Temporal Variations in CO$_2$ in Air in Pasadena, California

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How does an urban environment modify the global cycle of observed atmospheric CO$_2$? To address this question, we have studied CO$_2$ since 1998 on the Caltech campus and compared the observed temporal variations with relatively local clean air data from La Jolla (http://scrippSCO2.ucsd.edu/data/ljo.html). Time series analysis of daily [CO$_2$] and isotopic composition Caltech data reveal periodicities at 1 and 0.5 year and 7 days. This last period is not observed in La Jolla. In addition, the $\delta^{13}$C pattern is inverted in Pasadena relative to that at La Jolla, and there is no well-defined seasonal variation in CO$_2$ mixing ratio in Pasadena, in contrast to the La Jolla pattern (Figure 1). The seasonal variations in Pasadena reflect the superposition of local contributions of CO$_2$ in Pasadena on global clean air temporal variations. The local contributions are significant: e.g., the total CO$_2$ concentration in Pasadena is ~25 ppm higher than in clean air. Although the typical diurnal variation in CO$_2$ mixing ratio consists of a low [CO$_2$] plateau at about ~10 AM-4 PM PST and a high [CO$_2$] plateau at ~9 PM-3 AM, there are significant variations with season and day of the week (Figure 2). The amplitude of the diurnal variation in Pasadena varies from ~20 ppm in June to ~80 ppm in December. We typically observe a maximum in [CO$_2$] at ~5-9 AM on weekday mornings, which is smaller on weekends and coincides with increased traffic on surface streets in Los Angeles due to weekday morning rush hour. There is no corresponding peak that can be associated with afternoon rush hour.

**Figure 1.** Annual cycles of [CO$_2$], $\delta^{13}$C, and $\delta^{18}$O for mid-day flask samples for Pasadena and La Jolla from 2001-2008. Long-term linear trends have been subtracted from all analyses. The darker line segments indicate the averages for each month for all years, whereas the lighter time series indicate the averages for each month for individual years.

**Figure 2.** Changes in diurnal variations in [CO$_2$] with day of the week and month of the year. Summer months are in red and winter months in blue. [CO$_2$] is given as the difference from the long-term linear trend. The error bar in the Monday panel indicates the average standard error.