Scaling terrain attributes by fractal methods

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Abstract. Terrain attributes derived from grid digital elevation models (DEMs) are commonly used in distributed hydrologic models. However, many attribute estimations are biased by DEM grid cell size. For example, land surface slopes estimated from 30-m DEMs are, on average, less than slopes estimated from 5-m DEMs. Since land surfaces generally obey self-affine fractal behavior, scaling relationships for terrain attributes can be derived based on the Hurst exponent (*H*). In this study, centimeter-level accurate global positioning system (GPS) data were collected at 5-m spacing on 12 agricultural fields (3 to 109 ha) in Colorado and Maine. Using the variogram method, *H* was estimated from the elevation data on each field over various ranges of separation distances suggesting multifractal characteristics of land surface terrain. For the range of 5 to 30-m separation distances, a single *H* value ranging from 0.73 to 0.98 was estimated ($r^2 > 0.99$) for each field. Fields with greater mean slopes tended to produce higher *H*, while fine-scale surface roughness seen only on some of the relatively flat fields produced lower *H*. These estimates of *H* were incorporated into a slope scaling equation, and field mean slopes derived from 5-m DEMs were predicted from the field mean slopes derived from 30-m DEMs.