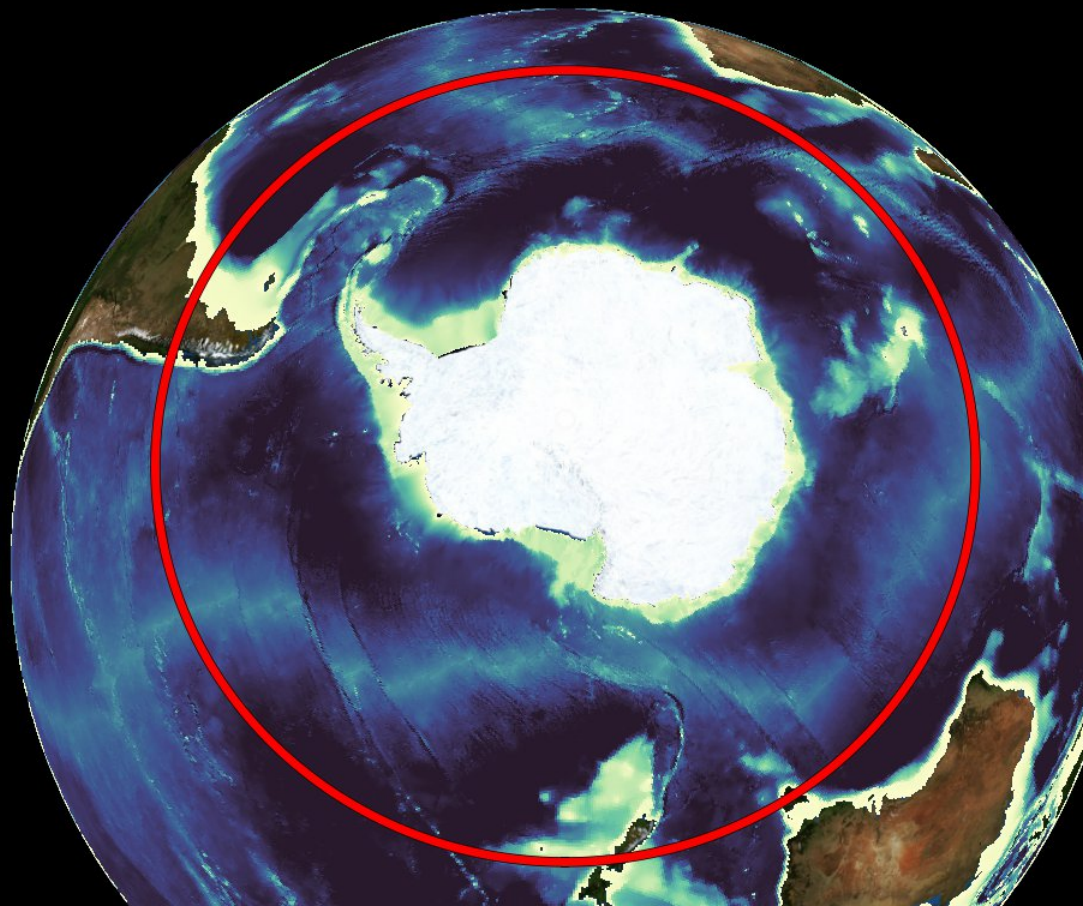
Downscaling ECCO for Greenland and Antarctica

Mike Wood, Moss Landing Marine Labs



Background

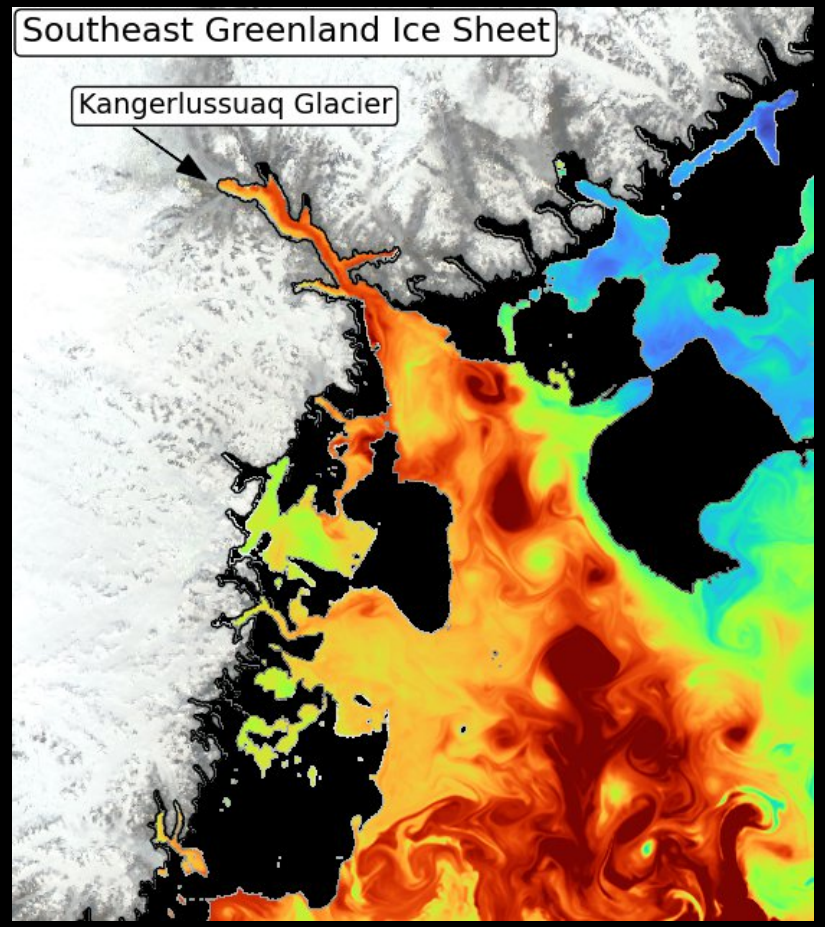
Throwback to 2018:

- I was a graduate student
- My first time to Austin
- My first ECCO meeting
- My PhD topic: Use ECCO output to estimate submarine melt on Greenland's glaciers
- ECCO-family models for glacier-ocean studies:
  - ECCO v4 (1992-2017)
  - LLC270 (alpha, 1992-2017)
  - 4km Forward Arctic Run (1992-2011)
  - An's Arctic Runs (ASTE)
  - No glaciers, no fjords, no ice shelves

ECCO Meeting 2018

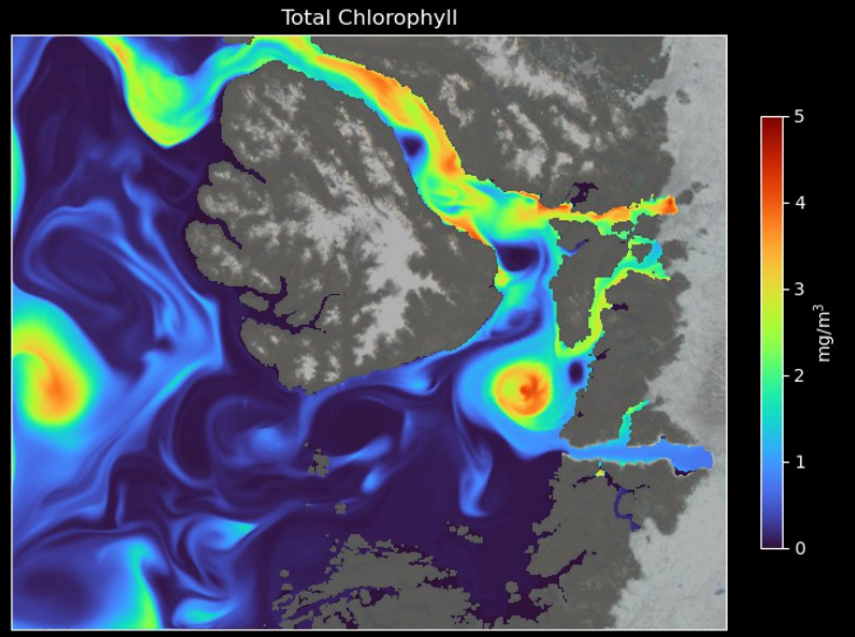
There's me!

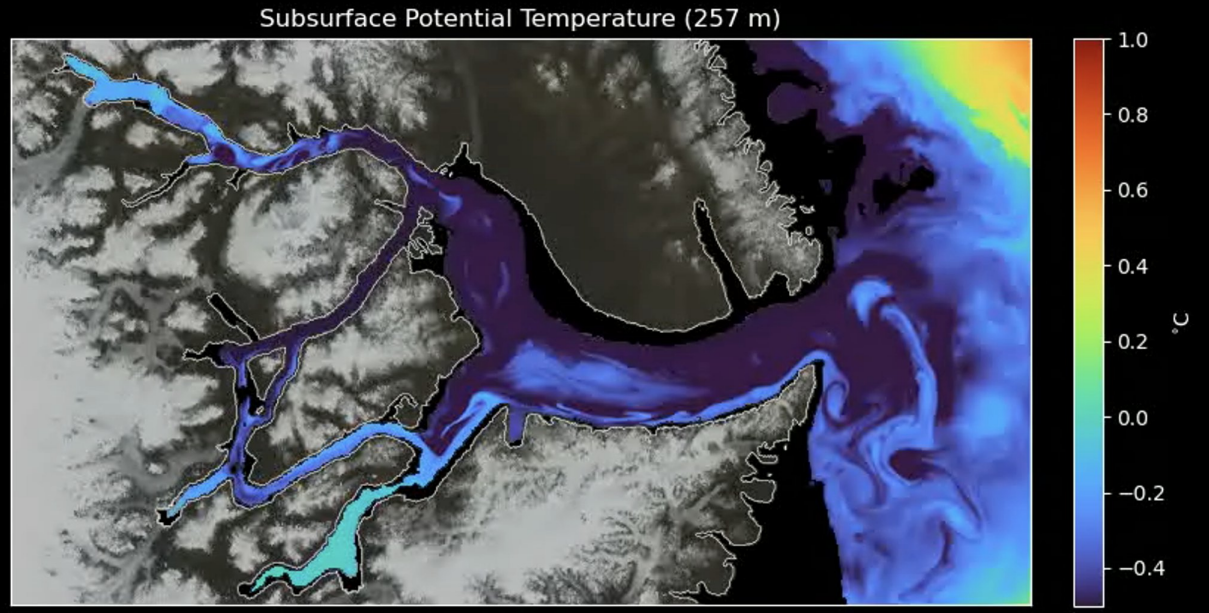
Recent Greenland Work



Kangerlussuaq, East Greenland
(Wood et al 2025a)

Disko Bay, West Greenland
(Wood et al 2025b)





Scoresby Sund, East Greenland (Wood et al 2024)

Background

What's new since 2026:

- Now an Assistant Professor ✔
- My third time to Austin ✔
- Many ECCO meetings ✔
- My research interests have expanded to BGC, etc ✔
- Models for glacier-ocean studies:
  - ECCO v4 ('92-'25, with Antarctic shelves) ✔
  - ECCO v5 R1 ('92-'25, with Antarctic shelves) ✔
  - No Greenland glaciers, no fjords ✕

Glacier and ice sheet community is (still) struggling with ocean model output on mutli-decadal scales

Toward Consistent Ocean Models for the Ice Sheet Community

- We have the tools and ability to generate these products
  - ECCO State Estimates as a starting point
  - *shelfice* for ice shelves (verified in ECCOv4/v5)
  - *iceplume* package (Cowton et al, big thanks to An!)
  - ice sheet runoff products hydrologically routed to coast (Mankoff et al)
  - *diagnostics_vec* for high frequency boundary conditions
- These runs can inform lots of different glacier-ocean studies, e.g.
  - Ice Sheet Model Intercomparisons (ocean forcing)
  - Step toward coupled ECCO-ISSM simulations
  - Regional glacier studies that require ocean forcing

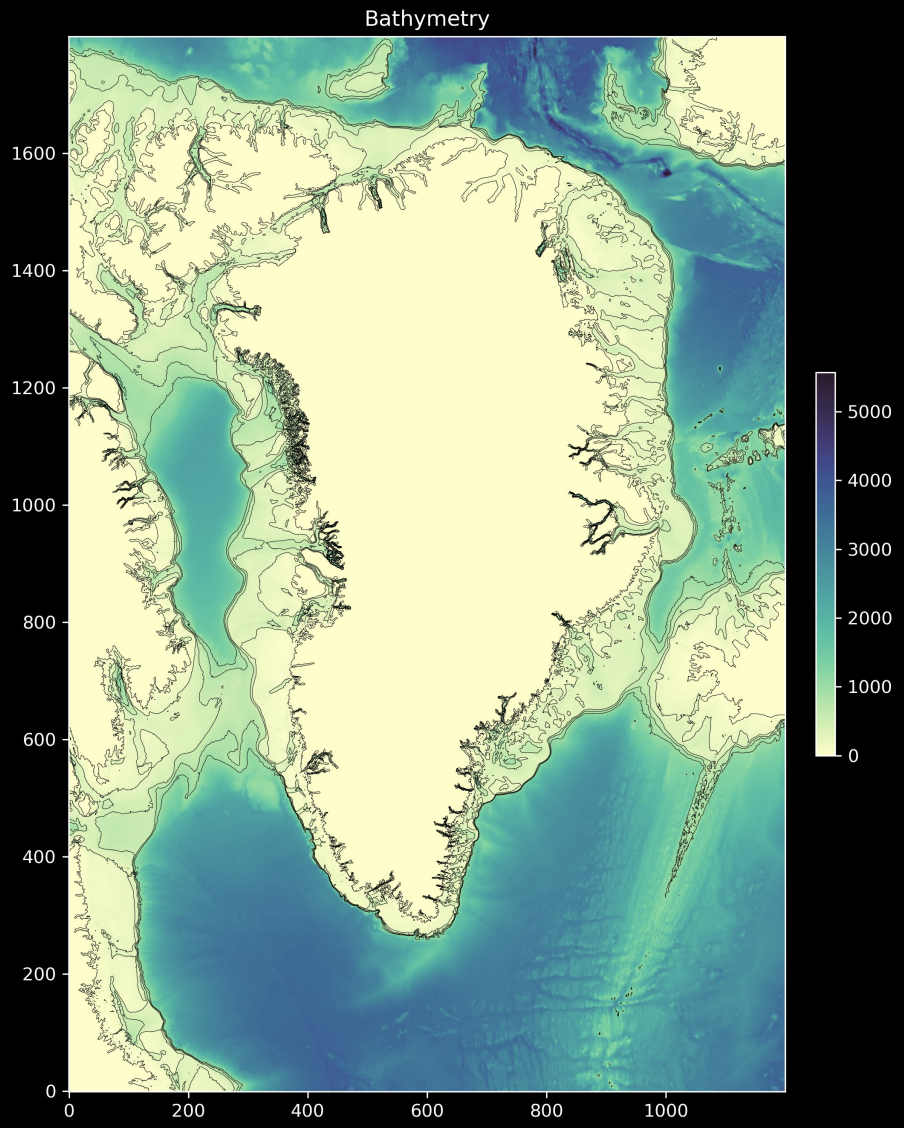
A Proposition for ECCO: Downscaled Greenland and Antarctica

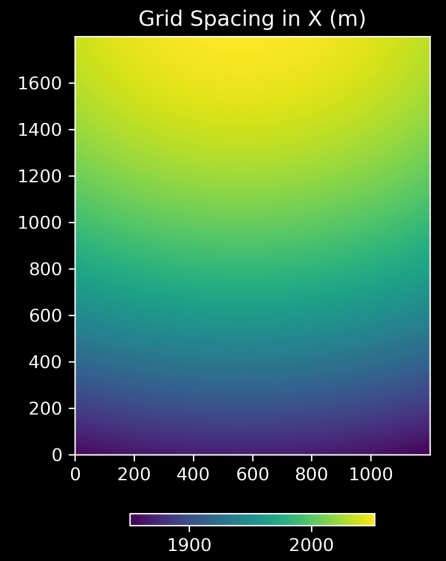
- Forward models only (no adjoints, etc)
  - Quick(ish) to produce
  - Ready for analysis by the ice-ocean community (released with caveats)
- From ECCOv5:
  - Daily boundary conditions (diagnostics_vec)
  - Initial conditions (1992, interpolated hydrodynamically)
  - External forcing (adjusted with LLC270 adjoint)
- Each new “good” ECCOv5 iteration ⇒ new downscaled simulations around the ice sheets
  - Along the way: compute costs in high resolution runs

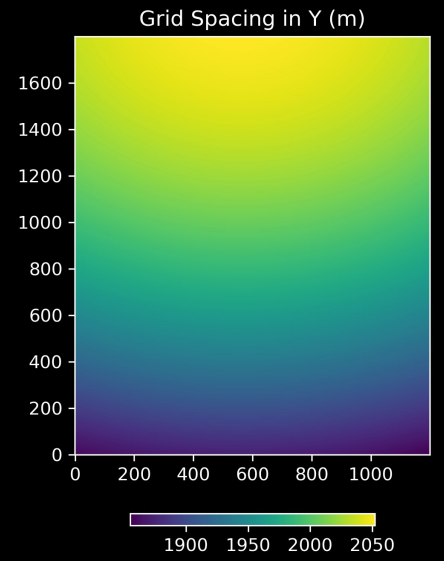
Greenland

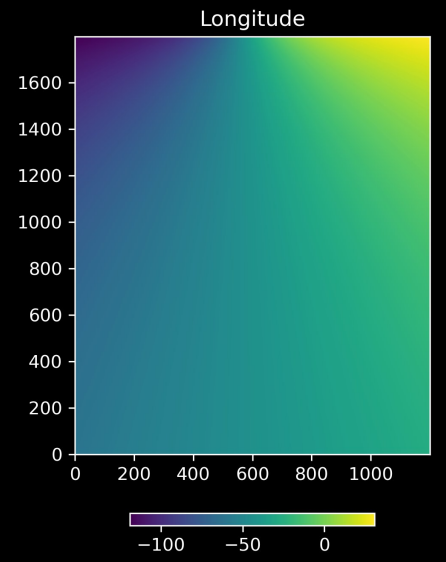
Greenland Model Domain

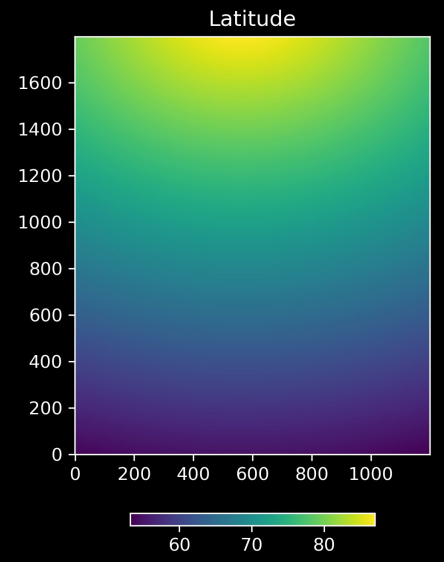
- 1800 rows x 1200 cols
- ~2km resolution
- Bathymetry from GEBCO 2024 (incl. Bedmachine Greenland)





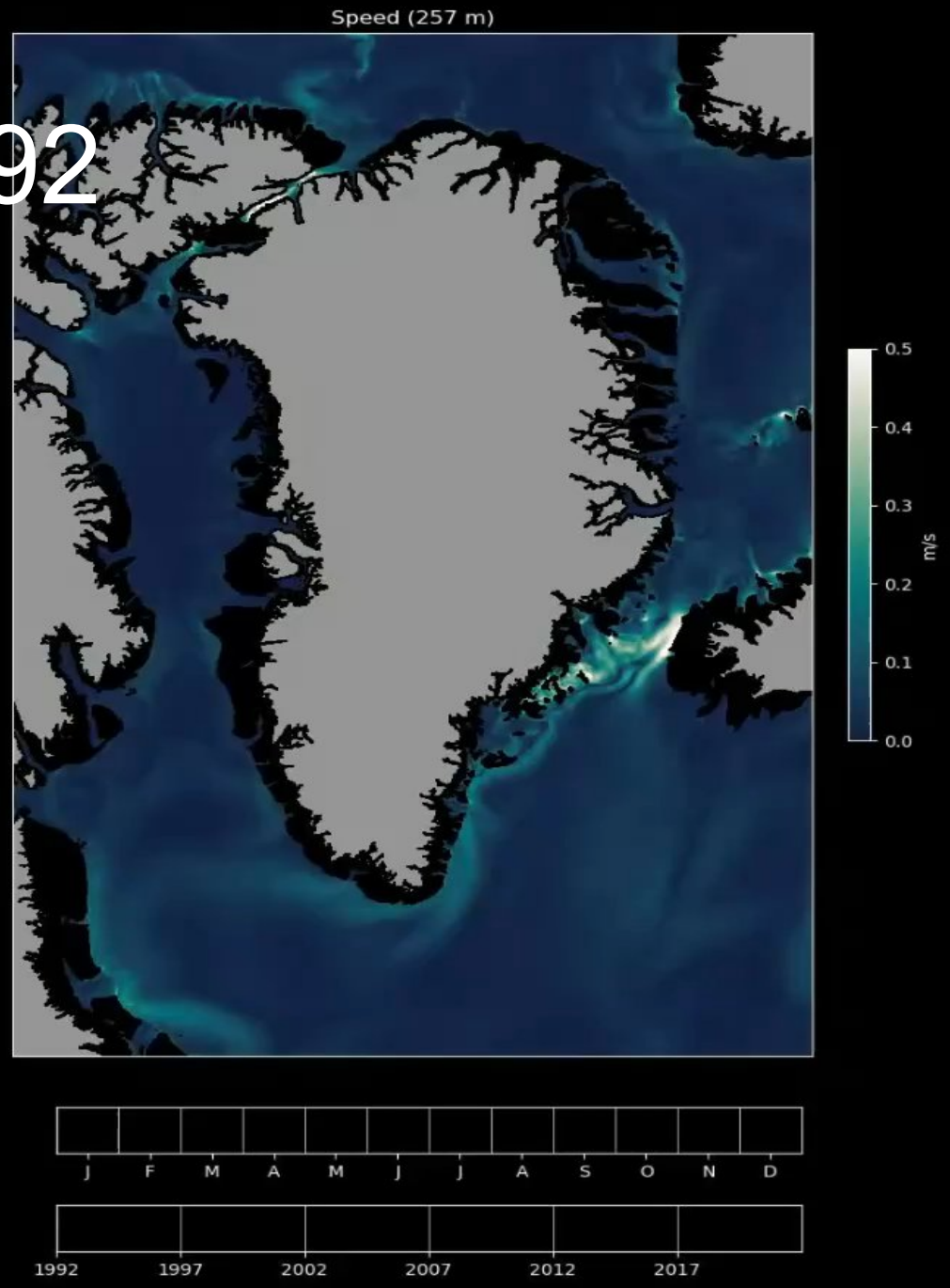






A 1-year Test Run in 1992

- During a spinup period, lots of new submesoscale features start to be resolved
- These features are key for transporting heat/salt onto the continental shelf and into glacier fjords

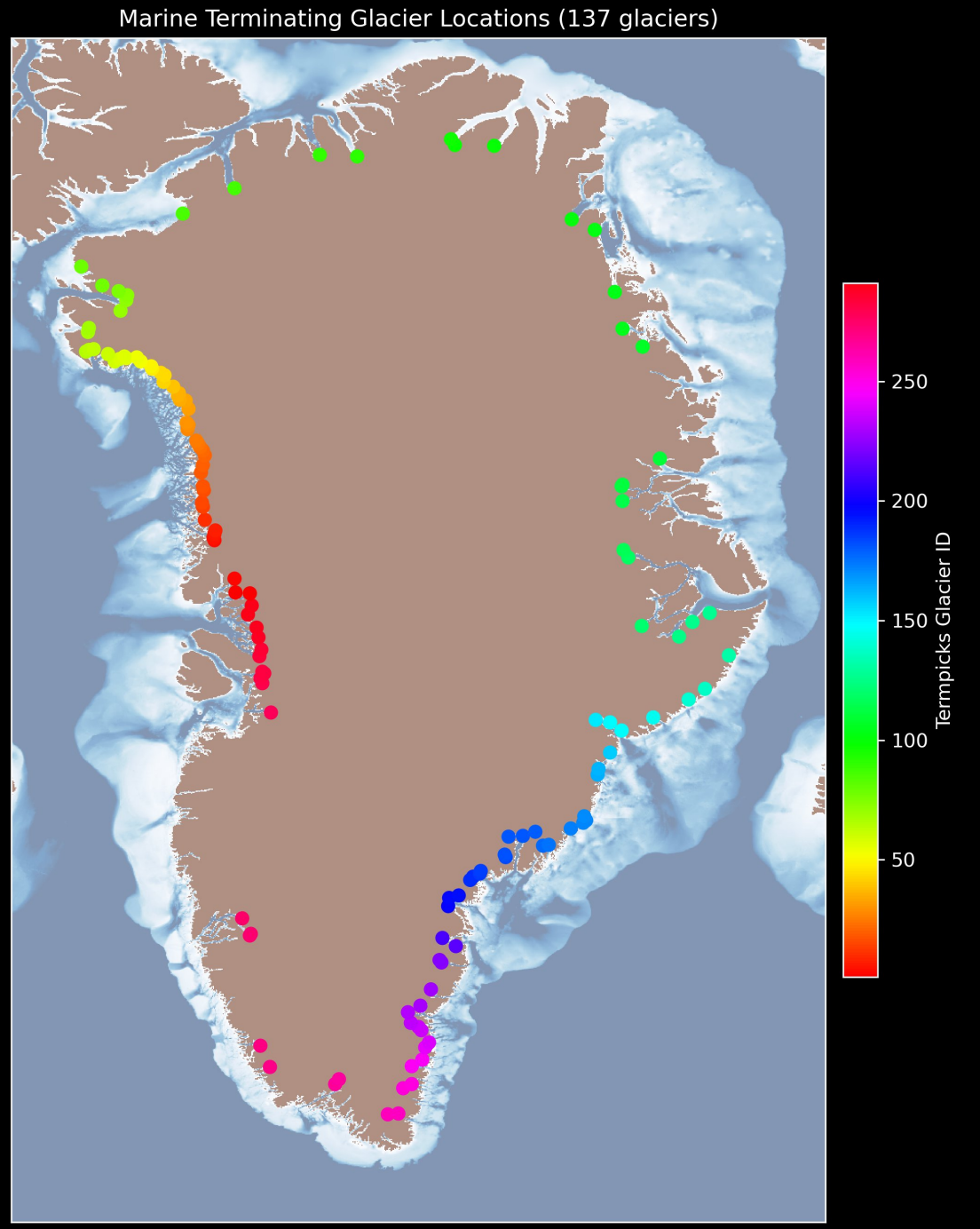


Glacier Implementation

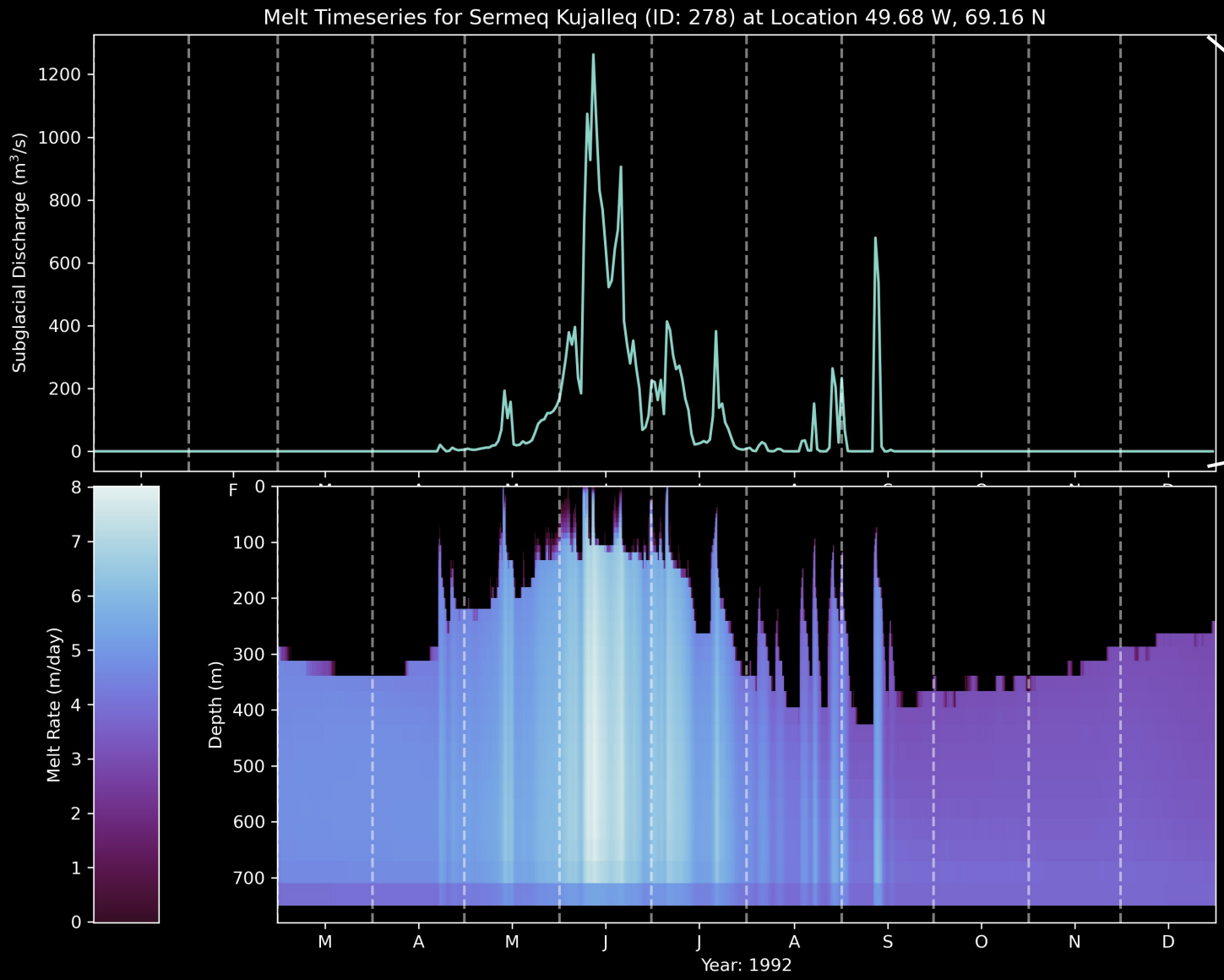
137 marine-terminating glaciers are implemented using *iceplume*

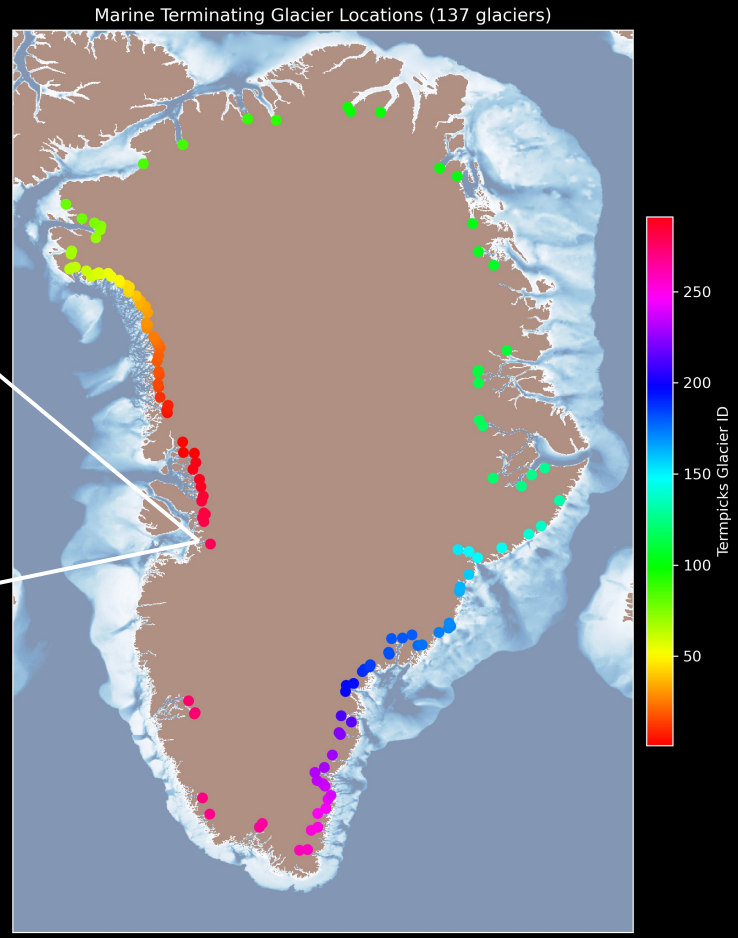
- Not all glaciers due to some unresolved fjords
- But they account for 99% of ice flux to ocean
- Sourced with hydrologically-routed subglacial discharge

All other ice sheet runoff is distributed at the surface (varies daily)



Melt at Sermeq Kujalleq





Glacier
Grounding Line

Ice Shelves

Ice shelves are implemented with *shelfice*

- 6 ice shelves in N Greenland

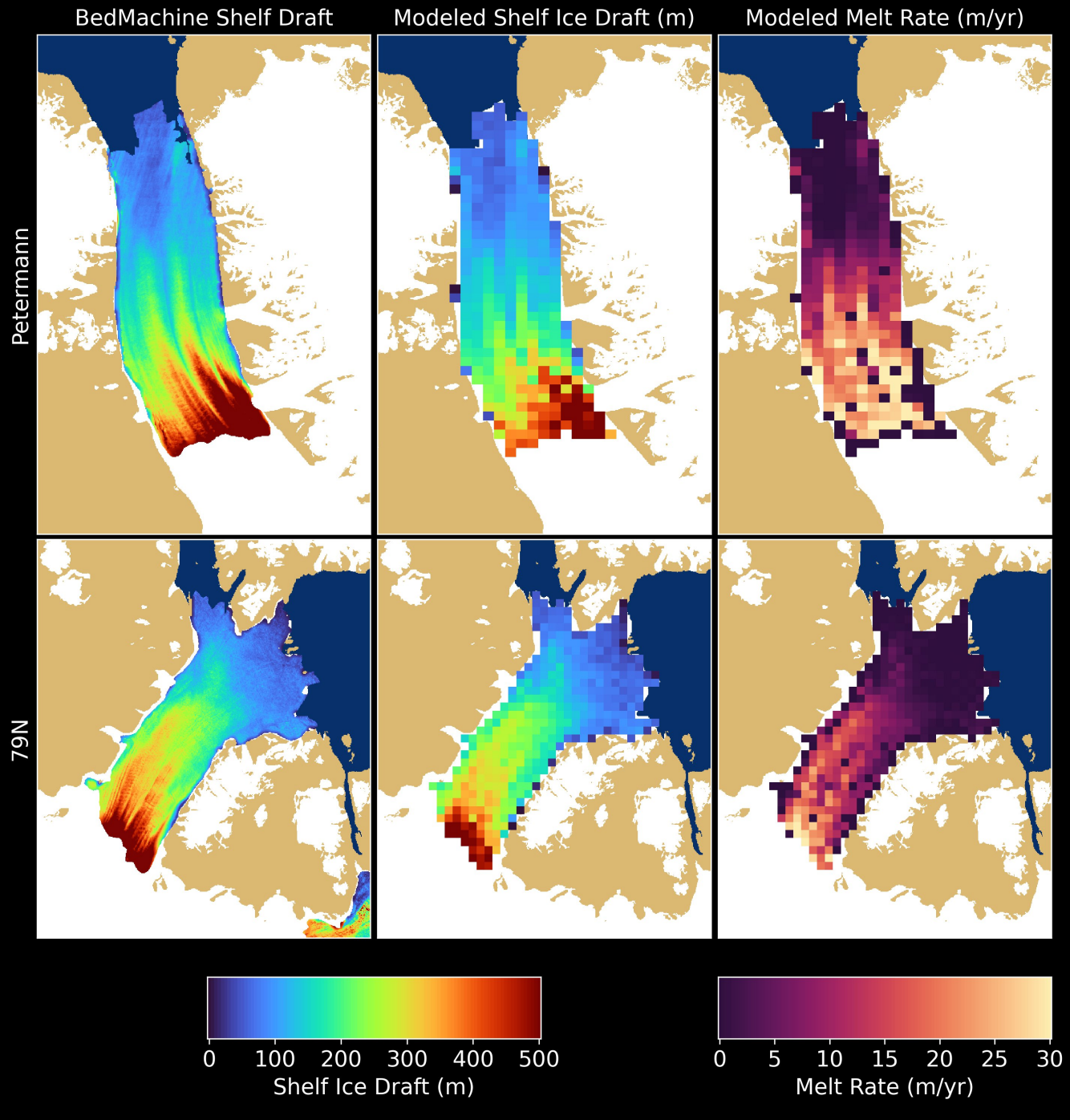
- does not include 4 shelves which broke up during the ECCO period (e.g. Sermeq Kujalleq)

Melt at Petermann and 79N

Melt under ice shelves is largely depth-dependent

- pressure dependency
- location of deep, warm AW

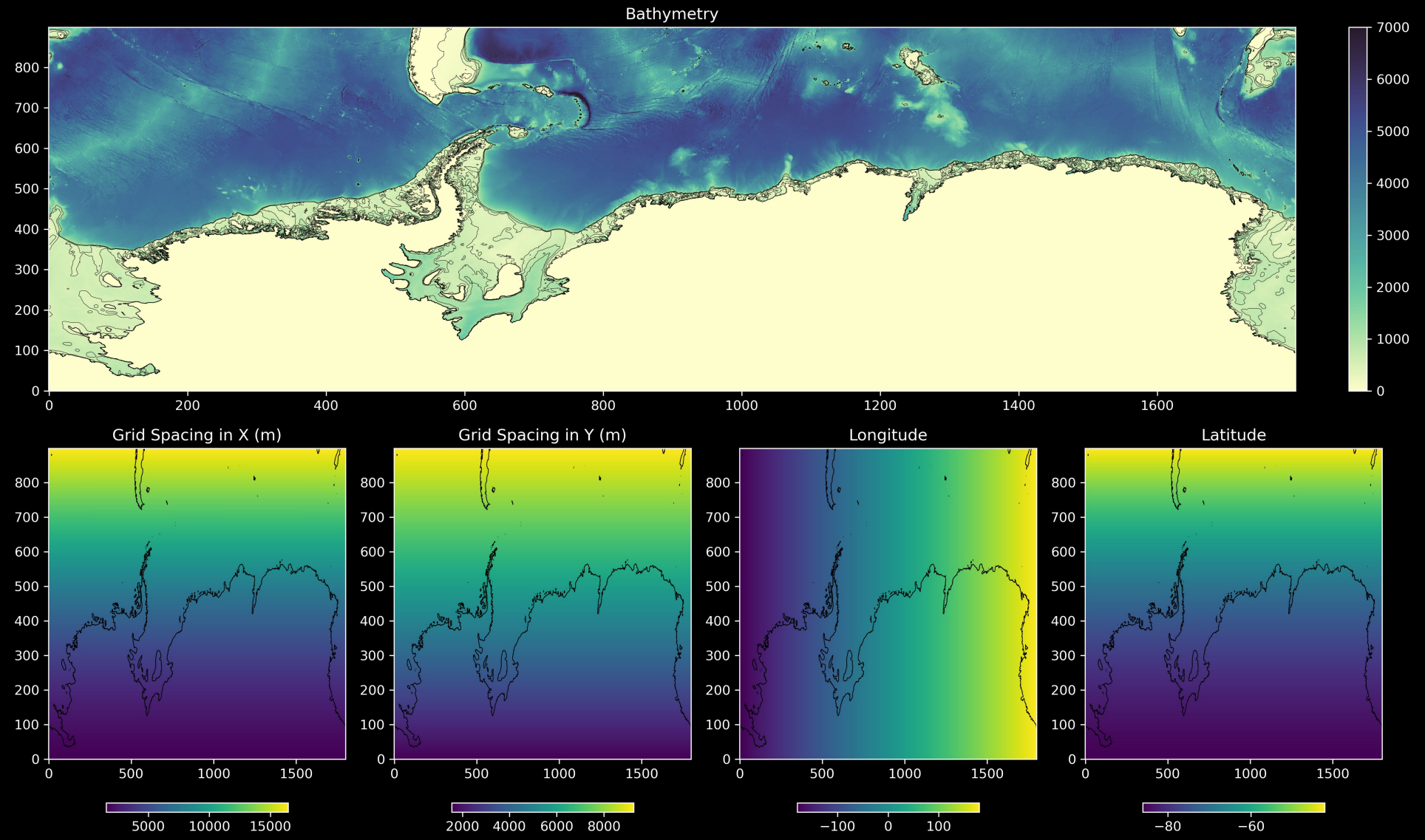
Discharge plumes are also active underneath the ice shelves!



Antarctica

Model Domain

- 900 rows x 1800 cols
- 2-4 km under shelves
- Resolution telescopes northward



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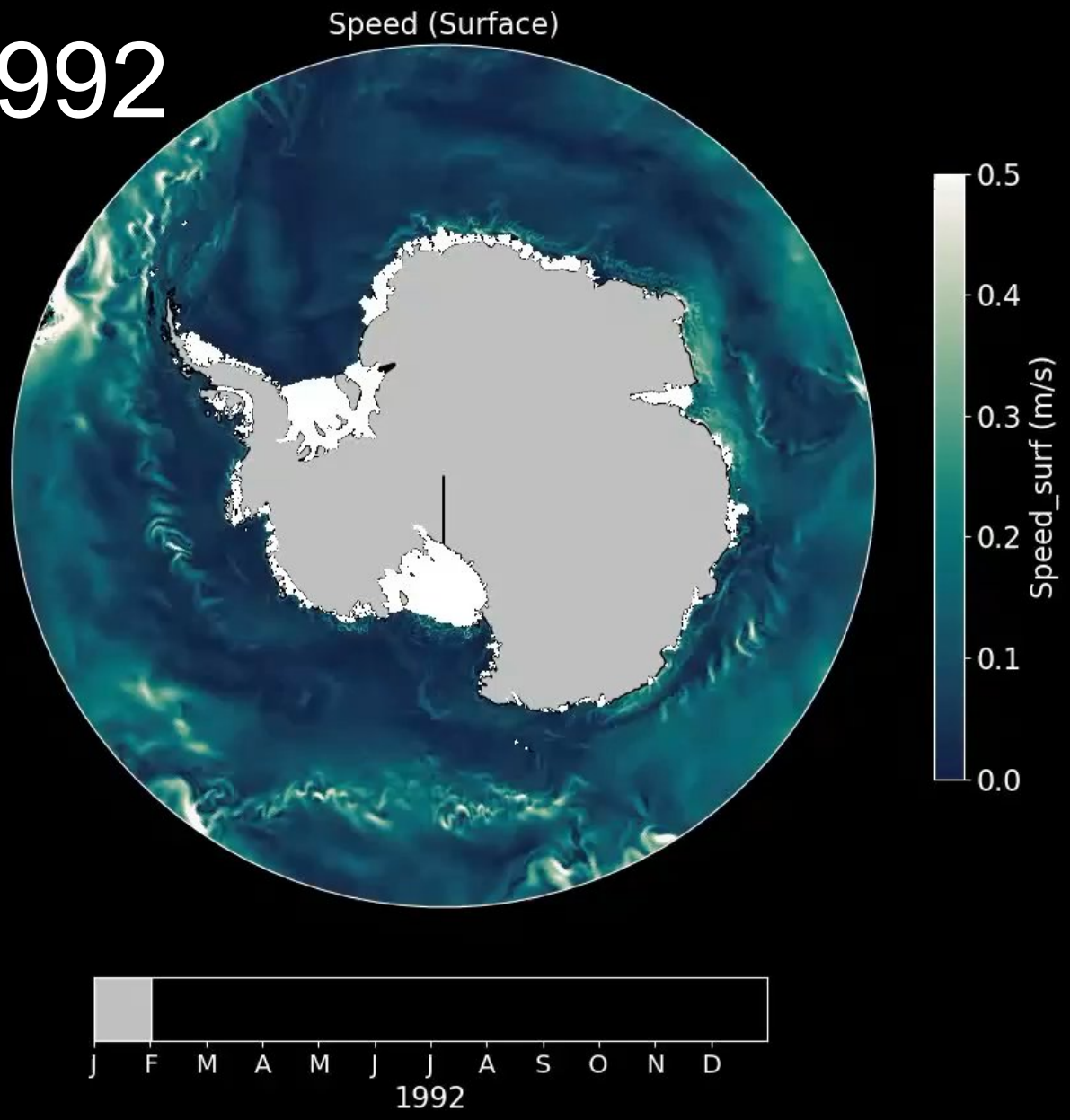
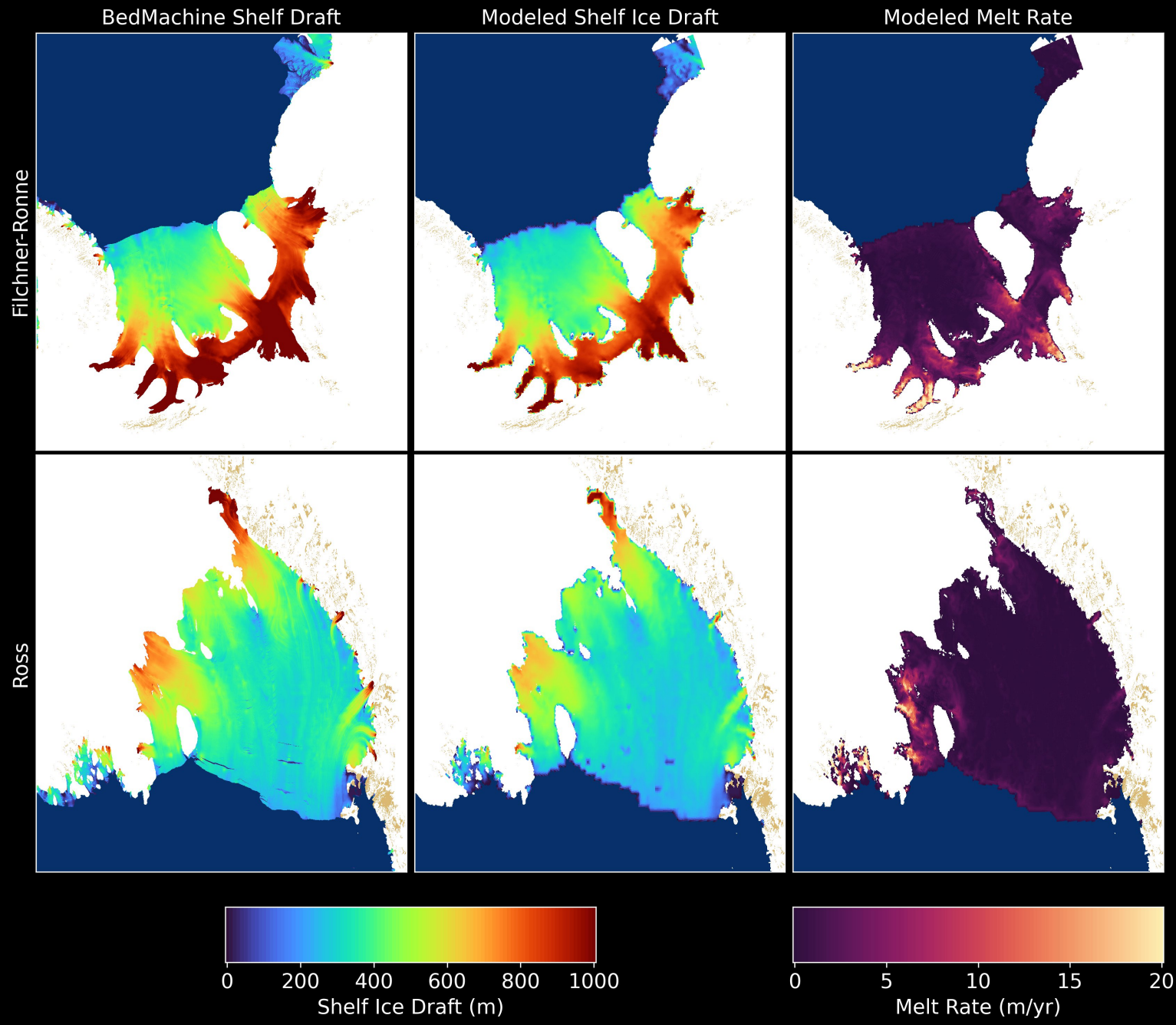


Ice Shelf Implementation

- Shelf geometry is derived from BedMachine Antarctica
- Melt is strongest near deep grounding lines



Computational Costs

	Forward LLC 270	Greenland	Antarctica
Δt	1200 s	120 s	120 s
Nominal nP x sNx x sNy	767 x 30 x 30	592 x 50 x 60	386 x 45 x 60
SBUs	~2000	~45,000	~21,000
SBU Cost Relative to Forward LLC270	1	~22	~10

Insight from community

Questions I have for you all at this meeting:

- General impressions on utility?
- Domain extents – are these the “right” size?
- Parameterizations (viscosity, kpp, etc) – what’s the latest/greatest?
- Diagnostics – what’s needed / what would you like to see?
- Other things I’m not thinking about?

Results:

Want to check out visualizations for more model fields?

Greenland

Antarctica