

## Bridging Carbon Cycling and Air Quality Studies Using Atmospheric $^{14}\text{CO}_2$

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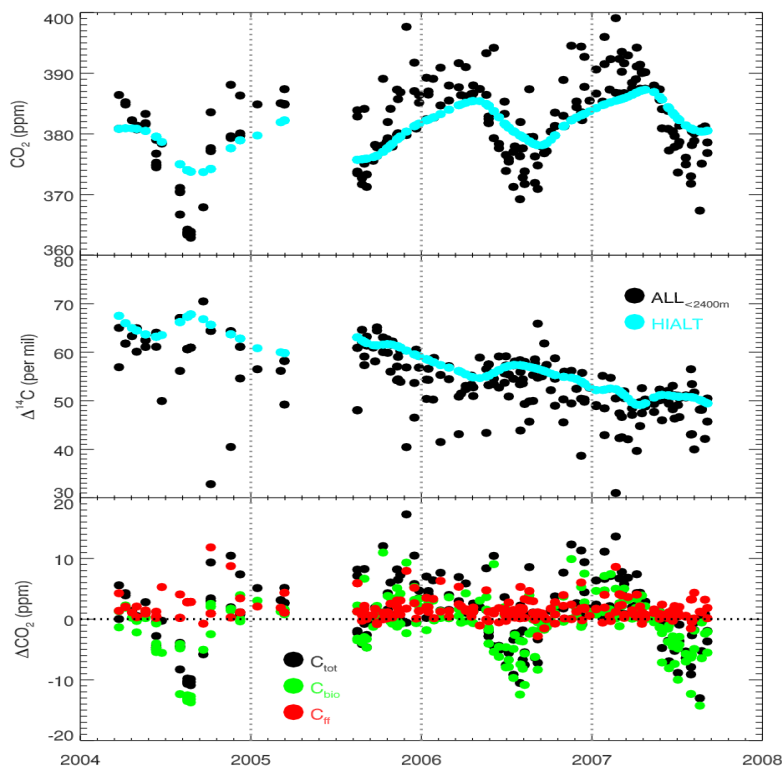
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$\Delta^{14}\text{C}$ , the ratio of radiocarbon to total carbon, is a theoretically ideal tracer for recently added fossil fuel  $\text{CO}_2$ , because fossil fuel is  $^{14}\text{C}$ -free. In contrast, all other carbon reservoirs that exchange  $\text{CO}_2$  with the atmosphere, like the terrestrial biosphere and the oceans, are relatively rich in  $^{14}\text{C}$ . Since 2004, NOAA ESRL and the University of Colorado Institute of Arctic and Alpine Research (INSTAAR) Radiocarbon Laboratory have worked together to make high precision ( $< 2 \text{‰}$ )  $\Delta^{14}\text{C}$  measurements. Our two sites in the eastern USA, Portsmouth, NH (NHA) and Cape May, NJ (CMA) exhibit large  $\text{CO}_2$  signals from anthropogenic and biogenic fluxes. Using  $\Delta^{14}\text{CO}_2$ , however, we are able to quantitatively partition the boundary layer  $\text{CO}_2$  signal into biogenic and fossil fuel components. Once separated, these signals are independently useful. The biological signal can be used directly to infer the uptake and release of carbon by the biosphere, and the fossil signal can constrain anthropogenic emissions of  $\text{CO}_2$ , without the use of inventories, which can never be as recent as the measurements. Furthermore, as we will show, the derived fossil fuel  $\text{CO}_2$  signal is closely related to boundary layer enhancements of many air quality tracers like  $\text{CO}$ ,  $\text{SF}_6$ , CFC-replacement compounds, and solvents like perchloroethylene and dichloromethane. These relationships can exist for total  $\text{CO}_2$ , but we will show that they are biased because of the biospheric contribution. Finally, having established a relationship between fossil fuel  $\text{CO}_2$  and air quality tracers, we will estimate regional scale (east coast) emissions of the air quality tracers by scaling the measured fossil- $\text{CO}_2$ :tracer emission ratios to the well-known U.S. fossil fuel  $\text{CO}_2$  inventory. As more  $^{14}\text{CO}_2$  measurements are made, we will improve not only our understanding of  $\text{CO}_2$  sources and sinks, but potentially emissions for a wide variety of other gases.



**Figure 1.** Fossil and biospheric  $\text{CO}_2$  signals for boundary layer (PBL) aircraft air samples above Portsmouth, NH (NHA) and Cape May, NJ. Top and middle panels show PBL (black) and a composite free troposphere (blue) reference time series for  $\text{CO}_2$  and  $\Delta^{14}\text{CO}_2$ , respectively. Note that whereas for  $\text{CO}_2$ , the PBL values are both above and below the reference, for  $\Delta^{14}\text{C}$ , the values are generally below the reference, showing the influence of fossil fuel emissions. The bottom panel shows the PBL-reference time series for  $\text{CO}_2$  (black;  $C_{\text{tot}}$ ) and the  $\Delta^{14}\text{C}$ -derived values of the biological (green;  $C_{\text{bio}}$ ) and fossil (red;  $C_{\text{ff}}$ ) components. We see that even in winter, there are significant contributions from both biospheric and fossil fuel  $\text{CO}_2$  to the total. In summer, we also see that  $C_{\text{tot}}$  underestimates the full extent of the photosynthetic drawdown of  $\text{CO}_2$  shown by  $C_{\text{bio}}$ .