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Phytoplankton growth response to physical forcing in a macrotidal estuary: coupling hydrodynamics, sediment transport and biogeochemistry

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A two-dimensional nested grid hydrodynamic and reactive-transport model of the macrotidal Scheldt estuary (B/NL) and its tributaries has been developed to identify the driving forces controlling the temporal and spatial dynamics of primary production during a summer diatom bloom. The hydrodynamic model indicates that energy dissipation reaches its maximum 90 km upstream from the mouth, closely followed by a minimum further upstream. Suspended particulate matter (SPM) dynamics is simulated to provide the transient light conditions in the water column. Results show that the spatial distribution of SPM mirrors closely the profile of energy dissipation. The temporal SPM dynamics is highly sensitive to fluctuations in river discharge, whose influence decreases in downstream direction. Peaks in SPM are triggered by high discharges and can be recorded as far as 50 km downstream of the upstream model boundary. Results from the phytoplankton model demonstrate the fast response of diatom growth to changes in the physical environment, especially those due to daily variation in river discharge which continuously modify the SPM concentrations and residence times. Episodes of persistent low flow conditions lead to a progressive depletion of dissolved silica, which can not be compensated by benthic recycling fluxes. Diatom growth becomes increasingly controlled by silica availability, until a collapse in primary production is simulated. The complex interplay between transient physical forcing conditions (temperature, solar radiation, discharge, SPM, nutrients) determines the observed primary production dynamics.