Hydrology and Earth System Sciences Discussions

Interactive comment on "The geomorphic structure of the runoff peak" *by* R. Rigon et al.

R. Rigon et al.

riccardo.rigon@ing.unitn.it

Answer to Reviewer No. 2 of: The geomorphic structure of the runoff peak, by Rigon et Al.

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Introduction

We thank the reviewers for the appreciation of the paper, and having allowed its improvement. We summarize here below the main comments of the Reviewer 2 and provide a point-by-point reply.

Comment 1: The methodology for the determination of the time to peak is unclear. The paper states: "The time-to-peak, $t*$, can be found either for $t = t_p$, or by solving Henderson's equation". Why "either", later in line 20, the authors mention "Therefore the solution, $t*$, of Eq. (4) needs to be searched in the interval $[t_p, c]$". This seems to indicate that the solution is also valid for tp. It also indicates that it is valid for τ_c then equation (4) should probably be valid for $t_p \leq \tau_c$.

Yes, the comment is correct. In the new version of the manuscript we rephrased those sentences:

" The time-to-peak, t^*, can be found by solving the ... Henderson's equation ... valid for ... $t_p \leq \tau_c$".

More details are given in Appendix A, which has been improved. In this revision we also stress that there is the need to check that the solution of Eq. (A6) actually corresponds to the maximum discharge. In fact, because the maximum could occur in correspondence of a possible discontinuity point in the first-order derivative of $Q(t)$ at $t^* = t_p$ (see Equation A5).

Comment 2: Figures 2 and 3 are mentioned respectively in the last paragraph of section 1.1 (page 1034) and in section 1.2 (page 1036), however both figures refer to kinematic wave celerities that are introduced within the framework of the geomorphologic width function approach described later in section 2.1 (page 1038). The next two points give more details for each figure.

The comment is correct. The captions of the figures have been modified accordingly. We have eliminated from the captions unnecessary information that could just confound

the reader. However, we need to stress that because these results do not depend on how the IUH is derived, a figure can allow the reader to better understand the method. Therefore,we decided to keep the Figure 2 in the same place and to move Figure 3, as suggested by the reviewer.

Comment 3: Fig. 2 mentions the use of hillslope velocities u_h, and the yet undefined celerities u, and has been derived using the "rescaled" width function approach not discussed in the paper. Instead, the paper discusses the derivation of the geomorphologic unit hydrograph using the width function approach in section 2.1 (page 1038) and the definition of u (flood wave celerity in channels) is in line 18 in that page. The caption mentions q that has not yet been defined in the paper (q is defined in section 3, page 1041). The caption also mentions the existence of secondary peak flows, not mentioned anywhere else (it might be more appropriate to remove the grey line from this figure), this is confusing, as the steps for obtaining this figure are not properly discussed. Therefore, this figure does not help in clarifying the methodology; instead as it stands, it generates confusion.

Figure 2 caption has been modified and does not contain anymore a reference to the derivation of the hydrograph from the rescaled width function. The presence of secondary peaks is now explained in the text (after henderson's equation). Therefore we did not remove the grey lines from this figure.

The new text reads: *"For example, in the case of the catchment discussed in Section 3, Δt is a decreasing function of t_p and becomes null as t_p approaches τ_c (Fig. 2). Moreover, Fig. 2 shows that for small values of t_p multiple peak flows, corresponding to secondary maxima, may occur."*

Comment 4: Figure 3 also generates a similar degree of confusion. It gives the graphical solution of equation (9), in section 1.2. However, as in the previous figure, the caption explains that the figure was derived using several concepts not yet described in section 1.2 (that is the width function approach). How is it relevant at this point the selection of different celerities if the link between celerity and the hydrograph has not yet been done? The notation for celerity in this figure is not consistent with that adopted in the rest of the paper. Note also that associated with the lack of description of the particular application that leads to this figure, is the selection of $m = 0.63$, for the Longo basin which looks "arbitrary" at this point, as the selection of case study catchments has not yet been discussed (it is discussed in section 3). A solution to the issues mentioned in points 2-4, regarding Figures 2 and 3 (probably not the only one, as the authors might find a better alternative) would be to move the figures and explain the concepts that they illustrate after section 2.1, probably in section 3 (case studies). If hillslope celerities have been used in the derivation of the hydrograph using the width function approach (as suggested in fig. 2), then the corresponding equation should be probably included and briefly discussed so the readers could understand the application of the methodology.

We accepted the suggestion of the reviewer, and we moved Figure 3 (now Figure 4) to Section 3.

The new text does not contain anymore any reference to the Figure: *"Depending on the rainfall duration t_p and on the shape of the IUH, for some values of m, it is possible to have multiple solutions of Eq. (9), which correspond to local minima or maxima of discharge, as shown on a case study in Section 3".*

Comment 5: Page 1040/1041, the portion of the methodology explained in the last paragraph of section 2.2 is unclear. Line 17 in page 1040 states: "once the function $W(u\ t)$ in Eqs. (13), (14) and Eq. (14)" Should it be Eq. 15? The variable "x^*" has not been defined. Please explain clearly why the domain of w(t) is infinite if eq. (17) has a well defined domain. The concepts in this last paragraph need to be explained in more detail, and some of the derivations that are mentioned here (i.e, substituting the time to peak into Eq (18)) included, so that the explanation becomes more clear.

Yes, it is eq 15. It must be observed that the domain of $\omega(t)$ is infinite while eq. (17) is defined between 0 and ∞. In this case, the substitution of the time to peak into Eq (18) should be done numerically, and is straightforward.

We rephrased the text in order to be more clear:

"Thus,the critical rainfall time t_p^* can be calculated by inserting Eq. (21) into Eqs. (14) and (15). It is found that the area, A^*, contributing to the flow peak is independent of the return period. However, when D assumes large values ($\sim 1000\ m^2/s$), it can be shown that A^* depends on D, the shape of $W(x)$, and on u."

The peak discharge can be obtained numerically by substituting the time to peak, t^*, into Eq. (18). Interestingly, the concept of concentration time, used in the non-diffusive (kinematic) framework, would be meaningless in this case because the domains of $\omega(t)$ and $f(t|x)$ are infinite."

Comment 6: Page 1042, line 1 states: "It is observed that τ_c...", it is not clear "how or where" it is observed. Please include a more thorough and clear discussion (a figure might help in clarifying this "observation"). Line 2 states: "In all these cases..." : it is unclear "which" cases, does it refer to the different basins? Please illustrate and/or explain the impact of hillslope extent on τ_c.

The observations refer to Table 1. The paper by D'Odorico and Rigon (2003) explains in detail the impact of hillslope extent on τ_c. Therefore, we have revised the text as follows:

"Table 1 reports the values of the variables τ_c, t^*, t_p^*, A^* and Q^* in the Longo basin for different values of the saturated fraction of the basin. It is observed that τ_c, non-linearly increases with increasing values of q".

Comment 7: Section 3/Figure 5: This figure mentions hillslope celerities, but as mentioned before, the equations in the paper do not include the effect of hillslopes. Section 3, page 1042, line 19 also mentions r=100 (which was only defined in the caption of figure 2). Please, add the necessary equations and discussion so the methodology and application becomes clearer.

At the beginning of section 3 we define these variables and introduce the notion of rescaled width function and refer the reader to D'Odorico and Rigon, (2003) for further details.

The text has been changed: *"In this application the width function was calculated differentiating for the velocities in channels, u_c, and in hillslopes, u_h, (Rinaldo et al., 1995; DíOdorico and Rigon, 2003), and introducing a rescaled-width function."*

Comment 8: Figure 5b seems to have some grey points, are they different from the black points in that figure? What are these grey points?

Grey points indicate the smaller contributing areas, which belong to the hillslopes.

We improved the caption: *"For smaller contributing areas (indicated in the Figure as grey points) t_p^* is affected by the variability of the hillslope length."*

Comment 9: Figure 6: The caption mentions: "Notice how $Q_p/(pA_T) = A^*/A_T$ does not depend on channel flow velocity, since Eq. (5) remains valid also in this more general case" The figure does not seem to display any variation of $Q_p/(pA_T) = A^*/A_T$ with channel flow velocity, so this comment seems misplaced here.

The caption has been modified. The comment has been removed.

Comment 10: Page 1044, line 4. Channel velocities are denoted "u_c", in other parts of the paper channel velocities (celerities) are denoted as u. Please unify notation.

We have put u_c after introducing the concept of channel velocity. We defined now clearly this quantity in Section 3.

Minor corrections:

11) **Abstract, line 6:** *"Semi-analitical" should be replaced by "semi-analytical".*

12) Page 1034, line 13:   *"DOdorico and al." should be "D'Odorico et al."*

13) Page 1037, line 10:   *"evaluated as a function "of" time to peak.*

All these minor points have been corrected.

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