Drought monitoring and early warning indicators as tools for climate change adaptation

Lučka Kajfež Bogataj,
University of Ljubljana, Slovenia

Integrated Drought Management Programme in Central and Eastern Europe
A GWP and WMO initiative
Bratislava
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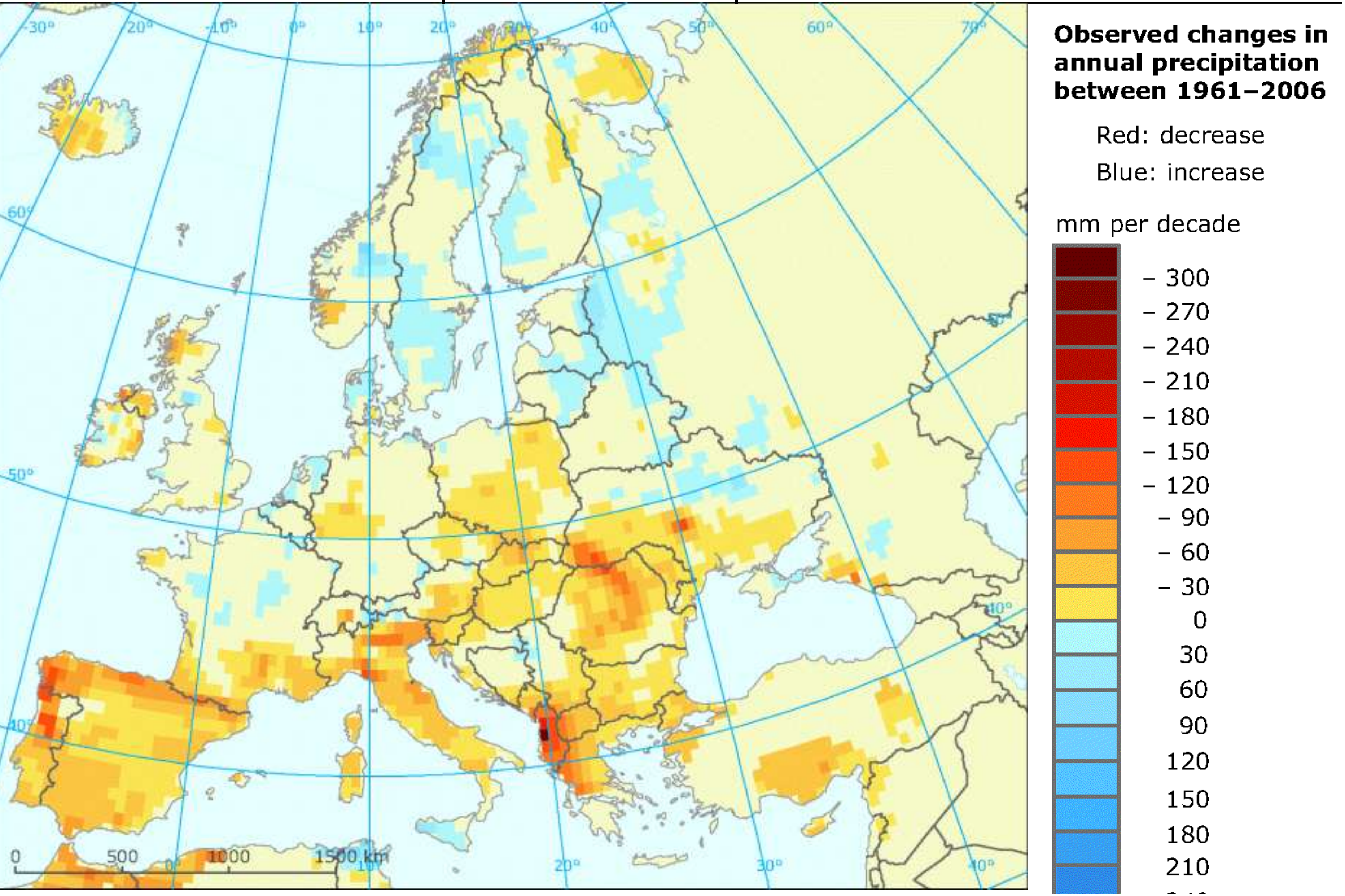
3 classes of water problems in CEE

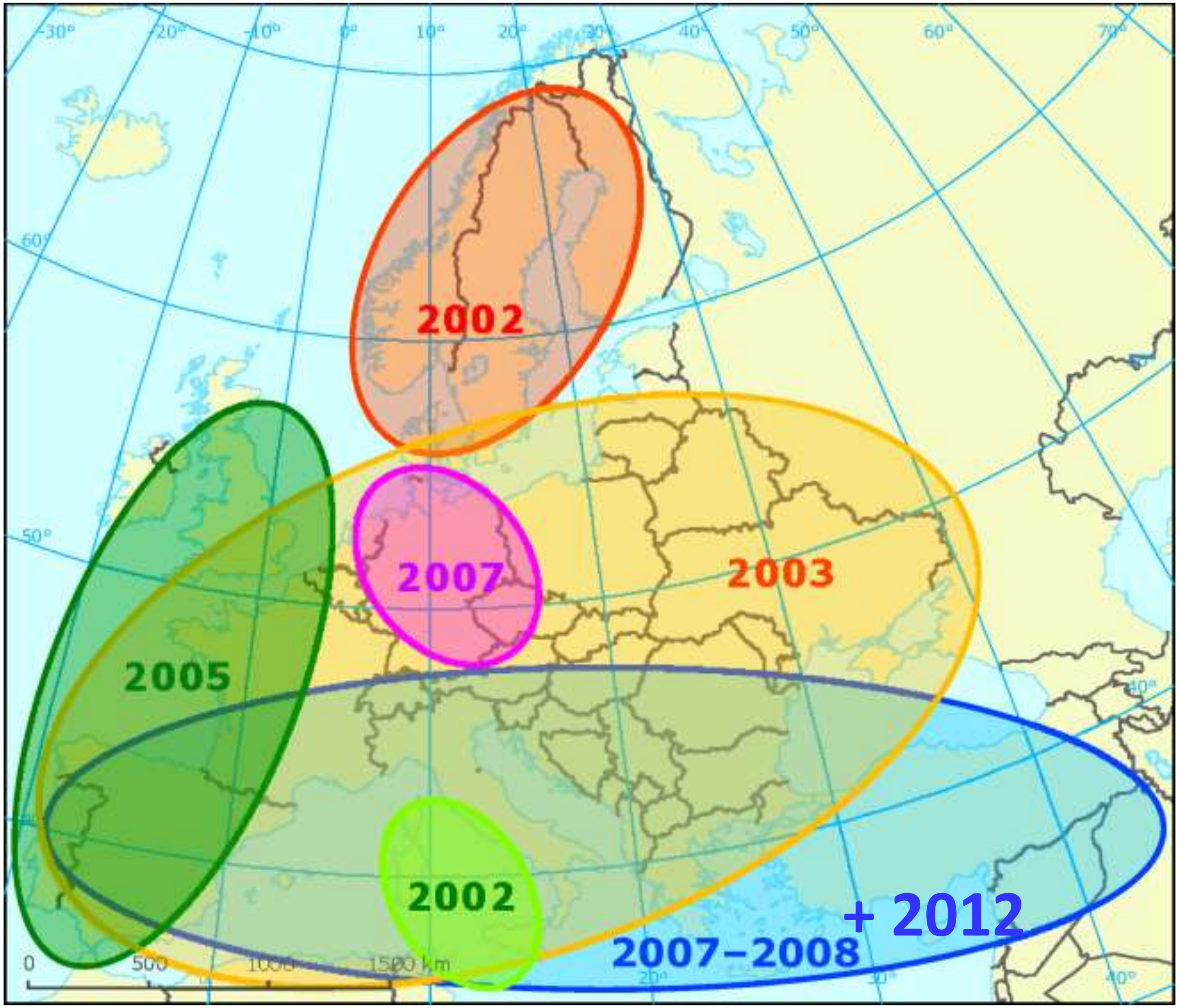
- too little water
- too much water
- water pollution

Can (and will) be exacerbated by climate change

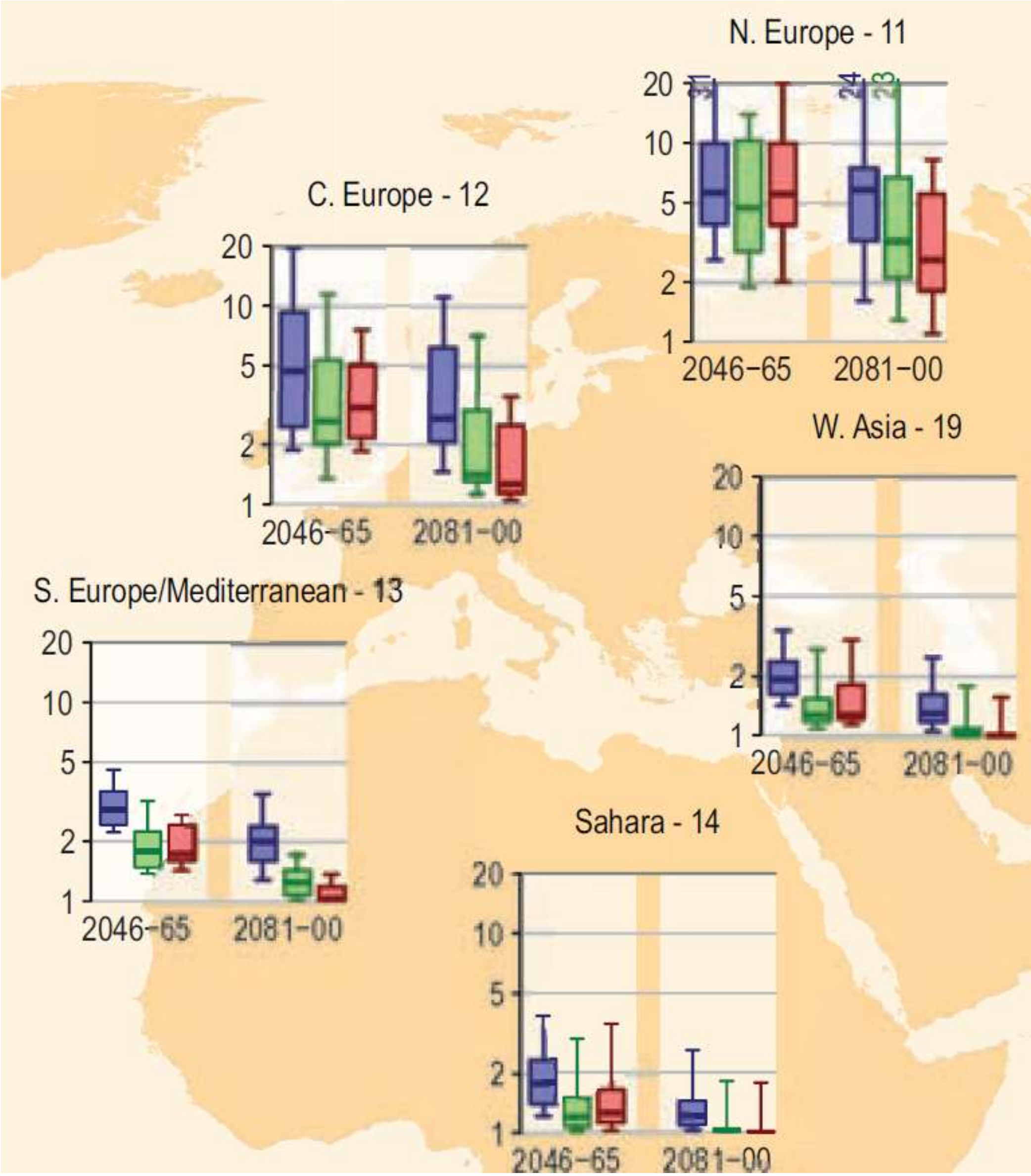
EEA www.eea.europa.eu/data-and-maps/

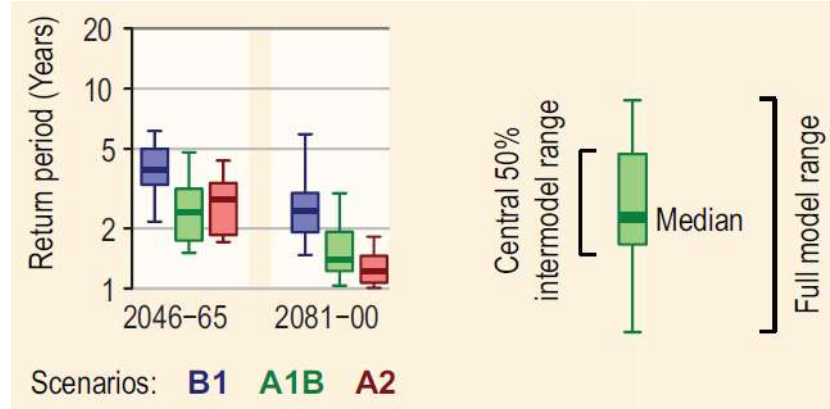


Main drought events in Europe, 2000–2009



Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (IPCC , 2012)



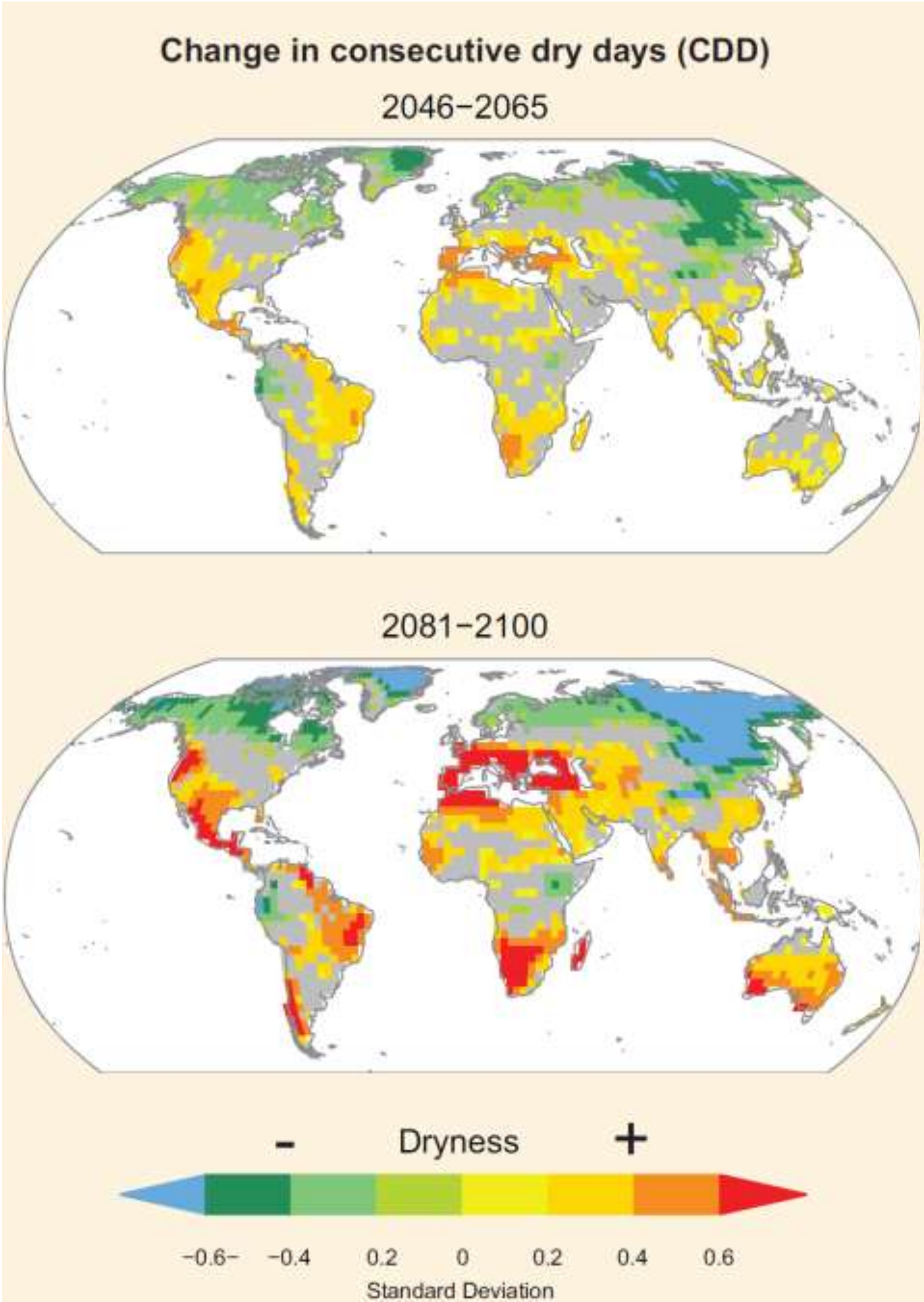


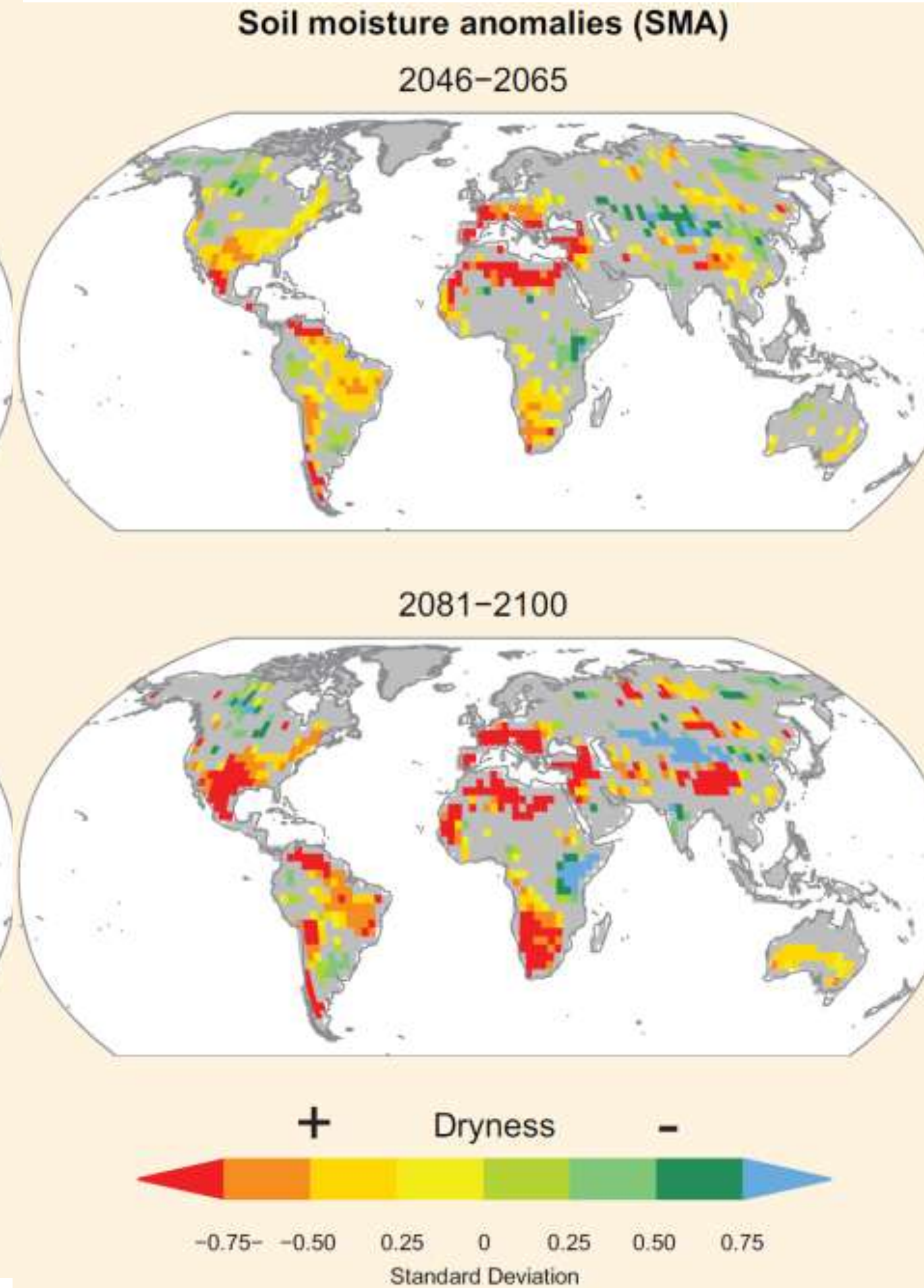
Decrease in return period implies more frequent extreme temperature events

The time between "20-year" (unusually) warm days will decrease

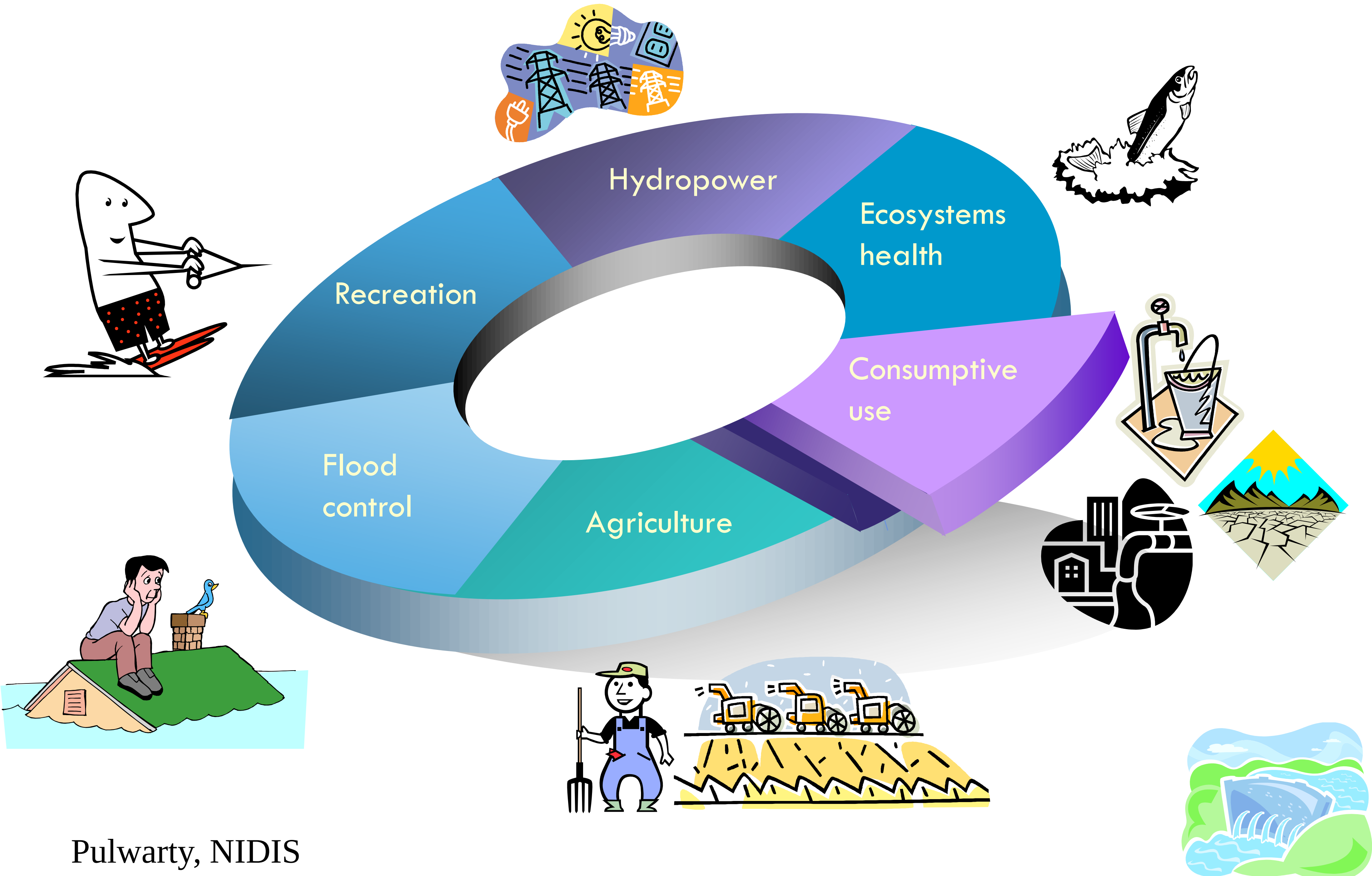
IPCC SREX: on drougt

- There is *medium confidence that droughts will intensify in the 21st century in some seasons* and areas, due to reduced precipitation and/or increased evapotranspiration.
- This applies to regions **including southern Europe and the Mediterranean region, central Europe**, central North America, Central America and Mexico, NE Brazil, and S Africa.


Change in consecutive dry days (CDD)
2046−2065
2081−2100
-
Dryness
+
−0.6− −0.4 0.2 0 0.2 0.4 0.6
Standard Deviation


Soil moisture anomalies (SMA)
2046−2065
2081−2100
+
Dryness
-
−0.75− −0.50 0.25 0 0.25 0.50 0.75
Standard Deviation

Multiple competing objectives



Pulwarty, NIDIS

Just what is drought?

- Precipitation deficits?
- Soil moisture?
- Streamflow?
- Plants wilting?
- Wildfire?
- Famine?
- Other?

Drought is a multi-faceted issue and requires a multi-faceted assessment.

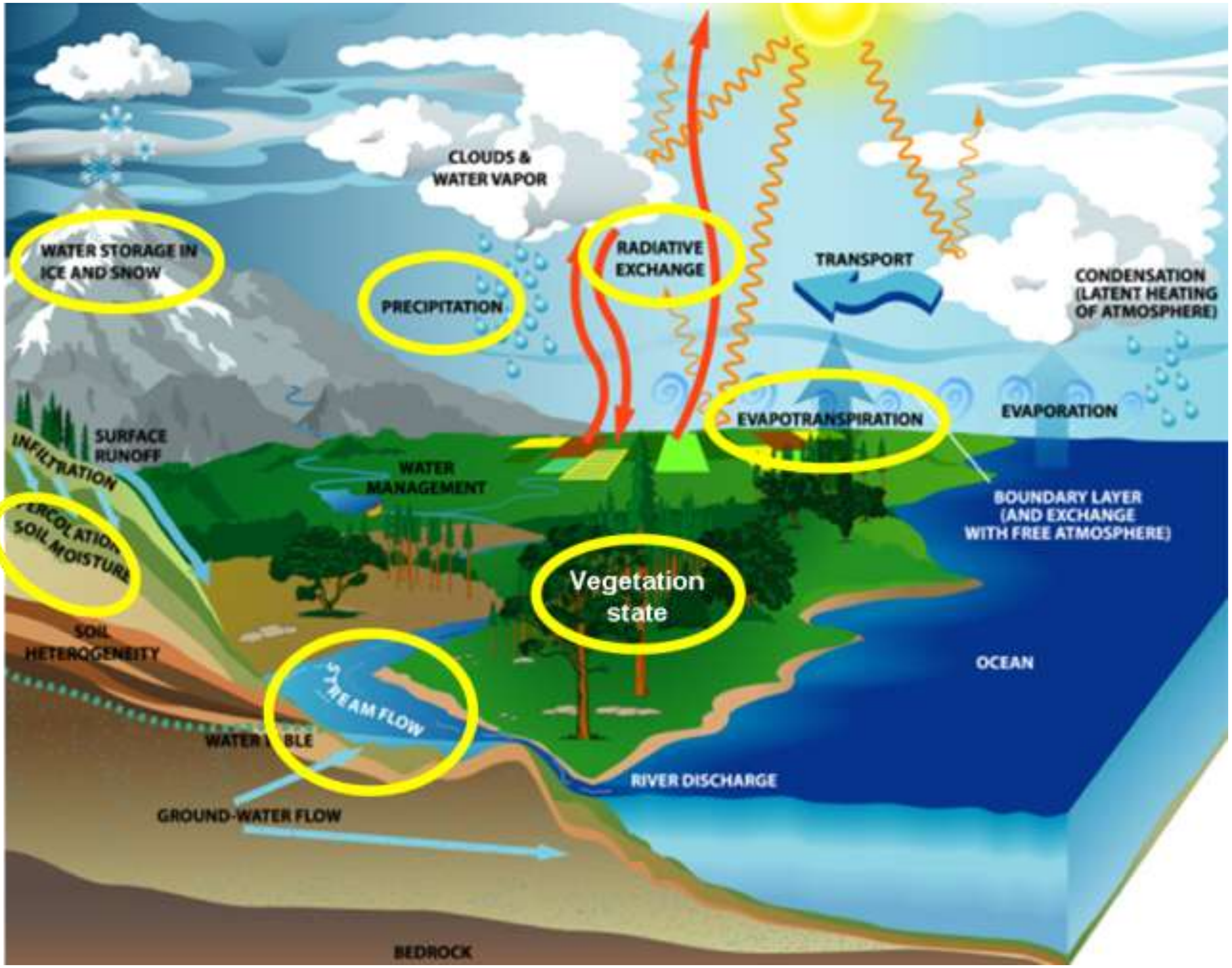
Key Variables for Monitoring Drought

- climate data
- soil moisture
- stream flow
- ground water
- reservoir and lake levels
- snow pack
- short, medium, and long range forecasts
- vegetation health/stress and fire danger

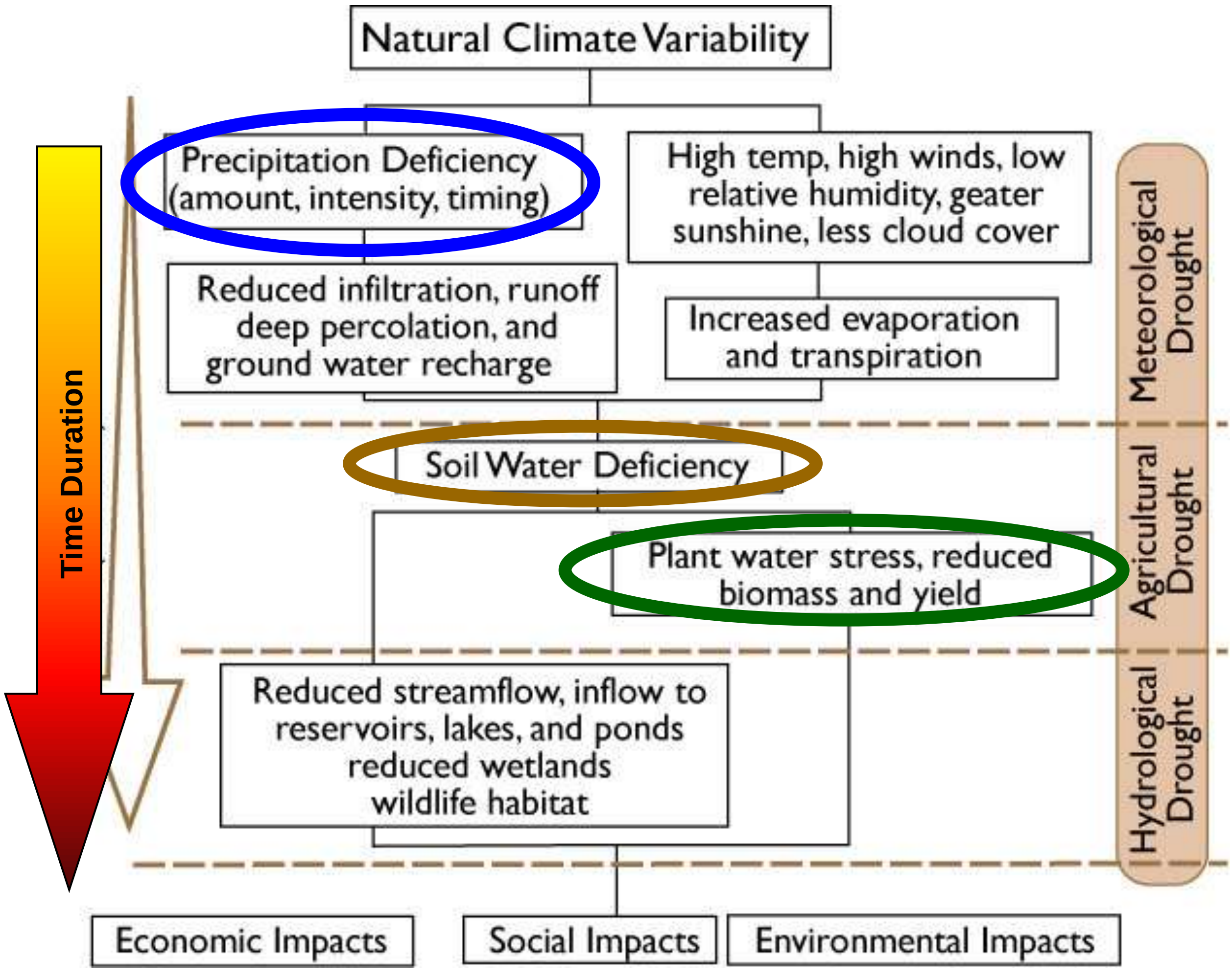
Different Drought indicators

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.



Multi-Indicator Approach



at continental scale

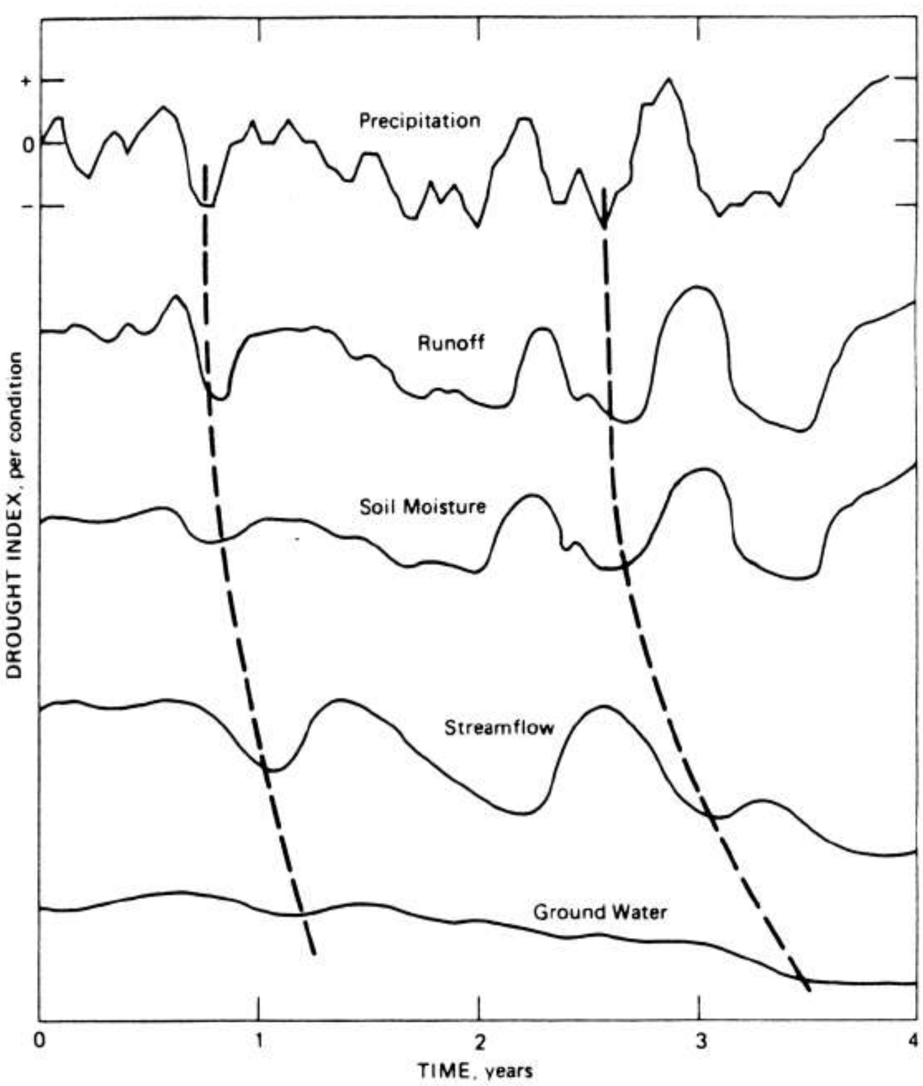
Standardized Precipitation Index

Soil Moisture Anomaly

Vegetation Response

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

Proceeding of precipitation deficit throughout the hydrological cycle



(Rasmusson, 1993)

Agricultural Drought Indices

- Agricultural drought indices should be based on soil moisture and evapotranspiration deficits and should help effectively monitor agricultural drought.
- A drought index should integrate various parameters like RR, T, ET, runoff and other water supply indicators into a single number and give a comprehensive picture for decision-making.

WMO, 2008

A consensus agricultural drought index?

- A consensus agricultural drought index should help explain not only the degree of severity of droughts, but also assist policy makers in taking early actions.
- Depending upon available data and resources a composite agricultural index is the best means of achieving a standard consensus index.
- Until the resources are available for the composite index, a simple index incorporating rainfall and soil moisture should first be adopted, then water balance index should be tiered into the agricultural drought indexing methodology. Finally, as the data and resource become available, a composite agricultural drought index should be adopted as a standard for monitoring the onset, severity, and end of agricultural drought.

SIMPLE APPROACH
Precipitation Departures

- Precipitation the key indicator for vegetation growth, water resources
- Temperature effects also important, but precipitation dominates
- Measured virtually everywhere
- Easy to calculate
- Can be done for points or over areas (such as a state or climate division)

Palmer Drought Severity Index (PDSI), 1965

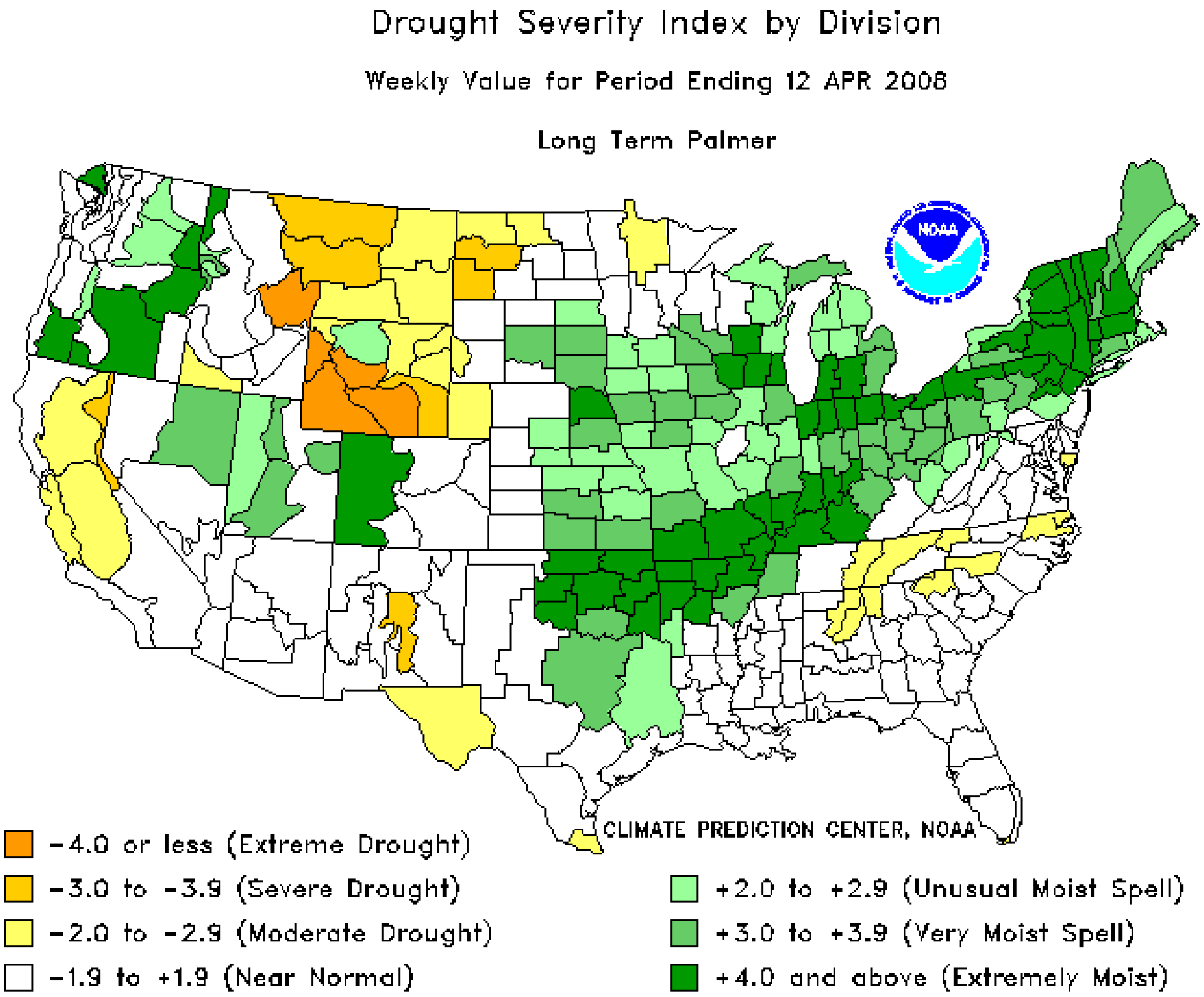
- First widely used soil moisture model
- Uses temperature and precipitation departures to determine dryness
- Ranges from -4 (extreme drought) to +4 (extreme wet)
- Standardized to local climate

  Based on departures from local climate normals
- Good for measuring long-term drought in relatively uniform regions

  Not good for short-term drought / rapid changes

  Not good for variable terrain (i.e., mountains)
- May lag emerging drought conditions by several months

Palmer Drought Severity Index (PDSI)



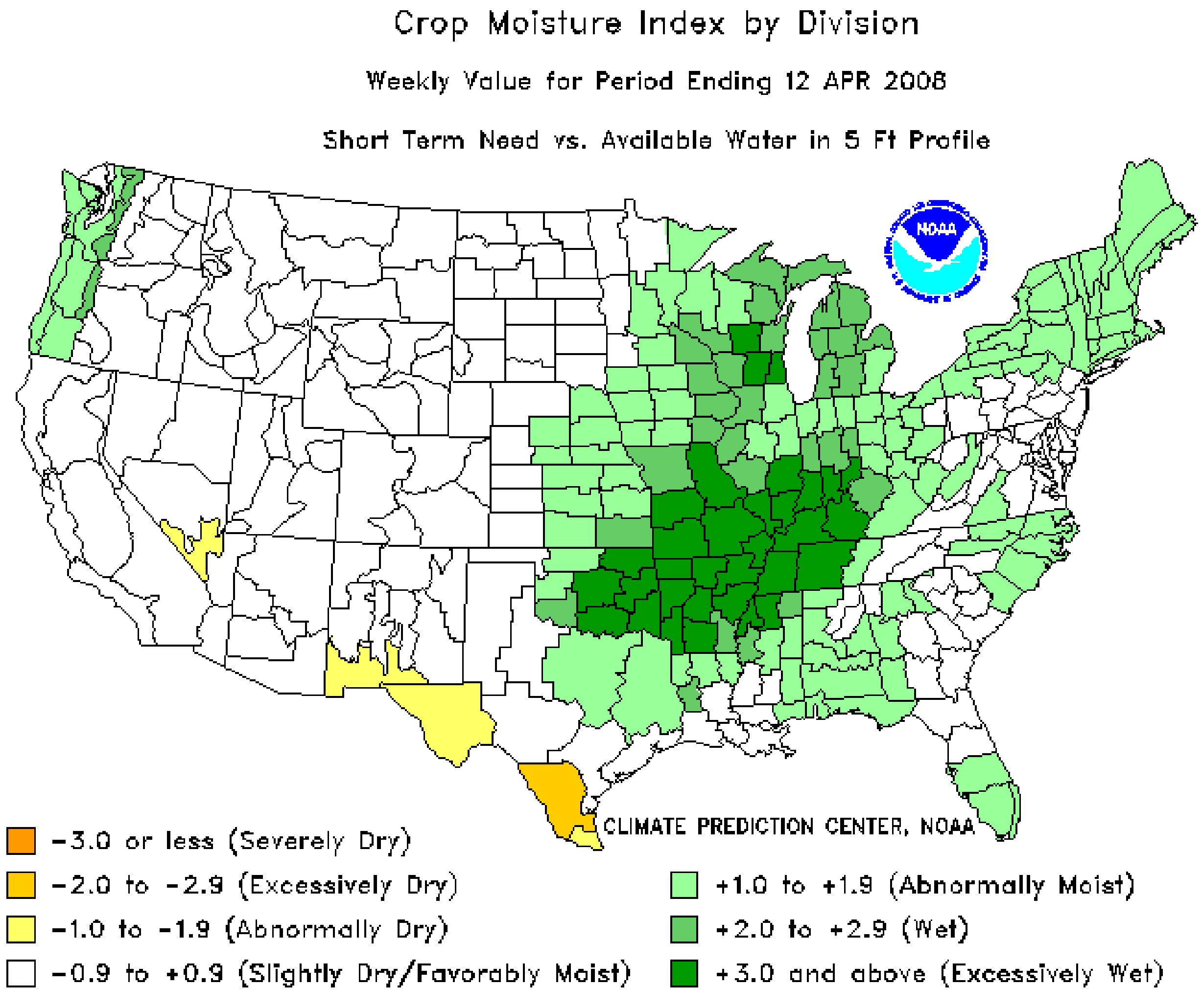
Crop Moisture Index (CMI), 1968

- Geared for agricultural drought
- Uses same categories as PDSI
- Responds more rapidly than PDSI

  Short-term dryness or wetness
- Starts and ends growing season at near zero

  Not good for long-term assessments
- May overestimate recovery resulting from short-term rainfall

Crop Moisture Index (CMI)

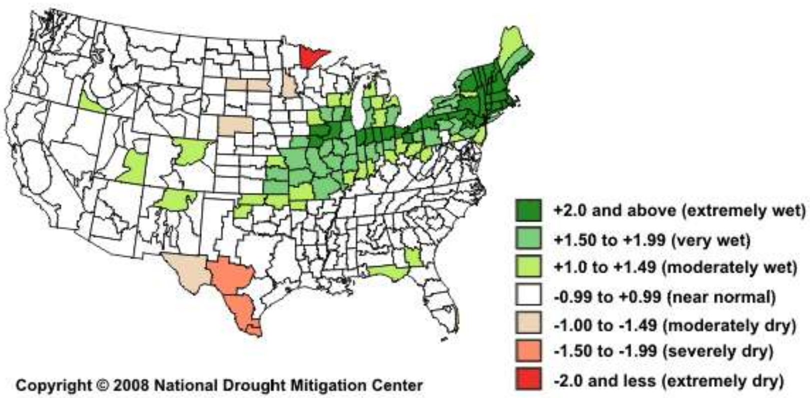


Standardized Precipitation Index (SPI), 1990s

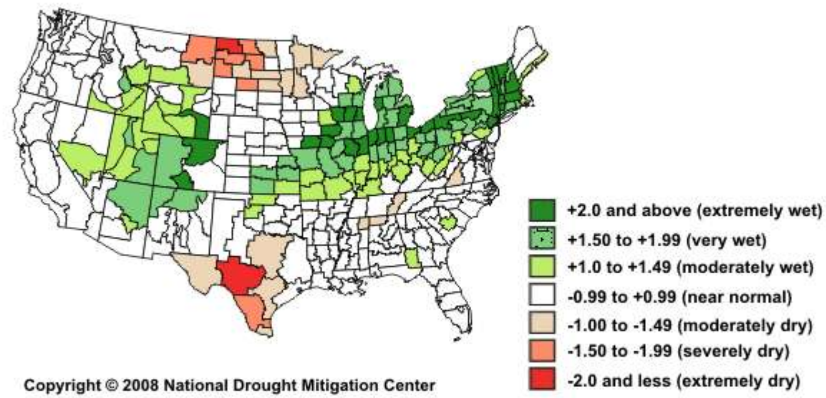
- Can be produced for a variety of time periods, depicting both short-term and long-term conditions
- Based on precipitation over an accumulation period compared to the station’s historical distribution
- Statistical “unusualness” of a period
- PDSI uses a water-balance model to estimate evaporation based on temperature
- Values of -2 or less are extremely dry; +2 and greater are extremely wet

Standardized Precipitation Index (SPI)

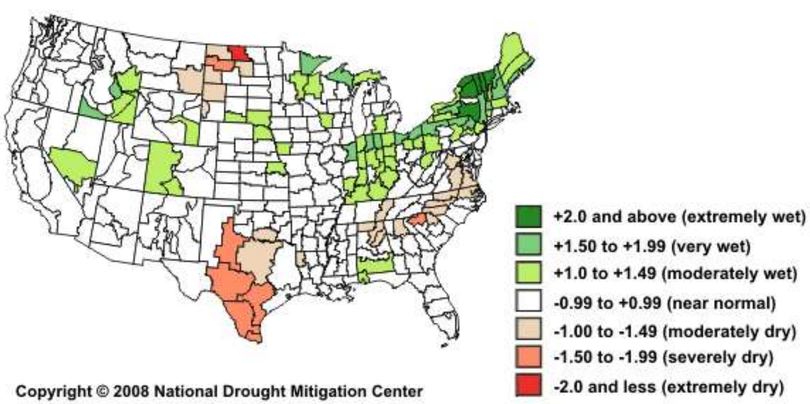
1-month SPI through the end of February 2008



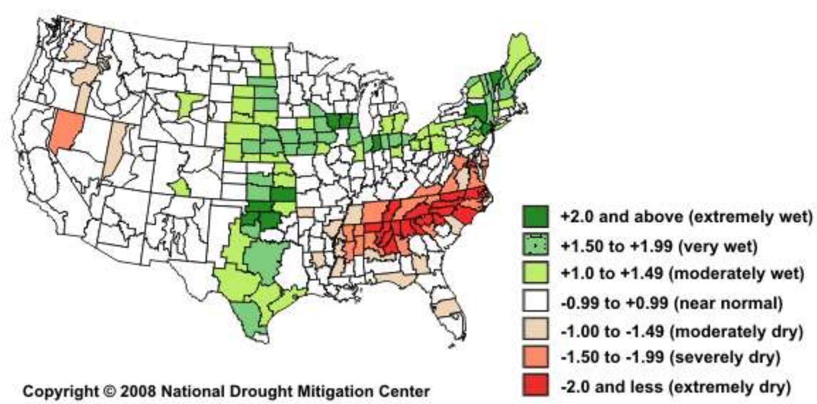
3-month SPI through the end of February 2008



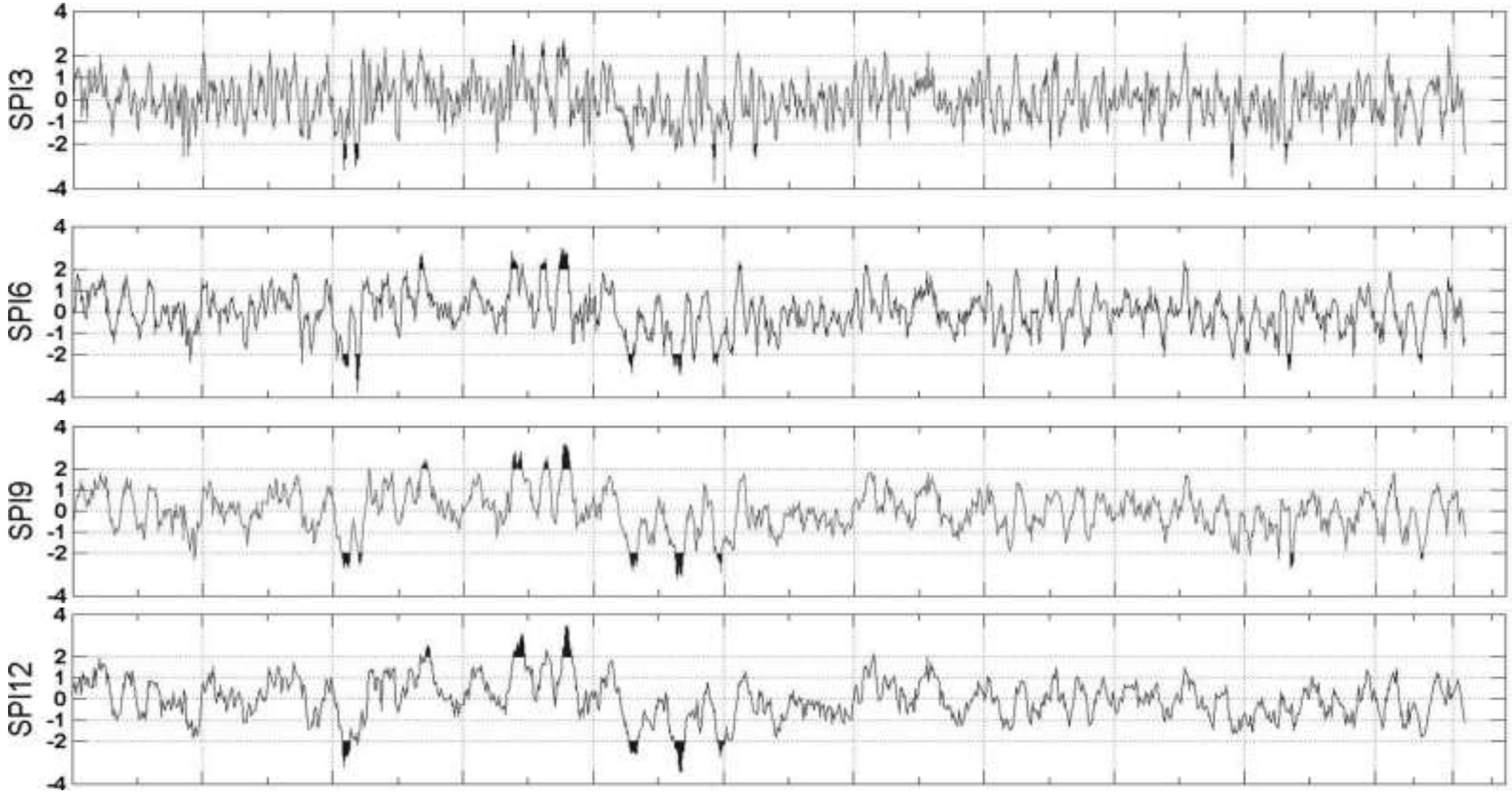
6-month SPI through the end of February 2008



12-month SPI through the end of February 2008

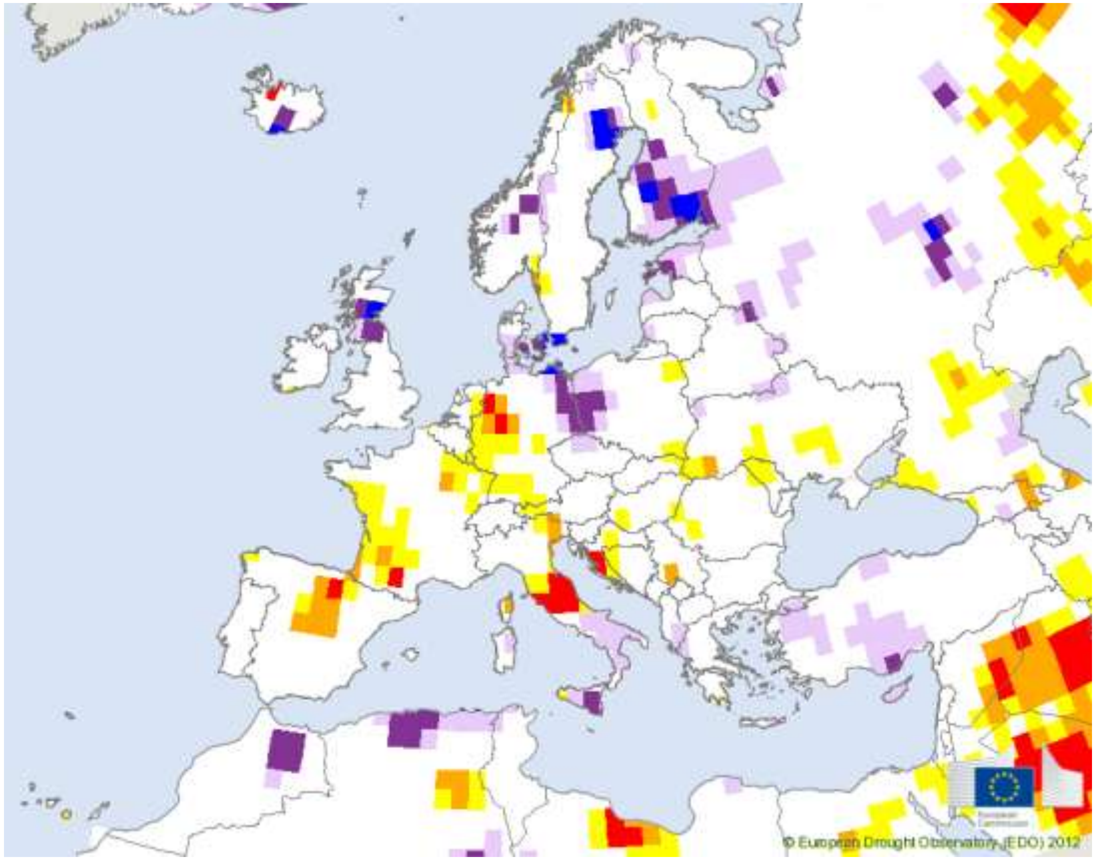


SPI on several time scales for Ljubljana



(Ceglar et al., 2007)

Monthly SPI: 24 Aug 2012

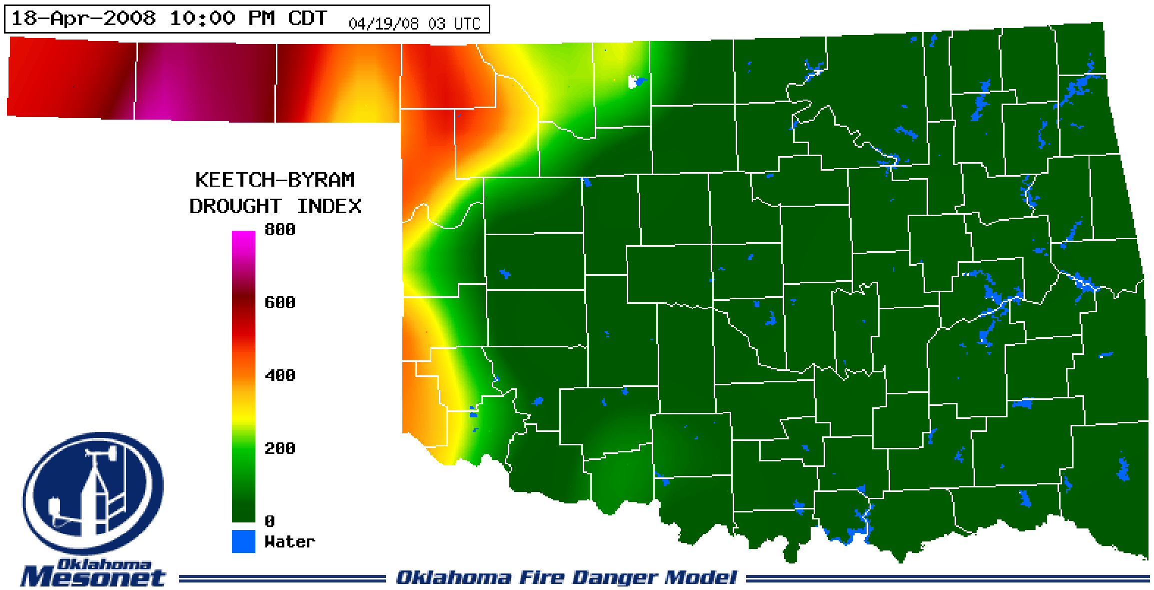


- Extreme dry (SPI ≤ -2)
- Severe dry (-2 < SPI ≤ -1.5)
- Moderate dry (-1.5 < SPI ≤ -1)
- Near normal (-1 < SPI ≤ 1)
- Moderate wet (1 < SPI ≤ 1.5)
- Severe wet (1.5 < SPI ≤ 2)
- Extreme wet (SPI ≥ 2)

Keetch-Byram Drought Index (KBDI)

- Estimates dryness of soil and dead vegetation
- Ranges from 0 (saturated soil) to 800 (dry soil)
- Based on combination of recent precipitation and estimated evaporation
  - Soil may dry because of extended periods without precipitation or by high temperatures / strong winds
- Developed for fire management purposes, but also a good short-term drought indicator

Keetch-Byram Drought Index (KBDI)



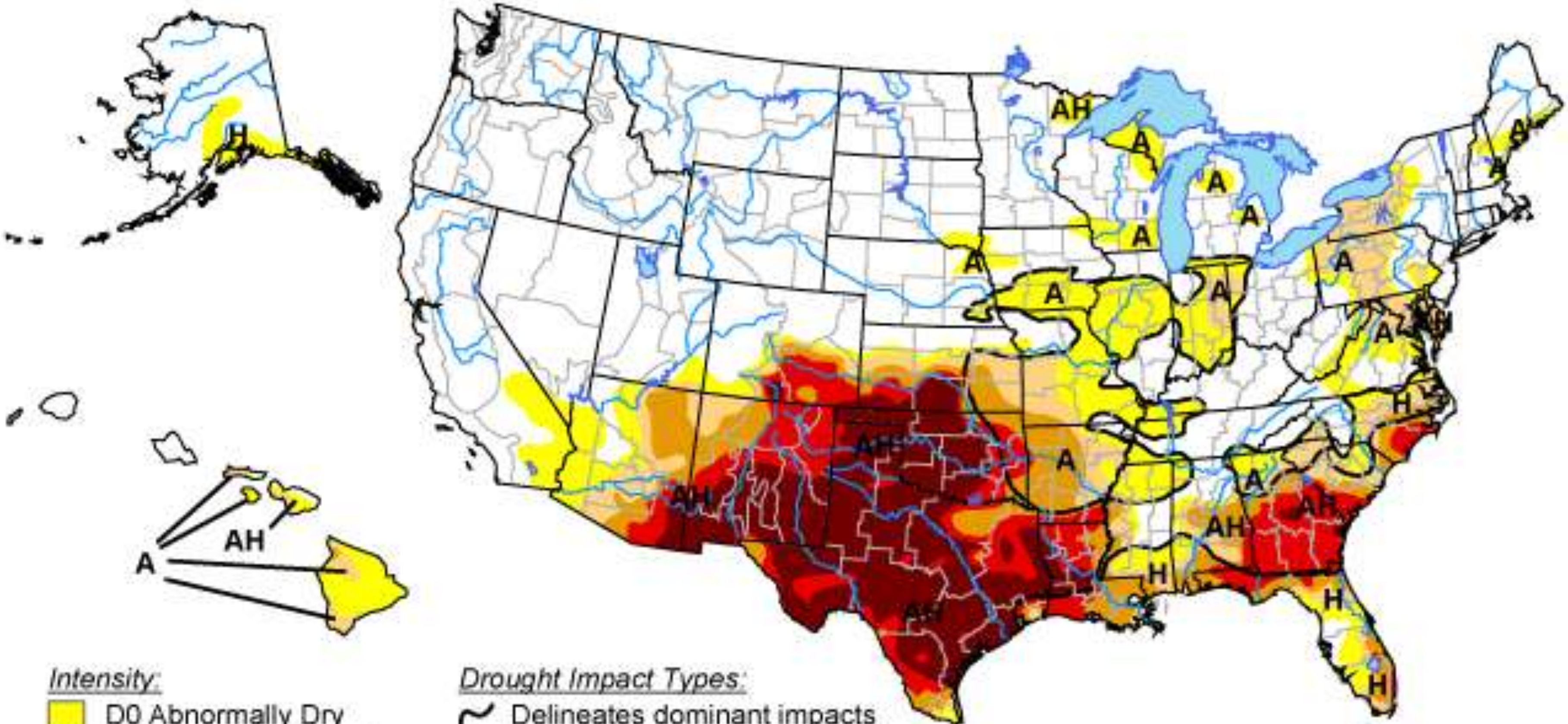
KBDI Value	Interpretation
0-200	No Drought-Slight Drought. Fuels and ground are quite moist.
200-400	Moderate Drought. Dry vegetation begins to contribute to fire.
400-600	Severe Drought. Escaped fire is difficult to control.
600-800	Extreme Drought. Fire suppression is a major problem.

Other Drought Tools

- Evaporation models
  - Often the missing link in drought understanding
  - Direct measurement difficult and disappearing (pan evap)
  - ET models are getting more sophisticated
- Soil Moisture
  - Integrates precipitation deficits over time
  - Lagging indicator but strongly related to impacts
  - Valuable for assessing recovery

U.S. Drought Monitor

August 2, 2011
Valid 8 a.m. EDT



Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

Drought Impact Types:

~ Delineates dominant impacts

A = Agricultural (crops, pastures, grasslands)

H = Hydrological (water)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://drought.unl.edu/dm

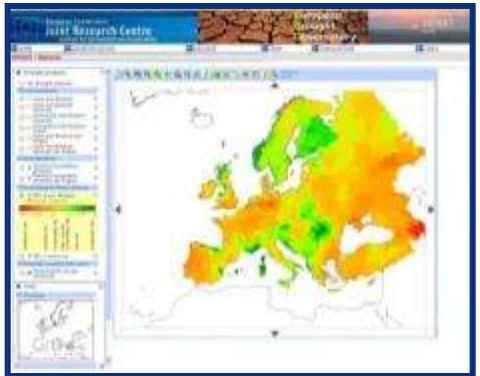
Released Thursday, August 4, 2011

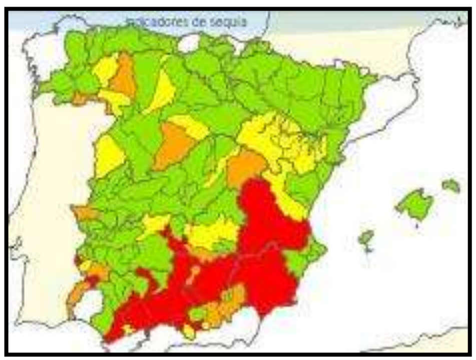
Author: Brad Rippey, U.S. Department of Agriculture

European Drought Observatory – EDO

General philosophy
&
Technical solutions

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





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

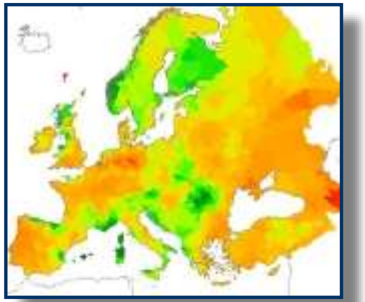
- EU / continental level
- MS level
- Regional / river basin level

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

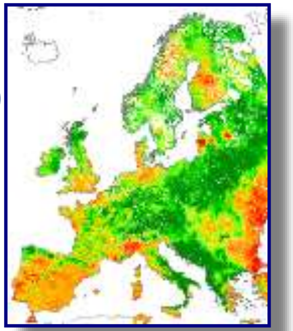
Precipitation (SPI)



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

Soil Moisture

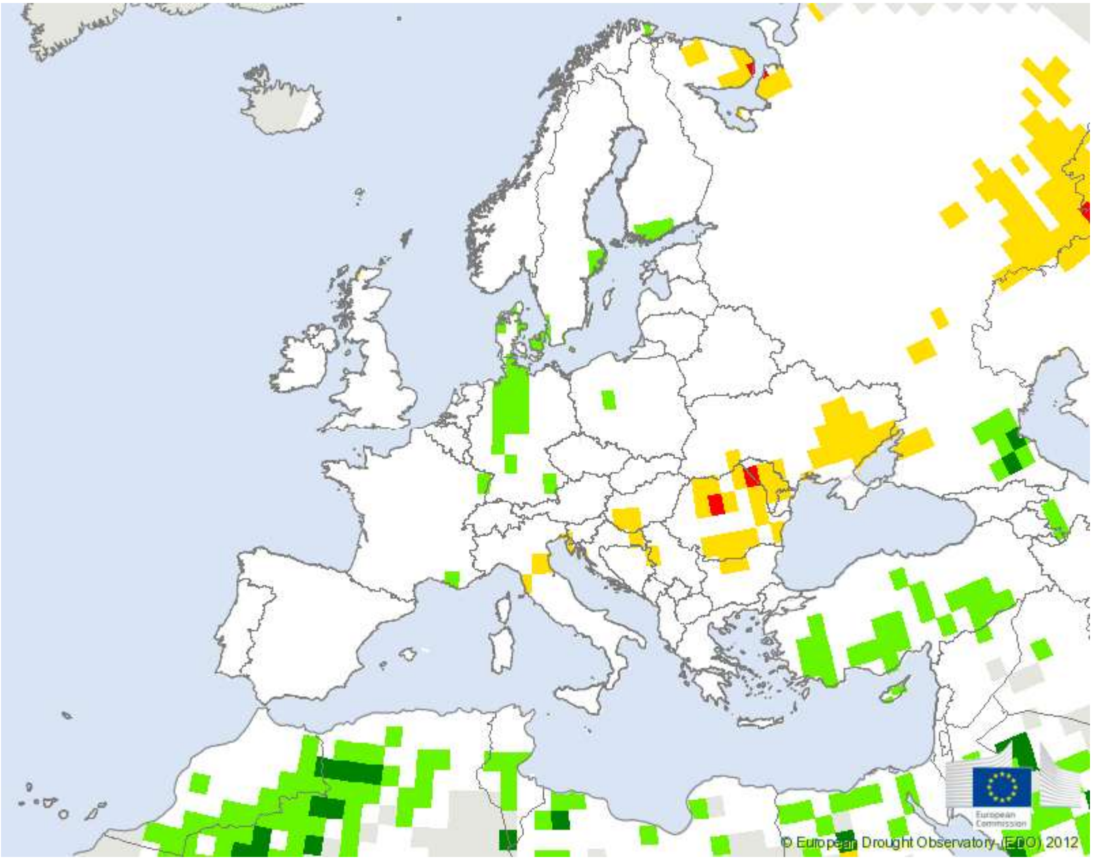
- ✓Daily soil moisture
- ✓Daily soil moisture anomaly
- ✓Forecasted soil moisture anomaly (7days)
- ✓Forecasted soil moisture trend

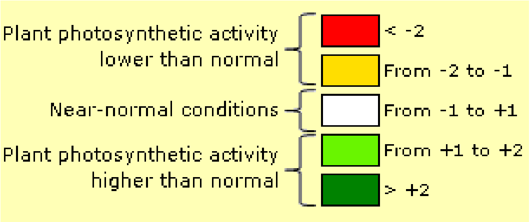


Vegetation status

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

Composite Drought Indicator (Drought Alert)

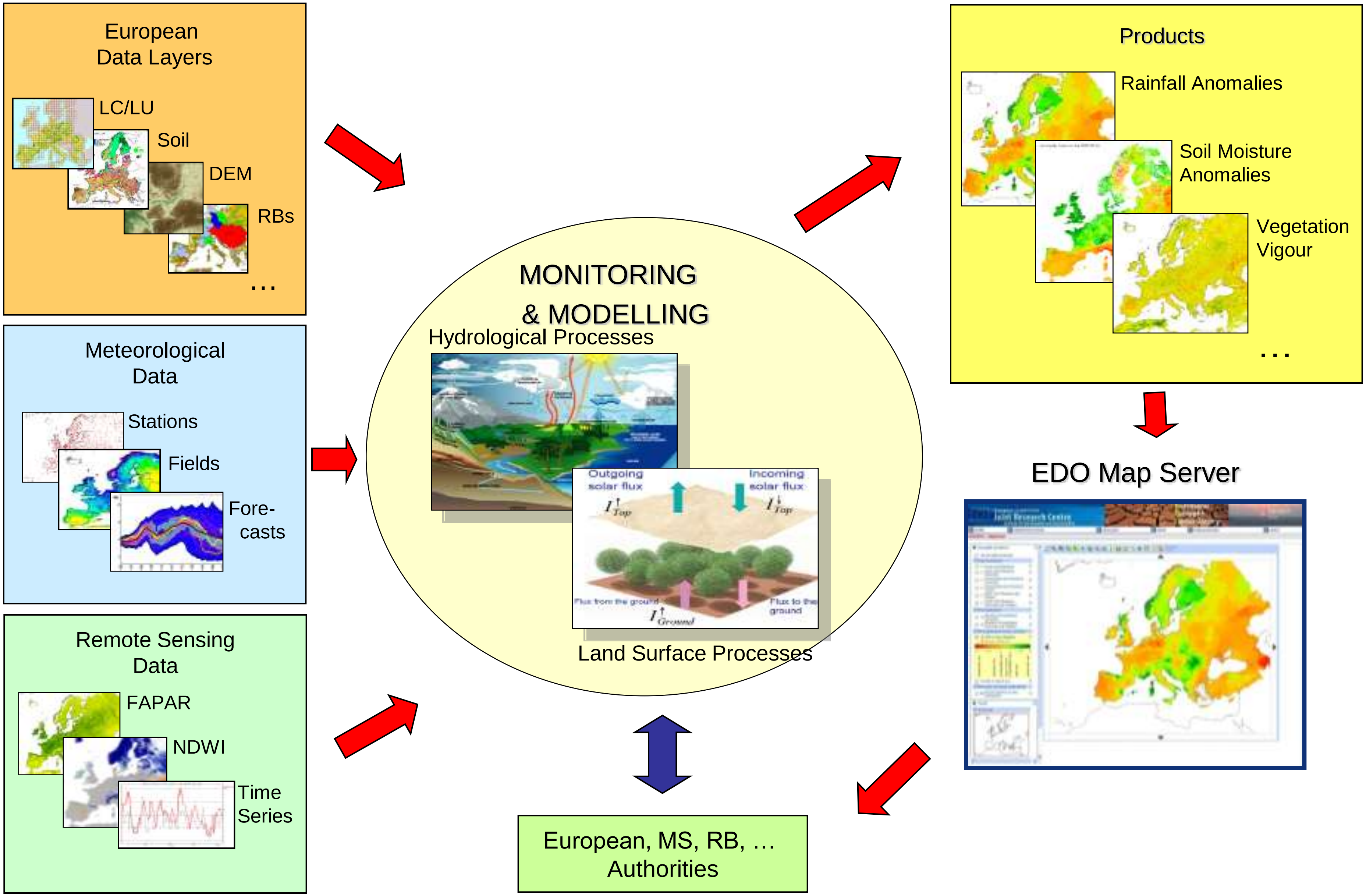




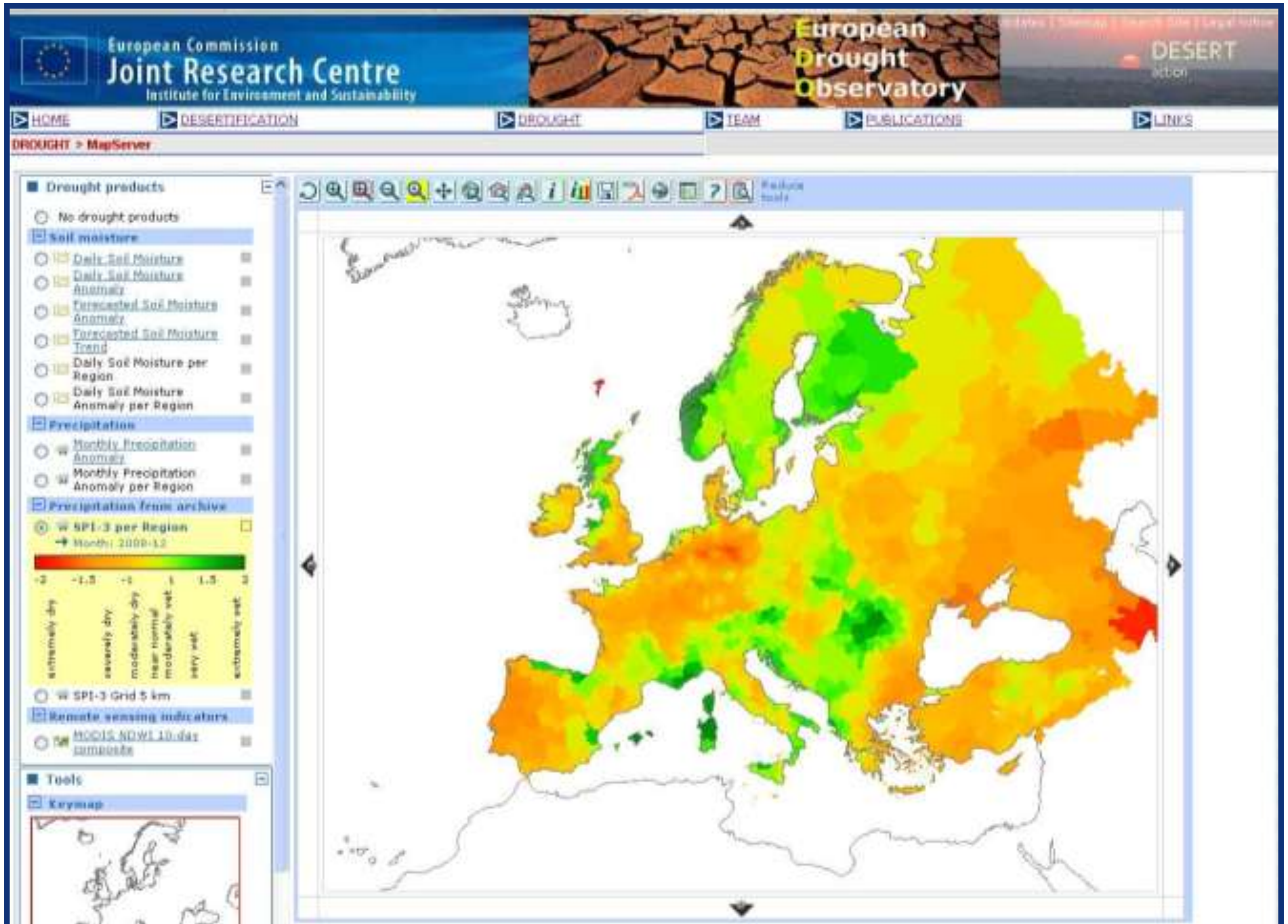
10-days fAPAR anomaly: 1. 8. 2012

Anomaly of fAPAR (fraction of Absorbed Photosynthetically Active Radiation): 10-day time composite, 1 Km spatial resolution, derived from MERIS fAPAR.

EDO data flow



EDO Map Server



3-month SPI for 10-12/2008 aggregated to regional level

Products:

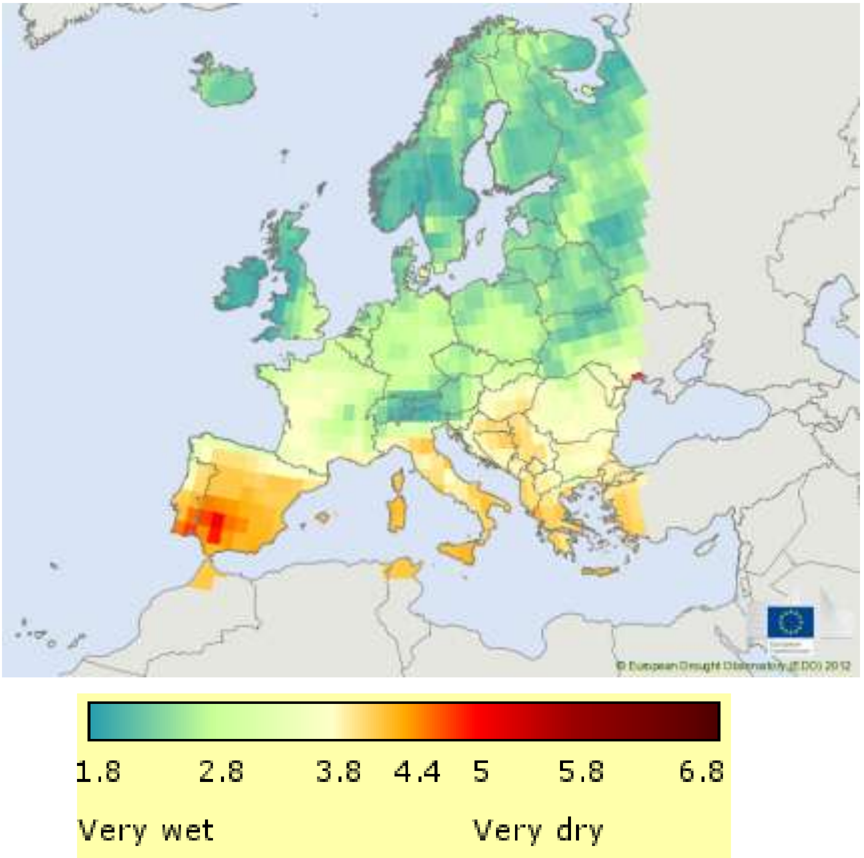
Precipitation Indicators

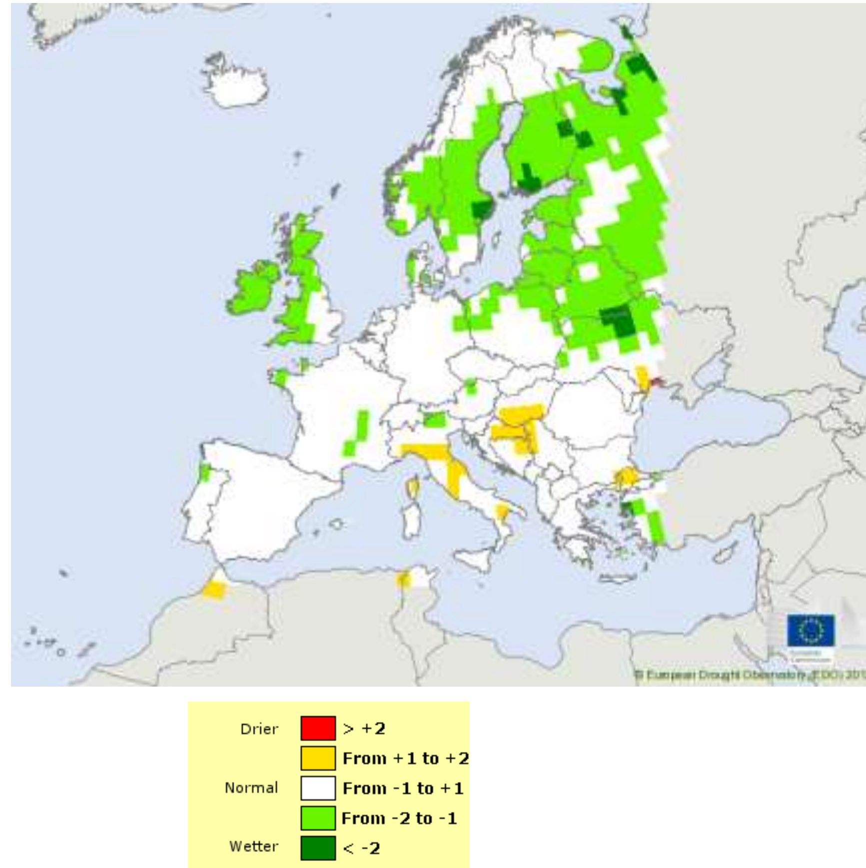
Modelled Soil Moisture

Remote Sensing Indicators

SPI: Standardized Precipitation Index

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





Soil moisture

Soil moisture anomaly

21. 8. 2012

Soil Moisture over 10 days: LISFLOOD modelled top soil moisture suction (pF value) for Europe in the original 5 km resolution. Information is presented where reliable data on the soil properties are available.

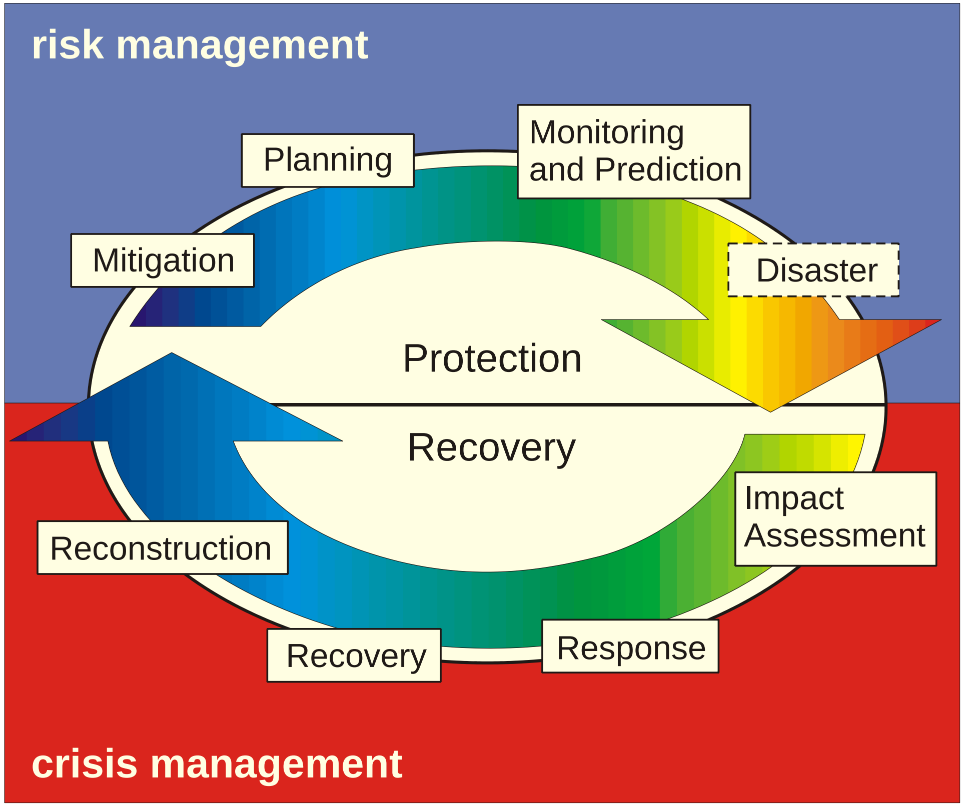
http://edo.jrc.ec.europa.eu/edov2/php/index.php?id=1000

Factsheets of EDO Indicators

INDICATOR	FACTSHEET	RELATED INFO
Combined Drought Indicator	factsheet_combinedDroughtIndicator.pdf	
Daily Soil Moisture	factsheet_soilmoisture.pdf	Average per Region
Daily Soil Moisture Anomaly	factsheet_soilmoisture.pdf	Average per Region
Forecasted Soil Moisture Anomaly	factsheet_soilmoisture.pdf	
SPI at SYNOP stations from the MARS database	factsheet_spi.pdf	
SPI at SYNOP stations interpolated to 0.25dd grid	factsheet_spi.pdf	
Spatial average of SPI at SYNOP stations / interpolated SPI for Eurostat NUTS3 regions	factsheet_spi.pdf	
Vegetation Productivity (fAPAR)	factsheet_fapar.pdf	
Vegetation Productivity Anomaly (fAPAR Anomaly)	factsheet_fapar.pdf	
Vegetation Water Content (NDWI)	factsheet_ndwi.pdf	
Vegetation Water Content (NDWI) Anomaly	factsheet_ndwi.pdf	

Characteristics of Crisis Management

- Reactive, post-impact
- Poorly coordinated
- Untimely
- Poorly targeted
- Ineffective
- Decreases self-reliance → greater vulnerability

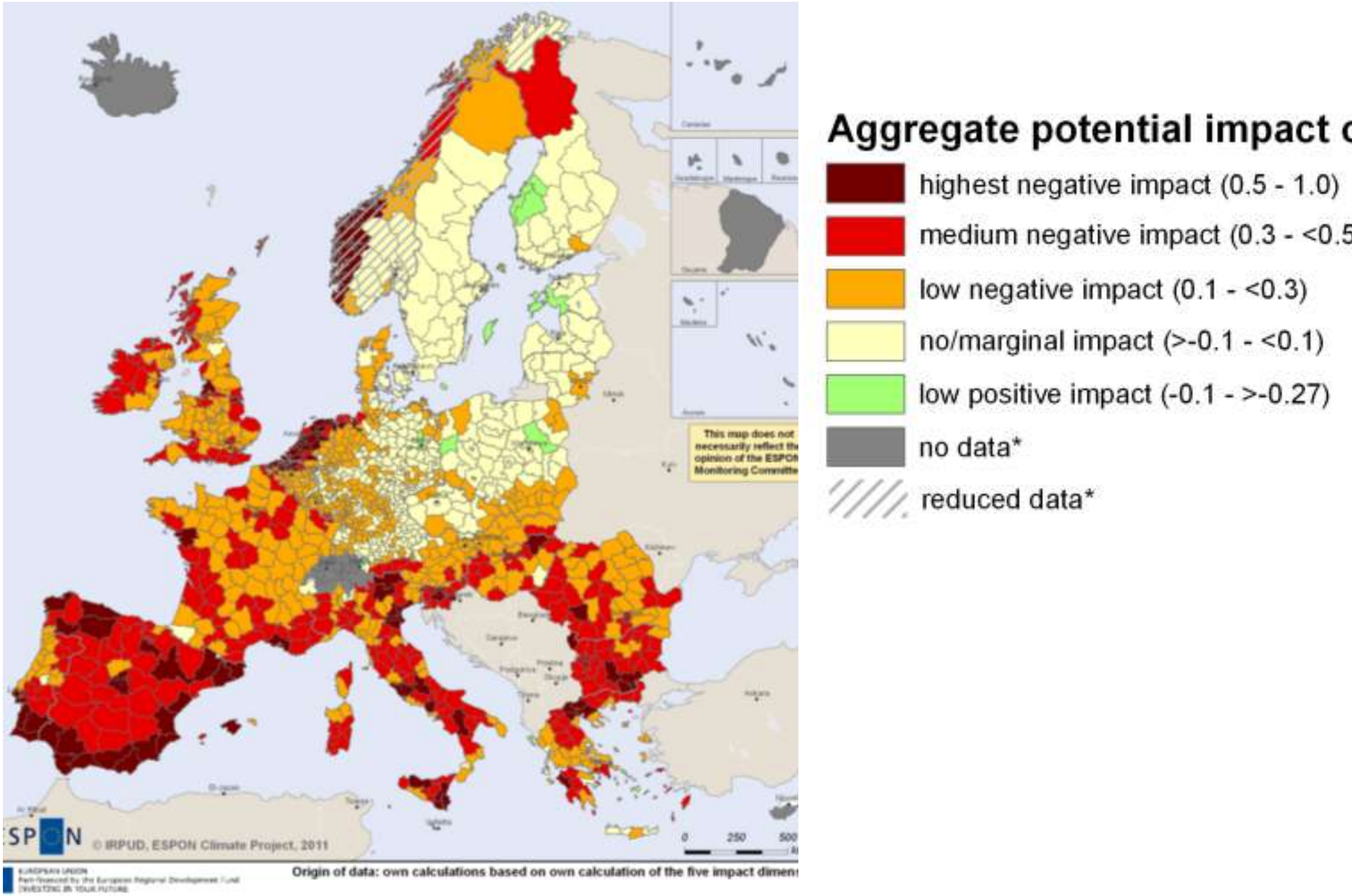


Need for Drought Mitigation Actions in CEE

- Improved monitoring
- Drought planning
- Communication and coordination
  - Information Services
- Education/public awareness
- Water supply augmentation
- Demand reduction/water conservation
- Water use conflict resolution
- Legislation/policy changes

Extra slides

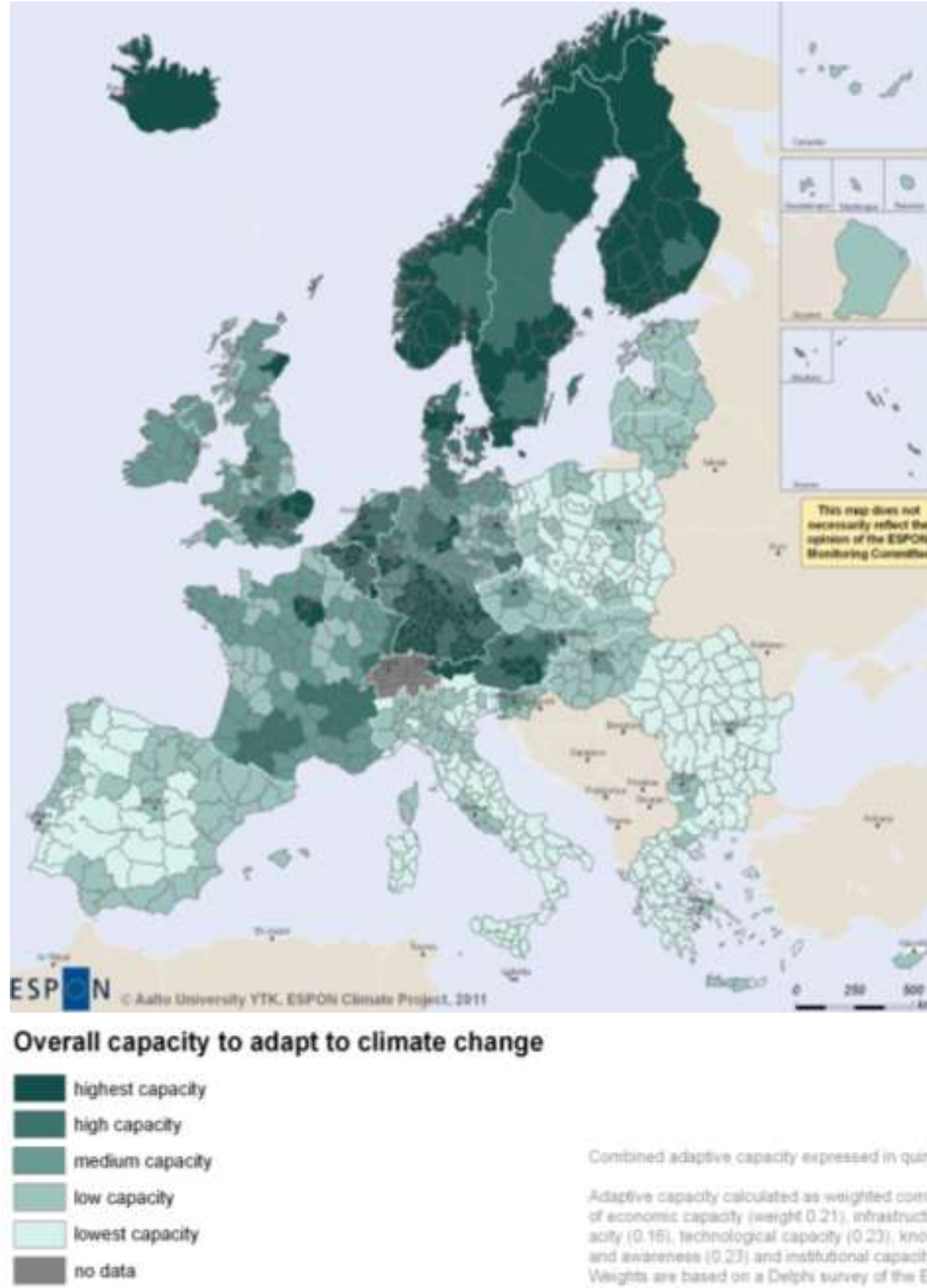
JRC DG Regio‘s 2020
„THE CLIMATE CHANGE CHALLENGE FOR EUROPEAN REGIONS“



Adaptive capacity

"the ability or potential of a system to respond successfully to climate variability and changes" (IPCC 2007)

- Awareness
- Technology and infrastructure
- Economic resources
- Institutions



Combined adaptive capacity expressed in quintiles.

Adaptive capacity calculated as weighted combination of economic capacity (weight 0.21), infrastructure capacity (0.16), technological capacity (0.23), knowledge and awareness (0.23) and institutional capacity (0.17). Weights are based on a Delphi survey of the ESPON Monitoring Committee.

Vulnerability to climate change “ is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity” (IPCC 2007).

- Countries which expect a high increase in impact seem to be less able to adapt
- Climate change would trigger a deepening of the existing socio-economic imbalances between the core of Europe and its periphery.

Future runs counter to territorial cohesion ?