

Mapping of an Urban Flood Caused by a Dam Break Using SPH Method Based on LiDAR Data

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ABSTRACT

Flooding is classified as a form of free surface flow in which water overflows onto normally dry land. Urban floods caused by dam-break flows can have disastrous effects on the downstream areas due to the sudden release of large amounts of water. A potential strategy for reducing the risk of flooding entails the creation of detailed flood maps that identify inundated regions through using Light Detection and Ranging (LiDAR) data. Recently, some LiDAR data are publicly available with a resolution of one meter. Influenced by structures as well as obstructions, the complex flow patterns of urban flooding pose a challenge to conventional Eulerian models. Smoothed Particle Hydrodynamics (SPH), employed in Computational Fluid Dynamics (CFD) as a meshless technique, presents a solution by mitigating issues associated with mesh distortion and grid generation.

This research aims to identify flooded areas caused by a dam break through the creation of flood maps using the SPH method and LiDAR data. The study uses DualSPHysics, an open-source code developed based on SPH, to map the urban flood. Although SPH models are computationally demanding, the code is optimized with high performance computing and modern graphic processing units (GPUs). The Lagrangian nature of the code allows for effective tracking of flood particles during the simulation.

To conduct the simulation and generate flood maps, the city's geometry is considered a solid boundary condition and dynamic boundary treatment is applied to simulate fluid particles. In the SPH technique, dynamic particles are positioned on the boundaries of the system. When a fluid particle gets closer to the solid boundary, the dynamic particles' density and pressure increase, which intensifies the repulsive force exerted on the fluid particle. Subsequently, the fluid particles remain inside the domain. The interparticle distance is accounted for as 0.5 meters in the SPH simulation. The application of the SPH method is evaluated through a comparative analysis with another numerical simulation, focusing on inundation extent and velocity. The comparison reveals both the strengths and weaknesses of the SPH method in simulating urban floods. In this comparison, the results indicate a close agreement with the targeted numerical simulation, highlighting the method's capability. While the goal of the research is to identify the flooded areas using LiDAR data and assess the SPH method's performance, the results may contribute valuable information for decision-makers dealing with urban flood challenges in the future.