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Expanding the temporal toolbox: Application of sulphur-35 as a novel isotope tracer for investigation of yearly and sub yearly residence times

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Sulphur-35 (^{35}S) is a cosmogenic radioisotope with a relatively short half-life ($t_{1/2}$ = 87.4 days) and a high solubility in water as $^{35}SO_4$ after oxidizing of elemental sulphur in the upper atmosphere. These characteristics make of ^{35}S a valuable short-term aqueous tracer, providing insight into groundwater flow paths and residence times within annual to sub-annual timeframes, thereby filling a temporal gap between commonly used daily and decadal tracers such as radon ($t_{1/2}$ = 3.8 days) and tritium ($t_{1/2}$ = 12.3 years), respectively. One significant aspect of this timeframe lies in the ability to provide critical information about the vulnerability of aquifers to quick/sub-annual infiltration by microbial and/or chemical pollutants. Similar to application of other cosmogenic radionuclides, ^{35}S requires an input value or input function, i.e., activity levels in precipitation representative of the study region, at least one year to determine (e.g. seasonal) fluctuations, to gain the finest time resolution benefits of the tracer. However, on a qualitative level, merely the presence or absence of ^{35}S in groundwater contributes baseline insight into the majority age fraction of the water mass assessed. The sample collection and preparation pose several challenges that have been addressed in recent method development, particularly, (1) to reduce sample volume needed and (2) to efficiently process the large amount of 10 – 20 Litres of sample in the field. Improvements to the sampling involved loading of an anion exchange resin in the field prior to sample elution and processing in the laboratory and quantification by liquid scintillation counting. Using data predominantly collected from precipitation, surface water and shallow groundwater sampled in Austria, the potential for the application of ^{35}S as a novel tracer will be described, alongside a recently developed sampling methodology, and detail how it can be paired with other, common temporal tracers to fine tune measurements of groundwater residence times and flow paths.