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Historical (1700-2012) global multi-model estimates of the fire emissions from the Fire Modeling Intercomparison Project (FireMIP)

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Fire emissions are a critical component of carbon and nutrient cycles and strongly affect climate and air quality. Dynamic global vegetation models (DGVMs) with interactive fire modeling provide important estimates for long-term and large-scale changes in fire emissions. Here we present the first multi-model estimates of global gridded historical fire emissions for 1700-2012, including carbon and 33 species of trace gases and aerosols. The dataset is based on simulations of nine DGVMs with different state-of-the-art global fire models that participated in the Fire Modeling Intercomparison Project (FireMIP), using the same and standardized protocols and forcing data, and the most up-to-date fire emission factor table based on field and laboratory studies in various land cover types. We evaluate the simulations of present-day fire emissions by comparing them with satellite-based products. The evaluation results show that most DGVMs simulate present-day global fire emission totals within the range of satellite-based products. They can capture the high emissions over the tropical savannas and low emissions over the arid and sparsely vegetated regions, and the main features of seasonality. However, most models fail to simulate the interannual variability, partly due to a lack of modeling peat fires and tropical deforestation fires. Before the 1850s, all models show only a weak trend in global fire emissions, which is consistent with the multi-source merged historical reconstructions used as input data for CMIP6. On the other hand, the trends are quite different among DGVMs for the 20th century, with some models showing an increase and others a decrease in fire emissions, mainly as a result of the discrepancy in their simulated responses to human population density change and land use and land cover change (LULCC). Our study provides an important dataset for further development of regional and global multi-source merged historical reconstructions, analyses of the historical changes in fire emissions and their uncertainties, and quantification of the role of fire emissions in the Earth system. It also highlights the importance of accurately modeling the responses of fire emissions to LULCC and population density change in reducing uncertainties in historical reconstructions of fire emissions and providing more reliable future projections.

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