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Relative importance of time, land use and lithology on determining aquifer-scale denitrification

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Unconfined shallow aquifers are commonly contaminated by nitrate in agricultural regions, because of excess fertilizer application over the last decades. Watershed studies have indicated that 1) changes in agricultural practices have caused changes in nitrate input over time, 2) denitrification occurs in localized hotspots within the aquifer, and 3) heterogeneous groundwater flow circulation has led to strong nitrate gradients in aquifers that are not yet well understood.
In this study we investigated the respective influence of land use, groundwater transit time distribution, and hotspot distribution on groundwater denitrification with a particular interest on how a detailed understanding of transit time distributions could be used to upscale the point denitrification measurements to the aquifer-scale. We measured CFC-based groundwater age, oxygen, nitrate, and dinitrogen gas excess in 16 agricultural wells of an unconfined crystalline aquifer in Brittany, France. Groundwater age data was used to calibrate a mechanistic groundwater flow model of the study site. Historical nitrate inputs were reconstructed by using measured nitrate concentrations, dinitrogen gas excess and transit time distributions of the wells. Field data showed large differences in denitrification activity among wells, strongly associated with differences in transit time distribution. This suggests that knowing groundwater flow dynamics and consequent transit time distributions at the catchment-scale could be used to estimate the overall denitrification capacity of agricultural aquifers.