Joint NASA LCLUC Science Team Meeting and
GOFC-GOLD/NERIN, NEESPI, MAIRS

Monitoring land cover, land use and fire in Northern Eurasia
September 16-19, 2009 - NCRST, Almaty, KAZAKHSTAN

The MARS project: Remote sensing in support of European Agriculture Policies

Olivier Léo
Bettina Baruth
& Philippe Loudjani

Outline

- **MARS Unit and JRC**
- **Managing EU Policy**
  - **Controls with Remote sensing**
  - **>Land parcel identification system**
- **Monitoring Agriculture**
  - Crop monitoring and Yield forecast
  - Area estimates
- **Conclusions**

JRC's Mission Statement

"… to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies.

the JRC functions as a centre of science and technology reference for the EU, independent of special interests, private and national".

MARS Project

- Started 20 years ago to provide more timely objective pan-european information and forecast on agriculture production (MARS STAT)
- Extended in 93 to the management and control of the Common Agriculture Policy (Direct Aids) MARSPAC

- Since 2000 development of Early Warning for Food Security MARSFOOD
- Since 2005 : A global strategy

MARS Unit (resources 2008)

58 Staff in total

48 paid by JRC,
10 paid by other DG's

27 permanent officials,
31 temporary: 3 Years CA, Post Doc, VS -SNE
+ circa 15 persons outsourced (MARS OP)

Budget

JRC credits:	1.1 Mio Euro
Admin Arrangements:	1.7 Mio Euro

AGRI Sub delegations: 6.5 + 1.9 Mio Euro

Main costumers / working relations

EC Directorates: AGRI, ENLARG, AIDCO, RELEX ENTR, RTD, INFSO…

Core expertise

- Agronomy
- Remote Sensing / Image analysis
- Geomatics, GNSS, GIS
- Crop modeling, Agro-meteorology
- Statistics
- ICT

Additional Expertise

Agricultural insurances

Vulnerability assess.

4 institutional Projects

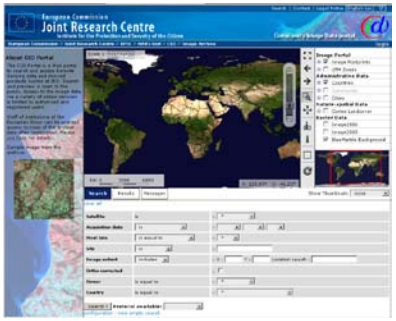
GEOCAP – Geo-Information Management and Control Methods

Support and addresses new information and controls needs for European Policies related to Common Agriculture, such as Cross Compliance, Farm Advisory System, traceability…

CID – Community Image Data Portal

Satellite (and aerial) remote sensing data management for DG AGRI and within the JRC.

30 TB on-line archive of HR+VHR imagery



AGRI4CAST - Crop/Production Forecasts/Estimates and Climate Change Impact on Agriculture

European activities & world wide activities related to Global trade in support to DG AGRI. Research & development related to crop insurance and climate change impact on Agriculture.

FOODSEC - Food Security Assessment

World wide activities related to Food Security, Focus on Sub Saharan Africa- in support to DG RELEX DEV, ECHO & direct links with UN FAO and WFP. Research & dev on Vulnerability assessment , post harvest losses, etc

The Common Agricultural Policy

- Direct Aids for farmers
- Total budget of 53 Bio Euros (41 % of 2008 EC budget)
- area based payments and since 2004, mainly decoupled
  - Single payment scheme
  - conditioned by Cross compliance (respects of EC Rules + maintenance in good conditions)
- Declarative system and integrated control system (IACS)
  - 100 % administrative checks / risk analysis
  - 5 % minimum On the Spot checks

- Statistics 2008
  - 8.3 Mio applications (27 Member-States)
  - 629,000 OTS checks (7.6%)
- 338,000 farms controlled with RS (55% of OTS)

CAPI = Computer assisted Photo interpretation

Farmers declaration data

Inputs of observation + anomaly codes

GIS navigation

1m OrthoImage to check area

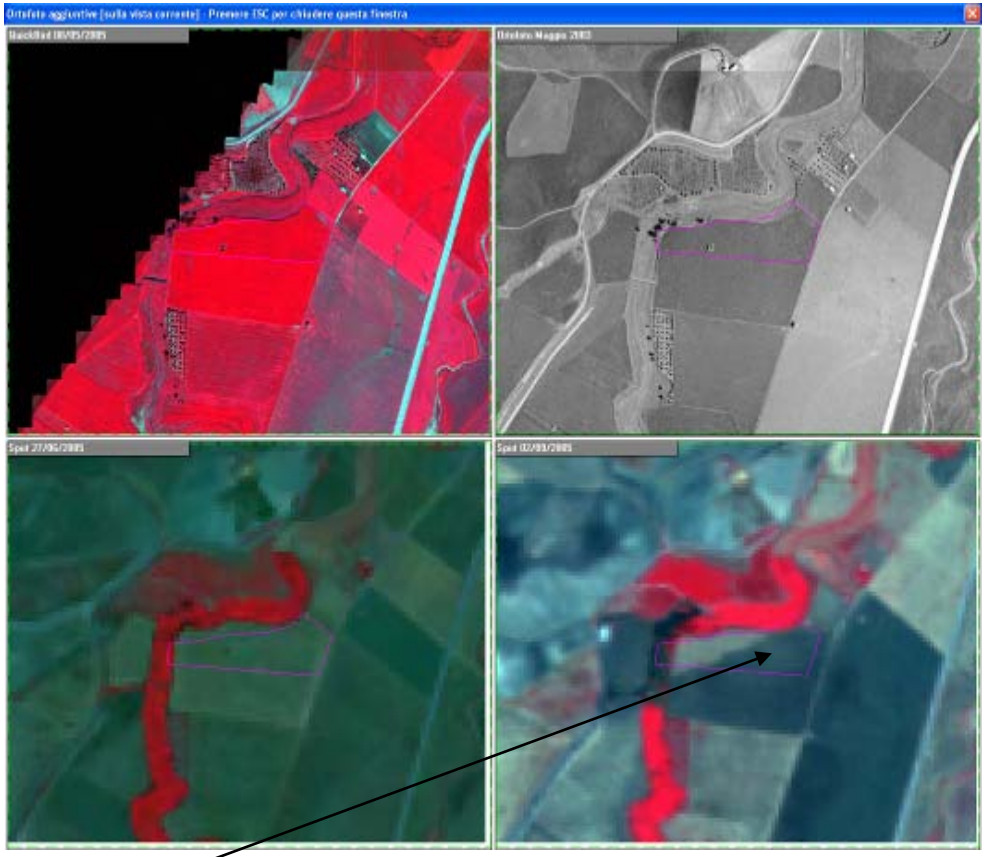
3 dates Multi spectral to check land use and eligibility Conditions

AUTO: Tech. tolerances, Cross checks, Quality Diagnostic / documentation of Control Report

GAECS: Good agricultural and environmental conditions

SPOT HR (Bulgaria)

July 2007



(Italy) SPOT HR

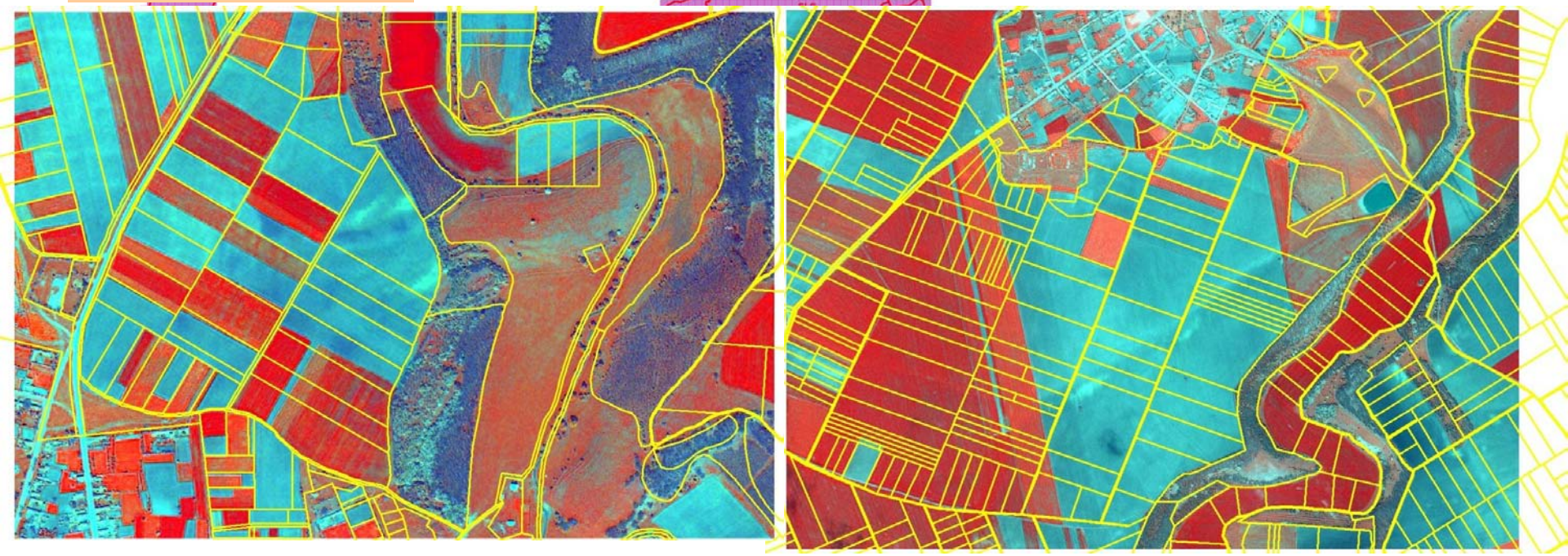
September 2005

Stubble burnt

Physical blocks and location of farmers as 27.11.2006 : 105 221 km² – 95%

Physical Block: 322 500 (without family gardens) -Mean area of the Physical Block : 15 ha

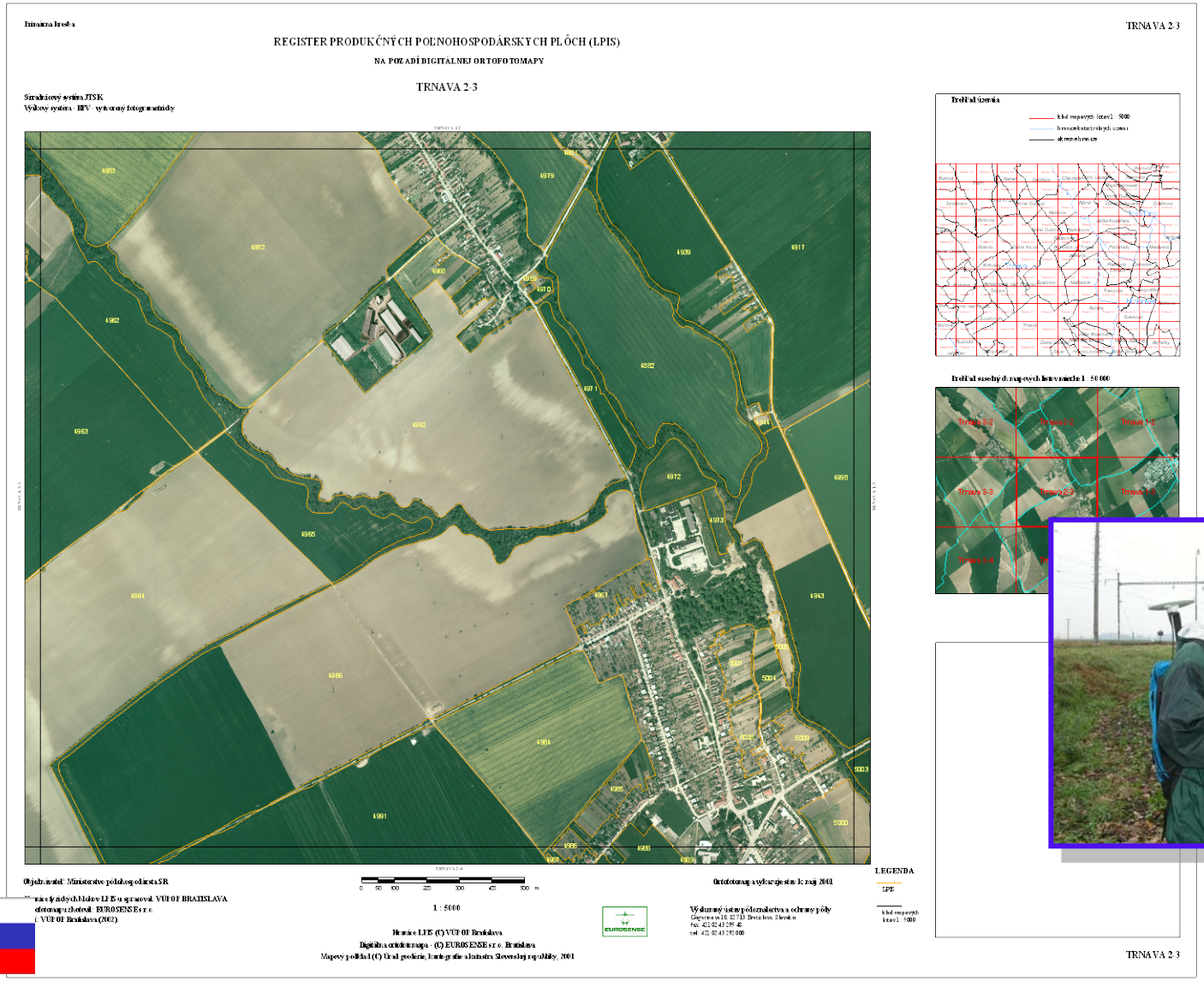
Exisitng Cadastre



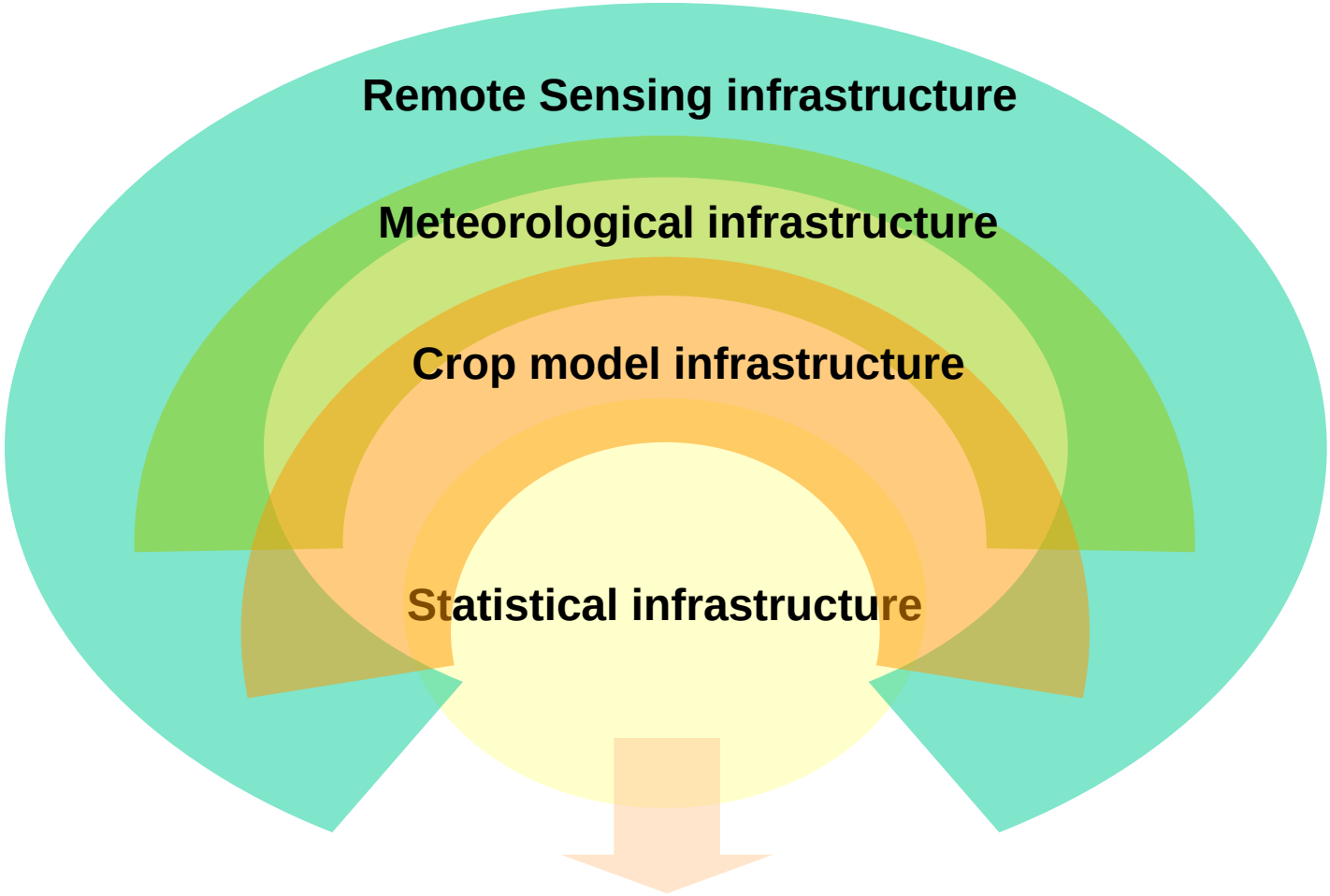
Recent archive Satellite 1m ortho were produced for 30% of the area
to allow block creation << 2007
Complete 50cm color orthophoto cover in 08

Courtesy of MAF- Bulgaria

EU Land parcel identification Systems

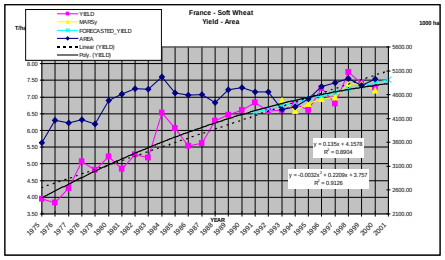


MARS general system design



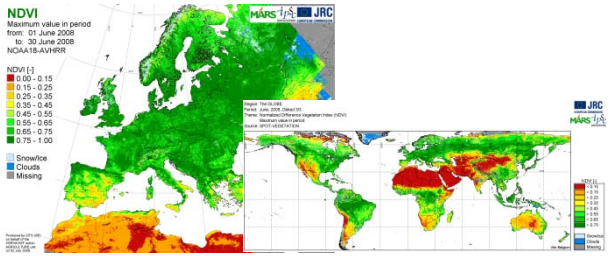
Crop yield forecasts and crop assessment

Statistical infrastructure



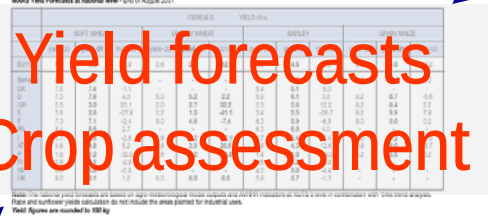
time series regression, similarity analyses

Remote Sensing infrastructure

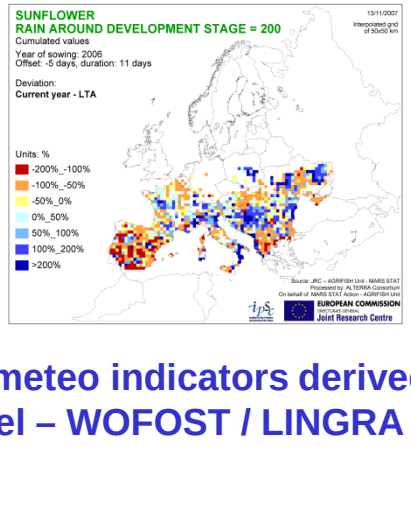


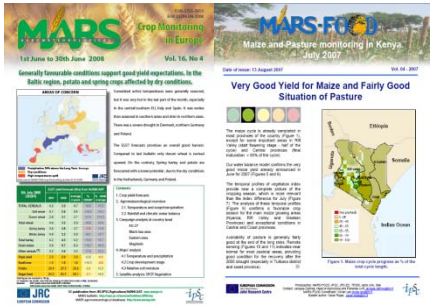
Vegetation state & meteo indicators since 1981 Europe, 1998 worldwide

Yield forecasts Crop assessment



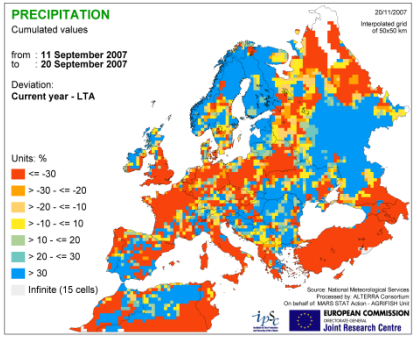
Crop Model infrastructure

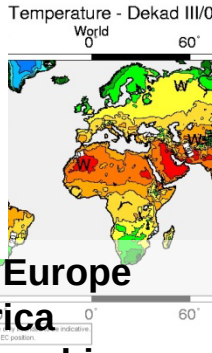




Agrometeo indicators derived from crop growth model – WOFOST / LINGRA / WARM and GWSI

Meteorological infrastructure

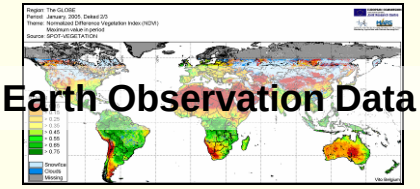




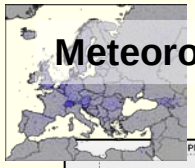
observed data since 1975 Europe under construction for Africa worldwide ECMWF data + archive

NRI, monthly / ad hoc monitoring

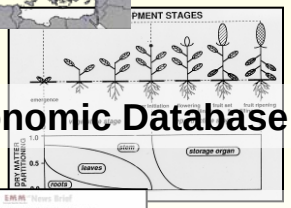
Data collection & retrieval



Earth Observation Data



Meteorological Data

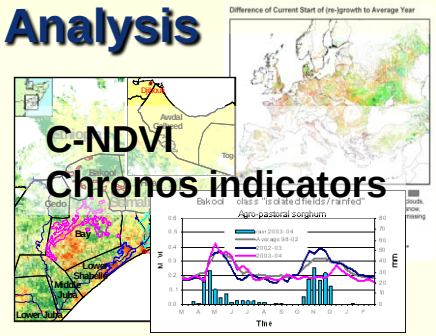


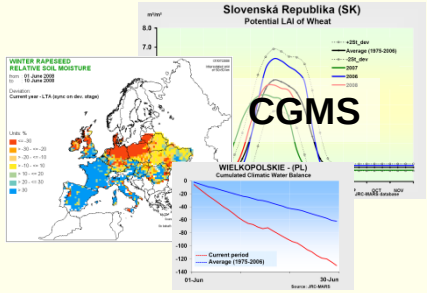
Agronomic Database

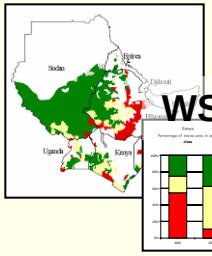
WEB Information
Media Monitor
Magazines

Agro-phenological network

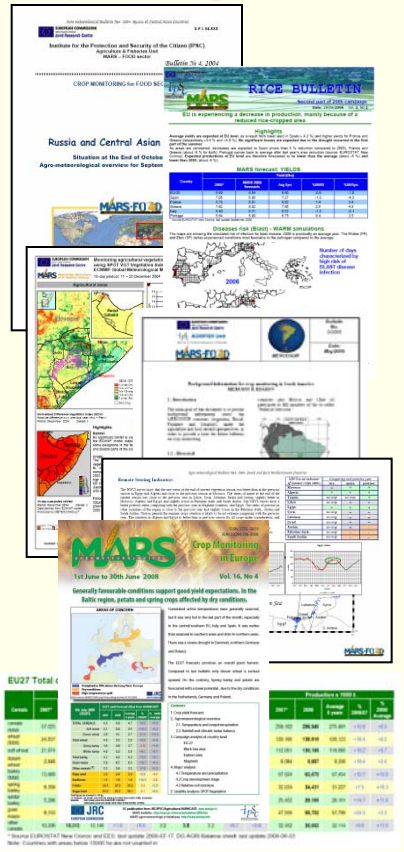
Processing & Analysis



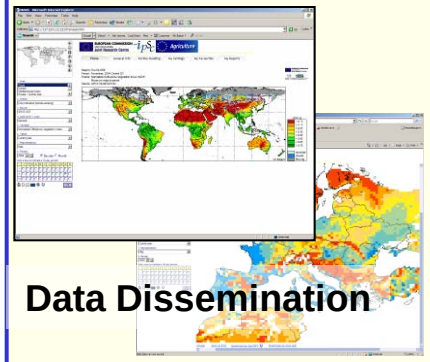


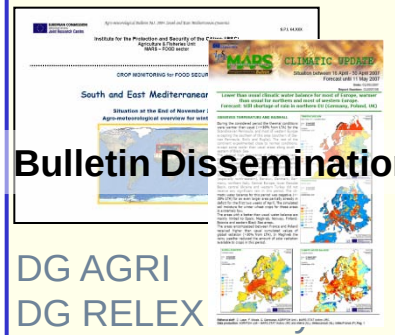


Reporting



Dissemination

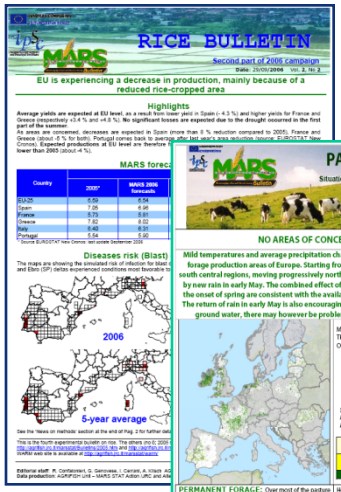


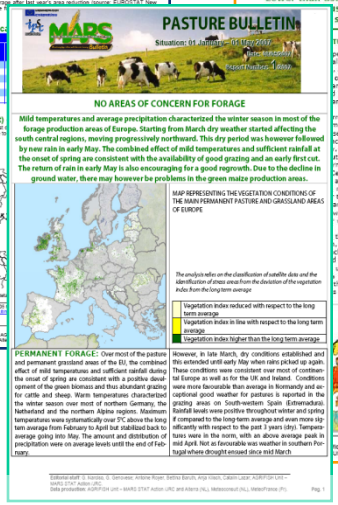


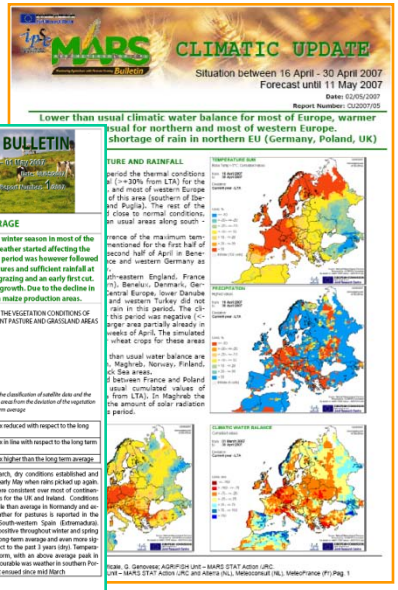
DG AGRI
DG RELEX
DG EUROSTAT
EU Delegations
Member States
National Agencies
Int. Institutions (FAO, …)

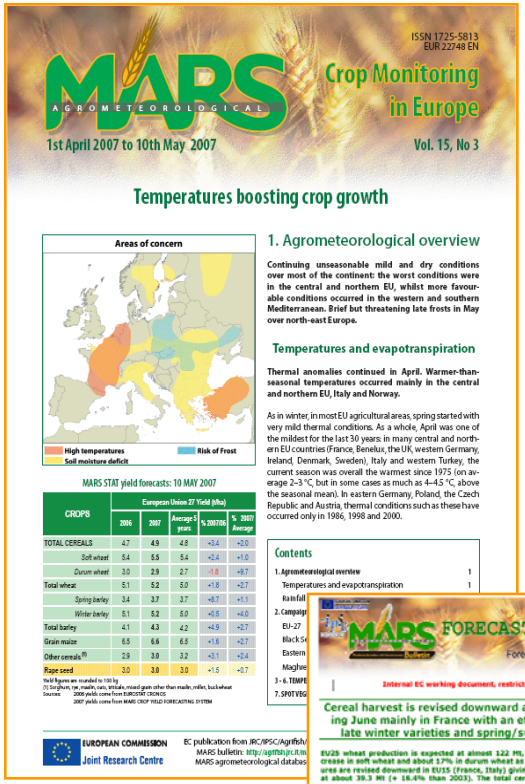
End of campaign evaluation & feed backs

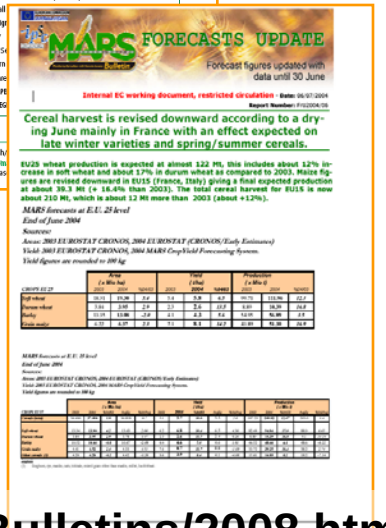
- **European Window**
- **35 countries covered**
- **11 crops of interest**
- **30 years of meteo and agrometeo data**
- **21 years of low resolution satellite information**
- **20 crop's indicators are daily simulated**





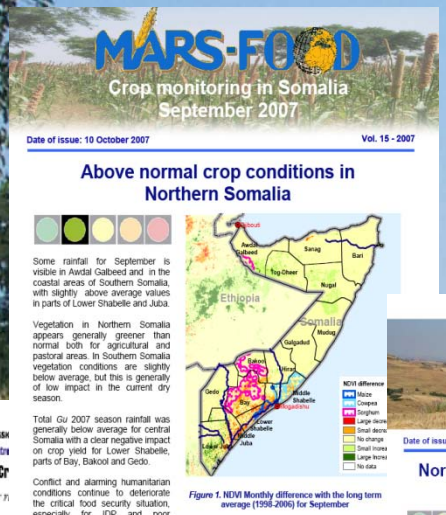


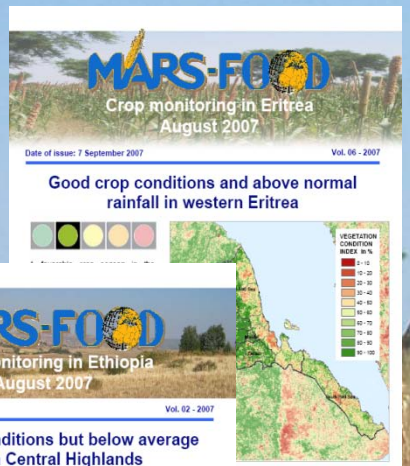


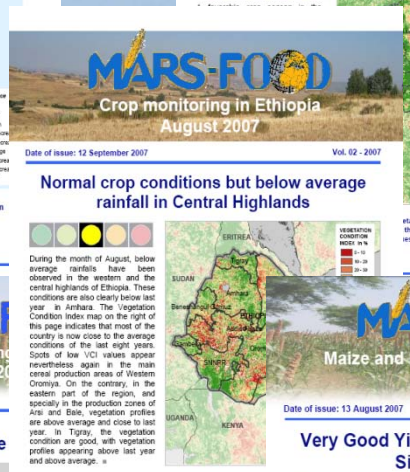


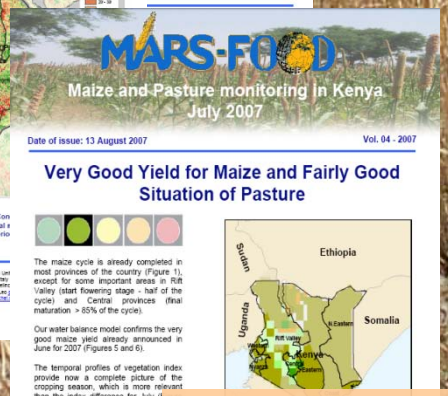
All MARS bulletins can be download from http://mars.jrc.it/marsstat/Bulletins/2008.htm

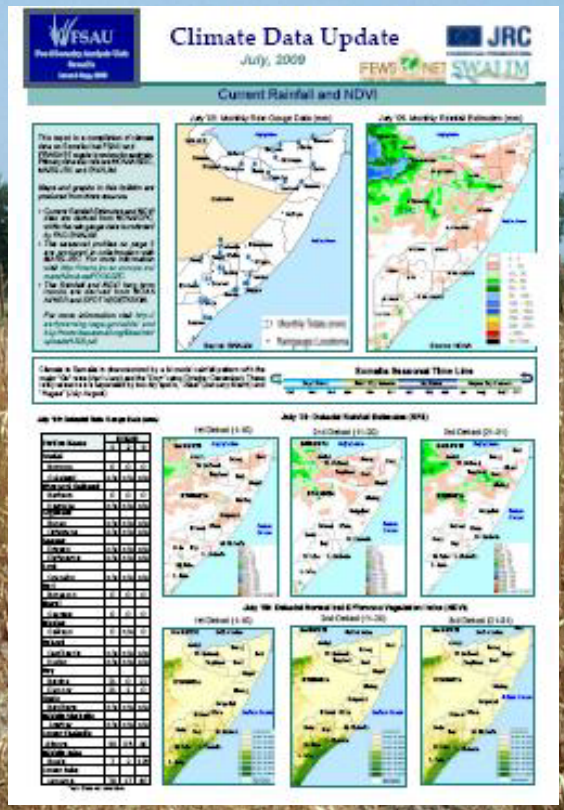
2003 – 2009 Focus on the Horn of AFRICA

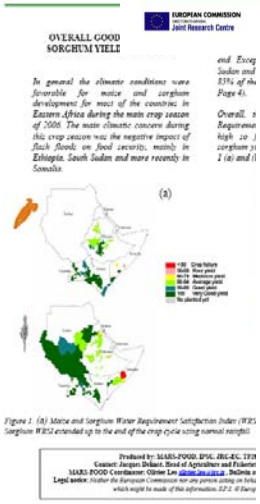


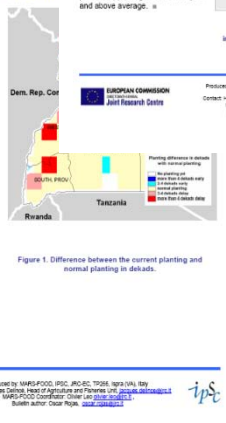




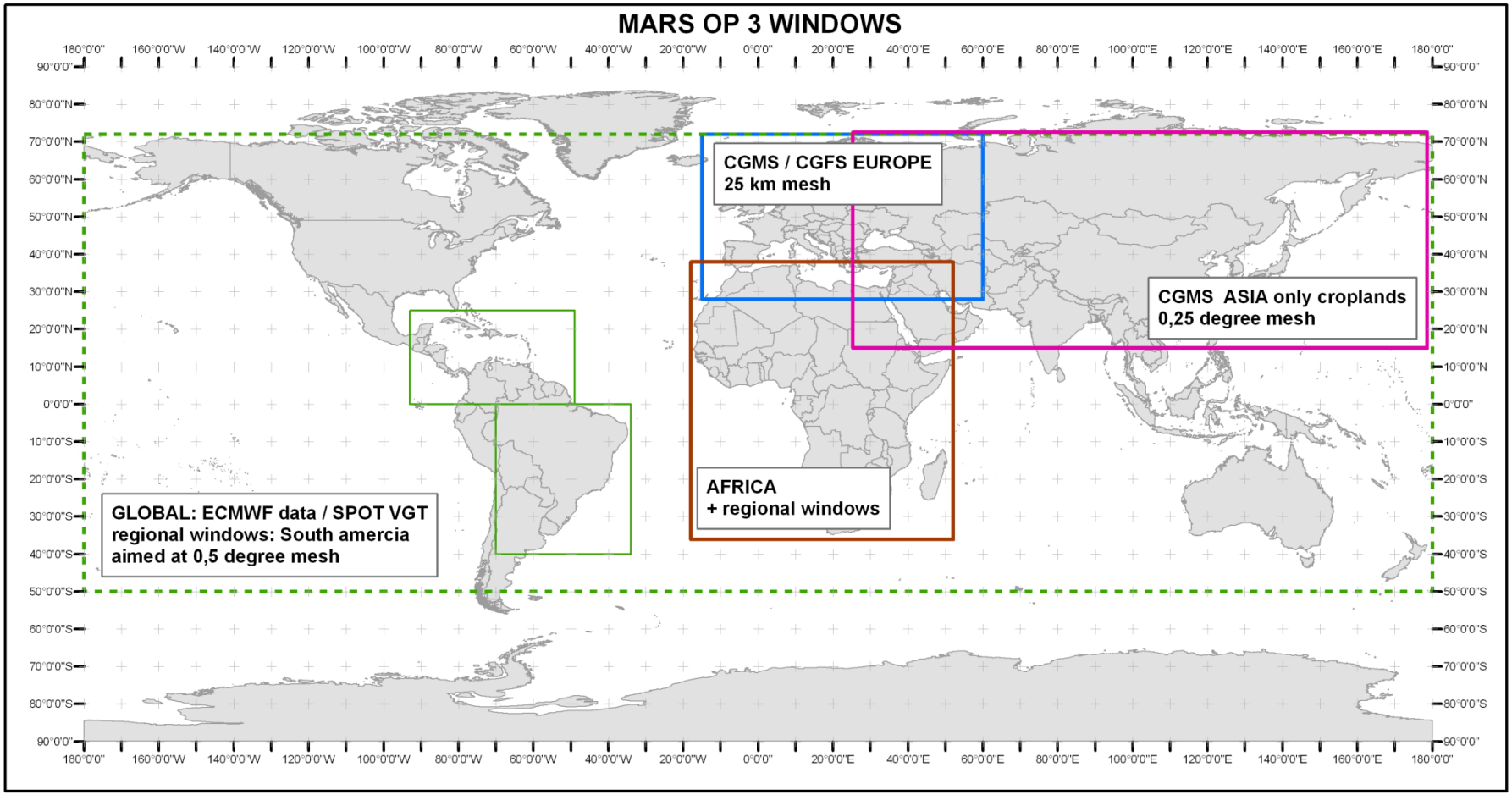








Capacity Building and transfer to National FS Teams

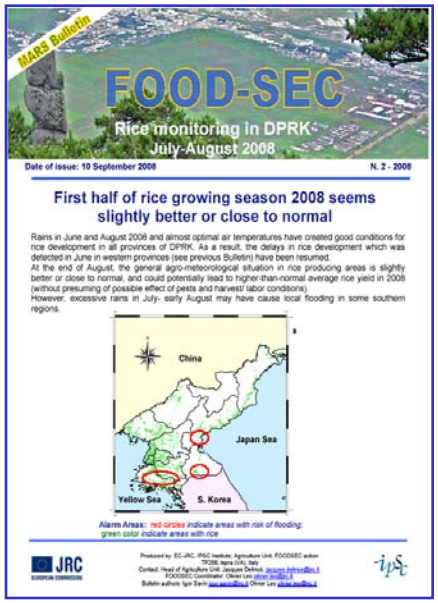


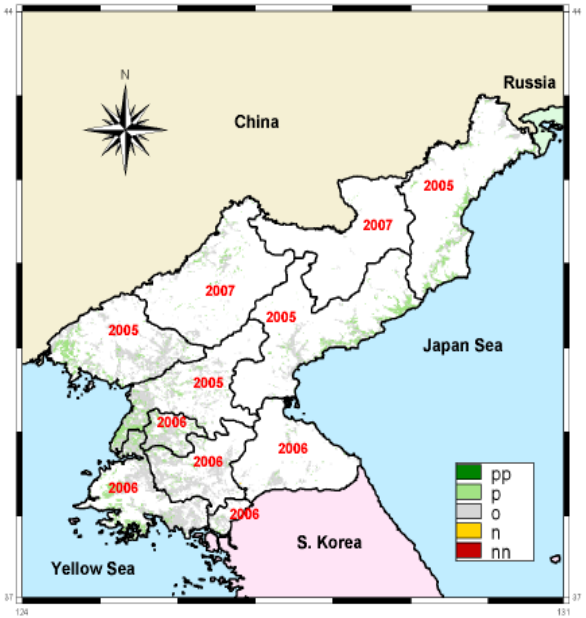
GLOBAL window
+ regional RS windows
data: ECMWF
SPOT VGT
model: GWSI,
CGMS level 1

EUROPEAN window
data: meteo station data
ECMWF
NOAA - AVHRR,
MODIS, MSG, SPOT VGT
model: CGMS
CGFS

ASIAN window
+ regional RS window
data: ECMWF
SPOT-VGT
model: CGMS

AFRICAN window
+ regional windows
data: meteo station
ECMWF
MODIS, MSG
SPOT VGT





Deviation of NDVI of 2nd dekad of August 2008 from long-term average (SPOT-VGT)
pp – *higher than average*, **p** – slightly higher than average, **o** – *close to average*, **n** – *slightly lower than average*, **nn** – *lower than average*; Red figures indicate for each province, the most similar past year in term of NDVI time profile

DPRK Close to average Rice crop performanc(2nd dekad August 2008 in nearly all rice zones

MOLDOVA:

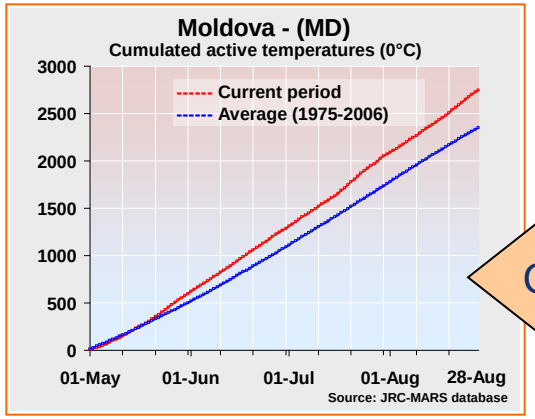
- 2007 Specific report / assessment Drought and Heat stress
- 2009 Drought _ Repport and yield forecast provided to FAO GIEWS

2007 drought & heat-stress in Moldova

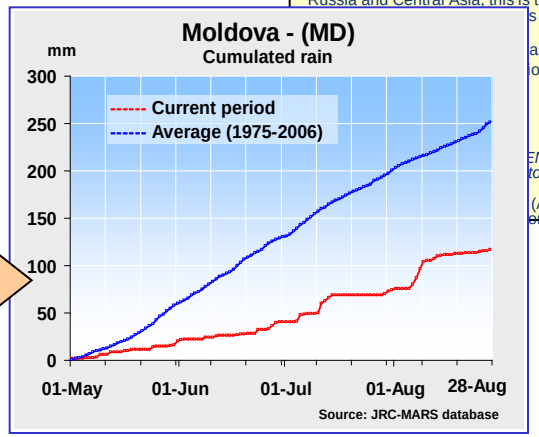
A request from AIDCO –A (6/08/07)

From: GIORGI Sergio (AIDCO) [mailto:Sergio.GIORGI@ec.europa.eu]
Sent: 06 August 2007 16:52
To: GENOVESE Giampiero (JRC)
Subject: FW: Agro-meteorological Bulletin for Russia and Central Asian Countries (2007-3)

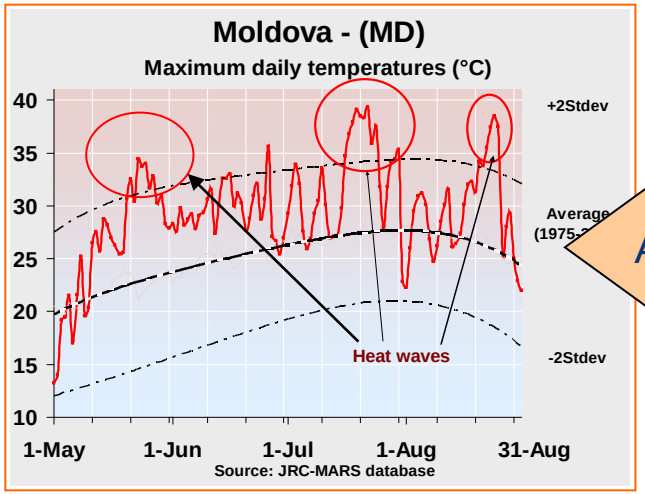
Dear Mr Genovese,
being somewhat familiar with the JRC bulletins produced for Russia and Central Asia, this is to kindly request your
s of information concerning
ast
ons (such as this year's
ENP countries and Yemen
tor
(AIDCO)
ordination & supervision for



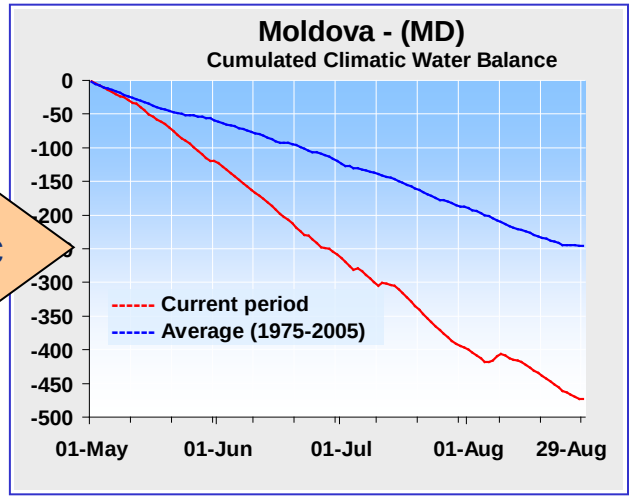
Quick analysis



A rapid analysis of the meteo data confirms the gravity of situation

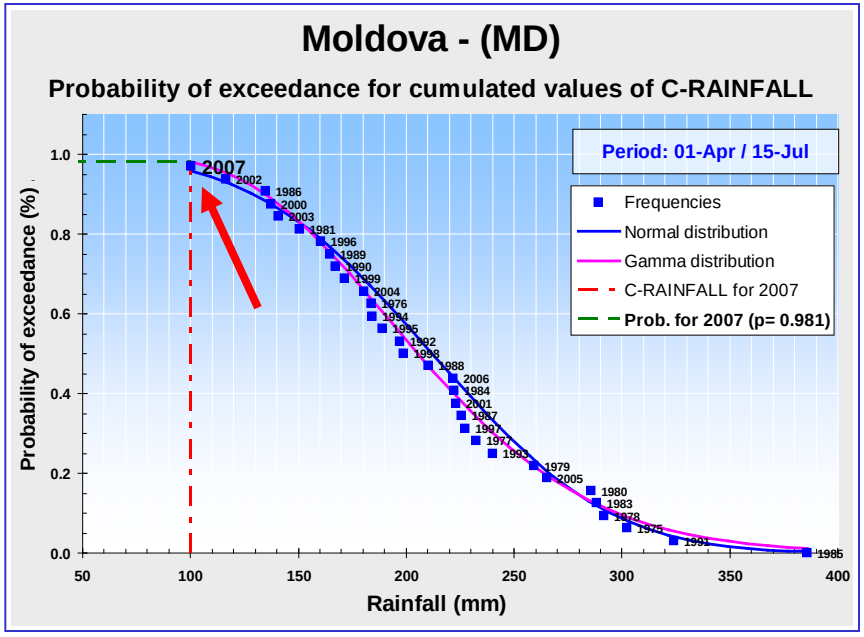


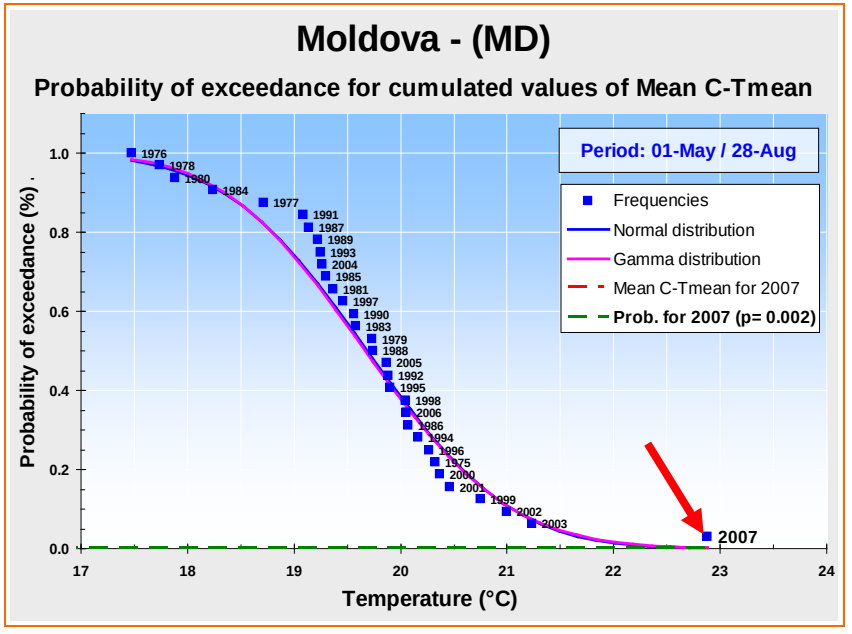
Agro climatic



2007 Drought and heat-stress in Moldova

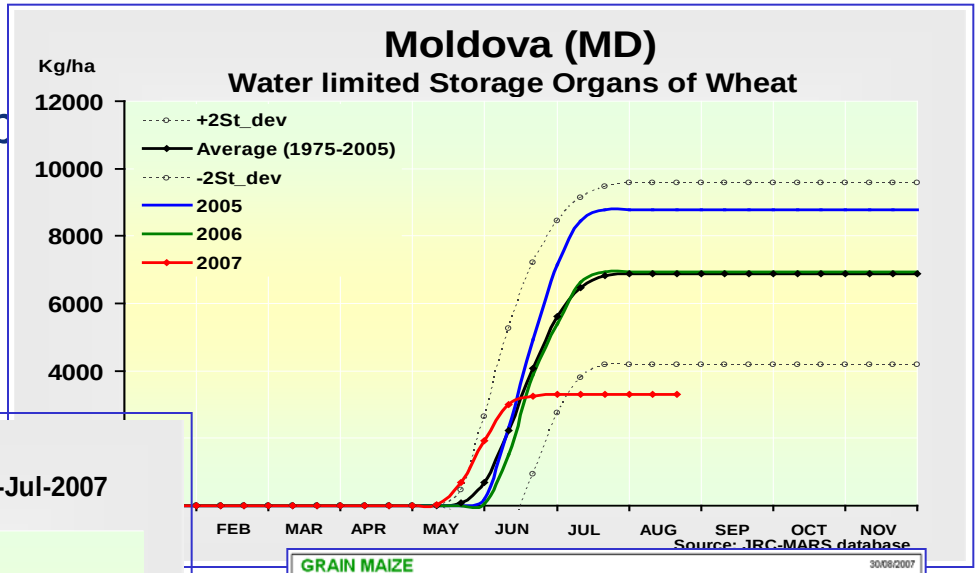
Frequency analysis on 32 years confirms a series of **extreme events** of Drought and Heat wave occurring at **key development stages for both winter and summer crops**

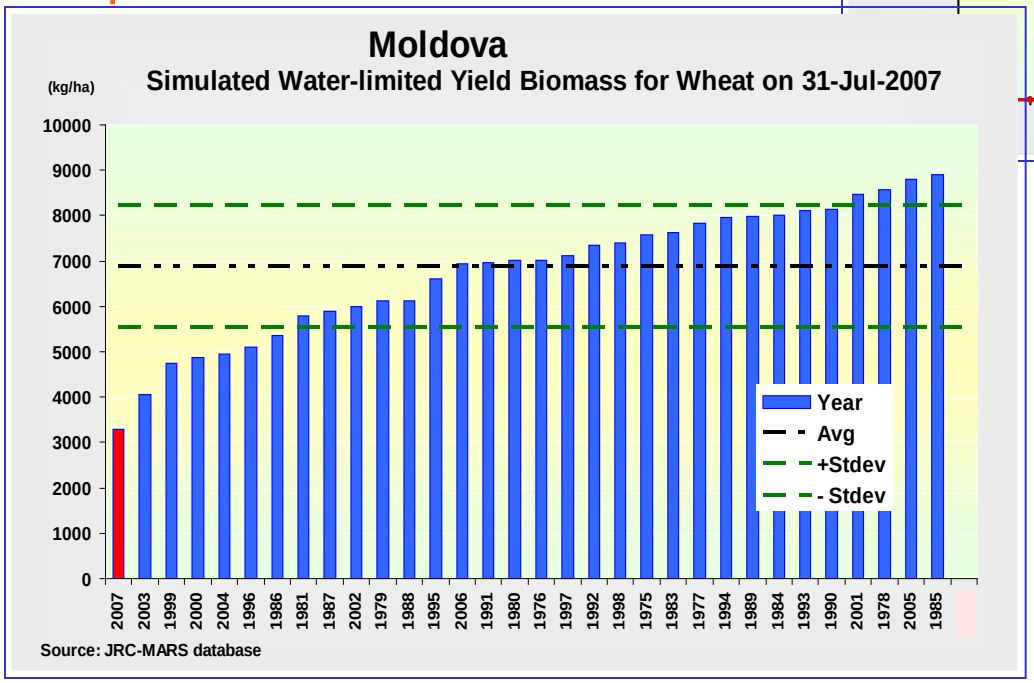


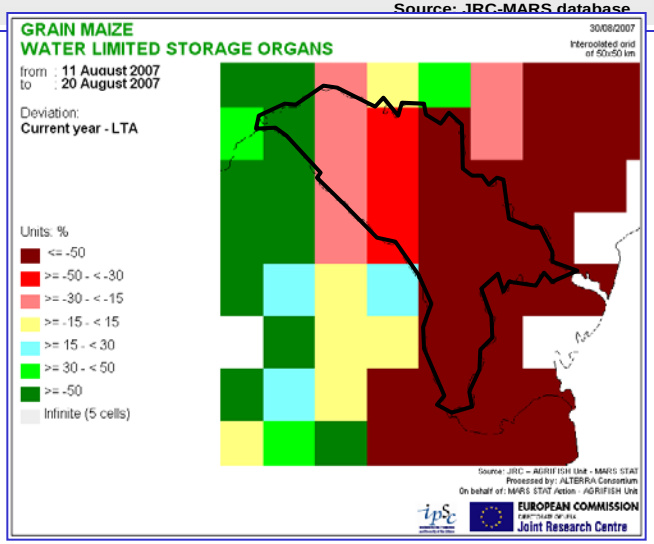


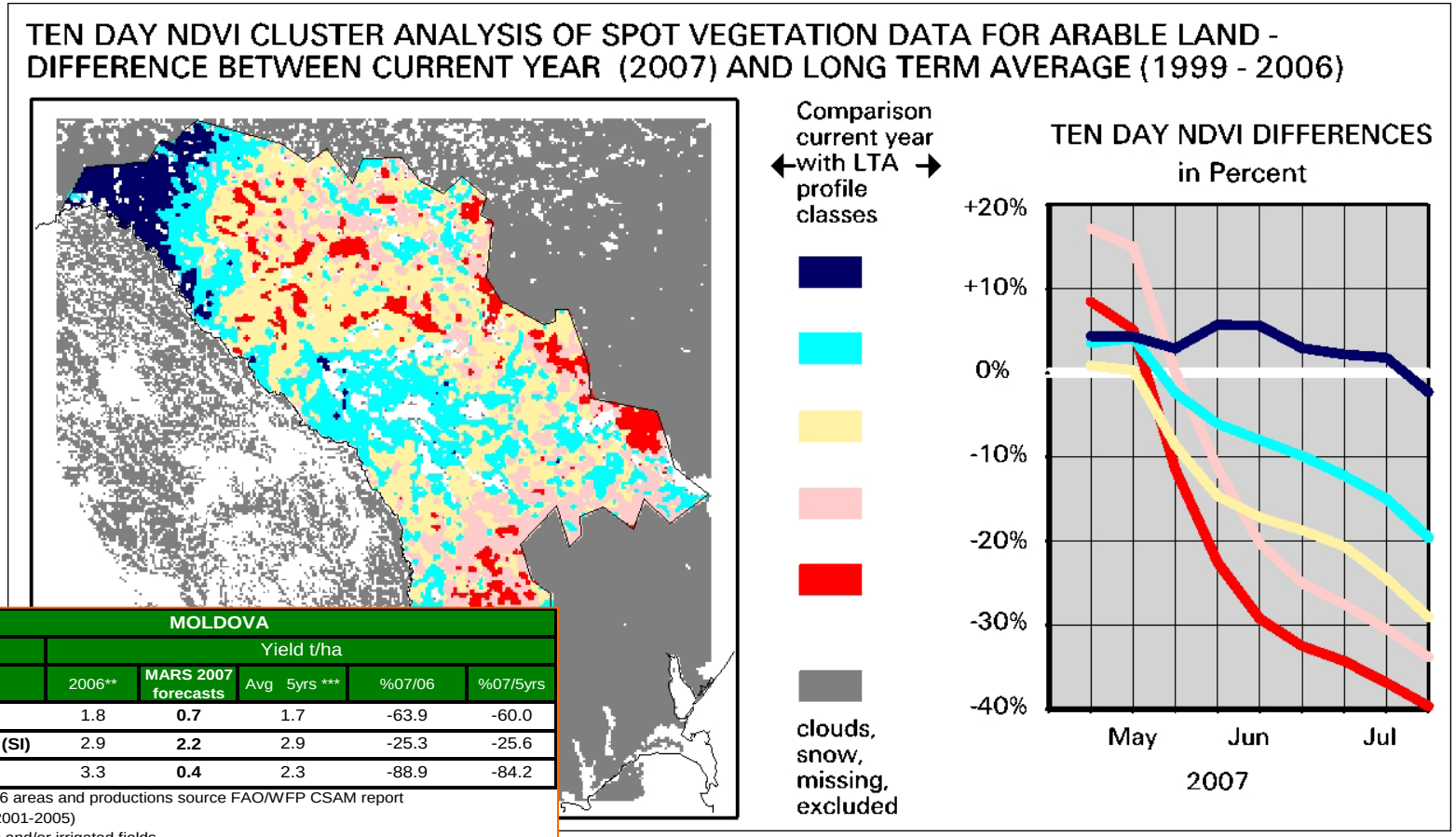
2007 Drought and heat-stress in Moldova

Crop Simulations (Wheat, rapeseed, sp
Barley, Sunflower) by WOFOST model (CGMS) indicated an exceptional damage to both winter and summer crops.







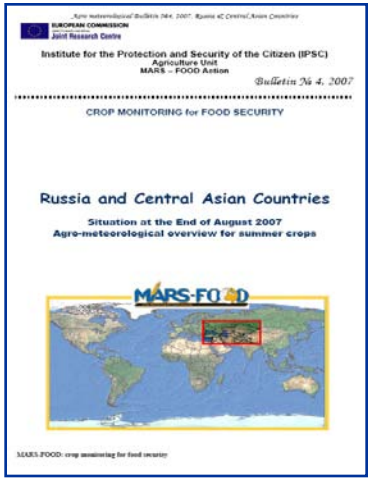


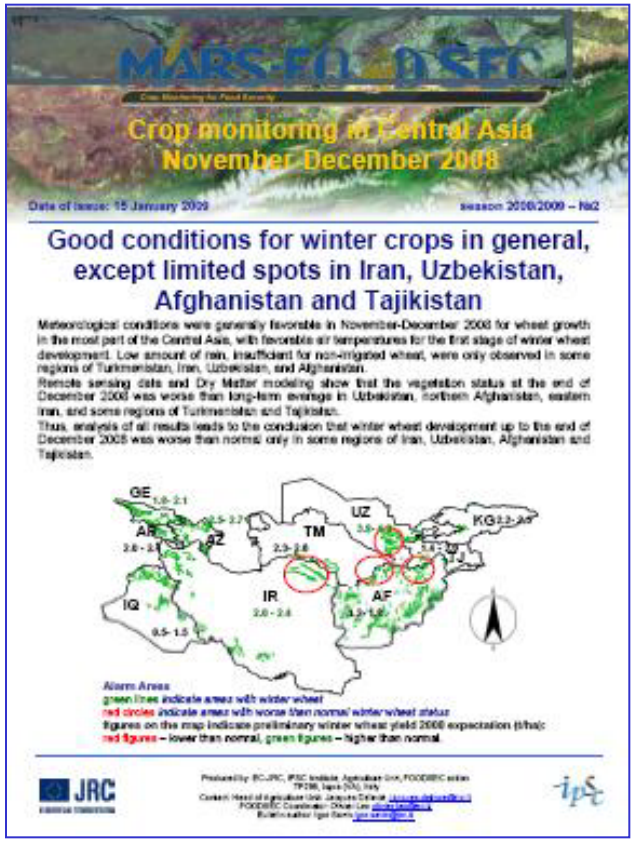
MOLDOVA					
	Yield t/ha				
	2006**	MARS 2007 forecasts	Avg 5yrs ***	%07/06	%07/5yrs
barley	1.8	**0.7**	1.7	-63.9	-60.0
grain maize (SI)	2.9	**2.2**	2.9	-25.3	-25.6
wheat	3.3	**0.4**	2.3	-88.9	-84.2

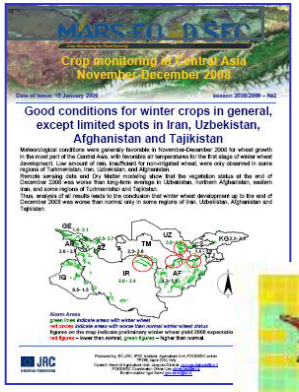
** based on 2006 areas and productions source FAO/WFP CSAM report
*** FAOSTAT (2001-2005)
(SI) only surving and/or irrigated fields

At least a quarter of the total crop areas are seriously affected (crop failure)

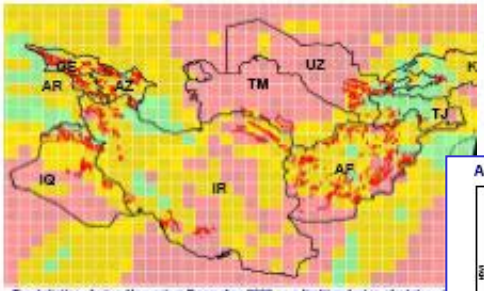
- **Transition period between redefinition of windows // Bulletins**
  - 2007 Russia and Central Asia
  - 2008 Russia and Ukraine covered in “European Window” + Specific Central Asia Bulletin , Disrupted early 2009
  - in 2010 Kazakhstan and Central Asia. in a large CGMS ASIA Window (incl. India, China)

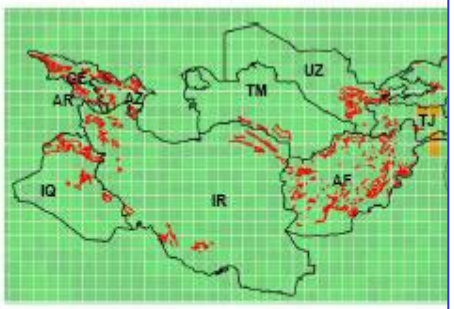




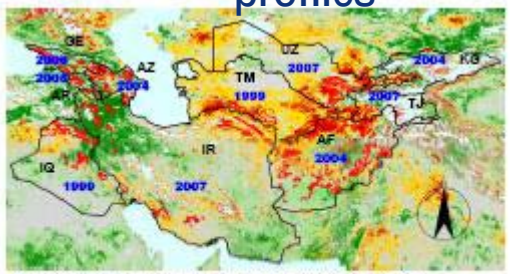


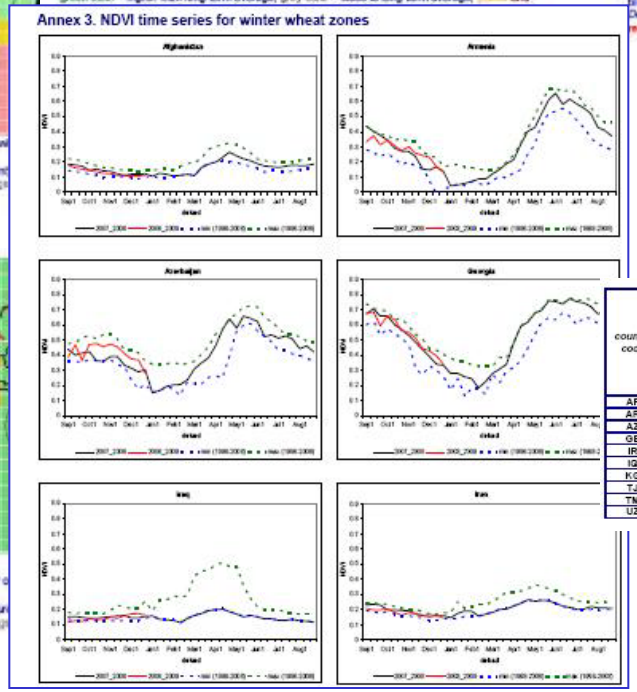
Meteo conditions



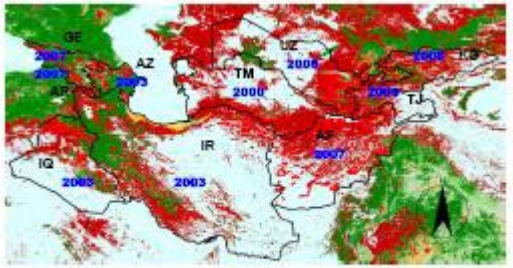


NDVI conditions & profiles





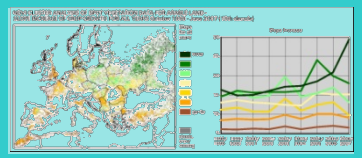
DMP



country code	crop growth indicator & winter wheat yield expectation (t/ha)									Winter wheat yield expectation for 2009 (t/ha)
	precipitation sum for the period from October to June (based on regression analysis, and year-analogue definition)			NDVI curve (based on regression analysis, and year-analogue definition)			DMP curve (based on regression analysis, and year-analogue definition)			
	yield	R^2	yield for year-analogue	yield	R^2	yield for year-analogue	yield	R^2	yield for year-analogue	
AF	-	-	1.5	-	-	1.3	-	-	1.7	1.2-1.8
AR	-	-	2.3	-	-	2.1	-	-	1.3	2.0-2.4
AZ	-	-	2.6	-	-	2.6	-	-	2.6	2.6-2.7
GE	-	-	1.9	-	-	2.0	-	-	1.5	1.8-2.1
IR	-	-	2.1	-	-	2.3	-	-	2.1	2.0-2.4
IQ	-	-	-	-	-	0.6	-	-	1.4	0.6-1.6
KG	-	-	2.3	-	-	2.4	-	-	-	2.2-2.5
TJ	-	-	1.5	-	-	1.9	-	-	-	1.4-2.0
TM	-	-	-	-	-	2.5	-	-	2.4	2.3-2.8
UZ	-	-	3.9	-	-	4.2	-	-	-	3.8-4.3

Preliminary Forecasts

Remote sensing infrastructure

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

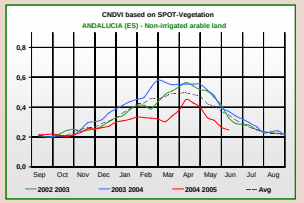
Asian Window defined

with same characteristic

C- indicator

Weighted mean according to land use within the unit of interest

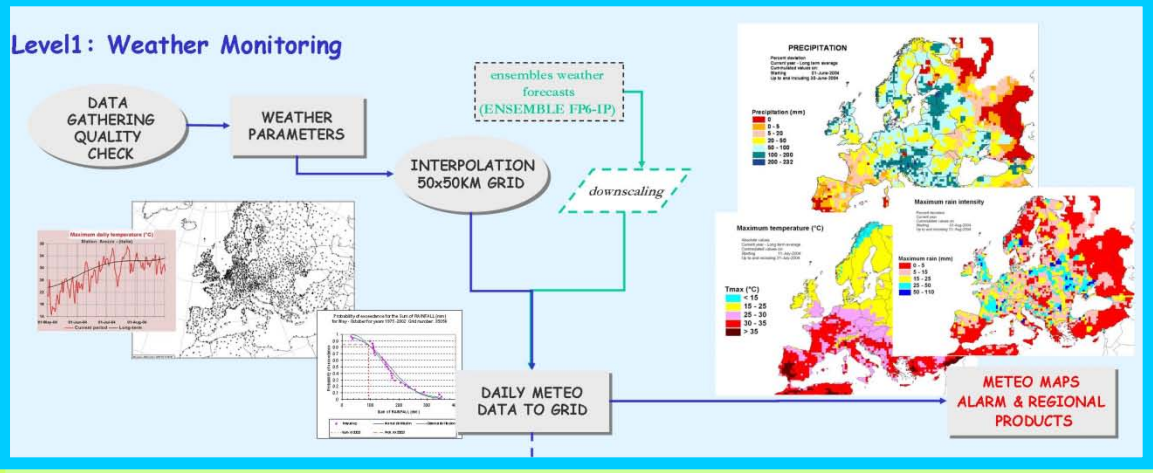
Administrative unit
Agri-ecological zonation
Grid (25 km * 25 km)



Remote Sensing integration

Complement station network
Enhance, fill gaps, increased density, cross-checking

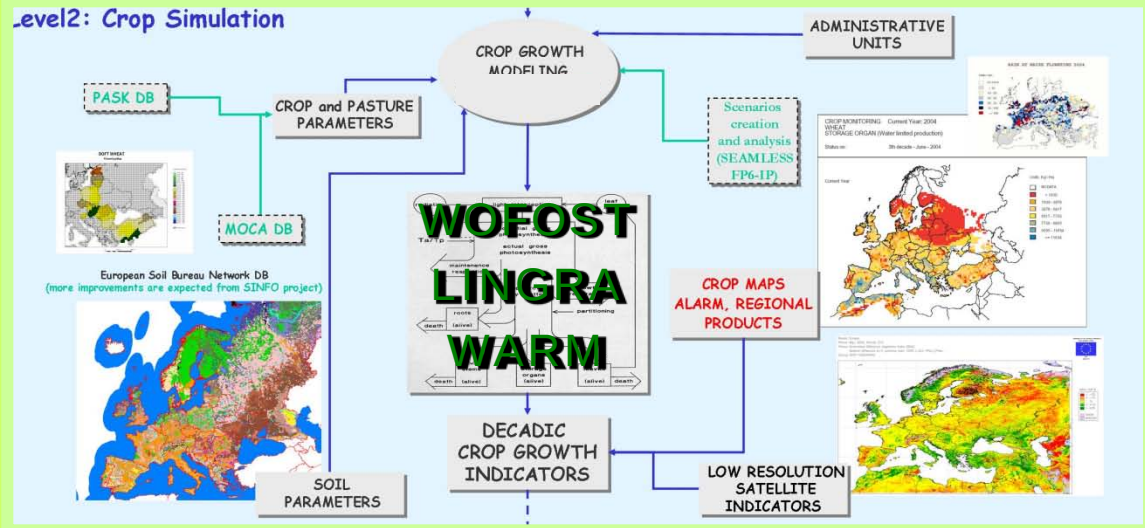
Parameter: LST, radiation, snow cover



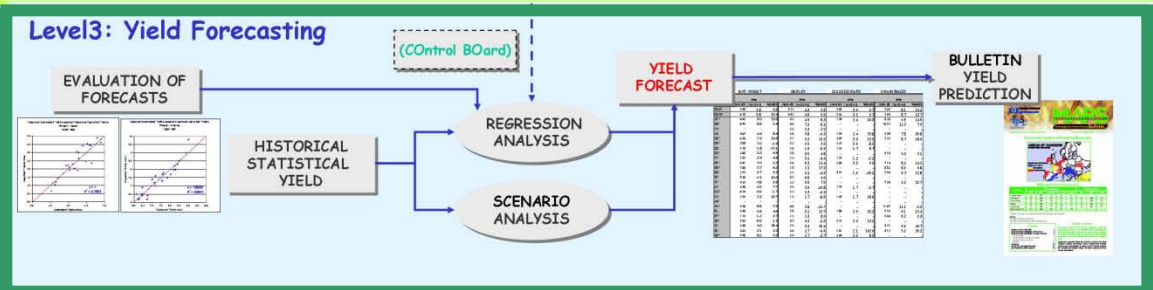
Alternative source for CGMS
data as direct input for crop models

Meteo: radiation, sunshine duration, snow cover
Vegetation state: NDVI, fAPAR, DMP to derive phenology or biomass

Input/calibration/update of CGMS



Regression indicator & scenario
Chronos indicators derived from NDVI, fAPAR
Similarity analysis



RS on going & future developments

-Radiation most promising parameter for direct ingestion by crop development modelevel I

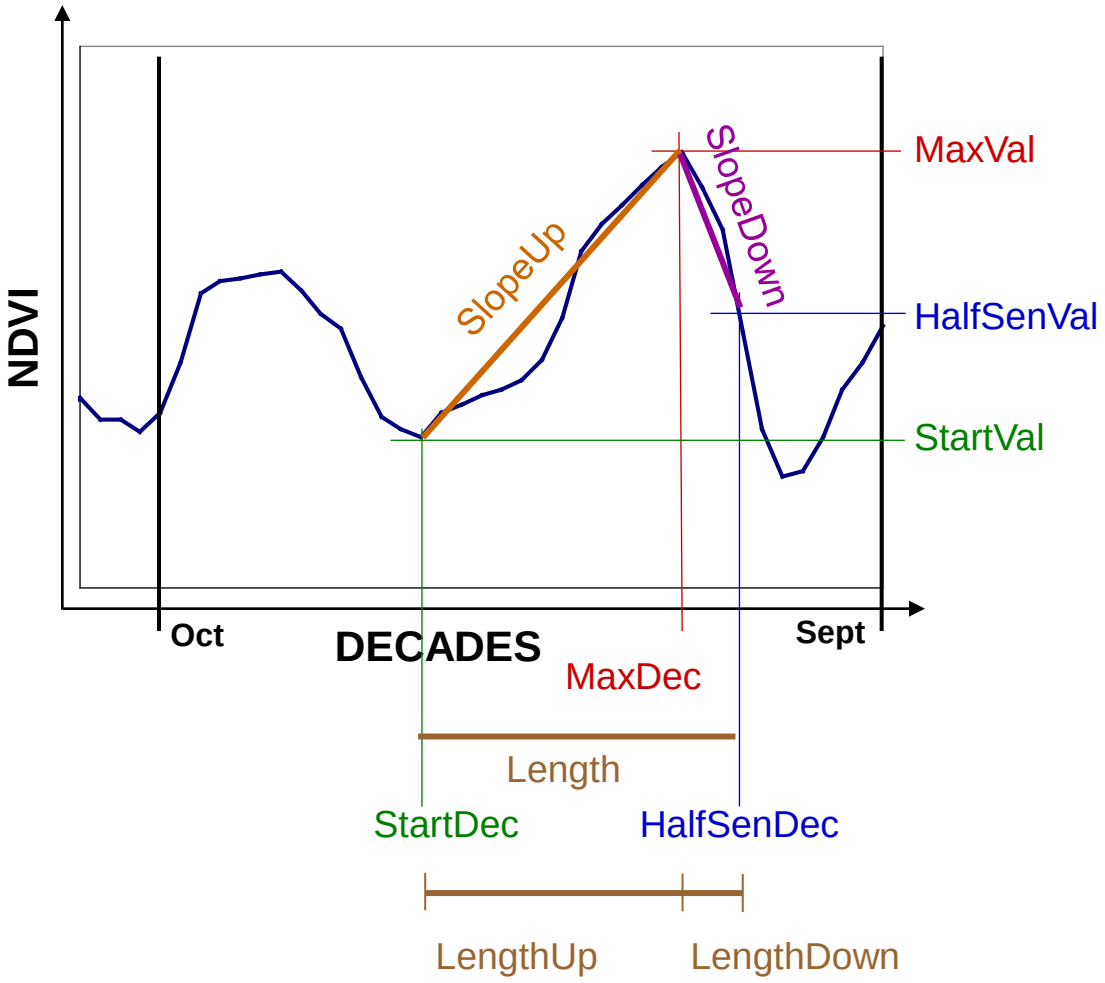
- RS vegetation state parameters very efficient in semi arid but CGMS 10 daily crop growth parameters are better predictors in non water limited situations

-**Vegetation state parameters – link between Chronos** indicators and crop phenology further to be established

- Collection of observed phenol data is crucial (agro-phenological network)

- Good crop masks for the extraction are needed, as regional / local statistics (weighting)

Chronos Key Indicators I



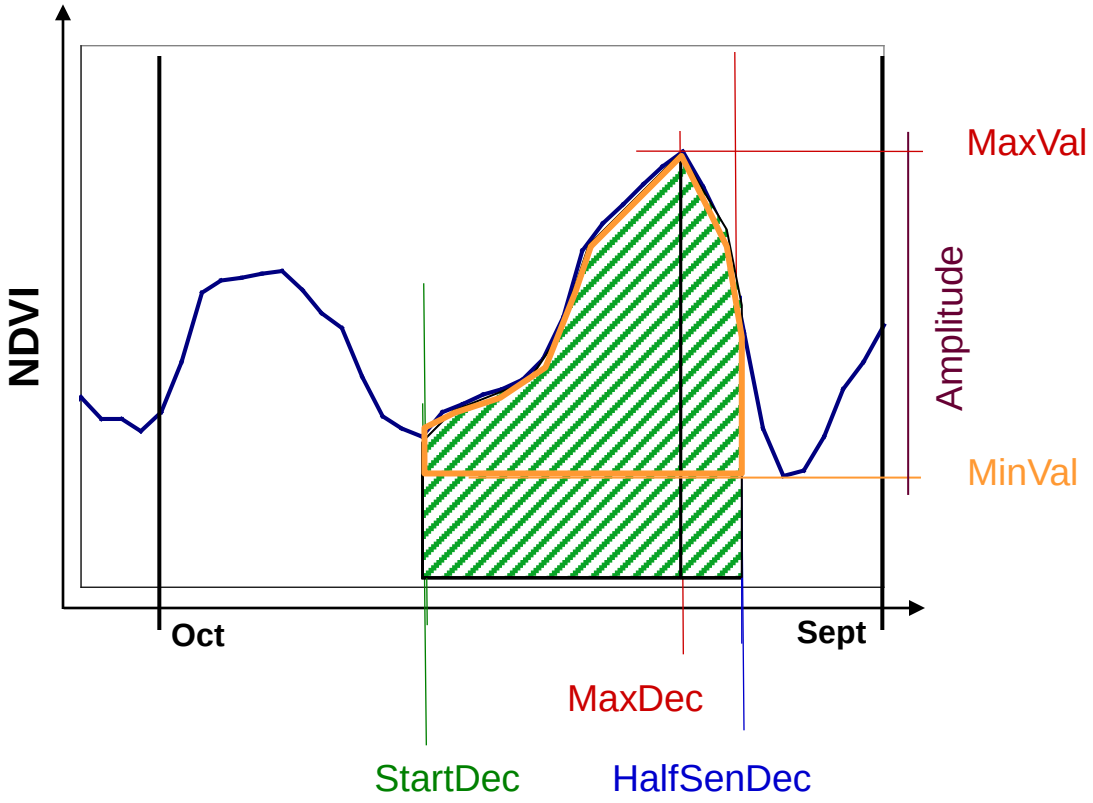
Chronos phasing indicators:
StartDec
MaxDec
HalfSenDec

Chronos intensity indicators:
StartVal
MaxVal
HalfSenVal

Chronos duration indicators:
Length
LengthUp
LengthDown

Chronos cumulative indicators I:
SlopeUp
SlopeDown

Chronos Key Indicators II



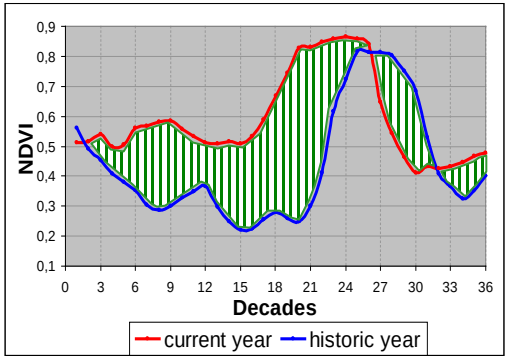
Chronos cumulative indicators II:

- Cum_StartMax
- Cum_MaxHalf
- Cum_StartHalf
- Cum_StartHalf_min
- Amplitude

Potential Use of Most Similar Year of the Time Series to Current Year

DISTANCE

Overall similarity dependent from phase and intensity



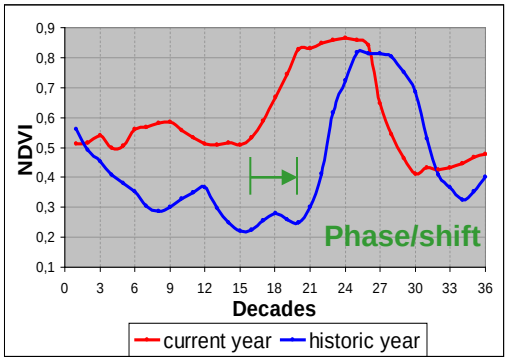
$$ABSdiff_k = \sum_{i=1}^{n} ABS\left(NDVI_{current,i} - NDVI_{k,i}\right)$$

$$simyear = MIN\left(ABSdiff_k\right)$$

k = year, i = decades

CORRELATION

Shift in crop cycle independent from intensity

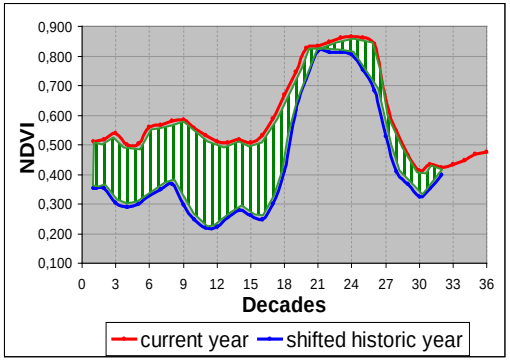


$$corr\_coeff1_k = \frac{\sum_{i=1}^{n}\left(NDVI_{current,i} - \overline{NDVI}_{current}\right)\cdot\left(NDVI_{k,i} - \overline{NDVI}_{k}\right)}{\sqrt{\sum_{i=1}^{n}\left(NDVI_{current,i} - \overline{NDVI}_{current}\right)^2 \cdot \sum_{i=1}^{n}\left(NDVI_{k,i} - \overline{NDVI}_{k}\right)^2}}$$

$$simyear = MAX\left(corr\_coeff1_k\right)$$

CORRELATION + DISTANCE

Cycle similarity independent from the date



$$ABSdiff_k = \sum_{i=1}^{n} ABS\left(NDVI_{current,i} - NDVI_{k,i}\right)$$

$$simyear = MIN\left(ABSdiff_k\right)$$

Crop Area estimates with R.S

Crop monitoring focusing on Yield

- Areas estimates provided by survey or trend analysis

Mapping information crucial for crop masks

- Extraction of cleaner low resolution indicators (agric / crop specific)
- In Europe use of Corine Land cover (1:200 000, 5 years Updating)
- Low - medium resolution classification 1-5 years updating.

Area Estimates with Remote sensing ?

Area Estimates ?

MARS Regional Inventories in EU 1988- 1995

- AFS Field Surveys (Regular grid, square segments - 500 m 1km)
- Regression estimates with 1 date (wall to wall) High Resolution images
  - –Small or very small parcel in most of old Europe
  - – poor cost-efficiency

New contexts and drivers:

- Decoupled policies, Development of biofuels
- Low cost wide Swatch Satellites with high or Medium resolution
- Important to test new approaches in Europe and “emerging” countries

But

- Target accuracy very high: << expected inter-annual variation Pixel counting doesn’t provide an unbiased statistical estimates

➢ *necessity of robust validation protocols*

Pilot activities foreseen in Central Asia

Ukraine:

AREA ESTIMATES

Region: 1- 2 oblasts 40 ~ 60,000 km2 + 1Mio ha of cereals (Wheat)

Images: 2 types of tests: Multi-date classification using AWIFS and MODIS

Ground data: >1000 points by AFS or randomly collected “along the road”

Special attention to the validation protocols

On going call for proposal → Campaign 2010

YIELD FORECASTING: Collaboration agreement with the “Leonid Pogorilyy Ukrainian Scientific Research Institute”

Kazakhstan:

Collaboration Agreement being signed with NCRST

- Crop Monitoring and Yield forecast systems
- Similar pilots on Area Estimates to be defined and carried out in 2010 - 2011 (GEOLAND2 Project)

Conclusions

MARS data infrastructures, Statistical tools + crop development models are open and ready to share with nat. or reg. organizations

- Implement operational monitoring system
- Carry out specific development or research in similar fields (ex desertification, drought…)
- Simulate Climate change impact and adaptation strategies…

We are interested in integrating user's feed backs, calibration / validation… geo-localized ground data (phenology, yields, pests)

Contact us or participate to a CGMS workshop and training course (ISPRA 2010) !

Thanks for your attention !

Olivier Léo - Bettina Baruth