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On the sensitivity of flood peak timing to spatial aggregation of rainfall

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We analyse the influence exerted by the representation of the space-time rainfall patterns on the hydrologic response to determine the conditions and the scales for which the use of basin-averaged rainfall play a significant role on flood peak timing error. Different flood and flash flood events are examined in two basins in northern Italy: the Sesia and the upper Tagliamento river systems. High resolution radar rainfall fields and a distributed hydrologic model are used to evaluate the sensitivity of flood peak timing to spatial aggregation of rainfall. The influence of rainfall spatial aggregation is examined by using the flow distance as a spatial coordinate, hence emphasising the role of river network in the averaging of space-time rainfall. In a parallel way, we use the analytical framework proposed by Woods and Sivapalan (1999) in order to identify the control exerted by the spatial variability of rainfall and runoff generation on catchment response for different flood event types in a parsimonious way. The assumptions at the base of the method provide, in fact, enough complexity to make the method useful but are simple enough to avoid overwhelming detail. The analytically derived equations quantify the catchment rainfall excess, and the mean and variance of catchment response time. The components of these equations explicitly show the contributions (and the spatio-temporal interactions) of the hydrological inputs and processes on the simulated catchment response time.
Our results confirm the suitability of the analytical model to describe the flood response for the considered events. It is shown that, for catchments of similar size and for rainfall events displaying similar spatial variability, the flood peak timing error is emphasized when there is a significant and systematic variation of rainfall with the flow distance. A typical physical mechanism leading to this situation is the orographic enhancement of precipitation.

Woods, R. and M. Sivapalan, 1999: A synthesis of space-time variability in storm response: Rainfall, runoff generation, and routing. Water Resources Research, 35(8), 2469-2485.