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Stratospheric impact of the anomalous 2023 Canadian wildfires

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The frequency of extreme wildfires has increased as a response to the regional and global warming trends and there is an emerging realization of their impact on climate through emissions of smoke aerosols into the stratosphere. The 2023 wildfire season in Canada was unprecedented in terms of its duration, burned area and cumulative fire power, rendering it the most destructive ever recorded.

Here we use various satellite observations (TROPOMI, OMPS-LP, OMPS-NM, MLS, CALIPSO, SAGE III) to quantify the stratospheric emissions of smoke aerosols and carbon monoxide by the 2023 Canadian wildfires and to characterize the long-range transport of smoke plumes in the stratosphere. Using multiwavelength lidar observations in Northern France, we show systematically distinct microphysical properties of UTLS smoke aerosols compared to their free-tropospheric counterparts.

The analysis of satellite data reveals multiple episodes of smoke intrusions into the stratosphere through pyroconvection (PyroCb) and synoptic-scale processes (warm conveyor belt, WCB). Model simulations using MOCAGE chemistry-transport model, which included emission data from GFAS (Global Fire Assimilation System) are shown to accurately capture the synoptic-scale uplift of smoke into the UTLS and reproduce the spatial evolution of the aerosol plumes.

We show that the multiple episodes of wildfire-driven stratospheric intrusions during Boreal Summer 2023 through PyroCb and WCB mechanisms are altogether responsible for the record-high and persistent season-wide smoke pollution at the commercial aircraft cruising altitudes and the lowermost stratosphere.