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Towards a process-based understanding of the contribution of human water use induced atmospheric feedbacks to continental drying

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Recent advances in earth system modeling allow us to represent physical processes of the terrestrial water cycle close to reality in an integrated manner, incorporating feedbacks across the soil-vegetation-atmosphere system at continental to global scales. Moreover, these modeling systems present an unparalleled opportunity to study anthropogenic impacts on the full terrestrial water cycle, i.e. by incorporating human water use beyond irrigation and including groundwater abstraction. However, typical applications and analyses rely on local differences between simulation experiments, thereby limiting our impact understanding to local feedbacks mechanisms.

In this study, we use the coupled groundwater-to-atmosphere modeling platform TerrSysMP, set up over the European continent, to study the influence of human water use on atmospheric water vapor transport and its contribution to continental drying. Four water use scenarios, based on two data sets and two water use schedules, are constructed to account for the uncertainties in human water use and related atmospheric feedbacks. Simulations are performed over the heatwave year 2003. In a first step, we analyze how human water use alters the continental sink at regional to continental scales. Our results show that human water use has impacts beyond the watershed scale and that the associated atmospheric feedbacks are a key contributor to potential continental drying in Southern Europe. In a second step, we apply the Lagrangian particle dispersion model FLEXPART-COSMO, adapted to read output from TerrSysMP, to trace atmospheric water vapor. This allows us to identify feedback pathways across watersheds and hence the remote impact of human water use. Our findings illustrate the importance and the challenge of an improved and process-based understanding of the anthropogenic impact on the terrestrial hydrologic cycle within integrated modeling systems.