Response of the Greenland Ice Sheet to temperature overshoot scenarios

M. Petrini, H. Goelzer, P. Langebroek, J. Schwinger

CESM Land Ice Winter Working Group Meeting

February 23th 2023

Outline

- Overview of the IMPOSE project and aim of this study
- Simulations setup: forcing CISM with elevation-varying NorESM SMB
- GrIS response to overshoot scenarios & impact of SMB-height feedback
- Conclusion and future work

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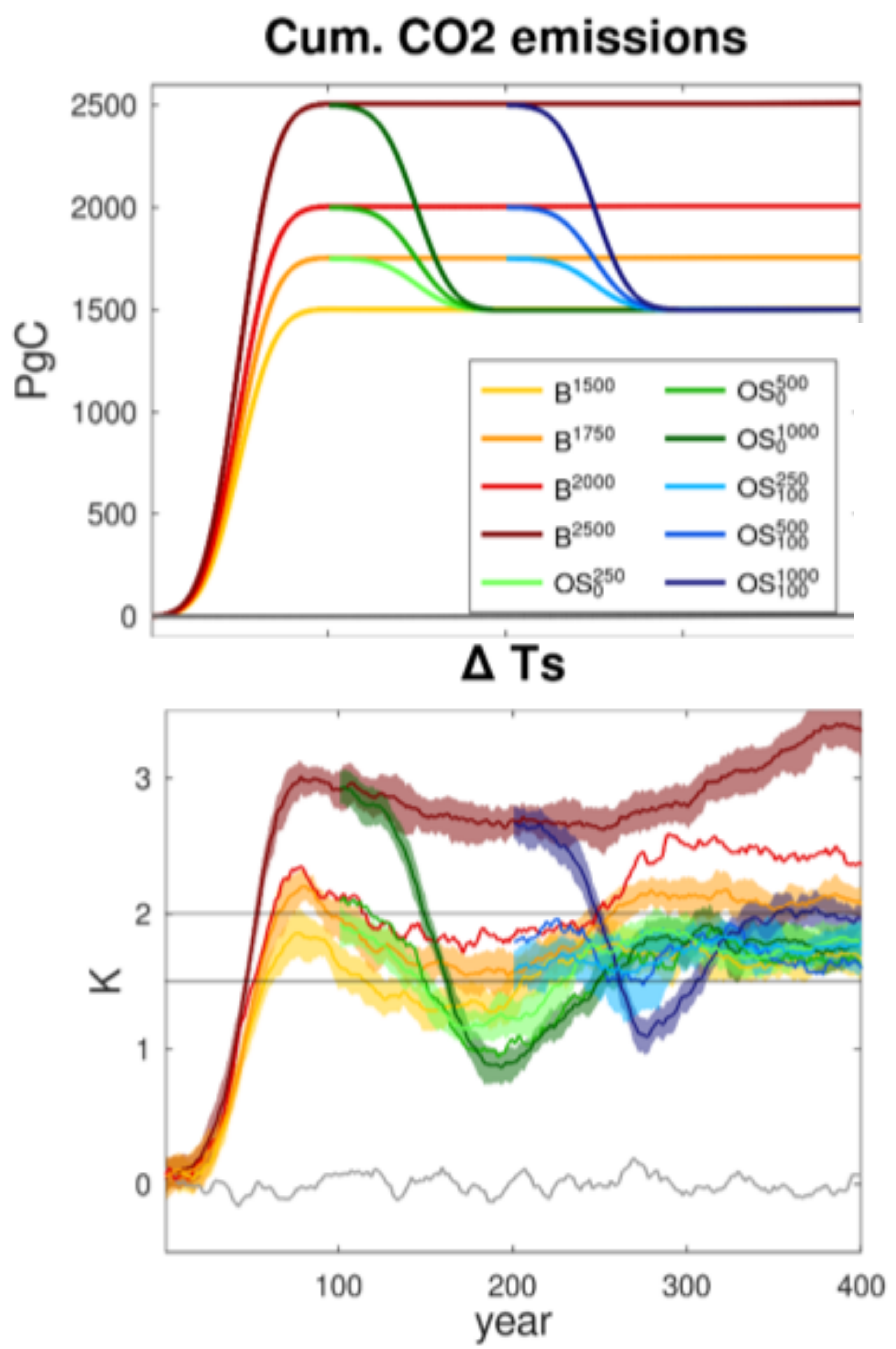

- PI: J. Schwinger (NORCE)
- Earth system reversibility after overshoots of different durations and magnitudes: idealized simulations with NorESM (2 degree ATM/LND);

Emit now, mitigate later? Earth system reversibility under overshoots of different magnitudes and durations

Jörg Schwinger[1], Ali Asaadi[1], Norman Julius Steinert[1], and Hanna Lee[1,2]

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ARTICLE

Check for updates

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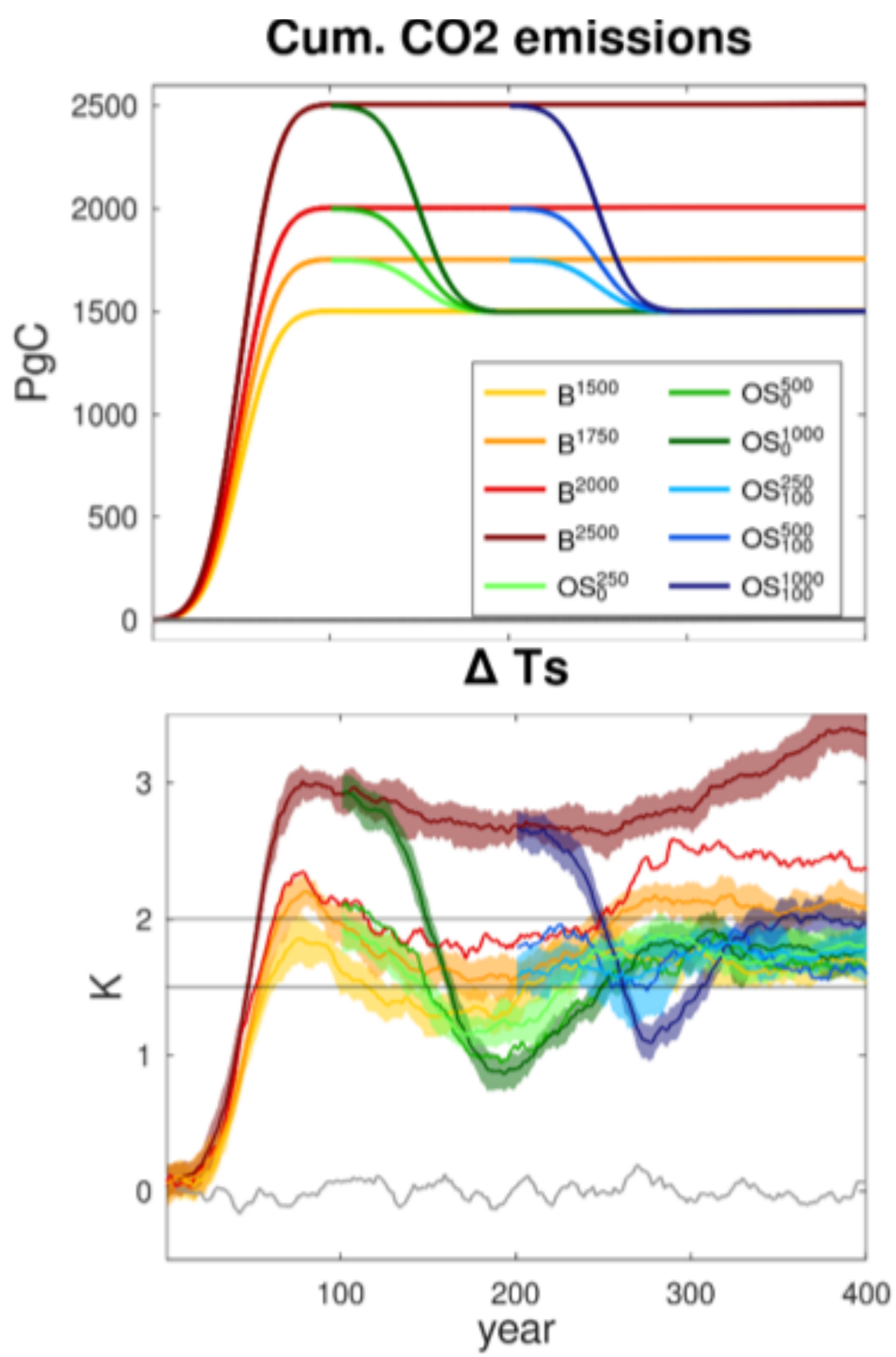
Possibility for strong northern hemisphere high-latitude cooling under negative emissions

Jörg Schwinger[1✉], Ali Asaadi[1], Nadine Goris[1] & Hanna Lee[1,2]

Overview of the IMPOSE project



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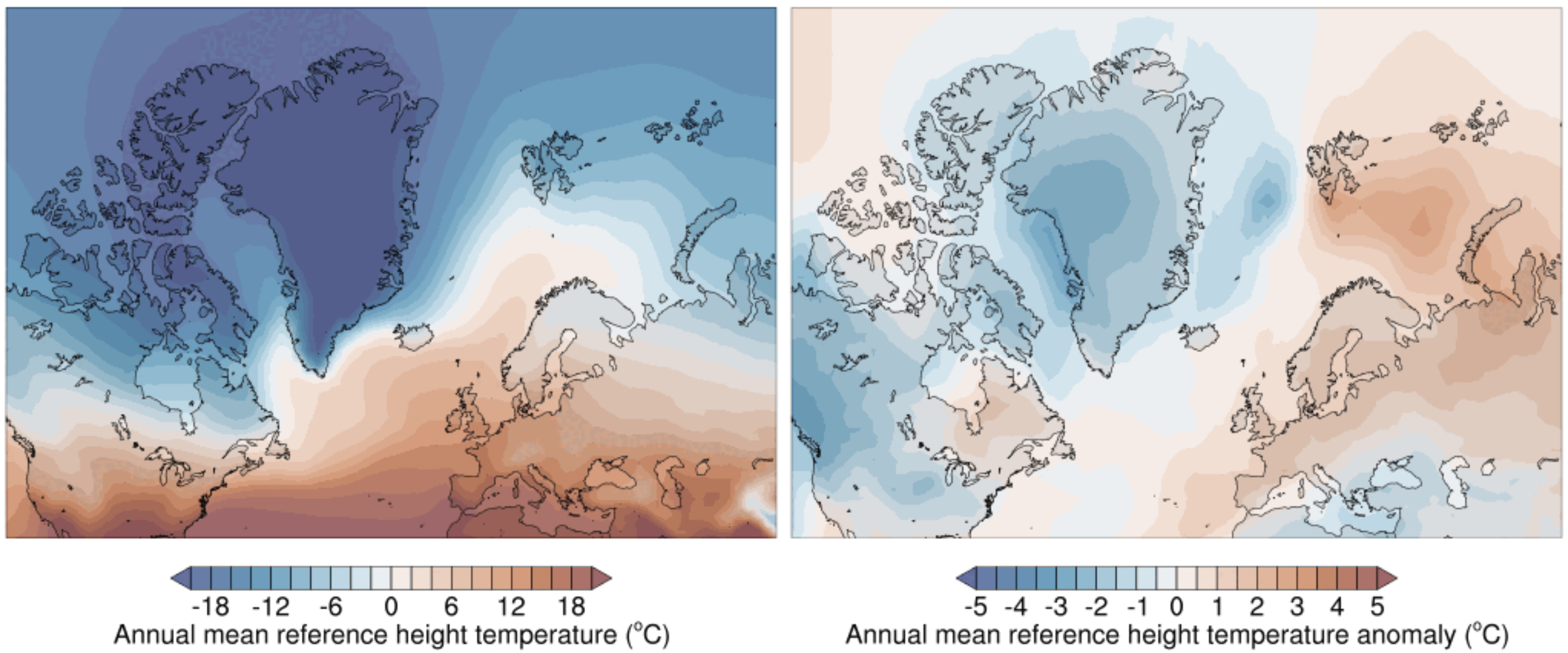
- CO_2 removal —> amplified Northern Hemisphere cooling due to AMOC decline, temporary undershoot;

Run IMPOSE_B5_02, Year 1850



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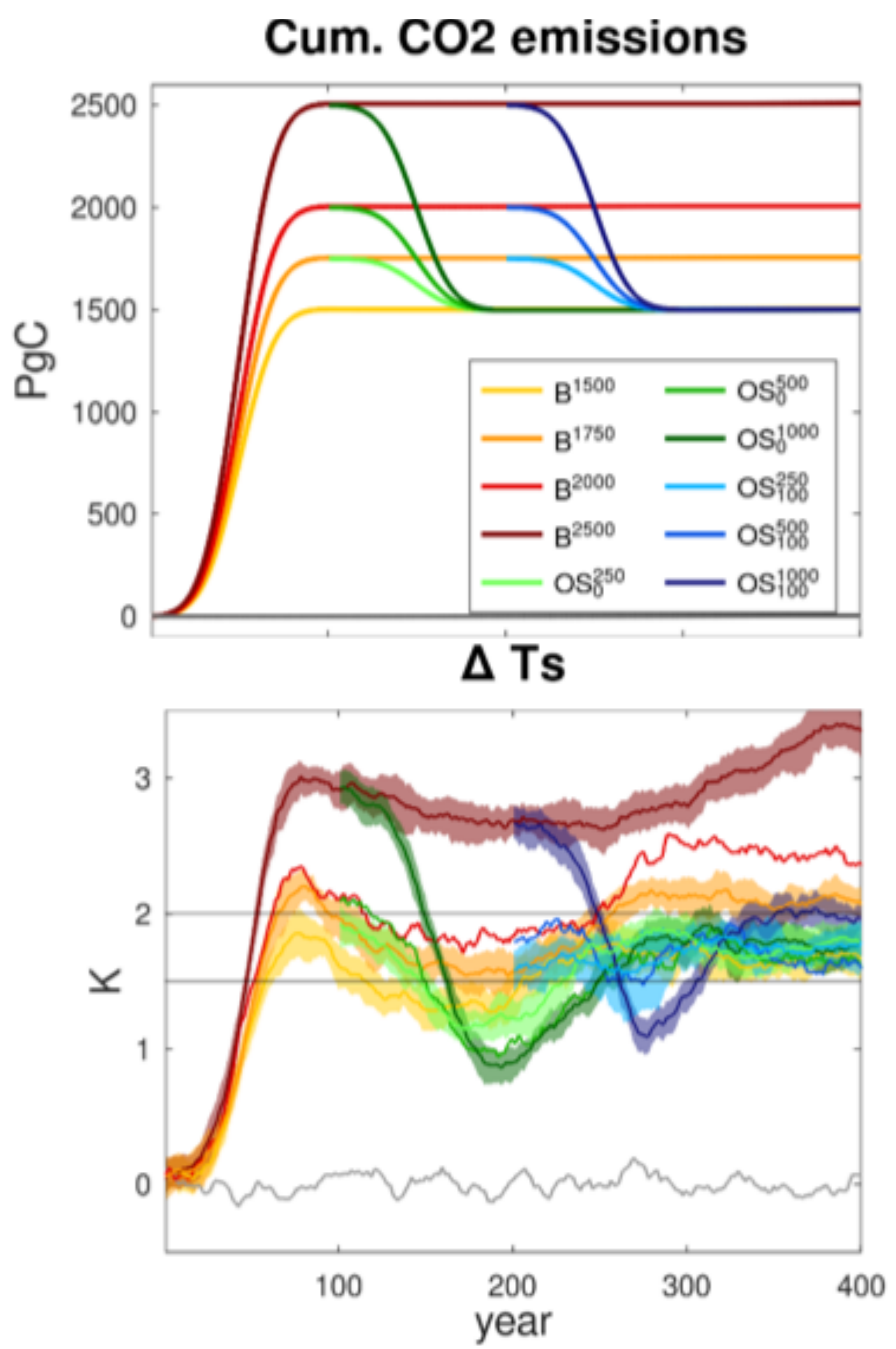

- Earth system reversibility after overshoots of different durations and magnitudes: idealized simulations with NorESM (2 degree ATM/LND);
- CO_2 removal —> amplified Northern Hemisphere cooling due to AMOC decline, temporary undershoot;

- **GrIS response/reversibility to overshoot scenarios?**
- **How Northern Hemisphere cooling affect GrIS response?**

- **We force CISM with NorESM SMB from following runs:**

B1500: +1500 PgC emission in 100 years, zero afterwards;

B2500: +2500 PgC emission in 100 years, zero afterwards;

OS1000_0: -1000 PgC emission between years 100-200;

OS1000_100: -1000 PgC emission between years 200-300;

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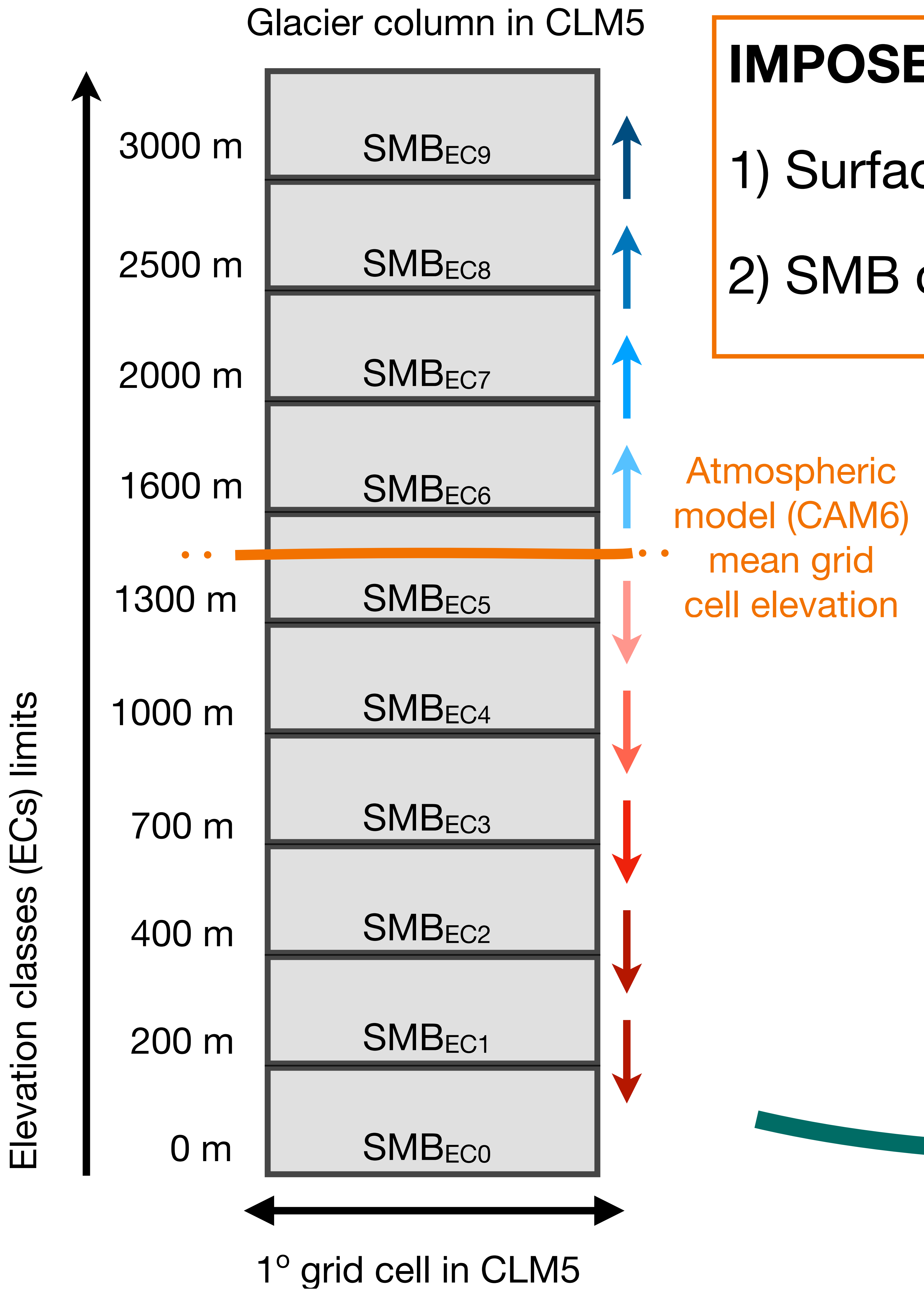
Simulation setup: running CISM in T-compset mode

- We run CISM within the NorESM architecture in T-compset mode: what this means?



IMPOSE NorESM runs (*or any NorESM/CESM run with active/inactive ice sheet domain*):

1) Surface air temperature downscaled to 10 virtual Elevation Classes (6 K/km);

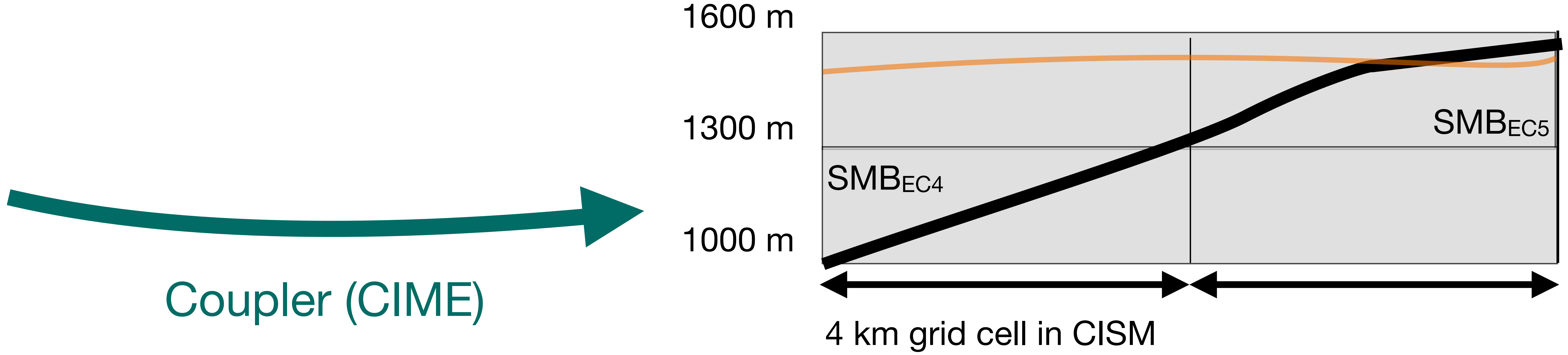
2) SMB calculated using energy-balance scheme **for each Elevation Class**;

CLM

T-compset CISM simulations in this study:

1) CISM forced with SMB at multiple Elevation Classes (CLM data-mode);
2) During runtime, coupler (CIME) downscales SMB to CISM 4 km grid;
3) SMB updated with topography changes (SMB-height feedback);

CISM



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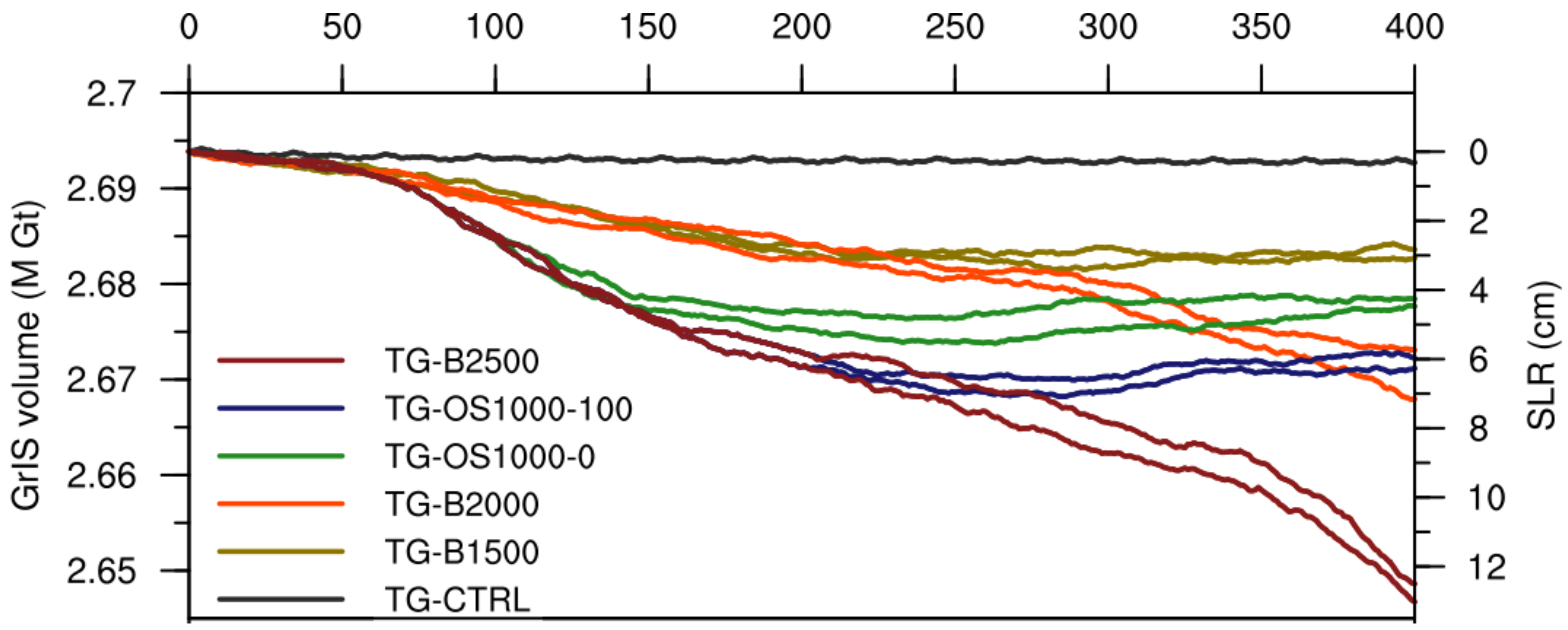
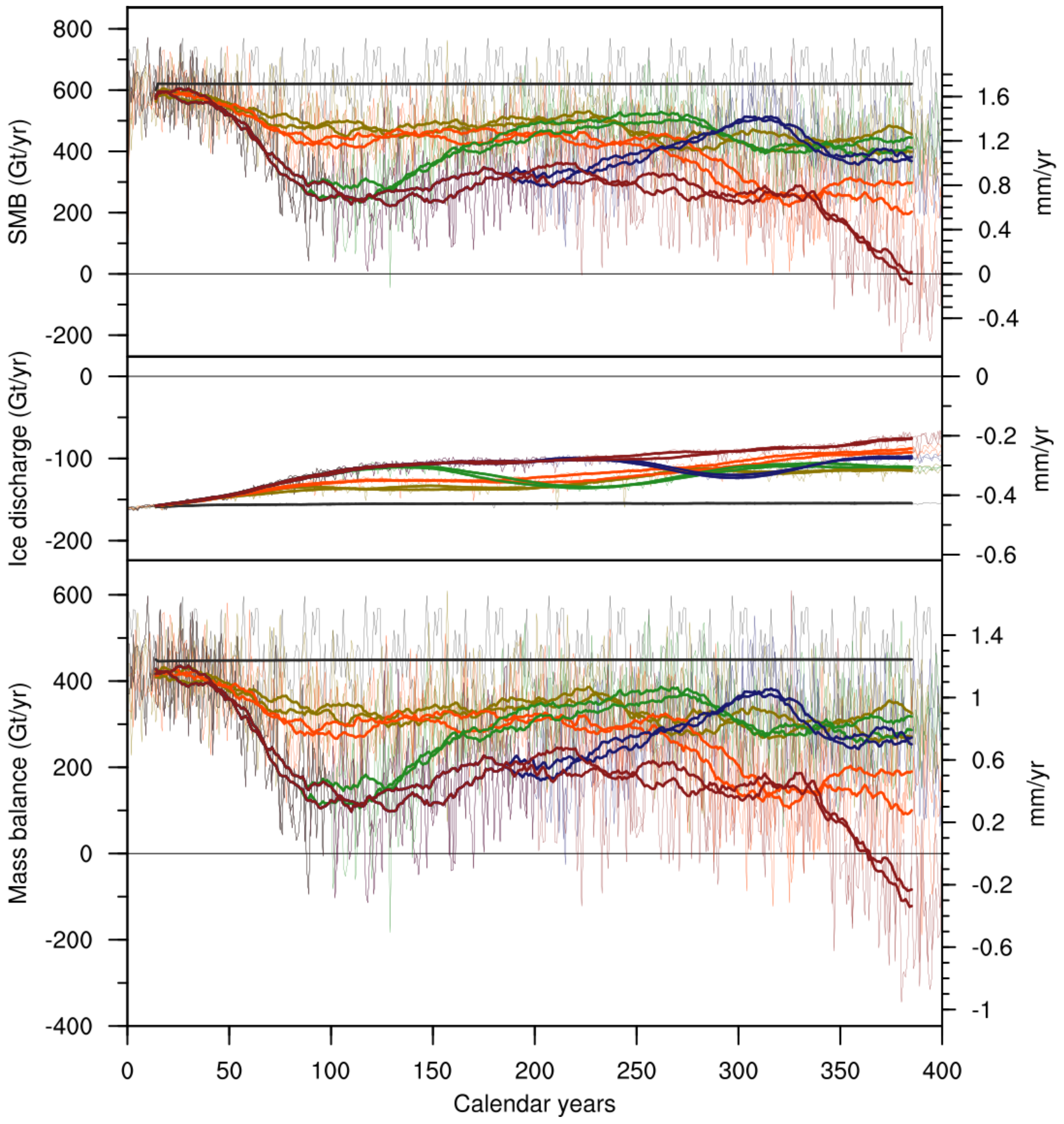
GrIS response to CO2 emission & overshoot scenarios





- Reference run (+1500 PgC emission): SLR ~3 cm
- +2000 PgC emission: SLR ~6-7 cm
- +2500 PgC emission: SLR ~12.5 cm
- In both overshoot runs, ~50 years before stabilisation;
- Short overshoot: SLR ~4.5 cm
- Long overshoot: SLR ~6 cm

GrIS response to CO2 emission & overshoot scenarios

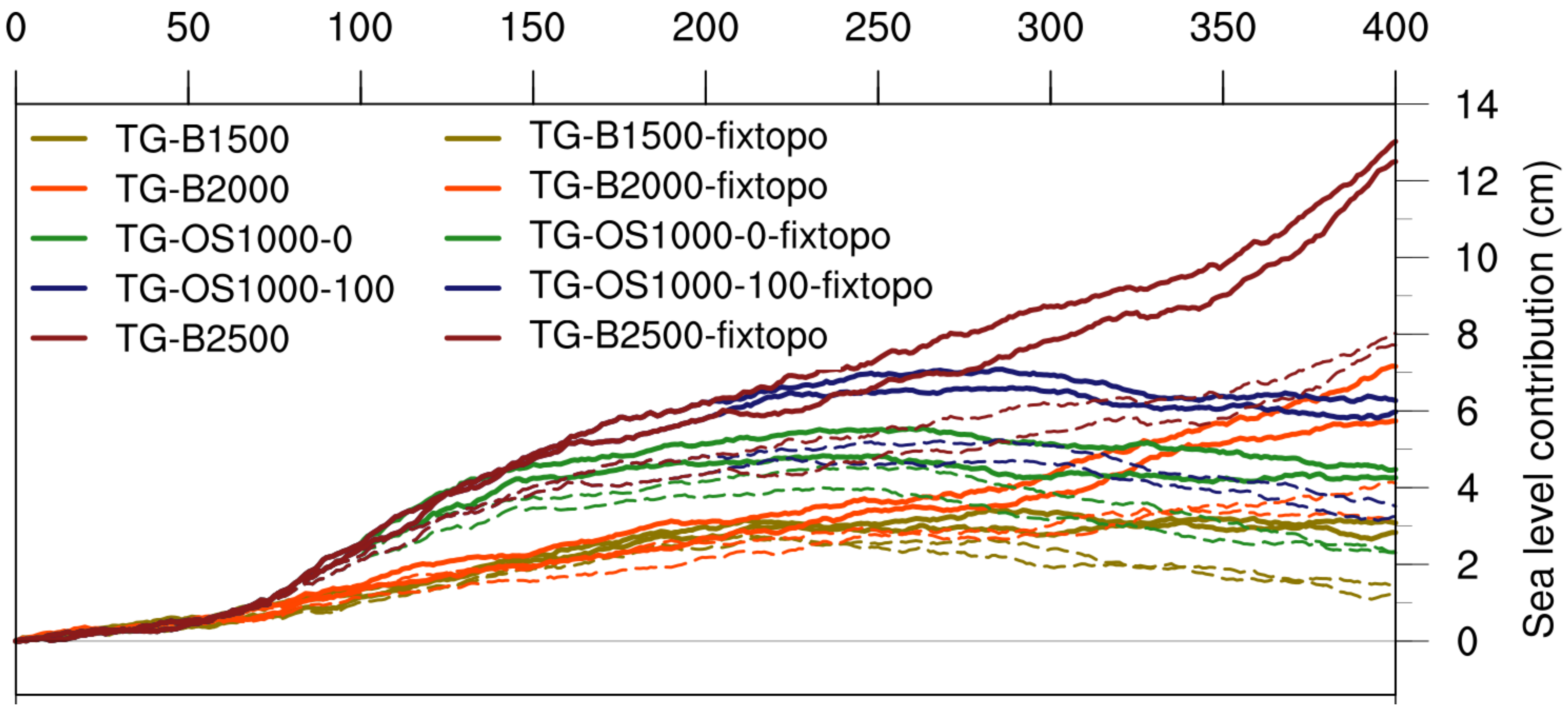
- Mass loss mostly in south-west, also north-west in overshoot runs, east only in high forcing scenario;

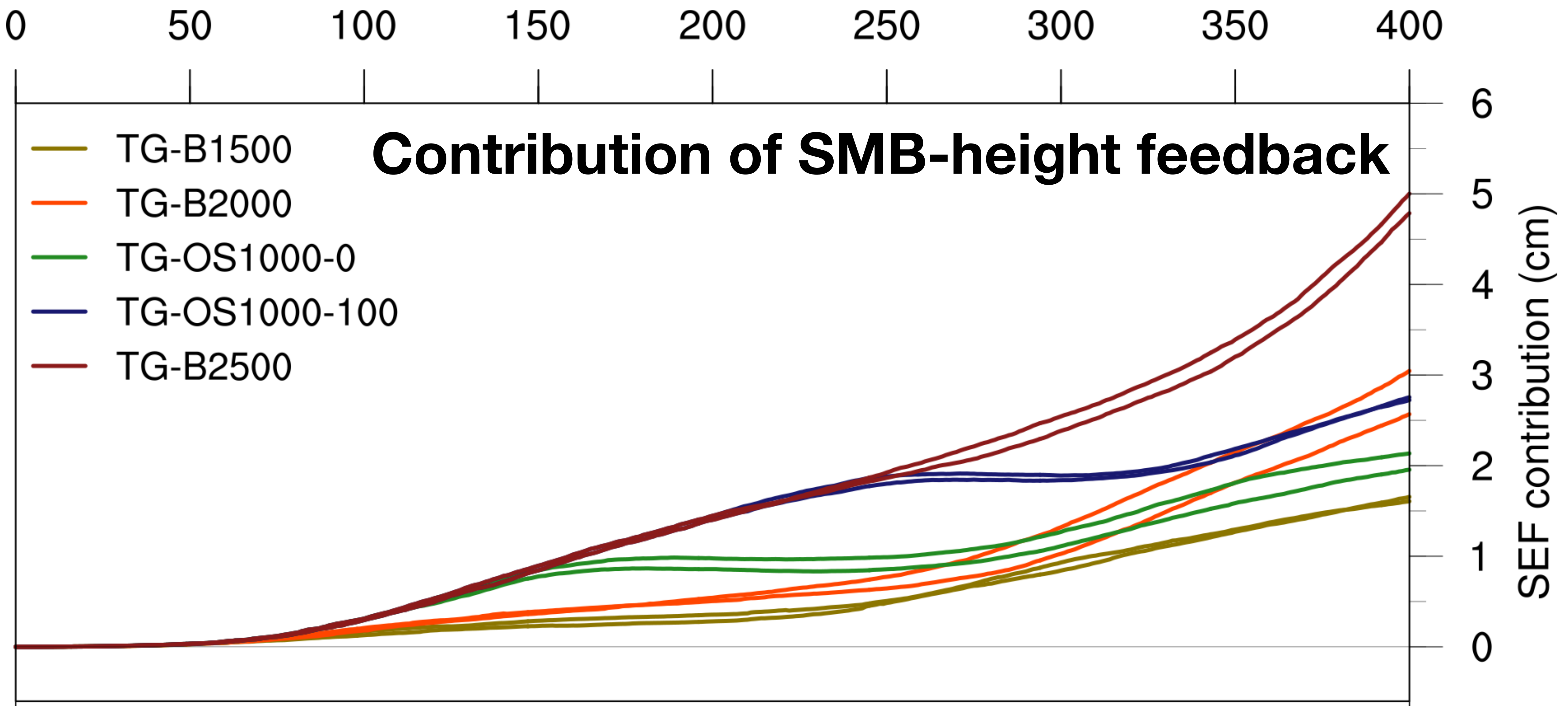
GrIS response to CO2 emission & overshoot scenarios

- Mass loss mostly in south-west, also north-west in overshoot runs, east only in high forcing scenario;
- Short overshoot: low excess mass loss at SW & N margins; more pronounced in long overshoot run;

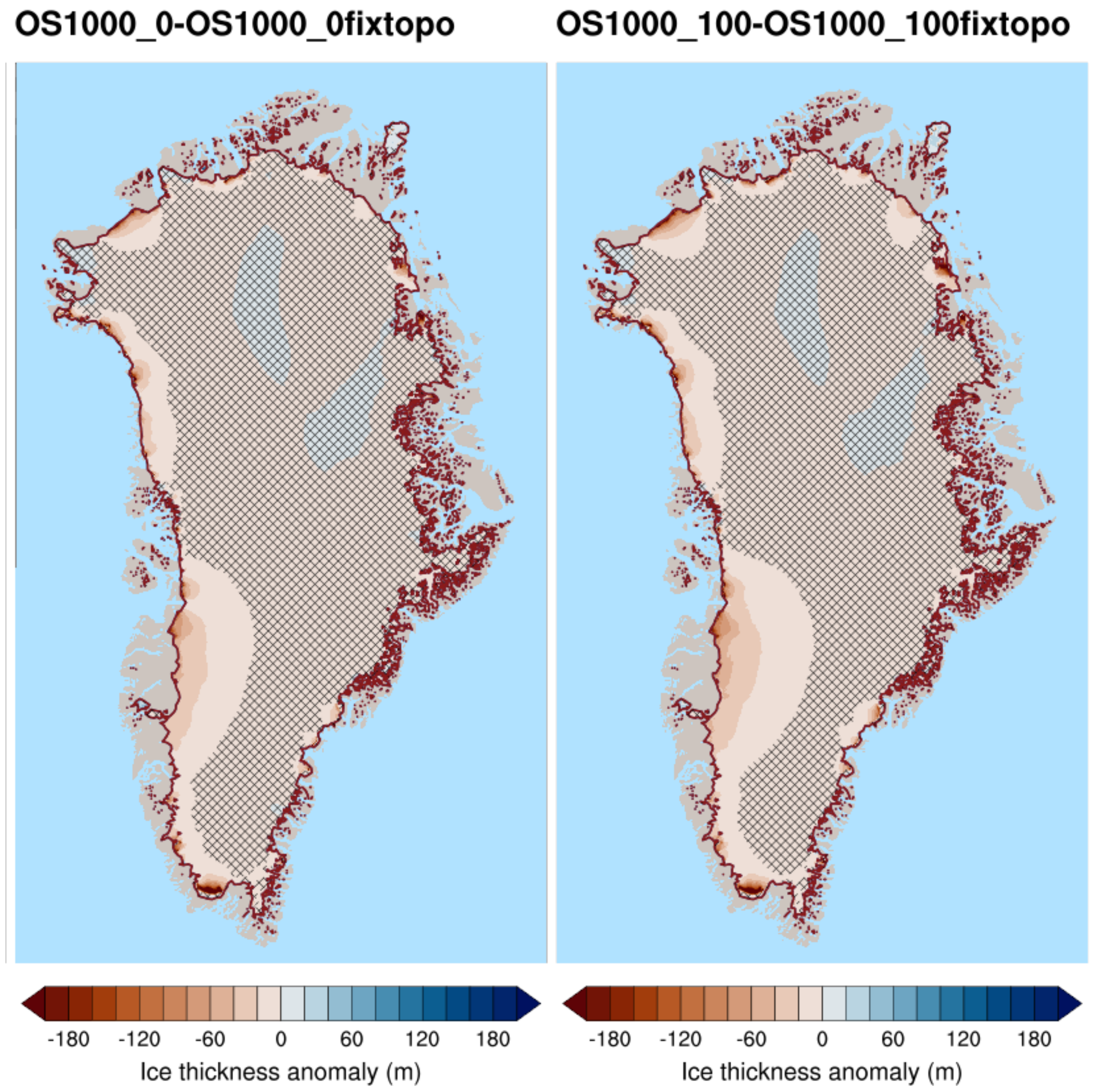
Isolating the impact of SMB-height feedback

- We repeat the runs without updating SMB for surface topography change (equivalent to CISM stand-alone);





- ~50% mass loss for low-intermediate forcing, OS;
- Slightly less than 50% for high forcing run;



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Conclusion

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- Higher sea level contribution for short overshoot (1.5x) & long overshoot (2x) compared to reference run;
- SMB-height feedback accounts for ~50% of the mass loss (slightly less in high forcing run);

Ongoing & future work

- Extend all runs (1000-2000 years) to check for long-term trajectories;
- Include and assess impact of ocean forcing at marine outlet (Spoiler: 45% more loss in high forcing run)
- If we ‘stretch’ forcing over time in overshoot runs, is the final point the same? (Spoiler: not always!)

Conclusion

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Thank you for the attention!

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Quick recap of spin-up procedure

1) Spin-up forced with 30-years SMB from NorESM PI-control run (part of IMPOSE NorESM runs);
2) SMB downscaled from CLM (2 deg) to CISM (4 km) using MEC-downscaling scripts;
3) First 5000 years stand-alone inversion to observed topography, then 5000 years stand-alone relaxation;
4) Final check for drifts (also, CISM control runs!): 400 years both in stand-alone and TG mode;
5) Two important things we learned from these experiments:

   a) SMB downscaled in TG mode and using MEC-downscaling are different (why? check with LIWG);

   b) Always use glc_renormalize_smb = .false. in TG runs which are not 'tied' to fully coupled runs;

Quick recap of spin-up procedure

Model year 400

TG vs TG-fixed topo: SMB