A Geometric-Optical Bidirectional Reflectance Model of Row Crops to Analyze FOOTPRINT UNCERTAINTIES in Ground-based Measurements

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Abstract:

Ground bidirectional reflectance should be measured with sufficient accuracy, since it is usually considered as the standard data to retrieve surface anisotropic characteristics, to support the validation and development of BRDF models, and to correct images acquired by satellites with wide-angle imagery sensors. However, experimental data on surface bidirectional reflectance is not commonly corrected for the footprint area uncertainties. For homogeneous and low canopies, the problems caused by the changing of footprint area can be ignored in ground multiangular measurements. But row-planted crops, which can be classified between homogeneous and heterogeneous vegetation, have their own special geometric characteristic. Footprint uncertainty problems should not be neglected in the directional observation of this kind of surface. This study introduces an equivalent footprint of sensor's field of view into the original Kimes model and developes a footprint uncertainty analysis model for multiangular in situ measurements of row crops through disassembling the entire equivalent footprint into three parts, which include the middle integral row periods and two additional parts by its sides. The model is validated against ground-based measurements taken over corn canopy both in the visible and near-infrared spectral regions. An inversion procedure, which is based on a multivariate constrained nonlinear optimization technique, is used to derive the optical properties of four components in the footprint area, which are hard to acquire accurately in field experiment. Then we use the optimal retrieval information to generate the predicted bidirectional reflectance, and compare it with the measured data. The analysis of comparative results indicates a good agreement between predicted and measured data when the nadir view comprises two or more row periods. However, up to 15% relative discrepancy is found between them when the nadir view is no more than one row period. Based on the same inversion procedure, we also fit Kimes model to the measured data. Results show that the model we proposed fits the field data slightly better than Kimes, especially with near nadir view angles. This study is a step toward the generation of more accurate BRDF database for the validation and calibration of air- and spaceborne remote sensing data. Further work is required to improve the performance of the model by taking into account gap probability and conical observation.

Keywords: row crops, BRDF, equivalent footprint, Kimes, footprint uncertainty analysis model

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