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Approximating photon recollision probability in vegetation canopies

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Physical modeling in remote sensing

To be applicable to a wide variety of biomes, algorithms for predicting remotely sensed signatures of forests have to rely on physically-based principles. These physically-based models are able to calculate the angular distribution of reflected intensity for any reasonable set of illumination conditions. Recently, parameterizations for physically-based models have been developed to relate canopy absorption and scattering, based on photon recollsion probability. Photon recollision probability is the probability that a photon, once scattered, will interact with the canopy again. As a first approximation, it can be considered wavelength-independent and thus connects canopy reflectance at different wavelengths in the visible and near-infrared spectral regions. It is also assumed to remain constant in successive interactions. We present formulas to estimate the first order photon recollision probability as an approximation to the effective recollision probability averaged over all scattering orders.

Using the analytical solution of the two stream equation in vegetation canopies, contributions of different scattering orders were compared. Using these contributions, the influence of the photon recollision probabilities of various scattering orders on the mean recollision probability was studied. The analytical expressions for the recollision probabilities of different scattering orders were derived for a canopy with horizontal leaves. Using a physically-based approach, first-order recollision probability was extended to other leaf inclination angle distributions. This approach was used to estimate the first-order recollision probability in a leaf canopy consisting of discrete crown envelopes. All approximations were compared with Monte Carlo simulations.