Direct observations of the effects of aerosol loading on net ecosystem CO_2 exchanges over different landscapes

Dev Niyogi,[1] Hsin-I Chang,[1] V. K. Saxena,[1] Teddy Holt,[1,2] Kiran Alapaty,[3] Fitzgerald Booker,[4] Fei Chen,[5] Kenneth J. Davis,[6] Brent Holben,[7] Toshihisa Matsui,[8] Tilden Meyers,[9] Walter C. Oechel,[10] Roger A. Pielke Sr.,[8] Randy Wells,[11] Kell Wilson,[9] and Yongkang Xue[12]

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[1] We present the first direct, multisite observations in support of the hypothesis that atmospheric aerosols affect the regional terrestrial carbon cycle. The daytime growing season (summer) CO_2 flux observations from six sites (forest, grasslands, and croplands) with collocated aerosol and surface radiation measurements were analyzed for high and low diffuse radiation; effect of cloud cover; and effect of high and low aerosol optical depths (AOD). Results indicate that, aerosols exert a significant impact on net CO_2 exchange, and their effect may be even more significant than that due to clouds. The response appears to be a general feature irrespective of the landscape and photosynthetic pathway. The CO_2 sink increased with aerosol loading for forest and crop lands, and decreased for grassland. The cause for the difference in response between vegetation types is hypothesized to be canopy architecture. *INDEX TERMS:* 0305 Atmospheric Composition and Structure: Aerosols and particles (0345, 4801); 0315 Atmospheric Composition and Structure: Biosphere/atmosphere interactions; 0345 Atmospheric Composition and Structure: Pollution—urban and regional (0305); 1610 Global Change: Atmosphere (0315, 0325); 1615 Global Change: Biogeochemical processes (4805). **Citation:** Niyogi, D., et al. (2004), Direct observations of the effects of aerosol loading on net ecosystem CO_2 exchanges over different landscapes, *Geophys. Res. Lett.*, *31*, L20506, doi:10.1029/2004GL020915.

1. Introduction

[2] Photosynthesis removes large amounts of CO_2 from the atmosphere. Net global terrestrial carbon exchange was nearly neutral in the 1980's, but resulted in a carbon sink in the 1990's [*Schimel et al.*, 2001]. CO_2 fertilization, land cover/land-use change, nitrogen loading, forest fires, and the regional hydrological cycle are some of the known factors affecting the carbon cycle [*Nemani et al.*, 2002]. Recent studies suggest that clouds and aerosols released in the atmosphere due to volcanic eruptions could also be important factors [*Gu et al.*, 2003; *Farquhar and Roderick*, 2003; *Krakauer and Randerson*, 2003].

[3] Given that previous studies cite significant events such as volcanic eruptions as the cause for variability in the carbon cycle, and that the mechanisms responsible for modified photosynthetic rates are modulated by aerosol loading, we ask the question: *can we detect the effect of relatively routine aerosol variability on field measurements of CO_2 fluxes, and if so, how does the variability in aerosol loading affect CO_2 fluxes over different landscapes*? Further, since studies such as *Krakauer and Randerson* [2003] question the positive effects of aerosols on the terrestrial carbon cycle; and modeling analysis of *Cohan et al.* [2002] indicated that the aerosol effects on CO_2 fluxes could depend on cloudiness, we seek to find: *whether or not the direct observations indicate an increase or a decrease in field scale CO_2 fluxes?* Thus, even though the effects of clouds on CO_2 fluxes are well documented [*Hollinger et al.*, 1998; *Gu et al.*, 2002], studies linking direct observations of aerosol loading on surface CO_2 fluxes are lacking. Using field measurements, we present additional evidence of the importance of aerosol feedback on regional climate via the biogeochemical pathways affecting the terrestrial carbon cycle.

2. Data and Methods

[4] We used CO_2 flux (*Fc*) data from the AmeriFlux network [*Baldocchi et al.*, 2001], and cloud-free aerosol optical depth (AOD) data from NASA Aerosol Robotic Network: AERONET [*Holben et al.*, 2001] for assessing the effect of aerosol loading on net ecosystem exchange (NEE). Six locations had concurrent *Fc* and AOD observations. The landscapes (locations and period with concurrent AOD and *Fc* data) were: broadleaf deciduous forest (Walker Branch, TN, 2000), mixed forest (Willow Creek/Lost Creek, WI, 2000–01), crops (winter wheat: Ponca, OK, 1998–99; alternate soybean or corn: Bondville, IL, 1998–2002), and grassland (Barrow, AK, 1999; Shidler, OK, 1998–99).

[1]Department of MEAS, North Carolina State University, Raleigh, North Carolina, USA.
[2]Also at Naval Research Laboratory, Monterey, CA, USA.
[3]University of North Carolina at Chapel Hill, Raleigh, North Carolina, USA.
[4]USDA-ARS Air Quality–Plant Growth and Development Unit, Raleigh, North Carolina, USA.
[5]National Center for Atmospheric Research, Boulder, Colorado, USA.
[6]Department of Meteorology, Pennsylvania State University, University Park, Pennsylvania, USA.
[7]NASA Goddard Space Flight Center, Greenbelt, Maryland, USA.
[8]Department of Atmospheric Science, Colorado State University, Fort Collins, Colorado, USA.
[9]Atmospheric Turbulence and Diffusion Division, National Oceanic and Atmospheric Administration, Oak Ridge, Tennessee, USA.
[10]San Diego State University, San Diego, California, USA.
[11]Department of Crop Science, North Carolina State University, Raleigh, North Carolina, USA.
[12]Department of Geography, University of California, Los Angeles, Los Angeles, California, USA.

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