What are comparison results telling us?

Ken Masarie, Tom Conway, Pieter Tans, and colleagues from all participating comparison laboratories
Study of Pacific and Atlantic signals

Comparison Study: Pacific and Atlantic Sites

CO₂ (umol mol⁻¹)

Year

Shemya Island, Alaska [53°N; Pacific]
Cold Bay, Alaska [55°N, Pacific]
Iceland [63°N; Atlantic]
Mace Head, Ireland [53°N, Atlantic]
Feature or Artifact?

Comparison Study: Pacific and Atlantic Sites (Trends)

- Shemya Island, Alaska [53°N, Pacific]
- Cold Bay, Alaska [55°N, Pacific]
- Iceland [63°N, Atlantic]
- Mace Head, Ireland [53°N, Atlantic]
Do Cold Bay measurements suggest a problem?
Does QA/QC in Boulder suggest a problem?
Comparison with an independent record

NOAA and SCRIPPS data from Cold Bay

- Cold Bay, Alaska [55°N, Pacific] NOAA DATA
- Cold Bay, Alaska [55°N, Pacific] SCRIPPS DATA

\[ \text{CO}_2 \text{ (umol mol}^{-1}\text{)} \]

Year


340 350 360 370 380 390

SIO data courtesy of Ralph Keeling
Co-located sampling suggests a problem
Leak in NOAA sampling system confirmed
Result: No Feature, lost data, improved record

A 3+ year gap in a NOAA long-term record caused by a missed opportunity to compare co-located independent measurements in near-real time.
Strategies to assess compatibility
Comparison strategies

Co-located air sampling
24 labs; ~hourly to weekly

Sausage
9 labs; bimonthly

Round Robin
44 labs; ~2-3 years

Cucumber
26 labs; ~9 months

*Gollum
29 labs; ~9 months

GGMT-2011 Meeting – 27 October 2011
Co-located atmos. measurements (24 labs; 28 sites)

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<tr>
<th>Location</th>
<th>Institutions</th>
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<tr>
<td>Alert, Canada</td>
<td>EC,CSIRO,LSCE,MPI-BGC,NOAA,SIO,UHEI-IUP</td>
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<td>American Samoa</td>
<td>AGAGE,NOAA</td>
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<td>Baring Head, New Zealand</td>
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<td>Cape Grim, Australia</td>
<td>CSIRO,NOAA,SIO</td>
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<td>Cape Point, South Africa</td>
<td>SAWS,LSCE,NOAA,UEA (O₂/N₂),RHUL (carbon isotopes)</td>
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<td>Cold Bay, Alaska, United States</td>
<td>NOAA,SIO</td>
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<td>Estevan Point, Canada</td>
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<td>Schauinsland, Germany</td>
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<td>Zeppelin, Norway and Sweden</td>
<td>ITM,NOAA</td>
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Detecting problems sooner rather than later

Possible if …

- Near real-time access
- Frequent comparison
- Automation
- Data management
- Routine inspection

Otherwise…

may have to live with data gaps
Intra-laboratory co-located atmospheric measurements

![Diagram showing NOAA co-located Flask/In Situ ICP measurements in Barrow, Alaska. The graph plots ΔCO₂ (μmol mol⁻¹) from 2000 to 2012 with specific notes on the accuracy and precision of the measurements.]
Inter-laboratory co-located atmospheric measurements

LSCE/NOAA co-located Flask/In Situ Comparison
Mace Head, Ireland

$\Delta CO_2$ (µmol mol$^{-1}$)

2006-01-16 to 2009-11-23 [UTC]

LSCE data courtesy of Michel Ramonet
Multiple co-located atmospheric measurement records

LSCE data courtesy of Michel Ramonet and Martina Schmidt
EC/NOAA same-air comparison at Alert
Complementary comparisons help identify causes

EC data courtesy of Doug Worthy
MPI-BGC/NOAA same-air comparison at Ochsenkopf

MPI-BGC data courtesy of Armin Jordan
MPI-BGC/NOAA complementary comparisons

[Graph showing comparisons between MPI-BGC and NOAA data]

 MPI-BGC data courtesy of Armin Jordan
Complementary comparisons: Multiple trace species

![Graphs showing CO2 and HFC-134a mixing ratios with varying latitudes and dates.](image)
Comparison distributions are dynamic

Prior to March 2011

Since March 2011

Data change as

1. New information becomes available
2. Problems are identified and rectified
3. Scales are updated
NOAA: reprocessed (X2007) minus X2005*

Alert (82°N)

Ascension Island (8°S)

South Pole (90°S)
Again… comparison results are dynamic

![Graph showing CO₂ comparison results between CSIRO and NOAA at Cape Grim, Tasmania](image-url)
So... what are comparison results telling us?

- Frequent and ongoing comparison of atmospheric measurements derived from independent systems is essential
  - *Infrequent comparisons can lead to loss of data*

- It is difficult to establish and maintain recommended target levels for measurement compatibility
  - *but it can be achieved and has been demonstrated at both baseline and continental sites*

- Complementary comparisons have proven to be extremely useful to narrow the potential causes of observed differences in atmospheric records

- Multi-species comparisons have also proven to be extremely useful

- Comparison results are dynamic

- **Ongoing** comparison experiments are required

- If atmospheric measurements derived from two laboratories meet the recommended WMO compatibility requirements, measurements from other sites in their respective networks are compatible to the same level. How good is this assumption?

- **53** labs participating in inter-laboratory comparison experiments
  - 24 labs have at least 1 co-located atmospheric measurement program
  - 52 labs participate in at least 1 complementary comparison experiment
Next steps …

- **Continue to fine-tune comparison activities**
  - e.g., work presented by Gomez, Jordan, and so many others

- **Document comparison methods**

- **Communicate what we have learned**

- **Identify what we believe data users should know**
  - Measurement accuracy
  - Analytical uncertainty
  - Network compatibility
Record with introduced measurement bias

CarbonTracker Sensitivity to Data Offsets: Wisconsin Tower (LEF)

$\text{CO}_2$ (umol mol$^{-1}$)

Year

2001 2002 2003 2004 2005 2006 2007 2008 2009
N.A. bias impacts fluxes globally

Where is the bias in these data?
Bias easily detected via comparison with flasks
A final thought…

Ongoing comparison activities may not have the appeal of new technology or the reward of scientific insight, but they are an essential and critical component of our measurement process and provide a realistic assessment of how well we can measure the atmosphere.
Thank you