



NORWEGIAN MAPPING
AUTHORITY

Past and present-day ice mass variation on Svalbard revealed by superconducting gravimeter, GPS and VLBI measurements

POSITIONING DATA – FOR SOCIETY'S BENEFIT

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7th IVS General Meeting
Madrid (Spain), March 4-9 2012

Outline:

- Background/motivation
- The geodetic observatory in Ny-Ålesund
- Uplift and gravity rates
 - vary with time (non linear)
 - larger than expected
- Geophysical origin (PDIM+GIA)
 - PDIM explain the time varying component
 - combine gravity and geometry to reveal the geophysical processes

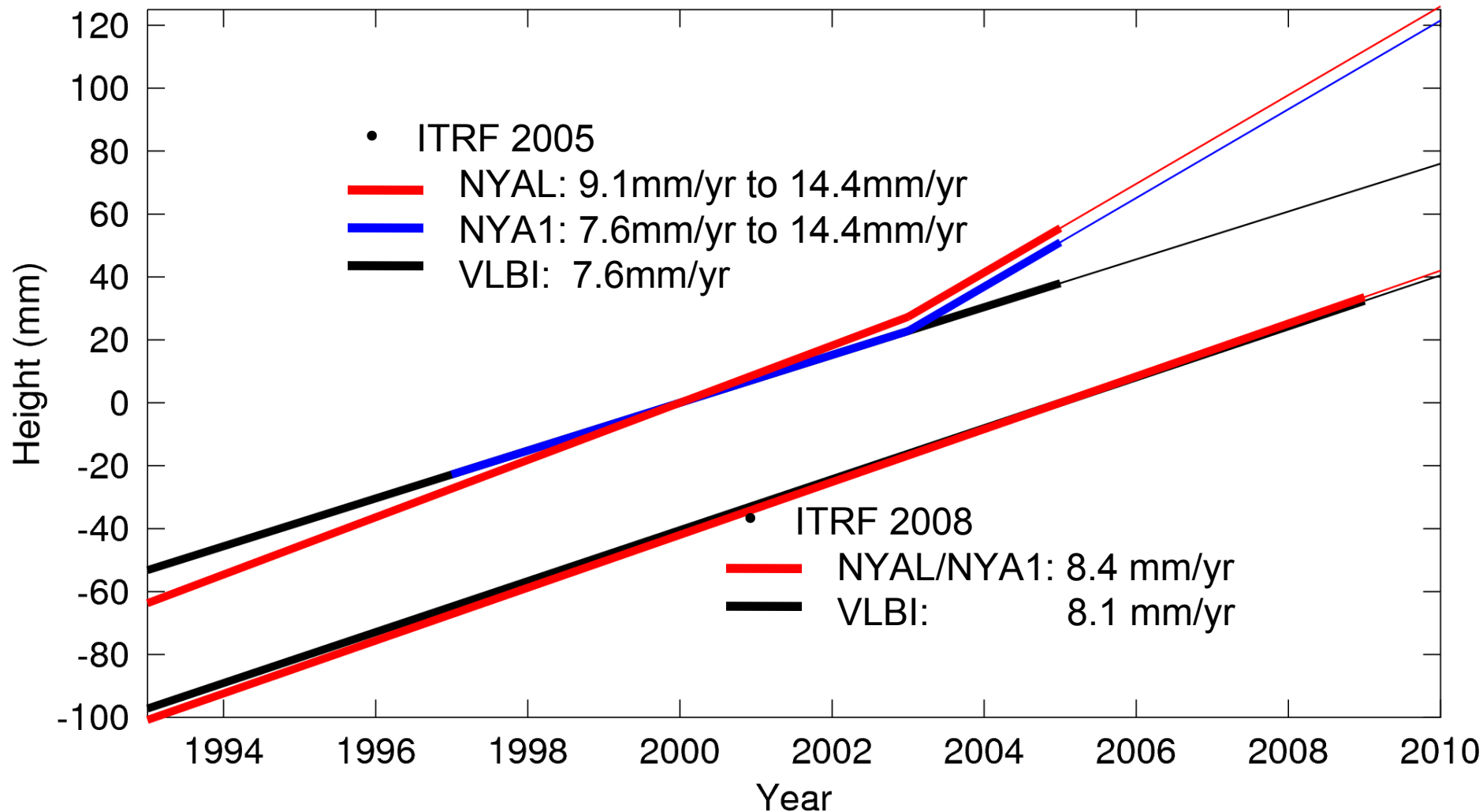
Based on:

-Omang, O. C. D. and H. P. Kierulf (2011), Past and present-day ice mass variation on Svalbard revealed by superconducting gravimeter and GPS measurements, Geophys. Res. Lett., 38, L22304

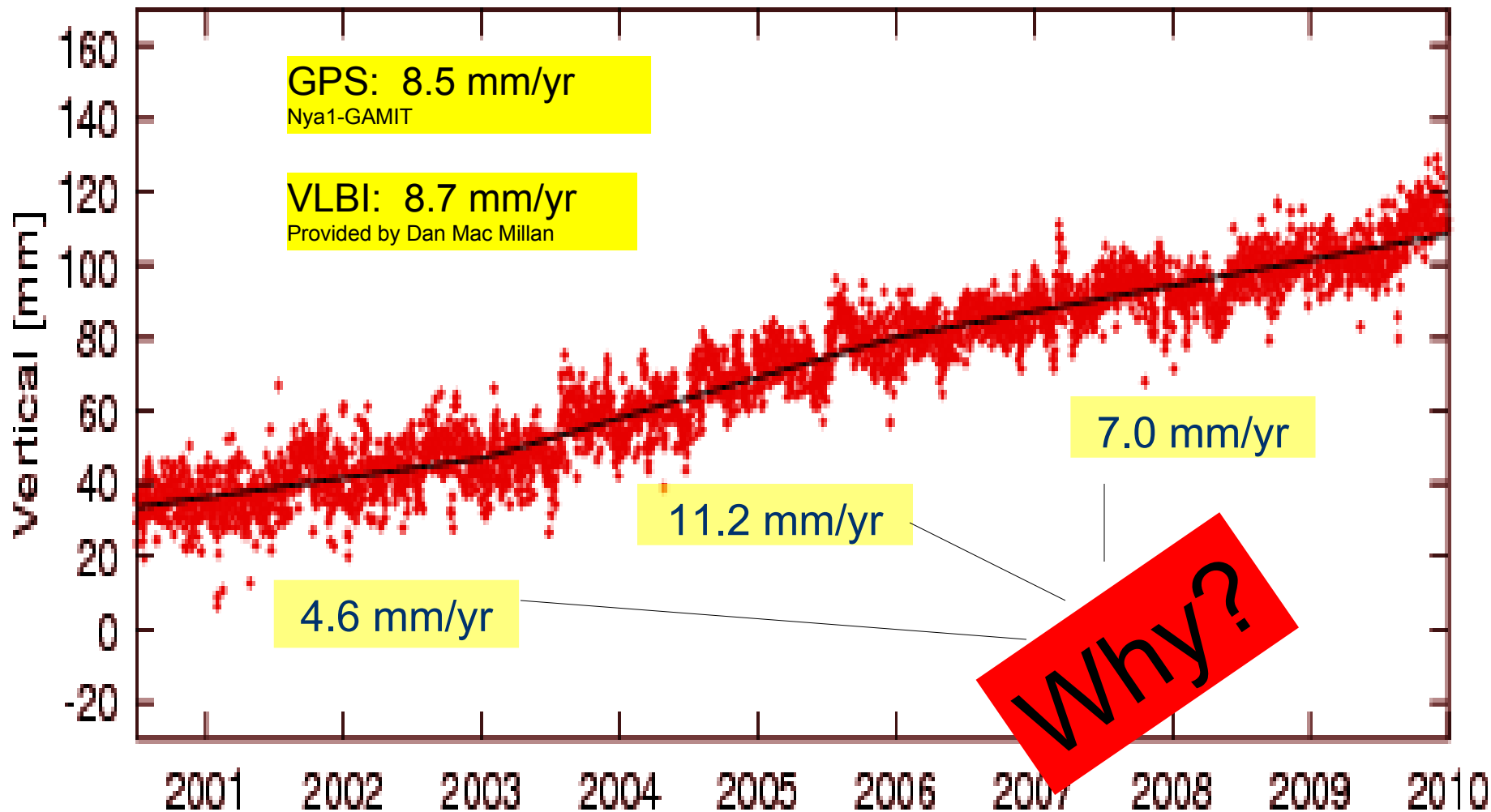
-Kierulf, H.P., Plag, H.-P., Kohler, J., 2009 Surface deformation induced by present-day ice melting in Svalbard, Geophys. J. Int., 179, 1, 1-13



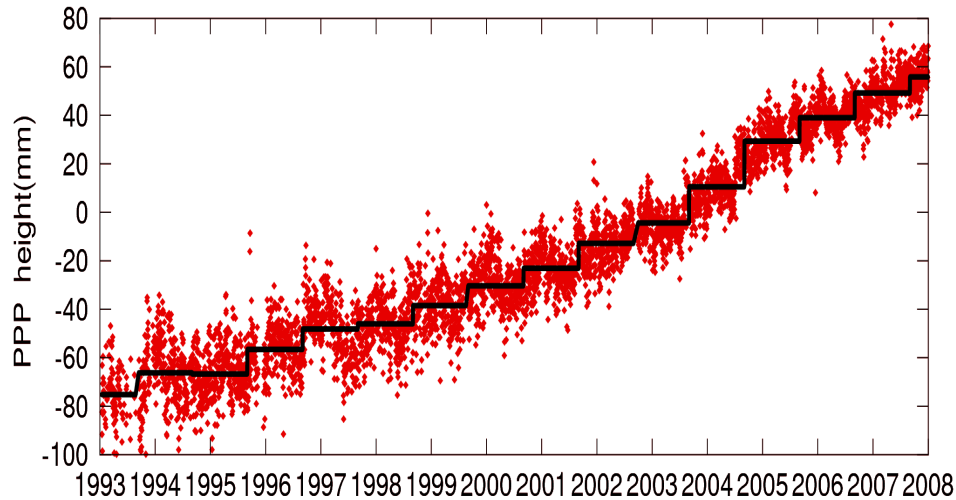
Motivation: Different velocities in Ny-Ålesund



Uplift in Ny-Ålesund

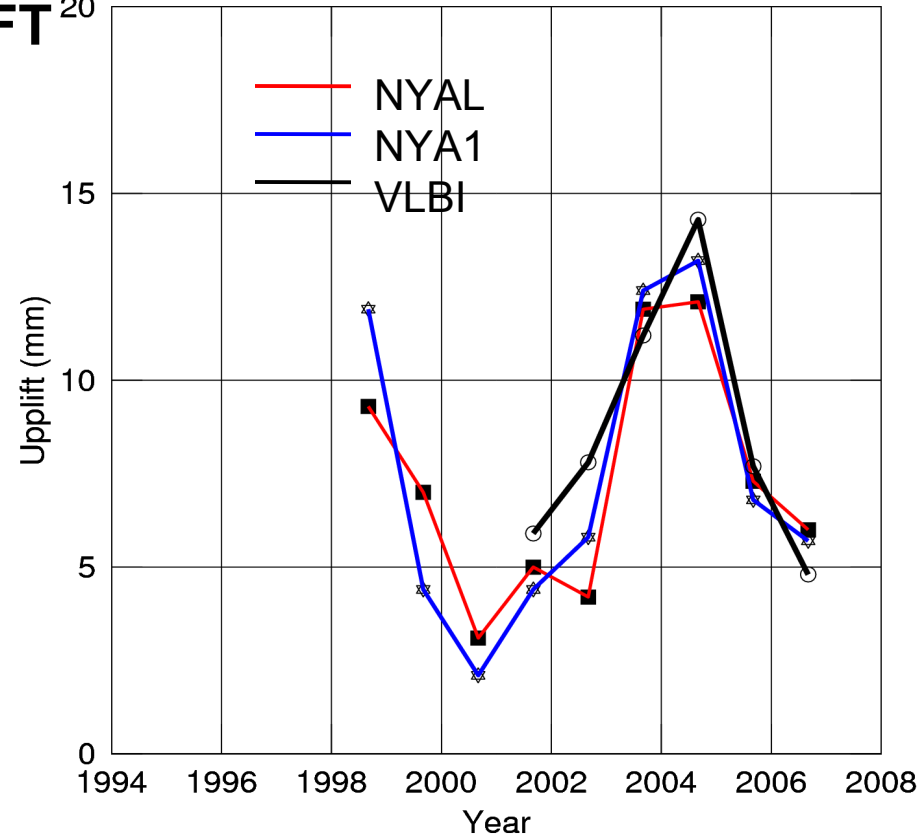


YEARLY CHANGES IN UPLIFT²⁰



Step function:

- $M(t) = a + \sum_j A_j \cdot H(t_j)$
- New Heaviside function included each year



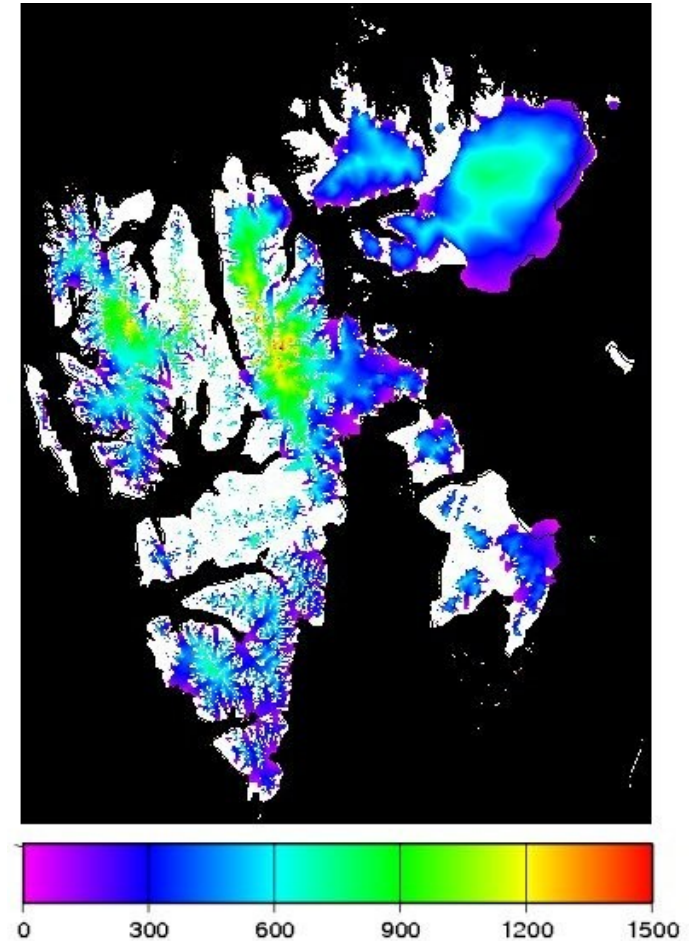
Each symbol represents the change in height from one year to the next



Loading computation

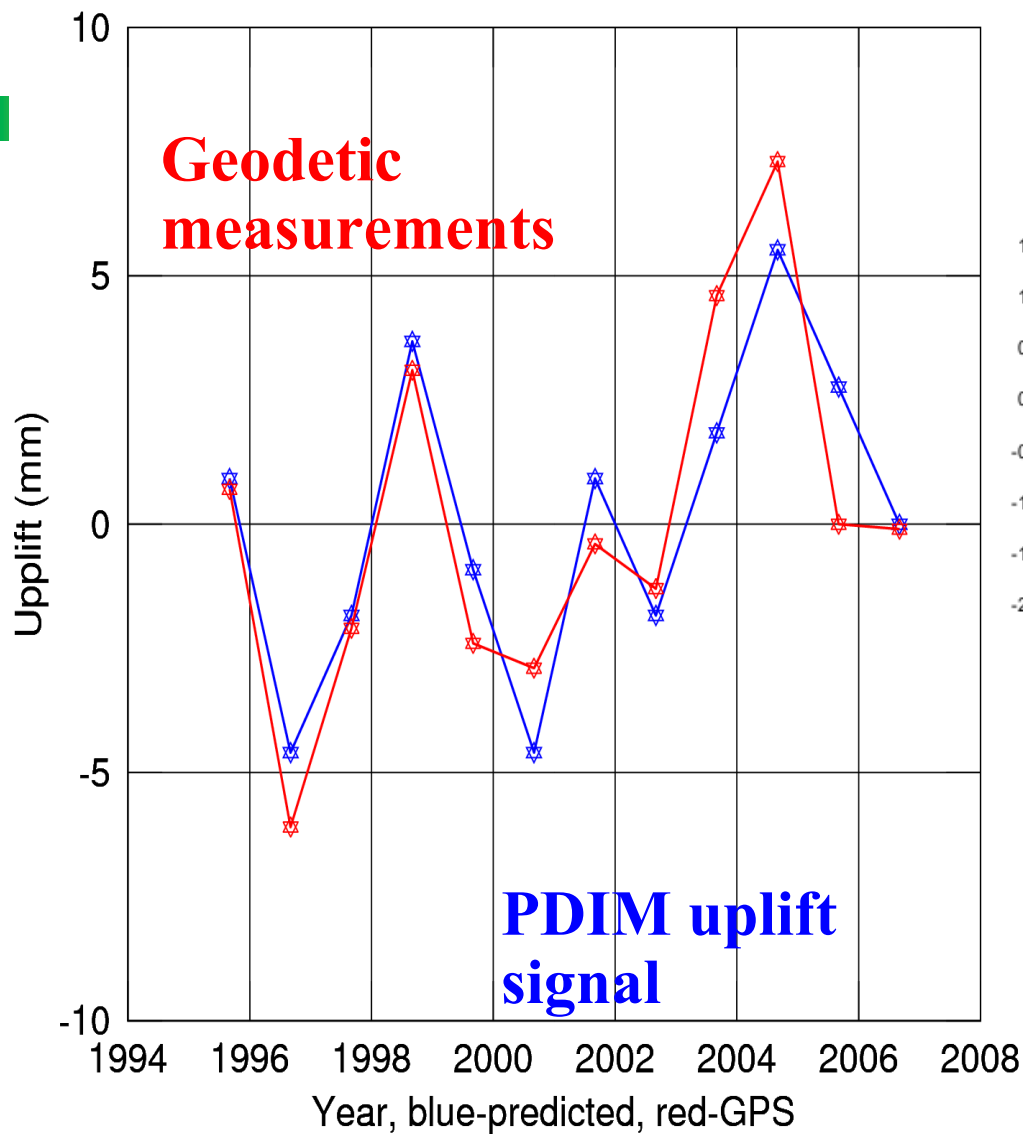
- Farrell [1972]
- Green's function

$$a(\mathbf{r}) = \int_A \rho \mathbf{Z}(\mathbf{r}') G|\mathbf{r} - \mathbf{r}'| dA$$

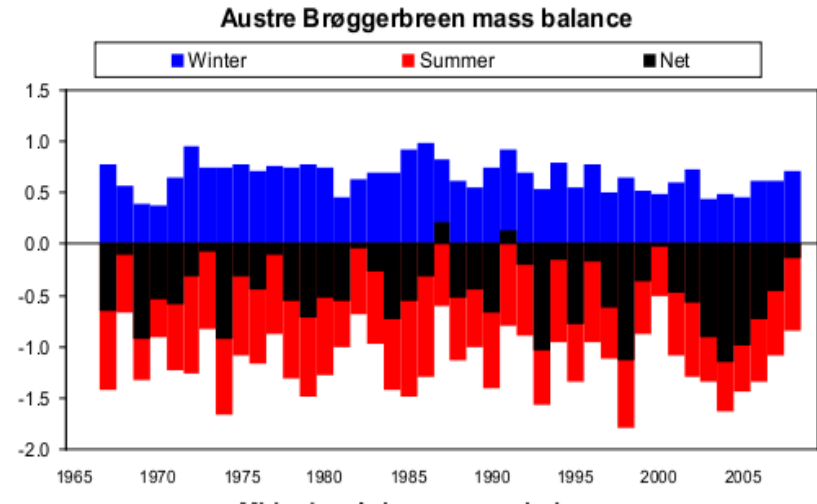


1 m weq. ice melting → 9.2 mm uplift in Ny-Ålesund





Yearly uplift



Geodetic observations

Geophysical predictions:

- Regression: 1.03
- Correlation: 0.8



Measurements/Models

Measurements:

Uplift 8.5 mm/yr

Model:

GIA: 1.6 mm/yr

PDIM: 3.1 mm/yr

Total

Uplift: 4.7 mm/yr

Unexplained:

Uplift 3.8 mm/yr

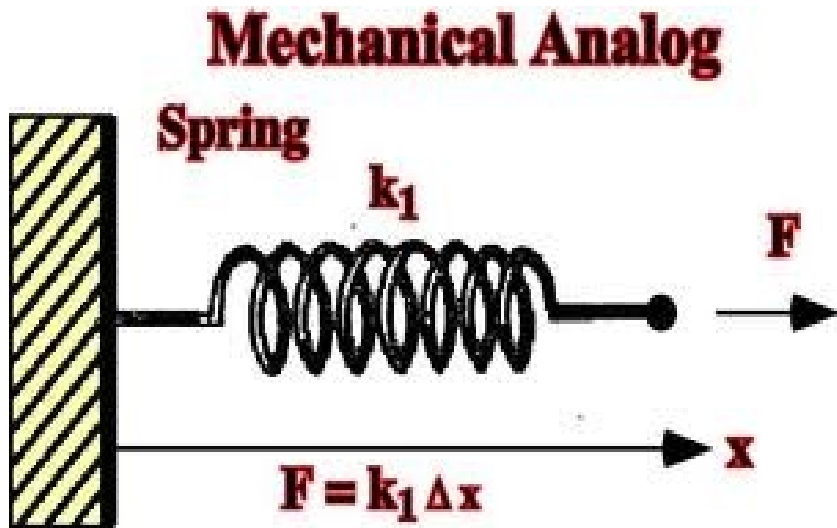
Why?



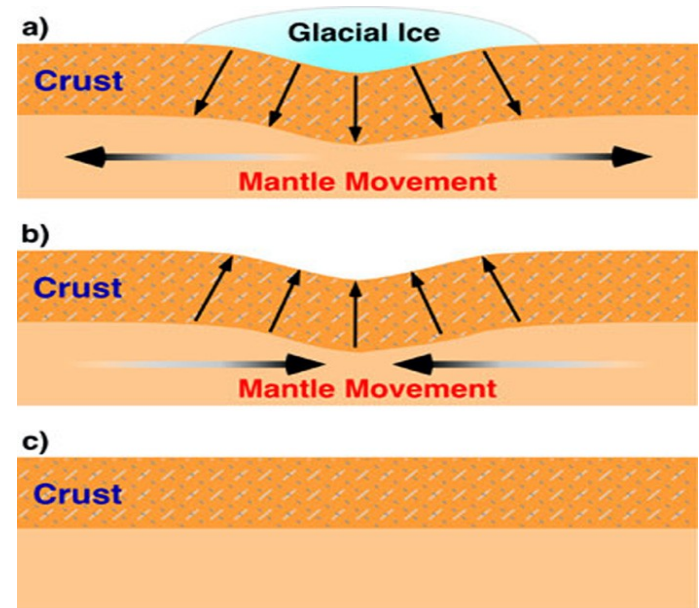
Elastic uplift

vers.

Viscoelastic uplift



$$\Delta g / \Delta h = -0.26 \mu\text{Gal/mm}$$



$$\Delta g / \Delta h = -0.15 \mu\text{Gal/mm}$$



Geodetic techniques (gravity)



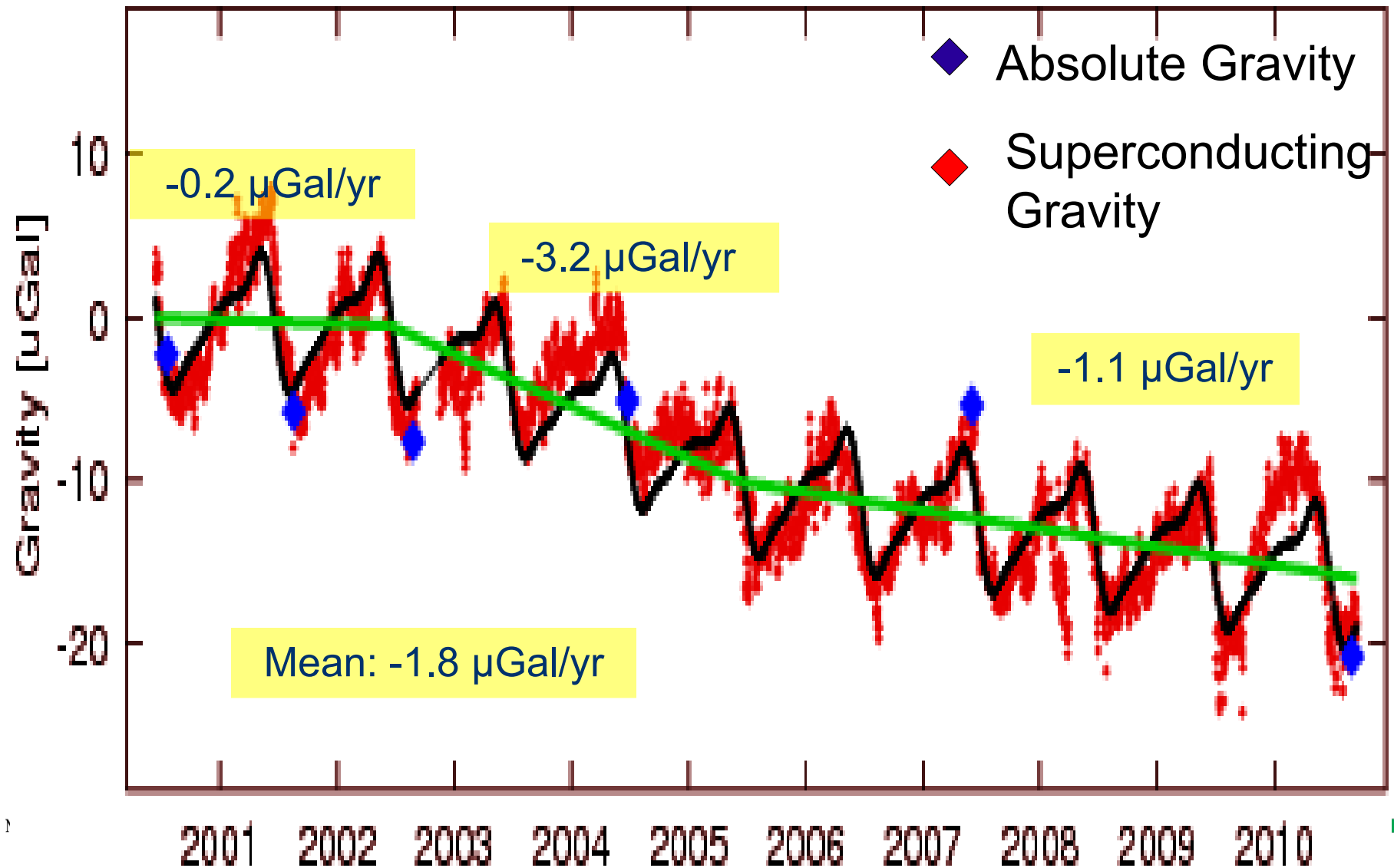
Gravimetry:

In-situ: AG/SG

Satellites: GRACE/GOCE



CHANGE IN dg/dt (SG)



Measurements/Models

Measurements: Uplift 8.5 mm/yr Gravity: $-1.8 \mu\text{Gal/yr}$

Model: Uplift: 4.7 mm/yr Gravity: $-1.1 \mu\text{Gal/yr}$

Unexplained: Uplift 3.8 mm/yr Gravity: $-0.7 \mu\text{Gal/yr}$

Unexplained $\Delta g/\Delta h = -0.19 \mu\text{Gal/mm}$
(indicating a viscoelastic process)



Glacier retreat during the last 100 years - Svalbard

Blomstrandbreen

1928



2002



Lovénbreen

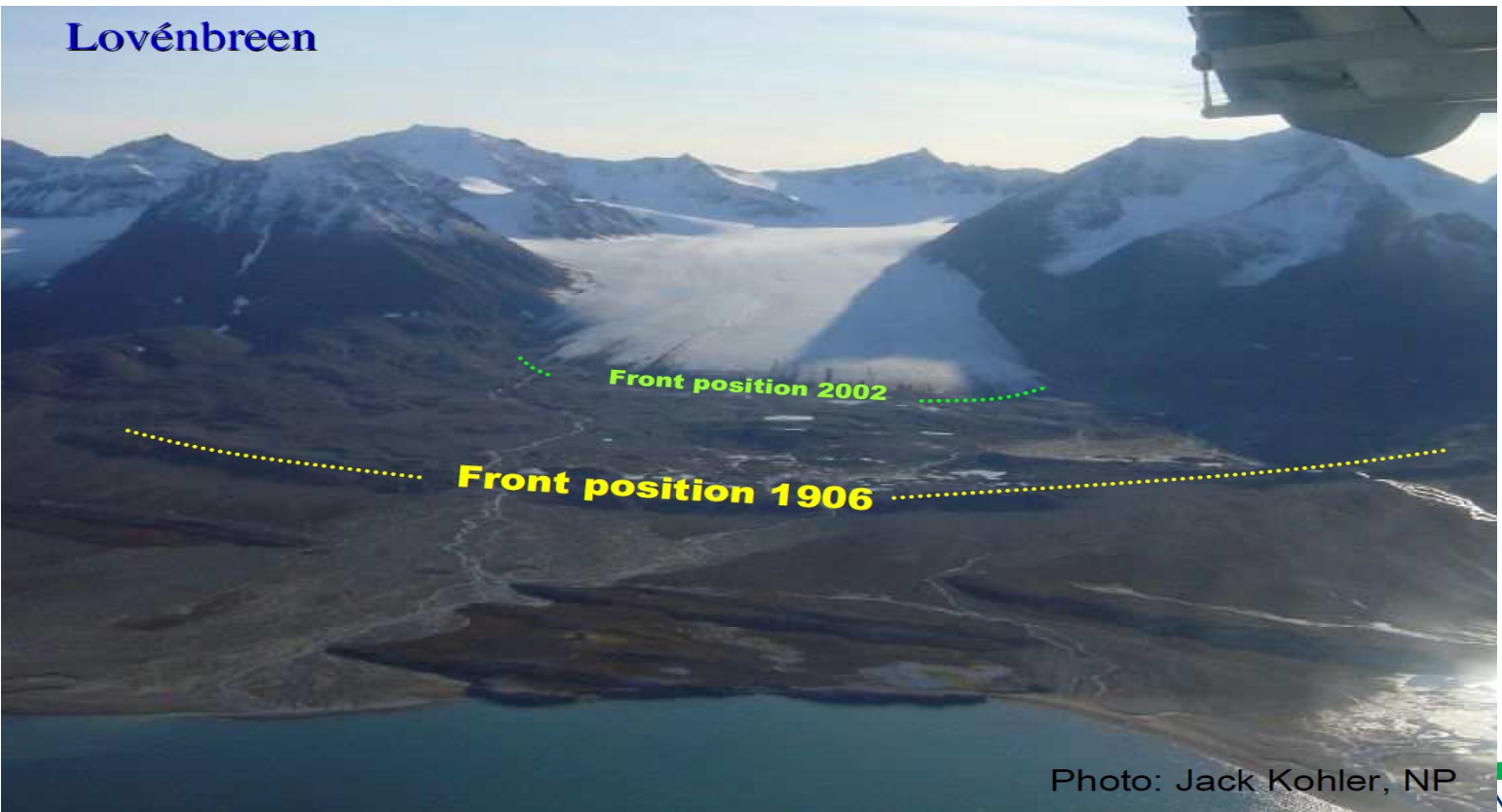


Photo: Jack Kohler, NP

Conclusions

- Changes in uplift/gravity in agreement with measured ice mass balance
- Measured uplift/gravity are larger than predicted from past and present ice mass changes
- A combination of geometry and gravity give a tool to separate geophysical processes
- De-glaciation after little ice age most likely explain the discrepancy



Thank you for your attention!



Hope everything is clear!