Massachusetts Institute of Technology

FINAL REPORT

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Description of M.Sc. Thesis — Jim Gunson

From two CTD surveys taken two months apart during the 1981 Ocean Tomography experiment southwest of Bermuda, a time-dependent ocean state is estimated that evolves from the first survey to the second survey.

Mesoscale motions in this region are modelled by quasi-geostrophic dynamics. The model domain is a doubly periodic 600km x 600km square centred at 26°N, 70°W. The oceanic density field is expanded in terms of a horizontal Fourier series with vertical modes. Freely propagating Rossby waves in the first and second baroclinic modes are fit to the data in a least-squares sense at the two survey times.

Linear dynamics are first used to evolve the waves in time, and are found to be too slow to evolve the ocean state to fit both surveys. Weakly nonlinear interactions between the waves are then allowed and are found to do a better job. The wave-wave interactions enable Rossby waves in the barotropic mode to enter into the baroclinic Rossby wave evolution as unknown control variables which can then be estimated.

Three techniques from optimal control theory are developed and applied to this estimation problem: the Kalman filter/smoother, the adjoint method and dynamic programming. These methods produce estimates of the baroclinic Rossby wave amplitudes and the barotropic Rossby wave amplitudes that are consistent with the data and the weakly nonlinear dynamics. The three methods all produce the same results. The adjoint method is fastest, the Kalman filter/smoother is slowest but is the only method that produces error estimates.

Assimilating a baroclinic wave model with CTD data, it is possible to estimate a barotropic flow that is consistent with the model and the data. The determination of the barotropic flow from observations has long been a frustrating problem for oceanographers. Here is presented a new approach to solving this problem.

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