Seasonal Mesoscale and Submesoscale Eddy Variability along the North Pacific Subtropical Countercurrent

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Abstract:

Located at the center of the western North Pacific subtropical gyre, the Subtropical Countercurrent (STCC) is not only abundant in mesoscale eddies, but also exhibits prominent submesoscale eddy features. Output from a 1/30° high-resolution OGCM simulation and a gridded satellite altimetry product are analyzed to contrast the seasonal STCC variability in the mesoscale versus submesoscale ranges. Resolving the eddy scales of > 150km, the altimetry product reveals that the STCC eddy kinetic energy and rms vorticity have a seasonal maximum in May and April, respectively, a weak positive vorticity skewness without seasonal dependence, and an inverse (forward) kinetic energy cascade for wavelengths larger (shorter) than 250 km. In contrast, the submesoscale-resolving OGCM simulation detects that the STCC eddy kinetic energy and rms vorticity both appear in March, a large positive vorticity skewness with strong seasonality, and an intense inverse kinetic energy cascade whose shortwave cutoff migrates seasonally between the 35-100 km wavelengths. Using a 2.5-layer reduced-gravity model with an embedded surface density gradient, we show that these differences are due to the seasonal evolution of two concurring baroclinic instabilities. Extracting its energy from the surface density gradient, the frontal instability has a growth timescale of O(7 days), a dominant wavelength of O(50 km), and is responsible for the surface-intensified submesoscale eddy signals. The interior baroclinic instability, on the other hand, extracts energy from the vertically-sheared STCC system. It has a slow growth timescale of O(40 days), a dominant wavelength of O(250 km) and, together with the kinetic energy cascaded upscale from the submesoscales, determines the mesoscale eddy modulations.