University of Wisconsin High Spectral Resolution Lidar Data Quality and Derived Optical Products from SEAC4RS

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Introduction

The HSRL technique relies on spectral discrimination between particle and molecular backscatter in the receiver using optical filters, this enables independent retrievals of backscatter and extinction without reliance on uncertain assumptions about the particle microphysics. By design the HSRL technique provides measurements that are self-calibrated requiring only the current atmospheric density profile.
HSRL data from SEAC4RS is available with automated QC flags based on signal SNR and system health status information.

Instruments

AHSRL

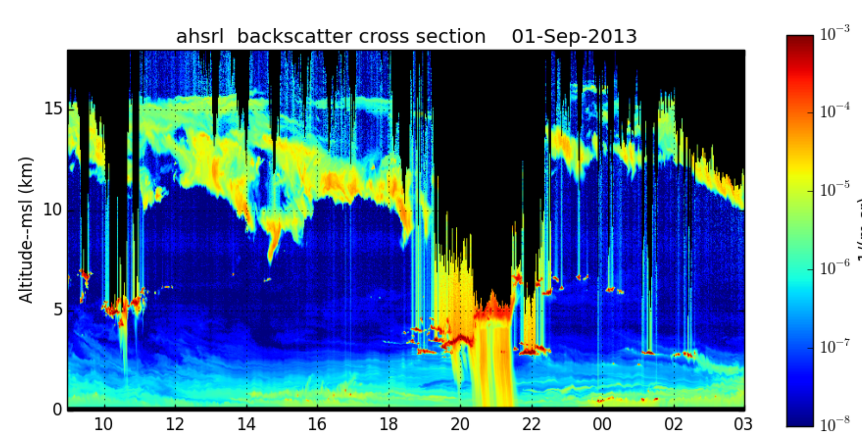
The Arctic HSRL (AHSRL) was deployed for SEAC4RS in Singapore from August 12, 2012, through September 8, 2013. This was the first generation autonomous HSRL system designed as an internet appliance and had been previously deployed in Barrow, Alaska, and Eureka, Nunavut, Canada from roughly 2004-2011.

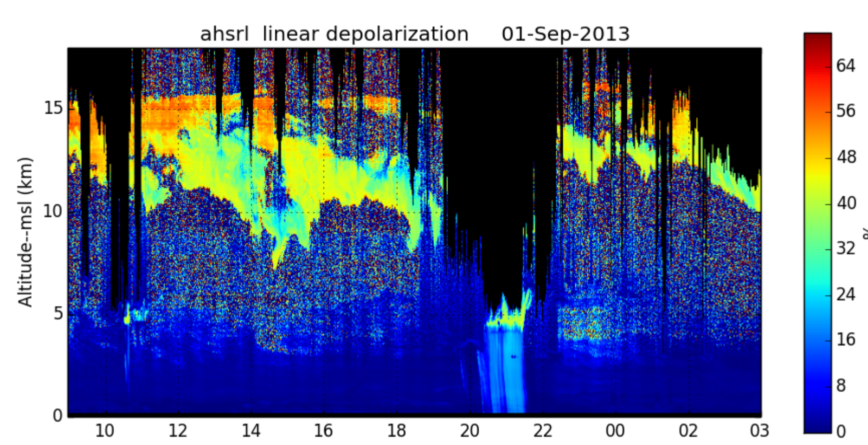
BagoHSRL

The bagoHSRL named after the UW-SSEC winnebago mobile measurement platform is our newest generation autonomous system. The bagoHSRL was deployed SEAC4RS in Huntsville, Al, from June 18 through November, 4 2013. This system has several upgrades and improvements that make calibration and quality assurance of the data products much easier than for earlier versions of the system.

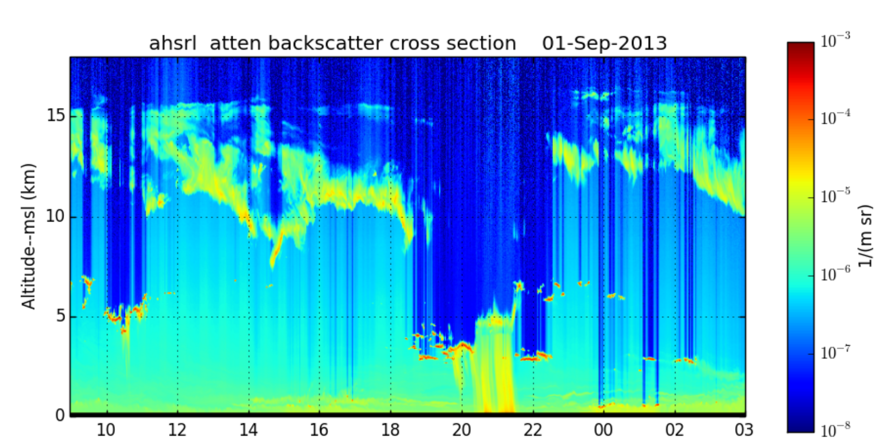
HSRL provides measurements of particulate backscatter cross section and depolarization.

AHSRL data from Singapore, Sept. 01, 2013





Compare this to the calibrated attenuated backscatter that is available from a single channel 'traditional' lidar



Acknowledgements

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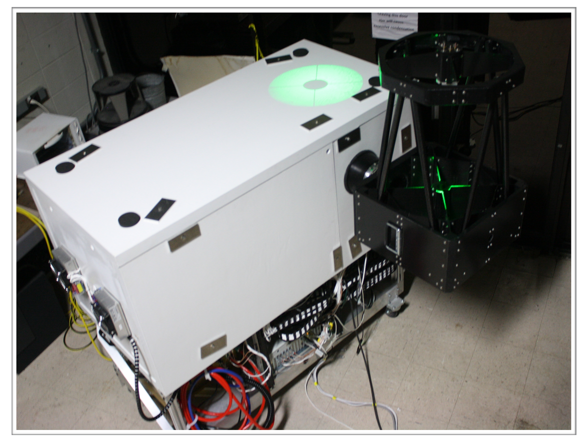
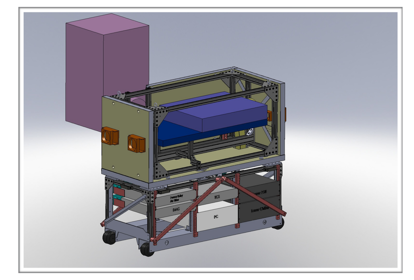
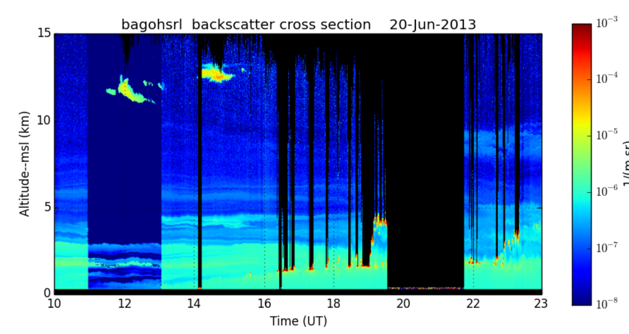
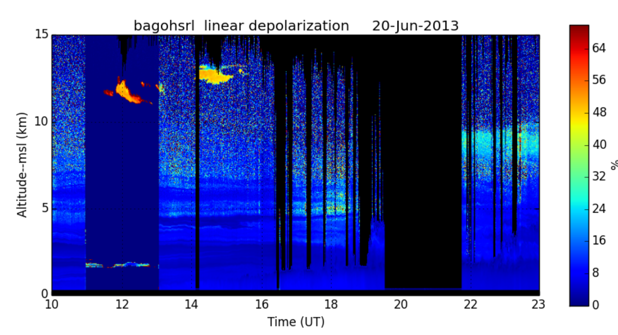




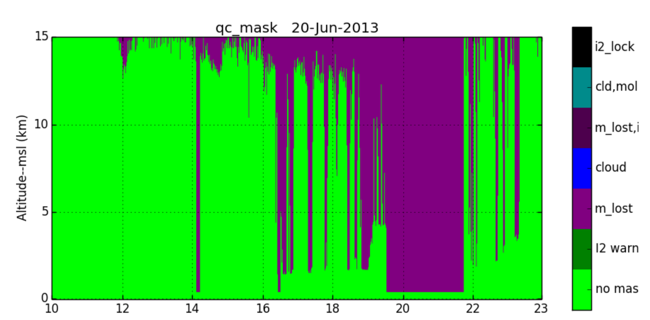
QA/QC flag examples

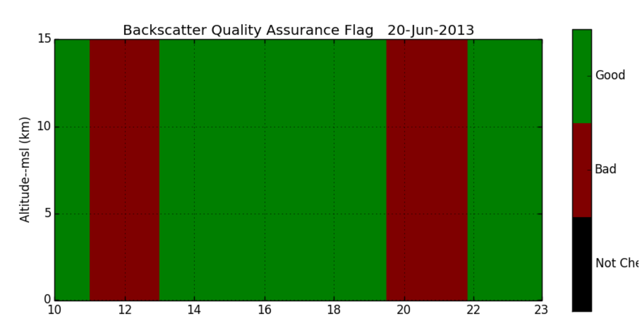




QC flags are based on quantitative measurements, in this example a low SNR in the measured molecular channel from signal attenuation is used to set a qc flag.

And QA flags based upon expert data inspection

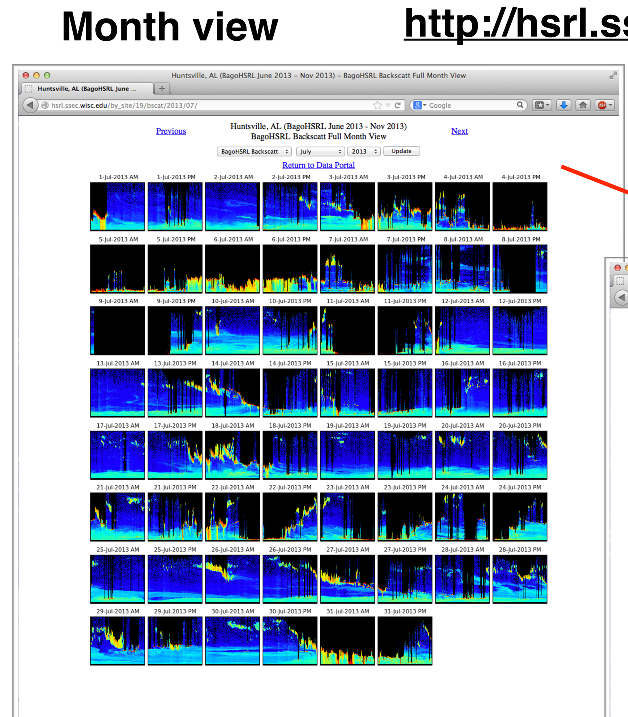




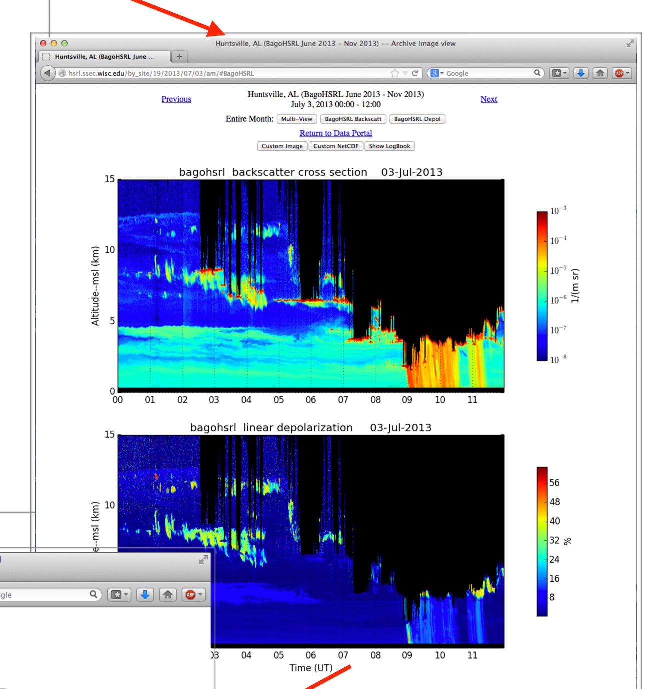
bagoHSRL data from June 20, 2013 while system was still be set up after deployment

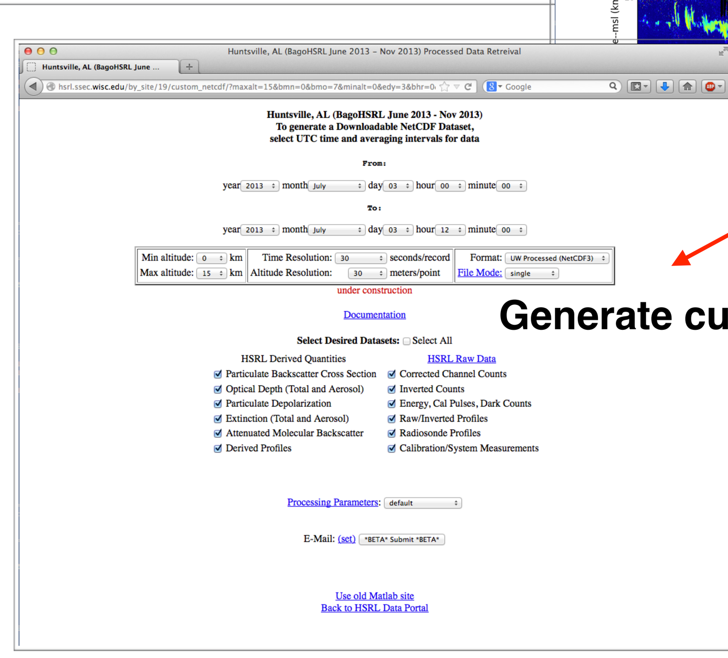
Getting the data
http://hsrl.ssec.wisc.edu

Month view



Quick looks



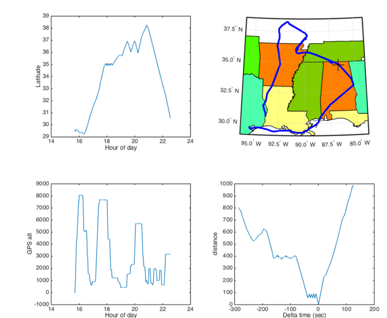


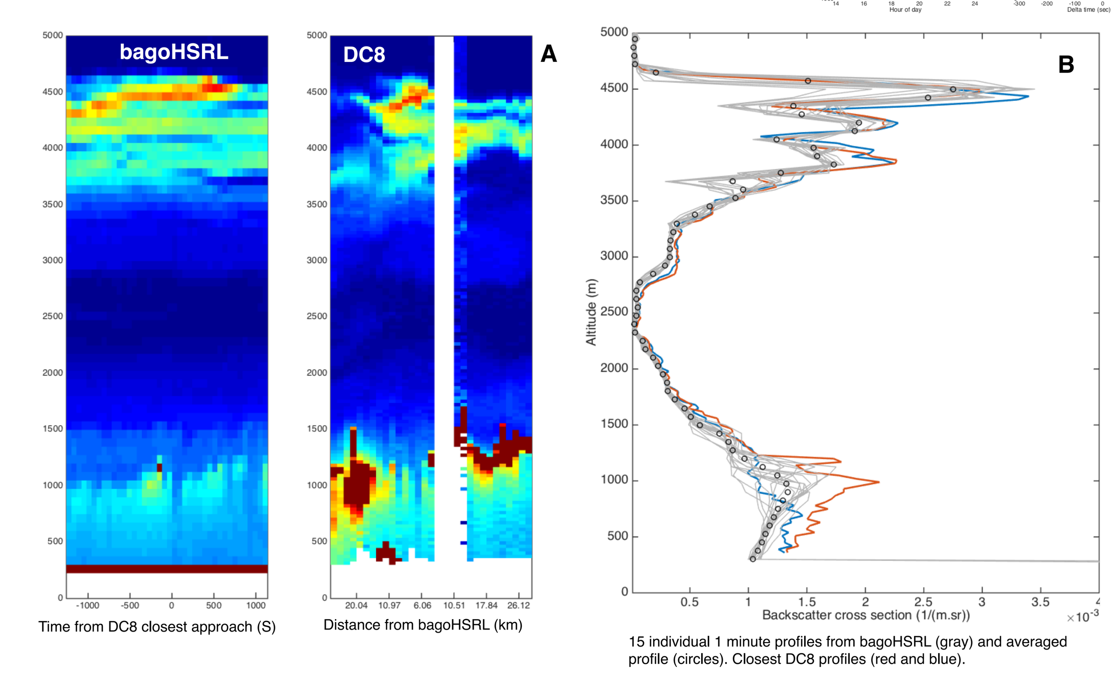
Generate custom data or images

Data Availability

Singapore: 8/23/12 - 9/8/2013
Huntsville, Al, USA: 6/19/2013 - 11/4/2013
http://hsrl.ssec.wisc.edu

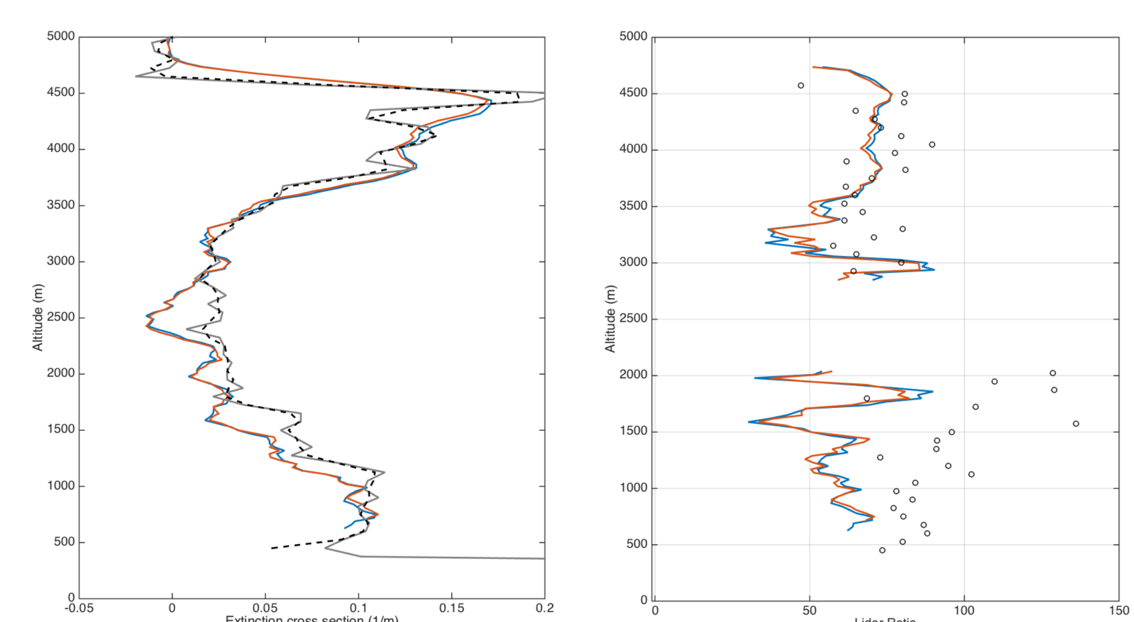
NASA Langley HSRL (DC8) and bagoHSRL comparison August 14, 2013





15 individual 1 minute profiles from bagoHSRL (gray) and averaged profile (circles). Closest DC8 profiles (red and blue).

HSRL comparisons are somewhat rare, and during SEAC4RS there were a few opportunities for the DC8 to overfly the bagoHSRL in Huntsville. The bagoHSRL observed few boundary layer clouds however for most of the flight within 30 km of the ground site clouds were encountered, this makes direct comparisons of aerosols more difficult. The backscatter cross-section comparisons are quite good between instruments, we've shown 15 1-minute profiles from the bagoHSRL to show temporal variability in the boundary layer (figure B, gray lines), as well as two profiles from the DC8 HSRL from the closest approach to Huntsville.

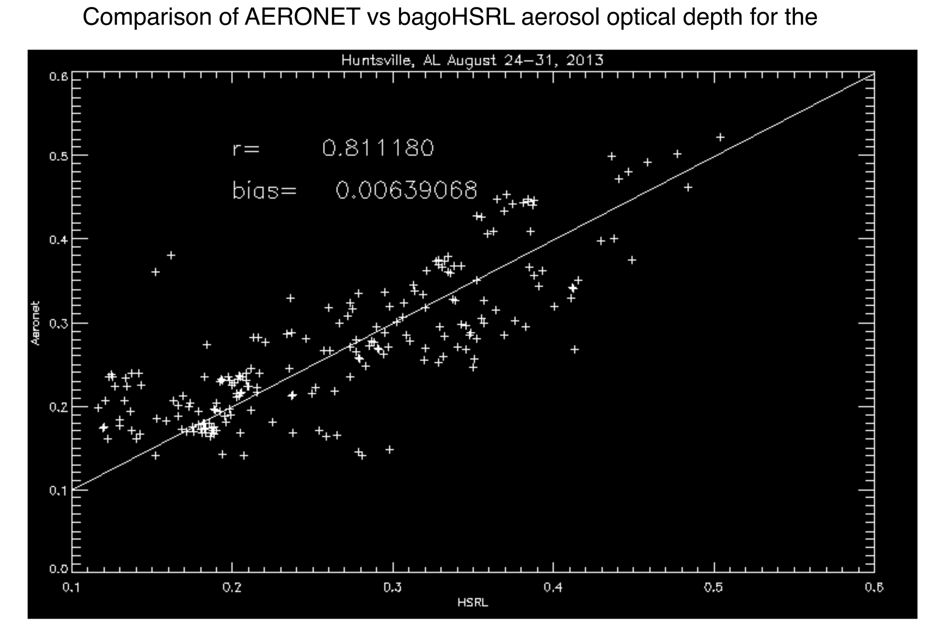


Extinction cross section and lidar ratio (ratio of the extinction to backscatter cross-sections), comparisons are also encouraging, especially for the elevated aerosol layer between 3.5 and 4.5 km. However the comparisons do highlight an outstanding challenge with the data from the bagoHSRL system. The bagoHSRL uses a very narrow receiver FOV, ~100urad, to minimize the contribution from multiple scattering in ice clouds. The consequence is that the field stop is not completely filled at close ranges and the iodine absorption channel (i.e. molecular) must be corrected for this effect. We are still currently working on an algorithm to actively correct for changes in the overlap correction on an hourly basis.

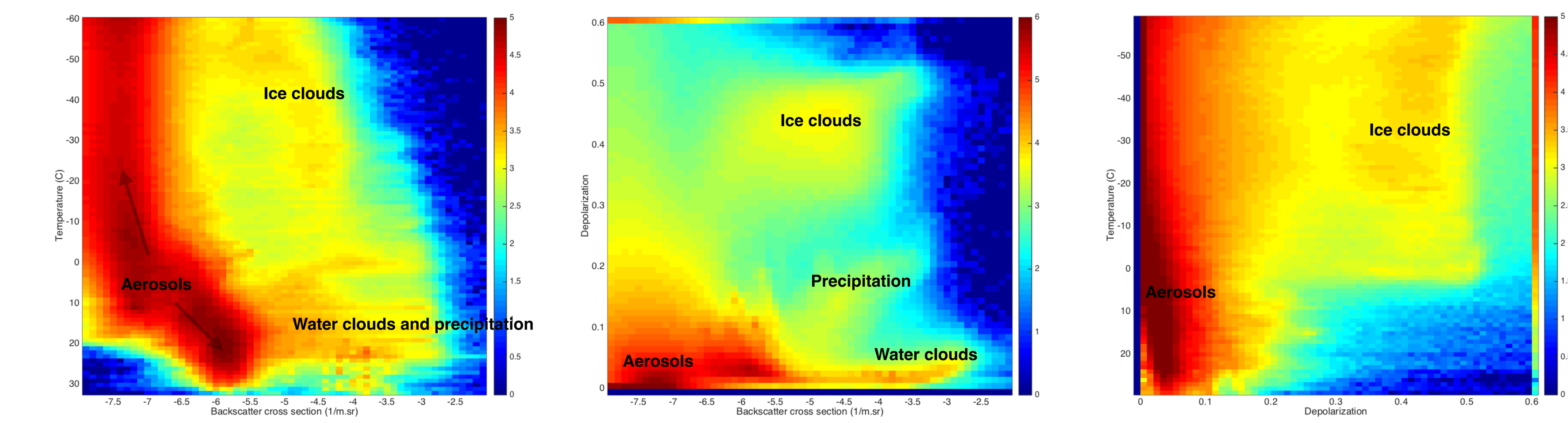
AERONET vs bagoHSRL

co Brad Pierce, NOAA

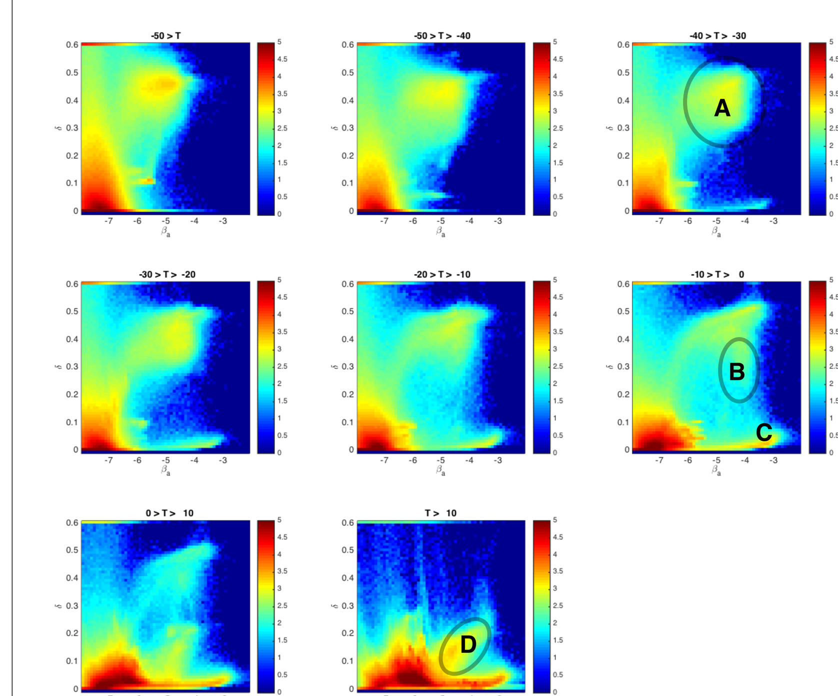
Comparison of AERONET vs bagoHSRL aerosol optical depth for the



Feature classification and development of a HSRL level 2 product



Three views of backscatter cross section, depolarization, and temperperature statistics



Two dimensional histogram of depolarization vs backscatter cross-section (log10) for different temperature regimes (T is in Celsius). Number concentration, i.e. intensity, is on a log10 scale. Annotated regions correspond to ice-clouds (A), melting ice-cloud that is precipitating (B), water clouds (C) and liquid precipitation (D). See text for further information.

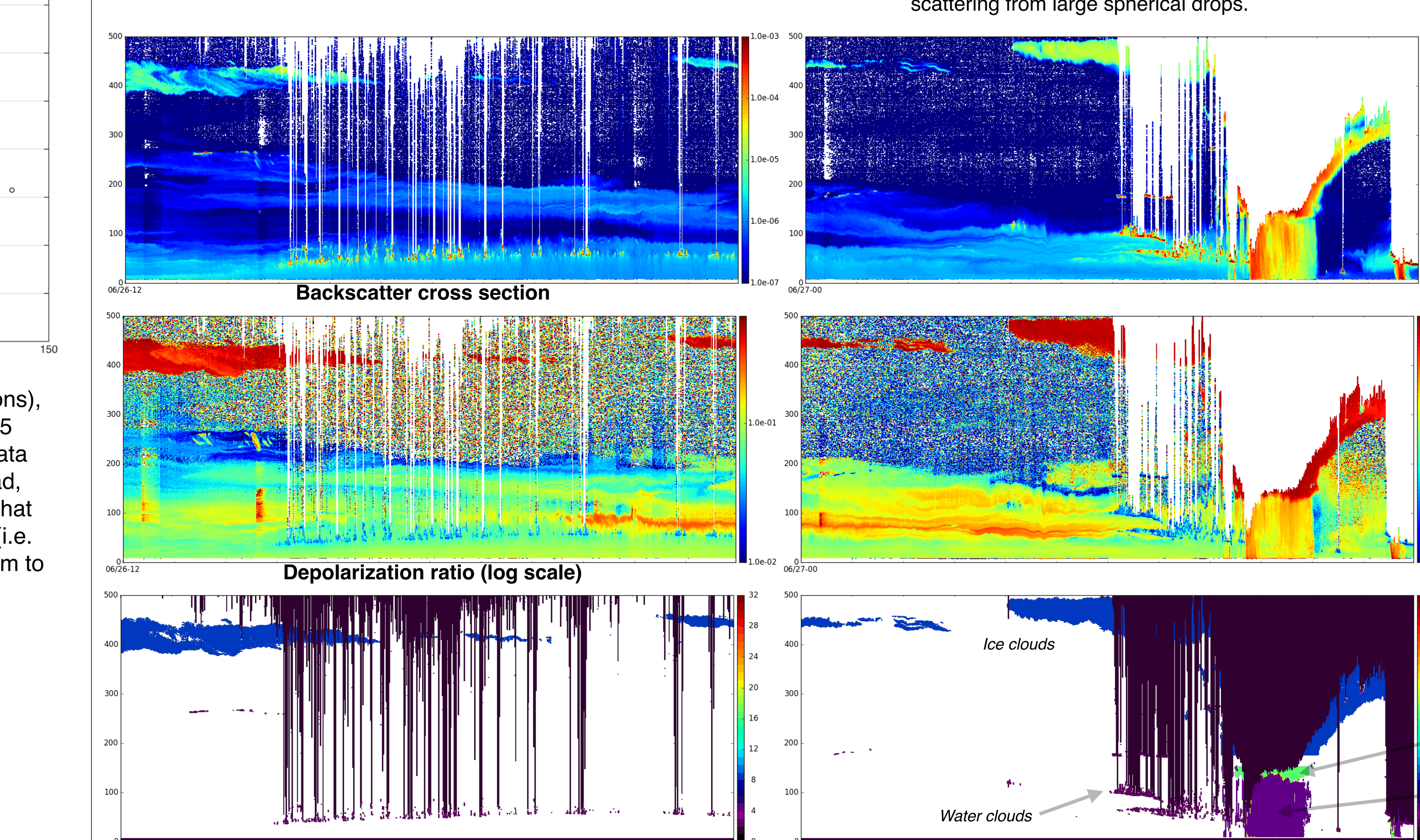
We've made significant progress in developing a layer classification scheme as well as a CALIPSO like level 2 product for the HSRL systems. The figures here (above and left) show statistics of individual range bins (30m) at a one minute time resolution for the entire Huntsville SEAC4RS campaign. QA and QC filters, in particular the molecular signal lost filter was applied. The molecular signal lost is valuable for filtering out low SNR data from above fully attenuating features.

We discriminate between:

- **Clouds vs aerosols**
- **Cloud phase: Ice, water, precipitating ice clouds**
- **Precipitation**

The classification of 'features' in HSRL data is done on a range bin-by-range bin basis rather than by scanning each profile. We've found that with the typically high SNR and up-looking orientation of the HSRL this allows for more flexibility in both finding and classifying features.

In the figure on the left backscatter vs depolarization (β vs. δ) are shown for different temperature regimes:, non-precipitating ice clouds dominate the region indicated by 'A', these clouds are not found below the freezing level and depolarization and backscatter cross-sections are tightly constrained around 0.4 and 1x10^(-5) (m*sr-1), respectively. Depolarizing aerosols at higher altitude typically have backscatter cross-sections below 1x10^(-6) (m*sr-1). Melting ice clouds are found in the temperature range -20 to 0 C. Backscatter cross-sections are high ~ 1.0x10^(-4) (m*sr-1) and depolarization are quite variable, from 0.1 to 0.55. The variability in depolarization can be explained by the contribution from multiple scattering at high depolarizations, to large quantities of liquid drops or melting ice at lower depolarizations. Almost all of these clouds are associated with moderate to high precipitation rates. Water clouds dominate the area indicated by 'C', low to no depolarization and large backscatter cross-section values. Note that the depolarization increases at very high backscatter values from the increase in multiple scattering at high extinction values. Also note that none of these water clouds are found below -40 C. Finally, area 'D' denotes liquid precipitation, these are all 'warm' features, above 0 C, and depolarization increases exponentially with backscatter because of the increase in multiple scattering from large spherical drops.



The regions, as described above are, used to separate the point measurements into 4 different feature masks for the different types: water clouds, ice clouds, melting ice clouds, and precipitation.

From the feature mask the following are reported:

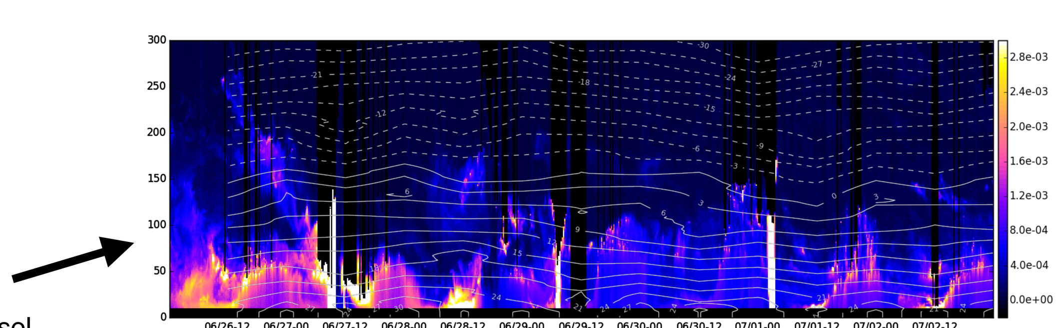
- Cloud top and bases
- Layer properties, backscatter and extinction cross sections, depolarization, temperature, etc. of the features are calculated.

Threshold values are shown below:

- Water cloud: β > 1.45x10^(-5), δ < line defined by y=m*x+b, where m = 0.0545, b= 0.2936, b is the log10 of β.
- Ice cloud: β > 1.87x10^(-5), 0.3 < δ < 0.58, T < -5 C.
- Ice cloud, precipitating: β > 1x10^(-5), 0.26 < δ < 0.53, T > 0 C
- Precipitation: β > 1x10^(-5), 0.08 < δ < 0.3, T > 0 C

These figure above show a 24 segment of data bagoHSRL data, backscatter cross section (top), depolarization (middle), and our new feature mask (bottom). Blue is ice clouds, water clouds are two different shades of purple, and green is precipitating ice cloud. Near-black is no-signal.

For the aerosols we provide an average cloud-cleared backscatter cross-section profile rather than a layer product. This provides the data user with the most flexibility, as defining tops and bases of aerosol layers is increasingly difficult, as these depend entirely on what one uses as a threshold in backscatter as an aerosol. This is evident from the image on right which shows one week of cloud-cleared aerosol backscatter there is indeed very little 'clear air'.



Cloud-cleared aerosol backscatter cross section product for one week in Huntsville. Overlay contours are temperature from 0z and 12z soundings in Birmingham, AL.