The impact of internal variability in ocean-induced melting on Totten Glacier

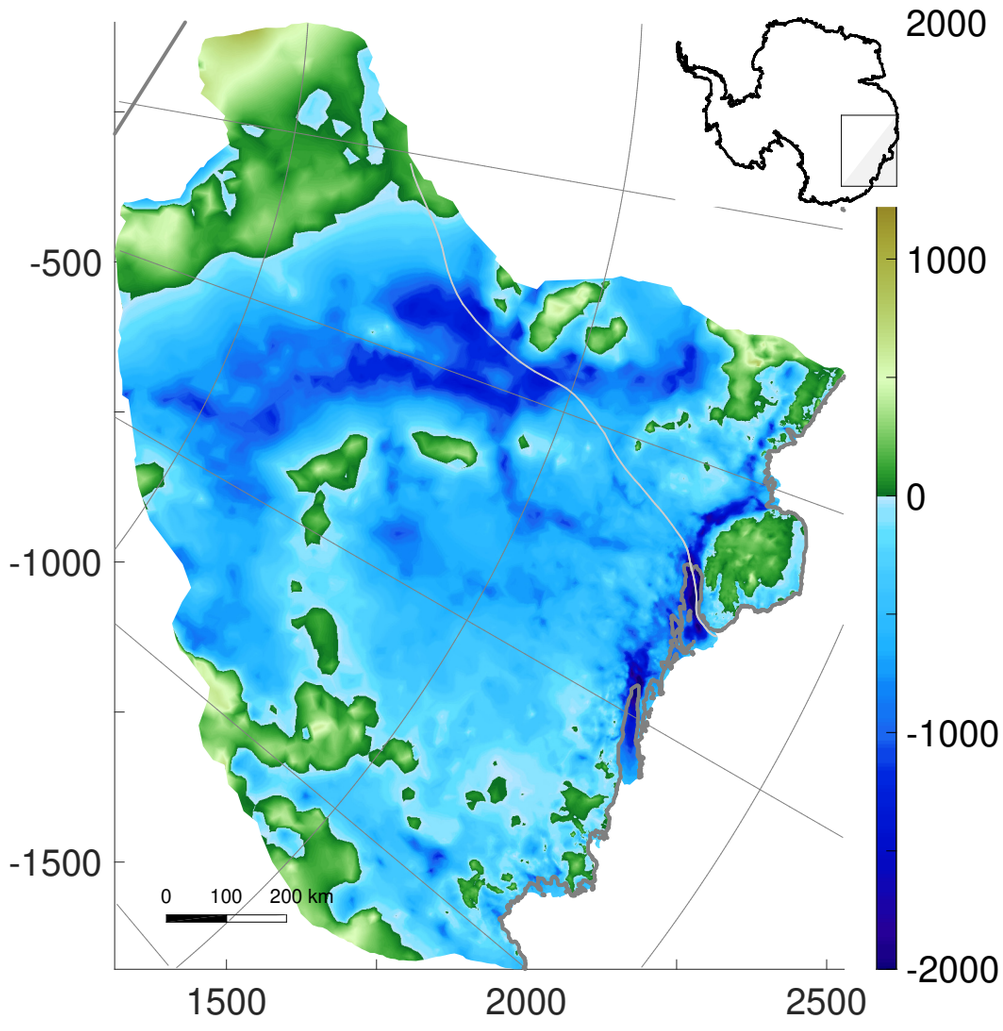
Felicity McCormack[1,2], Jason Roberts[3], David Gwyther[2], Mathieu Morlighem[4], Tyler Pelle[4]

[1]School of Earth, Atmosphere & Environment, Monash University, Victoria, Australia
felicity.mccormack@monash.edu
[2]Institute for Marine and Antarctic Studies, University of Tasmania, Tasmania, Australia
[3]Australian Antarctic Division, Tasmania, Australia
[4]Earth Systems Science, University of California, Irvine, California, USA

This research was supported under Australian Research Council's Special Research Initiative for Antarctic Gateway Partnership (Project ID SR140300001).

How does Totten Glacier respond to constant & variable ocean forcing?

Aurora Subglacial Basin domain
using the Ice Sheet System Model

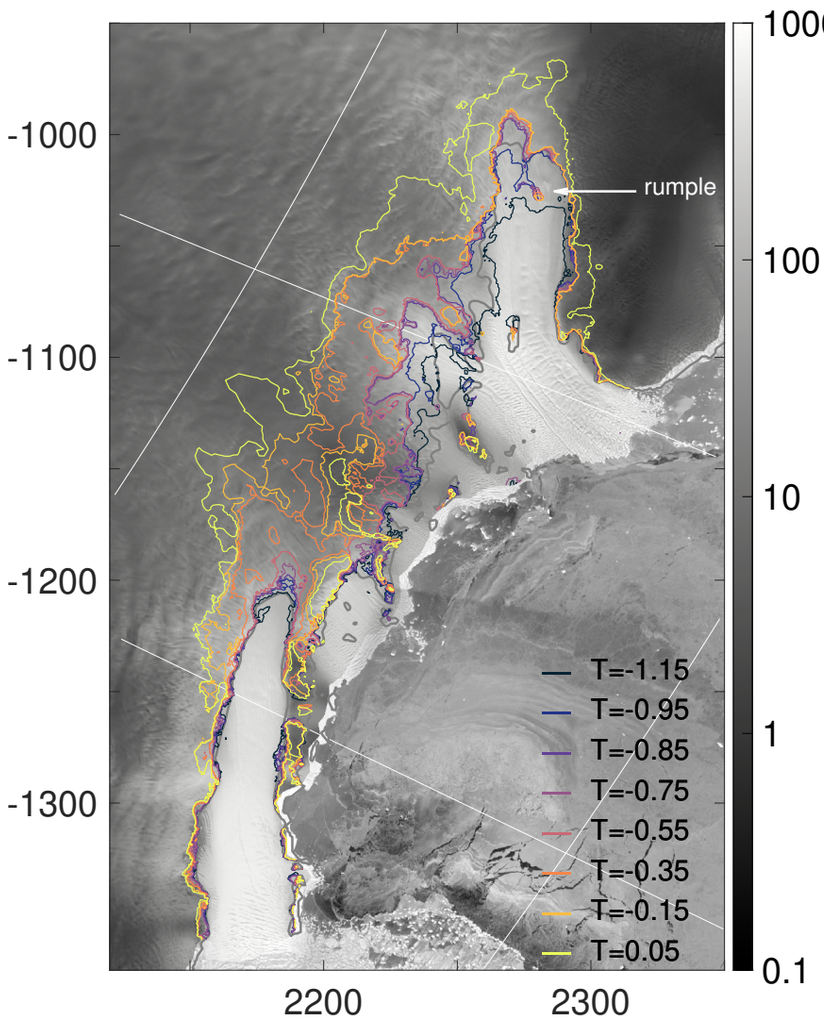


500 year simulations using ISSM with different ocean temperature forcing scenarios (PICOp parameterization):

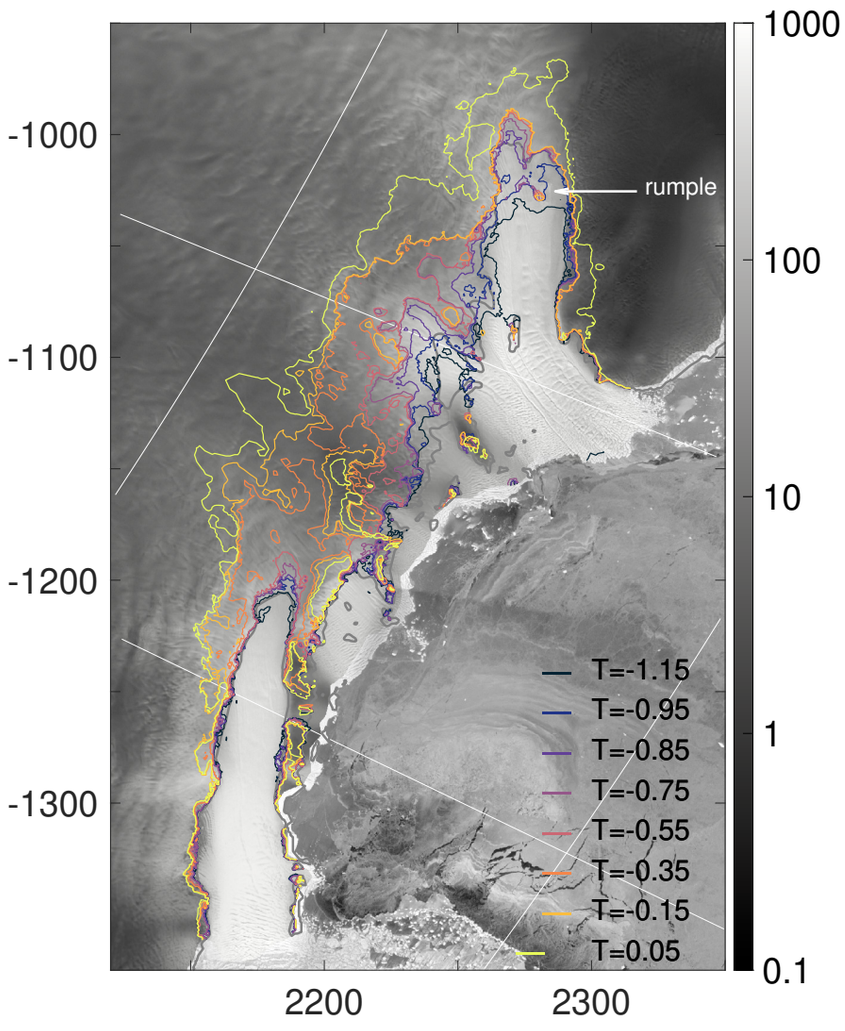
1. Mean temperatures of
   -1.15, -0.95, … 0.05 °C
   (7 scenarios)
2. Mean temperatures as above, plus variability based on ocean model output (varying magnitude of variability; 84 scenarios)

1. Final grounding line stable close to present-day position for T=-0.95°C, otherwise advance or retreat
2. Variability has stabilising effect on grounding line position for T=-0.85°C, but limited impact for simulations with large-scale advance or retreat

Constant ocean temperature forcing

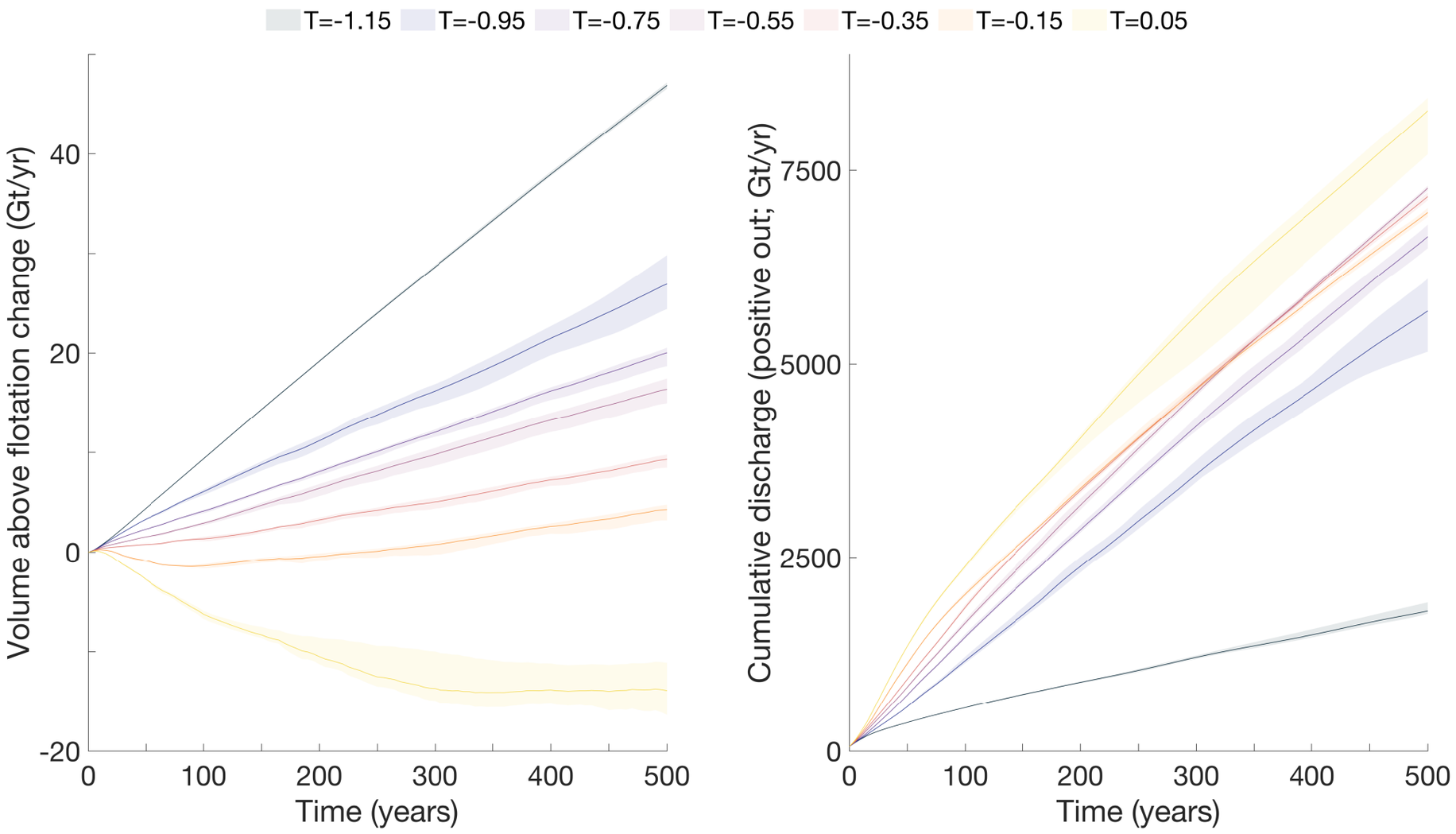


Variable ocean temperature forcing

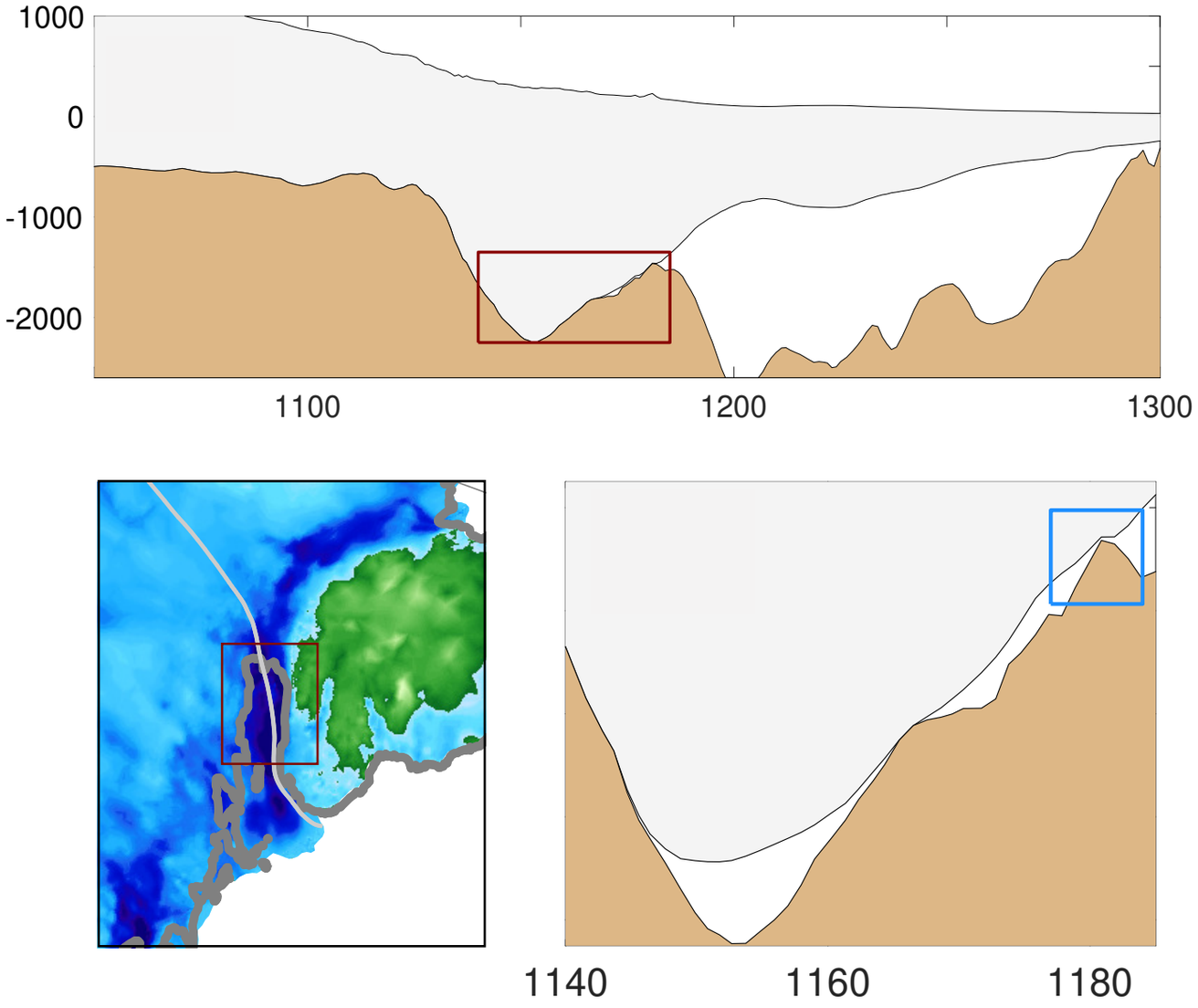


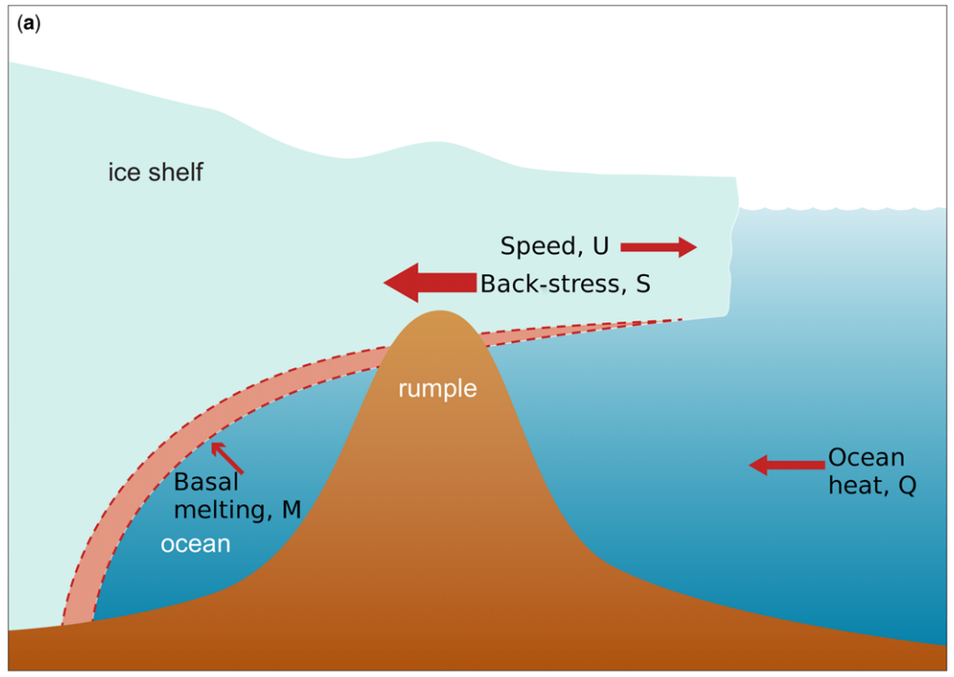
Grounding line migration more sensitive to effect of melt rate decreases than increases (Hoffman et al., 2019)

Constant background temperature plays a relatively more important role than variability in determining Totten's response to ocean forcing



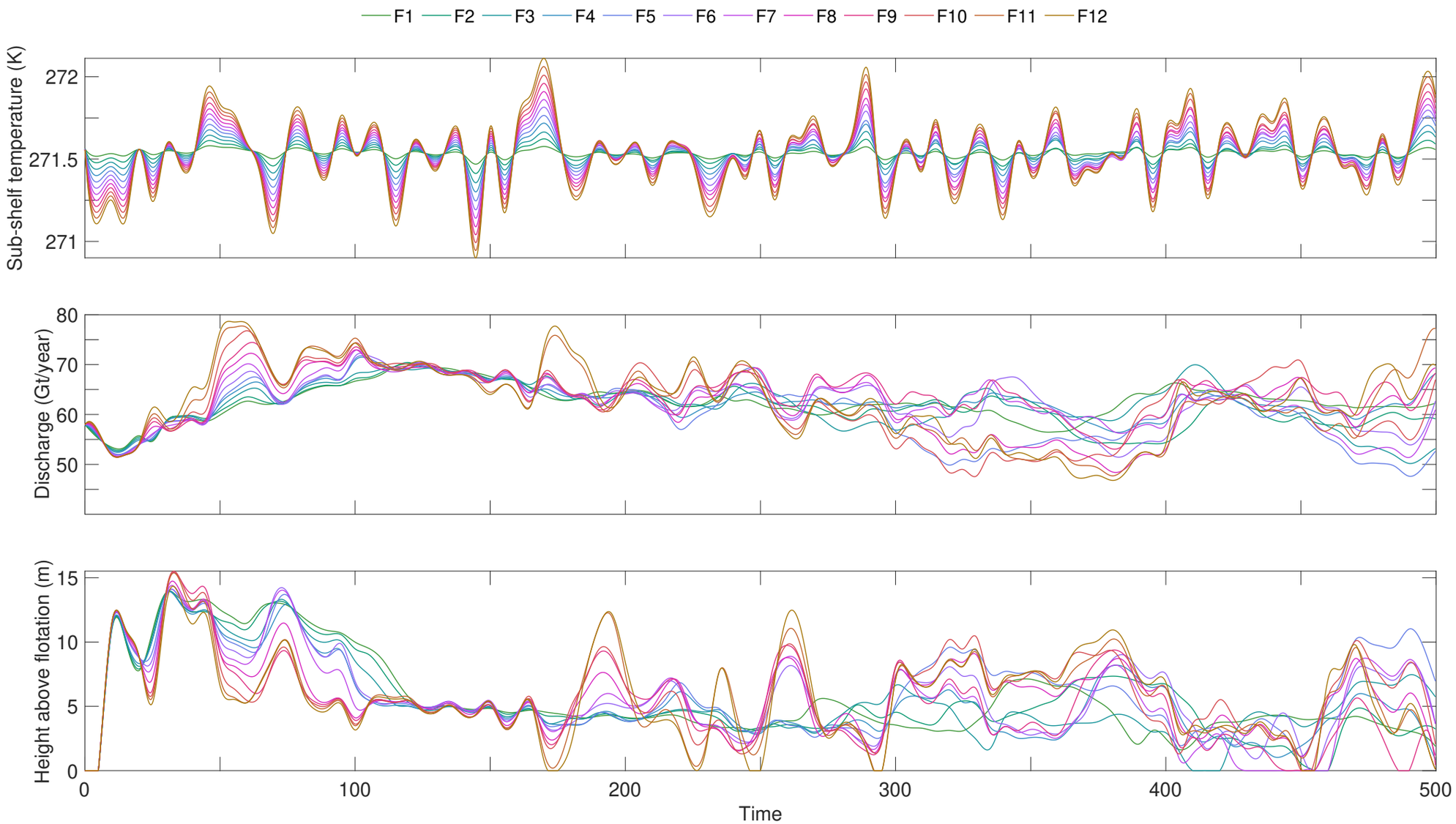
Grounding line stability in simulations with ocean temperature variability is linked to the influence of the pinning point at southern end of ice shelf





Pinning point changes back stress, with feedbacks on upstream ice speed and thickness (Roberts et al., 2017)

For variable ocean forcing simulations, nonlinear dynamics + ice shelf interaction with pinning point modify variance in ice discharge



Ice Sheet System Model (ISSM; Larour et al., 2012) of Aurora Subglacial Basin

- Shelfy-Stream Approximation (MacAyeal, 1989)
- Time stepping every 1/2 month, and ice velocity, thickness, surface, and grounding line are updated at each time step
- 114 915 anisotropic triangular elements, with maximum resolution of 1 km near grounding line
- BedMachine Antarctica bed topography (Morlighem et al., 2020)
- Constant surface mass balance and atmospheric temperature from RACMO2.3 (Lenaerts et al., 2012)
- Constant geothermal heat flux of 0.55mW/m^2
- Inversion for basal friction and ice shelf rigidity

PICOP ocean melt rate parameterisation (Pelle et al., 2019)

- Parameterises overturning circulation in ice shelf cavity
- Includes melt water plume at grounding line
- Inputs are far-field temperature and salinity near ocean base