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Validation of a 3D gas exchange model for a Picea abies canopy in the Fichtelgebirge, Germany

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Canopy exchange of water and carbon dioxide in a montane Norway spruce stand of Central Germany was analyzed with a three dimensional microclimate and gas exchange model STANDFLUX. The model describes canopy water vapor and carbon dioxide exchange based on rates calculated for individual trees and as affected by local gradients in photon flux density (PFD), atmospheric humidity, atmospheric carbon dioxide concentration, and air temperature. Direct, diffuse, and reflected PFD incident on foliage elements is calculated for a three dimensional matrix of points superimposed over the canopy. The model was used to calculate forest radiation absorption, net photosynthesis and transpiration of single trees, and gas exchange of the tree canopy. Model parameterization was derived for the Weidenbrunnen site, a 54-year-old Picea abies stand with a tree density of 730 trees per hectare in 2007. Parameterization included information on vertical and horizontal leaf area distribution, tree positions and tree sizes. Gas exchange was modeled using specific sets of physiological parameters for top, middle, and bottom of the canopy. Comparisons of the vertical distribution of modeled branch transpiration with water use estimates from xylem sapflow measurements in the canopy profile provided a test of the model. Estimates for canopy transpiration rate derived from the model and via xylem sapflow measurements agreed within expected uncertainty. The validation and documentation of STANDFLUX is an important step toward effective use of IOP-1 data from the entire EGER project. While one dimensional representations of canopy structure may often be applied in assessing vegetation/atmosphere exchanges of landscapes or regions, STANDFLUX provides a starting point for developing efficient tools for three dimensional simula-

tions of vegetation/atmosphere exchange of both, not reactive and reactive chemicals. Model development in the area of in-canopy turbulent transport is viewed as critical over the long-term in order to provide an efficient linkage between studies at the measurement sites and generalization via remote sensing/mesoscale modeling. The results are a contribution to the EGER project (Exchange Processes in Mountainous Regions, Deutsche Forschungsgemeinschaft), 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.