A National CO_2 Emissions Verification Facility

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Last June President Trump announced the withdrawal of the U.S. from the historic Paris climate accord, abdicating U.S. leadership on climate and energy security- two of the most important issues of the modern era. The international community responded by reaffirming its commitment to the goals of the agreement, as did U.S. industry and many U.S. states and cities. Combined CO_2 emissions from states joining the newly formed *U.S. Climate Alliance* now amount to 25% of the U.S. total, and commitments from more than a thousand cities (many outside *Alliance* member states) add substantially to its potential impact. As a result, the U.S. may still make progress towards its previously agreed goal of decreasing national total emissions by 26-28% with respect to 2005 levels by 2025. However, evaluating industry, state and regional progress towards this goal will require independent and objective measures of emissions and emissions trends. And, while national total emissions will likely continue to be compiled and reported by the *U.S. EPA* (a requirement of our 1992 commitment to the UNFCCC), their capacity to compile emissions at state or regional scale is severely hampered by de-funding and poor coordination of state offices. Only NOAA, which operates the most extensive greenhouse gas monitoring network in the world, has the capacity to determine emissions with the accuracy and at the spatial scales needed in order to inform existing stake holders of the *U.S. Climate Alliance* and its allies in industry. Achieving this requires only a relatively modest expansion of NOAA's $^{14}CO_2$ (radiocarbon in CO_2) sampling and measurement infrastructure, as previously advocated by the *U.S. National Academy of* Sciences [1], NOAA, and our local U.S. House Representatives. Funding requests for a facility meeting these requirements have been in the President's budget since 2012, but are now much less likely to be supported by Congress and the new administration. Filling the leadership and funding gap with support from city, state, and industry stakeholders is more critical than ever before.

Much of our understanding of the long term growth of atmospheric CO_2 and its causes is based on monitoring programs at NOAA's Earth System Research Laboratory, which has led the world's largest atmospheric sampling and measurement effort since the early 1980's [*see separate GGGRN document*]. While the global array of precise observations clearly constrain the size of the year-to-year increase in atmospheric CO_2 from combustion of fossil fuels and land use change, it has not been possible to use these observations to determine the locations and intensities of man made emissions. This is because observed CO_2 gradients over large land areas are often dominated by large and variable CO_2 exchange with land ecosystems [Figure 1]. However, precise measurements of $^{14}CO_2$ in the same samples that provide the primary CO_2 observations now allow for accurate and precise (~±1 ppm) observational constraint of the recently added fossil fuel derived CO_2 component alone. (The strong detection capability arises from the fact that fossil fuels and derived CO_2 are ^{14}C-free due to the complete radioactive decay of ^{14}C in oil, gas and coal, while the atmosphere and other CO_2 sources remain ^{14}C rich as a result of natural atmospheric production). Noting these developments, the *U.S. National Academy of Sciences* in 2010 recommended a five- to ten-fold increase in the number of high precision atmospheric ^{14}C measurements (about 1000/yr for the U.S. at that time) as the most reliable means of independently quantifying CO_2 emissions from fossil fuel use. NOAA and CU-Boulder investigators have added the computational machinery necessary to make use of ^{14}C measurements within NOAA's *CarbonTracker* CO_2 data assimilation system [carbontracker.noaa.gov], as needed in order to determine emissions directly from atmospheric observations [2]. The new system recovers annual emissions totals for the conterminous U.S. to better than 1% and monthly national totals to within ~3% [Figure 2]. This is also the case for some smaller, multi-state regions such as in the eastern half of the U.S. where emissions and sampling are presently concentrated. At these levels of accuracy, *CarbonTracker* can be expected to verify with high confidence whether or not annual emissions are headed towards national and regional emissions targets within a few years of beginning expanded ^{14}C monitoring. The sampling network is ultimately flexible, and can be configured to provide for enhanced detection over specific regions. And *CarbonTracker* is a global data assimilation system, allowing for international emissions detection and verification once ^{14}C sampling coverage is expanded either by NOAA or in collaboration with our international partners. The proposed facility is to be located in a new purpose-built laboratory [3] at CU-Boulder, close to NOAA's global network sampling hub in Boulder, CO. The facility will consist of an expanded CO_2 extraction and processing laboratory and an ultra-high precision ^{14}C-dedicated Accelerator Mass Spectrometer. The facility budget also includes support for expanded ^{14}C sampling infrastructure within the NOAA network and support of *CarbonTracker* personnel as needed for near-real time emissions reporting. Costs of instrumentation and its operation, sampling and *CarbonTracker* operations are $5M/yr (budget details available upon request).

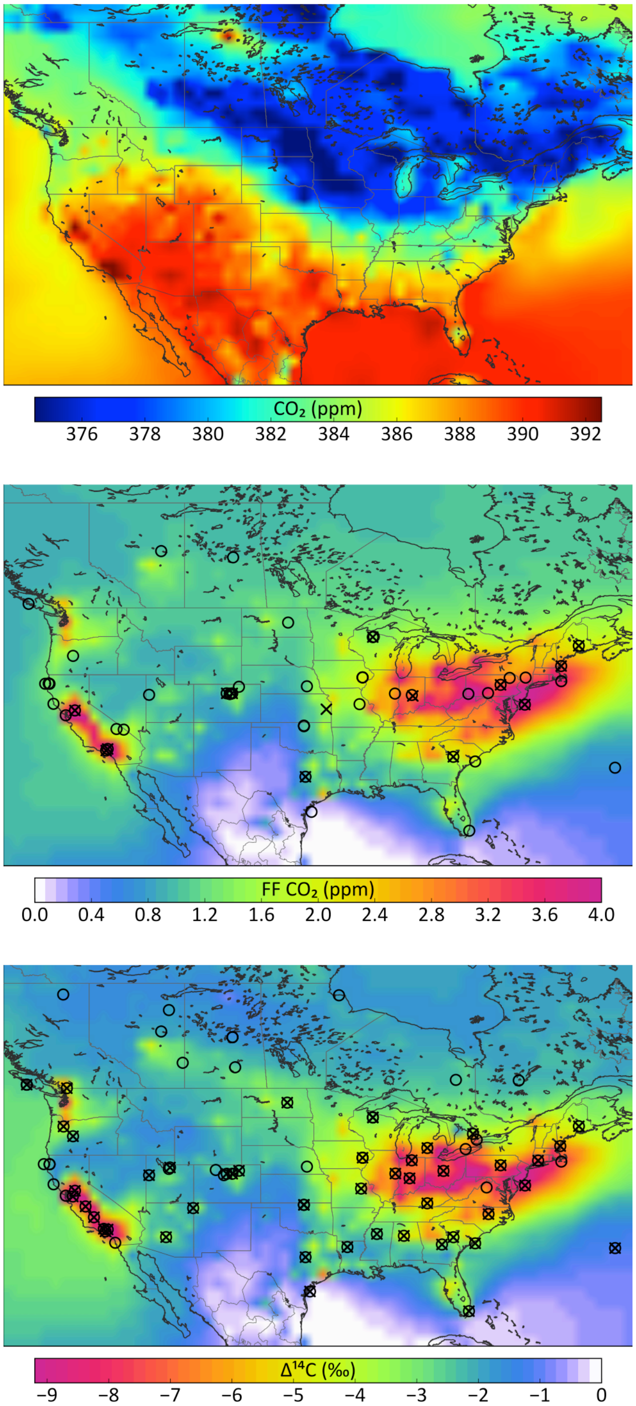

Figure 1. Near surface distributions of total CO_2 (*a*), fossil fuel derived CO_2 (*b*), and $\Delta^{14}C$ (*c*) over N. America for July 2010 from NOAA *CarbonTracker,* with current (*b*) and planned (*c*) sampling sites. $\Delta^{14}C$ (in CO_2) provides a measurement field that can be traced back to emissions at the surface.

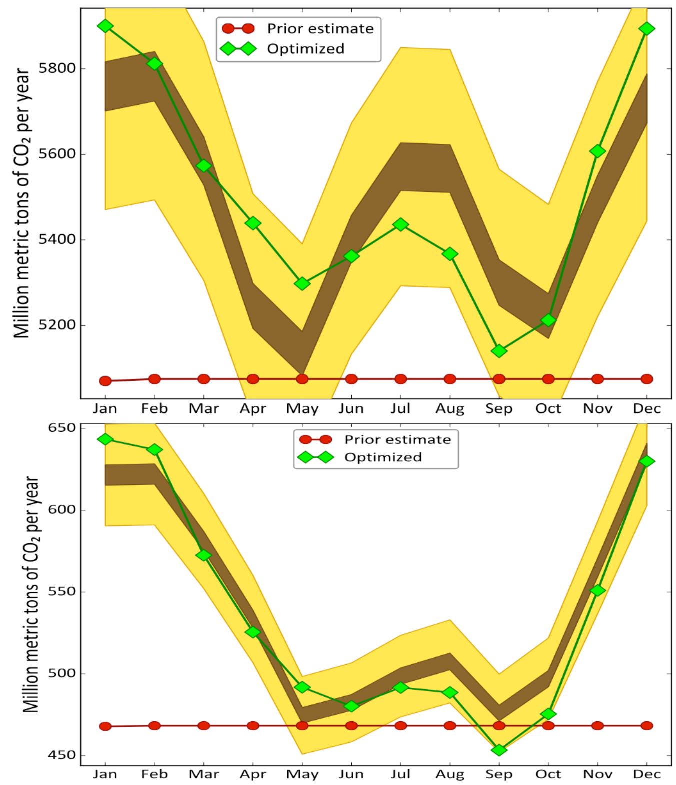

Figure 2. Fossil fuel CO_2 emissions recovered by *CarbonTracker* for an Observing System Simulation Experiment specifying ~5000 ^{14}C measurements per year over the U.S. as in *Fig. 1c*. OSSE results (green symbols) are compared to "true" emissions ±1% (brown) and ±5% (yellow) and a prior guess required by the system (red), for the conterminous U.S. *(a)* and for a grouping of states (the New England states plus NY, NJ & PA) that includes many of those in the Regional Greenhouse Gas Initiative [4] *(b)*. "True" annual national emissions totals are determined to within 1%.

References:

1. "Verifying Greenhouse Gas Emissions; Methods To Support International Climate Agreements", Committee on Methods for Estimating Greenhouse Gas Emissions (2010), National Research Council, *The National Academies Press*, 124 pp.

2. Basu, S., Miller, J.B., and S.J. Lehman (2016) Separation of biospheric and fossil fuel fluxes of CO_2 by atmospheric inversion of CO_2 and $^{14}CO_2$ measurements: Observation System Simulations. *Atmospheric Chemistry and Physics*.16, 5665-5683, doi:10.5194/acp-2016-6

3. "*The Climate Lab That Sits Empty*" in *The New York Times* 28 July, 2017

4. https://www.rggi.org