Hydrology and Earth System Sciences Discussions

Interactive comment on "Assessing rating-curve uncertainty and its effects on hydraulic model calibration" *by* A. Domeneghetti et al.

T. Moramarco (Referee)

t.moramarco@irpi.cnr.it

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I enjoyed reading this paper which conveys a significant message on the rating curve uncertainty assessment, which is a topic of utmost importance in the hydrology field. I recommend that the authors address the questions that I posed as best they can, but regardless of how well they answer them, I still recommend publication.

General Comments

The content of the paper can be summarized as follows. The authors propose a methodology for the rating curve uncertainty estimation at a gauged river site, when streamflow measurements might be absent or available only for ordinary flow. The

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analysis is based on two different approaches: 1) traditional, by following the EU ISO rules the rating curve uncertainty is addressed for a stage-discharge power law by using 50 synthetic sets each one of 15 (h,Q) pairs, which mimic the streamflow measurements for ordinary flow conditions; 2) constrained, the application of a hydraulic model along a river reach including the site of interest is calibrated for steady flow by using the largest discharge values of each synthetic set and the maximum inbank flow, Qmax, is estimated at river site. Then, based on Qmax, the empirical stage-discharge power law is again identified along with its uncertainty. The pairs (h,Q) of synthetic sets are randomly drawn out from the simulated historical floods by using a quasi 2-D hydraulic model calibrated for a recent flood event. Finally the impact of the rating curve uncertainty is investigated in terms of Manning's roughness calibration. The test river site is the Cremona gauged section along the Po river which is included in the investigated river reach having the gauged sites of Piacenza and Pontelagoscuro as channel ends

The analysis is of considerable interest, given that the rating curve accuracy at a gauged river site depends on velocity measurements availability for high stages, i.e., during high flood and this seldom occurs due to the difficulty and dangers that operators might face in sampling velocity points mainly in the lower portion of flow area. That's why, the works as that proposed in this paper are welcome.

I think, however, that the paper would be even more interesting if the following question could be answered (if possible). The authors obtained the synthetic sets of pairs (h,Q) from the simulated historical floods at Cremona gauged site, after that the "first quasi two-dimensional" hydraulic model was calibrated for the flood event of October 2000. This means that a single calibrated Manning value was used for identifying all synthetic measurement campaigns and, hence, the stage-discharge power relationships. However, my field experience on streamflow measurements leads to say that the Manning's roughness in the inbank channel varies from higher values for low flow depth and drops to asymptotic values for higher stages (Moramarco and Singh, 2010). This entails that

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if a single Manning's value is used for the calibration in the main channel, the discharge for low flow is overestimated and this might be the case of this work. Therefore, I guess that the extrapolation of the empirical stage-discharge relationship beyond 6000 m3s-1, mainly for the traditional approach, might be affected by the underestimation of the Manning's roughness for low flow with the direct consequence of an overestimation of discharge in the lower part of the channel and, perhaps (referred to the constrained approach), an underestimation of the maximum discharge capacity. It's true that the synthetic measurements campaigns are obtained by randomly sampling the pairs (h,Q) along the rising and recession limb of simulated discharge hydrographs, but I'm a little concerned on this, since these hydrographs are not identified in the more right manner. Certainly the analysis based on a single Manning's value can address the rating curve uncertainty at ungauged river sites wherein no information (stage, discharge) is available, but it doesn't seem to me the purpose of this work given that streamgauges are considered here.

However, knowing that the Cremona river site is a gauged site, I guess that recorded stages are available there for the historical floods. If so, the authors might calibrate each flood by matching the stages and then to draw out from each one, the 5 synthetic sets of 15 pairs (h,Q). In this way, for the traditional approach, I expect that the "new" empirical stage-discharge power relationships should be more "steep" than the ones shown in the paper and the extrapolation might achieve the "optimal" rating curve or at least approach to it, as instead it occurs for the constrained approach. Therefore, the difference in terms of uncertainty between traditional and constraint approaches should be less evident of that shown in Figs.6 and 7 and perhaps more coherent with the reality. If historical floods data at Cremona sites are not available in terms of recorded stages, the previous insights should be at least highlighted in the manuscript.

I would like to also emphasize that the same analysis proposed in this paper can be directly applied to measurement set of (h,Q) pairs, really observed at a gauged site, and this is a further asset for the hydrological practice. Indeed, for each measurement,

the hydraulic model can be applied for steady flow considering at the upstream end the observed discharge during the measurement and at the downstream end the Manning equation. Then, at the gauged site, Manning's roughness can be calibrated for each measurement by matching the observed discharge and the corresponding stage. In this way, the trend of Manning's roughness is identified in the inbank channel, and a robust Manning's value can be obtained for a more correct estimation of the maximum channel discharge capacity, of basis for addressing the rating curve uncertainty.

Specific Comments

I don't think that the term "optimal rating curve" is quite appropriate. "Optimal" is used if more solutions are compared and the best one is selected. It doesn't seem this the case. For that, it would be better to use the term "normal rating curve/discharge" rather than "optimal rating curve/discharge".

Fig.6 and Fig.7. If the previous comments are addressed, I guess that the difference in terms of bias and 90% confidence band should be less evident between the two investigated approaches. Analogously, the Table1 should show for the Manning's roughness a lower variation relative to calibration event. Obviously, Fig.8 (left panel) should change too.

The paper by Perumal/Moramarco/Sahoo/Barbetta is quoted in the references, but not in the manuscript. I guess that the reference should be placed at line 22, pag 10505

Additional Reference

Moramarco T., Singh. (2010). Formulation of the entropy parameter based on hydraulic and geometric characteristics of river cross sections. Journal of Hydrologic Engineering, 15(10), 852-858

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