



Climate change in the Mediterranean area, climate modelling and downscaling

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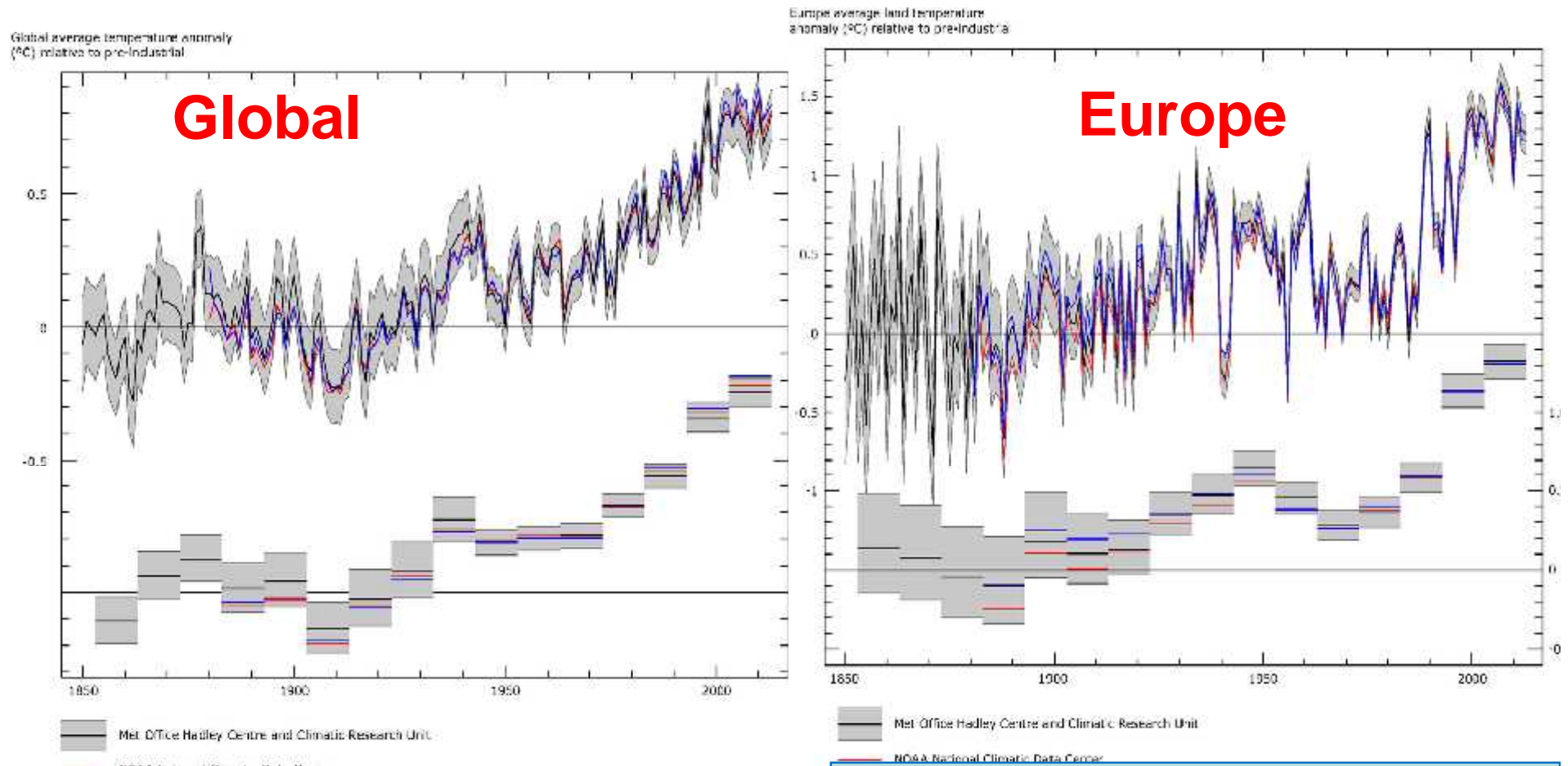


Outline of presentation

- Historical observations of climate trend
- Climate models and simulations of future climate changes
- Projection of climate change for the Mediterranean and North Tunisia



Historical observations of Temperature



Global average temperature shows an increase equal to 0.85 [0.65-1.06] °C during the period 1880-2012.

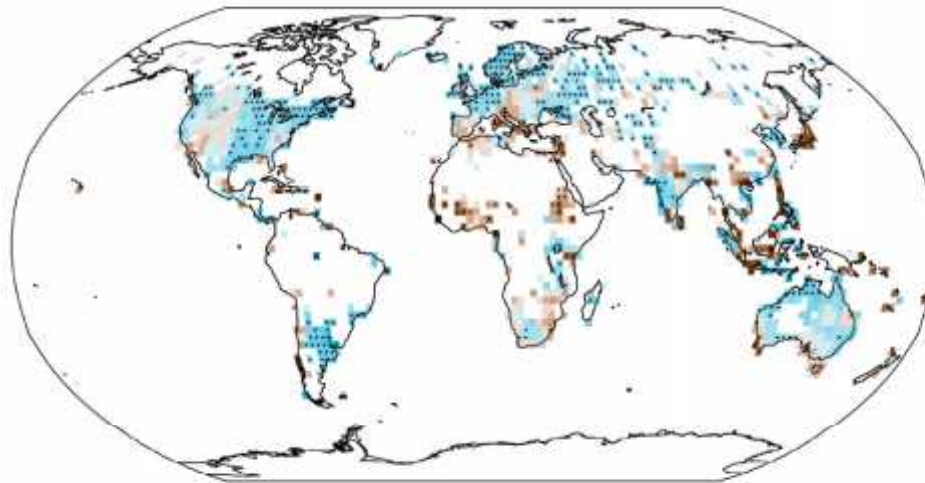
The average surface temperature for Euro-Mediterranean for the last decade (2004-2013) is 1.3 °C greater than pre-industrial level. The warmest recorded decade.



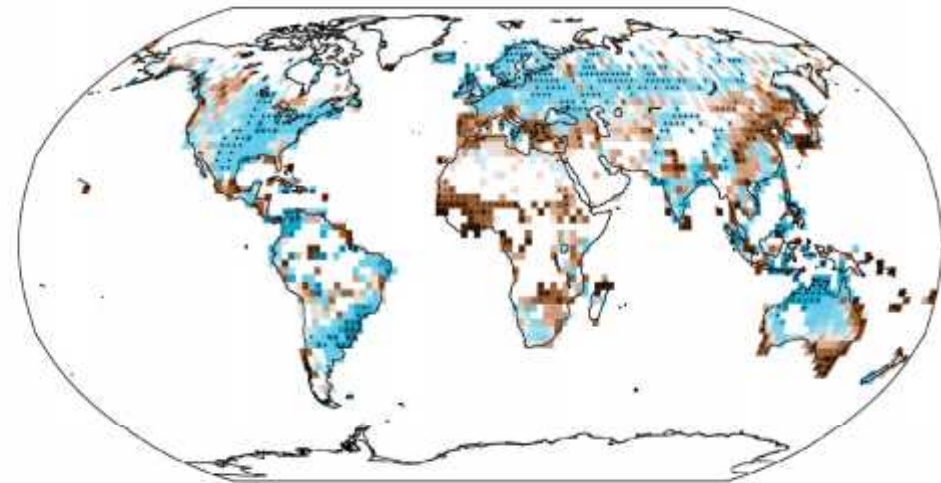
Historical observations of Precipitations

Observed change in annual precipitation over land

1901–2010



1951–2010



At medium-high latitudes, precipitation increase from 1901
Medium confidence level before 1951, high confidence level after 1951

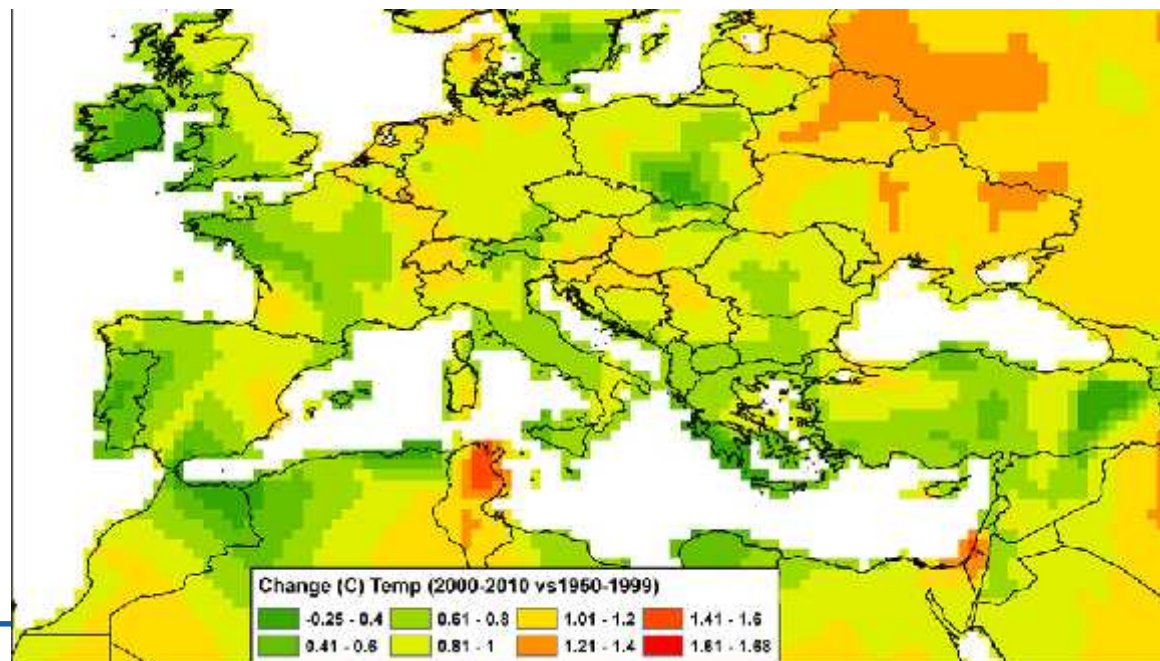
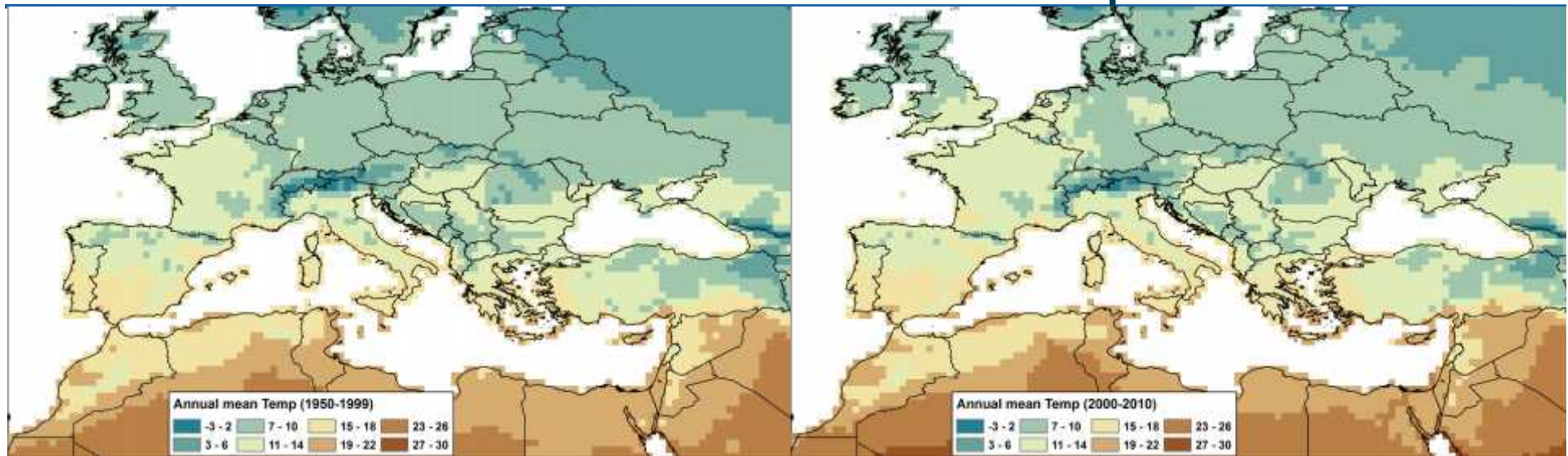
- Strong precipitation events increased in North America and Europa
- Drough tendency in Sahel, Mediterranean, Southern Africa and East Asia

Period 1900-2000:

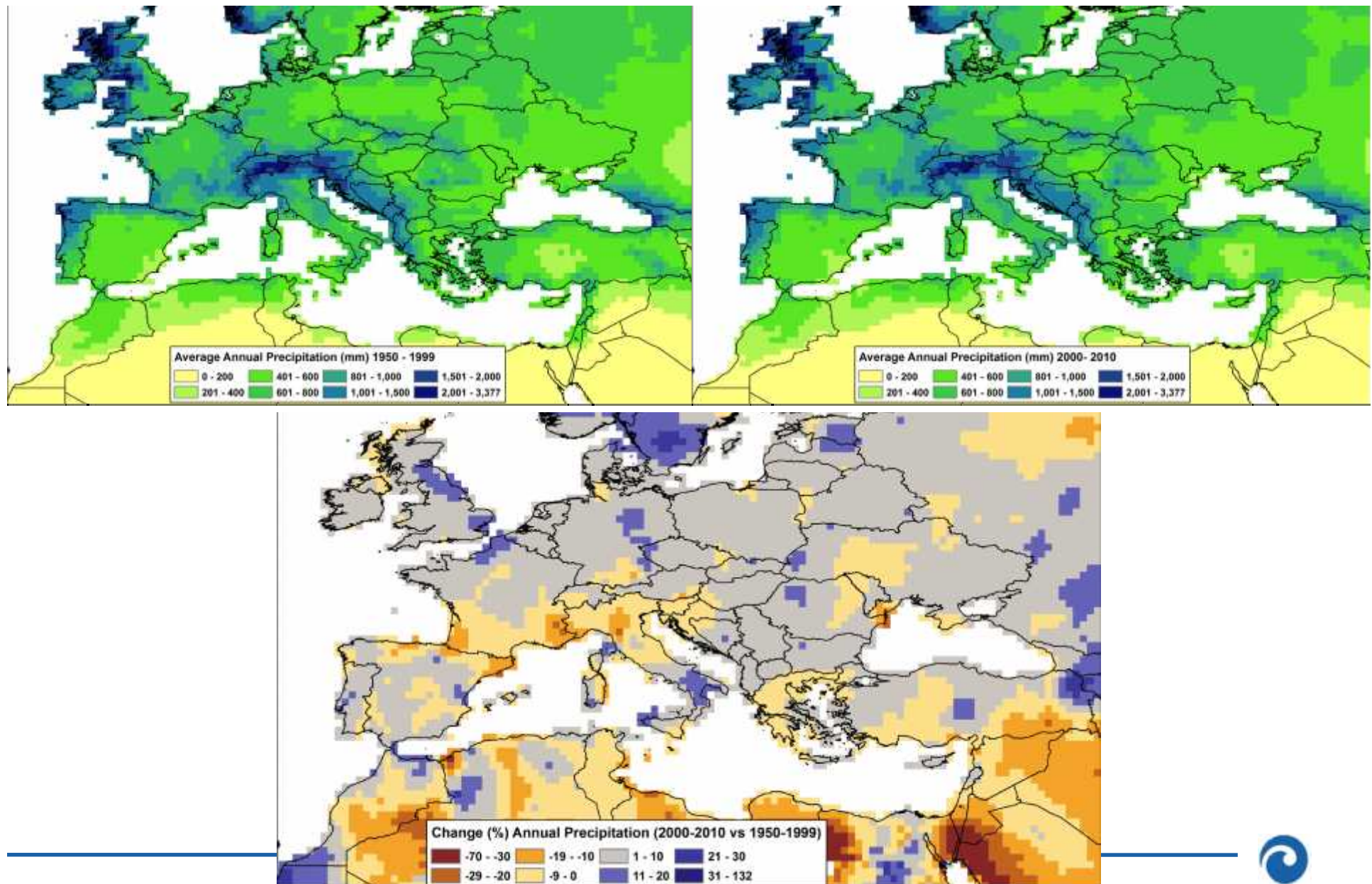
- North Europe +10-40%
- South Europe up to 20% less precipitation



Recent Med climate trend: Temperature



Recent Med climate trend: CRU - Precipitation

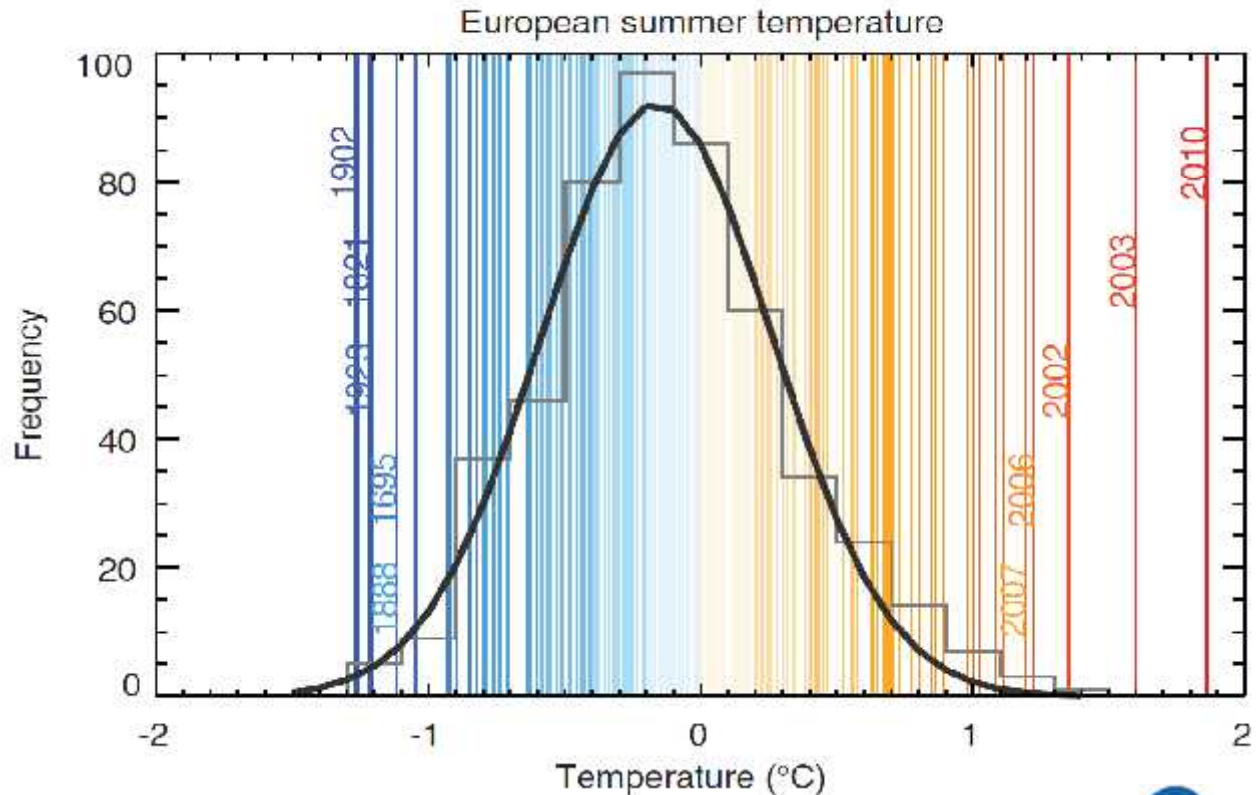


Recent Med climate trend: Extreme events

- In Europe extreme warm events have become more frequent, while extreme cold events have become less frequent
- From 1880 the average length of heat waves has doubled in western Europe, while the frequency of hot days has tripled.

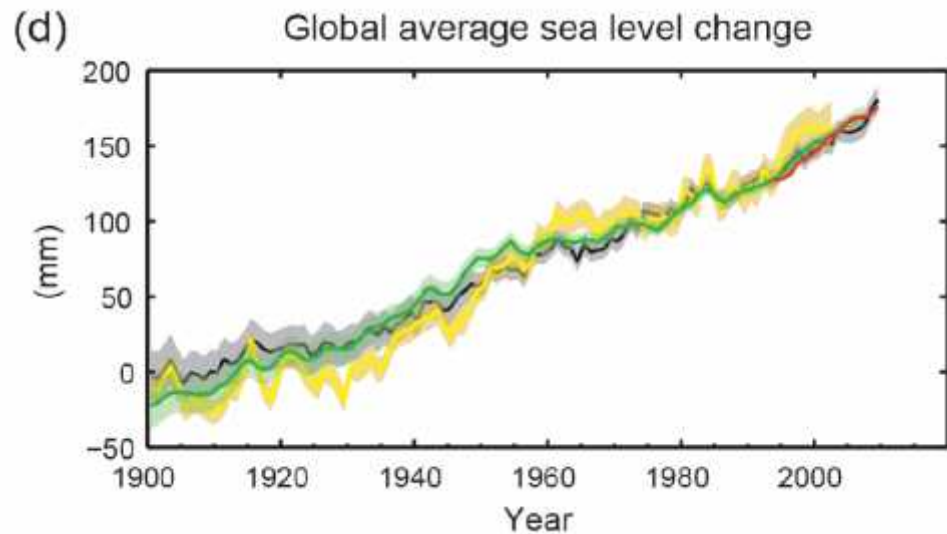
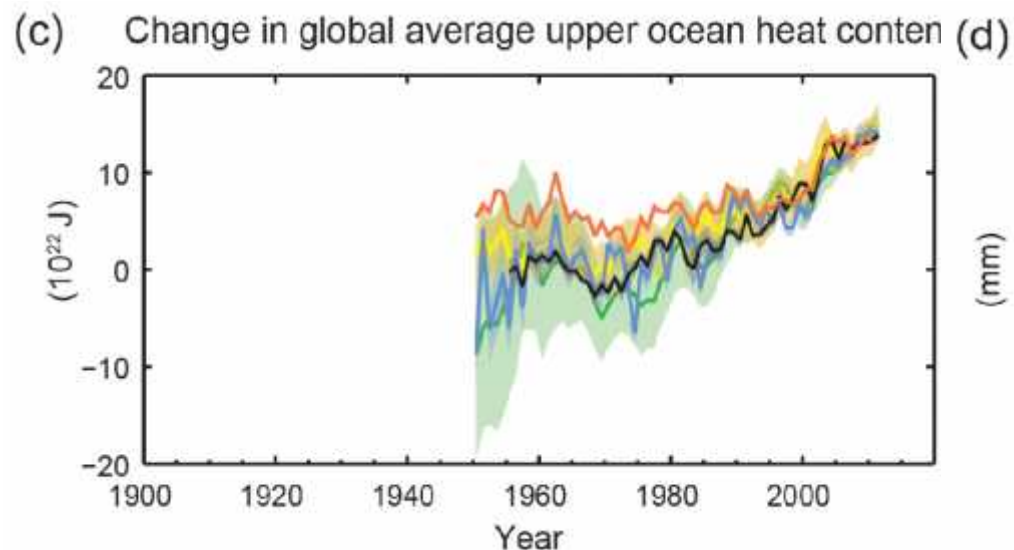
- 5 warmest summer in Europe after 2000, while 5 coldest summer before 1924.

- Increased frequency of events of strong precipitations.



Sea Level Rise

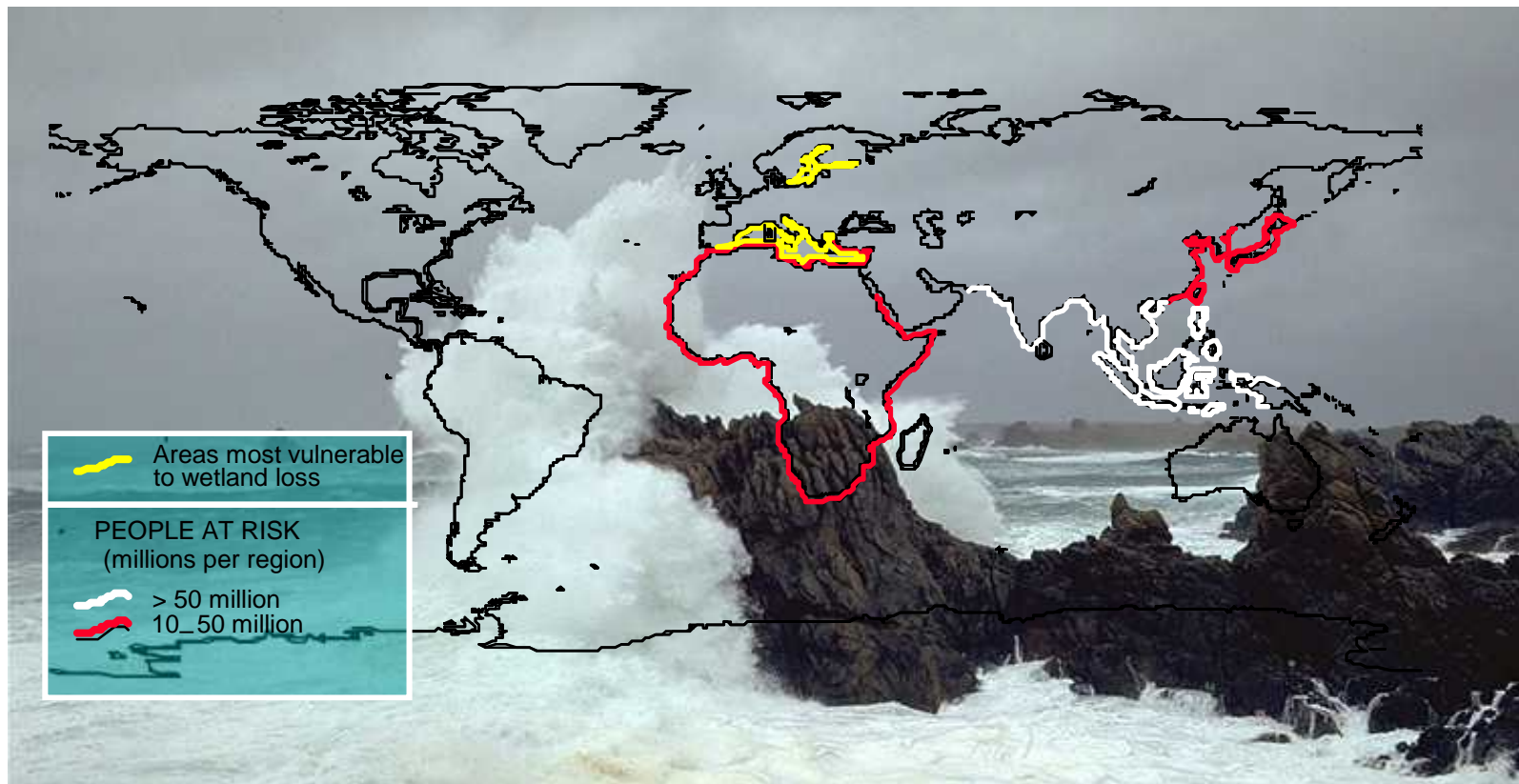
- The oceans have adsorbed up to 80% of the heat added to our planet
- The average temperature of oceans has increased down to a depth of at least 3000 m
- Sea surface is warming at a rate of 0.11 C per decade during 1971-2010.
- Sea warming causes water expansion, and thus sea level rise.
- Glaciers and snowcover are also decreasing, contributing to sea level rise.



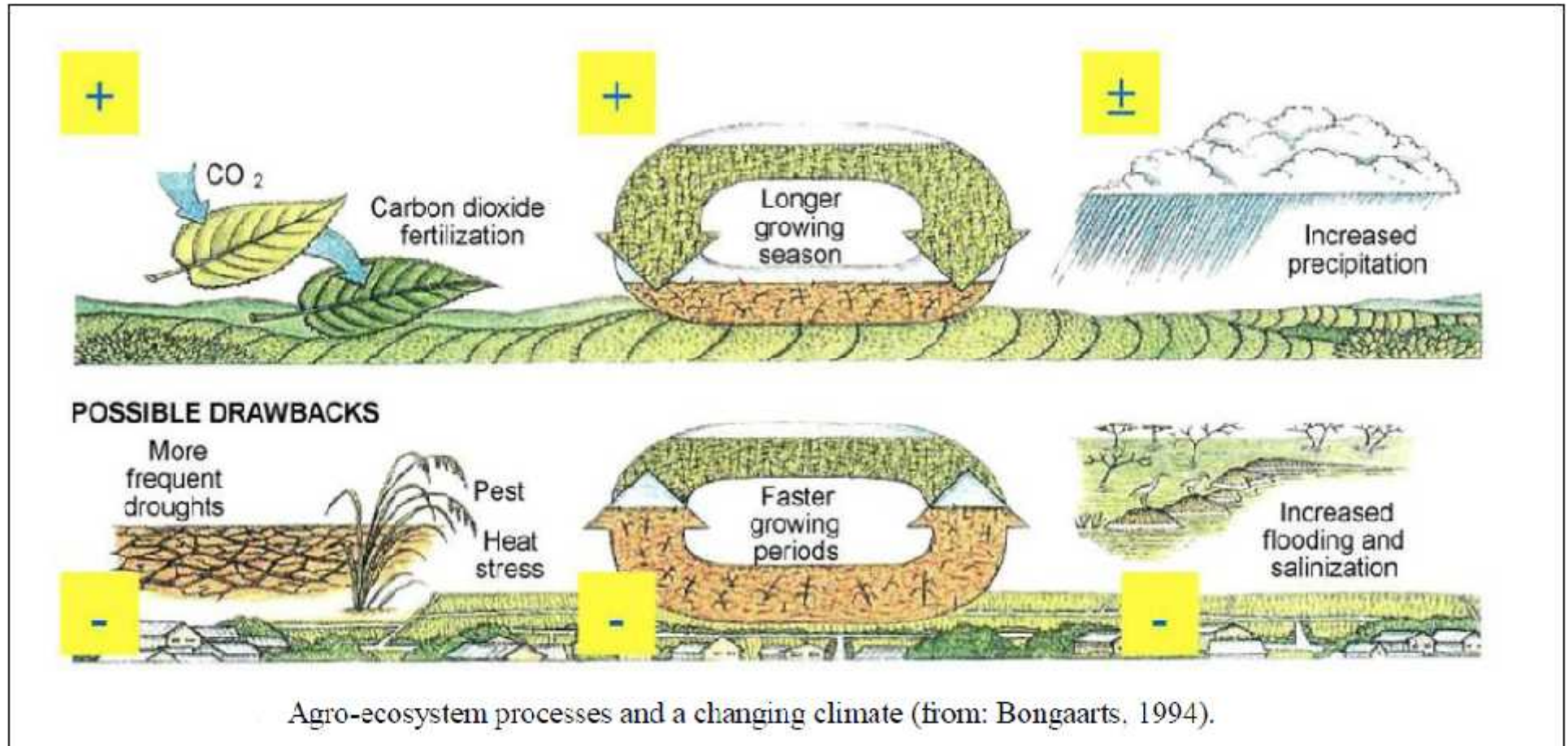
Sea Level Rise

Threats to:

- Coastal development and coastal wetland
- Sea water intrusion into costal aquifer

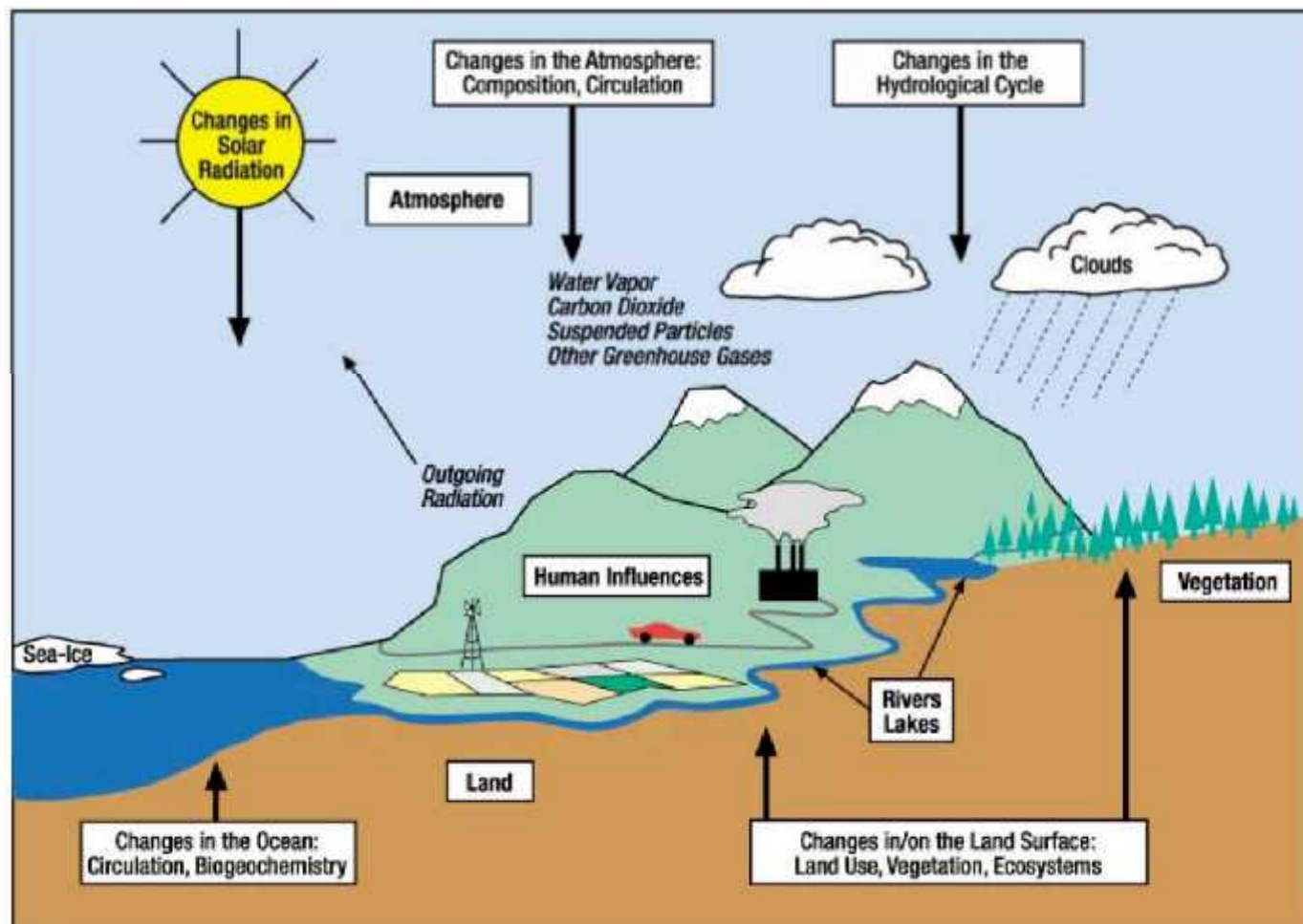


Impact of Climate Change on Crop productivity



Climate Modeling

The climate system

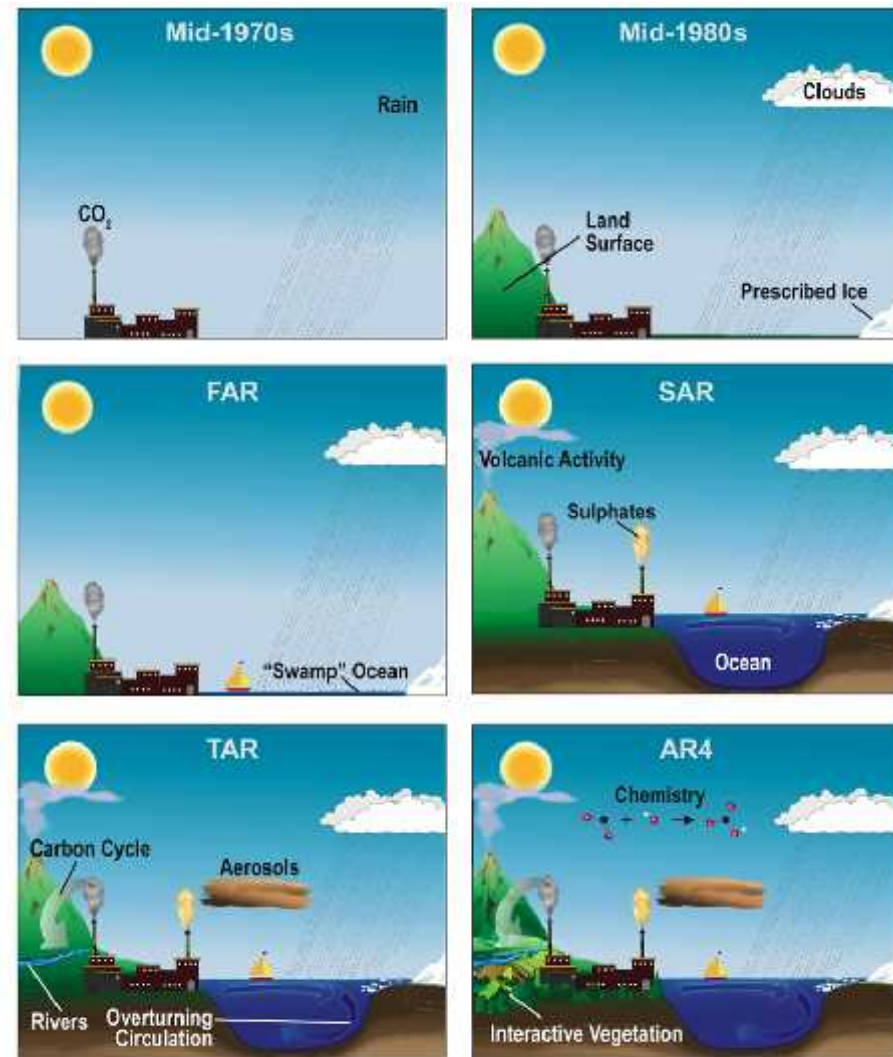


Climate Modeling

Reproducing the climate system

Increasing complexity

Climate models are a lot like weather forecast models, but include interaction among ocean, land surface, and sea ice, changes in atmospheric constituents (GHG), etc



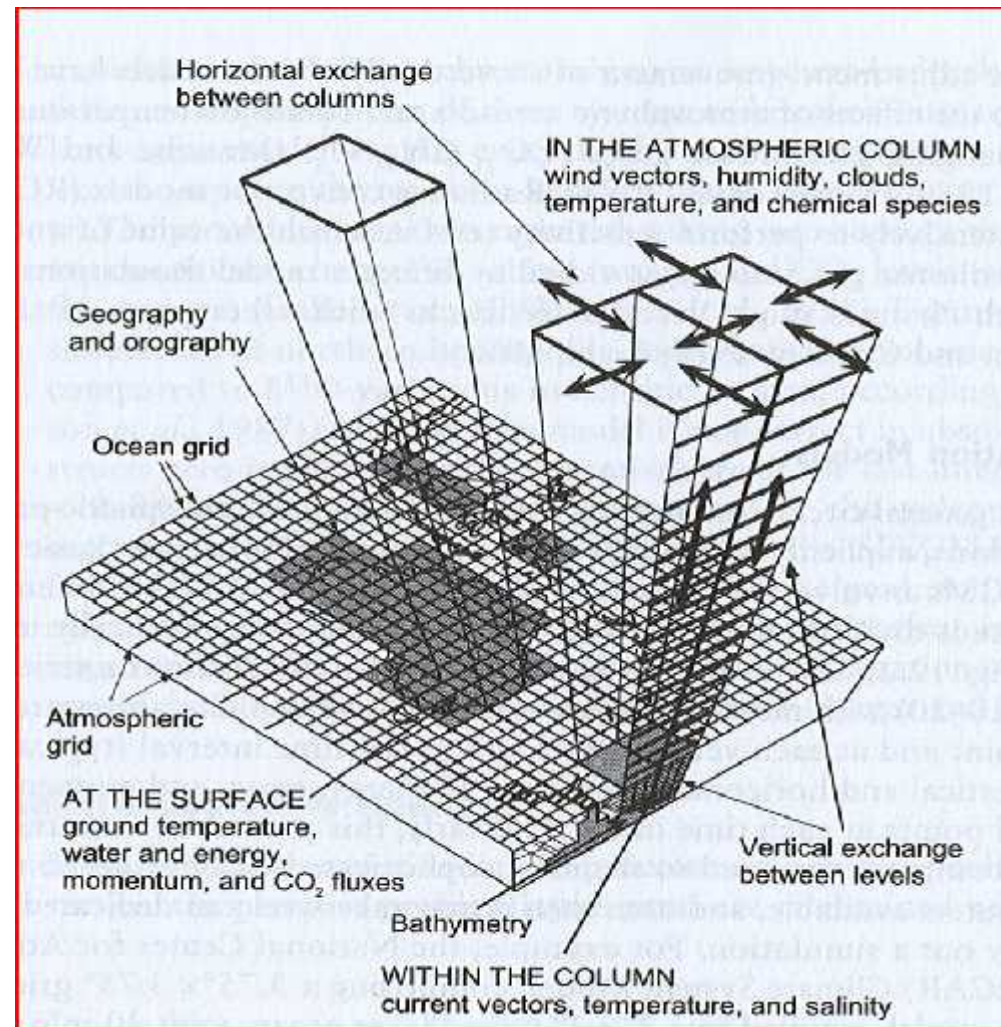
Climate Modeling

Reproducing the climate system

Horizontal and vertical flux distribution among soil and atmospheric layers

The earth system simulated as one system (Global Circulation Models, GCM)

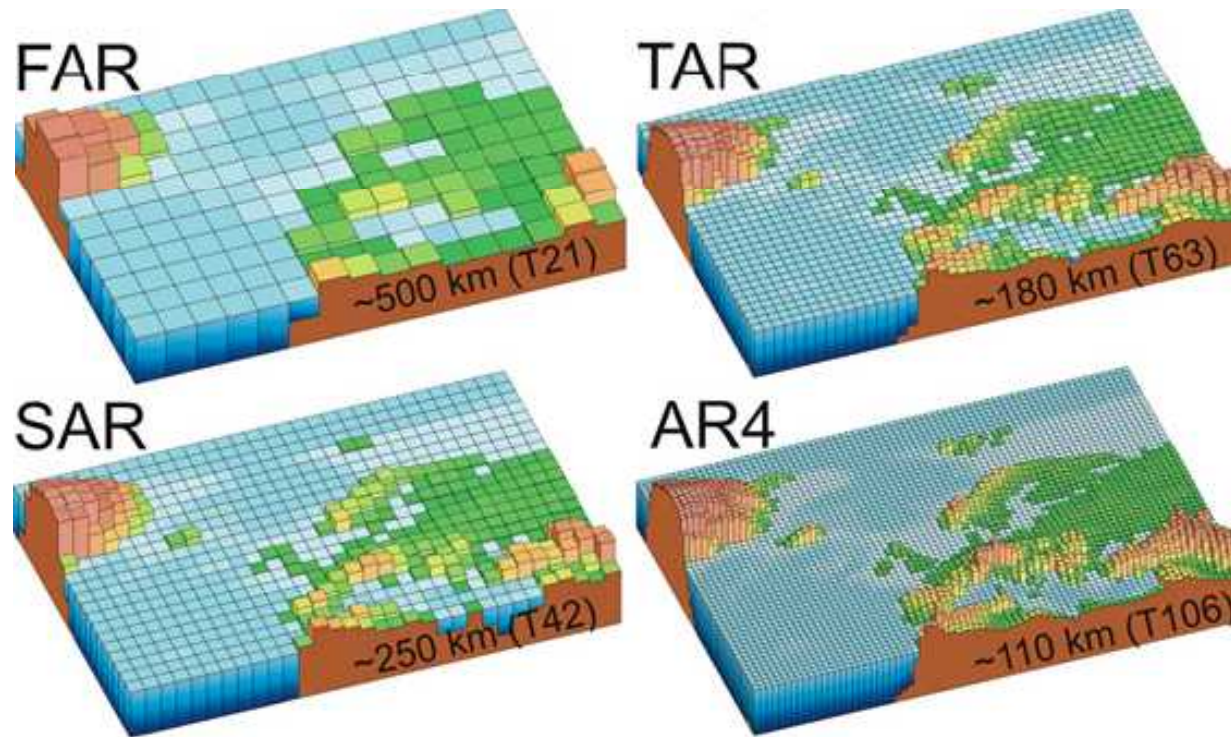
Computing demand increases inversely with cube of horizontal resolution



Climate Model Development

Reproducing the climate system

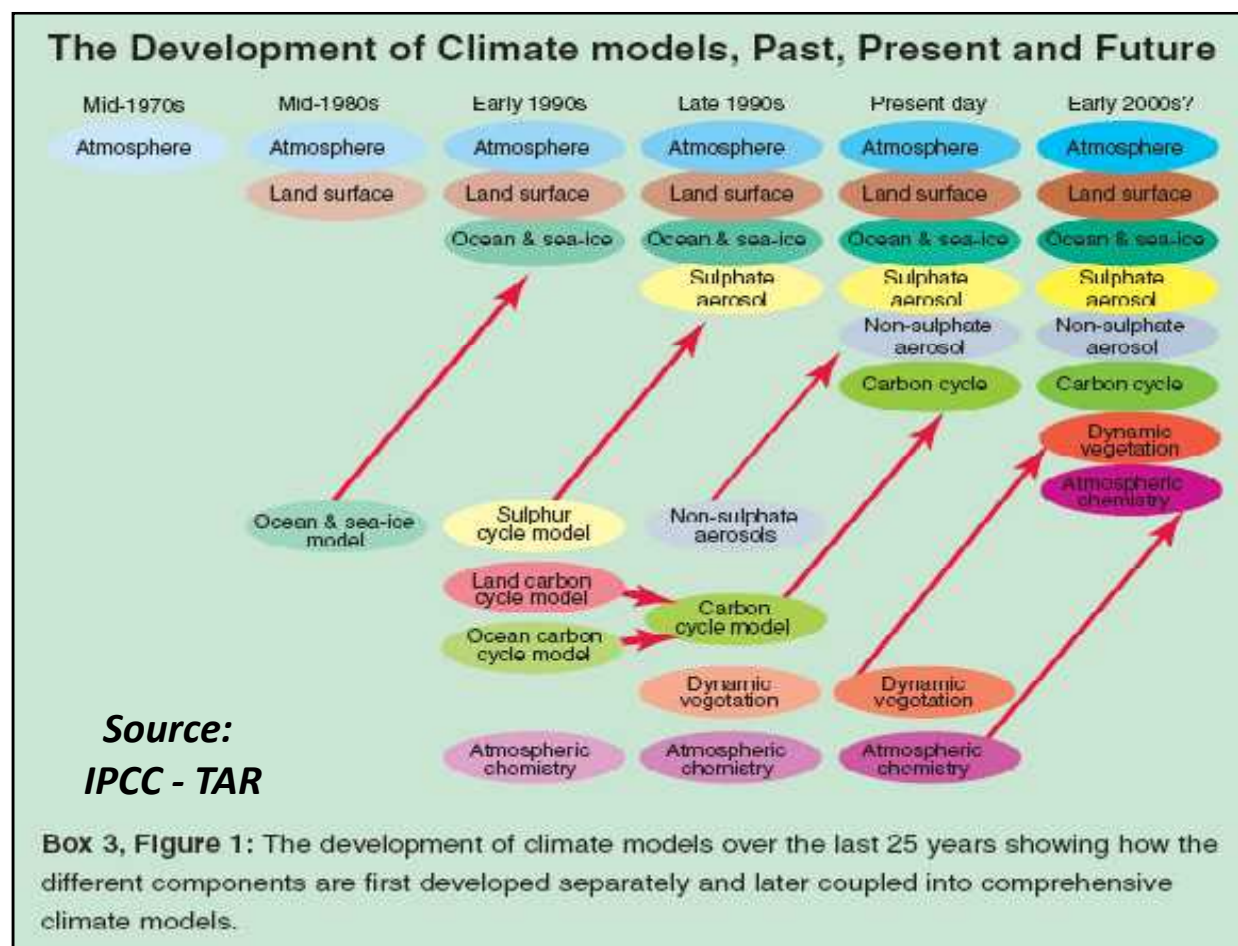
Resolution of GCM has increased over time



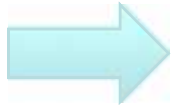
Climate Model Development

Different components have been added in climate models to represent more accurately the complexity of climate systems

More components are under development, to better understand and simulate the variation of climate (e.g. Oceans)



1988



United Nations (UNEP & WHO) form the **IPCC** -
Intergovernmental Panel on Climate Change

Report: 1990-1995-2001-2007-2014

Working Group I Report
"Climate Change 2013: The Physical Science Basis"



Working Group II Report
"Impacts, Adaptation and Vulnerability"



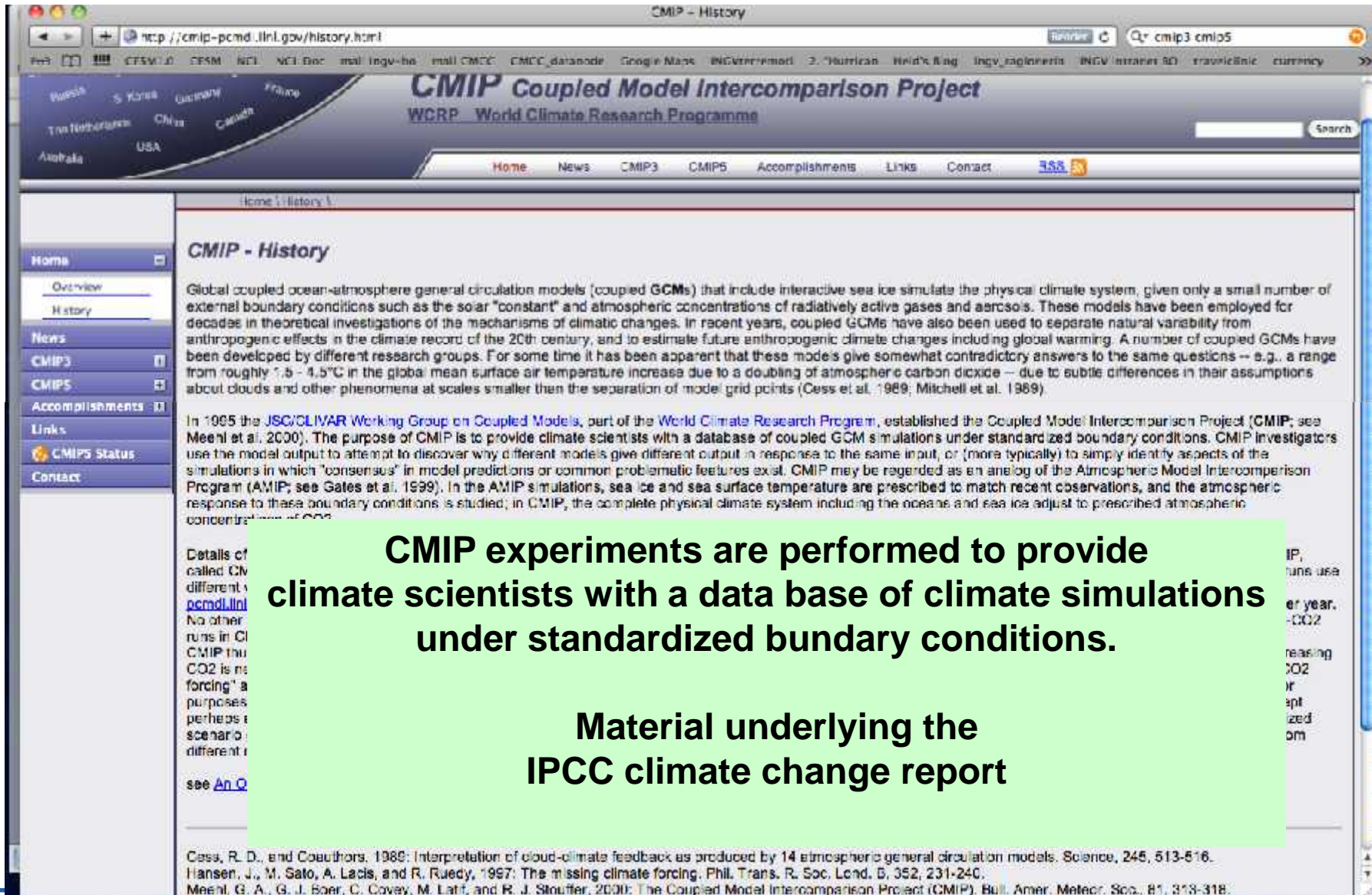
Working Group III Report
"Mitigation of Climate Change"



<http://www.ipcc.ch/>



Climate Model Development: CMIP dataset



The screenshot shows a web browser window displaying the 'CMIP - History' page. The browser's address bar shows the URL 'http://cmip-pcmdi.llnl.gov/history.html'. The page header includes the CMIP logo and the text 'CMIP Coupled Model Intercomparison Project' and 'WCRP World Climate Research Programme'. A navigation menu on the left lists 'Home', 'Overview', 'History', 'News', 'CMIP3', 'CMIP5', 'Accomplishments', 'Links', 'CMIP5 Status', and 'Contact'. The main content area is titled 'CMIP - History' and contains two paragraphs of text. The first paragraph describes the purpose of CMIP, and the second paragraph mentions the JSC/CLIVAR Working Group on Coupled Models. A green text box is overlaid on the page, containing the text: 'CMIP experiments are performed to provide climate scientists with a data base of climate simulations under standardized boundary conditions. Material underlying the IPCC climate change report'. At the bottom of the page, there is a list of references.

CMIP experiments are performed to provide climate scientists with a data base of climate simulations under standardized boundary conditions.

Material underlying the IPCC climate change report

Global coupled ocean-atmosphere general circulation models (coupled GCMs) that include interactive sea ice simulate the physical climate system, given only a small number of external boundary conditions such as the solar "constant" and atmospheric concentrations of radiatively active gases and aerosols. These models have been employed for decades in theoretical investigations of the mechanisms of climatic changes. In recent years, coupled GCMs have also been used to separate natural variability from anthropogenic effects in the climate record of the 20th century, and to estimate future anthropogenic climate changes including global warming. A number of coupled GCMs have been developed by different research groups. For some time it has been apparent that these models give somewhat contradictory answers to the same questions -- e.g., a range from roughly 1.5 - 4.5°C in the global mean surface air temperature increase due to a doubling of atmospheric carbon dioxide -- due to subtle differences in their assumptions about clouds and other phenomena at scales smaller than the separation of model grid points (Cess et al. 1989; Mitchell et al. 1989).

In 1995 the JSC/CLIVAR Working Group on Coupled Models, part of the World Climate Research Programme, established the Coupled Model Intercomparison Project (CMIP; see Meenl et al. 2000). The purpose of CMIP is to provide climate scientists with a database of coupled GCM simulations under standardized boundary conditions. CMIP investigators use the model output to attempt to discover why different models give different output in response to the same input, or (more typically) to simply identify aspects of the simulations in which "consensus" in model predictions or common problematic features exist. CMIP may be regarded as an analog of the Atmospheric Model Intercomparison Program (AMIP; see Gates et al. 1999). In the AMIP simulations, sea ice and sea surface temperature are prescribed to match recent observations, and the atmospheric response to these boundary conditions is studied; in CMIP, the complete physical climate system including the oceans and sea ice adjust to prescribed atmospheric concentrations of CO₂.

Cess, R. D., and Coauthors. 1989: Interpretation of cloud-climate feedback as produced by 14 atmospheric general circulation models. *Science*, 245, 513-516.

Hansen, J., M. Sato, A. Lacis, and R. Ruedy. 1987: The missing climate forcing. *Phil. Trans. R. Soc. Lond. B*, 352, 231-240.

Meenl, G. A., G. J. Boer, C. Covey, M. Latif, and R. J. Stouffer, 2000: The Coupled Model Intercomparison Project (CMIP). *Bull. Amer. Meteor. Soc.*, 81, 313-318.

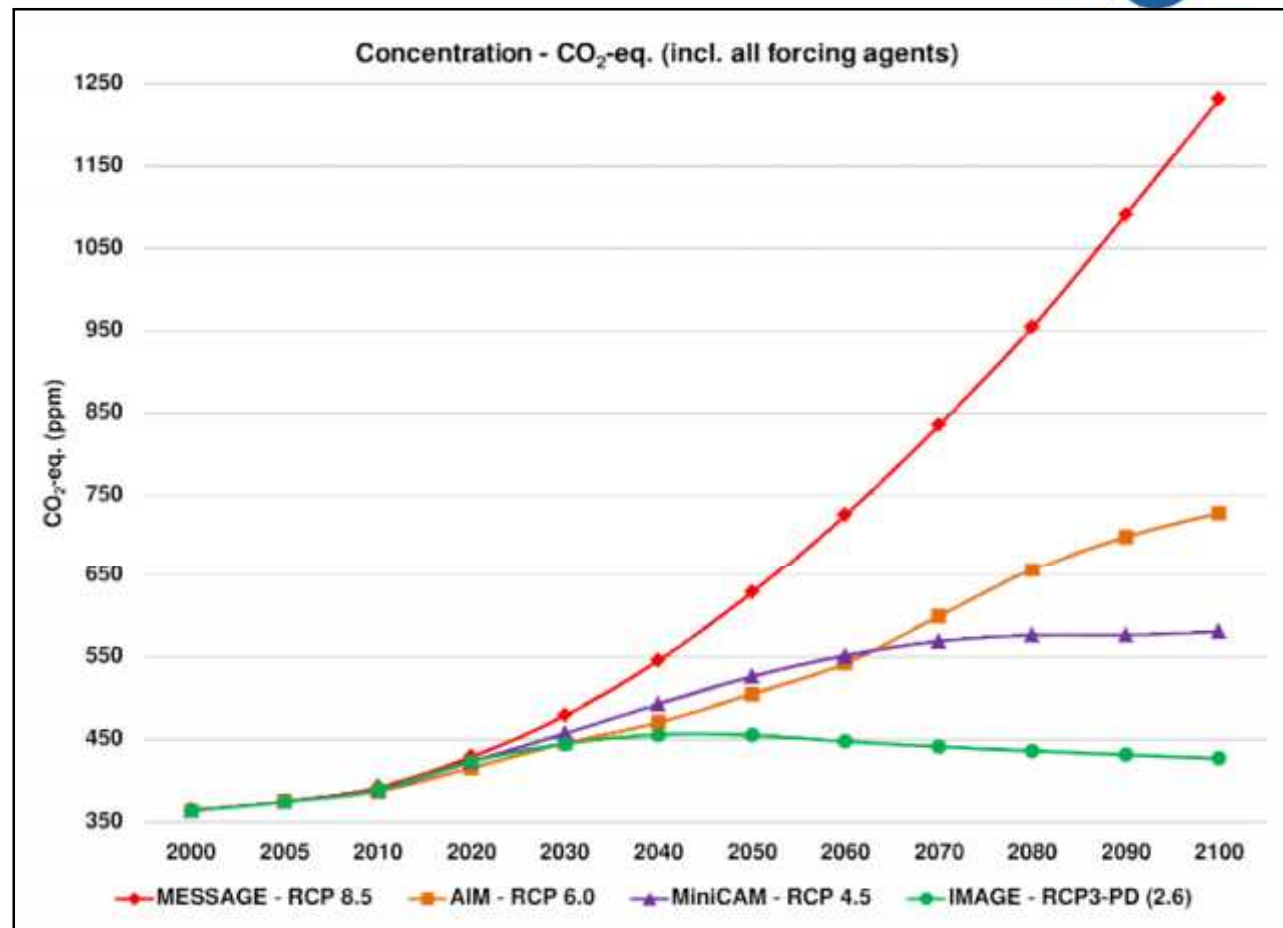
Emission Scenarios



Representative Concentration Pathway (RCP)

Based directly on the
radiative forcing of
CO₂ concentrations.

Previous emission
scenarios were
based on socio-
economic
development (SRES)



RCP 2.6 = 2.6 W m⁻²



421 ppm

RCP 4.5 = 4.5 W m⁻²



538 ppm

RCP 6.0 = 6.0 W m⁻²



670 ppm

RCP 8.5 = 8.5 W m⁻²



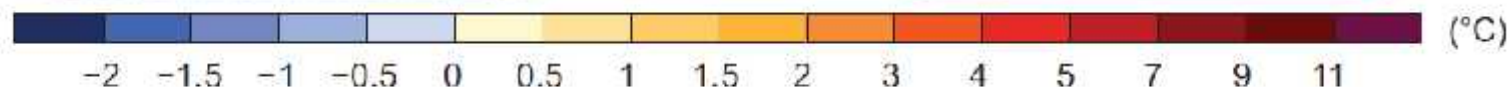
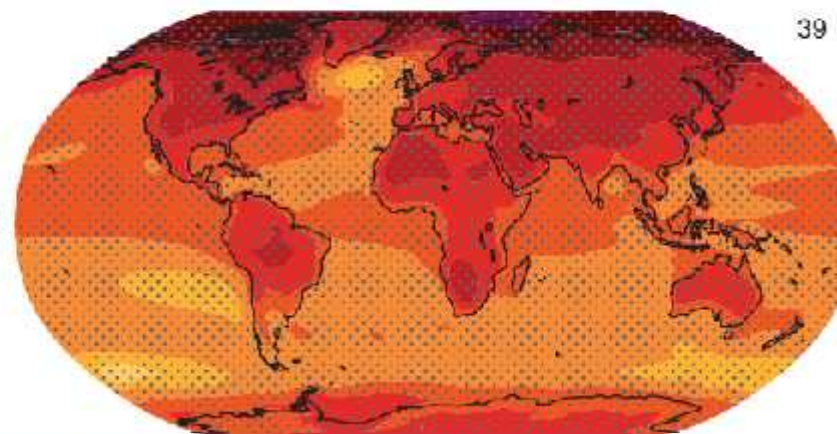
936 ppm

Climate Model projections: Global

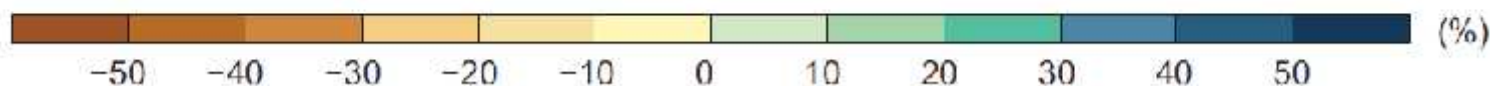
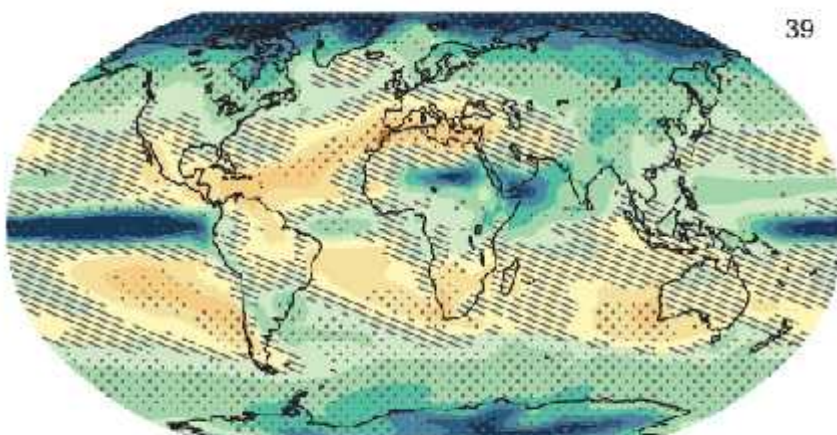
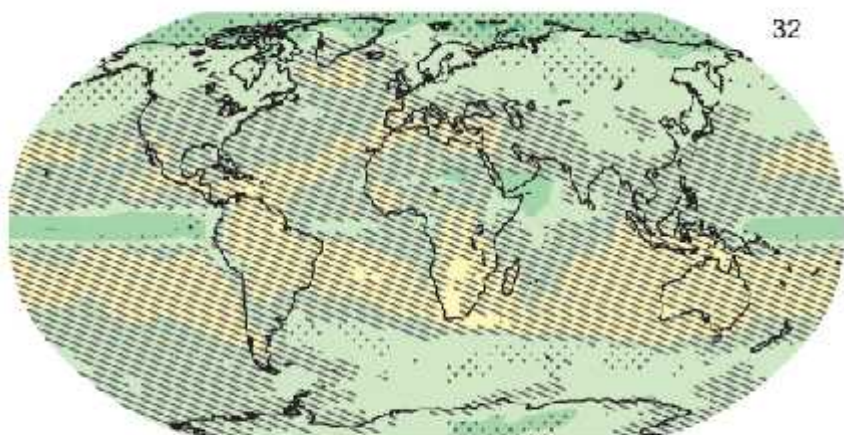
RCP 2.6

RCP 8.5

Change in average surface temperature (1986–2005 to 2081–2100)



Change in average precipitation (1986–2005 to 2081–2100)



Climate Model projections: EM

Mediterranean:

Average temperature increase:

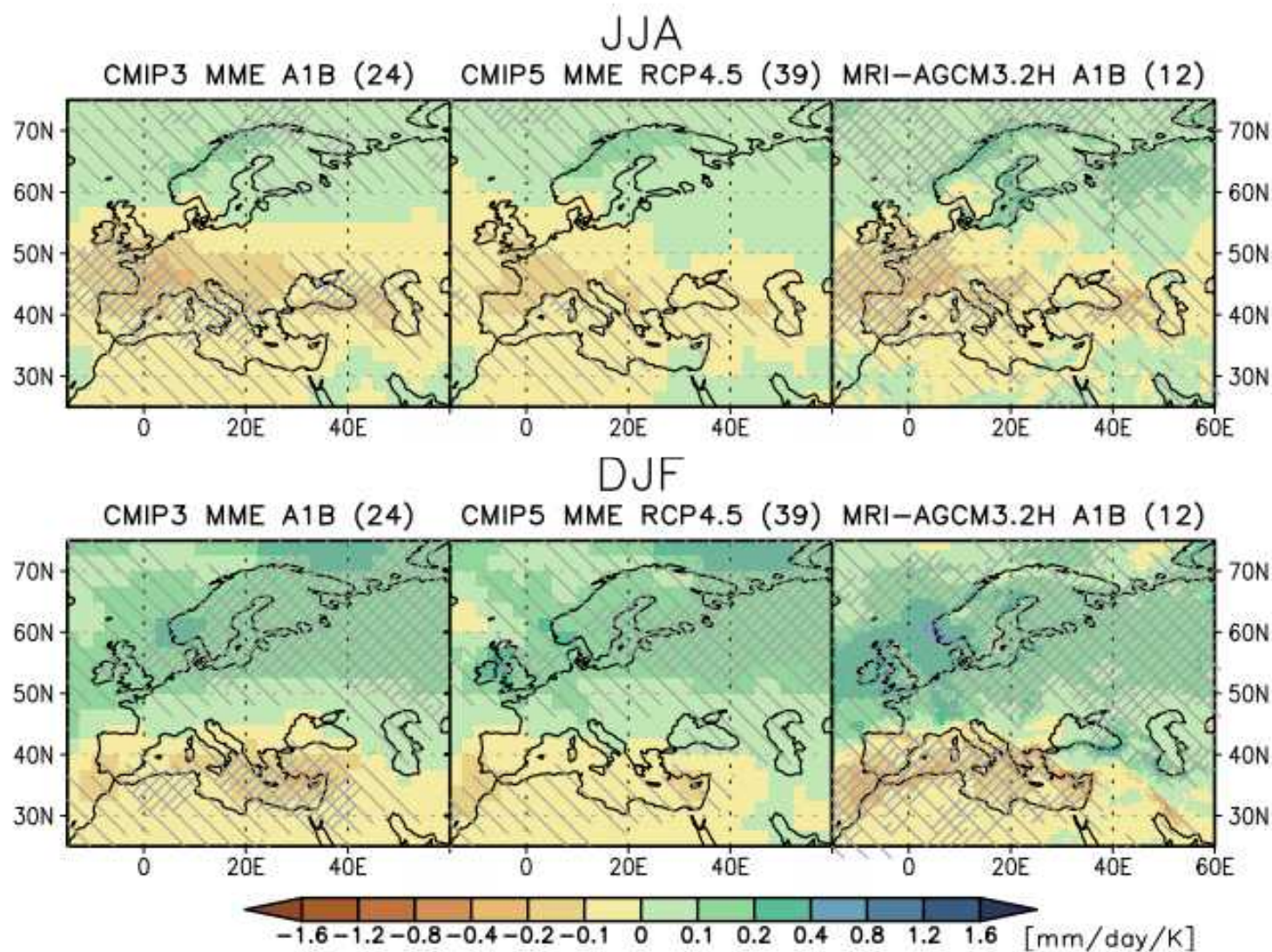
- highest : summer
- lowest : winter

Annual precipitation very likely to slightly decrease
during most months of the year

TEMP increase + significant PREC decrease → drought
risk will increase



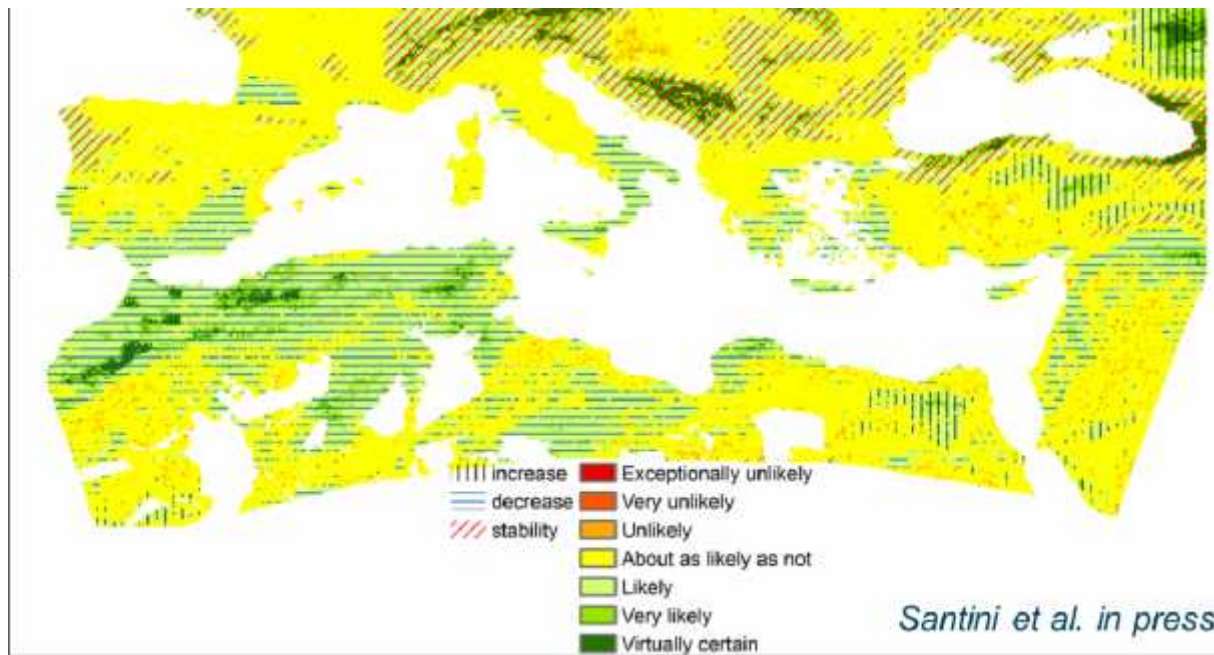
Climate Model projections: EM



Climate Model projections: Impacts in the EM

Higher risks of scarce water availability, especially in the mediterraneum due to:

- More extreme rainfall events will lead to less soil water recharge



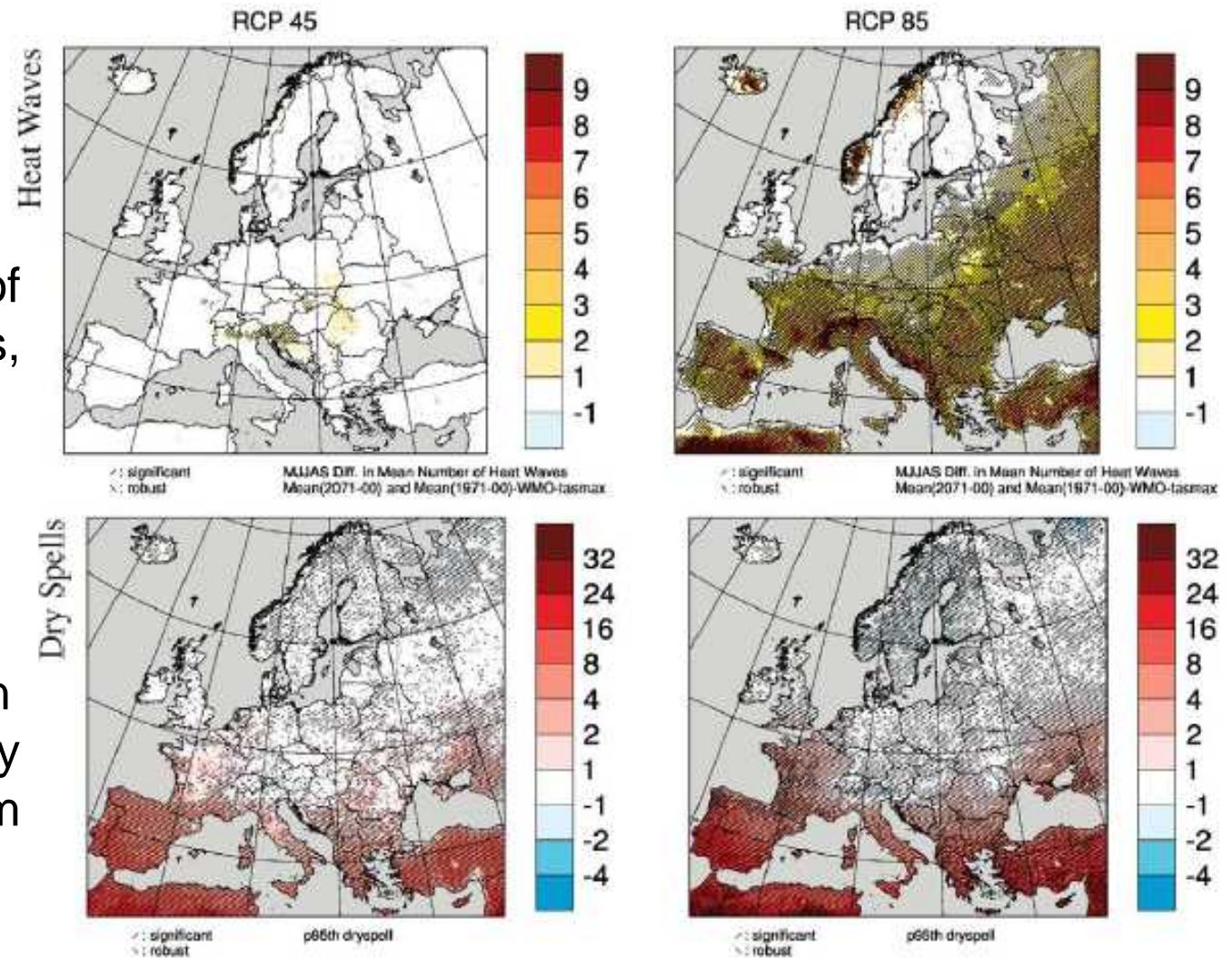
- Increasing vegetation water demand (higher EvapoTranspiration)
- Consequent increase of irrigation requirements
- Higher water conflicts with other sectors (domestic, industrial, etc)

Climate Model projections: Impacts in the EM

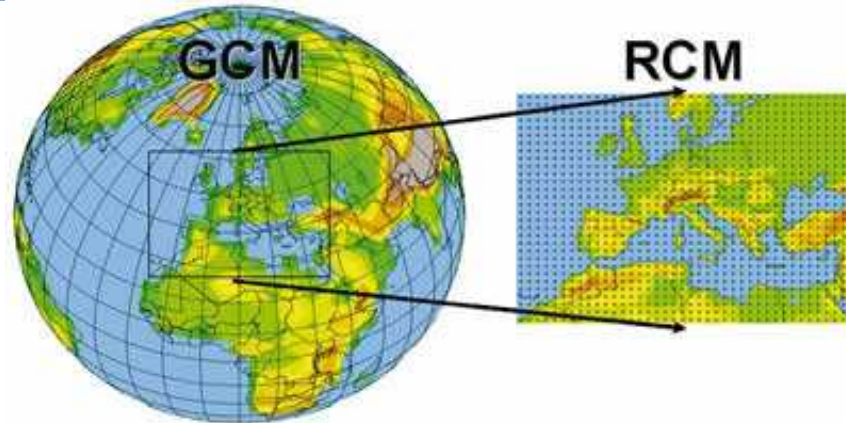
Increasing risk of extreme climate events, especially heat waves.

Impact on:

- Human health,
- Agricultural production
- Forest fires especially in the mediterraneum and boreal forests.



Climate Modeling: Downscaling



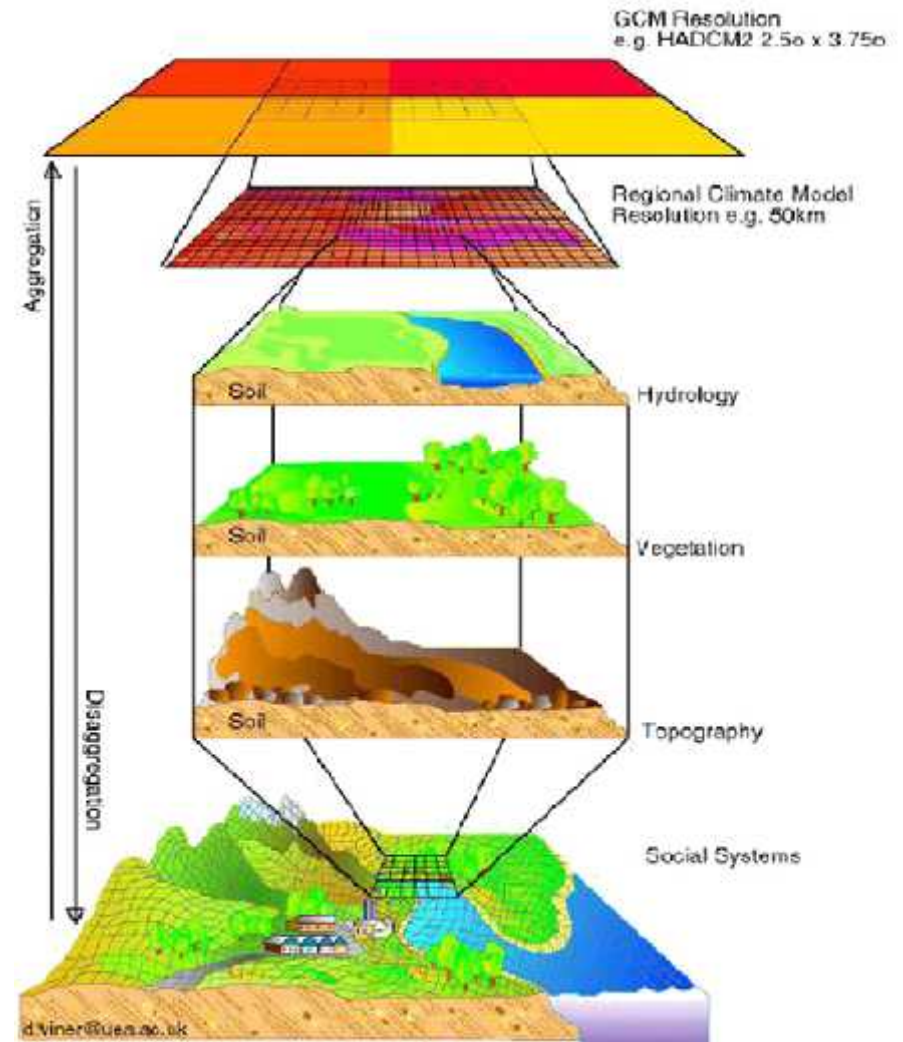
Downscaling indicates an increase of the spatial resolution from GCM.

Needed for climate impact studies

A Regional Climate Model (RCM) is an additional climate model that is run within a Global Circulation Model

Maintaining consistency with the general atmospheric physical GCM description.

Example: GCM HadCM downscaled with COSMO-CLM RCM



Climate Modeling: Downscaled data

<http://gisweb.ciat.cgiar.org/MarkSimGCM/>

The screenshot shows the MarkSim DSSAT weather file generator web interface. The browser address bar displays gisweb.ciat.cgiar.org/MarkSimGCM/. The page title is "MarkSim® DSSAT weather file generator". Below the title, a message states: "This is the MarkSim web version for IPCC AR5 data (CMIP5), for the previous (AR4, CMIP3) version please click [here](#)".

The interface is divided into a left sidebar and a main map area. The sidebar contains the following controls:

- Lat:** 30.4553
- Lon:** -1.1797
- Model:** Select All Models | None
- Scenario:** RCP 2.6, RCP 4.5, RCP 6.0, RCP 8.5
- Year:** 2010
- Replications:** 1
- Seed:** 1234
- Place:** C.75F
- Buttons:** "Climate Diagram" (green), "Run Model" (blue), "Clear Parameters" (link), "Reset" (link)

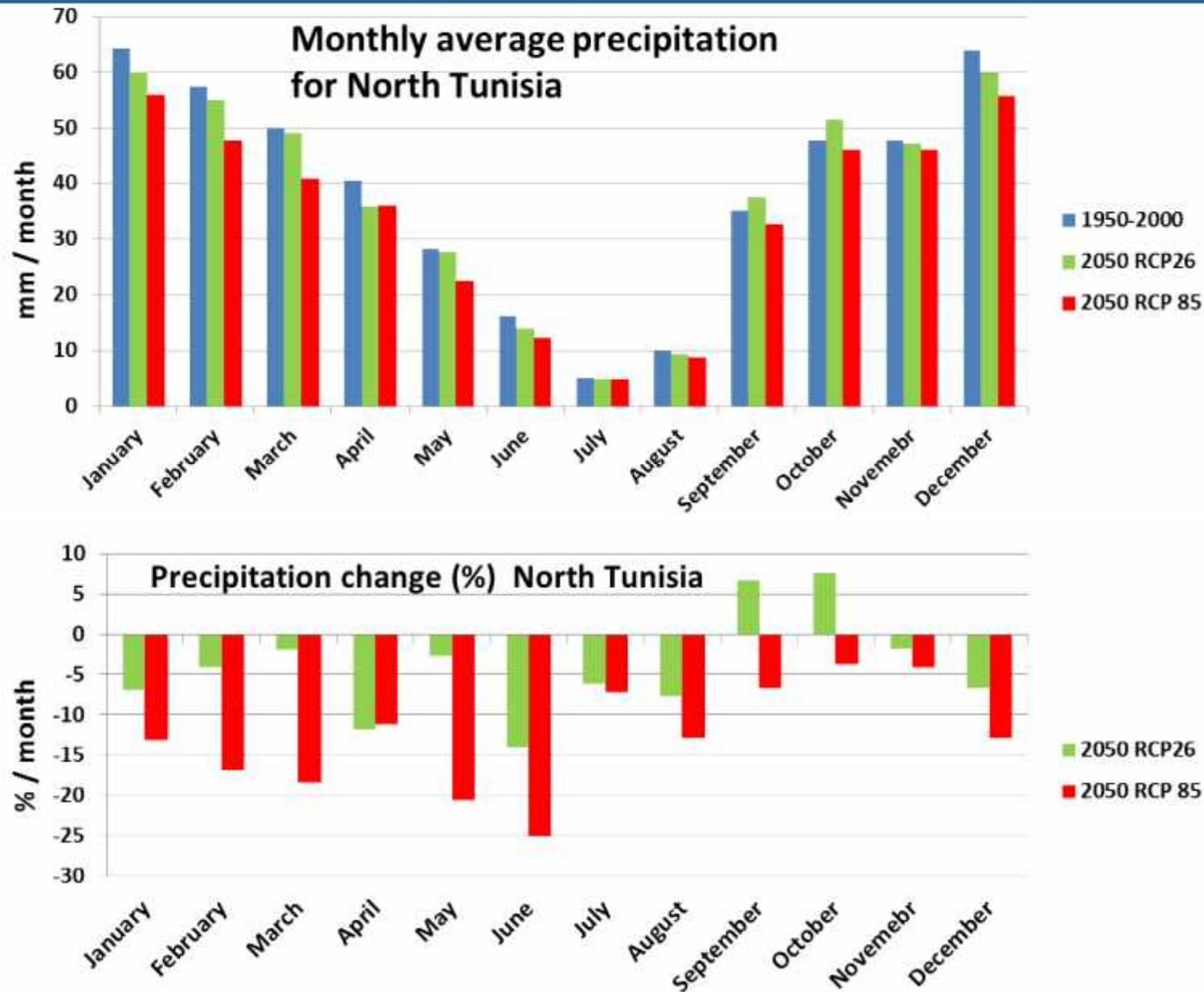
The main map area displays a satellite image of the Iberian Peninsula. A "Go to location" button is at the top. The map includes a legend at the bottom with checkboxes for: Borders, Roads, Buildings, Clouds, Grid, Status Bar, Overview Map, and Scale Legend. The map also shows a "How to use it" link and a "Show it" link.

Climate Modeling: communicating the issue

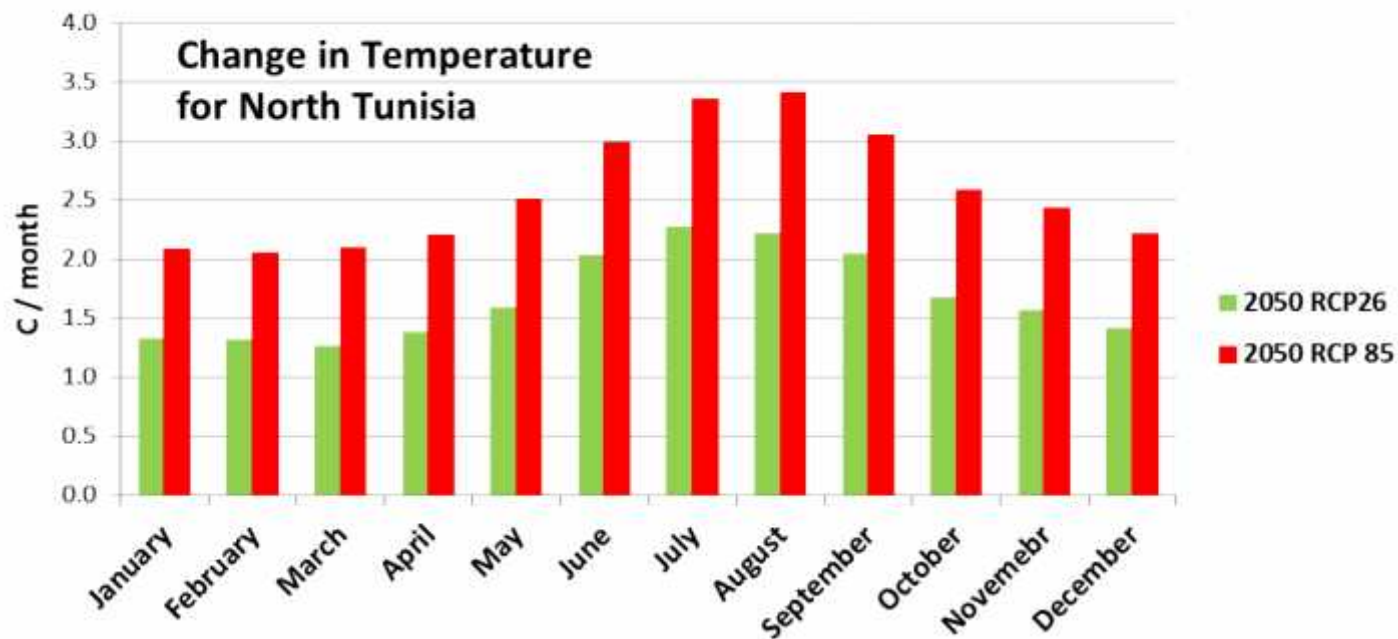
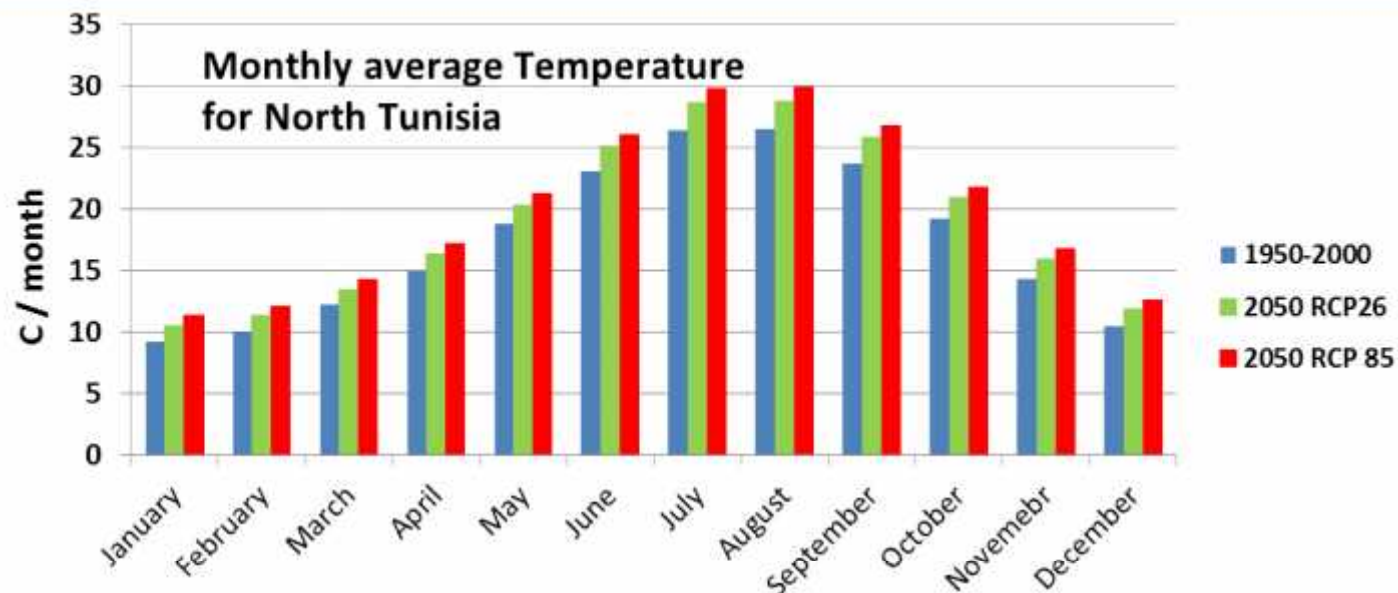
- Climate models have improved in the past few years, and society is now demanding ever more accurate information from climate scientists to study the impacts at smaller scales.
- More (less certain!) knowledge will have to be inserted into climate models, and early results may cause problems in the public understanding of climate change.
- Performing cutting-edge climate science in public could easily lead to misinterpretation, and it will take a great deal of work communicating carefully with the public and policy makers to ensure that the results are used appropriately. (K. Trenberth, 2010)



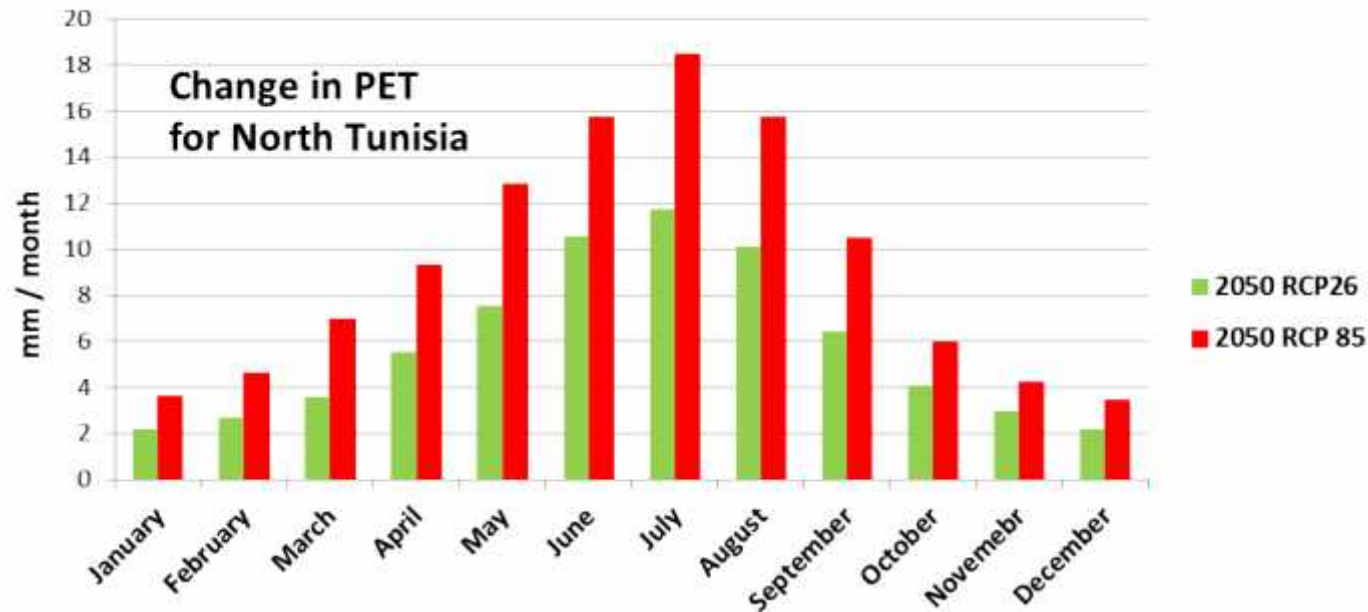
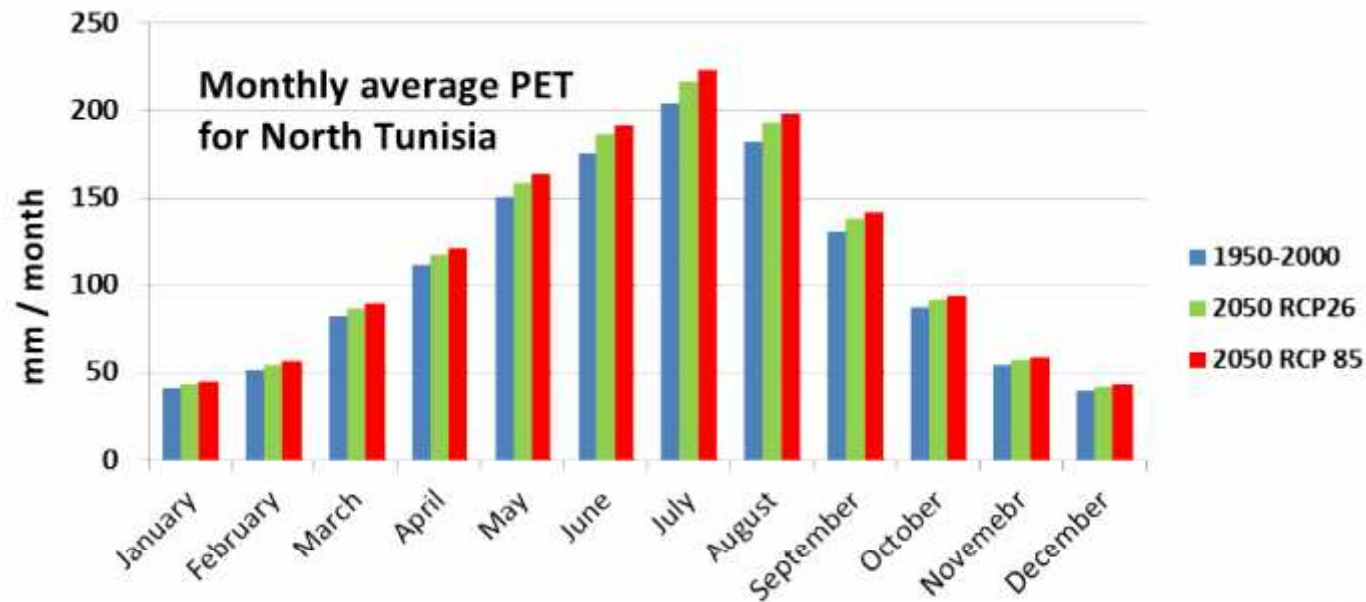
Climate Modeling: Impact in North Tunisia



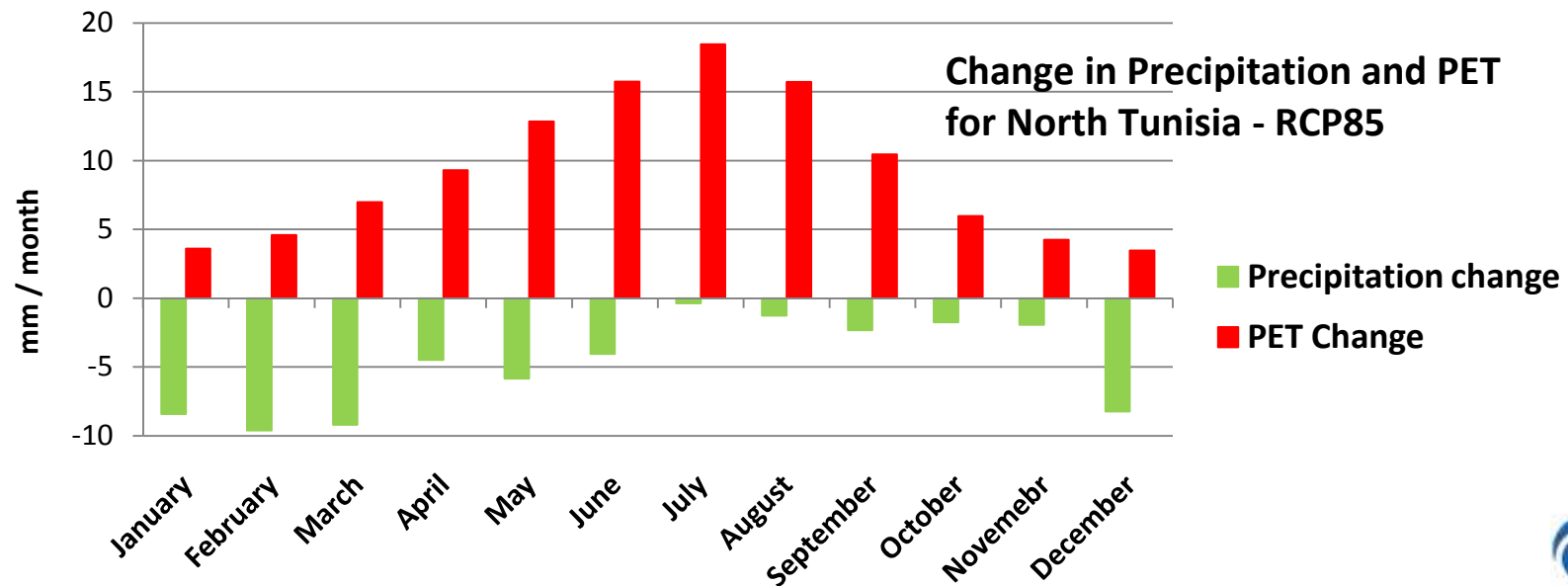
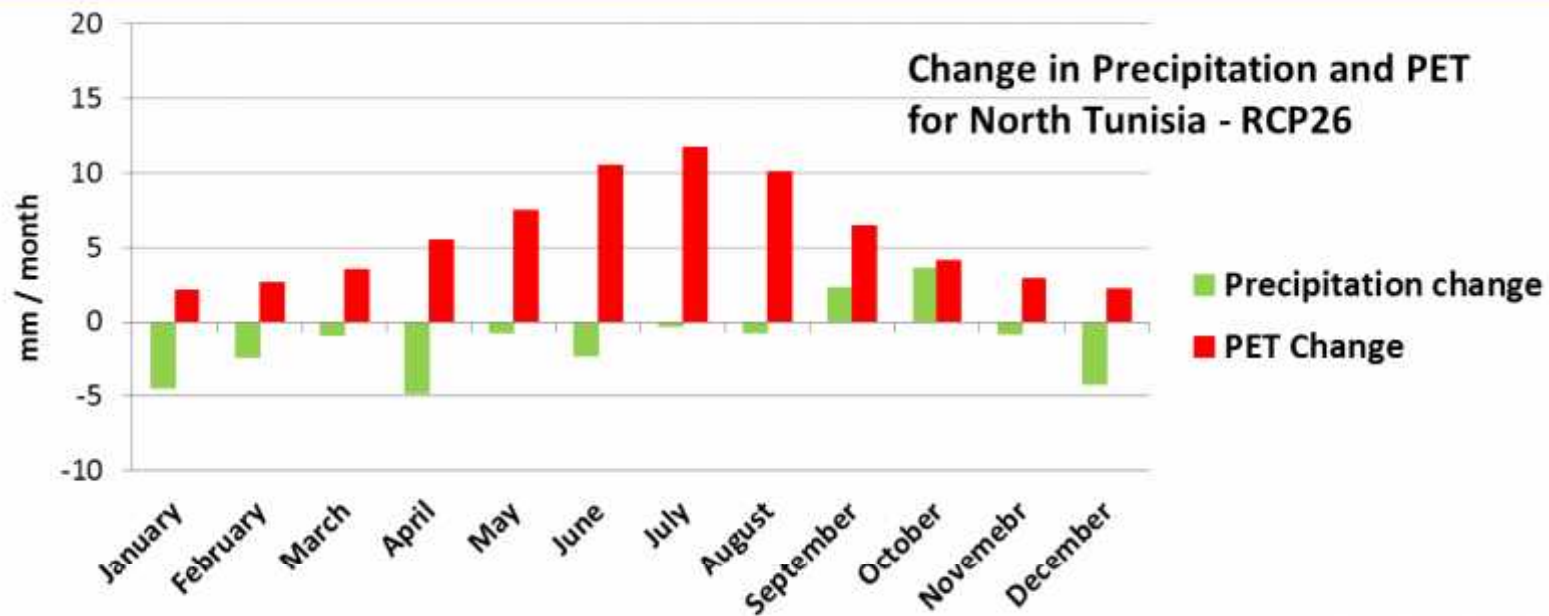
Climate Modeling: Impact in North Tunisia



Climate Modeling: Impact in North Tunisia



Climate Modeling: Impact in North Tunisia



Merci!!

