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Value of eddy-covariance data for individual-based, forest gap models

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Individual-based forest gap models simulate tree growth and carbon fluxes on large time scales. They are a well established tool to predict forest dynamics and successions. However, the effect of climatic variables on processes of such individual-based models is uncertain (e.g. the effect of temperature or soil moisture on the gross primary production (GPP)). Commonly, functional relationships and parameter values that describe the effect of climate variables on the model processes are gathered from various vegetation models of different spatial scales. Though, their accuracies and parameter values have not been validated for the specific model scales of individual-based forest gap models.

In this study, we address this uncertainty by linking Eddy-covariance (EC) data and a forest gap model. The forest gap model FORMIND is applied on the Norwegian spruce monoculture forest at Wetzstein in Thuringia, Germany for the years 2003-2008. The original parameterizations of climatic functions are adapted according to the EC-data. The time step of the model is reduced to one day in order to adapt to the high resolution EC-data. The FORMIND model uses functional relationships on an individual level, whereas the EC-method measures eco-physiological responses at the ecosystem level. However, we assume that in homogeneous stands as in our study, functional relationships for both methods are comparable. The model is then validated at the spruce forest Waldstein, Germany.

Results show that the functional relationships used in the model, are similar to those observed with the EC-method. The temperature reduction curve is well reflected in the EC-data, though parameter values differ from the originally expected values. For example at the freezing point, the observed GPP is 30% higher than predicted by the forest gap model. The response of observed GPP to soil moisture shows that the permanent wilting point is 7 vol-% lower than the value derived from the literature. The light response curve, integrated over the canopy and the forest stand, is underestimated compared to the measured data. The EC-method measures a yearly carbon balance of 13 mol(CO_2)m^{-2} for the Wetzstein site. The model with the original parameterization overestimates the yearly carbon balance by nearly 5 mol(CO_2)m^{-2} while the model with an EC-based parameterization fits the measured data very well. The parameter values derived from EC-data are applied on the spruce forest Waldstein and clearly improve estimates of the carbon balance.