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Simulation of climate change effects on the agricultural sector in the Danubia catchment in South Germany with a generic modeling framework

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Abstract: Current day literature expresses climate change effects on agriculture often as individual crop yield responses while often neglecting the adaptation potentials in farm management and the complexity of crop rotation. Including daily and annual individual farm management adaptation requires a modeling system on a fine temporal and spatial scale with large information flows.

In this paper we present simulations executed with the DANUBIA framework. A platform independent, generic framework equiped for integrative model simulations using distributed and parallel processing technology.

Pre-defined climate scenarios are fed into a model calculating, inter alia, the weather and water flows on an hourly base. This model is dynamically coupled, hence having spatial and temporal feedback mechanisms, with a set of models simulating hourly crop growth and soil nutrient flows. Furthermore, the crop growth model is dynamically coupled with an agent-based model in which more than 50.000 farm managers are simulated. Each farm manager has its own crop rotation and husbandry scheme derived from agricultural statistics. Every year a farm manager formulates its own farm management plan by individually dissagregating results from an district-level economic optimization model.
Based on this optimal plan and crop-based, expert-knowledge-driven learning algorithms the farm manager decides which crops he wants to plant when. After planting the farm manager monitors the daily weather conditions, its crop conditions and the water availability and uses this information to decide on additional farm management decisions such as fertilizing, irrigating and harvesting.

Due to the high level of modelled detail in a heterogeneous landscape we are able to analyse the agricultural hotspots for change not only per crop, but also per crop rotation and per farm-system under the different climatic scenarios. Analysis shows that a high number of variables such as soil structure, groundwater availability in summer, temperature variability and precipitation variability significantly affect the farm productivity and thus affect farm management risks; however also important effects are caused by the interplay of farm management adaptation with shifting and extending vegetation periods.

In order to execute and analyse such large, complex simulations with a multitude of models and project partners a transparent, generic framework is one of the pre-requisites. The DANUBIA framework, usable for any socio-environmental context, offers that and more. It easily deals with multiple time-scales and offers extensive logging, visualisation and data-analysis support. The framework only supports grid-based spatial structures and demands from the modellers to work according to a strict component-based architecture thereby increasing the clarity of the simulated complex. If a model is built using the extensive libraries of the framework it automatically makes use of its most dominant advantage: parallel and distributed processing. The framework divides the various computational tasks, and in case of the agent based models even sub-divides single processing tasks, of the models depending on the number of processing nodes available on the computer and in the defined calculation grid.

Keywords: *Climate change, Agriculture, Agent-based modelling, DANUBIA, generic modelling framework*

Abstract only