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Hydrological processes generating flash floods at hillslope scale in a small mountainous Mediterranean catchment

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This work deals with the understanding at the hillslope scale of the hydrological process that generate flash floods. The Valescure small catchment (4km2) is a mountainous Mediterranean catchment, with steep slopes (30°) and granitic geology. An intensive survey of the catchment was displayed along a 4-years period (2011-2014) at the local and hillslope scale, in order to grab properties of the soil such as depths, clay content, water content, hydraulic conductivity and water retention, latelal flux velocity, bedrock permeability.... A simplified physically-based model was used to simulate vertical fluxes at both atmosphere/soil and sub-surface/bedrock interfaces, as well as the lateral fluxes of both surface and sub-surface. The model combines an adapted Green&Ampt model with finite depth of the soil with a kinematic wave model for the surface routing, and a Darcy model for the sub-surface routing.

Most of the parameters of the model derive from the survey of the catchment: spatial distribution of the soil depth, vertical hydraulic conductivity at saturation, spatial and temporal variability of the soil moisture at various depths.... Some others are calibrated from observed rainfall and runoff data along a 10-years monitoring period (2005-2014): bedrock permeability, lateral hydraulic conductivity, initial water content in the soil. The model simulates quite well the observed floods over 30 events, based on the following assumptions : 1/ in spite of very high rainfall rates, most of the rainfall infiltrates in highly permeable soils (Ks $\sim$ 200-300 mm.h-1), 2/ runoff only occurs when the soil is totally saturated, 3/ saturation of soil is highly amplified due to fast lateral flow, around 1m.h-1, that converge along a dense gully network, 4/ most of the flash flood runoff is due to exfiltration of the water in those gullies, 5/ the calibrated parameters of the model are in very close agreement with their experimental estimation. In addition, the model was proved to be robust to the spatial resolution of the grid mesh: 25, 50, 100 m. The model was also successful to simulate flash floods at larger scales, over the Gardon at Anduze (500 km2), keeping the same parameters. The model highlights a comprehensive behavior of this kind of catchment under intense rainfalls, and shows the key role of the subsurface fluxes in the exfiltration processes that dominate the generation of the runoff. Additional geochemical experimentations based on water stable isotopes and trace elements are now carried out in order to confirm the generating processes of flash floods at the hillslope scale.