Abstract View

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Wind-Driven Motion of Estuarine Plumes

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ABSTRACT

The effect of wind forcing on existing estuarine plumes in a coupled estuary-shelf environment is studied here using a three-dimensional primitive-equation model. The emphasis is on wide estuaries so that the Coriolis force cannot be ignored. Over the shelf, the plume responds mostly to the wind-induced surface Ekman drift. Under downwelling-favorable wind, an additional downwind coastal jet occurs that elongates the plume along the shore. For cross-shelf winds, the nearshore Ekman drift is considerably retarded by the sea level setup or setdown. The retardation is particularly effective when the stratification increases. These properties of wind-driven coastal circulations determine the first-order plume responses.

Inside the estuary, the down estuary wind reinforces the gravitational circulation, but the up-estuary wind opposes it. Both winds are effective local forcings that make the remotely forced signals from the shelf unlikely to be detected. Compared to longitudinal winds, cross-estuary winds are less effective in diving the local circulation, allowing the remotely forced signals from the shelf to stand out better. The upwelling-favorable wind enhances the gravitationally induced longitudinal currents. In consequence, remote signals from the shelf are barely detectable. The downwelling-favorable wind first neutralizes longitudinal currents. Thereafter, the remotely forced signal becomes the dominant response.

Two types of wind-induced vertical mixing are produced by the model. The first is typically observed during seaward wind, which enhances the vertical current shear and destratifies the water column from the surface downward. The second is typically during the landward or downwelling-favorable wind, which weakens and then reverses the surface current and its associated vertical shear, transports heavier water atop the light water pool, and destratifies the water column.

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