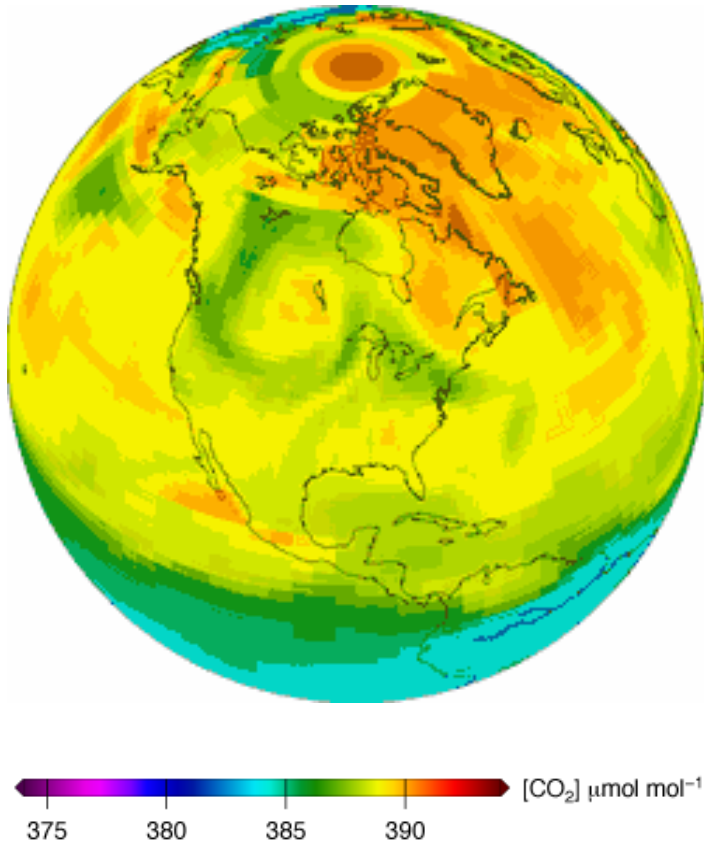


CarbonTracker-Lagrange: A model-data assimilation system for North American carbon flux estimates

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Why CarbonTracker-Lagrange?



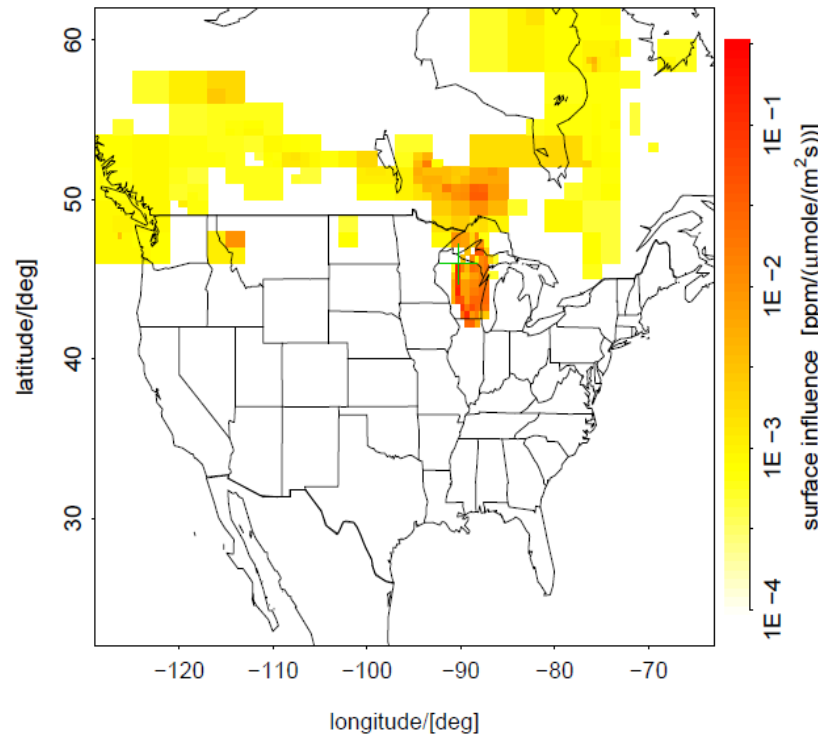
- CarbonTracker [Peters et al. 2007]

- CarbonTracker (CT) is a system that assimilates atmospheric CO₂ observations to infer surface fluxes
 - Global transport model TM5
 - 3 x 2 degree global or 1 x 1 degree regional
- CarbonTracker (CT)-Lagrange
 - High-resolution Lagrangian transport to improve regional carbon fluxes
 - **0.1 x 0.1 degree**



Lagrangian forward simulations

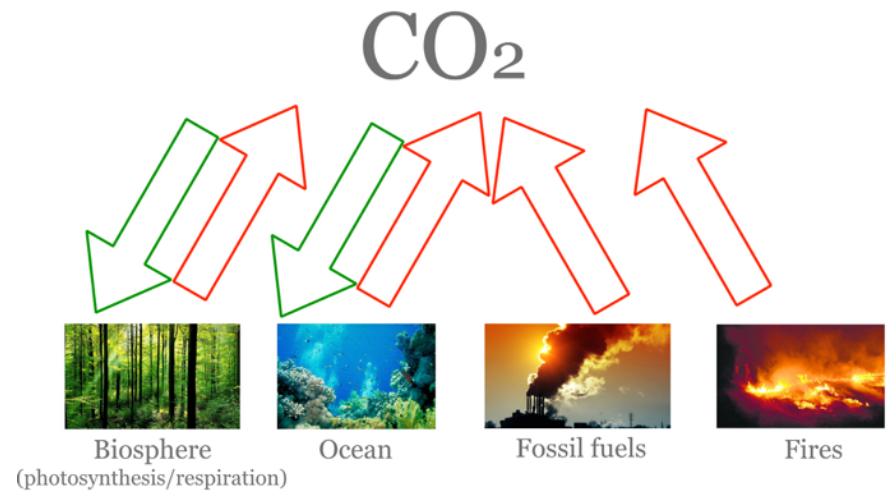
Lagrangian transport: WRF-STILT



Meteorological input: WRF

$$CO_{2.simu} = CO_{2.init} + \Delta CO_2$$

$$\Delta CO_2 = \text{Footprints} \times \text{Fluxes}$$

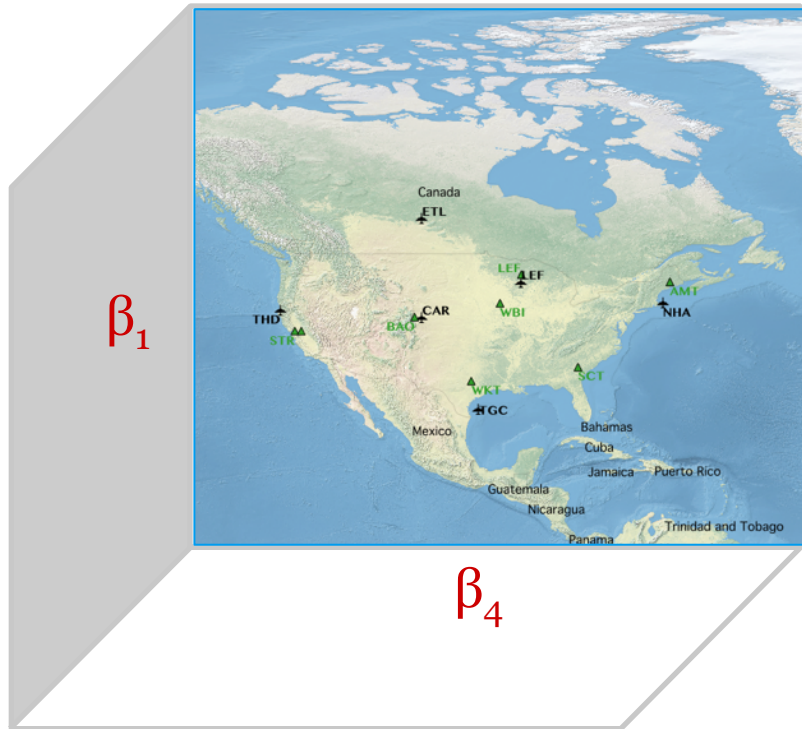




CT-Lagrange inversion system

$$C_{simu}(x, y, z, t) = C_{init}(x, y, z, t) + \Delta C^{flux}(x, y, z, t) + \Delta C^{BC}(x, y, z, t)$$

β_2



β_3

- **What do we optimize**

- Every 10-day biosphere fluxes, uncertainty 80%
- Every 10-day four boundary adjustment parameters, uncertainty 1.4 ppm

- **Observations**

- Tall towers
- Aircraft profiles

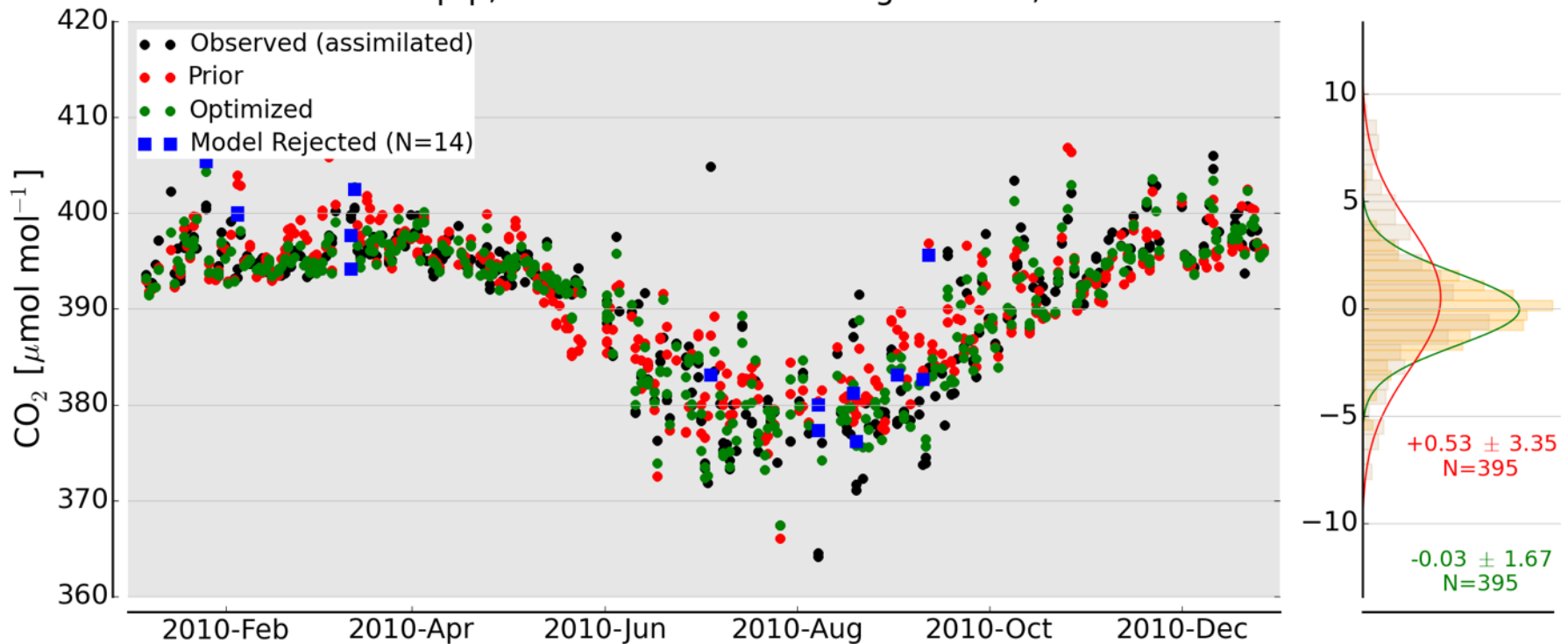
- **Prior**

- Biosphere fluxes: SiBCASA, SiB3, CT2013B
- Boundary conditions: CT2013B, CT-Europe EMP (NOAA “curtain”)



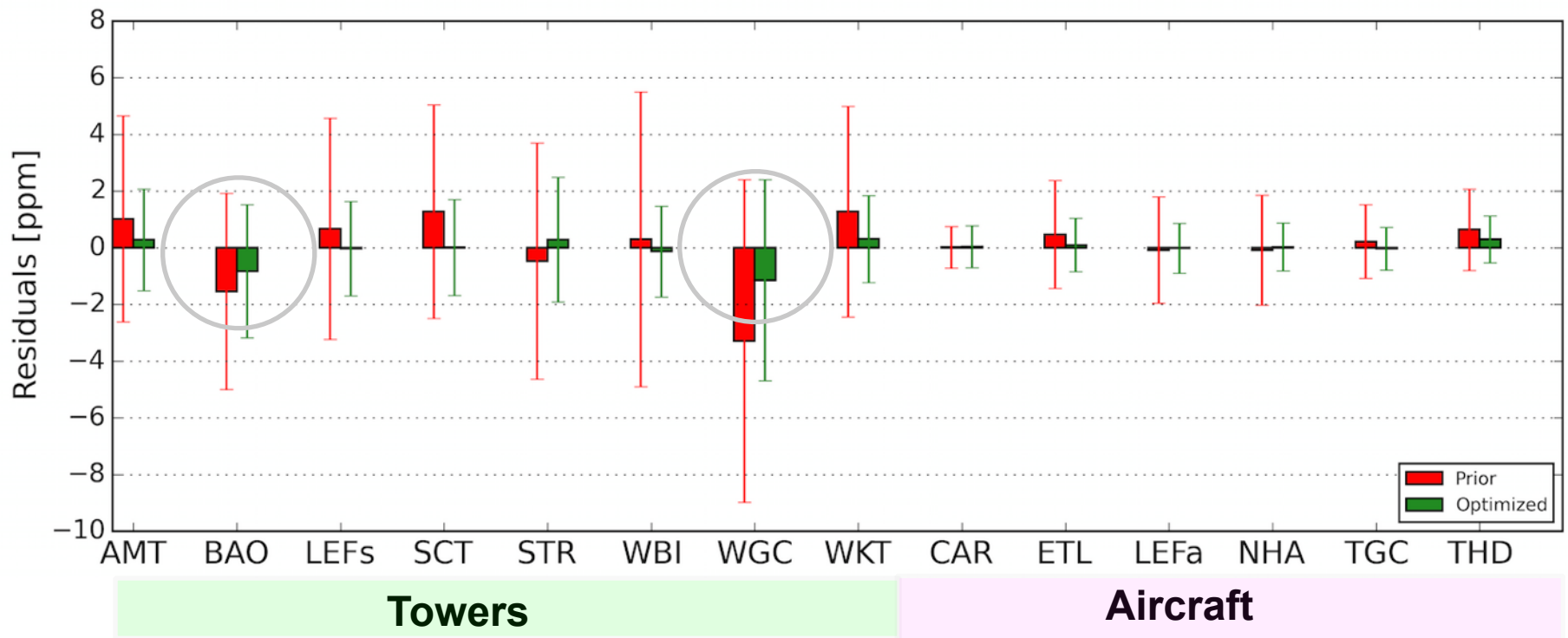
Take surface site LEF for example

Park Falls, Wisconsin, United States [45° 57'N, 90° 16'W, 472 masl]
surface-pfp, NOAA Global Monitoring Division, United States





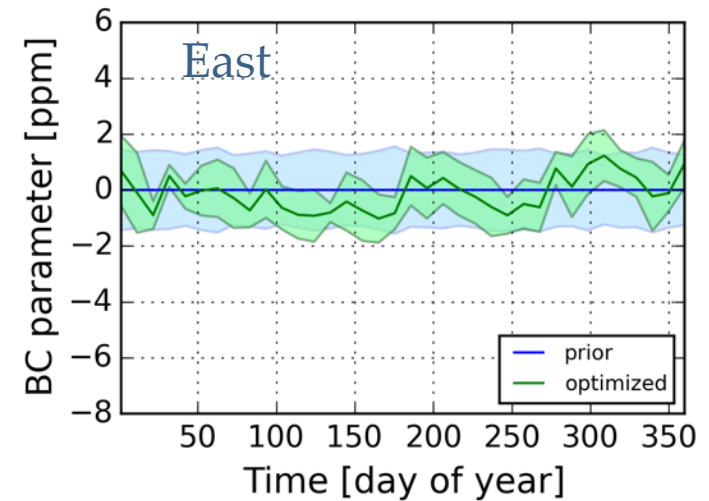
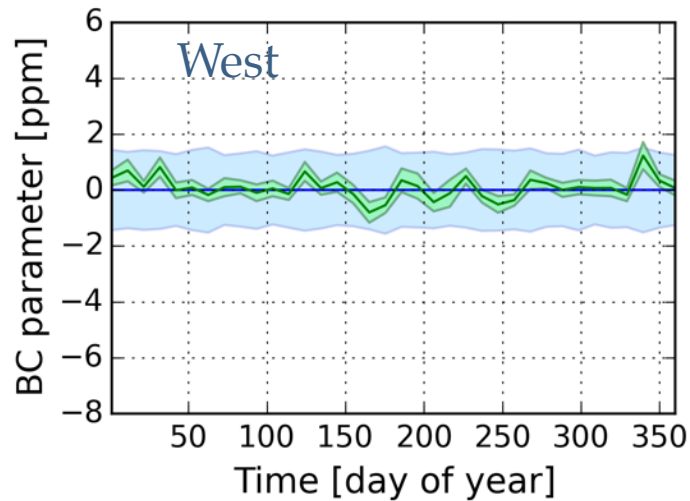
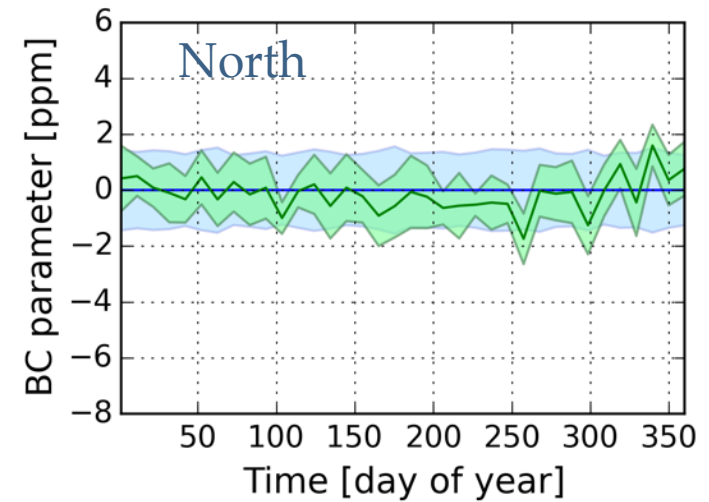
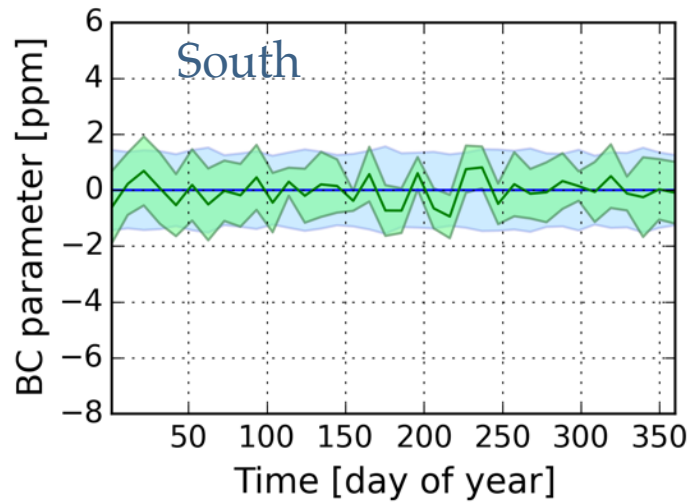
Model performance – residuals



residual=simulated-observed

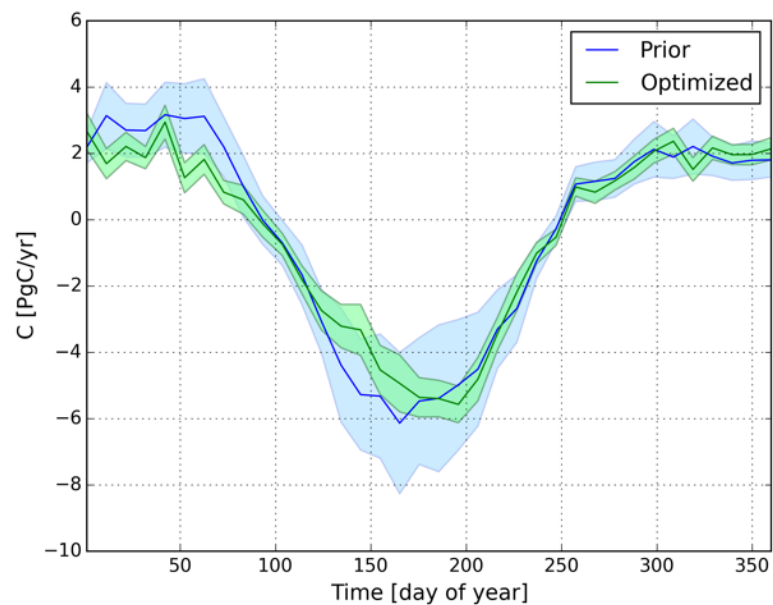


Boundary condition adjustment

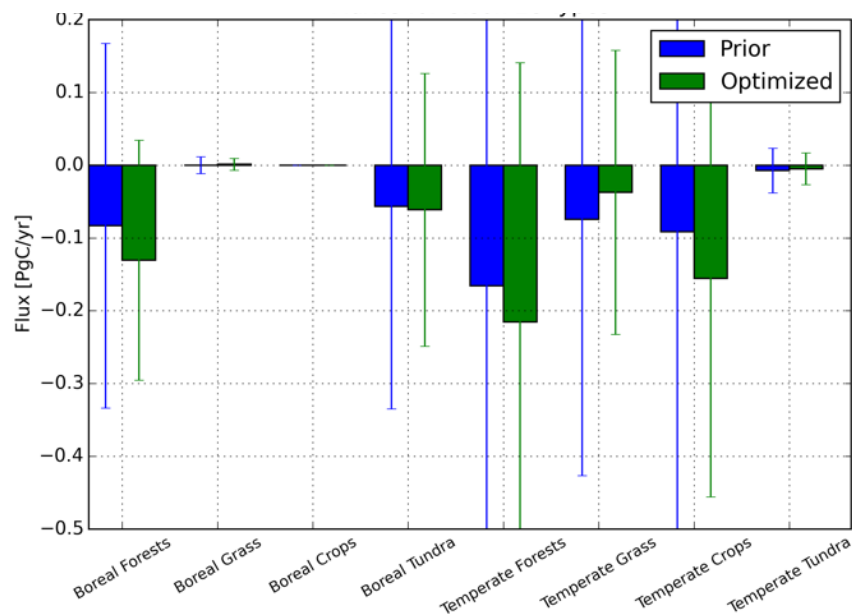




Flux adjustment



North America Temperate

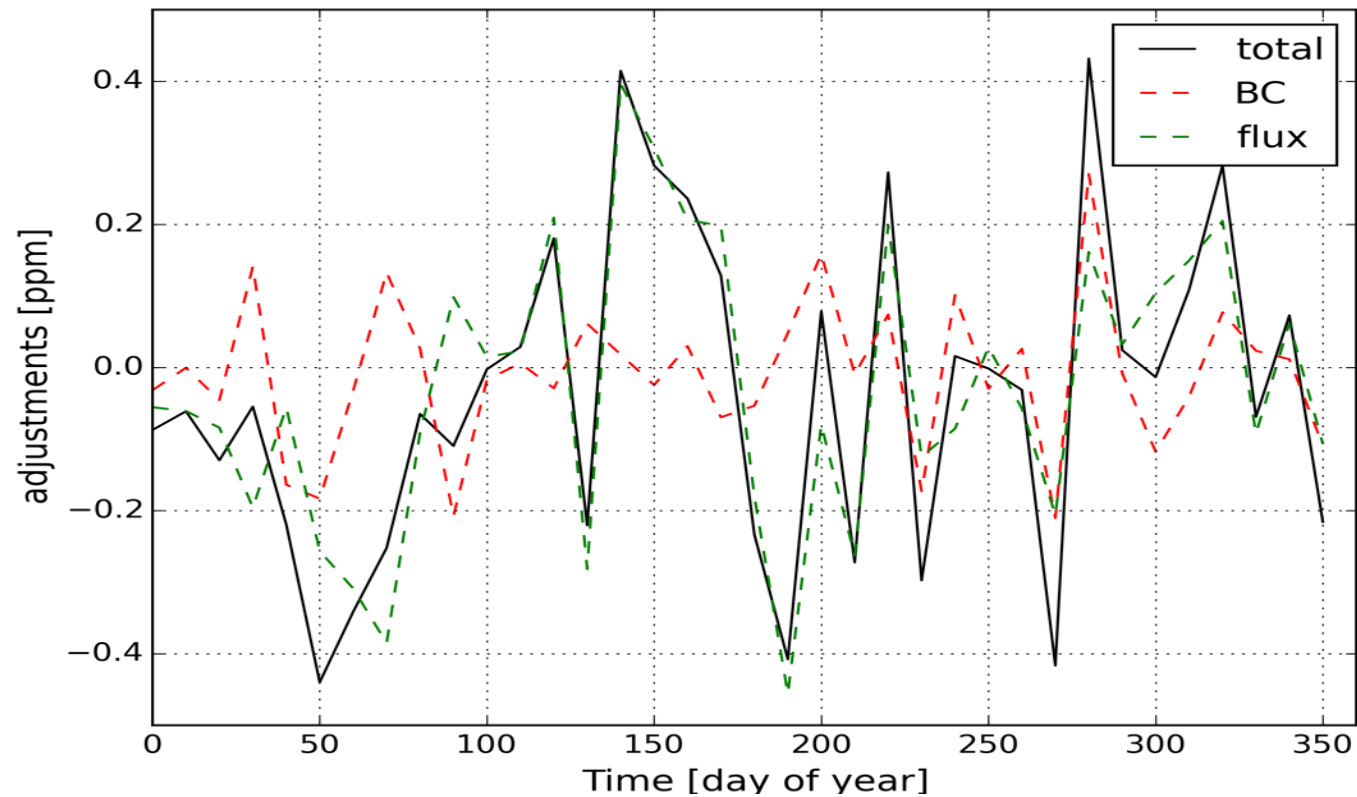


by Olson plant types



Contributions to concentration

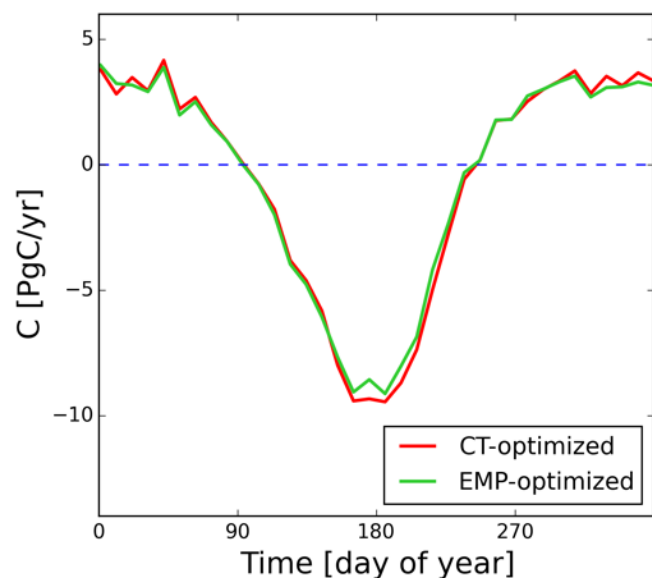
- 10-day average adjustment over all sites



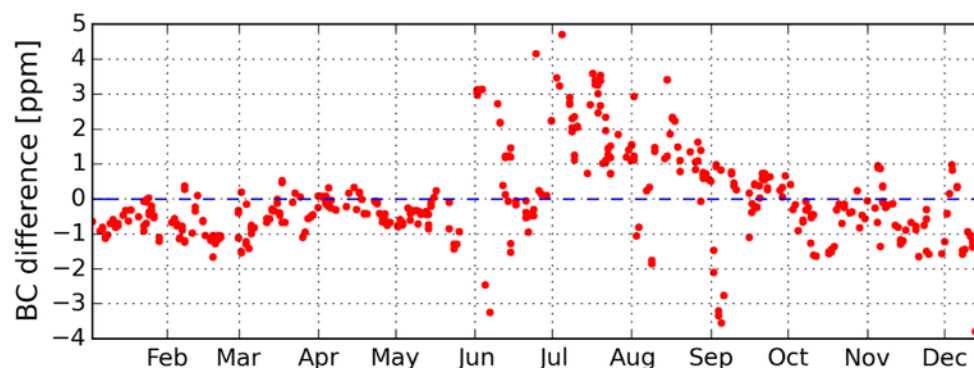


Sensitivity test - prior BCs

- Using different prior boundary conditions: CT and EMP



- CT minus EMP, at surface site LEF

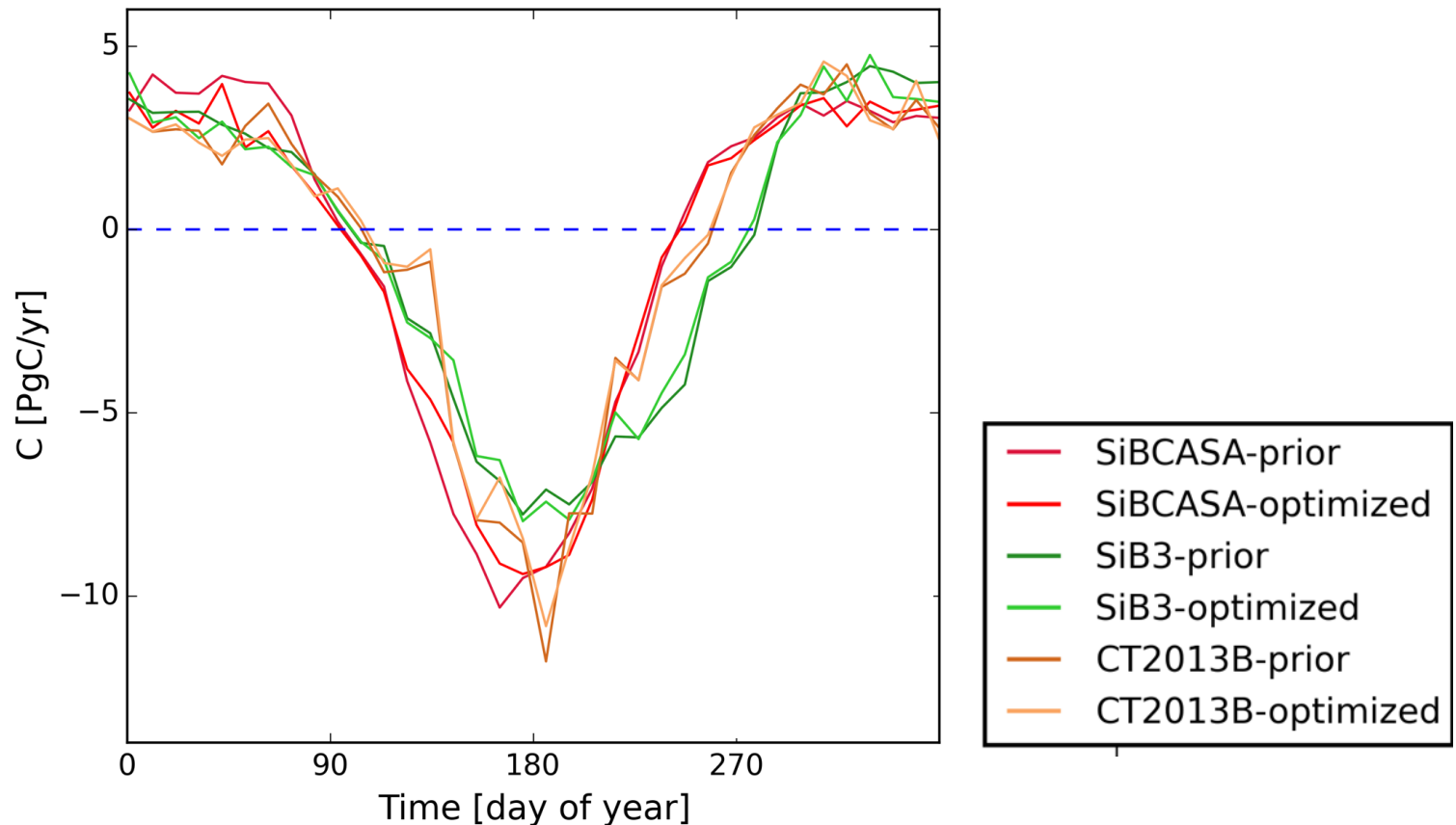


Unit:PgC/yr

Total flux	BC_CT	BC_EMP	difference
Flux+BC	-0.603(± 0.154)	-0.529(± 0.154)	0.074
Flux	-0.581(± 0.156)	-0.531(± 0.156)	0.050

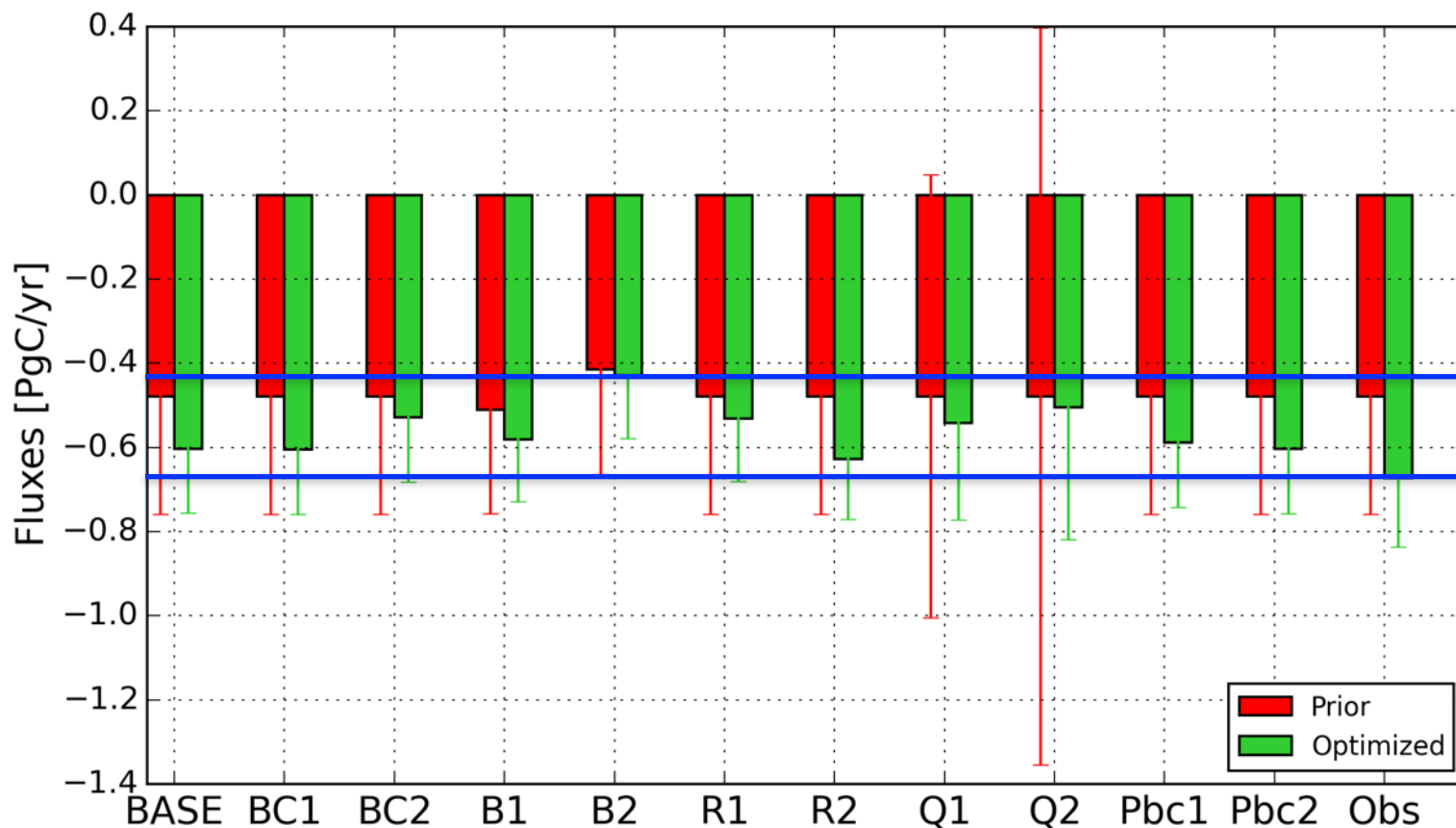


- Using different prior biospheric fluxes: SiBCASA, SiB3 and CT optimized





Ensemble estimates



BASE: SiBCASA fluxes, CT BC,...

BC1: CT-Europe BC

BC2: EMP BC

B1 : SiB3 fluxes

B2: CT fluxes

R1: mdm = 2 ppm

R2: mdm = 4 ppm

Q1: flux cov = 150%

Q2: flux cov = 250%

Pbc1: BC para = 0.5 ppm

Pbc2: BC para = 2.5 ppm

Obs: exclude BAO & WGC

Result comparison

- Compare with other estimates

Total fluxes (Unit: PgC/yr)			
CT	CT-Europe	Pacala et al., 2007	Our estimate
-0.41	-0.62	-0.50	-0.605 ~ -0.429

Pacala et al., 2007. The First State of the Carbon Cycle Report (SOCCR), pp. 29–36. published by NOAA.
(Inventory-based estimate)



Conclusions

- A new CT-Lagrange system was built for regional carbon assimilations:
- - Our carbon estimate is comparable with CT and CT-Europe on total fluxes;
- - This system simultaneously optimizes boundary conditions and biospheric fluxes;
- - Sensitivity tests (prior biospheric fluxes, boundary conditions and system setups) show the North American carbon fluxes is from -0.605 to -0.429 PgC in 2010.



Thanks for your attention!

Questions?



System setup

model-data mismatch (mdm)	3 ppm for surface sites, 1 ppm for aircraft
uncertainty of biospheric fluxes	80%
uncertainty of BC parameter	1.4 ppm
assimilation window	10 days for a lag, 2
number of ensembles	100



System inputs

CO2 concentrations

- NOAA flask data, 8 tower+6 aircraft sites
- filter out night time and local impacts using CO

boundary conditions

- CT North America (CT2013B)
- CT Europe
- NOAA empirical boundary -“curtain”

surface fluxes

- biospheric fluxes :
 1. SiBCASA simulated,
 2. SiB3 simulated,
 3. CT2013B optimised
- component fluxes :
CT2013B

footprints

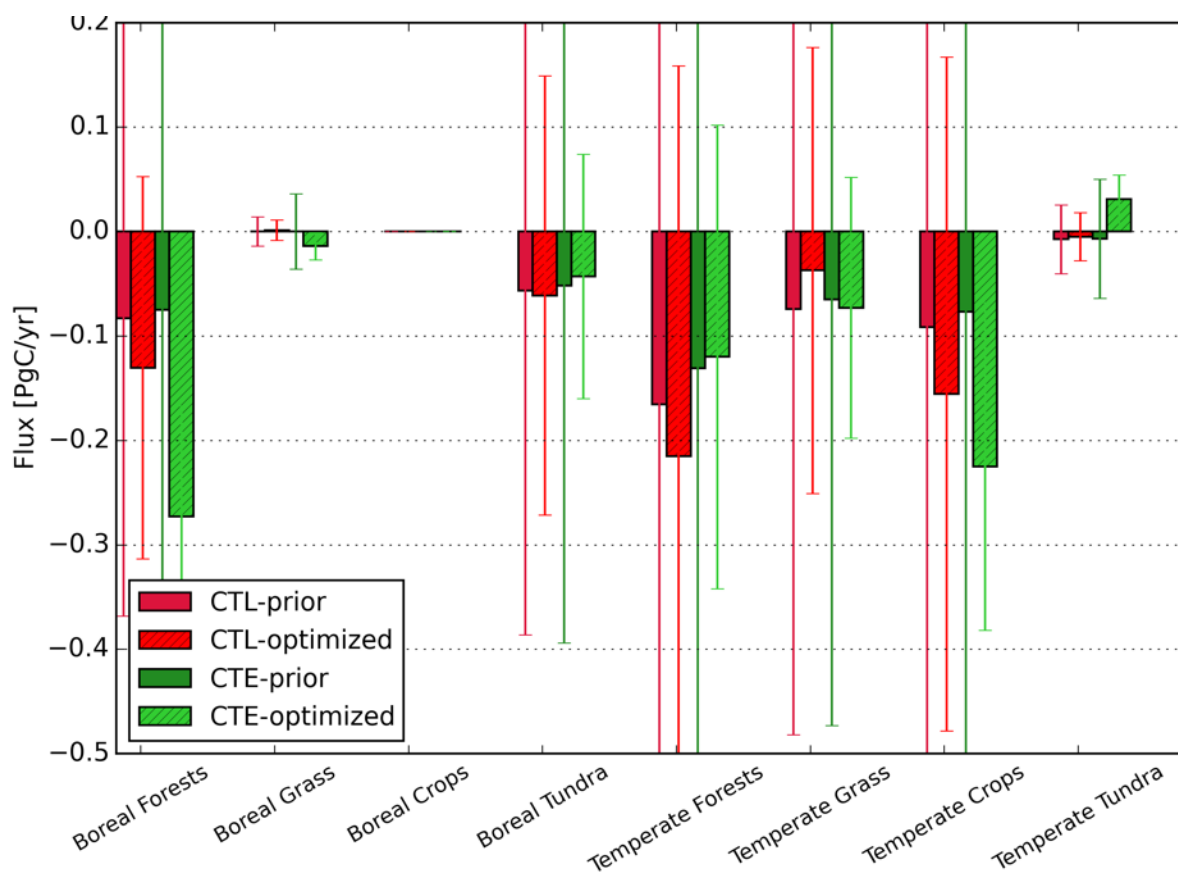
- WRF-STILT
- HYSPLIT-NAM12

● note: one year run for 2010



Result comparison

ecoregion level



- CTL=CT-Lagrange
- CTE=CT-Europe