



Polar Cryosphere development

Olga Sergienko

With contributions from Alexander Huth, Matthew Harrison, Nicole Schlegel, Mitchell Bushuk, Theresa Morrison, Alistair Adcroft, Raphael Dussin, Robert Hallberg, John Krasting, Brandon Reichl, Marshall Ward and Niki Zadeh

Q1: Concerning GFDL's core strength of building and improving models of the weather, oceans, and climate for societal benefits, how can GFDL leverage advances in science and computational capabilities to improve its key models? What are the strengths, gaps, and new frontiers?



NOAA
GEOPHYSICAL FLUID
DYNAMICS LABORATORY

5-YEAR REVIEW
JANUARY 28-30, 2025

Coupled ocean-cryosphere model

- Directly represents ice-sheet contributions to sea level rise
- Simulates ocean-cryosphere interactions in a self-consistent manner
- Improves the fidelity of simulations of regional extreme events by improving accuracy of the global sea level representation

Supports OM5's goals

A. Simulate regional-to-global Sea Level

B. Reduce Polar Biases

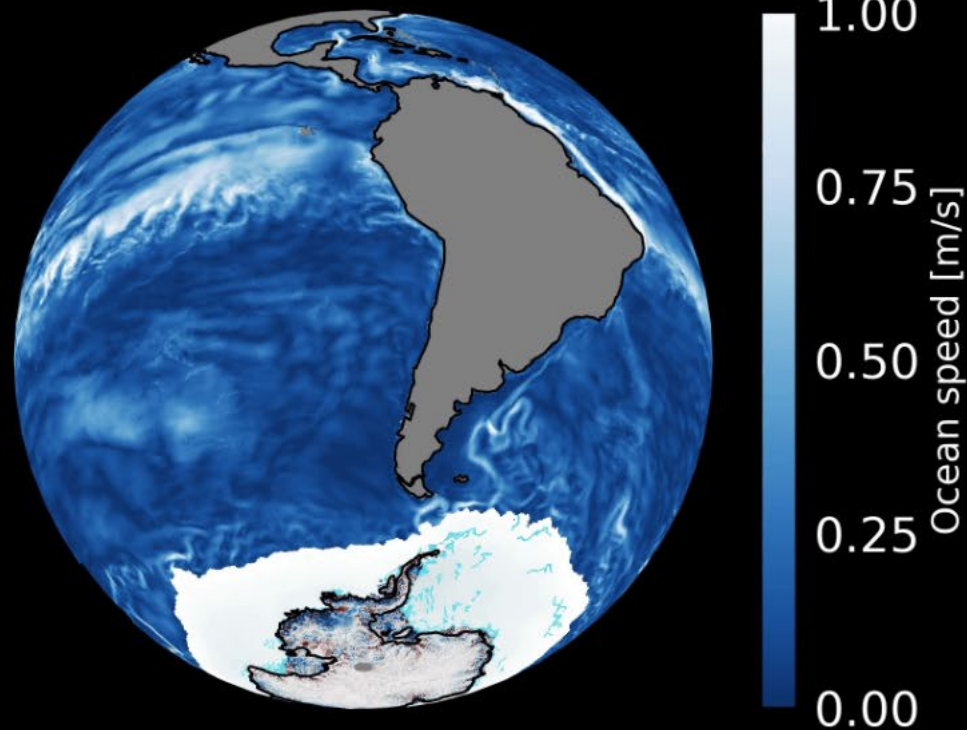


NOAA
GEOPHYSICAL FLUID
DYNAMICS LABORATORY



5-YEAR REVIEW
JANUARY 28-30, 2025

Global ocean-cryosphere model iOM 2008-06



Unique features: Includes all polar cryospheric components



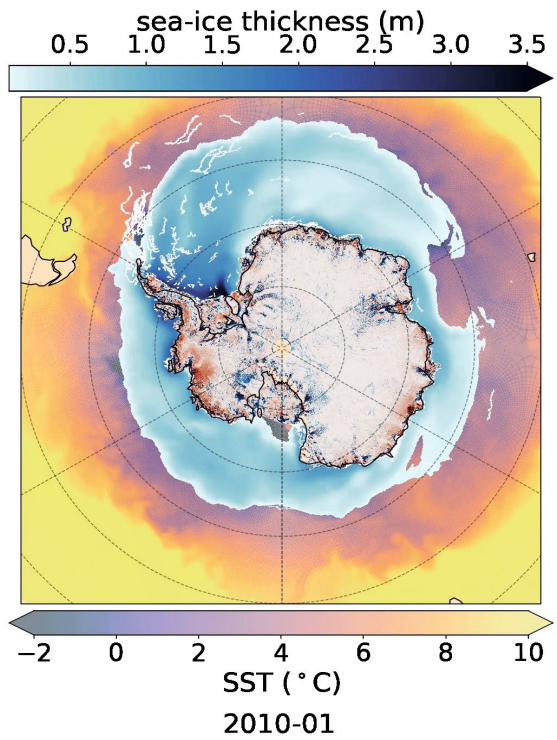
NOAA
GEOPHYSICAL FLUID
DYNAMICS LABORATORY



5-YEAR REVIEW
JANUARY 28-30, 2025

Sergienko et al. (*in prep.*)

Global ocean-cryosphere model

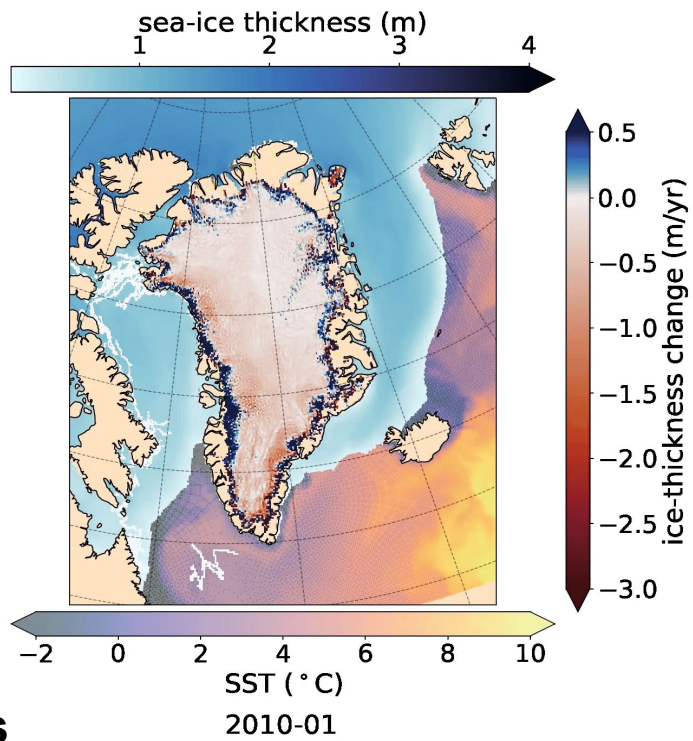


MOM6
ocean

MOM6-IS
ice sheet

SIS2
sea ice

KID
icebergs



Unique features

- Synchronous coupling between the dynamic ice sheets and the ocean
- Both ice sheets are coupled simultaneously

Sergienko et al. (in prep.)

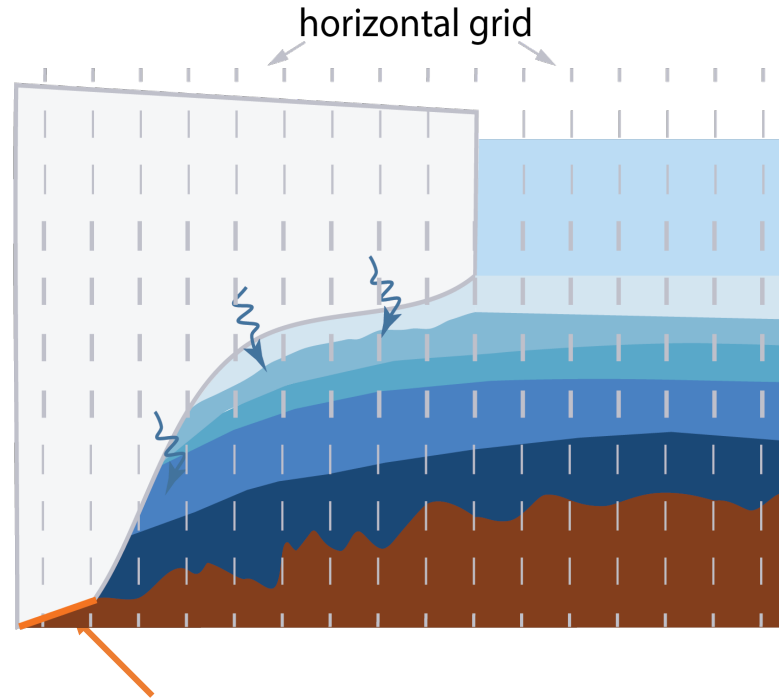
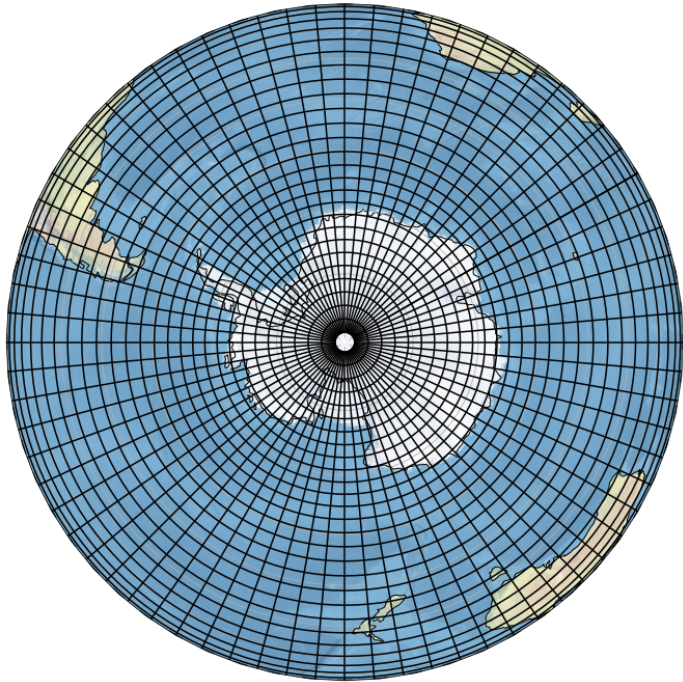


NOAA
GEOFYSICAL FLUID
DYNAMICS LABORATORY



5-YEAR REVIEW
JANUARY 28-30, 2025

Ice sheet model MOM6-IS



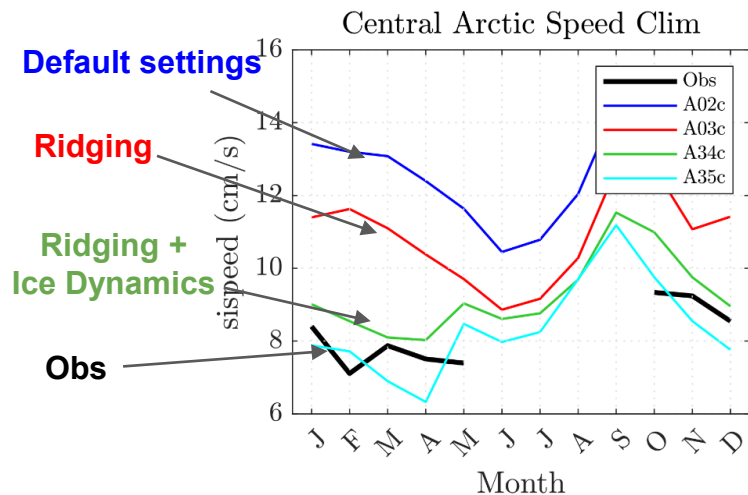
All layers are present under the ice sheet

Sea ice model SIS2

- GFDL's Sea Ice Simulator Version 2 (SIS2) is being developed under an open development paradigm on GitHub.

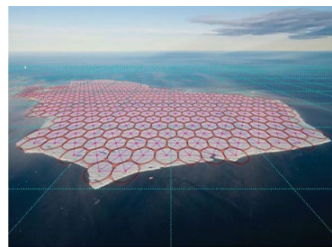
OM5 sea ice model development foci:

- Add sea ice ridging parameterization to SIS2
 - *Improve long-standing thin bias in GFDL models¹*
- Constrain sea ice dynamics using novel observations
 - *Improve sea ice velocities²*
- Better convergence in sea ice rheology solver
 - *Improve simulation of sea ice leads³*
- New formulation of ice-ocean coupling
 - *Better physical fidelity and numerical stability⁴*

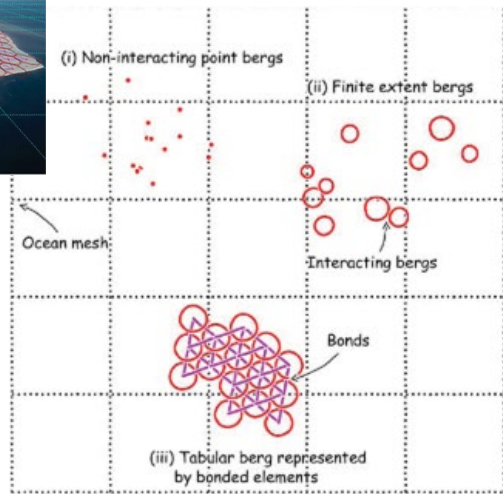


¹Bushuk et al. (2022), *J. Climate*; ²Held et al. (2019), *JAMES*; ³Li et al. (2023), *GRL*; ⁴Hallberg et al. (2014), *CLIVAR Exchanges*.

Iceberg model KID

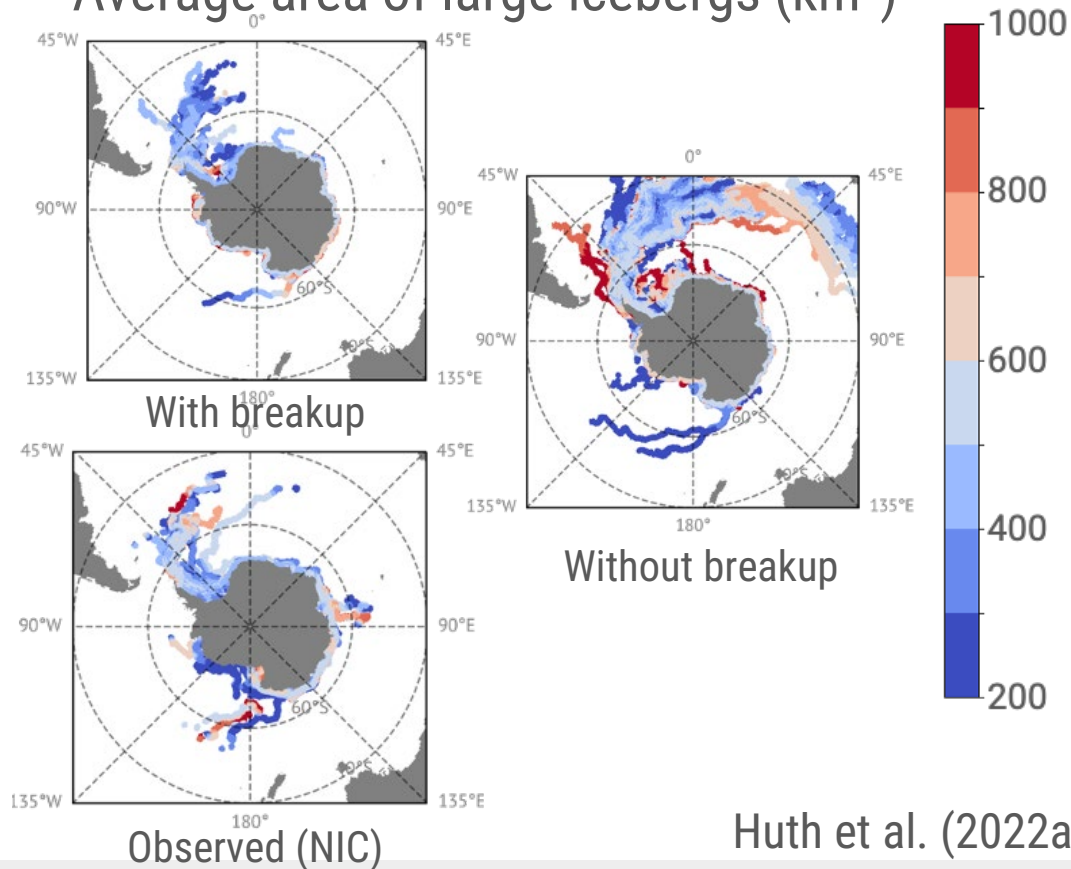


Stern et al. (2017)



New tabular iceberg modeling capability (Huth et al., 2022b)

Average area of large icebergs (km²)



Huth et al. (2022a)



NOAA
GEOPHYSICAL FLUID
DYNAMICS LABORATORY



5-YEAR REVIEW
JANUARY 28-30, 2025

Summary and future directions

- We have developed the first global ocean-cryosphere model with synchronously coupled dynamic Antarctic and Greenland ice sheets
- These new capabilities will improve the fidelity of sea level rise projections
- Advances in sea ice physics improve seasonal Arctic predictions

Support NOAA mission



NOAA
GEOPHYSICAL FLUID
DYNAMICS LABORATORY



5-YEAR REVIEW
JANUARY 28-30, 2025