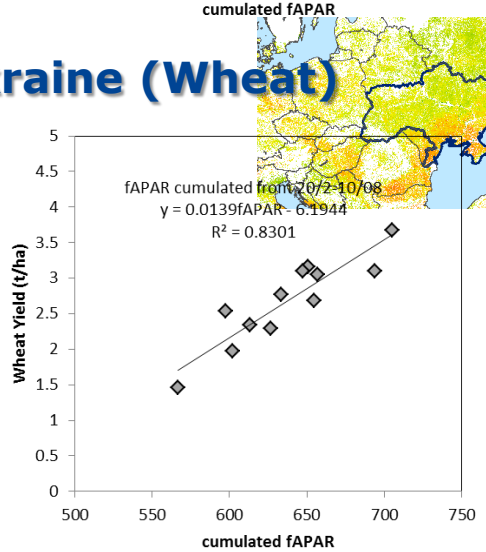


Evolution of RS regress. reliability along the season

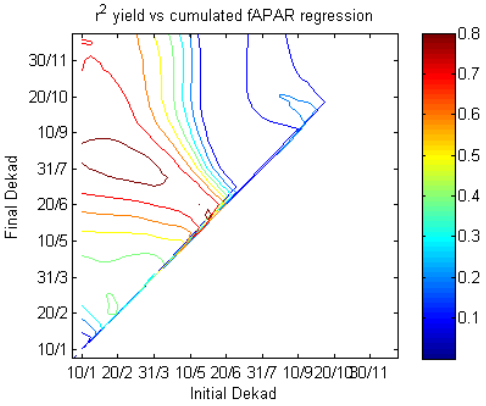


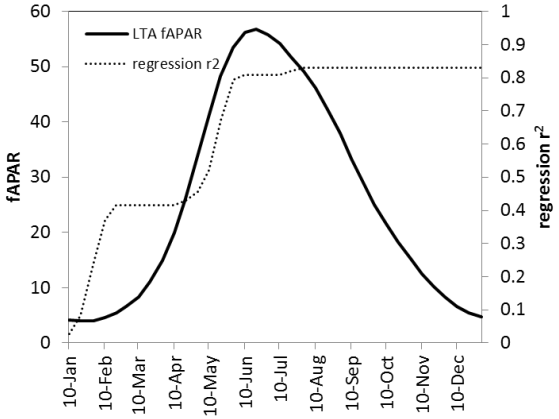


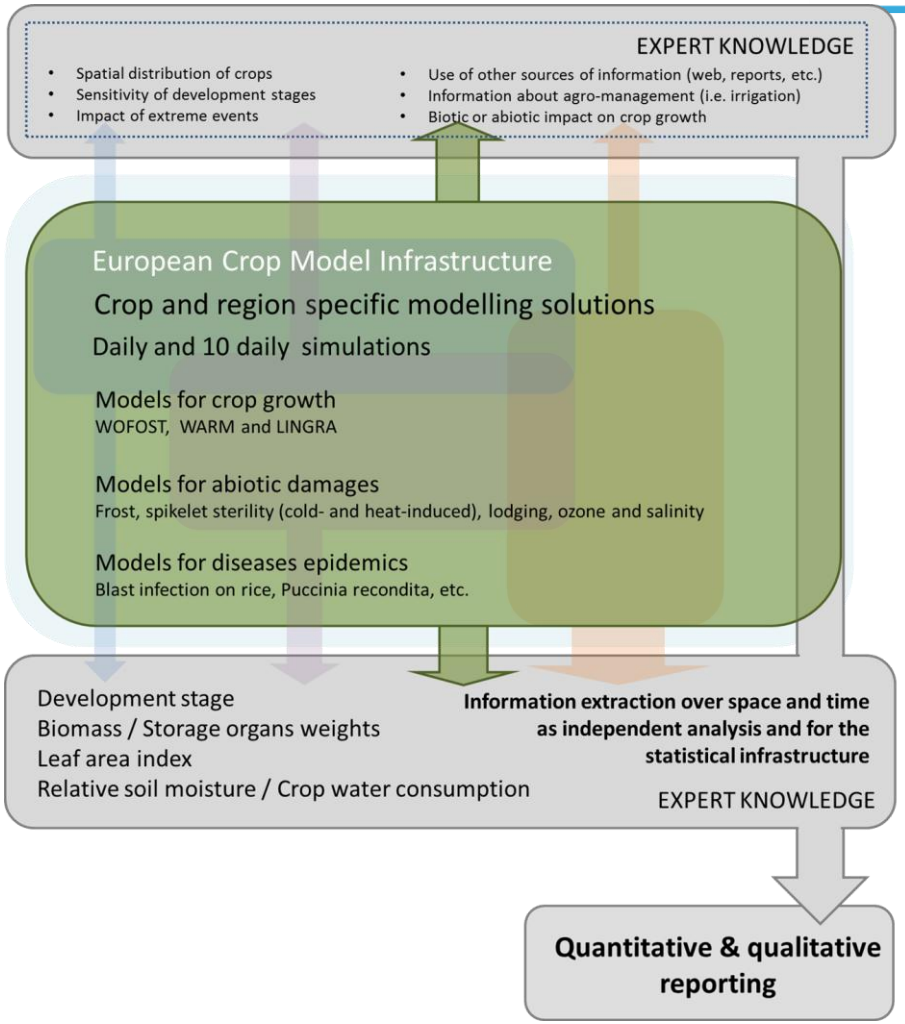
Ukraine (Wheat)



Evolution of RS regress. reliability along the season







European crop model infrastructure

Crop models are complex groups of algorithms that simulate crop growth: total biomass produced, grain biomass, etc. They use meteorological data as input as well as soil information and management data to account for the effects of changes in soil water content and crop management.

Crop simulation

The crop simulation module of the MCYFS integrates the effect of **weather**, **soil** and **crop characteristics** on crop growth assuming that the influence of other factors like farm management and socio-economic factors is constant.

The hart of the module consists of the **WOFOST** model which simulates crop development. These results are analyzed to identify abnormal situations and are used as input for the yield forecasting module.

Crop model infrastructure

European Commission

Input data

Static data

- Crop parameters
- Soil parameters
- Administrative units

Meteorological infrastructure

- Observed interpolated weather data
- Downscaled forecast data

Remote sensing infrastructure

- Radiation
- NDVI, fAPAR

Crop growth simulation

Pan-European
10-daily
long term average
AGRO-METEO DB

Crop growth models
in CGMS
WOFOST
LINGRA
WARM

Simulated crops
Wheat, Barley
Maize, Rice, Sunflower
Rapeseed, Sugar Beet
Potato, Field Beans
Pastures

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

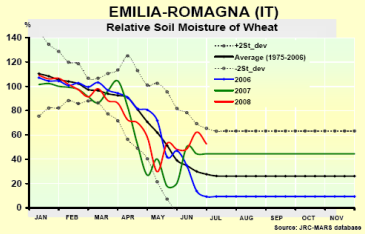
Ingestion into statistical infrastructure

Meteorological events in relation to crop development stage

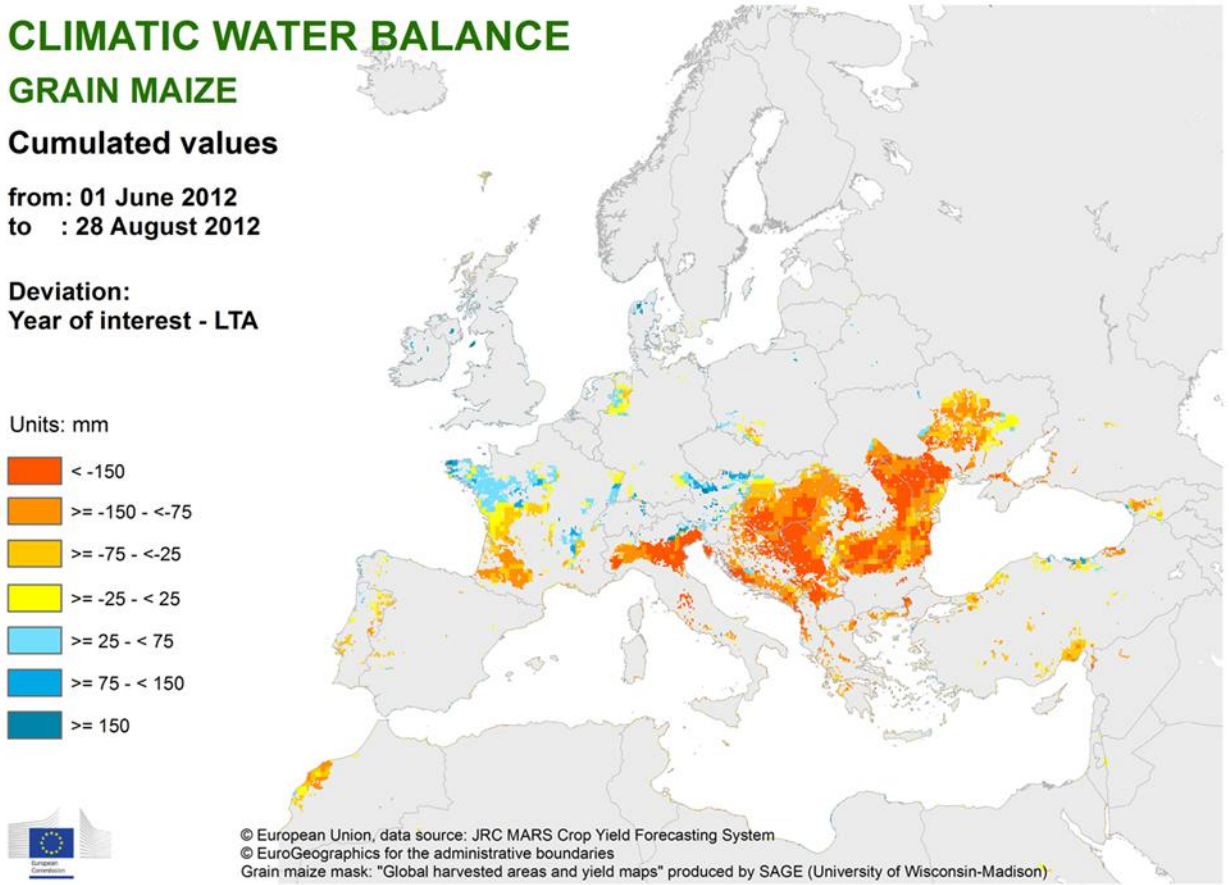
Info extraction over space and time

- Difference analysis
- Time profile analysis
- Similarity analysis
- Rank analysis

C- indicator
Weighted mean according to land use within the unit of interest



Outputs from the crop models



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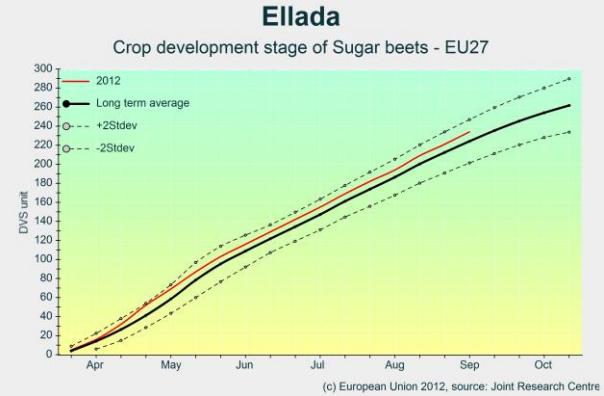
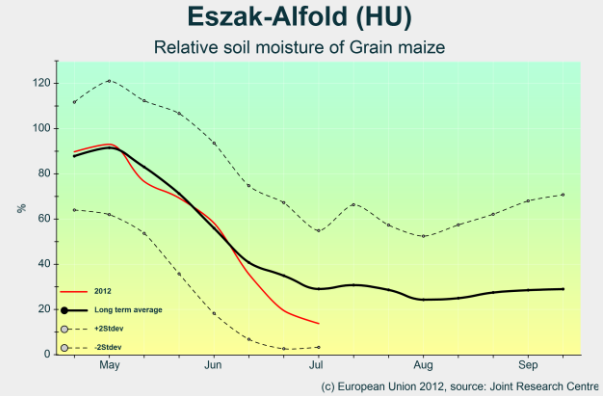
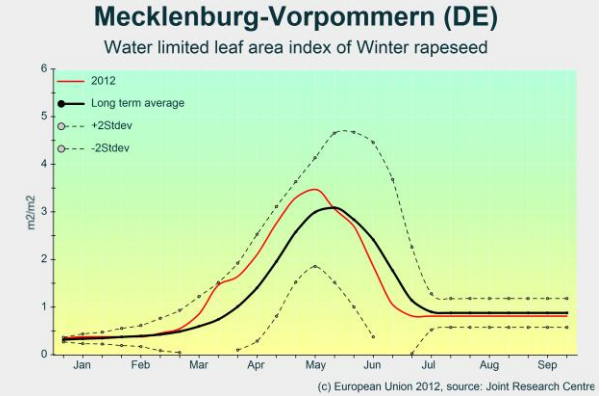
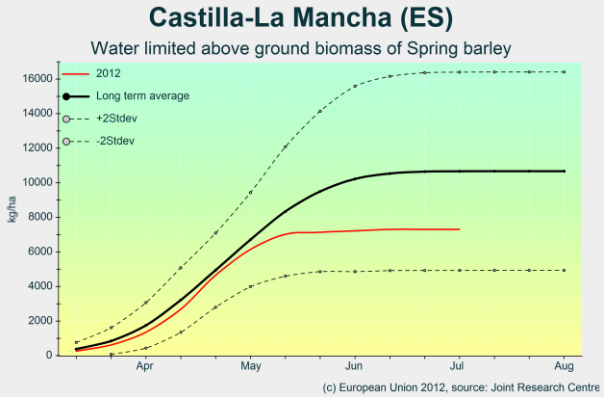
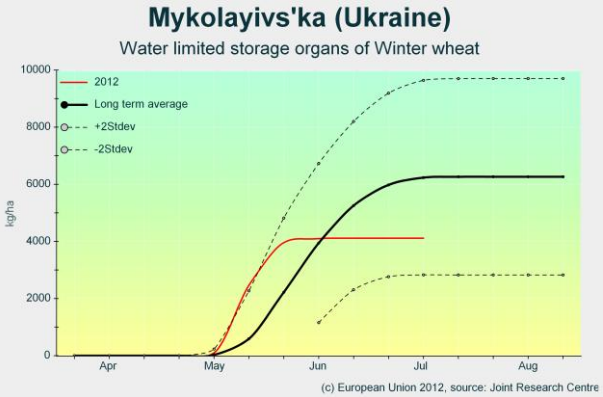
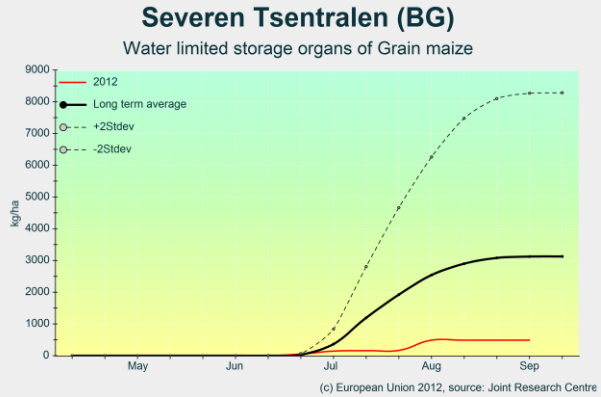












The libraries currently available

European Commission

Weather libraries

- AirTemperature, EvapoTranspiration, LeafWetness
- Climate indices
- Weather Generation (ClimGen, CLIMAK)

Stresses

Abiotic

- Heat damage
- Frost kill
- Rice cold shocks
- Lodging

Biotic

- Generic air-borne diseases
- Generic soil-borne diseases
- CornBorer simulator

Plant libraries

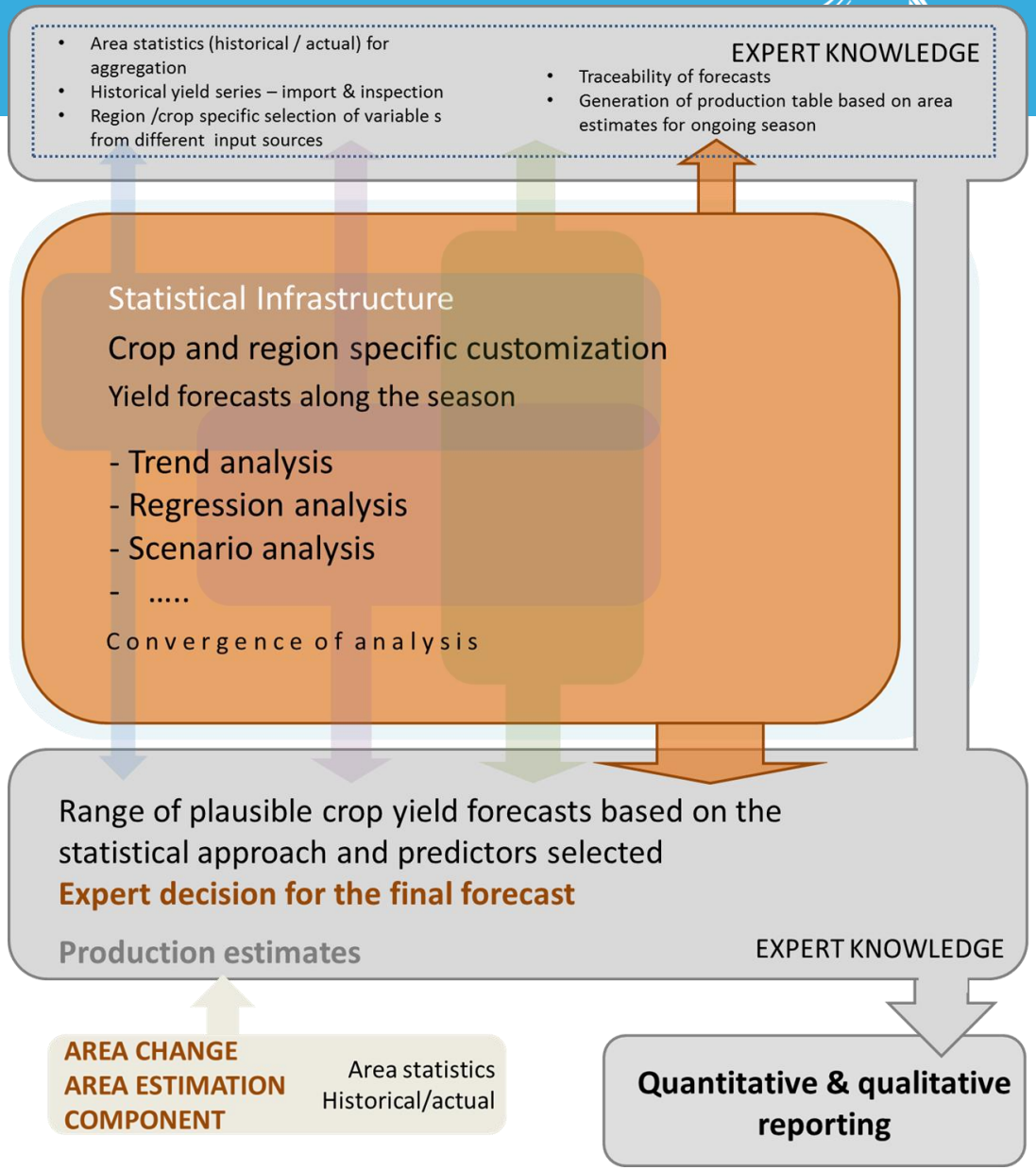
- Generic crop Simulation (CropSyst, WOFOST)
- Pasture (STIC)
- Rice (WARM)
- SugarCane (CANEGRO)

Agriculture management

- Rule based modelling

Soil libraries

- Soil water runoff and erosion
- Soil water redistribution (cascading, FiniteDifferences)
- Soil surface and profile temperature
- Soil Nitrogen
- Pedotransfer functions



European statistical infrastructure

This infrastructure integrates all the statistical methods, resources and information needed to forecast crop yields using the information provided by crop models, remote sensing and meteorological data.

MCYFS statistical forecast principles

Classic regression approach, focus relationship between a dependent variable –the yield– and one or more independent parameters related to climate/ weather effects

Scenario analysis, based on analogies between the contingent conditions and the past, investigating years that behave similarly with respect to selected events and reporting their measured effects on the actual state in order to predict final consequences.

The yield "predictors" consist in any variables related to crop yield at harvest time, belonging to and weighting one of the following aspects: meteorological impact evaluation (minimum or maximum temperature, rain, radiation level, etc.), crop status assessment (e.g. soil moisture, development stage) and crop growth expectations (e.g. potential yield biomass, potential yield storage).

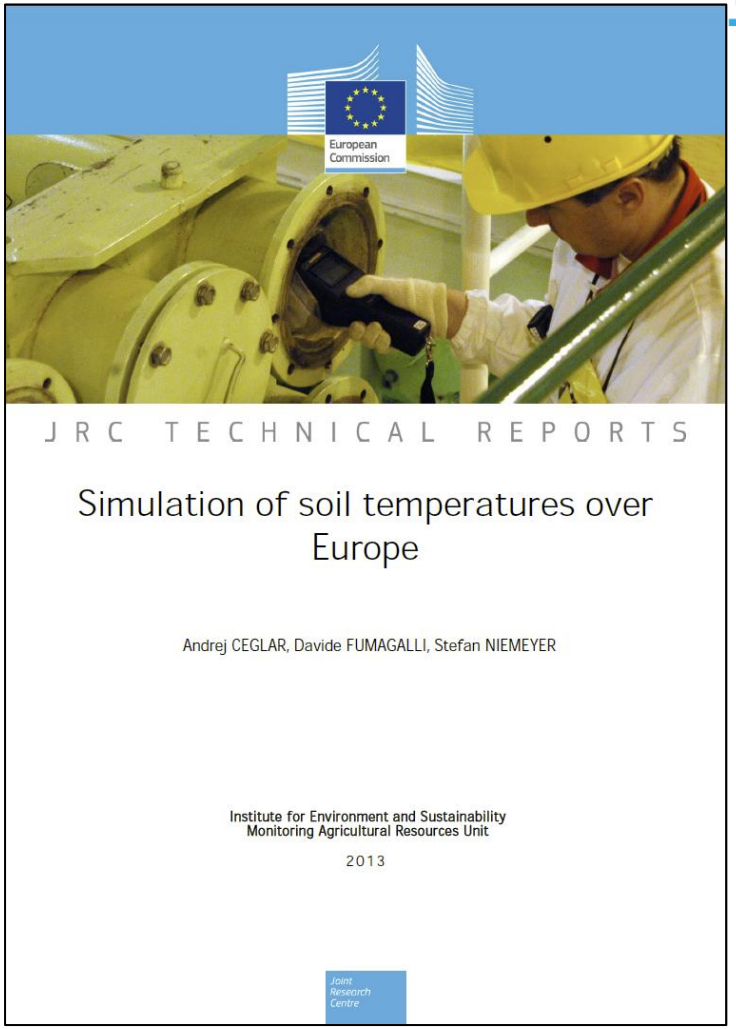
Content

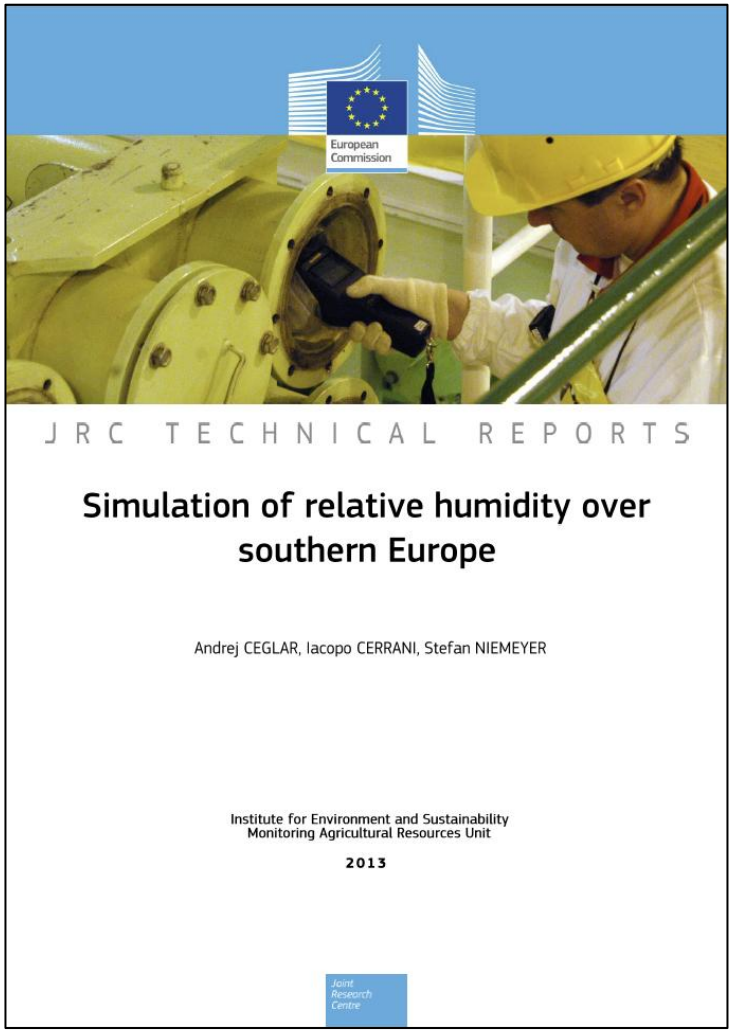
- MARS crop yield forecasting system
  - Meteorological infrastructure
  - Crop model infrastructure
  - Remote Sensing infrastructure
  - Statistical infrastructure

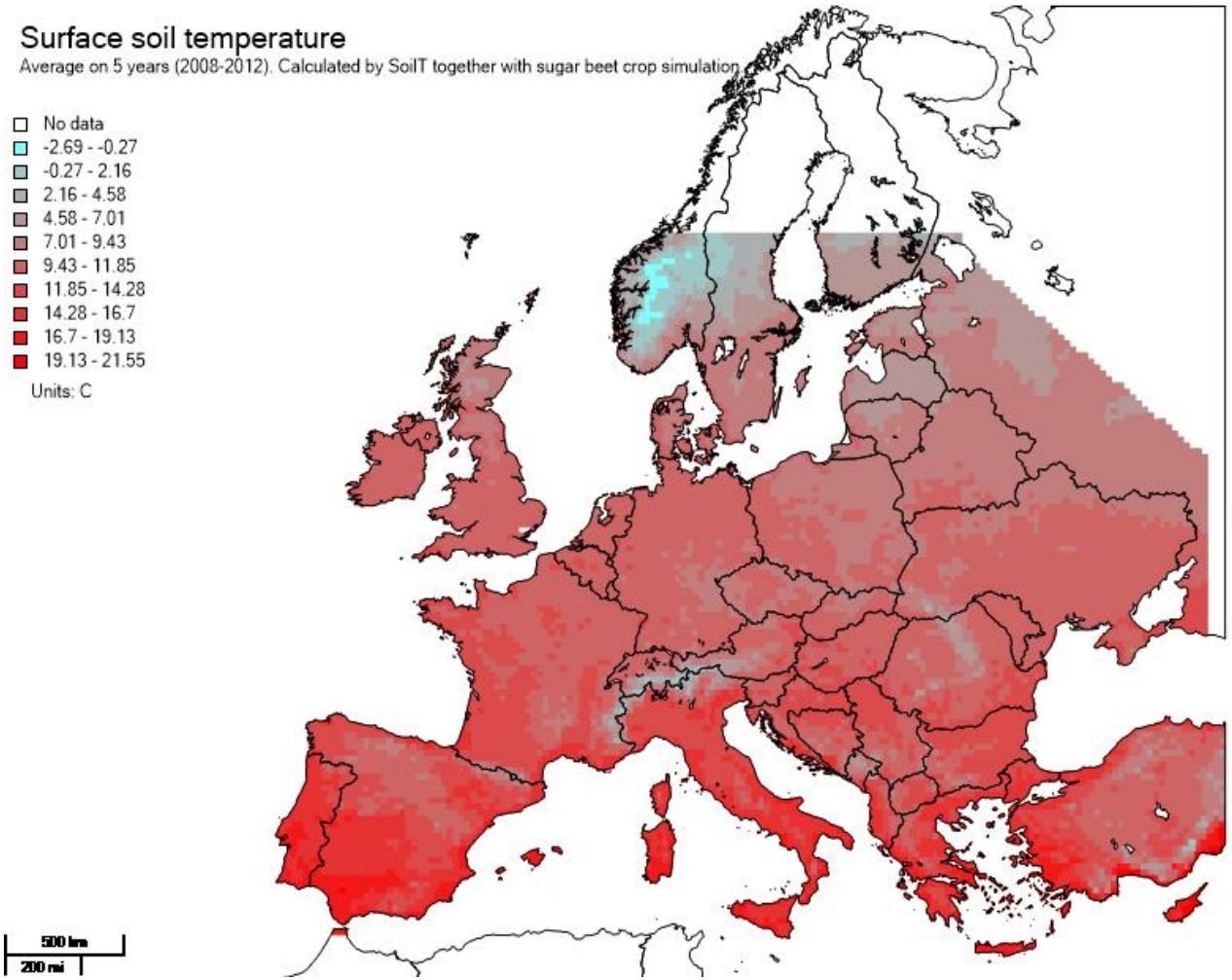
- Pest risk assessment support
  - Collaboration with EFSA
  - ClimPest
  - MYMICS

Collaboration with European Food Safety Authority (EFSA)

- Provision of climate data (e.g. air temperature, precipitation) for selected locations in Europe
- Provision of tailored environmental data (e.g. simulated soil temperatures at different soil depths for a given crop)
- CLIMPEST application: "*Model framework for the assessment of EU climatic suitability for the establishment of organisms harmful to plants and plant products*"
- Contribution to scientific opinions (e.g. Phytophtora fragariae, Phyllosticta citricarpa)


European Commission
JRC TECHNICAL REPORTS
Simulation of soil temperatures over Europe
Andrej CEGLAR, Davide FUMAGALLI, Stefan NIEMEYER
Institute for Environment and Sustainability
Monitoring Agricultural Resources Unit
2013
Joint Research Centre


European Commission
JRC TECHNICAL REPORTS
Simulation of relative humidity over southern Europe
Andrej CEGLAR, Iacopo CERRANI, Stefan NIEMEYER
Institute for Environment and Sustainability
Monitoring Agricultural Resources Unit
2013
Joint Research Centre


Surface soil temperature
Average on 5 years (2008-2012). Calculated by SoilT together with sugar beet crop simulation
No data
-2.69 - -0.27
-0.27 - 2.16
2.16 - 4.58
4.58 - 7.01
7.01 - 9.43
9.43 - 11.85
11.85 - 14.28
14.28 - 16.7
16.7 - 19.13
19.13 - 21.55
Units: C
500 km
200 mi

Supporting Publications 2012: EN-247

EXTERNAL SCIENTIFIC REPORT

Model framework for the assessment of EU climatic suitability for the establishment of organisms harmful to plants and plant products – CLIMPEST project (SLA/EFSA-JRC/2008/PLH/01)

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Institute for Environment and Sustainability (IES), Joint Research Centre (JRC), European Commission, TP 750, I-21020 Ispra (VA), Italy

ABSTRACT

In the frame of the SLA a model framework was developed named ClimPest allowing the assessment of EU climatic suitability for the establishment of organisms harmful to plants and plant products and more specifically to estimate the weather suitability for potential infection by the citrus pathogen *Guignardia citricarpa* (common name Citrus Black Spot - CBS). The model framework Climpest can be re-used for other plant diseases and pests and it contains the following modelling solutions: ClimIndices (calculation of climatic indexes) and Potential Infection Model (calculation of the potential infections of foliar fungal pathogens on plants). The software has access to a remote database containing historical series of daily weather data with Europe spatial coverage on a 25 x 25 grid. Climate change scenarios for 2020 and 2050 are also made available related to the emission scenarios A1B and B1. The software was designed to be extended autonomously by third parties with diverse modelling solutions, other than the ones provided in this first version.

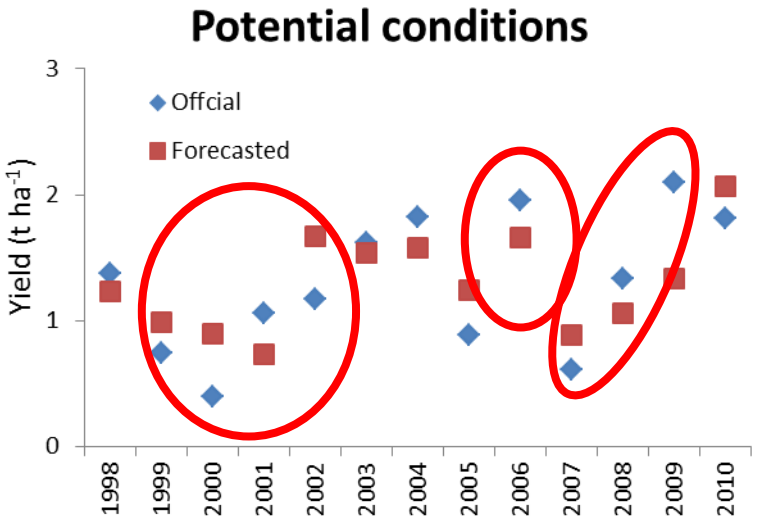
KEY WORDS

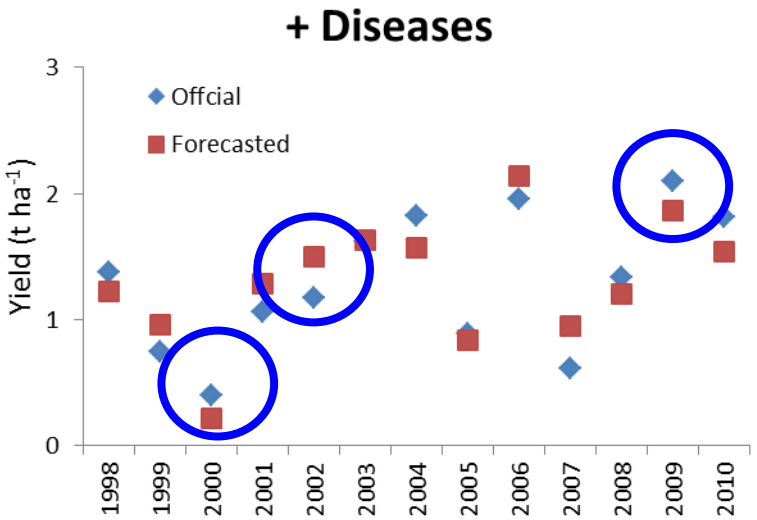
Model framework, potential infection model, BioMa, meteorological databases, climate change scenarios

DISCLAIMER

Any enquiries related to this output should be addressed to plh@efsa.europa.eu
Suggested citation: Donatelli M, Bregaglio S, Fumagalli D, and Baruth B; Model framework for the assessment of EU climatic suitability for the establishment of organisms harmful to plants and plant products – CLIMPEST project (SLA/EFSA-JRC/2008/PLH/01). Supporting Publications 2012: EN-247. [63 pp.]. Available online: www.efsa.europa.eu/publications

Black rust (Puccinia graminis) Durum wheat in Morocco





R^2 = 0.38 (no trend)

Indicators:

- DVS
- LAI
- WL biomass
- WL LAI

R^2 = 0.81 (no trend)

Indicators:

- Black rust-biomass
- Black rust infection events
- DVS
- WL biomass

MIMYCS

European Commission

MIMYCS project "*Maize Infection and Mycotoxin Contamination Simulator*"

- Development of a process-based phenological model for the **two main insect borers in maize:** Ostrinia nubilalis and Sesamia nonagrioides
- Development of a process-based model to simulate **toxigenic fungi development inside maize grain** and mycotoxin synthesis
- Development of an original model for the simulation of **moisture content in maize;**
- Simulations at EU scale **mycotoxin contamination in maize grain** in different climatic, environmental and agro-management situations

Collaboration Agreement with Syngenta Seeds SpA
Calibration and validation for the Po Valley, northern Italy

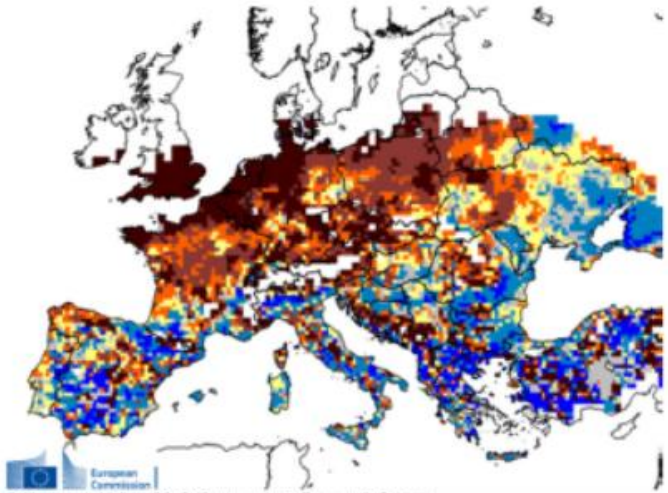


Figure 26a – Fumonisins by *Fusarium verticillioides*

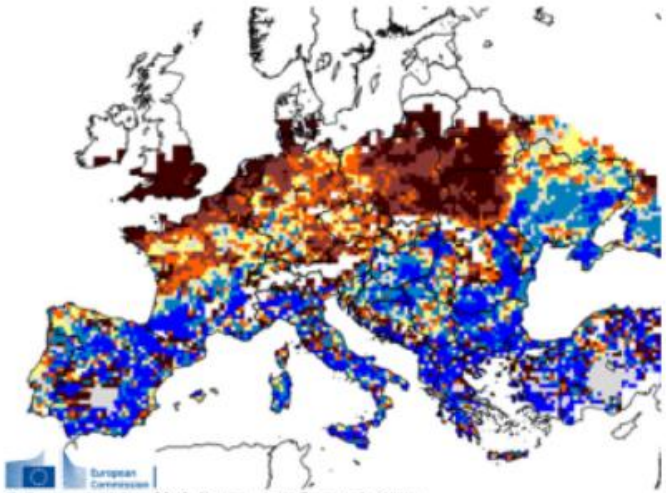
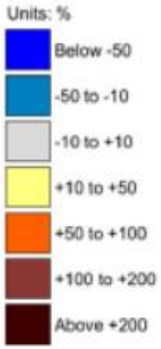


Figure 26b – Deoxynivalenol by *Fusarium graminearum*



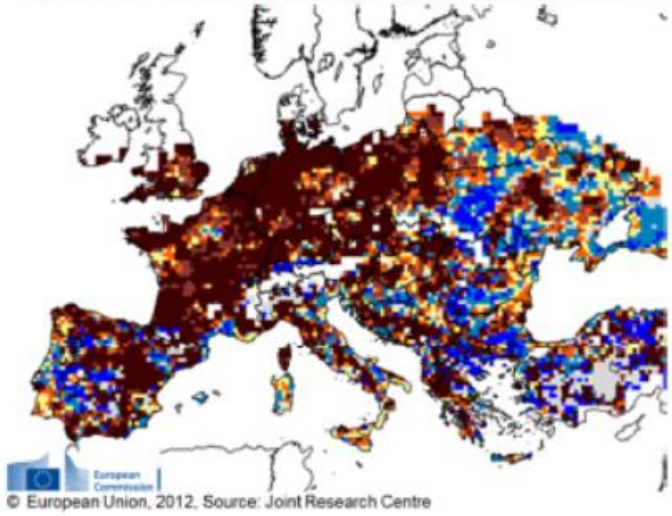


Figure 26c – Aflatoxins by *Aspergillus flavus*

Changes 2050 - 2000

Figure 26. Difference in the estimated contamination of maize grain kernels by fumonisins (25a), deoxynivalenol (25b), and aflatoxins (25c)

Thank you for your attention

fabien.ramos@jrc.ec.europa.eu

To know more?
Detailed information of the components of the MARS Crop Yield Forecasting System can be found in our webpages. The main product of the crop monitoring and yield forecasting activities are the MARS Bulletins regularly published on our web pages.
http://mars.jrc.ec.europa.eu/mars/About-us/AGRI4CAST

For a link into our online MARS Viewer with many near real-time information on crop weather conditions, please visit the MARSOP pages.
http://www.marsop.info/