Response of the cryosphere to ocean warming below Filchner Ronne Ice Shelf (Antarctica)

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Introduction

Projections of future ice shelf basal melting (Hellmer et al., 2012; Timmermann and Hellmer, 2013) indicate the potential of a rapidly increasing basal mass loss for the Filchner-Ronner Ice Shelf (FRIS). Those model studies assumed a steady-state ice shelf geometry. To study ice-ocean interaction in a more consistent way, the ice flow model RIMBAY has been configured in a domain that comprises the FRIS and its catchment area up to the ice divides. At the base of the model ice shelf, melt rates from the Finite-Element Sea ice–ice shelf–Ocean Model FESOM are prescribed. We use the RIMBAY thickness evolution to assess the feedback between ice thickness change and ice shelf basal melt rates in a warm-water scenario.

Acknowledgements

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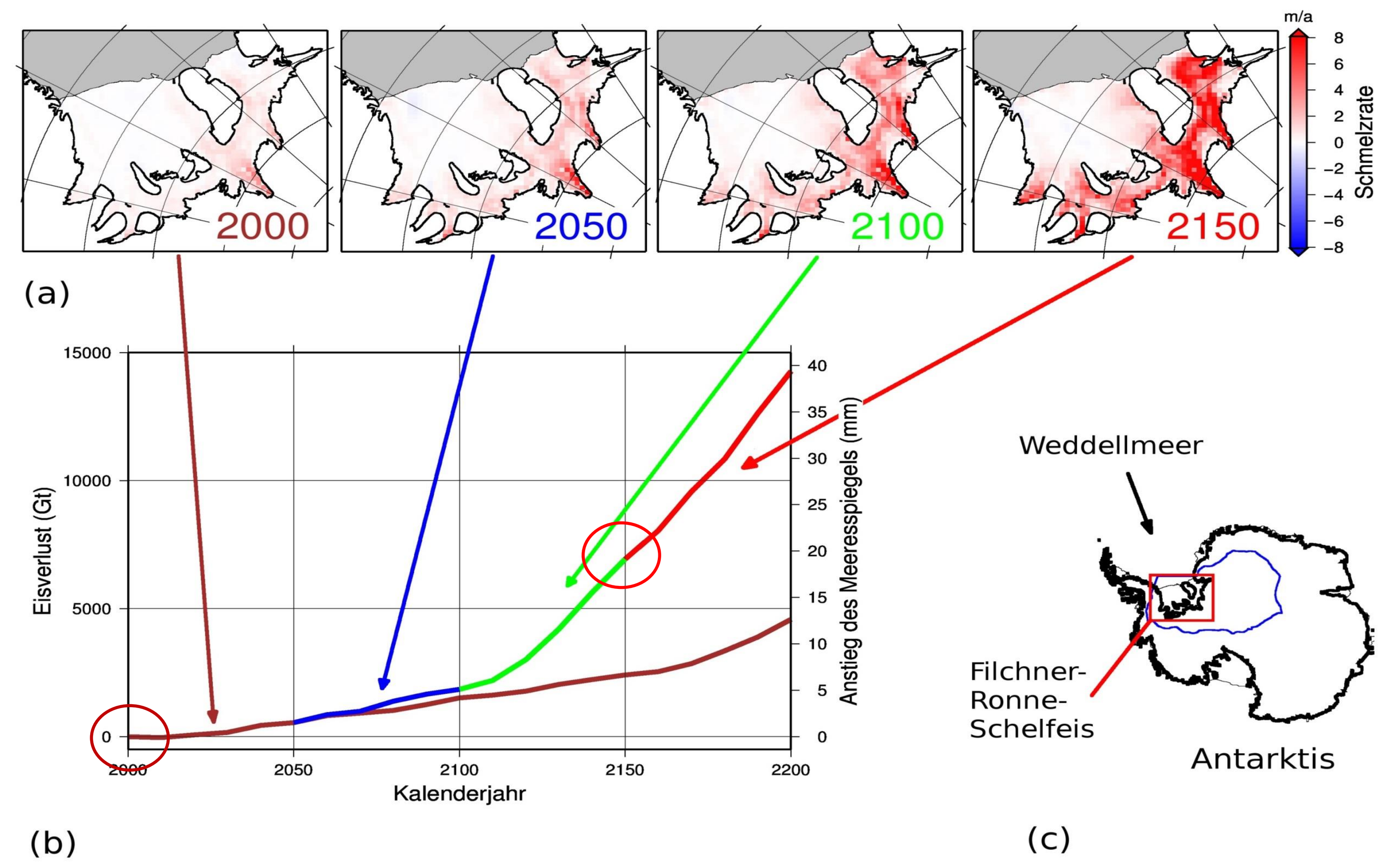
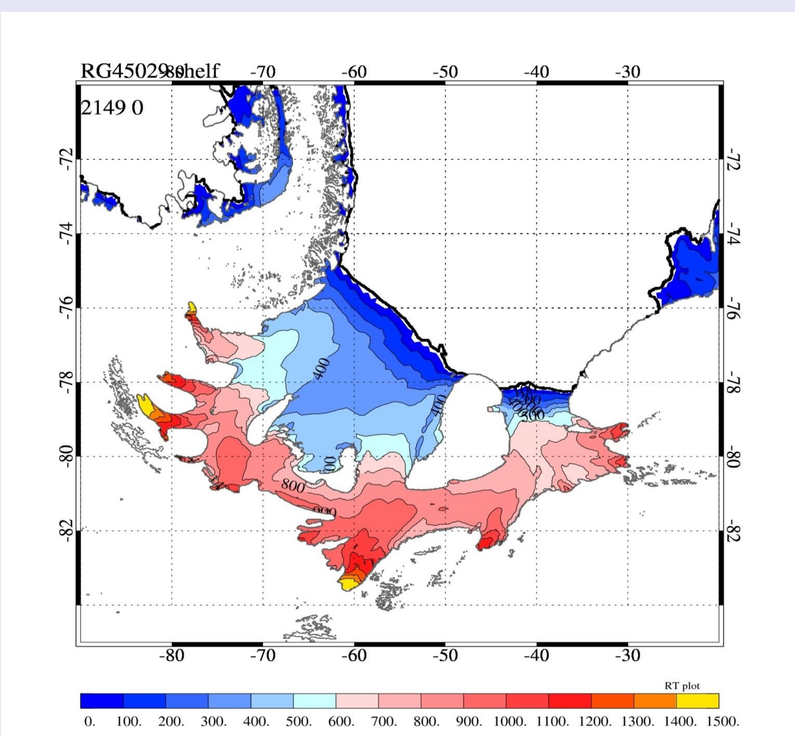
Concept: data exchange FESOM <-> RIMBAY

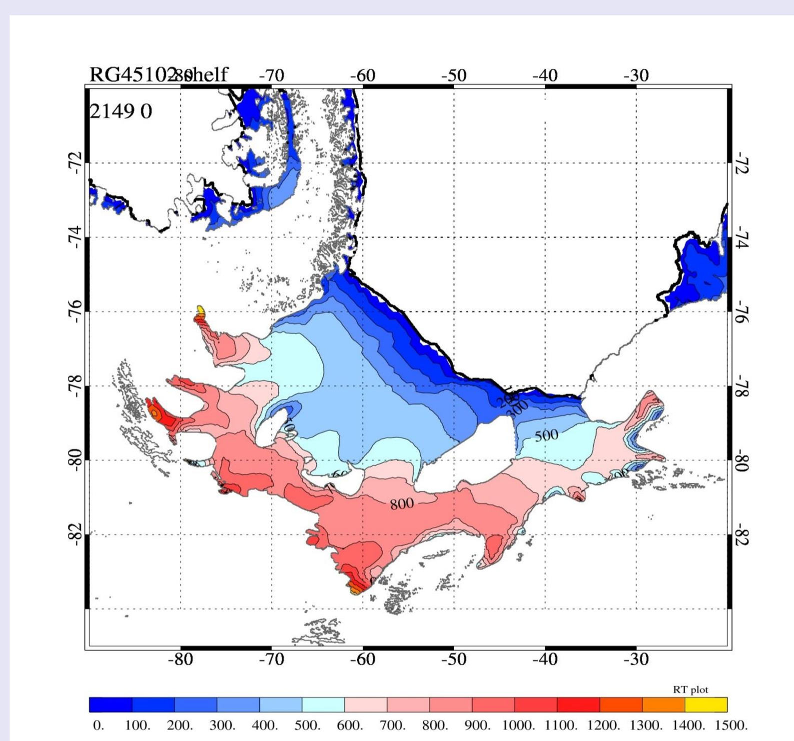


Results: Simulated ice shelf basal melt rates with

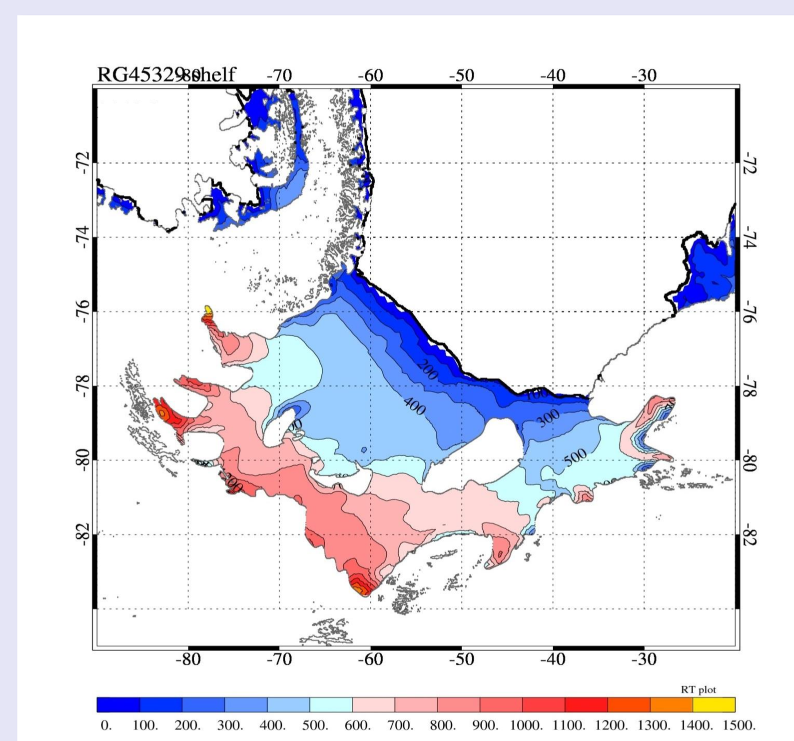
BEDMAP-2 ice draft:



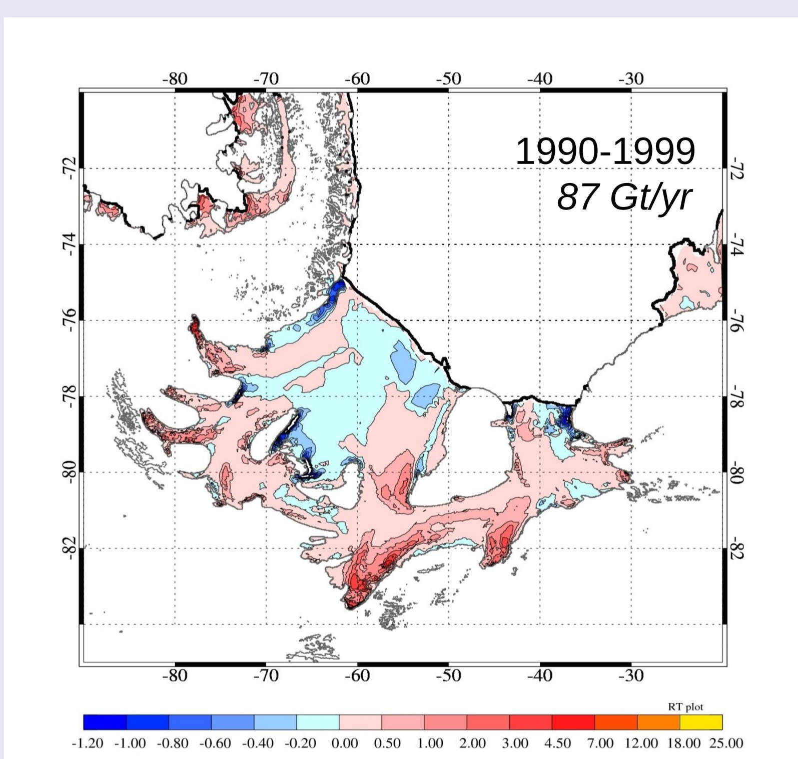
RIMBAY steady-state ice draft:



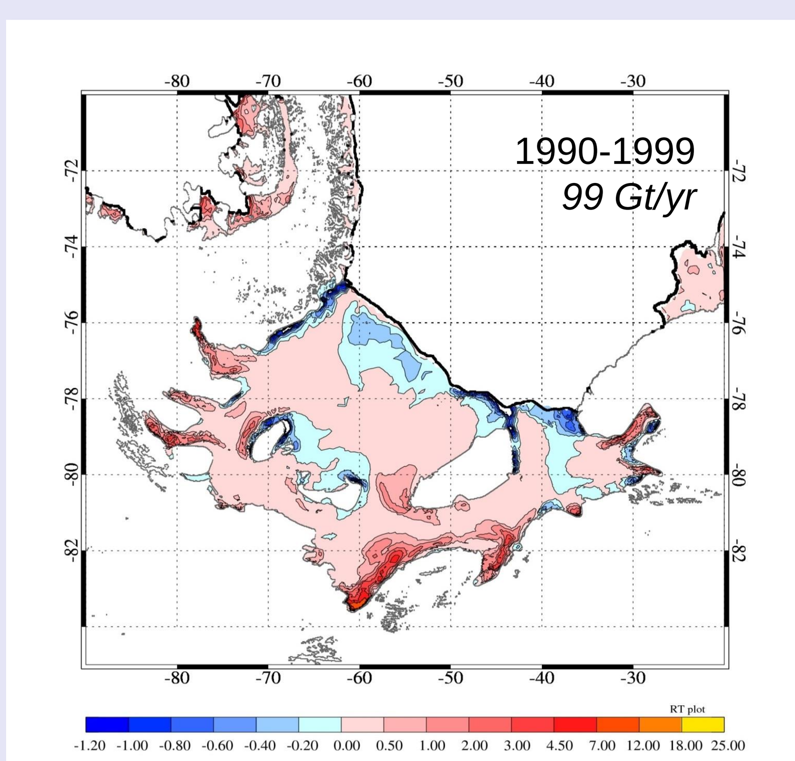
RIMBAY 2150 ice draft:



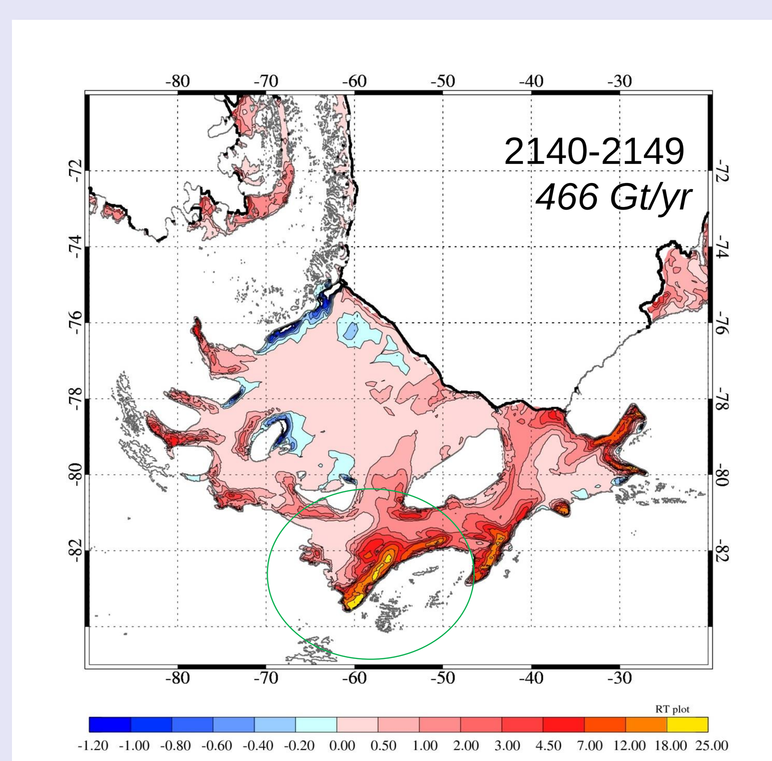
Ice draft (as seen by FESOM)



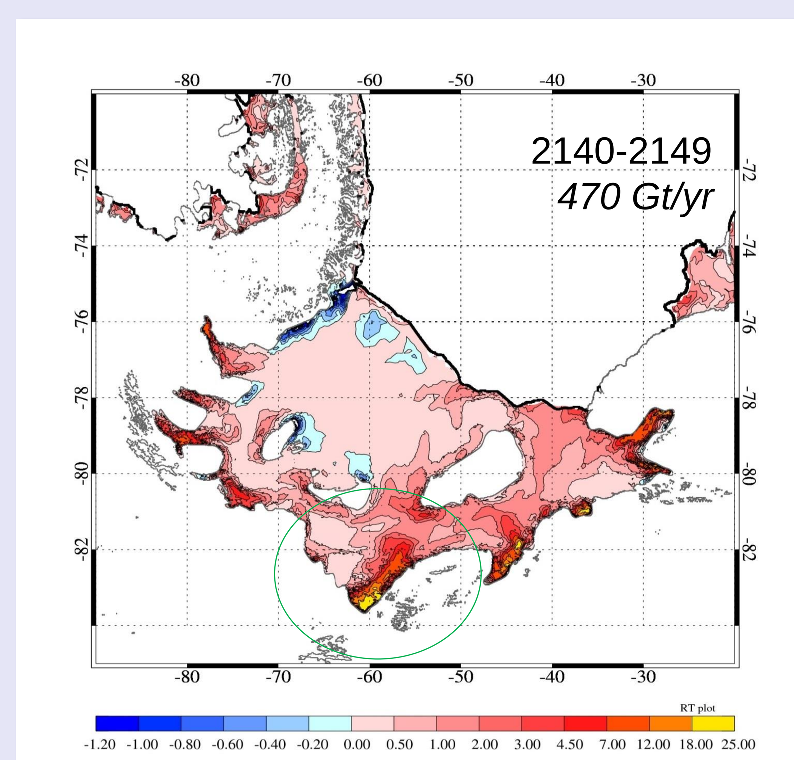
„Reference“



„Validation“



„Warm-water“



„Thickness feedback“

Ice shelf basal melt rates (m/yr)

Summary

- RIMBAY's steady-state geometry yields basal melt rates very close to those obtained with BEDMAP-2 ice draft (Validation √)
- Maximum thickness change for increased GL melting occurs **not** at the GL, but downstream (kind of obvious, once you think about it).
- Increased slope of lower ice surface fuels ice shelf pump and thus even more concentrates melting to the GL.
- **Increase of total mass loss is NOT reduced by ice shelf thickness reduction.**

Note that

- This study only adresses the sensitivity of ice shelf basal melt rate anomalies in a warm-water scenario to ice thickness changes.
- The question whether a warm water event on the Weddell Sea continental shelf is likely / unklikely / very likely is not adressed here. No feedback to deep ocean yet.
- We are coupling FESOM to a 10 km RIMBAY model now.

Appendix: Model components

Sea ice / ice shelf / ocean model

FESOM
Finite-Element Sea-ice Ocean Model

- Finite Element Sea ice-Ocean Model (FESOM; *Timmermann et al., 2012)*
- 3-equation model of ice-ocean interaction
- global domain, resolution varying from 1.5 km to 335 km; time step: 30 sec
- hybrid vertical coordinate: 36 z-levels, top 22 levels turn into sigma-levels on the Antarctic continental slope and enter the cavities
- ice and bedrock topographies: Bedmap-2/RTopo-1.5
- here: experiments initialized using time slices from coarser-scale simulation, HadCM3-A1B forcing

Ice shelf / ice sheet model

RIMBAY

- thermomechanical ice sheet / ice shelf model (Pattyn et al. / Thoma et al.)
- model domain: Filchner-Ronne Ice Shelf and its grounded ice catchment up to the ice divides
- Bedrock and initial ice thickness: Bedmap-2
- resolution: 20 km, time step: 1 yr
- forcing:
  surface accumulation, surface temperature, geothermal heat flux: present day
  basal ice shelf melting: from FESOM for 2000, 2050, 2100, and 2150
- New cavity geometries passed back to FESOM.