Geophysical Research Abstracts
Vol. 18, EGU2016-7992, 2016
EGU General Assembly 2016

"Physically-based" numerical experiment to determine the dominant hillslope processes during floods?

Eric Gaume (1), Thomas Esclaffer (2), Patrick Dangla (3), and Olivier Payrastre (1)

(1) LUNAM Univ, IFSTTAR, GERS, F-44344 Bouguenais, France (eric.gaume@ifsttar.fr), (2) EDF, DTG - Unité d'Expertise et de Mesure, Paris, France, (3) Univ Paris Est, CNRS, Ecole Ponts ParisTech, UMR Navier,UMR8205, F-77420 Champs Sur Marne, France

To study the dynamics of hillslope responses during flood event, a fully coupled "physically-based" model for the combined numerical simulation of surface runoff and underground flows has been developed. A particular attention has been given to the selection of appropriate numerical schemes for the modelling of both processes and of their coupling. Surprisingly, the most difficult question to solve, from a numerical point of view, was not related to the coupling of two processes with contrasted kinetics such as surface and underground flows, but to the high gradient infiltration fronts appearing in soils, source of numerical diffusion, instabilities and sometimes divergence.

The model being elaborated, it has been successfully tested against results of high quality experiments conducted on a laboratory sandy slope in the early eighties, which is still considered as a reference hillslope experimental setting (Abdul & Guilham). The model appeared able to accurately simulate the pore pressure distributions observed in this 1.5 meter deep and wide laboratory hillslope, as well as its outflow hydrograph shapes and the measured respective contributions of direct runoff and groundwater to these outflow hydrographs.

Based on this great success, the same model has been used to simulate the response of a theoretical 100-meter wide and 10% sloped hillslope, with a 2 meter deep pervious soil and impervious bedrock. Three rain events have been tested: a 100 millimeter rainfall event over 10 days, over 1 day or over one hour. The simulated responses are hydrologically not realistic and especially the fast component of the response, that is generally observed in the real-world and explains flood events, is almost absent of the simulated response.

Thinking a little about the whole problem, the simulation results appears totally logical according to the proposed model. The simulated response, in fact a recession hydrograph, corresponds to a piston flow of a relatively uniformly saturated hillslope leading to a constant discharge over several days. Some ingredients are clearly missing in the proposed model to reproduce hydrologically sensible responses. Heterogeneities are necessary to generate a variety of residence times and especially preferential flows must clearly be present to generate the fast component of hillslope responses. The importance of preferential flows in hillslope hydrology has been confirmed since this reported failure by several hillslope field experiments. We let also the readers draw their own conclusions about the numerous numerical models, that look very much alike the model proposed here, even if generally much more simplified, but representing the watersheds as much too homogeneous neglecting heterogeneities and preferential flows and pretending to be "physically based"...