A simplified procedure for a large scale LAI inversion from high resolution satellite data

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Abstract

The major physiological processes of vegetation including photosynthesis and evapotranspiration are influenced by the vegetation biophysical parameters that describe the canopy structure. Leaf area index (LAI) is one of the principal biophysical parameters in climate, weather, and ecological studies, and has been routinely estimated from remote sensing measurements. Remotely sensed data offer a wide range of resolutions to estimate the LAI, although only recently does the increasing availability of high spectral, spatial and angular resolution provide better products. The retrieval of LAI from remote sensing data is usually done based on empirical relationships between vegetation indices and ground based measurements [1]. The problem with this approach is that it is affected by the noise of understorey and soil background reflectance and the saturation of vegetation indices at high LAI values. Besides, empirical relationships are not portable as the statistical relationship is season-biome-vegetation specific. Another approach for canopy LAI retrieval is to invert a canopy reflectance model [2]. However, there are no ideal canopy reflectance models that can be directly used for LAI inversion over large areas. Additionally, selection of the parameters for the inversion of canopy reflectance models is complicated, and some parameters are very difficult to determine. Generally speaking, the success of LAI estimation from remotely sensed data remains cumbersome and there is always a need to calibrate remotely retrieved parameters with ground based observation.

The LAI determination algorithms are evaluated in the Great Lakes - St. Lawrence forest in Southern Quebec, Canada. The study site is a part of the Gatineau Park, and is mostly temperate hardwood forest. The study plots were located in the southern portion of the park. They have been part of ongoing research on monitoring forest damage, structure, health and succession following the ice storm of 1998 [3]. Remotely sensed data in radiance was obtained from SPOT 5 HRG instrument in 10 m nominal pixel size of four bands (green, red, NIR and SWIR). The inverted LAI from SPOT image was evaluated based on the ground measurements made in fifty-four plots of 20 m by 20 m using hemispherical photography and compared with the MODS LAI product at larger scale.

We anticipated that atmospheric correction would be crucial pre-processing step for any quantitative analysis of satellite observations. Three procedures of atmospheric corrections considered in this study are 1) apparent reflectance model, 2) absolute correction using four dark-object subtraction (DOS) methods, and 3) absolute correction based on radiative transfer model called 6S (second simulation of the satellite signal in the solar spectrum).The gap fraction is extracted based on the scaled difference of normalized difference vegetation index (NDVI), scaled difference vegetation index (SDVI) and modified soil adjusted vegetation index (MSAVI) [3;4]. This approach is applied to all reflectance factors (TOA, 4 DOS approaches and 6S) to evaluate the importance of atmospheric correction for the developed methodology as the major aim is to simplify the LAI determination (Figure 1). We also compared the resolution effect using various averaging methods of the vegetation indexes and reflectances.

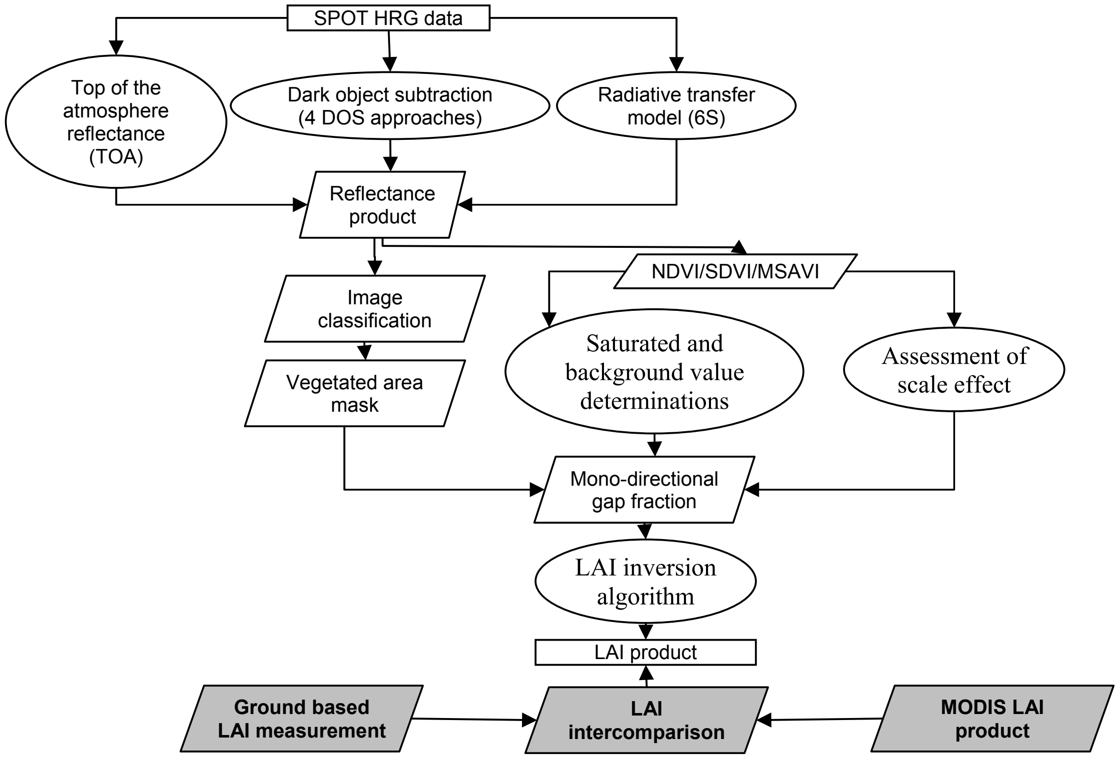

Figure 1. A flowchart of a large scale LAI inversion procedure

This study is aimed at demonstrating the feasibility of the large scale leaf area index (LAI) inversion algorithms using high resolution satellite imagery. The algorithms are developed based on the principle commonly used for ground-based optical determination of LAI by assuming that the same methodology can be applied by observing the canopy from above provided that high spatial resolution remote sensing imagery is available [5]. A new look to LAI inversion methodology and foliage clumping index derivation was demonstrated in this study. Compared with the existing approaches, it not only has the advantage of the use of vegetation index models, it is easy and simple to use. Generally speaking, the proposed methodology produced satisfactory result as it is evaluated in relatively high forest cover where remote sensing retrieval of biophysical parameters is commonly ill-posed.

References

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