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UAV-LiDAR observations increase the precision of urban flood modelling in Accra by detecting critical micro-topographic features

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Rapidly expanding cities are exposed to higher damage potential from floods, necessitating effective proactive management using technological developments in remote sensing observations and hydrological modelling. In this study we tested whether high resolution topographic data derived by Light and Detection Ranging (LiDAR) and Unmanned Aerial Vehicle (UAV) systems can facilitate rapid and precise identification of high-risk urban areas, at the local scale. Three flood prone areas located within the Greater Accra Metropolitan Area in Ghana were surveyed by a UAV-LiDAR system. In order to simulate a realistic flow of precipitation runoff on terrains, Digital Terrain Models (DTM) including buildings and urban features that may have a substantial effect on water flow pathways (DTMb) were generated from the UAV-LiDAR datasets. The resulting DTMbs, which had a spatial resolution of 0.3 m supplemented a satellite-based DTM of 10 m resolution covering the full catchment area of Accra, and applied to a hydrologic screening model (Arc-Malstrøm) to compare the flood simulations. The precision of the location, extent and capacity of landscape sinks were substantially improved when the DTMbs were utilized for mapping the flood propagation. The semi-low resolution DTM projected unrealistically shallower sinks, with larger extents but smaller capacities that consequently led to an overestimation of the runoff volume by 15% for a sloping site, and up to 65 % for 1st order sinks in flat terrains. The observed differences were attributed to the potential of high resolution DTMbs to detect urban manmade features like archways, boundary walls and bridges which were found to be critical in predictions of runoff's courses, but could not be captured by the coarser DTM. Discrepancies in the derived water volumes using the satellite-based DTM vs. the UAV-LiDAR DTMbs were also traced to dynamic alterations in the geometry of streams and rivers, due to construction activities occurring in the interval between the aerial campaign and the date of acquisition of the commercially available DTM. Precise identification of urban flood prone areas can be enhanced using UAV-LiDAR systems, facilitating the design of comprehensive early flood-control measures, especially in urban settlements exposed to the adverse effects of perennial flooding. This research is funded by a grant awarded by the Danish Ministry of Foreign Affairs (Danida).