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Using stable isotopes to estimate and compare mean residence times in contrasting geologic catchments (Attert River, NW Luxembourg)

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In recent years, stable isotopes have been increasingly used to characterize important aspects of catchment hydrological functioning, such as water storage dynamics, flow pathways and water sources. These characteristics are often synthesized by the Mean Residence Time (MRT), which is a simple catchment descriptor that employ the relation of distinct stable isotopic signatures in the rainfall input and streamflow output of a catchment that are significantly dampened through sub-surface propagation.

In this preliminary study, MRT was estimated in the Attert River catchment (NW Luxembourg), where previous studies have shown that lithology exerts a major control on runoff generation. The Attert catchment lies at the transition zone of contrasting bedrock lithology: the Northern part is characterized by Devonian schist of the Ardennes massif, while sedimentary deposits of sandstone and marls dominate in the south of the catchment. As a consequence of differing lithologic characteristics, hydrological processes change across scales. The schistose catchments exhibit a delayed shallow groundwater component, sandstone catchments have slow-responding year-round groundwater component, whereas flashy runoff regimes prevails in the marly catchments.

Under these circumstances, the MRTs are expected to vary significantly according to lithology, and provide additional understanding in internal catchment processes and their scale dependencies. In order to test this, bi-weekly monitoring of rainfall and discharge stable water isotope composition (oxygen-18 and deuterium) has been carried out since 2007 in 10 nested sub-catchments ranging in size from 0.4 to 247 km^2 in the Attert catchment.

MRT was estimated using different lumped convolution integral models and sine wave functions with varying transit times distributions (TTDs). TTDs were evaluated through calibration. Further research efforts will deal with the application of conceptual models to simulate and compare TTD, using additional data and process understanding for model evaluation in the studied catchments.