The Fram Strait tomography system for tomography, glider navigaton and passive acoustics

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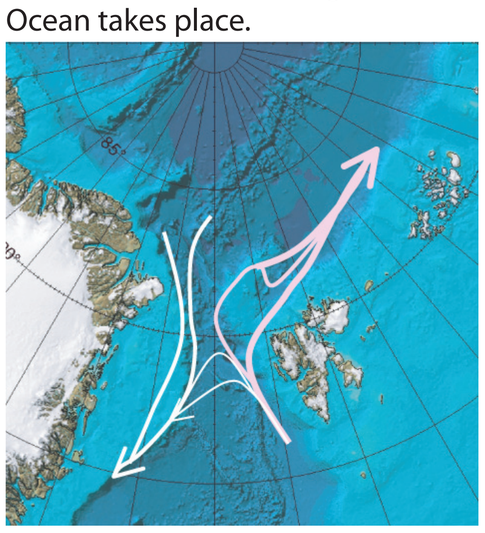
The Fram Strait

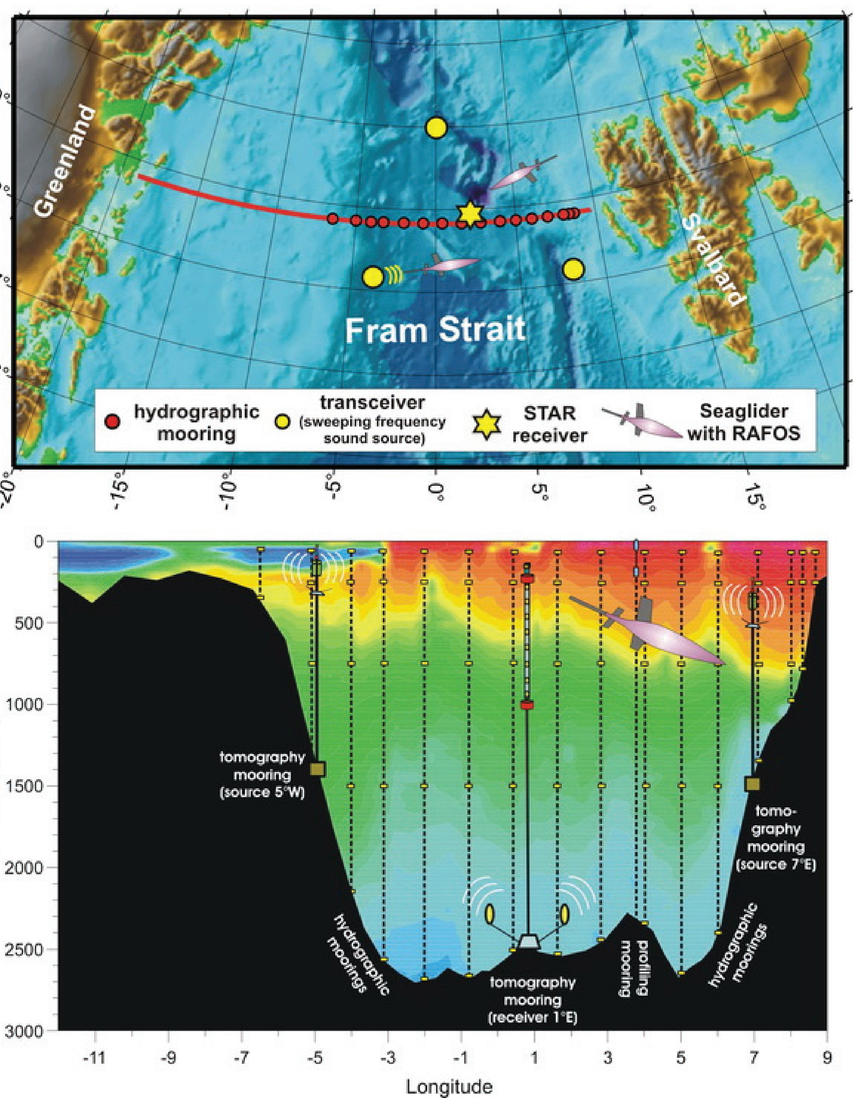
The Fram Strait is the main passage through which the ocean mass and heat exchange between the Atlantic and Arctic Ocean takes place.



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.

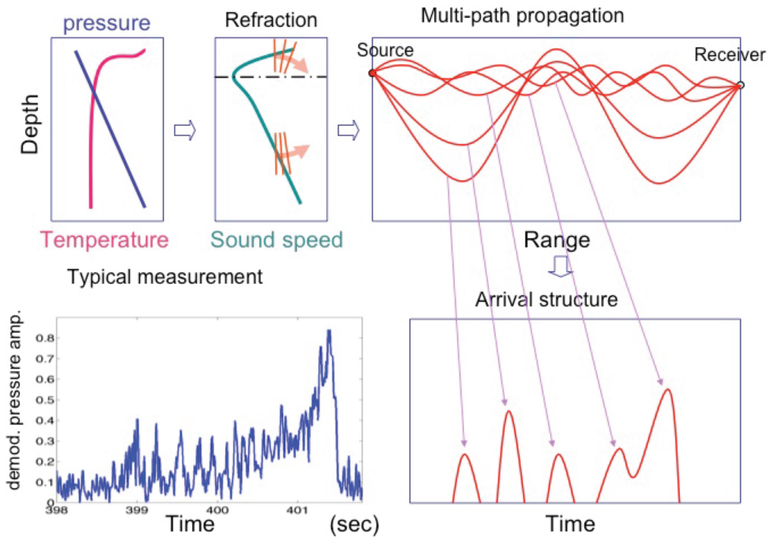
The Fram strait Ocean Observatory.



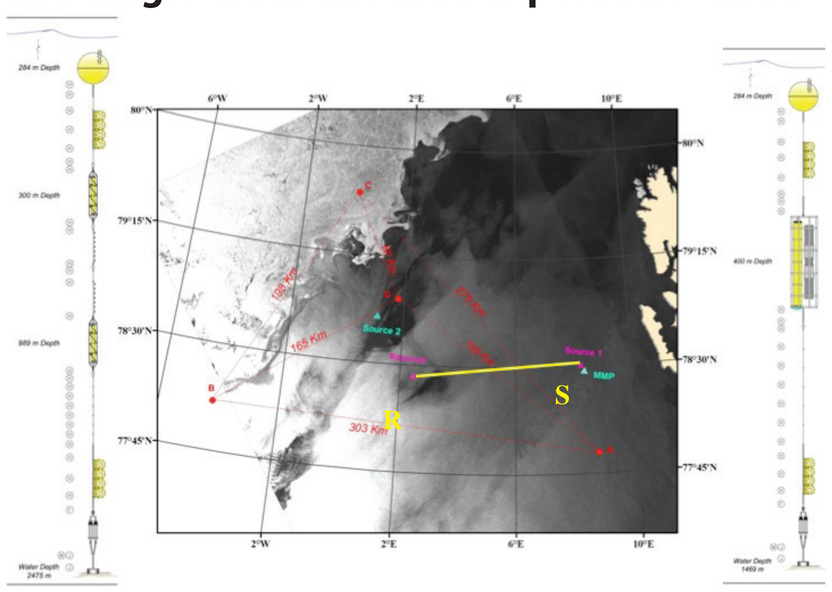
A section of oceanographic moorings (red dosts) across the Fram Strait was establish in 1997 to monitor the ocean volume and heat fluxes through the strait. Estimates of the transports over 9 years (1997-2006) indicate a mean northward transport of 12 Sv (1 Sv = 106 m3/s) (WSC), and a southward transport 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.

Our 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.

Principal of acoustic measurements



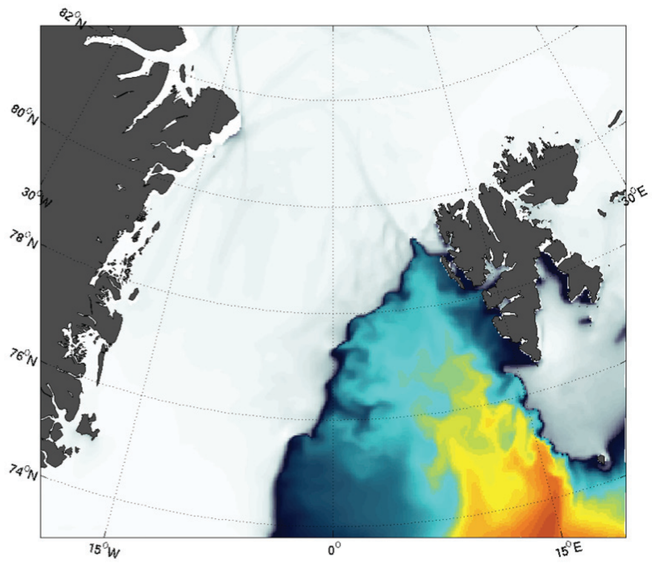
The single track acoustic experiment 2008-



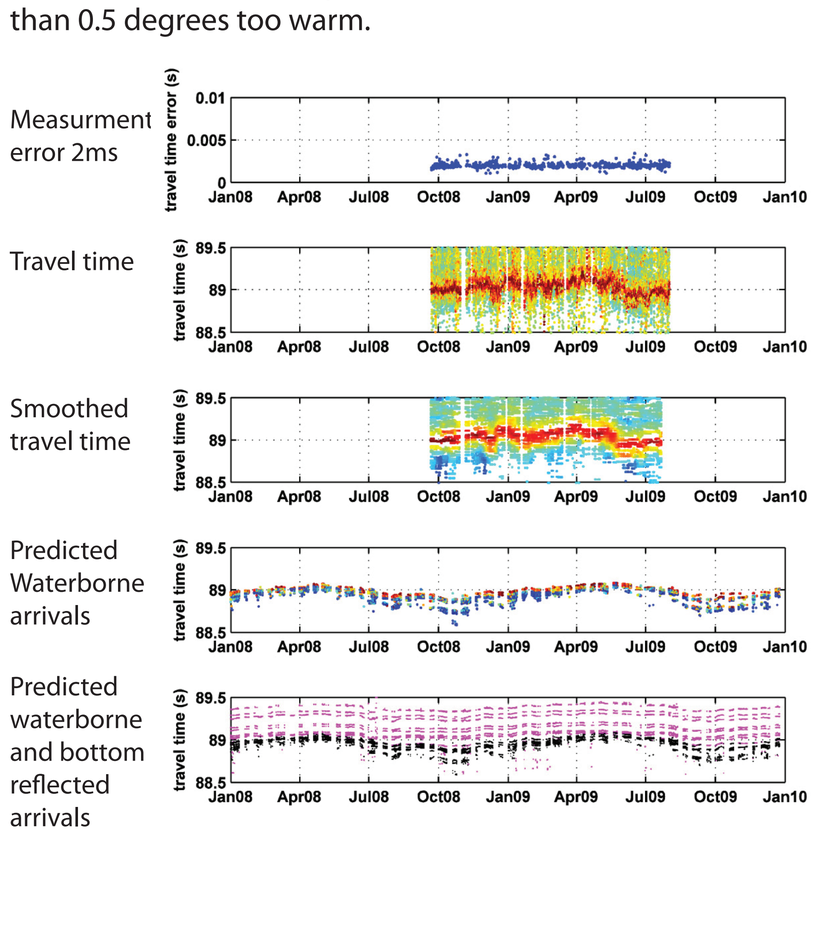
As a first step a single track acoustic thermometry experiment was successfully carried out from 2008 to 2009 in the Fram Strait under the DAMOCLES project. During the experiment the source produced a 60 s long frequency sweep from 190 Hz to 270 Hz every 3 hour . The signal was received at a 686 m long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

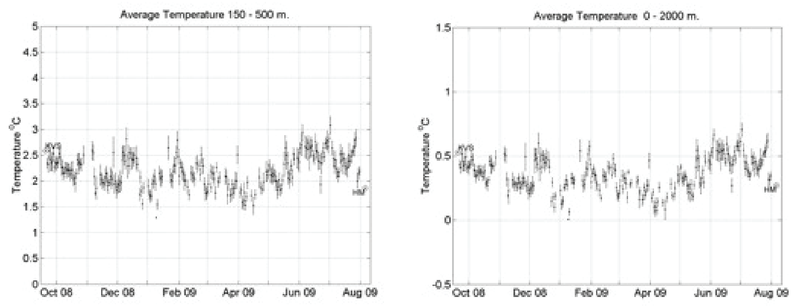
After the recovery the acoustic data has been carfully quality checked. The acoustic recordings have gone through arrival time detections, and the travel times have been corrected for clock drift and correction for mooring motion. Data have been used for validation of the high resolution Fram Strait 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.

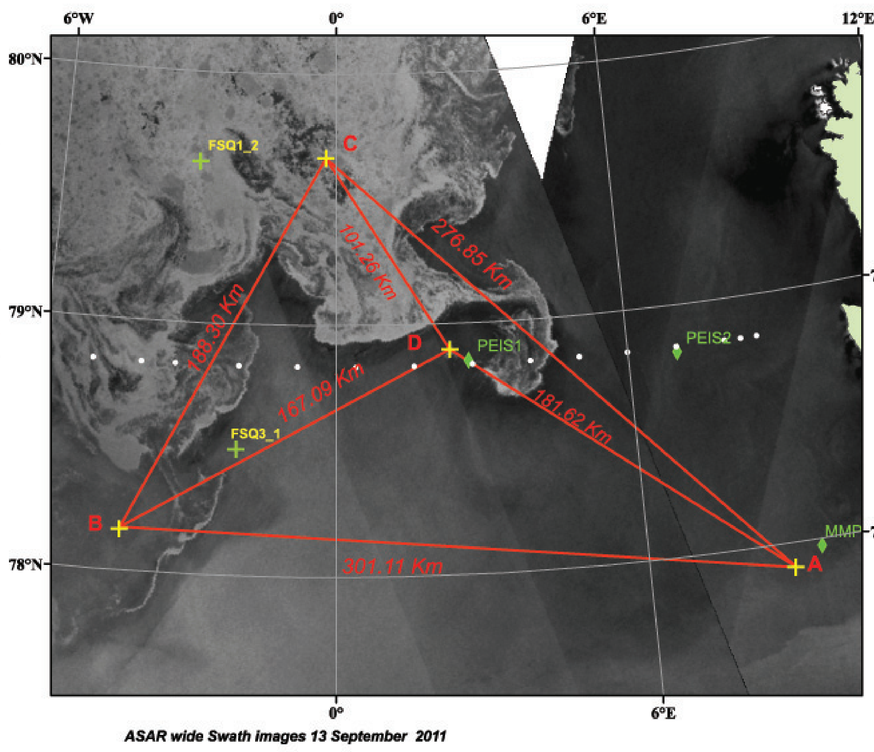


Acoustic Inversions



The one year long time series of travel time data from the vertical array has been analyzed at F**oundation for Research and Technology Hellas, Greece;** to recover temperature variations along the 130 km section over the duration of the experiment (Skarsoulis et al. 2010). 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.

The Triangle acoustic experiment 2010-2012.



The single track acoustic experiment is followed up by a 2-year triangle tomographic experiment from 2010 to 2012 (http://acobar.nersc.no, Sagen et al., 2008, 2010). The acoustic system was deployed with RV Håkon Mosby and KV Svalbard in august/September 2010. The satellite image show how the tomographic source moorings (yellow crosses in the triangle) in A, B, C and the receiver mooring in D are positioned in the MIZ. The tomographic moorings are separated by 100 km upto – 300 km. Green crosses corresponds to the RAFOS sources used for navigation and green and white dots are oceanographic moorings.

During the experiment the sources will produce 60 s long signals sweeping from 190 Hz to 290 Hz every 3 hour every other day for two year. Moreover, the three sources will produce 80 s long narrow banded sweeps at 260-261 Hz every six hours for glider navigation during selected time windows during fall 2010 and fall through winter 2011/2012. All acoustic sources has been confirmed operational. Signal from three of the sources have been received by gliders and drifting floats several hundred of kilometers away.

The experiment is designed to provide two-way travel times along each of the sides of the triangle). In addition one way travel times along sections between each of the corner of the triangle and the long vertical receiver array in the middle of the triangle (red lines). Acoustic data from six tracks will be available for analysis in summer 2012.

The system is unique and important both for navigation of gliders in under the sea ice and out again, and for the acoustic tomography. Each mooring records low frequency ambient noise, and represents a unique and forefront passive acoustic monitoring system of marine mammals.

Acknowledgement
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