Properties of Biomass Burning Aerosols and Their Variabilities in 2020 North American Wildfires

Qiaoyun Hu[(1)], Philippe Goloub[(1)], Igor Veselovskii[(2)], Thierry Podvin[(1)]

[(1)] *Univ. Lille, CNRS, Laboratoire d'Optique Atmosphérique, France, E-mail: qiaoyun.hu@univ-lille.fr*

[(2)] *Prokhorov General Physics Institute, Moscow, Russia, E-mail:iveselov@hotmail.com*

As an important contributor to atmospheric aerosols, biomass burning (BB) aerosols impact the Earth's climate in both direct and indirect manners. The properties and composition of BB particles are highly varying due to the complexity in the combustion and the aging processes. A better characterization of BB particles is required to improve our understanding about the role of BB aerosols in the ecosystem and to increase the accuracy of the climate model. In summer 2020, large scale wildfires emerged in the west of North America (NA) and the emitted BB plumes reached the upper troposphere and lower stratosphere (UTLS) and then transported to large areas in the northern hemisphere. In September 2020, the lidar LILAS operated at the ATOLL platform (ATmospheric Observatory of liLLe), North of France, belonging to ACTRIS atmospheric infrastructure, detected a series of long-range transported BB plumes originated from two intense wildfire complexes in NA (i.e., Creek fire and Oregon fire). The maximal optical depth of the BB plumes detected at ATOLL reached ~0.5 at 440 nm. This situation offered an opportunity to obtain high-quality observations and statistics. The lidar measurements revealed different characteristics of BB properties originated from the two different burning events and distinct plume features were also captured by satellites and ground-based photometers in AERONET.

LILAS provides profiles of 2 extinction coefficients (355 and 532 nm), 3 backscattering coefficients (355, 532, 1064 nm), 3 depolarization ratios, water vapor mixing ratio and aerosol fluorescence (at 460 nm). The fluorescence channel brings new atmospheric variables, i.e., fluorescence backscatter coefficient and fluorescence capacity, and enables the quantification of fluorescent aerosols, i.e., BB aerosols, even at very low concentrations. LILAS observed that BB plumes from the Creek fire have higher extinction Angstrom exponent (EAE~0.6), lidar ratios (40/60 sr at 355/532 nm), fluorescence capacity (~4.0) and lower particle depolarizations (0.10/0.05/0.01 at 355/532/1064 nm) compared to those from the Oregon fires, which have EAE about 0, depolarization ratio about 0.18 and lidar ratio as low as 25 sr at 355 nm. Aerosol properties derived from several AERONET stations located on the plume trajectory showed that BB particles from the Oregon fires are characterized with larger particle size and lower absorption (especially in the visible and near-infrared band), which is consistent with our lidar-derived aerosol properties within these BB plumes.

According to radiative transfer calculations, such differences in BB particle properties could lead to a difference of radiative forcing efficiency up to 15-25% at the surface level. It suggests that the variability of BB properties could introduce non-negligible uncertainties in the estimate of the radiative effect of wildfire emission.