Bibliographic information

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Abstract

The leaf area index (LAI) is one of the most important biophysical forest parameters describing canopy structure. Aside from empirical models for estimating LAI from optical remote sensing data, a number of physically based models have been created based on radiative transfer. Such models simulate the spectral response of forest stands to incident solar radiation and, through model inversion, can predict forest biophysical parameters. Their strong theoretical foundation provides sensor independence, scalability and potential to generalize. A branch of radiative transfer research in vegetation led to the development of the spectral invariants theory, or p-theory. The parameter p has later been interpreted as the photon recollision probability; the probability that, upon interacting with a canopy element, a photon will be intercepted again. This parameter allows for unmixing the spectral response of a forest stand into structural (spectrally invariant) and spectral parameters. Photon recollision probability is applied in an invertible model for the short-wave reflectance of forests, called PARAS. In this thesis, PARAS was applied to estimate LAI for 19 field plots and 746 lidar plots using Sentinel 2 MSI and Landsat 8 OLI data. The model was parameterized by a simulation based on existing knowledge of canopy structural relationships, and inverted through a k-nearest neighbor regression. PARAS overestimated most reflectance observations and also low LAIs, but accurately predicted larger LAIs. Band combinations including near-infrared and shortwave infrared bands showed best results for both Sentinel 2 (bias -0.31, RMSE 0.63) and Landsat 8 (bias -0.23, RMSE 0.60). Replacing Sentinel 2's near-infrared by the red edge bands 2 and 3 improved inversion results to bias 0.05 and RMSE 0.49. Additionally, some discrepancies appeared problematic in the visible bands of the two satellites. The lack of accounting for crown level clumping may have caused the majority of prediction errors.