MECHANISMS IMPACTING INTER-ANNUAL VARIATIONS IN REGIONAL $C^{18}OO$ ISOFLUXES: MODEL ESTIMATES WITH REGIONAL METEOROLOGICAL AND ISOTOPE FORCING DATA

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INTRODUCTION

Temporal and spatial distributions of the $\delta^{18}O$ value of atmospheric CO_2 (δC_a) can be used to constrain regional ecosystem carbon exchanges and linkages between carbon and water cycling. However, our understanding of the substantial observed temporal and spatial variability in δC_a is limited. Among many contributing factors, seasonal and inter-annual variations in climate are likely to be important. In this study we investigate the impact of dry climatic conditions on the ecosystem-atmosphere $C^{18}OO$ isoflux.
We conducted this study in the U.S. Southern Great Plains using five-year monthly-averaged precipitation $\delta^{18}O$ values (δ_p) from the National Atmospheric Deposition Program (NADP) network, Mesonet meteorological forcing, and MODIS-derived NDVI and land-cover characterization. These data are used to force the isotope ecosystem model ISOLSM [*Riley et al.,* 2002; *Riley et al.,* 2003] at 10 km resolution across the region for relatively drier (2003) and wetter (2004) years. The model has been calibrated and tested in the dominant herbaceous vegetation types in the region [*Biraud et al.,* this issue].

RESULTS

Because we are using MODIS NDVI to estimate vegetation cover type and LAI, differences in spatially averaged isoflux predictions between years occur both because of vegetation cover changes, differences in climate forcing, and model sensitivities to various forcings. For example, the proportion of winter wheat coverage was predicted to be 50% higher in 2003 than 2004 (there are a total of seven functional vegetation covers included in the region). Note that, because we only have five-year averages from the NADP network for δ_p, differences in this parameter between the dry and wet year are not reflected in our model forcing data, but are likely to be important.

Spatial heterogeneity in the $\delta^{18}O$ values of soil water, leaf water, and ecosystem CO_2 fluxes are large in each year. For this analysis, we focus on the period May 1 – 15, when precipitation in 2004 was about 25% higher than in 2003. For example, Figure 1(a) shows the $\delta^{18}O$ value of soil water in the top 10 cm at noon on May 15, 2004; values ranged from –8 to -2‰ across the domain. Midday isofluxes (I, μmol m^{-2} s^{-1} ‰) varied between 0 and 100 μmol m^{-2} s^{-1} ‰ over the domain (Figure 1(b)). Many factors conspire to impact I, including vertical root distributions (which impact both stem water $\delta^{18}O$ values and vertical distribution of soil CO_2 production), near-surface soil water $\delta^{18}O$ values, leaf water $\delta^{18}O$ values, C_i/C_a, plant physiological type (e.g., C_3 or C_4), plant growth form (herbaceous versus woody), and drought response. Further, hotter and drier weather can have contrasting impacts on the $C^{18}OO$ isoflux components (e.g., $\delta^{18}O$ of leaf and soil water, photosynthesis, and soil respiration). Our results suggest that the ecosystem isoflux is very spatially heterogeneous, and that errors in characterizing vegetation cover and precipitation amount and $\delta^{18}O$ value may cause substantial errors in regional isoflux estimates.

For spatially averaged predictions, the dry period resulted in elevated $\delta^{18}O$ values of near-surface soil water and leaf water (Fig. 2(a)), and enhanced soil-surface and leaf isofluxes. Enrichment of surface water occurs from surface evaporation; the $\delta^{18}O$ soil water gradients established near the surface can in turn impact the $\delta^{18}O$ value of the soil-surface isoflux [*Riley*, 2005]. To the extent that roots extract water from this enriched zone, xylem and leaf water can both become relatively enriched, leading to enriched leaf isofluxes.

Drought stress impacts leaf conductance, the $\delta^{18}O$ value of leaf water, and C_i/C_a and thereby the leaf photosynthetic isoflux. Consistent with the reduced precipitation, drought stress was predicted to be more prevalent in 2003 than in 2004. The net impact on ecosystem isoflux (e.g., Fig. 2(b)) resulting from these factors varied by vegetation type and season, but the photosynthetic isoflux response dominated the ecosystem isoflux response to drought for all vegetation types [*Still et al.*, 2005].

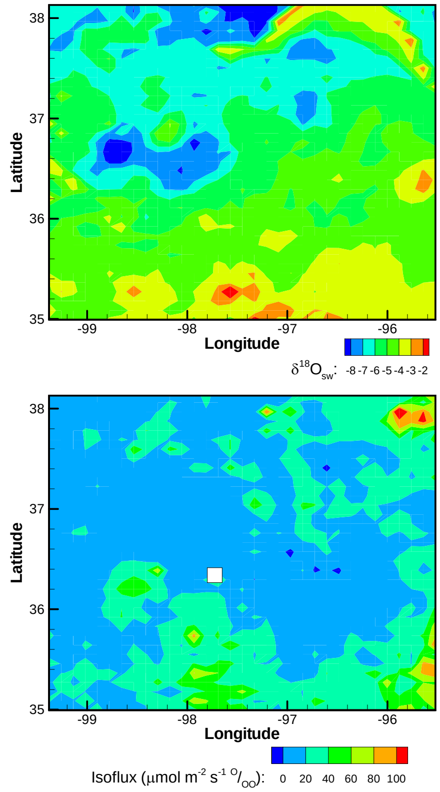

Fig. 1. (a) $\delta^{18}O$ values of soil water in the top 10 cm on May 15 2004 at noon. (b) Ecosystem isofluxes at the same time. The white box shows the Central Facility.

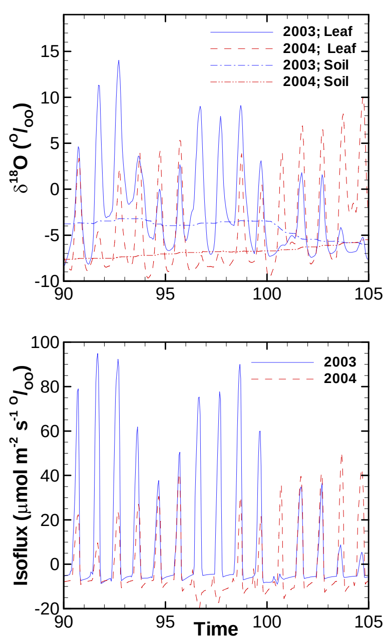

Fig. 2. Spatially integrated (a) $\delta^{18}O$ values of near-surface soil and leaf water and (b) ecosystem isofluxes.

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