Differential Environmental Control of Terrestrial Carbon Fluxes in Tropical and Temperate Zones

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Analysis of zonally averaged atmospheric CO_2 and its carbon isotopic ratio ($\delta^{13}C$) between 1992 and 2004 reveal large interannual variations in net surface uptake in both the temperate northern hemisphere and the tropics originating in the terrestrial biosphere. Analysis of co-variation of carbon fluxes and potential climate drivers shows that tropical fluxes are well correlated with temperature, moisture, and El Niño. In contrast, flux variability in the north shows no consistent relationship with climate (Figure 1). The two most prominent aspects of our flux record are the large release of terrestrial carbon that occurred in the tropics associated with the 1997/1998 El Niño, and a decreasing trend in total surface (land plus ocean) uptake in the northern temperate sink since the peak uptake year of 1997. There is some indication that the recent decline of the temperate northern hemisphere sink may be related to widespread drought since 1998. Both the large release of carbon associated with El Niño in the tropics and the decline of the midlatitude sink demonstrate the precarious nature of terrestrial carbon storage.

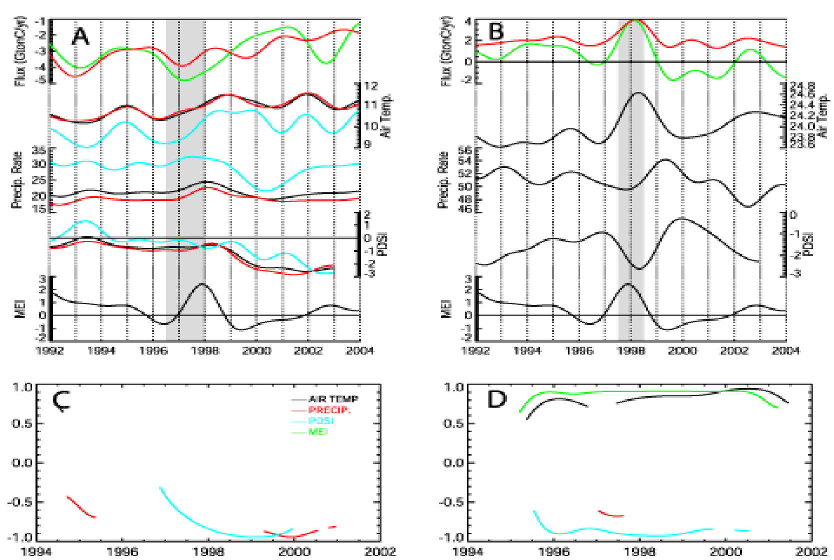

Figure 1. Comparison of terrestrial (green) and total (red) fluxes with surface air temperature, precipitation rate, Palmer Drought Stress Index (PDSI) and Multi-variate ENSO Index (MEI) in the temperate northern hemisphere (18 – 53°N, "A") and tropics (17°S – 17°N, "B"). The climate variables are spatial averages over land area only, excluding deserts (defined using annual-mean NPP less than 20 $gCm^{-2}yr^{-1}$). All curves are smoothed in the same manner as the fluxes to remove seasonal cycles in the data. In "A", blue curves refer to North American averages and red to Eurasian averages. The striped bands correspond to the anomalously high uptake calculated for 1997 in the temperate north and to the large release flux associated with the 1997/1998 El Niño in the tropics. Lower panels show statistically significant correlations (Pearson's r; p>0.95) between climate and terrestrial fluxes in the temperate northern hemisphere (C) and tropics (D) for 5-year periods between 1992 and 2004. We use a 5-year moving window incremented monthly to determine correlations along the time-series. Each point on the line segment represents the mid-point of the window, so, for example, a point at 1995 indicates a significant correlation from 1992.5 to 1997.5. Because both the flux and climate time-series are highly auto correlated, we use a nonparametric statistical test to determine significance.