CarbonTracker Flux Estimates Using Measurements from the Global Greenhouse Gas Reference Network

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Introduction

- What is CarbonTracker (CT)? A CO_2 data assimilation project that uses atmospheric measurements from the Global Greenhouse Gas Reference Network (Figure 3) and partnership measurement programs to infer the fluxes of carbon dioxide at the Earth's surface using models of atmospheric transport and terrestrial/oceanic exchange processes.
- What's the purpose? CT fluxes are an end-to-end product whereby network measurements undergo a process of quality control and are then used to infer CO_2 source and sink spatiotemporal patterns, monitor changes from year to year, and predict future atmospheric loading.
- What are the CT products? Fluxes (Figure 1) and 4-dimensional mole fraction fields (Figure 2) are data derived products that are made freely available to the public.
- Who are our customers? Optimized CO_2 fluxes are intended to be used in policy making decisions. The 4-dimensional fields are used by the satellite community for comparisons with mole fraction retrievals and by the modeling community for initial/boundary conditions.

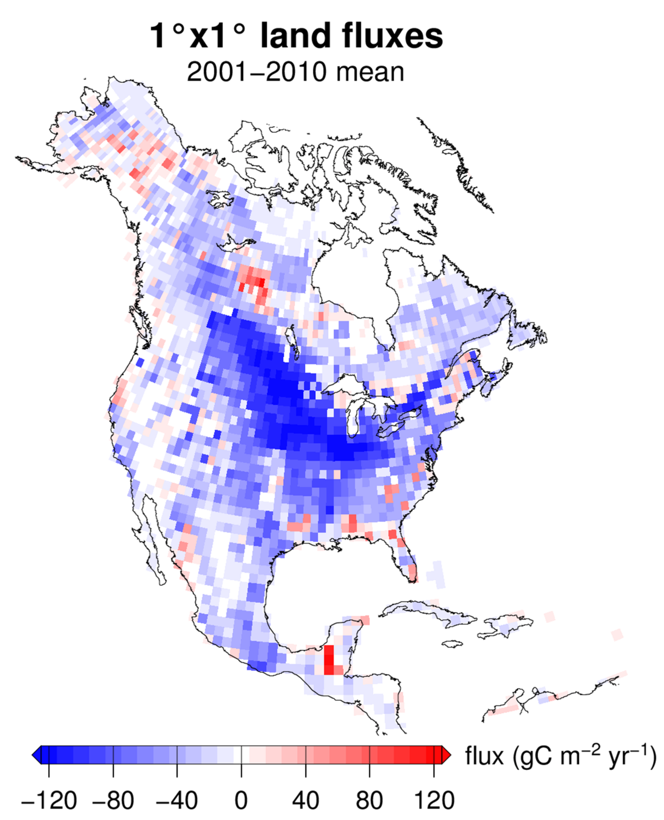

Figure 1: CT2011 CO_2 fluxes over North America

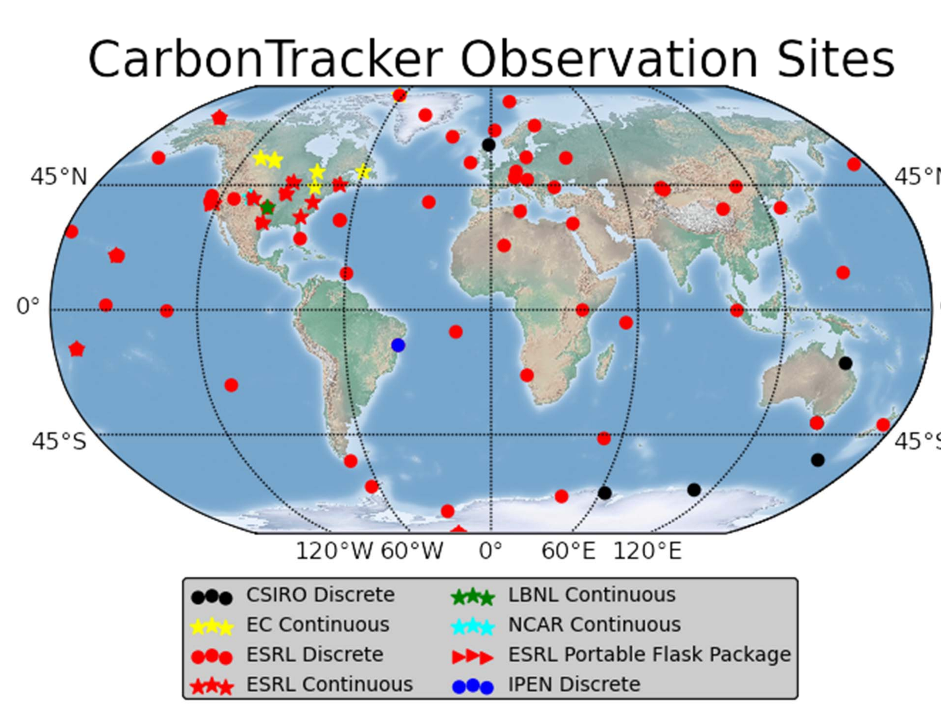

Figure 3: The network of observation sites assimilated for CT2011.

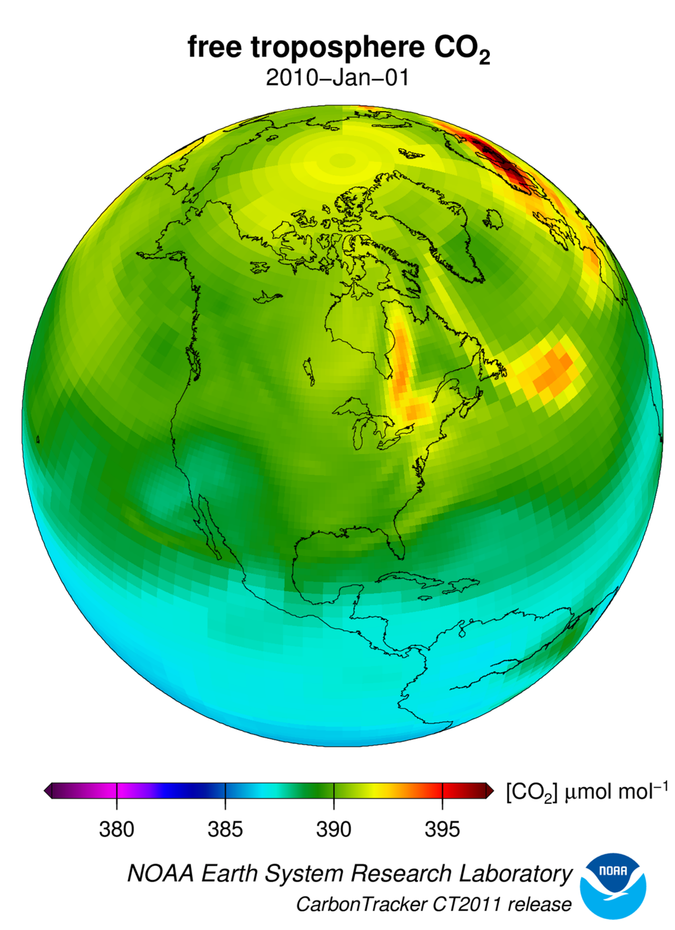

Figure 2: Global 3x2° /North America 1x1° CO_2 mole fraction field.

The Evolution of CarbonTracker

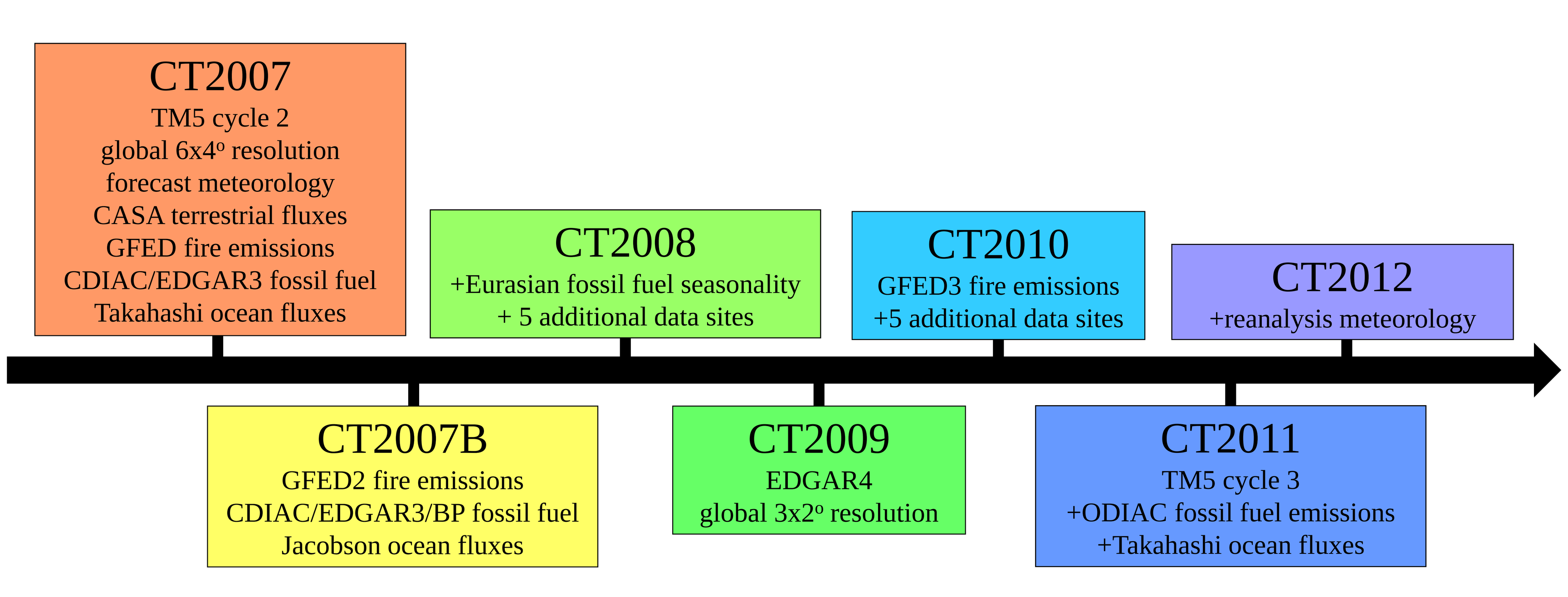

Figure 4: CarbonTracker Release Timeline showing the evolution of the CT modeling system.

International Collaborations

CarbonTracker Asia – Contact: Chun-Ho Cho (http://www.nimr.go.kr/2/carbontracker/)
CarbonTracker China – Contact: Lingxi Zhou, Xingqin An
CarbonTracker Europe – Contact: Wouter Peters (http://www.carbontracker.eu)
CarbonTracker Australasia – Contact: Sara Mikaloff-Fletcher
CarbonTracker Brazil – Contact: Luciana Vanni Gatti

Academic Partnerships

NCAR – Contact: Britt Stephens
University of Wisconsin – Contact: Bjorn Brooks
Colorado State University – Contact: David Baker, Scott Denning
Oregon State University – Dave Turner
Jet Propulsion Laboratory – Susan Kulawik

Methodology

CarbonTracker optimized fits use ensemble Kalman filtering (EnKF) to calculate scaling factors that are used to multiply initial flux estimates to better match the data.

- CarbonTracker fluxes are net ecosystem exchange (NEE). The current model design does not individually solve for photosynthesis and respiration fluxes.
- CT solves for 240 regions and ecosystems which are then aggregated to 11 TRANSCOM regions, 19 ecosystems, and 30 ocean regions.
- Only terrestrial and ocean fluxes are optimized. Fossil fuel and fire emissions are assumed to be known.
- 1 week of data is assimilated at a time in a 5 week moving window.

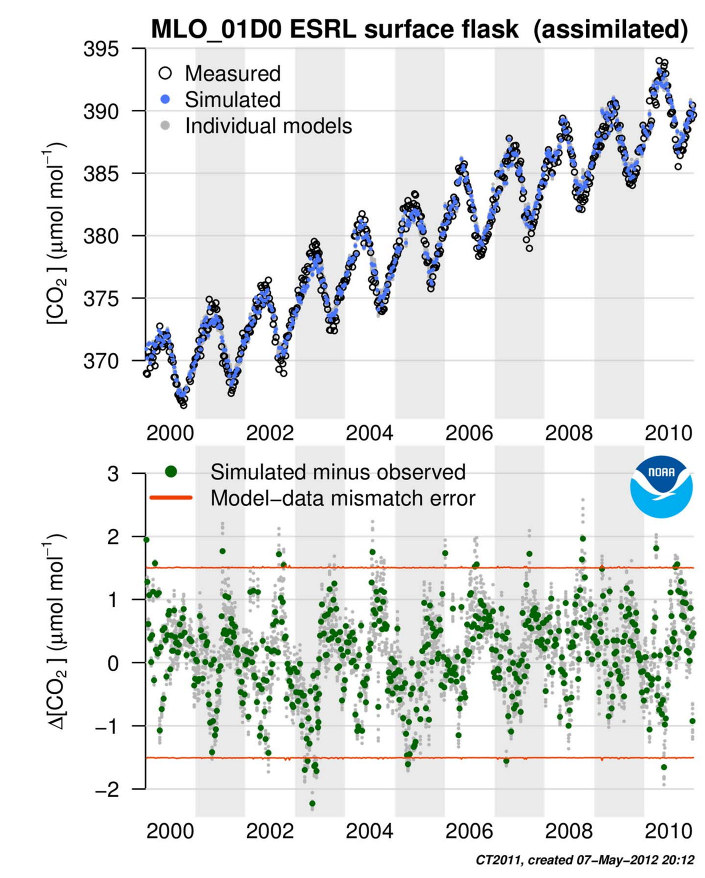

Figure 5: CT fit to Mauna Loa data

Current Activities and Future Plans

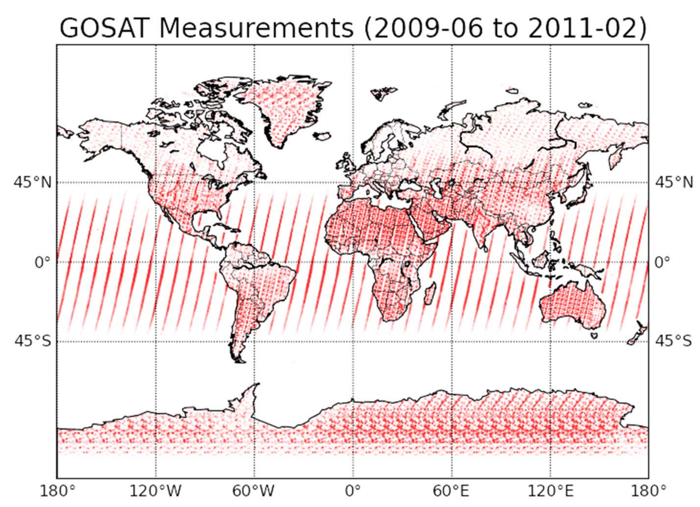

Figure 6: Cloud-free CO_2 measurement map from the GOSAT satellite. Data assimilations are being tested that use upper air data from the GOSAT satellite, TCCON network, and aircraft. Until now, CarbonTracker has used surface measurements almost exclusively for data assimilation.

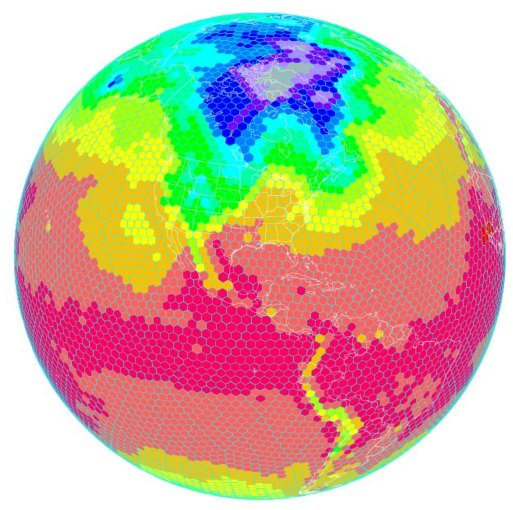

Figure 7: The hexagonal horizontal grid of NOAA GSD's Finite Icosahedral Model (FIM). The CT modeling group is working with GSD to do high resolution CO_2 forecast simulations with FIM in conjunction with near-real time forecasts with TM5. The forecast product is intended to be released more frequently than the annual CarbonTracker optimized flux product and more responsive to user requests.

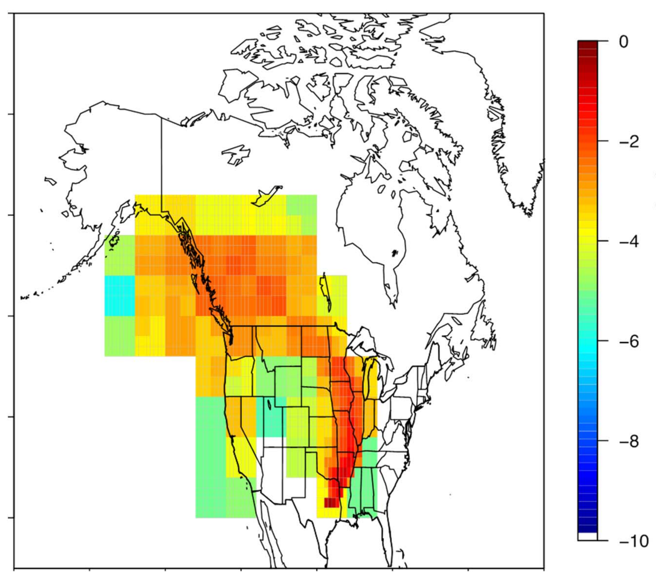

Figure 8: CarbonTracker-Lagrange uses Lagrangian Particle Dispersion Modeling (LPDM) to compute footprints of CO_2 surface sensitivity for individual measurements. Inversion methods such as Bayesian and Geostatistical techniques are under development to use these footprints to optimize the inferred fluxes using an ecosystem scaling approach similar to CarbonTracker–CO_2. Different LPDMs (e.g. HYSPLIT and STILT) and meteorological drivers will also be used to investigate the sensitivity of derived flux estimates to errors in simulated transport.

CarbonTracker Methane

The NOAA CarbonTracker–CH_4 data assimilation product is also under development as a companion to NOAA's CarbonTracker–CO_2, with the goal of producing quantitative estimates of emissions of methane to the atmosphere from natural and anthropogenic sources for North America and the rest of the world.

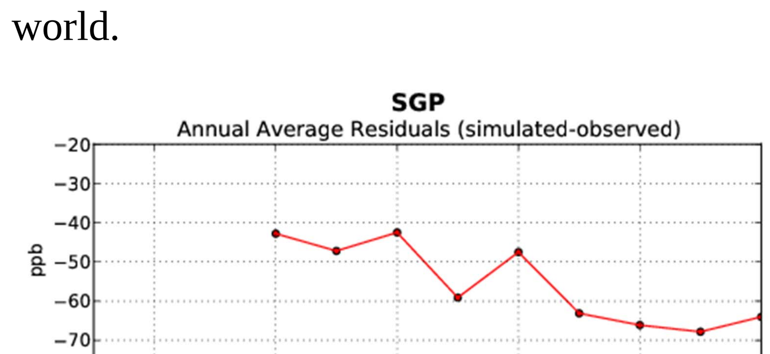

Figure 10: Residual plot for the Southern Great Plains showing the model has a harder time fitting data near fossil fuel production areas.

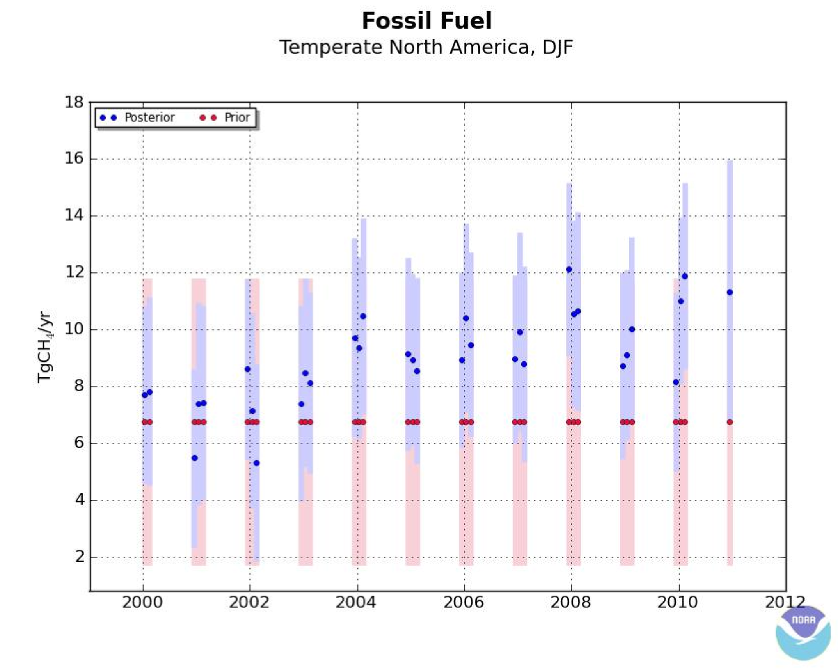

Figure 9: Estimated winter-time fossil fuel emissions from North America. Recent CarbonTracker–CH_4 research sees an increase in the methane contribution from the fossil fuel sector, likely due to increased natural gas production.