Observed and Projected Global Climate Change and its Regional Impacts

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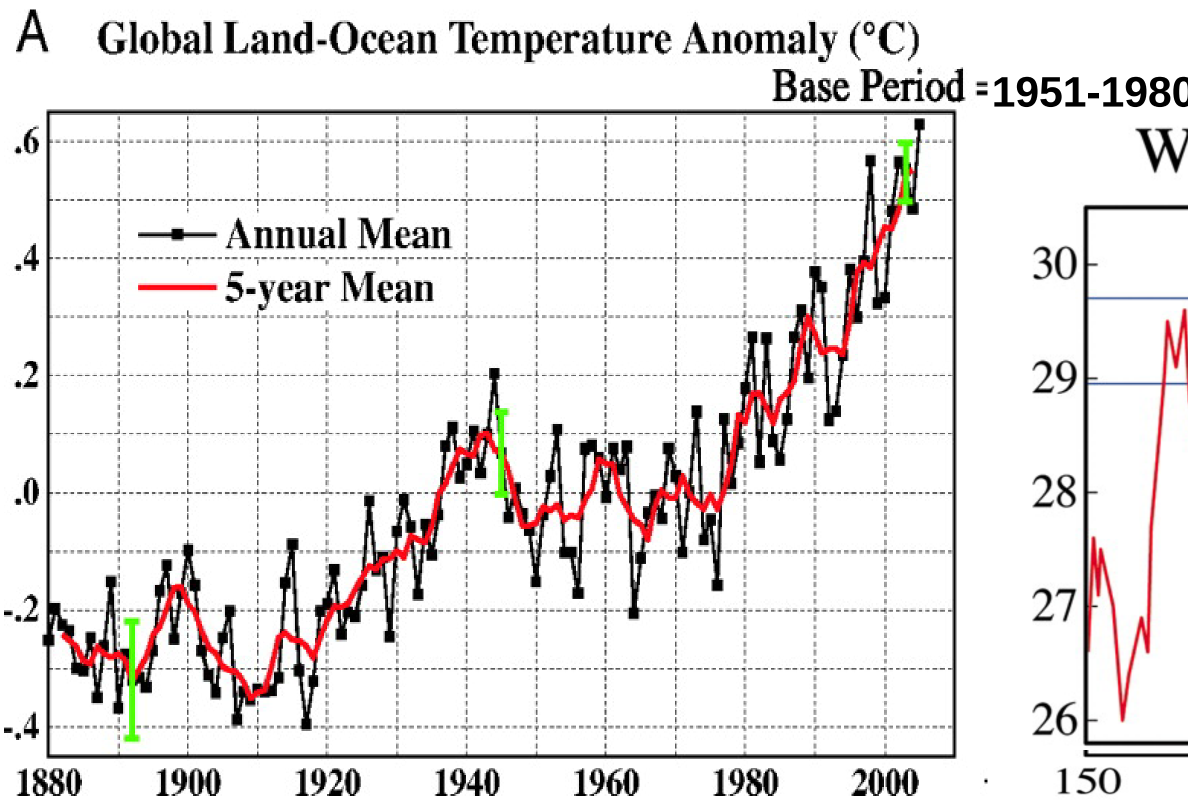
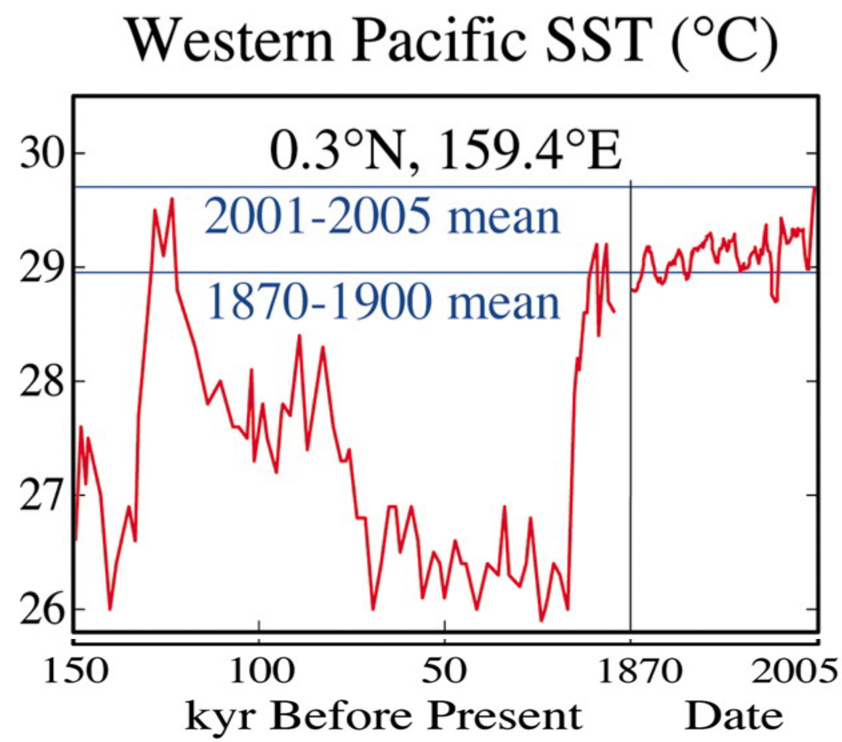
OUTLINE

- Is there Observational Evidence for Climate Change?
  - temperature trends
  - precipitation trends
  - extreme events
- Use of Numerical Models to Separate Cause and Effect
- Future Projections

Surface Temperature Change



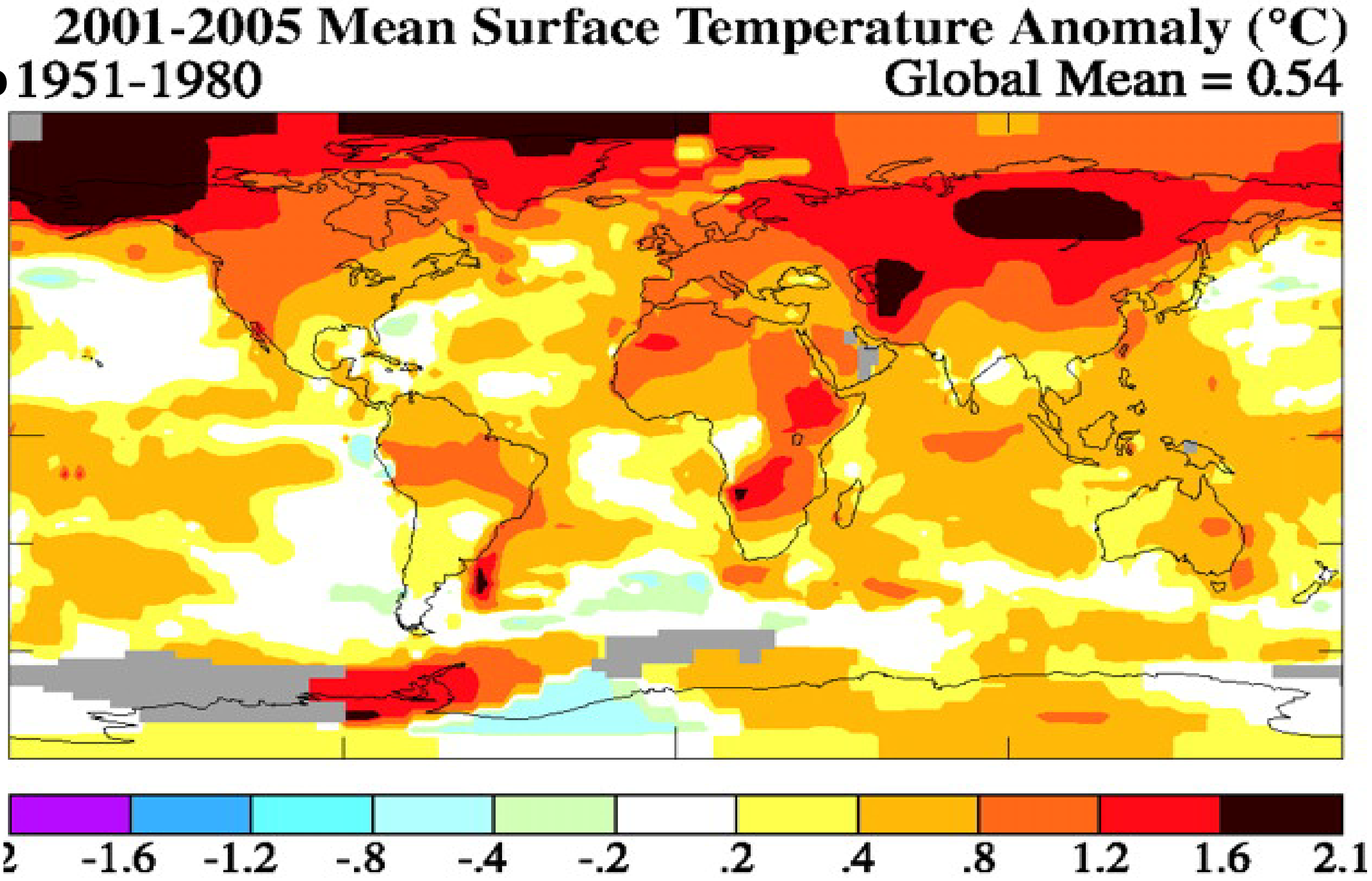


+ 0.35^{o}C between1910s–1940s
- 0.1 ^{o}C between 1950s and 1970s
+ 0.55^{o}C from 1970s to the present

Hansen, James et al. (2006)
Proc. Natl. Acad. Sci. USA 103, 14288-14293

Surface Temperature Change

compared to



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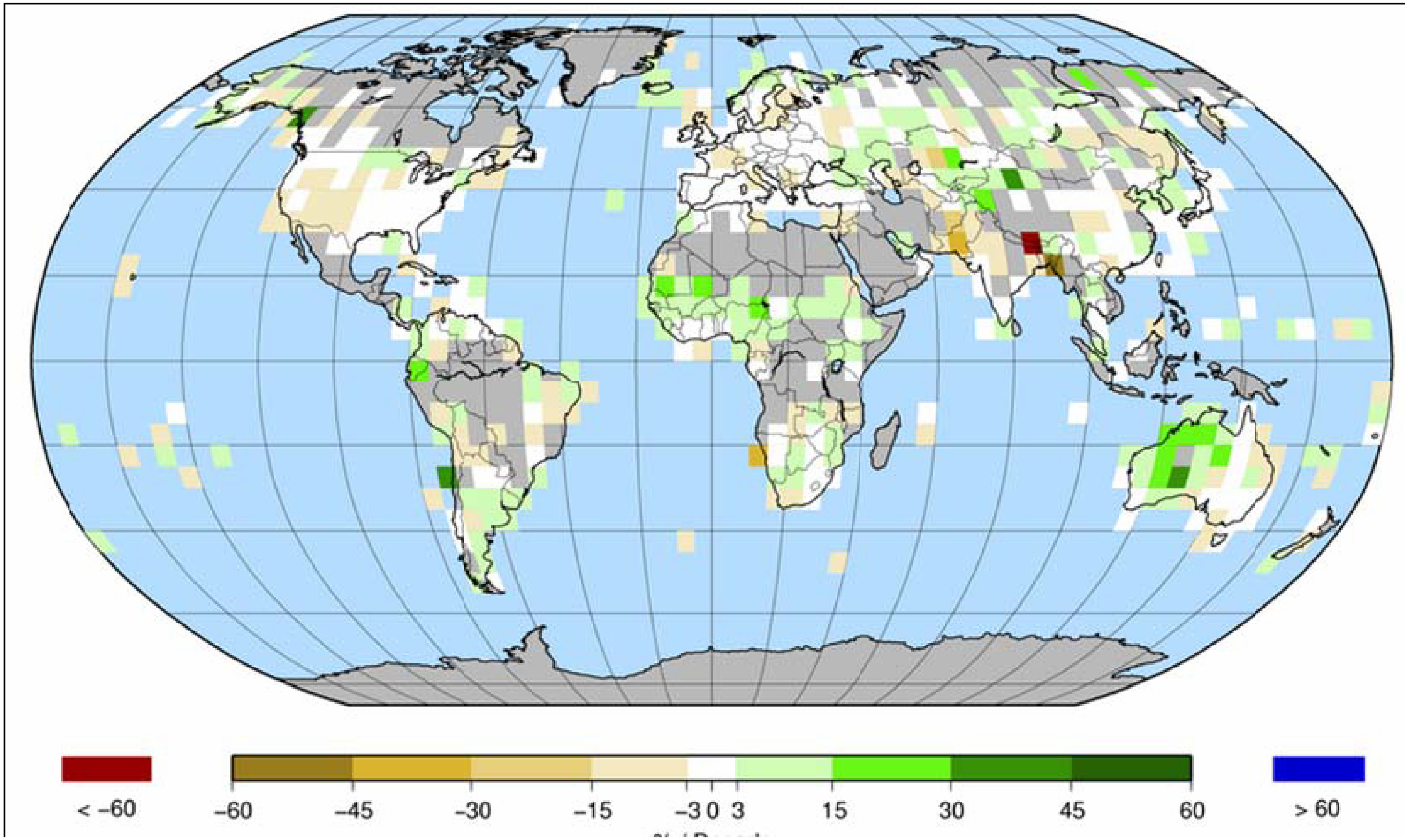
Precipitation Change

1979–2005 compared to 1961-90



percentage change

IPCC 4AR, WG1, Trenberth et al., 2007

Temperature Extremes

over 70% of the global land area

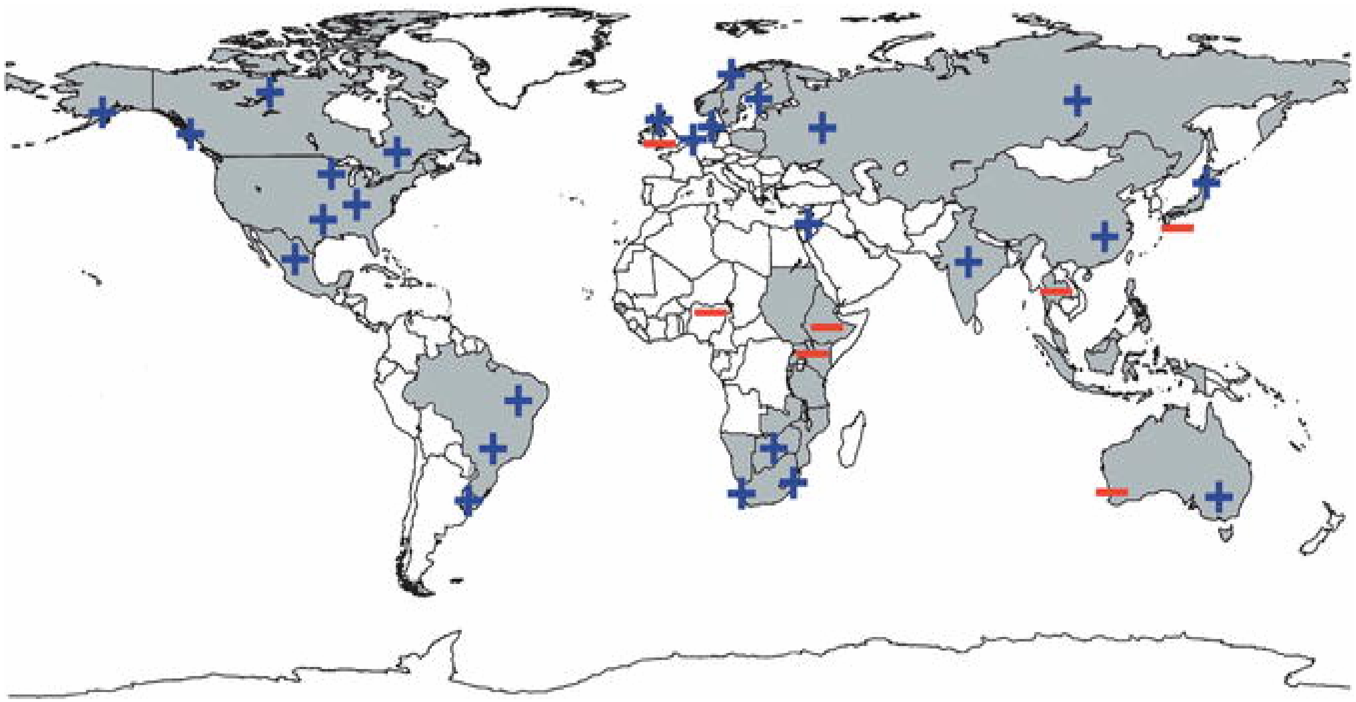
significant decrease in the annual occurrence of cold nights

and

significant increase in the annual occurrence of warm nights

- small increase of temperature maxima

Precipitation Extremes



Regions where disproportionate changes in heavy and very heavy precipitation during the past decades were documented

Groisman et al., JClim 2005

Climate Variability

1. internal variability

   non-linear dynamics – chaotic

2. forced variability

natural forcings –
volcanic eruptions, change in the solar constant, change in the orbital parameters

anthropogenic forcings –
land-use changes, emissions of greenhouse gases and aerosol particles

Attribution of Climate Change

Can we attribute observed climate change to human activities?

Can we separate internal variability, and response due to natural and anthropogenic perturbations?

→ Numerical Climate Models

„anthropogenic fingerprint“

Method of Climate Modeling

we integrate knowledge about some aspects of the climate system in a mathematical framework and conduct computer simulations.

Computer Simulations

predict the behaviour of the model system to given sets of boundary conditions and input parameters.

Earth System Models are the **Laboratories of Geoscientists**

we perform „experiments“

Can we trust models?

1. Proof model results by comparison to observations

2. Perception by the public

Make the evaluation process transparent by distributing results and model codes and by joining model intercomparisons.

Introduce standard procedures

Assess the confidence of statements about science

→ *IPCC procedure*

IPCC procedure to assure quality

- Define a set of scenarios
- Collect all model results
- Data processing and distribution
- Open access on request

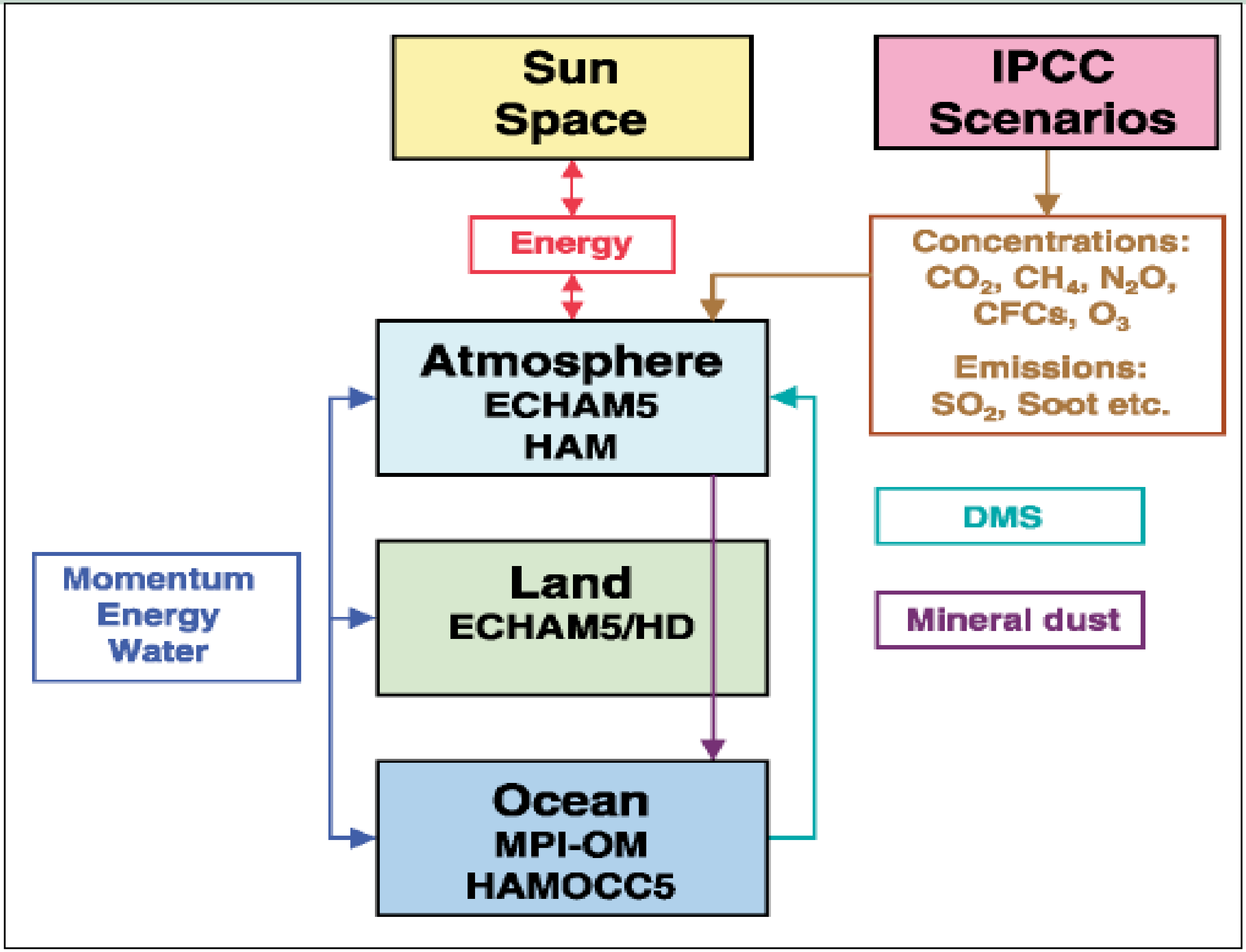
PCMDI *- Program for Climate Model Diagnosis and Intercomparison*

→ ~ 550 projects applied for data access

Model Simulations of Future Climate

- Emission scenarios
- Simulation of past climate 1860 - 2000
- Future projections 2001 – 2100

Earth System Model – MPI Hamburg



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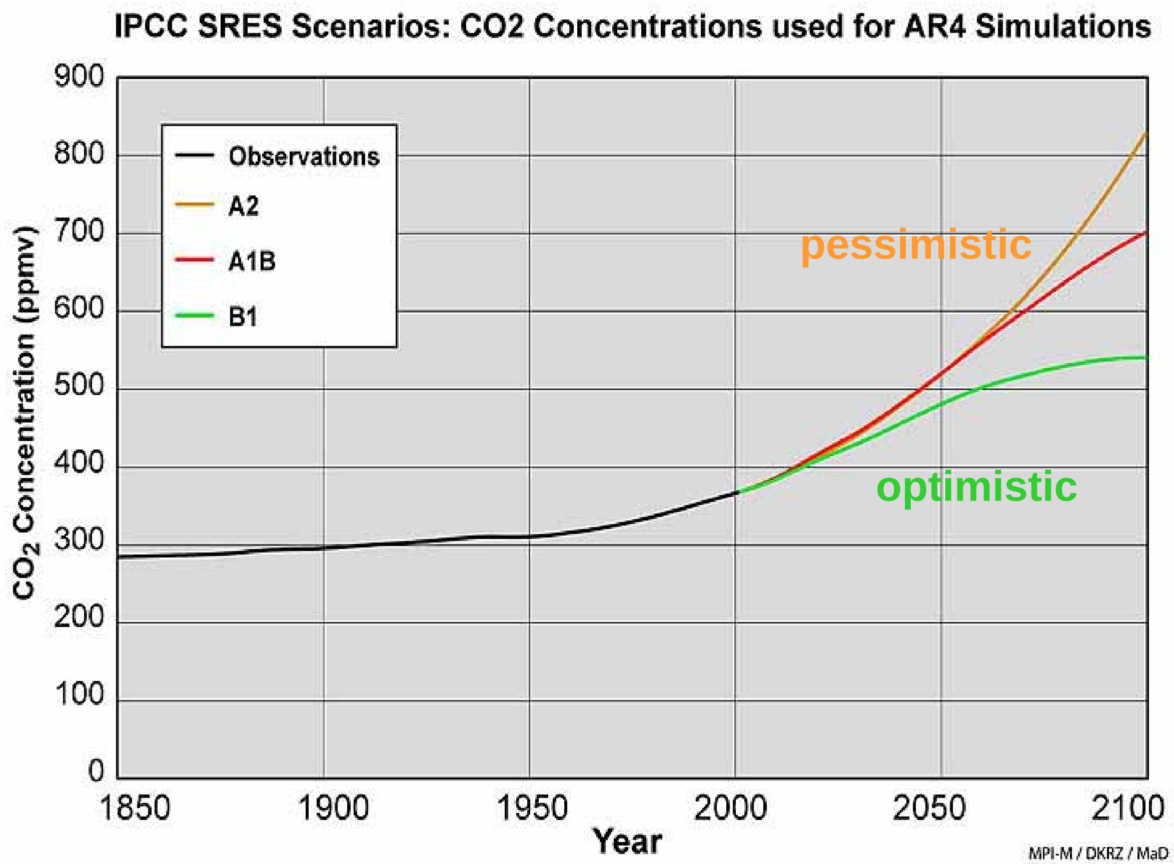
Socio-Economic Scenarios

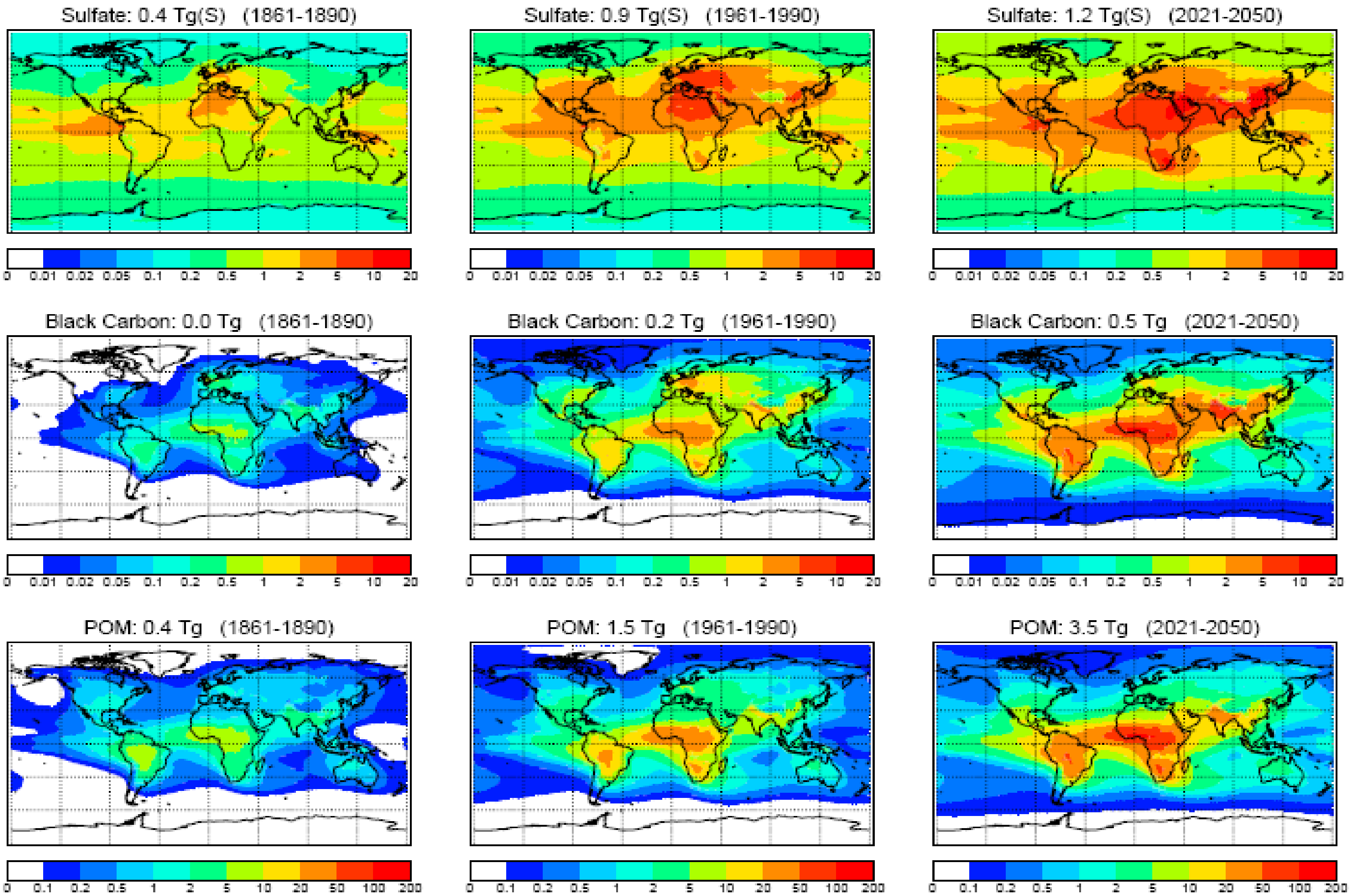


Scenarios

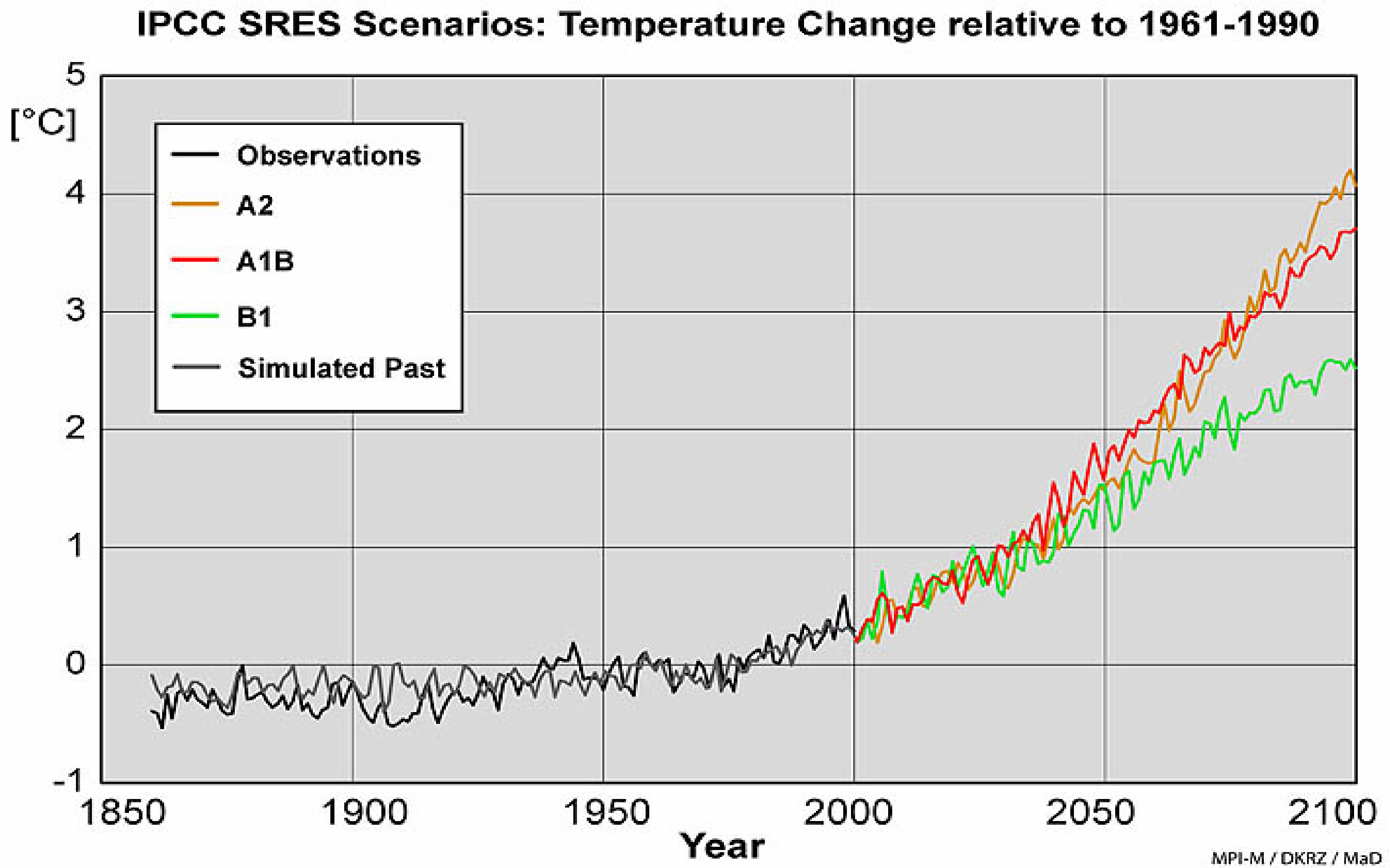
are options

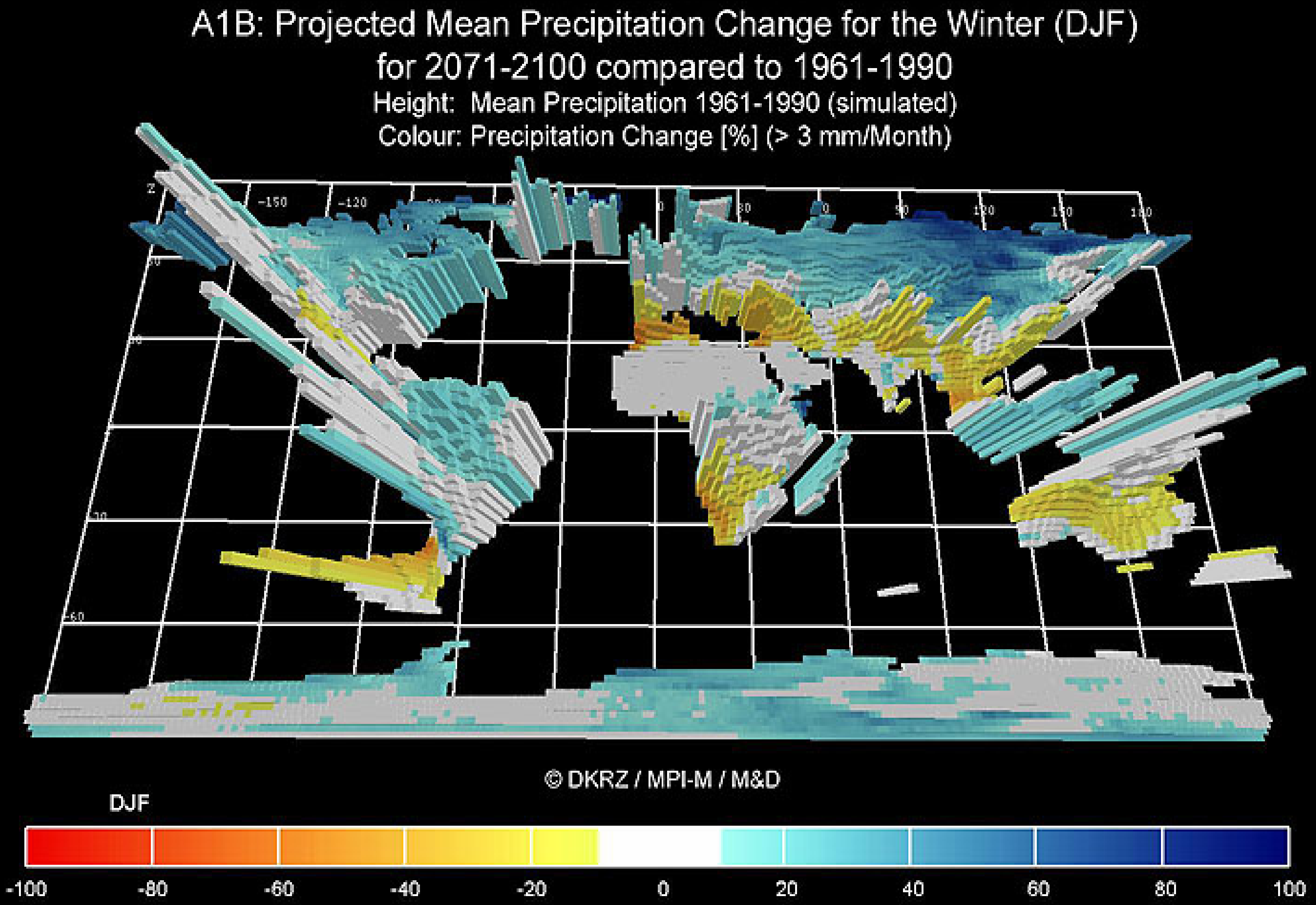
not

predictions



Sulfate: 0.4 Tg(S) (1861-1890)
Sulfate: 0.9 Tg(S) (1961-1990)
Sulfate: 1.2 Tg(S) (2021-2050)
0 0.01 0.02 0.05 0.1 0.2 0.5 1 2 5 10 20
Black Carbon: 0.0 Tg (1861-1890)
Black Carbon: 0.2 Tg (1961-1990)
Black Carbon: 0.5 Tg (2021-2050)
0 0.01 0.02 0.05 0.1 0.2 0.5 1 2 5 10 20
POM: 0.4 Tg (1861-1890)
POM: 1.5 Tg (1961-1990)
POM: 3.5 Tg (2021-2050)
0 0.1 0.2 0.5 1 2 5 10 20 50 100 200


IPCC SRES Scenarios: Temperature Change relative to 1961-1990
[°C]
Observations
A2
A1B
B1
Simulated Past
5
4
3
2
1
0
-1
1850
1900
1950
2000
2050
2100
Year
MPI-M / DKRZ / MaD



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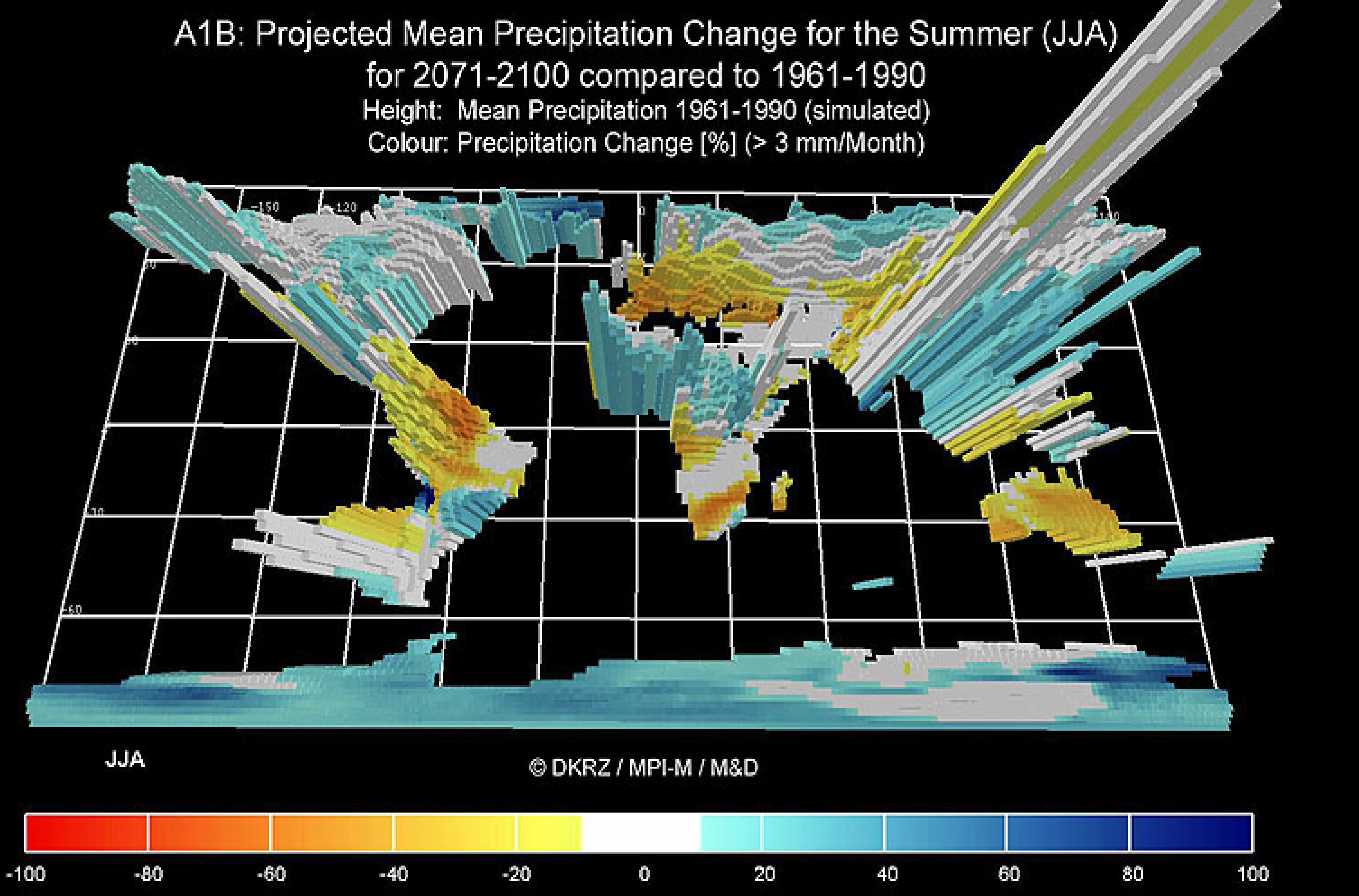
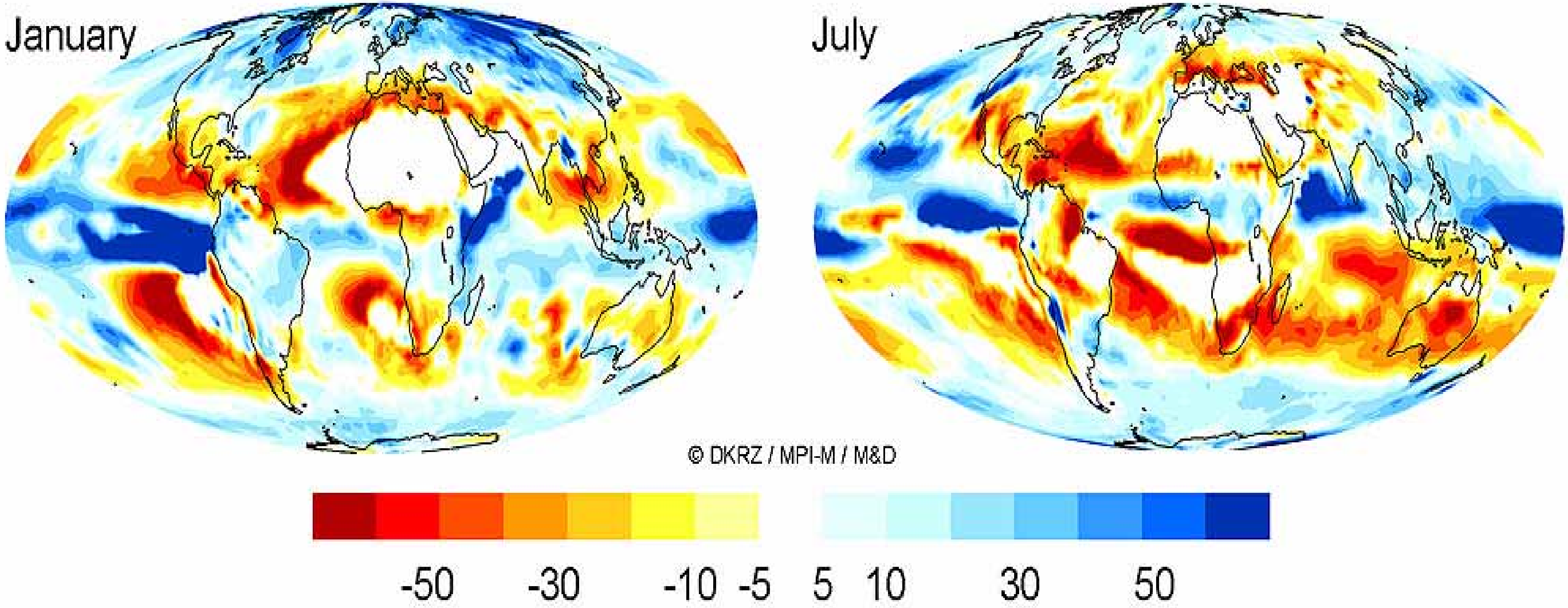
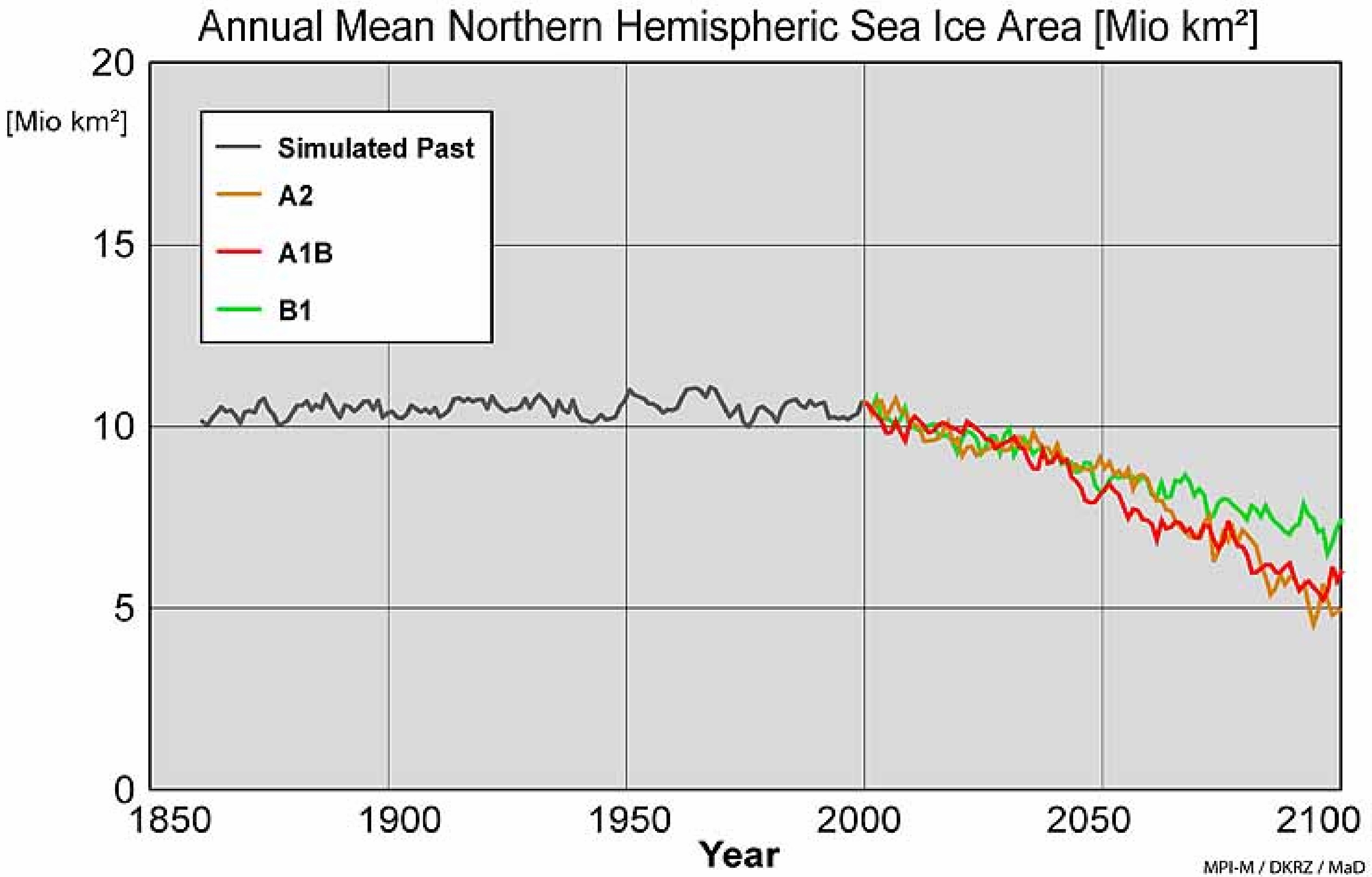

A1B: Projected Mean Precipitation Change for the Summer (JJA)
for 2071-2100 compared to 1961-1990
Height: Mean Precipitation 1961-1990 (simulated)
Colour: Precipitation Change [%] (> 3 mm/Month)
JJA
© DKRZ / MPI-M / M&D
-100
-80
-60
-40
-20
0
20
40
60
80
100

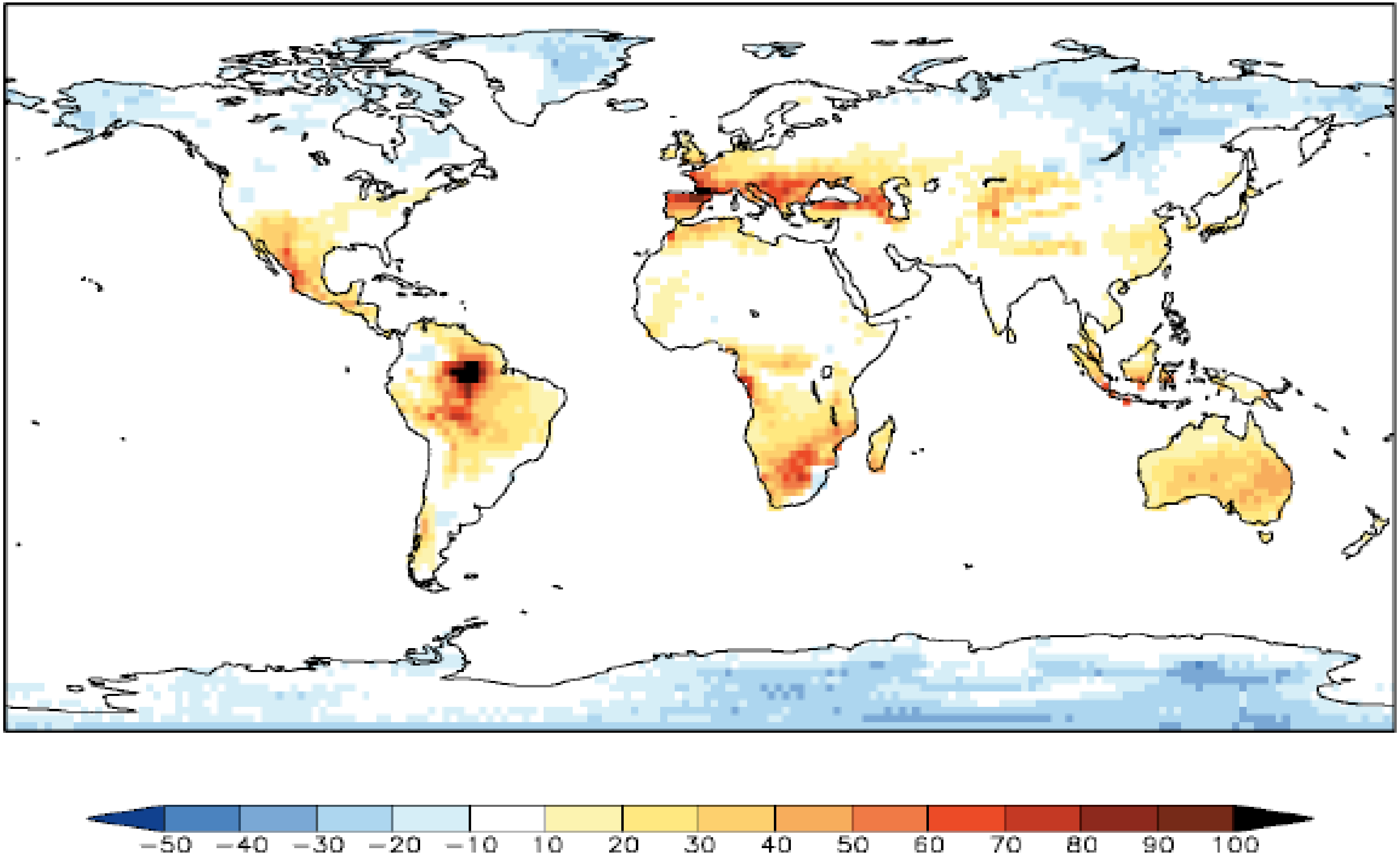
A1B: Mean Precipitation Change [%] for 2071-2100 compared with 1961-1990




Annual Mean Northern Hemispheric Sea Ice Area [Mio km²]
20
[Mio km²]
15
10
5
0
Simulated Past
A2
A1B
B1
1850
1900
1950
2000
2050
2100
Year
MPI-M / DKRZ / MaD

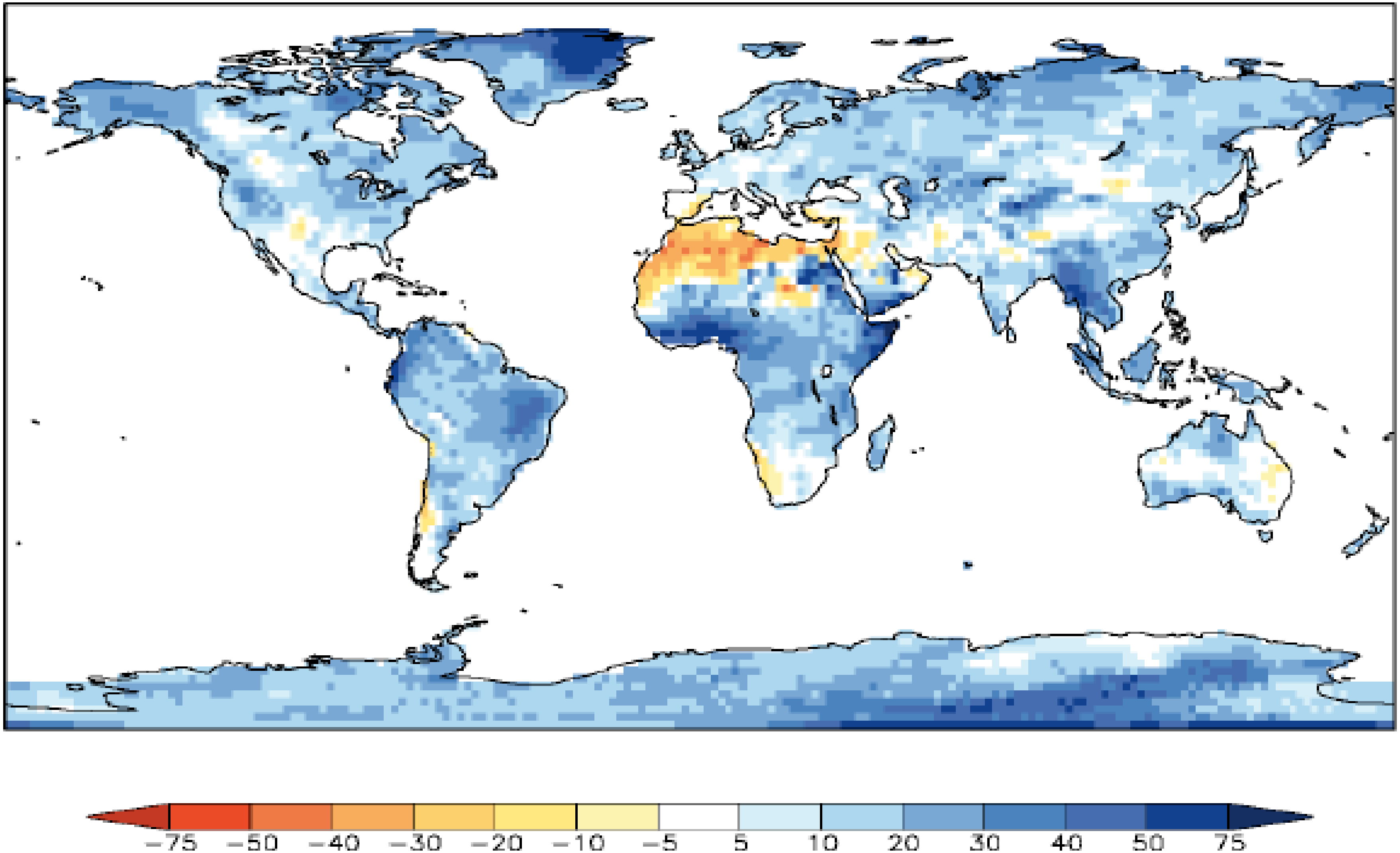
Percentage change of dry periods

2071-2100 compared to 1961-1990



Percentage change of annual extreme precipitation (5 days)

2071-2100 compared to 1961-1990



Summary

- greatest temperature increase at high northern latitudes and over continents
- more heat waves
- evaporation and precipitation increase
- more precipitation in high latitudes and in the tropics
- less precipitation in the subtropics
- summer drying over mid-latitude continents

East Asia:

- daily maximum and daily minimum temperatures will very like increase
- more non-precipitating days in winter
- more frequent heavy rainfall in summer

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