Outline

- Introduction; problem statement
- Changes in global mean temperature
- Changes in Arctic temperature
- Sea level rise
- Melting of the great ice sheets

Article 2, UNFCCC

Anthropogenic climate change:

the climate change caused by human interference with the climate system; Article 2 of the UN Framework Convention on Climate Change (UNFCCC) states that dangerous anthropogenic interference with the climate system must be prevented, by stabilising the concentration of greenhouse gases in the atmosphere.

Anthropogenic Climate Change

(a) Anthropogenic emissions of greenhouse gases will lead to a significant global warming

IPCC 2001: expected 1.4 – 5.8 ºC warming 1990-2100

(b) Human activities have already noticeably changed the climate

IPCC 1996: "*The balance of evidence suggests that there is a discernible human influence on global climate*"

Note: (a) is the policy-relevant one; it is not conditional on (b)

The Challenge

The challenge is to implement emission reduction pathways that stabilise GHG concentrations in the atmosphere at such a level, that in the end a targeted global mean temperature rise will occur, associated with ‘acceptable risks’

The EU position

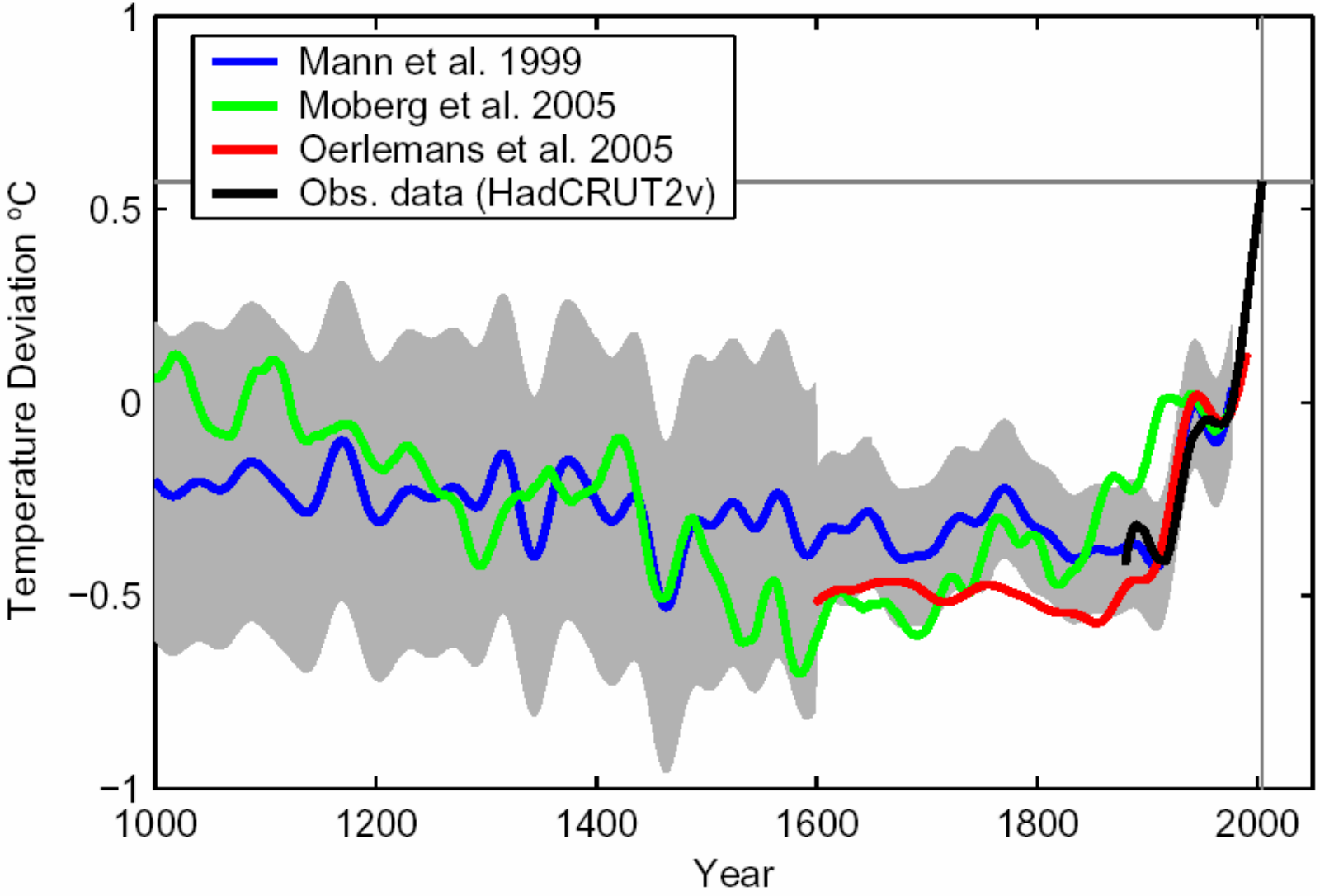
A discussion is going on about the choice of *an adequate temperature target* (with an associated level of greenhouse gas concentration). The EU is opting for the 2^0 C target.

Scientific information + ….

The choice of a temperature target in the context of Article 2 requires *scientific information* on the consequences and risks of a variety of options to achieve this target as well as a consideration and *balancing of the interests involved*

Changes in global mean temperatures

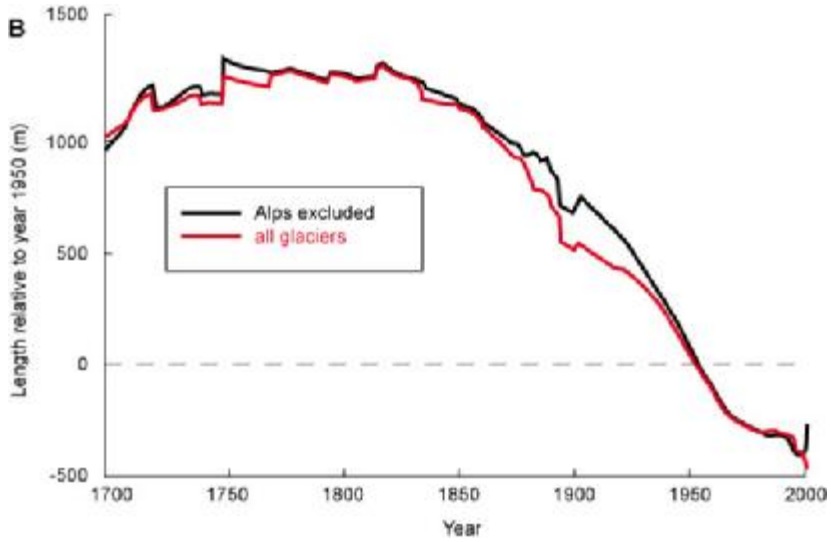
- The ‘hockeystick’ discussion
- Example of a proxy
- Recent NRC findings
- In conclusion


Mann et al. 1999
Moberg et al. 2005
Oerlemans et al. 2005
Obs. data (HadCRUT2v)
Temperature Deviation °C
1
0.5
0
−0.5
−1
1000
1200
1400
1600
1800
2000
Year

Example of a proxy

- Oerlemans (2005) related changes in glacier length to changes in temperature
- From 1900 to 1980, 142 of the recorded 144 glaciers retreated. Glacier retreat on the century time scale seems to be fairly uniform around the globe
- Most regions show a temperature increase from 1860 onwards. In the first half of the 20th century the temperature rise is notably similar for all regions in the world: about 0.5 K in 40 years

Stacked records of glacier lenght (Oerlemans, 2005)



Other evidence of global warming

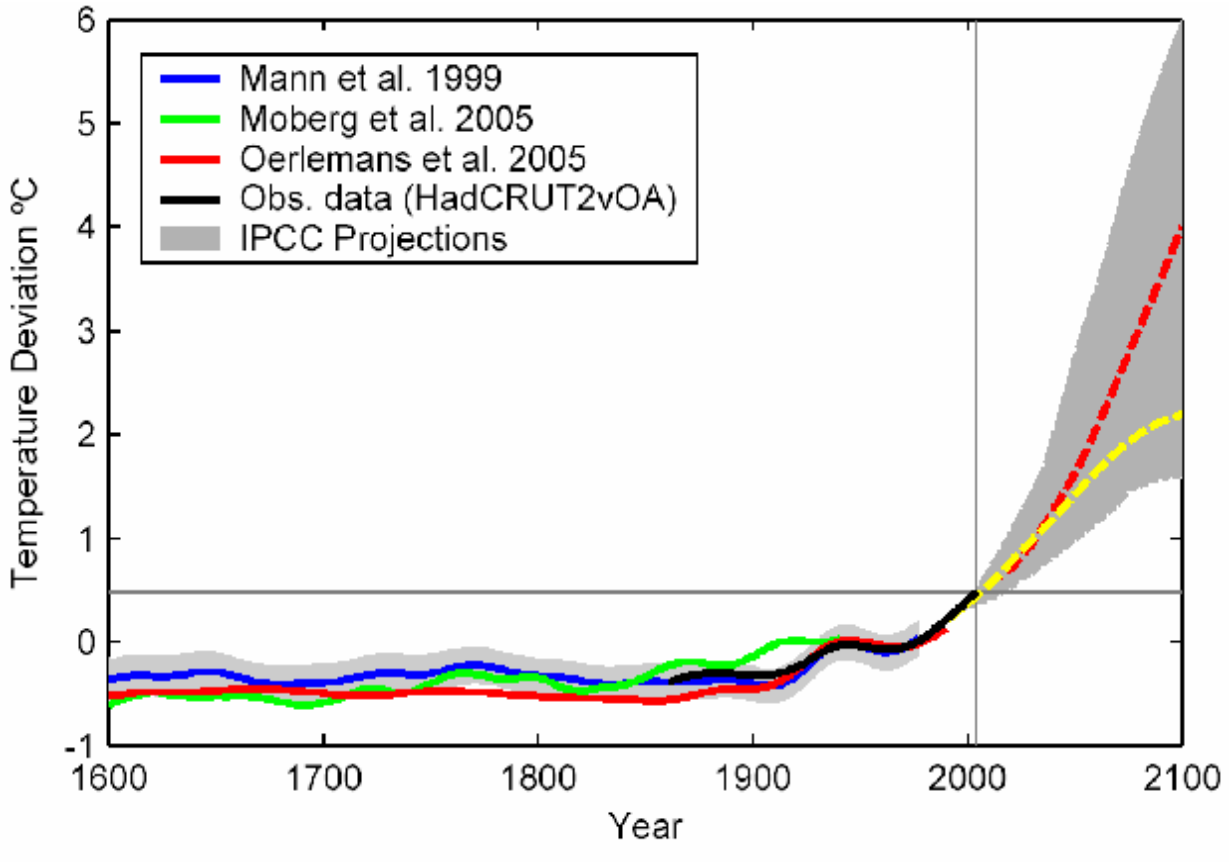
US National Research Council (Science, 30 June 2006):

the last decades of the 20th century were most likely warmer than any comparable period in the past 1000 years. This is a confirmation of the pattern: warm (10th and 11th century) – cool – much warmer.

Global warming: in conclusion

It can be stated that over de last 3-4 decades we can see *an increase of 0.12 – 0.16 ^{0}C in the average surface temperature* of the Earth. There is general agreement that part of this warming is caused by building up of heat-trapping gases, mainly emitted by burning coal and oil.

Past and future temperatures



Climate sensitivity (1)

The climate's sensitivity is expressed in terms of the global mean increase of the (surface) temperature (in degrees Celsius) resulting from a doubling of CO_2 (equivalent) concentration in the atmosphere, compared to the pre-industrial level, i.e. approx. 550 ppmv.

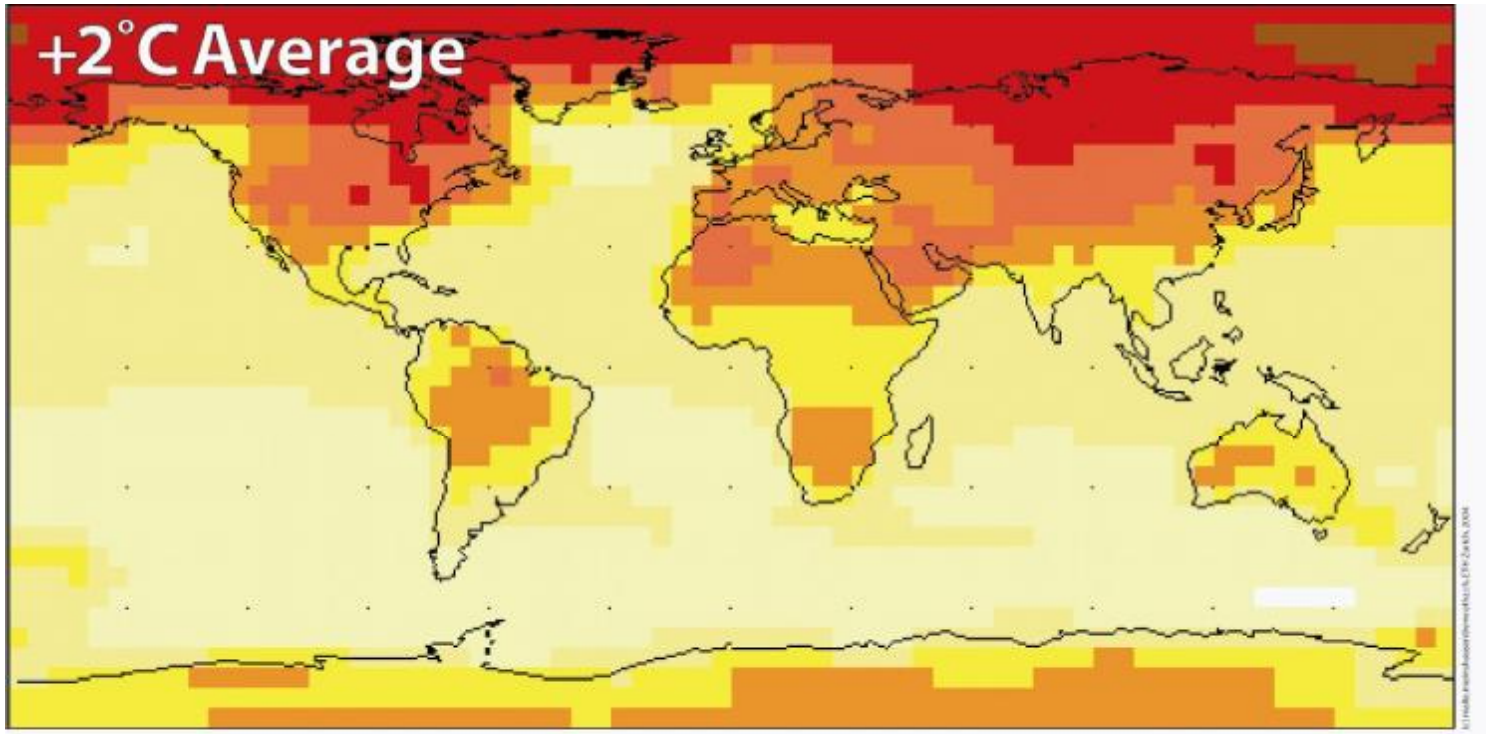
Climate sensitivity (2)

- The most recent insights give ranges (probability range per cent) of 1.5 C– 6.2 C (Hegerl et al,) and 1.5C – 4.5C (Annan and Hargreaves, 2006).
- If we are to stay under 2ºC, the concentration must be stabilised at a level below 550 ppmv.

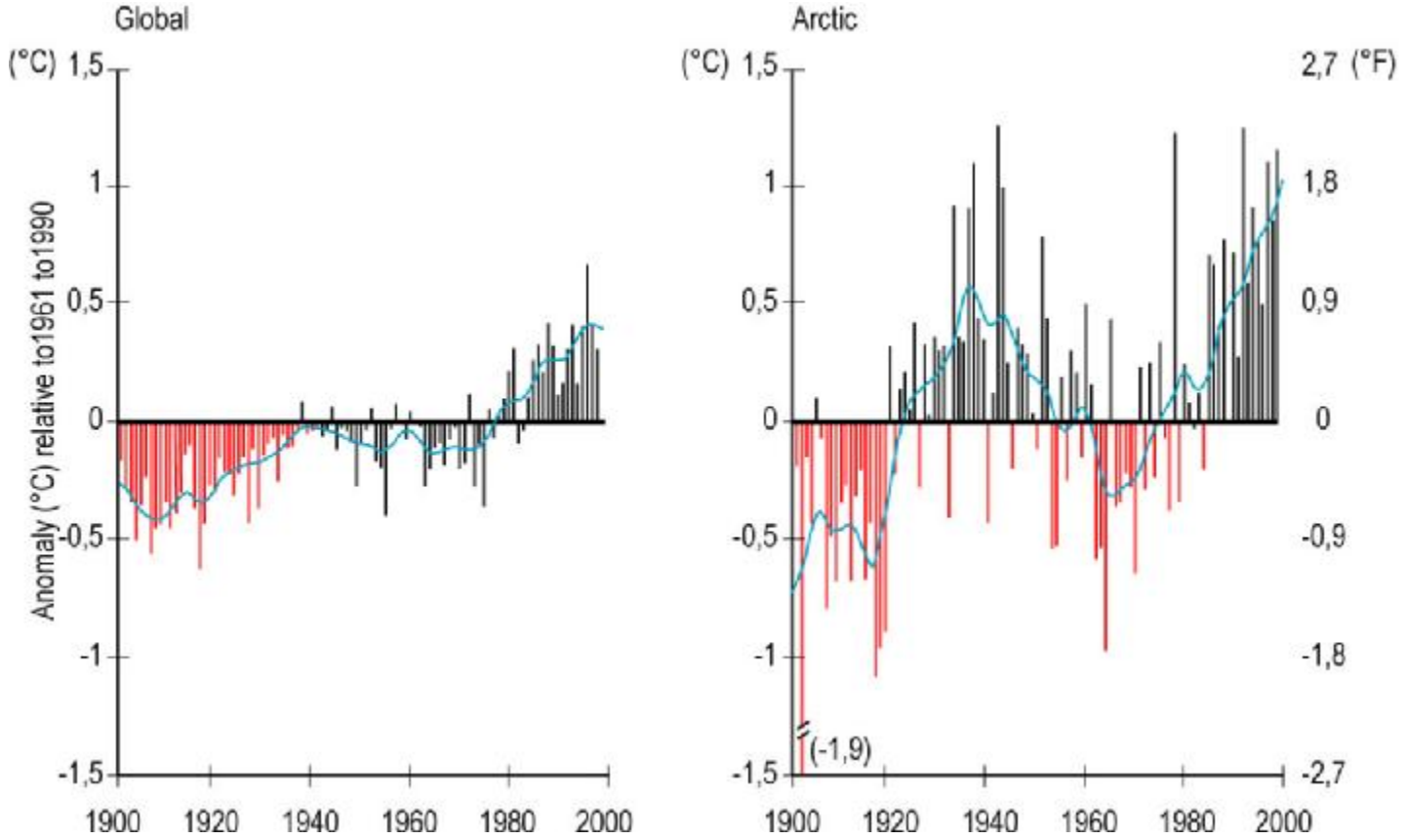
Arctic temperature rise and its impacts

- During the past few decades the average temperature in the Arctic has risen *nearly twice as fast as in the rest of the world*
- A number of mechanisms are responsible for this
- A global average warming of 2ºC (as is considered by the EU) corresponds to an increase of 4–8ºC in the Arctic

Regional surface temperatures at a global increase by 2^0C



Amplified Arctic temperatures



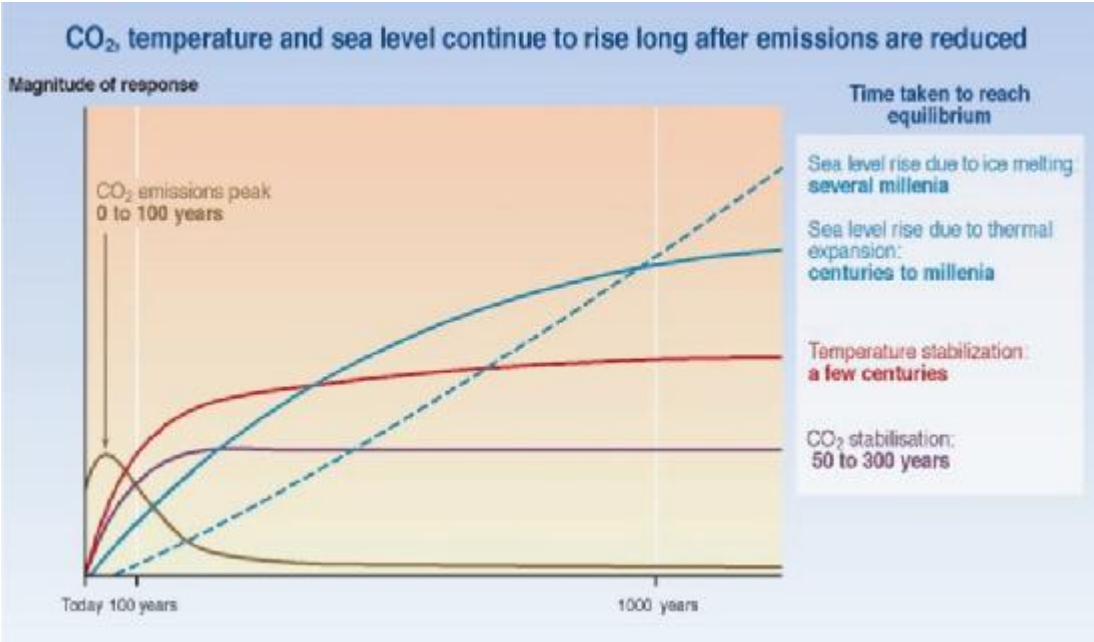
Impacts of amplified Arctic warming

- Melting of sea ice and associated effects on mammals, seabirds, etc.
- Melting of glaciers, resulting in sea level rise and decrease in salinity of northern seas
- Melting of permafrost, with risk of damage to infrastructure and acceleration of climate change

Sea level rise (1)

- Sea level movement is a natural phenomenon, but this can be reinforced by anthropogenic climate change
- Global mean sea level rise during the 20th century was 10–20 cm (Church and Gregory, 2001).
- Rapley (2005) estimates the current rate of sea level rise at ca. 1,8 mm/year.

Time lags in the climate system



Sea level rise (2)

- The process of thermal expansion is characterised by a long delay after a temperature increase, meaning that it is necessary to look several centuries ahead
- The IPCC expected the global mean sea level to rise in 2100 by 9–88 cm
- This range does not incorporate the major uncertainties attached to possible large changes in the West Antarctic Ice Sheet (WAIS) and the Greenland Ice Sheet

Sea level rise (3)

- A global mean sea level rise is thus unavoidable during the 21st century and thereafter. But we can influence the (rate of) sea level rise in the 22nd century and thereafter by cutting greenhouse gas emissions in the current century

Sea level rise (4)

- The changing mass of the great ice sheets of Greenland and Antarctica represents the largest unknown in predictions of global sea-level rise over the coming decades
- The *potential* effect of these ice sheets on the sea level as a result of global warming is great. Projections indicate that there is enough water in these ice sheets taken together for a sea level rise of up to 13 metres over the next 1000 year

Melting of the great ice sheets (1)

- Risk of non-linear effects (various disintegration processes, such as the ‘lubricant’ effect)
- Recent indications of these disintegration processes are a doubling of the frequency of icequakes during the past 5 years (Ekström, 2006) and a doubling of the net loss of ice of the Greenland ice sheet during the period 1996-2005.

Melting of an icesheet

Melting of the great ice sheets (2)

- These new observations lead one to expect a considerably *greater contribution from the ice sheets to sea level* rise this century than expected by the IPCC

Melting of the great ice sheets (2)

- The *conclusion* is that, while there are still many uncertainties about the longer term (after 2100), it is nevertheless probable that *a global temperature rise of more than 1–2°C will cause irreversible melting of the Greenland ice sheet*, resulting ultimately in a sea level rise of 7 metres
- Because natural variations in the mass balance are large, long term studies are necessary to be able to draw sound conclusions.

Overall conclusion

- Risks of global warming are higher than earlier estimated by the IPCC
- Impacts on the Arctic in particular are relatively high
- Associated effects on sea level: higher rate of change, due to various desintegration processes
- Stabilisation of GHG concentrations in the atmosphere is necessary, at such a level that temperature rise of 1-2^{0} C as a maximum

The Thermohaline Circulation