Geophysical Research Abstracts
Vol. 19, EGU2017-14122, 2017
EGU General Assembly 2017

Using high-frequency sensors to identify hydroclimatological controls on storm-event variability in catchment nutrient fluxes and source zone activation

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At the river catchment scale, storm events can drive highly variable behaviour in nutrient and water fluxes, yet short-term dynamics are frequently missed by low resolution sampling regimes. In addition, nutrient source contributions can vary significantly within and between storm events. Our inability to identify and characterise time dynamic source zone contributions severely hampers the adequate design of land use management practices in order to control nutrient exports from agricultural landscapes. Here, we utilise an 8-month high-frequency (hourly) time series of streamflow, nitrate concentration (NO_3) and fluorescent dissolved organic matter concentration (FDOM) derived from optical *in-situ* sensors located in a headwater agricultural catchment. We characterised variability in flow and nutrient dynamics across 29 storm events. Storm events represented 31% of the time series and contributed disproportionately to nutrient loads (43% of NO_3 and 36% of CDOM) relative to their duration. Principal components analysis of potential hydroclimatological controls on nutrient fluxes demonstrated that a small number of components, representing >90% of variance in the dataset, were highly significant model predictors of inter-event variability in catchment nutrient export. Hysteresis analysis of nutrient concentration-discharge relationships suggested spatially discrete source zones existed for NO_3 and FDOM, and that activation of these zones varied on an event-specific basis. Our results highlight the benefits of high-frequency *in-situ* monitoring for characterising complex short-term nutrient dynamics and unravelling connections between hydroclimatological variability and river nutrient export and source zone activation under extreme flow conditions. These new process-based insights are fundamental to underpinning the development of targeted management measures to reduce nutrient loading of surface waters.