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Optical, physical and chemical characteristics of Australian aerosols associated with fire events from 2002 to 2019

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Wildfires are an important contributor to atmospheric aerosols in Australia and could significantly affect regional and even global climate. This study investigates the impact of fire events on aerosol properties along with the long-range transport of biomass burning aerosol over Australia using multi-year measurements from Aerosol Robotic Network (AERONET) at ten sites over Australia, satellite dataset derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) and Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP), reanalysis data from Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2), and back-trajectories from the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT). The fire count, FRP, and AOD showed distinct and consistent interannual variations with high values during September-February (Biomass Burning period, BB period) and low values during March-August (non-Biomass Burning period, non-BB period) every year. Strong correlation (0.62) was found between fire radiative power (FRP) and aerosol optical depth (AOD) over Australia. Furthermore, the correlation coefficient between AOD and fire count was much higher (0.63-0.85) during October-January than other months (-0.08-0.47). Characteristics of Australian aerosols showed pronounced difference during BB period and Non-BB period. AOD values significantly increased with fine mode aerosol dominated during BB period, especially in northern and southeastern Australia. Carbonaceous aerosol was the main contributor to total aerosols during BB period, especially in September-December when carbonaceous aerosol contributed the most (30.08-42.91%). Aerosol size distributions showed a bimodal character with both fine and coarse aerosols particle generally increased during BB period. The mega fires during the BB period of 2019/2020 further demonstrated the significant impact of wildfires on aerosol properties, such as the extreme increase in AOD for most southeastern Australia, the dominance of fine particle aerosols, and the significant increase in carbonaceous and dust aerosols in southeastern and central Australia, respectively. Moreover, smoke was found as the dominant aerosol type detected at heights 2.5-12 km in southeastern Australia in December 2019 and at heights roughly from 6.2 to 12 km in January 2020. In contrast, dust was detected more frequently at heights from 2 to 5 km in November 2019, January, and February 2020. A case study emphasized that the transport of biomass burning aerosols from wildfire plumes in eastern and southern Australia significantly impacted the aerosol loading, aerosol particle size, and aerosol type of central Australia.