Geophysical Research Abstracts
Vol. 13, EGU2011-12834, 2011
EGU General Assembly 2011

An improved discrete cascade method for sub-daily rainfall modelling

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Precipitation is one of the most important inputs for hydrological modelling, such as sewer system simulation and surface runoff estimation. It is expected that a reliable estimation of the quantity of sewer discharge or surface runoff could be carried out if high-resolution predicted rainfall data were provided. However, conventional statistical theories are unable to fully cope with the highly nonlinear nature of high-resolution rainfall data. The theory of Multifractals has been widely applied to modelling high-resolution spatial and/or temporal distributions of rainfall by characterising their scale-invariant features.

The standard method for simulating Multifractals is the multiplicative cascade process. It is a process that fragments a set (e.g., the spatial or temporal scales) into smaller and smaller components according to a fixed rule and at the same time fragments the measure of the components (e.g., rainfall volumes) by another rule. In the literature, these fragmentation rules have been widely studied in both randomly and deterministically multiplicative manners (Molnar and Burlando, 2005; Wang et al., 2010). However, due to their discrete and symmetric natures, these cascade models are in general criticised for the artificial construction of the generated precipitation and the absence of causal characteristics (Lovejoy, 2010), although they have been proven to be able to reproduce critical statistical features of real observations. Continuous cascade methods have been developed to circumvent these two drawbacks (Marsan et al., 1996); their applicability however is limited due to the complex and time-consuming integration procedures. Concerning the issues of efficiency and applicability, the discrete-based cascade models are therefore necessary for practical use.

Based upon the state-of-the-art discrete-based cascade models, this work focuses on improving the cascading process of generating sub-daily rainfall sequences by introducing specific statistics of historical rainfall observations, instead of using an evenly random branching process, to strengthen and reflect the causality of rainfall time series. The 5-min rainfall observations in Greenwich (the Greater London) in the UK will be used to verify and assess the proposed study.

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