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Editorial: Observations and modelling of recent extreme wild fire events and their impact on the environment and climate

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Editorial on the Research Topic
Observations and Modelling of Recent Extreme Wild Fire Events and their Impact on the Environment and Climate

Anthropogenic climate change is known to increase the average global surface mean temperature, intensity of heatwaves, and decrease surface humidity and soil moisture (Pörtner et al., 2022). In a Science Brief Review, Smith et al. (2020) reveal the significant correlation between those factors, i.e. the occurrence of what is called "extreme fire weather" (Jain et al., 2022) and the already occurring increase in extent and frequency of wild fires. Through increased fire intensities, "mega fires" can develop, with particularly severe impacts on the atmosphere, environment, and climate. Some examples of mega fires during the past 5 years are:

- The British Columbia (Canada) fires from June/July 2017 with around 1,200,000 ha burned
- The Siberian fires (Russia) from July 2019 with 3,000,000 ha burned
- The Australian fires from September 2019 to February 2020 with 24,300,000 ha burned
- The Pantanal rainforest fires (in Brazil) from January to August 2020 with around 380,000 ha burned and
- The California (United States of America) wildfires from June/July 2021 with around 1,000,000 ha burned

All of the above-mentioned fires are associated with unusually long preceding drought phases alongside very low rainfall quantities and favoring conditions for the outbreak of extreme wildfires such as high winds. Those incidences generate unprecedented case studies in terms of their impacts, including environmental hazards such as implications for the ecosystems, animal biodiversity and air pollution through large areas burned. In addition, extreme fires can develop intense pyro-convection with possible upper-tropospheric injections or even stratospheric overshoots. Through stratospheric injections, biomass burning gaseous and aerosol pollutants can impact globally and over long time periods. Stratospheric biomass burning plumes can have significant impacts on the radiative balance and the climate system. The self-rising feature, driven by radiative heating of absorbing biomass burning aerosols in the upper troposphere and lower stratosphere (shown, e.g., for the aerosol plume of the 2017 British Columbia fires in Yu et al. (2019), for example, promotes a longer lifetime of aerosols in the stratosphere and thus a longer radiative impact compared to aerosol plumes originating from volcanic eruptions. The impact on climate of the 2019/2020 Australian fires has been the strongest ever recorded for wildfire events, comparable with the impact of moderate volcanic eruptions (e.g. from the Raikoke eruption in June 2019; Sellitto et al. (2022)). The intensity of these events have been of unprecedented consequences, such as significant H_2O anomalies at altitudes beyond 25 km (Kablick et al., 2020), mainly due to the severity of the fires and the level of energy emitted (Li et al., 2021).

This Research Topic aims to provide a platform for environmental and climatic impact studies of extreme fire events of the past few years, including studies of the impact on the atmospheric composition and regional air quality, as well as studies validating the methodology of retrievals and observations of fire-related parameters. Published studies within this Research Topic deal with environmental aspects of most of the intense wildfires of the past 2 years and give an overall overview of extreme fire events back to 2014. The broad scale effects of wildfires to peatlands in North America (2014/2015) under extreme drought conditions is studied in Bourgeau-Chavez et al. The impact of the Siberian fires in 2019 is discussed in Ansmann et al., the Australian fires 2019/2020 in Kloss et al. and the origin and distribution of the Pantanal fires in Brazil in 2020 is discussed in De Magalhaes et al. The four studies together cover a broad range of research fields, studying the atmospheric impact, examining the accuracy of satellite observation classifications, analyzing the burn severity and its association with human and climate factors.

Bourgeau-Chavez et al. studied 136 fire events and their respective effects on the hydrology and ecosystem functions of boreal peatlands, using their own developed Landsat-8 algorithm, to map severity of burn to the organic soil layers. They find that peatlands on the Taiga shield are more susceptible to wildfire events than those on the Taiga plains as they are smaller and hydrologically more isolated by the rocky landscape, as opposed to the hydrologically well-connected peatlands in the plains. As a consequence of the fires, the spatial diversity of the smaller peatlands in the shield may be reduced due to the relatively large area affected by more such extensive fires.

Ansmann et al. find methodological limitations of the aerosol speciation scheme algorithm from Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIOP) space-borne observations. With ground-based lidar observations they identify a stratospheric smoke aerosol plume, while CALIOP observations of the same plume were classified purely consisting of sulfate aerosols. This misclassification of CALIOP observations might have led to an overestimated impact of the volcanic eruption (at Raikoke in June 2019) and underestimated stratospheric impact of the Siberian fires in July 2019, respectively.

Kloss et al. investigate aerosol and trace gas plumes, originating from the Australian fires (2019/2020) and their respective transport around the globe in the free atmosphere. They show that the Australian fires already had a significant impact on the global free atmosphere, starting from September 2019, before the spectacular stratospheric injection *via* pyro-convection during the turn of the year 2019/2020.

De Magalhaes et al. explain the link between climate and human factors and the burn severity of the Pantanal fires (in South America in 2020). They show that most (~80%) of the fire outbreak occurred close (< 10 km) to areas with human activities. Furthermore, they find that favorable climate conditions (e.g., with a drought index < -2.6) enhanced the irreversible fire spread. This underlines the relationship between human activities (in this case expansion through road networks) into natural ecosystems and the increase of fire occurrences in such regions.

All together, the studies within this Research Topic emphasize the impact of extreme fire events on the global atmosphere, climate and its link to the regional ecosystem. They furthermore show that some caution is necessary when working with pre-classified space-borne observations and give concrete concern about road expansion projects (as in the Pantanal natural region), which may increase the risk for future fire events.

With increasing frequency and severity of wildfires with global warming, this Research Topic will remain of high importance and actuality for the coming decades.

Author contributions

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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