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Eddy energy sources and flux in the Red Sea

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In the Red Sea, eddies are reported to be one of the key features of hydrodynamics in the basin. They play a significant role in converting the energy among the large-scale circulation, the available potential energy (APE) and the eddy kinetic energy (EKE). Not only do eddies affect the horizontal circulation, deep-water formation and overturning circulation in the basin, but they also have a strong impact on the marine ecosystem by efficiently transporting heat, nutrients and carbon across the basin and by pumping the nutrient-enriched subsurface water to sustain the primary production.

Previous observations and modeling work suggest that the Red Sea is rich of eddy activities. In this study, the eddy energy sources and sinks have been studied based on a high-resolution MITgcm. We have also investigated the possible mechanisms of eddy generation in the Red Sea.

Eddies with high EKE are found more likely to appear in the central and northern Red Sea, with a significant seasonal variability. They are more inclined to occur during winter when they acquire their energy mainly from the conversion of APE. In winter, the central and especially the northern Red Sea are subject to important heat loss and extensive evaporation. The resultant densified upper-layer water tends to sink and release the APE through baroclinic instability, which is about one order larger than the barotropic instability contribution and is the largest source term for the EKE in the Red Sea. As a consequence, the eddy energy is confined to the upper layer but with a slope deepening from south to north. In summer, the positive surface heat flux helps maintain the stratification and impedes the gain of APE. The EKE is, therefore, much lower than that in winter despite a higher wind power input. Unlike many other seas, the wind energy is not the main source of energy to the eddies in the Red Sea.