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Integrated assessment of efficient adaptation measures in land and water use in a semi-arid region in Austria

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Climate information appears to be underutilized in water management in agriculture. A systematic and integrated assessment of efficient adaptation measures may inform decision making of farmers, policy-makers and water management authorities and may facilitate the uptake and use of climate information. Therefore, we aim at modeling interactions between hydrological processes, the groundwater status, land use and management choices considering stochastic climate scenarios on wetter and drier conditions. We have developed a spatially explicit integrated modeling framework consisting of climate scenarios, a crop rotation model, the bio-physical process model EPIC (Environmental Policy Integrated Climate), and a non-linear version of the bottom-up economic land and water use optimization model BiomAT. EPIC is used to simulate annual yields and irrigation water use on cropland, intensive and extensive grassland, and vineyards for a future period of 31 years. These land use categories are simulated with various adaptation measures including crop rotations, fertilization intensities, mowing frequencies, and irrigation intensities. EPIC simulates – inter alia – the hydrological processes at field scale as well as the CO_2 fertilization effect. In BiomAT, the water balance is represented in a dynamic and spatially explicit way using monthly outputs from EPIC on percolation and irrigation by land use and management options. This allows us to assess efficient land and water use choices for adaptation considering alternative water use restrictions. The integrated modeling framework is applied to the semi-arid case study region Seewinkel in eastern Austria. Model results for the case study region show that higher net-benefits can be achieved through an expansion of vineyards, and high irrigation water and fertilizer inputs if mean annual precipitation sums increase in the next decades, or groundwater extraction beyond recharge is allowed. Large economic losses are modeled in drier climate scenario conditions, or if groundwater extraction is limited due to regulations. The model results clearly show, if water use is restricted, high flexibility in land use is required to efficiently adapt to climate change, and vice versa. The stochasticity of results emphasize the relevance of accurate and timely climate information for decision-making and thus efficient agricultural adaptation. Including a water balance in the land use optimization model highlights the importance of considering land and water interactions for agricultural adaptation in a semi-arid region.