Effects of spatial vegetation roughness parameterization on 2D flow characteristics

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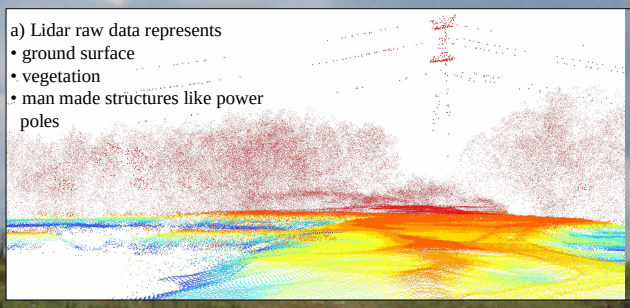
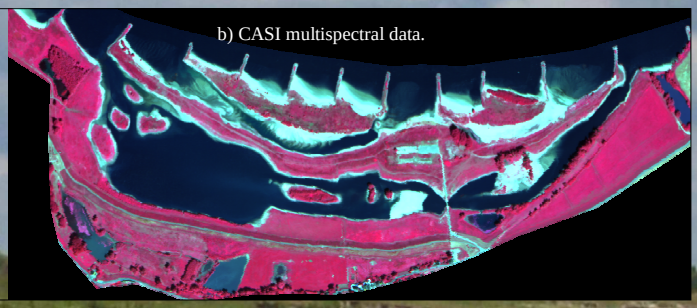
Introduction

Operational river management requires regular updates of roughness maps to drive the hydrodynamic models that predict peak water levels. Our aim is to compare two methods to map floodplain surface characteristics that are relevant for hydrodynamic modeling: (1) the Dutch ecotope approach based on the manual classification of aerial photographs, which lacks detail and repeatability and (2) a new semi-automatic high-resolution method based on the data fusion of airborne multispectral and lidar (Light Detection and Ranging) data. The effects on 2D flow patterns and water levels within a river and floodplain segment are assessed using the Delft3D hydrodynamic model.





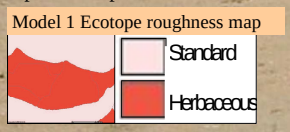
Data processing

The study area is located in the Gamerensche Waard (GW) floodplain section in the Netherlands. Both methods enable driving the rough model of Baptist (2005):

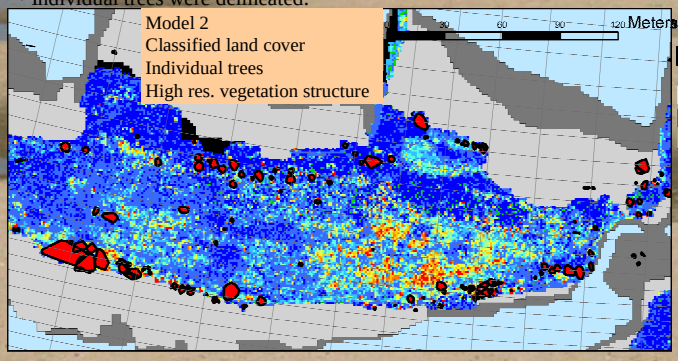
$$C_r = \sqrt{\frac{1}{C_b^{-2} + (2g)^{-1} C_d D_v H_v}} + \sqrt{\frac{g}{\kappa}} \ln \frac{h}{H_v}$$

where C_r is the composite Chézy coefficient representing roughness of a vegetated bed ($m^{1/2}s^{-1}$), C_b is the Chézy roughness of the bed ($m^{1/2}s^{-1}$), g is the gravitational acceleration (ms^{-2}), C_d is the drag coefficient for vegetation (-), D_v is the vertical vegetation density (the projected plant area in the direction of the flow per unit volume, m^{-1}) and h is the water depth (m), H_v is the vegetation height (m) and κ is the Von Kármàn constant (0.4)

Model 1: The ecotope map converted to model input, albeit at the expense of spatial detail.

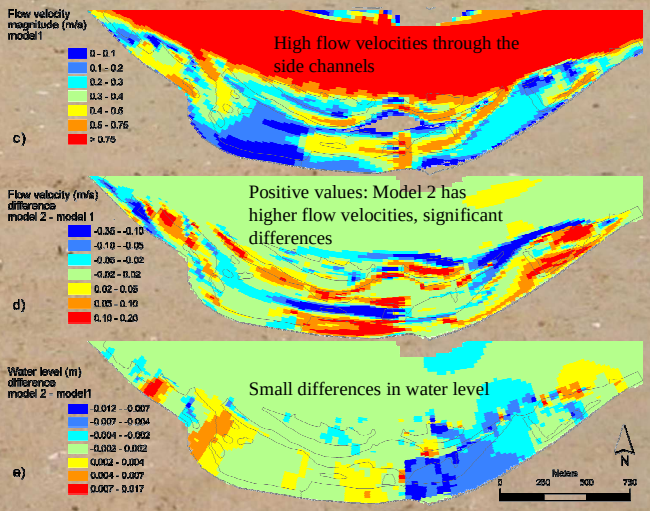


Model 2:
- Segmetation into image objects and classification.
- Extraction of vegetation height and density for forest and herbaceous vegetation from lidar data
- Individual trees were delineated.



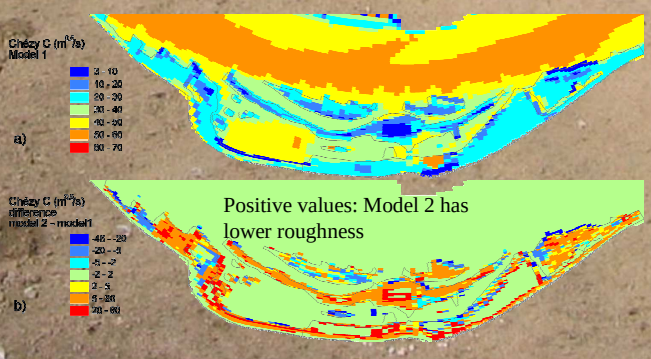
Modelling results

Model 2 generates overall a lower roughness, and hence higher flow velocities. Nonetheless, locally the reverse is found. Differences in water level are limited to 1.5 cm. Calibration showed that the new method gave better estimates of the side channel discharge in two out of three cases.



Conclusions

This study shows that:
- The new method provides much more detail in model input in a repeatable way.
- The disaggregation of floodplain roughness leads to significantly different flow patterns, which is of value for morphodynamic models of side channels.
- High quality hydrodynamic field measurements are required to quantitatively assess the different error contributions.



Model results for the GW floodplain section a) Chézy C roughness values ($m^{1/2}/s$) based on model 1, b) difference in Chézy C roughness values ($m^{1/2}/s$) between model 2 and model 1, c) magnitude of flow velocity (m/s), d) difference in flow velocity (m/s) between model 2 and model 1, and e) difference in water level (m) between model 2 and model 1.

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