Extending the Radiosity Method for non-Lambertian Environment

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Abstract:

To quantify the interaction between land surface and solar radiance, many physical remote sensing models were developed, for example, geometric optics, radiative transfer and computer simulation models. As one of the computer simulation models, the radiosity method can take all the radiative transfer (RT) processes, such as reflection, transmission and multiple scattering into account. However, there is currently a general assumption of Lambertian scatterers in the radiosity, namely, all the scene components (e.g., leaves, branches and the soil background) are Lambert in reflection/transmission.

In fact, many studies on leaf optical property have shown that leaf reflection is anisotropic, and its angular distribution can be described by the bidirectional reflectance distribution function (BRDF). In order to extend traditional radiosity method, a general equation for the radiant intensity of a facet in the environment is derived at first, which can include Lambertian and non-Lambertian surface. Then a modified Cook-Torrance model of leaf surface derived in Bousquet et al. (*Bousquet, L., Lachérade, S., Jacquemoud, S. and Moya, I., Leaf BRDF measurements and model for specular and diffuse components differentiation, Remote Sensing of Environment, 98:201-211, 2005*) is coupled in the Radiosity-Graphics combined Model (RGM), which is based on the method of radiosity, to consider the specular reflectance of leaves. At the same time, some hypotheses are made to simplify the calculation procedures for the extended RGM model based on the characteristics of vegetation.

Some bidirectional reflectance factor (BRF) results in red and NIR waveband for uniform (such as maize), planophile and erectophile leaf angle distribution (LAD) canopy are simulated by the extended RGM model using three group parameters given by Bousquet et al.(2005) and the BRF results from maize are compared with the measured data well.

The specular part of BRF from canopy are separated and analyzed individually. Some conclusions can be drawn: the specular parts of BRF are different with wavelength, canopy structures and incident zenith angle. Firstly, if only single specular reflectance is considered in the extended RGM, the specular part of BRF for canopy are the same in different wavelength because the specular parts of BRF are only from the single specular of leaf surfaces and independent of diffuse reflectivity of leaf. But if multiple specular between leaves are taken into account, the specular parts of BRF for canopy are different with wavelength, which are affected by reflectivity of leaf. Secondly, the specular parts of BRF from canopy are affected by canopy structures heavily. For example, planophile and erectophile canopies show the difference obviously. Thirdly, for all canopy structures and any wavelength, the specular parts of BRF from canopy increase with the incident zenith angle.

This new radiosity method keeps the merits of original model and improves the precision in calculation. It can also be used by the computer graphics and other remote sensing models for reference.

Keywords: Radiosity-Graphics combined Model (RGM), BRF, specular reflection, Cook-Torrance model, maize

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