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How hydrodynamics control algal blooms in the Ythan estuary, Scotland

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The Ythan estuary, northeast Scotland, was designated in 2000 as a Nitrate Vulnerable Zone (NVZ) under the European Commission (EC) Nitrates Directive. Much of the catchment is intensively farmed and water quality has been adversely affected by nutrients from agricultural fertilizers. As a result, algal mats develop annually on tidal flats where sediment from upstream and from the adjacent dune systems is deposited. Understanding the patterns of water (river and ocean) circulation in the estuary as well as understanding how nutrients and sediments are transported in the estuary is crucial for understanding the role of several factors (elevation; sediment characteristics; nutrient flux) control the locations and scale of annual algal blooms. In order to understand those controls, study of interactions between hydrodynamic factors and water quality, in particular chlorophyll levels, at different time scales has been carried out. The results from the study reveal complex seasonal and event-scale relationships of river flow with the amount of chlorophyll, which provide an initial comprehension of controls over the concentrations of chlorophyll in the estuary. The concentration of chlorophyll changes, whether increasing or decreasing, with regards to changes in river flow. During high flow events, high amounts of chlorophyll are found when the tide is low. During low flow events, high amounts of chlorophyll are found at high tides. These phenomena reveal that both river flow and tidal cycle affect the amount of chlorophyll in the estuary. In addition, the Delft3d flow model, which has been extensively applied to many coastal and estuarine studies is used to simulate hydrodynamic patterns in the estuary during high flow and low flow events. The model is composed of 36,450 fine resolution grids and the upstream/ downstream boundary that represents water level is based on time-series data from river flow and tidal measurements. The bathymetry used for the model domain is taken from an integration of single beam echo sounder data and terrestrial LiDAR data. The results derived from the simulation including flow velocity, bed shear stress, and current directions will be calibrated and validated against measured data. The results after calibration and validation will provide understanding of freshwater and sea water circulation patterns, which will be used in the next phase of the study to explain how nutrients and sediments are likely to move and whether they link to the locations and intensity of the algal blooms.