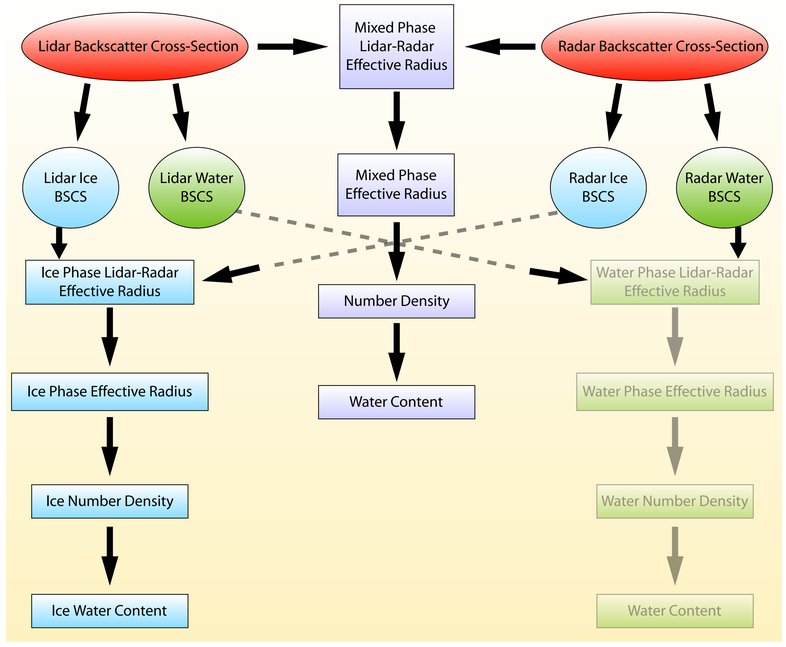
Development of Cloud Microphysical Property Retrievals Using the University of Wisconsin Arctic High Spectral Resolution Lidar

Gijs de Boer, Edwin W. Eloranta
The University of Wisconsin - Madison

Introduction

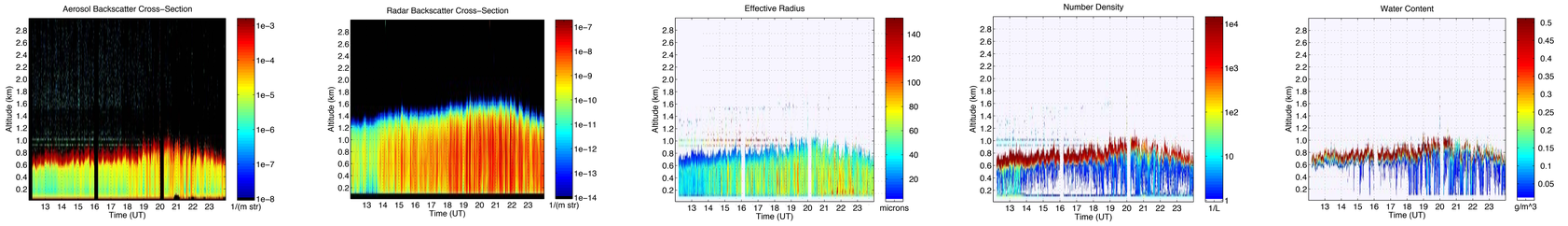
As a part of the **M**ixed-**P**hase **A**rctic **C**loud **E**xperiment (M-PACE), the UW-**A**rctic **H**igh **S**pectral **R**esolution **L**idar (AHSRL) was deployed to Barrow, AK during September-November 2004. During this time the system recorded data on a nearly continual basis. We have developed cloud microphysical property retrievals using a combination of the AHSRL and the NOAA **Milli**meter **C**loud **R**adar (MMCR) that was also located in Barrow. Properties such as particle size, number density, liquid water content, and ice water content have all been obtained. The general methodology used to obtain these retrievals, some data examples and validation efforts are shown here. The October 9 case is currently being analyzed by the ARM Cloud Parameterization and Modeling Workgroup to increase our ability to simulate mixed-phase boundary layer clouds, and is therefore featured here.

Method



The technique used mirrors that introduced by Donovan and Van Lammeren (2001), and has been modified by Eloranta to work with the available instruments. It utilizes the backscatter cross-sections from both the AHSRL and MMCR to estimate an effective particle size. From there, number density and water contents are estimated. The figure above outlines the steps in the retrieval process. Note that currently there is less confidence in water-only retrievals, since there is only a small contribution to the radar backscatter cross-section by water in mixed phase situations.

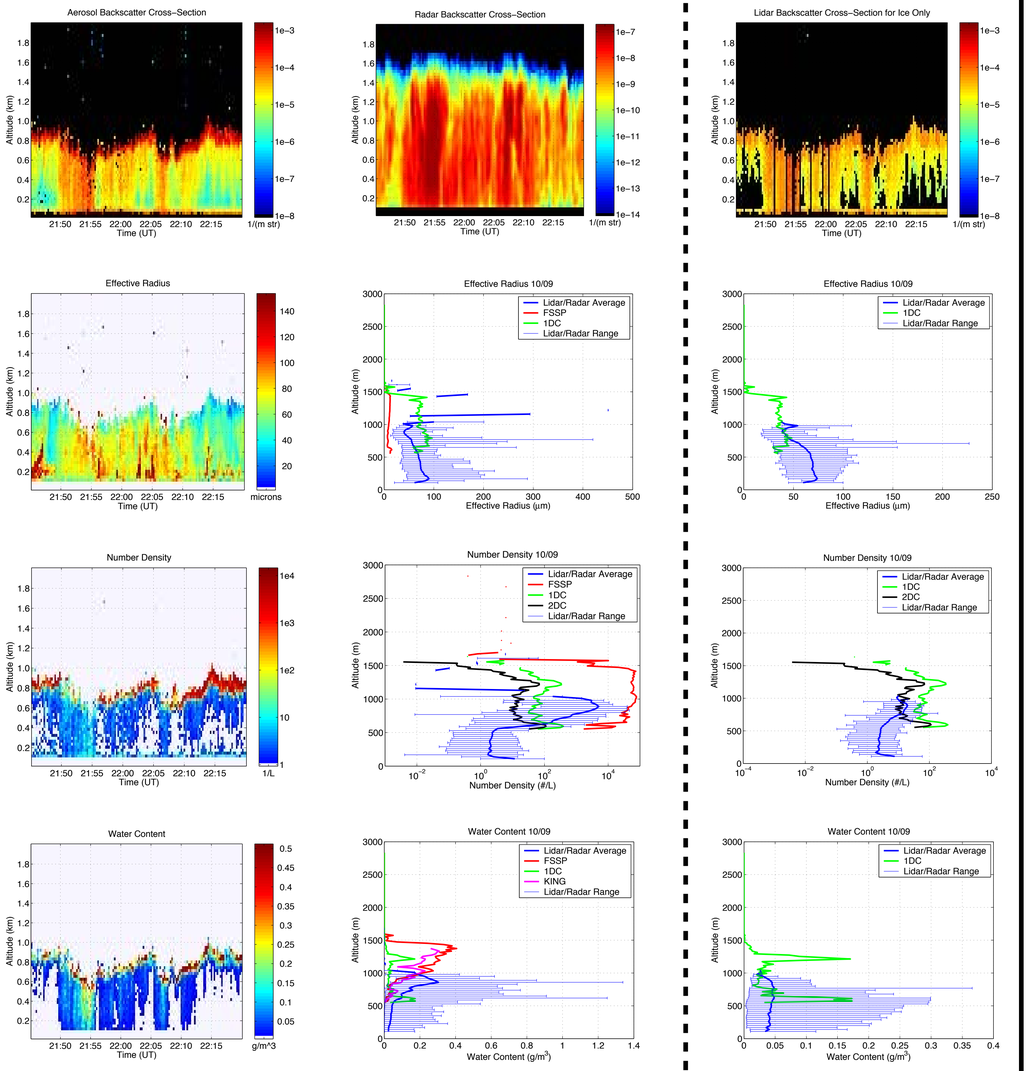
October 9, 2004



Lidar aerosol backscatter cross-section measurement, radar backscatter cross-section measurement, effective radius retrieval, number density retrieval, and water content retrieval (from left to right) for 12:00-24:00 UT on October 9, 2004.

Validation

Ice and Water

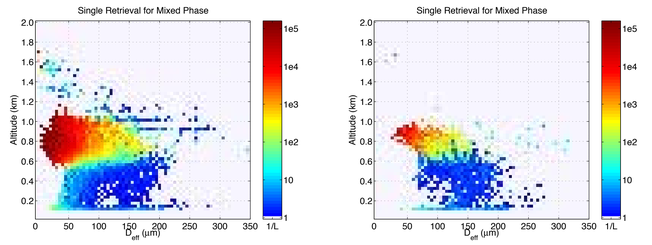


Measurement and retrieval cross-sections (top, left) for 21:45-22:17 UT on 9 October, 2004. Comparisons with aircraft measurements from that time are shown in the right hand column.

Ice Only

Similar profiles to those shown at left, but for the ice-only retrieval.

Concentration vs. Particle Size



Concentration shaded vs. particle size and altitude for 12:00-24:00 UT (left) and 21:45-22:17 UT (right) on October 9, 2004.

Distribution Model

Because we are not able to measure individual particles, we must make an assumption about the distribution of particles in the scattering volume. For the preceding examples, the following distribution has been used:

Modified Gamma Distribution

$$n(D) = aD^{\alpha} e^{-bD^{\gamma}}$$

For Example Retrievals:

$\alpha = 2 \quad \gamma = 1$

Where:

$$a = \frac{N_0 \gamma b^{\frac{\alpha+1}{\gamma}}}{\Gamma\left(\frac{\alpha+1}{\gamma}\right)}$$

$b =$ Size Distribution Parameter

$n =$ Number of Particles/Volume

$\alpha, \gamma =$ User-Provided Size Distribution Parameters

Also:

$$V = \sigma_V \frac{\pi}{6} D_r^{3-\delta_V} D^{\delta_V}$$

$$A = \sigma_A \frac{\pi}{4} D_r^{2-\delta_A} D^{\delta_A}$$

For Example Retrievals:

Water	Ice
$\sigma_V = 1$	$\sigma_V = 0.2$
$\delta_V = 1$	$\delta_V = 1$
$\sigma_A = 1$	$\sigma_A = 1$
$\delta_A = 1$	$\delta_A = 1$

Contact Information

Gijs de Boer, Department of Atmospheric and Oceanic Sciences, The University of Wisconsin - Madison, 1225 West Dayton Street, Madison, WI 53706. E-mail: gdeboer@wisc.edu