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Silicon - δ^{30} Si – Discharge dynamics during a storm event in an agricultural headwater catchment

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Storm events modify groundwater-surface dynamics, changing concentration-discharge (C-Q) relationships and thus nutrient export from watersheds. C-Q variations are helpful indicators of hydrologic and biogeochemical processes. The activation of new pathways, release of old water, and/or the chemical reaction of the material (rock, soil, organic matter) with new water explain these relations. However, due to the complexity of these systems, it is difficult to only use elemental concentrations to resolve the problem of changes in transport and/or reaction pathways. Reactive tracers such as isotope ratios “R” (e.g., silicon isotopes, δ^{30}Si), can additionally provide fingerprints reflecting changes in flow paths or reactivity in response to hydrologic events.

Here, we analyze in-stream δ^{30}Si-C-Q relationships during a storm event in the agricultural headwater catchment of Kervidy-Naizin, part of the AgrHyS Observatory in France. Groundwater, soil porewater and stream samples were taken under baseflow conditions, in addition to high-frequency sampling of the stream during storm (1 sample/hour). Major cations and anions, metals, DOC and δ^{30}Si were determined.

Baseflow isotope data show that soil solutions have heavier δ^{30}Si signature than groundwater, while stream water δ^{30}Si is likely a mix of these two sources. During the storm, Si concentration exhibits a dilution pattern and δ^{30}Si values decrease on the rising limb, and reverse on the falling limb. One explanation of δ^{30}Si behavior could be the contribution of a higher fraction of groundwater into the stream. However, the strong dilution of NO_3^- (related to groundwater reservoir) rejects this hypothesis. In contrast the flushing behavior of DOC and metals, associated to the soil, suggest an increase of water flowing through the soil layer. The decrease of the δ^{30}Si signature can be explained by the dissolution of clays in the soil, which is also supported by the decrease of Si/Al ratio and the increase of total Si exports during the storm. Our results point to changes in both water flow paths and reaction networks as drivers for the C-Q-R relationships.