

Creating an unified airborne database from multi-aircraft field campaigns

Assessment of Tropospheric Airborne Measurements

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Motivation

- Advantages:
 - Large suite of simultaneous measurements, e.g., O₃ and its precursors, particle optical and chemical properties.
 - Good spatial (both vertical and horizontal) resolutions.
- Challenges:
 - Lack of standardized format and central archives.
 - Lack of adequate metadata describing variables, and other critical information.
 - Lack of well defined uncertainties.

Highlights of Recent Progress

- Tropospheric Airborne Measurement Panel (TAbMEP) was assembled for reviewing, certifying, and distributing analysis results.
- First TAbMEP meeting held in August, 2008 in Baltimore, MD focused discussion on ICARTT data intercomparison results for supporting the on-going **HTAP Experiment Set 3**.
- Data driven algorithms have been established and further refined to Independently assess the random uncertainty σ_R , when possible, as well as systematic uncertainty (bias).
- **Random uncertainty:** inherently unpredictable, cannot be removed, but magnitude may be reduced by averaging.
- **Systematic uncertainty:** bias of the measurement means, can be corrected through mathematical models.
- **Through intercomparisons, unified ICARTT data defined by the average of all measurements involved, except “outliers” or measurements with identified problems.**
- **Systematic uncertainty for individual measurement is practically defined as the difference from the unified measurement.**

Highlights of Recent Progress (cont.)

- Analysis algorithm requires all aircraft involved participate at least one intercomparison exercise.

For example: 4 ICARTT aircraft and 5 intercomparisons:

3 comparisons between NASA DC-8 and NOAA WP-3D.

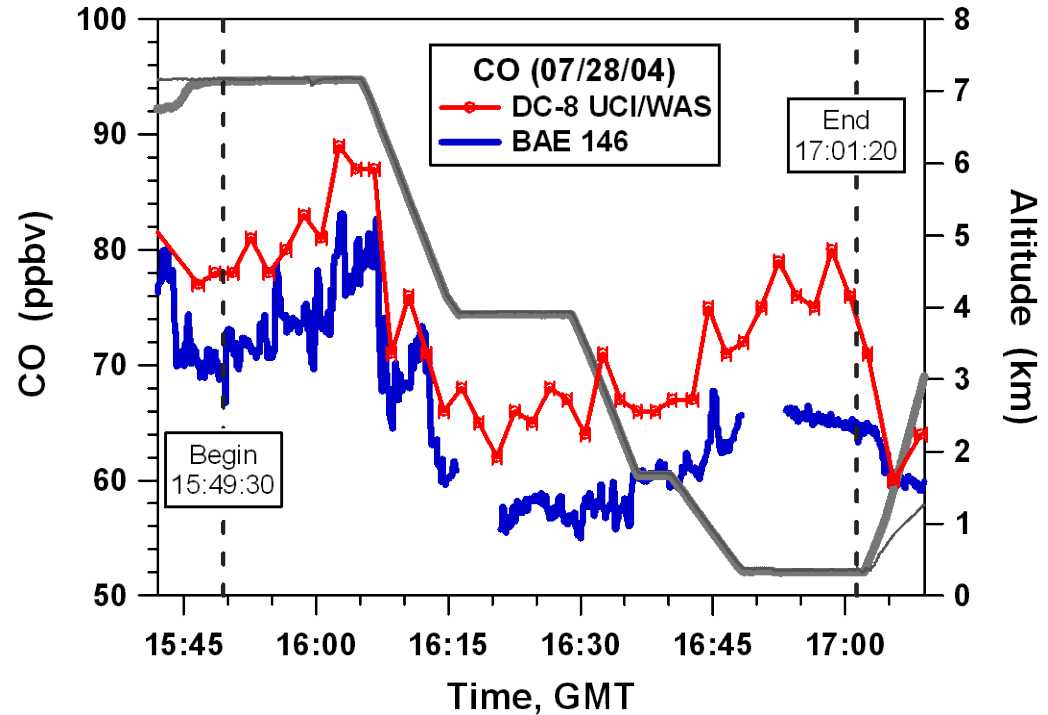
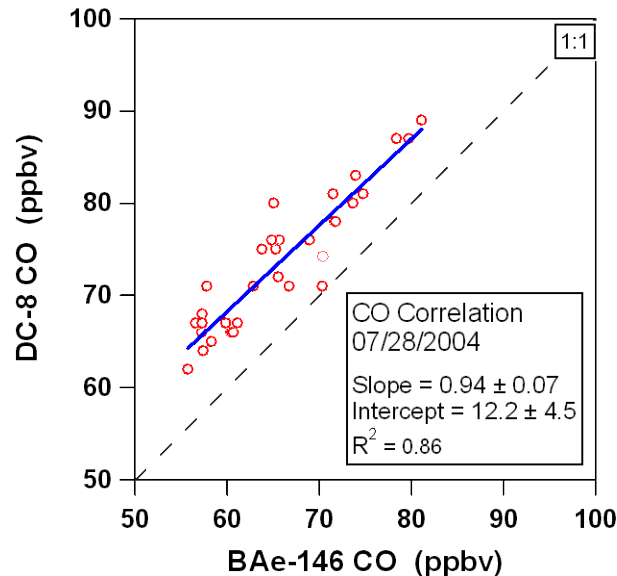
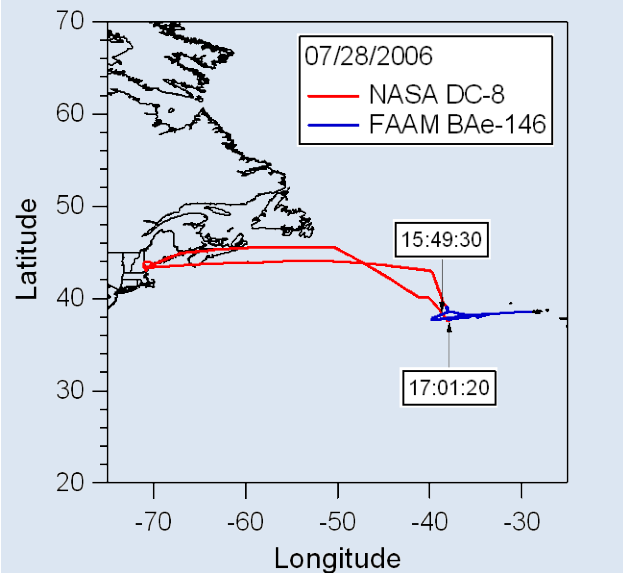
1 comparison between NASA DC-8 and FAAM BAe-146.

1 comparison between FAAM BAe-146 and DLR Falcon.

NASA DC-8 and FAAM BAe-146 were used as transferrable standard.

- ICARTT analysis near completion and panel report draft on-going.
- **Second TAbMEP meeting is scheduled in July with primary focus on review of the ICARTT assessment report and the POLARCAT intercomparison results. Much more aerosol measurement discussions.**
- Central archive development on schedule.
- Additional information: www-air.larc.nasa.gov

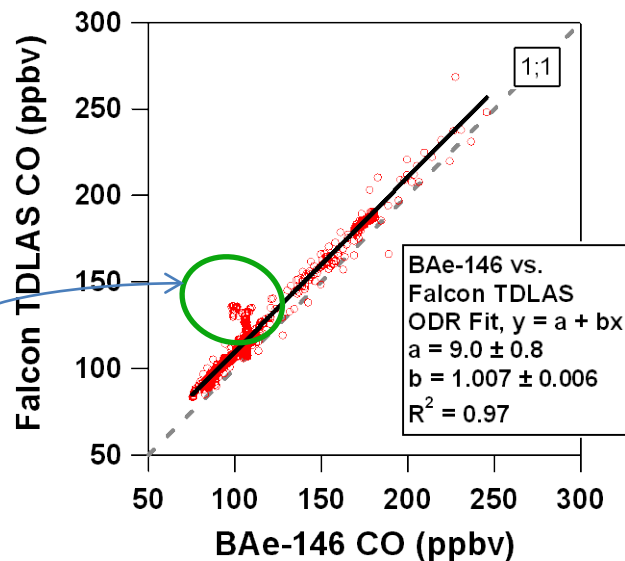
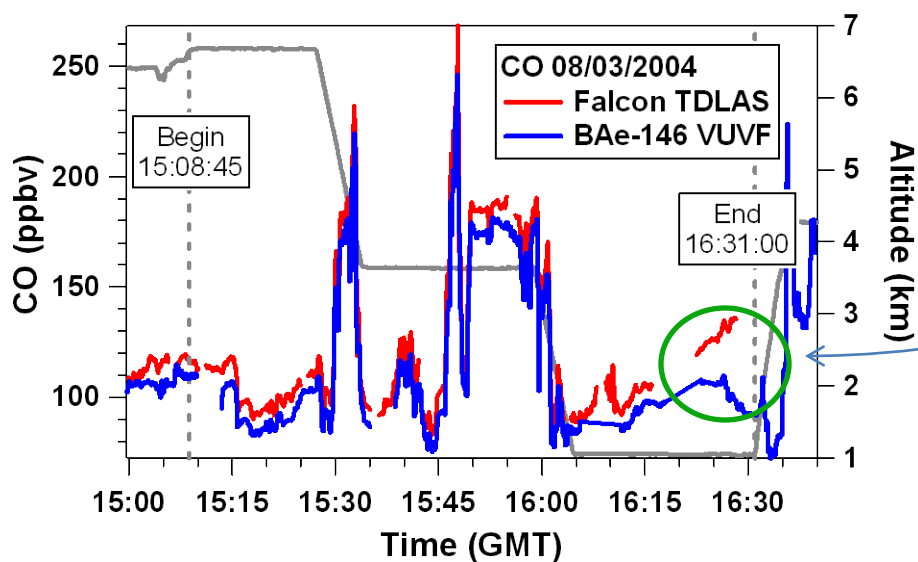
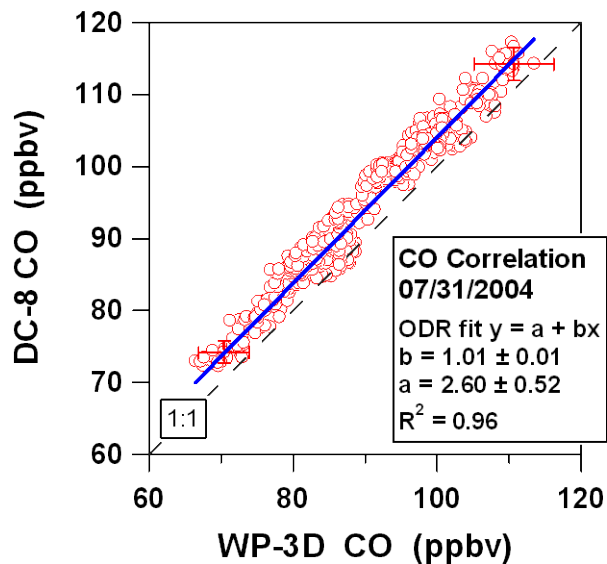
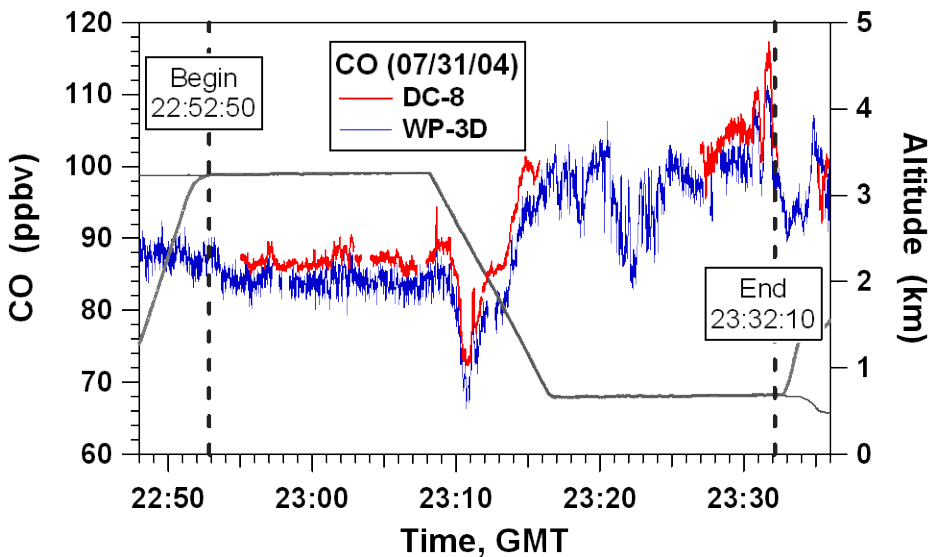
ICARTT CO Intercomparison DC-8 vs. BAe-146



ICARTT CO intercomparison involved 4 aircraft and 6 instruments.

- Coordinated wing-tip-to-wing tip intercomparison with distance between aircraft less than 200 m to ensure sampling the same air mass.
- Initial ICARTT results posted at: <http://www-air.larc.nasa.gov/missions/intexna/meas-comparison.htm>

ICARTT CO Intercomparison (Cont.)



Systematic Uncertainty (Bias) Assessment

- ICARTT CO Example -

Aircraft Platform	Instrument	Apparent Bias (ppbv)	Best Estimate Bias (ppbv)
NASA DC-8	DACOM	0	+0.49
NASA DC-8	WAS	+0.67	+1.16
NOAA WP-3D	VUVF	- 1.48	- 0.96
FAAM BAe-146	VUVF	- 6.97*	- 6.48
DLR Falcon	VUVF	- 1.16	- 0.67
DLR Falcon	TDLAS	Not assessed	Not assessed

* Outlier, not included in the average

– **Apparent bias = Measurement – Reference Measurement**

Reference can be arbitrarily selected. DC-8 DACOM was chosen here for convenience.

- The unified measurement is defined by the average of all measurements, except the outlier. The apparent bias values are averaged and:

Best Estimated Bias = Apparent Bias – Average bias, average bias = 0.49 ppbv.

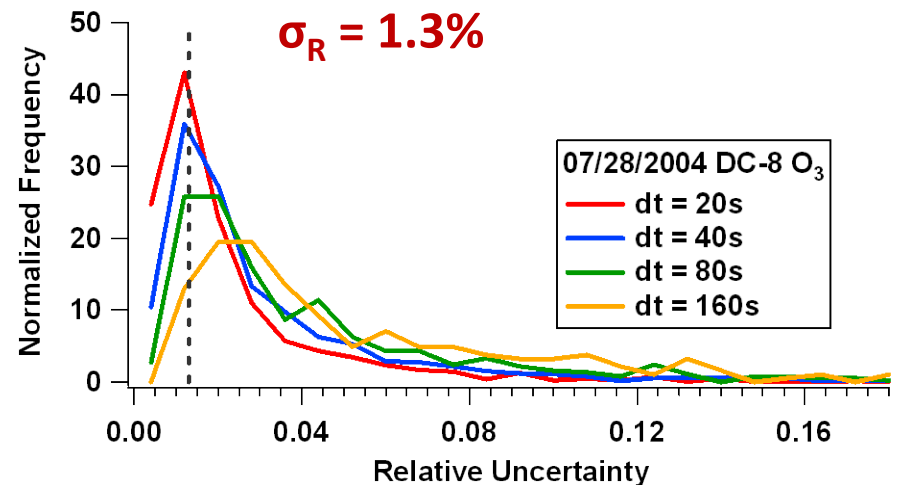
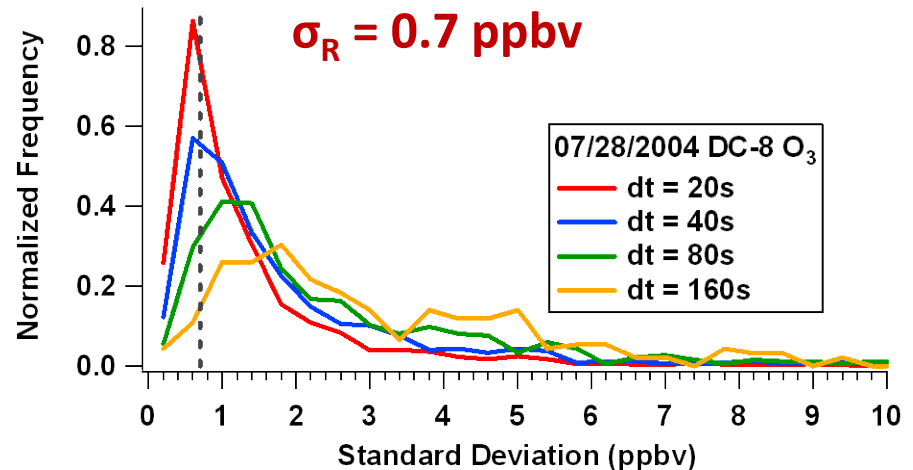
- In some other cases, the bias is a function of the measured values or some other variables.

Random Uncertainty (σ_R) Assessment

Random uncertainty = inherently unpredictable uncertainties, that can not be corrected.

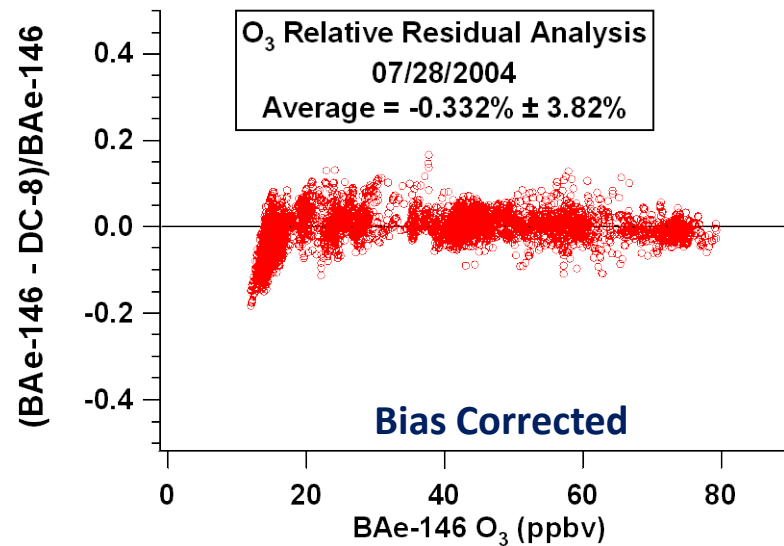
Internal Estimate of Instrument Precision (IEIP) analysis:

- Assuming the ambient variability was sufficiently small over a short time period, Δt , so that the observed variability mostly due to instrument precision.
- Advantage: Data driven and objective.
- Limitations: difficult to apply to intermittent or slow measurements. This method cannot detect the instrument variability at much larger time scale.

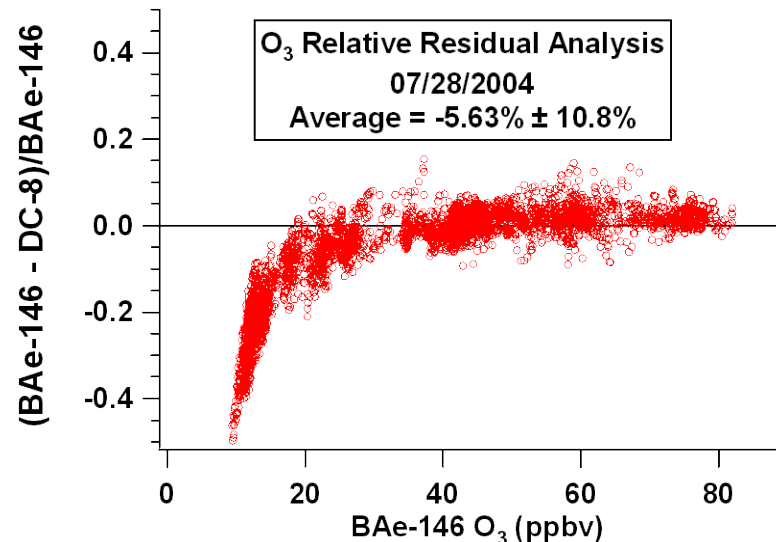


Random Uncertainty (σ_R) Assessment (cont.)

- IEIP analysis may not account for some uncertainties with longer time scales, e.g., uncorrelated changes in zero levels or instrument sensitivities.
- Comparison of expected variability with the observed variability provides further adjustments necessary to account for additional uncertainties.
- The observed variability is evaluated after correcting the bias between the paired measurements.



- **IEIP Assessed precisions:**
 $\sigma_R(\text{DC-8}) = 2.4\%$ and $\sigma_R(\text{BAe-146}) = 2.8\%$
- **Expected relative residual SD = 3.68%**
- **Adjusted Precisions: 2.5% and 2.9%.**



Example: Uncertainty Recommendation for ICARTT CO Measurements

Aircraft	Instrument	Reported Uncertainty	Assessed σ_R (2σ)	Assessed Bias (pptv)	Recommended Uncertainty (2σ)
NASA DC-8	DACOM	2% or 2 ppbv	2%	+0.5	2% or 2 ppbv
NASA DC-8	WAS	5%	11%	+1.2	$((0.11 \text{ CO})^2 + 1.4)^{1/2}$ ppbv
NOAA WP-3D	VUVF	5%	3.6%	-1.0	5%
FAAM BAe-146	VUVF	None	3.2%	-6.5	$((0.032 \text{ CO})^2 + 42)^{1/2}$ ppbv
DLR Falcon	VUVF	10%	3.2%	-0.7	10%
DLR Falcon	TDLAS	5%	6.8%	Not assessed	>6.8% ^b

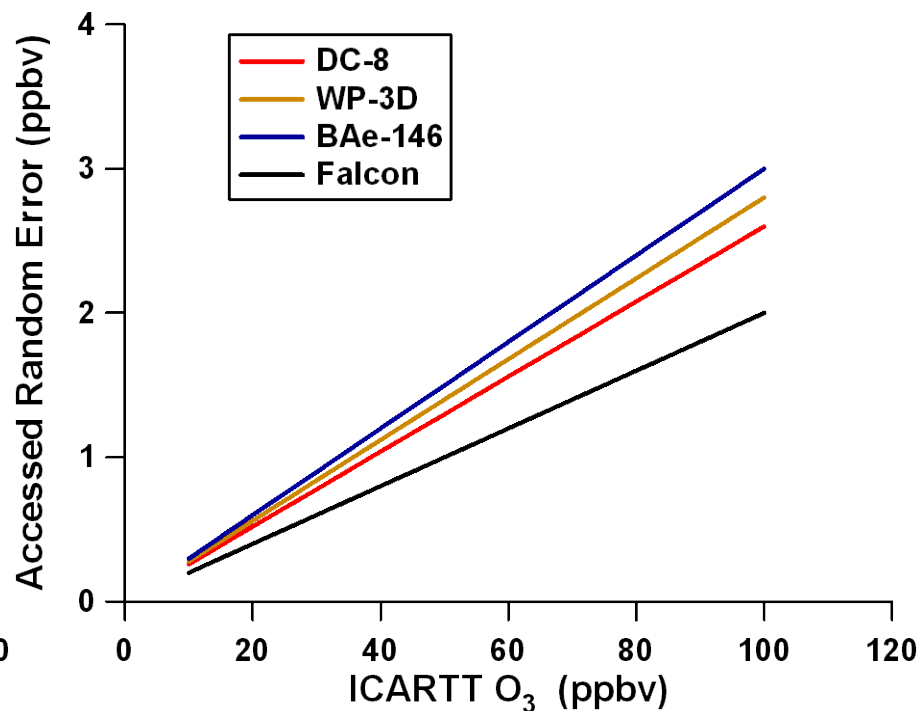
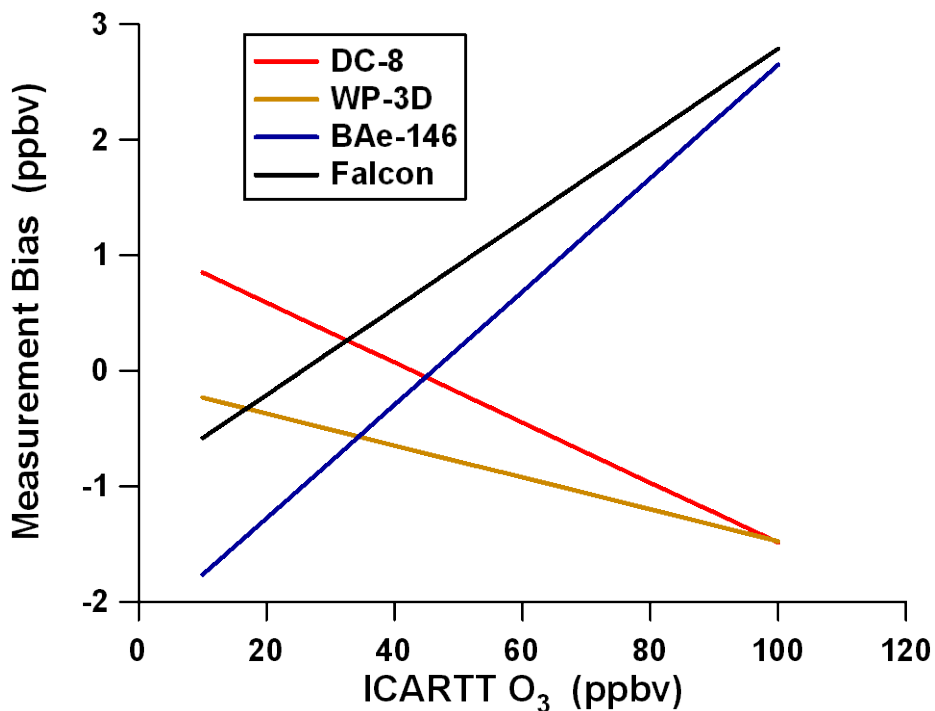
Assessed Bias = Measurement (e.g., DACOM, WAS) – Unified ICARTT CO

Example: Uncertainty Recommendation for ICARTT O₃ Measurements

Aircraft	Instrument	Reported Uncertainty	Assessed σ_R (1σ)	Assessed Bias (ppbv)	Recommended Uncertainty (2σ)
NASA DC-8	NO CLD	3% or 3 ppbv	1.3%	$1.11 - 0.0260 O_{3-DC8}$	3% or 3 ppbv
NOAA WP-3D	NO CLD	0.1 ppbv + 3%	1.4%	$-0.0965 - 0.0138 O_{3-WP3D}$	0.1 ppbv + 3%
FAAM BAe-146	TECO UVP	None	1.5%	$-2.26 + 0.0491 O_{3-BAe146}$	$\{(-0.0491 O_3 + 2.26)^2 + (0.03 O_3)^2\}^{1/2}$ ppbv
DLR Falcon	TECO UVP	5%	1.0%	$-0.959 + 0.0375 O_{3-Falcon}$	2 ppbv ^b or 5%

Assessed Bias = Measurement (e.g., NO CLD) – Unified ICARTT O₃

Example: 2σ Uncertainty Recommendation for ICARTT O₃ Measurements (cont.)



Example: Uncertainty Recommendation for POLARCAT CO Measurements

Aircraft	Instrument	Reported Uncertainty (1σ)	Assessed σ_R (1σ)	Assessed Bias (ppbv)	Recommended Uncertainty (2σ)
NASA DC-8	DACOM	2% or 2 ppbv	0.8%	-0.31	2% or 2 ppbv
NASA P3-B	VUVF	3%	9.6%	-0.97	10%
NOAA WP-3D	VUVF	3%	1.5%	0.95	$(1 + (0.03 \text{ CO})^2)^{1/2}$ ppbv
DLR Falcon	VUVF	10%	2.1%	-4.09	$(4.1^2 + (0.042 \text{ CO})^2)^{1/2}$ ppbv
ATR-42	VUVF	Not Given	4.3%	0.97	$(1 + (0.086 \text{ CO})^2)^{1/2}$ ppbv

Assessed Bias = Measurement (e.g., DACOM,) – Unified POLACAT CO

Looking forward:

- Unified ICARTT data will be released before the end of 2009 in NetCDF format, with TAbMEP certified uncertainty assessment.
- POLARCAT uncertainty assessment and data are scheduled release after July 2010.
- Hope to work with modeling communities to reconcile the model and observation differences and to gain better understanding of the processes.
- Comments, suggestions, requests?
- Additional information available: www-air.larc.nasa.gov
- Feel free to contact me for in-situ data questions
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