

Hydrol. Earth Syst. Sci. Discuss., 5, S2147–S2152, 2008

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**HESSD**

5, S2147–S2152, 2008

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Comment

## ***Interactive comment on “A modelling approach to assess the hydrological response of small Mediterranean catchments to the variability of soil characteristics in a context of extreme events” by C. Manus et al.***

**C. Manus et al.**

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**Important Preliminaries :** This document contains few equations that are difficult to upload properly through the HESSD website procedure. Please refer to the pdf document available at the following address : <http://lthel21.hmg.inpg.fr/PagePerso/anquetin/Access.html>

**Editor :** The paper presents a modeling approach aiming "to gain new insight into the processes controlling runoff generation at regional scale"; (page 3). The rainfall-runoff model combining the Richards equation approach to simulation of the effective rainfall

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with a very simple method of runoff discharges calculation was applied by the authors for 4 small (less than 10 km<sup>2</sup>) ungauged catchments in Gard region, France. The study was focused on the single flash-flood event occurred in September 2002. The model was applied without any calibration, in particularly the soil hydraulic parameters of the Richards equation were derived from the available soil database. To validate the model, the authors compared the maximum specific discharges simulated for 4 catchments with the specific discharges estimated for several small nearby catchments on the basis of the post-event investigations including investigations of water level marks and interviewing witnesses. Spatial distinguishing between the different runoff generation mechanisms (Horton process and Dunne process) was revealed within the considering basins on the basis of simulations General Comments The results of the model validation, as they presented in the paper (Figure 8), are deficient to get a reader any idea on the applicability of the model to the main problem examined in the paper, namely influence of soil spatial variability on catchment response to extreme precipitation. In essence, Figure 8 shows that the simulated maximum specific discharges for the considered catchments lie within the wide range of the specific discharge values estimated for several nearby catchments. For me, these results don't say anything about the model capability for the small basins under consideration, not to mention about using of these results for regional scale. Consequently, I can not give credence to the authors; conclusions which are based on untested simulations. I consider the presented study as incomplete one and my suggestion is to carry out validation of the model using observations in gauged basin(s).

Authors : The major criticism of the Editor is related to a lack of validation of the approach using gauged catchments. This point has been answered in the General comments section. Nevertheless, we can summarize here some specificities of flash flood events in relation to gauging. Few discharge data are in general available during flash-floods. When gauges exist, they can be seriously damaged and out of work during the event. If they provide data, the estimation of discharge is prone to large errors because, in general, state-discharge relationships are extrapolated far beyond the range

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of gauged values, because it is too dangerous for operators to gauge very large discharges. Furthermore, given the scarcity of these events, it is quite difficult to have a long series of events at a given location. The regional modelling approach we try to promote is consistent with the recommendation of Borga et al. (2008) about the value of post flash flood field survey combining 1/ re-analysis of radar rainfall at high spatial resolution and short time step (5min) in order to get a correct view of the spatial variability of rainfall 2/ field survey in order to provide a spatial reconstitution of peak discharge and timing of the event using flood marks and witnesses interviews for ungauged catchments covering a large range of scales and of catchment response 3/ a modelling approach to extend and check the consistency of the survey to the whole region. We also want to underline the value of post event peak discharge as they are, in general, the only information available.

Thus, we complemented the revised paper with a new section about model verification on catchments surveyed during field campaign.

Referee : Leaving aside some less serious remarks (for instance, I consider as incorrect the method of reducing of hydraulic conductivity and soil porosity because of rock fraction (page 13)),

Authors : This question was also raised by Reviewer#3. We propose the same answer.

Rock fragments affect infiltration by their presence in the soil matrix and on the soil surface (Brakensiek et al., 1994). They modify the infiltration rate, the flow paths and water storage. Thus, rock fragment leads an overestimation of the water content (Morvan et al., 2004). In that sense, stone content was accounted for soil porosity  $n$  and hydraulic conductivity  $K$ . The comment addresses the way these two variables were modified. Note that stones are considered impervious and non porous (or having a closed porosity non accessible to water).

- Soil porosity  $n$ : Soil porosity is defined as the volume of pores  $V_p$  divided by the total volume  $V_t$  of a soil elementary cell. If stones are present in the cell occupying a volume

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$V_s$  (e.g.  $V_s=V_t/2$ ),  $V_p$  is reduced in proportion ( $V_p$  reduces by 2 in the example) and  $V_t$  is unchanged. Thus, soil porosity is reduced exactly in proportion ( $n$  divided by 2 in the example) of the stone content.

- Hydraulic conductivity  $K$ : This is more complicated and has no exact solution for general case, but we claim that a reduction of the hydraulic conductivity proportionally to the stone content is the simplest way to account for it without further information on the stone distribution in space, volumes and shapes.

We remind that  $K$  is used within Darcy's law to calculate a water flux  $Q$  in the direction of the hydraulic head gradient :

$$Q = K S \Delta H / \Delta z \quad (1)$$

where  $S$  is cross section area,  $H$  is hydraulic head and  $z$  is vertical axis (the same development can be made however if flow occurs in another direction). Stone content affects both  $K$  and  $S$ . However, the same  $S$  value will be used in the model whatever the stone content can be. Thus, the modified conductivity value  $K^*$  has to account for both  $K$  and  $S$  effects :

$$Q = K^* S \Delta H / \Delta z \quad (2)$$

For clarity purpose, consider two particular cases

a) Stone distribution in space consists in a continuous layer perpendicular to the flux direction. Then, no flow can occur. This case is unrealistic in our study because it would be described as another layer within the soil database.

b) Stone distribution in space consists in a continuous layer parallel to the flux direction. Then, flow can occur only in the porous part of the cross section (e.g. cross section area is reduced by 2 if  $V_s=V_t/2$ ). This case is realistic in our study because stones and porous matrix lies within the same layer.

If  $K^*$  is reduced proportionally to the stone content ( $K^*=K/2$  in the example) this ac-

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counts exactly for the reduction of the cross section area while the flow lines within the soil matrix are unchanged (along the  $z$  axis). In true, the soil matrix conductivity is unchanged and  $K^*$  accounts only for cross section area effect.

The general case consists in randomly distributed stones within the soil layer. No general simple solution exists for this case. The solution we proposed in the paper is to consider that the closest simple situation is the b) case.  $K^*$  accounts for cross section [L2] reduction which is approximately equal to the soil matrix volume [L3] reduction while flow lines within the soil matrix are considered parallel to the hydraulic head gradient although there are certainly not. Obviously, there is a difference between cross section and soil matrix volume reduction factors but we are not aware of an existing relation between the two for randomly distributed stones (certainly of different volumes and shapes!) within the soil layer.

The two effects not accounted for are: 1. the cross section area reduction is not exactly equal to the soil matrix volume reduction, but we assume that they are only slightly different, 2. the deformation of flow lines around the stones within the soil matrix, impossible to account for without information about the stone volumes, shapes and distribution in space. But this effect is certainly minor compared to the previous one.

Finally, note that a reduction of  $K$  by a 2-fold does not imply a reduction of fluxes by a 2-fold. Indeed, because of the soil porosity reduction, water will move faster vertically for a given infiltrated volume and thus, the hydraulic head gradient will tend faster to unity.

In conclusion, the solution we proposed in the paper is simple and unbiased. The effects not accounted for (1. and 2. above) are impossible to estimate.

Editor : I suppose that the aforementioned remarks are a matter of principle and relate to the basis of the approach presented in the paper. In spite of the paper addresses relevant scientific problem within the scope of HESS, however scientific methods and assumptions which are suggested by the author for solving the problem were not vali-

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dated, and I can not recommend the paper for publication in HESS.

Authors : In the revised version of the paper, we improve the presentation of our approach and strategy. We better describe the context of flash-floods in terms of data and we add a section about model verification. In addition to the answers provided to reviewers' comments, we hope that these improvements of the paper will make it reach the standard required for a publication in HESS.

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December, 11th, 2009, Grenoble, France

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 5, 2687, 2008.

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