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Implementation of a Simple Fire Emission Height Model in ECHAM6-HAM2: Model Evaluation and Potential Climate Impact

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We use the global circulation model ECHAM6 extended by the aerosol module HAM2 to assess the impact of advanced fire emission height parametrizations in global climate models. Fire emission heights describe the altitudes at which vegetation fire smoke plumes release emissions into the atmosphere. In this study prescribed injection heights in ECHAM6-HAM2 are replaced by an implementation of a simple, semi-empirical plume model published by M. Sofiev in 2012. The 1-D plume model predicts maximum emission heights based on ambient meteorological conditions and fire radiative power (FRP). In a first step, the global model performance is evaluated against the latest version of the 'MISR Plume Height Project' data set. Our results show that the model simulates a largely reasonable global distribution of emission injection heights. Extra-tropical plume heights are represented slightly more adequate than tropical plumes, although deep extra-tropical injections are generally underestimated. By adjustment of the tuning parameters, the bias of the extra-tropical deep injections can be significantly reduced and thus the modified plume model offers a reasonable representation of fire emission heights in a global climate model.

In a second step, we apply the fire activity and emission inventory of the Global Fire Assimilation System (GFAS) to ECHAM6-HAM2. The assignment of single fires to a limited number of FRP classes enables a comprehensive and feasible representation of individual fire intensities within a global climate model. In addition to the meteorological parameters, the individual FRP values serve as input variable for the 1-D plume height model. We compare the results of our multi-year simulations based on this advanced fire emission height representation to standard ECHAM6-HAM2 simulations and discuss the effects of modified emission height distributions on global aerosol transport and radiative transfer. The changes in first order radiative aerosol effects turn out to be relatively small, but black carbon concentrations and deposition rates show significant changes in some regions. Furthermore, modelled changes in atmospheric aerosol concentrations and aerosol optical properties are compared to observations. Thus, we evaluate the specific influence of the plume height model on the overall performance of the global circulation model. In summary, this study contributes to a better understanding of the importance, the benefits and the limitations of advanced emission height parametrizations in global circulation models.