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Multi-decadal trajectory of riverine carbon, nitrogen and phosphorus dynamics in rural catchments

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Human activities have substantially altered riverine exports of carbon, nitrogen and phosphorus in the Anthropocene, causing major alterations of freshwater and marine ecosystems worldwide. Documenting anthropogenic alterations of carbon and nutrient cycles in aquatic ecosystems is a challenge as industrialization in western countries began in the 18th century and the green revolution in the mid-20th century, while river monitoring became widespread only since the 1990's. Brittany - France, is one of the few noticeable exceptions of a region with multi-decadal datasets of nitrate (NO_3-), soluble reactive phosphorus (SRP), total phosphorus (TP) and dissolved organic carbon (DOC) in meso-scale (< 5000 km^2) rural catchments.

Here we analyze these multi-decadal and multi-parameter time series with the objectives to investigate: i) long term trajectory of C, N, P concentrations in relation to the history of diffuse and point source pressures in seven catchments since the 1970's, ii) medium term variations in relation to inter-annual climate variability (during 5-year wet-dry cycles) and iii) seasonal variations (and their long term evolution) in relation to catchments properties and history. Statistical analyses include a seasonal-trend decomposition procedure based on Loess (STL) and long term input-output hysteresis plots.

Results show that long term NO_3- concentration is controlled by the agricultural N surplus with a hysteresis effect, indicating a time lag of approximately 10 years between decrease in N inputs and decrease in NO_3- loads. Long term SRP and TP concentrations are mainly controlled by point source emissions that have decreased continuously since the 1980's. Long term DOC concentration shows little variation contrary to many catchments of the northern hemisphere. Medium term inter-annual NO_3- concentration is controlled by discharge, with an increase in concentrations during wet years and a hysteresis effect indicating the flushing of a pool of nitrate stored in the catchments during antecedent drier years. Medium term SRP concentration is also controlled by discharge, with a dilution during wet years supporting the hypothesis of point-source dominated emissions. Medium term variations in TP and DOC concentrations are less clear, possibly because of opposite flushing and dilution effects during wet years. Seasonal variations exhibited winter maxima for NO_3- and summer maxima for SRP, TP and DOC, confirming the dominant diffuse nature of NO_3- emissions, the point-source dominated P emissions and possibly autochthonous DOC production during the summer period.

Despite the study catchments being of relatively small size (median 800 km^2), they were large enough to comprise a variety of point and diffuse sources which were not monitored individually, and the effect of hillslope processes could often not be disentangled from in stream processes. Therefore, future work will focus on combining monitoring in smaller headwater catchments, where few sources are present and in stream processes minimal, and in downstream stations representing the integrated signal discharging into the sea.