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Climatic and geomorphic controls on flash flood response in Europe

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High-resolution data enabling identification and analysis of the hydrometeorological causative processes of flash floods have been collected and analysed for 25 extreme flash floods (60 drainage basins) across Europe. Criteria for flood selection were high intensity of triggering rainfall and flood response and availability of reliable high-resolution data. Hydrometeorological data collected for each event were checked by using a hydrological model. The derivation and analysis of summarising variables has made it possible to outline some characteristics of flash floods in various morphoclimatic regions of Europe. Peak discharge data for more than 50% of the studied watersheds derive from post-flood surveys in ungauged streams. This stresses both the significance of post-flood surveys in building and extending flash flood databases, and the need to develop new methods for flash-flood hazard assessment able to take into account data from post-event analysis. Catchments do not need to be particularly steep to favour flash flooding. However, relief is important since it may affect flash flood occurrence in specific catchments by combination of two main mechanisms: orographic effects augmenting precipitation and anchoring convection, and topographic relief promoting rapid concentration of streamflow. Examination of data shows a peculiar seasonality effect on flash flood occurrence, with events in the Mediterranean and Alpine-Mediterranean regions mostly occurring in autumn, whereas events in the inland Continental region commonly occur in summer, revealing different climatic forcing. Consistently with this seasonality effect, spatial extent and duration of the events is generally smaller for the Continental events with respect to those occurring in the Mediterranean region. Furthermore, the flash flood regime is usually more intense in the Mediterranean Region than in the Continental areas. The runoff coefficients of the studied flash floods are usually rather low (mean value: 0.35). Moderate differences in runoff coefficient are observed between the studied climatic regions, with higher values in the Mediterranean region. Antecedent saturation conditions have a significant impact on event runoff coefficients, showing the influence of initial soil moisture status even on extreme flash flood events and stressing the importance of accounting soil moisture for operational flash flood forecasting. The runoff response displays short lag times (mostly < 6 hours). The identified relations between watershed area, stream length and response time enable determination of a characteristic velocity of the flash flood process (at basin scales less than 350 km^2), defined as the ratio of characteristic length (mean river length) and time (response time or lag time), equal to 3 m s^{-1}. This is related to the celerity with which the flood wave moves through the catchment.