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Feedbacks between hydrology, micrometeorology and reactive trace gas exchanges in Earth system modeling

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Model simulations of the atmosphere-surface energy and water budget are sensitive to the parameterizations of surface exchanges that generally occur at typical spatial scales smaller than the spatial resolution of Earth system models. For example, by neglecting the spatial variability in convective rainfall the simulated throughfall of precipitation is underestimated whereas the evaporation from the wet-skin fraction, the so-called interception loss, is overestimated. These sensitivities are not limited to land surface energy and water exchanges but extend to the atmospheric chemistry via feedbacks between the surface biogeophysical properties, surface trace gas exchanges, atmospheric transport, and atmospheric composition. The impact of the spatial variability in convective rainfall interception on surface trace gas exchanges and atmospheric chemistry is investigated using the coupled chemistry-climate model ECHAM5/MESSy by implementation of a parameterization that accounts for sub-grid scale throughfall and interception losses. We analyse the direct effects on the dry deposition of ozone and formic acid, to illustrate the potential impact on the exchanges of insoluble and soluble compounds, respectively. We also studied the indirect effects through changes in the micro-meteorology and hydrology on volatile organic compound emissions, transport and the removal of oxidation products. This shows the importance of fully interactive approaches with respect to hydrological, meteorological and atmospheric chemical processes in Earth system modelling.