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PROMICE

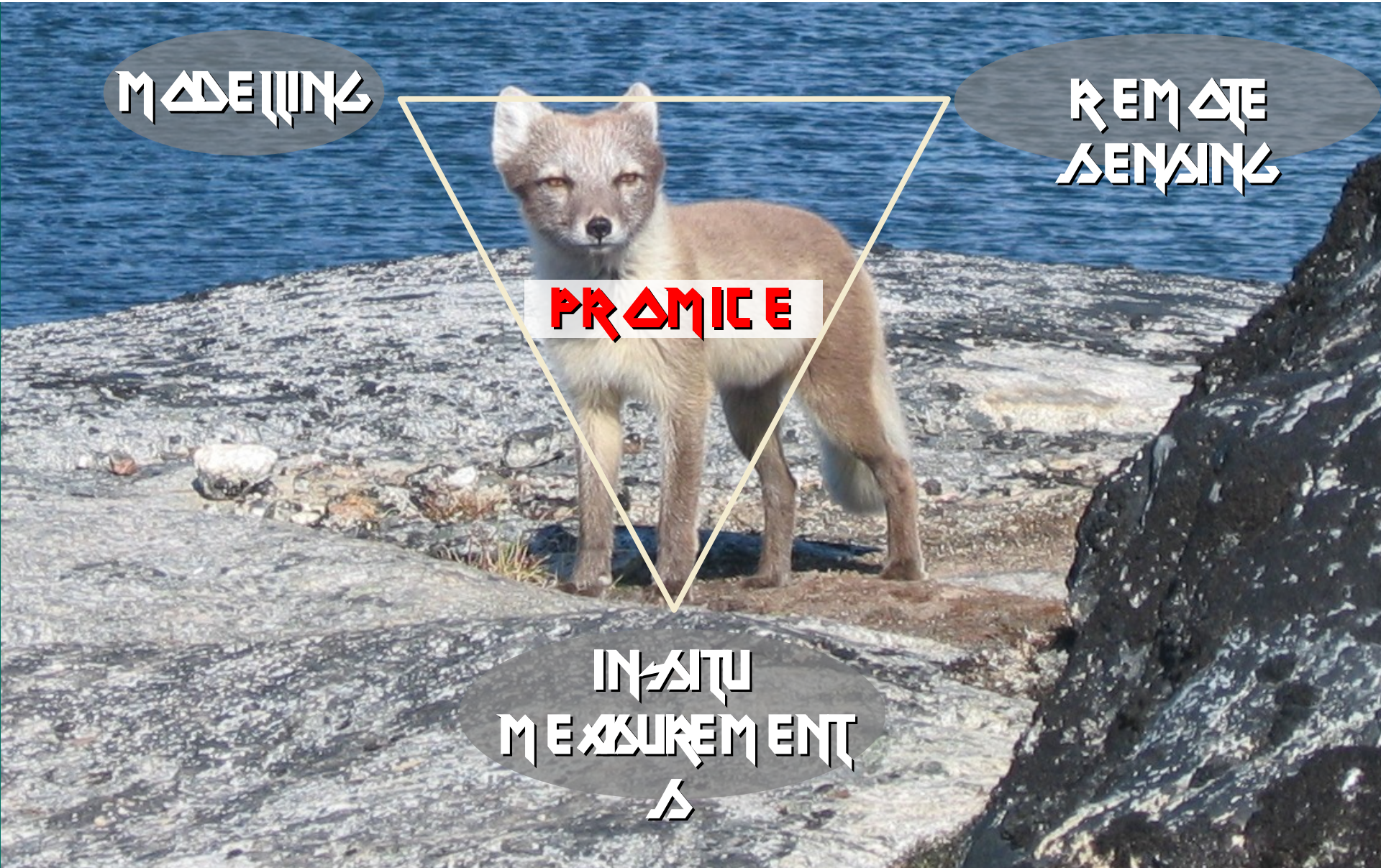
- a new monitoring programme for the Greenland ice sheet

Andreas Peter Ahlstrøm

Geological Survey of Denmark and Greenland

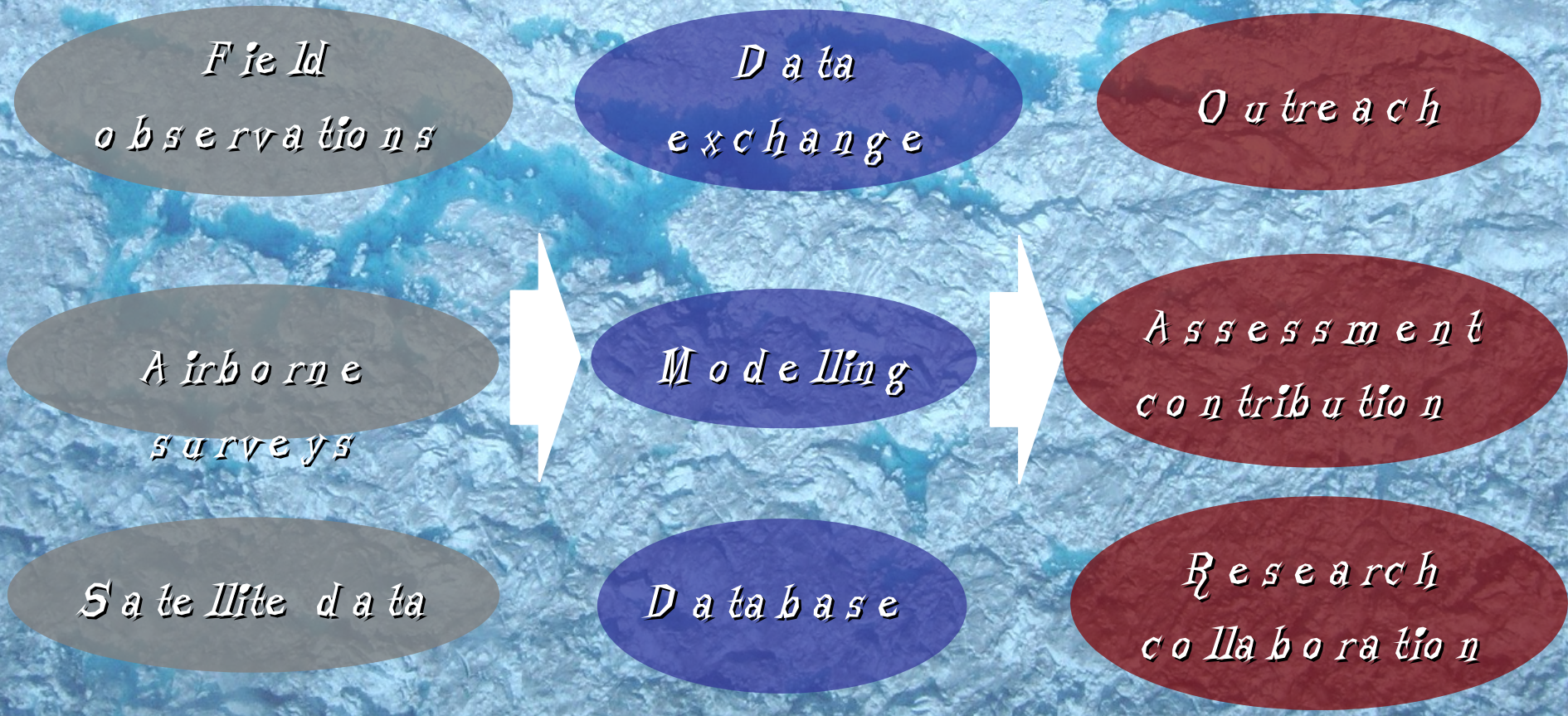
GEUS

Programme for Monitoring of the Greenland Ice Sheet



PROGRAMME FOR MONITORING OF THE GREENLAND ICE SHEET

PROMICE



Organisation

Ministry of the Environment

Miljøstyrelsen/DANCEA

Programme Manager:

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Head of Programme Andreas P. Ahlstrøm

Asiaq

Greenland Survey

Director

Keld Hornbech Svendsen

Danish National Space

Center

DTU

Head of Section

Rene Forsberg

PROMICE

Result

Quantitative knowledge of the mass loss of the Greenland ice sheet acquired on a regular basis

Immediate goal

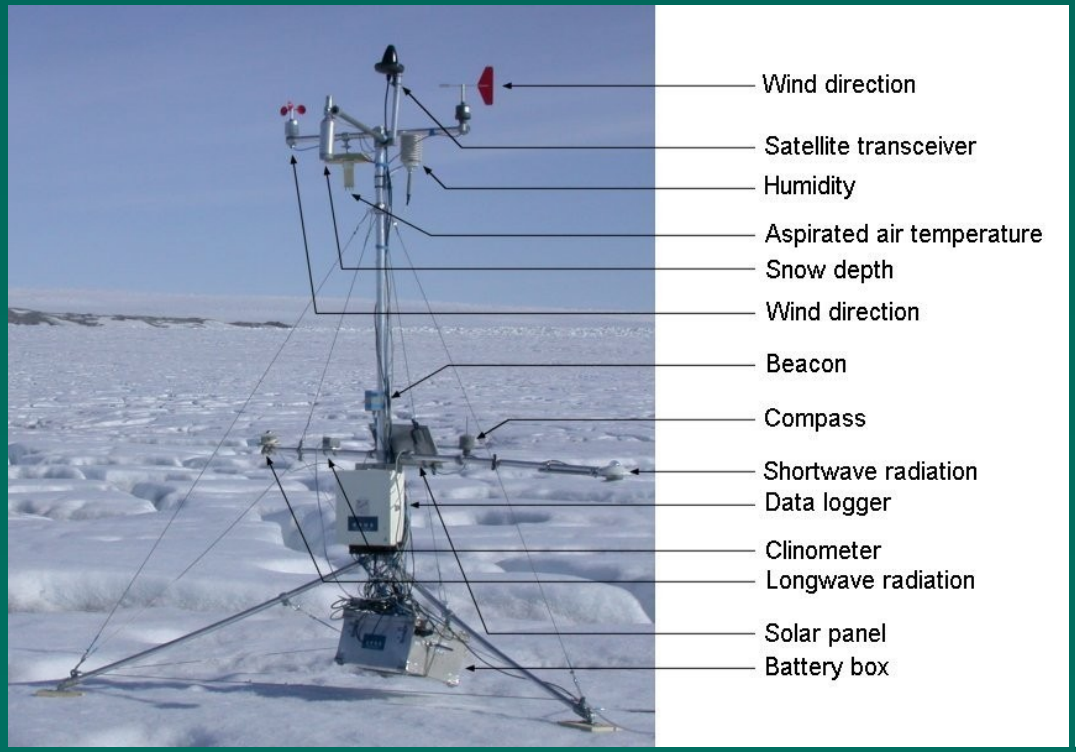
That the results of a systematic monitoring of the mass balance of the Greenland ice sheet and reaction to climate change enters into national and international assessments of climate change

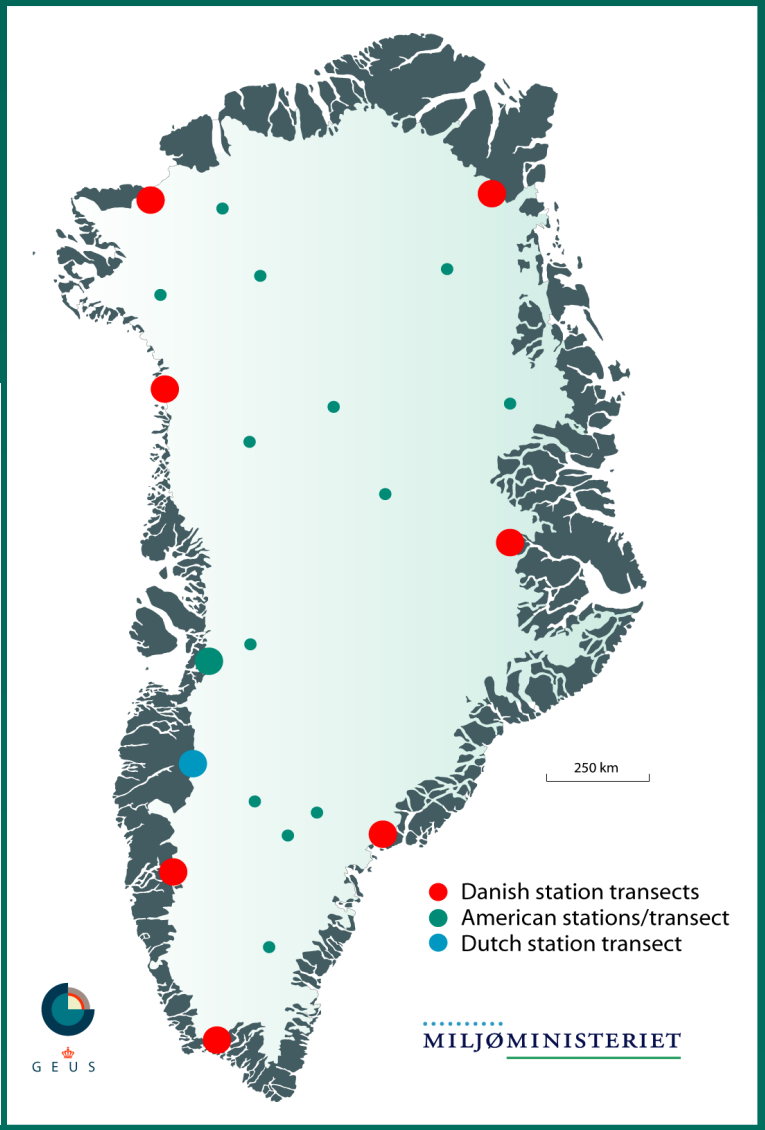
Long-term aim

That international negotiations on CO_2-emissions utilize the quantitative knowledge of the reaction of the Greenland ice sheet to the climate change and subsequently reduce emissions if deemed necessary

In-situ measurements

14 new mass-balance stations on the Greenland ice sheet (each red dot = two)

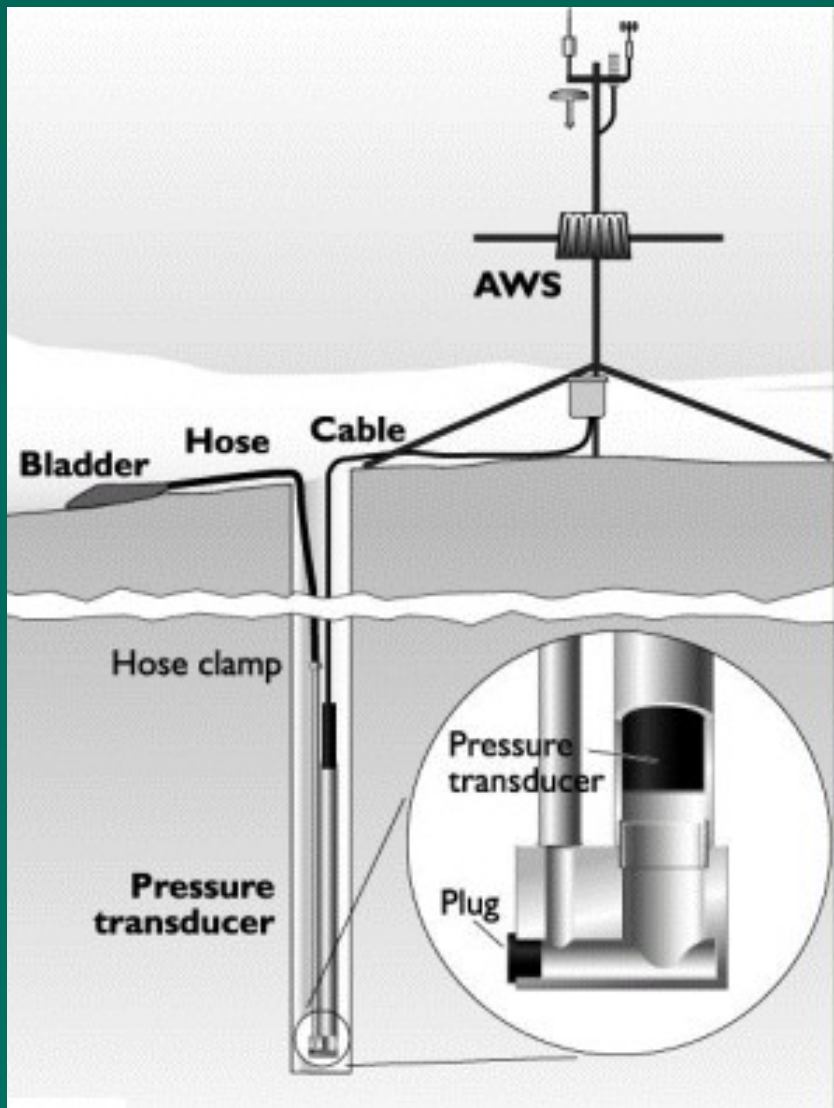




In-situ measurements

New station concept to reduce cost by reducing frequency of visits

Ablation measured with pressure-sensor in 30 m deep holes drilled with new high-performance steam drill



Satellite data

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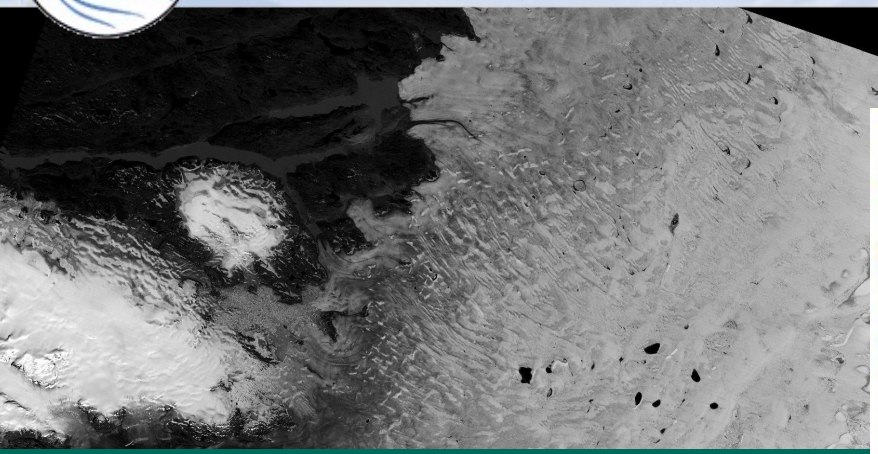
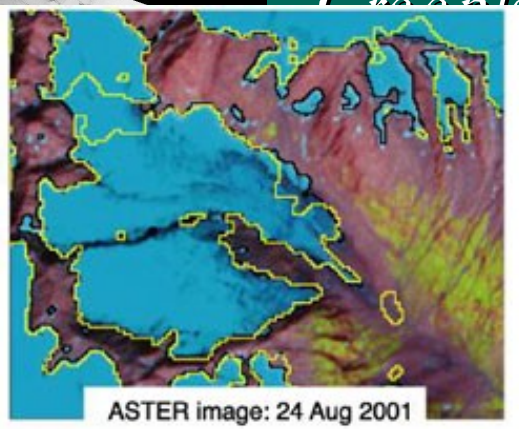
GLIMS - GLOBAL LAND ICE MEASUREMENTS FROM SPACE

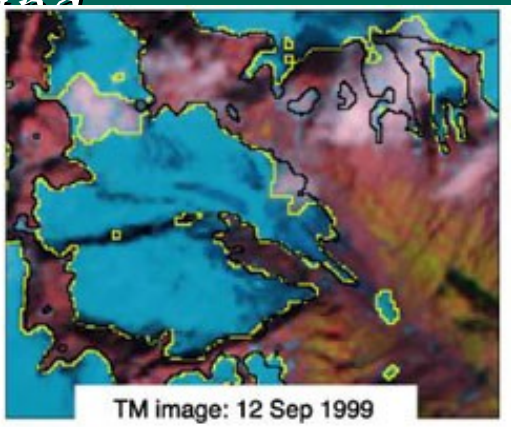
Participating in the surveillance of the Earths ice masses

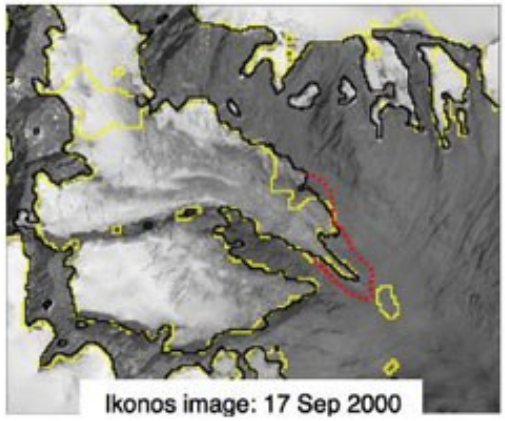


GEUS has assumed the role of Regional GLIMS Center for Greenland

...regular mapping of the extent of glaciers, ice caps and the ice sheet margin in Greenland







glacier mapped from ASTER 24 Aug 2001

glacier mapped from TM 12 Sep 1999

N
W E
S

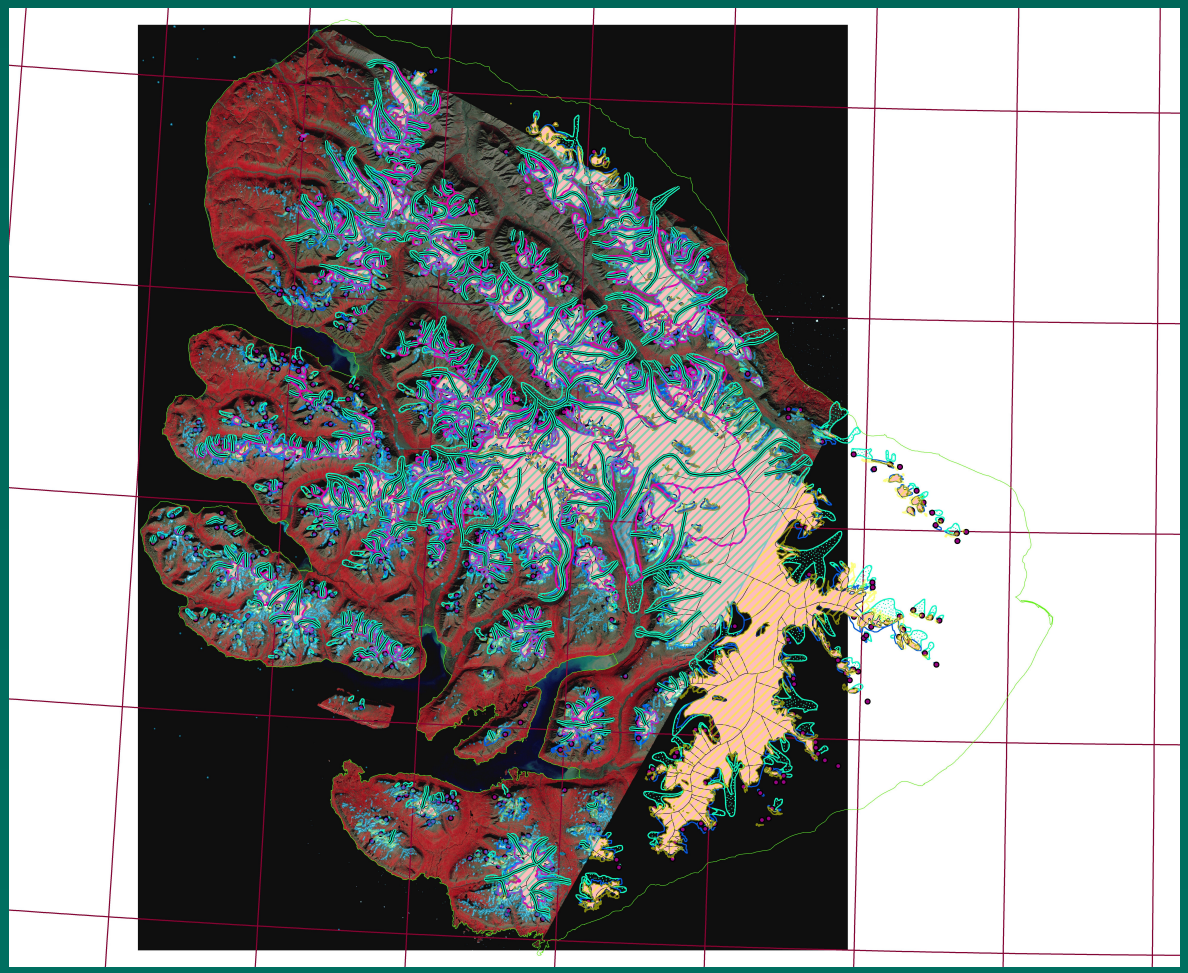
200 m 1km

A. Kääb

GLIMS work commenced

Disko island, West Greenland:

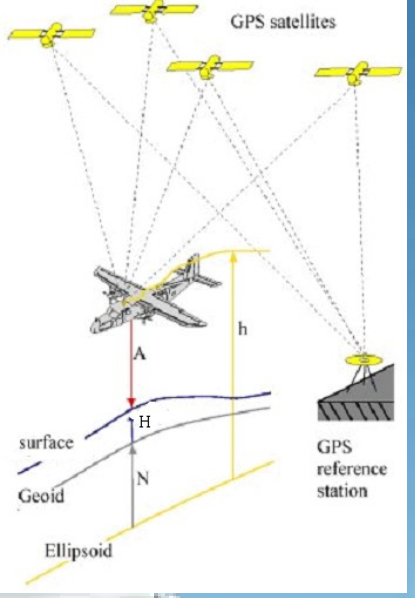
Comparing existing comprehensive digital maps from aerial photogrammetry with GLIMS satellite derived maps huge potential, but also many challenges

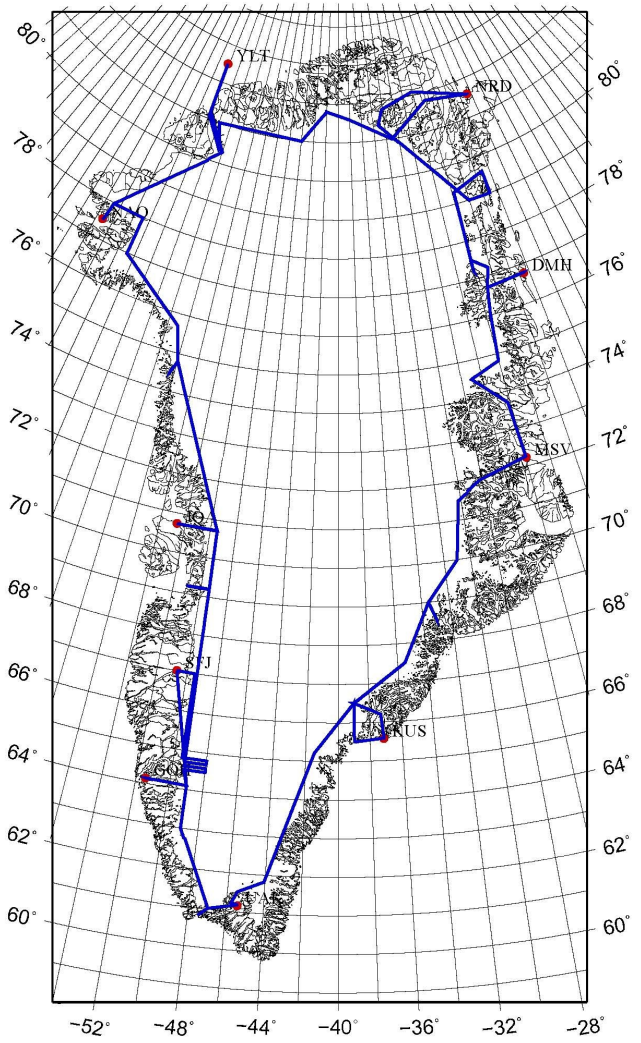


Satellite & airborne surveying

- Biannual airborne survey of the Greenland ice sheet margin
- Ice sheet flow velocity from ENVISAT
- Mass loss from GRACE
- Additional elevation change from CryoSat II and ICESat

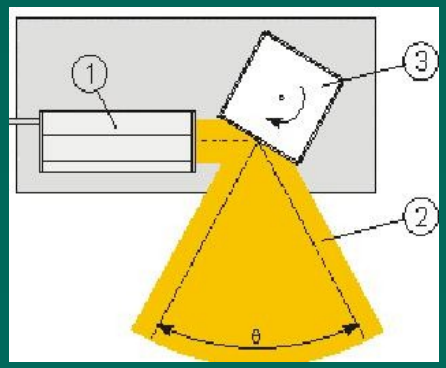
Airborne survey in 2007





Airborne survey in 2007

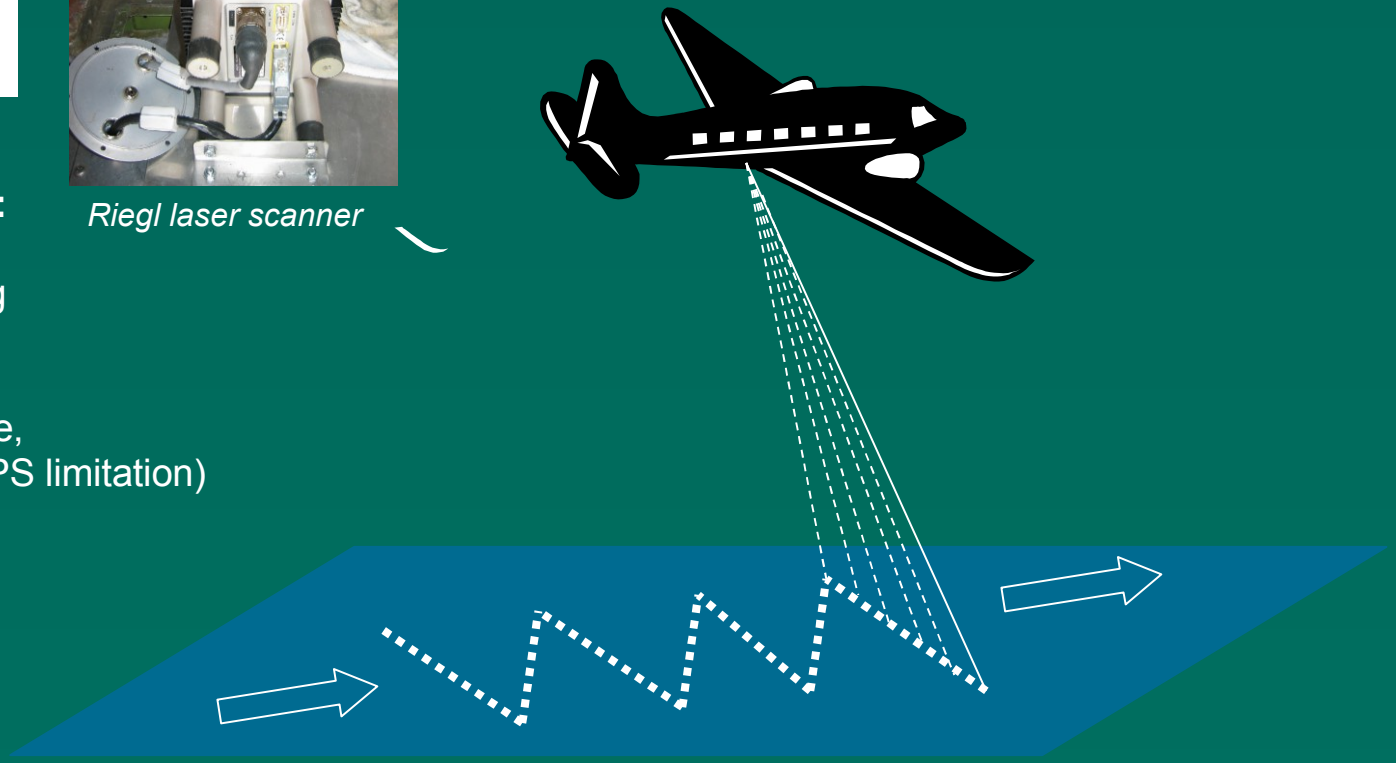
DRC airborne laser scanning



Riegl laser scanner

Typical scanner setup:
- 208 x 40= 8 kHz data
- Scan-angle: +/- 60 deg
- Swath width = altitude
- Footprint: 0.75 x 1 m
- Accuracy: 5 cm relative,
  15-20 cm absolute (GPS limitation)

Additional equipment:
- GPS
- INS
- Nadir video
- Radar (DTU/ESA)



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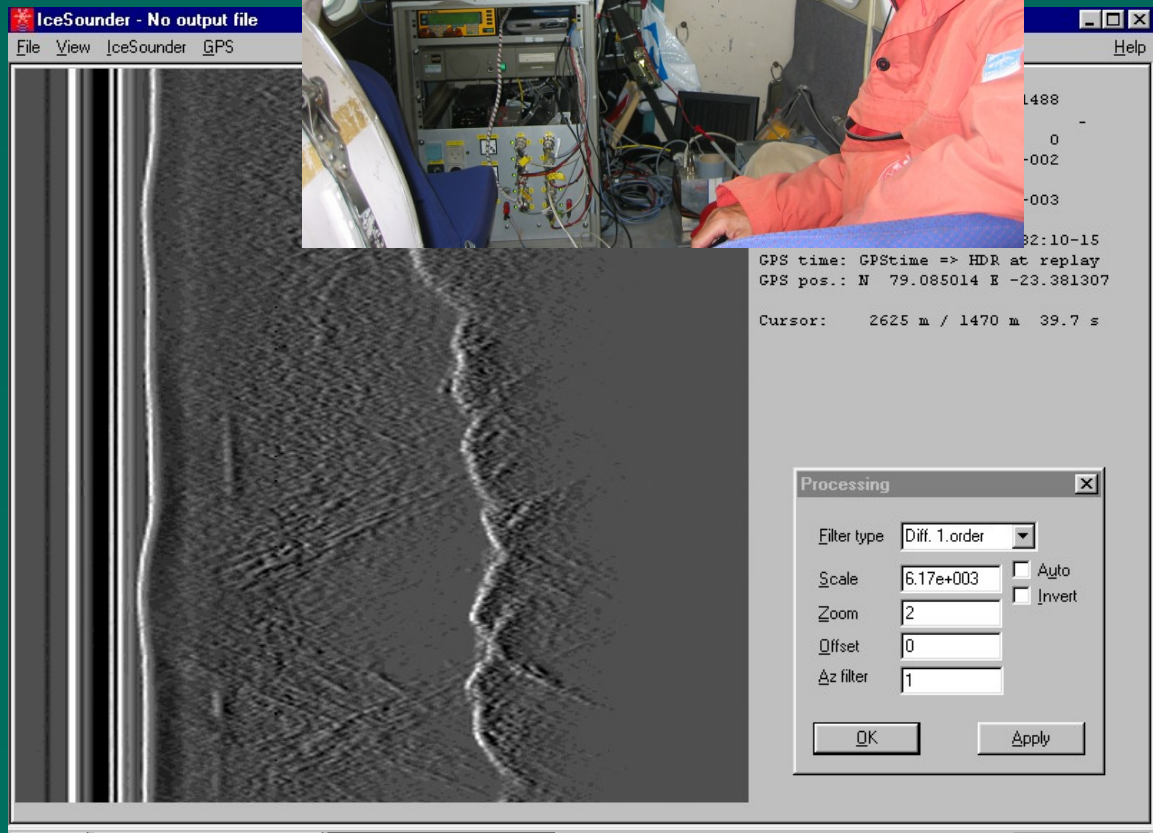
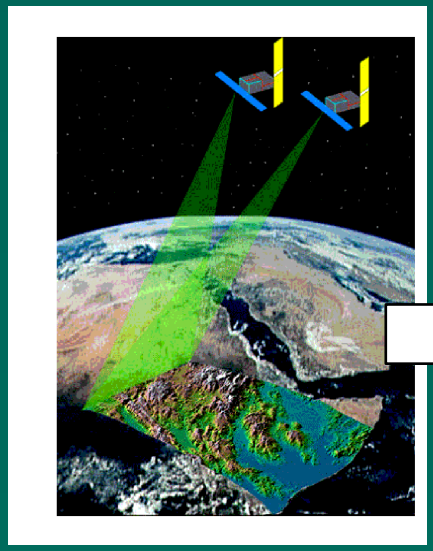
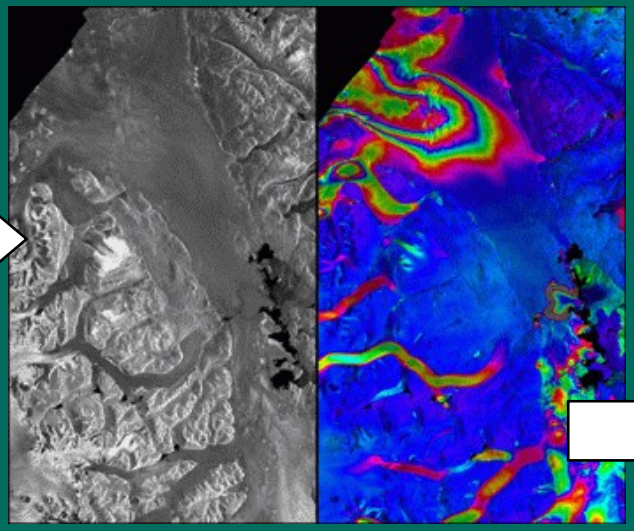
Ice thickness from ice-penetrating radar

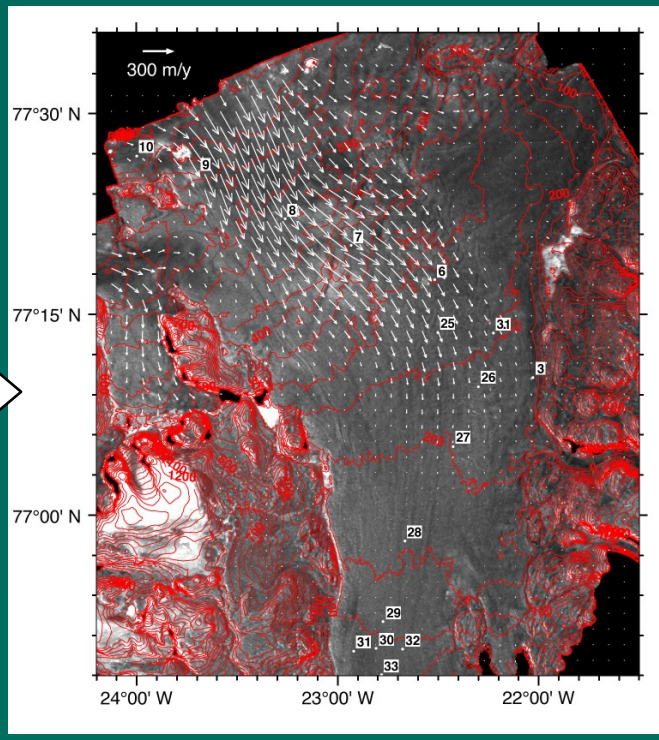


Flow velocity derived from satellite data

SAR interferometry and radar speckle-tracking
can reveal surface velocity and topography



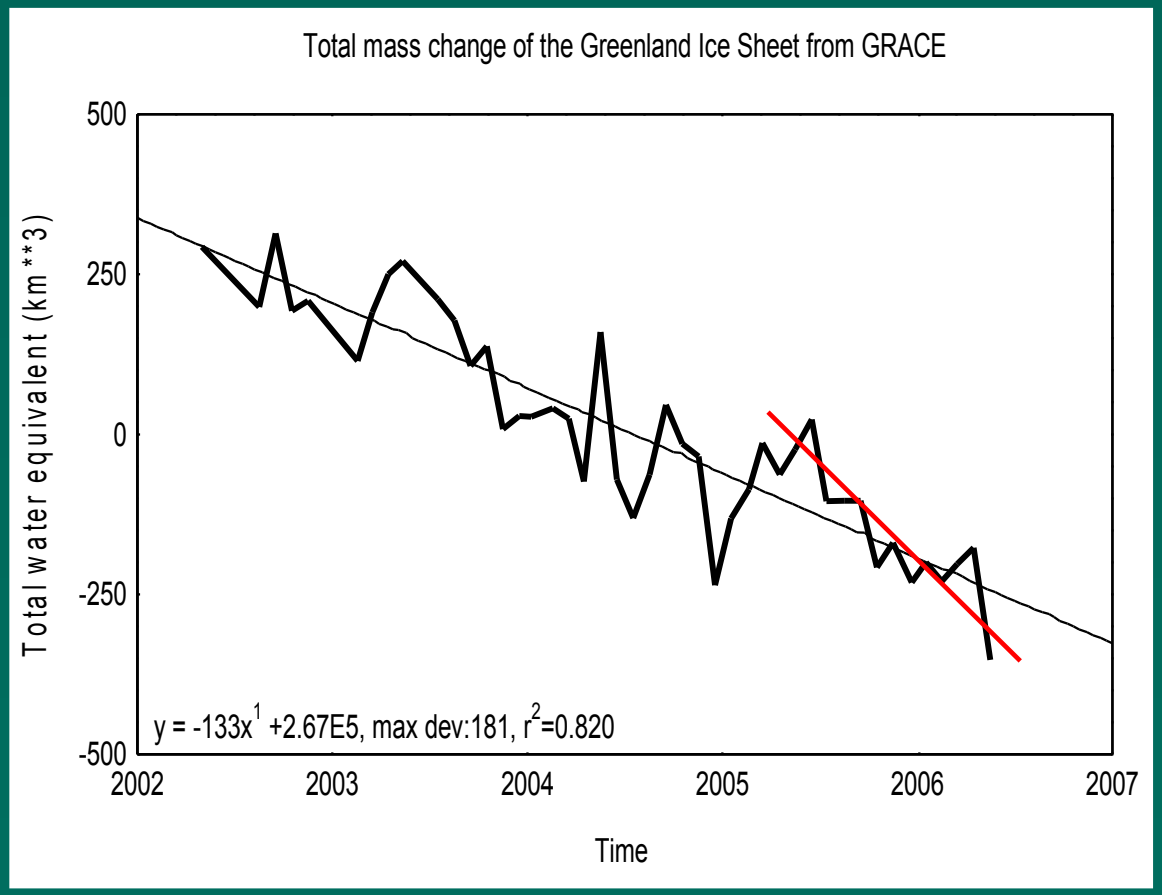




Storstrømmen, NE Grønland; ERS-1/2. J. Mohr, DTU

GRACE changes over the Greenland ice sheet

Estimates of mass loss (km^3/yr)

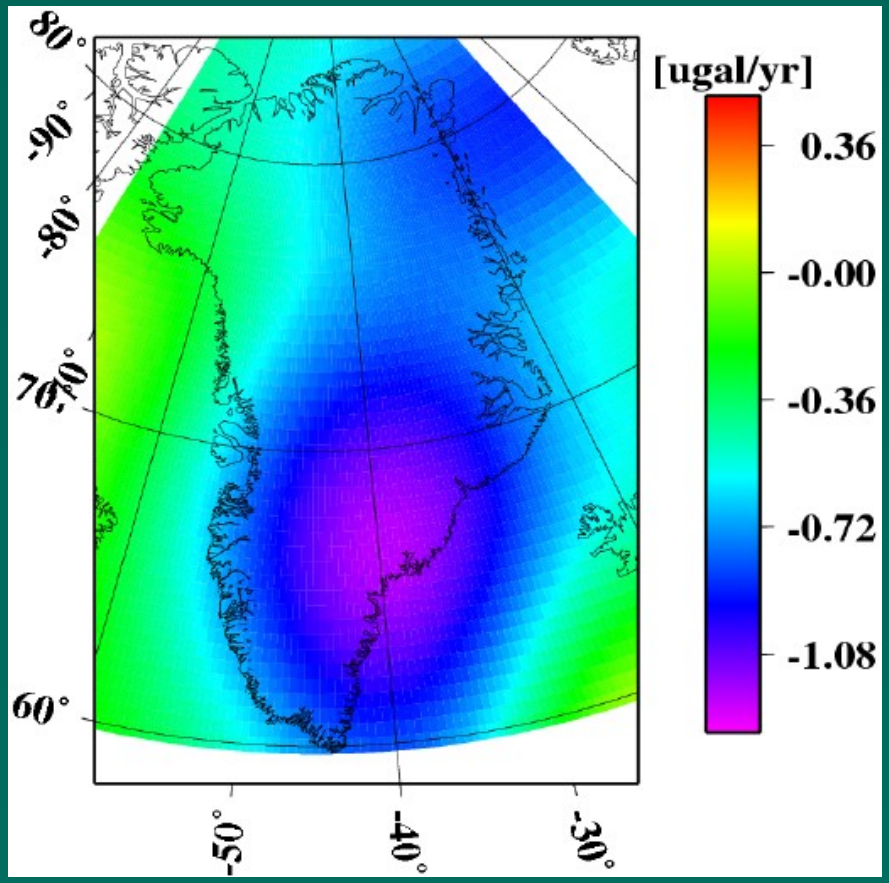


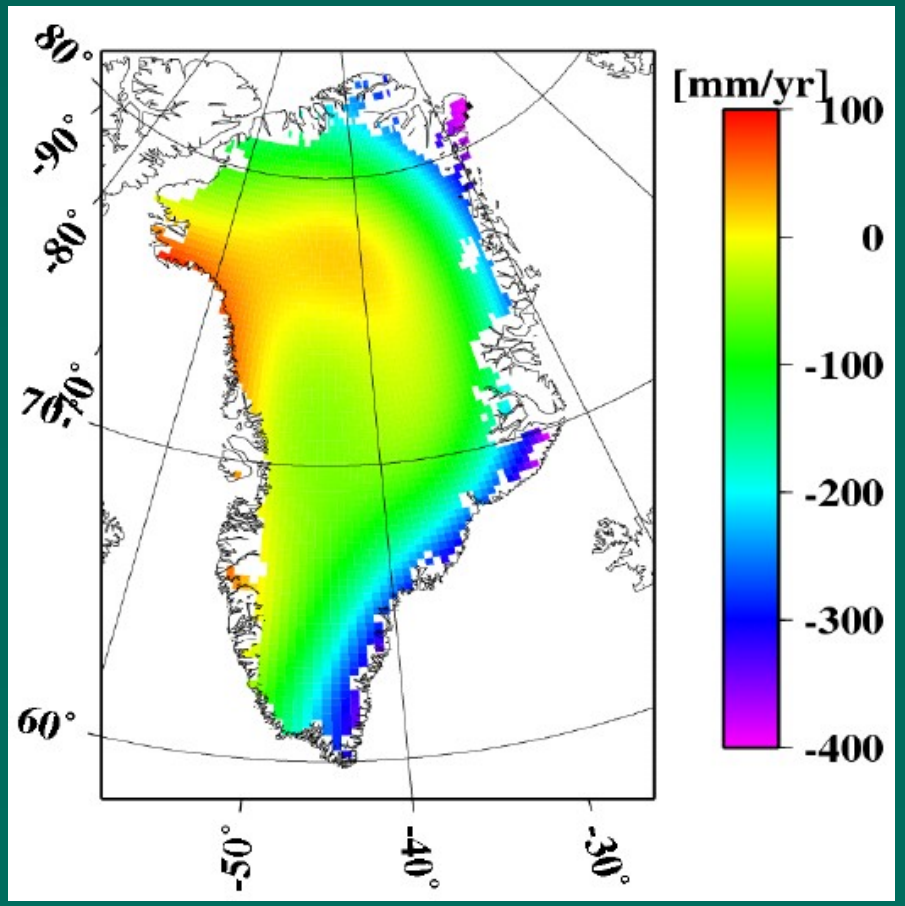
Forsberg and Reeh, AGU 2004	85
Velicogna et al, Univ. Colorado, GRL 2005	130
Chen et al, Univ. of Texas, Science 2006	239*
Velicogna et al., Nature 2006	330*
Lutsche, Zwally et al, Science 2006	101
Forsberg, Sandberg (IGFS/in print)	120**

*Since 2004 **Corrected for PGR

120 km^2/yr corresponds to 0.3 mm/yr global sea level rise

GRACE changes over the Greenland ice sheet





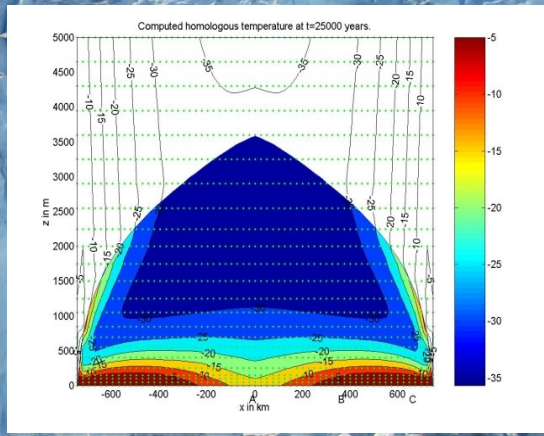
GRACE: Measured change in gravity

Inversion solution – elevation change (DRC, 2006)

Modelling

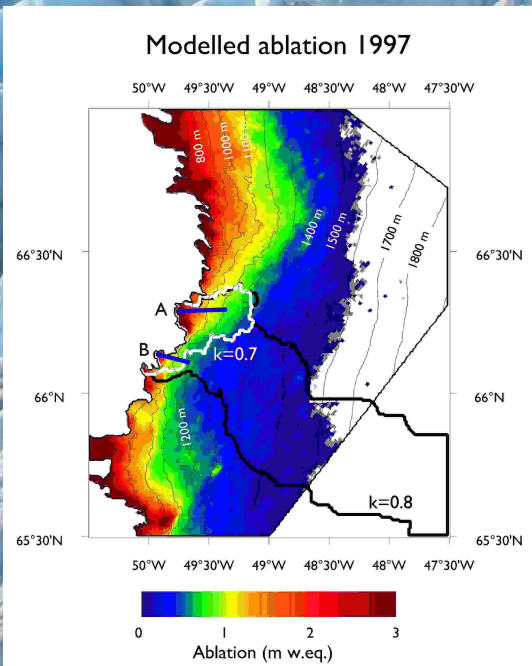
1) **Dynamic** mass loss by calving of icebergs modelled from:

- surface velocity (satellite, field)
- elevation change (airborne, satellite, field)
- ice thickness (airborne)



2) Mass loss by **melting** modelled from:

- climate and mass balance (field)
- elevation change (airborne, satellite, field)
- gauging ofice sheetcatchments (field)
- albedo (field, satellite)



Database & Outreach

Data will be made available for scientific research through a public database

The programme collaborates actively with ongoing research and monitoring efforts in Greenland

A public outreach programme is envisioned, aiming at awareness in Denmark and Greenland

We will deliver on behalf of the Danish Ministry of the Environment to international assessments and programmes, such as

AMAP, ACIA, IPCC, GCOS, GTN-G, WGMS, GLIMS

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Danish Ministry of the Environment

- in support of adaptation, mitigation and sustainable development

GEUS - Geological Survey of Denmark and Greenland

Technical University of Denmark/Danish National Space Center

ASIAQ - Greenland Survey

IPCC 2007 Summary for Policymakers

Table SPM-1. Observed rate of sea level rise and estimated contributions from different sources. {5.5, Table 5.3}

	Rate of sea level rise (mm per year)	
Source of sea level rise	**1961 – 2003**	**1993 – 2003**
Thermal expansion	0.42 ± 0.12	1.6 ± 0.5
Glaciers and ice caps	0.50 ± 0.18	0.77 ± 0.22
Greenland ice sheet	0.05 ± 0.12	0.21 ± 0.07
Antarctic ice sheet	0.14 ± 0.41	0.21 ± 0.35
Sum of individual climate contributions to sea level rise	1.1 ± 0.5	2.8 ± 0.7
Observed total sea level rise	1.8 ± 0.5[a]	3.1 ± 0.7[a]
Difference (Observed minus sum of estimated climate contributions)	0.7 ± 0.7	0.3 ± 1.0

?

Table note:

[a] Data prior to 1993 are from tide gauges and after 1993 are from satellite altimetry.