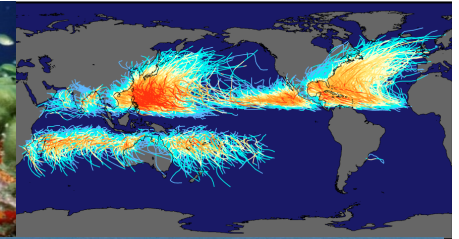
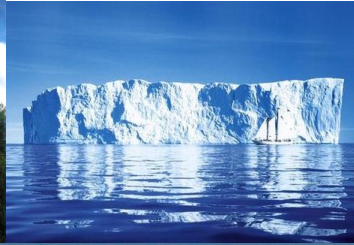




"The relevant content of the presentation was given as a talk during the conference. The slides alone can be misleading."



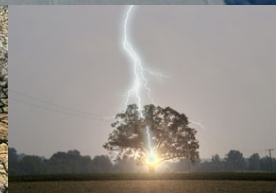
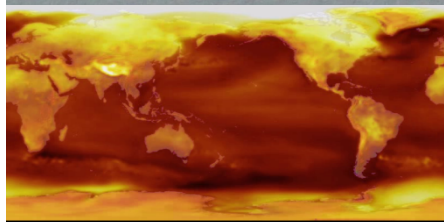
The Transition Ahead

Informing society for its decision on mitigation and adaptation

Collapse of Wilkins ice shelf
Feb. 2009

Prof. Dr. Anders Levermann

Potsdam Institute for Climate Impact Research, Germany





The Transition Ahead

Informing society for its decision on mitigation and adaptation

Prof. Dr. Anders Levermann, Potsdam Institute for Climate Impact Research



Chief economist
Prof. Edenhofer



IPCC lead authors
from all working groups



Co-chair 'Sustainable solutions' of
Intergovernmental Panel on
Climate Change (IPCC)

Scientific advice
during G8+5 summit



Scientific advice to
German government

Scientific advice to president
of EU- commission Barroso

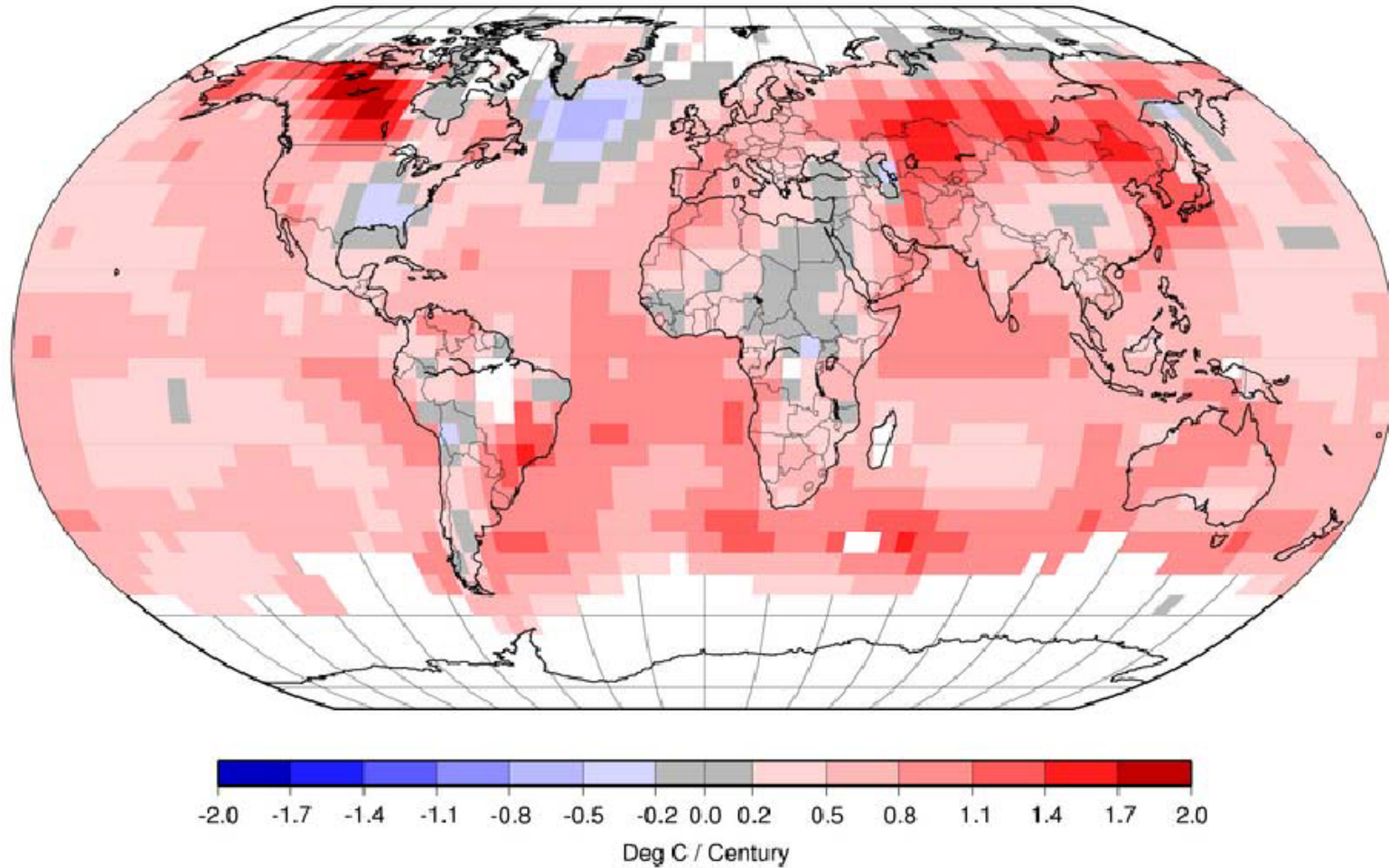
Ask a climate scientist !



www.pik-potsdam.de/~anders/GlobalExpert

Prof. Dr. Anders Levermann, Potsdam Institut for Climate Impact Research, Germany

What we know for sure...

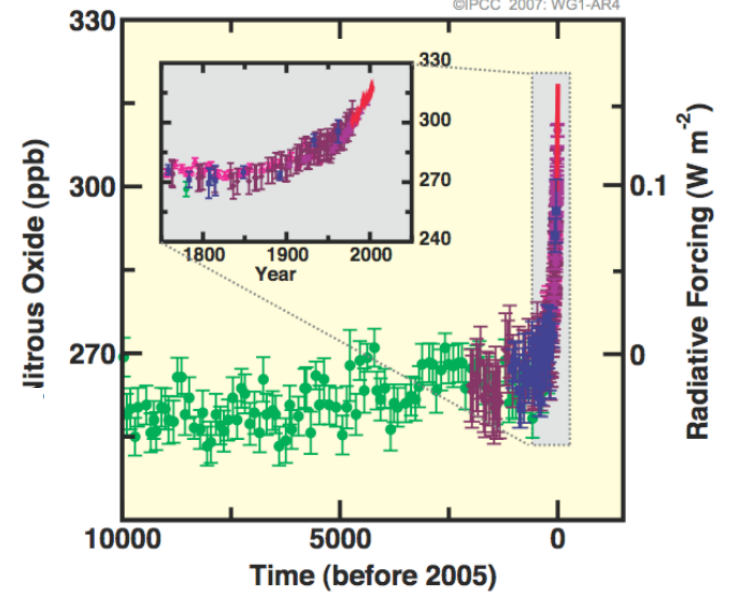
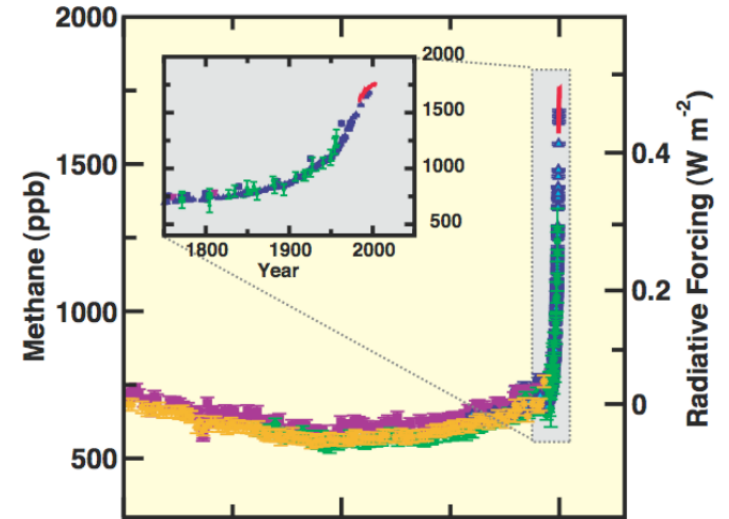
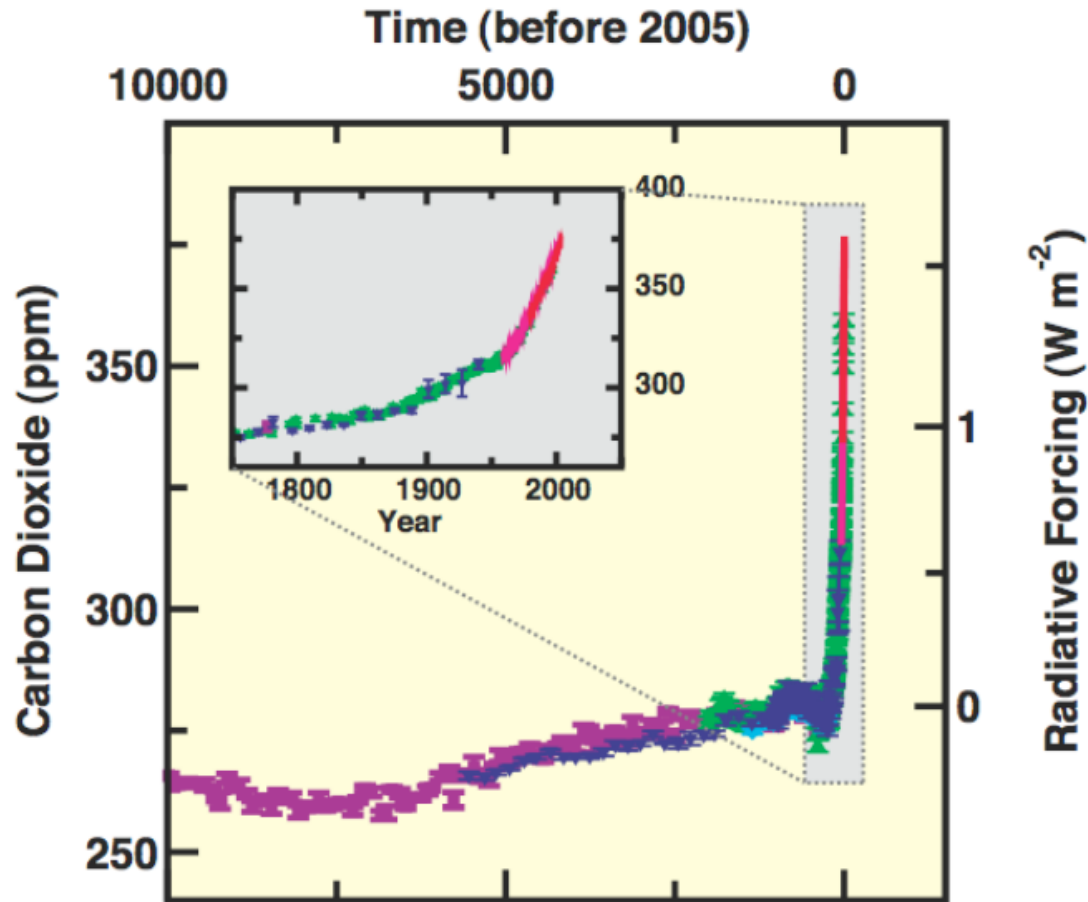


Temperatur trends of the last century



CO₂ is rising rapidly

... along with other greenhouse gases

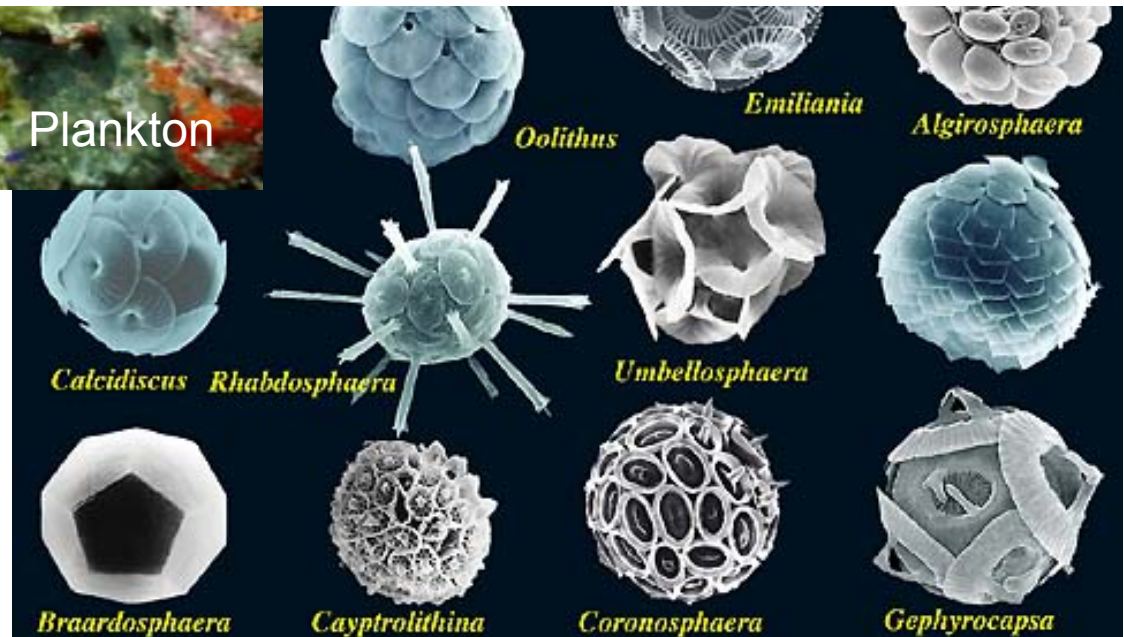
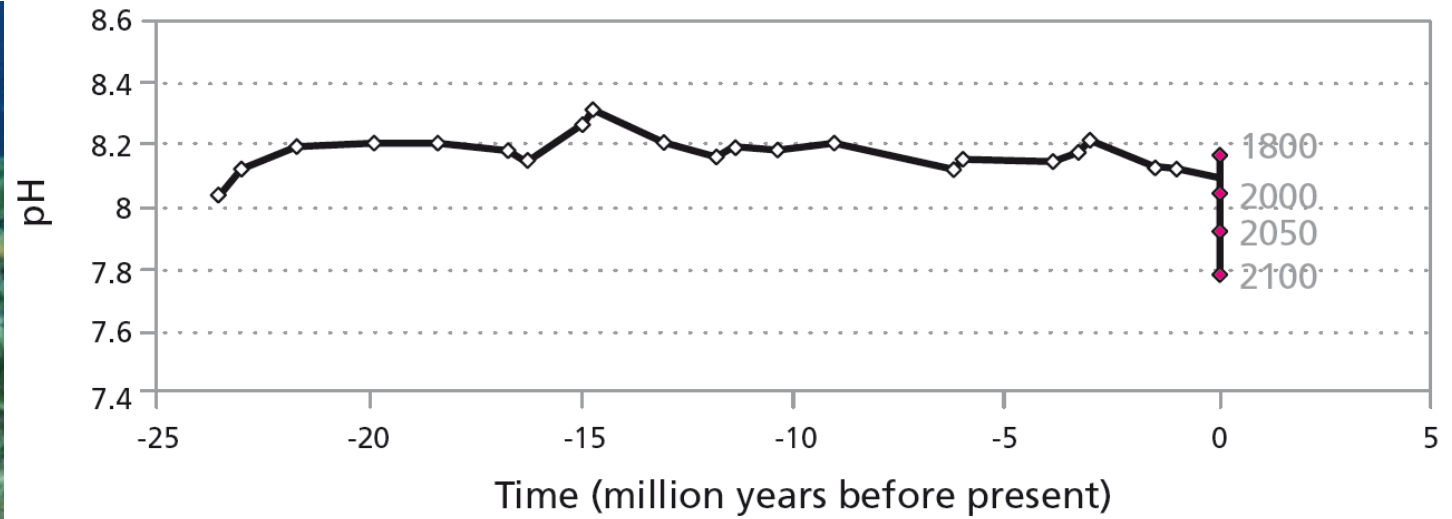


*Intergovernmental Panel on Climatic Change
4th Assessment Report (IPCC AR4, Feb. 2007)*



Ocean acidification

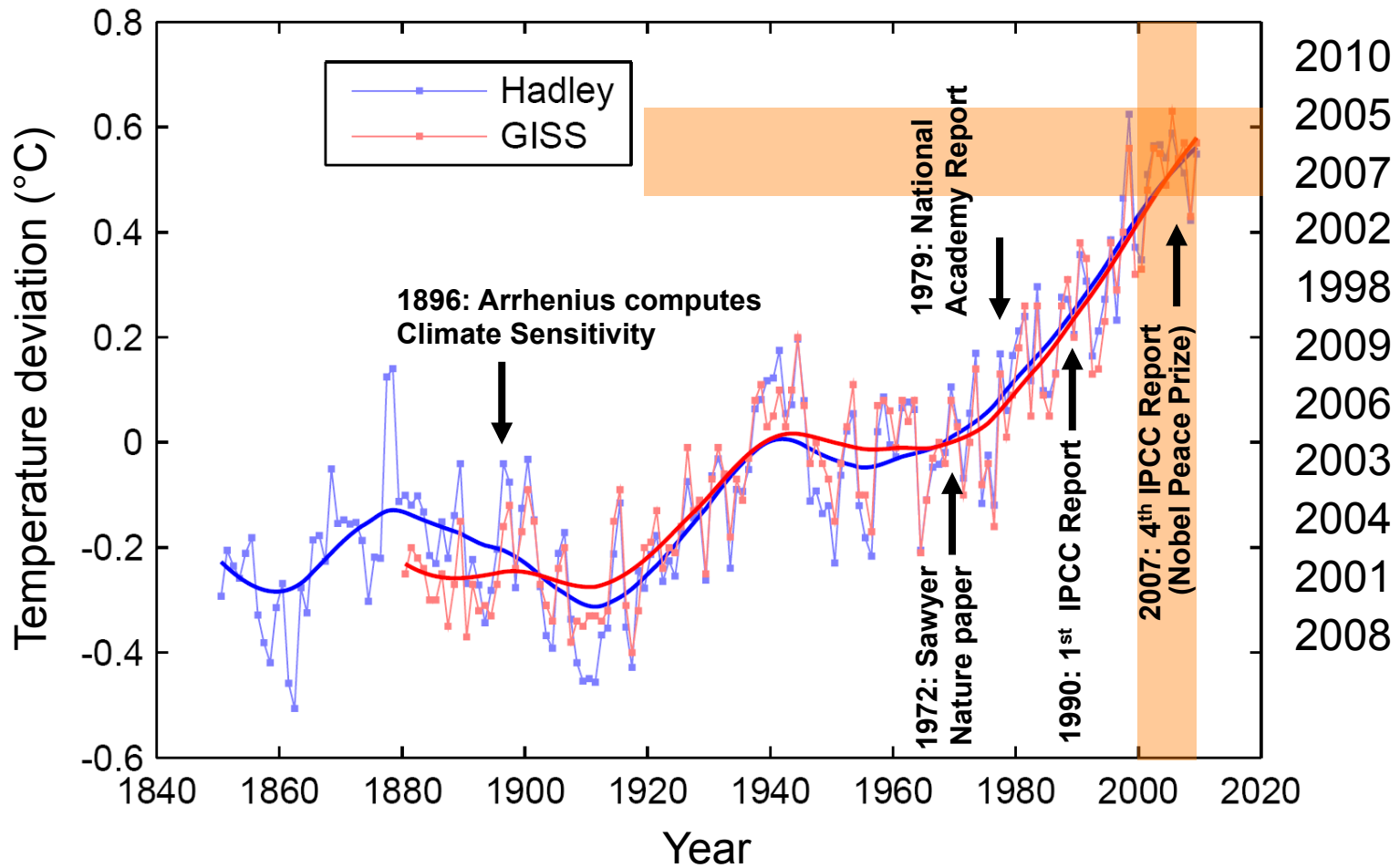
threatens marine food chain and coral reefs





Earth is warming

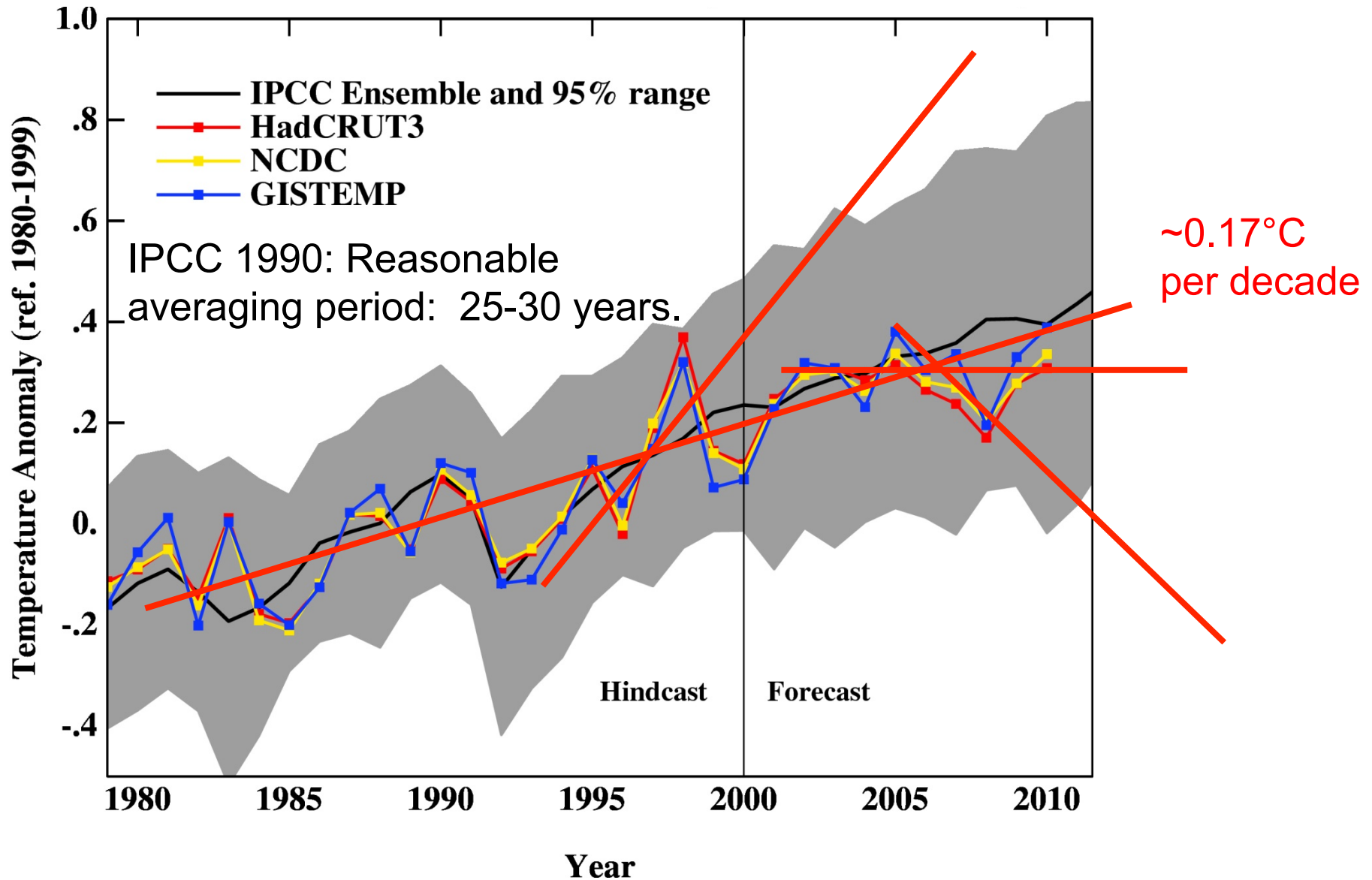
2000-2009 warmest decade



$0.7 \pm 0.1^{\circ}\text{C}$ increase in global mean temperature during last century



... and continues to warm!



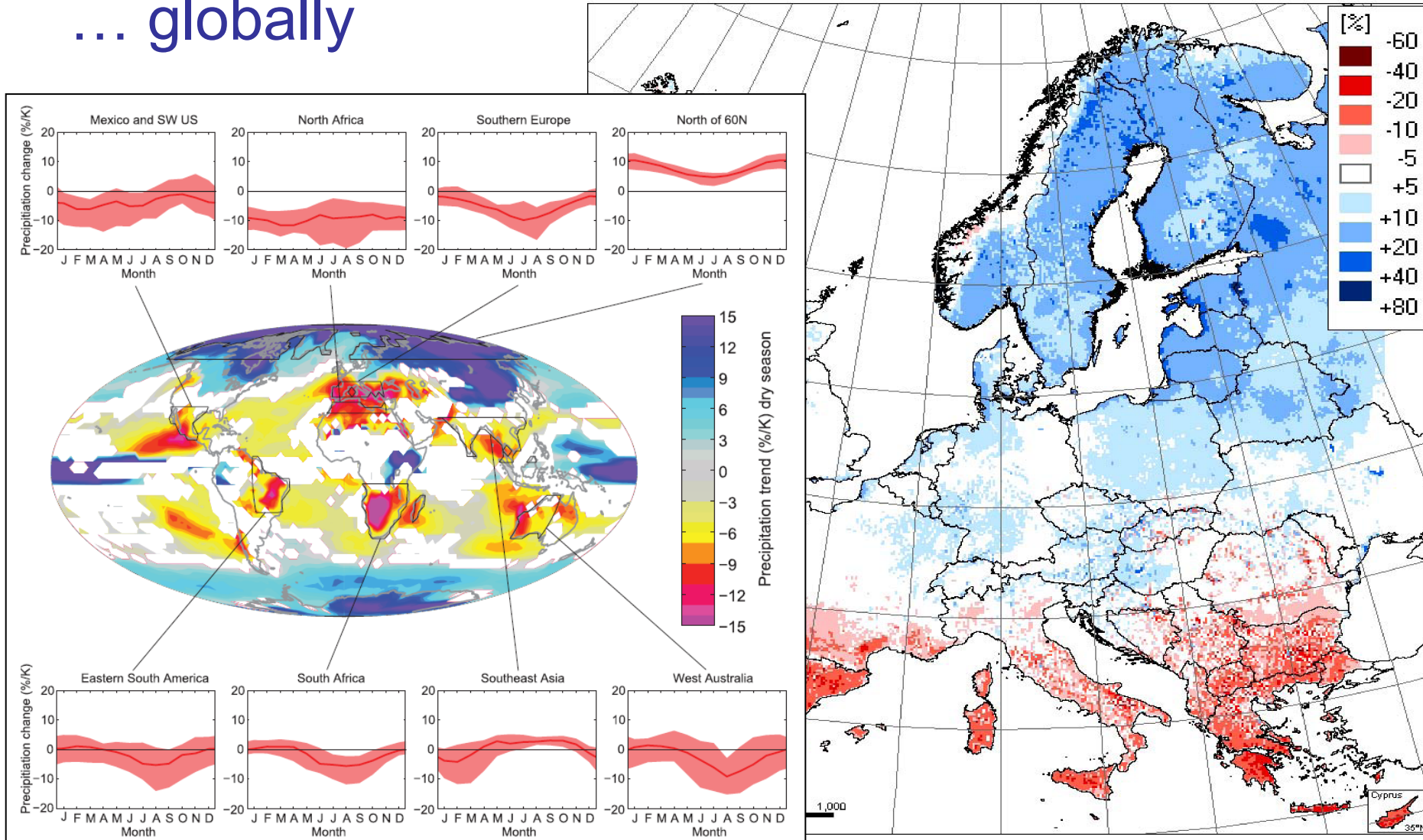


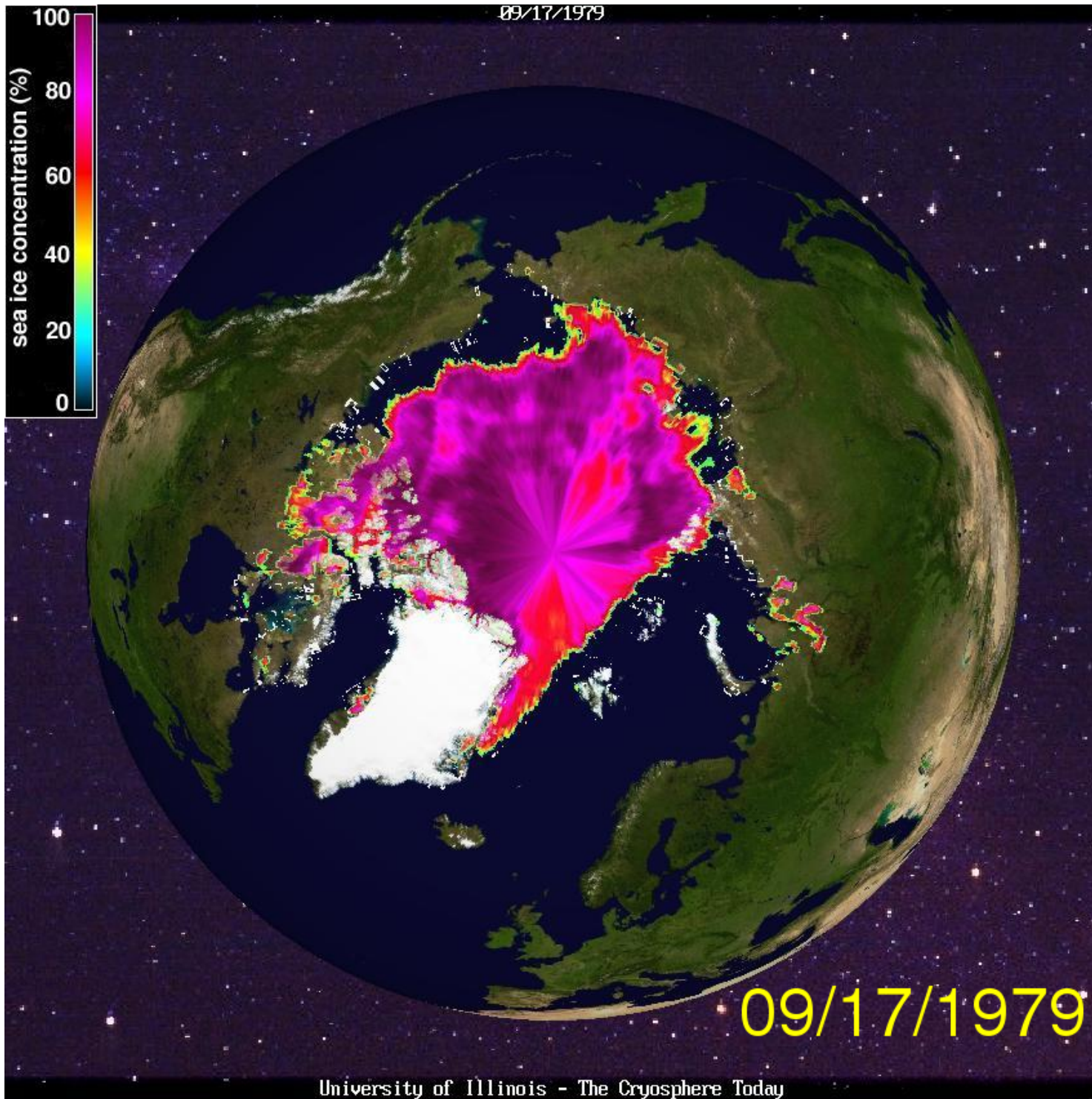
Wet regions get wetter

– dry regions get dryer

... globally

Precipitation: change in annual amount [%]





1979

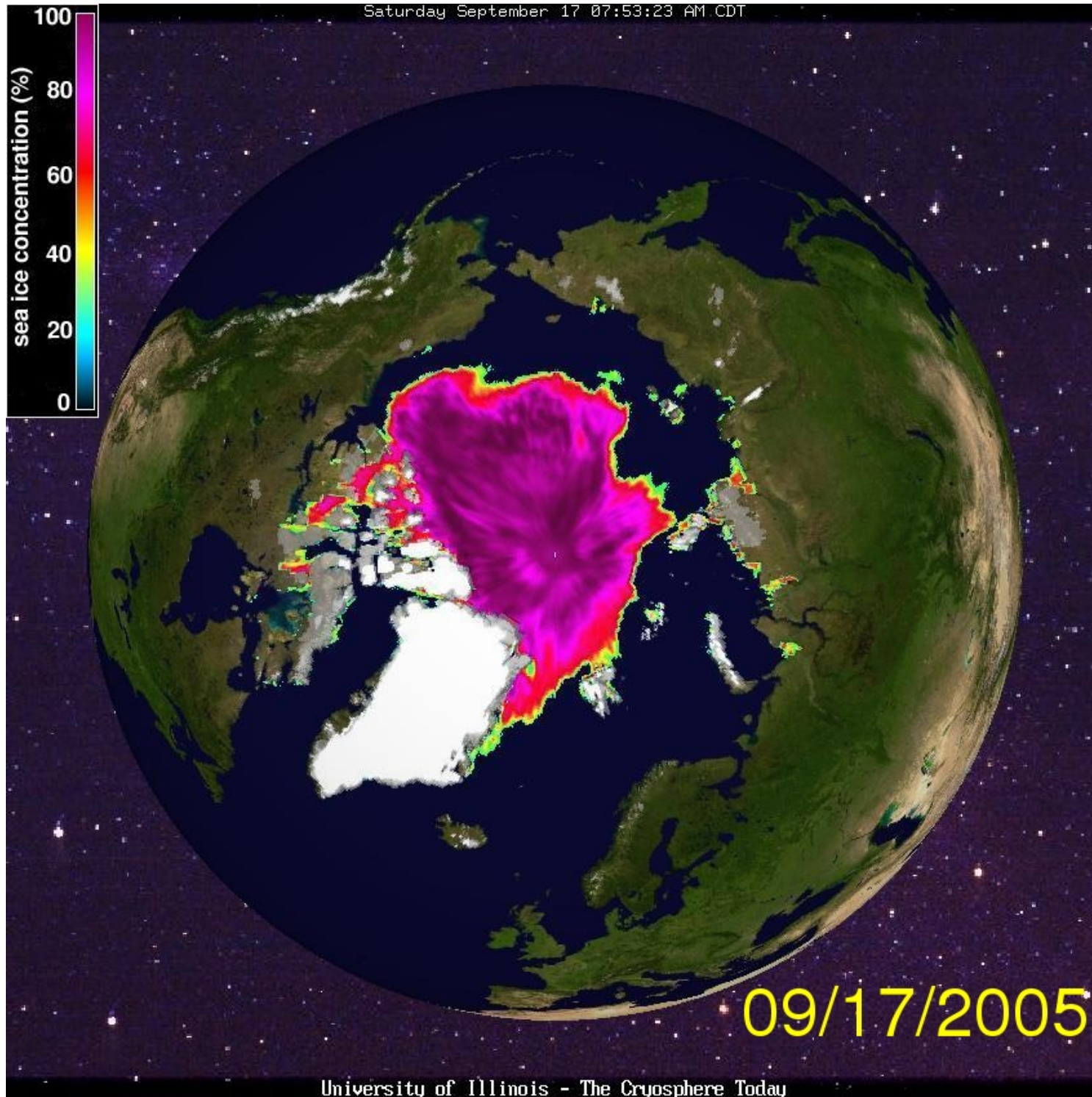
17th September

Arctic
sea ice

Saturday September 17 07:53:23 AM CDT

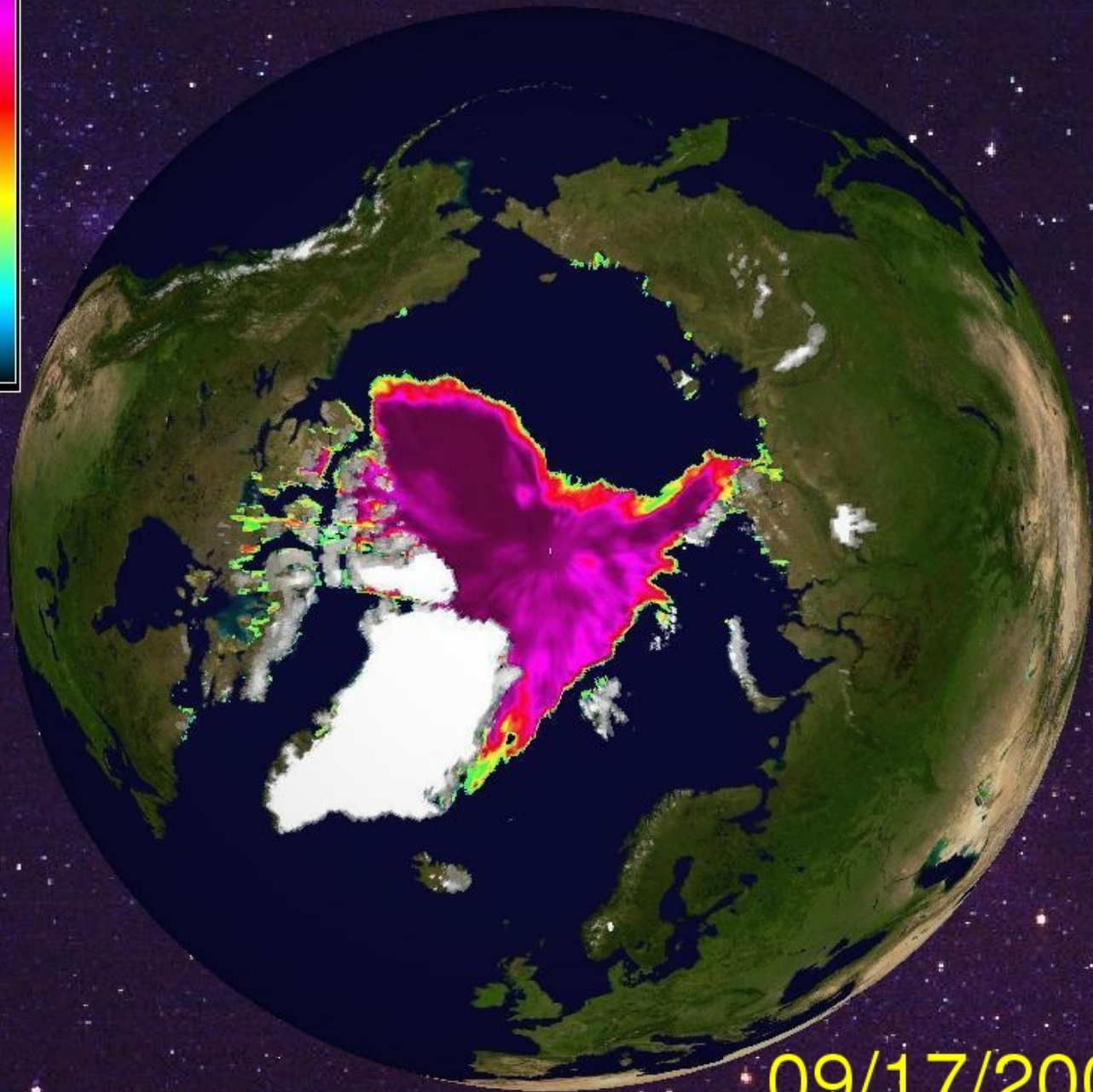
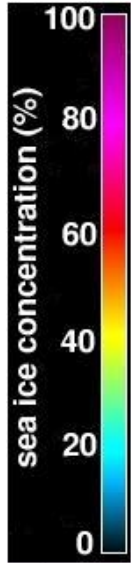
2005

17th September



Arctic
sea ice

Monday September 17 02:41:24 PM CDT



2007
17th September

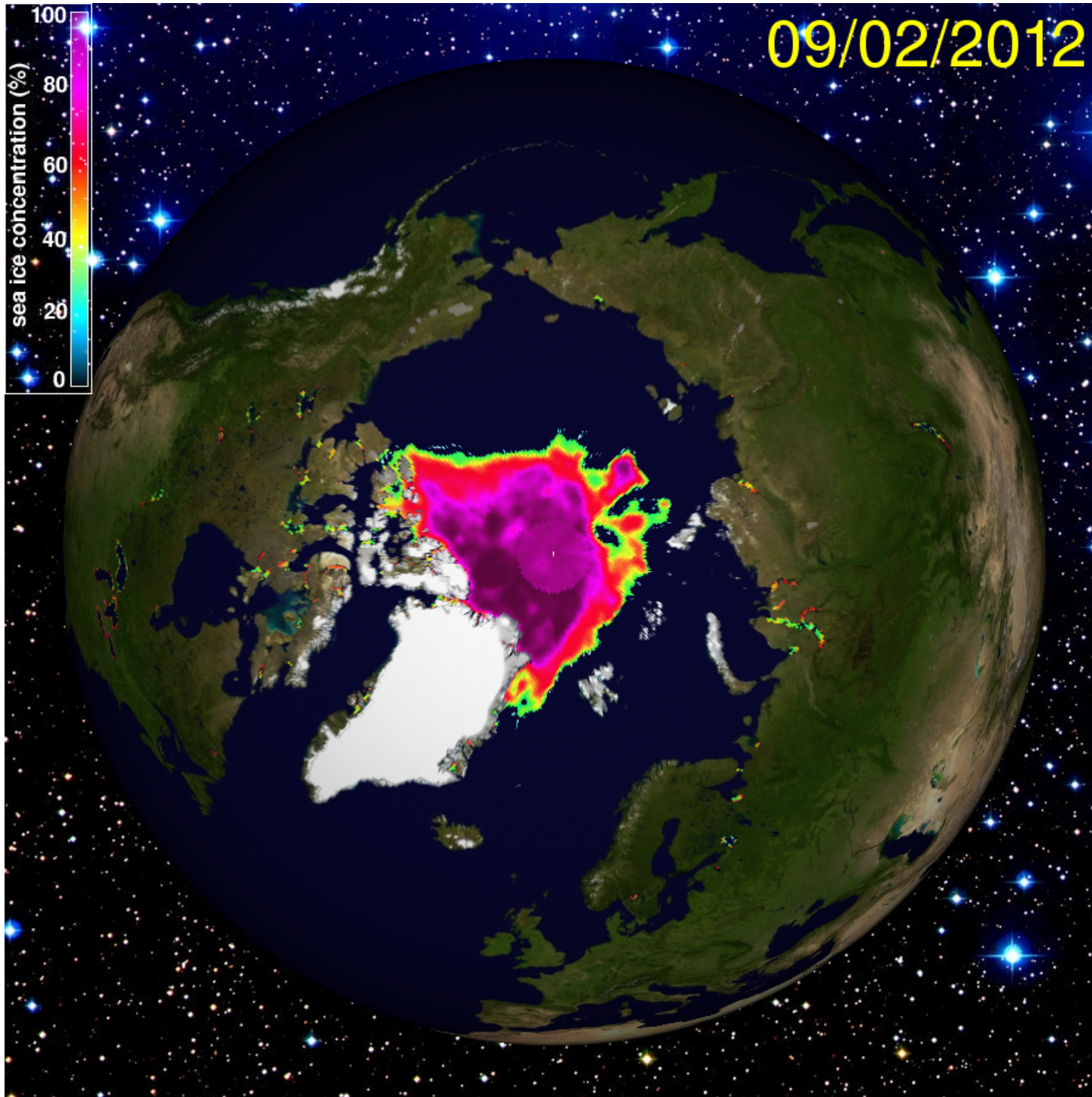
Arctic
sea ice

09/17/2007

09/02/2012

2012

2nd September

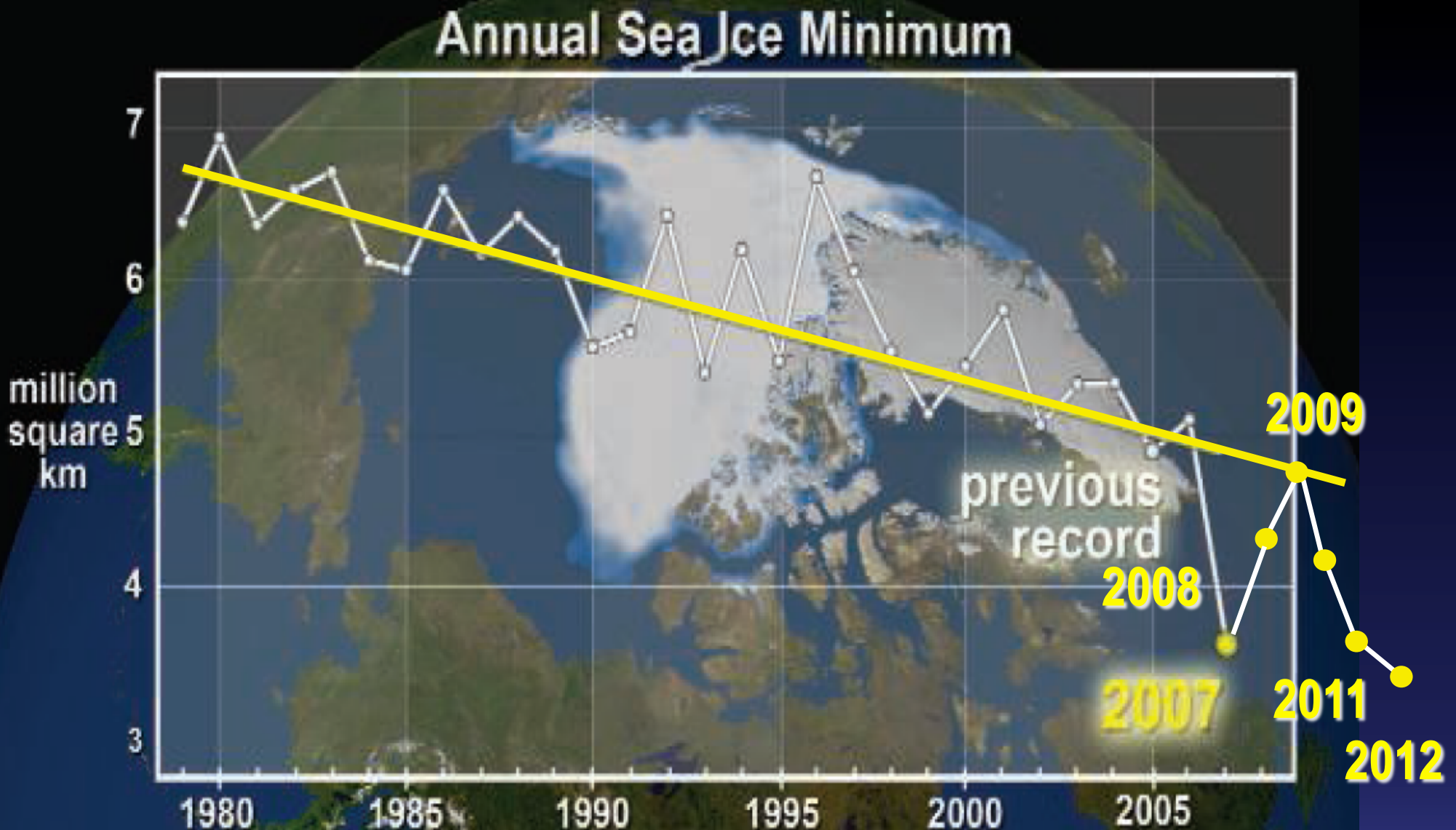


Arctic
sea ice

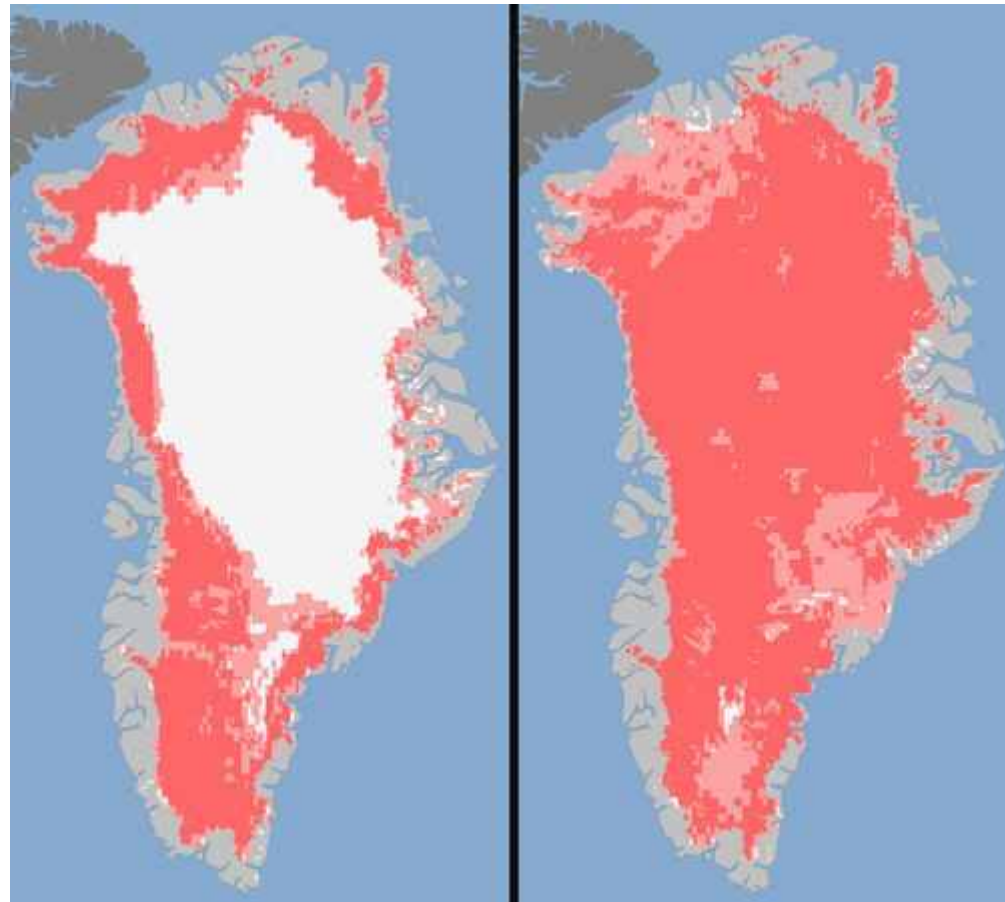


Melting of Arctic summer sea ice

Time series since 1979



Greenland Melting Season 2012



From general 50% to 97% of the surface

Mountain glaciers retreat globally

New Zealand



Mueller Glacier



Peru
Ururashraju Glacier
~ height: 5000 m





USA
Grinnell Glacier
Glacier National Park





Switzerland

Rhone Glacier





Austria

Pasterze





Alaska

Portage Glacier





Alaska

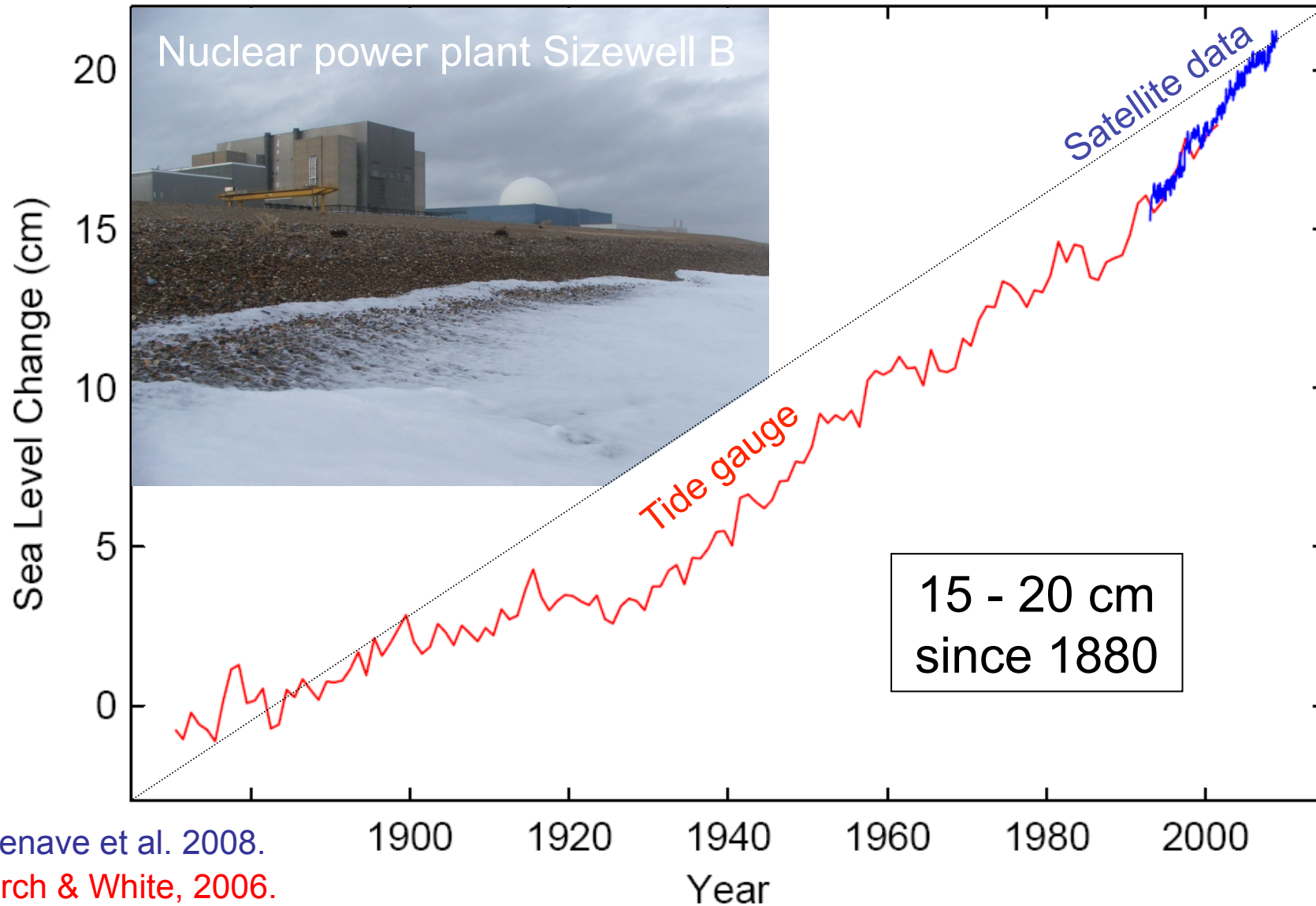
Portage Glacier





Sea level is rising

observed global sea level change of last century



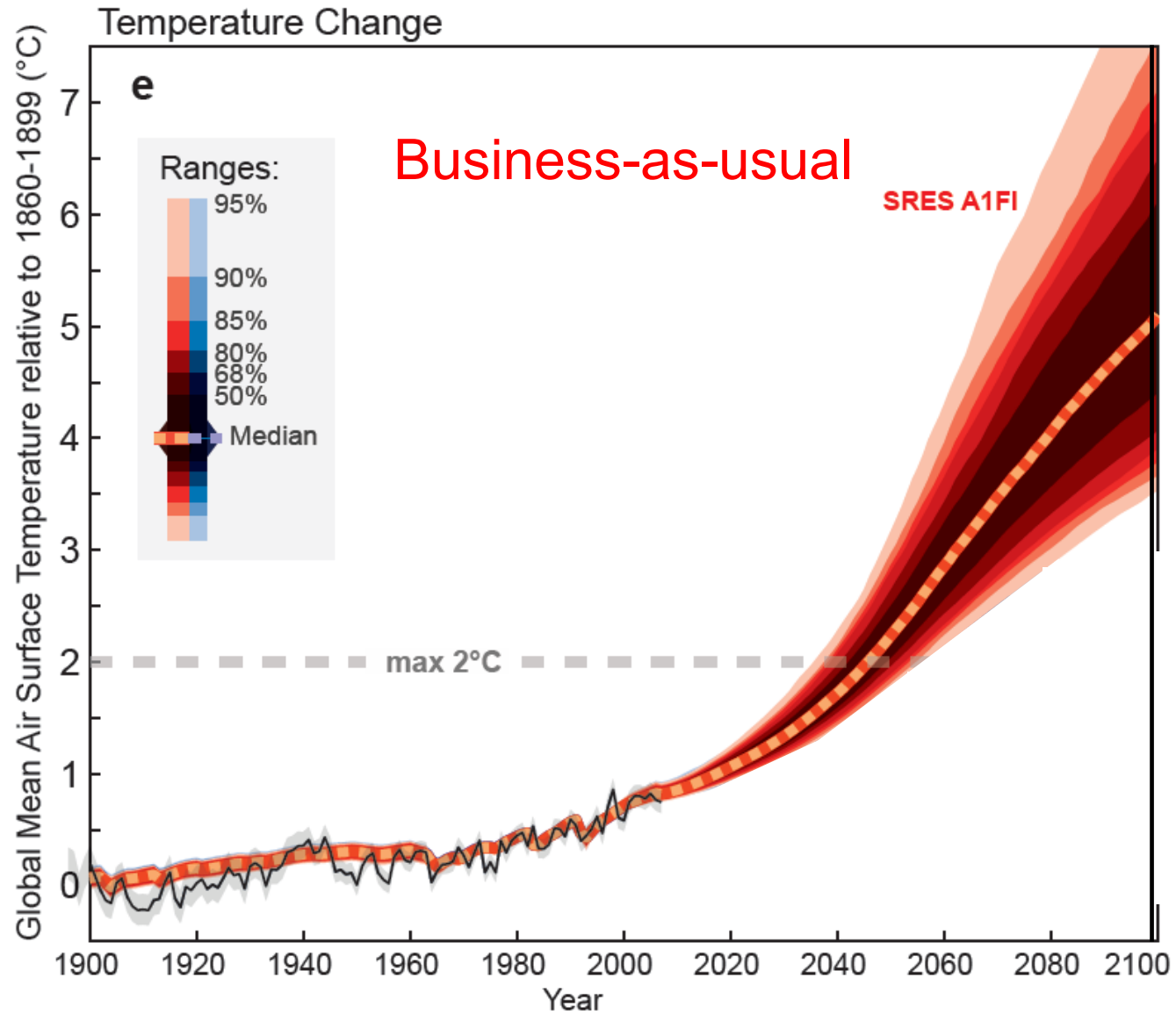
Cazenave et al. 2008.

Church & White, 2006.



Future projections

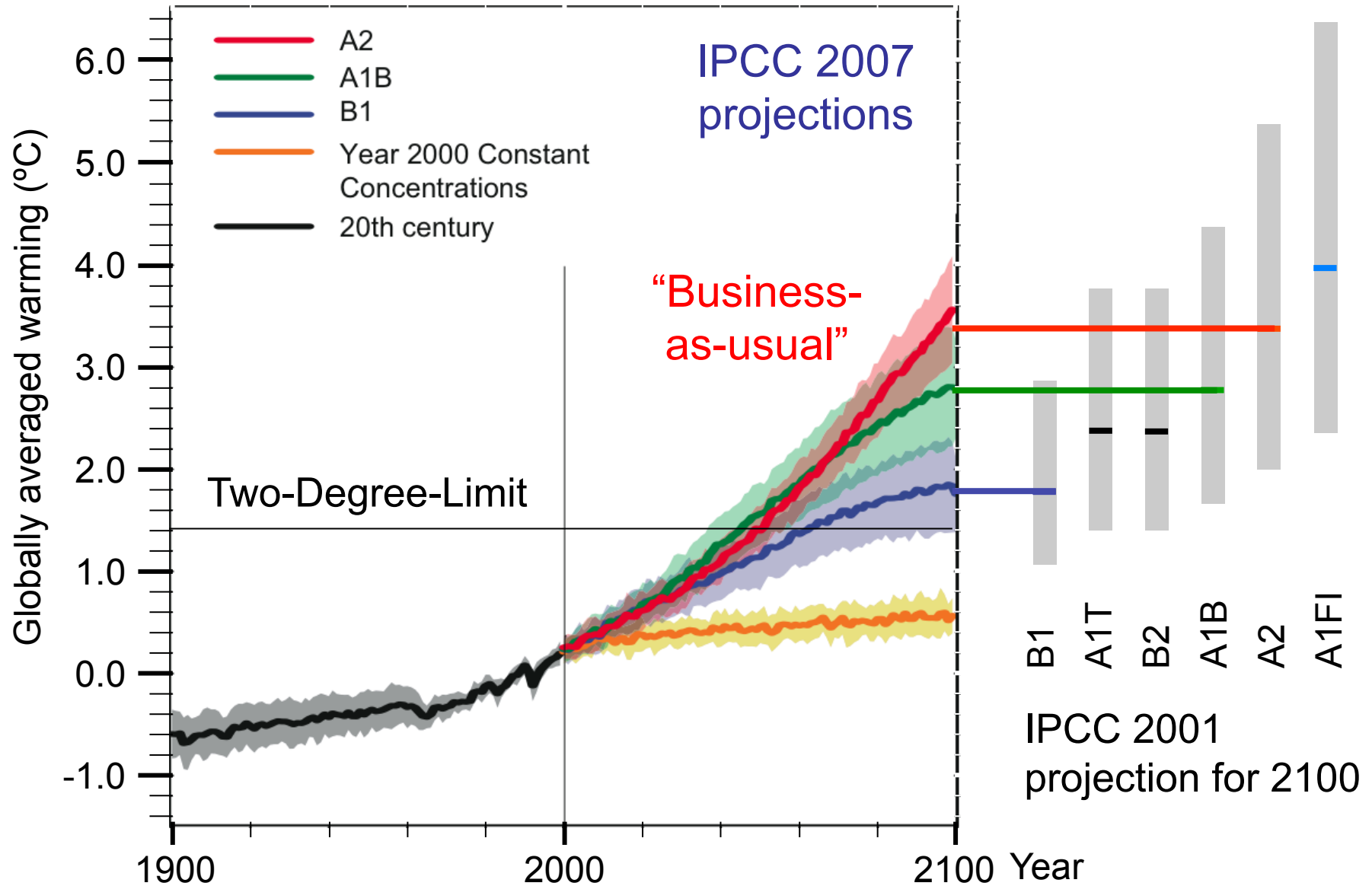
Meinshausen et al., 2009.





Multi-model future projections

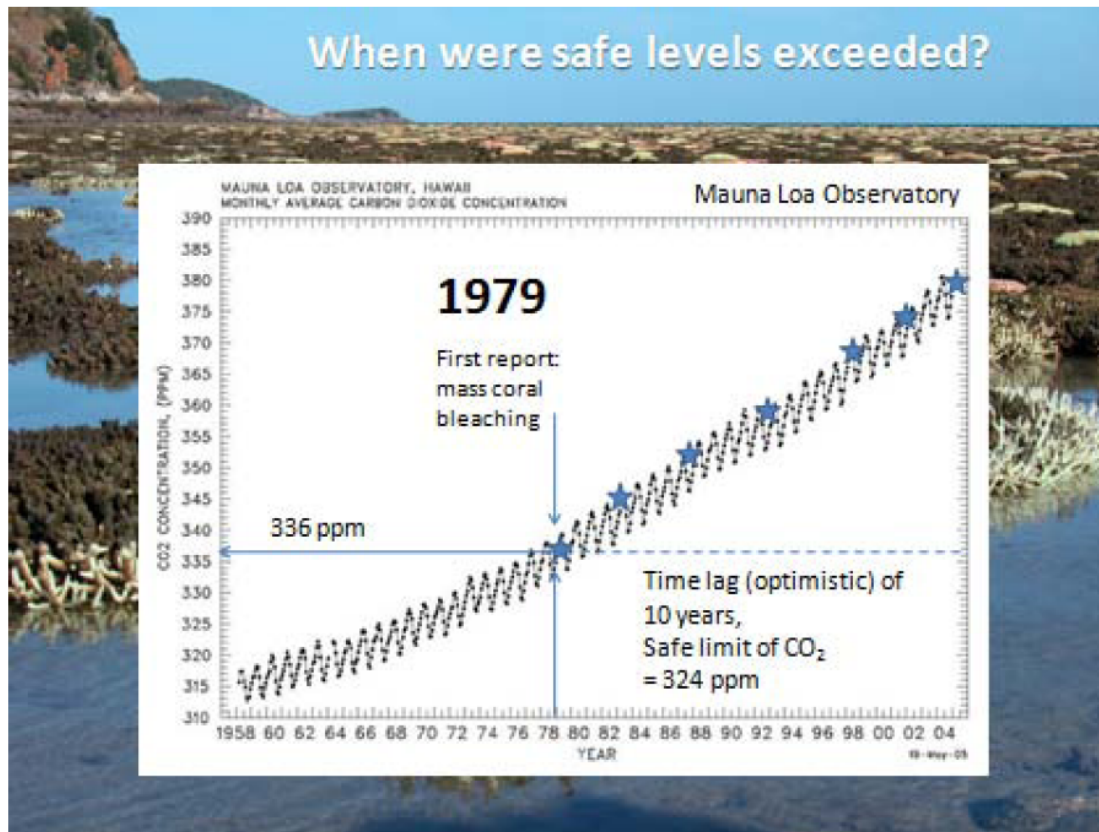
have not altered significantly since 2001



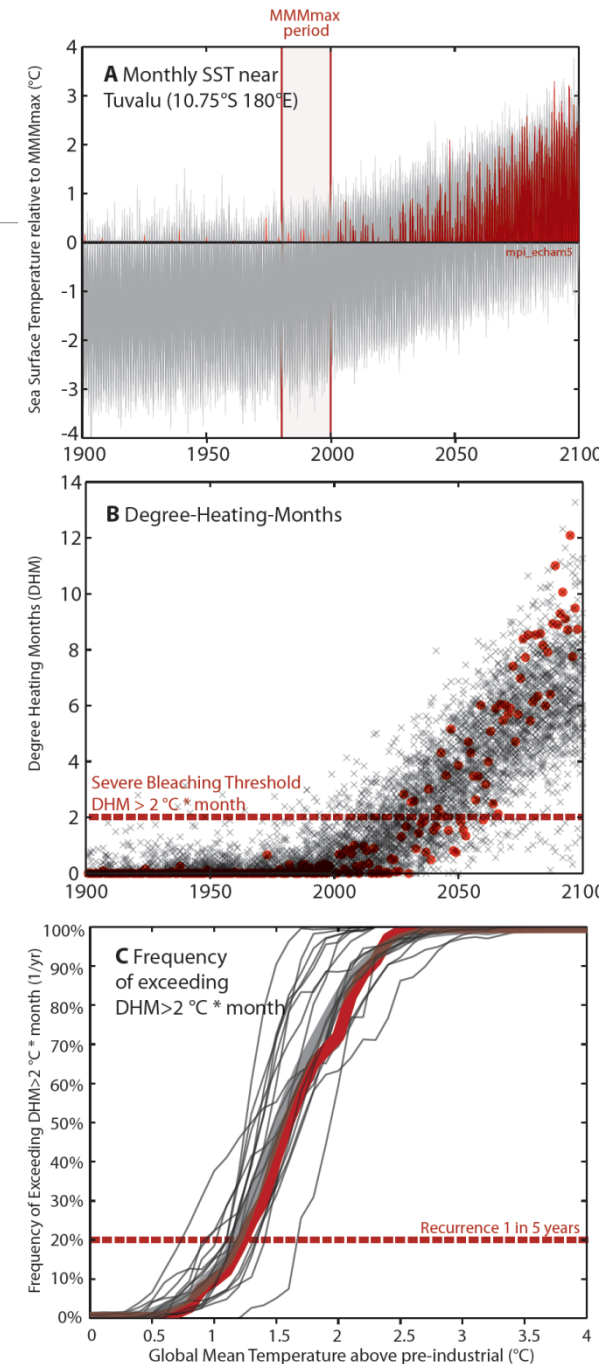


Coral bleaching

80% of coral reefs are at risk of disappearing already at 1.5°C.



Frieler et al. 2012





Things that might happen



Risks in a warming world ...



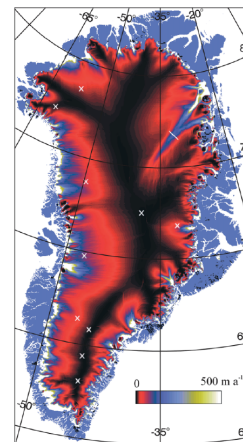
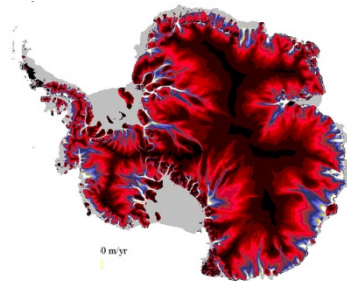
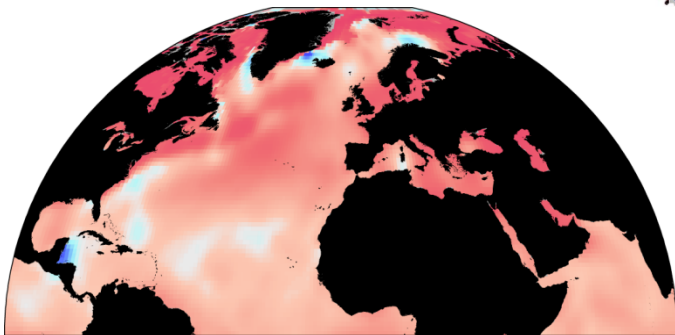
Observed contributions to sea level rise

1961-2003: 1.6 mm/year:
(Domingues et al., 2008)

- Ocean warming (~40 %)
- Mountain glaciers (~35 %)
- Ice sheets (~25 %)

2003-2008: 2.6 mm/yr:
(Cazenave et al., GPC 2008)

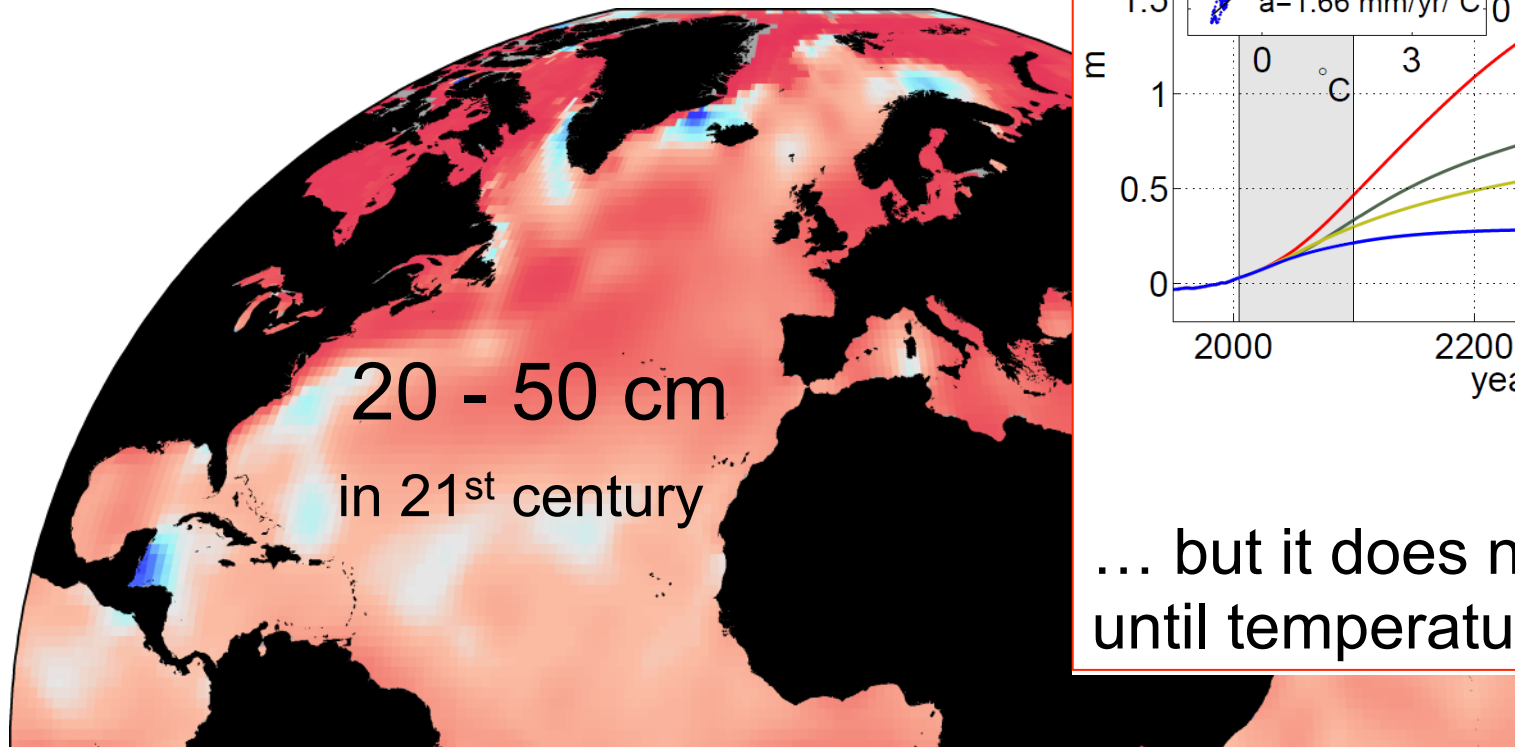
- Ocean warming (~20 %)
- Mountain glaciers (~40 %)
- Ice sheets (~40 %)



Ocean warming

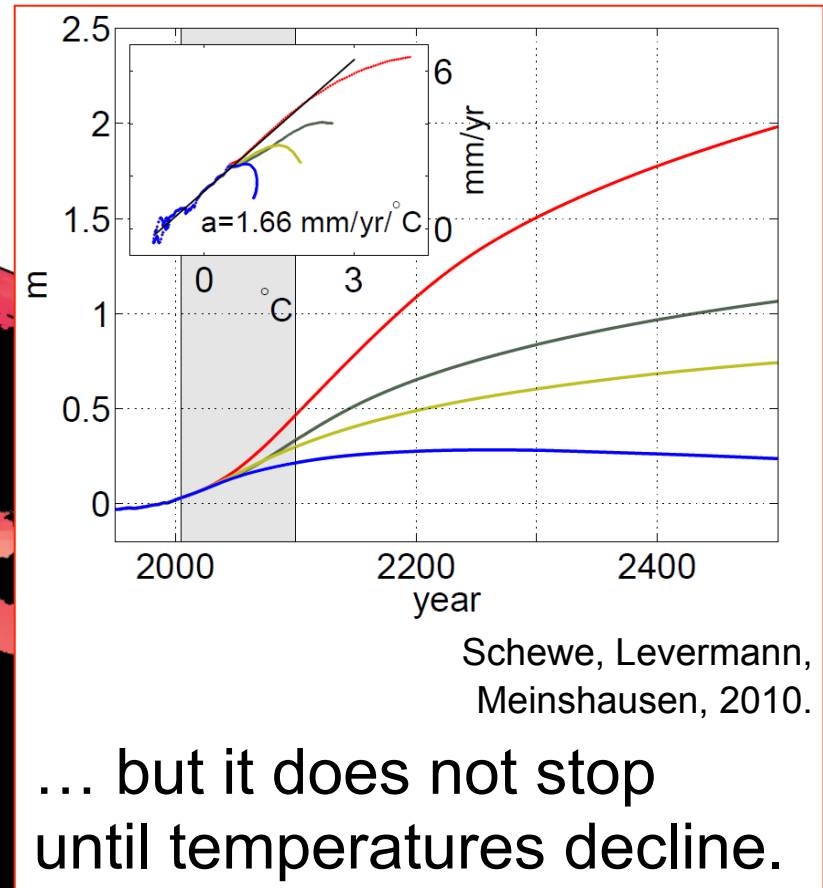
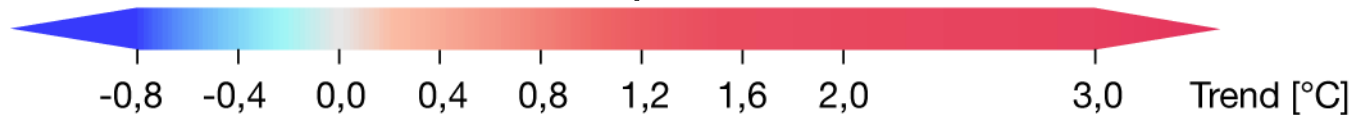
future contribution to sea level rise

No future surprises expected!



20 - 50 cm
in 21st century

Trend Sea surface temperature 1978 - 2002





Mountain glaciers

future contribution to sea level

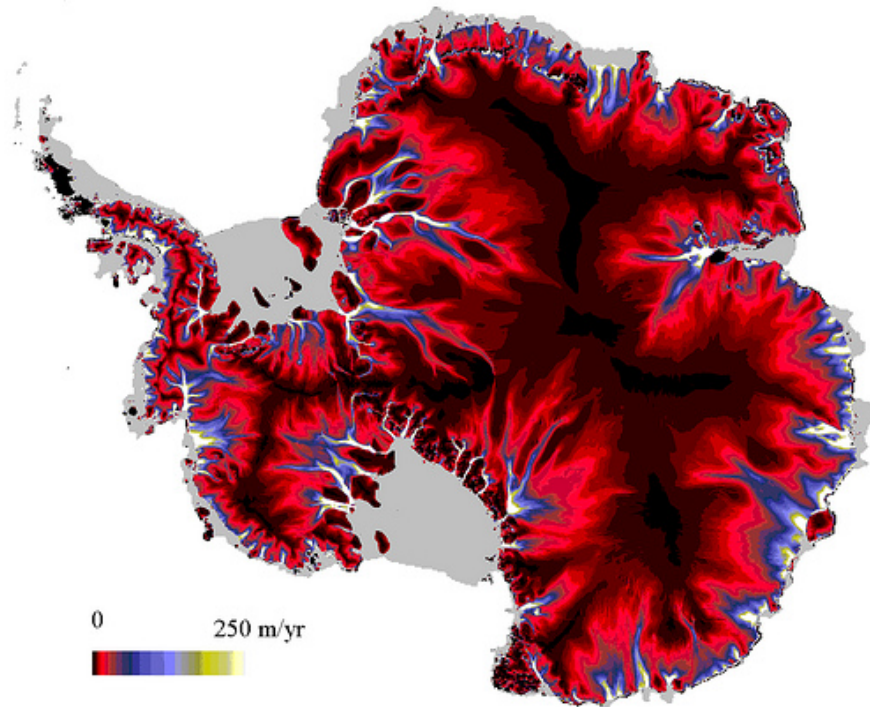
21st century: 5–15 cm (IPCC, 2007)

Maximum: 30-50 cm





What is missing? Big Ice Sheets

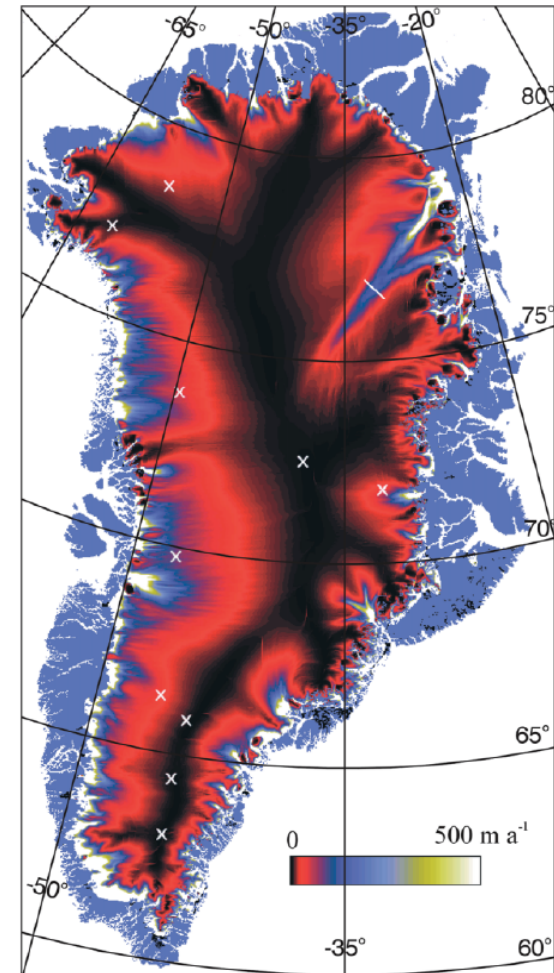


Antarctica

West Antarctica: 5 m

East Antarctica: 50 m

Bamber et al., 2008



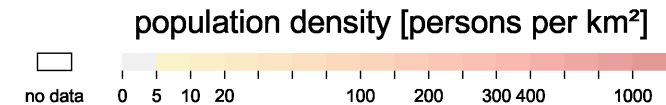
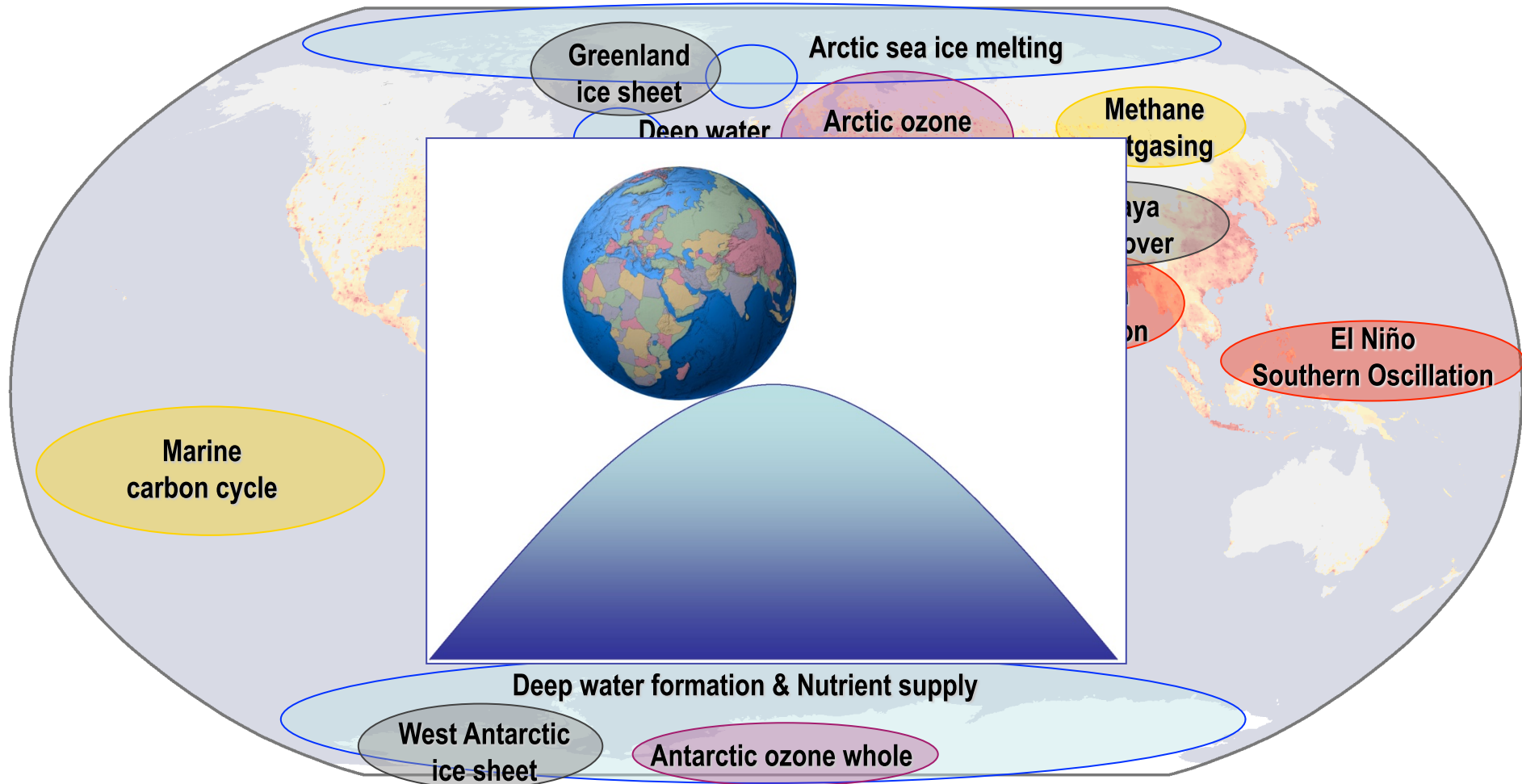
Greenland

Potential sea level rise: 7 m



Tipping elements

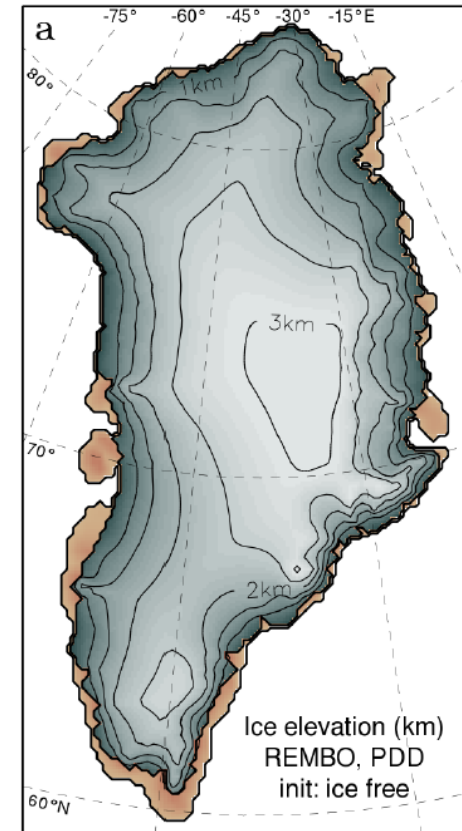
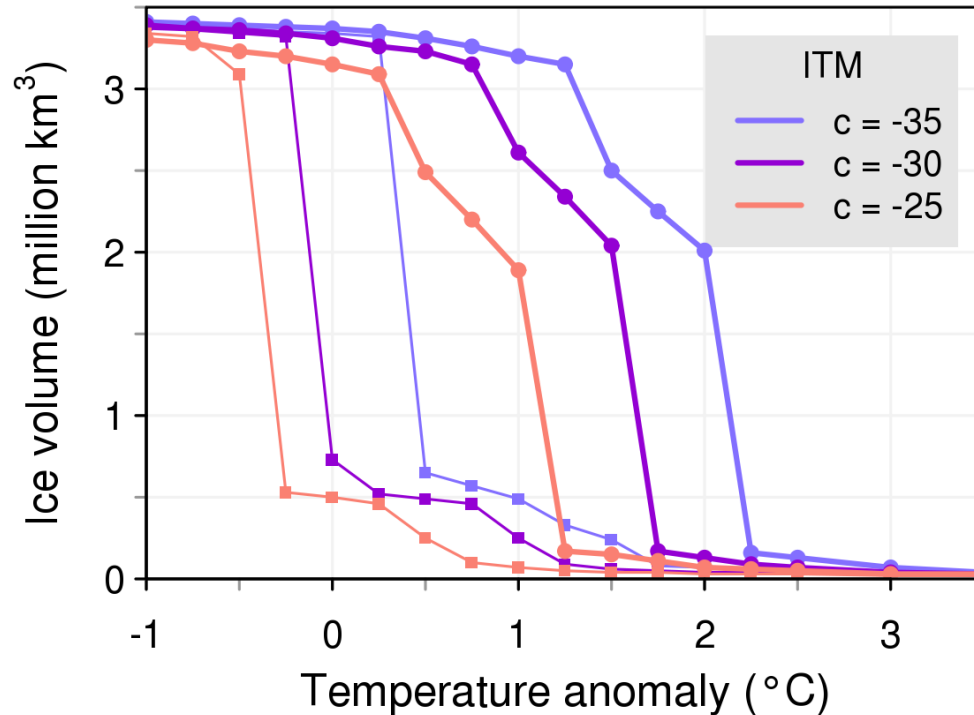
particularly sensitive to climate change





Greenland Ice Sheet

Risk of Irreversible Loss



The loss of the Greenland ice sheet may be triggered at 1.5 - 2.5°C additional global warming.

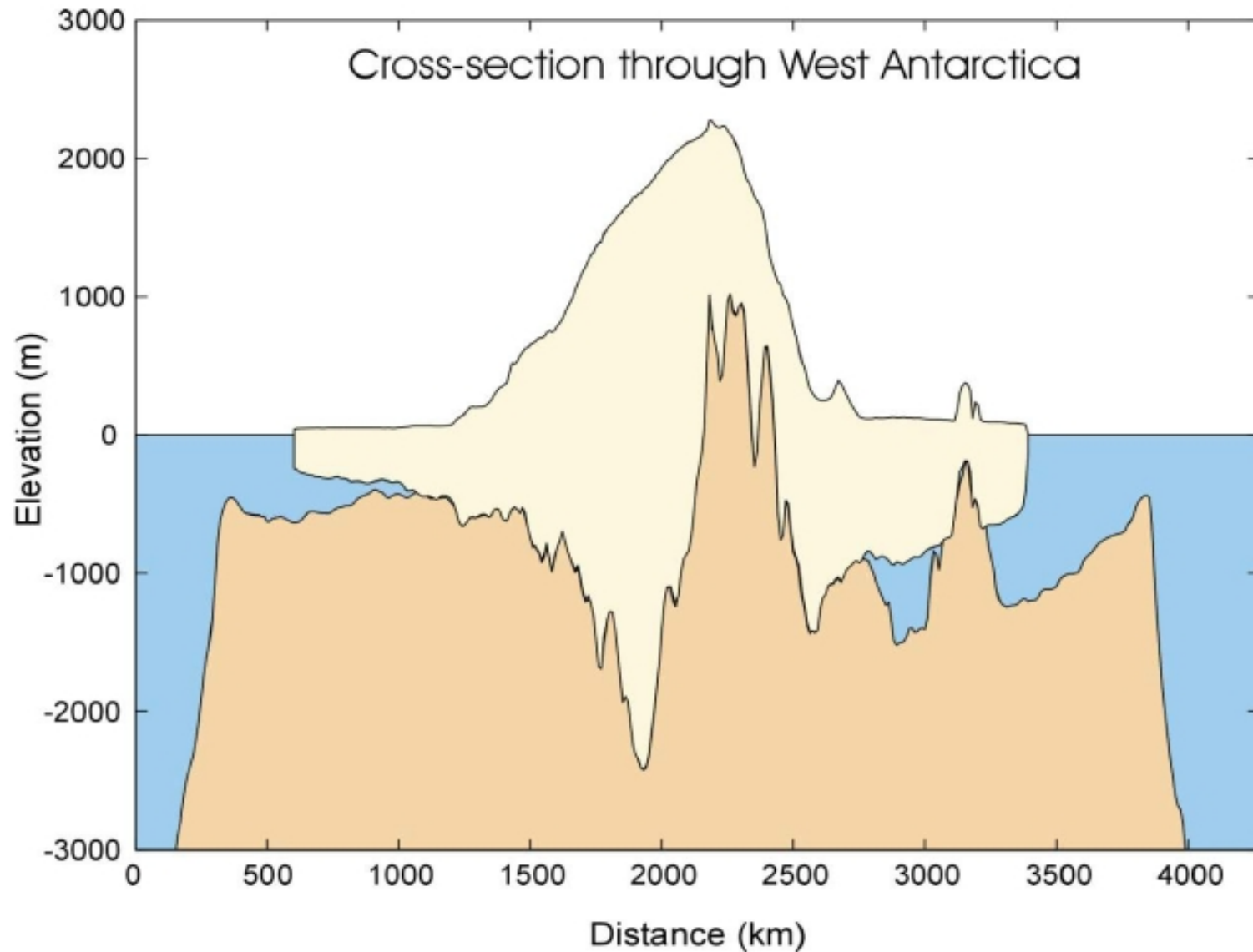
Hysteresis: The ice sheet does not regrow until lower temperatures are reached again.

Source: Robinson, Calov & Ganopolski, *submitted*



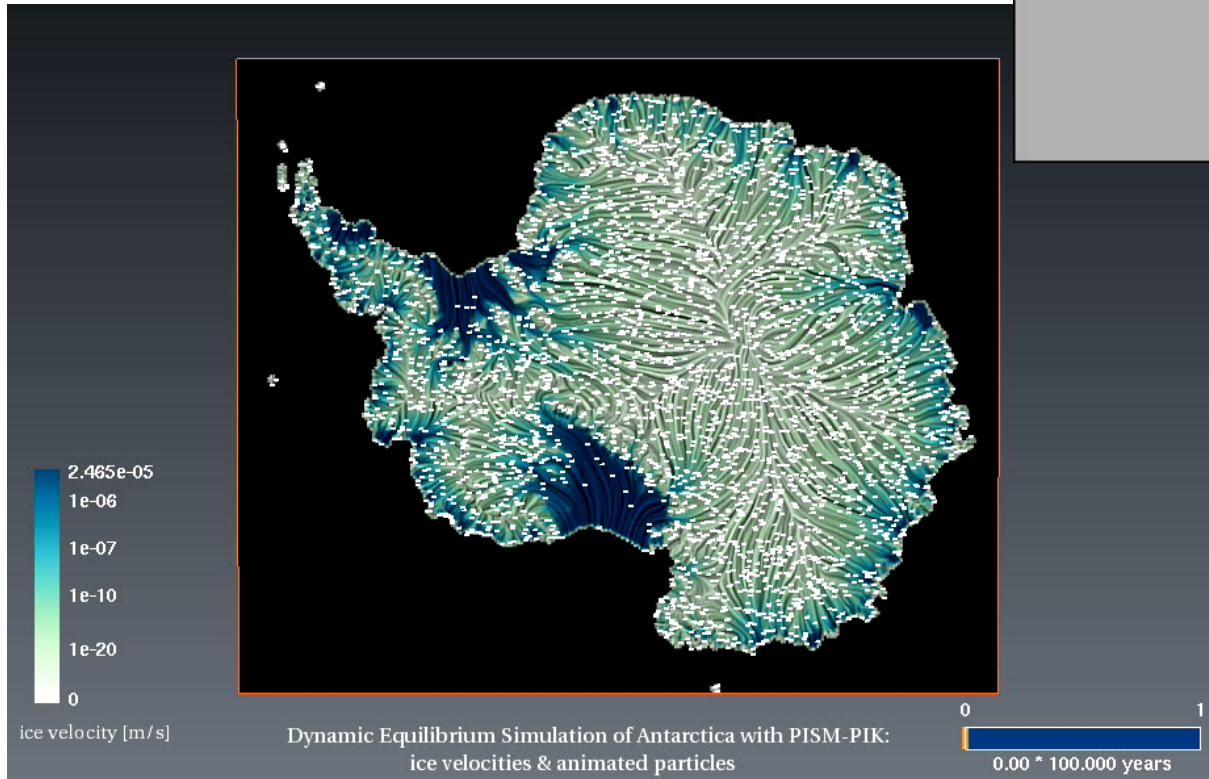
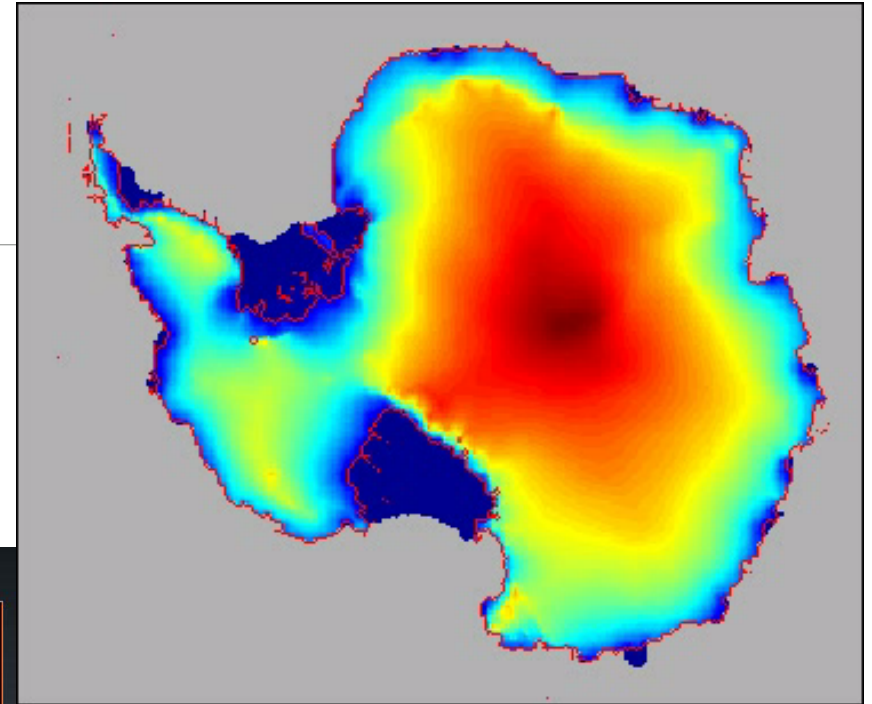
West Antarctic Ice Sheet

Mechanism of abrupt ice discharge





Abrupt ice discharge West Antarctica



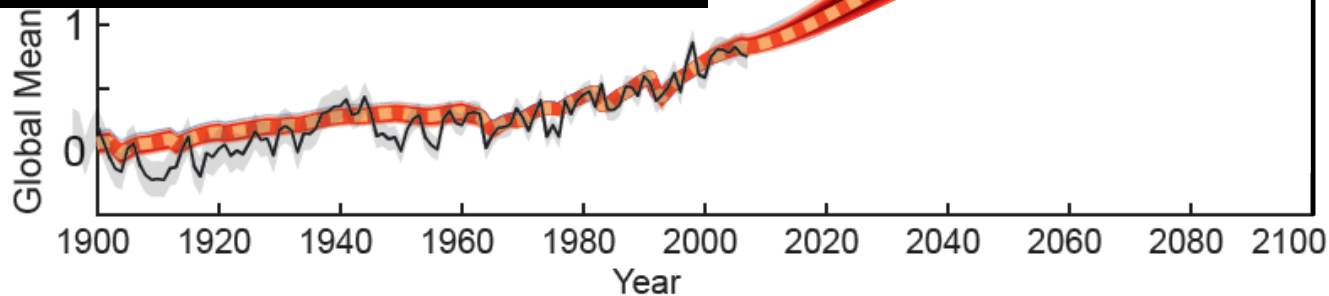
(Winkelmann & Levermann, 2011.)

(Martin & Levermann, 2011.)

future warming



Meinshausen

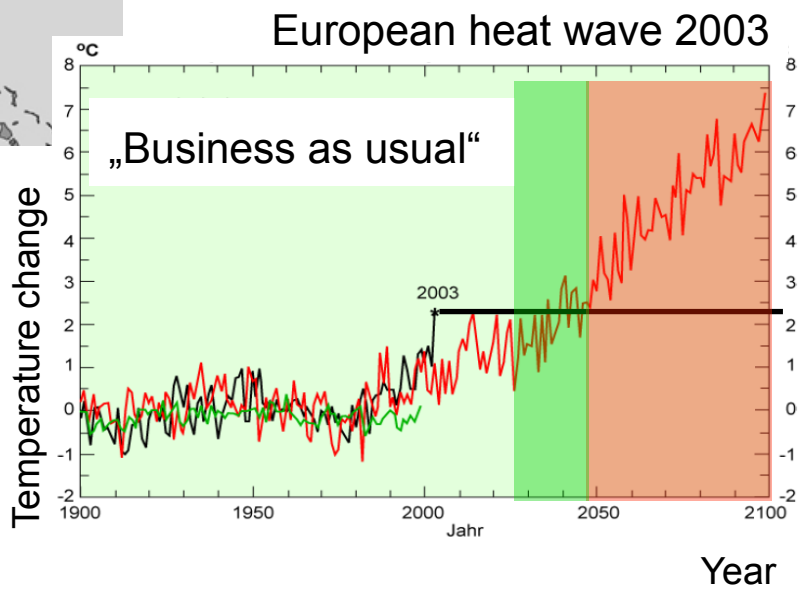
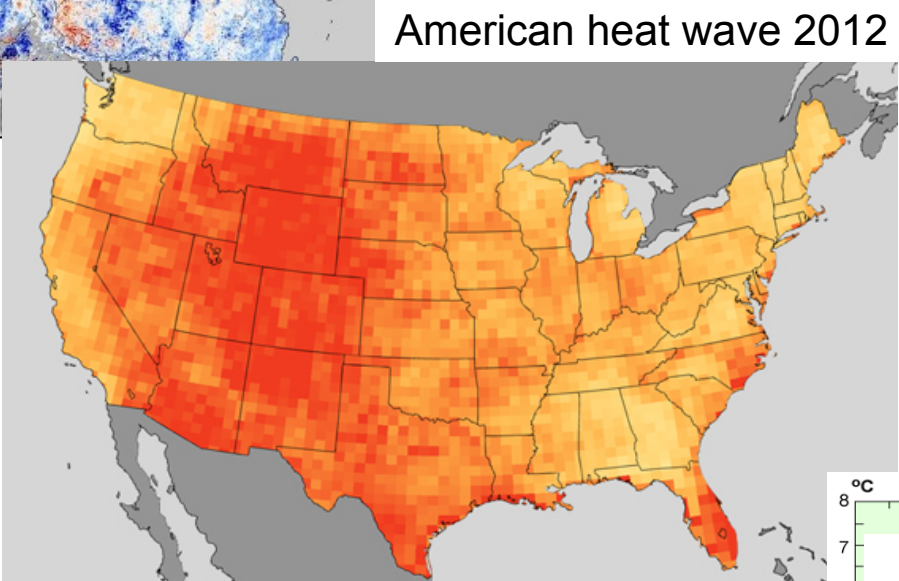
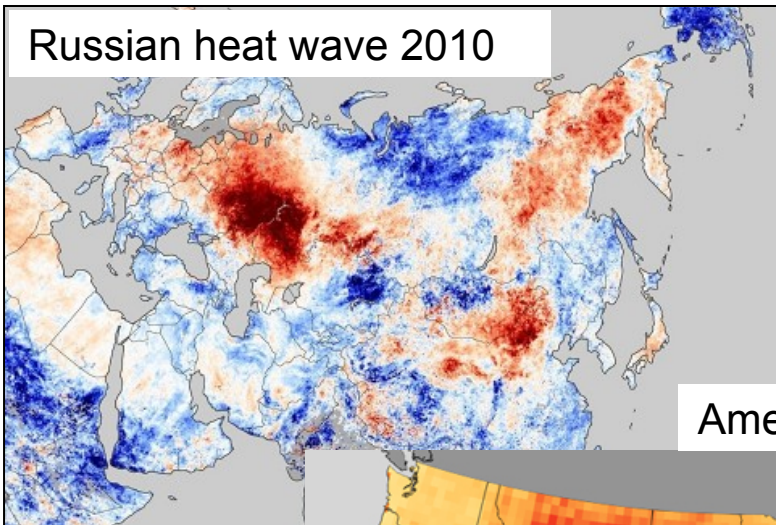


-as-usual

SRES A1FI

5 degrees:
Transition
between ice
age and
interglacial
naturally
takes 5000
years.

Extreme events



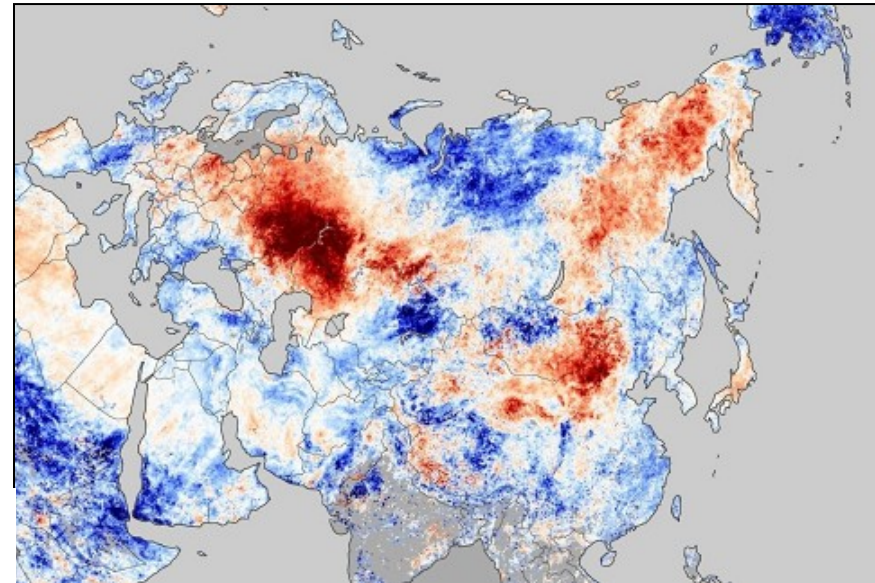
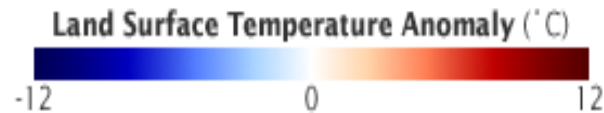
- ✧ More heat waves
- ✧ More droughts



Extreme Weather 2010

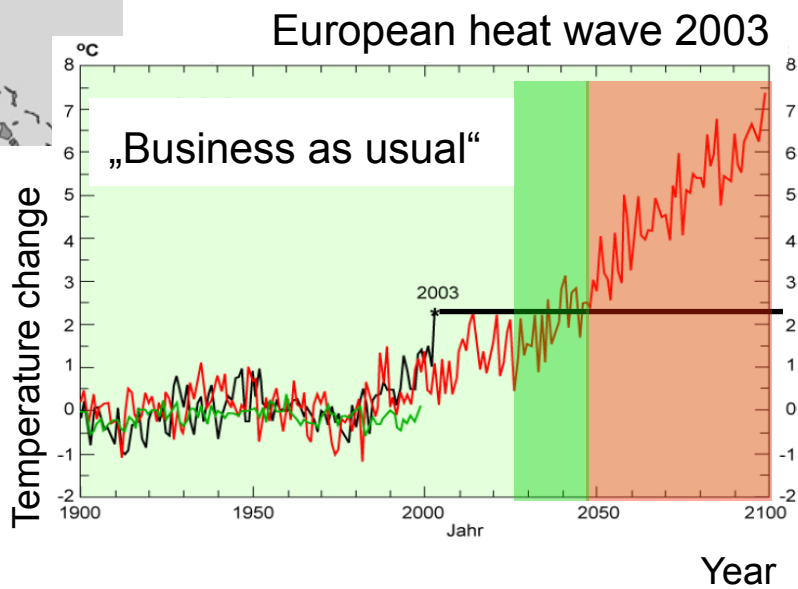
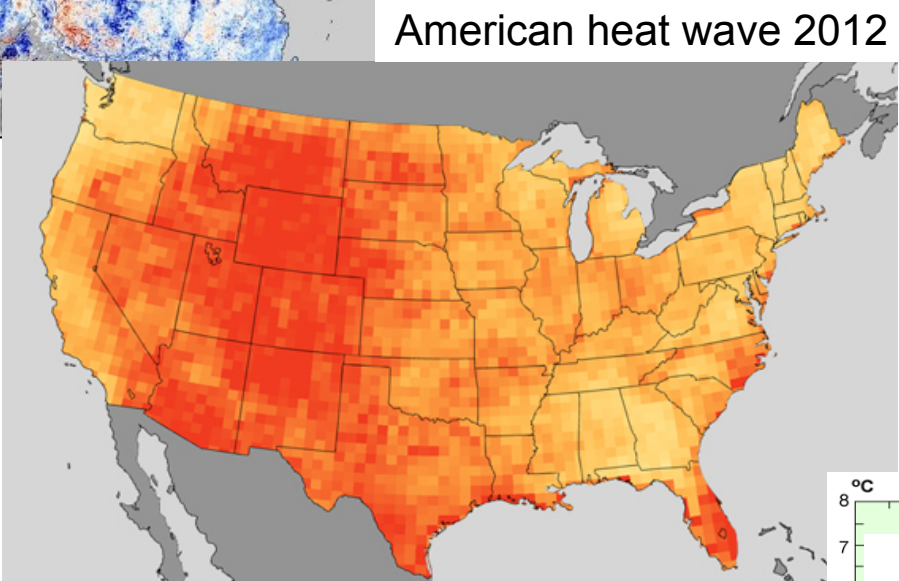
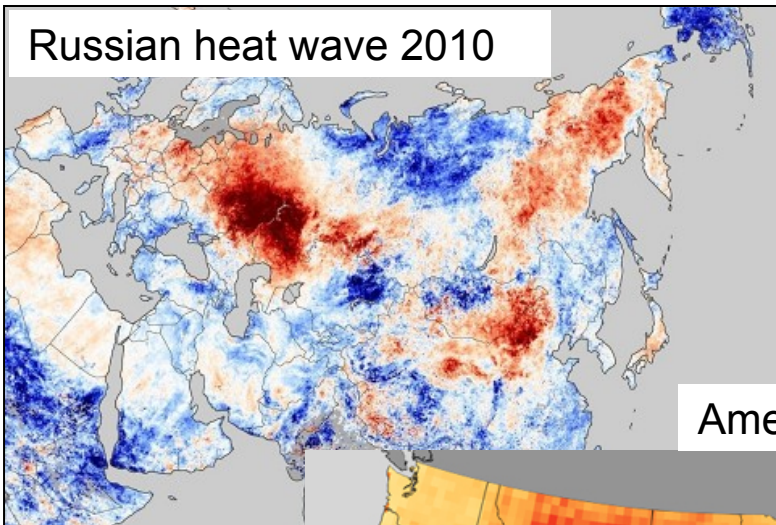
Wild fire in Russia

Temperature anomaly in Russia
July 20-27 2010 compared to 2000-2008



- ✧ July 2010 warmest month ever in Moscow since the beginning measurements 130 years ago.
- ✧ Temperature exceeded the long-term average by 7.8° C.
- ✧ ~ 12 million hectare land burnt.
- ✧ Heatwave destroyed crops in many parts of the country, pushing food prices up.
- ✧ Export ban for wheat.

Extreme events



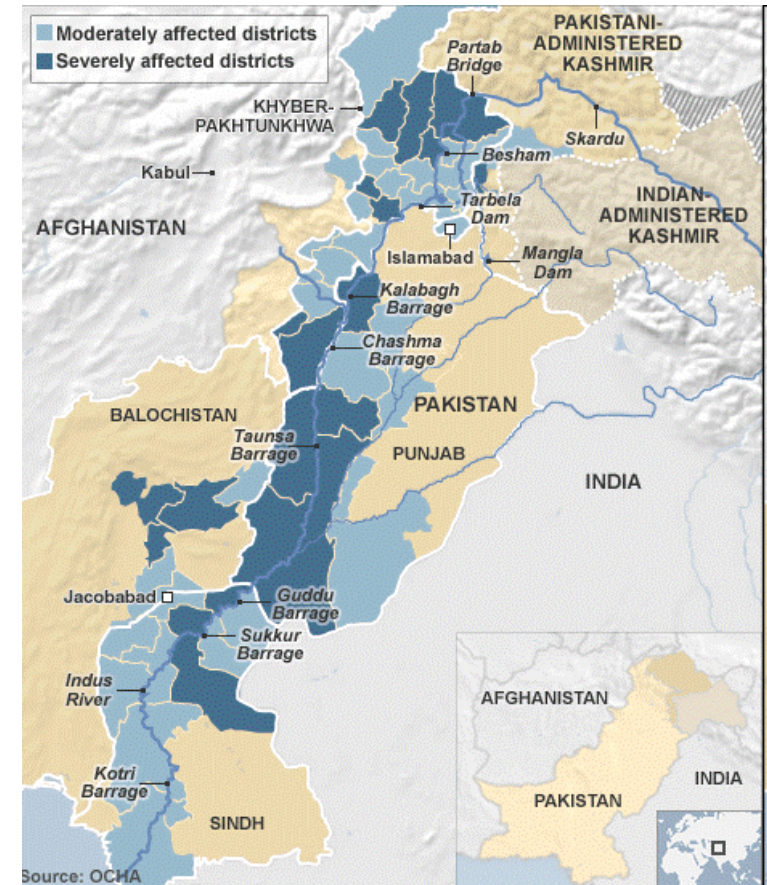
- ✧ More heat waves
- ✧ More droughts
- ✧ More extreme rainfall events



Extreme Weather 2010

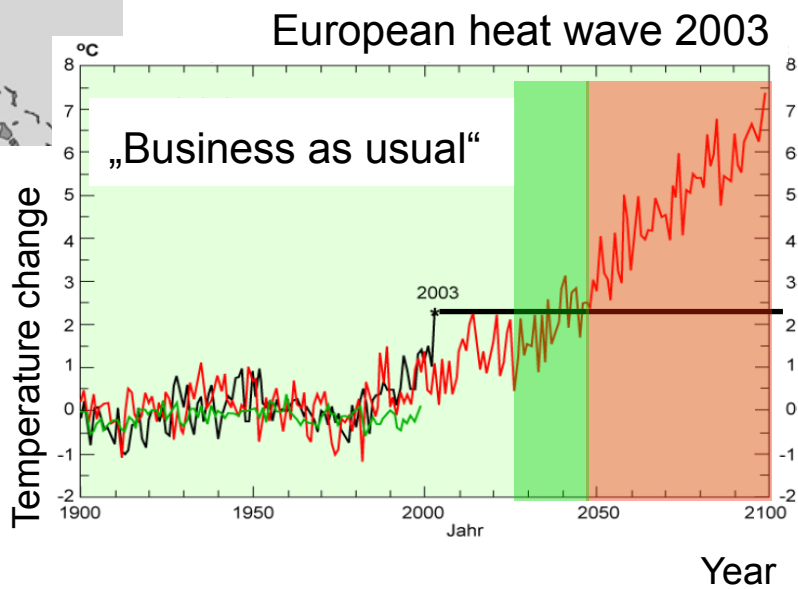
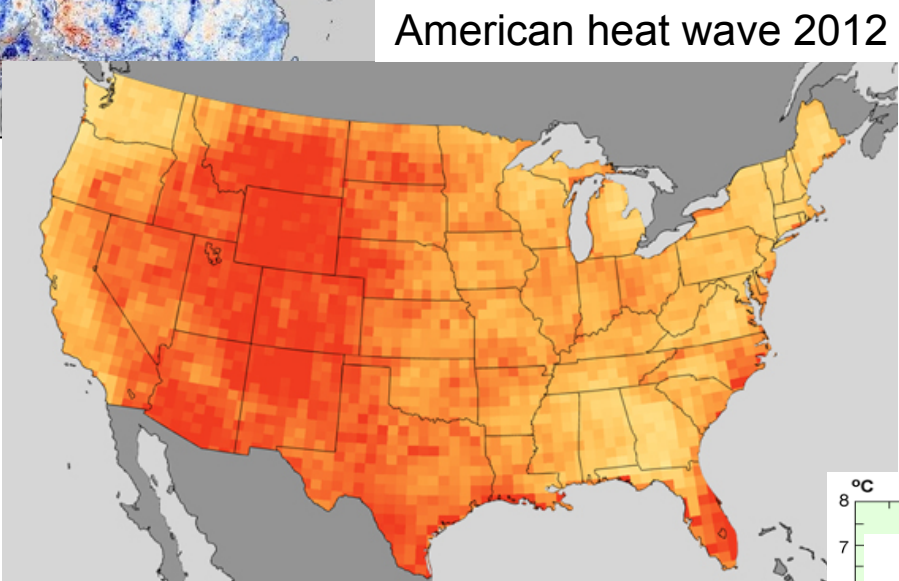
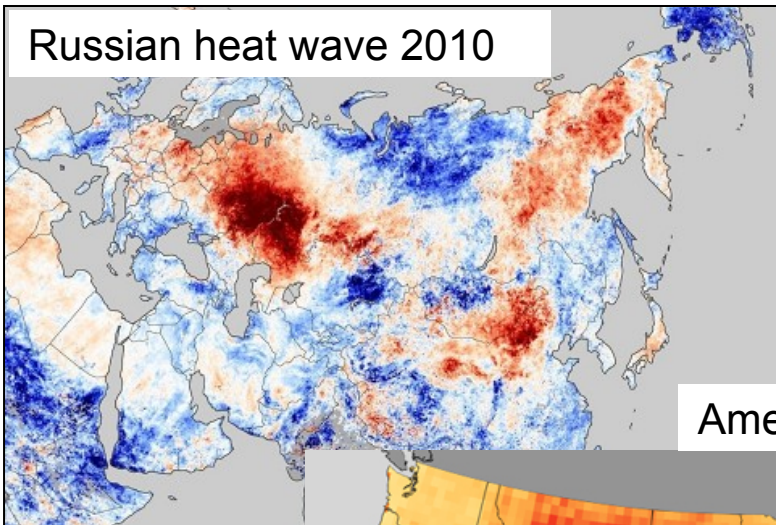
Monsoon rainfall in Pakistan

- ✧ Unprecedented July rainfall
- ✧ Following highest-ever temperature in Asia: 53,5°C.
- ✧ Initial rain intensity: 300 mm in 36 hours.
- ✧ Flooded areas constitute world's largest freshwater lake.
- ✧ More than 20 million people lost homes.
- ✧ About 1600 people died.



Source: www.dfid.gov.uk

Extreme events



- ✧ More heat waves
- ✧ More droughts
- ✧ More extreme rainfall events
- ✧ More extreme cold periods

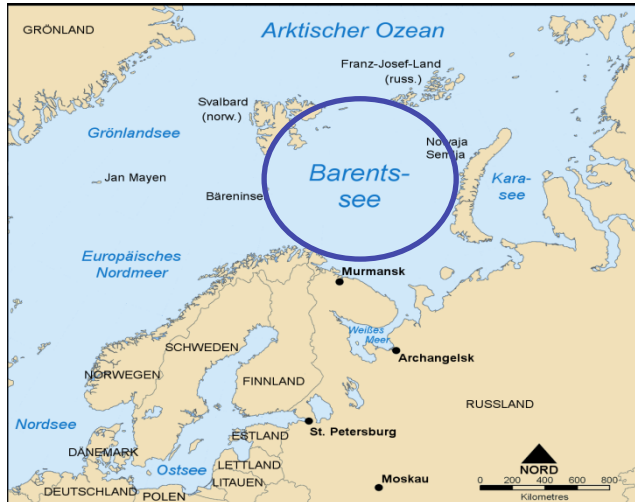


Extreme Weather 2010 Snow in Germany

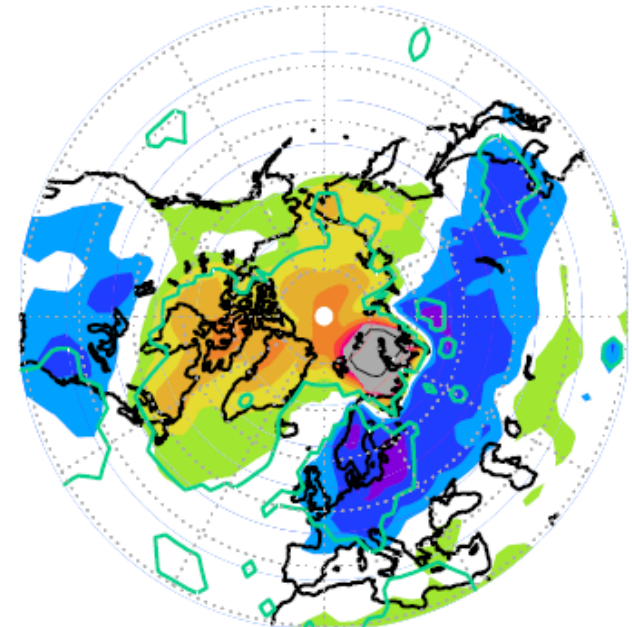
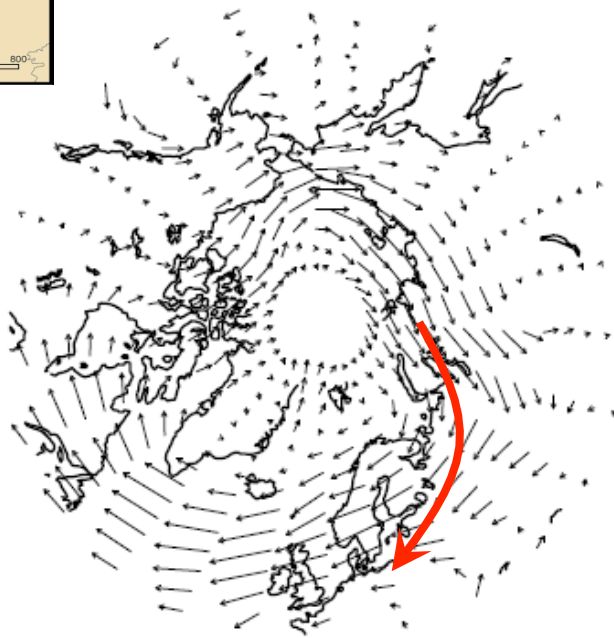


- ✧ Extraordinary snow fall in winter 2010 & 2011
- ✧ Collapse of German transportation system

Extremely cold winter in Europe cause by global warming?

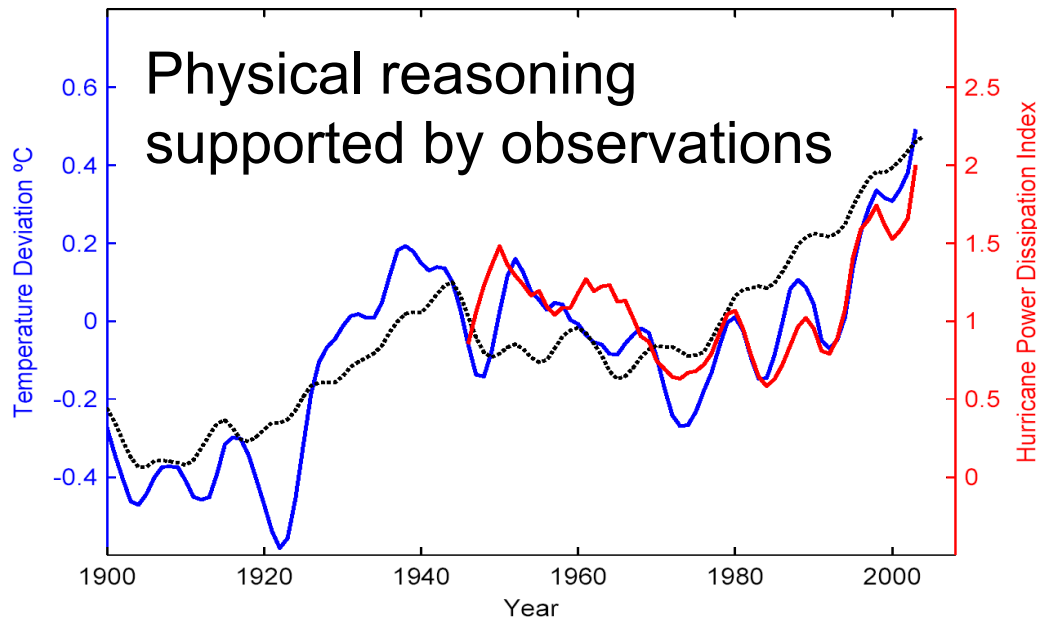
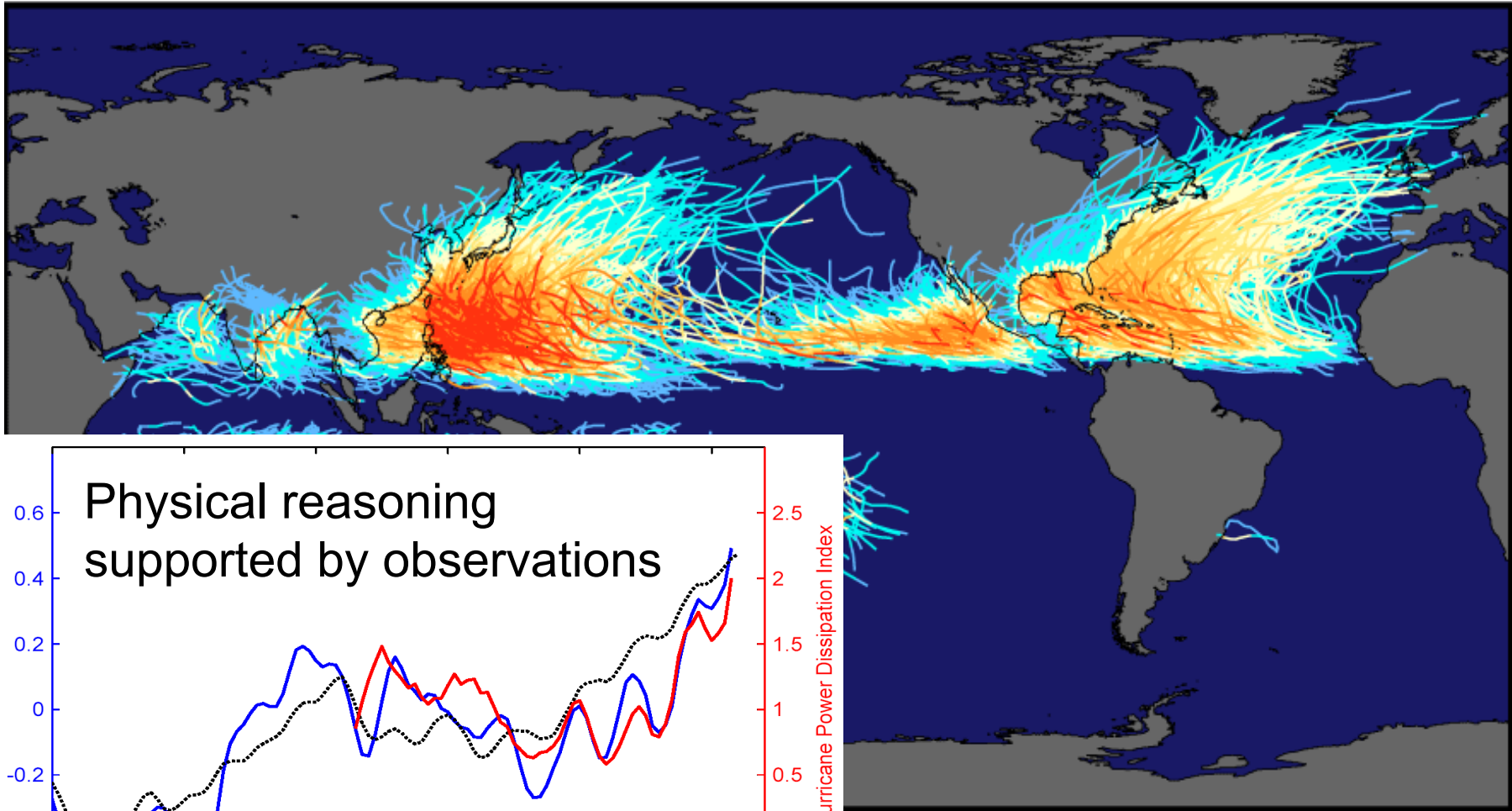


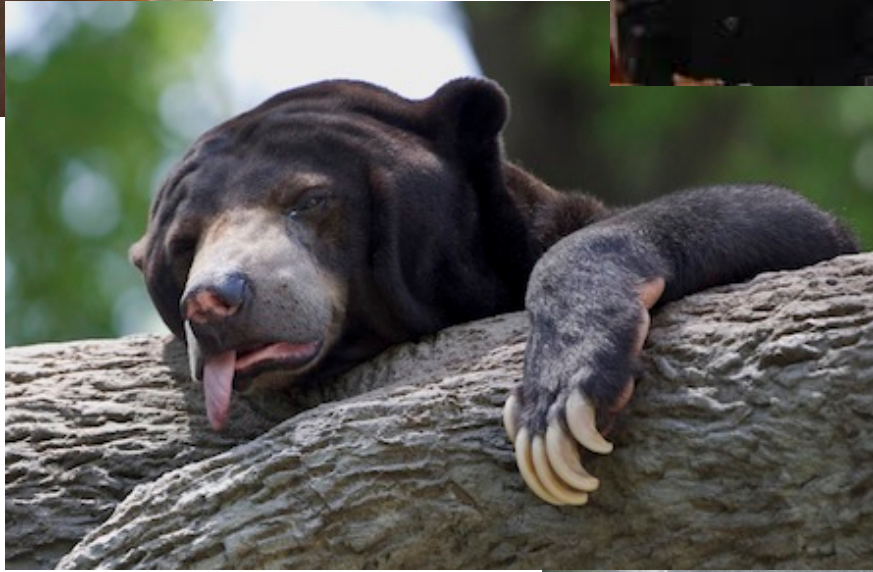
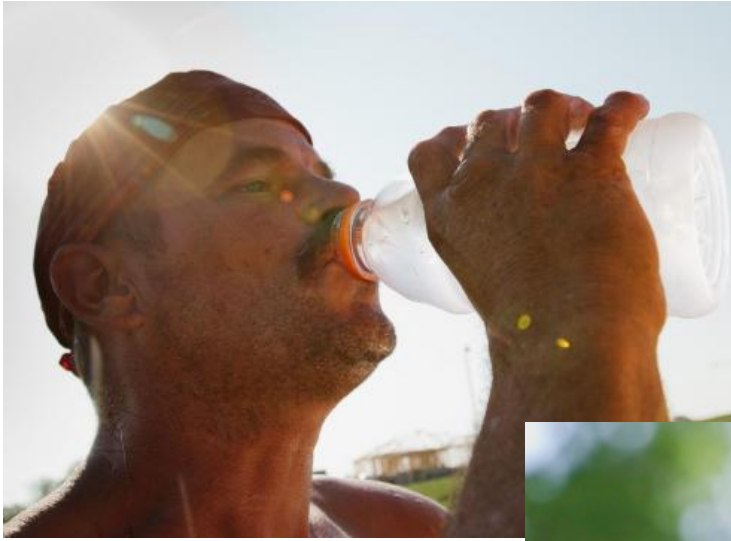
- Global warming
- Ice melting in Barents Sea
- High pressure system
- Arctic winds
- Cold winter in Europe





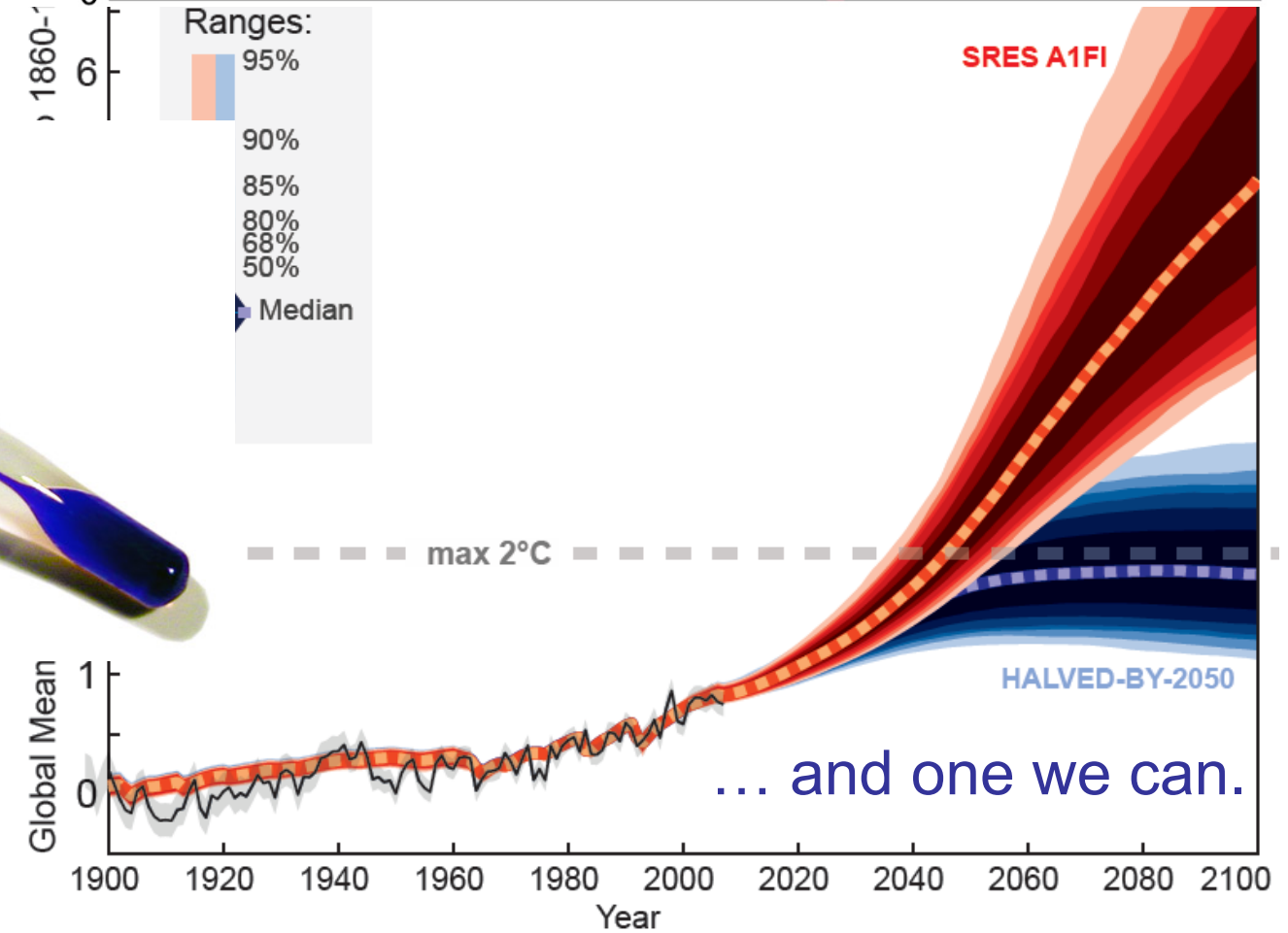
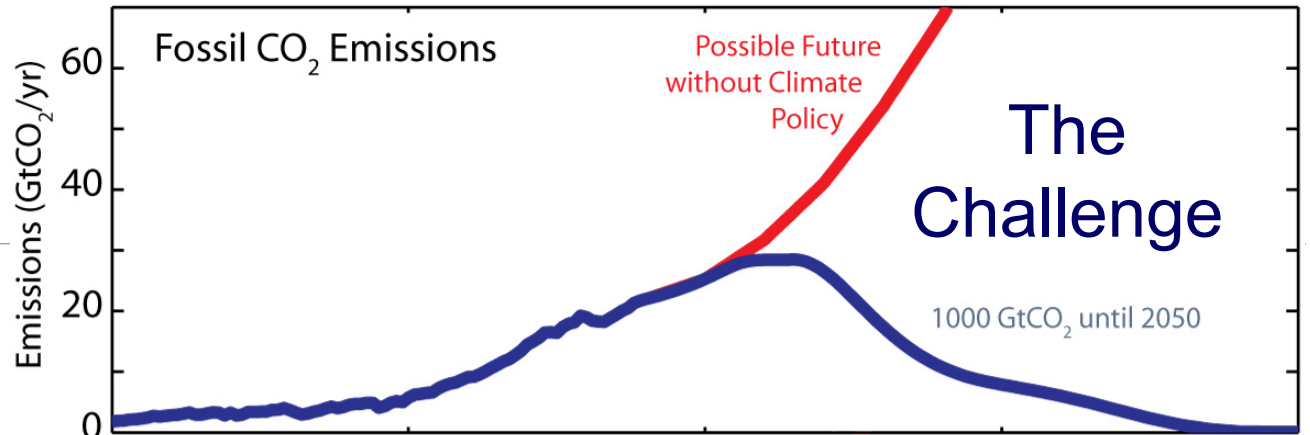
Intensification of tropical storms







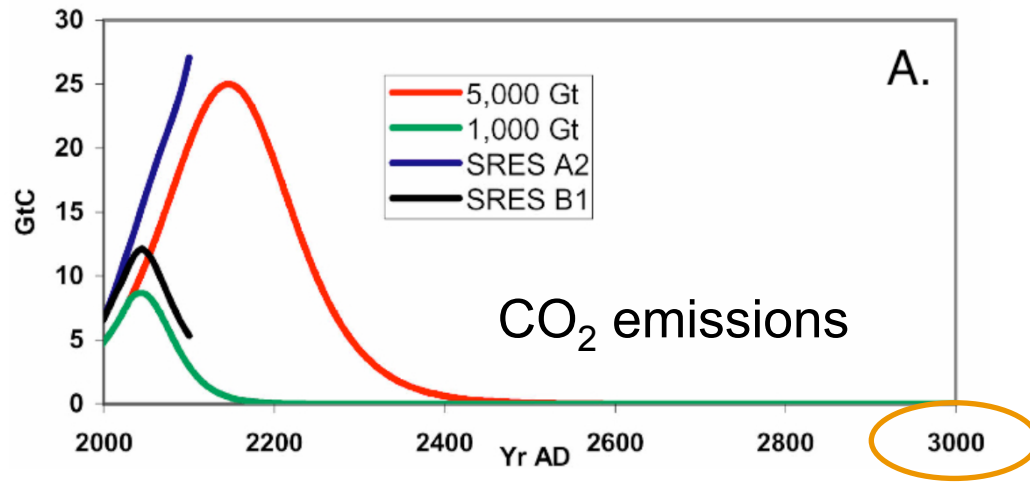
Two future pathways ...



... and one we can.

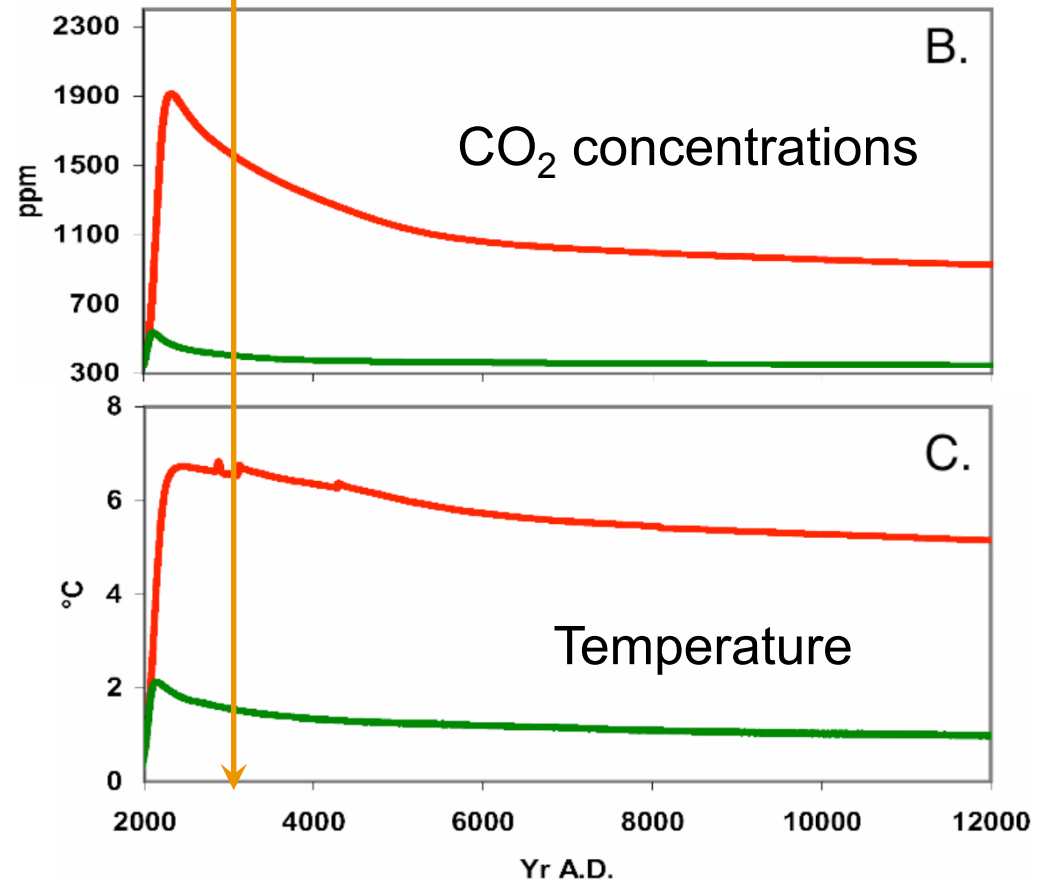
Meinshausen et al., 2009.

Stabilizing Earth's temperature



CO₂ persists for millenia

Stable temperature
means
zero emissions



Archer & Brovkin, 2009.

Solomon et al. 2009.

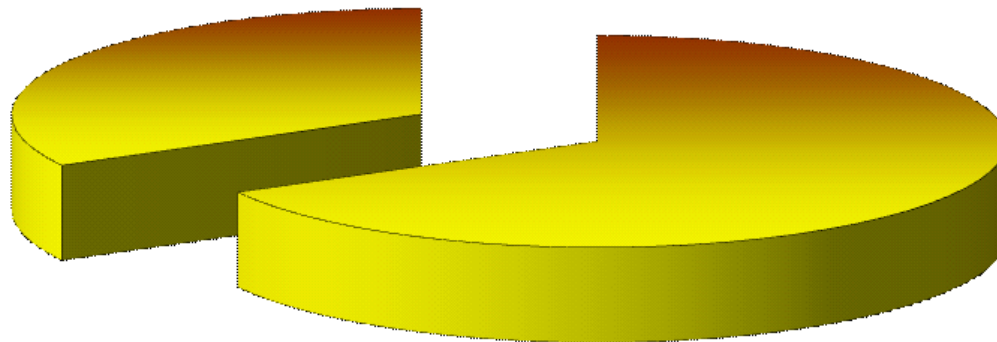
Allen et al. 2009.



CO₂-Budget (2000-2050)

2/3 Chance to stay below 2°C means:
Global CO₂-budget of ~1 trillion tons

2000-2009: 33%



2010-2050: 67%

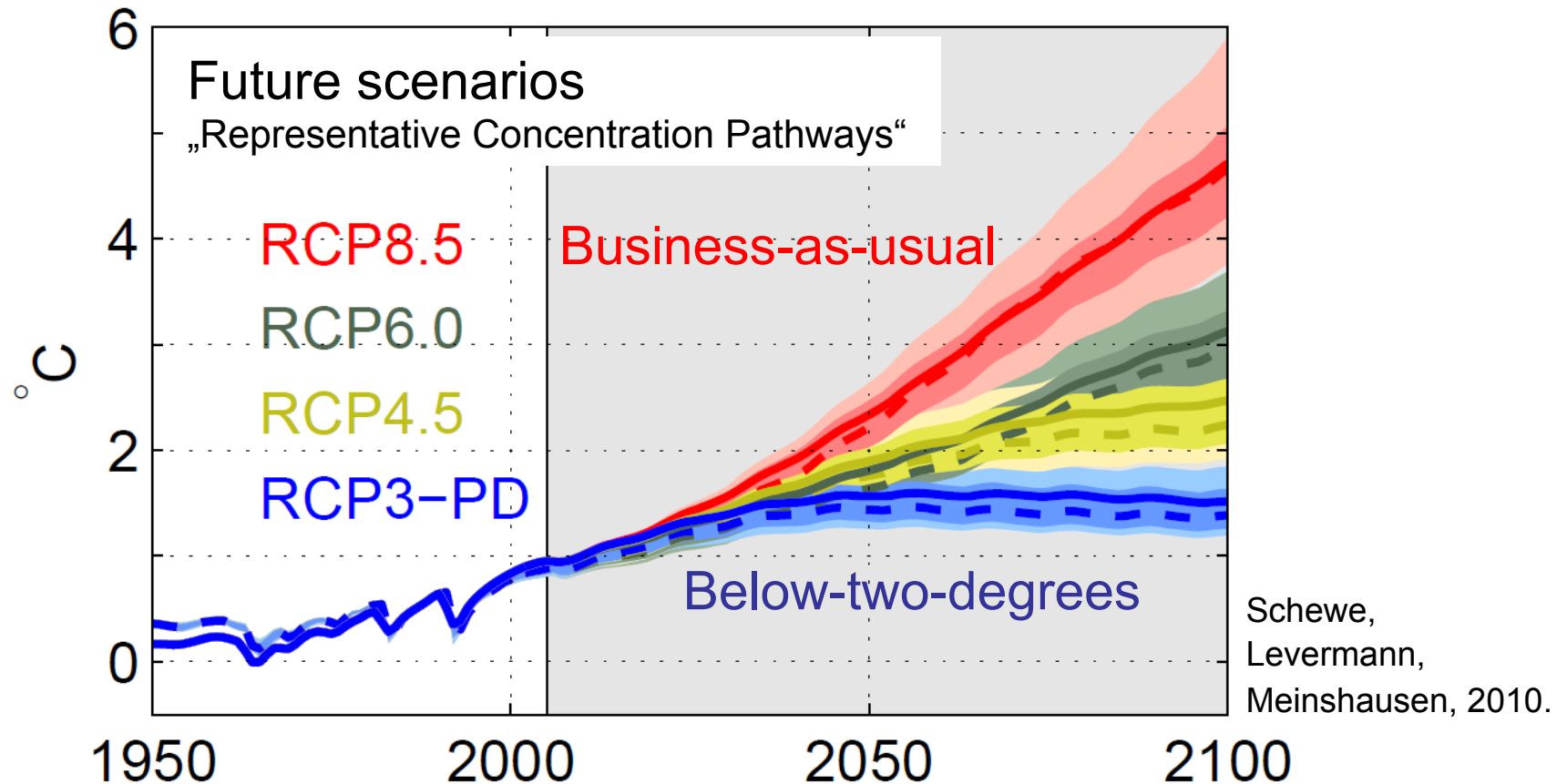
At same consumption budget exhausted in 2030.



Can we solve it only by Carbon Capture and Storage?

„Below-two-degrees“ scenario
2050: < 0.1 t per person per year
of „negative emission“

Without mitigation:
2050: ~ 2 t per person each year
2100: > 3 t per person each year



Thank you for your attention !



Avoid the unmanagable.
Adapt to the unavoidable.

2100



Prof. Dr. Anders Levermann, Potsdam Institute for Climate Impact Research, Germany.
www.pik-potsdam.de/~anders