"Progresses in Large-scale Water Cycle Modeling in a Changing World"

Yadu N. POKHREL
Department of Civil and Environmental Engineering
Michigan State University, East Lansing, MI, 48823 USA

Humans have historically modified the Earth's landscape as a consequence of the exploitation of natural resources. It is suggested that human impacts on the natural environment now rival global geophysical processes, transforming our planet into a new geological epoch termed as the Anthropocene. Today, evidences are overwhelming that these human forces have been fundamentally altering the natural patterns of freshwater flows and storages over a broad range of spatio-temporal scales. Human perturbation of freshwater resources expanded profoundly during the past century and it is highly likely that this will further accelerate in the coming decades due to increasing demand for water and food associated with population and socio-economic growths especially in the developing world, and the potentially adverse climate impacts on water availability and food production in many regions. Since the changes in water cycle can affect the functioning of a wide range of biophysical and biogeochemical processes of the Earth system, it is essential to account for human land-water management in land surface models (LSMs) which are used for water resources assessment and to simulate land surface hydrologic processes within Earth system models (ESMs). During the last two decades, noteworthy progress has been made in modeling human impacts on the water cycle but sufficient advancements have not yet been made, especially in representing human factors in large-scale LSMs toward integrating them into ESMs.

This talk provides an overview of the recent advancements in modeling human activities (e.g., irrigation, reservoir operation and water diversion, groundwater pumping) with a particular emphasis on the incorporation of these human factors into global and regional LSMs for their integration into ESMs. The algorithms currently employed to account for human land-water management in large-scale models are discussed in close dialogue with model simulations and observations, the methodological deficiencies in current modeling approaches and existing challenges are highlighted, and light is shed on the sources of uncertainties associated with model parameterizations and grid resolution as well as with the datasets used for forcing and validation. Results from global and regional LSMs, which take into account both natural and human-induced changes in the water cycle, are used to demonstrate the importance of representing human factors in large-scale hydrological models. Model results are presented in close dialogue with the observations of river discharge including flow regulation by dams, evapotranspiration, irrigation and groundwater use, changes in water table depth, and the variation of terrestrial water storage (TWS) over a wide range of basin scales around the world. The changes in various compartments of TWS, which are directly altered by human water use, are then linked to global sea level change over the last half century. Observational data of various hydrologic fluxes from ground-based observations and TWS inferred from the GRACE (Gravity Recovery and Climate Experiment) satellite mission are used to support model results. The talk finally highlights the importance of representing human land-water management in global LSMs as an important research direction toward developing integrated models using ESM frameworks for the holistic study of human-water interactions and the associated impacts and feedbacks within the Earths system as a whole.