High-resolution simulation of nitrate leaching from agricultural land across Germany

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Abstract

Germany is under high pressure to further reduce nitrate emissions into water bodies from agriculture. Currently, the connection between observed nitrate concentrations in wells across Germany and agricultural management is not sufficiently understood. We use the mechanistic agro-ecosystem simulation model MONICA on a high-performance cluster computer to simulate crop growth, management and resulting nitrate leaching on a hectare scale. The simulations are informed by satellite information on crop rotation patterns and grassland use intensity. The determination of organic nitrogen utilisation still remains the largest knowledge gap und source of uncertainty for this method.

Keywords: modelling, EU Nitrate Directive, remote sensing

1. Introduction

Germany is under high pressure to further reduce nitrate emissions into water bodies from agriculture. Currently, the connection between observed nitrate concentrations in wells across Germany and agricultural management is not sufficiently understood. Process-based simulation modelling provides a useful tool to represent agricultural production at larger scales and to test different options towards reducing nitrate emissions from crop production and grassland management.

2. Materials and Methods

We use the mechanistic agro-ecosystem simulation model MONICA (Nendel et al. 2011) on a 5000 core high-performance cluster computer to simulate crop growth, management and resulting nitrate leaching on a hectare scale. Germany-wide crop rotation patterns and grassland use intensity are derived from remote sensing (Griffiths et al. 2019a, b) to inform the model. Weather and phenology data was taken from the 1 km² product of the German Weather Service (DWD). Simulations for 2m deep soil profiles based on the BÜK1000 soil map were conducted to produce 30y averages on 16.6 M grid cells. Organic fertiliser input on cropland has been estimated from livestock densities. Inorganic nitrogen input has been estimated from grassland use intensity and crop yield expectations.

3. Results

The resulting map on nitrate leaching reveals a pattern of high leaching in the North-West of Germany for its high nitrogen input, and on areas with shallow groundwater, sandy soils and high rainfall. The information on nitrogen input that the model is supplied with proves highly influential on the results, while the simulations show less sensitivity to other information sources.

4. Outlook

The simulation set-up is ready to be used for system optimisation, climate change mitigation and adaptation strategy development and the investigation of trade-offs with other goals that the agricultural sector in Germany has to accomplish.

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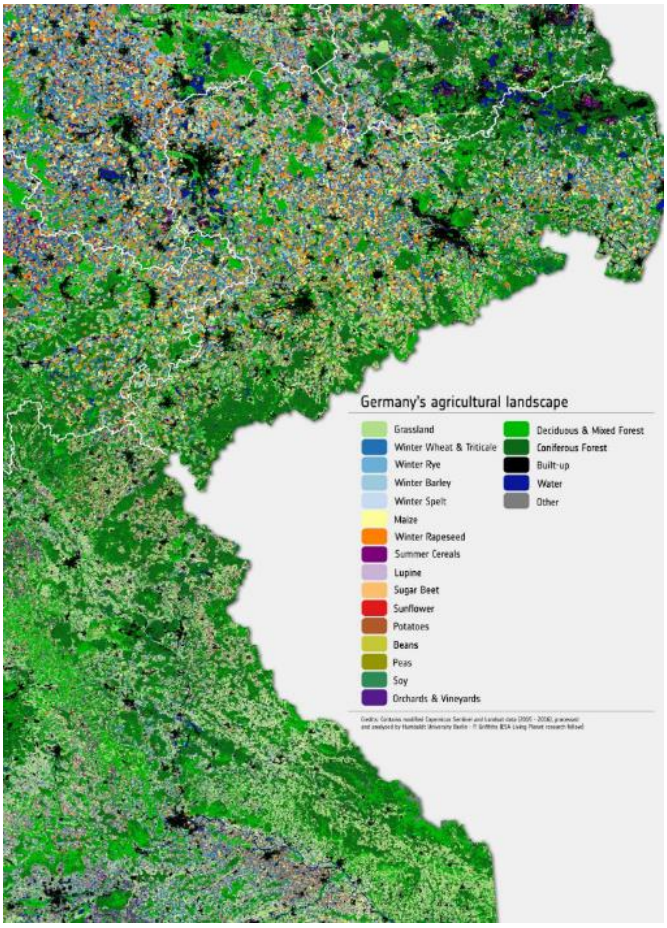

Fig. 1: Crop type identification from remote sensing as a source of information for agro-ecosystem modelling (Griffiths et al. 2019).

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