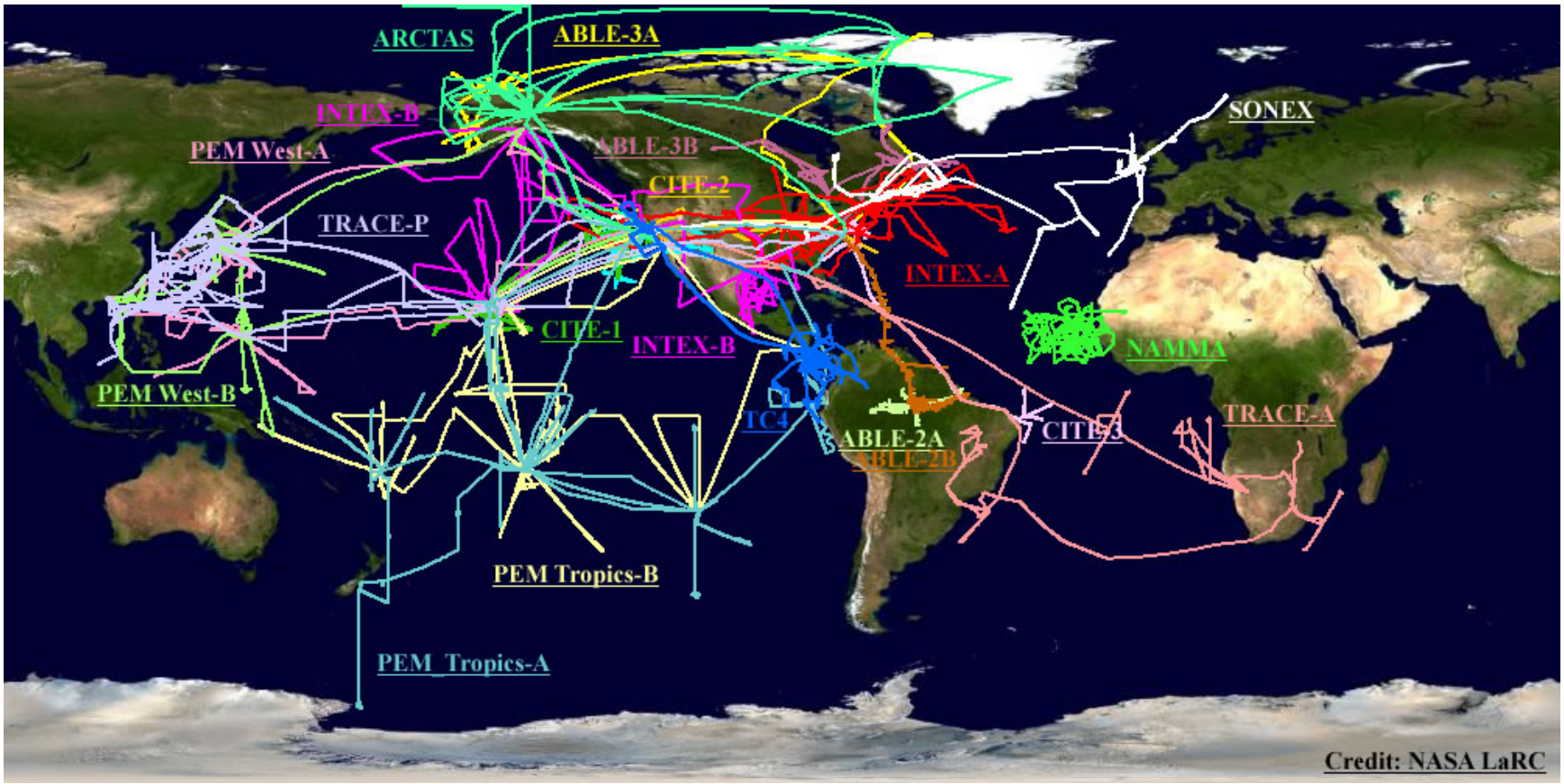
Airborne Observations for Aerosol Model Assessment

Prepared by M. Kleb and G. Chen

NASA Airborne Campaign Map

from mid 1980s to present



Summary of NASA Tropospheric Airborne Particle Measurements

Missions	Aerosol Measurements			
	Composition	CN	N/S Dististribution	Optical Properties
CITE-1C & ABLE-1 ('84)			✓	
ABLE-2A ('85)	✓			
CITE-2 ('86)		✓		
ABLE-2B ('87)	✓	✓	✓	
ABLE-3A ('88)	✓	✓	✓	
CITE-3 ('89)		✓	✓	
ABLE-3B ('90)	✓	✓	✓	
PEM-West A ('91)	✓	✓	✓	
PEM-West B ('94)	✓	✓	✓	
PEM-Tropics A ('96)	✓	✓	✓	✓
PEM-Tropics B ('99)	✓	✓	✓	✓
TRACE-P ('01)	✓	✓	✓	✓
INTEX-NA ('04)	✓	✓	✓	✓
NAMMA ('05)		✓	✓	✓
INTEX-B ('06)	✓	✓	✓	✓
TC4 ('07)	✓	✓	✓	✓
ARCTAS ('08)	✓	✓	✓	✓

Other Important Airborne Campaign for Aerosol Observations

NSF ACE-1, 1995

NSF ACE-2, 1997

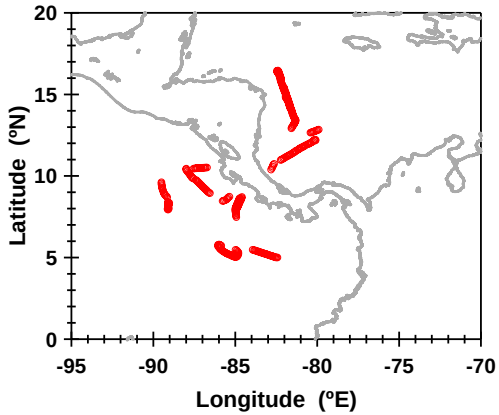
NSF ACE-Asia, 2001

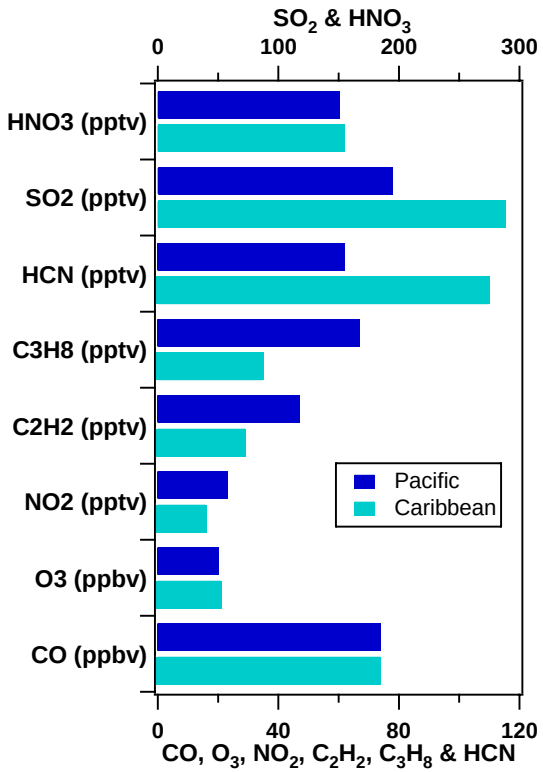
NOAA NEAQS-ITCT, 2004

EU AMMA, 2006

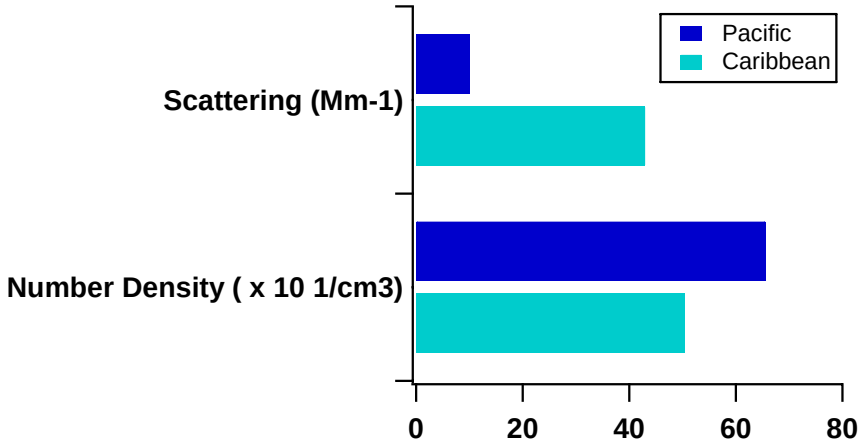
NOAA ARCPAC, 2008

TC^4 Example



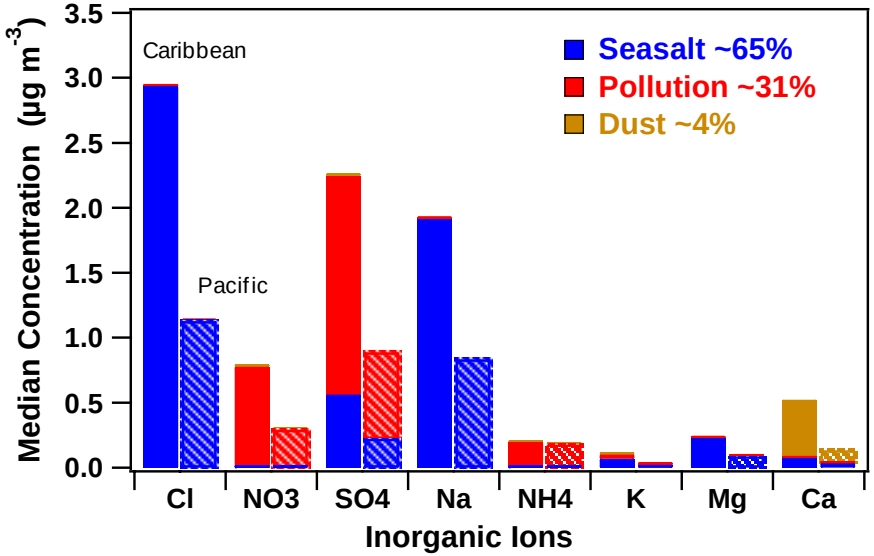


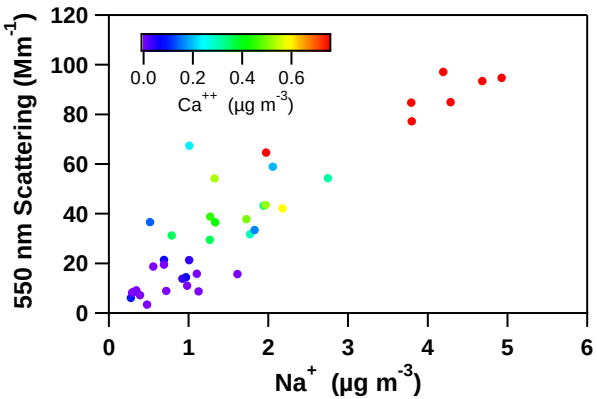
Boundary Layer Comparison: Caribbean vs. Pacific

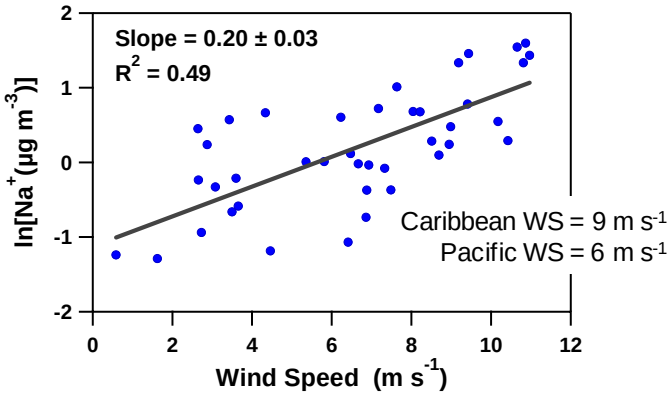


- **Both Caribbean and Pacific observations are mostly consistent with typical tropical marine boundary layer (TMBL) conditions, except elevated SO_2.**
- **Particle scattering and number density are also consistent with typical TMBL values.**
- **Larger particles and heavier loading are seen in the Caribbean observations.**

TC^4 Example (cont.)







- Sea salt is the largest particulate component.
- Significant pollution and dust contribution.
- Sea salt loading is likely a strong function of wind speed.

- **Airborne aerosol observations can be used to assess spatial and temporal distribution.**
- **Allow detailed and direct comparison for aerosol volume loading, chemical composition, number and size distribution, and optical properties.**
- **Companion gas phase observations can be used as tracers for airmass classification and source assessment.**

The LaRC MEaSUREs Project:

Creating a Unified Airborne Database for Assessment and Validation of Global Models of Atmospheric Composition

- The first international Tropospheric Airborne Measurement Evaluation Panel (TAbMEP) meeting, held in Baltimore, MD August 19-21, 2008, was sponsored by the LaRC MEaSUREs project and received broad endorsement and participation from NASA, NOAA, NSF, EPA, DOE and IGAC.
- TAbMEP is a group of measurement and modeling experts representing a broad spectrum of trace gas and particle measurement techniques/ instruments as well as global and regional models
- TAbMEP serves as a steering committee to guide the LaRC MEaSUREs project in achieving its overarching goal to generate unified data products for model assessment and validation.

MEaSUREs = Making Earth System data records for Use in Research Environments.

First TAbMEP Meeting Goals

- To objectively assess measurement uncertainties for ICARTT airborne data.
- To objectively evaluate measurement consistency between techniques, instruments, and platforms.
- To assess the suitability of measurements for model assessment and validation and to identify problematic measurements.
- To establish community-accepted approaches for combining data sets and creating a unified airborne database from multiple instruments and aircraft platforms.

Particulate Phase measurements of interest for 1st TAbMEP Meeting: total number density, submicron and total volume densities, sulfate, ammonium, nitrate mass concentration, scattering coefficients, and absorption coefficients

TAbMEP Members

Attendees	Contributions	Affiliation	Attendees	Contributions	Affiliation
Bruce Anderson	Aerosol Measurements	NASA LaRC	Jose Jimenez	Aerosol Measurements	Univ. of CO
Eric Apel	Trace Gas Measurements	NCAR	Terry Keating	HTAP & EPA Representative	EPA
Melody Avery	Trace Gas Measurements	NASA LaRC	Mary Kleb	Organizer, data analysis	NASA LaRC
Steve Arnold	Global & Reg. Model: Trace Gas	Univ. of Leeds	Qing Liang	Global Model: Trace Gas	NASA GSFC
Don Blake	Trace Gas Measurements	Univ. of CA, Irvine	David McCabe	EPA Representative	AAAS/EPA
Chuck Brock	Aerosol Measurements	NOAA/ESRL	Pete Parker	Statistician	NASA LaRC
Greg Carmichael	Reg. Model: Trace Gas & Aerosol	Univ. of IA	David Parrish	Trace Gas Measurements	NOAA/ESRL
Gao Chen	Organizer, data analysis	NASA LaRC	Margaret Pippin	Organizer, data analysis	NASA LaRC
Mian Chin	Global Model: Aerosols	NASA GSFC	Tom Ryerson	Trace Gas Measurements	NOAA/ESRL
Jack Dibb	Trace Gas & Aerosol Measurements	Univ. of NH	Jian Wang	Aerosol Measurements	DOE/BNL
Glenn Diskin	Trace Gas Measurements	NASA LaRC			
Louisa Emmons	Global Model: Trace Gas	NCAR	**Absent Panel Members**		
Mat Evans	Global & Reg. Model: Trace Gas	Univ. of Leeds	Greg Huey	Trace Gas Measurements	GA Tech
Arlene Fiore	Global Model: Trace Gas	NOAA/GFDL	Trish Quinn	Aerosol Measurements	NOAA/PMEL
Frank Flocke	Trace Gas Measurements	NCAR	Michael Schulz	Global Model: Aerosols	LSCE

Key TAbMEP Recommendations

- **TAbMEP Assessment Report**: Summary of TAbMEP meeting discussions and results of the follow-up analysis, publically available tentatively by June 2009.
- **Significant and irreconcilable differences between measurements:**
  - Panel often recommended more than one measurement as suitable for model assessment .
  - Measurements unified by increasing systematic uncertainties to encompass all measurements within 2-σ total uncertainty limits.
  - Individual data sets will not adjusted - average is unlikely to be closer to the actual ambient value.
- **Internal estimate of instrument precision (IEIP):**
  - Panel established as useful data-driven independent check on the PI reported uncertainties.
  - IEIP analysis will be performed on all applicable data (i.e., high time resolution and continuous).
- **Measurement consistency analysis for the intercomparison data:** Reports absolute or relative difference between coincident points in addition to the orthogonal distance regression (ODR) slopes and intercepts.

The scope of the TAbMEP meeting is to evaluate the implementation of techniques, but not to critique the techniques themselves.

Unified Airborne Database

- **Format:**
  - netCDF using standard nomenclature developed by Christiane Textor.
  - Provide temporal and spatial resolution necessary for model assessment
  - No consensus reached on merge time scale
    - Option: provide 1 sec. merge files and develop web tools to allow the users to produce a merge time interval of his interest.
    - Disadvantage: difficult to specify measurement uncertainties when merge time scale is smaller than the measurement integration time.
- **Content:**
  - One field campaign per file.
  - Complete metadata : PI contact information, field campaign, aircraft platform, the panel assessed uncertainty, consistency, and suitability for model assessment
  - Standard housekeeping variables (date, time, lat, lon, alt, temp, pressure, water concentration, etc.)

The LaRC MEaSUREs project team will work closely with the modelers to explore the best method for meeting the model assessment needs.

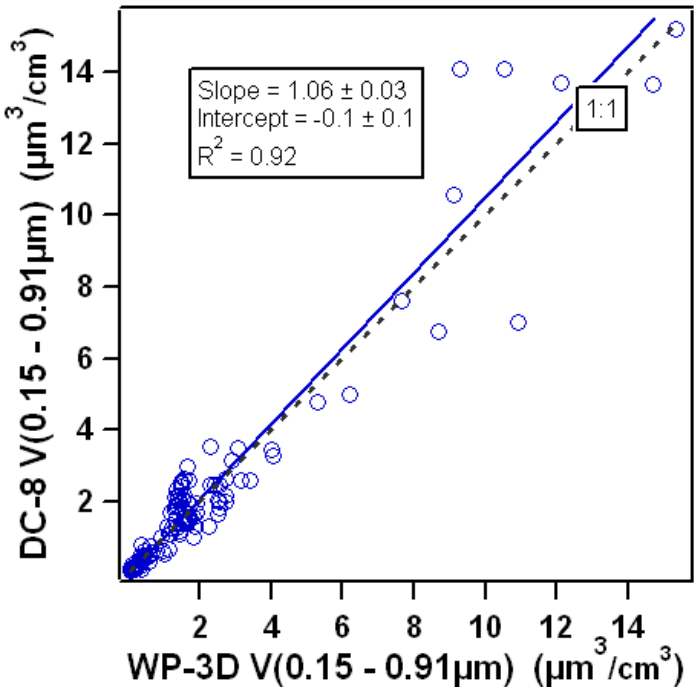
Assessment of Integrated Volume Density and Size Distribution Measurements

Volume Density Measurement Precision Assessment

Date	DC-8:V(< 1 µm)* ($\mu m^3 cm^{-3}$)	WP-3D:V(< 1 µm) ($\mu m^3 cm^{-3}$)	WP-3D: V_{Total} ($\mu m^3 cm^{-3}$)
07/22/2004		4%	7%
07/31/2004	35%	5%	15%
08/07/2004	28%	4%	25%

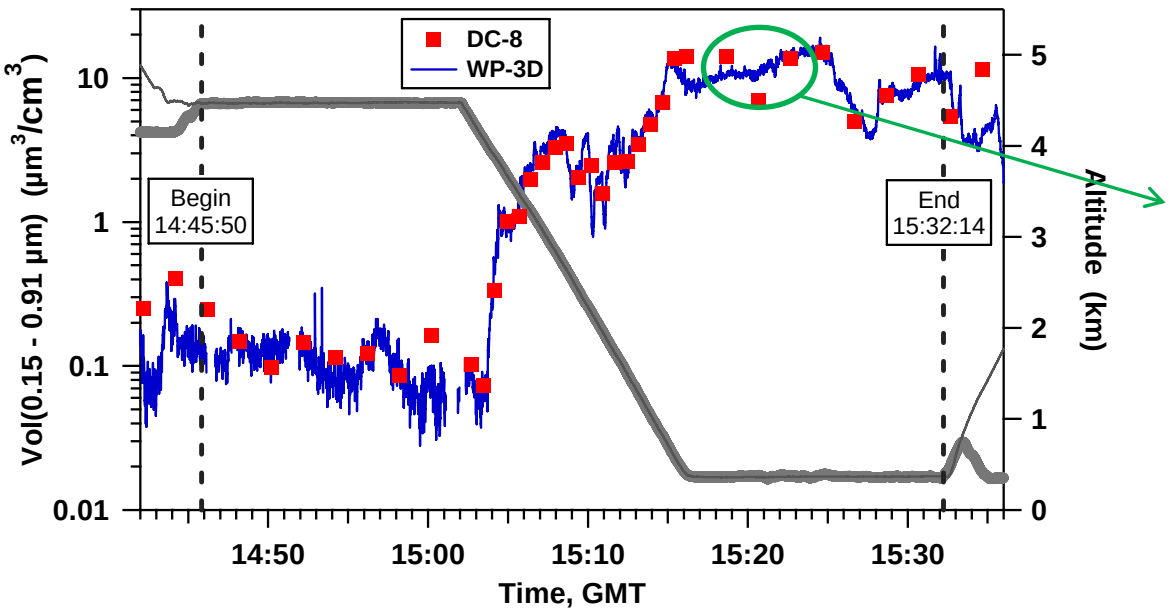
*Derived from OPC data only, i.e., 150 – 1000 nm

- Data collected from NASA DC-8 and NOAA WP-3D.
- WP-3D data: 1 sec, nearly continuous data .
- DC-8 data: slower time resolution with gaps.
- WP-3D PI reported uncertainty: ~50%.
- DC-8 total uncertainty not specified.

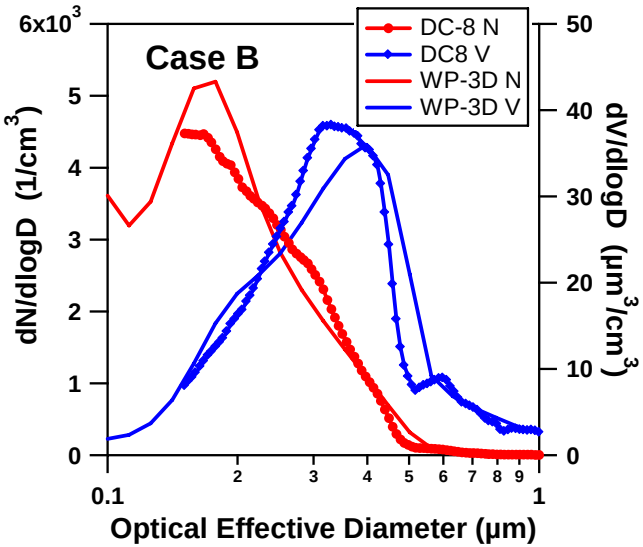


- WP-3D data appears to be more precise, however, the panel believes that the overall uncertainty should quite similar for both measurements at ~ 50%.
- The total volume measurement is less precise than that of the PM1. This reflects low coarse particle number density.
- The agreement between the integrated quantities is significantly better than the size distributions, see next slide.

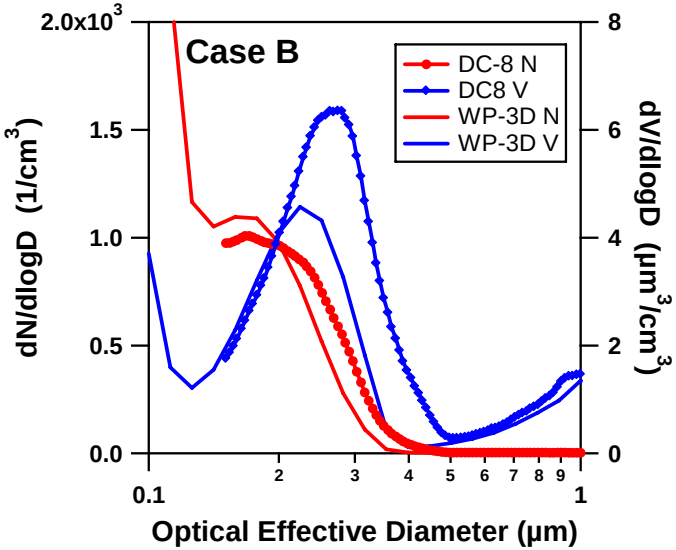
Size distribution comparison

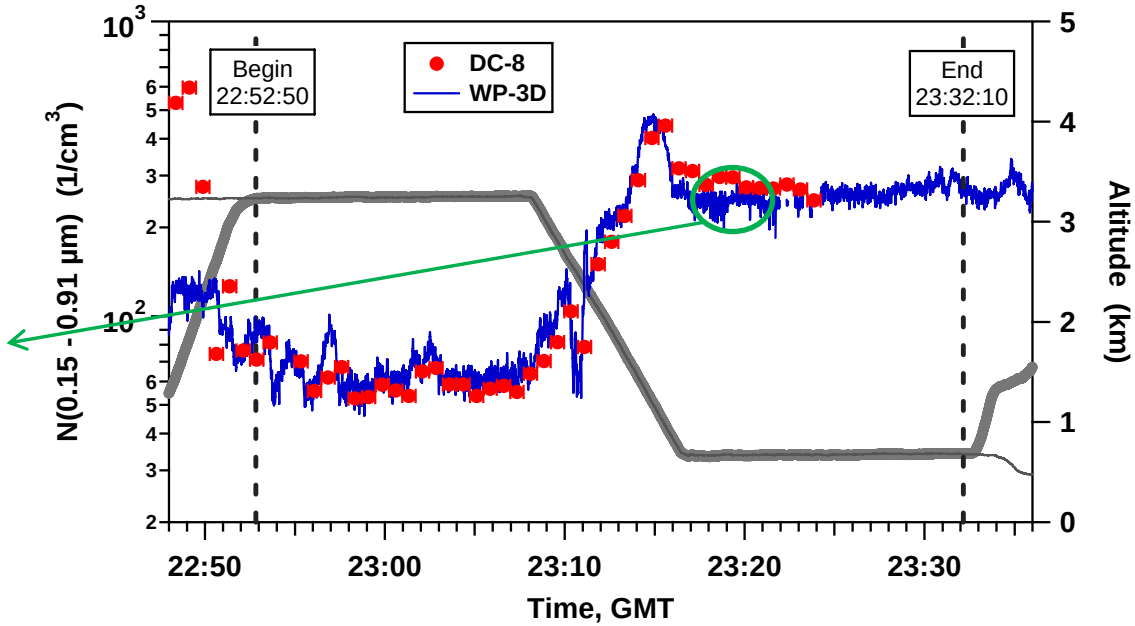


15:22:39 – 15:24:39



23:17:51 – 23:22:21

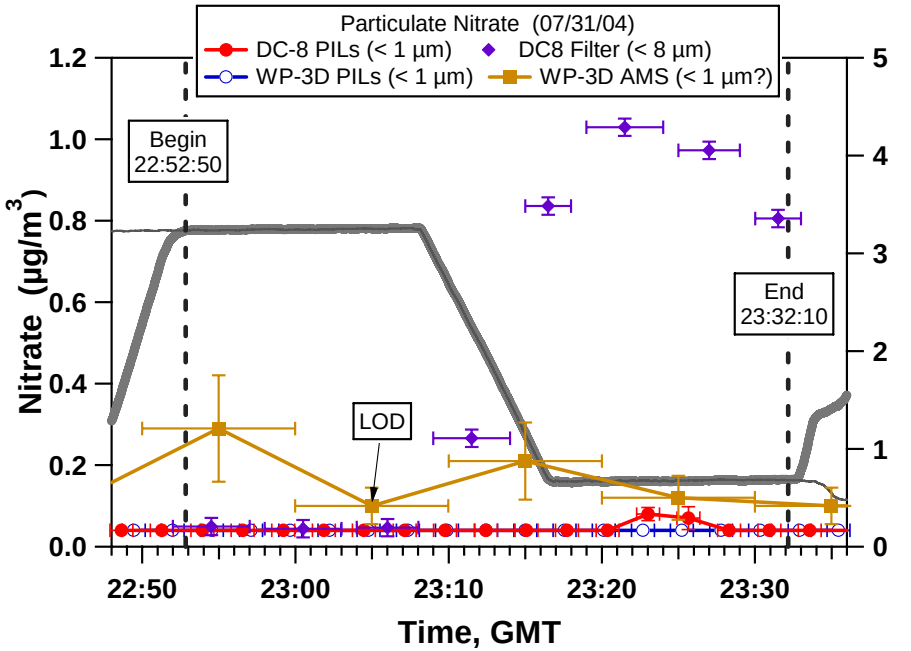


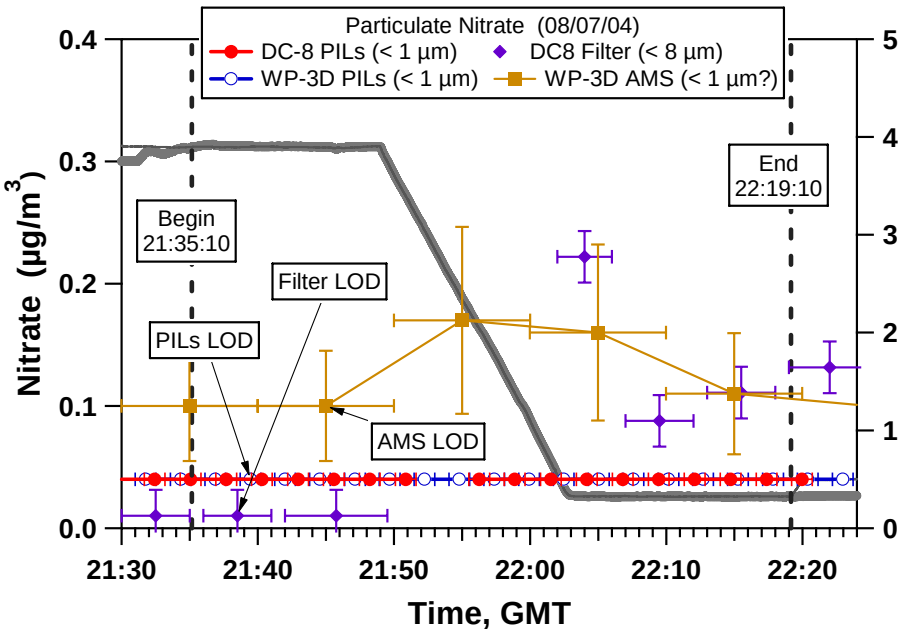


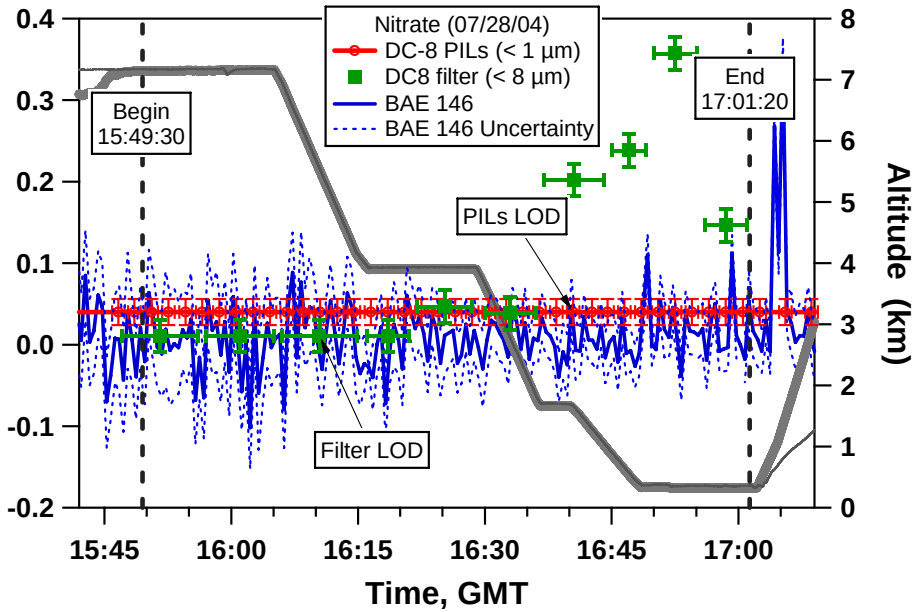
Scattering and Absorption

- Panel did not have a full discussion on scattering and absorption measurements (made only onboard NASA DC-8).
- Results from intercomparison analysis of INTEX-B and ARCTAS analysis suggests nephelometer scattering measurement is typically more precise and highly consistent between instruments and platforms. The ARCTAS and INTEX-B data will be discussed at future TAbMEP meetings.
- Absorption measurement precision is estimated about 35% or 0.1 Mm^{-1}. Typically, scattering precision is estimated from 5-20%. The intercomparison results are less conclusive due to limited range reflecting weak absorption environment.

Aerosol Nitrate Measurement Assessment

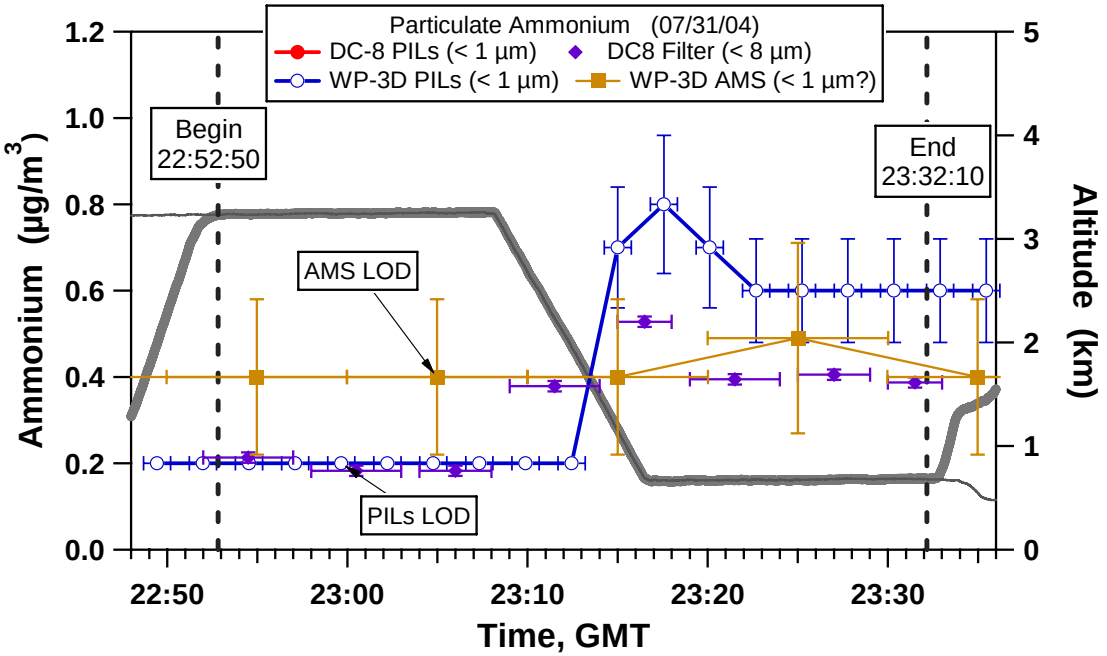






The nitrate comparison is not conclusive since most of the submicron data are near or under limit of detections.

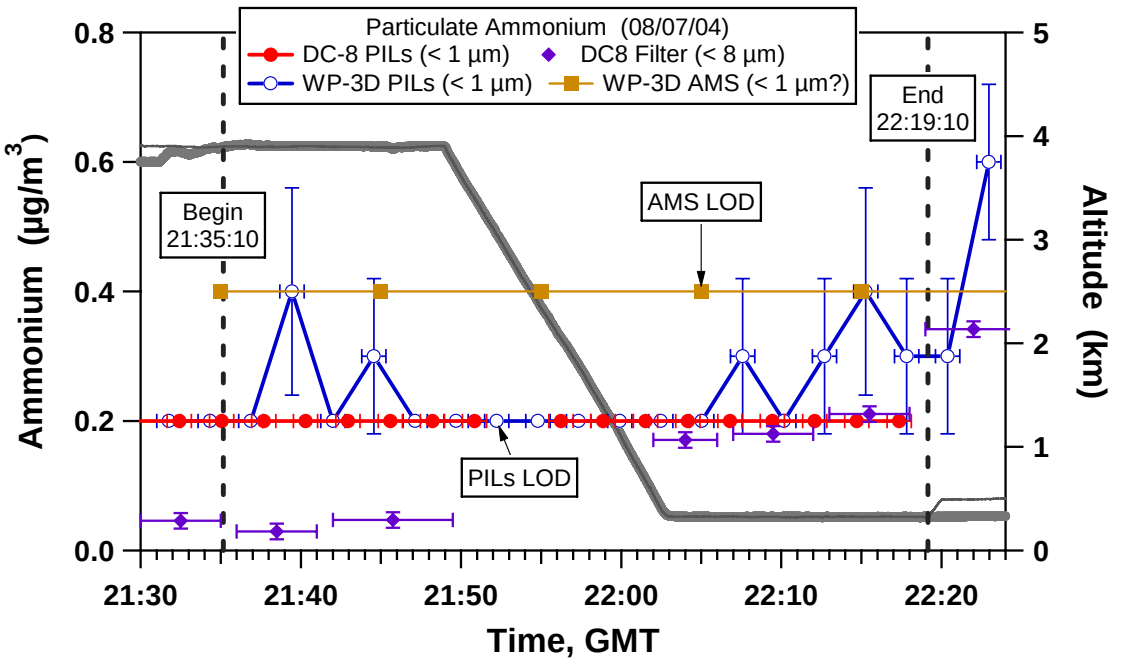
The internal estimate of instrument precision procedures can not be applied because of long integration time and/or gaps between data points.



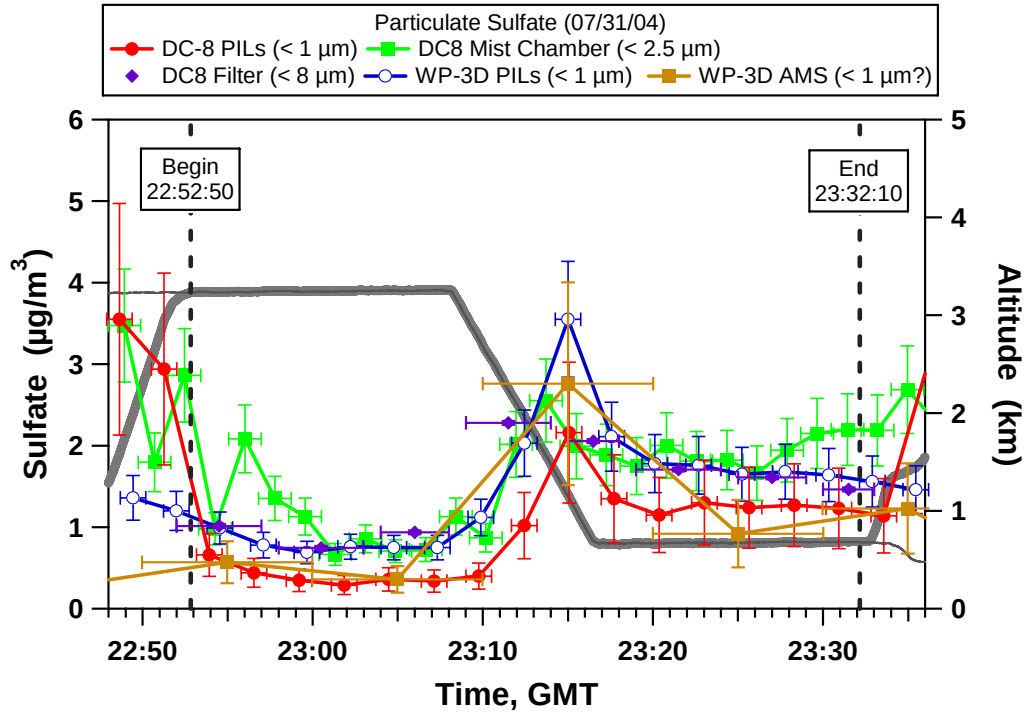
Aerosol Ammonium Measurement Assessment

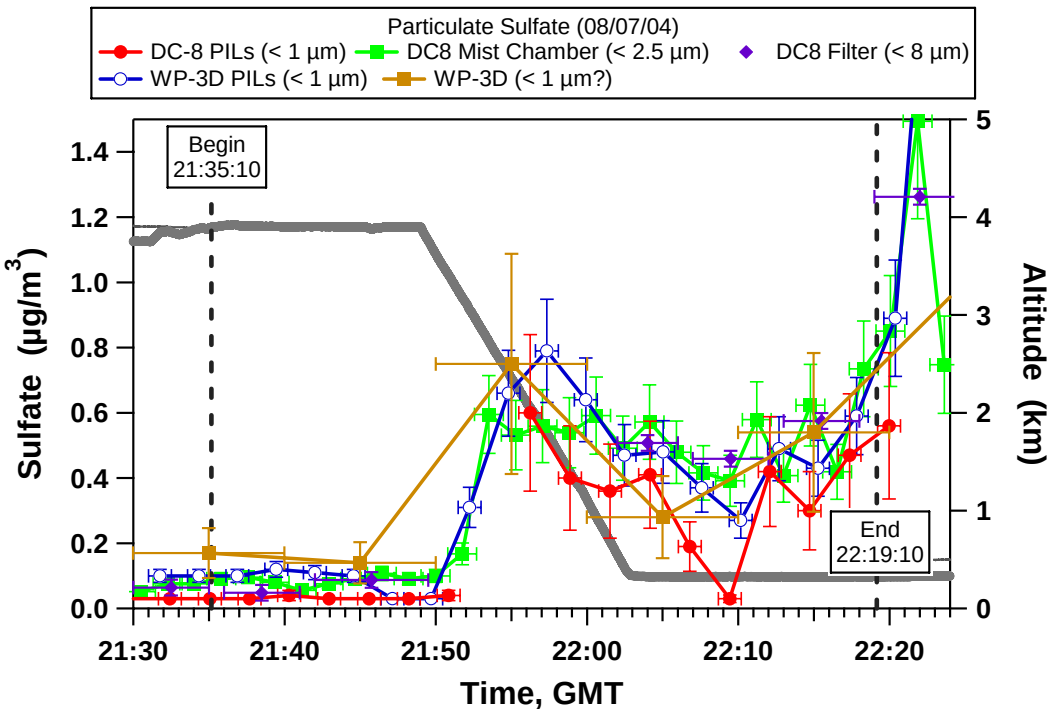
The intercomparison between DC-8 and WP-3D is inconclusive due to low nitrate values, while DC-8 PILS appears to be systematically high.

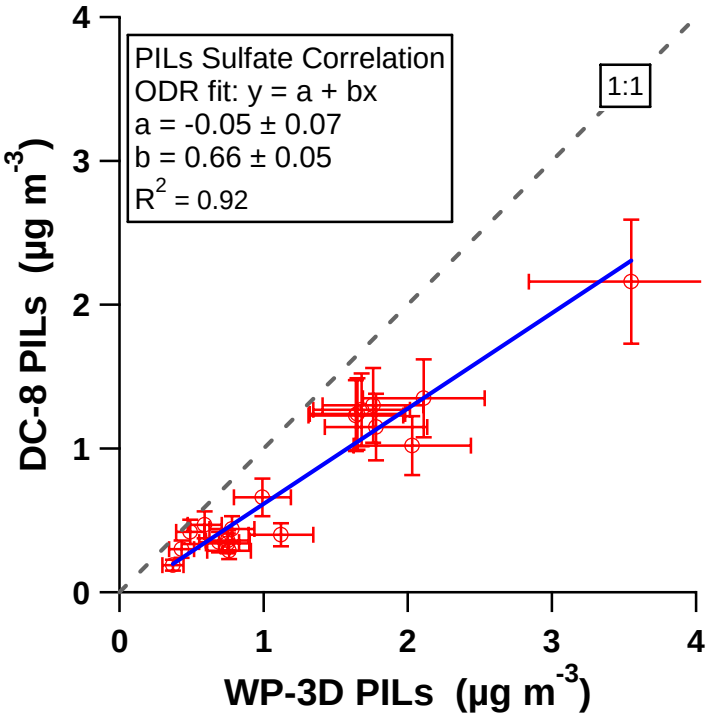
The panel recommended further comparison analysis between DC-8 PILs and filter measurements.



Aerosol Sulfate Measurement Assessment

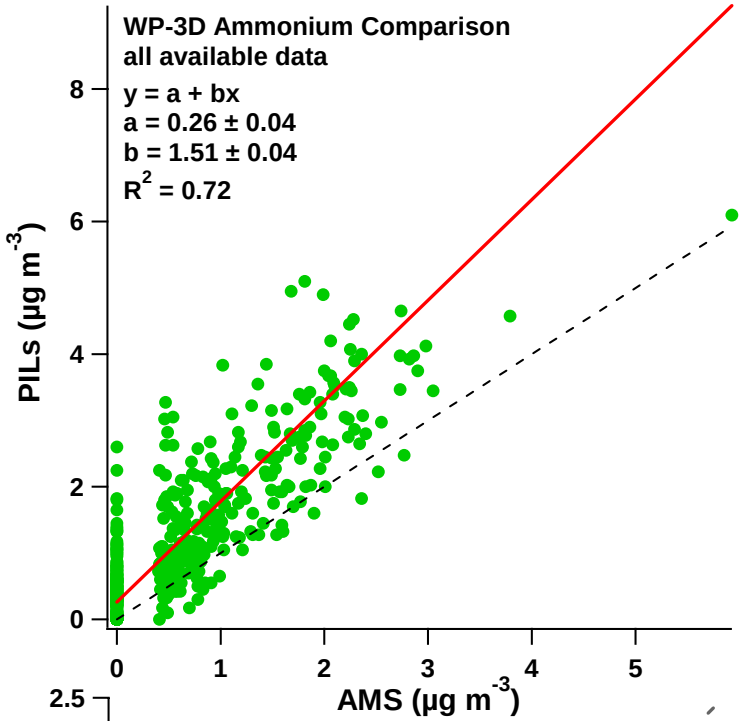


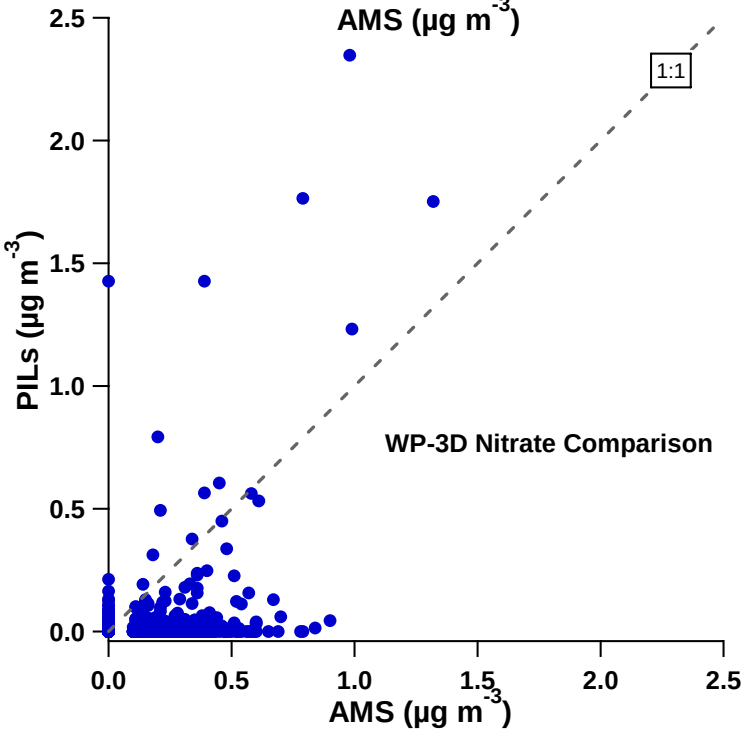


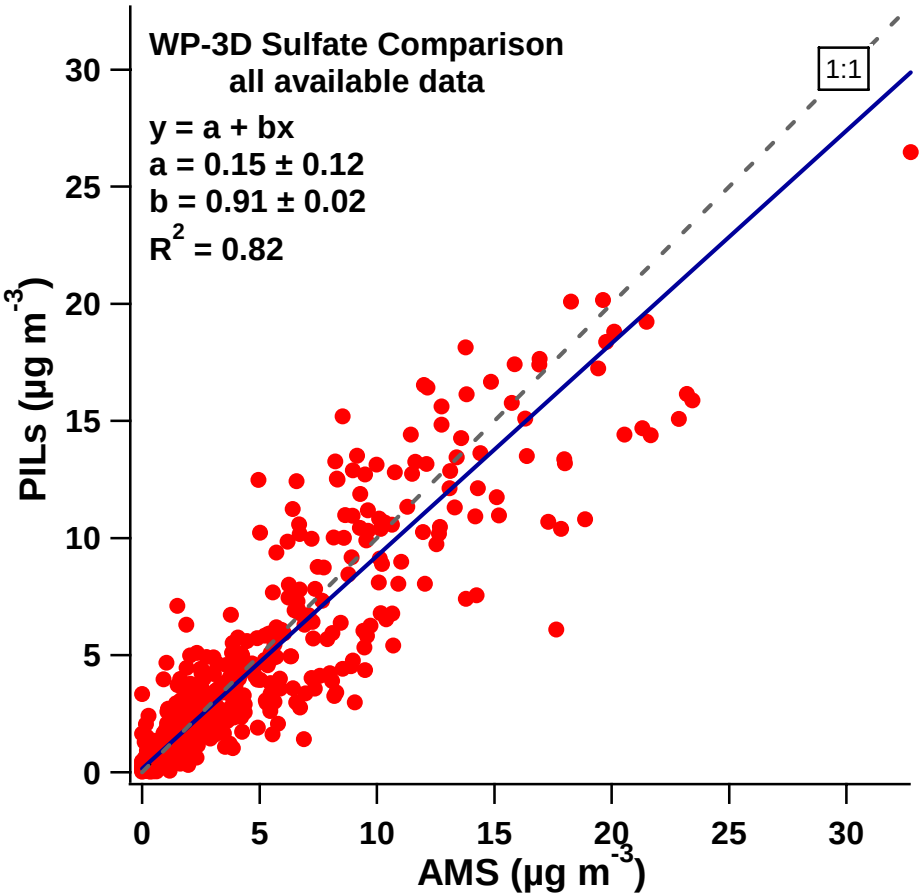


The panel believes that the agreement between the instruments and platforms is about as good as one can expect.

WP-3D Comparison: AMS vs. PILs







AMS reported 10 min. averages which is not typical for other field campaigns. Some panel member noted that the AMS suffered some instrument problems during this study

AeroCom Feedback