Cells vs. objects and scale issues in terrain-based environmental modeling

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Introduction

Digital Elevation Models (DEMs) and their extracted land-surface parameters have been increasingly used in terrain-based environmental modeling. Most applications use algorithms operating in small neighborhood (usually 3 X 3 rowing window) to perform geomorphometric analysis, thus tying the scale of resulting layers to the spatial resolution of the available DEM. But this is likely to induce mismatches between scale domains of land-surface information and the environmental variable of interest. Since the control of topography on natural processes is scale specific, techniques for finding the characteristic scale in terrain-based environmental modeling should be implemented as routine applications. In this context, new techniques of land-surface segmentation need to be evaluated against more traditional cell-based approach.

Objectives

Our objective is to perform a systematic evaluation of both cell-and object-based scaling techniques and their potential of being incorporated as routines in geomorphometric analysis.

Methodology

The methodology consists in generalization of DEMs into increasing scale levels through different techniques (resampling, filtering, multiscale surface characterization (Wood, 1996), and land-surface segmentation), and correlation analysis. For each scale level, the degree of association between each land-surface parameter and environmental variable of interest is established iteratively through correlation analysis. The first peak of correlation indicates the scale level to be further retained. So far, the methodology has been applied to soil-landscape modeling (Drăguț et al., in press), where the variable of interest was crop yield data (assumed to represent a surrogate for soil fertility). Scale levels were created by using both filtering with focal statistics on increasing neighborhood size, and land-surface segmentation.

Results

While in a standard 3 X 3 window-based analysis mean curvature was one of the poorest correlated land-surface parameters, after generalization it turned into the best correlated parameter. To illustrate the importance of scale, we compared the regression results of unfiltered and filtered mean curvature vs. crop yield. The comparison shows an improvement of R squared from a value of 0.01 when the curvature was not filtered, to 0.16 when the curvature was filtered within 55 X 55 m neighborhood size (corresponding to the first peak of correlation as described in Methodology). This indicates the optimum size of curvature information (scale) that influences soil fertility.

We further used these results in an object-based image analysis environment to create land-surface objects containing aggregated values of both land-surface parameters and crop yield. Hence, we introduce land-surface segmentation as an alternative method for generating scale levels in terrain-based environmental modeling. Based on segments, R squared improved up to a value of 0.47.

Conclusions

The results so far indicated that considering scale in DEM processing yields better results in terrain-based environmental modeling. Not only appropriately scaled land-surface parameters predict better the environmental variable of interest, but their importance in controlling this variable changes. We also demonstrated that the irregular tessellation of DEM produced through land-surface segmentation techniques challenges the traditional per cell approach.

Before integrating the procedure described above into a software application, thorough comparison between the results of different generalization/aggregation techniques, on different datasets and terrain conditions is necessary. This is the subject of our ongoing research as part of the SCALA project (Scales and Hierarchies in Landform Classification).

References:

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