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# Anticipating on amplifying water stress: Optimal crop production supported by anticipatory water management

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Agricultural crop yields depend largely on the soil moisture conditions in the root zone. Drought but especially an excess of water in the root zone and herewith limited availability of soil oxygen reduces crop yield. With ongoing climate change, more prolonged dry periods alternate with more intensive rainfall events, which changes soil moisture dynamics. With unaltered water management practices, reduced crop yield due to both drought stress and waterlogging will increase. Therefore, both farmers and water management authorities need to be provided with opportunities to reduce risks of decreasing crop yields. In The Netherlands, agricultural production of crops represents a market exceeding 2 billion euros annually. Given the increased variability in meteorological conditions and the resulting larger variations in soil moisture contents, it is of large economic importance to provide farmers and water management authorities with tools to mitigate risks of reduced crop yield by anticipatory water management, both at field and at regional scale.

We provide the development and the field application of a decision support system (DSS), which allows to optimize crop yield by timely anticipation on drought and waterlogging situations. By using this DSS, we will minimize plant water stress through automated drainage and irrigation management. In order to optimize soil moisture conditions for crop growth, the interacting processes in the soil-plant-atmosphere system need to be considered explicitly. Our study comprises both the set-up and application of the DSS on a pilot plot in The Netherlands, in order to evaluate its implementation into daily agricultural practice. The DSS focusses on anticipatory water management at the field scale, i.e. the unit scale of interest to a farmer. We combine parallel field measurements ('observe'), process-based model simulations ('predict'), and the novel Climate Adaptive Drainage (CAD) system ('adjust') to optimize soil moisture conditions. CAD is used both for controlled drainage practices and for sub-irrigation. The DSS has a core of the plot-scale SWAP model (soil-water-atmosphere-plant), extended with a process-based module for the simulation of oxygen stress for plant roots. This module involves macro-scale and micro-scale gas diffusion, as well as the plant physiological demand of oxygen, to simulate transpiration reduction due to limited oxygen availability. Continuous measurements of soil moisture content, groundwater level, and drainage level are used to calibrate the SWAP model each day. This leads to an optimal reproduction of the actual soil moisture conditions by data assimilation in the first step in the DSS process. During the next step, near-future (+10 days) soil moisture conditions and drought and oxygen stress are predicted using weather forecasts. Finally, optimal drainage levels to minimize stress are simulated, which can be established by CAD. Linkage to a grid-based hydrological simulation model (SPHY) facilitates studying the spatial dynamics of soil moisture and associated implications for management at the regional scale. Thus, by using local-scale measurements, process-based models and weather forecasts to anticipate on near-future conditions, not only field-scale water management but also regional surface water management can be optimized both in space and time.