Radiocarbon ($^{14}CO_2$) traces fossil and biogenic components of total CO_2

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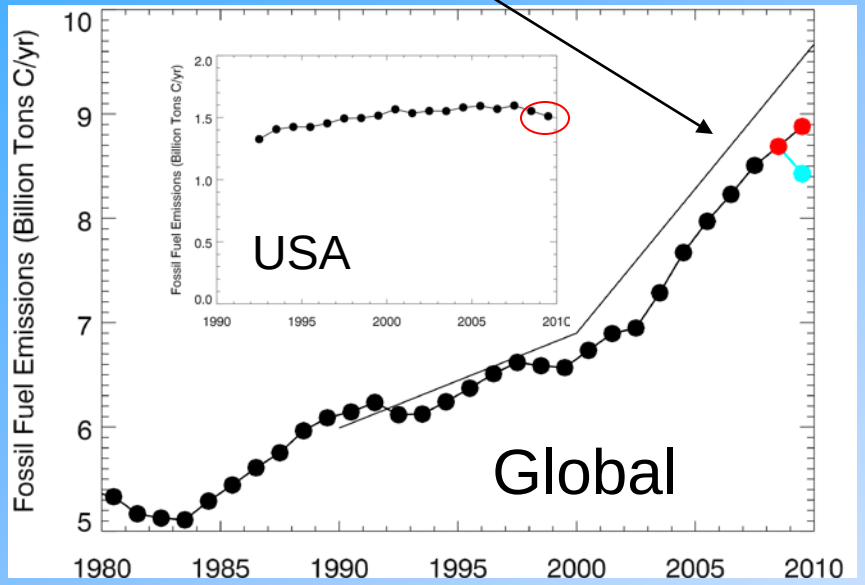
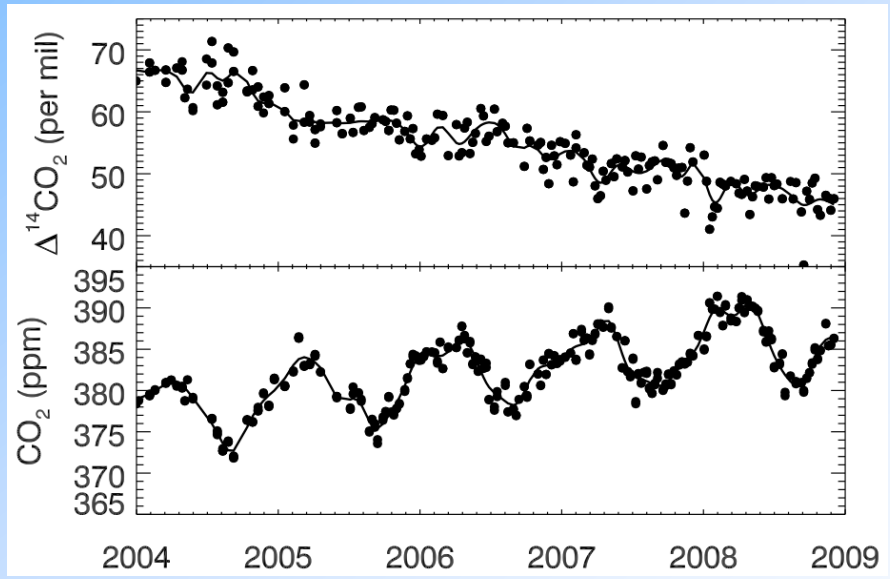
Fossil Fuel and $\Delta^{14}C$

IPCC 95th %ile!





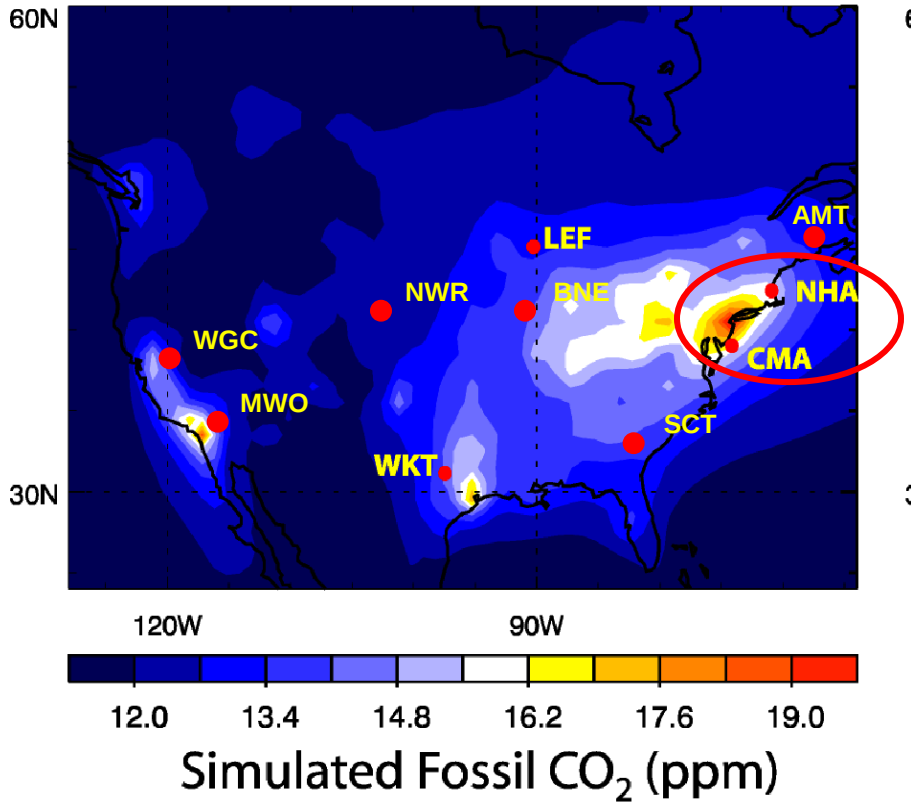
$$\Delta^{14}C = \left[\frac{(^{14}C/C)_{sam}}{(^{14}C/C)_{std}} - 1 \right] \times 1000$$

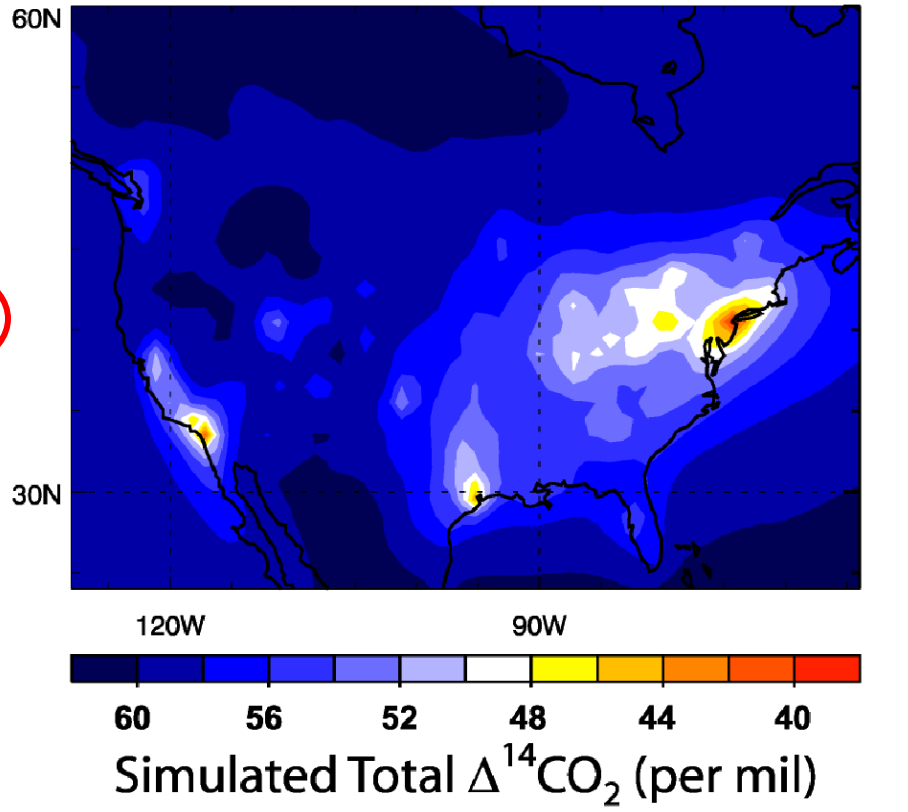
By definition, ^{14}C absent from fossil fuels => Δ_{ff} = -1000 per mil

$$\frac{dC}{dt} = F_{surface} + F_{fossil}$$

$$C\frac{d\Delta}{dt} = \Delta F_{fossil} + (\Delta F_{diseq} + \Delta F_{nuclear} + \Delta F_{cosmo})$$

^{14}C is an excellent tracer for fossil fuel emissions





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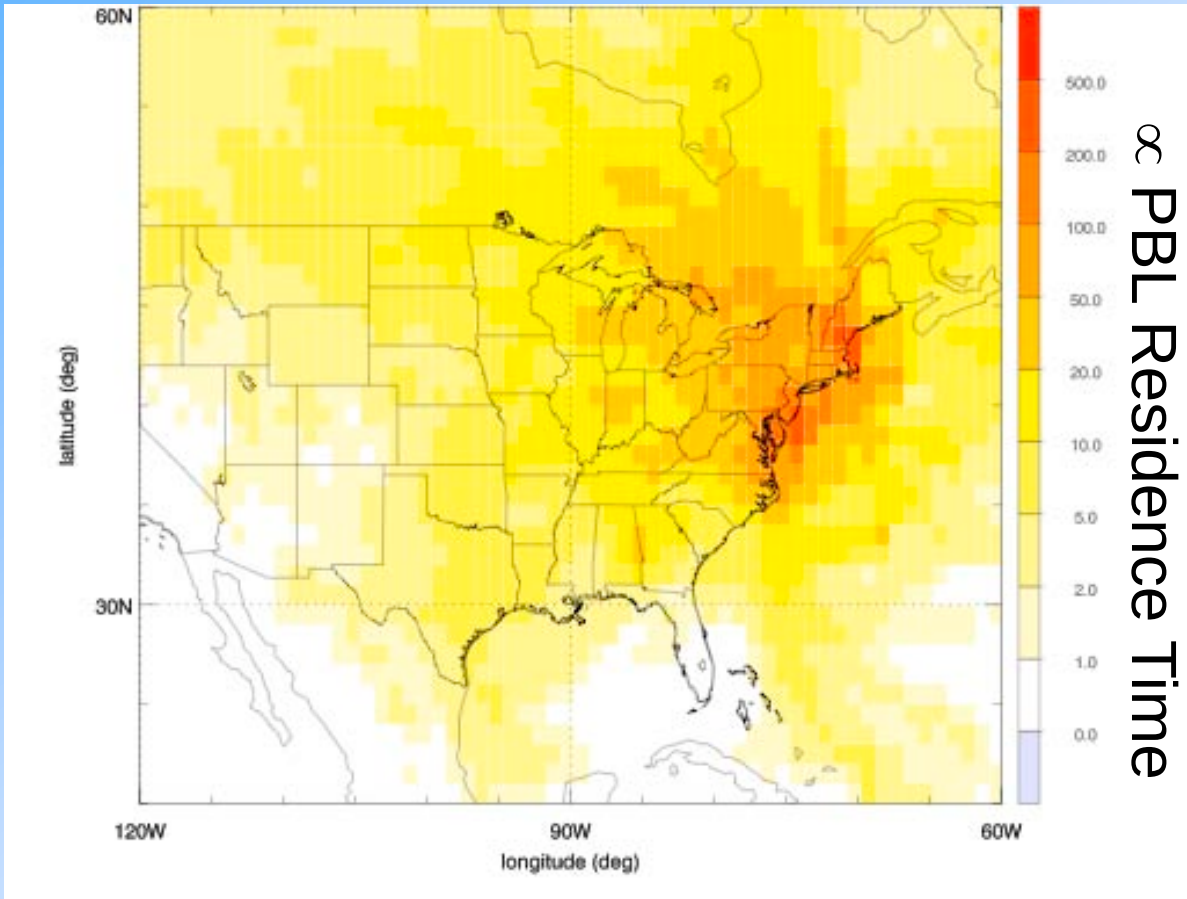
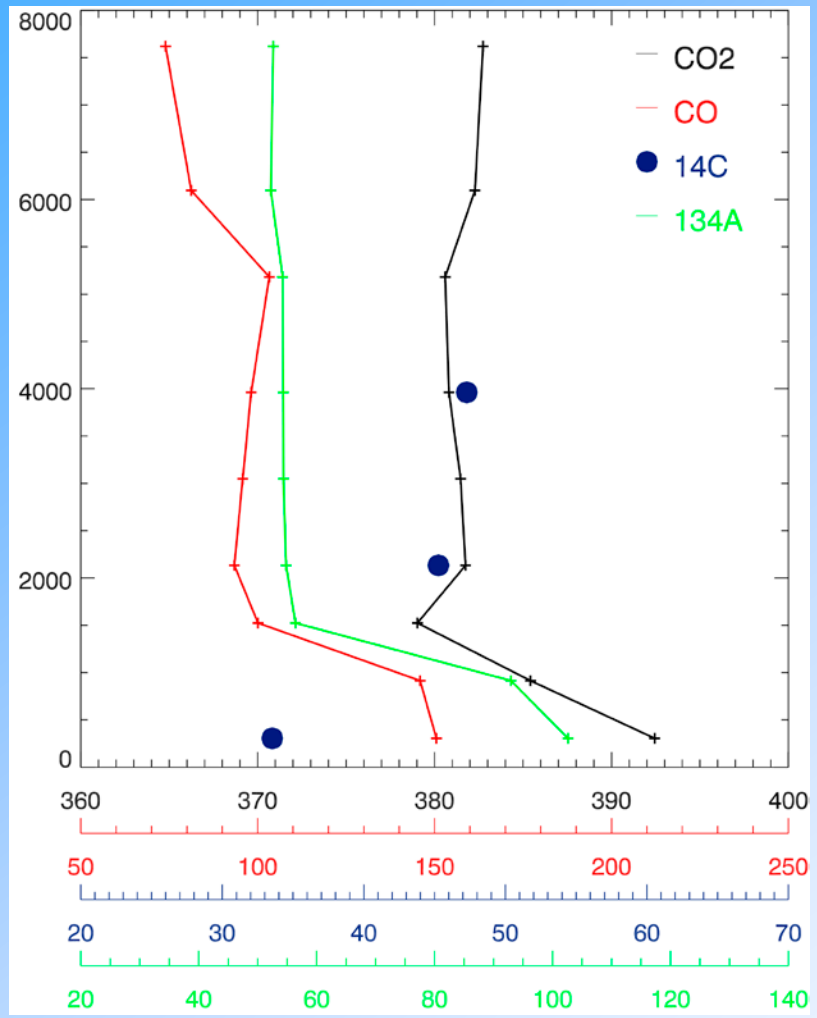
NHA+CMA ‘Footprint’

(From Flexpart/GFS)

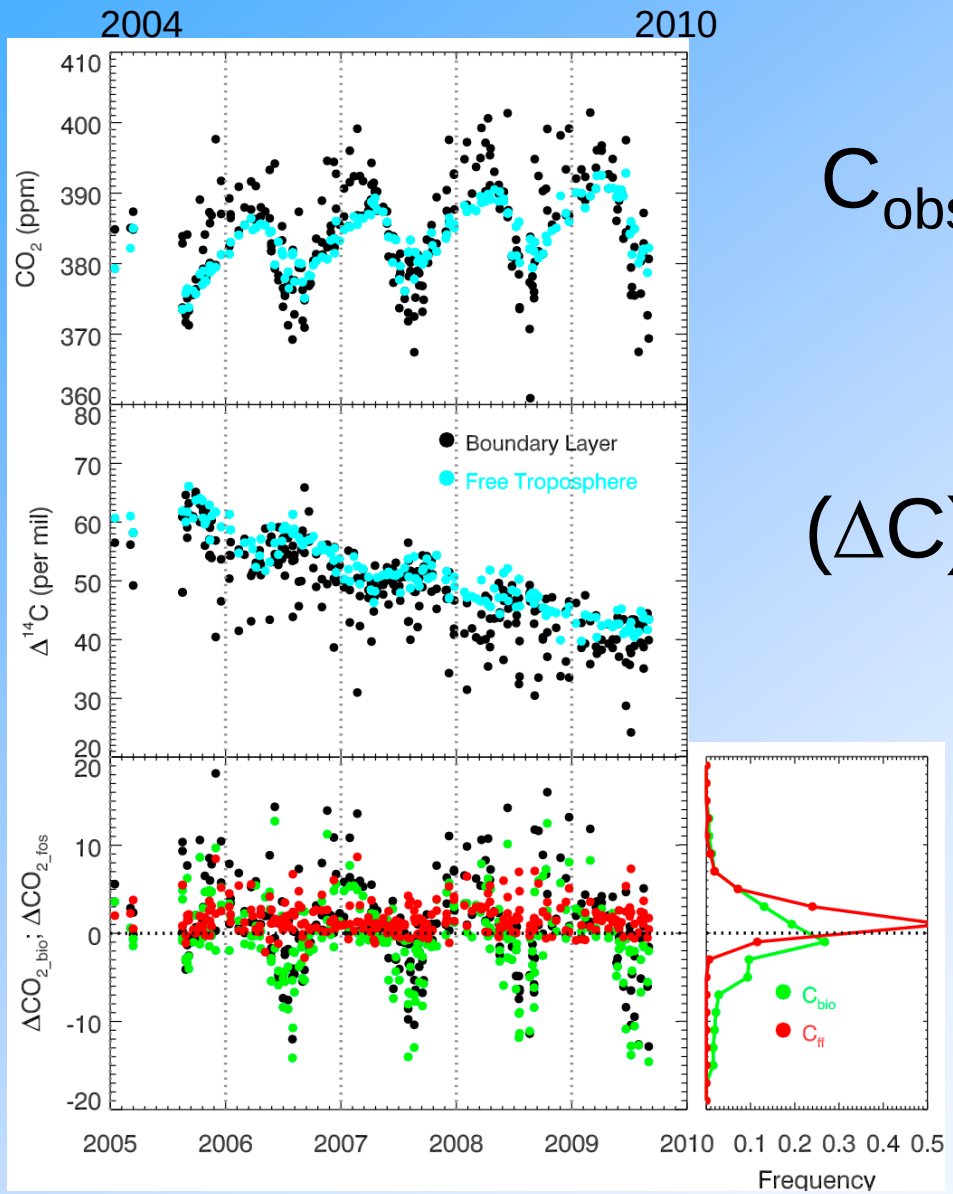


Vertical Profiles Show Anthropogenic Influence near surface.



- High Values of: CO2, CO, HFC134a
- Low Values of $^{14}CO_2$

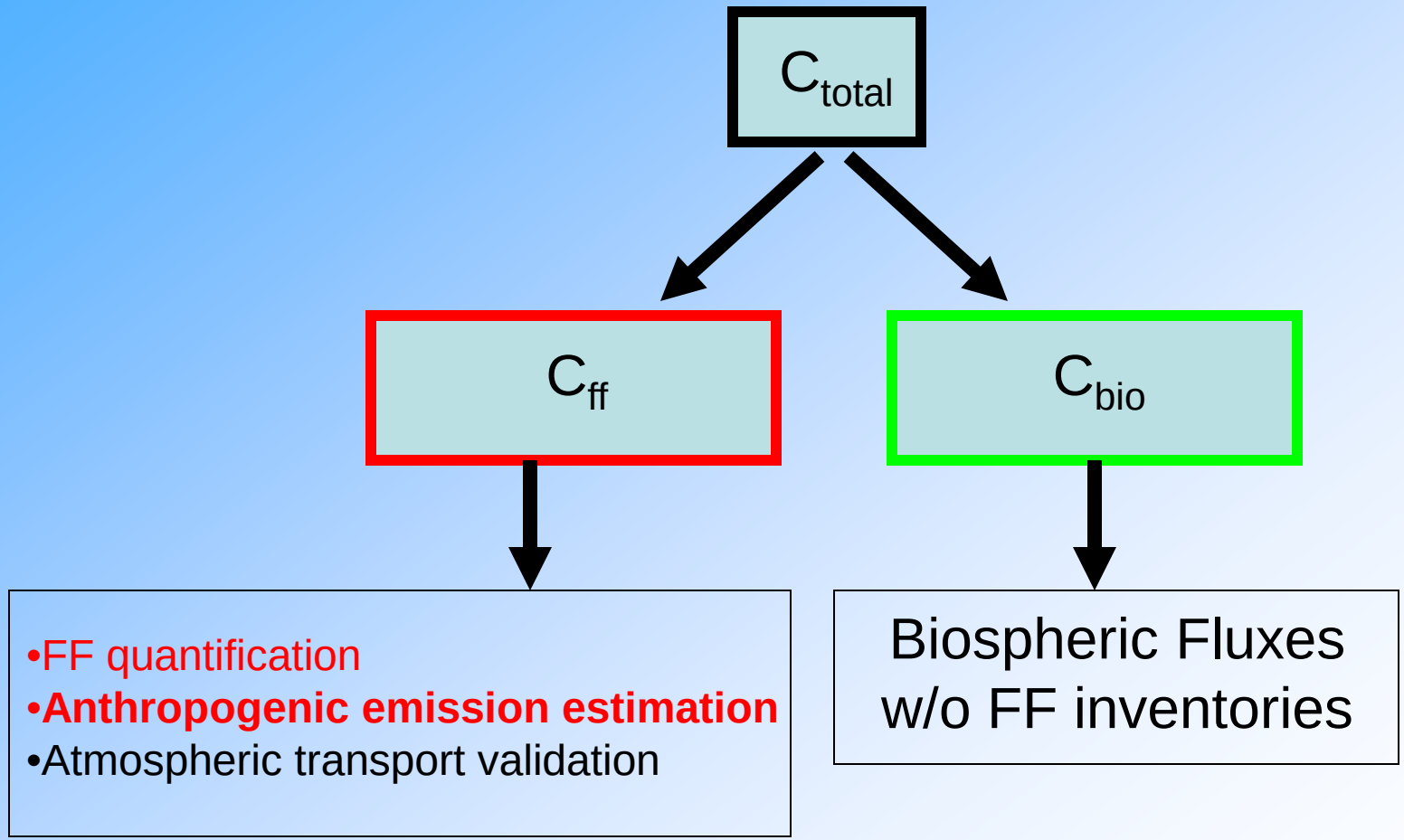
East Coast CO_2 and $\Delta^{14}C$ (NHA + CMA)



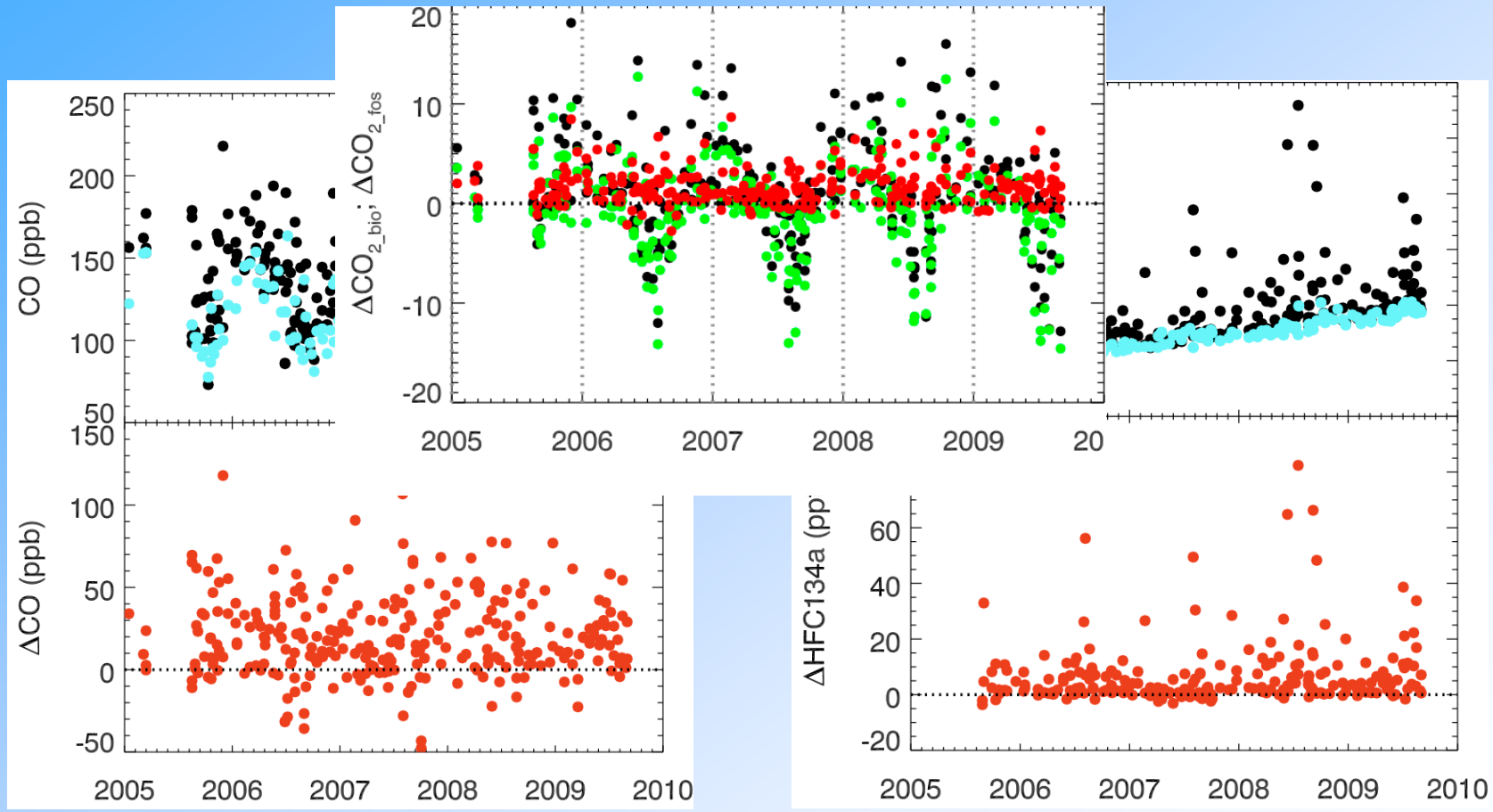
$$C_{obs} = C_{bg} + C_{fos} + C_{bio}$$

$$(\Delta C)_{obs} = (\Delta C)_{bg} + (\Delta C)_{fos}$$

C_{ff} vs. C_{bio}

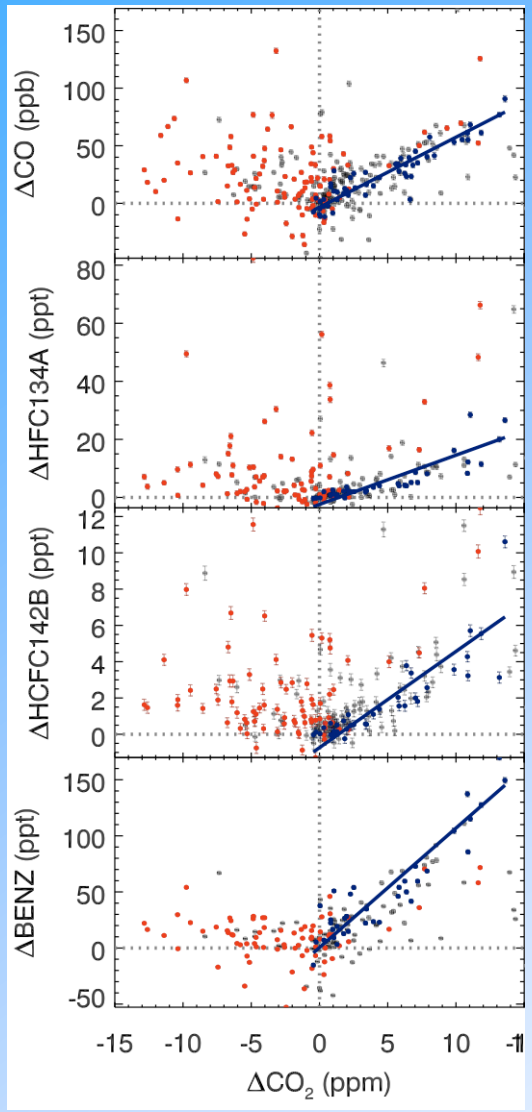

C_{total}
C_{ff}
C_{bio}
•FF quantification
•**Anthropogenic emission estimation**
•Atmospheric transport validation
Biospheric Fluxes
w/o FF inventories

PBL and Free Troposphere CO and HFC134a



$C_{obs} = C_{bg} + C_{net\_source}$

Correlating tracers with ***total*** CO_2 doesn't work.



m=?? ppb/ppm
m=6.0 ppb/ppm

m=?? ppt/ppm
m=1.7 ppt/ppm

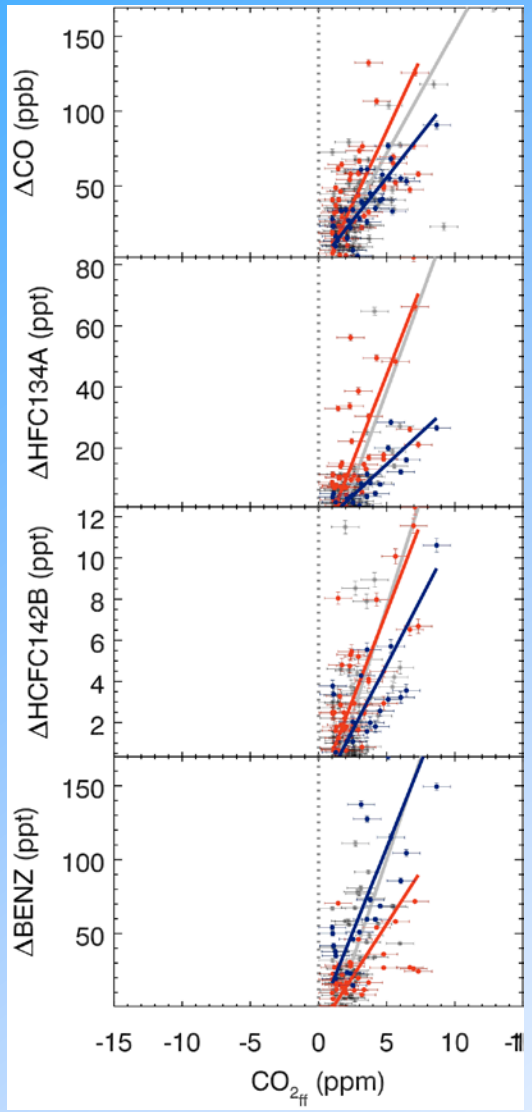
m=?? ppt/ppm
m=0.5 ppt/ppm

m=?? ppt/ppm
m=11 ppt/ppm

- No summer correlation due to biospheric uptake of CO_2.

Red=Summer; Blue=Winter

Correlating tracers with $^{14}CO_2$ (C_{ff}) does work.



m=19 ppb/ppm
m=12 ppb/ppm

m=11 ppt/ppm
m=4.1 ppt/ppm

m=1.7 ppt/ppm
m=1.3 ppt/ppm

m=14 ppt/ppm
m=23 ppt/ppm

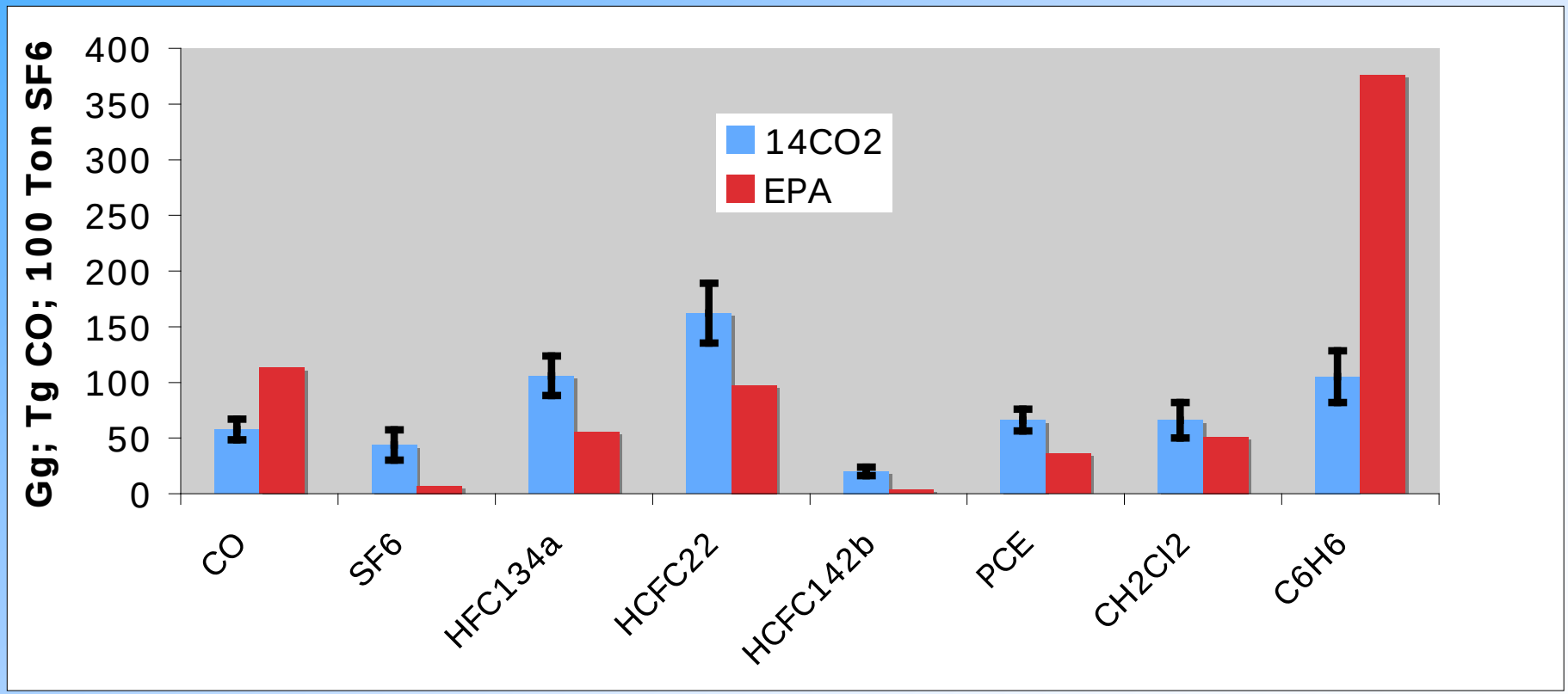
Red=Summer; Blue=Winter

- Winter correlation is also biased due to biospheric release.

Fossil fuel CO_2 emissions inventories are known better than any other.

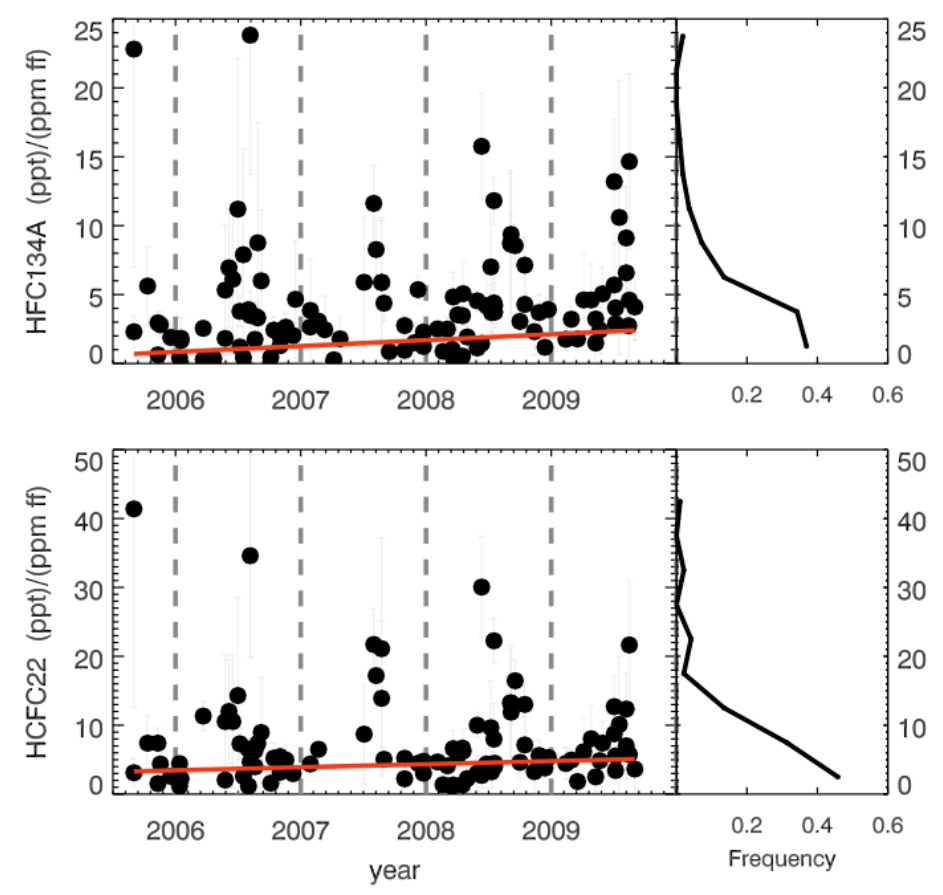
$$m_{gas} \times E_{ff} = E_{gas}$$

USA* Emission Estimates



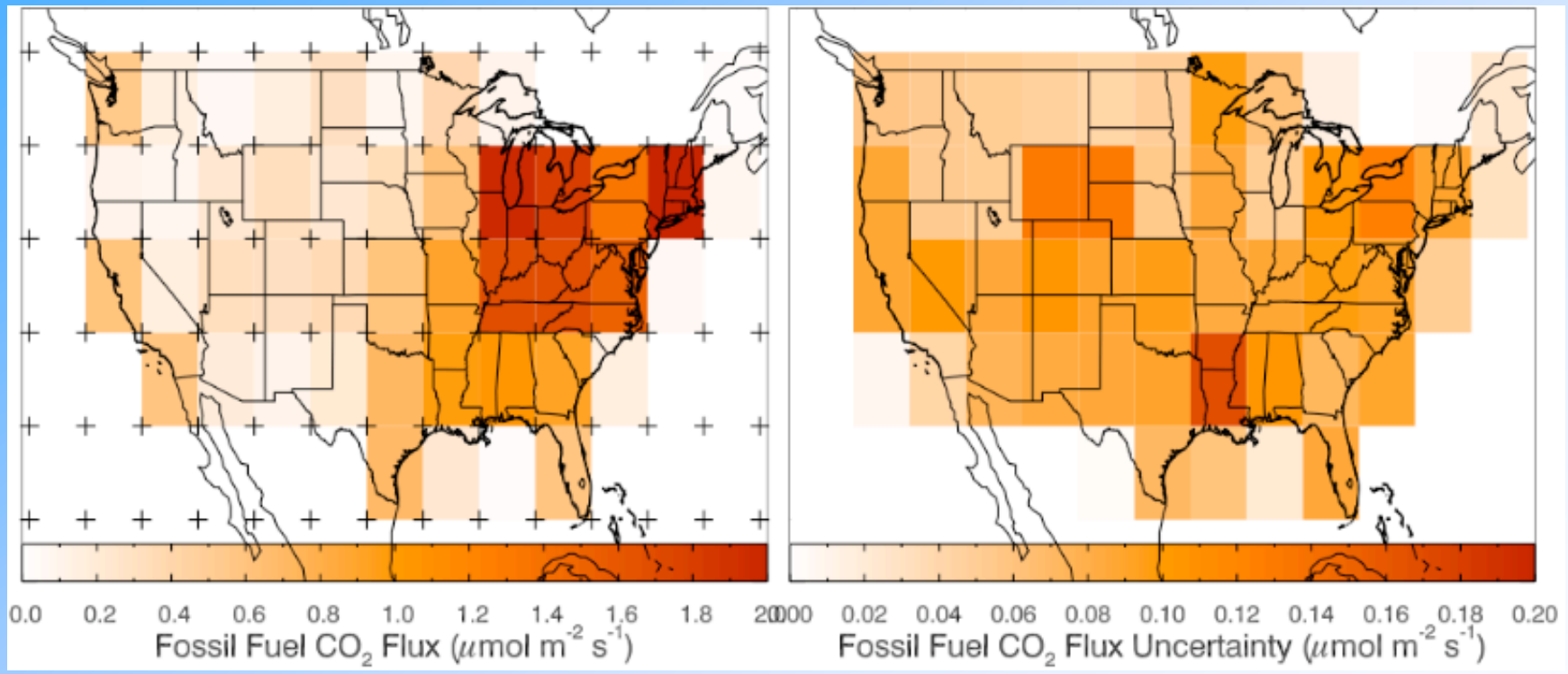
*This assumes that NE ratios are valid nationally.

Time dependent emission ratios show seasonality and hints of trends.



- Because we are subtracting a background values, we can plot each measurement as a ratio.
- This allows for the possibility of each ratio being connected to an individual back trajectory/footprint.

800 $^{14}CO_2$ measurements could give you ~5% uncertainty on *monthly* Fossil CO_2 emissions



-This is a simulated result (OSSE) using a regional Lagrangian model. How well could we retrieve a coarse version of the Vulcan Inventory?

Conclusions

- $^{14}CO_2$ enables the separation of biogenic and fossil CO_2
- Fossil CO_2 correlates well with many other anthropogenic tracers
- Emissions estimates for these tracers show some surprising magnitudes and seasonality
- Eventually, calculating fossil CO_2 will enable atmospheric ‘top-down’ calculation of fossil emissions.