GROUP DELAY INVERSION FOR OCEAN PROPERTIES

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ABSTRACT

Ocean acoustic tomography has enjoyed success at shorter ranges (<2Mm) by using ray theory to model the acoustic propagation. As the ranges of these experiments increase to basin and global scale it is necessary to consider the dispersive effect of the medium by using mode theory to model the propagation. This is useful at shorter ranges as well to correctly interpret the final cutoff which contains a substantial amount of energy for axial transmissions.

1. Climate Signal

One chief goal of the Acoustic Thermometry of Ocean Climate (ATOC) network is to measure the basin scale warming due to anthropogenic climate change. Climate models predict that the basin scale signal will occur at the sound channel axis. Figure 1 shows the signal as constructed from a climate model experiment run by the Geophysical Fluid Dynamics Laboratory. Mesoscale processes also affect the acoustic travel times. The network should therefore to be a basin averaging, mesoscale rejecting filter.

2. Modal Propagation

A mesoscale rejecting acoustic measurement implies long paths which in turn implies low frequencies. Low frequency propagation can be effectively modeled as the sum of many propagating modes with frequency dependent group delays. The individual modes can be separated by using a vertical receiving array with the proper spatial filtering. An example of the pressure signal measured at a vertical array is shown in figure 2. The dispersion curves are shown in the upper half of the figure. The output phase of a properly constructed beamformer can is then used to estimate the group delay of the mode.

3. Ocean Estimation

Ocean properties are then estimated using a standard Gauss-Markov technique for mesocale perturbation from the standard climatology. Empirical orthogonal function analysis is used to classify typical perturbations from a quasi-geostrophic ocean model. The figure shows the travel time anomaly to be expected from a canonical profile by an ocean EOF. The resolution and bounds on errors can then be calculated.

It is also important to quantify the errors introduced by the reference or base state model of the ocean. Comparisons of the final inversions for ocean temperature are sensitive to the a priori estimates but initialization by direct methods can be extremely useful even if they are not synoptic, i.e. they are time aliased.

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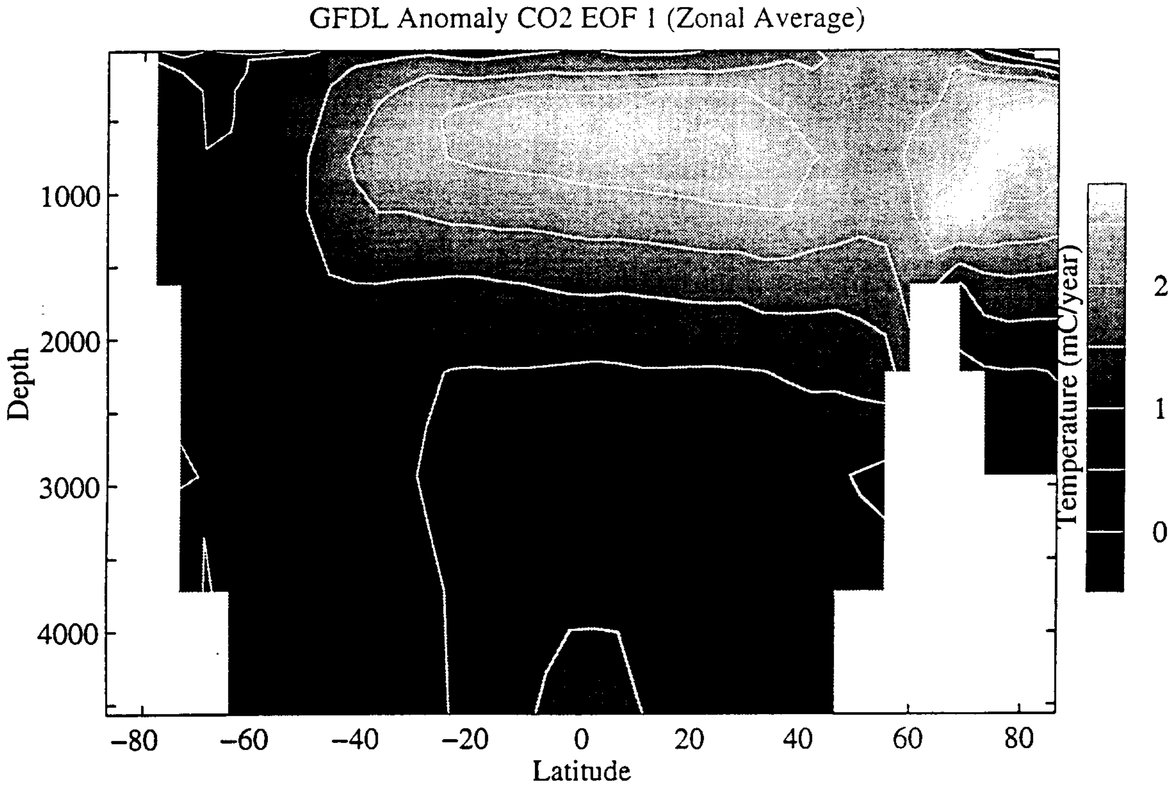

FIGURE 1. Predicted spatial pattern of anthropogenic warming.

4. AET Example

This type of analysis has only been applied on a very limited basis in deep water ocean acoustics to date. It was used extensively for the first time in an ATOC engineering experiment (November 1994) to determine mesocale and internal wave scattering parameters. A typical reception measured on a 9.6 Mm path from Jasper Seamount to the East coast of New Zealand is shown in figure 3. The SOFAR crescendo is clearly visible.

References

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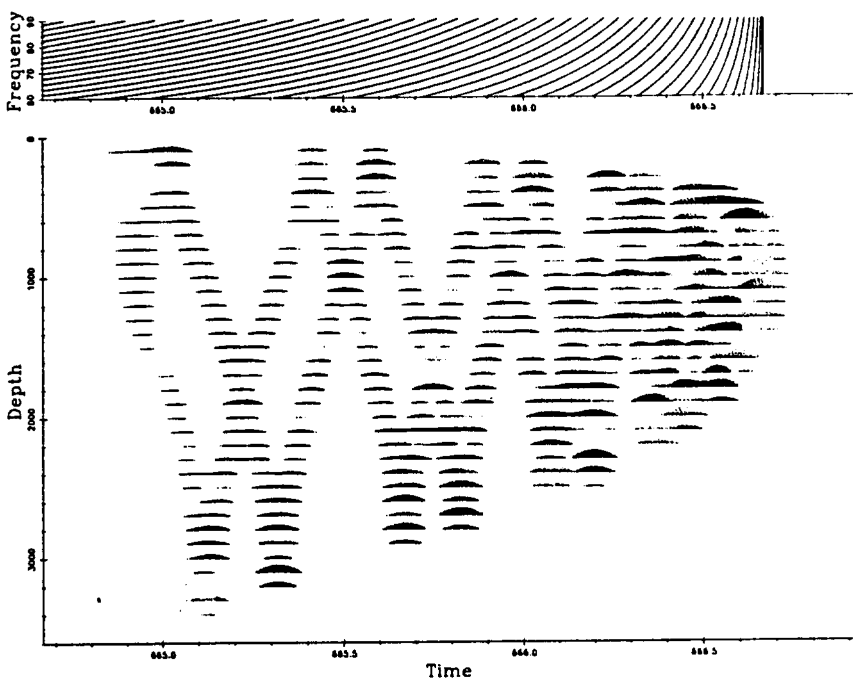

FIGURE 2. Modal prediction of the demodulated pressure signal measured by a vertical array at a range of 1 Mm.

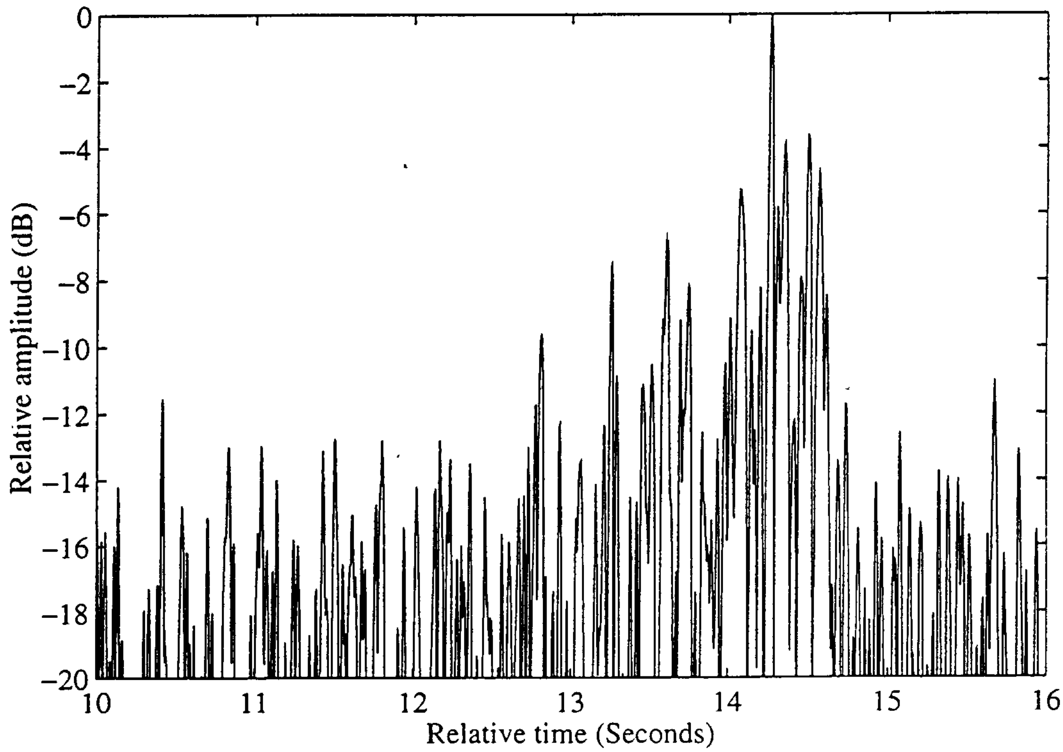

FIGURE 3. Amplitude of measured pressure at one mid axis hydrophone at a range of 9.6 Mm during the AET.