Greenland Ice sheet Ocean Interaction

ALFRED-WEGENER-INSTITUT HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

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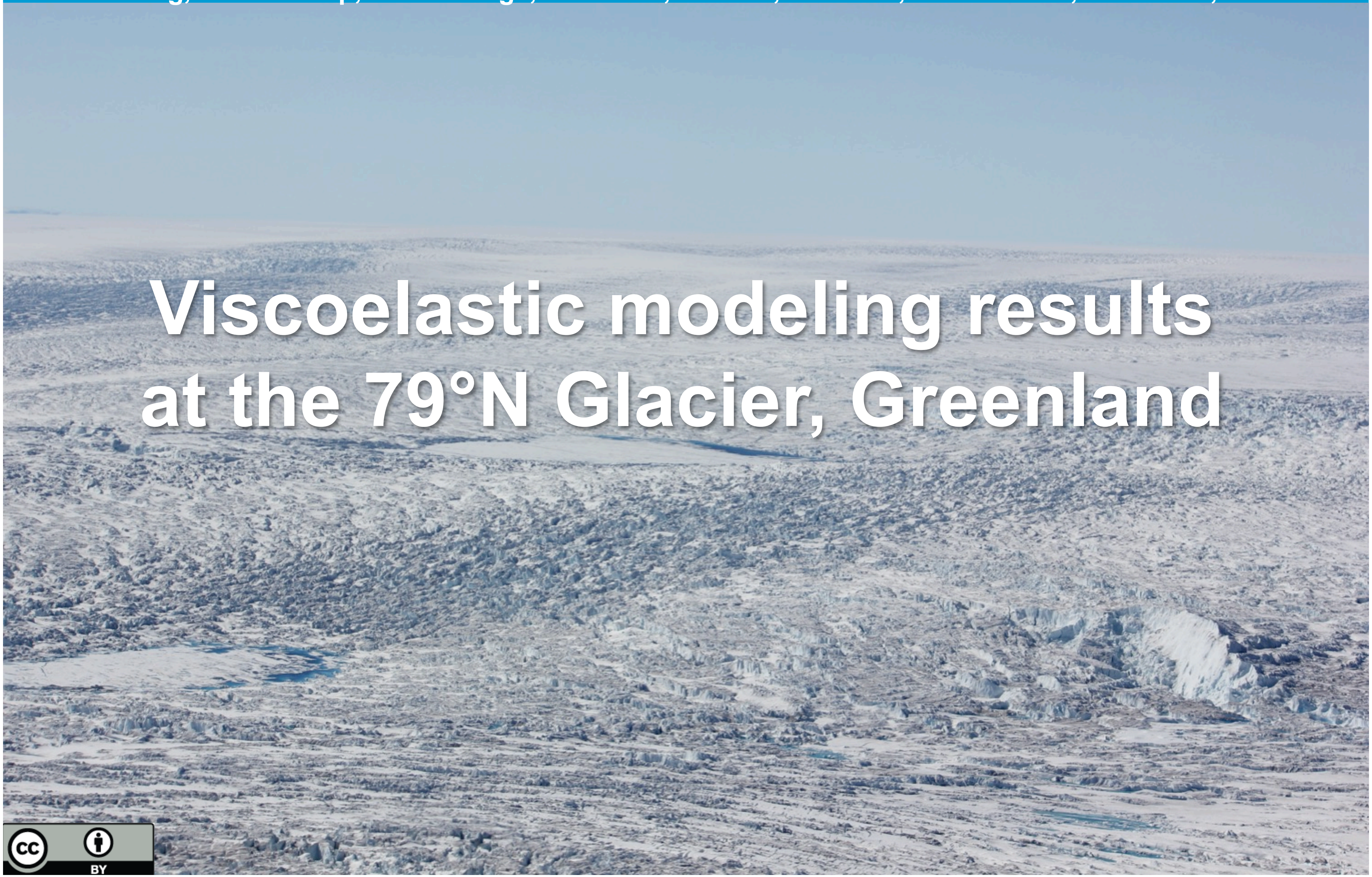
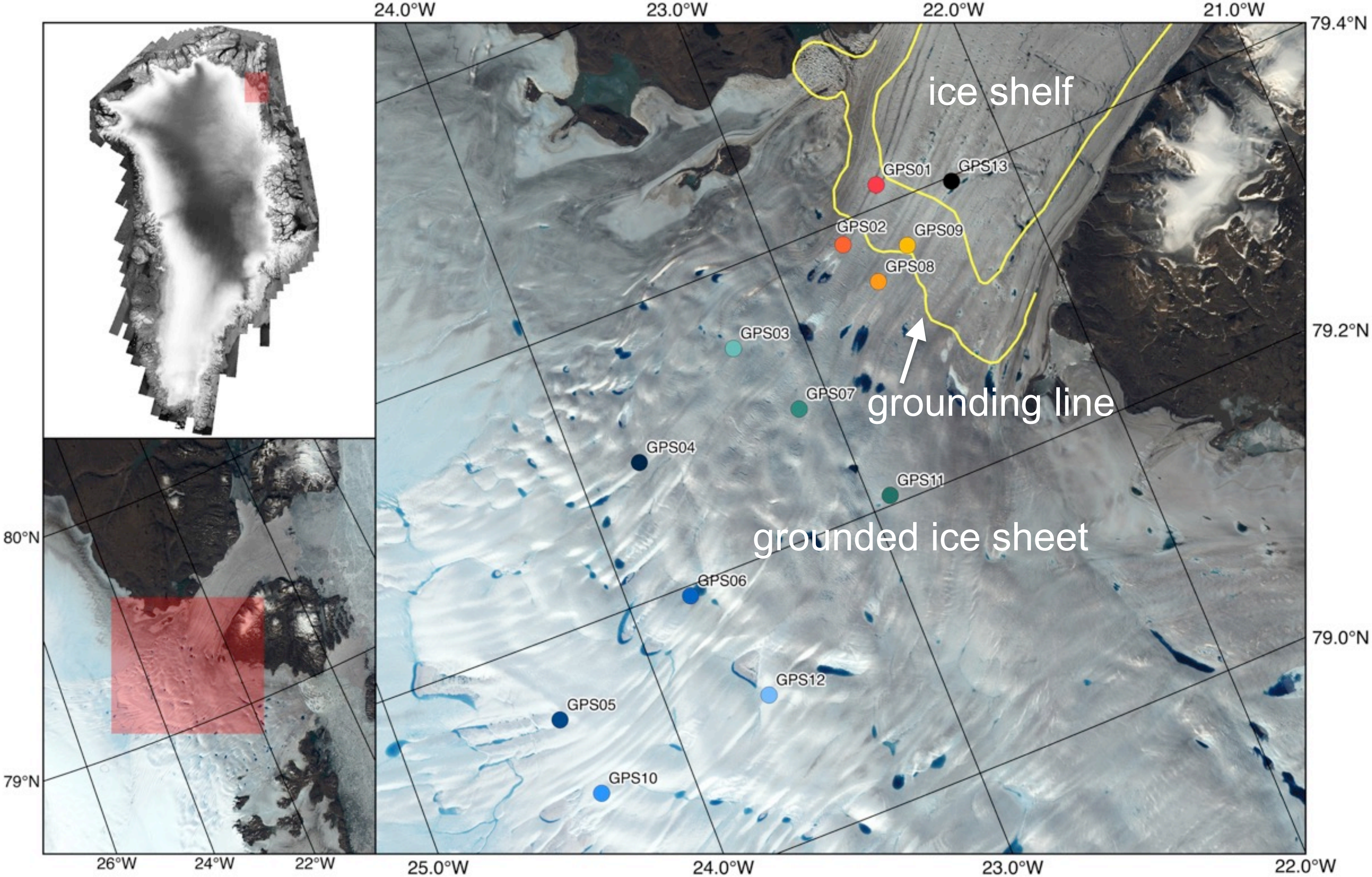
Viscoelastic modeling results at the 79°N Glacier, Greenland



Where: Nioghalvfjerdsbrae (79°N Glacier)



GROCE Greenland Ice sheet Ocean Interaction

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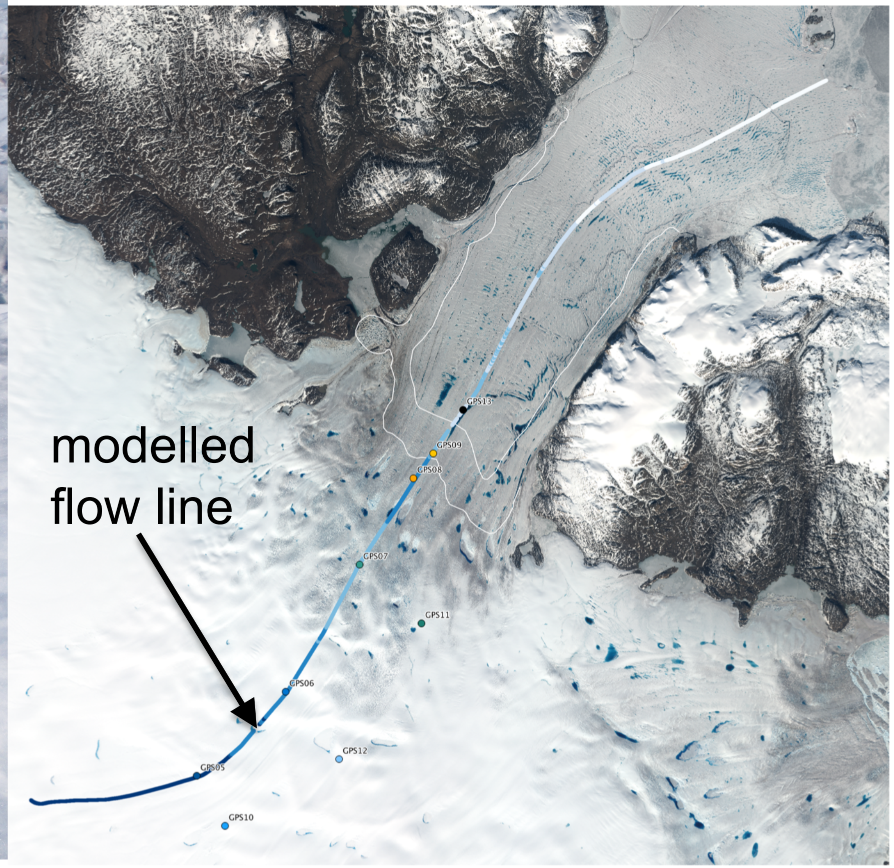
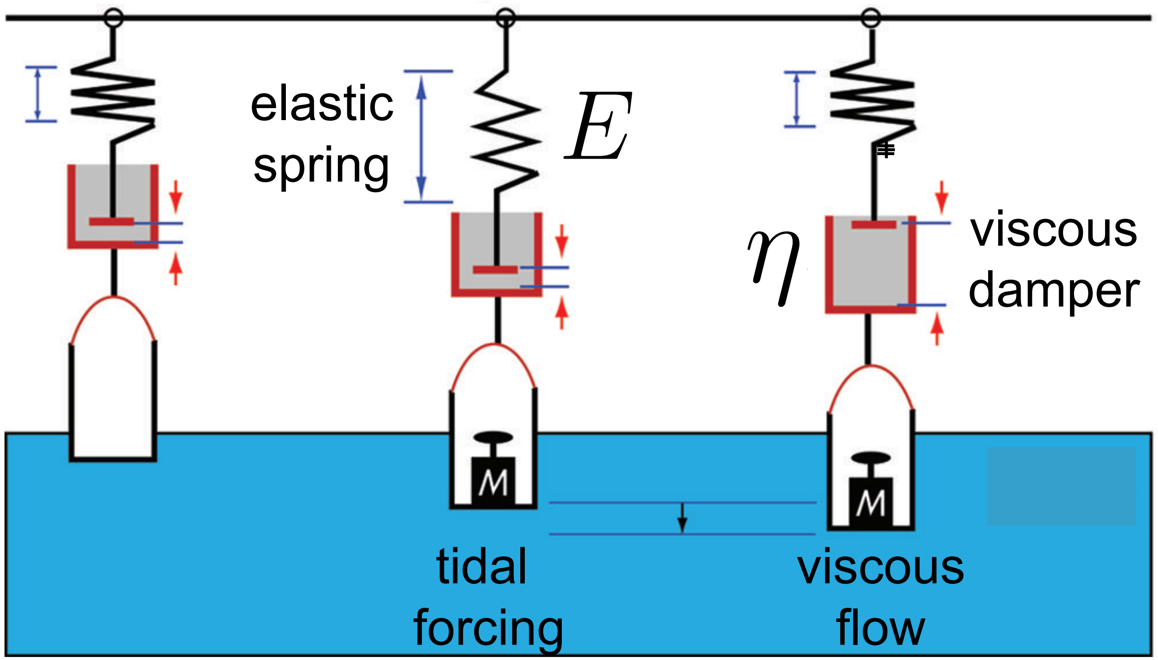
GPS Stations at 79° North Glacier

- data rate: every 15 seconds
- measurement period: July 2017
- vertical accuracy: 0.1 m



HELMHOLTZ GEMEINSCHAFT

What: Viscoelastic Maxwell Material



1D rheological model:

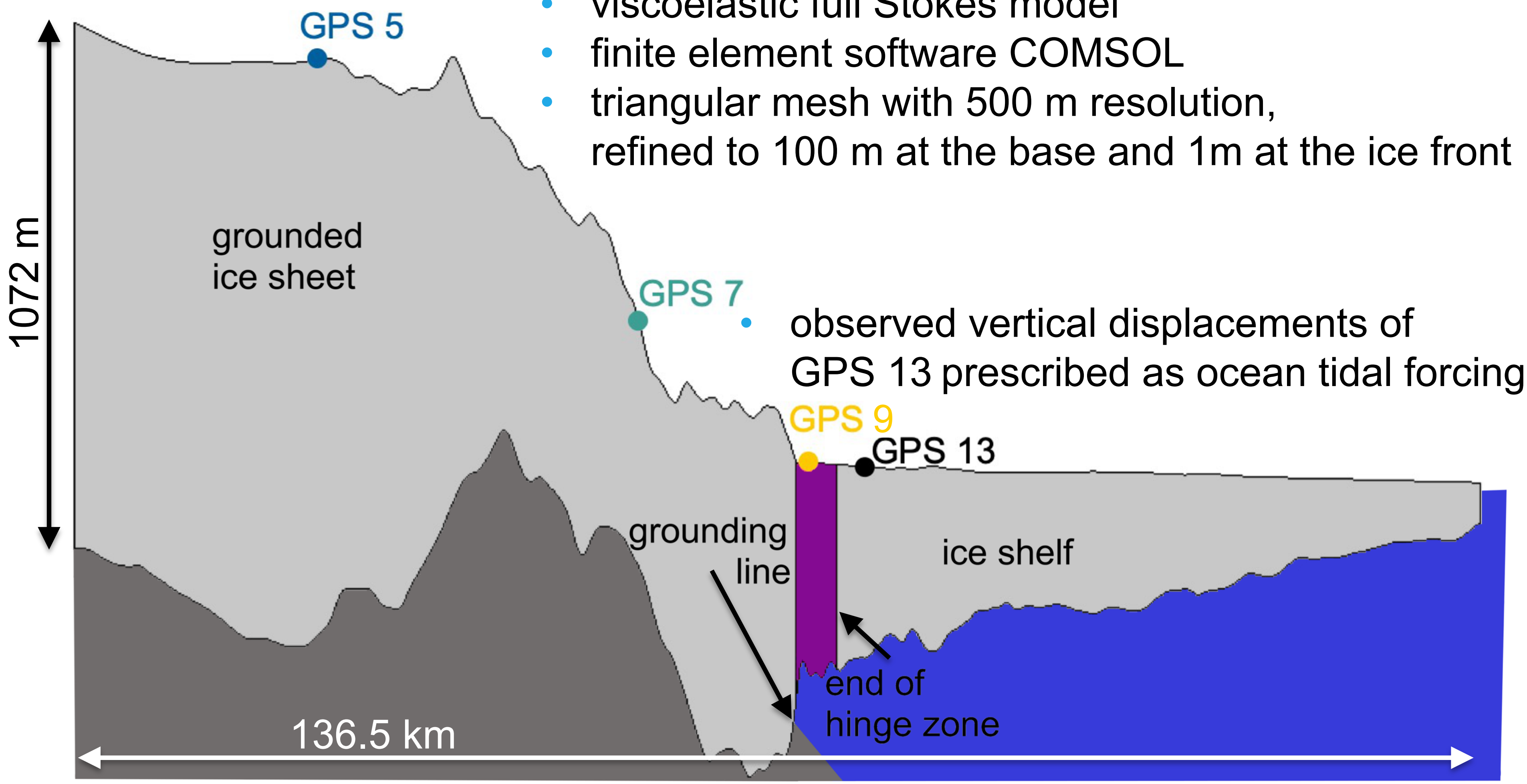
$$\varepsilon = \varepsilon_{\mathrm{e}} + \varepsilon_{\mathrm{v}}$$

$$\sigma = \sigma_{\mathrm{e}} = \sigma_{\mathrm{v}}$$

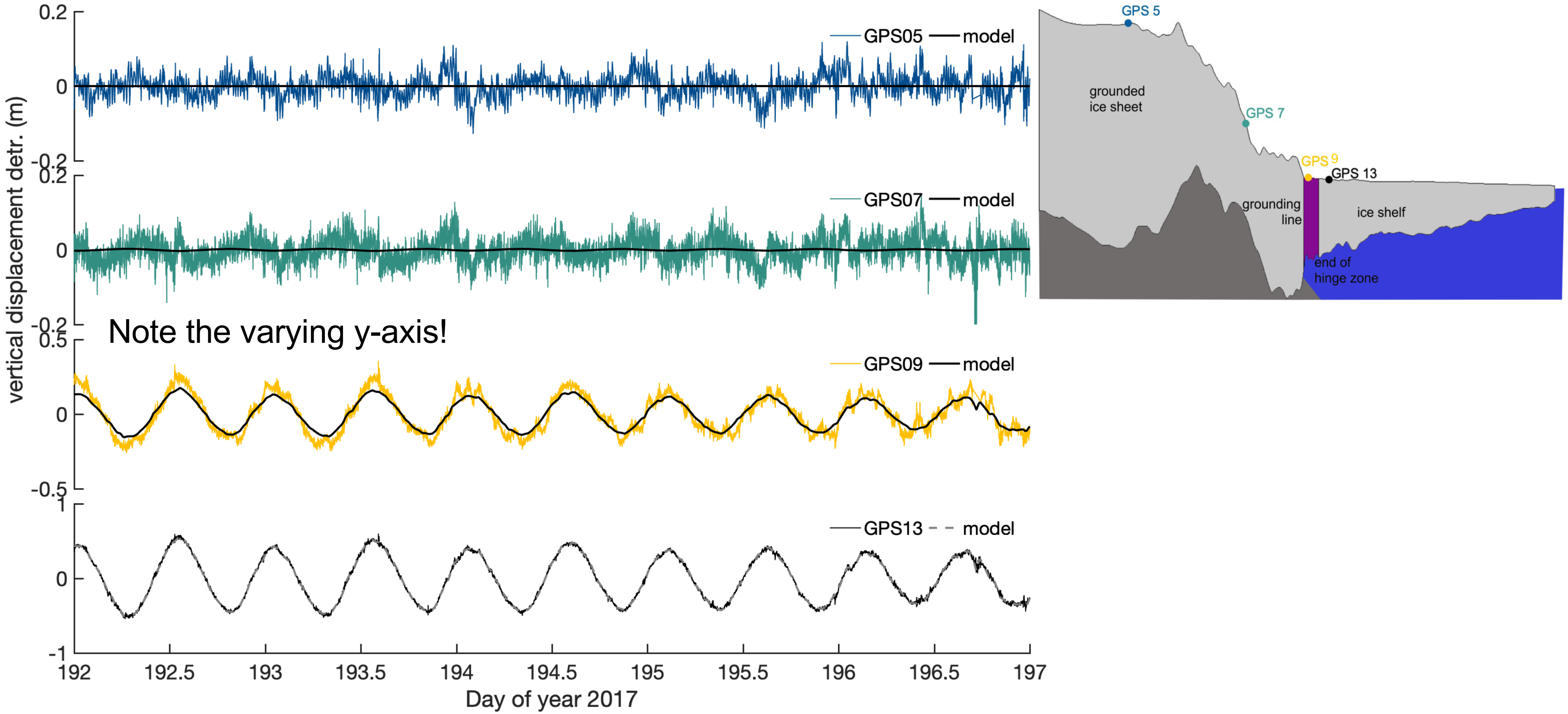
Christmann et al. (2019): On nonlinear strain theory for a viscoelastic material model and its implications for calving of ice shelves, Journal of Glaciology, 65 (250), https://doi.org/10.1017/jog.2018.107

Setting of Flow Line Model

- viscoelastic full Stokes model
- finite element software COMSOL
- triangular mesh with 500 m resolution, refined to 100 m at the base and 1m at the ice front
- observed vertical displacements of GPS 13 prescribed as ocean tidal forcing

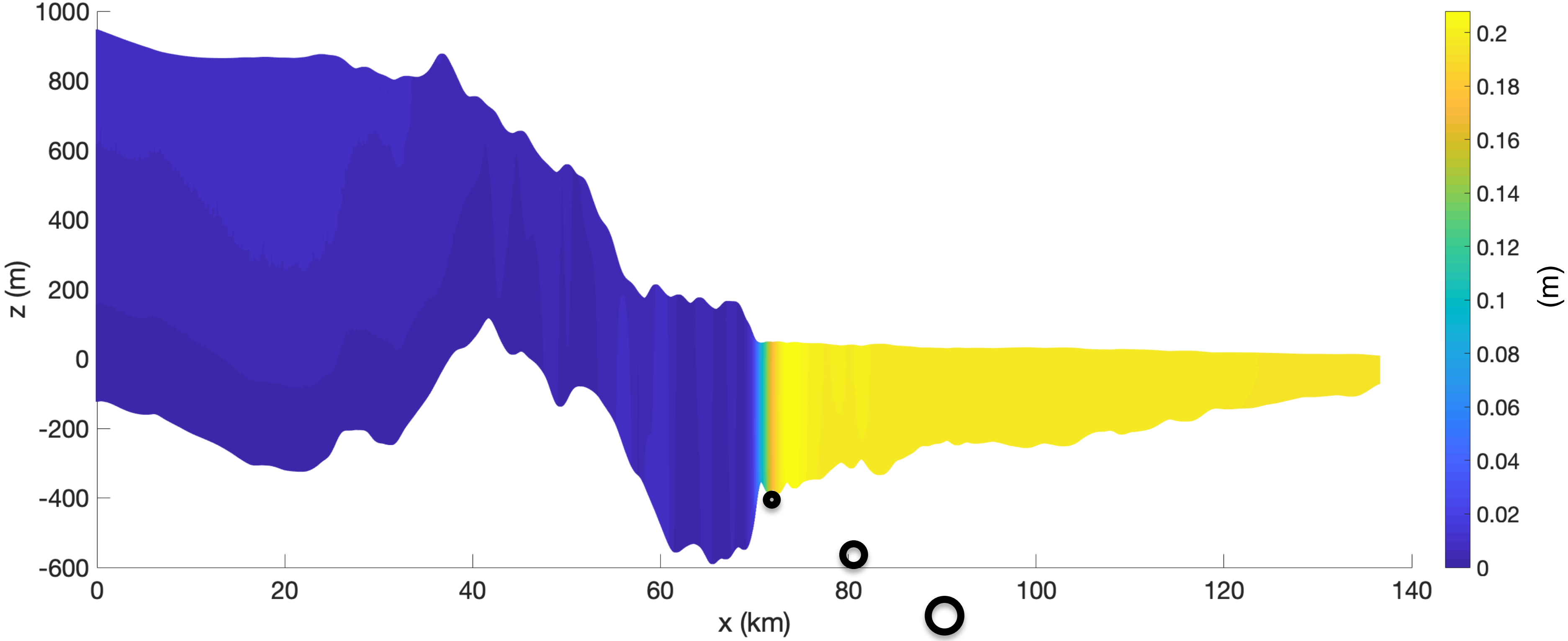


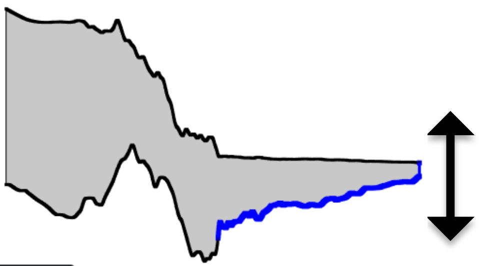
Results: Vertical Displacement



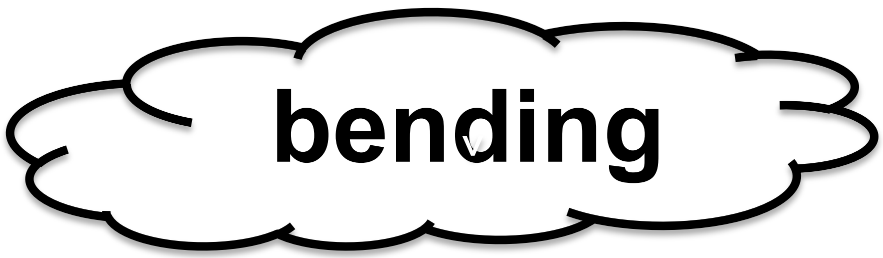
- pure tidal signal on the ice shelf
- effect of bending reduces modeled vertical displacements very similar to observed displacements in the hinge zone
- no tidal signal measured for grounded ice (smaller than noise), small tidal signal in model (~ 0.01m)

Modelled Vertical Amplitude (semidiurnal)

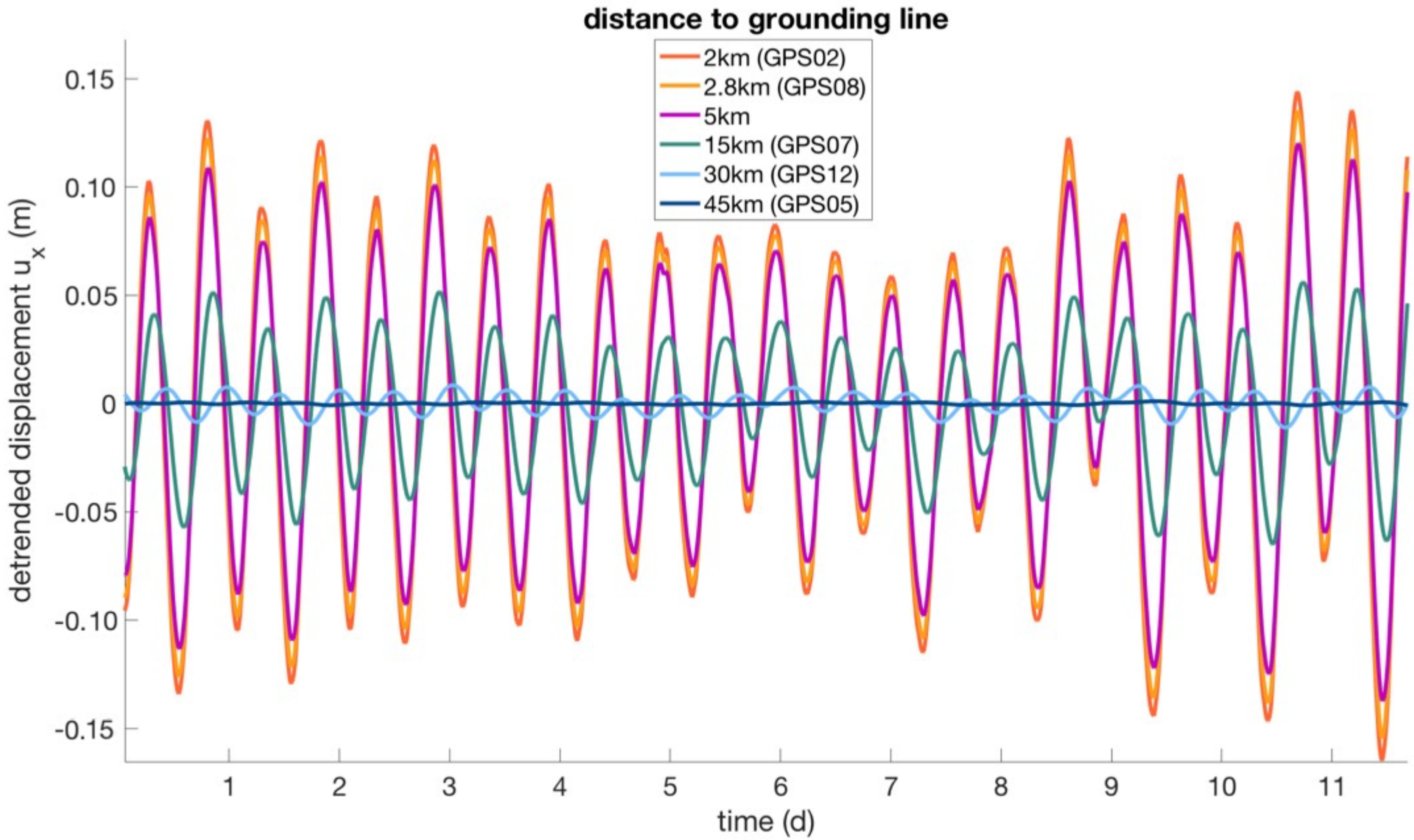


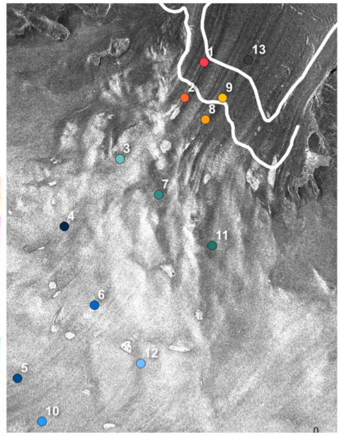


tides



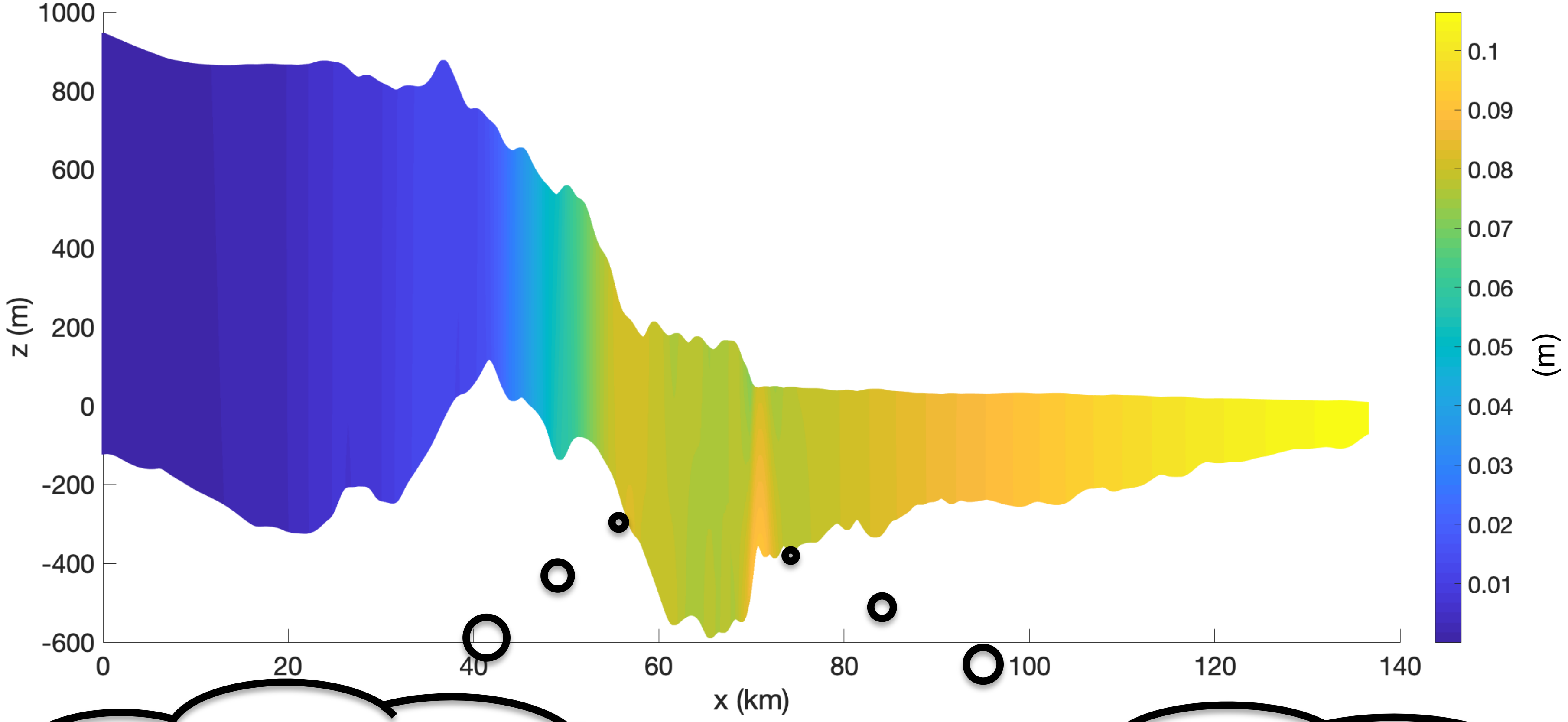
Horizontal Displacement (grounded ice, model)





- amplitude decreases with increasing distance to grounding line
- phase shift increases with distance

Modelled Horizontal Amplitude (semidiurnal)



phase shift

bending

Summary and Conclusions

Modelling and observations by GPS measurements show for

vertical displacements:

- bending effects through reduced vertical displacements in the hinge zone downstream from the grounding line
  (measurements and model agree very well)
- no tidal signal measured for grounded ice (smaller than noise), small tidal signal in model (~ 0.01m)

horizontal displacements grounded ice:

- amplitude decreases with increasing distance to grounding line
- the phase shift increases with distance to grounding line
  (no phase shift for a purely viscous material model)

horizontal displacements floating ice:

- amplitude increases towards the ice shelf front, no pinning point in the model