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MONTE CARLO SIMULATION OF THE BIDIRECTIONAL REFLECTANCE DISTRIBUTION FUNCTION OF THE RICE PADDY

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ABSTRACT

As we would like to utilize the airborne multi-spectral scanner data to estimate the acreage of the rice paddy, the most important crop in Taiwan, we have been measuring the bidirectional reflectance of the rice paddy using two GSFC/ Mark II three band radiometers. The preliminary results show that, for TM3 and TM4 bands, the reflectance exhibits a strong dependence on observed and solar zenith angles. For a fixed solar zenith angle, the reflectance is larger for a larger vertical view angle, i.c., a "V" shaped distribution. Thus, a complete understanding of the bidirectional reflectance distribution function, called BRDF, is needed to better utilize the airborne MSS data (note that the scanning range of our Daedalus 1260 scanner is about 80^{o}).

Previously, people used a plane stratified medium to describe the plant canopy (see, for example, Allen and Richardson, 1968; Suits, 1972 and Smith and Oliver, 1972). These models are not directly applicable to the rice paddy, because the geometric features of the paddy are quite different from those of a plane stratified medium. It is very time consuming, if not all impossible, to measure a complete set of BRDF data. We, therefore, propose a Monte Carlo model to simulate the radiation-rice paddy interaction.

In our Monte Carlo model, we have to treat the geometric arrangement of the rice leaves and the radiation-rice paddy interaction. As the rice is planted in groups and is regularly spaced, we can use a "leaf box" concept with a periodic boundary condition to describe each group. Each group is composed of a number of "planted" leaves (at the active tillering stage, for example, the number is about 110). Each individual leaf is considered as portions of a curved surface, which is described by two mathematical parameters with limited ranges. Depending on different growing stages, the shape, position and orientation of each leaf is "planted" as similar to real rice one as possible. However, during the final growing stage, due to the large leaf area coverage, it is very difficult to "plant" the leaves without introducing the unreal effect of mutual intersections of "planted" leaves.

Currently our model can only apply to early and middle growing stages when our leaf box concept remains valid. Once the leaf box is constructed, we inject photons into it and follow the path of each individual photon until it is absorbed or escaped. The phase function of upper and lower epidermis, ground reflectance, and absorption coefficient for each medium are treated as input parameters (or functions). Our results show (1) for a given growing stage and each photon incident angle, about 10^5 photons are needed to get statistical meaningful BRDF. (2) it correctly predicted the "V" shape phenomena and (3) the simulated results agree quite well with those measured data.