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Coupling of the atmospheric mesoscale model FOOT3DK to a photosynthesis model

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The interdisciplinary project SFB Transregio 32 aims at monitoring and modelling of patterns in soil-vegetation-atmosphere systems. Field and aircraft measurements show temporal and spatial small scale variability of CO2 and H2O fluxes, which are associated with small scale vegetation structures of varying photosynthetic activity. Within the subproject D1 of the SFB Transregio 32 the influence of surface heterogenities on atmospheric fluxes is simulated using the atmospheric mesoscale model FOOT3DK. Simulations are performed for the TR32 investigation area near Selhausen, located in North-Rhine-Westphalia, Germany, with a horizontal resolution up to 100 m. Since in the original model set-up no carbon cycle is included, FOOT3DK is coupled to a photosynthesis model, which consists of a C3 single-leaf model following Farquhar et al. (1980). Big-leaf approaches tend to overestimate photosynthesis activity, therefore an extended big-leaf model (de Pury and Farquhar, 1997) is used for the upscaling from leaf to canopy scale. In this so-called sun/shade model the canopy is divided into sunlit and shaded fractions and the net CO2 fluxes are calculated for both fractions separately.

For the validation simulations with the stand-alone version of the photosynthesis model are compared with field measurements for wheat and sugarbeet. Despite some slight overestimations simulated CO2 fluxes exhibit a good overall agreement with measured values. The general diurnal variation as well as local extrema (e.g. caused by clouds) are reproduced well.

High resolution simulations of the coupled FOOT3DK-photosynthesis model show reasonable results. While the diurnal cycle is matched well, the magnitudes of the simulated CO2 fluxes are considerably overestimated compared to measurements. The overestimations are probably caused by the ratio of photosynthetic active radiation to incoming solar radiation, which currently is assumed to be constant.

To investigate the influence of small scale heterogenities on the spatial variability of the CO2 and H2O fluxes, simulated near surface CO2 and H2O concentrations are compared to real concentrations available from aircraft measurements. These aircraft measurements are performed in the lower planetary boundary layer on altitudes down to 100 m.