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Simulating and Quantifying Legacy Topographic Data Uncertainty: An Initial Step to Advancing Topographic Change Analyses

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Integrating the disparate datasets (e.g. aerial photographs and point cloud data gathered with a variety of more recent sources) to unravel topographic changes in varying geomorphic contexts involves a number of issues. These issues range from data compatibility associated with the different data collection techniques, to legacy data that contain unknown error, unreported error, or in some cases known deficiencies, to integrating this information in a manner whereby scientists can definitively derive the extent to which a landform or landscape has and will continue to change in response natural and/or anthropogenic processes. Here, we examine the question: how do we evaluate and portray data uncertainty from the varied topographic legacy sources and combine this uncertainty with current spatial data collection techniques to detect topographic changes? Digital terrain model (DEM) uncertainty can be modeled as a stochastic process. The uncertainty model tends to vary across the region of interest, and yet remain locally correlated. We consider the spatial variability and correlation on a grid of anchor points. The elevation uncertainties observed on the anchor points are modeled using “states” in a stochastic estimator. This type of estimators is used track the evolution of the uncertainties. The estimator is natively capable of incorporating sensor measurements with various times of validity. Even when a sensor does not directly observe an anchor point, the geometric relationship between the anchor point and the sensor measurement can still be approximated, thanks to spatial correlation. Our results show it is indeed possible to incorporate measurements and data from a variety of sources and quality. The estimator provides a history of DEM estimation as well as the uncertainties and cross correlations observed on anchor points. Our work provides preliminary evidence that our initial approach is valid and warrants further exploration. Our intent is to corroborate and further develop this work with data and results from physical models and multi-temporal field data and analyses.

Keywords: data uncertainty, topography, geomorphology

