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10.7 ASSESSING THE POTENTIAL IMPACT OF AEROSOL LOADING ON THE TERRESTRIAL CARBON EXCHANGES

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INTRODUCTION: In this study we propose that the aerosol induced radiative feedback could be an important modulator of terrestrial carbon exchange. This is because, aerosols can influence radiation and radiative processes affect vegetation – atmosphere interactions. Indeed, one of the important feedback pathways in the carbon cycle is the vegetation - atmosphere interactions as part of the terrestrial ecosystem. Hence, understanding this interaction is important not only because of its magnitude but also because of the uncertainty and the variability associated with the carbon source / sink values. In this study, we hypothesize that the potential of the vegetated land surface to be a source or sink for carbon will depend on the basal vegetation characteristics (such as C3 or C4 photosynthesis pathways), and the environmental feedbacks from hydrological and radiative effects. To test this hypothesis, we present the first results based on CO_2 observations taken from an AmeriFlux site in Oak Ridge, TN under pre-selected hydrological and radiative conditions.

ANALYSIS: Observations of CO_2 flux from the Walker Branch AmeriFlux site in Oak Ridge, TN were clustered according to *dominant aerosol loading* influencing the study site. The dominant aerosol loading is based on air mass classifications that uses air particle trajectories created with the HySplit transport and dispersion model (Draxler and Hess 1998). The air masses are classified as highly polluted (HP), continental (C), and marine (M), based on SO_2 and NOx emission inventory. The HP, C, and M regimes correspond to high, medium, and low aerosol loading values, as based on a climatological analysis of the circulation patterns, remote sensed data inversion studies, and physico-chemical analysis of the air samples. With higher aerosol loading the Diffuse-to-Direct Solar Irradiance Ratio (DDR) increases. According to Yu et al. (2000), the representative DDR values at 500 nm for HP, M, and C air masses were 1, 0.4, and 0.15, respectively. The CO_2 flux data was grouped based on air mass classifications. The data chosen for analysis was further qualified as those clusters with most representative, dominant air mass influence. That is, the analysis showing influence of a specific air mass for at least 48-hours and from multiple levels (1000, 2000, 3000 AMSL) was identified.

The CO_2 flux data, measured in half-hour intervals, were then further grouped with positive and negative net radiation measurements. Only the data corresponding to a positive net radiation are discussed here. Typical dates that satisfied the air mass criteria for 2000 summer were June 3–5 and July 1–13 for continental regime; June 16–18 and July 30-31 for marine regime, June 7-8, and July 15-18 for highly polluted regime. The June and July periods correspond to periods in which the soil and the vegetation characteristics at the observational site did not show any significant changes. After grouping the data as described above for each of the three regimes, descriptive statistics, and significance tests between each of the three air mass classifications were considered.

Based on the initial analysis, the different aerosol loading corresponding to HP, M, and C air mass classifications respectively, appear to significantly (at 95% or higher level of confidence) affect the surface CO_2 flux. The magnitude of the mean (and variance) for CO_2 flux is -17.6 (112.4), -14.1 (83.3), -12.6 (52.7) μmol m^{-2} s^{-1}, for C, M, and HP respectively. Two-sample t-test, Z-test, and nonparametric U-test all show that the differences between the observed CO_2 fluxes corresponding to each air mass groups are significant (with sample size between 70 and 154 for the three regimes). Also, Figure 3 is a graphical representation of the CO_2 flux data in half-hour intervals for each of the air mass groups. Having plotted every sample data measurement onto the graph, a polynomial least square fit curve is charted for each air mass group. The analysis suggests that higher aerosol loading corresponding to HP, M, and C air mass trajectories respectively decreases the observed CO_2 flux at the Walker Branch site.

Fig. 1 Air mass classifications based on the air mass trajectory analysis. The polluted sector has high aerosol loading, marine region has cloudiness often associated with them and though the loading is less, the size of the aerosols is larger (possibly due to hygroscopic growth) and influences the DDR. The continental air mass has lowest aerosol loading and generally smallest DDR values. This is a generic representation and specific episodes may show significant variability (such as for the Mexico fire and aerosol plume in summer of 1998; which both the TOMS data and this study site showed a clear response for.

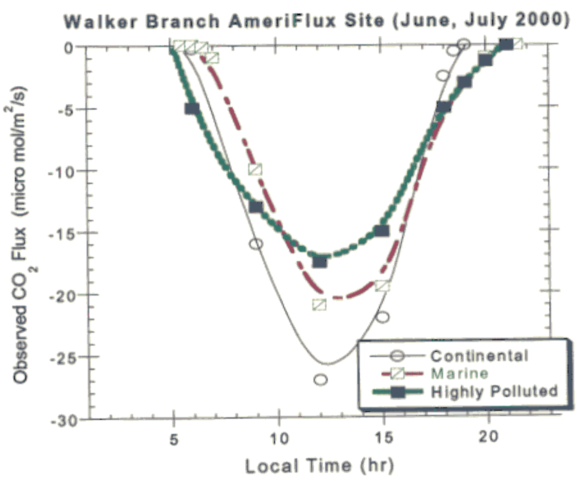

Fig. 2. Summary plot for the half – hourly CO_2 flux observations clustered for different air mass regimes (corresponding to different aerosoll DDR loading). Both the statistical analysis discussed in the text and the graphical analysis suggests, aerosol effects may be significant for observed field-scale CO_2 flux.

CONCLUSIONS: The initial findings of this study suggest aerosol loading does appear to significantly affect observed field scale CO_2 fluxes. More studies are needed on different locations, landscapes, and hydrological conditions to understand the feedback between the environmental processes and the terrestrial carbon exchange.

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