Topographic effects on submesoscale eddy mixing around the Kuroshio off the Ryukyu Islands

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Abstract

The synoptic, regional downscaling experiment of the Kuroshio off the Ryukyu Islands, Japan, exhibits the evident predominance of submesoscale anticyclonic eddies over cyclones in the narrow strip between the Kuroshio and the islands (Uchiyama et al., 2013). In order to investigate the mechanism of the anticyclone dominance, we carry out a detailed oceanic downscaling experiment in a double nested configuration forced by JCOPE2 and GPV-MSM with a horizontal resolution of 1 km. To pay a particular attention to island topographic effects on eddies, an accompanying experiment is also conducted by removing all the island topography above z > -1000 m with retaining the other configuration unaltered. If the islands are removed, the submesoscale negative vorticity on the eastern side of the Kuroshio is pronouncedly attenuated as compared to the baseline case with the islands.

An energy conversion analysis relevant to eddy kinetic energy demonstrates that the dominance of negative vorticity between the Kuroshio and the Ryukyu Islands is induced by a combination of the lateral shear instability and the baroclinic instability in the upper ocean, leading to development of anticyclonic submesoscale eddies confined in the Okinawa Trough between the continental shelf slope of the East China Sea and the Okinawan ridge. We further examine the heat transport due to the eddying currents, and focus on the divergent component of the eddy heat flux (EHF) that is responsible for the transport normal to the Kuroshio. The diagnostic EHF analysis suggests that the energetic submesoscale anticyclonic eddies promote lateral mixing, abrupt warm water intrusion, and resultant material exchange between the Kuroshio and the Ryukyu Islands.