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Aerosol light scattering effect on terrestrial plant productivity and energy fluxes over the eastern United States

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[1] This study reports the first regional-scale assessment of aerosol effects on plant productivity and surface energy fluxes over the eastern United States. Analysis is conducted using an established modeling framework, which is composed of a regional land surface model, regional daily aerosol optical depth (AOD) estimates, and meteorological forcings. The sensitivity experiments were conducted from May to September in 2000 and 2001 over the eastern United States with and without the aerosol light scattering effect. Results show that the aerosol light scattering effect results in enhanced productivity for high-LAI and optimum temperature environments under cloudless-sky conditions around noon, while it results in least productive for low-LAI, low-temperature environments under cloud-sky conditions in early morning or late afternoon. As a result, domain-averaged plant productivities, measured as net primarily production, are changed by −0.71 g C m^{-2} (−0.09%) in 2000 and +5.00 g C m^{-2} (+0.5%) in 2001. These responses of plant productivity and photosynthesis to the aerosol light scattering effect uniquely modulate the surface flux as follows. The aerosol light scattering effect reduces the surface downwelling solar radiation (14.9 W m^{-2} in 2000 and 16.0 W m^{-2} in 2001) and net radiation in vegetation canopy, but simultaneously increases the photosynthesis and stomatal conductance. Consequently, surface latent heat flux (transpiration and evaporation) is reduced by a small amount particularly over the forests, while aerosol loading often results in larger reduction in the sensible heat flux. For the whole domain, latent heat flux is changed by −3.10 W m^{-2} (−2.1%) in 2000 and −3.12 W m^{-2} (−2.1%) in 2001, sensible heat flux is changed by −7.57 W m^{-2} (−12.9%) in 2000 and −8.36 W m^{-2} (−11.3%) in 2001, and surface skin temperature is changed by −0.25 K (−0.1%) in 2000 and −0.27 K (−0.1%) in 2001.

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1. Introduction

[2] Diffuse solar radiation is suggested to be more advantageous for plant productivity than direct radiation [e.g., *Goudriaan*, 1977; *Gu et al.*, 2002; *Law et al.*, 2002; *Niyogi et al.*, 2004; *Rocha et al.*, 2004; *Min*, 2005]. This is because diffuse solar radiation is absorbed on the plant canopy more homogeneously than direct radiation, and is efficiently utilized in the photosynthesis process without exceeding the plant photosynthesis capacity. Direct solar radiation is absorbed by the sunlit canopy and usually exceeds the plant photosynthesis capacity when solar elevation is high [*Goudriaan*, 1977; *Gu et al.*, 2002].

[3] Recently the impact of aerosol light scattering on terrestrial plant productivity and carbon sink has been addressed [*Roderick et al.*, 2001; *Cohan et al.*, 2002; *Gu et al.*, 2003; *Niyogi et al.*, 2004; *Chang*, 2004; *Misson et al.*, 2005; *Kanniah et al.*, 2006; *Oliveira et al.*, 2007]. Following the massive eruption of Mt. Pinatubo in 1991, abnormal carbon sinks were observed on the global scale the following year. *Roderick et al.* [2001] and *Gu et al.* [2003] proposed that the volcano eruption-derived sulphate aerosols in the upper troposphere enhanced solar radiation scattering that ultimately increased the terrestrial carbon sink by increasing plant productivity.

[4] *Niyogi et al.* [2004] and *Chang* [2004] provided the first observational evidence of links between variability of routine aerosol optical depths (AODs), diffuse solar

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