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Stochastic simulation of high-resolution daily precipitation using Gaussian Markov Random Fields

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Single-site and multi-site weather generators are common tools in hydrological analysis. More recently there has been an interest in the use of fully gridded stochastic precipitation generators. This introduces a range of new challenges. Precipitation fields are complex and irregular, and are not easy to model. Gaussian random field theory is one option for representing precipitation in time and space. While it is acknowledged that Gaussian fields are unable to fully mimic real precipitation patterns, the Gaussian assumption provides a convenient framework for handling the multi-dimensionality of gridded precipitation simulation and may, depending on the application, be an acceptable approximation. In this presentation, we focus on the use of transformed Gaussian variables to represent daily precipitation on a high-resolution (15 km) spatial lattice. Our interest is to apply the model to a large river basin. Because of the dimension of the problem, some simplifying assumptions are required to handle numerical issues that may otherwise arise. We specifically make use of Gaussian Markov Random Fields as approximations to Gaussian fields. The generated Gaussian fields can be transformed to represent both precipitation occurrence and precipitation depths on the lattice. The model is applied in a study of precipitation in the Canadian Prairie region. For model estimation, we use historical gridded daily precipitation data from the Canadian Precipitation Analysis (CaPA) system which is available on a 15-km grid. CaPA fields are constructed by combining the output of Environment Canada's numerical weather forecast model and observations from Canada's synoptic weather network.