EARTH SYSTEM RESEARCH LABORATORY

Serving Society through Science

Future plans and directions

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Carbon Cycle Group

ESRL Atmospheric Chemistry Review

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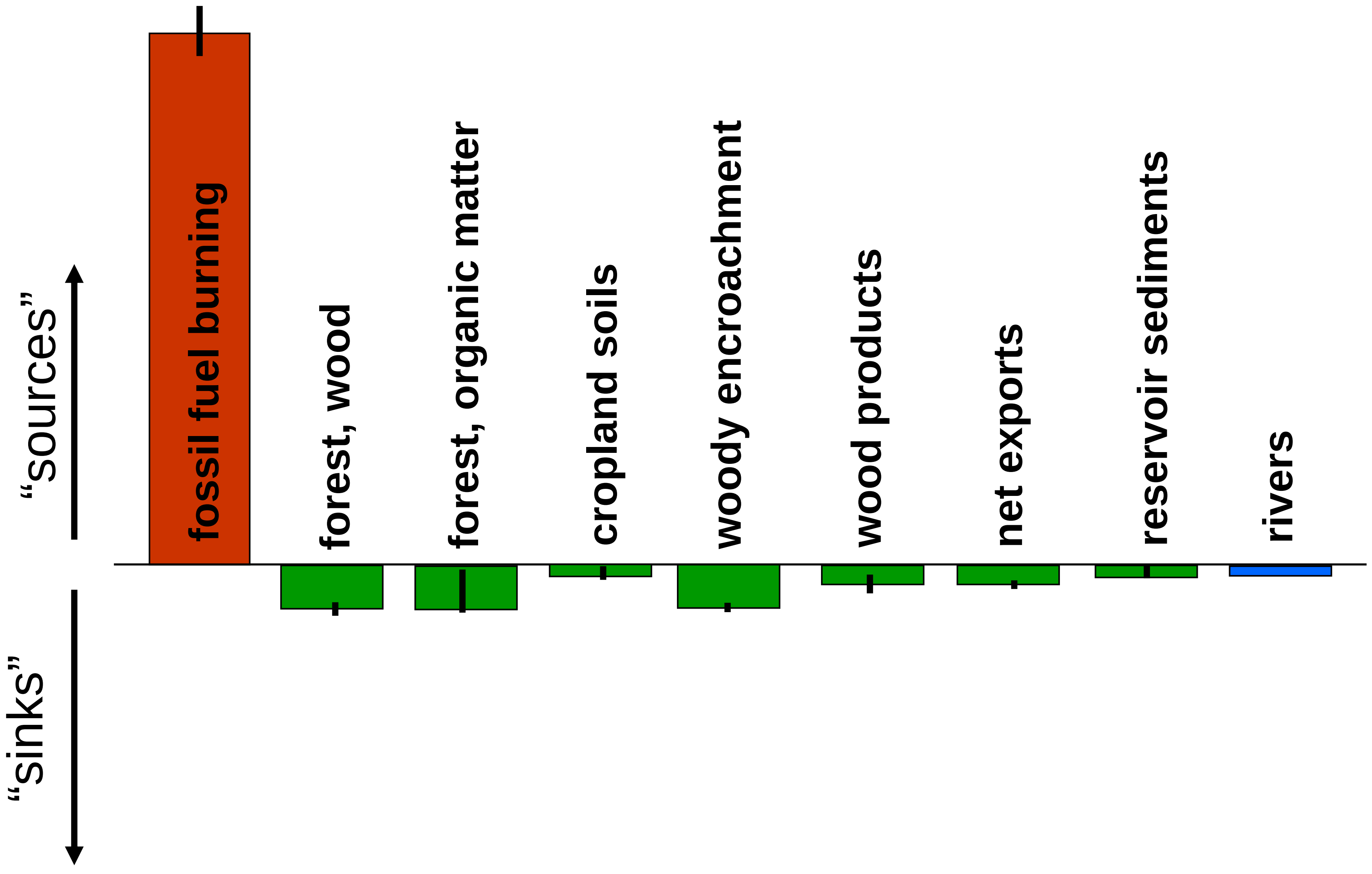
What is society likely to need that we can supply?

- ***Ongoing diagnoses as the earth system changes unfold***

- ***Objective verification of emissions on national, regional, and local scales***

- ***Assessment of mitigation solutions, proposed or actual***

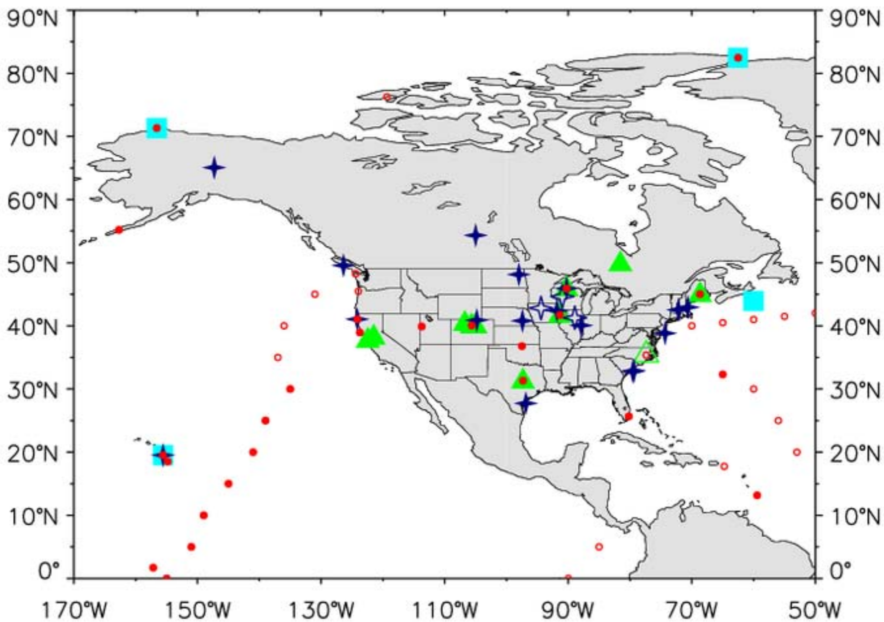
Tentative carbon “budget” for the U.S.



Source: Pacala et al., Science (2001)

REQUIRED ACCURACY

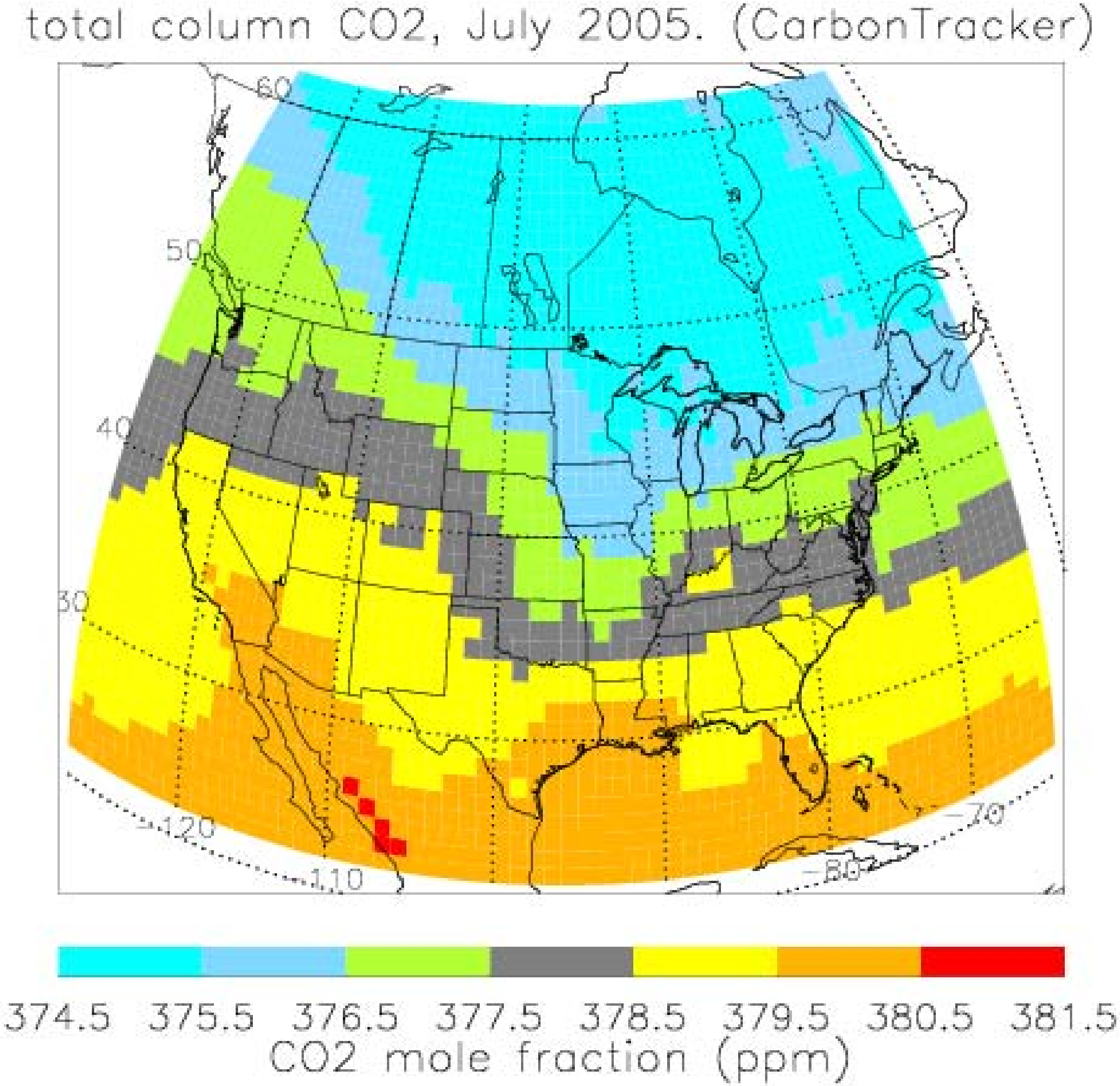
1.7 billion metric ton FF C yr^{-1} (US) and 5-day residence time ⇒
~0.7 ppm excess total column CO_2 leaving toward North Atlantic



observed atmospheric variability		
	1 sigma (ppm)	altitude
Mauna Loa	0.5	3.4 km
Niwot Ridge	1.0	3.5 km
vertical profiles	1.1 -1.6	3 km
towers	3.5	0.4 km
continental surface	~20	10 m

source: Ken Masarie

WHAT DOES CO2 OVER NORTH AMERICA LOOK LIKE?



carbontracker.noaa.gov

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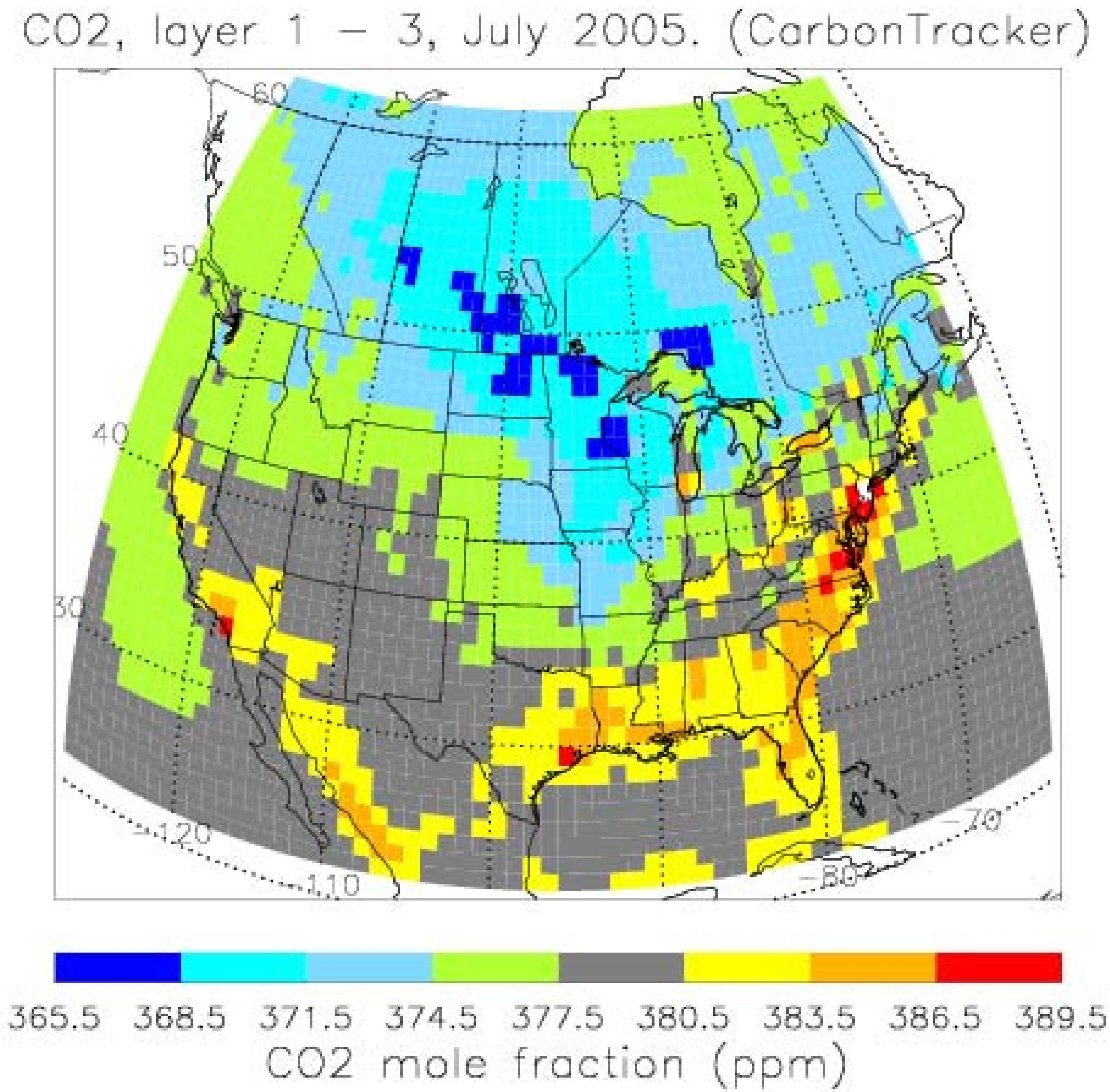

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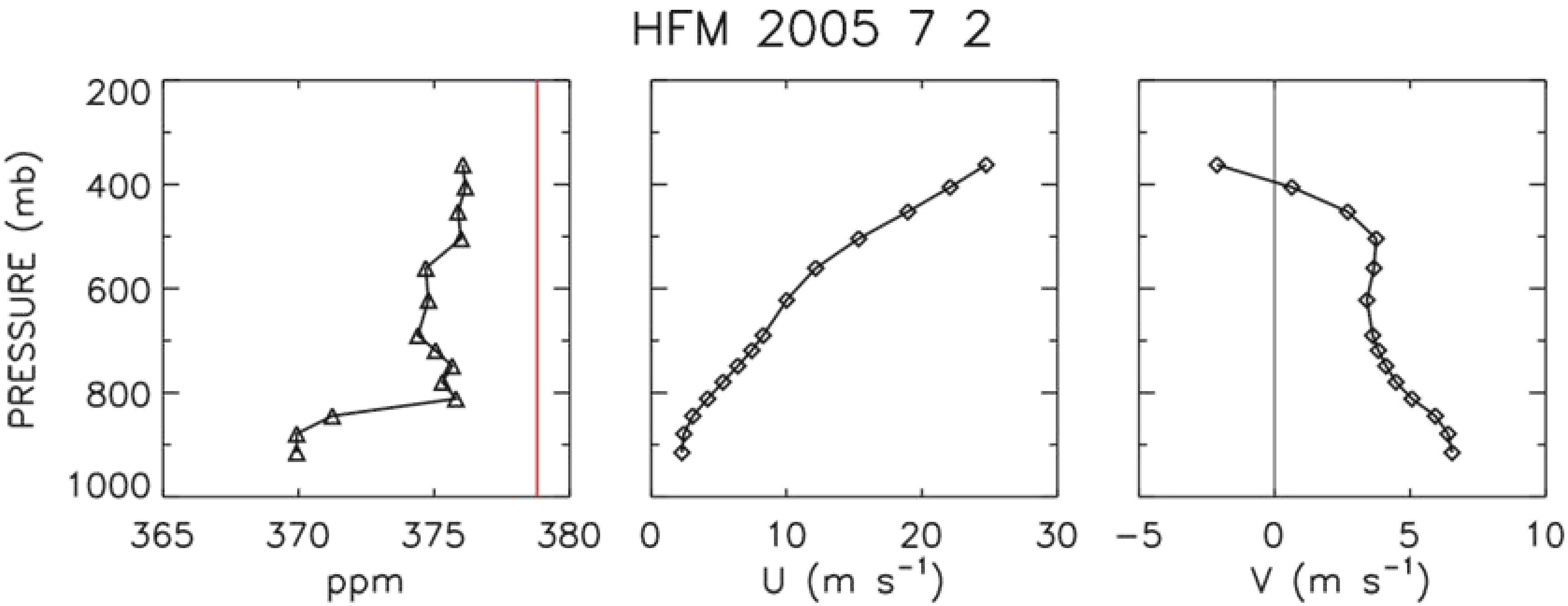
THE NEED FOR VERTICAL DATA



ANNUAL MEAN HORIZONTAL FLUX

	Vancouver Isl. inflow (toward the east)	New England outflow (to east-northeast)	
CO_2	-0.07 ± 0.12	0.50 ± 0.19	GtonC yr $^{-1}$ (500km)$^{-1}$
CH_4	8.2 ± 1.6	12.5 ± 1.7	Tg yr $^{-1}$ (500km)$^{-1}$
SF_6	161 ± 39	367 ± 58	ton yr $^{-1}$ (500km)$^{-1}$

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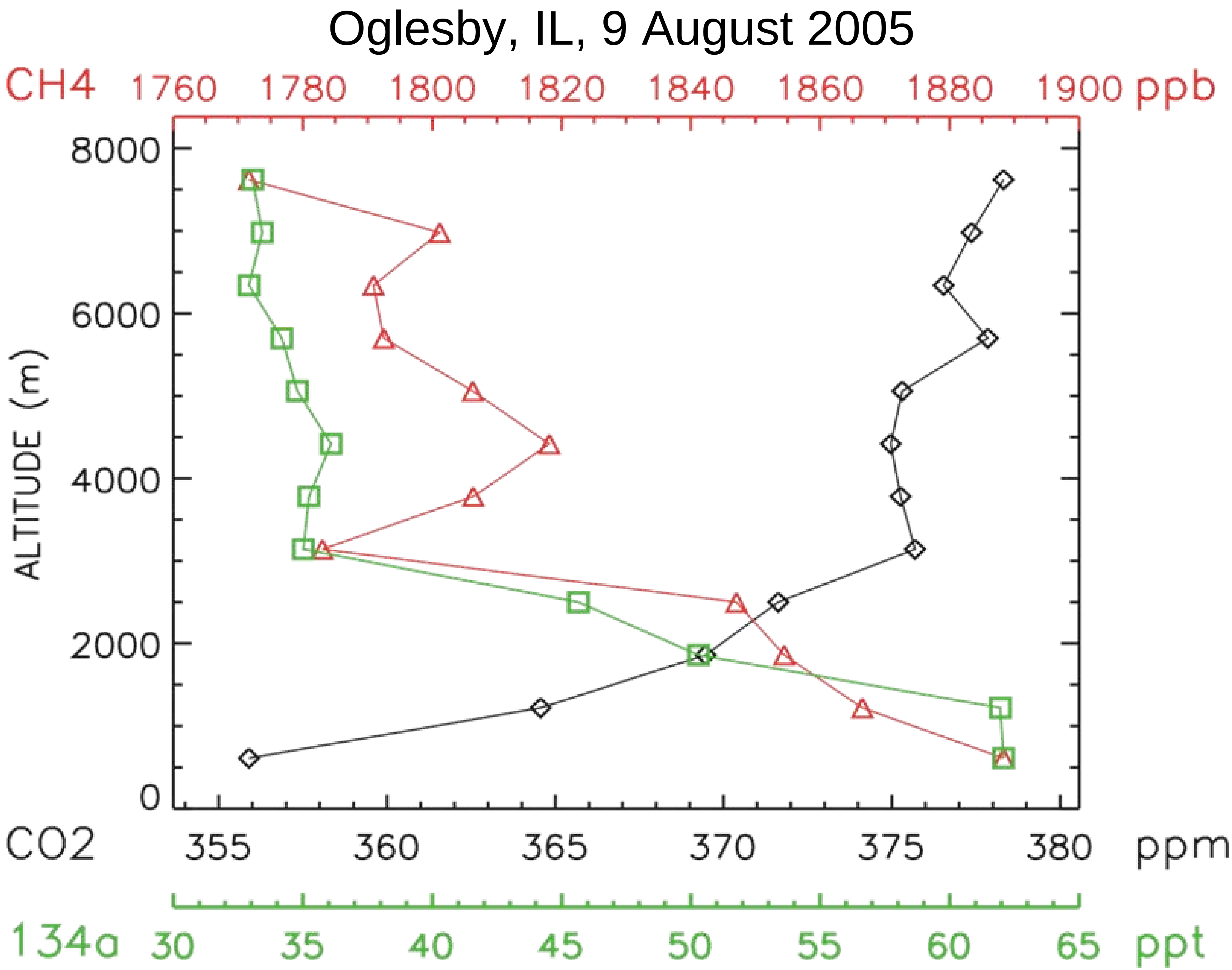
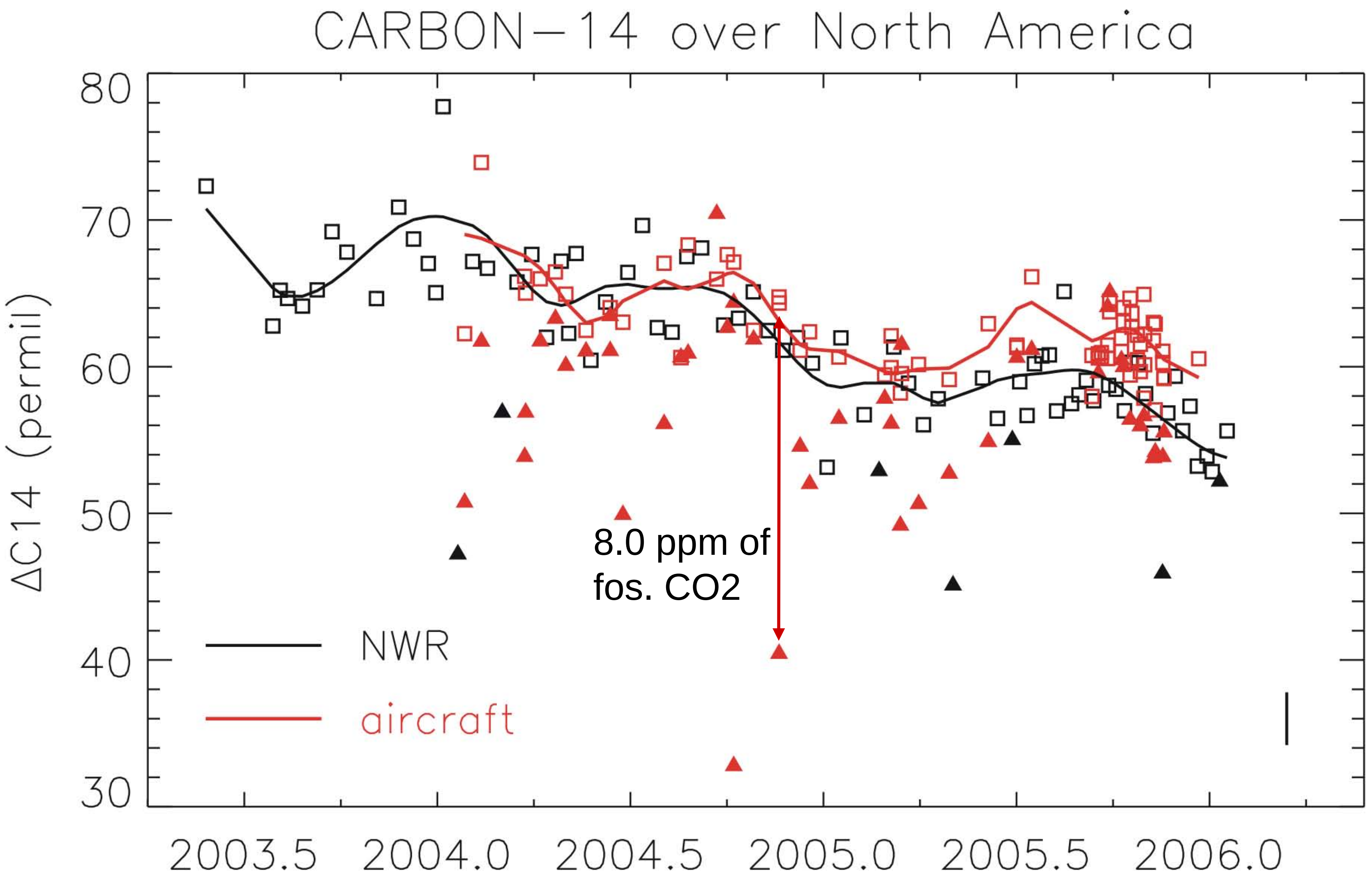
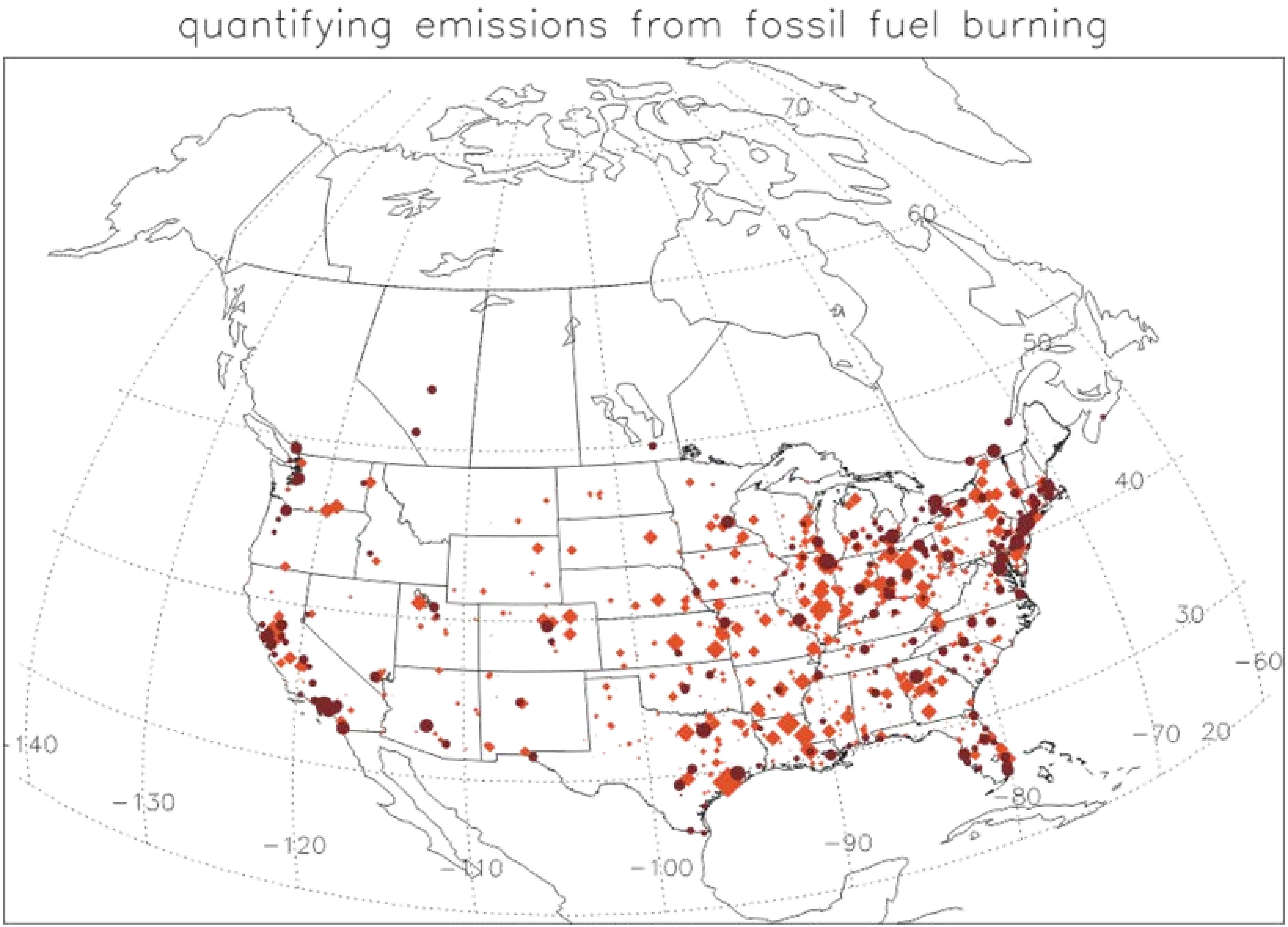


CARBON -14 IS ESSENTIAL FOR FOSSIL FUEL QUANTIFICATION



Source: Jocelyn Turnbull and Scott Lehman, CU-INSTAAR

HOW MANY OBSERVATION SITES ARE NEEDED?



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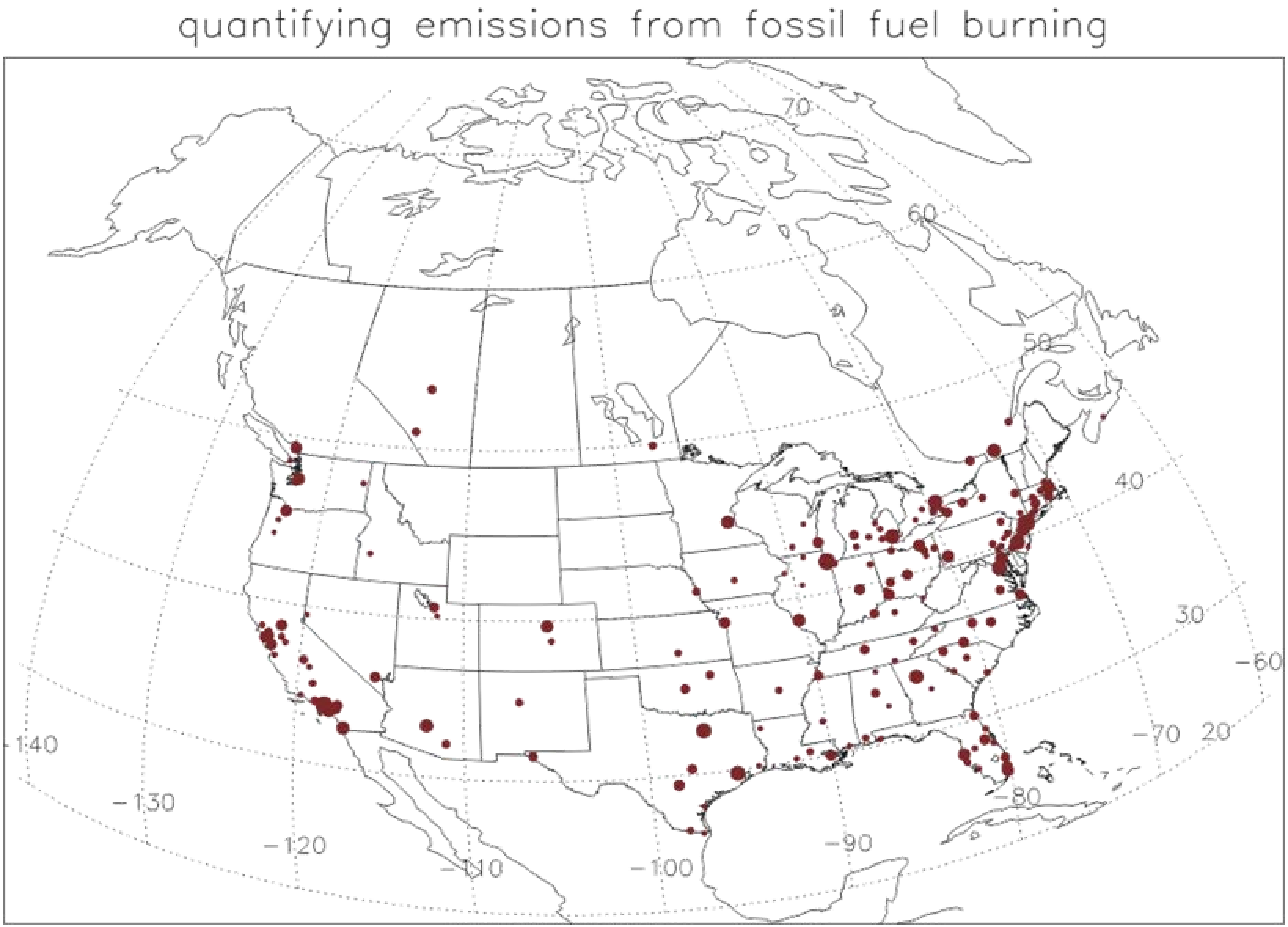
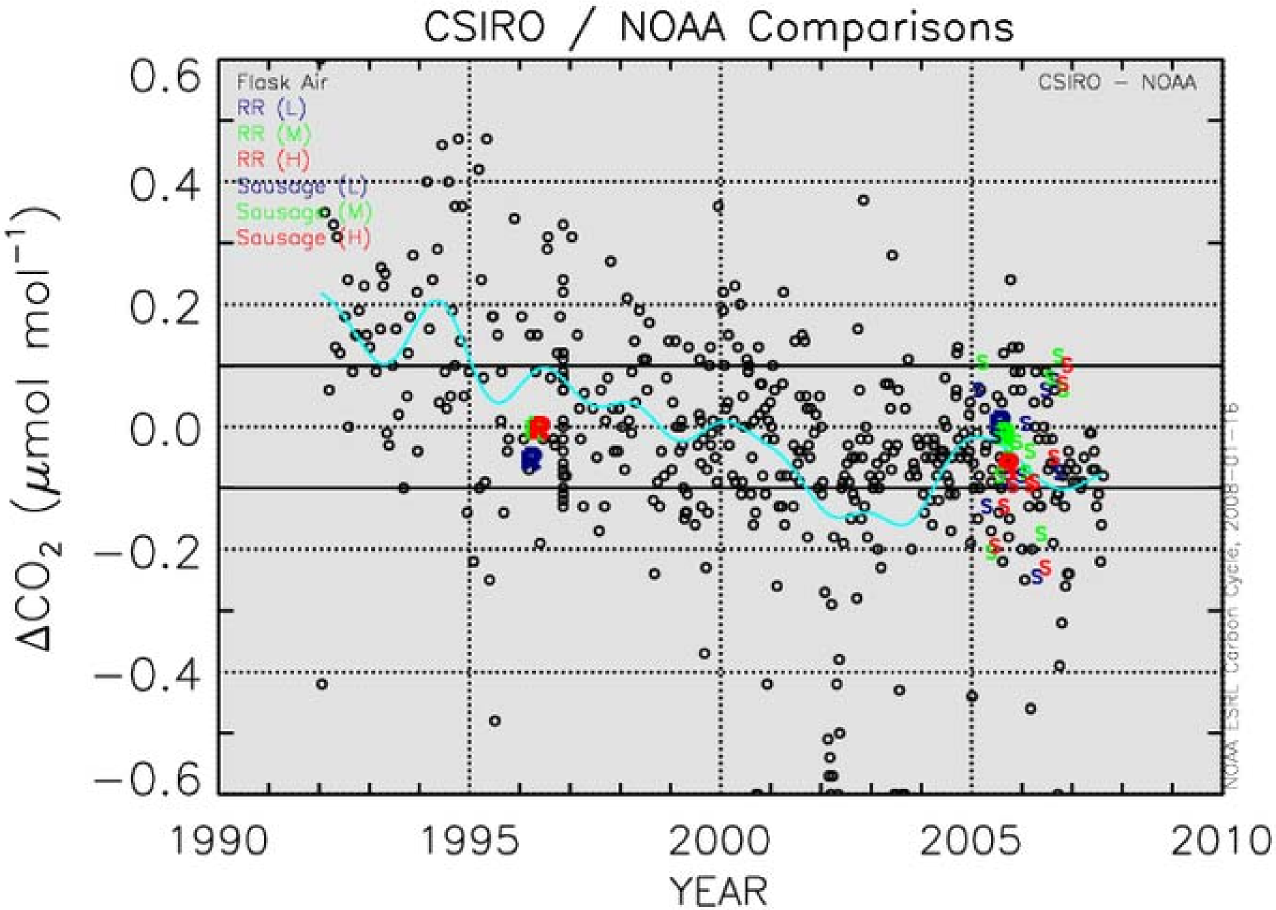
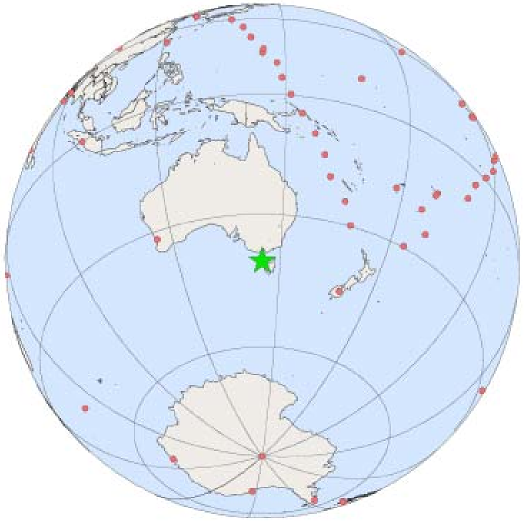


REQUIR

Same Air Comparison (CSIRO-NOAA)		
CGO ICP (weekly)	92-07	-0.03 ± 0.21 (453)
CGO ICP (weekly)	2006	-0.13 ± 0.16 (36)*
Sausage (bi-monthly)	2006	-0.04 ± 0.11 (18)
RR (2-3 years)	2005	-0.03 ± 0.04 (3)
NOAA pair agreement (	92-07	⟨|Δ|⟩ = 0.09 (186)





source: Ken Masarie

main objectives of observing system:

1. **Quantification of CO_2 emissions from fossil fuel burning on global to regional scales.**

2. **Early detection and quantification of "surprises" such as emissions of CH_4 and CO_2 resulting from warming of permafrost.**

3. **Understanding trends in natural sources/sinks, both managed and unmanaged.**

Essential elements of the approach:

- *multi-species, especially carbon-14*
- *very high accuracy for long-lived species*
- *continuous measurements of CO_2, CH_4, CO in boundary layer*
- *vertical profiles, to decrease sensitivity of results to transport biases*
- *use of high-resolution chemical transport models*
- *data assimilation with regional driver variables of the carbon cycle*
- *duplication by independent laboratories as well as methods*
- *need more robust instrumentation*

Longer -lived gases

Compound	lifetime (yr)
CFC-115	1700
CFC-13	640
CFC-114	300
HFC-23	270
*CFC-12	100
*CFC-113	85
*H-1301	65
HFC-143a	52
*CFC-11	45
HFC-125	29
HFC-227ea	34
*CCl_4	26
*H-2402	20
*HCFC-142b	18
*H-1211	16
*HFC-134a	14
*HCFC-22	12
HFC-134	9.6
*HCFC-141b	9.3
HFC-365mfc	8.6
HCFC-124	5.8
*CH_3CCl_3	5

Shorter-lived gases

Compound	lifetime (yr)
*COS	2 to 3
*HFC-152a	1.4
*methyl chloride	1.0
*methyl bromide	0.7
*chloroform	*0.41*
*dichloromethane	*0.38*
*dibromomethane	*0.33*
*PCE	*0.27*
*chloroethane	*0.08*
*bromoform	*0.07*
*methyl iodide	*0.02*
*carbon disulfide	*short*
*propane	*short*
**n*-butane	*short*
*i-pentane	*short*
**n*-pentane	*short*
*benzene	*short*

(Italicized numbers represent a local lifetime for short-lived gases)

* NOAA calibration scale exists

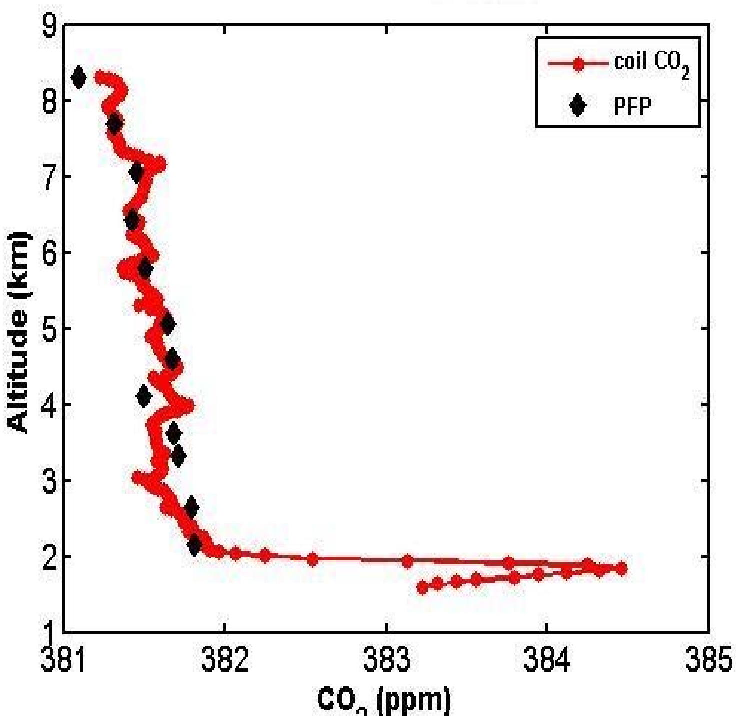
Source: Steve Montzka

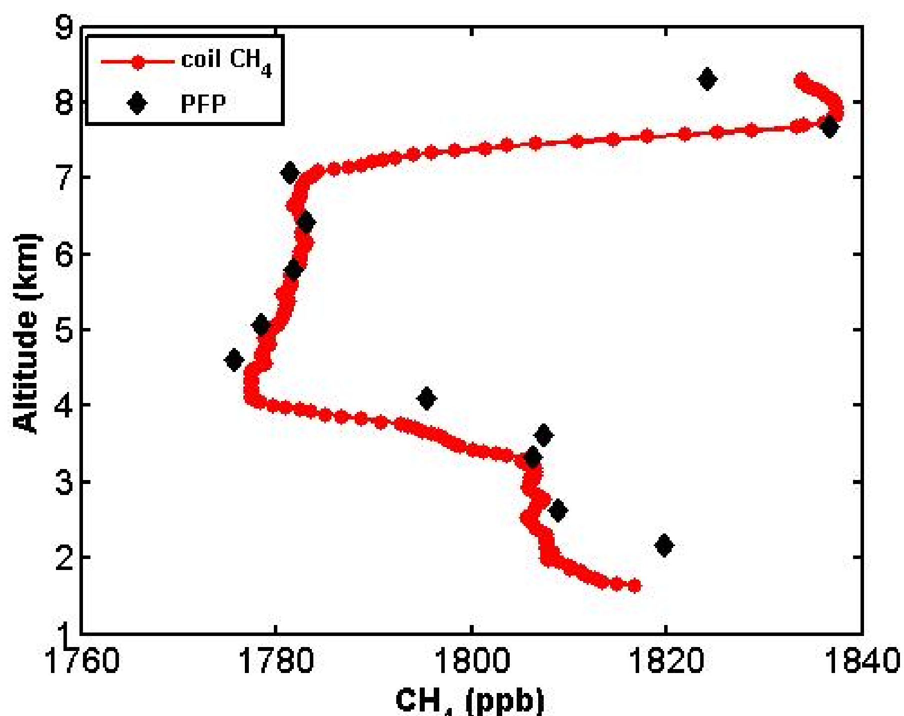
PEOPLE CHALLENGES

How can we continue to assure the required quality (comparability) of the measurements when there are hundreds of sites and many institutions involved?

- maintain partnerships, national and international; entrain and educate new participants; collaborate with air quality community
- full and prompt availability of all data and methods
- promote continuing calibrations as well as comparisons between in-situ analyzers and flask samples
- data management is paramount, incl. automated data exchange, automated QC algorithms that generate warnings

Automated air samples
versus
AirCore





source: Colm Sweeney and Anna Karion