

Our Climate 2100



Dietmar Dommenges

My Research Themes

[2008] *Generation of Hyper Climate Modes.*

[2009] *The Ocean's Role in Continental Climate Change and Variability.*

[2011] *Conceptual Understanding of Climate Change with a Globally Resolved Energy Balance Model.*

[2012] *Analysis of the Model Climate Sensitivity Spread forced by Mean Sea Surface Temperature Biases.*

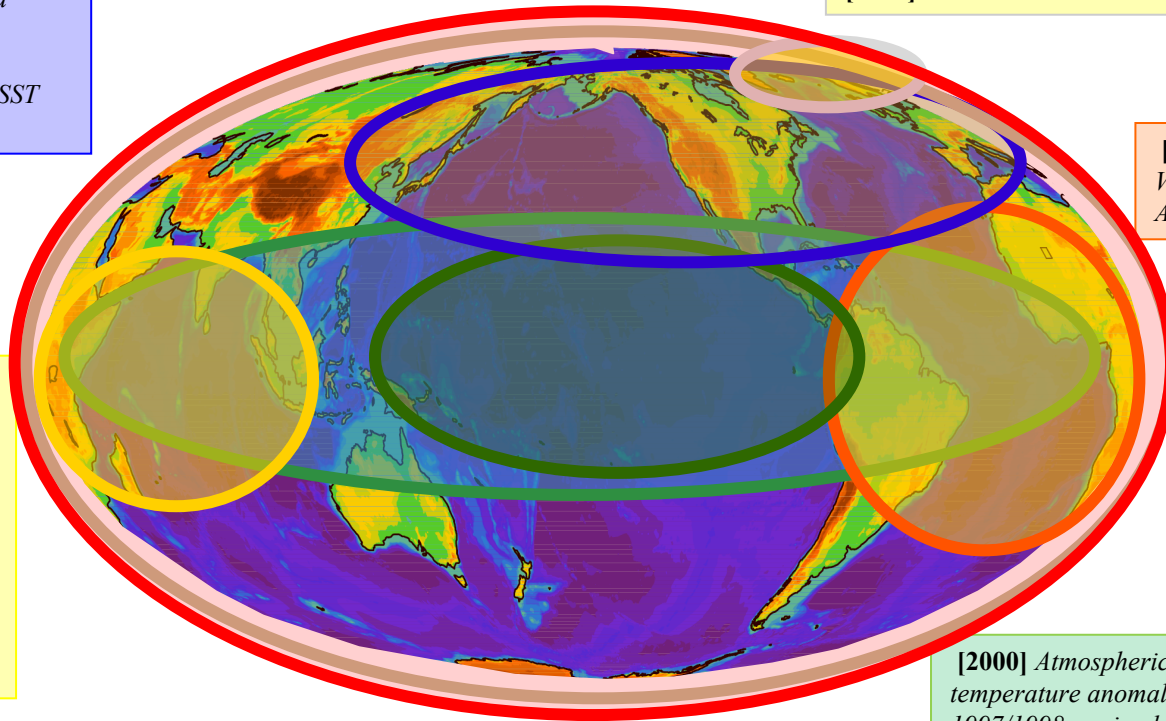
[1999] *Interdecadal interactions between the tropics and the midlatitudes in the Pacific basin*

[2002] *Analysis of observed and simulated SST spectra in the midlatitude*

[2008] *The Annual Peak in the SST Anomaly Spectrum*

[2010] *Can the Arctic warm the Earth?*

[2000] *Interannual to Decadal Variability in the Tropical Atlantic*



[1999] *The Role of Indian Ocean Sea Surface Temperature in Forcing East African Climate Anomalies*

[2003] *Reply to Comments of Behera et al.*

[2009] *Predictions of Indian Ocean SST indices with a simple Statistical Model: A Null Hypothesis*

[2006] *Impacts of the tropical Indian and Atlantic Oceans on ENSO*

[2009] *Tropical Atmosphere-Ocean Interactions: A Conceptual Framework*

[2002] *A Cautionary Note on the Interpretation of EOF*

[2007]: *Evaluating EOF-modes against a stochastic null hypothesis*

[2000] *Atmospheric response to sea surface temperature anomalies during El Nino 1997/1998 as simulated by ECHAM4*

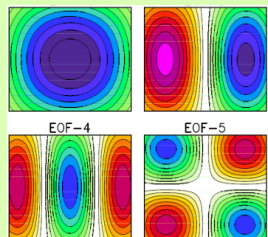
[2004] *Improving ENSO Simulations and Predictions Through Ocean State Estimation*

[2010] *El Nino and La Nina amplitude asymmetry caused by atmospheric feedbacks*

[2010] *The Slab Ocean El Nino*

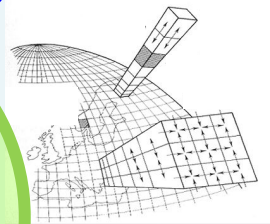
My Research Methods

Modes



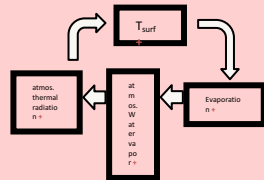
- [2000] *Interannual to Decadal Variability in the Tropical Atlantic*
- [2002] *A Cautionary Note on the Interpretation of EOF*
- [2006] *Impacts of the tropical Indian and Atlantic Oceans on ENSO*
- [2007] *Evaluating EOF-modes against a stochastic null hypothesis*
- [2008] *Generation of Hyper Climate Modes*
- [2011] *An Objective Analysis of the Observed Spatial Structure of the Tropical Indian Ocean SST Variability*

Simulations



Atmos.-Ocean Climate models

Simple Models



- [2006] *Impacts of the tropical Indian and Atlantic Oceans on ENSO*
- [2007] *Evaluating EOF-modes against a stochastic null hypothesis*
- [2008] *Generation of Hyper Climate Modes*
- [2009] *Tropical Atmosphere-Ocean Interactions: A Conceptual Framework*
- [2009] *The Ocean's Role in Continental Climate Change and Variability*
- [2009] *Predictions of Indian Ocean SST indices with a simple Statistical Model: A Null Hypothesis*
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- [1999] *Interdecadal interactions between the tropics and the midlatitudes in the Pacific basin*
- [1999] *The Role of Indian Ocean Sea Surface Temperature in Forcing East African Climate Anomalies*
- [2000] *Interannual to Decadal Variability in the Tropical Atlantic*
- [2000] *Atmospheric response to sea surface temperature anomalies during El Nino 1997/1998 as simulated by ECHAM4*
- [2002] *Analysis of observed and simulated SST spectra in the midlatitude*
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- [2008] *The Annual Peak in the SST Anomaly Spectrum*
- [2008] *Generation of Hyper Climate Modes*
- [2009] *The Ocean's Role in Continental Climate Change and Variability*
- [2010] *Can the Arctic warm the Earth?*
- [2010] *El Nino and La Nina amplitude asymmetry caused by atmospheric feedbacks*
- [2010] *The Slab Ocean El Nino*

Outline

History

Models

Impact

Media

Outline

History

Models

Impact

Media

History of climate change predictions

1900

2000



Svante August Arrhenius (1859-1927,
Nobel Prize in Chemistry 1903)

THE
LONDON, EDINBURGH, AND DUBLIN
PHILOSOPHICAL MAGAZINE
AND
JOURNAL OF SCIENCE.

[FIFTH SERIES.]

APRIL 1896.

XXXI. *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground.* By Prof. SVANTE ARRHENIUS*.

I. *Introduction: Observations of Langley on Atmospherical Absorption.*

A GREAT deal has been written on the influence of the absorption of the atmosphere upon the climate. Tyndall† in particular has pointed out the enormous importance of this question. To him it was chiefly the diurnal and annual variations of the temperature that were lessened by this circumstance. Another side of the question, that has long attracted the attention of physicists, is this: Is the mean temperature of the ground in any way influenced by the presence of heat-absorbing gases in the atmosphere? Fourier‡ maintained that the atmosphere acts like the glass of a hothouse, because it lets through the light rays of the sun but retains the dark rays from the ground. This idea was elaborated by Pouillet§; and Langley was by some of his researches led to the view, that "the temperature of the earth under direct sunshine, even though our atmosphere were present as now, would probably fall to -200° C., if that atmosphere did not possess the quality of selective

* Extract from a paper presented to the Royal Swedish Academy of Sciences, 11th December, 1895. Communicated by the Author.

† *Heat a Mode of Motion*, 2nd ed. p. 495 (Lond., 1857).

‡ *Mém. de l'Ac. R. d. Sci. de l'Inst. de France*, t. vii. 1827.

§ *Comptes rendus*, t. vii. p. 41 (1838).

Phil. Mag. S. 5. Vol. 41. No. 251. April 1896.

S

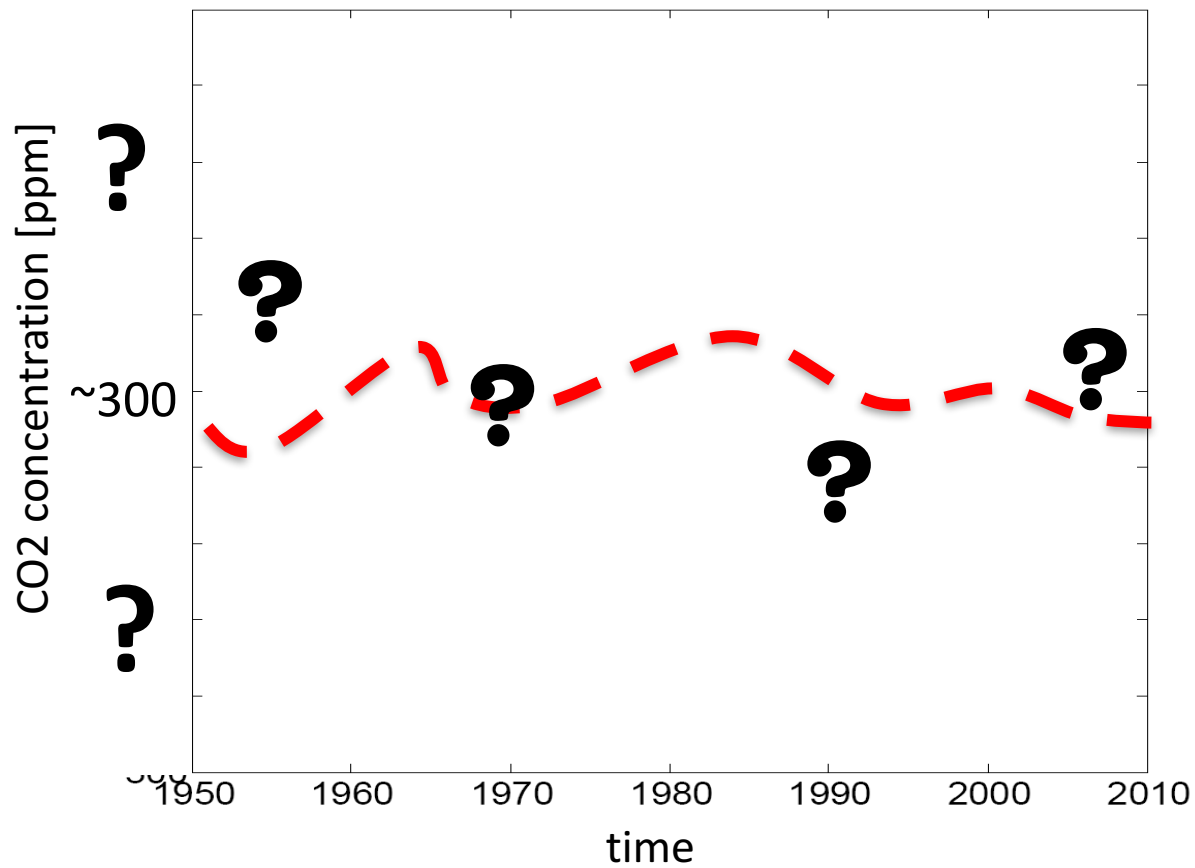
Result: about +5 degree in about 3000 years if caused by human emissions. Note at this point human emissions were quite low.



1900

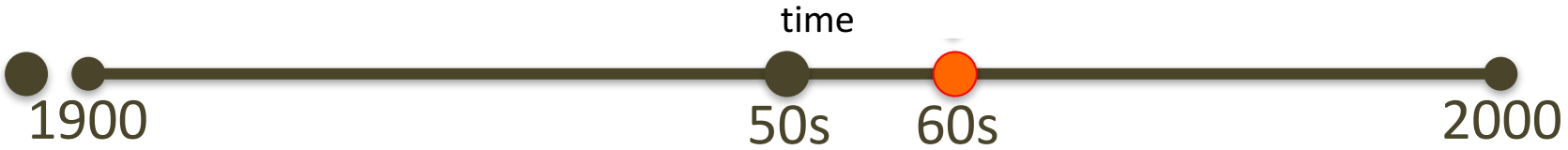
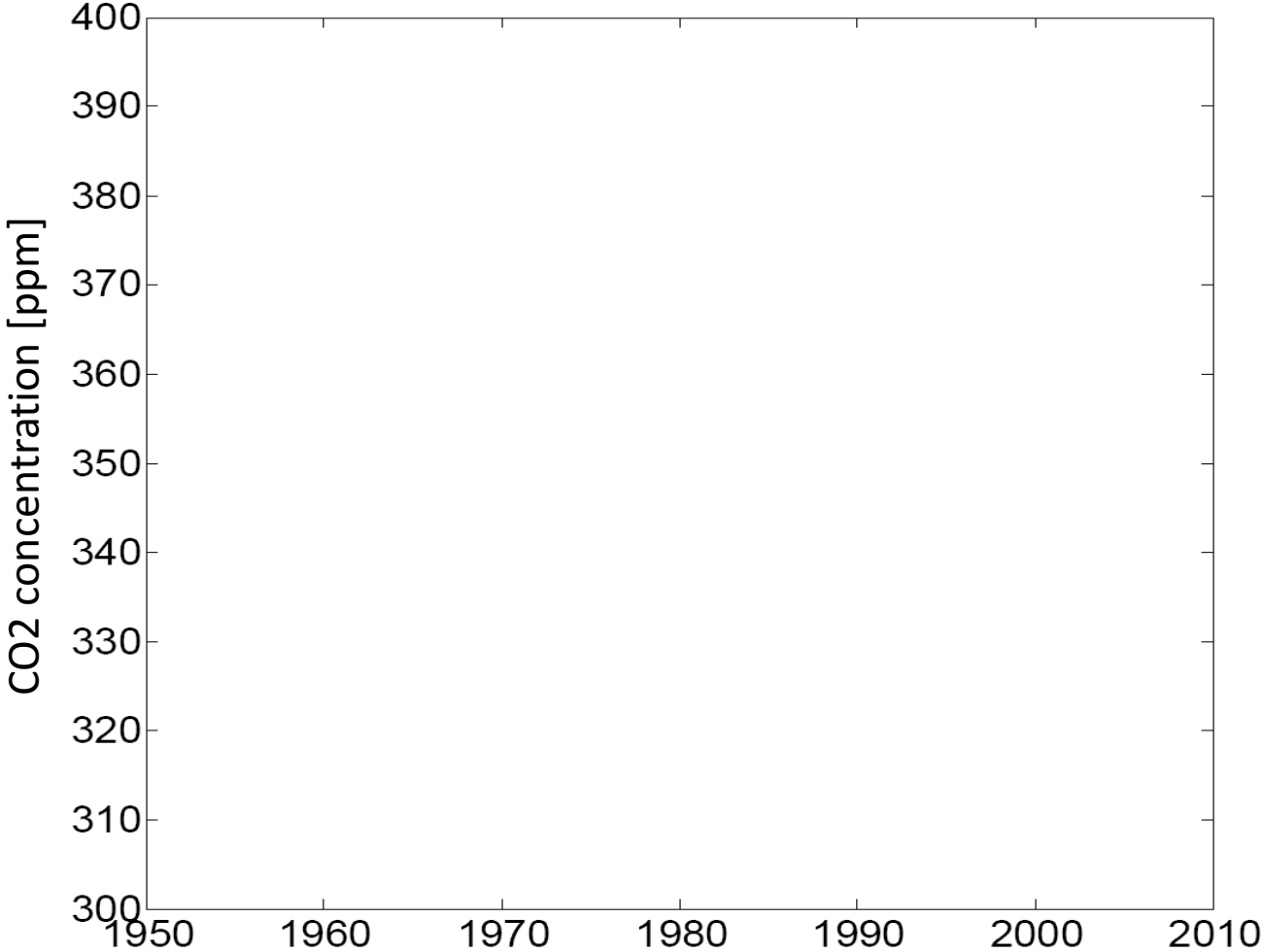
2000

Atmospheric CO₂ Concentrations

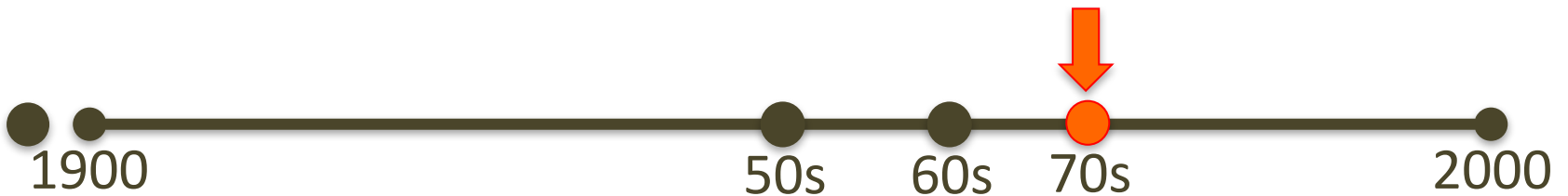
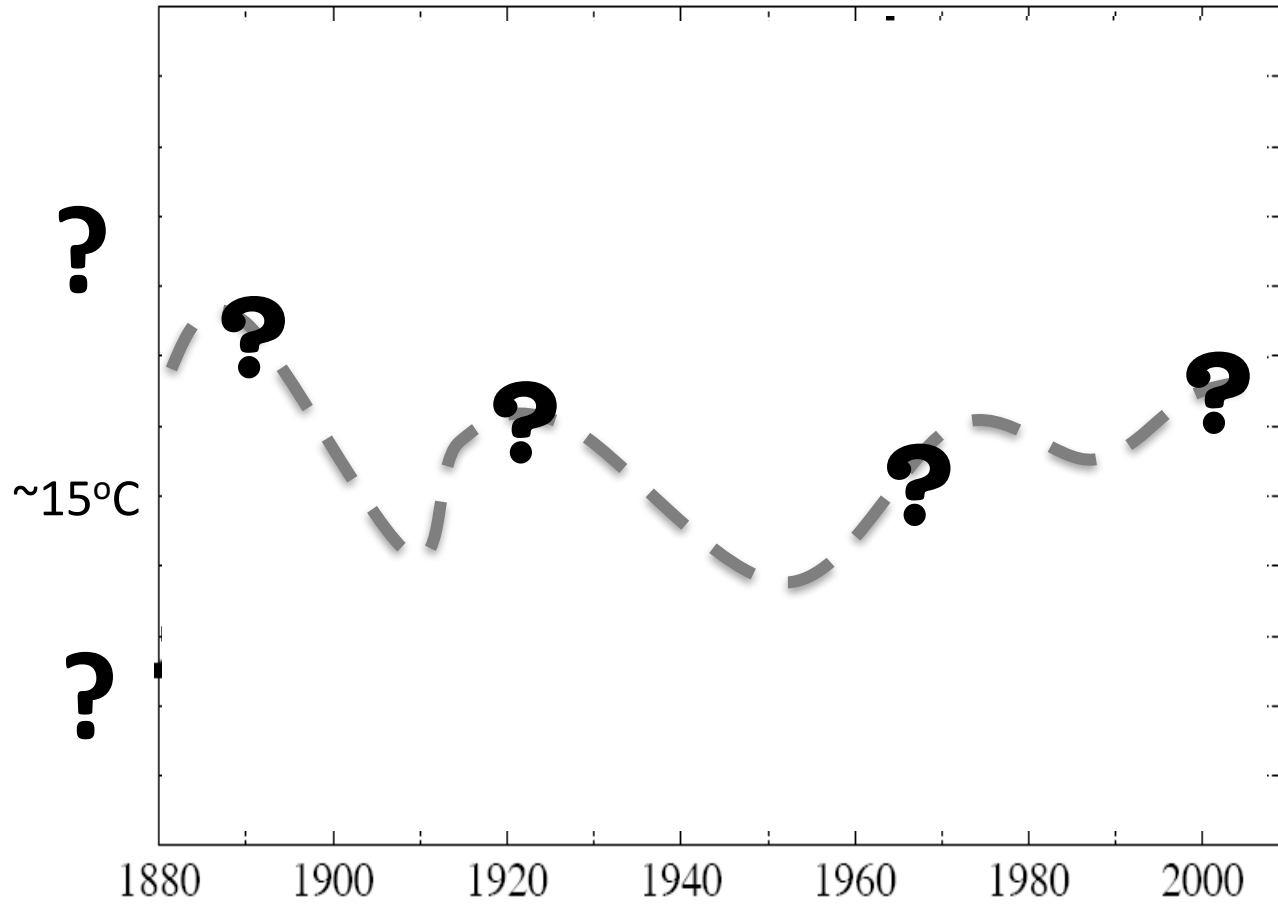


Atmospheric CO₂ Concentrations von 1958-2008

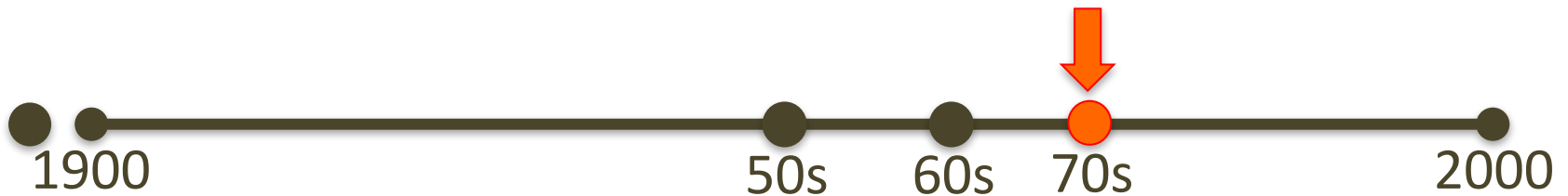
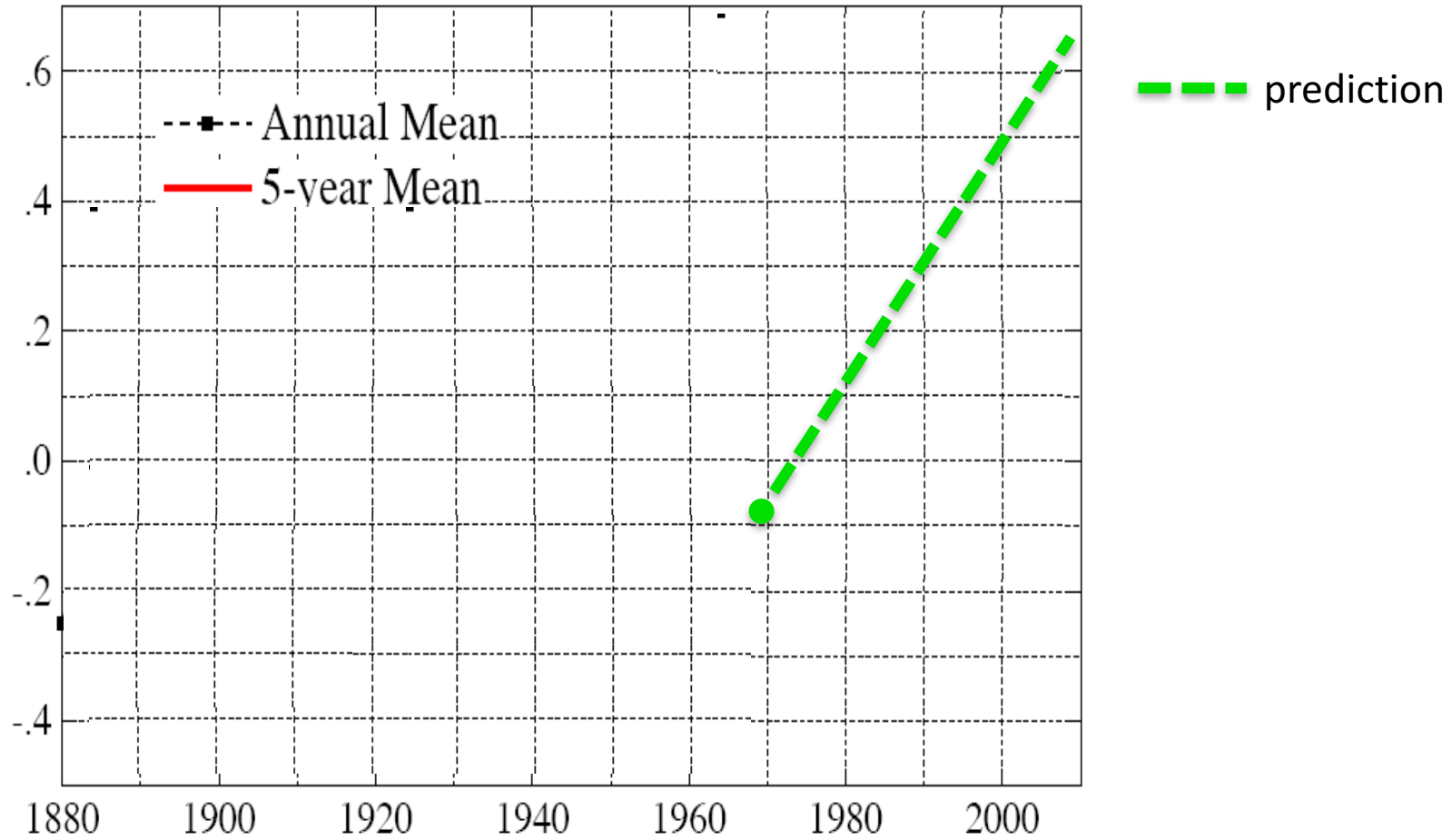
Mauna Loa (Hawaii)



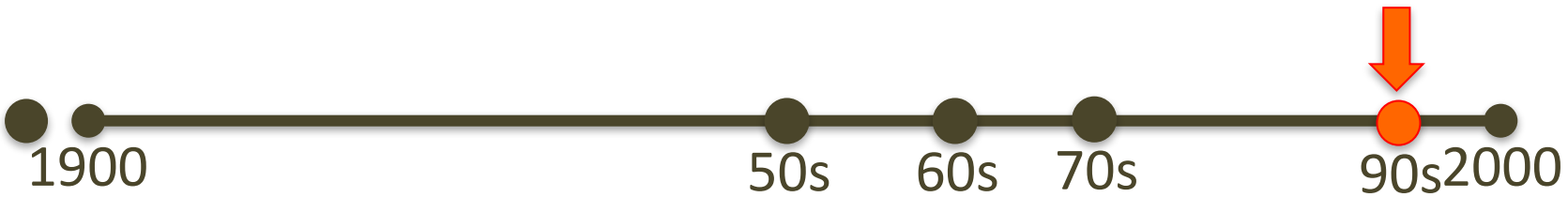
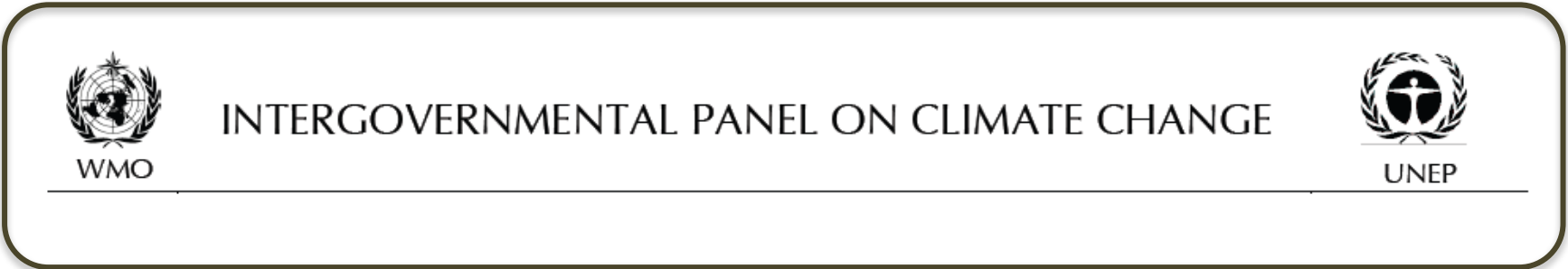
Global mean temperature



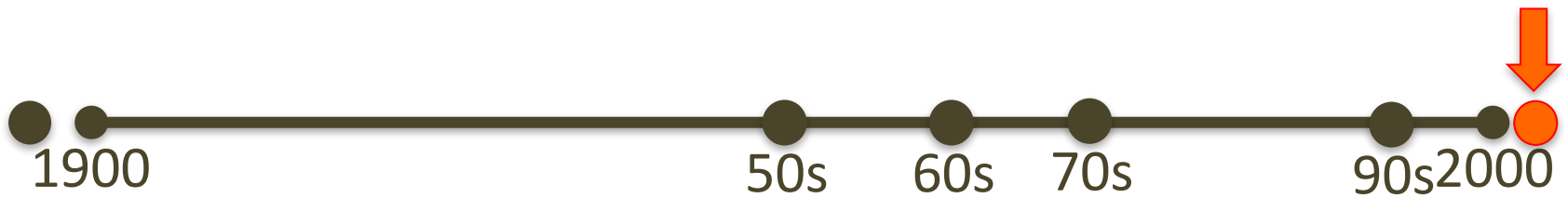
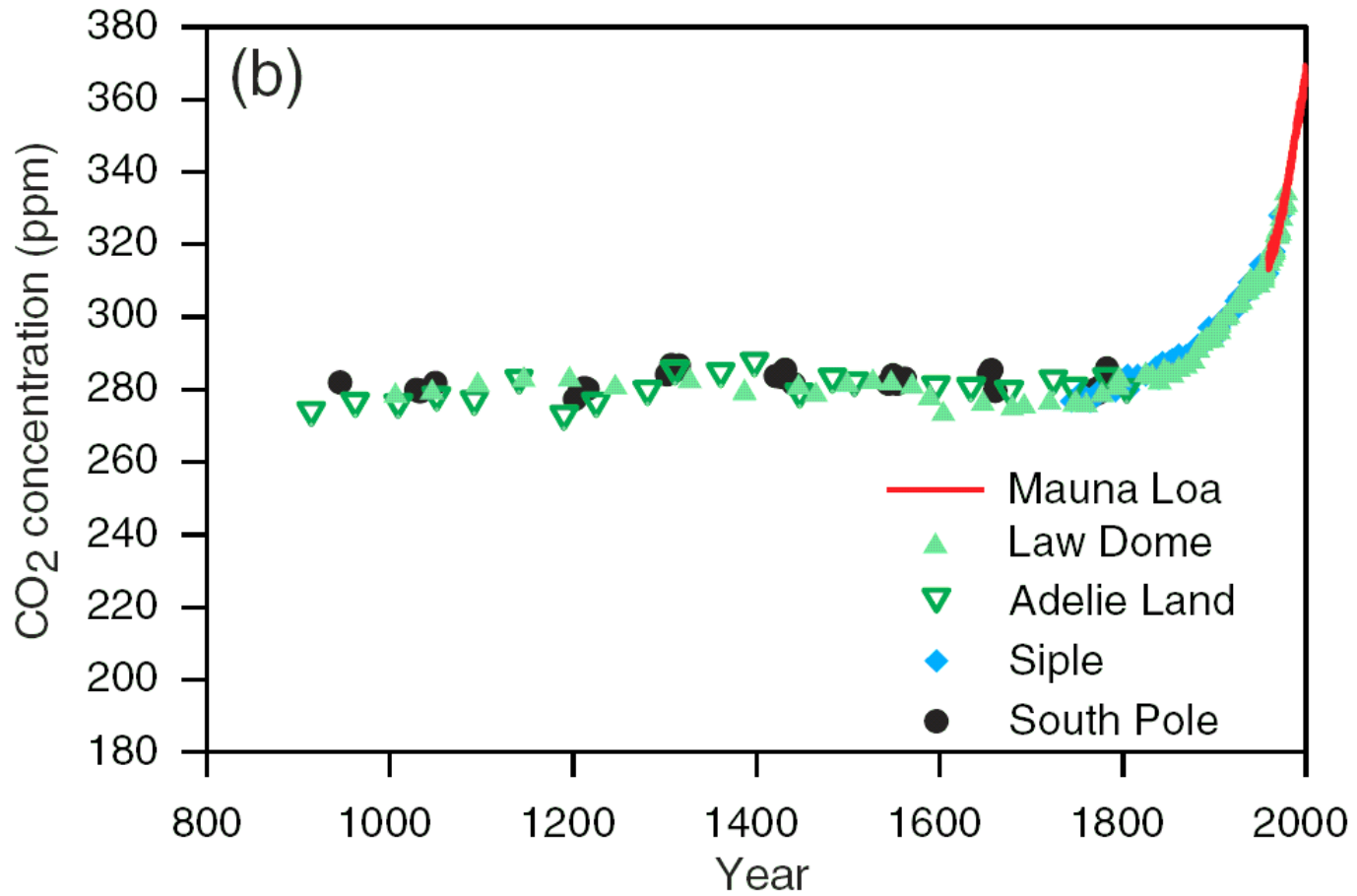
Global mean temperature



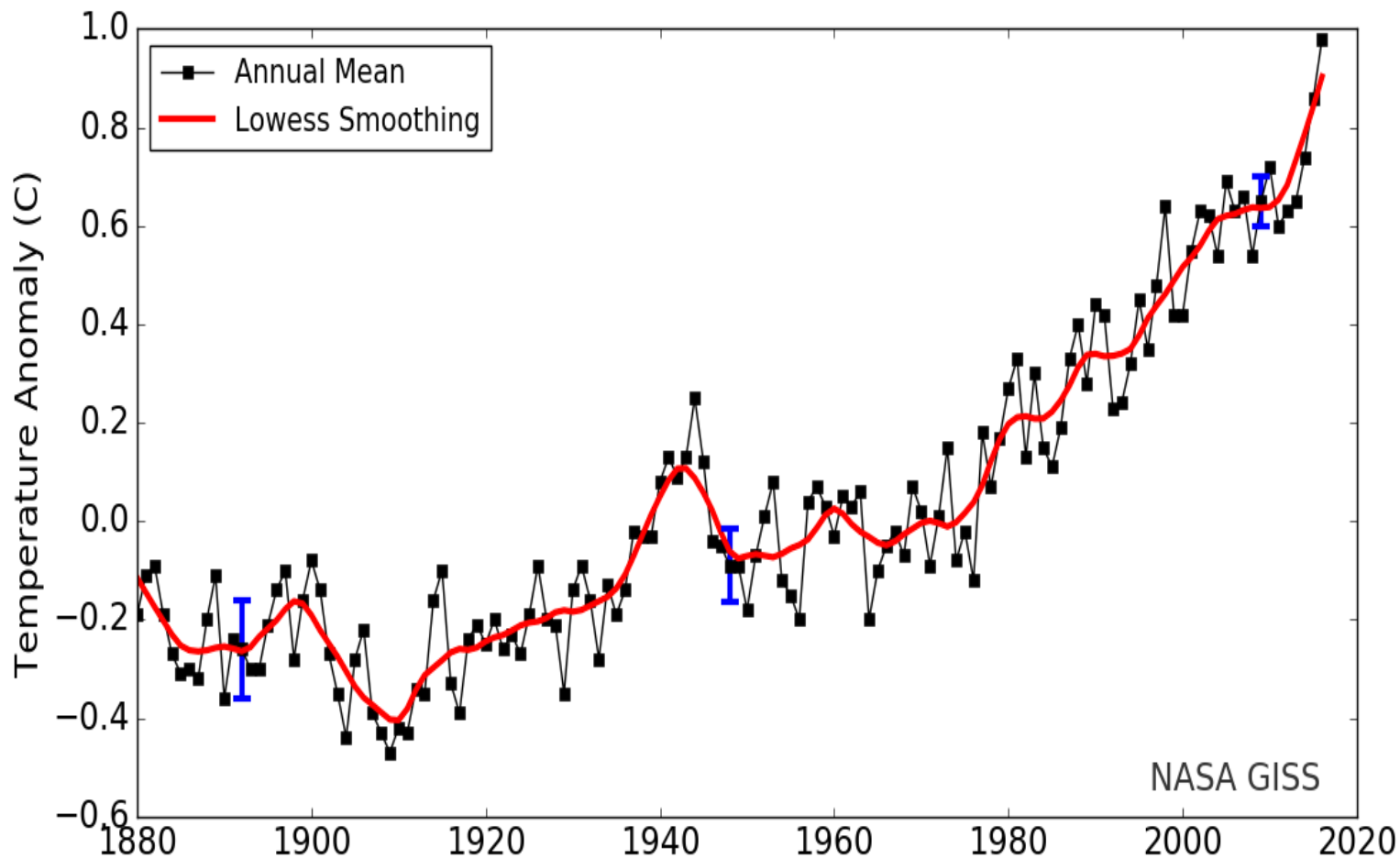
History of climate change predictions



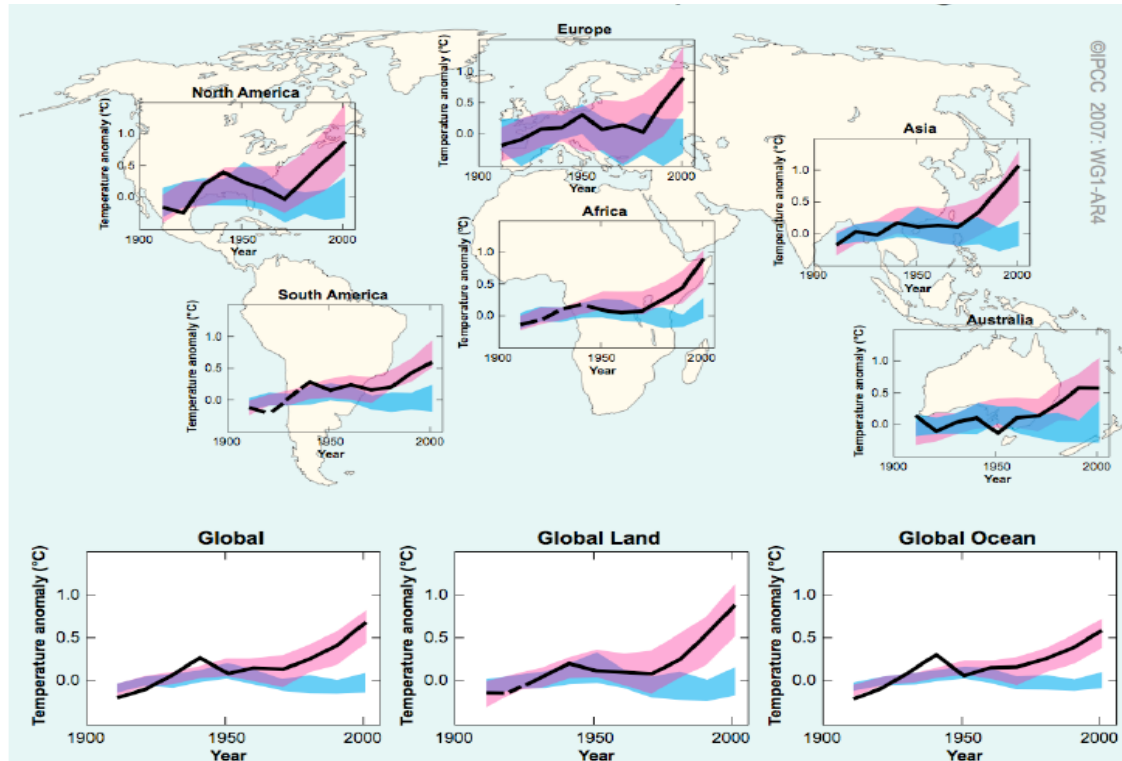
Atmospheric CO₂ Concentrations von 800-2000



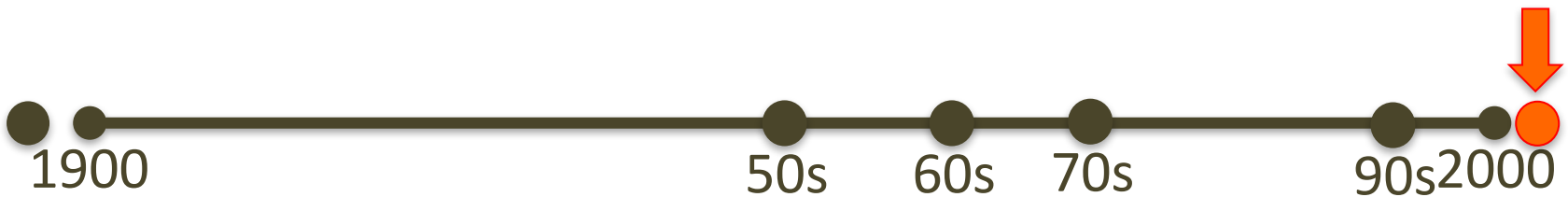
Global mean temperature



Observed Warming

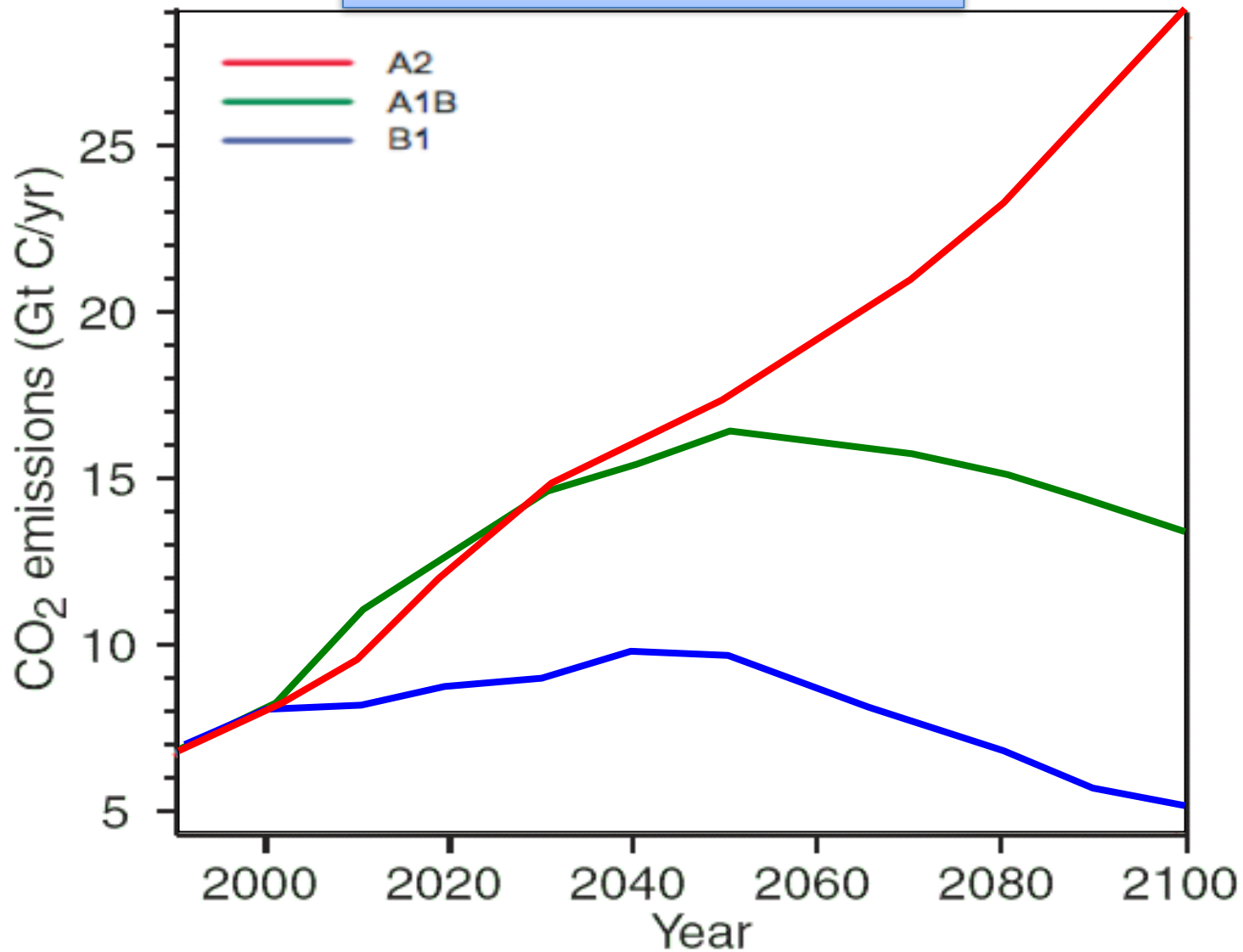


The best explanation for 20th century warming is anthropogenic forcing. Natural forcing (e.g. solar radiation) cannot explain the warming trend



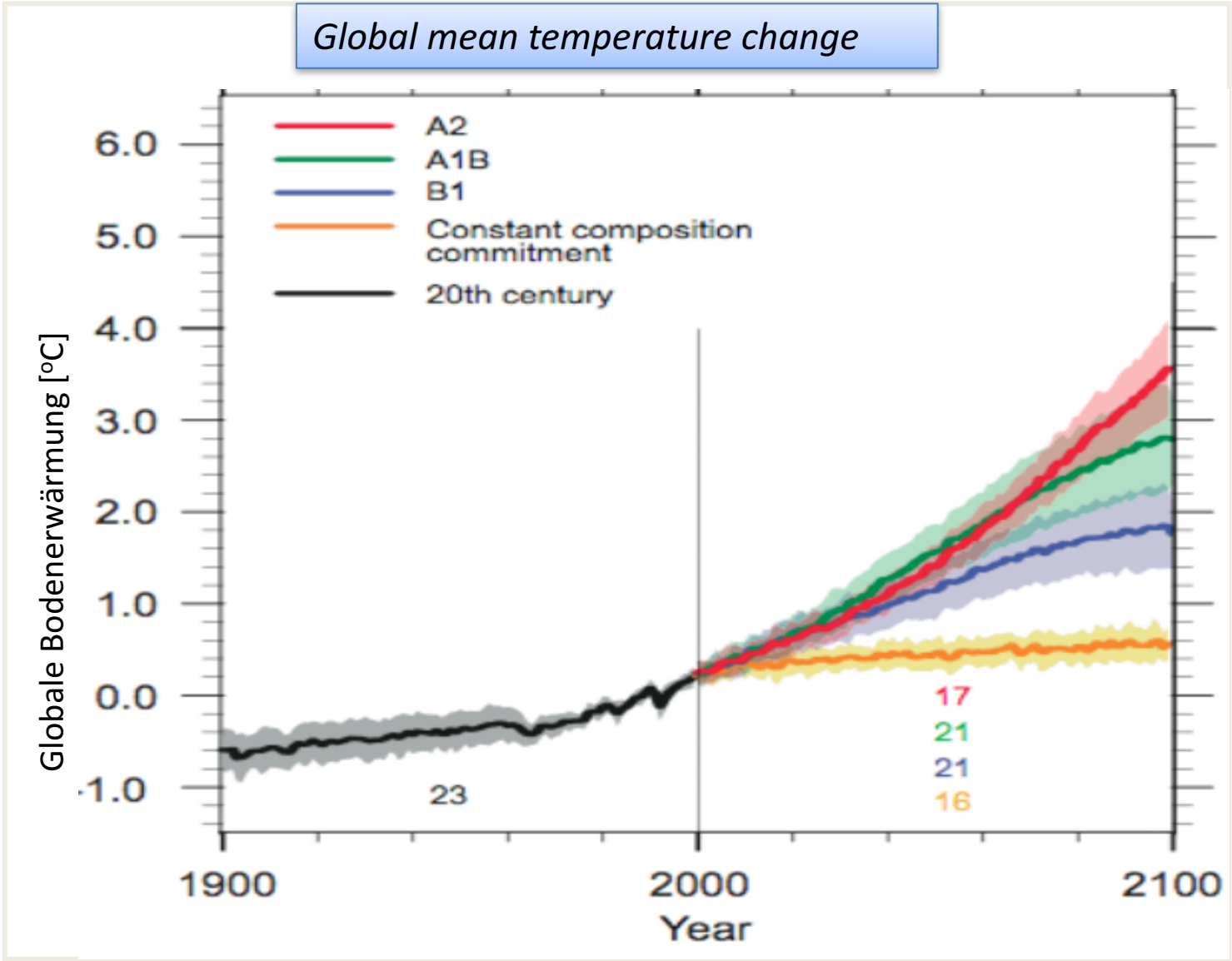
IPCC CO₂ scenarios

CO₂ Emissionen



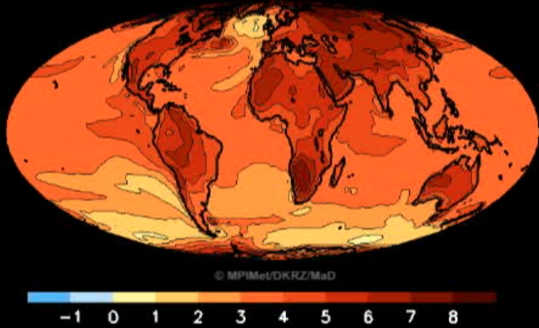
IPCC global mean response

Global mean temperature change

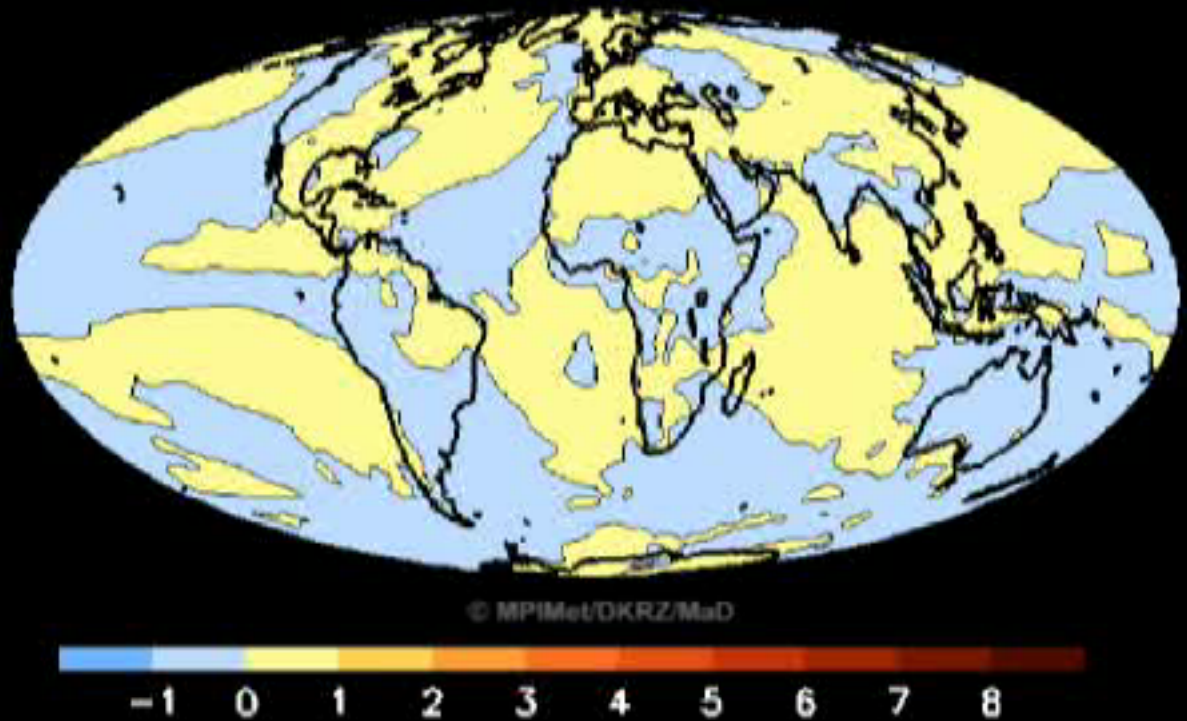


Climate Change

SRES A2 -- 5ym Temp. Change [Deg C] 2099

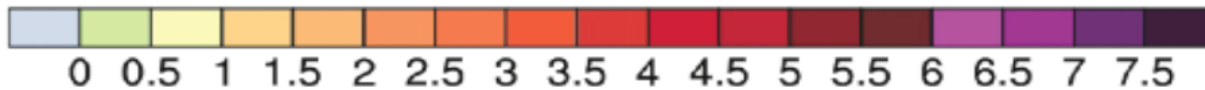
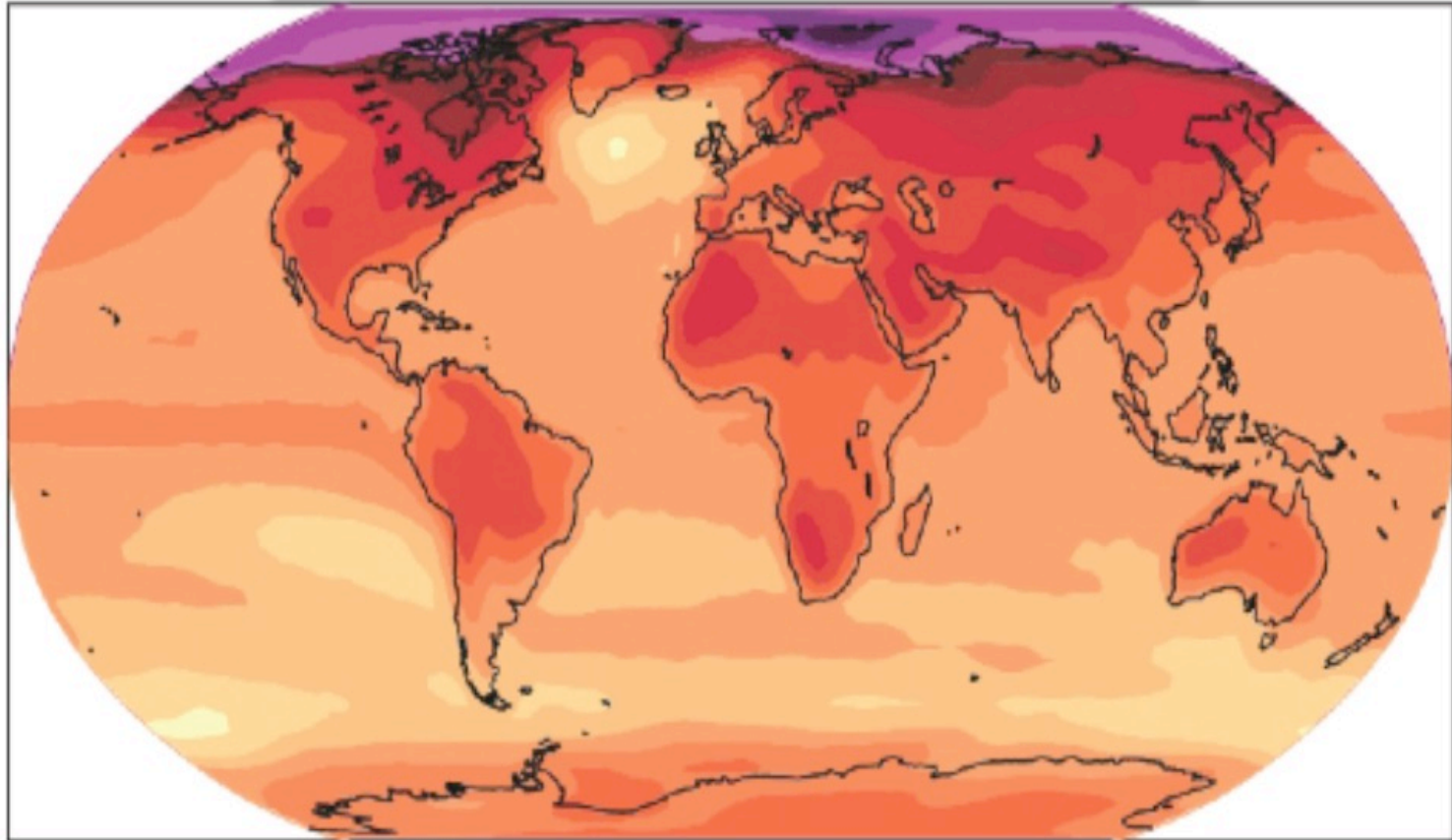


SRES A2 -- 5ym Temp. Change [Deg C] 1980



Prediction vs. Reality

Temperature change until 2100 (Scenario A1B)



INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

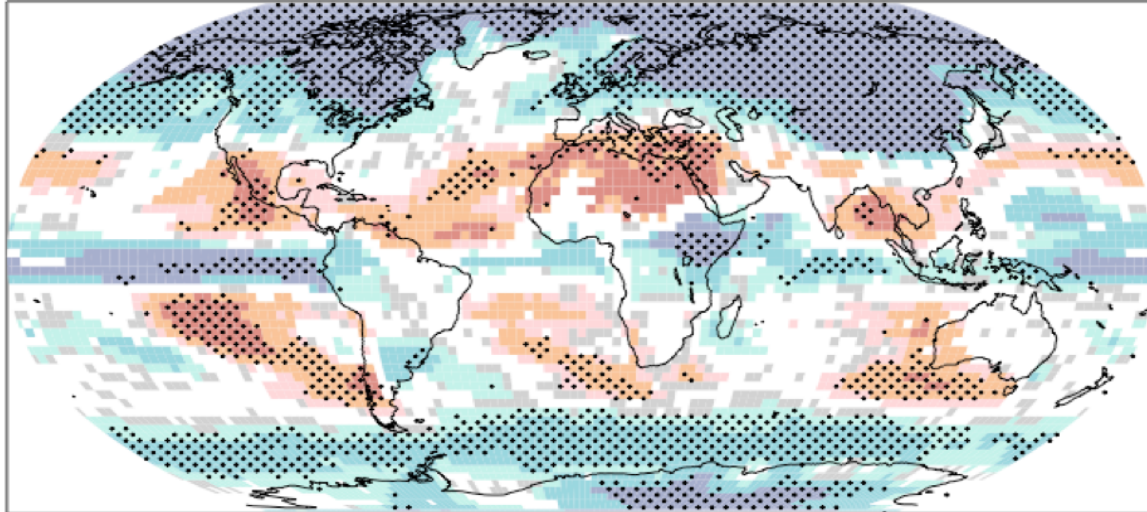


Precipitation

multi-model

A1B

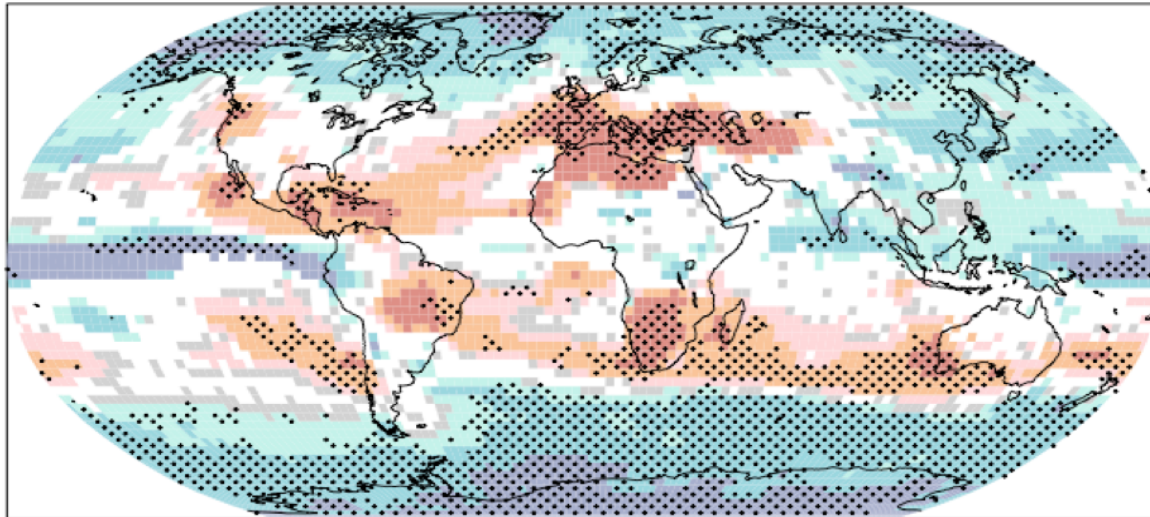
DJF



multi-model

A1B

JJA



%



-20

-10

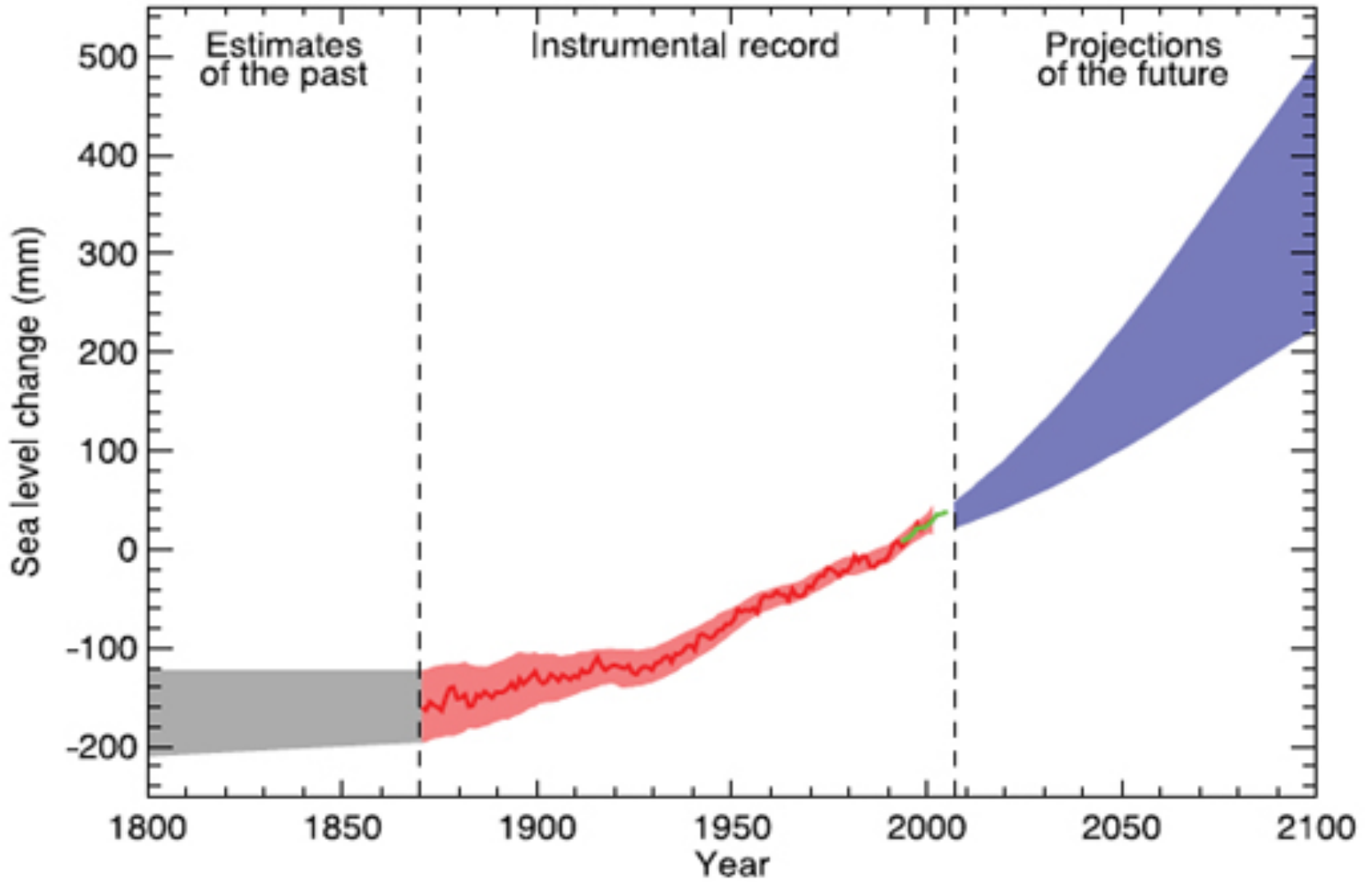
-5

5

10

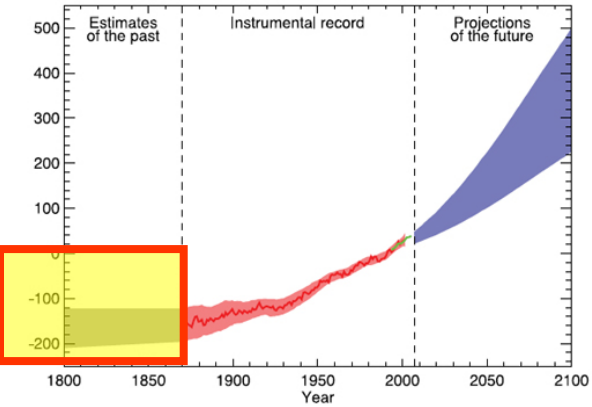
20

Sea level

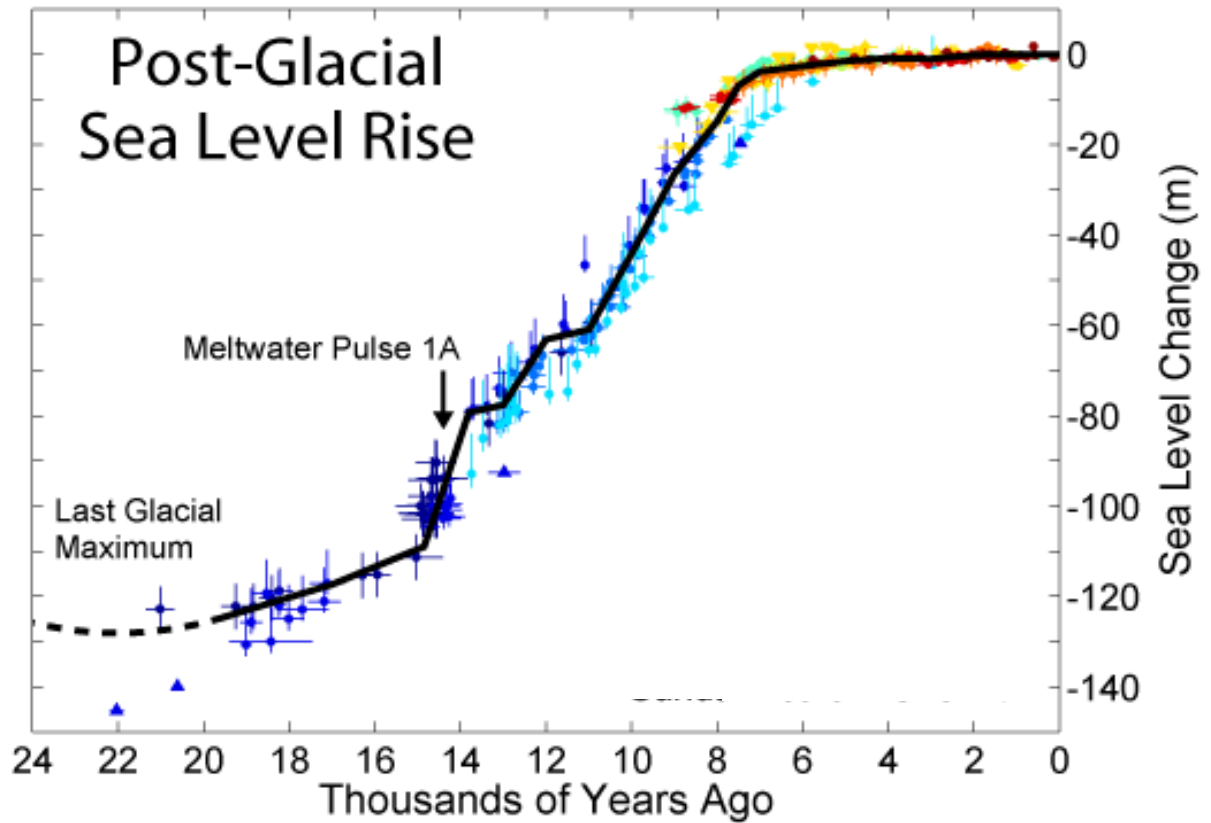


Sea level

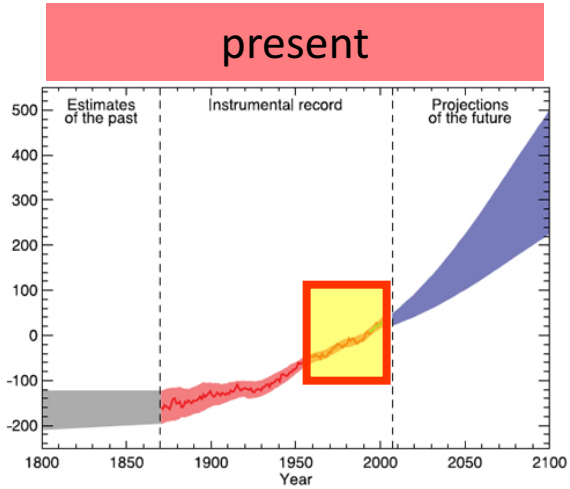
past



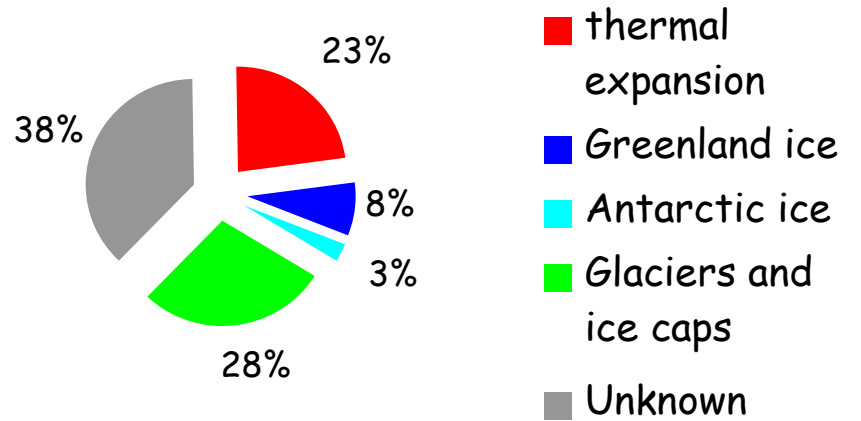
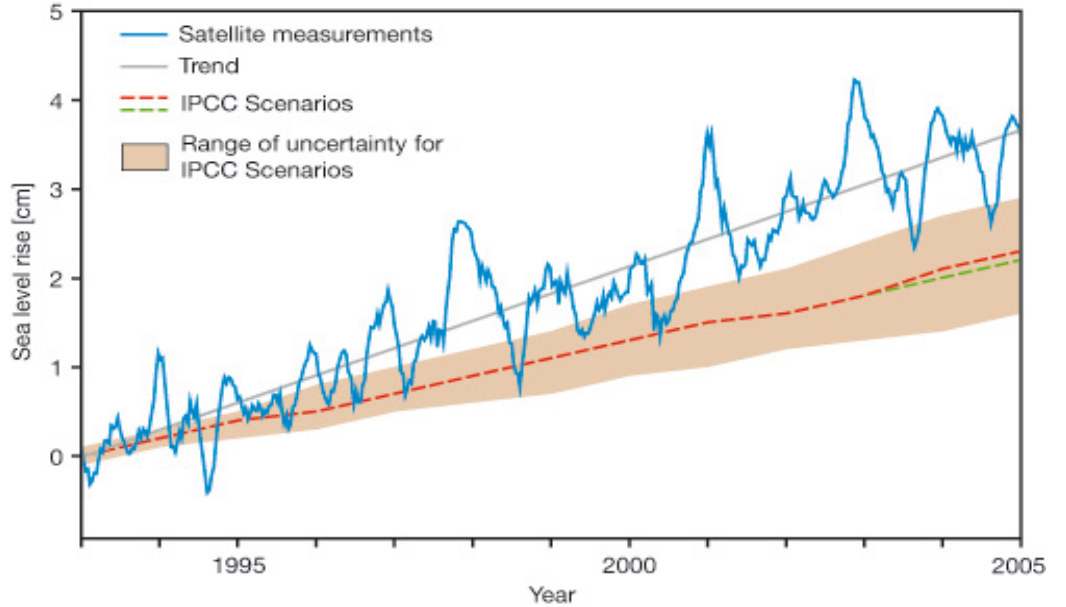
Sea level change



Sea level



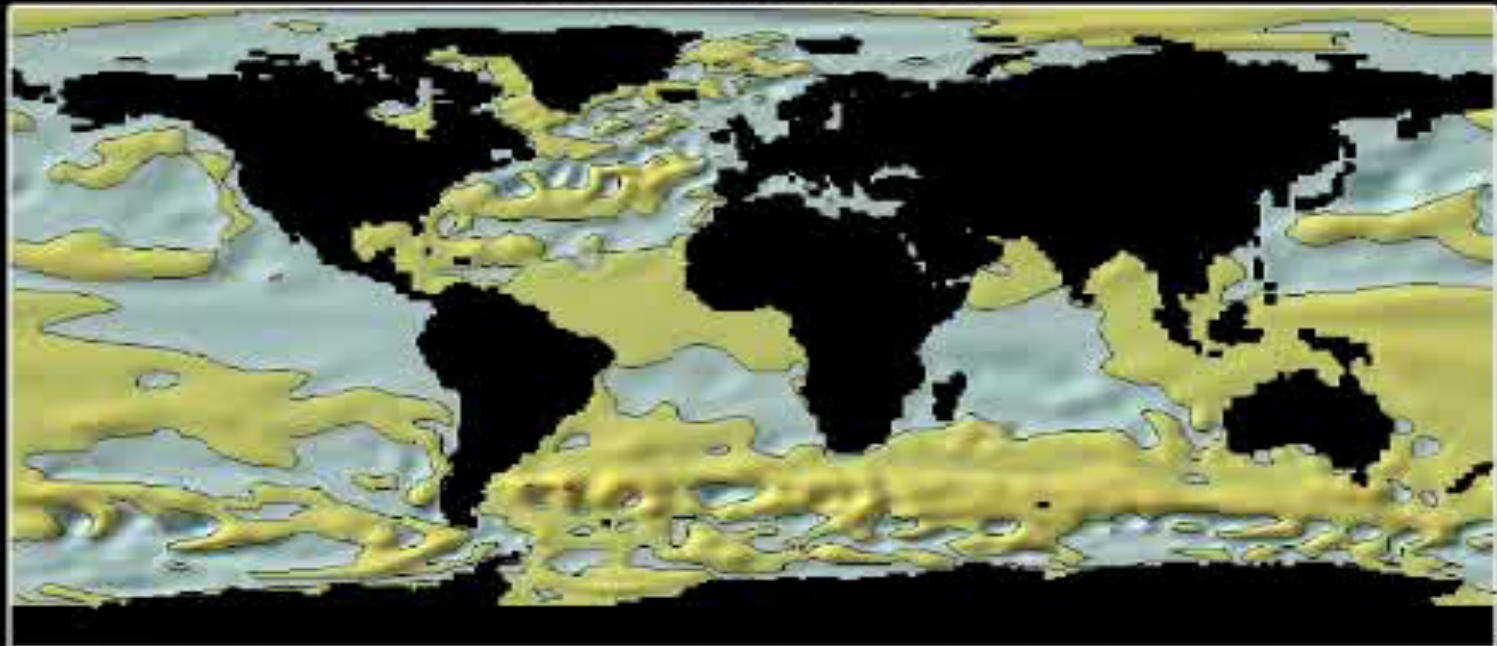
Sea Level rise between 1961 to 2003 and its causes



Sea level

Sea Level Change [m]
IPCC Scenario A1B

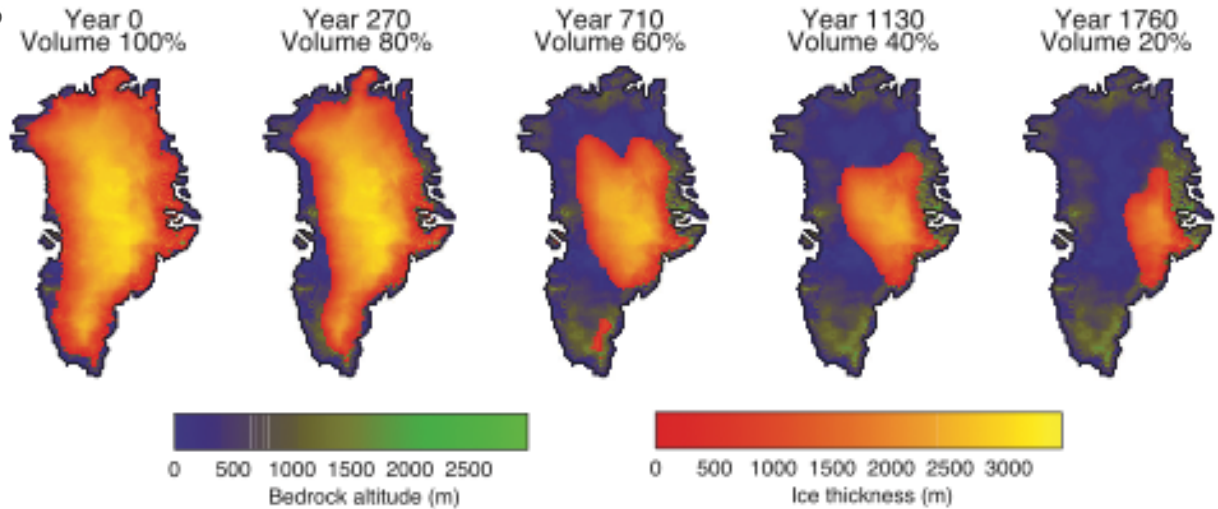
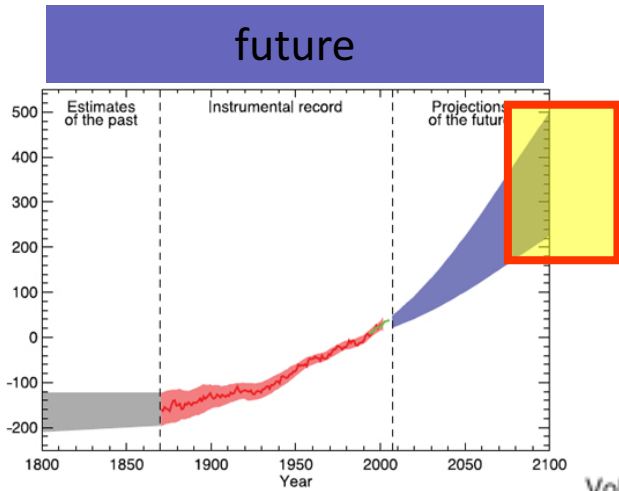
Year: 2000



© DKRZ / MPI-M



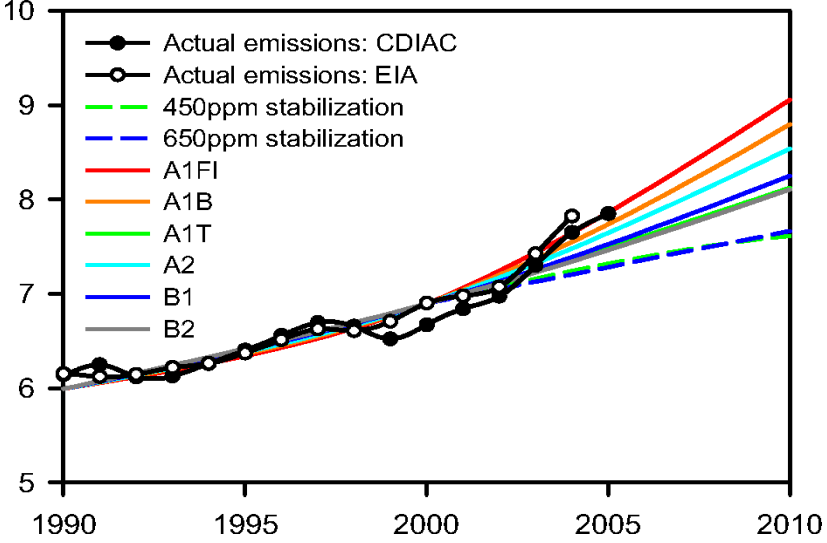
Sea level



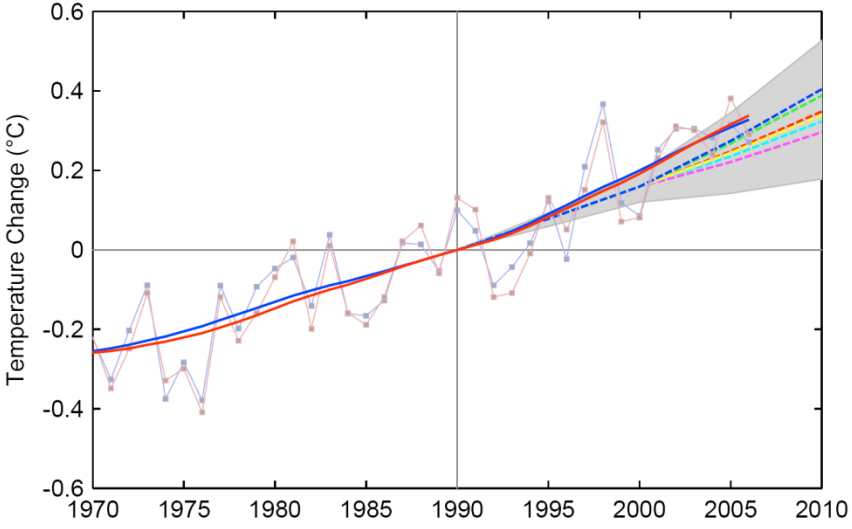
Changes in Greenland ice sheet for $4xCO_2$ concentrations

Prediction vs. Reality

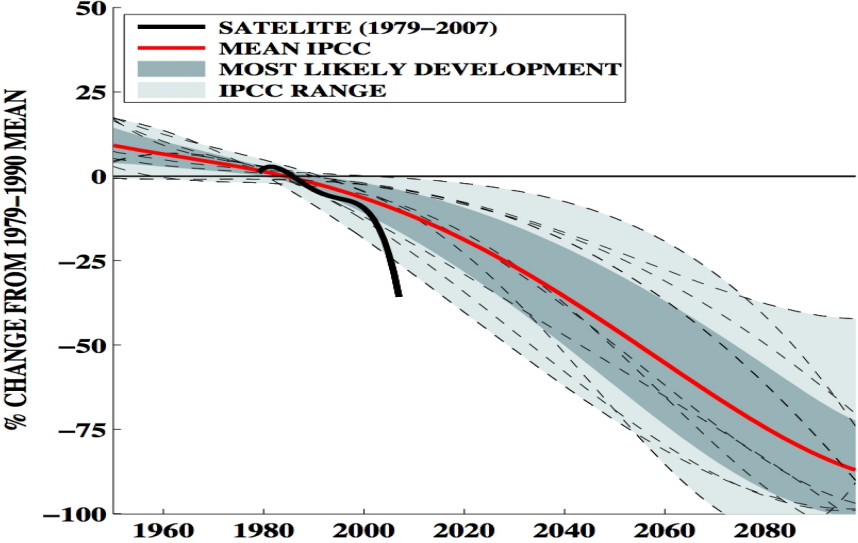
CO2-Emissionen since 1990



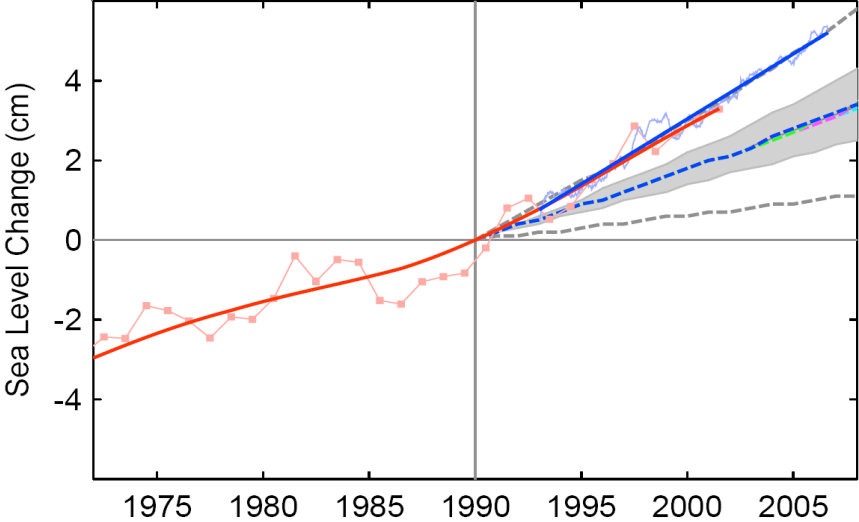
Global temperature since 1970



Sea ice since 1980

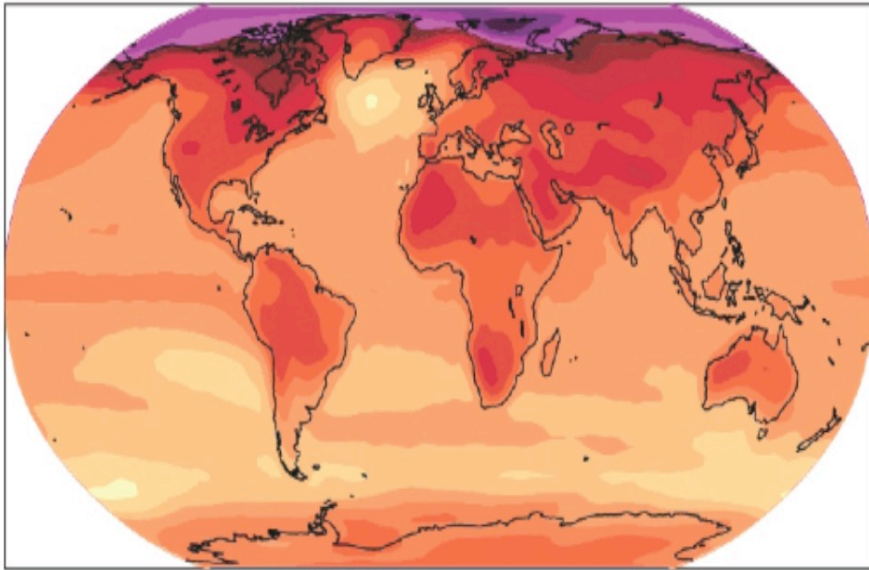


Sea level since 1970



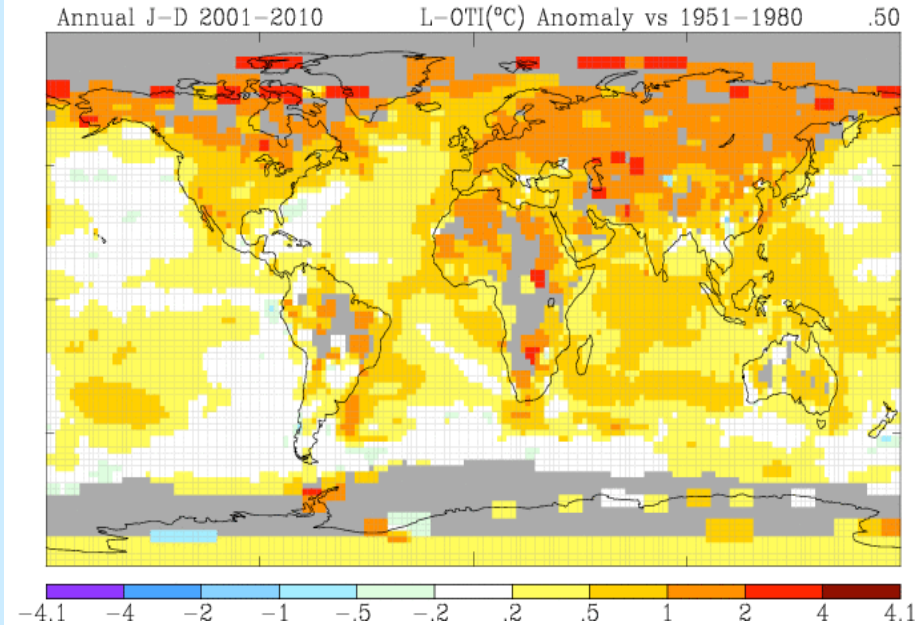
Prediction vs. Reality

Prediction 2100



[IPCC]

Observed 2001-2010



[NASA]

Temperature change relative to 1950-1980 mean climate

Outline

History

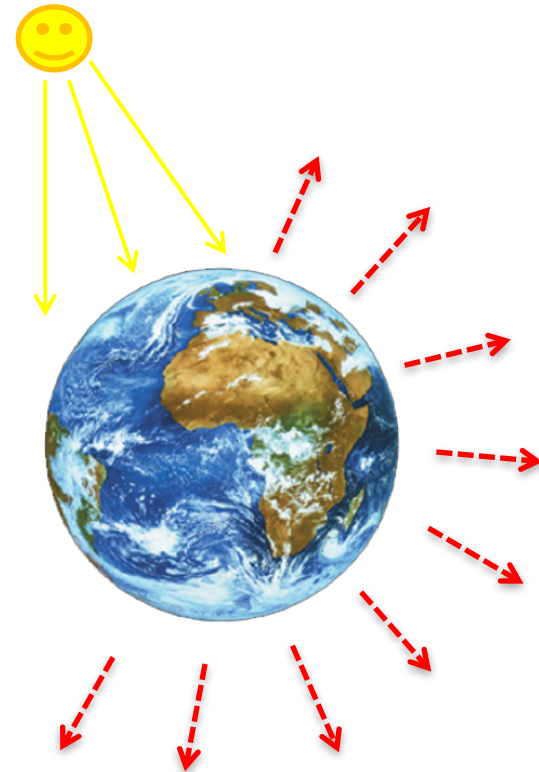
Models

Impact

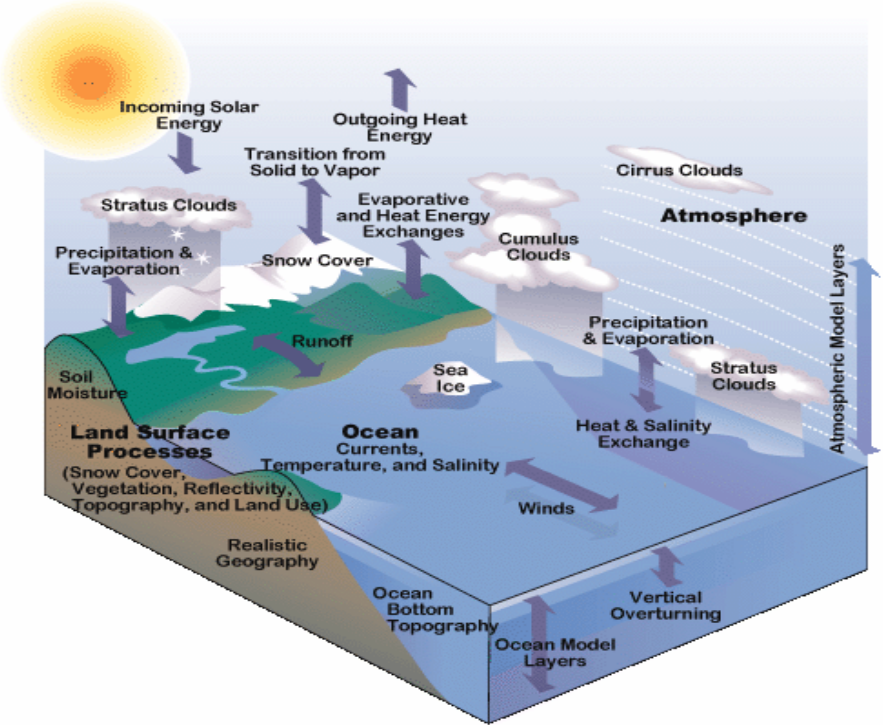
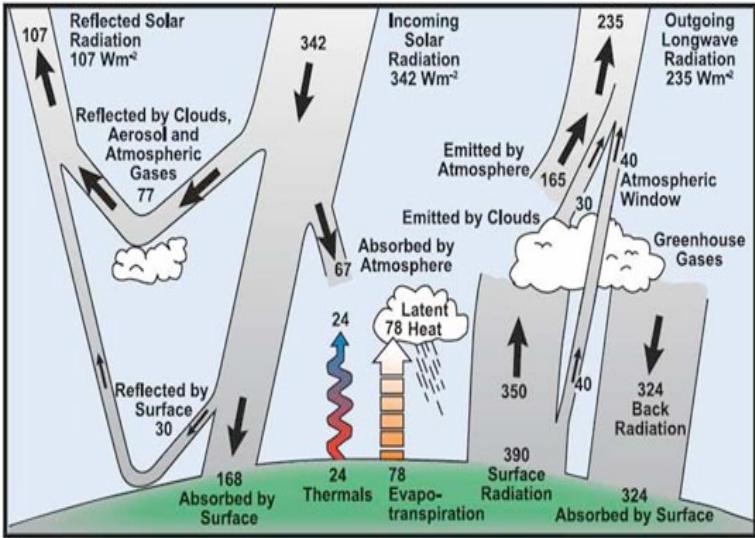
Media

The Basic Principle of Climate Models

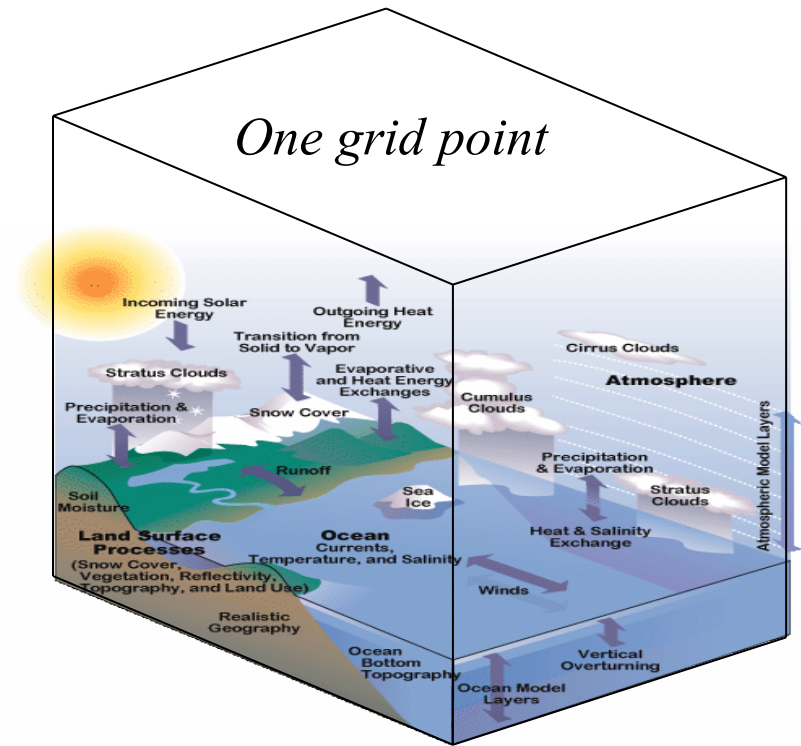
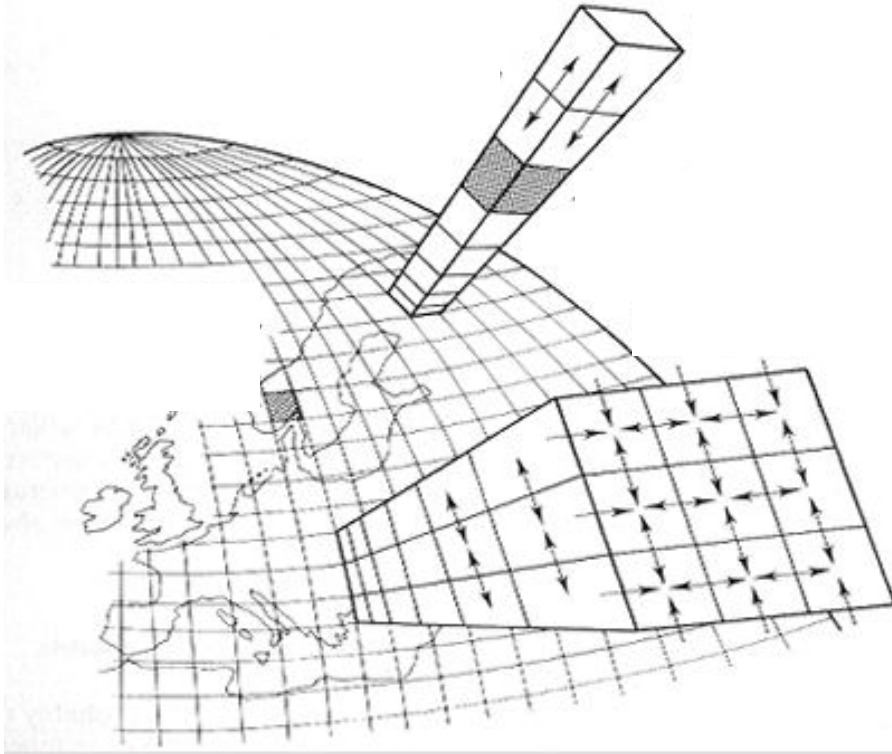
Energy Balance



IPCC Climate Models



IPCC Climate Models



Resolution:

Longitude: $1^\circ = 360$ points

latitude: $1^\circ = 180$ points

Vertical levels: 30 points

Total (ocean and atmosphere) $\approx 4,000,000$ points

Time step = 20min.

Equations:

About 4,000,000 lines of computer code;

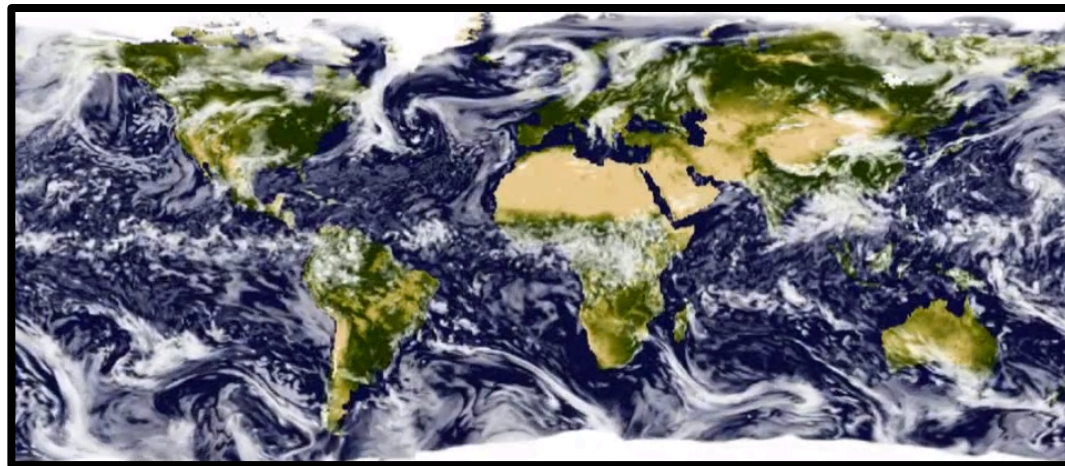
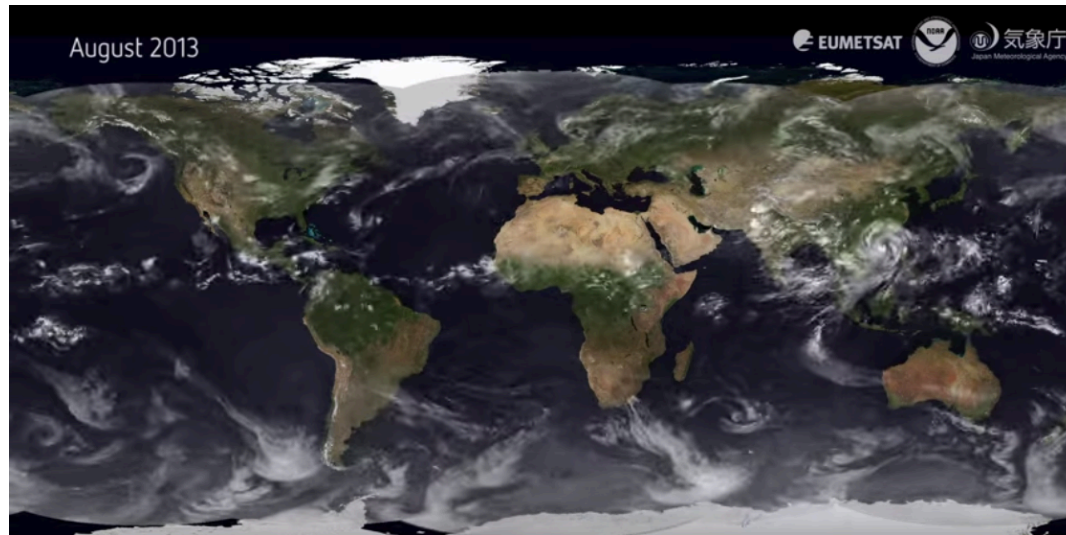
Developed by about 1000 researcher.

-> 4,000,000 computation of all equations to simulate 200yrs

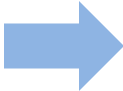
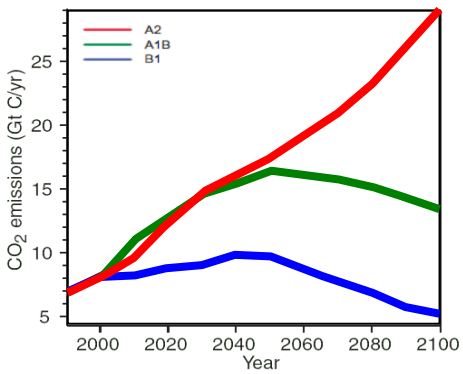
Computer for climate models



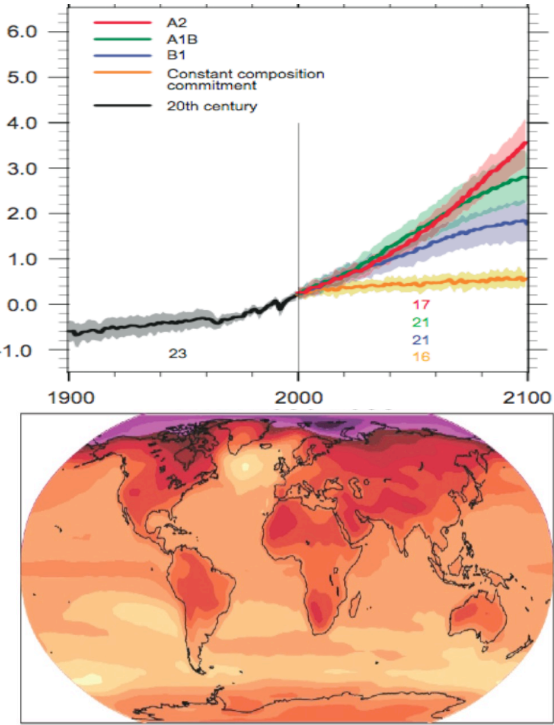
State of the Art Climate Model



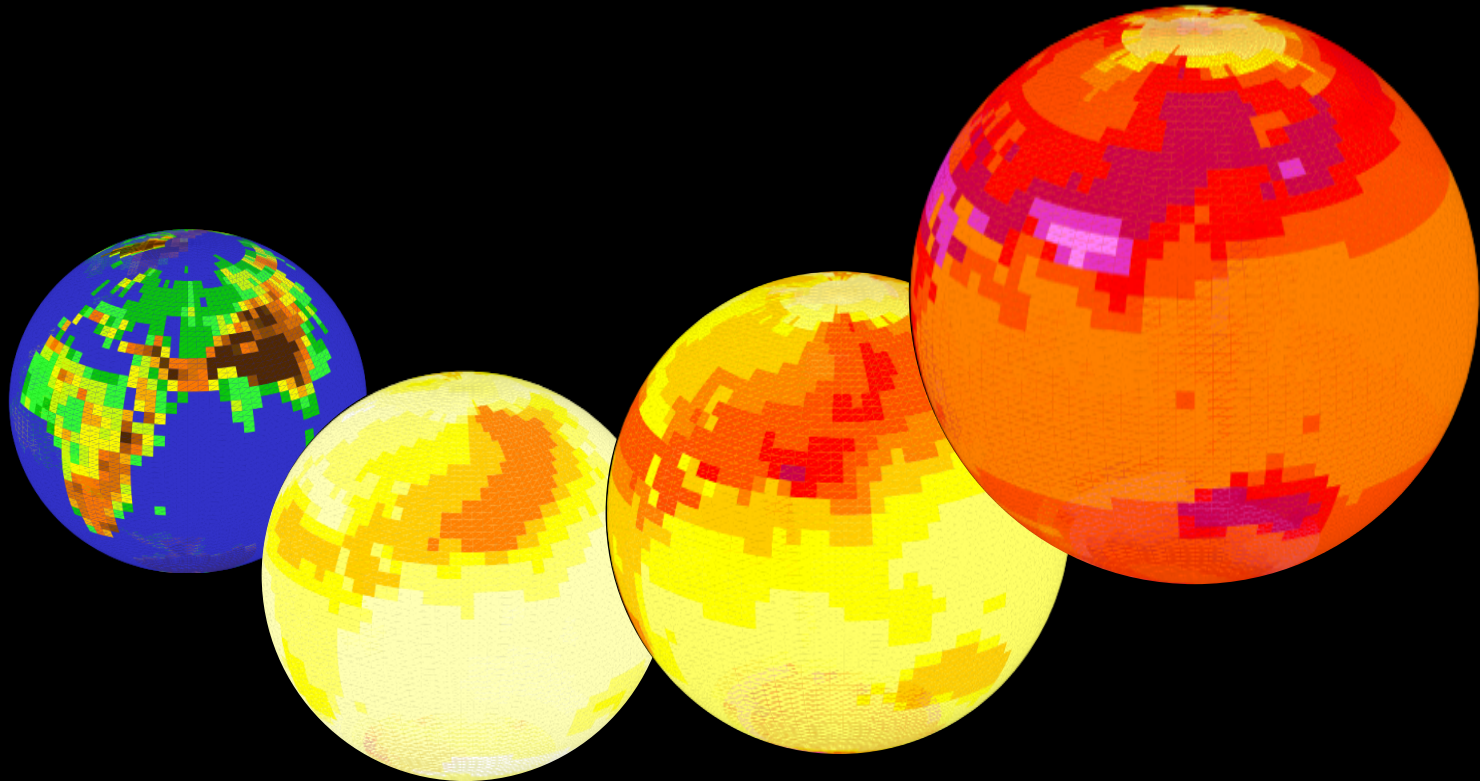
IPCC climate models are a big black box



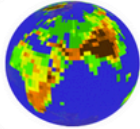
IPCC prediction



The MONASH University *Simple Climate Model*

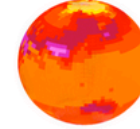


enter



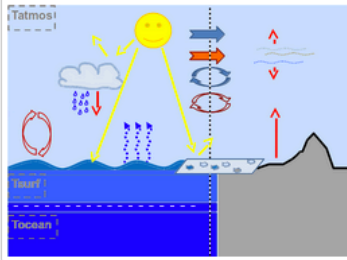
Monash simple climate model

Deconstruction of the mean climate



Language: [English](#) Version: [Basic Version](#)

Experiment A

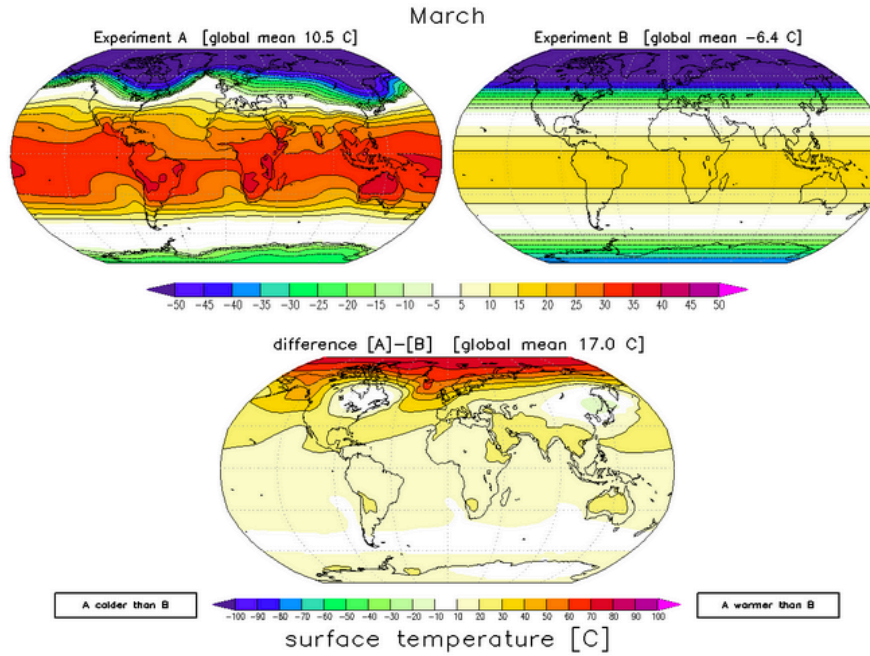


- Ice-albedo
- Clouds
- Oceans
- Atmosphere
- CO₂
- Hydrological cycle

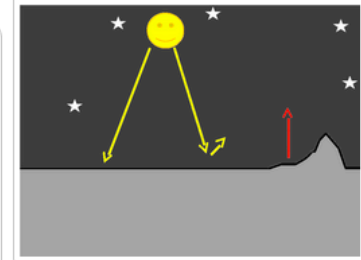
Location for time series graph -
Global mean (default) ⇅

Map

Time Series

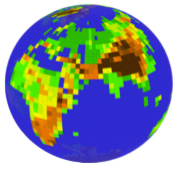


Experiment B



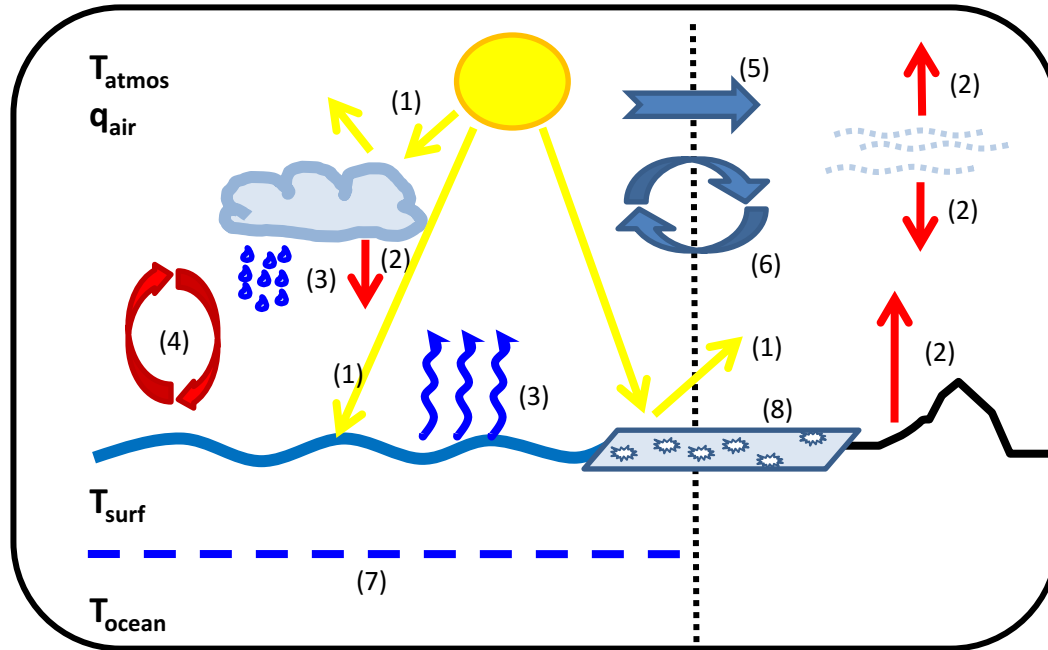
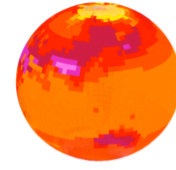
- Ice-albedo
- Clouds
- Oceans
- Atmosphere
- CO₂
- Hydrological cycle

Stop - + Continue

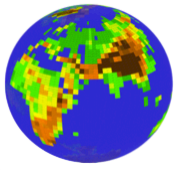


Monash simple climate model

The scientific basis

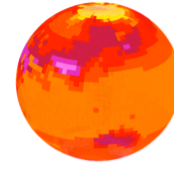


Processes:



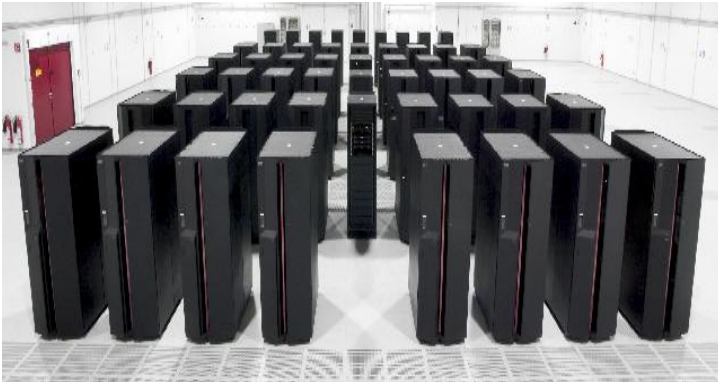
Monash simple climate model

Benchmark



IPCC-models

2,000,000 lines of code



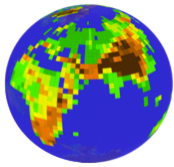
20C+A1B = **2 weeks** of computation
5yrs/day

MSCM

700 lines of code

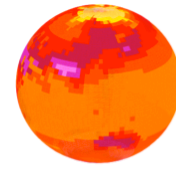


20C+A1B = **1 min.** of computation
200,000yrs/day



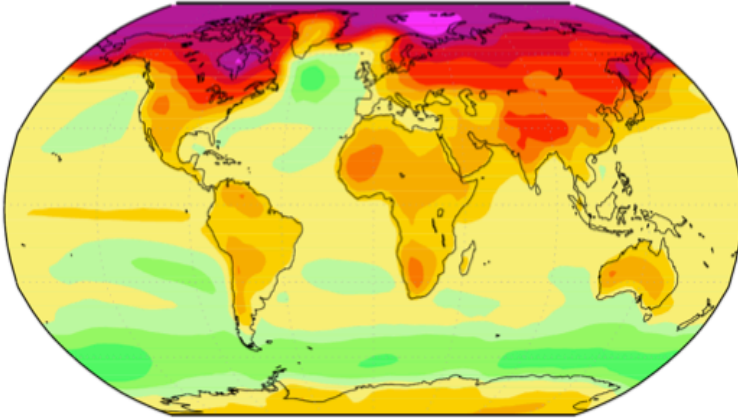
Monash simple climate model

Benchmark: response to increased CO₂

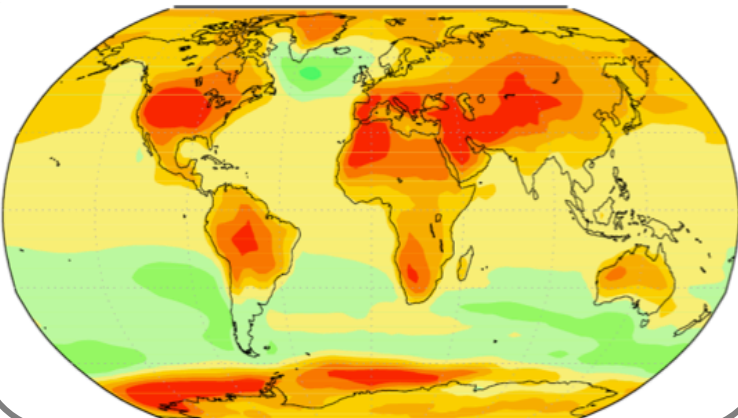


IPCC-models

Jan./Feb./Mar.

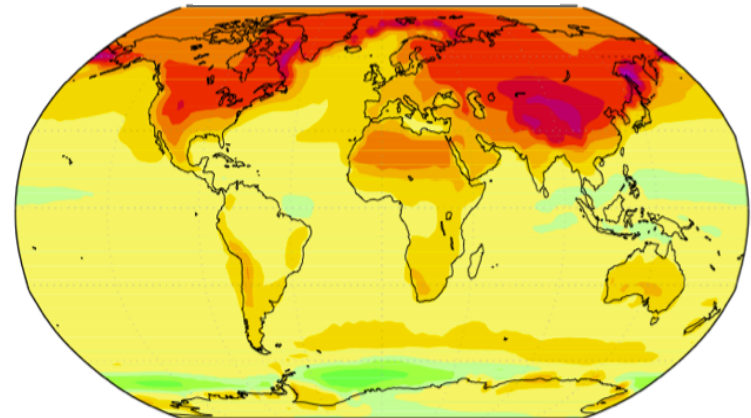


Jul./Aug./Sep.

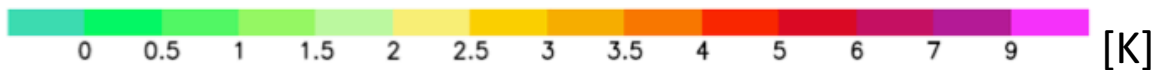
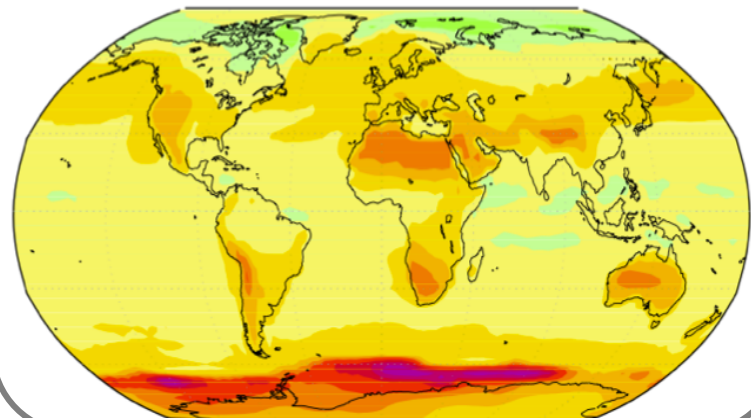


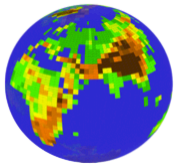
GREB

Jan./Feb./Mar.



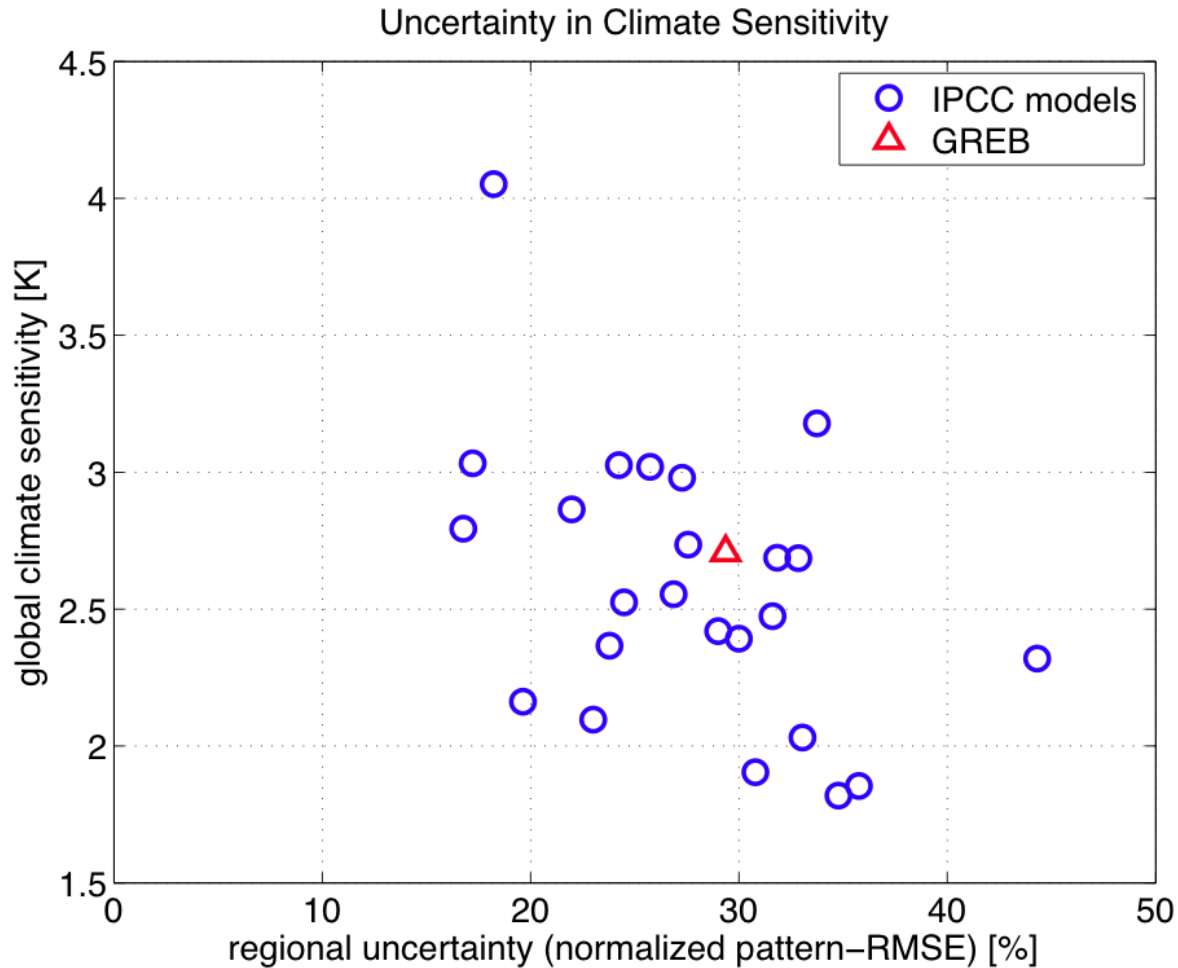
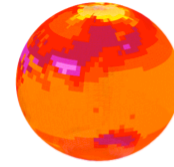
Jul./Aug./Sep.





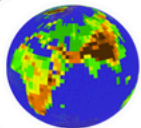
Monash simple climate model

Benchmark: response “skill”



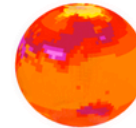
Note: nothing is said about whether or not this response is similar to what the real world is doing.

-> webpages



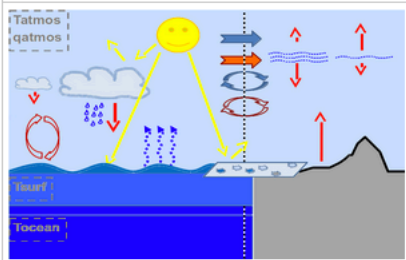
Monash simple climate model

Deconstruction of the response to 2xCO₂ forcing



Language: [English](#) Version: [Basic](#)

Experiment A



Boundary Conditions

Clouds (climatology)

Humidity (climatology)

Feedbacks/Processes

Ice-albedo

Ocean heat uptake

Hydrological cycle

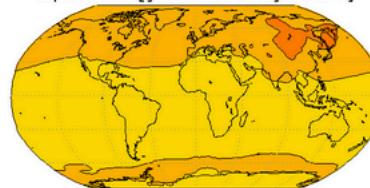
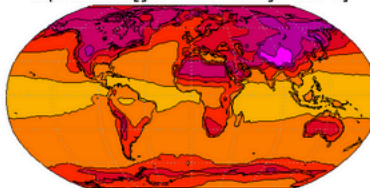
Map

Time Series

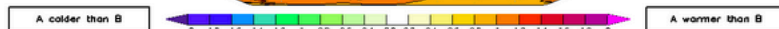
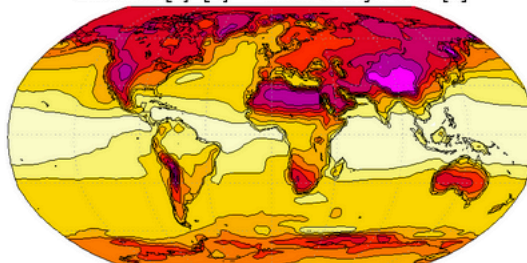
year: 45

Experiment A [global mean change: 2.51 K]

Experiment B [global mean change: 1.63 K]



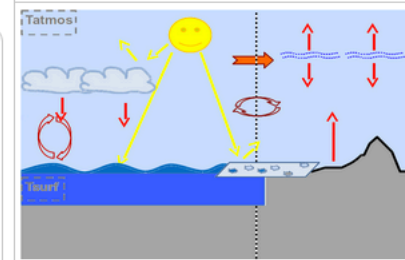
difference [A]-[B] mean change: 0.87 [K]



surface temperature [K]

Stop - + Continue

Experiment B



Boundary Conditions

Clouds (climatology)

Humidity (climatology)

Feedbacks/Processes

Ice-albedo

Ocean heat uptake

Hydrological cycle

Variable:

Surface temperature

Outline

History

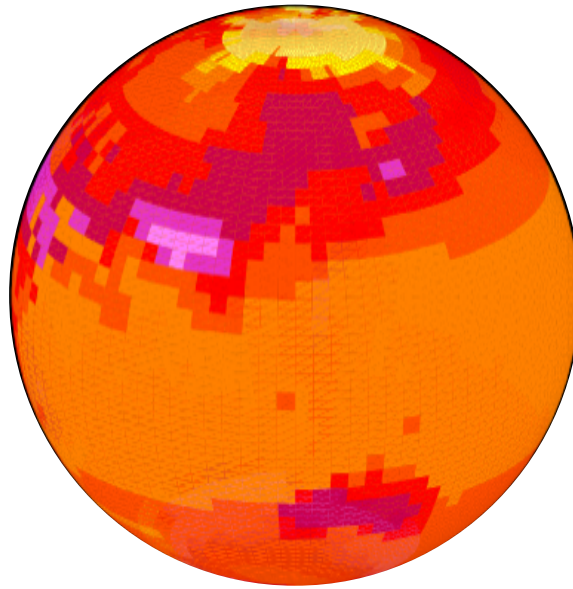
Models

Impact

Media

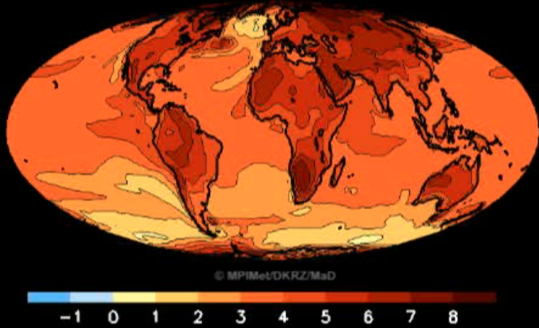
The recent Climate History

What is the meaning of 3°C warming?

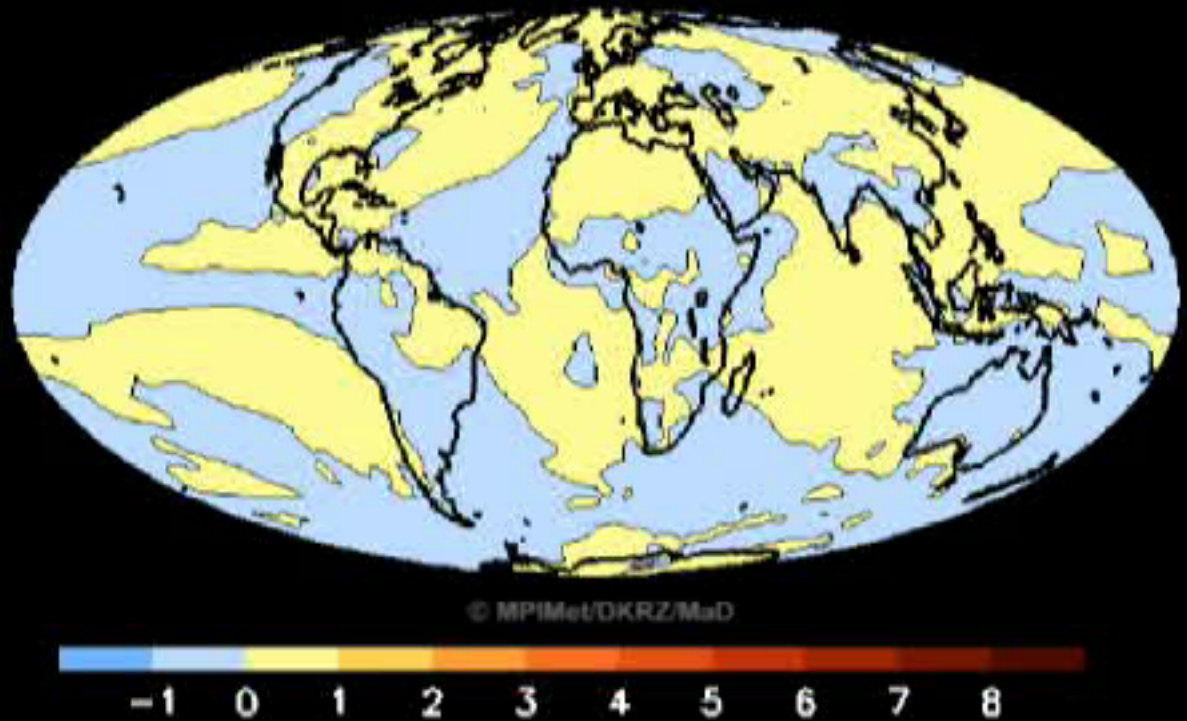


Climate Change

SRES A2 -- 5ym Temp. Change [Deg C] 2099

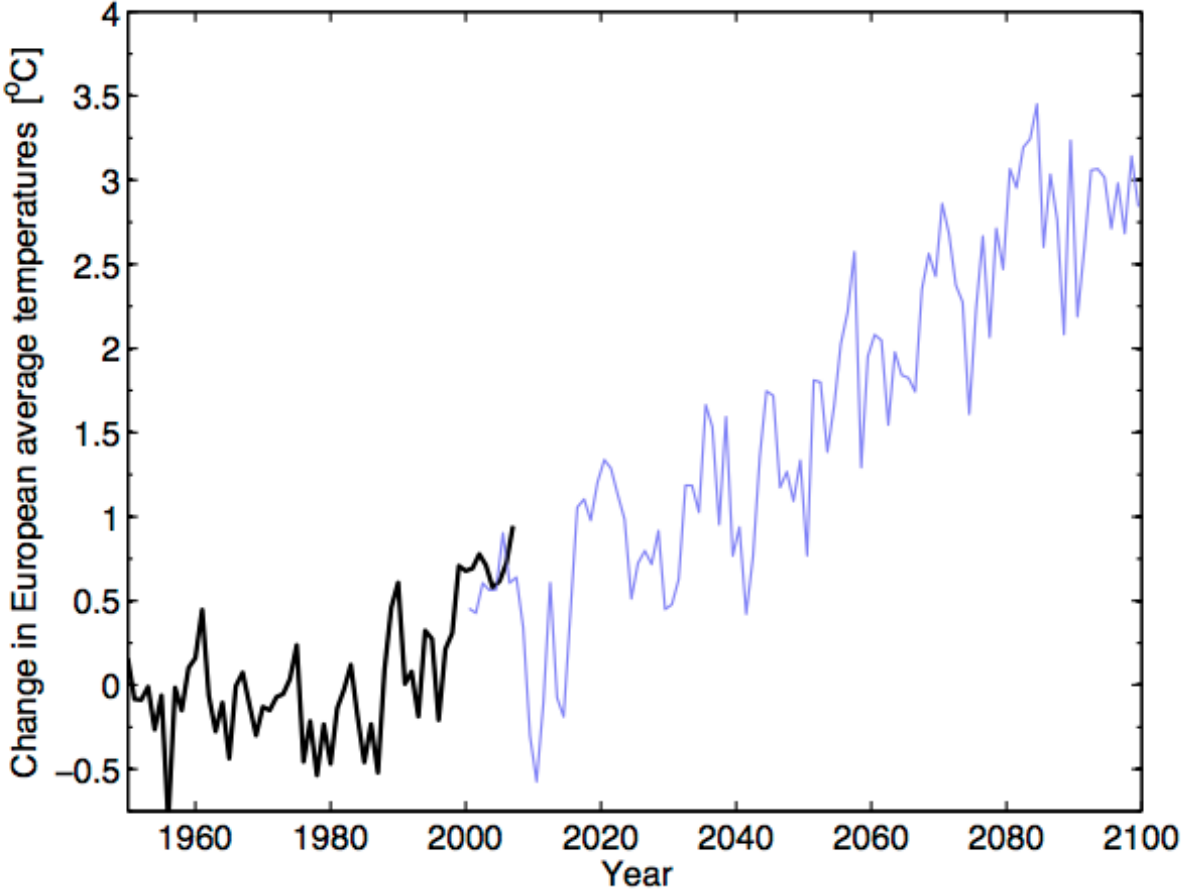


SRES A2 -- 5ym Temp. Change [Deg C] 1980



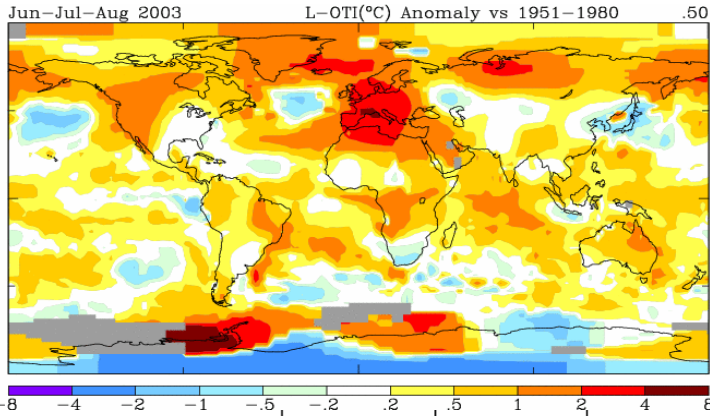
Climate change with natural variability

A single simulation of future European temperatures

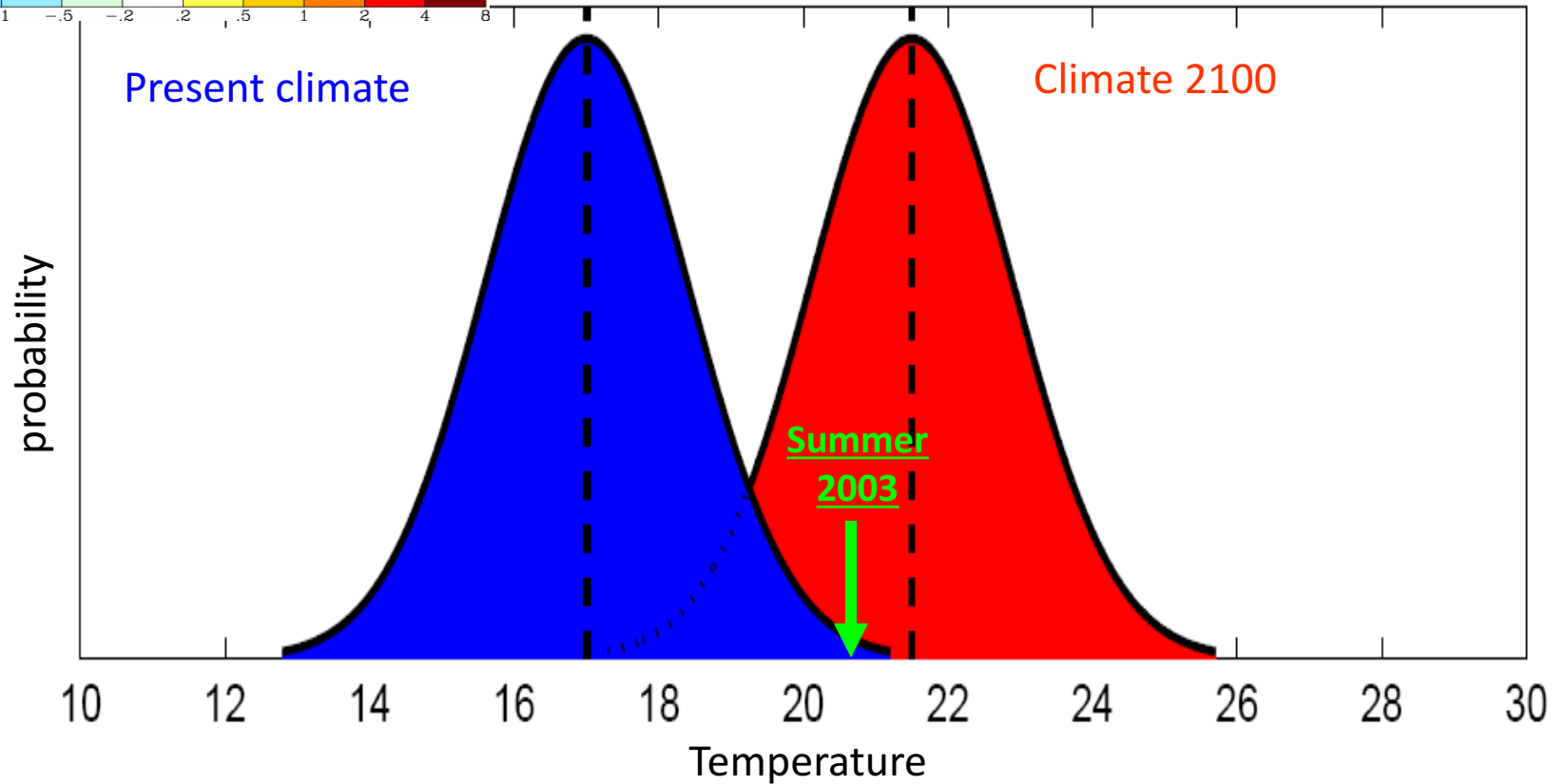


Seasonal shifts

Example: Germany

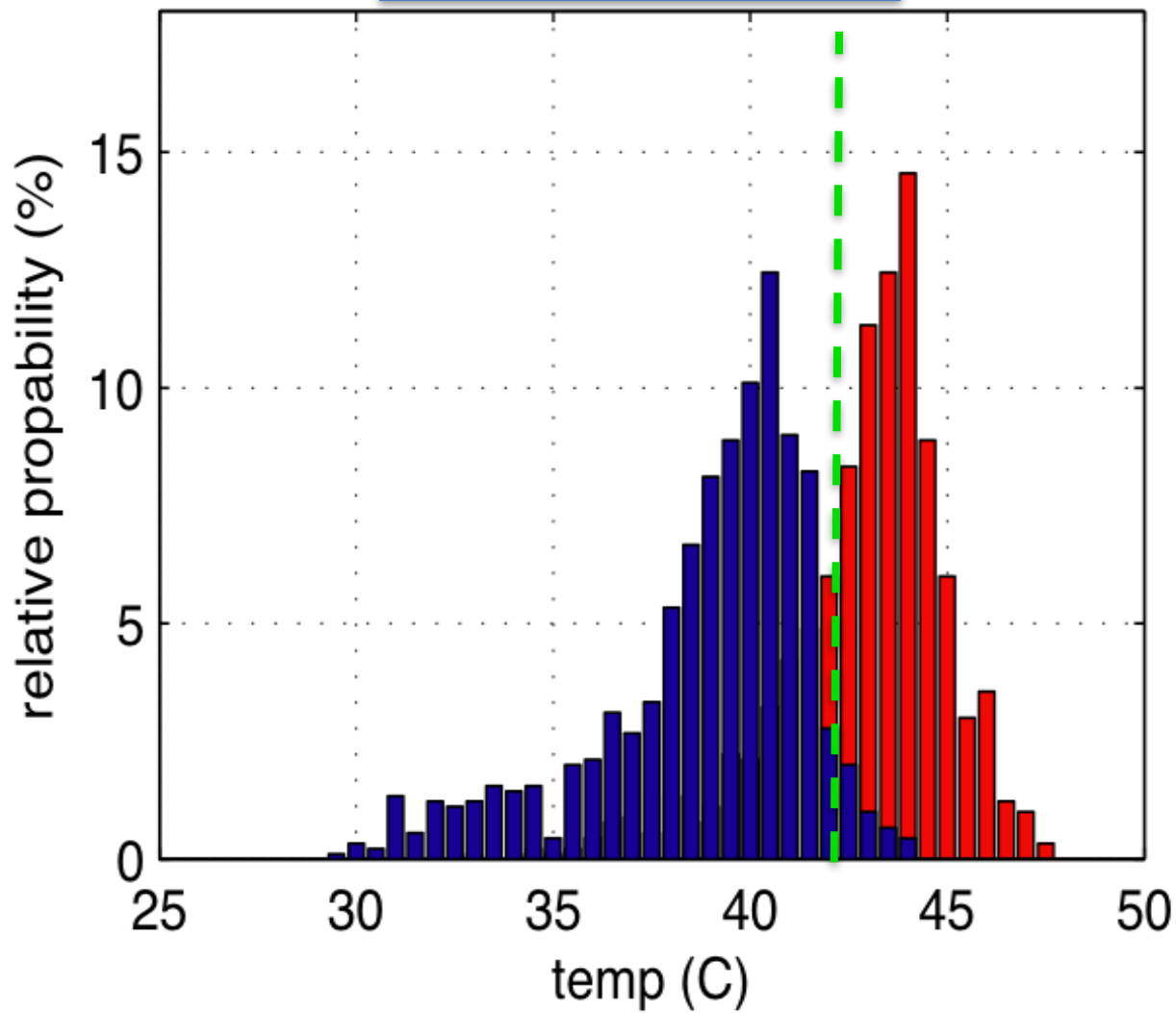


Summer mean Temperature distribution

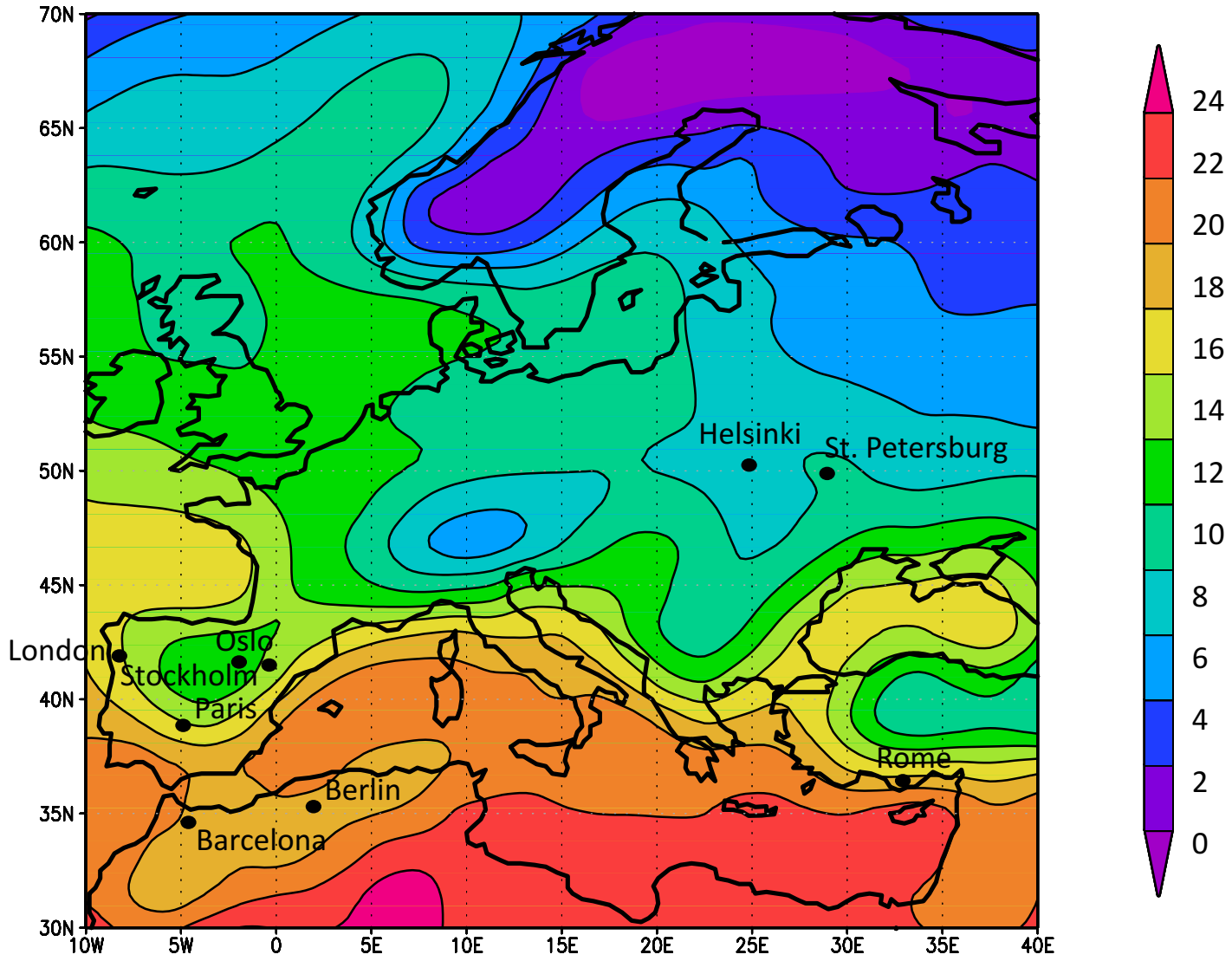


Seasonal shifts

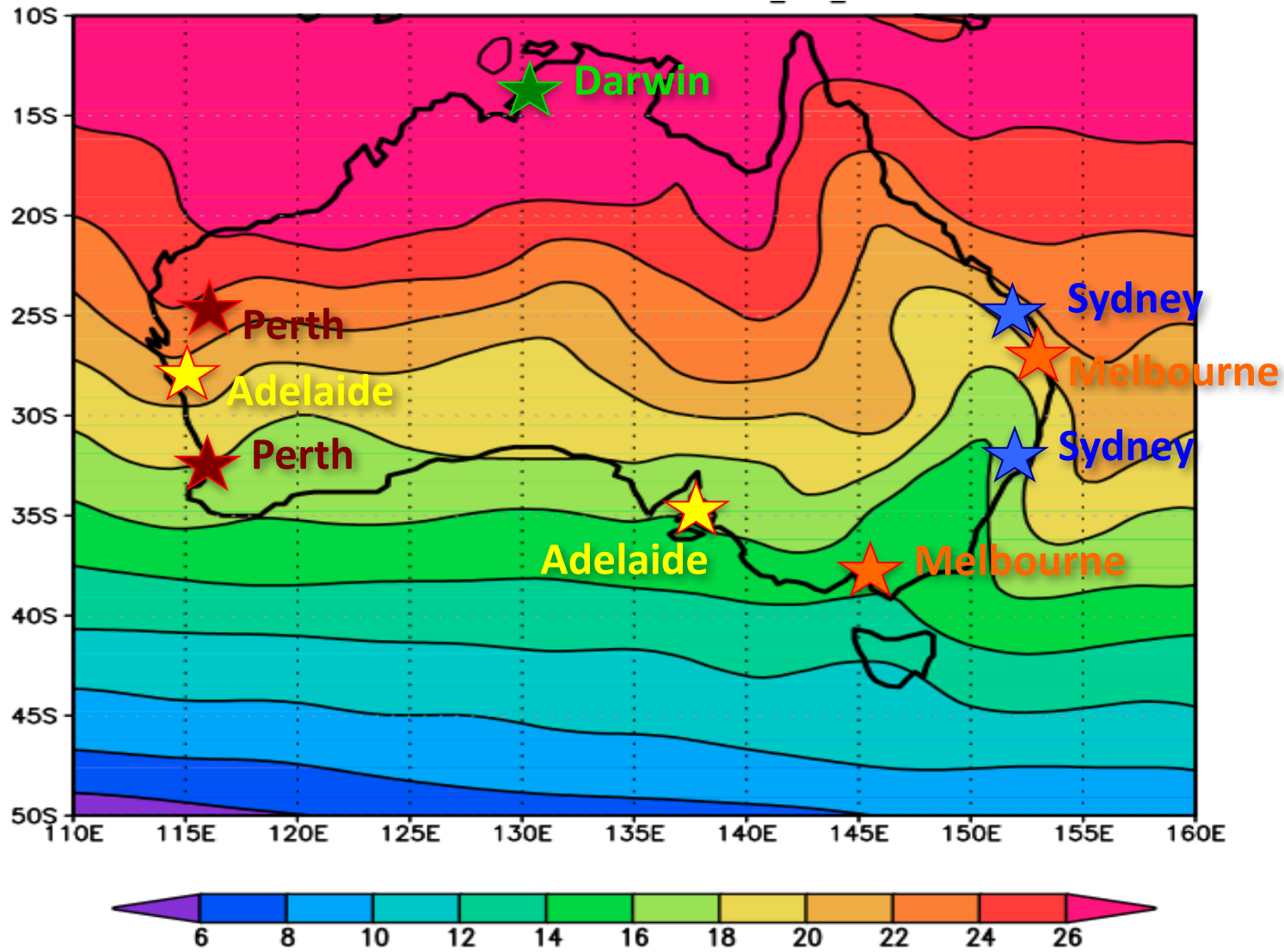
Example: Central India



Climate Map 2071



Australia Climate Map 2100

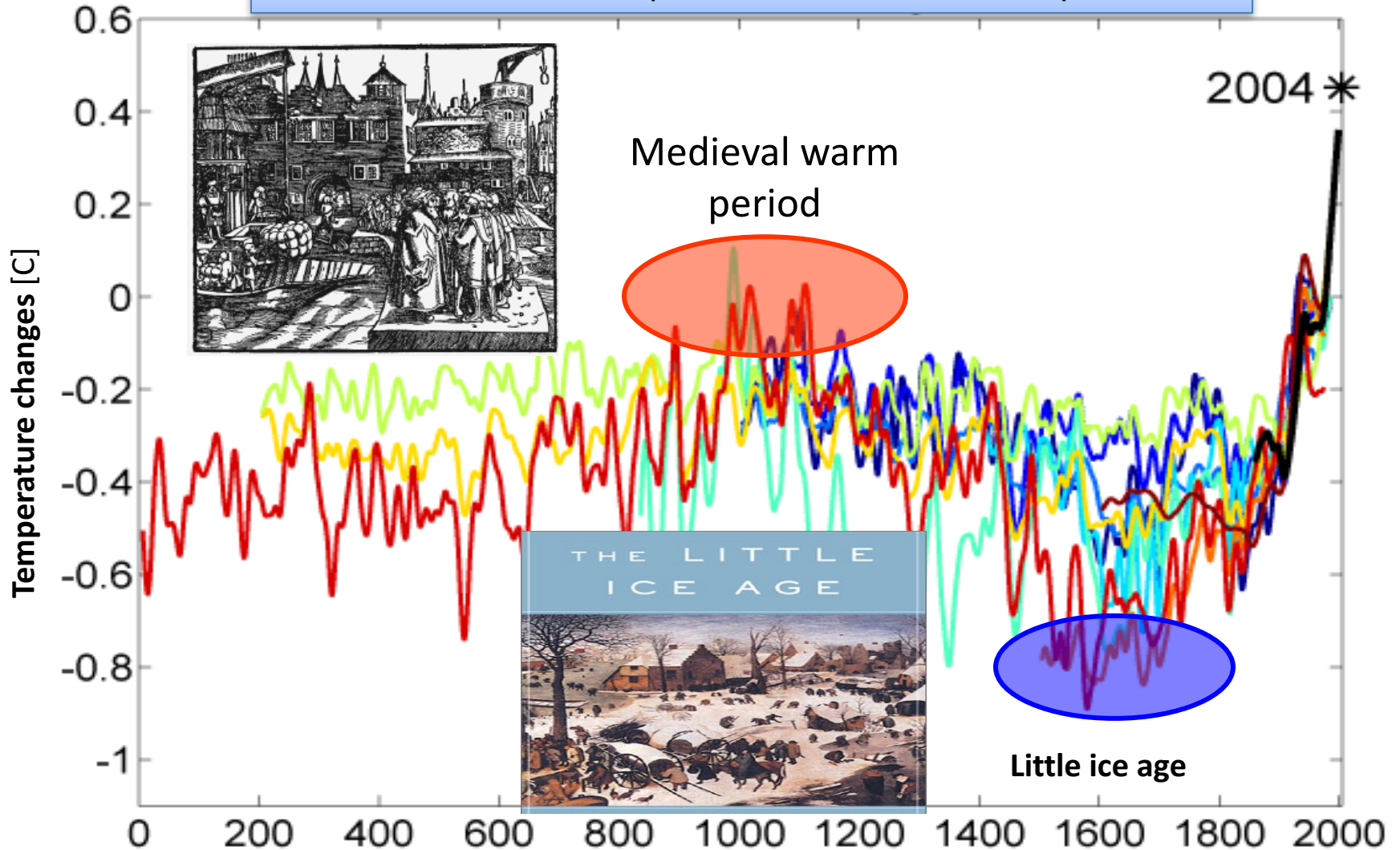


★ Darwin

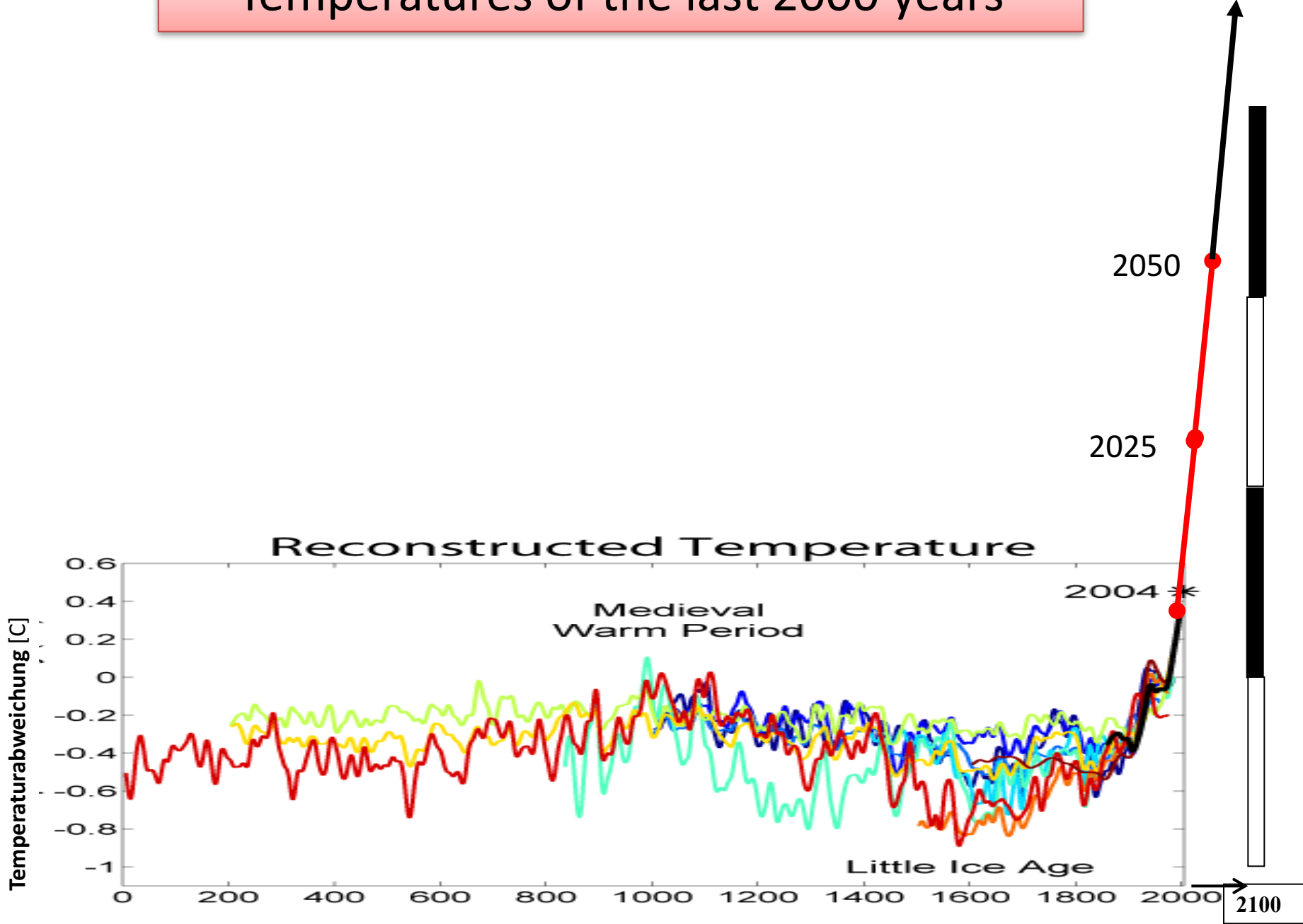
Current climate does not have a place on earth that would be similar to the Darwin climate in 2100

Temperatures of the last 2000 years

Reconstructed temperatures Northern Hemisphere



Temperatures of the last 2000 years



Outline

History

Models

Impact

Media

Climate Change in the Media

Public perception of scientific evidence

Pro anthropogenic
climate change

51%

Contra anthropogenic
climate change

49%

Scientific perception of evidence

99.9%

0

1

%

0.1%

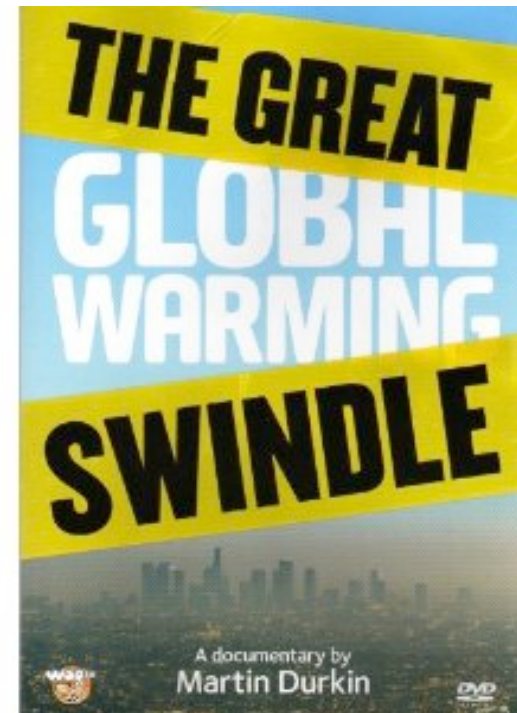
Climate Change Propaganda

Some examples how both sides manipulate and spread false ideas.

Pro anthropogenic
climate change

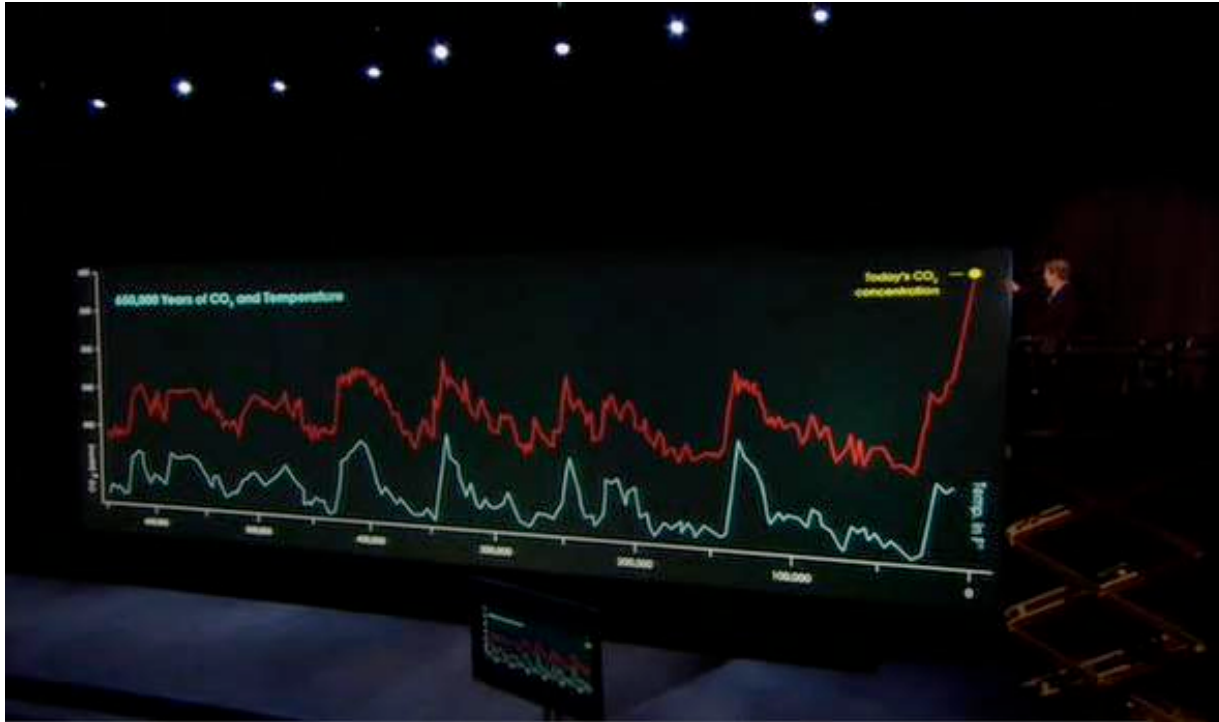


Contra anthropogenic
climate change



They are available on *youtube*.

Example I: CO₂ and Ice ages



First: Ice ages are mainly caused by changes in the incoming solar radiation, not by changes in CO₂.

Second (more importantly): Calculating his statement: He is suggesting doubling of CO₂ causes 40°C of global warming, which is highly exaggerated.

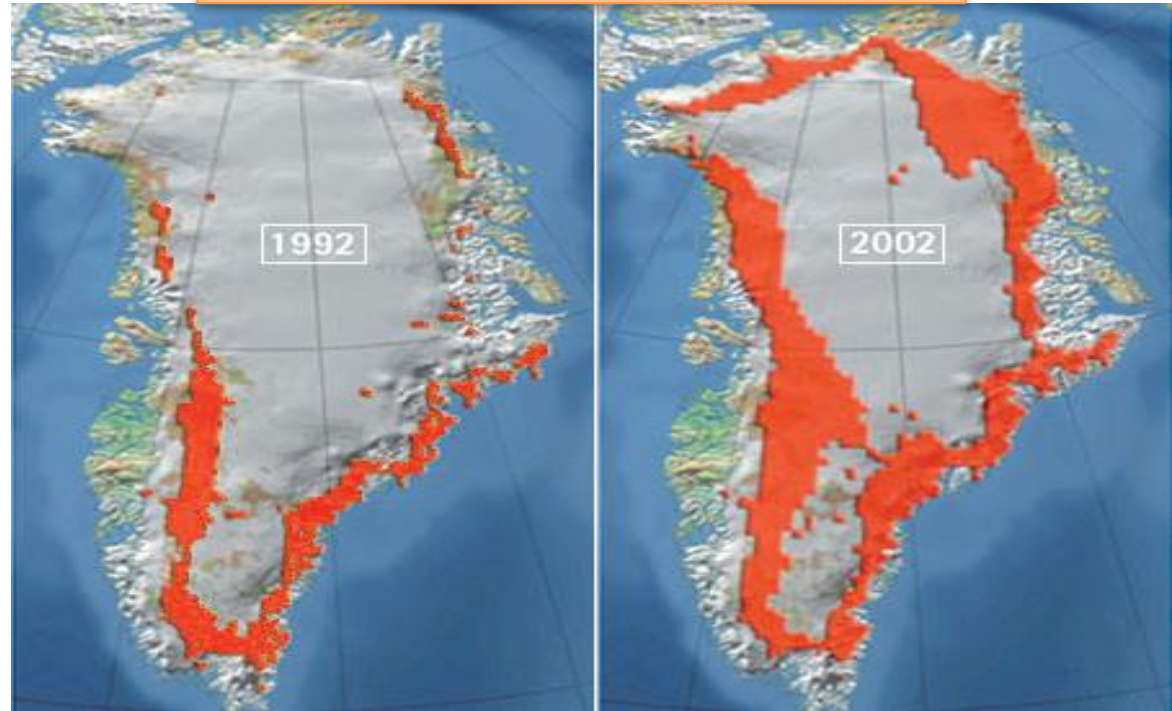
This is not good science!!!

240ppm to 300ppm → $\Delta T = 10^\circ\text{C}$
⇒ $\Delta\text{CO}_2 = 60\text{ppm}$ → $\Delta T = 10^\circ\text{C}$
linear interpolation:
⇒ $\Delta\text{CO}_2(2\times\text{CO}_2) = 280\text{ppm}$ → $4\times\Delta T = \mathbf{40^\circ\text{C}}$

Example II: Melting of Greenland

From a newspaper arguing for dramatic melting of Greenland ice sheets

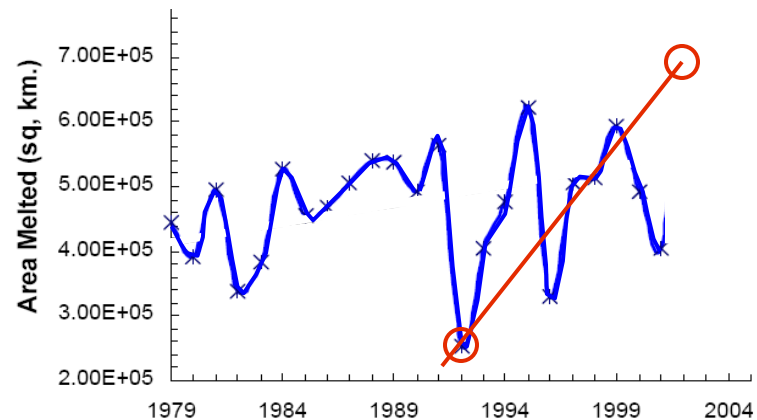
Areas with at least one day of melting



Glacier mass balance:

$$\Delta M = +\Delta_{snow} - \Delta_{icebergs} - \Delta_{melting}$$

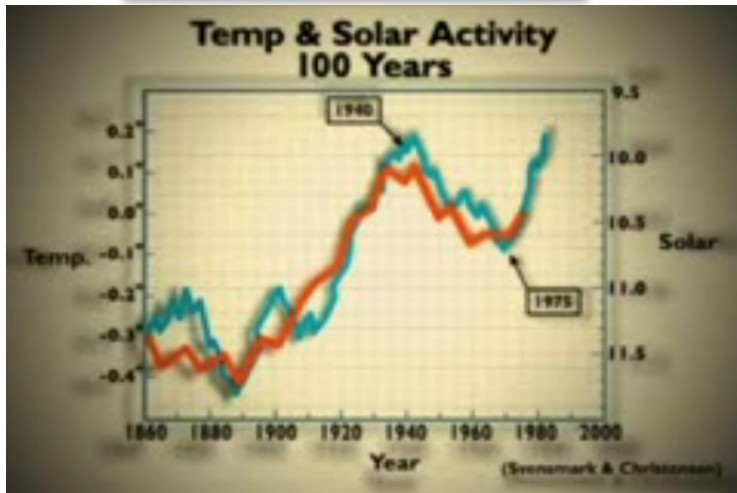
Melting alone does not tell you if the glacier is decreasing. Warmer climate also causes more snow accumulation



Example II: Sun causes climate Change

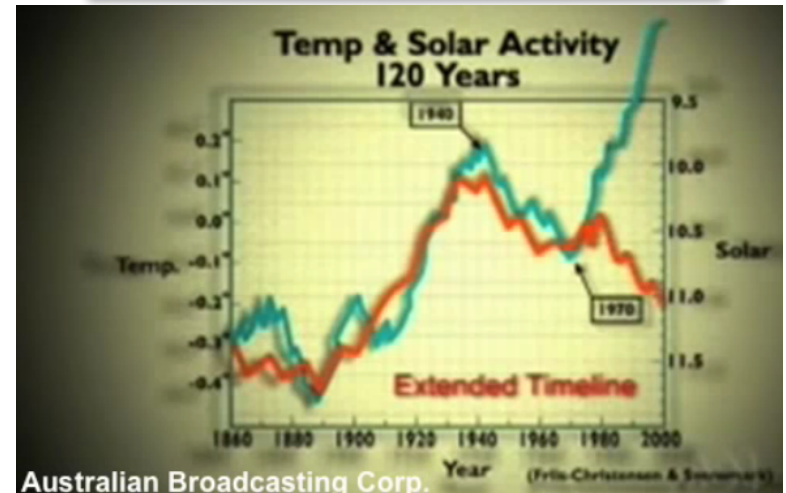
Climate Swindle: The sun is the cause of climate change

Figure from climate swindle



Blue line: global mean temperature
Red line: 'solar activity'

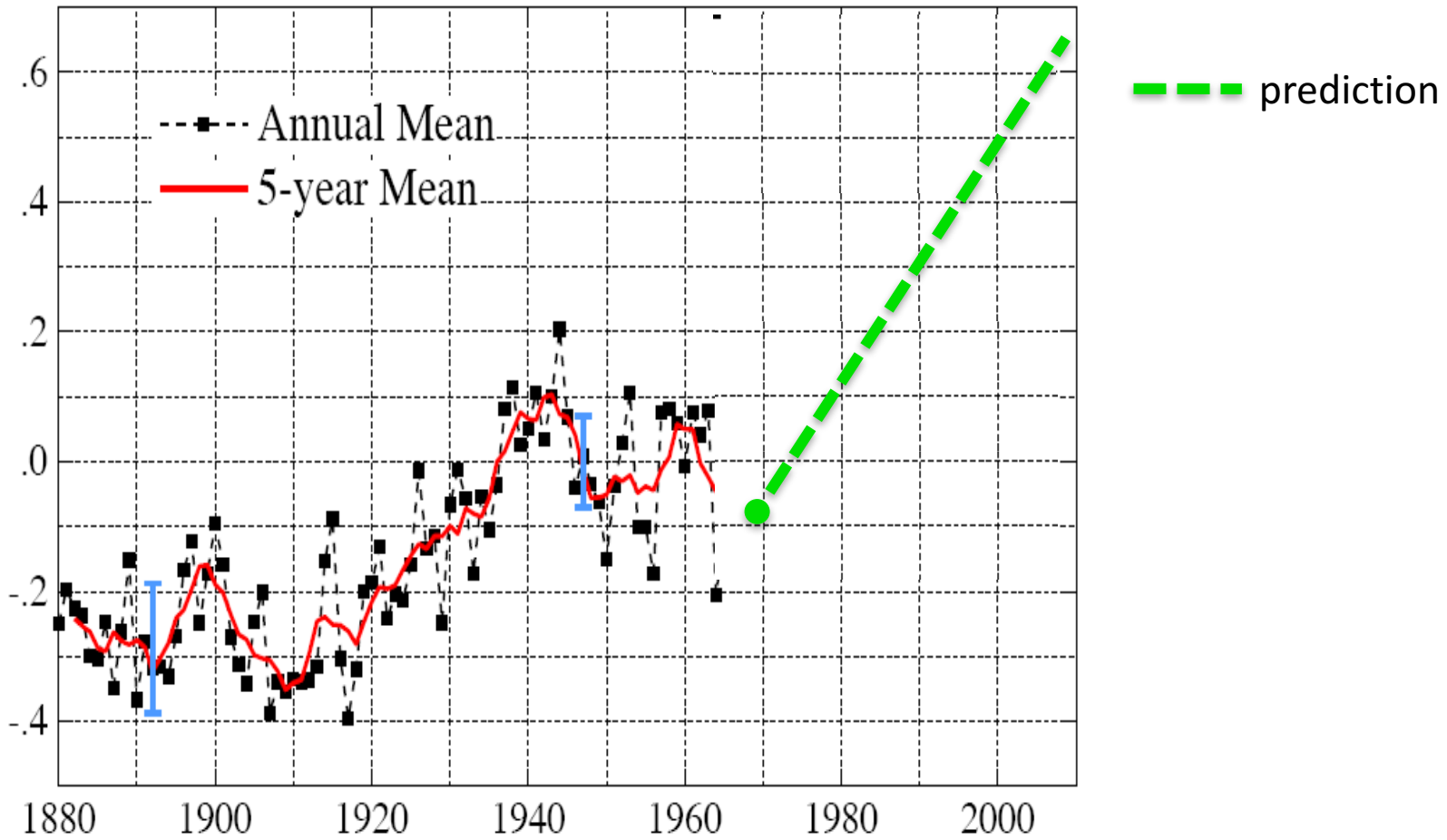
Figure from www.skepticalscience.com



Australian Broadcasting Corp.

The authors continued the lines for the last decades, showing that the apparent relationship breaks down over the last decades

Global mean temperature



Short summary of anthropogenic climate change

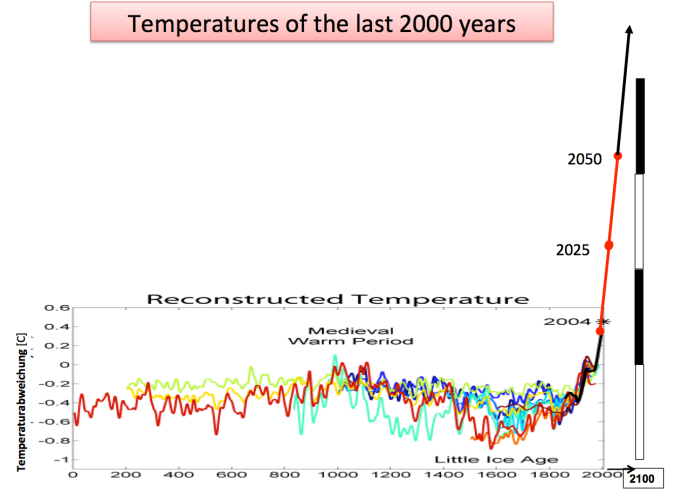
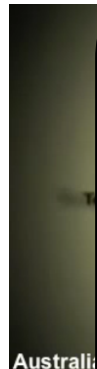
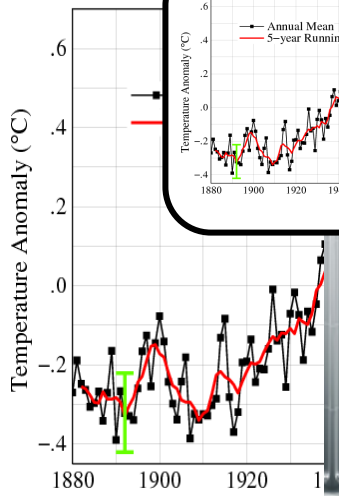
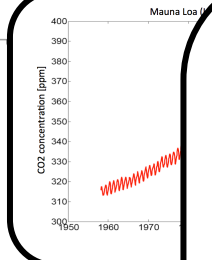
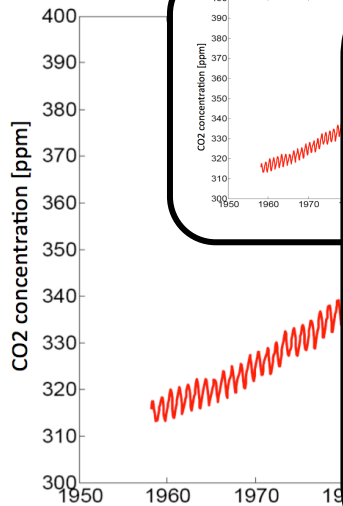
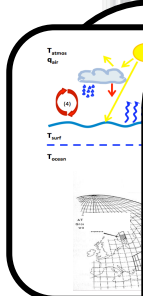
Theory

CO₂ trend

Climate change

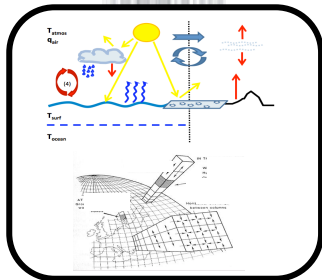
Missing alternative

Significance

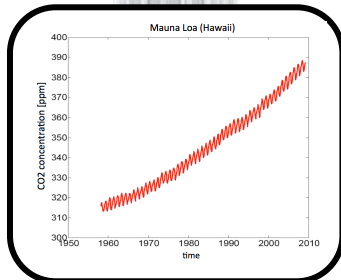


The 5 Pillars of anthropogenic climate change

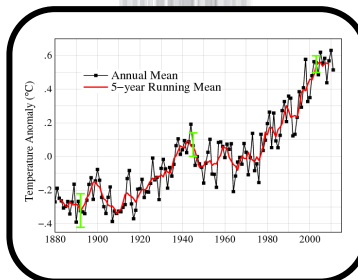
Theory



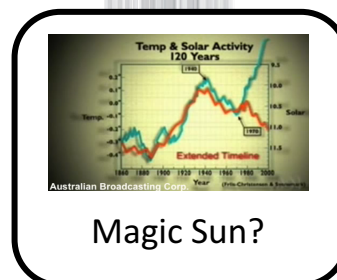
CO₂ trend



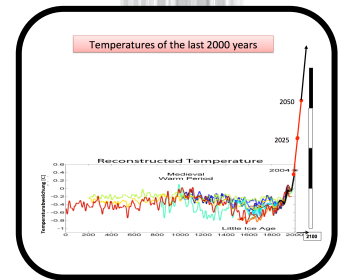
Climate change



Missing alternative



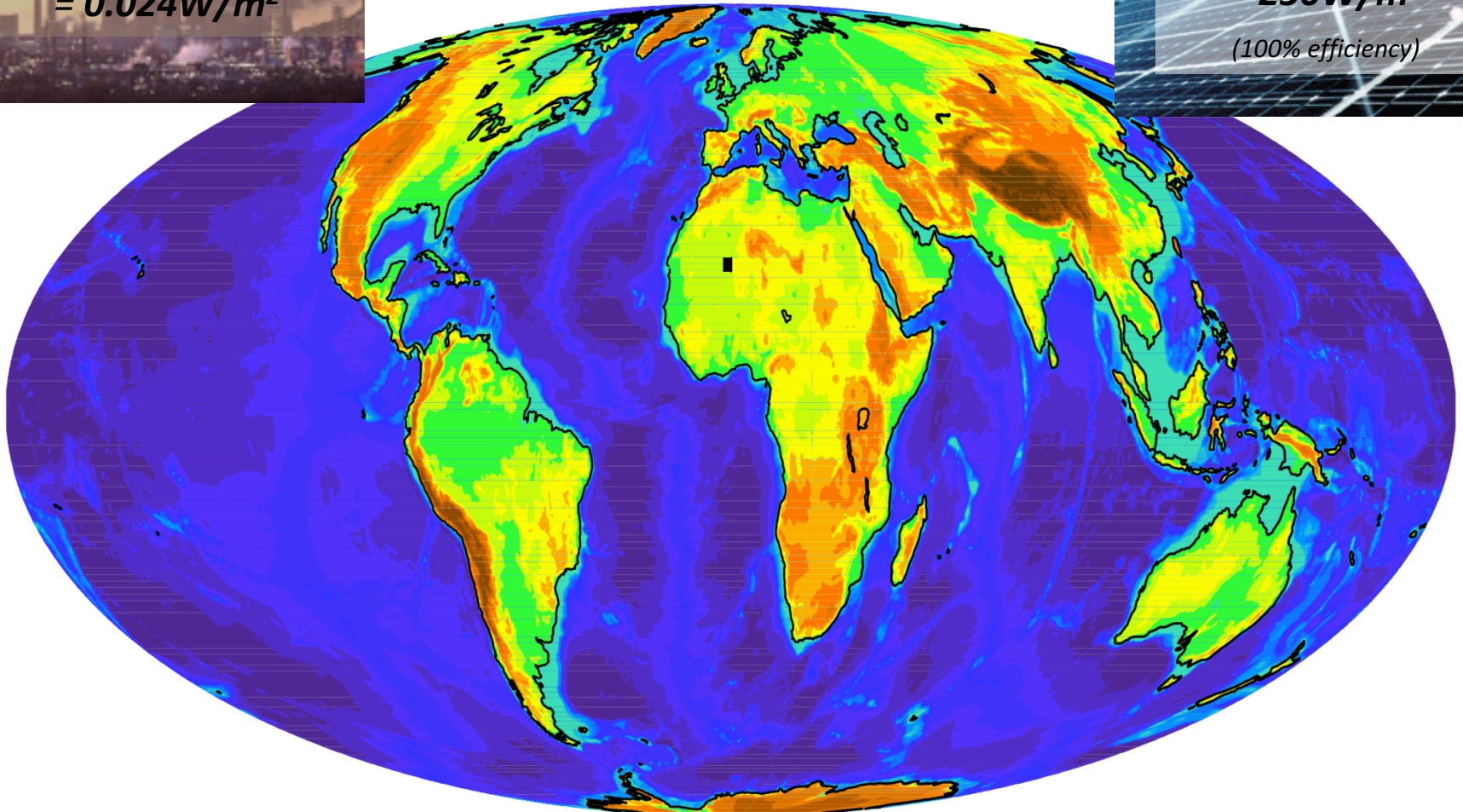
Significance



Energy Balance

Energy usage all
mankind
= 0.024W/m^2

Sun
= 250W/m^2
(100% efficiency)



Thank you!

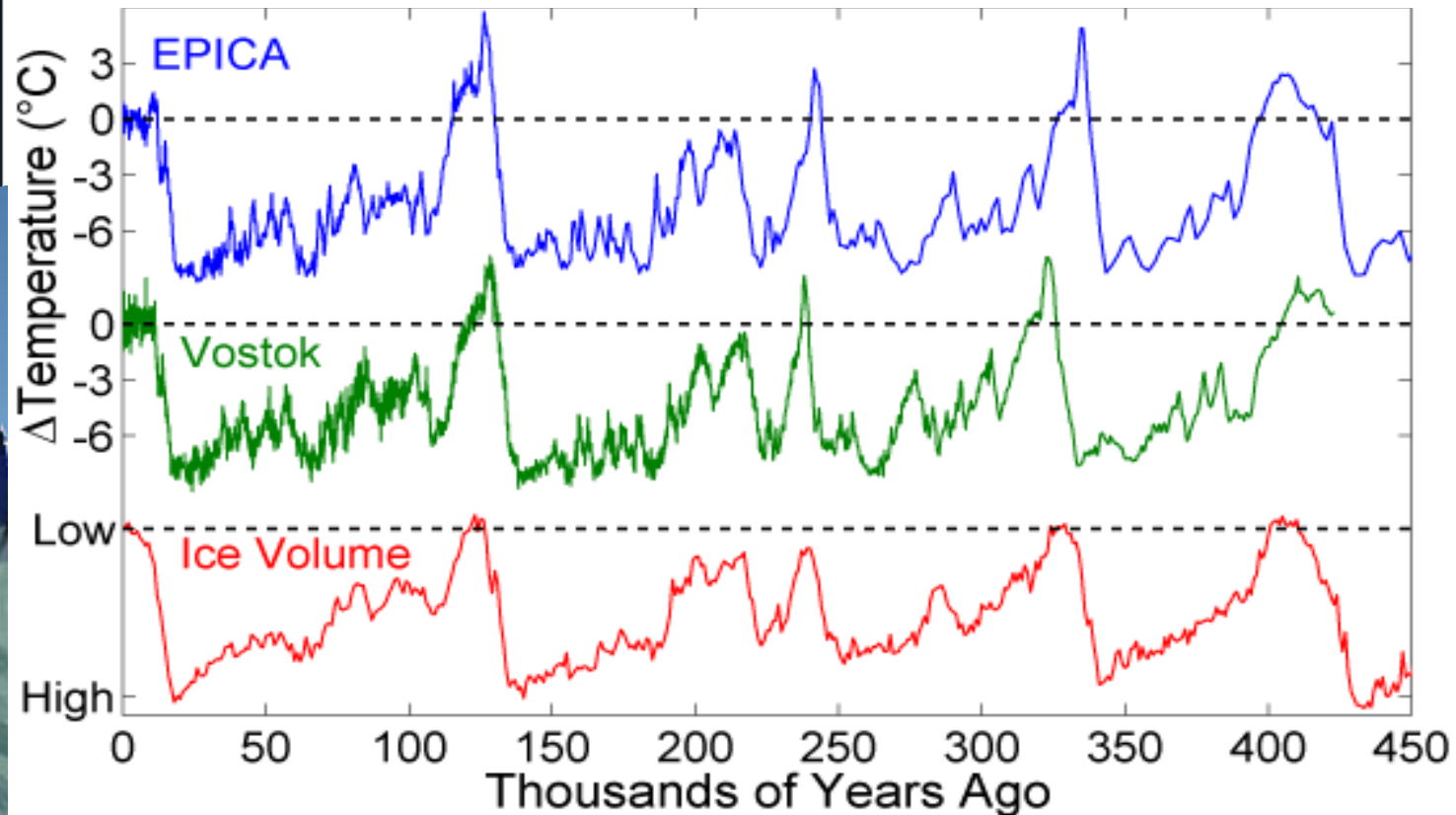


Dietmar Dommenget

Eiszeiten

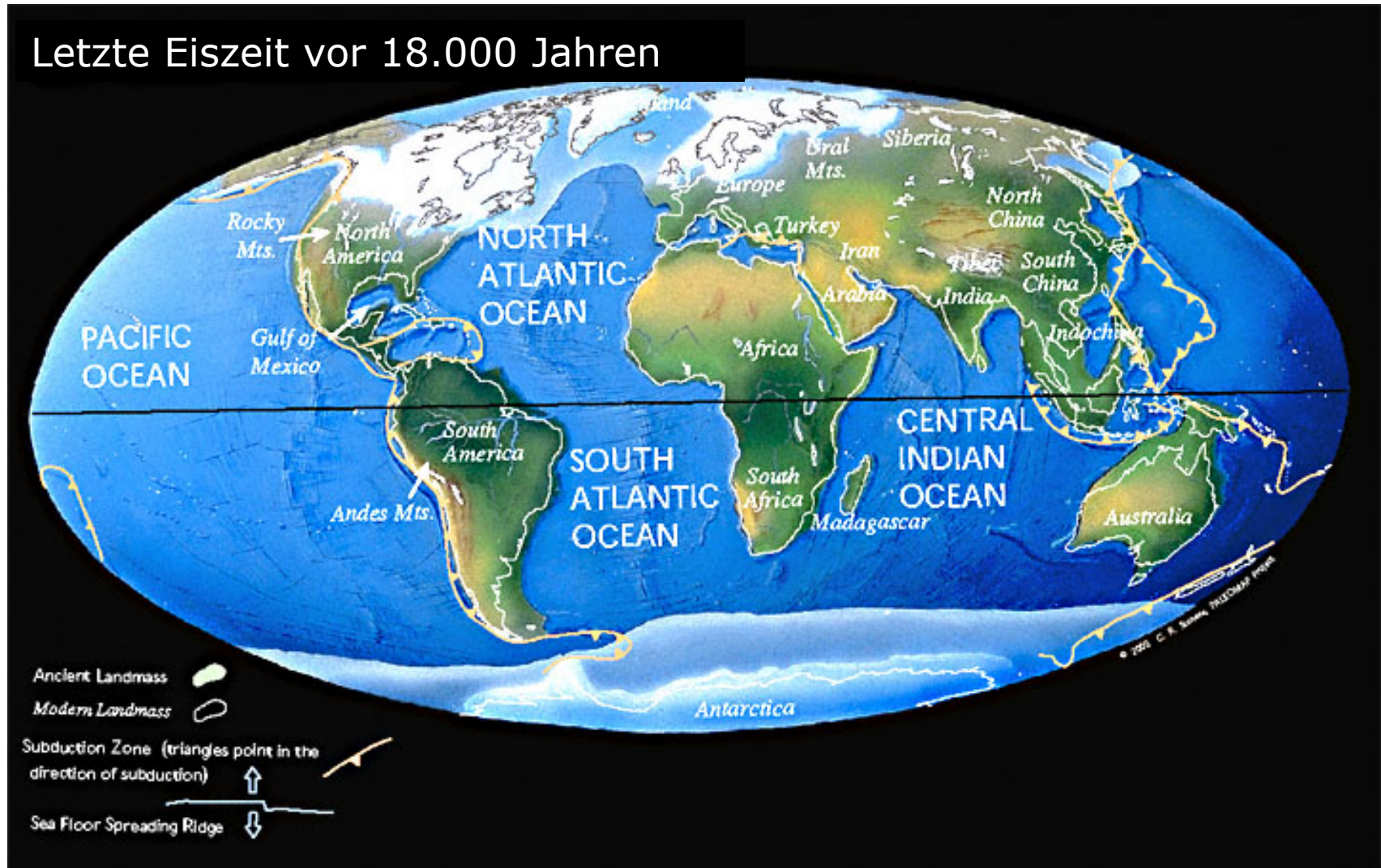


Temperaturänderungen der Eiszeiten (Eisborkern Antarktis)

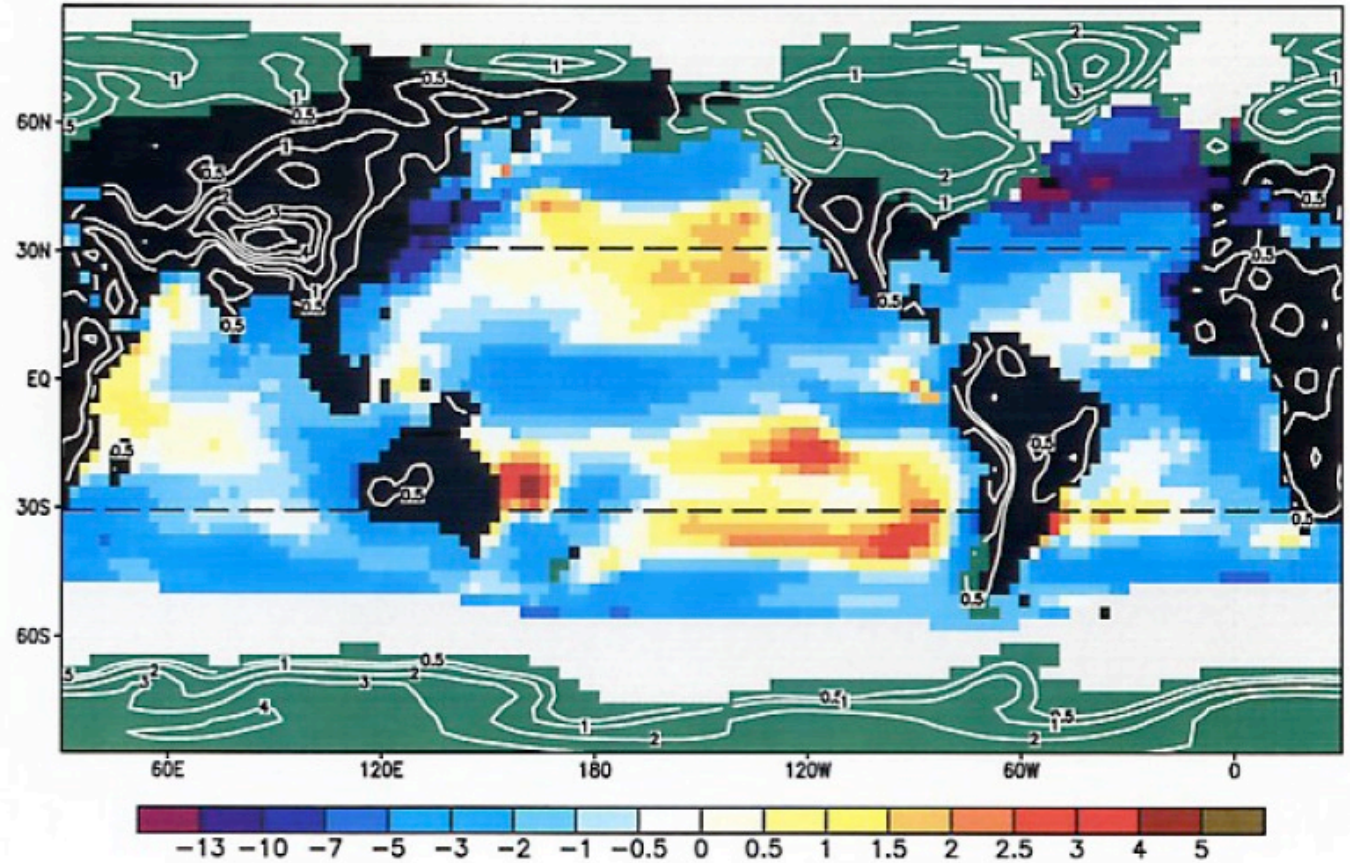
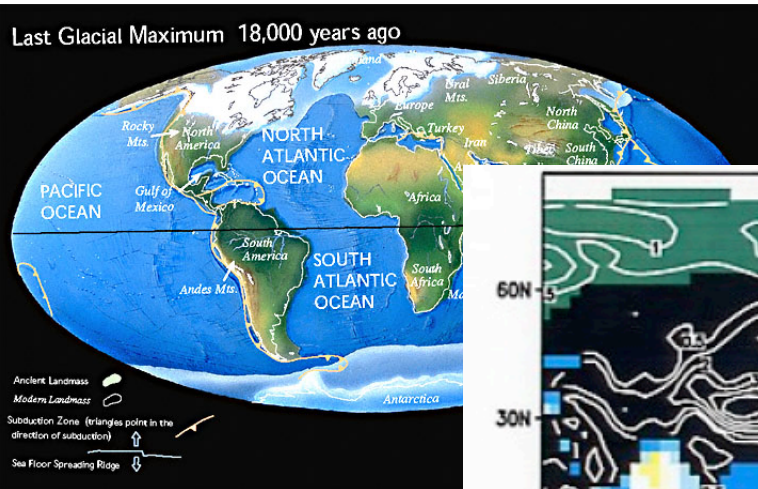


Letzte Eiszeit

Letzte Eiszeit vor 18.000 Jahren

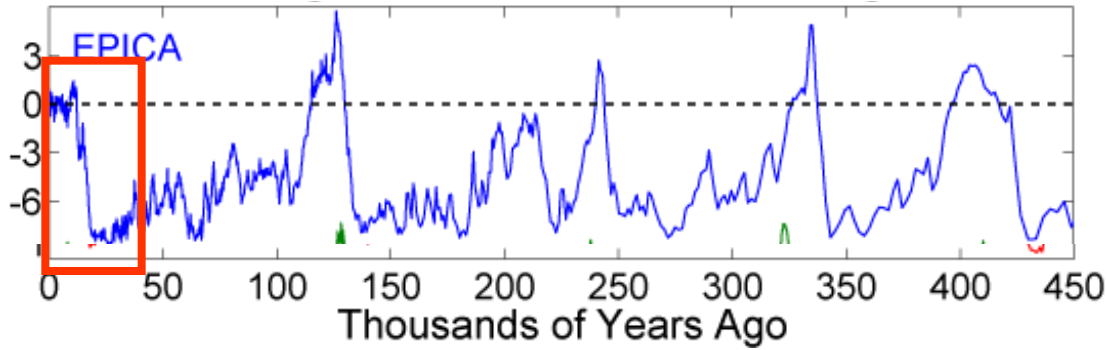


Letzte Eiszeit

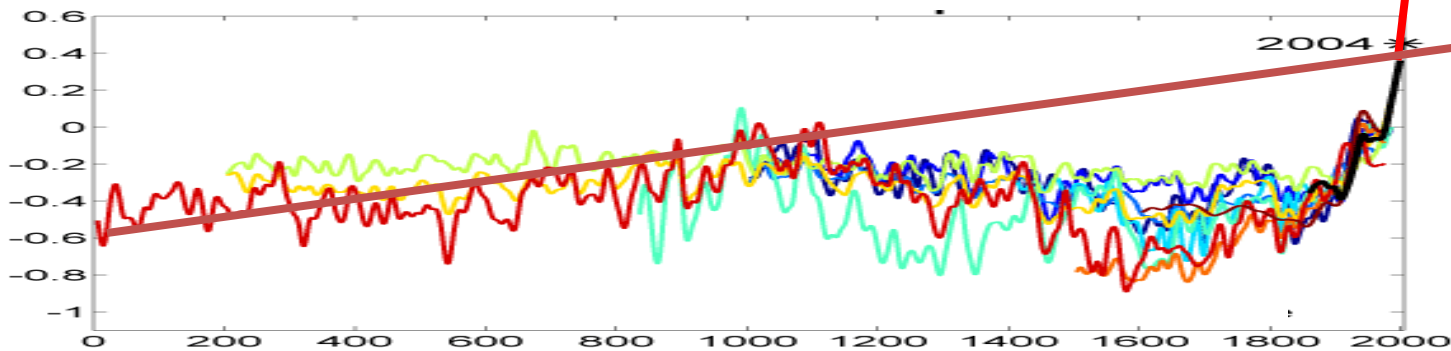


Letzte Eiszeit

Temperaturänderungen der Eiszeiten



heutiger
Klimawandel



Natürlicher
Klimawandel