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Radiative Transfer Based Synergistic MODIS/MISR Algorithm for the Estimation of Global LAI & FPAR

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The objective of our effort is to develop a radiative transfer based synergistic algorithm for estimation of global leaf area index (LAI) and fraction of photosynthetically active radiation absorbed by vegetation (FPAR). The algorithm consists of a main procedure that exploits the spectral information content of MODIS measurements and the angular information content of MISR measurements to derive accurate estimation of LAI and FPAR. Should this main algorithm fail, a back-up algorithm is triggered to estimate LAI and FPAR using vegetation indices. Both algorithms are capable of executing in MODIS-only or MISR-only mode, should cloud contamination, data frequency and spatial or temporal resolution requirements hinder a joint MODIS/MISR mode of operation. A comprehensive three-dimensional radiative transfer model for vegetated surfaces is utilized by both the algorithms to connect remote observation to surface variables of interest. The algorithm requires a land cover classification that is compatible with the radiative transfer model used in their derivation. Such a classification based on vegetation structure was proposed and it is expected to be derived from the MODIS Land Cover Product. Therefore, our algorithm has interfaces with the MODIS/MISR surface reflectance product and the MODIS Land Cover Product. The following is a brief description of our activities during the third quarter of 1997 (July through September).

Our algorithm is based on representation of the canopy-leaving radiance as a sum of the solutions of two independent sub-problems. The first describes photon interaction with the vegetation canopy when soil reflectance is zero. The second one describes the radiative regime in the plant canopy generated by an anisotropic and heterogeneous source located at the canopy bottom. A special technique was developed and implemented to store the solutions of these problems in LUT in a very compact form. Canopy reflectance models are used to create LUT. In spite of the diversity of canopy reflectance models, their direct use in an inversion algorithm is ineffective. In the case of biomes 2-6, for example, the interaction of photons with the rough and rather thin surface of the tree crowns and with the soil in-between crown openings are the most important factors causing the observed variation in the directional reflectance distribution of plant canopies. Many canopy reflectance models essentially use this property. As a result, they are only slightly sensitive to the within-canopy radiation regime. Mathematically, this assertion is based on the fact that a rather wide family of canopy radiation models is equivalent to the solution of the transport equation which includes a non-physical internal source. Within such of a model, therefore, the radiation absorbed, transmitted and reflected by the canopy is not equal to the radiation incident on the canopy. On the contrary, just the within-canopy radiation regime is very sensitive to the canopy structure and, as a consequence, to LAI. The within-canopy radiation regime also determines the amount of solar energy absorbed by tree. Ignoring this in canopy radiation models leads to a big number of non-physical solutions when one inverts a canopy reflectance model. In order to avoid such solutions in our algorithm we introduce weights defined as the ratio of the BRF to hemispherically integrated reflectance. This allows us to convert measured BRF to BHR which, in turn, can be expressed via canopy transmittance and absorptance, which are elements of LUT. Thus, our algorithm is now sensitive both to the factors determining the directional reflectance distribution of plant canopies and to the within canopy radiation regime. The LUT with weights as a function of sun-view geometry, LAI and wavelength was created. A new version 2 (Prototype 2) of algorithm which realizes this technique was prepared. The MISR LAI/FPAR ATBD was completely rewritten and sent to JPL. The algorithm code was delivered both to the MISR project at JPL and to the University of Montana (our MODIS collaborators). The latest version of the MISR ATBD will soon be made available on the WEB. A description of our approach was prepared as a contribution to a collaborative MODLAND paper for TGARS. A paper describing our algorithm and its features of MODIS-only and MISR-only modes of functioning will be prepared for JGR by Oct 25.