Aerosol direct radiative effects from extreme fire events in Australia, California and Siberia occurring in 2019-2020.

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The purpose of this study is to investigate extreme biomass burning events observed during the years 2019-2020 over three specific regions (Australia, California, and Siberia), in terms of aerosol emission, vertical structure, transport, and direct radiative forcing. This study is based on the comparison between global climate simulations carried out with the ARPEGE-Climat model developed at CNRM and reference datasets (reanalyses, ground-based observations and satellite data). Our results first demonstrates the need to constrain the injection heights in the model to realistically represent the extinction vertical profiles observed during the period of fires, both in the troposphere and in the lower stratosphere due to the contribution of pyro-convection. In this sense, specific emissions profiles for fires over the three study regions have been defined. Without these specific profiles, our simulations as well as aerosol reanalyses suffer to represent biomass burning aerosol extinction vertical profiles for such events. For each region studied, the modeled aerosol optical depth is extremely high, exceeding the value of 2 at 550 nm, and remaining very high during the transport of smoke over ocean. In addition, the ARPEGE-Climat simulations clearly indicate that biomass burning aerosols can significantly affect the lower stratosphere over Australia by increasing extinction by 10 times during the fire period, which is less marked over the two other regions studied here. These extremely dense plumes significantly perturb the solar radiation reaching the surface and exert an important direct shortwave radiative forcing up to -90 W.m-2 over the Australian region. At the top of the atmosphere, the direct aerosol radiative forcing from biomass burning plumes is generally negative (cooling), but is found positive (warming) when dense and strongly absorbing smoke plumes are advected over regions with high albedo due to cloud cover such as in the Pacific Ocean off the coasts of Australia and California. This positive forcing is not simulated in the absence of aerosol plumes in the lower stratosphere brought by pyro-convection. Over each region, aerosol absorption leads to an increase of solar heating rate, this increase represents a doubling of the initial quantity in the stratosphere.

Keywords: Biomass Bunrning Aerosols, Direct Radiative Forcing at regional scale, Extreme fire events

References