Coherence analysis of multimegameter range acoustic signals

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Abstract: The quality of acoustic travel time measurements depends on the coherence of the signal as well as the bandwidth. Ocean acoustic signals exhibit coherence properties in four ways: in time, in bandwidth, and in vertical and horizontal extent. (These are conjugate to Doppler broadening, pulse time spread, and rms vertical and horizontal arrival angle.) These properties have recently been measured and can be compared for several different ranges (80-5000 km), center frequencies (28-250 Hz), and geometries (source on-bottom vs. off-bottom). For signals of less than perfect coherence, techniques from communications theory can be used to improve the quality of travel time measurements by relaxing the resolution requirement. For instance, if the coherence bandwidth is less than the signal bandwidth, it is possible to consider subbands of the signal as separate measurements. How to best combine these measurements then depends crucially on the SNR. While acoustic thermometry has relied on electronically controlled sources, by allowing for the coherence structure of stochastic sources (such as T-phases, explosives, or marine mammals) an improved signal processing strategy may result.

RESULTS

An important and often overlooked fact in the processing of tomography data is the tracking and identification of the raypaths. The data often exhibits considerable scattering and only after averaging successive transmissions can the appropriate identification be made. The pulse data is spread in time as a result of the lack of coherence across the transmitting bandwidth. One can therefore regard the reception as several separate experiments. The loss of coherence implies that the subband data be combined incoherently.

The result of processing the long range transmission data can be seen in the figure below. The plots show the outputs of a beamformer. The top plot shows the standard coherent processing of a 10 Hz wide signal. The bottom plot shows the same data processed in 3 separate 3 Hz subbands and then incoherently recombined. Although there is loss of resolution it is not so severe that the different ray arrivals are smeared. In fact, the multiple peaks are no longer present and thus the data is much easier to identify and track.

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Figure 1. Beamformer output. Top: standard coherent processing. Bottom: incoherent recombination of subbands.