Global, Regional, and Local-scale Assessment of the Impacts of Irrigation and Reservoir Operation on Land Hydrology and Climate

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In this study, we use two different land surface hydrological models to assess the global, regional, and local-scale impacts of human land-water management practices on land surface hydrology and climate system. The first model is a global land surface model called the HiGW-MAT that simulates the flows and storages of water globally at 1-degree grids, taking into account various human activities such as irrigation, reservoir operation, and groundwater pumping. The second model is the regional hydrological model called the LEAF-Hydro-Flood, which simulates surface and sub-surface hydrological processes including river-floodplain dynamics at 2 to 5km grids; the model has recently been enhanced to simulate anthropogenic water flows by incorporating the schemes to represent the aforementioned human activities. A series of numerical experiments are carried out by turning the human impact schemes on and off in each of the two models. We present four sets of analysis by using the results from the two models. First, results from the global model are used to examine the human-induced changes in global and regional water balance, with an emphasis on the widely debated issue of the desiccation of the Aral Sea in central Asia and the groundwater depletion in northwest India and Pakistan. In this analysis, we make an integrated use of model results and the data from the Gravity Recovery and Climate Experiment (GRACE) satellite mission. Second, we examine the global and regional climate impacts of human activities, particularly irrigation, again by using the results of the global model coupled with its parent climate model MIROC. Third, we compare the results from the two models over the selected river basins to examine the role of increased spatial resolution in the regional model to better simulate certain hydrologic fluxes and stores, essential to capture the human footprint. Finally, we use the results from the regional model to highlight the importance of and challenges in using the high-resolution model to simulate reservoir operation over regional to local scales.

Keywords: Hydrological modeling, Irrigation, Reservoir Operation

