The Potential of $^{14}CO_2$ Measurements to Constrain the North American Fossil Fuel CO_2 Flux

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Atmospheric inversions estimate surface sources and sinks of carbon dioxide (CO_2) from its observed atmospheric gradients. These gradients are determined by the total CO_2 flux, which includes biogenic, oceanic and fossil fuel components. Traditional inversions infer the biogenic and oceanic components by assuming a fixed, perfectly well known fossil fuel CO_2 flux. This assumption, while generally valid (~5% error) for annual national totals for developed countries (such as the annual total fossil fuel CO_2 emission from the continental U.S.), may be much less accurate for weekly/monthly emissions from individual states and counties. Therefore, any error made in prescribing this “well known” fossil fuel flux at those smaller scales results in errors in the inferred biosphere flux from traditional inversions.

We have developed an atmospheric inversion technique to assimilate CO_2 (which depends on the sum of natural and fossil fuel fluxes) and $^{14}CO_2$ (which depends primarily on the fossil fuel flux) measurements to separately estimate the biogenic and fossil fuel CO_2 fluxes. Using this technique in an observation system simulation experiment (OSSE), we show that given the coverage of $^{14}CO_2$ measurements available in 2010 (~850/year), we can estimate the U.S. national total fossil fuel emission to within 5% for a year and for most months. However, if we ramp the coverage up to 5,000 measurements/year, not only can we estimate the monthly U.S. national total fossil fuel emission to within 5%, we can also estimate with that same accuracy monthly fossil fuel emissions from smaller regions such as the New England states or the Mid-Atlantic states. This result suggests that a program of 5000 $^{14}CO_2$ measurements per year would allow for independent verification of bottom-up inventories of fossil fuel CO_2 at the regional and national scale.

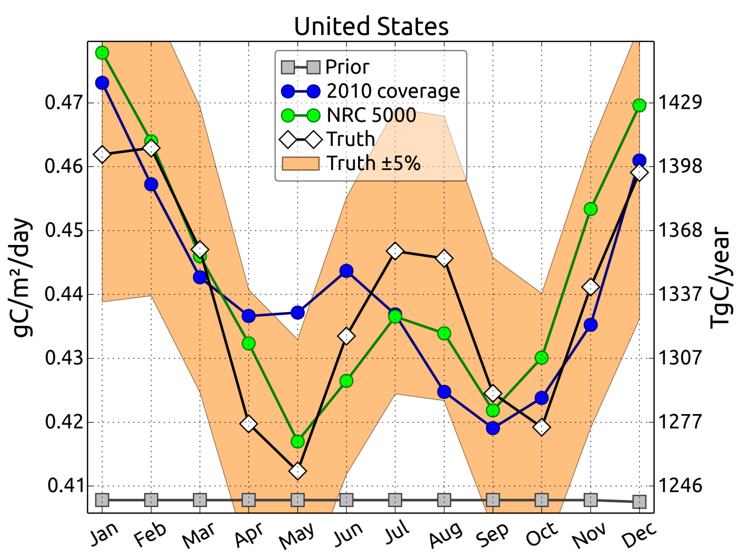

Figure 1. Monthly national total fossil fuel carbon dioxide fluxes from the continental United States. Observations were simulated using the true fluxes (white diamonds), then fed into our data assimilation system, which started from a deseasonalized and biased prior flux estimate (grey squares). The true fluxes were recovered with varying fidelity depending on the coverage of radiocarbon measurements. The orange shaded region around the true fluxes is the region of 5% tolerance.