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# The nitrate response of a lowland catchment and groundwater travel times

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Intensive agriculture in lowland catchments causes eutrophication of downstream waters. To determine effective measures to reduce the nutrient loads from upstream lowland catchments, we need to understand the origin of long-term and daily variations in surface water nutrient concentrations.
Surface water concentrations are often linked to travel time distributions of water passing through the saturated and unsaturated soil of the contributing catchment. This distribution represents the contact time over which sorption, desorption and degradation takes place. However, travel time distributions are strongly influenced by processes like tube drain flow, overland flow and the dynamics of draining ditches and streams and therefore exhibit strong daily and seasonal variations.
The study we will present is situated in the 6.6 km2 Hupsel brook catchment in The Netherlands. In this catchment nitrate and chloride concentrations have been intensively monitored for the past 26 years under steadily decreasing agricultural inputs. We described the complicated dynamics of subsurface water fluxes as streams, ditches and tube drains locally switch between active or passive depending on the ambient groundwater level by a groundwater model with high spatial and temporal resolutions. A transient particle tracking approach is used to derive a unique catchment-scale travel time distribution for each day during the 26 year model period. These transient travel time distributions are not smooth distributions, but distributions that are strongly spiked reflecting the contribution of past rainfall events to the current discharge. We will show that a catchment-scale mass response function approach that only describes catchment-scale mixing and degradation suffices to accurately reproduce observed chloride and nitrate surface water concentrations as long as the mass response functions include the dynamics of travel time distributions caused by the highly variable connectivity of the surface water network.