ArcTrain

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Investigating Arctic sea ice properties with an adjoint model

Introduction

An adjoint model computes the sensitivities of a certain scalar cost function to all model variables in a single model integration. We use this powerful tool to investigate the behavior of sea ice. On this footing we hope to improve our sea ice model and contribute to closing the gap between current model results and observations of the Arctic.

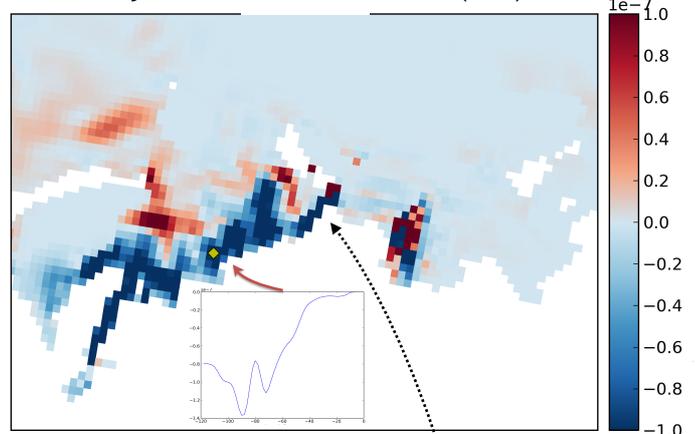**ice concentration (color shading), mean thickness (contour lines), ice drift field**

modeled ice distribution in January
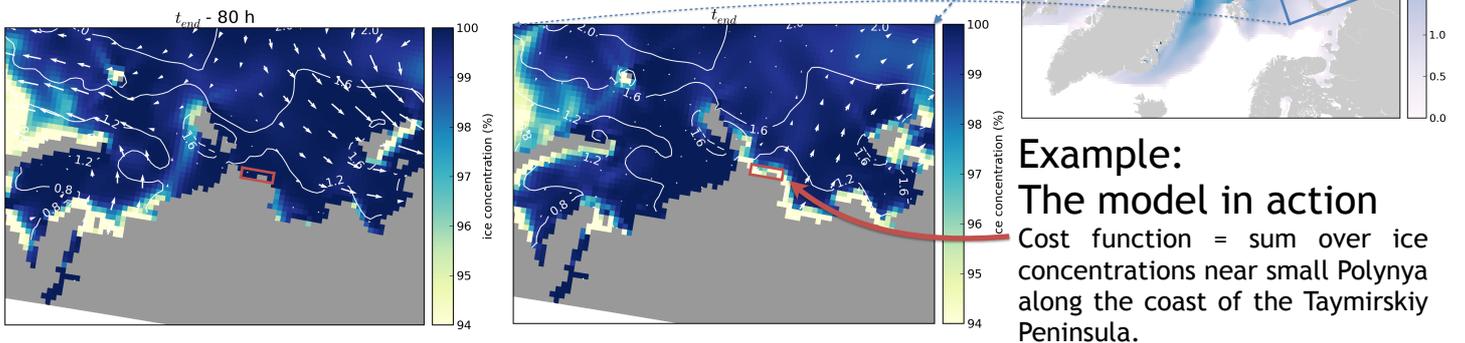
Example:
The model in action

Cost function = sum over ice concentrations near small Polynya along the coast of the Taymirskiy Peninsula.

### Sensitivity to v-wind speed at t(end) - 60h
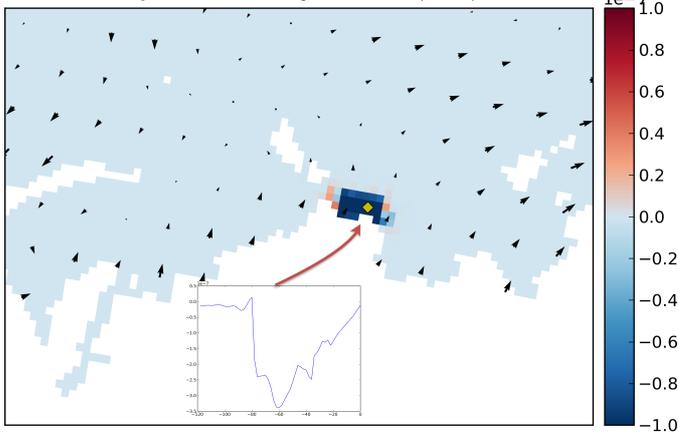
Sensitivity to ice concentration at t(end) - 100h

The sensitivity to wind stress is local (offshore wind increases concentration), but sensitivities to ice concentration are non-local. These far-field negative sensitivities can be explained by possible blocking of the *Vilkitsky Strait*.

Technical details

Often the adjoint of the non-linear sea ice dynamics solver is approximated [1]. Doing so can introduce considerable errors in the adjoint solution, especially in zones of strong convergence.

ice state at t(end) - 120h	approximate adjoint	full adjoint of solver
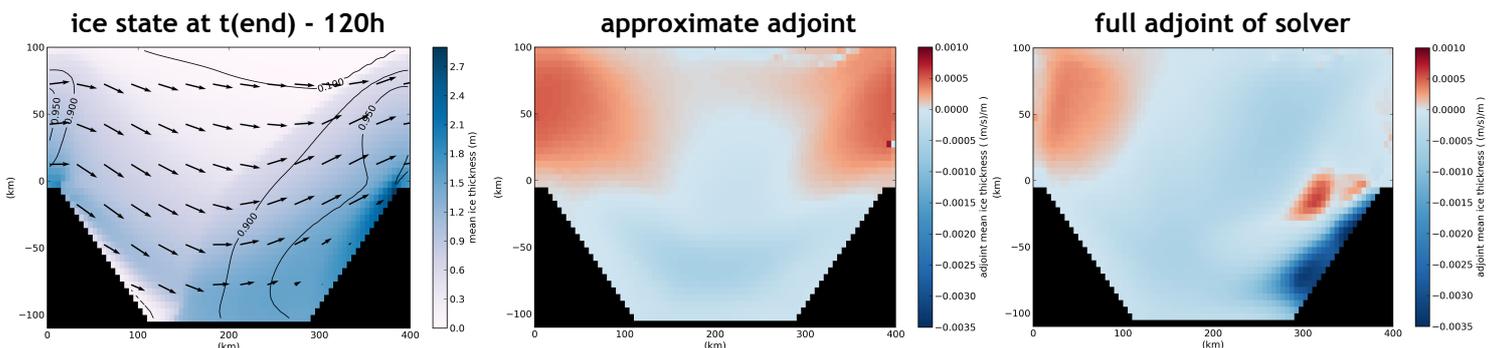
References
[1] Ian Fenty and Patrick Heimbach, 2013: Coupled Sea Ice-Ocean-State Estimation in the Labrador Sea and Baffin Bay. *J. Phys. Oceanogr.*, **43**, 884-904, doi: http://dx.doi.org/10.1175/JPO-D-12-065.1