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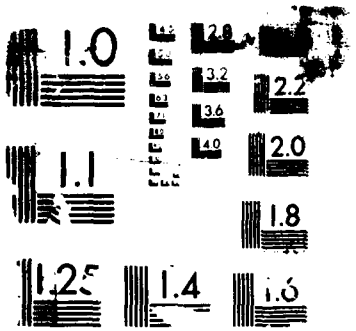

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This report describes progress on research on a Secretary of the Navy Research Professor grant. Studies have been made directed at: modelling high energy, near Gulf Stream, regions; optimally combining data with general models, including inverse and control methods; ~~at~~ reducing satellite data (altimetry and Scatterometry) for combination into the models; and developing a new generation of operational tomographic instruments.

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Progress Report on N00014-86-G-0241, "Studies Toward Observing and Modelling Large ScaleEnergetic Oceanic Regions", Year 2.

Under this Secretary of the Navy Chair, we have continued a diverse set of activities begun last year, focussed on the Gulf Stream system, and techniques for relating ocean data to ocean models in energetic regions. The work is collaborative amongst Profs. Malanotte-Rizzoli, Young, Flierl, and the chair holder, Prof. Wunsch.

Prof. Rizzoli with Dr. Roberta Young have studied thoroughly the sensitivity of a primitive equation model of the Gulf Stream system to data initialization and assimilation schemes. A grossly unbalanced initialization is required to induce model misbehavior. Simple balanced initializations are sufficient to avoid excitation of gravity waves and to insure smooth jet evolution. Surface pressure data only are insufficient to improve estimates of the deep circulation: it is necessary to project surface information onto the baroclinic modes or deep layers by assimilation techniques, or direct measurements.

In another theoretical study related to the Gulf Stream, Prof. Flierl and Dr. Steve Meacham have been studying weakly nonlinear disturbances to barotropic shear layers, and jets composed of one or two bands of uniform potential vorticity on a beta-plane. The amplitude equation for the nonlinear disturbances was found by using what is known as "contour dynamics". The solutions depended on the assumptions made about the dynamics FAR from the jet. Small amplitude, steady solutions, at linearly unstable wavenumbers were found near the long wave limit of instability, but not near the short wave limit. This result was used to account for the equilibration of moderately long wave disturbances to a barotropic jet obtained by Flierl, Stern and Zabusky (1986). The conditions under which long packets of neutral waves would exhibit modulational instablity were also determined.

S. Sakai, working with Prof. Young, has studied the ageostrophic version of Phillips' two layer model. This provides the simplest example of an unstable resonance between a gravity mode, such as a Kelvin wave, and a vorticity mode. This interaction (which is not captured by the quasigeostrophic approximation) is presumably the

mechanism of the frontal instability observed by Griffiths and Linden (GAFD, 1982, 159-187) in laboratory experiments. The work has been submitted (Sakai, 1987).

J. Federiuk, working with C. Wunsch completed a Master's thesis on an inverse analysis of the Navy sponsored C-Salt Expedition data. This work is part of the on-going effort to find methods for systematically combining data sets with theoretical ideas and models.

I. Fukumori, also working with Wunsch, is continuing work on his PhD thesis directed at other data/model problems. In part 1, he inverted the data from the warm-rings program to estimate the circulation and mixing in a near-Gulf Stream ring. In part 2, he is applying the ideas to the entire North Atlantic, but with the focus on reducing the large scale data base to a set of economical empirical orthogonal functions.

Wunsch has been continuing his work on the study of data/model combined usage in time-evolving models. We have found that systematic application of methods derived from control theory presents a very general framework encompassing both classical assimilation, but senstivity and inversion as well. The work originated in applications to transient tracers, but is now turning toward dynamical evolution models.

Two Naval Officers, K. Holderied and J. Campbell, here under the Secretary of the Navy's initiative, are analyzing two types of remote sensing data (scatterometry and Geosat altimetry respectively), for the purpose of combining these data sets with the models being developed concurrently. Both these students will receive Master's degrees.

Preparation of the tomographic instruments which will be deployed near the Gulf Stream, and provide a novel in situ estimate of vorticity there has proceeded. Construction of the prototypes has been completed by Webb Research Inc., and delivered to the Ocean Engineering Department at Woods Hole Oceanographic Institute. A change in plan was the decision to spend a full year in laboratory and in situ (i.e., in the water) testing of the instruments prior to deployment, rather than going so quickly from prototype to scientific experiment. These instruments will be deployed as part of

SYNOP in Autumn 1988 for one year in an effort collaborative with French tomographers in Brest.

Theoretical work on tomography in collaboration with Walter Munk and others continues.

Papers Supported (wholly or in part) on this Chair.

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Haidvogel, D., J. Wilkin and R. Young, 1987. A primitive equation model for coastal applications., in preparation.

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W. Munk and C. Wunsch, 1987. Bias in acoustic travel time through an ocean with adiabatic range-dependence. Geophysical and Astrophysical Fluid Dynamics, 39, 1-24.

Ponte, R. M., C. Wunsch and J. R. Luyten, 1987. Apparent vertical propagation of equatorial deep jets., submitted for publication.

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