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Use of acoustic travel times for ocean model validation, and assimilation

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Data Treatment

Data treatment for Ocean Acoustic Tomography primarily deals with the issues of mooring motion, clock drift and arrival time estimation.

Mooring Motion

Mooring motion is monitored using a 3 or 4 transponder "Long Baseline (LBL) positioning system. A scatter of the mooring position of the Fram Strait Acoustic Tomography System during the 2008/2009 experiment is shown in figure 1. By monitoring the position of the mooring instruments, all travel times can be corrected in post experimental analysis as if the moorings were in their nominal upright position.

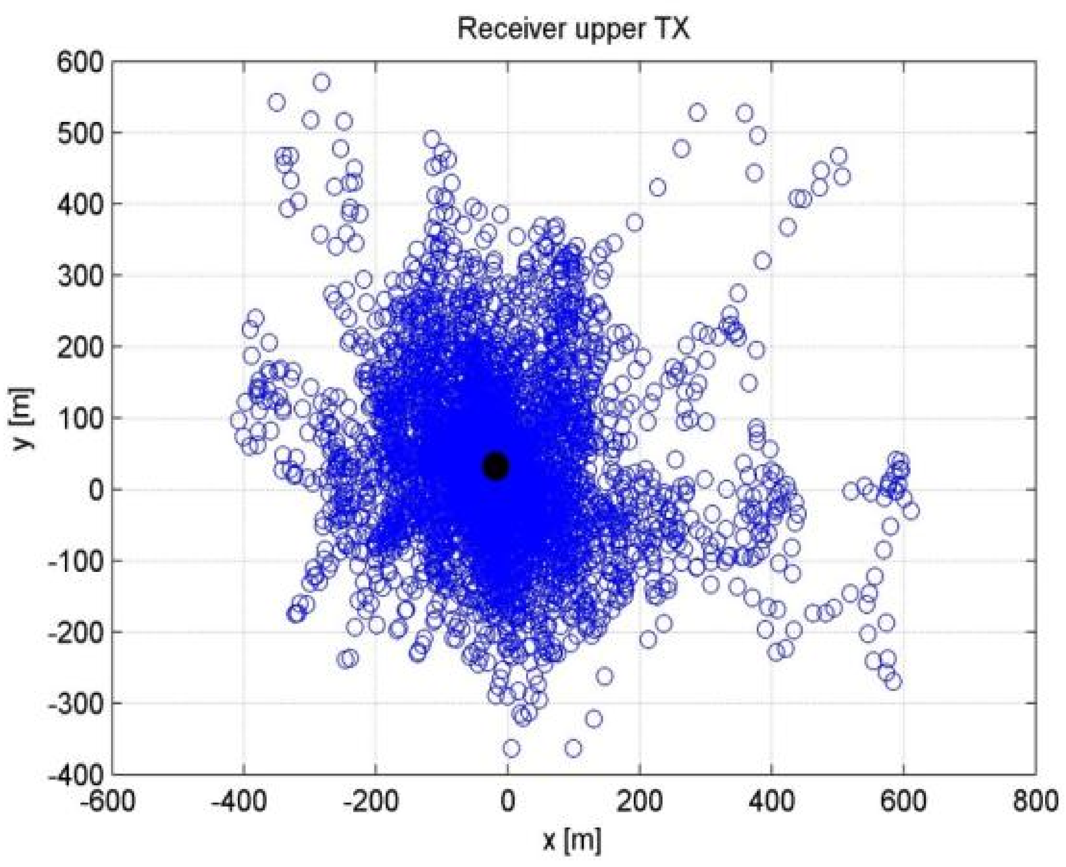


Figure 1 – Scatter of receiver mooring motion at 300m of depth throughout sept 2008- aug 2009.

Clock Drift

Clock drift correction is carried out in several steps, with the most important one employing a dual clock system where the frequency of an accurate but power hungry Rubidium oscillator is compared to the oscillation frequency of a less accurate and less power hungry MXCO. Also, synchronization to GPS time before and after experiment is carried out. The timestamps provided by the continuously run MCXO oscillator clock can thus be corrected during post experimental data treatment.

Arrival Time Estimation

Accurate arrival time estimation is facilitated using Frequency Modulated Sweeps for the Acoustic Tomography Transmissions, as shown in figure 2. Employing matched filtering for these types of signals makes the arrival to stand clearly out from the noise.

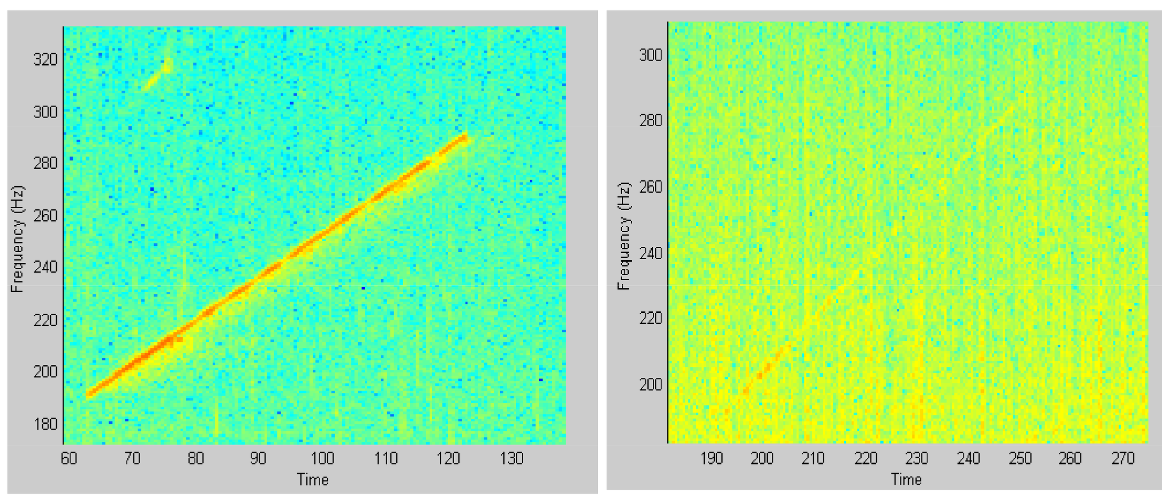


Figure 3 – FM sweep at source (left) and r=60km (right). Duration is 60 seconds and frequecies are from 190 to 290 Hz.

Also the arrivals are transformed to narrow pulses such that multiple arrivals as close as 10 ms can be resolved. As shown in figure 3, the FM sweep can hardly be distinguished from noise at a distance of 60 km from the source. It is virtually impossible to observe reception of the signals in the raw data at any of the receivers 130 km from the source as seen in figure 3 (left). After matched filtering, the multiple resolved receptions stand clearly out, on all 8 receiver depths as shown in figure 3 (right).

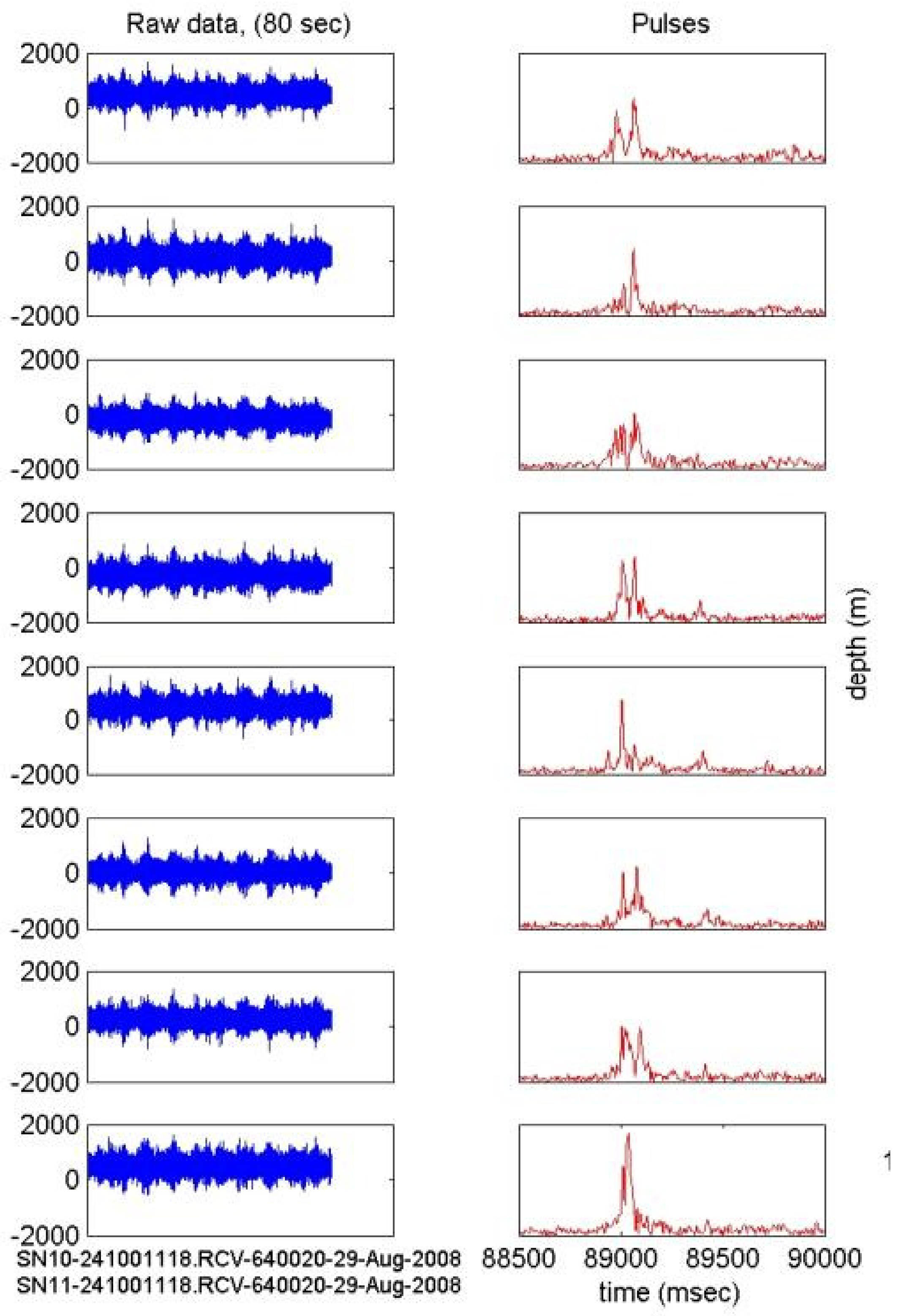
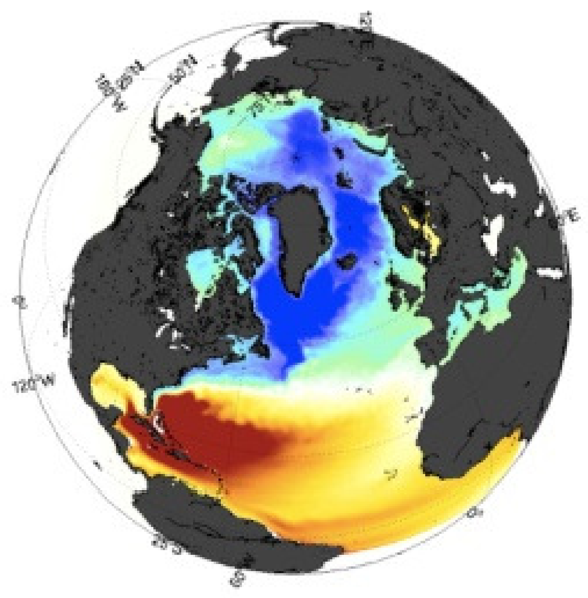


Figure 3 – Acoustical raw data (left) and pulse compression (right) on all 8 channels (from 307 to 979m of depth in 96 m increments).

Trave time predictions and measurements

Having detected the multiple arrival times and introduced the corrections terms related to mooring motion and clock drift, travel times for a nominal mooring position can be measured throghout the experiment. Correspondingly, travel times have been predicted on the basis of the temperature and salinity fields of TOPAZ3 numerical ocean model.



TOPAZ 3 model system has a resolution of 3.5 km and 22 hybrid layers in the vertical. The model does not resolve mesocale processes properly and does not include tides. 100 members and assimilation of satelite data and ARGO profiles using EnKF.

Ocean model validation

The multiple travel times and the corresponding travel times predicted are shown in figure 4. In the beginning of the period the meassured and prediced travel times differ noticable, by ca 200 ms, while the correspondence improves after 2-3 months. Comparison of mesured and predicted travel times provides a method for ocean model validation.

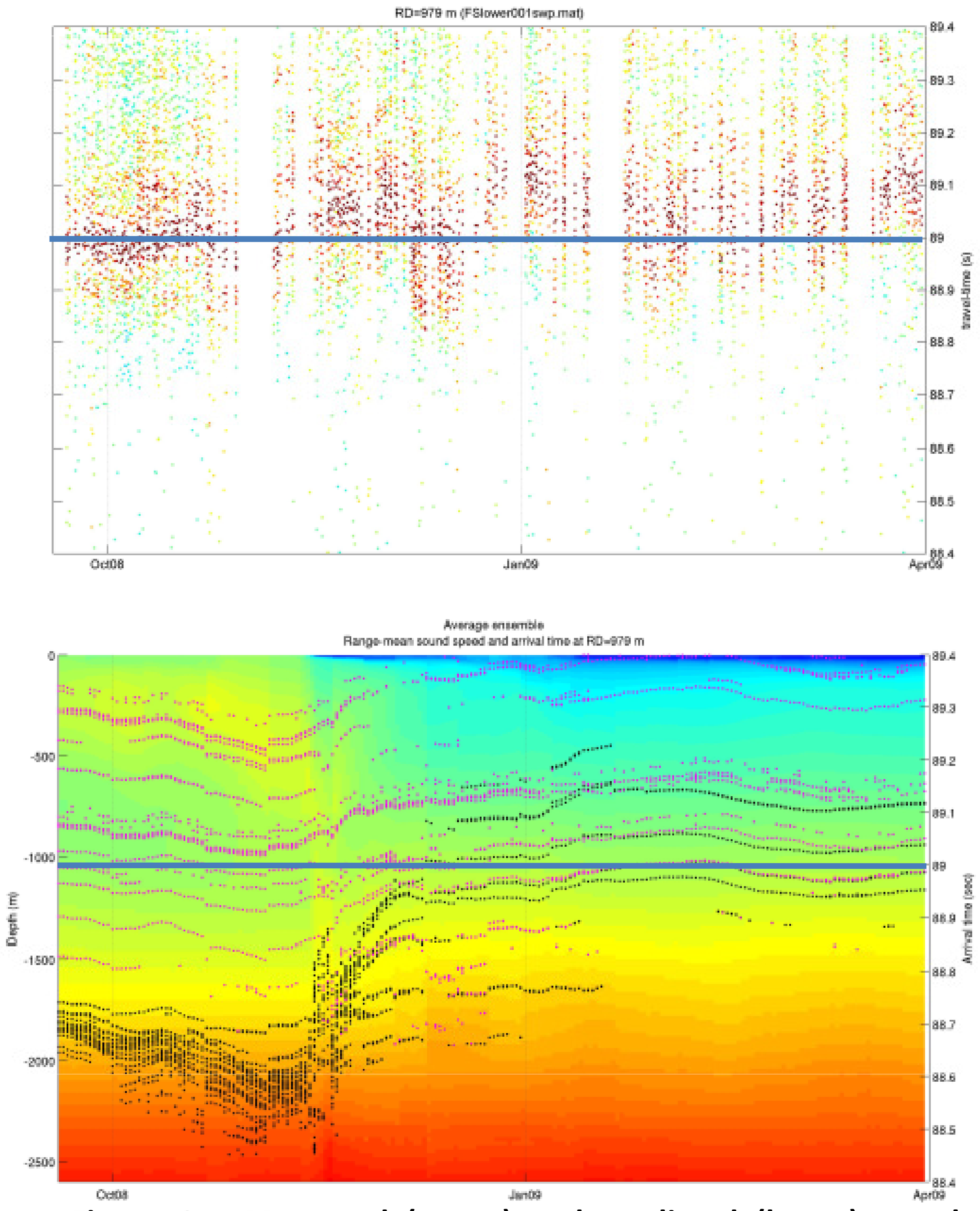
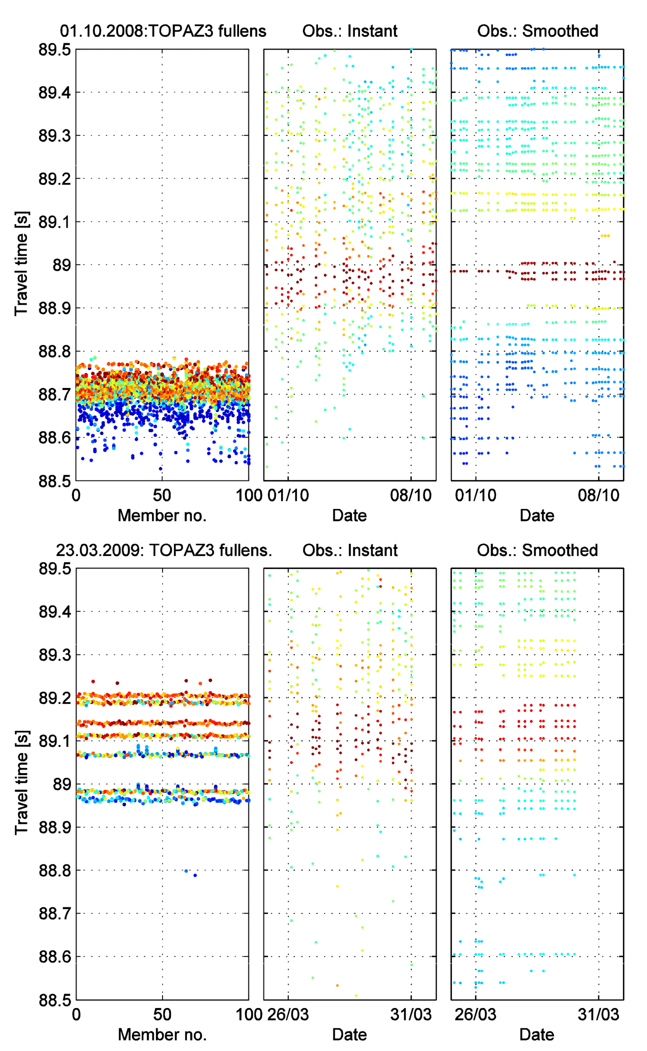


Figure 4 – Measured (upper) and predicted (lower) travel times throughout the experiment. The dots indicate individual arrivals. The color of the dots of measurements indicates the intensity of the arrival. For the predictions black dots represent waterborne arrivals, while pink dots represent bottom intracting arrivals. The colored background of the predictions represent the sound speed field provided by TOPAZ3.

Preparation for data assimilation

Having measured and predicted the acoustic travel times of several multipath arrivals, fetures of these arrival patterns will be used for data assimilation. As a preprocessing step, the matched filter outputs of one week of receptions have been averaged, to emphaize on the most stable of the arrivals .



Left: Predicted Travel times of all 100 TOPAZ3 ensemble embers

Middle: Instant travel time measurements

Right: Averaged travel time mesurements

Upper: 01.10.2008
Lower:27.03.2009

There is a good overlap between TOPAZ3 member predictions and mesurements for 26.03.2009, while a bias is evident for 01.10.2008

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