The response of northern Gulf of Mexico estuary plume, water exchange to wind forcing: A model-guided mechanism study to Perdido Bay

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Abstract

In this study, the Environmental Fluid Dynamic Code (EFDC) is used to simulate the salinity plume distribution at the mouth of the Perdido Bay Estuary (PBE), a typical shallow bay in the northern Gulf of Mexico. To better understand the plume structure in the PBE, and in other similar bay systems in the future, ideal sensitivity experiments were conducted to examine the sensitivity of the plume structure to various horizontal and vertical grid resolutions, and an advection scheme was developed to compare the differences in the surface plume structure. An existing calibrated EFDC Perdido Bay model has been demonstrated and calibrated in detail elsewhere [Xia, 2010], which includes variable wind, river flow, and realistic boundary conditions from five major tidal constituents. With the help of model sensitivity experiments, the effect of wind stress on the plume simulation was tested to investigate the 3-D plume PBE structure. The results were then applied to realistic simulations. The ramifications to previous studies of idealized plume models is also discussed. Wind direction dominates plume orientation, while wind speed significantly influences the plume size and vertical depth. Salt flux is a key for the 3-D plume structure. Under the wind forcing condition, water exchange and salt flux were analyzed to see how the wind forcing interacted with the bay-ocean. It was obvious that an unforced northerly wind favored the salt flux into the bay, while a south wind with a high wind speed resulted in less salt in the bay. Thus, a significant surface plume consists with salt flux into the bay system; since the surface favors the water outflow to the bay while the bottom estuarine circulation should increase the salt flow into the bay. Additional particle transport analysis was conducted with a variable wind forcing to determine the influence of the plume on particle distribution. Results showed a consistency between the surface plume and particle transport.