Investigation Rationale

Near-surface pollution is one of the most challenging problems for Earth observations from space…

Near-surface information must be inferred from column-integrated quantities obtained by passive remote sensing from nadir-looking satellite instruments.

Some constituents have large relative concentrations in the stratosphere and/or free troposphere (e.g., O_3 and NO_2) making it difficult to distinguish the near-surface contribution to the total column.

Diminished sensitivity near the Earth's surface is another fundamental problem.

Long-range transport of lifted pollution can complicate interpretation of column quantities.

Boundary layer depth plays a crucial role in determining surface concentrations for constituents emitted at the surface.

Additional challenges exist in the horizontal dimension as the resolution of satellites and models cannot account for important subgrid variability in ozone precursors and their associated nonlinear impacts.

Investigation Overview

Deriving Information on Surface Conditions from Column and VERtically Resolved Observations Relevant to Air Quality

A NASA Earth Venture campaign campaign intended to improve the interpretation of satellite observations to diagnose near-surface conditions relating to air quality

Objectives:

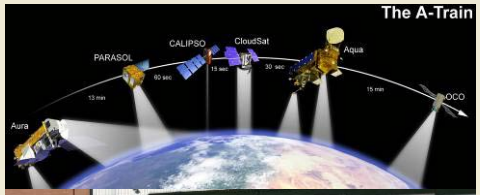
1. Relate column observations to surface conditions for aerosols and key trace gases O_3, NO_2, and CH_2O

2. Characterize differences in diurnal variation of surface and column observations for key trace gases and aerosols

3. Examine horizontal scales of variability affecting satellites and model calculations

Deployments and key collaborators

Maryland, July 2011 (EPA, MDE, UMd, and Howard U.)
California, January 2013 (EPA and CARB)
Texas, September 2013 (EPA, TCEQ, and U. of Houston)
TBD, Summer 2014



Deployment Strategy

Systematic and concurrent observation of column-integrated, surface, and vertically-resolved distributions of aerosols and trace gases relevant to air quality as they evolve throughout the day.

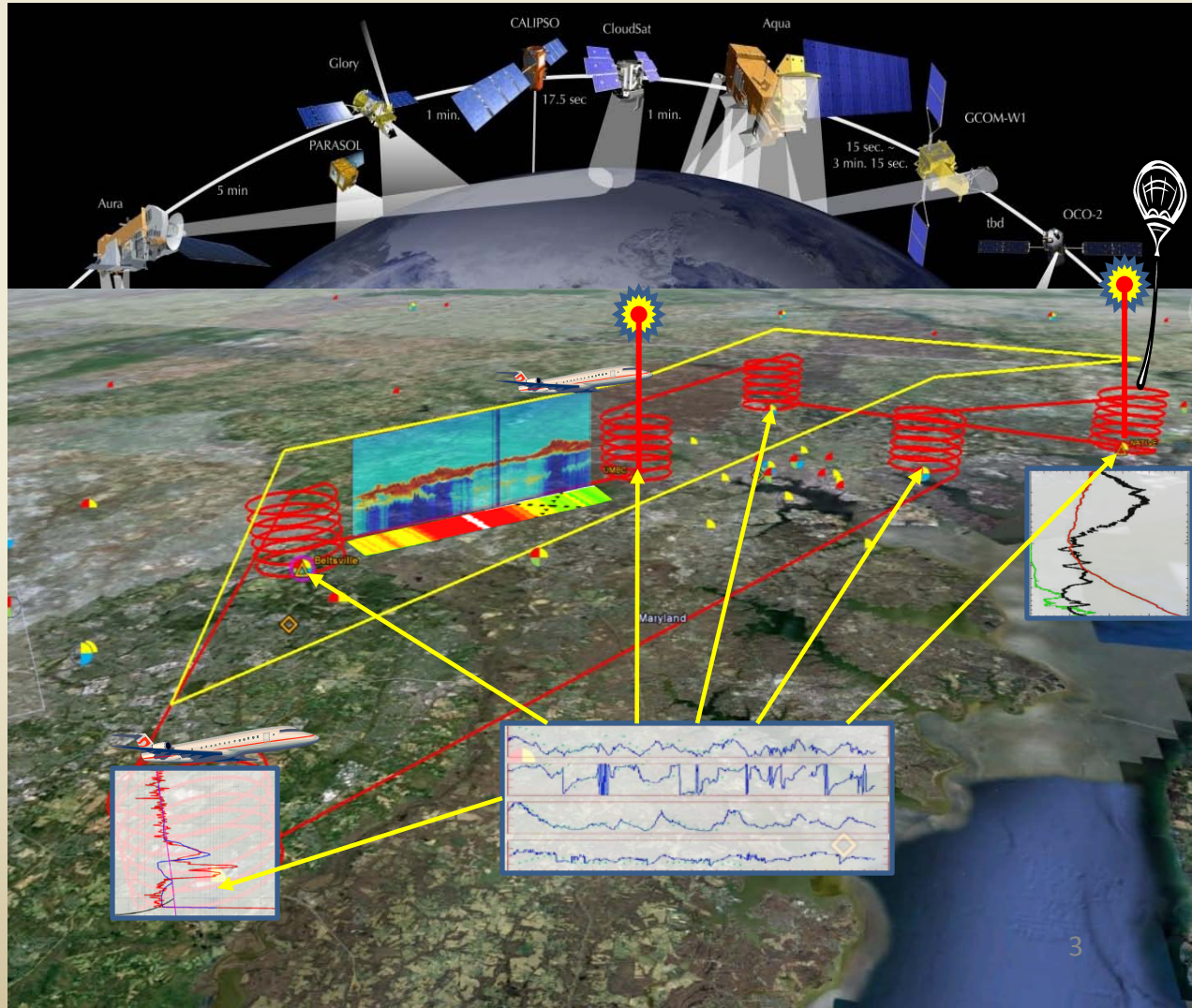
Continuous lidar mapping of aerosols with HSRL on board UC-12

Continuous mapping of trace gas columns with ACAM on board UC-12

In situ profiling over surface measurement sites with P-3B

Continuous monitoring of trace gases and aerosols at surface sites to include both in situ and column-integrated quantities

Surface lidar and balloon soundings

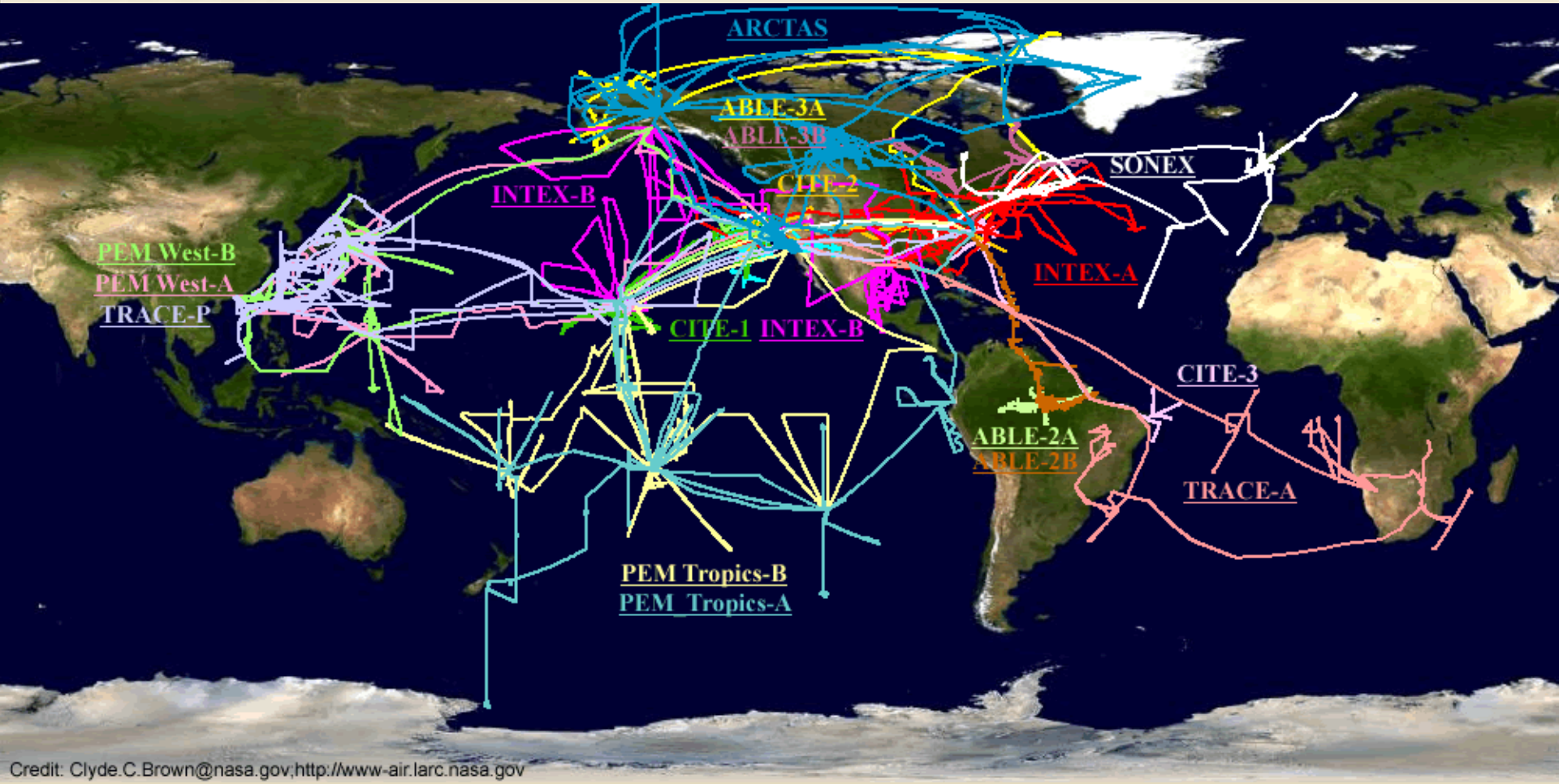


Science Team

Leadership	
Jim Crawford, NASA LaRC	Principal Investigator
Mary Kleb, NASA LaRC	Project Manager
Ken Pickering, NASA GSFC	Project Scientist
Gao Chen, NASA LaRC	Science Data Manager
P-3B In Situ Airborne Measurements	
Ronald Cohen, UC Berkeley	NO_2, ANs, PNs, HNO_3
Andrew Weinheimer, NCAR	O_3, NO_2, NO, NO_y
Alan Fried, NCAR	CH_2O
Armin Wisthaler, Innsbruck	Non-methane hydrocarbons
Glenn Diskin, NASA LaRC	H_2O, CO, CH_4
Stephanie Vay, NASA LaRC	CO_2
Bruce Anderson, NASA LaRC	aerosol optical, microphysical, and chemical properties
B-200 Remote Sensing Airborne Measurements	
Chris Hostetler, NASA LaRC	High Spectral Resolution Lidar (HSRL) aerosol profiles
Scott Janz, NASA GSFC	Airborne Compact Atmospheric Mapper (ACAM) nadir trace gas columns for O_3, NO_2, and CH_2O
Ground-based Measurements	
Jay Herman, UMBC	Pandora network for total trace gas columns of O_3, NO_2, and CH_2O
Anne Thompson, Penn State	Nittany Atmospheric Trailer and Integrated Validation Experiment (NATIVE) in situ O_3, CO, NO, NO_y; aerosol lidar; ozonesondes.
Ray Hoff, UMBC	Lidar aerosol profiles, AERI, Raman H_2O, ground data
Brent Holben, NASA GSFC	Aeronet
Data Analysis and Modeling (PI, Project Scientist, and Science Data Manager will also participate)	
P.K. Bhartia, NASA GSFC	trace gas retrievals and interpretation
Allen Chu, UMBC	aerosol retrievals and interpretation
Robert Chatfield, NASA ARC	statistical data analysis and interpretation
Rich Ferrare, NASA LaRC	aerosol analysis and interpretation of HSRL observations

Participation	
LaRC	***8***
GSFC	***6***
Univ	***5***
ARC	***1***
Foreign	***1***

Heritage: Tropospheric Chemistry Airborne Field Campaigns, 1983-2008



Typical Field Campaign Timeline: Cycles overlap between campaigns which occur ever 2 years on average

-18 months	-12 months	-9 months	-1 month	+6 months	+12 Months	+24 Months
Solicit proposals	Team selection	Convene Science Team	Integrate aircraft	Preliminary data archived	Final data made public	Submission of publications

Heritage: Team Experience

	PEM-West A (1991)	TRACE-A (1992)	PEM-West B (1994)	PEM-Tropics A (1996)	SONEX (1997)	PEM-Tropics B (1999)	TRACE-P (2001)	INTEX-A (2004)	INTEX-B (2006)	TC4 (2007)	ARCTAS (2008)	Other NASA Airborne Campaigns
Crawford	■		■	■	■	■	■	■	■		■	
Pickering		■			■	■	■	■	■	■		CRYSTAL-FACE
Kleb						■	■	■	■		■	
Chen	■		■	■		■	■	■	■	■	■	NAMMA, GRIP
Anderson (LARGE)	■	■	■	■	■	■	■	■	■	■	■	SOLVE, NAMMA, GRIP
Barrick (PDS)	■	■	■	■		■	■	■	■		■	IceBridge
Cohen (TD-LIF)								■	■	■	■	
Diskin/Sachse (DACOM/DLH)	■	■	■	■	■	■	■	■	■	■	■	SOLVE II, NOVICE, IceBridge
Fried (DFGAS)							■	■	■		■	
Hostetler/Ferrare (HSRL)						■			■		■	CRYSTAL-FACE, NAMMA, CALIPSO validation
Janz (ACAM)												AVE, GloPac
Thompson (NATIVE)		■		■	■	■	■	■	■	■	■	
Weinheimer (Chemiluminescence)							■		■	■	■	SUCCESS, CRYSTAL-FACE
Wisthaler (PTR-MS)											■	
Vay (AVOCET)				■		■	■	■	■	■		SUCCESS, IceBridge

Deviations from Proposed Investigation

Item	Description	Areas Impacted	Change	Impacts	Mitigation
1	Conflict in timing of 2012 deployment (Houston) with R&A-sponsored field campaign to SE Asia (SEAC^{4}RS)	Schedule Science Team Cost Phasing	Houston deployment moved to Sept. 2013	Uneven costing with no deployment in FY2012 Diversion of large portion of science team	2013 turns out to align more favorably with plans of local collaborators in Texas Enables fulfillment of critical R&A needs
2	Conflict in use of B200 needed by a competing project (DEVOTE)	Research Platform	Initial deployment will use UC-12 rather than B200	No real impact. B200 and UC-12 are essentially equivalent King Air platforms.	Transition to UC-12 offers flexibility to use either aircraft in subsequent deployments
3	Co-Investigator Bhartia (GSFC) on detail at NASA HQ	Science Team Data Analysis	One year detail affects commitment to DISCOVER-AQ	Minimal long-term impact since the workload of the Co-I's group (analysis and retrievals) will be heaviest during post-deployment periods	Nick Krotkov (GSFC) will assume Co-I duties during absence
4	Consideration given to adding a tethered balloon measurement capability to the ground component of the investigation	Cost Science Team Science	Unsolicited proposal for tethered balloon observations	Improved characterization of the gradient from the surface to the lowest aircraft altitude. Additional cost ($110 K) constitutes a lien against reserves	If proposal is accepted, initial commitment would only be for one year to assess value
5	Winter deployment flexibility impacted by P-3B availability (Annual Maintenance each November can sometimes reach into first half of December and aircraft must be turned over to Icebridge on 1 Feb each year)	Cost Research Platform Schedule Science Team	A possible contingency is to consider substituting the DEVOTE package (UC-12/B200) for the DISCOVER-AQ suite (UC-12/P-3B)	Adds flexibility to the winter campaign schedule Eliminates in situ trace gas profiling from aircraft	The primary focus of the winter campaign is aerosol pollution Trace gas column and in situ sampling at the surface would be preserved Cost to deploy the DEVOTE package would be cheaper allowing additional flight hours

Level 1 Requirements are Being Derived from DISCOVER-AQ Objectives

1. Relate column observations to surface conditions for aerosols and key trace gases ozone (O_3), nitrogen dioxide (NO_2), and formaldehyde (CH_2O)

2. Characterize differences in diurnal variation of surface and column observations for key trace gases and aerosols

3. Examine horizontal scales of variability affecting satellites and model calculations

Draft Baseline Science Requirements Section 4.1.1

The DISCOVER-AQ Investigation shall

a. **conduct at least four (4) aircraft measurement campaigns over four years to the following locations, or as approved by the Program Scientist:**

   1. **DC-Baltimore, Maryland metropolitan region**
   2. **Sacramento, California**
   3. **Houston, Texas**
   4. **A location that routinely exceeds EPA air quality standards**

b. **acquire science data during at least 300 *in situ* aircraft flight hours and 240 remote aircraft flight hours.**

c. **characterize aerosol optical depth (σ) over selected AQS ground sites for temporal and spatial variation as specified in Section 4.2, through concurrent measurements of column-integrated amounts and boundary layer in situ profiles**

d. **characterize ozone (O_3), nitrogen dioxide (NO_2), and formaldehyde (CH_2O) during photochemically active seasons over selected AQS ground sites for temporal and spatial variation as specified in Section 4.2, through concurrent measurements of column-integrated amounts and boundary layer in situ profiles**

e. **obtain interpretive observations from the in situ aircraft (H_2O, CO_2, CO, CH_4, non-methane hydrocarbons, and total reactive nitrogen) during photochemically active seasons**

Draft Baseline Science Requirements Section 4.1.1 (continued)

f. characterize the diurnal variation in trace gas column abundances for O_3, NO_2, and CH_2O at nine (9) ground-based sites during each deployment

g. characterize the diurnal evolution of boundary-layer aerosol profiles in the deployment region using at least one (1) ground-based lidar

h. characterize the diurnal evolution of aerosol optical depth at 5 ground sites during each deployment

i. measure the vertical structure of ozone, humidity, temperature and pressure from ground to tropopause using sonde-based sensors.

j. augment AQS trace gas measurements with research grade measurements at one (1) ground site during each deployment

k. record, validate, publish, and deliver science data and calibrated geophysical data products to the scientific community.

Draft Threshold Science Requirements Section 4.1.2

The DISCOVER-AQ Investigation shall

a. **conduct at least three (3) aircraft measurement campaigns over four years to the following locations, or as approved by the Program Scientist:**
    1. **DC-Baltimore, Maryland metropolitan region**
    2. **Sacramento, California**
    3. **Houston, Texas**

b. **acquire science data during at least 225 *in situ* aircraft flight hours and 180 remote sensing aircraft flight hours**

c. **characterize aerosol optical depth (σ) over selected AQS ground sites for temporal and spatial variation as specified in Section 4.2 through concurrent measurements of column-integrated amounts and boundary layer *in situ* profiles**

d. **characterize ozone (O_3) and nitrogen dioxide (NO_2) over selected AQS ground sites for temporal and spatial variation as specified in Section 4.2 through concurrent measurements of column-integrated amounts and boundary layer *in situ* profiles**

e. **characterize the diurnal variation in trace gas column abundances for O_3 and NO_2 at six (6) ground-based sites during each deployment**

f. **measure the vertical structure of ozone, humidity, temperature and pressure from ground to tropopause using sonde-based sensors**

g. **augment AQS trace gas measurements with research grade measurements at one (1) ground site during each deployment**

h. **record, validate, publish, and deliver science data and calibrated geophysical data products to the scientific community as described in Section 4.5**

Draft Baseline versus Threshold Requirements

The DISCOVER-AQ Investigation shall

a. **conduct 4 versus 3 aircraft measurement campaigns**

b. **acquire science data for 300 versus 225 *in situ* flight hours and 240 versus 180 remote sensing flight hours (equivalent to 4 versus 3 deployments)**

c. **characterize aerosol optical depth (σ) (Unchanged)**

d. **characterize ozone (O_3), nitrogen dioxide (NO_2), and formaldehyde (CH_2O) (threshold does not require characterization of formaldehyde)**

e. **obtain interpretive observations from the in situ aircraft (eliminated from threshold)**

f. **characterize diurnal variation in trace gas column abundances at 9 versus 6 ground sites for O_3, NO_2, and CH_2O (CH_2O not required by threshold)**

g. **characterize aerosol profiles with ground lidar at one site (eliminated from threshold)**

h. **characterize diurnal evolution of AOD at 5 sites (eliminated from threshold)**

i. **measure vertical structure with sondes (unchanged)**

j. **augment AQS trace gas measurements at one ground site (unchanged)**

k. **Record, validate, publish, and deliver science data and calibrated geophysical data products to the scientific community. (unchanged)**

Draft Science Instrument Requirements Section 4.2

a. In situ aircraft measurements shall be reported at 1 second, corresponding to a nominal 100 m horizontal and 10 m vertical spatial resolution, with the exception of aerosol absorption (10 seconds), size distributions (1 minute) and hydrocarbons (10 seconds).

b. Aircraft remote measurements shall have a horizontal resolution of 1 km, and remote profile measurements shall have a vertical resolution of 60 m, with the exceptions of 6 km horizontal and 300 m vertical resolution for AOD and extinction and 7 km cross-track horizontal resolution for formaldehyde.

c. Instrument measurement requirements necessary to achieve science requirements in Section 4.1.1 or Section 4.1.2 are listed in Table 4.2.1.

Table 4.2.1. DISCOVER-AQ Measurement Requirements

Measurement	Remote Sensing Measurements Detect variation of at least:	In Situ Measurements units, 1 Hz, 1σ precision
O_3	1 Dobson Unit	ppbv, 5%
NO_2	3×10^{15} molecules/cm^2	20% at >1 ppbv
CH_2O	3×10^{15} molecules/cm^2	20% at >1 ppbv
AOD (σ)	0.1	NA
NO and NO_y	NA	20% at >1 ppbv
H_2O	NA	varies, 10%
CO	NA	ppbv, 5%
CH_4	NA	ppmv, 1%
CO_2	NA	ppmv, 1%
Non-methane hydrocarbons	NA	ppbv, 20% at >1 ppbv (10 sec)
Condensation Nuclei	NA	cm^{-3}, 10% at > 1000 cm^{-3}
Aerosol Scattering	NA	Mm^{-1}, 15% at >20 Mm^{-1}
Aerosol Absorption	NA	Mm^{-1}, 20% at >5 Mm^{-1}
Aerosol Backscatter	0.36 Mm^{-1} sr^{-1}	NA
Aerosol Extinction	0.055 km^{-1}	NA

Most instruments have capability well exceeding these requirements

Draft Investigation Data Requirements Section 4.5

4.5.1e All terms and conditions of the transfer of data products and associated information to the NASA Langley Atmospheric Science Data Center shall be **documented in a Data Management Plan that is approved by the Earth Science Data and Information System Project.**

Table 4.5.1. DISCOVER-AQ Data Products

Product	Description	Latency
Airborne Remote Sensing Measurements		
Level 1	Aerosol Backscatter and Depolarization (532 and 1064 nm)	6 months
Level 2	Aerosol Extinction and Optical Depth (532 nm)	6 months
Level 2	Slant Column O_3, NO_2 and CH_2O	6 months
Airborne In Situ Trace Gas Measurements		
In situ	O_3, NO_2, NO, and total reactive nitrogen	6 months
In situ	CH_2O, CO_2, CO, and CH_4	6 months
In situ	H_2O	6 months
In situ	Non-methane hydrocarbons	6 months
Airborne In Situ Aerosol Measurements		
In Situ	Total and Nonvolatile CN	6 months
In Situ	Aerosol Particle Size Distribution	6 months
In Situ	Cloud Condensation Nuclei	6 months
In Situ	Aerosol Scattering and Absorption	6 months
In Situ	Humidity Dependence of Scattering	6 months
Ground-Based Remote Sensing Measurements		
Level 2	Total Column O_3, NO_2, and CH_2O	6 months
Level 1	Aerosol Backscatter	6 months
Ground-Based In Situ Measurements		
In situ	O_3, NO, CO, and total reactive nitrogen	6 months
In situ	Temperature, Pressure, and Relative Humidity	6 months
In situ	Wind Speed and Direction	6 months
In situ	Profiles of O_3, Temperature, Pressure, and Relative Humidity	6 months
Merged Data Products		
Level 2	Merged time series of airborne navigation and meteorology parameters	7 months
Level 2	Merged time series of in situ airborne observations	7 months
Level 2	Merged time series of ground-based measurements	7 months

PRELIMINARY

The completeness of Level 1 requirements is such that flow down to secondary requirements will only be needed to link individual instruments to specific measurement requirements and data products

Draft Investigation Success Criteria Section 4.6

The DISCOVER-AQ Investigation shall be successful if it

a. **Conducts aircraft measurement campaigns over EPA AQS ground sites in urban regions that routinely exceed EPA air quality standards**

b. **Provides co-located observations of column and surface trace gases and aerosols**

c. **Records the diurnal variability of trace gases and aerosols that impact air quality**

d. **Performs statistical analysis of DISCOVER-AQ measurements to characterize variability in column and surface trace gases and aerosols and the conditions that influence their relationship**

e. **Delivers calibrated science data and geophysical data products for use by the scientific and applied science research community as specified in Section 4.5.**

These criteria are consistent with the design of the DISCOVER-AQ investigation and should be easily achieved

Operations, Logistics, and Flight Planning

Prior to each deployment, the basic flight strategy must be developed into a specific flight plan in consultation with relevant parties to establish feasibility and safety. These include:

Pilots – Developing a successful flight plan starts with the platform pilots who provide critical input on flight capabilities and guidance on airspace controls. The pilots are materially involved in all stages of flight plan evolution and negotiation, and are responsible for safe execution of flights.

Airworthiness Safety Review Board (ASRB) – Reviews of P-3B and UC-12 operations will be conducted by their respective centers. Separate reviews are adequate since there is no formation flying and altitude separation between planes.

FAA – Specifically for the Baltimore-DC flights, consultation with FAA is critical due to unique control measures (FRZ) and complex traffic patterns associated with 3 large airports (DCA, BWI, IAD)

Local Collaborating Partners – Selection of sites to overfly must be done in consultation with partners to establish the best options for hosting DISCOVER AQ ground instrumentation, maximizing overlap with airborne measurements, and sampling historical air quality patterns. For the initial deployment, these partners include the Maryland Department of the Environment, University of Maryland, and Howard University.

Restricted Airspace Owners – For the Baltimore-DC flights, the ideal sampling pattern requires flight access to restricted airspace over Aberdeen Proving Ground.

Flight Planning Progress

3 August – DISCOVER-AQ Pilots and Science Leads visit FAA to present initial flight plan. Permission is secured to profile with P-3B over 5 locations with defined ceilings of 5.5 kft for southern sites and 10.5 kft for northern sites. Permission to enter the FRZ also granted. High altitude flight of UC-12 was not a concern.

13-14 September – Site survey of surface locations with Maryland Department of the Environment and Howard University to determine feasibility of hosting DISCOVER-AQ instrumentation (Pandora, Aeronet, NATIVE, and instruments contributed by EPA)

6 October – Evaluation of flight plan at the DISCOVER-AQ Science Team meeting identifies two more sites (Aldino and Fairhill) where profiling would be desired. Tentative flight plan updated. Need for flight operations over Aberdeen Proving Ground defined.

15 December – Record of Environmental Consideration filed with Aberdeen Proving Ground for permission to pursue surface and airborne operations within installation boundaries.

23 December – Record of Environmental Consideration approved, allowing negotiation for overflight with the Office of Security and Range Control

1 February – Overflight permission for Aberdeen Proving Ground granted with stipulation to turn video cameras off when over the installation

8 February – Revisit to FAA secures permission to add profiling over the Aldino and Fairhill sites. Other assistance offered (e.g., waiver for low altitude flight over highways, DoD public affairs contact regarding outreach, face-to-face coordination with Potomac Center)

Baltimore-DC Flight Plan

Plan as of 2/8/11

NCORE

O_3 PM
NO_2 CO

AQS Site Legend

Green Line: UC-12 flight path
Green Boxes: estimated ACAM swath
Yellow Line: P-3B flight path
Red line: R-4001 restricted area (cameras off during overflight)
Blue Line: ICAO FIR Boundary

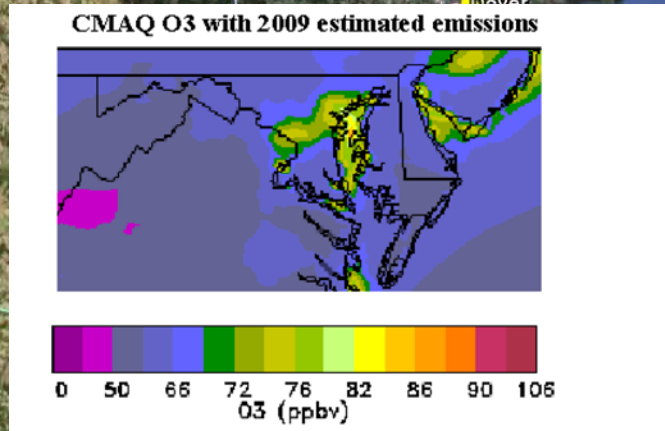
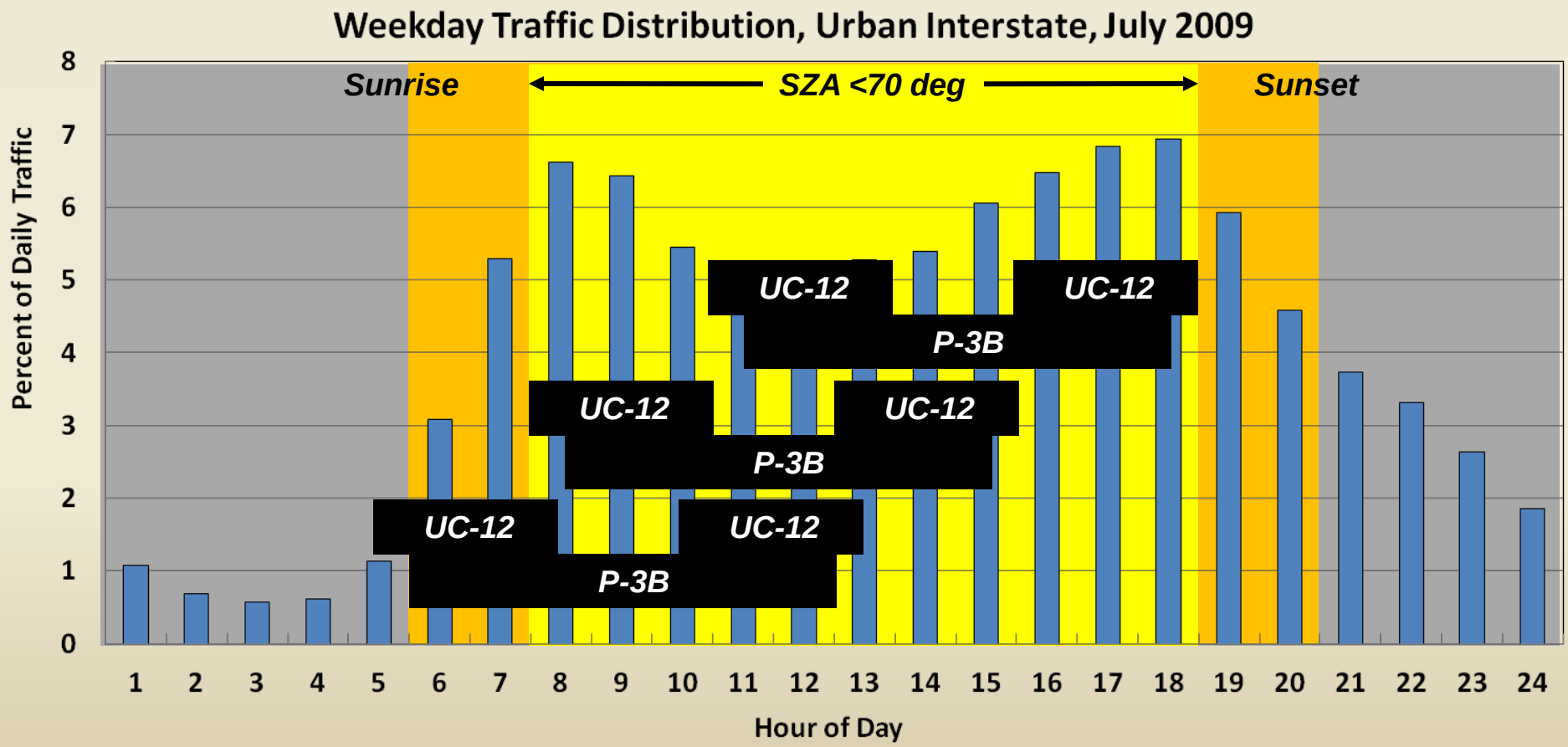


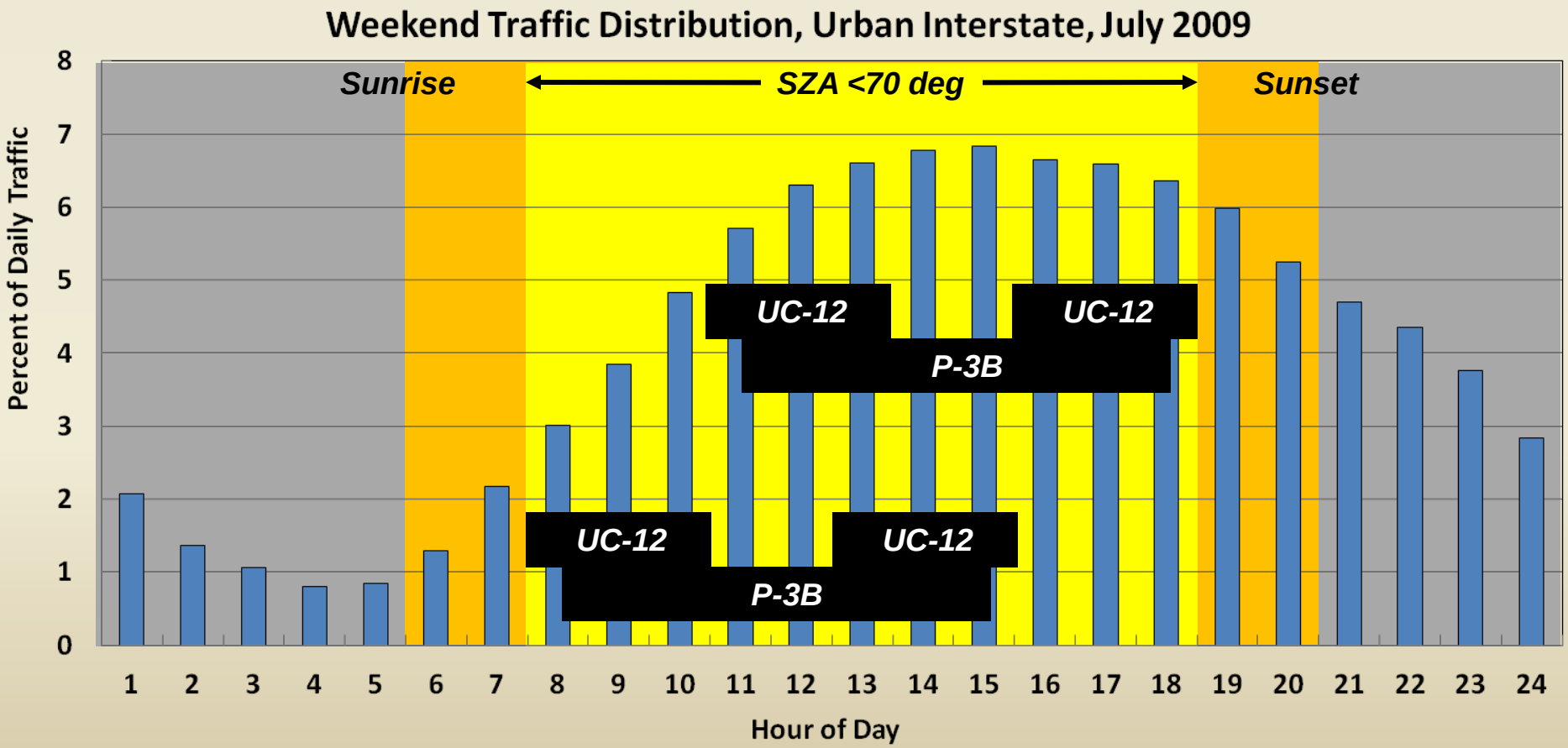
Figure 2-5. CMAQ modeled mean 8-hour maximum ozone during high ozone days (16 high ozone days between 6/1/2002-7/4/2002 using 2009 emissions estimates. Details of the modeling are in Piety et al. [2006]. See Figure 2-10 and Figure 2-3 for monitor locations.

Weekday flight window options and traffic distributions



MD State Hwy Admin (http://shagbhisdadt.mdot.state.md.us/TrafficTrends2/)

Weekend flight window options and traffic distributions



MD State Hwy Admin (http://shagbhisdadt.mdot.state.md.us/TrafficTrends2/)

Flight Planning: Next Steps

14-31 March – Window for UC-12 test flight well in advance of the summer deployment

- **Test operation of HSRL and ACAM**
- **Evaluate feasibility of flight design**
- **Test ability to turn aircraft around for second flight in one hour or less**

20 May – Expected delivery date for P-3B from Operation IceBridge

- **Allows plenty of time for integration**
- **No time for test until just prior to experiment (not unusual)**

Contingency plan for P-3B in case low altitude flight leads to overheating. Chief Pilot, Mike Singer, designing high altitude flight leg to east of study area that can be exercised if cooling is necessary. (If FAA provides dispensation to profile up to 15.5 kft at northern locations of Aldino and Fairhill, this concern will be largely mitigated)

Begin arranging outreach for awareness of overflights (e.g., news, radio, paper, traffic reports, etc.) Need to saturate media starting in mid-June and throughout the campaign.

Platform and Payload Overview

WFF P-3B
Martin Nowicki - WFF

LaRC UC-12B and Ground Instrumentation
Mike Alexander - LaRC

P-3B Specifications

Duration - 8-12 Hours

Payload - Up to 16,700 Pounds

Altitude - 28,000 Feet

Airspeed - 330 Knots

Range - Up to 3,800 Nautical Miles

Height - 34 Feet, 3 inches

Wingspan - 99 Feet, 8 inches

Length - 116 Feet, 10 inches

P-3B INTEGRATION

Configuration Management

830-PG-1410.2.1B: Aircraft/Unmanned Aerial System (UAS) Engineering and Configuration Management (CM) Process

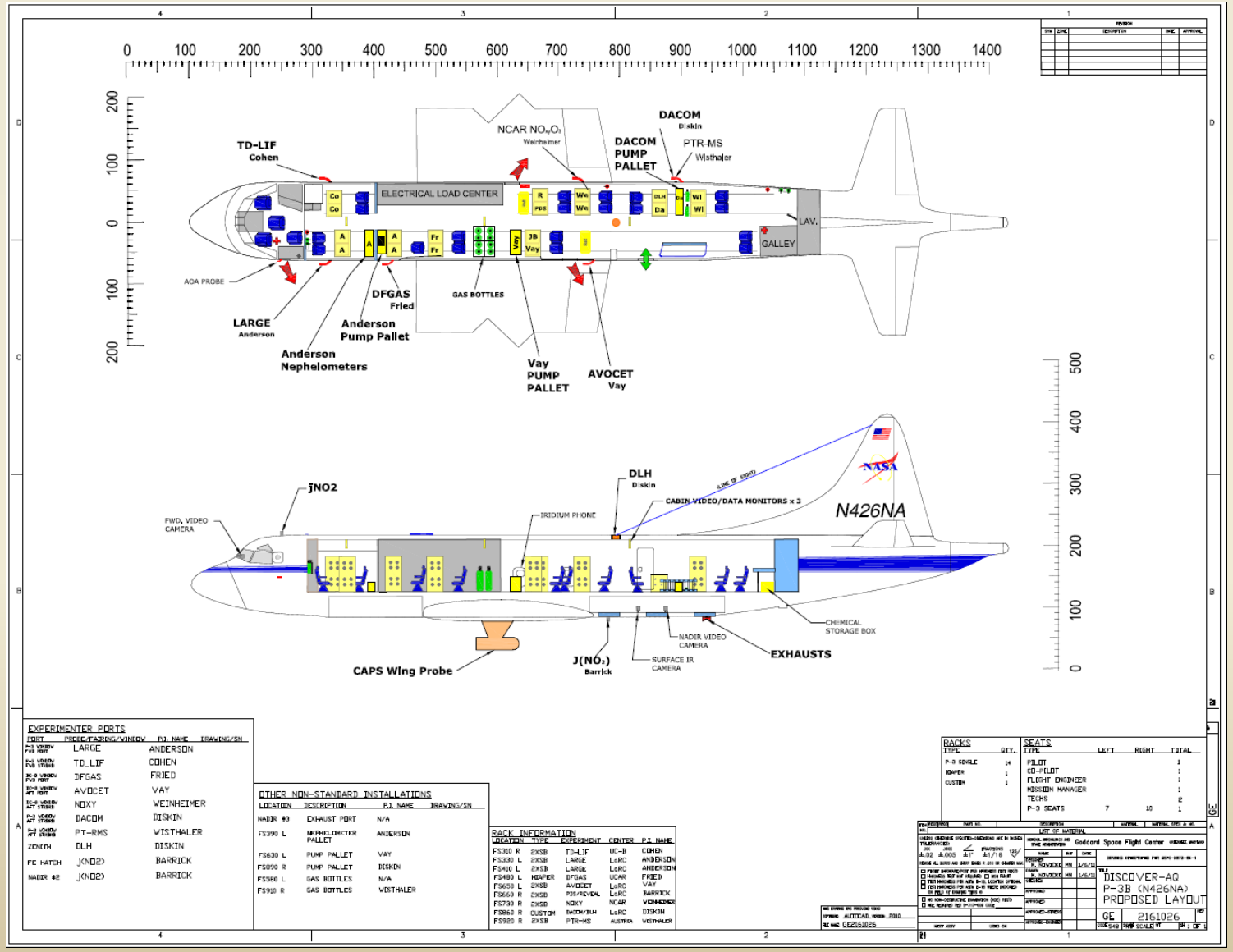
"This PG describes the processes by which the GSFC/WFF Aircraft Office (AO), Code 830, modifies NASA aircraft/UAS and installs customer equipment on NASA aircraft/UAS. It sets basic engineering modification/installation standards and describes engineering review processes and documentation requirements for modifications and installations, as well as covering management and quality assurance controls for the authorization, implementation, and modifications of NASA/GSFC Program Support Aircraft/UAS. This PG also describes the configuration control and management process applicable to all NASA and Non-NASA aircraft/UAS reviewed. The Configuration Management (CM) portion of this PG describes identification and processing of configuration control items for the Aircraft Office. The CM portion also describes the documentation control nomenclature scheme for Aircraft Office documents and individual aircraft/UAS projects."

800-PG-1060.2.2A: Airworthiness Review Process

"This PG details the Goddard Space Flight Center (GSFC) Airworthiness Review Process (ARP) for NASA and non-NASA aircraft, as well as Unmanned Aerial Systems (UAS). In order to enhance the likelihood of mission and program success, while minimizing risk to persons or property, this PG establishes the Airworthiness and Flight Safety Review Board (AFSRB), a non-advocate board responsible for conducting and documenting formal airworthiness reviews."

P-3B INTEGRATION

Floor Plan



P-3B INTEGRATION

LARGE Instrument

- Description: Aerosol Probe
- Re-fly:
  - Probe: Yes
  - Rack: Approved P-3 style
  - Nephelometer Pallet: Flew on DC-8
  - Pump Pallet: No
- Flight Information:
  - Rack: 4 Single Bay Racks
  - Rack Location: 330L, 410L
  - Probe Location: P-3 Window (Fwd, Port)
  - Weight: ~1000 lbs.
  - Power:

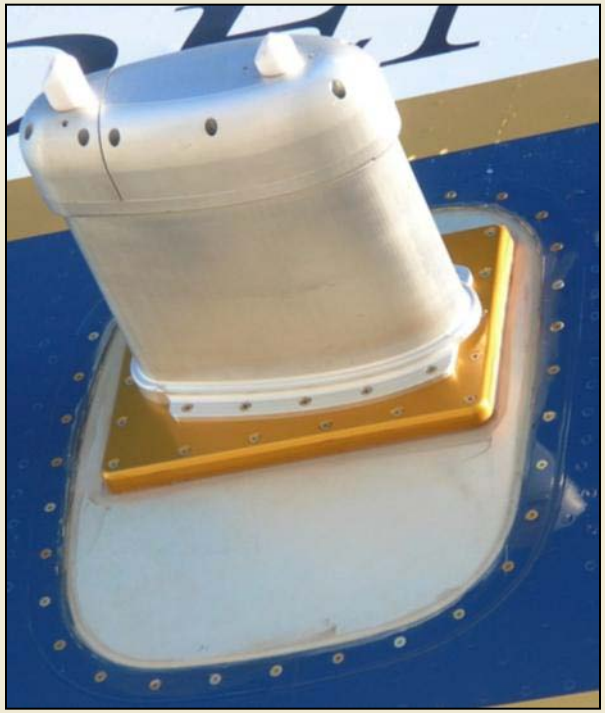
			Power (Watts)	Current (Amps)	
				Peak	Run
115V	60 Hz	1 Φ	3850	35	35
	400Hz	1 Φ	N/A	N/A	N/A
		3 Φ	N/A	N/A	N/A
28 V DC			196	15	7

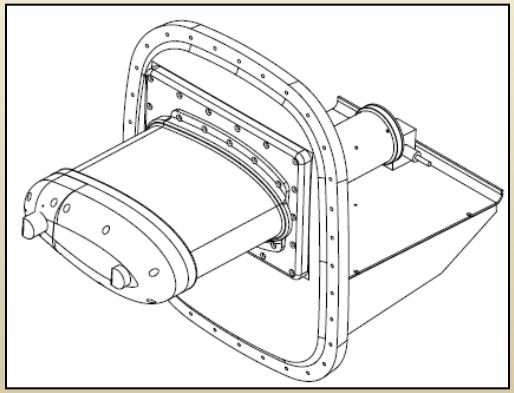
P-3B INTEGRATION

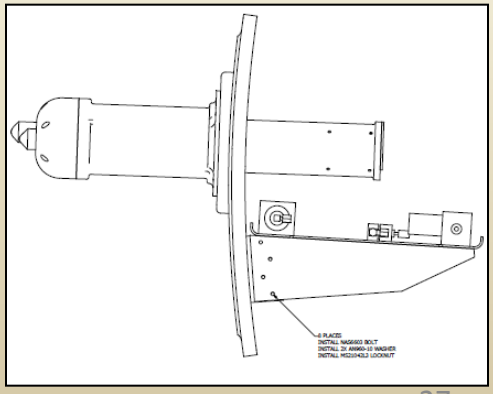
NOXY Instrument

- Description: $NO_{xy}O_3$ Probe
- Re-fly:
  - Probe: Flew on DC-8
  - Rack: Approved P-3 style
- Flight Information:
  - Rack: 2 Single Bay Racks
  - Rack Location: 730R
  - Probe Location: DC-8 Window (Strbrd)
  - Weight: ~800 lbs.
  - Power:

			Power (Watts)	Current (Amps)	
				Peak	Run
115V	60 Hz	1 Φ	1100	10	4
	400Hz	1 Φ	600	5	4
		3 Φ	N/A	N/A	N/A
28 V DC			N/A	N/A	N/A





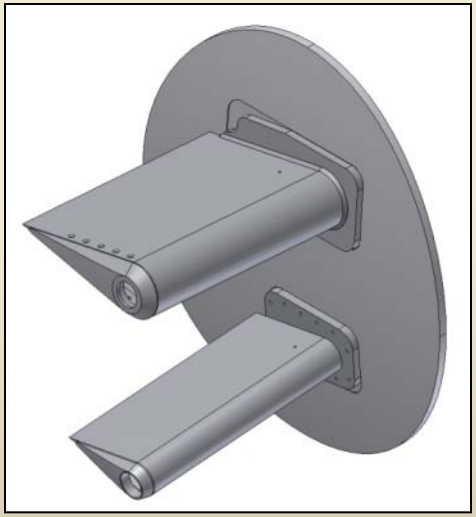


P-3B INTEGRATION

TD-LIF Instrument

- Description: NO2, PANs, Alkylnitrates, HNO3 Probe
- Re-fly:
  - Probe: Flew on DC-8
  - Rack: Approved P-3 style
- Flight Information:
  - Rack: 2 Single Bay Racks
  - Rack Location: 310R
  - Probe Location: P-3 Window (Fwd, Strbrd)
  - Weight: ~600 lbs.
  - Power:

			Power (Watts)	Current (Amps)	
				Peak	Run
115V	60 Hz	1 Φ	600	8	5
	400Hz	1 Φ	700	10	6
		3 Φ	N/A	N/A	N/A
28 V DC			1100	50	40

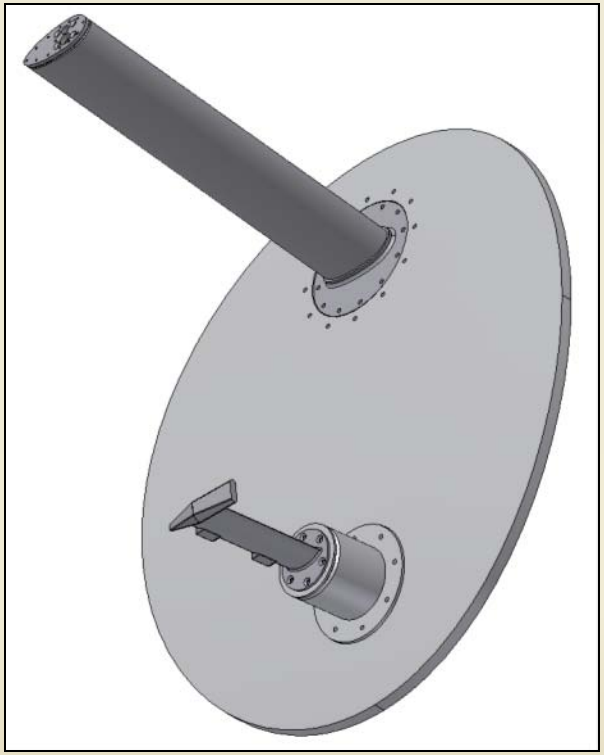


P-3B INTEGRATION

DLH Instrument

- Description: CO, CH_4, N_2O Mixing Ratios Probe
- Re-fly:
  - Probe: Flew on DC-8
  - Rack: Flew on DC-8
  - Pump Pallet: No
- Flight Information:
  - Rack: Custom Double Bay, shared with DLH
  - Rack Location: 860R
  - Probe Location: P-3 Window (Aft, Strbrd), shares with PTR-MS
  - Weight: ~710 lbs.
  - Power:

			Power (Watts)	Current (Amps)	
				Peak	Run
115V	60 Hz	1 Φ	1000*	10	8
	400Hz	1 Φ	N/A	N/A	N/A
		3 Φ	N/A	N/A	N/A
28 V DC			N/A	N/A	N/A



*Note: Power usage for DACOM and DLH

P-3B INTEGRATION

DFGAS Instrument

- Description: Formaldehyde (CH_2O) Probe
- Re-fly:
  - Probe: Flew on DC-8
  - Rack: Flew on DC-8
- Flight Information:
  - Rack: Double Bay HIAPER Rack
  - Rack Location: 480L
  - Probe Location: DC-8 Window (Fwd, Port)
  - Weight: ~780 lbs.
  - Power:

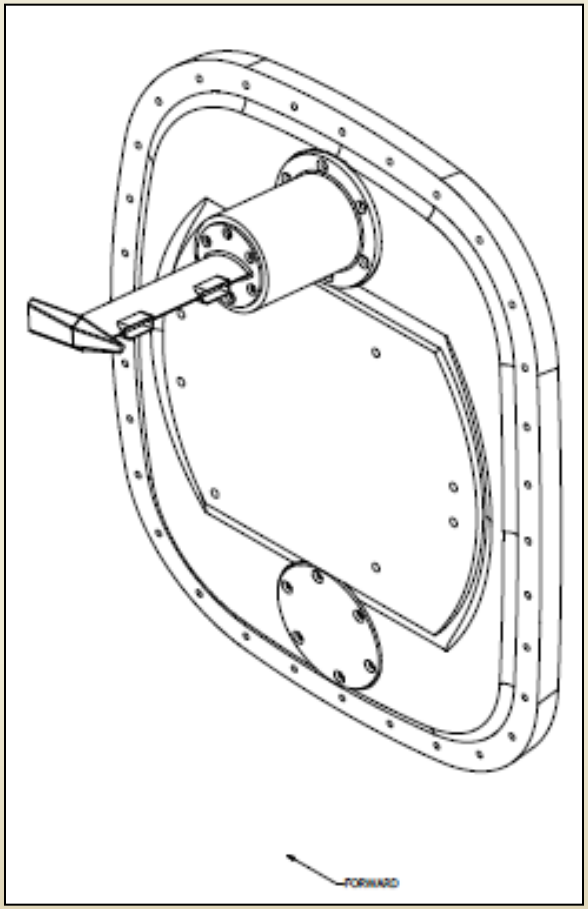
			Power (Watts)	Current (Amps)	
				Peak	Run
115V	60 Hz	1 Φ	2900	25	20
	400Hz	1 Φ	N/A	N/A	N/A
		3 Φ	N/A	N/A	N/A
28 V DC			N/A	N/A	N/A

P-3B INTEGRATION

AVOCET Instrument

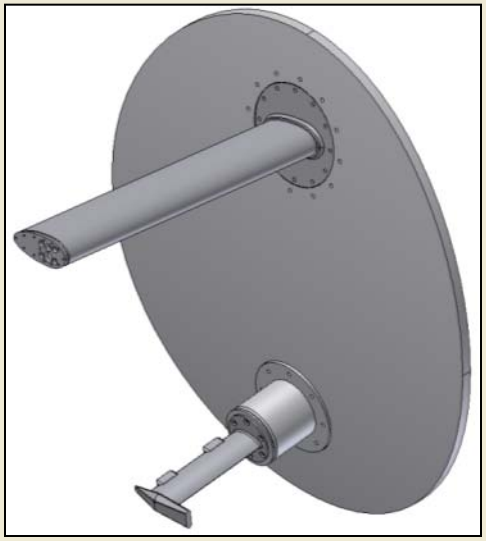
- Description: CO_2 Probe
- Re-fly:
  - Probe: No
  - Rack: Approved P-3 style
  - Pump Pallet: Flew on DC-8
- Flight Information:
  - Rack: 1 Single Bay Racks
  - Rack Location: 650L
  - Probe Location: DC-8 Window (Aft, Port)
  - Weight: ~300 lbs.
  - Power:

			Power (Watts)	Current (Amps)	
				Peak	Run
115V	60 Hz	1 Φ	1000	8	5
	400Hz	1 Φ	N/A	N/A	N/A
		3 Φ	N/A	N/A	N/A
28 V DC			N/A	N/A	N/A



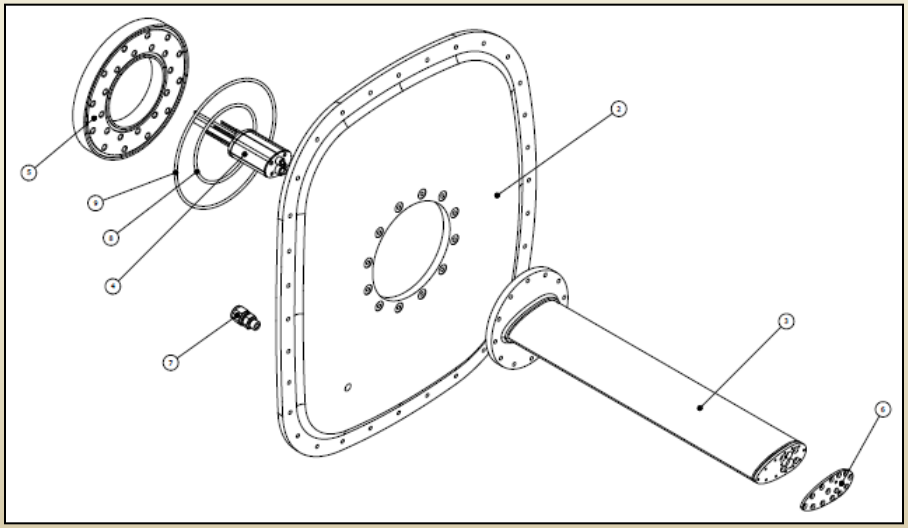
P-3B INTEGRATION

PT-RMS Instrument



- Description: VOC Probe
- Re-fly:
  - Probe: Flew on DC-8
  - Rack: Approved P-3 style
- Flight Information:
  - Rack: 2 Single Bay Racks
  - Rack Location: 920R
  - Probe Location: P-3 Window (Aft, Strbrd), shares with DACOM
  - Weight: ~1000 lbs.
  - Power:

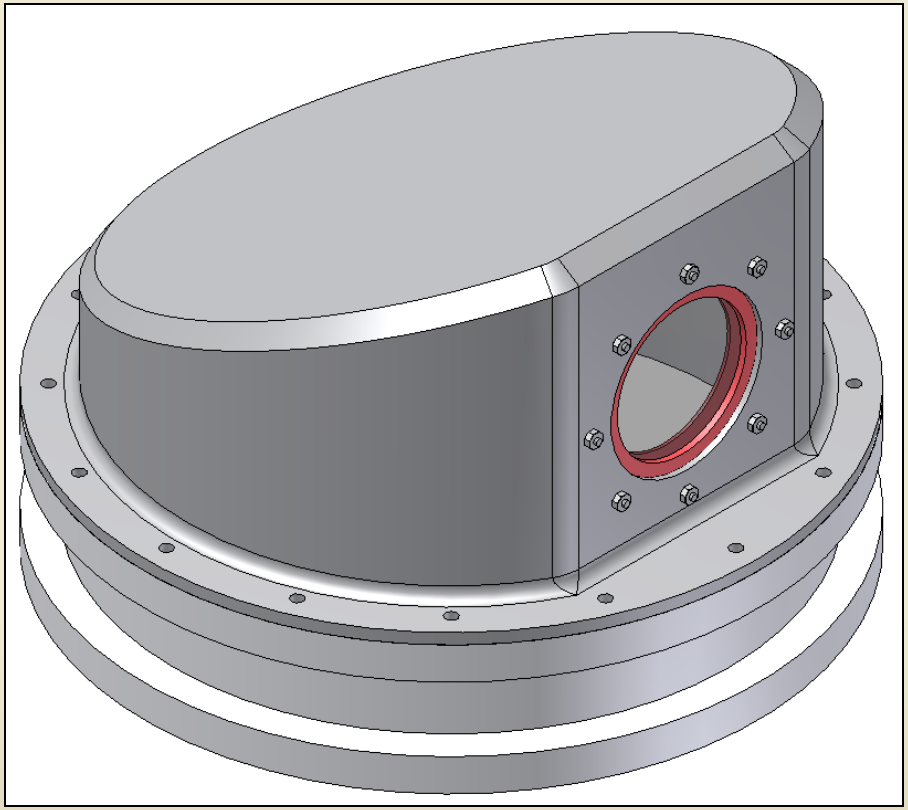
			Power (Watts)	Current (Amps)	
				Peak	Run
115V	60 Hz	1 Φ	1200	12	10
	400Hz	1 Φ	N/A	N/A	N/A
		3 Φ	N/A	N/A	N/A
28 V DC			N/A	N/A	N/A



P-3B INTEGRATION

DLH Instrument

- Description: H2O Mixing Ratio Probe
- Re-fly:
  - Probe: No
  - Rack: Approved P-3 style
- Flight Information:
  - Rack: Shares DACOM Rack
  - Probe Location: Zenith Port
  - Weight: ~100 lbs.
  - Power (See DACOM)



P-3B INTEGRATION

J(NO2) Instrument

- Description: Filter Radiometer
- Re-fly:
  - Probe: No
  - Rack: Approved P-3 style
- Flight Information:
  - Rack: 1 Single Bay Rack
  - Rack Location: 650L
  - Probe Location: FE Hatch and Nadir #2
  - Weight: ~ 50 lbs.
  - Power: Passive

P-3B INTEGRATION

CAPS Instrument

- Description: Cloud Aerosol Precipitation Spectrometer
- Re-fly:
  - Probe: No
  - Rack: Shares LARGE Rack
- Flight Information:
  - Rack: LARGE Rack
  - Power:

			Power (Watts)	Current (Amps)	
				Peak	Run
115V	60 Hz	1 Φ	N/A	N/A	N/A
	400Hz	1 Φ	N/A	N/A	N/A
		3 Φ	N/A	N/A	N/A
28 V DC			1200	50	46

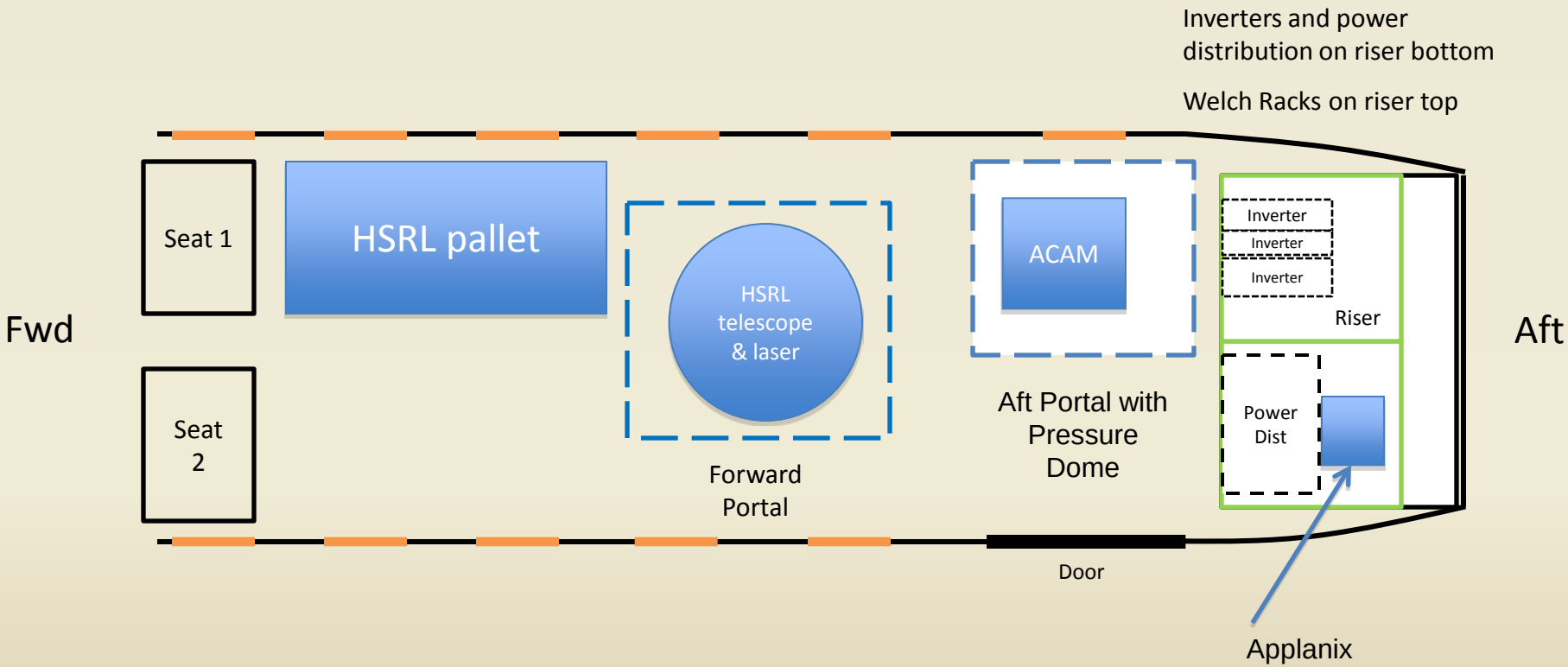
P-3B INTEGRATION

Progress

Instrument	Component	Drawings		CAD		Analysis	FEM?	Report
		New Components	Installation	Components	Assembly			
LARGE	Probe	Done		N/A		Done	N/A	N/A
	Nephelometer	N/A	Convert DC-8 to P-3	N/A		Convert DC-8 to P-3	N/A	Needed
	Pump Pallet	0%	0%	0%	0%	New	N/A	Needed
NOXY	Probe	N/A	Convert DC-8 to P-3	100% Complete	100% Complete	Verify DC-8 meets P-3	N/A	Awaiting Peer Review
TD-LIF	Probe	N/A	0%	100% Complete	Needs to be Verified	New	Started	Needed
DACOM	Probe	N/A	0%	100% Complete	100% Complete	Complete	Complete	Started
	Pump Pallet	N/A	Convert DC-8 to P-3	N/A		Convert DC-8 to P-3	N/A	Needed
DF-GAS	Probe	N/A	Convert DC-8 to P-3	100% Complete	100% Complete	Verify DC-8 meets P-3	N/A	Awaiting Peer Review
AVOCET	Probe	90% Complete	0%	100% Complete	0%	New	Needed	Needed
	Pump Pallet	N/A	0%	N/A		Verify DC-8 meets P-3	N/A	Needed
PT-RMS	Probe	90% Complete	0%	100% Complete	100% Complete	Complete	Complete	Started
	Floor Bottles	0%	0%	0%	0%	New	N/A	Needed
DLH	Probe	90% Complete	0%	100% Complete	Needs to be Verified	Complete	Complete	Reviewed, Awaiting Action
j(NO2)	Zenith	100% Complete	0%	100% Complete	0%	New	N/A	Needed
	Nadir	50% Complete	0%	50% Complete	0%	New	Needed	Needed
CAPS	Probe	0%	0%	0%	0%	New	Needed	Needed
Gas Bottles	150 cf Rack	0%	0%	0%	0%	New	N/A	Needed
	1 cf Rack	0%	0%	0%	0%	New	N/A	Needed
Exhaust Port		0%	0%	0%	0%	New	Needed	Needed

A statement of work (SOW) has been issued requesting contract support for all drafting work.

Generalized Instrumentation Layout on UC-12B



UC-12B Mod for ACAM

- the ACAM instrument will be located over the rear portal of the UC-12B
- The ACAM instrument will be located inside the pressure box (dog house) and will look downward through an opening in an Outer Mold Line (OML).
- Design and Fab an ACAM instrument mounting plate for use in the rear portal in the UC-12B. This plate adapts the ACAM instrument bolt pattern to the UC-12B mounting flanges located in the rear portal.
- The instrument will be brought as close to the Outer Mold Line (OML) of the aircraft as possible to minimize the opening in the lower adapter plate.
- The limiting factor on how close to the OML the ACAM can be brought is interference with the aircraft FOD shutter mechanism.

UC-12B Trial Fit

UC-12B Integration Status

HSRL

- Previously installed on LaRC B200 (same forward nadir portal on both aircraft)
- Currently being refurbished by Science Directorate
- Installed on UC-12B on 2-15-11
- Complete installation on 2-25-11

ACAM

- Test fit of instrument with prototype mounting fixture completed in Oct. 2010
- Fabrication of actual mounting fixture complete
- Instrument delivery to LaRC on 3-3-11
- Complete Installation on 3-10-11

- Complete joint HSRL/ACAM integration and V&V on 3-17-11

UC-12B Description

- Physical Description

Aircraft	Tail Number	Length	Height	Wingspan	Engine	Engine Power
B200	529	43 ft 9 in.	14 ft 6 in.	54 ft 6 in.	2 x Pratt & Whitney PT6A-42	850 SHP each
UC-12B	528	43 ft 10 in.	14 ft 6 in.	54 ft 6 in.	2 x Pratt & Whitney PT6A-41	850 SHP each

Aircraft	Min. Sustained IAS, knots	Normal Cruise Speed, TAS, knots	Service Ceiling (b), kft	Service Ceiling, km	Duration w/max. fuel@55% power, hr	Range w/max. fuel@55% power, n.mi.
B200	100	260	28/35 (c)	8.5/10.7	6.2	1250
UC-12B	100	260	28/31 (c)	8.5/9.5	6.2	1250

- Research Attributes

Aircraft	Tail Number	Avail. Elect. Power, W	Max. Payload (a)(b), lbs	Pressurized	Air Condition-ing	Existing Instr.	Max. Number of Experimenters
B200	529	4200	4100	Yes	Yes	Mission specific	4
UC-12B	528	4200	4100	Yes	Yes	Mission specific	4

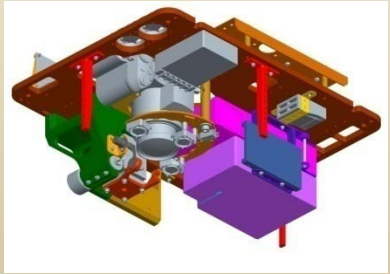
Description of Instruments

High Spectral Resolution Lidar (HSRL)

- Continuous lidar mapping of aerosols
- HSRL provides quantitative information on extensive and intensive aerosol properties.
- This instrument has flown previously on the Langley B-200.
  - Instrument recently surpassed 1000 hours of flight operations.
- HSRL is being moved from B-200 to UC-12 to accommodate DEVOTE.
- Installation requirements for the two aircraft are identical.

Airborne Compact Atmospheric Mapper (ACAM)

- Continuous mapping of trace gas columns
- Two spectrographs and HD video camera
  - Air Quality (NO_2, O_3, UV absorbing aersols, SO_2 HCHO
  - Video camera (2592x1936 pixels)
- This instrument has flown previously on the NASA WB-57.
- Engineering underway to install ACAM in the aft nadir pressure.
- Necessary modifications require fabrication of a mounting plate for the instrument and installation of a zenith-looking fiber optic in the fuselage.



UC-12B Mod for ACAM

ACAM Mounting Plate

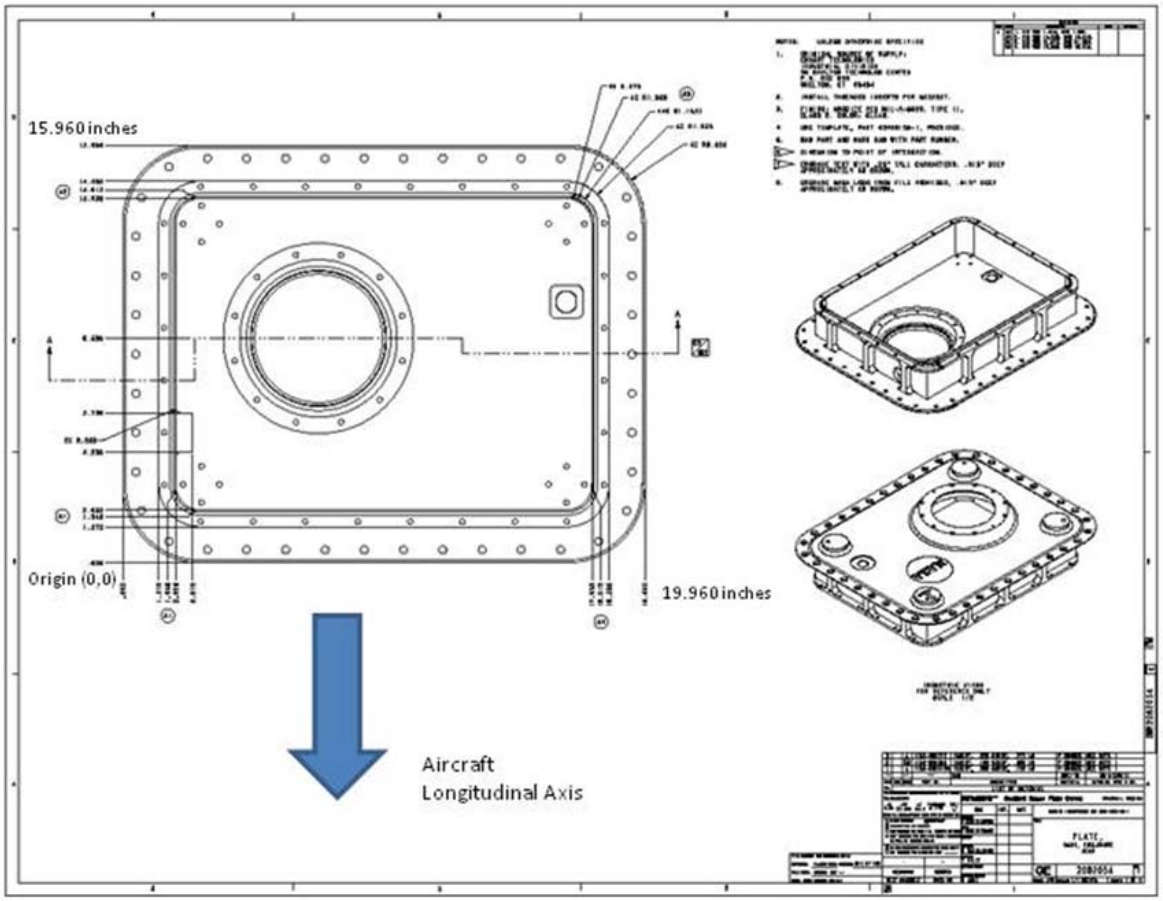
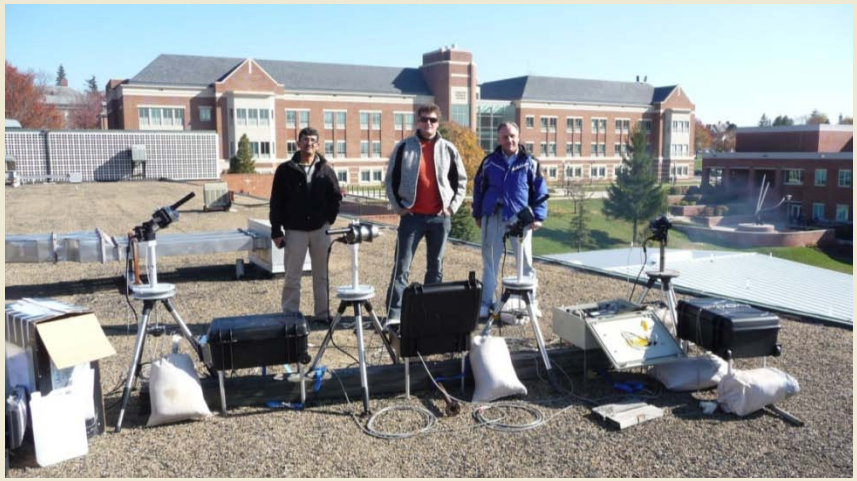


Figure 3. ACAM Instrument Mounting Plate

Ground Instrumentation Status



Testing of newly fabricated Pandora Spectrometers at Frostburg State

NATIVE: *Site plan for approval to place the trailer within Aberdeen Proving Ground being submitted with help of Terry Meade (APG) and Jennifer Hains (MDE)*

Aeronet: *Purchase order for new instruments submitted. DRAGON network will provide for many more (as much as 50) instruments across the area arranged in coordination with Aeronet PI Brent Holben (also a DISCOVER-AQ Co-I).*

Pandora Schedule

October 2010
Received Most Long-Lead items (remaining optical heads due 2/11)
Tested 4 Pandoras in a two week field mission (completed with lessons learned)

November 2010
Ordered/received additional parts, delivery of all parts complete in 2/11

December 2010 – February 2011
Complete assembly of the Pandoras
Mechanical testing of the Pandoras
Radiometric, wavelength, temperature calibration of the Pandoras
(Redoing temperature calibration based on field results)

March 2011
Finish laboratory calibration
Start deployment at GSFC for field calibration and intercalibration

April 2011
Finish field calibration and intercalibration at GSFC
Discuss deployment schedule with DISCOVER-AQ project

Draft DISCOVER-AQ Data Plan

Gao Chen and Jennifer Olson

NASA Langley Research Center

Data Policy

- **Responsibilities of participants:**
  - Submit data according to agreed upon schedule and format
  - All final aircraft data, especially 1 s measurements, should be synchronized to DLH H_2O time line.
  - Provide adequate metadata in data files.
  - Consult with PIs and offer co-authorship when using their measurement data and/or modeling products
  - PIs should be available to answer questions about their data after submission (contact info provided in file headers)
- **All data will become public 4 months after the completion of the experiment**
- **Data updates will be posted prominently, user notification approaches will be explored.**
- **Data to be archived:**
  - Aircraft measurements
  - Model products
  - Ground based measurements
- **Transfer data to LaRC ASDC and ADAM within ~12 months.**

Data Submission Schedule

- Data exchange during the field study
  - Aircraft navigation and ancillary measurement data (REVEAL) within 24 hours of each flight.
  - All other Data should be posted within 24 hours of measurement (if possible).
  - All posted field data deleted when final data become available
- Post-mission data exchange and deadlines
  - Final REVEAL data (P-3B Nav and Met) available 1 month after the deployment.
  - Final data available for public access 4 months after the deployment

Data Format

- The DISCOVER-AQ observational data products will conform to NASA Earth Science Division approved data system standards.
  - in-situ measurement data products will be reported in ICARTT format (ESDS-RFC-019):

http://www-air.larc.nasa.gov/missions/etc/IcarttDataFormat.htm

  - Lidar and other remote sensing products may be reported in HDF 5 format (ESDS-RFC-007):

http://www.esdswg.org/spg/rfc/ese-rfc-007

- All collaboration partners, especially ground-based partners, are strongly encouraged to adopt ICARTT format as the standard for data archival to enhance the capability to exchange data among the group.

Metadata Requirement

DISCOVER-AQ data files require the following metadata:

- ✓ ***Platform and associated location data***
- ✓ ***Data Source Contact Information*** **for** **measurement Co-I and one alternate contact**
- ✓ ***Data Information:*** **Clear definition of measured quantities, along with reporting unit and limitation of data use if applicable**
- ✓ ***Measurement Description:*** **sufficient description of the instrument (operation, capability, calibration procedure, and uncertainties) specific to DISCOVER-AQ campaign operations**
- ✓ ***Measurement Uncertainty:*** **accuracy, precision, and associated confidence level**
- ✓ ***Data Revision Comments:*** **sufficient discussion about rationales for data revision, highlighting issues, solutions, and assumptions**

Data Repositories

DISCOVER-AQ data archive will be open 1 month before the first deployment.

<u>After the archive opens, investigators must:</u>

- **Register their PI dataID (this determines filenaming structure and directory name and location on the NASA archive)**
- **In-situ measurement PI should download FScan (this executable allows data files to be checked for compliance on any computer. The file will be automatically scanned remotely when uploaded to the archive.)**
- **Secured FTP is now a requirement for NASA sponsored ftp sites.**

Data Merge

Combining all measurements from one platform or ground site on a common time base to facilitate analysis of the correlation between measurements.

- Merges will be generated for NASA P-3B data files as well as for ground measurement sites if needed.
- Merges will be generated for both field and final data.
- Merge time base will be 1 sec., 10 sec., and others upon request (e.g., aerosol chemical composition measurement time scale).

Potential Intercomparison Opportunities

For redundant and overlapping measurements:

- **Will accommodate data exchange needs for intercomparison excercises.**
- **Will conduct initial analysis of the intercomparison data**
- **Will communicate results with science team and partners in a timely fashion**
- **Will host a panel review of the intercomparison results.**

(These activities enabled by TABMEP)

Points of contact for DISCOVER-AQ Data Format and Submission Procedures:

Gao Chen (gao.chen@nasa.gov)
Jennifer Olson (jennifer.r.olson@nasa.gov)
Ali Aknan (ali.a.aknan@nasa.gov)
Clyde Brown (clyde.c.brown@nasa.gov)

DISCOVER-AQ
Science Algorithms

Ken Pickering, NASA/GSFC
Scott Janz, NASA/GSFC
Jay Herman, UMBC
Nick Krotkov, NASA/GSFC
Xiong Liu, Harvard-Smithsonian
Maria Tzortziou, UMD

Pandora Trace Gas Retrievals

Jay Herman, UMBC

Maria Tzortziou, UMD

Pandora Total Column Retrievals

- For total column ozone (TCO) and other trace gas amounts, Pandora is operated in direct-sun viewing mode

- A DOAS (Differential Optical Absorption Spectroscopy) spectral fitting algorithm and laboratory measured cross sections are used in the retrieval.

- The fitted functions are a low-order polynomial for aerosols and Rayleigh scattering, the absorption spectra of each atmospheric absorber, and wavelength corrections *[Herman et al., 2009;Tzortziou et al., In Prep].* Wavelength correction functions are applied to provide the best match of the measured spectrum compared to a solar reference spectrum containing the solar Fraunhofer line structure.

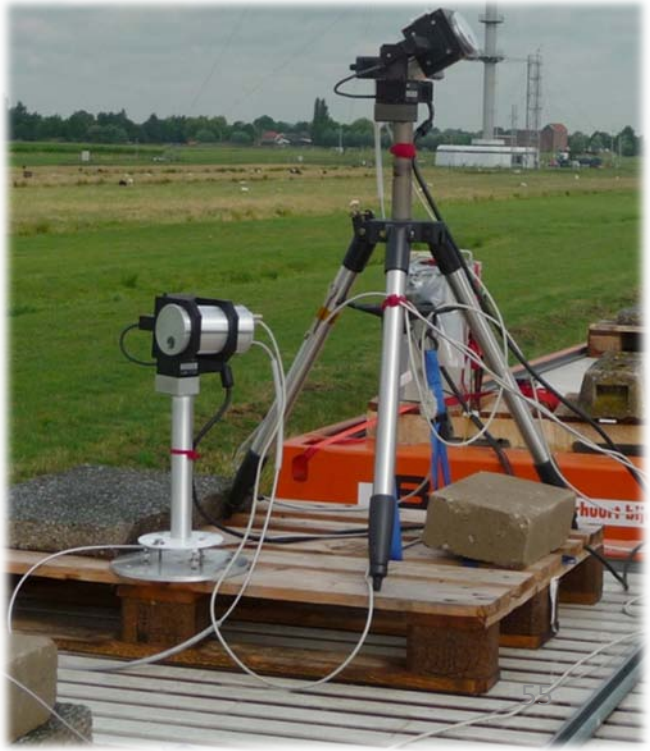
- Spectral fitting window for TCO: 310-330 nm.

- O_3 cross sections: High resolution Daumont (1992)

- Kurucz + SUSIM extraterrestrial solar spectrum

Table: Characteristics of the various TC retrieval algorithms

Trace gas	Fitting window	Cross sections	Calibration method
O_3	310-330nm	Daumont [1992] at 225K	Use Extraterrestrial spectrum
NO_2	400-460nm	Vandaele et al. [1998] at 255K	Use Extraterrestrial spectrum
SO_2	310-330nm	Vandaele et al. [1994] at 259K	MLE (modified Langley extrap.)
H_2O	464-515nm	Rothman [2009] at 273K	MLE
HCHO	328-357nm	Meller and Moortgat [2000] at 257K	MLE
CHOCHO	414-457nm	Volkhamer et al. [2005] at 257K	MLE



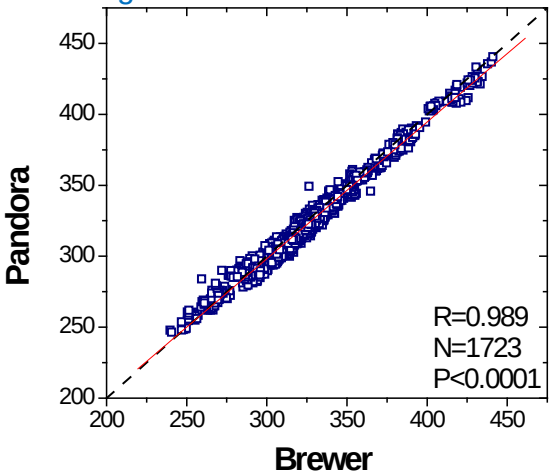
Jay Herman (Jay.R.Herman@nasa.gov)
Maria Tzortziou (maria.a.tzortziou@nasa.gov)

Pandora Total Column Ozone Retrievals

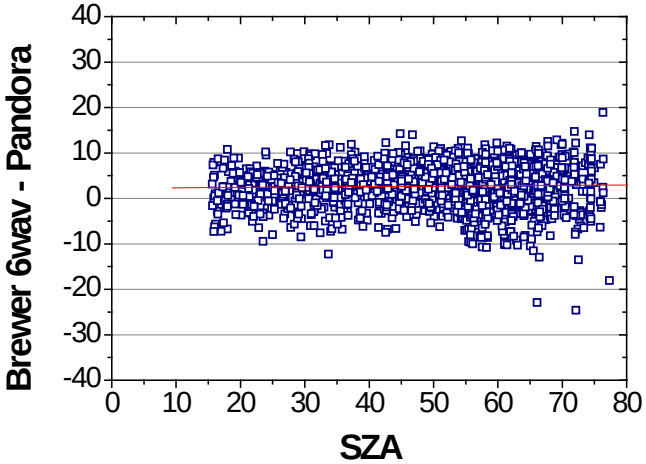
Comparison between TCO from Pandora and Brewer (#171) at the GSFC site

→ Pandora was interpolated to Brewer time (only if closer than 5 min.).
→ Pandora filtering: Normalized RMS of weighted spectral fitting residuals < 0.05 and uncertainty in TCO <2 DU.
→ Brewer filtering: standard error in TCO < 2 DU (the Brewer 6-wavelength algorithm was used in the retrievals).

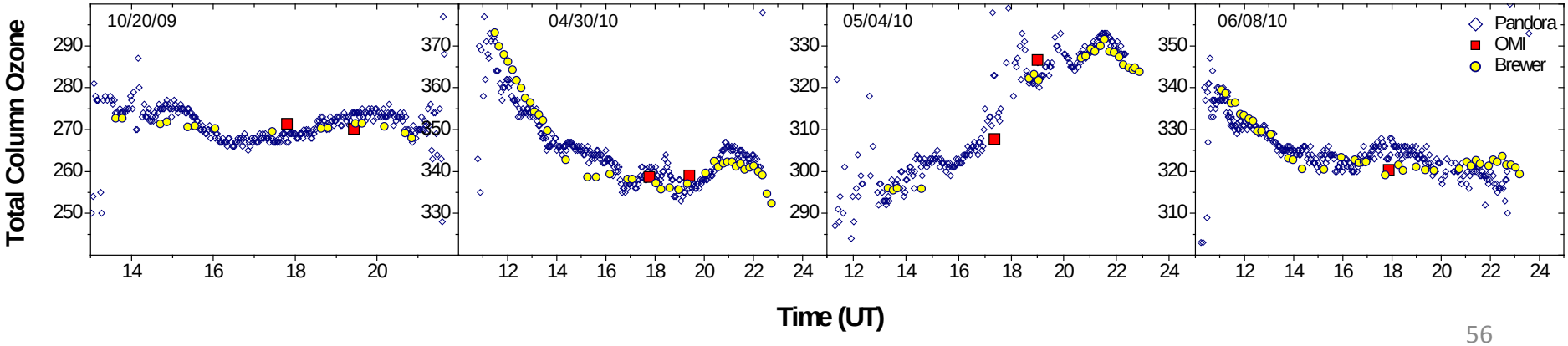
- Very good correlation between Pandora and Brewer
- Average Difference of 2.7 DU



- No significant solar-zenith-angle dependence of Brewer-Pandora residuals



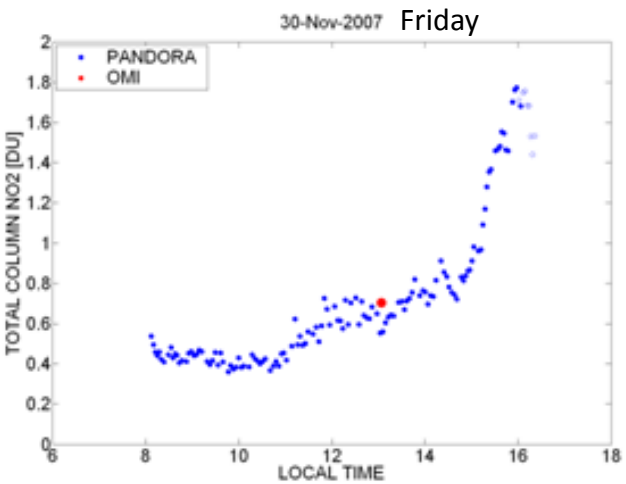
- Close agreement throughout the day between Brewer and Pandora, and also good agreement with OMI over GSFC

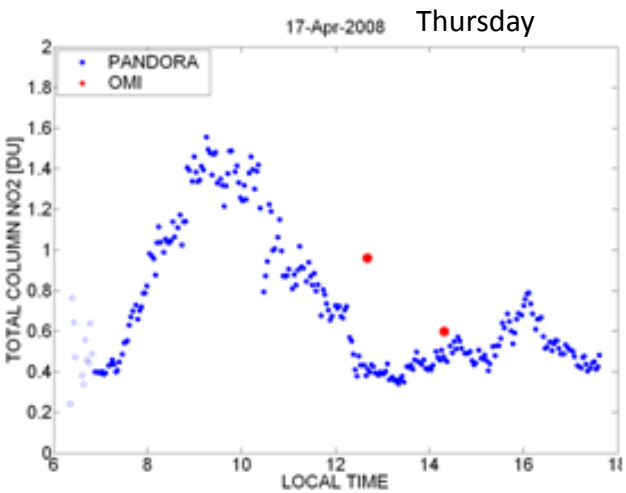


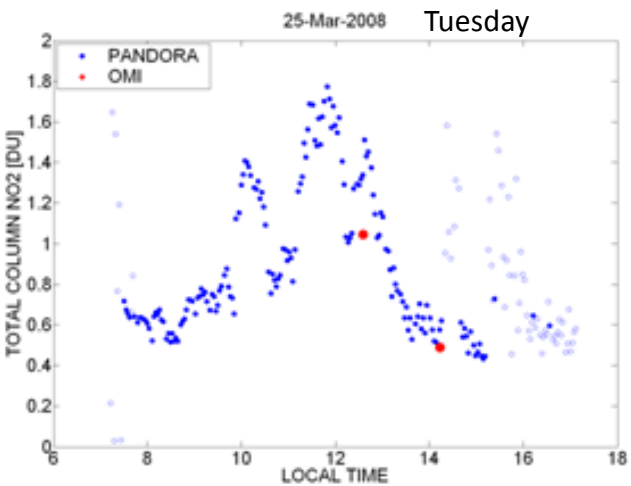
Maria Tzortziou (maria.a.tzortziou@nasa.gov)

How Does NO_2 vary day to day?

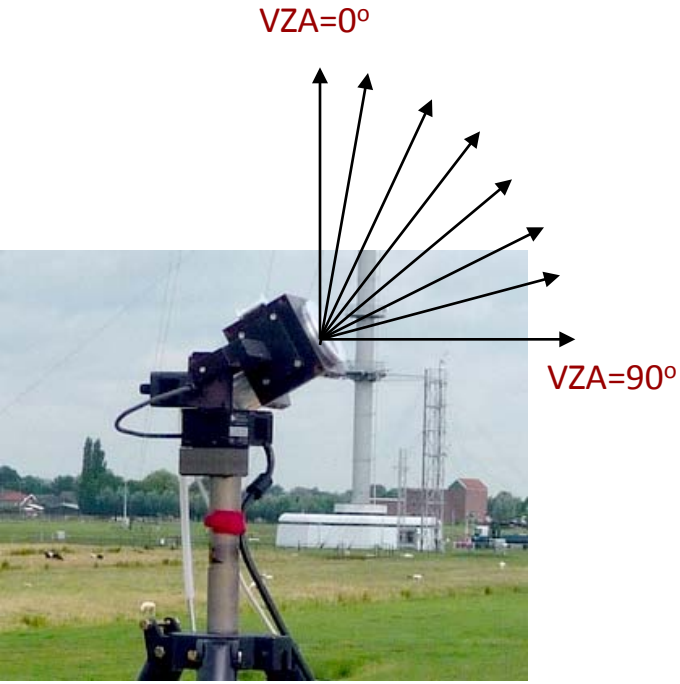
3 examples of the diurnal variation of the total NO_2 column at Goddard Space Flight Center measured with PANDORA-1; days with large NO_2 amounts were picked; OMI data are red and PANDORA data are solid blue for cloud screened data and open blue for cloud-affected data







Pandora Profile Retrievals



Examples from Brewer retrievals

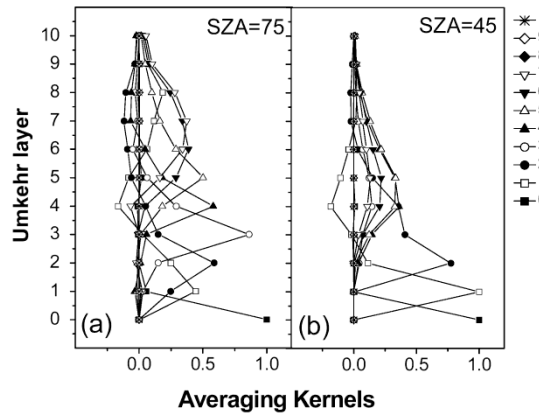


Fig 1: Averaging Kernels at SZAs (a) 75º and (b) 45º. Umkehr layers are just 5 km thick layers.

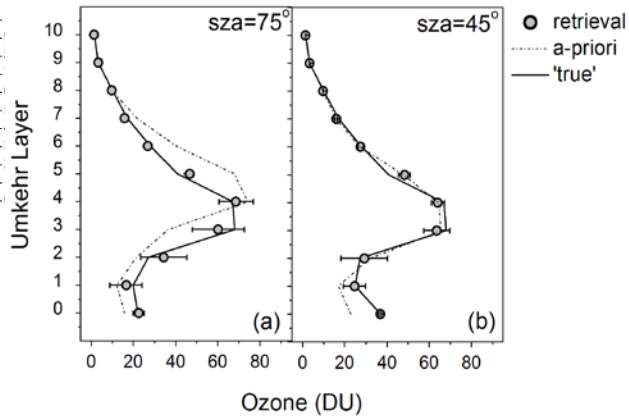


Fig 2: Climatological a-priori, "true", and retrieved O_3 profiles for retrievals at (a) SZA=75º and (b) SZA=45º.

Profile Inversion Algorithm:

● The inversion strategy for O_3 profile retrieval uses a vector multiple scattering forward radiative transfer model to simultaneously fit Pandora's **angular** and **high-resolution spectral measurements of sky radiance** constrained by nearly simultaneous direct-sun total column ozone measurement (TCO).

● The inversion algorithm is based on the optimal estimation approach [Rodgers, 2000], and uses climatological a-priori O_3 profile information to stabilize the retrieval.

- Similar approach will be used for NO2 profiles

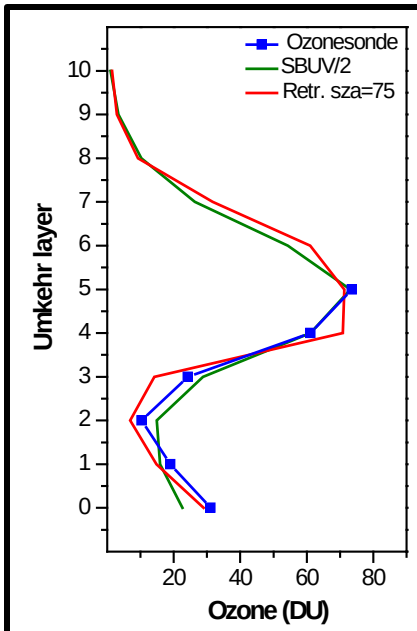


Fig 3: Brewer O_3 profile retrieval (sza=75°) for 23 July 2005 for the real atmosphere with aerosols. The SBUV2 O_3 profile and the ozonesonde results are also shown.

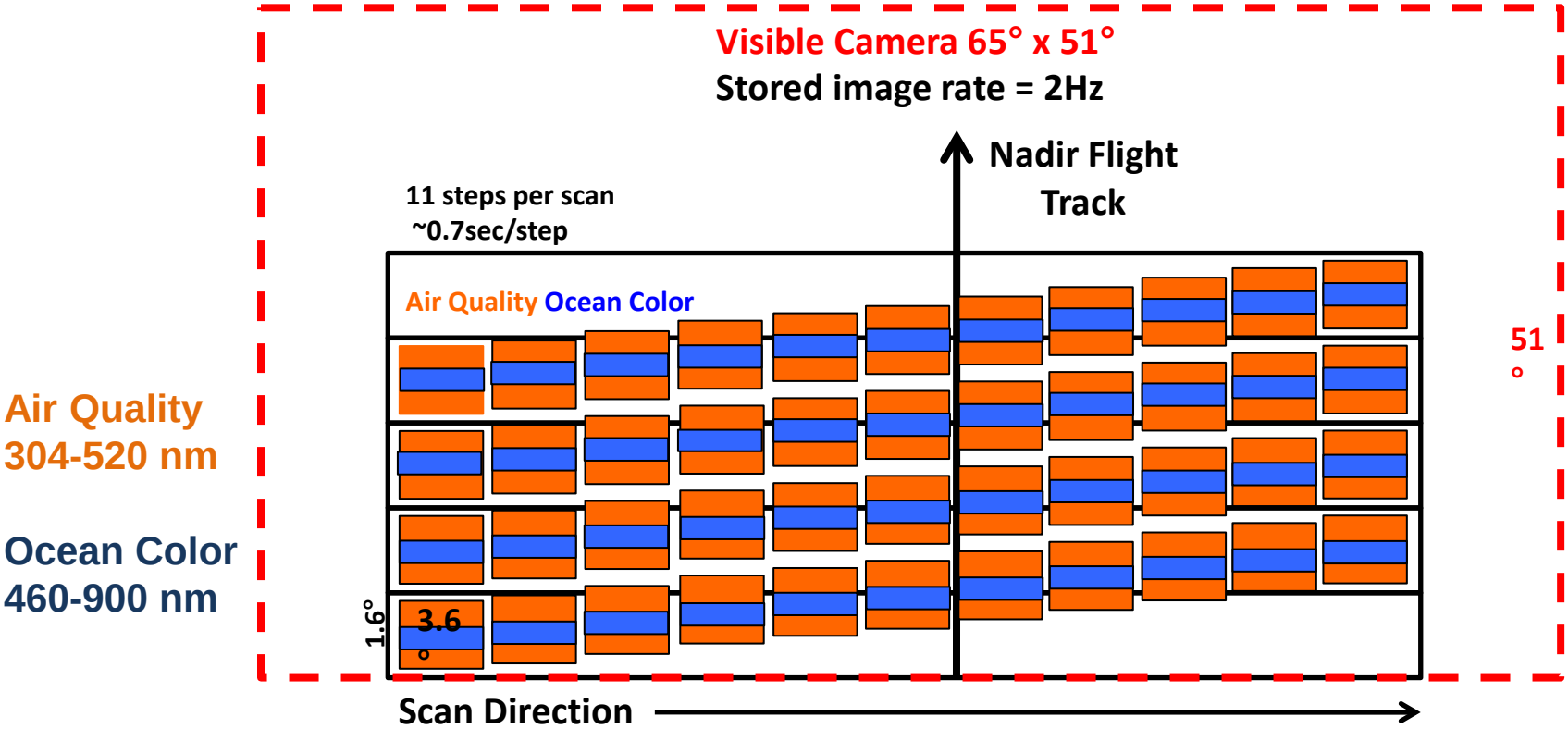
ACAM Slant Column NO_2 Retrievals

S. Janz/GSFC

Measurement Flow

- Sensor Response
  - Calibrated and geolocated radiances
    - Slant Column amounts

- The sensor response is recorded at each scan position in the cross-track direction for each spectrometer simultaneously. A zenith sky measurement is taken every 10 minutes for calibration.



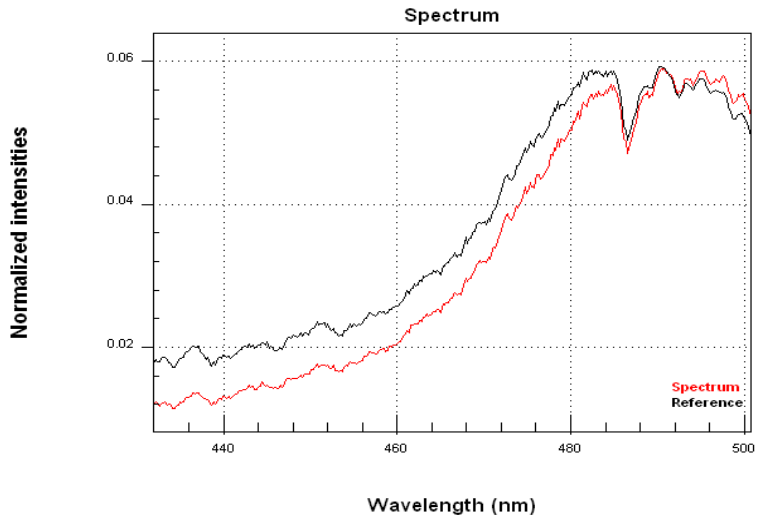
Calibrated Radiances

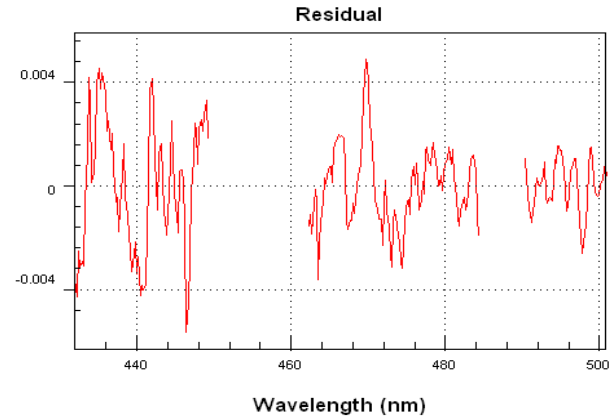
- The algorithm for converting from sensor counts to radiance [mW/m^2/ster/nm] is a straightforward application of sensor artifact subtraction [dark current, bias, linearity table, etc.] followed by normalizing the pixel response to it's calibrated sensitivity.
- Pre and post-mission radiometric calibrations are performed at GSFC's Radiometric Calibration and Development Facility (RCDF) in code 613.3
- Spectrometer calibration stability is monitored during the mission with a portable calibration system.
- Absolutely calibrated radiances are not required for the GSFC NO_2 slant column algorithms but are required for the SAO vertical column algorithms.
- It's still TBD whether radiances will be archived.

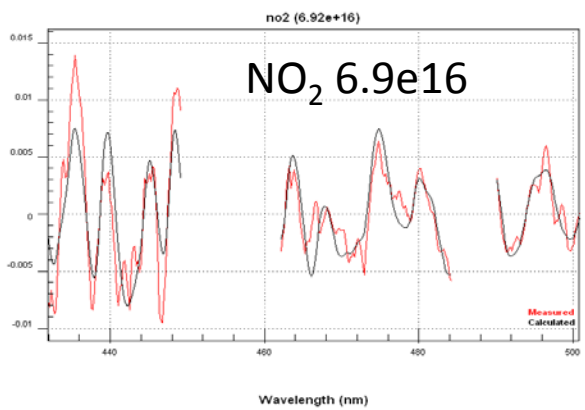
Slant Column NO_2

- Slant column amounts are derived by normalizing the sensor spectra to a reference (usually zenith) to remove stratospheric absorption and solar spectral features.
- The log-normalized spectra is fit by a low-order polynomial and a linear combination of absorber cross-sections. (The ring effect is included as a pseudo-absorber.) The Non-linear Least Squares (NLLS) fitting routine also fits wavelength shifts between measured and reference spectra.
- One or more fitting windows (432-449 nm is typical) are used that have high sensitivity to the NO2 cross-section. High resolution database cross-sections are convolved with the instrument slit function prior to fitting.

Fit Example Results







- High resolution cross-sections are convolved with the measured instrument slit function
- NLLS routine minimizes residual between the sum of the cross-sections and polynomial included in fit and ln(spectrum/reference)
- A wavelength shift parameter is included in the fitting to account for instrument spectral registration drift.

Development Plans

- Development plans
  - Slant column NO_2 algorithm is in-place and needs no further development
  - Vertical column NO_2 by direct fitting is being developed at SAO (Rob Spurr) and at GSFC using air-mass factor method (GSFC). Both techniques should be available approximately 6 months after 1st deployment.

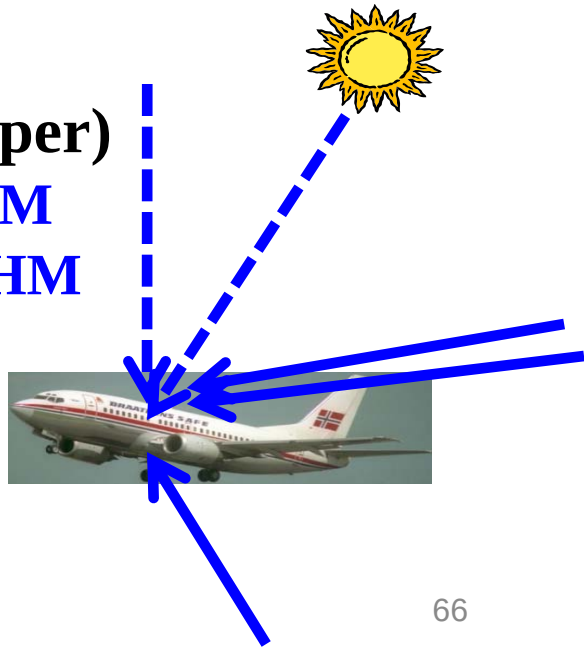
Retrievals of Tropospheric Ozone Profiles, HCHO Vertical Column Density, and Aerosol Index from ACAM Measurements

Xiong Liu (xliu@cfa.harvard.edu)

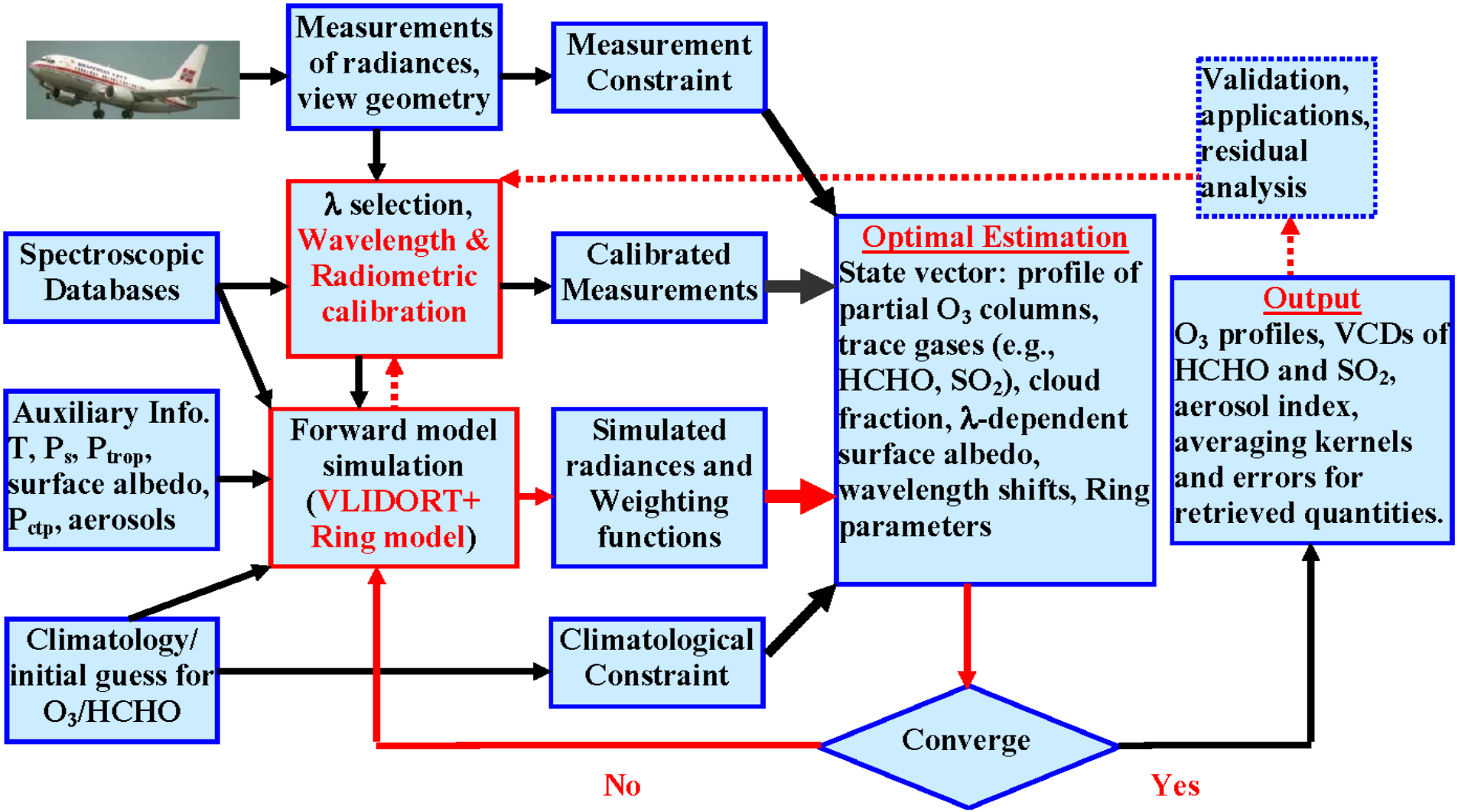
Harvard-Smithsonian Center for Astrophysics

Introduction

- **An algorithm has been developed to retrieve O_3 profile including tropospheric O_3, vertical column densities of a few trace gases (e.g., BrO, HCHO), and aerosol index from GOME and OMI BUV measurements (270-340 nm) (Liu et al., 2005, 2010).**
- **A technique was proposed to retrieve tropospheric O_3 profiles from Airborne UV and Visible data (300-340 nm, 500-650 nm) at two up-looking and one down-looking angles (Liu et al., 2005), as shown in the diagram below.**
- **ACAM (Airborne Compact Atmospheric Mapper)**
  - **Air Quality channel: 304-520 nm, 0.8 nm FWHM**
  - **Ocean Color channel: 460-900 nm, 1.5 nm FWHM**
  - **Cloud camera for cloud detection**
  - **Nadir scan (-21º to 18º), zenith-sky (2º)**
- **Modify the OMI algorithm for ACAM data.**



Schematic Diagram of Retrieval Algorihtm



- **Keys to successful retrievals: accurate calibration and forward model simulation**

Algorithm Description

- **Measurement Vector:**
  - **Down-looking UV/Vis. data normalized by zenith-sky measurements**
  - **or Down-looking and zenith-sky data normalized by solar reference**
- **Spectral fitting (304-360 nm, and 500-650 nm if possible)**
- **Use VLIDORT to simulate radiances and Jacobians, accounting for the sensitivity of measurements to O_3, trace gases, surface, aerosol, and cloud properties:**
  - **Cloud: Mixed Lambertian with effective cloud-top pressure and cloud fraction derived from ACAM data (non O_3 absorbing, Ring effect, O_4/O_2 absorption)**
  - **Aerosols: using either known measurements on the same aircraft or effectively accounting for aerosols in the surface albedo treatments**
  - **Surface albedo: Lambertian surface with wavelength-dependent surface albedo (partly account for aerosols or calibration)**
  - **Trace gases: monthly mean profiles from GEOS-Chem or GMI simulations, profile shapes at a location/month are fixed.**

Algorithm Description

- **State vector/outputs:**
  - **Profile of partial O_3 columns**
  - **Vertical column densities trace gases (e.g., HCHO): implicitly use model profile shapes and wavelength dependent air mass factors to directly retrieve VCD**
  - **Aerosol index: derived from the first-order wavelength dependence in the surface albedo α_1 as follows (λ_1 and λ_2 can be 340 and 360 nm like those in the TOMSV8 algorithm)**

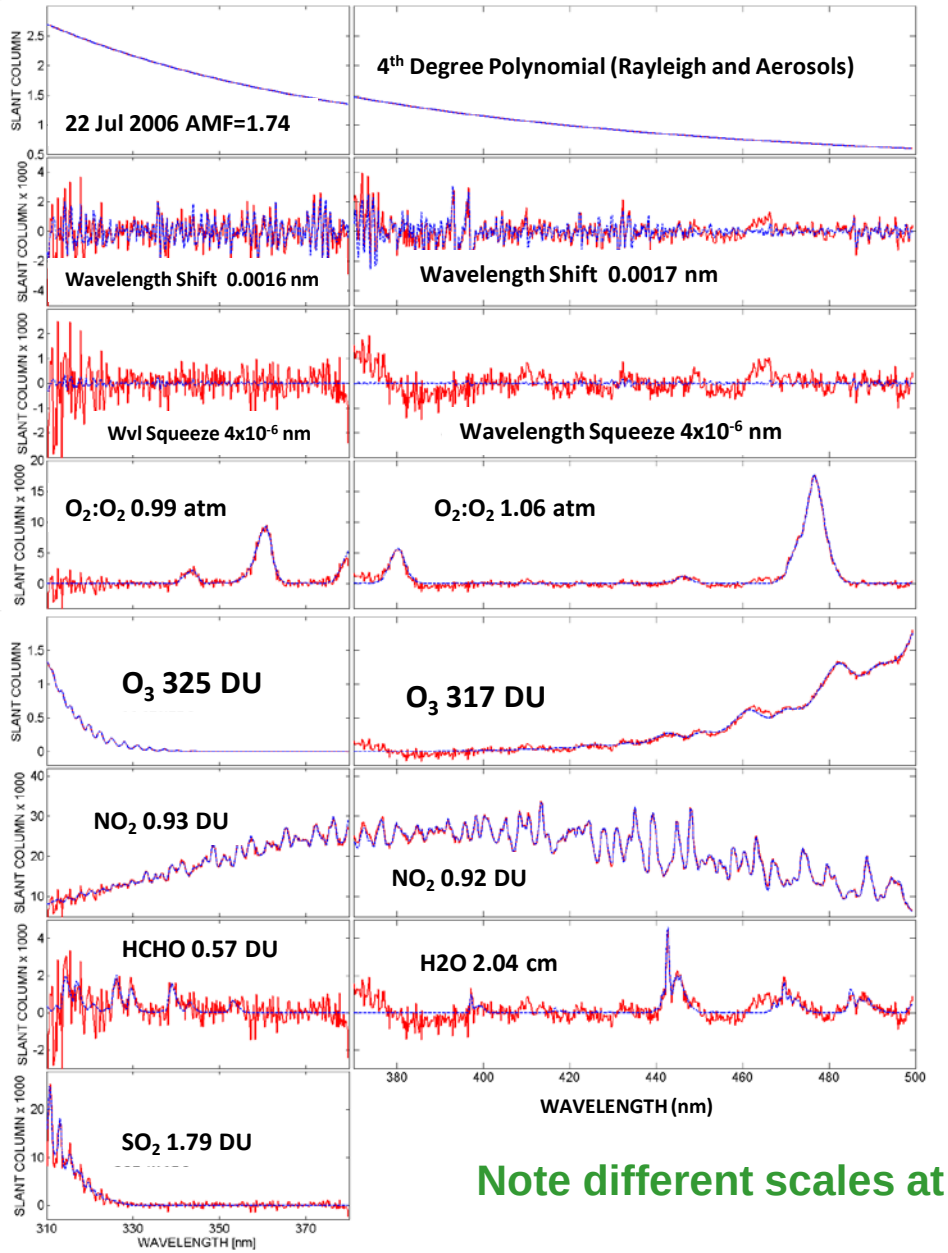
$$AI = 100 \times \left(\frac{d \ln I_{\lambda 2}}{d\alpha_1} - \frac{d \ln I_{\lambda 1}}{d\alpha_1} \right) \times \alpha_1$$

  - **Averaging kernels for both O_3 (matrix) and HCHO (vector)**
  - **Random-noise/smoothing errors for O_3, HCHO, and aerosol index**

ACAM Algorithm Development Plan

- **Currently, the algorithm is operational for OMI data, need to modify this algorithm for using ACAM data**
- **ACAM Algorithm Development Plan**
  - **Add interfaces to read ACAM data, prepare outputs, and perform radiative transfer calculations**
  - **Test ACAM data from the GloPac measured in April 2010**
  - **Initially do UV retrievals for clear-sky conditions (use cloud camera)**
  - **Check instrument slit functions and wavelength calibrations using a high-resolution solar reference spectrum**
  - **Check radiometric calibrations using collocated OMI/MLS retrievals**
  - **Determine whether to use zenith-sky/external solar reference as normalization and optimize fitting windows**
  - **Determine if need to co-add ACAM data spatially and spectrally**
  - **Make the retrieval algorithm operational for clear-sky UV measurements before the first DISCOVER-AQ campaign**
  - **Develop cloud retrieval algorithm: combine Ring effect or O_4/O_2 absorption bands, non O_3 absorbing wavelengths)**

Backup Slides



Spectral fitting

Left (310-375 nm) **Right** (375-500)

Measurement (**red**), Spectral fit (**blue**)

Left side: Fit with a 4th order polynomial, wavelength correction, and absorptions of O_2:O_2, O_3, NO_2, HCHO, and SO_2 in the 310-380nm window, fitting rms=0.085%

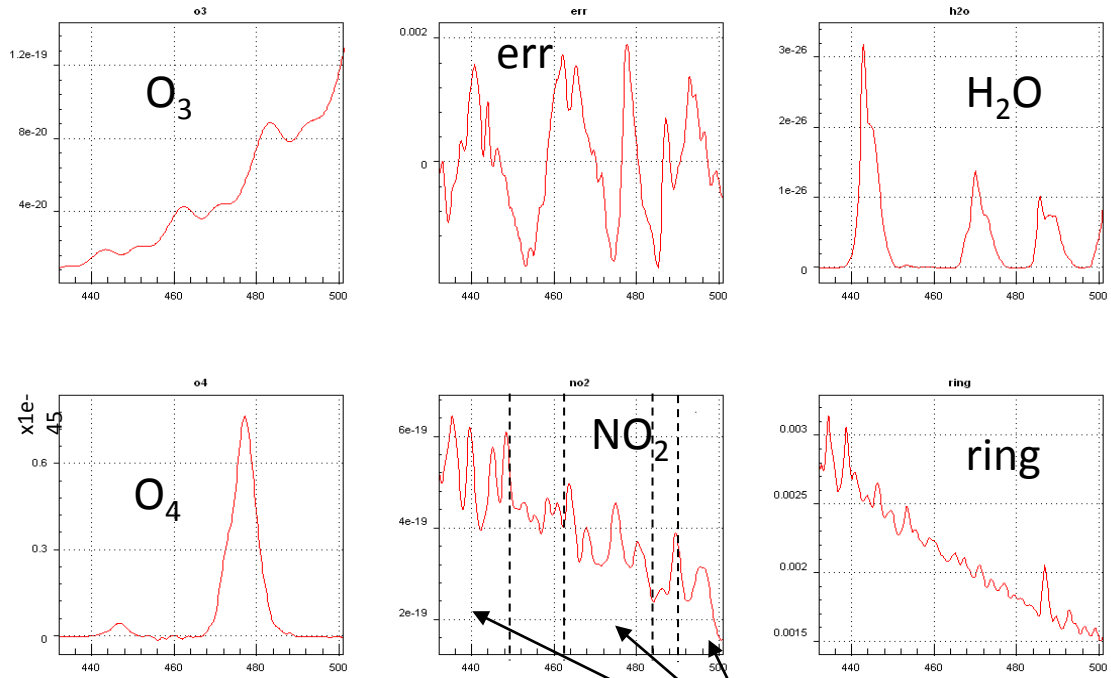
Right side: fit with a 4th order polynomial, wavelength correction, and absorptions of O_2O_2, O_3, NO_2, and H_2O in the 370-500nm window, fitting rms=0.058%

Data in figure legends give the retrieved vertical columns

Note different scales at y-axis!

Fit example cross-sections

[CR-AVE mission - Houston]



Cross-sections [cm2] used in fitting routine

NO_2 - Vandaele
H_2O - HiTran
O_2O_2 – Merged Hermans/Newham
O3 – Merged Bass&Paur/GOME-2
Ring – Chance & Spurr algorithm
Err – empirically derived instrument error function

Fitting Windows
432-449 nm
462-484 nm
490-501 nm

Algorithm Description

- **Correction of Ring effect: model 1st-order RRS using a single scattering model (Sioris and Evans, 2000)**
- **Daily NCEP/GEOS-5 temperature profiles and surface pressure**
- **Check ACAM slit functions and wavelength registration with a high-resolution solar reference spectrum and check ACAM radiometric calibrations (using collocated O_3 data)**
- **Inversion technique: Non-linear iterative optimal estimation with ozone profile climatology (McPeters et al., 2007) and CTM trace gas profiles to constrain retrievals**

Cost Function

$$\chi^2 = \left\| \mathbf{S}_y^{-\frac{1}{2}} \{ \mathbf{K}_i (\mathbf{X}_{i+1} - \mathbf{X}_i) - [\mathbf{Y} - \mathbf{R}(\mathbf{X}_i)] \} \right\|_2^2 + \left\| \mathbf{S}_a^{-\frac{1}{2}} (\mathbf{X}_{i+1} - \mathbf{X}_a) \right\|_2^2$$

Solution

$$\mathbf{X}_{i+1} = \mathbf{X}_i + (\mathbf{K}_i^T \mathbf{S}_y^{-1} \mathbf{K}_i + \mathbf{S}_a^{-1})^{-1} \{ \mathbf{K}_i^T \mathbf{S}_y^{-1} [\mathbf{Y} - \mathbf{R}(\mathbf{X}_i)] - \mathbf{S}_a^{-1} (\mathbf{X}_i - \mathbf{X}_a) \}$$

ACAM Algorithm Development Plan

- **ACAM Algorithm Development Plan (continue)**
  - **Prepare spectroscopic databases for using Visible measurements**
  - **Test and optimize retrievals with additional Visible measurements**
  - **Improve aerosol treatments using in-situ/LIDAR aerosol properties measured from the same aircraft.**
  - **Simultaneous retrievals of aerosols, ozone, and HCHO.**
  - **Improve the treatment of surface albedo (especially in the Chappuis bands) using surface albedo models of various vegetation types**
  - **Validation retrievals against other correlative satellite or in-situ measurements.**

Approach to Requirements Verification and Validation

DISCOVER-AQ will track requirements through the use of a Verification and Validation (V&V) matrix identifying each requirement and assigning responsibility to appropriate team members with the necessary activity to verify that the requirement has been met.

Requirement flow down will be established from Level 1 requirements down to the individual instruments in the DISCOVER-AQ suite.

It will be the Principal Investigator's responsibility to approve the verification of individual requirements. From the combined achievement of individual requirements, it will be the PI's responsibility to validate the attainment of stated science objectives to the satisfaction of stakeholders and requirement owners at NASA HQ.

Verification and Validation Matrix Structure

The V&V matrix will follow the example format provided below:

Requirement No.	Requirement Text	Verification Method	Activity associated with Verification	Executer of Verification	Requirement Owner	Approver	Planned Verification Date(s)	Actual Verification Date
411a	Conduct at least four (4) aircraft measurement campaigns over four years to sample locations that routinely exceed EPA air quality standards	I	Inspection of deployment records (e.g., flight requests and flight reports)	PM (Mary Kleb)	NASA-HQ	Jim Crawford	After each deployment and at investigation closeout	

Data fields in the V&V matrix are defined as follows:

Requirement No. – Based on the section and paragraph of the PLRA document from which the requirement is derived

Requirement Text – A clear and concise statement of the requirement

Verification Method – Chosen from Inspection, Analysis, Testing, or Demonstration

Activity Associated with Verification – A clear and concise statement of the necessary action enabling verification

Executer of Verification – Team member responsible for executing the verification method and reporting on the verification activity

Requirement Owner – NASA HQ

Approver – Principal Investigator

Planned Verification Date – Deadline for meeting the requirement

Actual Verification Date – Date on which the approver signed off on verification

(Plan to introduce an additional column to address intermediate verification dates. For instance, verification of measurement requirements will consist of an initial test flight, monitoring of instruments during science flights, and QC of post-mission data)

Verification and Validation Matrix Delegation of Execution

The following team members will be delegated responsibility for requirements verification and reporting to the PI for approval

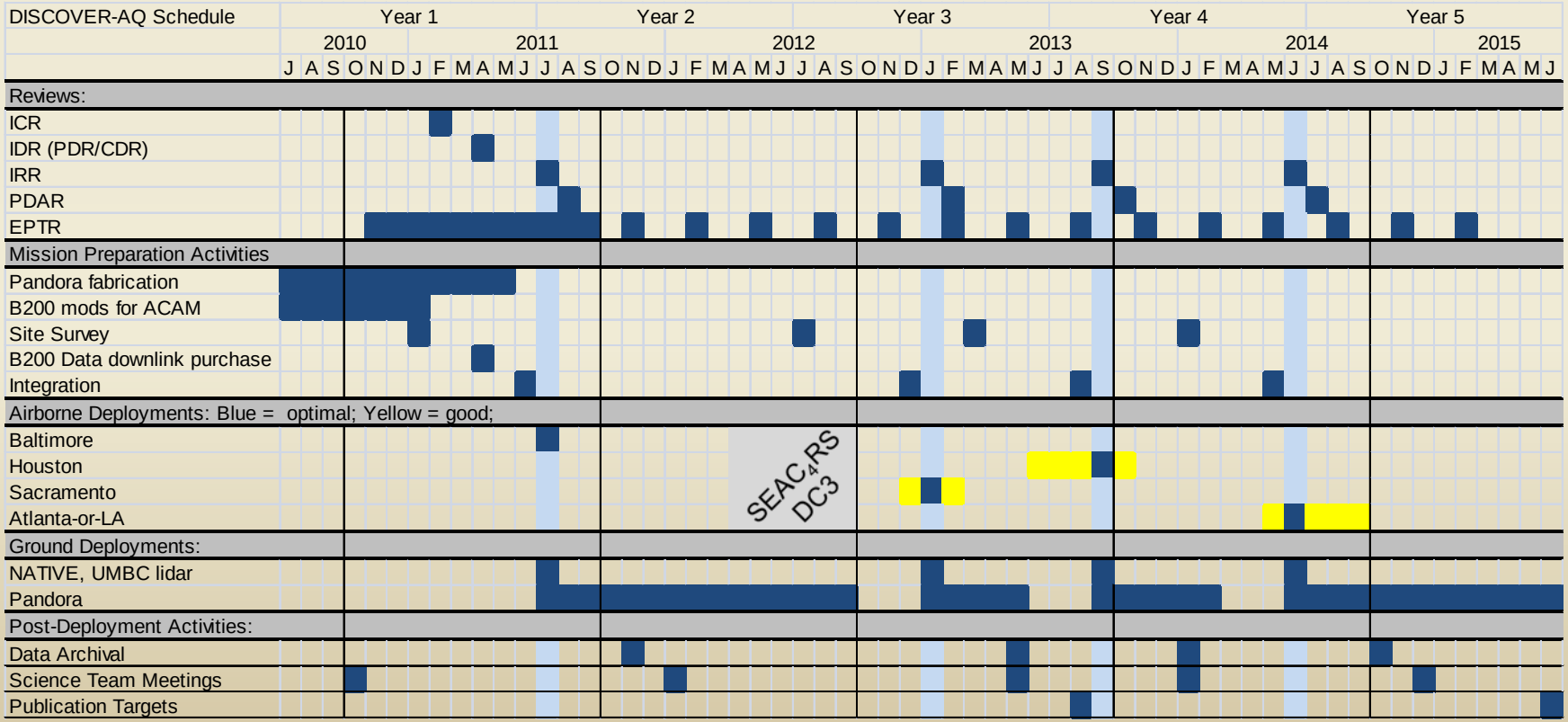
Team Member:	Responsible for requirements related to verification of:
Project Manager	Operational statistics (e.g., completed deployments)
Project Scientist	Operational design (e.g., successful characterization of atmosphere through concurrent measurements
Data Manager	Requirements related to data standards and archival
Co-Investigators	Requirements related to measurement requirements specific to their instrument(s)*
Chief Engineer	Requirements related to platform capabilities
Platform Pilots	Requirements for flight airspace

*Preliminary verification of instrument requirements already demonstrated through deployment in previous campaigns. It is standard practice for instrument performance to be reverified at the beginning of each deployment and continuously scrutinized throughout the deployment both during flight as well as on the ground to ensure high standards are met.

Project Management - Schedule

General Schedule

- For big picture – not official schedule
- Light blue vertical lines reference deployments
- Note – other R&A activities in FY12



Schedule for Finalizing Future Deployments

Winter 2013 - Sacramento

- Final decision no later than January 2012 (Science Team Meeting)
- Informal discussions indicate the California's Central Valley, Bakersfield-Fresno area, in February may be more appropriate than Sacramento and preserves partnership with California Air Resources Board.
- Utah also a candidate.

Fall 2013 - Houston

- Location is solid, but precise timing to be negotiated with partners (TCEQ and University of Houston) at least one year in advance
- DOE partners are expressing interest in proposing a collaborative flight study

Summer 2014 – TBD (Los Angeles or Atlanta-Birmingham suggested in proposal)

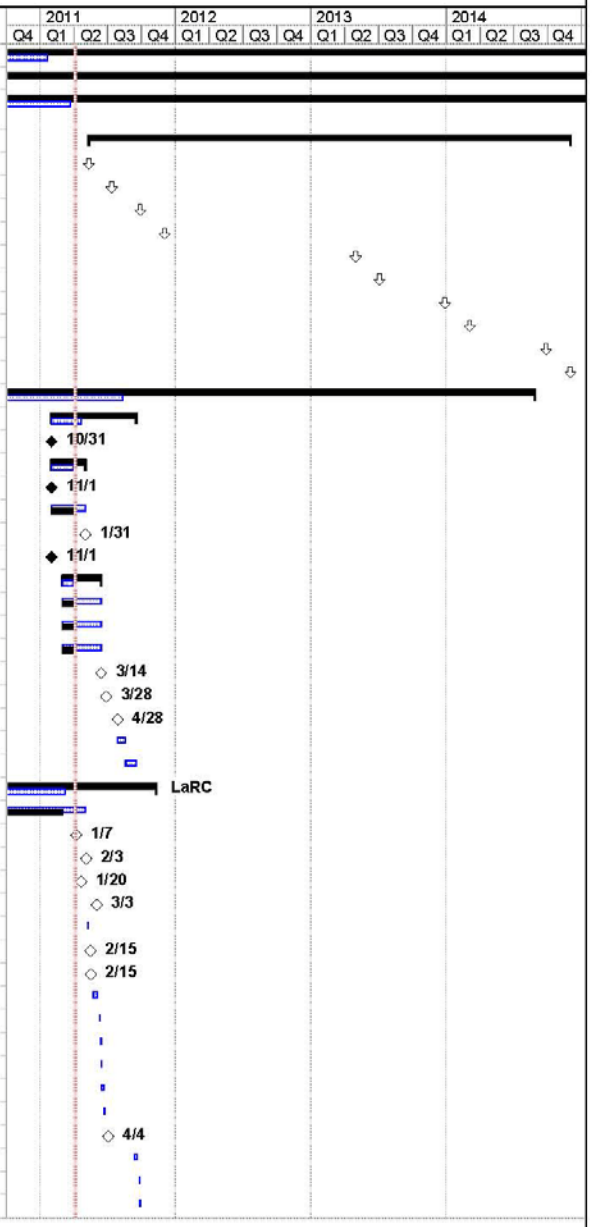
- Final decision no later than April 2013 (Science Team Meeting)
- News of partner activities being planned for the summer 2014 time period could accelerate this decision.
- Additional candidates include: St. Louis, Chicago, and Indianapolis (all have sufficient ground networks)

Earth System Science Pathfinder (ESSP) Program Office

*** For Internal Review Use ONLY ***

Status as of 12/31/10
Today's Date: 1/11/11

ID	Proj WBS	Name	Duration	Start	Finish
90		**Earth Venture**	**2953 days?**	**1/4/10**	**9/30/21**
91		**Earth Venture-1 (Sub-orbital)**	**1421 days?**	**1/4/10**	**8/28/15**
391		**Deriving Information on Surface Conditions from Column and Vertically Resolved (DISCOVER-AQ) Milestones**	**1296 days**	**7/1/10**	**8/28/15**
392		**Major Reviews**	**896 days**	**2/10/11**	**9/3/14**
393		ICR	0 days	2/10/11	2/10/11
394		IDR	0 days	4/13/11	4/13/11
395		IRR (1)	0 days	6/29/11	6/29/11
396		PDAR (1) (NLT)	0 days	9/2/11	9/2/11
397		IRR (2)	0 days	1/31/13	1/31/13
398		PDAR (2) (NLT)	0 days	4/5/13	4/5/13
399		IRR (3)	0 days	9/30/13	9/30/13
400		PDAR (3) (NLT)	0 days	12/5/13	12/5/13
401		IRR (4)	0 days	6/30/14	6/30/14
402		PDAR (4) (NLT)	0 days	9/3/14	9/3/14
403		**Mission Preparation Activities**	**982 days**	**7/1/10**	**5/30/14**
404		**Pandora**	**158 days**	**10/31/10**	**6/17/11**
405		Received Long-lead items	0 days	10/31/10	10/31/10
406		**Pandora Assembly**	**61 days**	**11/1/10**	**1/31/11**
407		Start Assembly of the Pandoras	0 days	11/1/10	11/1/10
408		Assembly of the Pandoras	61 days	11/1/10	1/31/11
409		Finish Assembly of the Pandoras	0 days	1/31/11	1/31/11
410		Start Mechanical Testing of the Pandoras	0 days	11/1/10	11/1/10
411		**Pandora Calibration**	**70 days**	**12/1/10**	**3/14/11**
412		Radiometric Calibration of the Pandoras	70 days	12/1/10	3/14/11
413		Wavelength Calibration	70 days	12/1/10	3/14/11
414		Temperature Calibration	70 days	12/1/10	3/14/11
415		Finish Laboratory Calibration	0 days	3/14/11	3/14/11
416		Start Deployment at GSFC for Field Calibration and Intercalibration	0 days	3/28/11	3/28/11
417		Finish Field Calibration and Intercalibration at GSFC	0 days	4/28/11	4/28/11
418		Installation of Pandoras at remote sites	15 days	4/29/11	5/19/11
419		Operation of Pandoras at remote sites prior to aircraft flights	20 days	5/20/11	6/17/11
420		**UC-12 Mods for ACAM**	**279 days**	**7/1/10**	**8/10/11**
421		UC-12 mods for ACAM	145 days	7/1/10	1/31/11
422		UC-12 SRR	0 days	1/7/11	1/7/11
423		Airworthiness and Safety Review Board	0 days	2/3/11	2/3/11
424		UC-12B Flight Test Operations and Safety Report (FTOSR)	0 days	1/20/11	1/20/11
425		UC-12 ASRB: OSR (If needed)	0 days	3/3/11	3/3/11
426		UC-12B Flight Safety Release (FSR)	1 day	2/7/11	2/7/11
427		Deliver ACAM to UC-12	0 days	2/15/11	2/15/11
428		Deliver HSRL to UC-12	0 days	2/15/11	2/15/11
429		UC-12B Upload	9 days	2/22/11	3/4/11
430		UC-12B Functional Flight Check (FCF) & Flight Readiness Review (FRR	1 day	3/11/11	3/11/11
431		UC-12B Experimental Systems Readiness Review (ESRR)	1 day	3/14/11	3/14/11
432		UC-12B Instrument Check Flight (ICF) & ???	1 day	3/15/11	3/15/11
433		UC-12B Test Flights	5 days	3/16/11	3/22/11
434		UC-12B Download	3 days	3/23/11	3/25/11
435		Initiate PR for UC-12 ???	0 days	4/4/11	4/4/11
436		UC-12B Upload	5 days	6/14/11	6/20/11
437		UC-12B Flight Readiness Review (FRR)	1 day	6/27/11	6/27/11
438		UC-12B Functional Flight Check (FCF) & Experimental Systems Readine	1 day	6/28/11	6/28/11



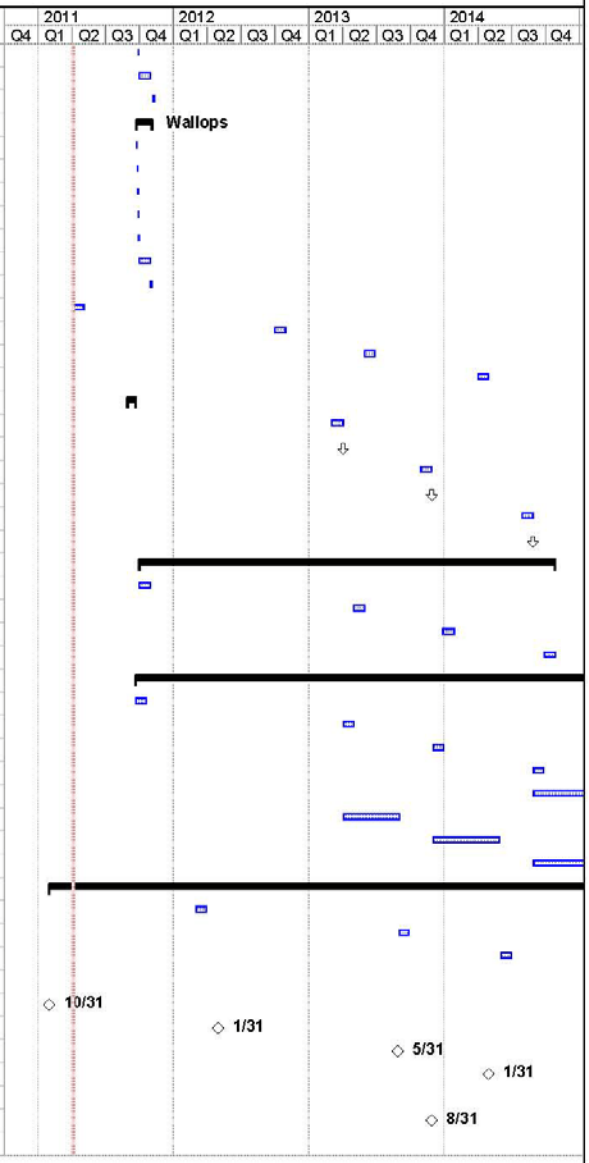
DRAFT

Earth System Science Pathfinder (ESSP) Program Office

*** For Internal Review Use ONLY ***

Status as of 12/31/10
Today's Date: 1/11/11

ID	Proj WBS	Name	Duration	Start	Finish
439		UC-12B Instrument Check Flight (ICF)	1 day	6/29/11	6/29/11
440		UC-12B Science Flights	30 edays	7/1/11	7/31/11
441		Download ACAM	3 days	8/8/11	8/10/11
442		**P3B Detail**	**30 days**	**6/24/11**	**8/5/11**
443		Final Installation & Inspection Review (FIIR)	1 day	6/24/11	6/24/11
444		P-3B Funcational Check Flight (FCF)	1 day	6/27/11	6/27/11
445		P-3B Flight Readiness Review (FRR)	1 day	6/28/11	6/28/11
446		P-3B PCF (Project ...)	1 day	6/29/11	6/29/11
447		P-3B Mission Readiness Review (MRR)	1 day	6/30/11	6/30/11
448		P-3B Science Flights	31 edays	6/30/11	7/31/11
449		Download P-3B	5 days	8/1/11	8/5/11
450		Site Survey (1)	20 days	1/4/11	2/1/11
451		Site Survey (2)	20 days	7/2/12	7/30/12
452		Site Survey (3)	20 days	3/1/13	3/28/13
453		Site Survey (4)	20 days	1/2/14	1/30/14
454		**Integration (1)**	**16 days**	**5/31/11**	**6/21/11**
467		Integration (2)	21 days	12/3/12	1/2/13
468		Integration (2) complete	0 days	1/2/13	1/2/13
469		Integration (3)	22 days	8/1/13	8/30/13
470		Integration (3) complete	0 days	8/30/13	8/30/13
471		Integration (4)	21 days	5/1/14	5/30/14
472		Integration (4) complete	0 days	5/30/14	5/30/14
473		**Airborne Deployements**	**771 days**	**7/1/11**	**7/30/14**
474		Baltimore	30 edays	7/1/11	7/31/11
475		Houston	30 edays	1/31/13	3/2/13
476		Sacremento	30 edays	9/30/13	10/30/13
477		Altanta or LA	30 edays	6/30/14	7/30/14
478		**Ground Deployments**	**1052 days**	**6/22/11**	**8/28/15**
479		NATIVE, UMBC Lidar (1)	20 days	6/22/11	7/20/11
480		NATIVE, UMBC Lidar (2)	20 days	1/3/13	1/31/13
481		NATIVE, UMBC Lidar (3)	20 days	9/3/13	9/30/13
482		NATIVE, UMBC Lidar (4)	20 days	6/2/14	6/27/14
483		Pandora (1)	314 days	6/2/14	8/28/15
484		Pandora (2)	105 days	1/3/13	6/3/13
485		Pandora (3)	122 days	9/3/13	2/28/14
486		Pandora (4)	272 days	6/2/14	6/30/15
487		**Post Deployment Activities**	**1169 days**	**10/31/10**	**6/30/15**
488		Data Archival (1)	20 days	12/1/11	12/29/11
489		Data Archival (2)	20 days	6/3/13	6/28/13
490		Data Archival (3)	20 days	3/5/14	4/1/14
491		Data Archival (4)	20 days	12/1/14	12/29/14
492		Science Team meetings (1)	0 days	10/31/10	10/31/10
493		Science Team meetings (1)	0 days	1/31/12	1/31/12
494		Science Team meetings (1)	0 days	5/31/13	5/31/13
495		Science Team meetings (1)	0 days	1/31/14	1/31/14
496		Science Team meetings (1)	0 days	12/31/14	12/31/14
497		Publication Target (1)	0 days	8/31/13	8/31/13
498		Publication Target (2)	0 days	6/30/15	6/30/15



DRAFT

Project Management - Schedule

Schedule Reserve

- 30 day deployment scheduled for 10-12 flight days (100 hours total) – allows for instrument maintenance/repair, weather delays, etc.
- UC-12B shake-down flights in mid-March
  - Do science measurements work as expected?
  - Is the flight plan feasible?
  - Can 2 flights per day be accomplished?
- Pandoras scheduled to be ready by 4/30/11, 2 months ahead of airborne deployment
- AERONET delivery expected by April 2011
- Data archival – PLRA requires 6 months after deployment, project goal is 4 months post-deployment

Underlying Schedules

- Pandora fabrication
- P-3B integration
- UC-12B modification for ACAM
- UC-12B integration
- Ground system emplacement (Pandoras, AERONETS, NATIVE, lidar)
- Review schedule

Project Management - Schedule

Review Schedule Summary

- Investigation Concept Review (ICR) – 2/10/2011
- Investigation Design Review (IDR) – April 2011
- Investigation Readiness Review (IRR) – June 30, 2011
- Post Deployment Assessment Review (PDAR) – late August 2011
- IRR (Sacramento) – December 30, 2012
- PDAR (Sacramento) – late February 2013
- IRR (Houston) – August 30, 2012
- PDAR (Houston) – late October 2013
- IRR 4 (TBD) – May 30, 2014
- PDAR (TBD) – late July 2014

- P-3B and UC-12B aircraft reviews adhere to their center policy

Project Management – Life Cycle Cost

Total Direct Budget	Desc	FY10	FY11	FY12	FY13	FY14	FY15
	Direct $	$1,800,274	$5,533,961	$5,004,328	$7,831,682	$6,521,586	$3,298,672
	Procurement	$1,734,623	$4,093,147	$3,086,042	$5,232,481	$4,353,539	$1,559,252
	Travel	$13,396	$118,641	$33,402	$431,438	$267,080	$21,126
Total	Labor	$52,255	$1,222,174	$1,168,038	$1,450,917	$1,184,122	$1,001,448
	Reserve	$0	$100,000	$716,846	$716,846	$716,846	$716,846
	Civil Service FTE's	0.29	8.04	7.11	8.98	6.79	6.71
	Contractor WYE's (On-Site)	0.00	9.60	9.60	9.60	9.60	8.55
	Contractor WYE's (Near-Site)	0.00	1.80	1.70	1.70	1.70	1.70
	Direct $	$1,546,397	$3,868,784	$3,854,619	$5,788,793	$4,948,336	$2,357,039
	Procurement	$1,496,724	$2,713,432	$2,227,525	$3,501,088	$3,036,037	$854,888
	Travel	$12,641	$107,119	$21,574	$419,294	$254,611	$15,366
LaRC	Labor	$37,032	$948,233	$888,675	$1,151,565	$940,843	$769,940
	Reserve	$0	$100,000	$716,846	$716,846	$716,846	$716,846
	Civil Service FTE's	0.21	6.57	5.7	7.54	5.72	5.44
	Contractor WYE's (On-Site)		3.5	3.5	3.5	3.5	3.15
	Contractor WYE's (Near-Site)		1.8	1.7	1.7	1.7	1.7
	Direct $	$231,305	$1,579,402	$1,058,548	$1,948,708	$1,473,313	$882,126
	Procurement	$230,550	$1,361,686	$838,535	$1,711,970	$1,296,087	$694,121
	Travel	$755	$7,858	$8,093	$8,336	$8,586	$2,165
GSFC	Labor		$209,858	$211,920	$228,402	$168,640	$185,840
	Reserve						
	Civil Service FTE's		1.14	1.08	1.11	0.74	1.02
	Contractor WYE's (On-Site)		5.85	5.85	5.85	5.85	5.15
	Contractor WYE's (Near-Site)						
	Direct $	$22,572	$85,776	$91,161	$94,181	$99,937	$59,506
	Procurement	$7,349	$18,029	$19,983	$19,423	$21,415	$10,243
	Travel		$3,664	$3,735	$3,808	$3,883	$3,595
ARC	Labor	$15,223	$64,083	$67,443	$70,950	$74,639	$45,668
	Reserve						
	Civil Service FTE's	0.08	0.33	0.33	0.33	0.33	0.25
	Contractor WYE's (On-Site)		0.25	0.25	0.25	0.25	0.25
	Contractor WYE's (Near-Site)						

Project Management – Life Cycle Cost

LCC derived by sorting the WBS items by center and totaling by FY

Labor funding is relatively level while deployment costs are the primary source of budget fluctuations by FY

Reserves

- Held at LaRC
- Calculated at Level 2 as 10% of the total budget (primarily Labor and Grants)
- Exception for WBS elements 7.0 and 10.0 associated with deployment and integration costs calculated at 15%

Reserve Plan Options (budget)

- Tethered balloon (Richard Clark, Millersville Univ.)
- Expand analysis team
- Add flight hours

Reserve Plan Options (schedule)

- Add flight hours if budget allows
- Begin Pandora operation early if possible

Project Management – Descope Plan

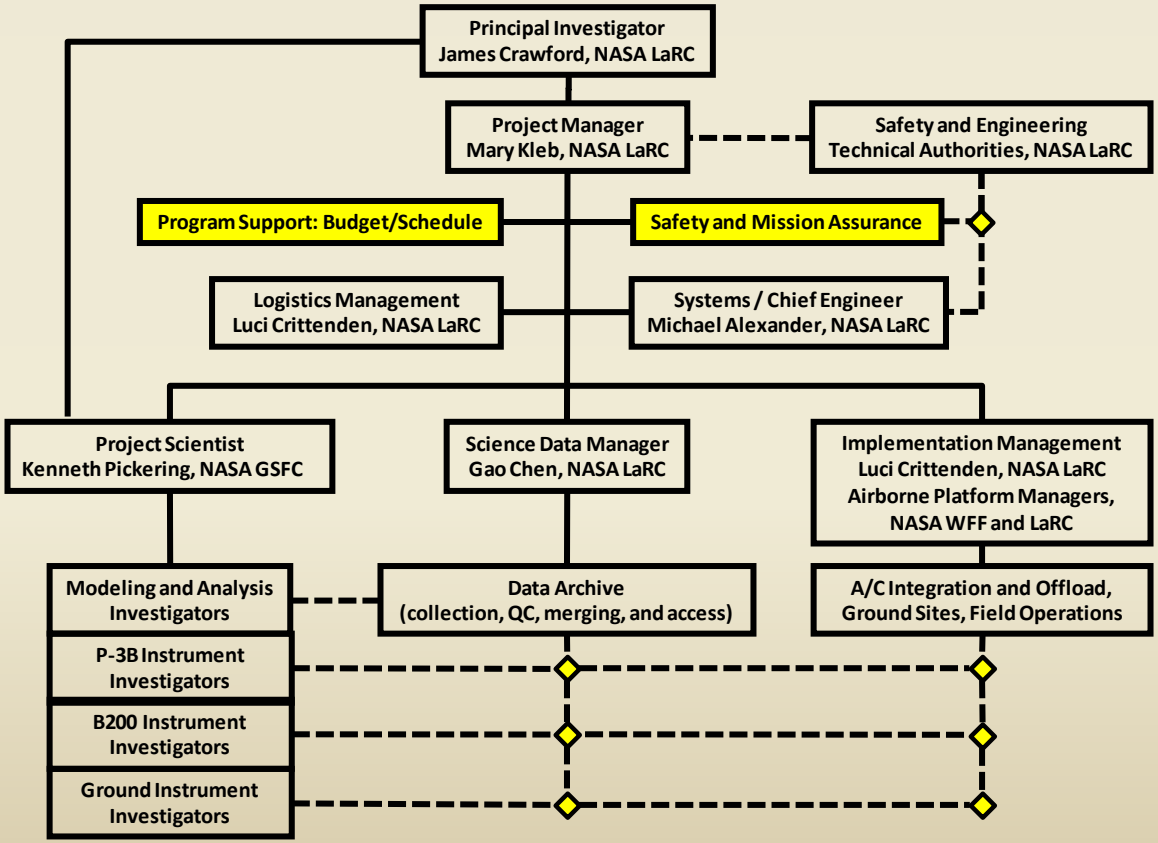
Descope Plan as presented in proposal

Descope option	Year 1	Year 2	Year 3	Year 4	Year 5	Total
AERONET procurement		$150,000				$150,000
UMBC lidars	$123,610	$127,785	$132,127	$136,641	$141,338	$661,501
6 fewer Pandora units	$90,000					$90,000
PT-RMS VOCs	$143,900	$149,601	$155,597	$161,979	$168,579	$779,656
AVOCET CO2	$137,707	$133,341	$104,567	$116,995	$124,495	$617,105
DACOM	$204,000	$211,752	$218,582	$226,494	$234,490	$1,095,318
Eliminate 3rd Deployment				$1,356,804		$1,356,804
Total	$699,217	$772,479	$610,873	$1,998,913	$668,902	$4,750,384

- Year 1 descope options are no longer available
- AERONET descope option no longer available

Project Management – Management Approach

DISCOVER-AQ Organization & Staffing



- Solid lines indicate lines of authority
- Dashed lines indicate lines of relationship between responsible parties
- Yellow boxes indicate distributed functions shared among several team members

Project Management - Management Approach

Principal Investigator (James Crawford): Responsible for the overall success of the DISCOVER-AQ project and team reporting requirements including verification of PLRA.

Project Manager (Mary Kleb): Responsible for coordination of all DISCOVER-AQ activities (oversight and monitoring of budget, scheduling and preparation for reviews, annual science team meetings, and deployment-related travel). Serves as configuration management lead and technical monitor for grantees.

Project Scientist (Kenneth Pickering): Responsible for assessing progress toward DISCOVER-AQ science goals, specifically the outcomes listed in the project science traceability matrix.

Science Data Manager (Gao Chen): Responsible for the project's web presence including basic project information as well as a public data archive (monitor data submission and ensure that the science team complies with data deadlines and reporting requirements)

Chief Engineer (Michael Alexander): Responsible for guiding the Technical Authority process to include organizational procedures and the verification of Technical Authority implementation in the Project. Primarily responsible for evaluating the technical content and performance of the project elements to assure that NASA Langley, NASA Goddard, NASA Wallops, and the other participants are meeting their commitments consistent with applicable Agency and center policies, requirements, and standards, including safety and mission assurance

Project Management - Management Approach

Staffing (continued)

Logistics/Implementation Manager (Lucille Crittenden): Responsible for assisting the PM in the logistical support of the DISCOVER-AQ deployments by providing implementation management to facilitate the investigation. This will include preparation for each deployment to include conducting site surveys in advance of each deployment to arrange for appropriate support to include facilities (e.g., hangar, office, and lab space; airport charges; badging; ground support equipment), communications (e.g., phone and network support), logistics (e.g., shipping of equipment; critical supplies to include compressed gases, cryogens), and all other matters requiring negotiation for support with local providers at each deployment site. During deployments, she will oversee coordination of daily schedules and activities as outlined in Section 9.5 (Logistics Planning) of the Project Plan.

Project Management - Management Approach

Tools Used:

- Microsoft Project (schedule)
- Excel (budget, logistics)
- NASA Business Warehouse and SAP (spending)
- LaRC NX server (secure document repository)

Budget tracking

- Review monthly summaries of commitments, obligations, and costing at each center. Large deviations from the plan are investigated further (if necessary to individual investigator WBS).
- At LaRC ~weekly summaries are provided by the Science Directorate Resource Management Team summarizing commitments, obligations, and costing by WBS for procurement, labor, travel, and fabrication.
- At LaRC monthly labor summaries are provided to ensure accurate and appropriate labor charging.
- GSFC budget tracked at highest level, but managed locally under the instruction of the Project Scientist.

Project Management - Management Approach

Schedule Tracking

- Once integrated schedule is complete monthly updates will occur (to include updates from all elements on schedule).
- Currently (until integrated schedule is complete)
  - Aircraft schedules for instrument integration account for engineering and safety reviews, check flights, etc.
  - Periodic updates are provided as the aircraft reviews progress
  - Instrument co-investigators are expected to provide the necessary information directly to the integration engineers to facilitate integration and safety reviews.
  - Other schedules are tracked through conversations with responsible parties (e.g. Pandora fabrication schedule has been provided by the co-investigator and approved by the project PI. Periodic updates are provided. Periodic meetings with L. Crittenden ensure logistics needs are being addressed)

Project Management - Management Approach

Team Reporting Requirements

- Data – field and final (meet deadlines in Science Data and Knowledge Management Plan)
- Annual Reports – for grant renewal
- Data Workshops – Data sharing for co-investigators
- Publications
- Considering annual review with all co-investigators (including Civil Servants) to ensure objectives/obligations are being met

Project Management - Management Approach

Subcontractors

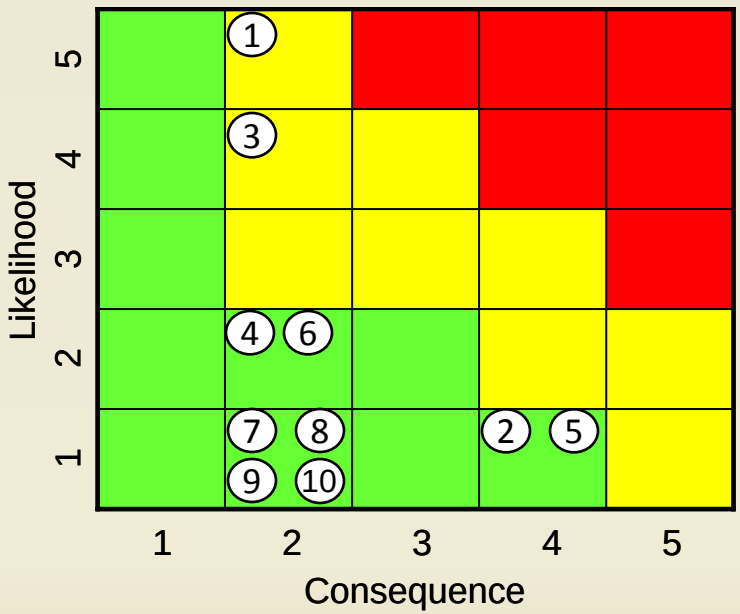
- Subcontractors are handled individually (as separate tasks) by each co-investigator (or as a single omnibus task at GSFC) and administered according to center policy (technical monitor at LaRC).
- Reporting requirements vary according to task (LaRC)
- Annual reviews by the technical monitor (LaRC)
- Grants
    - 6 grants funded via the NSSC for 1 year and renewed annually
    - PM is technical monitor
    - Annual report submitted prior to renewal

Project Management – Risk Assessment and Mitigation

- Risks defined by PI and PM in consultation with ESSP PO
- Risk levels (likelihood and consequence) defined according to ESSP PO Risk Management Plan (dated July 28, 2010), Section 3.2.1 Risk Rating Definitions
- DISCOVER-AQ Risk Management Policy
  - Anyone may raise a risk with PI, PM, or CE
  - PI and PM in consultation with ESSP PO determine whether or not to add proposed risk to set of tracked risks
  - Risks updated monthly and reported to ESSP PO in monthly reports and at EPTR

Project Management – Risk Assessment and Mitigation

Risk Classification Matrix



Legend

- Decreasing (Improving)
- Increasing (Worsening)
- Unchanged
- Action: R,A,W,M
- Timeframe: N,M,F
- ▲ Project Office Risk
- ◆ Top Project Risk (TProjR)

ID	Trend	Title	Risk Owner	Likelihood	Consequence				Action	Timeframe
					Safety	Technical	Schedule	Cost		
1	→	◆Need to accommodate competing airborne projects	PI	5	1	1	2	2	W	F
2	→	▲ACAM failure	PI	1	1	4	4	2	A	F
3	↓	▲Restrictions on flight clearances	PI	4	1	2	1	2	M	M
4	↓	▲Pandora fabrication delay	PI	2	1	2	2	1	W	M
5	→	▲ HSRL failure	PI	1	1	4	4	2	A	F
6	→	▲Uncertainty in air pollution episodes	PI	2	1	1	1	2	A	F
7	→	▲P-3B Instrument failure	PI	1	1	2	1	1	A	F
8	→	▲ P-3B NO2 instrument failure	PI	1	1	2	2	1	A	F
9	↓	▲ACAM integration	PI	1	1	2	2	1	W	N
10	→	▲ Ground network instrument failure	PI	1	1	2	1	1	A	F

Project Management – Risk Assessment and Mitigation

Risk Title: Need to accommodate competing airborne projects. **Escalation Level:** Investigation	**Date Submitted:** 10/13/2010 **Risk Owner:** James Crawford, PI

Risk Statement: DISCOVER-AQ will occur between Operation IceBridge and DEVOTE. IceBridge will not release the P-3B until 20 May and DEVOTE would like to have the UC-12 by 1 August. In addition, the LARGE instrument ensemble is participating in both DISCOVER-AQ and DEVOTE, thus coordination will be needed for integration/de-integration of this instrument for both missions.

Context: The tightness of the DISCOVER-AQ schedule leaves no room for delays, either for technical issues or uncooperative meteorological conditions. Each project has been informed of the consequences of schedule delays.

Likelihood: 5 **Consequences:** **Safe: 1** **Tech: 1** **Sched: 2** **Cost: 2** **Timeframe: F**

Status:

Mitigation Summary & controls

Action: Watch

Mitigation Plan: None

Task No.	Task Description	Actionee	Resulting L x C	Success Criteria
1				
2				
3				

Project Management – Risk Assessment and Mitigation

Risk Title: Airborne Compact Atmospheric Mapper (ACAM) failure. **Escalation Level:** Investigation	**Date Submitted:** 10/13/2010 **Risk Owner:** James Crawford, PI

Risk Statement: The possibility exists that a malfunction will occur, requiring a short stand down to make repairs.

Context: While trace gas columns from ACAM fill important gaps in the regional variability of trace gases, its malfunction would not be sufficient to stand down for an extended period given the continuous monitoring of trace gas columns by the Pandora network.

Likelihood: 1 **Consequences:** **Safe: 1** **Tech: 4** **Sched: 4** **Cost: 2** **Timeframe: F**

Status:

Mitigation Summary & controls

Action: Accept

Mitigation Plan: None

Task No.	Task Description	Actionee	Resulting L x C	Success Criteria
1				
2				
3				

Project Management – Risk Assessment and Mitigation

Risk Title: Restrictions on flight clearances. **Escalation Level:** Investigation	**Date Submitted:** 10/13/2010 **Risk Owner:** James Crawford, PI

Risk Statement: The risk of severe flight restrictions for the proposed flights over the chosen urban areas is a significant possibility, especially in the highly restricted Washington, D.C./Baltimore area.

Context: Advance planning and heavy coordination with local air traffic controlling authorities will be essential and is already underway for the first deployment. An early visit to FAA in Washington, DC indicates that compromises are already required on profile depth. Continued negotiation will be needed to ensure that science goals can be accomplished.

Likelihood: 4 **Consequences:** **Safe: 1** **Tech: 2** **Sched: 1** **Cost: 2** **Timeframe: N**

Status:

Mitigation Summary & controls

Action: Mitigate

Mitigation Plan: Continue to develop flight plan and negotiate with flight control authorities

Task No.	Task Description	Actionee	Resulting L x C	Progress
1	Revise flight plan and reengage FAA	Crawford		Return visit planned for Feb 8, 2011
2	Assess possibility of flight in Aberdeen Proving Ground restricted area	Crawford		Initial plan drafted
3	Initial request package submitted to Aberdeen Proving Ground (11/2010)	Crawford		Approval secured, negotiation with individual offices required.

Project Management – Risk Assessment and Mitigation

Risk Title: Restrictions on flight clearances. **Escalation Level:** Investigation	**Date Submitted:** 10/13/2010 **Risk Owner:** James Crawford, PI

Mitigation Summary & controls (cont.)

Action: Mitigate

Mitigation Plan: Continue to develop flight plan and negotiate with flight control authorities

Task No.	Task Description	Actionee	Resulting L x C	Success Criteria
4	Negotiation with Office of Security, range control, and site selection board at Aberdeen Proving Ground concerning operational details.	Crawford		

Project Management – Risk Assessment and Mitigation

Risk Title: Pandora fabrication delay **Escalation Level:** Investigation	**Date Submitted:** 10/13/2010 **Risk Owner:** James Crawford, PI

Risk Statement: Since the 12 Pandora instruments needed do not yet exist and must be fabricated, there is some risk in delay.

Context: Risk associated with the fabrication of a dozen Pandora instruments is small. There is no development and all parts are available off the shelf with little lead time required. Nevertheless, since P-3B profiles will be limited to profiling over 6 sites, science objectives 1 and 2 could be accomplished with as few as 6 instruments. This broader coverage needed to characterize regional variability in support of science objective 3 would still be supported by ACAM.

Likelihood: 2 **Consequences:** **Safe: 1** **Tech: 2** **Sched: 2** **Cost: 1** **Timeframe: M**

Status: **Decreasing**

Mitigation Summary & controls

Action: Watch

Mitigation Plan: Monitor progress on fabrication

Task No.	Task Description	Actionee	Resulting L x C	Success Criteria
1	Received fabrication and calibration schedule from co-I (10/20/2010)			
2	4 Pandoras in place and testing at Frostburg, MD (11/4/2010)			
3				

Project Management – Risk Assessment and Mitigation

Risk Title: High Spectral Resolution Lidar (HSRL) failure. **Escalation Level:** Investigation	**Date Submitted:** 10/13/2010 **Risk Owner:** James Crawford, PI

Risk Statement: Even though reliability of the HSRL is evidenced by over 1000 flight hours onboard the B200 since 2006 in support of ten airborne science field campaigns, a malfunctions could occur.

Context: Though not likely, any malfunction of HSRL would be sufficient to stand down until repairs could be accomplished.

Likelihood: 1 **Consequences:** **Safe: 1** **Tech: 4** **Sched: 4** **Cost: 2** **Timeframe: F**

Status:

Mitigation Summary & controls

Action: Accept

Mitigation Plan: None

Task No.	Task Description	Actionee	Resulting L x C	Success Criteria
1				
2				
3				

Project Management – Risk Assessment and Mitigation

Risk Title: Uncertainty in air pollution episodes. **Escalation Level:** Investigation	**Date Submitted:** 10/13/2010 **Risk Owner:** James Crawford, PI

Risk Statement: While there are optimal times for deployment to capture air pollution episodes, the occurrence of such episodes are not assured.

Context: The existence of air pollution episodes are not critical to the science objectives as stated; however, lack of acceptable meteorological conditions (e.g., less than 50% cloudiness) could cause an extension in the deployment.

Likelihood: 2 **Consequences:** **Safe: 1** **Tech: 1** **Sched: 1** **Cost: 2** **Timeframe: F**

Status:

Mitigation Summary & controls

Action: Accept

Mitigation Plan: None

Task No.	Task Description	Actionee	Resulting L x C	Success Criteria
1				
2				
3				

Project Management – Risk Assessment and Mitigation

Risk Title: P-3B instrument failure. **Escalation Level:** Investigation	**Date Submitted:** 10/13/2010 **Risk Owner:** James Crawford, PI

Risk Statement: Given the advanced TRL level of instrumentation onboard the P-3B, risk is primarily limited to partial loss of data due to instrument malfunction during flight.

Context: Given a 30-day deployment, previous experience suggests that there should be sufficient time to stand down for repairs in the event of any major instrument failures.

Likelihood: 1 **Consequences:** **Safe: 1** **Tech: 2** **Sched: 1** **Cost: 1** **Timeframe: F**

Status:

Mitigation Summary & controls

Action: Accept

Mitigation Plan: None

Task No.	Task Description	Actionee	Resulting L x C	Success Criteria
1				
2				
3				

Project Management – Risk Assessment and Mitigation

Risk Title: P-3B NO2 instrument failure. **Escalation Level:** Investigation	**Date Submitted:** 10/13/2010 **Risk Owner:** James Crawford, PI

Risk Statement: Given the advanced TRL level of instrumentation onboard the P-3B, risk is primarily limited to partial loss of data due to instrument malfunction during flight.

Context: Given a 30-day deployment, previous experience suggests that there should be sufficient time to stand down for repairs in the event of any major instrument failures. For the most critical trace gas measurement, NO2, redundancy essentially eliminates any risk of data loss.

Likelihood: 1 **Consequences:** **Safe: 1** **Tech: 2** **Sched: 2** **Cost: 1** **Timeframe: F**

Status:

Mitigation Summary & controls

Action: Accept

Mitigation Plan: None

Task No.	Task Description	Actionee	Resulting L x C	Success Criteria
1				
2				
3				

Project Management – Risk Assessment and Mitigation

Risk Title: Airborne Compact Atmospheric Mapper (ACAM) integration delay. **Escalation Level:** Investigation	**Date Submitted:** 10/13/2010 **Risk Owner:** James Crawford, PI

Risk Statement: Since ACAM has not flown on the NASA UC-12, it must be newly integrated on the platform.

Context: The underlying goal in this integration is to not require changes to the ACAM instrument, keeping it as close to its current configuration as possible. It will be located inside an already existing pressure housing and will look downward through an opening. Mounting hardware and plate must be fabricated.

Likelihood: 1 **Consequences:** **Safe: 1** **Tech: 2** **Sched: 2** **Cost: 1** **Timeframe: N**

Status: Initial fit test for instrument (3 Oct 2010) was successful.

Mitigation Summary & controls

Action: Watch

Mitigation Plan: Monitor progress with integration design and fabrication

Task No.	Task Description	Actionee	Resulting L x C	Success Criteria
1	SRR completed (1/7/2011)	Fisher		
2				
3				

Project Management – Risk Assessment and Mitigation

Risk Title: Ground network instrument failure. **Escalation Level:** Investigation	**Date Submitted:** 10/13/2010 **Risk Owner:** James Crawford, PI

Risk Statement: Given the advanced TRL level of ground instrumentation, risk is primarily limited to partial loss of data due to instrument malfunction at a specific location.

Context: Given the extensive redundancy in the surface network, it is unlikely that instrument malfunction would constitute a critical degradation in science capability. Should a Pandora instrument fail at a key location, repositioning of an instrument from another site could be accomplished on short notice. The AQS network is extensive enough to absorb malfunctions. Sites over which flight profiles are conducted can be altered based on instrument capability and function as it evolves. The NATIVE trailer and aerosol lidars have low risk and are value added such that science operations would continue in the event of failures.

Likelihood: 1 **Consequences:** **Safe: 1** **Tech: 2** **Sched: 1** **Cost: 1** **Timeframe: F**

Status:

Mitigation Summary & controls

Action: Accept

Mitigation Plan: None

Task No.	Task Description	Actionee	Resulting L x C	Success Criteria
1				
2				
3				