Characterization of Surface Directional Reflectance Properties from Airborne Angular Reflectance Measurements to Improve the Accuracy and Consistency of Long-Term Data Records

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Validation of global land surface reflectance products is accomplished by comparing satellite retrievals to other high-quality measurements as determined by applying a radiative transfer model supported with high accuracy atmospheric parameters [1, 2]. A major challenge to the operational implementation of these models lies in the assignment of crucial *a priori* knowledge of the underlying reflectance anisotropy as described by the Bidirectional Reflectance Distribution Function (BRDF) [3]. The determination of surface BRDFs at the operational level is currently done by either using a single overpass retrieval from satellite sensors with multi-angular capability [4, 5], or by using multi-date retrievals (nominally 16 days) from wide-swath off-nadir sensors [6]. With the increasing need to detect and monitor changes on the Earth's surface (e.g., variations in the extent of snow cover and flooding, the phenology of natural vegetation and agricultural crops, as well as other signatures from rapidly changing surface conditions), airborne angular reflectance measurements have become an essential element in the characterization of surface BRDF properties. The purpose of this study is to develop a multi-angle and multi-scale BRDF dataset from the NASA's Cloud Absorption Radiometer (CAR) [7] to help quantify the uncertainties in satellite-derived retrievals, particularly across complex heterogeneous environments such as populated urban areas and other aerosol source regions. The CAR instrument, a 14-channel airborne scanning radiometer with a spectral range from 0.34 – 2.3 μm, has been used extensively over the past 18 years to acquire spectral BRDFs of ocean, sea ice, snow, tundra, cropland, urban, forest, savanna, salt pan, and wetland, aboard various aircraft, most recently, NASA's P-3B [8]. This airborne sensor has a wide aperture of 190°, an instantaneous Field of View of 1°, and can capture the full BRDF, including the hotspot under low sun angle conditions commonly found in the Arctic. When coupled with simultaneous airborne measurements of sun/sky radiance and adjusted through atmospheric correction using MODTRAN®5.1 – a radiative transfer model that fully accommodates parameterized surface BRDF representations [9, 10] – the CAR measurements can provide powerful constraints on the uncertainties in surface BRDFs derived from at-sensor radiances, also of value when the satellite data are used to constrain climate and ecosystem models. The multi-scale and multi-angle retrievals from CAR will provide further insight into issues of scale-dependent uncertainties in downstream reflectance-based products (e.g. surface albedo and snow/sea-ice cover) whose accuracies are dependent on their ability to characterize the scattering and absorption properties of complex heterogeneous environments.

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