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Potential impacts of human water management on the European heat wave 2003 using fully integrated bedrock-to-atmosphere simulations

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Recent studies indicate that anthropogenic impacts on the terrestrial water cycle lead to a redistribution of water resources in space and time, can trigger land-atmosphere feedbacks, such as the soil moisture-precipitation feedback, and potentially enhance convection and precipitation. Yet, these studies do not consider the full hydrologic cycle from the bedrock to the atmosphere or apply simplified hydrologic models, neglecting the connection of irrigation to water withdrawal and groundwater depletion. Thus, there is a need to incorporate water resource management in 3D hydrologic models coupled to earth system models.

This study addresses the impact of water resource management, i.e. irrigation and groundwater abstraction, on land-atmosphere feedbacks through the terrestrial hydrologic cycle in a physics-based soil-vegetation-atmosphere system simulating 3D groundwater dynamics at the continental scale. The integrated Terrestrial Systems Modeling Platform, TerrSysMP, consisting of the three-dimensional subsurface and overland flow model ParFlow, the Community Land Model CLM3.5 and the numerical weather prediction model COSMO of the German Weather Service, is set up over the European CORDEX domain in 0.11° resolution. The model closes the terrestrial water and energy cycles from aquifers into the atmosphere. Anthropogenic impacts are considered by applying actual daily estimates of irrigation and groundwater abstraction from Wada et al. (2012, 2016), as a source at the land surface and explicit removal of groundwater from aquifer storage, respectively. Simulations of the fully coupled system are performed over the 2003 European heat wave and compared to a reference simulation, which does not consider human interactions in the terrestrial water cycle. We study the space and time characteristics and evolution of temperature extremes, and soil moisture and precipitation anomalies influenced by human water management during the heat wave. A first set of simulations utilizes the spectral nudging technique to keep the large-scale circulation consistent to the driving ERA-Interim reanalysis and examines the direct and local feedback pathway, along which irrigation cools the land surface, enhances evapotranspiration and increases the total atmospheric water vapor, which may induce local precipitation. A second set of simulations without spectral nudging addresses the indirect feedback, where the atmospheric circulation is modified indirectly by irrigation. Simulations are evaluated over a range of spatial and temporal scales, i.e. from daily to seasonal variations. Results indicate systematic responses at the land surface, but a strong non-linearity of the local feedback affecting tropospheric processes and the occurrence of precipitation, and hence emphasize the need to integrate human water management in regional climate simulations.

References:

Wada, Y., L. P. H van Beek, and M. F. P. Bierkens (2012), Nonsustainable groundwater sustaining irrigation: A global assessment, Water Resources Research, 48, W00L06, doi: 10.1029/2011WR010562.

Wada, Y., I. E. M. de Graaf, and L. P. H. van Beek (2016), High-resolution modeling of human and climate impacts on global water resources, J. Adv. Model. Earth Syst., 8, 735–763, doi: 10.1002/2015MS000618.