Geophysical Research Abstracts
Vol. 18, EGU2016-13636, 2016
EGU General Assembly 2016

Inverse hydrological modelling of spatio-temporal rainfall patterns

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Distributed hydrological models are commonly used for simulating the non-linear response of a watershed to rainfall events for addressing different hydrological properties of the landscape. Such models are driven by spatial rainfall patterns for consecutive time steps, which are normally generated from point measurements using spatial interpolation methods. However, such methods fail in reproducing the true spatio-temporal rainfall patterns especially in data scarce regions with poorly gauged catchments or for highly dynamic, small scaled rainstorms which are not well recorded by existing monitoring networks. Consequently, uncertainties are associated with poorly identified spatio-temporal rainfall distribution in distributed rainfall-runoff-modelling since the amount of rainfall received by a catchment as well as the dynamics of the runoff generation of flood waves are underestimated. For addressing these challenges a novel methodology for inverse hydrological modelling is proposed using a Markov-Chain-Monte-Carlo framework. Thereby, potential candidates of spatio-temporal rainfall patterns are generated and selected according their ability to reproduce the observed surface runoff at the catchment outlet for a given transfer function in a best way. The Methodology combines the concept of random mixing of random spatial fields with a grid-based spatial distributed rainfall runoff model. The conditional target rainfall field is obtained as a linear combination of unconditional spatial random fields. The corresponding weights of the linear combination are selected such that the spatial variability of the rainfall amounts as well as the actual observed rainfall values are reproduced. The functionality of the methodology is demonstrated on a synthetic example. Thereby, the known spatio-temporal distribution of rainfall is reproduced for a given number of point observations of rainfall and the integral catchment response at the catchment outlet for a synthetic catchment which is only partly covered by rainfall. Furthermore, results of a real case study for a flash flood event in the arid mountainous region in Oman are presented. They underline that the spatio-temporal distribution of rainfall is crucial for flash flood modelling even in small catchments and arid and semiarid environments.