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Large-scale hydrological modelling: Parameterisation of runoff generation with high-resolution topographical data

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Runoff generation is one of the most important components in hydrological cycle and in hydrological models at all spatial scales. The spatial distribution of the effective storage capacity accounts largely for the non-linearity of runoff generation dynamic. Many Hydrological models account for this spatial variability of storage in terms of statistical distributions; those models are generally proven to perform well. For example, both VIC and PDM account for the storage variability at sub-grid level. It is more important to account for the storage distribution for large river basins, where the varying land surface properties could mean a large variation in both the average storage capacity and the shape of the distribution of storage capacity when going from one part of the basin to another. However, limited by the statistical approaches same runoff generation parameters often have to be used everywhere in the basin. This is because it is harder to account for the spatial auto-correlation between those parameters than just the range of them. The Topmodel concept allows a linkage between the effective maximum storage capacity, or the maximum deficit, and the topography. It has the advantage of both a physically sound interpretation of runoff generation mechanism and the generally good availability of topography data. However, the strict limitation of the Topmodel assumption may limit its application in parts of the world with deep groundwater system or flat terrain. In this paper, we present a new runoff generation model designed for large-scale hydrology. The model relaxes the topmodel assumptions and only uses topographic index as a tool to distribute average storage to each topographic index class. The maximum storage capacity is proportional to the range of topographic index and is scaled by the recession parameter in Topmodel. The sub-cell distribution of storage capacity is obtained through topographic analysis. We then feed this topography-derived distribution function to a runoff generation mechanism similar to VIC model. In this way, different parts of the catchment are parameterised with different storage capacity parameter, and different shapes for the storage distribution curve depending on their topographic characteristics. The new model is coupled to a runoff routing algorithm that is also based on high-resolution topographic data. The new model is driven with the HydroSHEDS global hydrographic dataset, combined TRMM and GPCP precipitation and temperature data from ERA-interim reanalysis. We validated the new model against VIC model in 4 large river basins lies in different climate zone. Discharge data were obtained from GRDC database. The new model offers improved model results, in the mean time, requires less parameters to be calibrated, i.e., the storage capacity, and shape parameter for storage distribution, as required in VIC model, can be obtained directly through topography. The new model also offers a more realistic spatial pattern of runoff generation.