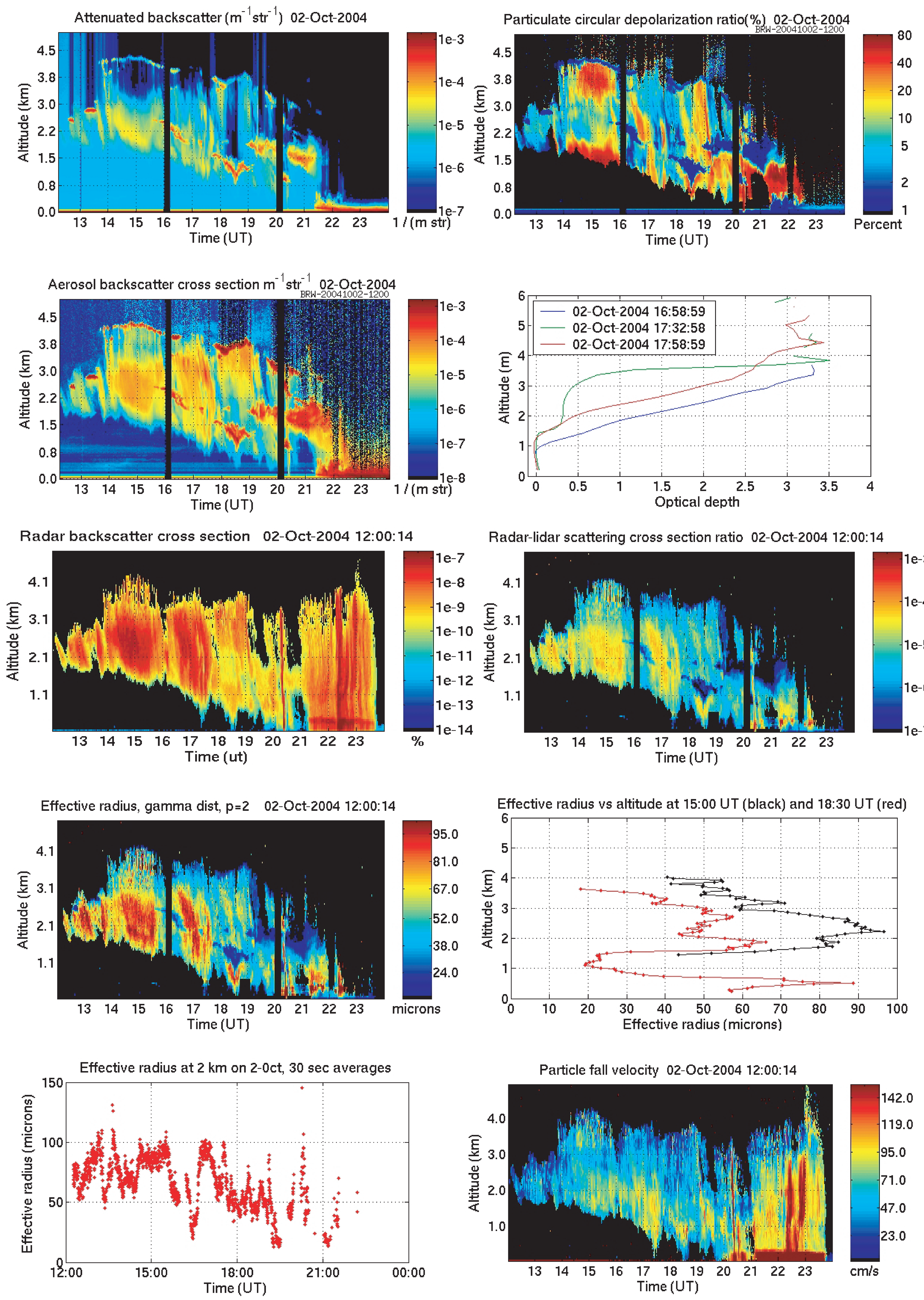
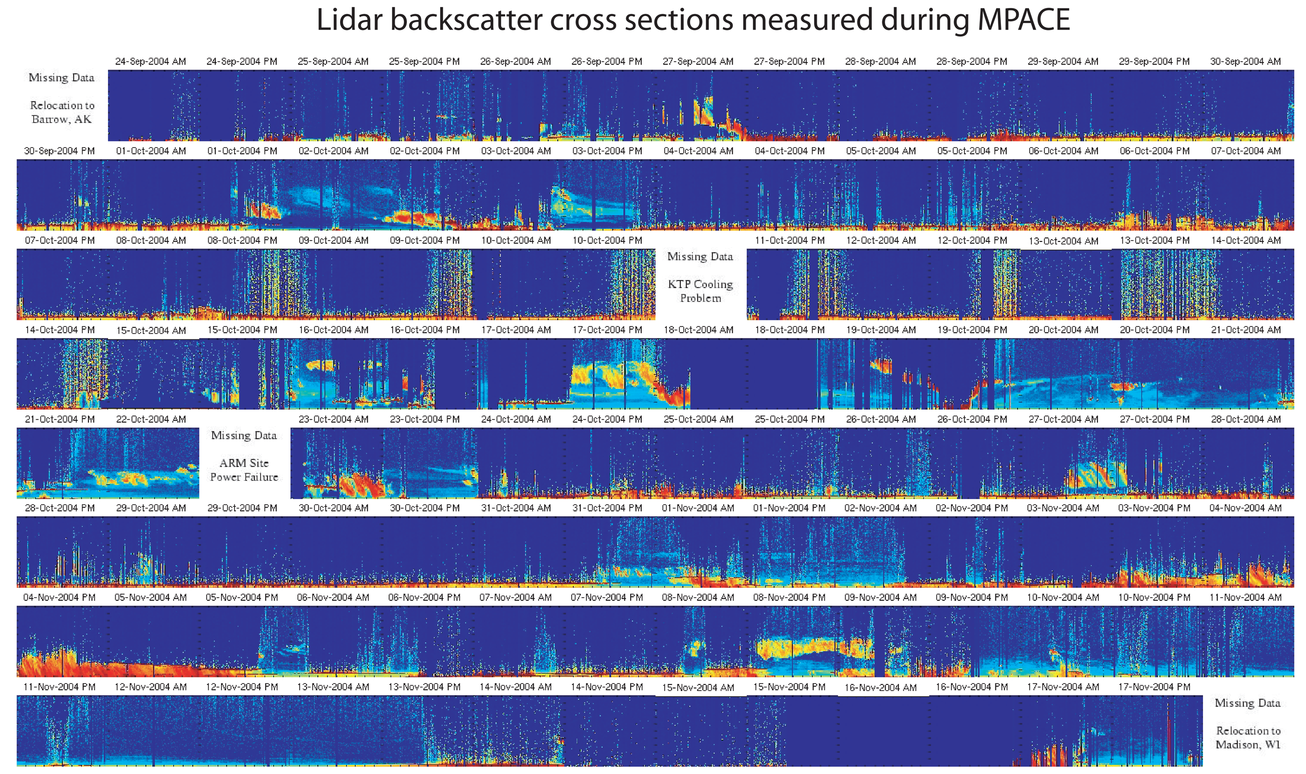
# University of Wisconsin High Spectral Lidar operations during MPACE: Examples of AHSRL-MMCR particle size retrievals

## Mixed-Phase cloud observations on 2-Oct-04




## Lidar backscatter cross sections measured during MPACE



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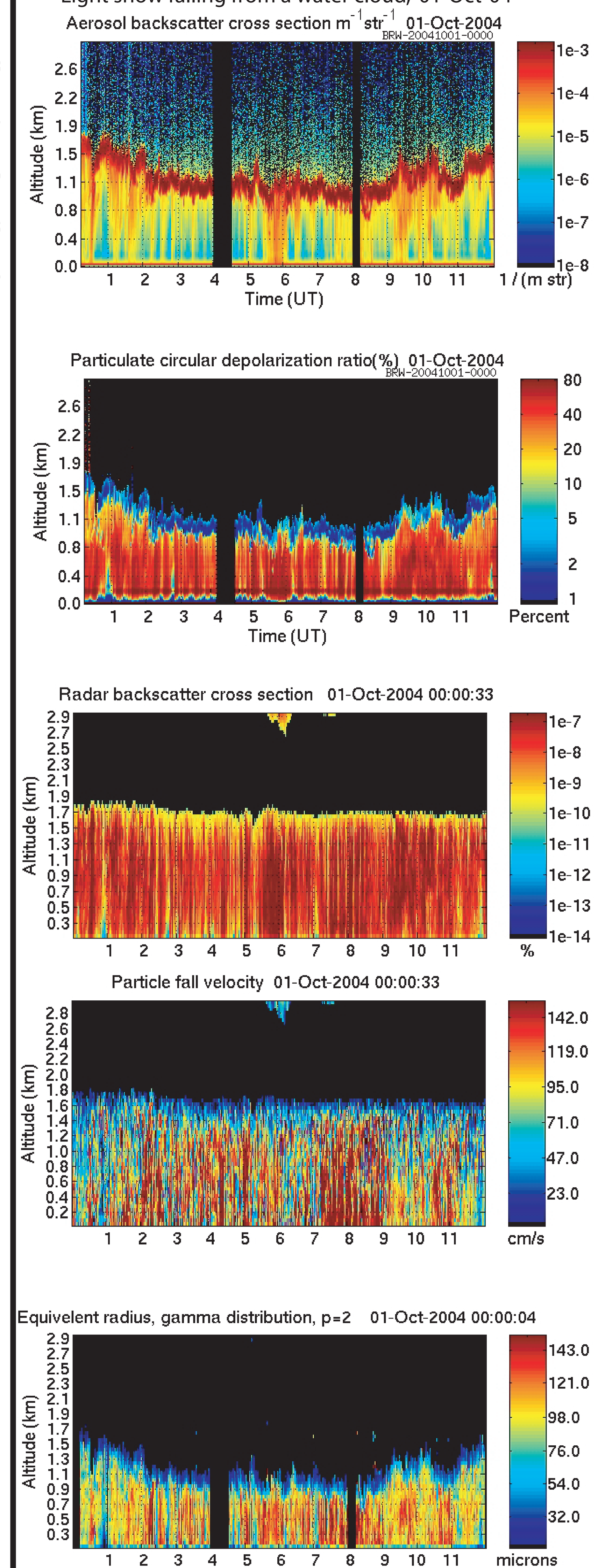
The Arctic High Spectral Resolution Lidar(AHSRL) operated at the North Slope ARM site as part of MPACE from 24-Sept-04 to 17-Nov-04. This was the first deployment where the AHSRL was operated remotely over the network from our Madison, WI laboratory. Data was archived 24-hours/day for the entire period with only minor interruptions. During of 1262 hours of operation, 1147 hours of lidar data was collected (ice system produced lidar data 91% of the time). During 941 hours the system maintained frequency lock allowing fully calibrated operation (75 % of total hours). 115 hours was used during automatic calibration cycles which occurred at 6 hour intervals. One day of data was lost due to a problem in the laser cooling system, and one-half of a day was lost due to an electrical power failure at the site. All of the data is archived on our web site and can be accessed using web routines which process data on demand. These allow users to specify the exact time and altitude range of the data they wish acquire and to specify both the temporal and spatial averaging which is most appropriate for their application. A minimum signal-to-noise level can also be specified to exclude noisy data points

AHSRL data was used extensively to support aircraft flight planning during MPACE. Planners at the Dead Horse experiment headquarters were able to access processed lidar data from our Barrow lidar site in real time via our Madison, WI web site.

This poster illustrates the use of AHSRL data along with the MMCR 8.6 cm wavelength ARM NSA radar to retrieve measurements of effective particle size. This is one of many applications for the HSRL MPACE data.

Particle size retrievals proceed as follows:
1)AHSRL backscatter cross sections were converted to scattering cross section per unit volume, assuming a backscatter phase function, P(180)/4pi=1/(8*pi) (In a more refined treatment this value will be derived from the AHSRL data).
2) Radar dBZ values were converted to scattering cross sections per unit volume, assuming Rayleigh scattering and the index of refraction for ice.
3) A gamma distribution of particle sizes, $N(r)=N_o*r^{(p-1)}*\exp(-r*(p+2)/r_e)$ is assumed, where r is the particle radius, $r_e$ is the effective radius, and p is a parameter controlling the width of the size distribution.
4) The lidar cross section is assumed to be twice the cross sectional area of the particle (ice $\sim r^2$) and the radar cross section is assumed to be given by the Rayleigh scattering cross section for spheres (ice $\sim r^6$). This allowed us to write an equation for the ratio of the radar to the lidar scattering cross section in terms of the effective radius and p.
5) Assuming a value for p =2, measured values of the radar to lidar scattering cross section ratio were used to obtain the effective radius at each point where valid lidar and radar measurements were obtained.
6) Lidar and radar data were averaged to the same time and space intervals (dt=30 sec and dz=45 m). These values were interpolated to common time and altitude bins. Measurements within 6 dBZ of the radar's minimum detectable reflectivity are removed along with those where the signal-to-noise ratio in the lidar molecular channel was less than 5.
7) Measurements of ice fall velocities as a function of particle effective radius used the lidar depolarization to eliminate data points with liquid water. Points with depolarizations greater than 15% were classified as ice.

## Light snow falling from a water cloud, 01-Oct-04




## Cirrus cloud observations on 17-Oct-04