Platforms and Instrumentation

Figure 3 gives an overview of TARFOX platforms and instrumentation. Specific elements are described below.

7.1 AIRCRAFT

Four aircraft will be used for TARFOX. Their characteristics are summarized in the table below. Descriptions of each aircraft follow the table.

TABLE 2. Aircraft Characteristics

	NASA ER-2	UK MRF C-130	UW C-131A	CIRPAS Pelican
Tail Number	NASA 708	XV208	N327UW	N84NX
Call sign	"NASA 708"	"METMAN 59" or "METMAN 60"	"Husky One"	"Pelican"
Maximum Altitude (km)	21	10	7.6	3
Maximum Range (km)		5500	2160	1472
Speed (m/s)	210	50-150	80	51
Maximum Endurance (h)		11h00m	7h30m	8h (manned)
Expected flight duration for TARFOX	5h30m	8h00m	4h00m	7h00m

7.1.1 NASA ER-2

The NASA ER-2 will provide a platform for imaging spectroradiometers, a lidar, and potentially flux radiometers and narrow-field-of-view radiometers. Multispectral images will be acquired with the MODIS Airborne Simulator (MAS) on most flights. One flight will provide a cross-calibration between MAS with the Airborne Visible/InfraRed Spectrometer (AVIRIS). It is expected that the LASE (Lidar Atmospheric Sensing Experiment) airborne lidar will operate on the non-AVIRIS flights, producing measurements of aerosol and water vapor vertical profiles from the aircraft altitude (20 km) down to the surface. Such profiles would show the vertical context in which the TARFOX in situ and radiometric measurements are made, thus

supporting the vertical extension of the in situ measurements and detecting any unsampled layers or inhomogeneities, which would impact the airborne and satellite radiative flux measurements.

LASE

Point of contact for LASE are:

NAME	ADDRESS	EMAIL	PHONE/FAX
1) Edward Browell	M.S. 401A NASA Langley Research Center Hampton, VA 23665	e.v.browell@larc.nasa.gov	804/864-1273 928-7790
2) Al Moore	NASA Langley Hampton, VA 23681	a.s.moore@larc.nasa.gov	804-864-7094 804-864-1762
3) Syed Ismail	M.S. 401A NASA Langley Research Center Hampton, VA 23665	s.ismail@larc.nasa.gov	804/864-2719, 804/864-7790

The Lidar Atmospheric Sensing Experiment (LASE) Instrument is the first fully-engineered, autonomous Differential Absorption Lidar (DIAL) System for the measurement of water vapor, aerosols, and clouds in the troposphere. LASE uses a double-pulsed Ti:Sapphire laser for the transmitter with a 30 ns pulse length and 150 mJ/pulse. The laser beam is "seeded" to operate on a selected water vapor absorption line in the 815-nm region using a laser diode with an onboard absorption reference cell. A 38 cm diameter telescope collects the back scattered signals and directs them onto two detectors and three signal digitizers with different gain settings. LASE collects DIAL data at 5 Hertz while onboard a NASA/Ames ER-2 aircraft flying at altitudes from 16-21 km. LASE was designed to meet the performance specifications provided by the DIAL water vapor measurement requirements, to operate autonomously, and to perform within the aircraft environmental and physical constraints. The LASE Instrument was custom built and tested at NASA-Langley Research Center in Hampton, Virginia.

LASE will not be operated when the ER-2 is below 60,000 feet. To ensure eye safety, while LASE is in operation the other three TARFOX aircraft will fly at altitudes below 15,000 ft whenever they are vertically aligned with the ER-2.

MAS (MODIS Airborne Simulator)

Point of contact for MAS are:

NAME	ADDRESS	EMAIL	PHONE/FAX
Kaufman, Yoram J.	NASA Goddard Space Flight Center Code 913 Greenbelt, MD 20771-0001	yoram@ltpsun.gsfc.nasa.gov	301/286-4866 301/286-1749
Remer, Lorraine	NASA Goddard Space Flight Center Code 913 SSAI Greenbelt, MD 20771-0001	remer@climate.gsfc.nasa.gov	301/286-8325 301/286-1759
Tanre, Didier	Laboratoire d'Optique Atmospherique Universite de Sciences et Techniques de Lille Villeneuve d'Ascq FRANCE	tanre@loaser.univ-lille1.fr	

The Modis Airborne Simulator (MAS) is configured to replicate the capabilities of the Moderate-Resolution Imaging Spectrometer (MODIS), an instrument to be orbited on an EOS platform. MODIS is designed for the measurement of biological and physical processes and atmospheric temperature. The Modis Airborne Simulator records fifty channels of multispectral data.

MAS is a modified Daedalus multispectral line-scan system, with 50 channels in the visible and infrared regions.

Spectral Bands:

9 bands from 0.529 - 0.969 micron
16 bands from 1.595 - 2.405 microns
15 bands from 2.925 - 5.325 microns
9 bands from 8.342 -14.521 microns

Digitization: 16 bits
IFOV: 2.5 mrad.
Total Field of View: 85 degrees

MAS Sensor/Aircraft Parameters:

Spectral Bands: 50 (digitized to 16-bit resolution)
IFOV: 2.5 mrad
Ground Resolution: 163 feet (50 meters at 65,000 feet)
Swath Width: 22.9 mi/19.9 nmi (36 km)
Total Scan Angle: 85.92o
Pixels/Scan Line: 716
Scan Rate: 6.25 scans/second
Ground Speed: 400 kts (206 m/second)

Roll Correction: Plus or minus 3.5 degrees (approx.

7.1.2 UK C-130

The primary point of contact for the UK C-130 is:

NAME	ADDRESS	EMAIL	PHONE/FAX
Phil Hignett	Meteorological Research Flight Y46 Building DRA Farnborough Hampshire GU14 6TD U.K.	phignett@meto.gov.uk	+44 1252 395403 +44 1252 376588

This aircraft has a standard instrumentation package, which enables measurements to be made of:

- Temperature, dew point, pressure and wind speed and direction
- Turbulent fluxes of heat, moisture and momentum
- Aerosol and cloud particle size spectra for particle sizes from 0.1 to 6400 mm
- Aerosol scattering (nephelometer)
- Aerosol Absorption (Particle Soot Absorption Photometer)
- CCN supersaturation spectra
- Liquid water and total water content
- Broadband irradiances and narrowband radiances in the short wave and long wave
- Surface or cloud top temperature
- Forward facing video recordings of the cloud conditions

The following table lists the instrumentation to be operated on the C-130 during TARFOX:

TABLE 3. UK C-130 Instrumentation

Inst/variable	Specification	Manufacturer/Model
Navigation and winds:		
Inertial Navigation Unit		Honeywell H423
Global Positioning System		Navstar XR5
Radar Altimeter	0-1525m	Honeywell YG9000D1
Basic Meteorological:		
Static Pressure		Rosemount 1201F
Total air temperature	De-iced and non de-iced	Rosemount 102BL/AL
Dewpoint	Thermoelectric	General Eastern 1011B
Absolute Humidity	Lyman-alpha absorption and fluorescence	UK Met. Office
Total water content	Lyman-alpha absorption	UK Met. Office

Radiation:		
Radiometric Surface Temperature	8-14m	Heimann
Hemispheric Infrared down and upwelling broadband radiation	4-50m	UK Met. Office
Hemispheric Solar down and upwelling broadband radiation	0.3-3.0m	Eppley PSP
Hemispheric near IR down and upwelling broadband radiation	0.7-3.0m	Eppley PSP
Atmospheric radiance filter wheel radiometer	narrow fov. 0.5-15m	UK Met. Office
Microwave radiation	89 and 157GHz	UK Met. Office
Scattering coefficient Integrating total and backscatter Nephelometer	450, 550 and 700nm	TSI 3563
Absorption coefficient		Radiance Research
Ptl. Soot Absorption Photometer.		
Cloud and aerosol microphysics:		
Aerosol size spectrum	0.1-3.0m diameter	Ptl. Measuring Systems
Cloud droplet spectrum	0.5-45m diameter	Ptl. Measuring Systems
Cloud condensation saturation gradient		UK Met. Office
Aerosol chemical composition	0.1-3.0m diameter	VACC UMIST

7.1.3 UW C-131A

The primary point of contact for the UW C-131 is:

NAME	**ADDRESS**	**EMAIL**	**PHONE FAX**
	Atmospheric Sciences Room 504		

Peter V. Hobbs	University of Washington Box 351640 Seattle, WA 98195-1640	phobbs@atmos.washington.edu	206/543-6027 206/685-7160

The University of Washington C-131A is an integrated atmospheric research facility that is well equipped to measure (1) atmospheric aerosols and trace gases, (2) the microphysical structures of clouds, and (3) the radiative properties of aerosols and clouds.

The following table lists instruments that will be operated from the C-131 during TARFOX:

TABLE 4. UW C-131A Instrumentation

PARAMETER	INSTRUMENT Type	MANUFACTURER	RANGE* (AND ERROR)	CERTAIN(C) OR UNCERTAIN (U)
(a) Navigational and Flight Characteristics				
Latitude and longitude, ground speed and horizontal winds	VLF: Omega navigator	Litton LTN-3000	0 to 300 m s-1 (± 1 m s-1 ground-speed and ± 1° drift angle)	C
Latitude and longitude, ground speed and horizontal winds	Global positioning system	Trimble TNL-3000	global	C
True airspeed	Variable capacitance	Rosemount Model 831 BA	0 to 250 m s-1 (< 0.2%)	C
Heading	Gyrocompass	King KCS-55A	0 to 360° (± 1°)	C
Pressure	Variable capacitance	Rosemount Model 830 BA	150 to 1100 mb (< 0.2%)	C
Altitude above terrain	Radar altimeter	AN/APN22	0 to 6 km (< 5%)	C
Aircraft position and course plotter	Derived from VLF/OMEGA or GPS	In-house	180 km (1 km)	C
Angle of attack	Potentiometer	Rosemount Model 861	± 23° (indicator only)	C
(b) General Meteorological				

Total air temperature	Platinum wire resistance	Rosemount Model 102CY2CG and 414 L Bridge	ñ60 to 40°C (< 0.1°C)	C
Static air temperature	Reverse-flow thermometer	In-house	ñ60 to 40°C (< 0.5°C)	C
Dew point	Cooled-mirror dew point	Cambridge System Model TH73-244	ñ40 to 40°C (< 1°C)	C
Absolute humidity	IR optical hygrometer	Ophir Corp. Model IR-2000	0 to 10 gm-3 (~ 5%)	C
Air turbulence	RMS pressure variation	Meteorology Research, Inc. Model 1120	0 to 10 cm2/3 s-1 (<10%)	C
UV hemispheric radiation, one upward, one downward	Diffuser, filter photo- cell (295 to 390 nm)	Eppley Lab. Inc. Model 14042	0 to 70 W m-2 (± 3 W m-2)	C
VIS-NIR hemispheric radiation (one downward and one upward viewing)	Eppley thermopile (0.3 to 3 µm)	Eppley Lab. Inc. Model PSP	0 to 1400 W m-2 (± 10 W m-2)	C
Surface radiative temperature	IR radiometer 1.5° FOV (8 to 14 µm)	Omega Engineering 053701	-50° to 1000° C ± 0.8% of reading	C
Video image	Forward looking camera and time code	Sony Hi8 camera	SVHS tape	C
(c) Aerosol				
Number concentrations of particles	Water expansion cloud chamber	General Electric Model CNC I	3.0 to 3¥105 cm-3 (particles > 0.01 µm)	C
Number concentrations of ultrafine particles	Condensation particle counter	TSI Model 3760	10-2 to 104 cm-3 (> 0.02 µm)	C
Cloud condensation nucleus spectrometer	Vertical-plate continuous flow Thermal diffusion cloud	In-house	Four super-saturations, between 0.2 and 2%	C

	chamber			
Size spectrum of particles	90° light-scattering	Particle Mea suring Systems Model LAS-200	0.5 to 11 µm	C
Size spectrum of particles	Forward light-scattering	Particle Measuring Systems Model FSSP-300	0.3 to 20 µm	C
Size spectrum of particles	35 to 120° light-scattering	Particle Measuring Systems Model ASASP-100X	0.18 to 3.0 µm	C
Size spectrum of particles	35 to 120° light-scattering	Particle Measuring Systems Model PCASP-100X	0.12 to 3.0 µm	C
Size spectrum of particles	Forward light-scattering	Particle Measuring Systems Model FSSP-100	2 to 47 µm	C
Size spectrum of particles	Differential Mobility Particle Sizing Spectro-meter (DMPS)	TSI, modified in-house	0.01 to 0.6 µm	C
Light-scattering coefficient	Integrating 3-wavelength nephelometer with backscatter shutter	MS Electron	1.0 x 10-7 m-1 to 1.0 x 10-3 m-1 for 550 and 700 nm chan nels, 2.0 x 10-7 m-1 to 1.0 x 10-3 m-1 for 450 nm channel	C
Light-scattering coefficient	Integrating nephelometer	Meteorology Research, Inc. Model 1567 (modified for increased stability and faster response time)	1.0 x 10-5 m-1 to 2.5 x 10-3 m-1	C
Light-scattering coefficient	Integrating nephelometer	Radiance Research	1.0 x 10-6 m-1 to 2.0 x 10-4 m-1 or 1.0 x 10-6 m-1 to 1.0 x 10-3 m-1	C
Light absorption	Particle		Absorption coeffi cient: 10-7 to 10-2	

and graphitic carbon	soot/absorption photometer	Radiance Research	m-1; Carbon: 0.1 µg m-3 to 10 mg m-3 (± 5%)	C
Aerosol-shape asymmetry analyzer	Change in light-scattering with applied electric field	Radiance Research	Detects ~2% deviations from sphericity	C
Graphitic and/or Organic Carbon	Quartz filters Thermal optical technique	T. Novakov (LBL)	4 to 160 µg m-3 (± 1.6 µg m-3) for 1 m3 sample	U
Hygroscopic growth factor for aerosol light-scattering	Scanning humidigraph	In house (designed and built by Mark Rood)	bsp (RH) for 30% < RH < 90%	C
(d) Cloud Physics				
Liquid water content	Hot wire resistance	Johnson-Williams	0 to 2 and 0 to 6 g m-3	C
Liquid water content	Hot wire resistance	King/PMS	0 to 5 g m-3	C
Liquid water content; particle surface area; effective droplet radius	Optical sensor	Gerber Scientific Inc. PVM-100A	0.001-10 g m-3; 5-10,000 cm2m-3; 2-70 µm	C
Size spectrum cloud particles	Forward light-scattering	Particle Measuring Systems FSSP-100	2 to 47 µm *	C
Size spectrum of cloud and precipitation particles	Diode occultation	Particle Measuring Systems OAP-200X	20 to 310 µm*	C
Images of cloud particles	Diode occultation imaging	Particle Measuring Systems OAP-2D-C	Resolution 25 µm*	C
Images of precipitation particles	Diode imaging	Particle Measuring Systems OAP-2D-P	Resolution 200 µm*	C
Ice particle concentrations	Optical polarization technique	In-house	0 to 1000 l-1 (detects particles >50	C

			µm)*	
(e) Chemistry				
Particulate species SO o (4,=), NO o(3,ñ), Clñ, Na+, K+, NH o(4,+), Ca++, Mg++	Teflon filters Ion exchange chromatography	Gelman Dionix	0.1 to 50 µg m-3 (for 500 liter air sample)	C
SO2	Pulsed fluorescence	Teco SP43 (modified in-house)	0.1 to 200 ppb	C
Ozone	Chemi-luminescence (C2H4)	Monitor Labs Model 8410 A	0 to 5 ppmv (< 7 ppb)	C
CO	Infrared correlation spectrometer	Teco Model 141	0 to 50 ppmv (~0.1 ppmv)	C
CO2	Infrared correlation spectrometer	Customized Teco Model 41H	0 to 1000 ppmv (~4 ppmv)	C
CO2	Infrared correlation spectrometer	LI-COR Li-6262	0 to 300 ppmv (0.2 ppmv at 350 ppmv)	C
(f) Remote Sensing				
Absorption and scattering of solar radiation by clouds and aerosols; reflectivity of surfaces	Thirteen wavelength scanning radiometer	NASA-Goddard/University of Washington	13 discrete wavelengths between 0.47 to 2.3 mm or 0.31 to 2.3 mm	C
Optical backscatter	Nd-YAG lidar (dual-wavelength, polarization diversity)	Georgia Tech/University of Washington	0 to 15 km (7.5 m resolution)	C
Optical depth spectrum	Six wavelength tracking sunphotometer	NASA Ames	6 discrete wavelengths between 0.38 and 1.02 mm	C
(g) Data Processing and Display				

Ground communication	FM transceiver	Motorola	200 km	C
In-flight data processing	Microcomputer	In-house, based on Motorola MVME-133A technology	--	C
In-flight data processing and display	Microcomputer	Sun Workstations	--	C
In-flight color graphics	Microcomputer	In-house, based on Motorola MVME-133A technology	--	C
Recording (digital)	Microcomputer-directed cartridge recorder	In-house, based on 3M technology	--	C
Recording (analog voice transcription)	Cassette recorder	--	--	C
Digital printout	Impact printer	EPSON MX-80	--	C

7.1.4 CIRPAS Pelican

The primary point of contact for the ONR Pelican is:

NAME	ADDRESS	EMAIL	PHONE/FAX
Philip Durkee	Meteorology Department, Code MR/DE Naval Postgraduate School 589 Dyer Road, Room 254 Monterey, CA 93943-5114	durkee@nps.navy.mil	408/656-3465 408/656-3061

The Pelican is a modified Cessna Skymaster developed for the Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS). Intended for eventual use as an Optionally Piloted Aircraft (OPA), it will be operated with human pilots in TARFOX as a test platform for sensors developed for Remotely Piloted Aircraft (RPAs). The modified Cessna's primary goal in TARFOX is to support sunphotometer measurements of the full vertical column (from as close to the surface as possible up to space) while parts of the column are sampled by other aircraft. Broadband radiative fluxes and spectrally-resolved water-leaving radiance will also be measured. Other instruments will also be tested depending on availability and aircraft accommodations. Apart from basic meteorological parameters, the following instrumentation package is planned:

- Fourteen-Channel Airborne Tracking Sunphotometer (NASA/ARC) (described in more detail below)
- Hemispheric Radiometers:
  - solar-up total
  - solar-down total

- solar-down NIR filter
- IR down
- Multispectral radiometer for ocean color
- Temp, Dew Point, Pressure
- Winds using GPS TANS Vector system
- Radial DMA from CalTech
- PMS PCASP-100X
- PMS FSSP-100
- ERAST Thermodynamic package

Fourteen-Channel Airborne Tracking Sunphotometer

The main point of contact for the NASA Ames Sunphotometer is:

NAME	ADDRESS	EMAIL	PHONE/FAX
Philip B. Russell	NASA Ames Research Center Mail Stop 245-5 Moffett Field, CA 94035-1000	philip_russell@qmgate.arc.nasa.gov	415/604-5404 415/604-3625

The sunphotometer determines atmospheric transmission by tracking the sun and measuring the relative intensity of the direct solar beam in 14 spectral channels. The telescope mounts external to the aircraft skin, to increase data-taking opportunities relative to in-cabin sunphotometers and to avoid data contamination by cabin-window effects. Each channel consists of a baffled entrance tube, interference filter, photodiode detector, and integral preamplifier. Filters are at wavelengths from 380 to 1558 nm, chosen to allow separation of aerosol, water vapor, ozone, and nitrogen dioxide transmission. Detectors in the two longest-wavelength channels incorporate thermoelectric coolers that maintain the detector at 0 ±1 C. The other 12 channels are maintained at +40 ±1 C. Solar tracking is achieved by azimuth and elevation motors driven by error signals derived from a quad-cell photodiode. The instrument is designed to operate on a variety of aircraft, some of which will be remotely piloted or autonomous. Hence it must locate and track the sun without input from an operator and record data in a self contained data system. In addition, it must interface to an aircraft-provided telemetry system, so as to receive and execute commands from an operator station, and transmit science and instrument-status data to that station. The instrument must maintain its radiometric calibration (including window and filter transmittance, as well as detector responsivity and electronic gain) to within 1% in each spectral channel for periods of several months.

Fourteen-Channel Airborne Tracking Sunphotometer parameters

Location/ Port/Inlet	Weight (lb)	Power (W)	Dimensions (in)	Status/Schedule
Top of cabin, nose, wing, or	70 (goal) 135 (max)	500 (est peak)	**Outside A/C:** 8" D dome (hemisphere) atop 5" H pedestal. (Total H: 9" above A/C skin)	Assemble 4/96; Test 3-6/96; Integrate 6/96;

pod. 9" D port			**Inside A/C:** 12" D x 18" H cyllinder. + laptop computer for checkout and test flights	TARFOX: 7/96

7.2 SATELLITES

The table below shows the four polar-cobiting satellites that will be used for TARFOX.

TABLE 5. Core Polar Satellites in TARFOX

Polar Satellite	Sensor	Local Overflight Time
NOAA-14	AVHRR	1-3 pm
ERS-1/2	Along-Track Scanning Radiometer (ATSR-1/2)	~10:30 am
MSX	Steerable UV/Vis spectrographs	2-4 pm
IRS	Modular Optoelectronic Scanner	

7.2.1 Enhanced Analyses For Core TARFOX Satellites. (so-ordination: L. Stowe, S. Brown, J. Fischer, C. Davis, E. Shettle)

Several investigators plan to conduct enhanced analyses for sensors such as the ATSR-2 instrument on the ERS-2 satellite and UVISI on the MSX satellite (core TARFOX satellites listed in Table 3.)

7.2.2 POLDER and OCTS algorithm studies. (co-ordination: T. Nakajima)

It is planned to use TARFOX data to test and refine aerosol-retrieval algorithms for the POLDER and OCTS sensors scheduled for launch on the ADEOS satellite in August 1996.

7.3 SURFACE-BASED INSTRUMENTS

7.3.1 GSFC Sun/Sky Photometers (ground-based and ship-based)

Points of contact for these instruments are:

NAME	ADDRESS	EMAIL	PHONE/FAX
Lorraine Remer	NASA Goddard Space Flight Center Code 913 Greenbelt, MD 20771-0001	remer@climate.gsfc.nasa.gov	301/286-8325 301/286-1759
	NASA Goddard Space Flight		(301)286-

Brent Holben	Center Code 923 Greenbelt, MD 20771-0001	brent@kratmos.gsfc.nasa.gov	2975 (301)286-1757

The GSFC Sun/Sky Photometer complement consists of the following equipment:

3 Cimel sun/sky radiometers (1 regular, 1 with polarization, 1 thermal)
1 Eppley pyranometer
1 PAR sensor
1 Optronics hemispherical spectral radiometer
1 or 2 Yankee shadowband radiometer(s)

These instruments will be located at Wallops Island, on the roof of Bldg. Y15 and possibly at other sites that have adequate exposure to the sky. A regional network of regular Cimel Sun/Sky Photometers will be in operation with instruments at:

Sandy Hook NJ (40 deg 26' 53" N; 73 deg 59' 36" W)
Hog Island VA (37 deg 27' 30" N; 75 deg 40' 15" W)
Hampton Roads VA (36 deg 47' N; 76 deg 27' W)
Bermuda (32 deg 22' N ; 64 deg 41' W)

In addition, two cruise ships, the Zenith and Meridian of Celebrity Cruise Lines will be instrumented with manually operated Cimel sun/sky radiometers. Both ships transit between New York City and Bermuda. The schedule for the Zenith and the Meridian are given in Table 6 on the next page.

The science objectives for these instruments are : to measure total column ambient optical properties of aerosol, variation of aerosol regionally and variation of aerosol as a function of distance from shore, to compare aerosol optical thickness measured by ground-based instruments with optical thickness derived from satellite/MAS imagery and in situ measurements, and to provide "truth" in validation of MODIS algorithms that derive aerosol properties over ocean and land.

TABLE 6. Sun-Sky Photometer Cruise Ship Schedule

DATE	Near New York		Open Ocean	Near Bermuda	
	AM	PM	All Day	AM	PM
6		Z			
7	M		Z		
8		M		Z	
9				M	
10					
11					Z
12			Z		M
13	Z	Z	M		

14	M	M	Z		
15			M	Z	
16				M	
17					
18					Z
19			Z	M	
20	Z	Z	M		
21	M	M	Z		
22			M	Z	
23				M	
24					
25					Z
26			Z		M
27	Z		M		
28	M				

NOTES:
M= S.S. MERIDIAN All departures 1700, all arrivals 1000
Z= M/V. Zenith; All departures 1500, all arrivals 0830
M/V. Zenith & S.S. Meridian courses: New York to Bermuda 137 degrees True
Bermuda to New York 317 degrees True
Speeds: Zenith 18.5 Kts. and Meridian 19.5 Kts.
All times are given in Local Time.

7.3.2 GSFC Raman LIDAR

The primary points of contact for this instruments are:

NAME	ADDRESS	EMAIL	PHONE/FAX
Richard Ferrare	Code 912 Hughes STX NASA Goddard Space Flight Center Greenbelt, MD 20771	ferrare@agnes.gsfc.nasa.gov	301-286-9089 301-286-1762 fax
Geary Schwemmer	Code 912 NASA/GSFC Greenbelt, MD 20771	geary@virl.gsfc.nasa.gov	301-286-5768 301-286-1762 fax

This is a custom-built, trailer based Raman lidar system used to measure aerosols and water vapor. For daytime operation, the system uses a Nd:YAG laser which has an output wavelength of 355 nm; for nighttime operation, the system uses an excimer laser with an output wavelength of 351 nm (laser and eye safety details are given in Appendix B). The laser light is sent into the atmosphere where it is scattered by molecules and aerosols; the backscattered light is detected by a telescope which is also part of the lidar system. The lidar system will be used to acquire data both pointing vertically and in a scanning mode. For the scanning mode, the system is mechanically limited to a fixed azimuth. The entire lidar system is contained in two environmentally controlled trailers; one trailer houses the laser, telescope, optics, and data acquisition electronics, while the second contains computers for data acquisition, analysis, and display as well as the operating personnel.

The plan is to deploy the trailers in the south parking lot adjacent to building U-70 on the island. The trailers will be oriented so that the scan azimuth (which has been previously surveyed) lies between 124.3° and 124.6°. As in previous experiments, pressure, temperature, and humidity data will be obtained from existing Wallops instruments mounted on the top of building X85. These sensors record data once per minute. The location of the sensors on top of building X85 will allow comparison of these in-situ measurements with lidar measurements of water vapor mixing ratio and relative humidity obtained by scanning above the building.

Both lasers are class IV laser systems. The excimer laser is eye safe beyond 2.9 km while the Nd:YAG laser is eye safe beyond 3.1 km. These calculations are based on the assumption that the laser beam would be viewed for a full 10 seconds. The exposure time for aircraft would be much less than 10 seconds. The beam size at a distance of 3 km is about 1 meter by 1 meter. Assuming an exposure time of 0.25 seconds, which is much longer than the beam could be viewed from even the slowest of aircraft, then the laser beam would be eye-safe at a range of 500m for either laser. In addition, any normal aircraft window will partially absorb laser radiation at the 351nm and 355nm laser wavelengths. The laser beam exits the trailer at a height of 8 feet above ground level providing protection for personnel in the vicinity of the lidar system.

The scanning Raman lidar will be used to acquire daytime profiles of aerosol backscattering and extinction at Wallops Island during TARFOX. The lidar will provide vertical profiles of aerosol backscattering and extinction for use in analyzing and interpreting coincident sun photometer measurements of solar and sky radiance. These lidar profiles will be used to measure the boundary layer thickness and locate the presence of elevated haze layers. The lidar profiles of aerosol extinction will be integrated to obtain aerosol optical thickness; this will permit direct comparisons with the sun photometer instruments and will help ascertain the sun photometer calibration. The lidar measurements of aerosol backscattering and extinction will be: 1) compared with measurements of aerosol scattering and extinction acquired by various aircraft, 2) compared with values derived from in-situ aircraft measurements of size and composition, and 3) used to identify altitudes where aerosol physical properties vary with time.

7.3.3 JPL/Multi-angle Imaging SpectroRadiometer (MISR) - Associated Instruments

The primary points of contact for this instruments are:

NAME	ADDRESS	EMAIL	PHONE/FAX
Conel, James E.	Jet Propulsion Laboratory 4800 Oak Grove Drive	jconel@jord.jpl.nasa.gov	818/354-4516

	Mail Stop 183-501 Pasadena, CA 91109-8099		818/393-4619
Mark Helmlinger	Jet Propulsion Laboratory 4800 Oak Grove Drive Mail Stop 183-501 Pasadena, CA 91109-8099	mch@jord.jpl.nasa.gov	818/354-4516 818/393-4619

The MISR complement for TARFOX includes the following instrumentation, which will be located on Wallops Island, on the roof of Building Y15.

1. A semi-automatic tracking sunphotometer, which consists of a sensing head, tracking mount & stand, control box, gel-cell battery, cables, and small solar panel, custom made by the University of Arizona and modified by JPL.
2. A Multi-filter Rotating Shadowband Radiometer. Includes sensing head and shadowband drive stand, control box, gel-cell battery, cables, and small solar panel, made by Yankee Engineering Systems.

7.3.4 S. Dakota School of Mines Spectral Sun Photometer

The primary point of contact for this instruments is:

NAME	ADDRESS	EMAIL	PHONE/FAX
Ron Welch	South Dakota School of Mines Inst. of Atmos. Science 501 E. St. Joseph Rapid City, SD 57701	welch@cumulus.ias.sdsmt.edu	605/394-2291 605/394-6061

The spectrometer is a passive device that measures energy in the 0.3 to 1.1mm range. Spectral filtering is achieved with wedge interference filters and detection is with a CCD array. It does not radiate or transmit any energy (except for the ambient EM energy that any electrical device radiates). It is cylindrical in shape and is approximately 2 feet long and 6 inches in diameter. It is mounted on small tripod. It also has an electronics box that is approximately 8 inches on a side. An older 286 PC is interfaced to it for data recording and display. The entire setup operates on 120V and consumes about 3-4 amps.

The above-described sun photometer will be used to obtain measurements of aerosol spectral optical depth over the 0.3 mm to 1.1 mm wavelength interval at a spectral resolution of approximately 20 nm. This measurement is derived from a series of relative direct solar irradiance measurements over a period of approximately 2 hours just after sunrise and just before sunset. Langley plots are generated for each wavelength over the period of the measurements from which the slope of fitted points determines the optical depth. The characteristics of the spectral optical depth curve will hopefully provide insights into the absorptive/scattering properties, the type, and the size distribution of the aerosol.

The spectral sunphotometer will be located at Wallops Island, near either building X-15 or U70.

7.3.5 Johns Hopkins University Spectroradiometer

The primary point of contact for this instruments is:

NAME	ADDRESS	EMAIL	PHONE/FAX
William Swartz	Johns Hopkins University Applied Physics Laboratory Near-Earth Env. Remote Sensing Group Johns Hopkins Road Laurel, MD 20723-6099	bill.swartz@jhuapl.edu	301-953-6000 (ext 8462) 301-953-6670

This is a UV-B spectroradiometric system, which includes a lightweight Ebert-Fastie double-pass spectroradiometer with entirely reflective optics. It collects light via a hemispherical cosine diffuser. The instrument, designed ultimately for air-based observations, has a spectral range from 180-330 nm. Ground-based observation of UV-B radiation will be supported for TARFOX. The wavelength resolution is 0.3 nm (FWHM), with accurate, reproducible wavelength registration of +/- 0.02 nm.

Hemisperical UV-B measurements will be collected from the island throughout the day. There are retrieval algorithms for column ozone. Aerosol optical depth may also be obtained from the data.

The spectroradiometer will be located outside Bldg Z-65 on Wallops Island.

7.3.6 GSFC Scanning Mobility Particle Sizer (SMPS)

The primary point of contact for this instruments is:

NAME	ADDRESS	EMAIL	PHONE/FAX
Qiang Ji	SSAI NASA GSFC 5900 Princess Garden Parkway Suite 300 Lanham, MD 20706	ji@climate.gsfc.nasa.gov	(301)731-9300 (301)731-1180

This experiment will consist of the following instrumentation:

1. Scanning Mobility Particle Sizer (SMPS), made by TSI
   measures the size distribution of sub-micron aerosol particles
2. CCN Remover, custom made
   an add-on to SMPS to measure cloud condensation nuclei (CCN)
3. CCN counter, made by DH Associaton
   counts CCN
4. Aerosol Volatility Device, custom made
   an add-on to SMPS to measure volatility of aerosols

This instrumentation will be used to study the microphysical and chemical properties of aerosols. Collaborating with the aerosol science group at the University of Alaska-Fairbanks, various ground-based instruments will be used to measure the number concentration and size distribution of submicron particles, the number concentration and supersaturation spectra of CCN, and the volatility of aerosols.

This instrumentation will be located at Wallops Island, outside Bldg. X15.

7.3.7 Bermuda Aerosol Analyses

The primary point of contact is:

NAME	ADDRESS	EMAIL	PHONE/FAX
Joseph M. Prospero	Rosensteil School of Marine and Atmospheric Sciences University of Miami 4800 Rickenbacker Causeway Miami, FL 33149	jprospero@rsmas.miami.edu	305/361-4789 f305/361-4891

The Bermuda site of the AEROCE network of monitoring stations will provide measurements of aerosol physical and chemical properties. These will include filter and impactor analyses of composition, light scattering and absorption, and optical depth and sky radiance spectra from sunphotometers, a shadowband radiometer, and a solar/sky radiometer. Collaborators include Y. Kaufman and B. Holben of NASA Goddard Space Flight Center, and R. Frouin of NASA Headquarters.

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