Overview of NASA B-200 King Air RACORO Operations and Science

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Atmospheric Science Program (ASP)

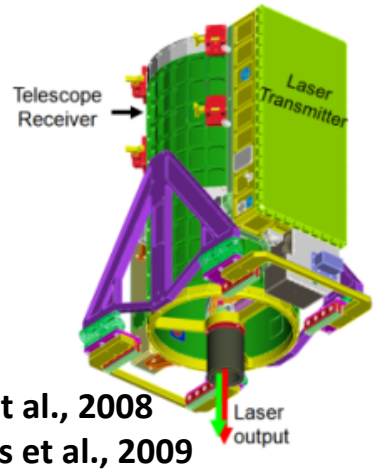
B200/HSRL/RSP RACORO Objectives

- Investigate variations in aerosol properties near clouds
- Investigate variations in aerosol properties due to changes in RH
- Evaluate RSP retrievals of cloud properties
- Provide the vertical context for airborne in situ measurements of aerosols and clouds
- Characterize the PBL height and distribution of aerosols within and above PBL
- Characterize the vertical and horizontal distribution of aerosols and aerosol optical properties, including mapping aerosol by type and partitioning optical depth by type.
- Develop combined active+passive retrieval algorithms relevant to "A Train" satellites and the NASA Aerosol-Clouds-Ecosystem (ACE) Decadal Survey Mission
- CALIPSO Validation

Instruments

High Spectral Resolution Lidar (HSRL)

- Independently measures aerosol/cloud extinction and backscatter profiles at 532 nm
- Profile 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



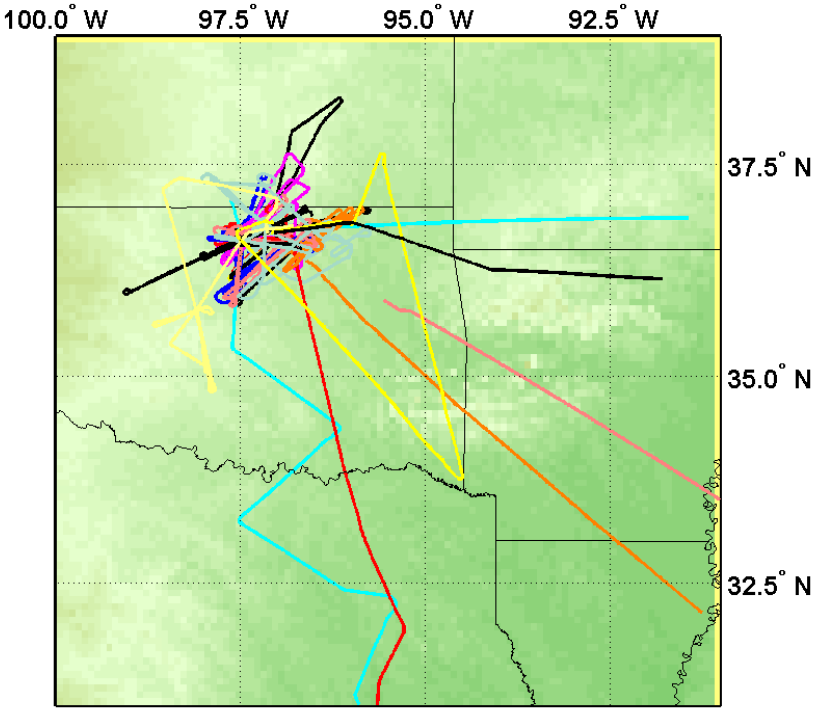
Hair et al., 2008
Rogers et al., 2009

Research Scanning Polarimeter (RSP

- Precursor to APS on NASA Glory mission
- Measures total and linearly polarized reflectance in 9 spectral bands (412 nm – 2.25 μm)
- Retrieval of Stokes parameters
- Columnar Aerosol retrievals
  - Optical depth
  - Size distribution
  - Refractive index
- Cloud retrievals
  - Optical depth
  - Effective radius, variance of cloud droplet size distribution
  - Cloud top and base heights
  - Liquid water path and droplet number distribution

RACORO Operations Scorecard

- B200 based in Ponca City
- 19 science flights
- 15 flights coordinated with Twin Otter
- 4 flights included underpass of CALIPSO and A Train
- 16 flights included overpass near or over DOE ARM SGP site



HSRL Flights and Flight Coordination[1]

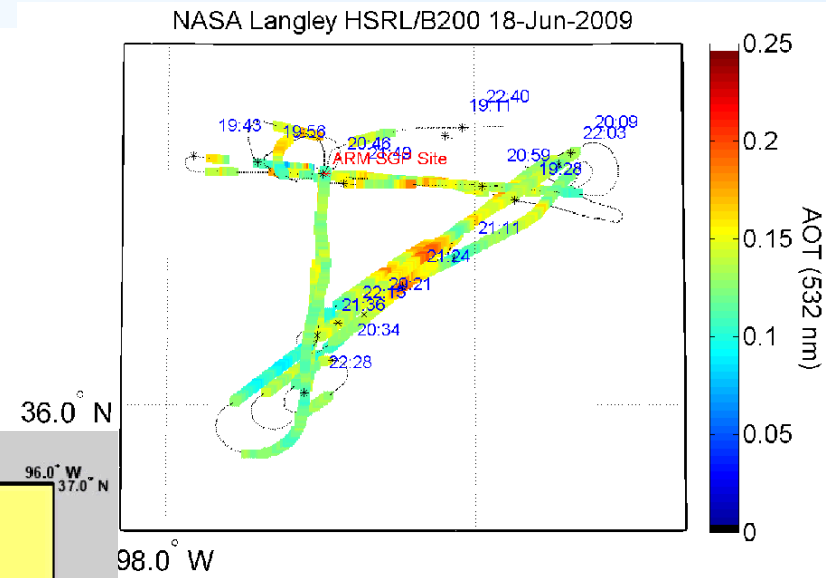
	Aircraft and HSRL spatially and temporally coordinated flights
	Aircraft and HSRL flew partially coordinated flights
	Aircraft and HSRL flew UNCOORDINATED flights
	B200 Transit flight
	Aircraft operations unknown
	Aircraft did not fly ARCTAS science flight

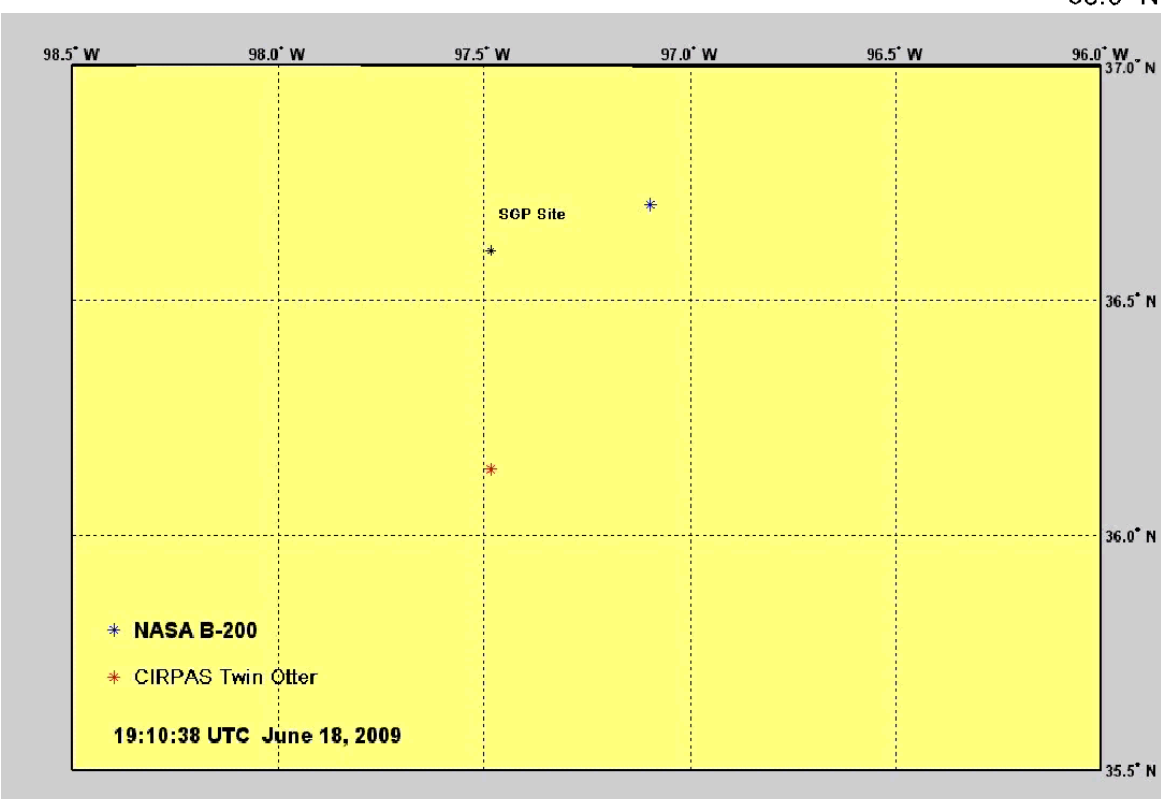
Date	HSRL Flight Number	HSLR Data Filename	Cirpas Twin Otter	CALIPSO underflight included?	SGP site overflight included?[3]
05/31/09	R-184a	20090531_L1			
	R-184c[4]	20090531_L3			
06/01/09					
06/03/09	R-185	20090603_L1			10
06/04/09	R-186	20090604_L1			
06/05/09	R-187a	20090605_L1			
	R-187b	20090605_L2		Yes	
06/07/09	R-188	20090607_L1			
06/08/09	R-189	20090608_L1			
06/09/09	R-190	20090609_L1			
06/11/09	R-191	20090611_L1			
06/12/09	R-192	20090612_L1			
06/15/09	R-193	20090615_L1			
06/17/09	R-194a	20090617_L1			
	R-194b	20090617_L2		Yes	
06/18/09	R-195	20090618_L1			
06/19/09	R-196	20090619_L1			
06/20/09	R-197	20090620_L1			
06/22/09	R-198	20090622_L1			
06/23/09	R-199	20090623_L1			2
06/24/09	R-200	20090624_L1		Yes	1
06/26/09	R-201	200906_26_L1			1
06/27/09	R-202a	20090627_L1			
	R-202b	20090627_L2			
Total Number of Coordinated Flights with NASA HSRL:			15	4	16

June 18

June 18 - Coordinated B200-Twin Otter Flight

- B200 and Twin Otter flew triangular coordinated cloud pattern typical of the pattern that was conducted on several days

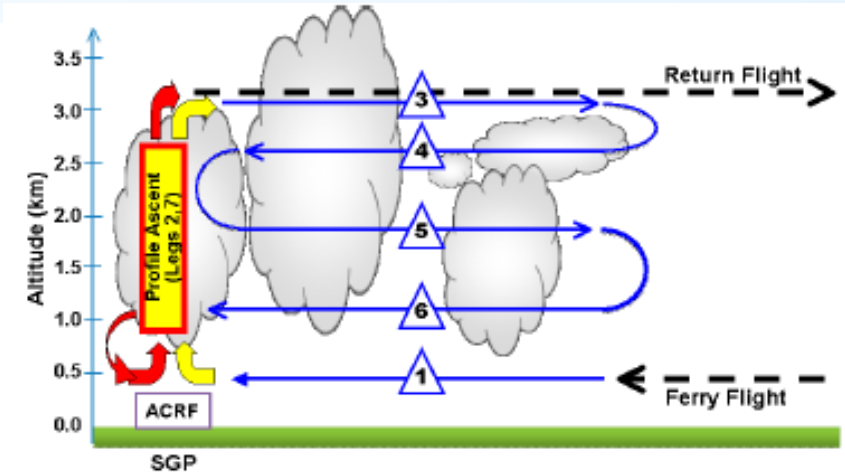


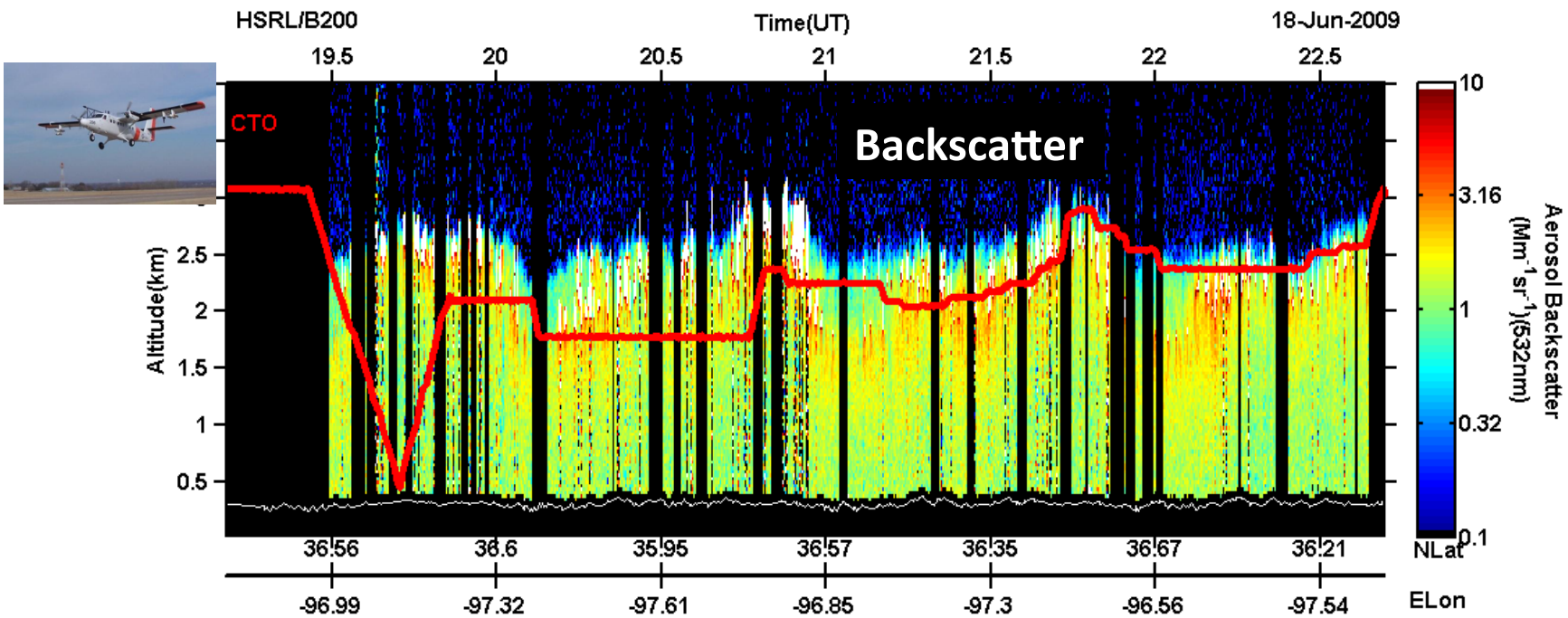


NASA B200
CIRPAS Twin Otter

June 18 - Coordinated B200-Twin Otter Flight

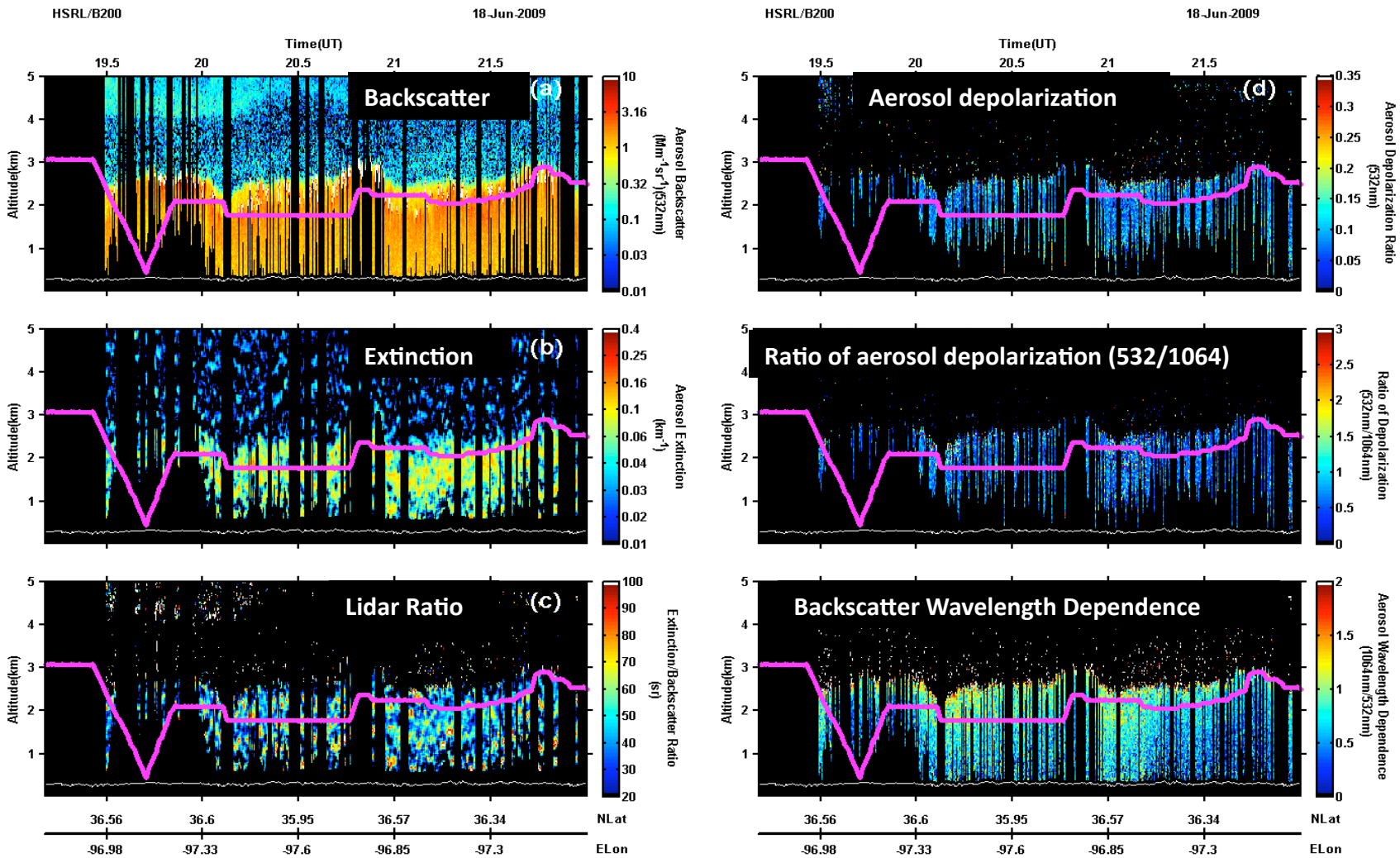
- Cloud locations, heights, thicknesses often varied during the flights
- HSRL profile data can be used to:
  - Identify location of Twin Otter measurements relative to cloud and aerosol locations
  - Provide the vertical context for the Twin Otter in situ measurements





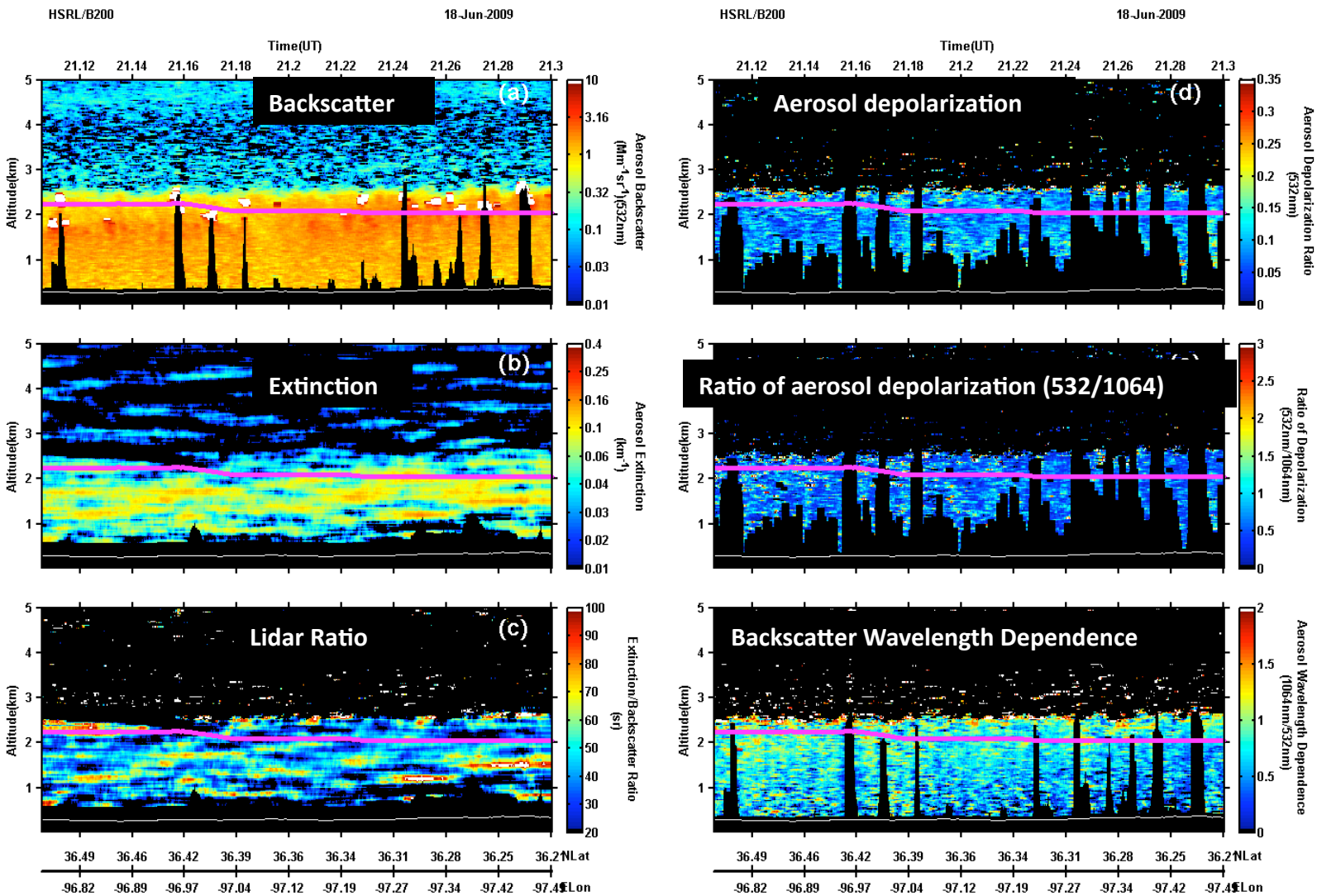
June 18 - Coordinated B200-Twin Otter Flight

- Suite of HSRL measurements over entire flight



June 18 - Coordinated B200-Twin Otter Flight

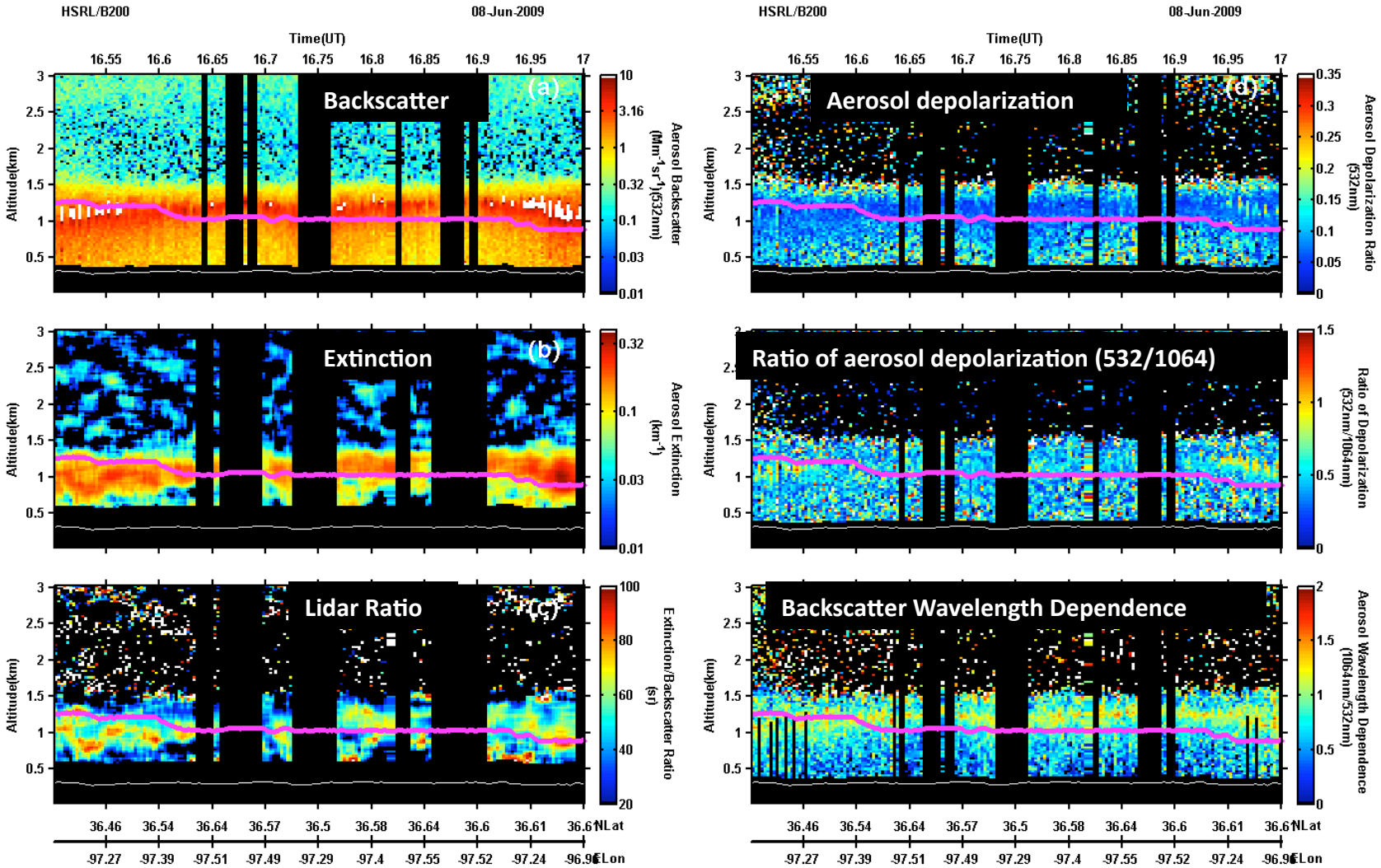
- Suite of HSRL measurements over 12 minute section (21:06-21:18 UT)



June 8

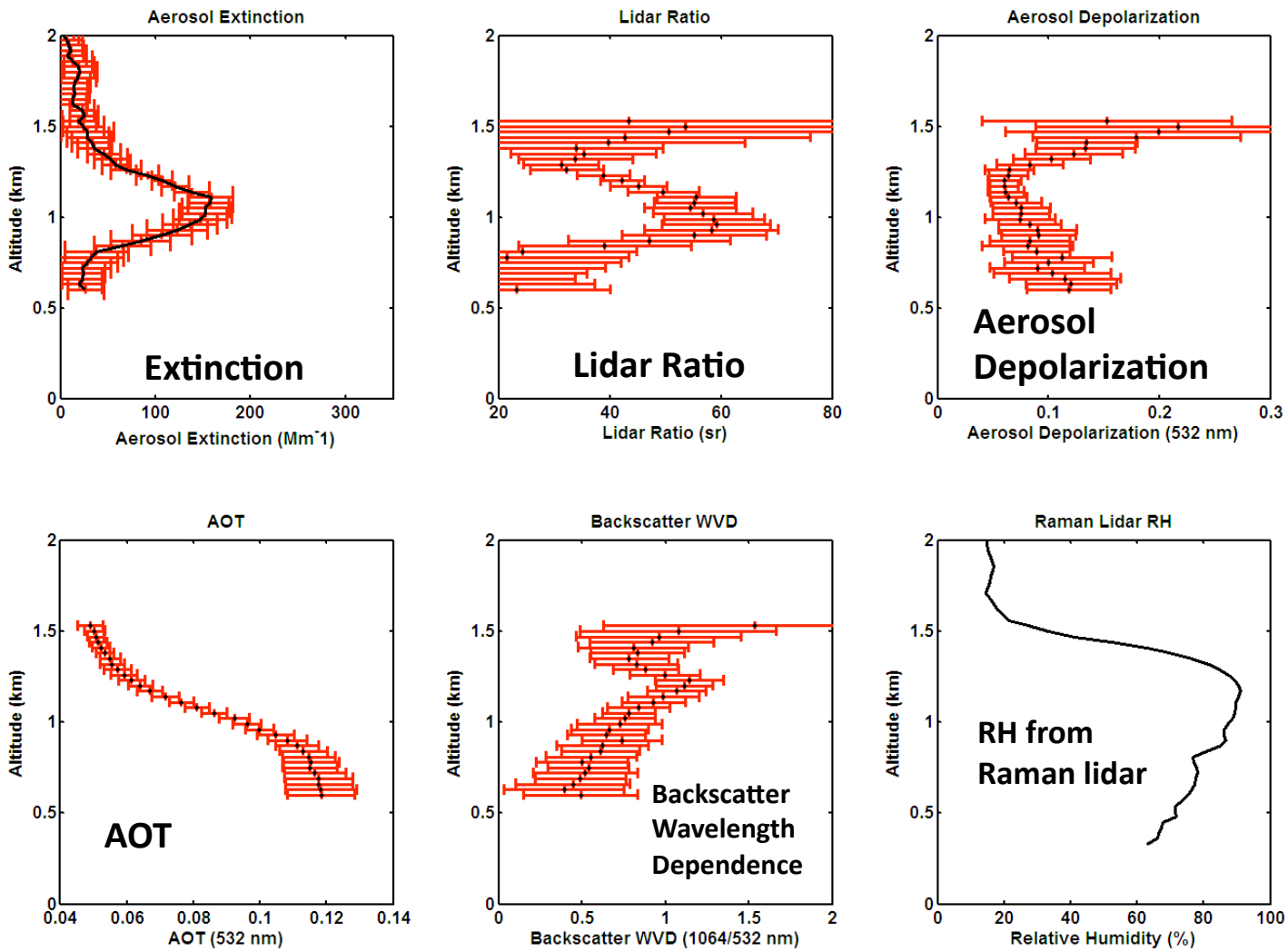
June 8 - Coordinated B200-Twin Otter Flight

- HSRL measurements over 30 minute portion (16:30-17:00 UT)
- Vertical variability of aerosol parameters within PBL due to changes in RH



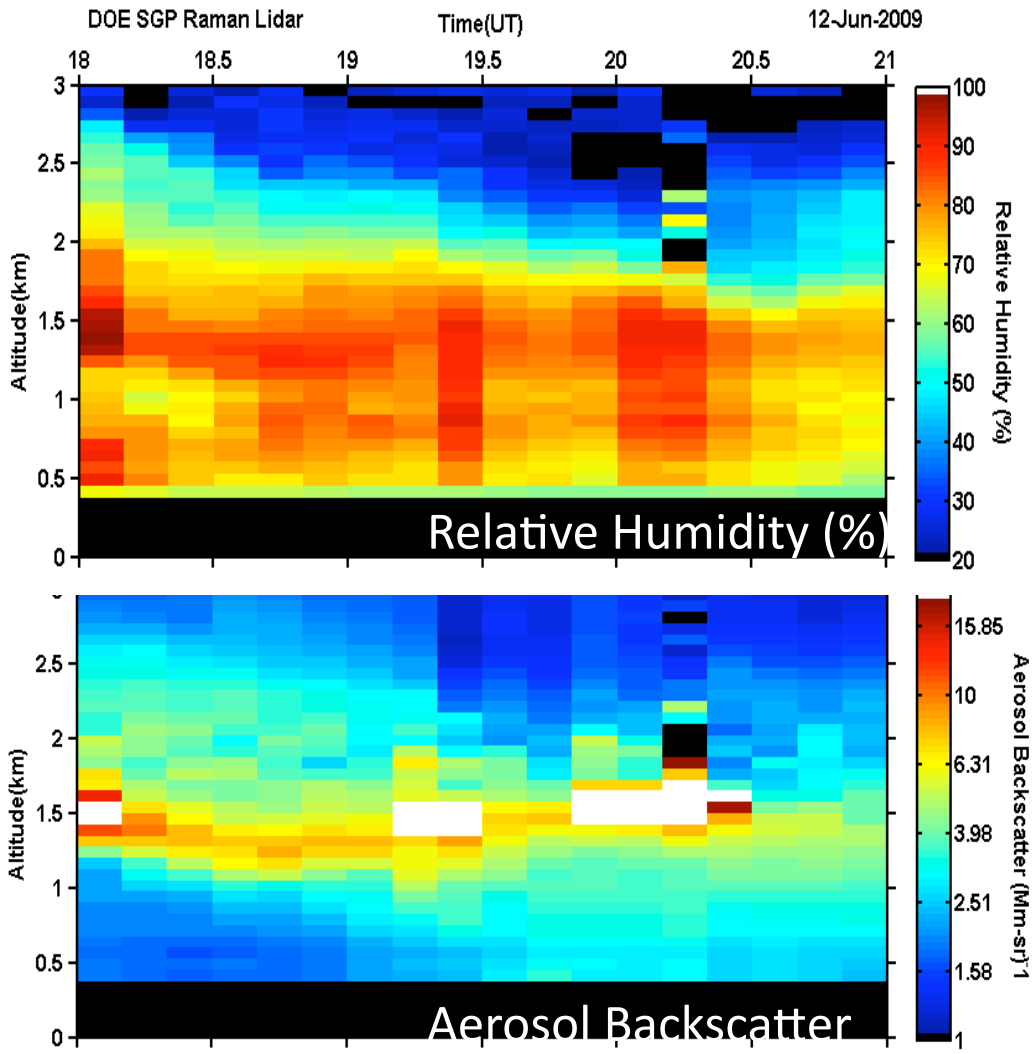
June 8 – Variation of Aerosol Parameters within PBL associated with humidification

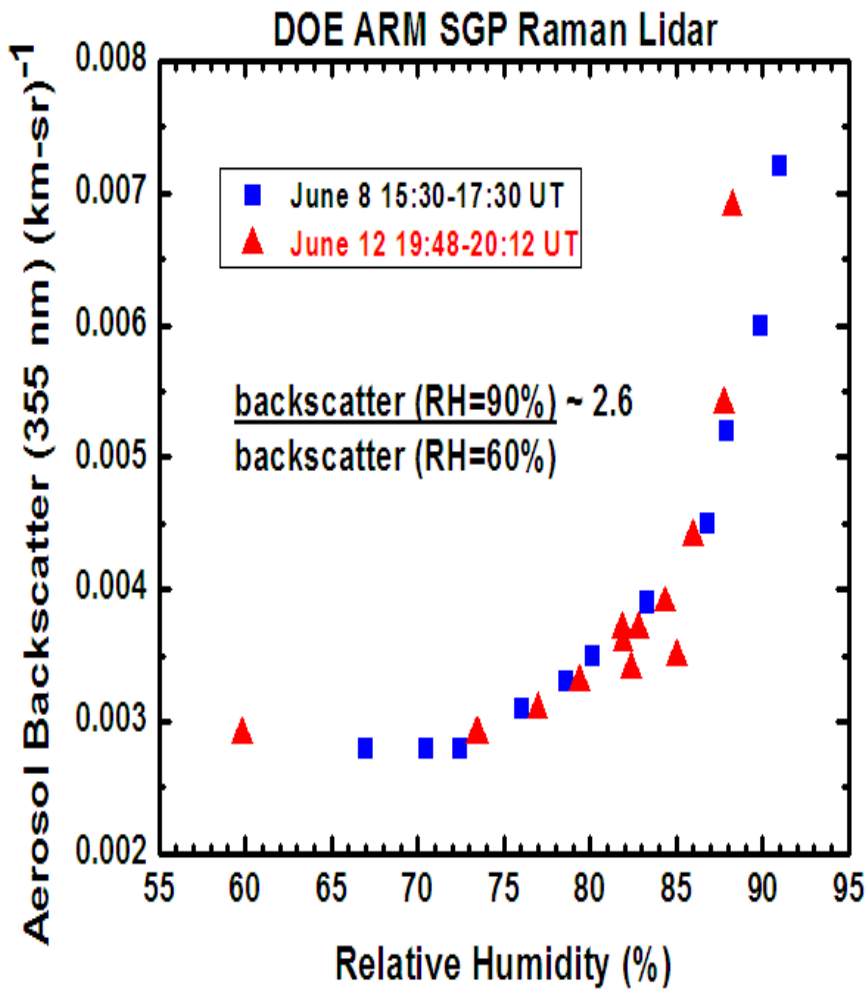
- HSRL profile measurements averaged over 7 minutes (16:36-16:43 UT)
- Vertical variability of aerosol parameters within PBL due to changes in RH



Raman lidar measurements of Aerosol Humidification

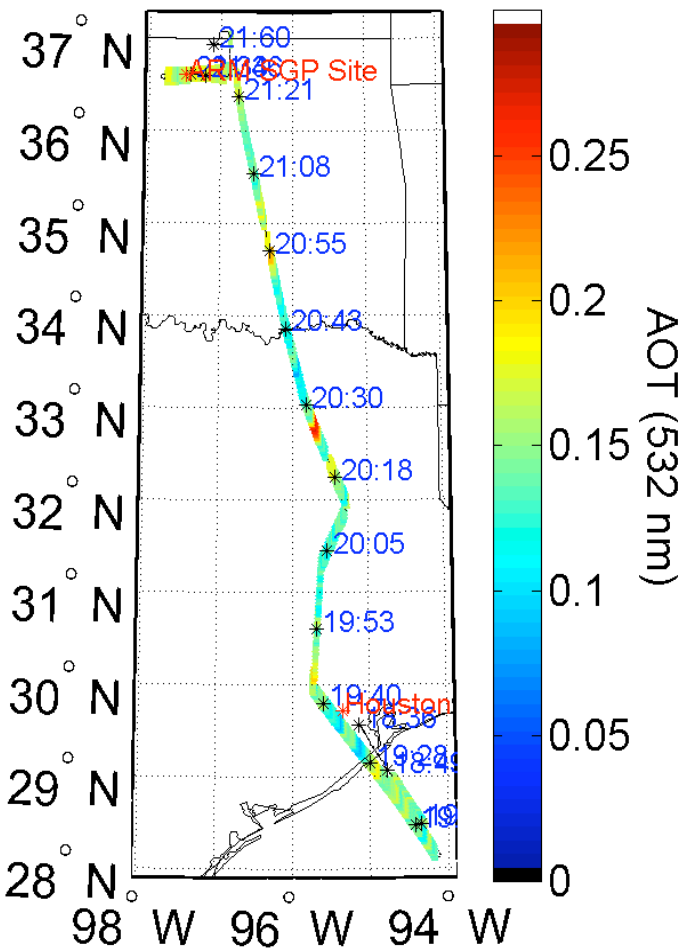
- Aerosol humidification derived from Raman lidar measurements

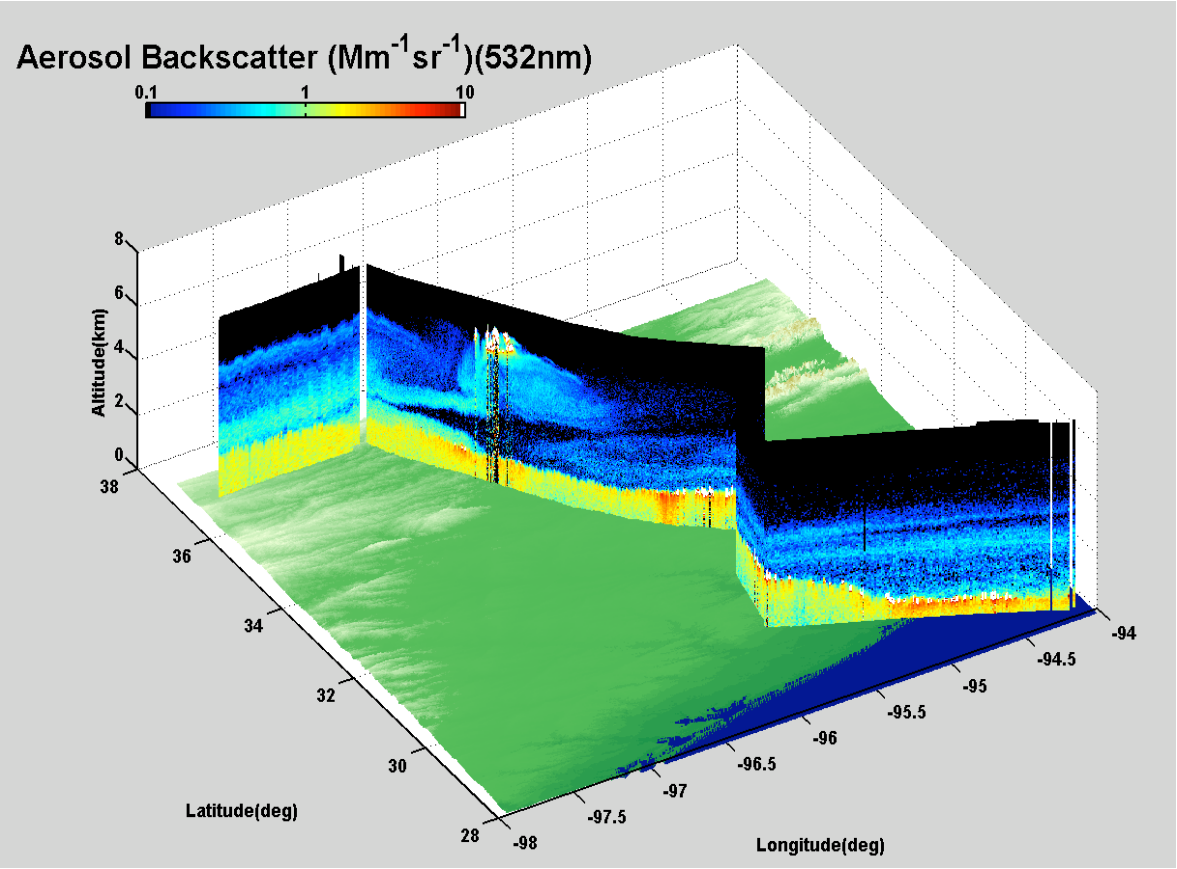




June 17

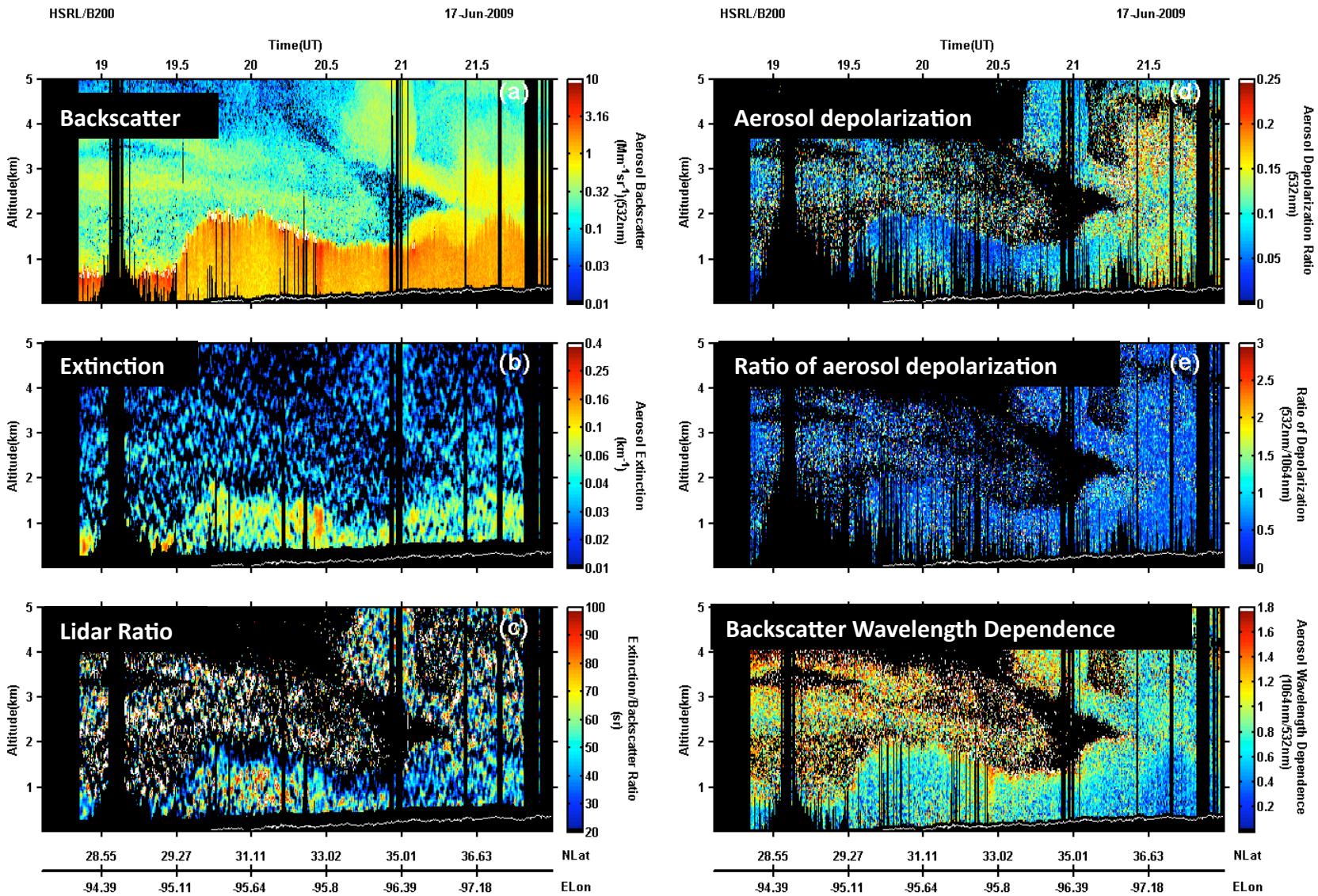
June 17 – CALIPSO – “A Train” Flight





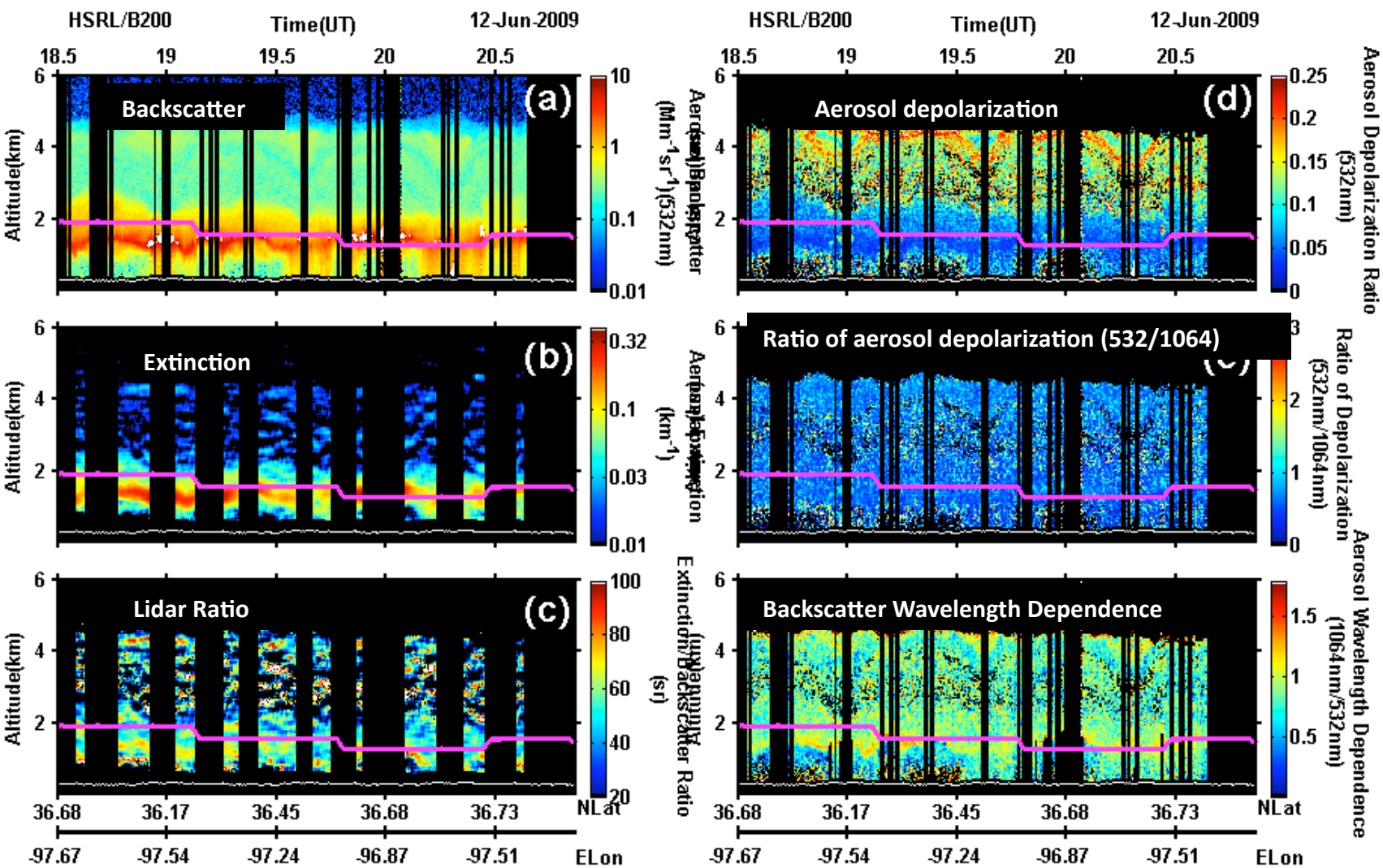
June 17 – CALIPSO – "A Train" Flight

- Note variability of aerosol parameters along flight path

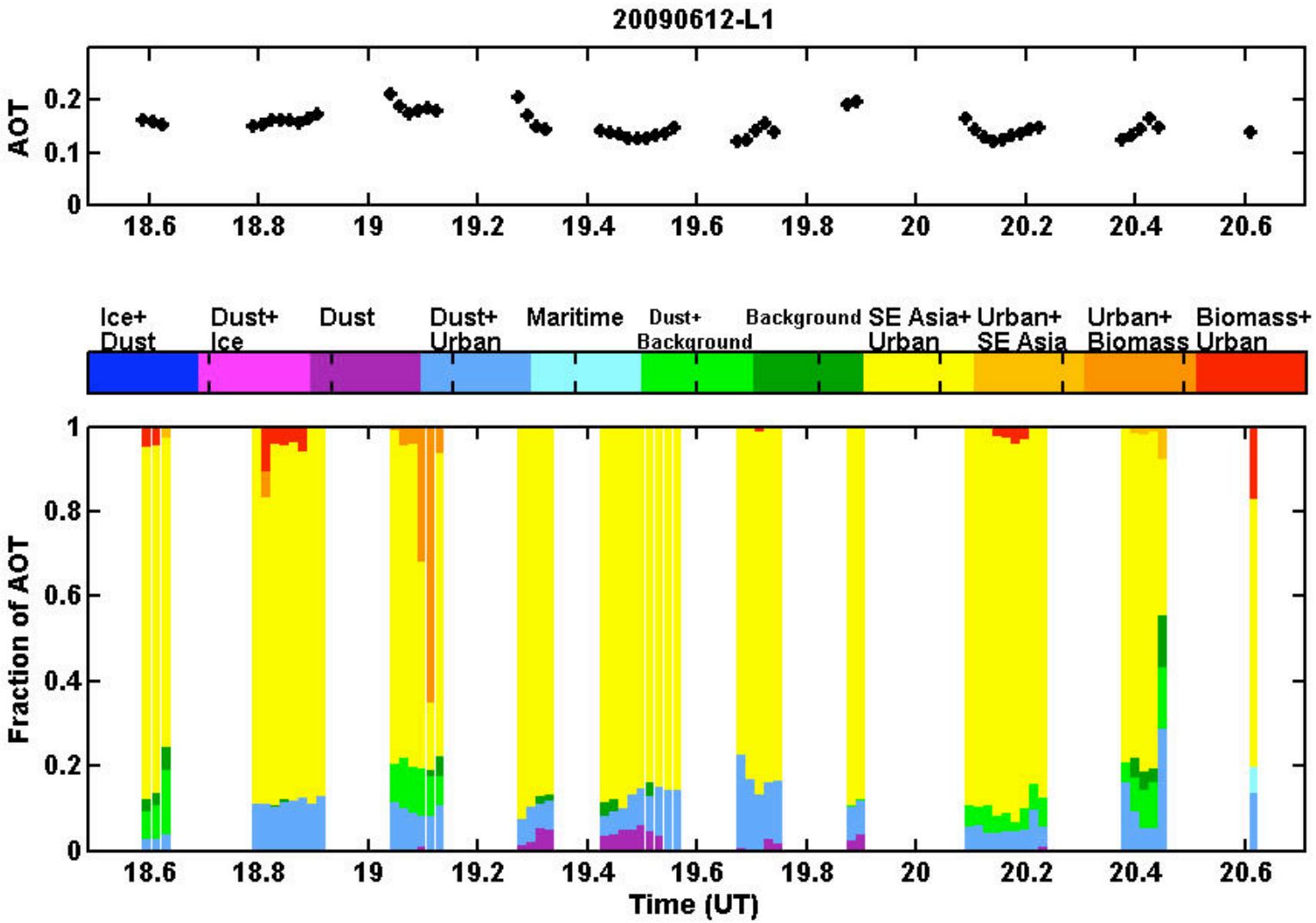


June 12

June 12

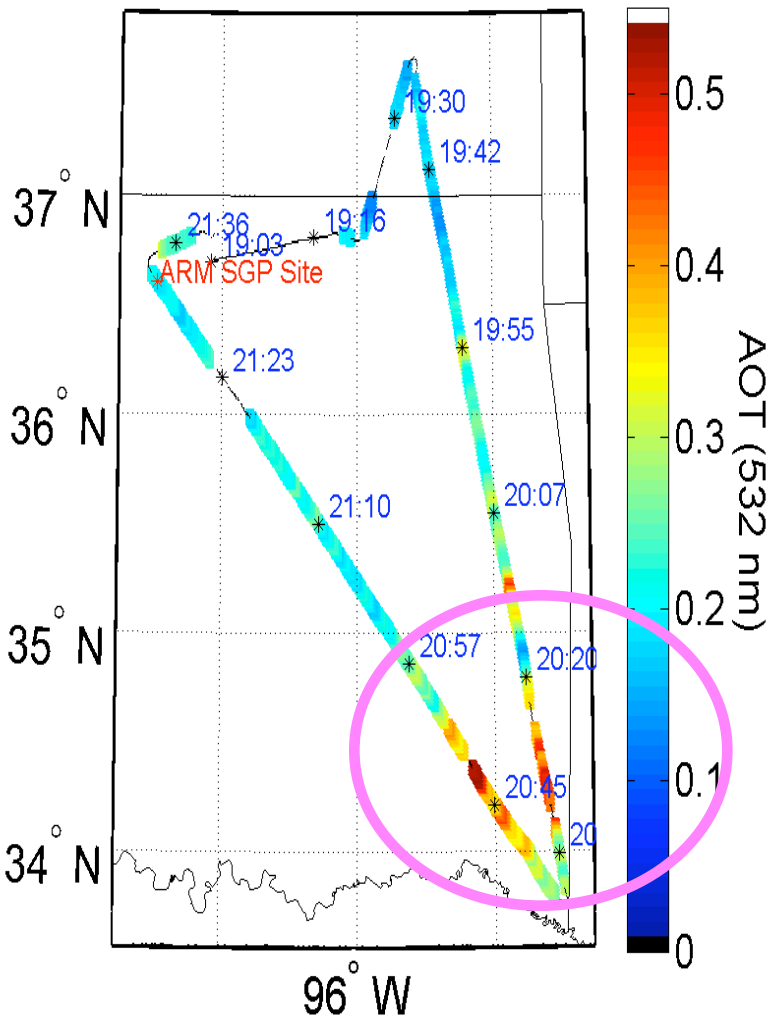

HSRL/B200
Time(UT)
12-Jun-2009
Backscatter
(a)
Aerosol depolarization
(d)
Extinction
(b)
Ratio of aerosol depolarization (532/1064)
Lidar Ratio
(c)
Backscatter Wavelength Dependence
Altitude(km)
Aerosol Depolarization Ratio (532nm)
Ratio of Depolarization (532nm/1064nm)
Aerosol Wavelength Dependence (1064nm/532nm)
NLat
ELon

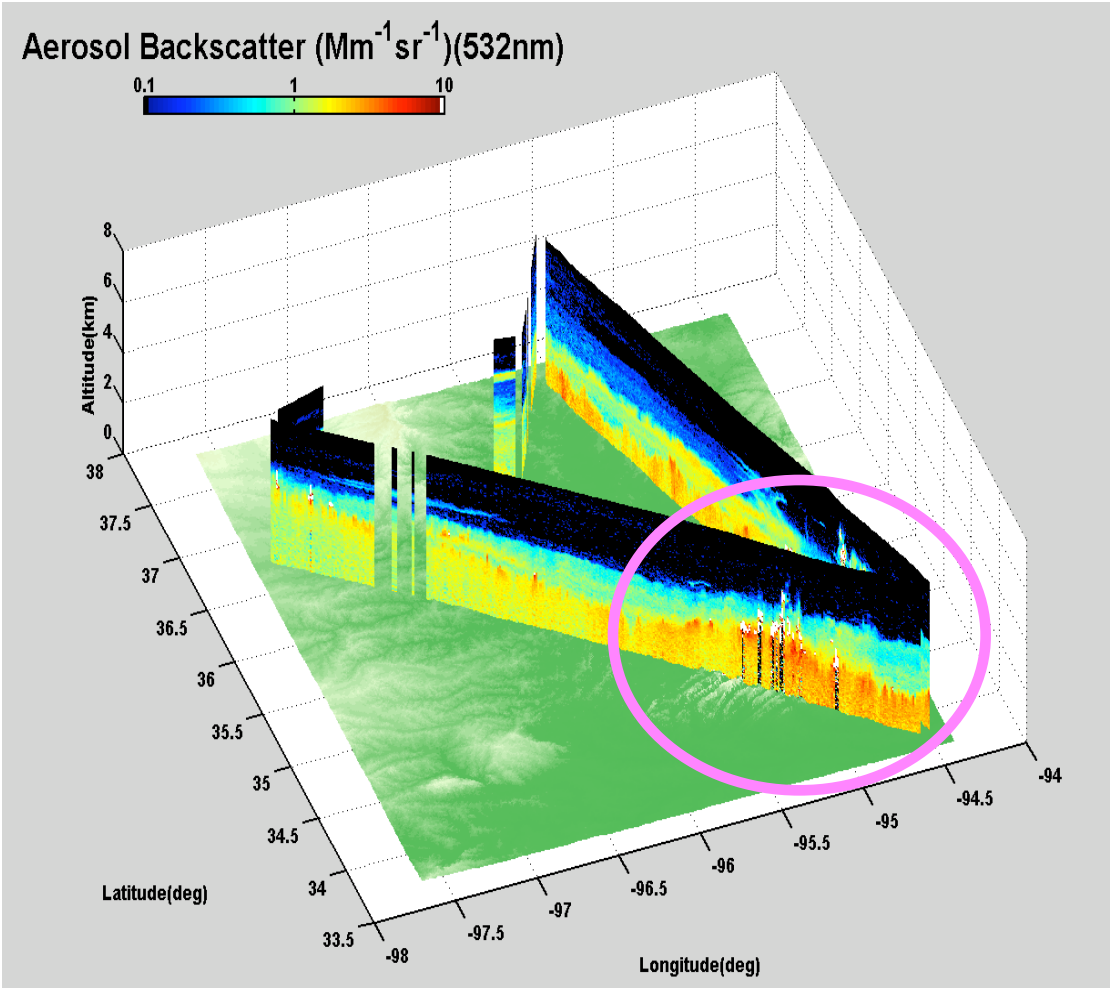
June 12


20090612-L1
AOT
0.2
0.1
0
18.6
18.8
19
19.2
19.4
19.6
19.8
20
20.2
20.4
20.6
Ice+ Dust
Dust+ Ice
Dust
Dust+ Urban
Maritime
Dust+ Background
Background
SE Asia+ Urban
Urban+ SE Asia
Urban+ Biomass
Biomass+ Urban
Fraction of AOT
1
0.8
0.6
0.4
0.2
0
Time (UT)

June 26

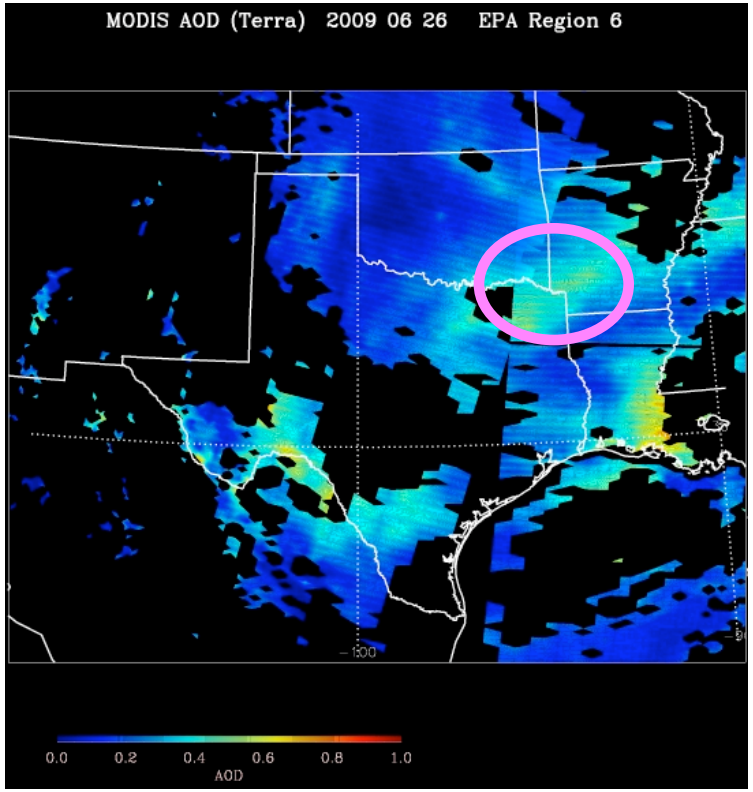
June 26 – Smoke over SE Oklahoma

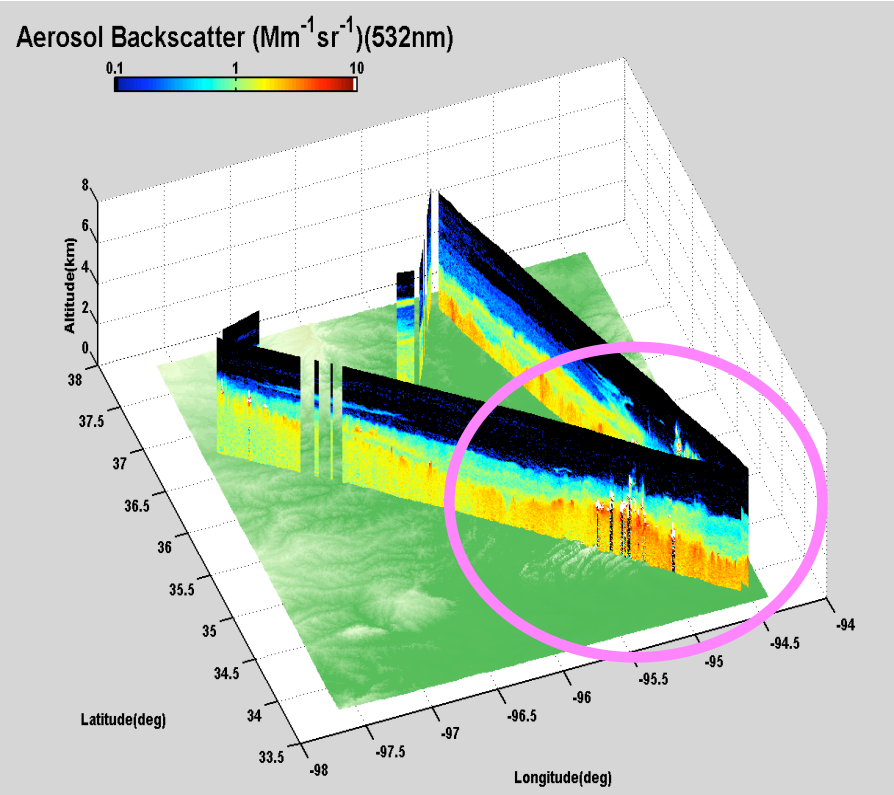




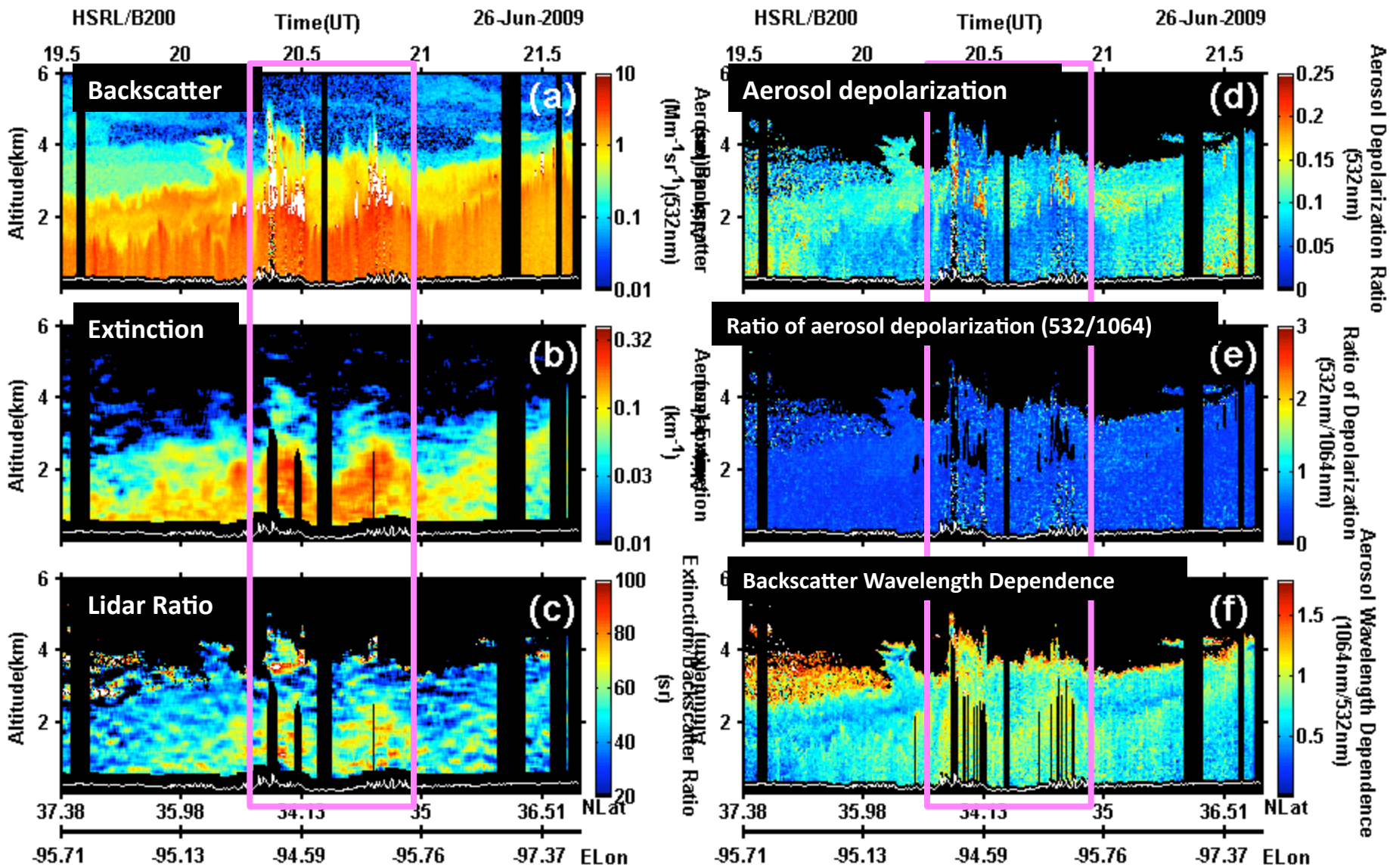
June 26 – Smoke over SE Oklahoma

- AOT from Terra MODIS





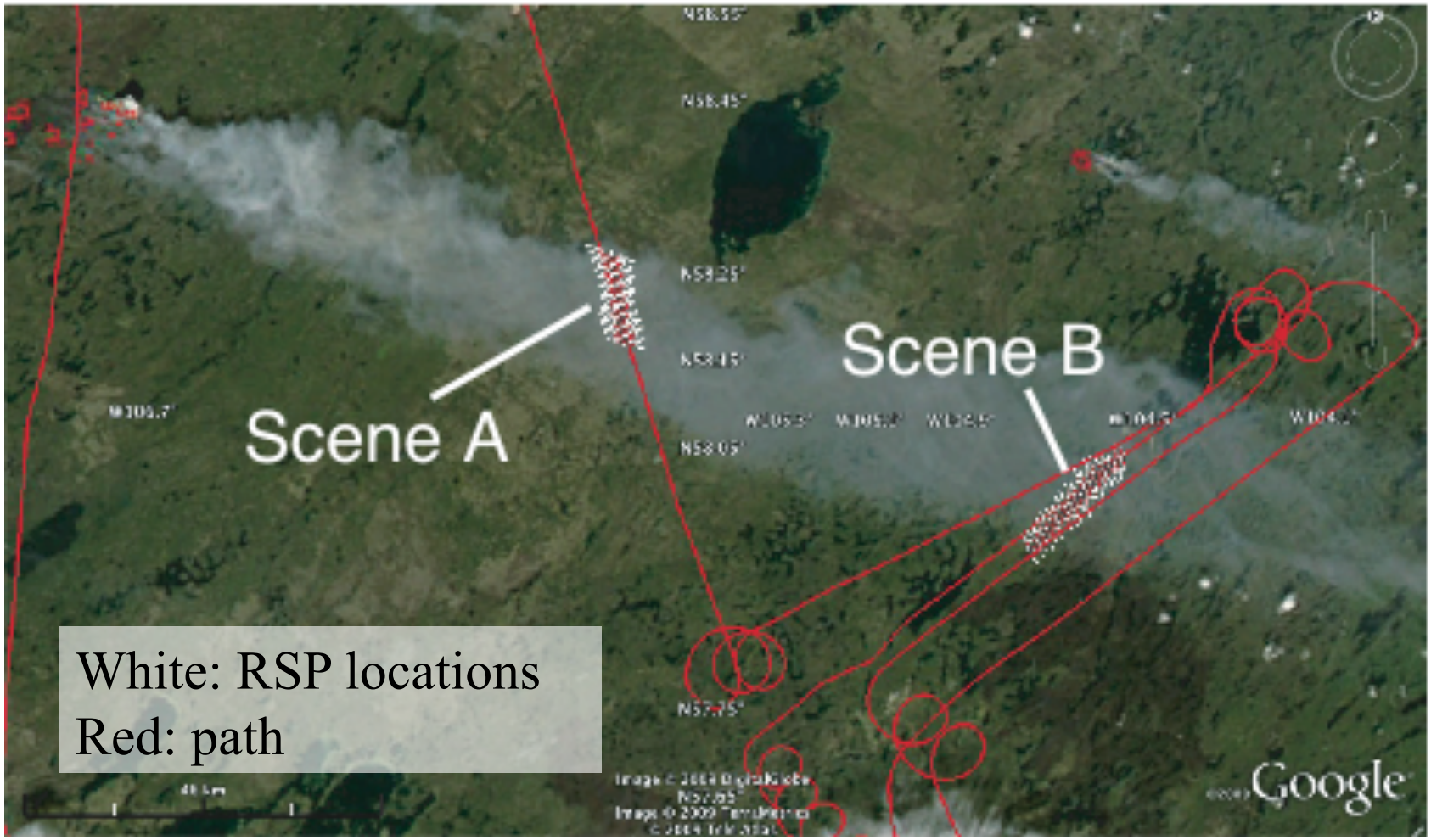
June 26 – Smoke over SE Oklahoma



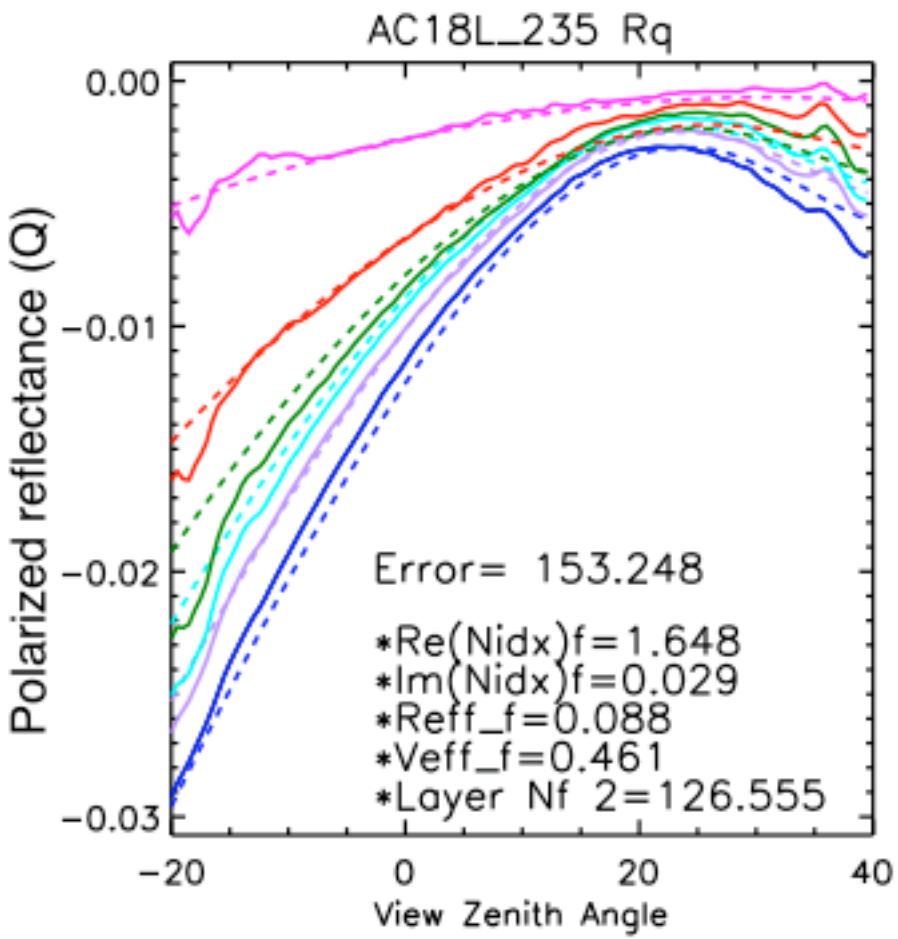
RSP/HSRLAerosol Retrieval Example
June 30, 2008

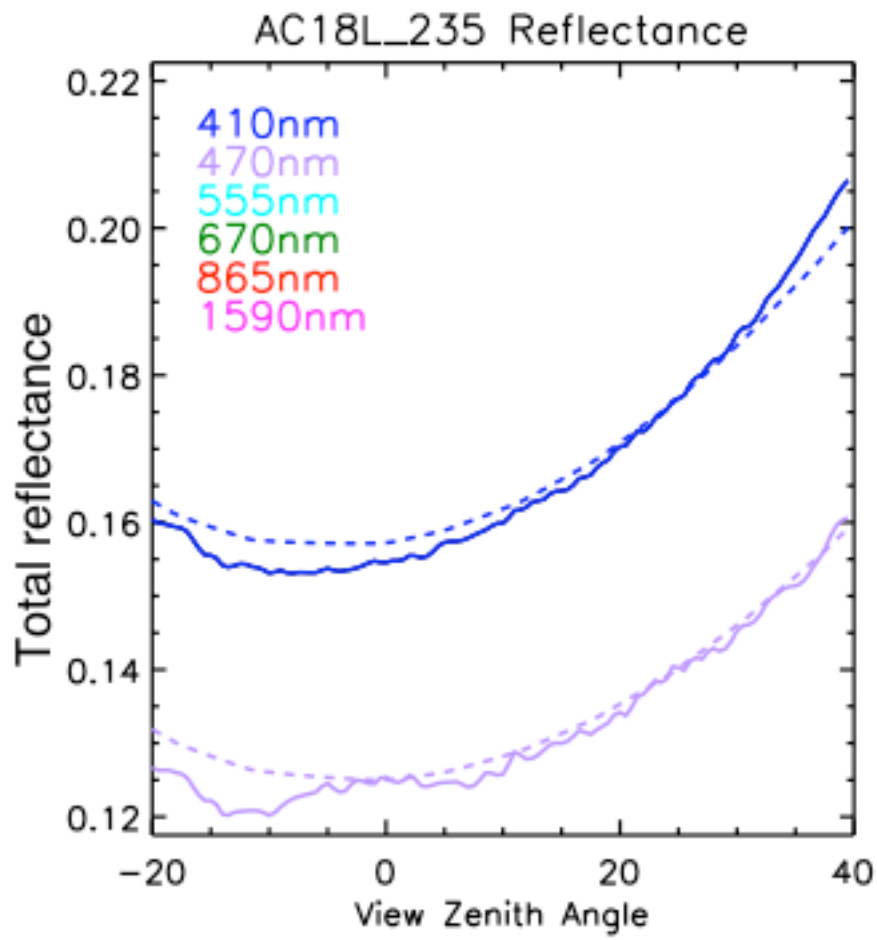
ARCTAS June 30th

- RSP observations of a young smoke plume at two places
- RSP and HSRL on B200 flight coordinated with low altitude in situ observations on the P-3



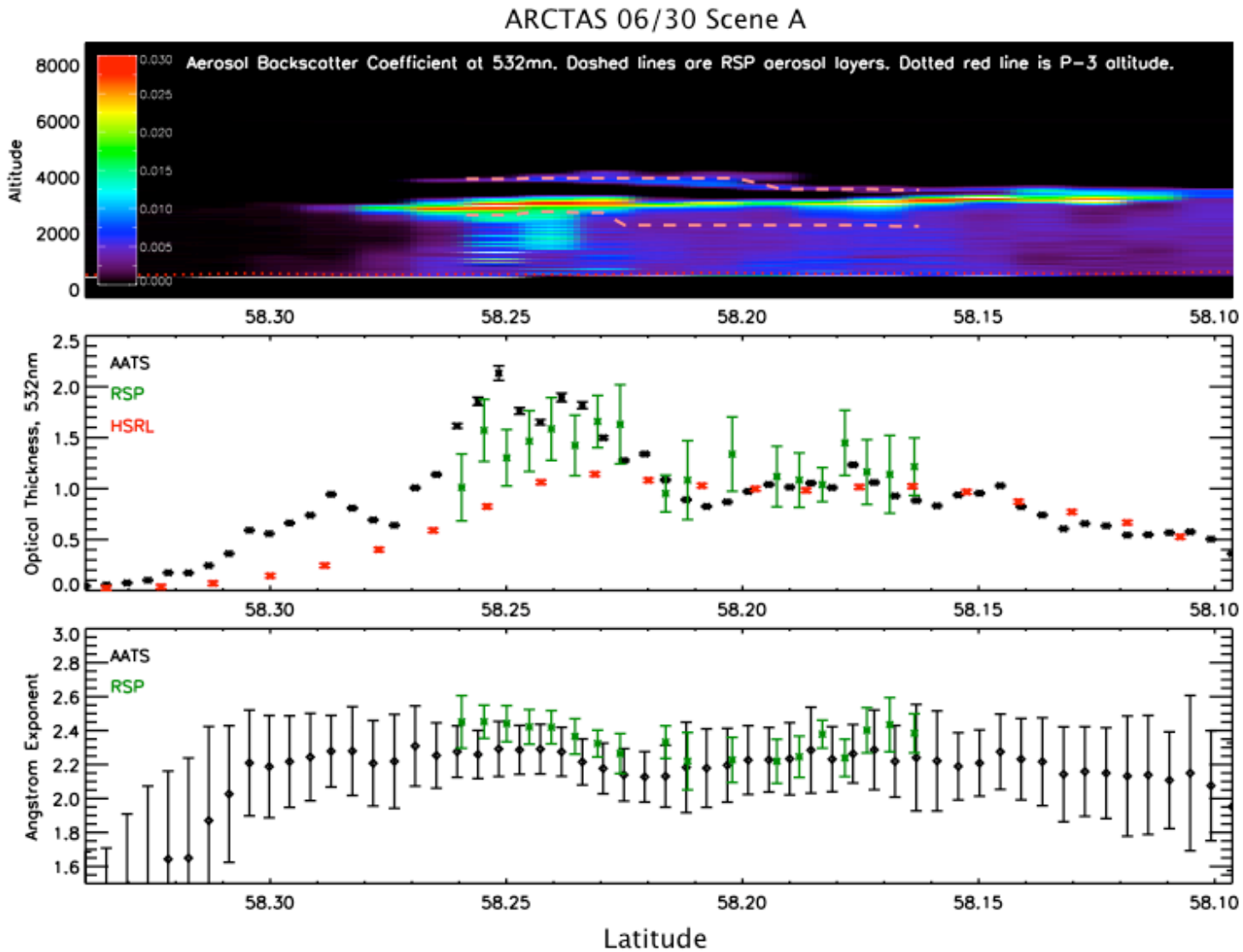
RSP observations matched to radiative transfer model



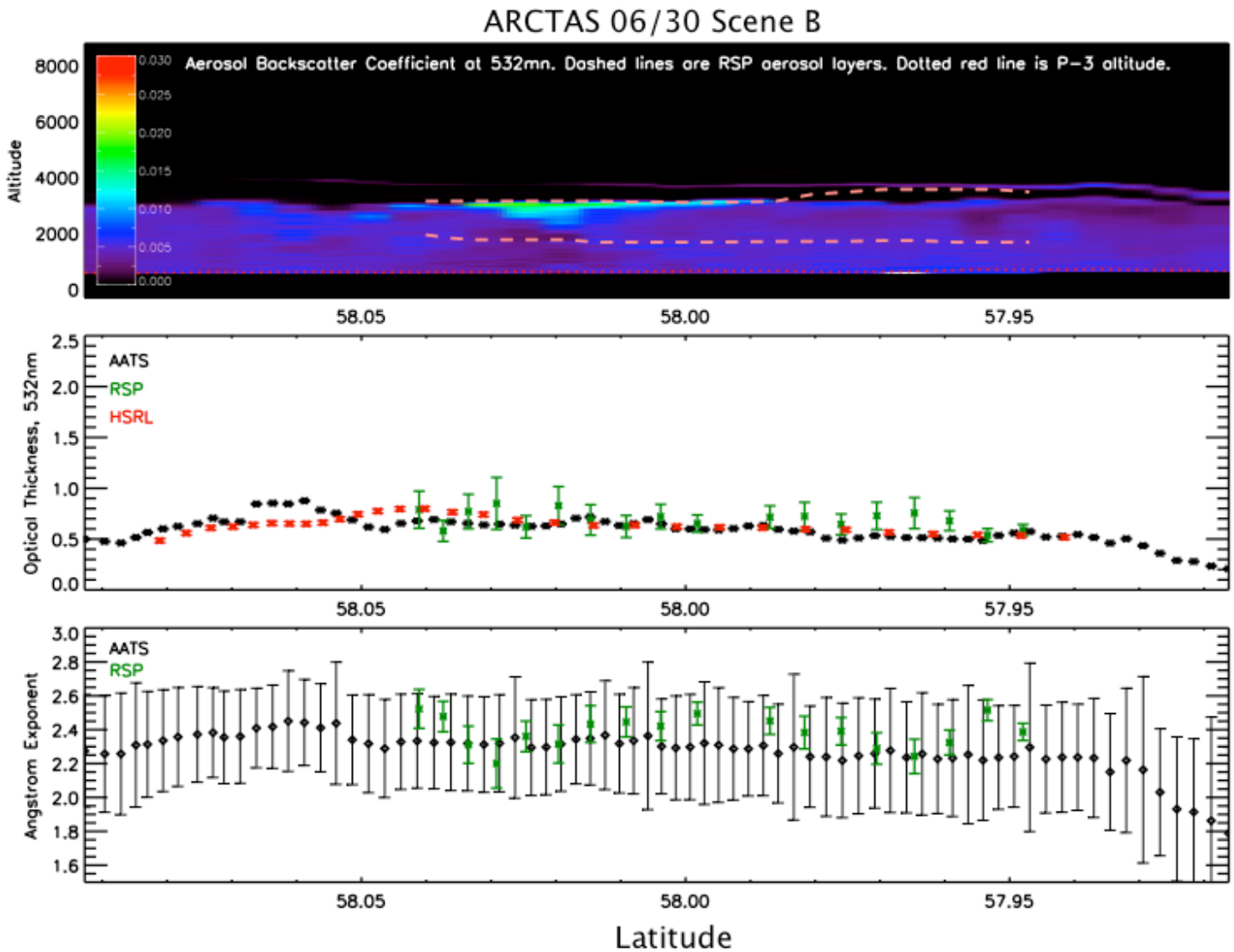


Dotted: model **Solid: observation**

Scene A


ARCTAS 06/30 Scene A
Aerosol Backscatter Coefficient at 532mn. Dashed lines are RSP aerosol layers. Dotted red line is P-3 altitude.
Altitude
8000
6000
4000
2000
0
0.030
0.025
0.020
0.015
0.010
0.005
0.000
58.30
58.25
58.20
58.15
58.10
Optical Thickness, 532nm
AATS
RSP
HSRL
2.5
2.0
1.5
1.0
0.5
0.0
Angstrom Exponent
AATS
RSP
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
Latitude

Scene B

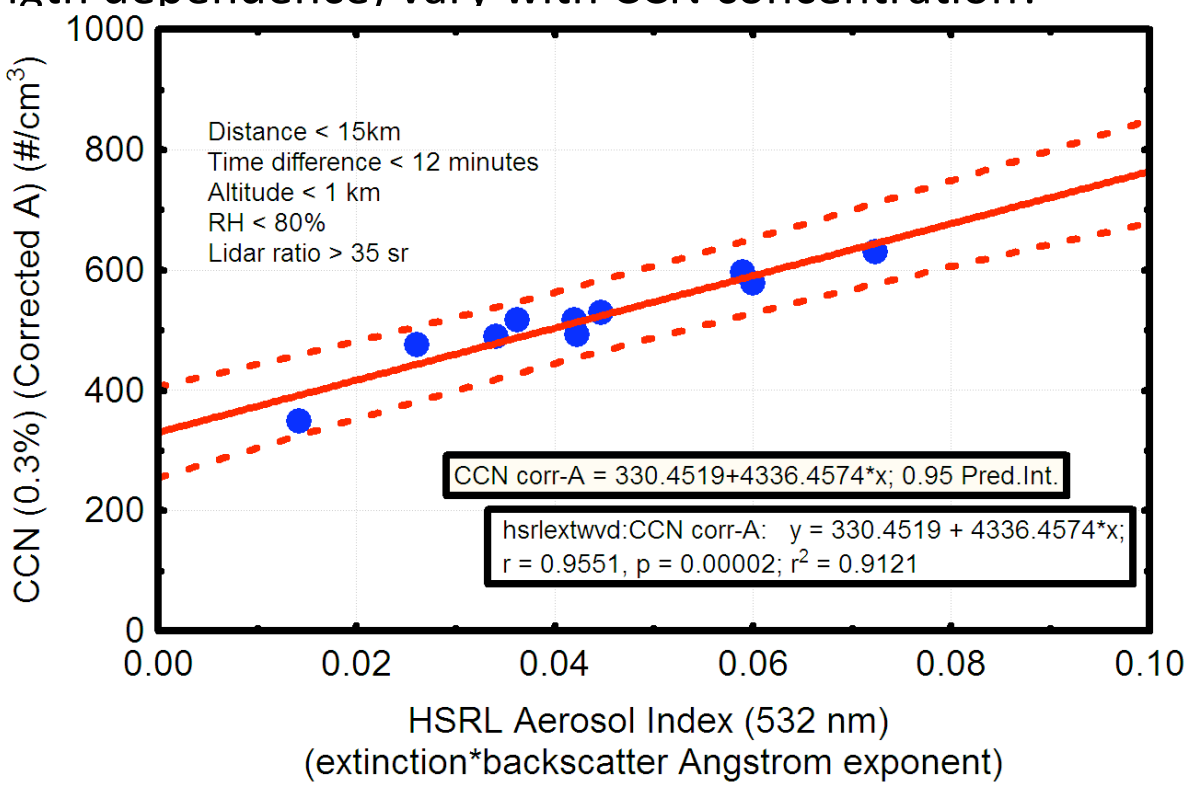

ARCTAS 06/30 Scene B
Aerosol Backscatter Coefficient at 532nm. Dashed lines are RSP aerosol layers. Dotted red line is P-3 altitude.
Altitude
8000
6000
4000
2000
0
0.030
0.025
0.020
0.015
0.010
0.005
0.000
58.05
58.00
57.95
Optical Thickness, 532nm
2.5
2.0
1.5
1.0
0.5
0.0
AATS
RSP
HSRL
Angstrom Exponent
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
Latitude

HSRL Data and Image Availability

- Quicklook images of HSRL data are available from RACORO wiki http://wiki.arm.gov/bin/viewauth/AAF/
- Preliminary HSRL images and data are available via ftp; contact us for username, password
- A link to this ftp site will be added to the RACORO directory in the DOE IOP data archive
- RSP data will be available from the GISS ftp server by the time you read this? Information will be provided to Andy Vogelmann for distribution to those interested.

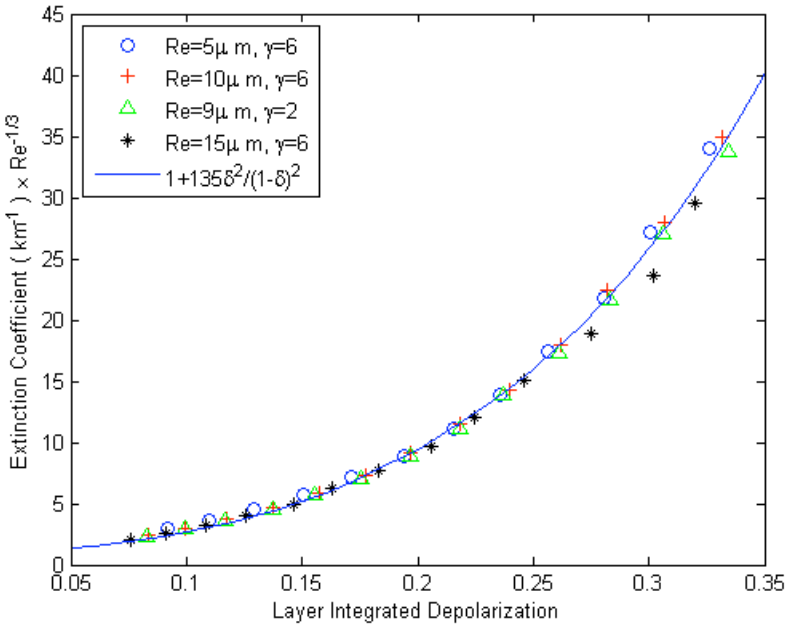
Twin Otter Data Sets of Particular Interest

- Aerosol size distribution (TDMA, PCASP) measurements
  - How does aerosol size distribution vary in relation to:
    - distance from clouds?
    - changes in RH?
- CCN Measurements
  - How do aerosol parameters measured by HSRL (extinction * backscatter wavelength dependence) vary with CCN concentration?



Twin Otter Data Sets of Particular Interest

- Cloud particle size, COD (FSSP, Gerber probe, hot wire) measurements
  - For these heterogeneous clouds fields how good are the polarimetric size distribution estimates?
  - Are the optical depth estimates useful?
- Cloud extinction (CIN, FSSP) measurements
  - Is the theoretical relationship between lidar depolarization and extinction robust?



- If the particle sizing and extinction estimates are robust for CLOWD then lidar +polarimetry will allow N_c to be accurately estimated from space.

References

- Hair, J. W., C. A. Hostetler, A. L. Cook, D. B. Harper, R. A. Ferrare, T. L. Mack, W. Welch, L. R., Izquierdo, F. E. Hovis, Airborne High Spectral Resolution Lidar for Profiling Aerosol Optical Properties, *Applied Optics*, 47,doi: 10.1364/AO. 47.006734, 2008.
- Rogers, R.R., J. W. Hair, C. A. Hostetler, R. A. Ferrare, M. D. Obland, A. L. Cook, D. B. Harper, S. P. Burton, Y. Shinozuka, C. S. McNaughton, A. D. Clarke, J. Redemann, P. B. Russell, J. M. Livingston, and L. I. Kleinman, NASA LaRC airborne high spectral resolution lidar aerosol measurements during MILAGRO: observations and validation, Atmos. Chem. Phys., 9, 4811-4826, 2009