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CANADIAN CARBON PROGRAM
PROGRAMME CANADIEN DU CARBONE

Introduction

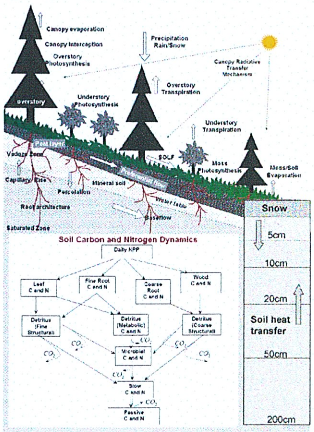
High latitude boreal forests play a major role in the global climate dynamics. Vegetation in these ecosystems is dominated by coniferous forests, whose canopy architectures are highly clumped and non-randomly distributed in space. This is an adaptation to facilitate a greater amount of light penetration deep into the canopy. The probability of the transmission of a beam of light through the canopy is greatly controlled by the clumping nature of the canopy elements, which is conventionally denoted by the clumping index (Ω). Currently, very few regional scale models explicitly consider canopy architectural properties to realistically represent the canopy radiative transfer (RT) mechanism that in-turn affects simulated leaf physiology and the related feedback mechanisms, which greatly govern the results. Considering this, our overall objective was to explore whether detailed information on the canopy architecture is an essential requirement in order to realistically simulate ecophysiological processes of C and water fluxes in a spatially explicit manner.

In this study, we used the BEPS-TerrainLab V2.0 model of Govind et al. (2009 a and b) as a framework for a numerical experiment to explore the implication of Ω on the simulated ecophysiological processes in a boreal ecosystem. We constructed two modeling scenarios (***CLUMPED*** and ***RANDOM***) that differed only in the manner in which Ω was parameterized within the model and analyzed the simulated ecophysiological processes. We considered the spatio-temporal distribution of the two main ecohydrological indicators: the gross primary productivity (GPP) and evapotranspiration (ET) under the two scenarios. We hypothesized that Ω can affect the partitioning of light distribution within the canopy and hence the accuracy of the simulated GPP and ET via leaf physiological variability. Changes in ET due to Ω can also affect the nature of the soil water balance and can cause a feedback loop that further affect the leaf physiology.

Modeling & Upscaling (Leaf to Canopy) Ecophysiological Processes

BEPS-TerrainLab V2.0 is a spatially explicit model that simulates the hydrological, ecophysiological and biogeochemical processes and the related feedback relationships in a tightly coupled manner. A detailed description of this model can be found in Govind et al. (2009 a and b).

Leaf-level processes (GPP and ET) are upscaled to the canopy using fractions of LAIs as weighting terms that correspond to variability in leaf physiological statuses mainly due to the two main resources, light and water. BEPS-TerrainLab V2.0 employs a modified sunlit-shaded leaf strategy i.e. the four-leaf approach to spatially upscale leaf-level processes to the canopy scale. It is assumed that within the two light regimes (sunlit and shaded), there are two states of moisture regimes, i.e. canopy is comprised of 4 physiologically-distinct leaf-types based on the differences in light and water status. In this model, upscaling of leaf-scale ecophysiological process to the canopy-scale is conceptualized in the following manner. Firstly, leaf-level ecophysiological processes are calculated using leaf-specific parameters and then upscaled to the canopy using respective LAI fractions as shown below. Further, the effects of rhizosphere wetting patterns on the leaf physiological status are considered. It is assumed that rhizosphere wetting patterns proportionately influence the physiological variability of the canopy under a given light regime. This is manifested through the variable μ (after Gale and Grigal, 1987), the fraction of roots in the unsaturated zone and the fraction of roots in the saturated zone. This operation finally results in 4 LAI fractions that have unique physiological statuses which vary in space and time.



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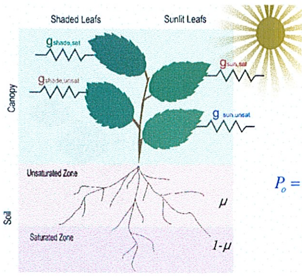

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$$P_o=\left\{\begin{array}{l}\left[P_{sun,unsat}LAI_{over,sun}.\mu\right]+\\ \left[P_{sun,sat}LAI_{over,sun}(1-\mu)\right]+\\ \left[P_{shade,unsat}LAI_{over,shade}.\mu\right]+\\ \left[P_{shade,sat}.LAI_{over,shade}(1-\mu)\right]\end{array}\right\}$$

A conceptual sketch of the upscaling philosophy in *BEPS-Terrain Lab v2.0*

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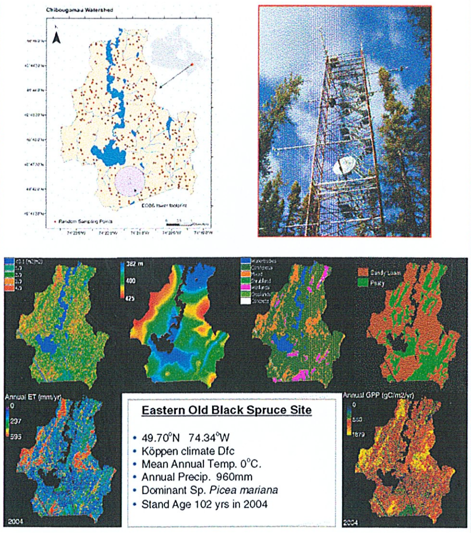

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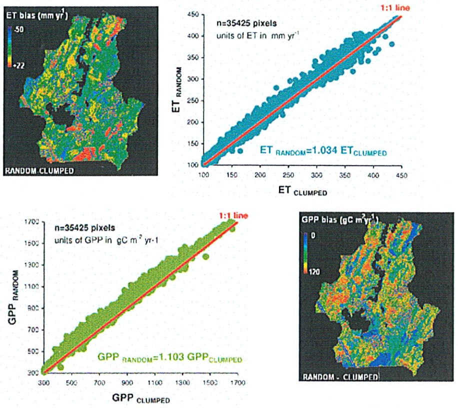

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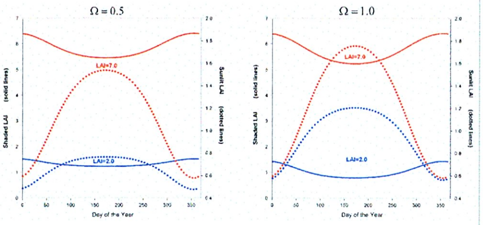
Statistical analyses were performed for the linear relationships ($y=\beta_1 x+\beta_0+\varepsilon$) made between the *CLUMPED* (x) and *RANDOM* (y) scenario-results at the 400 sampling points. Test-specific hypotheses were used to ascertain how the slopes of these linear regressions were statistically different from 1 ($H_0:\beta_1=1$; $H_1:\beta_1\neq 1$) and how the intercepts were different from 0 ($H_0:\beta_0=0$, $H_1:\beta_0\neq 0$). It was seen that the slopes of the *RANDOM* and *CLUMPED* scenarios were significantly different from 1 for ET (0.98 $p=0.0017$) and GPP (1.12 $p<0.04$). The intercepts were also significantly different from 0 for ET (12 $p<0.001$) and GPP (75 $p<0.0001$).



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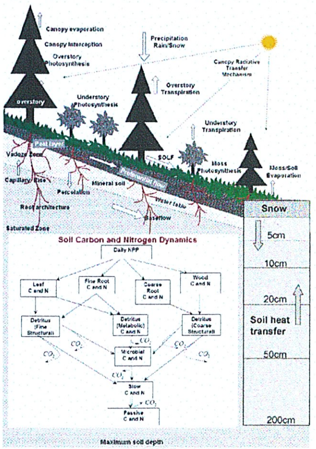

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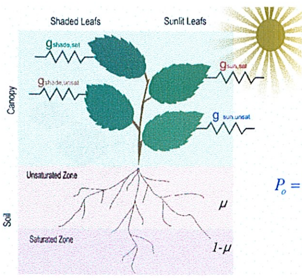

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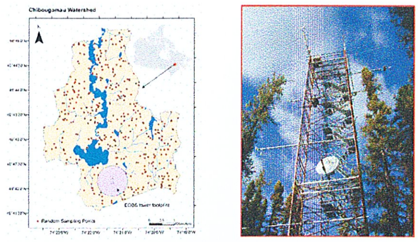

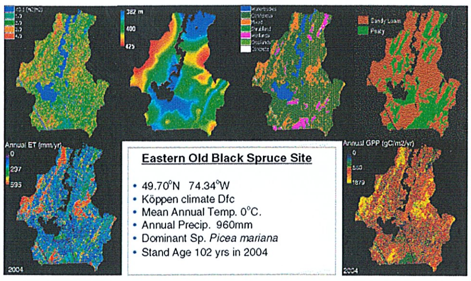

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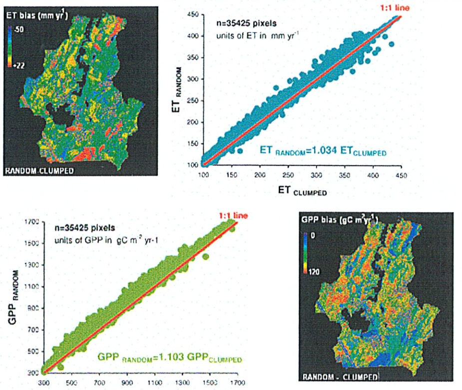

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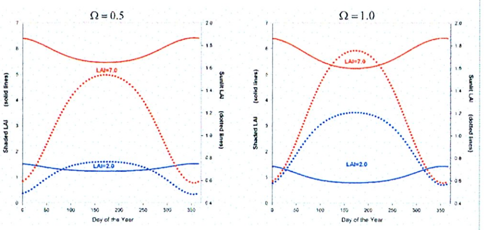

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