North American CO_2 Fluxes, Inflow, and Uncertainties Estimated Using Atmospheric Measurements from the North American Carbon Program

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The North American atmospheric carbon dioxide (CO_2) measurement network has grown from three sites in 2004 to >100 in 2014. The US network includes tall tower, mountaintop, surface, and aircraft sites in the NOAA Global Greenhouse Gas Reference Network along with sites maintained by university, government and private sector researchers. The Canadian network is operated by Environment Canada. This unprecedented dataset can provide spatially and temporally resolved CO_2 emissions and uptake flux estimates and quantitative information about drivers of variability, such as drought and temperature.

CarbonTracker-Lagrange (CT-L) is a new modeling framework developed to take advantage of newly available atmospheric data for CO_2 and other long-lived gases such as methane (CH_4). CT-L provides a platform for systematic comparison of data assimilation techniques and evaluation of assumed prior, model and observation errors. A novel feature of CT-L is the simultaneous optimization of surface fluxes and boundary values, taking advantage of vertically resolved data available from NOAA's aircraft sampling program. CT-L uses sampling footprints (influence functions) from the Weather Research and Forecasting/Stochastic Time-Inverted Lagrangian Transport (WRF-STILT) modeling system to relate atmospheric measurements to upwind fluxes and boundary values. First-guess or prior fluxes are adjusted using Bayesian or Geostatistical methods to provide optimal agreement with available observations. Footprints are pre-computed and the optimization algorithms are efficient, so many variants of the calculation can be performed. For example, we can test alternate prior flux estimates, data weighting scenarios and assignment of flux error covariance parameters. CT-L is also powerful tool for observing-system design.

Preliminary CT-L flux and inflow estimates for North America will be presented along with corresponding uncertainties. We have begun to evaluate the consistency among available *in situ* and remote sensing data such as from the GOSAT and OCO-2 satellite sensors and the ground based Total Carbon Column Observing network. We are developing flux estimation strategies that use remote sensing and *in situ* data together, and we are investigating what new measurements would best complement the existing carbon observing system.