Mode tomography using LOAPEX signals

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Ocean acoustic tomography uses acoustic signals to infer the environmental properties of the ocean. The procedure for tomography consists of low frequency acoustic transmissions at mid-water depths to receivers located at hundreds of kilometer ranges. The arrival times of the signal at the receiver are then inverted for the sound speed. The received signal can be represented in terms of rays or modes, which can in turn be used in ray tomography or mode tomography respectively. A modal description is more apt frequencies less than 100 Hz. Low frequencies propagate with minimum attentuation over longer ranges and thus mode based tomography can be used at longer ranges. Modes populate the mid-water depths at which mesoscale effects occur, thus mode tomography can measure phenomena such as currents and eddies. Although using modes can significantly extend tomographic capabilities, mode tomography has received less attention than ray-based tomography. This is mainly for two reasons. First, mode tomography relies on spatial filtering with vertical line arrays. Few experiments have deployed arrays with the vertical aperture necessary to resolve modes. Second, internal waves in the ocean cause travel time variance and fading, which impacts the accuracy of the tomographic inverse. Unlike internal wave effects on rays, the internal wave effects on modes are not completely understood. Mode tomography should take into account the time and range dependent statistics of internal waves. However, the current literature does not contain a complete statistical model for the internal wave effects. To perform mode tomography it is important to be able to resolve the modes and have a statistical model for internal wave effects.

In 2004 the Long Range Ocean Acoustic Propagation EXperiment (LOAPEX) used a 1400 m vertical line array to measure low frequency broadband signals at seven ranges from 50 km to 3200 km in the North Pacific. LOAPEX presented an opportunity to measure the modes at different ranges and study the evolution of internal wave effects on modes. This talk consists of two parts. The first part uses simulations and LOAPEX signals to define a statistical model for the mode signals for ranges up to 400 km. The second part uses the model to predict the effect of internal waves on mode tomography and also suggest methods to mitigate internal wave effects on modes. LOAPEX signals measured at ranges of 50 km and 250 km are then used to invert for the average sound speed across the LOAPEX path.