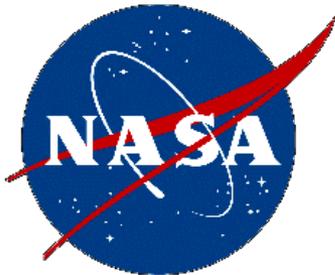


Overview of NASA B-200 King Air ARCTAS/ISDAC Operations and Science

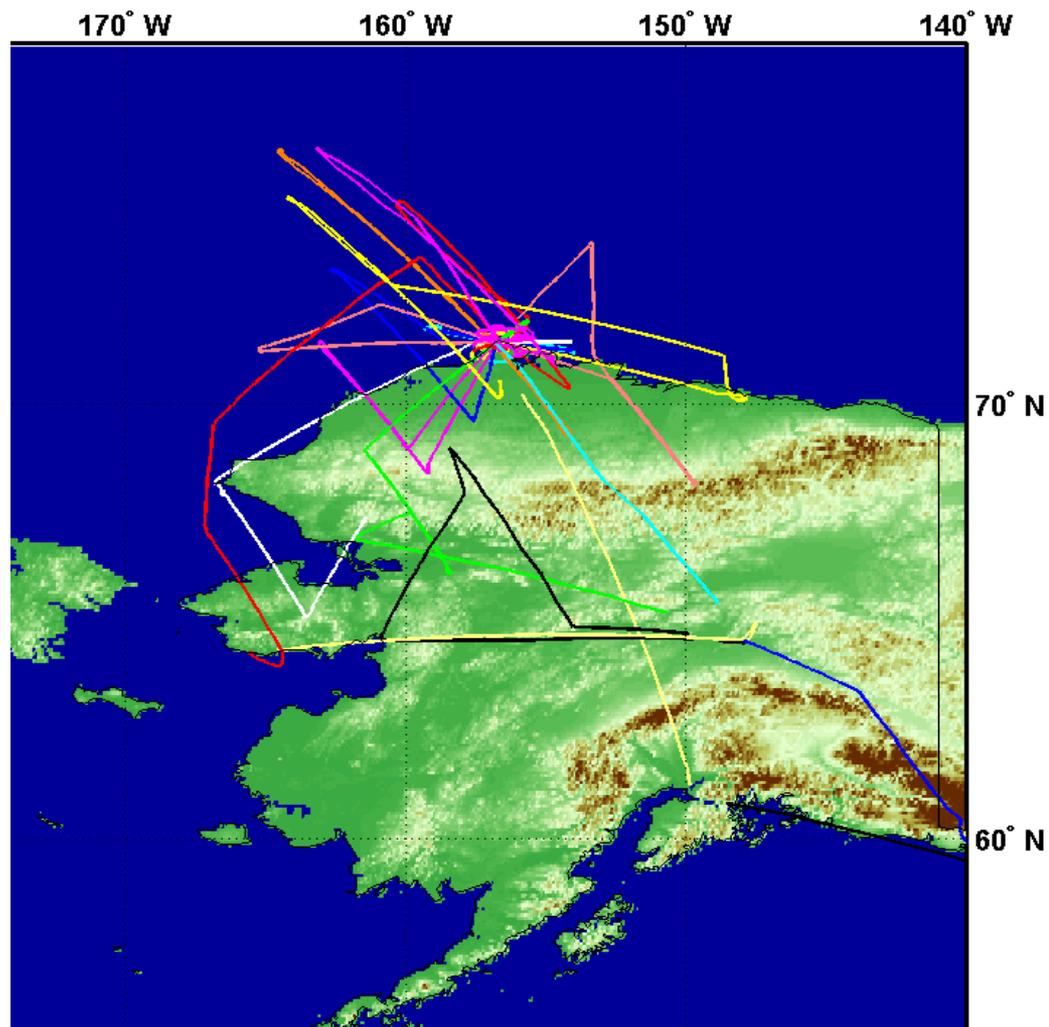


Richard Ferrare, Chris Hostetler, John Hair, Anthony Cook,
David Harper, Mike Obland, Ray Rogers, Sharon Burton,
Matt Shupe, Dave Turner, Connor Flynn



High Spectral Resolution Lidar (HSRL)

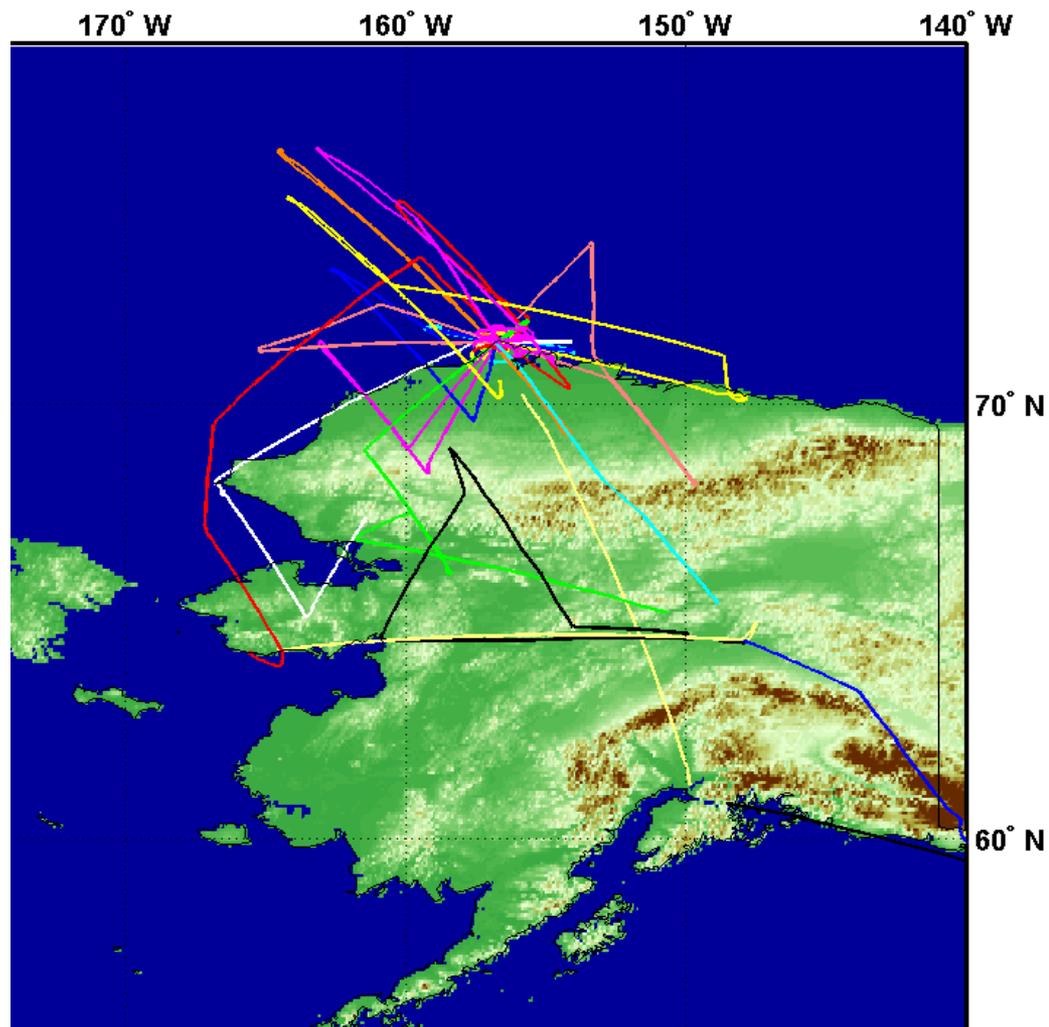
- Independently measures aerosol/cloud extinction and backscatter profiles at 532 nm
- Includes
 - Backscatter channels at 1064 nm
 - Polarization sensitivity at 532 and 1064 nm
- Profile Measurement capabilities
 - Extensive measurements
 - Backscatter at 532 and 1064 nm
 - Extinction at 532 nm
 - Intensive 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



B200/HSRL Deployment During ARCTAS (Spring)



- B200 based in Barrow, Alaska
- 18 flights in Alaska
- 96 hours total, 59 hours science
- 5 flights coordinated with NASA DC-8
- 3 flights coordinated with NASA P-3
- 3 flights coordinated with NOAA P-3
- 5 flights over 4 days coordinated with DOE (Canada) Convair 580
 - April 4, 8, 13, 19
- 12 flights included underpass of CALIPSO and A Train
- Several flights included underpass of Terra MODIS/MISR
- 10 flights included overpass near or over DOE ARM North Slope of Alaska (NSA) Climate Research Facility
 - April 3, 4, 6, 8, 9, 12, 13, 16, 19





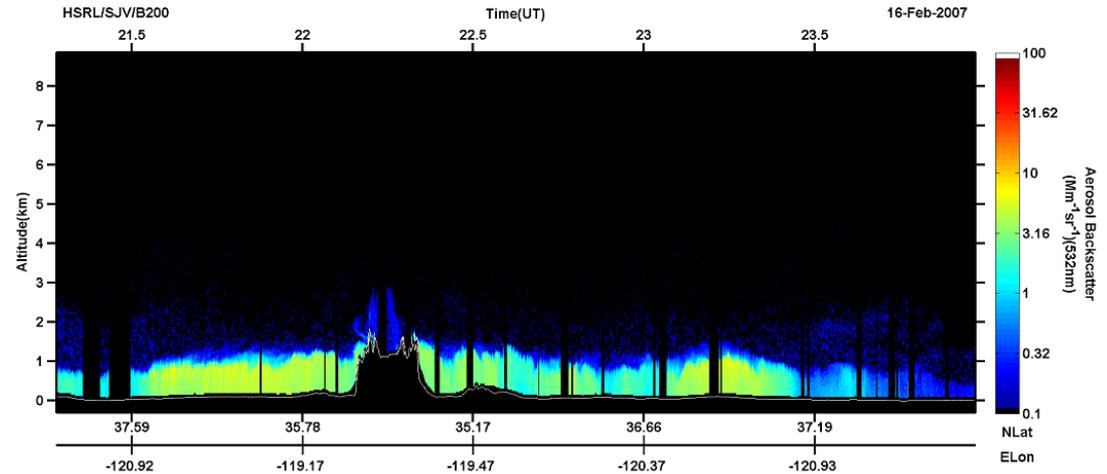
Approximately 40-50% of aerosol optical thickness was in elevated layers more than 2 km above the surface, which is much higher than found during previous HSRL missions

Vertical Distribution of Aerosols

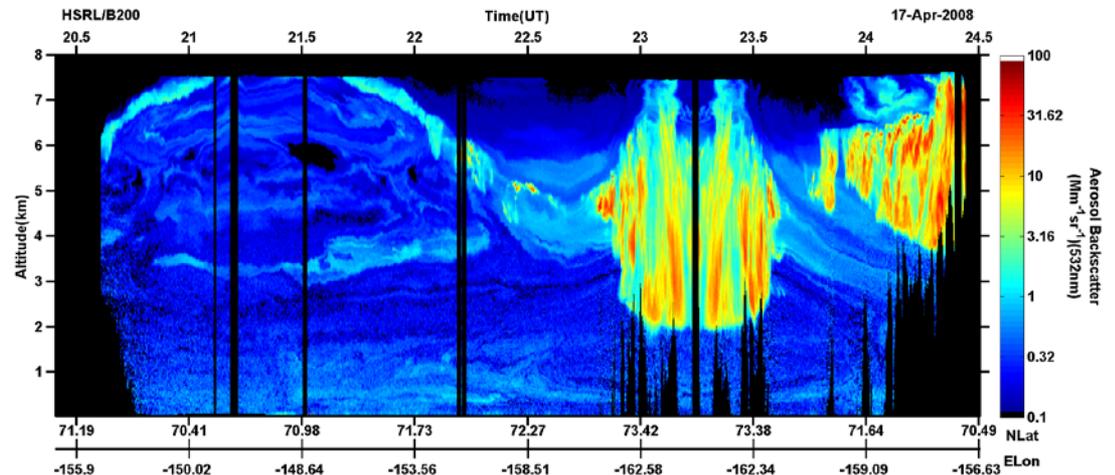


During ARCTAS aerosols were distributed throughout entire troposphere and not primarily located in the lowest 1-2 km, in contrast to previous HSRL missions at lower latitudes

San Joaquin Valley, California, Feb. 16, 2007



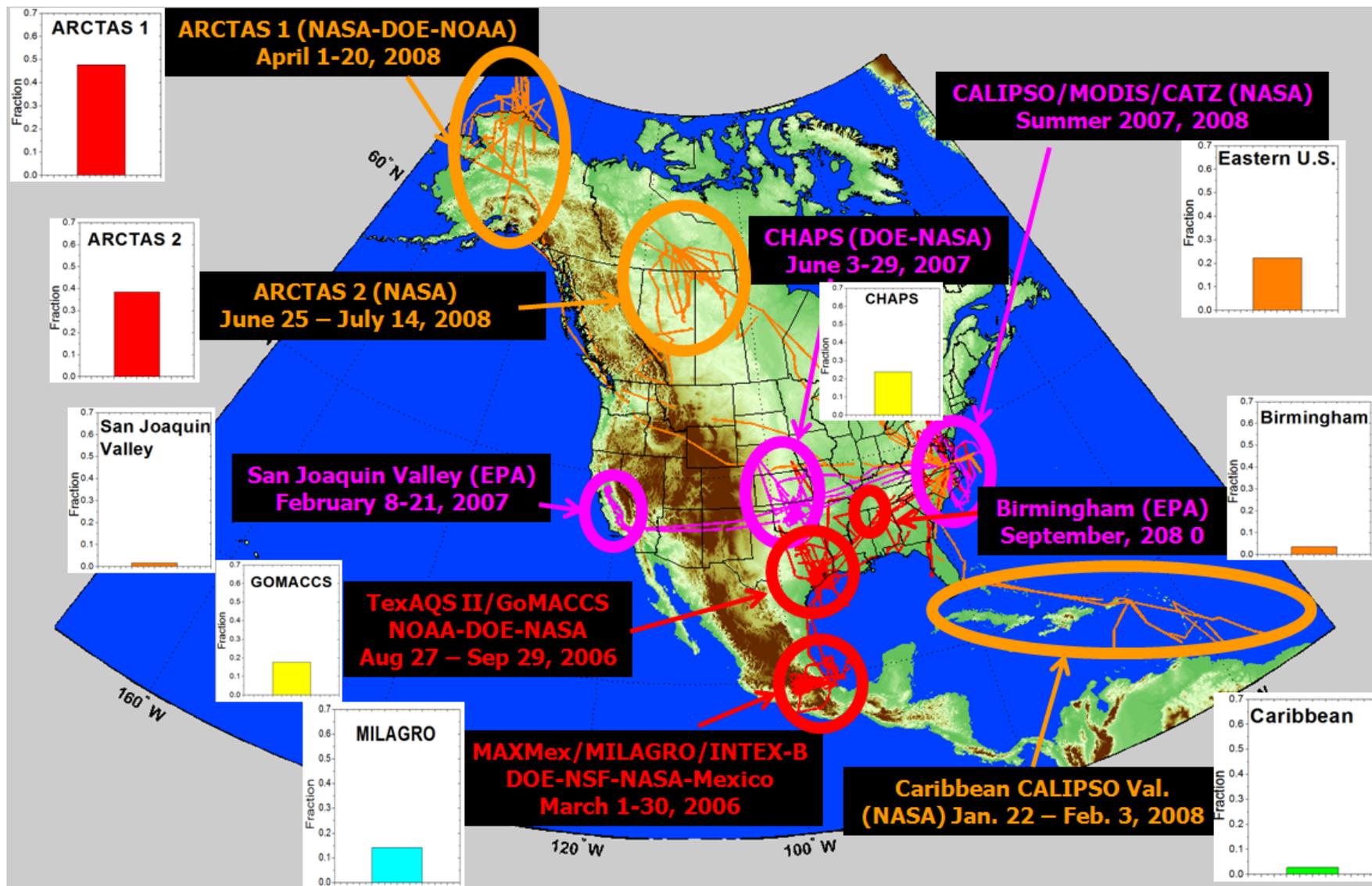
Barrow, Alaska, Apr. 17, 2008





Fraction of Aerosol Optical Thickness Above 2 km

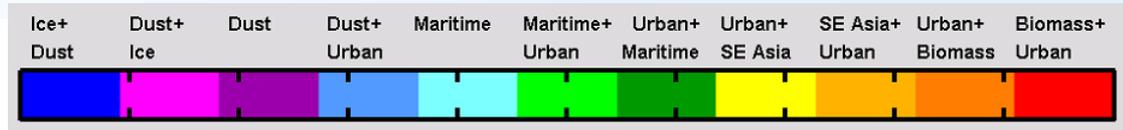
- ARCTAS 1 and 2 had much higher fractions (40-50%) of AOT above 2 km than other locations (1-20%)





Most of the aerosol optical thickness was contributed by aerosols inferred to be biomass burning aerosols

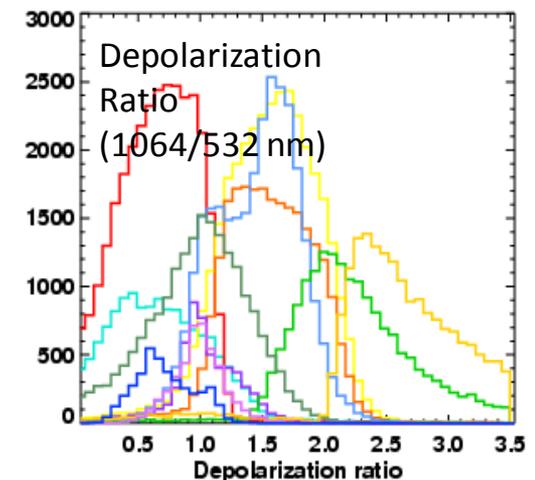
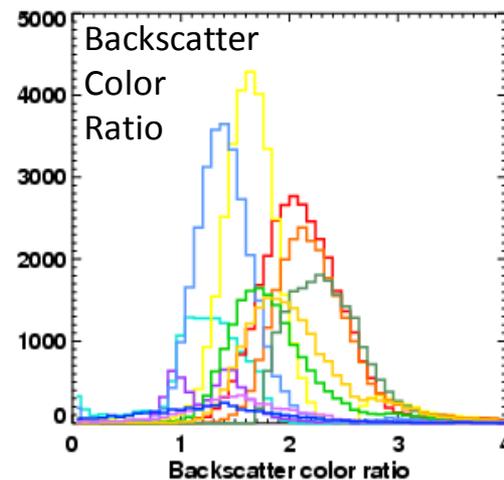
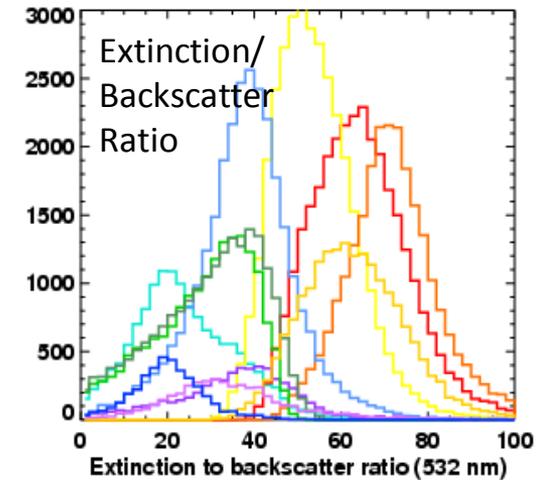
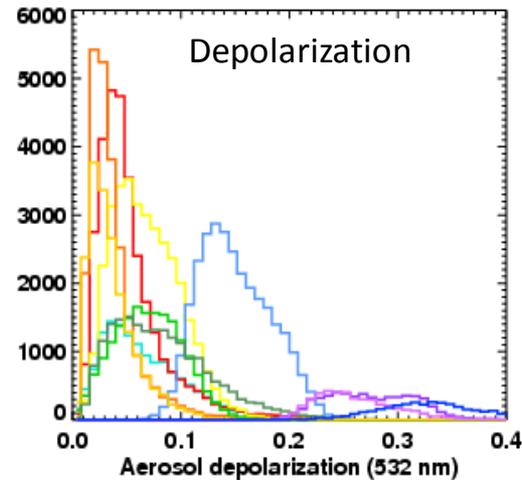
Aerosol Classification using HSRL measurements



Aerosol classification is based on HSRL measurements of aerosol intensive parameters

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

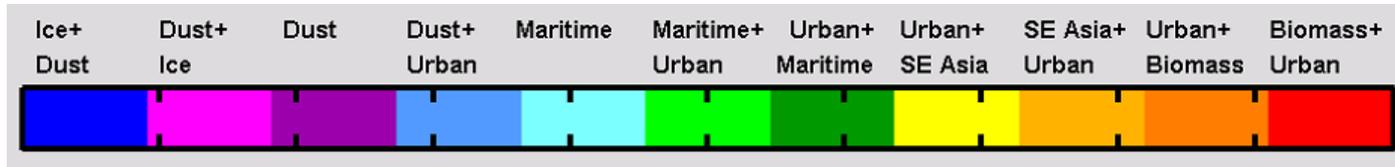
The HSRL measurements of aerosol intensive parameters were used in an objective cluster analysis scheme to discriminate aerosol type. These aerosol types were subjectively related to the aerosol types inferred from AERONET data by Catrall et al. (2005).



Apportionment of Aerosol Optical Thickness

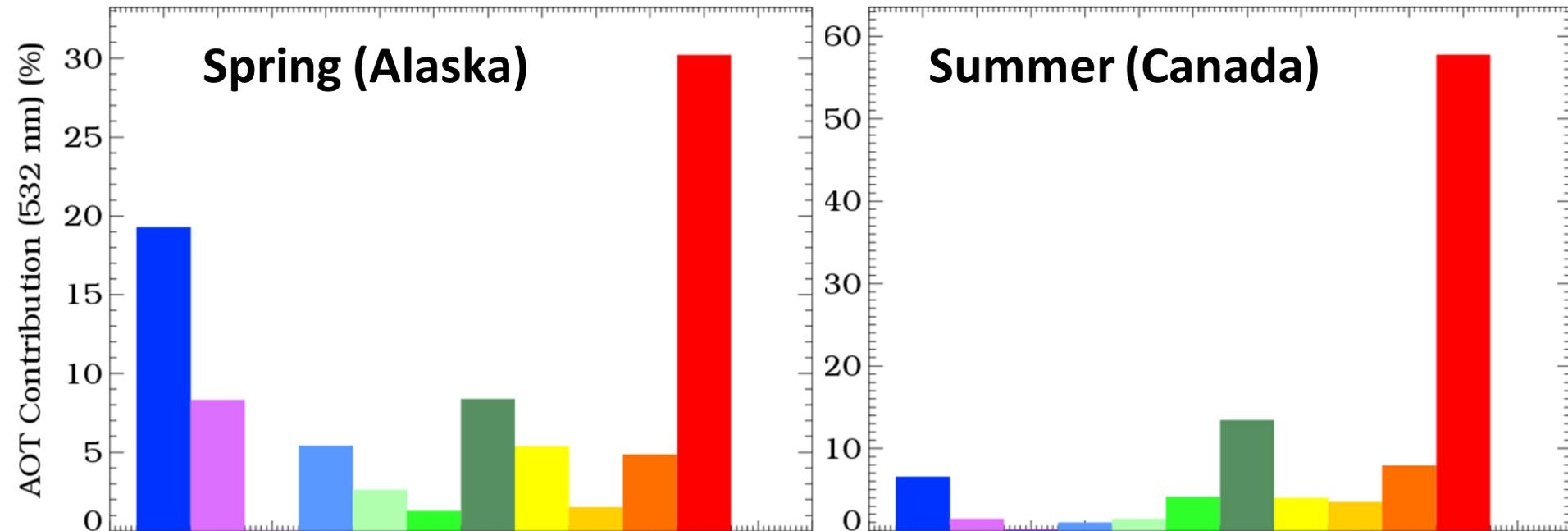


- ARCTAS 1 and 2 were dominated by the biomass/urban aerosol type
- ARCTAS 1 had fraction significant (~20% or more) of aerosol type classified as ice



ARCTAS1

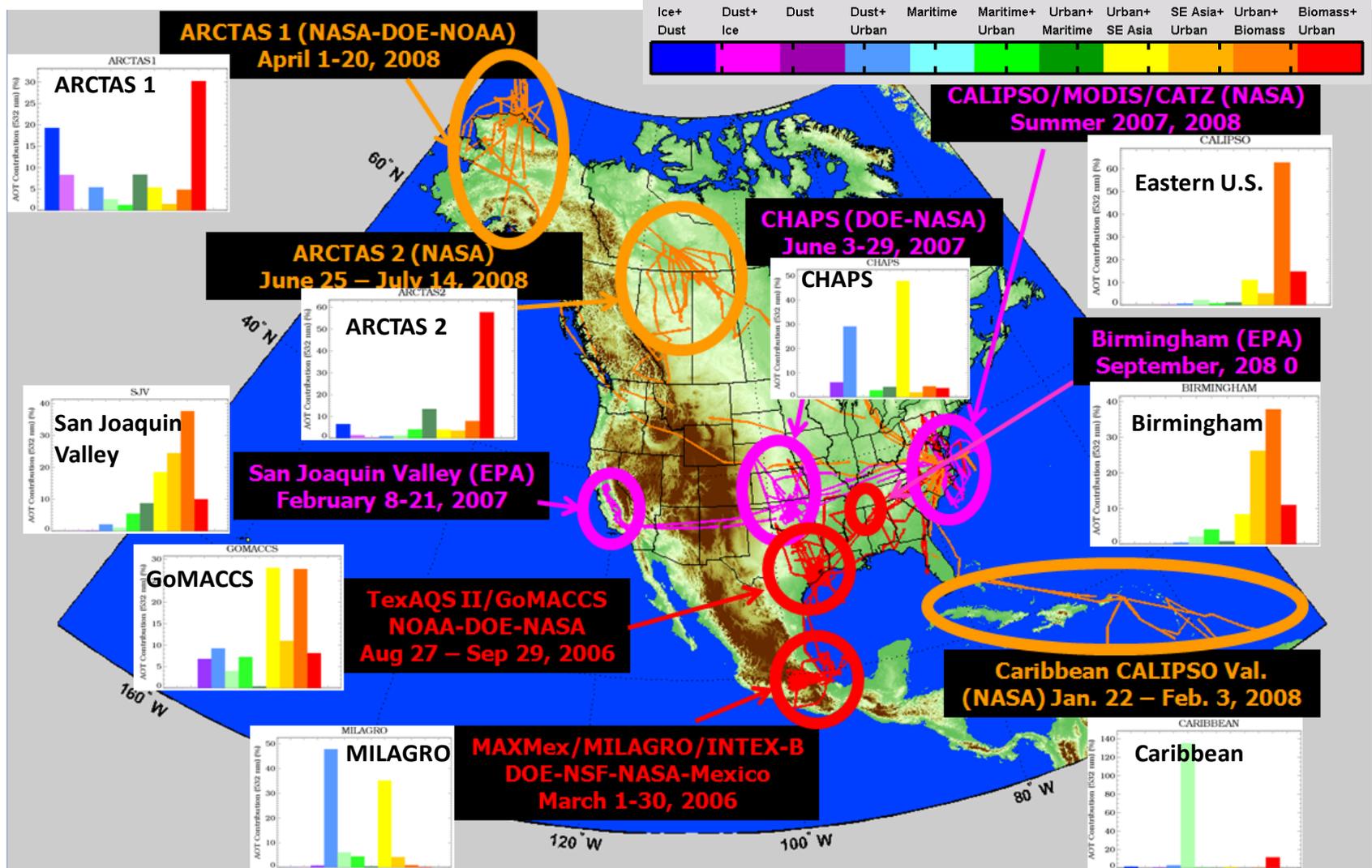
ARCTAS2



Apportionment of Aerosol Optical Thickness



- ARCTAS/ISDAC was dominated by the biomass/urban aerosol type
- ARCTAS/ISDAC had significant fraction (~20% or more) of aerosol type classified as ice





- **Ice, either by itself or mixed with aerosols, was often present during ARCTAS 1**
- **Ice/aerosol discrimination is often difficult for passive (and active) remote sensors; HSRL data may help**

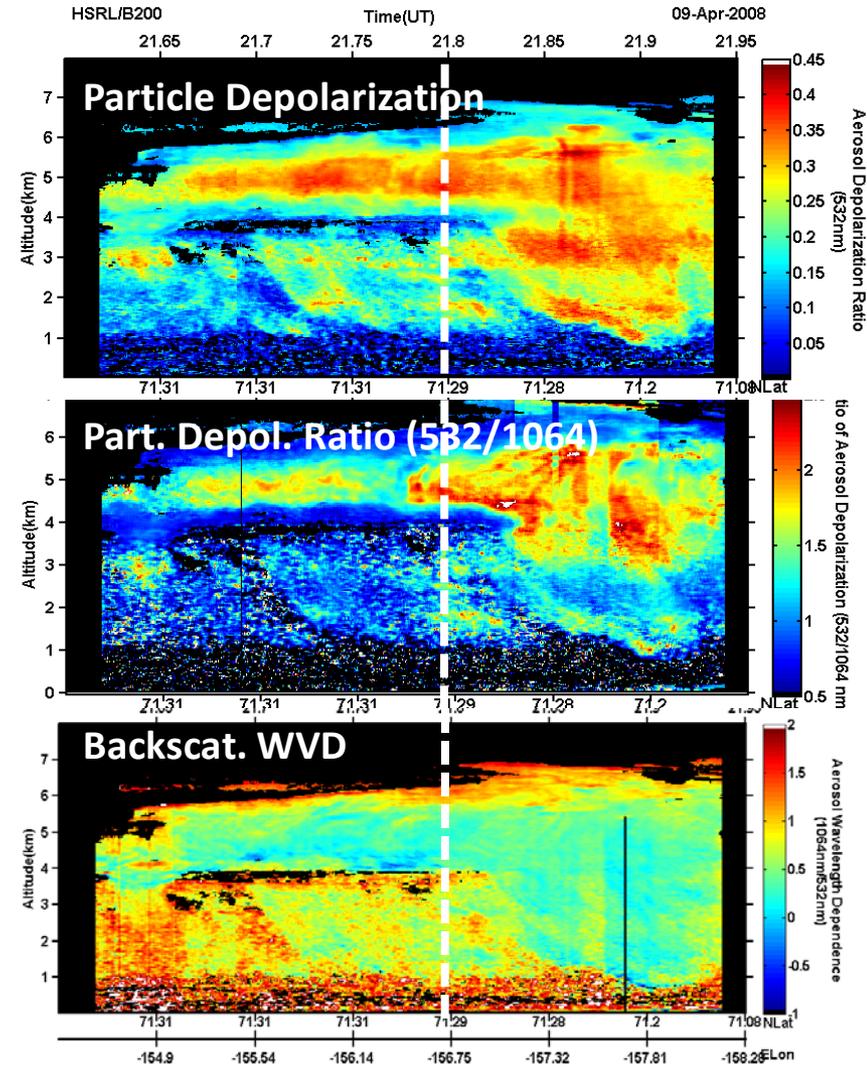
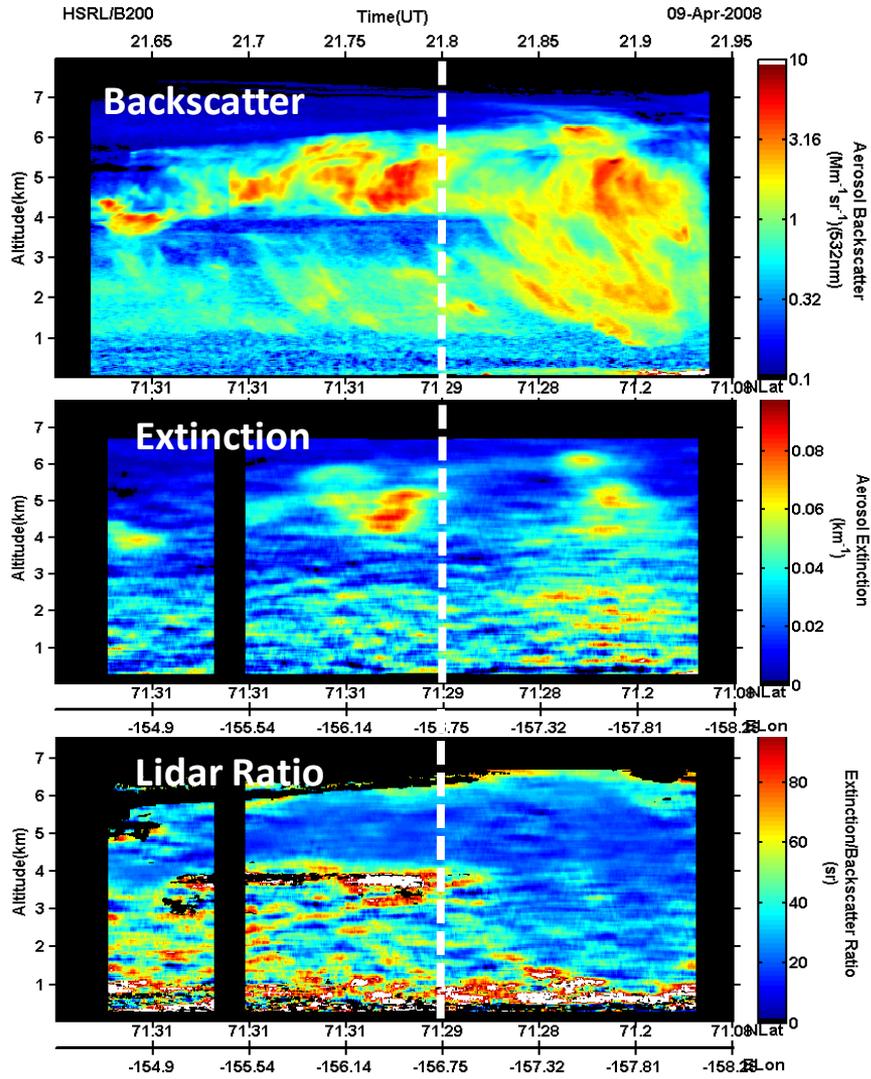
HSRL Observations of Ice Above Barrow (April 9)



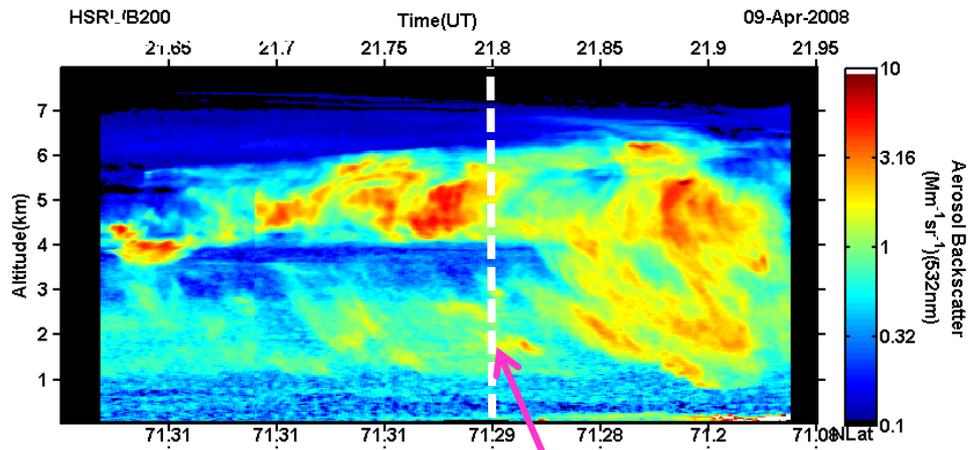
Ice indicated by:

- Low lidar ratio ~ 20 sr
- Low Backscatter Wavelength Dependence (-0.5-0.5)

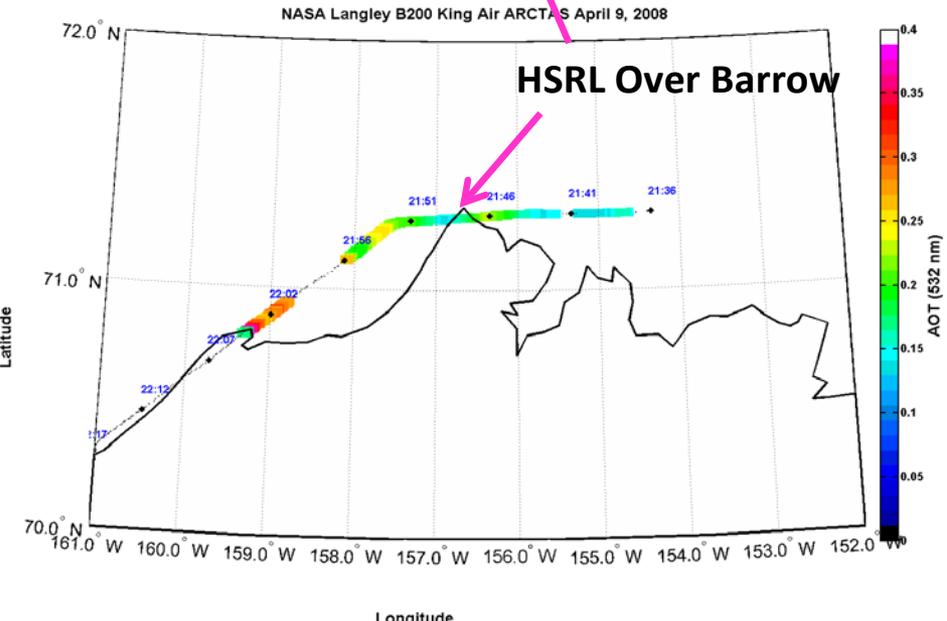
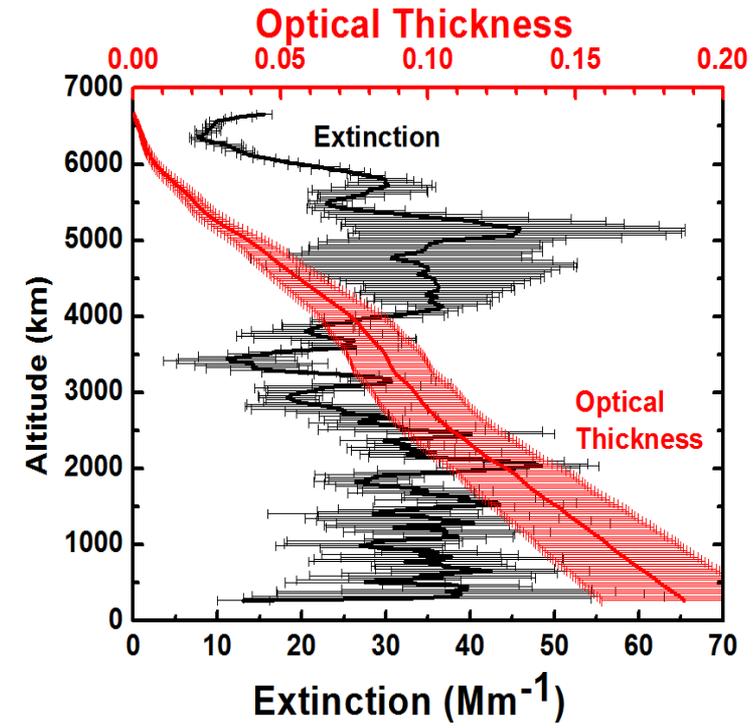
- High Depolarization $\sim 30-40+$ %
- High ratio of Depolarization (532/1064 nm) $>1.5-2.0$



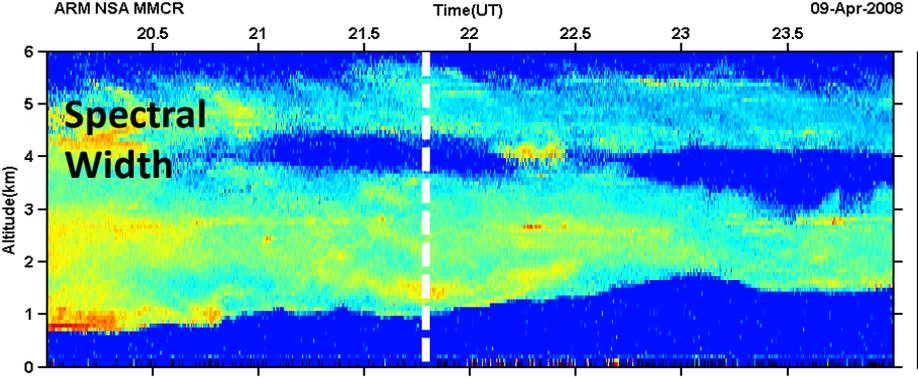
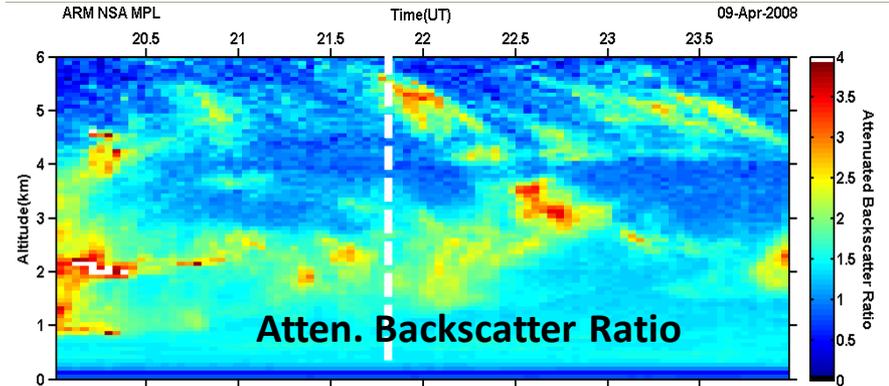
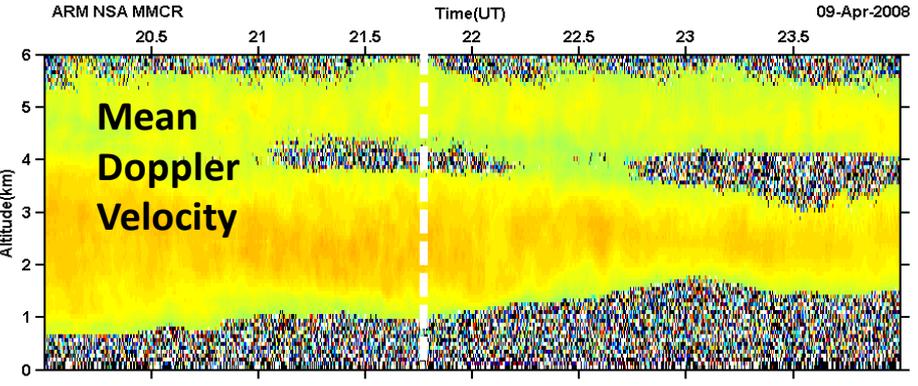
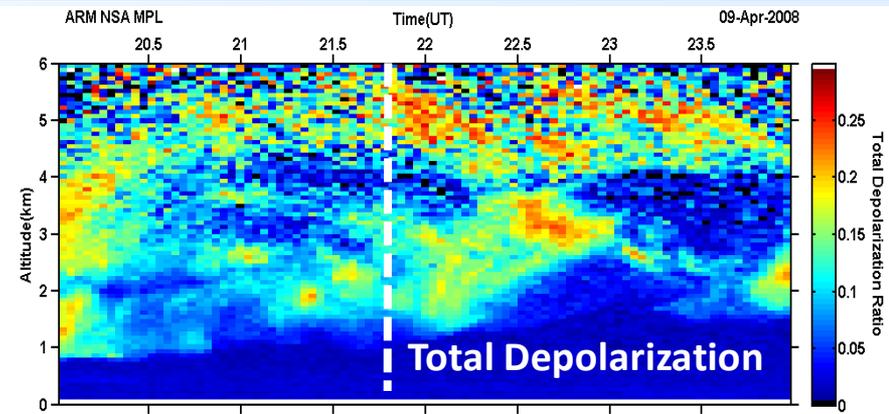
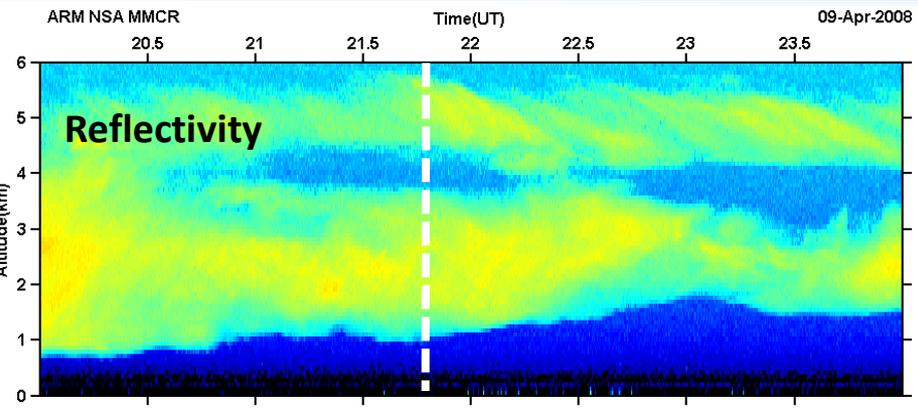
HSRL Observations of Ice Above Barrow (April 9)



HSRL data indicate a significant fraction (0.05-0.08; 30-40%) of aerosol optical thickness reported by AERONET was due to ice in this case



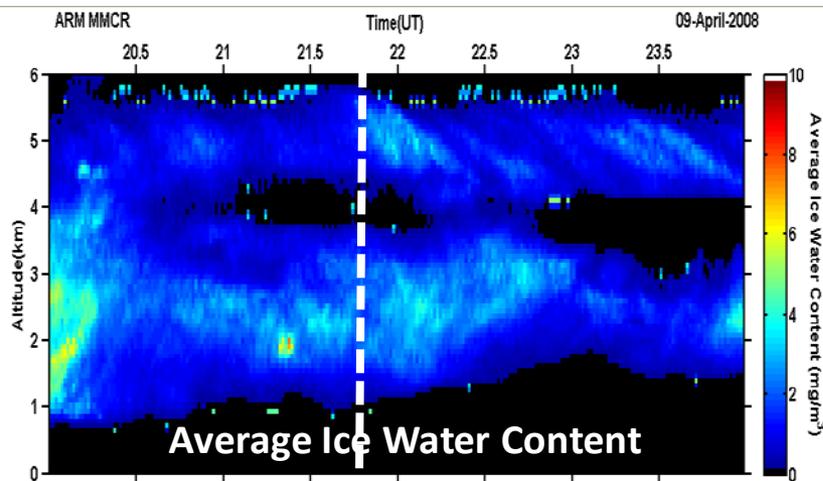
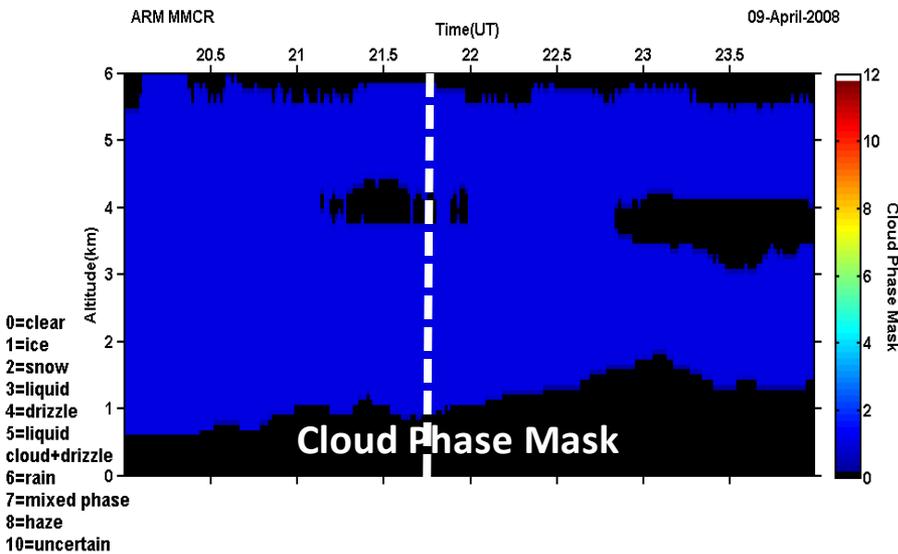
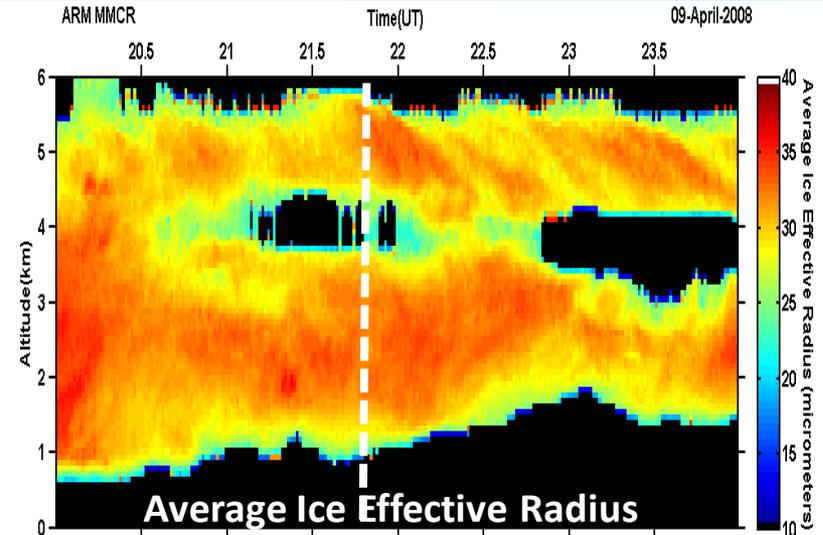
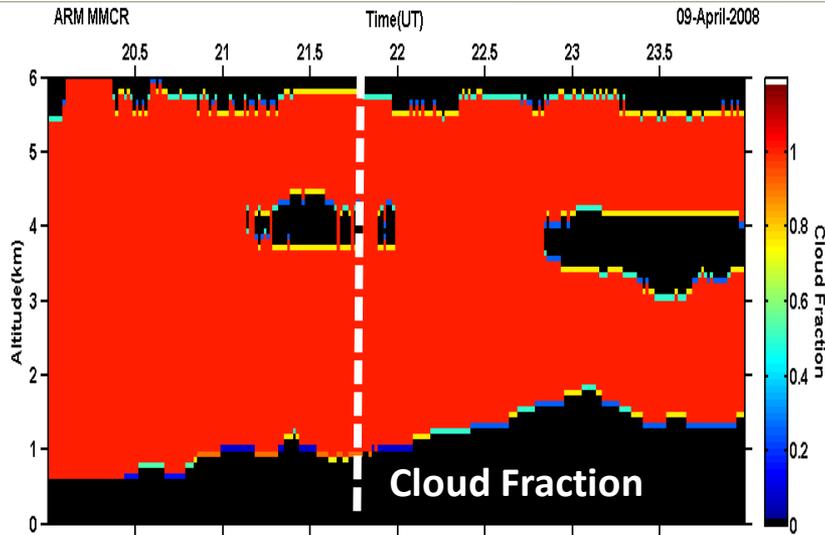
MMCR and MPL Measurements Above Barrow (April 9)



MPL Measurements
MMCR Measurements

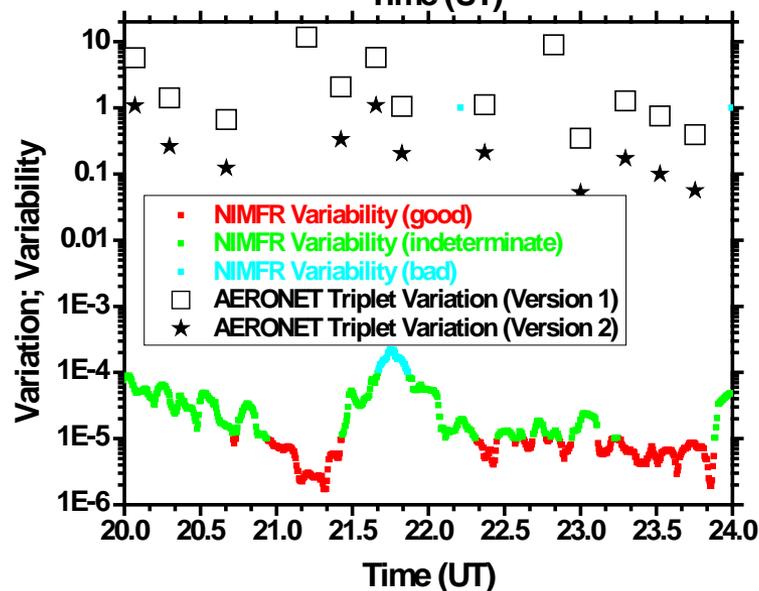
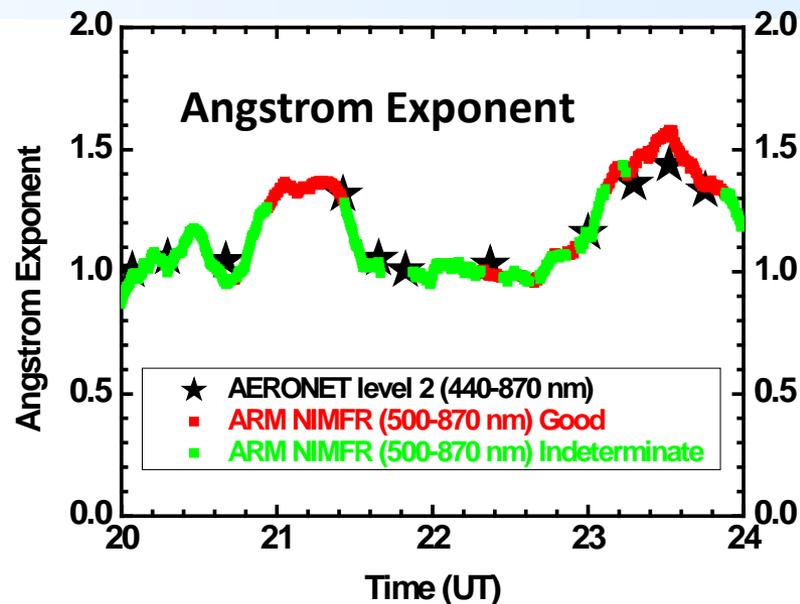
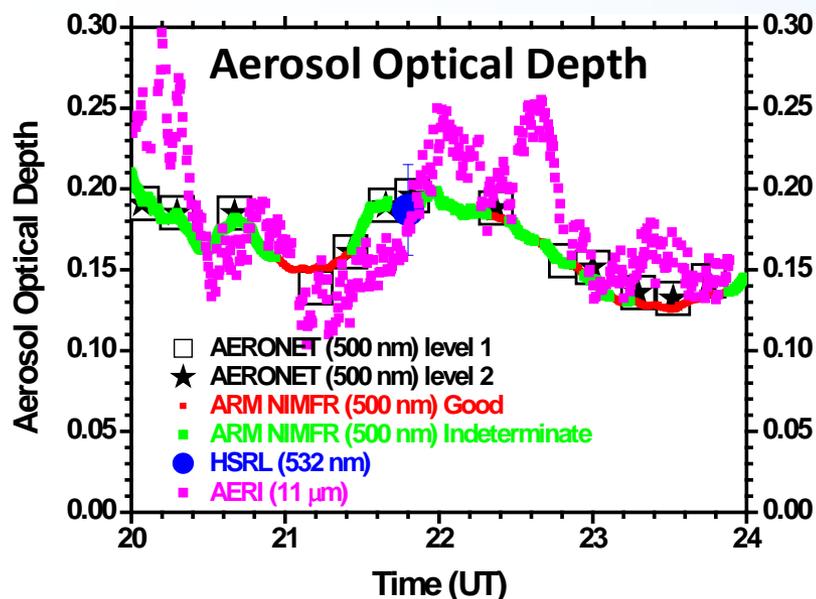
Two arrows point from the text to the MPL and MMCR plots respectively.

Cloud retrieval products from MMCR (microbase) (April 9)





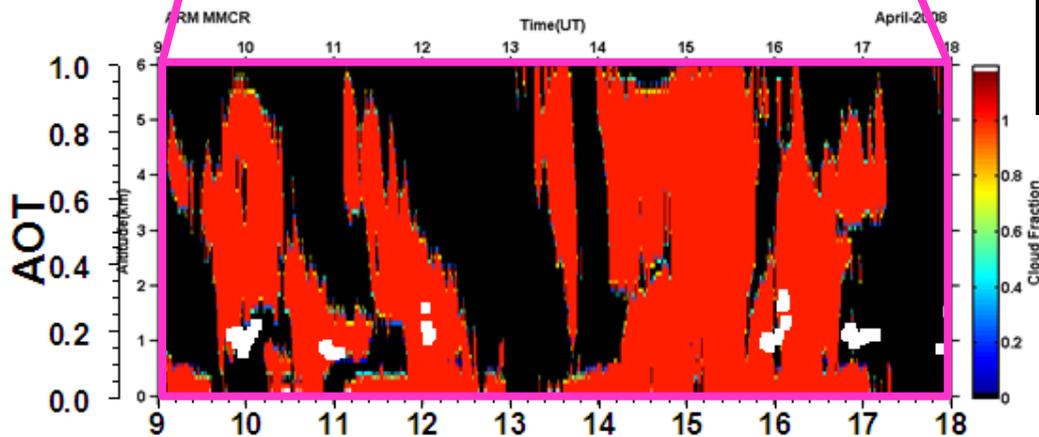
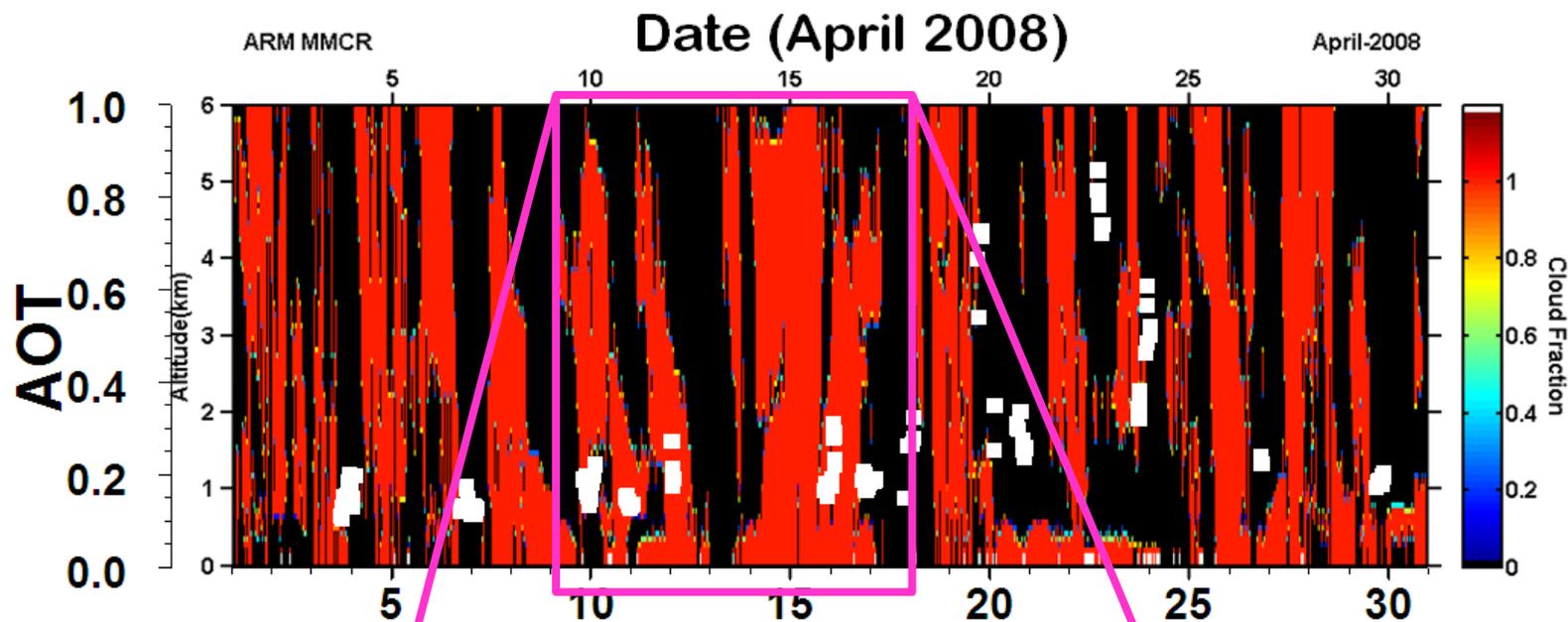
AOT and Angstrom exponent from AERONET and NIMFR (April 9)



- AOT (500 nm) \sim 0.15-0.2
- AOT (11 μ m) \sim 0.15-0.25
- Angstrom Exponent (440-870 nm) (\sim 1.0-1.5)

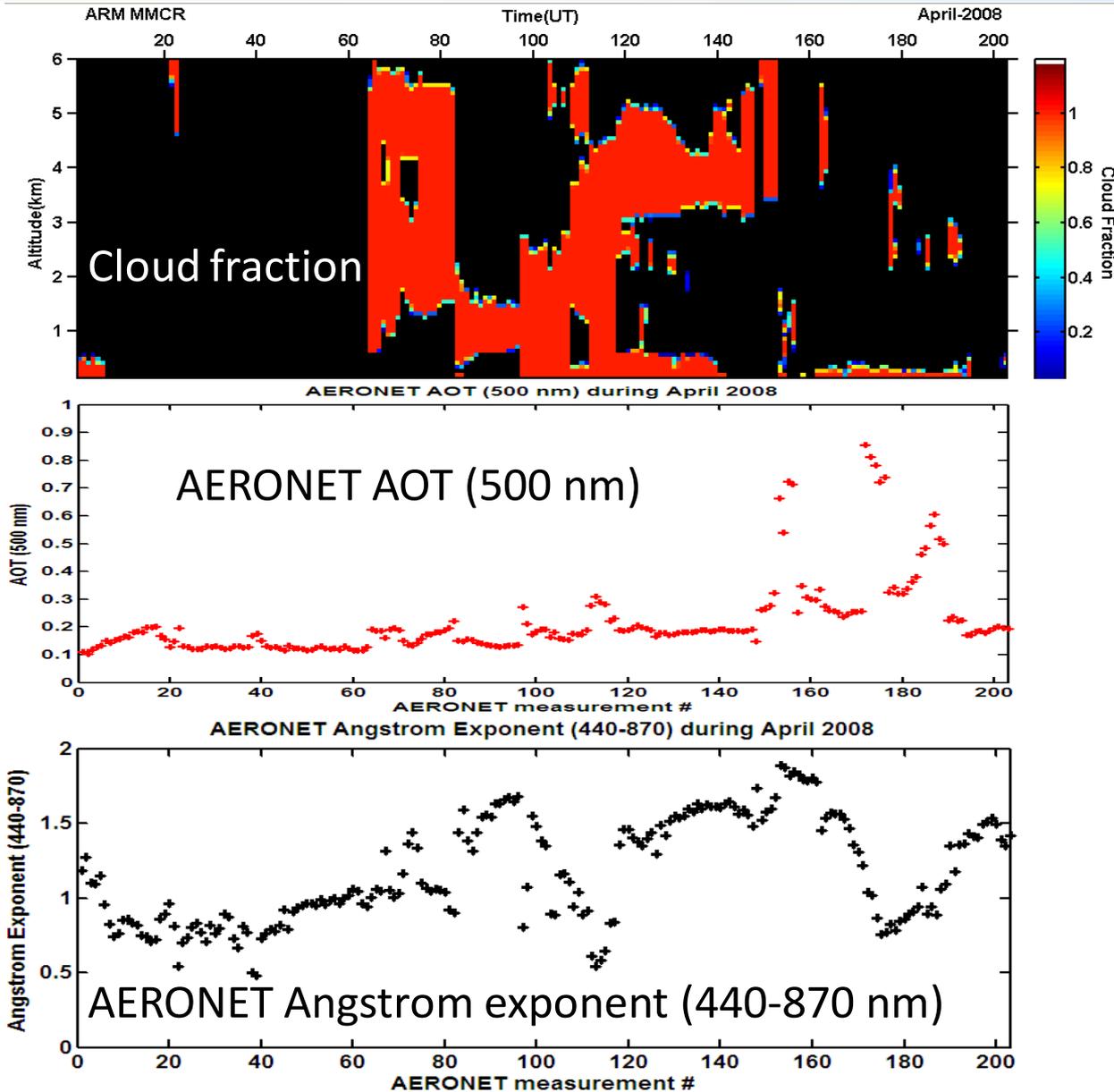


Cloud fraction from MMCR (microbase) AERONET Level 2 AOT (500 nm) (April 2008)



**Microbase Cloud fraction
AERONET AOT (500 nm)**

Cloud fraction from MMCR (microbase), AERONET Level 2 AOT (500 nm), Angstrom Exponent (April 2008)



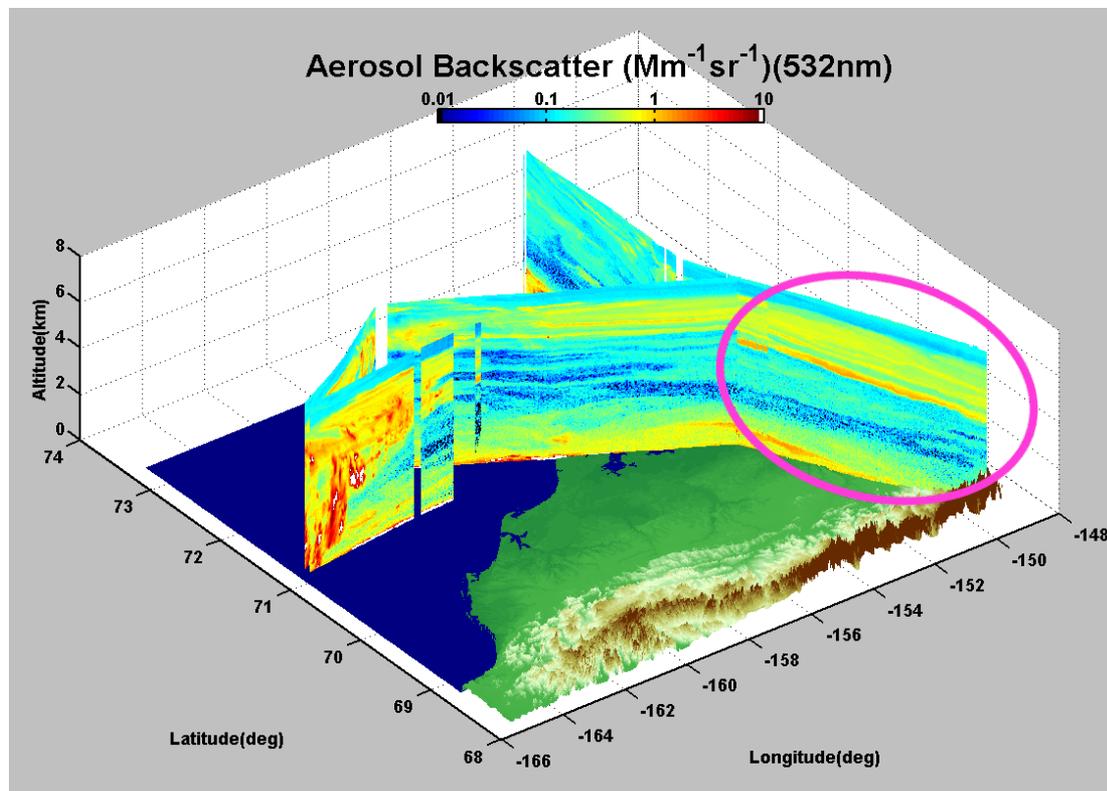
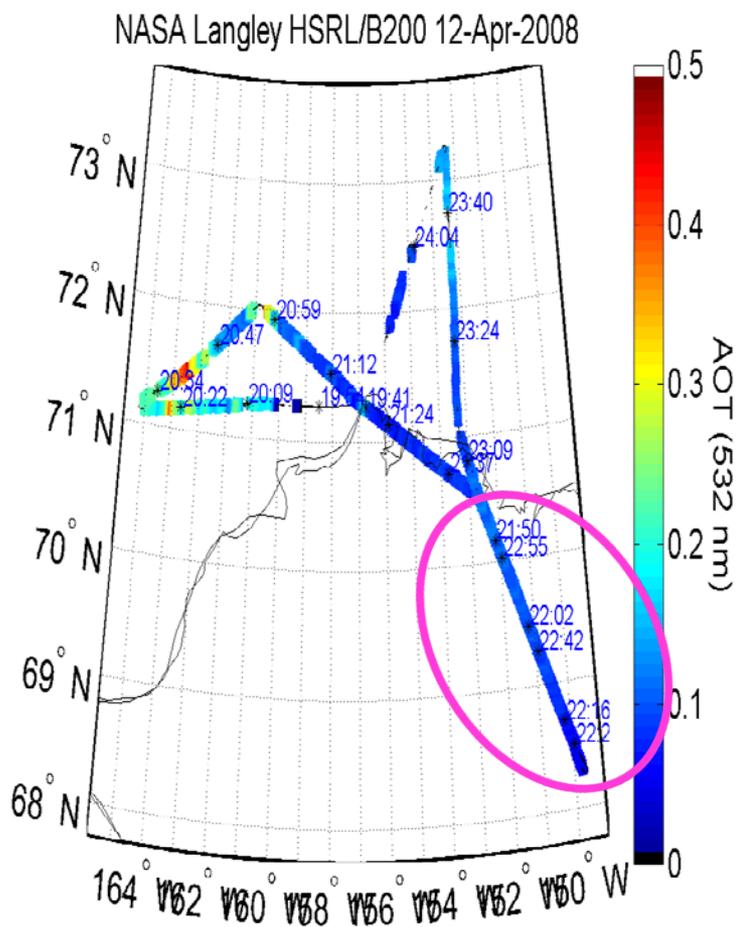
- During April 2008, there were 203 level-2 AERONET AOT measurements
- Of these 203 AERONET measurements, coincident microbase results showed:
 - 80 (39%) were cloudfree
 - 107 (53%) had cloud thickness of at least 200 m
 - 95 (47%) had cloud thickness of at least 500 m
 - 78 (38%) had cloud thickness of at least 1 km



- **CALIPSO daytime measurements often did not detect the thin aerosol layers commonly seen during ARCTAS 1**
- **CALIPSO retrievals of aerosol backscatter and extinction profiles of thick smoke plumes show good agreement with HSRL measurements**

April 12 Smoke Case

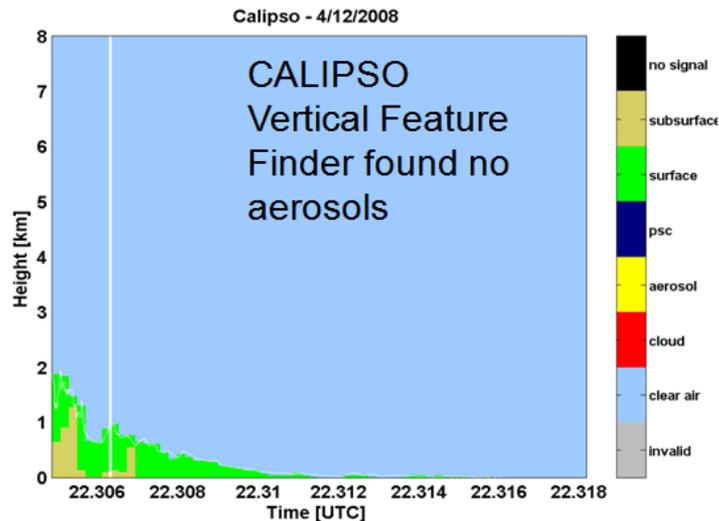
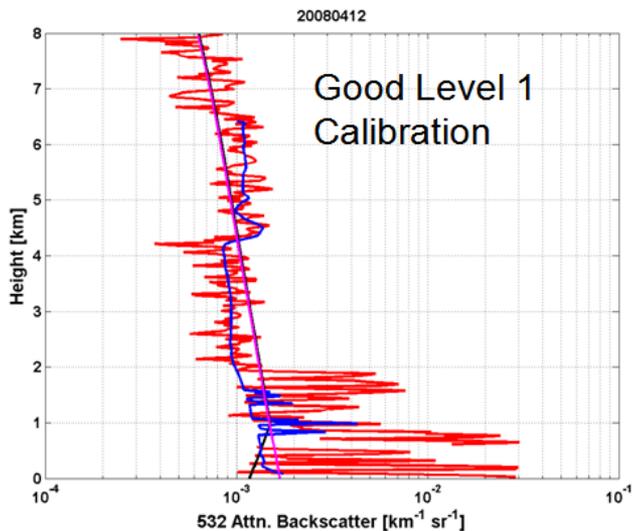
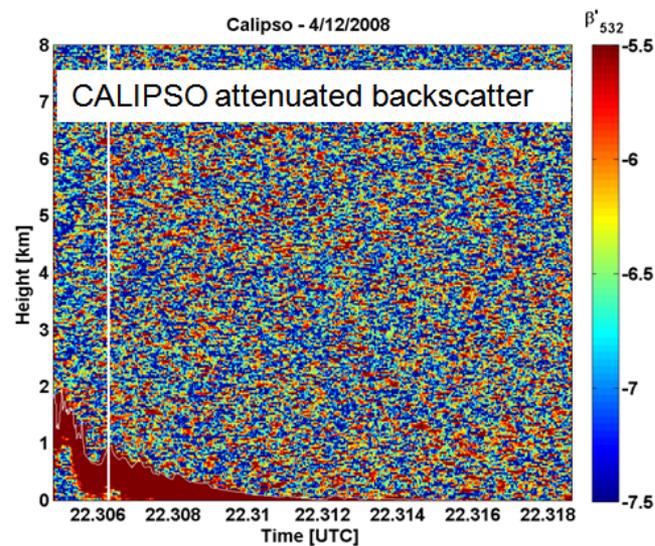
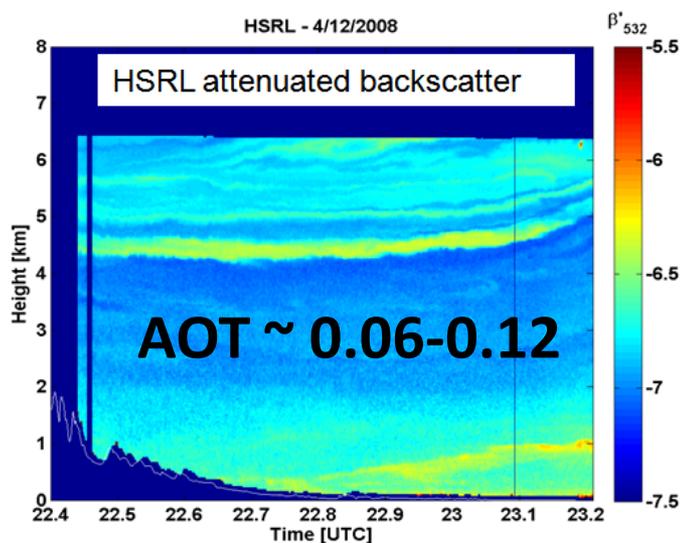
- Coordinated B200/DC-8 flight leg along CALIPSO track



CALIPSO Validation

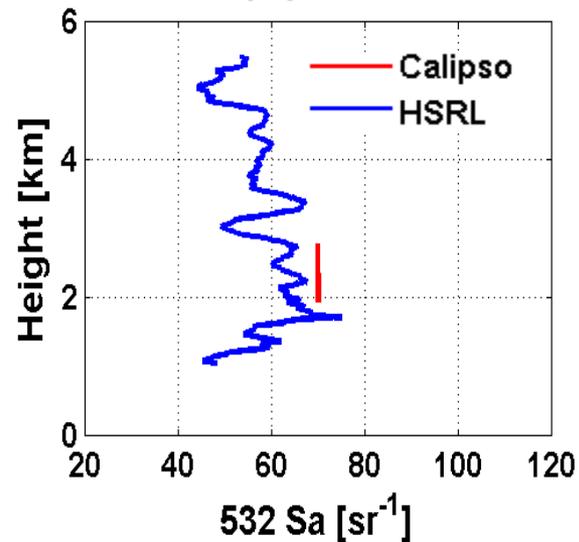
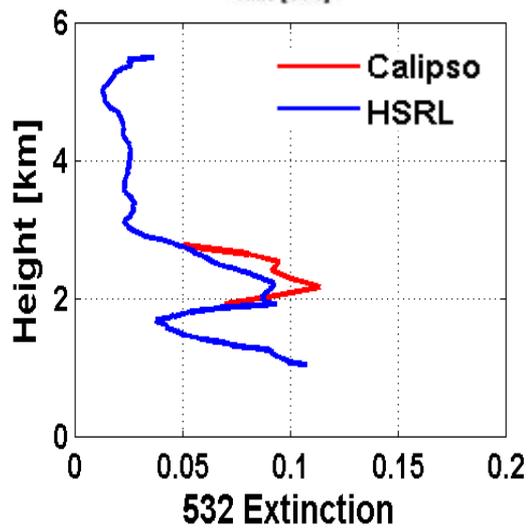
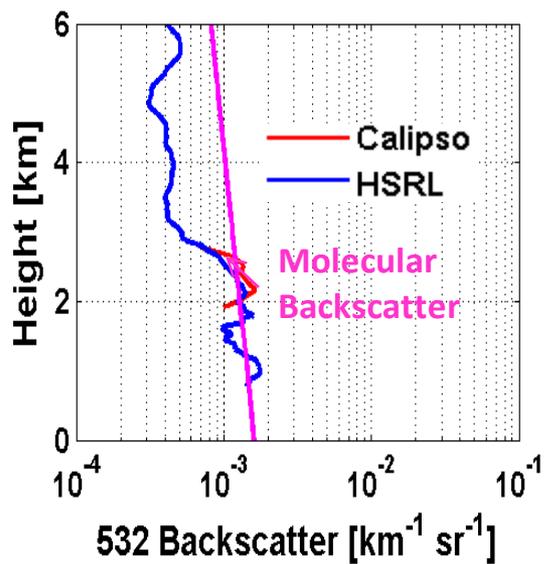
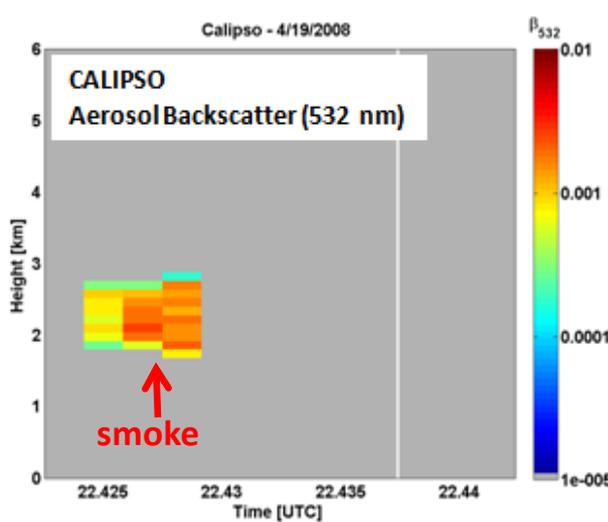
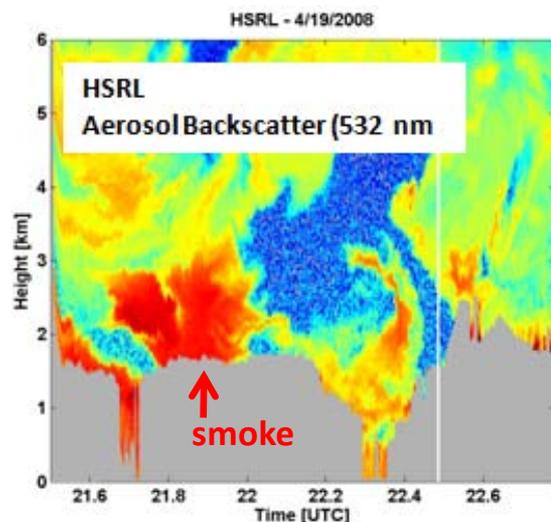
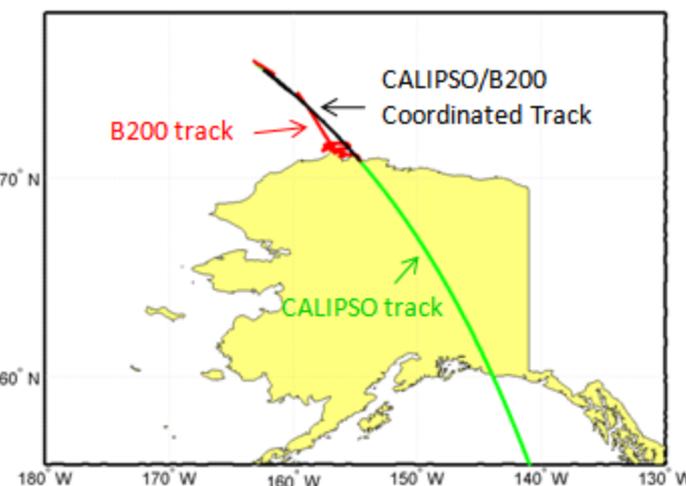


CALIPSO reported no aerosols during coordinated B200/DC-8 leg on April 12



CALIPSO Level 2 Validation During ARCTAS (Spring)

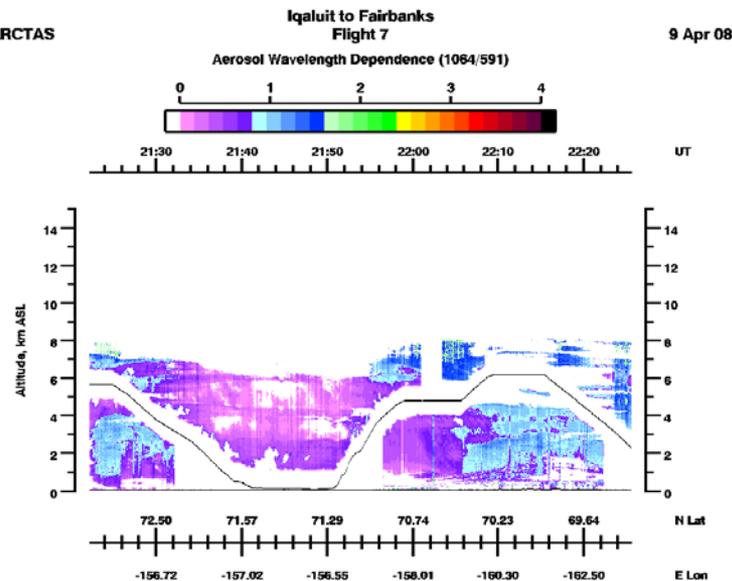
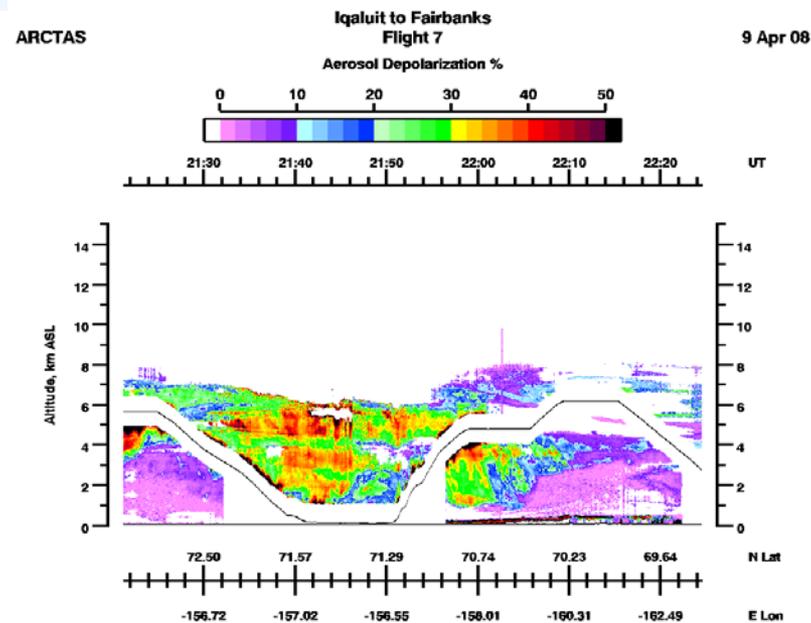
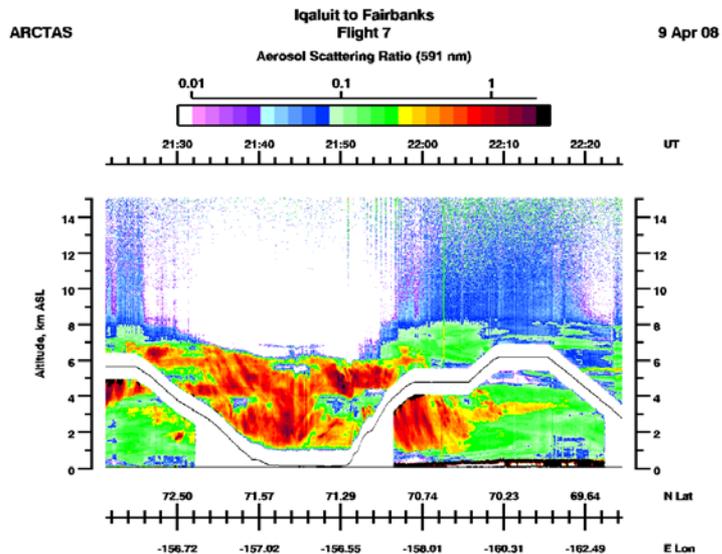
Example – April 19 ~ 22:00 UT



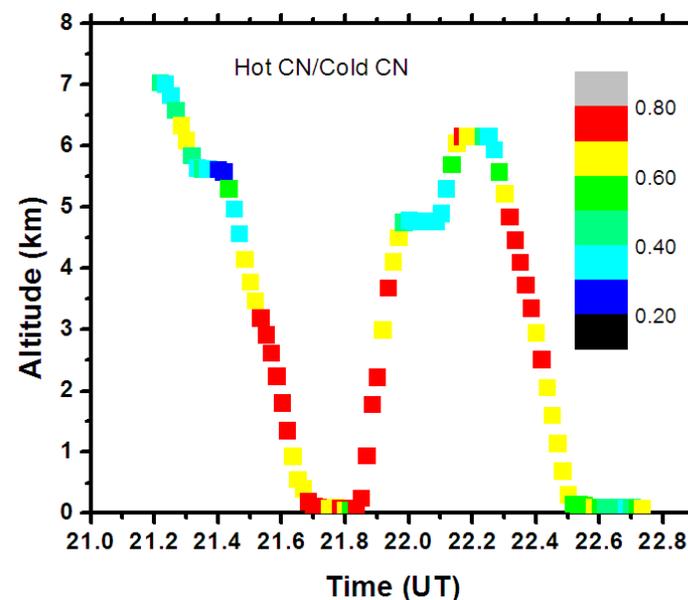
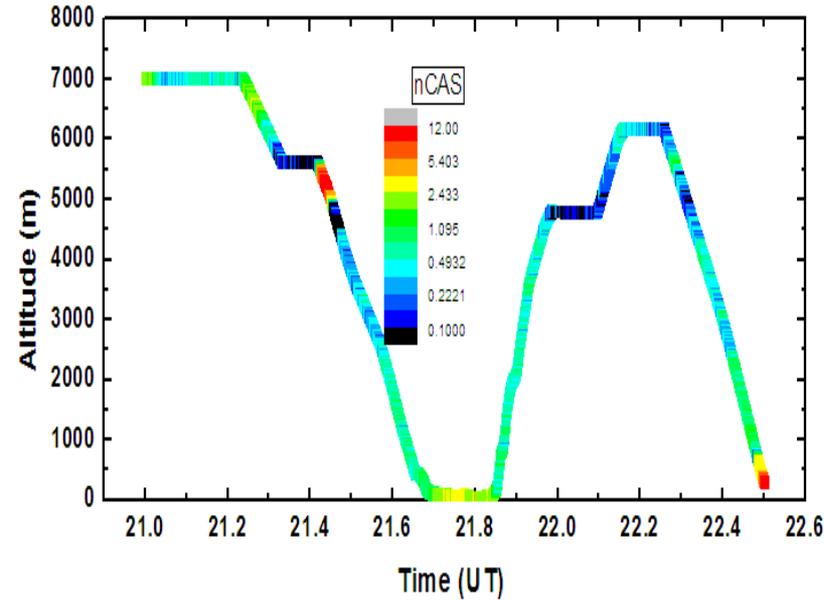
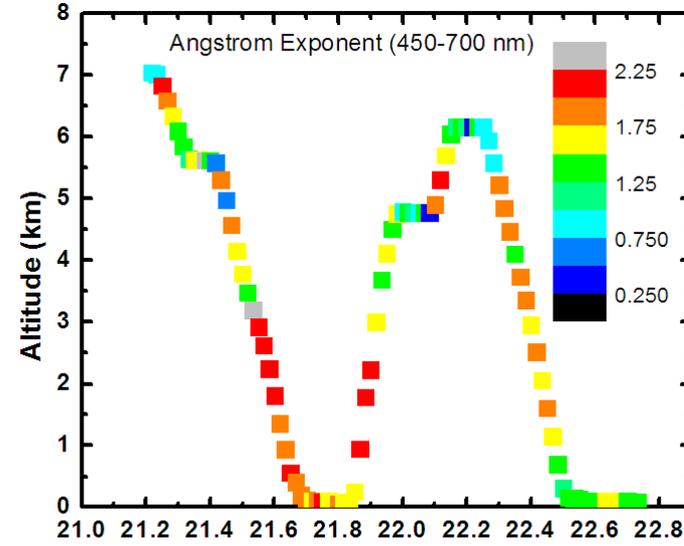
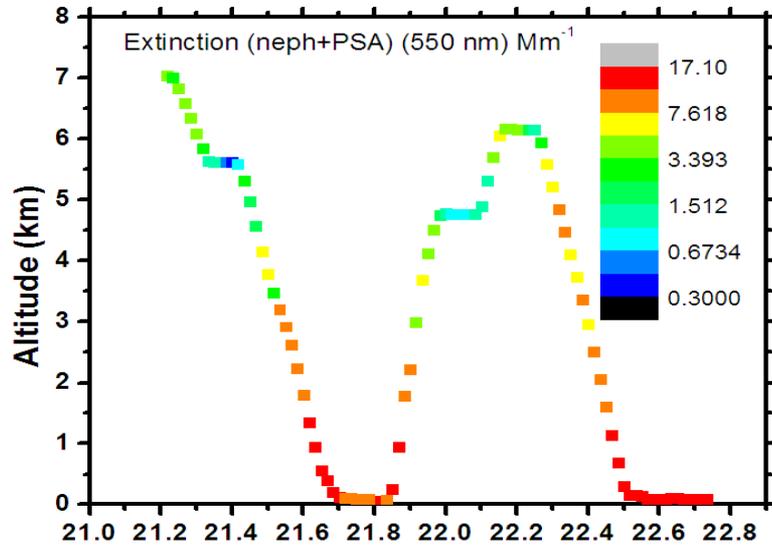
Special Thanks to B200 Crew !



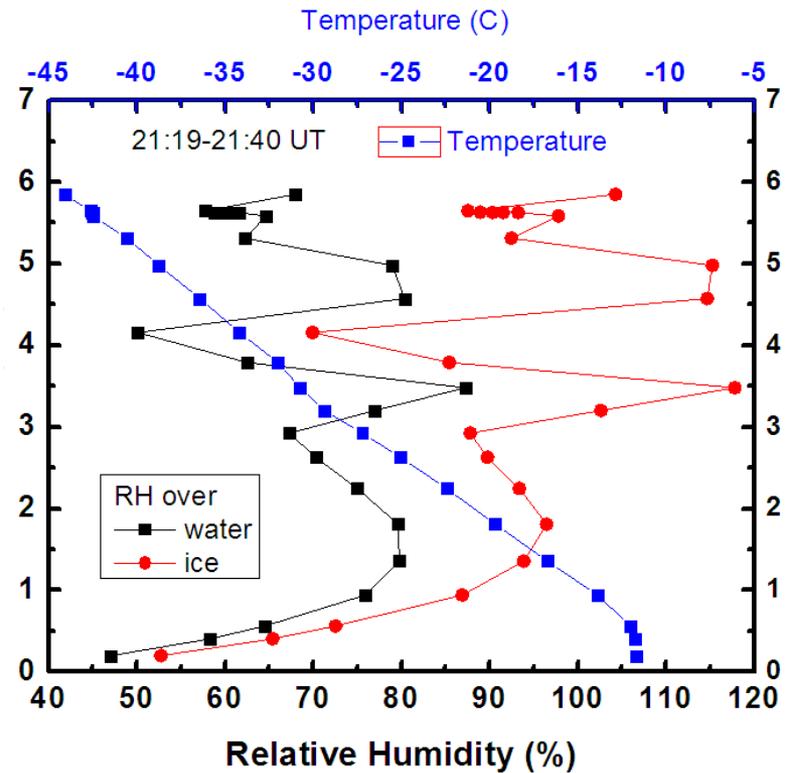
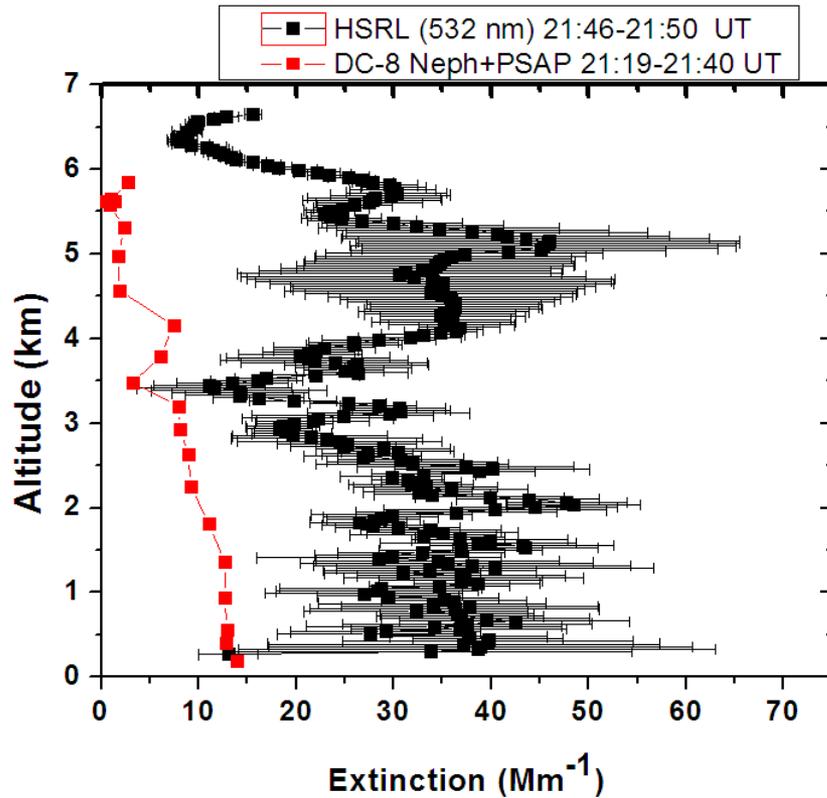
DIAL (on NASA DC-8) aerosol "curtains" – April 9, 2008



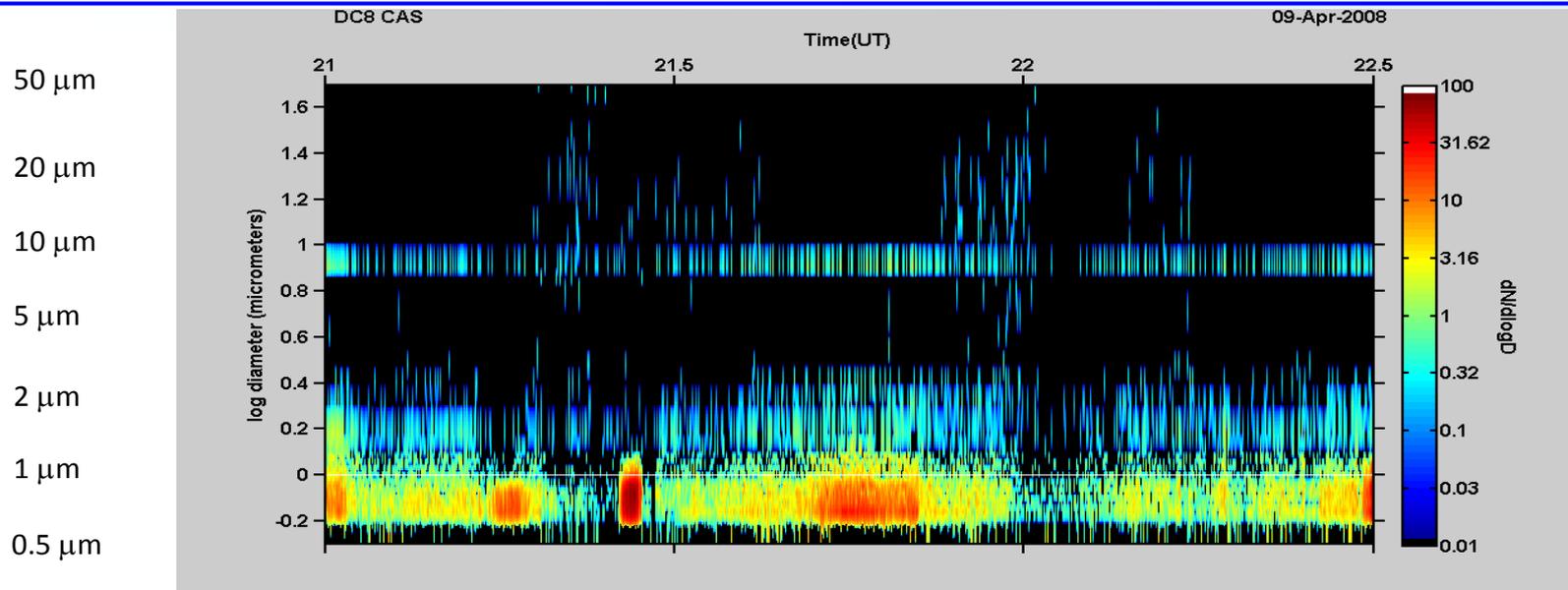
DC-8 particle in situ measurements during missed approach at Barrow on April 9



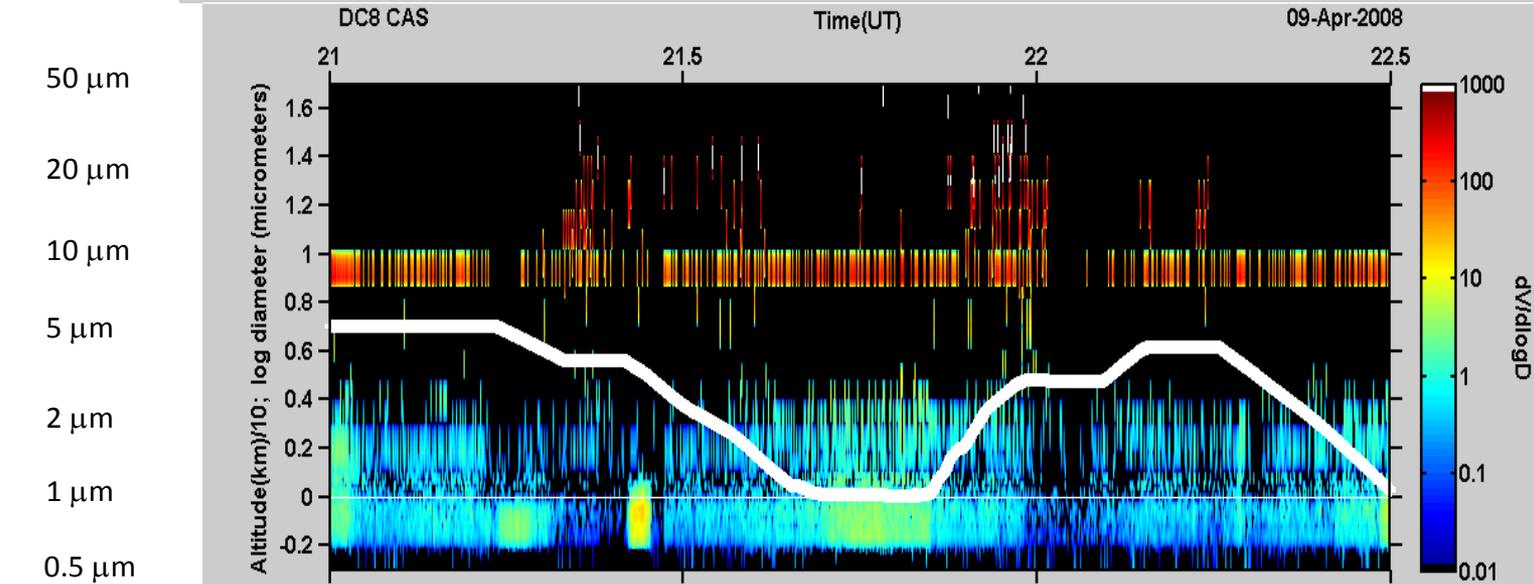
DC-8 profile measurements during missed approach at Barrow on April 9



DC-8 CAS particle size distribution measurements on April 9



$dN/d\log D$



$dV/d\log D$