

Climate Science - What do we know about past, current and future climate change?

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4.7.2013

STÜRME +++ HITZE-REKORDE +++ UND JETZT DIE JAHRHUNDERT-
FLUTEN

Klimawandel schlägt voll zu

SCHOCK-FOTOS WARNEN VOR KLIMAWANDEL

Droht Amerika bald der Untergang?



Bild-Zeitung



Climate change overseas likely to affect UK food supplies



By Roger Harrabin
Environment analyst

BBC



NEUE STUDIE

Erde erwärmt sich langsamer als befürchtet



Features

GOT A STORY? E-

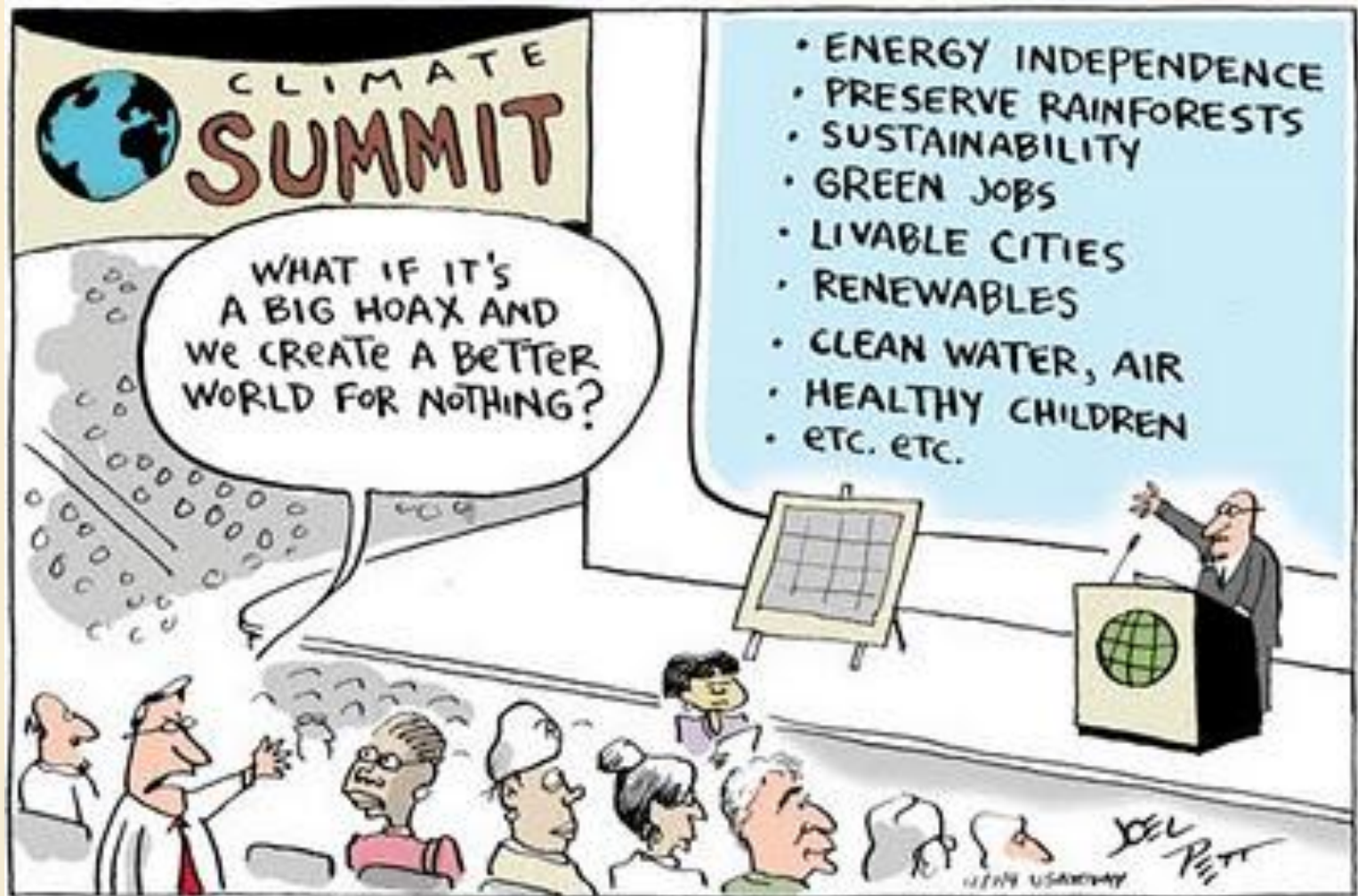
Apocalypse snow? The truth behind our changing temperatures



The Medias point of view?



The policy makers point of view ?



The engineers point of view ?



The science point of view

- Observed changes in the climate system
- Drivers of climate change
- Understanding of processes and climate models
- Long-term projections

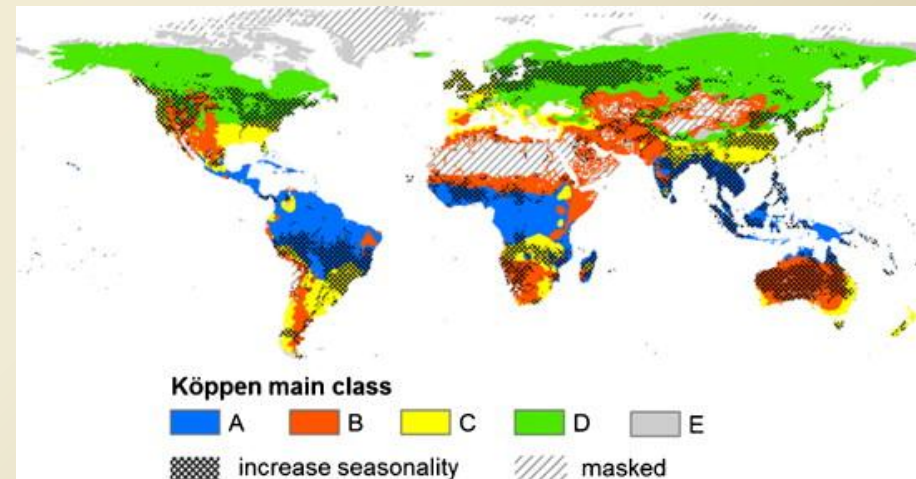
Weather and Climate

- IPCC (2007) Glossary: Climate in a narrow sense is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization ([WMO](#)). These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system*

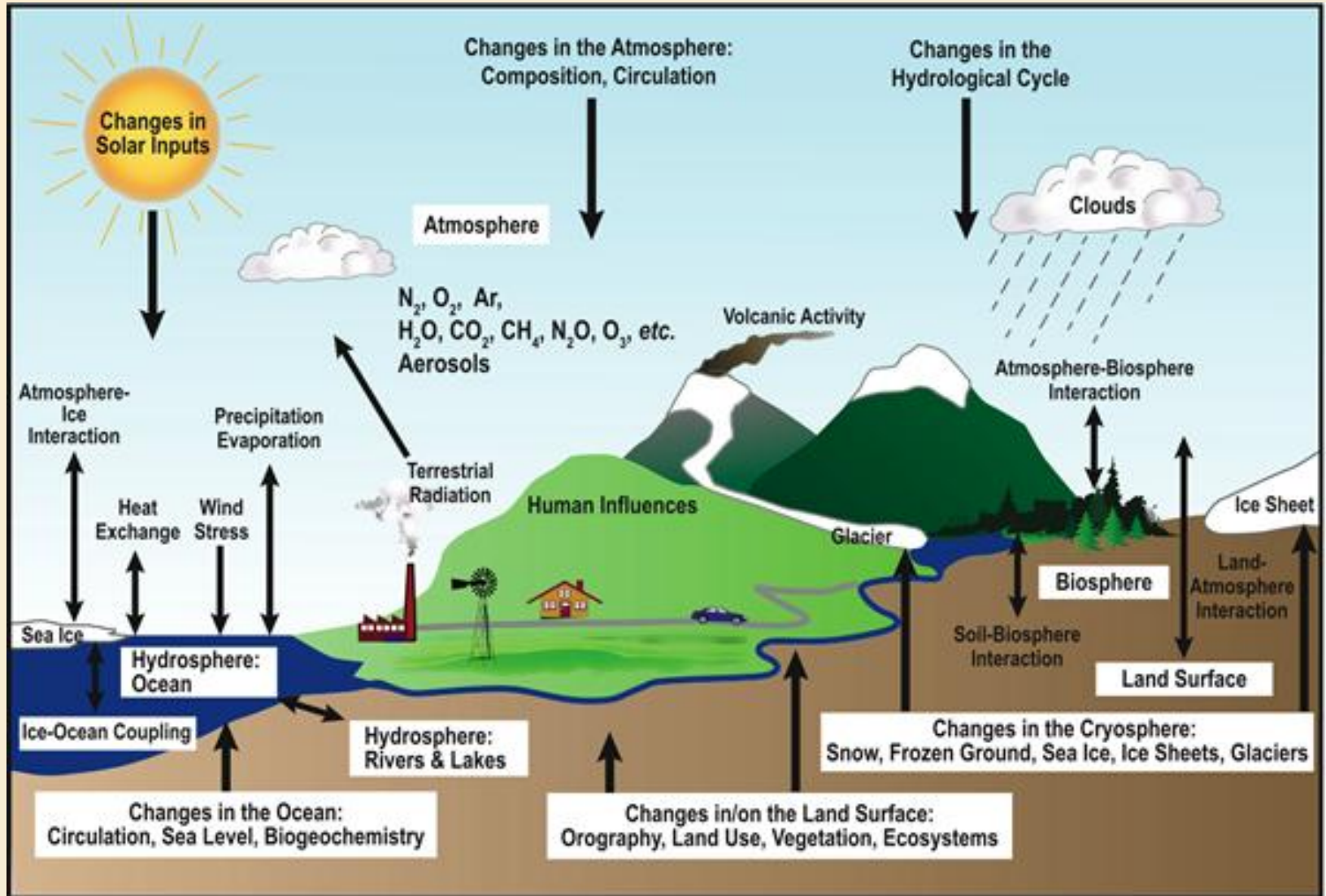
Weather



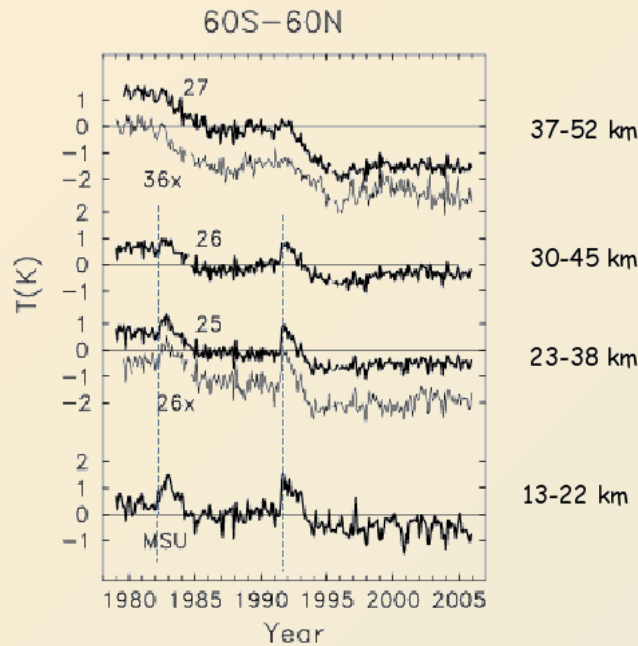
Climate



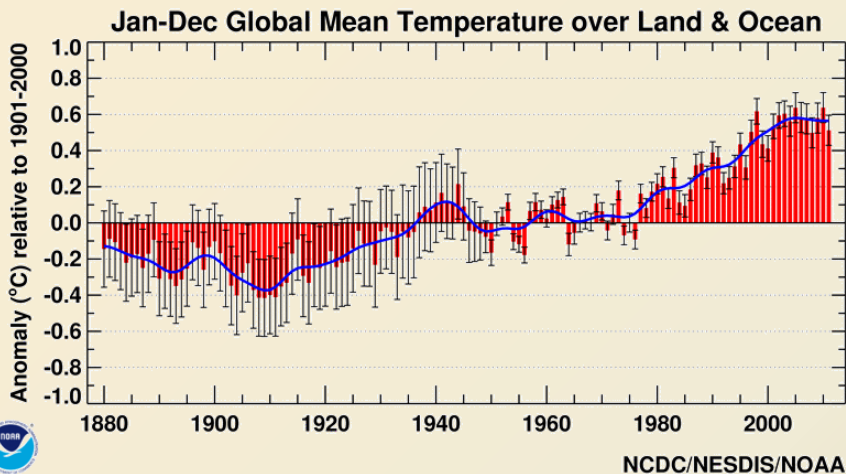
The climate system



Observed climate changes



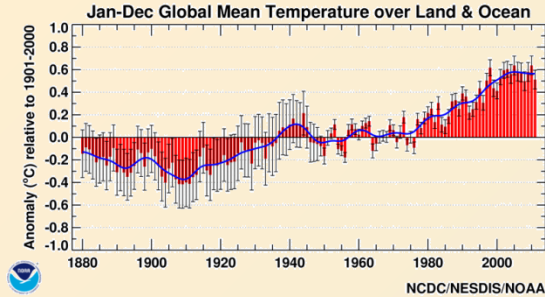
Stratospheric temperature



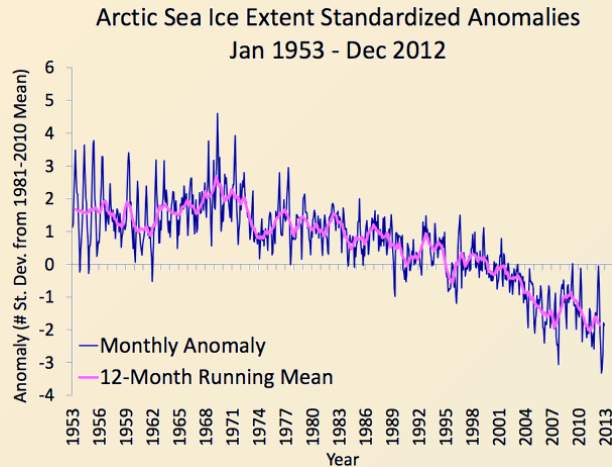
Global mean
near surface temperature

Observed climate changes

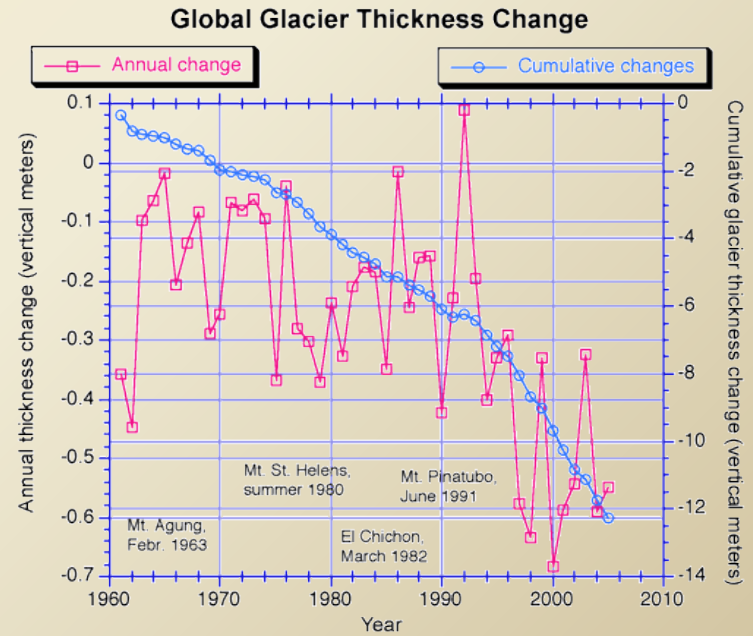
Global mean near surface temperature



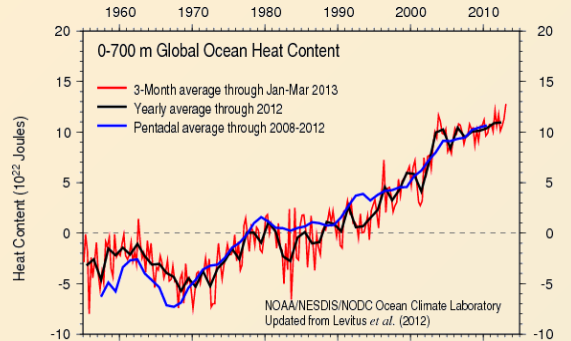
Arctic sea ice changes (National Snow and Ice Data Center, University of Colorado)



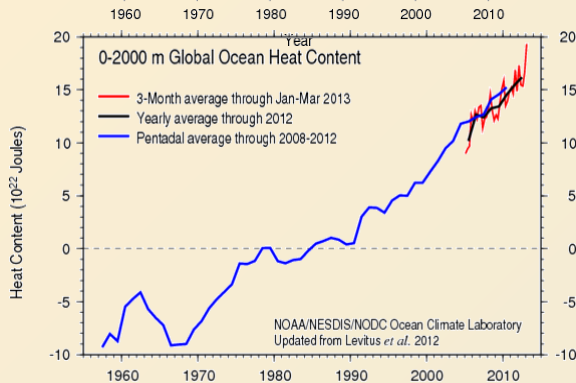
Glacier changes (National Snow and Ice Data Center, University of Colorado)



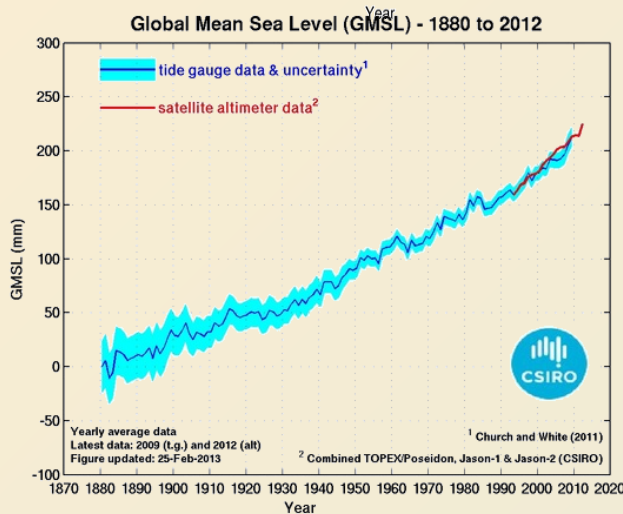
Observed climate changes



Upper Ocean heat content change

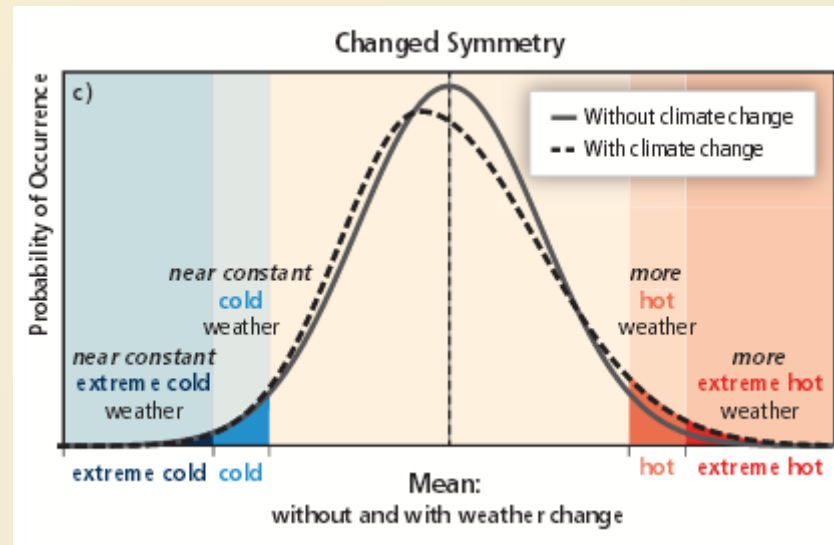
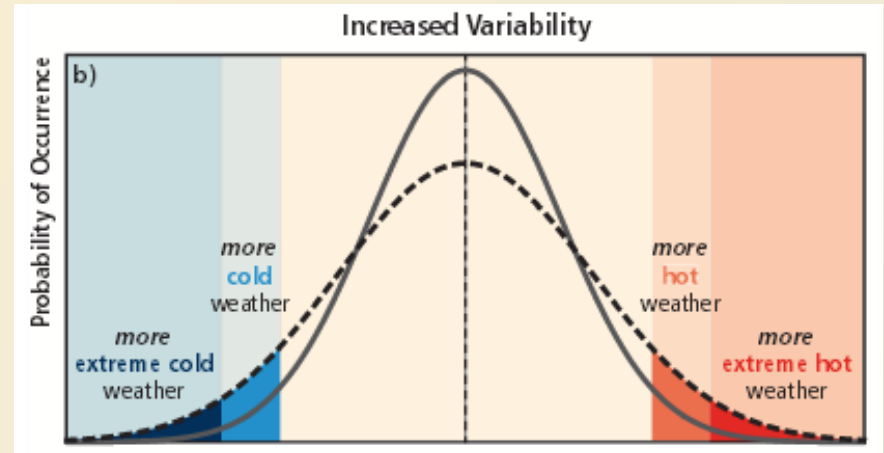
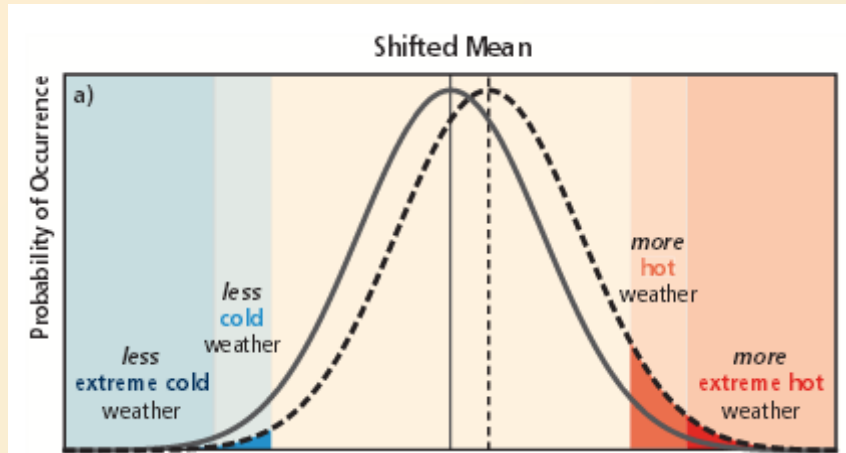


Deeper Ocean heat content change



Sea Level Rise

How does changes in climate affect climatic extremes ?

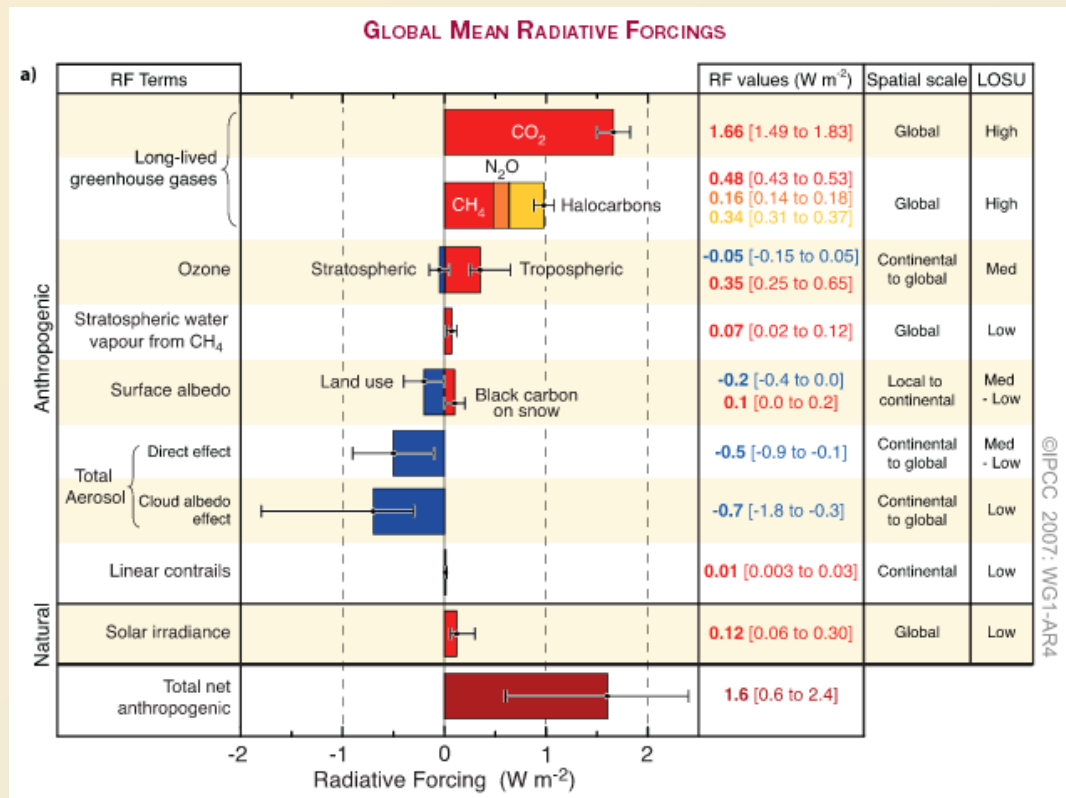
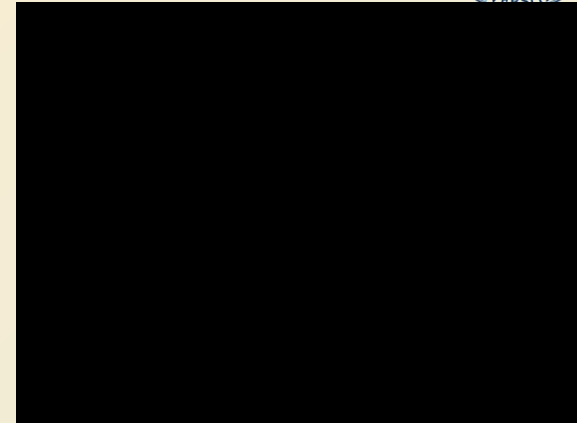
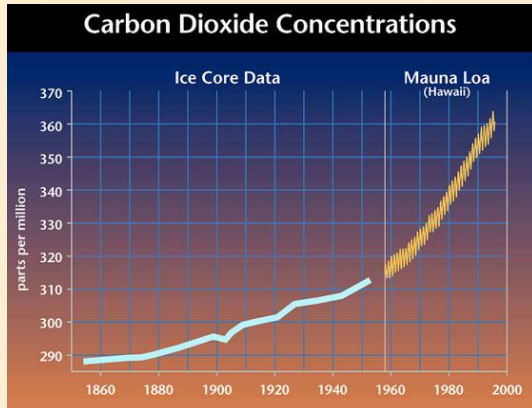


Observed climate changes

SREX (2012)

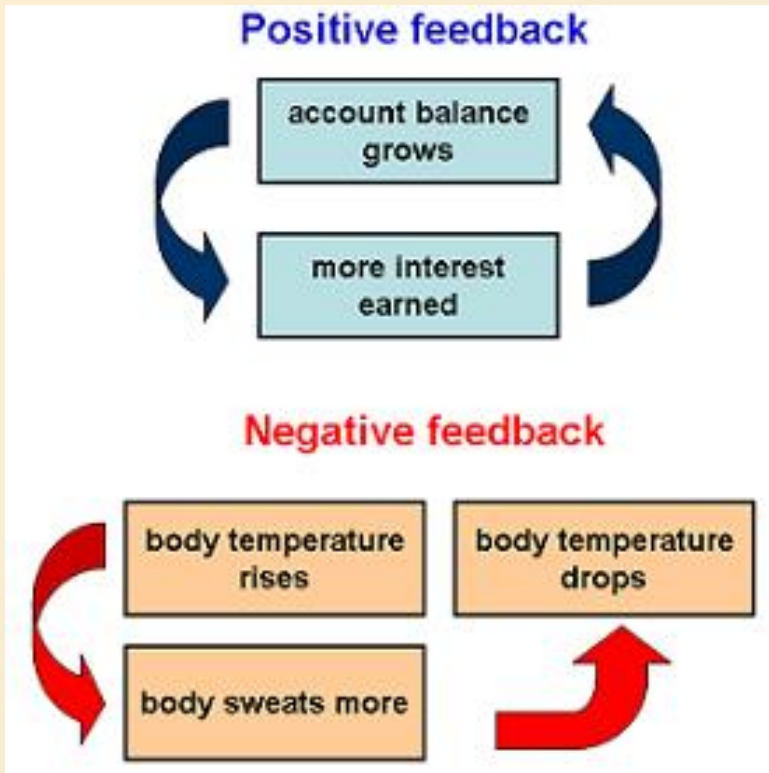
Climate extremes	Observed changes since 1950
Temperature	<p><i>Very likely</i> decrease in number of unusually cold days and nights at the global scale.</p> <p><i>Very likely</i> increase in number of unusually warm days and nights at the global scale.</p> <p><i>Medium confidence</i> in increase in length or number of warm spells or heat waves in many (but not all) regions. <i>Low or medium confidence</i> in trends in temperature extremes in some subregions due either to lack of observations or varying signal within subregions.</p>
Precipitation	<p><i>Likely</i> statistically significant increases in the number of heavy precipitation events (e.g., 95th percentile) in more regions than those with statistically significant decreases, but strong regional and subregional variations in the trends.</p>
Droughts	<p><i>Medium confidence</i> that some regions of the world have experienced more intense and longer droughts, in particular in southern Europe and West Africa, but opposite trends also exist.</p>
Floods	<p><i>Limited to medium evidence</i> available to assess climate-driven observed changes in the magnitude and frequency of floods at regional scale. Furthermore, there is <i>low agreement</i> in this evidence, and thus overall <i>low confidence</i> at the global scale regarding even the sign of these changes. <i>High confidence</i> in trend toward earlier occurrence of spring peak river flows in snowmelt- and glacier-fed rivers.</p>

Drivers of climate change



Why is there no simple formular?

Climatic Feedbacks



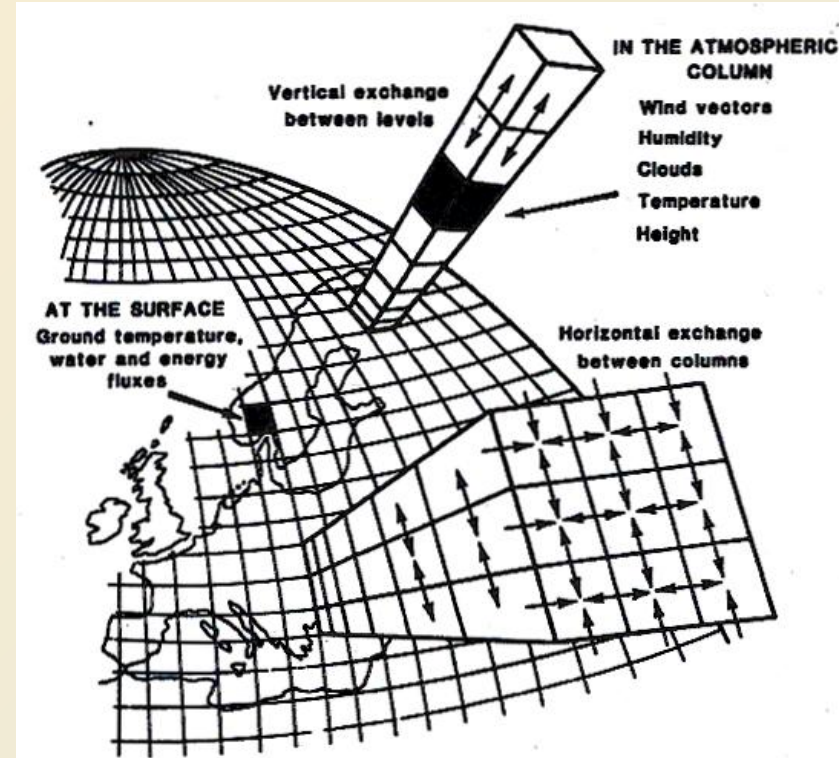
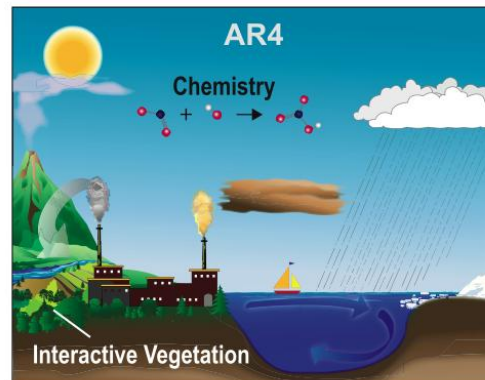
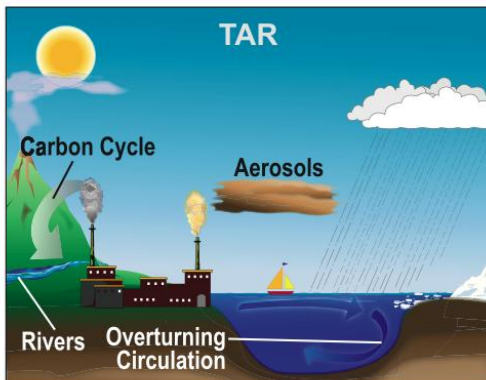
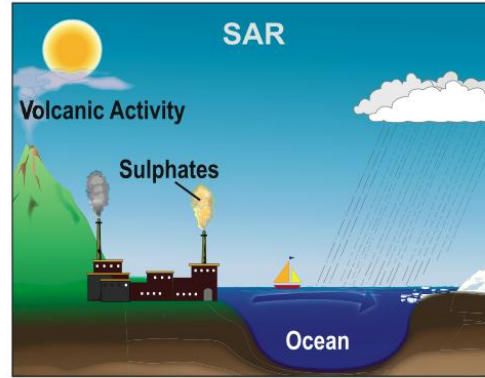
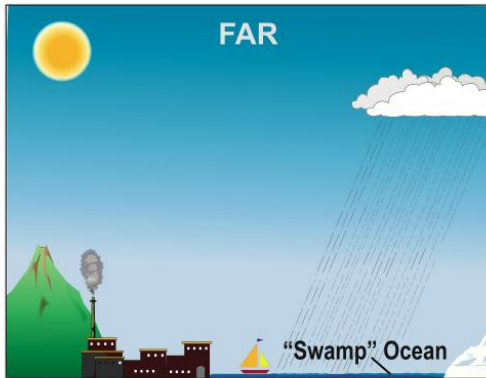
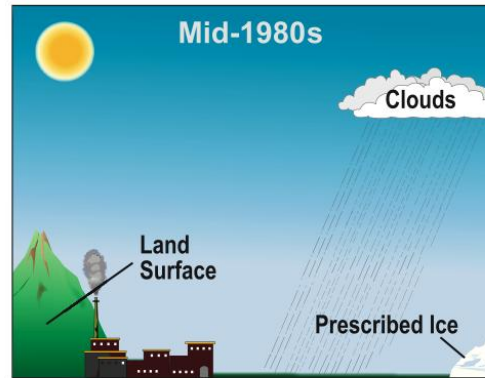
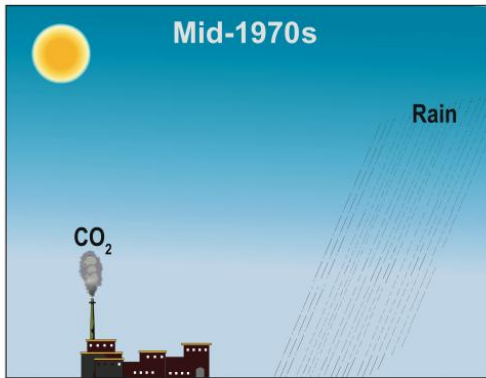
Examples of Feedbacks in the Climate System

- + Ice-albedo feedback
- Blackbody radiation feedback
- + Lapse rate feedback
- Peat and permafrost decomposition
- +/- Cloud Feedbacks
- Air-sea CO₂ exchange
- + Water vapor feedback

Examples from everyday life (NOAA)

Climate models

The World in Global Climate Models



Model

$$\frac{du}{dt} = \frac{\tan \phi}{R} uv - \frac{uv}{R} + fv - \dot{w} - \frac{1}{\rho R \cos \phi} \frac{\partial p}{\partial \lambda} + F_x$$

$$\frac{dv}{dt} = \frac{\tan \phi}{R} u^2 - \frac{vw}{R} - fu - \frac{1}{\rho R} \frac{\partial p}{\partial \phi} + F_y$$

$$\frac{dw}{dt} = \frac{u^2}{R} + \frac{v^2}{R} + \dot{w} - \frac{1}{\rho} \frac{\partial p}{\partial z} - g + F_z$$

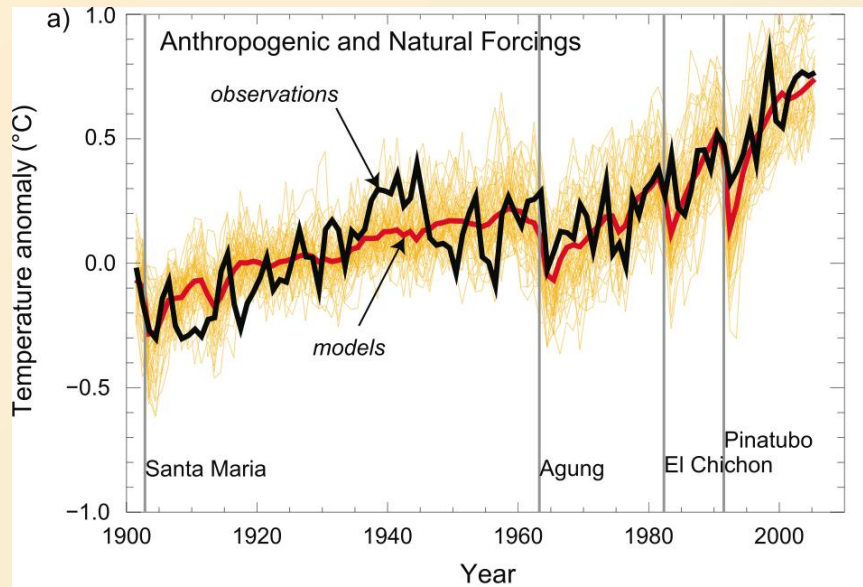
$$\frac{dp}{dt} = -\rho \text{div} \mathbf{v}; \quad \dot{z} = \mathbf{\Omega} \times \mathbf{r}$$

$$\frac{dT}{dt} = Q + \sigma \frac{dp}{dt}$$

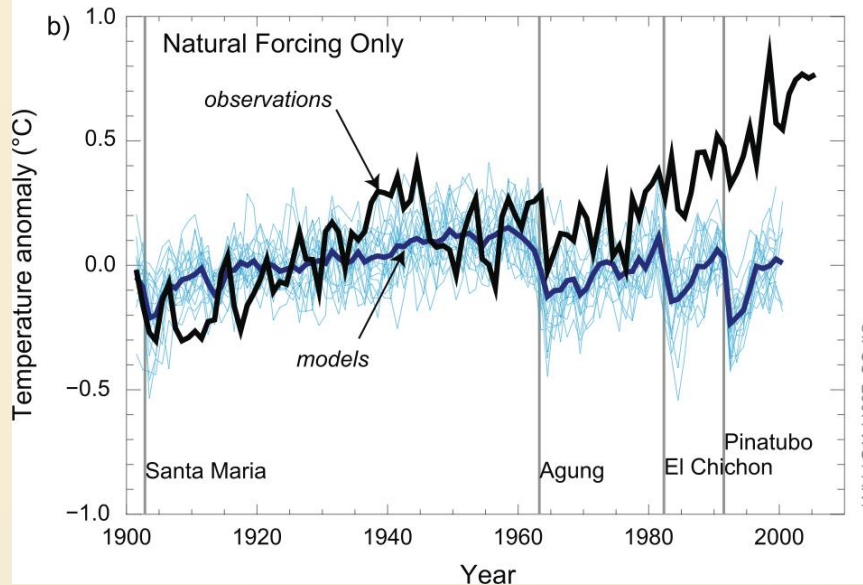
$$\frac{dq}{dt} = \epsilon(q) - D$$

$$p = \rho R T (1 - 0.61q)$$

Simulating past climate changes

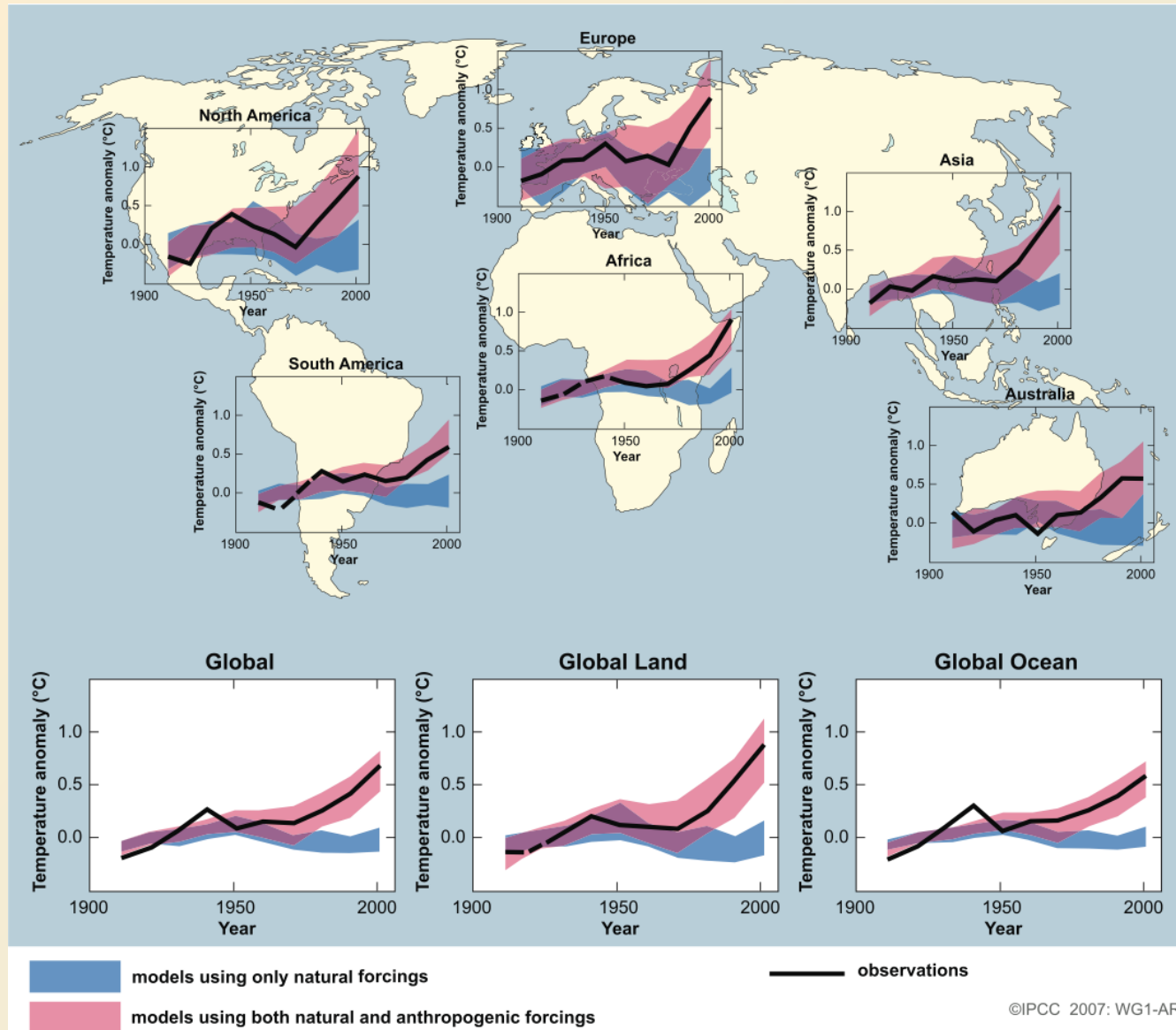


Anthropogenic
and Natural Forcings



Natural Forcing
Only

Detection and Attribution of Climate Change



From Observed Changes and their understanding to projections

„Seamless Prediction“



Ozean/Kryosphäre

Aerosole

Treibhausgase & solarer Strahlungsantrieb

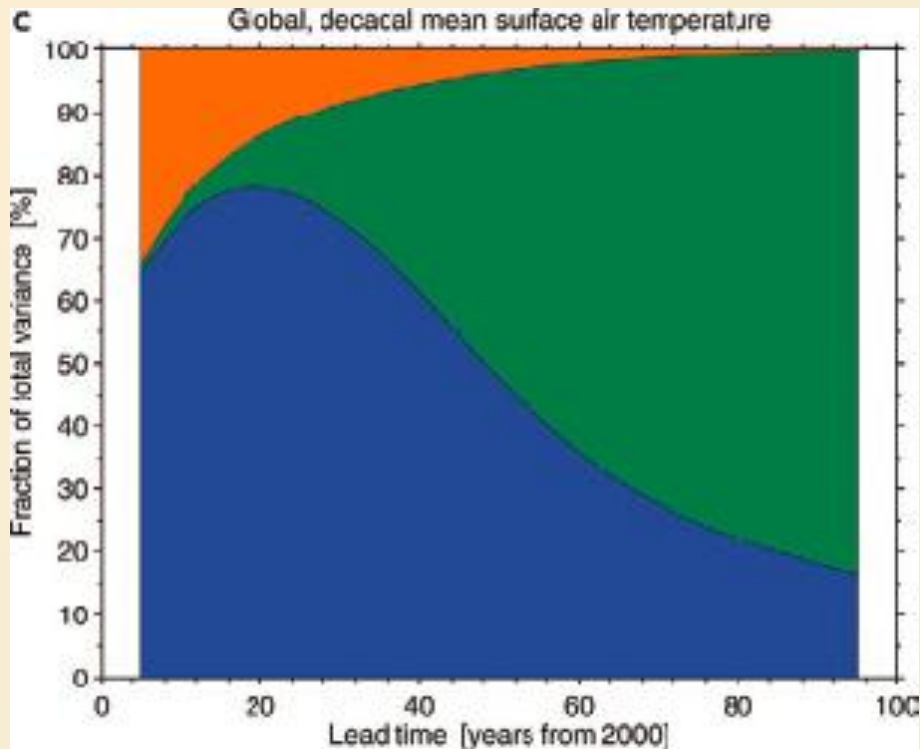
Biosphäre

hell: als Randbedingung ggf. variabel vorgegeben

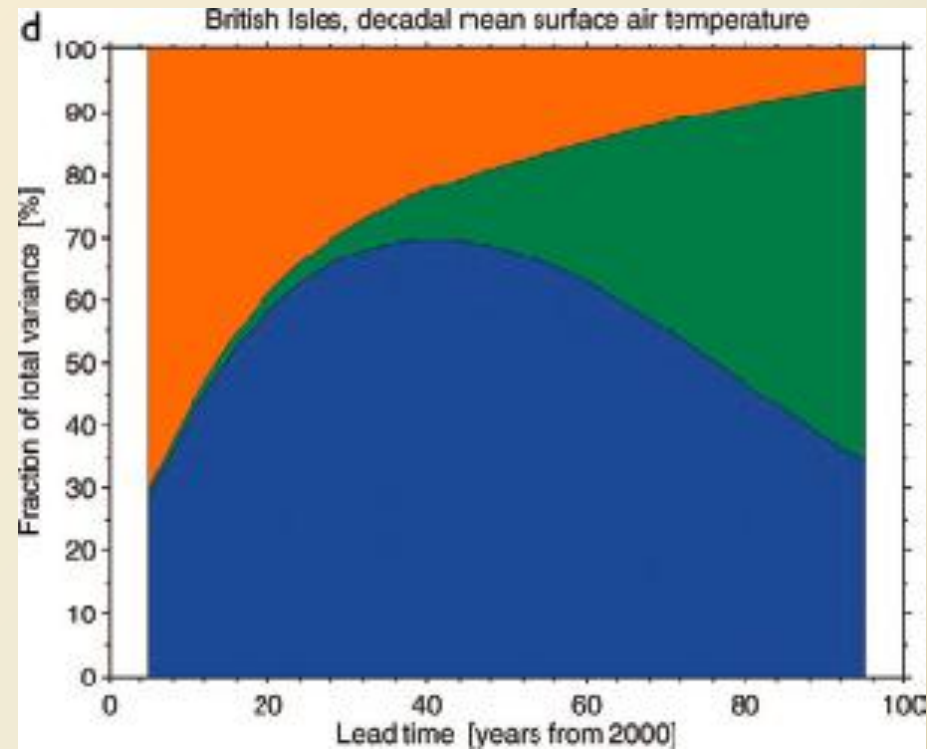
dunkel: interaktiv, d.h. vollständig gekoppelt, mit zu modellieren

The role of uncertainty on different time scales

Global

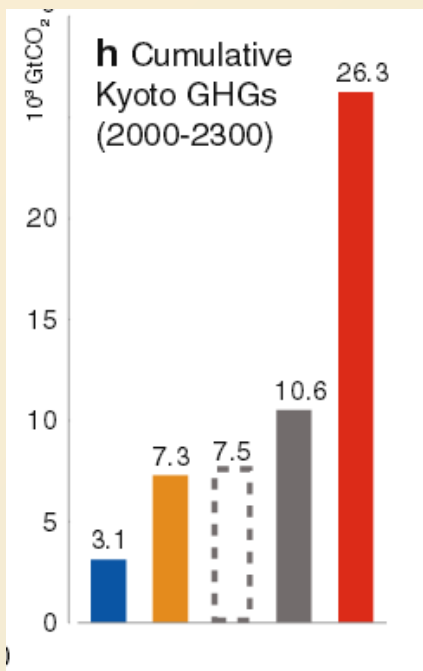
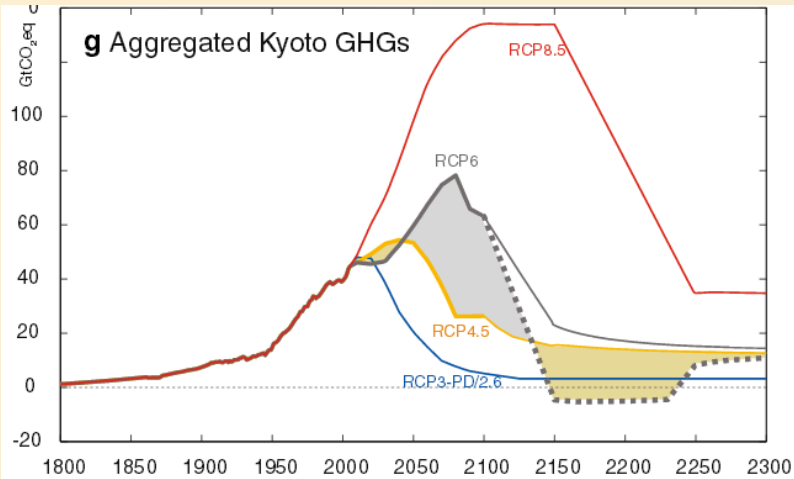


Regional

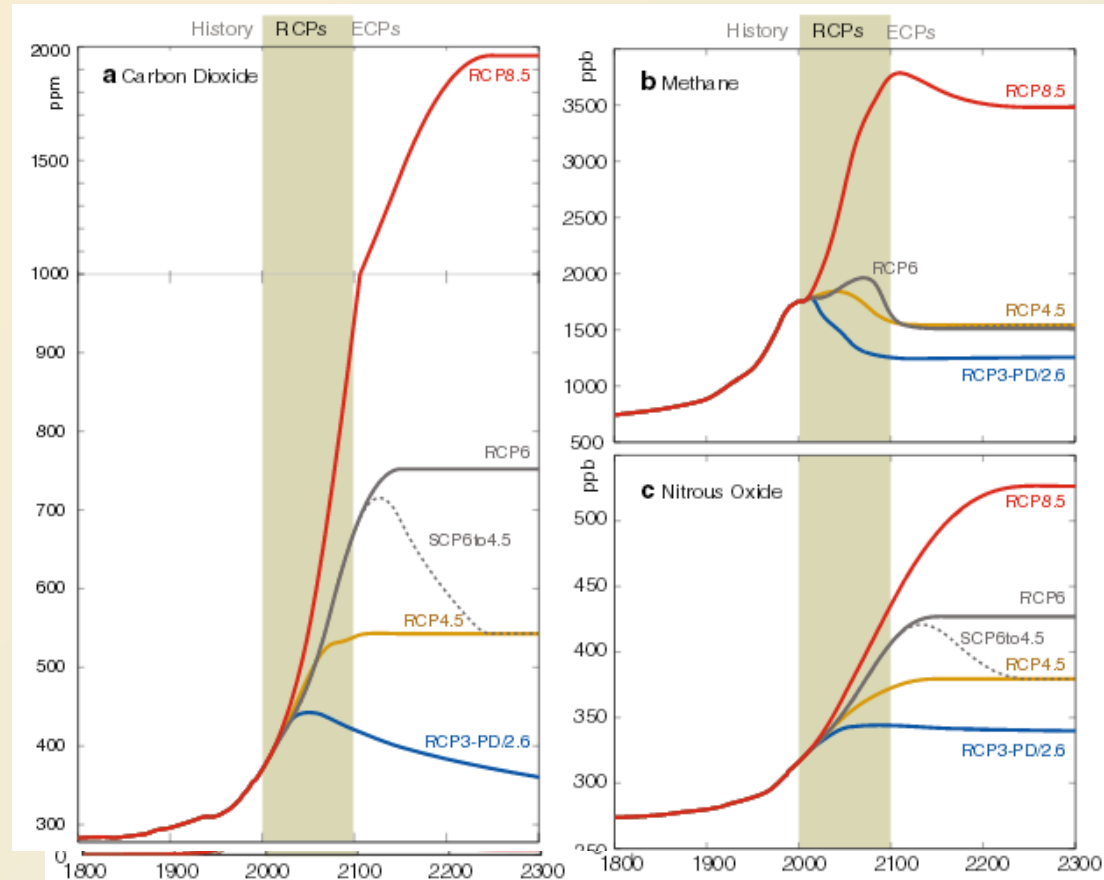


Scenarios for the future

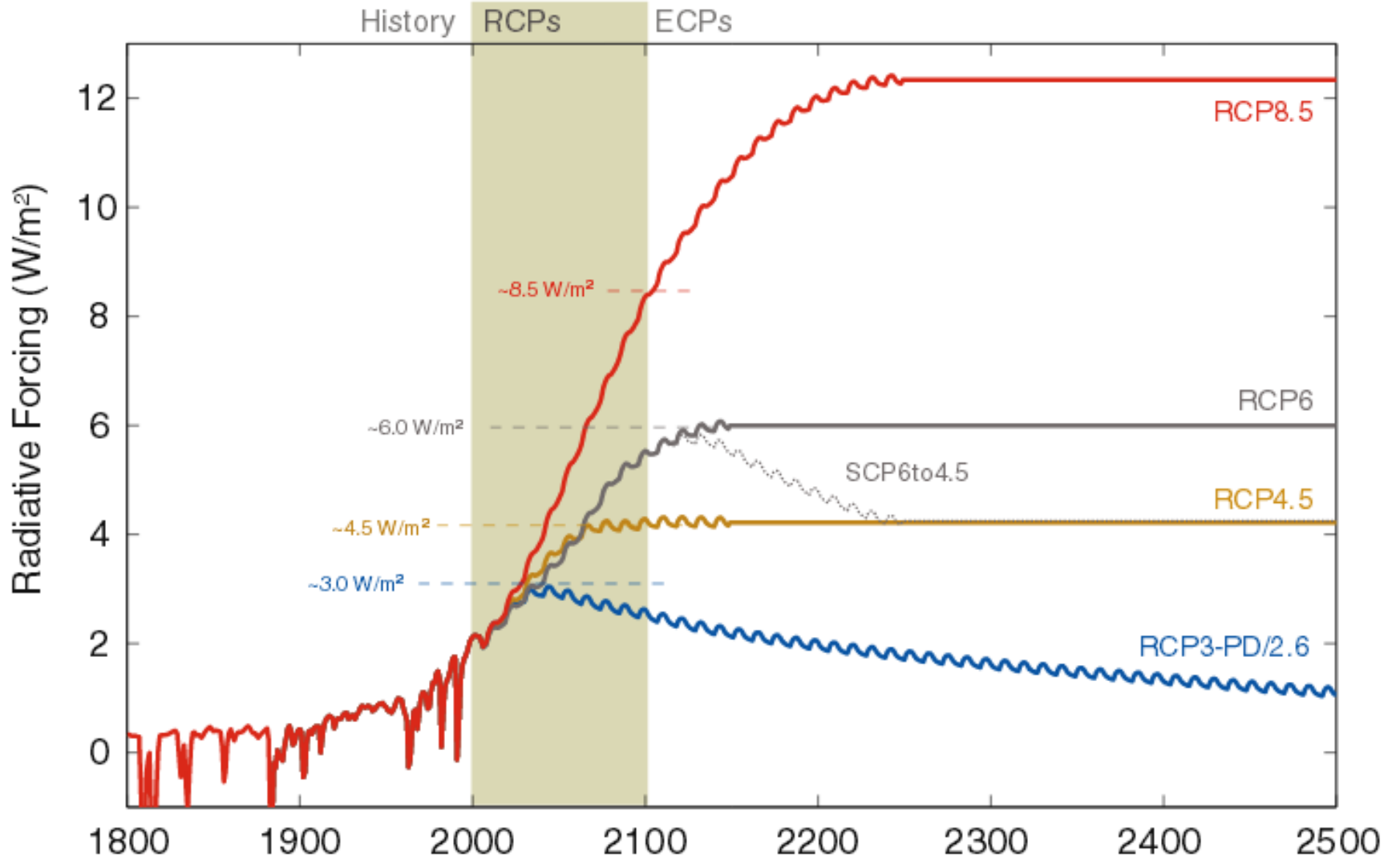
From Emissions



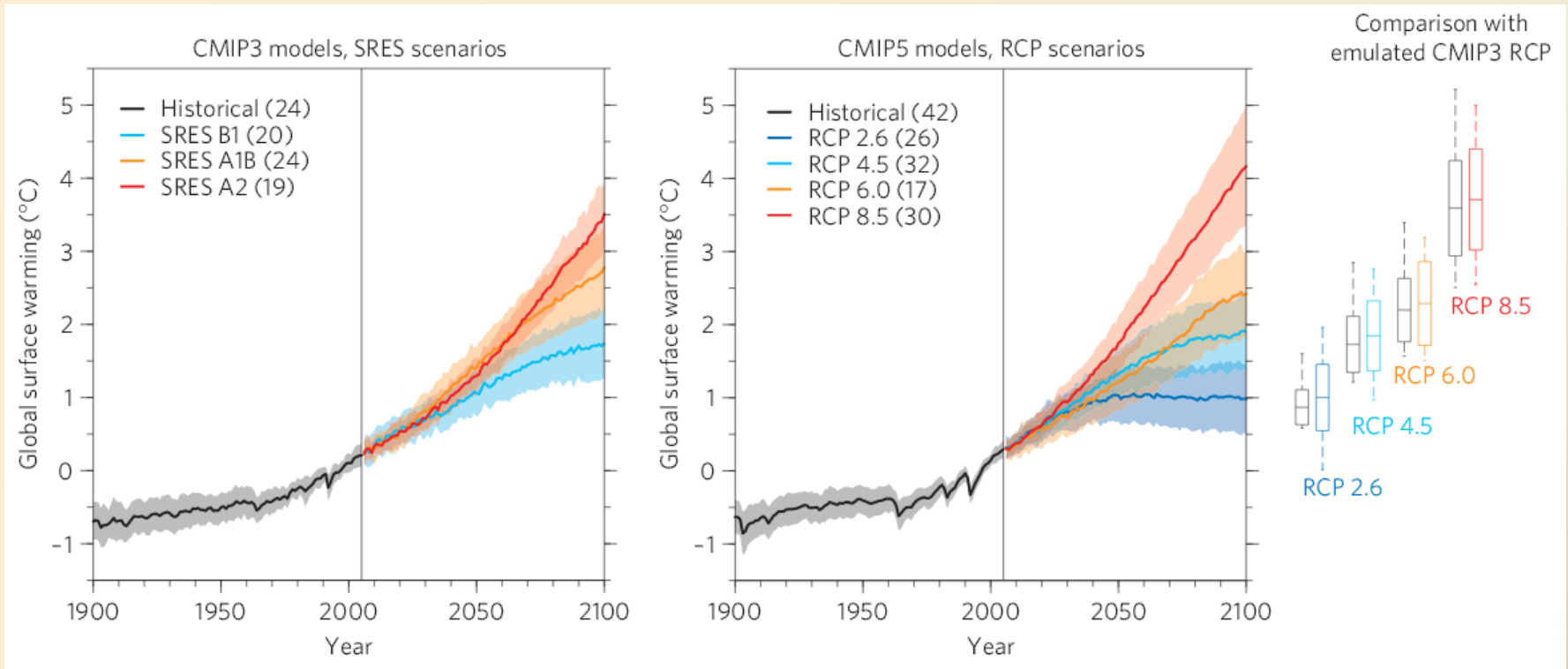
To Concentrations



Scenarios for the future



Model projections of future temperature change



Projections of temperature change

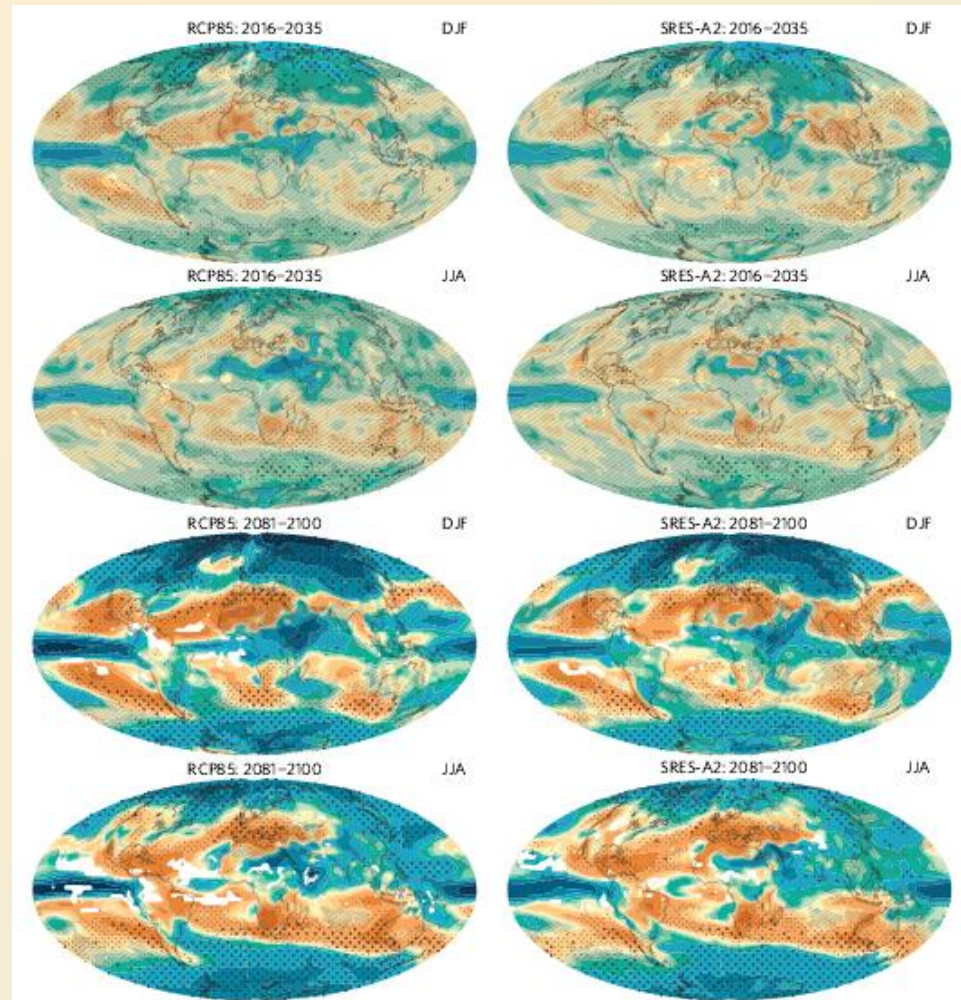
Freie Universität



Berlin



Projections of precipitation change



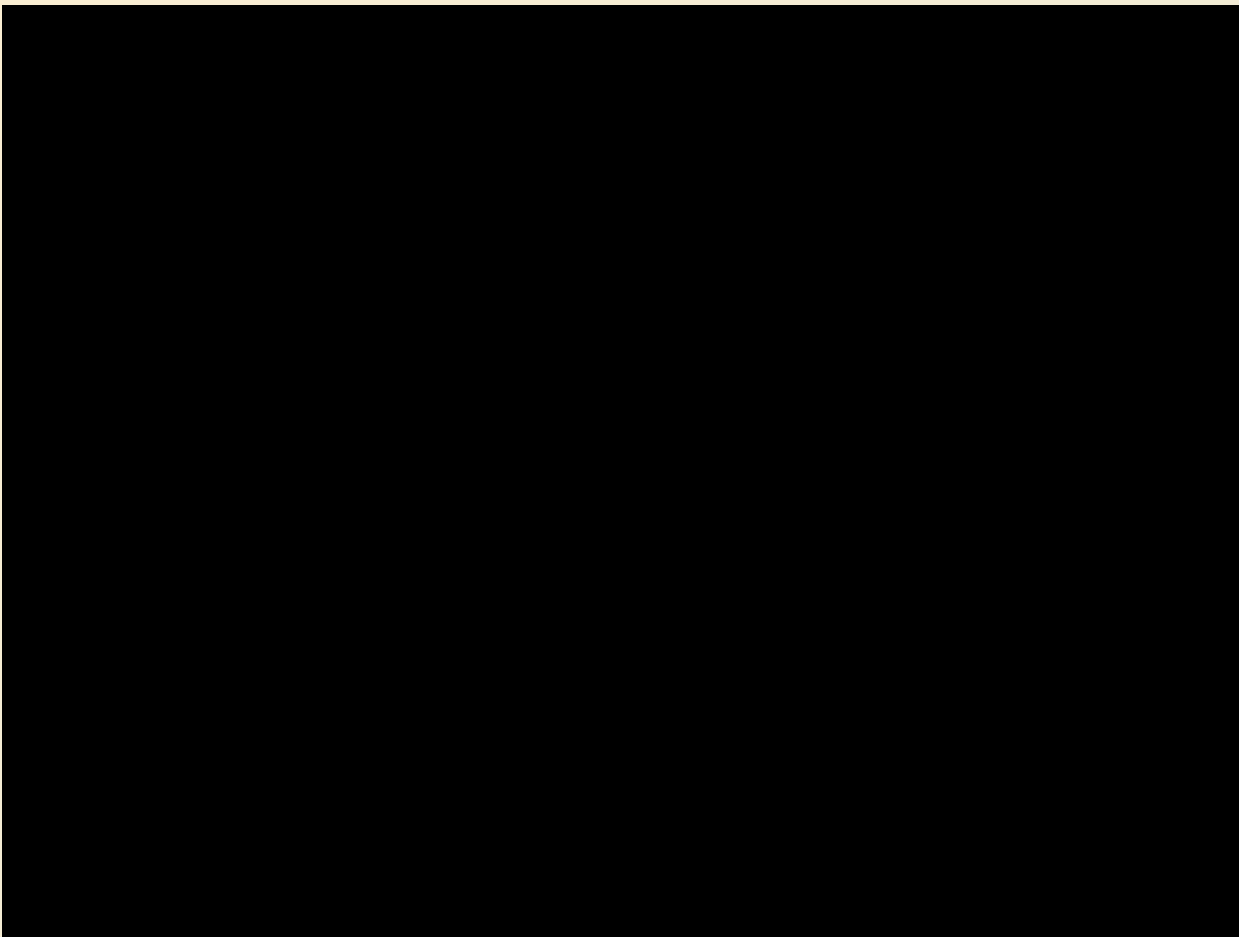
2016-2035

2081-2100



Precipitation change (%)

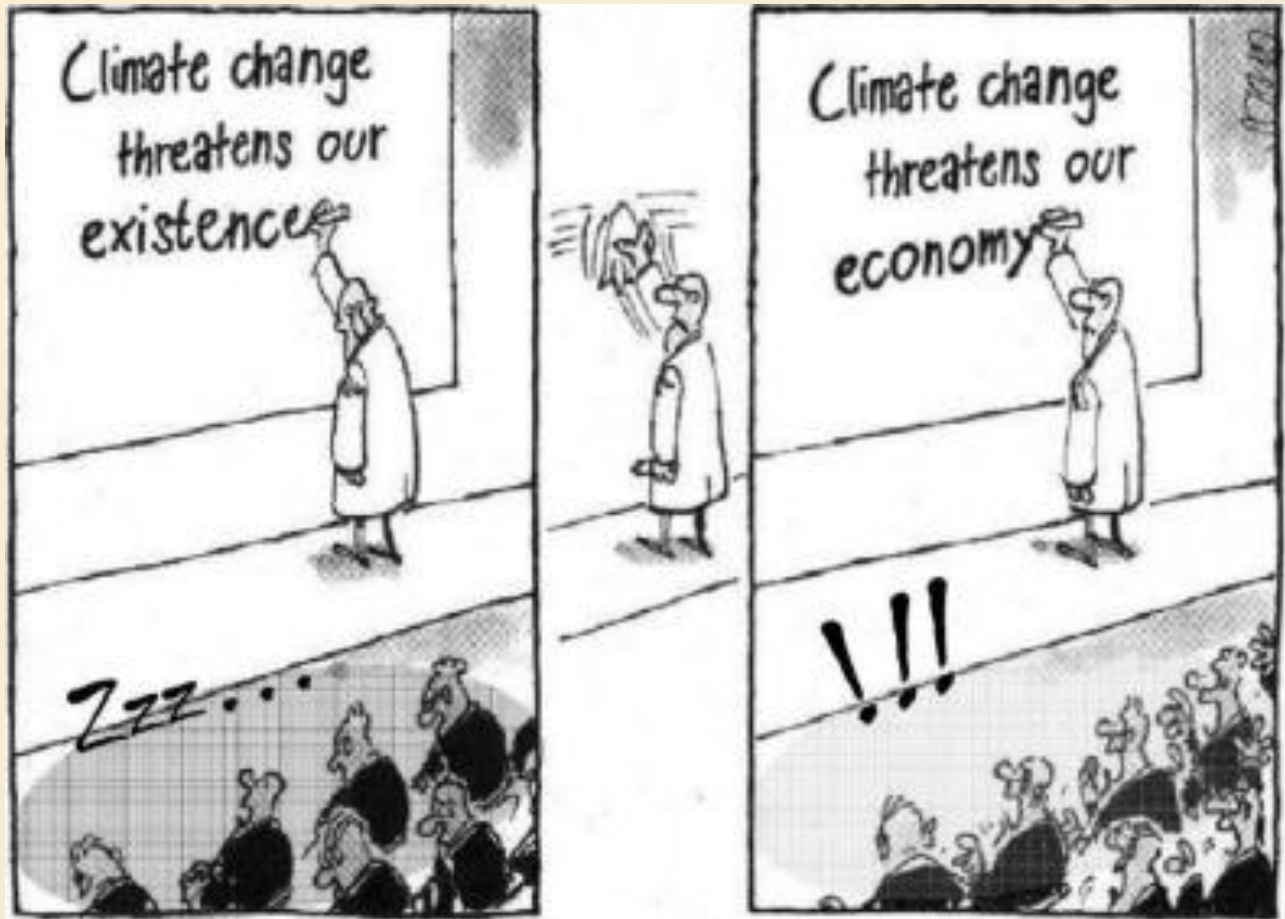
Projections of sea level change



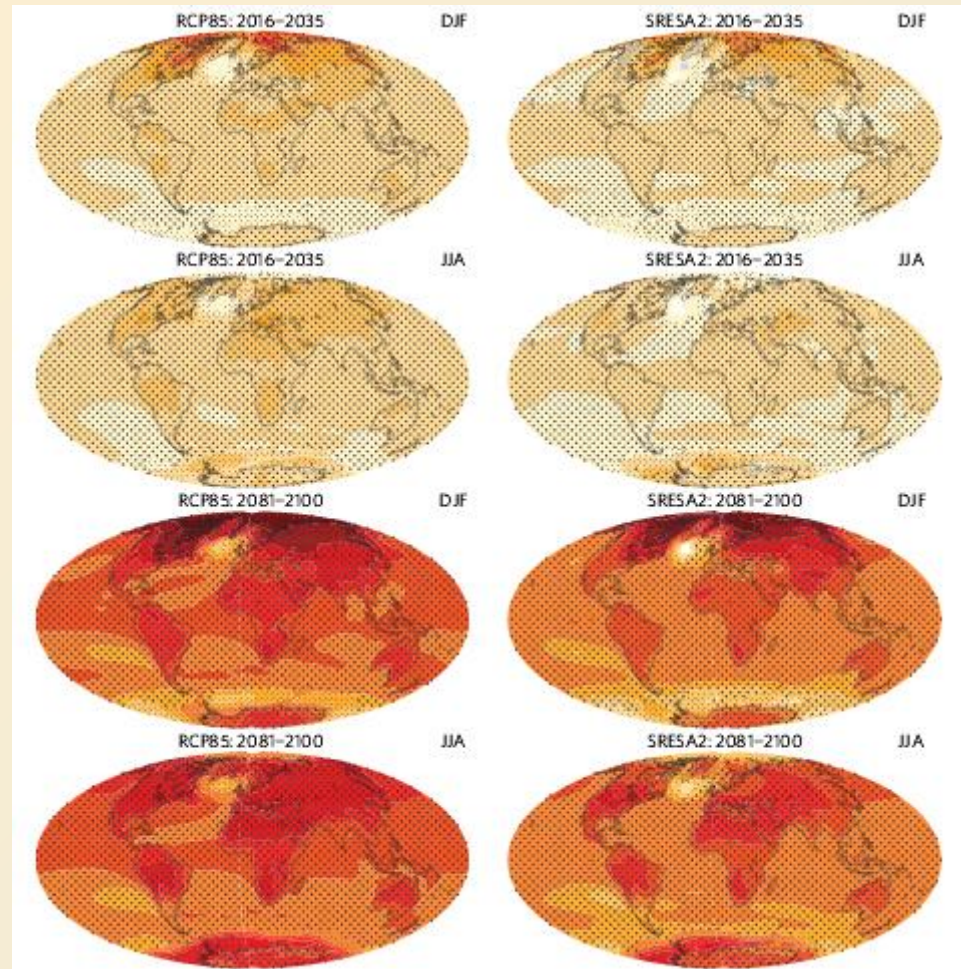
Take Home Messages

- There is ongoing climate change.
- The observed climate change is not consistent with natural forcing alone -> there is a significant anthropogenic contribution.
- CO₂ is the most important driver of the current climate change.
- Climate change will continue, if emissions of greenhouse gases are not substantially reduced.

Thank you for your attention



Projected surface warming



2016-2035

2081-2100

