Freshwater forcing from Greenland and Antarctica: Observations and protocols

Progress since the
Anomalous Freshwater Workshop
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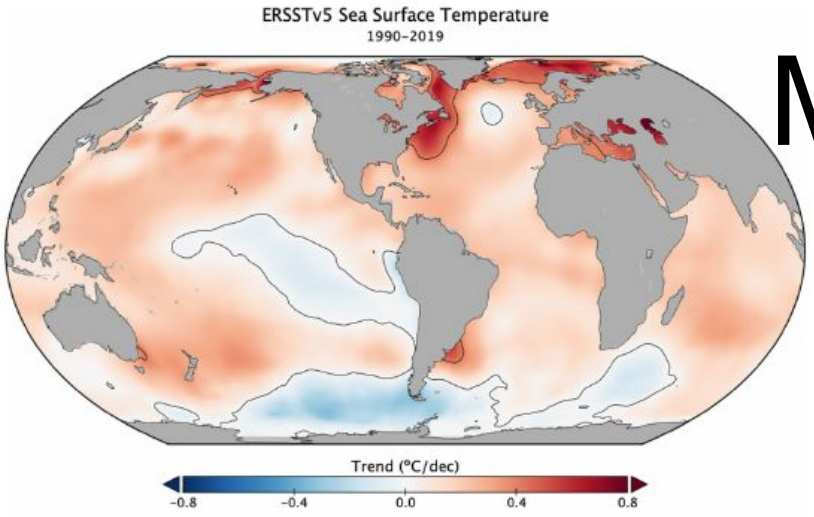
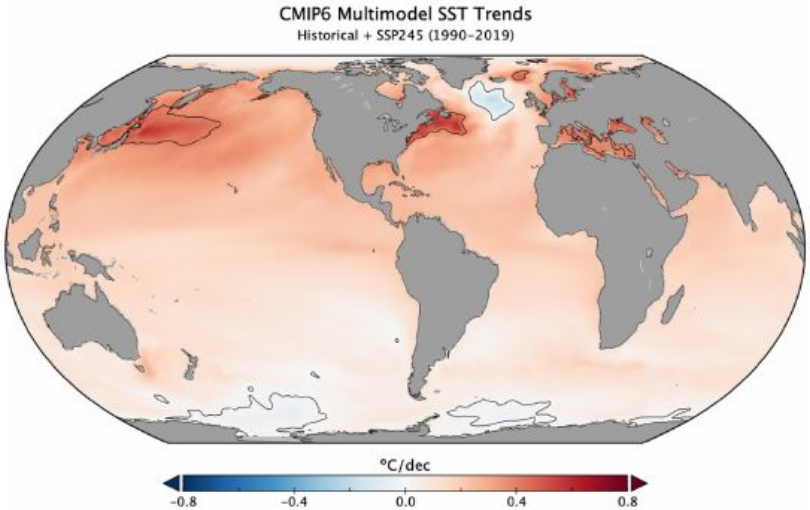
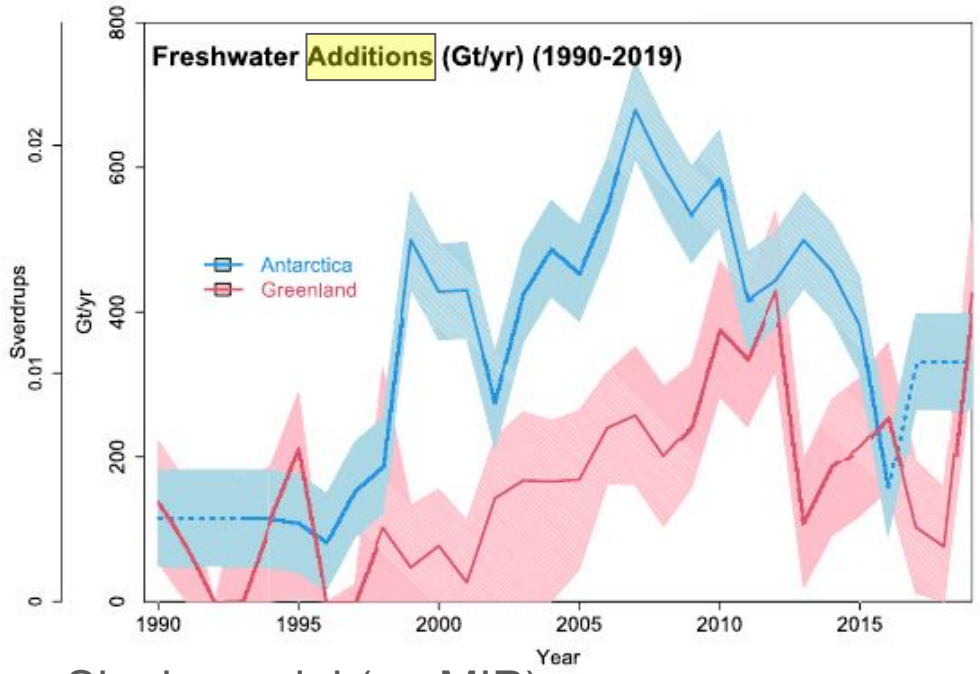
Contributors from the workshop
(presented here by Ken Mankoff; ken.mankoff@nasa.gov)

Motivation

Schmidt et al. (2023)



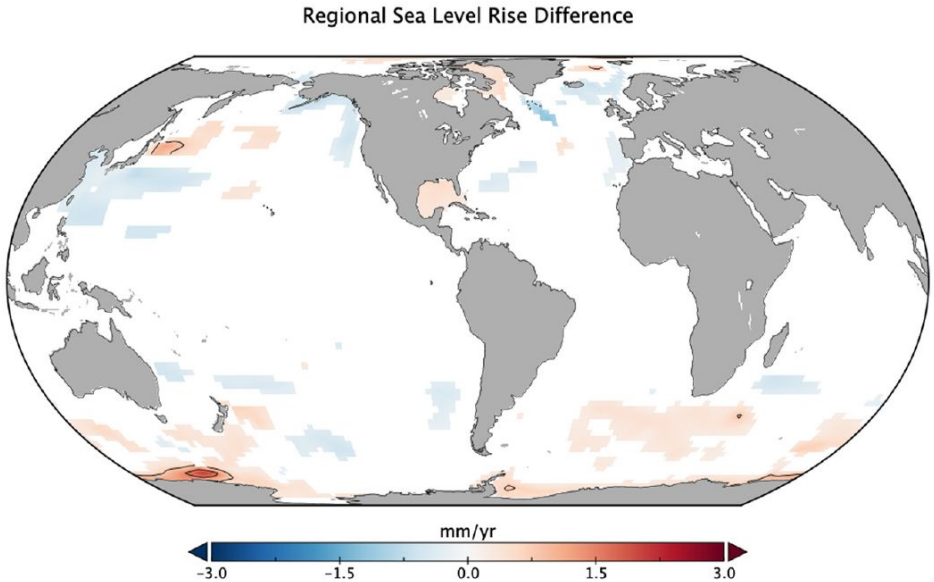


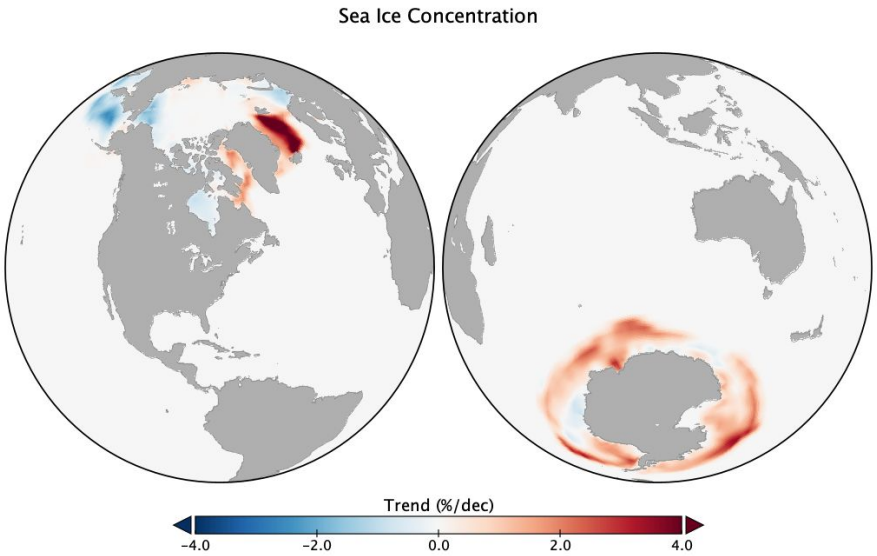


- Single model (no MIP)
- Limited treatment of heat
- Spread around AQ/GL at surface

Motivation

Schmidt et al. (2023)





Impacts on regional SLR, sea ice and temperature trends in Southern Ocean.

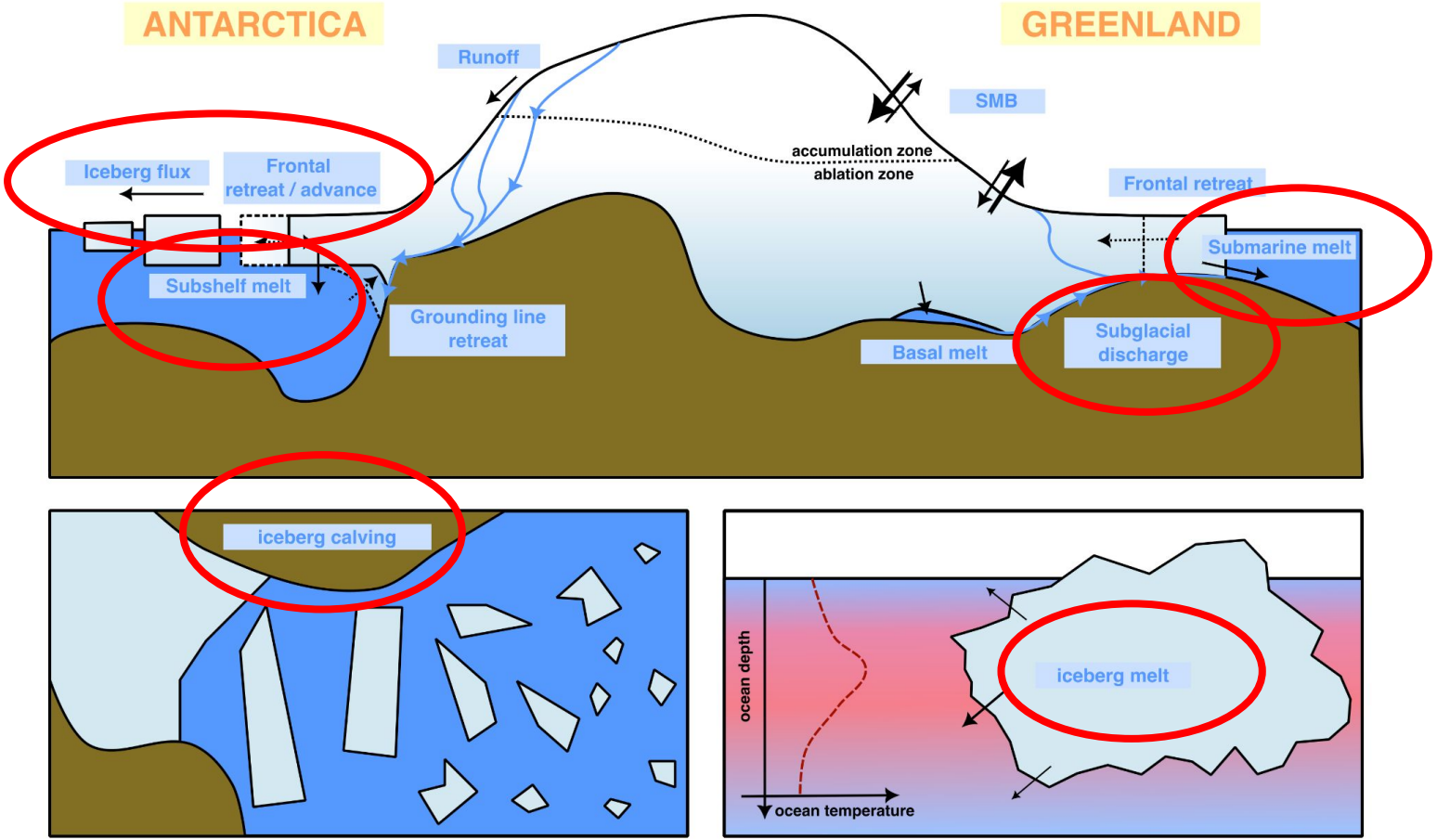
Motivation

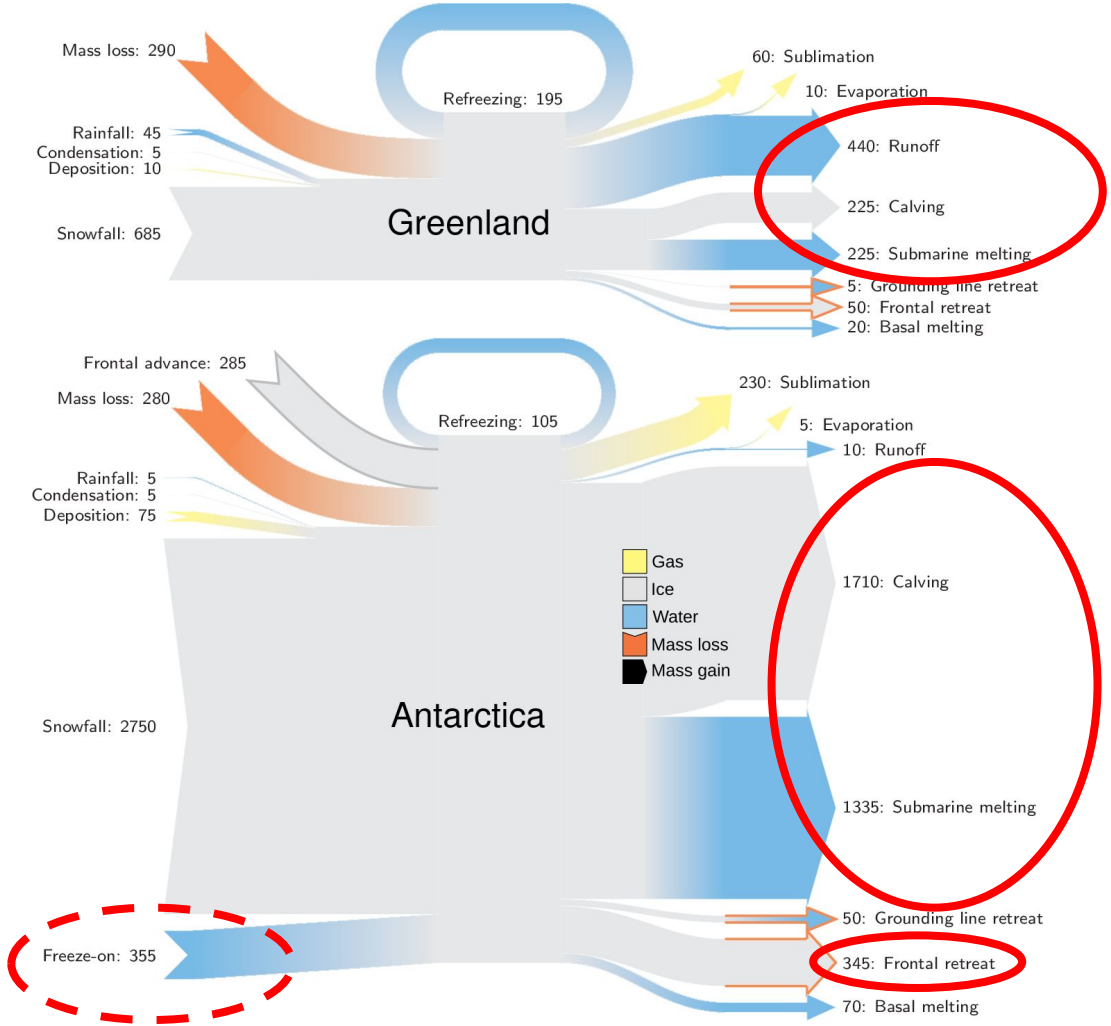
Swart et al. (2023)

- Only: Antarctica & Southern Ocean
- Used Slater (2021): ~500 Gt / yr (possibly **net not gross**)
- Tier 1 & 2: Grid cell adjacent to all coast and at ocean surface
- No treatment for latent heat of melt
- Tier 3:
  - Spread evenly S of 60 ° and/or
  - Spread only in Bellingingshousen & Amundsen and/or
  - Spread with vertical depth distribution

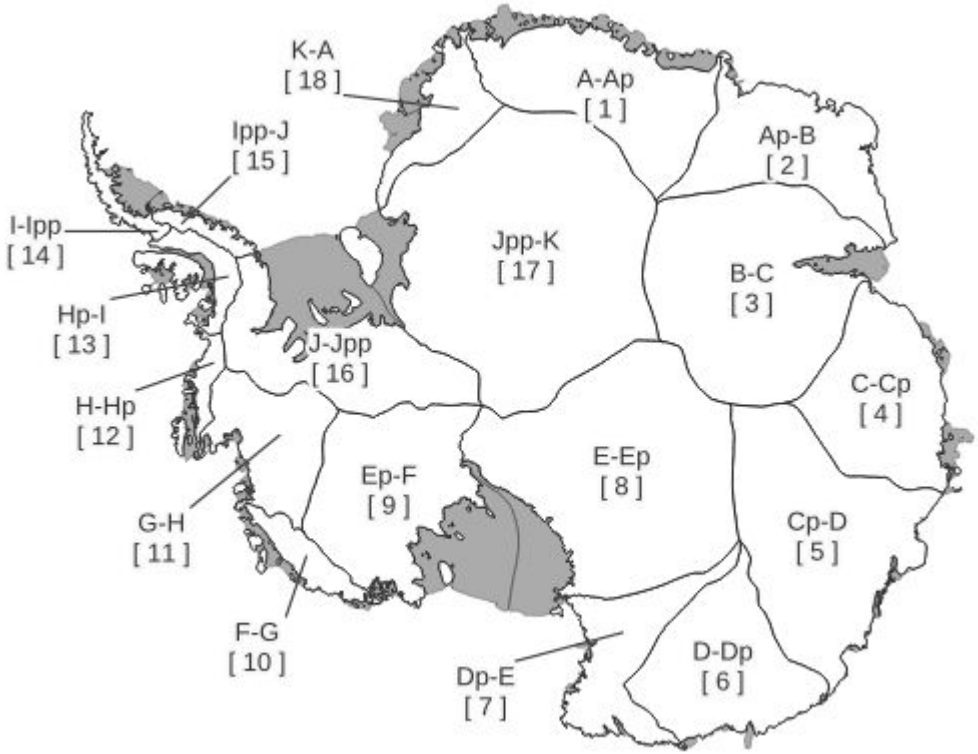
Forcing recommendations

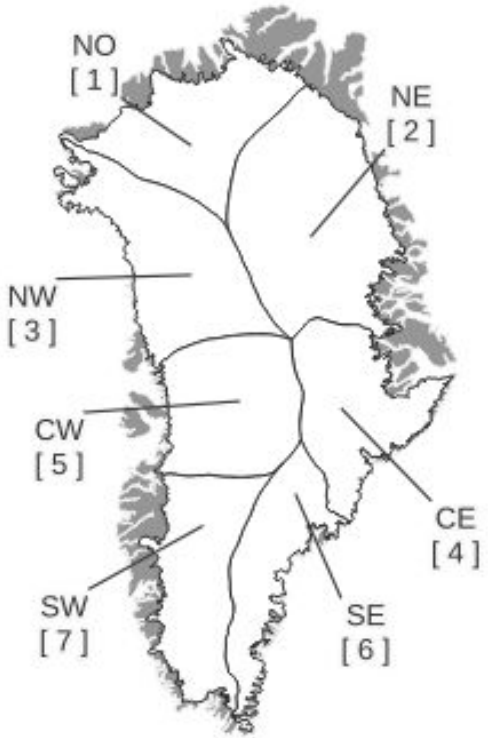
- Longer time series of observations
- Greenlandic and Antarctic
- Distinguish surface runoff, sub-shelf melt, iceberg melt
  - Matters for heat, xy, and z
- Resolve where freshwater enters oceans based on source
  - dest(x,y,z) = f(source(x,y,form))


ANTARCTICA
GREENLAND
Runoff
SMB
accumulation zone
ablation zone
Iceberg flux
Frontal retreat / advance
Frontal retreat
Submarine melt
Subshelf melt
Grounding line retreat
Basal melt
Subglacial discharge
iceberg calving
ocean depth
iceberg melt
ocean temperature



Q: I think sub-shelf melt should be **net** (not **gross**; i.e., **subtract freeze-on)** and all other terms should be **gross** (not **net**)



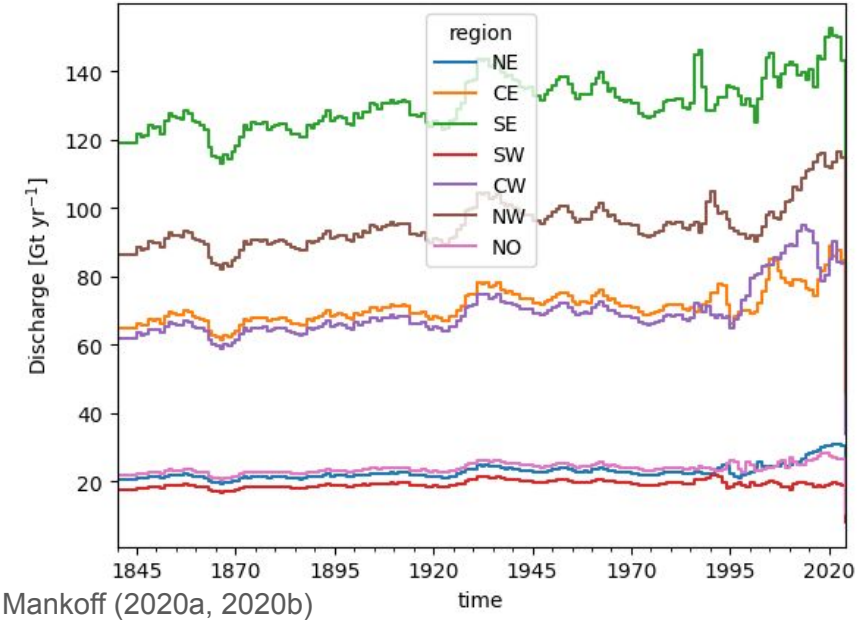


Rignot (2017); Mouginot (2019)

Greenlandic freshwater

Solid discharge: 10 % uncertainty

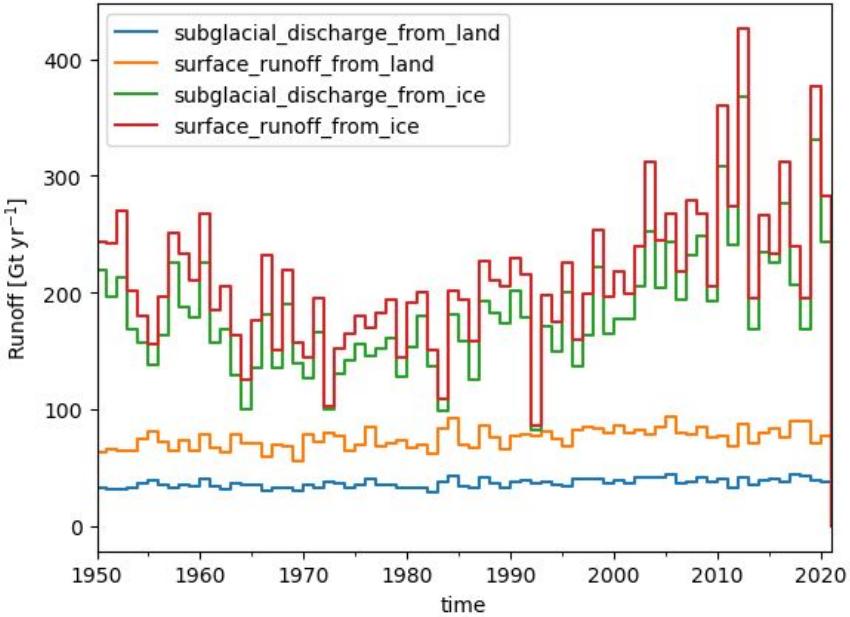
50 % melts at terminus (**+- 40 %;** Enderlyn 2013)
25 % icebergs melt in fjord (**guess**)
25 % icebergs melt outside (**guess;** see next slide).
Operational: Updates monthly



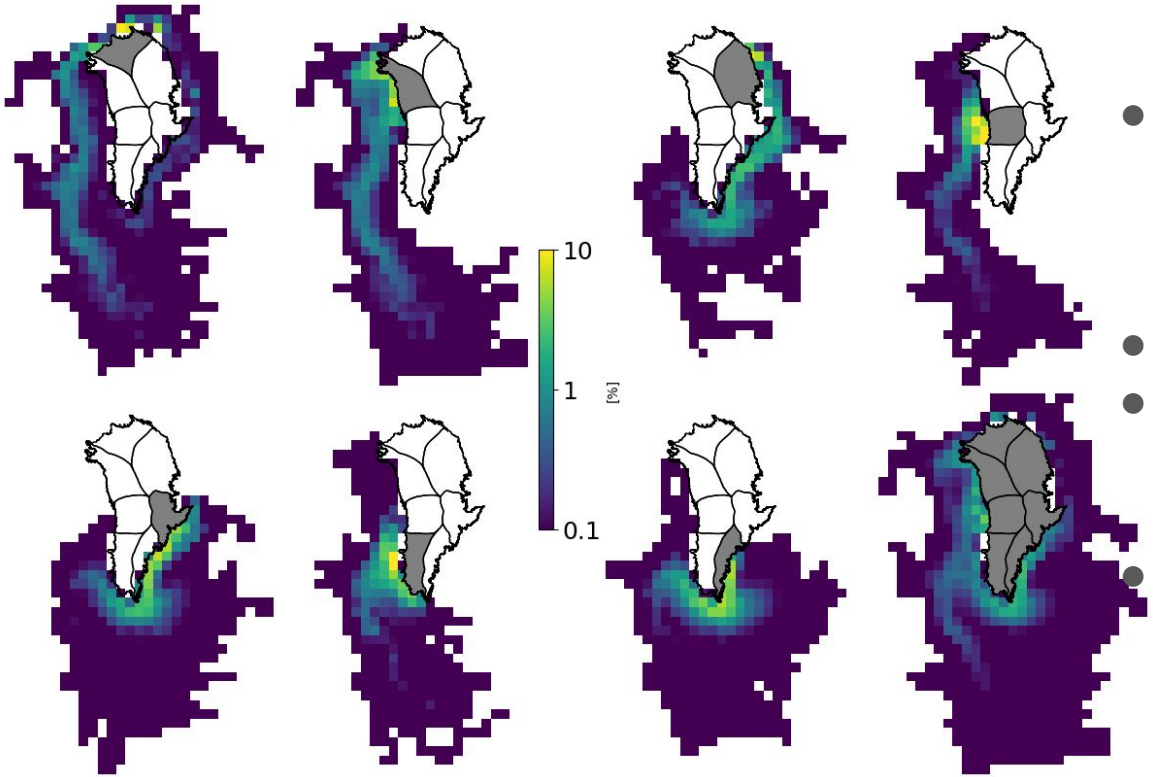
Mankoff (2020a, 2020b)

Liquid runoff: 15 % uncertainty

Melted ice, melted snow, rain, etc.
Updates annually



Greenland iceberg meltwater: x & y distribution

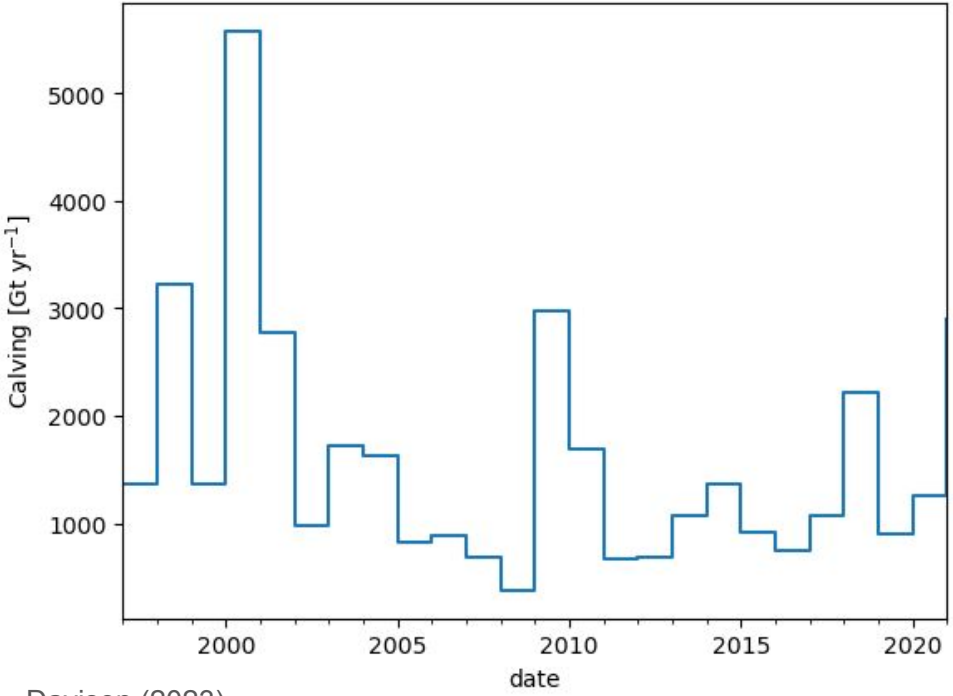


- ~50 % submarine melt at ice/ocean boundary
  - Treat as “subglacial discharge” (previous slide)
- ~25 % melts within fjords
- ~25 % melts around Greenland
- z: Top 200 m (Slater, 2022)

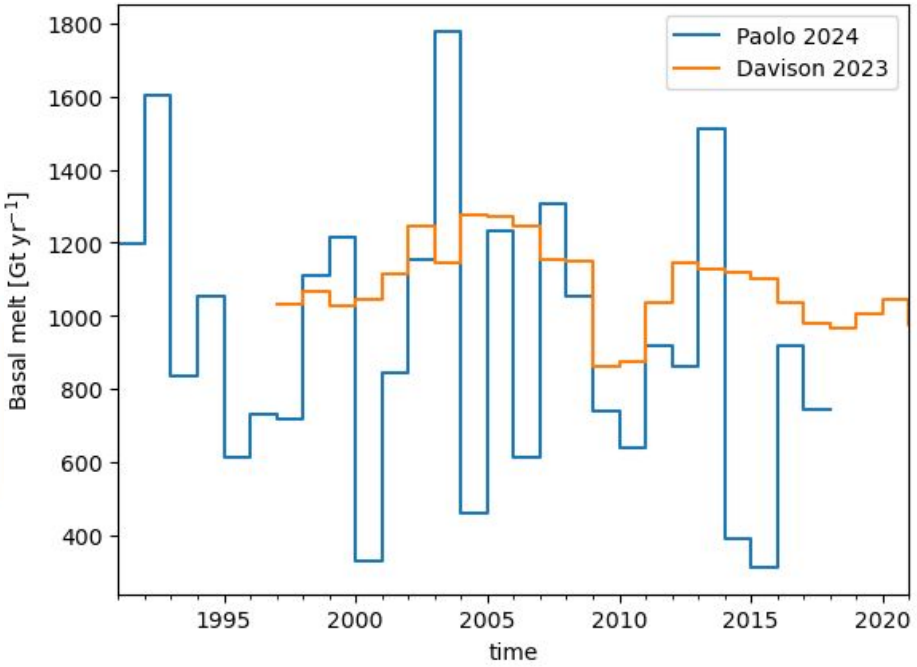
Marson (2024) processed by Mankoff

Antarctic freshwater inputs

Solid (icebergs)

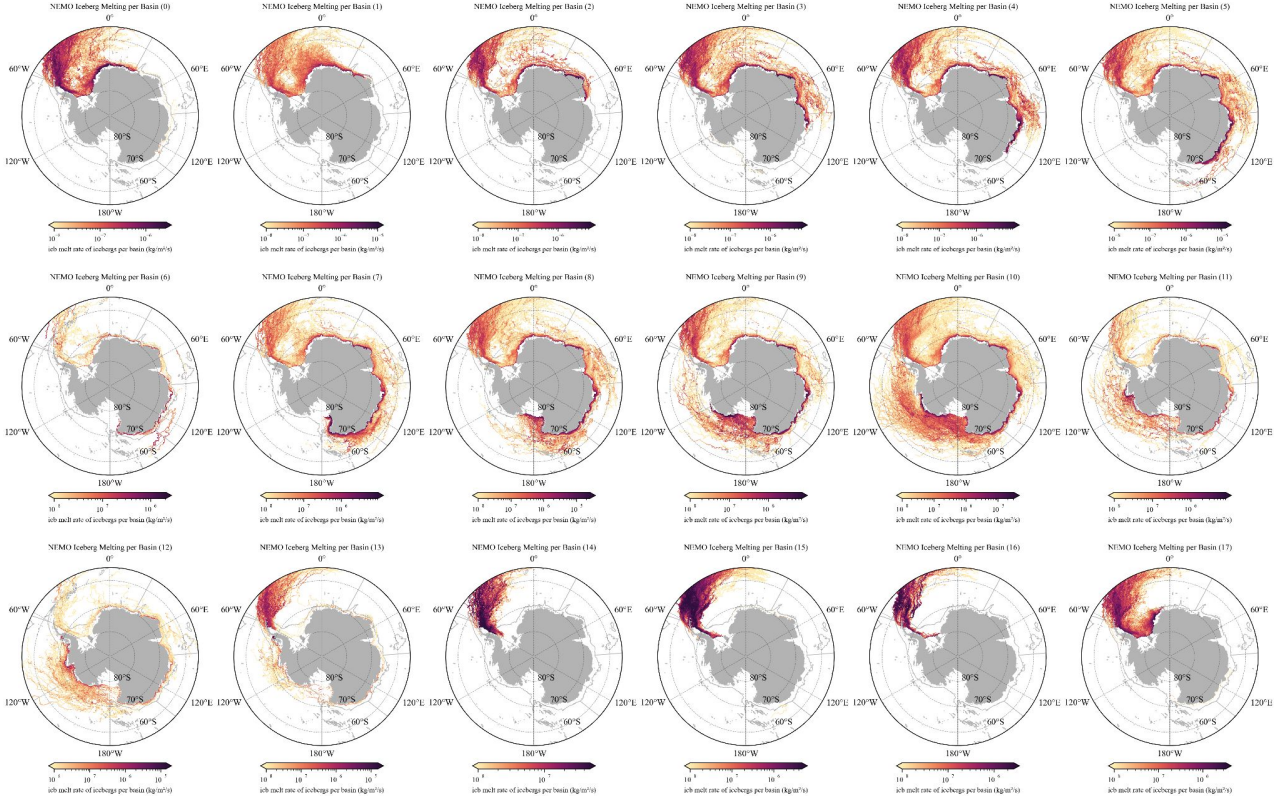


Ice shelf basal melt



Davison (2023)

Antarctic freshwater distribution



- z: Top 220 m (Naughten, 2022)

Mathiot et al. (2023) processed by Jourdain

Summary

Ice sheet	Product	Time	Uncertainty	Recommended treatment
GL	Iceberg	1850 –	10 % to 50 %	XY: 50 % terminus; 25 % fjord, 25 % iceberg map Z: Top 200 m
GL	Runoff	1950 – (can be 1850)	15 %	XY: terminus Z: 50 % surface; 50 % top 200 m
AQ	Iceberg	1997 –	~25 %	XY: Iceberg melt map Z: Top 220 m
AQ	Sub-shelf melt	1992 –	~30 %	XY: Shelf edge Z: Shelf draft

Not addressed:
GL: Frontal retreat (~5 %), Grounded basal melt (~2 %), Sea ice melt in fjords (??)
AQ: Grounding line retreat (2 %), Grounded basa melt (2 %)

Summary

- Freshwater forcing from unresolved changes in ice sheets/shelves may be a key driver of SO trends/variability, and impacts N. Atlantic sea level and (maybe AMOC - though magnitudes are small to date)
- Community effort has developed regional timeseries of inputs from ice sheet basins (7 in Greenland, 18 in Antarctica)
  - Basal melt, runoff + calving
- Hi-res modeling to estimate horiz/vert distribution of iceberg flux per region
- Guidelines on implementation within coupled models that respects choices made in development
- Usable in historical runs, scenarios/idealized simulations/paleo under development
- Paper near submission!