OCEAN DYNAMICS SOUTH SHORE OF OAHU, HAWAIʻI: FROM MEAN CIRCULATION TO NEAR-INERTIAL WAVES AND SUBMESOSCALE.

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ABSTRACT

Recent analytical and numerical studies have shown that submesoscale processes (approximately order one Rossby and Richardson number) in the ocean are important contributors to the fluxes of potential vorticity and are vital for the transfer of energy from the larger mesoscale to the smaller scales. My doctoral dissertation examines submesoscale processes and their interactions with other motions using ocean surface velocities observed from High Frequency Doppler Radar (HFR) at a ~1.5 km resolution, and a Regional Ocean General Circulation Model (ROMS) producing ocean velocities at a ~4 km spatial resolution.

In the first part of the dissertation I examine vortical motions. I focused on deriving the surface vorticity balance south of the island of Oahu, Hawaii using the HFR surface ocean velocities and ROMS product. The first order terms in the balance are advection of vorticity, vortex stretching and a residual which includes the wind stress curl and the divergence of eddy fluxes. A depth integrated vorticity balance was also made assuming an equivalent barotropic flow resulting in bottom pressure torque as a first order term in areas of shallow topography. It was also found that this shallow topography modified the canonical westward Hawaiian Lee Current flowing south of the Hawaiian Archipelago.

The second part describes the spatial variations of surface Near Inertial Oscillations (NIOs) observed in the presence of large Rossby number submesoscale flows. Sea Surface Height (SSH) observations were used alongside HFR and ROMS to study the NIOs spatial variability and frequency characteristics in the presence of the submesoscale (HFR and ROMS) and mesoscale flows (SSH). It was found that the frequency and wavelength of the NIOs are modified by the high Rossby number submesoscale flow. The amplitudes of the NIOs, on the contrary, are modified by the submesoscale flow. In particular, the small-scale gradient of vorticity and divergence fields derived by the HFR surface velocities appear as lead contributors to the damping and growth of the NIOs. These results have implications for the global energy budget of the ocean since the decay and growth of surface NIOs contributes to internal waves and mixing in the interior. Furthermore, the zonal scale

is affected by the coast as well as the Laplacian of the vorticity. An energy budget for the NIO taking into account the influence of the mean background flow is also computed.

The third part of this dissertation describes the submesoscale processes at scales of 5 to 40 km. Submesoscale positive vorticity filaments are routinely observed from the southwest coast of Oahu. These filaments sometimes roll into vortices with diameters of ∼30 km and Rossby numbers $O(1)$. They are generated by barotropic shear instabilities and are amplified by the shear of the mean background flow. It is suggested that frontogenesis and PV dissipation formed the necessary shear to produce the instability. Kinetic energy wavenumber spectrum estimates at scales from 5 to 40 km are consistent with isotropic interior quasigeostrophic turbulence. Ageostrophic motions account for a part of this variance, in particular, at scales of less than 10 km. There is a slight seasonality in the spectrum estimates, with larger variance in winter and spring due to the observed submesoscale eddies. Future studies with high resolution models and three dimensional observations around the Hawaiian archipelago are recommended.