Geophysical Research Abstracts
Vol. 13, EGU2011-3911, 2011
EGU General Assembly 2011

Tidally-induced mixing and enhanced cross-shore transport near coastal capes

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Wind-driven alongshore currents and summer upwelling of cold waters are the dominant patterns of coastal circulation on the Oregon shelf, varying on scales of a few days to several months. This subinertial circulation can be modulated and affected by high-frequency barotropic and internal tides. Using a 1-km horizontal resolution model based on the Regional Ocean Modeling System (ROMS), wind-driven and tidally-driven flows are studied in combination. The study period is May-August 2002, when data from the GLOBEC field program are available for model verification. Realistic time-and-space-varying atmospheric forcing is provided by COAMPS and NCEP. Open boundary conditions are a combination of a solution from a larger scale, 3-km resolution ROMS model (run without tidal forcing) and barotropic tides from a data-assimilating shallow-water model. The shape of the upwelling front looks very different in model cases run without tides, with the semi-diurnal M2 component alone (which is the dominant barotropic component), or with 8 tidal constituents. These differences are either due to purely numerical reasons (the hydrostatic model is known to be very sensitive to changes in boundary conditions) or due to dynamical mechanisms associated with the relatively mild tidal currents (0.05-0.15 m/s on the shelf). To understand whether tidal motions contribute to cross-shore transport on subtidal scales, intensity and intermittency in the semidiurnal and diurnal tidal components has been analyzed. Although the diurnal K1 currents are generally smaller than M2, large K1 barotropic flows have been found in shallow areas (50 m) near capes, in particular in the area off Cape Blanco where the coastal current separates from the shelf. In that area, bathymetry varies strongly in the alongshore direction. Analysis of the vertical sections reveals structures common for hydraulic flows. Experiments with a passive tracer continuously released at one grid cell near bottom at 50 m depth show that the tracer reaches the near surface much faster and spreads over a larger surface area than in the model without tides. Strongly sheared flows over abrupt bathymetry yield enhanced turbulence and mixing throughout the water column, changing the pattern of upwelling in this area. Large tidal excursion of diurnal tides helps to spread the tracer over a large shelf area (20 x 20 km) in a few days. In our ongoing work, we investigate the effect of the tidal mixing on the pathway of waters upwelled over the shelf bottom, the relative impact of semi-diurnal and diurnal tides in these processes, and the potential long-term effects of the tidal variability on the shelf-open ocean exchange.