Geophysical Research Abstracts
Vol. 19, EGU2017-14113, 2017
EGU General Assembly 2017

Spatial aggregation for crop modelling at regional scales: the effects of soil variability

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Modelling agriculture production and adaptation to the environment at regional or global scale receives much interest in the context of climate change. Process-based soil-crop models describe the flows of mass (i.e. water, carbon and nitrogen) and energy in the soil-plant-atmosphere system. As such, they represent valuable tools for predicting agricultural production in diverse agro-environmental contexts as well as for assessing impacts on the environment; e.g. leaching of nitrates, changes in soil carbon content and GHGs emissions. However, their application at regional and global scales for climate change impact studies raises new challenges related to model input data, calibration and evaluation. One major concern is to take into account the spatial variability of the environmental conditions (e.g. climate, soils, management practices) used as model input and because the impacts of climate change on cropping systems depend strongly on the site conditions and properties (1). For example climate change effects on yield can be either negative or positive depending on the soil type (2). Additionally, the use of different methods of upscaling and downscaling adds new sources of modelling uncertainties (3).
In the present study, the effect of aggregating soil input data by area majority of soil mapping units was explored for spatially gridded simulations with the soil-vegetation model CoupModel for a region in Germany (North Rhine-Westphalia, NRW). The data aggregation effect (DAE) was analysed for wheat yield, water drainage, soil carbon mineralisation and nitrogen leaching below the root zone. DAE was higher for soil C and N variables than for yield and drainage and were strongly related to the spatial coverage of specific soils within the study region. These 'key soils' were identified by a model sensitivity analysis to soils present in the NRW region. The spatial aggregation of the key soils additionally influenced the DAE. Our results suggest that a spatial analysis of the pattern of these key soils (i.e. presence / absence, coverage and aggregation) can help in defining the appropriate grid-resolution that would minimize the error caused by aggregated soil input data in regional model simulations. In a second step the method will be applied and evaluated with respect to another European region (Tuscany) which is characterised by a warmer and drier climate.

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