Geophysical Research Abstracts, Vol. 9, 01939, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-01939

Modelling spectral radiation extinction in forest stands

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To investigate the interactive effects of canopy structural and optical properties and O3 and NO2 photolysis by high UV doses, validated models are necessary, that allow for canopy heterogeneity in structure and physiological traits.

We used a 3D canopy light absorptance model (STANDFLUX, Ryel et al. 1993, Falge et al. 1997) to illustrate how spectral reflection and transmission properties of needles interact with canopy structure and reproduce a wavelength dependence of transmittance probability density functions (TPDFs) in horizontal canopy layers of a Norway spruce canopy in the Fichtelgebirge, Germany. Expectedly, the position of the TPDF maxima shift from high to low transmittances when moving further down in the canopy, accumulating more leaf area above the layer of interest. Light penetration depends crucially on the 3D distribution or clumping of leaf area in the canopy. The more homogeneous this distribution, the lower the probability for sunflecks below the canopy.

Visible radiation is transmitted in a more bimodal way with a higher probability for sunflecks and umbra, and intermediate probability for penumbra below the canopy, indicating an "on-off" regime for example for understory CO2 uptake. UV radiation shows a more monomodal transmittance with highest probabilities in the penumbra, indicating an overall "average" regime for example for O3 and NO2 photolysis. However, as the latter is autocatalytic, such an average regime is eventually more effective in triggering below canopy photochemical cascades, especially when below canopy air mixing is underdeveloped.

For future research, model validation is envisioned via in canopy O3, NO and NO2 and spectroradiometer measurements. The results are a contribution to the EGER project,

which investigates the role of process interactions among different scales of soil, in-canopy and atmospheric processes for mass and energy budgets of vegetated surfaces.