캘리포니아지역 산불 발생에 따른 블랙카본과 브라운카본의 광흡수 기여도 변화

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Changes in the contribution of black and brown carbon to aerosol light absorption during wildfire events in California

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요 약

In this study, the changes in the contribution of black carbon and brown carbon to aerosol light absorption during wildfire events in California is estimated by analyzing the variation of aerosol optical properties during wildfire events and quantifying the contribution of BC and BrC to column absorption aerosol optical depth. Also, the relationship between fire counts and BC and BrC contribution is investigated and suggests that wildfires play an important role in the radiation budget by increasing the contribution of BrC to column aerosol light absorption.

1. Introduction

It has been reported that since the late 20th century, significant fire events in California tend to occur every five to seven years. This apparent oscillation has implications on the physical coupling of climate and wildfire. Smoke aerosols from wildfire in a daytime convective boundary layer was found to warm the atmosphere leading to the direct radiative effect (DRF) due to fire aerosols at shortwave was +0.16 W m^{-2} (Liu *et al.*, 2014; Jiang *et al.*, 2020). When such wildfires occur contributing to the heating of the atmosphere, a large amount of brwon carbon (BrC) is emitted with black carbon (BC), which are major contributor to the atmospheric heating by absorbing the solar radiation reaching the Earth's surface. However, most optical instruments that quantify light absorption are unable to distinguish one type of absorbing aerosol from another (Moosmüller *et al.*, 2009). The limitation of measurements could cause the uncertainties of DRF by BC and BrC.

According to IPCC AR5, BrC from biomass burning such as wildfires has a greater radiative forcing than fossil fuel. Therefore, the BrC from wildfires could significantly affect the global climate comparable to BC.

In this study, the changes in the contribution of BC and BrC to aerosol light absorption during wildfire events in California is estimated by analyzing the variation of aerosol optical properties during wildfire events and quantifying the contribution of BC and BrC to column absorption aerosol optical depth. Also, the relationship between fire counts and BC and BrC contribution is investigated.

2. Site and Method

In this study, column aerosol optical properties observed at Fresno, Monterey and UCSB sites of Aerosol Robotic Network (AERONET) in California from 2002 to 2020 were analyzed and Moderate Resolution Imaging Spectroradiometer (MODIS) data was used for fire data.

BC and BrC have their own spectral dependence on absorption. Usually, the wavelength dependence of BC is considered as to be 1, whereas that of BrC is higher than that of BC. The use of differences in wavelength dependence for type of aerosols is called as absorption Ångström exponent (AAE) method and this method is used in this study to classify the effect of BC and BrC.

3. Result

Fresno, Monterey and UCSB sites showed significant increase in aerosol optical depth (AOD), absorption aerosol optical depth (AAOD) and fine mode aerosols during wildfire events in August to October 2020 compared to the past. The increase in scattering Ångström exponent (SÅE) and AÅE at the point of increasing AOD and AAOD showed the effect of BrC from wildfires.

The BrC contribution to column AAOD was well consistent with the variations of fire counts at the three sites and the ratio of BrC to BC contribution well correlated with the fire pixel counts. In Fresno, the contribution of BrC tended to increase up to about 60% or more when there are many fire pixel counts, and when it is directly affected by a wildfires, the contribution of BrC was higher than 40%. Compared to Fresno, in Monterrey and UCSB, it is somewhat difficult to determine the continuous change in the contribution of BC and BrC due to the missing data, but also in these two sites, when the fire pixel counts increased, the contribution of BrC was relatively high.

For Aug. - Oct. 2020 (Jan. - Dec. 2002 to 2019), the BrC contribution to AAOD at 440 nm on the day of the wildfire impact was about 19%, 16%, and 20% (12%, 10%, 18%) higher than that of the other day at Fresno, Monterey, and UCSB, respectively. This result suggests that wildfires play an important role in the radiation budget by increasing the contribution of BrC to column aerosol light absorption.

Reference

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