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RESEARCH ARTICLE

Sensitivity analysis for leaf area index (LAI) estimation from CHRIS/PROBA data

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Abstract Sensitivity analyses were conducted for the retrieval of vegetation leaf area index (LAI) from multi-angular imageries in this study. Five spectral vegetation indices (VIs) were derived from Compact High Resolution Imaging Spectrometer onboard the Project for On Board Autonomy (CHRIS/PROBA) images, and were related to LAI, acquired from *in situ* measurement in Jiangxi Province, China, for five vegetation communities. The sensitivity of LAI retrieval to the variation of VIs from different observation angles was evaluated using the ratio of the slope of the best-fit linear VI-LAI model to its root mean squared error. Results show that both the sensitivity and reliability of VI-LAI models are influenced by the heterogeneity of vegetation communities, and that performance of vegetation indices in LAI estimation varies along observation angles. The VI-LAI models are more reliable for tall trees than for low growing shrub-grasses and also for forests with broad leaf trees than for coniferous forest. The greater the tree height and leaf size, the higher the sensitivity. Forests with broad-leaf trees have higher sensitivities, especially at oblique angles, while relatively simple-structured coniferous forests, shrubs, and grasses show similar sensitivities at all angles. The multi-angular soil and/or atmospheric parameter adjustments will hopefully improve the performance of VIs in LAI estimation, which will require further investigation.

Keywords CHRIS/PROBA, LAI, sensitivity, vegetation index, vegetation type

1 Introduction

Vegetation structure, a concept describing vegetation spatial and temporal distributions, is very important for environmental research, climate change monitoring and natural resources management. Many factors are sensitive to vegetation structure, including biodiversity, hydrologic cycle, ground energy flux exchange, and carbon storage in land ecosystems (Smith et al., 2008; Ganguly et al., 2008; Fernández et al., 2010; Wu et al., 2014). Leaf area index (LAI), one of many vegetation structure measurements, defined as one-sided surface area of leaves per unit ground area (Chen and Black, 1992), is the key biophysical variable influencing land surface photosynthesis, transpiration, and energy balance (Running et al., 1989; Bonan, 1995).

LAI measurements are traditionally undertaken by acquisitions of vegetation area on the ground (e.g., Duan, 1996), or by the measurement of solar radiance under vegetation using various instruments (e.g., Gower et al., 1999; Hyer and Goetz, 2004). Direct measurement of LAI is usually labor intensive, impractical at large scales, and problematic for capturing seasonal or annual variations. Remote sensing techniques provide a means of quickly estimating LAI in local or global regions. The methods for remotely estimating the LAI are generally grouped into two main classes. One utilizes radiative transfer models to derive the LAI via inversion techniques (Houborg et al., 2007; Darvishzadeh et al., 2008; Vohland et al., 2010). Even though the models are mechanism-based, selection of the model parameters is not straightforward, and inversion is often time-consuming. The other is based on empirical relationships between vegetation indices (VI) derived from satellite data and LAI acquired through field measurement. These empirical models can easily be built and therefore, have been universally applied in LAI estimation over long periods of time (Baret and Guyot, 1991; Chen et al., 2002; Cohen et al., 2003; Fernandes et al., 2003; Gu et al., 2012). Regression models are based on the experimental relationships between combinations of reflectance in different spectral bands and the parameter to be retrieved. The

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