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Variation of flow resistance: insights from hydrodynamic modelling using UAV-borne observations of water surface elevation

Liguang Jiang, Filippo Bandini, and Peter Bauer-Gottwein
Technical University of Denmark, Department of Environmental Engineering, Copenhagen, Denmark (ljia@env.dtu.dk)

Modelling of river flow is an essential tool in water resources management and flood forecasting. Computation of flow in open-channel requires determination of flow resistance, which determines the water surface elevation (WSE) and the flow velocity. Such resistance is typically represented by a roughness parameter, i.e. Manning's coefficient. Currently, uniform coefficient is routinely used in hydrodynamic modelling. A key problem is that uniform value degrades the calculation of WSE. Despite the importance, its variation is not well accounted for due to the lack of high spatial observations of discharge/WSE data.

In this context, more efficient methods are needed to deliver high-resolution spatial WSE datasets with a higher resolution than presently available from satellite altimetry missions. Unmanned aerial vehicle (UAV) can provide observations of WSE with very high spatial resolution and data accuracy, in a time-saving and cost-effective way.

Here we investigate the potential for identifying spatial-temporal variation of Manning's roughness coefficient via inverse modelling using UAV-borne WSE data in the Åmose river, Denmark. The survey results show that UAV-borne WSE observations have shown an accuracy of ca. 3 cm when compared with in-situ Real Time Kinematic (RTK) GPS observations and a high spatial resolution of ca. 0.5 m. Hydrodynamic modelling shows that UAV-borne WSE data is able to identify the variation of Manning's coefficients; a significant variation exists for such a small and vegetated stream.

Moreover, simulation shows overwhelmingly better performance using distributed Manning's coefficient than using spatially uniform value. We conclude that variation of Manning's coefficient for vegetated rivers should be considered in hydrodynamic modelling. As a consequence, application of UAV-borne WSE to determine Manning's coefficient for small rivers is suggested.