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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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Rewiever: *The paper's aim is the derivation of a novel technique for the estimation of river discharge hydrographs during flood events using water level measurement data, 1-D flow routing model and a few measurements of surface flow velocity at a site. Due to well known problems related to rating curve estimation, the method would be very useful in a number of hydrological and hydraulic applications, not only at sites where the rating curves are not established but also for evaluating the correctness of existing rating curves and its uncertainty. The authors combine two techniques, entropy theory and hydraulic routing modelling.*

Authors: The reviewer got the point. Indeed, the proposed procedure well lends itself both to estimate the rating curve at ungauged sites and to evaluate the accuracy of existing rating curve, mainly in the extrapolation limb over the velocity measurements field.

Rewiever: *However it is not clearly explained what advantages the new method offers in comparison with the other methods, and in particular, entropy measure and hydraulic routing modelling approaches. The latter methods allow for the derivation of discharge hydrographs, based on different types of available measurements when certain assumptions are met. The authors are asked to give a discussion on the assumptions required, the generality of the proposed approach and to give an estimate of errors.*

Authors: In the revised manuscript we addressed the reviewer's questions. In particular, it's shown how the procedure, based on the coupling of the hydraulic model and the two-dimensional velocity distribution model, allows overcoming the age-old question of velocity measurements during high floods with a great benefit in the field of streamflow measurements in terms of costs, safety of operators and capability to monitor the same flood for different gauged sites. Another positive impact of the method is the possibility to calibrate in robust way and, above all, in near-real time the Manning's roughness coefficient, thus allowing to achieve a good estimation of discharge hydrographs at gauged sites. This aspect is of great interest for the general issue of open channels flow, because it would allow to estimate, in a simple way, the average Manning's roughness which is the critical parameter of whatever flood routing analysis. In the revised manuscript, the assumptions of the method are explained in details along with performances, these latter identified in terms of efficiency measures based on Nash Sutcliffe index and errors in peak discharge.

Rewiever: *I have to agree with the first reviewer that this paper is difficult to follow. It seems that the information is there, but in a wrong order. In particular, the authors are advised to clarify the introduction. The authors introduce four main configurations of*

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the monitoring available in practice and specify that their approach is suited for one of the configurations. The authors should discuss the advantages and disadvantages of each configuration. This should be followed by an explanation of disadvantages of the methods used so far and the advantages of the newly developed approach. A list of assumptions required for the application of the proposed method should be also given. In the introduction the authors should state precisely what they are going to present in the following part of the paper, giving a clear picture of what follows.

Authors: Accordingly, we have modified the Introduction by addressing the reviewer's points. First of all, to avoid any misunderstanding, we have discussed two configurations in which a gauged river site can be found, avoiding to consider the two cases of equipped river reaches, wherein the uncertainty of the lateral flows estimation is an addition issue beyond the scope of this study. Then, we have described the approaches generally used to convert stages in discharges in the two monitoring configurations, highlighting limits in terms of parameters calibration as well. The novelty of proposed method is also outlined. Finally, the organization of the paper is detailed.

Rewiever: *They should describe in simple terms how the two methods are combined and what advantages from this combination are envisaged. In section 2 the authors present flow routing model. There are too many details given which should be put into the appendix, if they are necessary for the explanation of the approach. This would simplify the presentation and make it clearer. At the moment the reader is lost in too detailed information that cannot be followed without referring to the papers where it comes from and the aim of the presentation is thus lost.*

Authors: Accordingly, we have revised the Section proposing a new one named 'Hydraulic Model' and moving details concerning the numerical scheme in Appendix A.

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Rewiever: *Section 3 gives a presentation of the entropy approach to model flow velocity. It is a difficult concept and the authors do not make it any easier by copying the equations from the work of Chiu without a proper introduction to the approach.*

Authors: Accordingly, we revised the Section concerning the flow velocity distribution model. In particular, we have clarified the entropy concept which is used, in general, as a statistical inference method to select, for instance, a probability distribution function, when the information available of the variable is limited to some average quantities, defined constraints, such as the mean, variance and so on. Then, we have better explained the velocity distribution model proposed by Moramarco et al.(2004) and how it was derived from the one developed by Chiu (1989). To this end, Appendix B is added in the revised manuscript showing some details on Chiu's velocity model. Finally, further references are also added.

Rewiever: *There are no assumptions/conditions of model validity given. Section 4 presents the domain extension criterion. The authors discuss here the length of the river reach required to avoid the influence of downstream boundary conditions. This section is also difficult to follow and it seems a bit removed from the main aim of the paper. As the authors refer to this section in the next section (5), it would be better to combine both sections and simplify the presentation with the formulae derivations moved into the appendix and only the main, important results left. If the reader wanted to apply the proposed approach, he/she would need some algorithm- a scheme describing what to do, what assumptions should be met and what errors could be expected. It should be given in a 'methodology' section.*

Authors: We have revised this Section attempting to address the reviewer's points. In particular, also based on the revised Introduction, the purpose of this Section should appear more clear and in accordance with the main aim of the paper. As far as the formulae derivation is concerned, they represent the core of the adopted methodology for estimating the minimum channel length and that's why we keep the formulations

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in the Section. However, for addressing the reviewer's question we have tried to make more simple the formulae definition. Finally, in the Section named 'discharge estimation methodology' we sketched the steps for using the proposed procedure.

Rewiever: *Technical comments: Page 2712, line 13: there are some problems with equation 2, that the authors refer to and in the next section 5. The authors (presumably) made a mistake in the first line of the section 5, referring to eq. 2.*

Authors: We thank the reviewer for his carefully reading. The reference of eq. (2) in the first line of section 2 is correct, but maybe the sentenced is unclear.

From the eq. (2):

$$\nabla_x H = \frac{\partial H}{\partial x} = -\frac{n^2 q\,|q|}{A^2 R^{4/3}}$$

the discharge q is:

$$q = -\frac{\nabla_x H}{\sqrt{|\nabla_x H|}} \frac{A R^{2/3}}{n}$$

where the area, A, and the hydraulic radius, R, are functions of recorded water levels only. Therefore, the error in discharge estimation is tied to the errors on the computation of water level gradient,$\nabla_x H$, and on the estimation of the Manning's rougheness coefficient, n. For assigned n, the error in the computation of peak discharge, q_{max}, is depending on the related error on water level gradient,$\nabla_x H_{max}$, only.

Rewiever: *Further on (page 2714, line 7), the authors wrongly mention section one, where the numerical model is supposed to be described. The authors are advised to check all their references to equations and sections (see above and also page 2715 - line 6)*

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Authors: Accordingly, we checked all points underlined from the reviewer

Rewiever: *What do the authors mean by 'solid of velocity' (e.g. page 2700, line 20), and later through the text?*

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'.

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

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