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Comparing methods to reconstruct river cross sections from LiDAR DEMs for improved flood plain modelling

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Abstract: LiDAR-derived high-resolution digital elevation models (DEMs) can provide accurate channel cross-sectional data but often fail in the presence of water in channels, requiring channel cross-section reconstruction methods. Three empirical cross-section reconstruction methods: linear, slope break and modified double linear were tested at a river reach in the North Para River, South Australia, with the aid of hydraulic modelling. The modified double linear method delivered the highest accuracy, outperforming the linear method, which overestimated flow area, and the slope break method, which was effective only with clear morphological changes.

Keywords: *Digital Elevation Model (DEM), cross-section, LiDAR, hydraulic modelling*

1. INTRODUCTION

DEMs and river channel geometry are fundamental inputs to hydraulic modelling as they define the topography over which a river flows. The level of detail (pixel resolution) and spatial accuracy of the DEM used directly impact hydraulic model simulation results. Coarser resolutions and lower accuracies will misinterpret the channel geometry, leading to inaccurate water levels and flow dynamics. This will severely compromise the accuracy of the hydraulic model, and most importantly, it will lead to substantial errors in floodplain mapping (Neal et al. 2015).

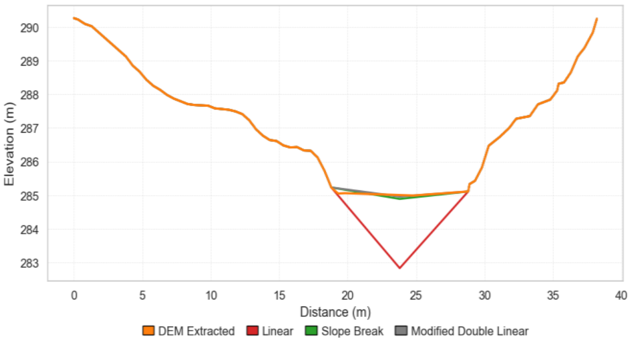
Field measurements of river bathymetry are costly in terms of equipment, labour-intensive and logistically challenging, resulting in limited availability of bathymetric datasets. Obtaining cross-section data from high-resolution LiDAR (light detection and ranging) derived DEMs is often preferred for hydraulic modelling. However, a topographic LiDAR system is unable to capture the channel bottom as the laser beam is fully absorbed by water. Therefore, it is helpful to examine the possibility and accuracy of using non-field-based data in-filling methods to extract cross sections from LiDAR-derived DEMs in the context of South Australia.

2. METHODOLOGY AND RESULTS

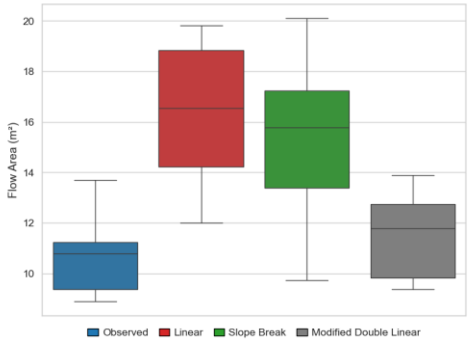
This study aimed to compare three empirical methods, namely linear (Podhoranyi and Fedorcak 2015; Mersel et al. 2013), slope break (Mersel et al. 2013; Domeneghetti 2016), and double linear methods (Podhoranyi and Fedorcak 2015), for infilling channel bottom profiles by using LiDAR-derived cross sections. All of these methods are based on the elevation and width (z-w) pairs extracted from cross sections. The linear method fits a single straight line to the z-w relationship, and it is extrapolated until the width approaches zero. The slope break method identifies a sudden change in the derivatives of z-w pairs, marking a transition from a low-flow channel to a steeper bank section. Two linear relationships are fitted for moderate-high and low flow regimes, with the low flow segment below the slope break point extrapolated to w = 0. The modified double linear approach uses one linear fit for the portion above water and another for the submerged section, where the submerged slope is set to 0.3 times the slope above water, and the relationship is extrapolated until the channel width reaches zero. All these methods have been previously tested in perennial and snowmelt-dominated rivers. However, their applicability in arid to semi-arid regions, such as in South Australia, is yet to be evaluated.

These three methods were applied to a river reach from a freely available 50 cm DEM at the North Para at Penrice Gauge Station (A5050517). The results were validated against seven cross sections derived through a 50 cm terrestrial LiDAR-derived DEM (data capture was performed during summer when there was no water present in the reach), with an EMESENT SLAM device (global accuracy under 11mm). HEC RAS 1D steady flow simulations were run for each reconstruction method to compare the flow area, water surface elevations (WSE) and the mean velocity at each cross-section with the reference dataset. The accuracy of these parameters was quantified using root mean squared error (RMSE) and mean error (ME).

The linear method overestimated the flow area at most of the cross sections (RMSE = 6.68 m2), as a result of extending steeper slopes (Figure 1 (a)). It was observed that the applicability of the slope break method highly relied on the cross-section geometry. It was found to be effective when there is a clear representation of a low-flow area and a high-flow area in a cross-section. When side slopes are comparatively uniform, the slope break method is inapplicable. The modified double linear method produced the most realistic flow area estimates (RMSE = 2.92 m2), mainly because it estimated a shallower submerged flow area, which is ideal for DEMs resulting from data captures carried out during low flow scenarios, particularly in arid to semi-arid regions such as South Australia. Therefore, it is highly important to consider the date and season of LiDAR data capture and the rainfall in days leading up to data collection, as it governs the flow in rivers. Figure 1 (b) shows the flow area comparison between different reconstruction methods used in this study.



(a)



(b)

Figure 1 (a) Selected cross-section profile; (b) Flow area comparison

The large flow area estimates from linear and slope break methods lead to an underestimation of velocities, which resulted in higher mean errors. The modified double linear method minimised the bias (ME = -0.06 ms-1), producing velocity estimates closer to the actual conditions. The WSE estimates between different methods had subtle variations as a result of complex flow dynamics, and hence, it should be assessed along with geometric parameters like flow area. WSE estimates from the modified double linear method (RMSE = 0.52 m) were well supported by realistic channel geometry.

3. CONCLUSIONS

Among the three channel bottom reconstruction methods tested, the modified double linear method consistently provided realistic estimations with minimum errors for arid to semi-arid low flow conditions. The slope break performed well only when clear morphological changes were present at the cross-section, and the linear method consistently overestimated the cross-sectional area. This study highlights the importance of aligning the channel bottom reconstruction with local hydrologic and geomorphologic conditions to achieve more realistic hydraulic simulations.

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REFERENCES

Domeneghetti A (2016) On the use of SRTM and altimetry data for flood modeling in data-sparse regions. Water Resources Research 52(4), 2901-2918. Doi: 10.1002/2015wr017967.

Mersel MK, Smith LC, Andreadis KM and Durand MT (2013) Estimation of river depth from remotely sensed hydraulic relationships. Water Resources Research 49(6), 3165-3179. Doi: 10.1002/wrcr.20176.

Neal JC, Odoni NA, Trigg MA, Freer JE, Garcia-Pintado J, Mason DC, Wood M and Bates PD (2015) Efficient incorporation of channel cross-section geometry uncertainty into regional and global scale flood inundation models. Journal of Hydrology 529, 169-183. Doi: 10.1016/j.jhydrol.2015.07.026.

Podhoranyi M and Fedorcak D (2015) Inaccuracy introduced by LiDAR-generated cross sections and its impact on 1D hydrodynamic simulations. Environmental Earth Sciences 73(1), 1-11. Doi: 10.1007/s12665-014-3390-7.

