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Event-Based Calibration of a Physically-Based Hydrological Model for Flood Simulation in the Arno River Basin Tuscany Region

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Accurate flood forecasting in complex river basins depends on the effective use of high-resolution hydro-meteorological information, physically based hydrological models, and appropriate calibration procedures. This work describes the development of an event-based flood modelling framework for the Arno River basin (Italy), designed to enhance the simulation of flood hydrographs and support operational flood forecasting activities.

Spatially distributed rainfall data were obtained from raster-based precipitation products and transformed into event-specific time series suitable for use within the distributed hydrological model MOBIDIC. Observed discharge records from several gauging stations were retrieved from raw monitoring archives and reorganized into event-based datasets, allowing a coherent and consistent comparison between simulated and observed hydrographs. A unified processing workflow was established to ensure proper temporal synchronization among rainfall inputs, model outputs, and discharge observations.

The proposed framework was tested on major flood events that occurred in November 2023. Model performance was assessed using standard evaluation metrics, including the Nash–Sutcliffe Efficiency (NSE), Root Mean Square Error (RMSE), correlation measures, and time-lag analysis. Results from the initial simulations show that the model is able to capture flood timing satisfactorily, while differences in peak discharge magnitude and recession dynamics indicate the necessity for targeted parameter calibration.

A preliminary manual sensitivity analysis was carried out to identify key soil and hydraulic parameters influencing runoff generation and channel routing processes. Building on these results, an automated calibration approach based on PEST++ is currently being developed to systematically optimize the most sensitive parameters and improve model performance across multiple flood events.

Overall, the presented framework offers a reproducible and scalable methodology for event-based flood modelling and calibration in complex catchments. It provides a solid basis for multi-event analyses, automated calibration, and the future incorporation of data assimilation and artificial intelligence techniques into operational flood forecasting systems.