Climate change: implications on water cycle and its extremes

(drought, flooding, desertification)

Fabio Micale Ph.D.

Climate Risk Management Unit

www.jrc.ec.europa.eu

Joint Research Centre

The European Commission's Science Policy Support Organisation

Outline

JRC presentation

Evidences on occurring changes in climate

Climate change vs. plants: impacts and evidences

The Climate Risk Management Unit activities

European Commission

Court of Auditors

European Parliament

Council of Ministers

Committee of the Regions

Court of Justice

European Commission

Economic and Social Committee

Commissioner for Research

DG ENTR

DG ENV

DG INFSO

DG RTD

DG JRC

DG AGRI

EUROSTAT

DG DEVCO

DG RELEX

EI

IPSC

IRMM

IES

IHCP

ITU

IPTS

Climate Risk Management Unit

...since January 2012

Joint Research Centre

Robust science for policy making

European Commission

The Joint Research Centre's mission

As the Commission's in-house science service, the Joint Research Centre's mission is **to provide EU policies with independent, evidence-based scientific and technical support** throughout the whole policy cycle.

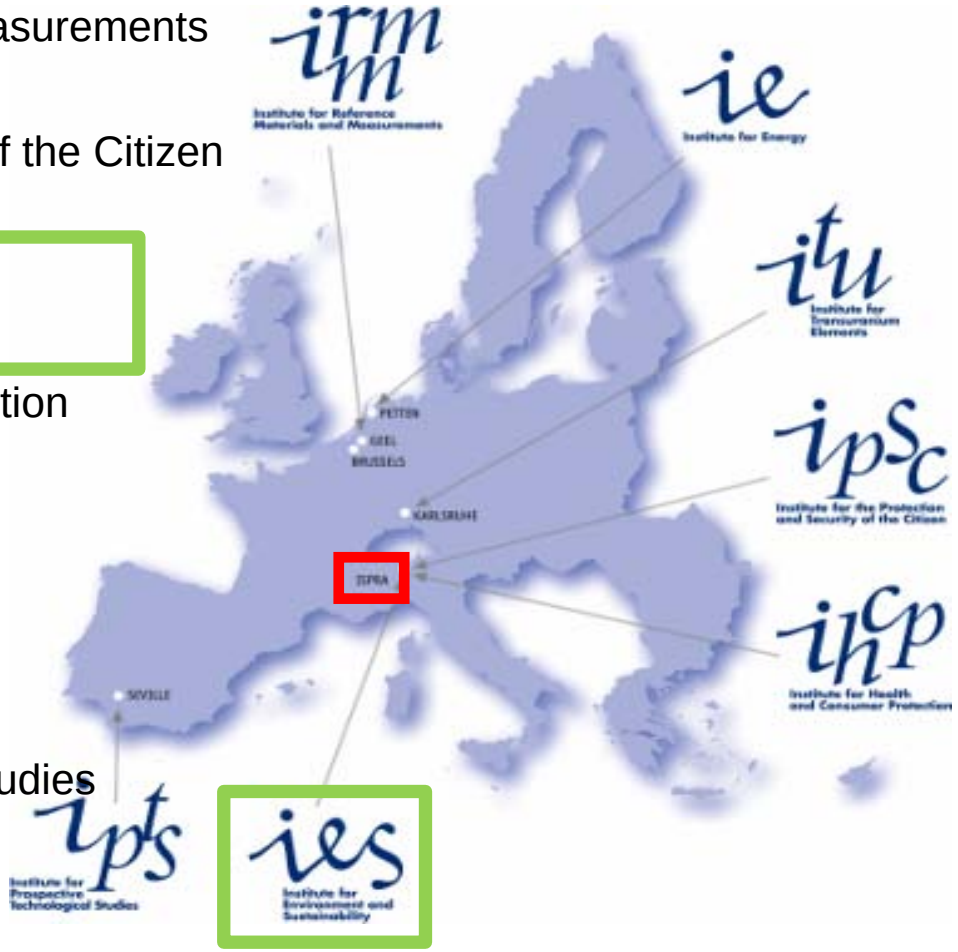
Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while **stimulating innovation** through developing new methods, tools and standards, and **sharing its know-how with the Member States, the scientific community** and international partners.

Key policy areas include: environment and **climate change**; energy and transport; **agriculture and food security**; health and consumer protection; information society and digital agenda; safety and security, including nuclear; all supported through a cross-cutting and multi-disciplinary approach.

Joint Research Centre

Our structures: 7 Institutes across 5 Member States

- Institute for Reference Materials and Measurements
  IRMM – Geel, Belgium
- Institute for the Protection and Security of the Citizen
  IPSC – Ispra, Italy
- Institute for Environment & Sustainability
  IES – Ispra, Italy
- Institute for Health and Consumer Protection
  IHCP – Ispra, Italy
- Institute for Transuranium Elements
  ITU – Karlsruhe, Germany
- Institute for Energy
  IE – Petten, The Netherlands
- Institute for Prospective Technological Studies
  IPTS – Seville, Spain



Total staff > 2,700

JRC-Ispra:

3 Institutes

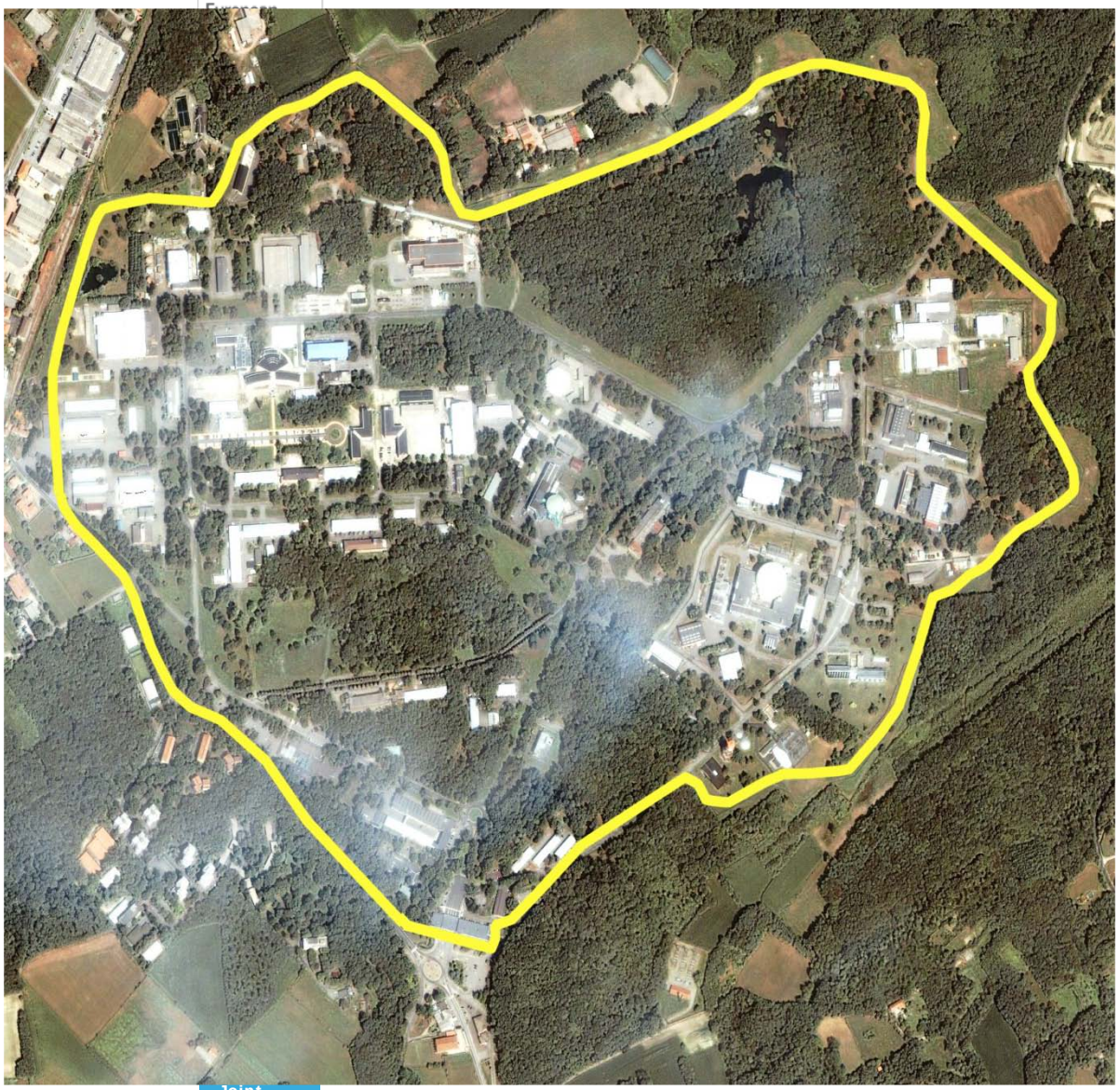
150 ha campus

- **~100 buildings**
- **>40 km roads**

~ 2000 staff

- **~750 scientific researchers**

5 EU Reference Labs.



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JRC-IES's groups working on climate change vs. water vs. plants

JRC.H01- Water Resources Unit: sustainably manage water resources

JRC.H02- Air and Climate Unit: evaluation of emissions of greenhouse gases and air pollutants

JRC.H03- Forest Resources and Climate Unit: sustainable, global, forest management practices

JRC.H04- Monitoring Agricultural Resources Unit: crop production, agricultural activities and rural development

JRC.H07-Climate Risk Management Unit: impacts of current weather extremes and future climate change

Evidences on occurring changes (variations) in climate

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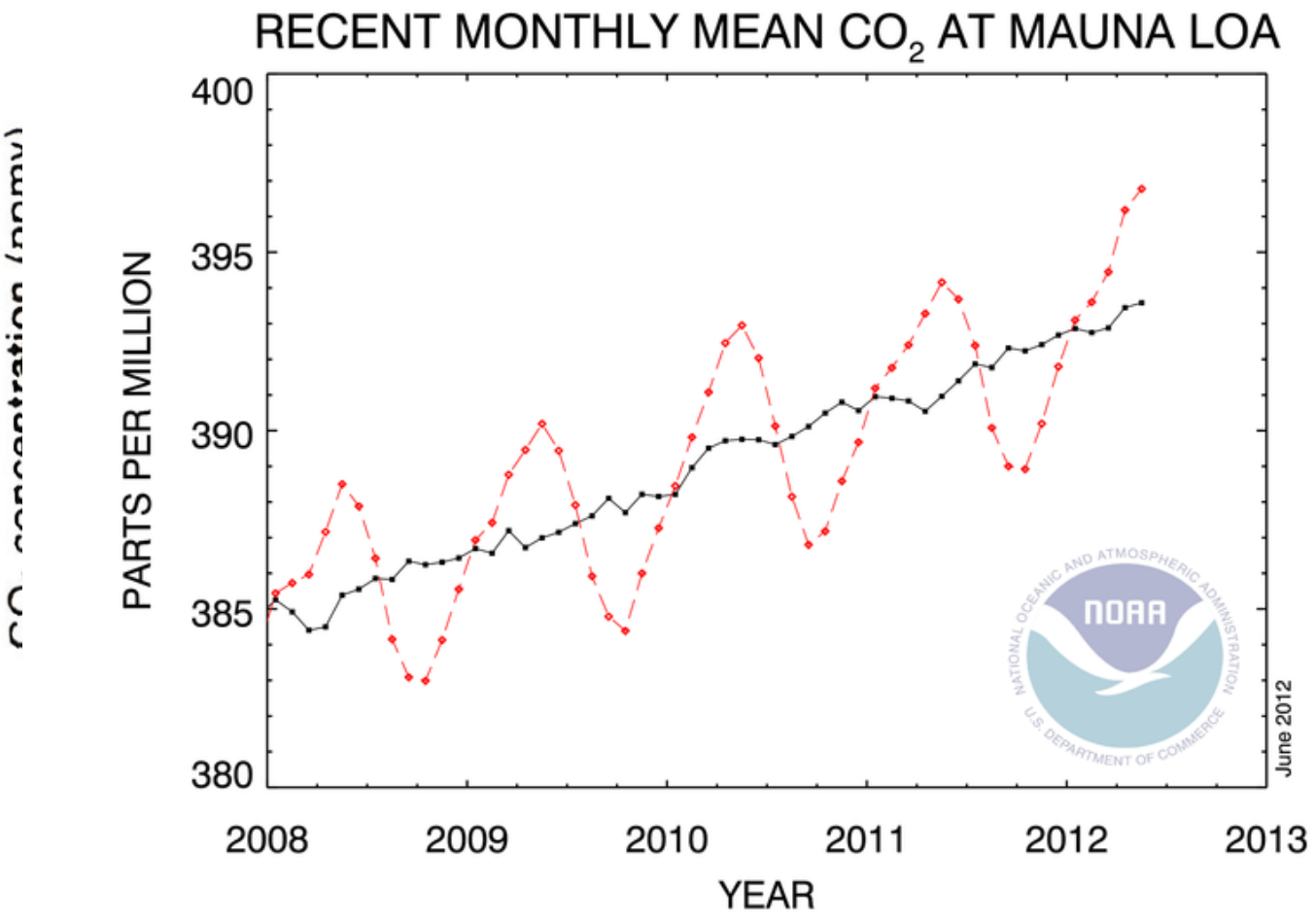
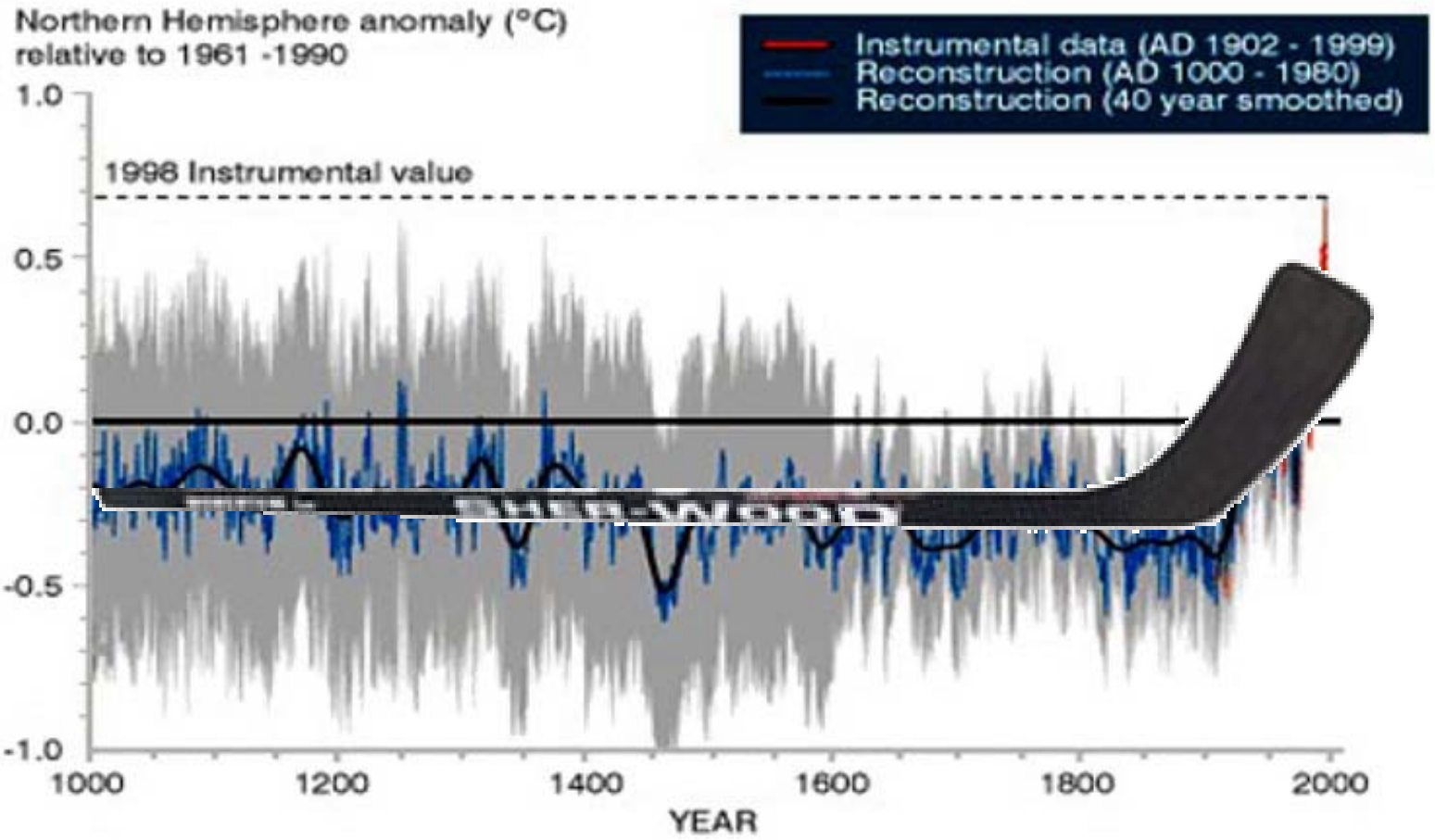
Recent Mauna Loa CO_2

May 2012:	396.78 ppm
May 2011:	394.16 ppm

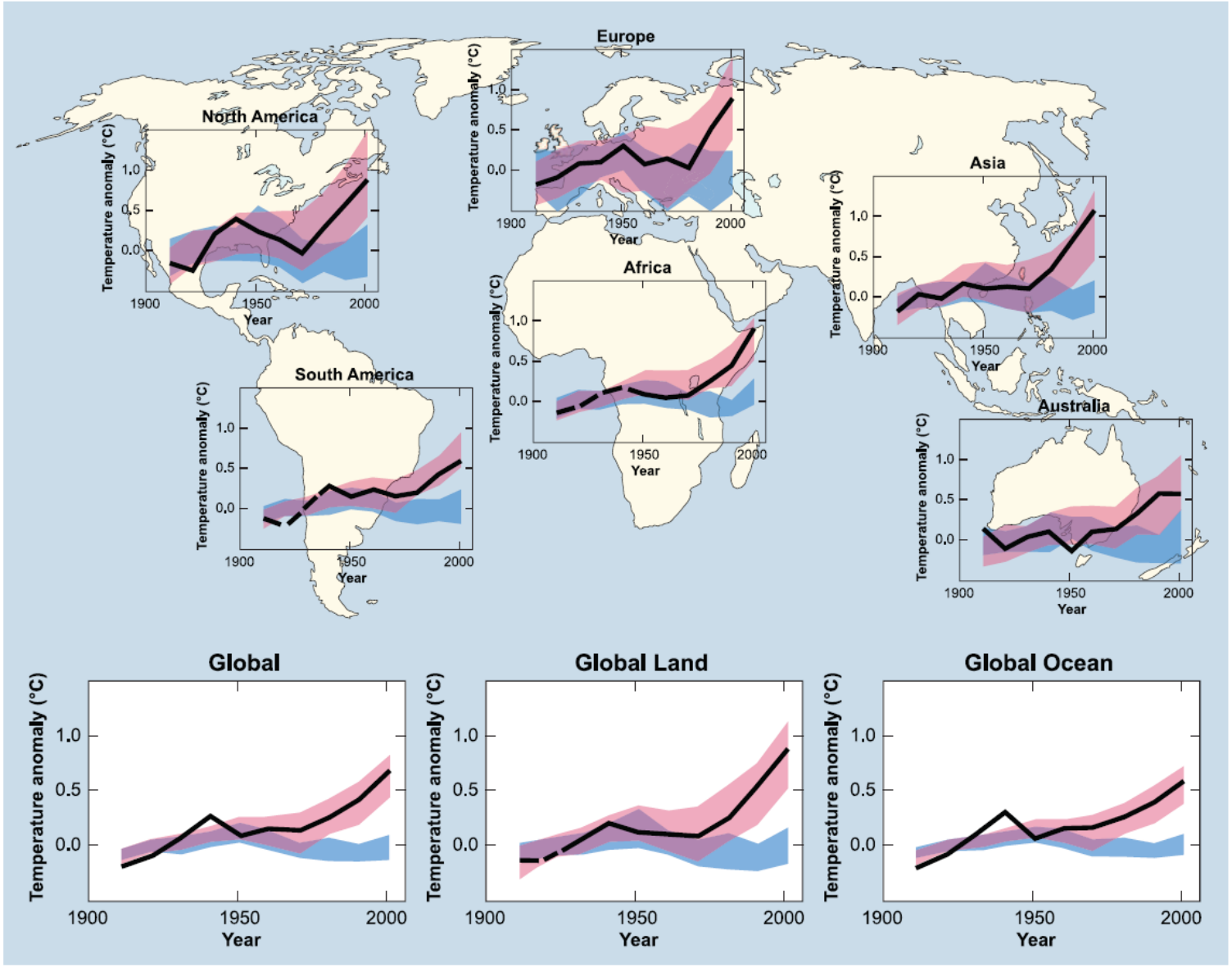


Research Centre

Mann, Bradley, & Hughes (1998): surface temperature



Global and continental temperature change



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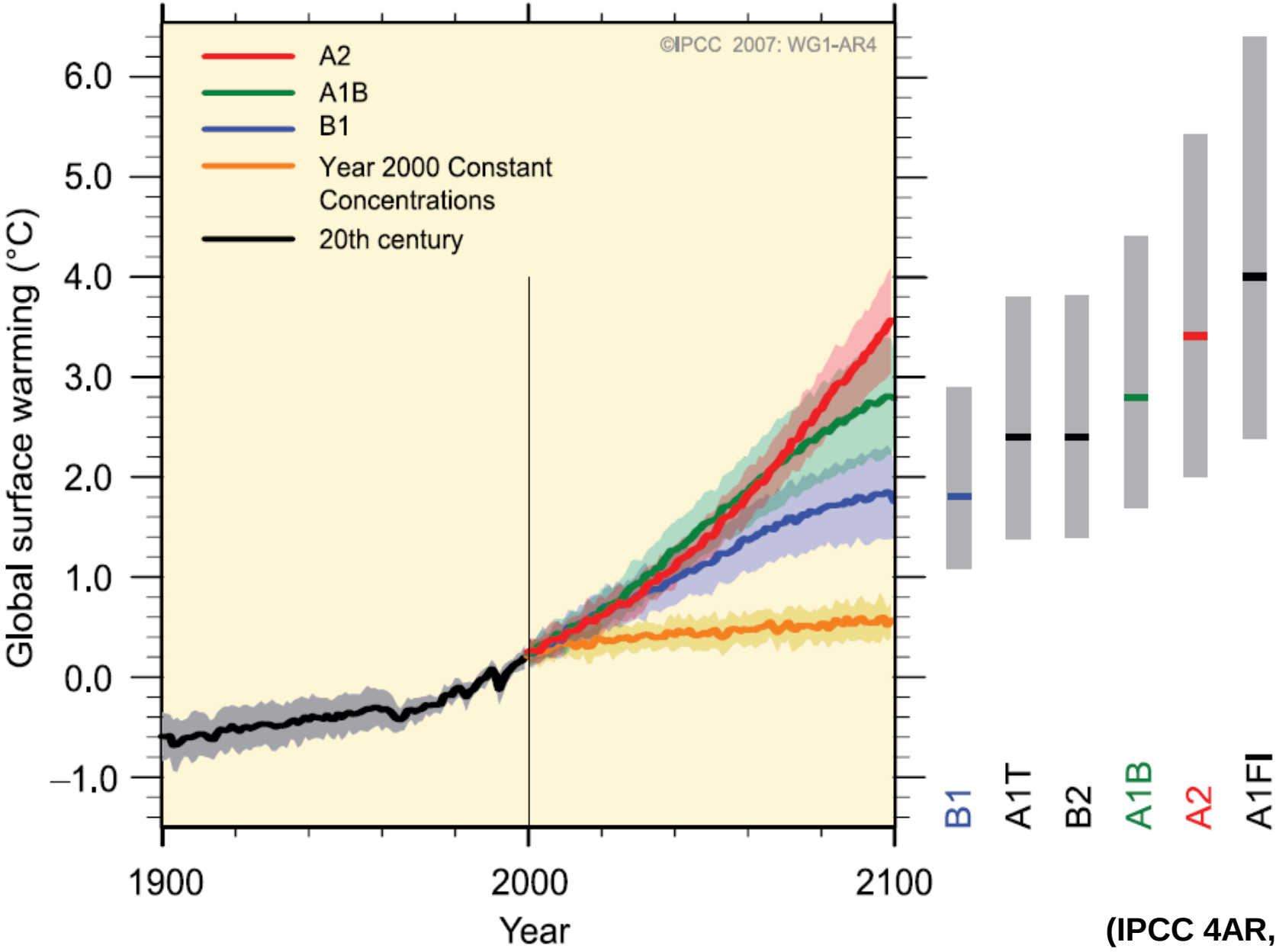
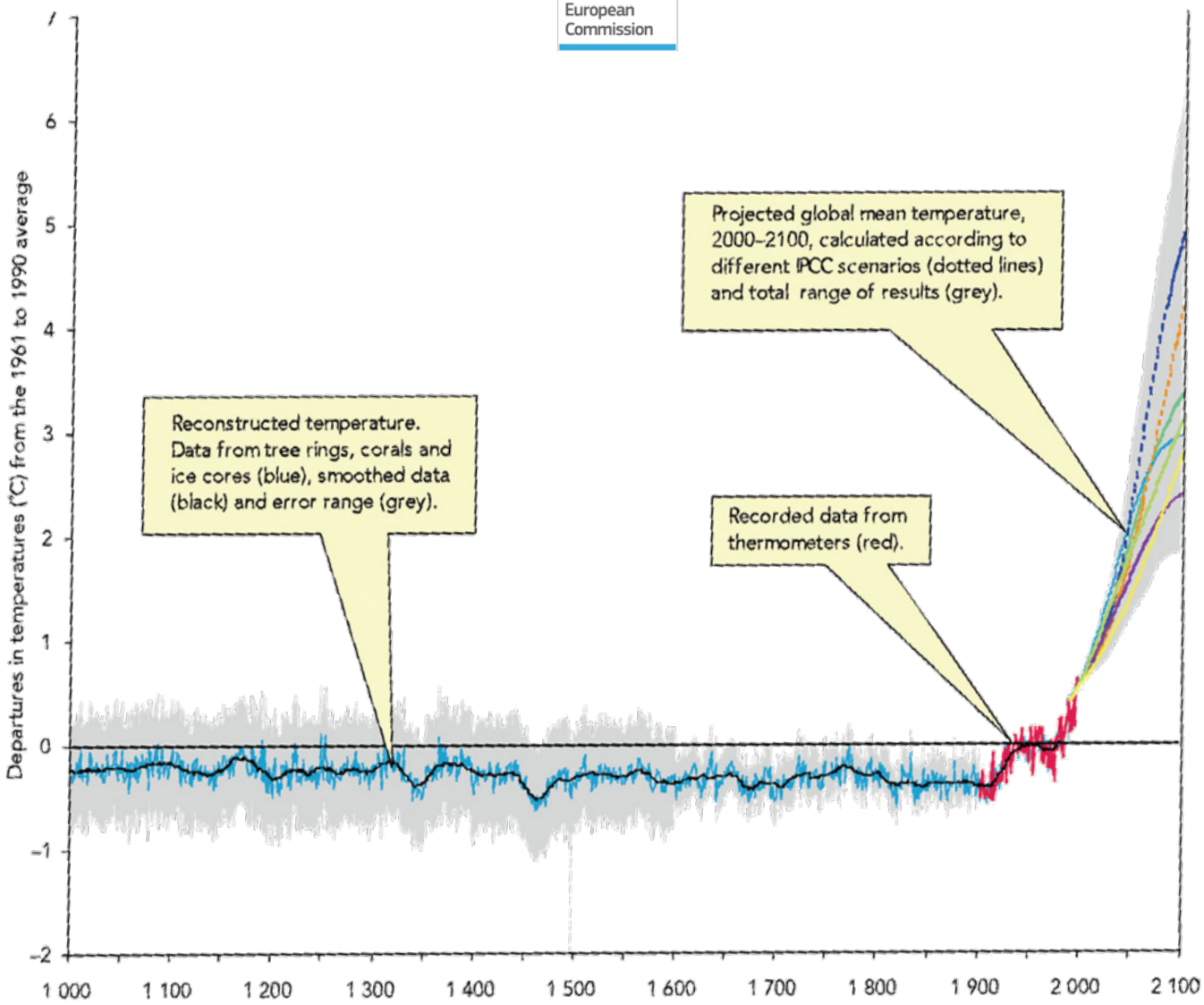
Centre

Multi-Model Averages and Assessed Ranges for Surface Warming

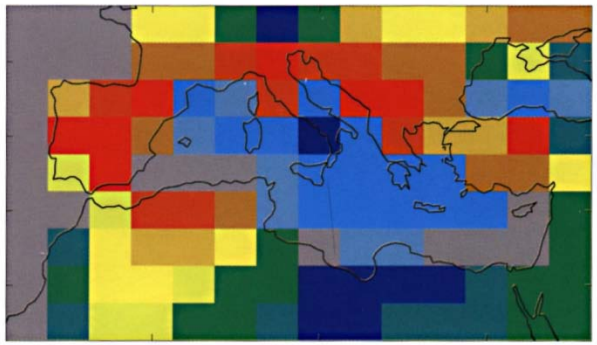


(IPCC 4AR, 2007)


Departures in temperatures (°C) from the 1961 to 1990 average
6
5
4
3
2
1
0
−1
−2
1 000
1 100
1 200
1 300
1 400
1 500
1 600
1 700
1 800
1 900
2 000
2 100
Years
Reconstructed temperature. Data from tree rings, corals and ice cores (blue), smoothed data (black) and error range (grey).
Recorded data from thermometers (red).
Projected global mean temperature, 2000–2100, calculated according to different IPCC scenarios (dotted lines) and total range of results (grey).

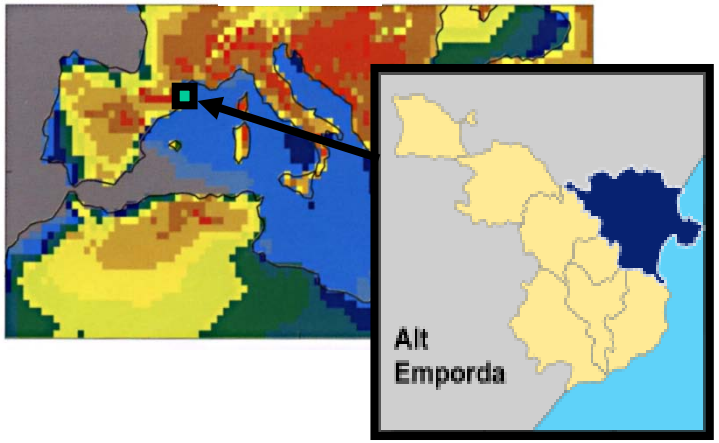
Large scale climate -> local scale impacts

GCM



Downscaling

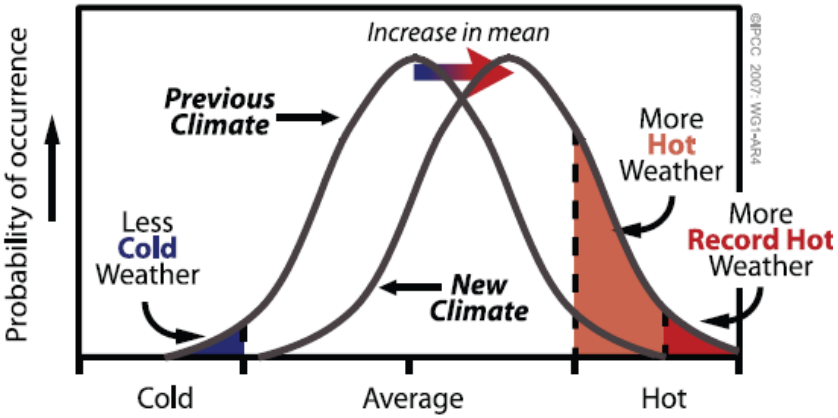
RCM Impact models



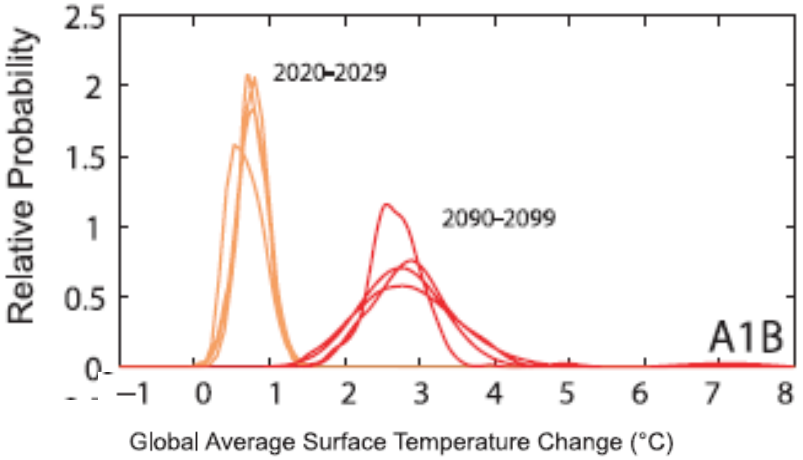
High resolution (20 – 50 km)
Limited area (5000 Km^2)
Atmosphere and land surface only

Extreme events

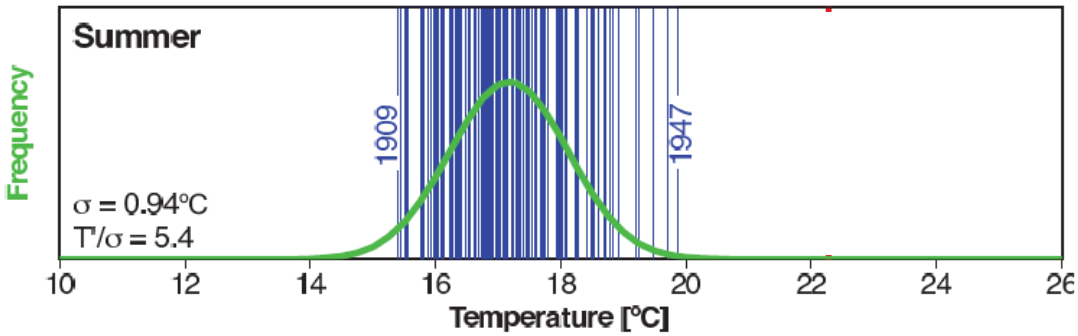
Theory



Model prediction



Observations



(IPCC 4AR, 2007)

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Climate change vs. plants: impacts and evidences

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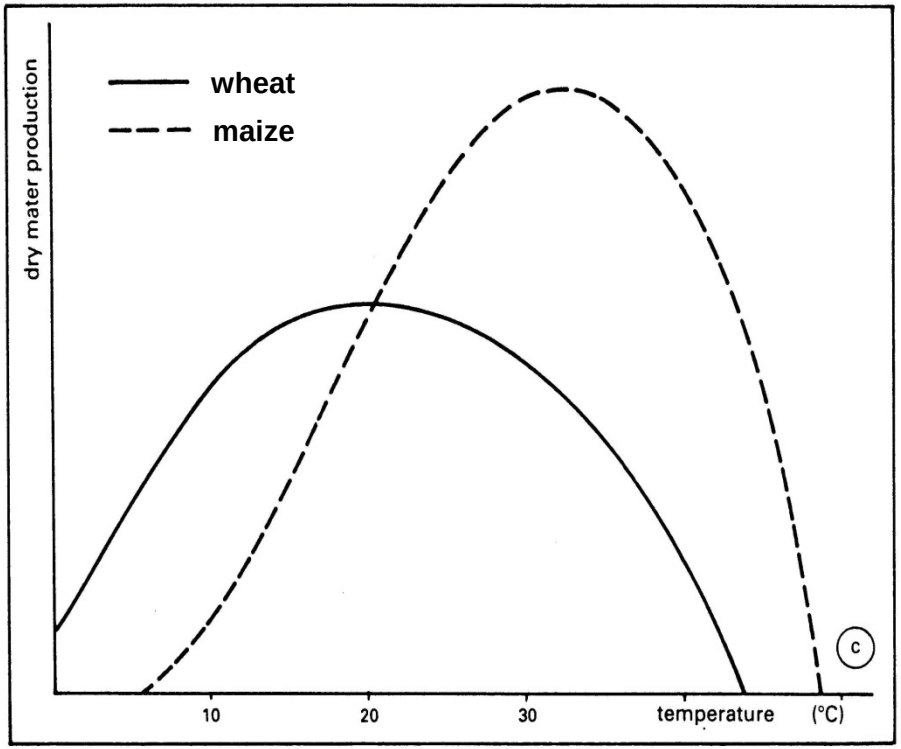
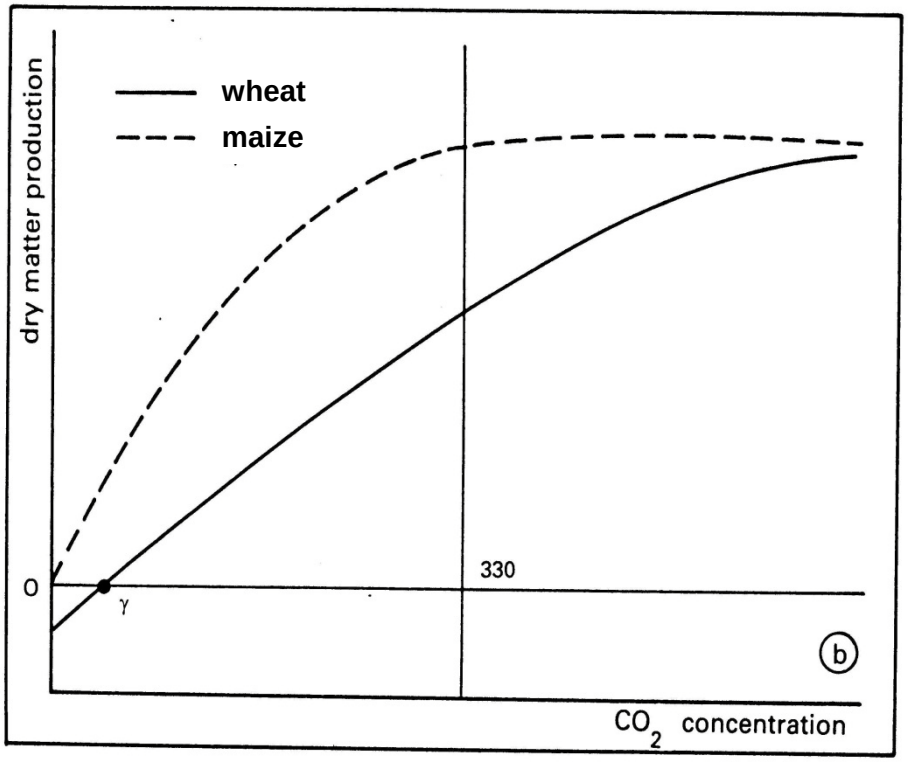
EFFECT OF SOME WEATHER PARAMETERS ON DRY MATTER PRODUCTTION



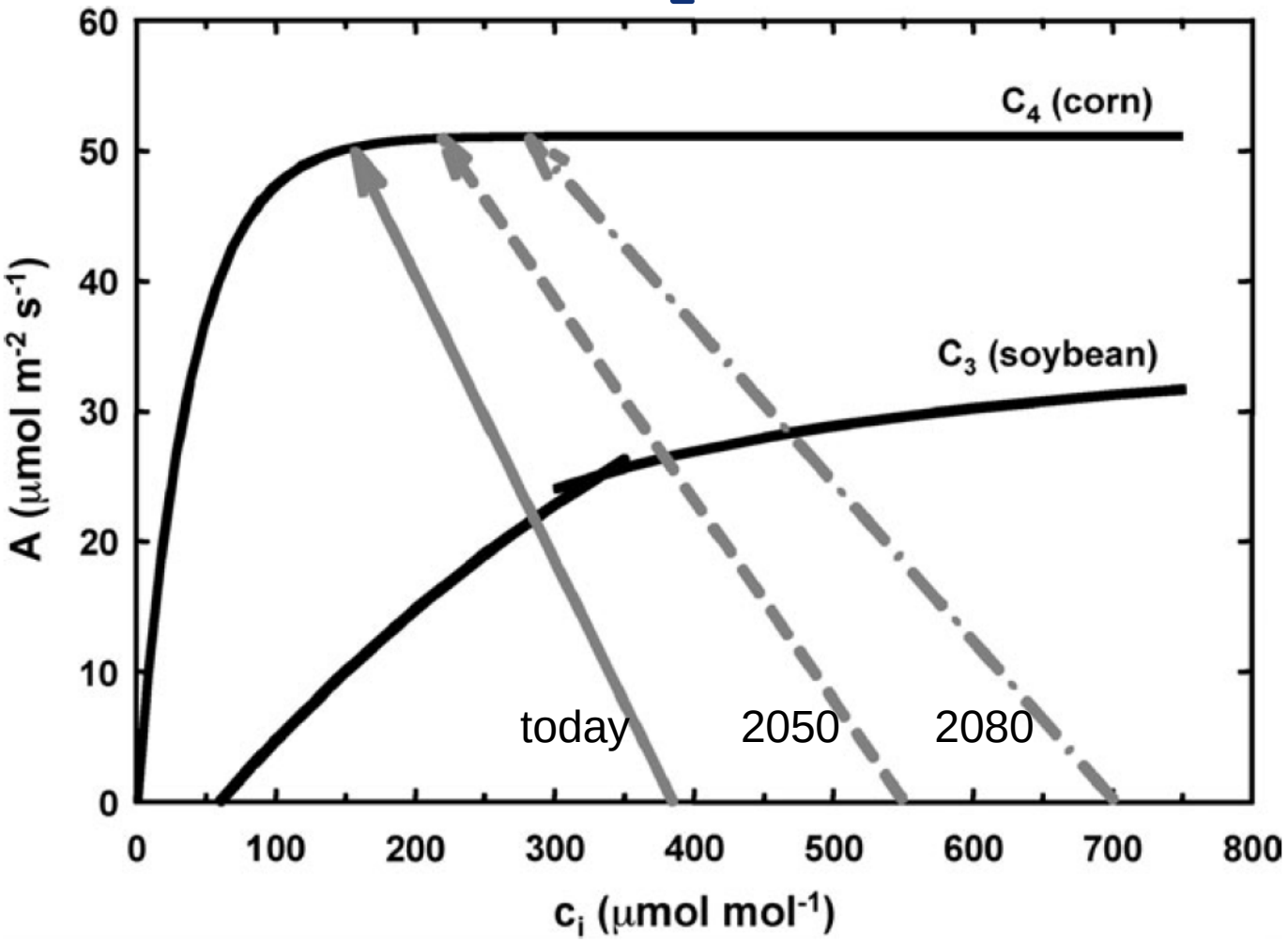
TEMPERATURE



CO_2 CONCENTRATION

CO_2 "fertilization"

Photosynthesis efficiency



CO_2 concentration

FRANCE:

Advance of apricot and peach trees flowering of 1-3 weeks
(Seguin et al., 2004)
Advance of maize sowing dates by 20 days
(Benoit and Torre, 2004)

GERMANY:

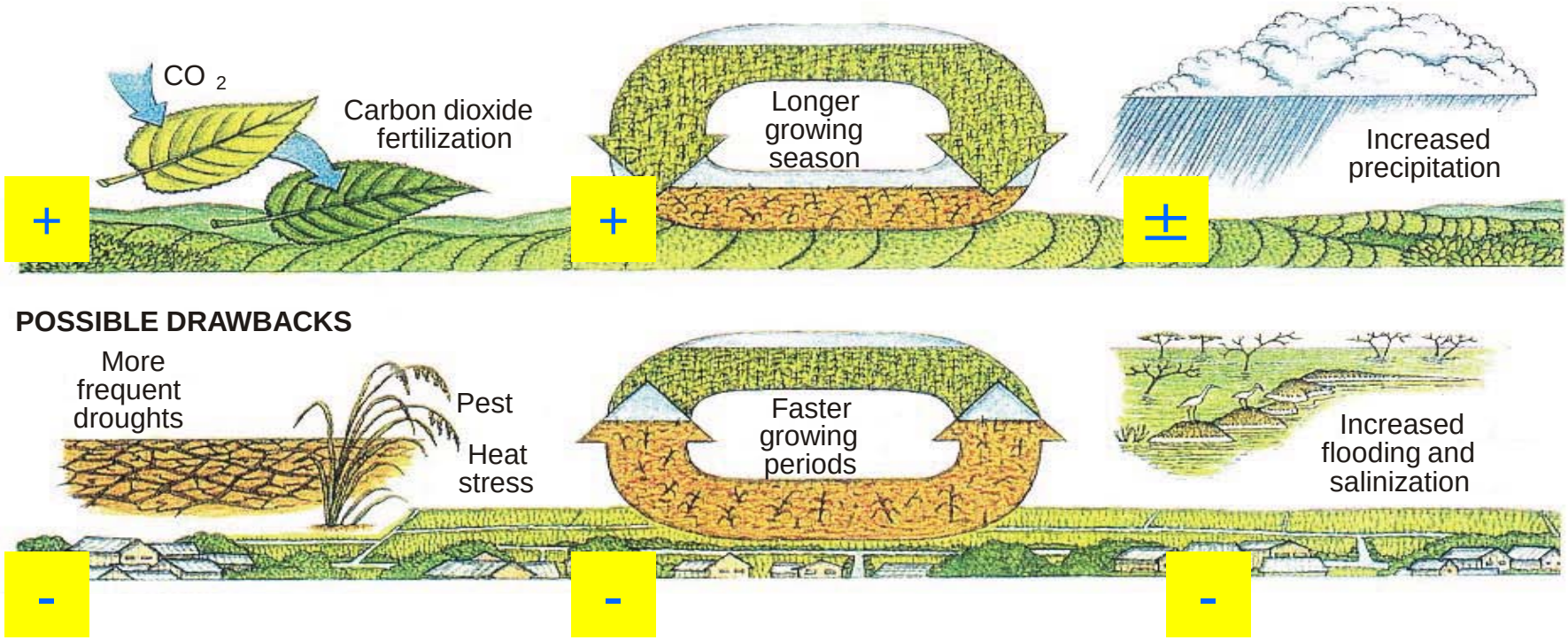
Advance of stem elongation for winter rye (10 days) and emergence for maize (12 days)
Advance of seeding dates for maize and sugarbeet (10 days)
(Chmielewski et al., 2004)

PHILIPPINES:

Decrease of rice yield associated with increase of temperature during 1979-2003
(Peng et al., 2004)

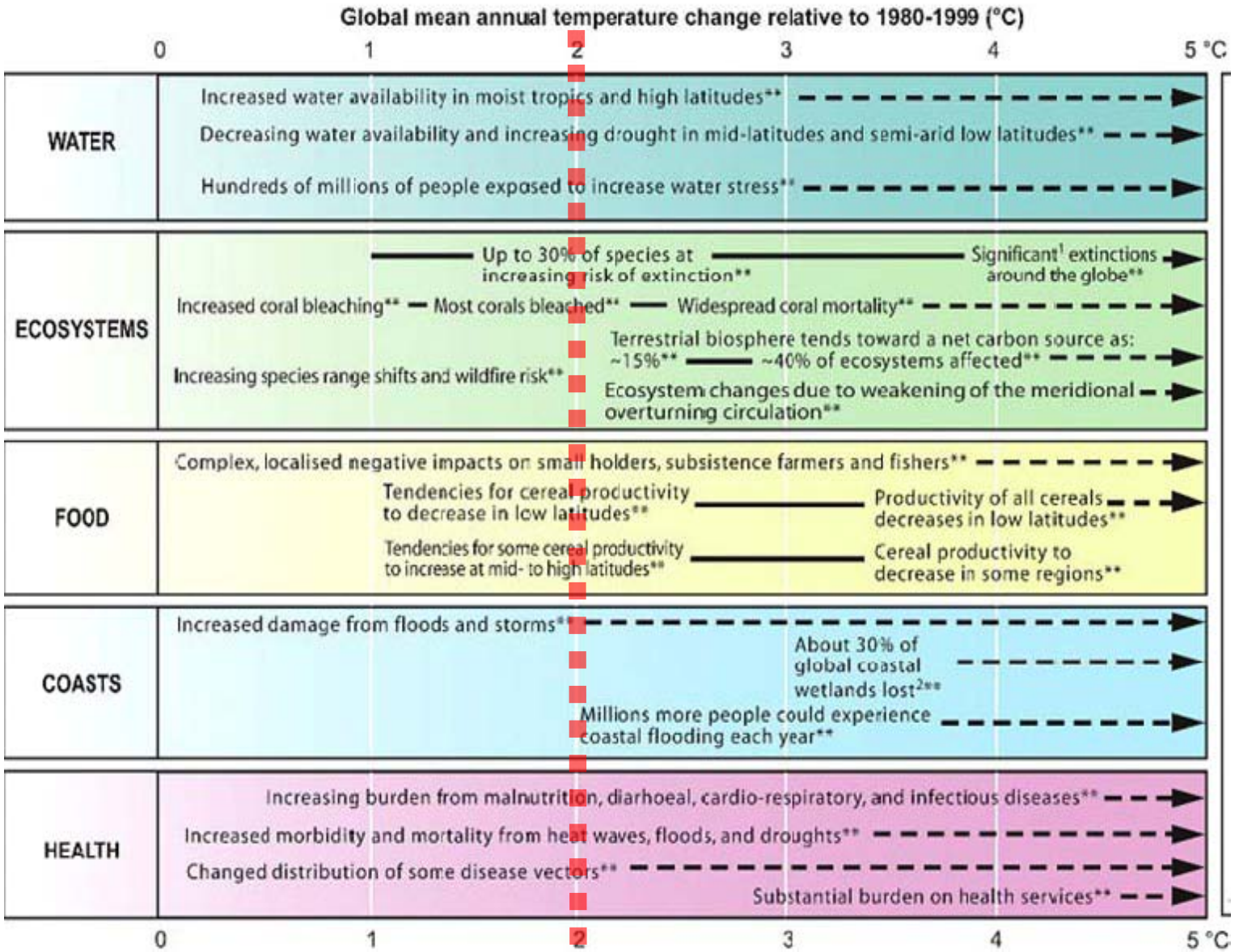
European Commission

Impacts on Agriculture



From Tubiello, IIASA, 2007

IPCC impacts

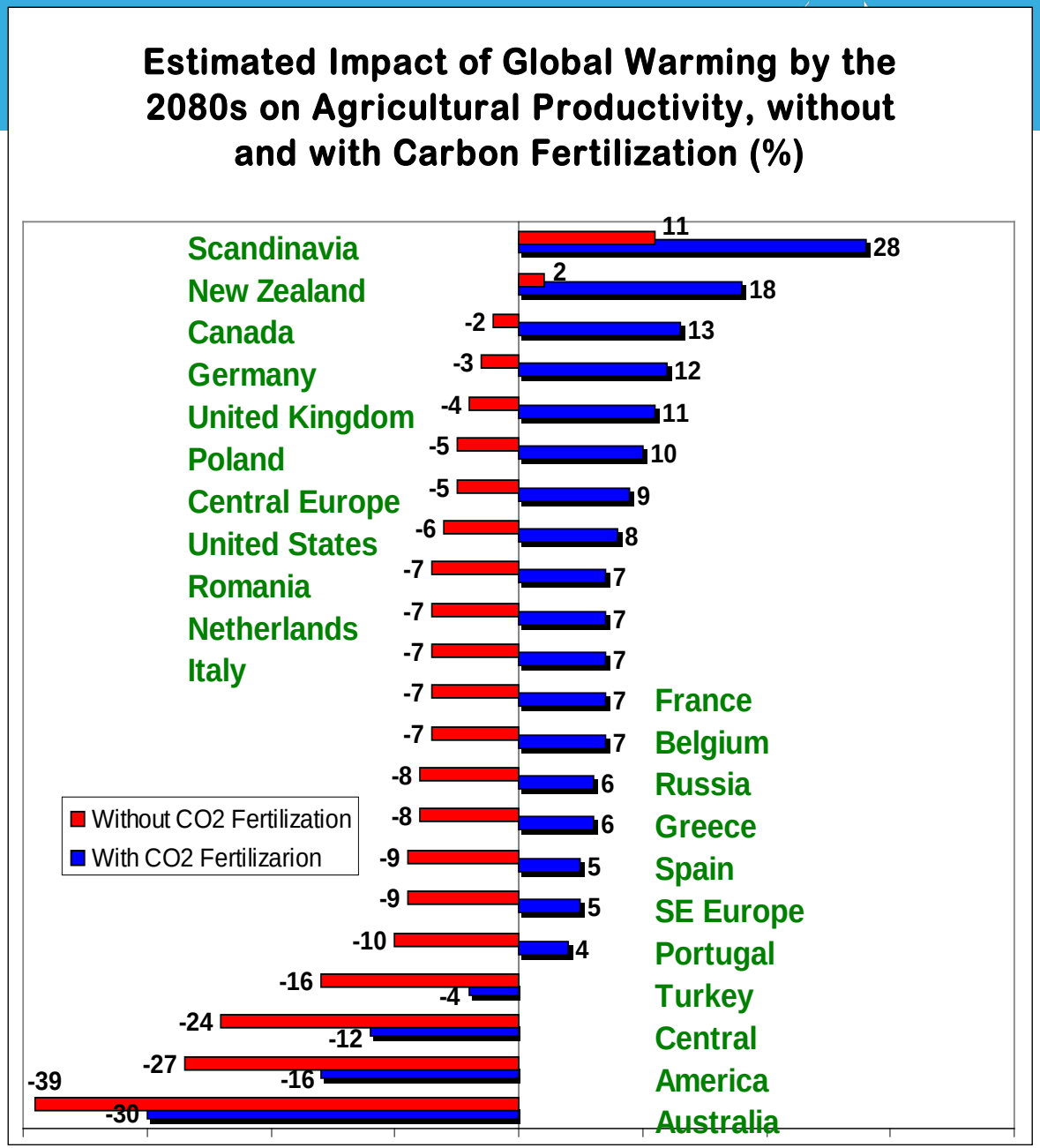


IPCC impacts

European Commission

Table 12.4. *Summary of the main expected impacts of climate change in Europe during the 21st century, assuming no adaptation.*

Sectors and Systems	Impact	Area				
		North	Atlantic	Central	Mediterr.	East
Agriculture and fisheries	Suitable cropping area	↑↑↑	↑↑	↑	↓↓	↓
	Agricultural land area	↓↓	↓↓	↓↓	↓↓	↓↓
	Summer crops (maize, sunflower)	↑↑↑	↑↑	↑	↓↓↓	↓↓
	Winter crops (winter wheat)	↑↑↑	↑↑	↑ to ↓	↓↓	↑
	Irrigation needs	na	↑ to ↓	↓↓	↓↓↓	↓
	Energy crops	↑↑↑	↑↑	↑	↓↓	↓
	Livestock	↑ to ↓	↓	↓↓	↓↓	↓↓
	Marine fisheries	↑↑	↑	na	↓	na



Possible "winners" & "loosers"

Global Warming and Agriculture: Impact Estimates by Country

by William R. Cline

Joint Research Centre

Key messages:

- Adequate and reliable long **time series of data** are necessary to assess occurred changes in climate and their impacts
  - long-term trends
  - extremes events
- Both observations and predictions are affected by error and **uncertainty**
- **Models** can compensate (but partially) the lack of data
- Due to the **non-linear response of plants to climate change**, validated impact models are necessary to assess the CC impacts
- High relevance of adequate **downscaling** of data in space and time

European Commission

The Climate Risk Management Unit activities

Joint Research Centre

Schematic framework of anthropogenic climate change drivers, impacts and responses

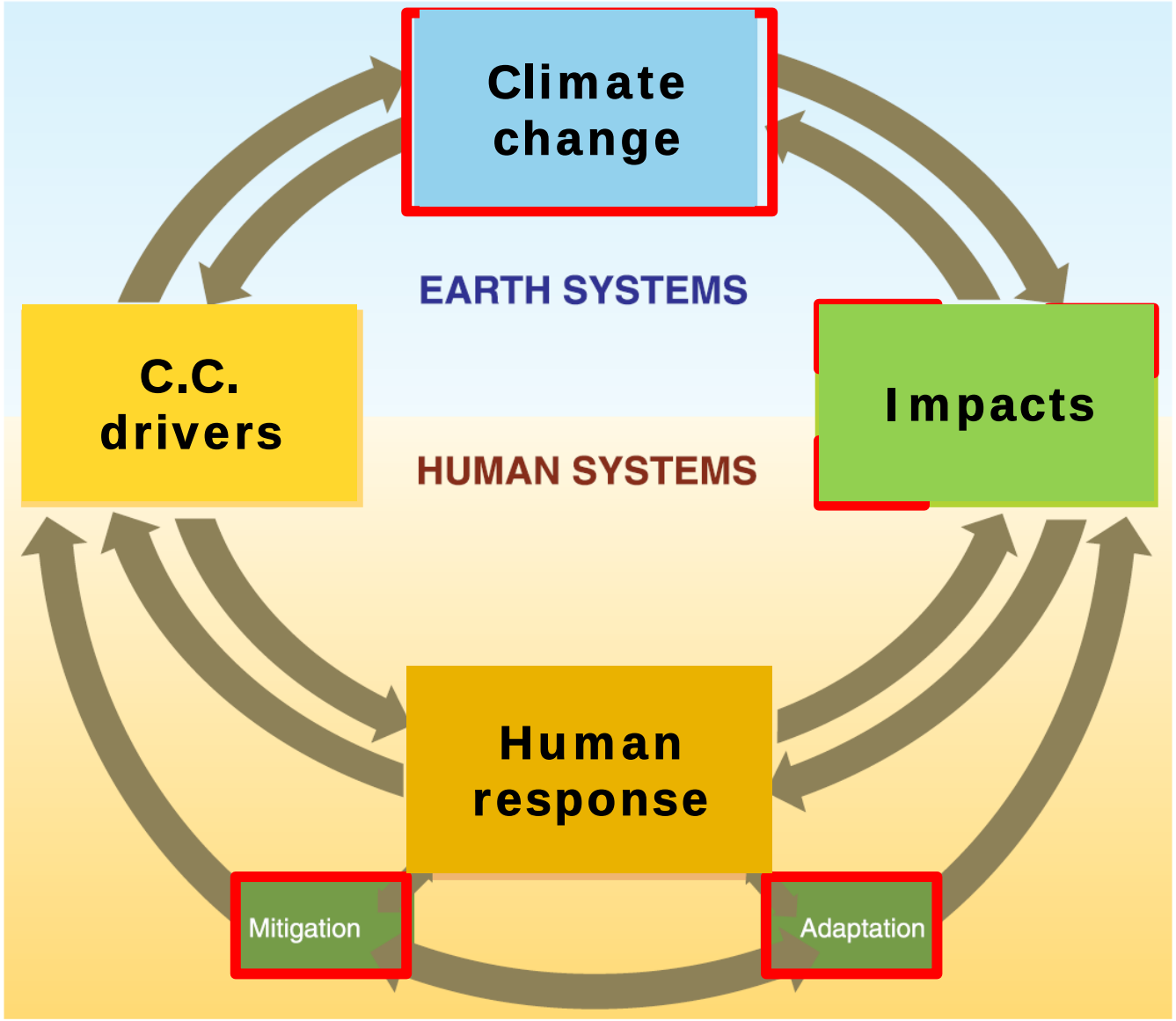


Figure I.1. *Schematic framework representing anthropogenic drivers, impacts of and responses to climate change, and their linkages.*

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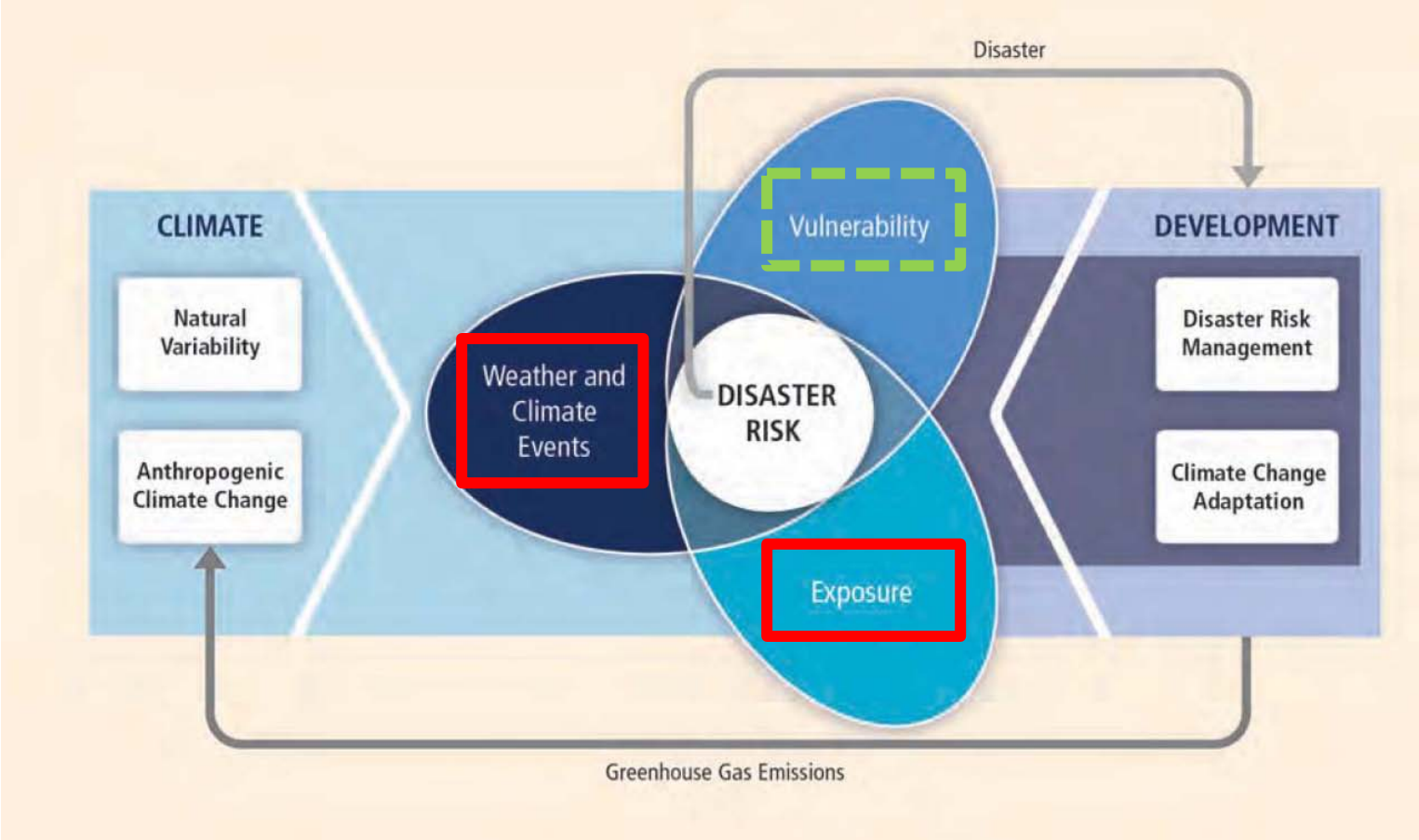

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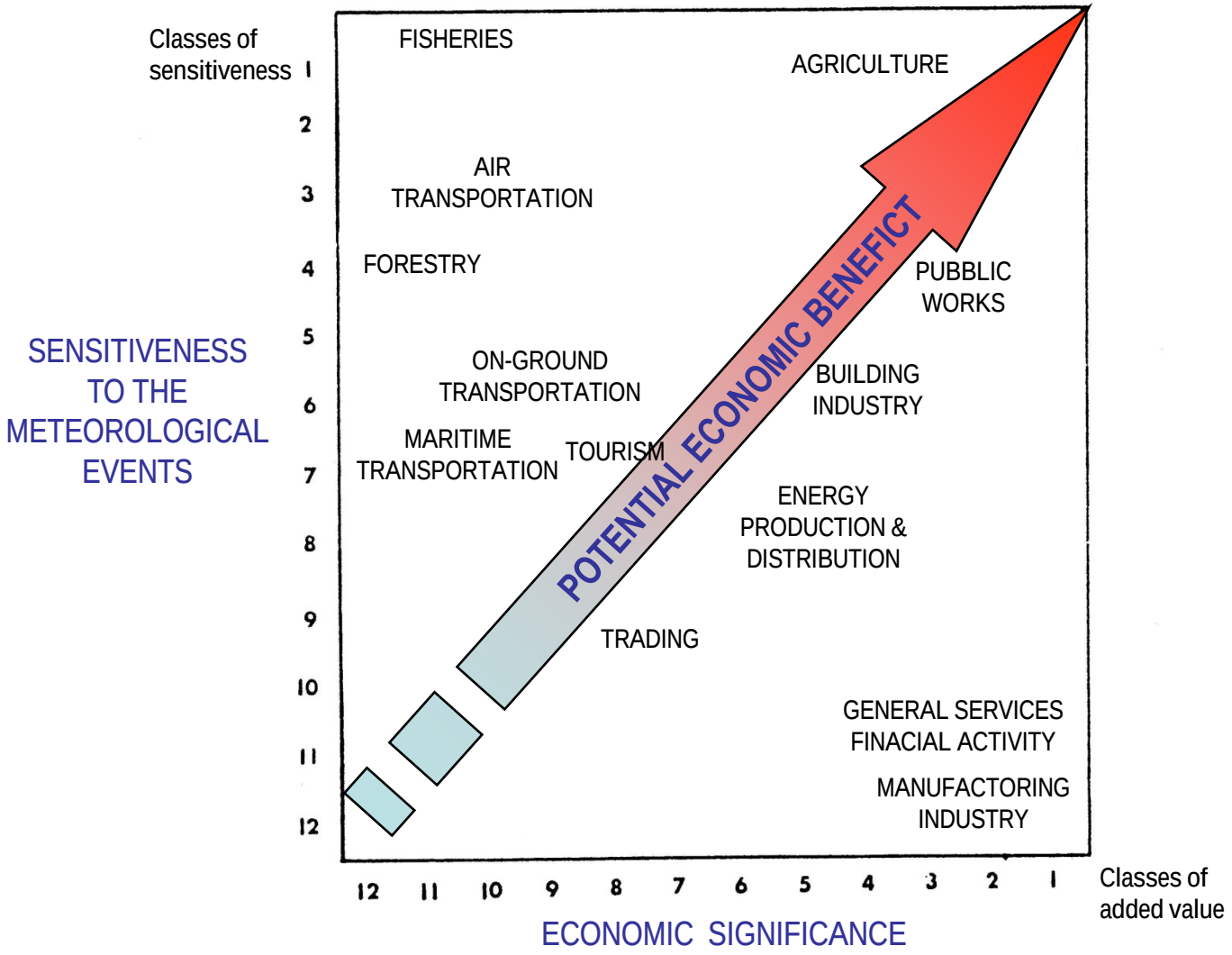
Weather sensitiveness



Weather/climate hazards

- Drought
- Flooding
- Desertification/soil degradation
- Long term trends

Areas of interest

- Europe
- Africa
- Latin America

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DROUGHT

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Drought definition

European Commission

Peel et al. 2004
*(…) the **median** is used as the truncation level. The choice of the sample median as the truncation level (…) is arbitrary (…).*

McKee et al. 1993
*A drought event (…) is arbitrarily defined here (…) as a period in which the SPI (…) reaches a **value of -1 or less.***

Sheffield et al. 2009
*A drought is defined conceptually as (…) deficits below the **20th percentile**, which represents relatively rare conditions.*

Kinninmonth et al. 2000
*If the sum falls within the **lowest decile** of the historical distribution, then the region is considered to be "drought affected".*

Drought ??

Steinemann 2003
*A mild drought corresponds to a **percentile threshold of 0.35**.*

Agnew 2000
*It is suggested that climatologists should (…) employ a threshold similar to **Q95** for defining meteorological drought.*

Svoboda et al. 2002
*Perhaps the idea of having a meaningful **drought classification** process is a **utopian concept**.*
…
*Ultimately, **drought refers to a condition** of an **insufficient supply of water** necessary to meet demand, both being **highly location-specific**.*

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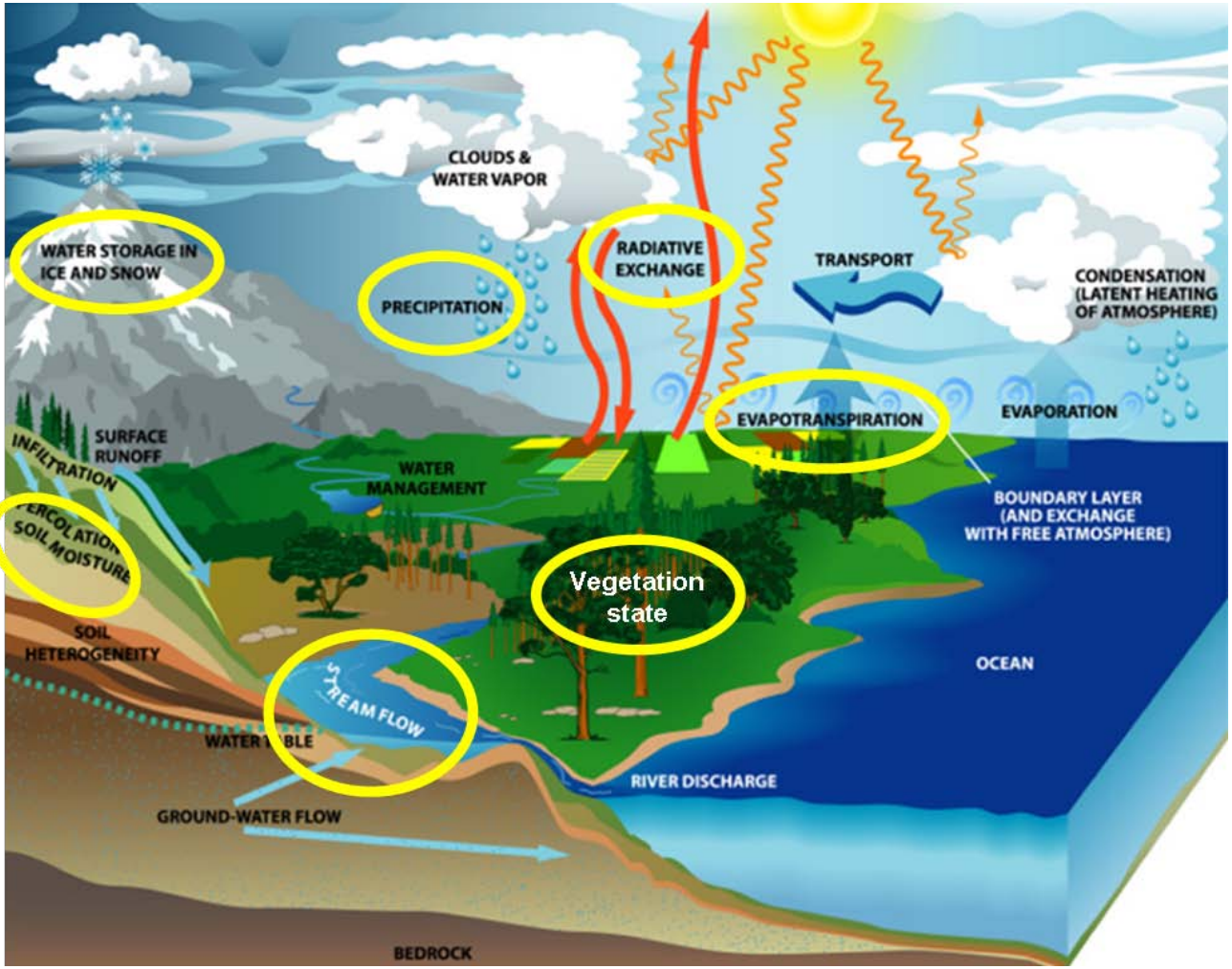
drought vs. water cycle complexity

European Commission

NO SINGLE DEFINITION OF **DROUGHT**

A multidisciplinary set of indicators to constantly monitor the various environmental components potentially affected by droughts (soil, vegetation, etc.) in order to obtain a comprehensive and updated picture of the situation.



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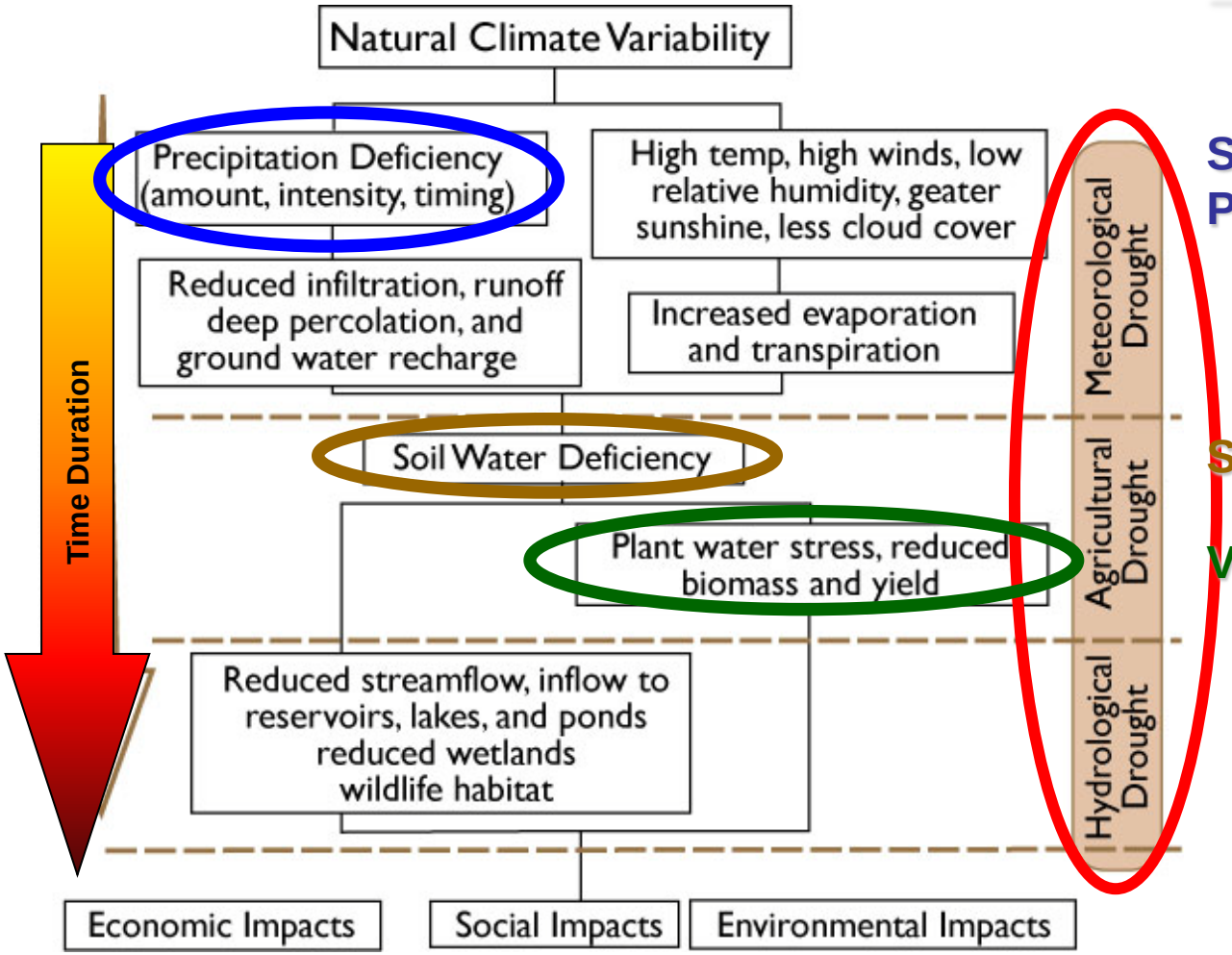
Different Drought definitions/indicators

European Commission

at continental scale



Standardized Precipitation Index

Soil Moisture Anomaly

Vegetation Response

Source: National Drought Mitigation Center, University of Nebraska-Lincoln, USA

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Economic impacts of drought

European Commission

In EUROPE:

Last 30 years: estimated cost of at least **100 billion Euros**

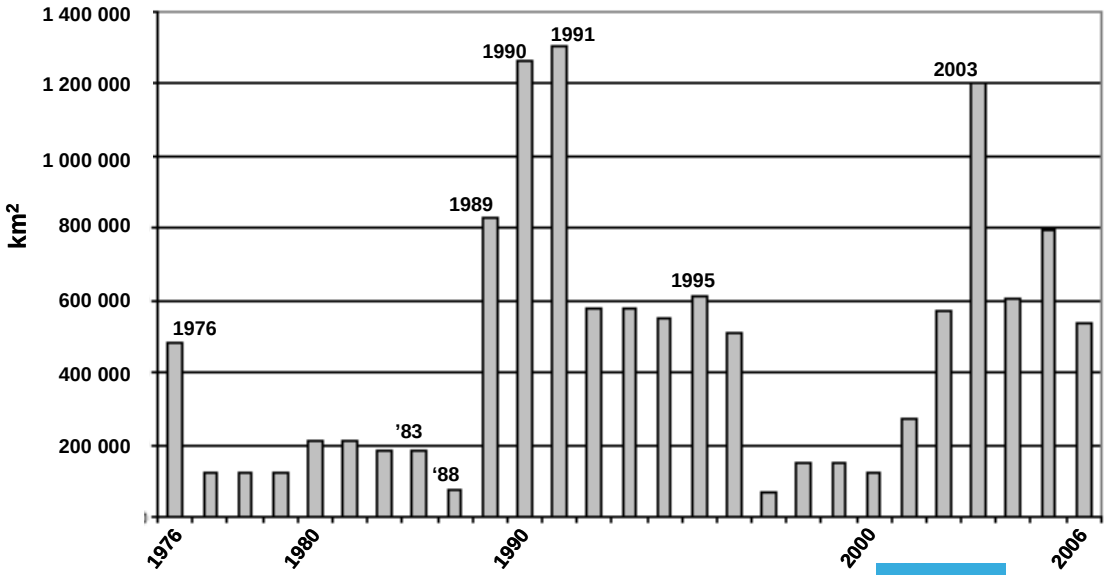
Annual economic impact **doubled** from 1976-1990 to 1991-2006

Period	Total Impact	Impact/year
1976 – 1980	12 340	2 470
1981 – 1985	4 360	870
1986 – 1990	14 460	2 890
1991 – 1995	23 390	4 680
1996 – 2000	8 060	1 610
2001 – 2006	37 400	6 230
TOTAL	**100 000**	

All figures in million Euros

Source: European Commission, 2007 (WS&D, 2nd Interim Report)

EU area affected by drought in the last 30 years



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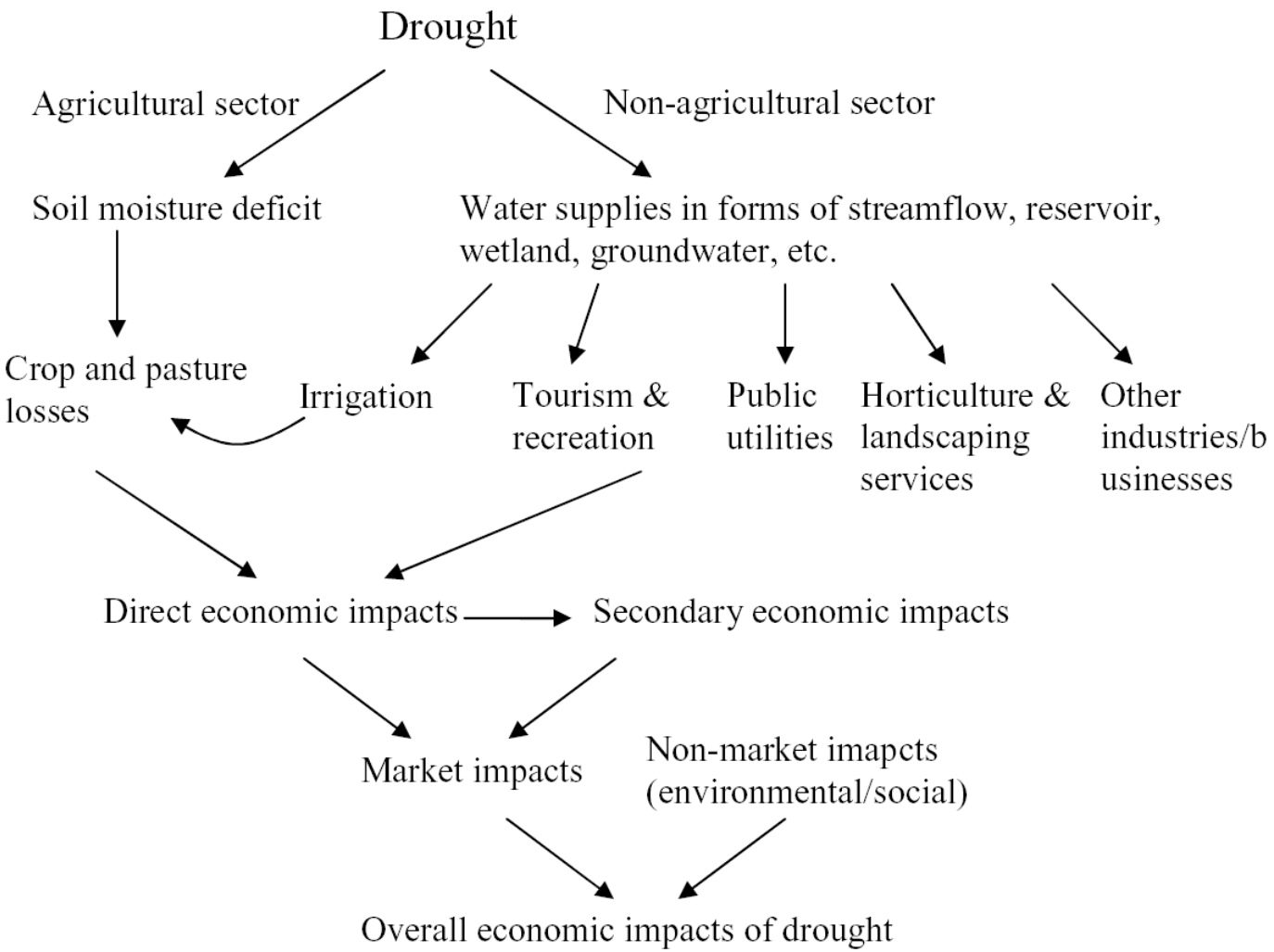
In the last 30 – 35 years Europe has repeatedly been affected by major droughts

Economic impacts of drought



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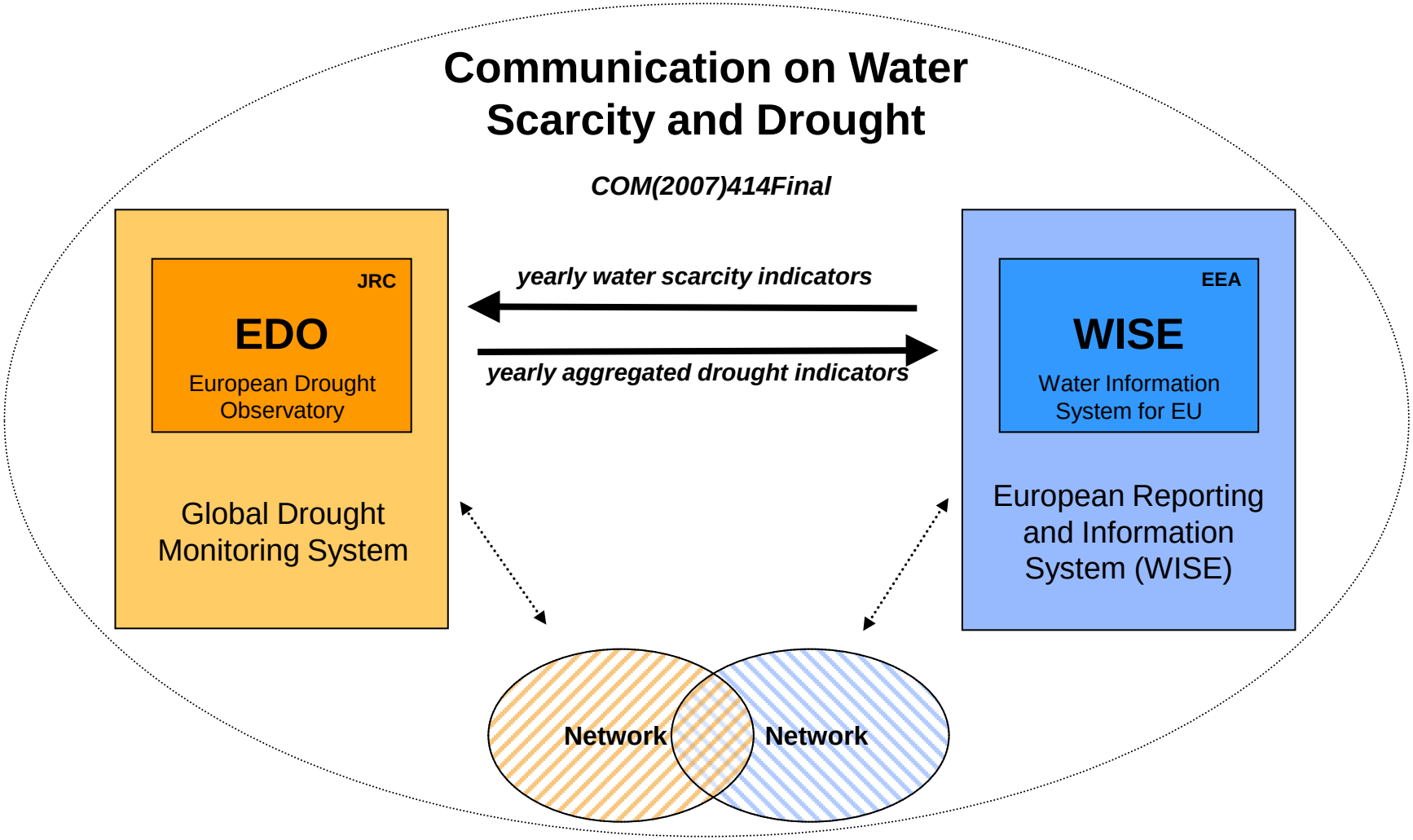
Ya Ding, et al. : Measuring Economic Impacts of Drought: A Review and Discussion. 2010 University of Nebraska - Lincoln



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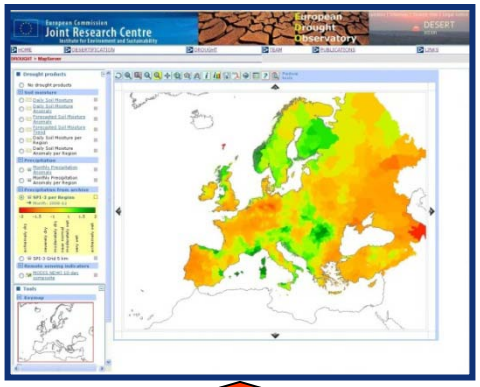
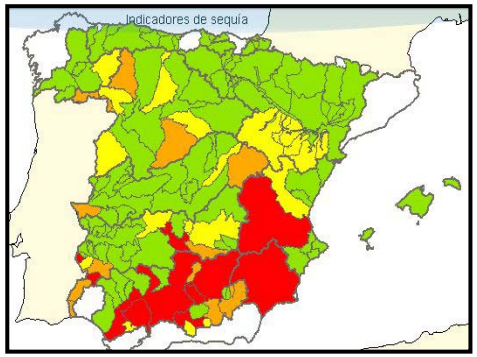
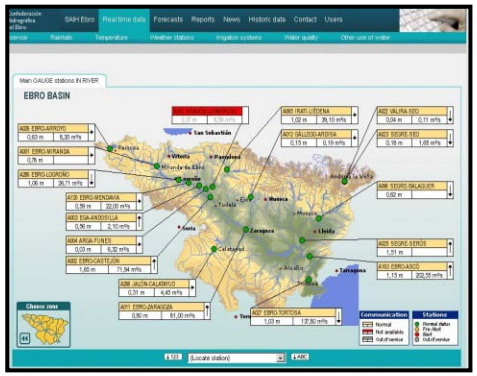
EDO Vision







Web-based Platform for detection, monitoring, forecasting and information exchange

- commonly agreed products (e.g. drought indices)
- joint comparison and analysis of information
- mutual exchange of knowledge & methodologies
- direct up- and downscaling
- real-time monitoring and forecasting (early warning, preparedness)

Multi-scale approach, integrating

- EU / continental level
- MS level
- Regional / river basin level

Data Infrastructure INSPIRE

Subsidiarity principle

- European level information + platform (JRC)
- National datasets managed at MS level
- regional information processed by river basin / regional environmental authorities
- De-central data holding

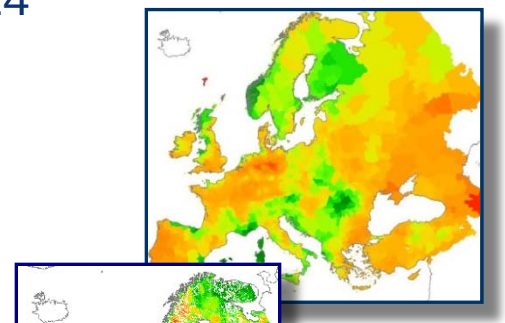
Multi-Indicator Approach

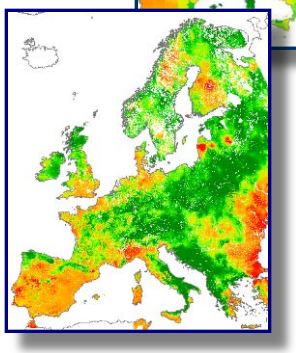
Precipitation (SPI)

- ✓for aggregation periods of 1, 3, 6, 9, 12, 24 months

Soil Moisture

- ✓Daily soil moisture
- ✓Daily soil moisture anomaly
- ✓Forecasted soil moisture anomaly (7days)
- ✓Forecasted soil moisture trend





Vegetation status

- ✓NDWI 10-day composites
- ✓NDWI anomalies
- ✓fAPAR 10-day composites
- ✓fAPAR anomalies

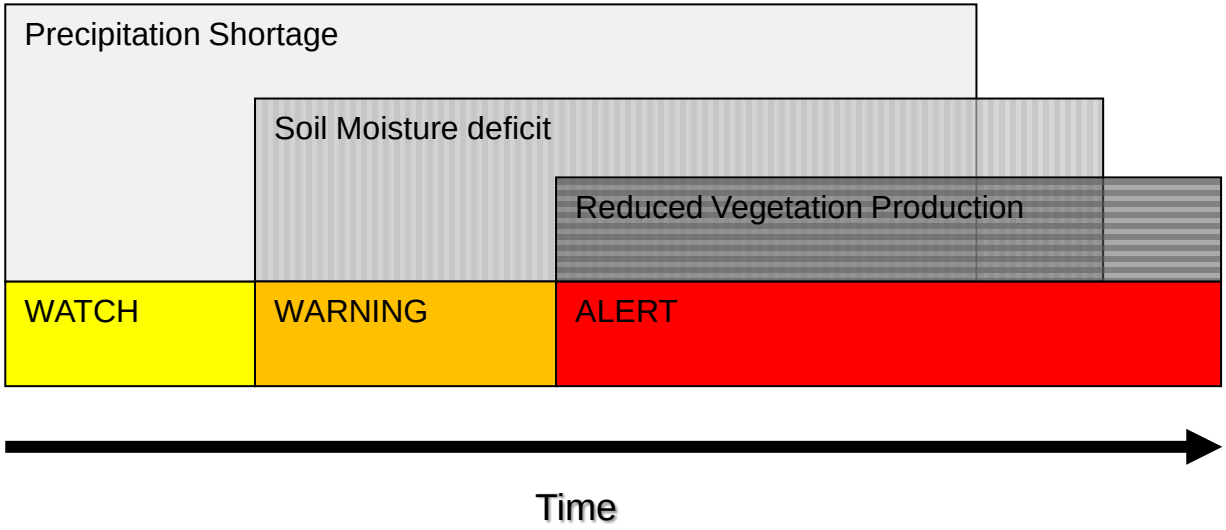
Composite Drought Indicator (Drought Alert)

Combined Drought Indicator: Conceptual Framework

European Commission

Combined Drought Indicator (CDI) for Agricultural Drought

Cause-effect relationships and related warning levels



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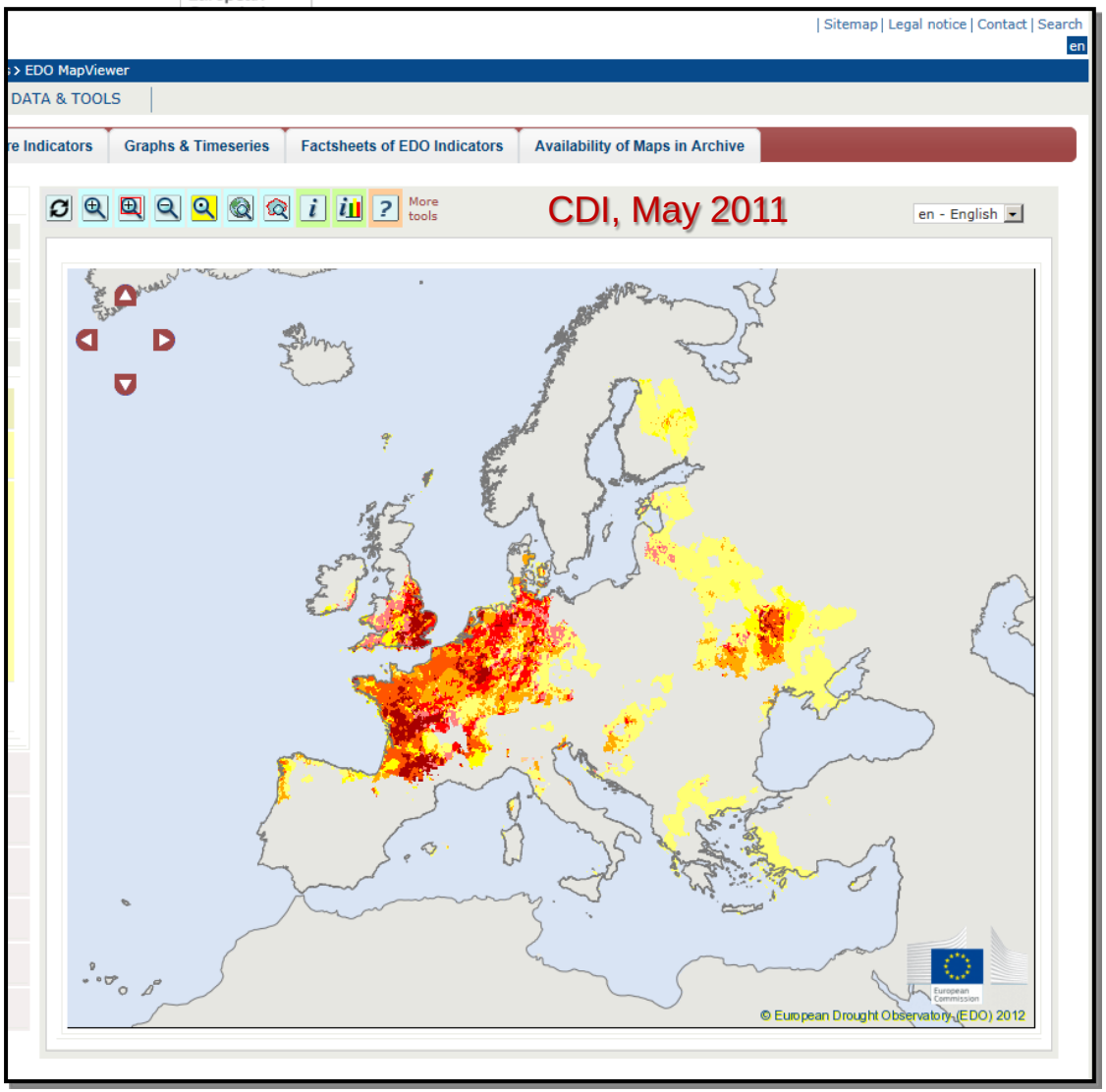
Combined Drought Indicator (CDI)

Impact	Level
Watch: rainfall deficit	1
	2
	3
Warning: soil moisture deficit	1
	2
	3
Alert: vegetation stress following rainfall/soil moisture deficit	1
	2
	3
	4

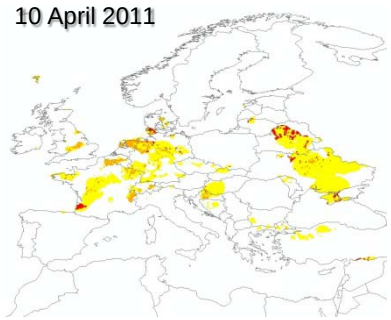
Increasing Dryness

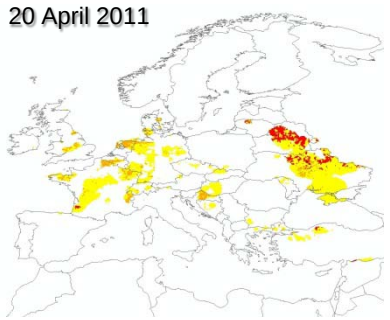


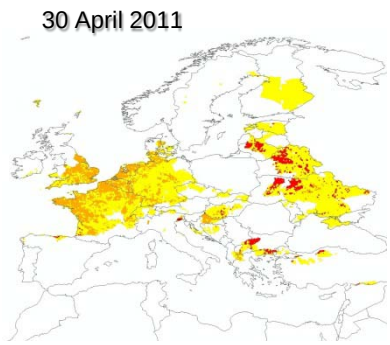
http://edo.jrc.ec.europa.eu/

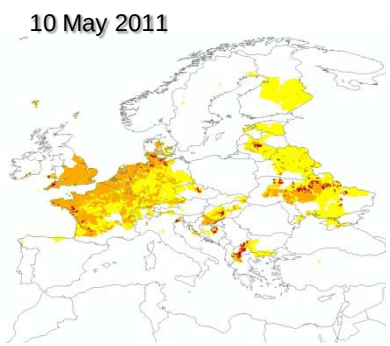
CDI : Evolution Spring 2011

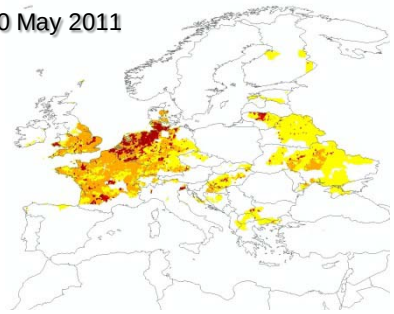
European Commission

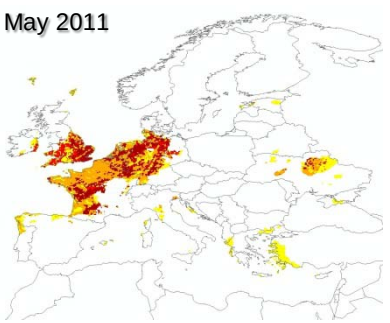


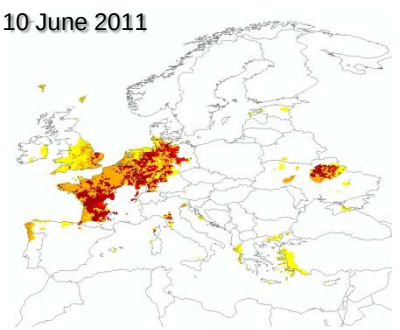


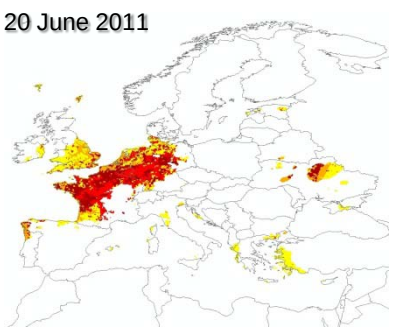


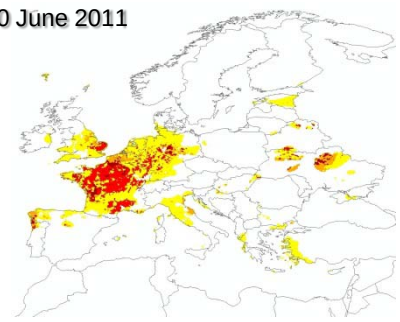


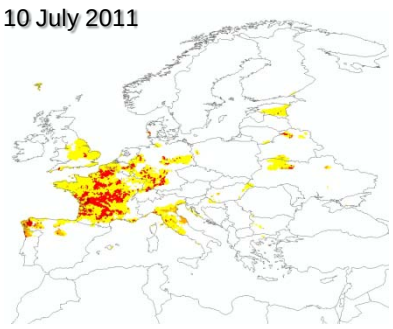


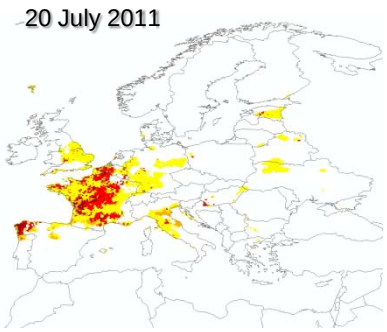


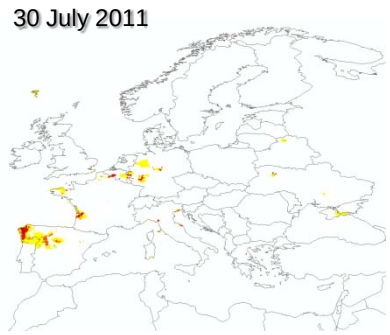










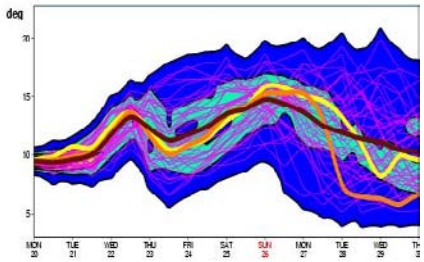


Joint Research Centre

Testing seasonal forecasting products

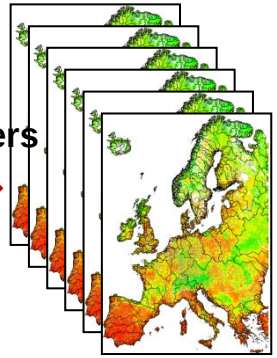
European Commission

Exploiting medium- & long-range meteorological ensemble forecasts

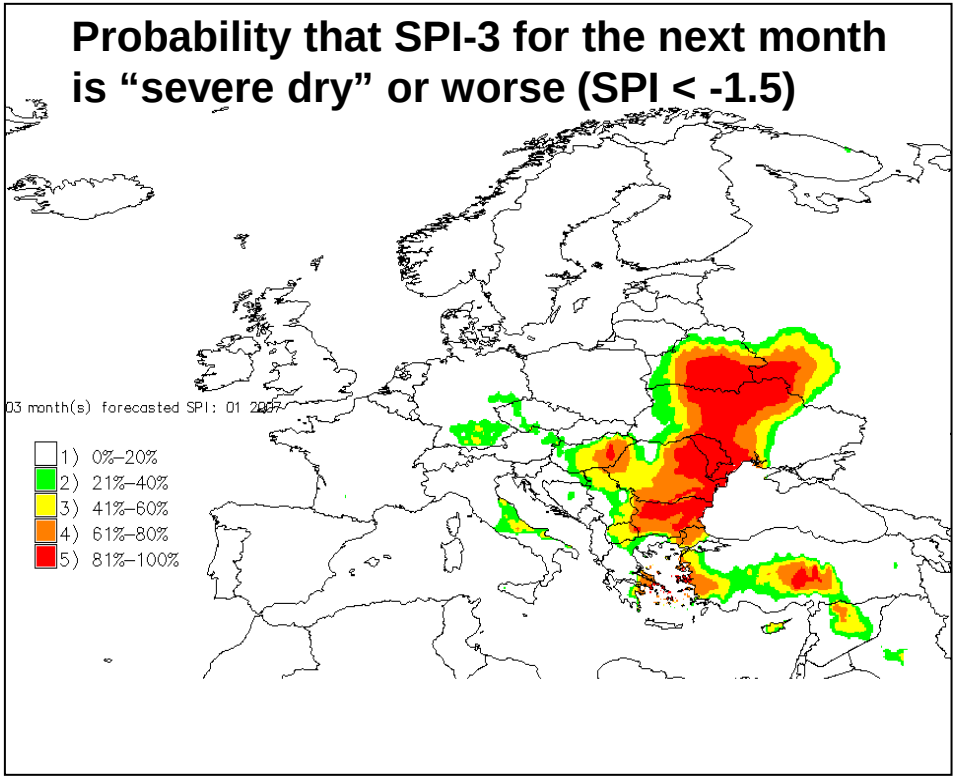


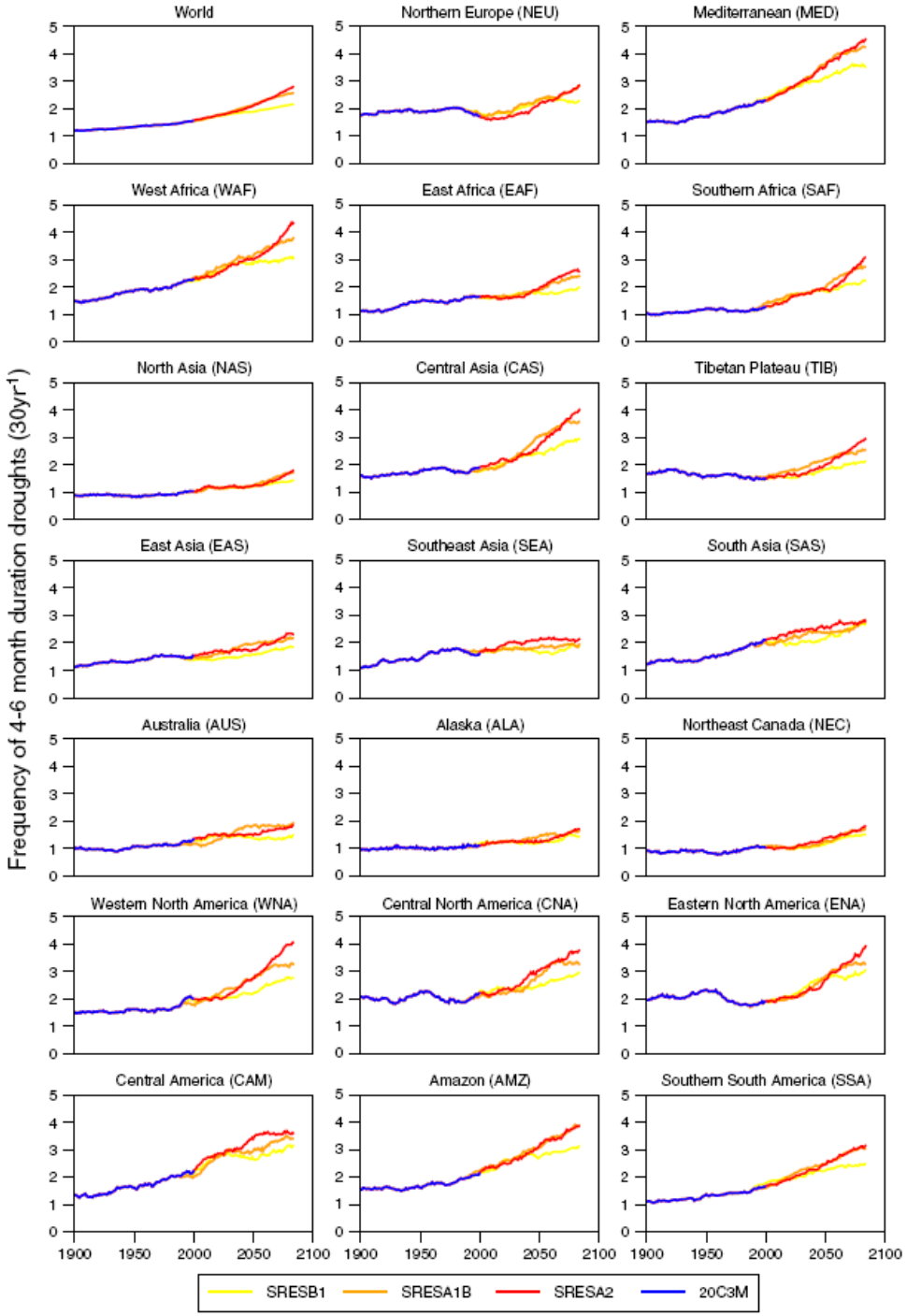
ECMWF

51 members



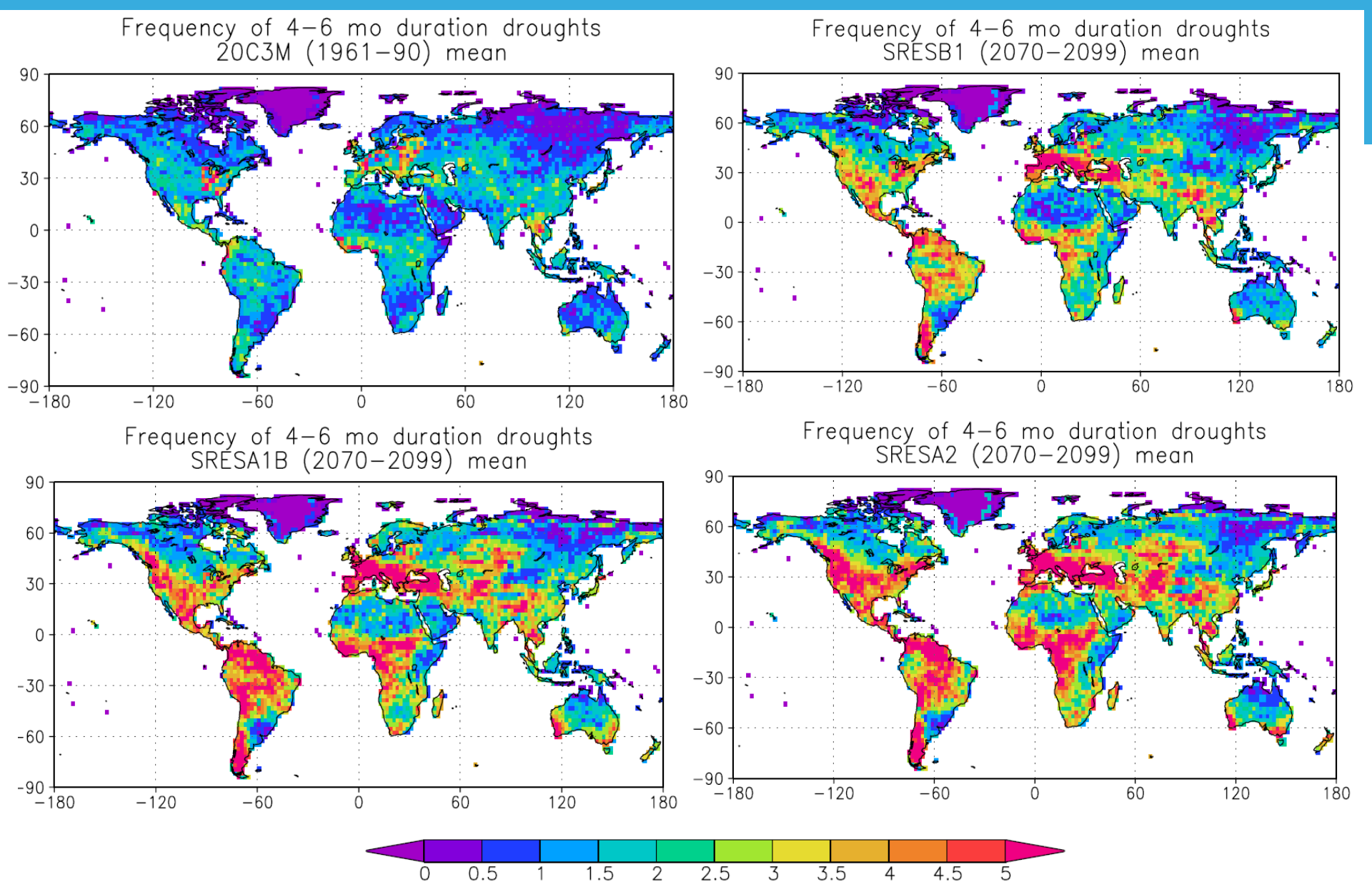
Probability that SPI-3 for the next month is “severe dry” or worse (SPI < -1.5)





Projected changes in drought occurrence

***Sheffield J, Wood, E.**. Projected changes in drought occurrence under future global warming from multi-model, multi-scenario, IPCC AR4 simulations.*
Clim Dyn (2008) 31:79–105

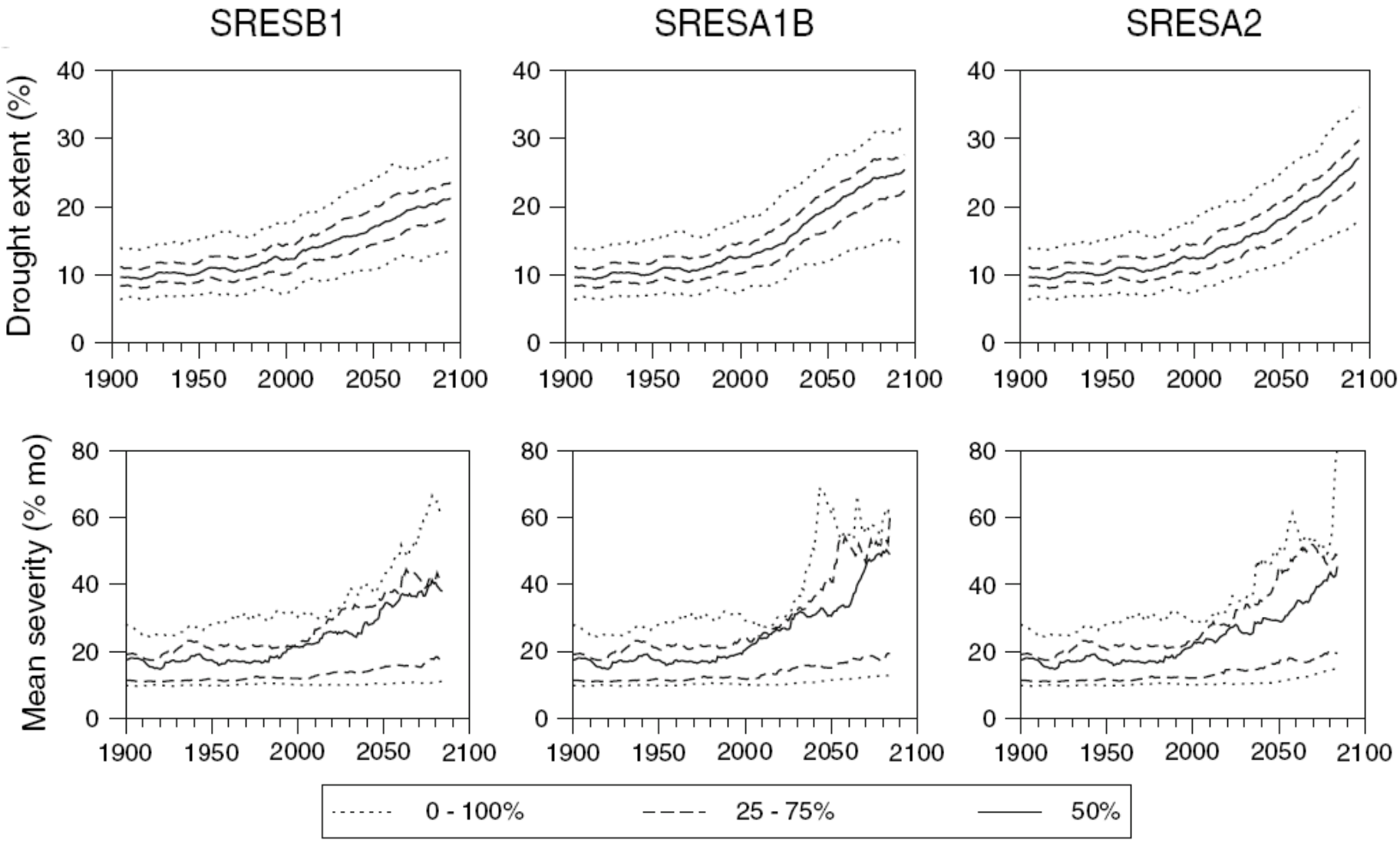


Projected changes in drought occurrence

Joint Research Centre

Justin Sheffield Æ Eric F. Wood. Projected changes in drought occurrence under future global warming from multi-model, multi-scenario, IPCC AR4 simulations. Clim Dyn (2008) 31:79–105

Projected changes in drought occurrence



European Commission

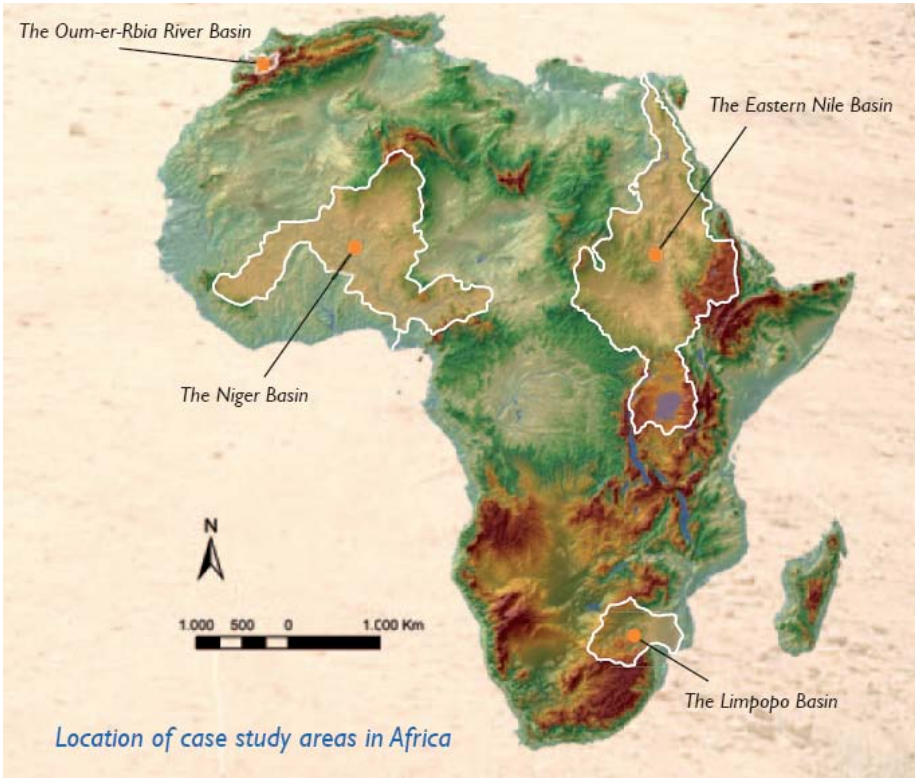
2011-2013

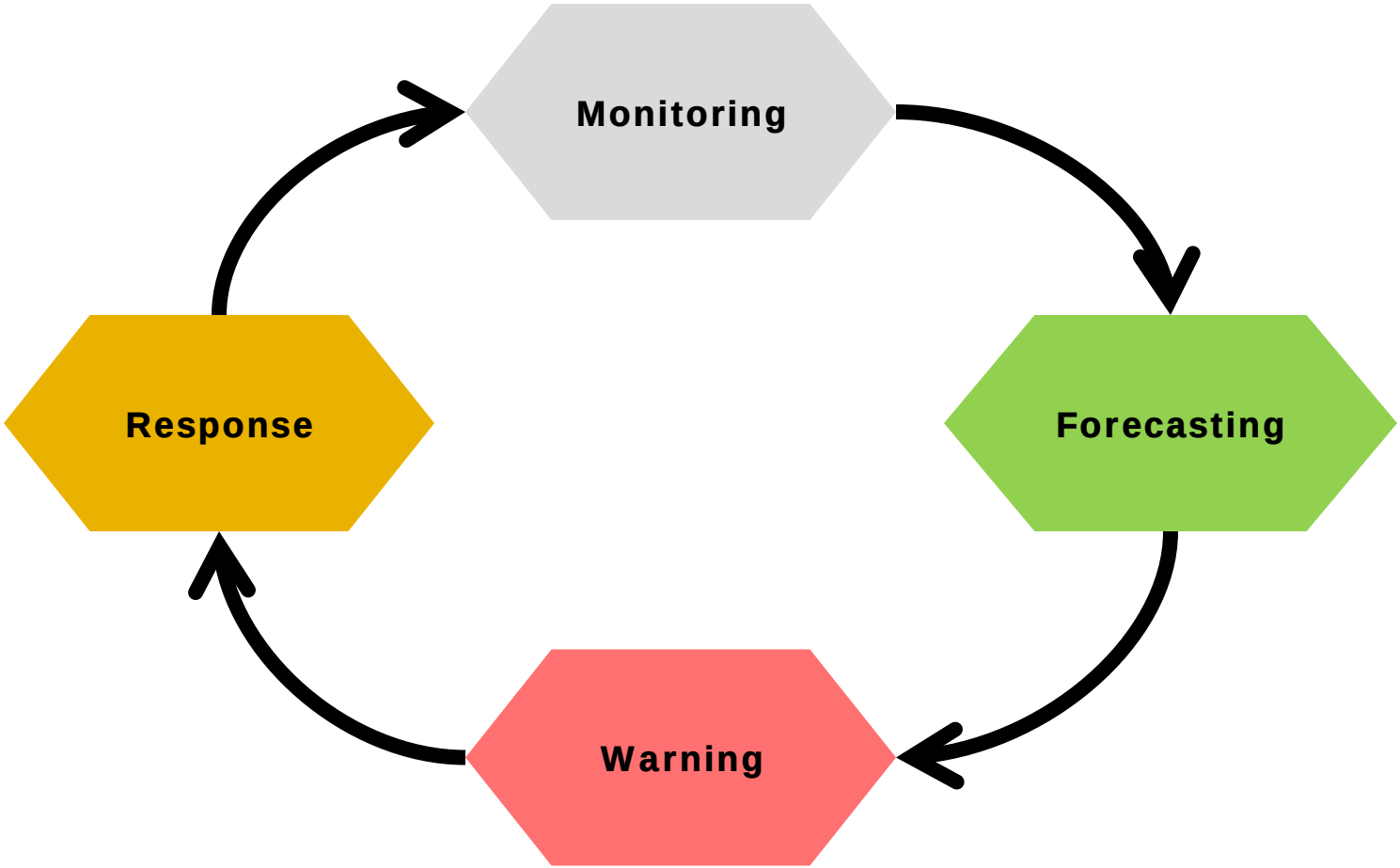
http://www.dewfora.net/

Joint Research Centre

Objectives

- Assessing existing capacities in Africa in term of monitoring, forecasting and warning of drought
- Test new methods to improve forecasting performances
- Improving early warming of drought
- Transferring knowledge




Monitoring
Forecasting
Warning
Response

Drought Management Guidelines (DEWFORA)

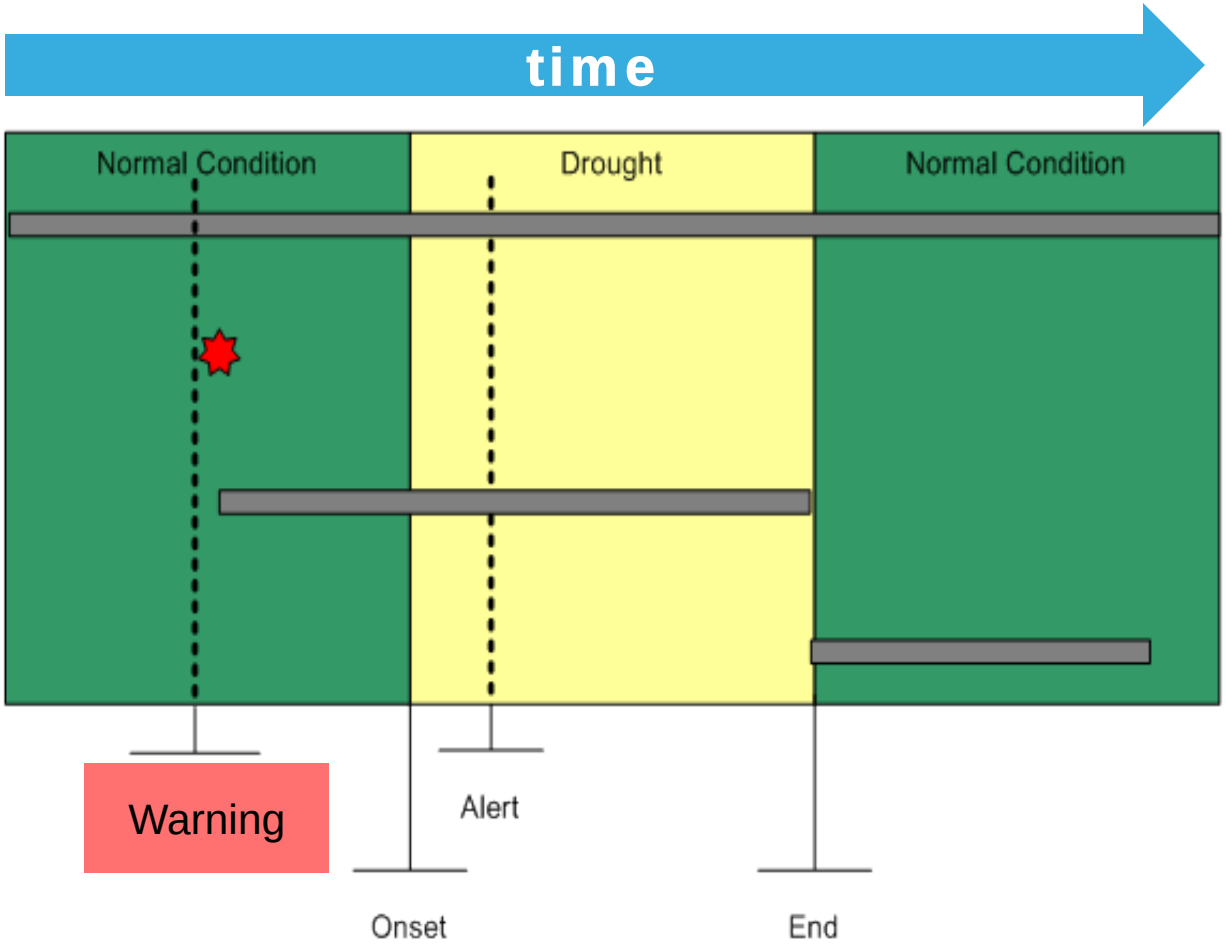
European Commission

Monitoring hydro-meteo variables

Drought forecasting

Implementation of drought mitigation plan

Implementation of post-drought recovery plan



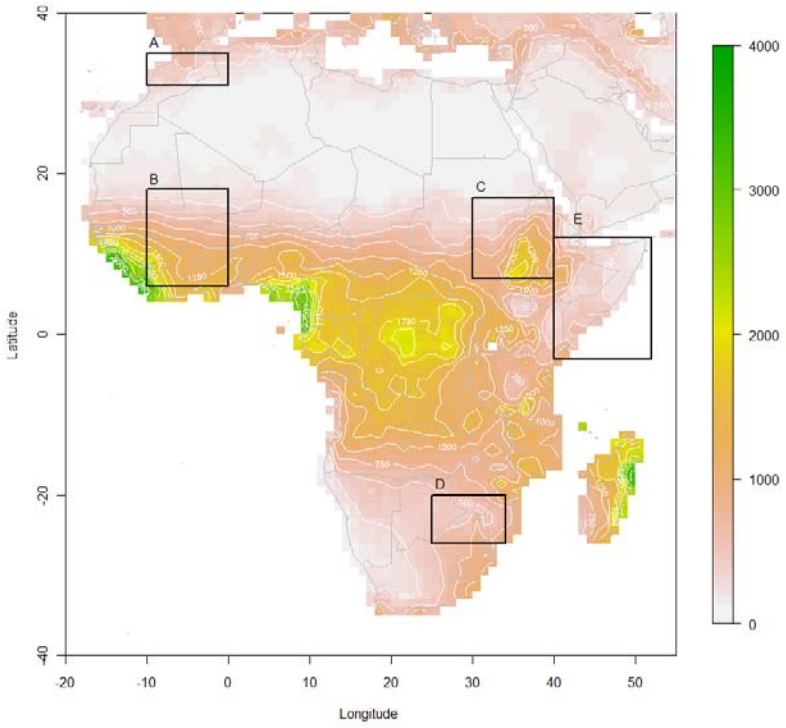
Joint Research Centre

Datasets

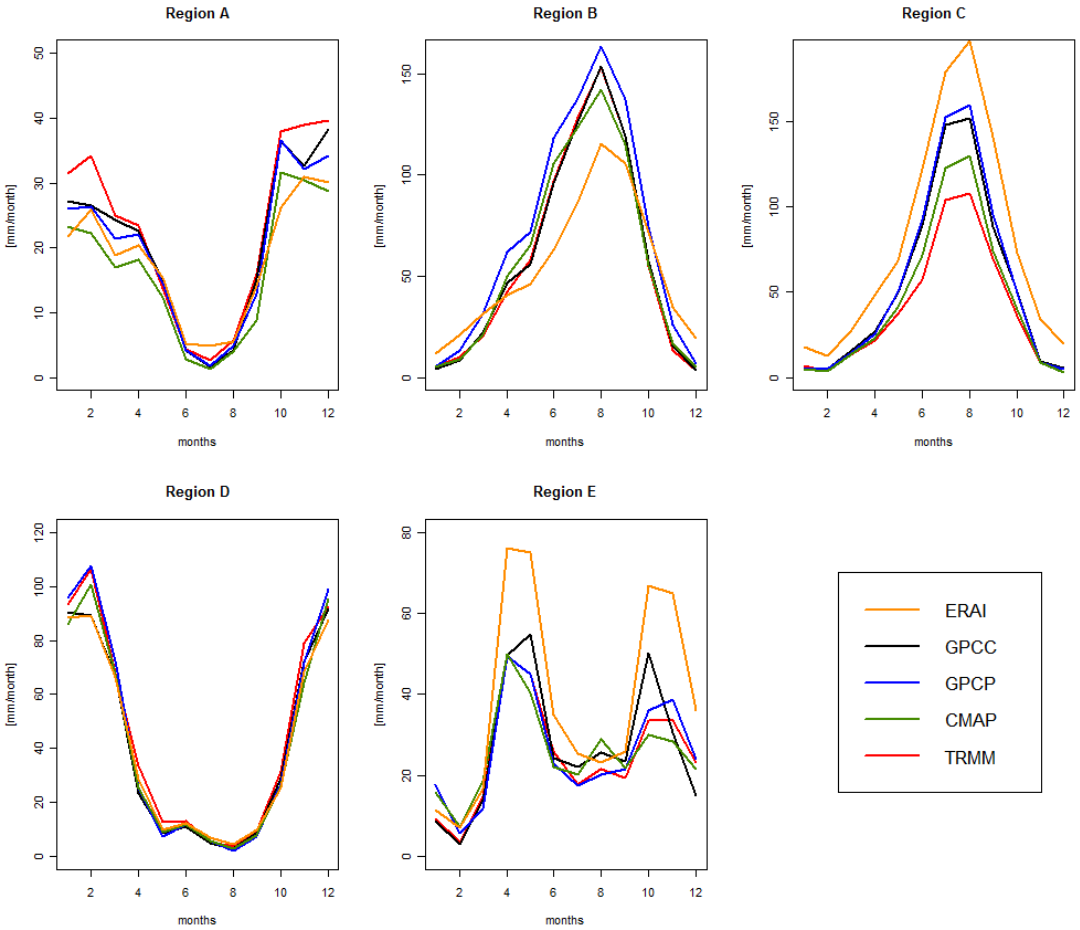
Datasets	resolution	period	Source	delay
ERA INTERIM	0.5ºx0.5º	1979-present	ECMWF Reanalysis	½ month
TRMM 3B-43 **v.6 (v.7 when available)**	0.25ºx0.25	1998-present	RSE (combination 3B-42, CAMS and/or GPCC)	1/2 months
GPCC **v.5**	1ºx1º	1901-2010 (-present)	In-situ data	1 month
GPCP **v.2.2**	2.5ºx2.5º	1979-2010	RSE (merged from microwave, infrared and sounder data and precipitation gauge analyses (GPCC).	irregular
CMAP	2.5ºx2.5º	1979-2009	RSE (GPI, OPI,S SM/I scattering, SSM/I emission and MSU + NCEP/NCAR Reanalysis)	irregular

Description of global datasets available in near-real time and could be used for monitoring precipitation conditions at continental level.

Annual cycle

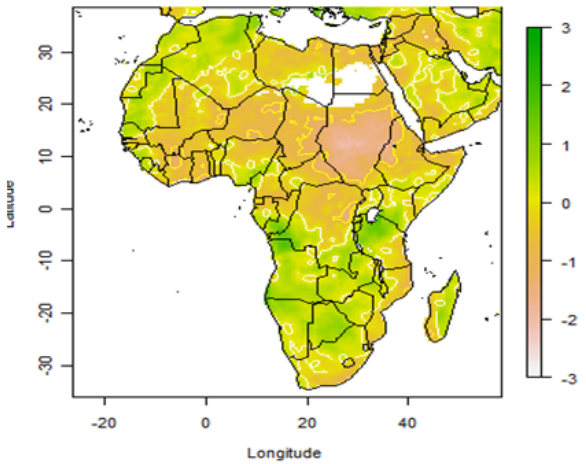


Mean annual cycle of precipitation (1998-2010)

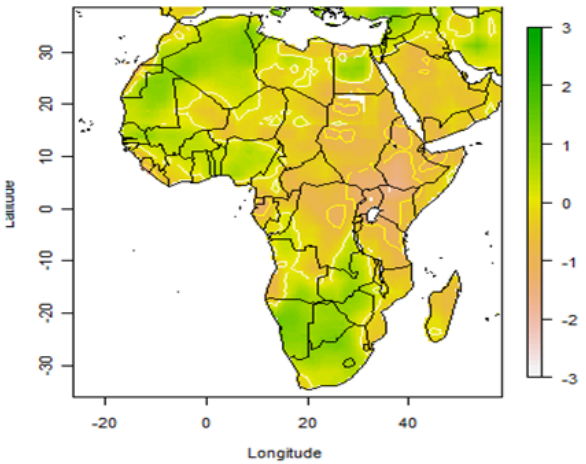


Drought indicators (2009)

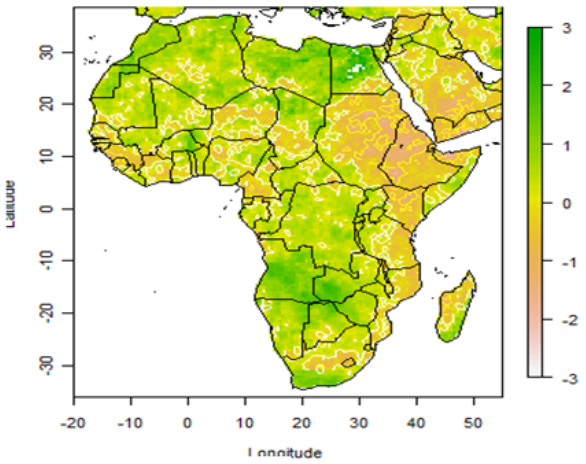
SPI3-ERAI



SPI3-GPCP



SPI3-TRMM



Yearly anomalies in SPI-3 (ERAI, GPCP, TRMM) for 2009.

en

European Commission

JOINT RESEARCH CENTRE

EUROCLIMA - Desertification, Land Degradation and Drought Observatory for Latin America

European Commission > JRC > DLDD Information System

EUROCLIMA | DLDD RESOURCE CENTER | DLDD INFORMATION SYSTEM

DLDD Information System for Latin America

DLDD INFORMATION SYSTEM

- MapViewer
- Compare Indicators
- Indicator by Date

The **DLDD Information System** (Figure 1) will provide the necessary data, information and tools for a comprehensive analysis of the drought phenomenon and the problem of land degradation and desertification in Latin America (LA). The web-based map server is a knowledge transfer platform that aims at being a structure for capacity building in LA and serving as a decision support system on the problems of DLDD for region.

The map server viewer, which is still in development, will allow to retrieve the following information:

- Socio-economical and Biophysical data;
- 10-daily Vegetation Indices (fAPAR, NDVI, NDWI) and respective anomalies derived from medium spatial resolution satellite images (SPOT-VGT, MERIS);
- Time-series of phenological metrics derived from medium spatial resolution satellite images (NOAA-AVHRR);
- Monthly Standardized Precipitation Index (SPI) maps derived from GPCC monitoring products;
- Drought frequency maps;
- National Desertification, Land Degradation and Drought products.

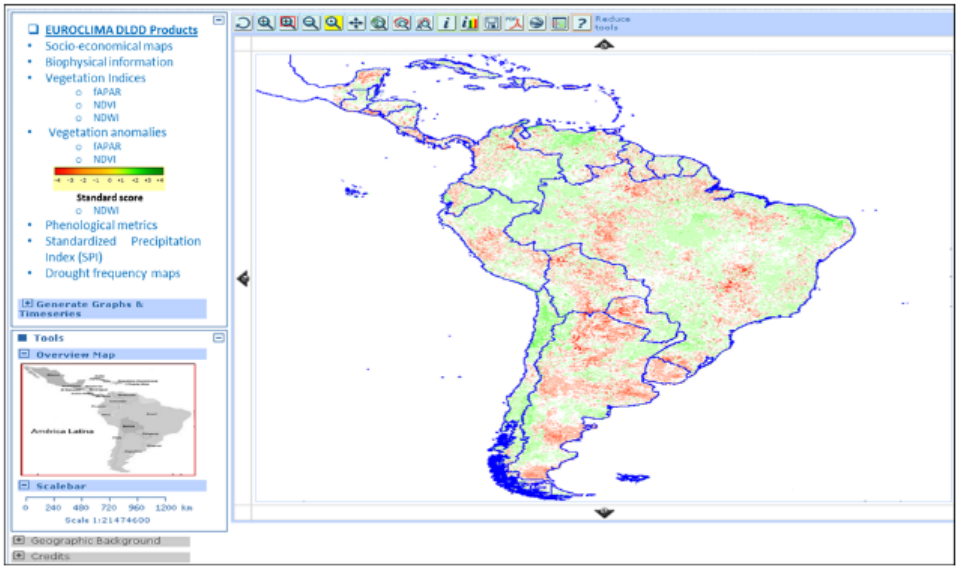


Figure 1: EUROCLIMA DLDD Information System: Example of the Future Mapserver

For more information or to leave feedback please contact **Hugo Carrão**

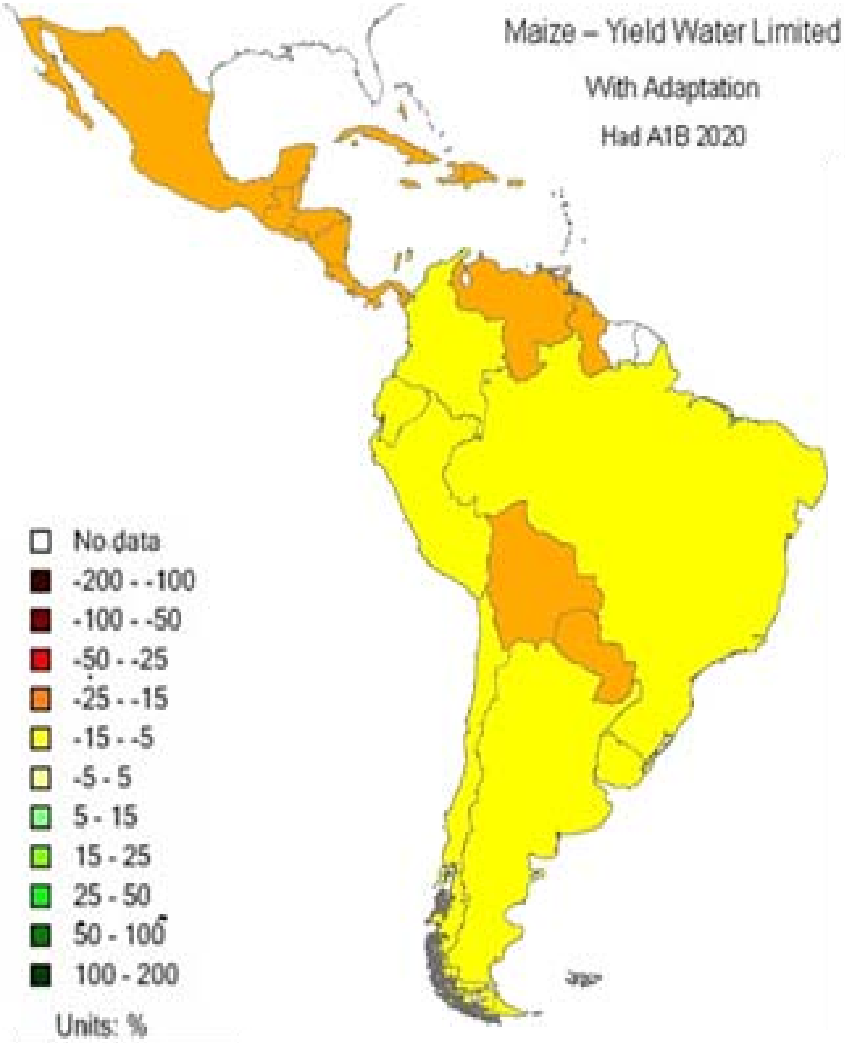
Send a message

Edit this page

See page row

Climate change impacts in LA

European Commission



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CRA IDSIA Lugano-Switzerland BioMA

Climate change impacts in LAC

European Commission

Adaptation strategies

- **Genotype**: the duration of the crop cycle evaluated was medium for the analysis of the baseline, whereas early and late maturity genotypes were also evaluated in the simulation of weather scenarios;
- **Planting time** was explored by testing the anticipation of planting dates;
- **Water supply** was implemented using the same rule-based model used for the baseline simulation, parameterized in order to provide a medium level of water availability as detailed in the simulation protocol.

Climate change impacts in LA

European Commission

Results - maize

- **Relevant impacts** throughout Latin America and Caribbean, **regardless** of either the emission scenario or the GCM used;
- **Reduction** of the **grain filling period**, **not compensated** by higher daily biomass accumulation rate and **CO_2 fertilization**;
- Countries **most affected** were **Brazil, Ecuador, Mexico and Caribbean** countries;
- **Adaptation** strategies **positively contributed** to limit these impacts.

European Commission

DEVELOPMENT AND COOPERATION – EUROPEAID

European Commission > EuropeAid > Where we work > ... > Regional cooperation > EUROCLIMA

- Homepage
- Who we are
- What we do
- Where we work
  - Africa, Caribbean & Pacific
  - Asia & Central Asia
  - Latin America
    - Overview
    - Regional cooperation
    - Country cooperation
  - Gulf region
  - Our Neighbourhood & Russia
  - Overseas territories
- How we work
- Work with us
- Multimedia library

EUROCLIMA - Climate change regional cooperation programme

The EUROCLIMA regional cooperation programme was approved by the European Commission on 18 December 2009 to encourage cooperation between Latin America and the EU on climate change issues. The total foreseen Commission budget for this project is €5 million.

Call for tenders for services contract

- **4th February 2010**: Individual service contract forecast.

Provisional dates:

- **May 2010**: Procurement notice.

Regional cooperation

- RALCEA
- LAIF
- Euroclima
  - In detail
- Copolad
- Alfa
- Alban
- Al-Invest
- @LIS
- Urbal
- Euro-Solar
- Eurosocial

Key documents

- Climate change in Latin America
- Lima declaration

Contact

- Europeaid- cooperation office. Latin America

Joint Research Centre

European Commission

FLOODING

Joint Research Centre

Flood early warning systems as a tool for adaptation to climate change:

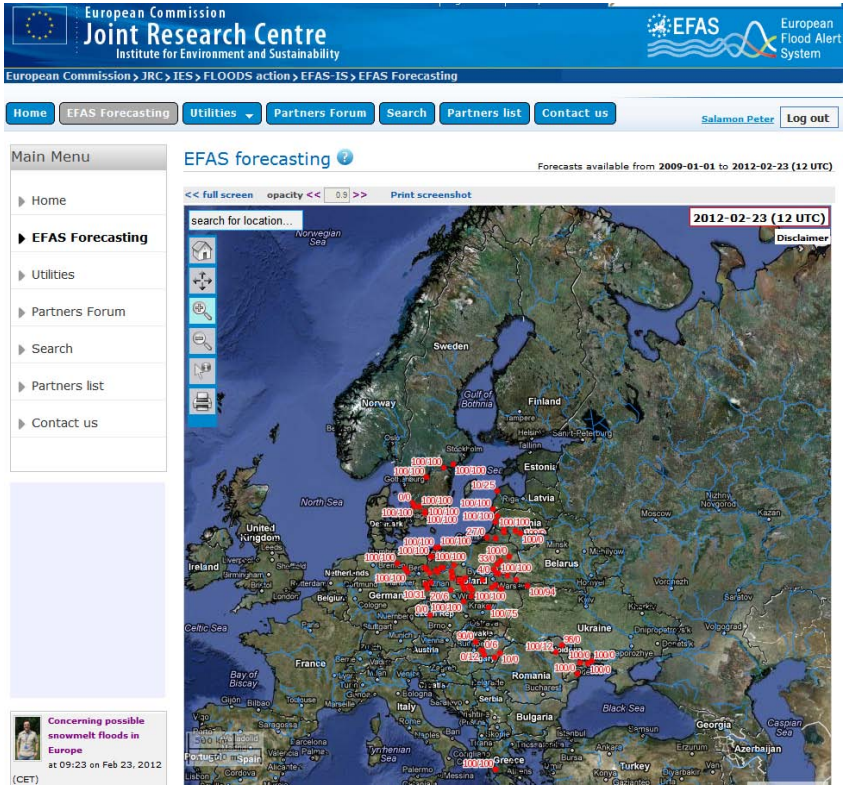
European Commission

European Flood Awareness System

Main purpose:

Improving preparedness for floods in Europe

- Added value for national systems
- Harmonized information for European crisis management (EC MIC)
- Knowledge exchange platform
- Network of operational flood forecasting services in Europe



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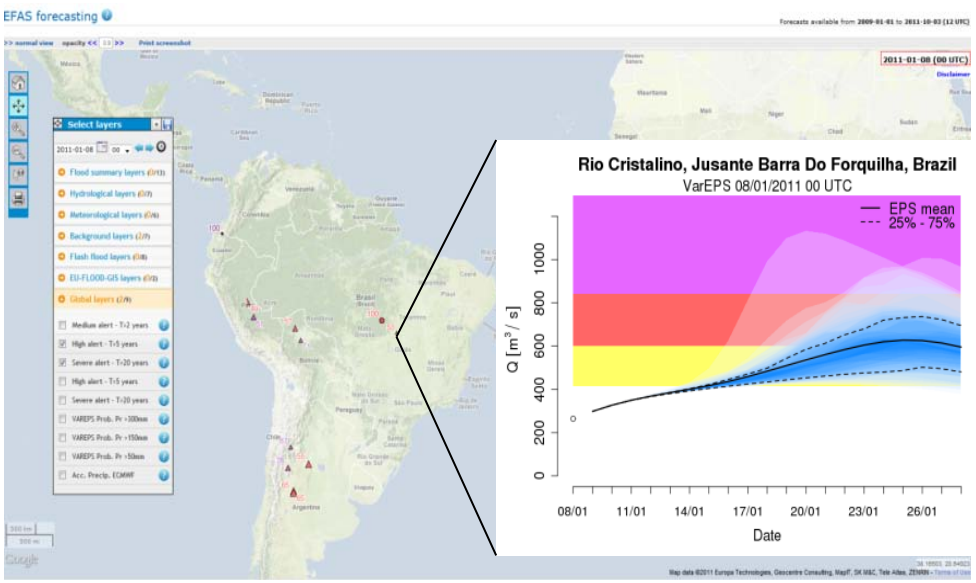
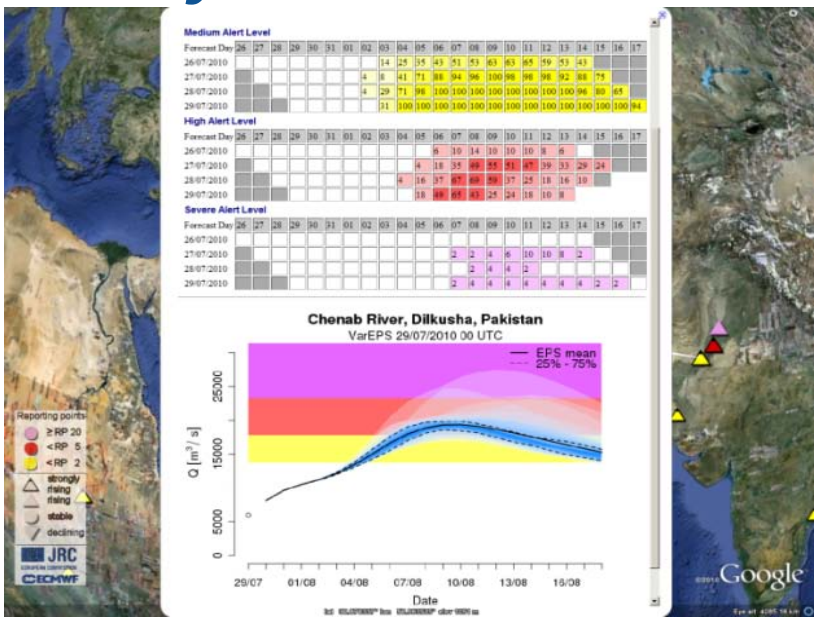
Global Flood Alert System

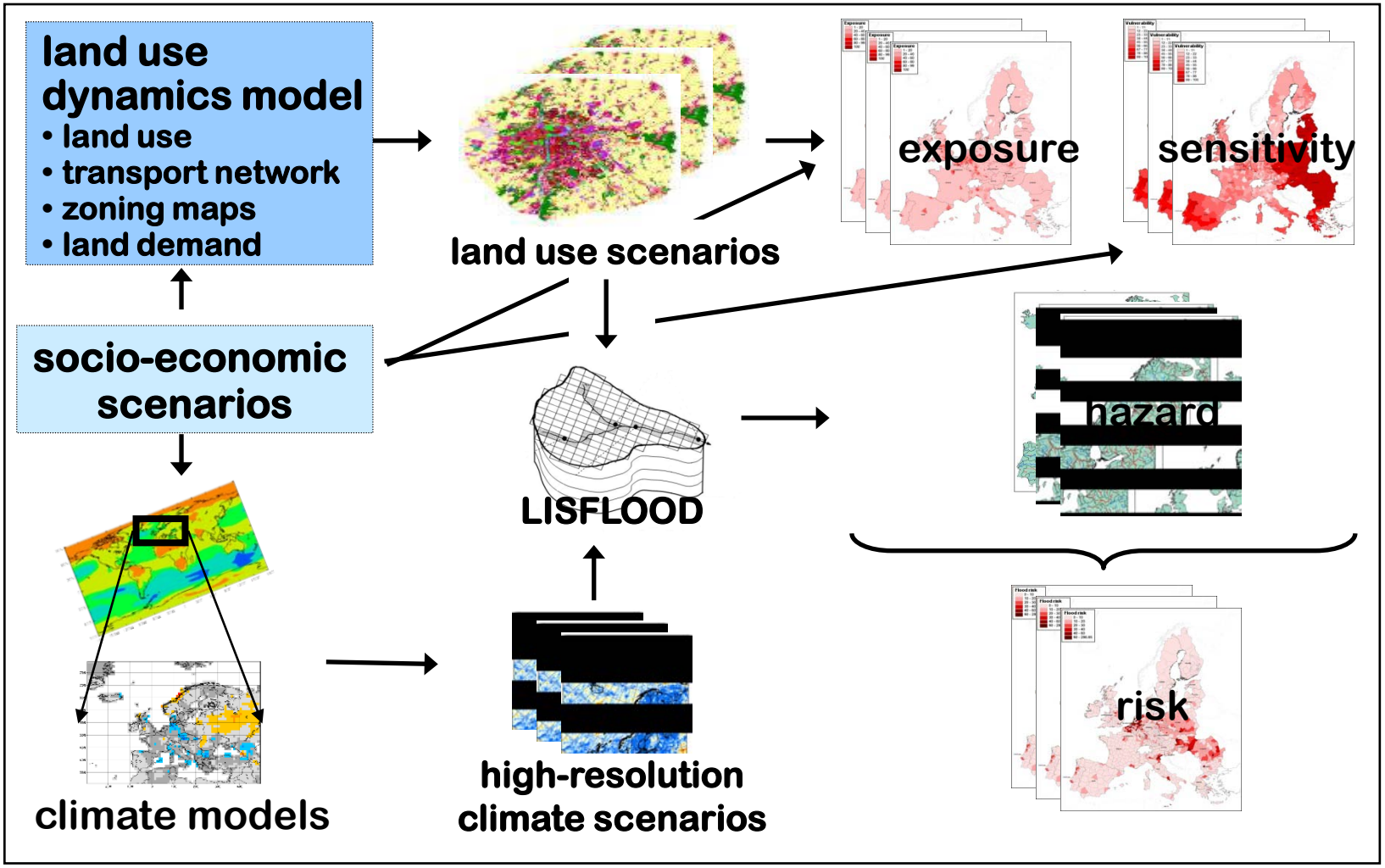




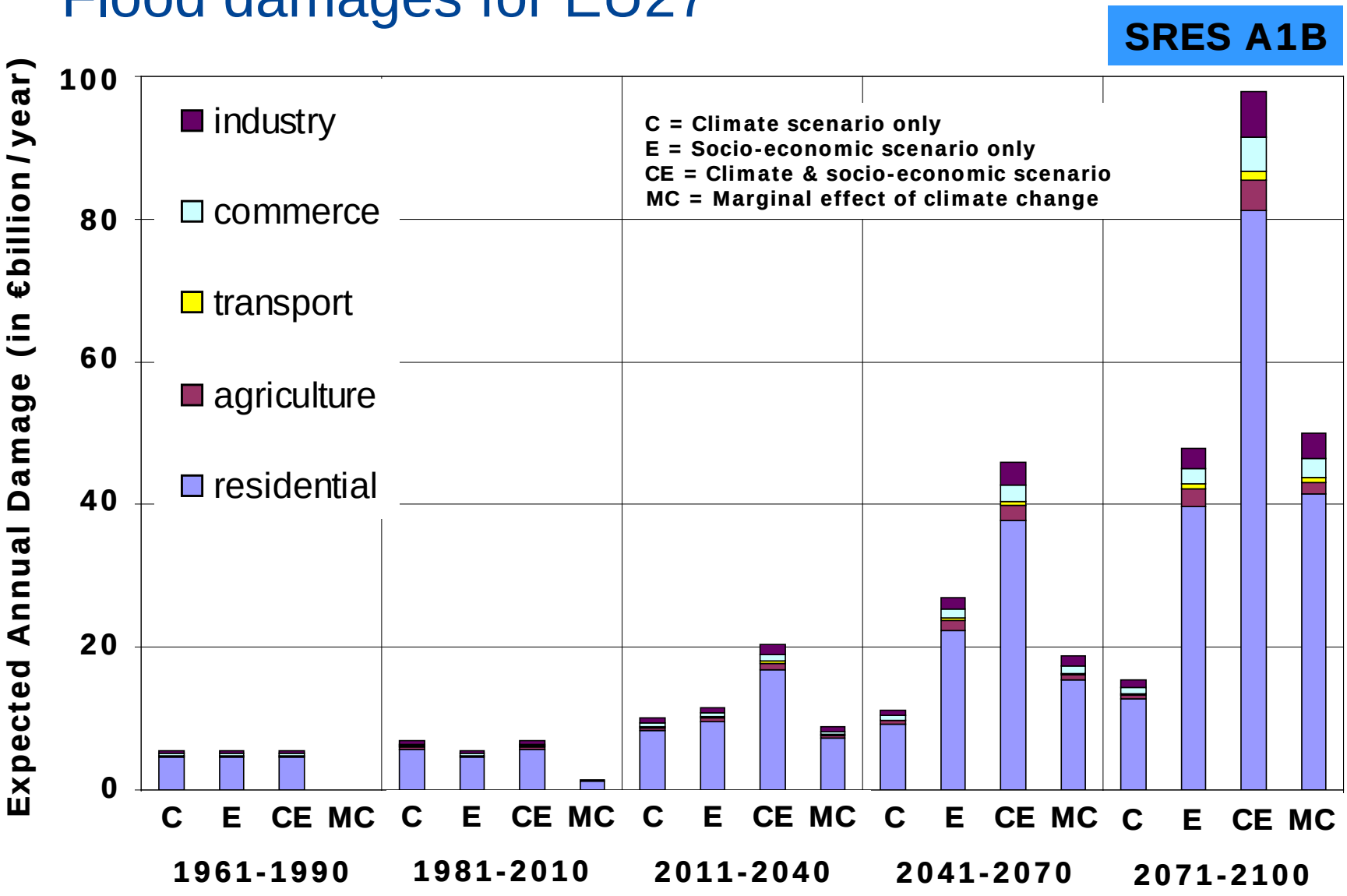
Main purpose: improving preparedness for floods worldwide

- Only source of flood forecast information for some regions
- Harmonized information for global crisis management organizations (e.g. Red Cross, EC MIC…)
- Promoting early warning systems as efficient risk reduction tools

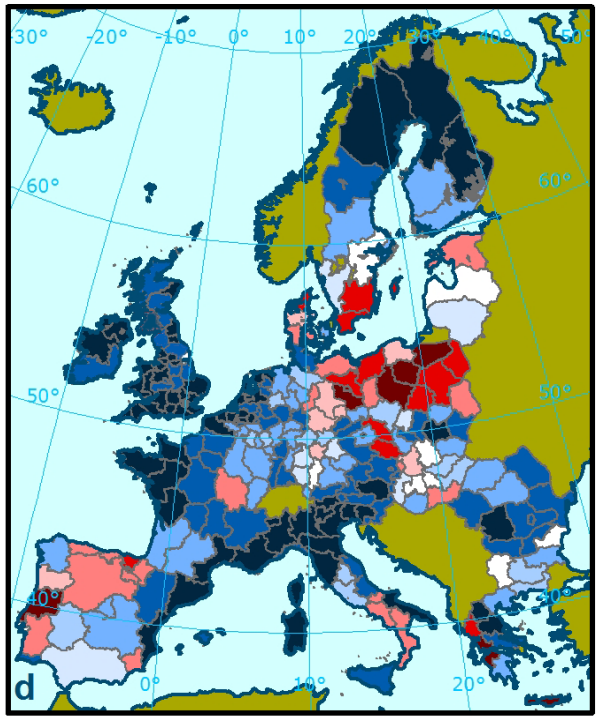
Assessing Pan-European Flood Risk under current and future climate

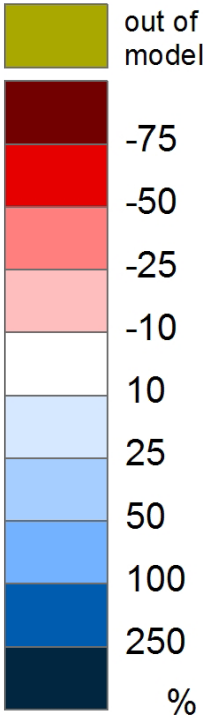


Flood damages for EU27



Projected change in flood damage





Relative change between 1961-1990 and 2080s
(only climate change, static exposure)

SRES A1B

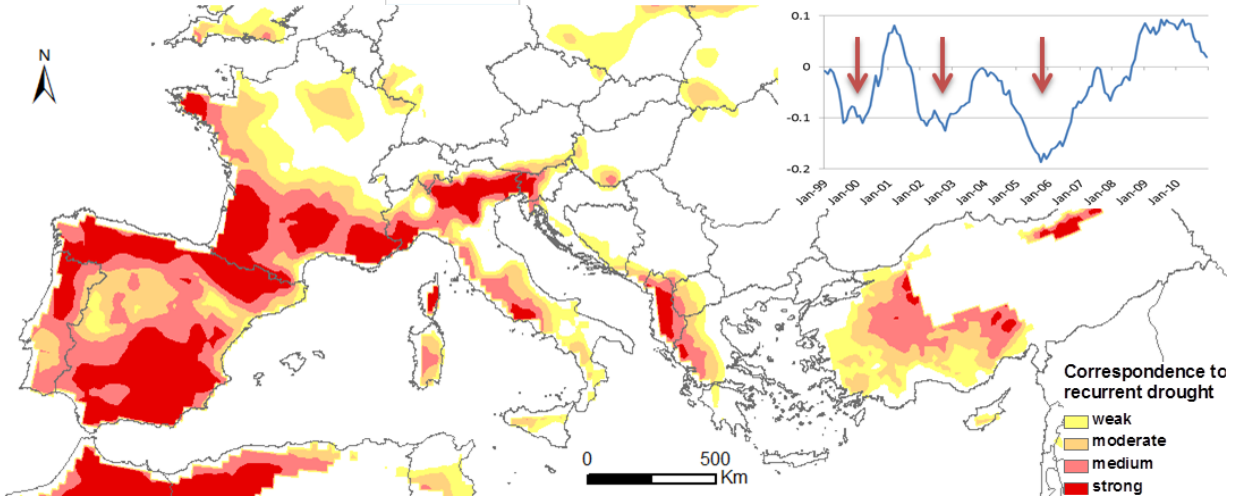
Joint Research Centre

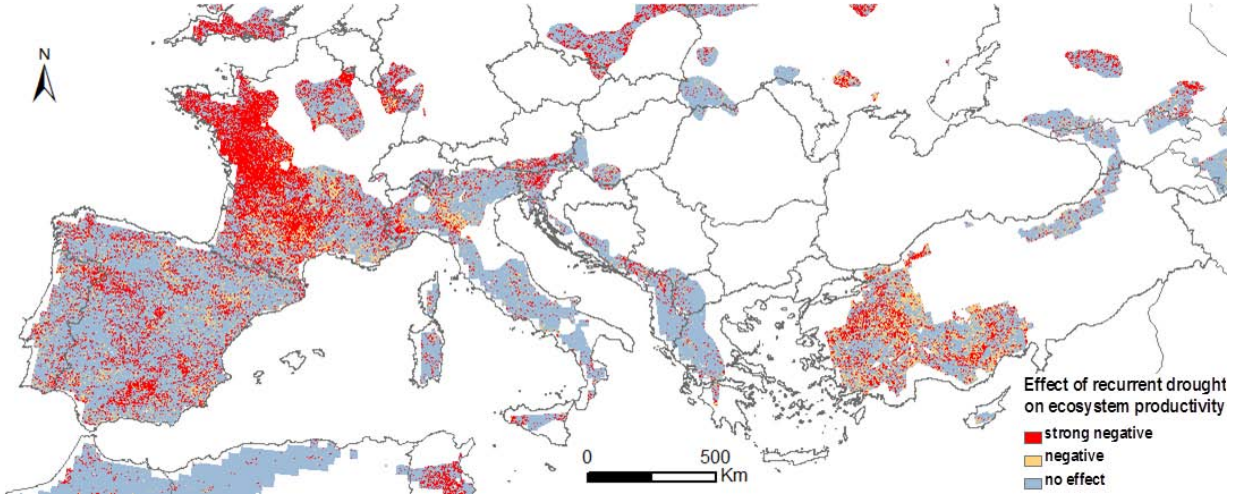
DESERTIFICATION
&
LAND DEGRADATION

Joint Research Centre

European Commission

Assessment of impact of **recurrent droughts** on the ecosystem dynamics for assessing cause-effect with **land degradation**





Joint Research Centre

Land degradation

Global problem:

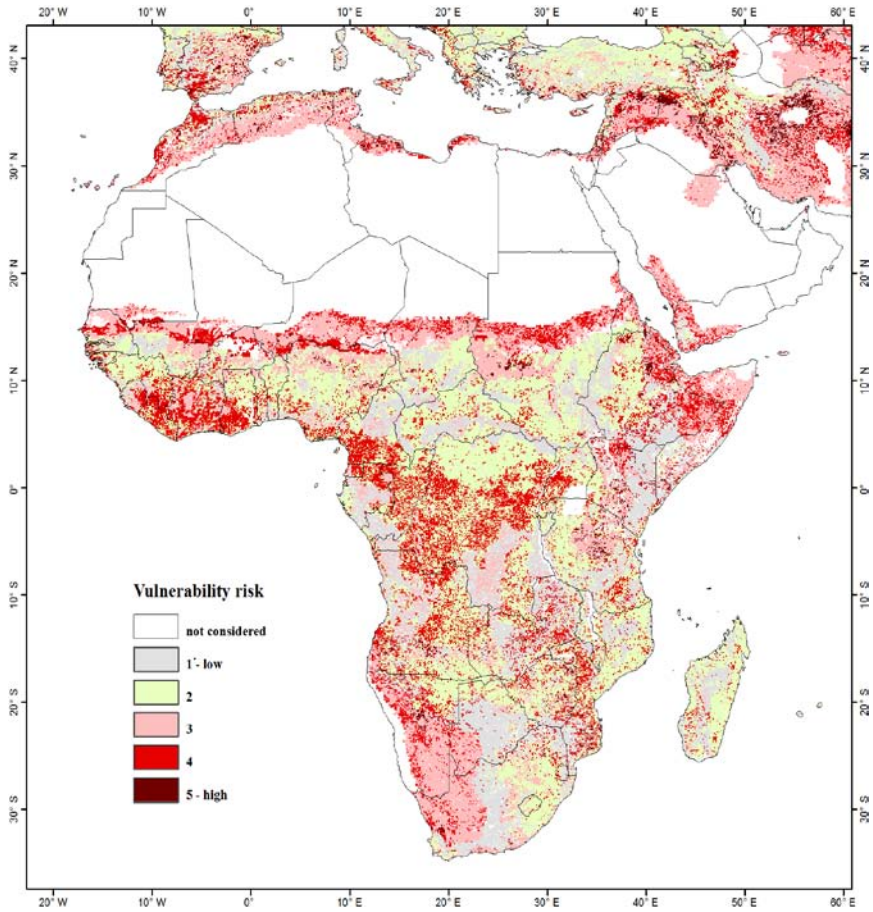
10- 35 % of land surface affected
loss of 24 bill. tons of fertile soil/yr
12% reduction in food production next 25 yrs.

Drylands:

40% of the world surface; +- 2 bill. People
44% of cultivated land in drylands
10-20 % affected by land degradation

Africa:

* approx. 20% of land surface suffered consistent decrease in productivity during last three decades *(JRC estimate)*
* 50,000 km^2 of natural vegetation converted to agriculture each year



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UNCCD statements on: Land degradation, desertification & climate change

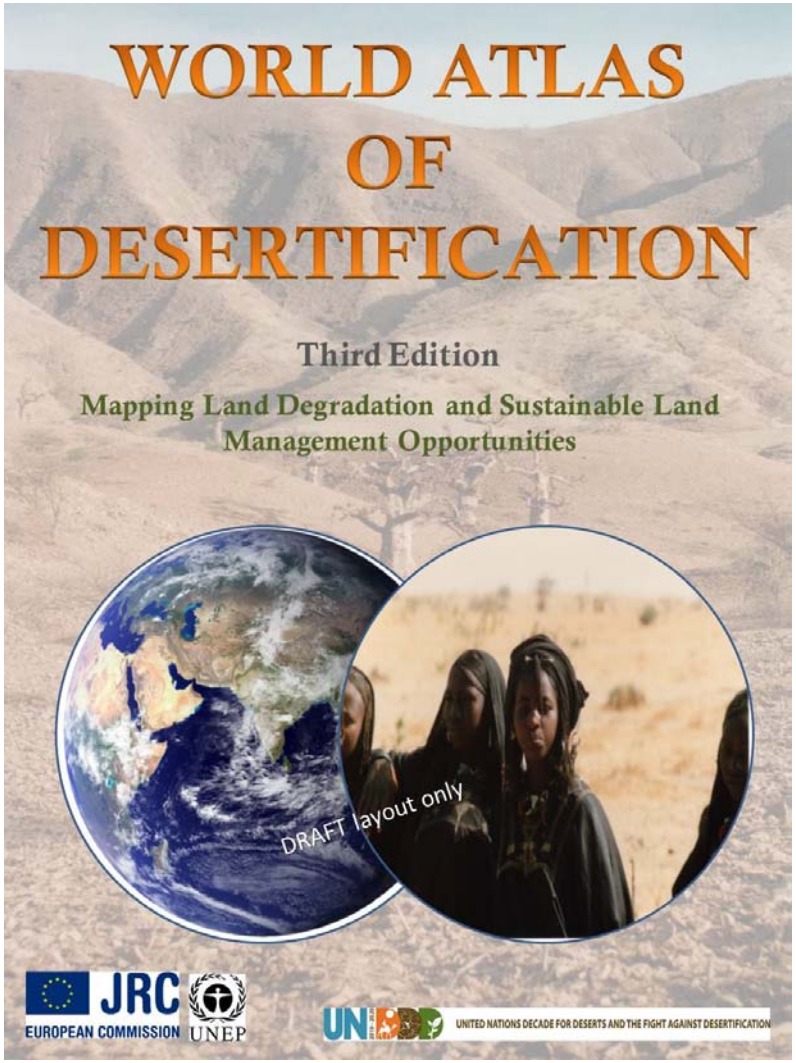
European Commission

UNCCD definition of land degradation assign ample importance to climatic factors contributing to land degradation, but no concerted global effort to identify and monitor fully the effects and feedbacks.

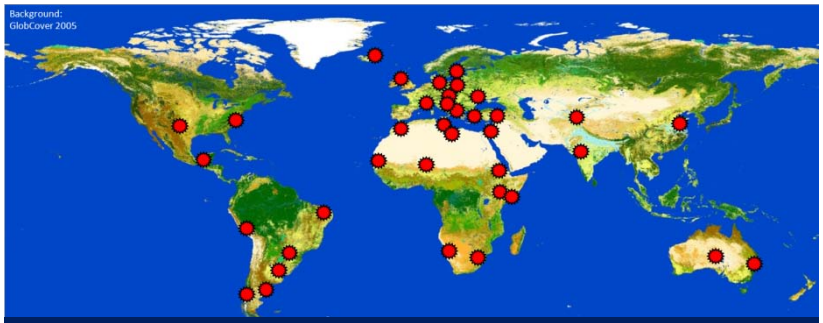
UNCCD reports facts and figures:

- Current agricultural practices represent over 13% GHG emissions
- **Climate change will depress agricultural yields by up to 15-50%** in most countries by 2050
- **Percentage of earth's land stricken by serious drought has more than doubled from '70s to 2000s** (to be checked!)

For sure Climate change has effects on rainfall, drought, floods, solar radiation which through land use influence land degradation
(How, how much and where!)



- foundation to address the global challenges related to desertification and land degradation, including climate change
- global reference and contribution to the attempt for a land degradation neutral world
- crucial aspects on the linkage of land degradation with food security, poverty-reduction, resource efficiency, land-market issues, biodiversity and climate change



Coordinated by JRC
In collaboration with UNEP, FAO and an extensive global network of experts

Joint Research Centre

Key messages:

- Climate is changing and will continue to change
- Understanding of the climate system and its prediction is continuously improving
- "Scale" approach issue:
  climate drivers: global scale
  impacts drivers: very locally specific
- High complexity of the natural phenomena and their impacts mirrored on mitigation/adaptation strategies
- Local studies/analyses are necessary to "tune" local strategies and actions in order to be "climate charge compliance"

Thank you!

fabio.micale@jrc.ec.europa.eu

http://desert.jrc.ec.europa.eu/

http://edo.jrc.ec.europa.eu/