Contribution ID: **129** Type: **not specified**

Hybrid modelling setups for real-time urban pluvial flood mapping

Monday 17 March 2025 17:00 (15 minutes)

Extreme rainfall events and the resulting pluvial floods are projected to increase in frequency due to climate change. Accurate and timely flood forecasts are crucial for mitigating the impact of these events, but traditional hydrodynamic models are computationally expensive, limiting their use for real-time processing of probabilistic rainfall forecasts. This study explores the development and evaluation of spatiotemporal surrogate models that can rapidly convert rainfall nowcasts into probabilistic flood maps for highly urbanized catchments.

The focus of this research is on the hybrid surrogate modeling approach, which combines a simplified, physically-based hydrodynamic model with a data-driven component. The study investigates different formulations of the simplified physically-based model setup, ranging from coarse-resolution 1D-2D coupling to models that entirely neglect the subsurface sewer system dynamics. These simplified models are then paired with a data-driven module that bridges the gap to the detailed flood inundation patterns simulated by the reference hydrodynamic model. This hybrid structure offers a potentially beneficial balance between physical representation and computational efficiency.

In an initial analysis for the city of Antwerp, Belgium, the hybrid modelling approach resulted in a calculation speed improvement with a factor between 30 and 300, depending on the selected physically-based model component. Interestingly, utilisation of a relatively fast physically-based model which ignores the sub-surface component altogether, resulted in the best R^2 at the peak of the flood event (0.86), slightly better than a 1D2D physically-based model component with thrice the calculation time with (R^2 = 0.85). These preliminary findings will be further investigated through an extended analysis incorporating a wider range of storm events and additional physically-based model configurations to better understand the trade-offs between model complexity, computational efficiency, and prediction accuracy.

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Session

Precipitation and Hydrological Models: Extreme precipitation events

Preferred Contribution Type

Oral Presentation

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