Geophysical Research Abstracts
Vol. 20, EGU2018-10282, 2018
EGU General Assembly 2018

Bedrock geology controls on catchment functions of storage, mixing and release : findings from a nested catchment set-up in the Alzette River basin (Luxembourg)

Laurent Pfister (1), Jeffrey J. McDonnell (2), Núria Martínez-Carreras (1), Christophe Hissler (1), Gwenael Carrer (1), and Michael K. Stewart (3)

(1) Luxembourg Institute of Science and Technology, ERIN, Esch-sur-Alzette, Luxembourg (laurent.pfister@list.lu), (2) University of Saskatchewan, Global Institute for Water Security, Saskatoon, Canada, (3) GNS Science, New Zealand

The way how basin geology, catchment water collection/mixing, storage and release are connected remains poorly understood to date. Most investigations on the influence of catchment geology on catchment mean transit time were based on flow and isotope tracer data and rarely exceeded 2-3 bedrock types. The bedrock controls on catchment mixing, storage, and release have been actively studied in recent years. However, comparative analysis across different neighboring lithologies has been a major challenge.
Here we present data from 16 nested catchments located in the Alzette River basin (Luxembourg, Europe), spanning a wide range of sizes (0.47 to 285 km2) and contrasted bedrock geology. We have analysed 9 years' worth of precipitation and discharge data (for all 16 nested catchments), 6 years of fortnightly stable isotope and chemistry data in streamflow (for a subset of 12 catchments). Our aim was to investigate bedrock geology controls on (1) streamflow regime metrics, (2) catchment storage, (3) stream chemistry and (4) isotope response and catchment mean transit time.
We characterised streamflow regime through catchment specific winter runoff/precipitation ratios, as well as average summer/winter discharge ratios. We used catchment storage (and subsequent 'active' and 'total' storage) as a metric for catchment comparison. Water mixing potential of all investigated catchments was assessed through the standard deviation in chemical element concentrations, streamflow deuterium, as well as the amplitude ratio of annual cycles of oxygen-18 in streamflow and precipitation. We determined catchment mean transit time values both via stable isotope signature damping and hydraulic turnover.
In our area of interest, the variance in summer vs. winter average runoff was best explained by bedrock geology – and more specifically bedrock permeability. In most investigated catchments stream chemistry and stable isotopes (O and H) exhibit contrasted signatures along their flow duration curves (FDCs). We hypothesize that breaks in the FDCs mirror the onset/cessation in contributions from various storage compartments. Total catchment storage (i.e. the largest possible extent of catchment storage connected to the stream network) extended up to 1700 mm (+/- 200 mm). Active storage (as a measure of the observed maximum inter-annual variability in catchment storage) ranged from approximately 100 to 370 mm. The ratio between active and total catchment storage was found to increase as bedrock permeability decreases. The latter was strongly correlated with water mixing proxies (standard deviation in streamflow D, ratios in oxygen-18 amplitudes in streamflow and precipitation). In our set of 12 nested catchments, mean transit time values ranged from 0.5 to 2 years when inferred from stable isotope signature damping (from 0.5 to 10 years when based on hydraulic turnover calculations).
Ongoing hydrometric and tracer monitoring programmes in our area of interest will continue for multiple years. These datasets will eventually serve as a backbone to further concept development and testing of time-variant catchment (water and solute) storage and release functions.