Directional reflectance signatures in aerial images - an aid to tree species classification?

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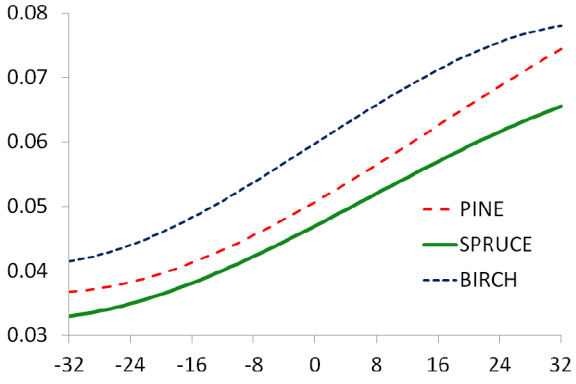
Tree species identification is a bottleneck in remote sensing of Scandinavian boreal forests. Airborne LiDAR gives acceptable estimates of the total growing stock, while species-specific estimates remain less accurate. Aerial images are widely used as a alleviating data source. Image observations include directional effects from trees and the atmosphere, which has traditionally been considered a nuisance. We estimated species-, band-, and illumination-specific anisotropy models to assist tree species classification in real and simulated image data. Multispectral Leica ADS40 line-sensor data from Finland (62°N, 24°E) were analyzed using mixed-effects modeling. This allowed the division of the reflectance variation between directional anisotropy, tree and image effect, and the residual. The anisotropy models and the covariance structures were then utilized in a Monte-Carlo simulation, which aimed at quantifying the gain from directional signatures under different assumptions for reflectance calibration accuracy. A simple classifier employing Mahalanobis distance was implemented to classify the multiangular directional signatures. In real data, directional signatures suffered from reflectance calibration inaccuracy, and no gain was obtained in classification performance compared to averaged spectral features and discriminant analysis. Simulations however implied that directional signatures comprise an improvement provided that the reflectance calibration is accurate. The gain from using the directional signatures was however low, less than 5% in overall classification accuracy. The optimal selection of the flying direction with respect to the solar azimuth was influenced by the classification strategy. Species classification accuracy of dominant–co-dominant Scots pine, Norway spruce and birch seems to saturate at 85–90% even in multiangular data owing to the strong within-species variation and correlation of the spectra in individual trees. These factors relate to the inherent structural variation in trees and constitute a natural upper bound.



An example (1-dimensional cut) of anisotropy models (reflectance) for GRN band and direct illumination along the solar principal plane (–32° to +32°). The relative brightness of pine varies and the classifier considers these between species differences.