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The impact of trans-boundary transport of carbonaceous aerosols on the regional air quality in the United States

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1. Introduction

Recent research on sources of carbonaceous aerosols in United States using global simulation GEOS-CHEM performed a quantitative estimation of Elemental Carbon (EC) and Organic Carbon (OC) concentration influenced by both domestic anthropogenic sources and trans-boundary transport (Park et al., 2003). Their results revealed significant imports from Canada and Mexico on carbonaceous aerosols in the United States. Such a long-range transport of aerosols became a subject of extensive studies to quantify background level of aerosols in the United Sates. In the year of 1998, in particular from April to June, severe biomass burning in central and southern America brought out resulting from an enhanced drought condition (Bell et al., 1999). Our study imposes focus on quantitative estimation of carbonaceous aerosols transport by incorporating GEOS-CHEM as initial and boundary conditions of CMAQ for the episodic event of May 1998 Mexican fire.

2. Methods

US EPA National Emission Inventory (NEI) 99 is anthropogenic emission source for this EC/OC simulation and processed using the Sparse Matrix Operator Kernel Emission (SMOKE) version 1.4 for providing emission input compatible with CMAQ. NEI99 does not include biomass burning emission which is critical source for EC/OC production. The absence of fire emission leads us to adopt global scale dry mass burnt as total of a month compiled at $1°\times1°$resolution (Duncan, 2002) and re-gridded for CMAQ domain configuration under a mass-conserving constraint after mapping. We adopt general linking procedure which is described by Moon et al. (2005) where key points are coordinate conversion in horizontal and vertical and chemical mapping between GEOS-CHEM and CMAQ. Boundary conditions are given by three-hour archived GEOS-CHEM model outputs continuously.

3. Results and discussions

Figure 1 shows simulated monthly mean spatial distribution of EC and OC concentration in the lowest bottom layer (sigma value=0.998) under three different run scenarios and also observed monthly mean values from IMPROVE surface network marked by circles. Simulation with NEI99 and profile boundary values (NEI99_Profile run)reproduces a air quality pattern of high concentration in several Eastern States and western coastal states (states of California, Oregon, and Washington) reflecting lots of emission, however, fails to track carbonaceous aerosol concentrations in southern several states (Arizona, Texas, Arkansas, Georgia, and Tennessee) due to lack of biomass burning emission in NEI99. EC/OC simulation with NEI99 plus biomass burning emission without GEOS-CHEM linkage (NEI99sBIO_Profile run) shows an intense concentration in Mexico as a response to additional emission. Biomass burning emission in Mexico region included in modeling domain also causes an enhance of EC and OC in southern United States but its effecting region is not as much as broad compared to the trans-boundary transport. The best simulation(NEI99sBIO_Linkage run) of EC and OC captures very well spatial concentration pattern characterized by high concentration in neighboring Mexico and southern eastern states, reflecting the trans-boundary transport effect.

Scatter plots of EC/OC as a monthly mean simulated versus observed values at IMPROVE sites under the best run scenario show correlations of R=0.60 for EC and R=0.85 for OC, respectively (Fig. 2). The slopes of the reduced major axis regression line however, reveal low bias of EC (0.69) and high bias of OC (1.10) concentrations. The low bias of EC indicates the emission error by the NEI99 inventory. Figure 2 shows that our linking approach increases accuracy of simulated aerosol concentrations preciously as resulted in the regression line which moves closer to one-to-one line.

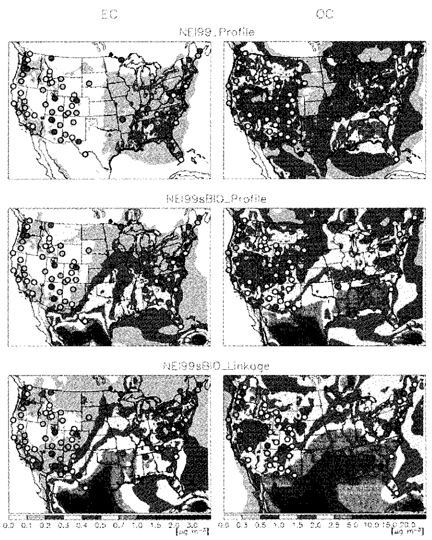

Figure 1. Simulated monthly mean spatial distribution of EC/OC concentration in the lowest bottom layer of model (sigma value=0.998) under three run scenarios.

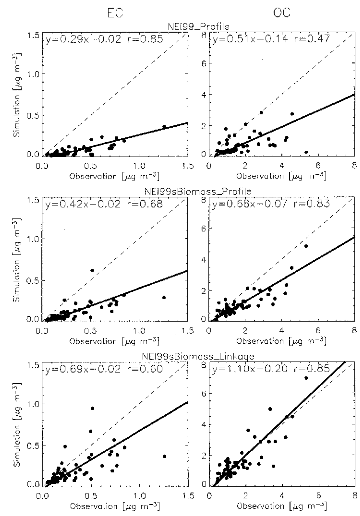

Figure 2. Scatter plots of EC/OC monthly mean simulated versus observed values at IMPROVE sites under three run scenarios.

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