PISM (Parallel Ice Sheet Model)

Current status and future plans

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PISM in 3 slides (1 of 3)

User's point of view

- runs on Linux, Unix, and Mac OS X: from workstations to supercomputers
- stable versions are released once a year
- source code or a Debian/Ubuntu package
- website: `www.pism-docs.org`
- comprehensive User's Manual (PDF, 120+ pages)
- designed with usability in mind

PISM in 3 slides (2 of 3)

Power user's point of view

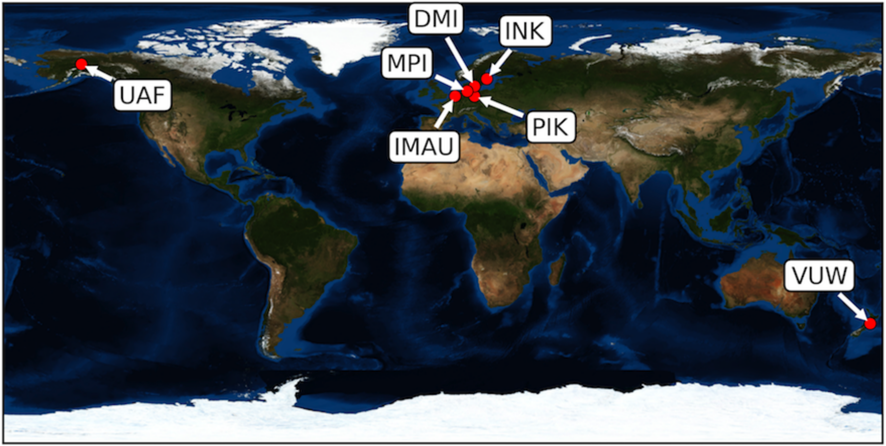
- modular and extensible
- documented source code (`doxygen`)
- everything is parallel (PETSc and MPI)
  - whole Greenland at 2 km resolution
- open source (GPL, hosted on `github.com`)
- well-tested physics
  - shallow hybrid
  - enthalpy method

PISM in 3 slides (3 of 3)

Development point of view

- supported by the NASA Modeling, Analysis and Prediction grant NNX09AJ38G through 2013
- since April 2011 PISM is developed jointly at UAF and the Potsdam Institute for Climate Impact Research (PIK)

What do people do with PISM?



People publish papers (with pretty pictures)

During the past year *nine* PISM-related papers were published (or are about to appear):

- two papers by PISM users outside of UAF and PIK
  - **Solgaard et al** (2011) *Snapshots of the Greenland ice sheet configuration in the Pliocene to early Pleistocene*
  - **van Pelt et al** (2012) *Numerical simulations of cyclic behaviour in the Parallel Ice Sheet Model (PISM)*
- six papers from the PIK group
  - one description paper
  - three modeling
  - two applications
- **Aschwanden et al** (2012) *An enthalpy formulation for glaciers and ice sheets*

We feature one project a month

All "PISM Applications of the Month"

February 2012

Fracture field for large-scale ice dynamics	
ice sheet:	Antarctic ice sheet
investigators:	Torsten Albrecht and Anders Levermann
venue:	Journal of Glaciology

A macroscopic fracture-density field is introduced into PISM. Its evolution includes the initiation and growth of fractures as well as their advection with two-dimensional ice flow. To first approximation, fracture growth is assumed to depend on the spreading rate only, while fracture initiation is defined in terms of principal stresses. The inferred fracture-density fields compare well with observed elongate surface structures. The aim of this study is to introduce the field and investigate which of the observed surface structures can be reproduced by the simplest physically motivated fracture source terms.

Click on the thumbnail to get PDF from the J. Glaciol. site.

2012/02/01 00:01 · Ed Bueler

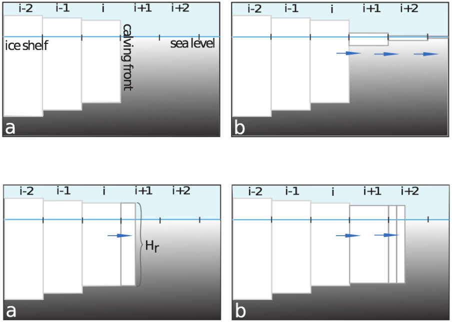
January 2012

Fine-grid simulation of Antarctic ice stream dynamics at the Last Glacial Maximum	
ice sheet:	Antarctic ice sheet (LGM)
lead investigator:	Nick Golledge
venue:	INQUA 2011 and SCAR International Symposium on Antarctic Earth Sciences, 2011

The Antarctic Research Centre is using PISM to study Antarctic ice sheet behaviours during key periods of the past, particularly the LGM and the mid-Pliocene.

PISM-PIK merge

Subgrid-scale motion of the calving front

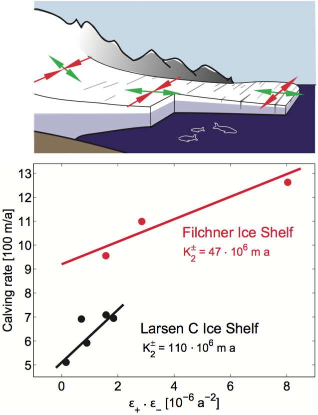


- avoids artificial thinning
- better modeling of the location of the front
- allows for advancing shelves

Albrecht et al (2011) *Parameterization for subgrid-scale motion of ice-shelf calving fronts*. The Cryosphere 5 pp. 35–44.

PISM-PIK merge

First-order calving law



- calving rate proportional to spreading rates in both eigen-directions:

$$C = K_2^{\pm} \cdot \dot{\epsilon}_+ \cdot \dot{\epsilon}_-$$

- has one scalar parameter
- allows for ice shelf retreat

Levermann et al (2011) *Kinematic first-order calving law implies potential for abrupt ice-shelf retreat*. The Cryosphere Discussions 5 (5) pp. 2699–2722.

PIK application

Dynamic equilibrium simulation of the Antarctic ice sheet

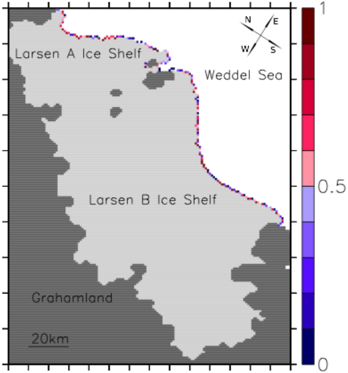


Fig. 7. Snapshot of a realistic steady state model simulation of Larsen A and B Ice shelf (light gray) with grounded parts (dark gray) and the ice-free ocean (white). Values of R at the propagating ice shelf front are colored.

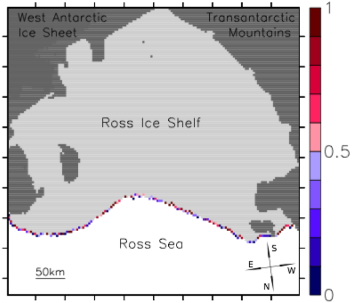


Fig. 8. Snapshot of a realistic steady state model simulation of Ross Ice shelf (light gray) with grounded parts (dark gray) and the ice-free ocean (white). Values of R at the propagating ice shelf front are colored.

tive time step occurs for a single pair of cells, which is located probably at the ice front with distance from confinements, whereas along the rest of the ice-shelf front velocities

Martin et al (2011) *The Potsdam Parallel Ice Sheet Model (PISM-PIK) Part 2: Dynamic equilibrium simulation of the Antarctic ice sheet*. The Cryosphere 5 pp. 727–740.

PIK project

Fracture field for large-scale ice dynamics

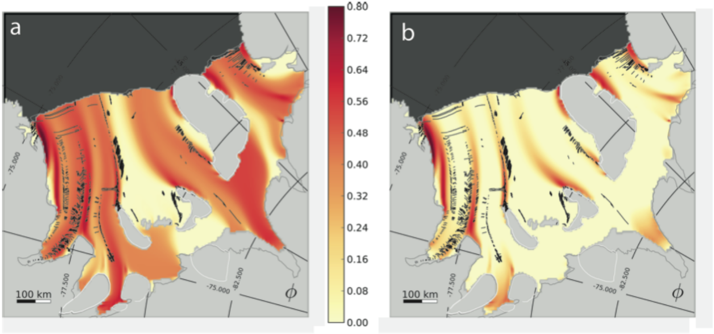


Fig. 7. Steady-state fracture density for Filchner–Ronne simulation with (a) fracture density boundary condition for the inlets $\phi_0 = 0.4$ and (b) healing rate, $\gamma_h = 0.1$, and $\psi_h = \dot{\epsilon}_1 - 2 \times 10^{-10}\,\mathrm{s}^{-1}$, but with $\phi_0 = 0$. Parameters for fracture initiation are chosen as $\sigma_{cr} = 70$ kPa and $\gamma = 0.3$ (cf. Fig. 4b).

step toward fracture-based calving

Albrecht et al (2012) *Fracture field for large-scale ice dynamics.* Journal of Glaciology 58 (207) pp. 165–176.

UAF project

Enthalpy model

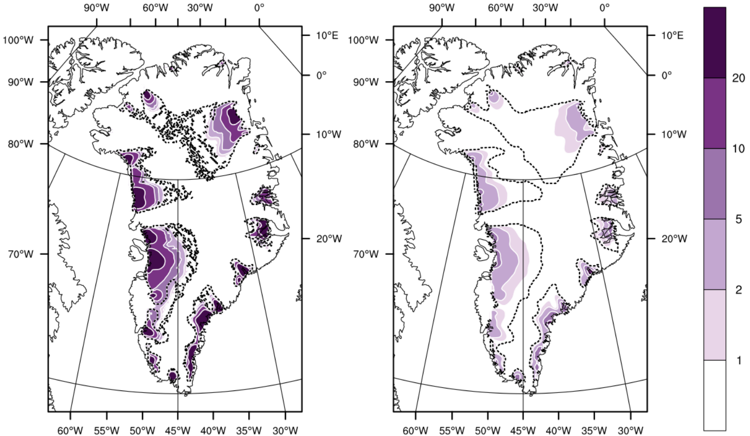
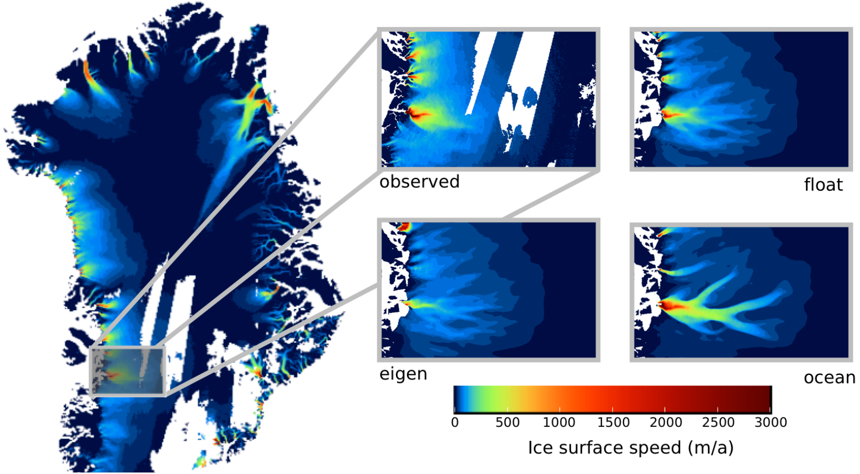


Figure 8. Basal melt rate for the ENTH run (left) and the TEMP run (right). Values are in millimeters per year. The dashed line is the cold-temperate transition surface.

Aschwanden et al (2012) *An enthalpy formulation for glaciers and ice sheets*. Journal of Glaciology, to appear

UAF project

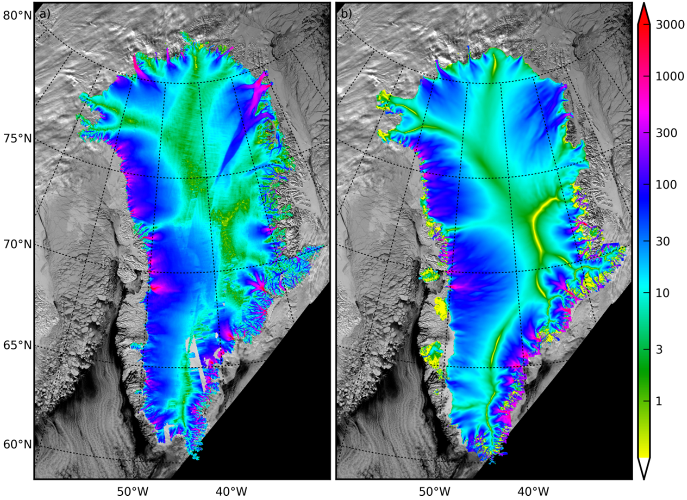
PISM as a regional model



Daniella DellaGiustina (2011), *Regional modeling of Greenland's outlet glaciers with the Parallel Ice Sheet Model*, M.S. Computational Physics thesis, UAF

UAF project

Validation using InSAR surface speed



Left: InSAR surface speed in meters per year (Joughin, 2010)
Right: PISM simulated surface speed

- no inversion
- small number of parameters
- constant climate spin-up
- 2km grid
- Aschwanden et al, in prep.

Future plans

- inverse modeling (lead by David Maxwell and Marijke Habermann)
  - uses new tools (written in Python)
  - shares code with PISM
  - well under way
- basal hydrology model (Ed Bueler and Ward van Pelt)
- Blatter stress balance solver*
- better coupling
- better transport/advection algorithm

* See **Brown et al** (2011) *Achieving textbook multigrid efficiency for hydrostatic ice sheet flow*, submitted to SIAM J. Scientific Computing.