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Snow darkening caused by black carbon emitted from fires

Jessica Engels (1,2), Silvia Kloster (1), Quentin Bourgeois (3,4)

(1) Max Planck Institute for Meteorology, Land in the Earth System, Hamburg, Germany (jessica.engels@mpimet.mpg.de), (2) International Max Planck Research School on Earth System Modelling, Hamburg, Germany, (3) Center for Climate Systems Modeling, Institute for Atmospheric and Climate Science, ETH Zürich, Zurich, Switzerland, (4) Institute of Environmental Engineering, Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

We implemented the effect of snow darkening caused by black carbon (BC) emitted from forest fires into the Max Planck Institute for Meteorology Earth System Model (MPI-M ESM) to estimate its potential climate impact of present day fire occurrence. Considerable amounts of black carbon emitted from fires are transported into snow covered regions. Already very small quantities of black carbon reduce the snow reflectance, with consequences for snow melting and snow spatial coverage. Therefore, the SNICAR (SNow And Ice Radiation) model (Flanner and Zender (2005)) is implemented in the land surface component (JSBACH) of the atmospheric general circulation model ECHAM6, developed at the MPI-M.

The SNICAR model includes amongst other processes a complex calculation of the snow albedo depending on black carbon in snow and snow grain growth depending on water vapor fluxes for a five layer snow scheme. For the implementation of the SNICAR model into the one layer scheme of ECHAM6-JSBACH, we used the SNICAR-online version (http://snow.engin.umich.edu). This single-layer simulator provides the albedo of snow for selectable combinations of impurity content (e.g. black carbon), snow grain size, and incident solar flux characteristics. From this scheme we derived snow albedo values for black carbon in snow concentrations ranging between 0 and 1500 ng(BC)/g(snow) and for different snow grain sizes for the visible (0.3 - 0.7 μm) and near infrared range (0.7 - 1.5 μm). As snow grains grow over time, we assign different snow ages to different snow grain sizes (50, 150, 500, and 1000 μm). Here, a radius of 50 μm corresponds to new snow, whereas a radius of 1000 μm corresponds to old snow. The required snow age is taken from the BATS (Biosphere Atmosphere Transfer Scheme, Dickinson et al. (1986)) snow albedo implementation in ECHAM6-JSBACH.

Here, we will present an extended evaluation of the model including a comparison of modeled black carbon in snow concentrations to observed ones, as well as the impact on simulated snow cover. The potential climate impact will be analyzed in terms of the radiative forcing caused by the snow darkening induced changes in surface albedo.