Simulations of the last deglaciation using the Glimmer ice-sheet model and a fully coupled GCM (GENMOM)

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Outline

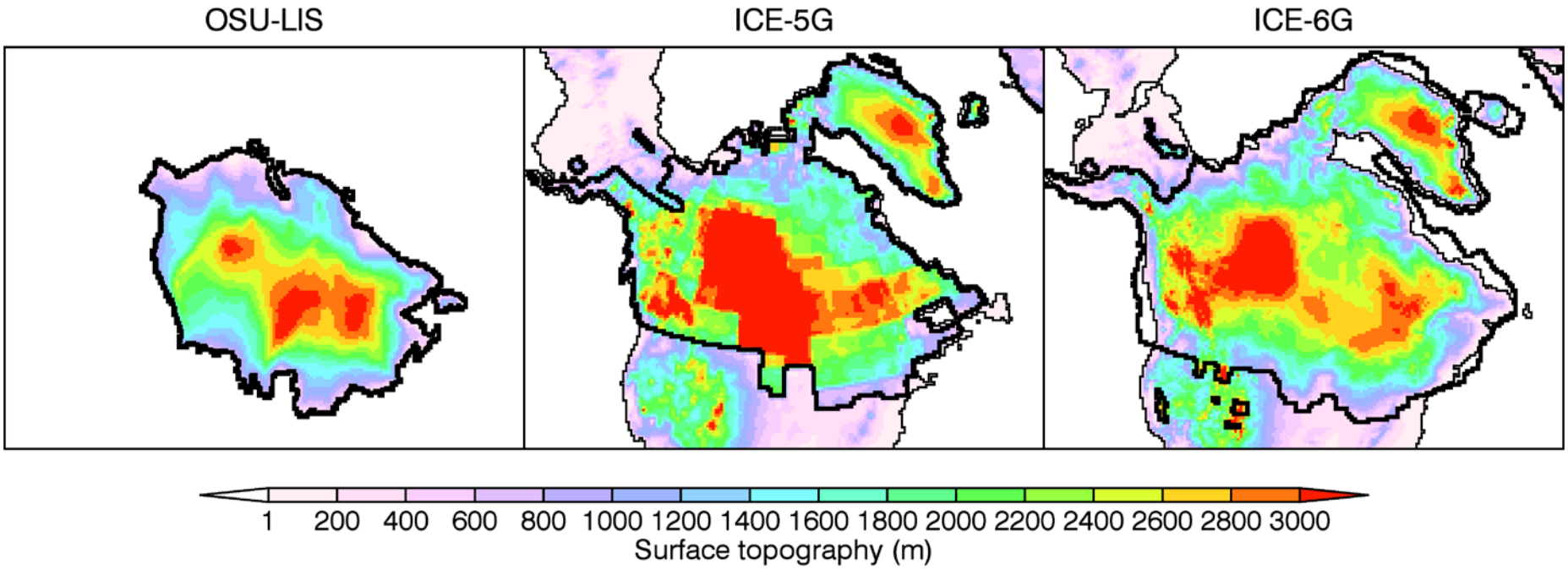
1. Experimental setup
2. Build-up of Laurentide Ice Sheet
3. Deglaciation of Laurentide Ice Sheet
4. Sensitivity experiments
   - Fixed CO_2
   - Fixed insolation
5. PMIP3 model evaluation

(1) Experimental setup

- AOGCM GENMOM (v. 3 Genesis ATM model & v. 2 MOM OCN model : 3.75°x 3.75° [Alder et al. (2011)]
- Simulated climate at 8 time periods:
  - 21, 18, 15, 12, 9, 6, 3 ka and Pre-industrial
- Appropriate boundary conditions
  - Insolation [Berger and Loutre, 1991]

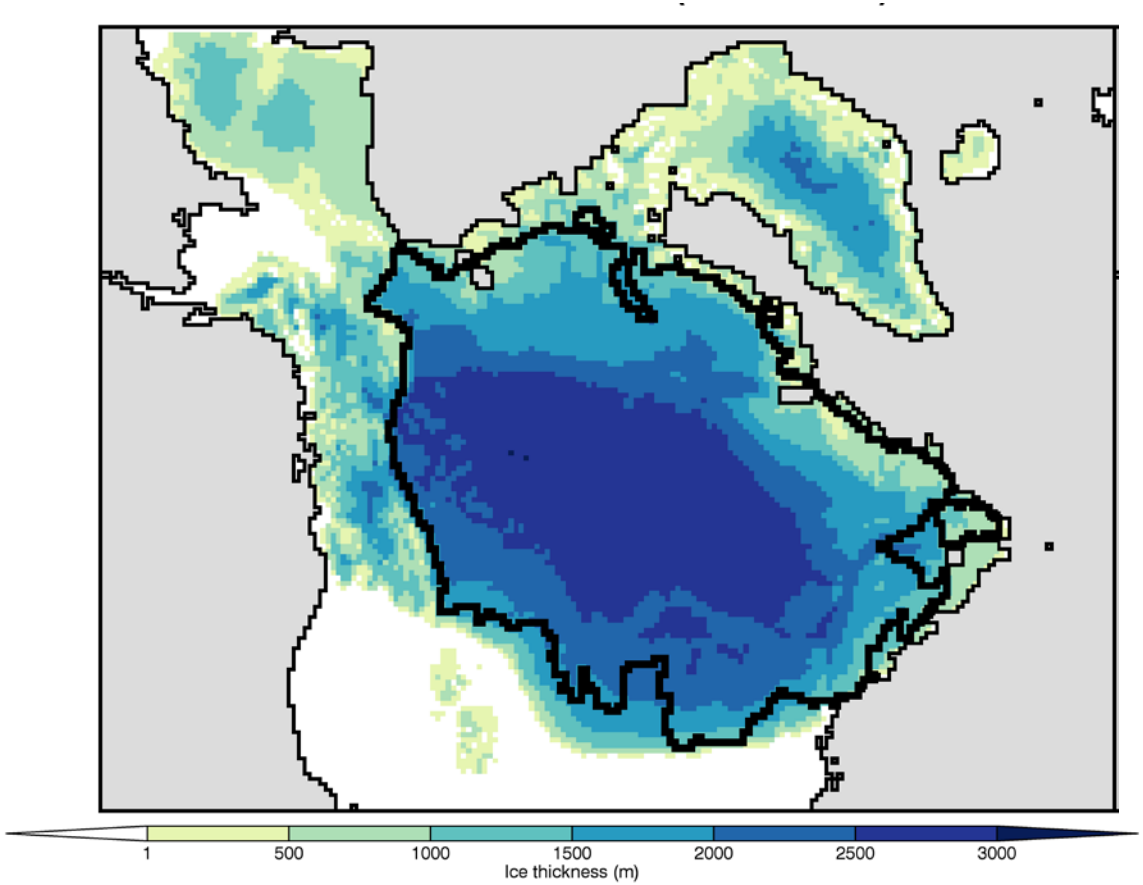
    GHG [*Monnin et al., 2001; Brook et al., 2000], *Sowers et al., 2003]*

- Orography:
  - ICE 4G for Fennoscandian and Cordilleran ice sheets[Peltier, 2002]
  - Oregon State University reconstruction of Laurentide Ice Sheet (OSU-LIS-MAX) [Licciardi et al., 1998].



(2) Build up of Laurentide Ice Sheet

- Used a constant LGM forcing of monthly means for temp./precip. (last 400 years of 21ka output).
- Default input parameters for Glimmer used (no isostasy).
- Initial run: Ice-sheet extent too large.



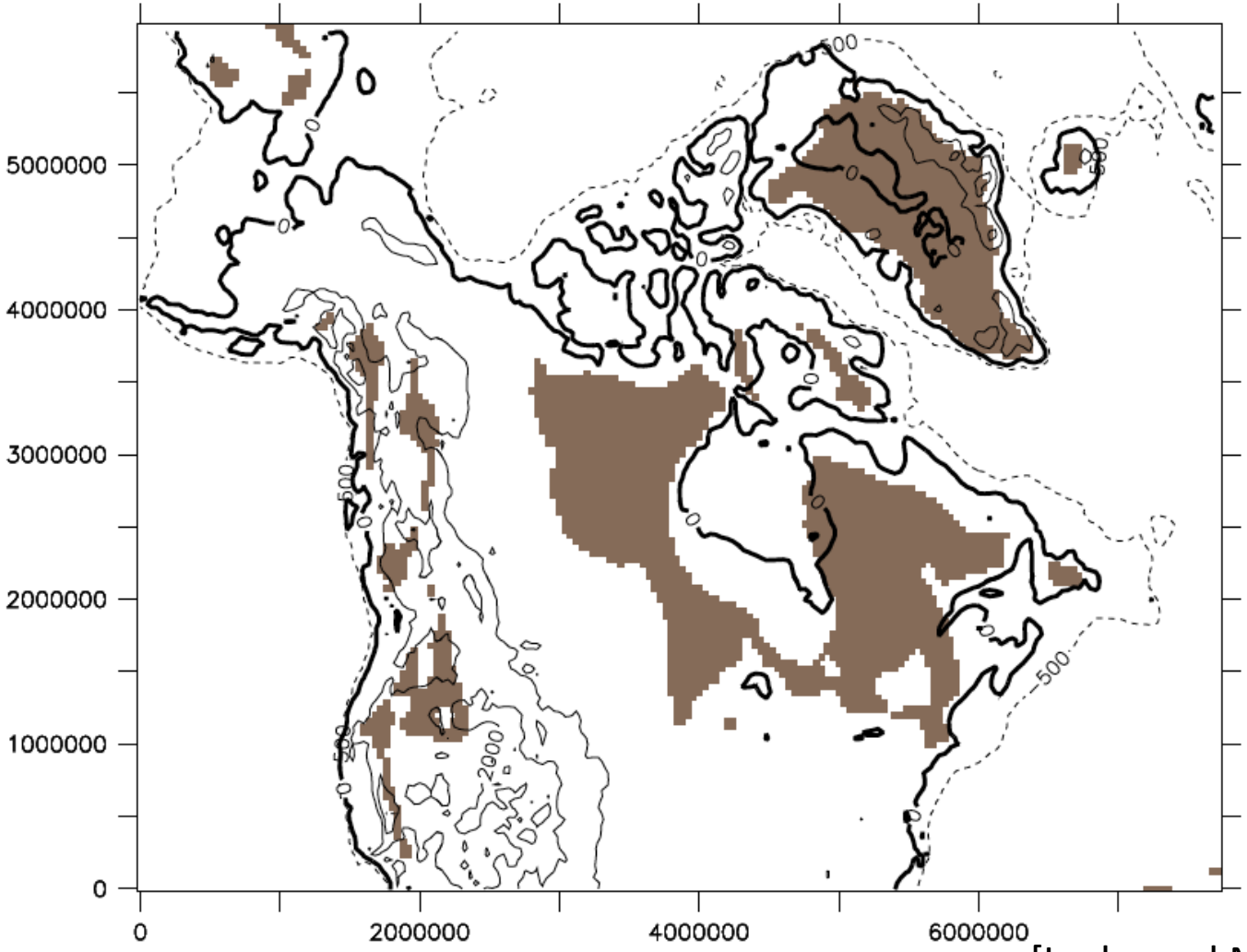
Sensitivity to parameters

Parameters	Value Used	Min	Max	Unit
$PDD_{snow}(\alpha_s)$	3	2	5	mm d^{-1} °C^{-1}
$PDD_{ice}(\alpha_{ice})$	8	7	12	mm d^{-1} °C^{-1}
Flow Factor	3	1	10	none
Mantle Relaxation time	1000	300	9000	years
Geothermal Heat Flux	50	35	65	W m^{-2}
Marine Limit	-200	-100	-500	m

Varying basal sliding

Brown: sediment thickness < 20m (i.e. Hard bed) – Basal sliding = **0.5 mm yr^{-1} Pa^{-1}**

White: Sediment thickness > 20m – Basal sliding = **5 mm yr^{-1} Pa^{-1}**

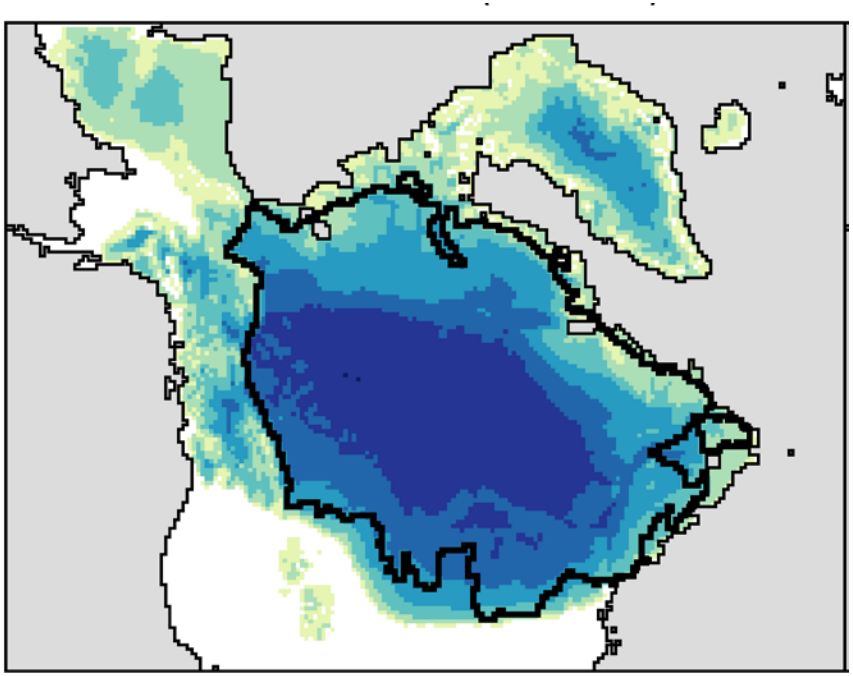


[Laske and Masters (1997)]

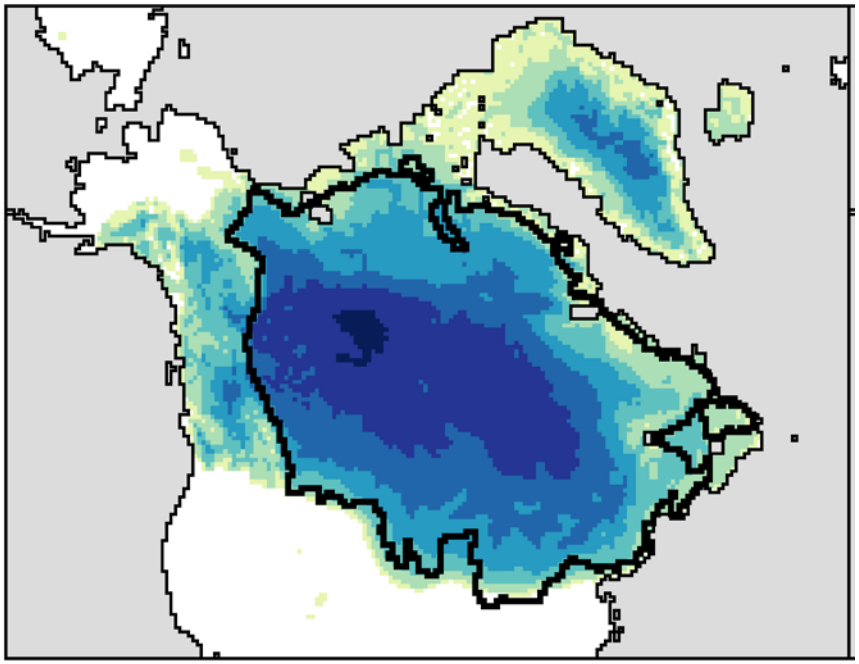
Results

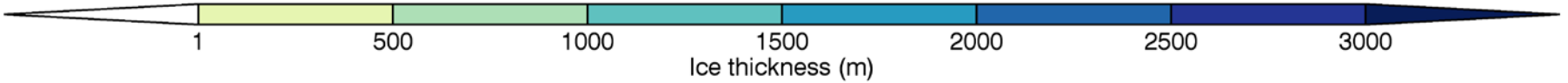
PDD and basal sliding parameters have largest effect on ice-sheet extent and volume.

21ka “Un-tuned”

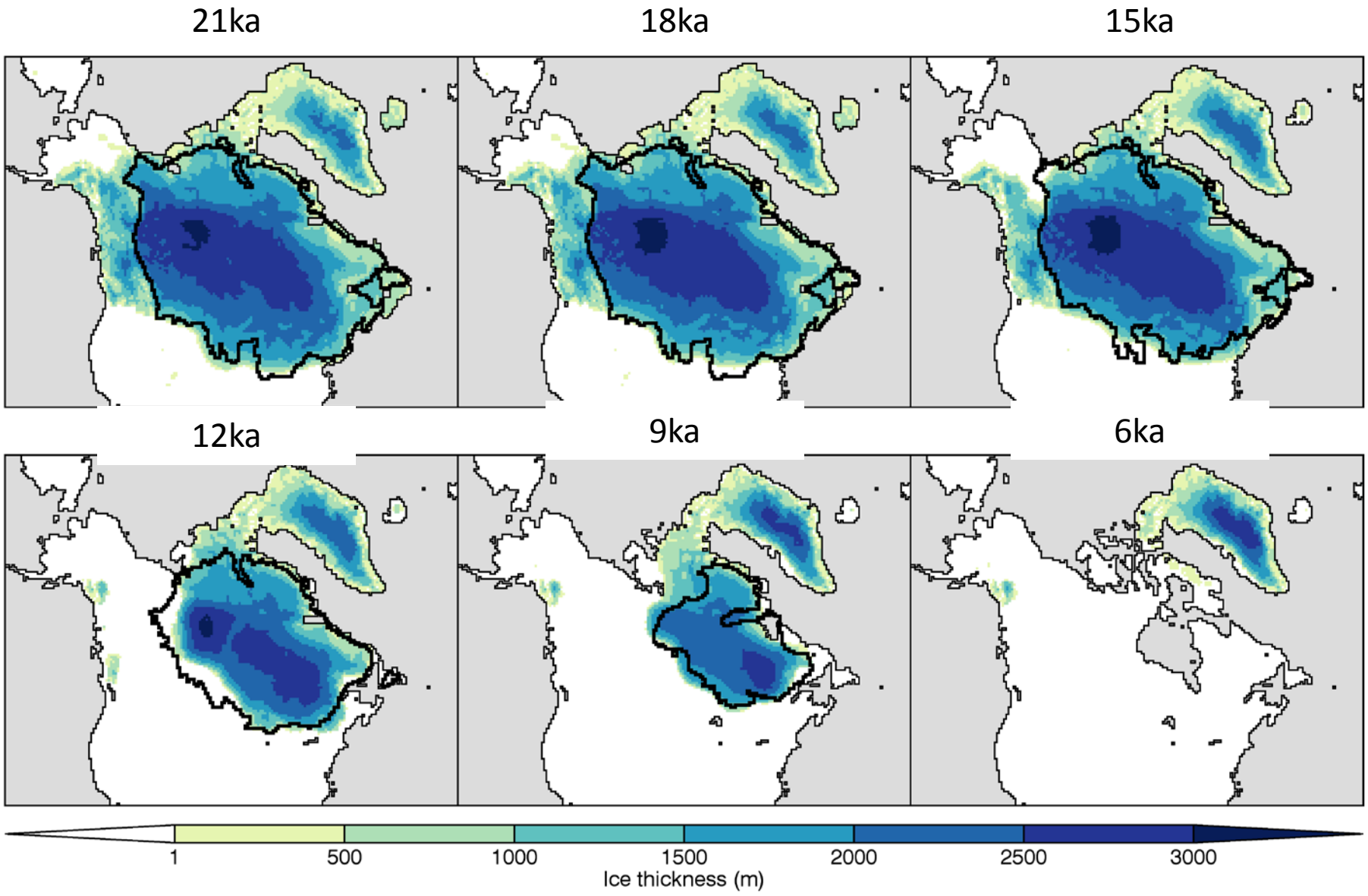


21ka “Tuned”

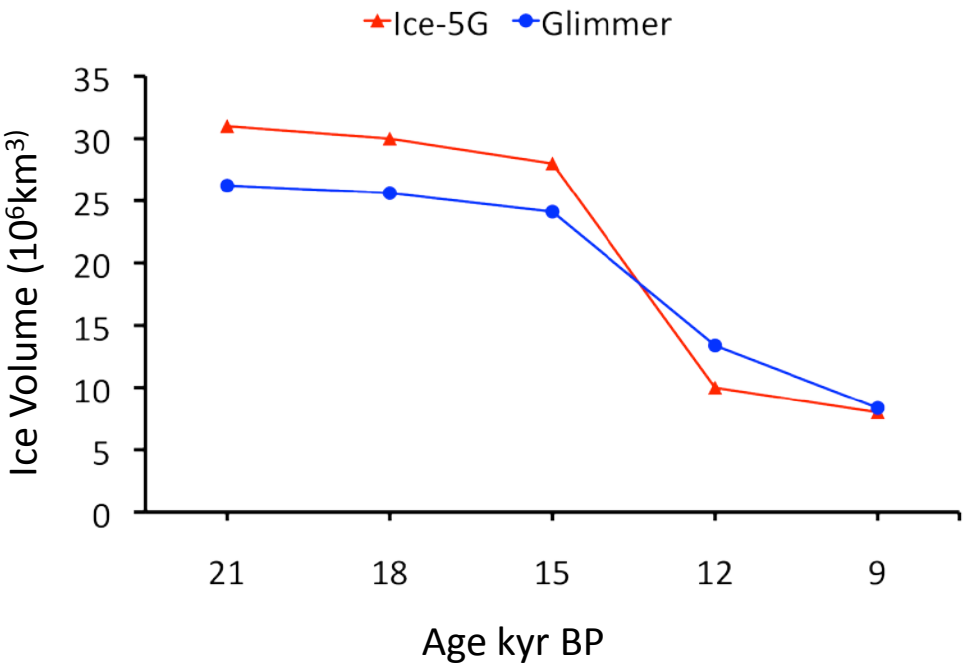


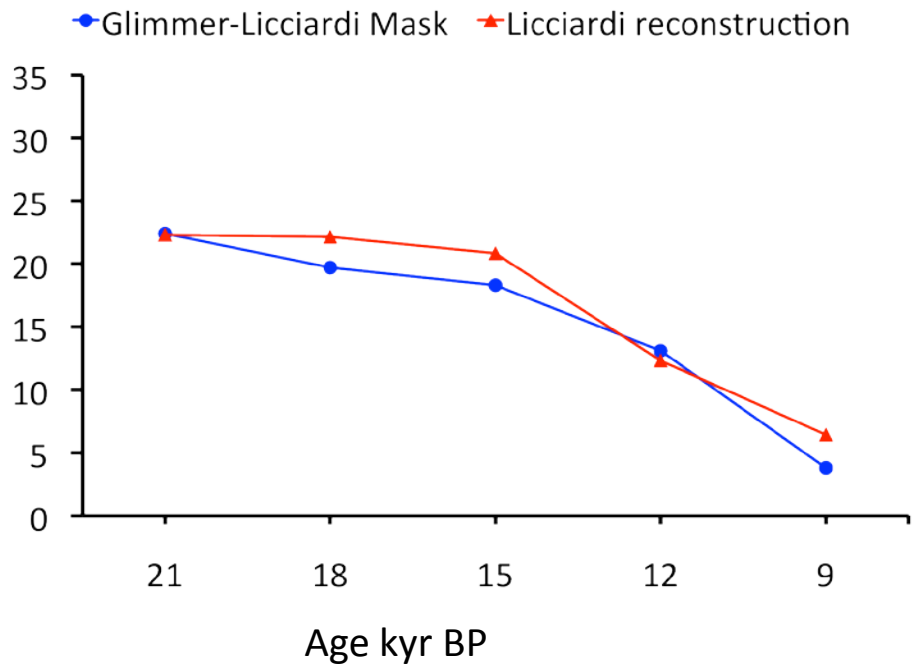


(3) Ice-sheet deglaciation



Volume Comparisons

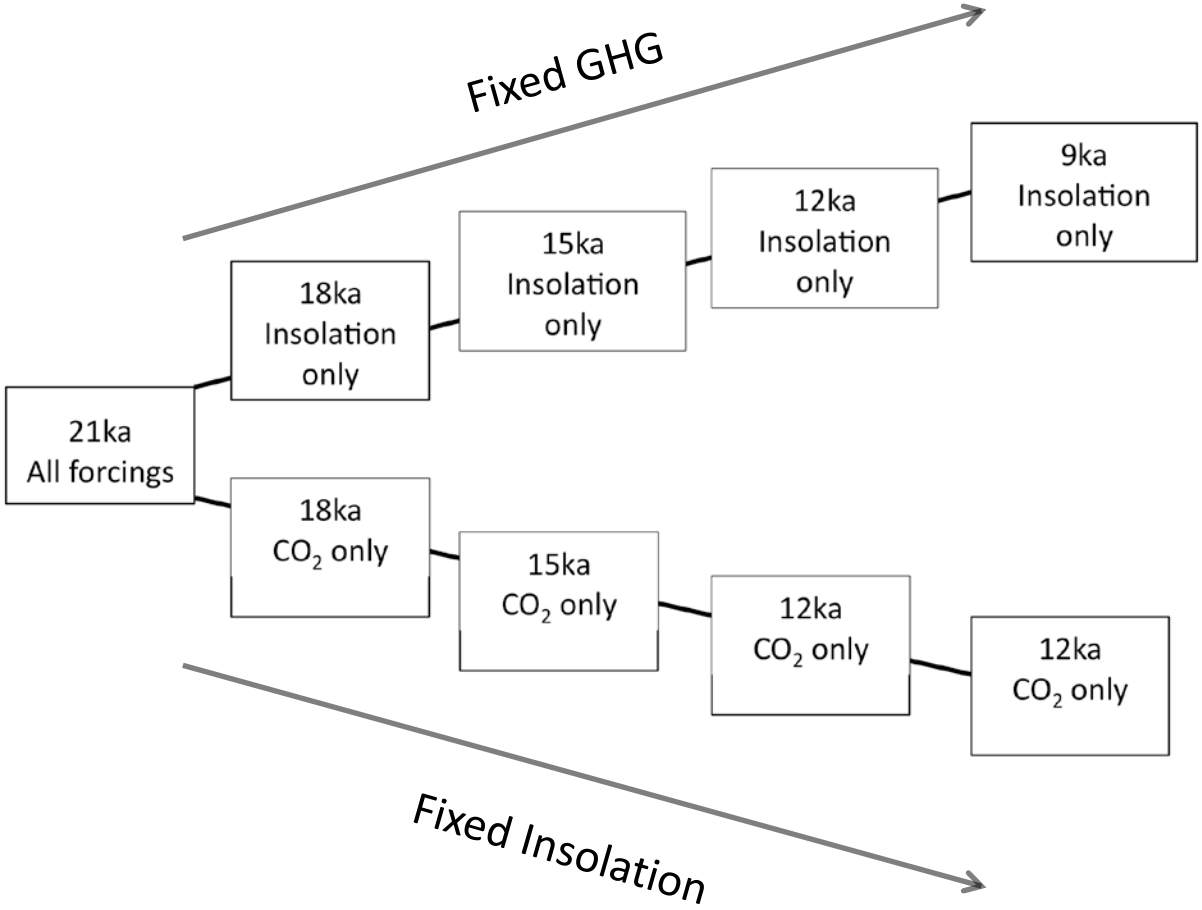




Results

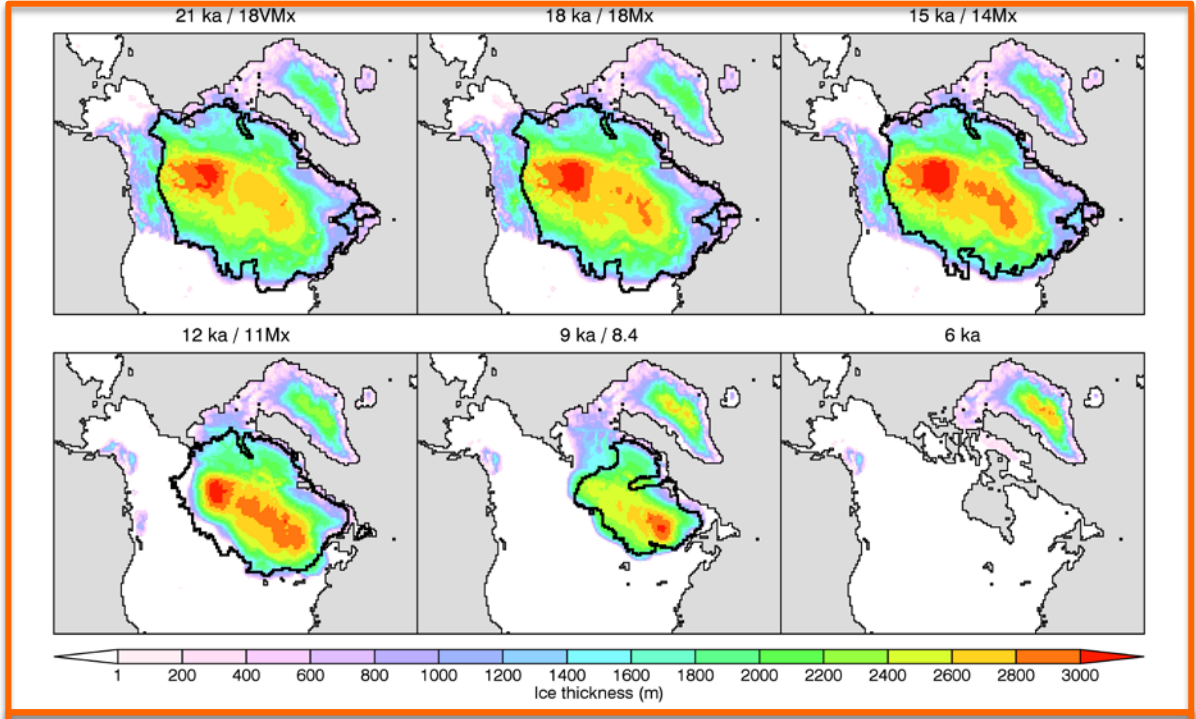
- GENMOM climatology results in an ice sheet simulated by Glimmer comparable to reconstruction. Glimmer simulation validates GENMOM climatology.

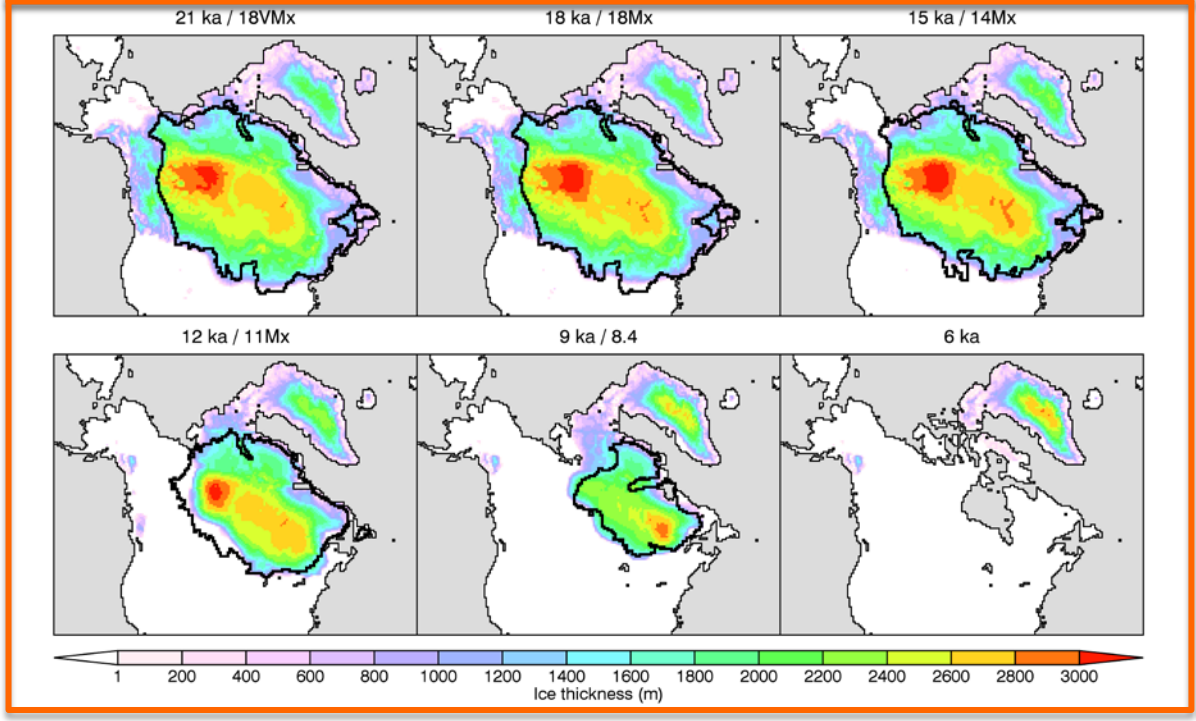
(4) Sensitivity to forcings



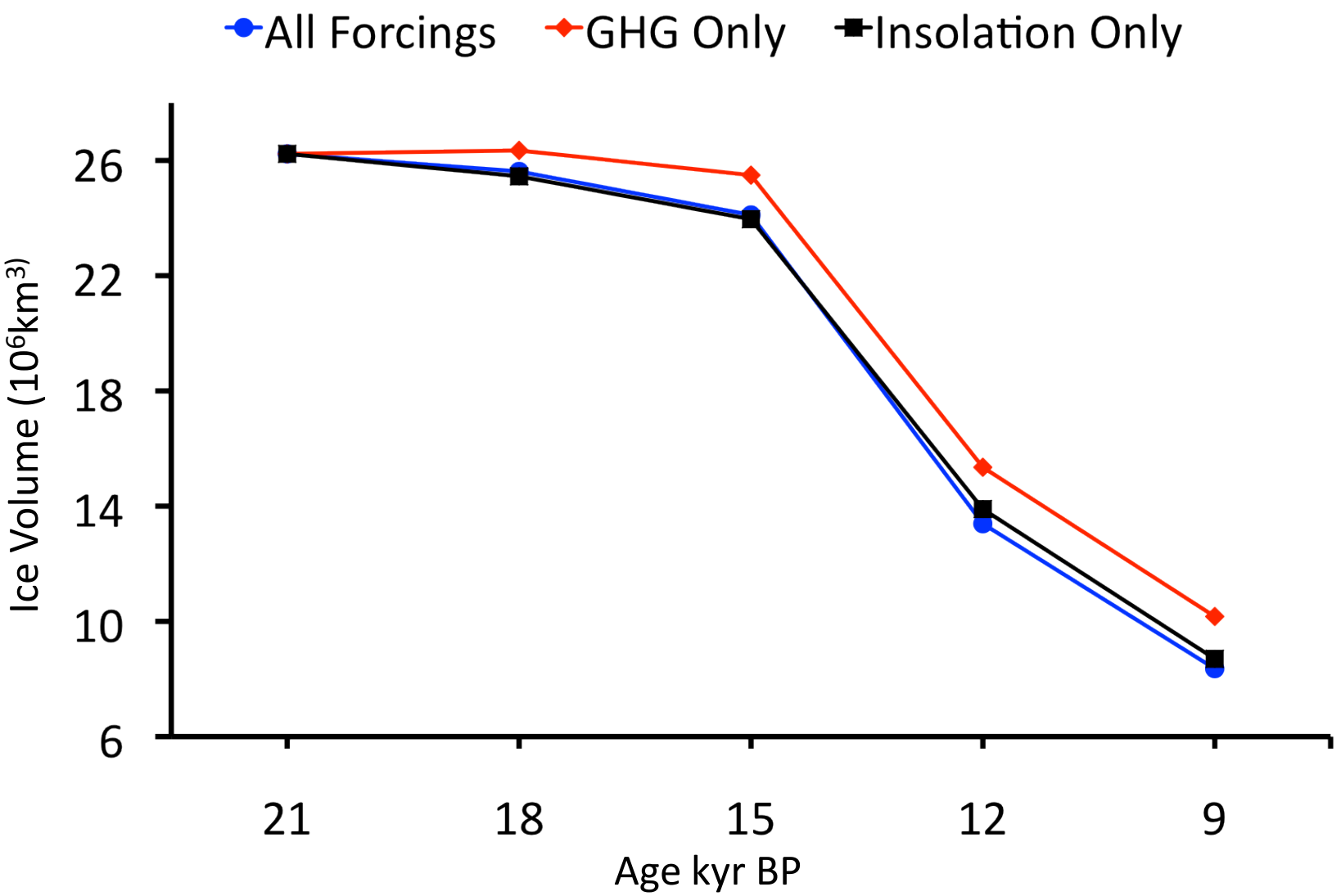
GHG only

Insolation only





Volume Comparisons



Results

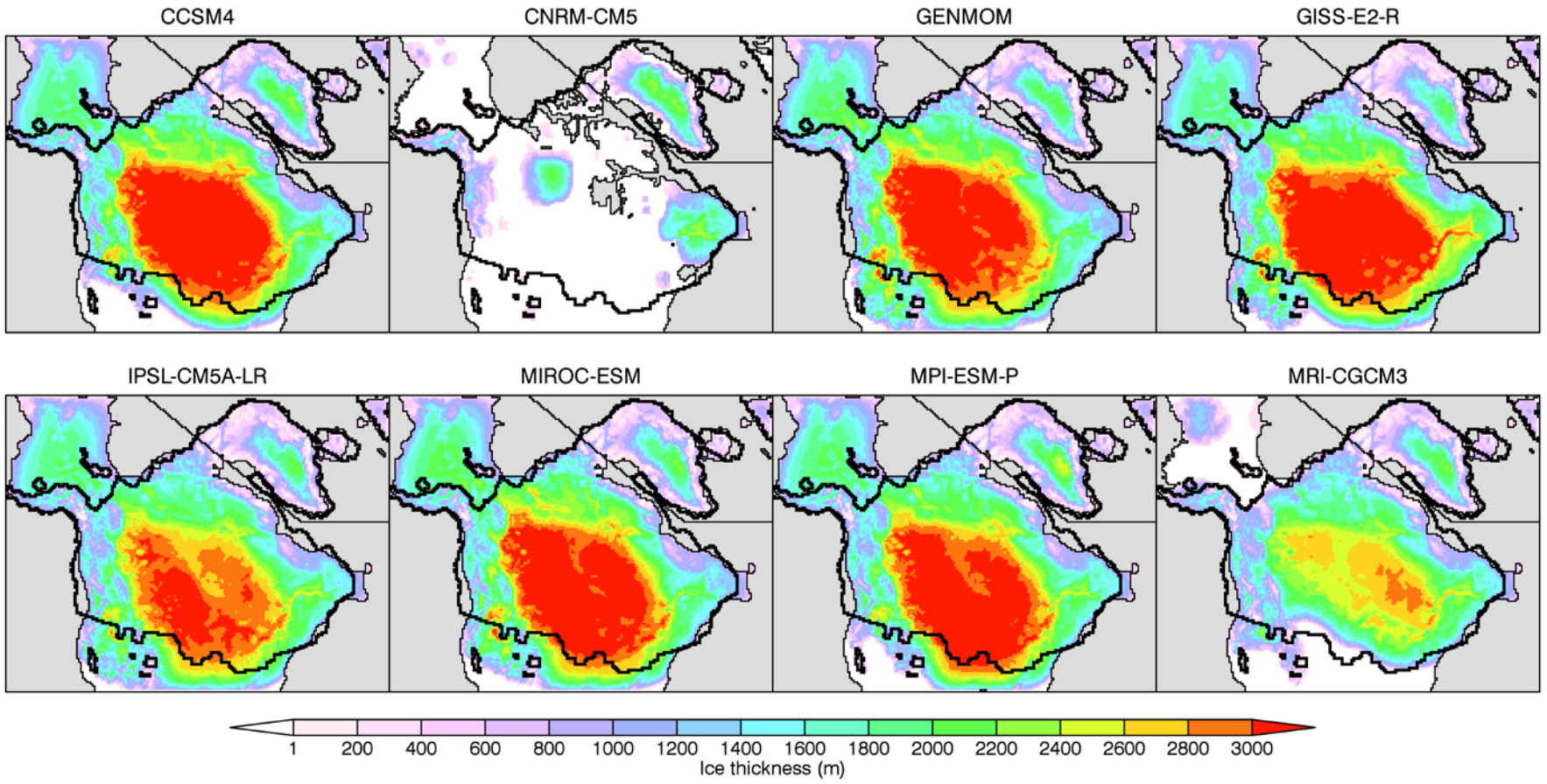
- Similar mass loss for all three forcing scenarios.
- Good agreement suggests strong influence of ice-sheet boundary condition in GENMOM in producing a climatology that results in an ice sheet simulated by Glimmer comparable to reconstruction, regardless of forcing.

(5) Sensitivity to GCM used (PMIP3)

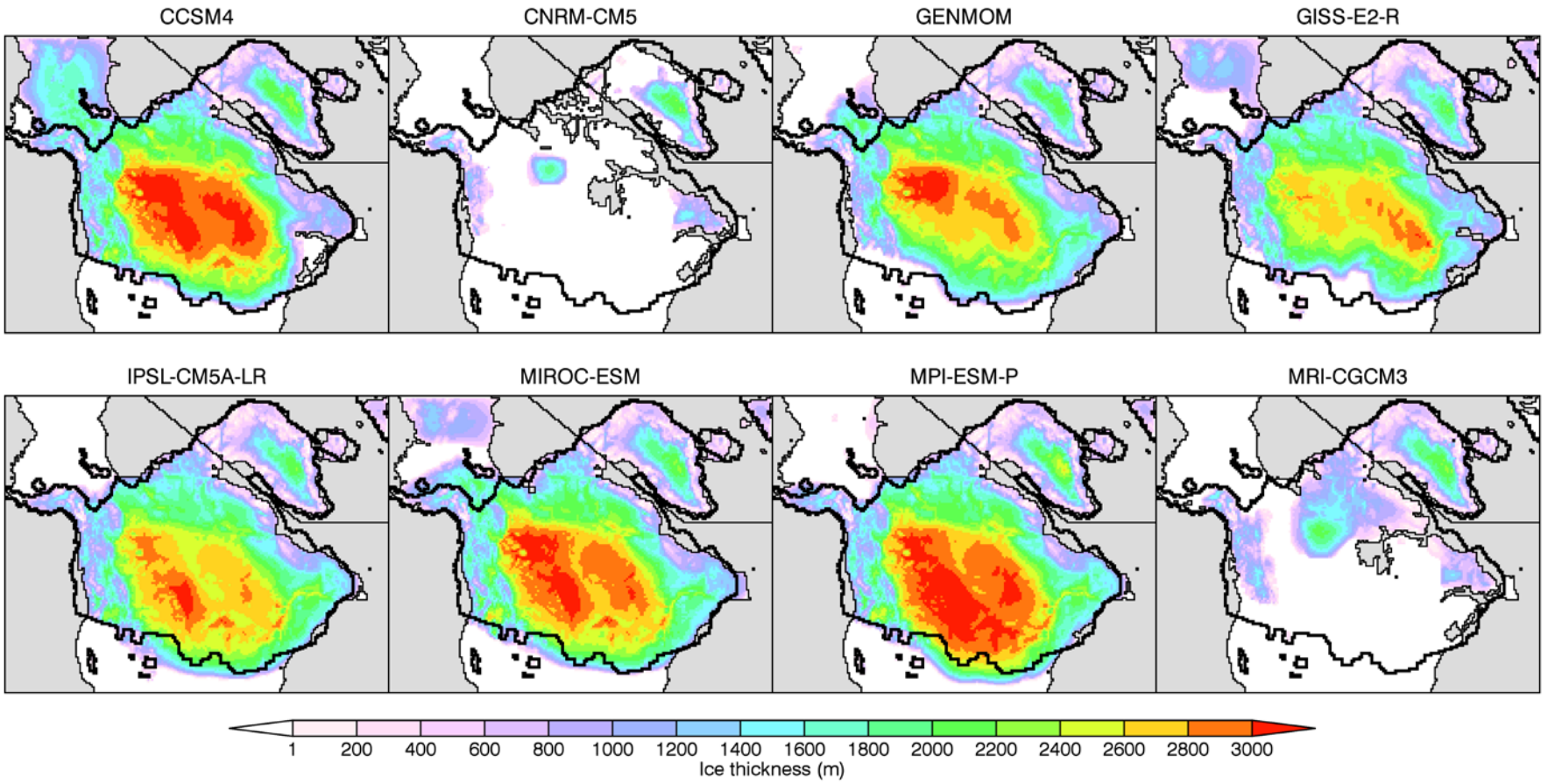
Forced with constant LGM climate, but varied PDD factors.

Label	pdd_ice	pdd_snow	notes
p0	0.006	0.001	high ice
p1	0.007	0.002	
p2	0.008	0.003	
p3	0.009	0.004	
p4	0.01	0.005	
p5	0.011	0.006	
p6	0.012	0.007	low ice

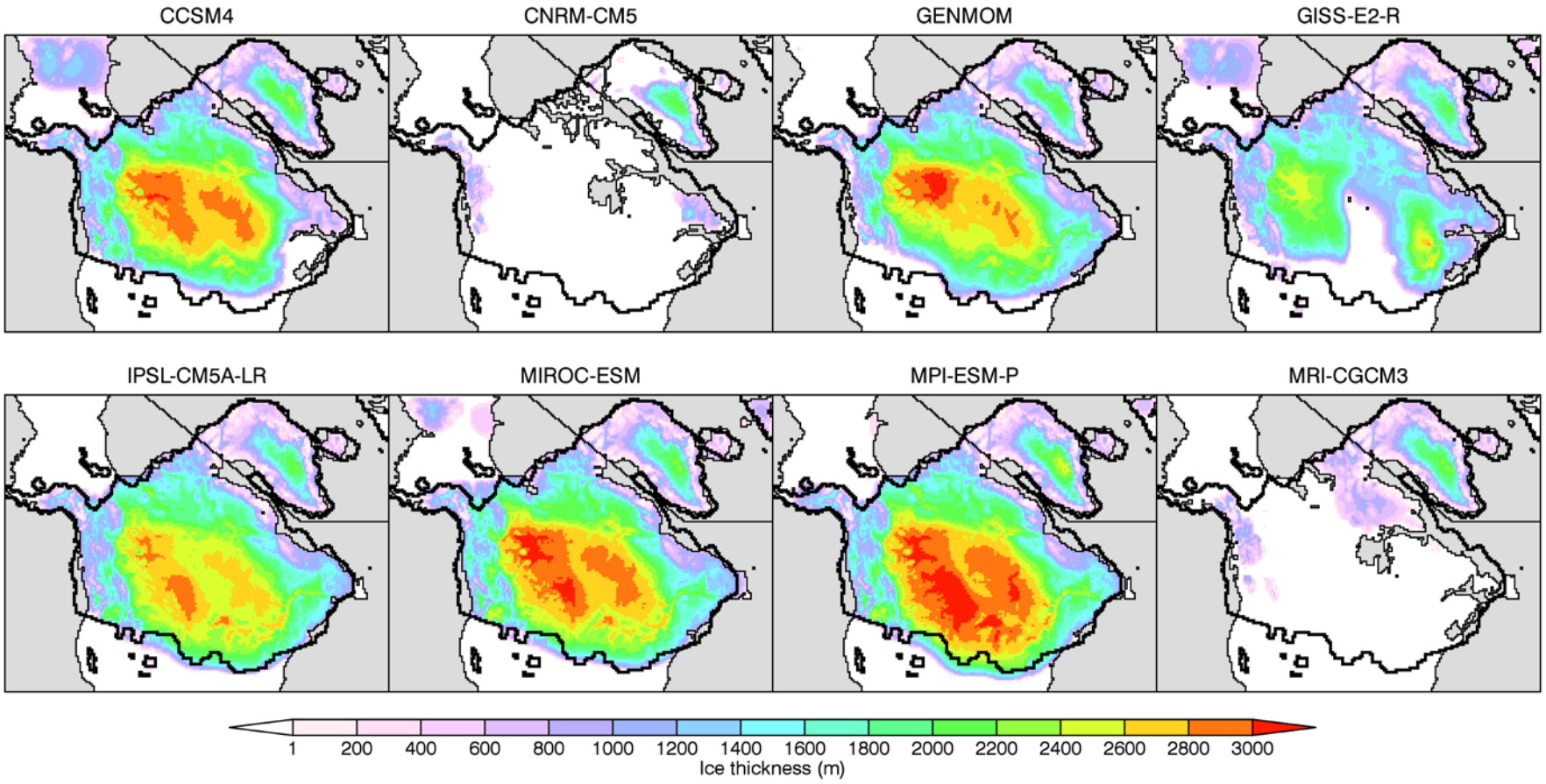
Thickness (p0)



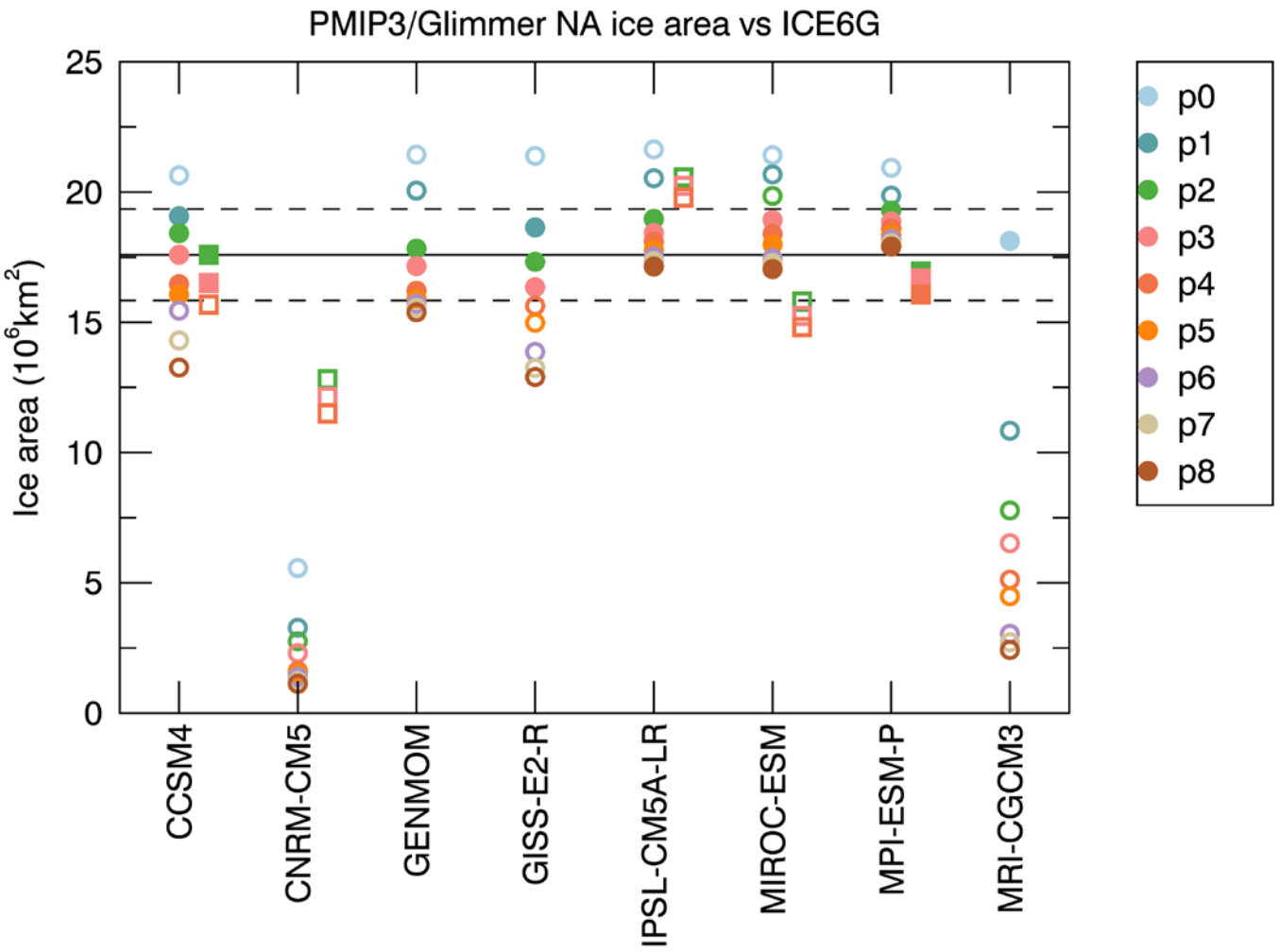
Thickness (p3)



Thickness (p6)



Area Summary



Results

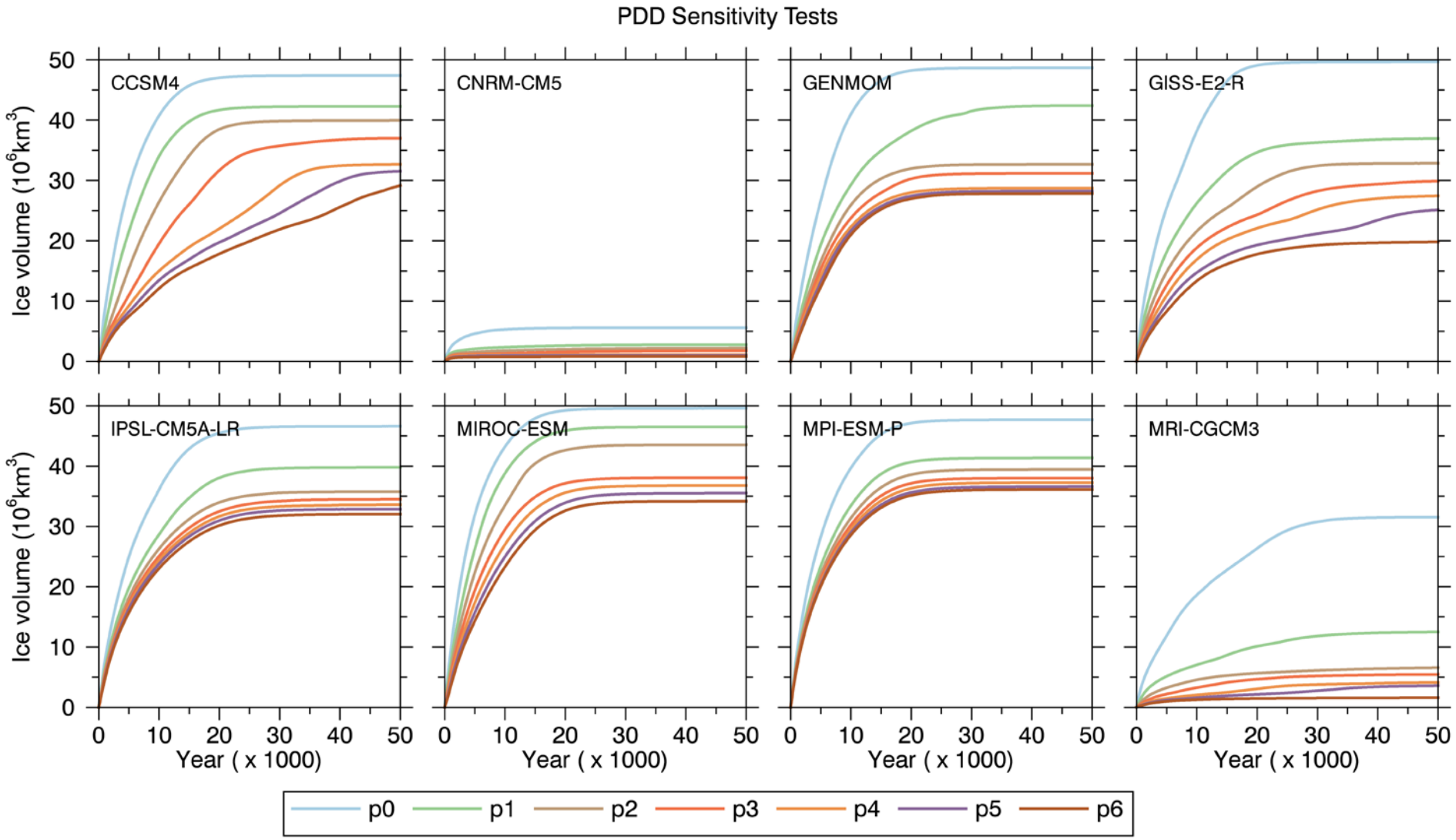
- Models exhibit different sensitivity to changes in pdd factors.
- Three models agree with the extent of the Laurentide Ice Sheet at the LGM, using the P3 factor (GENMOM, MPI-ESM-P, IPSL-CM5A-LR). Two models have too little ice, three models have too much ice in Beringia.
- Glimmer simulations used to validate GCM climatologies.

Conclusions and future work

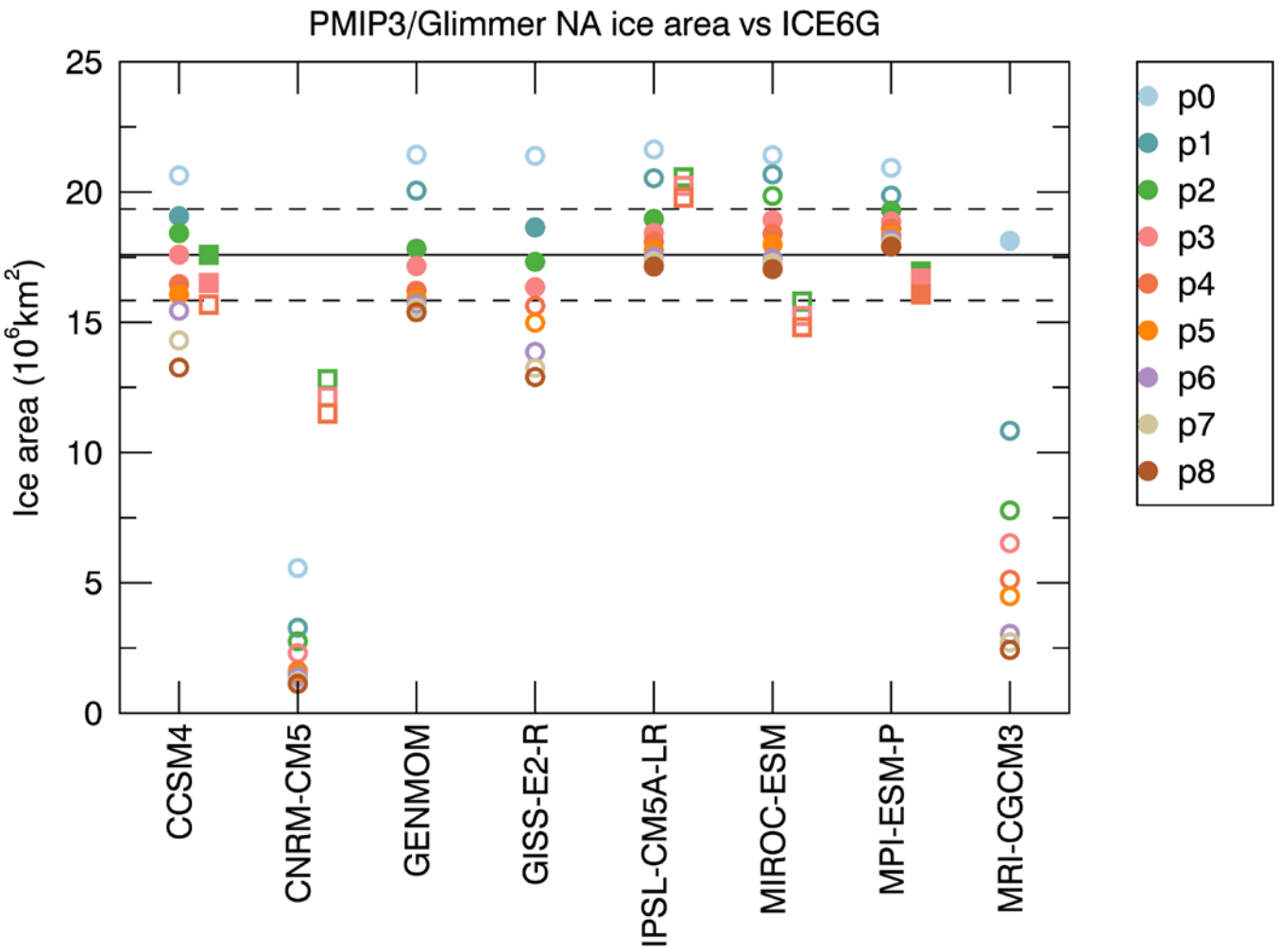
- Glimmer is useful for addressing the performance of a GCM climatology in reconstructing ice-sheet extent.
- An interactive ice sheet-climate model (i.e., CESM) is needed to address ice-sheet sensitivity to insolation and GHG and the feedbacks associated with the changes.

Extras

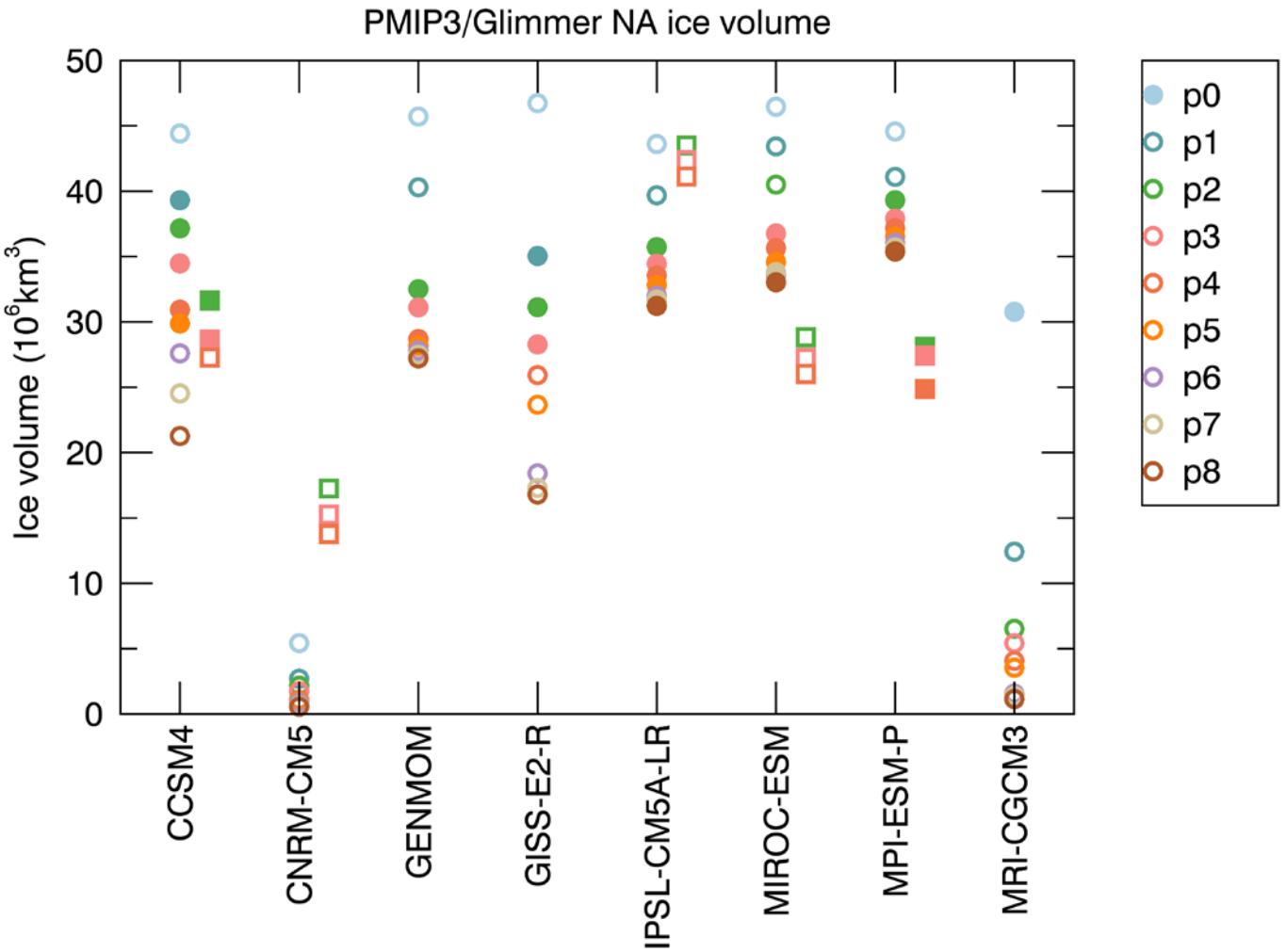
Volume – by model



Area Summary



Volume Summary



- We projected the ETOPO1 data from a 1′ longitude-latitude grid onto our carte-sian grids using a Lambert Equal Area Azimuthal projection (Snyder, 1987). This projection was chosen because it is an equal area projection and is suitable for con-tinent size mapping.