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Dancing with the Tides: Fluctuations of Coastal Phytoplankton Orchestrated by Different Oscillatory Modes of the Tidal Cycle

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Strongly fluctuating variables, such as phytoplankton concentrations, require high resolution monitoring programs to enable accurate detection of trends. For the design of monitoring strategies it is important to know the characteristic time scales of fluctuations. Moreover, we would like to know what drives these fluctuations. We have analyzed high resolution data series from a mooring with the statistical techniques wavelet analysis and wavelet coherence analysis, to investigate characteristic time scales and drivers of chlorophyll fluctuations in the North Sea..

Time series of chlorophyll fluorescence, suspended particulate matter (SPM), salinity and temperature were obtained from an automated measuring platform in the southern North Sea, covering 9 years of data at a resolution of 12 to 30 minutes. Wavelet analysis showed that chlorophyll fluctuations were dominated by periodicities of 6 hours 12 min, 12 hours 25 min, 24 hours and 15 days, which correspond to the typical periodicities of tidal current speeds, the semidiurnal tidal cycle, the day-night cycle, and the spring-neap tidal cycle, respectively. During most of the year, chlorophyll and SPM fluctuated in phase with tidal current speed, indicative of alternating periods of sinking and vertical mixing of algal cells and SPM driven by the tidal cycle. Spring blooms slowly built up over several spring-neap tidal cycles, and subsequently expanded in late spring when a strong decline of the SPM concentration during neap tide enabled a temporary “escape” of the chlorophyll concentration from the tidal mixing regime.

Our results demonstrate that measurements with high temporal resolution are required not only for accurate trend detection, but also for an analysis of possible causes of trends. Modern statistical techniques, such as wavelet analysis, are required to detect the patterns present in high resolution time series.