Hydrology and Earth System Sciences Discussions

Interactive comment on "Scale effect on overland flow connectivity at the plot scale" *by* A. Peñuela et al.

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Received and published: 20 September 2012

AC:Author comment RC:Reviewer comment

AC: First of all we would like to thank you for your interesting and valuables comments. We acknowledge that the scale definitions that we have provided in this study are not the most appropriate. This study focuses on the plot scale, for which there is not a unique definition in the literature, and aims to study the potential of extrapolating the connectivity indicator RSC function to larger scales. However, for computational reasons, that will be explained later, this study could only evaluate this potential at scales below the typical grid cell size of catchment-scale distributed hydrological model. Nevertheless, we still consider that these results are valuable in order to be applied in

hydrological models at the hillslope and the small catchment scale. According to these considerations, the "plot scale" will be redefined in the text, so it will range between $1m^2$ to $1.000m^2$. Besides, the term "watershed-scale" will be replaced by "hillslope-scale and small watershed-scale".

RC1:The paper concentrates on a Relative Surface Connection (RSC) function to express the connectivity to the outlet (or outlet boundary in their rectangular fields) in function of the depression storage. The authors point out that distributed models use relatively large grid-cells and that most hydrological models assumed a maximum depression storage as a threshold before overland flow generation. This often leads to underestimation of the low flows at the initiation of the hydrographs. The paper focuses on scales from 0.18 to 36 m2 for different width and length of rectangular fields. The results are based on simulations for one "real" field (Lidar measured high accuracy microtopography) and 3 alternative types micro-topography for synthetic fields.

AC1:The technique used to obtain the "real" DEM is not Lidar. It is a laser scanning technique that consists in projecting a horizontal line of intense light across the surface and then scanning the surface at a constant velocity. The distortion of the line caused by the microtopography is captured by a camera at fixed intervals of time. The obtained images are treated based on geometrical considerations after a calibration, transforming the projected line into an elevation profile. These profiles are then merged to obtain the digital elevation model of the scanned surface.

RC2:The title mentions a plot scale, which also partially justifies the choice for rectangular fields. Unfortunately the maximum field length of 9 meter is low. It is not clear why the study did not try to incorporate larger lengths (like 100 m or more).

AC2:Larger lengths could not be studied for computational reasons; it was not possible to generate very large synthetic fields with similar resolution (10 mm). Larger fields could be obtained by reducing the resolution, but valuable micro-topographical information would be loosed, and thus it would increase the uncertainty (Antoine et al.,

2009). In the case of real fields, obtaining high resolution DEMs over large surfaces using our laser scanner technique outdoors was not possible for technical reasons. Therefore we did not have a larger DEM available to use in this study. In the future we are going to try to generate new and larger DEMs using a photogrammetry technique that will greatly facilitate the characterization of real DEMs.

RC3:Now this question is left open in the final paragraph of the conclusions. The concept of minimal representative scale (0.4 to 2.5 m depending on the case) is introduced. This appears logical and correct but for practical applications of the paper there is more interest in the larger scales (going up to the grid-cells, often in the order of magnitude of hectares or more, as used in distributed models). Moreover the small scale (maximum length of 3m) comes close to the minimal representative scale.

AC3:We agree with the reviewer that extending the methodology to larger scales would be of great interest but, as explained above, we were constrained by computational / instrumental factors which prevented us from extending the study to larger scales while keeping the same resolution. Working at a lower resolution would most likely strongly alter the connectivity function, which would be undesirable. We believe the present results are already relevant for hillslope models or small watershed models, for which grid cells are compatible with our work. We also believe that the scale at which we worked is relevant as this is a scale for which microtopographical characterization remains practical. Nevertheless, are currently working on a methodology to obtain larger DEMs from real fields with similar resolution, which would allow us to test the scaling effect at larger scales. Please note that the maximum length of 3m is only used for the "real" field, whose maximum value of the minimal representative scale is 1.2m (less than a half of the total width). For the synthetic fields, the maximum length was 6m, well in excess of the minimal representative scale.

RC4:The calculation is based on a filling algorithm without considering infiltration and with an infinite velocity of flow. In this way the "routing" is instantaneous and they estimate the RSC directly as what they call a simplified hydrograph. A Maximum De-

pression Storage (MDS) is defined as a function of width. The "representative" width is defined as the width at which the MDS crosses the MDS value at infinite width + 10%. In a similar way a "representative" length is defined (be it at -10%). No explanation is given why 10 % and not any other value.

AC4:The tolerance of 10% can be justified based on the following consideration. A 10% error in MDS would barely affect results in a hydrological model. Indeed, in our study, absolute MDS values ranged from 0.5 mm to 2.5 mm, such that a 10% relative error would lead to an absolute error comprised between 0.05 mm and 0.25 mm. We believe that having a greater accuracy on the MDS would not be relevant for most practical applications, whereas a higher relative error, especially in fields with high values of MDS, may lead to a substantial bias in hydrogram estimation.

RC5:Especially Figure 2 is quite informative showing the RSC function and the connectivity within the plots to the downstream outlet boundary. However, the discussion of this interesting phenomenon is only present in section 2.2 (Material and methods). This effect could have been more elaborated during the discussion.

AC5:We are not sure about which phenomenon the reviewer refers to, but I suppose that it is the percolation threshold. This sharp threshold in the RSC function theoretically occurs when the area connected (to the downstream outlet), reaches the upstream boundary, as shown in Figure 2. This is further explained in section 4.3 and in the cited references inside this section (page 14 line 8 to 23).

RC6:It is shown that the same semi-variogram but with a different micro-topography pattern can lead to a different RSC function. This is an important conclusion. As expected the length has a major effect. The width had border effects but less scale effects. Border effects are probably the consequence of a rather artificial rectangular setting.

The major unanswered question is whether at larger lengths (25, 50, 100 and more) the RSC functions are starting to converge or not. It would make the paper more

interesting and with relevant practical consequences for distributed modeling if such larger scales were included. On synthetic plots this should not form a lot of extra work.

AC6:In our opinion, this convergence is fairly well shown for the four connectivity scenarios when either length or width is modified (Figures 4, 6, 9, 12). Nevertheless, studying the scale effect at larger scales would be highly relevant. This is a perspective that was mentioned in the conclusions. A greater variety and larger fields should be studied in order to evaluate the robustness of the results obtained in this paper. However, as explained above, this was not possible for computational and technical constraints.

RC7:Structure of the paper could improve: as an example the definition of MDS and representative widths and lengths should not be presented within the results section.

AC7:The minimal representative length and width is a term that we define after the results but the existence in the literature of a minimal representative scale concept is already mentioned in the introduction. MDS is defined in the Materials and Methods section. We added a new paragraph in the Materials and Methods section in order to define the representative width and length.

RC8:In the results section for synthetic fields no mention is made for results for the three types of surfaces.

AC8:We agree with this comment and this section has been modified.

RC9:Figure 1 (page 7902) is not informative in its current form. Possibly a longitudinal transect would make the concept of River versus Crater more clear. There could be reduction in Figures. At this moment there are 17 moreover including composed figures.

AC9:We chose this format since we wanted to show the different spatial configurations and connectivity patterns of the fields, i.e., how micro-depressions are distributed and connected between each other. In our opinion, a longitudinal transect cannot properly

reflect the degree of connectivity between the depressions. The figure was modified to show the stored water over the field, in a similar way as Figure 2. In this way, it can be shown how the different parts of the field connect or disconnected to each other in the 4 different scenarios.

RC10:The objective of introducing connectivity within a grid-cell for improving distributed modeling could be elaborated more so that the paper becomes more relevant in a general context.

AC10:The potential of the RSC function to be integrated in hydrological models was introduced in a new paragraph which was added in the Literature Review.

RC11:The number of the references is relatively limited but appropriate for the content.

Technical corrections

RC12:The paper is in general well-edited.

AC12:Thank you.

RC13:Pag 7885 line 21: Formula 1 mentions that the plot width is in m however it appears in Table 2 (page 7900) that mm's are used. Please ensure consistency in units between the formula and the table.

AC13:Thank you for this correction, the formula has been modified accordingly.

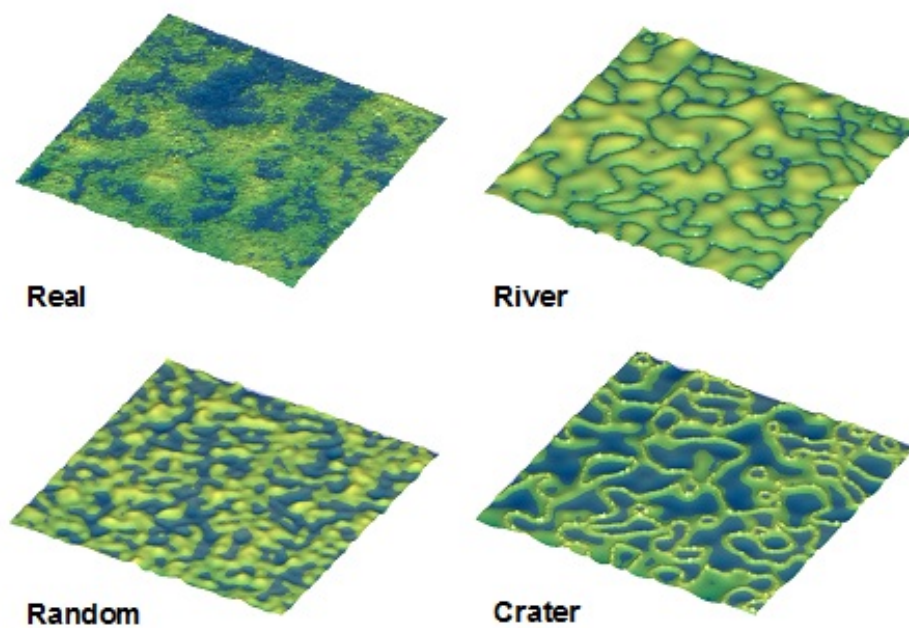Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 7877, 2012.

Fig. 1. Microtopography types (2 m x 2 m detail) with depressions partially filled (stored water in blue)

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