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Linking Climate Change to Impact and Adaptation Studies in Civil Engineering: Recent Advances in Modelling of Precipitation and Extreme Temperature Processes

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Climate change has been recognized as having a profound impact on the design, planning, and management of various infrastructure systems in Civil Engineering (transportation systems, urban drainage systems, etc.), and Global Climate Models (GCMs) have been extensively used in many studies for assessing this impact. However, outputs from these models are usually at resolutions that are too coarse (generally greater than 200km) and not suitable for the impact assessment at a regional or local scale. Hence, different downscaling methods have been proposed for linking GCM predictions of climate change to meteorological processes at the relevant space and time scales for these impact studies. Of particular importance for civil engineering applications are those procedures dealing with the linkage of the large-scale climate variability to the historical observations of the precipitation and temperature processes at a local site or over a given area. If this linkage could be established, then the projected change of climate conditions given by a GCM could be used to predict the resulting changes of the precipitation and temperature characteristics at a location of interest. Therefore, the overall objective of the present lecture is to provide an overview of some recent progress in the modeling of precipitation and extreme temperature processes in a changing climate from both theoretical and practical viewpoints. In particular, the main focus of this lecture is on recently developed statistical downscaling (SD) methods for linking GCM climate predictors to the observed precipitations and temperature extremes at a single site as well as at many sites concurrently. Notice that many previous works have been dealing with downscaling of these physical processes at a single site, but very few studies are concerned with the downscaling of these series for many locations concurrently because of the complexity in describing accurately both observed at-site temporal persistence and observed spatial dependence between the different sites. In addition, new SD procedures are presented for describing the linkages between GCM outputs and precipitation characteristics at a given location where the precipitation data are limited or unavailable, a common and crucial challenge in engineering practice. Examples of various applications using data from different climatic conditions in Canada and in other countries will be presented to illustrate the feasibility and accuracy of the proposed methods.