Eddy interactions and associated dynamic regime shifts in two-layer wind-driven ocean circulation

Toshihiro Sakamoto[1]

[1] Earth and Planetary Sci., Tokyo Univ.

Interactions of unstable mesoscale eddies are investigated, in particular, associated with dynamic regime shifts in preturbulent states.

We have conducted numerical experiments with a two-layer quasigeostrophic fluid on a square plane with side 1000 km bounded by no-slip walls. The forcing which models the subtropical winds is assumed to be time-independent and its mean strength is the sole control parameter. Other physical parameters are fixed at values typical of the subtropical gyre. We have combined 2D wavenumber spectra of the streamfunctions, frequency spectra of the basin-averaged energy and the energy-budget box diagram to detect and specify nonlinear interactions associated with the dynamic regime shifts of our model ocean when the control parameter is changed. Both wavenumber and frequency spectra show that mesoscale eddies tend to be locked in the Rossby basin modes and that these eddies experience a triad of distinct modes and subharmonic instability. Thus we have verified, to some extent, the nonlinear interactions predicted analytically by Ben Jelloul and Huck (2003) using a 1.5-layer quasigeostrophic model, although there is no corresponding study using the same two-layer model.

The present result is different from Holland's (1978) with the free-slip condition in that the barotropic instability appears to be stronger, but we confirm that the relative importance of the baroclinic instability increases systematically as the control parameter is increased. We also observe that the energy conversion, such as conversion from mean potential to eddy potential energy, changes discontinuously in accord with each regime shift. In particular, the work done by the wind does not simply increase monotonically with increasing the parameter but attains a clear maximum in some interval of a periodic state, indicating that there exists very coherent states below the regime of fully developed turbulence.