The Influence of Hydrological Changes on the $^{18}$O Content of Atmospheric CO$_2$

N. Buenning$^1$, D. Noone$^1$, J. Randerson$^2$, W. Riley$^3$ and C. Still$^4$

$^1$Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO 80309; 720-839-4225, E-mail: buenning@colorado.edu
$^2$Department of Earth System Science, University of California, Irvine, CA 92697
$^3$Earth Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720
$^4$Geography Department, University of California, Santa Barbara, CA 93106

Observations show no long-term trend in the $^{18}$O content of atmospheric CO$_2$ (denoted as $\delta$Ca), though stations around the world observe similar interannual variations in $\delta$Ca values. Modeling studies have shown evidence that the seasonal cycle and spatial structure of $\delta$Ca values result from land ecosystem fluxes. This study evaluates the $\delta$Ca budget to identify meteorological variables that could potentially cause the observed variations. It is found that observed $\delta$Ca values negatively correlate with relative humidity in certain regions of the tropics and mid to high latitudes, and it is estimated that the variations in relative humidity would drive a 0.25‰ decrease in $\delta$Ca values during the 1990s. It is also shown that there are similar variations in precipitation totals within the tropics that would suggest positive correlations between $\delta$WP and $\delta$Ca values consistent with an amount effect ($\delta$WP values typically decreasing as precipitation amounts increase). The decrease in $\delta$WP values would act to decrease $\delta$Ca values by as much as 0.56‰. A global model is constructed to simulate the atmospheric concentrations of both CO$_2$ and CO$^{18}$O. Model results agree well with observations in the global mean and zonal mean (Figure 1). Sensitivity experiments were conducted with the model, and the results confirm that $\delta$Ca values respond to changes in relative humidity and $\delta$WP values. This study suggests that interannual $\delta$Ca variations are driven primarily by isotope hydrology and relative humidity. In contrast to previous work, we find little evidence of changes to photosynthesis or respiration driving the observed $\delta$Ca variations.

Figure 1. Simulated north-south gradient in $\delta$Ca values (‰) (solid line) and the contributions from leaves (dark dotted), respiration (dark dashed), oceans (dash-dot), fossil fuel consumption (light dotted), and biomass burning (light dashed). Asterisks are values from an observed mean value, and the squares are from the closest grid-cell to each observation.