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Influence of gap fraction on coniferous needle optical properties measurements

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Abstract

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Influence of gap fraction on coniferous needle optical properties measurements

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Optical properties (OPs) of non-flat narrow leaves, i.e. coniferous needles, are extensively used by the remote sensing community, e.g. for calibration and validation of radiative transfer models at both leaf and canopy levels. Measurement of such small elements is, however, a technical challenge with a very little knowledge about related errors. Consequently two situations appear among the users of OPs: 1) the lack of such measurements forces them to make assumptions with a potentially negative impact on the interpretation of remote sensing data of coniferous forests (e.g. in radiative transfer modelling, needle transmittance is often assumed to be zero, or needle reflectance and transmittance are assumed to be equal); or 2) the used available datasets are of unknown reliability. This demonstrates a need for a robust, efficient and systematic measuring technique of narrow-leaf OPs.

Compared to the broad leaves, measurement of reflectance (R) and transmittance (T) of narrow leaves require adapting the conventional techniques (i.e. coupling a spectroradiometer to an integrating sphere) to a sample size smaller than the area illuminated by the incident light beam. Reduction of the illuminated area to the dimensions of one narrow leaf would result in a very low signal-to-noise performance. An alternative solution is to measure the signal from several needles simultaneously mounted next to each other in a carrier, and to correct such measurement for the portion of photons passing through the air gaps (gap fraction of the illuminated area – GF). The objective of this paper is to estimate an error budget of this technique by analysing errors originating from: 1) use of the carrier, 2) gap fraction estimation via digital image processing, and 3) multiple scattering caused by the non-flat nature of the needle leaves. To achieve this we measured OPs from an optically stable silicon material, which was cut in 1 mm thick strips to simulate needle shaped leaves. We build on the results presented by Mesarch et al. (1999) in which this technique was applied only on flat film paper, and we investigated the influence of the non-flat objects (needle leaves) on accuracy of the measurements. Computed R and T for different tested settings (i.e. carrier combinations, image processing settings, and distances between measured needles) were analysed to point out the best configurations and to estimate errors introduced by this technique.

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