Estimating Pine Island Ice Shelf melt rates from hydrography and an ocean circulation model

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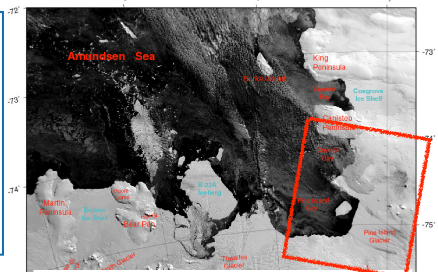
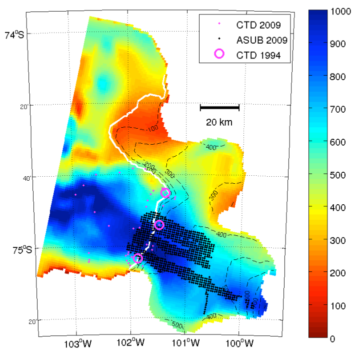
Approach

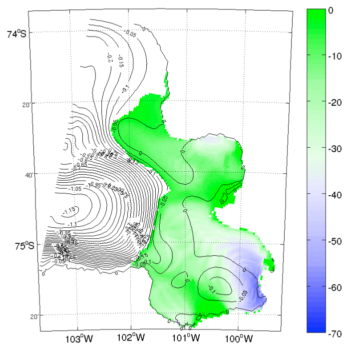
- ocean circulation model represents 3D flow in sub-ice cavities (MITgcm at 1km resolution, including thermodynamic melt rate parameterization following Losch, 2008), sub-domain with boundary conditions of Schodlok et al. (2012)
- fit model hydrography to observations from different sources: CTD, AUV (Jenkins et al. 2010, M. Schröder, unpublished data) with the help of an adjoint model based on automatic differentiation (Heimbach and Losch, 2012)
- control parameters: boundary conditions, initial conditions, melt rates, vertical mixing coefficients



Pine Island Glacier & Ice Shelf in the Amundsen Sea Embayment, West Antarctica

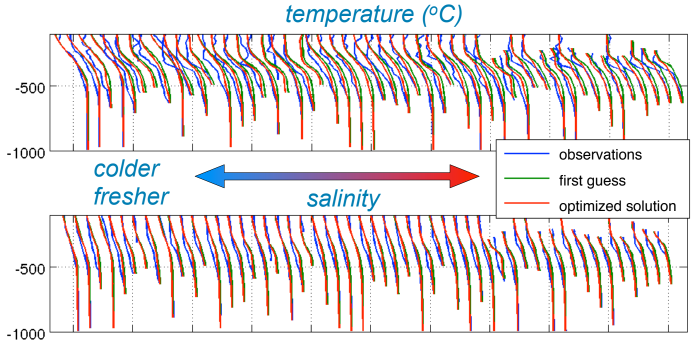


Bed rock bathymetry (color, in m) and ice shelf geometry (contours, in m) (RTOPO, Timmermann et al. 2010) of the model and data locations. The white contour indicates the ice edge.



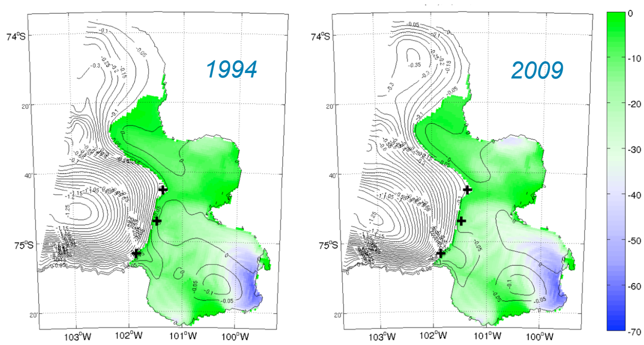
Melt rate (in color, in m/a) and vertically integrated stream function (contours, in intervals of 0.05 Sv, 1).
Mean melt rate: 17.74 m/a.

Effect of observations: Colder and fresher deep water reduces melt rate estimates

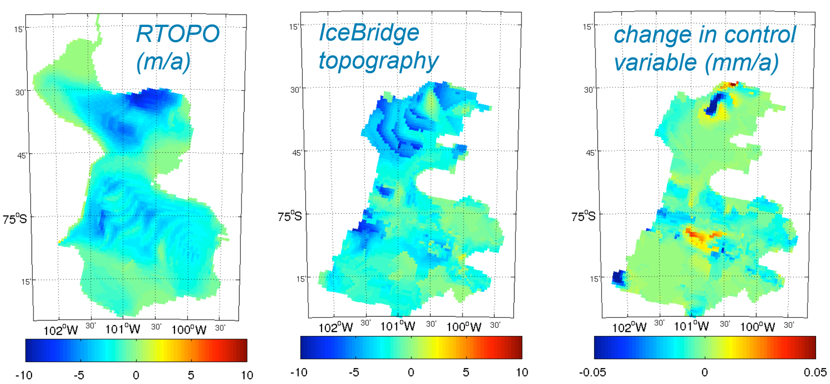


Hydrographic profiles at all available 2009-CTD locations show lower model temperatures and salinity after fit to observations. Melt rates reduce from 19.80 m/a (108.05 Gt/a) to 17.74 m/a (96.78 Gt/a) (RTOPO) from 26.52 m/a (121.30 Gt/a) to 24.28 m/a (111.02 Gt/a) (IceBridge) from 18.07 m/a (98.58 Gt/a) to 15.19 m/a (82.89 Gt/a) (different melt rate parameterisation)

1994 CTD data and effect of sparse data



Preliminary results: With very few observations (crosses mark 3 hydrographic casts) we estimate different mean melt rates (15.44 m/a in 1994, 19.10 m/a in 2009), although the strength of the circulation does not change much.



Difference maps of melt rates (m/a) after fit to observations. The melt rate control variable contribution (right panel, in mm/a, net melt rate is only 26.5 kg/a) is orders of magnitude smaller than the temperature effect due to colder open boundary values.

Results and Conclusions

- initial model simulation is too warm compared to 2009 data
- fit to observations reduces melt rates below previous estimates of, e.g., Schodlok et al. (2012), Rignot et al. (2008)
- melt rates are lower after fit to 1994 data than to 2009 data

References

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