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Spatio-temporal crop-yield variability and water use efficiency under diverse land use patterns and climatic conditions – a case-study for maize in the Lower Danube Plain, south of Romania

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Climate and environmental conditions, water availability, land and crop system management are major determinants of crop yields. Annual fluctuations in crop yields can significantly impact the economic viability of farms, particularly small and medium farms, while, at larger scale, can trigger chain reactions on the global market, leading to price increases. Here, we assessed the fraction of county-level reported yield variabilities attributed to climate parameters variation, while for water use efficiency (WUE) we employed a scenario-based approach by comparing actual data of crop yields and WUE to their potentials in terms of optimal fertilization and irrigation. We based our analyses on simulation ensembles from two spatially-explicit process-based crop models (i.e. EPIC+ and PROMET models) to quantify crop-yield variability and WUE in maize cropping system in the Lower Danube Plain, south of Romania over the last 15 years. The study area is the main agricultural region in Romania ($\sim$ 52 600 sq. km), being also important at European level and having a large potential for agricultural production increase. The land use in the Lower Danube Plain has experienced disruptive trends since early ‘90s due to the structural transformations in the economic, social, political and institutional settings during the transition and post-transition periods in Romania, from communism toward market economy, having great implications for agricultural land use patterns and irrigation system operation. The two models were run assuming each model’s best representation of the present-day conditions so that the simulations covered a broad range of model choices with regard to input data. The results show that the observed weather variation can explain more that 50% of the variability in maize yield in the eastern counties of the study area. Furthermore, avoiding water stress by simulating yields under full irrigation conditions, it is shown that water limitation is a major driver of the observed yield variations in many cases and that WUE can be maximized under irrigation only. The results are particularly relevant for the study area, especially in the context of land fragmentation, irrigation water use and drought frequency increase during the growing season. Analyzing the main causes of crop-yield variability is necessary for designing strategies to minimize them, being also important for studies on climate change adaptation. In this respect, process-based crop models account for plant growth stress conditions and provide options for representing farming practices, being thus useful in exploring management alternatives to reduce yearly yield fluctuations as well as for sustainable use of resources.