Using atmospheric 14CO2 measurements for quantification of fossil fuel emissions and evaluation of simulated atmospheric transport.

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$\Delta^{14}CO_2$ is a theoretically ideal tracer for recently added fossil fuel derived CO_2 in the atmosphere because fossil fuel is entirely devoid of ^{14}C due to radioactive decay whereas all other sources of CO_2 to the atmosphere are relatively ^{14}C rich. On the delta scale, the $\Delta^{14}C$ of fossil fuel CO_2 is -1000‰ (i.e. no ^{14}C), while the ambient atmospheric value is ~+50‰. Thus, the addition of 1 ppm fossil CO_2 to the current atmospheric CO_2 burden of ~380 ppm will reduce the ambient isotopic signature by ~2.8‰. Working with the Keck accelerator team at UC-Irvine, we have obtained a long-term $\Delta^{14}CO_2$ measurement precision of 1.8‰ (1-sigma), providing for sub-ppm detection of recently added fossil fuel CO_2. From a theoretical basis, we expect atmospheric $\Delta^{14}CO_2$ gradients over the continents to very closely resemble atmospheric fossil fuel CO_2 gradients, and we have shown that this is indeed the case in simulations of atmospheric CO_2 and $\Delta^{14}CO_2$. Based on this fact, we also present results showing a $^{14}CO_2$ - based deconvolution of atmospheric CO_2 measurements into fossil fuel and (by residual) biological components.

Used in a different way, $^{14}CO_2$ measurements can be used together with inventories of fossil fuel emissions. Knowing an emissions source and the atmospheric distribution of a tracer for that source allows us to test our knowledge of atmospheric transport. As we make more and more measurements of $^{14}CO_2$ over the United States and elsewhere, these will become powerful constraints for atmospheric transport models. Eventually, we will be able to test not just model transport accuracy but our entire atmospheric top-down source estimation techniques (data assimilations and inversions) by attempting to directly estimate fossil fuel emissions from atmospheric $^{14}CO_2$ data. Along these lines, we present comparisons of simulated and observed $^{14}CO_2$ in a transect across Siberia showing its sensitivity to modeled transport. $^{14}CO_2$ is a tracer sensitive to both atmospheric transport and fossil fuel emissions, two of the most critical components to understanding the contemporary carbon cycle.