THE IMPACT OF CLOUDS ON ECOSYSTEM $CO^{18}O$ ISOFLUXES IN THE GREAT PLAINS

C.J. Still[1,2], W.J. Riley[3], S.C. Biraud[3], D. Noone[4], N. Buenning[4], J. Welker[5], R. Vachon[6], J. White[6], J.T. Randerson[7], L. Welp[8], J.A. Berry[9], G.D. Farquhar[10]

[1]*Geography Department, 3611 Ellison Hall, UC Santa Barbara, Santa Barbara, CA 93106; still@icess.ucsb.edu*
[2]*Institute for Computational Earth System Science, University of California, Santa Barbara, 93106*
[3]*Earth Sciences Division, LBNL 90-1106, 1 Cyclotron Rd., Berkeley, CA 94720; wjriley@lbl.gov, scbiraud@lbl.gov*
[4]*Program in Atmospheric and Oceanic Sciences; University of Colorado at Boulder; Stadium 255-10 (Gate 7); dcn@colorado.edu,*
[5]*University of Alaska, Anchorage, Director, ENRI, 707 A Street, Anchorage, AK 99501; afjmw1@uaa.alaska.edu*
[6]*Department of Geological Sciences, Campus Box 450, University of Colorado, Boulder, Colorado 80309; ryan.vachon@colorado.edu; jwhite@spot.colorado.edu*
[7]*Earth System Science Department, 3212 Croul Hall,University of California, Irvine, CA 92697-3100; jranders@uci.edu*
[8]*Environmental Science and Engineering, Mail Code 100-23, California Institute of Technology, Pasadena, CA 91125; welp@caltech.edu*
[9]*Department of Global Ecology; Carnegie Institution of Washington; 260 Panama St., Stanford, CA 94305-1297; joeberry@globalecology.stanford.edu*
[10]*Environmental Biology Group, Research School of Biological Sciences, Australian National University, GPO Box 475, Canberra ACT 2601; graham.farquhar@anu.edu.au*

ABSTRACT
Mechanistic explanations for the downward excursion in $\delta^{18}O$ of atmospheric CO_2 observed during the mid-1990s and the generally large interannnual variability characteristic of this isotopologue are lacking. We hypothesize that the excursion and related variations in $\delta^{18}O$ of atmospheric CO_2 may be linked to global-scale variations in cloud cover. However, very little is known about the influence of clouds on biosphere-atmosphere $CO^{18}O$ exchanges. Recent work has demonstrated the influence of boundary layer clouds on canopy photosynthesis through increases in the diffuse radiation fraction and relative humidity, combined with decreases in leaf temperature. In concert, these alterations tend to increase canopy photosynthesis and conductance, which should also increase $CO^{18}O$ isofluxes. However, photosynthetic $CO^{18}O$ isofluxes also depend critically on the $\delta^{18}O$ of leafwater, and enhanced cloudiness typically decreases the $\delta^{18}O$ of leafwater by enhancing relative humidity and water vapor exchange across stomata. Thus, the *net* impact of differing cloud regimes on biosphere-atmosphere $CO^{18}O$ exchanges is difficult to predict. Preliminary simulations suggest a large impact of diffuse radiation on canopy photosynthesis by increasing the flux from shade leaves. The impact of this effect on biosphere-atmosphere $CO^{18}O$ exchanges is diluted somewhat by the lower enrichment in leafwater $\delta^{18}O$ on cloudy days with high diffuse radiation fractions. Our results suggest that these effects are very dependent on LAI and photosynthetic pathway (C_3 or C_4).

INTRODUCTION
To capture these contrasting effects in evaluating the net impact of clouds on ecosystem $CO^{18}O$ isofluxes, we employed a comprehensive ecosystem isotope model (ISOLSM – *Riley et al*. 2002, 2003, *Still et al*. 2005) in the ARM Southern Great Plains (SGP) region of Oklahoma and Kansas. This region is particularly amenable for such a study because of the density of cloud property and radiation measurements. The region contains natural and agricultural ecosystems representing a variety of photosynthetic pathways and growth forms, including tallgrass prairie pastures, broadleaf forests, and crops. To drive the model across the entire region, we used Mesonet meteorological data collected at 120 stations in 2004, as well as precipitation $\delta^{18}O$ values from the National Atmospheric Deposition Program (NADP) network. LAI profiles from 2004 were derived from MODIS data.

RESULTS

Our preliminary results suggest a large impact of clouds on photosynthetic CO_2 and $CO^{18}O$ isofluxes. Much of this impact is mediated through increases in shade leaf photosynthesis. Figures 1-3 show three summer days with contrasting cloudiness and its impact on the physical environment, photosynthesis, leaf water, and $CO^{18}O$ isofluxes in an unstressed broadleaf deciduous forest (LAI=6.3) in the SGP region. Julian Day 222 is sunny, JD 223 is partly cloudy, and JD 224 is very cloudy.

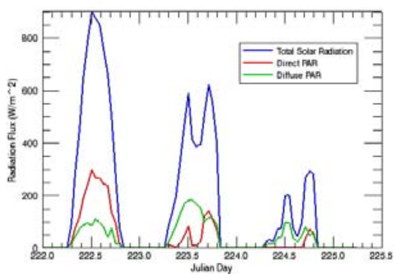
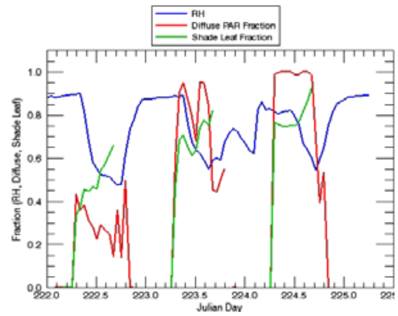
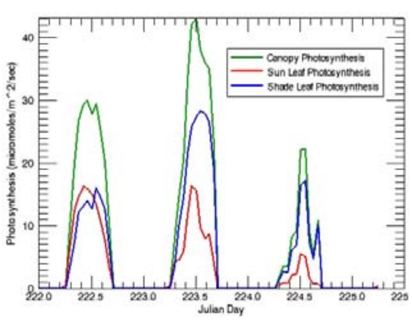
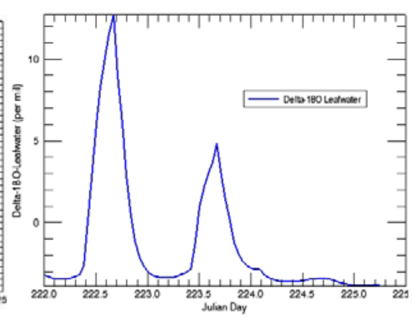


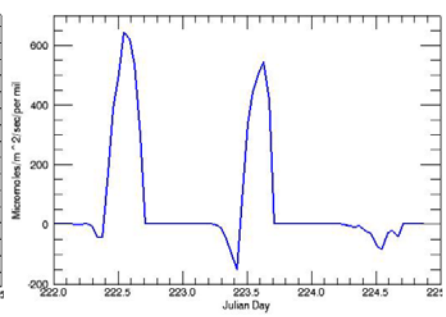
Fig. 1 (left) and 2 (right). Changes in solar radiation fluxes (total solar (PAR+NIR), and direct and diffuse PAR) for three consecutive summer days, and The diffuse PAR fraction, relative humidity, and shade leaf fraction of canopy photosynthesis.



In Figure 2, the increasing cloud cover from JD 222-224 drives increases in relative humidity, the diffuse PAR fraction, and the fraction of canopy photosynthesis from shade leaves. The impact of these changes on canopy photosynthesis is given in Figure 3. Despite the lower total PAR on JD 223, total canopy photosynthesis is increased over the sunny day (JD 222), an effect that is driven by a large increase in shade leaf photosynthesis following the increase in diffuse PAR. The effect of these cloudiness changes on $\delta^{18}O$ of leafwater is given in Figure 4, and the photosynthetic isoflux (photosynthetic flux times isotopic discrimination) is shown in Figure 5. Although canopy photosynthesis is higher on the partly cloudy day (JD 223) than the sunny day (JD 222), the photosynthetic isoflux and attendant impact on the atmosphere is lower due to the less enriched leafwater (Figures 3-5). The very cloudy day (JD 224) is predicted to have a negative isotopic discrimination and thus photosynthetic isoflux due to the lack of leafwater enrichment throughout the daytime.







Figs. 3-5 (left to right). Canopy (shade and sun leaf) photosynthesis, $\delta^{18}O$ of leafwater, and photosynthesis multiplied by discrimination against $CO^{18}O$

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