Changes in nitrate concentrations in Scottish catchments – investigating the influence of climate and land use drivers by simulation with NIRAMS II

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Diffuse nitrogen pollution from agriculture is a major threat to both surface and groundwater quality in Scotland. Evaluation of the implementation of the EU Nitrates Directive and the Water Framework Directive requires designation and periodic review of Nitrate Vulnerable Zones. To this end, Dunn et al. (2004) developed the grid-based Nitrogen Risk Assessment Model for Scotland (NIRAMS, current version NIRAMS II) to predict the annual nitrate concentrations in Scottish aquifers and streams. This physically-based distributed model consists of both a water balance and a nitrate leaching module. The water balance module simulates overland flow, interflow and groundwater flow based on gridded weather, soil and land use data. Nitrate leaching is then predicted taking into account simulated runoff and information on agricultural inputs derived from available national datasets.

Evaluation and future development of mitigation measures to reduce diffuse nitrate pollution require an understanding of potential climate and land use change impacts on nitrate concentrations. In a simulation study using NIRAMS II Sample et al. (2013) detected a decline in nitrate concentrations between 2007 and 2010 in three of four Nitrate Vulnerable Zones in Scotland. By re-running the model for fixed climate or land use conditions, they have been able to attribute the decline mainly to weather conditions (comparably wet years between 2007 and 2010 due to either high precipitation or low evapotranspiration) and to a lesser extent to reduced organic nitrogen inputs.

In this study, we analyse changes in observed and simulated nitrate concentrations up to 2015 and undertake a sensitivity analysis regarding both model parameterisation and model input using a Gaussian process emulator. Thus, the study contributes to our understanding of the inter-annual variability of nitrate concentrations, the effectiveness of the implementation of the Nitrates Directive and the likely impact of potential future climate and land use changes on nitrate concentrations.

References:
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