Digital Elevation Model Resolution: Effects on Terrain Attribute Calculation and Quantitative Soil-Landscape Modeling

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The accuracy of a digital elevation model (DEM) and DEM-derived products depends on (i) the resolution (both horizontal and vertical) at which the elevation data is represented, (ii) the source of the elevation data, and (iii) the data model, or structure of the elevation data (grid, contour), that is used. This accuracy becomes more important as we extend the use of DEM data for quantitative soil-landscape modeling for prediction of the spatial distribution of soil attributes. Our previous research has led to the development of empirical models that were used to predict the spatial distribution of A-horizon thickness, depth to secondary carbonates, and a soil color index related to soil organic carbon content. The objective of this research was to compare terrain attributes and quantitative soil-landscape models derived from grid-based DEMs (i) represented at different horizontal and vertical resolutions and (ii) collected by different methods. For a hillslope in west-central Minnesota we generated a DEM with a 10-m horizontal and 0.1m vertical resolution from an intensive field survey. For the same 17-ha study area, USGS DEM data with 30-m horizontal and 1m vertical resolution was also acquired. Interpolation and subsampling of these data sets produced both field survey-derived and USGS-derived DEMs with 10- or 30-m horizontal and 0.1- or 1-m vertical resolutions. Primary and secondary terrain attributes (e.g., slope gradient, slope curvature, specific catchment area, and the compound topographic index) were calculated from each of the DEMs. Distributions of terrain attributes were compared using matched t-tests. Significance tests were also performed on correlation coefficients and regression line slopes between paired data sets. Empirical models relating a soil color index, the Profile Darkness Index, to selected terrain attributes were developed from the field survey-derived DEMs and the USGS-derived DEMs. On average, the elevations from the USGS DEM were approximately 9m above the elevations from the field survey DEM within this study area. Slope gradients calculated from the USGS DEM were also significantly steeper than slope gradients calculated from the field survey DEM. While elevations were highly correlated in comparisons of DEM source, other terrain attributes were not and the distributions of terrain attributes were significantly different. For the field survey DEMs represented at different horizontal resolutions, slope gradients were steeper and compound topographic index values were less when calculated from the 10-m resolution DEM. A decrease in vertical resolution of the 10-m horizontal resolution field survey DEM produced a large proportion of points with zero slope gradients and zero slope curvatures as a result of the loss of vertical precision. However, this also produced a large number of steeply sloping and more highly curved points because all relief between points in the DEM must be in increments of 1m. Empirical models developed at different resolutions included different predictive terrain attributes. Slope gradient, profile curvature, and elevation above local depression were included in the model developed from field survey DEM (10m horizontal resolution, 0.1m vertical resolution). The model developed from the USGS DEM (30m horizontal, 1m vertical) included the compound topographic index and elevation above local depression.