Process controls on the mapping of rainfall to flood return periods

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Even if floods are the product of storms, the magnitude of floods is not always clearly related to the magnitude of storms. In other words, the return period of a peak discharge can be extremely different from the return period of the producing storm. The mapping of rainfall to flood return periods is a complex issue, that still needs a complete understanding, but which is at the basis of widely used methods for design purposes in operational hydrology. The "obscure nature" of the mapping of return periods is a consequence of the complexity of the rainfall process and the transformation into runoff performed by the basin. Moreover, the lack of an unambiguous definition of the storm return period makes the problem even more confused. This study attempts to shed more light on the subject, trying to identify the processes that control the mapping. As a necessary requirement, we provide an objective definition of storm return period, consistent with the design engineering practice. The relative effects of the meteorological forcing and the hydrological filtering on the mapping of rainfall to flood return periods are then analyzed considering increasing degrees of complexity. (1) Only the variability of storm durations is taken into account, and the problem of identifying the "critical storm duration" is discussed. (2) The focus of our attention is then directed to the effects of the runoff coefficient as a random variable, considered to be independent or non-linearly related to the overall storm volume. (3) Storm time-patterns and multiple storms are finally examined. The study is conducted with Monte-Carlo simulations and, where possible, in the domain of the frequency distributions using the derived distribution approach.