ABSTRACT

Landscape pattern is spatially correlated and scale-dependent. Thus, multiscale analysis is imperative for understanding the structure, function and dynamics of landscape. In this study, we employed two complementary, yet parallel approaches (the direct and indirect approaches) to multiscale analysis of landscape maps from northern Ghana. First, moving window analysis was conducted to investigate the data sets for heteroscedasticity and proportional effect. In the direct approach, the Maximal Overlap Discrete Wavelet Transform was used for a wavelet-based analysis of variance of the Normalized Difference Vegetation Index (NDVI) and the Digital Elevation Model (DEM). Also, an orthogonal and compactly supported wavelet was applied through seven levels of dyadic decompositions of each data set into large- and small scale features in the horizontal, vertical and diagonal directions. The small-scale features were analyzed with moments and scale plots to investigate statistical self-similarity in the three directions. In the indirect approach, 18 commonly used landscape metrics were used to investigate (1) the effects of changing grain size and (2) the effects of changing extent on the metrics. In case (1), the grain size of each original data set was systematically changed using the majority, mean and median rules through 18 separate aggregation levels; while the extent was kept constant. The values of the 18 metrics were then computed for each resampled data set. In case (2), we systematically increased the extent of the maps (starting from each of the four corners) from 56 km^2 to 5,633 km^2; while keeping the grain size constant.

The results of moving window analysis showed that the local means of the NDVI data sets in some regions were more variable than in others, while their corresponding standard deviations remained fairly constant over the study area. Both local means and standard deviations of DEM remained fairly constant. Thus, estimates from any particular sector of the study area will be as good as estimates elsewhere. No proportional effect was observed between local means and corresponding standard deviations for all three data set. The change in the wavelet variance of the NDVI data sets was not a simple function of resolution. For DEM, however, the wavelet variance varied linearly with its resolution. The dominant scale for the NDVI data sets was found to be 240 meters; however, DEM did not exhibit a dominant scale. The small-scale features of the NDVI data sets were shown to be self-similar over the 120 meter to 3.84 kilometer scales in all the three directions; while those of DEM were self-similar over the 3.6 kilometer to 11.52 kilometer scales in all the three directions. The scaling exponents were different in the three directions for all the data set, indicating the anisotropic nature of the landscapes. Again the scaling exponents were all negative, indicating increasing variability with decreasing scales. The large magnitudes of the slopes indicated long range behavior and may imply a methodology for statistically assimilating remotely sensed data set into large-scale meso and global climate models.

Changing grain size and extent both had significant effects on landscape metrics, and the effects in each case could be grouped into three main types: Type I – simple scaling relationships; Type II – unpredictable behavior and Type III – fixed responses. In general, the effects of changing grain size were more predictable than those of changing map sizes. It was also revealed that the direction of analysis in the case of changing extent had significant effects on landscape pattern analysis, as did the method of aggregation in the case of changing grain size. A comparison of the effects of changing grain size and extent on landscape metrics showed that our results are consistent with the statistical correlations that exist among the metrics. The findings from this study corroborate the general notion: there is no single “correct” or “optimal” scale for characterizing and comparing landscape patterns. Therefore, landscape metric scalograms should be used for characterizing, comparing and monitoring landscape patterns instead of using single value.