

***Interactive comment on* “Discharge hydrograph estimation at upstream-ungauged sections by coupling a Bayesian methodology and a 2D GPU Shallow Water model” by A. Ferrari et al.**

A. D. Koussis (Referee)

akoussis@noa.gr

Received and published: 21 May 2018

Estimating an unknown discharge hydrograph at an upstream cross-section is useful in flood hydrology both as a forensic activity (to find the inflow that caused a flood event observed at a certain downstream section) as well as operationally (to determine the operational mode of a reservoir in order to protect a downstream area). Such (rather special, but not rare) problems are tackled either by reverse routing the observed hydrograph to the upstream cross-section (an inverse problem, the solution of which exists, but is not unique and must be regularised; the authors should note, in their relevant section, that the solution does exist), or via optimisation. Both inversion approaches

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are subject to instabilities that must be controlled (e.g., smoothing). Past research has been referenced properly.

The submitted research opts for an optimisation approach: the procedure applies a Bayesian geostatistical methodology coupled with forward routing that solves the full 2-D shallow water equations. Using a 2-D flow model in the context of inverse flood routing is an advance beyond the state of the art. But the computational load caused by the necessary multiple 2-D flow runs is heavy. Therefore, the authors have carried out their inversion procedure by parallelising the evaluation of the Jacobian matrix (it assesses the solution sensitivity to each unknown flow value), taking advantage of the floating point calculation capabilities of an array of Graphical Processing Units grouped in a remote High Performance Computing cluster.

The testing and validation of the method is sound and thorough; it includes simulations of generic floods with perfect (error-free) and with corrupted data, as well as of real flood events. The achieved accuracy is very good, including the peak region. Large oscillations of the inverted flow (recovered inflow) hydrograph occurring near its end are explained (Figs. 10 and 16); oscillations occurring at the start of the flood (e.g., Fig. 9a) seem to be due to the somewhat abrupt initiation of the transient from the steady state, while oscillations in the peak region are likely due to the change from a rising to a falling flood flow (Figs. 13a and 14a). The largest oscillations of the stage hydrograph occur at the start of the flood (Figs. 9b and 17) and should be also attributable to the somewhat abrupt initiation of the transient from the steady state (please comment). These oscillations are, of course, stronger in the simulations with corrupted data. Relevant comments by the authors would be appreciated; they would help the reader, too. It is noted, as an aside, that evidence is not conclusive as to which approach, reverse routing or optimisation, is more prone to spurious oscillations; a specific comparative investigation, under identical conditions, is required.

The paper is structured well. The theory is presented succinctly, with adequate mathematics, and contains all relevant information; the same holds for the (important) com-

putational aspects of the modelling approach. Figures and tables add significantly to the understanding of the textual account, and figures are of good quality. The language is generally quite good, yet the paper would benefit from careful editing (e.g., most 'which' should be 'that', 'resulted' should be 'resulting' etc.); some indentations must be corrected. (I will mail my marked up manuscript to the corresponding author for the consideration of the team of authors).

The Conclusions section could be enhanced. Particularly, given that the computing facilities and arrangements required for the inverse modelling approach reported in the manuscript are currently tailored to research rather than to the work of professional hydrologists, the authors should comment on how they envision their model finding its way to the hydrological practice.

Assessment: The paper addresses in a novel way an interesting topic (for specialists) that is within the scope of HESS, is scientifically sound and methodologically solid. It is very good and should be published after minor revision.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2018-118>, 2018.

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