Geophysical Research Abstracts
Vol. 14, EGU2012-11337, 2012
EGU General Assembly 2012

Exploring the variability of the hydrologic response due to rainfall spatial heterogeneity: Analytical derivations and numerical simulations

E. Volpi, A. Fiori, and M. Di Lazzaro
Department of Civil Engineering, University of Roma Tre, Rome, Italy (evolpi@uniroma3.it)

The spatial distribution of rainfall can play a key role in determining the hydrological response of river basins. Circumstances under which this role is dampened or enhanced, while extensively discussed in previous literature works, have not yet received a clear assessment.
We propose an analytical approach to investigate the dependence of basin hydrograph variability on the spatial heterogeneity of rainfall, specifically considering the response of a catchment to an instantaneous unit pulse of spatially-variable excess rainfall. Catchment response to rainfall input is assumed to be completely described by the time-invariant distribution of travel times. The excess-rainfall field accounts for the variability of both precipitation and soil characteristics and is assumed to be represented as a stationary and isotropic process, defined by its variance and integral scale. The sensitivity of the hydrologic response to the rainfall spatial variability is evaluated describing the variance of the generated hydrograph as function of basin characteristics and the stochastic properties of excess-rainfall field. This analytical approach allow us to infer results that do not depend on a specific study case.
Results suggest that the variability of the hydrologic response due to spatial rainfall heterogeneity mainly depends on the ratio between the integral scale of the excess-rainfall field and basin drainage area. For basins which are small compared to the integral scale of excess rainfall, rainfall spatial heterogeneity has a minor relevance on the hydrologic response, i.e. basin sees the precipitation as uniformly distributed. In the opposite case, for relatively large basins the spatial variability of excess rainfall is averaged over the basin area and the hydrologic response is approximately equal to the travel time distribution; under such circumstances the system is ergodic. However, at the early and late branch of the travel time distribution, i.e. in areas close to the basin outlet and those far away from it, the coefficient of variation of the hydrographs may be still high even for large basins. This happens where the isochrones are small, leading to a poor averaging of the rainfall field (non-ergodic behavior).
These asymptotic limits have been confirmed by the performance of numerical simulations, based on a Monte Carlo approach and applied to a specific study basin. Numerical experiments use a simplified width-function geomorphological model. They helped us in understanding the behavior of the response function for intermediate conditions (medium size basins), when the square of the integral scale and the drainage are same order of magnitude.