



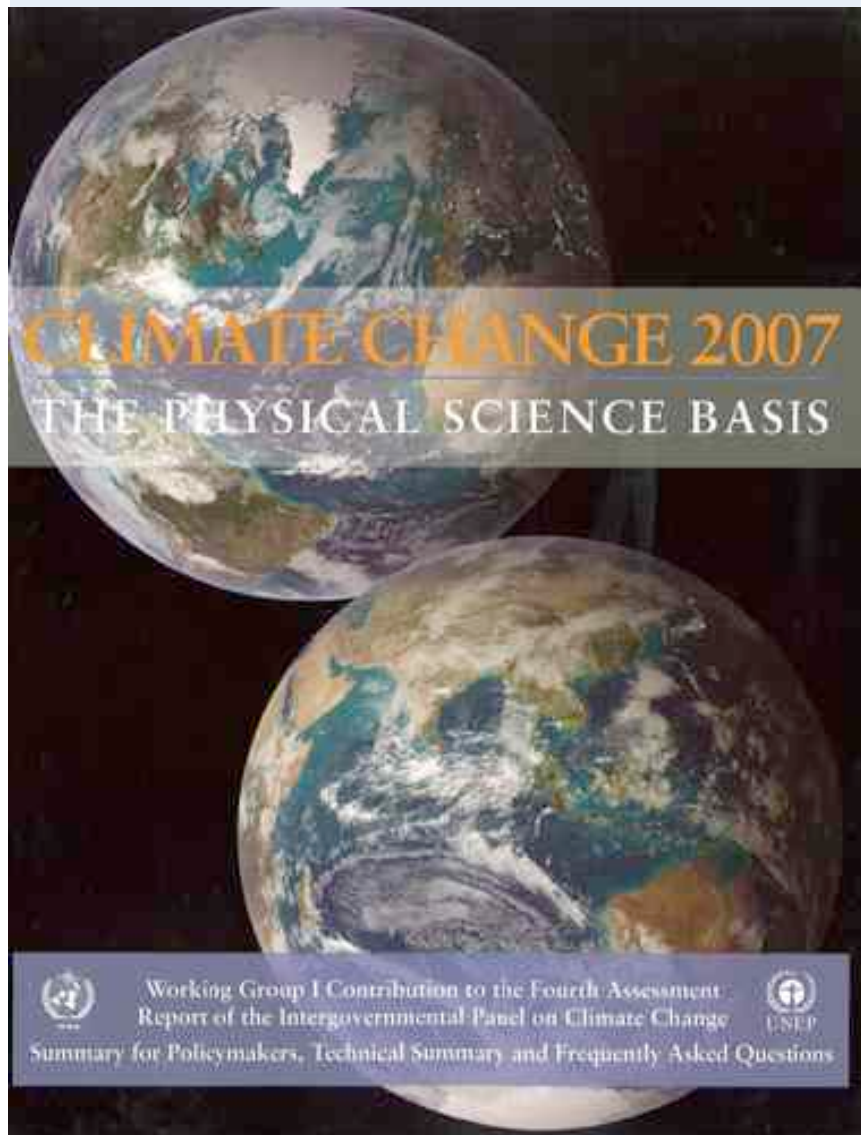
Climate, Ice Sheets, and Ocean

Which evolution short and long term ?

Thomas Stocker

Oeschger Centre for Climate Change Research
Physics Institute
University of Bern, Switzerland

IPCC Fourth Assessment Report 2007

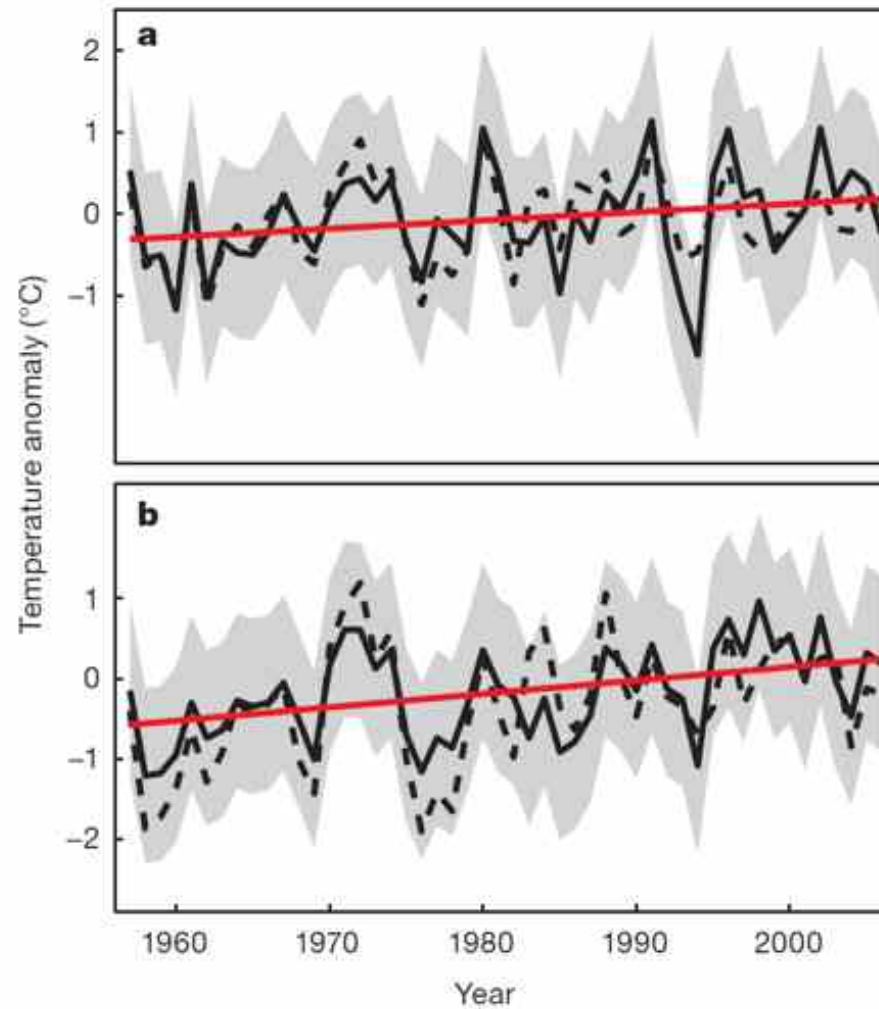


Warming in the climate system is unequivocal ...

It is *likely* that there has been significant anthropogenic warming over the past 50 years averaged over each continent except Antarctica

Continental warming in Antarctica

East Antarctica



West Antarctica

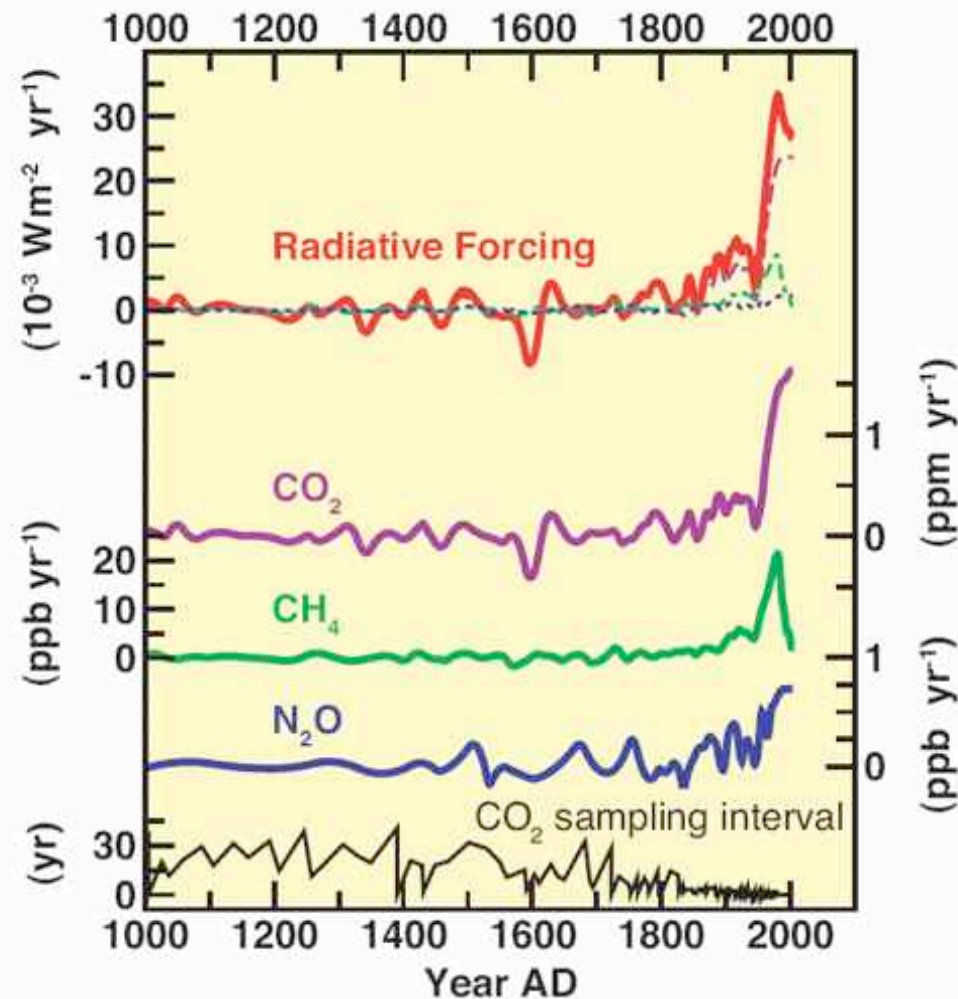
(Steig et al., 2009)



Colloque: Clôture de la 4^{ème} Année Polaire

1. News from polar ice cores
2. Surprises in the Earth System
3. Arctic sea ice
4. Ice sheet instabilities
5. Conclusions and open issues

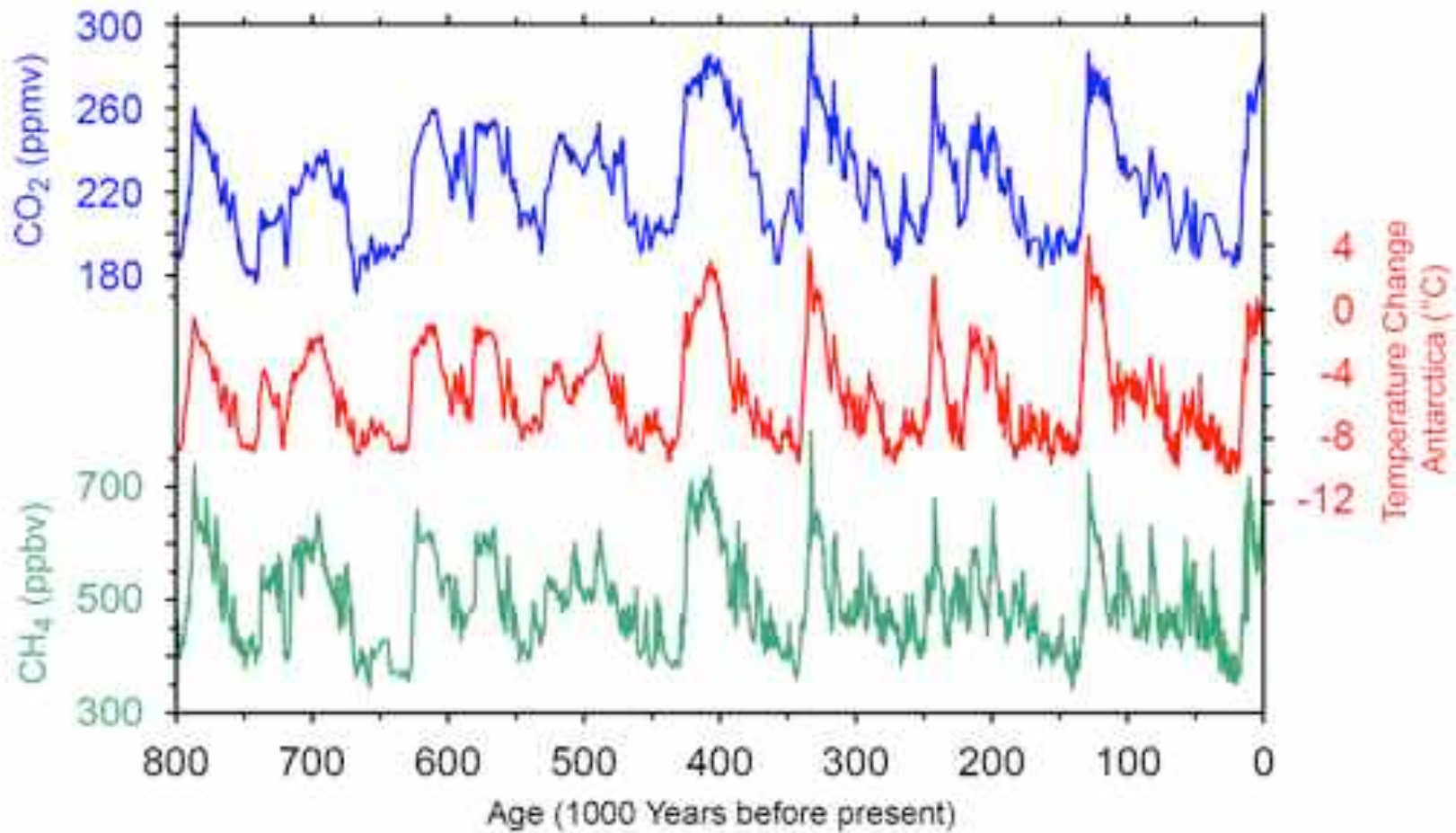
CO₂ : Higher levels and faster rise



(Joos & Spahni, 2008)

Rates of greenhouse gas increase are now more than 100 times higher than during the last 20,000 years

Greenhouse gases over the past 800,000 years

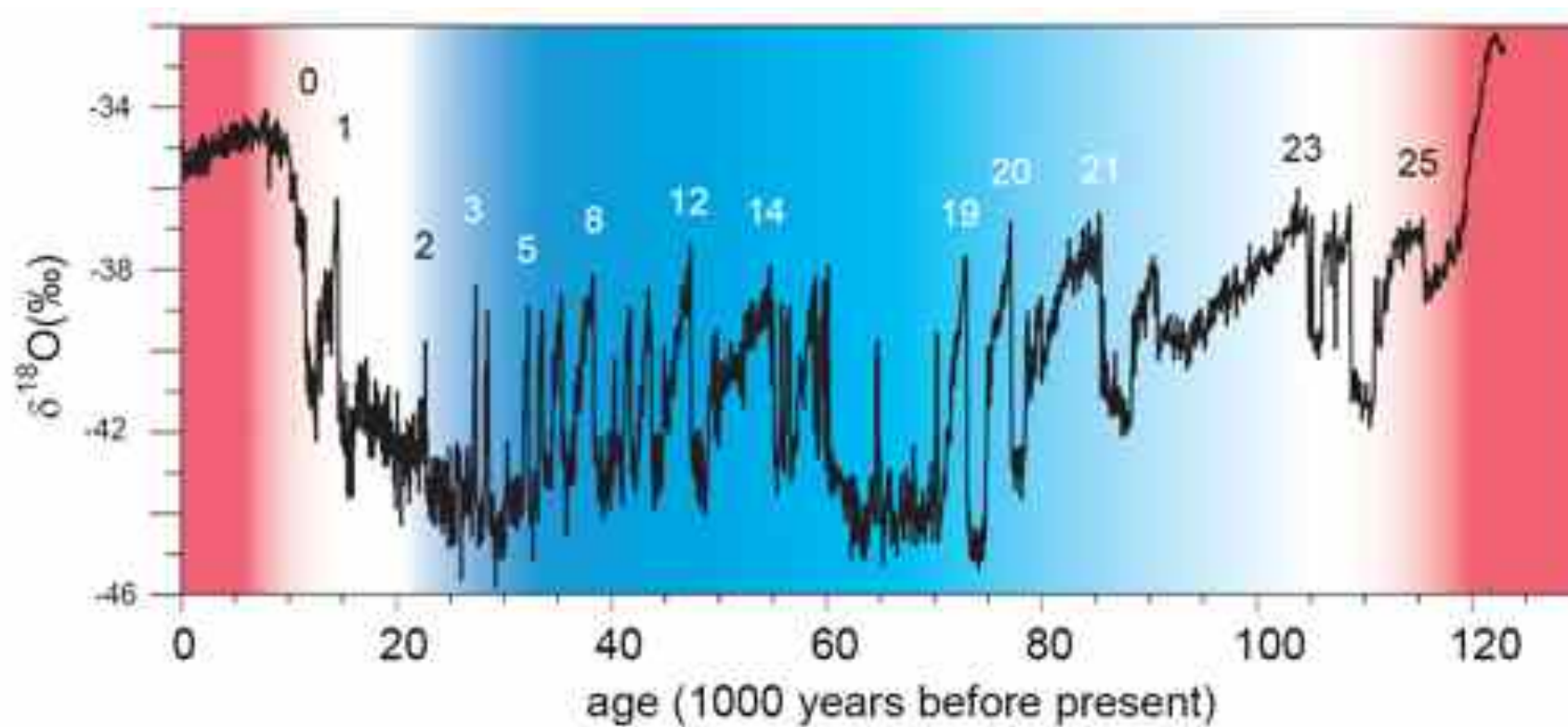


Abrupt change and surprises in the climate system

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UNIVERSITÄT
BERN

OESCHGER CENTRE
CLIMATE CHANGE RESEARCH



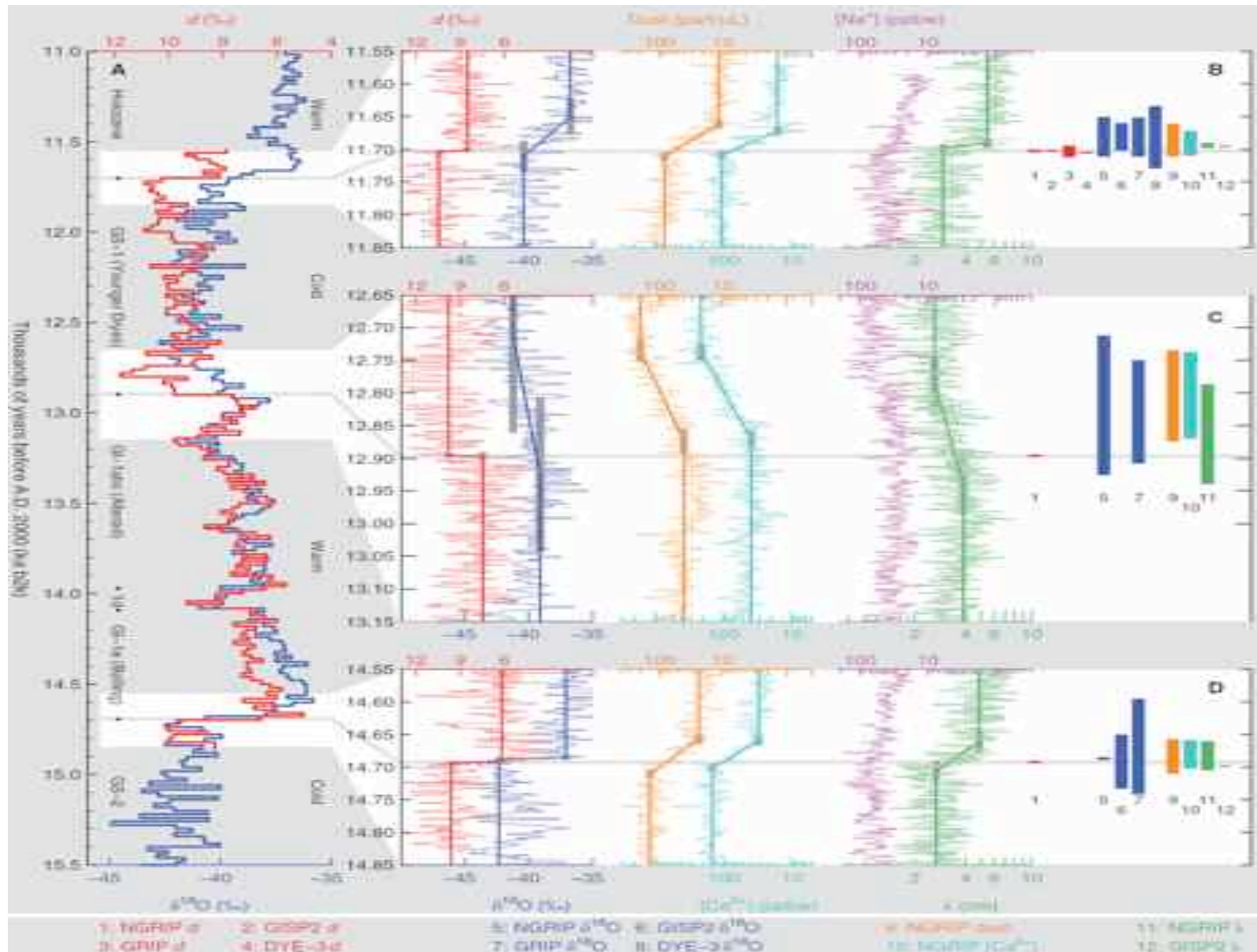
NorthGRIP Members (2004)



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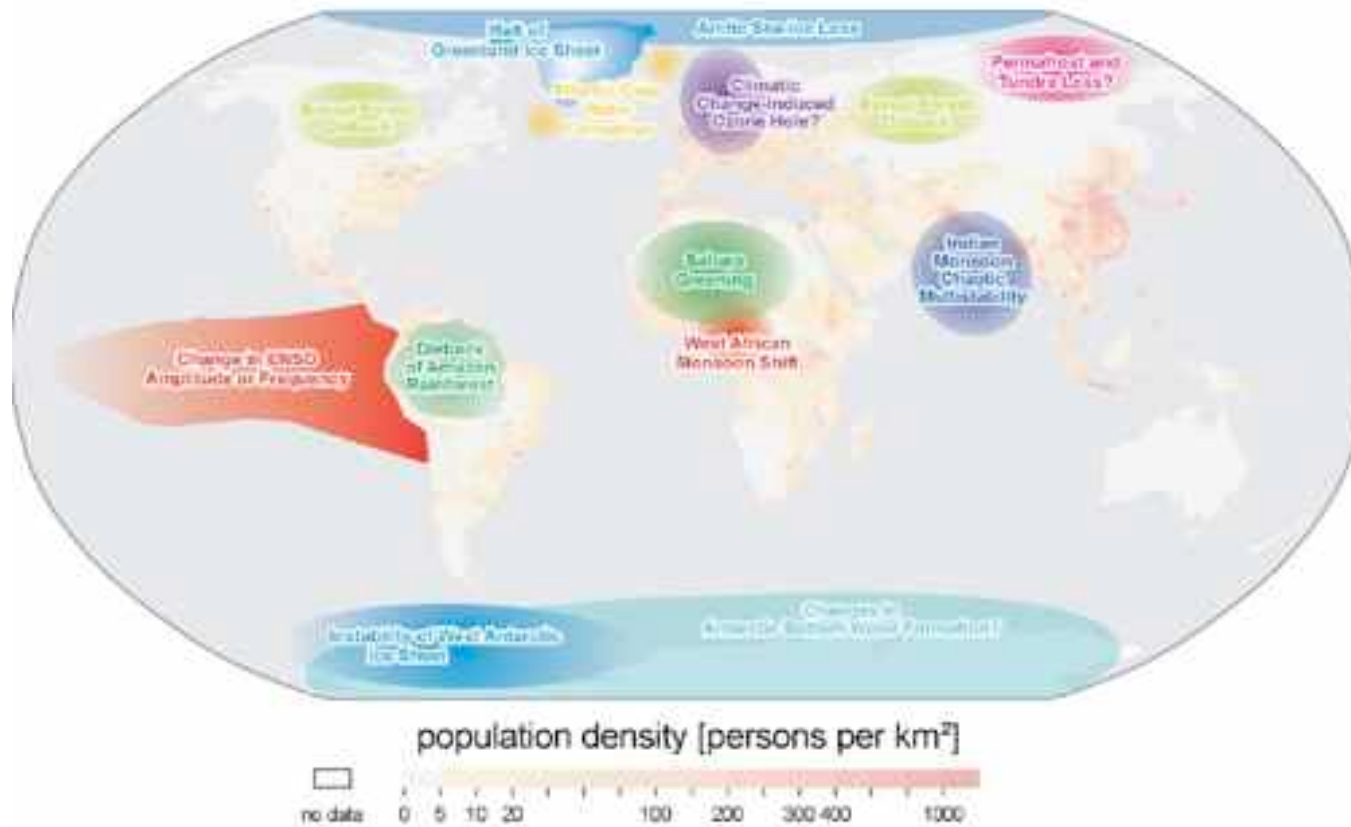
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Abrupt change and surprises in the climate system



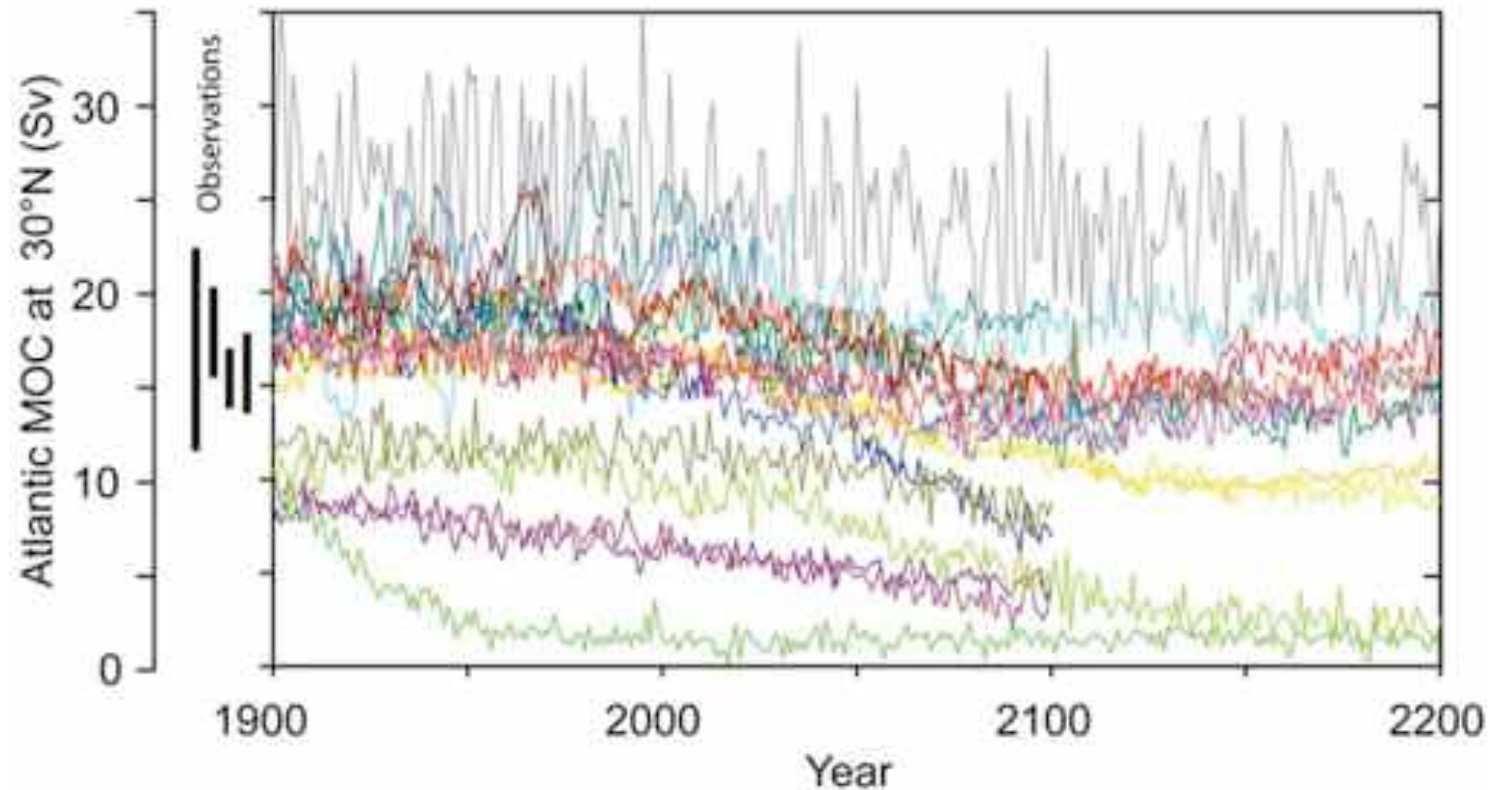
(Steffensen et al., 2008)

Collection of potential „tipping elements“



(Lenton et al., 2008)

Tipping point in Atlantic meridional overturning ?



Very likely reduction of the Atlantic MOC

Very unlikely an abrupt reduction or collapse of the MOC



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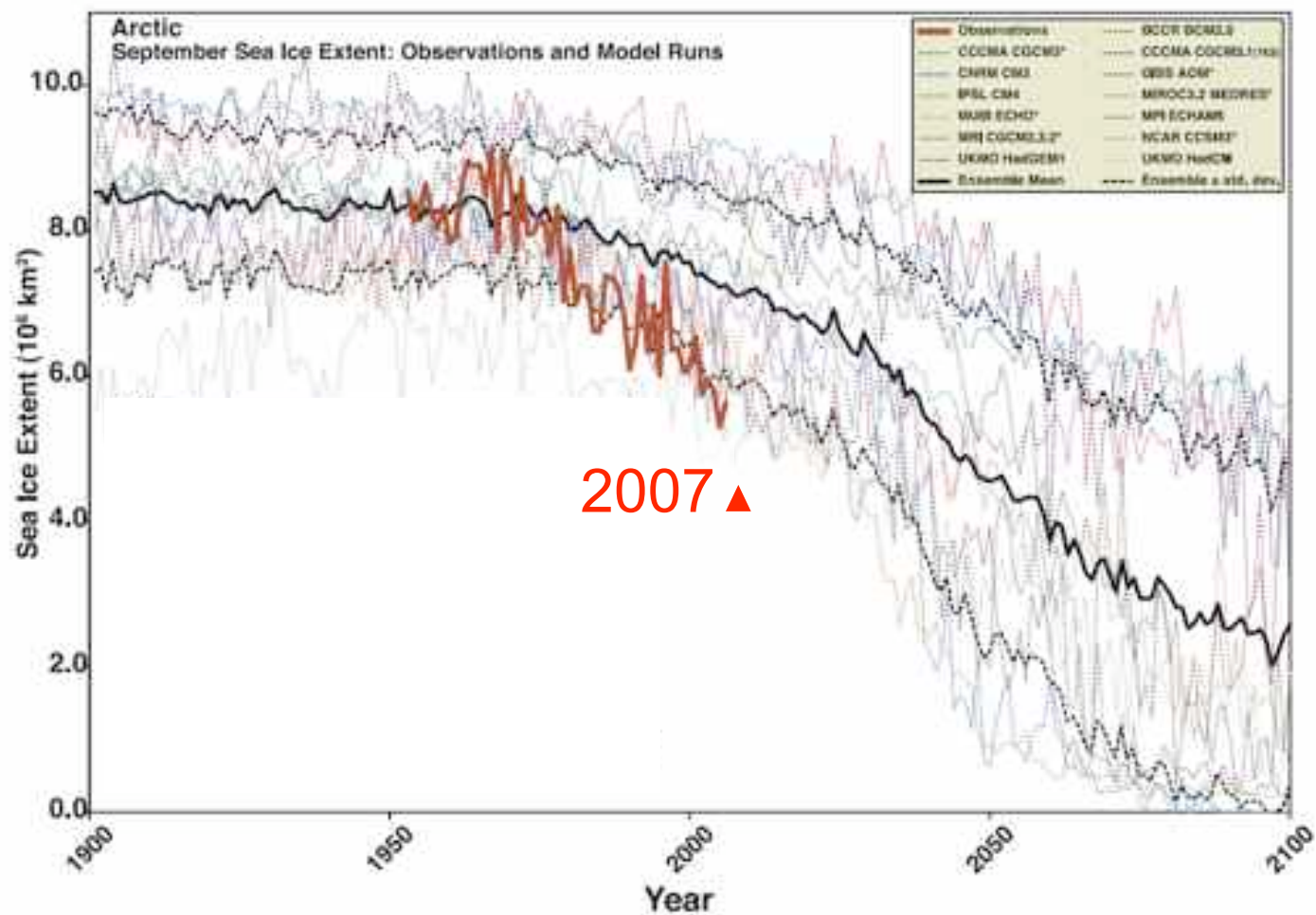
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Summer sea ice extent 2007: A record low



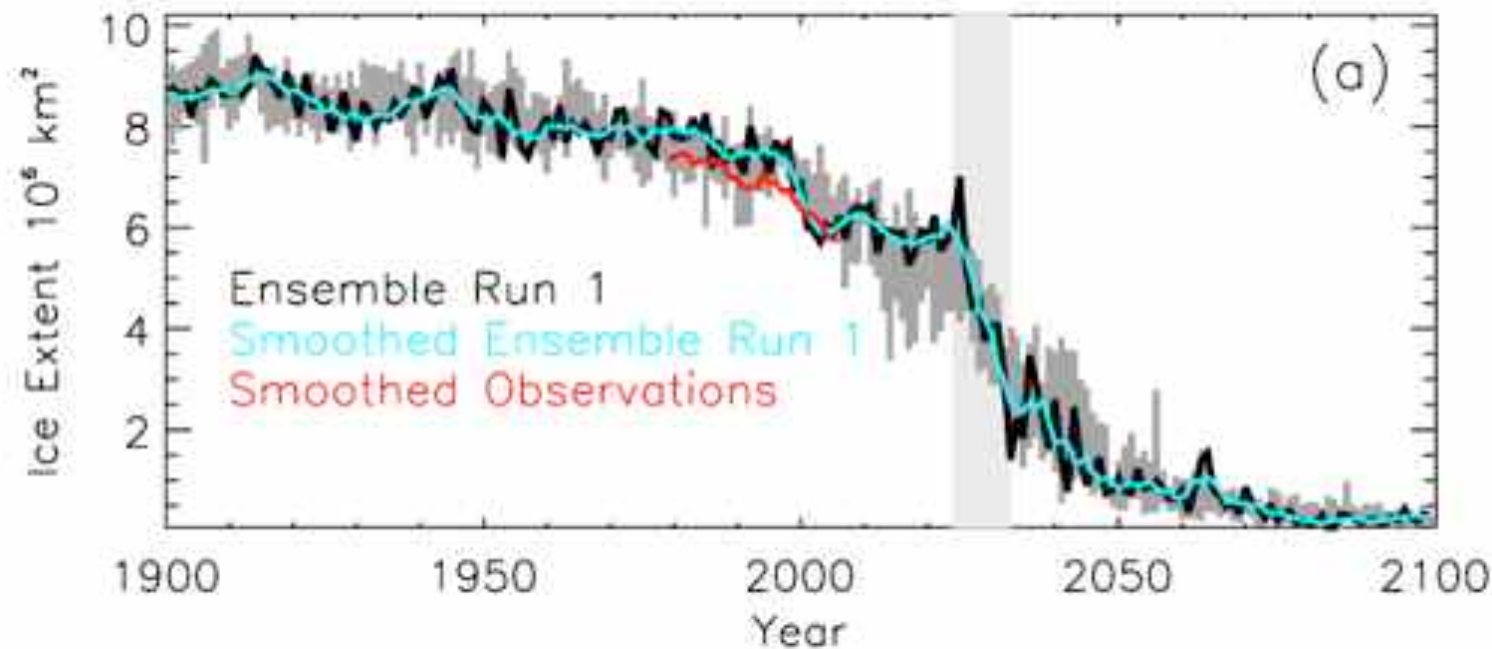
Record 2007:
collapse or natural
variability ?

Arctic sea ice reduces rapidly



(Stroeve et al., 2007)

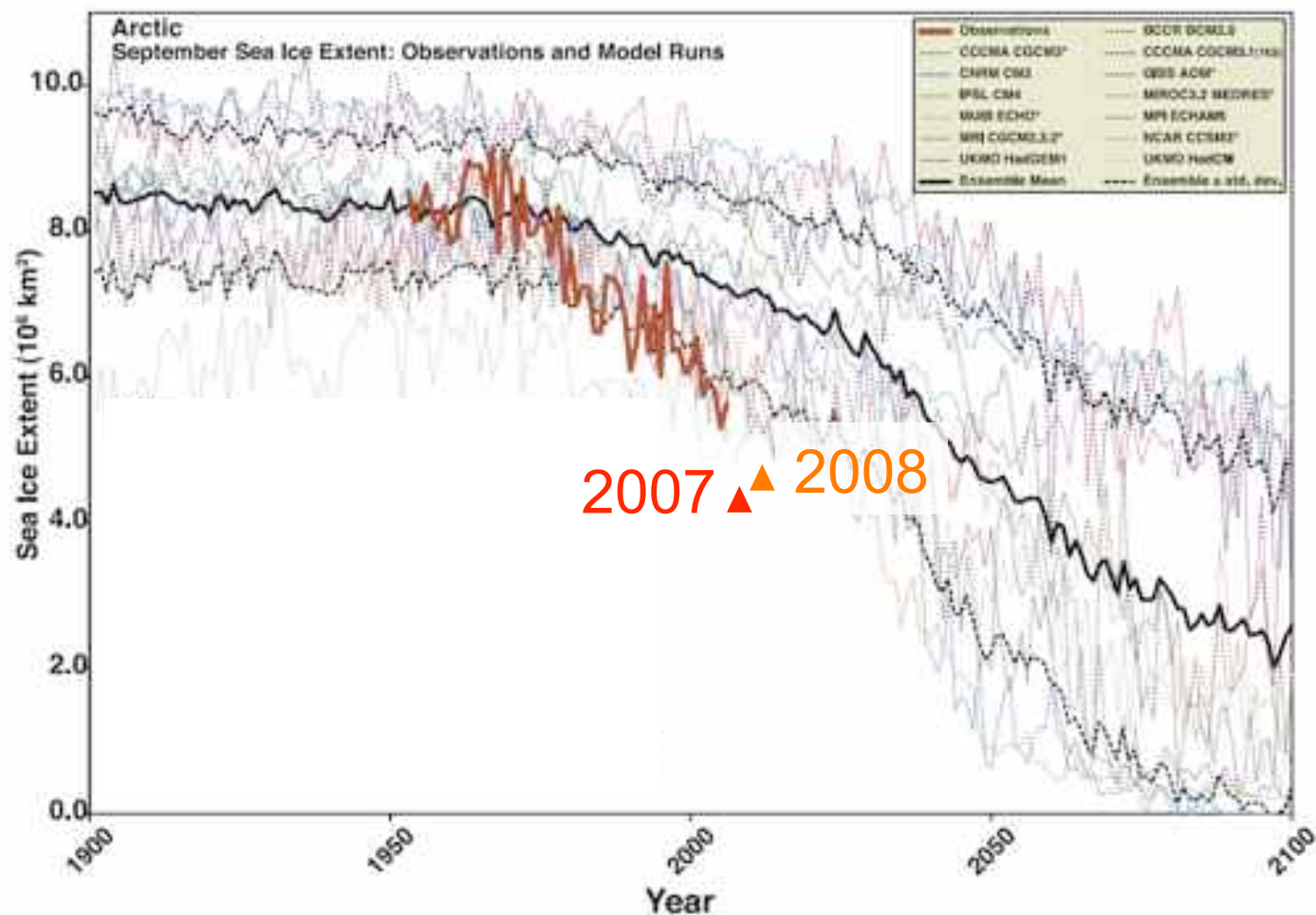
Simulated reductions of Arctic summer sea ice



(Holland et al., 2006)

Decade-long rapid decrease of summer sea ice
„4 times larger than comparable observed trends“

Arctic sea ice reduces rapidly



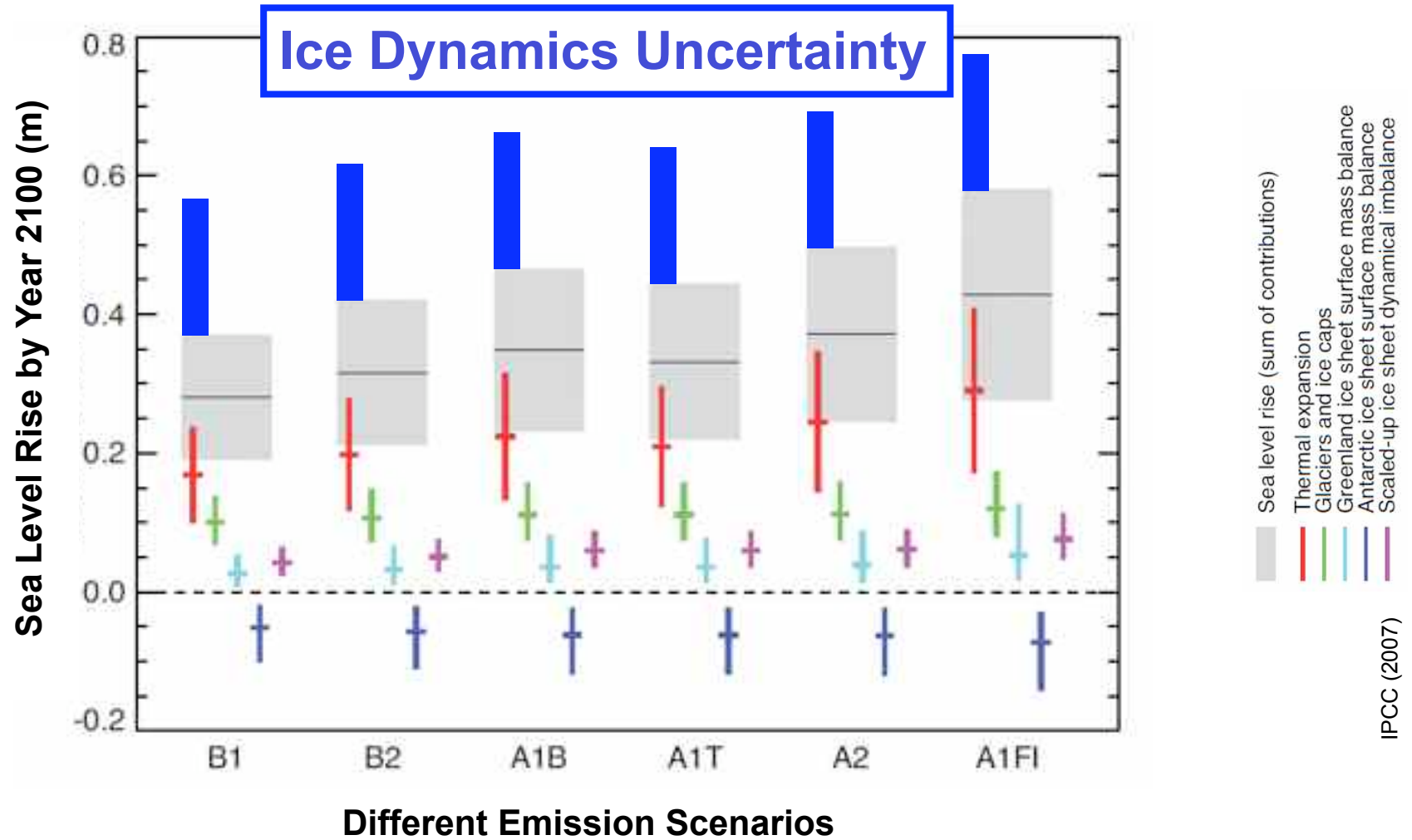
(Stroeve et al., 2007)



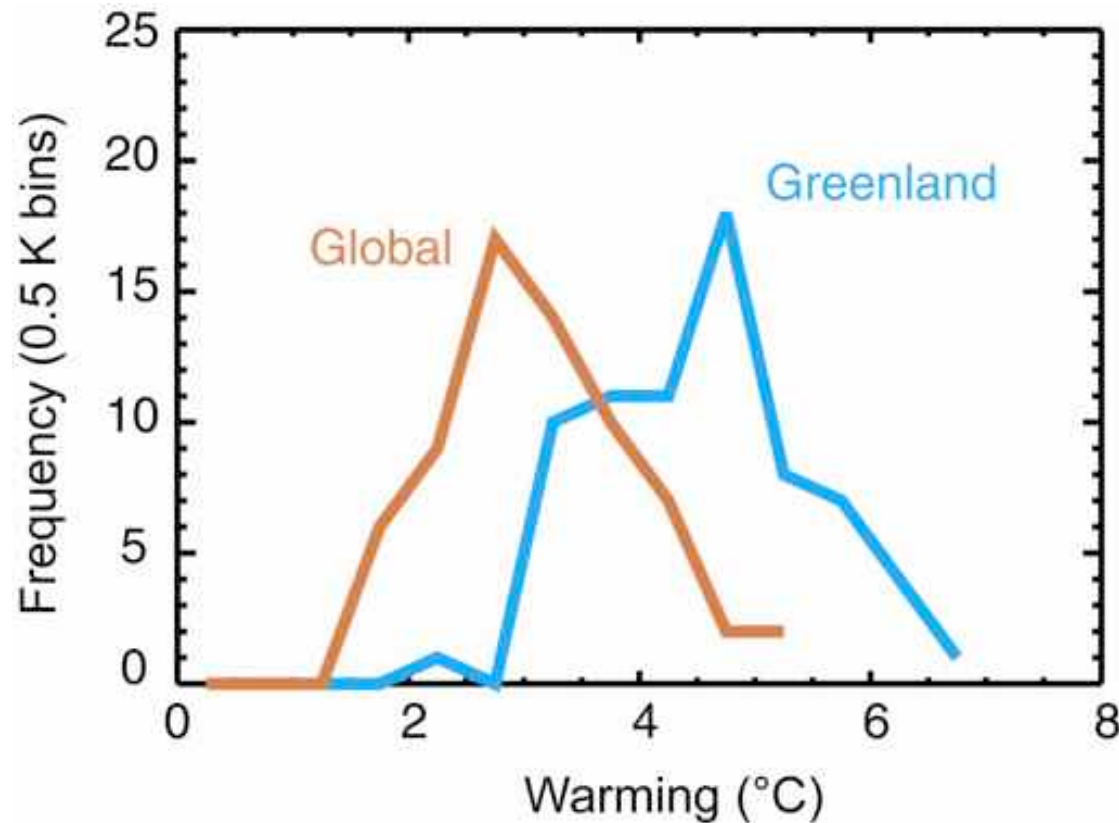
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Implications for sea level rise ?



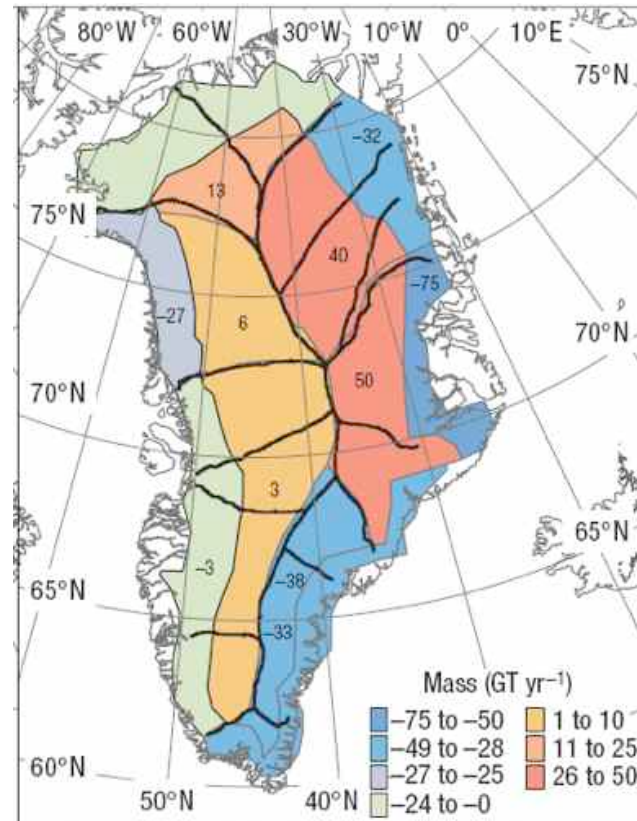
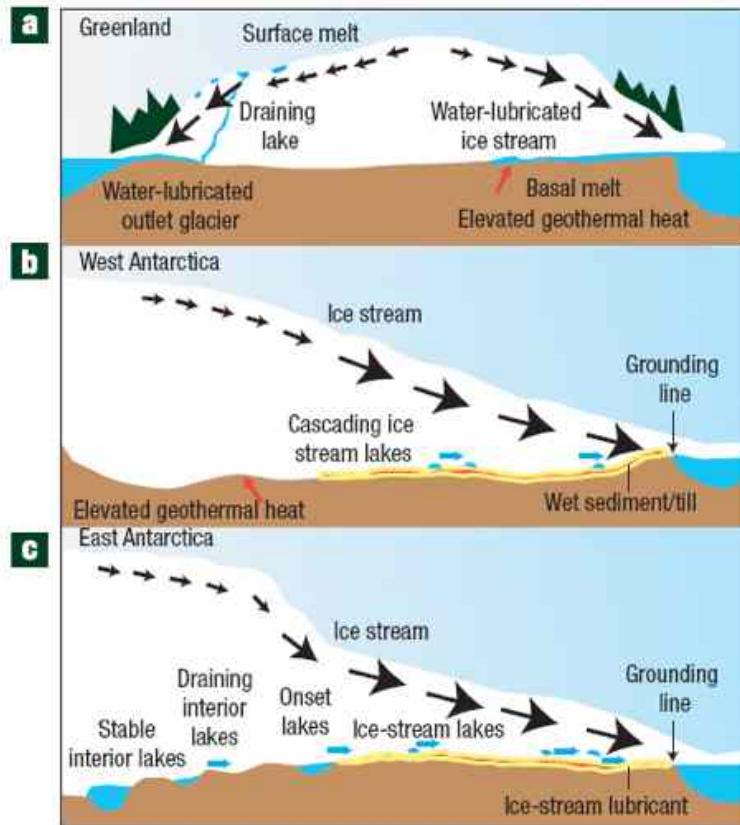
Temperature threshold in Greenland mass balance



(Gregory & Huybrechts, 2006)

"For sustained warmings above this threshold, it is likely that the ice sheet would eventually be eliminated."

Mechanisms of ice sheet acceleration





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Conclusions and open issues

- Each International Polar Year has provided a quantum leap in our understanding of the Earth System;
- The polar areas are sensitive recorders and indicators of past and future climate change. They are particularly vulnerable;
- Essential new observations and paleoclimate reconstructions from polar areas permit a more reliable quantification of natural ranges of climate change;
- Better understanding of ice sheet mechanisms is needed in order to reduce uncertainties in long-term sea-level projections.

Conclusions and open issues

Key Questions to be answered:

1. What is the fate of the West Antarctic Ice Sheet ?
2. Where is, or is there, a tipping point for Greenland melt down ?
3. How will Arctic permafrost react to the warming ?
4. What is the effect of a decrease in ocean pH on marine ecosystems ?
5. To which extent is anthropogenic climate change irreversible ?



NEEM Station: $77^{\circ} 26' 54.9''$ N $51^{\circ} 03' 19.9''$ W