The Effective Nature of LAI as measured from Remote Sensing Observations

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Abstract

Leaf area defines the size of interface between the canopy and the atmosphere for mass and energy exchange. Further, it also provides a good indicator of canopy state resulting from the functioning of the canopy during the past period. The leaf area index (LAI) is thus highly desirable for diagnostic and prognostic studies regarding vegetation description within a range of applications including, agriculture, environment or climate (Fang, Liang et al. 2008).

Leaf Area Index (LAI) is defined as half the total area of green leaf per unit horizontal ground area (Chen and Black 1992). Direct measurement of the LAI is often tedious and impractical over extended spatial and temporal domains. For this reason, LAI is often estimated through indirect means from ground based transmittance measurements transmittance. However, one of the major problem identified corresponds to the non randomness in leaf spatial distribution known as leaf clumping (Chen, Menges et al. 2005) and general lack of detailed information about the canopy architecture features. For this reason, the effecive LAI is used to describe the canopy which is defined as the LAI value that would produce the same indirect ground measurement as that observed while assuming a simple random (1D) foliage distribution. More extensive LAI estimates are obtained from air-borne or space-borne platforms from which canopy reflectance is measured and now widely used from local to global scales (medium resolution satellite sensors) (Knyazikhin 1998; Chen, Pavlic et al. 2002; Deng, Chen et al. 2006; Baret 2007). Radiative transfer models are used to retrieve LAI from the reflectance measurements using inversion techniques. However, the LAI data so retrieved depart from the actual LAI because of the violated assumptions on canopy architecture and ambiguities in the radiative transfer model inversion (Baret 2007) thus leading to a biased LAI estimate known as the 'apparent LAI' which may depend on the observation configuration as well as the inversion procedure adopted.

The objective of this study is to better describe and understand the difference between actual, effective and the apparent LAI values retrieved as a function of the type of canopy

considered, the type of radiative transfer model used in the inversion process and the observational configuration selected.

For this purpose, the FLIGHT 3D architecture model is used (North 1996). Crown cover, crown dimensions, leaf size and inclination angle and LAI were manipulated to generate a large range of canopies with contrasting architectures. The leaf optical properties were simulated with the PROSPECT model (Jacquemoud and Baret 1990) by varying the cholorophyll content, water, dry matter and the leaf structure index. The reflectance of the soil background is also manipulated thus resulting in a wide range of canopies with different soil backgrounds. Canopy reflectance in the bands spanning across visible, near infrared and short wave infrared are simulated using the FLIGHT model with the sun located at 45° from the zenith.

A Look-up Table (LUT) technique is implemented to invert the radiative transfer models. Two models are considered to build the LUT: 1D (random distribution of leaves) and 3D (the FLIGHT model). Results are discussed with due attention to the above mentioned factors, i.e. the clumpiness of the cases studied, the radiative transfer model (1D or 3D) used in the LUT, and the directional configuration. Comparison between actual, effective and apparent LAI values will allow to understand the role of the configuration and model assumptions on retrieved LAI estimates.

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