

New Capabilities For Interpreting Comparison Data

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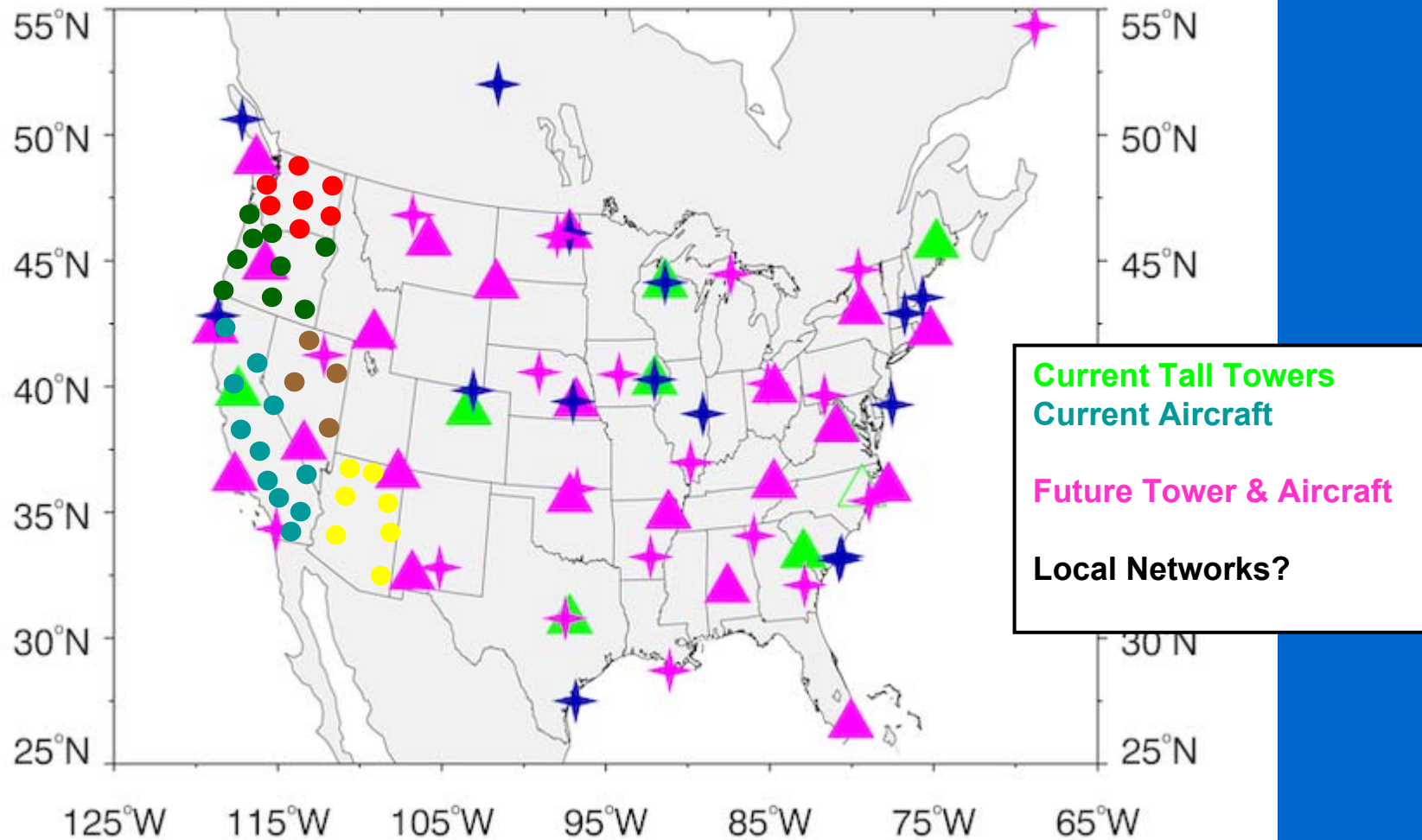
²Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, U.S.A

Through The Years ...

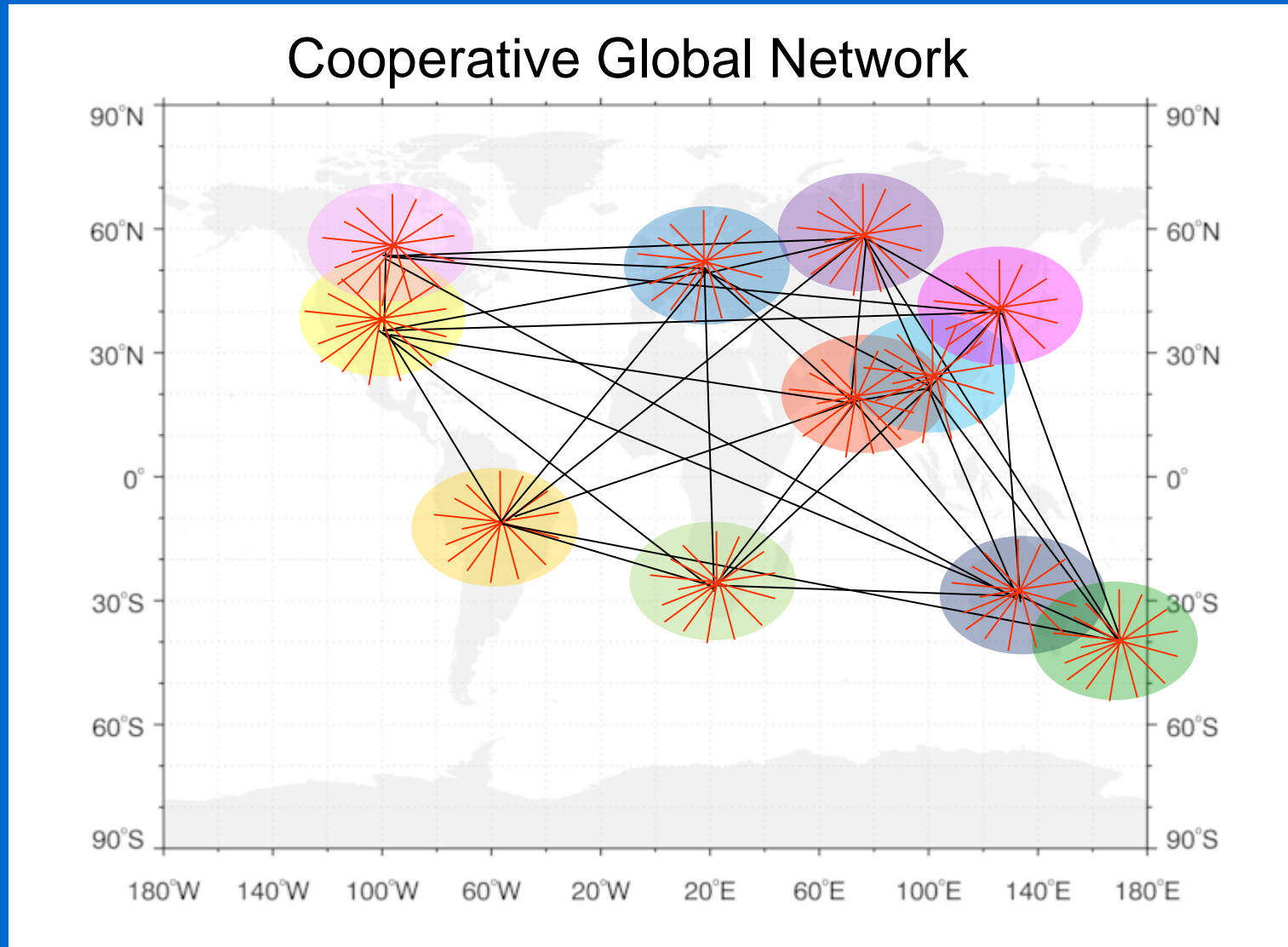
- ❑ **NOAA Comparison Activity: Are we closer to the required measurement accuracy? (Finland 2007)**
- ❑ **Making Quality Measurements without a Data Management Strategy (Canada 2003)**
- ❑ **A Web-based Interactive Atmospheric Data Visualization Tool: Near real-time access to data from the NOAA CMDL CCGG Observing Network (Canada 2003)**
- ❑ **GLOBALVIEW-CO₂: Past, Present and Future (Japan 2001)**
- ❑ **GLOBALVIEW-CO₂: An Update (Australia 1997)**
- ❑ **An Update on the Ongoing Flask-Air Intercomparison Program between NOAA and CSIRO (Australia 1997)**
- ❑ **Extension and Integration of Atmospheric CO₂ Data into a Globally Consistent Measurement Record (U.S. 1995)**

Motivation: Cooperative Observing Systems

Regional and Local Networks



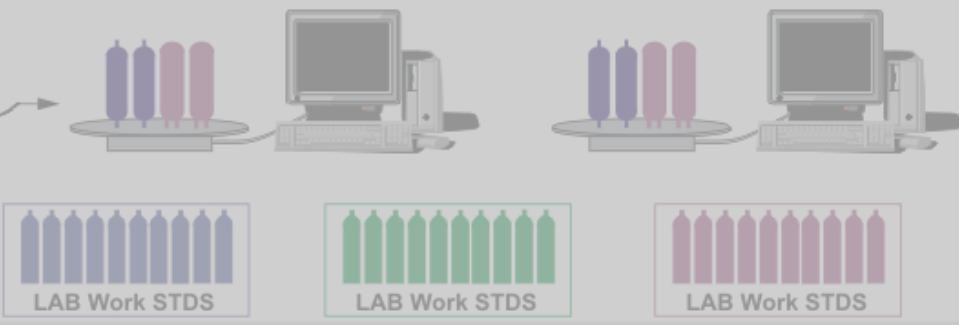
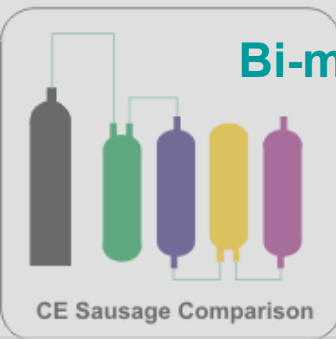
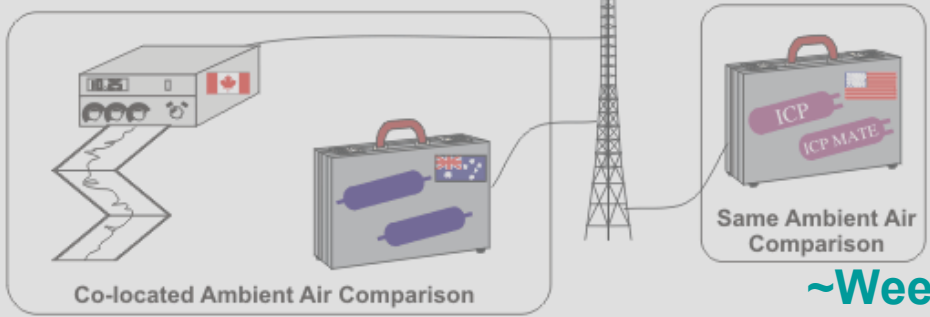
Motivation: Global Network of Regional Networks



conceptual

Motivation: Multiple Comparison Strategies

ATMOSPHERE



EC / NOAA

WMO RR
CE Sausage
CE Cucumber

Same Air (ALT)
Flask/In Situ (ALT)
Flask/In Situ (LLB)

ESRL Inter-Laboratory Comparison Activities

Partner	Location	Frequency	Method	Type	Parameters
CSIRO	CGO	Weekly	Flask	Same Air	CO ₂ ,CH ₄ ,CO,H ₂ ,N ₂ O,CO ₂ C ₁₃ ,CO ₂ O ₁₈
CSIRO	ALT	Weekly	Flask/Flask	Co-located	
EC	ALT	Weekly	Flask	Same Air	CO ₂ ,CH ₄ ,CO,H ₂ ,N ₂ O,SF ₆
EC	ALT, LLB	Weekly	Flask/In Situ	Co-located	CO ₂ , CH ₄ , CO
MPI-BGC	O XK	Weekly	Flask	Same Air	CO ₂ ,CH ₄ ,CO,H ₂ ,N ₂ O,SF ₆
LSCE	MHD	Weekly	Flask	Same Air	CO ₂ ,CH ₄ ,CO,H ₂ ,N ₂ O,SF ₆
LSCE	MHD	Weekly	Flask/In Situ	Co-located	CO ₂
IPEN	ABP	Weekly	Flask/Flask	Co-located	CO ₂ ,CH ₄ ,CO,H ₂ ,N ₂ O,SF ₆
NCAR	NWR	Weekly	Flask/In Situ	Co-located	CO ₂
NIWA	BHD	Weekly	Flask	Same Air	CO ₂ ,CH ₄ ,CO,N ₂ O,CO ₂ C ₁₃ ,CO ₂ O ₁₈
CE Sausage	CEI	Bi-Monthly	Flask/Flask	Same Air	CO ₂ ,CH ₄ ,CO,N ₂ O,CO ₂ C ₁₃ ,CO ₂ O ₁₈
FMI	PAL	Weekly	Flask/In Situ	Co-located	CO ₂ ,CH ₄
ESRL/HATS	TST	Weekly	Flask	Same Air	N ₂ O,SF ₆
AEMET	IZO	Weekly	Flask/In Situ	Co-located	CO ₂
ENEA	LMP	Weekly	Flask/In Situ	Co-located	CO ₂ ,CH ₄
LBNL	SGP	Weekly	Flask/In Situ	Co-located	CO ₂
CMA	WLG	Weekly	Flask/In Situ	Co-located	CO ₂ ,CH ₄ ,CO
Round Robin	RRI	3-4 Years	Cylinder	Same Air	CO ₂ ,CH ₄ ,CO,N ₂ O,CO ₂ C ₁₃ ,CO ₂ O ₁₈

ESRL Intra-Laboratory Comparison Activities

Location	Frequency	Method	Type	Parameters
TST	Daily	Flask	Same Air	CO ₂ ,CH ₄ ,CO,H ₂ ,N ₂ O,SF ₆ ,CO ₂ C ₁₃ ,CO ₂ O ₁₈
KUM	Weekly	Flask	Same Air	CO ₂ ,CH ₄ ,CO,H ₂ ,N ₂ O,SF ₆
AAO	Monthly	Flask	Same Air	CO ₂ ,CH ₄ ,CO,H ₂ ,N ₂ O,SF ₆
BRW	Weekly	Flask/In Situ	Co-located	CO ₂ ,CH ₄ ,CO
MLO	Weekly	Flask/In Situ	Co-located	CO ₂ ,CH ₄ ,CO
SMO	Weekly	Flask/In Situ	Co-located	CO ₂
SPO	Weekly	Flask/In Situ	Co-located	CO ₂
AMT	Weekly	Flask/In Situ	Co-located	CO ₂ ,CO
BAO	Weekly	Flask/In Situ	Co-located	CO ₂ ,CO
LEF	Weekly	Flask/In Situ	Co-located	CO ₂ ,CO
SCT	Weekly	Flask/In Situ	Co-located	CO ₂ ,CO
WBI	Weekly	Flask/In Situ	Co-located	CO ₂ ,CO
WGC	Weekly	Flask/In Situ	Co-located	CO ₂ ,CO
WKT	Weekly	Flask/In Situ	Co-located	CO ₂ ,CO

Looking For A More Flexible ICP Application

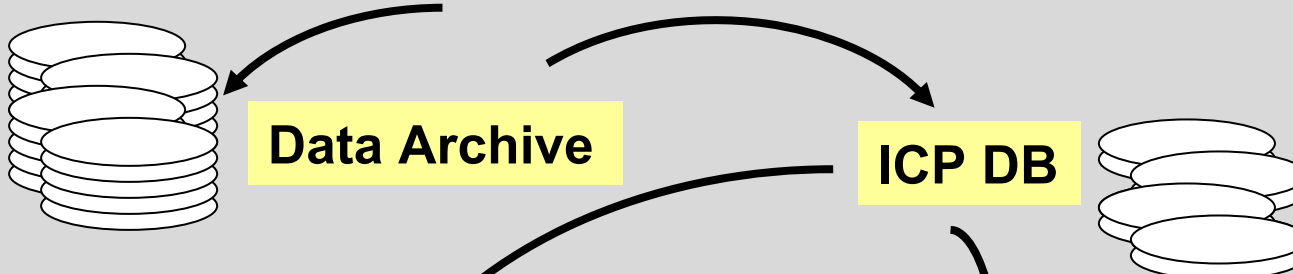
- ❑ View results from multiple ICPs among multiple labs
- ❑ Accommodate many same-air and co-located ICP strategies
- ❑ Scale to a 10-fold increase in ICP experiments
- ❑ Automate data transfer and archive, and DB and Web updates
- ❑ View key images and statistical summaries (Production)
- ❑ Create custom comparisons and images (Interactive)
- ❑ Web-based, Fast, Free, Robust
- ❑ Minimal Software/Hardware Requirements
- ❑ Portable

Interactive ICP Framework

1



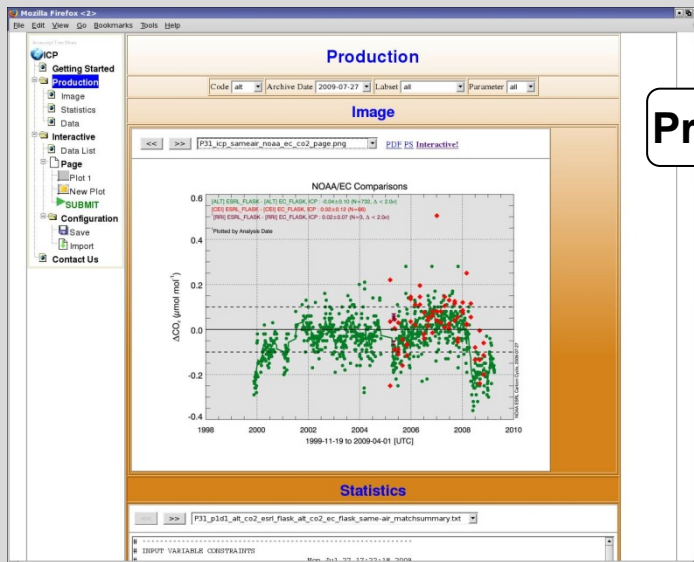
2



Host Lab

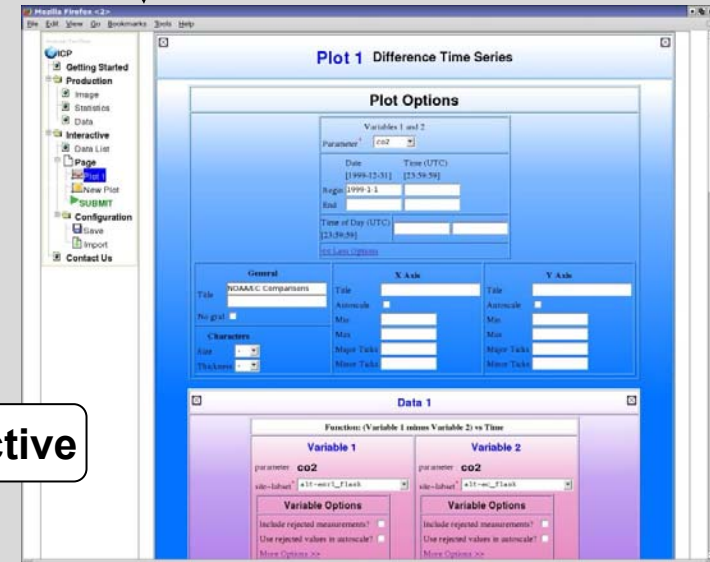
3

WEB App



Production

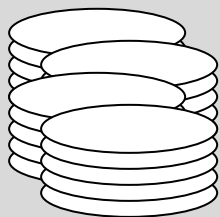
Interactive



Interactive ICP Framework

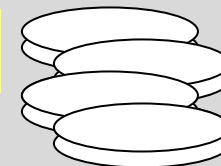
FAIL TO AUTOMATE Data Transfer

Host Lab



Data Archive

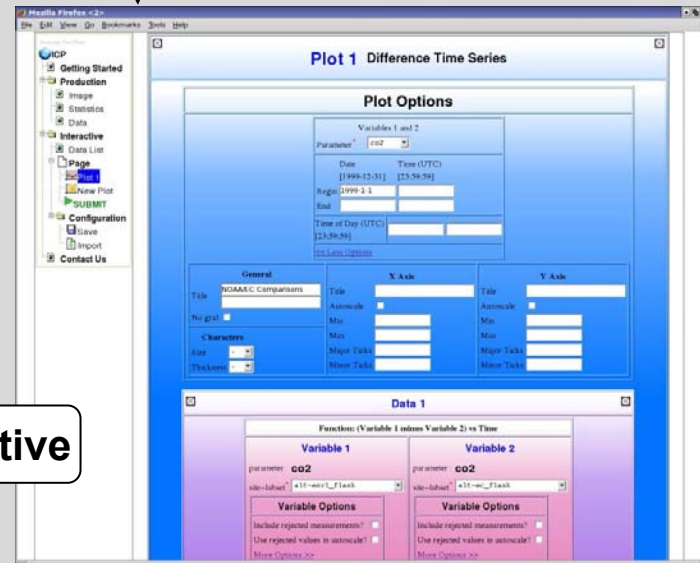
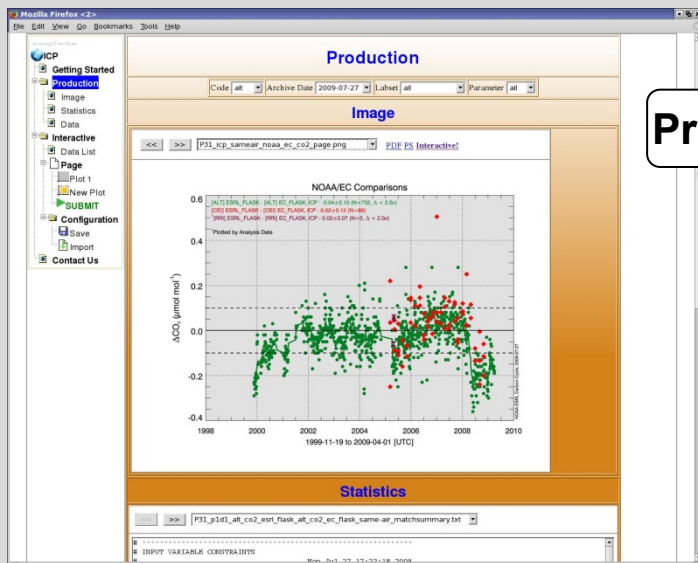
ICP DB



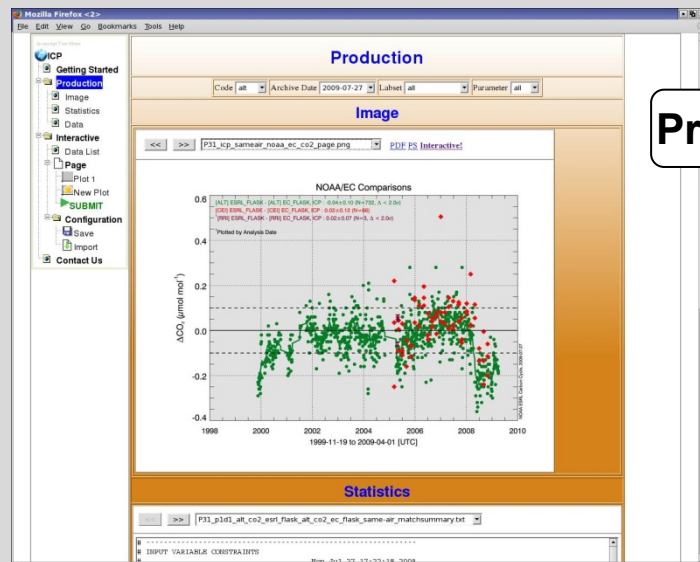
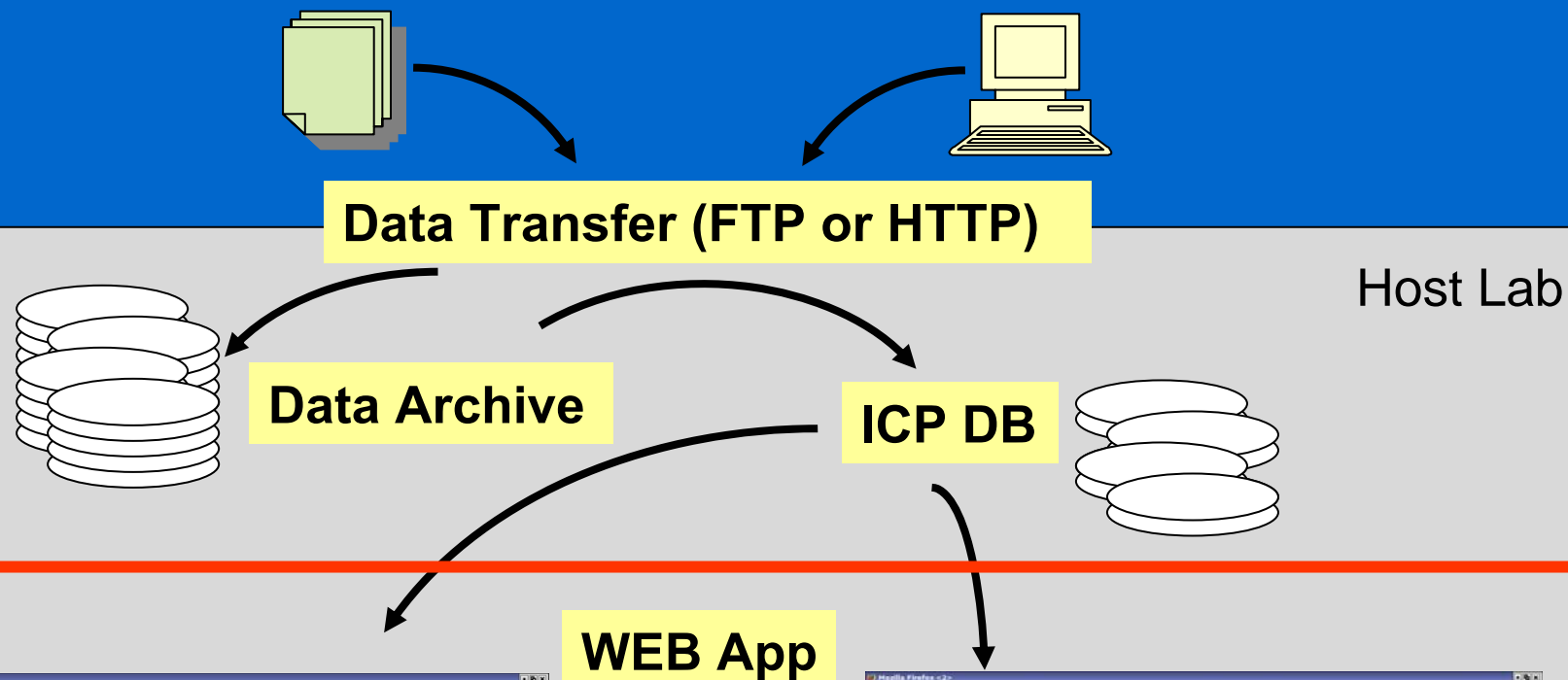
WEB App

Production

Interactive

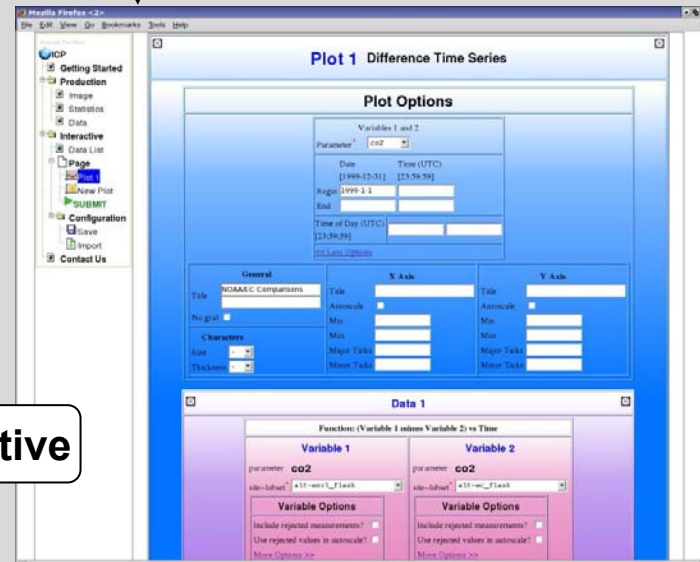


Interactive ICP Framework

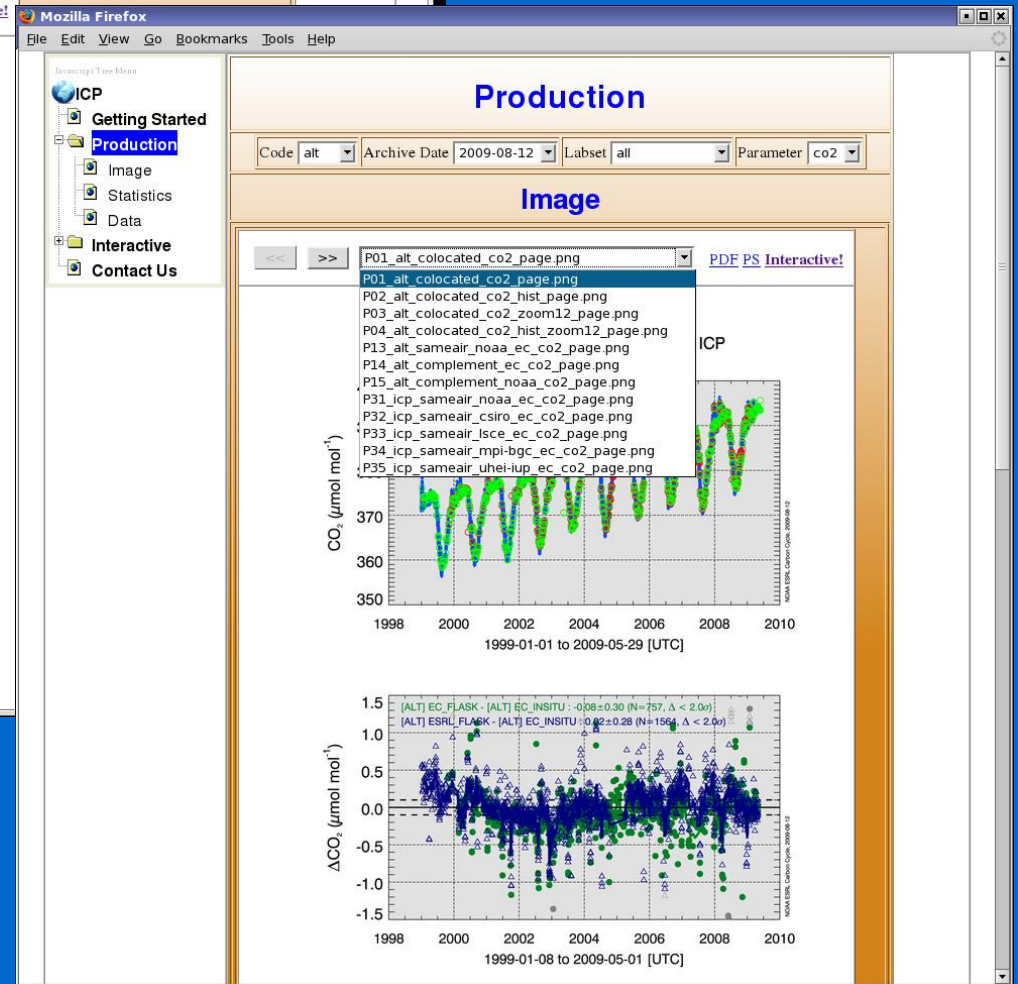
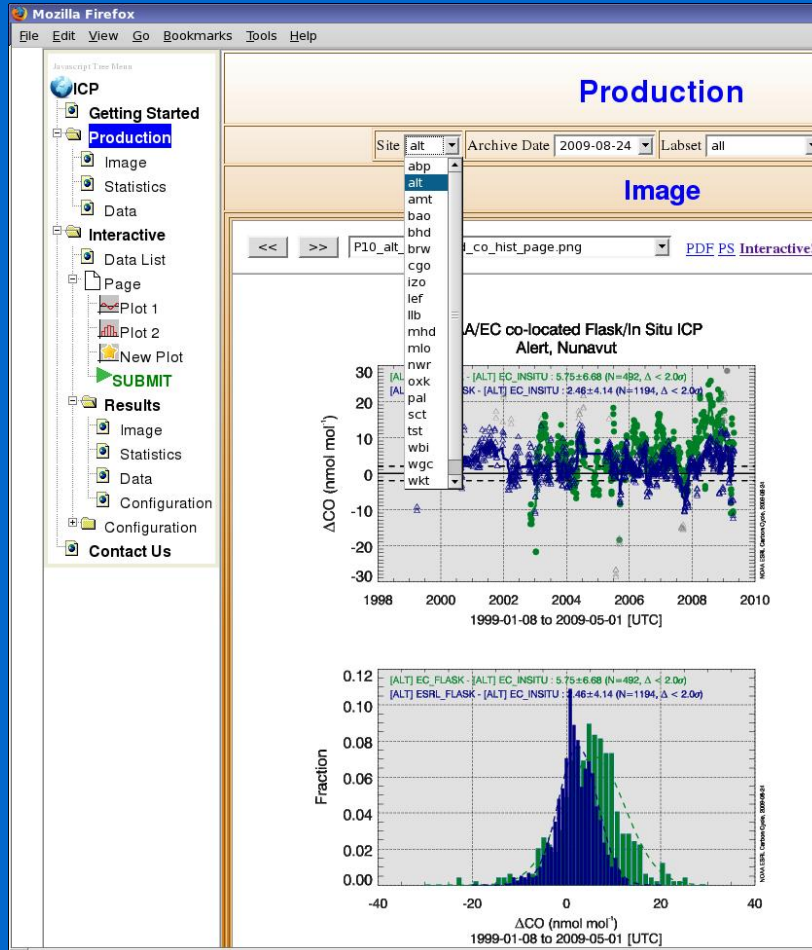


Production

Interactive



Production Images



EC data courtesy of D. Worthy

Production Statistics and Data

Mozilla Firefox

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Statistics

P31_p1d1_alt_co2_esrl_flask_alt_co2_ec_flask_same-air_matchsummary.txt

```
#####
# INPUT VARIABLE CONSTRAINTS
#
#                               Mon Aug 24 15:35:30 2009
#
# VARIABLE 1:
#   Parameter:                    CO2
#   Site:                          ALT
#   Lab Set:                        ESRL_FLASK
#
# VARIABLE 2:
#   Parameter:                    CO2
#   Site:                          ALT
#   Lab Set:                        EC_FLASK
#
#-----
# MATCH CONDITIONS
#                               Mon Aug 24 15:35:30 2009
#
# Match Type:                      ID
# Flask Comparison:                 ICP
# Time Window (hr):                49.0000
#
#-----
# MIXING RATIO DIFFERENCES
#                               Mon Aug 24 15:35:30 2009
#
# a = [ALT, CO2] ESRL_FLASK ICP
# b = [ALT, CO2] EC_FLASK ICP
# a minus b
#
# All Available
#
# YEAR      MEAN      STDEV      N
# 1999-2009 -0.0604   0.2275     742
# 1999      -0.2223   0.0580     13
# 2000      -0.0908   0.0514     60
# 2001      -0.0426   0.0860     46
# 2002      -0.0140   0.0594     89
# 2003      -0.0226   0.0750     88
# 2004      -0.0333   0.0865     73
# 2005      -0.0597   0.0939     76
# 2006       0.0129  0.0784     97
#-----
```

[Get Data](#)

[P31_p1d1_alt_co2_esrl_flask_alt_co2_ec_flask_same-air_matchdata.txt](#)

Mozilla Firefox <2>

File Edit View Go Bookmarks Tools Help

```
#####
# INPUT VARIABLE CONSTRAINTS
#
#                               Mon Aug 24 15:35:30 2009
#
# VARIABLE 1:
#   Parameter:                    CO2
#   Site:                          ALT
#   Lab Set:                        ESRL_FLASK
#
# VARIABLE 2:
#   Parameter:                    CO2
#   Site:                          ALT
#   Lab Set:                        EC_FLASK
#
#-----
# MATCH CONDITIONS
#                               Mon Aug 24 15:35:30 2009
#
# Match Type:                      ID
# Flask Comparison:                 ICP
# Time Window (hr):                49.0000
#
#-----
# MATCHED DATA
#                               Mon Aug 24 15:35:30 2009
#
# v1 = [ALT, CO2] ESRL_FLASK ICP
# v2 = [ALT, CO2] EC_FLASK ICP
#
# Vn      date/time      Id      value      unc      flg meth  mag1
# v1 1999 11 19 16 41 00 4825-91 370.430 -999.990 ..I P 10.0
# v2 1999 11 19 16 41 00 4825-91 370.720 -999.990 ..I P 10.0
# v1 1999 11 19 16 41 00 4826-91 370.440 -999.990 ..I P 10.0
# v2 1999 11 19 16 41 00 4826-91 370.670 -999.990 ..I P 10.0
# v1 1999 11 25 16 26 00 4842-98 370.620 -999.990 ..I P 10.0
# v2 1999 11 25 16 26 00 4842-98 370.860 -999.990 ..I P 10.0
# v1 1999 12 02 20 09 00 4835-98 370.260 -999.990 ..I P 10.0
# v2 1999 12 02 20 09 00 4835-98 370.470 -999.990 ..I P 10.0
# v1 1999 12 02 20 09 00 4836-98 370.280 -999.990 ..I P 10.0
# v2 1999 12 02 20 09 00 4836-98 370.540 -999.990 ..I P 10.0
# v1 1999 12 11 17 50 00 4843-98 371.620 -999.990 ..I P 10.0
# v2 1999 12 11 17 50 00 4843-98 371.880 -999.990 ..I P 10.0
# v1 1999 12 11 17 50 00 4844-98 371.570 -999.990 ..I P 10.0
# v2 1999 12 11 17 50 00 4844-98 371.790 -999.990 ..I P 10.0
# v1 1999 12 16 15 13 00 833-91 373.660 -999.990 ..I P 10.0
# v2 1999 12 16 15 13 00 833-91 373.850 -999.990 ..I P 10.0
# v1 1999 12 16 15 13 00 834-91 373.370 -999.990 ..I P 10.0
# v2 1999 12 16 15 13 00 834-91 373.570 -999.990 ..I P 10.0
# v1 1999 12 23 15 23 00 4833-91 373.460 -999.990 ..I P 10.0
# v2 1999 12 23 15 23 00 4833-91 373.710 -999.990 ..I P 10.0
# v1 1999 12 23 15 23 00 4834-91 373.420 -999.990 ..I P 10.0
# v2 1999 12 23 15 23 00 4834-91 373.700 -999.990 ..I P 10.0
# v1 1999 12 30 16 55 00 4845-98 373.750 -999.990 ..I P 10.0
# v2 1999 12 30 16 55 00 4845-98 373.810 -999.990 ..I P 10.0
# v1 1999 12 30 16 55 00 4846-98 373.680 -999.990 ..I P 10.0
```


ICP Between co-located In Situ Systems

Mozilla Firefox

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https://om.c...an/index.php https://om.cmdl.noaa.gov/index.php ESRL Global Monitoring Divisio... CO2 Expert Meeting 2009 (Untitled)

ICP

- Getting Started
- Production
 - Image
 - Statistics
 - Data
- Interactive
 - Data List
 - Page
 - Plot 1
 - New Plot
 - SUBMIT
 - Results
 - Image
 - Statistics
 - Data
 - Configuration
 - Configuration
 - Save
 - Import
 - Contact Us

Results - Image

[PS PDF](#)

NOAA co-located In Situ/In Situ ICP
Walnut Grove, California [91 mag]

ΔCO_2 ($\mu\text{mol mol}^{-1}$)

10 11 12 13 14 15 16 17 18

2009-03-10 to 2009-03-17 [UTC]

Results - Statistics

Text file:

```
-----  
# INPUT VARIABLE CONSTRAINTS  
#  
# Wed Sep 2 14:37:20 2009  
#  
# VARIABLE 1:  
# Parameter: CO2
```

Done om.cmdl.noaa.gov

ESRL data courtesy of A. Andrews

Multiple ICPs Between 2 Labs

Mozilla Firefox

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ICP

- Getting Started
- Production**
- Image
- Statistics
- Data
- Interactive
 - Data List
 - Page
 - Plot 1
 - Plot 2
 - New Plot
 - SUBMIT**
- Results
 - Image
 - Statistics
 - Data
 - Configuration
 - Configuration
 - Save
 - Import
- Contact Us

Production

Site: alt Archive Date: 2009-08-31 Labset: all Parameter: all

Image

P31_icp_sameair_noaa_ec_co2_page.png PDF PS Interactive!

NOAA/EC Comparisons

$[ALT] ESRL_FLASK - [ALT] EC_FLASK, ICP : -0.04 \pm 0.10 (N=722, \Delta < 2.0\sigma)$
 $[CEI] ESRL_FLASK - [CEI] EC_FLASK, ICP : 0.01 \pm 0.12 (N=75)$
 $[RR] ESRL_FLASK - [RR] EC_FLASK, ICP : 0.02 \pm 0.07 (N=3, \Delta < 2.0\sigma)$

Plotted by Analysis Date

ΔCO_2 ($\mu mol\ mol^{-1}$)

NOAA/ESRL Carbon Cycle, 2008-08-31

1998 2000 2002 2004 2006 2008 2010

1999-11-19 to 2009-05-05 [UTC]

Statistics

Results - Image

PS PDF

NOAA/EC co-located Flask/In Situ ICP Alert, Nunavut

NOAA/ESRL Carbon Cycle, 2008-09-02

MAR APR MAY JUN

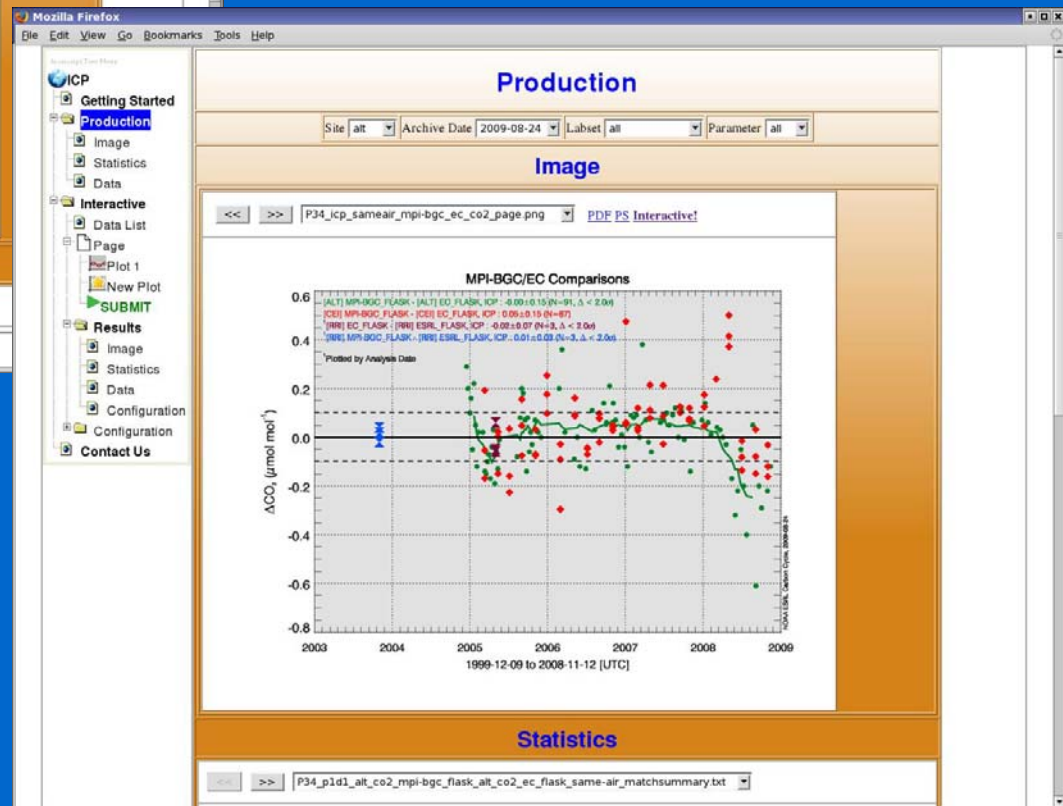
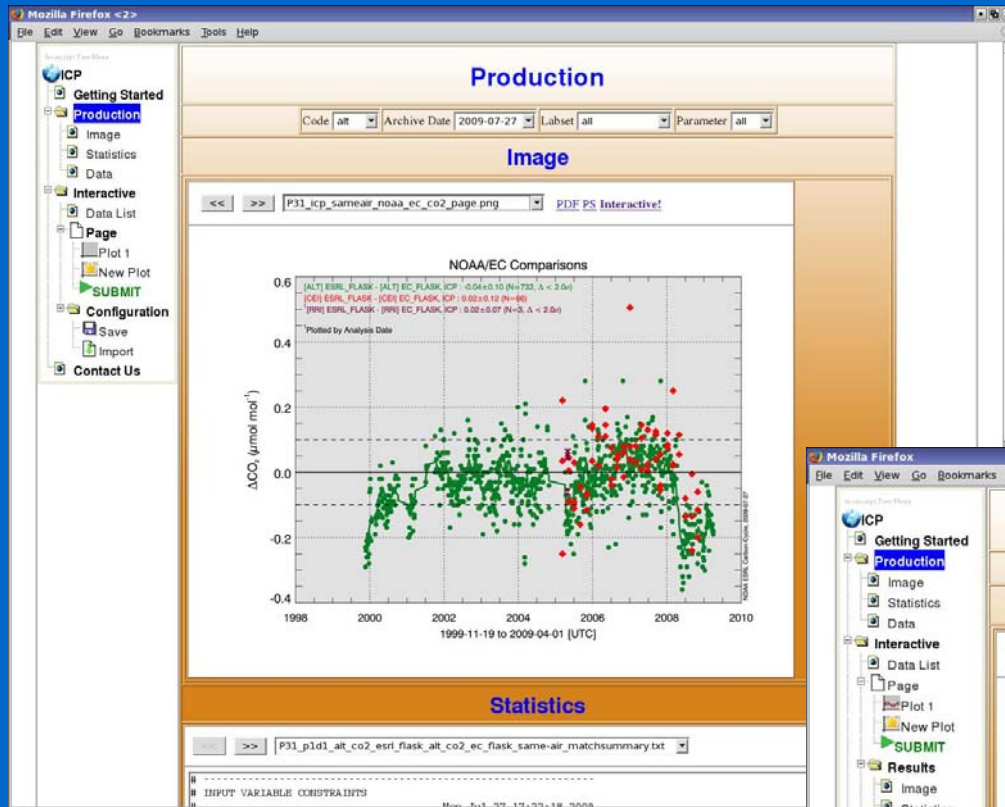
2009-03-01 to 2009-05-29 [UTC]

MAR APR MAY JUN

2009-03-06 to 2009-05-01 [UTC]

Results - Statistics

Multiple ICPs Among Multiple Labs



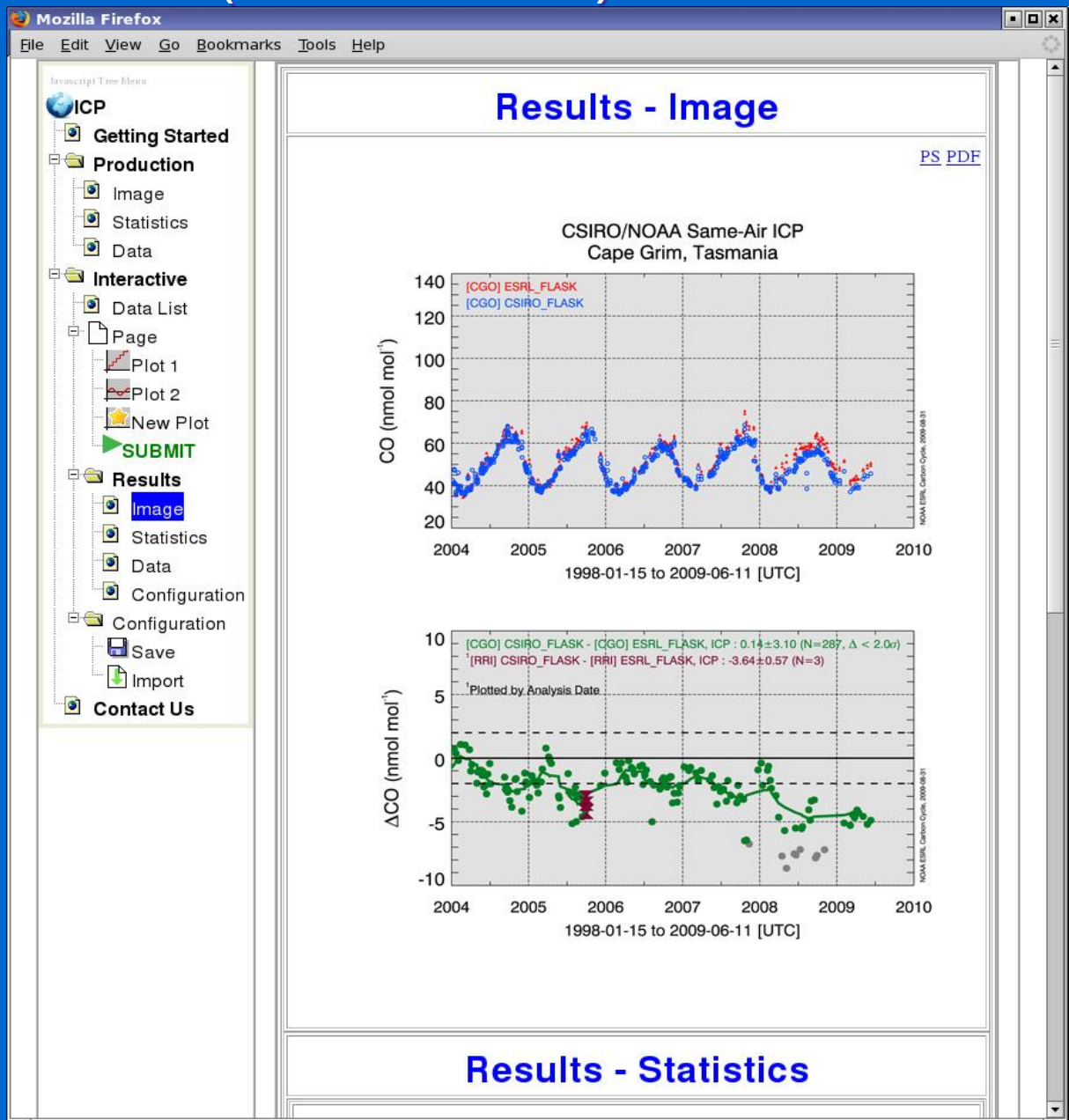
EC data courtesy of D. Worthy
MPI-BGC data courtesy of A. Jordan

“Production” to “Interactive”

The screenshot shows the 'Production' interface in Mozilla Firefox. The main content area displays a scatter plot titled 'NOAA/EC Comparisons' with the y-axis labeled ΔCO_2 ($\mu\text{mol mol}^{-1}$) and the x-axis showing dates from 1998 to 2008. A red circle highlights the 'Interactive' link in the top navigation bar. The left sidebar contains a menu with options like 'Getting Started', 'Production', 'Image', 'Statistics', 'Data', 'Interactive', 'Data List', 'Page', 'New Plot', 'SUBMIT', 'Configuration', 'Save', 'Import', and 'Contact Us'.

The screenshot shows the 'Plot 1 Difference Time Series' interactive configuration interface. It features a 'Plot Options' section with a 'Variables 1 and 2' dropdown set to 'co2'. Below this are fields for 'Date' [1999-12-31] and 'Time (UTC)' [23:59:59], along with 'Begin' and 'End' time pickers. A 'Time of Day (UTC)' field is also present. The interface is divided into three columns: 'General' (Title: NOAA/EC Comparisons, No grid, Characters: Size and Thickness), 'X Axis' (Title, Autoscale, Min, Max, Major Ticks, Minor Ticks), and 'Y Axis' (Title, Autoscale, Min, Max, Major Ticks, Minor Ticks). At the bottom, the 'Data 1' section shows 'Function: (Variable 1 minus Variable 2) vs Time' with two variable configuration blocks for 'co2' at sites 'alt-esr1_flask' and 'alt-ec_flask', each with 'Include rejected measurements?' and 'Use rejected values in autoscale?' checkboxes.

Example: A First Look (Production)



ESRL data courtesy of P. Novelli
CSIRO data courtesy of P. Krummel

A Closer Look (Interactive)

MOZILLA FIREFOX
File Edit View Go Bookmarks Tools Help
https://om.cmdl.noaa.gov/icp/index.php
Go

MAGICC-1

MAGICC-2

PS PDF

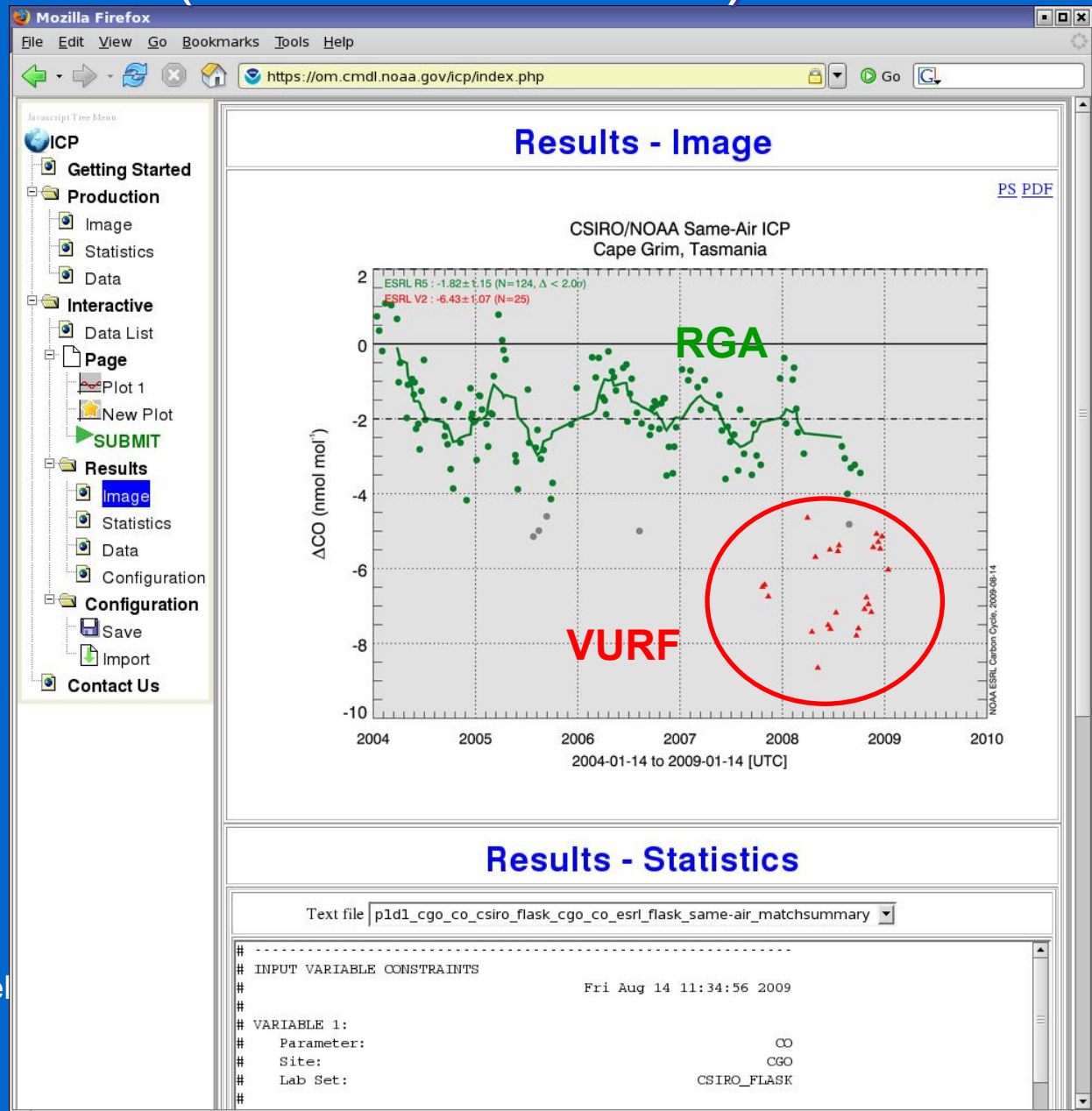
NOAA ESRL Carbon Cycle, 2009-08-14

#	Site:	CGO
#	Lab Set:	CSIRO_FLASK
#		



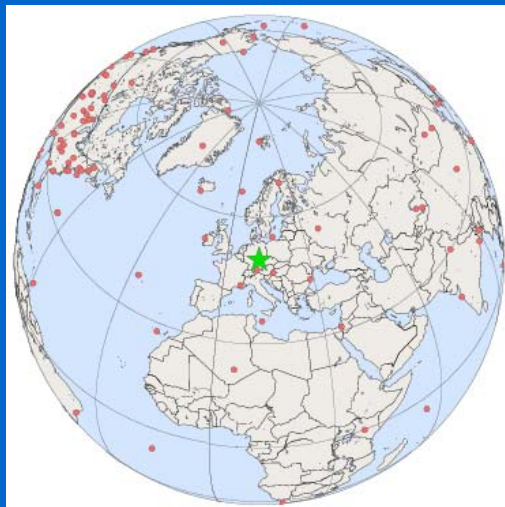
ESRL data
CSIRO data

NOAA CO Detection (RGA and VURF)



NOAA data courtesy of P. Novelli
CSIRO data courtesy of P. Krummel

MPI-BGC/NOAA ICP Results



NOAA data courtesy of P. Novelli
MPI-BGC data courtesy of A. Jordan

Mozilla Firefox
File Edit View Go Bookmarks Tools Help
https://om.cmdl.noaa.gov/icp/index.php

Results - Image

[PS PDF](#)

MPI-BGC/NOAA Same-Air ICP
Ochsenskopf, Germany

ESRL R5 : -2.05 ± 1.89 (N=71, $\Delta < 2.0\sigma$)
ESRL V2 : -2.23 ± 1.36 (N=35)

ΔCO (nmol mol⁻¹)

2004 2005 2006 2007 2008 2009 2010

2006-07-25 to 2009-04-01 [UTC]

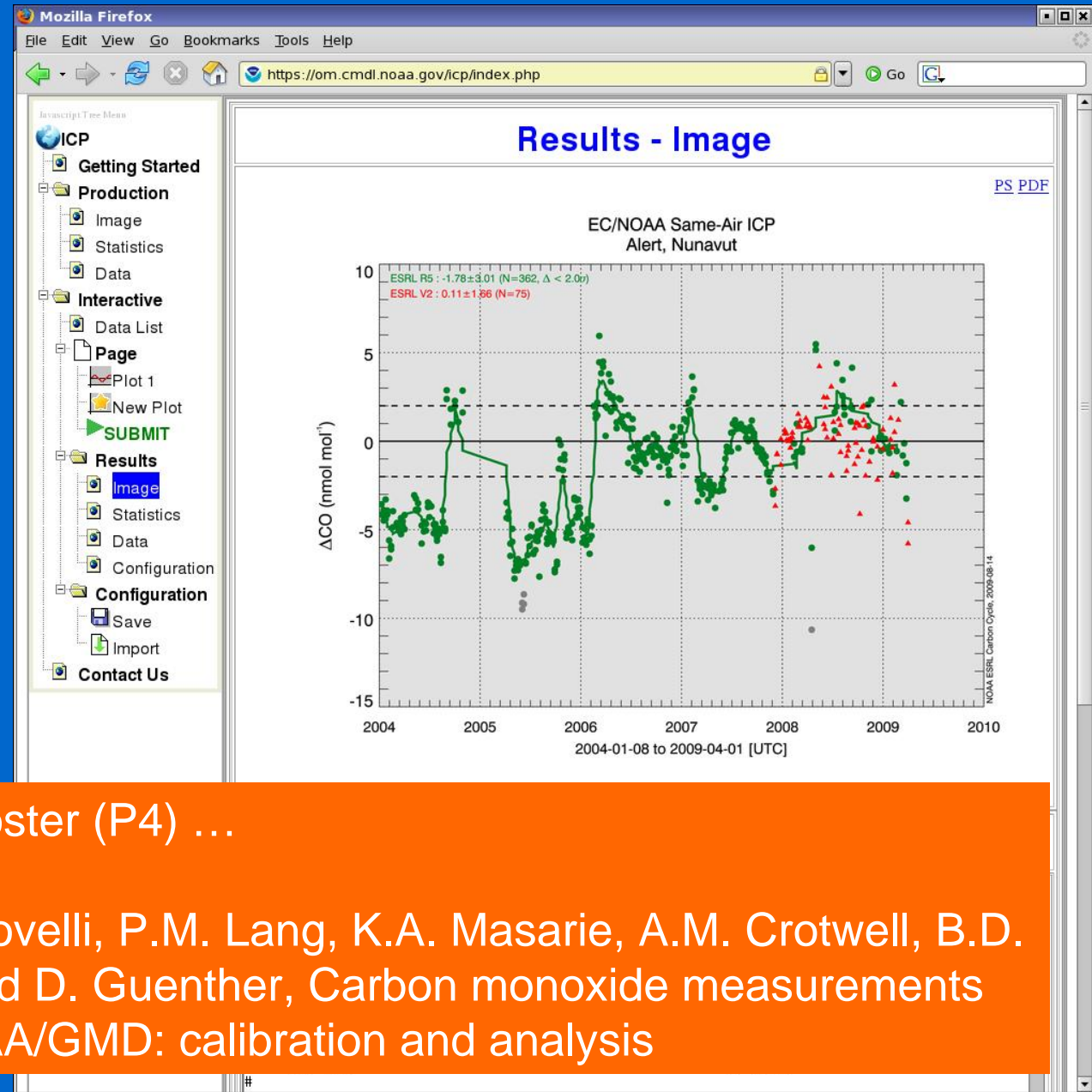
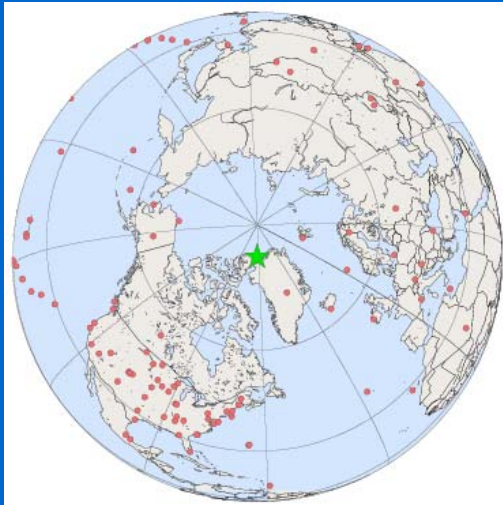
NOAA ESRL Carbon Cycle, 2009-08-14

Results - Statistics

Text file

```
#-----  
# INPUT VARIABLE CONSTRAINTS  
#  
#                               Fri Aug 14 11:58:13 2009  
#  
# VARIABLE 1:  
#   Parameter:                   CO  
#   Site:                         OXK  
#   Lab Set:                       MPI-BGC_FLASK  
#
```

EC/NOAA ICP Results



See Poster (P4) ...

NOAA data courtesy of
EC data courtesy of D.

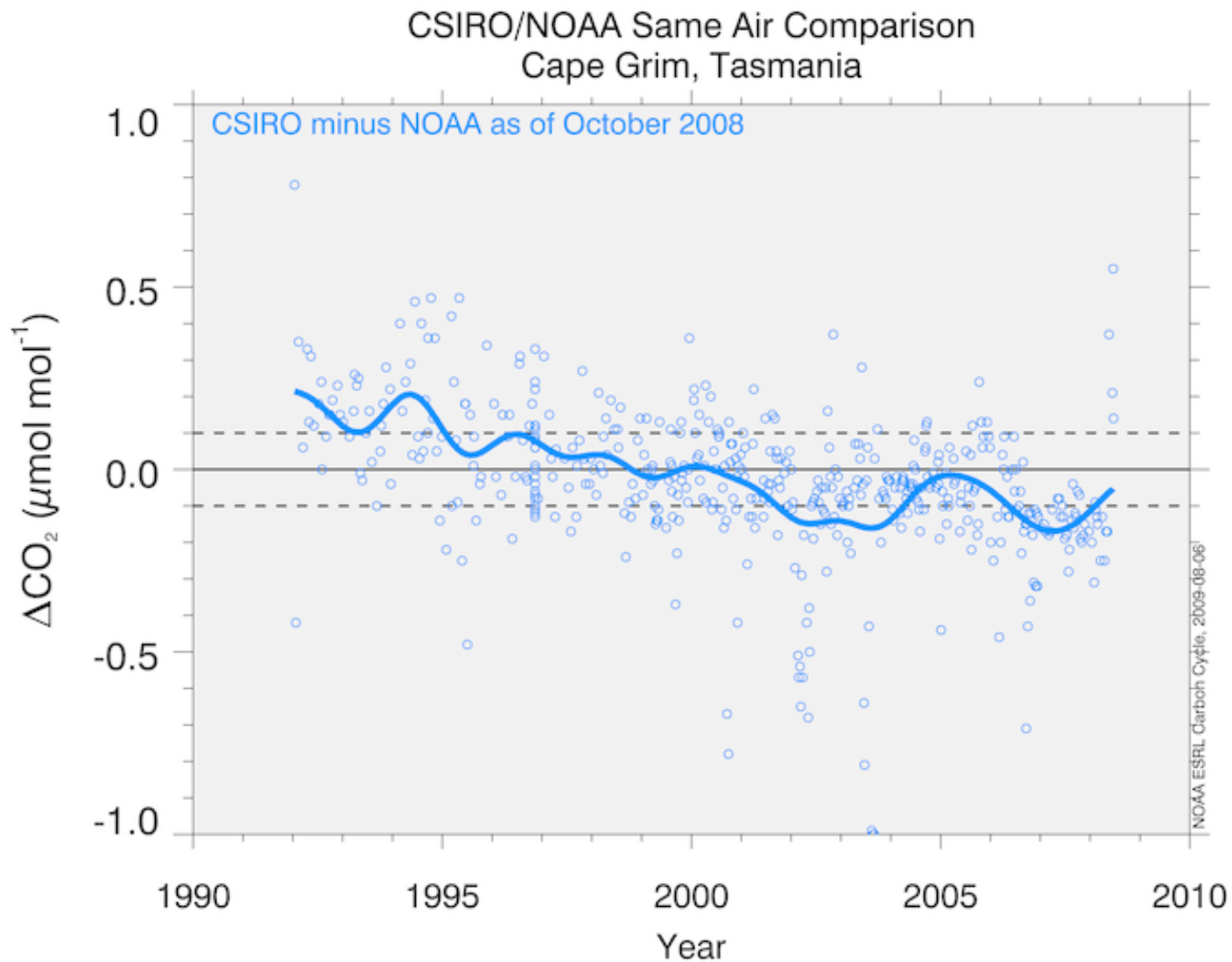
P.C. Novelli, P.M. Lang, K.A. Masarie, A.M. Crotwell, B.D. Hall and D. Guenther, Carbon monoxide measurements at NOAA/GMD: calibration and analysis

Direct Comparisons of Atmospheric Air

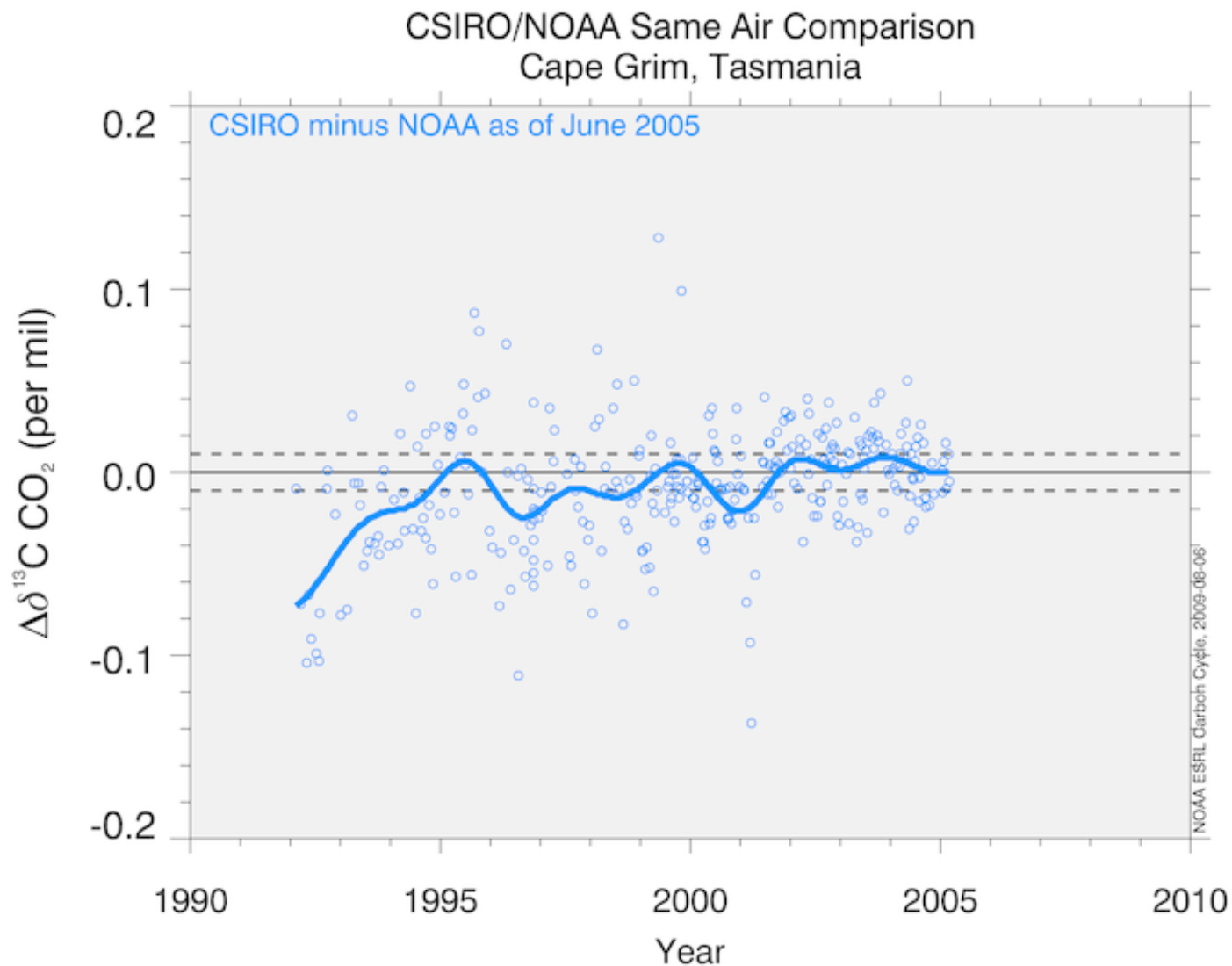
- ❖ **ICP results suggest a problem**
- ❖ **ICP tools help identify possible causes**
- ❖ **Return to lab to evaluate hypotheses using fundamental methods**
- ❖ **Correct experimental problem if confirmed within the lab**
- ❖ **Edit existing data if defensible**

→ **improved confidence in measurements**
→ **may or may not improve ICP results!**

ICP Results are Dynamic



ICP Results are Dynamic



Summary

- ❖ **Merging independent observations into cooperative data sets must be defensible**
- ❖ **Ongoing and direct comparisons of atmospheric air measurements are essential**
- ❖ **ICPs provide independent feedback on how we are doing**
- ❖ **ICPs motivate to identify and solve problem**
- ❖ **Complementary comparisons can help narrow possible causes of observed differences**
- ❖ **ICP application to help us manage and visualize comparison data from many ICP strategies between many labs**
- ❖ **Tool that will scale to a major (10-fold) increase in the number of ICPs**
- ❖ **Success completely depends on data availability and readability (self-documenting files?)**
- ❖ **Next steps?**

Thank You

Co-located Comparisons – WGC Tower

Intra-laboratory

