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Impact of future climate projections on carbon and water vapour fluxes of forest sites in two study regions in eastern Germany

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Observations in the past show effects of climate trends on site conditions and vegetation. The impact will continue or even increase in the future leading to changes in site conditions, land management and land-use distribution. However future climate projections depend on emission scenarios and are highly uncertain. The primary production is a sensitive parameter for studying early impacts on plants, because photosynthesis is affected by climatic variables and quantifies effects of shifts in phenological phases. Ecosystem production derived from eddy covariance (EC) measurements at the scale of the footprint area represents a link between the leaf and landscape scale. They serve for model validation when scaling from leaf to region by ecophysiological models. This study shows the combination of model parameterisation with spatially distributed data, model validation by time series of EC study sites and changes of gross primary production (GPP) and water-use efficiency (WUE) within the next 30 years for two different study regions (Weißeritz catchment in the Ore Mountains and Uckermark in the North German Lowlands). In contrast to the low mountain region, the northern lowlands are already limited by plant available water and increased drought effects are expected for the future. The study quantifies changes in GPP and WUE of forest and grassland sites for three decades (1990-1999, 2016-2025 and 2036-2045). Carbon and water fluxes are simulated by an ecophysiological based Soil-Vegetation-Atmosphere-Transfer model (SVAT-CN), which is parameterised by different input data of weather, land use and soil considering the spatial distribution. Areas with similar data for soil parameters, weather data and land use are combined to functional units of the model runs. The input parameters are derived by pedotransfer functions of soil maps and the CORINE land-use distribution of Germany was applied. The weather input data are simulation results of the regional climate model COSMO-CLM considering the IPCC emission scenarios A1B and B1 and available in one hour time steps for the considered ten periods. The ecophysiological parameters are taken from the literature and the validation results for carbon and water vapour fluxes are in acceptable similarity with the EC measurements (R2 = 0.60 for spruce (12 years) and R2 = 0.74 for beech (3 years)) comparing daily data. While the increase of GPP is similar for both emission scenarios (up to 8%) in the Weisseritz catchment, the increase is less pronounced in the North German Lowlands for the B1 scenario (up to 5 %) in comparison to the A1B scenario (up to 8 %). Therefore, WUE increases stronger for the B1 scenario (up to 16 %) in comparison to the A1B scenario (up to 12 %). Simulations for the Weisseritz catchment show a similar tendency. An exception of this results is the second comparison for A1B scenario in the Uckermark, which shows even a slightly decrease in WUE for the deciduous forest in comparison to an increase for the coniferous forest. The simulation results value future site conditions with respect to GPP and WUE and quantify uncertainty of the climate change impact related to different emission scenarios.