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Modeling tidal circulation and stratification in Skagit River estuary using an unstructured grid ocean model

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ABSTRACT

Tidal circulation and river plume dynamics in shallow-water estuarine systems with large intertidal zones are complex. Strong asymmetries in tidal currents and stratification often occur in the intertidal zones and subtidal channels over a tidal cycle. The Skagit River is the largest estuary with respect to the discharge of a significant amount of freshwater and sediment into Puget Sound, Washington. It consists of a large intertidal zone with multiple tidal channels near the mouth of the estuary. To simulate the tidal circulation and salinity stratification accurately in the intertidal region, an unstructured grid numerical model with wetting–drying capability and the capability to accurately represent the bathymetry of tidal flats and the geometry of shallow distributary channels is necessary. In this paper, a modeling study for the Skagit River estuary using a three-dimensional unstructured grid, finite-volume coastal ocean model (FVCOM) supported by high-resolution LIDAR data is presented. The hydrodynamic model was validated with observed water surface elevation, velocity, and salinity data over spring and neap tidal cycles under low-river-flow and high-river-flow conditions. Wetting and drying processes in the intertidal zone and strong stratification in the estuary were simulated successfully by the model. Model results indicate that the Skagit River estuary is a highly stratified estuary, but destratification can occur during flood tide. Tides and baroclinic motion are the dominant forcing in the Skagit River estuary, but strong wind events can affect the currents in the intertidal zone significantly. Preliminary analysis also indicated that the salinity intrusion length scale is proportional to the river flow to the $-1/4$ power.