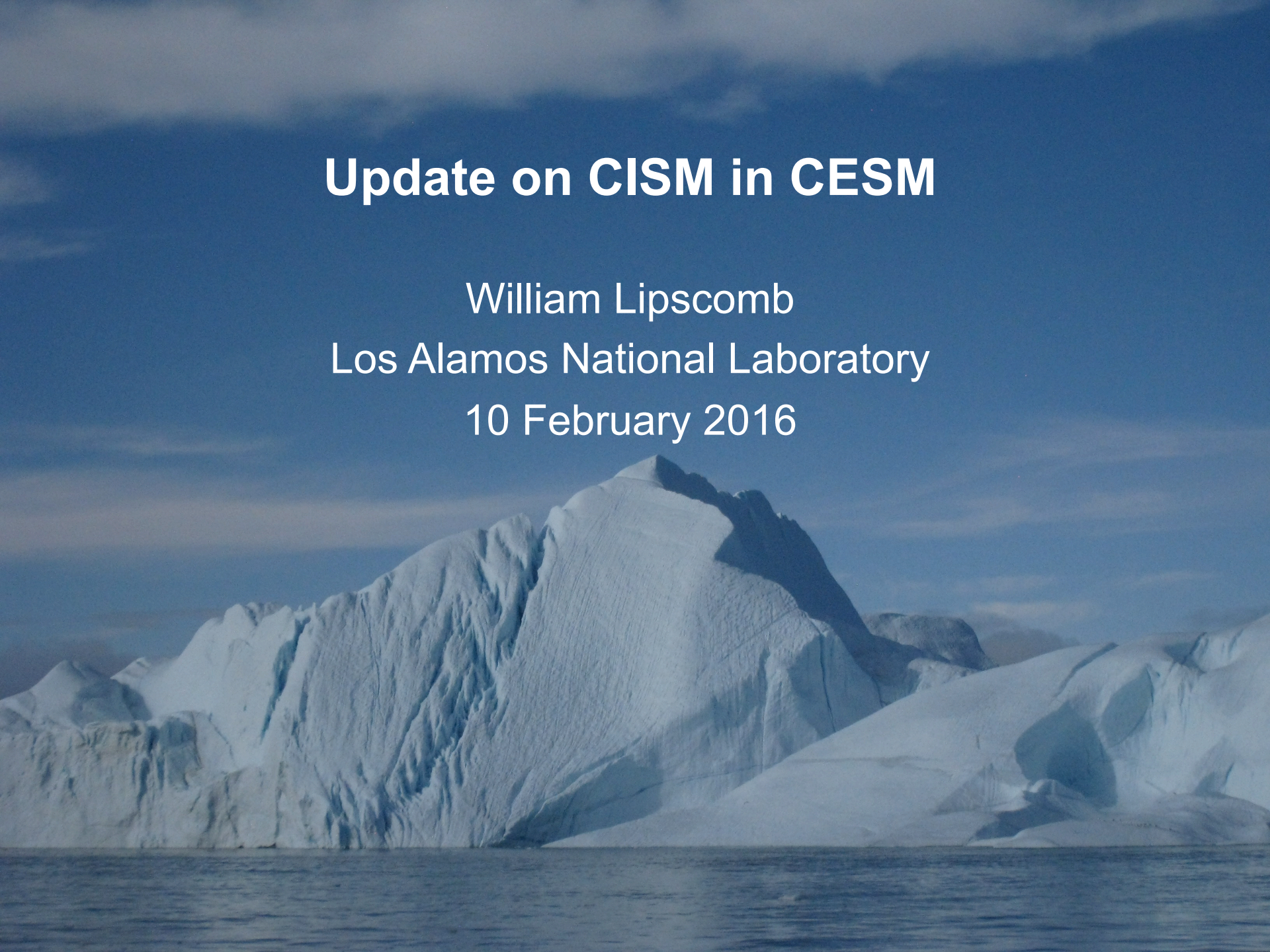


Update on CISM in CESM

William Lipscomb
Los Alamos National Laboratory
10 February 2016

Community Ice Sheet Model, version 2

CISM 2.0 was released in Oct. 2014:

- Replaced CISM1 (shallow-ice model using older Glimmer code) as the ice sheet component of CESM
- Parallel dynamical core (Glissade) with a suite of velocity solvers (including higher-order Blatter-Pattyn)

CISM 2.1 is scheduled for release in spring 2016:

- Depth-integrated viscosity approximation (DIVA; Goldberg 2011) is similar in accuracy to Blatter-Pattyn, but ~10x faster
- A grounding-line parameterization has been added for marine ice sheets.

Goals for Greenland simulations

We need a **robust**, **efficient** and **accurate** ice sheet model for Greenland Ice Sheet simulations

- with higher-order dynamics
- at moderately high resolution (~4 km)
- on century-to-millennial time scales (required to equilibrate the ice sheet and choose optimal parameters)
- under past, present and future forcing
  - SLICE project: (Bette Otto-Bliesner et al.): Simulate Greenland during the Pliocene, Last Interglacial and future to ~3000

Robustness

- Parameter sweep, round 1 (July 2015): ~800 Greenland simulations with various parameter sets. Most crashed within 1 model year.
- Various problems were diagnosed and fixed. Many were related to complex topography in Greenland fjords.
- Parameter sweep, round 2 (Nov. 2015): Most tests ran 50 model years to completion. Several selected tests were extended successfully to 10,000 years.

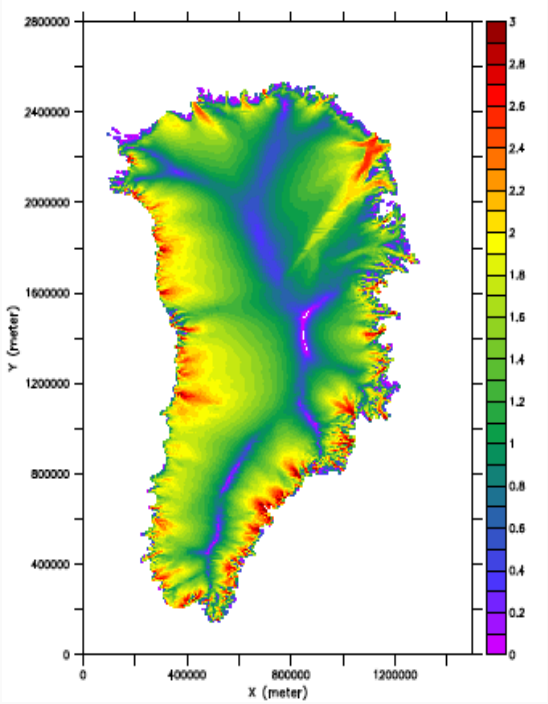
Efficiency

Timing for 4-km Greenland simulations on yellowstone:

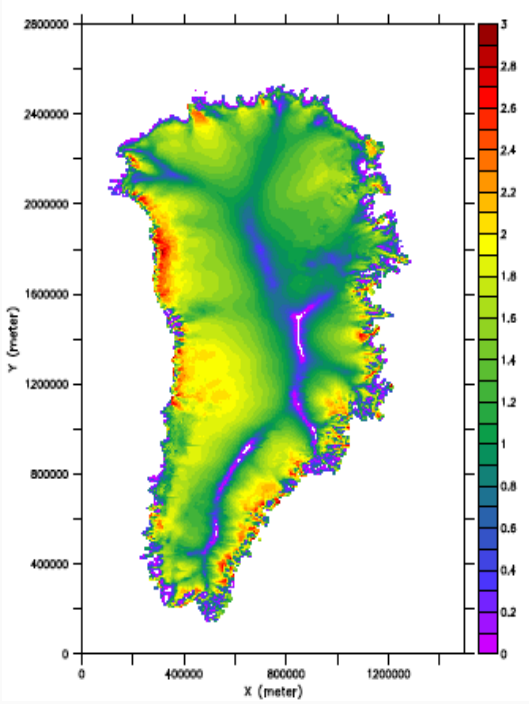
Number of cores	Core-hours / model year	Model years/ wall clock day
128	1.4	2200
240	1.7	3400
480	2.4	4800

Accuracy

- We are working to improve the ice-sheet surface mass balance computed by CLM (talk by Jan Lenaerts).
- We are testing new physics parameterizations that are valid for past and future climates (not just tuned for present day).



Log of surface speed (m/yr): optimized to match present day



Log of surface speed (m/yr): pseudo-plastic sliding law

Ice sheets in CESM: Progress since CESM1

CESM 1.0	CESM2.0
One-way coupling	Two-way coupling
Serial, shallow ice approximation	Parallel, higher-order
No way to run standalone CISM	TG compset for running standalone CISM
1-m snow pack in CLM	10-m snow pack in CLM
Only 3 land/atm resolutions supported	All land/atm resolutions supported
SMB only computed in runs done by LIWG	SMB computed in all runs

Recent science and software changes

- Improved snow physics in CLM
  - Deeper snowpack, reworked snow capping, wind-dependent snow density
- Improved downscaling to elevation classes
  - Repartition rain/snow from atmosphere
- Remapping moved to CESM coupler
  - Conservative remapping on general grids
- Runtime specification of glacier regions
  - ‘virtual’, ‘multiple’ or ‘single’ elevation classes for Greenland, Antarctica and/or mountain glaciers

Remaining tasks for CESM2

- Finish work to compute glacier surface mass balance (in multiple elevation classes) by default in all runs
- Create out-of-the-box Greenland initial condition
- Create out-of-the-box TG forcing data (precomputed SMB for standalone ice sheet simulations)
- Release standalone CISM2.1
- Submit GMD papers on CISM2.1 (Lipscomb et al.) and CISM-CESM coupling infrastructure (Fyke et al.)

Acknowledgments

- Bill Sacks (CLM and coupling infrastructure)
- Jeremy Fyke (coupling infrastructure, Greenland analysis and stress testing)
- Lauren Vargo (Greenland stress testing)
- Matt Hoffman, Steve Price (CISM2 development, testing and consultation)
- Jan Lenaerts, Leo van Kampenhout, Marcus Löfverström (surface mass balance and snow modeling)
- Joe Kennedy, Andrew Bennett (upgrade of LIVV software)
- Gunter Leguy, Xylar Asay-Davis (grounding lines)