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Elevation error and uncertainty in DEM-derived channel networks

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Channel network geometry is commonly used in environmental process models because it influences the route that water and sediment follow from catchment divides to the outlet. Channel networks are now routinely extracted from digital elevation models (DEMs) because automated procedures are more efficient and reproducible than manual mapping techniques. Channel extraction algorithms can be categorized as either valley recognition approaches, which search for V-shaped profiles in DEMs, or channel-initiation based approaches, which simulate channelization processes to locate channel heads. The quality of a DEM-derived network is influences both by the nature of the specific extraction method and the quality of the DEM. This study examines the sensitivity of several network extraction algorithms to uncertainty due to elevation error. Experiments are conducted using a fine resolution (2 m) LiDAR DEM of the Upper North Grain catchment, a highly dissected peatland catchment located in the Peak District National Park, UK. The Monte Carlo method is applied, whereby an error field is added to the DEM and a channel network is extracted. This processes is repeated numerous times, using unique error fields with each realization. Examining the variability in the extracted networks allows uncertainty to be measured given the specific error model.

The findings show that valley recognition algorithms yield more realistic drainage patterns than channel-initiation based methods for the catchment; however, overall, valley recognition approaches are more sensitive to elevation error than channel-initiation based methods, likely owing to their localized nature. Uncertainty in the networks derived using valley recognition algorithms can be reduced by running a low-pass filter over the error-added DEM. Nonetheless, filtering results in loss of network detail, particularly in headwater areas. Channel-initiation based approaches tend to be less sensitive to elevation error in higher-order reaches, likely reflecting the quality of the

LiDAR DEM, however, exterior links identified using these algorithms are very sensitive to error. In fact, the uncertainty in network extent resulting from elevation error is of the order of that resulting from variations in the channel initiation threshold. These results suggest that even relatively small elevation errors (˜0.3m) present in fine resolution DEMs can result in significant uncertainty in the channel network derived using any of the available network extraction methods. This has major implications for error propagation in the hydro-geomorphic models that rely on DEM-derived channel networks.