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Gyre-Scale Acoustic Tomography: Modeling Simulations

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ABSTRACT

Ocean Acoustic Tomography was proposed by Munk and Wunsch as a method for making measurements of ocean variability over large areas. After the successful demonstration of the feasibility of the idea in the 1981 three-dimensional Mesoscale Experiment the tomography group has proposed a new experiment to be carried out in the Eastern Pacific Ocean, on ranges as long as the subtropical gyre scale.

This paper address the question of which average quantities of importance for the ocean general circulation and ocean climate can be measured by tomography and with what accuracy. The paper focuses upon the following quantities i) measurement of the heat content vertical profile horizontally averaged over a tomographic section; ii) time variability of the average heat content, or average pycnocline displacement, at different depths; iii) measurement of the average pycnocline slope at different depths.

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To answer the above question the tomographic experiment is simulated in a given model ocean, using Holland's eddy-resolving general circulation quasi-geostrophic model. The results of the modeling simulations can be summarized as follows.

> The tomographic technique bars upon the use of inverse methods to reconstruct the interior sound speed perturbation field, or, equivalently, the heat content field. Over ranges as long as the gyre scale, the typical result of a single inversion is to provide an ocean with warm or cold biases. A simple iterative procedure allows the removal of these biases. The final estimates of the mean heat content (averaged over the tomographic section) at different depths is very good.

Through a time-evolution experiment carried out for the duration of a full year, the time evolution of the average pycnocline displacement can be monitored at various depths. Thus tomography can measure the frequency spectrum of the average pycnocline displacement in layers below the surface mixed layer in which the circulation is basically wind-driven.

The initial estimate of the average heat content can be significantly improved through a better specification of the statistics of the region, like the inclusion of a spatial mean in the horizontal covariance function for the sound speed perturbation. In particular, the inclusion of an inhomogeneous covariance modeling long-scale pycnocline trends allow us to estimate the average pycnocline slope at various depths. The obtained slope estimates are very good. Measurement of isopycnal slopes averaged in time could be used for β-spiral calculations. Thus, simple "density" tomography would provide a tool to evaluate the absolute velocity field and not only the geostrophic velocity shear.

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