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Feature Based Error model construction for Digital Elevation Models and Hazard Analysis

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Information about topography is necessary for landscape evaluation, erosion studies, hydrologic and geophysical modeling, and natural hazard pre-vention. Digital Elevation Models (DEMs) are digital representations of a terrain surface and are often subject to significant error [Stefanescu et al., 2012b] as a result of the method used in collecting and post-processing the raw data. Even though DEM users are aware that DEM error affects the results of their application, in most cases the DEMs are accepted as the true representation of the earth's surface. Naive, cell-by-cell approaches to treating DEM uncertainty quickly lead to the use of thousands if not millions of random variables, resulting in a computationally infeasible problem. In recent work we presented a method to quantify the variation in the output of a computational flow model for block and ash flows, when the model inputs, including the elevation values represented in the DEM, are uncertain or given as a range of possible values. Integrating these variations in the possible flows as a function of input uncertainties provides well-defined data on the probability of hazard at specific locations, i.e., a hazard map. In particular, the focus here is on assessing the influence of DEM uncertainties using a stochastic conditional simulation to generate multiple equally likely representations of an actual terrain surface. We computed a normal distribution of maps or realizations to reproduce the spatial autocorrelation encountered in the original error surface with the help of only two random variables Ehlschlaeger and Shortridge [1996], Stefanescu et al. [2012a]. We next extend the above stochastic method to a "feature" based error model, by considering the problem of DEM segmentation into homogeneous regions. In this model, we make the assumption that regions such as plateaux, ridges, small drainages, valleys, and crests have different error bounds. To be able to perform the segmentation of the DEM into homogeneous regions we need to specify a range of geomorphometric measures which can be extracted from the surface. We define a feature matrix of DEM attributes, consisting of elevation and first and second derivatives of elevation (slope, profile curvature and tangential curvature). Two segmentation methods are implemented and compared: Gaussian Mixture Model and Spectral Clustering. These are two complex methods which account for the spatial correlation of the elevation points and have the advantage that they can be used for almost any application where relationships between topographic features and other components of landscapes are to be assessed. The error model is then applied for each homogeneous region. Results are based on potential flows at Mammoth Mountain, California, and Galeras Volcano, Colombia. The analysis establishes the soundness of the approach and the eect of including the uncertainty in DEMs on the construction of probabilistic hazard maps.

References

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