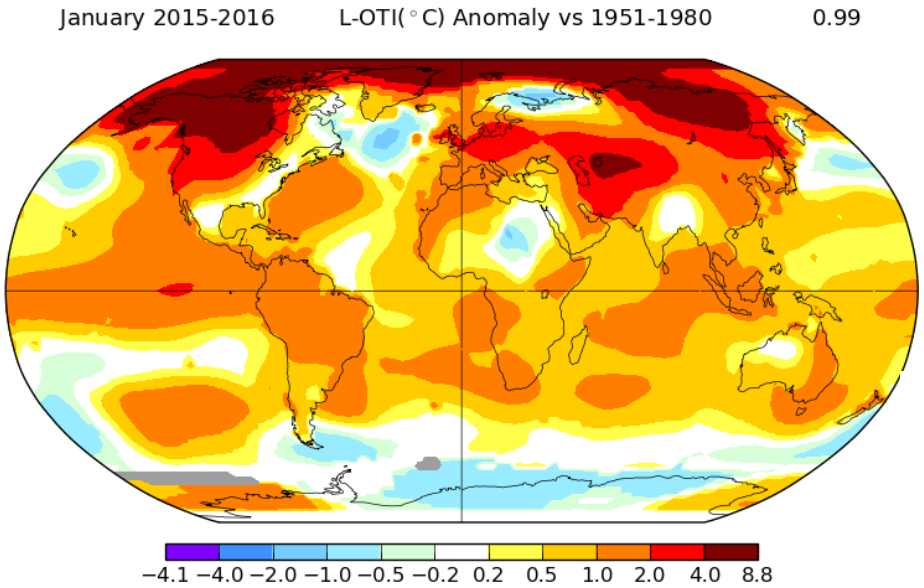
# Brug af satellitter i polarforskning

*Satellite image by NASA*

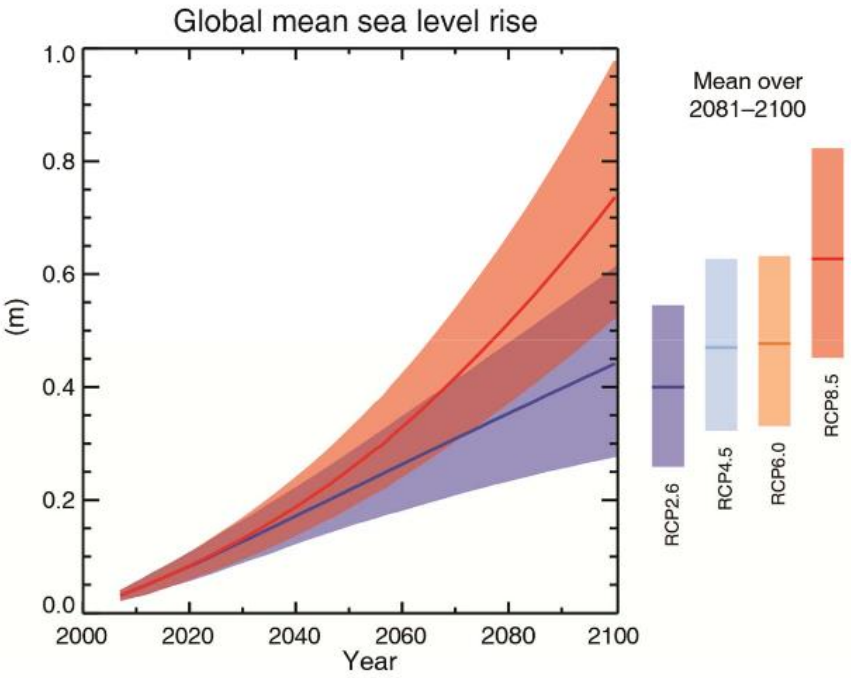
**Louise Sandberg Sørensen**

*Seniorforsker,*
*Geodynamik, DTU Space*
*slss@space.dtu.dk*

# De polare områder i fokus.




Fra: http://data.giss.nasa.gov/




*Figur fra IPCC SPM 2013*

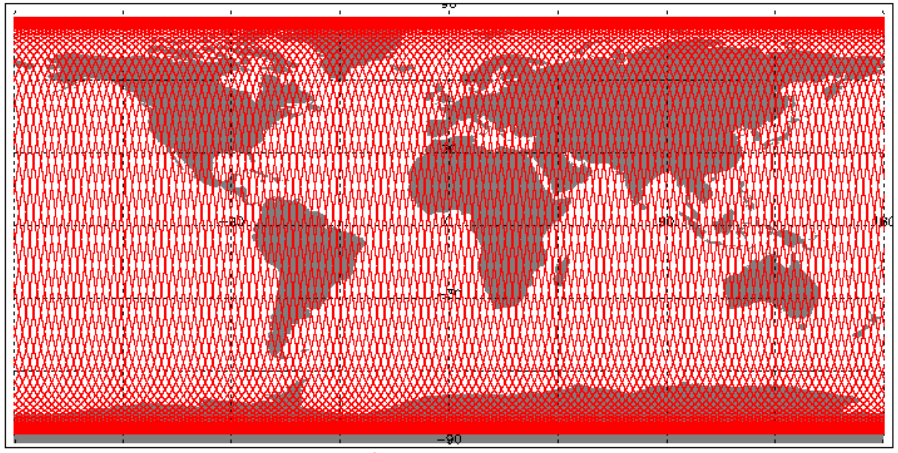
# Satellit-data

Satellitter er helt essentielle fordi

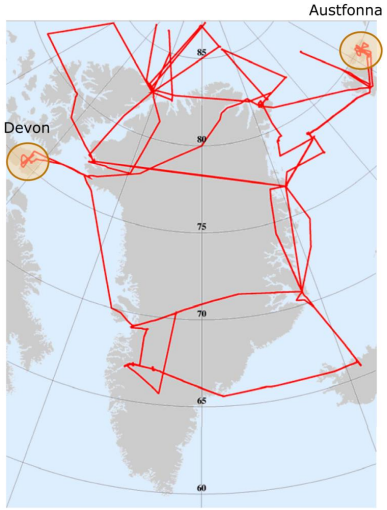
- ❖Kontinuerte målinger
- ❖Global dækning (næsten)
- ❖Data er tilgængelige for alle

Men der er udfordringer:

- ❖ Mange vigtige parametre kan ikke måles direkte fra satellit
- ❖ Tolker vi satellit-data korrekt?



*Dækning fra en måneds ICESat data (nsidc)*




*Cirka en måneds flykampagne CryoVEX 2012*

# Essentielle klima-variable

En essentiel klima-variable er en fysisk, kemisk eller biologisk variabel der er med til at karakterisere Jordens klima.
Disse datasæt danner baggrunden for at forstå og forudse klimaforandringerne.

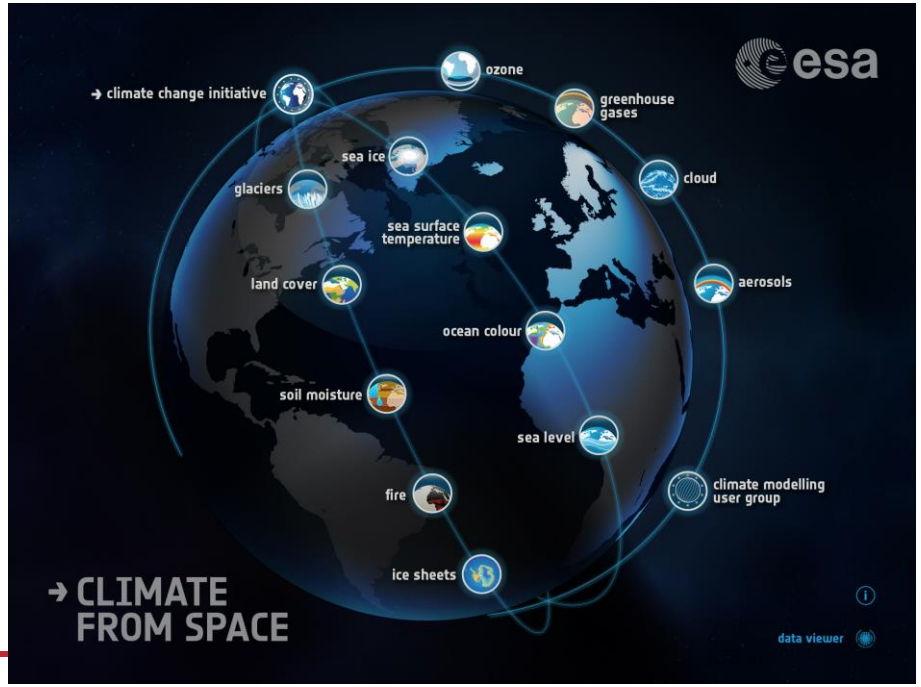
glaciers cci

sea ice cci

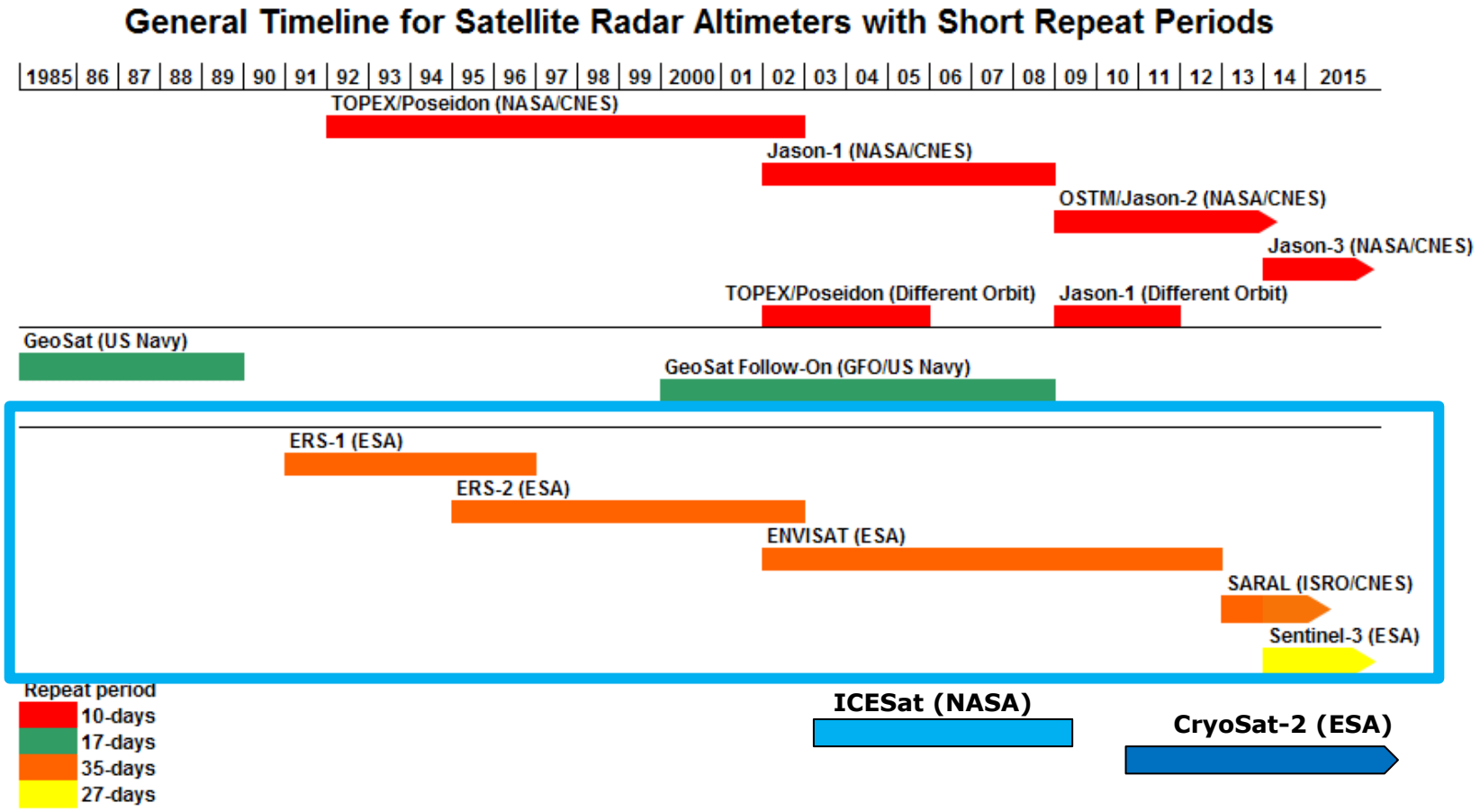
ice sheets greenland cci

antarctic ice sheet cci

esa
European Space Agency



# Altimetri-satellitter

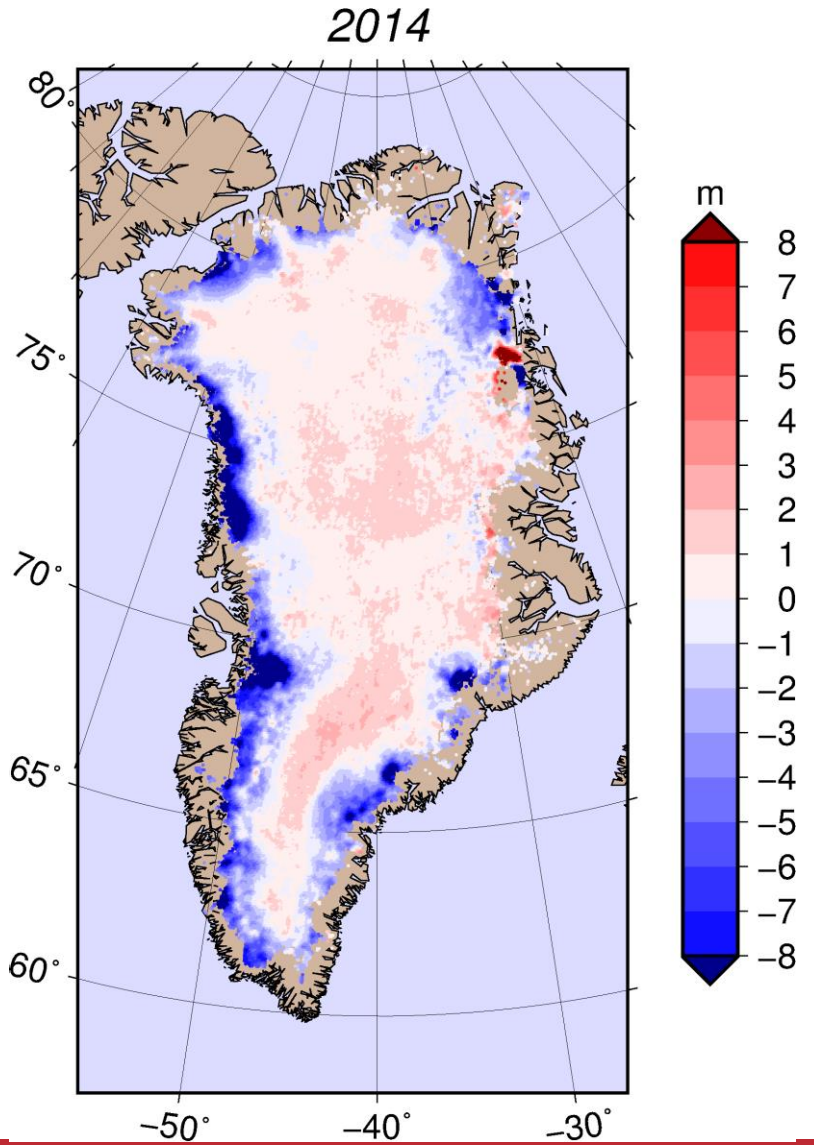



Fra : http://www.pecad.fas.usda.gov/

# Højdeændringer fra altimetri-satellitter

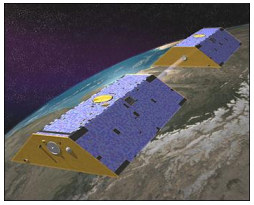
ice sheets greenland cci

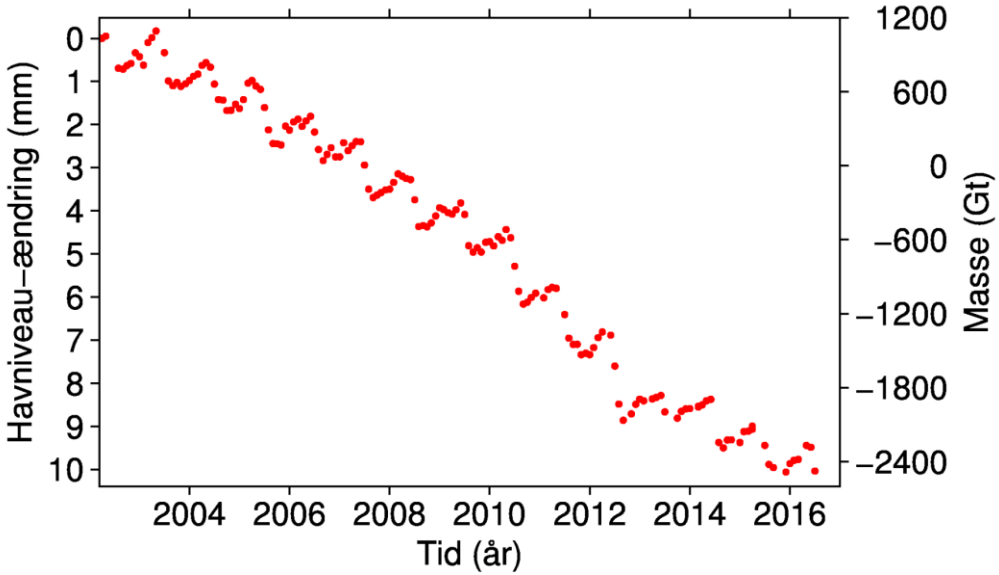
Akkumulerede højde-ændringer siden starten af 1992.

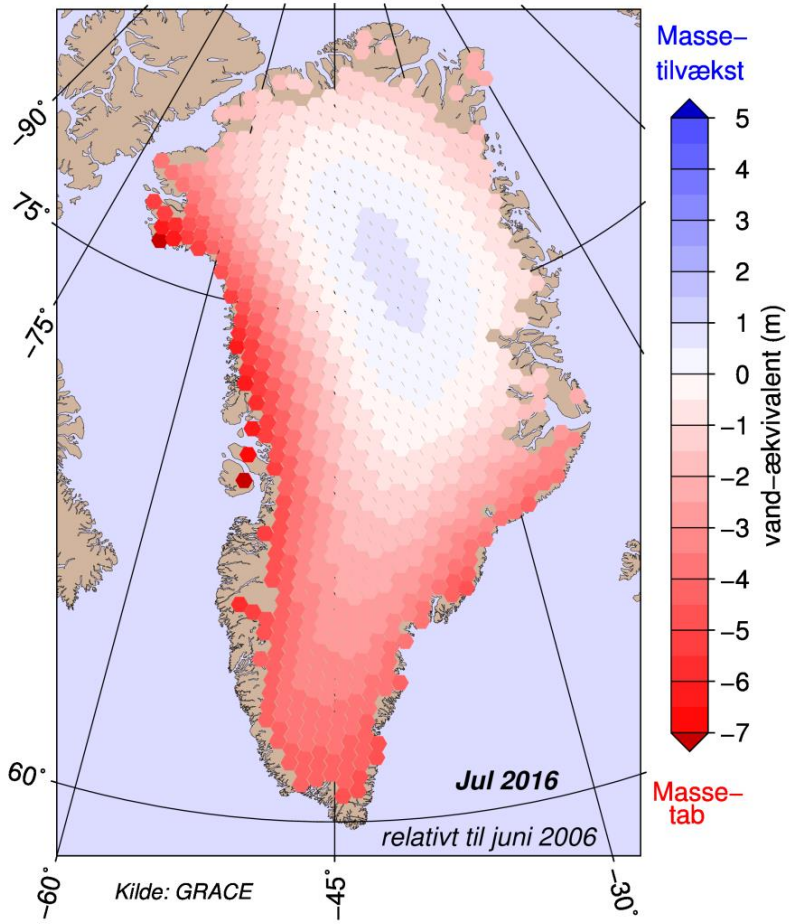


# Masseændringer fra GRACE tyngdemissionen

- 2002 – nu
- NASA/DLR
- GRACE FO planlagt til 2017





# Følg med på www.polarportal.org

POLAR PORTAL
MONITORING ICE AND CLIMATE IN THE ARCTIC

Home | Greenland | Arctic Sea Ice | Weather | News | About Polar Portal

Sitemap | Print page | På dansk | Tweet 56

**Welcome to the new arctic monitoring web-site**
The Danish Arctic research institutions present updated knowledge on the condition of two major components of the Arctic: The Greenland Ice Sheet and the sea ice

Surface conditions
Glacier front positions
Total mass change

Understanding the Greenland Ice Sheet
More ice-monitoring products

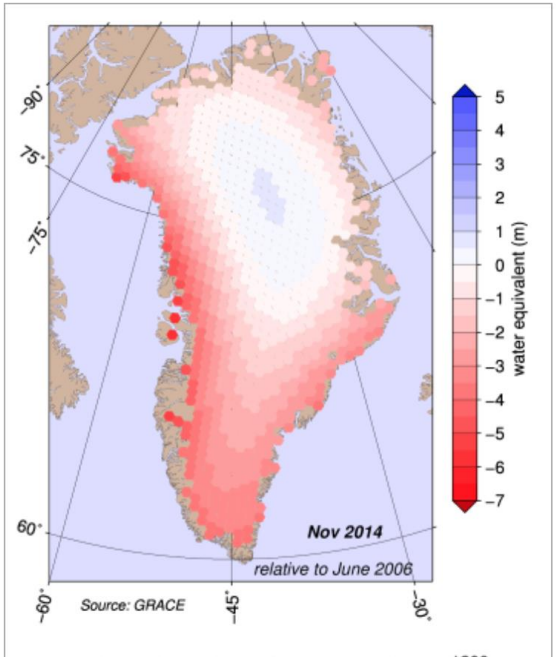
## Total mass change

This page illustrates the total change in mass of the Greenland Ice Sheet. Here you can follow how the ice sheet gains mass through snowfall accumulating on the surface and how it shrinks through melting from the surface and discharge of icebergs from glaciers that end in the sea.

- The map illustrates the latest GRACE satellite-derived mass changes.
- The curve shows the change in the total mass balance month by month measured in gigatonnes (1 Gt is 1 billion tonnes or 1 km$^3$ of water. 100 Gt corresponds to 0.28 mm global sea level). All mass changes are relative to June 2006.

The figures are based on monthly measurements of changes in gravity. Gravity changes as the amount of ice changes and this can be detected by the GRACE satellites. Scientists at DTU Space have contributed to developing the methods used to derive ice mass changes from the gravity changes. The raw GRACE satellite data is carefully processed and validated before it is released to the user, and the product presented here might be delayed by 2-3 months. See Barletta et al. 2013.

The map illustrates the latest monthly mass change map derived from the GRACE satellite data. The curve illustrates the total mass change month by month measured in gigatonnes (1 Gt is 1 billion tonnes or 1 km$^3$ of water. 100 Gt corresponds to 0.28 mm global sea level).



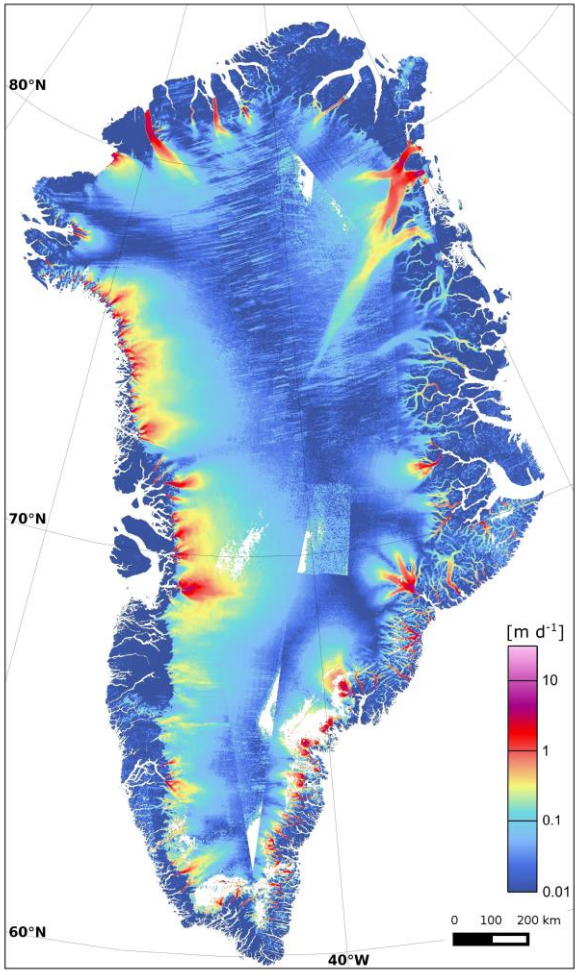
# Isflyde-hastigheder fra Sentinel-1A

Sentinel-1A blev opsendt 3 April 2014.

Ishastigheder baseret på 3 måneders data (januar-marts 2015)

Baseret på offset tracking af SAR data.

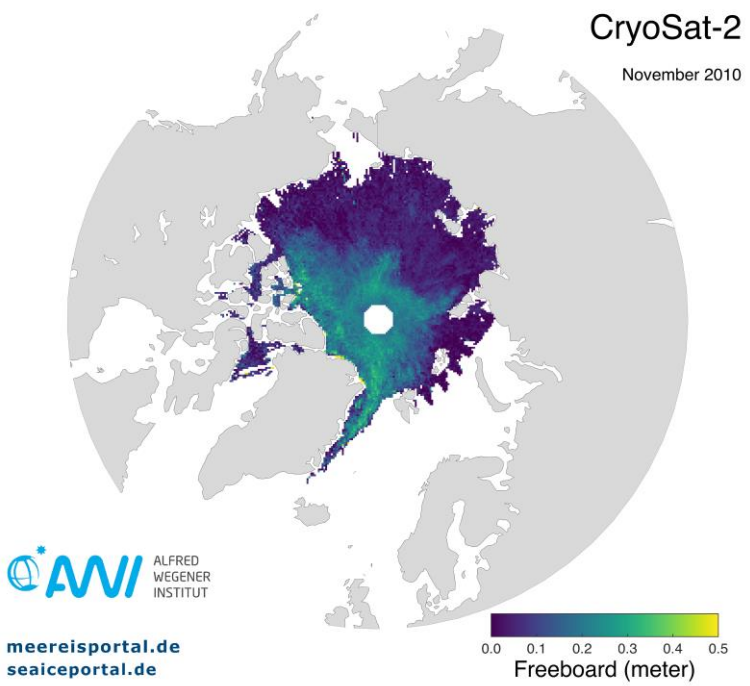
En del af sentinel “familien” der skal levere robuste datasæt til Copernicus.



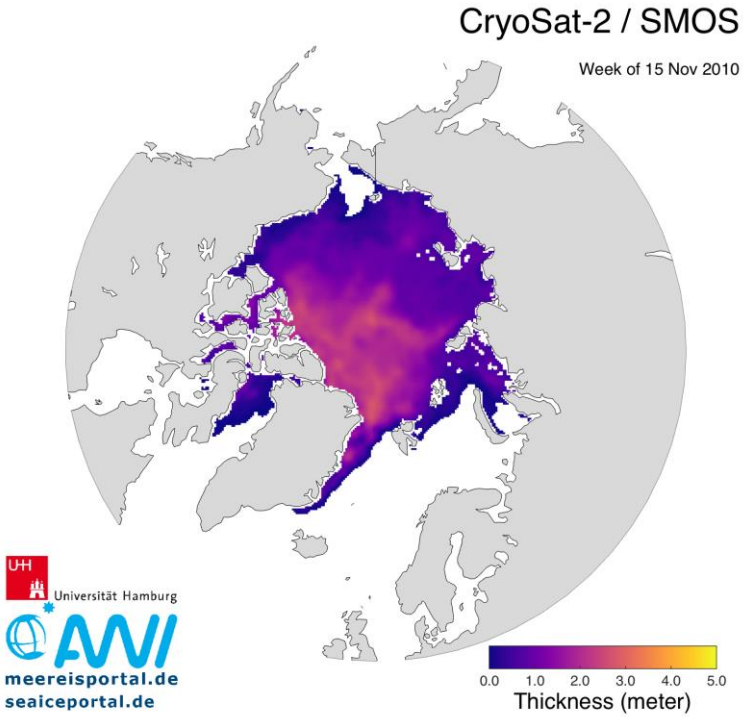

esa
European Space Agency

ice sheets greenland cci

# Havis-tykkelser




Månedlige kort af fribord fra CryoSat-2



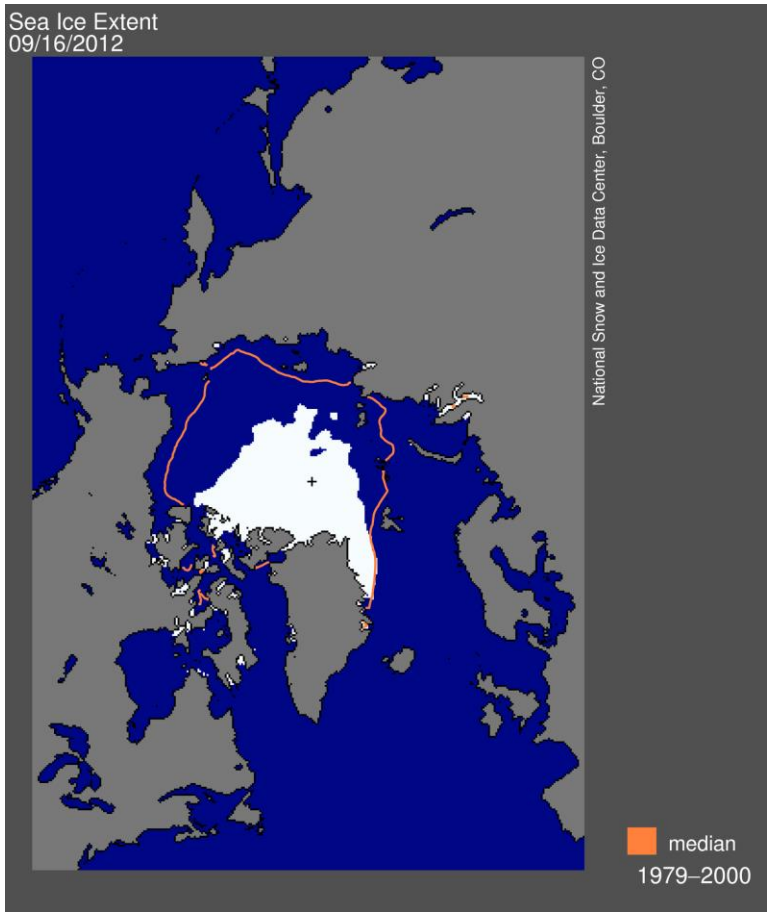

Ugenlige kort af tykkelser fra CryoSat-2/SMOS

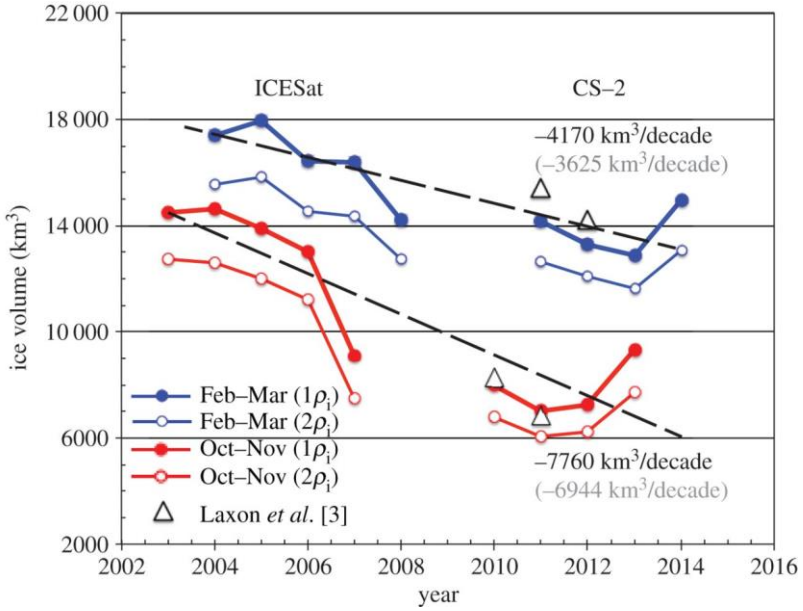
# Havis – udbredelse og volumen

Essentiel klima-variabel.

Der er sket store forandringer i både udbredelse og tykkelse.

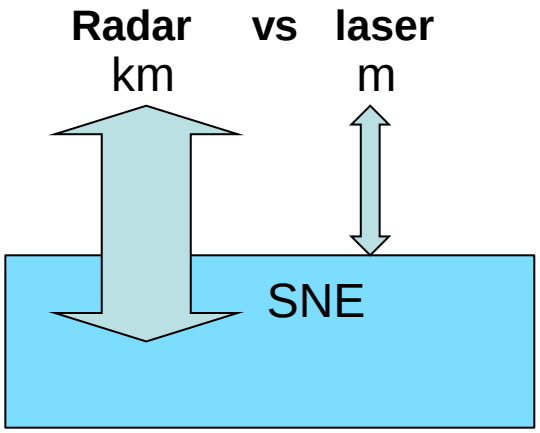
Udbredelse fra AMSR-E (NASA Aqua satellitten) og SSM/I (DMSP).

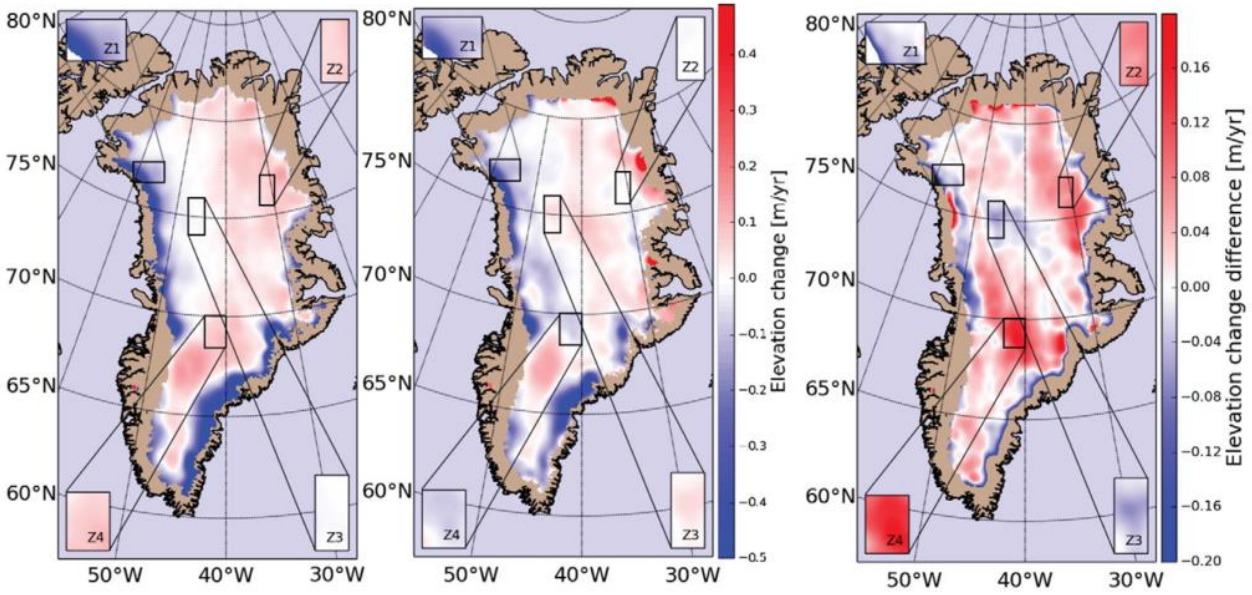



*(Kwok & Cunningham, 2015)*

# Nogle udfordringer



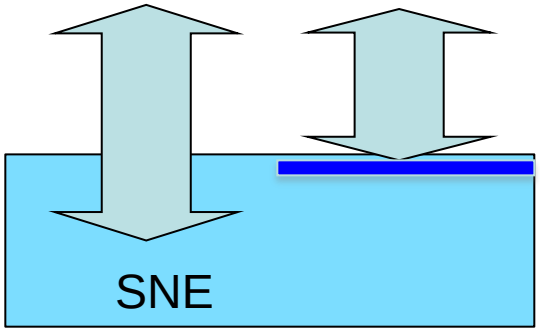

Højdeændringer fra ICESat laser altimetri og ENVISAT radar altimetri.

De ser ikke samme overflade.

Stadig ikke klart hvordan dette skal håndteres

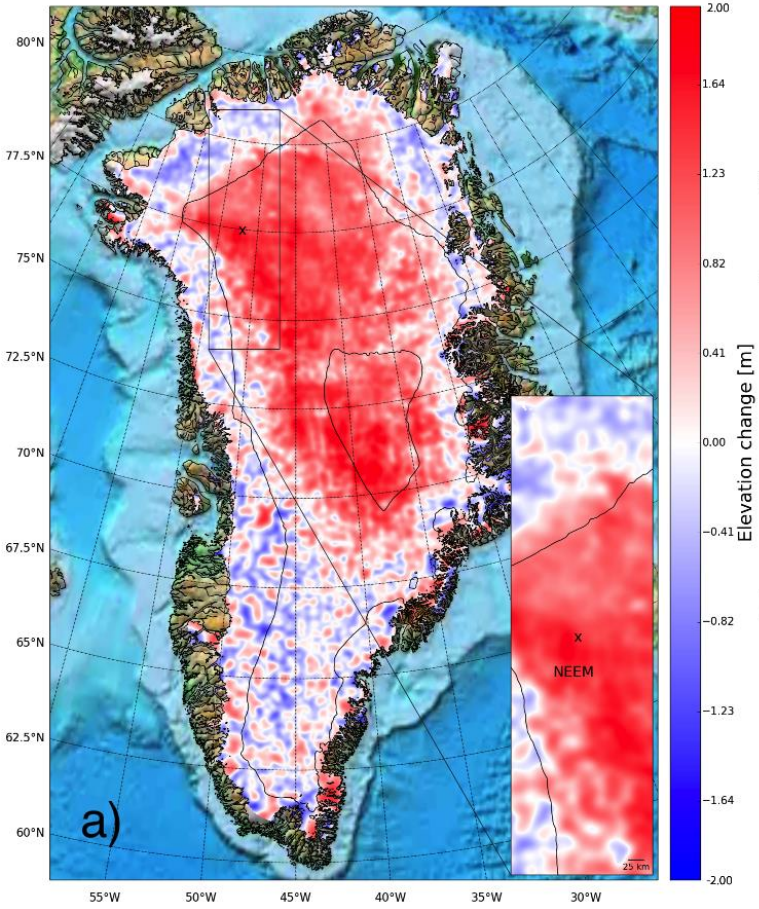
# Nogle udfordringer

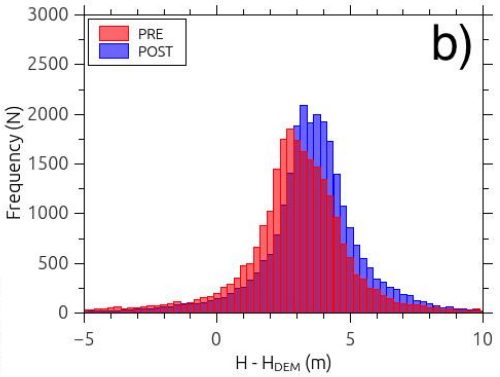
**Radar**

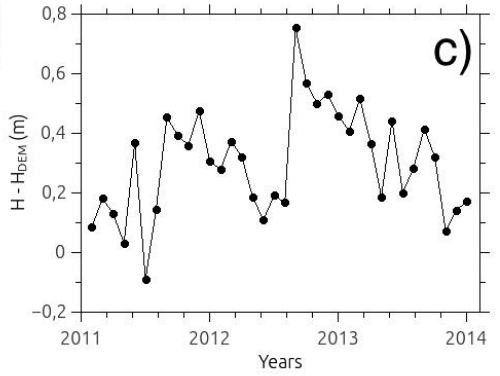



dH = 0.5±0.17 m

Cryosat-2 derived elevation changes from 2012 (Nilsson et al. 2015)

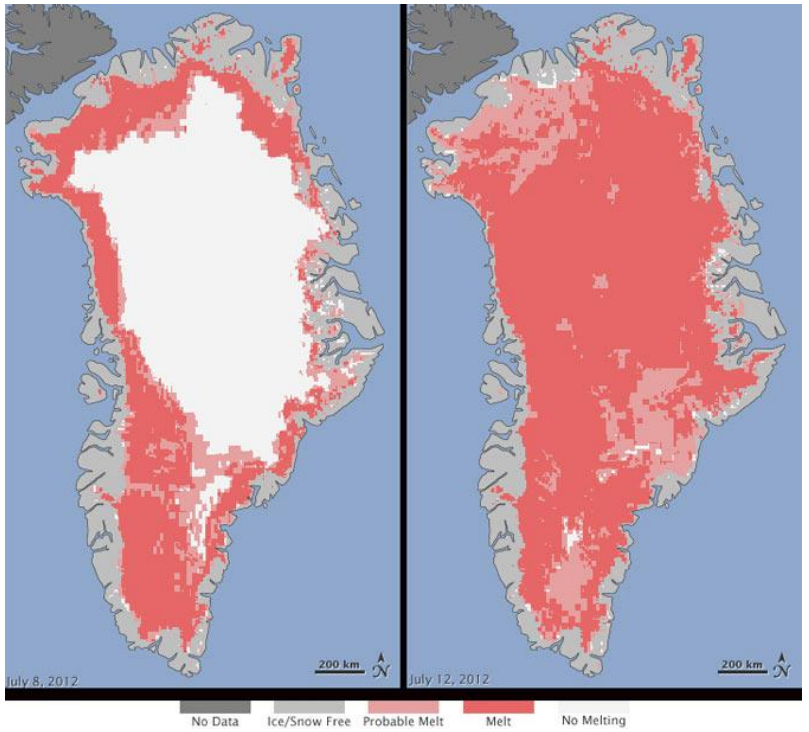


# Overfladesmeltning

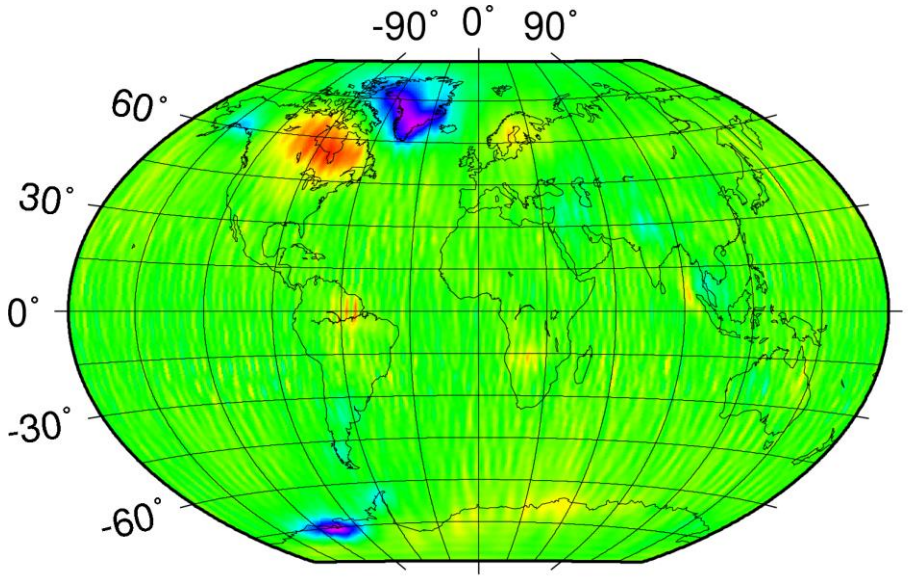
- I juli 2012 blev der observeret overfladesmeltning på op imod 90% af Grønlands indlandsis.
- Dette dannede et lag af is nær overfladen
- Baseret på bl.a. MODIS data
- Stor effekt på radar altimetrien

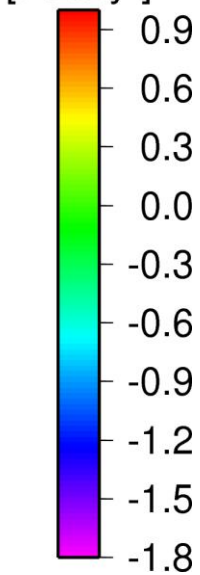


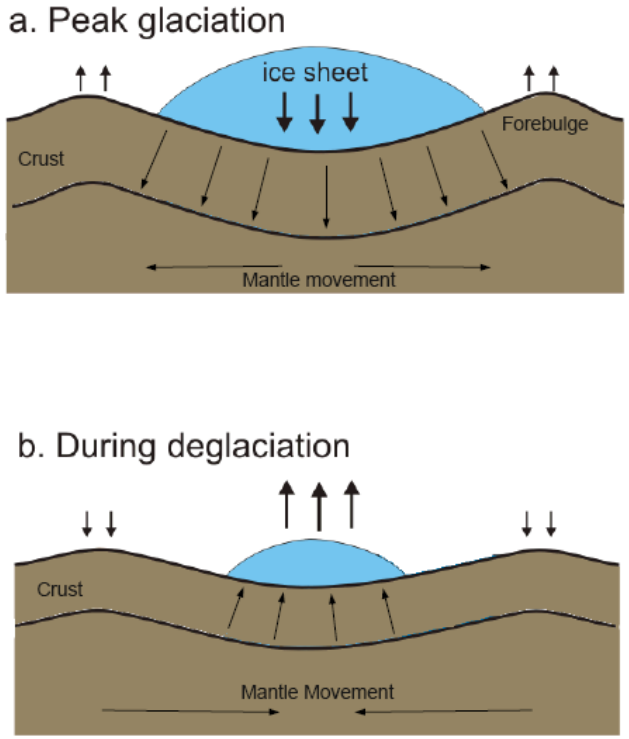
# Nogle udfordringer

Tyngdeændringer observeret med GRACE.

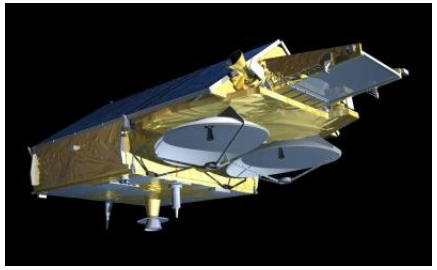
Der er mange kilder til disse – bl.a. post glacial landhævning.



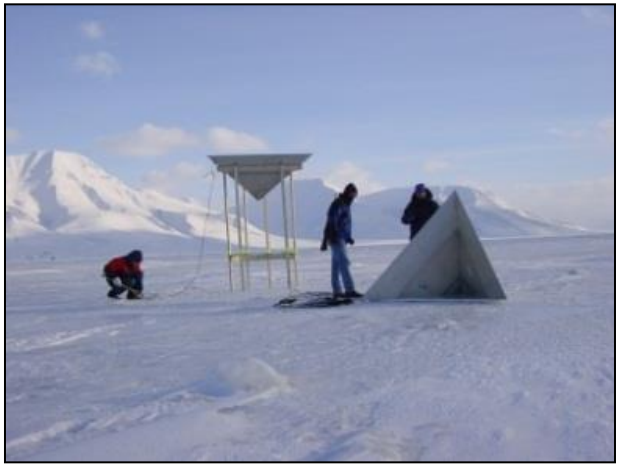



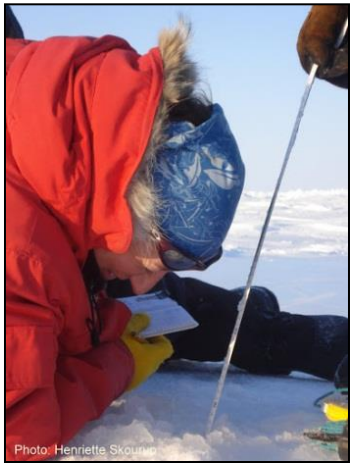
# Der er brug for validerings-data



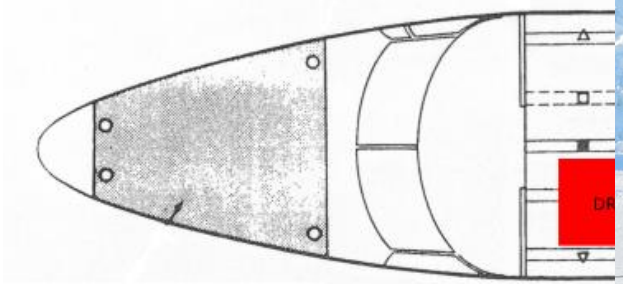
Global


Regional






Local



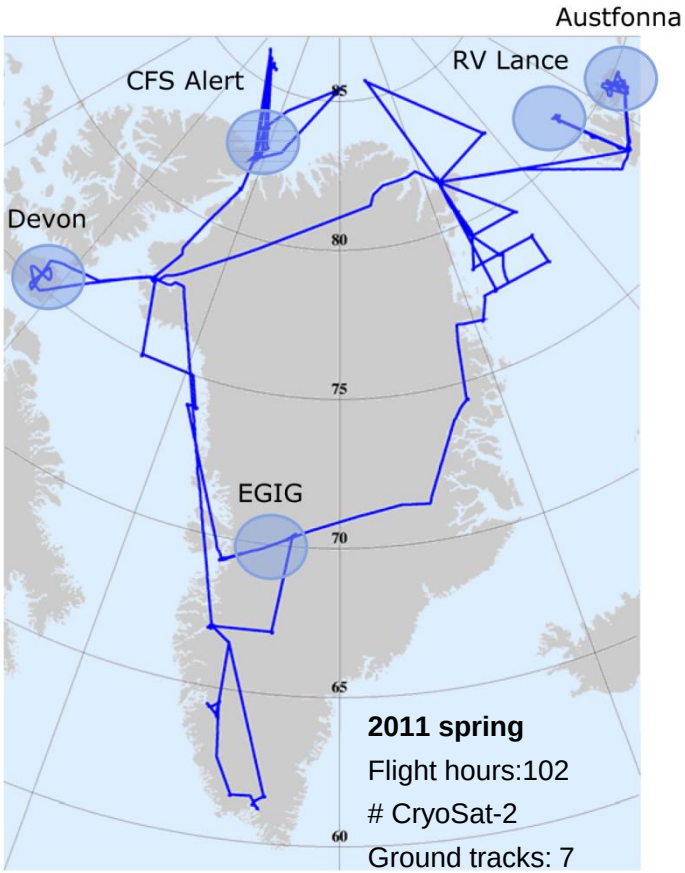
DTU / Norlandair - CryoVEx Team

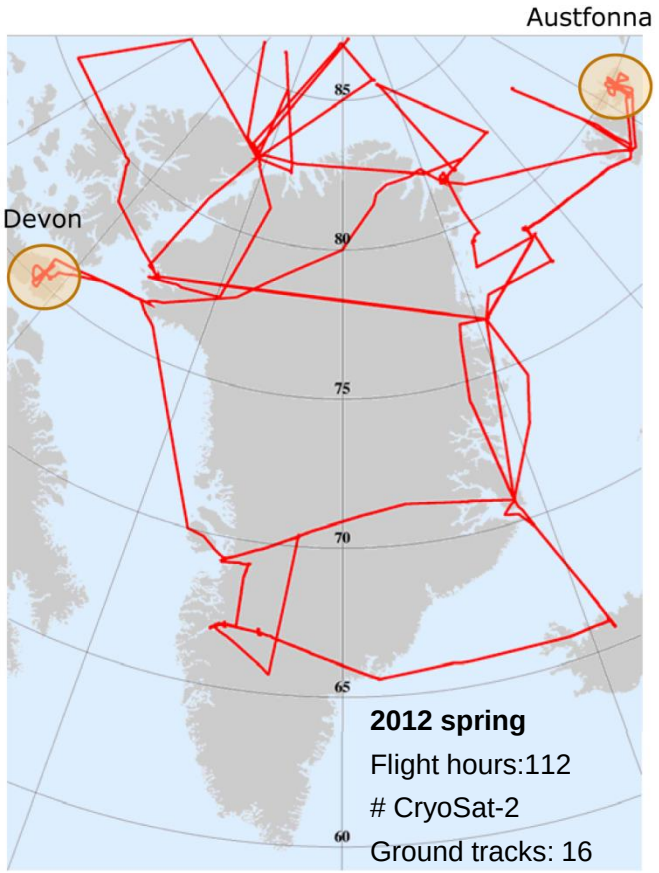
**Apr 2014 Danmarkshavn**

DTU / ESA / Norlandair - CryoVEx Team

**Apr 2012 Danmarkshavn**

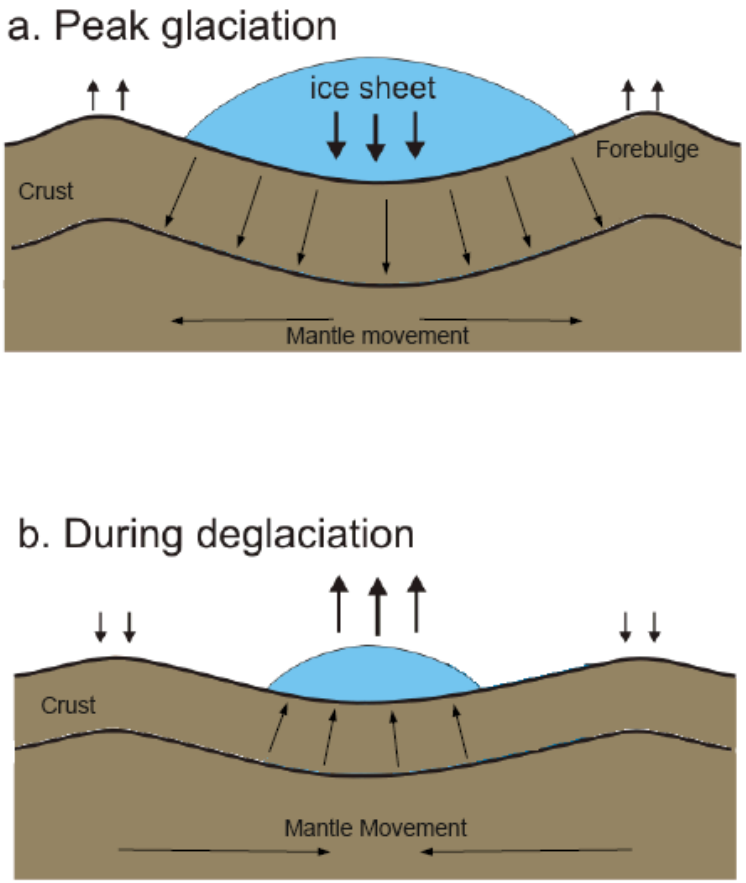
# CryoVEx 2011 og 2012

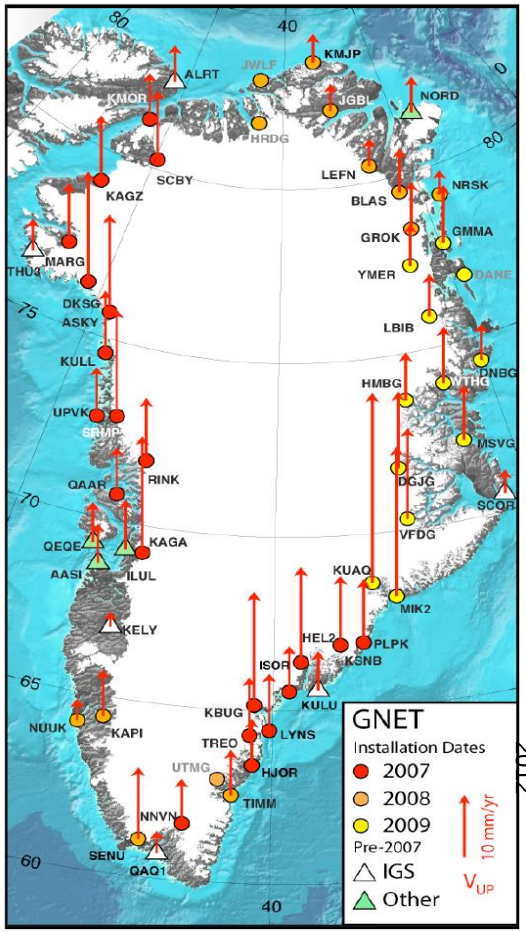


# Absolut tyngdemåling i Grønland

Camp Tuto

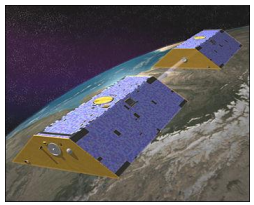
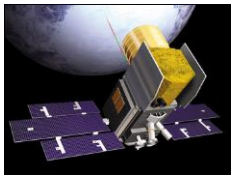


# Absolut tyngde og GPS

Qaarsut

# Målinger i forskellig højde

| | Tyngde | Højder |
|---|---|---|
| Fra satellit |  **GRACE** |   **Altimetri: ICESat, Envisat, CryoSat** |
| På/nær jorden |  **A10** |  **LiDAR/radar/foto fra fly og drone** |

# Tak for opmærksomheden