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Improving a stage forecasting Muskingum model by relating local stage and remote discharge

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Following the parsimonious concept of parameters, simplified models for flood forecasting based only on flood routing have been developed for flood-prone sites located downstream of a gauged station and at a distance allowing an appropriate forecasting lead-time. In this context, the Muskingum model can be a useful tool. However, critical points in hydrological routing are the representation of lateral inflows contribution and the knowledge of stage-discharge relationships. As regards the former, O'Donnell (O'Donnell, T., 1985. A direct three-parameter Muskingum procedure incorporating lateral inflow, Hydrol. Sci. J., 30[4/12], 479-496) proposed a three-parameter Muskingum procedure assuming the lateral inflows proportional to the contribution entering upstream. Using this approach, Franchini and Lamberti (Franchini, M. & Lamberti, P., 1994. A flood routing Muskingum type simulation and forecasting model based on level data alone, Water Resour. Res., 30[7], 2183-2196) presented a simple model Muskingum type to provide forecast water levels at the downstream end by selecting a routing time interval and, hence, a forecasting lead-time allowing to express the forecast stage as a function of only observed quantities. Moramarco et al. (Moramarco, T., Barbetta, S., Melone, F. & Singh, V.P., 2006. A real-time stage Muskingum forecasting model for a site without rating curve, Hydrol. Sci. J., 51[1], 66-82) enhanced the modeling scheme incorporating a procedure for adapting the parameter linked to lateral inflows. This last model, called STAFOM (STAge FOrecasting Model), was also extended to a two connected river branches schematization in order to improve significantly the forecasting lead-time. The STAFOM model provided satisfactory results for most of the analysed flood events observed in different river reaches in the Upper-Middle Tiber River basin in Central Italy. However, the analysis highlighted that the stage forecast should be enhanced when sudden modifications occur in the upstream and downstream hydrographs recorded in real-time.
Moramarco et al. (Moramarco, T., Barbetta, S., F. Melone, F. & Singh, V.P., 2005. Relating local stage and remote discharge with significant lateral inflow, J. Hydrol. Engng ASCE, 10[1], 58-69) showed that for any flood condition at ends of a river reach, a direct proportionality between the upstream and downstream mean velocity can be found. This insight was the basis for developing the Rating Curve Model (RCM) that allows to also accommodate significant lateral inflow contributions, permitting, without using a flood routing procedure and without the need of a rating curve at a local site, to relate the local hydraulic conditions with those at a remote gauged section.
Therefore, to improve the STAFOM performance mainly for highly varying flood conditions, the model has been here modified by coupling it with a procedure based on the RCM approach. Several flood events occurred along different equipped river reaches of the Upper Tiber River basin have been used as case study. Results showed that the new model, named STAFOM-RCM, apart from to improve the stage forecast accuracy in terms of error on peak stage, Nash-Sutcliffe efficiency coefficient and the coefficient of persistence, allowed to use a larger lead time thus avoiding the two-river branches cascade schematization where fluctuations in stage forecasting occur more frequently.