

An aerial photograph of a vast, rugged glacier. The ice is a deep blue color, showing numerous crevasses and ridges. A small helicopter is visible in the center of the frame, providing a sense of scale to the immense size of the ice mass.

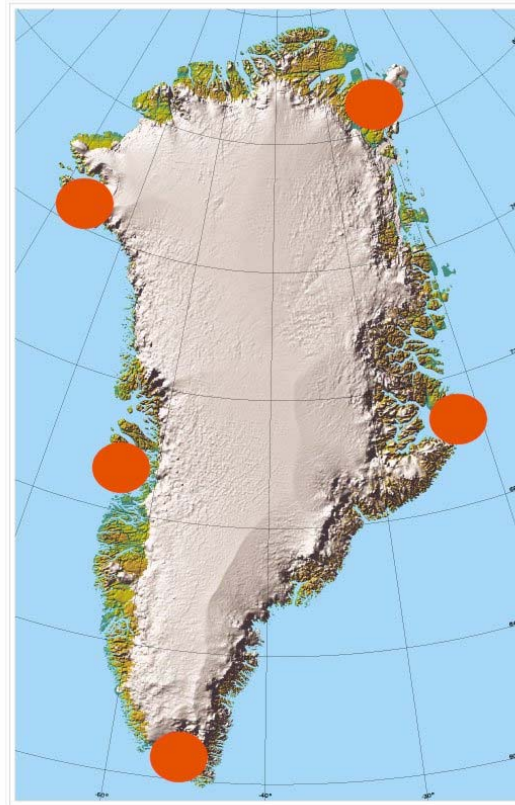
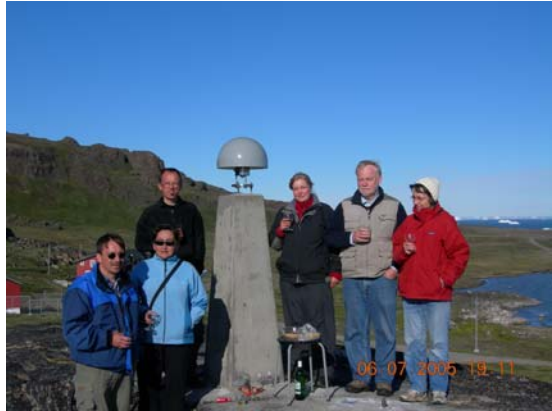
# Present-day surface deformations due to ongoing and past ice mass changes

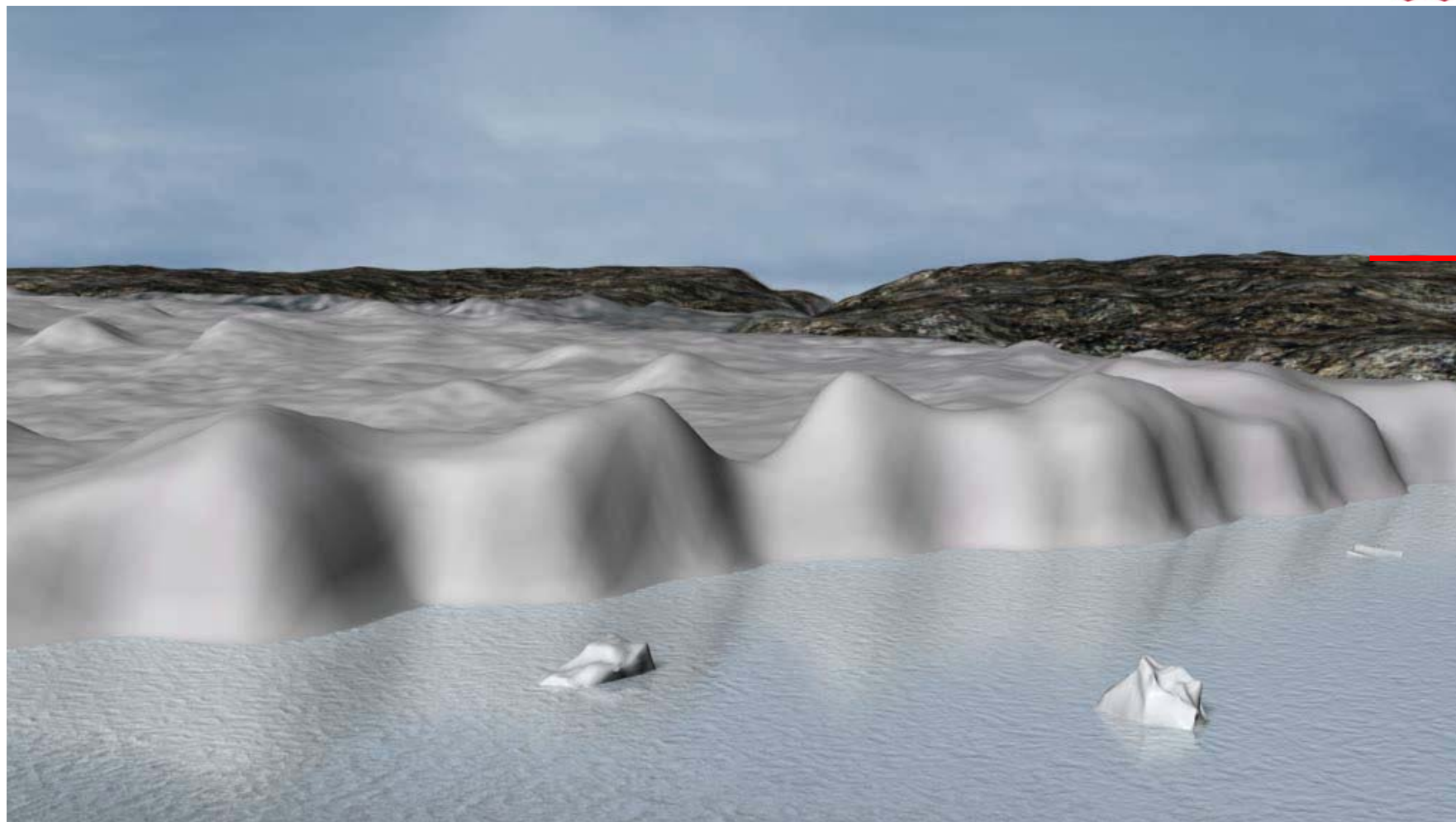
Per Knudsen<sup>1</sup>, Shfaqat Abbas Khan<sup>1</sup> and John Wahr<sup>2</sup>

<sup>1</sup>) DTU Space, National Space Institute, Denmark

<sup>2</sup>) University of Colorado, USA.

# Permanent GNSS stations in Greenland



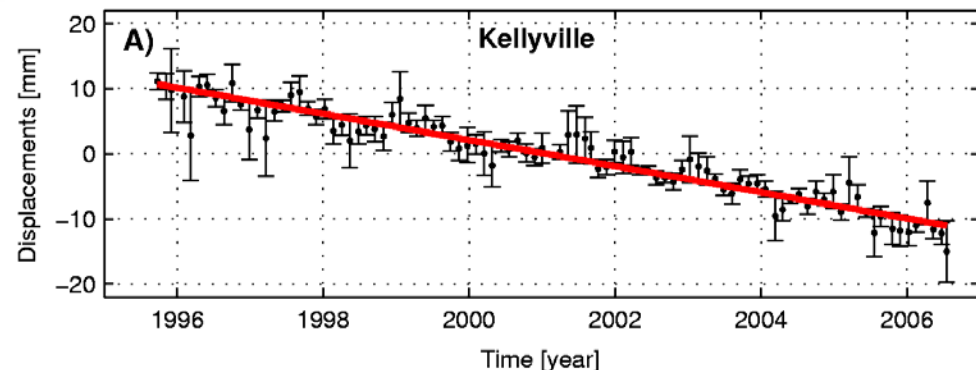
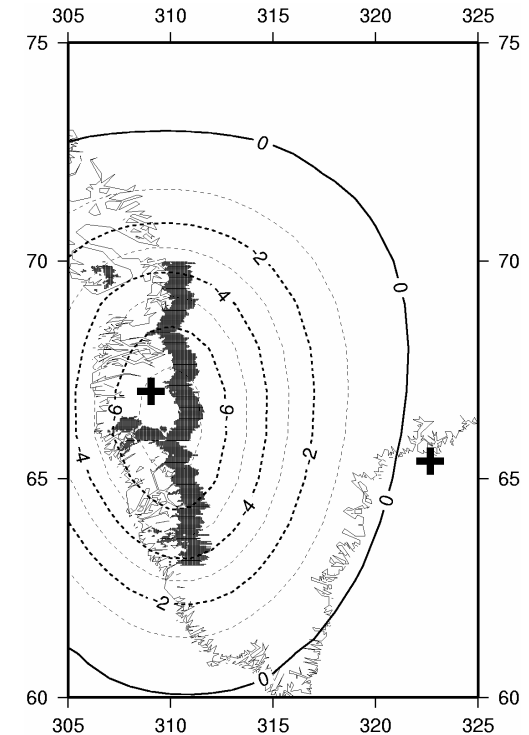
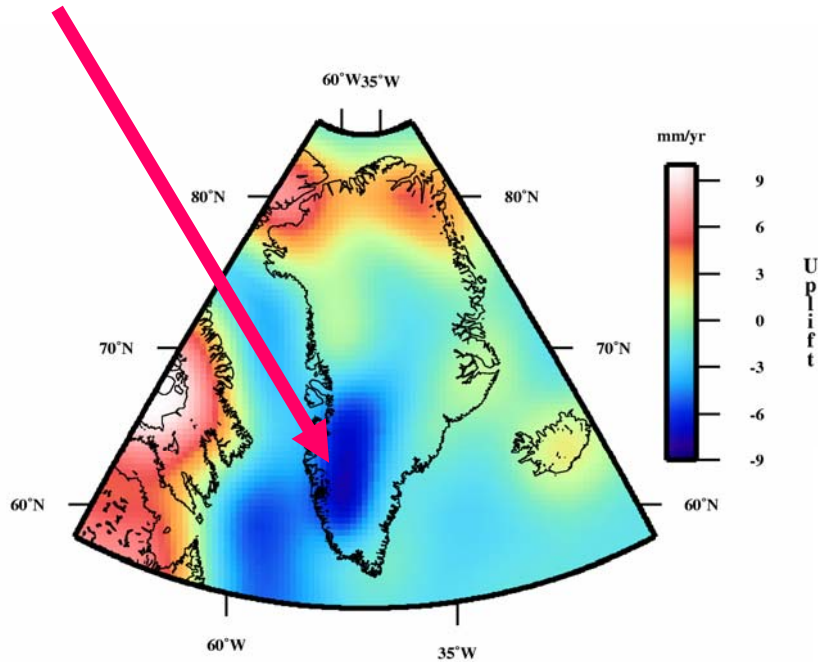


# Uplift due to **past** ice mass changes

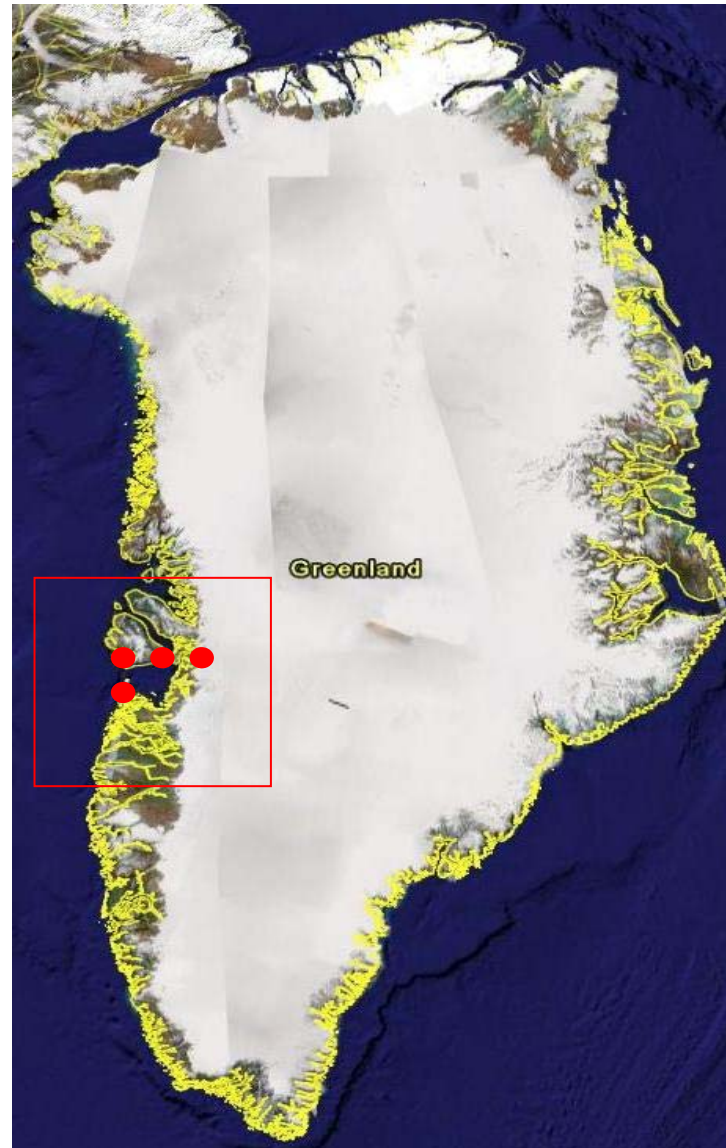


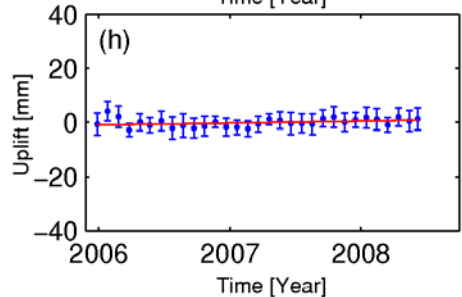
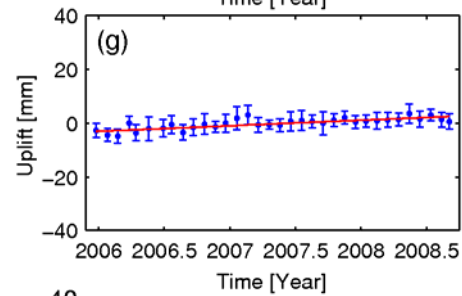
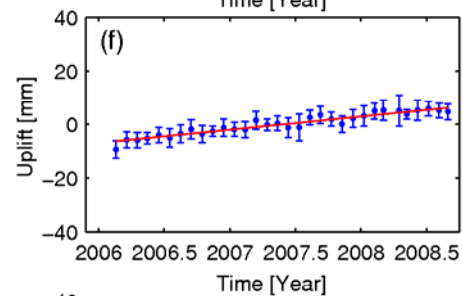
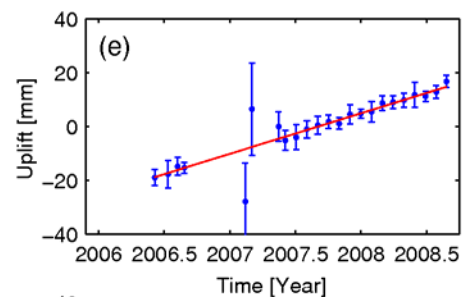
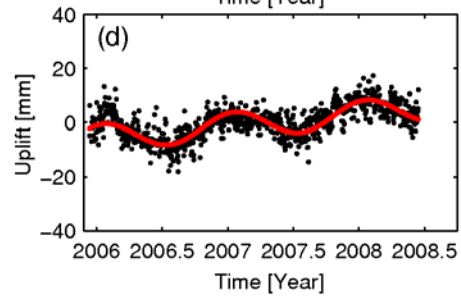
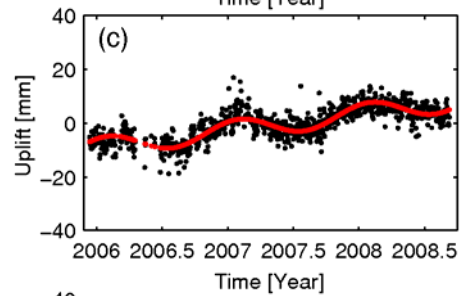
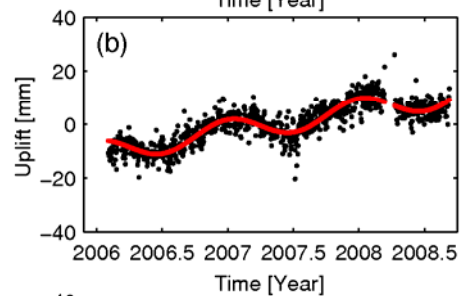
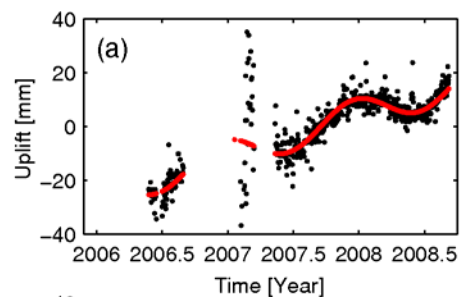
Geological evidence suggest that ice sheet has re-advanced 50 km during last 3000 yrs.

Subsidence at Kellyville is explained as re-advance of the ice-sheet



# Uplift due to **Ongoing** ice mass changes

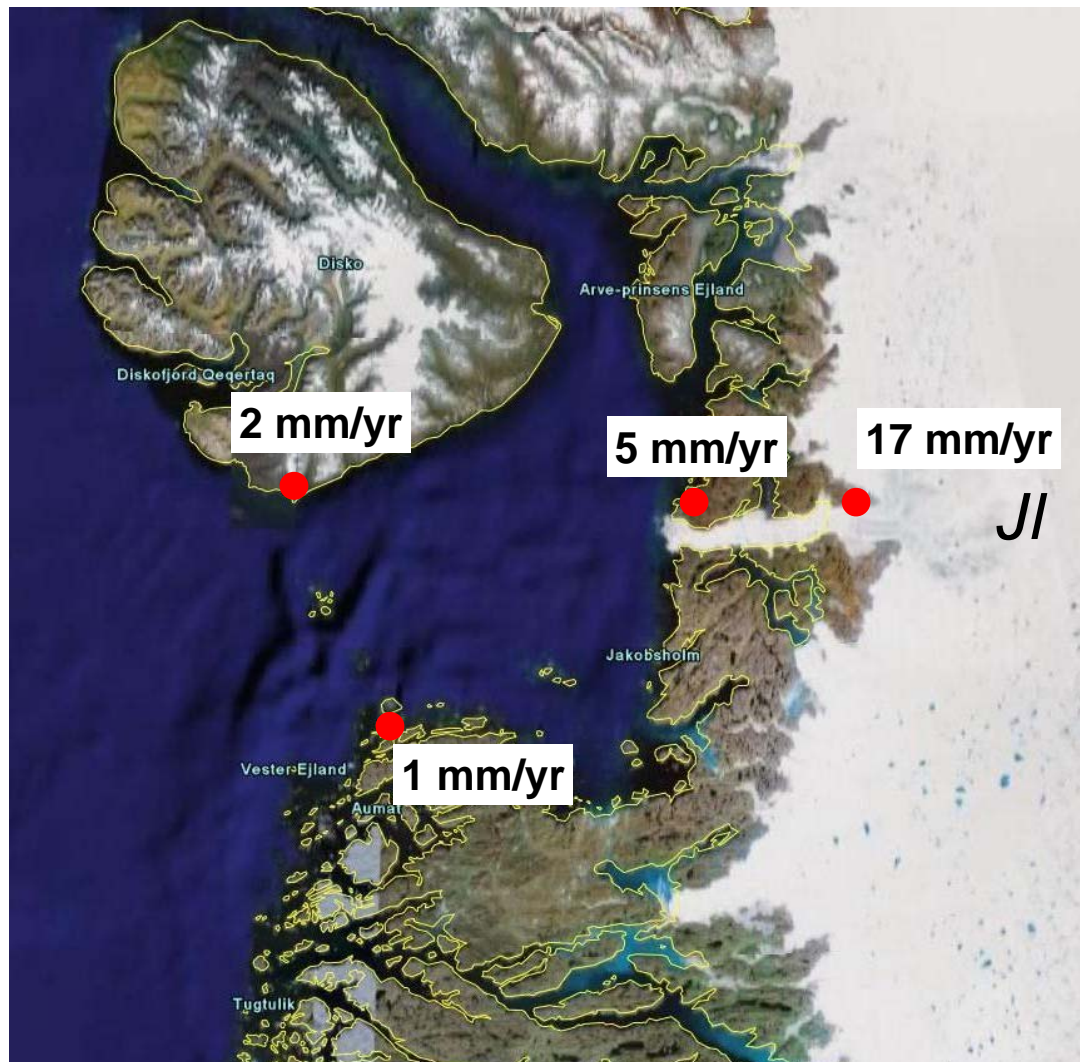




## Data processing

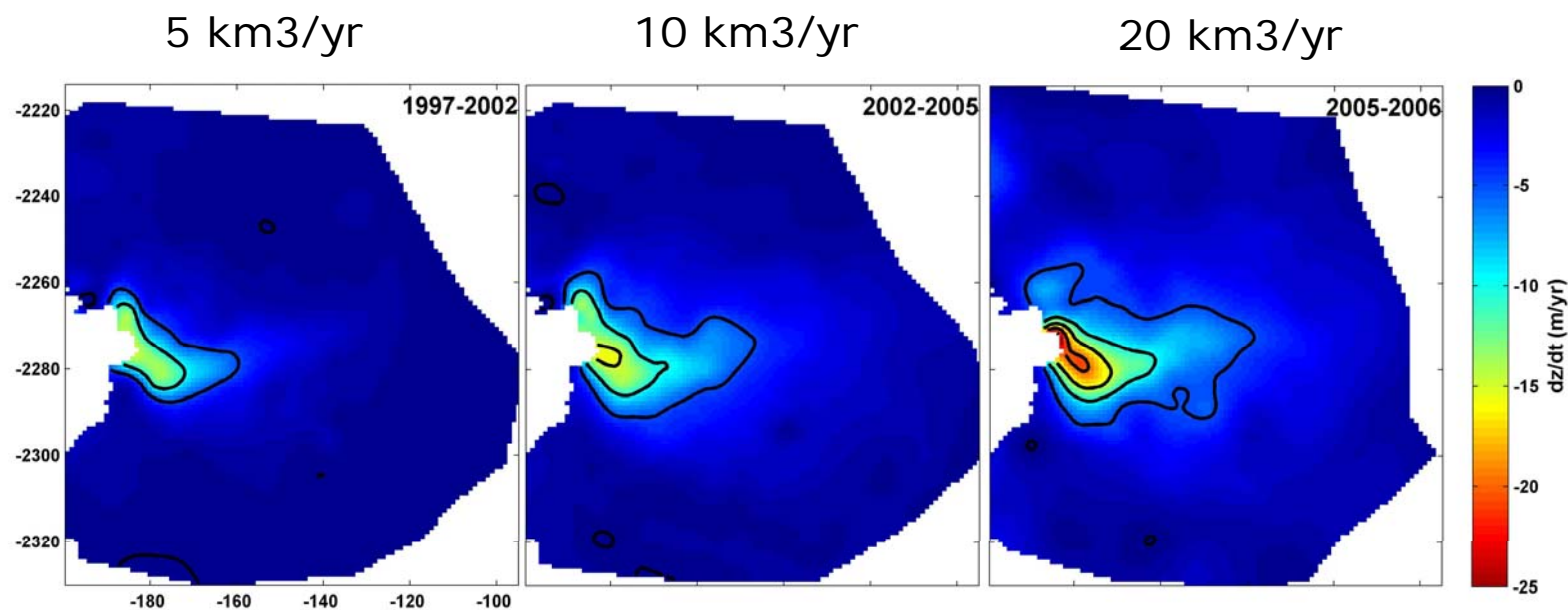
To estimate site coordinates, we use the GIPSY OASIS 5.0 software package with

- 1) JPL orbits, clock parameters, and earth orientation parameters
- 2) We correct for antenna phase center offsets of transmitters and receivers
- 3) Receiver clocks and atmospheric delay parameters.
- 4) Corrections for solid earth tide and ocean tidal loading.
- 5) Site coordinates for each day are obtained using the GIPSY OASIS 5.0 Precise Point Positioning (PPP) strategy.
- 6) The site coordinates are transformed to the IGS2005 frame





# Mass loss confirmed by NASA's ATM flight



2007-2008: 25-30 km<sup>3</sup>/yr



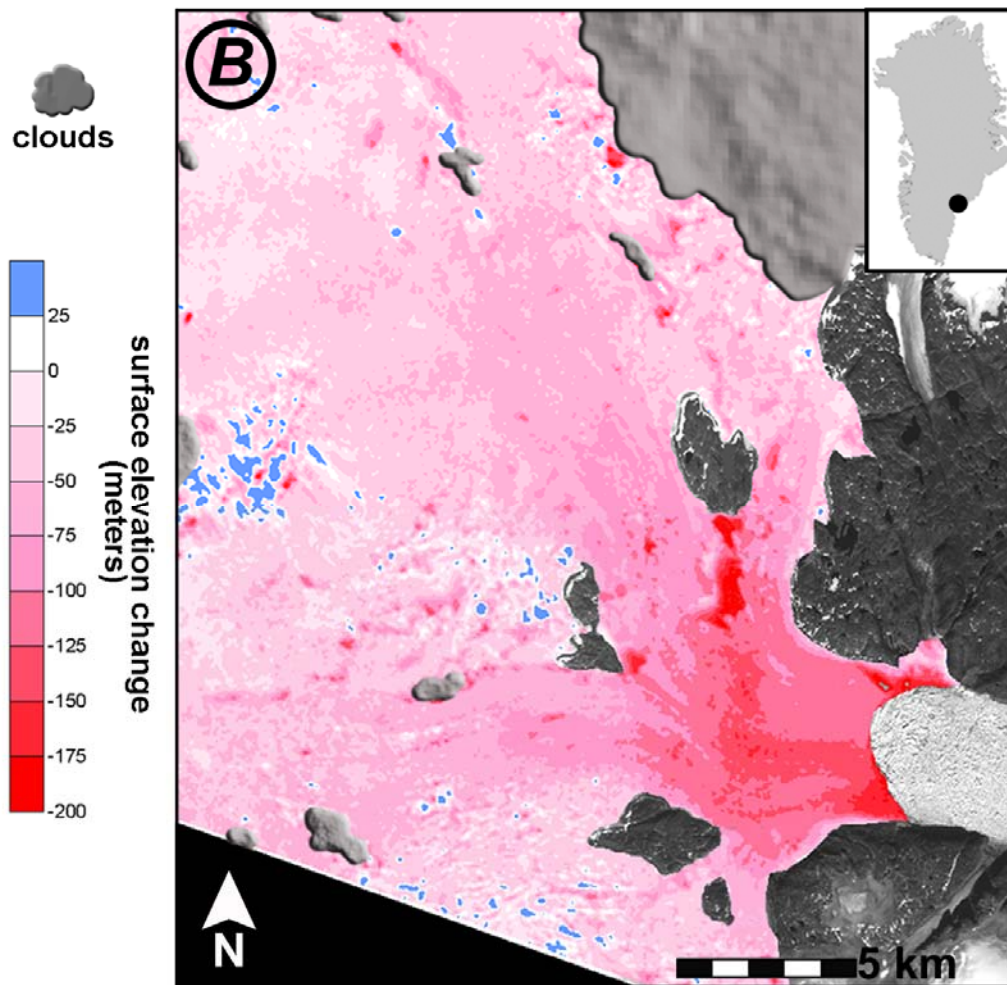




# Helheim glacier:

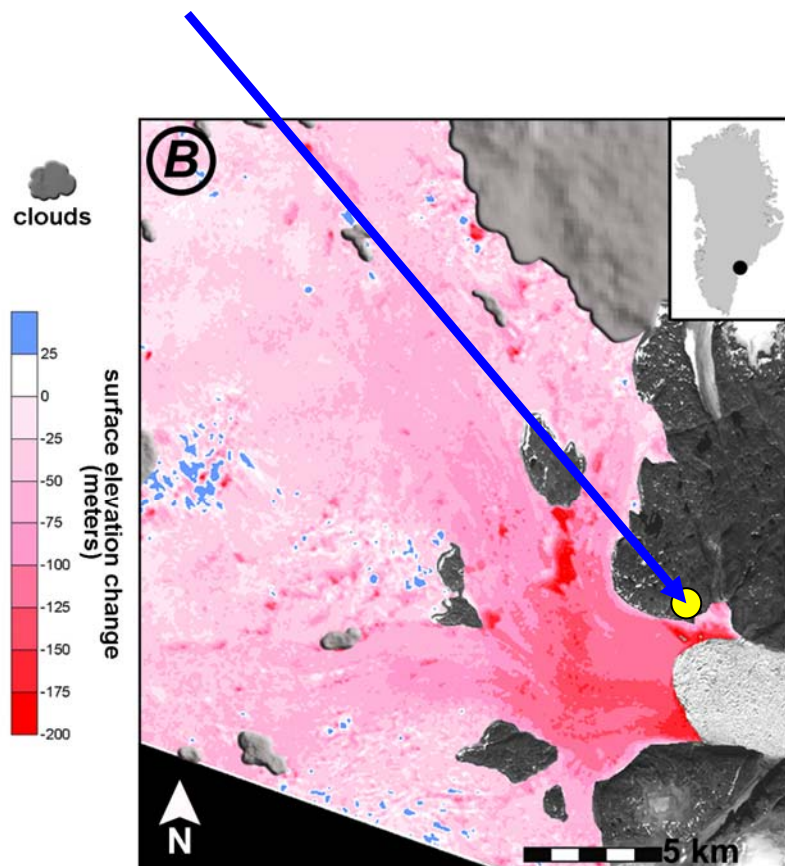
## Elevation change model by the ASTER.

Map of surface elevation change between 2002-2005

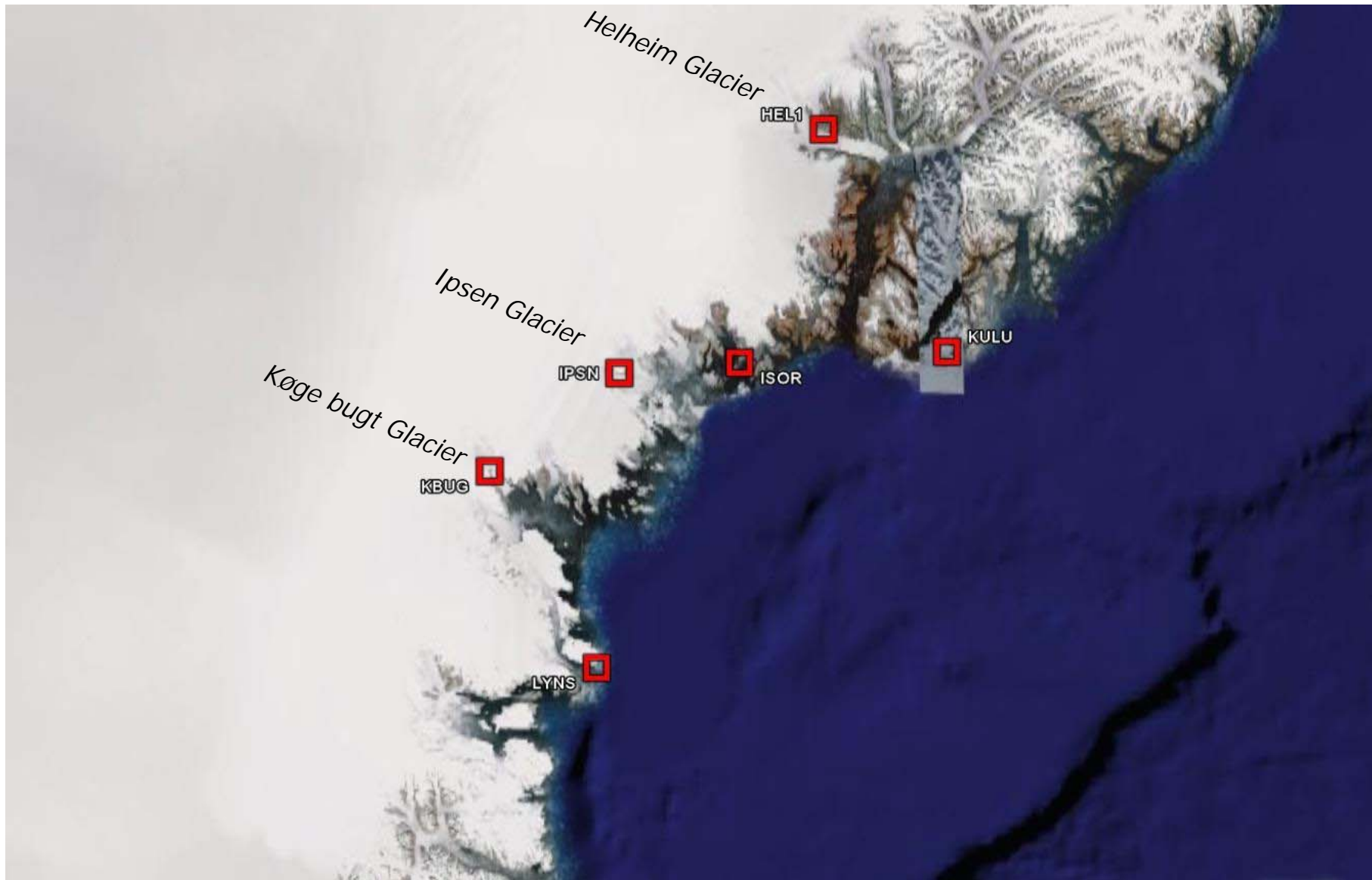


Helheim:

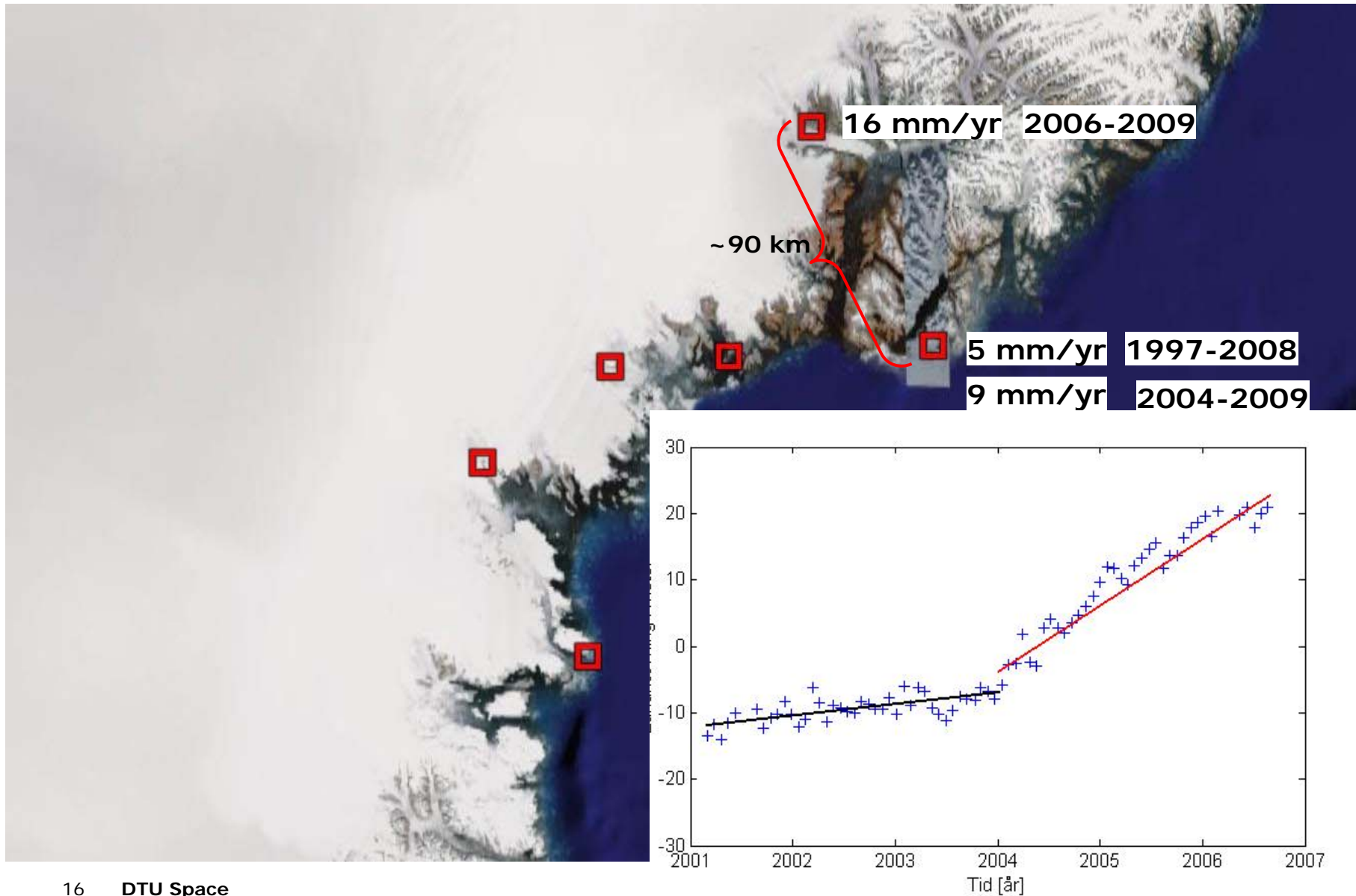
Uplift of  $\sim 40$  mm/yr due to elevation change/mass loss



# Location of the GPS sites and the main glaciers

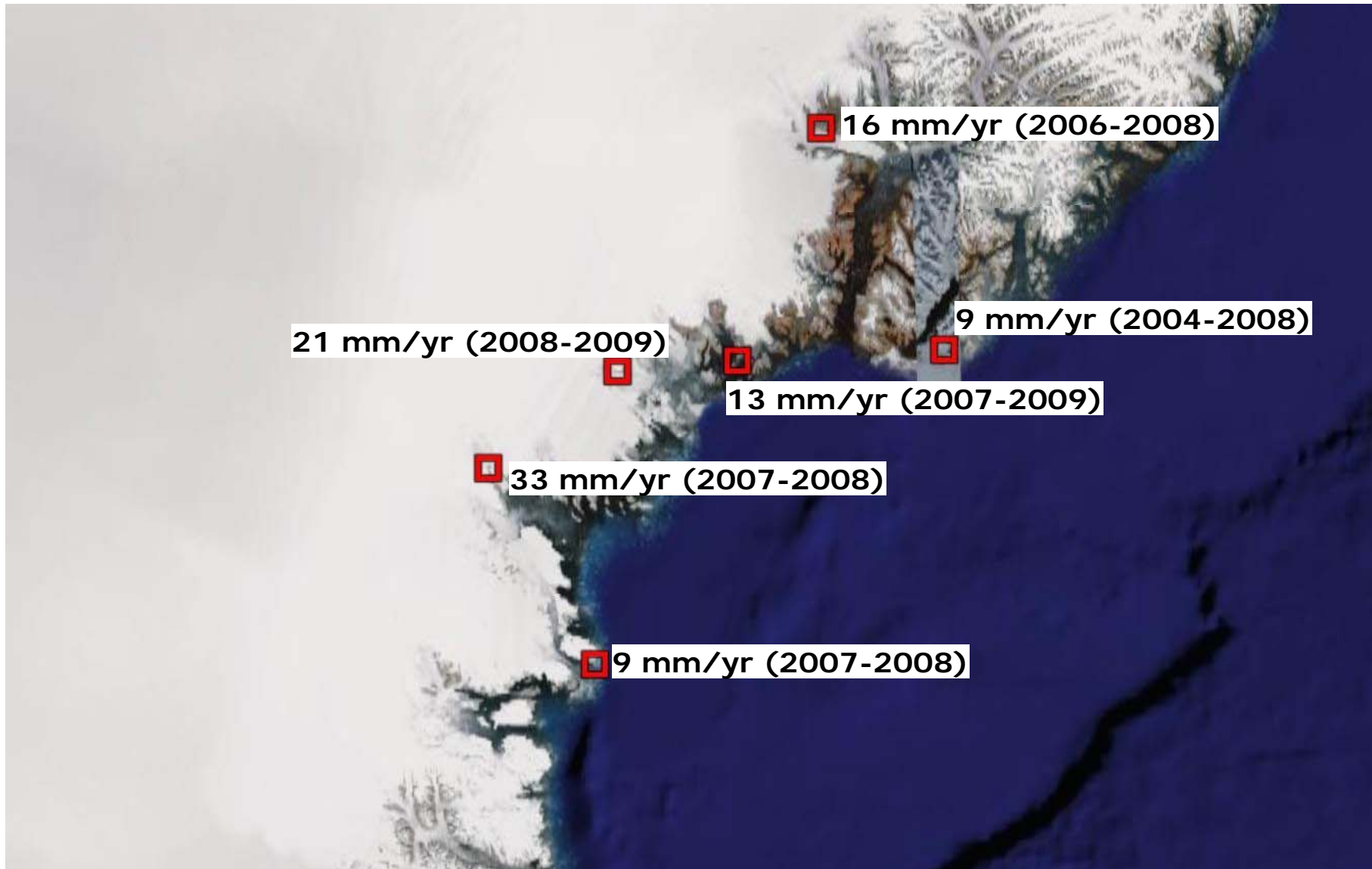


# KULU uplift rate suggest acceleration

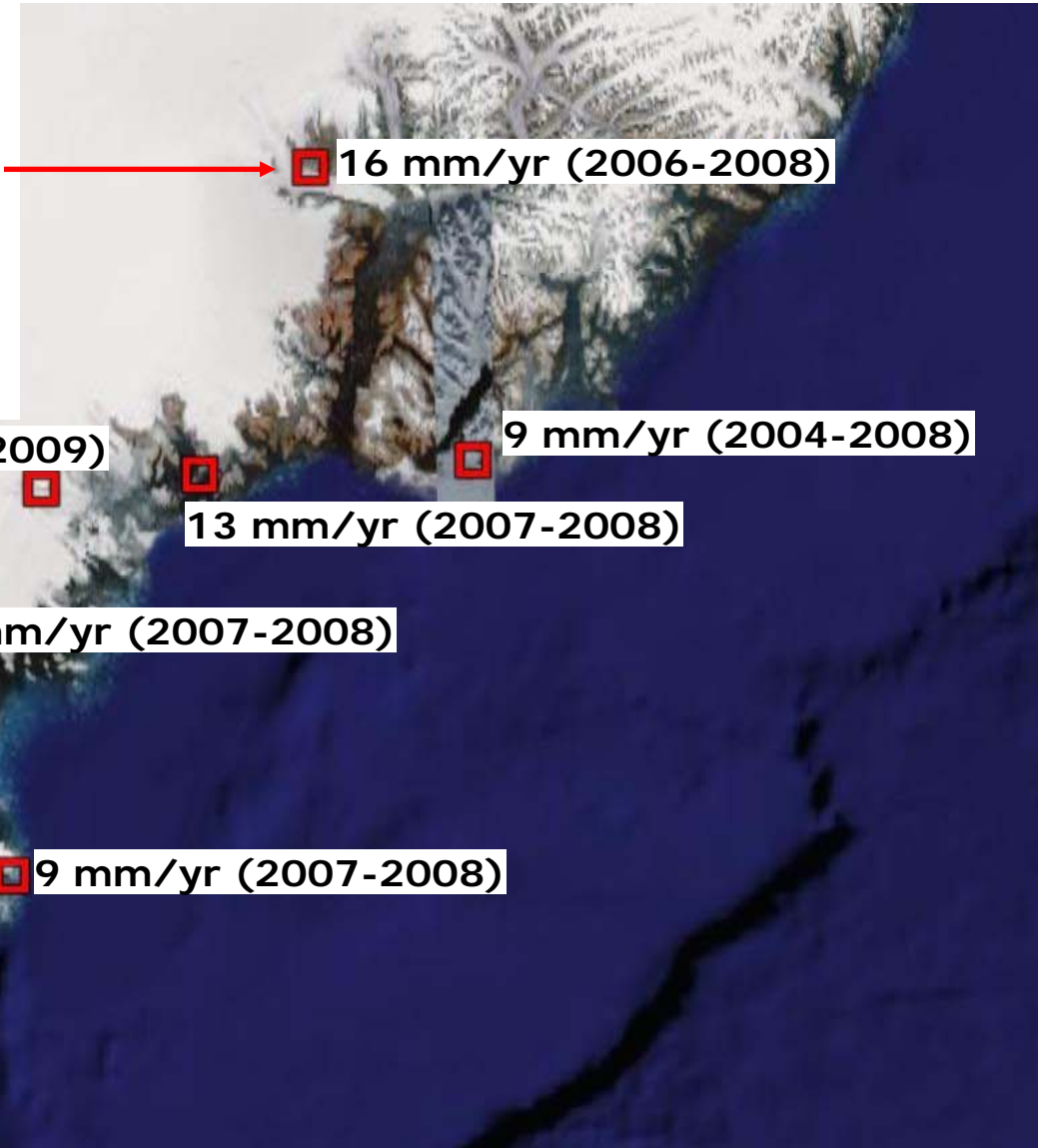
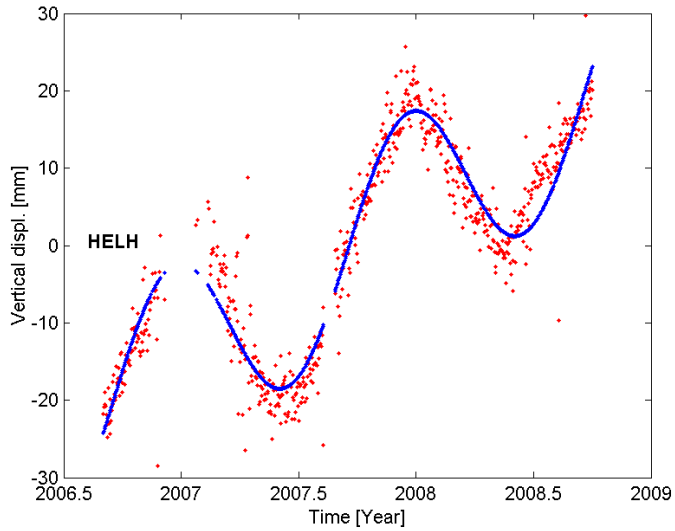




# Preliminary uplift rates !!!



# Helheim GPS time series



16 mm/yr (2006-2008)

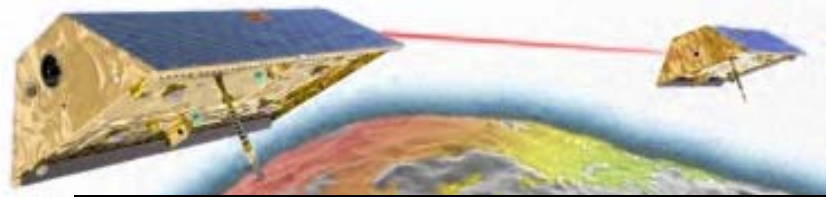
9 mm/yr (2004-2008)

13 mm/yr (2007-2008)

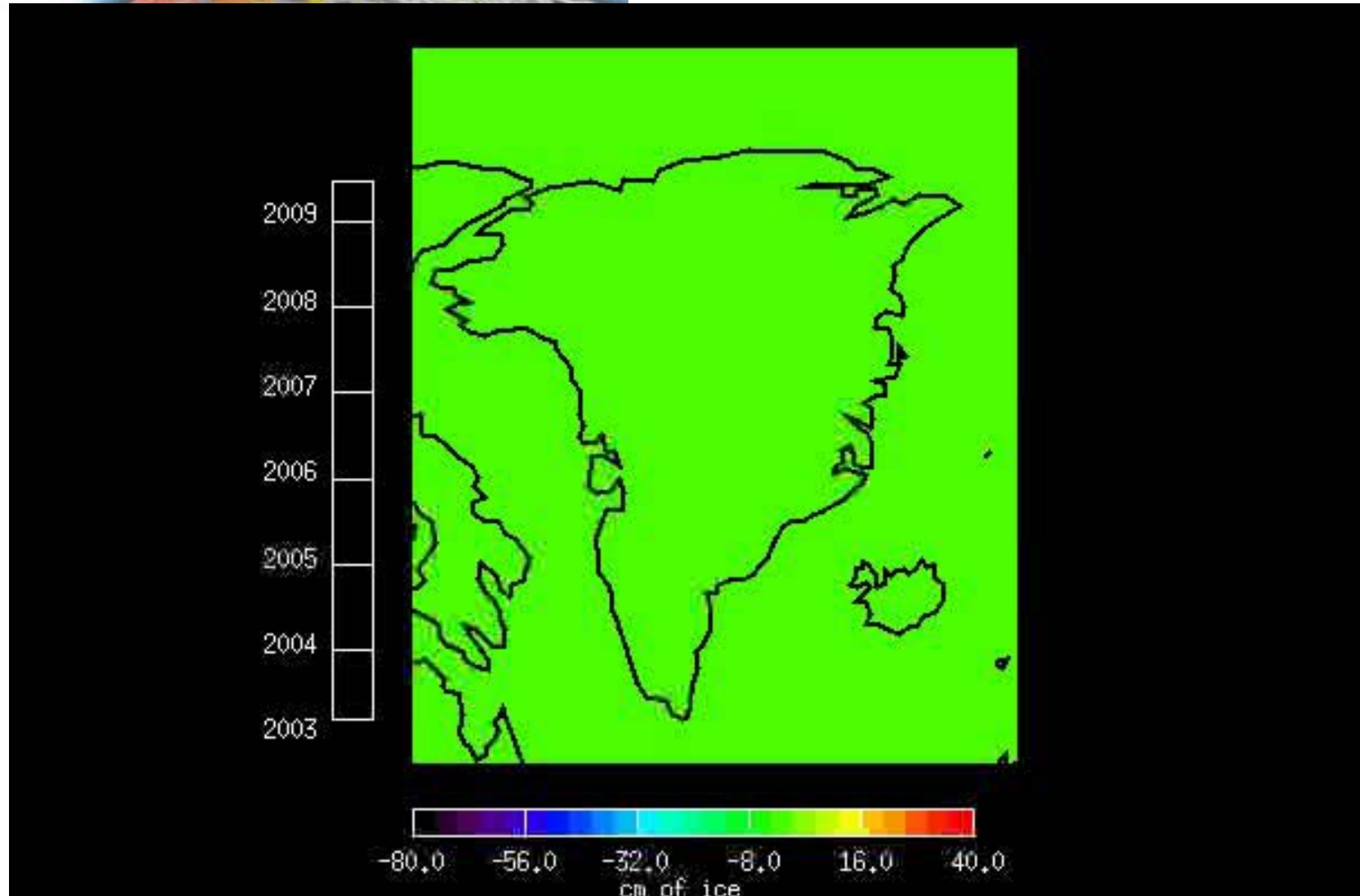
33 mm/yr (2007-2008)

9 mm/yr (2007-2008)

21 mm/yr (2008-2009)



# Gravity Field Mission – GRACE



# Greenland Network – GNET

Collaboration between:

- Ohio State University
- DTU Space
- University of Luxembourg

Stations:

- – 23 stations build 2007
- – 11 stations build 2008
- – 11 stations to be build 2009
- + 9 existing stations

