MEASUREMENTS OF CANOPY NONRANDOMNESS AT JARVSELJA RAMI (RADIATION TRANSFER MODEL INTERCOMPARISON) TEST SITES

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1. INTRODUCTION

RAdiation transfer Model Intercomparison (RAMI) was designed as an on-going mechanism to benchmark radiation transfer (RT) models used to simulate the transfer of radiation at or near the Earth's terrestrial surface, i.e. in plant canopies and over soil surfaces [1]. For the future phases of intercomparisons, one of the expected goals would be to investigate the potential of RT models to reproduce in situ measurements of transmitted light by various methods such as Tracing Radiation and Architecture of Canopies (TRAC; 3rd Wave Engineering, ON, Canada) instrument or digital hemispherical photography (DHP) [2]. The intensive collection of the optical measurements in the RAMI-selected real world forest stands is thus required.

Besides the information about the canopy gap fraction and radiation regimes at the forest floor, concurrent TRAC and DHP measurements are also vital to address current challenges of the indirect methods with respect to quantifying architecture of forest canopies. One of the recurrent themes for the investigations concerning the vegetation structure is clumping of plant canopies [3]. Clumping describes the spatial aggregation foliage elements. The clumping has been quantified by the aggregation or dispersion parameter [4] or clumping index [5]. The clumping index thus describes the level of foliage grouping within distinct canopy structures, such as tree crowns, shrubs, and row crops, relative to a random distribution [4]-[6]. The clumping index is useful in ecological and meteorological models because it provides new structural information to the effective leaf area index [7]. Clumping, through a better separation of sunlit and shaded leaves, has profound effects on the radiation regime of a plant canopy and photosynthesis [8]. The clumping index (Ω) larger than unity implies the foliage is regularly distributed; $\Omega = 1$ for a random distribution and in the case of foliage more clumped than random, $\Omega < 1$ [9].

Various methods were proposed for the assessment of the non-random spatial distribution from field measurements [3], [10]-[14]. Considerable differences were observed between the approaches to quantify beyond-shoot clumping (e.g. [3], [14]-[16]), yet the role of important factors, such as the common practice of assuming spherical leaf projection function [17], the choice of segment size [5], [18], or the assumed consistency between measurements while using different instruments [14] has been seldomly assessed. This practice calls for a comprehensive investigation to evaluate the performance and consistency of the methods with the commonly used instruments, and to define their merits and limitations

2. METHODOLOGY

The objective of our study is to determine the canopy nonrandomness at one Silver birch and one Scots pine RAMI stand in Jarvselja, Estonia. To achieve this goal, we acquired information about the leaf inclination angles, carried extensive measurements by means of TRAC, DHP, and LAI-2000 instruments, and finally characterized beyond-shoot clumping based on six different methods found in the literature. We report on the following issues: a) how spatially homogeneous are the two Jarvselja RAMI stands with respect to the foliage clumping; b) how does the beyond-shoot clumping change with the view zenith angle and height over the stands; c) what are the strengths and limits of various methods, and which one performs the best; d) what are the implications of assuming spherical leaf distribution function on calculating the beoynd-shoot clumping; e) if is there any agreement between results derived from TRAC and DHP. In addition, we suggest a method how to determine the appropriate segment length while working with TRAC data.

3. CONCLUSIONS

The major aim was to define the merits and limitations of the various methods. We conclude the gap size distribution and beyond-shoot clumping is very stable across the stands for the solar zenith angle range from 30 to 60 degrees. Estimates based on the combination of gap size and logarithm methods [14] performed the best while compared with an independent gap fraction model [13]. The highest correlation between different ways of quantifying the beyond-shoot clumping was achieved for CC [11] and CLX [14] methods. We highlight the sensitivity of clumping estimates to the segment length, and we propose an approach how to select the appropriate length for TRAC measurements. Our results indicate that choosing a segment length of 100 times the mean element width provides the closest results to the expected values. We clarify the effect of the assumed leaf inclination angle distribution on gap size distribution and differences between clumping estimates. We demonstrate that the effect of the leaf inclination angle is inherently incorporated in the original methodologies of [11] and [14]. We also illustrate the changes in selected clumping indices with measurement height. The compiled data extend the original parameter dataset to be used in the next (fourth) phase of RAMI for different benchmark tests and reflectance modeling experiments, and contribute toward systematic validation efforts of radiative transfer models, operational algorithms, and field instruments, as promoted by the Comittee on Earth Observation Satellites (CEOS). The achieved results are also highly important for the validating of the current global foliage clumping maps from multi-angle POLDER data [19]-[20] using the different methodologies of assessing the beyond-shoot clumping.

3. REFERENCES

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