Unstructured-grid modeling of the biogeochemistry of a complex estuary

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The Columbia River estuary (CRE) is a river-dominated estuary located on the West Coast of the United States. Even though the residence time of the CRE is very short (ranging from hours to days depending on the season) there is strong evidence that important nutrient transformations take place in the estuary. A biogeochemical model for the estuary–the Bioreactor Model– has been developed to understand these nutrient transformations and their consequences in terms of nitrogen budgets and oxygen availability. The Bioreactor Model is an adaptation of the Spitz et al (2001) model [Configuring an ecosystem model using data from the Bermuda Atlantic Time Series Deep-Sea Research II, 48 (2001) 1733-1768] to an estuarine environment, and is coupled to the unstructured-grid finite element SELFE circulation and transport model. It has fourteen state variables in the water column, including two groups of phytoplankton (marine and freshwater) and their respective chlorophyll concentration, two groups of zooplankton (meso and micro), dissolved inorganic nutrients, oxygen and an explicit microbial loop. A simple benthos (detritus, NO3, NH4, oxygen) is coupled to the water column model. Biogeochemical data recorded during the last decade by the SATURN observation network (through field campaigns and long term endurance stations) were used in conjunction with skill assessment tools to validate the model. The results show a dynamic system highly dependent on the river discharge (upstream boundary conditions) and seasonal upwelling events in the ocean (downstream boundary conditions). Estuarine turbidity maxima (ETM), where phytoplankton species die preferentially due to sharp gradients of salinities that they are not adapted to, are among the most biologically active areas of the estuary. High bacterial productivity and high zooplankton concentrations occur in these ETM due to the high concentration of particulate material sinking to the benthos and its subsequent resuspension into the water column. Challenges associated with developing predictive biogeochemical models for estuaries as well as our finding about ETM and the spatial and temporal variability in the estuary will be discussed.