TRANSIENT UPWELLING HOT SPOTS IN THE OLIGOTROPHIC OCEAN AROUND HAWAI'I: THE IMPORTANCE OF MESO- AND SUBMESOSCALE PROCESSES

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Abstract

Large wind stress curl caused by the funnelling of winds through the Hawaiian Archipelago creates eddies in the lee of the islands. An ocean model is applied to understand the effect of temporal and spatial resolutions of the wind stress on the formation of eddies and on eddy kinetic energy levels. Only high-resolution winds produce values comparable to observations, demonstrating that the surface eddy field in the region is mostly dominated by the local winds. Modeled cyclones and anticyclones formed in the lee of the Hawaii are shown to have different propagation patterns. Anticyclones intensify and propagate west-southwestward, maintaining their coherence for a long time. Cyclones wobble in the region of relatively large eddy kinetic energy and often break down into filaments of positive vorticity. The Rossby number within the filaments and eddies is often $O(1)$, in which case nonlinear effects become important. Nonlinear Ekman pumping is shown to be large in regions where the relative vorticity gradient is large. A biological model is embedded into the physical model and the high-resolution wind forcing is shown to affect the supply of new nutrients in the lee of Hawaii. Vertical flux of nitrate is much larger in the immediate lee than in the surrounding oligotrophic ocean. New production is enhanced during the formation stage of cyclones. The $f$-ratio increases from 0.2 to 0.8. As cyclones mature and decay, regenerated production dominates and the $f$-ratio decreases. Submesoscale motions, by creating large vertical velocities, are potentially the main drivers of the streaky chlorophyll-a pattern observed in the region. Numerical simulations show large vertical velocities associated with strong density fronts and gradients of relative vorticity. Vertical velocities derived from the Q-vector divergence yield good agreement with model vertical velocities. The agreement between model vertical velocities and nonlinear Ekman pumping is less satisfactory, although large values of both occur in similar places. The biogeochemical impact of these motions is potentially larger in the summer, with a shallower mixed layer. Hence, they could serve as a partial explanation for the appearance of late summer chlorophyll blooms northeast of the Hawaiian Islands.