Scale-dependency of LiDAR derived terrain attributes in quantitative soil-landscape modeling: effects of grid resolution vs. neighborhood extent

Abstract

Quantifying the spatial distribution of soil properties is essential for ecological and environmental modeling at the landscape scale. Terrain attributes are one of the primary covariates in soil-landscape models due to their control on energy and mass fluxes, which in turn control the spatial distribution of soil properties and processes. While numerous studies have demonstrated the importance of terrain attributes for predicting landscape-scale soil variability, considerable uncertainty exists as to the scale-dependency of light detection and ranging (LiDAR) derived terrain attributes on the accuracy of soil-landscape model predictions. Thirty five pedons were sampled by genetic horizon and analyzed for 26 physical and chemical soil properties in a 2300 ha forested watershed. K-means clustering and principle component analysis revealed three main groupings of soil properties that relate to the dominant pedogeomorphological processes occurring within the watershed. From each grouping a representative soil property (i.e., percent clay, sum of bases, and total carbon) was selected as the dependent variables in a spatial regression analysis. Terrain attributes calculated from LiDAR derived DEMs of various grid resolutions (1, 5, 10, 30, and 50 m) and neighborhood extents (15, 30, 60, 90, 150 m) were used as predictor variables. In general, results show that model predictions exhibit a strong scale-dependency, with percent clay, sum of bases, and total carbon having the lowest root mean square error (RMSE) at coarser spatial scales (i.e., 30-50 m grid resolution) both between soil variables and across soil depths. Furthermore, results indicate that soil properties respond differently to scale effects with clay and sum of bases exhibiting a

stronger response to changes in neighborhood extent and total carbon responding stronger to changes in grid resolution. These results show that fine scale topographic information does not necessarily provide the strongest predictor of soil spatial variability due to the strong scale dependency of pedogeomorphological processes which result in the spatial range and pattern of soil properties across a landscape. This study provides a robust framework for investigating pedogeomorphological processes on a landscape scale through the prediction and interpretation of soil-landscape models.

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