Ocean-forced Antarctic Ice Sheet simulations: the effect of the present-day disequilibrium and calving.

Land Ice winter meeting – 28/01/2024

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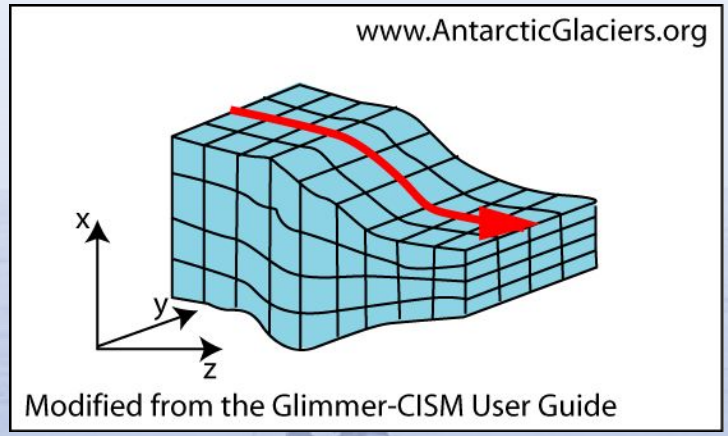
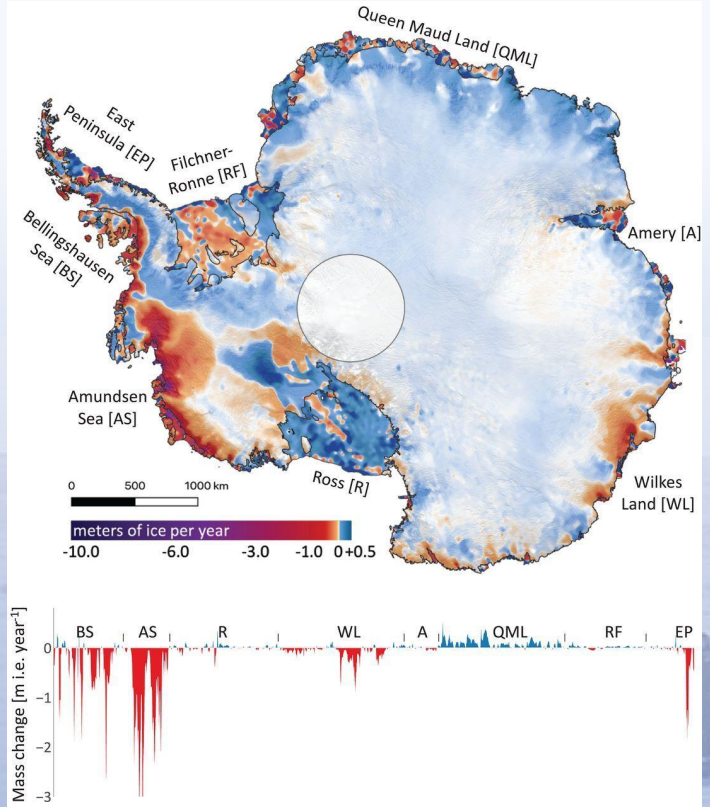
Modelling context

- Community ice sheet model CISM development version
- Depth-integrated viscostiy approximation
- Whole Antarctic Ice Sheet, but with a focus on the Amundsen sea
- Zoet – Iversson sliding, tuning friction parameters and ocean temperature perturbations, based on <u>thickness</u>

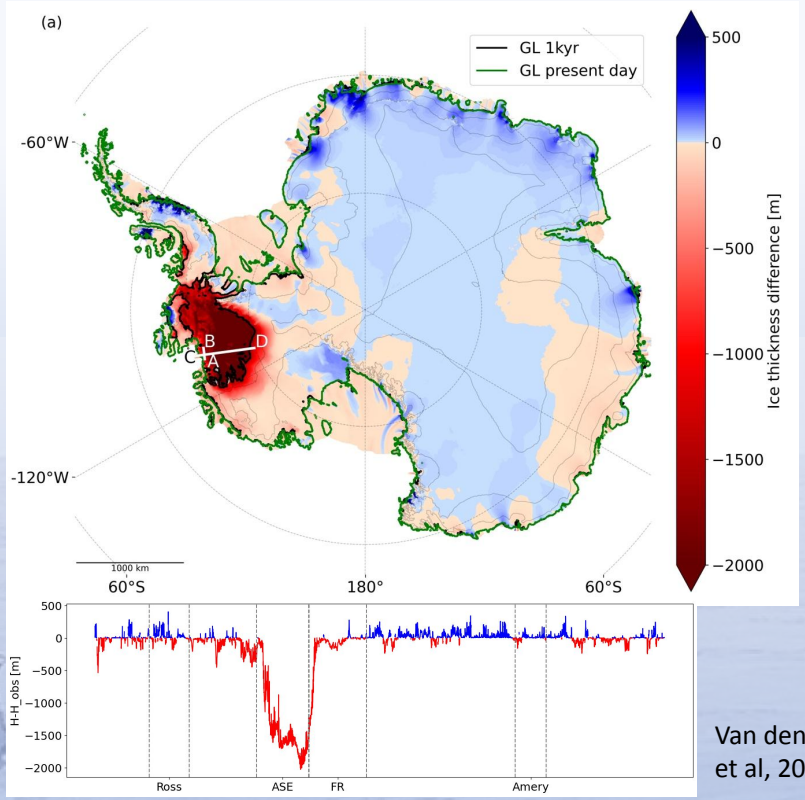


Further modelling context

- We initialize with or without the observed mass change rates
- We apply <u>no forcing</u>! and then run for 1 to 2 kyr



Smith et al, 2020

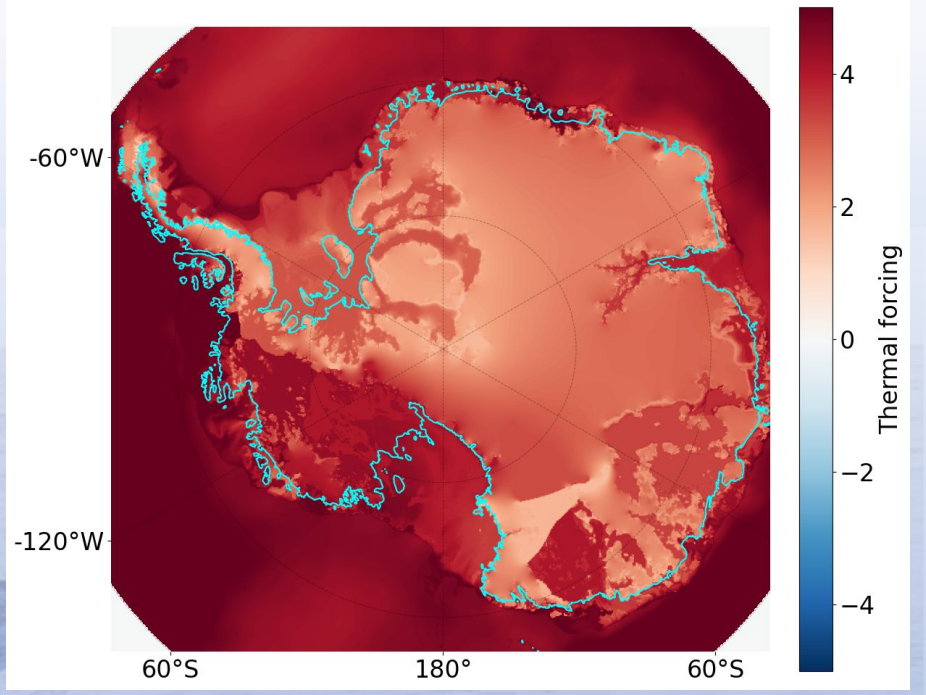


Van den Akker et al, 2025

What will happen if we add ocean forcing?

- We add ocean (thermal) forcing
- From 7 ESM simulations (CMIP6)
- To ice sheet initialized with and without the observed mass change rates

Typical depth/time averaged forcing

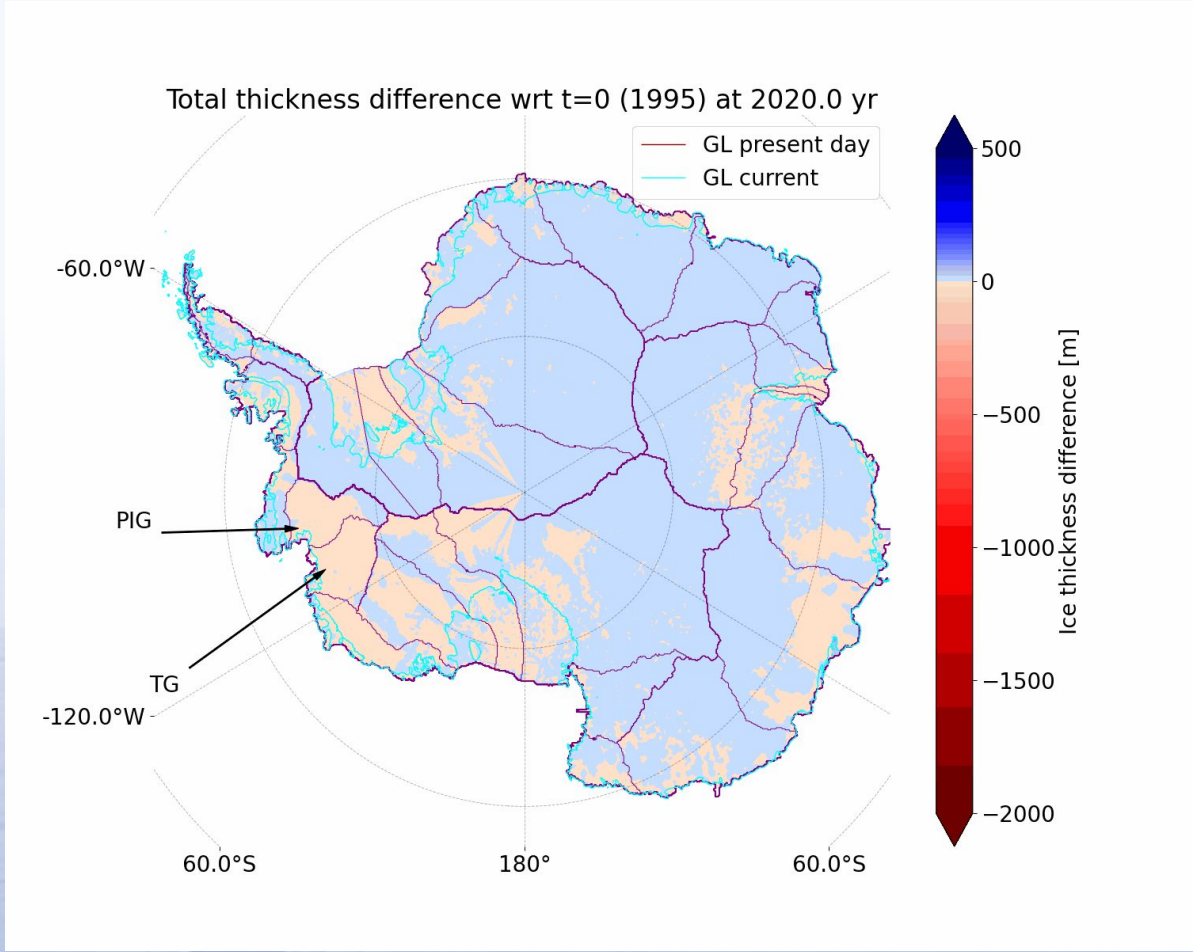


This happens:

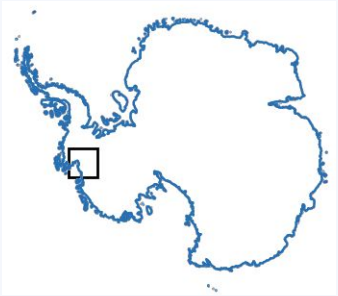
- Dissappearance of FR and Ross
- In many ESM-forcing cases: earlier than WAIS collapse
- WAIS starts from FR or Siple Coast, depeding of the ESM forcing chosen

- Additionally: Amery disintegrates and Wilkes land deglaciates.

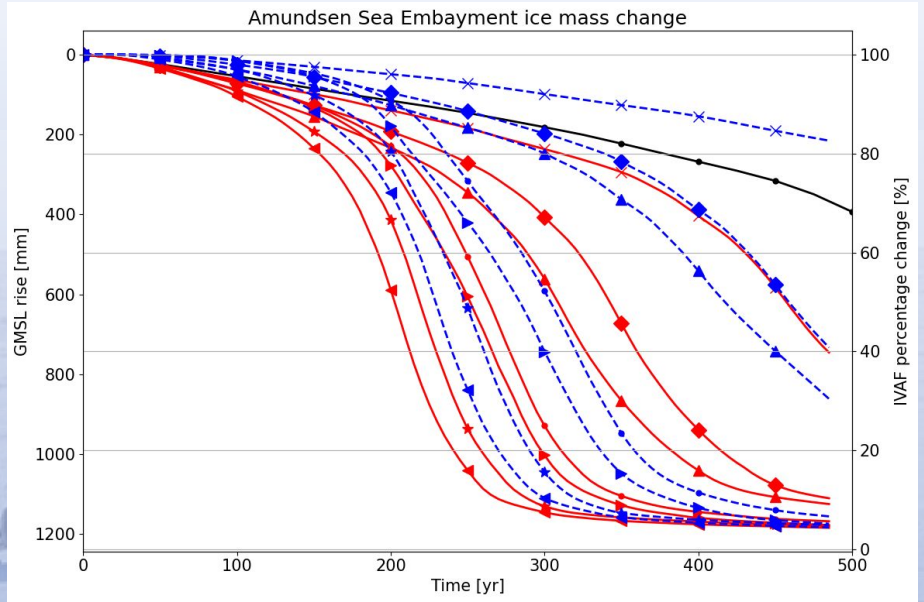
Typical forced simulation



WAIS collapse is sped up by adding forcing

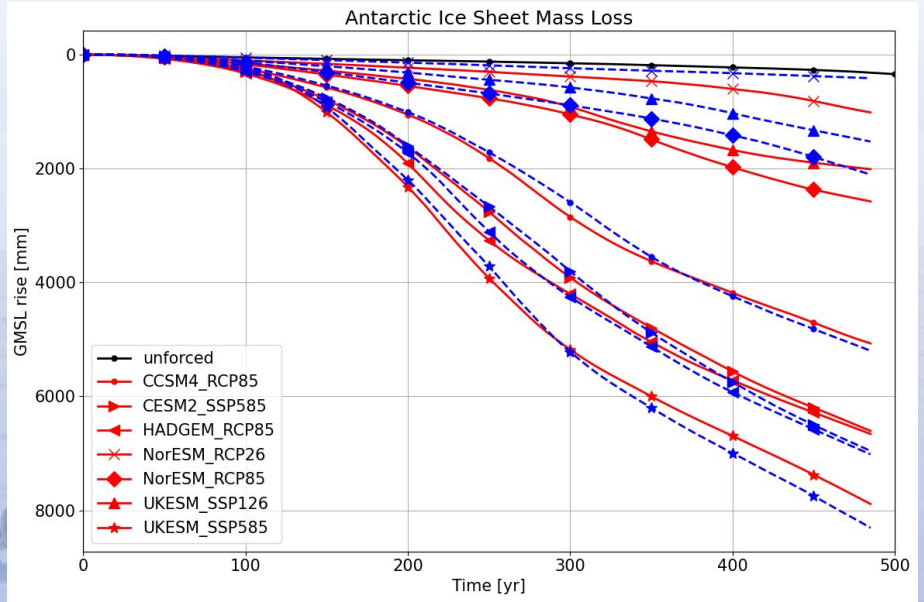


- Initializing with the observed mass change rates (red = with, blue = without) :
  - Forcing makes it faster!
  - Initialization matters more for less extreme forcing scenarios (RCP126 versus RCP585)
  - Initialization choice as important as ESM choice



AIS retreat is not sped up by adding forcing

- Initializing with the observed mass change rates (red = with, blue = without)
- Two important observations:
  - Little difference in initialization
  - Lot of difference in scenario



Stress based calving (implemented by Bill)

- Calving front position determined by difference in horizontal velocity and lateral calving rate

– Use this to formulate calving law:

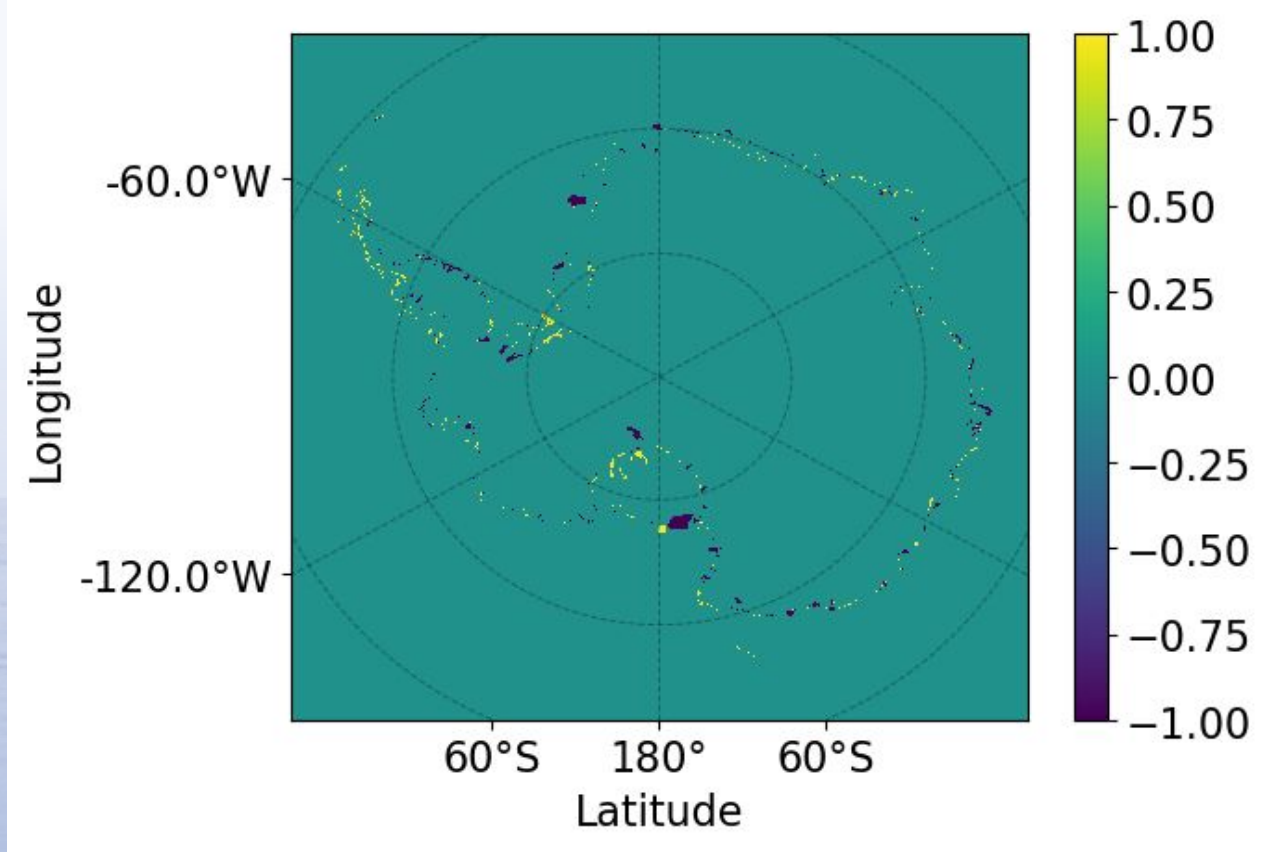
  - Stress at calving front > threshold? Calving front retreats
  - Stress at calving front < threshold? Calving front can advance

$$C = |v| * \frac{\tau}{\tau_{thresh}}$$

$$\tau = \sigma_1 * \tau_{eigen,1} + \sigma_2 * \tau_{eigen,2}$$

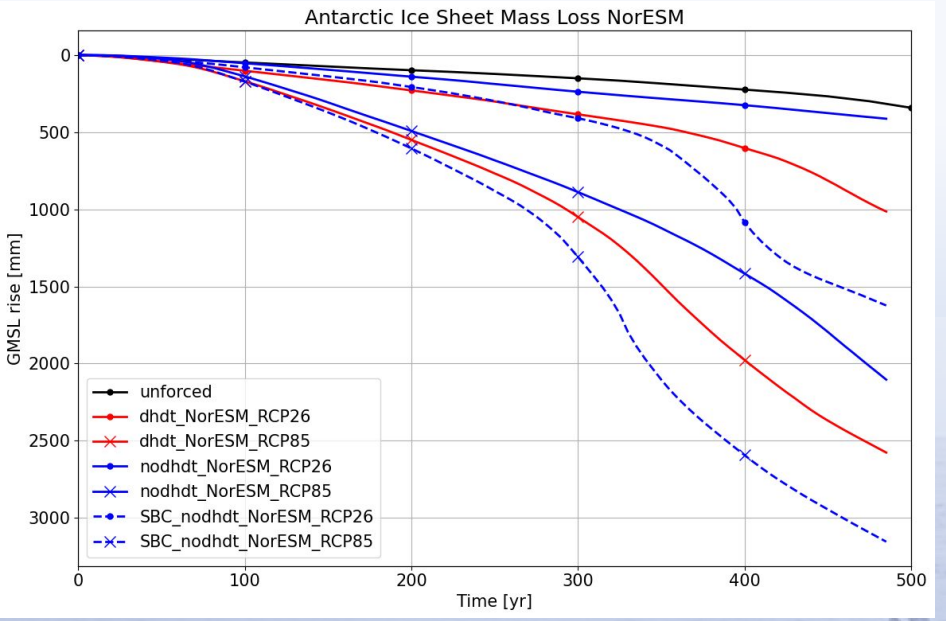
Stress based calving (threshold: 85 kPa)

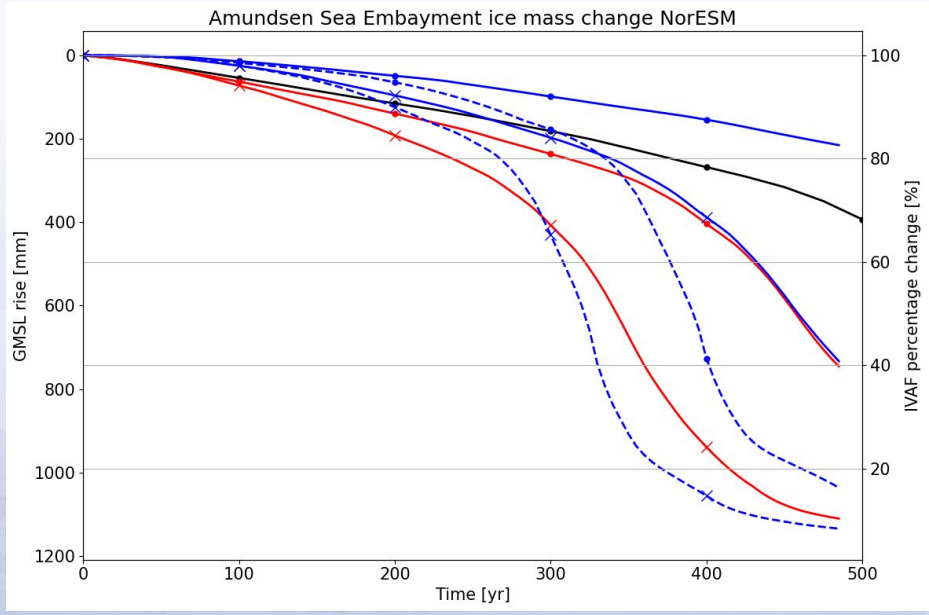
- Spinup evaluation: (yellow (1) is floating where it should not be, blue is other way around



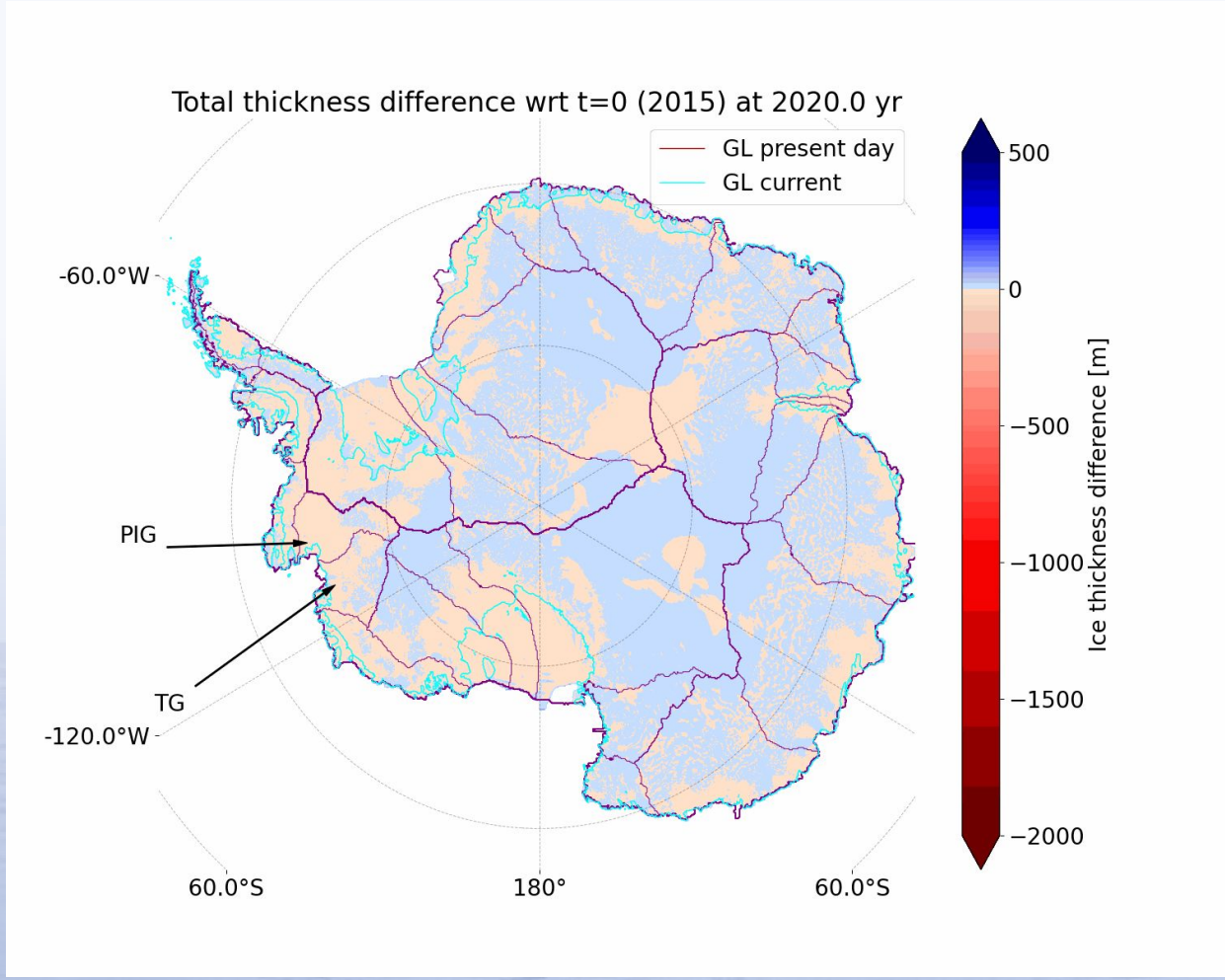
Stress based calving: typical forced simulation

- Ice mass loss is accelerated compared to the no-advance case
- Has more influence compared to the

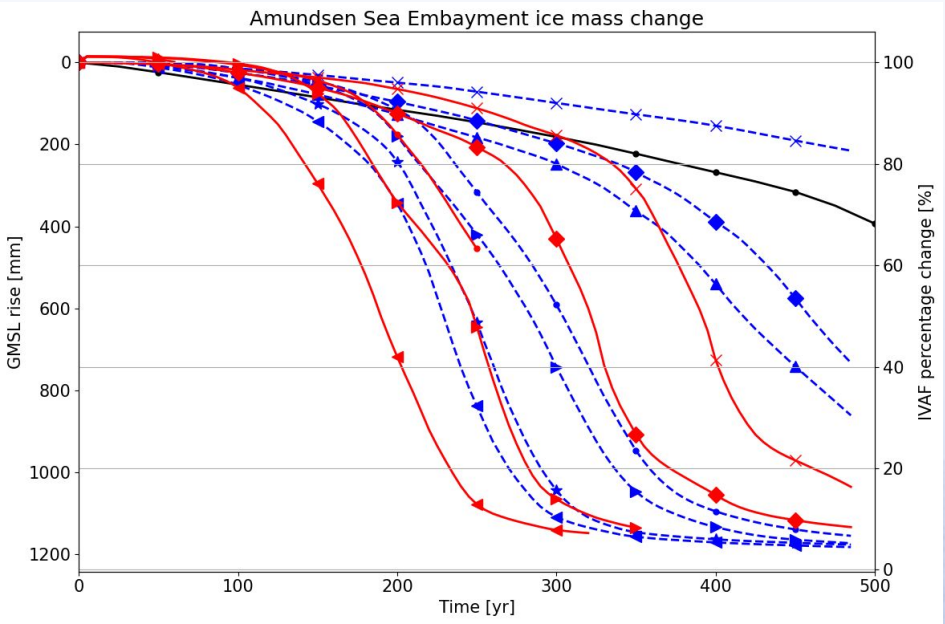


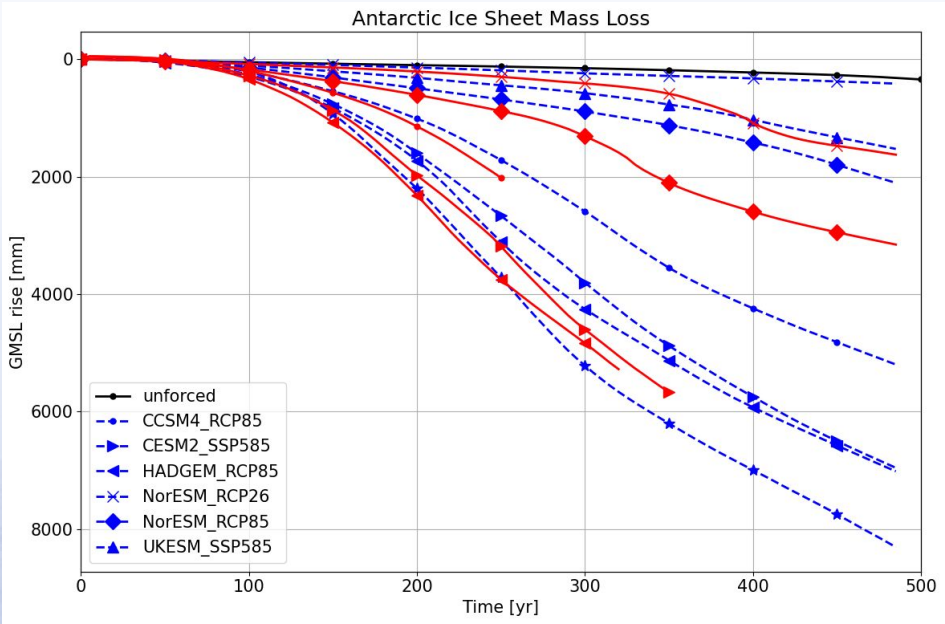


Stress based calving: typical forced simulation



Stress based calving: preliminary results





Stress Based Calving - concluding

- Mass change rates including in your initialization matter:
  - For WAIS simulations/projections
  - Less for EAIS
- Stress based calving leads to faster projected SLR (preliminary)

Thank you for your attention!

Questions?