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The Fram Strait tomography system for ocean model validation, assimilation and inversion

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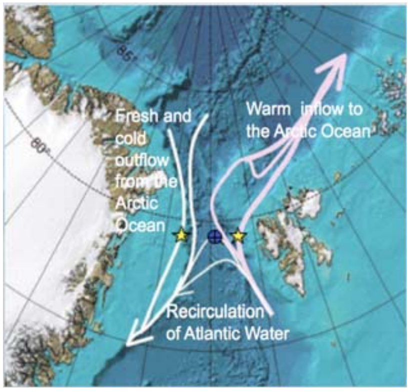
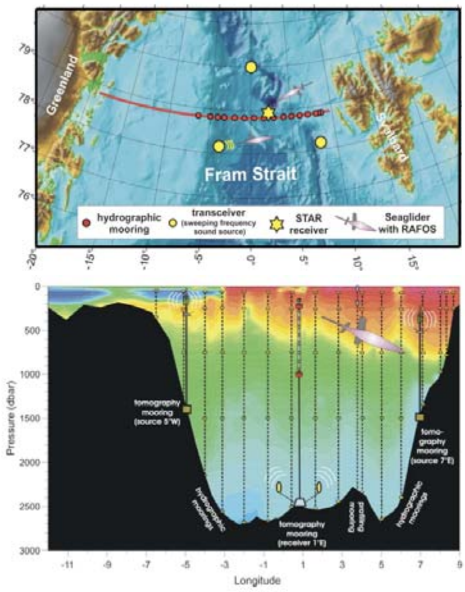
The Fram Strait

The Fram Strait is the main passage through which the ocean mass and heat exchange between the Atlantic and Arctic Ocean takes place.



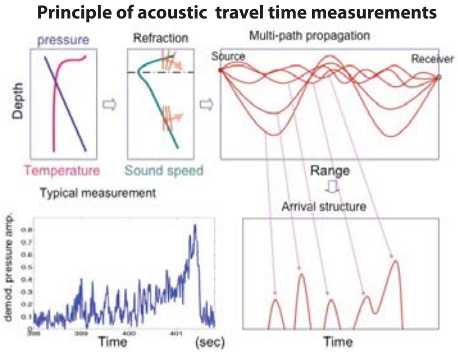
On the eastern side of the strait the West Spitzbergen Current (WSC) transports Atlantic water to the Arctic Ocean, whereas on the western side the southbound East Greenland Current (EGC) transports sea ice and polar water from the Arctic Ocean, to the Nordic Seas and the Atlantic Ocean.The topographic structure of the strait causes a splitting of the WSC into at least three branches, of which one recirculates between 78 N - 80 N.

The Fram Strait Ocean Observatory



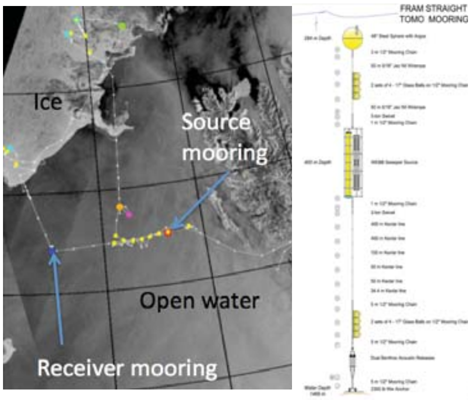
A section of oceanographic moorings (red dosts) across the Fram Strait was establish in 1997 to monitor the ocean volume and heat fluxes through the strait. Estimates of the transports over 9 years (1997-2006) indicate a mean northward transport of 12 Sv (1 Sv = 106 m3/s) (WSC), and a southward transport of 14 Sv (EGC). The spatial resolution of the moorings, which varies from 10 to 30 km, is not sufficient to resolve the meso-scale variability and estimate the volume and heat transport by the recirculation current. Therefore, the transports have significant uncertainty e.g. 40 % in the WSC and above 100 % for the EGC.

Principle of acoustic travel time measurements



Objective

The goal is combine observations from acoustic tomography, gliders and oceanographic moorings with ice-ocean models through data assimilation to determine the volume and heat fluxes with better accuracy and more cost-effectively than the present stand alone array of standard oceanographic moorings.

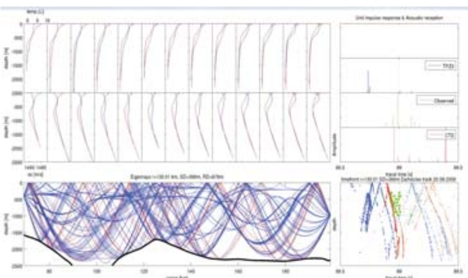


As a first step a single track acoustic thermometry experiment was successfully carried out from 2008 to 2009 in the Fram Strait under the DAMOCLES project. During the experiment the sourc produced a 60 s long frequency sweep from 190 Hz to 270 Hz every 3 hour . The ssignal was received at a 686 m long aperture vertical array with 8 individual hydrophones space by 96 m. Source and receiver mooring was separated by 130.01 km

Advanced instrumentation is used to control the source transmission and the acoustic receptions. The STAR serves 4 hydrophones and are equipped with modem interface, and is also integrated into the Webb source. The STAR provides a precise clock, using a two-oscillator system (MCXO plus Rubidium) with precision/stability better than 3 ms over a year. Four acoustic transponders surrounding each mooring provide a long-baseline acoustic navigation system to measure the position source/receiver at a accuracy of 0.5 - 1 m.

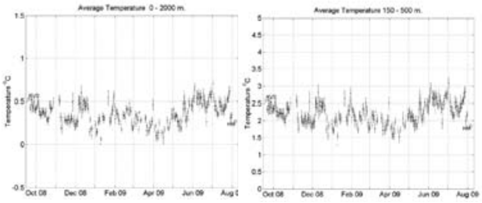
After the recovery the acoustic data has been carfully quality checked. The acoustic recordings have gone through arrival time detections, and the travel times have been corrected for clock drift and correction for mooring motion (See Poster by S. A. Haugen, H. Sagen et al).

Below, the temperatur, sound speed profiles (blue) from the Fram strait model are compared to CTD measured profiles (red) for 21 of september 2008 and 5 august 2009. Acoustic eigen rays (SD 400 m and RD 989 m) corresponding travel times and timefronts has been calculated by use of modelled sound speed profiles (blue) and CTD data (red). The result of comparison show that the Fram Strait model agrees very well with observations and is less than 0.5 degrees to warm.



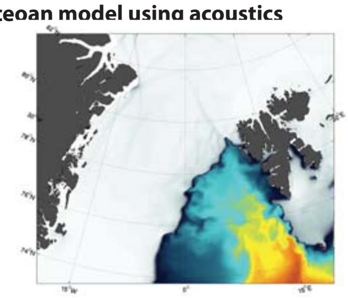
Acoustic Inversions

The one-year long series of travel-time data from the vertical receiving array are analysed to recover temperature variations along the 130-km section over the duration of the experiment.

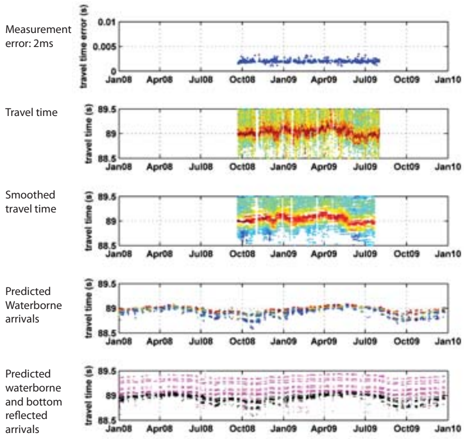


The temperature distribution is parameterized in terms of empirical orthogonal functions (EOFs) based on historical data collected by the Alfred Wegener Institute (AWI) in the period from January 2006 to June 2008 along 78o50 N. The Chen-Millero formula is used to convert temperature into sound speed assuming a constant salinity of 35 ppt, which is an average value for the salinity in the area. A Monte Carlo Markov Chain (MCMC) inversion scheme is used relying on the matched-peak approach, seeking to maximize the agreement between theoretical and measured travel times.

Validation of the high resolution Fram Strait ice-ceoan model using acoustics



The model has a resolution of 3.5 km and 28 hybride layers in the vertical. The model captures the recirculation and meso scale features, but do not include tides. It is a single member integration nested to a clone of the TOPAZ-4 system. No assimilation. Acoustic data and CTD sections are used to validate theFram Strait model (3.5 km).



The comparison show that observed acoustic arrivals are 100 ms later than the calculated arrivals from the high resolution Fram Strait model. This leads to the conclusion that the temperature from Fram Strait model is less than 0.5 degrees too warm.

Acknowledgement
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