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Detection of signatures and controlling processes in flood annual maxima by theoretically derived probability distributions

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In last few years, the scientific community has developed several hydrological models aimed at the simulation of hydrological processes acting at the basin scale. Nevertheless, the struggle between model complexity and parameterization, along with data scarcity, still deeply affect the uncertainty of prediction and limit the modeler's choices. On the other hand, while a huge amount of data potentially available for hydrological applications has been (and will be) released by remote sensing and earth observation, the climatic and land use changes strongly challenges the long-term prediction of extreme events.
In this context, the need for physically-based statistical models is growing since they provide an ideal analytical environment for the evaluation of risk and relative uncertainty.
Theoretically derived probability distributions attempt to interpret the flood-peak frequency process from the analysis of rainfall stochastic features and basin hydrologic response. The identification of a feasible probabilistic model of basin response, accounting for fundamental geomorphoclimatic signatures, is crucial for the evaluation of critical quantities such as runoff contributing areas and soil moisture conditions.
In general, different thresholds and mechanisms may be identified as responsible of runoff generation during ordinary events or extraordinary events at the basin scale. Nevertheless, the use of a "two-component" derived distribution model allows to account for both ordinary floods, produced by less severe storms insisting on relatively small contributing areas, and extra-ordinary floods that arise when a large part of the basin area contributes to runoff with high net rainfall intensity. To face up the open problem of identifying hydrologic similarity and heterogeneity, the most appropriate relationships between model parameters and river basin descriptors related to climate, geomorphology, vegetation coverage, soil type and permeability are investigated in the framework of regional analysis.
Finally, important increase of knowledge arises from the comparison between runoff models exploiting schematizations at different time scales, like daily runoff and annual maximum flood-peak time series, providing results that pave the road for the use of daily runoff data for flood frequency evaluation in river basins with limited availability of annual maxima flood data.