Detecting Trends in Fossil Fuel Emissions with $^{14}CO_2$ in the Presence of Transport Errors and Biased Inventories

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In earlier work, we developed an atmospheric inversion framework to estimate regional emissions of fossil fuel CO_2 by assimilating atmospheric measurements of CO_2 and $^{14}CO_2$ [Basu et al., 2016]. We showed that given a realistic network of ~5,000 $^{14}CO_2$ observations per year located primarily over North America, our framework could estimate monthly US national totals to within a few percent, and the annual national total to within 1%. We also showed, however, that the absolute accuracy of our estimate was strongly dependent on the atmospheric transport model used, an Achilles' heel of all atmospheric inversions.

Here we investigate whether the interannual variability of emissions derived from our framework is less sensitive to biases in the atmospheric transport model than are the absolute annual estimates themselves. Specifically, we evaluate whether it is possible to derive robust estimates of decade long trends in fossil fuel emissions using biased atmospheric transport, and test the sensitivity of trend detection capabilities to the design of the observational network. These issues relate directly to the feasibility of verifying national emission trajectories pledged by countries within their Intended Nationally Determined Contributions (INDCs) at UNFCCC's COP21 climate summit.

Preliminary results show that given a network of ~5,000 observations per year, we can robustly estimate US national emission trends, even when starting from a "first guess" emission inventory without a trend and with biased atmospheric transport. We also show how far our estimated trends deviate from the truth under the "current best case" scenario of assimilating 1,000 observations per year, and how a badly informed prior (~40% bias) affects those estimate.

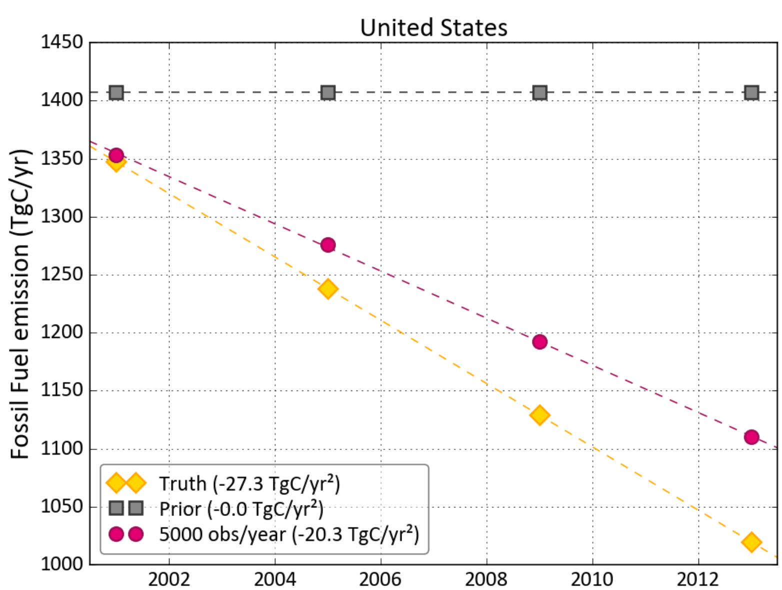

Figure 1. Preliminary results from our trend detection experiment. In our OSSE, the "nature run" or "true" fossil fuel (FF) emissions had a negative trend, while the first guess or "prior" emissions did not. Our inversion system could recover part of that trend with 5000 $^{14}CO_2$ observations per year (primarily over North America). Efforts to minimize the trend detection error are in progress.