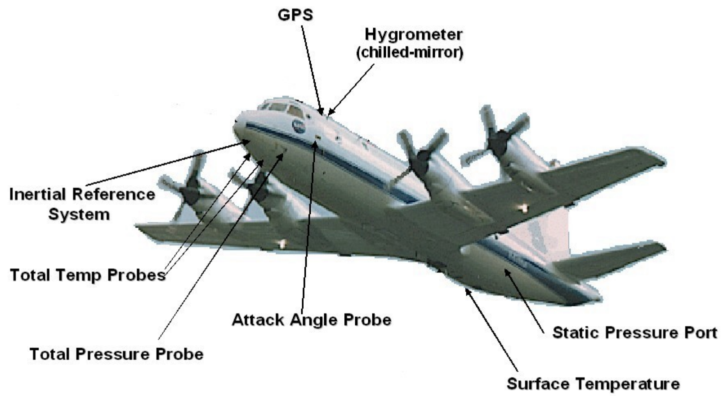
Supporting Measurements

John Barrick
NASA Langley Research Center

Primary sensors, instrumentation, data acquisition, display, and data distribution systems required for meteorology, navigational, and flight related measurements.

- **Robust Suite of Instrumentation and Sensors**
- **Data Acquisition and Distribution System**
  - Records meteorology, navigational, and flight related parameters.
  - Distributes all parameters via serial and network connections.
- **Real-time Data Analysis and Plotting System**
  - System configuration emulates data acquisition system. (Back-up for data acquisition system)
  - Generates multiple and variable axis plots.
  - Plotting software (RTplot) developed for simultaneous graphical display of real time and pre-recorded data.
  - Meteorological, navigational, and flight data displays.
  - Completely separate from data acquisition tasks and available to airborne science teams decision planning.
- **Video Display/Recording System**
  - LCD flat panel monitors distributed throughout aircraft.
  - Multiple and independent display formats available via cabin LCD and network. (Alpha-numeric Data, Graphics and Plotting, Forward and Nadir video)
  - Video recorded in digital format for post-mission distribution via data disks and/or FTP site.
- **Post-flight Plotting, Analysis, and Archiving Software (Web-based)**

Supporting Measurement Instrumentation/Sensors



Aerosol Radiative Forcing in the Arctic – NASA P-3 Measurements of Solar and IR Irradiance

Anthony Bucholtz, Elizabeth Reid
Naval Research Laboratory, Monterey, CA

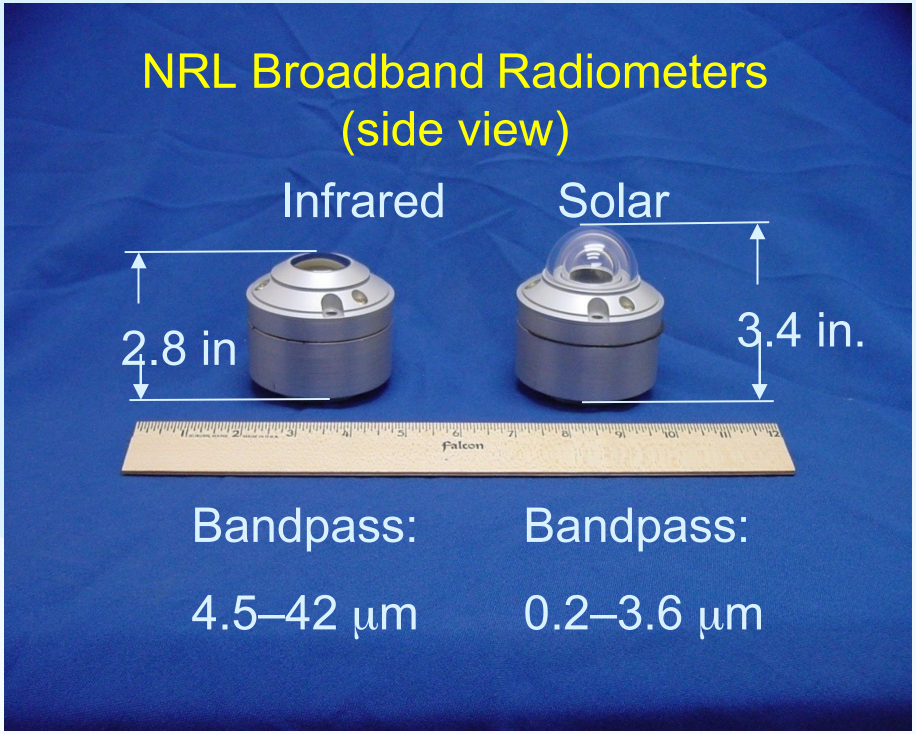
Measurements:

- Upwelling and Downwelling Solar and IR irradiance =>
- Net flux, forcing efficiency, radiative forcing, absorption, heating rates, albedo

Scientific Objectives:

Quantify the impact of the vertically and horizontally stratified springtime haze and summertime boreal forest fire smoke on the radiative budget of the Arctic:

- Measure the solar and IR forcing throughout the atmospheric column
- Quantify the impact of pollution on the IR emission of Arctic clouds
- Measure surface albedo

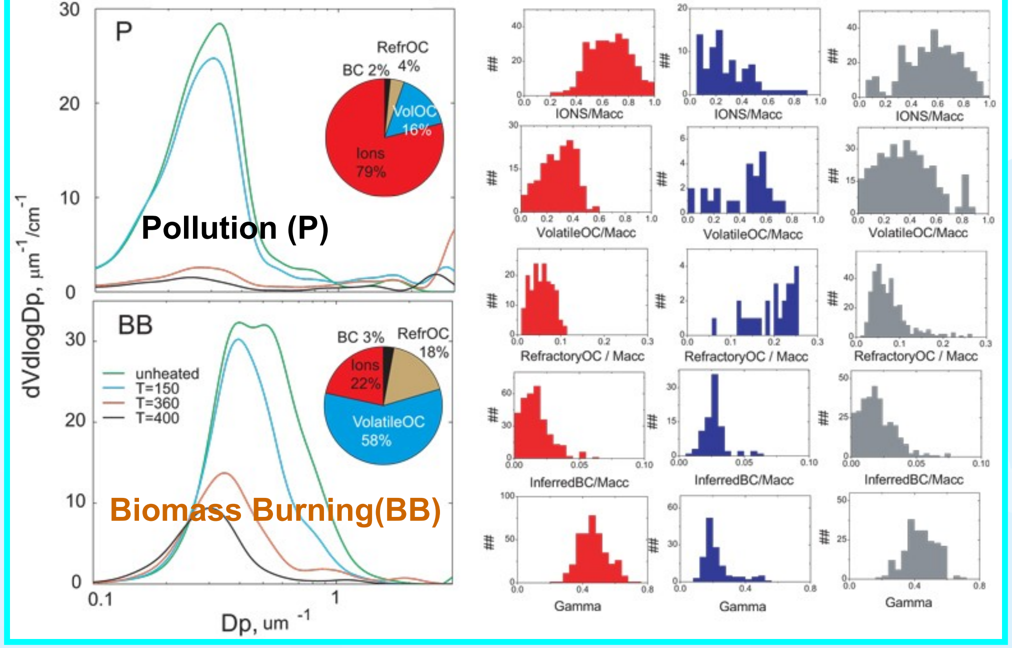


Aerosol Radiative Forcing in the Arctic – NASA P-3 Measurements of Solar and IR Irradiance

Operational Requirements:

- Level Flight During Data Runs
  - Pitch/Roll limits: +/- 2 deg ideal, +/- 5 deg max
- Airspeed: N/A
- Desired Flight Altitudes:
  - Multiple levels throughout atmospheric column (surface to above aerosols)
  - Flights underneath a gradient in the aerosols
- Undesirable Flight Conditions:
  - Spiral ascents and descents
- Requested Calibration Maneuver => ‘Square-Box Pattern’
  - Four constant altitude, level legs (each leg offset 90 deg from previous)
  - Each leg 3-5 min duration
  - Clear skies
  - Performed near beginning, middle, and end of mission

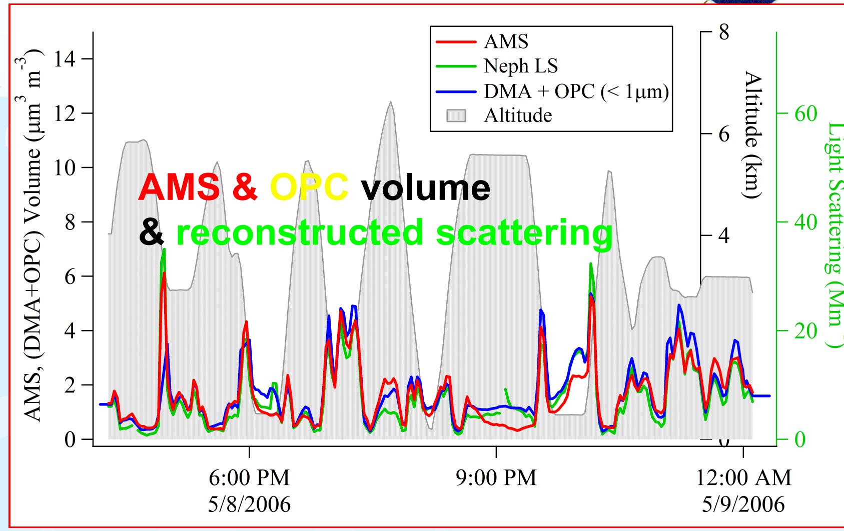
INTEX A OPCdata



Size-resolved volatility (OPC) and composition (AMS) characterizes the different aerosol mass fractions in pollution (P) and biomass burning (BB) and humidity response (above). Radiative closure will link radiances & AOD to aerosol physics, chemistry and water uptake.

A.D. Clarke, PI
University of Hawaii

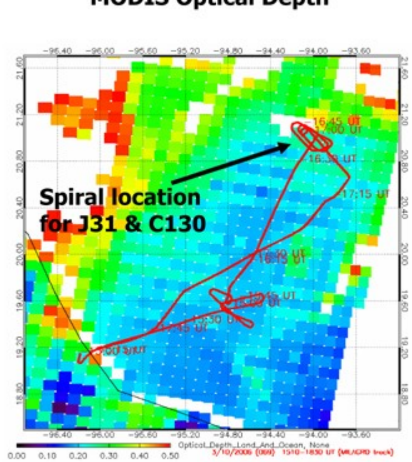
HiGEAR – Hawaii Group for Environmental Aerosol Research



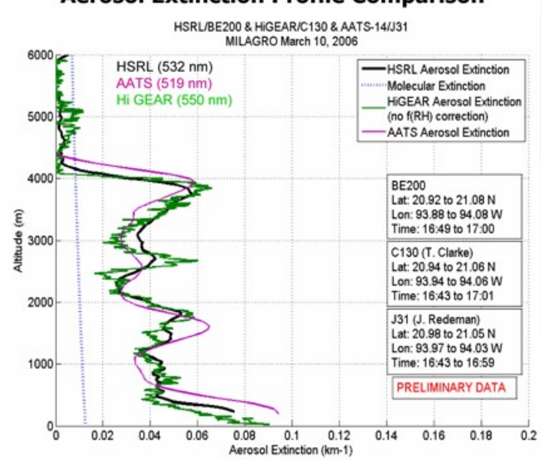
We want to examine the extent to which CCN are linked to primary soot particles (SP2) and the ions and OC condensed upon them (AMS above). Differences in Estimated (OPC) vs. observed CCN activation is expected to be linked to OC mass fractions (see rainbow in the data below for Mirage).

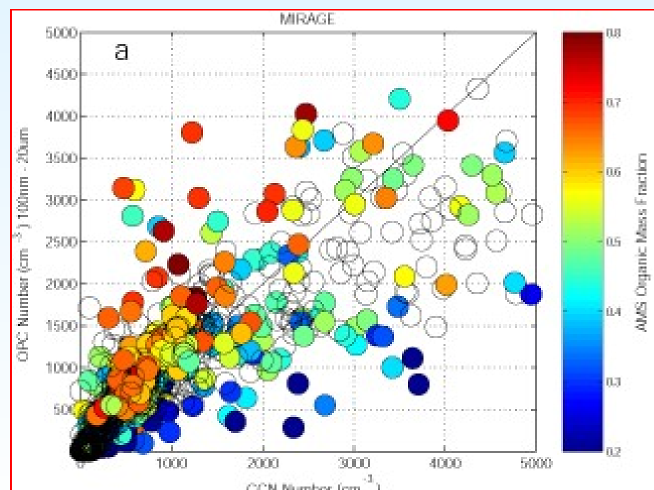
Satellite Retrieval Studies and Extinction Profile Comparison

MODIS Optical Depth



Aerosol Extinction Profile Comparison





Operational Requirements, Issues

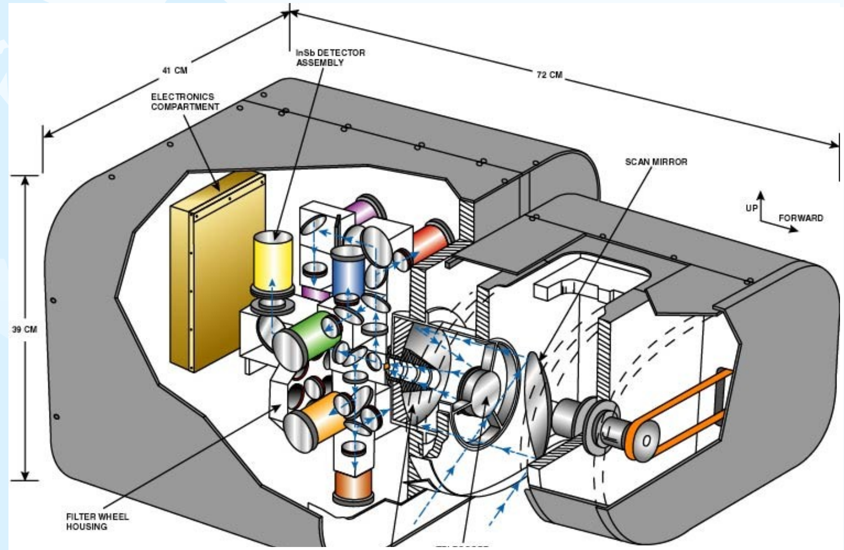
- Need Inlet Probe Fabricated by Feb 15
- Ascents – Descents < 1000'/min
- 2 hr warm up; 20min shut down
- No freeze on plane if possible
- Butanol Fill of CN counters during warm up?
- Flights linked to lidar curtains when possible
- Communication and image transfer between planes (lidar)?
- Impact of Thule flights on available personnel
- Model products – how reliable for radiation mission guidance in Arctic? *Do they capture aerosol conc. and AOD for both surface layer and decoupled upper layers when compared to existing surface and lidar sites (Barrow, NyAlesunde, Alert etc.)?*

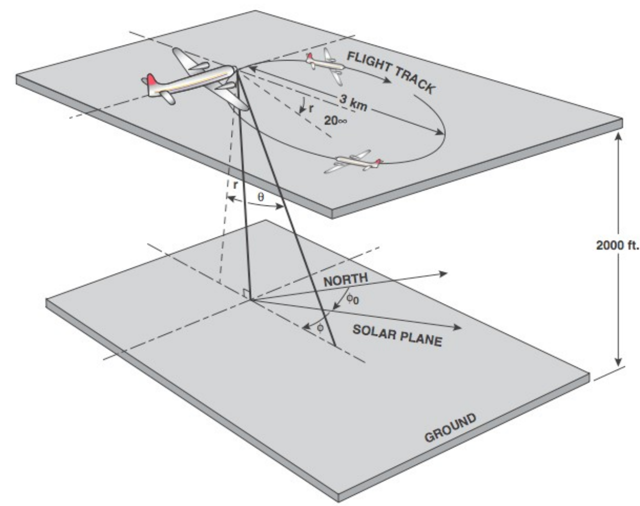
"Characterization of Aerosols & BRDF from Airborne Measurements over Snow, Tundra, and Clouds"

C. K. Gatebe & M. D. King

Sensor characteristics/ measurements requirements:

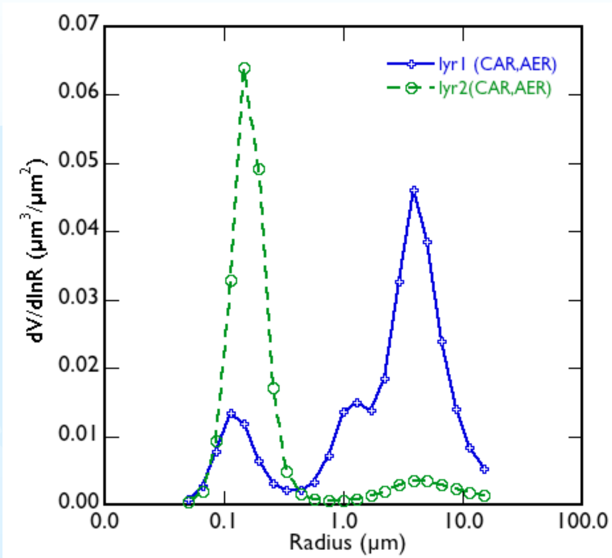
- 14 spectral bands (0.34 to 2.29 µm)
- scan ±95° from horizon on right-hand side of aircraft
  - IFOV: 17.5 mrad (1°)
- scan rate 1.67 Hz (100 rpm)
- data system 9 channels @ 16 bit; 395 pixels in scan a line
- Aircraft speed: 140-160 knots during BRDF
  - 2-3 min/aircraft orbit
- Clear sky measurements over AERONET sites
- Cloud top (CT) BRDF measurements with clear sky above (2 levels: CT & 600 m above CT)
  - AATS critical

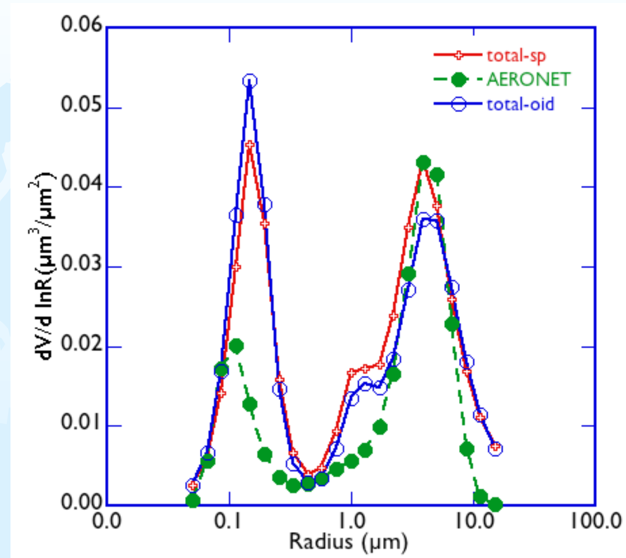




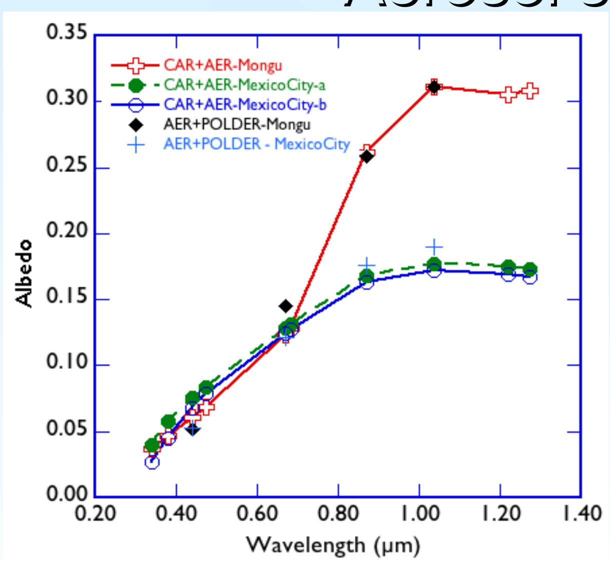
Flight Pattern for BRDF

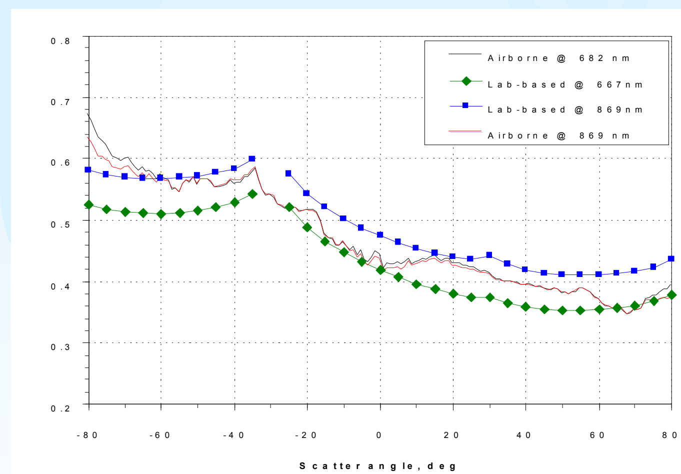
Example Results





Aerosol size distr. (Mexico City)





Albedo: airborne vs satellite

BRDF: Lab vs airborne

1) Summary of Scientific Contributions

- Spectral (353-2139nm) AOD above NASA P-3, usually to within 0.01 ⟶ aerosol extinction in vertical profiles
- Columnar water vapor, usually to within 5-10% ⟶ water vapor concentration in vertical profiles

4) Summary of Scientific Objectives

- Horizontal and vertical structure of Arctic Haze and high-lat. biomass burning aerosol
- Properties of Arctic aerosol in the vicinity of clouds
- Direct radiative effects of Arctic Haze and high-lat. biomass burning aerosol from flux and AOD gradient and divergence methods (SSFR+AATS), dependence of radiative forcing on surface albedo
- Spectral single scattering albedo of Arctic Haze and high-lat. biomass burning aerosol (SSFR+AATS)
- Validation of satellite retrievals of Arctic aerosol properties
- Closure of HiGEAR, AERO3X w above [e.g., AOD(λ), SSA(λ)]

a) Operation requirements:

- Prefer dry environments, like to avoid clouds & precip.;
- All aircraft speeds, T, p, OK;
- Avoid orientation of flight legs where instrument's view of sun is obstructed by aircraft fuselage, tail, etc.

e) Any other operational information specific to your investigation:

- Require access to instrument (i.e., top of a/c) before and after each flight;
- Require N_2 for purging on ground and possibly in flight.

h) Perceived gaps and issues requiring WG discussion:

ARCTAS Science Objectives

Solar Spectral Irradiance

Solar Spectral Flux Radiometer (SSFR):

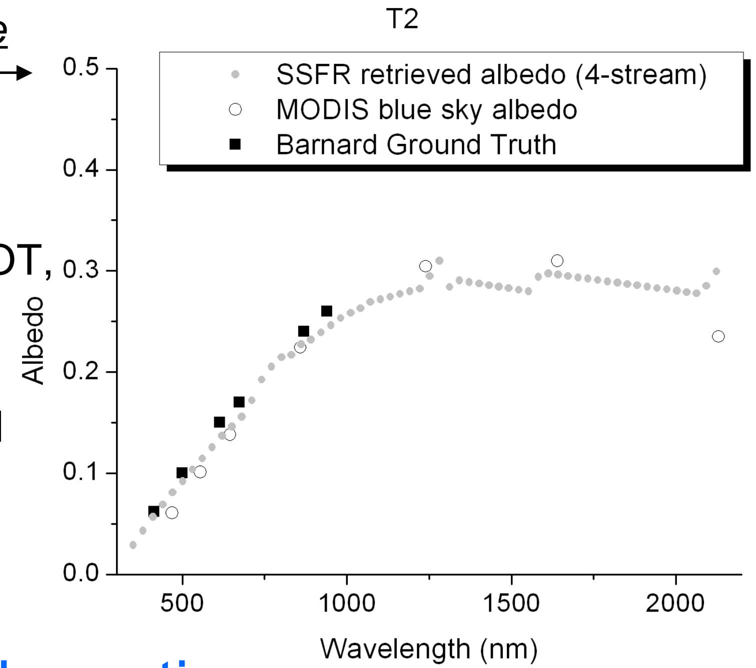
- Up- and downward irradiance 380 nm to 2100 nm
- 8-12 nm spectral resolution
- 1 Hz sampling
- 3-5% absolute accuracy; 0.5% precision
- Experience operating in the ARCTAS environment: FIRE SHEBA and MPACE

Objectives/Measurements

3. Surface spectral albedo, area-averaged and along flight track
4. Characterize surface radiation budget in Arctic and quantify aerosol perturbations. Aerosol forcing, absorption, and single scattering albedo.
5. Retrievals of cloud droplet radius and optical depth; aerosol indirect effect
6. Test/validation/comparison with satellite cloud retrievals (MODIS), aerosol effects on remote sensing of clouds.

1. Surface spectral albedo, area-averaged and along flight track

Example of *SSFR* *measured albedo* and *retrieved surface albedo* for MILAGRO:

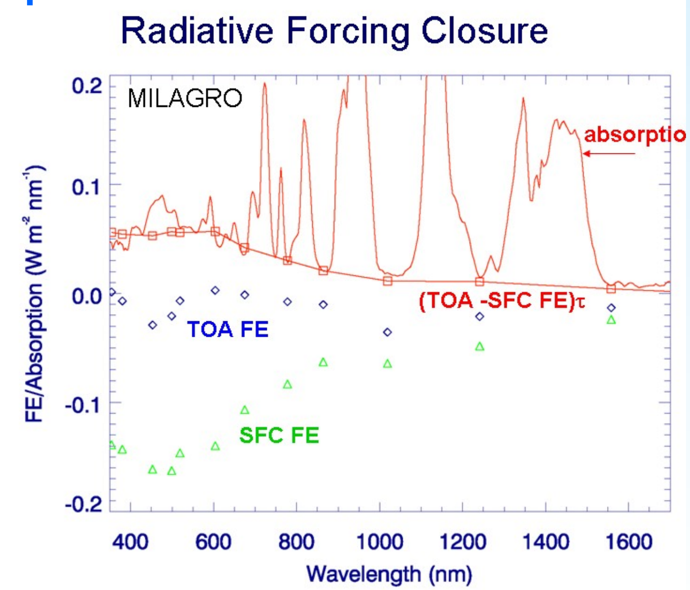


- ➢For the conversion SSFR albedo → surface albedo, we need AOT between the surface and the aircraft.
- ➢Collaboration: HSRL (extinction profiles), AERONET (AOT, SSA?, g?), aerosol in situ measurements?
- ➢With HSRL measurements, can resolve surface albedo *along flight track*. Uncertainty (3-5%) gets larger if aerosol (AOT, SSA, g) is not sufficiently constrained.
- ➢Comparison with MODIS albedo product. MISR?
- ➢Separation of cloud features from underlying surface.

2. Radiation budget; aerosol forcing, absorption

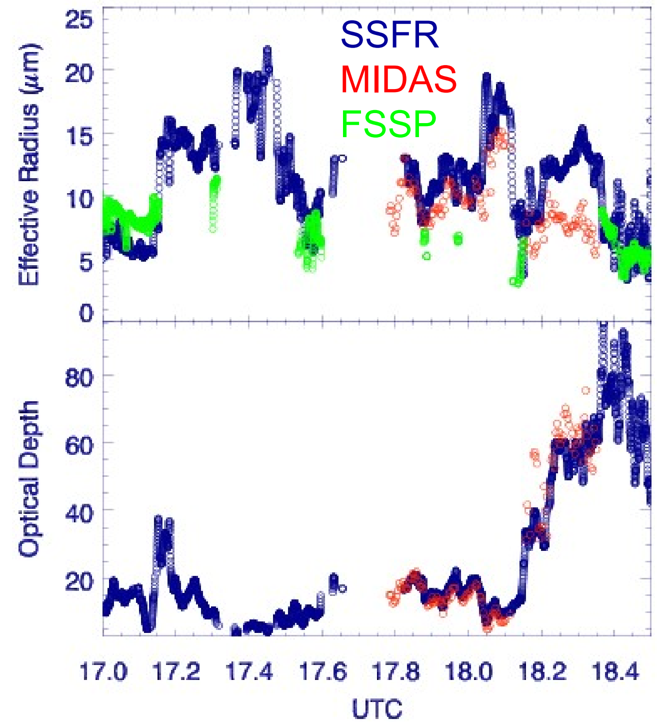
In conjunction with AATS-14 measurements, we have measured *aerosol forcing*, *aerosol forcing efficiency*, and *aerosol absorption* over **land** and over **sea**, for moderate surface albedo. We are hoping to do the same over ice surfaces and the open sea using:

- ➢ low level horizontal leg under aerosol gradient
- ➢ vertical profile (e.g., spiral)
- ➢ parallel low-level and high-level leg
- ➢ Currently working on aerosol + 3D cloud effects



3. Retrieval of cloud thermodynamic phase, optical depth and effective radius

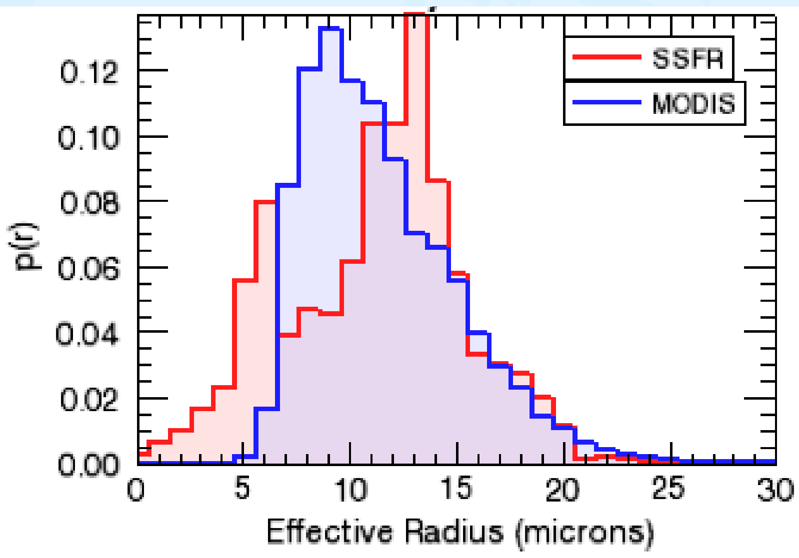
Example from ICARTT 2004



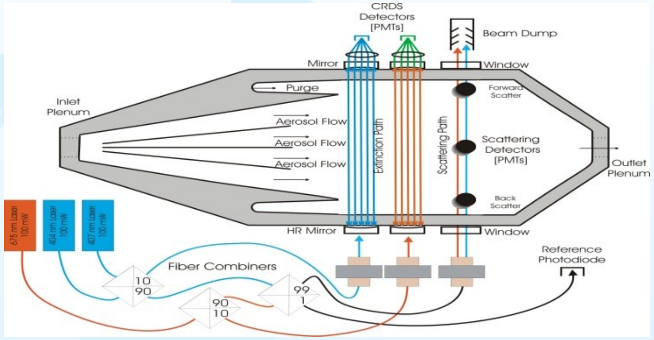
- From flight legs *above* cloud layer, retrieve cloud water phase, optical depth and effective radius
- From flight legs below cloud layer, water phase and optical depth.
- Potential for identifying/quantifying mixed phase clouds

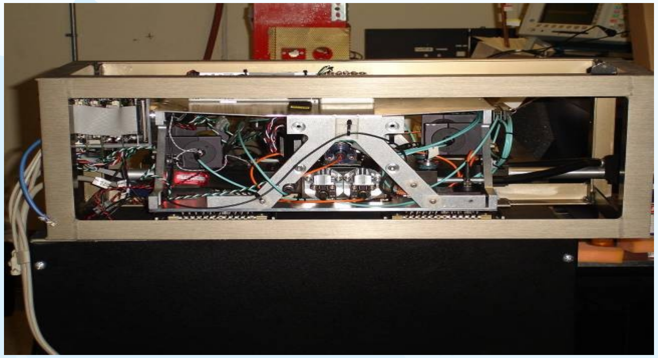
4. Test/validation/comparison with satellite cloud retrievals

- Compare SSFR cloud retrievals with MODIS retrievals
- Examine effects of aerosol layers and surface albedo on MODIS cloud retrievals.



Aero3X





- Measurement of
  - •Aerosol extinction and scattering @ 405 nm and 675 nm
  - •Hemispheric Forward- and Back-Scatter @ 405 nm and 675 nm
  - •NO_2 mixing ratio
  - •fRH
  - •Black Carbon Mass with 2-wavelength aethalometer
- •Determination of
  - •Absorption coefficient, both wavelengths
  - •Single-scattering albedo, both wavelengths
  - •Extinction to backscatter ratio, both wavelengths
  - •Estimate of asymmetry parameter, both wavelengths

Other Requirements

- Operation requirements:
  - Request 5 min level legs for aethalometer measurements
  - Will need to refill distilled water reservoir in-flight
- Aircraft speed, temperature, pressure: no special requirements
- Suitcase flight: Will need assistance removing humidification system if AC temperature is to be below freezing.
- Other issues: We require to take our instrument back to Ames after integration.
- Perceived gaps and issues requiring WG discussion: None.

P-3/B-200 Working Group

B-200

Richard Ferrare, Chris Hostetler, John Hair, Brian Cairns

P-3

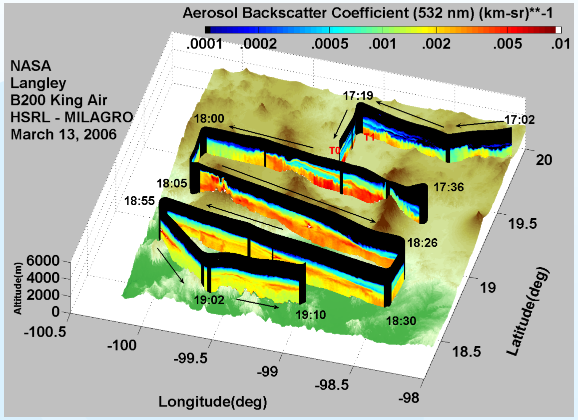
Platform Scientist : Phil Russell

Instrument PIs: John Barrick, Anthony Bucholtz, Antony Clarke, Charles Gatebe, Jens Redemann, Sebastian Schmidt (Peter Pilewskie), Tony Strawa

Deployment of LaRC Airborne High Spectral Resolution Lidar (HSRL) for ARCTAS (Ferrare, Hostetler, Hair)

Objectives

- Characterize the vertical and horizontal distribution of aerosols and aerosol optical properties
- Map and partition aerosol by type
- Evaluate/validate CALIPSO aerosol measurements
- Evaluate/validate high-latitude satellite aerosol measurements
- Evaluate/validate MISR retrievals of boreal fire smoke plume heights
- Investigate new active+passive (lidar+radiometer) aerosol retrieval techniques
- Provide vertical context for in situ measurements of aerosols and trace gases
- Assess aerosol model transport simulations.
- Characterize the PBL height and distribution of aerosols within and above PBL
- Support DOE ARM ISDAC and NOAA ARCPAC missions

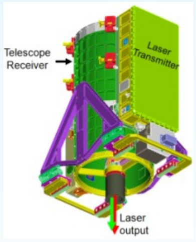


HSRL Data Products

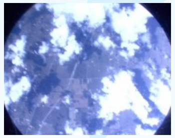
- Aerosol scattering ratio (aerosol/molecular backscatter) (532 nm) ($\Delta x \sim 1$ km, $\Delta z \sim 60$ m)
- Aerosol backscatter coefficient at 532 nm ($\Delta x \sim 1$ km, $\Delta z \sim 60$ m)
- Aerosol extinction coefficient at 532 nm ($\Delta x \sim 6$ km, $\Delta z \sim 300$ m)
- Aerosol wavelength dependence (532/1064) (i.e. Angstrom exponent for aerosol backscatter) (similar to backscatter color ratio)
- Aerosol extinction/backscatter ratio ("lidar ratio") (532 nm) ($\Delta x \sim 6$ km, $\Delta z \sim 300$ m)
- Aerosol depolarization (532 and 1064 nm) ($\Delta x \sim 1$ km, $\Delta z \sim 60$ m)

Extensive – depend on aerosol amount and type

Intensive – depend on aerosol type



HSRL



Digital Camera

Research Scanning Polarimeter (RSP) (Summer Only)

RSP Derived Products

Aerosols
- Optical Depth
- Location & width of bimodal size distr.
- Refractive Index

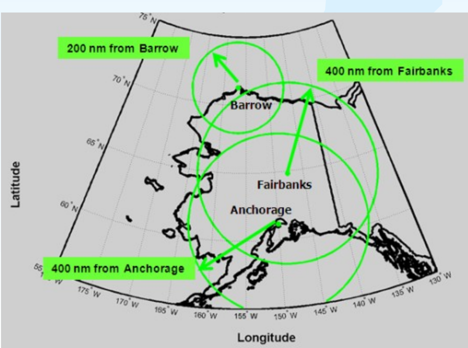
Clouds
- Optical Depth
- Effective Radius, variance
- Liquid water path
- Cloud Drop Number

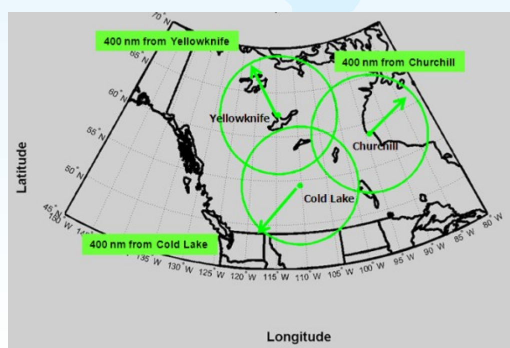
Deployment of LaRC Airborne High Spectral Resolution Lidar (HSRL) for ARCTAS (Ferrare, Hostetler, Hair)

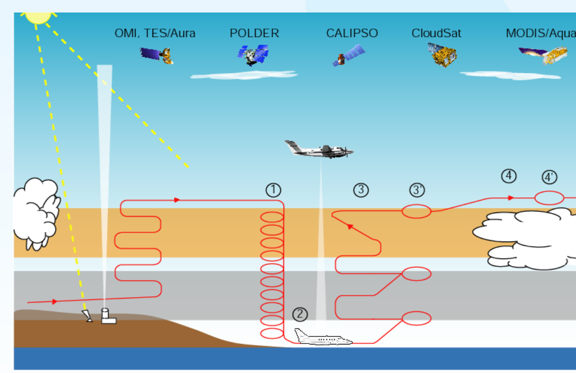
- **Spring**
  - **goal is to operate from Barrow**
  - **for King Air flights planning to land in Barrow, flights must land in Barrow with at least 3 hours worth of fuel remaining on board in case diversion to Fairbanks is required; this should permit 2.5-3 hours to address science objectives.**
  - **anticipate some flights out of Fairbanks and perhaps Anchorage as warranted by conditions and joint operations with other aircraft**
- **Summer**
  - **goal is to operate from Yellowknife**
  - **anticipate some flights out of Cold Lake and elsewhere as warranted by conditions (e.g. smoke), logistics, and joint operations with other aircraft**
- **Most if not all flights during daylight**
- **Must have one hard down day during a span of 7 days**
- **In general, flights to be coordinated with other aircraft (NASA and NOAA P-3, DC-8, DOE ARM ISDAC Convair) and/or with satellite overpasses**

Platform (NASA King Air B200)

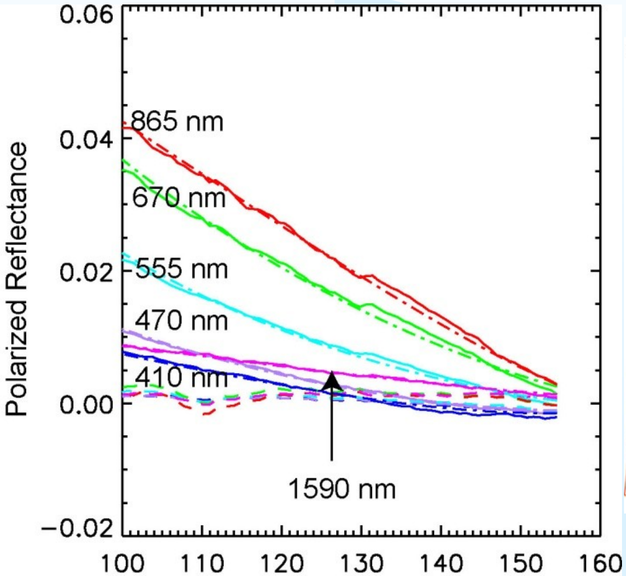
- 27-28 kft (~9 km) nominal flight altitude
- Spring and Summer (~80 hours each; ~30-40 hours in transit)
- Aircraft Speed ~ 200-220 knots
- Aircraft Duration 4-6 hours depending on payload

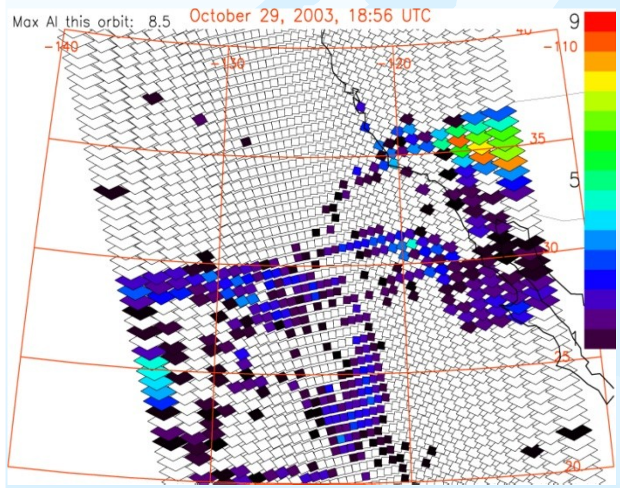


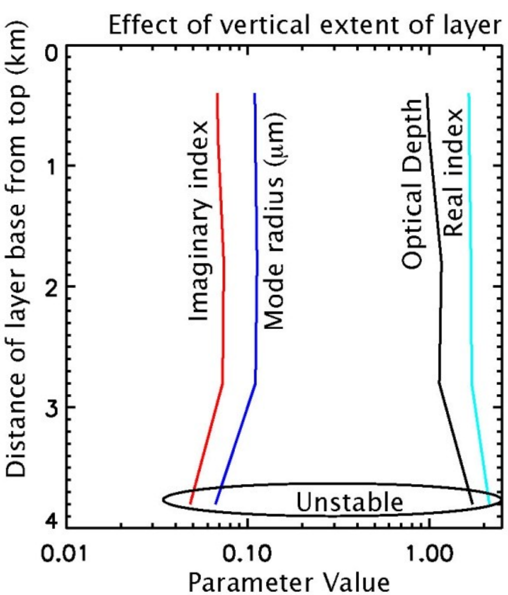


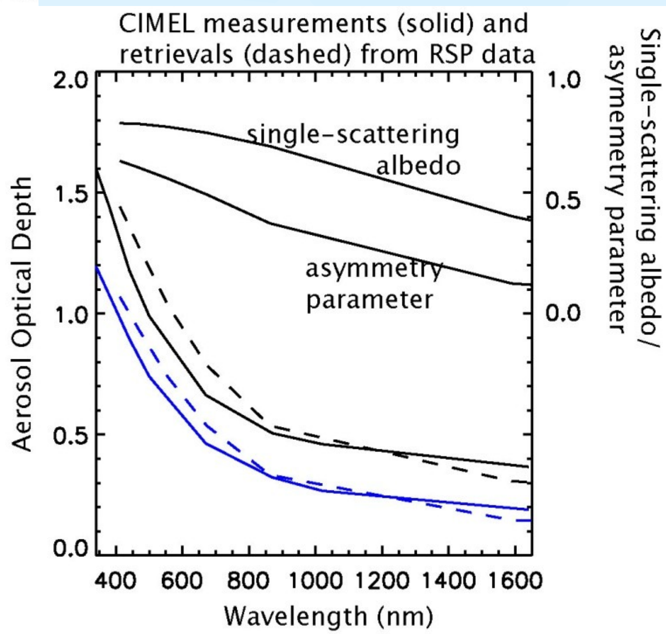


Research Scanning Polarimeter on the B200









The RSP measures multi-angle polarized radiances over the spectral range from 410 to 2250 nm and an angular range of ±60°.

Analysis of RSP data taken over fires in S. Cal. in October 2003 indicate that these measurements allow for accurate estimates of aerosol particle size, real and imaginary refractive index and optical depth.

Comparisons with sun photometer spectral optical depths and TOMS AI are consistent with retrieved parameters within the combined uncertainties.

Real refractive index was higher than typical values assumed.

Research Scanning Polarimeter on the B200

- The RSP is only participating in the summer deployment of the B200.
- (a) operation requirements: aircraft speed, temperature, pressure, suitcase, …

Operations straight and level above the aerosol layer are preferred. Instrument is heated and outside the pressurized skin of the aircraft. Only operational constraints are to close instrument cover when landing, or passing through thick clouds.

- (b) any other operational information specific to your investigation;

In order for the SWIR (1.6 and 2.2 μm) bands to work the instrument needs to be cooled with LN2. This requires the availability of LN2. If the instrument warms up then it is usually necessary to pump down the vacuum again. This can only be on a down day that is NOT a rest day. These operational constraints have been discussed with the B200 PIs (Hostetler/Ferrare). Valid data is still obtained in the VIS/NIR if the sensor is not cooled and can still be used for aerosol remote sensing.

- (c) perceived gaps and issues requiring WG discussion.

None at this point.