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Effects of dynamic agricultural decision making in an ecohydrological model

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Due to various interdependencies between the cycles of water, carbon, nitrogen, and energy the impacts of climate change on ecohydrological systems can only be investigated in an integrative way. Furthermore, the human intervention in the environmental processes makes the system even more complex. On the one hand human impact affects natural systems. On the other hand the changing natural systems have a feedback on human decision making. One of the most important examples for this kind of interaction can be found in the agricultural sector. Management dates (planting, fertilization, harvesting) are chosen based on meteorological conditions and yield expectations. A faster development of crops under a warmer climate causes shorter cropping seasons. The choice of crops depends on their profitability, which is mainly determined by market prizes, the agro-political framework, and the (climate dependent) crop yield.

This study investigates these relations for the district Günzburg located in the Upper Danube catchment in southern Germany. The modeling system DANUBIA was used to perform dynamically coupled simulations of plant growth, surface and soil hydrological processes, soil nitrogen transformations, and agricultural decision making. The agro-economic model simulates decisions on management dates (based on meteorological conditions and the crops' development state), on fertilization intensities (based on yield expectations), and on choice of crops (based on profitability). The environmental models included in DANUBIA are to a great extent process based to enable its use in a climate change scenario context.

Scenario model runs until 2058 were performed using an IPCC A1B forcing. In consecutive runs, dynamic crop management, dynamic crop selection, and a changing agro-political framework were activated. Effects of these model features on hydrological and ecological variables were analyzed separately by comparing the results to a model run with constant crop distribution and constant management.

Results show that the influence of the modeled dynamic management adaptation on variables like transpiration, carbon uptake, or nitrate leaching from the vadose zone is stronger than the influence of a dynamic choice of crops. Climate change was found to have a stronger impact on this modeled choice of crops than the agro-political framework. These results suggest that scenario studies in areas with a large share of arable land should take into account management adaptations to changing climate.