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Climate and its impacts on water resources: a case for nonlinear data downscaling approaches

B. Sivakumar
University of California, Davis, USA

The most complex environmental issue facing humans today is the global climate change, with threatening consequences for our water resources. Although no one can predict the exact impact of climate change on our water resources, studies generally suggest an increase in abnormal events, such as floods and droughts. With the Global Climate Models (GCMs) providing climate data only at much coarser spatial and temporal scales than that are required for hydrologic predictions at regional levels, 'downscaling' of data becomes essential. Currently, two broad approaches exist for downscaling: (1) Statistical downscaling, where an equation is used to represent the relationship between the small-scale phenomena and the large-scale behavior of the model; and (2) Dynamical downscaling, where a high-resolution regional climate model (RCM) is embedded within a GCM. While either of these approaches can provide reasonable results, there are also concerns on their performances, since they view the downscaling problem essentially in a 'linear' context, whereas the climate system (and the associated processes) is largely 'nonlinear.' The intention of the present study is to emphasize the need for a nonlinear approach to downscaling and also discuss potential directions for achieving such. First, the inherent nonlinear (and possibly chaotic) nature of the climate system is highlighted. Next, the concepts and assumptions involved in the development of GCMs are presented. Then, the existing approaches for downscaling of GCM outputs to regional levels are discussed, as are the associated limitations. Finally, a nonlinear (and chaotic) downscaling approach is proposed and its effectiveness tested through its application to rainfall conditions in the Korean peninsula and elsewhere. Important implications of the present study for regional hydrologic predictions in the context of global climate change and scope for

further improvements are also highlighted.