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Production and spreading of glacial melt water from the West Antarctic Ice Sheet

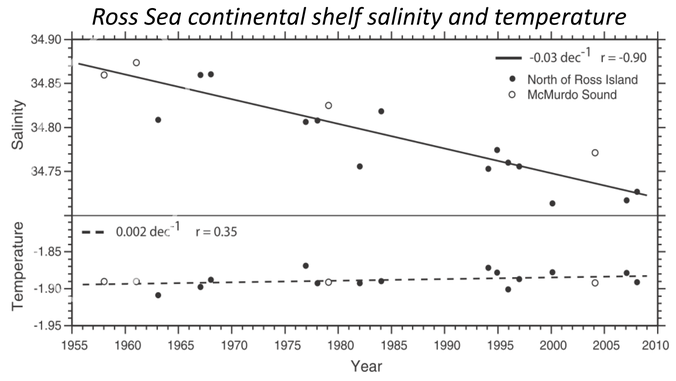
A cross-cutting project on Southern Ocean modelling and sea level rise

1. Motivation and Objectives

Rapid thinning of West Antarctic Ice Sheet (WAIS)

- Contribution to global sea level rise (~ 0.3 mm/yr)
- Freshening of shelf water locally in the Amundsen Sea and remotely in the Ross Sea (see below), which may weaken global thermohaline circulation

Ross Sea continental shelf salinity and temperature



The objective is to **simulate the input and spreading of glacial melt water from the Westantarctic Ice Sheet (WAIS)** in the Amundsen (AS) and Bellingshausen (BS) Seas

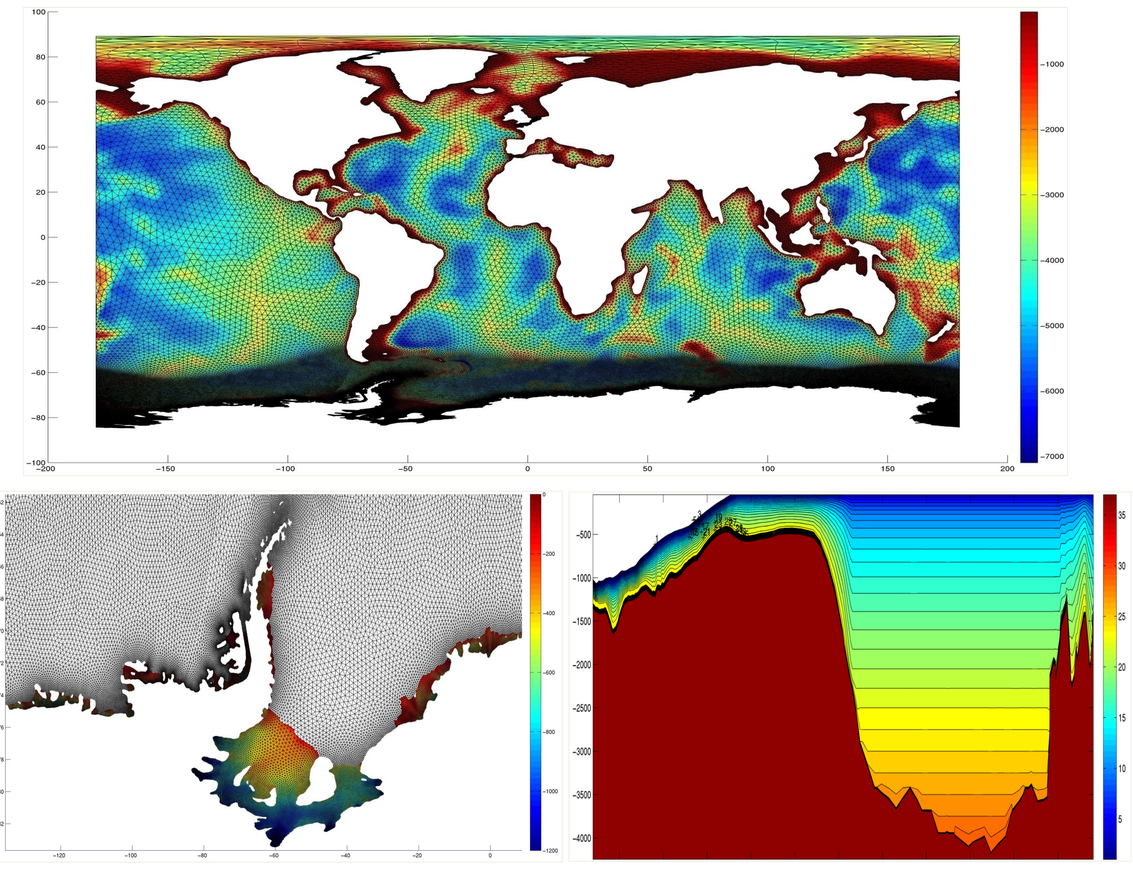
Two main difficulties

(1) obervations are scarce

(2) none of the high-resolution global models have been able to simulate realistic water mass pathways on the Amundsen Sea continental shelf so far

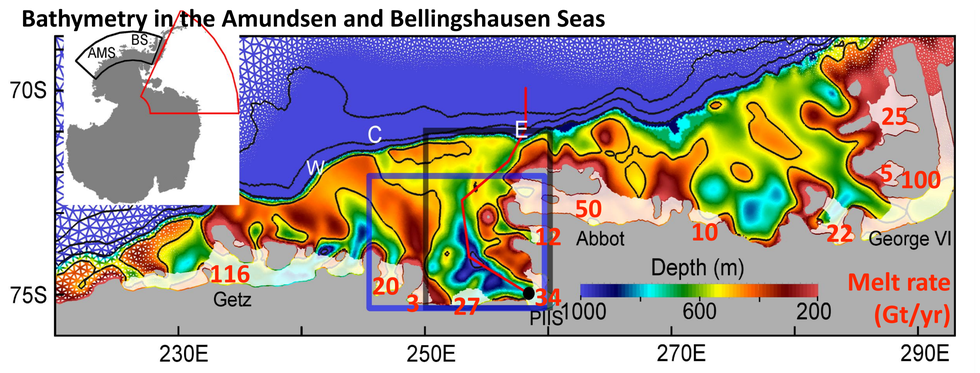
2. Model configuration

FESOM

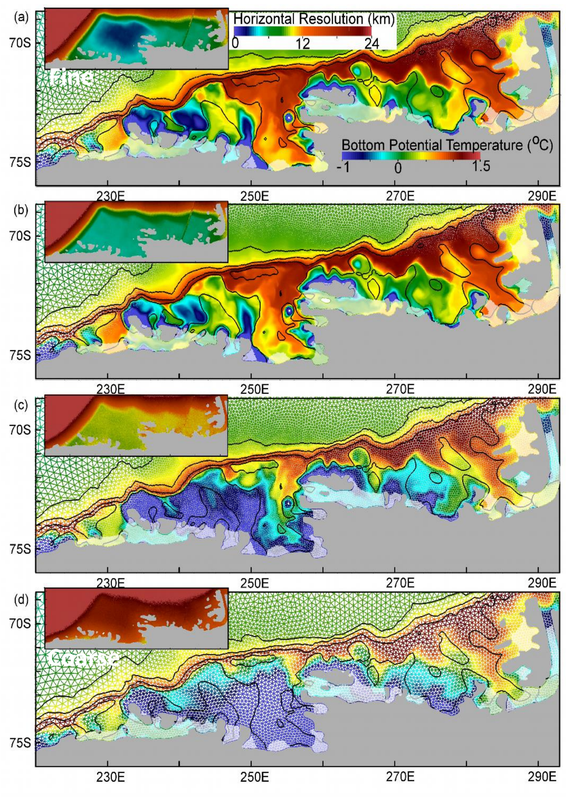


- global domain, resolution varying from 3.5 to 350 km. 1.8 million grid nodes in total.
- hybrid vertical coordiate: 41 z-levels, 21 of which turn into sigma levels on the Antarctic continental slopand enter the sub-ice cavities
- ice shelf and ocean bottom topography: RTopo-1 (*Timmermann et al., 2010*)
- requires approx 2300 CPUh per model year on 256 CPUs (with 180 sec time step)
- configurations with further refinement are even more expensive computationally
- This study: forcing with NCEP reanalysis and NCEP CFSR data

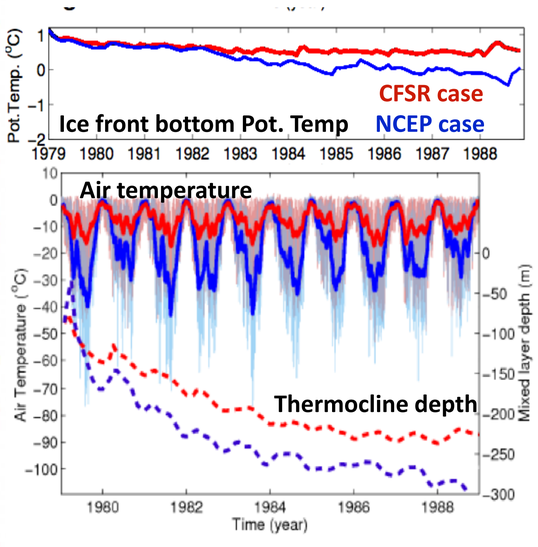
3. Resolution-dependence of simulated warm deep water intrusion on the Amundsen Sea continental shelf



- The narrow troughs (esp. along Section E) make modelling of near-bottom flow in this area very challenging. This step is key to a realistic simulation of ice sheet-ocean interaction in the Amundsen Sea.

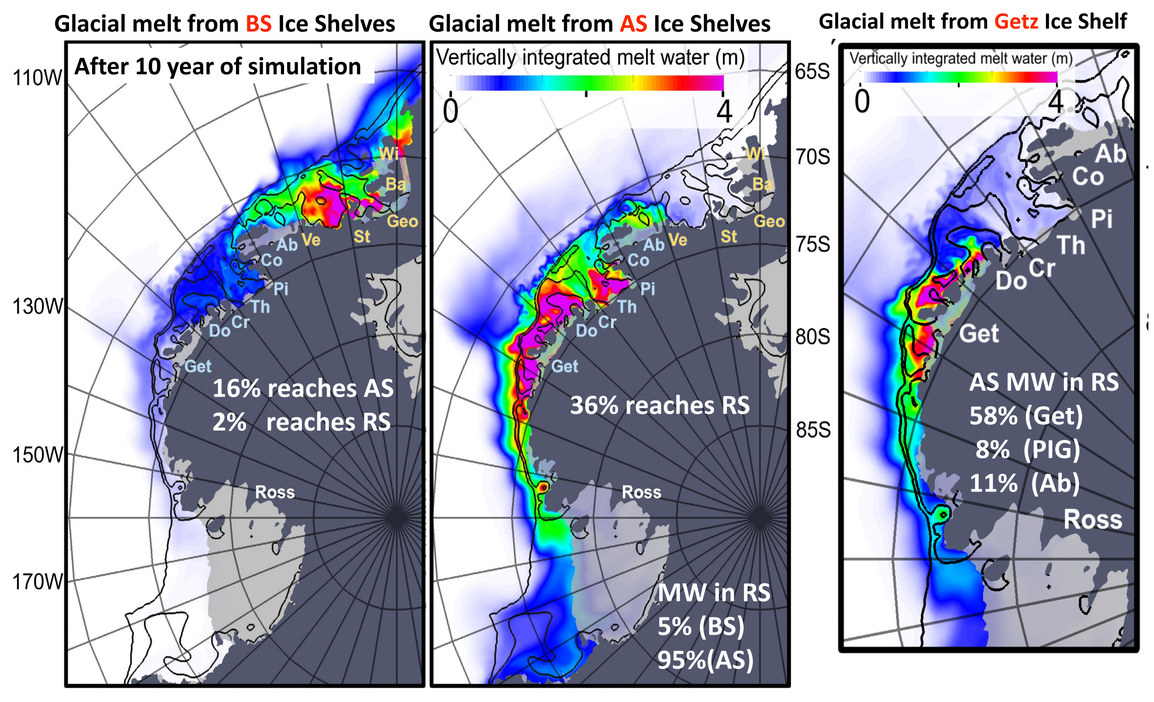


Simulated bottom temperature (large panels) and resolution (insets) for four different configurations. Bottom temperatures of 1°C are typical in the Amundsen Sea.



- A horizontal resolution of about 5 km or smaller is required over the continental shelves to simulate CDW intrusions realistically.
- A cold bias of (and with) NCEP reanalysis data (compared to NCEP-CFSR) is evident.

4. Modeling the spreading of glacial melt water from the Amundsen and Bellingshausen Seas



5. Summary

With a fine horizontal resolution (~2.5 or 5 km in the eastern Amundsen Sea) and NCEP-CFSR forcing, FESOM is able to reproduce warm deep water intrusions onto the continental shelf close the reality. Increased melting of ice shelves fringing Amundsen Sea may contribute substantially to the observed Ross Sea freshening.

Publications

Nakayama, Y., M. Schröder, and H. H. Hellmer (2013), From circumpolar deep water to the glacial meltwater plume on the eastern Amundsen Shelf, Deep Sea Res. I, 77, 50–62.

Nakayama, Y., R. Timmermann, M. Schröder, and H. H. Hellmer (2014), On the difficulty of modeling Circumpolar Deep Water intrusions onto the Amundsen Sea continental shelf, Ocean Model. 84, 26–34.

Nakayama, Y., R. Timmermann, C. Rodehacke, M. Schröder, and H. H. Hellmer (2014), Geoph. Res. Lett. 41(22), 7942-7949.