This project is a joint CESM and SIMA activity funded by the National Science Foundation

Coupling a variable-resolution atmosphere to POP2: preindustrial control and an idealized warming experiment

February 2023

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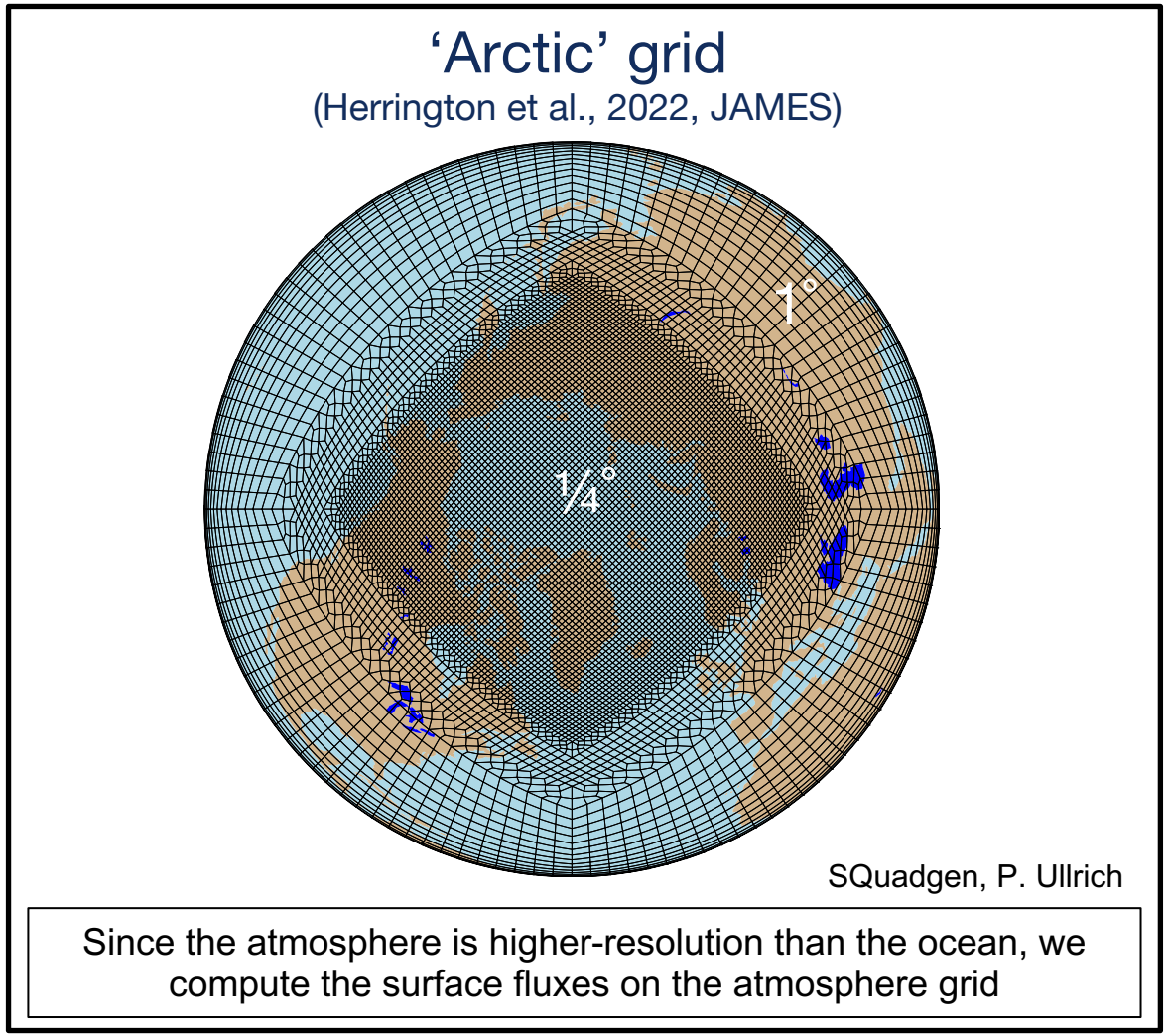
Outline

Coupling the Arctic grid to 1° POP2 in CESM2.2:

- Challenges, e.g., tuning
- piControl climate
- 1pctco2 experiment
- Greenland Ice Sheet in CISM and its response

Compare to CMIP6 1° workhorse (CESM2.1)

- piControl (Lofverstrom et al 2020)
- 1pctco2 (Muntjewerf et al 2020)



Challenges with Variable-Resolution (VR) Grids

Two orthogonal problems with conventional physics packages:

(1) Inadequate scale awareness

- Not much we can do about this except to avoid refining regions with lots of diabatic forcing and vertical motion

(2) Large sensitivity to physics time-step

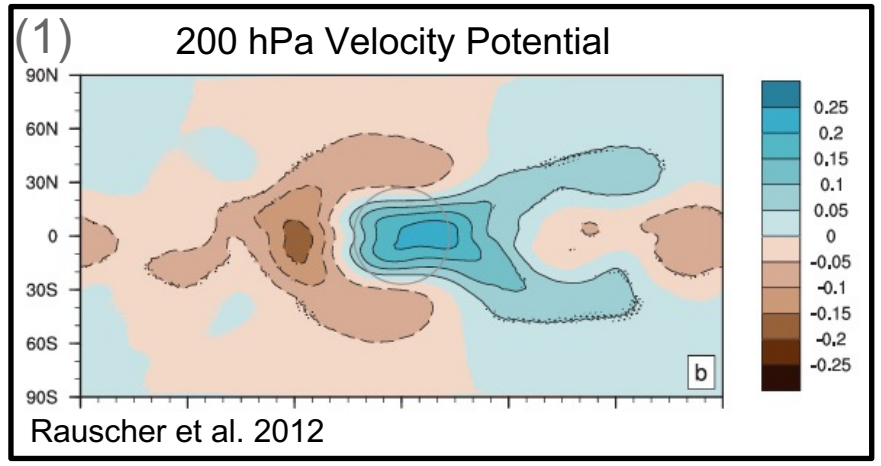
- We could run with the 1˚ physics time-step to avoid re-tuning from (2), but solution accuracy is reduced substantially.

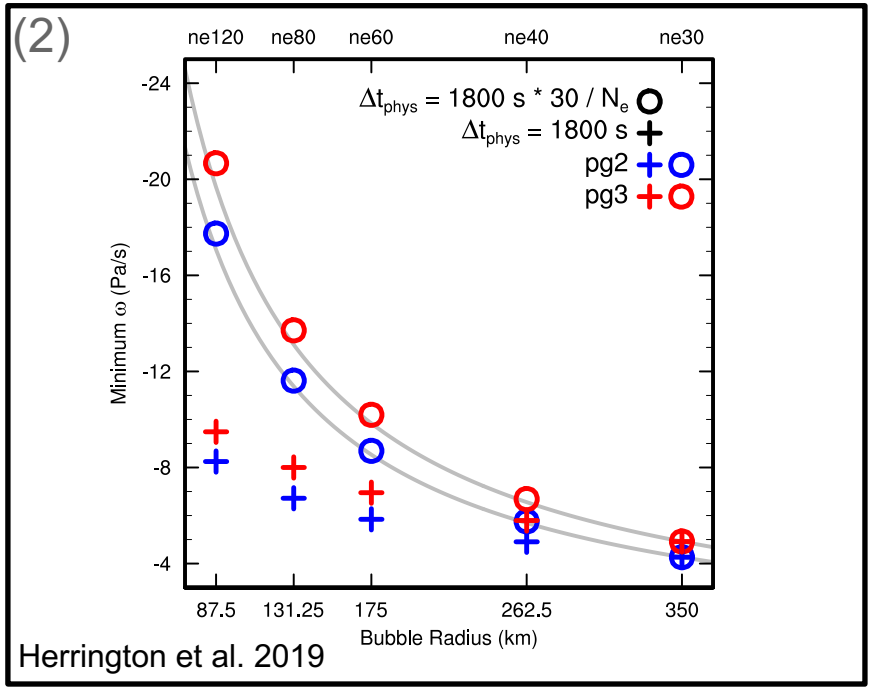
Tune by proxy – tune the 1˚ model using the (small) VR time-step

Estimated cost of tuning

- Prioritize balanced RESTOM, reasonable cloud cover and SSTs
- About 20 x 10 year simulations + a couple 20 year simulations
- *3 times more expensive than 1˚ ~ 1.5-2 M core hours

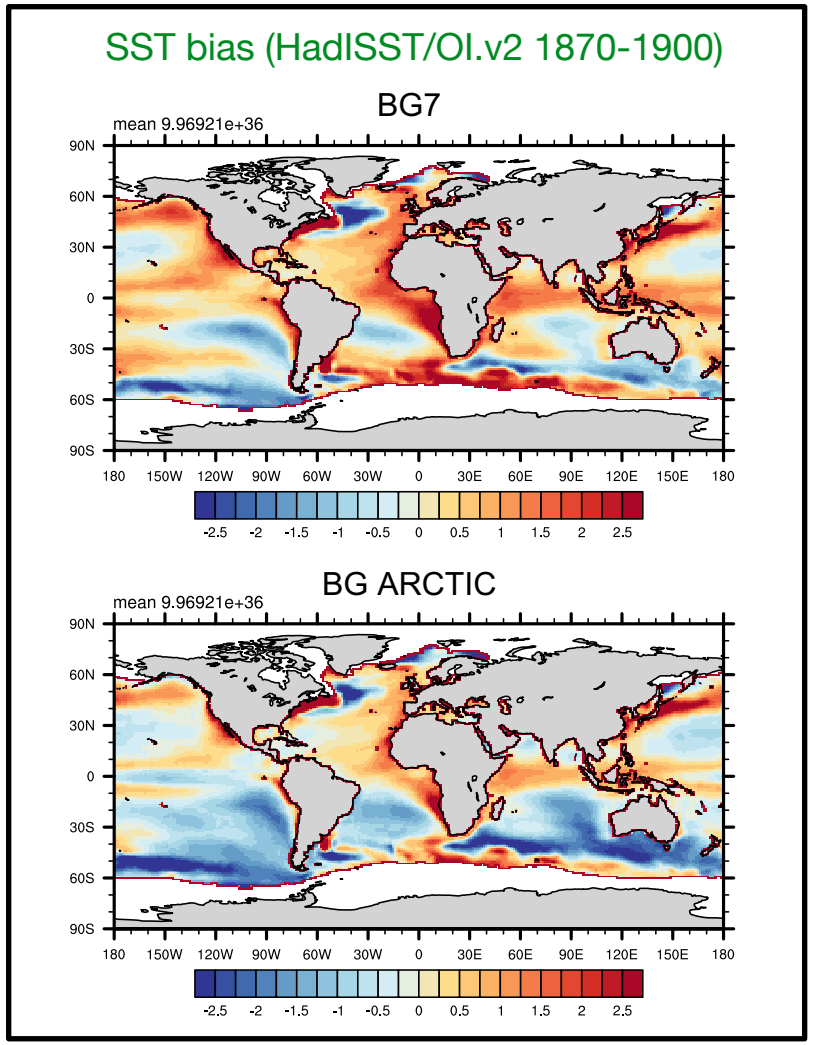
*the Arctic grid is 10 times more expensive than 1˚

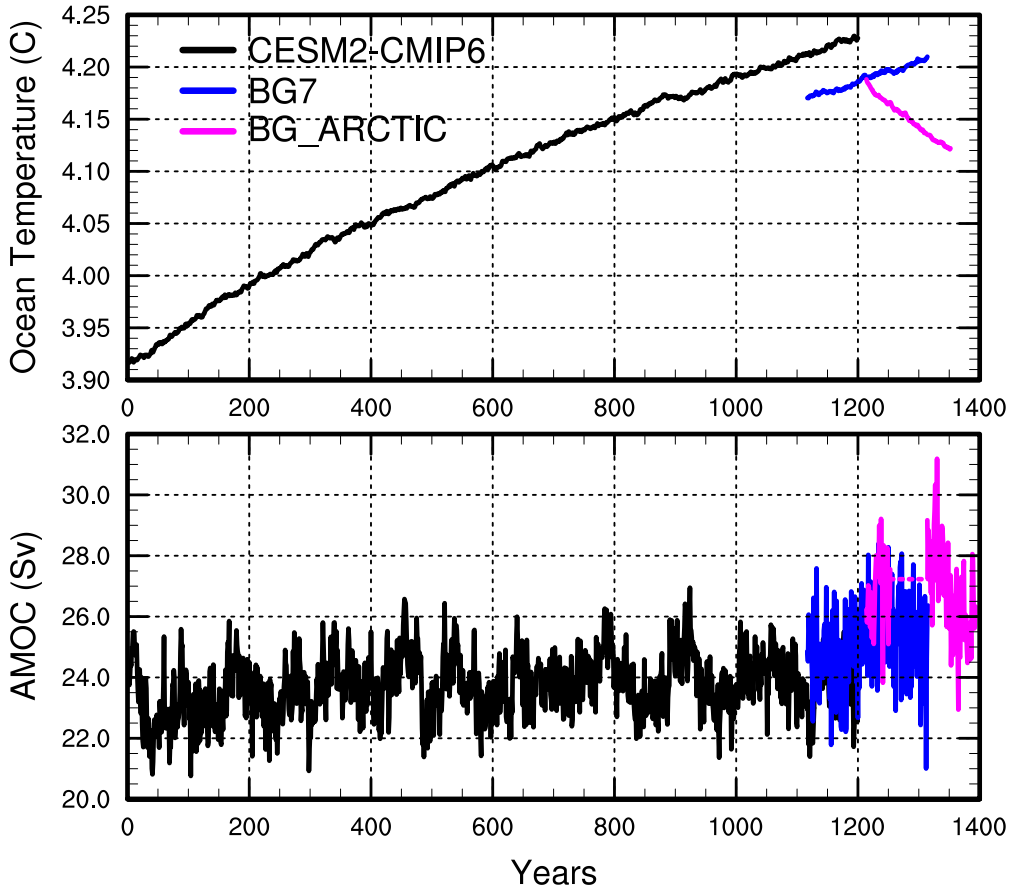




Preindustrial Control

CISM is on; **BG ARCTIC** is branched from the **BG7 control** of Lofverstrom et al. 2020

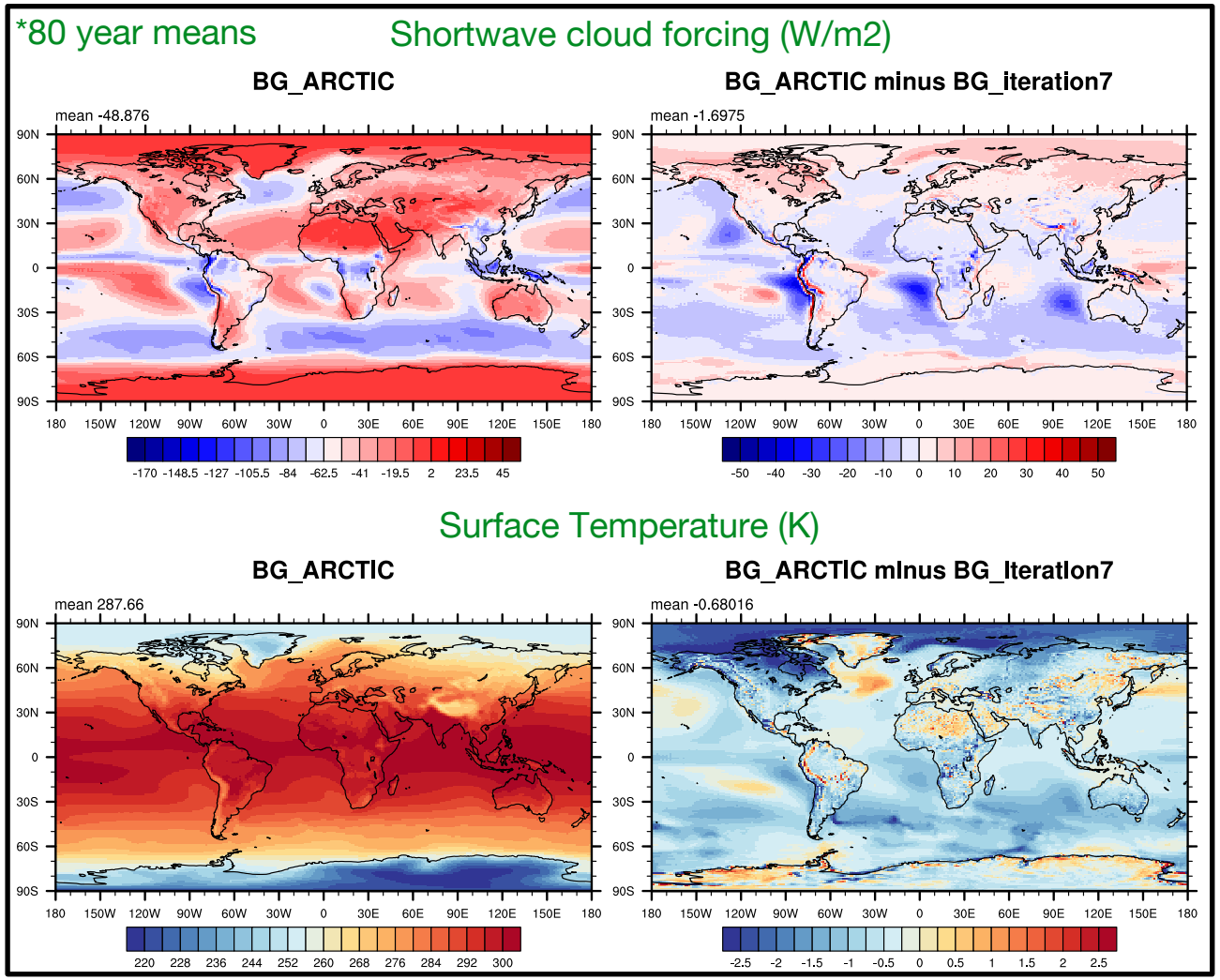


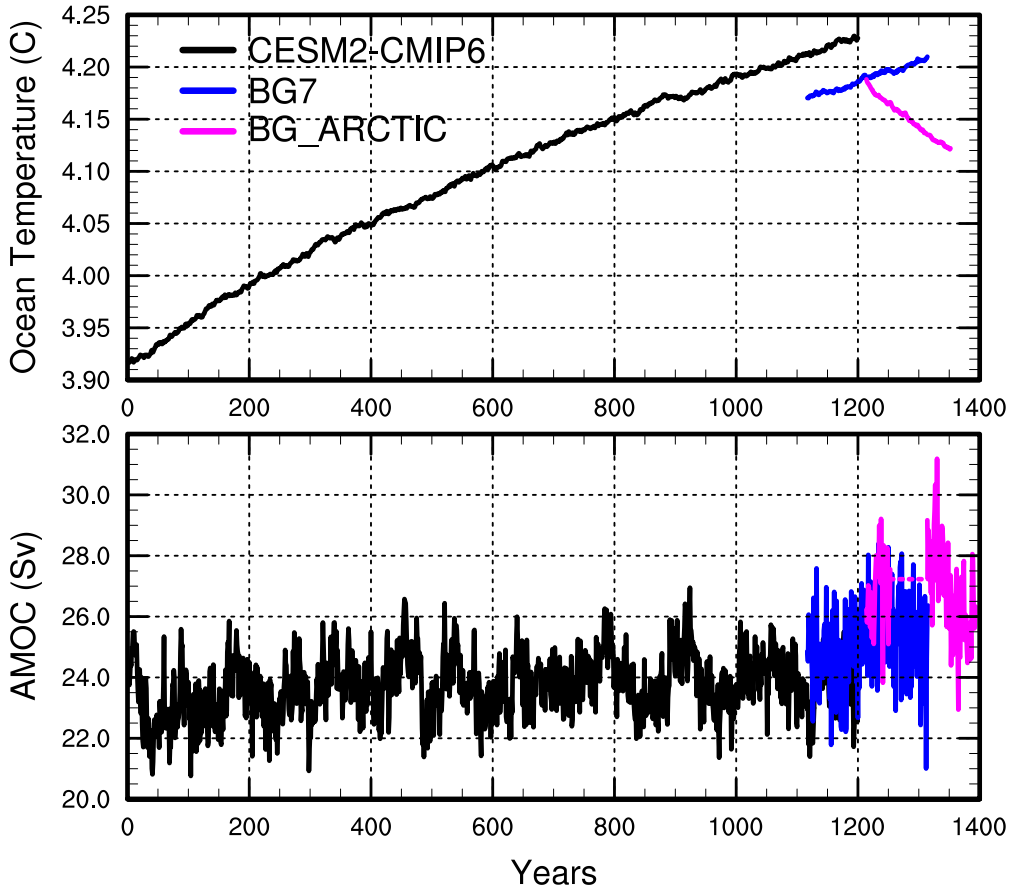


2-3 W/m2 reduction is SW absorbed by ocean (not shown)

Preindustrial Control

Comparing **BG ARCTIC** to **BG7**





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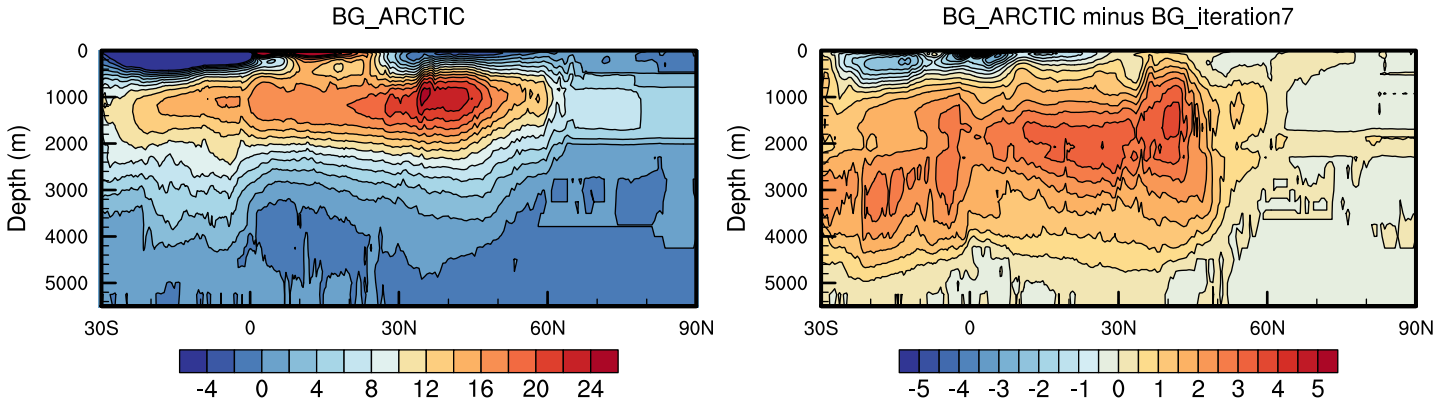
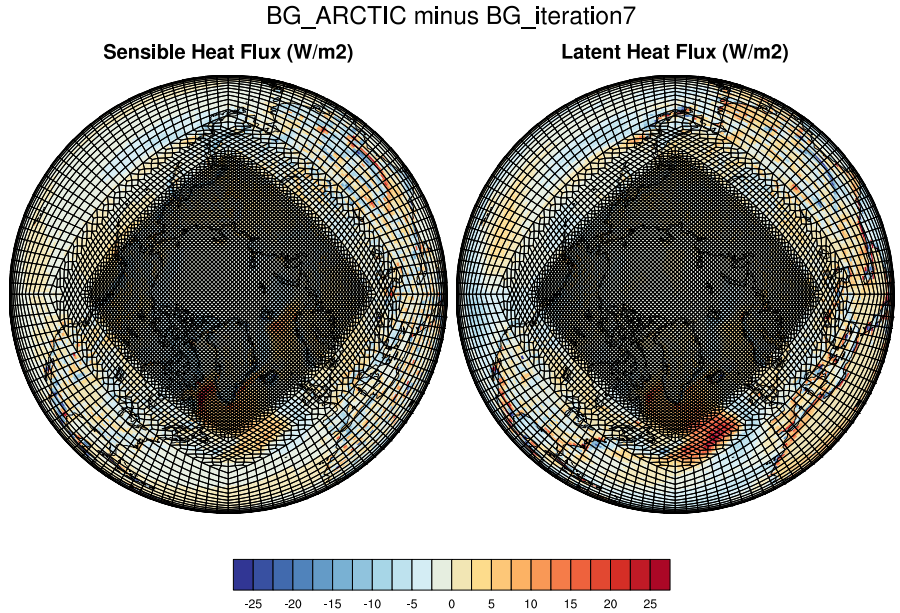
Preindustrial Control

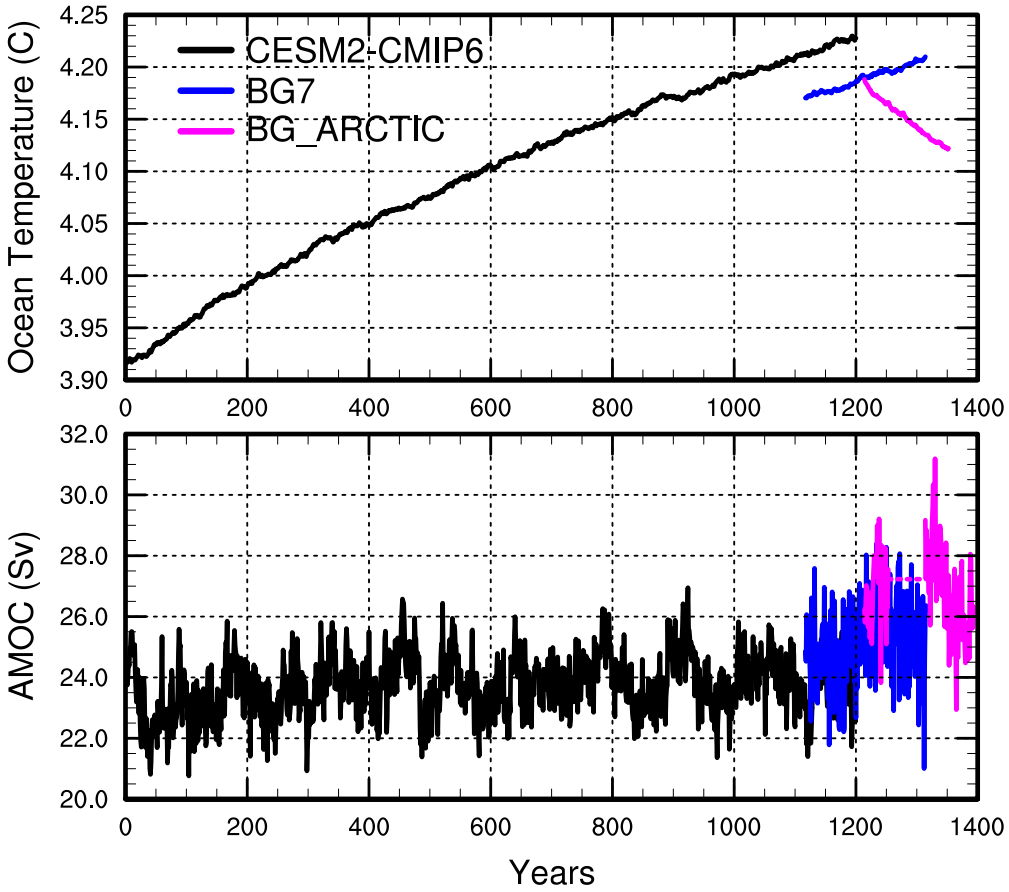
Comparing BG ARCTIC to BG7

*80 year means

AMOC (Sv)

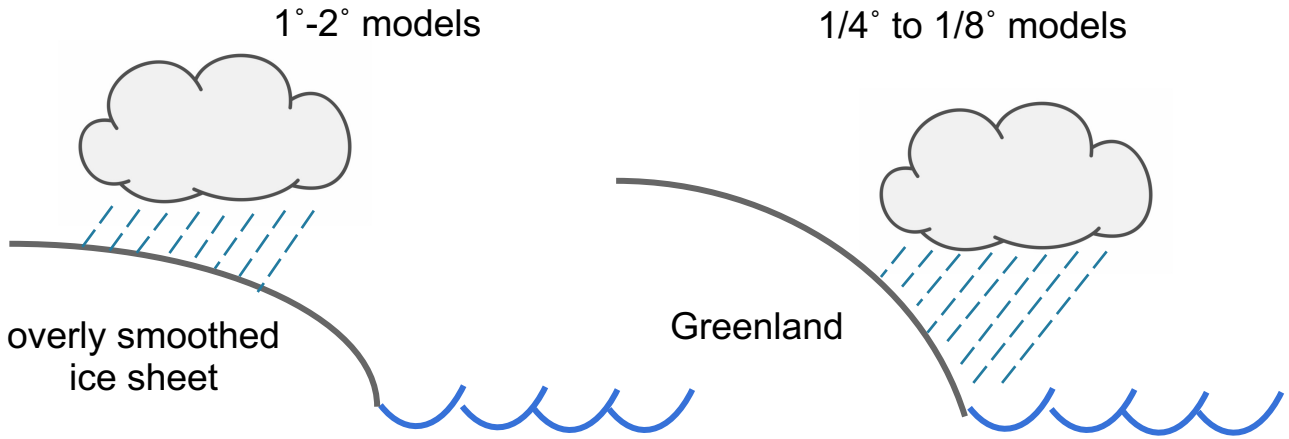


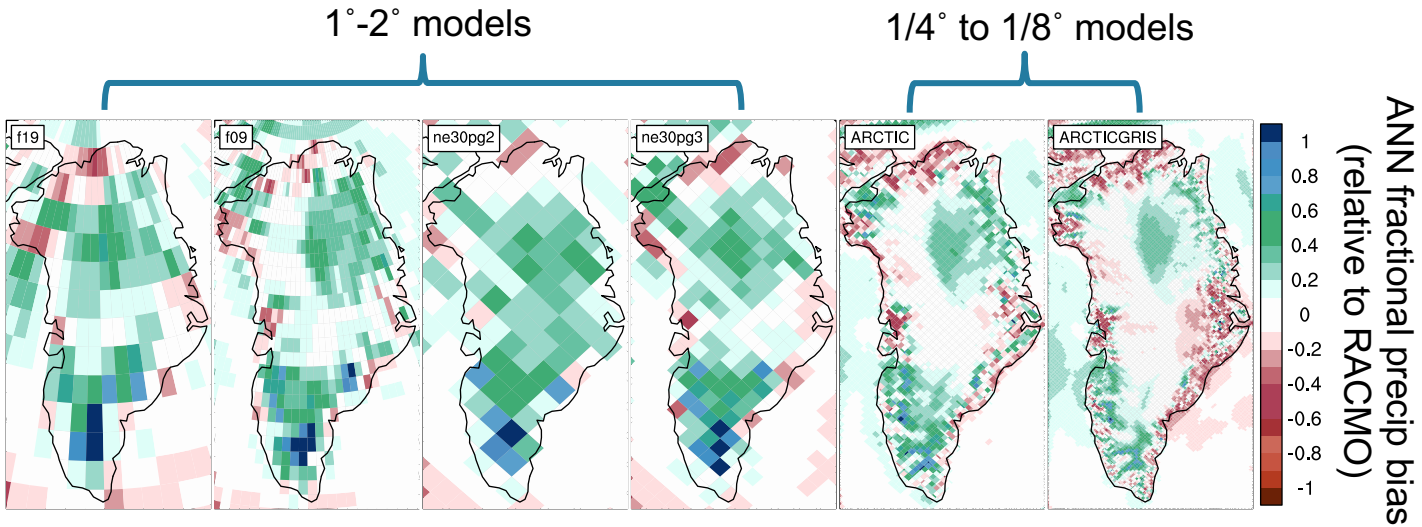




Greenland clouds / precipitation sensitive to resolution

1-2˚ models are missing clouds around the coastlines, and the interior is too cloudy





Herrington et al. 2022, JAMES

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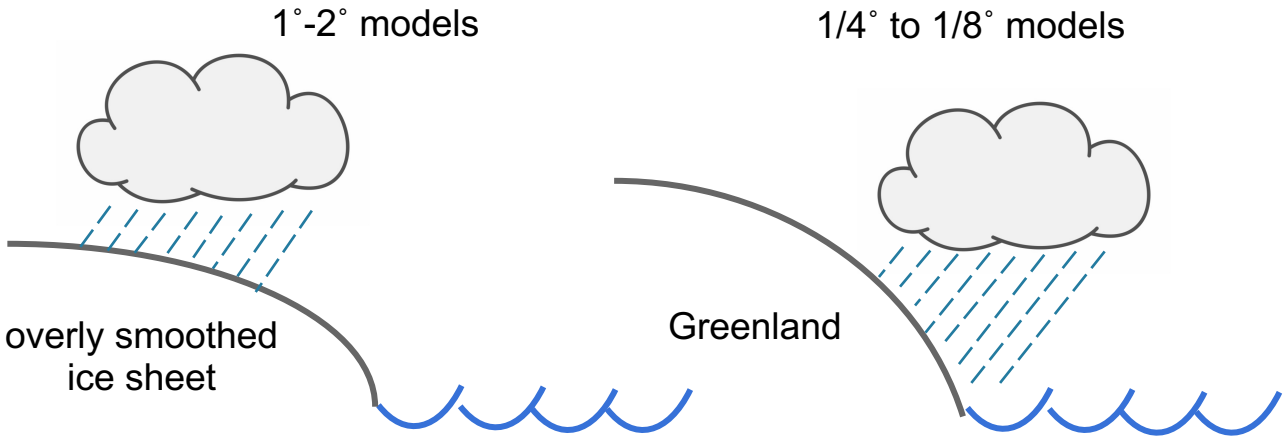
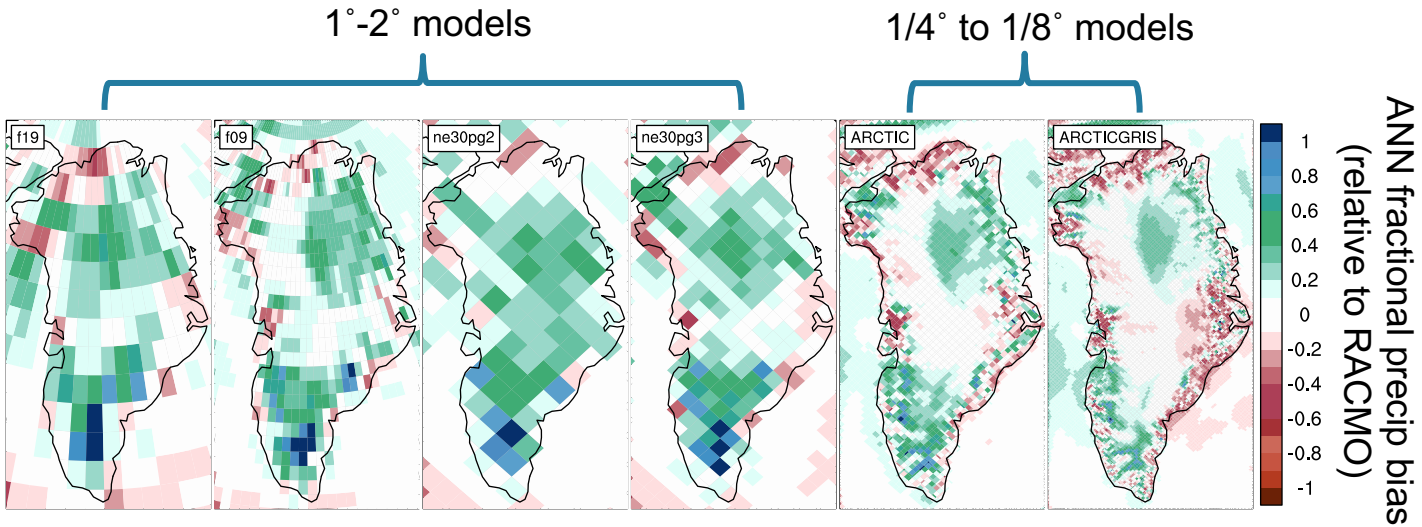
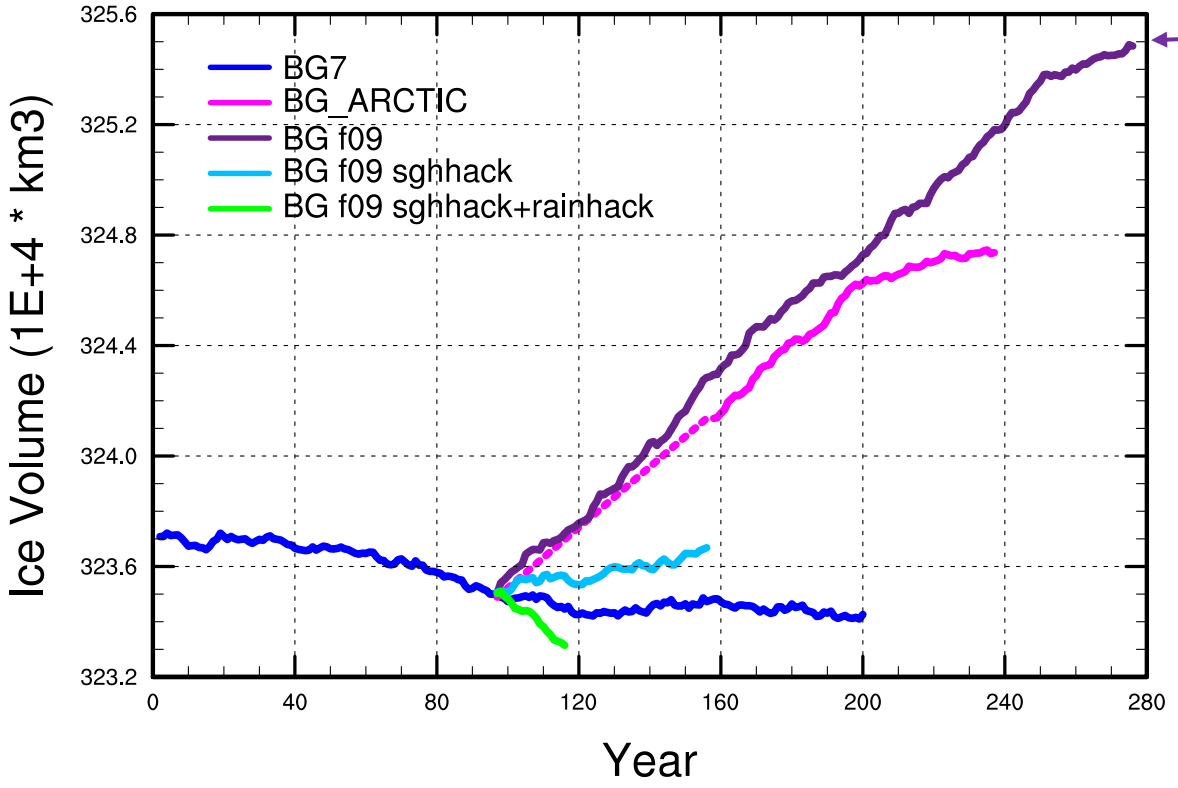




BG7 uses 1˚ FV dycore; employs creative methods for reducing GrIS precip. bias

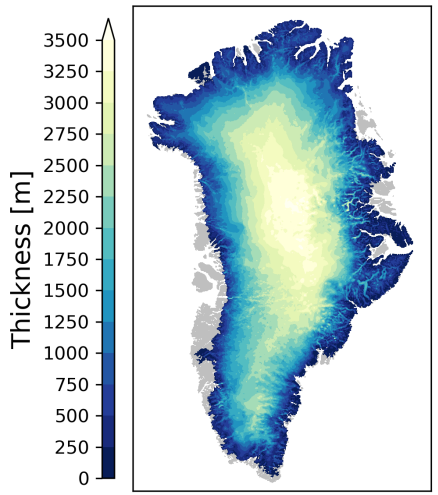
REDACTED

Preindustrial Control – Greenland Ice Sheet

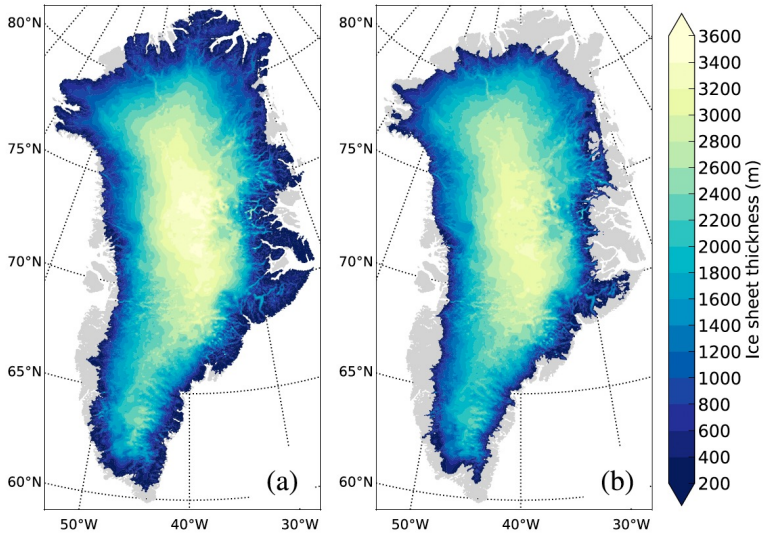


Still spinning up
re-do 1pctco2 exp of Muntjewerf et al

BG ARCTIC



BG7 Observations

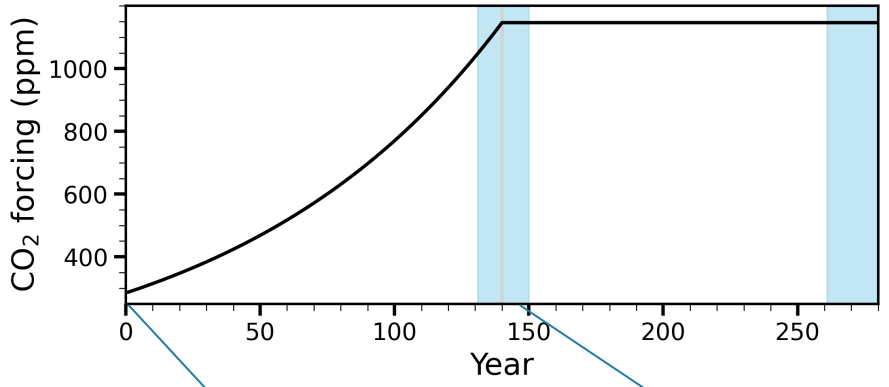


Morlighem et al. 2014

Thanks also to Miren Vizcaino and Kate Thayer-Calder for help with reproducing these results

Idealized Warming Experiment

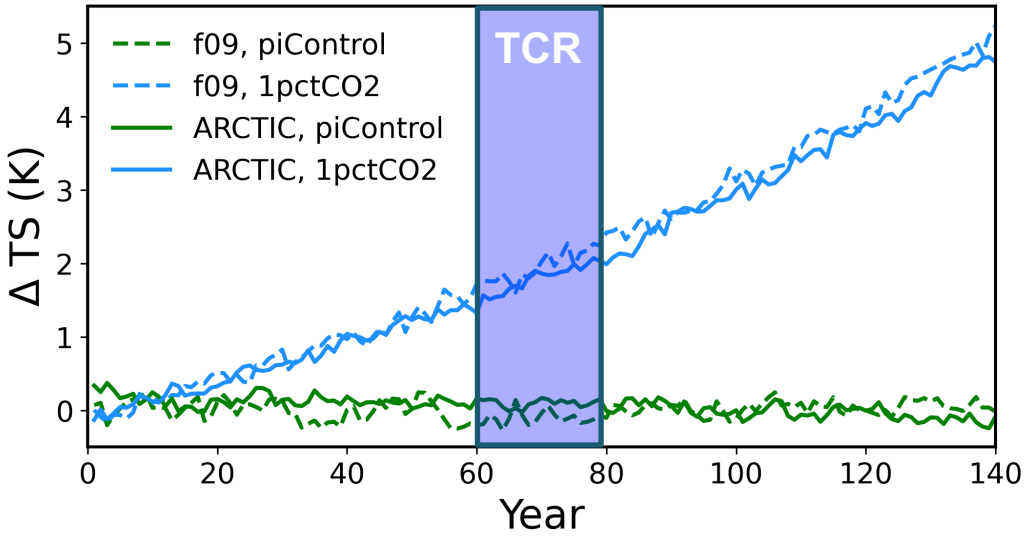
1%CO2/yr; hold fixed at 4XCO2



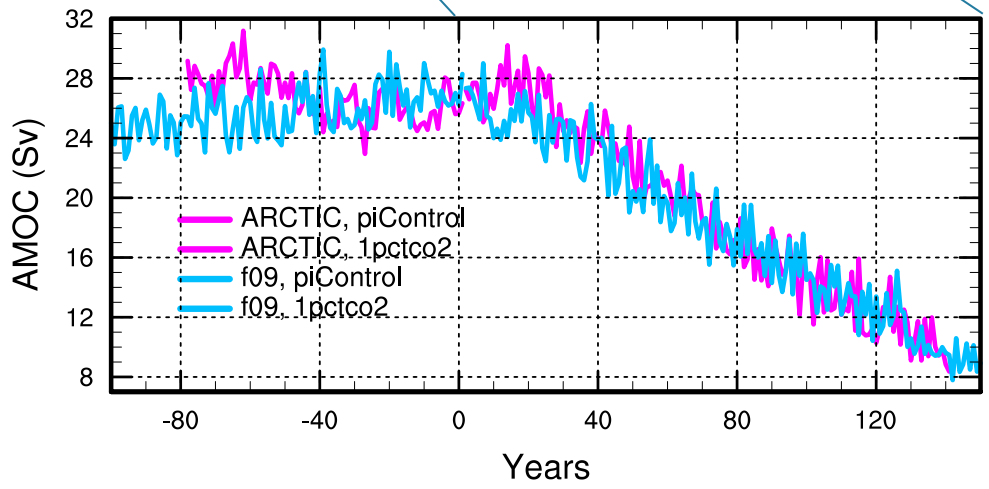
Compare to **f09** in Muntjewerf et al. (2020)

First results: lower TCR*

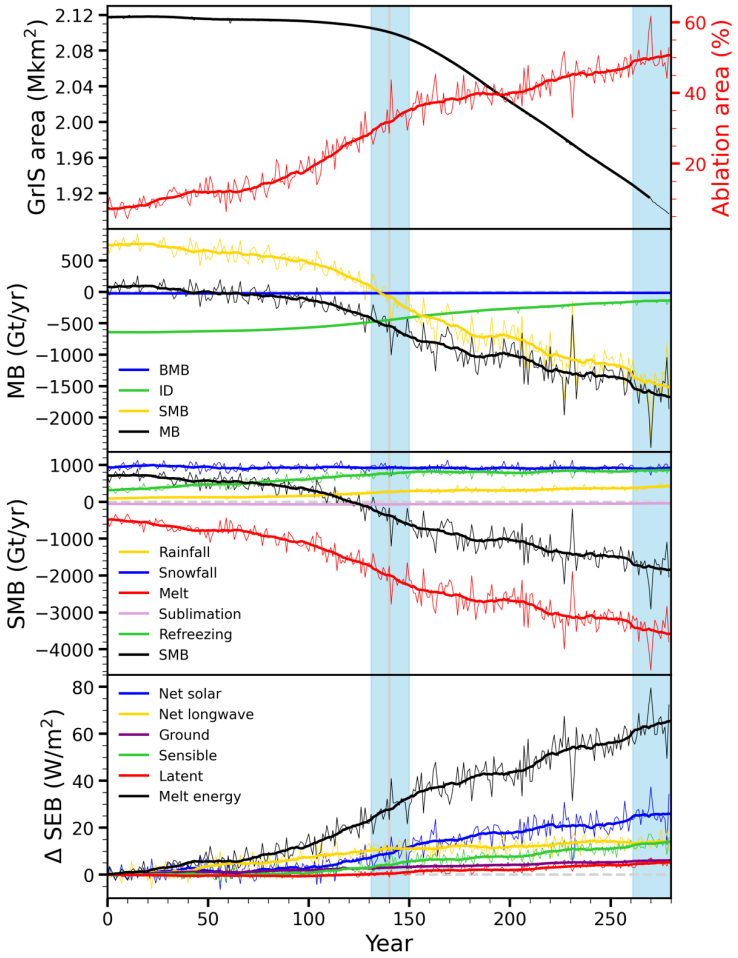
- **f09**: 1.95 K
- **ARCTIC**: 1.65 K – 1.78 K

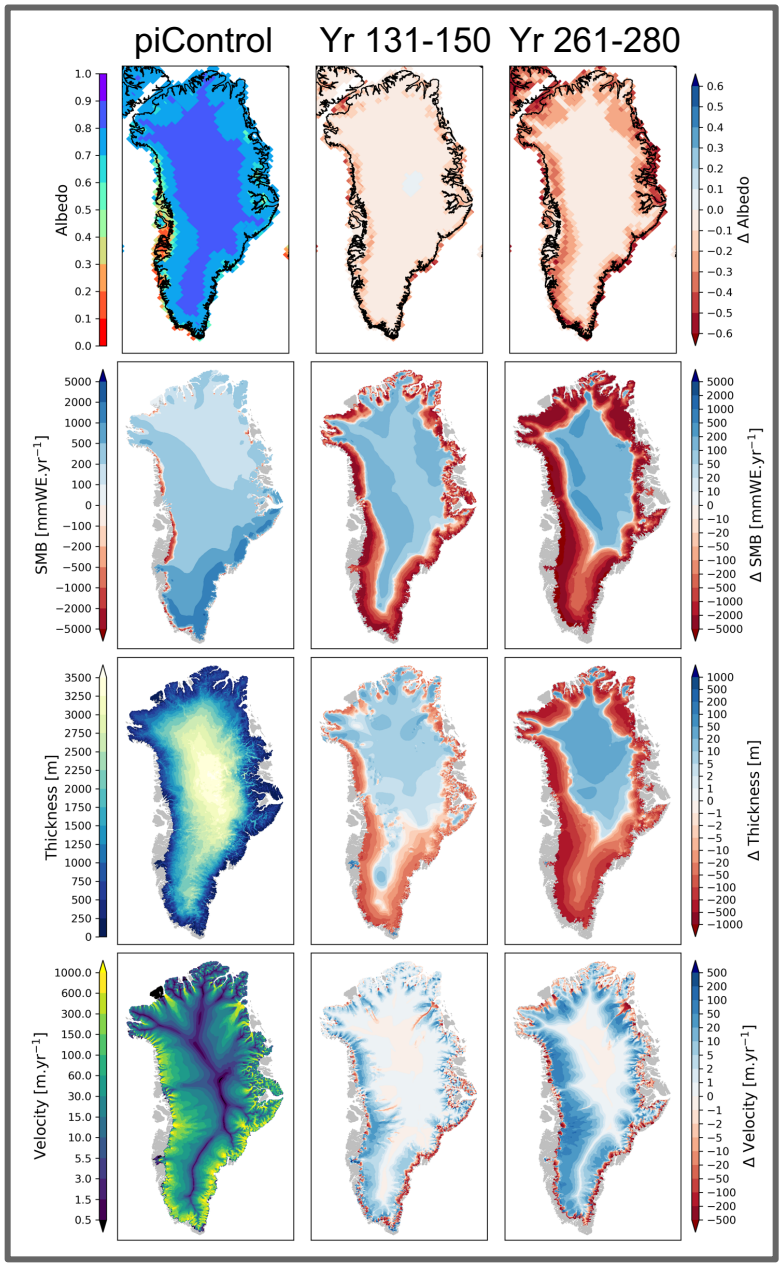


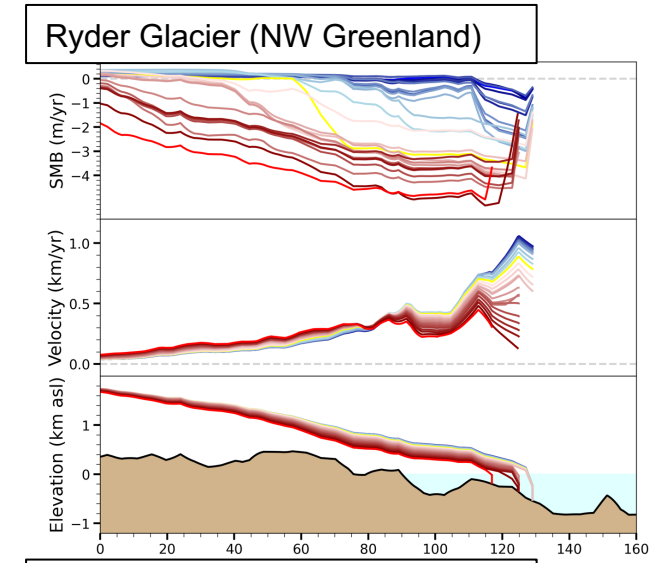
*Transient Climate Response (TCR) is the avg sfc temperature change in the 20-year period when the CO2 concentration doubles in a 1%CO2 experiment

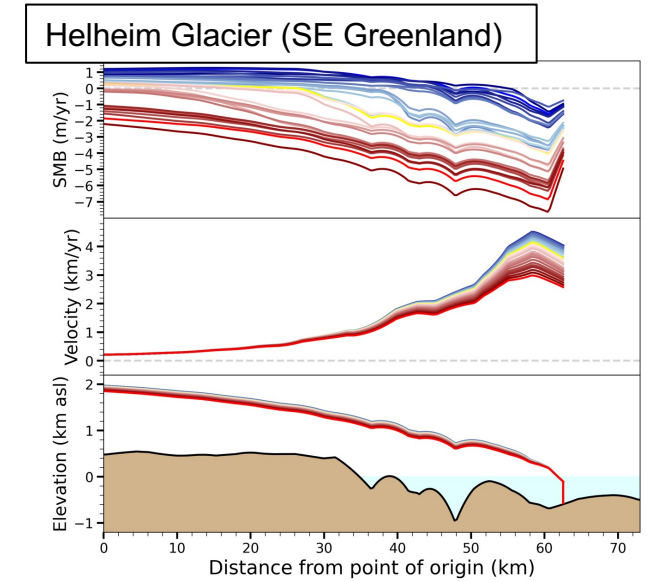


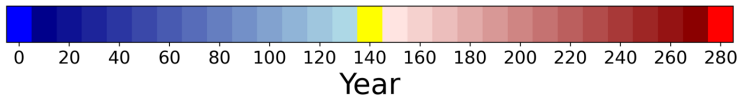
GrIS response in BG ARCTIC 1pctco2









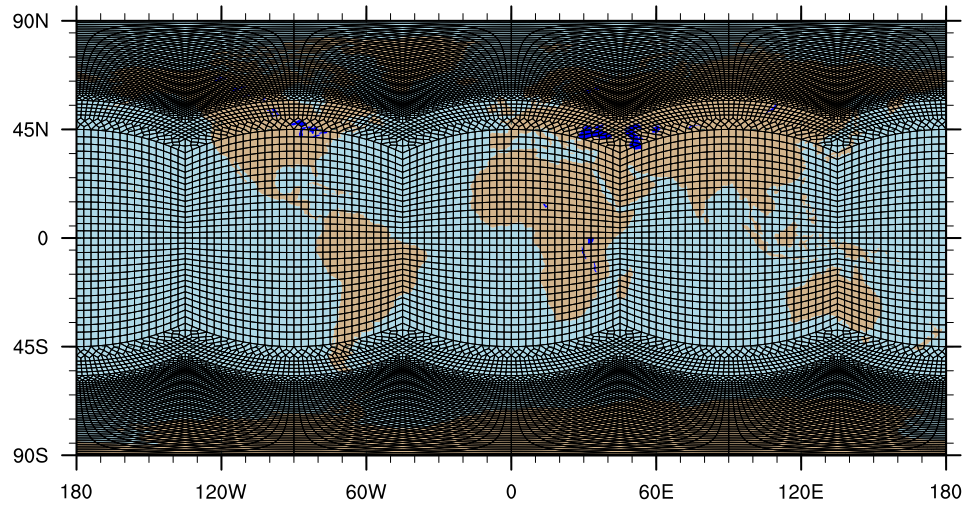


Flowline coordinates courtesy of Michele Petrini

A question to think about

- Is there community interest in “this” being “supported”
  - anyone can check out https://github.com/ESCOMP/CESM and reproduce my results
  - anyone can check out https://github.com/ESCOMP/CESM and run this configuration (outdated tunings as the code base is well into transition to CAM7/CESM3)

- Supporting a POP2 configuration is not very forward looking
  - We will begin coupling the DUAL POLAR grid to MOM6 later this year

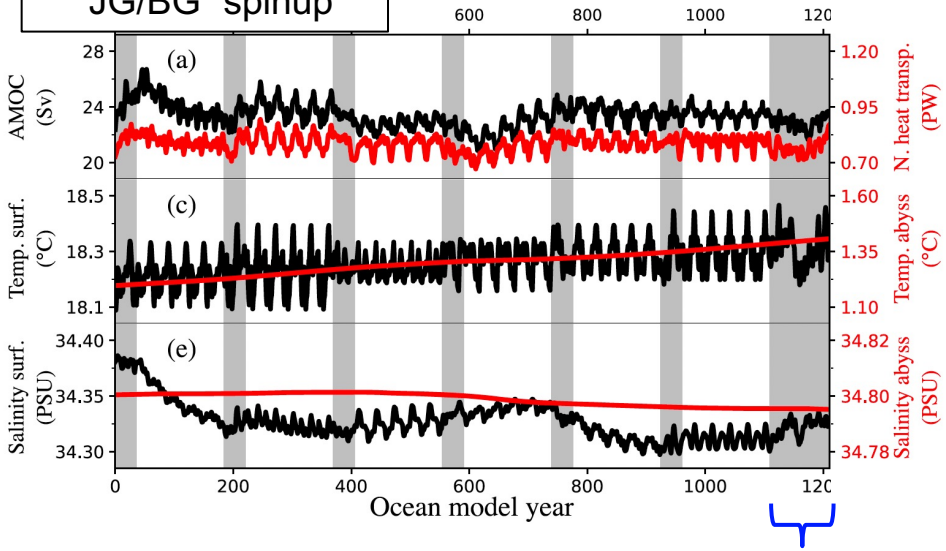


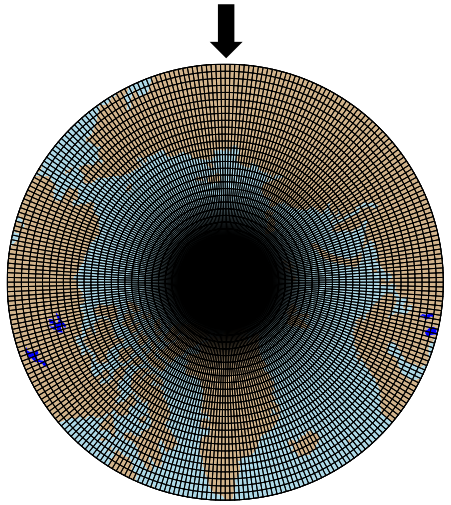
Extra Slides

Preindustrial Control

CISM is on; branch from **BG7 control** (Lofverstrom et al. 2020)

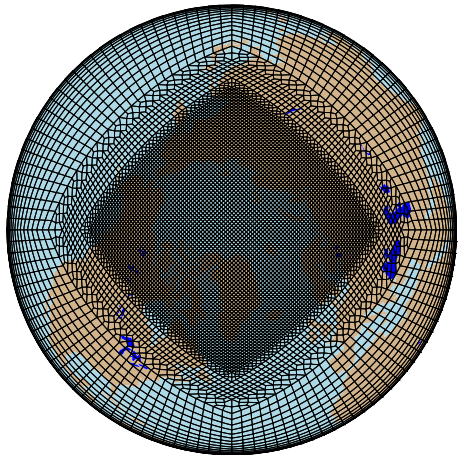
"JG/BG" spinup





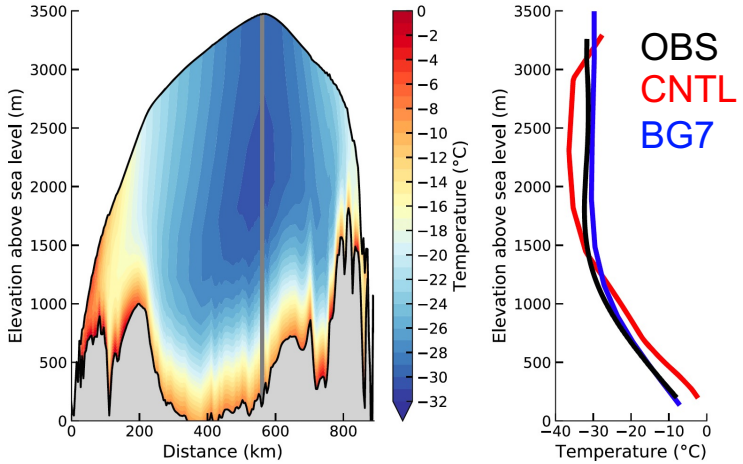
1° FV dycore

BG ARCTIC (this study)



10X more expensive
(30k core hrs / sim. yr.)

BG7 = BG iteration 7



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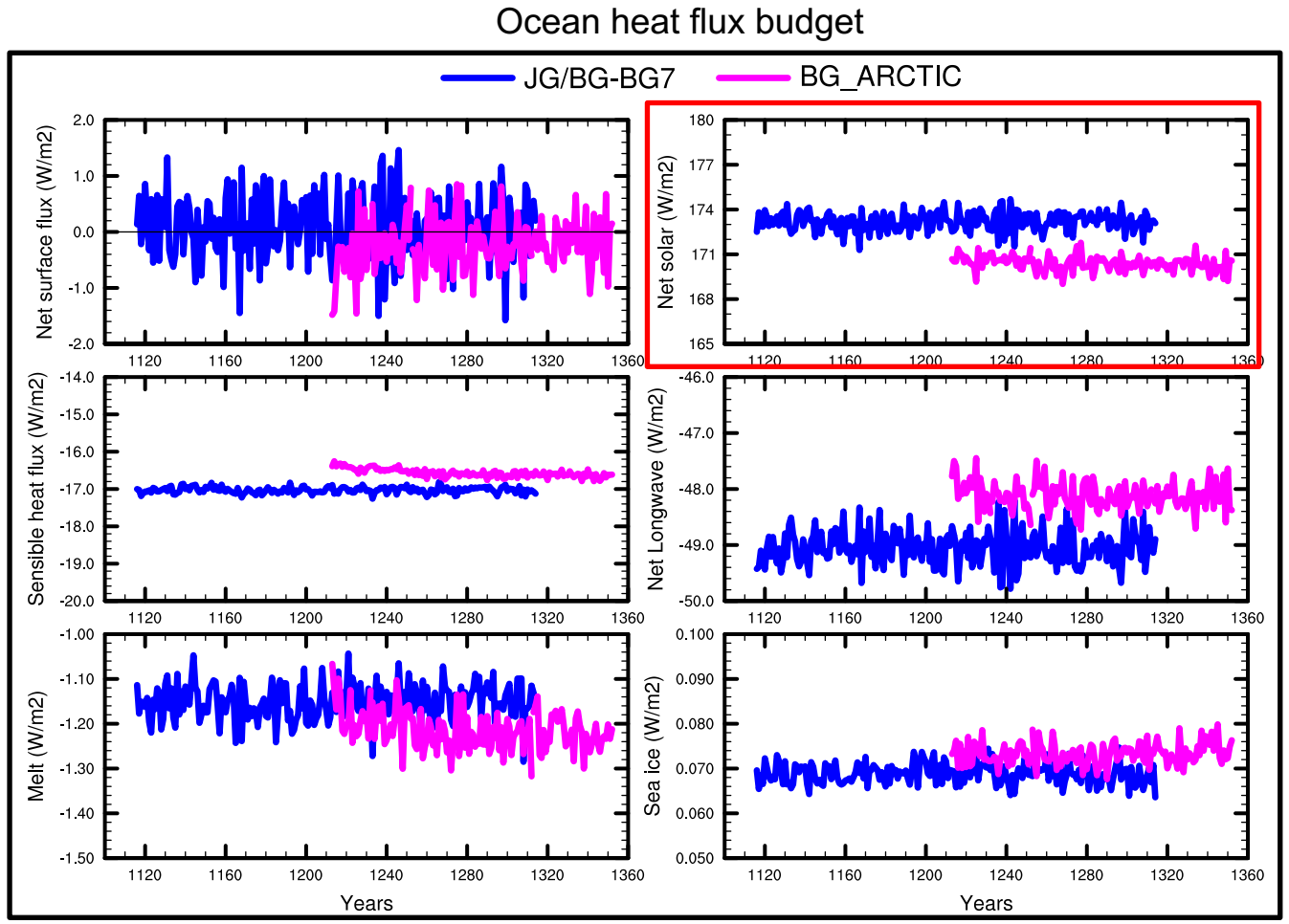
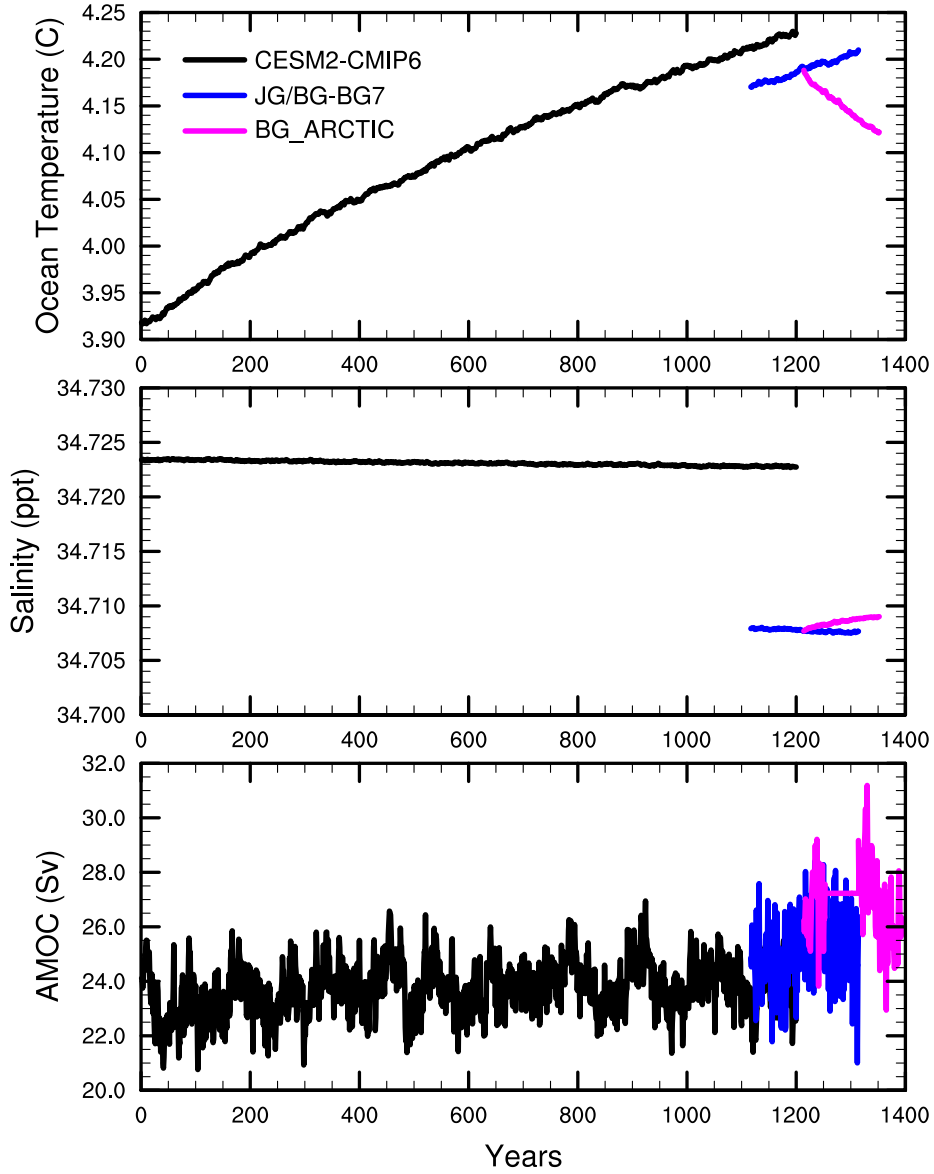
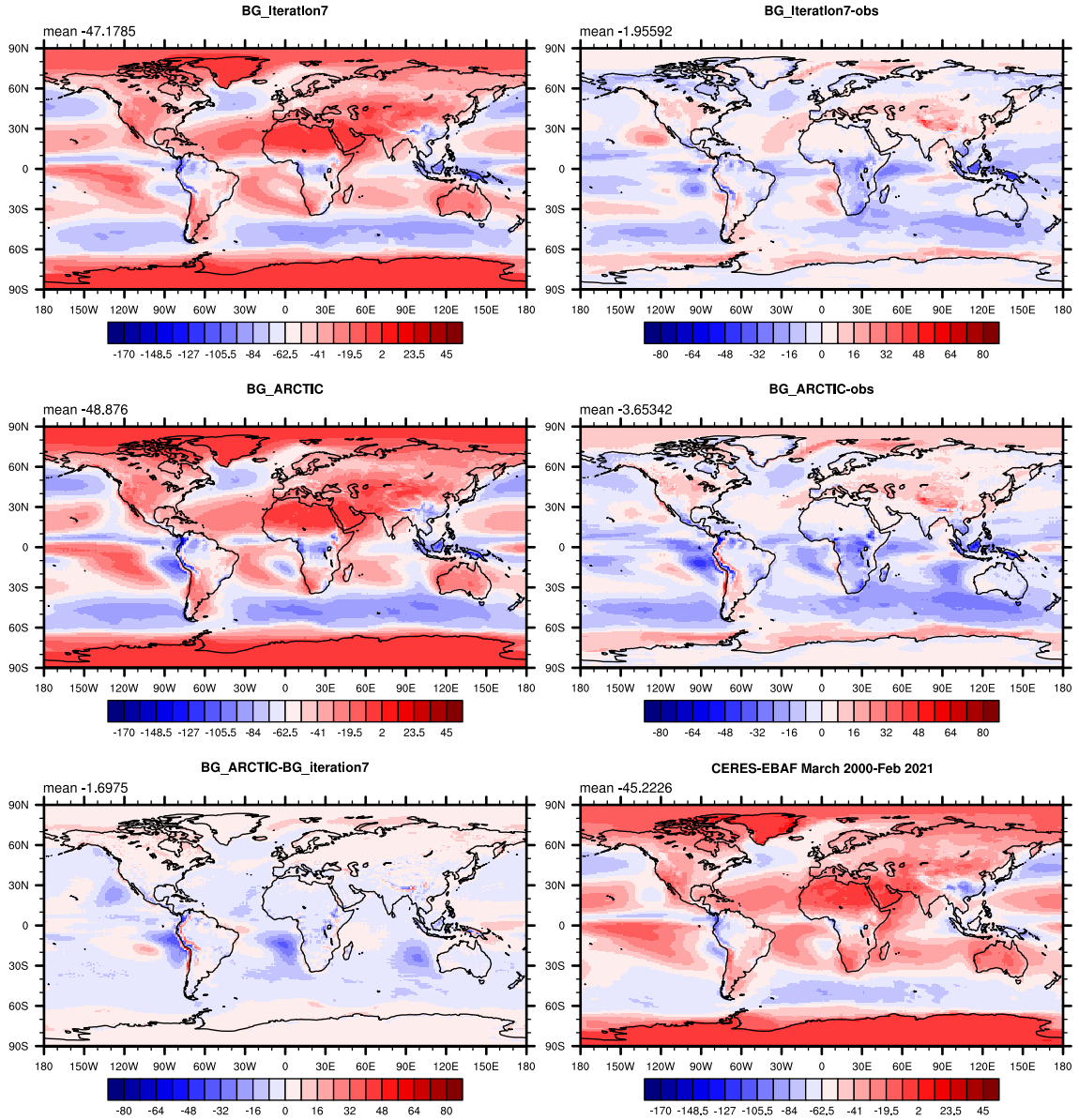


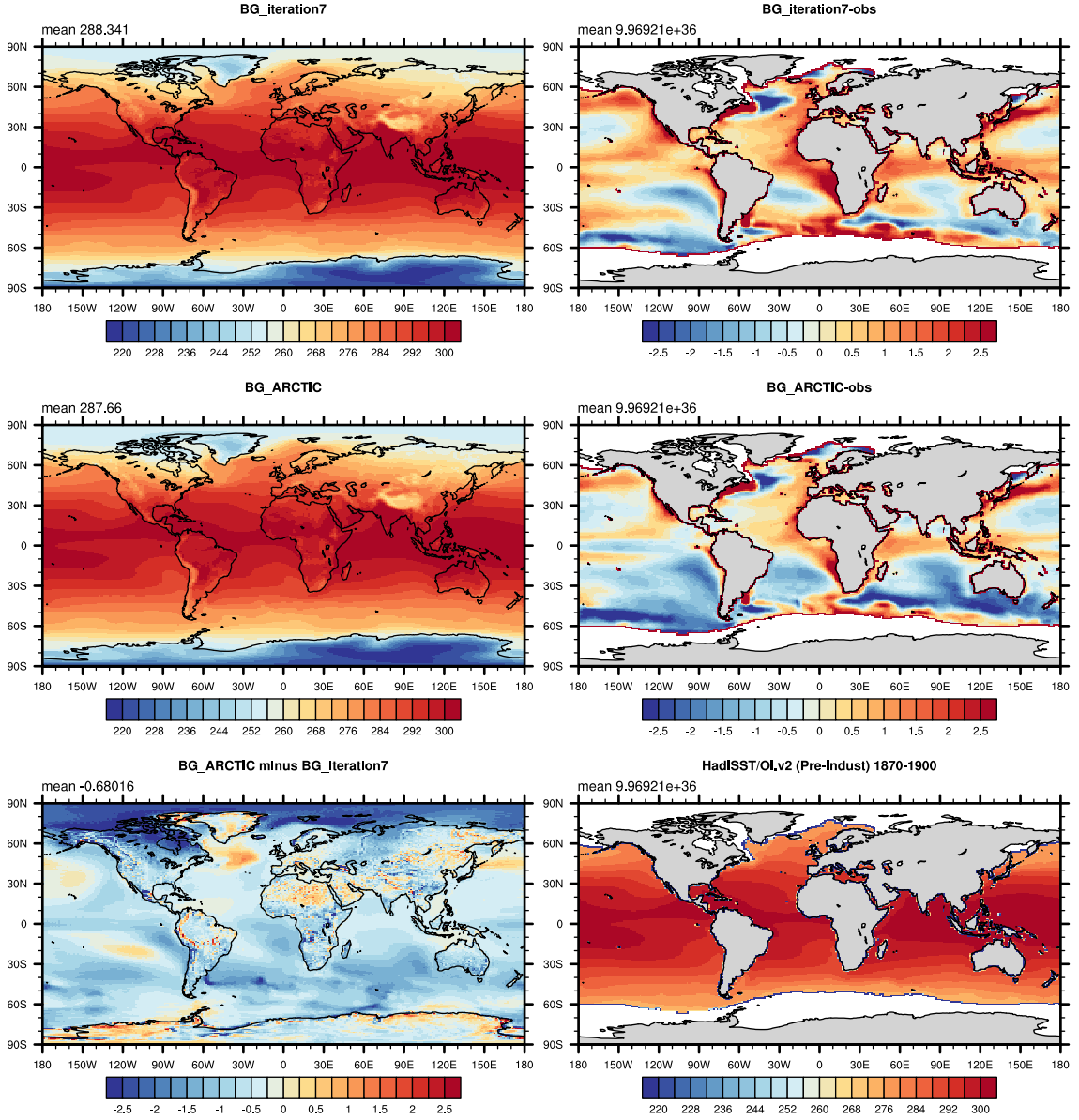


Overshot the cloud forcing; ~3 W/m2 reduction in absorbed solar

SWCF (W/m2)



SST (K)



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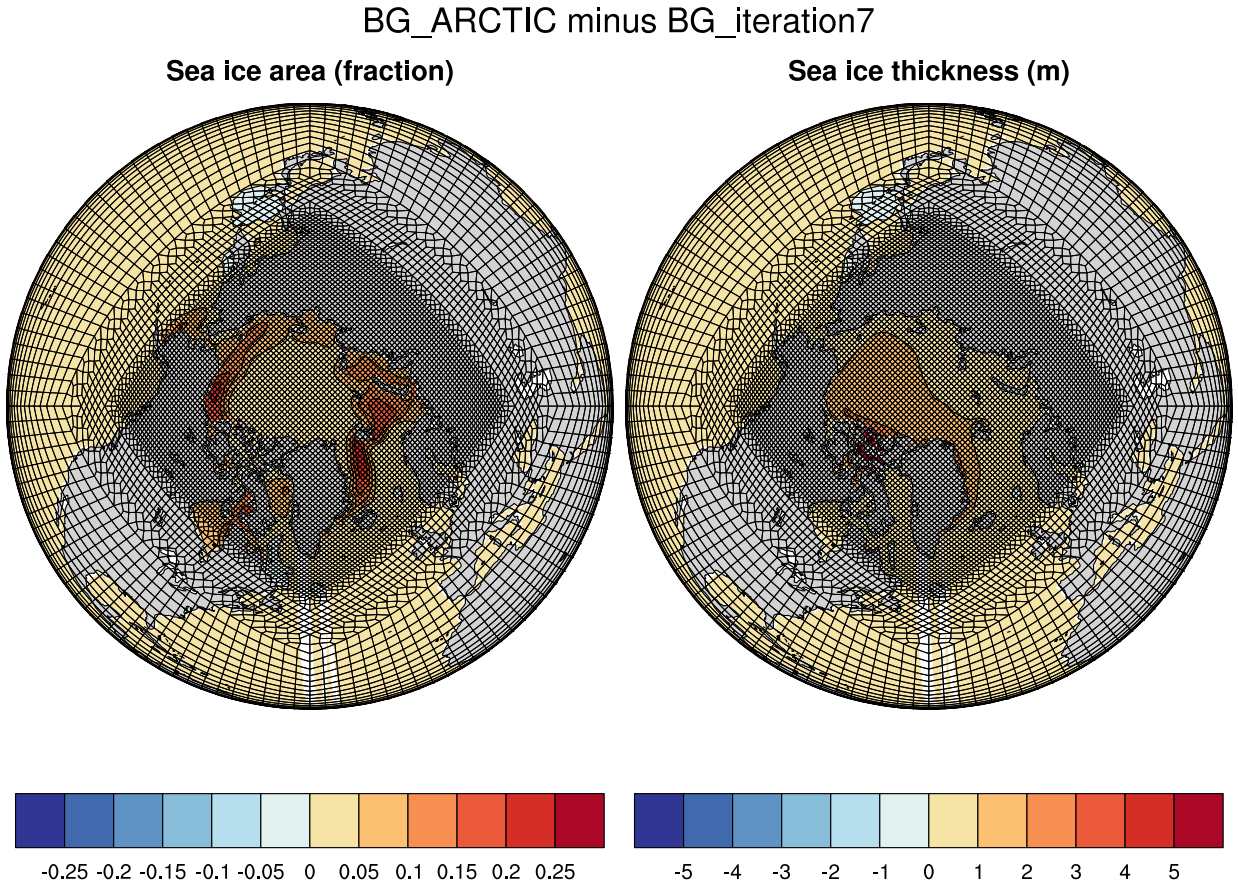
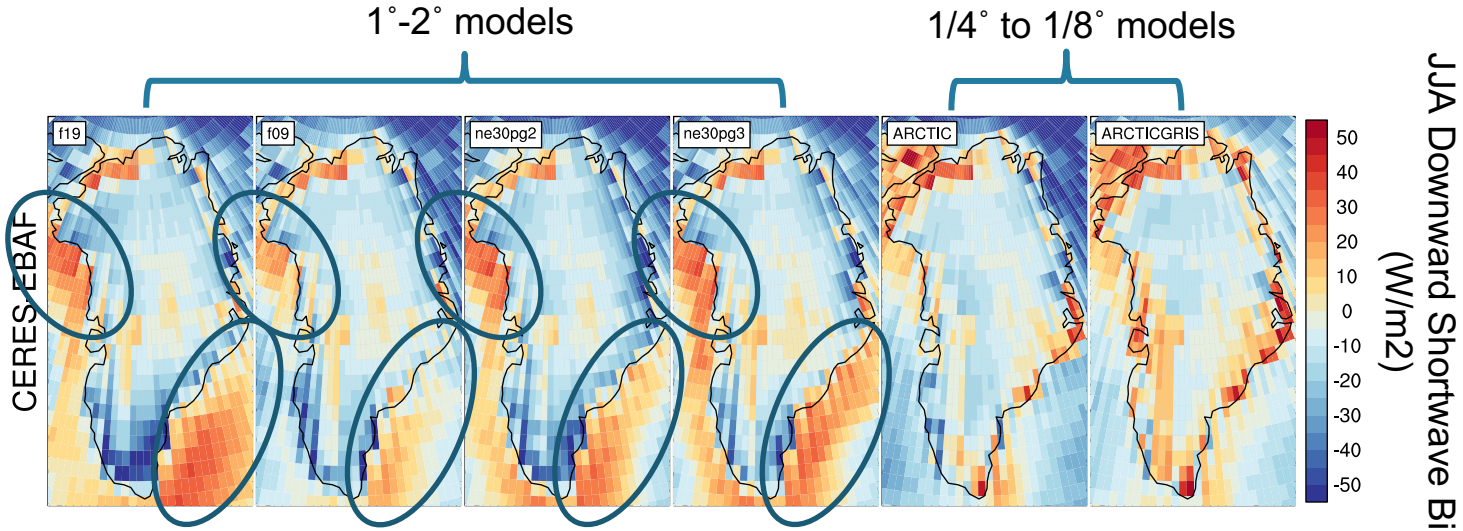
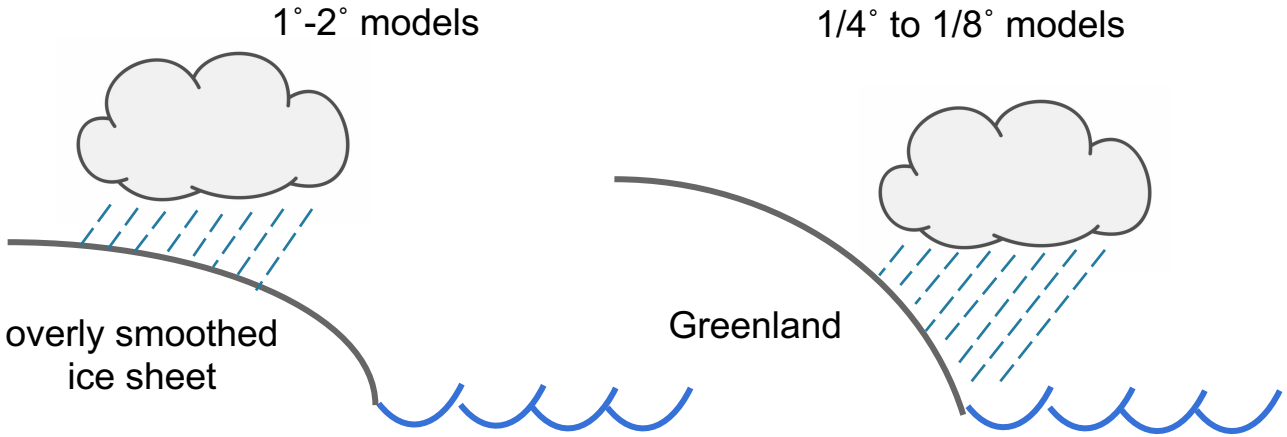
*80 year means



Greenland clouds / precipitation sensitive to resolution



1-2˚ models are missing clouds around the coastlines, and the interior is too cloudy



Herrington et al. 2022

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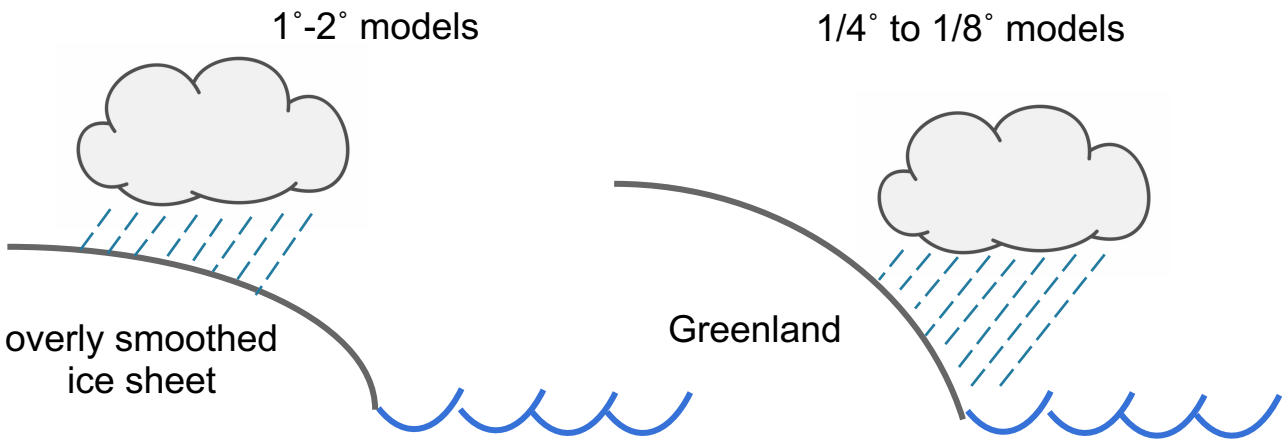

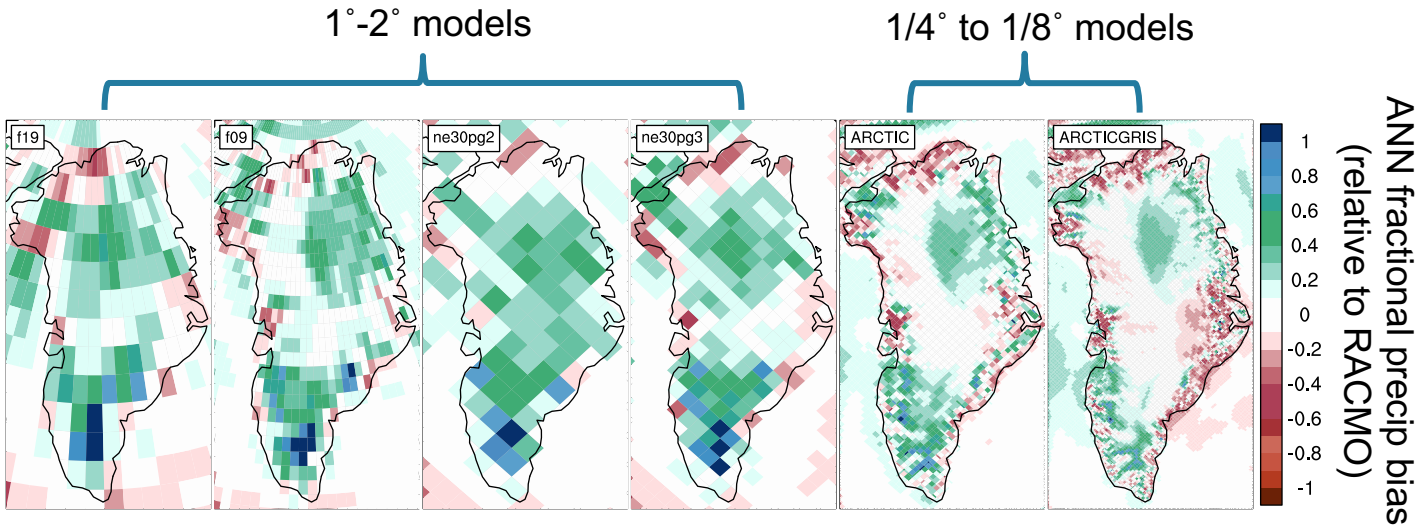
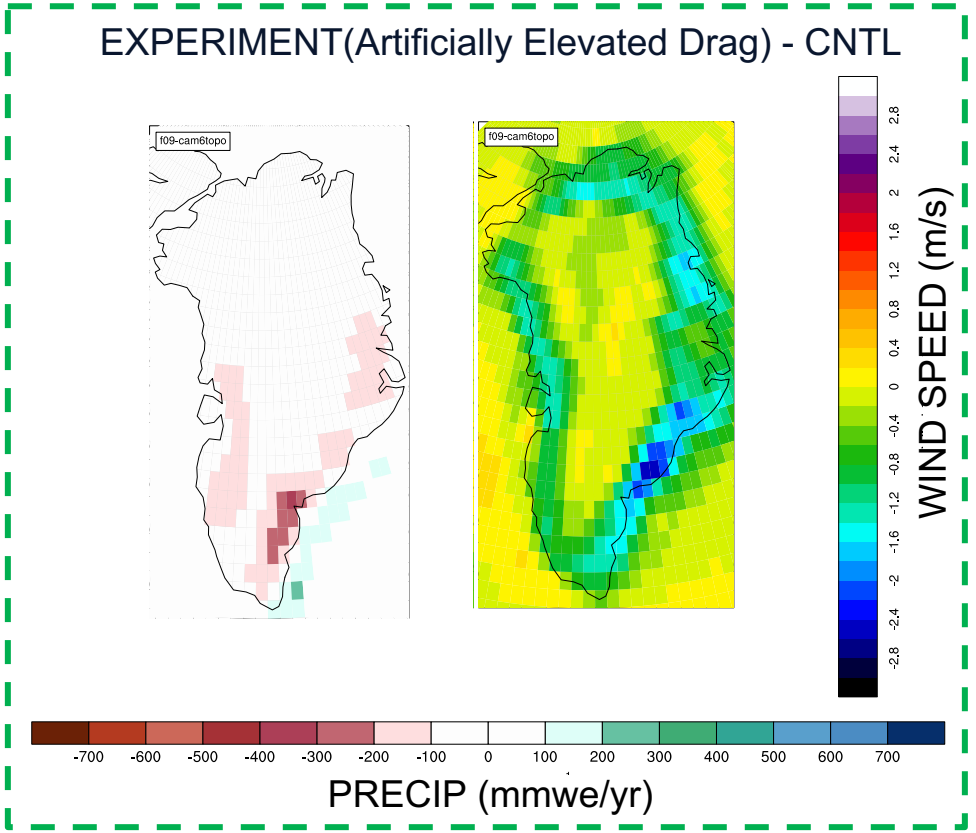
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