Decay of glaciers, ice caps and ice sheets

Speaker: Atsumu OHMURA

IAC, ETH Zurich, Switzerland

Moderator: Ralf GREVE

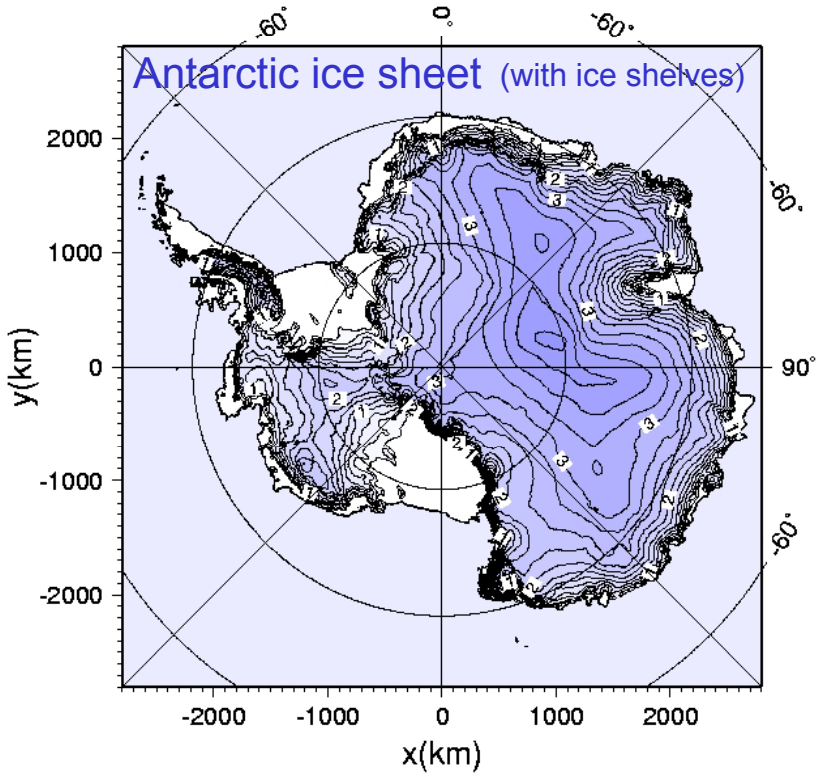
ILTS, Hokkaido Univ., Japan

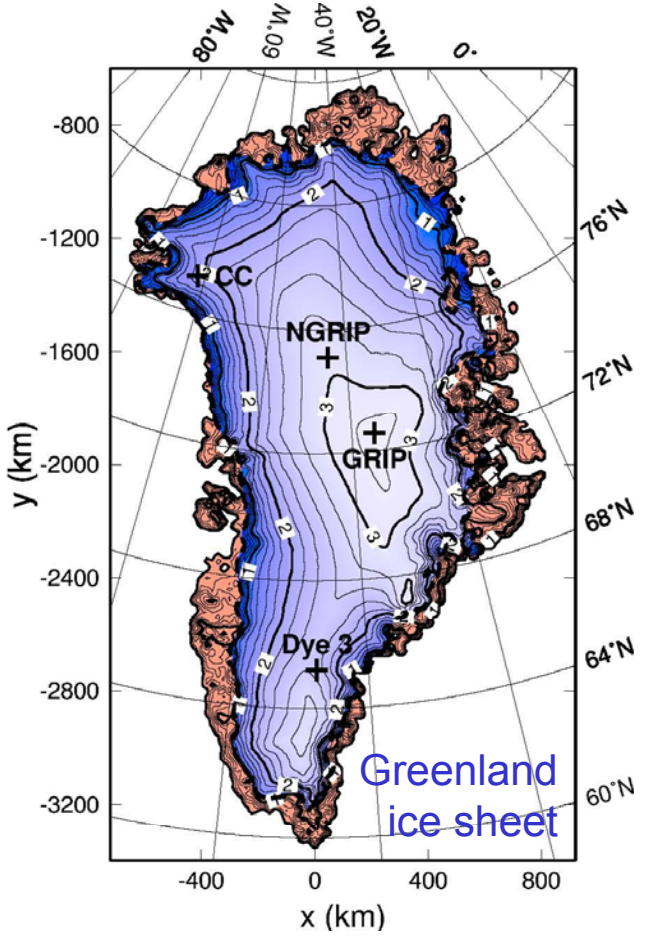
Glaciers and small ice caps

- Number: > 160000.
- ~ 0.5 m sea-level equivalent.

Photo credit: www.glaciers-online.net

Ice sheets





~ 61 m sea-level equivalent.

~ 7.2 m sea-level equivalent.

Contribution to sea level rise

- Sea level rise in the 21st century is predicted to be mainly caused by thermal expansion of sea water and the melting of glaciers and small ice caps.

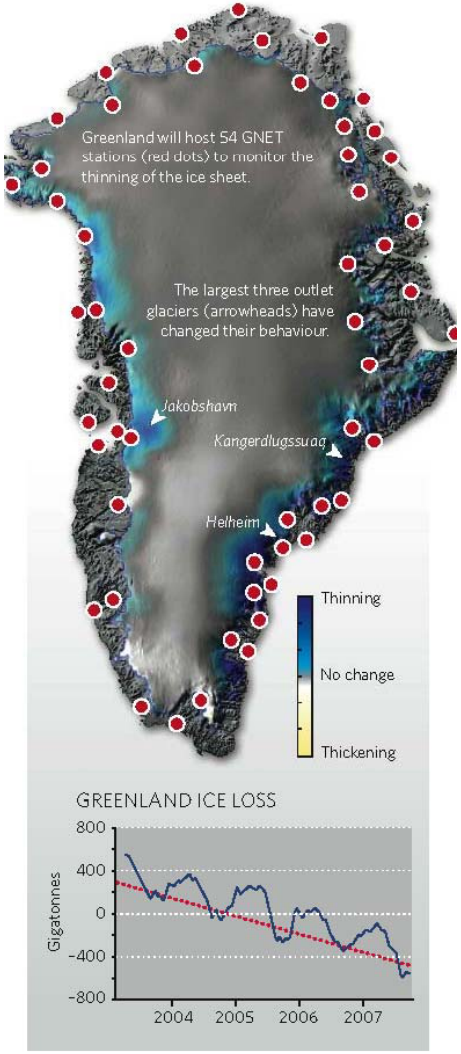
~ 0.5 m sea-level equivalent

- However, surprisingly rapid decay of the large ice sheets (Greenland, Antarctica) has been detected recently, in conjunction with a general speed-up of ice streams and outlet glaciers (ice dynamics!).

~ 7.2 m sea-level equivalent

~ 61 m sea-level equivalent

Recent changes of the Greenland ice sheet



Source: Witze (2008)

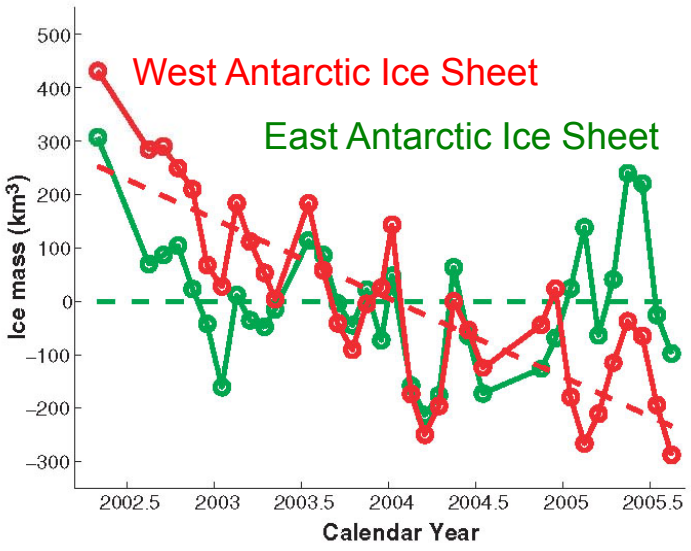
- Interior ice sheet:
  on average in balance, some regions of local thickening or thinning.
- Marginal areas: thinning predominant.
- Overall mass balance negative: –50 to –90 km^3/a, corresponding to a sea-level contribution of 0.15 to 0.25 mm/a.

  (Ohmura, 2004)
- New results from satellite gravity measurements indicate -239 ± 23 km^3/a for the period 2002 – 2005 (sea-level contribution 0.66 ± 0.06 mm/a).

  (Chen et al., 2006)

Recent changes of the Antarctic ice sheet

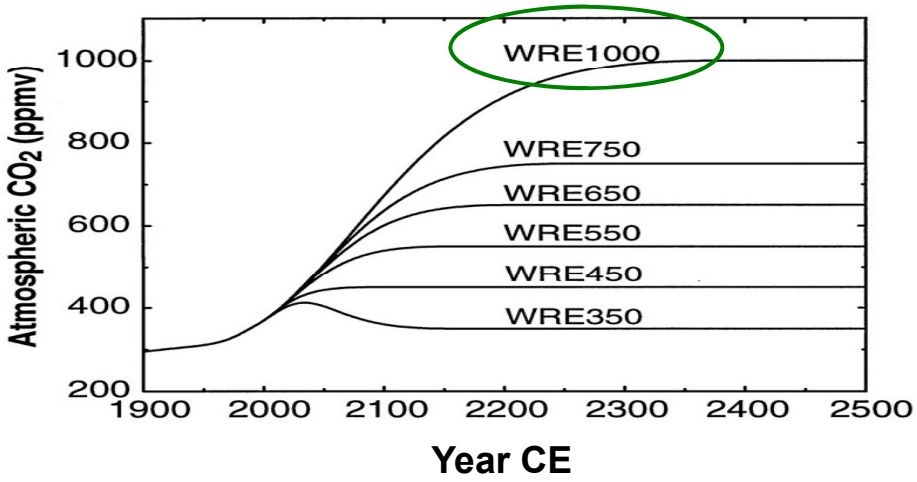
- The Third Assessment Report (TAR) of the IPCC lists an overall mass balance of –376 ± 384 km^3/a (sea-level contribution 1.04 ± 1.06 mm/a). (Church et al., 2001)



- New results from satellite gravity measurements indicate –152 ± 80 km^3/a for the period 2002 – 2005 (sea-level contribution 0.42 ± 0.22 mm/a). (Velicogna and Wahr, 2006)
- Main contribution seems to be from West Antarctica.

Simulation results for Greenland

- Model time: t = 1990 CE (present) ... 2350 CE.
- Climatic forcing: "WRE1000" scenario (future stabilization of atmospheric CO_2 at 1000 ppm).



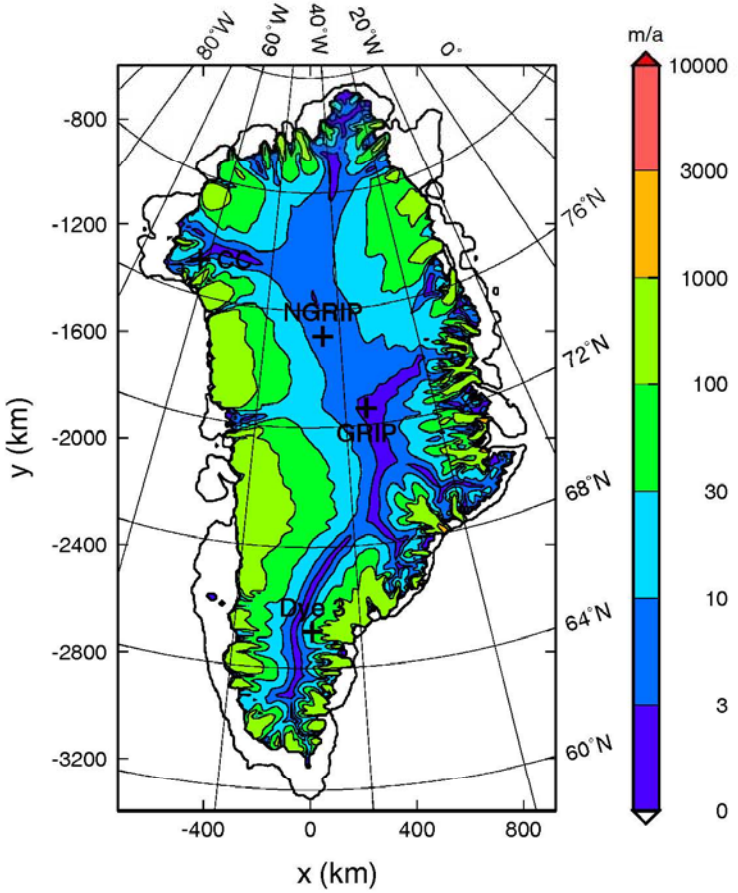
- Ice flow: Set-up #1 → slow basal sliding (usual approach).
  Set-up #2 → basal sliding accelerated by surface meltwater (controversial process).

(Greve and Otsu, 2007)

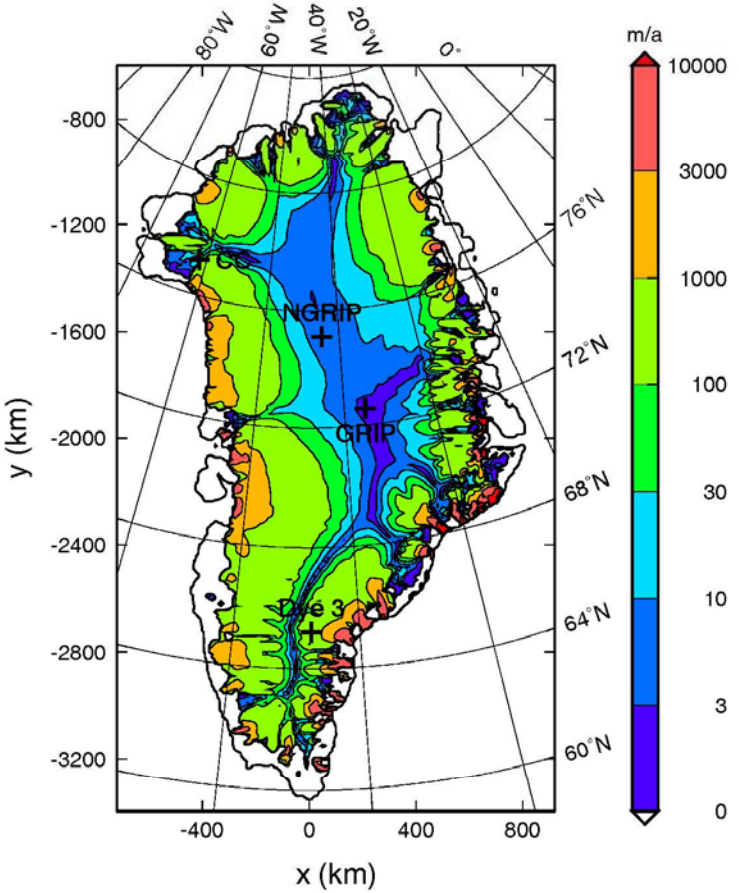
Simulation results for Greenland

Surface velocity → differs greatly for the two set-ups!

2100 CE, set-up #1:



2100 CE, set-up #2:



Simulation results for Greenland

Contribution to sea-level rise

	2100 CE	2200 CE	2300 CE
Set-up #1	0.12 m	0.55 m	1.21 m
Set-up #2	0.58 m	1.51 m	2.71 m

And there is also Antarctica…

→ Large uncertainties due to ice-sheet dynamics

→ IPCC AR4 (Fourth Assessment Report) sea-level predictions for the 21st century may be significantly too small!