Regional paleo ice-sheet simulations with Elmer/Ice

Clemens Schannwell[1]

Drews, R.[2], Ehlers, T.A.[2], Eisen, O.[3,4], Mayer, C.[5], Malinen, M.[6], Smith, E.C.[3], H. Eisermann[3], and C. Henry[1,2]

[1]Max Planck Institute for Meteorology, Hamburg, Germany (contact: Clemens.Schannwell@mpimet.mpg.de)
[2]Department of Geosciences, University of Tübingen, Tübingen, Germany
[3]Glaciology, Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany
[4]Department of Geosciences, University of Bremen, Bremen, Germany
[5]Bavarian Academy for Sciences and Humanities, Munich, Germany
[6]CSC-IT Center for Science Ltd., Espoo, Finland

Max-Planck-Institut für Meteorologie

Talk outline

1) Glacial cycle simulations for the Ekström Ice Shelf embayment

2) Synthetic ice rise simulations

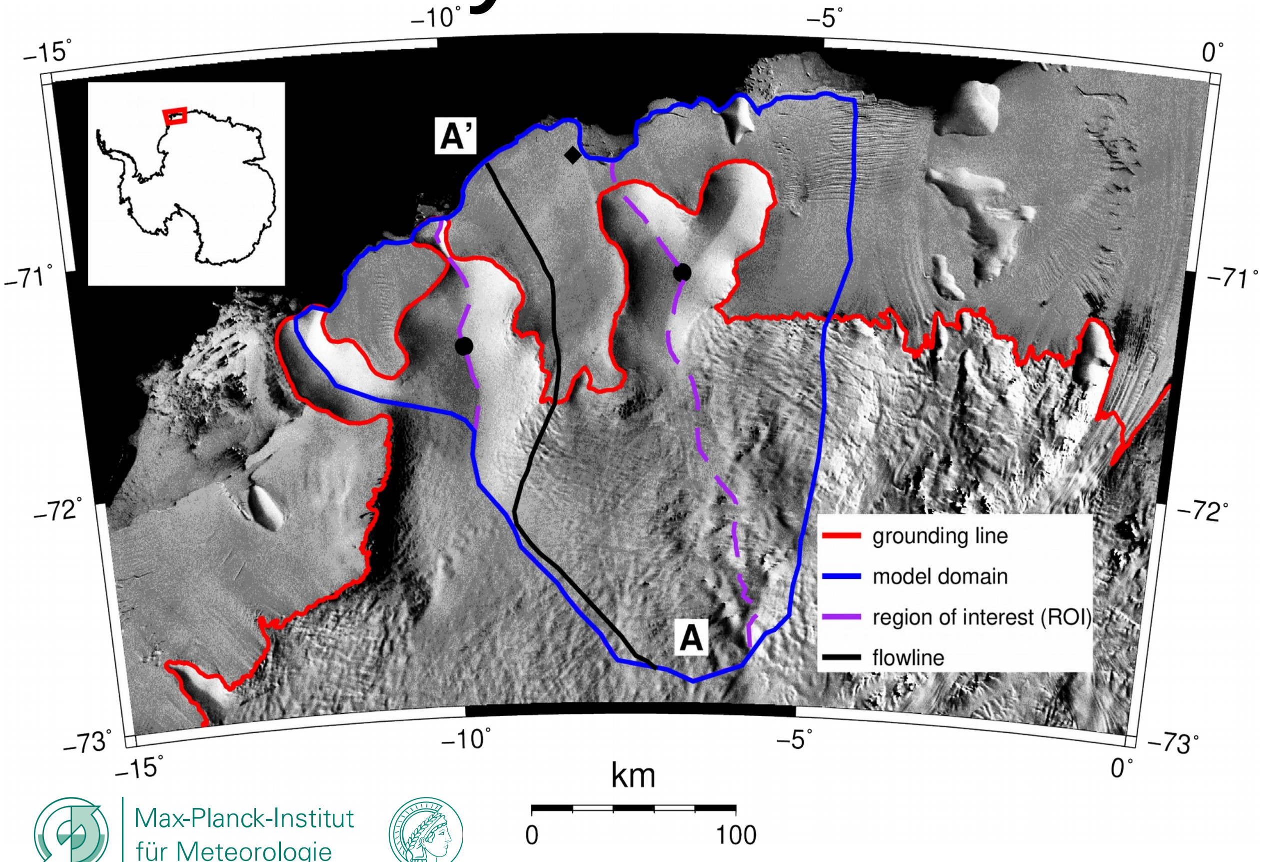
3) Problems and questions

Research Goals

1) Extend the applicability of full-Stokes models to glacial cycle time scales

2) What is the effect of different ocean bed properties on ice-sheet geometry over a glacial cycles

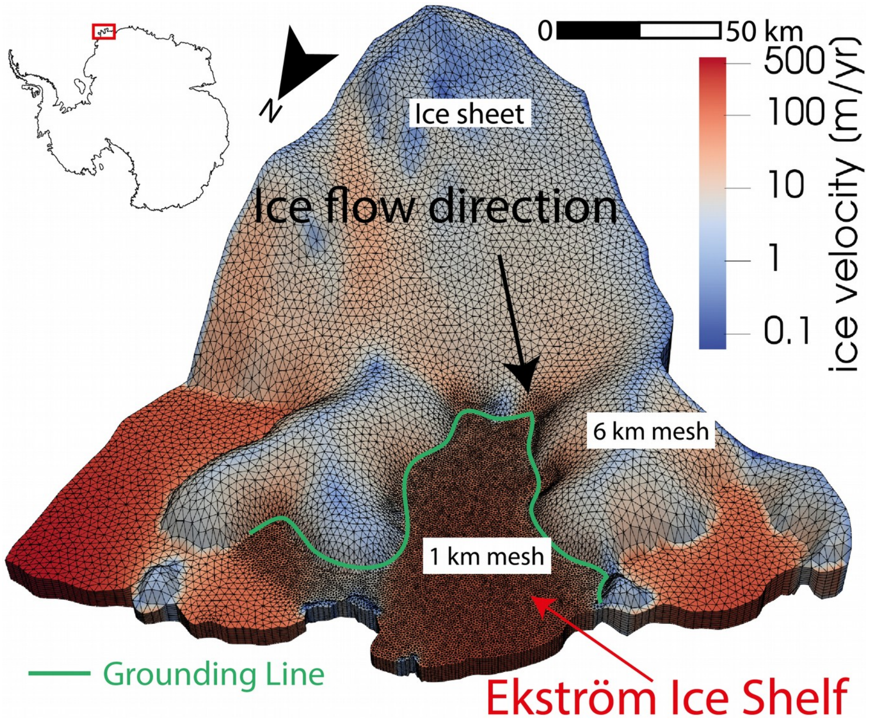
Study site: Ekström Ice Shelf



- Availability of excellent boundary datasets (e.g. bathymetry)
- diverse glaciological features (e.g. ice rises)

Max-Planck-Institut für Meteorologie

Model setup



Model setup details:

Model: Elmer/Ice
Force balance: full-Stokes
Thermomechanically coupled: yes
Mesh resolution: 1-6 km
Verical mesh layers: 10
Basal sliding: linear Weertman
Basal melting: follows Beckmann and Goosse, 2003
Surface mass balance: follows Ritz et al.,2001
No glacial isostatic rebound

Max-Planck-Institut
für Meteorologie

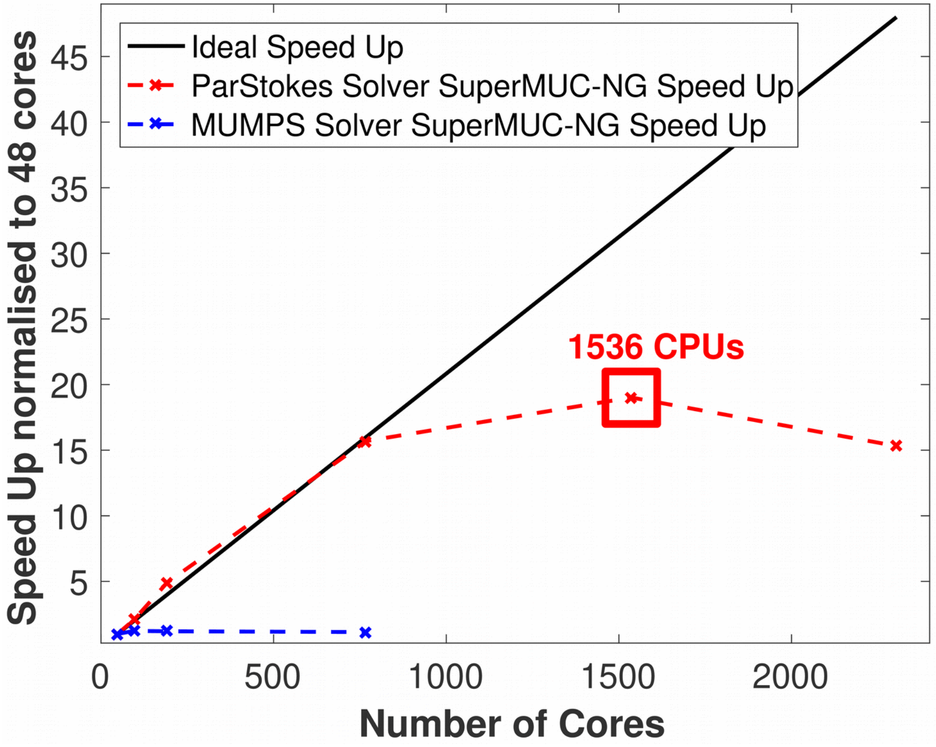
Experimental Design

1) We simulate a 40,000 year glacial cycle starting from present-day conditions.

2) We study the effect of different ocean bed properties by prescribing soft or hard bed conditions for present-day ocean cavities.

3) We perform these two end member simulations with classic solver setup (MUMPS) and block-preconditioned solver setup (ParStokes)

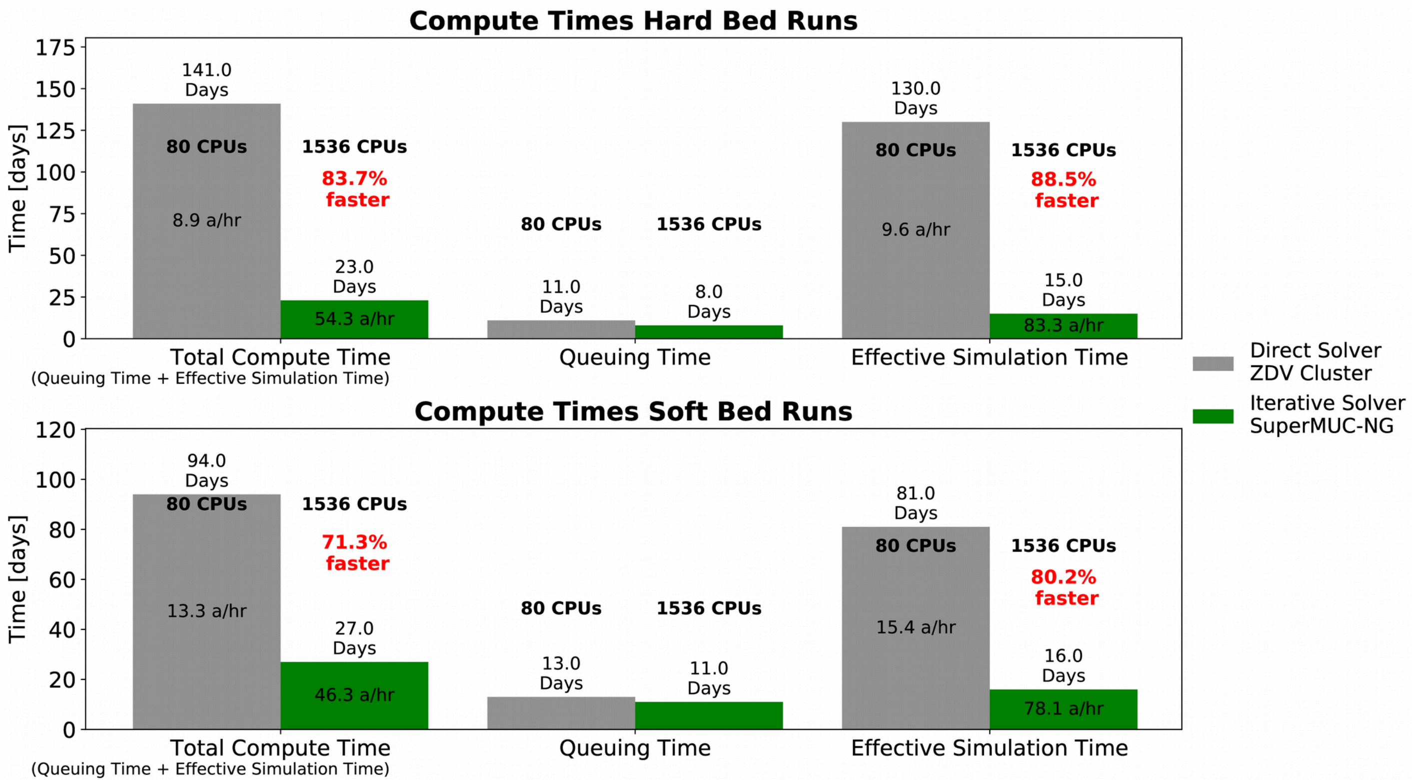
Results: Scaling of ParStokes



- Scales linearly up to ~700 CPUs (~200,000 nodes)
- Decrease in computation time up to ~1,500 CPUs
- Scaling depends on problem size

Max-Planck-Institut
für Meteorologie

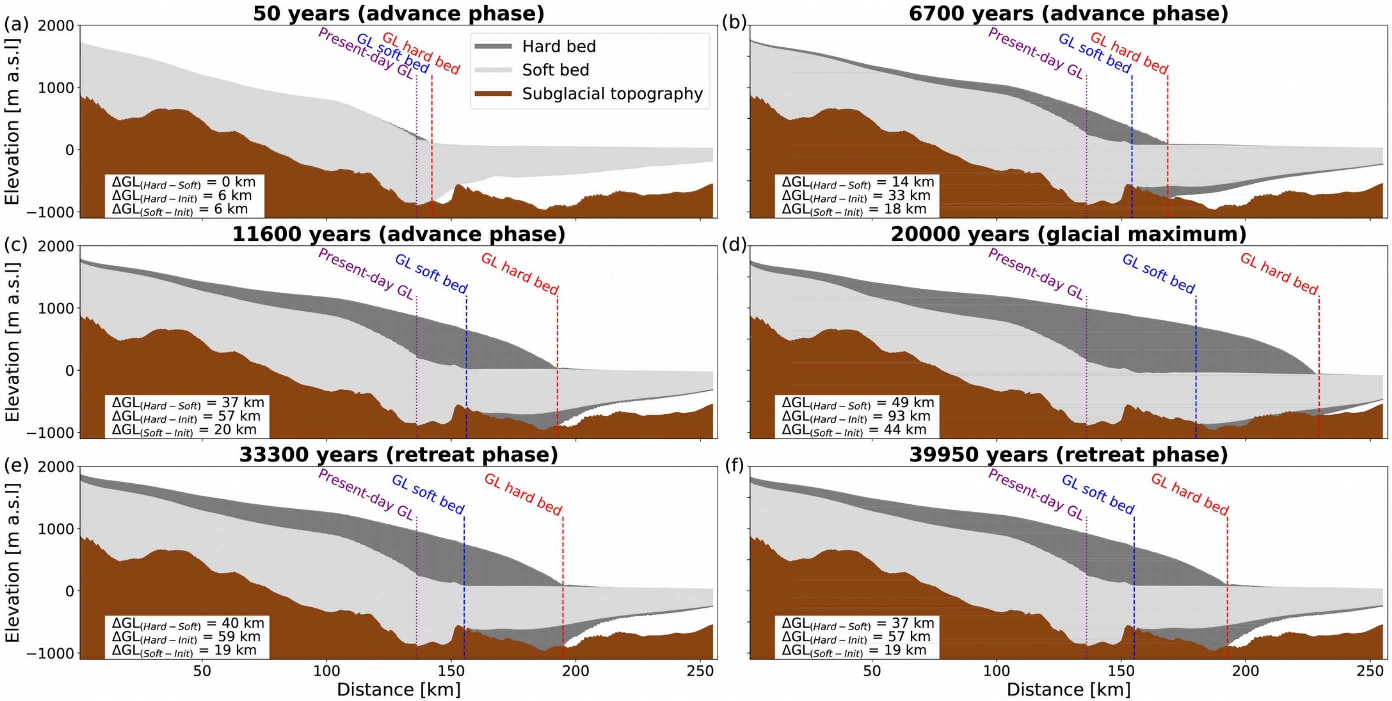
Results: Speed up of simulations



- Computation time in comparison to classic direct solver (MUMPS) setup reduces by factor 3-6
- comparable results between solver setups (<5 % difference in grounded area).

Max-Planck-Institut für Meteorologie

Results: Response to different ocean bed properties

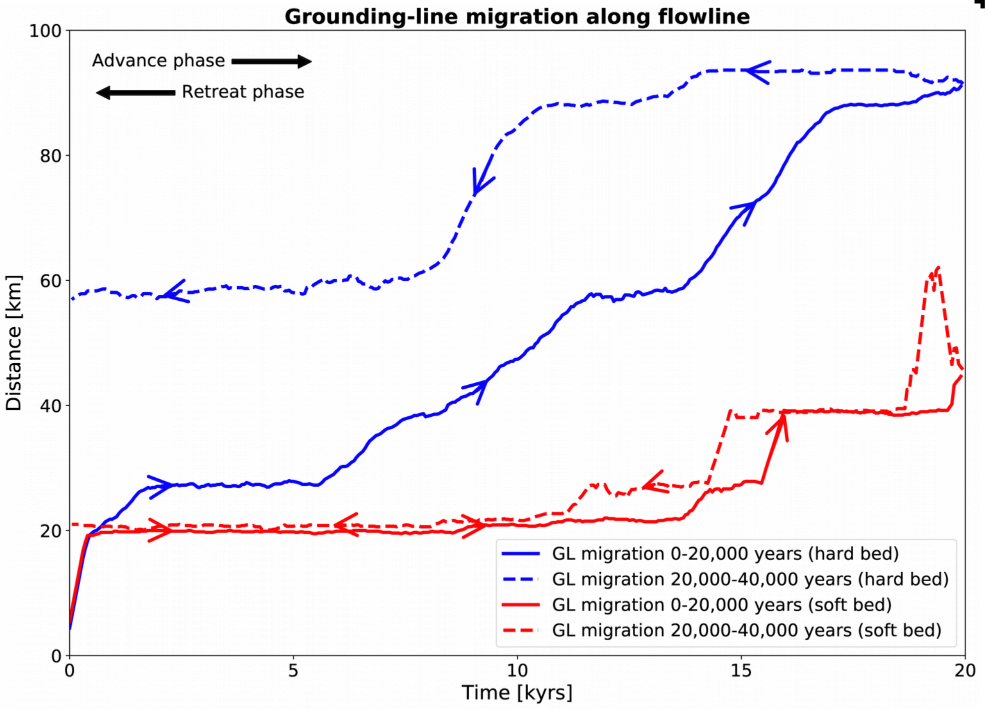


- Up to 50 % difference in ice-sheet volume under almost identical forcing

- thick and slow vs. thin and fast ice sheet

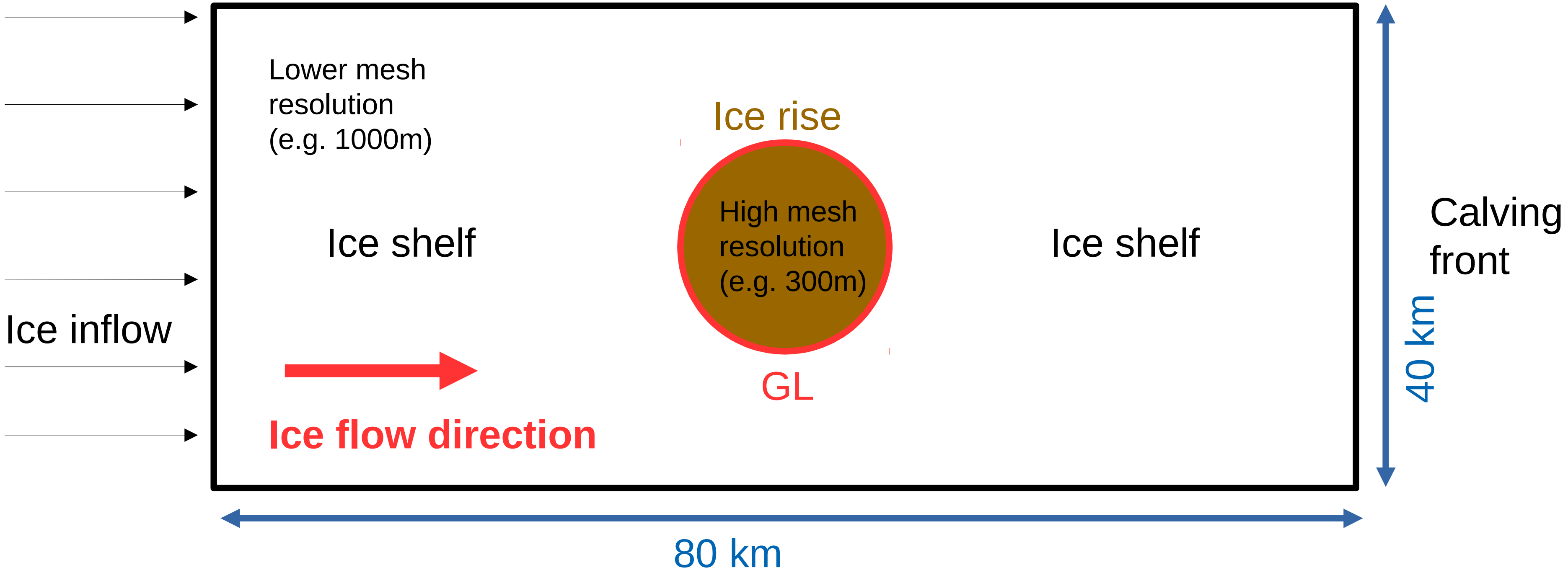
Max-Planck-Institut für Meteorologie

Results: Response to different ocean bed properties



- Ocean bed properties provide an additional parameter that induces hysteresis

Ongoing work: Synthetic 3D ice rise modelling



Max-Planck-Institut für Meteorologie

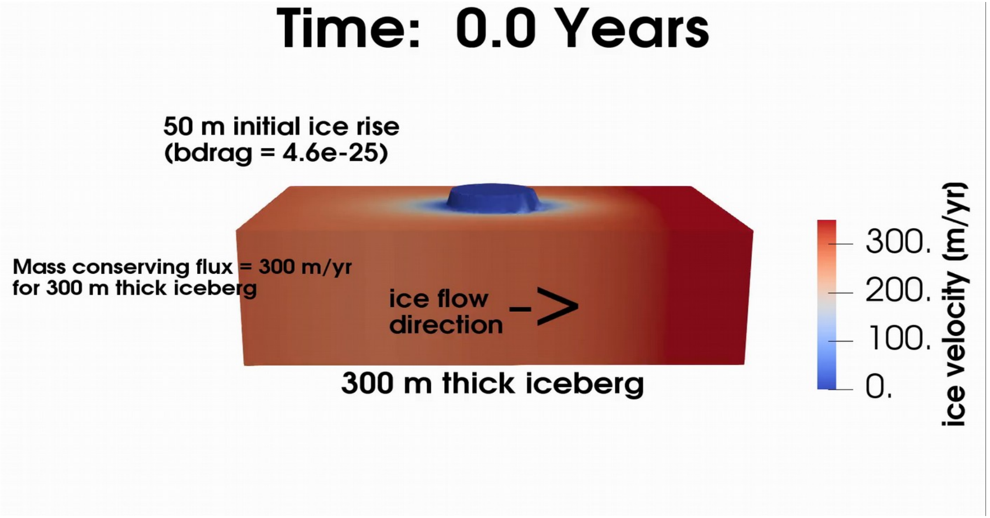
Ongoing work: Research Goals

1) What controls the stability of ice rises (e.g. predominately flat bed?)

2) What conditions are required to simulate a curved divide as observed on Derwael Ice Rise

3) Develop flexible modelling framework for real world 3D ice rise modelling for others to use

Ongoing work: Steady state ice rise video



Max-Planck-Institut
für Meteorologie

Problems and questions

1) Convergence of vectorized NS solver (anyone tried this for sheet-shelf?)

2) ParStokes convergence (even though outer (GCR) iteration converges quickly inner iteration does not)

3) Upper surface spikes come and go (see video)

Thank you!