Simulating 50 years of land management and groundwater flow to explain today's nitrate concentrations in Flemish surface waters

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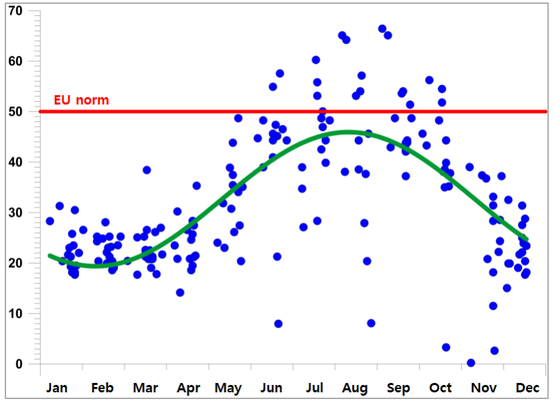
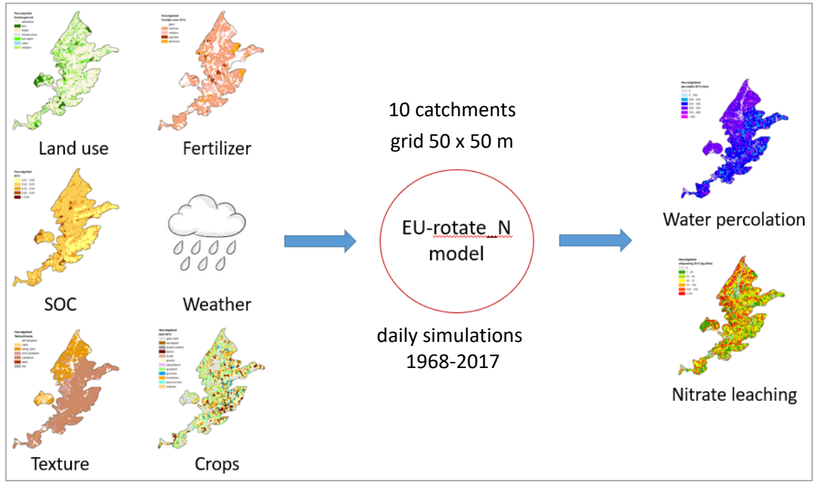
Introduction

Elevated nitrate (NO_3) concentrations in both ground and surface water are a common problem in regions with intensive agriculture such as Flanders. Fertilizer restrictions have in many catchments been awarded with reduced NO_3 concentrations, but not everywhere. In catchments with substantial NO_3-rich baseflow, the response may be delayed due to long travel times of historically contaminated groundwater travelling through oxidized parts of the aquifer systems.



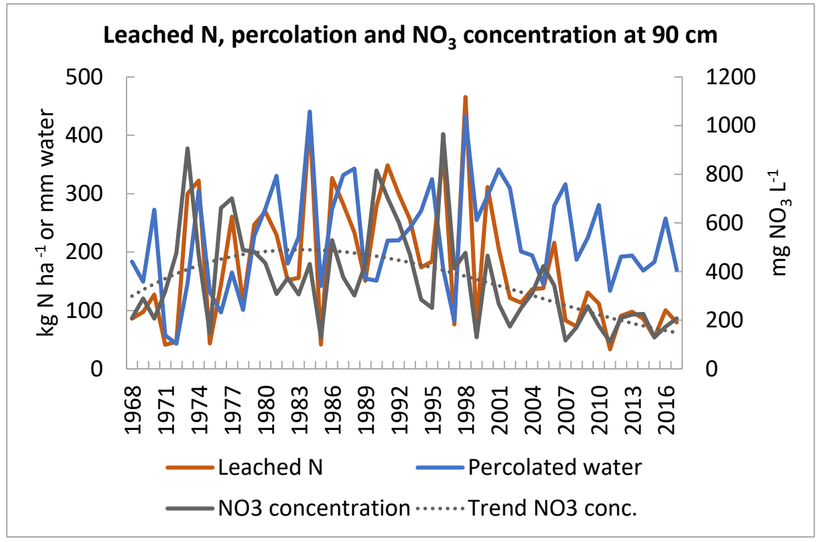
Measured NO_3 concentrations (mg NO_3 L^{-1}) in surface water showing a typical average seasonal trend for catchments with nitrate-rich baseflow, resulting in higher summer and lower winter concentrations.

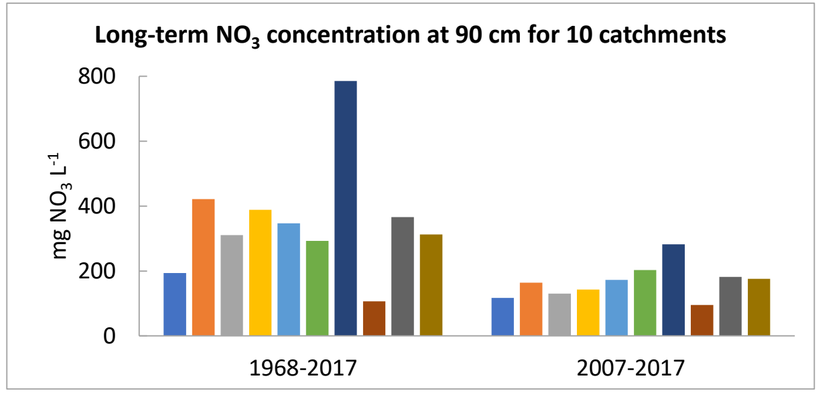
Material and methods

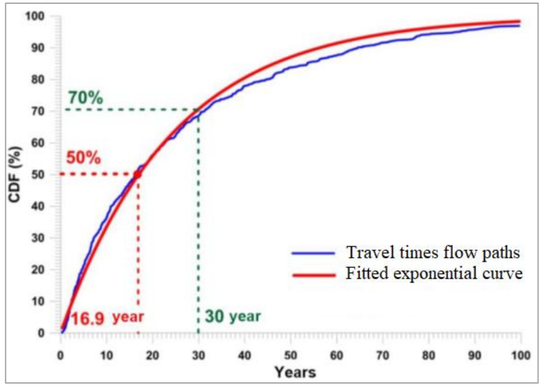


Yearly downward fluxes of NO_3 and water at a depth of 90 cm were used as input for the groundwater model. Where relevant, a fraction of these fluxes was subtracted and considered as a direct input to surface water by drain pipes. Groundwater flow paths were traced by Modflow and were separated in oxidized and reduced paths based on their depth. The NO_3 concentration of reduced groundwater was assumed to be zero.

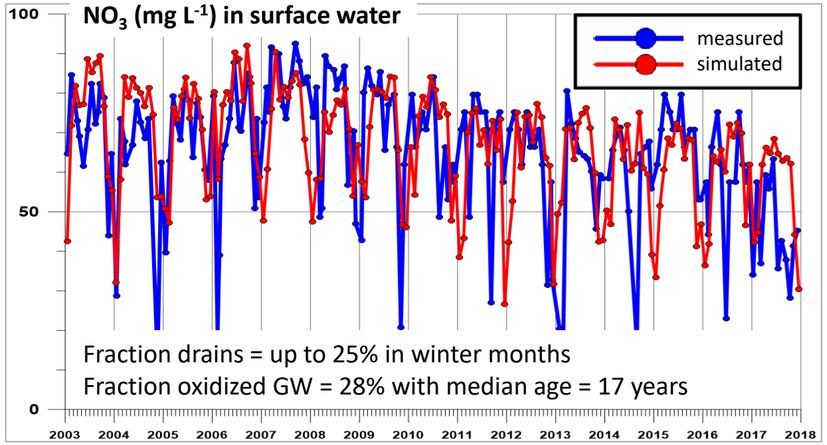
Results







For oxidized groundwater, age distributions were used to calculate the yearly contribution from the oxidized groundwater with a convolution model (Van Camp et al., 2021).



Some conclusions

- The long-term NO_3 concentrations just below the root zone decreases due to implementation of the legislation, but the effect on the concentration in the surface water is delayed depending on the contribution and age of oxidized groundwater.
- Reductions in NO_3 concentrations below the root zone are more explicit in catchments with historically high concentrations, as a result of strongly decreased manure inputs.
- NO_3 concentrations below the root zone in more recent years are mainly influenced by land use and crop types and to a lesser extent by weather conditions and soil texture.