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Event-based hydrological modelling in Puyango-Tumbes transboundary river basin, Peru – Ecuador

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The city of Tumbes, in northern Peruvian coast, is regularly affected by floods which causes social and economic losses. When a flood occurs thousands of hectares of crop fields near the river course are destroyed, urban and hydraulic infrastructure are damaged and in some events, such as El Niño 1997-98, there has been loss of human life. In this context, hydrological modelling in a short time scale is a valuable tool for flood forecasting and to understand the associated processes. However, long-term rainfall and discharge data in this region is found mainly in a daily time step. Furthermore, the city is located at the lower part of Puyango-Tumbes transboundary river basin between Peru and Ecuador where access to data is difficult.

In this work, we performed an event-based hydrological modelling of Puyango-Tumbes basin at El Tigre stream gauge (4710 km2) in a semi-distributed manner using HEC-HMS (Hydrologic Engineering Center – Hydrologic Modeling System) at an hourly time step. We selected the 45 highest events based on the daily discharge records at El Tigre for 1970/71-2014/15 period. The catchment was divided into 21 sub-basins and the methods to simulate the rainfall-runoff processes were: (i) Curve Number for modelling losses, (ii) Clark Unit Hydrograph for the direct-runoff, (iii) the Exponential Recession model for baseflow and (iv) Muskingum routing model for channel flow. Daily rainfall in each sub-basin was obtained by Thiessen method using 25 rainfall stations and then it was disaggregated by a statistical distribution obtained by hourly records from automatic stations for Peruvian side of the basin (23% of the area) and GPM-IMERG for Ecuadorian side (77% of the area) since 2014. In respect of the streamflow information, only 4-hourly data (between 6 a.m. and 6 p.m.) were available at the outlet of the basin for the 22 most recent events, which were linearly interpolated to perform the validation of the simulated hydrographs. Automatic calibration was only executed for obtaining Muskingum parameters.

Preliminary results show regular to good agreement between observed and simulated hydrograph in 50% of the 22 events with Nash-Sutcliffe efficiency between 0.46 and 0.93 (mean of 0.67), where the major flood peak is underestimated by a mean error of 4%. The low performance of the remaining events is possibly related to poor spatio-temporal rainfall estimation, interpolated streamflow or the importance of moisture initial conditions which the Curve Number method considers according 5-day antecedent arbitrary rainfall intervals. The results revealed that the methodology proposed is suitable for simulating flood hydrographs in northern Peru though more hydro-meteorological data is needed for further improvement.