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Spatial and temporal variation of denitrification in the riparian zone during the hydrological year

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In the riparian zone, where stream water mixes with groundwater, biogeochemical reactions and solute transformations occur which may enhance the self-cleaning mechanisms of aquatic ecosystems. The water exchange and solute transport through the riparian zone is controlled by hydraulic gradients between stream and groundwater and thus varies seasonally and during stream discharge events.
In this study, we focus on transport, mixing and the distribution of nitrate in the riparian zone of a gravelly alluvial aquifer with the aim to quantify its denitrification potential during the hydrological year. For this purpose, 25 groundwater wells were drilled along a 2 km stream section of the Selke river, a third-order stream in Germany. From the stream and the wells, water samples were taken 4-weekly over a period of 2 years. Water samples were analyzed to field parameters, major ions, dissolved organic carbon, and N-O isotopes.
Results show a strong influence of the stream on the adjacent groundwater, which varies both in time and space. In general, we can distinguish between two endmembers: a) the stream water with low chloride (<30 mg/L) and nitrate (<10 mg/L) concentrations and b) the groundwater in 100m distance to the stream with high chloride (>70 mg/L) and nitrate (>50 mg/L) concentrations. Based on conservatively transported chloride, the mixing of the endmembers can be determined in the riparian zone. Deviations in nitrate concentrations from this mixing model may indicate nitrate degradation by e.g. denitrification. By combining this chloride-nitrate-ratio method with dissolved oxygen data and the isotopic signature of the nitrate molecule, we are able to determine the timing and the location of high denitrification patterns in the riparian aquifer. Highest variability of denitrification occurs over the year in terms of seasonality (temperature-driven) and is temporally fueled by additional organic carbon supply during discharge events.