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Pyrocumulonimbus Events over British Columbia, 2017: The Long-term Transport and Radiative Impacts of Smoke Aerosols in the Stratosphere

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Interactions of meteorology with wildfires in British Columbia, Canada during August 2017 led to several extreme pyrocumulonimbus (PyroCb) events that resulted in the injection of smoke aerosols and other combustion products into the lower stratosphere. These plumes of stratospheric smoke were observed by many satellite instruments to have elevated values of aerosol extinction and backscatter compared to the background state and were readily tracked as they spread across the Northern Hemisphere and resided in the lower stratosphere for about ten months following the fires. To investigate the radiative impacts of these events on the Earth system, we performed a number of simulations with the Goddard Earth Observing System (GEOS) global Earth system model, which includes detailed aerosol and chemistry packages coupled to the underlying model physical and dynamical cores. Retrievals of smoke aerosol properties from space-based OMPS/NPP, SAGE-III/ISS, and CALIOP/CALIPSO instruments were used to calibrate the injection location, timing, amount, and optical properties of the smoke aerosols. The resulting simulations of three-dimensional smoke transport were evaluated over a year following the injections using observations from OMPS-Limb Profiler (LP), which provides aerosol retrievals at a high temporal and vertical resolution for altitudes greater than 10 km. We found that diabatic heating due to aerosol absorption, combined with the large-scale atmospheric motions, play important roles in lifting the smoke plumes from near the tropopause altitudes to about 22 km into the atmosphere. The model was able to simulate the rate of plume ascent from lower to the middle stratosphere, hemispherical spread and residence time of the smoke aerosols in the stratosphere in close agreement with OMPS-LP. Finally, we also investigated the impact of these PyroCb emitted smoke aerosols on the stratospheric radiative forcing and the subsequent impact on temperature tendencies.