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Enabling high-quality observations of surface imperviousness for water runoff modelling from unmanned aerial vehicles

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Modelling rainfall-runoff in urban areas is increasingly applied to support flood risk assessment particularly against the background of a changing climate and an increasing urbanization. These models typically rely on high-quality data for rainfall and surface characteristics of the area.

While recent research in urban drainage has been focusing on providing spatially detailed rainfall data, the technological advances in remote sensing that ease the acquisition of detailed land-use information are less prominently discussed within the community. The relevance of such methods increase as in many parts of the globe, accurate land-use information is generally lacking, because detailed image data is unavailable. Modern unmanned air vehicles (UAVs) allow acquiring high-resolution images on a local level at comparably lower cost, performing on-demand repetitive measurements, and obtaining a degree of detail tailored for the purpose of the study.

In this study, we investigate for the first time the possibility to derive high-resolution imperviousness maps for urban areas from UAV imagery and to use this information as input for urban drainage models. To do so, an automatic processing pipeline with a modern classification method is tested and applied in a state-of-the-art urban drainage modelling exercise. In a real-life case study in the area of Lucerne, Switzerland, we compare imperviousness maps generated from a consumer micro-UAV and standard large-format aerial images acquired by the Swiss national mapping agency (swisstopo). After assessing their correctness, we perform an end-to-end comparison, in which they are used as an input for an urban drainage model. Then, we evaluate the influence which different image data sources and their processing methods have on hydrological and hydraulic model performance. We analyze the surface runoff of the 307 individual sub-catchments regarding relevant attributes, such as peak runoff and volume. Finally, we evaluate the model's channel flow prediction performance through a cross-comparison with reference flow measured at the catchment outlet.

We show that imperviousness maps generated using UAV imagery processed with modern classification methods achieve accuracy comparable with standard, off-the-shelf aerial imagery. In the examined case study, we find that the different imperviousness maps only have a limited influence on modelled surface runoff and pipe flows. We conclude that UAV imagery represents a valuable alternative data source for urban drainage model applications due to the possibility to flexibly acquire up-to-date aerial images at a superior quality and a competitive price. Our analyses furthermore suggest that spatially more detailed urban drainage models can even better benefit from the full detail of UAV imagery.