MAPPING THE VEGETATION CLUMPING INDEX AND LAI USING MULTI-ANGLE AIRBORNE IMAGERY

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1. INTRODUCTION

Rapid developments in multi-angle remote sensing technologies over the last two decades provide new opportunities for mapping vegetation structural parameters, which are needed for various ecological and climate change studies. Measurements at more than one angle capture the directional anisotropy of solar radiance reflected from vegetated surfaces. The multi-angle Compact Airborne Spectrographic Imager (CASI) data, acquired over the study area near Sudbury in the southern part of Ontario, are used to generate the clumping index (Ω) and leaf area index (LAI) maps. This study is part of a larger project related to the refined multi-angular and hyperspectral measurement concept developed by Simic and Chen [1].

2. THE NORMALIZED DIFFERENCE BETWEEN HOTSPOT AND DARKSPOT (NDHD)

According to our recent research, we propose that the best two view angles for vegetation structural mapping are: (i) the hotspot, where the Sun and view directions coincide, and (ii) the darkspot, where the sensor sees the maximum amount of vegetation structural shadows. The Normalized Difference between Hotspot and Darkspot (NDHD), an angular index was developed by [2] to characterize the anisotropic behaviour of the vegetated surface. This index was successfully related to ground-based measurements [2], [3] and to modeled-derived clumping index [1], [3]. The foliage clumping index characterizes the spatial distribution pattern of leaves. It is of equal importance as the leaf area index (LAI) for quantifying radiation interception and distribution in plant canopies, and it also affects LAI mapping using remote sensing data. As the clumping index can vary considerably within a cover type, it is highly desirable to map its spatial distribution for various ecological applications.

3. METHODS

We produced clumping index maps based on the algorithms of correlation between the NDHD and Ω for the red and NIR spectra. First, we used algorithms generated by [2] using appropriate coefficients for each cover type and created the map based on the model approach. We also generated a clumping index map based on the empirical relationship between the field-measured clumping index and CASI-derived NDHD. The algorithms were derived for three cover types (mature coniferous, deciduous and regrowth forest) separately and were applied to 20-m NDHD maps. In addition, we examined the relationships between model-derived and field-measured clumping index. The steps used to produce the LAI map were based on two approaches: 1) the previous algorithms by [4]; and 2) the relationship between the simple ratio (SR) and field-measured effective LAI (Le) and Ω. The main goal was to validate the existing algorithms and to explore the effect of Ω used in the relationship between SR and Le.

4. CONCLUSIONS

Through intensive validation using field data, we demonstrate that the combination of the hotspot and darkspot reflectances has the strongest signals about the vegetation structure. High correlation between NDHD and field-measured clumping index suggests the importance of multi-angle measurements in retrieving structural vegetation parameters. Two crown structural characteristics, crown height and within-crown density, are major factors which impact the NDHD and clumping index difference between the mature and young (regrowth) coniferous forests.

Through this intensive validation using multi-angle airborne data and field measurements, the following conclusions are drawn: 1) The clumping index algorithm initially developed by [2] for global applications has some shortcomings; 2) Separate Le and clumping mappings do not seem to improve LAI mapping due to the confounding influence of the understory and possibly due to errors in co-registering multi-angle images. However, clumping should be considered in ground measurement of LAI for its algorithm development. A clumping index map would nevertheless be useful in conjunction with a LAI map for estimating the radiation distribution within the canopy and vegetation productivity.

References:

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