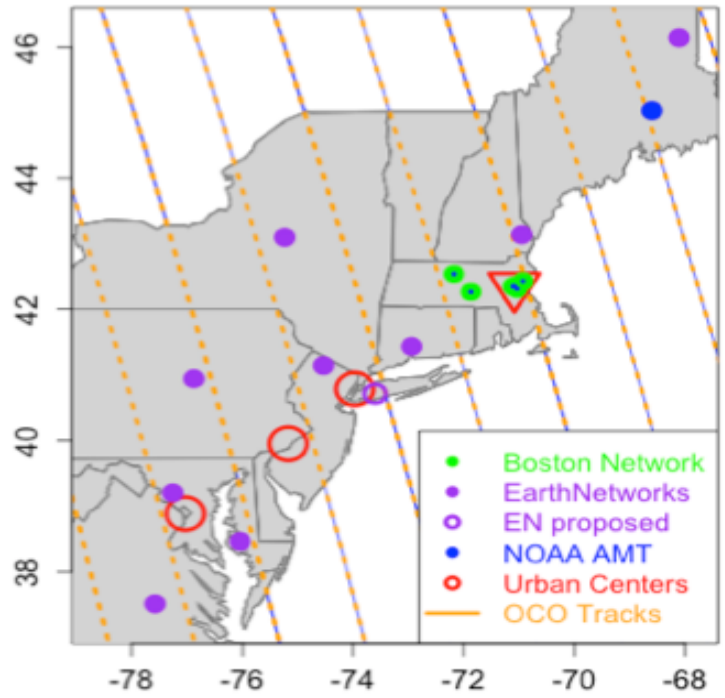
Prototype Monitoring, Reporting and Verification System for the Regional Scale: The Boston-DC Corridor

- Objective:
  - downscale the current NASA CMS flux products to the regional and local scales pertinent to Monitoring, Reporting, and Verification (MRV)

- Approach:
  - focus on the Boston-DC megalopolis corridor
    - 17% of the U.S. population, less than 2% of the land area
  - design a measurement network
  - develop an atmospheric modeling framework
  - High-resolution transport modeling
    - Mesoscale atmospheric model (WRF) coupled to Lagrangian particle dispersion model (STILT)
    - Verification includes PBL data from lidar profilers (**MiniMPL)**
  - High-resolution CO2 flux model incorporating
    - anthropogenic emissions estimates and the
    - CASA model (including its 0.5-deg resolution variant)
  - Inverse CO2 flux estimates



Prototype Monitoring, Reporting and Verification System for the Regional Scale: The Boston-DC Corridor

Institutions involved:

Organization	Institutional PI	Project Role
Atmospheric and Environmental Research	Thomas Nehrkorn	PI, meteorological modeling and verification, transport modeling, flux inversion
Harvard University	Steven C. Wofsy	Co-I, Boston measurements, flux inversion
Boston University	Lucy Hutyra	Co-I, *a priori* anthropogenic and biosphere flux models
Goddard Space Flight Center	G. James Collatz	Co-I, CASA-GFED biosphere fluxes at 0.5˚ and downscaling
Sigma Space	Philip L. DeCola	Co-I, Mini MPL deployment, operation, and data analysis
Earth Networks	William J. Callahan	Co-I, Tower Measurements of CO_2 and other greenhouse gases
Jet Propulsion Laboratory	Charles E. Miller	Collaborator, OCO-2 analysis
University of Massachusetts, Boston	Crystal Schaaf	Collaborator, Analysis of UMass Boston data

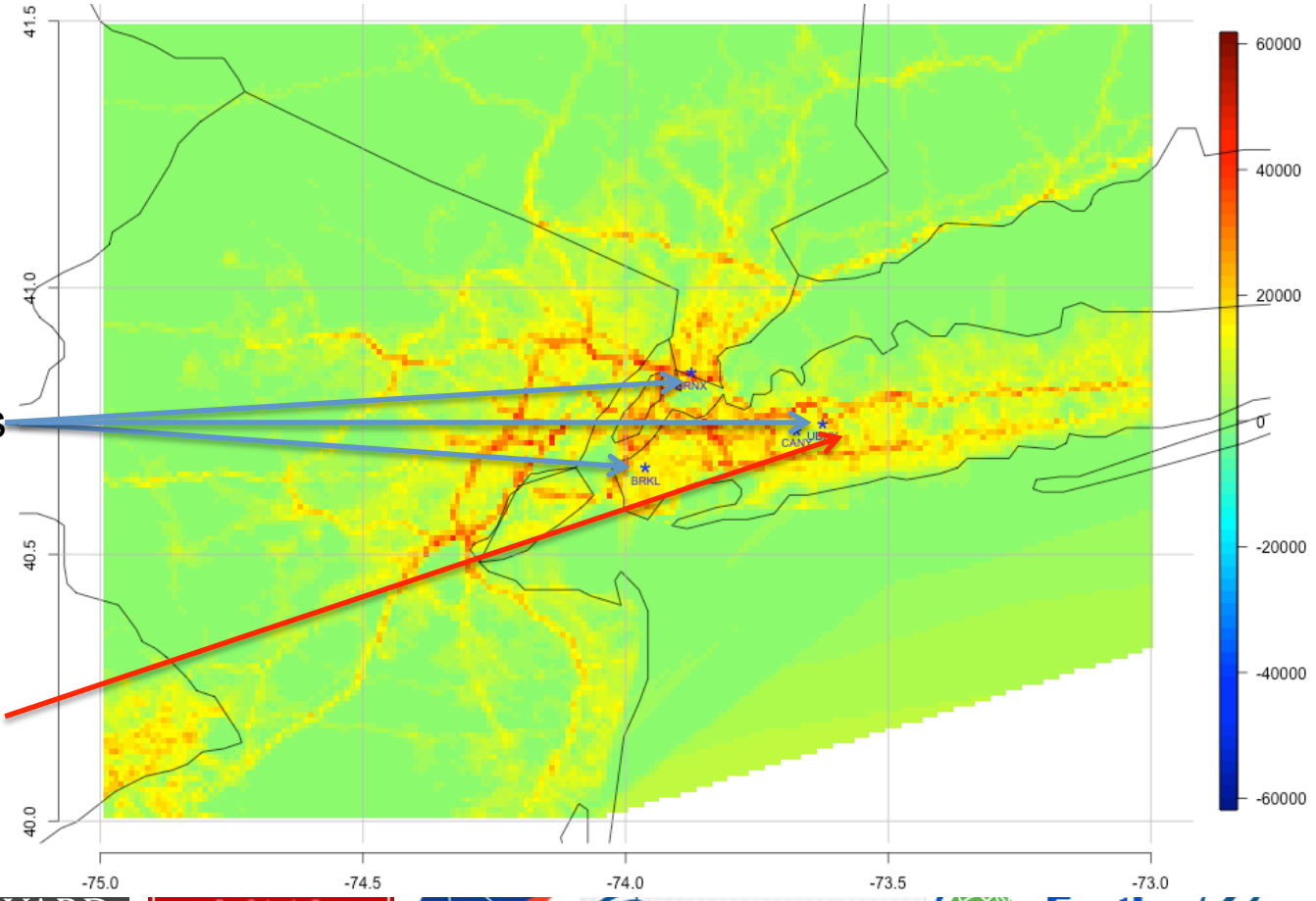
Some Recent Activity

- Observing Network:
  - Added a new GHG tower Earth Network site on Long Island
  - Includes a miniMPL deployed at the same site
  - Planning underway for deployment of second miniMPL at an upwind Earth Networks GHG tower site

Map of traffic-related CO2 emissions

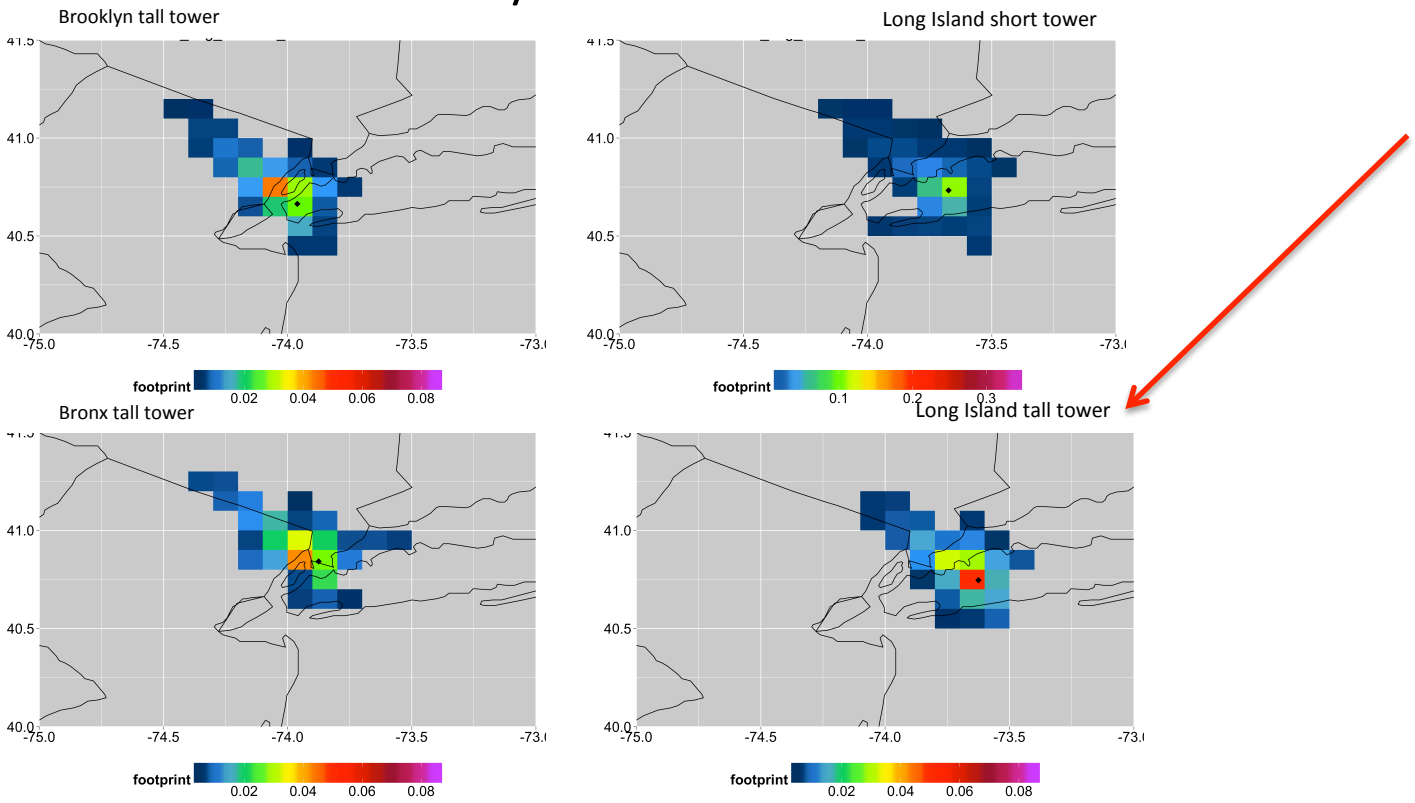
Candidate sites

Final site



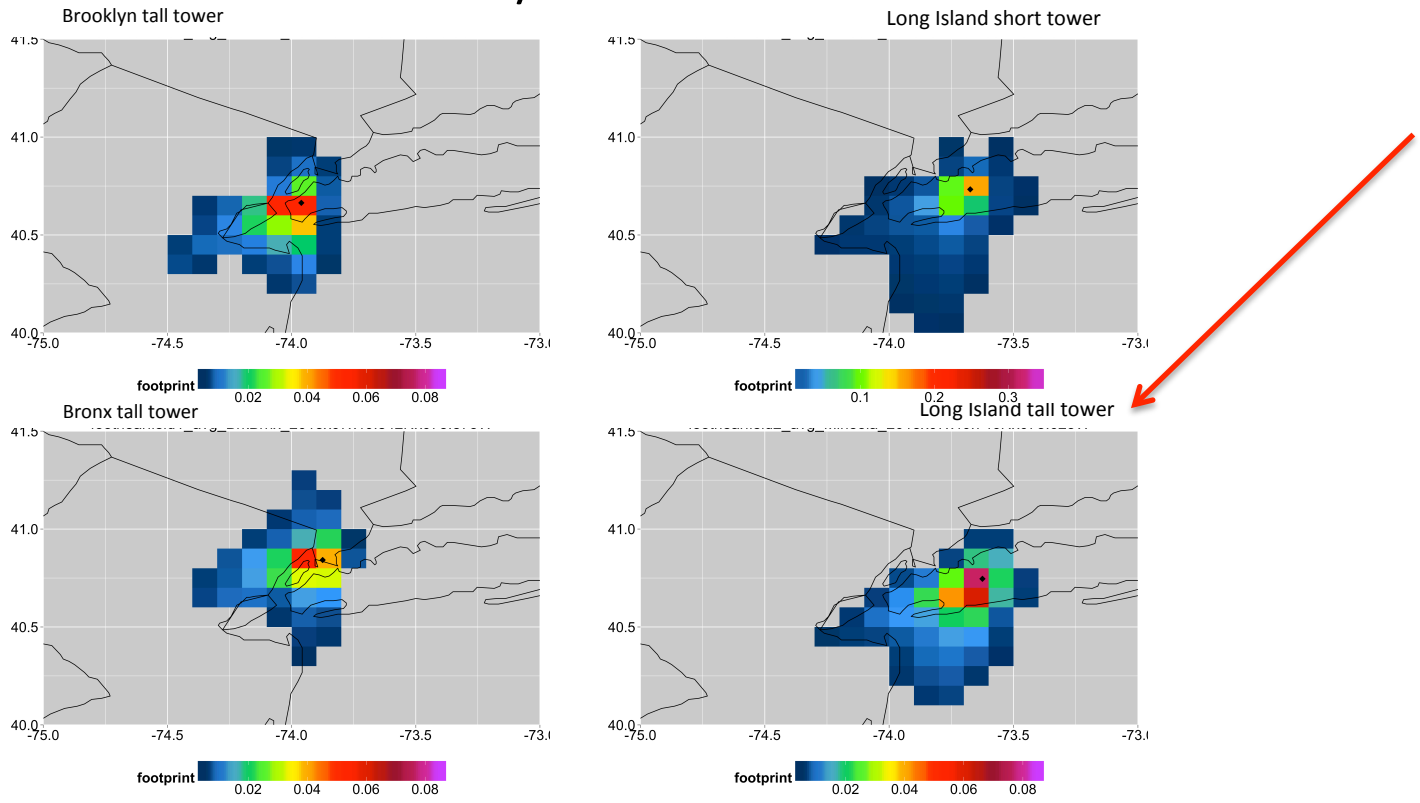
Analysis of tower sensitivity for candidate sites

3/2013



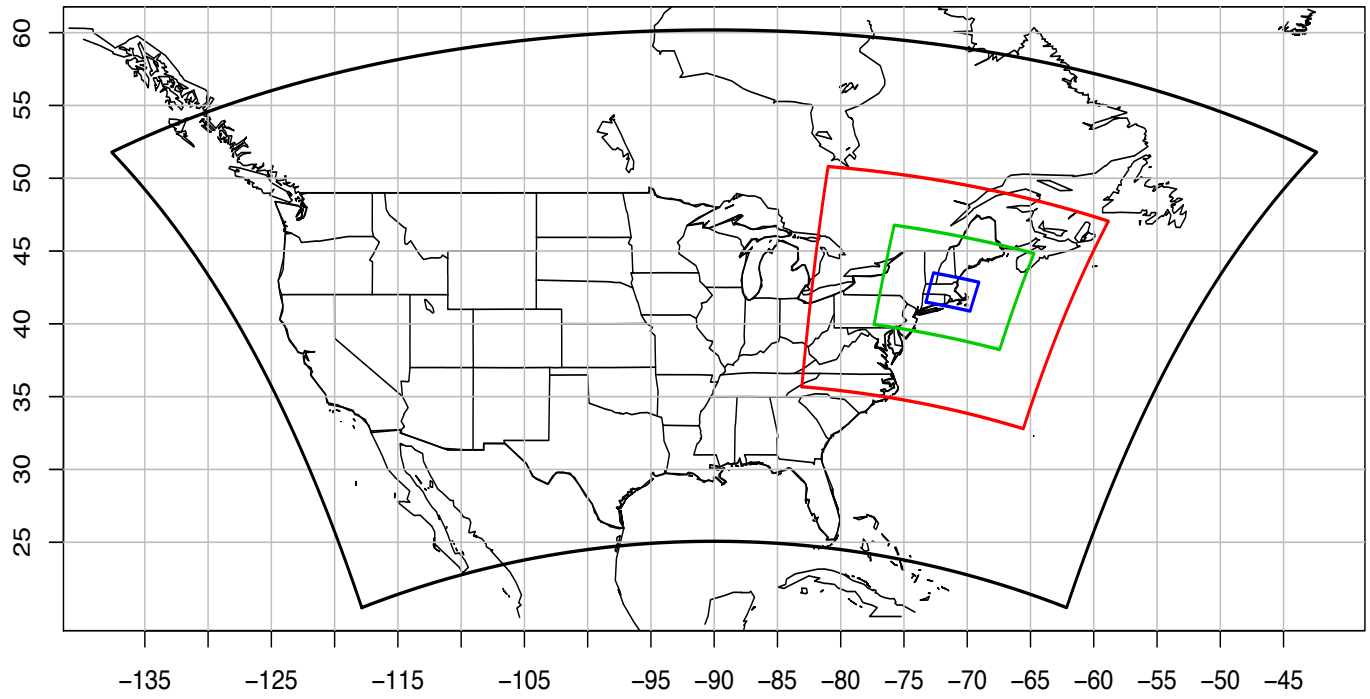
Analysis of tower sensitivity for candidate sites

7/2013



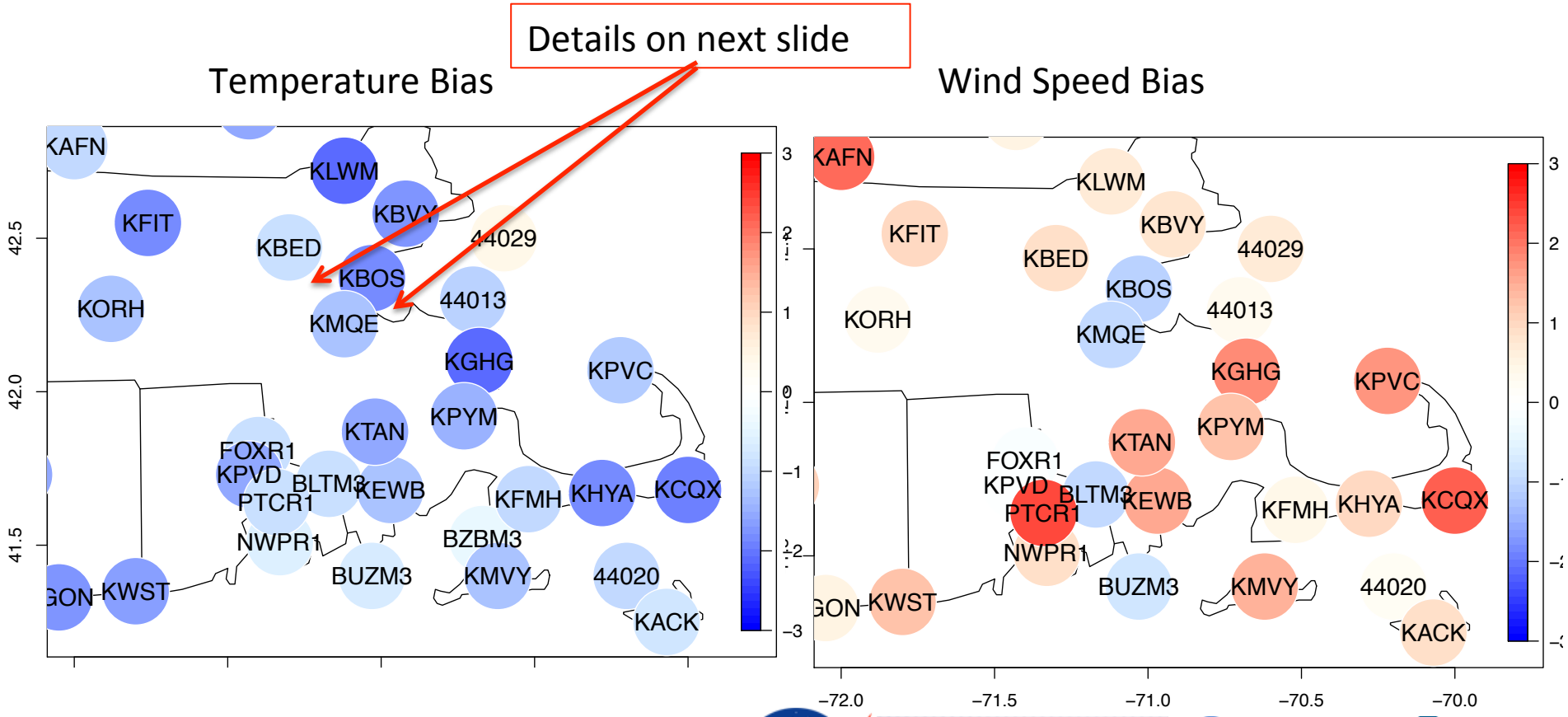
Some Recent Activity

- Modeling framework: WRF model evaluation in light of Methane study of Boston area
  - Evaluation against standard NWS data
  - Acquiring and evaluating high-density Earth Networks Meteorological data (“weatherbug”)
  - Analyzing and evaluating miniMPL data for evaluation of WRF PBL simulations



WRF model evaluation

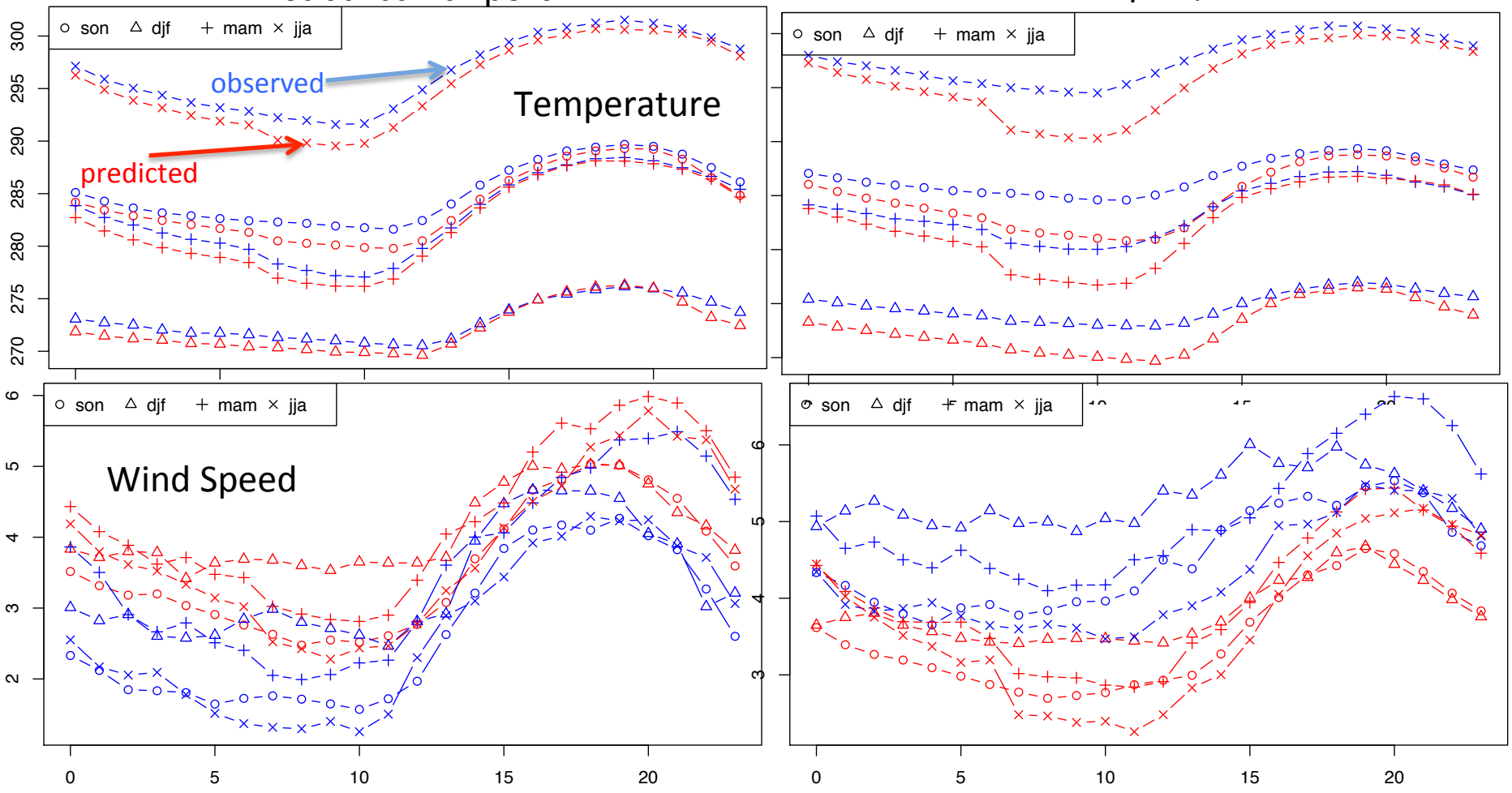
- Comparison against NWS surface stations
  - Year-long statistics (Sep 2012 – Aug 2013)



- Mean diurnal cycle of temperature and wind speed
  - Overpredicted nighttime stability (➔PBL scheme, sfc scheme, …)
  - High wind speed bias over land at all hours (➔ WRF upgrades)

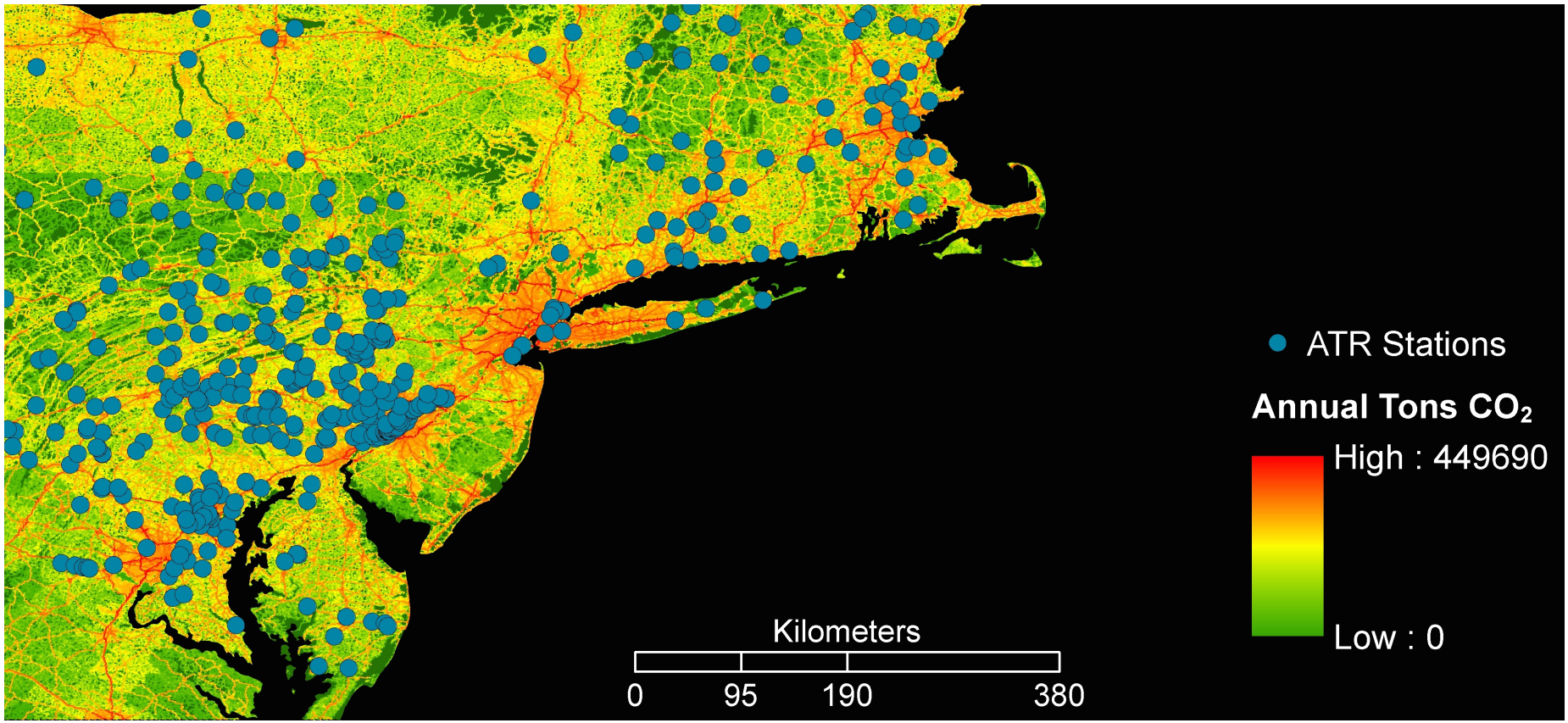
KBED: suburban airport

KBOS: urban airport/harbor

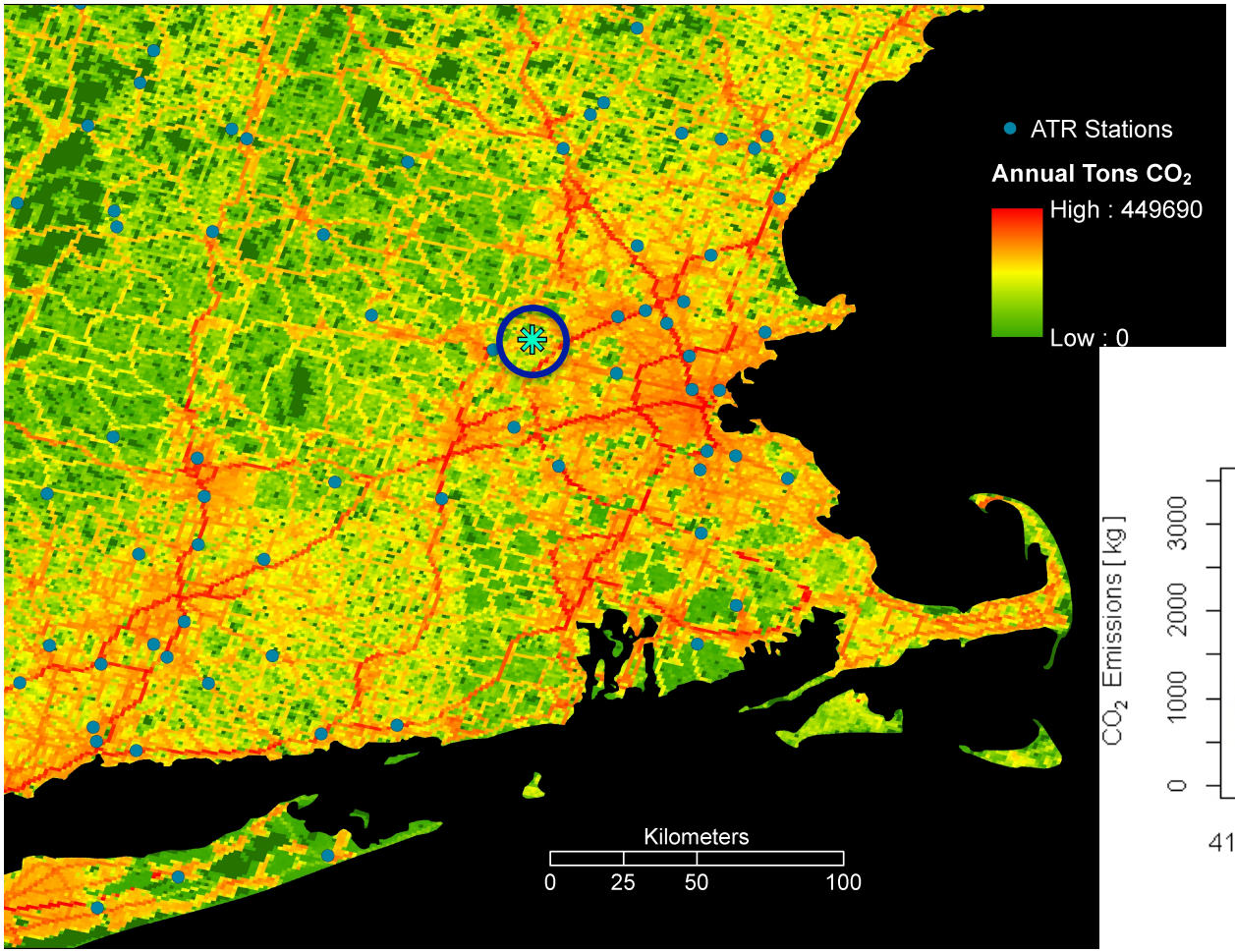


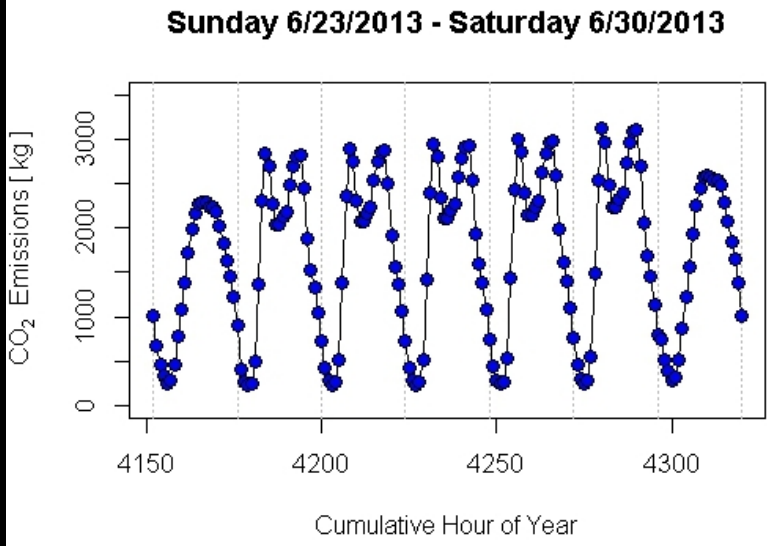
$FFCO_2$

Constructing a customized emissions dataset.
Example below is transportation emissions -> hourly 1km emissions for 2013.

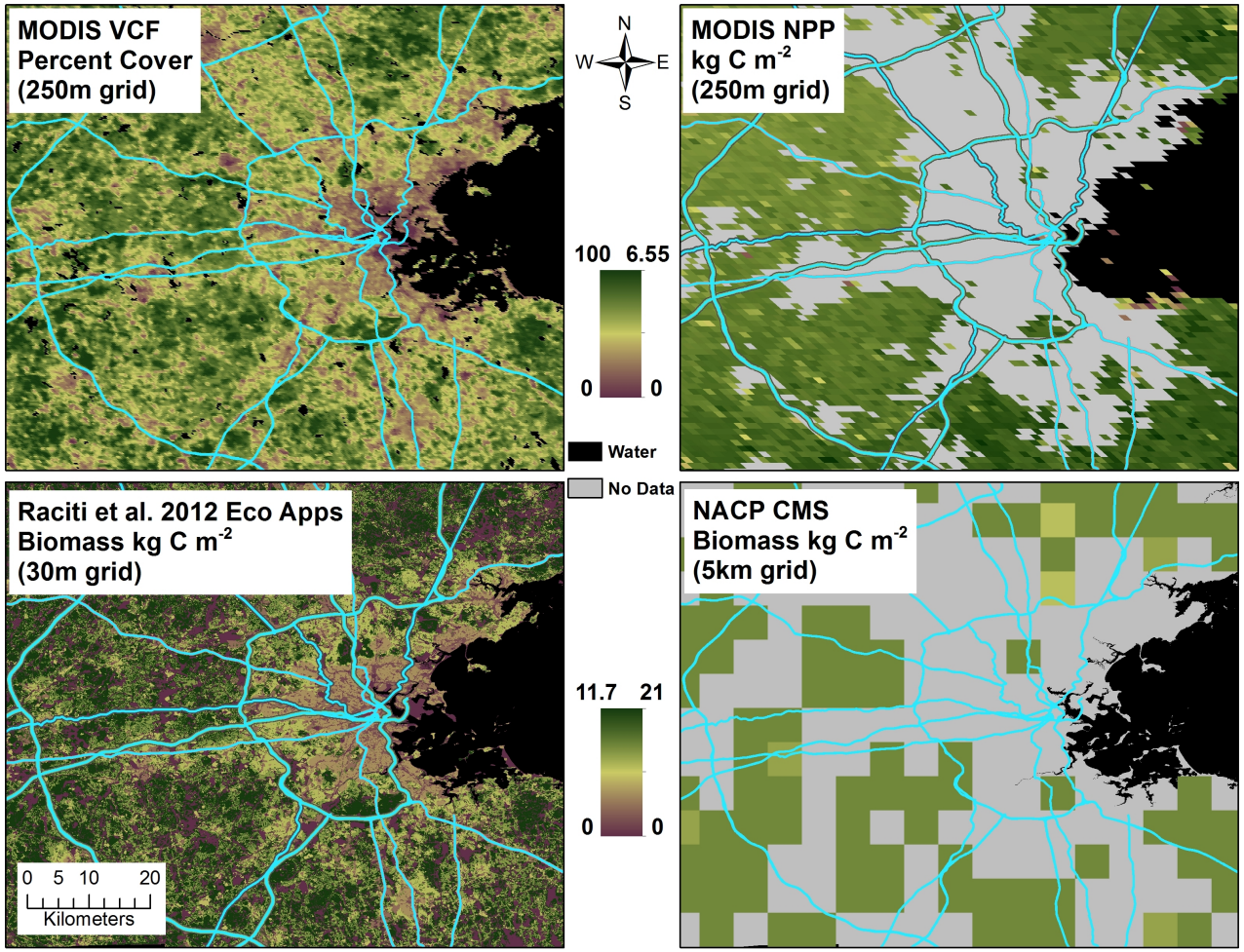


$FFCO_2$


ATR Stations
Annual Tons CO_2
High : 449690
Low : 0
Kilometers
0 25 50 100

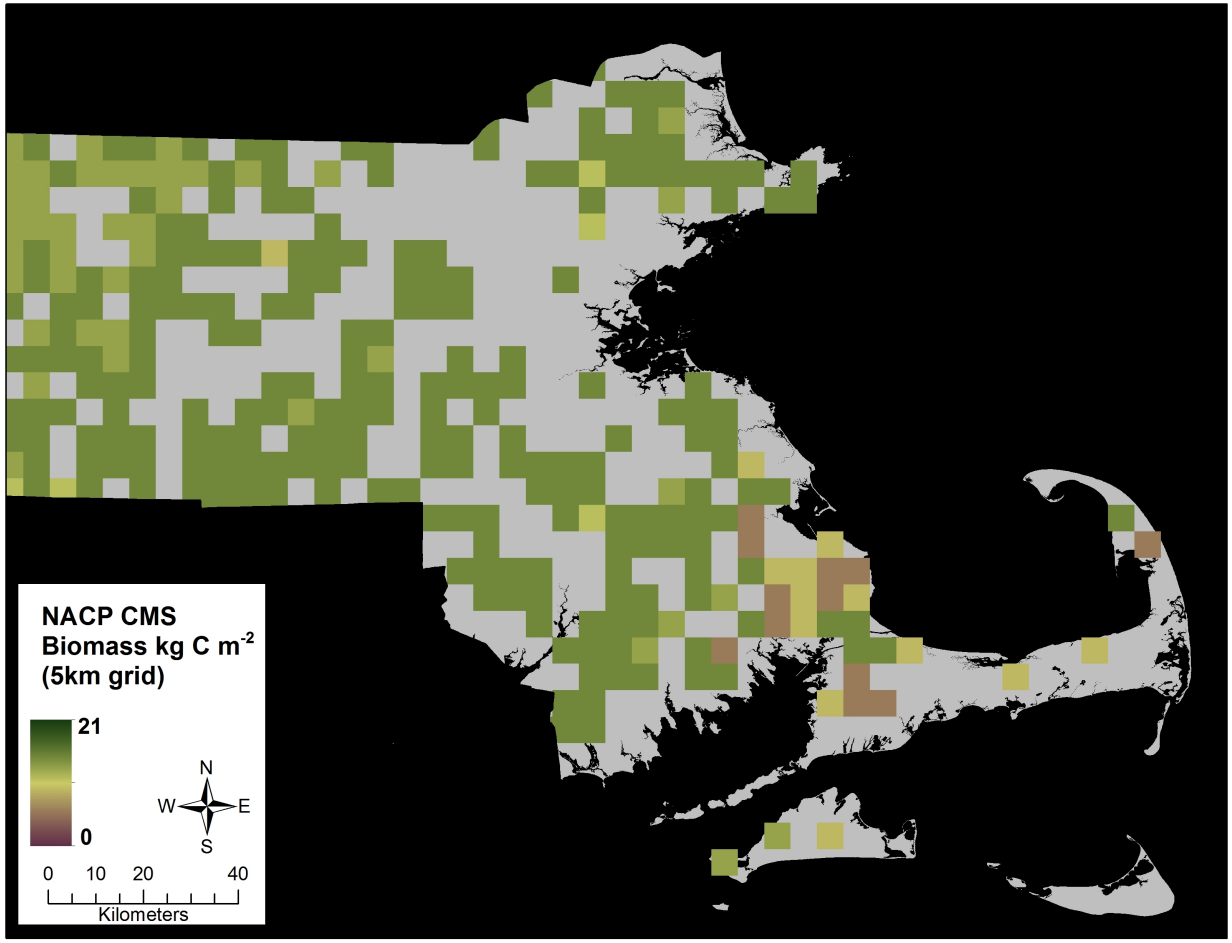

Sunday 6/23/2013 - Saturday 6/30/2013
CO_2 Emissions [kg]
0
1000
2000
3000
4150
4200
4250
4300
Cumulative Hour of Year

Ecosystem fluxes



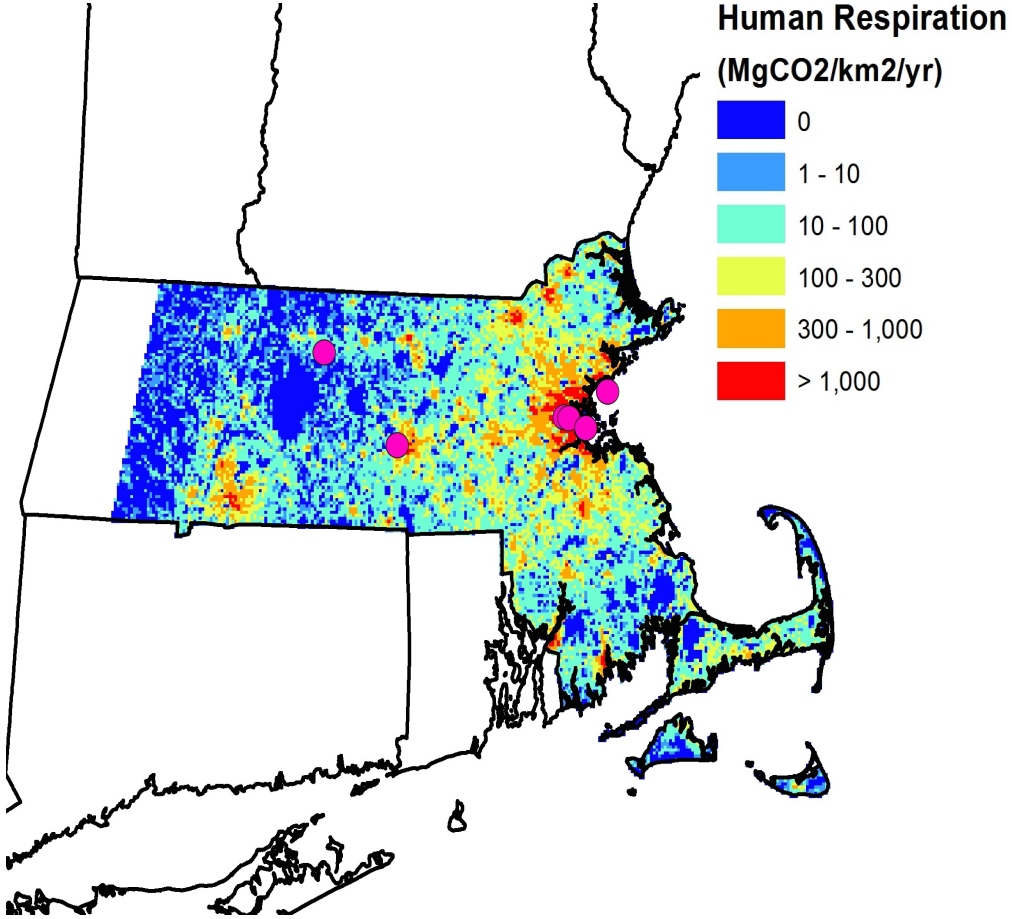
- While urban biomass pools are reduced, they are far from zero and will influence atmospheric mixing ratios.
- New urban vegetation productivity data suggests ~2x the ecosystem productivity per unit biomass due to urban growing conditions.

Ecosystem fluxes



- Gray = NO DATA
- Opportunities for refinement to capture biomass and fluxes within developed areas.

Human Respiration



Next steps:

- Observation Network:
  - Intercalibration of Boston and Earth Networks GHG sensors
  - Selection of study period using historical data
  - Real-time acquisition of GHG and miniMPL data
- Modeling Framework
  - WRF sensitivity studies
  - miniMPL <-> WRF PBL comparisons
  - Complete custom emissions estimations
  - CASA runs over urbanized areas (w/ Collatz)

Using Atmospheric Observations to Validate/Evaluate/Benchmark Carbon Cycle Process Models

Jim Collatz

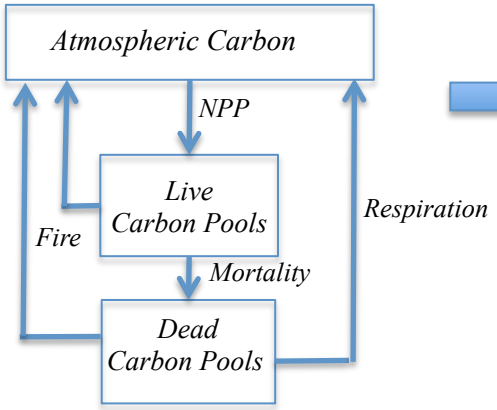
CASE Study: CASA-GFED Land Carbon Cycle Model of physiological (NPP, Heterotrophic respiration) and Fire Fluxes.

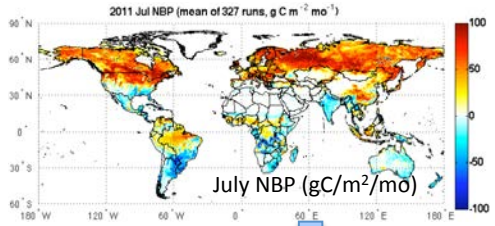
Are CO2 observations good enough or how good do they have to be to constrain estimates and attribution of carbon fluxes?

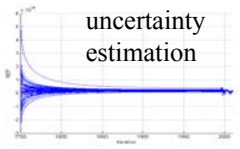
In collaboration with Randy Kawa, Lesley Ott, and others

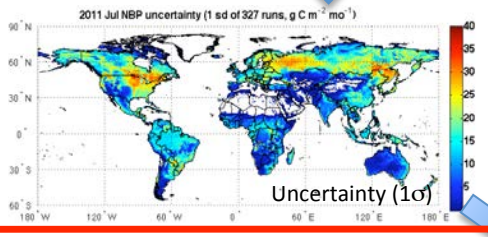
GSFC CASA-GFED System

Satellite data constrained diagnostic land carbon cycle model, monthly fluxes, MERRA meteorology, ½°, monthly

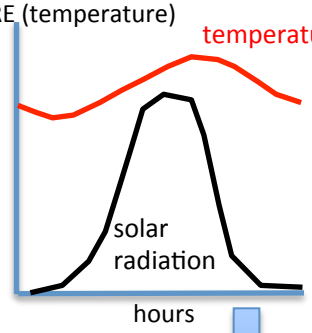








MERRA 3 hrly scaling of GPP (solar radiation) and RE (temperature)

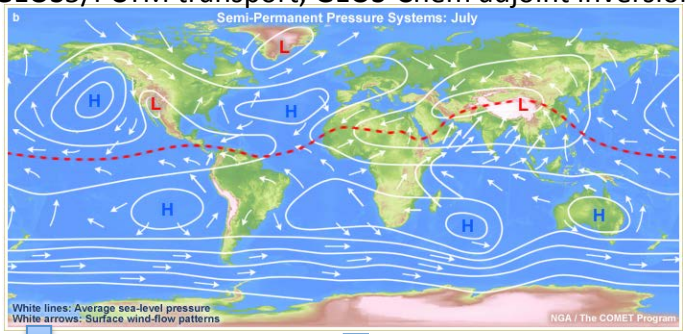


Ocean, Fossil Fuel fluxes

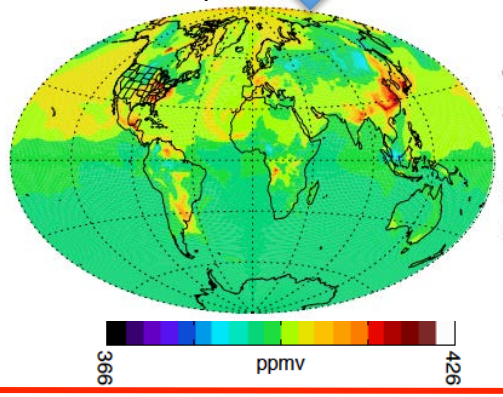
model improvements

satellite CO2

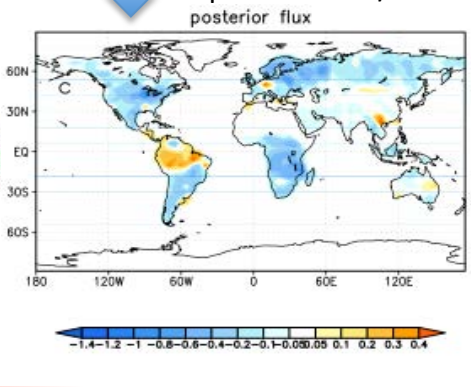
GEOS5/PCTM transport, GEOS-Chem adjoint inversion



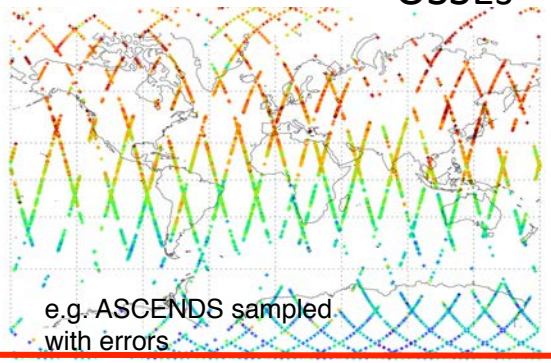
maps of CO2 variability

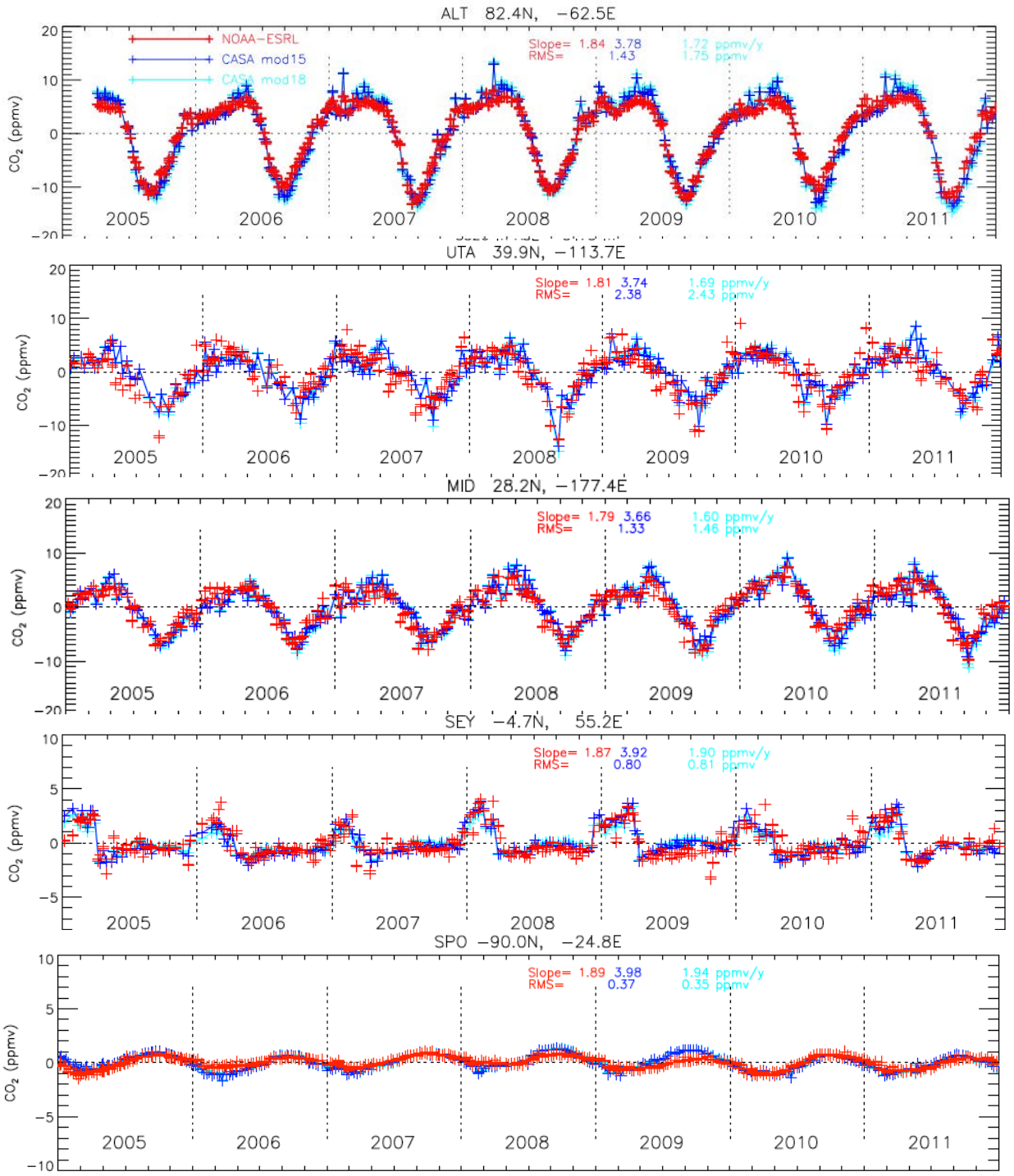


maps of sources/sinks



OSSEs

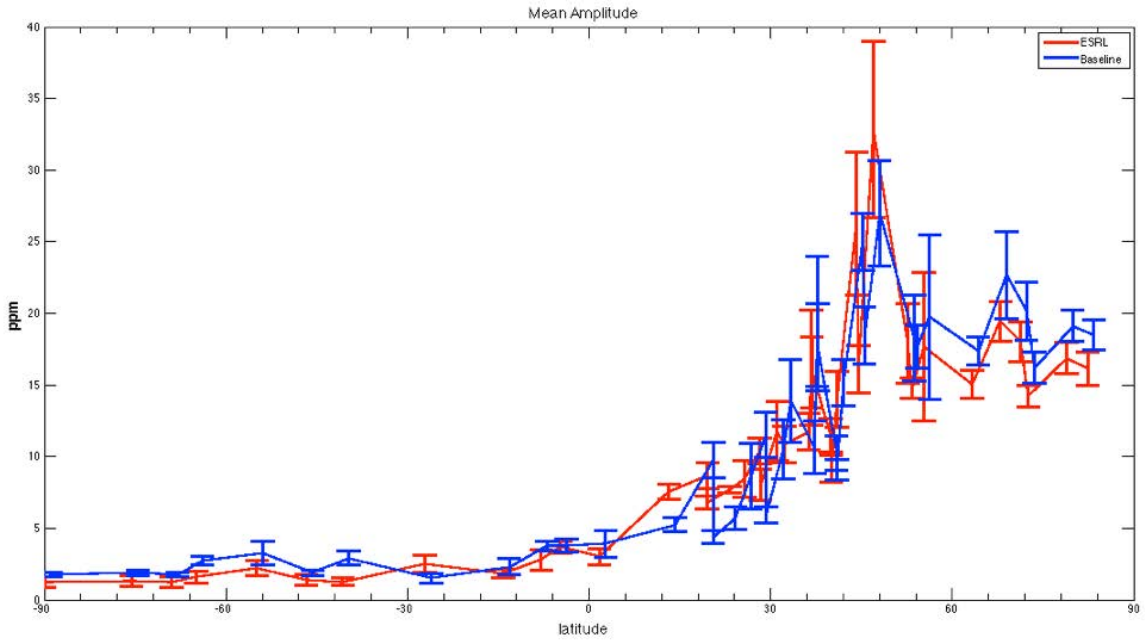


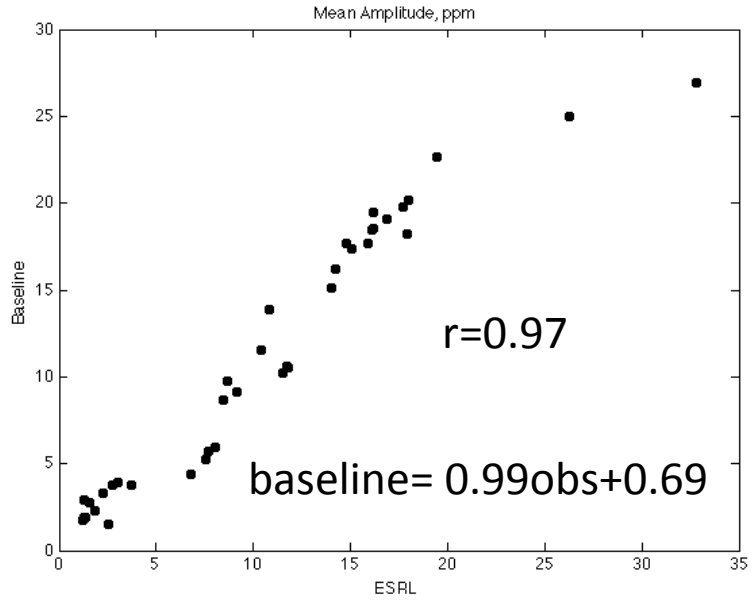


Flask Network Weekly

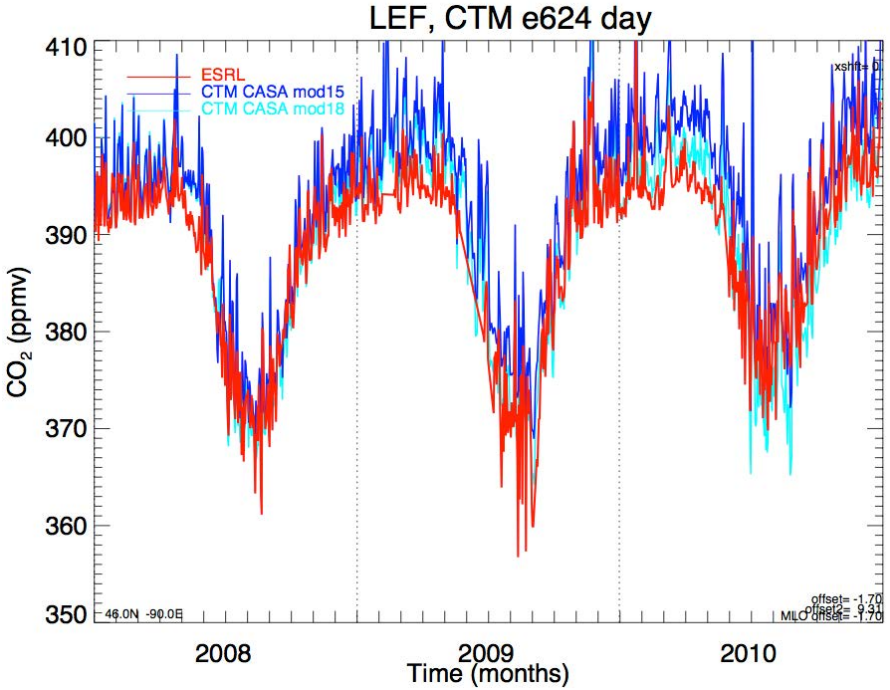
Fig. 2. Detrended CO2 variability measured (red) and modeled (baseline blue) over a latitudinal gradient from north (Alert 82.4N) to south (South Pole 90S). Also shown are results from a simulation with an imposed global carbon land sink of 3PgC/yr (cyan). Detrend slopes and RMSE are indicated for observations and simulations.

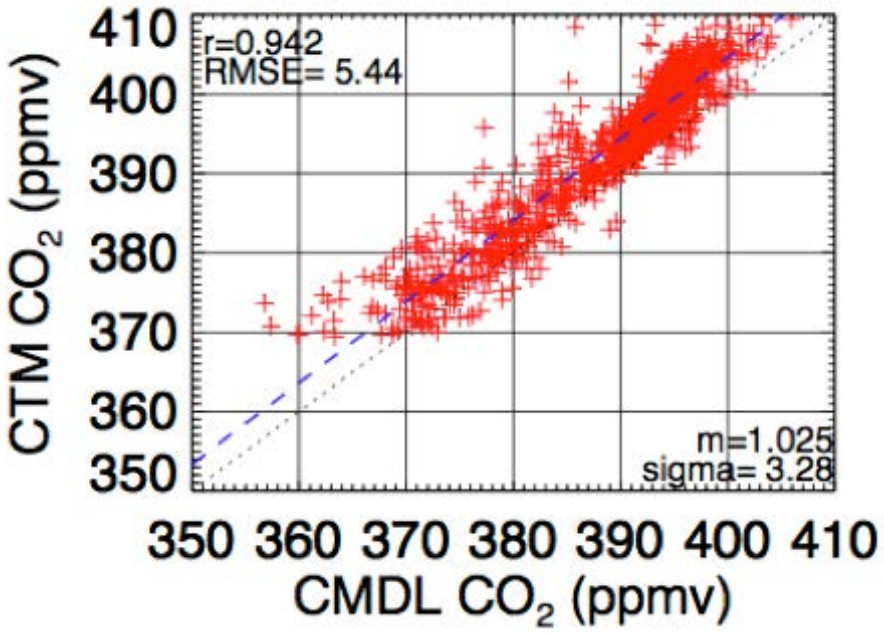
Annual Mean Amplitude, 2003-2011, 38 sites



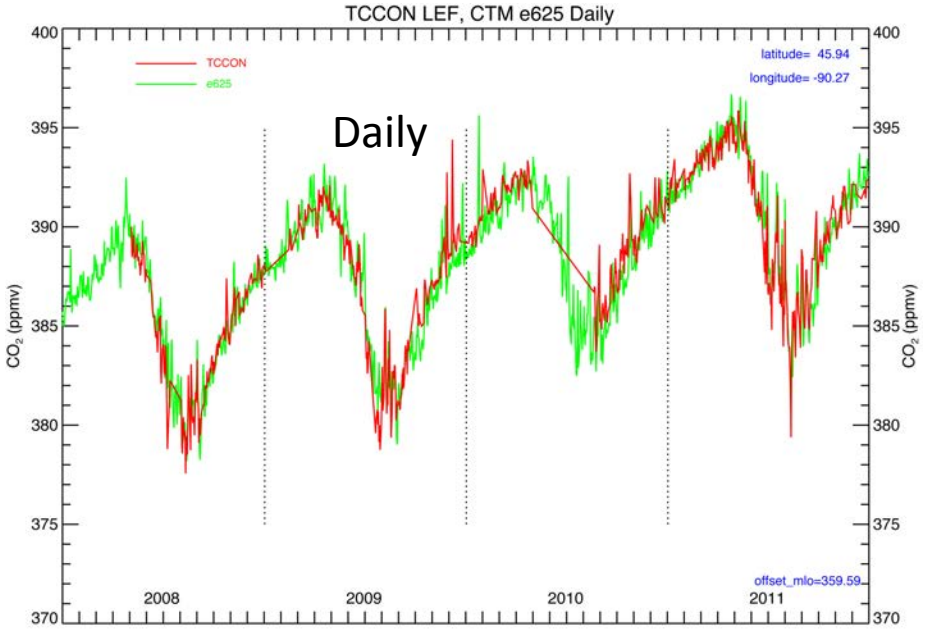


Continuous Measurements
Daily

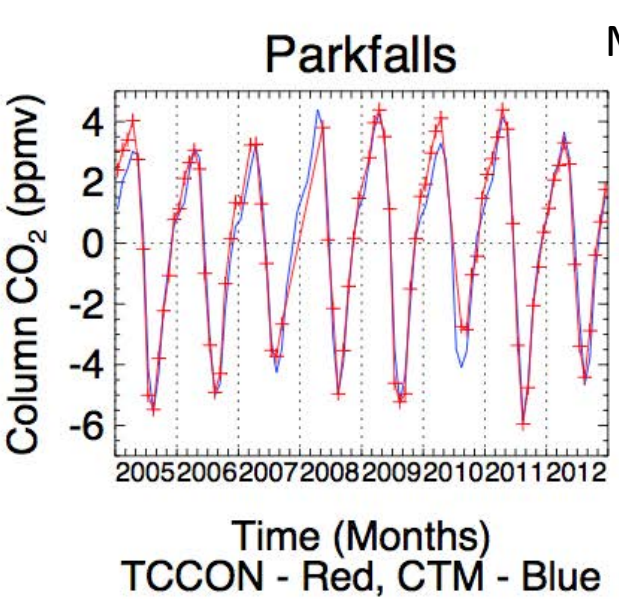


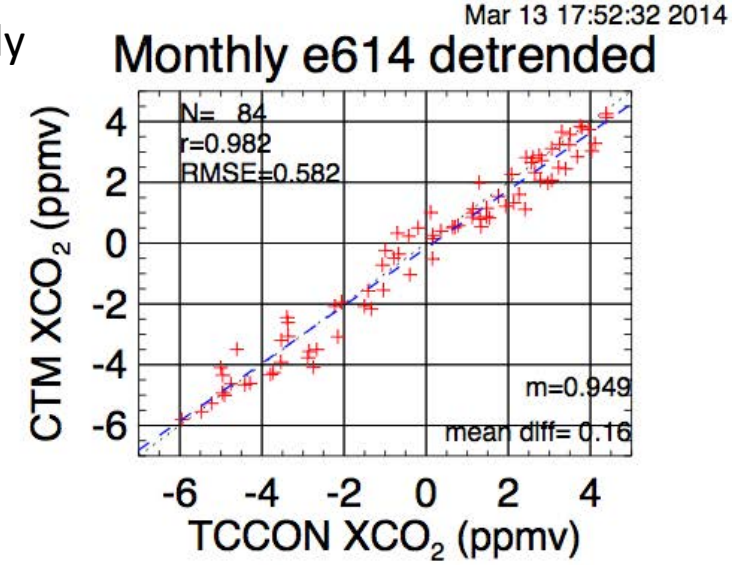


TCCON Column



Monthly





HIPPO Profiles

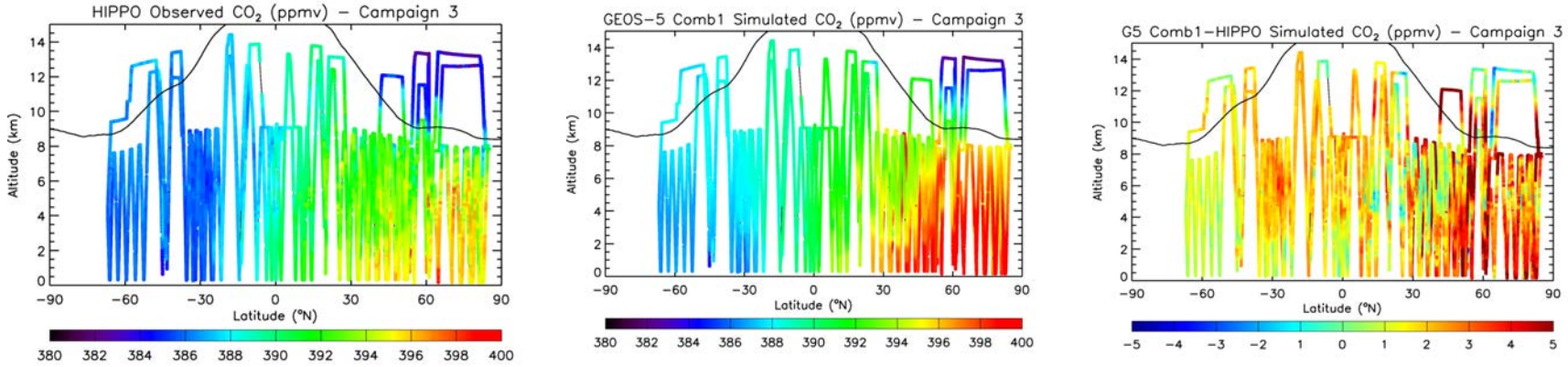


Figure 12. Comparison of observed and simulated CO_2 mixing ratios (top) during HIPPO Phase III in March and April, 2010 show HIPPO observations (left), GEOS-5 using CASA-GFED3 and NOBM (middle) and the simulated minus observed difference (right).

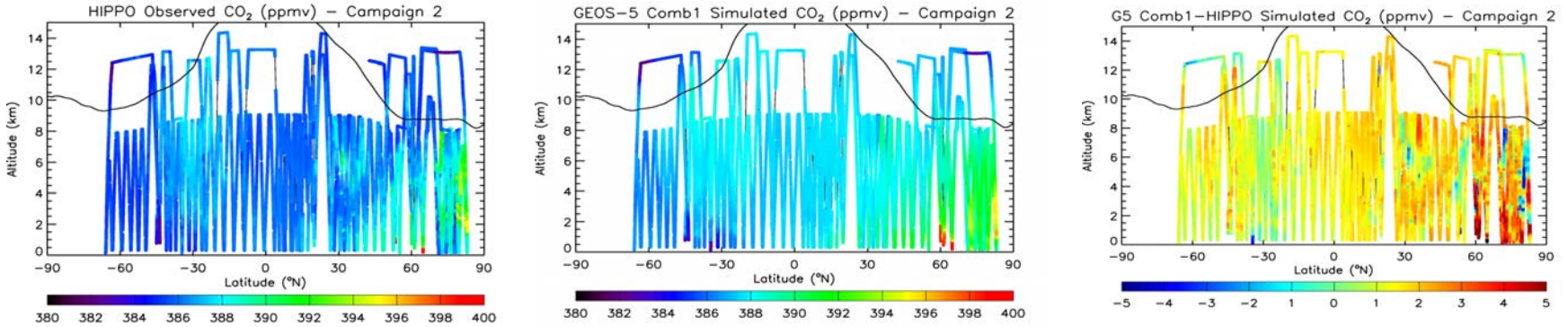
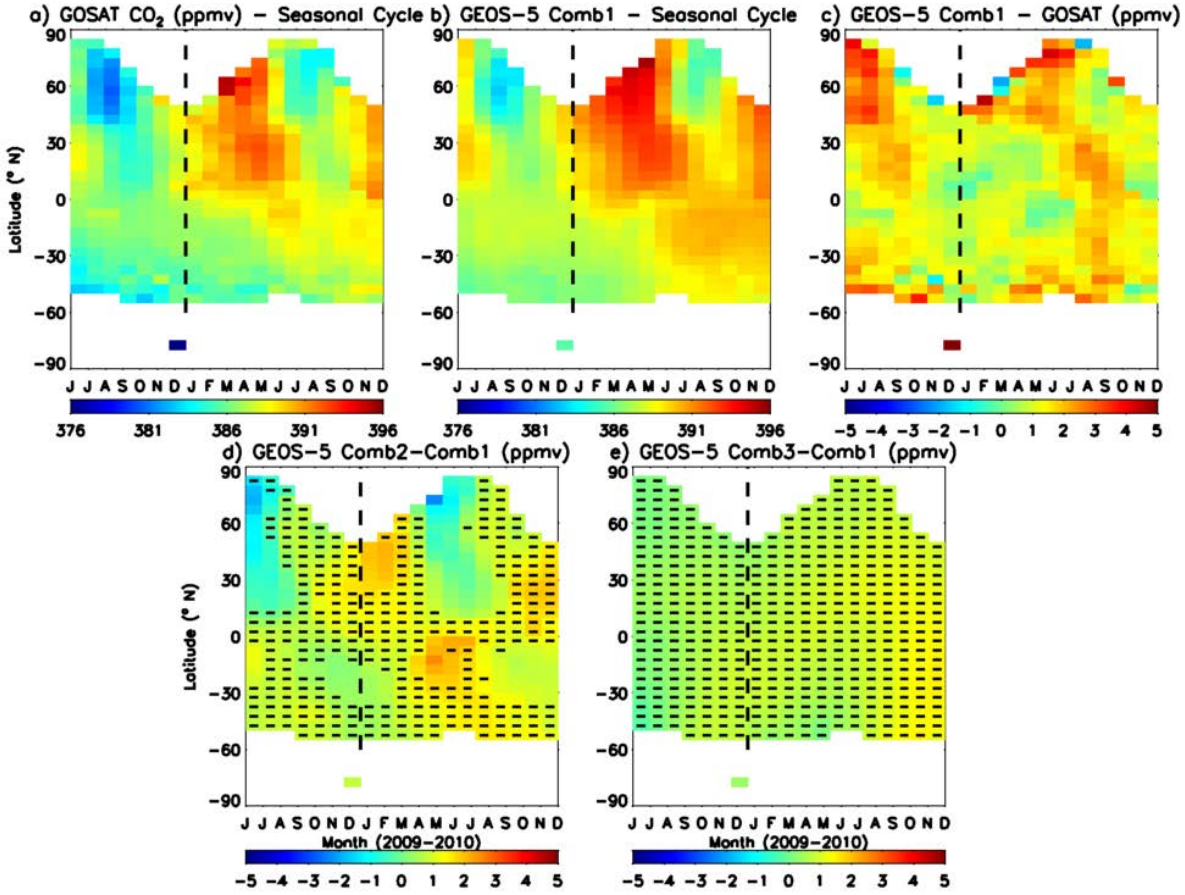


Figure 11. Comparison of observed and simulated CO_2 mixing ratios (top) during HIPPO Phase II in October and November, 2009 show HIPPO observations (left), GEOS-5 using flux combination 1 (middle) and the simulated minus observed difference (right).

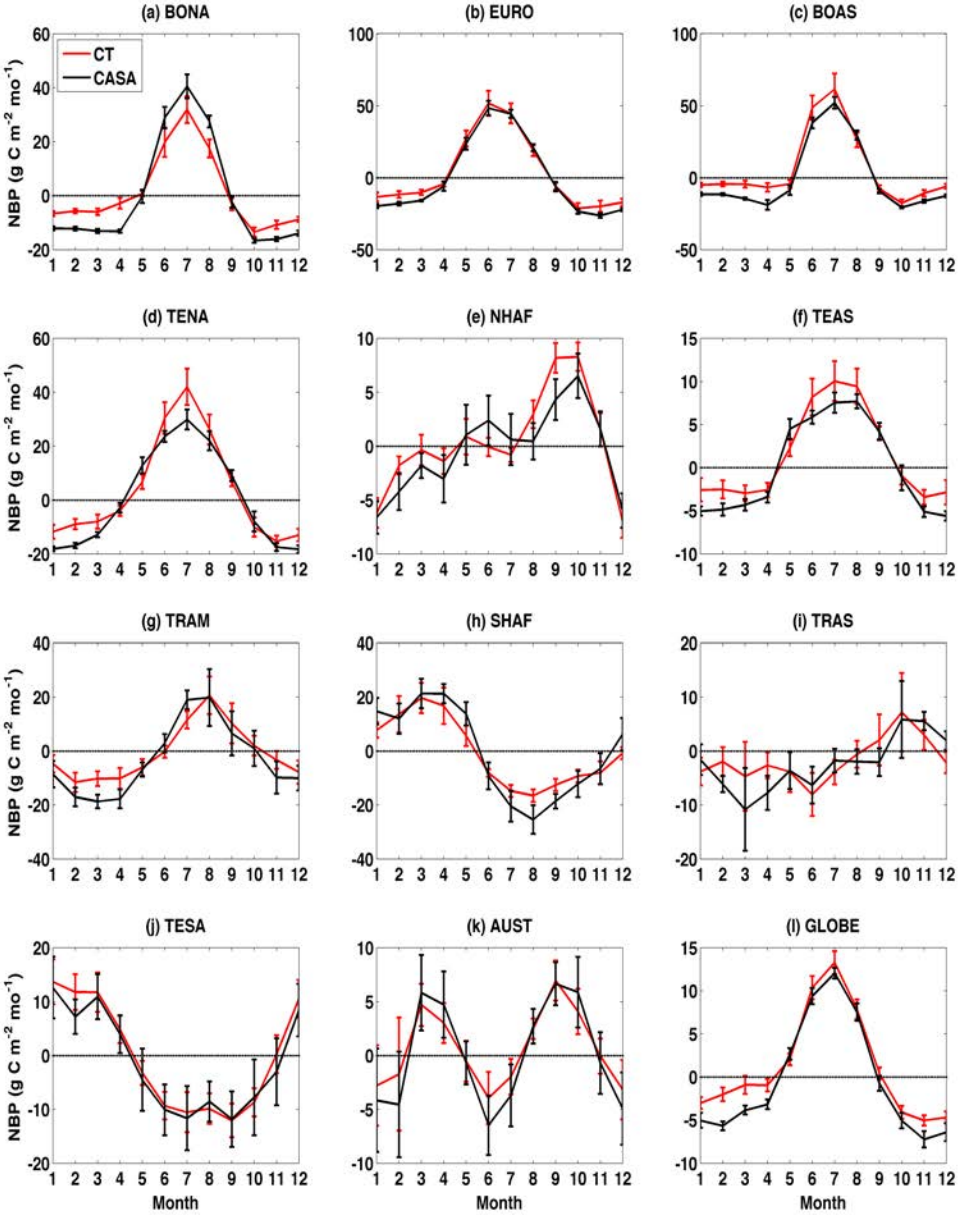
GOSAT Column



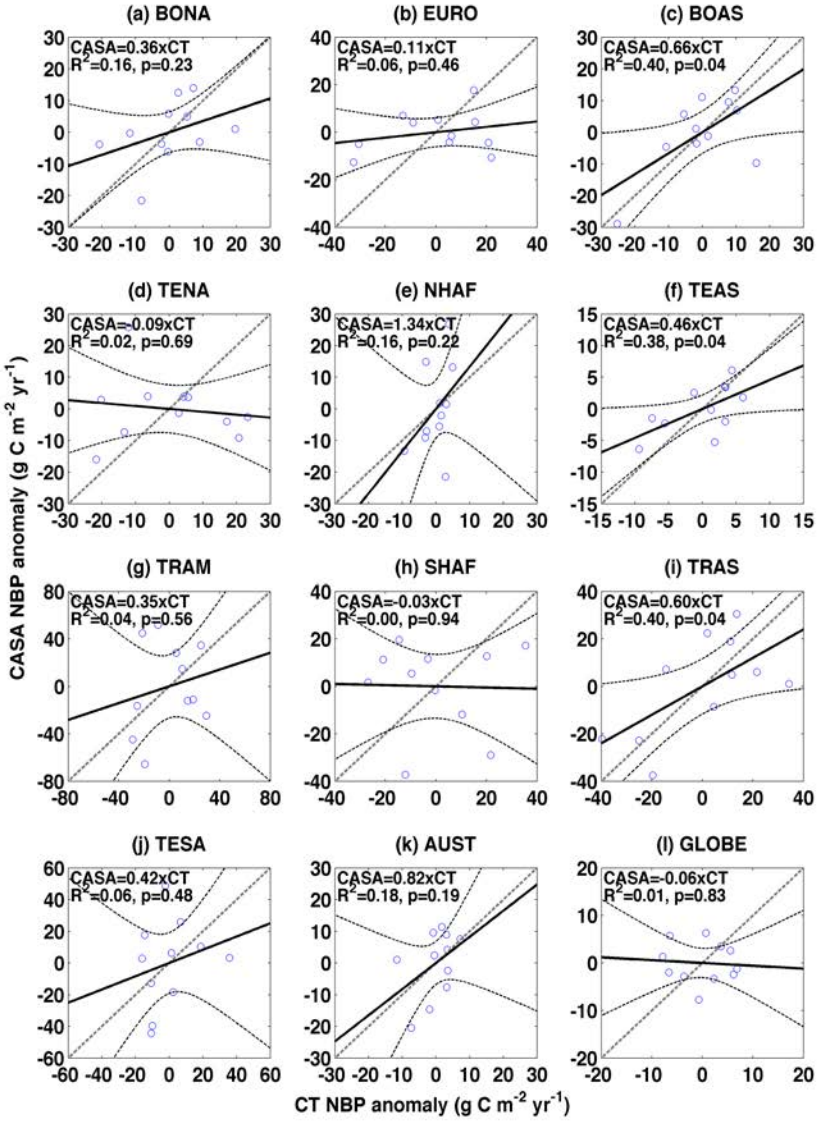
Seasonal cycle of (a) zonal mean GOSAT observed mixing ratios, (b) zonal mean GEOS-5 mixing ratios, and (c) the difference between zonal mean model results and observations. Bottom left (right) plot show the difference in simulated zonal mean CO2 when different land (ocean) fluxes are assumed. Cells where these differences are not statistically significant at the 95% confidence level are indicated by black lines. All units are ppmv.

Inversions: Carbon Tracker

Mean Seasonal Cycle



Interannual Variability

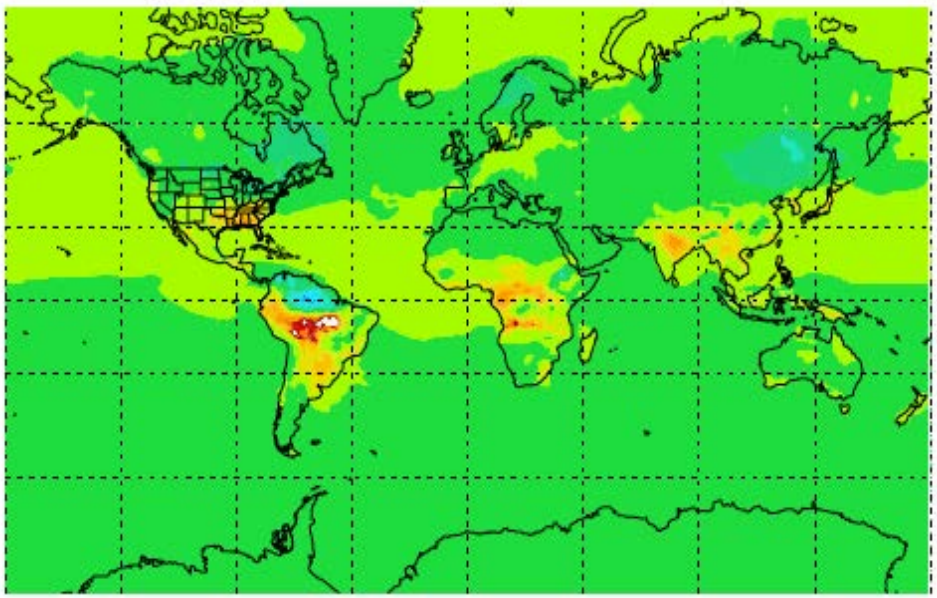


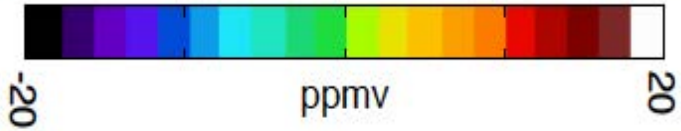
FIRE – NO FIRE

August 2010

Surface

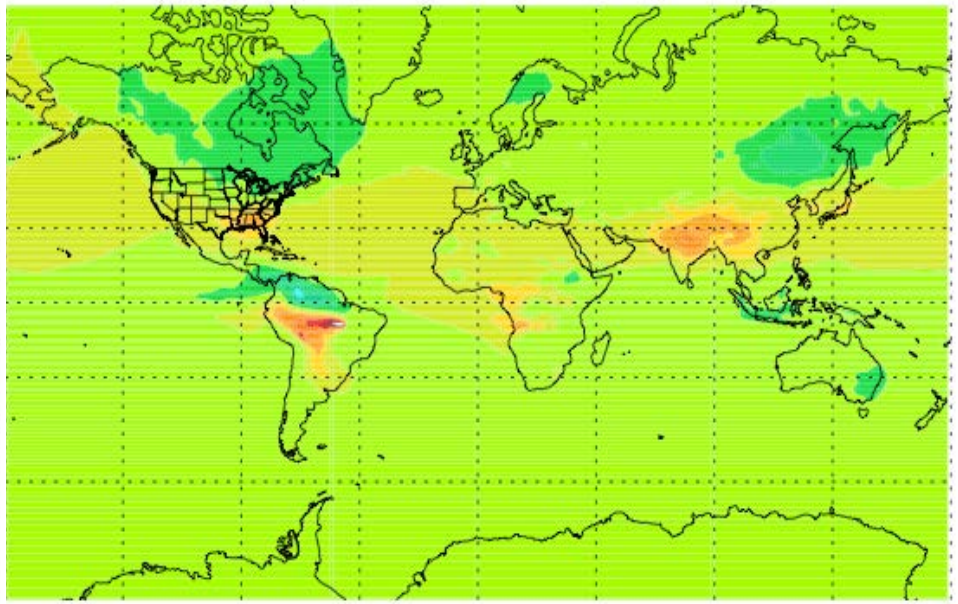
<10ppm

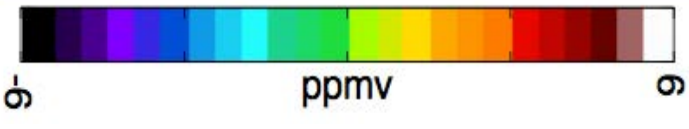




Column

<3ppm





Are CO2 observations good enough or how good do they have to be to constrain estimates and attribution of carbon fluxes?