NASA King Air B200 Deployment Plans for ARCTAS

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B200 Objectives for ARCTAS

- Characterize the vertical and horizontal distribution of aerosols and aerosol optical properties, including mapping aerosol by type and partitioning optical depth by type.
  - Spring – Arctic haze
  - Summer – smoke from boreal fires (Canada); smoke, pollution in California
- CALIPSO Validation
  - Validation of aerosol backscatter and extinction profiles
  - Supplement data base of extinction/backscatter (“lidar ratio”) measurements used as a basis for key assumptions made in CALIPSO aerosol retrievals
- Validation of high-latitude satellite measurements of aerosol optical depth for MISR and MODIS over both snow/ice backgrounds (spring deployment) and forest/ocean backgrounds (summer deployment)
- Evaluation/validation of MISR retrievals of boreal fire smoke plume heights
- Investigation of new active+passive (lidar+radiometer) aerosol retrieval techniques - HSRL+MODIS, CALIPSO+MODIS, HSRL+RSP
- Provide the vertical context for airborne in situ measurements of aerosols and trace gases and use those in situ measurements to validate new combined active+passive aerosol retrievals
- Assess aerosol model transport simulations
- Characterize the PBL height and distribution of aerosols within and above PBL
- Support Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) Indirect and Semi-Direct Aerosol Campaign (ISDAC) and NOAA (Aerosol, Radiation, and Cloud Processes affecting Arctic Climate) ARCPAC missions

Project Description

- Instruments
  - High Spectral Resolution Lidar
  - Digital Camera
  - Research Scanning Polarimeter (Cairns)

  (High Spectral Resolution Lidar, Digital Camera: Spring; all three: Summer)

- Platform
  - NASA Langley King Air B-200
  - 27-28 kft (~ 9 km) nominal flight altitude
  - Spring and Summer (~80 hours each; ~ 30-40 transit)
  - Aircraft speed 200-220 knots
  - Aircraft duration 4.5-6 hours depending on payload

- Base of Operations:
  - Barrow, Alaska (primary)
  - Fairbanks, Alaska (secondary)
  - Yellowknife, Canada (primary)
  - Cold Lake, Canada (secondary?)

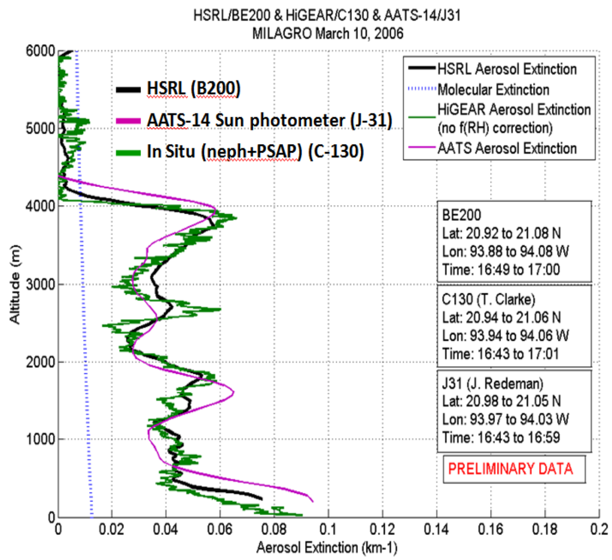
  (Barrow, Fairbanks: Spring; Yellowknife, Cold Lake: Summer)

Airborne HSRL System and Data

HSRL Technique:

- Relies on spectral separation of aerosol and molecular backscatter in lidar receiver
- Independently measures aerosol backscatter, extinction, and optical thickness
- Requires no assumptions or additional data to relate backscatter and extinction
- Can be internally calibrated
- Provides intensive aerosol parameter to help determine aerosol type

Validation – aerosol extinction

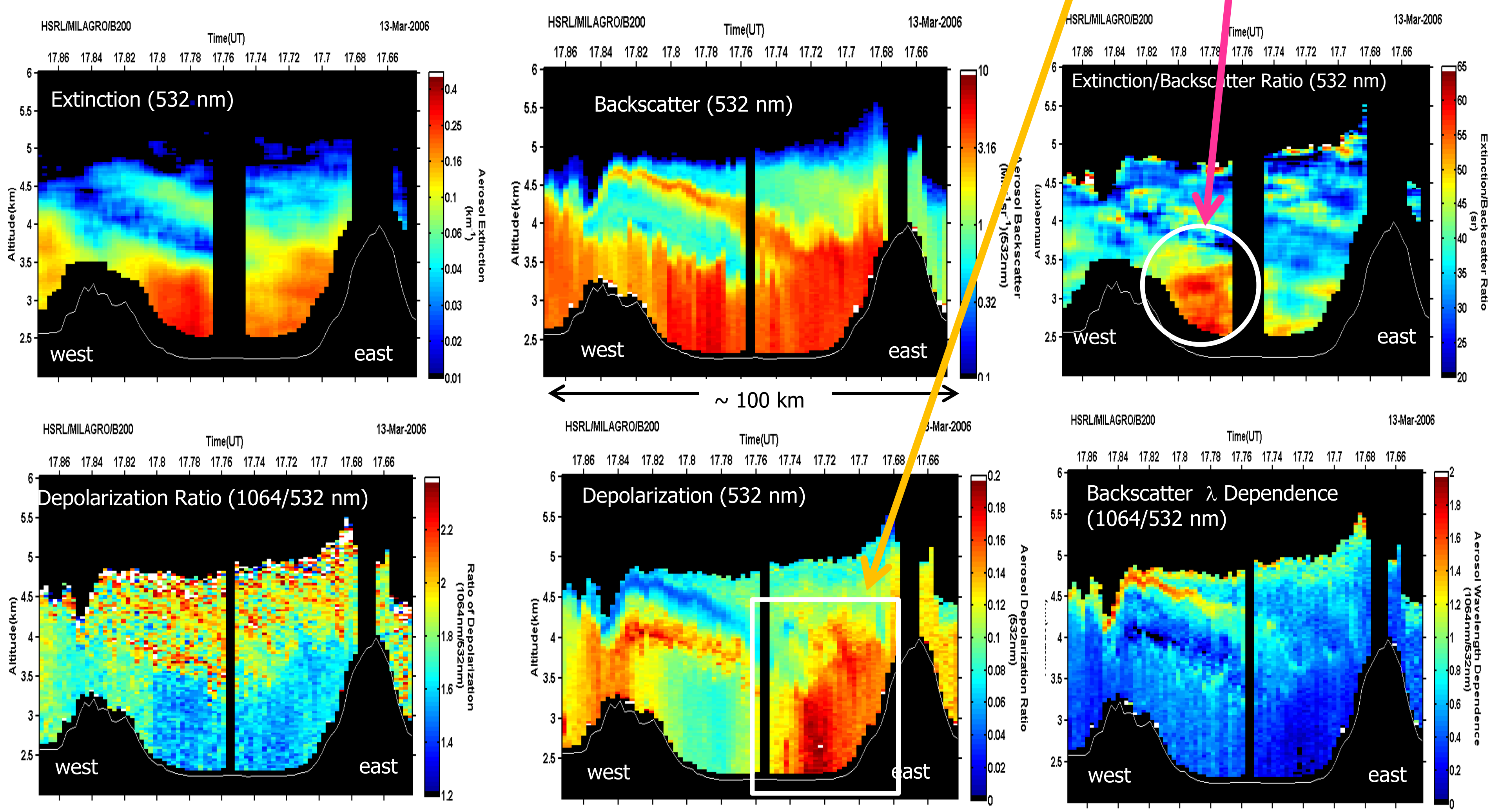


- Independently measures aerosol/cloud extinction and backscatter at 532 nm
- Includes
  - Backscatter channels at 1064 nm
  - Polarization sensitivity at 532 and 1064 nm
- Measurement capabilities
  - Extensive measurements
    - Backscatter at 532 and 1064 nm
    - Extinction at 532 nm
  - Intensive measurements
    - Color ratio (or Angstrom coeff.) for backscatter (β_{1064}/β_{532})
    - Extinction-to-backscatter ratio at 532 nm
    - Depolarization at 532 and 1064 nm

HSRL - Characterizing the spatial distribution of aerosol type

LaRC Airborne HSRL Measurements over Mexico City, March 13, 2006

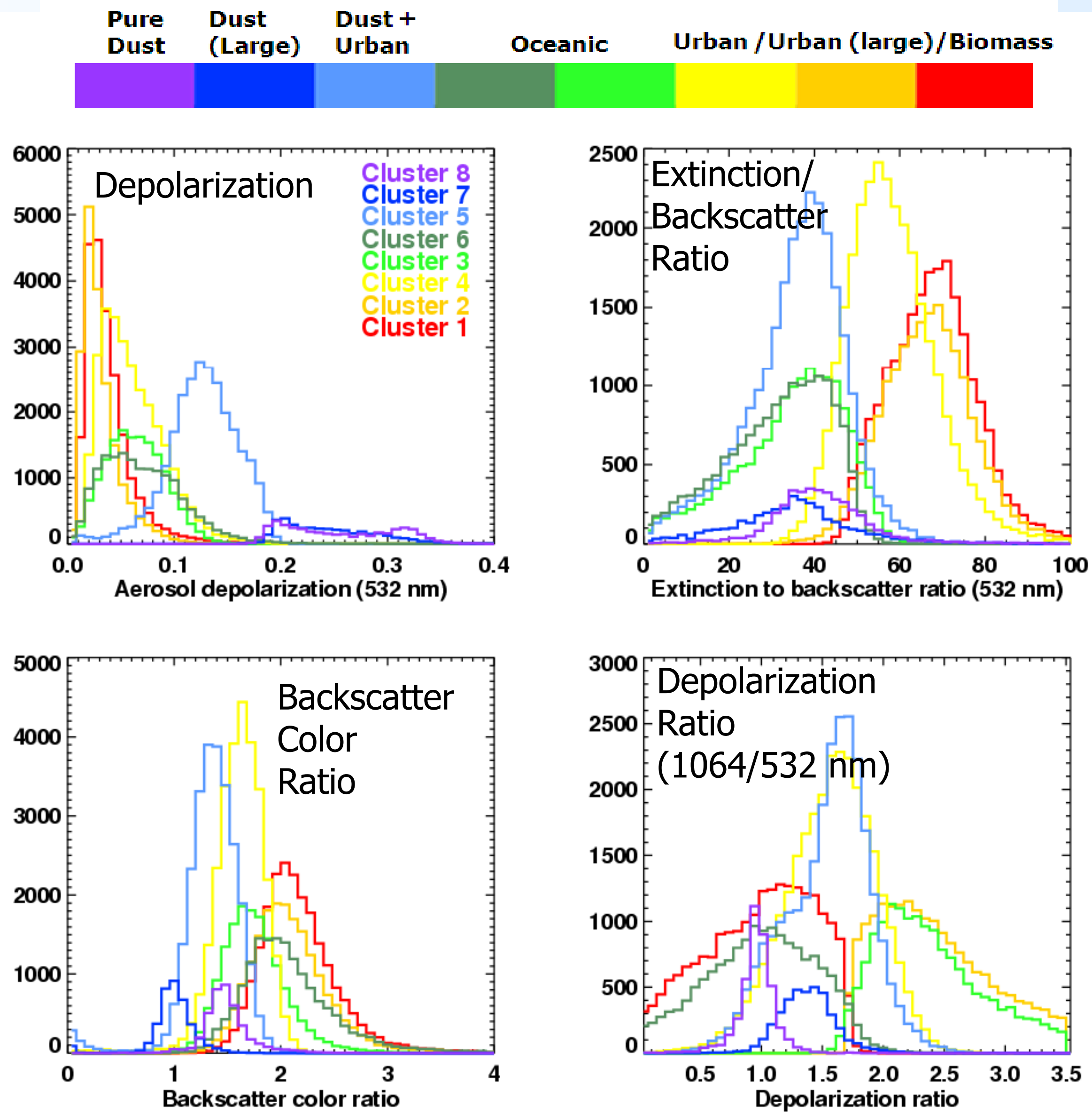
- western part of city- high S_a, high WVD, low depolarization – urban aerosol
- eastern part of city - low Sa, low WVD, high depolarization – dust



Aerosol Classification using HSRL measurements

Aerosol classification is based on HSRL measurements of aerosol intensive parameters

- Extinction/Backscatter Ratio (~absorption)
- Depolarization (~spherical vs. nonspherical – dust/ice)
- Backscatter Color Ratio (~size)
- Depolarization Ratio (1064/532 nm) (~nonspherical/spherical size)

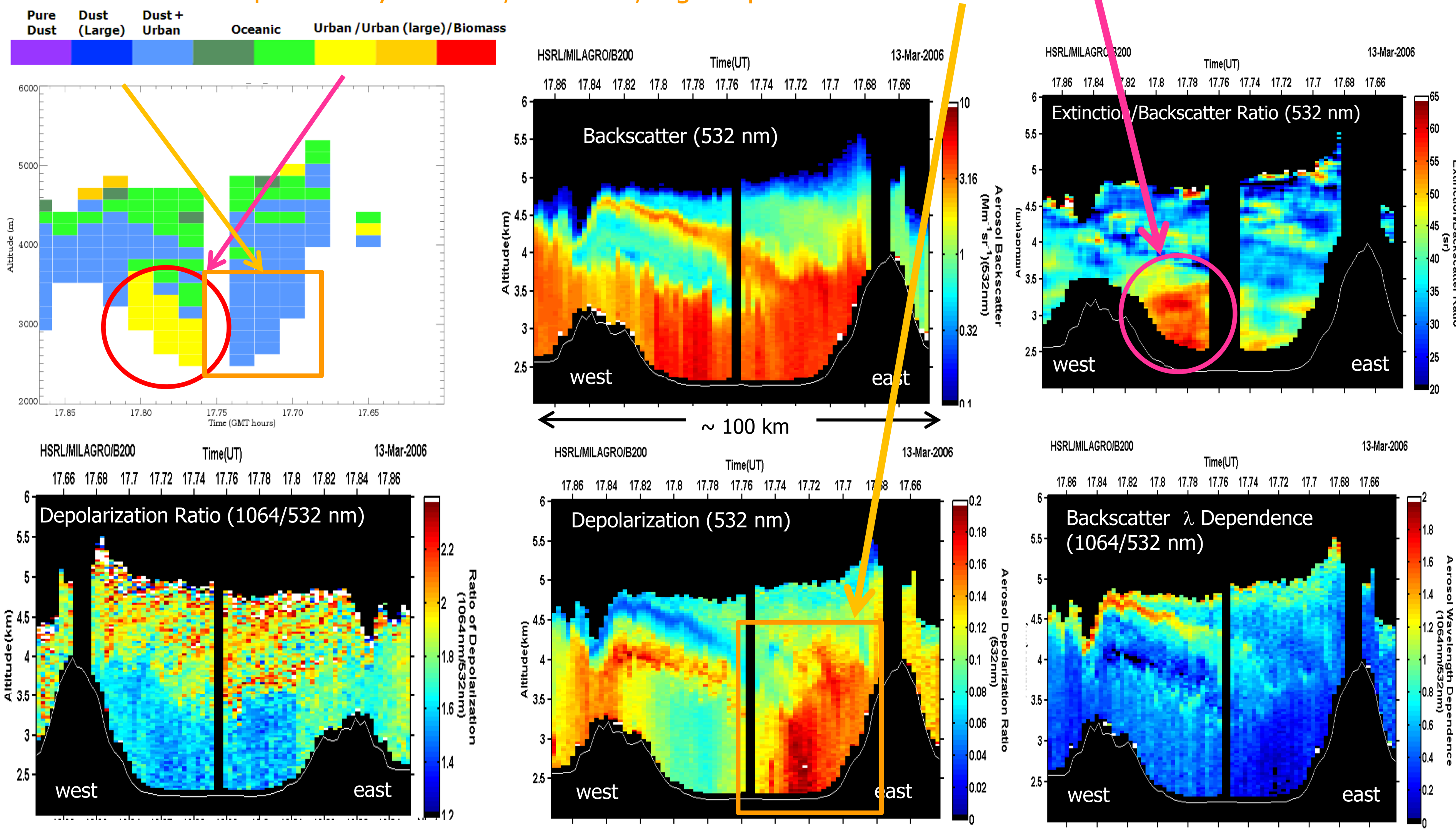


The HSRL measurements of aerosol intensive parameters were used in an objective cluster analysis scheme to discriminate aerosol type. These aerosol types were subjectively related to the aerosol types inferred from AERONET data by Cattrall et al. (2005).

Characterizing the spatial distribution of aerosol type

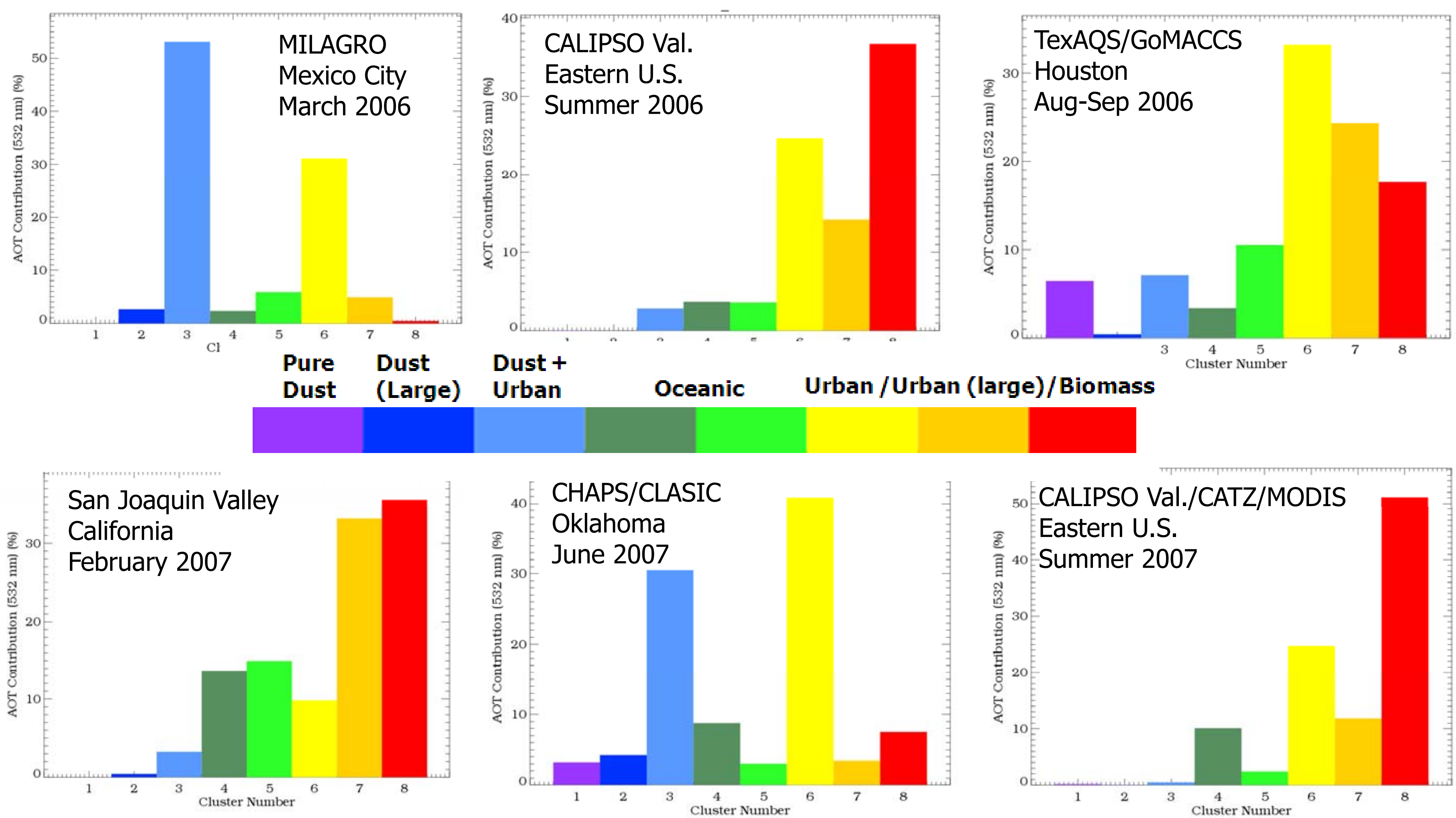
LaRC Airborne HSRL Measurements over Mexico City, March 13, 2006

- western part of city- high S_a, high WVD, low depolarization – urban aerosol
- eastern part of city - low Sa, low WVD, high depolarization – dust



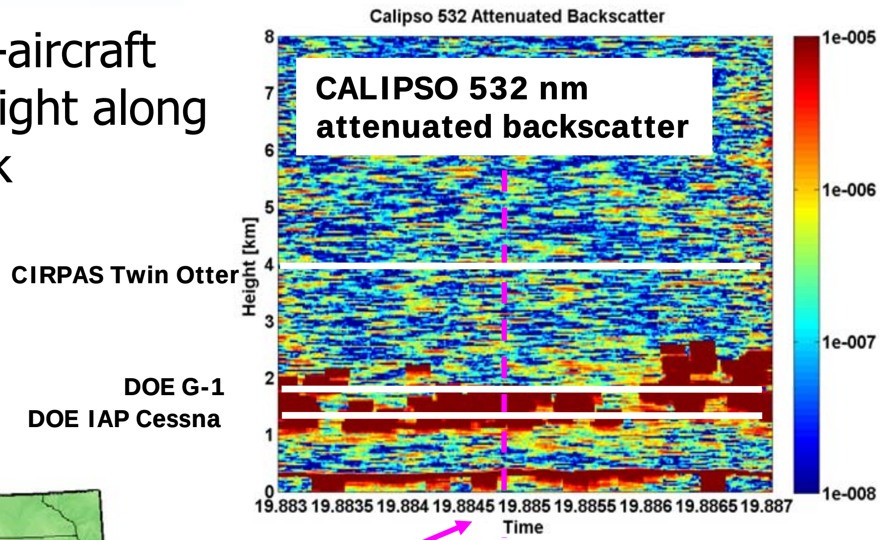
Apportionment of Aerosol Optical Thickness

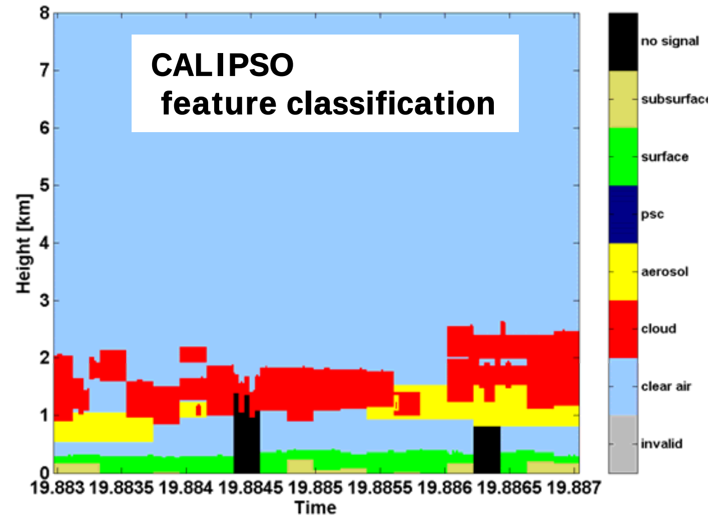
MILAGRO (Mexico City) - AOT dominated by dust
CALIPSO/GOMACCS/SJV (eastern U.S., California Central Valley) - AOT dominated by urban/biomass
CHAPS (Oklahoma) – AOT from both urban and dust

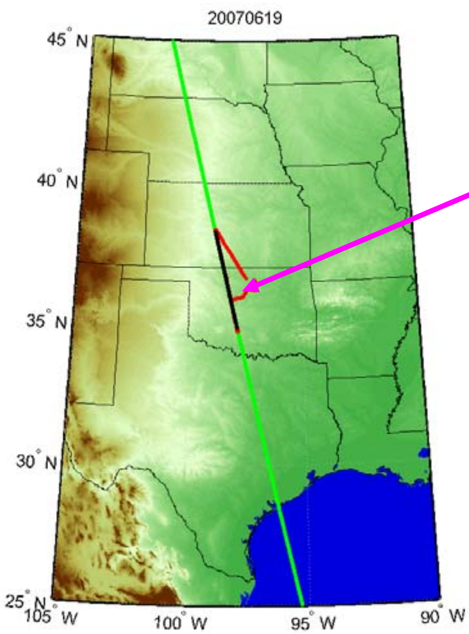


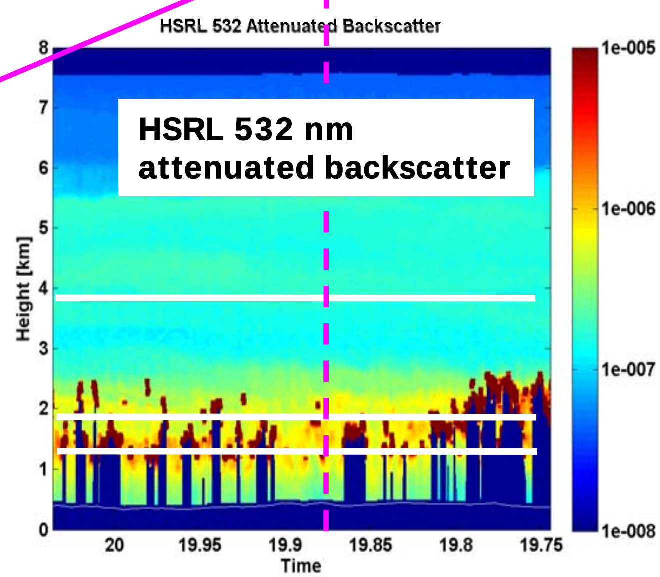
CALIPSO Validation – June 19

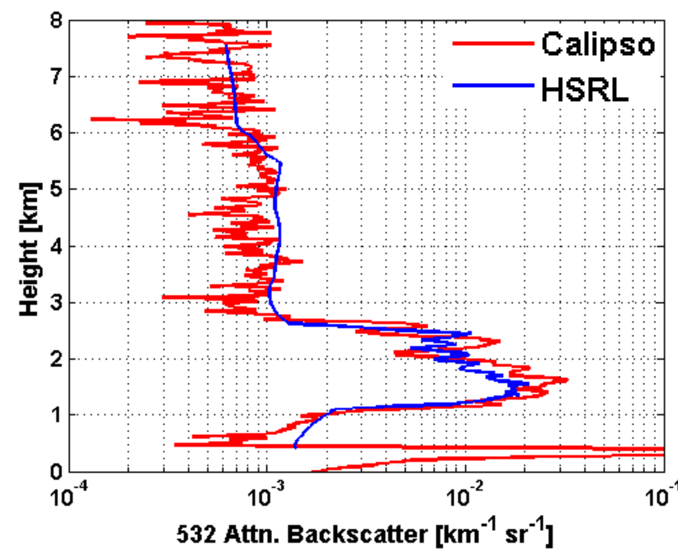
June 19 Multi-aircraft coordinated flight along CALIPSO track



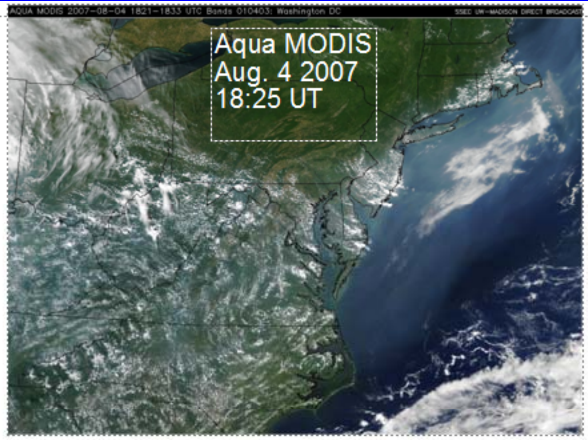


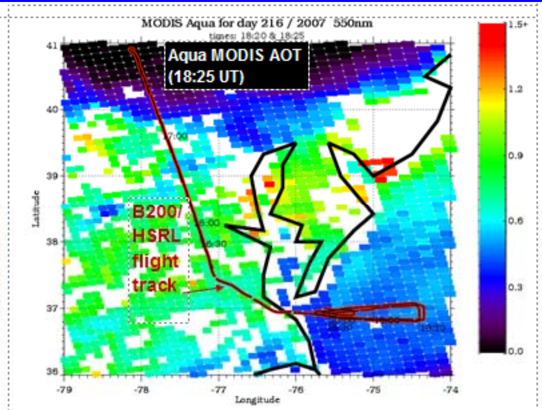




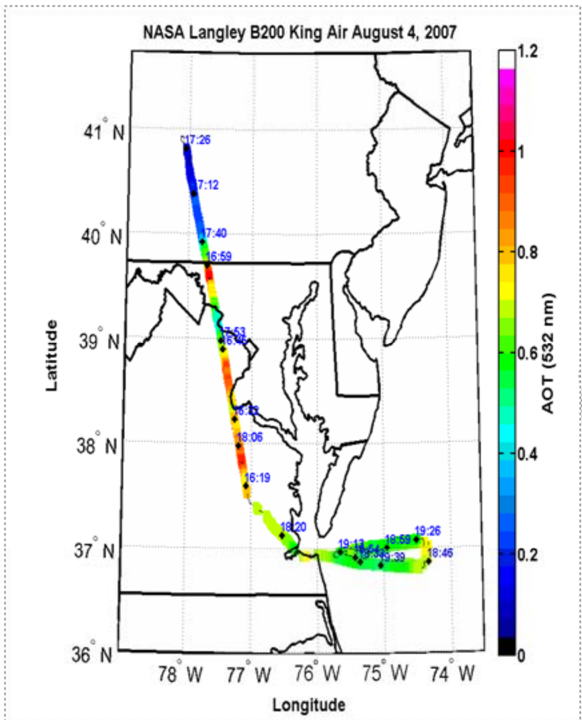


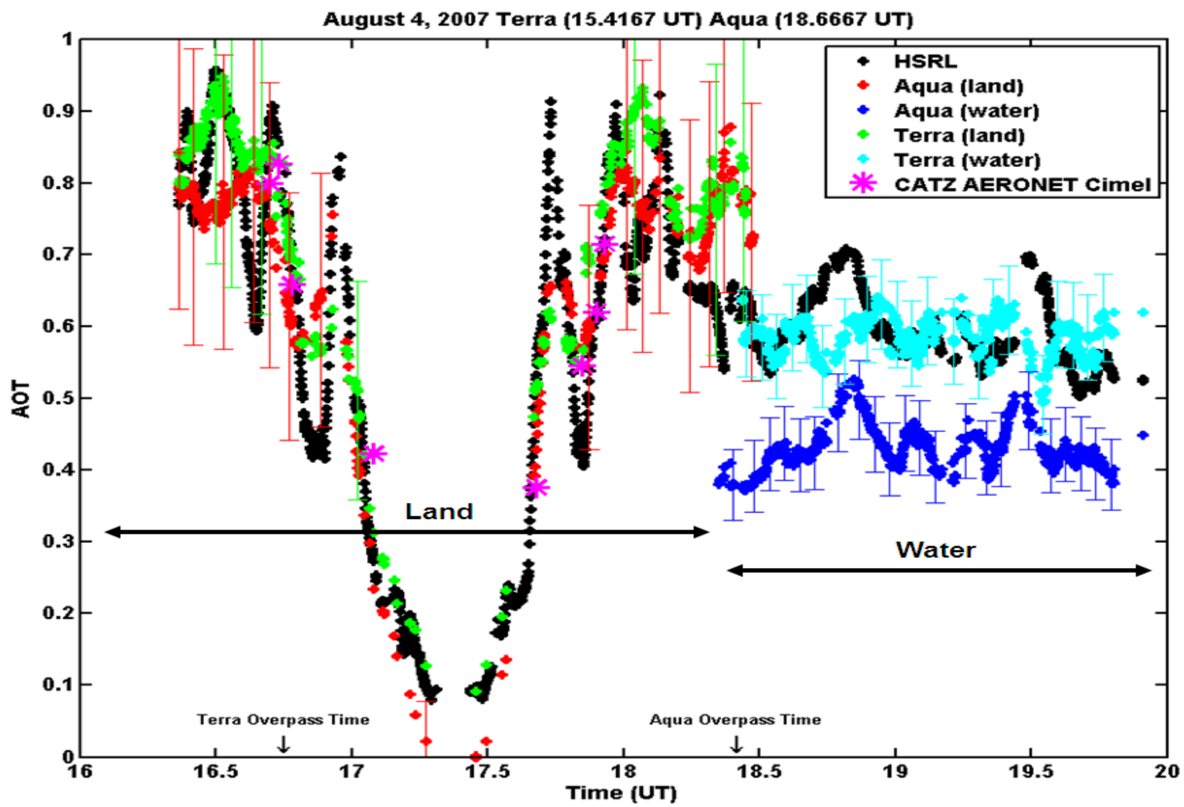
HSRL Measurements used to evaluate satellite retrievals of aerosol optical depth



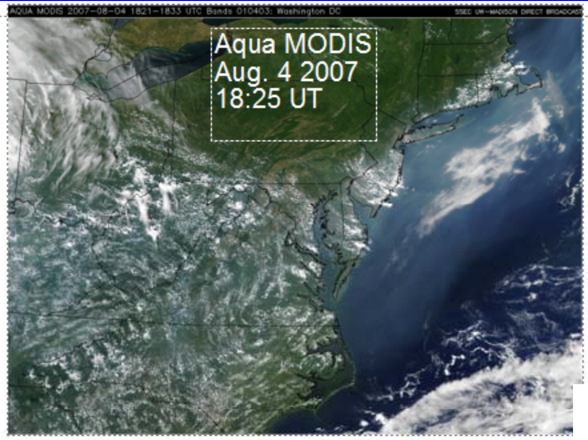


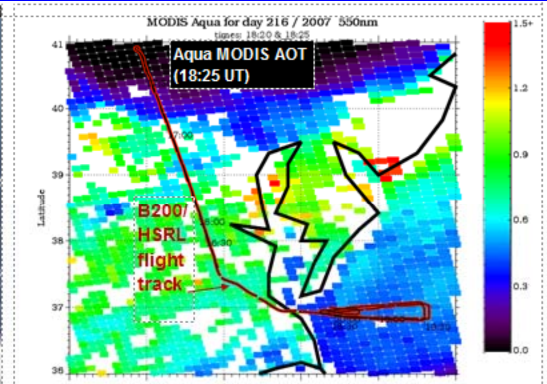
HSRL technique allows direct measurements of aerosol extinction and optical thickness to evaluate satellite optical thickness



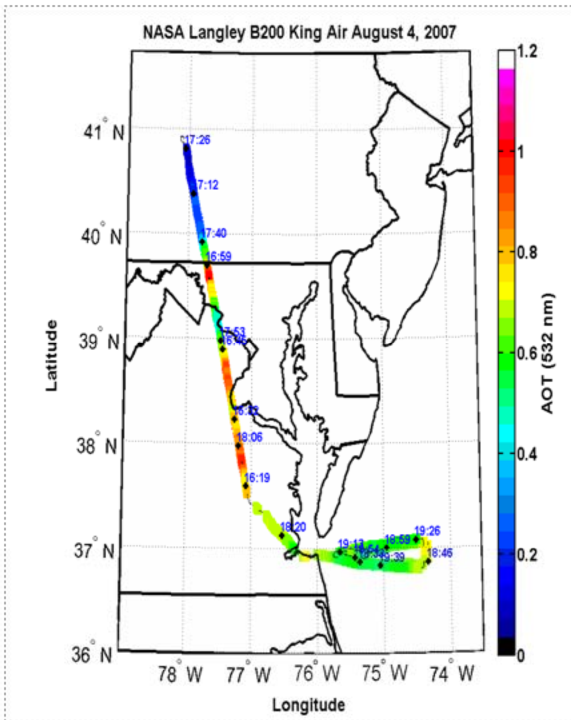


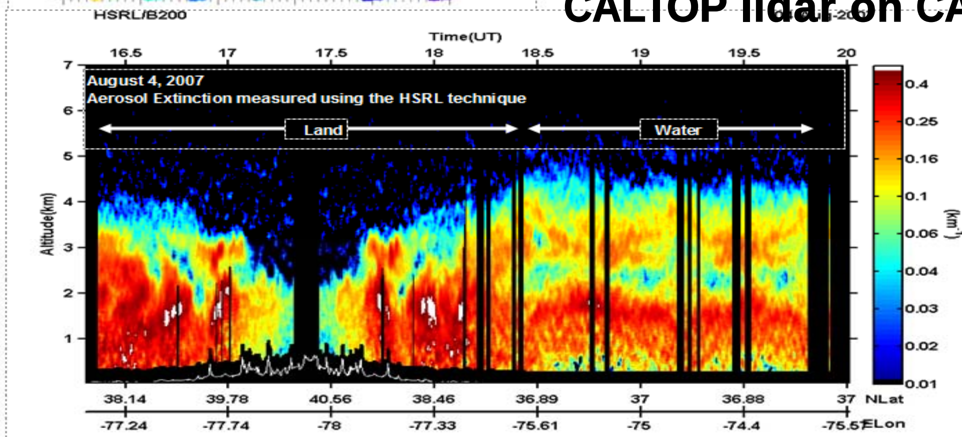
HSRL Measurements used to investigate active (CALIPSO) - passive (MODIS) satellite aerosol retrievals



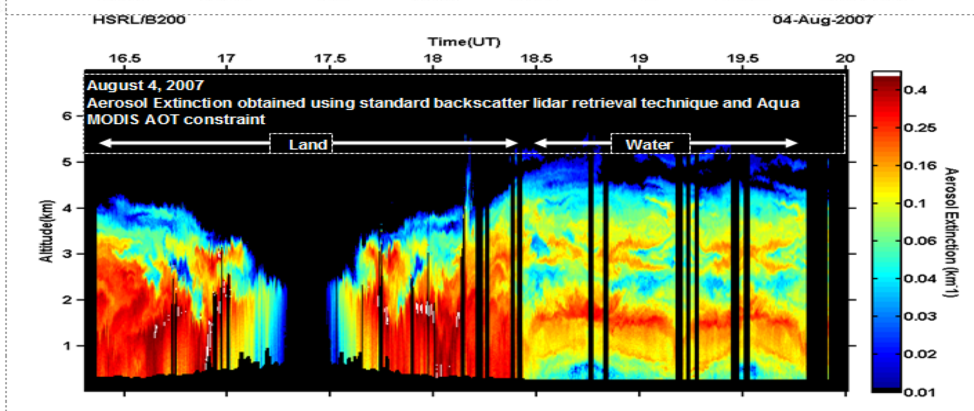


HSRL data are used to develop and test techniques designed to improve retrievals of aerosol extinction and backscatter profiles derived from measurements acquired by the CALIOP lidar on CALIPSO



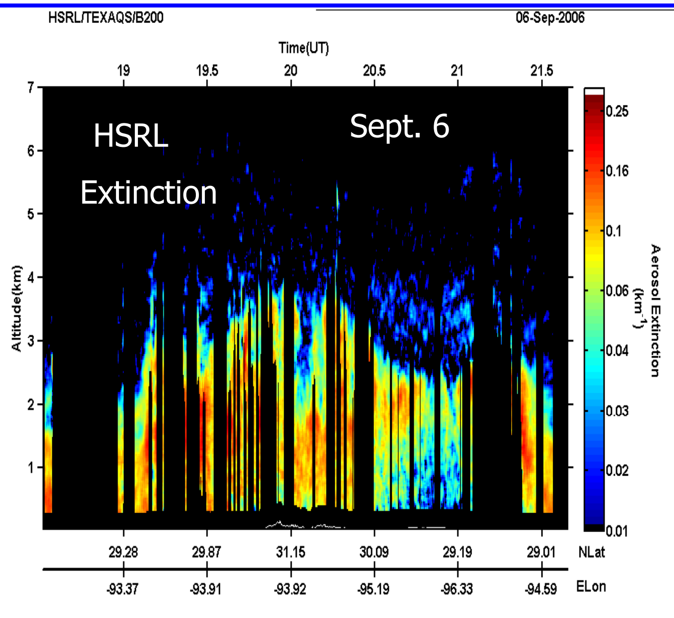


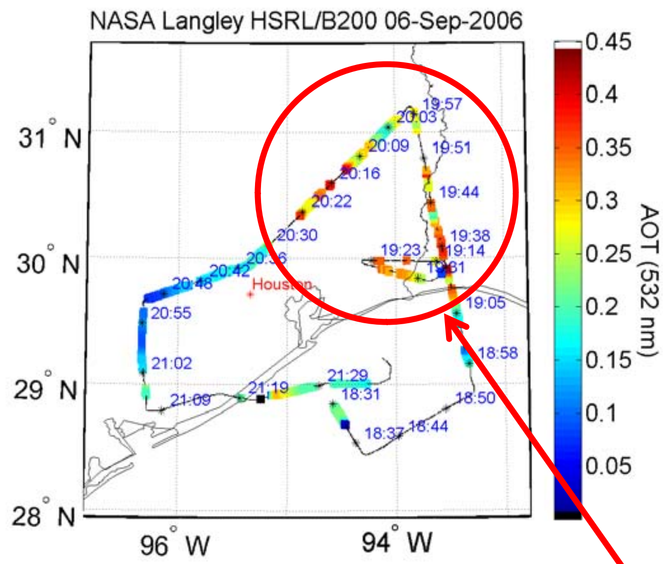
Aerosol Extinction measured directly using HSRL technqiue



Aerosol Extinction using backscatter lidar retrieval technique and Aqua MODIS AOT constraint

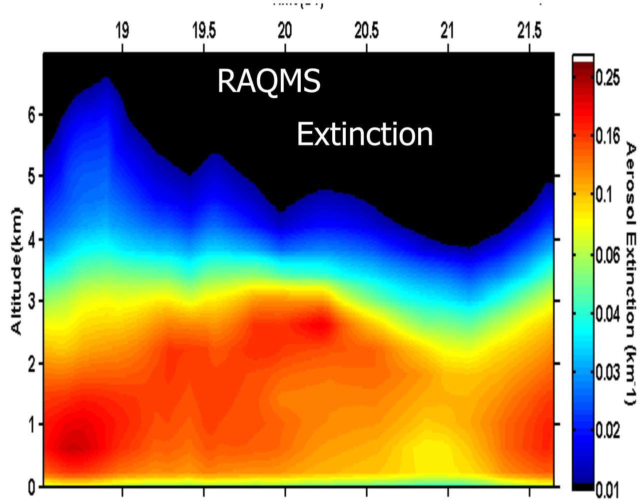
Assessment of Aerosol Transport Models – HSRL/RAQMS Example – September 6, 2006

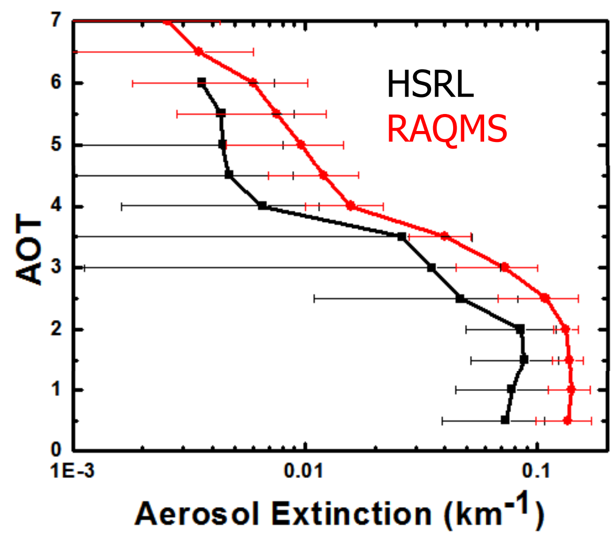


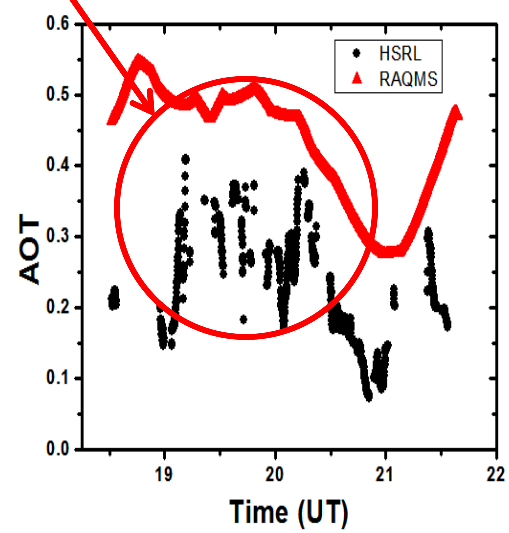


RAQMS aerosol extinction profiles show similar large scale variability and generally represent urban plume

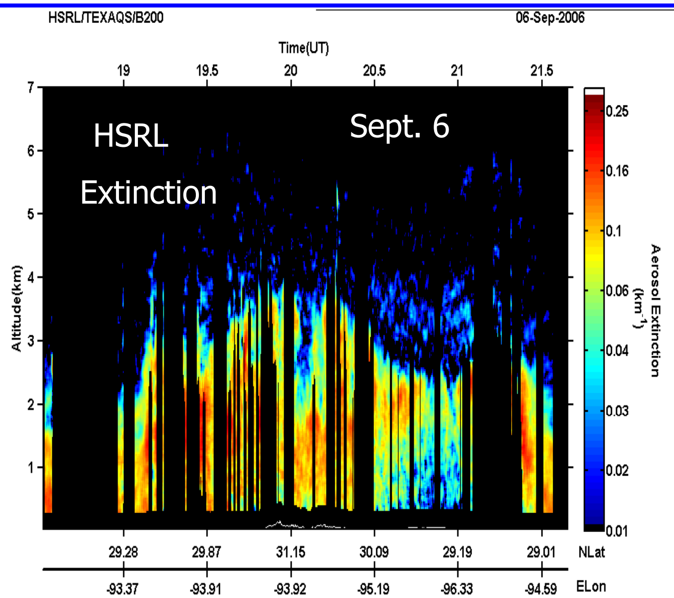
In this example, RAQMS overestimates aerosol extinction and AOT

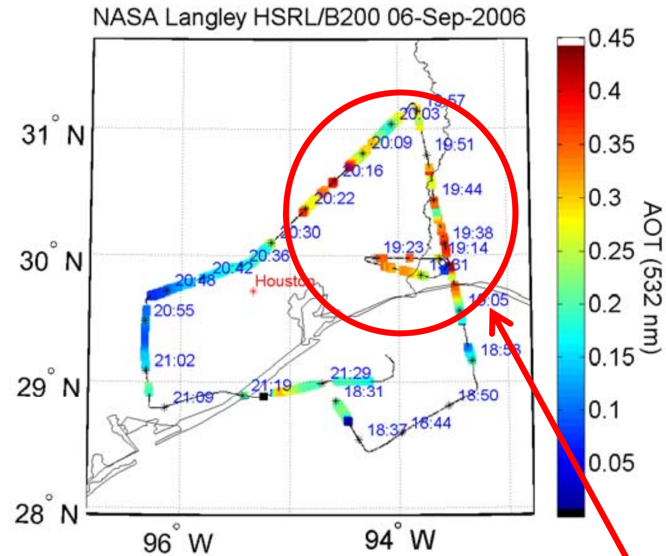






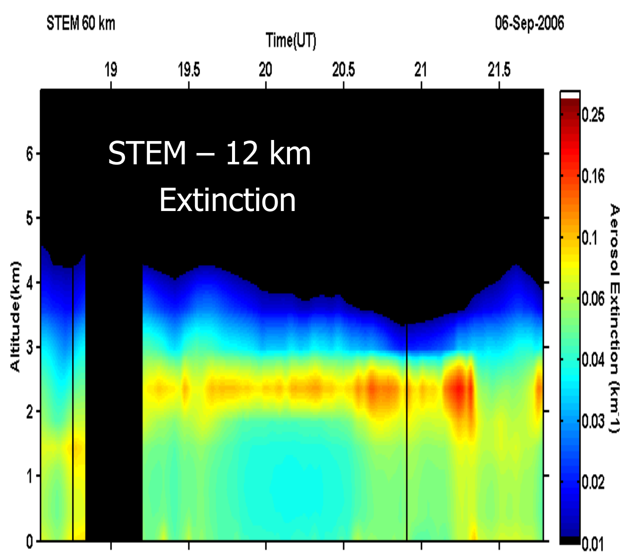
Assessment of Aerosol Transport Models – HSRL/STEM Example – September 6, 2006

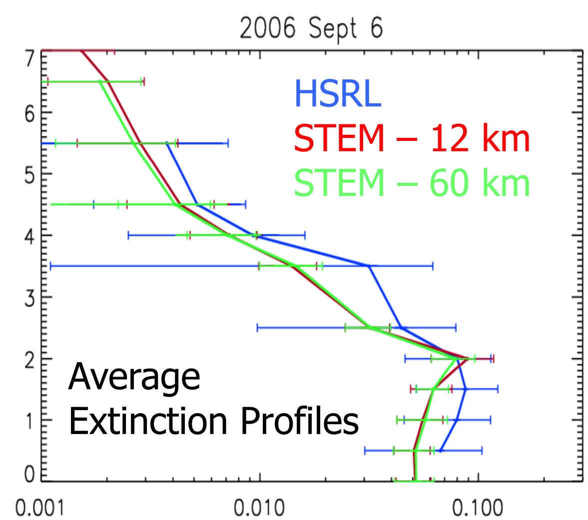


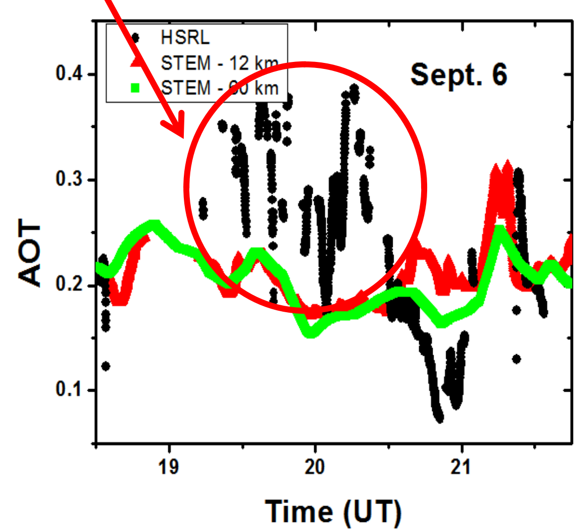


STEM extinction profiles have similar gross features as HSRL profiles, but don't show similar small scale variability

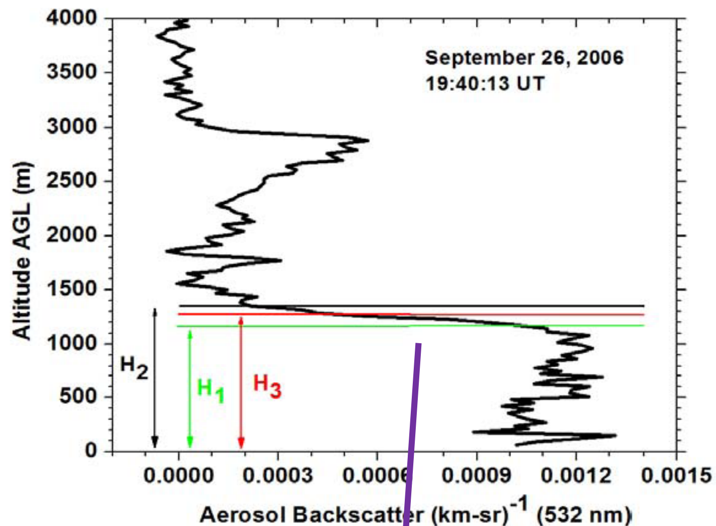
Largest differences typically found near locations of urban sources and plumes







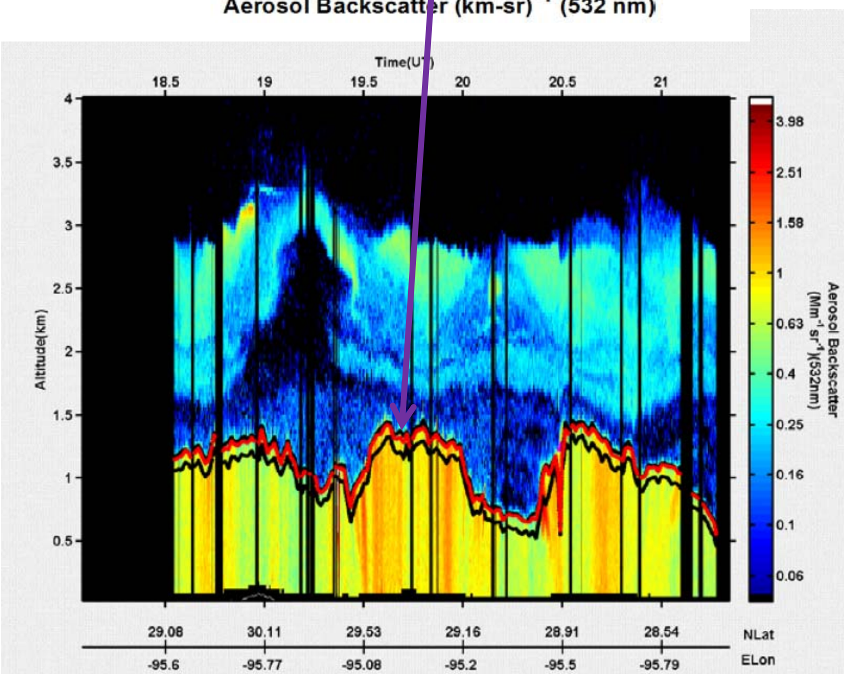
Assessment of Aerosol Transport Models – HSRL/STEM Example – September 6, 2006

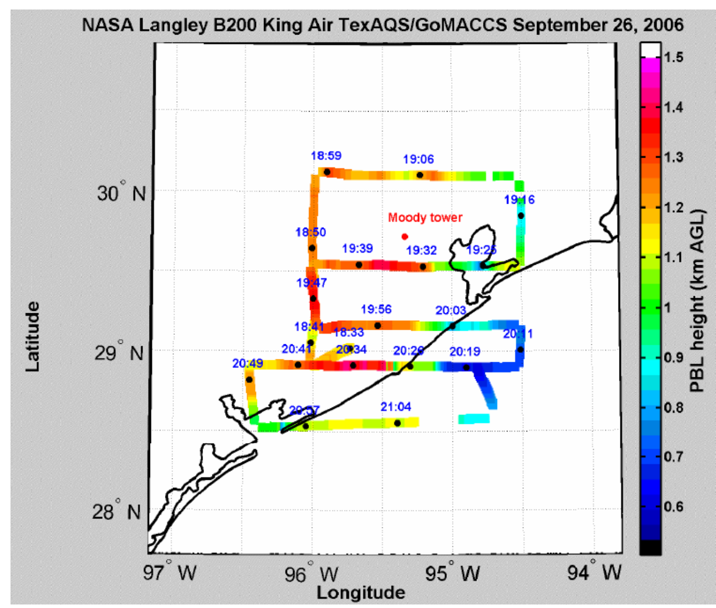


Long range transport of aerosols depends on injection height and whether aerosols injected above PBL

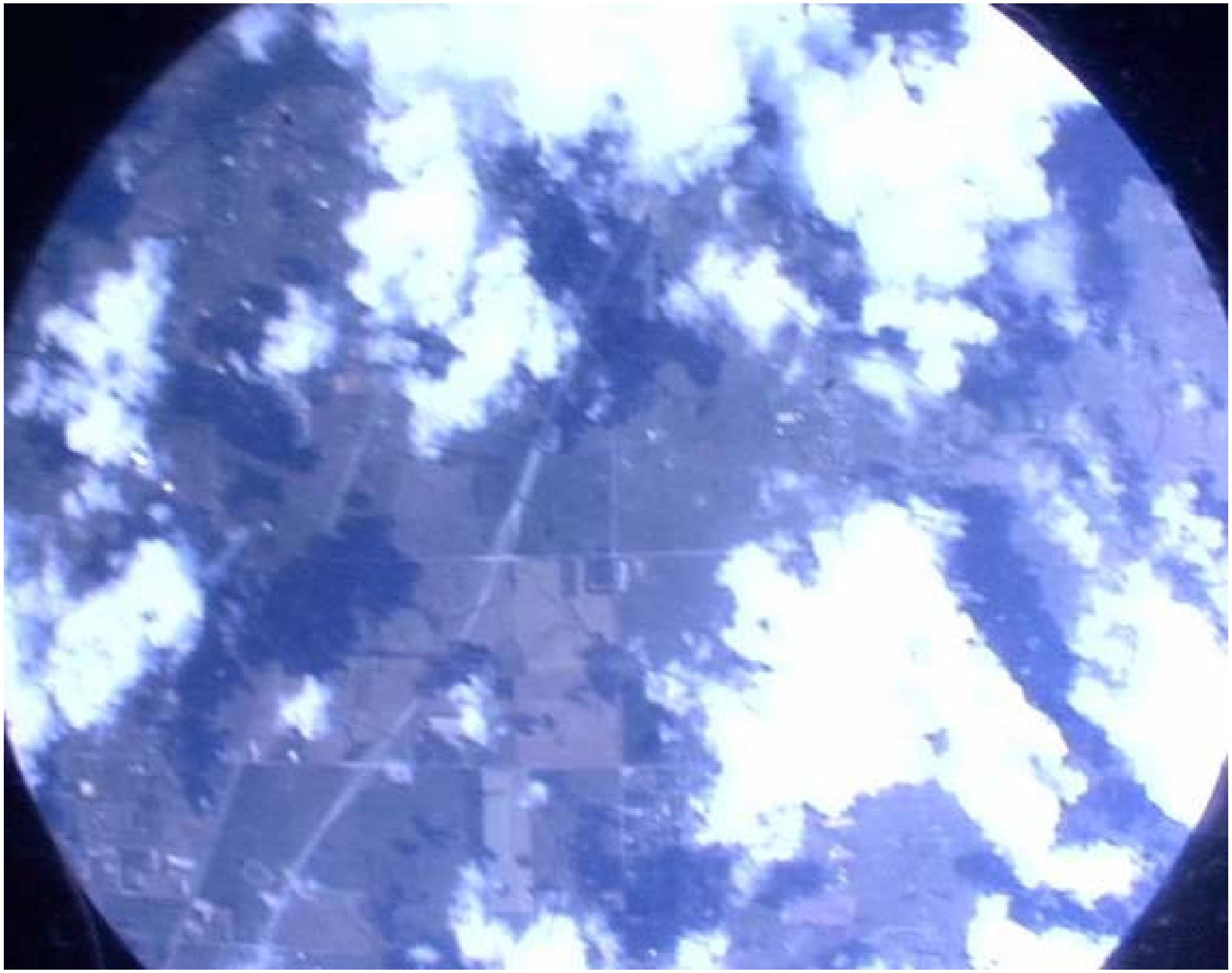
PBL retrieval uses an automated technique that uses a Haar wavelet covariance transform with multiple wavelet dilations to determine:

- PBL height
- Upper and lower limits of the backscatter transition (i.e. entrainment) zone





Onboard Digital Camera



Research Scanning Polarimeter (RSP)

Measurements

- Total and linearly polarized reflectance in nine spectral channels
- 152 viewing angle samples over 120 deg angular range

Derived parameters

- Aerosols
  - optical depth
  - location and width of both modes of bimodal size distribution
  - refractive index
  - estimates of size and amount of accumulation mode aerosols above clouds
- Clouds
  - optical depth
  - effective radius, variance
  - liquid water path
  - cloud drop number concentration
- RSP to be deployed during Summer ARCTAS mission

LaRC King Air B200

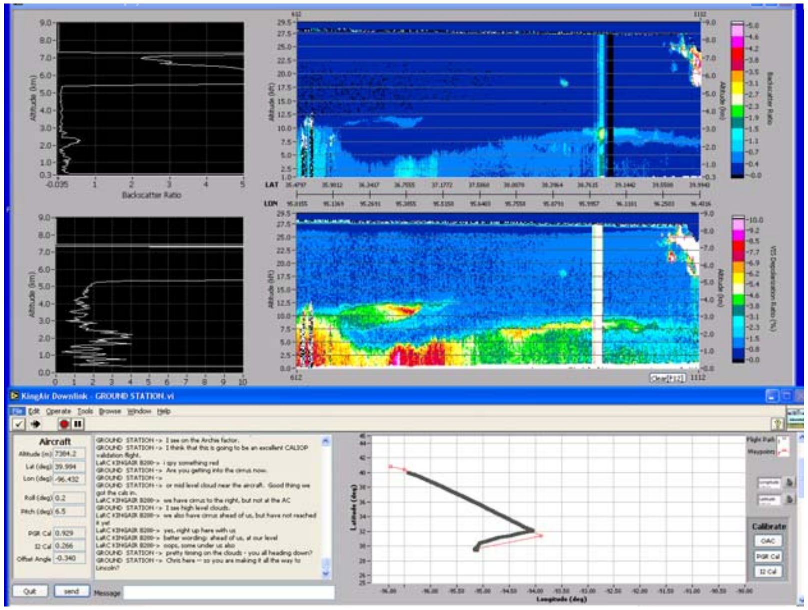
Altitude	35,000 ft (10.7 km), maximum operating
Range	800 nmi (1,300 km) at sampling speed
Endurance	4.5-5.5 hr, maximum (with IFR reserve)
Speed	259 KIAS (133 m/s) cruise

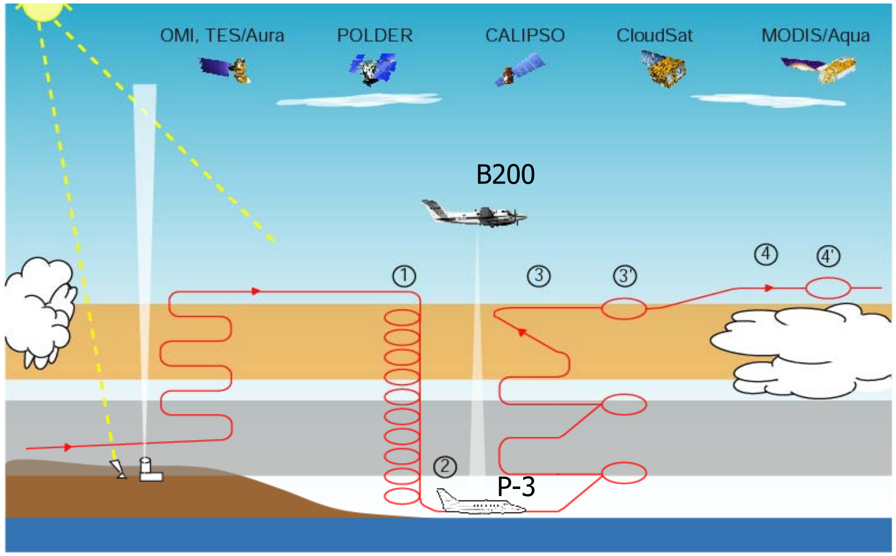
Payload	2500 lb (1,136 kg), maximum 500 lb (227 kg), with full fuel
Electrical Power	2 250A 30V DC generators, 3 1400VA, 400 Hz inverters supply 115V AC
Comm.	Iridium phone and modem

Spring - B200 Deployment Plans

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

- Map out aerosol and cloud locations to direct other aircraft for optimal sampling of Arctic haze and clouds
- Goal – real-time data display to help direct other aircraft

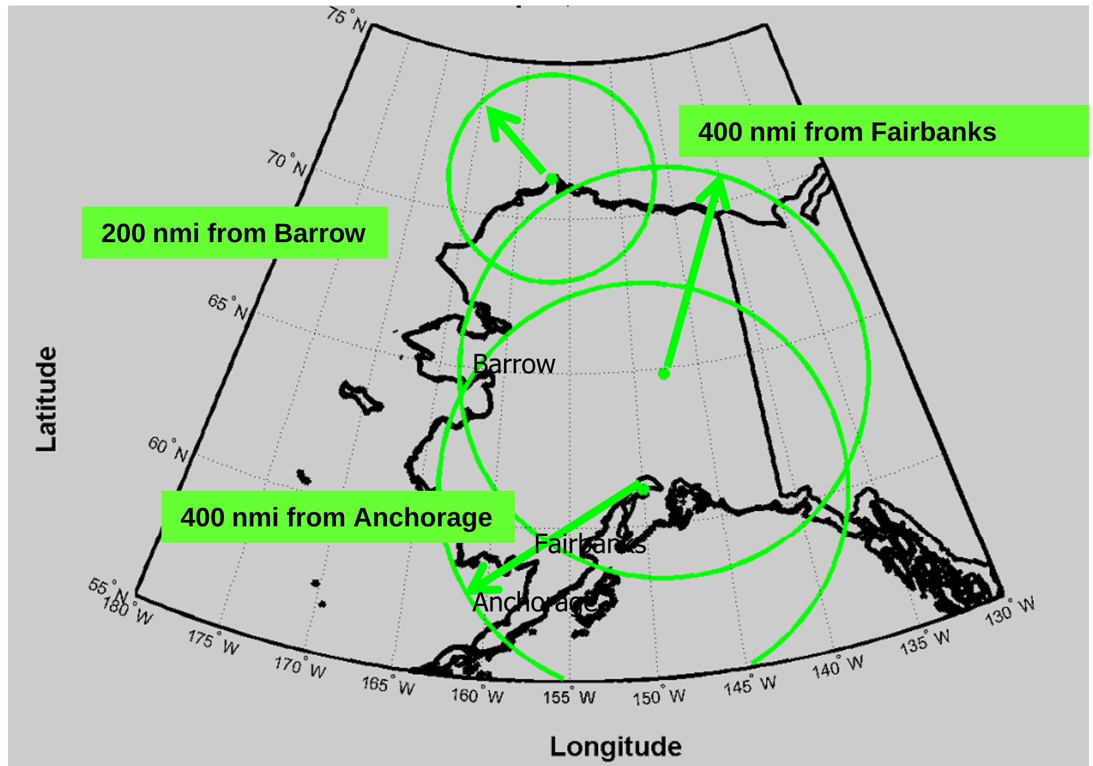




See NASA P-3 plans (Phil Russell)

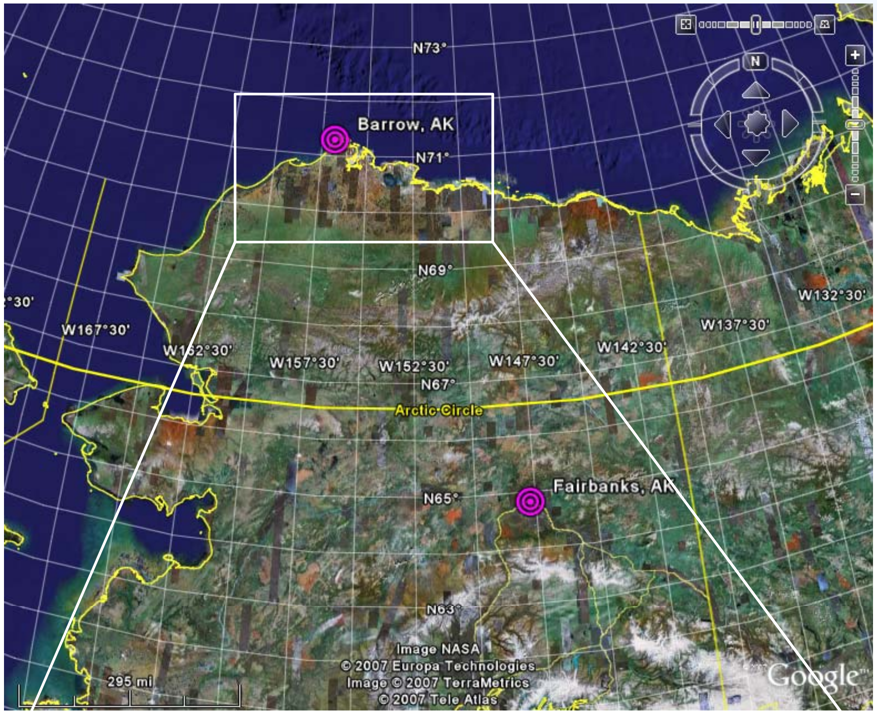
Spring - B200 Deployment Plans

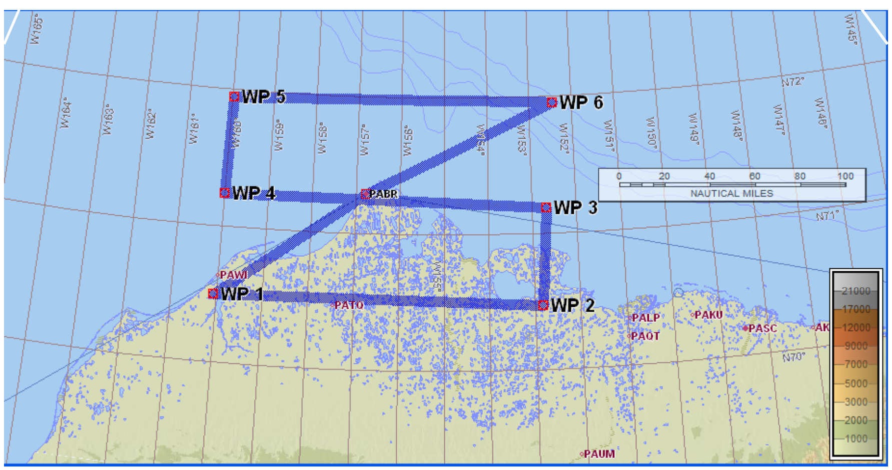
- Primary base is Barrow
- Endurance ~ 4-6 hours
- Speed ~ 200-220 knots
- Spring - for King Air flights planning to land in Barrow, flights must land in Barrow with at least 3 hours worth of fuel remaining on board in case diversion to Fairbanks is required; this should permit 1-3 hours to address science objectives.
- Green circles show approximate range of B200



- Anticipate some flights out of Fairbanks as warranted by conditions and joint operations with other aircraft
- Most if not all flights during daylight
- The following plans may not include all flight scenarios

Spring - B200 Flight #1 – Arctic Haze



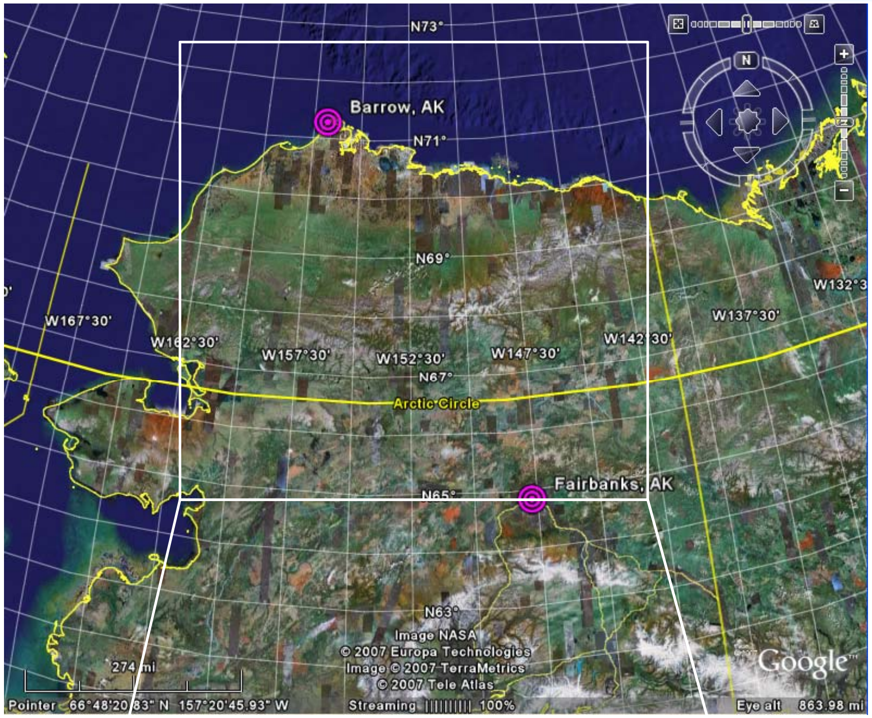


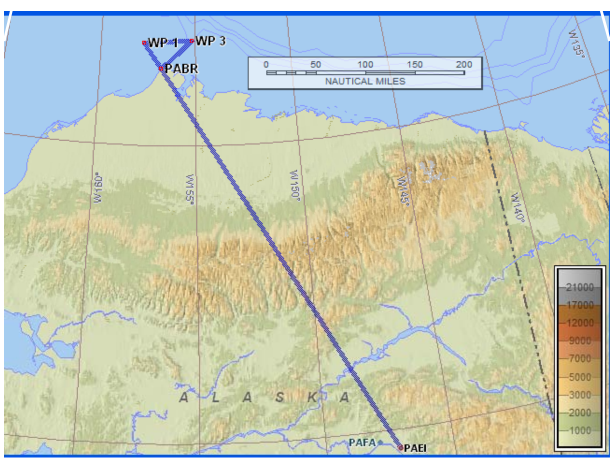
Motivation: Investigate the spatial variability of aerosol optical properties of the Arctic haze over the northern Alaska region within the geographical domain to be sampled via *in situ* measurements from the NASA and/or NOAA P-3 and/or NASA DC-8. The plan would address investigations of aerosol layer radiative properties. This would address the P-3 clear sky modules 1 and 2, partly cloudy module 1, and cloudy module 1.

Conditions: flights will be conducted when models forecast arctic haze to be present in northern Alaska region with clear to partly cloudy conditions. This pattern requires clear to scattered (1/3) mid-level (10 kft-25 kft) cloud coverage to avoid clouds interfering with HSRL sampling of the region where the other aircraft will sample.

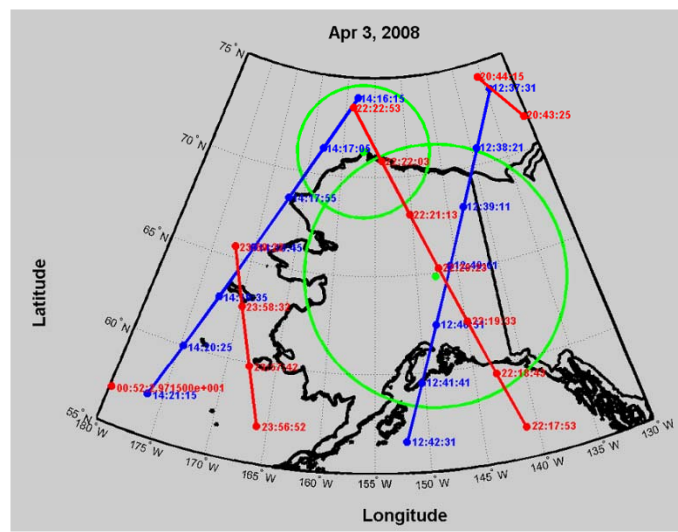
Basic idea: make constant altitude at ~ 28 kft above the P-3 and/or DC-8 transects through the haze.

Spring - B200 Flight #2 – CALIPSO Validation - South

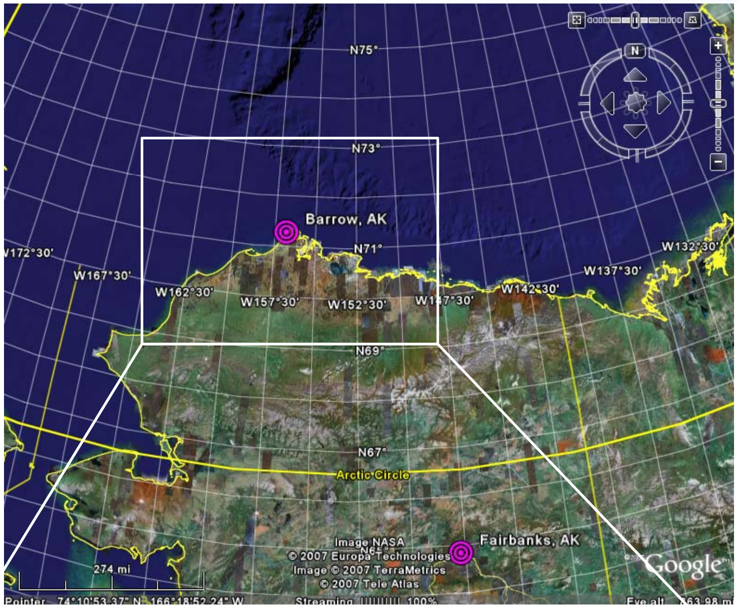


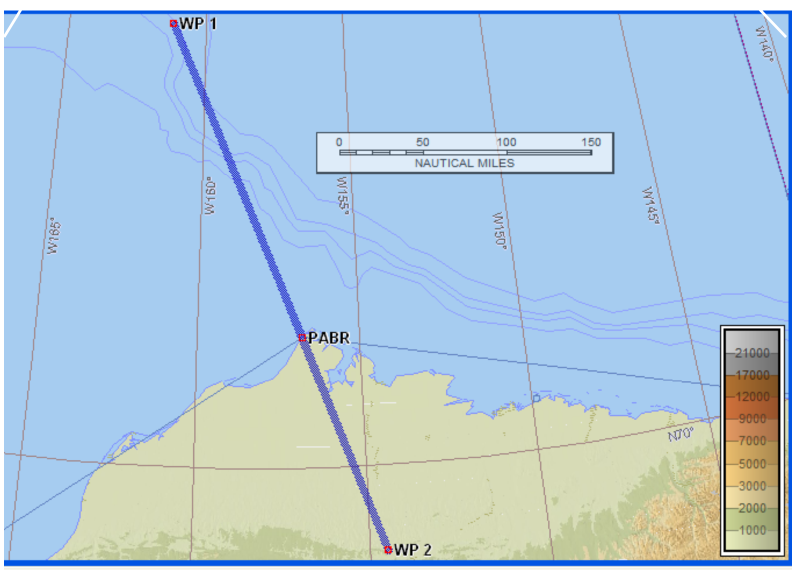


Motivation: The HSRL is a primary instrument for evaluation/validation of the CALIPSO aerosol and cloud measurements.
Conditions: Clear to partly cloudy mid to high level clouds to minimize cloud interference of the satellite and HSRL measurements.
Basic Idea: The King Air will perform a series of flights designed to validate the aerosol and cloud measurements acquired by the CALIOP instrument on board the CALIPSO satellite. These flights will be designed to acquire data along the ground track of the CALIOP lidar. The King Air flight tracks will be designed such that the HSRL will acquire data along the CALIOP ground track at least 15 minutes before and after the time of satellite overpass. These flights will target clear to partly cloudy conditions at the point of satellite coincidence to help reduce potential cloud interference of HSRL and CALIOP aerosol measurements. It is likely that, during some of these flights, the NASA and NOAA P-3 and NASA DC-8 aircraft will also be flying along this same flight track, below the King Air, to also acquire CALIPSO/CloudSat validation data.

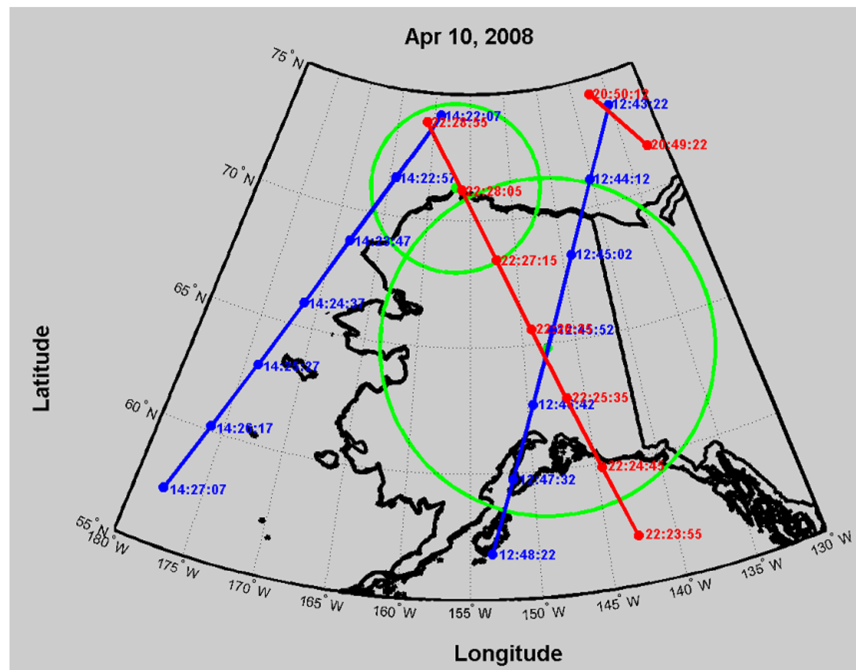


Spring - B200 Flight #3 – CALIPSO Validation - North

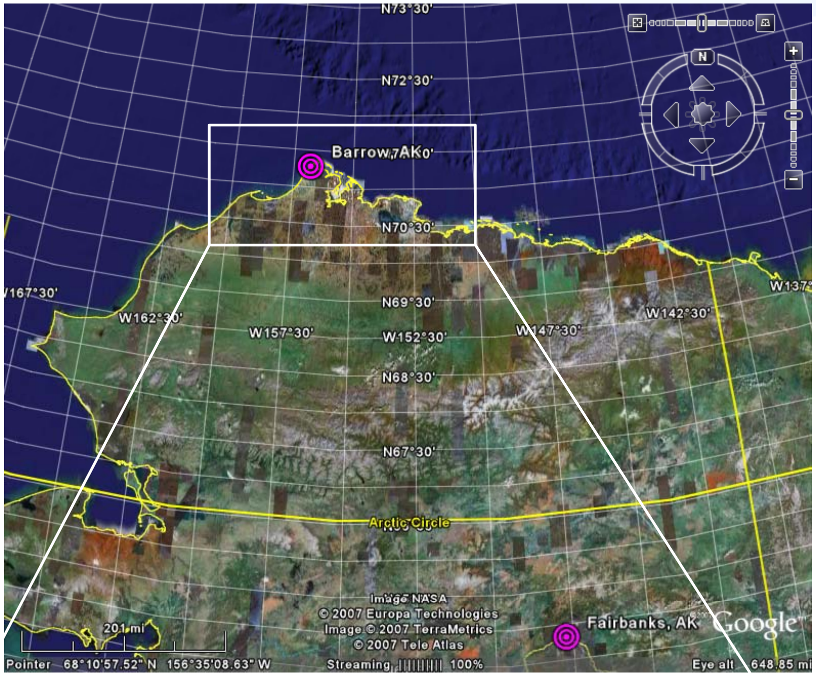




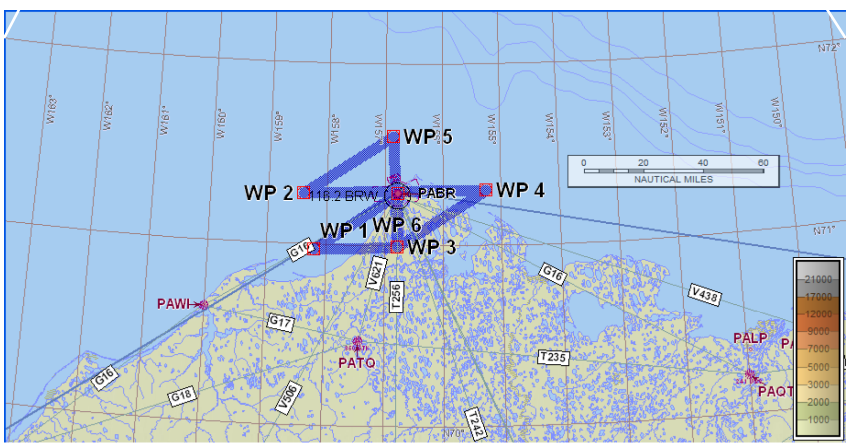
Motivation: The HSRL is a primary instrument for evaluation/validation of the CALIPSO aerosol and cloud measurements.
Conditions: Clear to partly cloudy mid to high level clouds to minimize cloud interference of the satellite and HSRL measurements.
Basic Idea: Similar to flight #2, except this flight is designed to reach higher latitudes in order to investigate CALIPSO performance at higher latitudes. We anticipate the B200 can reach approximately 200 nm north of Barrow.

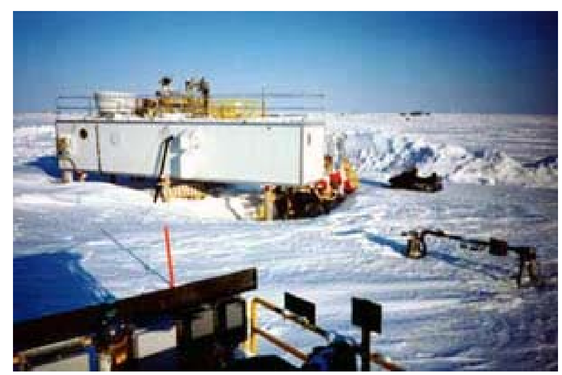


Spring - B200 Flight #4 – DOE ARM NSA

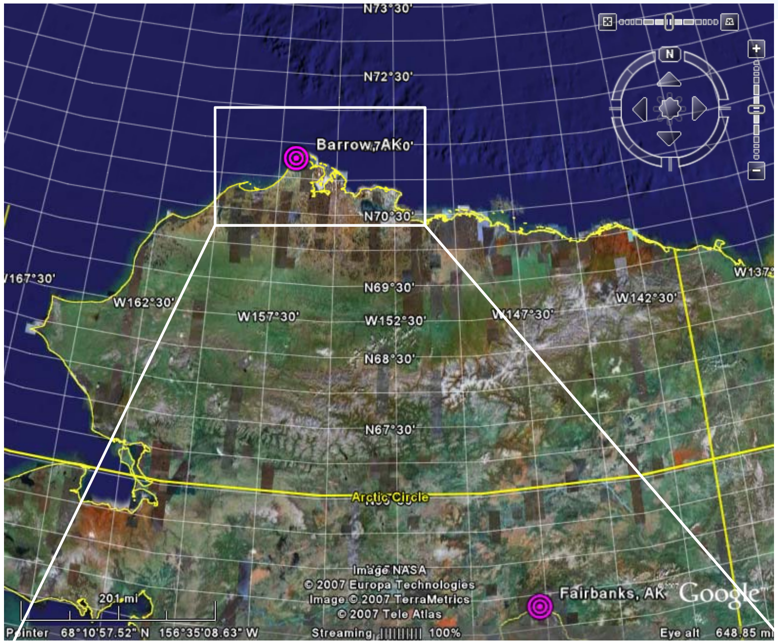


Motivation: Acquire data over the ARM NSA CRF site data. These flights are designed to acquire combined profile (HSRL) and surface in situ (ARM) and remote sensing data to study arctic haze aerosols.
Conditions: Clear to partly cloudy mid to high level clouds to avoid interference of the HSRL measurements, and generally hazy conditions.
Basic Idea: Fly a series of transects above the ARM NSA site under hazy conditions to acquire combined data sets. Ideally, these flights would be coordinated with other aircraft (e.g. DOE ARM ISDAC Convair) and/or coincident satellite measurements.





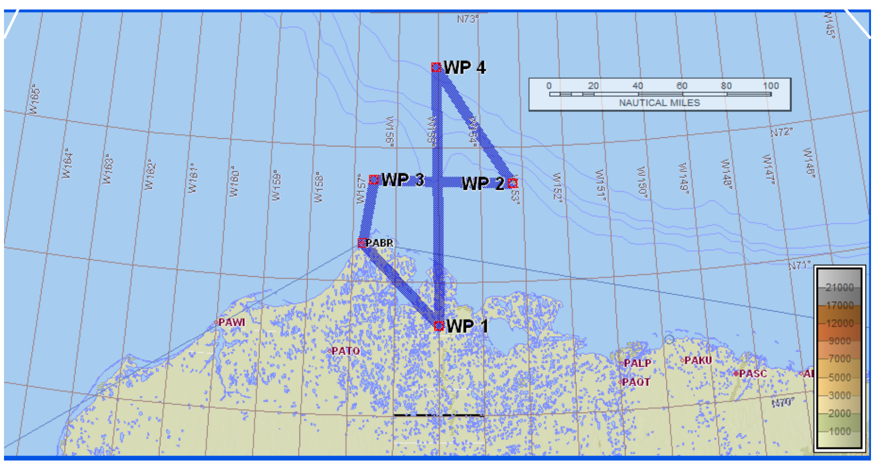
Spring - B200 Flight #5 – ISDAC



Motivation: Investigate aerosol conditions around ARM NSA site and during ARM ISDAC Convair flights as well as examine aerosol conditions between and above clouds to help support ISDAC objectives. ISDAC seeks to investigate how the properties of arctic aerosols impact the microphysical and macrophysical properties of clouds and the surface energy budget. HSRL measurements would provide vertical context for the ARM surface and airborne in situ measurements of aerosols and clouds.

Conditions: ISDAC plans flights during both clear and cloudy conditions. Clear to partly cloud low to mid level clouds conditions would permit HSRL sampling, and with close coordination of ISDAC airborne platforms (Convair)

Basic Idea: Location would likely be in Barrow region close to ARM NSA site. Flights coordinated with the ISDAC aircraft would also likely occur in region between Fairbanks and Barrow as part of transit between the Fairbanks and Barrow regions.



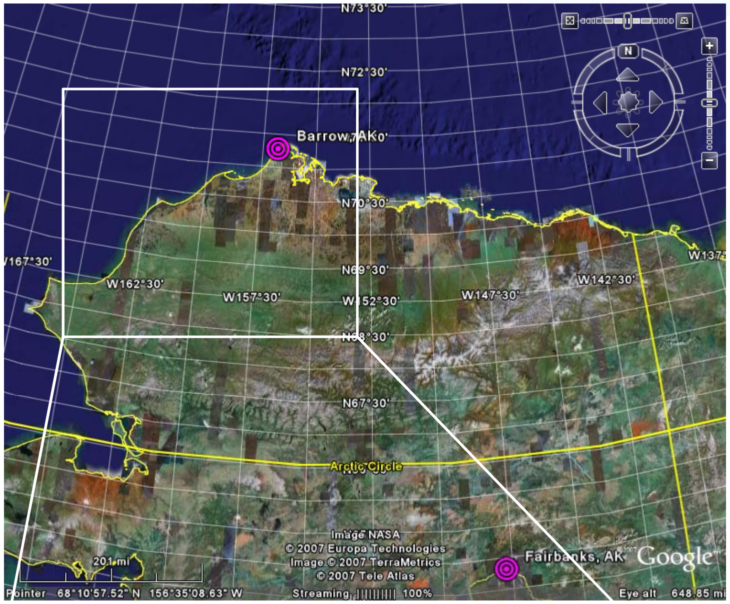
Indirect and Semi-Direct Aerosol Campaign (ISDAC)

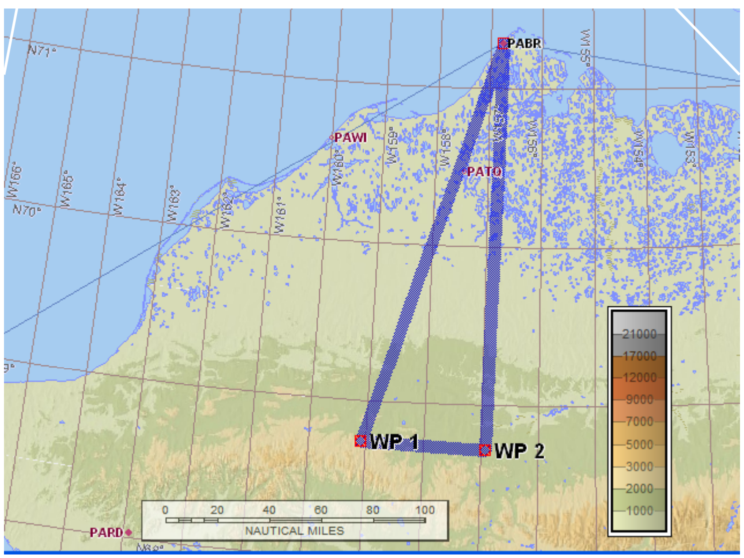
An intensive cloud and aerosol observing system will obtain airborne measurements during the Indirect and Semi-Direct Aerosol Campaign (ISDAC) at the ACRF North Slope of Alaska locale in April 2008. Taking place during the International Polar Year, many ancillary observing systems will be collecting data to allow synergistic interpretation of ISDAC data. This period also provides an important contrast with the October 2004 Mixed-Phase Arctic Cloud Experiment (M-PACE). Cloud property measurements obtained during ISDAC can be used to evaluate cloud simulations and evaluate cloud retrievals from M-PACE, and the aerosol measurements can be used to evaluate the aerosol retrievals. By running the cloud models with and without solar absorption by the aerosols, scientists can determine the semi-direct effect of aerosols on clouds.

Using instrumented aircraft, the ISDAC field campaign will obtain aerosol and cloud property measurements from the sky above the ARM Climate Research Facility site in Barrow, Alaska.

http://acrf-campaign.arm.gov/isdac/

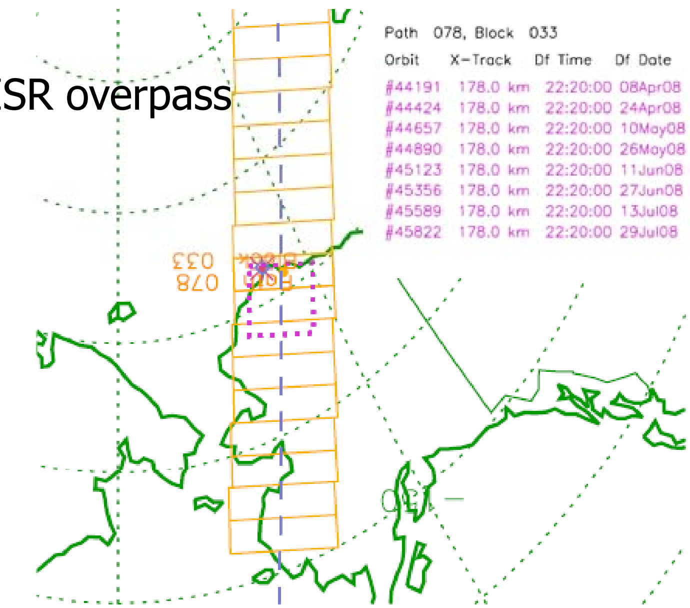
Spring - B200 Flight #5 – Satellite Sample 1



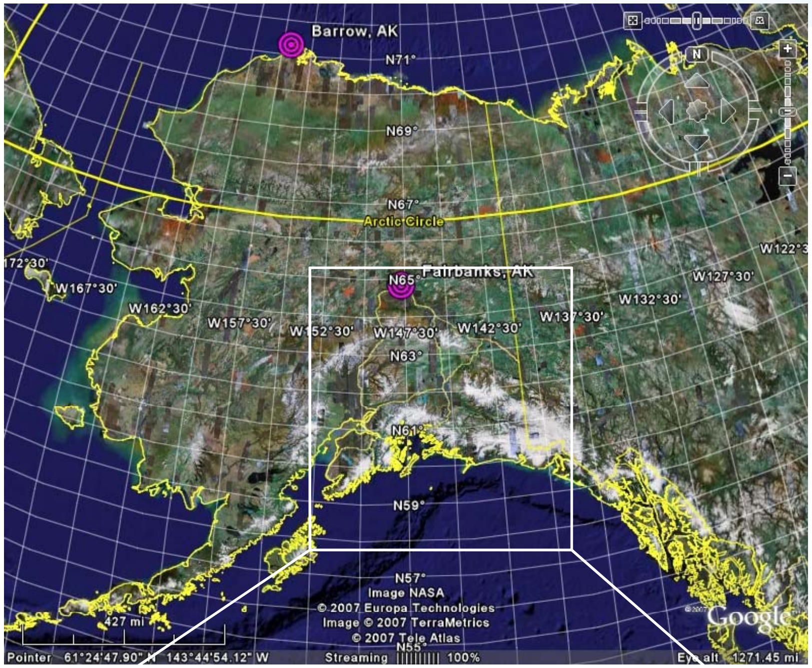


Motivation: Evaluation of satellite aerosol retrievals and investigation of combined active/passive aerosol retrievals.
Conditions: Clear to partly cloudy mid to high level clouds to minimize cloud interference of the satellite and HSRL measurements.
Basic Idea: The King Air would also perform flights to acquire data coincident with the NASA MODIS (Terra and Aqua) and MISR (Terra) sensors to investigate algorithms that combined active (lidar) and passive (MODIS/MISR) measurements to retrieve aerosol parameters. It is likely that, during some of these flights, the NASA and NOAA P-3 and NASA DC-8 aircraft will also be flying along this same flight track, below the King Air, to also acquire satellite validation data.

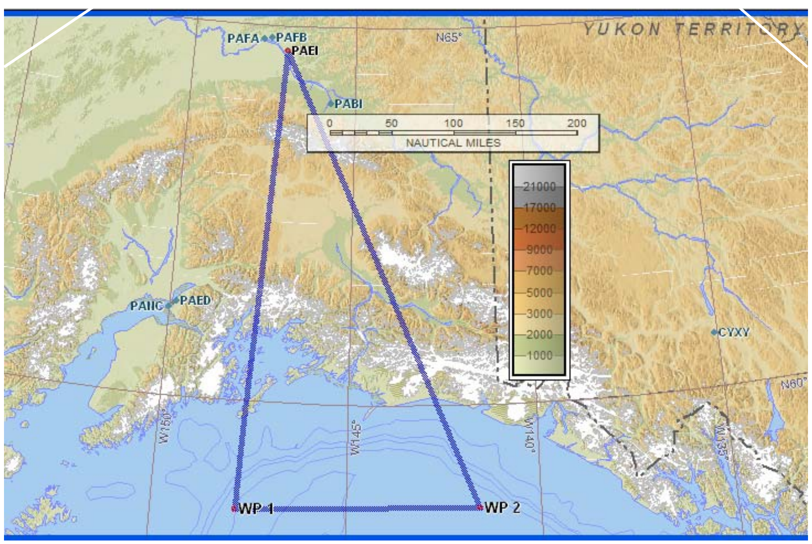
MISR overpass

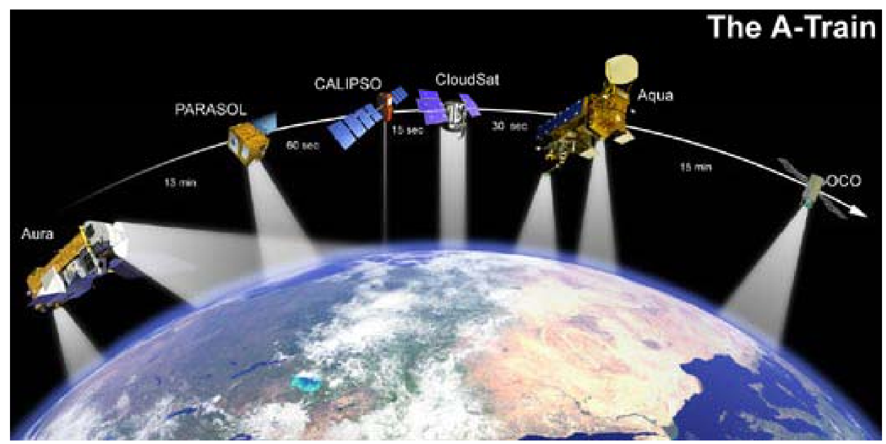


Spring - B200 Flight #6 – Satellite Sample 2



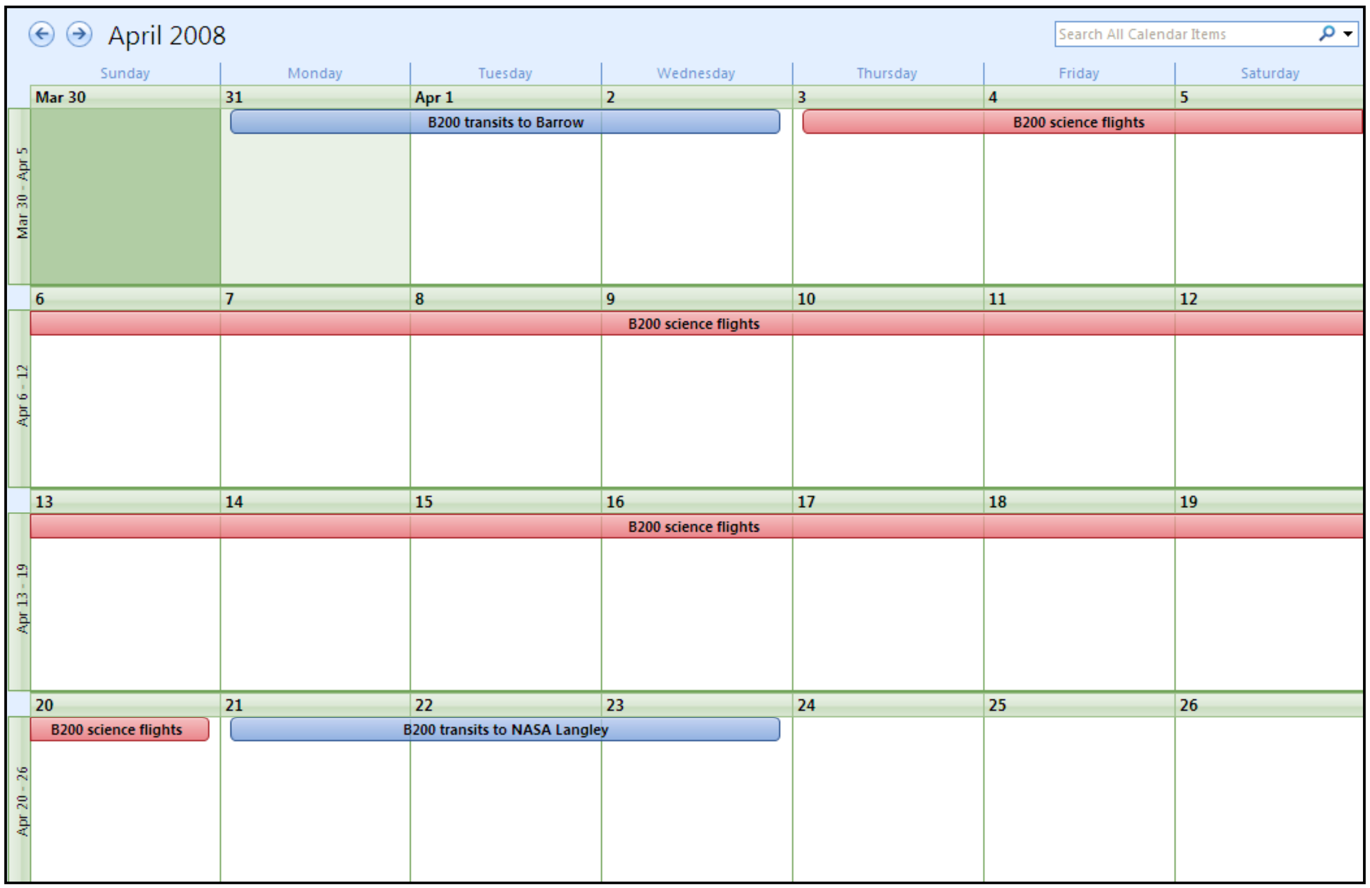
Motivation: Evaluation of satellite aerosol retrievals and investigation of combined active/passive aerosol retrievals.
Conditions: Clear to partly cloudy mid to high level clouds to minimize cloud interference of the satellite and HSRL measurements.
Basic Idea: The King Air would also perform flights to acquire data coincident with the NASA MODIS (Terra and Aqua) and MISR (Terra) sensors to investigate algorithms that combined active (lidar) and passive (MODIS/MISR) measurements to retrieve aerosol parameters. It is likely that, during some of these flights, the NASA and NOAA P-3 and NASA DC-8 aircraft will also be flying along this same flight track, below the King Air, to also acquire satellite validation data. This is similar to #5 except designed to acquire data over open water, since satellite (e.g. MODIS, PARASOL) aerosol retrieval algorithms operate differently over land and water.





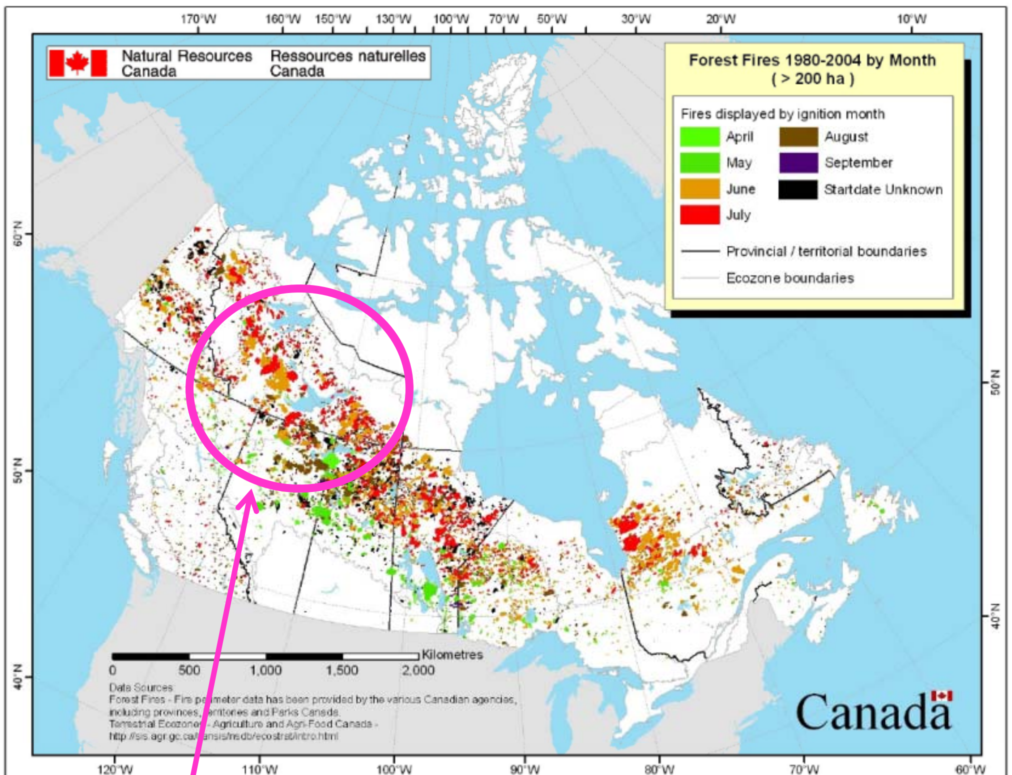
B200 Spring Schedule

- Science flights from ~April 3-20
- Anticipate about 80 hours; ~ 30-40 (~6 days) used for transit
- Must have one hard down day during a span of 7 days
- Anticipate ~4 suitcase flights to/from Fairbanks/Anchorage



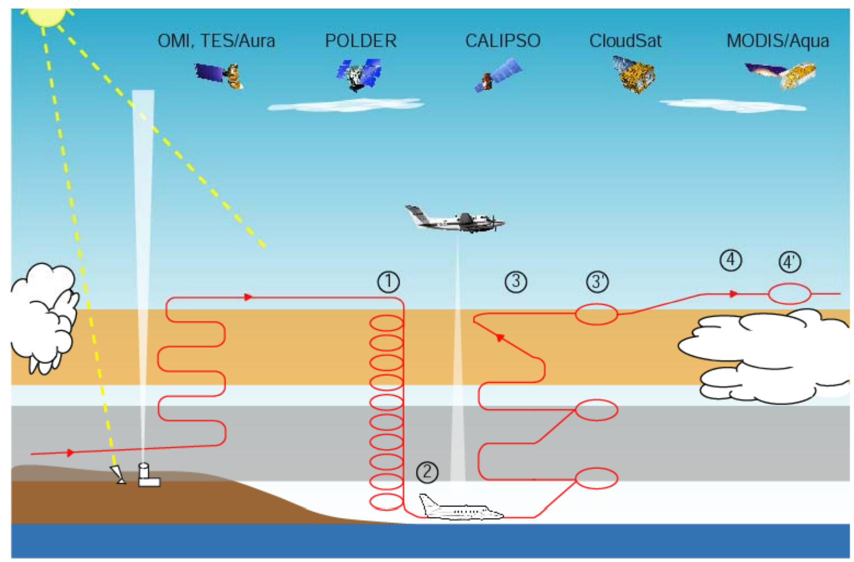
Summer - B200 Deployment Plans

In general, flights to be coordinated with other aircraft (NASA P-3, DC-8) and/or with satellite overpasses



Approximate B200 range from Yellowknife

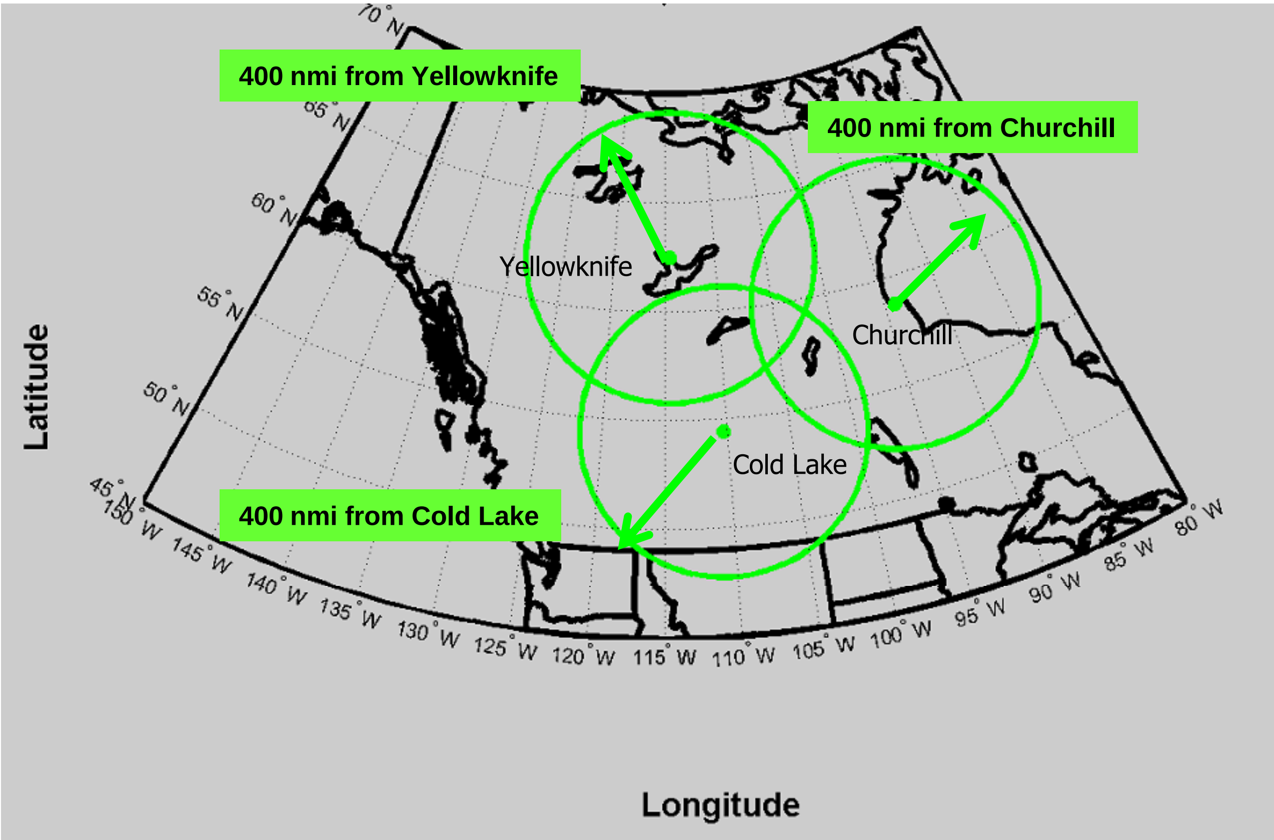
- Study horizontal and vertical variability of smoke from boreal fires in northwestern Canada
- Goal – real-time data display to help direct other aircraft



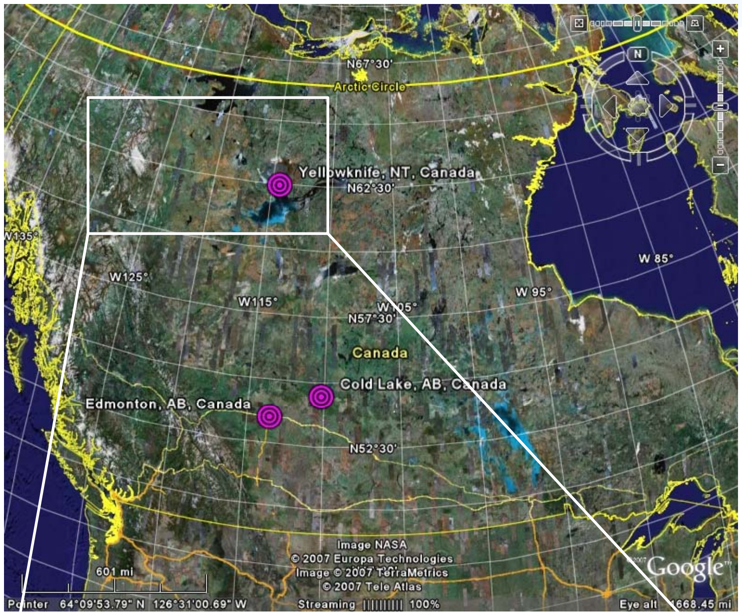
See NASA P-3 plans (Phil Russell)

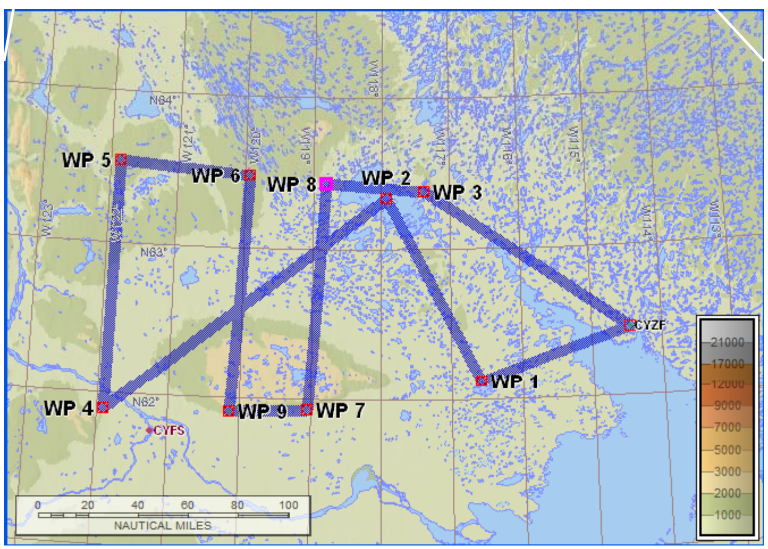
Summer - B200 Deployment Plans

- Endurance ~ 4.5-5 hours (less than spring deployment due to addition of RSP)
- Speed ~ 200-220 knots
- Primary base is Yellowknife
- Cold Lake and Churchill are shown as possible additional bases for illustration only; exact locations of additional bases will be determined as smoke conditions warrant and logistics permit
- Green circles show approximate range of B200



Summer - B200 Flight #2 – Smoke Mapping - Local

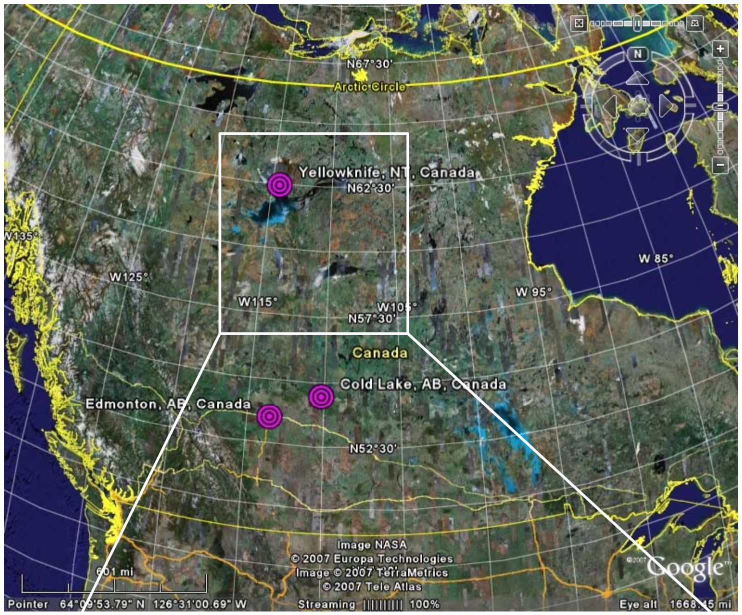




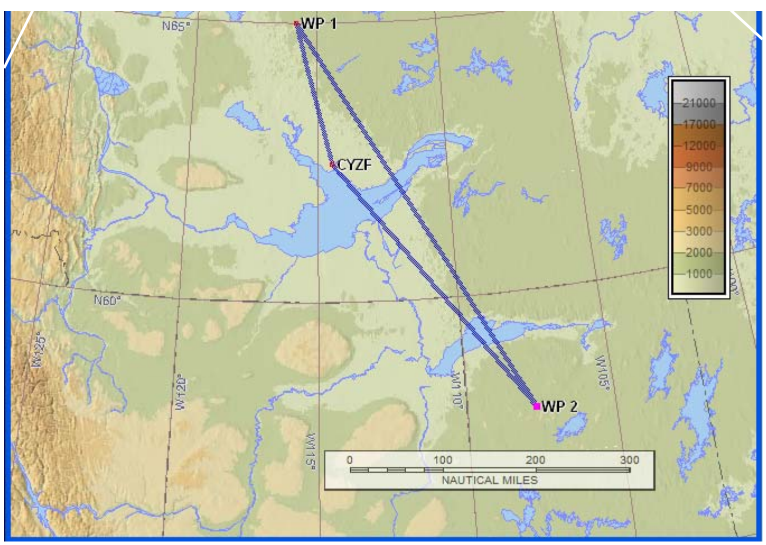
- **Motivation:** Investigate the spatial variability of boreal forest fire smoke within the geographical domain to be sampled via *in situ* measurements from the NASA and/or NOAA P-3 and/or NASA DC-8. The plan would address investigations of aerosol layer radiative properties. This would address the P-3 clear sky modules 1 and 2, partly cloudy module 1, and cloudy module 1.
- **Conditions:** flights will be conducted when smoke is present in western Canada with clear to partly cloudy conditions. This pattern requires clear to scattered (1/3) mid-level (10 kft-25 kft) cloud coverage to avoid clouds interfering with HSRL sampling of the region where the other aircraft will sample.
- **Basic idea:** make constant altitude at ~ 28 kft above the P-3 and/or DC-8 transects through the haze.

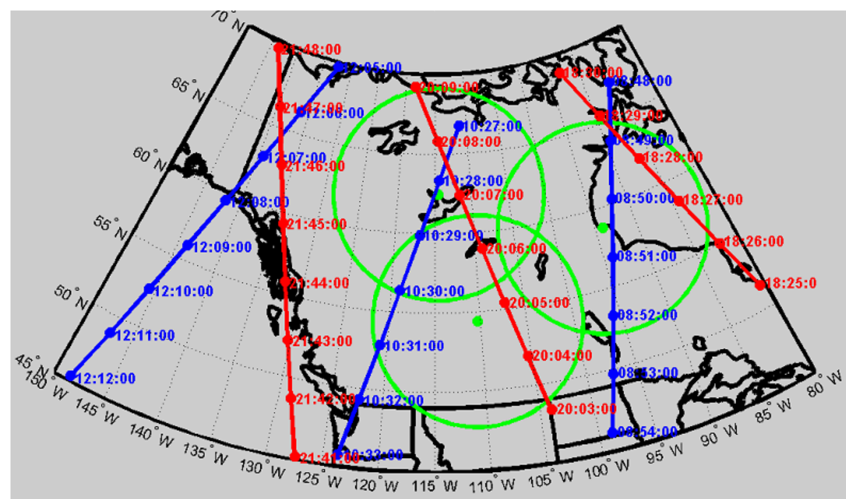
- While traveling en route to the anticipated location of the coordinated P-3/DC-8 pattern, the King Air will perform a mapping pattern centered on the expected location of the smoke. This pattern is designed to help define the exact location of the haze and to direct the other aircraft to the optimal position to sample the smoke.

Summer - B200 Flight #3 – CALIPSO Validation 2; Yellowknife local

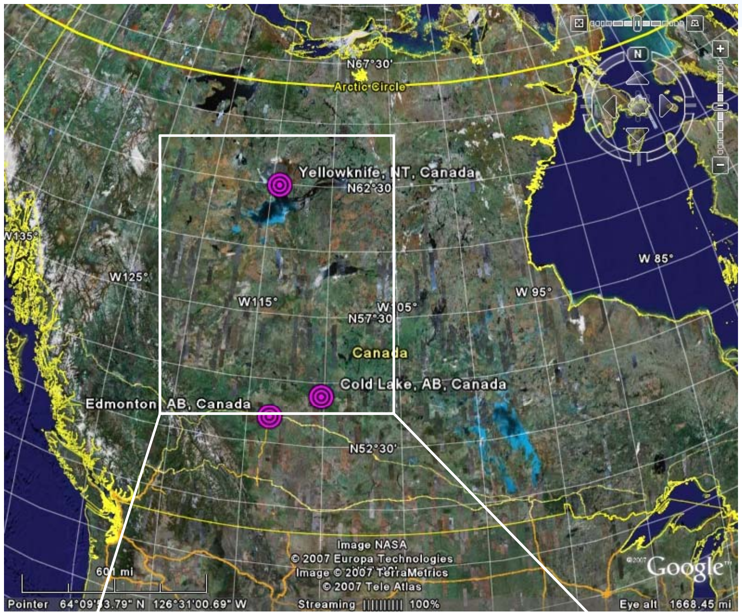


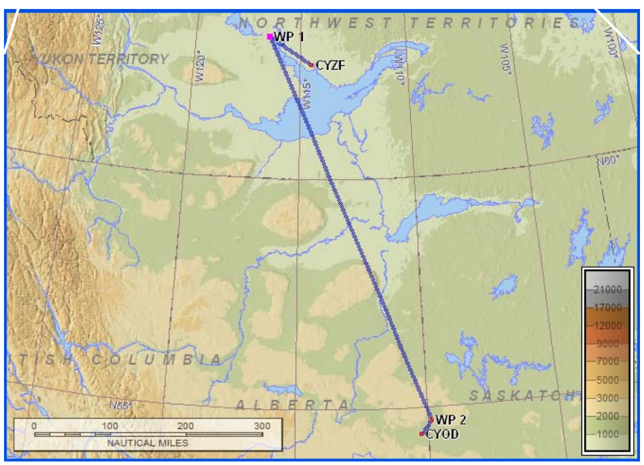
Motivation: The HSRL is a primary instrument for evaluation/validation of the CALIPSO aerosol and cloud measurements.
Conditions: Clear to partly cloudy mid to high level clouds to minimize cloud interference of the satellite and HSRL measurements.
Basic Idea: The King Air will perform a series of flights designed to validate the aerosol and cloud measurements acquired by the CALIOP instrument on board the CALIPSO satellite. These flights will be designed to acquire data along the ground track of the CALIOP lidar. The King Air flight tracks will be designed such that the HSRL will acquire data along the CALIOP ground track at least 15 minutes before and after the time of satellite overpass. These flights will target clear to partly cloudy conditions at the point of satellite coincidence to help reduce potential cloud interference of HSRL and CALIOP aerosol measurements. It is likely that, during some of these flights, especially for those tracks that pass close to the line between Yellowknife and Cold Lake, the NASA and NOAA P-3 and NASA DC-8 aircraft will also be flying along this same flight track, below the King Air, to also acquire CALIPSO/CloudSat validation data.





Summer - B200 Flight #4 – CALIPSO Validation 1; Yellowknife – Cold Lake

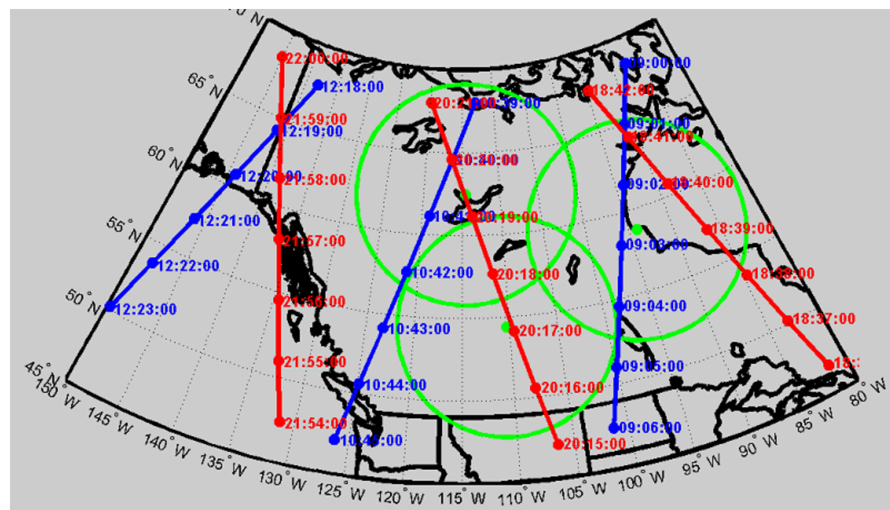




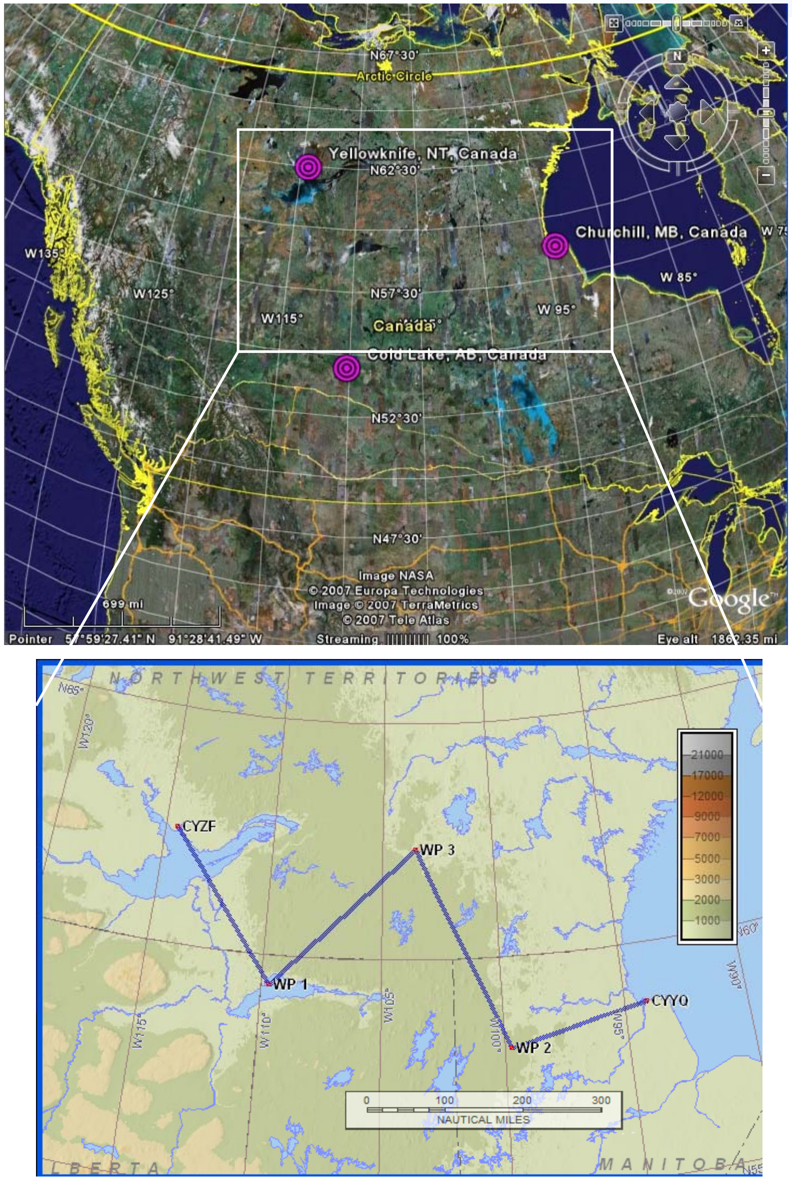
Motivation: The HSRL is a primary instrument for evaluation/validation of the CALIPSO aerosol and cloud measurements.

Conditions: Clear to partly cloudy mid to high level clouds to minimize cloud interference of the satellite and HSRL measurements.

Basic Idea: The King Air will perform a series of flights designed to validate the aerosol and cloud measurements acquired by the CALIOP instrument on board the CALIPSO satellite. These flights will be designed to acquire data along the ground track of the CALIOP lidar. The King Air flight tracks will be designed such that the HSRL will acquire data along the CALIOP ground track at least 15 minutes before and after the time of satellite overpass. These flights will target clear to partly cloudy conditions at the point of satellite coincidence to help reduce potential cloud interference of HSRL and CALIOP aerosol measurements. It is likely that, during some of these flights, especially for those tracks that pass close to the line between Yelloknife and Cold Lake, the NASA and NOAA P-3 and NASA DC-8 aircraft will also be flying along this same flight track, below the King Air, to also acquire CALIPSO/CloudSat validation data. This track is designed so the B200 can cover an extended portion of a CALIPSO track by taking off in Yellowknife and landing in Cold Lake, or vice versa.



Summer - B200 Flight #5 – Smoke Mapping - Extended



• **Motivation:** Investigate the spatial variability of boreal forest fire smoke within the geographical domain to be sampled via *in situ* measurements from the NASA and/or NOAA P-3 and/or NASA DC-8. The plan would address investigations of aerosol layer radiative properties. This would address the P-3 clear sky modules 1 and 2, partly cloudy module 1, and cloudy module 1.

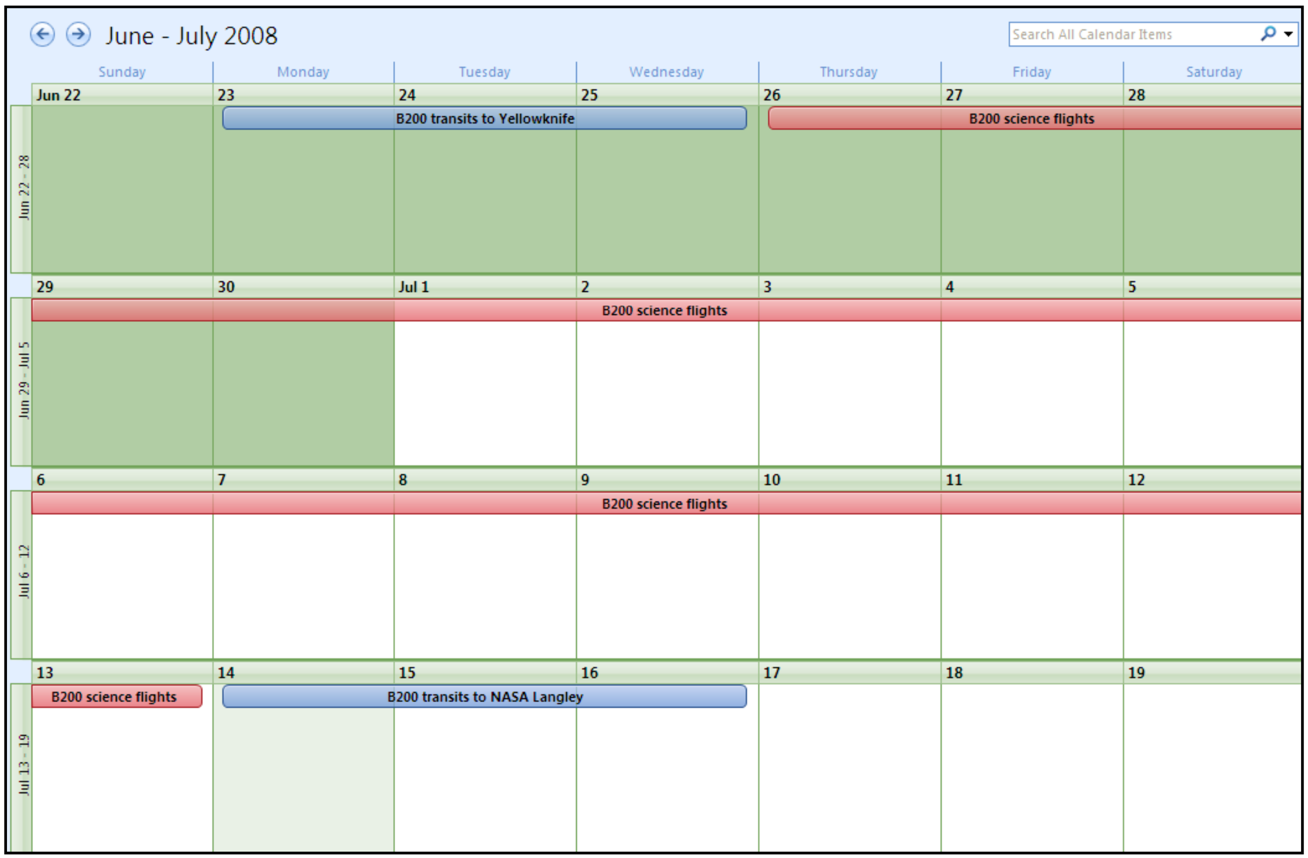
• **Conditions:** flights will be conducted when smoke is present in western Canada with clear to partly cloudy conditions. This pattern requires clear to scattered (1/3) mid-level (10 kft-25 kft) cloud coverage to avoid clouds interfering with HSRL sampling of the region where the other aircraft will sample.

• **Basic idea:** make constant altitude at ~ 28 kft above the P-3 and/or DC-8 transects through the haze.

- This pattern is designed to investigate smoke that is an extended distance away from Yellowknife and would, therefore, require one or more refueling/overnight stops away from Yellowknife. Churchill is shown here as such a refueling/overnight stop for illustration only. Another possible location for refuel/overnight stop would be Cold Lake. Exact locations of such stops will be determined as smoke conditions and logistics permit.

B200 Summer Schedule

- Science flights from ~June 26 – July 13 depending on smoke conditions
- Anticipate about 80 hours; ~ 30-40 (~6 days) used for transit
- Must have one hard down day during a span of 7 days
- Anticipate ~4 suitcase flights to/from Cold Lake, ?



Contacts

- Science/Data Products
  - Rich Ferrare, Richard.A.Ferrare@nasa.gov, 757-864-9443
  - Chris Hostetler, Chris.A.Hostetler@nasa.gov, 757-864-5373
  - John Hair, Johnathan.W.Hair@nasa.gov, 757-864-1406

- Flight Operations
  - Mike Wusk, Michael.S.Wusk@nasa.gov, 757-864-3937

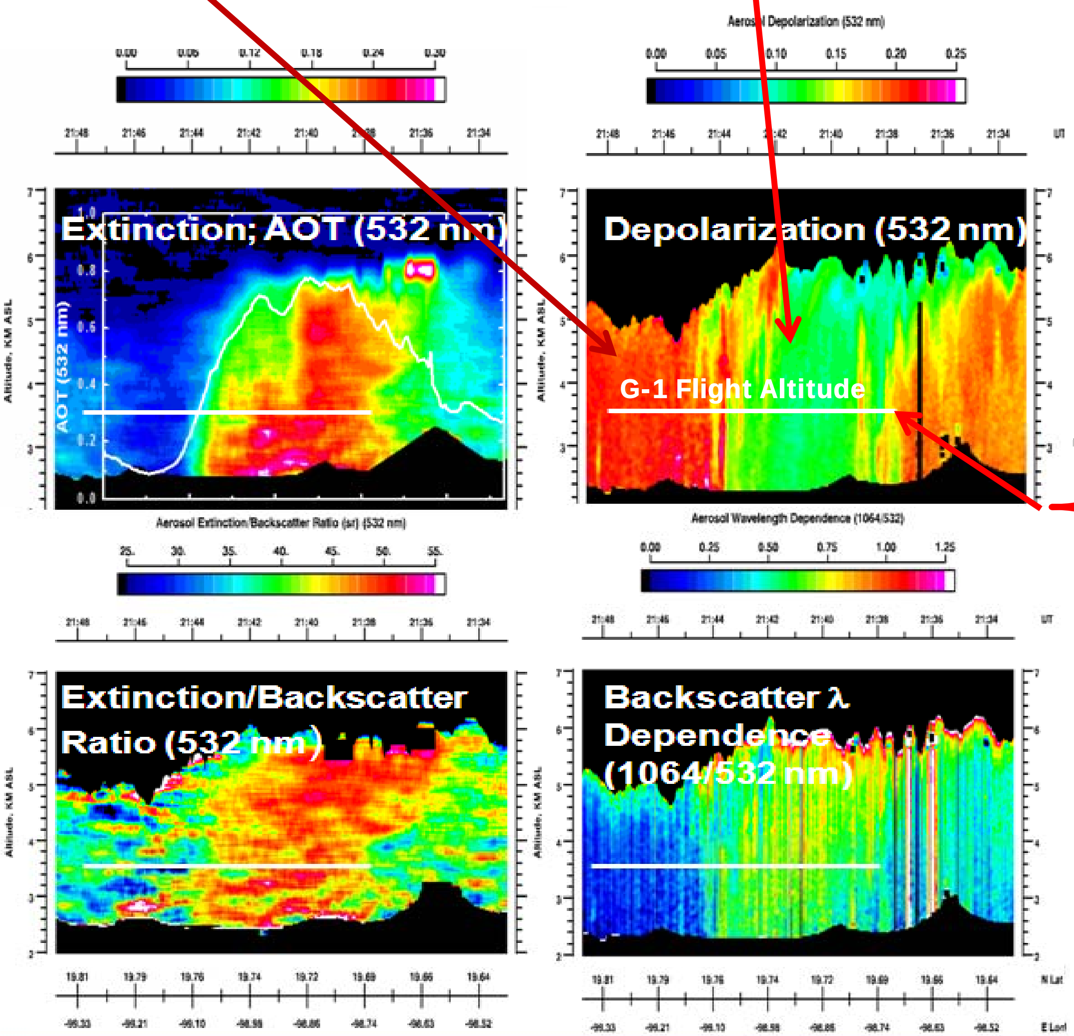
Backups

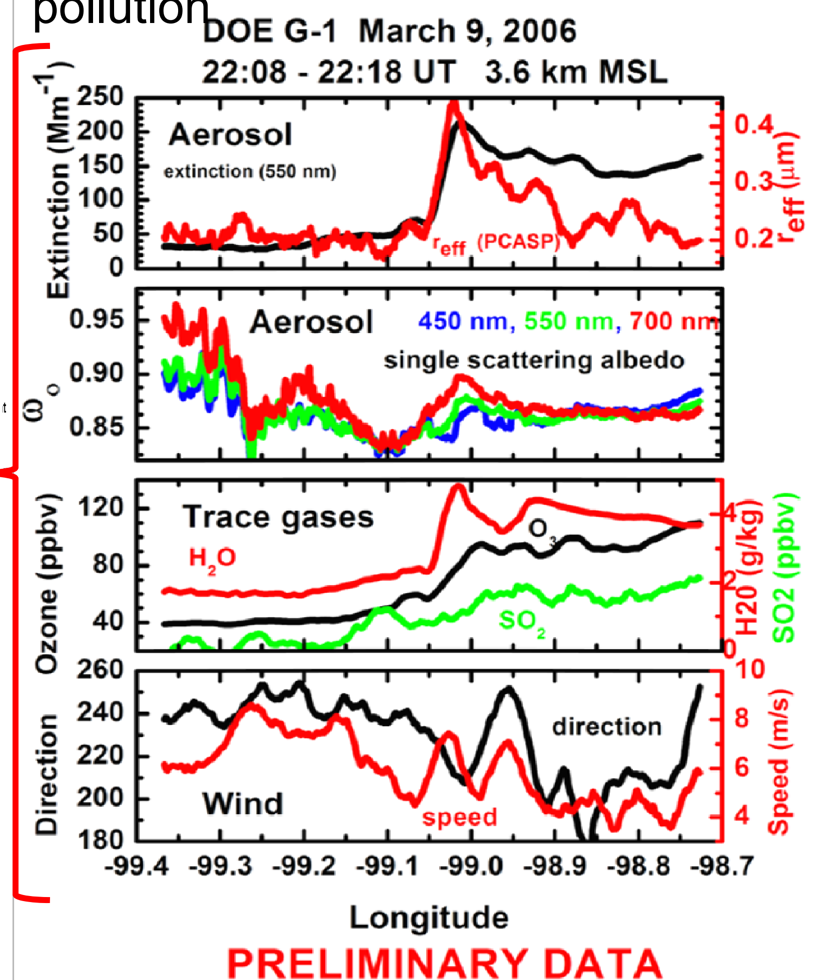
Coordinated B200/HSRL - Airborne in situ Measurements
Ex. INTEX-B/MILAGRO/MAX-Mex – March 2006

West side of MC basin
- High depolarization, low aerosol/extinction ratio: dust

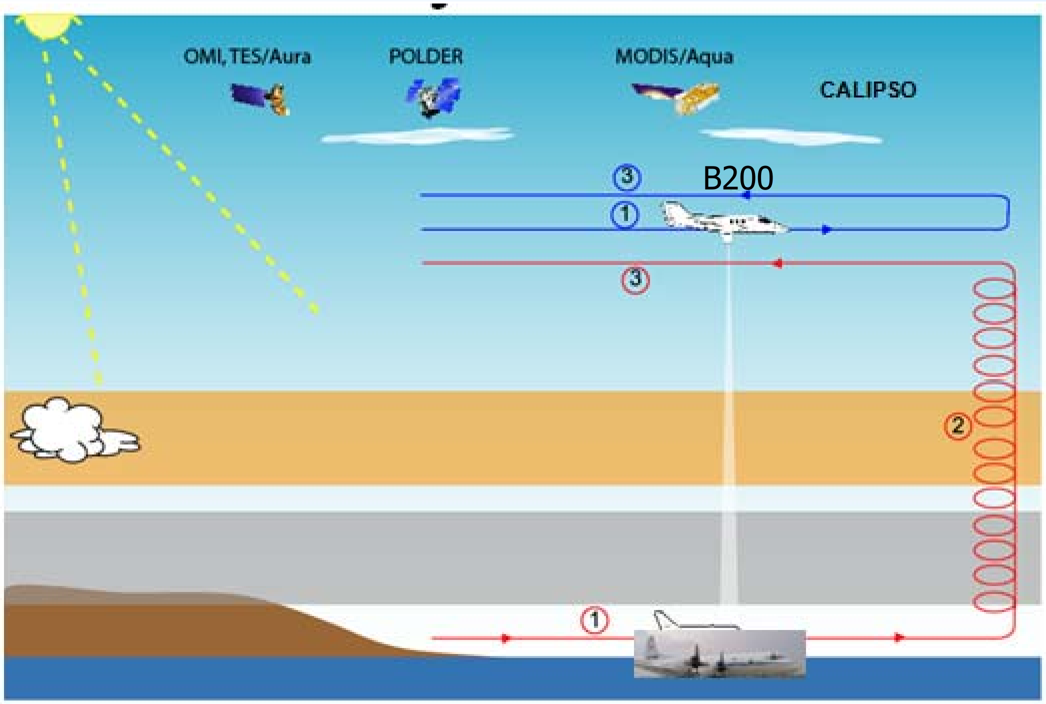
East side of MC basin
- Low depolarization, high extinction/backscatter ratio: urban pollution

- HSRL data provide vertical context for in situ data
- HSRL and G-1 measurements show changes associated with Mexico City pollution





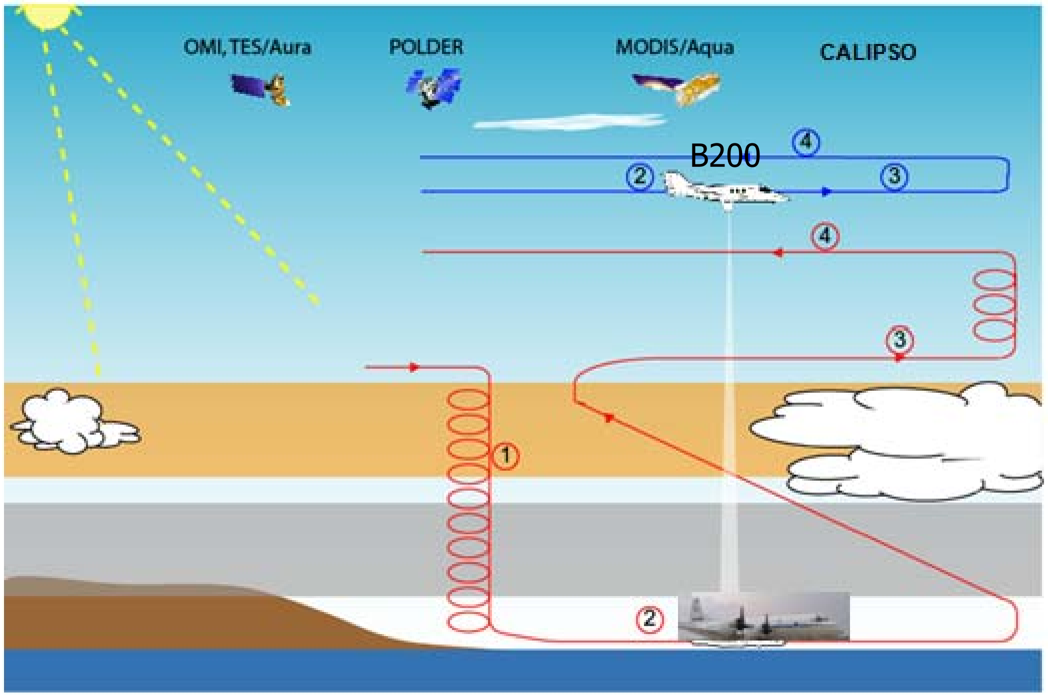
P-3/B200, Clear sky, Module 1



P-3 Plans from
Phil Russell

Clear Module 1	Science objectives	P-3 instruments involved	Coordination with instruments on other aircraft	Coordination with satellite-instruments
	-Find AOD+flux gradients -Compare HSRL, AATS, HiGEAR, AERO3X, CALIPSO ext. profiles	AATS, SSFR, BBR, HiGEAR, AERO3X, CAR	B-200 – HSRL+RSP	CALIPSO – CALIOP Aqua - MODIS PARASOL - POLDER Aura - OMI, TES Terra - MISR

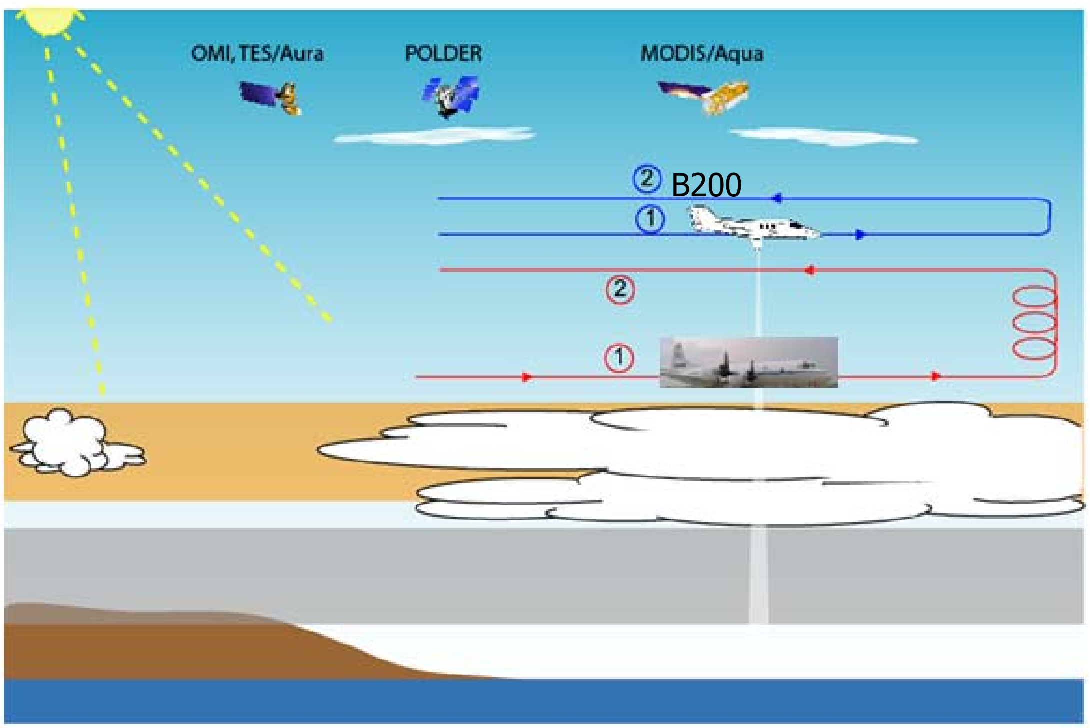
P-3/B200, Partly cloudy, Module 1



P-3 Plans from Phil Russell

Partly cloudy Module 1	Science objectives	P-3 instruments involved	Coordination with instruments on other aircraft	Coordination with satellite-instruments
	-Study AOD in vicinity of clouds (aerosol-cloud sep.) -Aerosol indirect effect -Compare RSP+SSFR cloud retrievals	AATS, SSFR, HiGEAR, AERO3X	B-200 – HSRL+RSP	CALIPSO Aqua - MODIS PARASOL - POLDER Aura - OMI, TES

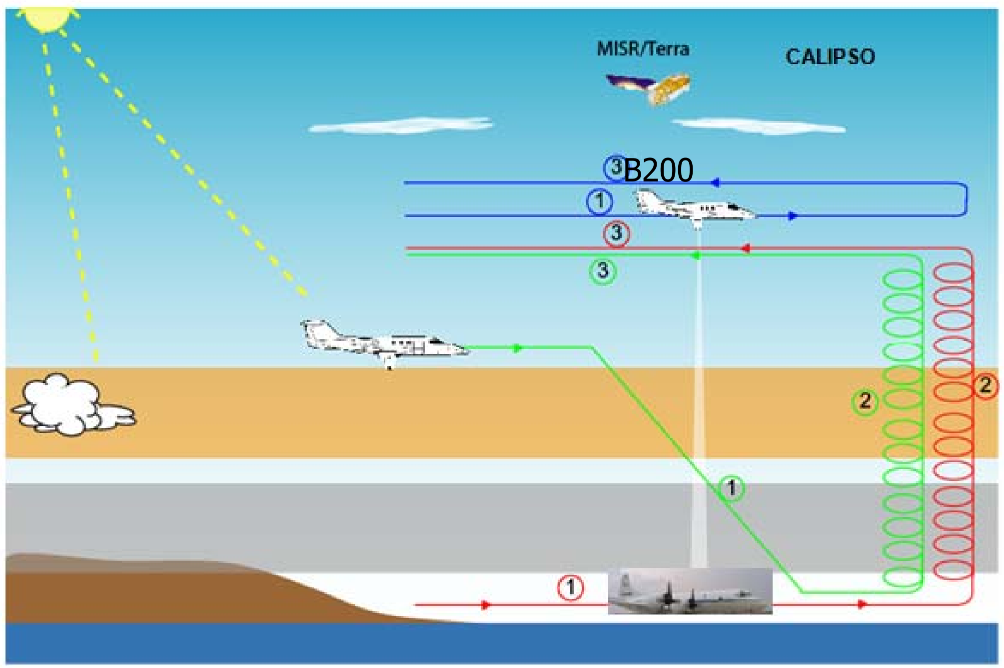
P-3 / B200 Cloudy, Module 1



P-3 Plans from Phil Russell

Cloudy Module 1	Science objectives	P-3 instruments involved	Coordination with instruments on other aircraft	Coordination with satellite-instruments
	-Compare RSP+SSFR cloud retrievals -Aerosol above clouds	AATS, SSFR, BBR, HiGEAR, AERO3X, CAR	B-200 – HSRL+RSP	Aqua - MODIS PARASOL-POLDER Aura - OMI, TES

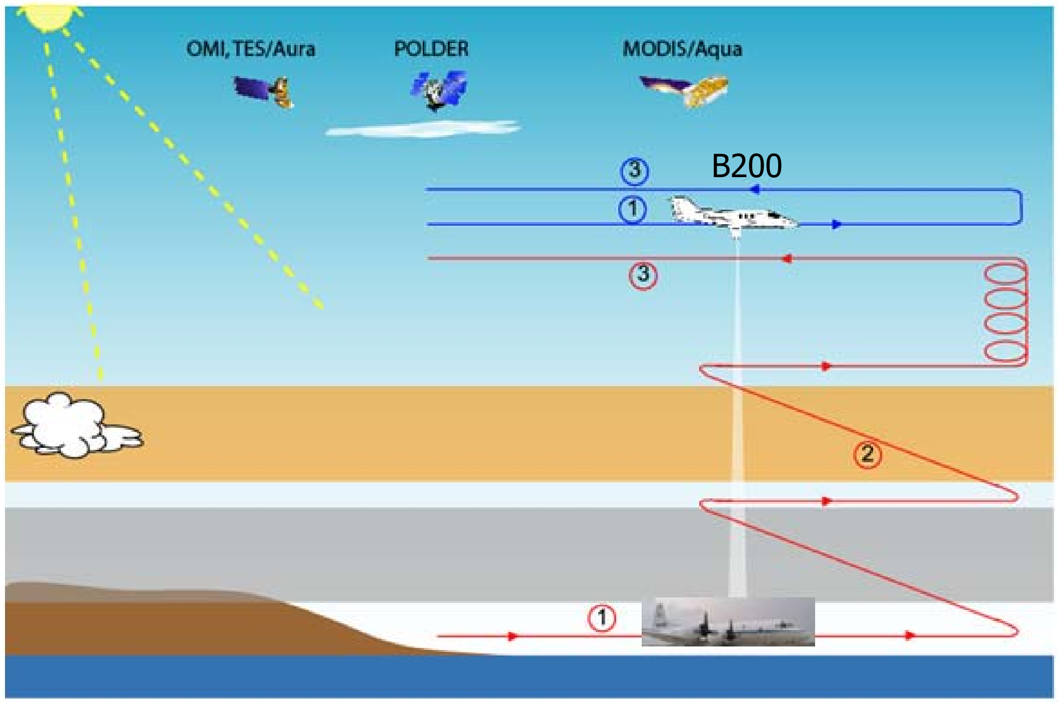
P-3 / B200 Clear sky, Module 2



P-3 Plans from
Phil Russell

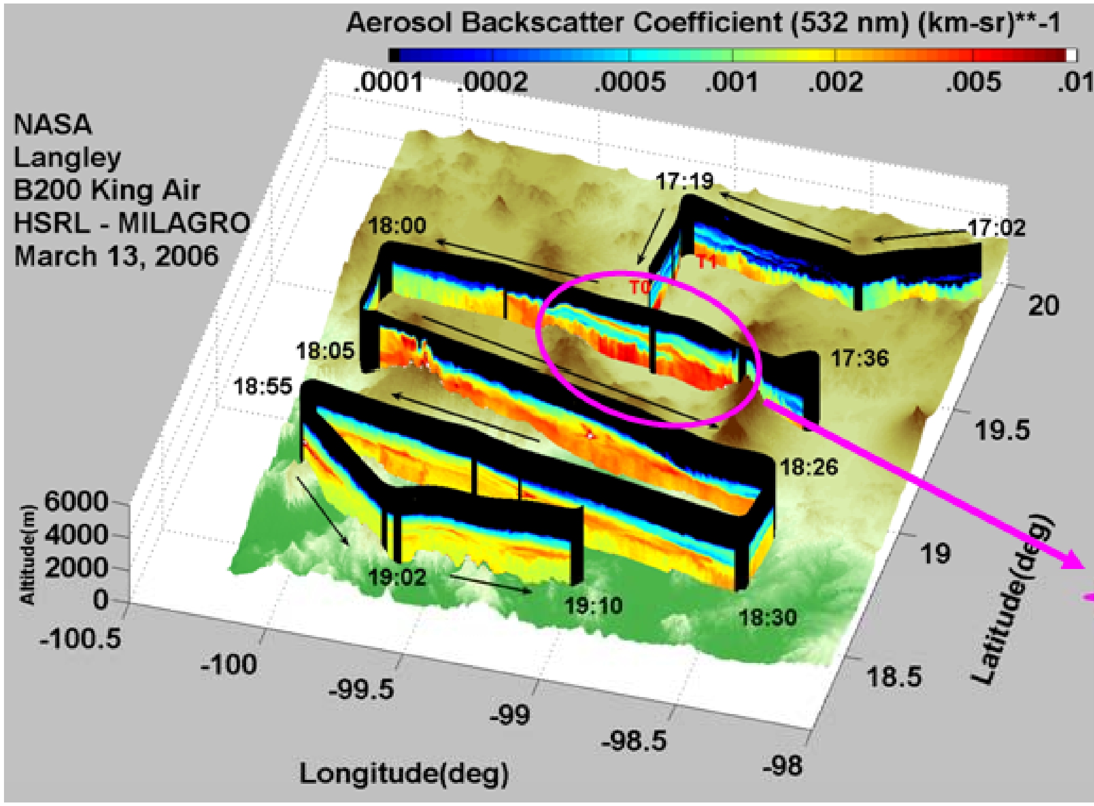
Clear Module 2	Science objectives	P-3 instruments involved	Coordination with instruments on other aircraft	Coordination with satellite-instruments
	-MISR local mode val. -Closure AATS+SSFR vs. DC-8 in situ -Compare HSRL+AATS+HiGEAR+AERO3X+CALIPSO ext.	AATS, SSFR, HiGEAR, AERO3X, CAR	B-200 – HSRL+RSP DC-8 – in situ + lidar	Terra – MISR Terra – MODIS CALIPSO A-Train

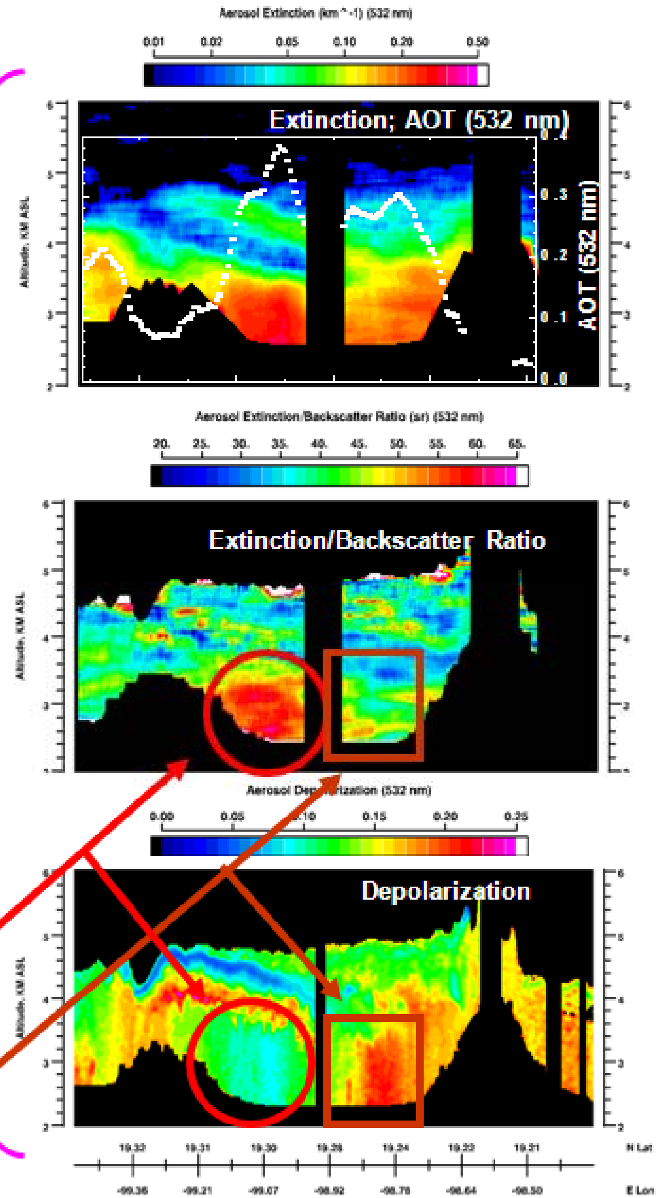
P-3 / B200 Clear sky, Module 3



P-3 Plans from Phil Russell

Clear Module 3	Science objectives	P-3 instruments involved	Coordination with instruments on other aircraft	Coordination with satellite-instruments
	-SSFR+AATS flux divergence for aerosol absorption compared to HiGEAR, AERO3X in situ	AATS, SSFR, BBR, HiGEAR, AERO3X, CAR	B-200 – HSRL+RSP	Aqua – MODIS (possibly in-glint) PARASOL-POLDER Aura - OMI, TES





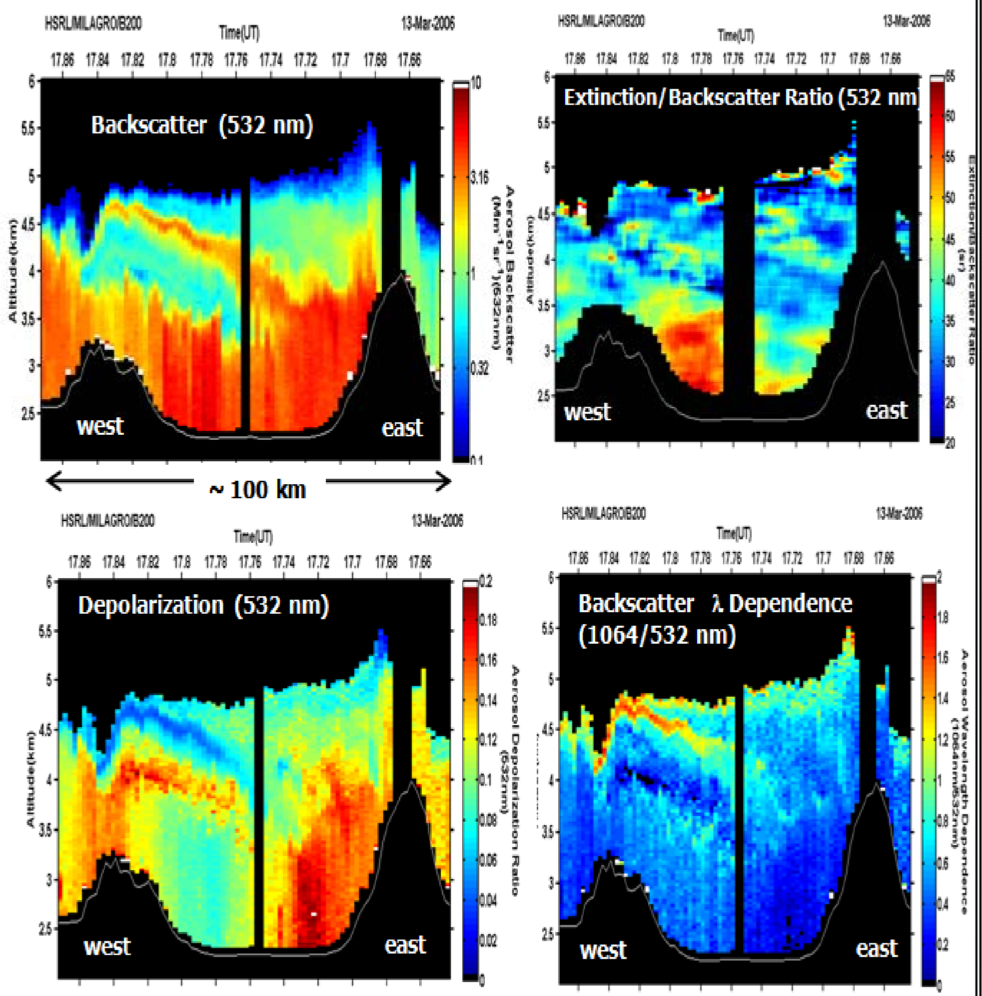
Aerosol types inferred from HSRL measurements

- West side of MC basin
  - High extinction/backscatter ratio, low depolarization: urban pollution
- East side of MC basin
  - Low extinction/backscatter ratio, high depolarization: dust

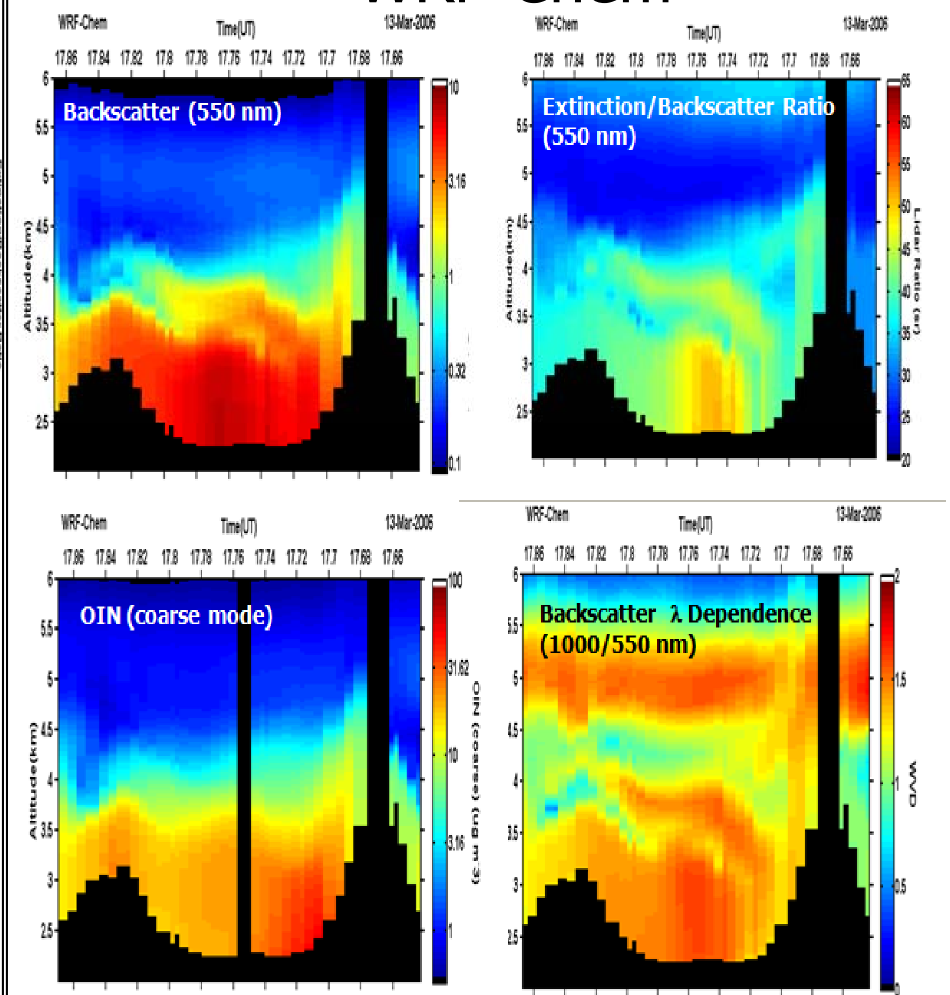
HSRL/WRF-Chem Example – March 13, 2006

- High resolution WRF-Chem shows much of the small scale structure shown in HSRL data

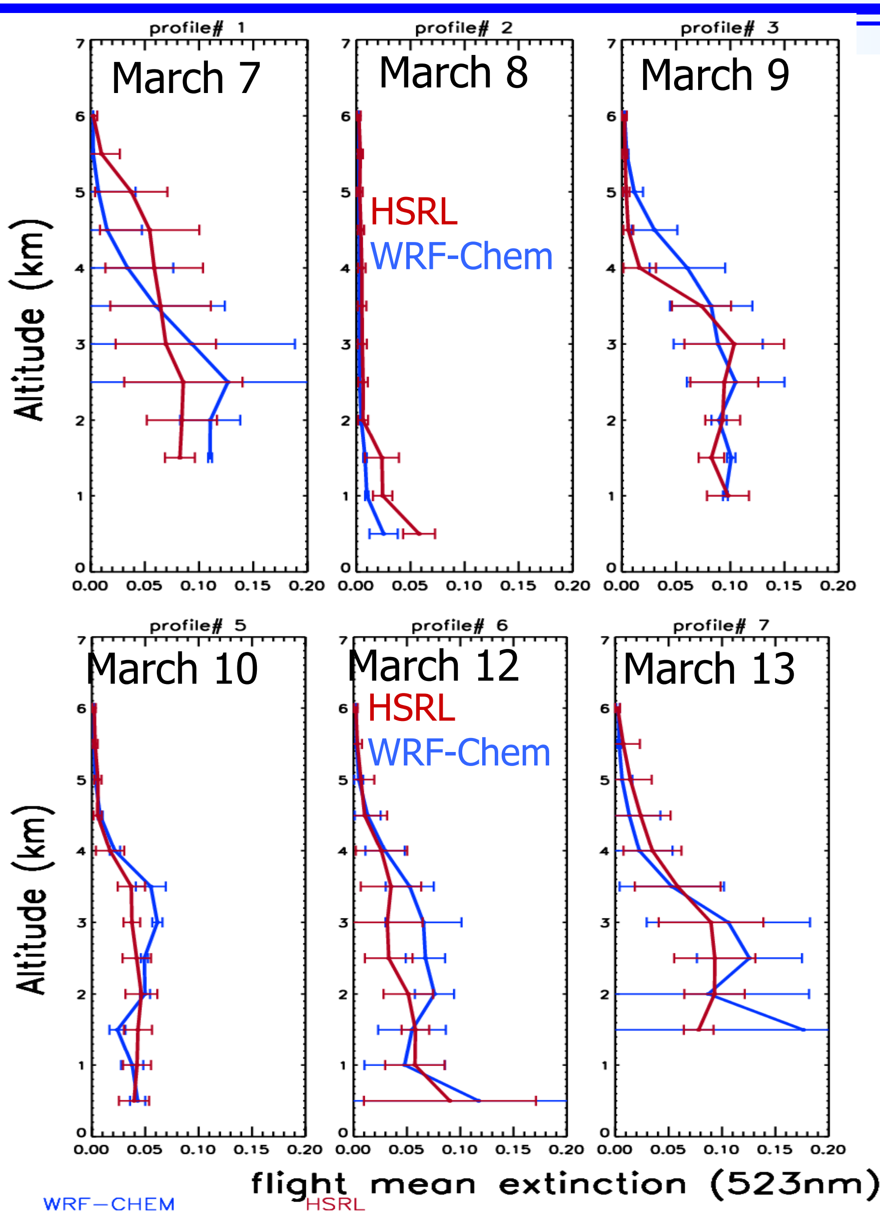
HSRL



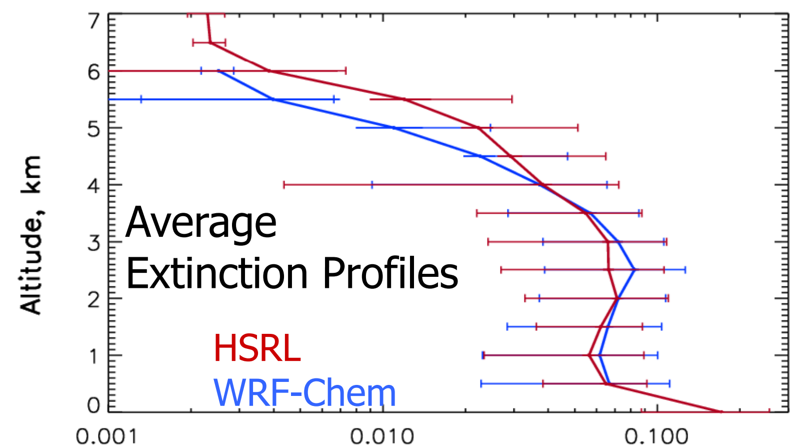
WRF-Chem

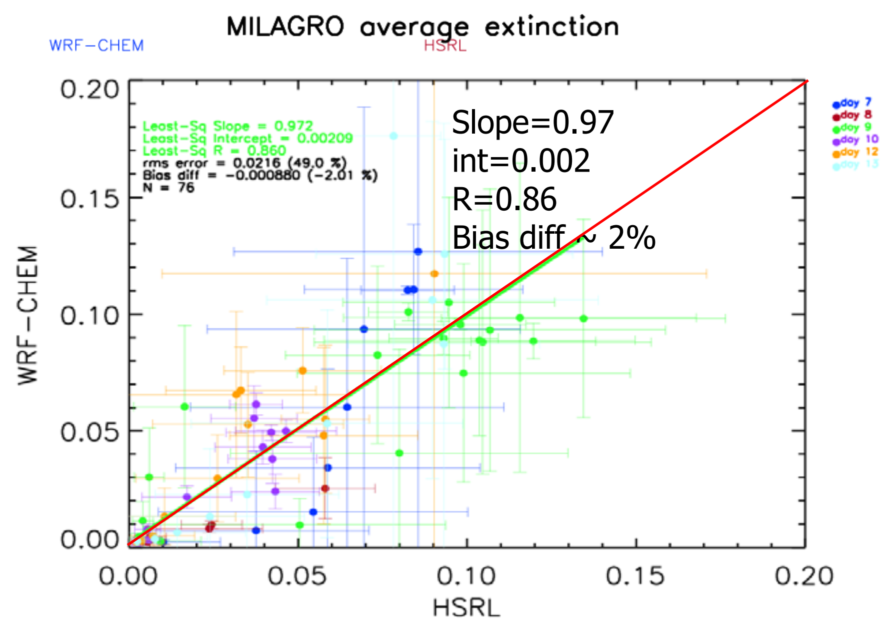


HSRL/WRF-Chem Aerosol Extinction Comparison

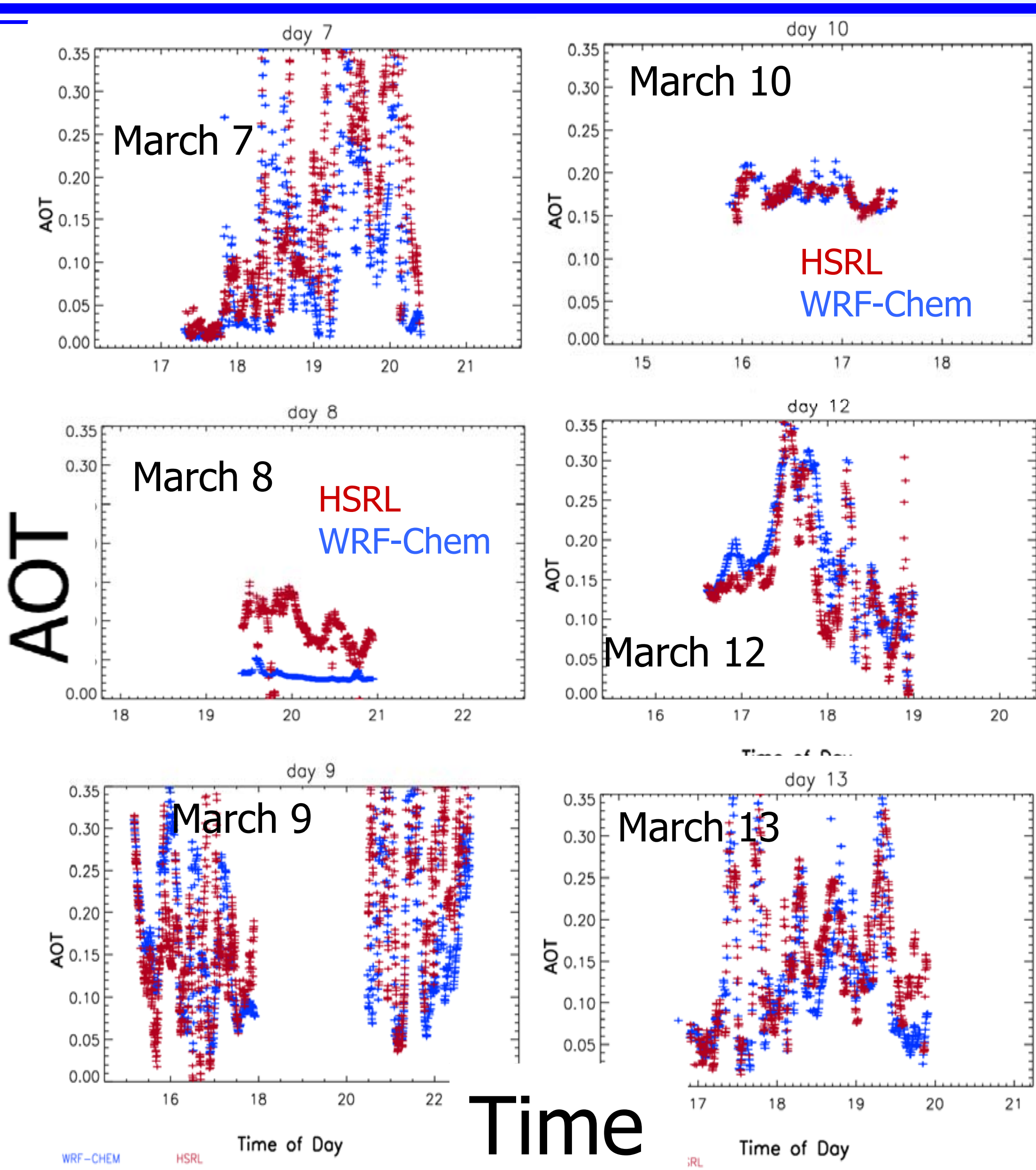


WRF-Chem aerosol extinction profiles in very good overall agreement with HSRL





HSRL/WRF-Chem Aerosol Optical Thickness Comparison



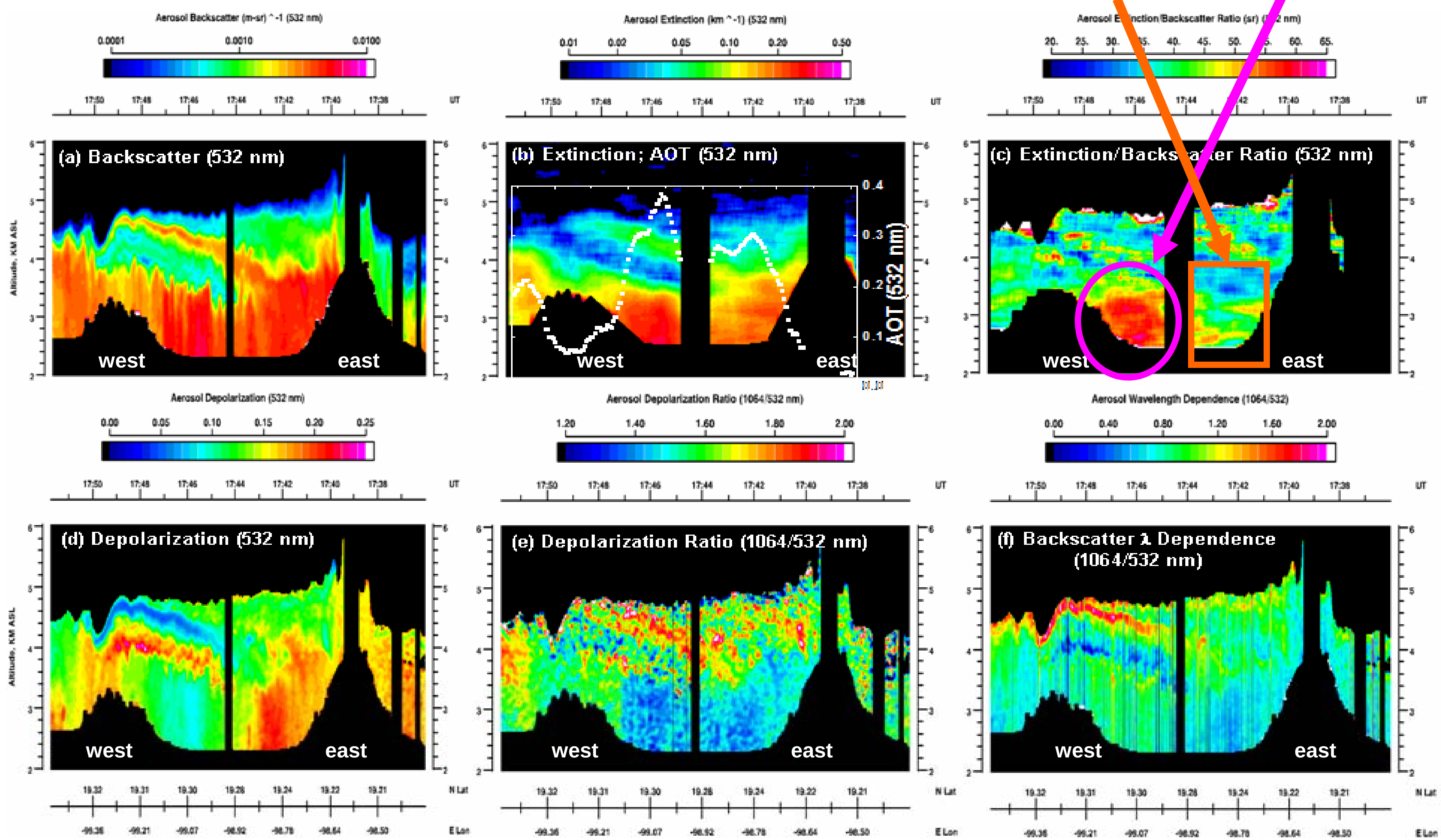
WRF-Chem aerosol optical thickness in very good overall agreement with HSRL

- Performance varies with location: WRF-chem overestimates backscatter and extinction over Gulf and coast - perhaps too much model dust?
- Some fine scale layers only crudely represented by model
- Some differences between measured and modeled PBL growth rate

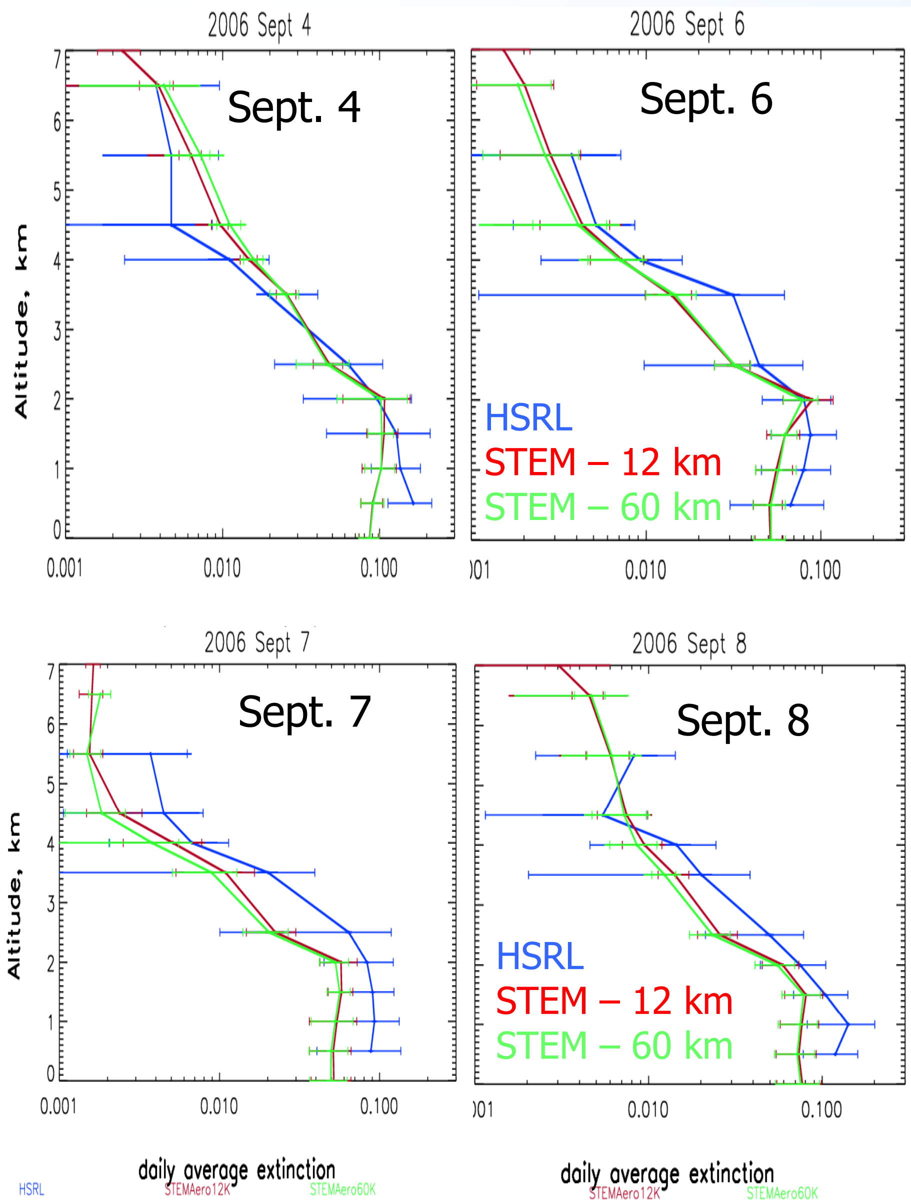
HSRL - Characterizing the spatial distribution of aerosol type

LaRC Airborne HSRL Measurements over Mexico City, March 13, 2006

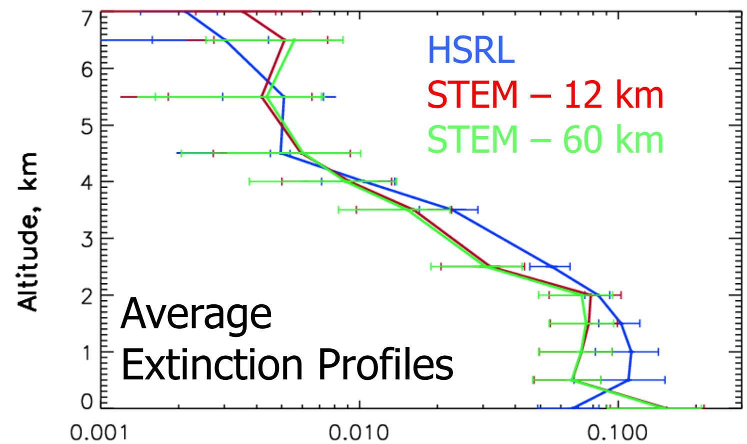
- western part of city- high S_a, high WVD, low depolarization – urban aerosol
- eastern part of city - low Sa, low WVD, high depolarization – dust

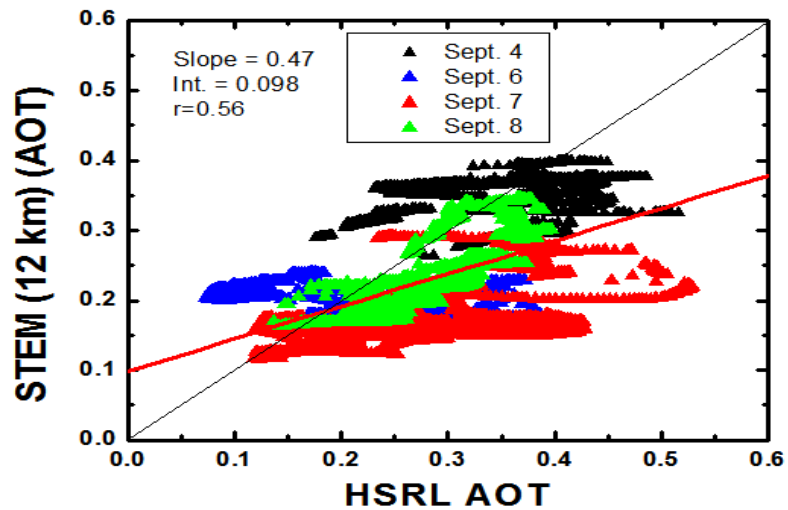


HSRL/STEM Aerosol Extinction Profile Comparison



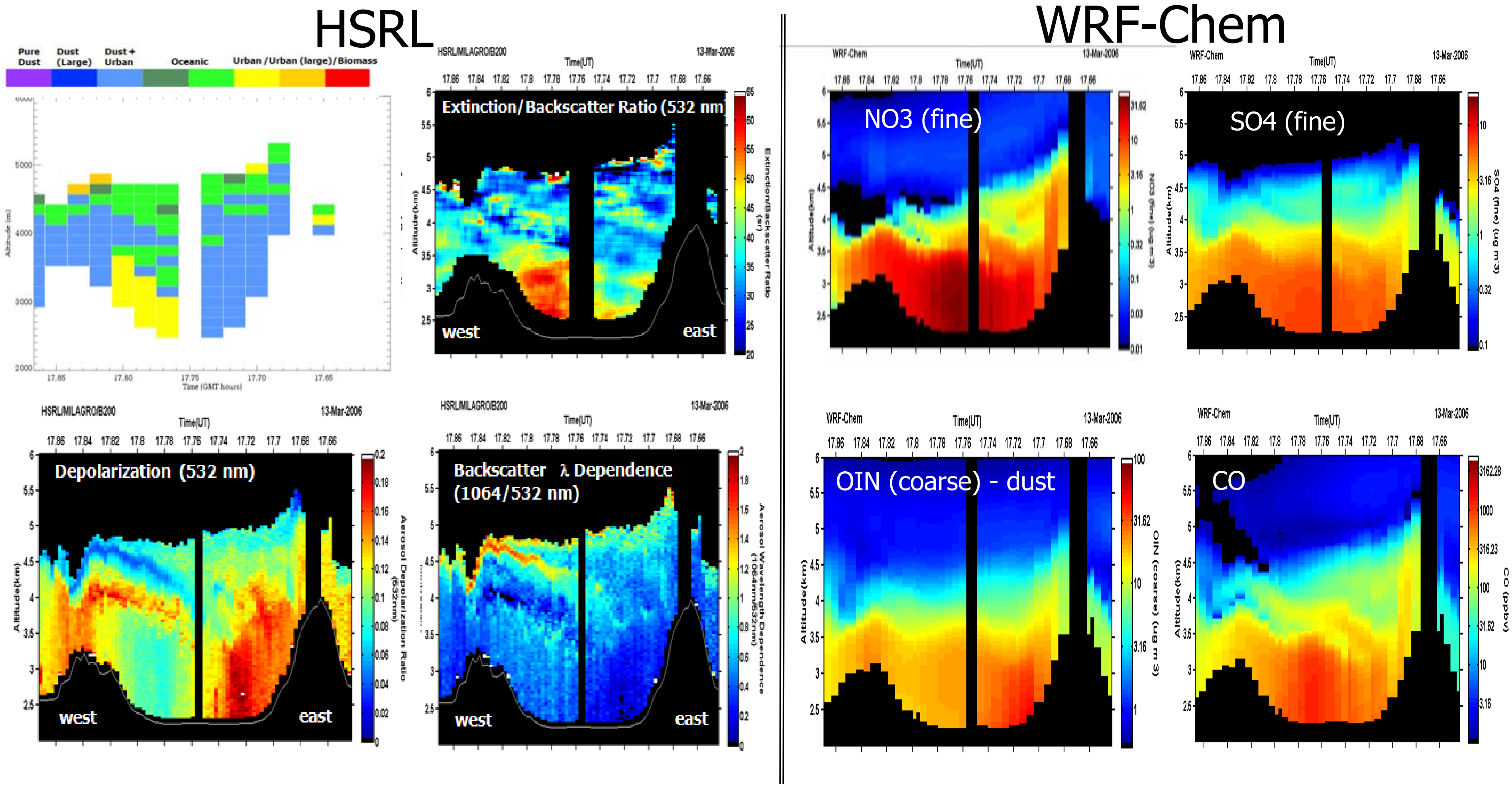
- STEM extinction and AOT typically smaller than HSRL
- STEM extinction profiles show less day-to-day variability than HSRL profiles



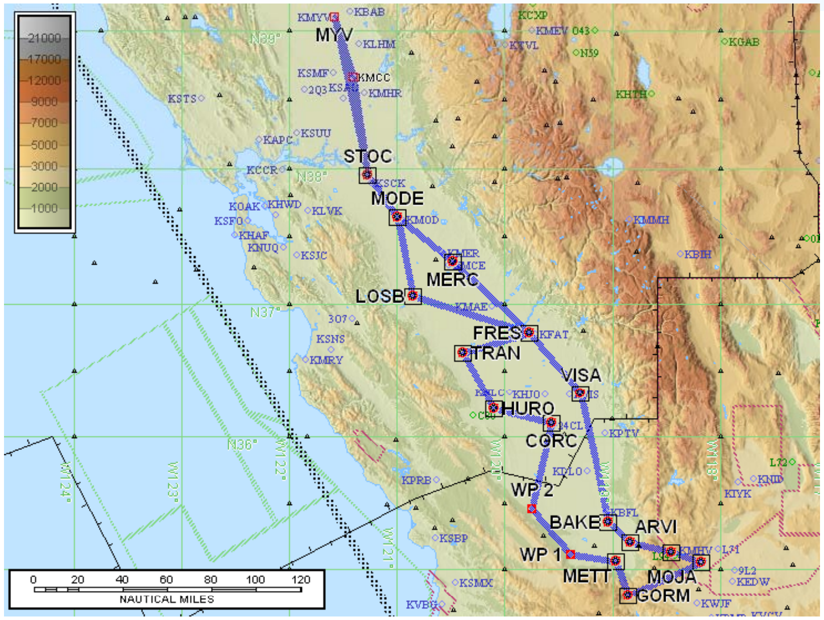


HSRL Aerosol Classification – Comparison to WRF-Chem

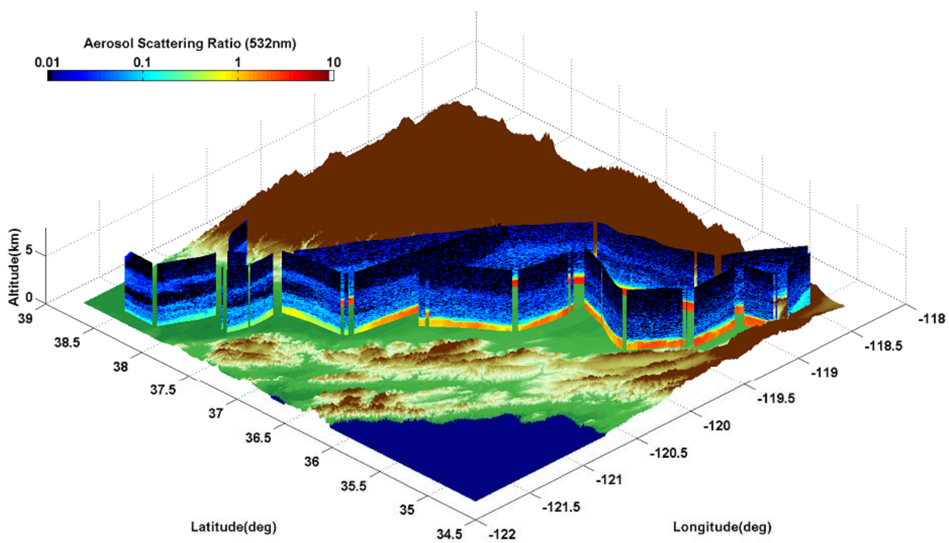
- In the vicinity of Mexico City, WRF-CHEM compositions qualitatively agree with aerosol types inferred from HSRL measurements
  - High concentrations of NO_3, SO4, EC -> urban
  - High concentrations of dust (other inorganics, OIN, in the model) -> mix of dust and urban
- Outside of Mexico City, dust and urban pollutants mix together

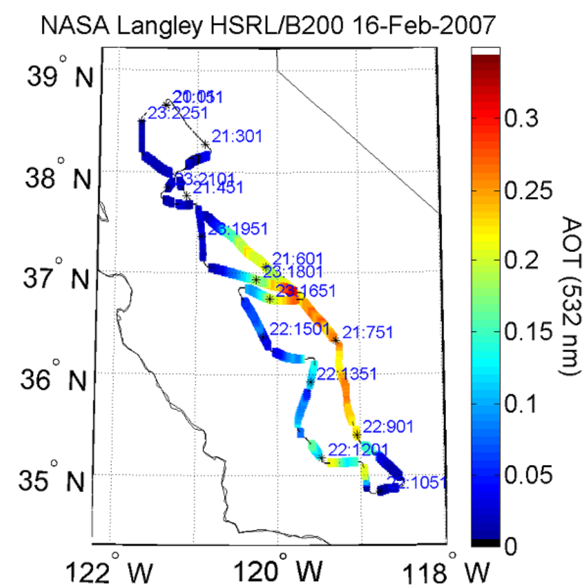


Summer - B200 Flight #1 – California Air Quality, Pollution, Smoke



- This pattern is designed to measure aerosol distributions throughout California, and in particular, the San Joaquin Valley, where major air pollution episodes often exist. The pattern would be conducted in coordination with DC-8 and/or P-3 in situ sampling. The B200 pattern would likely be designed to sample ahead of the other aircraft in order to locate aerosol layers and vector the other aircraft to the desired location. Note that the B200 flew such patterns during February 2007 as part of an EPA/NASA study to investigate the relationship between aerosol optical thickness (AOT) and surface $PM_{2.5}$ concentrations. The pattern flown on Feb. 16 2007 is shown here along with the HSRL aerosol scattering ratio “curtain” file and AOT along the B200 path. The pattern includes passes over surface $PM_{2.5}$ and AERONET sites.

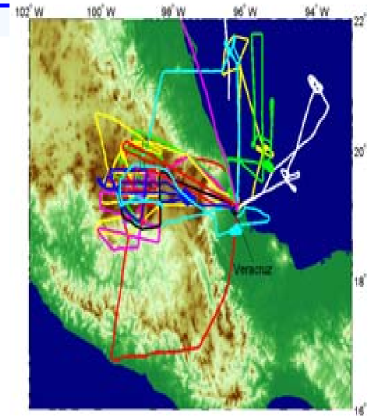




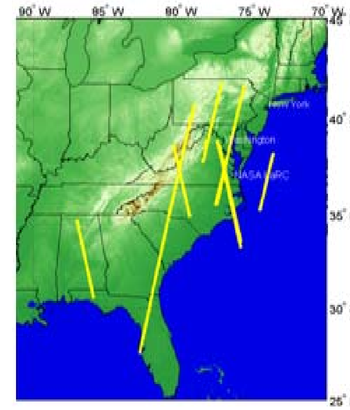
Airborne HSRL Missions 2006-2007

History

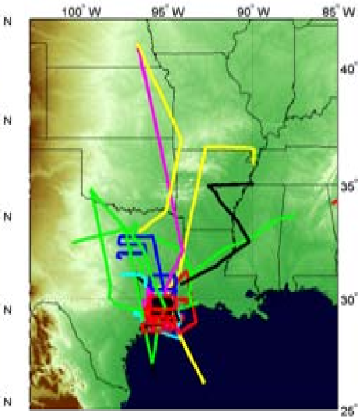
- 2000-2004: instrument development and integration
- Dec 2005: first test flight NASA Langley King Air
- 2006: flew on 3 major campaigns:
  - MILAGRO (55 hours)
  - TexAQS/GoMACCS (90 hours)
  - CALIPSO Val (51 hours)
- 2007: flew on 3 campaigns:
  - San Joaquin (EPA) (43 hours)
  - CHAPS/CLASIC (70 hours)
  - NASA CALIPSO/CATZ (50 hours)
- Nearly 400 hours of airborne data over two years!
- 2008:
  - CALIPSO Validation
  - ARCTAS



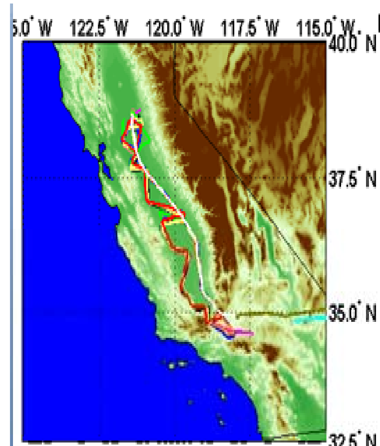
MAXMex/MILAGRO/INTEX-B
Mexico City
March 1-30, 2006



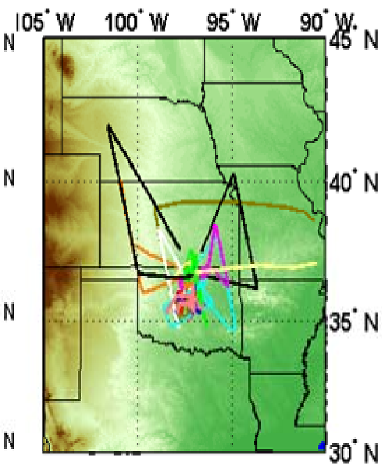
CALIPSO Validation
Eastern U.S.A.
June 14 – Aug 10, 2006



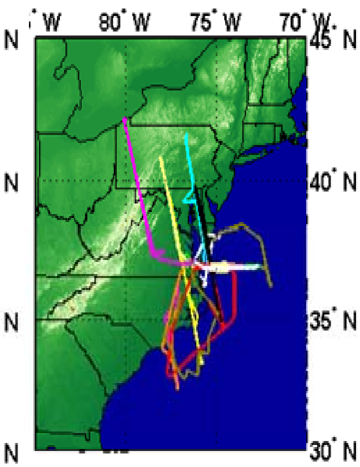
TexAQS II/GoMACCS
Houston
Aug 27 – Sep 29, 2006



San Joaquin Valley
California
February 8-21, 2007



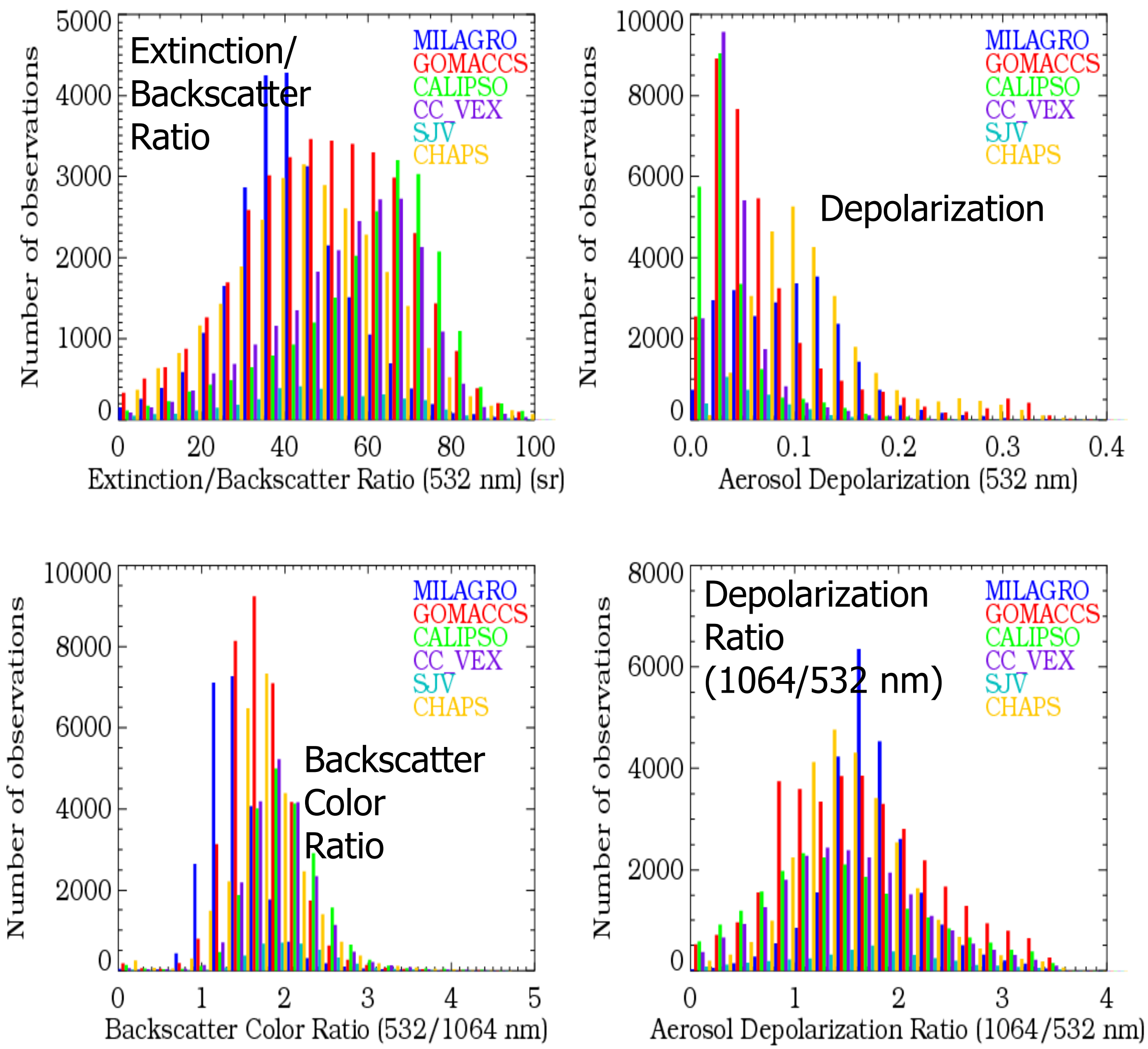
CHAPS
Oklahoma
June 3-29, 2007



CALIPSO/MODIS/CATZ
Eastern U.S.
January 17– Aug 11, 2007

Aerosol Classification using HSRL measurements

Variability of aerosol parameters during several field missions



Aerosol classification is based on HSRL measurements of aerosol intensive parameters

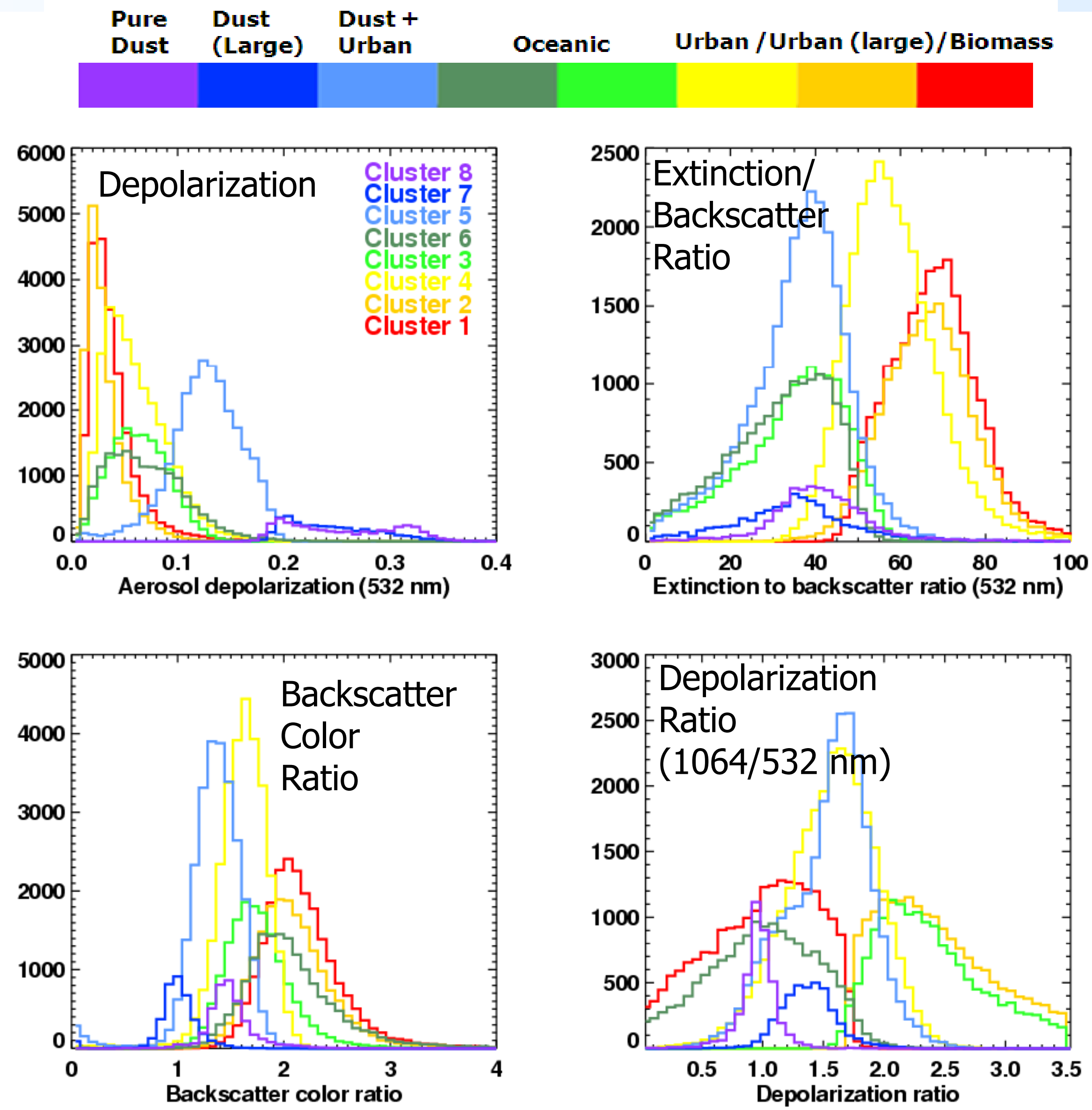
- Extinction/Backscatter Ratio (~absorption)
- Depolarization (~spherical vs. nonspherical – dust/ice)
- Backscatter Color Ratio (~size)
- Depolarization Ratio (1064/532 nm) (~nonspherical/spherical size)

Aerosol Classification using HSRL measurements

The HSRL measurements of aerosol intensive parameters were used in an objective cluster analysis scheme to discriminate aerosol type. These aerosol types were subjectively related to the aerosol types inferred from AERONET data by Cattrall et al. (2005).

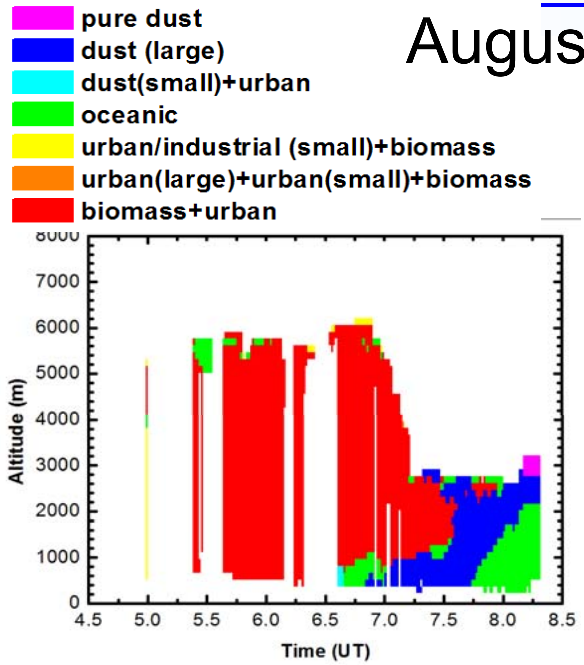
Airborne G-1 in situ measurements acquired during MILAGO generally support inferred aerosol types

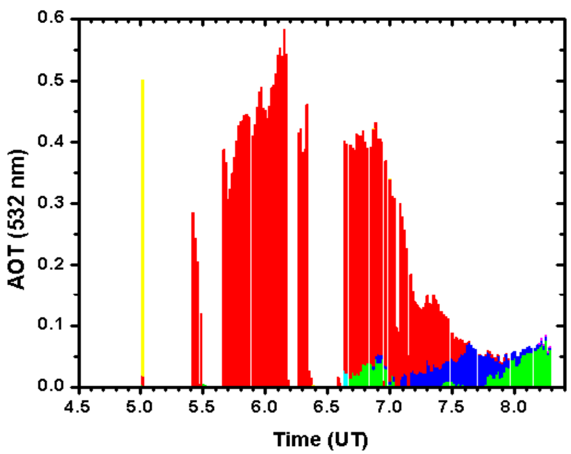
- nonspherical, larger dust (HSRL) → large, absorbing particles (G-1)
- smaller, urban/biomass (HSRL) → smaller, less absorbing (G-1)

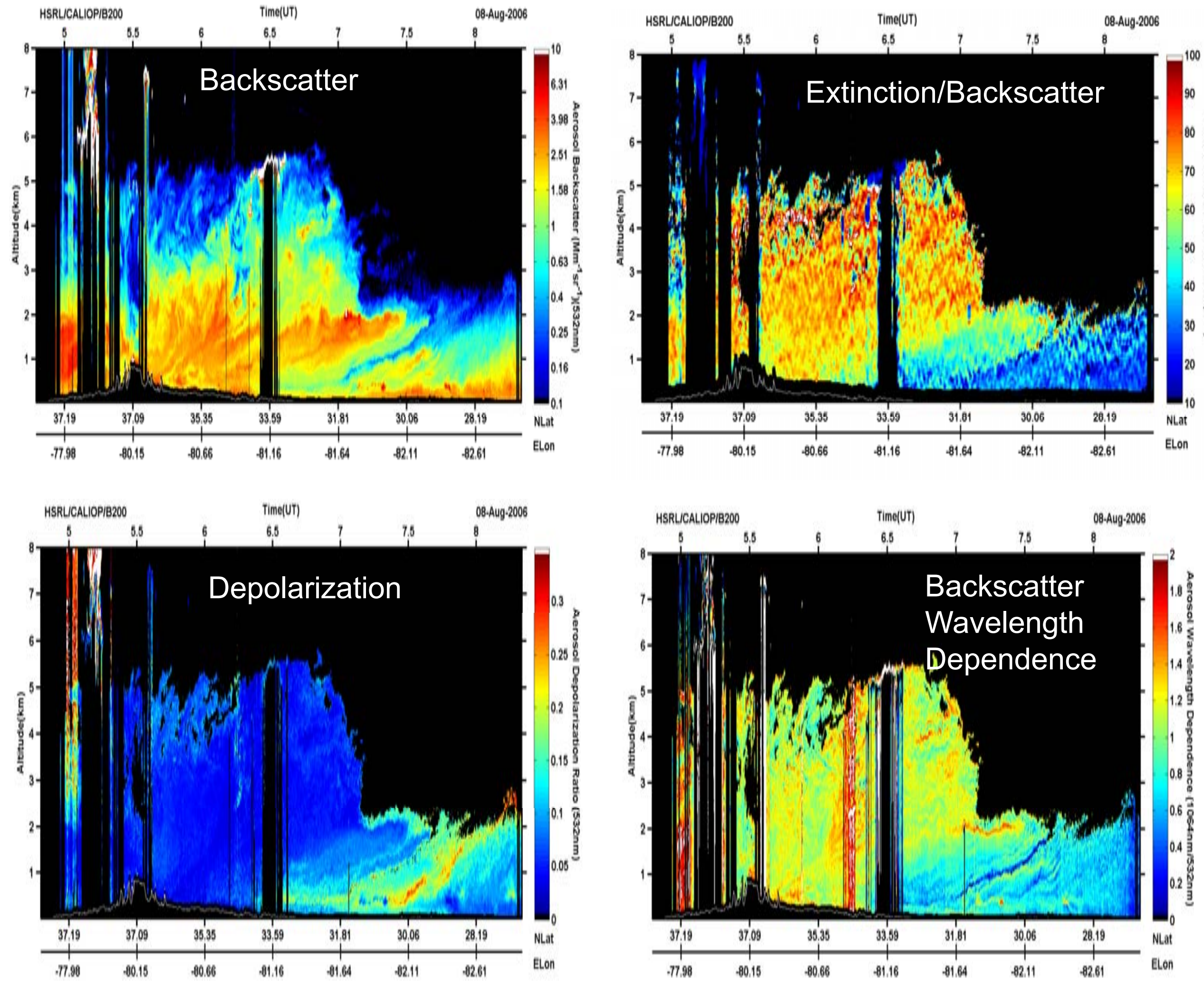


Aerosol Characterization Example

August 8, 2006 CALIPSO Validation Flight



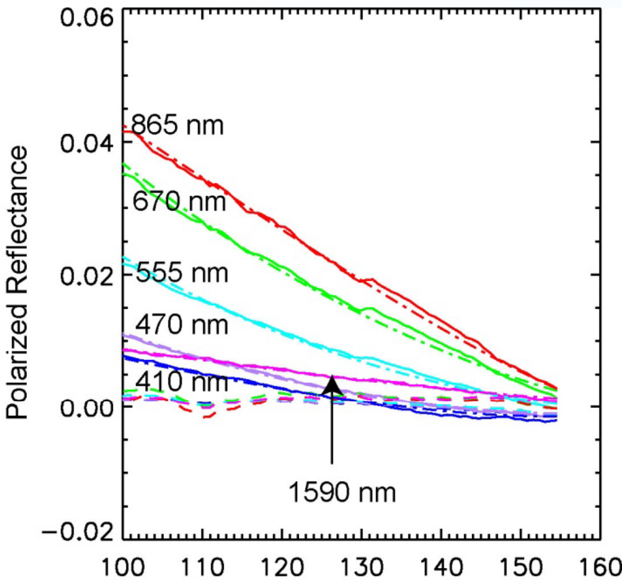


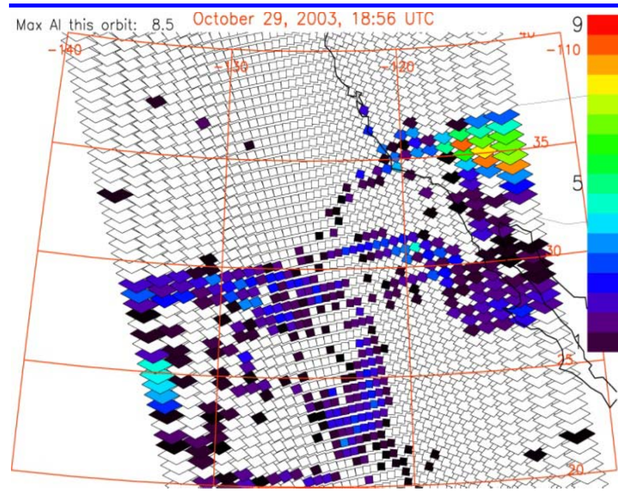


B200 Flight Operations and Patterns

- Preliminary flight plans for B200 operations out of
  - Barrow, Fairbanks (Spring)
  - Palmdale, California; Yellowknife, Cold Lake, Canada (Summer)
- These drafts are intended to initiate negotiations with air traffic controllers on final flight plans that will accomplish as many of our scientific objectives as possible within the constraints of their air-traffic control system.
- These plans may not include all flight scenarios
- Spring - 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.
- Spring
  - goal is to operate from Barrow
  - anticipate some flights out of Fairbanks 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

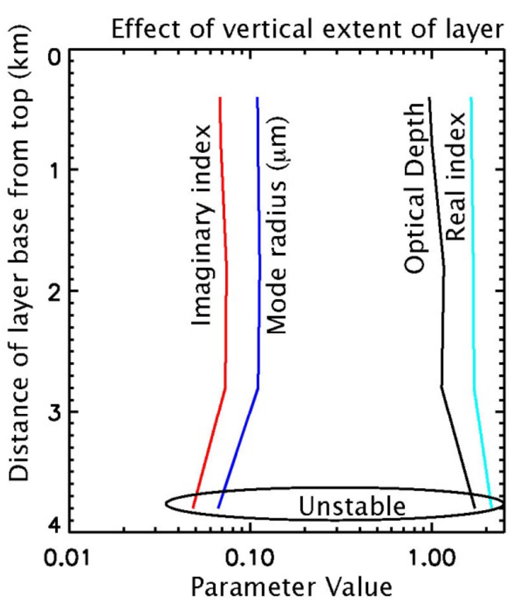
Research Scanning Polarimeter on the B200

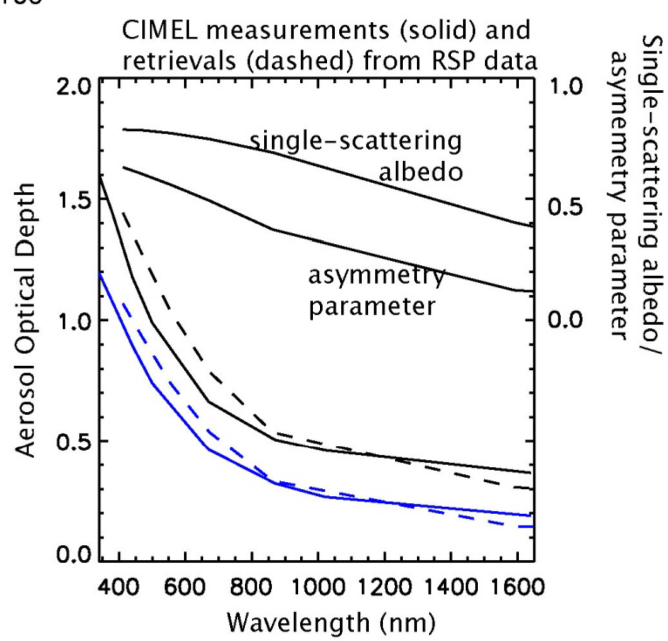




The RSP measures multi-angle polarized radiances over the spectral range from 410 to 2250 nm and an angular range of ±60°.

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.