VERTICAL STRUCTURE OF MESOSCALE OCEAN CURRENTS IN THE INDIAN OCEAN – OBSERVATION, NUMERICAL MODELING AND THEORY

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Abstract

The classical linear Rossby wave theory suggests that the barotropic and baroclinic modes of the mesoscale eddy field would disperse and become uncorrelated with each other in space and time. In contrast, the correlation between the barotropic and first baroclinic modes was noted from moored current meter records by Davis (1976). The sparse vertical sampling and inadequate record length left room for doubt and no dynamical explanation has been offered since then. In this study, hundreds of full-depth Lowered Acoustic Doppler Current Profile (LADCP) velocity profiles and the three years output from a General Circulation Model (GCM) are used. Analyses of the observation and model output confirm that outside the equatorial region the barotropic and first baroclinic modes are indeed correlated so that the velocity decreases throughout the water column from its maximum at the surface. We may call this the dominant vertical structure, which is quantified by the first Empirical Orthogonal Function (EOF) from the LADCP profiles and model output.

The phase speed of the dominant vertical structure in the model is approximately that of non-dispersive first mode long Rossby waves, even at frequencies above the Rossby wave cutoff. The model also shows that, even though the dominant vertical structure contains 50-80% of the variance, it alone provides an incomplete picture of the vertical structure of mesoscale eddies. There is a phase shift of almost 90° from top to bottom; in a zonal section, lines of constant phase slope down to the west. Or, the lower layer leads the upper layer, given westward propagation.

We could not find a satisfactory theory which could fully explain the following features: 1) correlation of the barotropic and first baroclinic mode; 2) enhanced westward propagation; and 3) phase shift in the vertical. The non-linear model with

finite interface perturbation succeeds partially. The linear Rossby waves with bottom dissipation could explain the above features if dissipation is strong enough.