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A European vision for hydrological observations and experimentation

Reconstructing the history of flowing waters from freshwater mussels in the context of interdecadal climate variability

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The ongoing intensification of the hydrological cycle calls for the identification and assessment of factors controlling catchment resilience to climate change. Stable isotopes of O and H in streams and precipitation are cardinal tools in this respect – notably for investigating questions related to water source, flowpaths and transit times. However, the spatial and temporal variability of these tracers remain largely unknown – essentially due to the limited availability of long historical time series of O-H isotope signatures in stream water, as opposed to the multi-decadal records in precipitation of the IAEA's GNIP database (https://www.iaea.org/services/networks/gnip).

Based on their quality as natural archives of in-stream environmental conditions, freshwater mussels have been recently used for complementing stream water $\delta^{18}O$ isotope records. With an average life span of ca. 10 years (up to 200 years for the freshwater pearl mussel), their potential is significant, considering the fact that nearly 1200 freshwater bivalve species inhabit a large variety of river systems and lakes around the globe (Pfister et al., 2018). Our proof-of-concept work has shown that $\delta^{18}O$ values extracted from their shells closely mirror the variance of the measured stream water $\delta^{18}O$ – both showing a strong damping of the precipitation signal. In our follow-up study, we leverage prior work by Schöne et al. (2020) on potential links between the NAO index, precipitation isotope signatures and subsequent interdecadal variabilities in reconstructed stream water $\delta^{18}O$ signals for three catchments located in Sweden. Using freshwater bivalve shell $\delta^{18}O$ as a proxy of stream water $\delta^{18}O$ signatures, we hypothesize that interdecadal shifts in atmospheric circulation patterns translate into modifications of $\delta^{18}O$ isotope signatures in precipitation and subsequent stream water $\delta^{18}O$ signals – the latter potentially revealing changes in young stream water fractions related to fast flow paths. In parallel, we stipulate that the long-term $\delta^{18}O$ signal in precipitation can be retrieved from historic records and reanalysis data of climate variables, as well as from synoptic atmospheric circulation classifications.

Here we focus on findings gained from a unique dataset of 5 years-worth of sub-daily precipitation O-H isotope data from the Belvaux (L) meteorological station, comprising 1443 rainfall samples. We investigated the links between local climate variables, the rainfall amount, atmospheric circulation patterns, and the precipitation $\delta^{18}O$ signal. Our results show (i) an anticipated strong

temperature-induced seasonality of the δ^{18}O signal, characteristic for semi-continental sites, (ii) a weak but significant amount effect, (iii) a circulation type-dependant influence of local climate variables on the δ^{18}O signal, and (iv) a high variability at the event-scale – indicating the influence of complex frontal systems and moisture recycling. We leveraged these findings for building a multiple linear regression model, explaining up to 50 percent of the variability of the δ^{18}O signal at sub-daily resolution and closely matching the isotopic signal when applying moving averages over periods within a monthly range.