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Deforestation fire carbon emissions for the last millennium simulated with the global vegetation model JSBACH

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Humankind has fundamentally modified the Earth's terrestrial surface to secure food and other resources by conversion of natural ecosystems to managed areas. Until today, these anthropogenic changes in land cover have resulted in an extent of conversion from natural land cover by human activities to managed areas between one-third and one-half of the total Earth's land cover (Vitousek (1997)). Large parts of this conversion take place in the form of deforestation fires, which release atmospheric trace gases and aerosols into the atmosphere. These deforestation fires are climate dependent and follow a strong seasonal cycle, which is important for atmospheric chemistry.

In the present study, the offline version of the JSBACH carbon pool model of the Max Planck Institute for Meteorology (MPI-M) is used to simulate climate dependent deforestation fire carbon emissions over the last millennium (800-2010). For this, the standard carbon allocation scheme is extended by four additional anthropogenic carbon pools. These pools separate the carbon amount released due to anthropogenic land cover change from the carbon amount released due to natural processes to the atmosphere. The climate dependent deforestation fire emissions are simulated in the model by a linear dependency on the soil moisture. This new carbon allocation scheme results in land cover change carbon emissions, which accumulate between 800 and 2010 to 239.8 PgC. Thereby, the climate dependent deforestation fire carbon emissions accumulate over the last millennium to 182.6 PgC yr^{-1} in the year 2010, which accounts for 76% of the total land cover change carbon emissions. Compared to present day satellite based observational data sets (GFED3) the simulated mean deforestation fire carbon emissions (1422.5 TgC yr^{-1}) averaged over the time period 1997-2009 are about a factor of 4 higher than the observed carbon emissions (386.4 TgC yr-1) on a global scale. However, compared to a field-observational based estimate, the simulations underestimate deforestation fire carbon emissions by around 54% for the time period 1990-2007.

Generally, the simulations performed for the present study capture the observed peak fire months of deforestation fire carbon emissions. However, the length of the burning season is slightly overestimated, and the range between the maximum and minimum deforestation fire carbon emissions within a year is underestimated in the model.

This study provides a consistent modelling estimate of monthly mean deforestation fire emissions for the last millennium that resolve the seasonal dependent nature of the deforestation process, which can be applied in atmospheric chemistry modelling studies.