ARCTAS Measurement Comparison Strategy

Hanwant Singh, Gao Chen, William Brune

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Introduction

Frequent comparisons between instruments that measure the same atmospheric constituents are essential for producing the highest quality data for complex field studies, like ARCTAS, which involve multiple investigators and multiple aircraft. The overarching goal is to ensure that the measurements on different platforms are consistent, making it possible to use the data taken from multiple platforms as one in scientific analyses. In practice, these comparisons often help the investigators produce the highest quality data possible by revealing instrument operation and/or calibration issues, which the investigators can then resolve, sometimes during the field study.

A number of instruments have been used for several field campaigns over the years (e.g. NASA INTEX-NA, INTEX-B, NOAA NEAQS 2004, and NSF MILAGRO and IMPEX). Because instrument investigators modify their instruments over time and some instrument components must be replaced, comparisons provide information about the consistency of the instrument calibrations as the instruments are changed. Thus, comparisons provide information on measurement consistency across time (i.e., several field campaigns) as well as across platforms. The ARCTAS comparisons are an important next link in this comparison heritage.

The ARCTAS Measurement Comparison Group (MCG), consisting of Hanwant Singh, Bill Brune, and Gao Chen, has been given the responsibility of organizing the ARCTAS comparisons. After consulting with project science management and the ARCTAS science team, the MCG has adopted the same measurement comparison protocol as the one used successfully during INTEX-NA and INTEX-B.

All measurements that are duplicated on the DC-8 and other aircraft are included in this protocol. The field data comparison of these duplicate measurements will be “blind”. Within 24 hours after each flight, investigators will, without knowledge of the other measurements, submit their data, which will be directed to a restricted data depository that is accessible only by the MCG. This protocol does not apply to measurements that are not duplicated. Once all of the duplicate measurements for an atmospheric constituent are in the depository, those measurements will be released immediately to the ARCTAS archive. Duplicated measurements, especially those critical to flight planning, should be accessible to the entire ARCTAS science team within 48 hours after each flight. Some exceptions to this procedure may be made if a submission of a duplicate measurement is delayed and the other duplicate measurement is needed for flight planning. This exception mostly applies to comparisons of measurements from separate platforms.

Comparisons of measurements will be “blind” only for the field data phase and will not be blind for the preliminary and final data submission phases. However, any changes that the investigators make during or after the field campaign must be accompanied by an explanation of the changes. This explanation should be submitted to the MCG as well as noted in the data submission header. To aid the post-campaign analysis of the comparisons, all duplicate measurements, from the initial field submission to final data submission, will be saved along with the explanations of changes.

The MCG encourages the ARCTAS investigators to engage in informal comparison activities before, during, and after the field campaign, including the following:

- Exchange of calibration standards
- Ground based instrument comparisons
- Comparisons with models
- Open discussion of test flight data, which is not under the ARCTAS comparison protocol control.

ARCTAS Measurement Comparison Protocol

Comparison of measurements made on the NASA DC-8

- The real-time measurements to be compared are listed in the following table.

Measurement	instrument	Instrument	Frequency	time for data submission
OH and HO_2	Penn State ATHOS	NCAR CIMS	every flight	24 hours (48 hrs initially)
NO_2	Berkeley TD-LIF	NCAR CLD[1]	every flight	24 hours
HNO_4	CIT CIMS	GIT CIMS	every flight	24 hours
HNO_3	CIT CIMS	UNH SAGA Berkeley TD-LIF	every flight	24 hours
OVOCs[2]	NCAR TOGA	HS-PTR-MS UCI WAS[3]	every flight	48 hours
$SO_4^{=}$ (< 1 μm)	UNH SAGA GIT PILs	UColorado AMS	every flight	48 hours

1: CLD = Chemiluminescence Detector
2: In OVOC field data comparison will be focused on 4 species: acetone, acetaldehyde, methanol, and acetonitrile.
3: UCI WAS data will only be available for post mission comparison.

- The referee for comparisons of DC-8 measurements is Hanwant Singh.
- The field data comparison will be "blind". The compared field data will be released into the archive for everyone to use after both sets of data are submitted.
- Other measurements are sent directly to the archive.
- The protocol applies for all flights.
- The intra-platform lead will discuss preliminary findings with PIs to help resolve obvious problems
- Investigators will give the explanations for any changes to the previously submitted data that occur either later in the mission or post mission.

Comparison of measurements made from different platforms

- Inter-Platform comparison lead: Bill Brune
- Comparisons should be made early and as often as is feasible.
- Every effort should be made to include the time, usually about an hour, for comparisons in the flight planning.
- The comparison at field data phase is "blind", i.e., intercomparison data will not be released to science team until paired comparison data is submitted or the data is requested by science management for flight planning purposes.
- Inter-platform lead will discuss preliminary findings with PIs to help resolve obvious problems.
- Comparison of final data will not be blind.
- Potential comparison opportunities are presented in the following tables.

Table A. Proposed Measurement Comparison Variable List - Gas Phase Species

Measurement	NASA DC-8	NASA P-3B	NOAA WP-3D	NSF HIPPO	DOE/CNRC CV-580
O_3	CLD, Weinheimer	TECO, Clarke	CLD., Ryerson	NOAA/UCATS/UV	
CO	DACOM, Diskin	COBALT, Podolske	UV- Fluorescence, Holloway Flasks, Montzka	Harvard/QCLS, NOAA/GC-ECD, Miami/WAS, & VUV	
H_2O	DLH, Diskin	Cryo, Barrick	TD-Laser Absorption and chilled mirror hygrometers, facility instruments	NOAA/TDL CU/CLH	LICOR LIC2G2, Wolde CR-2 Chilled Mirror, Strapp & Hubbe
NO	CLD, Weinheimer		CLD, Ryerson	NCAR/HAIS	
NO_2	UV-CLD, Weinheimer TD-LIF, Cohen		UV-CLD, Ryerson		
NO_y	CLD, Weinheimer		CLD, Ryerson	NCAR/HAIS	
PANs	CIMS, Huey		CIMS, Roberts	NOAA/PANTHER/GC	
SO_2	CIMS, Huey SAGA, Dibb		UV- Fluorescence, Holloway CIMS, Nowak		
CO_2	AVOCET, Vay		IR-Absorption, Ryerson Flasks, Montzka	Harvard/QCLS & IGRA NCAR/MEDUSA flask	LICOR LIC2G2, Wolde
CH_4	DACOM, Diskin		Flasks, Montzka	Harvard/QCLS NOAA/UCATS/GC-ECD	
N_2O	DACOM, Diskin		Flasks, Montzka	Harvard/QCLS NOAA/GC-ECD	
VOCs & OVOCs	PTRMS, Wisthaler TOGA, Apel & WAS, Blake		PTRMS, de Gouw Flasks, Montzka	Miami/WAS	
Halocarbons	WAS, Blake		Flasks, Montzka	Miami/WAS NOAA/NWAS	
Halogens	CIMS, Huey		CIMS, Neuman		

Note: 1) Comparison with WAS and/or Flasks data will not be conducted on field data. 2) Field data comparison of OVOC will be focused on acetone, acetaldehyde, methanol, and acetonitrile. 3) CLD = chemiluminescence detector

Table B. Proposed Measurement Comparison Variable List - Particle Microphysical and Optical Properties

Measurement	NASA DC-8	NASA P-3B	NOAA WP-3D	NSF HIPPO	DOE/CNRC CV-580
Ntotal	CPC (>3 nm), Anderson	CPC (>3 nm), Clarke	CPC (>4 nm), Brock		TSI 3775 (> 4 nm), Liu
CN_cold	CPC (>10 nm), Anderson	CPC (>10 nm), Clarke	CPC (>8 nm), Brock		TSI 7610 (> 11 nm), Liu
CN_hot	CPC (>10 nm), Anderson	CPC (>10 nm), Clarke			
N_{Fine} (120 - 800 nm)	UHSAS, Anderson	OPC, Clarke	UHSAS, Brock		UHSAS, Liu
S_{Fine} (120 - 800 nm)					
V_{Fine} (120 - 800 nm)					
N_{coarse} (1 - 10 µm)	APS, Anderson	APS, Clarke	WLOPC, Brock		PCASP, Liu
S_{coarse} (1 - 10 µm)					
V_{coarse} (1 - 10 µm)					
CCN	CCN Counter, Nenes	CCN Counter, Nenes	CCN Counter, Nenes		CCN Counter, Laskin
Size Distribution*	SMPS, UHSAS, OPC & APS, Anderson	DMA, OPC, & APS Clarke	5 CPCs, UHSAS & WLOPC, Brock		
Scattering (3-λ)	Nephelometer, Anderson	Nephelometer, Clarke AERO3X, Strawa	Derived, Brock		Nephelometer, Hubbe, Ogren, & Liu
Absorption (3-λ)	PSAP, Anderson	PSAP, Clarke & AERO3X, Strawa	PSAP, Lack CRD-AES, Lack		PSAP, Liu & Ogren Photo-acoustic Spectrometer, Dubey
f(RH)*	Humidified Neph., Anderson	Humidified Neph., Clarke Humidified Neph, Strawa	Humidified CRD-AES, Lack		
Black Carbon	SP2, Kondo/Zhao	SP2, Clarke Aethalometer, Strawa	SP2, Gao	NOAA SP2	

Cloud Properties*	CAS & CIP, Anderson		CAS & CIP, Brock		CAPS, McFarquhar & Lawson CIP, Strapp

*** Comparison of particle size distribution and cloud properties will not be conducted on field data.**

Recommended Conditions for Particle Microphysical and Optical Measurement Comparisons:

- **STP condition definition: 273.15K and 1013 mb.**
- **The CPC saturator ΔT will be set at 22 degrees for NASA DC-8 and P-3B.**
- **The temperature for Hot_CN will be set at 350 °C.**
- **For comparisons of integrate N, S, and V, the size range for fine particle is defined between 0.12 and 0.8 µm, calibrated by $(NH_4)NO_3$ particles.**
- **Coast particle comparison will be based on APS and OPC measurement between 1 and 10 µm. The APS size will be calculated using density of 2.24 and shape factor of 1.1 (assuming sea salt particles).**
- **Scattering Coefficient Comparison:**
  - **Comparison between P-3B and DC-8: Total scattering for 3 wavelengths with no truncation correction applied.**
  - **Comparison with WP-3D: submicron scattering at 532 nm.**
- **Absorption Coefficient Comparison:**
  - **For DC-8 and P3-B, comparison will be conducted on direct PSAP readings under low RH with no correction procedures applied. PIs will determine reporting time interval as suitable for the ambient conditions; while estimated LOD value for the integration time should be reported in the data file header.**
  - **Comparison with WP-3D: submicron absorption only.**
  - **For CRD comparison: data should be fully processed for 532 and 1064 nm, RH = 10 - 20%.**
- **SP2 data analysis may require extra time. But the target is to turn in the intercomparison period within 48 hours.**

- **CCN comparison will be conducted at a nominal super-saturation level of 0.4%. This level may be subject to change according to the actual comparison conditions (e.g., different types of particles); however, any change will require a prior consensus between the PIs involved .**

Table C. Proposed Measurement Comparison Variable List - Particle Chemical Compositions

<table>
<tr><th>Measurement</th><th>NASA DC-8</th><th>NASA P-3B</th><th>NOAA WP-3D</th><th>NSF HIPPO</th><th>DOE/CNRC CV-580</th></tr>
<tr><td>$SO_4^{=}$</td><td rowspan="4">SAGA Sulfate, Dibb
PILs, Weber
AMS, Jimenez</td><td rowspan="4">AMS, Clarke</td><td rowspan="4">PILs, de Gouw and Quinn
AMS, Middlebrook</td><td></td><td></td></tr>
<tr><td>NO_3^-</td><td></td><td></td></tr>
<tr><td>Cl^-</td><td></td><td></td></tr>
<tr><td>NH_4^+</td><td></td><td></td></tr>
<tr><td>K^+</td><td rowspan="4">PILs, Weber</td><td></td><td rowspan="4">PILs, de Gouw and Quinn</td><td></td><td></td></tr>
<tr><td>Na^+</td><td></td><td></td><td></td></tr>
<tr><td>Ca^{++}</td><td></td><td></td><td></td></tr>
<tr><td>Mg^{++}</td><td></td><td></td><td></td></tr>
<tr><td>Organics</td><td>PILs (WSOC), Weber
AMS, Jimenez</td><td>AMS, Clarke</td><td>AMS, Middlebrook</td><td></td><td></td></tr>
</table>

Note: 1) PILs and AMS will have a turn-around time of <48 hours for data collected during the intercomparison period.
2) Due to different nature of the instruments, PILs will not be directly compared against AMS for Cl^- measurement.

Table D. Proposed Measurement Comparison Variable List - Ancillary Measurements

Measurement	NASA DC-8	NASA P-3B	NOAA WP-3D	NSF HIPPO	DOE/CNRC CV-580

Pressure	Facility Instrument	PDS, Barrick	Facility Instrument		
Temperature	Facility Instrument	PDS, Barrick	Facility Instrument	Facility Instrument	Rosemount 102 Probes, Strapp & Wolde NCAR reverse flow Probes, Strapp
Wind Speed	Facility Instrument	PDS, Barrick	Facility Instrument		
Wind Direction	Facility Instrument	PDS, Barrick	Facility Instrument		
j(NO2)	CAFS, Hall		ZAPHROD, Stark		
j(O1D)	CAFS, Hall		ZAPHROD, Stark		
Solar Flux		SSFR, Schmidt BBR, Bucholtz	SSFR, Pilewskie		
Longwave Flux		BBR, Bucholtz	CG4, Gore		