Nonlinear Rossby Eddy-Kuroshio Interaction at the Luzon Strait

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Abstract

Satellite altimeter sea level height data show that in the subtropical Pacific there is a zonal band between 20°N and 25°N, in which nonlinear Rossby eddy trains, consisting of the cyclonic and anticyclonic mesoscale eddies and originating from the tropic Pacific, propagate westward, and finally reach South China Sea (SCS) in the form of wave motion all year round. Thus, the tropic Pacific is a source of the mesoscale turbulence, and the SCS is a sink for eddies. The Luzon Strait (LS) lying between Taiwan Island and Luzon Island, a large gap of the Pacific western boundary, is just facing the zonal band and serves as an interface between the Pacific and SCS. The horizontal length scale of eddies is O(300 km). The field measurements show that the vertical scale of eddies is O(2000 m). The average angular velocity is $O(5\times10^{-6}\ s^{-1})$ and the average westward propagation speed is $O(0.1\ ms^{-1})$.

Before entering LS, eddies meet the Kuroshio first. The calculation results of this study indicate that the momentum and kinetic energy ratios of Kuroshio with the width of 100 km and the depth of 1000 m, and the velocity of $O(1\ ms^{-1})$ to eddy with the same horizontal length scale monotonically decrease with the eddy radius. For small eddies with radii smaller than 70 - 100 km, the ratios are greater than 2, implying that the Kuroshio would play a dominant role when they collide or interact with each other. Thus, for small eddies, the Kuroshio might serve as a dynamic shield to block eddies' westward propagation. For large eddies with radii greater than 200 km, the ratios are smaller than 0.3, implying that eddies would play a dominant role when they collide or interact with the Kuroshio. Thus, for large eddies, the Kuroshio is relatively weak compared to eddies, it is unable to keep itself unchanged under the forcing by a large eddy or multiple eddies. In contrast, the Kuroshio mainstream path would be modified by eddies, including cutting off, meandering, and bifurcating sometimes. As a result, the Kuroshio behaves as an unsteady flow in the study area.

A case study of an anticyclonic mesoscale eddy passing through LS in June-July 2004 gives a complete description of Kuroshio bifurcation process. The eddy penetrates through LS and enters into SCS simultaneously with Kuroshio bifurcation. The bifurcated westward branch forms Kuroshio Loop Current (KLC) in the northeast SCS deep basin. The dynamic analysis indicates that the behavior of eddies entering SCS can be described by the solution to the quasi-geostrophic vorticity equation. An eddy may gain the vorticity from KLC through the eddy-current coupling. While the eddy would be decaying with a time scale of O(3 d) due to the side friction dissipation after being of independence of KLC.