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Gained insights from combined high-frequency and long-term water quality monitoring in agricultural catchments

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Despite extensive efforts to reduce nitrate (NO_3) transfer in agricultural areas, the NO_3 concentration in rivers often changes little. To investigate the reasons for this limited response, NO_3 dynamics in a 100 km^2 agricultural catchment in eastern Germany was analysed from decadal to infra-hourly time scales.
First, Dynamic Harmonic Regression (DHR) analysis of a 32-year (1982-2014) record of NO_3 and discharge revealed that i) the long-term trend in NO_3 concentration was closely related to that in discharge, suggesting that large-scale weather and climate patterns were masking the effect of improved nitrogen management on NO_3 trends; ii) maximum winter and minimum summer concentrations had a persistent seasonal pattern, which was interpreted as a dynamic NO_3 concentration from the soil and subsoil columns; and iii) the catchment progressively changed from chemodynamic to more chemostatic behaviour over the three decades of study, which is a sign of long-term homogenisation of NO_3 concentrations in the profile.
Second, infra-hourly (15 min time interval) analysis of storm-event dynamics during a typical hydrological year (2005-2006) was performed to identify periods of the year with high leaching risk and to link the latter to agricultural management practices in the catchment. Also, intra-hourly data was used to improve NO_3 load estimation during storm events. An Event Response Reconstruction (ERR) model was built using NO_3 concentration response descriptor variables and predictor variables deduced from discharge and precipitation records. The ERR approach significantly improved NO_3 load estimates compared to linear interpolation of grab-sampling data (error was reduced from 10 to 1%).
Finally, this study shows that detailed physical understanding of NO_3 dynamics across time scales can be obtained only through combined analysis of long-term records and high-resolution sensor data. Hence, a joint effort is advocated between environmental authorities, who usually perform long-term monitoring, and scientific programmes, which usually perform high-resolution monitoring.