Melt rate sensitivities underneath Pine Island Ice Shelf derived from an adjoint general circulation model

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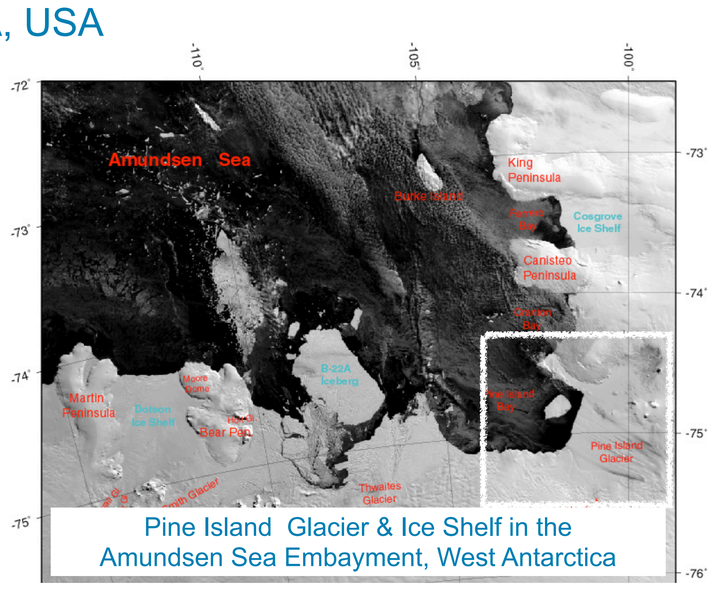
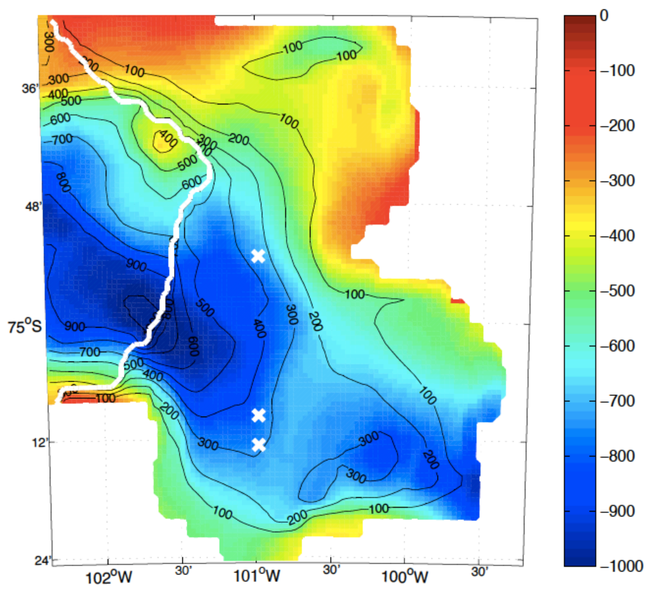
Approach

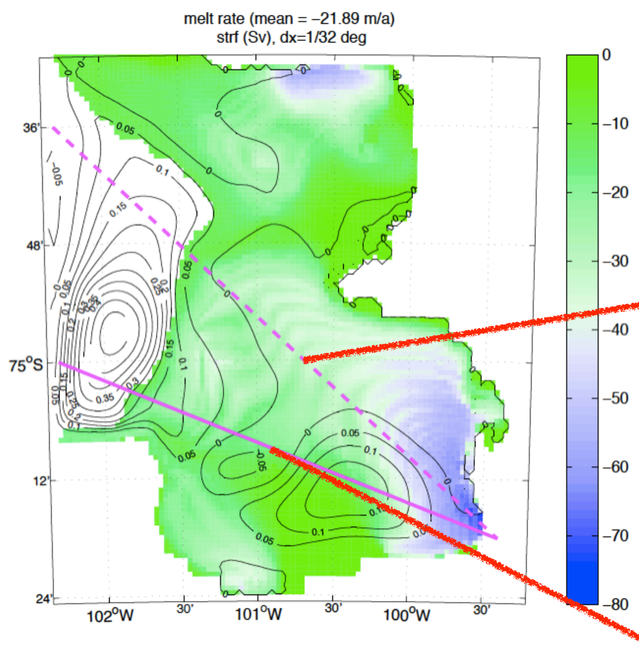
- ocean circulation model represents 3D flow in sub-ice cavities (MITgcm), geometry: RTOPO
- adjoint model based on automatic differentiation, integration backward in time
- derivatives of meltrates with respect to model variables are stored during integration



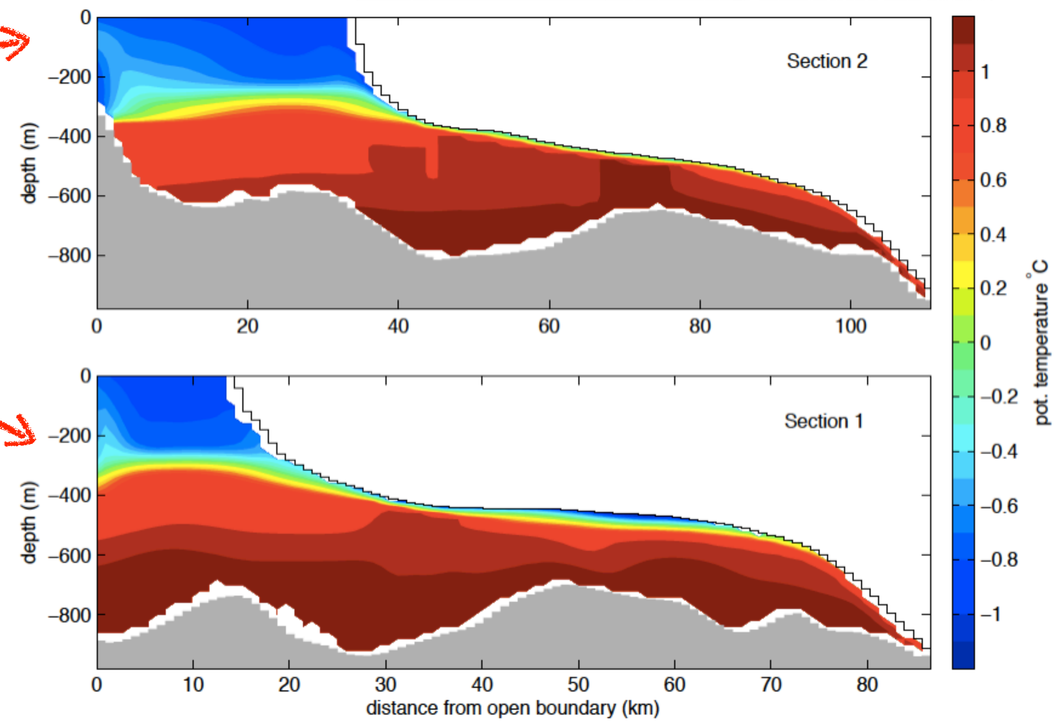
Pine Island Glacier & Ice Shelf in the Amundsen Sea Embayment, West Antarctica



Bed rock bathymetry (color, in meters), and water column thickness (contours, meters) (Timmermann et al. 2010) of the 900±30 m horizontal resolution model. The white contour indicates the ice edge.

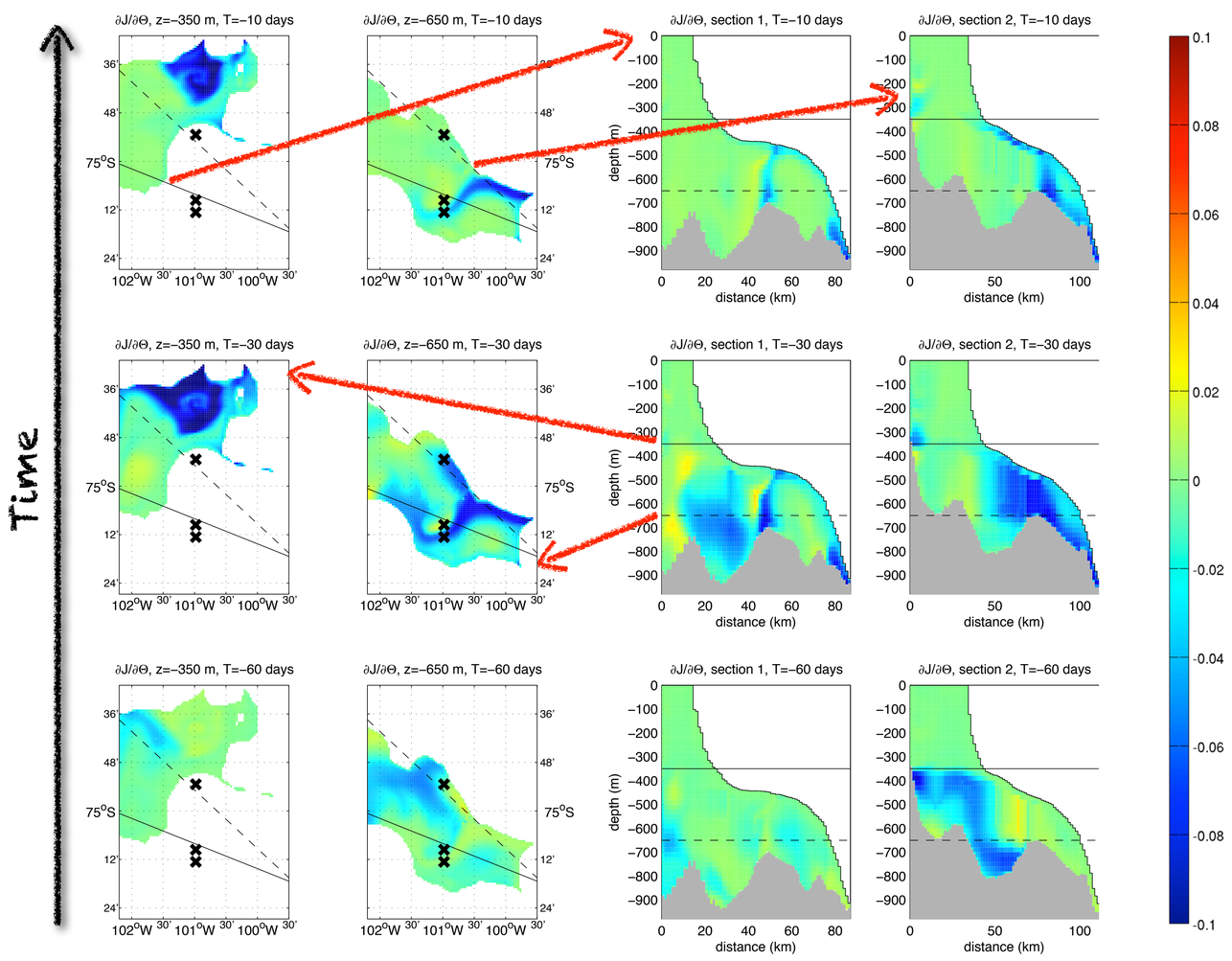


Mean melt rate (in color, in m/a) and vertically integrated stream function (contours, in intervals of 0.05 Sv, 1). The cyan lines show the location of Section 1 (solid) and Section 2 (dashed).



Potential temperature section along dashed (top) and dotted (lines) (in ˚C)

Sensitivity of mean meltrate to ocean temperature



Horizontal (left) and vertical (right) slices of adjoint sensitivities $\delta_* T = (\partial(\text{melt rate})/\partial T)^T$ at $t = \tau_f$ −10 days (top) , −30 days (middle) , and −60 days (bottom) (backwards in time)

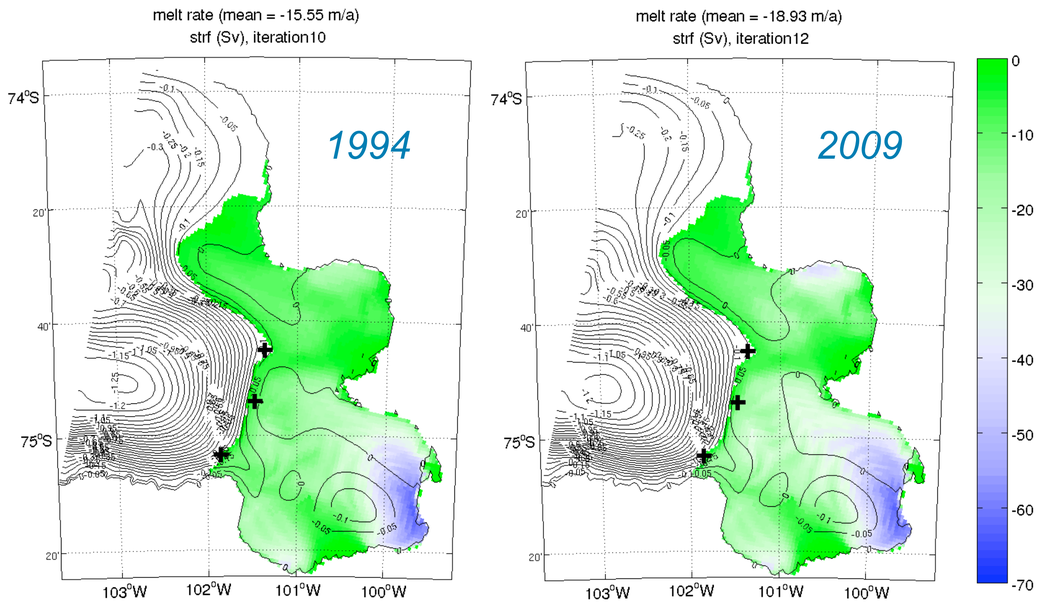
Results and Conclusions

Adjoint sensitivies reveal

- time scales of 30-60 days
- three dimensional flow patterns that evolve with time
- implications for observations and monitoring

➡ use this information to guide observational campaigns

Outlook: optimizations with in-situ data



Preliminary results: With very few observations (crosses mark 3 hydrographic casts, data compiled by P. Dutrieux, BAS) and incomplete optimizations we estimate different mean melt rates.

References

- Heimbach, P. and M. Losch, 2011: Adjoint sensitivities of sub-ice shelf melt rates to ocean circulation under Pine Island Ice Shelf, West Antarctica. Annals Glaciol., in press.
- Losch, M., 2008: Modeling ice shelf cavities in a z coordinate ocean general circulation model, J. Geophys. Res., 113, C08043, doi:10.1029/2007JC004368
- RTOPO: Timmermann, R. et al., 2010: A Consistent Data Set of Antarctic Ice Sheet Topography, Cavity Geometry, and Global Bathymetry. Earth Syst. Sci. Data, 2(2), 261-273, doi:10.5194/essd-2-261-2010

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