EGU23-14225, updated on 27 Apr 2024
https://doi.org/10.5194/egusphere-egu23-14225
EGU General Assembly 2023

High-resolution modelling of heavy precipitation runoff behavior in urban areas using a coupled rainfall-runoff and hydrodynamic modelling approach

Christoph Sauer[1], Saskia Nagrelli[2], and Peter Fröhle[1]
[1]Institute of River and Coastal Engineering, Hamburg University of Technology, Hamburg, Germany
[2]Behörde für Umwelt, Klima, Energie und Agrarwirtschaft, Hamburg, Germany

Flood damage is not only caused by river floods. In particular, highly sealed urban areas are repeatedly affected by flooding as a result of convective heavy precipitation, regardless of their proximity to surface waters. Floods are often very localized due to the small spatial extent of the heavy precipitation cells. However, the spatial and temporal prediction of these precipitation cells is subject to great uncertainty due to the multitude of meteorological influences. In many cases, only the affected large areas in which convective heavy precipitation events can occur are known. The spontaneous implementation of safety measures by municipalities and residents is therefore rarely effective, which has already led to high damages in the past.

Hydrodynamic numerical (HN) models for simulating runoff, water levels and water velocity for heavy precipitation events require a high spatial and temporal resolution. Therefore, computational costs for pure HN models are high, so that a novel coupling approach with a hydrological rainfall-runoff (RR) model, which computes comparatively fast, is suggested. To represent the flooding events resulting from convective heavy precipitation events in highly heterogeneous inner-city areas, surface runoff can be simulated using RR models. Overloads of the existing drainage system are also identified. Averaging of, for example, sealing values, as is the case with conventional RR modelling, is dispensed with using high-resolution area information. A particularly detailed analysis of the study area at street level is thus possible as long as the flow directions are unambiguous. Subsequent coupling of the RR-simulated runoff to an HN model represents flooding of the area away from the fixed RR model runoff pathways. Due to the model concept developed for our study, runoff is represented with high temporal and spatial resolution and very short response times in the RR model. In the case of identified flooding of a road section, the flooding is then followed up with a non-uniform and transient HN model for the respective area. The combined approach reduces the model area of the HN model, which simulates dynamic flooding into the area, to the flood critical areas. In addition, this approach increases the accuracy of hindcasts compared to observations and delivers the opportunity to assess weak spots in the drainage system of complex urban areas. Municipalities may use the knowledge to create adapted and adequate risk management approaches for heavy precipitation events and make structural adjustments to reduce the now known risks.