The Fram Strait Acoustic Tomography Experiment -2008

DAMOCLES Task 8.2

Nansen Environmental and Remote Sensing Center
http://www.nersc.no

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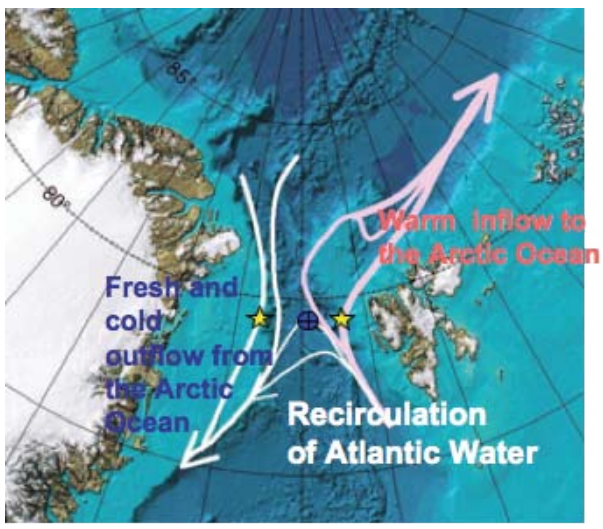
What is ocean acoustic tomography ?

Low frequency acoustical waves in the oceans travel fast (around 1500 m/s) with little attenuation around the world oceans. Their propagation speed varies with changes in temperature, salinity, pressure and currents as they propagate through the water masses. Thus, the travel time of acoustic signals can provide integrated measurements of ocean temperature and current for the insonified ocean, when used in conjunction with appropriate inversion schemes. This is the fundamental principle used in ocean acoustic tomography and thermometry. Today, acoustic tomography/ thermometry can provide measurements of internal ocean temperature at an accuracy of 0.01°C over a 200 km distance (Munk et al. 1995, Bold et al. 2001). To retrieve current from acoustic measurements one need two-way travel time measurements, which requires as a minimum two transceivers in the tomography array.

Acoustic tomography is a cost effective method for obtaining time series of unique, synoptic and horizontally averaged oceanographic depth profiles of temperature (sound speed) at a high temporal resolution, which can be tailored and implemented in any ocean area including deep and ice covered oceans. Stand-alone acoustic tomography systems in Arctic regions have been developed and successfully tested in ice covered regions such as in the Greenland Sea Experiment in 1988-1989 (Worcester et al. 1993), in the Labrador Sea tomography experiment (Kindler et al., 2001), in the Trans Arctic Acoustic Propagation Experiment (TAP) (Mikhalevsky et al. 1999), and in the more recent, 14- month long ACOUS (Gavrilov and Mikhalevsky, 2002)

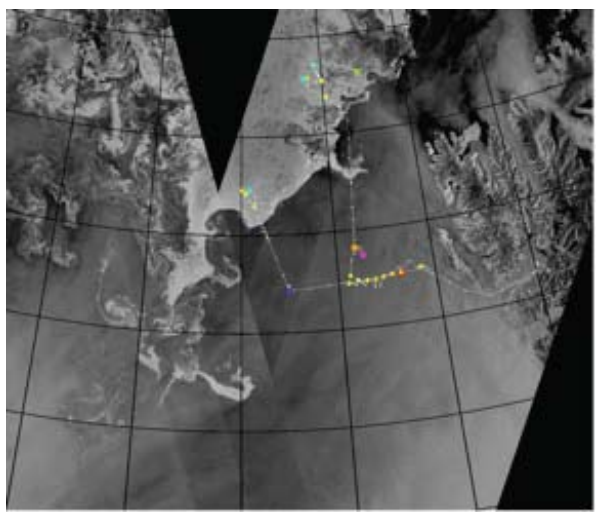
Our DAMOCLES objective is to build, test, validate and use an innovated integrated observing and modelling system for improved monitoring of volume , heat and freshwater in the Fram Strait.

This includes the development and implementation of an ocean acoustic tomography system to monitor the average heat content across the eastern (WSC). The the tomographic array, includes the source on the east (WSC) and the vertical receiving array in the middle of the strait.



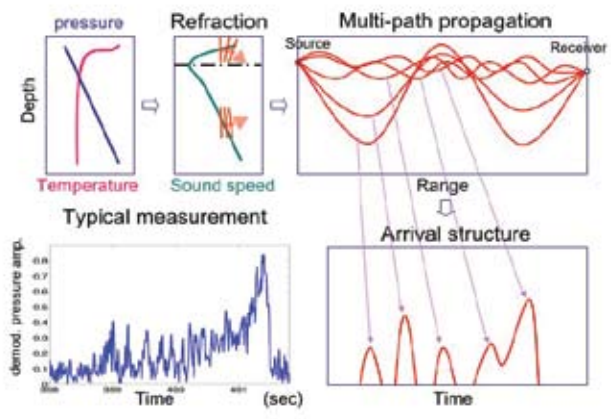
Acoustic tomography successfully deployed in the Fram Strait.

The two moorings were successfully deployed from the RV Håkon Mosby 14-18 August. After one year of operation the instruments will be recovered and redeployed for two more years within the new project ACOBAR. Distance between moorings is calculated (using WGS 84 ellipsoid) to be 130 010 m.



The above picture is a ASAR image from 20 September 2008.
Ovelaid are the positions of the Source mooring, Receiver mooring, Acoustic recordings, Glider recovery, AWI-Winch mooring recovery, UPMC-MOPS mooring recovery, and the 3 Ice stations.

The fundament of acoustic tomography



Acoustic transmission schedules.

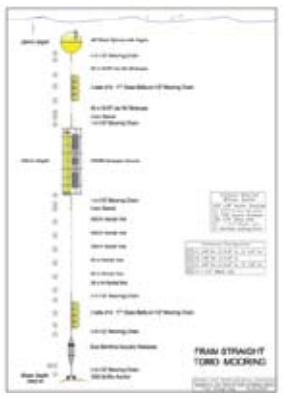
The source transmit 60 s long sweeps from 190 to 290 Hz every third hour (at 00:10, 3:10, 6:10, 9:10, 12:10, 15:10, 18:10, 21:1 all times given in GMT). While the STARs are scheduled to monitore 10 s before expected first arrival, during the 60 s long sweep, and 10 s after the expected last arrival.

To accurately monitor the mooring motion during the experiment a navigation transducer is attached to the Source and the two stand alone STAR receiver units. The NAV transducer pings at 9 kHz every hour and each of the four bottom mounted transponders replies at at separate frequencies. A ship survey was carried out to position the transponders accurately.

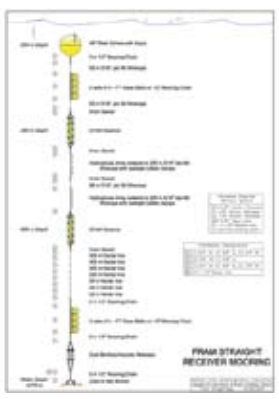
Pre-processed data is stored in Aquatec modems during the experiment, and it was planned to dowload these data to a shipborne deck-modem.

Raw data from each of the hydrophones will be available after recovery and detailed signal processing will be carried out and compared to the pre-prossessed data stored in the modems.

Source deployment from RV Håkon Mosby 15 August 2008.
Mooring design to the left.



STAR receiver deployment from RV Håkon Mosby 16 August 2008.
Mooring design to the left.



Download of acoustic data using modem.

A second acoustic cruise was carried out 19-26 September 2008 using the KV Svalbard. One of the main objectives of the cruise was to test download of processed acoustic data using acoustic modem. The download failed partly due to software problems and due to limitations in the hardware.

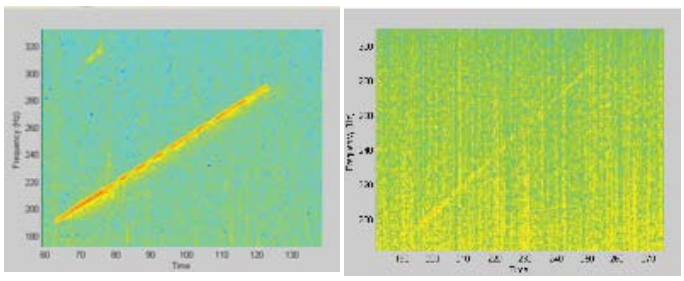
However tiny portions of data was downloaded. The small postion of data is currently analysed to improve the existing software and hardware. This imples that there is currently no tomography data from the acoustic modems.

Data processed for the acoustic modems will be available after mooring recovery. These data will be corrected for clock drift and mooring motion and forwarded for tomographic inversions and data assimilation. Thereafte,r raw data will be processed and forwarded to the inverison and data assimilation activity.

Acoustic propagation study

By using a small 4 element hydrophone array from a small boat during the KV Svalbard cruise it was confirmed that the source is transmitting according to the pre-programmed schedule! Acoustic recording was carried out using the hydrophone "sausage" attached to a 150 m long cable hanging out from the small boat "Sjøbjørn" 1-2 nm away from a relatively silent KV Svalbard. At some locations the source signal is very clear on others more carefully analysis is required to determine if the source signal can be detected at that particular positoions .We have listen to the source at 20 stations at different ranges from the source, inside ice edge, outside ice edge and at the 500 m depth contour east of the source near Forlandet. The data is under processing and will be used in sound propagation

Listening to the acoustic source side the ice edge at the first ice station



Source sweep recorded at the source location (left) and the sweep recorded 60 km west from the source (right).

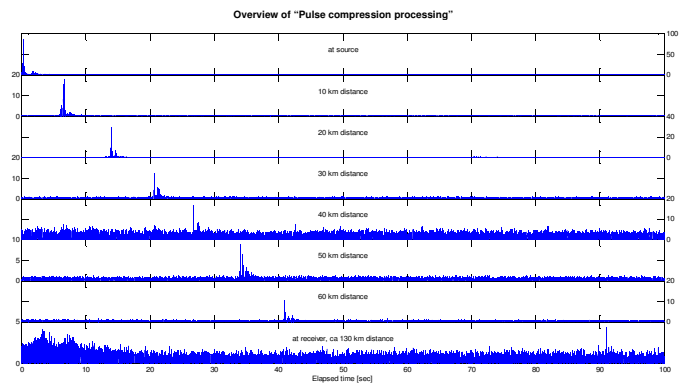


Figure 1: Overview of pulse compression processing for the tests in the line betwen source and receiver. The x-axis shows elapsed time since start of transmission. The y-axis is the crosscorrelation (un normalized) between the receioved signal and the replica (190 to 290 Hz linear FM sweep in 60 seconds).

Streaming Mode Tomography Analysis System (SMTAS)

- SMTAS is a system for asynchronous reception, validation, processing and inversion of the acoustic tomography data collected and pre-processed in-situ by the tomography instruments in the Fram Strait experiment area.
- All dataflow is performed in near-real time through the internet using standard communication protocols (SMTP and POP3).
- SMTAS allows for both on-line (near-real-time) analysis of incoming data and off-line (batch mode) analysis of already stored data.
- SMTAS supports asynchronous reception, validation, processing and inversion of acoustic tomography data. The data (free of clock-drift errors and mooring-motion effects) will be transmitted directly from the experiment location or sent in batches at a later time, whenever data are manually recovered from the moorings.
- The produced inversion results, in the form of horizontally averaged temperature profiles or heat contents of particular depth layers and associated error estimates, are archived locally. A selected subset of the results is uploaded in near-real time to the web for further dissemination.
- To assess the functionality of SMTAS, a number of simulated data transmissions have been performed using synthetic data. The system was then used to

SMTAS in action: On-line operation mode (left) and off line mode (right).

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