The Isotopic Composition of Oxygen in Atmospheric CO_2 and El Niño: A New Constraint on Global Productivity

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Three decades of oxygen isotope ratios in atmospheric CO_2 measured in the SIO global flask network have revealed a strong correlation with the El Niño-Southern Oscillation (ENSO). During the El Niño phase, the $\delta^{18}O$ of CO_2 increased by approximately 0.5‰ at all stations. We have confirmed this general pattern by comparing SIO data with similar measurements made by NOAA and CSIRO. Station $\delta^{18}O$-CO_2 time series are positively correlated with predictions of the $\delta^{18}O$ of precipitation in Southeast Asia and Northern South America from the IsoGSM model, and are negatively correlated with relative humidity in these same regions. We suggest that the redistribution of moisture and rainfall in the tropics during El Niño increases the $^{18}O/^{16}O$ of precipitation and plant water, and this signal is then passed onto atmospheric CO_2 by vegetation-atmosphere gas exchange. Further exchange with the ocean and the biosphere, including the extra-tropics, provides damping of the $\delta^{18}O$-CO_2 to stable background levels.

We use a simple two-box model to estimate that the global turnover time of O-isotopes in atmospheric CO_2 from fitting the decay of the ENSO-related anomalies is 1.1 – 1.7 yrs. The turnover time of O in CO_2 is related to global gross primary production (GPP) and stomatal conductance. This study suggests that the response time of $\delta^{18}O$-CO_2 may be shorter than previously estimated and that the fast response can be accounted for by revising global GPP upwards from 120 Pg C yr^{-1} to 150–175 Pg C yr^{-1}. A detailed understanding of $\delta^{18}O$ in the hydrologic cycle is not required to make use of this top-down damping constraint on gross exchange of O in CO_2.

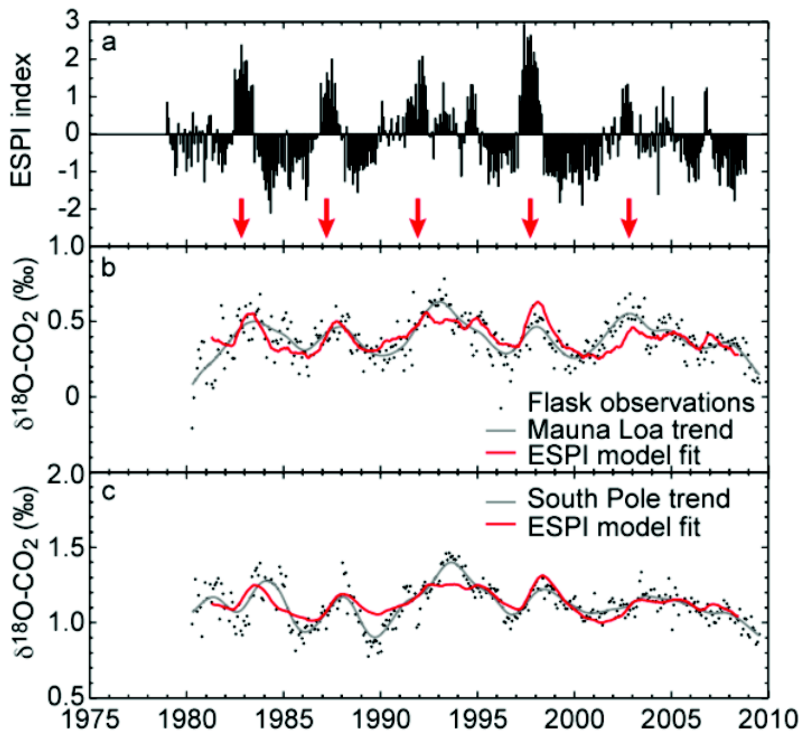

Figure 1. (a) El Niño Precipitation Index was used as a proxy for ENSO variability. Red arrows denote El Niño events. (b) Empirical ENSO model fit for the northern hemisphere (red line) compared against deseasonalized flask observations (black dots) and spline fits (grey line) at Mauna Loa, Hawaii Station. (c) Same as (b) but for the southern hemisphere model fit and the South Pole station.