Carbon Cycle Linkages to Air Quality

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Great opportunity for ESRL collaboration

- *GMD long-term monitoring + CSD short-term intensives*

Mutual benefits of carbon cycle and air quality measurements

- *Evaluate and improve air quality emission inventories*
- *Improve carbon cycle flux determinations*

Today's presentation

- *A few examples of ESRL top-down evaluations of bottom-up inventories*
  - *Texas urban areas: aircraft, tall tower CO and CO_2 measurements*
  - *East Coast: ^{14}C measurements*

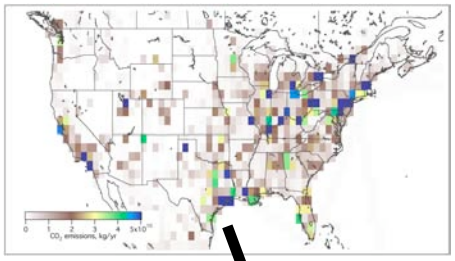
Future collaborations

- *2008 - BAO Tall Tower, Erie, CO*
- *2010 - California Air Quality Study*

Need for Top-Down Assessment of Emission Inventories

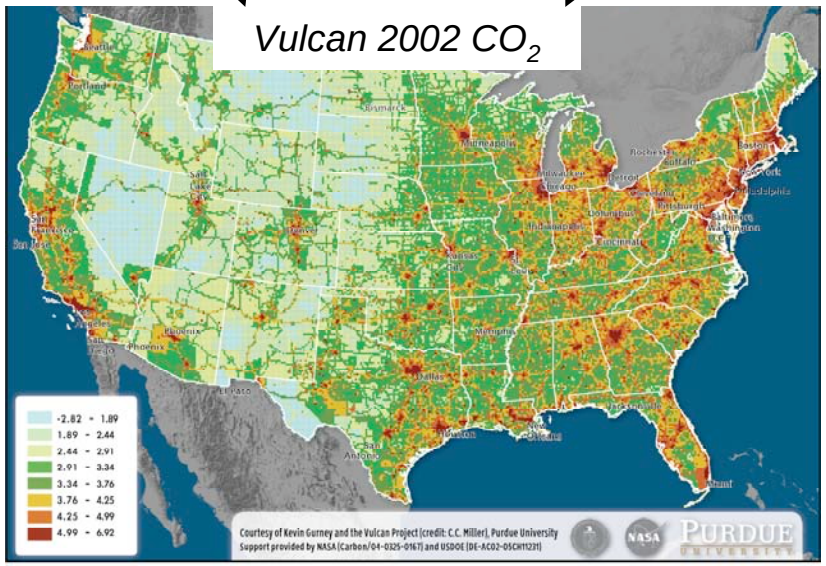
- Emission inventories for CC and AQ uses are evolving

EDGAR 2000 CO_2

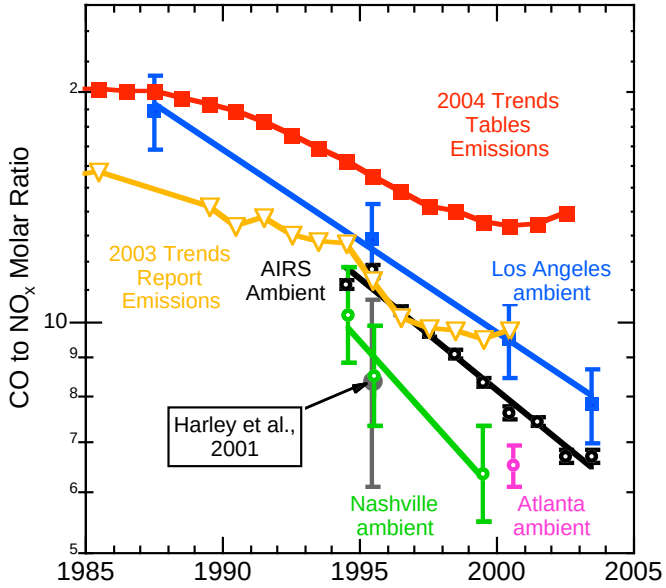


NEI 1999 NO_x

Vulcan 2002 CO_2



- AQ inventory emissions and trends subject to considerable uncertainties

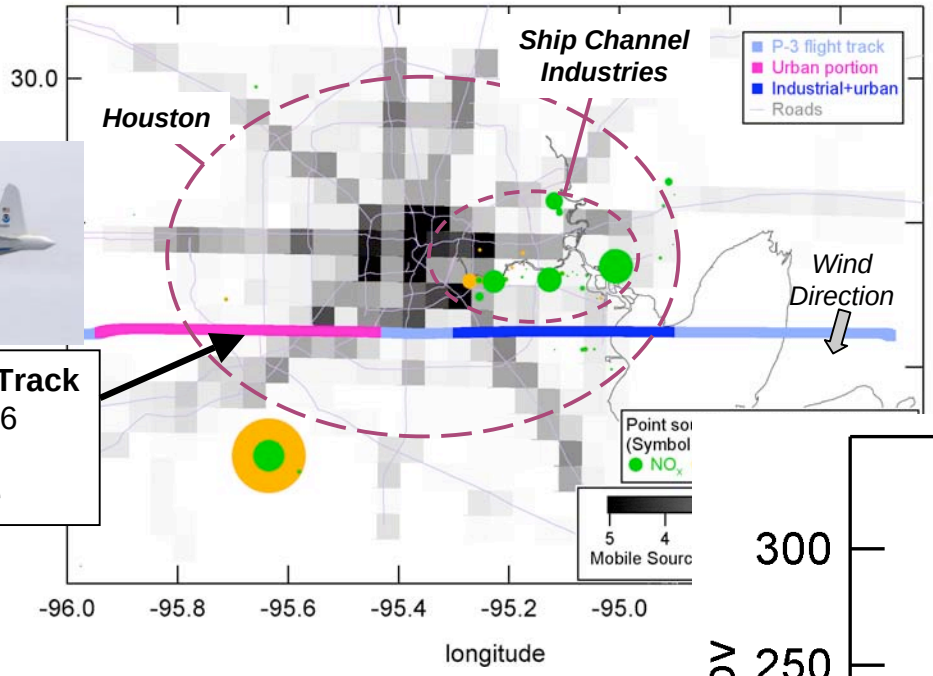


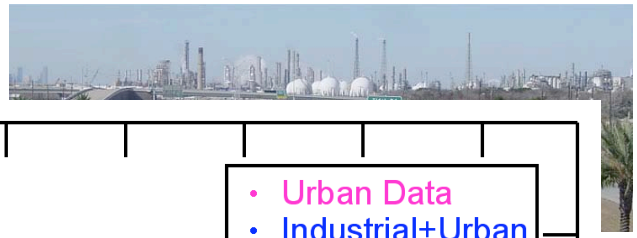
Parrish, D.D., (2006), Atmos. Environ. 40, 2288-2300

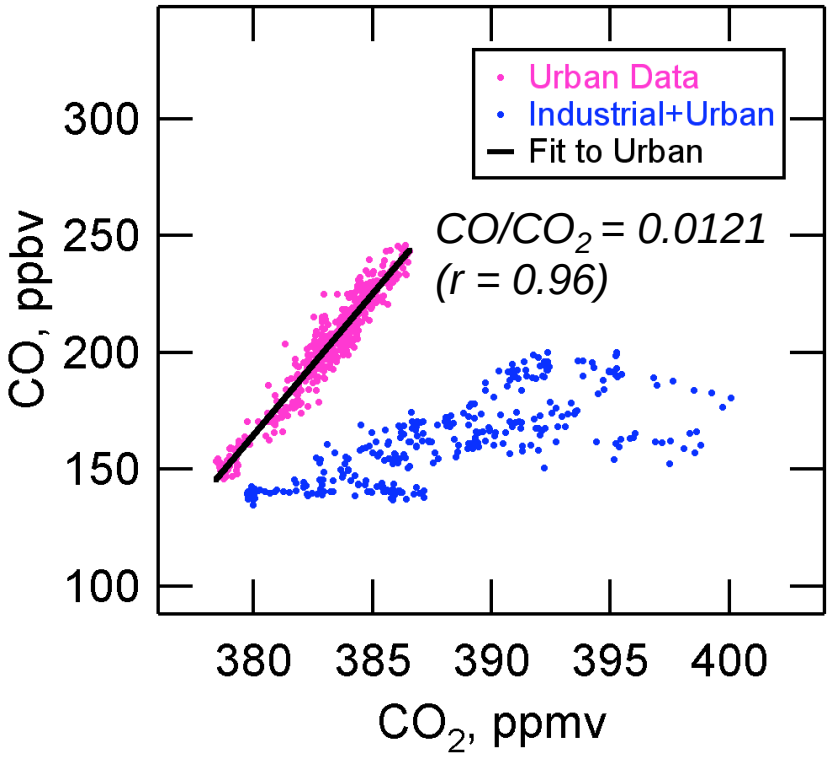
➢ *NOAA observations provide top-down assessment of bottom-up inventories*

Aircraft Observations of Houston Urban Emissions

NOAA P-3 Flight Track
26 September 2006
1258-1318 CDT
400-500 m altitude







➢Derive urban emission ratios from targeted aircraft sampling

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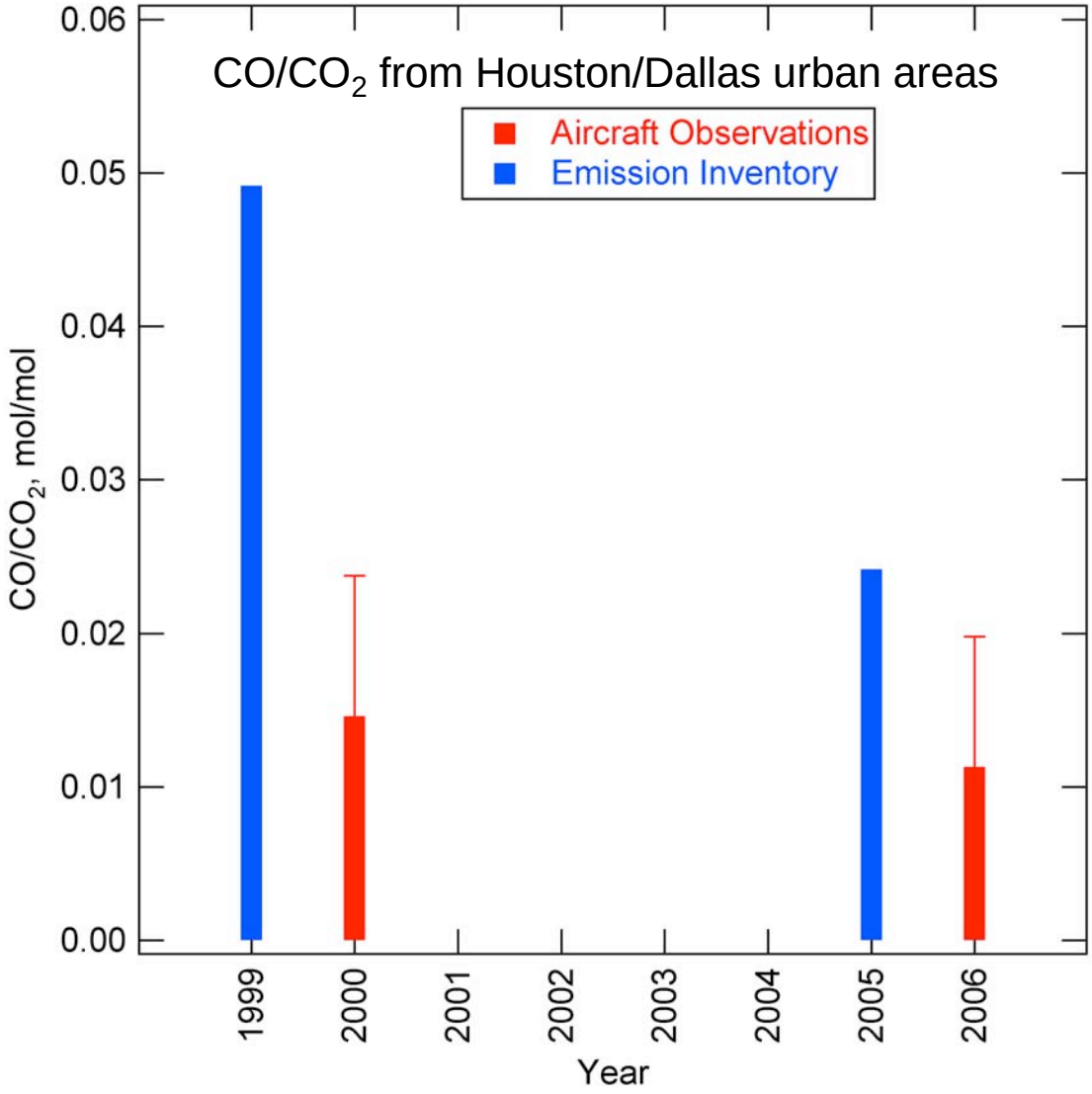
Aircraft Assessment of Houston/Dallas CO Emissions



- CO_2 emissions relatively well known
  - ➢Evaluate CO emissions
- Aircraft observations detect decline in mobile source CO emissions
  - ➢Cleaner gasoline vehicles
- ➢Inventories also report decline in CO emissions
- ➢But inventory mobile source CO emissions overestimated (factors of 2-3)

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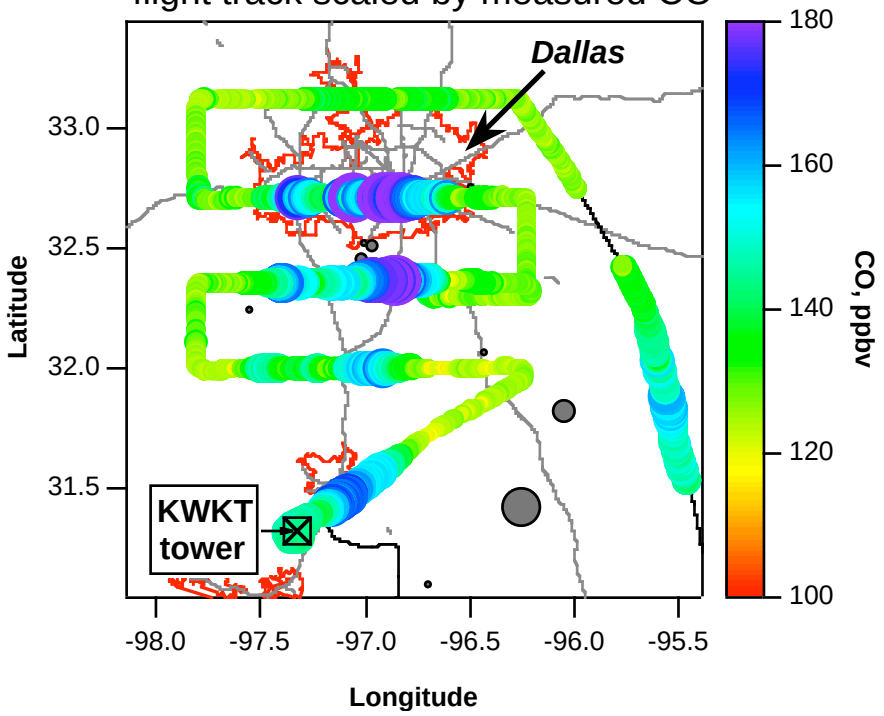
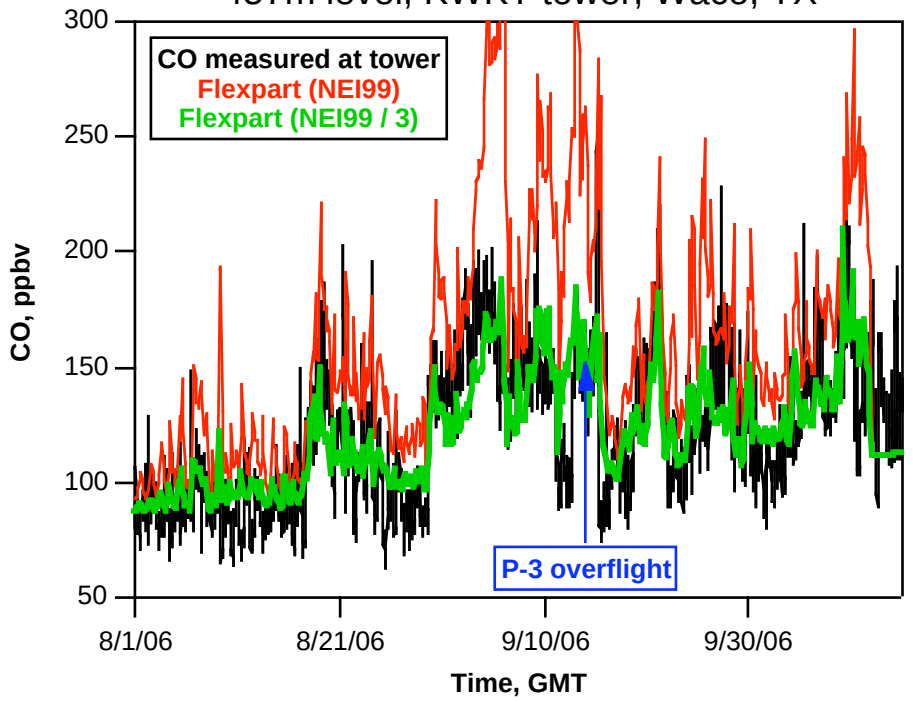
Aircraft and Tall Tower Evaluation of CO Urban Emissions

NOAA WP-3D aircraft data
flight track scaled by measured CO



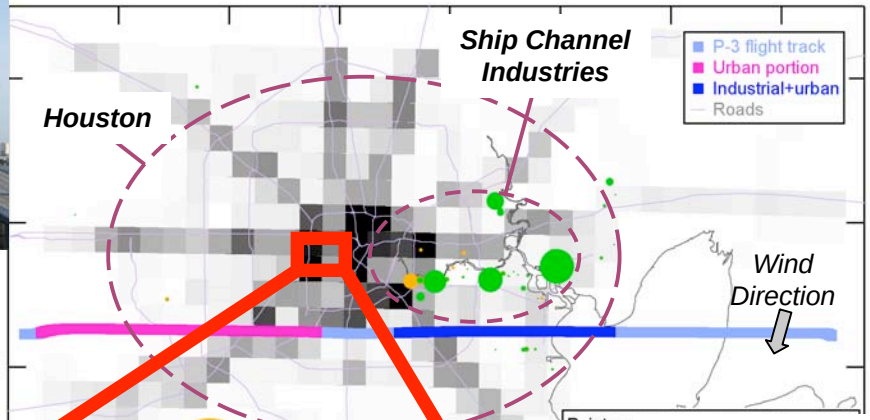
NOAA Tall Tower Network data
457m level, KWKT tower, Waco, TX

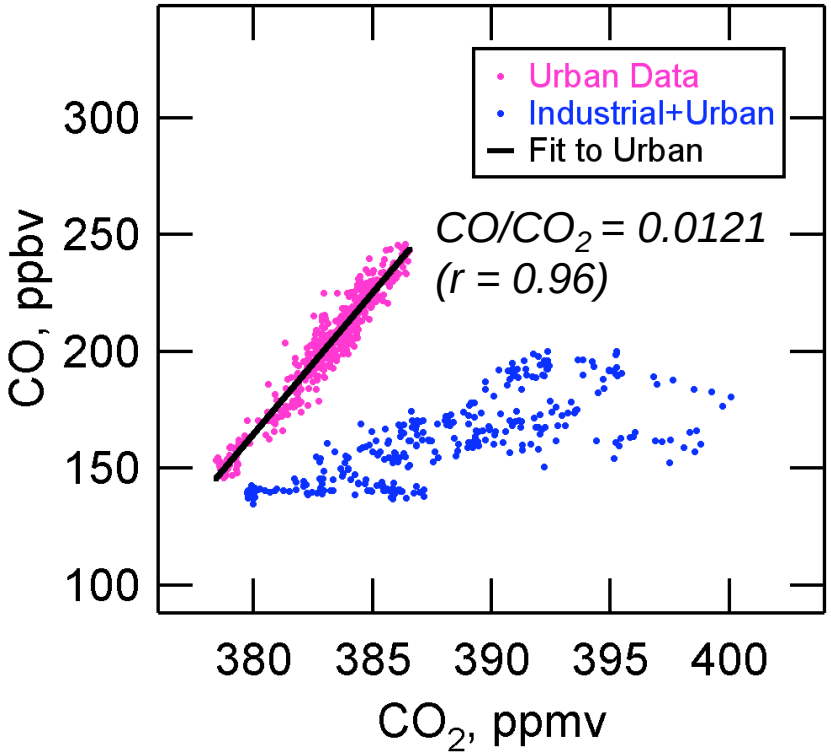


- Urban CO emissions overestimated in inventory
- Ties field project inventory “snapshots” to longer-term monitoring time scales
- Top-down assessments critical for **carbon cycle** and **air quality** issues

T. Ryerson (CSD), A. Andrews (GMD), A. Stohl (NILU)

Aircraft Observations of Houston Urban Emissions





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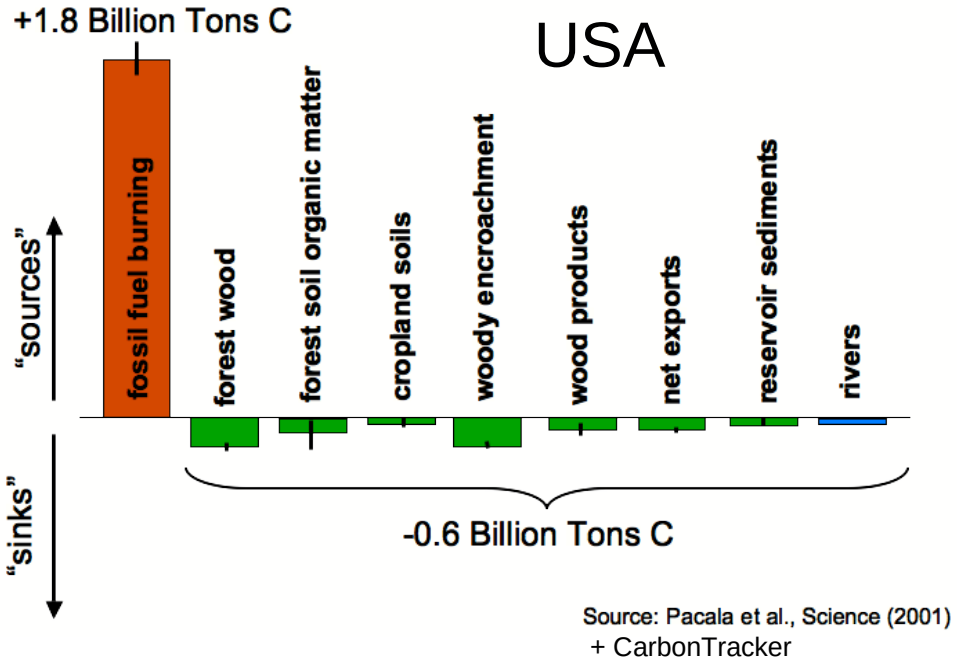
Bridging Carbon Cycling and Air Quality Studies using $^{14}CO_2$

- ^{14}C naturally occurs in atmosphere (cosmic rays)
- ^{14}C is absent from fossil fuels (^{14}C half-life = 5.7 kyrs)
- ^{14}C excellent tracer for fossil fuel emissions



Source: Pacala et al., Science (2001)
+ CarbonTracker

Some isotopic notation:

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

Δ_{ff} = -1000 per mil
Δ_{atm} ~ +55 per mil

➢ $^{14}CO_2$ allows partitioning of CO_2 into fossil fuel and biological components

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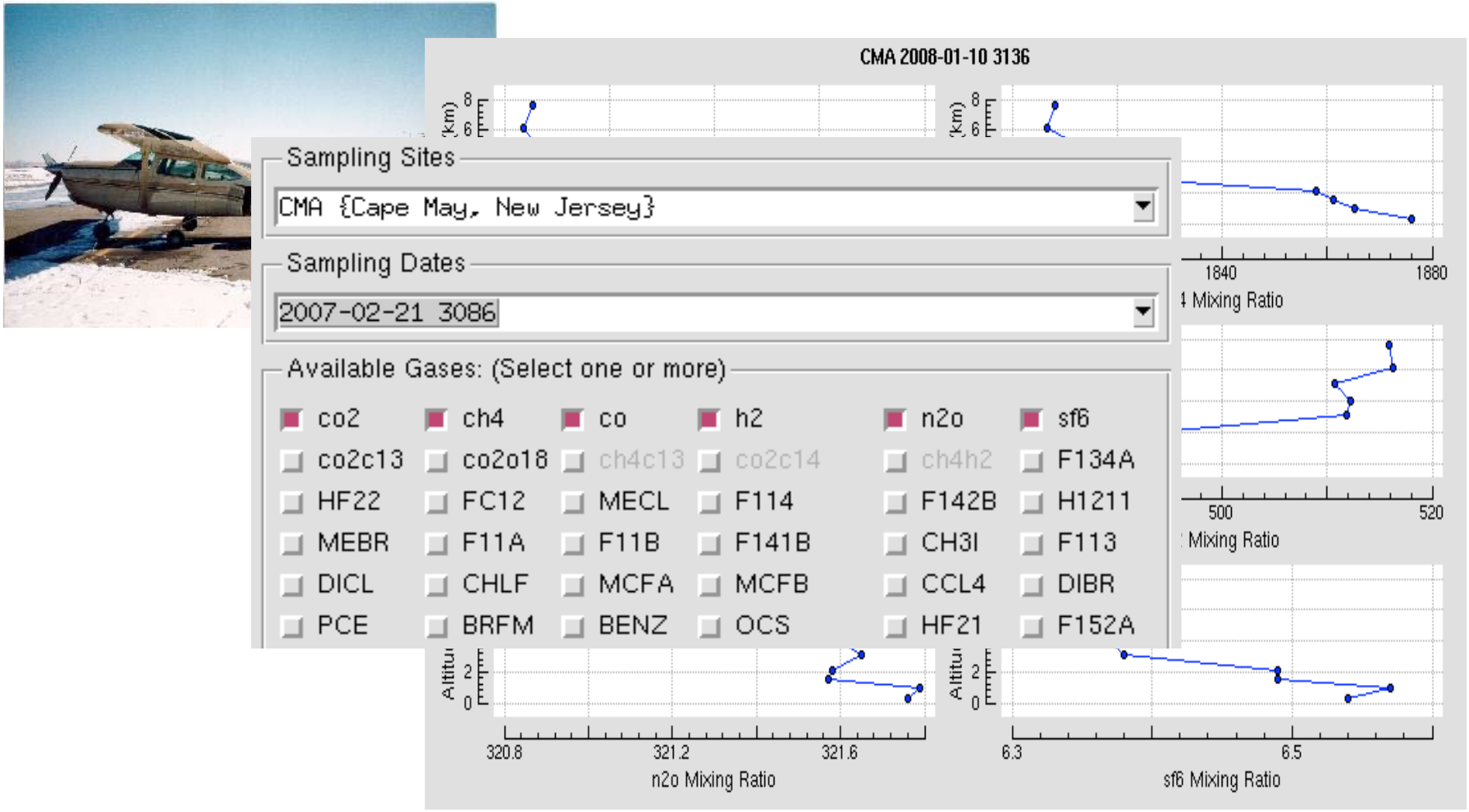
GMD Airborne Sampling of CC and AQ Gases



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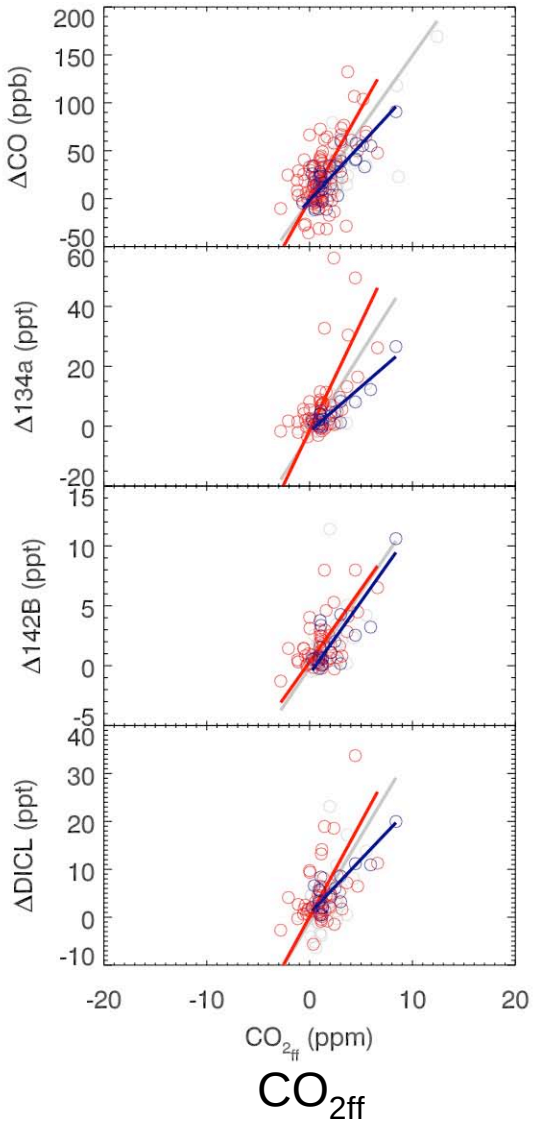
Tracer Relationships to CO_{2ff}

CO

HFC-134A

HCFC-142B

Dichloro-methane



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

m=7.2 ppt/ppm
m=3.0 ppt/ppm

m=1.2 ppt/ppm
m=1.2 ppt/ppm

m=4.0 ppb/ppm
m=2.3 ppb/ppm

Red=Summer
Blue=Winter

Many species appear to exhibit significant seasonal emission cycles

Use relationships with CO_{2ff} to calculate regional emissions of anthropogenic gases

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

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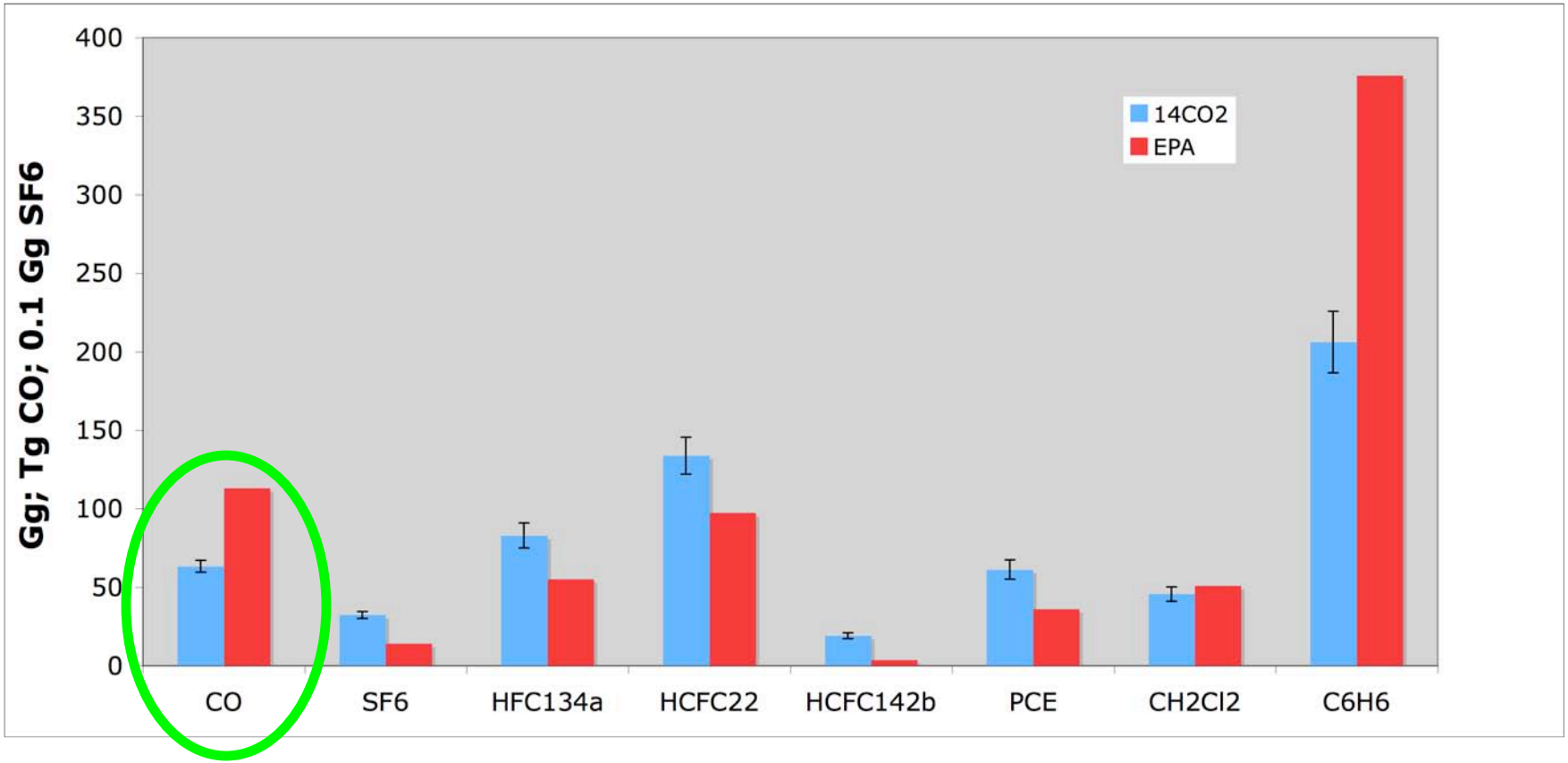
USA Emission Estimates: EPA Bottom-Up vs. $^{14}CO_2$ Top-Down



Concurrent analysis of $^{14}CO_2$ and atmospheric gas samples

- Assessment of regional emission inventories
- Factor of 2 overestimate in CO inventory

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