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Accessing topography-related spatial variability in crop yields using coupled agroecosystem-geomorphic modelling approach

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A majority of the European arable fields is situated on rolling topographies, characterized by high in-field crop yields variability. In addition, geomorphic research has indicated that considerable within-field redistribution of soil material occurs. However, crop yield prognoses based on agroecosystem modelling typically characterize the soil system as static and as a point, i.e. as a single profile with generally unknown uncertainty. In order to improve the confidence levels for future agroecosystem development, it is essential to include this interaction between geomorphic and crop growth processes and to include uncertainty estimation while presenting the modelling results.

We applied a spatially explicit approach in order to analyze relations between geomorphic processes, landscape position and crop growth. For this purpose, we use three computer experiments ("past", assuming homogenous soil properties; "present", time correspondent to the measured year; and "future", in 50 years from "today" assuming the same soil redistribution rates) using downscaling technique. The approach was developed by implicit combination of the FASSET agroecosystem model, dynamically simulated crop growth dependent on meteorological and soil conditions, and the SPEROS geomorphic model, dynamically simulated lateral transfers of soil material and nutrients in the given landscape. To evaluate the approach, site-specific experimental data for croplands from two European locations (Belgium and the UK) were used, differing in climatic conditions, soil properties and management. Besides spatial difference in meteorological and initial soil properties in the fields, twofold water effect on soil-crop modelling system was considered: (1) effect related to differences in water retention as a result of differences in soil properties (e.g. texture, SOM), and (2) effect related to the topographical position. The results clearly show that soil redistribution significantly affected crop yields in all three computer experiments using the FASSET model. However, the model captured the observed effects in crop yields satisfactory only when both water effects were included in the simulations. Our simulations indicate that future landscape development as a result of ongoing soil redistribution will further increase spatial variability in crop yields. Furthermore, the results indicate higher crop variability and low potentials for reducing modelling uncertainty for intensively tilled scenarios in both locations. Finally, we show how this approach can be developed further as a tool for a long-term agroecosystem evolution analysis.