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Fire-driven dust emissions – applying a newly developed parameterization scheme in a global aerosol-model

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Vegetation fires represent a major, mostly anthropogenically-driven, component of the Earth system that are affecting different landscapes in multiple regions of the globe and are supposed to increase further in number and severity with the ongoing climate change. Measurements and conceptional model studies have already shown that the fire-induced disturbance of the near-surface wind patterns allow for the mobilization of soil dust particles and their injection into the atmosphere through the pyro-convective updrafts related to the fires. However, the dust emission schemes of the current generation of aerosol-climate models do not consider this fire-related emission pathway and focus on wind-driven dust emissions of mostly unvegetated landscapes such as deserts only. This can result in an underrepresentation of dust particles in the fire-affected regions with consequences regarding a correct representation of aerosol-atmosphere interactions such as the radiation budget.

Therefore, the present study aims to provide more insights concerning the importance of fire-driven dust emissions in the climate system. In order to achieve this, the process was implemented as a new emission pathway into the aerosol module HAM (Hamburg Aerosol Module) of the newly coupled aerosol-climate model ICON-HAM. Information about the behavior of the fire-affected wind fields and their potential to overcome typical emission thresholds have been used to set the dust emission fluxes in relation to data of the global fire activity, expressed by the fire radiative power (FRP), and to land-surface characteristics such as soil type and surface roughness.

Multi-year global simulations of ICON-HAM were analyzed to quantify the impacts of the additional dust emissions caused by the fire activity and their injection parameterization on a seasonal and continental scale. It was found that the strength of the fire-related dust emissions strongly depends on the region where the fire occurs, which is determined by the local soil-surface conditions and not only by the fire strength. However, the vegetation fires can lead to an increase of the atmospheric dust load even in regions far away from those commonly known as dust source areas, highlighting that fire-driven dust emissions can substantially contribute to the total aerosol load and in particular its composition within fire-prone regions or also within a fire-prone climate.