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Modeled and measured fPAR in a boreal forest

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Highlights: A new model was developed for the estimation of fPAR based on the spectral invariants theory. Good agreement was found between modeled and measured fPAR in boreal forests. The model was applied to study the effect of canopy structure and sky conditions on fPAR.

Keywords: fPAR, canopy structure, photosynthesis, spectral invariants, canopy radiation

The fraction of absorbed Photosynthetically Active Radiation (fPAR) plays a critical role in carbon balance studies and is one of the Essential Climate Variables (ECV). fPAR can be used to monitor CO_2 assimilation by vegetation both seasonally and inter-annually. Temporal courses of fPAR cannot be directly measured but need to be estimated based on models which quantify the dependency of absorbed radiation on canopy structure. The aim of this study was to develop a physically-based canopy absorption model and to compare modelled and measured fPAR in structurally different forest stands.

We extended a previously developed model (Rautiainen & Stenberg 2005) for the estimation of fPAR based on the spectral invariants theory (Knyazikhin et al. 2011). The model uses leaf area index (LAI), canopy gap fractions and spectra of foliage and understory as input data. For validation of the model, measurements of instantaneous fPAR were performed using the TRAC instrument (Leblanc et al. 2002) in nine Scots pine, Norway spruce and Silver birch stands at Hyytiälä Forestry Field Station in June 2012. Continuous data on incoming radiation were obtained from the SMEAR flux tower. In addition, extensive stand inventory, LAI and canopy gap fraction data were acquired for all stands. Good agreement (RMSE ~0.05) was found between modeled and measured fPAR. Next, we applied the model to estimate temporal courses of fPAR. Polynomial functions were fitted to the measured canopy gap fractions to create a hemispherical gap fraction distribution for each stand. These hemispherical gap fraction distributions were used together with the sky irradiance models by Grant et al. (1996) to simulate incoming radiation fields. We show diurnal and seasonal courses of fPAR and how they are linked to forest structure.

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