Preparing high-resolution elevation data and terrain derivatives for soil and landscape modelling

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Background

High-resolution, high-precision digital elevation models (DEMs) are becoming widely available throughout Aotearoa. These are produced using LiDAR or photogrammetry and depict the landscape with unprecedented clarity. Pixel size is commonly 1 m or less, with vertical accuracy 5-50 cm. For soil and landscape mapping, this detail can be excessive even at farm scale. Certain data preparation steps can make working with these products easier and improve output map quality.

File formats

Elevation data are commonly delivered as a set of small GeoTiff-format tiles. Use GDAL to create VRT files to virtually mosaic these without duplication, and/or the Cloud-Oriented GeoTiff (COG) specification for high performance, especially over networks.

Normalise data

Terrain data that will be used in predictive modelling will generally benefit from z-score normalisation and transformation to handle extreme values (Csillik et al. 2015).

Noise removal

Detailed elevation data contains local roughness. Some is random noise, and some is related to surface textures (vegetation, tillage). This roughness can cause suboptimal results when calculating terrain derivatives. The noise can be removed safely with the 'Feature Preserving Smoothing' (FPS) method (Lindsay et al. 2019).

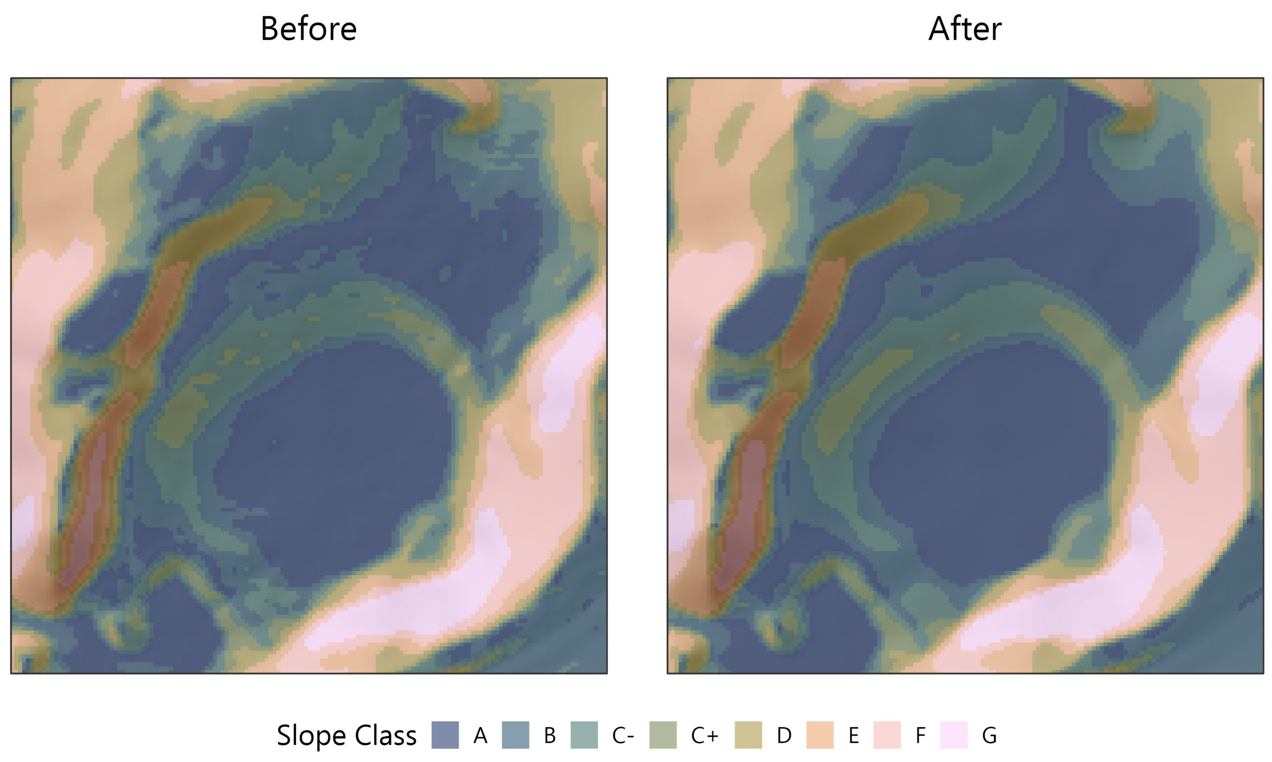

Fig 1 Slope classification on a 150 x 150m section of 1m lidar data before and after FPS denoising (Tahaki Reserve, Maungawhau, Auckland). Note the smoother patch boundaries and relative lack of speckling on the right.

Off-terrain object removal

Off-Terrain Objects (OTOs) like buildings and hedges are usually removed during lidar DTM production. Lidar DSMs and photogrammetry DEMs that still contain these features can be at least partly converted to DTMs using the 'Remove Off-Terrain Objects' (ROTO) method (Lindsay 2018).

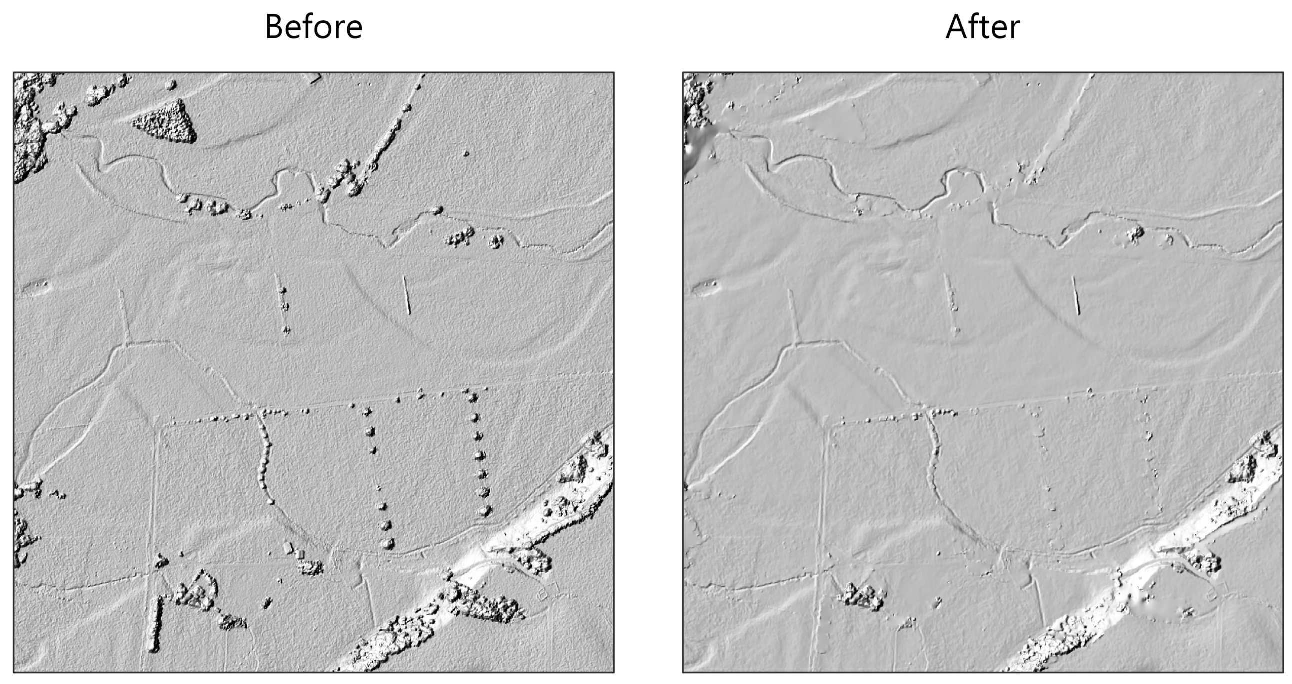

Fig 2 Hillshades on a 1000 x 1000m section of photogrammetry-based DSM before and after FPS and off-terrain object removal (Kumeroa, upper Manawatu River). The area of LUC slope class A (0-3 degrees) within the plot window nearly tripled after cleaning.
Note that these results could be further improved with multiple passes of the ROTO method at different settings, but it can't always handle large treed areas, particularly on steeper slopes.

Cell aggregation

The current literature around digital soil mapping recommends using 10-30 m cells for high quality results, efficient processing, and compatibility with other spatial products (Sørensen and Seibert 2007; Wu et al. 2008; Arnone et al. 2016; Thompson et al. 2020). These cell sizes are also practical targets for field sampling.

Aggregation to an appropriate cell size should be the final task in a processing workflow. Calculating derivatives after aggregation causes progressively worse underestimates, as the input dataset has a lower information content.

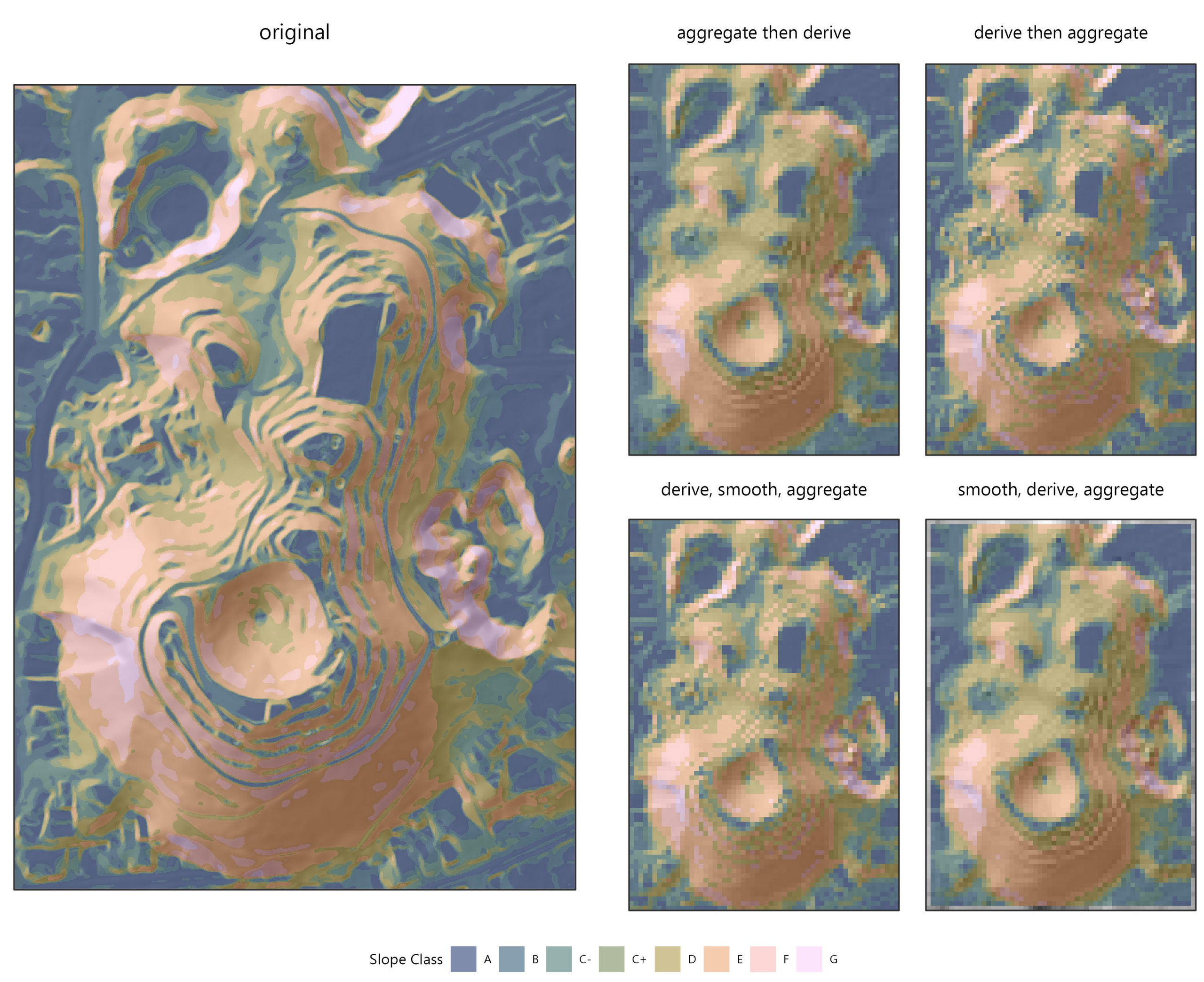

Fig 3 Slope classification on a 600 x 860m section of lidar DEM (Maungawhau, Auckland), showing the results of various aggregation workflows to an output cell size of 10m. Aggregation before deriving slope does not preserve the original data structure and range as accurately, but doing the opposite can result in an overly messy spatial structure at short range. A smoothing stage prior to aggregation, where the smoothing window matches the target cell size, can help minimise this effect. Smoothing first can cause additional data loss around the edges of the dataset.

References

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Learn more

Demonstration code and source data can be found at
https://github.com/lauren-obrien/nzsss_2022_dems

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