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Hydrology and Earth System Sciences Discussions

Interactive comment on "Combining flow routing modelling and direct velocity measurement for optimal discharge estimation" *by* G. Corato et al.

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UTILITY OF THE PROPOSED METHODOLOGY

Reviewer: *Both these methods, viz., the velocity entropy model (Moramarco et al., 2004) and the stage hydrograph routing method of Arico et al. (2009) are not new. But the ingenuity of the proposed methodology arises from the combined use of these methods for determining the Manning's roughness values at different water levels and the subsequent use of the same for stage hydrograph routing and the consequent estimation of corresponding discharge hydrograph at the gauging site. The authors, based on their field experience, state that the surface flow velocity measurement is not tedious, time consuming and dangerous as the conventional river velocity measure-*

ments normally practiced in many countries. Accordingly, the proposed methodology is a boon to hydrologists and engineers engaged in hydrometric measurements by overcoming the professional hazard associated with the conventional velocity measurements.

Authors: We thank the reviewer for his positive comments on the capability of the proposed procedure in the framework of the flow velocity monitoring during floods.

SPECIFIC COMMENTS:

Reviewer: *1) The word "optimal" is used only when many feasible solutions are examined and the best among them is selected. The authors do not estimate discharge based on this consideration. They measured the direct surface velocity sporadically, as they have stated in number places in the text, and, therefore, the title may be changed to 'Discharge estimation by combining flow routing and sporadic measurements of surface velocity';*

Authors: We agree with the reviewer's point and, accordingly, we modified the title of the paper.

Reviewer: *2) Many researchers who study this paper would be curious to know, like this reviewer, that if the surface velocity during a flood can be measured by 'no-contact' method as stated in the paper, and subsequently the average velocity can be estimated, then why not adopt this technique for the direct surface velocity measurement at specified regular intervals over the entire duration of flood event without involving flood routing;*

Authors: The reviewer is right, what was underlined by him is true. The flow velocity distribution model can be applied to assess the discharge hydrograph from direct measurements of surface flow velocities carried out at specified regular intervals. This can be even done, showing the further advantage of the approach! However, currently our main target is to propose a procedure able to provide a reliable estimation of discharge hydrographs in different gauged sites for the same flood starting from recorded stages and occasional measures of surface flow velocity. This is achieved through a robust procedure of Manning's roughness calibration that, apart from the great advantage to being done in near real-time, is useful for providing information about the average roughness of the river, which is of paramount importance for whatever application of flood routing as, for instance, the hydraulic risk analysis. Moreover, we all know that the discharge estimation performed with non-contact instruments is still less accurate then the discharge estimation carried out by measuring velocities with contact instruments even only in the upper part of the cross-section. This could be done during the rising limb of the stage hydrograph, even if it is more expensive and not easy to carry out at specified regular intervals. We didn't add this discussion into the paper for sake of simplicity.

Reviewer: *3) Question pertaining to general applicability of the method: How the assumption of wide rectangular channel concept used in Eqn. (11a) is valid when flood occupies flood plains and flow moves at a section with significantly different velocities. Under such condition the flow section cannot be considered as wide rectangular.*

4) Again this question is related to general applicability of the method: How the linear variation of input stage hydrograph applied in Eqn. (11b) is valid for all field conditions considering the nonlinear nature of the rise of input stage hydrograph.

Authors: The reviewer observes that Eq. (11a) does not hold when the Manning coefficient n changes along the section or when the river cross section has flood plains with different elevations. Moreover, the hypothesis of a linear variation of the upstream stage hydrograph is not realistic. We want to point out that the aim of the analysis is to give only a rough estimation of the minimum channel length based on simplified

hypotheses as rectangular wide section and linear stage hydrograph As far as the rectangular wide section is concerned, as better explained in the revised paper, the procedure for the minimum channel length computation is meant only for the case of initially missing cross-sections topographic information. If DEM or detailed topographic surveys of the area are available, the extension of the computational domain can be addressed with the simple criterion of extending its length until any meaningful change of the estimated discharge takes place. The computational efforts associated to each model run are, in practice, always negligible, even if thousands of river sections are used to define the bed geometry. On the other hand, if the cross section geometry is not known 'a priori' and a specific field survey is required, the extension of the investigated channel length becomes the major cost of the procedure. In this case, the proposed estimation for the minimum channel length represents a simplified tool to initialize the iterative process, where the results of the sensitivity analysis suggest the opportunity of extending or not the field survey campaign. As regards the assumption on linear stage hydrograph, we fully agree with the reviewer's point about the non linearity of the rising limb in the discharge hydrograph. However, this assumption is merely speculative and it has been done here in order to minimize the number of parameters that somehow could influence the outcome of synthetic tests. Indeed, we well known that assuming at upstream end hypothetical stage hydrographs such as those given, for instance, by a four-parameter Pearson type III distribution many parameters are involved (peak stage, time to peak, shape factor, etc). That's why we use a linear stage hydrograph that, besides, can be easily estimated for real case as the maximum slope in the observed rising limb of historical flood events. In spite of this assumption, the results of synthetic tests summarized in the figs. 2-3 (3-4 in revised version of manuscript) are fairly accurate when applied to field data as shown in section 7.1 (6.1 4 in revised version of manuscript), referring the river reach downstream the investigated gauged sites.

Reviewer: *5): The derivation made by this reviewer shows that the right side of Eqn.*

(3) should be Q/T rather than Q as given in the paper.

Authors: The reviewer's point is correct. Accordingly, we have corrected Eq (3).

Reviewer: *6) Some of the comments related to language: i. Solid velocity (also pointed out by Reviewer-2): Whether the authors imply the mean velocity of flow area? (The authors need to use standard technical terminologies)*

Authors: 'Solid of velocity' stands for the graph of velocity vectors at a river section, in the longitudinal direction. However, to avoid misunderstanding we have replaced the term with 'two-dimensional flow velocity'.

Reviewer: *ii. Change 'roughness Manning coefficient to 'Manning's roughness coefficient'. iii. Change 'occurring in' to 'recorded at'. iv. Change 'analysis outcomes' to 'outcome of analysis'. v. Change 'practice hydrology' to 'hydrological practices'. Many such language problems remain in the draft paper.*

Authors: Accordingly, we addressed all requested changes and revised the language.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 2699, 2011.