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The simulation of the opposing fluxes of latent heat and CO2 over various land-use types – coupling a gas exchange model to a mesoscale atmospheric model

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A mesoscale meteorological model (FOOT3DK) is coupled with a gas exchange model to simulate surface fluxes of CO2 and H2O under field conditions. The gas exchange model consists of a C3 single leaf photosynthesis sub-model and an extended big leaf (sun/shade) sub-model that divides the canopy into sunlit and shaded fractions. Simulated CO2 fluxes of the stand-alone version of the gas exchange model correspond well to eddy-covariance measurements at a test site in a rural area in the west of Germany. The coupled FOOT3DK / gas exchange model is validated for the diurnal cycle at singular grid points, and delivers realistic fluxes with respect to their order of magnitude and to the general daily course. Compared to the Jarvis based big leaf scheme, simulations of latent heat fluxes with a photosynthesis based scheme for stomatal conductance are more realistic. As expected, flux averages are strongly influenced by the underlying land-cover. While the simulated net ecosystem exchange is highly correlated with the leaf area index, this correlation is much weaker for the latent heat flux. Photosynthetic CO2 uptake is associated with transpirational water loss via the stomata, and the resulting opposing surface fluxes of CO2 and H2O are reproduced with the model approach. Over vegetated surfaces it is shown that the coupling of a photosynthesis-based gas exchange model with the land-surface scheme of a mesoscale model results in more realistic simulated latent heat fluxes.