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Probability distribution of peak discharge at hillslope scale derived by an eco-hydrological approach

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On the hypothesis of a prevalent Hortonian mechanism of runoff production, the objective of this work is to obtain the probability distribution of peak discharge at the bottom of a hillslope. It is well-known that, in general, the probability distribution of peak discharge depends on both the probability of the rainfall event and the probability of the antecedent soil moisture condition si. Particularly, the probability of the rainfall event can be assigned according to the rainfall duration-intensity frequency approach, while the eco-hydrological approach introduced by Rodriguez-Iturbe et al. (1999, 2000) could be used in order to define the probability of the antecedent soil moisture condition. The peak discharge is derived by a physically-based model recently established (Agnese and Baiamonte, 2005, AB model), by coupling the analytical solution of the overland flow equations over a hillslope (Agnese et al., 2001), with the Green-Ampt model (GA) accounting for the infiltration process. According to the AB model, the peak discharge at the bottom of the hillslope essentially depends on five parameters: i) the rainfall duration, d, ii) the rainfall intensity, i, which presence highlights the nonlinear character of the hillslope response, iii) a characteristic time scale of the infiltration process, i.e. the sorptivity time-scale tc, iv) a k* parameter, representing the "geometry" of the hillslope (length, slope and roughness) and v) the ratio rho between the rainfall intensity and the saturated hydraulic conductivity. Particularly, scale parameter tc depends on both soil characteristics and antecedent soil moisture condition; then, a bijective correspondence could be established between tc and si. Accordingly, the probability distribution of tc could be derived by the eco-hydrological theory (Rodriguez-Iturbe et al. (1999, 2001), as a function of a set of parameters, describing the dynamic interactions between climate, soil and vegetation. Specifically, climate parameters can be deduced by daily rainfall and temperature data.

The proposed methodology was applied to two soils (silty clay loam, SCL and silty loam, SL), for two climatically different regions in Sicily (Trapani, located at the North West coast and Linguaglossa, located near Etna volcano), for which a wide rain gauge and temperature data set are available.