Why CarbonTracker?

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CarbonTracker Science Review
Earth System Research Laboratory
Boulder, 16 September 2008

The need for an observing system producing regional flux estimates

Modeling as part of the observing system

A denser observing network

Integration of satellite data

Starting point:

1. **Climate change caused by human activities is being observed. Uncertain feedbacks make prediction difficult, but could also plausibly lead to catastrophic change.**

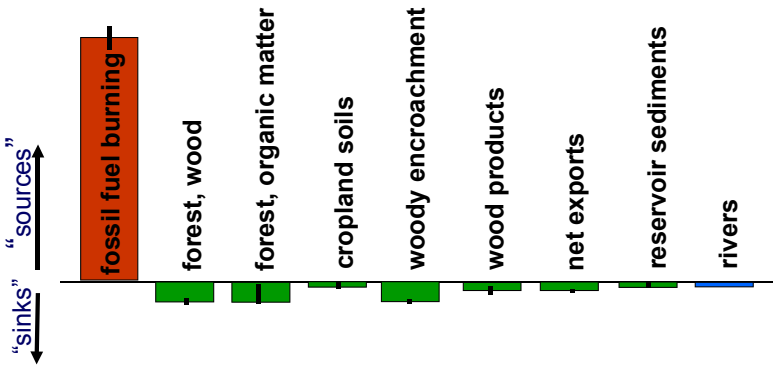
5. **The world will find itself forced to engage in both mitigation and adaptation in the near future and beyond.**

7. **We have a planetary emergency. As scientists we have a duty to serve society by providing:**

   - ***Ongoing diagnoses as the earth system changes unfold***
   - ***Objective verification of emissions on regional/local scales (Mitig)***
   - ***Prediction of climate impacts on regional/local scales (Adap)***
   - ***Assessment of proposed solutions (Mitig, Adap)***

WHAT DO WE NEED TO MEASURE?

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



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U.S. carbon budget, Source: Pacala et al., Science 2001

Dominating role of fossil fuel burning among all net sources/sinks. Thus far, we have taken inventories as given. They may be fairly reliable for the U.S. as a whole, but are not well known regionally.

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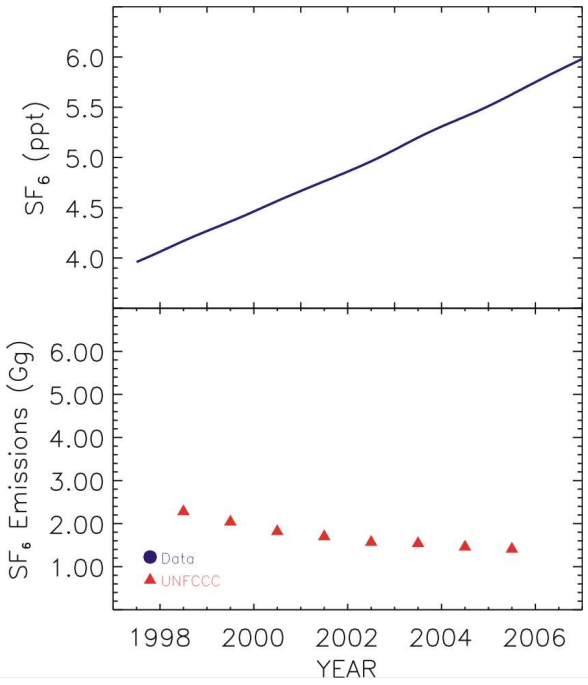

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Reported SF6 emissions by Annex 1 countries, as required by international treaty. They have two existing non-binding agreements, to voluntarily decrease emissions in the electricity sector, as well as in magnesium smelters. According to their own accounting, they succeeded. In reality, based on atmospheric data, which are definitive in this case, global emissions were much higher in 1998, and since then they went up instead of down.

WHAT DO WE NEED TO MEASURE?

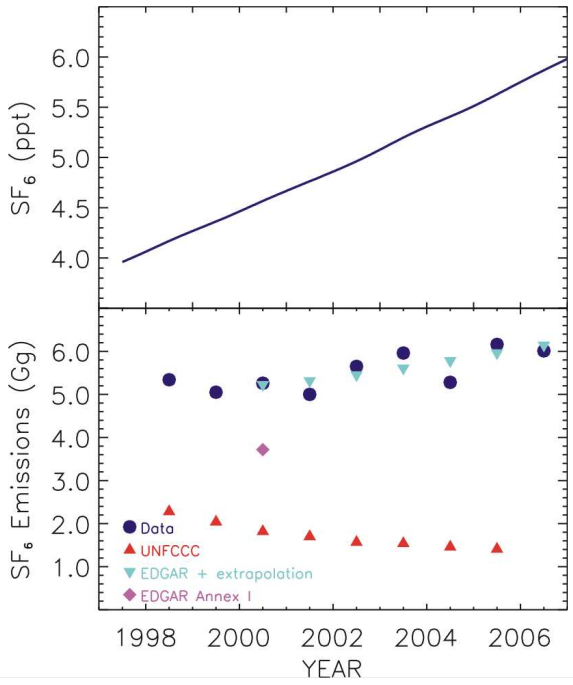
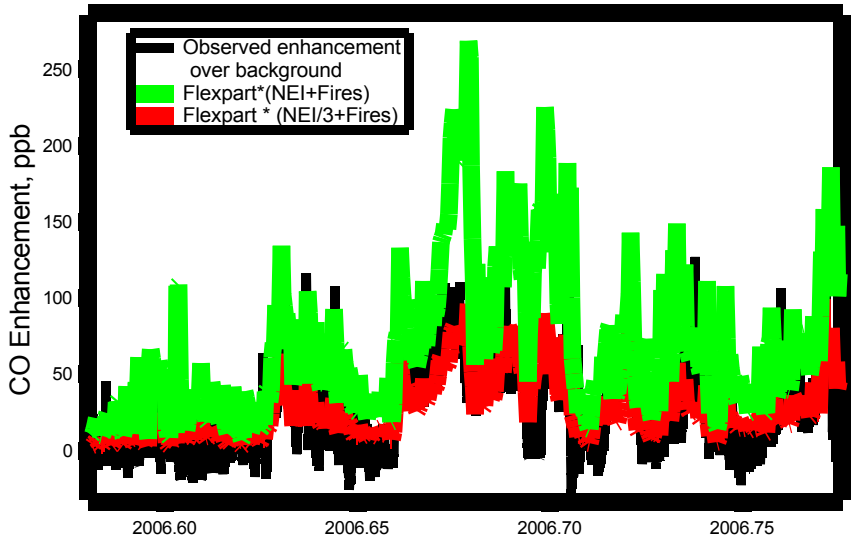


Figure:
Molly Heller
Ed Dlugokencky
Gabrielle Petron

The EDGAR (updated thru 2000) looked at our atmospheric data, and forced agreement with the observations by increasing the official Annex 1 emissions by 900 ton, plus 350 ton for Russia, which had declared 5 ton. The remainder they assigned to developing countries, of which 350 ton to China.

WHAT DO WE NEED TO MEASURE?

CO enhancement at NOAA ESRL tall tower near Waco, Texas, 1 July – 15 October 2006



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Source: Arlyn Andrews (data), Andreas Stohl (Flexpart model)

The EPA is also wrong about CO inventories by a factor of 2-3. There are several other pieces of evidence showing the same thing. "Enhancement" is relative to background. The latter can be defined by the MBL reference surface, or locally as a moving average 20th percentile of the data, for example.

Currently we have a fair amount of trust in the U.S. national inventory of CO2 emissions. Can we afford to trust that will remain? Future claims of mitigation will be grand, but will they be true? A few weeks ago the price was 28 euro/ton CO2, which equates to ~150 $/ton C, or ~250 B/year for U.S., and also 38 c/gallon of gasoline emissions, probably 45 c/gal gross because crude needs to be extracted, refined to gasoline, transported etc. That level of price increase appears to be not enough, by itself, to affect significant behavior change….

WHAT DO WE NEED TO MEASURE?

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

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

Photo: Geological Survey of Canada

Zimov's estimate: 500-950 GtonC is currently locked up in permafrost. What fraction is going to be lost as CH_4, as CO_2, and at what rate?

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

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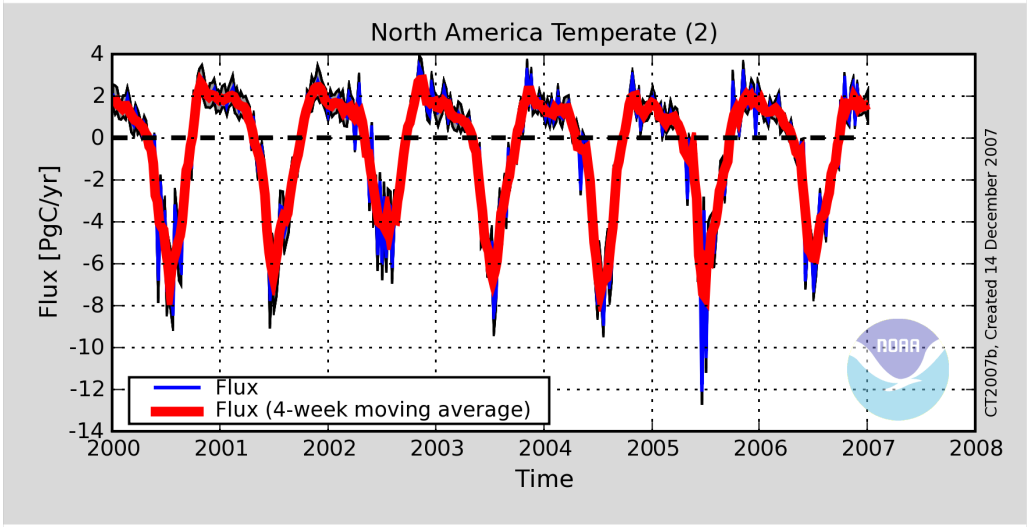
Response of the biosphere and oceans to the climate changes that are occurring, and to human management, such as deforestation, soil sequestration, etc.

We need to develop tools to quantify the effectiveness of policies that promote carbon offsets, presumably traded on the Chicago Climate Exchange and elsewhere. If the market is not firmly tied to reality, it will be volatile and inefficient.

MODELING AS A PART OF THE OBSERVING SYSTEM



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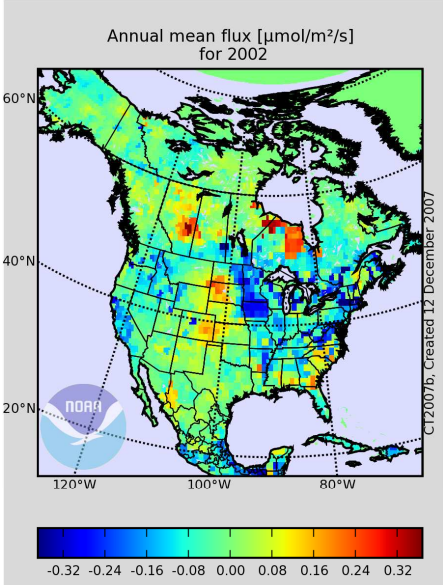
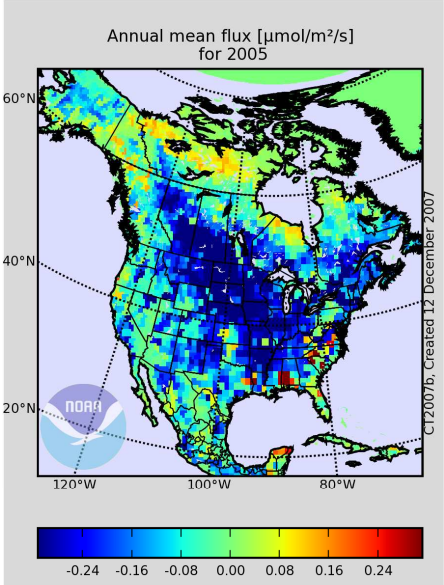
There is considerable interannual variability in sources/sinks of CO2. Can we pin down the causes?

MODELING AS A PART OF THE OBSERVING SYSTEM



Net ecosystem flux for North America for 2002: -0.17 Gton C



Net ecosystem flux for North America for 2005: -0.76 Gton C

Average annual net uptake 2000-2006 estimated as 0.57 Gton C. Note different color scales

DENSER NETWORK, MITIGATION VERIFICATION

Hybrid mobile lab

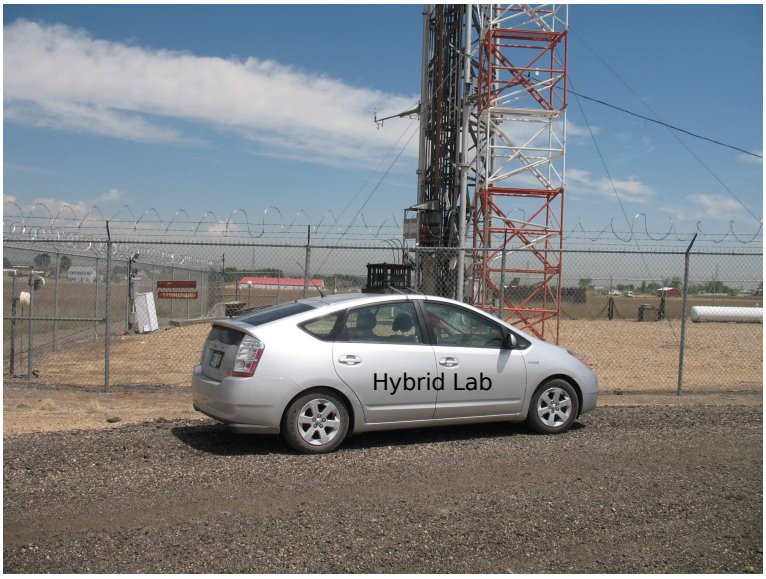


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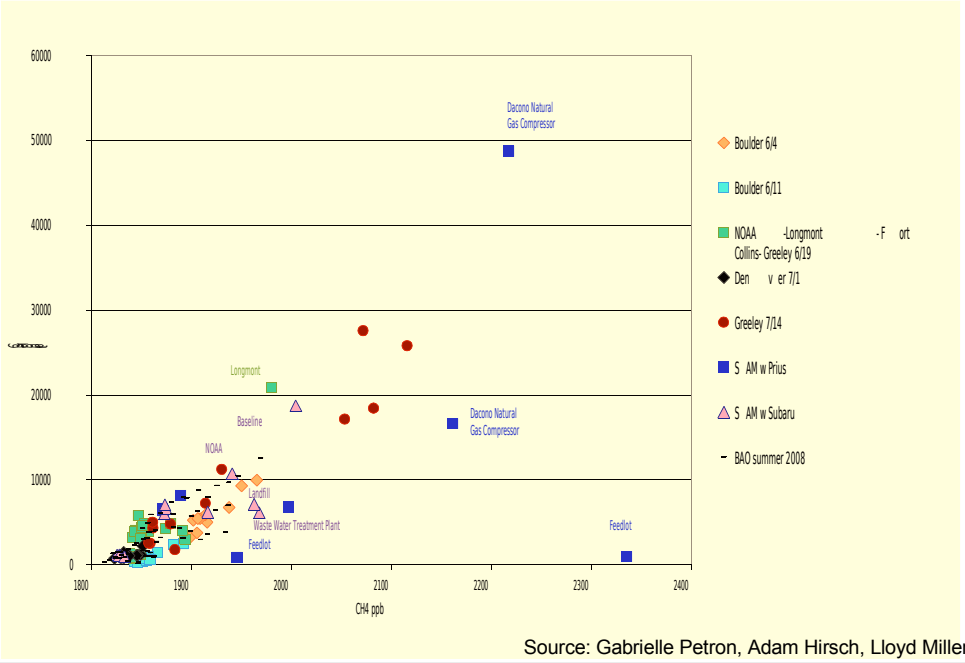
Figure: Gabrielle Petron, Adam Hirsch

The Boulder Atmospheric Observatory is a 300m tall tower in Erie, 10 miles east of Boulder. We started monitoring in May 2007. This summer several groups in ESRL coordinated to make measurements on, and around, the tower to explore multi-species chemical signatures of CO2, CH4, CO anomalies.

DENSER NETWORK, MITIGATION VERIFICATION

Propane and methane at the Boulder Atmospheric Observatory tower and its surroundings



Source: Gabrielle Petron, Adam Hirsch, Lloyd Miller

The correlation we see on the tower between methane and propane we see also in a wide area around the tower, and points the finger at the operation of gas wells as the main culprit. An example of another telltale correlation is between CO2 and HFC-134a from automobile traffic. These chemical "fingerprints" will help when we are going to solve for fossil fuel CO2 emissions its components.

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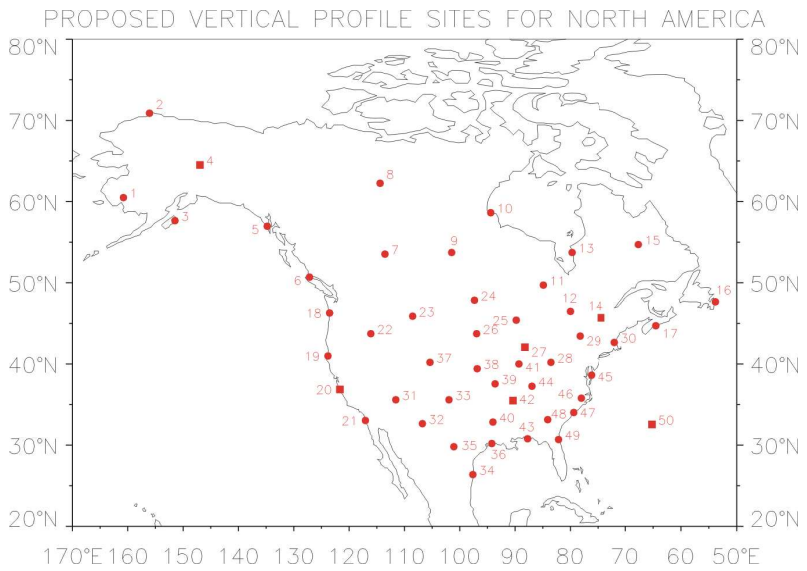

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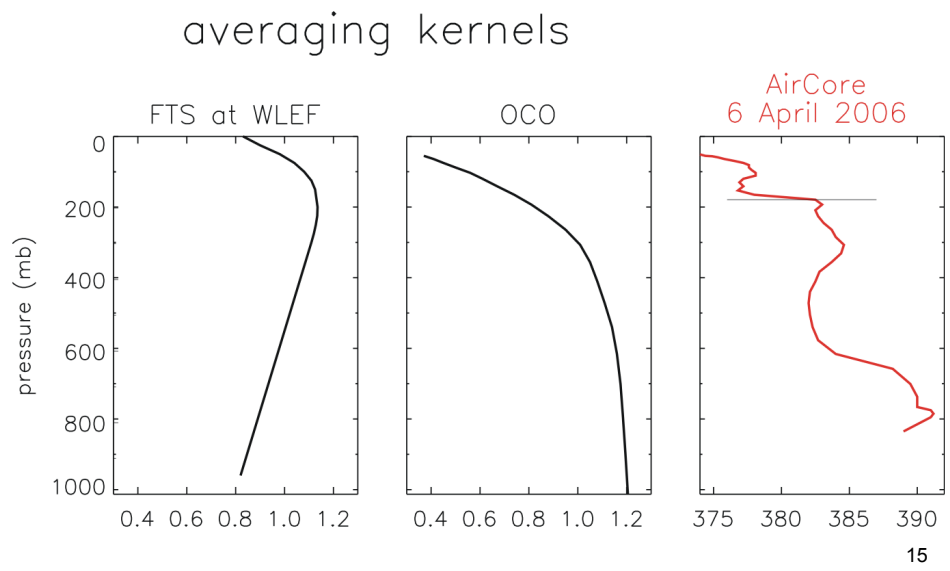
This is a plan that I proposed in 1995, consisting of weekly vertical profiles by aircraft, mostly with turboprop engines (up to ~8km altitude), and a few by jet aircraft going to higher altitudes (square symbols). The idea was to pin N. Am. sources through regular measurements of inflow and outflow, and in between to provide more spatial detail beyond a continental integral. The vertical measurement component is essential to prevent the conclusions from being strongly driven by potential model transport biases, esp. exchange between the PBL and the free troposphere. Our thinking has evolved significantly since then. We now envision a mixed system of continuous tower measurements and aircraft profiles. The overall system should be run by many institutions in collaboration instead of just NOAA. In 1995 I had never heard of data assimilation, which allows intelligent use of many types of constraints other than CO2 data. We did propose multiple chemical species to constrain the problem.

INTEGRATION OF SATELLITE DATA



It is a great challenge to produce the very high level of sustained measurement accuracy that is necessary to infer useful quantitative information about sources/sinks of CO2. Starting with Dave Keeling in 1958, it has been a never ending battle against biases. Experience has shown us that careful calibration procedures are necessary, but not sufficient. We have a system of ongoing comparisons of our measurements with those of other labs, currently twelve. Satellite retrievals will be no exception because the measurement technique is more challenging. We will have to learn through comparisons between independently derived retrievals, and between independent measurement methods where we may have biases that could invalidate the source/sink determinations. I doubt that the task can be efficiently done, or even done at all, if we do not produce vertical profiles on an ongoing basis that anchor “truth”.