2D2) Effects of Siberian Forest Fires on Air Quality in East Asia during May 2003 and Its Climate Implication

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1. Introduction

Forest fires are one of the major sources of CO, volatile organic compounds, and nitrogen oxides and thus have a significant effect on tropospheric ozone. They also release high concentrations of aerosols into the atmosphere and result in a severe visibility degradation and harmful effects on human health(Bowman and Johnston, 2005; Park et al., 2006). The ozone precursors and aerosols from forest fires are transported over long distances, affecting air quality in downstream regions (Park et al., 2007). In addition, ozone and aerosols have important climatic implications because of their effects on the earth-atmosphere radiative system(Pfister et al., 2008).

In May 2003, intense forest fires occurred over Siberia, which were the largest fires in the past decade. In this study, we have quantified the effects of the Siberian forest fires on regional air quality and their impact on climate over East Asia.

2. Methods

We conducted fully coupled oxidant-aerosol simulations using a 3-D global chemical transport model(GEOS-Chem) to quantify the effects of the Siberian forest fires on PM_{10} and ozone concentrations over East Asia in May 2003. The injection height of the forest fire emissions is one of the critical factors in determining the spatial range of fire plume transport and hence the air quality in the downwind regions. Therefore, we also examine the sensitivity of the model to different injection heights of fire emissions by comparing the simulated results with the observations. Differences between simulations with and without fire emissions are used to determine enhancements in concentrations due to the fires. We applied the model results to compute the radiative forcing of aerosols and ozone from the Siberian forest fires as a measure of the climate impact over East Asia.

The GEOS-Chem includes more than 80 species and 300 reactions for a detailed ozone-NOx-hydrocarbon chemistry coupled with aerosol chemistry. The aerosol simulation includes H_2SO_4-HNO_3-NH_3 aerosol thermodynamics, primary organic carbon(OC) and elemental carbon(EC), secondary organic aerosol(SOA), soil dust, and sea salt(Park et al., 2006). Biomass burning emissions for 2003 were computed using dry mass burned data with a spatial resolution of 1°×1° and monthly time resolution from the Global Fire Emissions Database version 2.

3. Results and discussion

Fig. 1 shows the spatial distributions of the simulated monthly mean PM_{10} and daytime ozone concentrations in surface air over East Asia in May 2003. The enhancements in the PM_{10} and ozone concentrations due to the Siberian fires are also shown in the figure. The peak increases in the surface PM_{10} and ozone concentrations were up to 90μg m^{-3} and 33ppbv, respectively, over Siberia. In the downwind regions, the increases ranged from 5 to 30μg m^{-3} and from 3 to 20ppbv for PM_{10} and ozone concentrations, respectively, having an important implication for air quality over East Asia.

We computed the radiative forcing of aerosols and ozone from the Siberian forest fires as a measure of climate impact. Siberian forest fires were found to act mainly as a cooling agent resulting in a negative radiative forcing of $-5.8 W m^{-2}$ at the surface over East Asia. The value at the top of the atmosphere was $-1.5 W m^{-2}$, indicating that a considerable absorption of radiation occurred in the atmosphere. This result implies that the Siberian forest fires may affect the regional climate over East Asia by intensifying atmospheric stability.

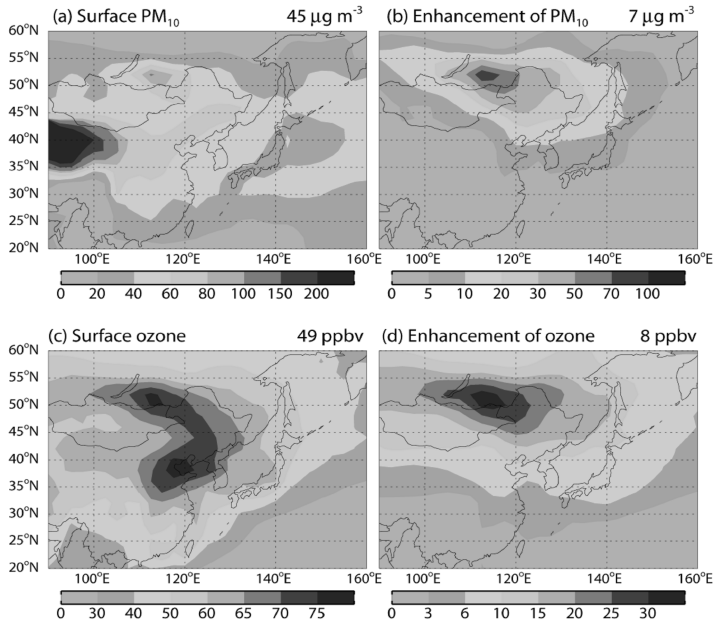

Fig. 1. Spatial distributions of the simulated monthly mean (a) PM_{10} and (c) daytime ozone concentrations at the surface. The enhancements in (b) PM_{10} and (d) daytime ozone concentrations due to the Siberian forest fires were computed by subtracting the simulation without the fire emissions.

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