Assimilation of range-and-depth-averaged sound speed in Fram Strait

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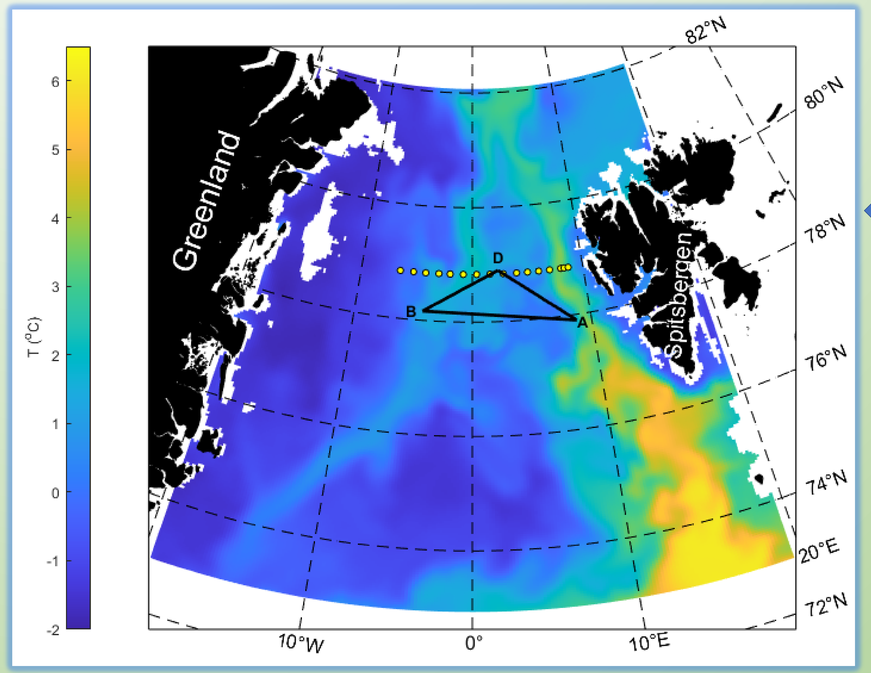
Summary

Acoustic thermometry measurements of ocean sound speed were used to improve state estimates of ocean temperature in Fram Strait. **This is the first time that large-scale acoustic measurements have been assimilated into an ocean model in the Arctic.** From September 2010 to July 2012 the Acoustic Technology for Observing the Interior of the Arctic Ocean (ACOBAR) experiment measured acoustic travel times between Greenland and Spitsbergen. The measurements were inverted to yield time series of range-and-depth-averaged ocean sound speed for 0-1000 m ocean depth.

The ocean sound speed time series was assimilated into a regional numerical ocean model using the Massachusetts Institute of Technology General Circulation Model-Estimating the Circulation and Climate of the Ocean four-dimensional variational (MITgcm-ECCO 4DVAR) assimilation system.

The data assimilation improved the range-and-depth-averaged ocean temperatures at the independent 78°50'N oceanographic mooring section in Fram Strait (0-1000 m depth). The RMS error of the ocean state estimate (0.21°C) was comparable to the uncertainty of the interpolated mooring section (0.23°C). The lack of depth information in the assimilated ocean sound speed measurements caused an increased temperature bias at shallow depths (0-200 m). The temporal correlations with the mooring section were not improved because short-term variations in the mooring measurements and the ocean state estimate did not coincide in time. This was likely due to the small-scale eddying and non-linearity of the ocean circulation in Fram Strait. Furthermore, the horizontal resolution of the state estimate (4.5 km) was eddy-permitting, rather than eddy resolving. Therefore, the state estimate could not represent the full ocean dynamics of the region. **This study demonstrates the usefulness of large-scale acoustic measurements for improving ocean state estimates at high latitudes.**



Model area in Fram Strait between Greenland and Spitsbergen

Black triangle: acoustic tomography sections between 3 acoustic moorings A, B and D. The sections are 167-301 km long.

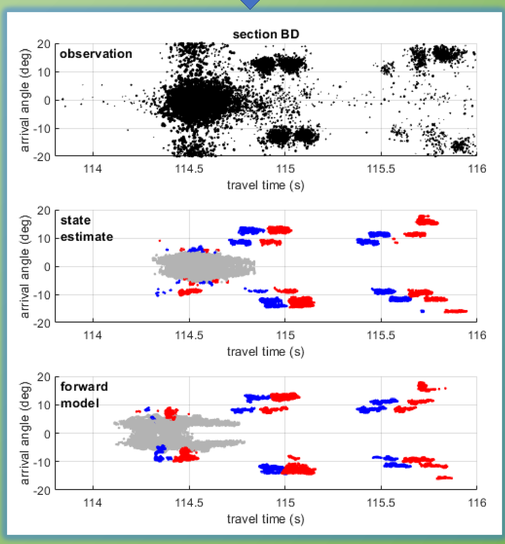
Yellow circles: Oceanographic mooring section at 78°50'N used for model evaluation

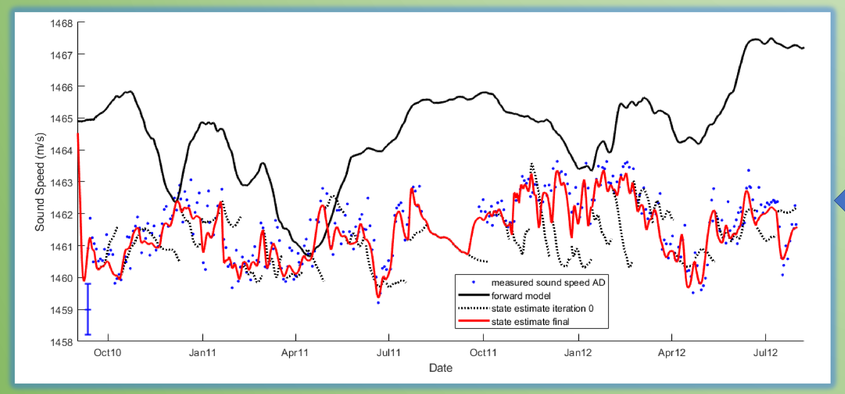
Color map: temperature snapshot of ocean state estimate at 95 m depth for June 19, 2011. Horizontal model resolution 4,5 km, 52 vertical z-levels

Acoustic evaluation of ocean state estimate

Comparison of observed acoustic arrival structure to simulated acoustic arrivals obtained by acoustic ray modelling on ocean model fields from forward model and ocean state estimate

Early arrivals in state estimate improved compared to forward model

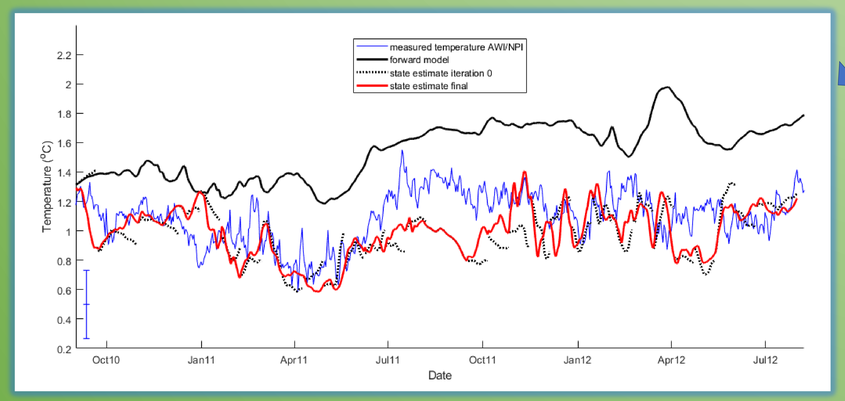




Oceanographic evaluation

Upper panel: Evaluation of ocean state estimate against assimilated data. Measured ocean sound speed at acoustic tomography section A-D compared to forward model and ocean state estimate.

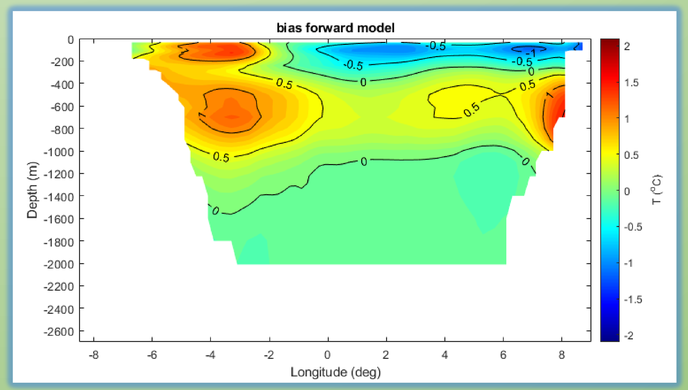
Lower panel: Evaluation of ocean state estimate against independent data. Interpolated ocean temperature from oceanographic mooring section at 78°50'N compared to forward model and ocean state estimate.

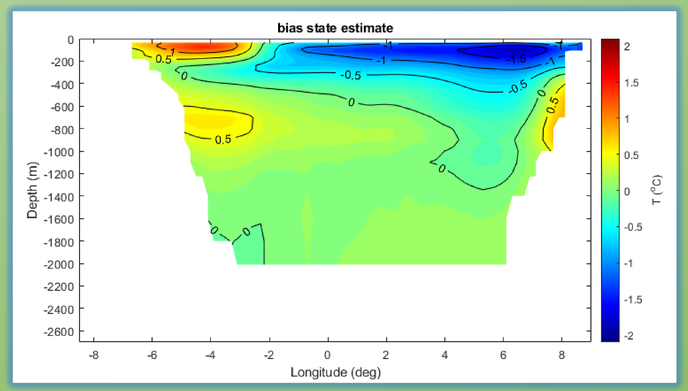


Effect of data assimilation

Upper panel: Temperature bias of forward model (without data assimilation) compared to interpolated oceanographic mooring section at 78°50'N

Lower panel: Temperature bias of ocean state estimate (with data assimilation) compared to interpolated oceanographic mooring section at 78°50'N





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