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Mesoscale eddies, 3D turbulence, internal waves and associated nutrient flux in the Kuroshio Front

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The Kuroshio, one of western boundary currents in the North Pacific, plays very important roles in transporting heat, organic and inorganic constituents. Because it also carries many pelagic fish larvae along with its strong current from their spawning grounds toward feeding grounds, the Kuroshio-Oyashio confluent regions, primary and associated secondary production in the Kuroshio are considered to be critical for their recruitments. In this study, we attempt to quantify the nutrient fluxes to the Kuroshio, which sustain the biological production there, through variety of physical processes, including along isopycnal fluxes: (1) mesoscale eddy flux, (2) subduction and obduction near the front, and diapycnal fluxes: (3) turbulent mixing and (4) double-diffusive mixing.

We conducted field campaigns to measure three-dimensional density structures and microscale turbulent kinetic energy dissipation rates in the Kuroshio Extension Front in Oct., 2009. Results from the Oct. 2009 cruise suggest that low salinity water is subducted from the surface to over 300 m depth, forming low salinity tongue on the north side of the front. The simultaneous nitrate measurements show that within this tongue, nitrate concentration is high, suggesting that subduction of the low sanity water could also contribute to the nutrient flux to the Kuroshio. Using an Omega-equation, we estimate that O(10 m/day) vertical velocity could lead large nitrate flux of O(100 mMol/m^{-2}day^{-1}) at 60 m depth. However, because of the alternating meanders of the front, how much net nitrate flux to the Kuroshio euphotic zone occurs is still unclear. The series of microstructure measurements taken near the Kuroshio Front suggest that turbulence is enhanced under the Kuroshio main stream in the thermocline, where bands of ageostrophic shear is frequently accompanied. The shear bandings could be due to wind-induced near-inertial internal waves. However, our hypothesis is that the meandering Kuroshio Front can spontaneously radiate near-inertial internal waves. The 1-km horizontal resolution numerical simulation shows that near inertial waves are generated from the meandering front with no external forcing. Because near inertial waves can be trapped and dissipated near the front (Kunze 1985, Whitt and Thomas 2013), this spontaneous near inertial waves with wind-induced inertial waves could be source of turbulent nutrient flux right under the Kuroshio main stream. Our measurements using a microstructure profiling float and EM-APEX floats, support the hypothesis. In this talk, the results from eddy-resolving simulation to evaluate the eddy nutrient flux to the Kuroshio will also be presented.

Keywords: Kuroshio, Turbulence, Mesoscale eddies, Internal waves, Double diffusion, Nutrients

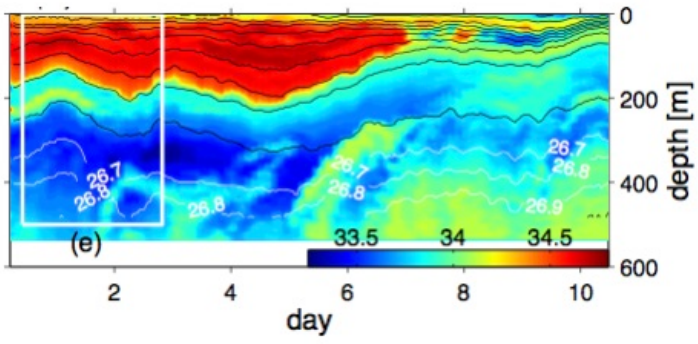

Fig. 1: Salinity measured along the Kuroshio main stream using an EM-APEX Float. White box is measurement range of the microstructure profiling float.