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Interactive comment on "Comment on "A dynamic rating curve approach to indirect discharge measurement" by Dottori et al. (2009)" *by* A. D. Koussis

Anonymous Referee #2

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The Author A. Koussis moves a comment on the paper "A dynamic rating curve approach to indirect discharge measurement" by Dottori et al. 2009. I agree with the Author where he states that ". . . there seems to be an oversight in the sign of Eq. (4) of DMT for the celerity c of the kinematic wave (KW), which should be positive . . .". The main point where I disagree with the Author is: ". . . Measuring at two cross-sections is not convenient; also, the two gauges would have to be so positioned that the recorded stages give a good representation of the slope of the wave profile. . . .". The use of two water level sensors located in two different river sections has been proposed since about ten years ago. Most of the Authors have proposed more or less simplified mod-

els to relate directly the downstream rating curve with the measured stage hydrograph in both sections and the upstream rating curve. Moramarco et al. (2005) and Tayfur and Moramarco (2008) use a "black box" model, including a set of parameters that have to be calibrated using known rating curves. The advantage of using a synthetic model is that the channel geometry does not have to be known. On the other hand, the use of such models requires the calibration of several parameters, with a potential error that can be limited only by using several events for calibration (see Bru et al., 2001). Birkhead and James (1998) use the Muskingum algorithm to route a measured rating curve up to the downstream section; the use of the classical Muskingum algorithm, with respect to other diffusive or complete dynamic numerical models, simplifies the computation and avoids the need to specify the downstream boundary condition. Franchini and Ravagnani (2007) use a diffusive model adopting a more general numerical scheme than the Muskingum algorithm, including two unknown parameters that have to be calibrated using known rating curves. The above mentioned papers, as well as the one by Dottori et al. (2009), require knowledge of at least one directly measured discharge for the calibration of the model parameters. The need for direct velocity measurements, for discharge measurement or stage-discharge relation reconstruction, derives basically from the quasi-stationarity hypothesis. If stationarity occurs, a single water level profile does not correspond to a single flow rate, as it is also a function of the bed roughness. This implies that water level data alone are not enough for discharge measurement. In reality, the peak flows associated with even small time return periods are, in most western country climates, associated with quite unsteady discharge and stage hydrographs. In recent papers Perumal et al. (2007), as well as Aricò et al. (2007; 2008), applied their flow routing algorithms to directly relate the stage hydrograph with the downstream rating curve, using the measured downstream stage hydrograph for the model calibration. The algorithm by Perumal et al. (2007) deals with the case of a prismatic channel with simple cross-section geometry and constant bed slope. The algorithm is "diffusive" in the sense that it includes the water depth gradient terms in the momentum equation but adopts a Muskingum numerical scheme.

Recently, Aricò C. et al. (2009), present a new methodology based on the acquisition of synchronous water level measurements in two or three different river sections, does not require the use of any instrumentation for velocity measurement and has not restrictions on the channel cross-section geometry and the bed slope. The methodology is first analyzed for the simplest case of a channel with a large slope, where the kinematic assumption holds. A sensitivity and model error analysis are carried out in this hypothesis in order to show the stability of the results with respect to the error in the input parameters in the case of homogeneous roughness and to analyze the effect of unknown roughness heterogeneity on the estimated discharges. The methodology is then extended to the more general case of channels with mild slope and validated using field data previously collected in three Italian rivers. Field data collected in river Arno (in Tuscany), River Tiber (in Latium) and the river Vallo di Diana, a small tributary of the river Tanagro (Southern Italy), have been used. The computed peak flow discharges in the first test site are very close to the measured ones for all the four events, even though the calibration of the Manning coefficient was only carried out for the first event, when a very small lateral inflow occurred within the reach. Worse results were obtained in the Tiber river, where the location of the peak water depth was subject to large uncertainty and major roughness heterogeneity occurs. In the Vallo di Diana channel the procedure has been finally applied using three water level sensors, even if the small measured discharge was only partially affected by the backwater effect of the downstream channel restriction. The calibration of the single unknown parameter, the Manning coefficient, was carried out for the Arno and the Tiber rivers by selecting only one single event for calibration. The event was selected on the basis of the consistency of the shape of the stage hydrographs with the fundamental hypothesis of the conceptual model. The remaining information, embedded in the other measured stage hydrographs, could be efficiently used in the context of a multiparameter analysis. This requires good knowledge of the investigated reach at the measurement time. The performance of the proposed algorithm has been investigated according to three criteria estimating: a) the quality of the match between the measured and the com-

puted hydrographs, b) the relative error in the peak of the routed and measured stage and discharge hydrographs and c) the errors in time to peak stage and discharge respect to the measured ones. Results of the proposed model can be considered good, since also the uncertainties field data and measured values.

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