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Hydrologic Impacts of Climate Change: Quantification of Uncertainties (Alexander von Humboldt Medal Lecture)

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Climate change results in regional hydrologic change. The three prominent signals of global climate change, viz., increase in global average temperatures, rise in sea levels and change in precipitation patterns convert into signals of regional hydrologic change in terms of modifications in water availability, evaporative water demand, hydrologic extremes of floods and droughts, water quality, salinity intrusion in coastal aquifers, groundwater recharge and other related phenomena.

A major research focus in hydrologic sciences in recent years has been assessment of impacts of climate change at regional scales. An important research issue addressed in this context deals with responses of water fluxes on a catchment scale to the global climatic change. A commonly adopted methodology for assessing the regional hydrologic impacts of climate change is to use the climate projections provided by the General Circulation Models (GCMs) for specified emission scenarios in conjunction with the process-based hydrologic models to generate the corresponding hydrologic projections. The scaling problem arising because of the large spatial scales at which the GCMs operate compared to those required in distributed hydrologic models, and their inability to satisfactorily simulate the variables of interest to hydrology are addressed by downscaling the GCM simulations to hydrologic scales. Projections obtained with this procedure are burdened with a large uncertainty introduced by the choice of GCMs and emission scenarios, small samples of historical data against which the models are calibrated, downscaling methods used and other sources. Development of methodologies to quantify and reduce such uncertainties is a current area of research in hydrology.

In this presentation, an overview of recent research carried out by the author's group on assessment of hydrologic impacts of climate change addressing scale issues and quantification of uncertainties is provided. Methodologies developed with conditional random fields, Dempster-Shafer theory, possibility theory, imprecise probabilities and non-stationary extreme value theory are discussed. Specific applications on uncertainty quantification in impacts on streamflows, evaporative water demands, river water quality and urban flooding are presented. A brief discussion on detection and attribution of hydrologic change at river basin scales, contribution of landuse change and likely alterations in return levels of hydrologic extremes is also provided.