EFFECT OF EDDY-WIND INTERACTION ON EKMAN PUMPING AND EDDY KINETIC ENERGY: A REGIONAL COUPLED MODELING STUDY FOR THE CALIFORNIA CURRENT SYSTEM

HYODAE SEO
Woods Hole Oceanographic Institution
Woods Hole, MA 02543

ARTHUR J. MILLER, JOEL R. NORRIS
Scripps Institution of Oceanography
University of California, San Diego
La Jolla, CA 92093-0206

The California Current system (CCS) is characterized by the energetic summertime mesoscale and filamentary eddies with typical anomalies in sea surface temperature (SST) and surface current exceeding 2˚C and 0.5 cms^{-1}, respectively. Recent satellite observations show that both SST and surface current at oceanic mesoscales significantly influence the Ekman pumping velocity, suggestive of a subsequent dynamical feedback effect on the eddy energetics. The extent to which this mesoscale coupling is important for the Ekman pumping and the eddy kinetic energy (EKE) budget in the CCS is the focus of this study.

A series of the 7 km SCOAR regional coupled model simulations is carried out, in which the effects of mesoscale SST and mesoscale surface current are selectively removed in the formulation of surface wind stress. This is achieved by invoking an interactive spatial smoother, which removes oceanic structures with scales smaller than 300 km from the wind stress calculation. The total summertime Ekman pumping velocity is explained largely by two terms having comparable magnitudes: the linear Ekman pumping resulting from the curl of wind stress and the nonlinear Ekman pumping due to the gradient of surface vorticity by mesoscale current. The Ekman pumping due to the mesoscale SST through the linear relationship between the wind stress curl and the crosswind SST gradient is comparatively small. The simulated summertime EKE level in the CCS is reduced by ~30% (fig. 1) when the mesoscale eddies are allowed to influence the wind stress, and this reduction is almost entirely due to the effect of mesoscale current.

Examination of the upper ocean EKE budget terms shows that the dissipation of the EKE results mainly from the increased surface drags associated with a stronger correlation between the eddy-induced current and the wind stress. The change in SST climatology in the CCS is a resulting response from the offshore temperature advection by the mean and eddy currents of the upwelled water over the shelf. The magnitude of the mean SST change is greater with the mesoscale current than the mesoscale SST. Overall, the demonstrated importance of the eddy-wind interactions via mesoscale surface current suggests that the high-resolution ocean and coupled modeling studies over the energetic (sub) mesoscale variability and transient mixed layer fronts need to evaluate the dynamics and impact of small-scale air-sea coupling via surface current.

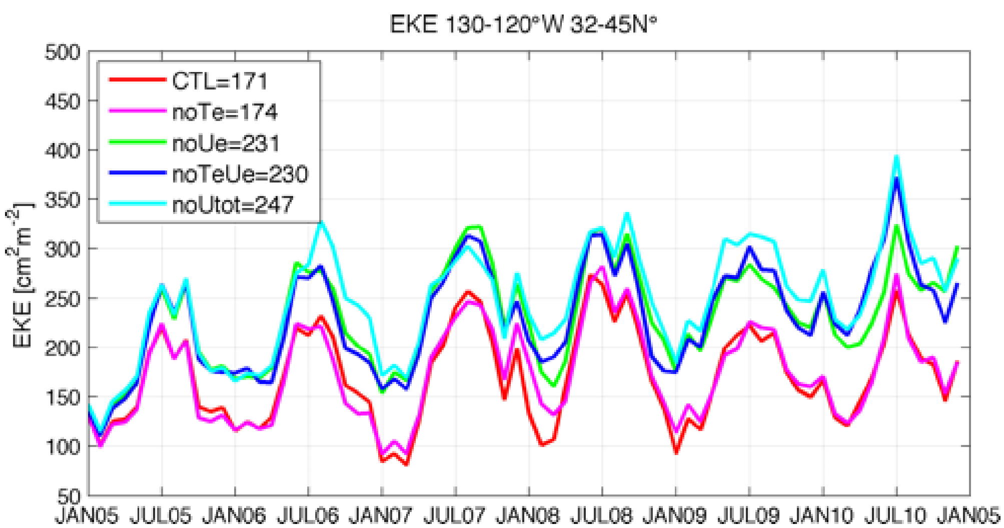

Figure 1. Eddy kinetic energy (EKE) for simulated surface currents in the five model cases averaged over each month of the year from 2005–10. Red is for full coupling. Purple is for no mesoscale SST coupling in wind stress. Green is for no mesoscale current coupling in wind stress. Dark blue is for no mesoscale SST or current coupling in wind stress. Light blue is for no ocean (mesoscale and large-scale) current coupling in wind stress. Allowing mesoscale eddies to affect the wind stress coupling reduces EKE by 25%–30%, while mesoscale SST coupling has very small effects on EKE.