Raman Lidar and HSRL Measurements of Aerosol and Water Vapor Variability

Richard Ferrare[1], Marian Clayton[2], Dave Turner[3], Chitra Sivaraman[4], Wenying Su[2],
Chris Hostetler[1], John Hair[1], Mike Obland[1], Ray Rogers[1], Amy Swanson[2], Anne Jefferson[5]
[1] NASA Langley Research Center, Hampton, VA, USA; [2] Science Systems and Applications, Inc., Hampton, VA, USA
[3] NOAA NSSL, Norman, OK, USA ; [4]PNNL, Richland, WA; [5]NOAA GMD, Boulder, CO, USA

Background

- Satellite, airborne, and surface sensors have noted significant changes in aerosol properties in transition zones near clouds
- 3D radiative effects can hamper passive remote sensing retrievals of aerosols near clouds
- Satellite-derived estimates of direct aerosol radiative forcing can be biased 35-65% low unless these estimates correctly sample the regions within a few kilometers from clouds where aerosol humidification increases aerosol optical thickness

Questions

- How do aerosol optical and physical properties vary near clouds?
- How are these variations related to changes in relative humidity?
- How well can we use lidar to measure or infer these variations?

Approach

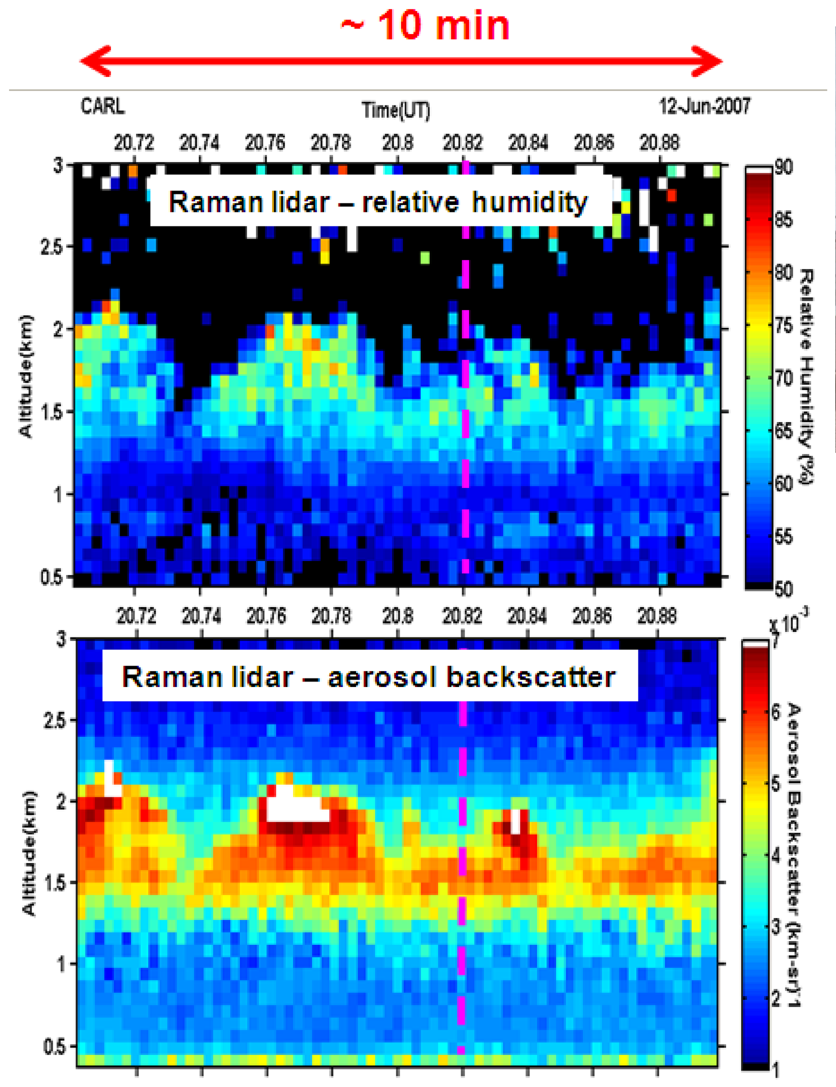
SGP Raman lidar aerosol and water vapor measurements and NASA Langley Research Center airborne High Spectral Resolution Lidar (HSRL) measurements acquired during the Cumulus Humilis Aerosol Processing Study (CHAPS-June 2007) and Routine ARM Aerial Facility (AAF) Clouds with Low Liquid Water Depths (CLOWD) Optical Radiative Observations (RACORO-June 2009) campaigns are used to investigate aerosol hygroscopicity and variations in aerosol properties near clouds in the daytime boundary layer.

Summary

- Raman lidar data show increases in relative humidity (5-10%) near clouds
- Raman lidar and HSRL measurements show increases in aerosol extensive parameters (backscatter (20-40%), AOT (5-10%)) near clouds; these increases appear consistent with observed increase in RH near clouds
- Decreases in aerosol depolarization near clouds (10-20%) suggest that aerosols become more spherical with higher RH near clouds
- Variations in aerosol properties and RH are largest at or within about 200 m below cloud base
- Aerosol humidification factor (f(RH)) derived from Raman lidar data 1-2 km above the surface is consistent with that derived from surface in situ measurements

Lidars

DOE ARM Raman Lidar



ARM SGP TSI
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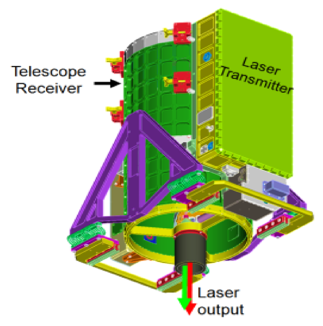
NASA Langley Research Center Airborne High Spectral Resolution Lidar (HSRL)



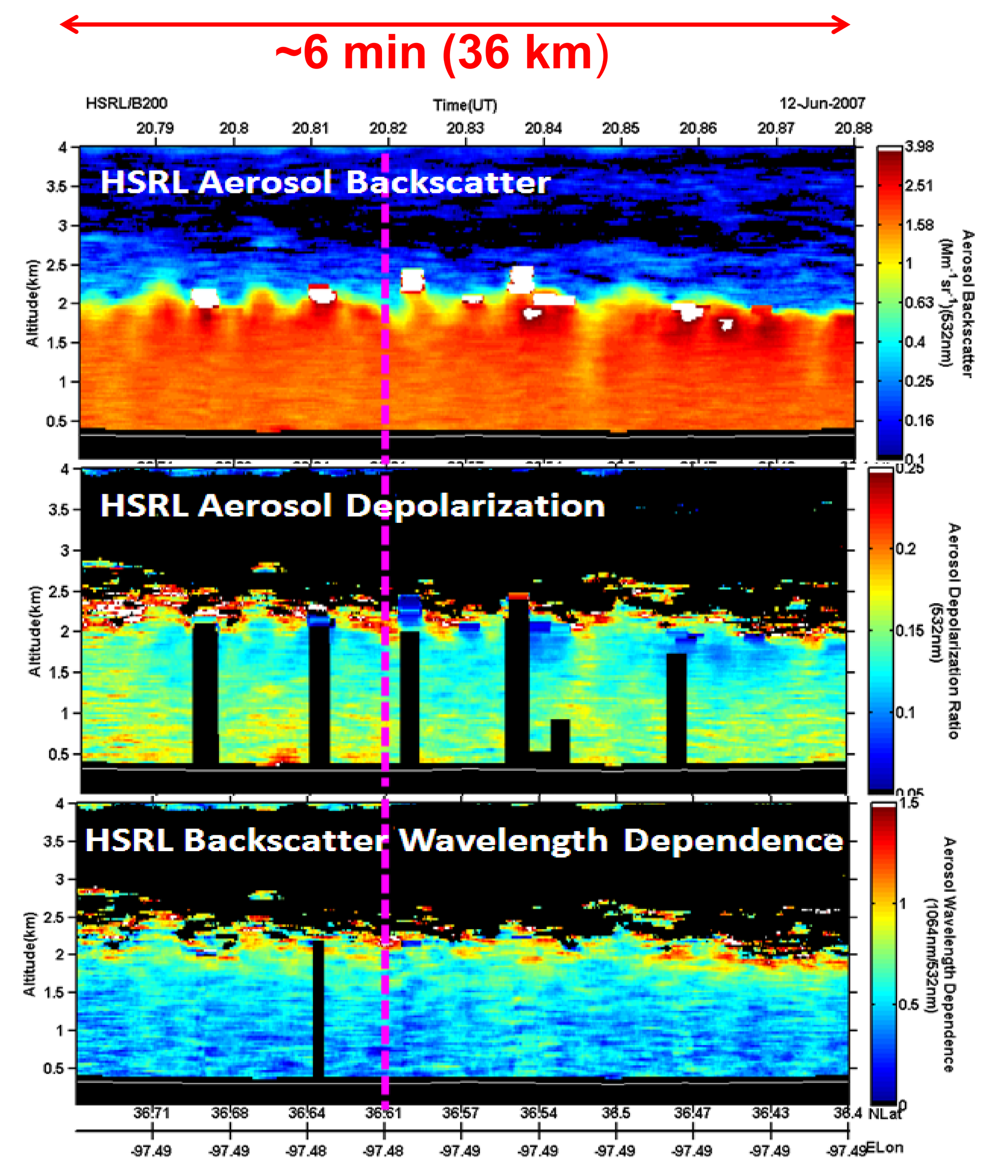


Image from digital camera on NASA B200 King Air

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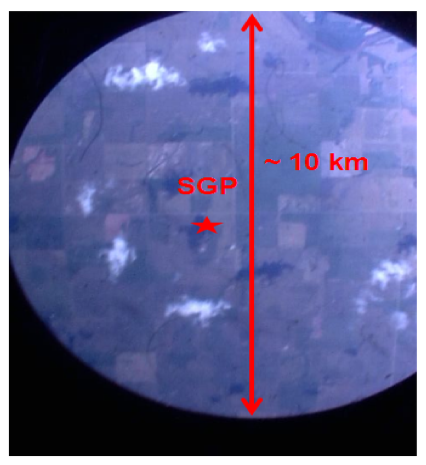
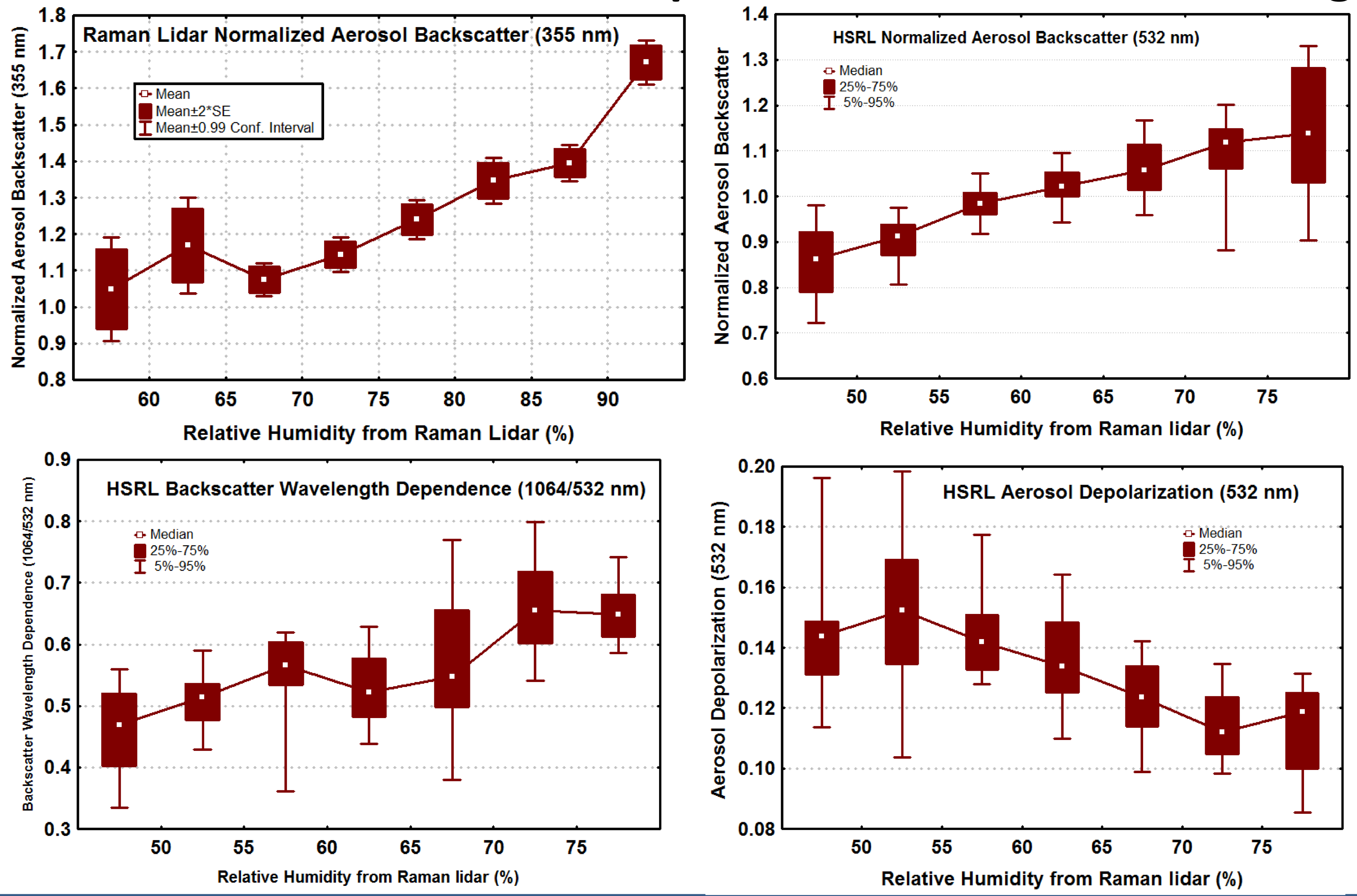
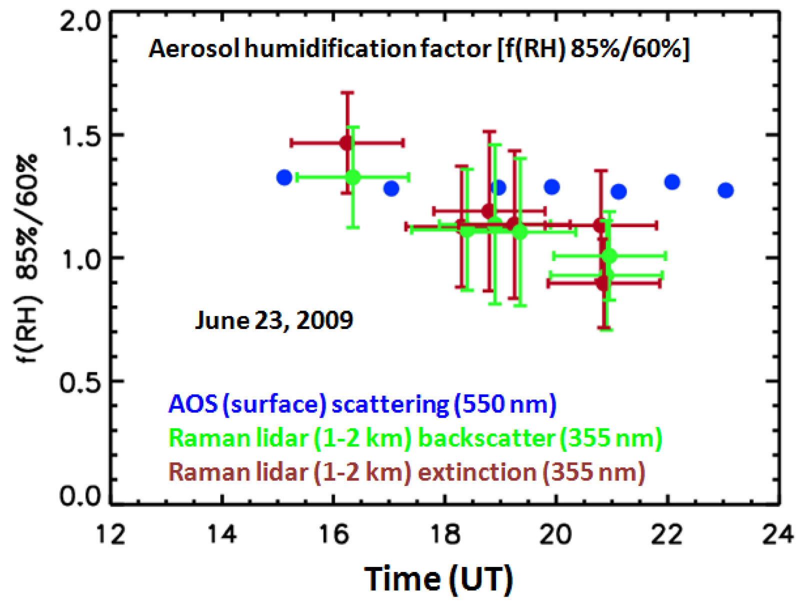


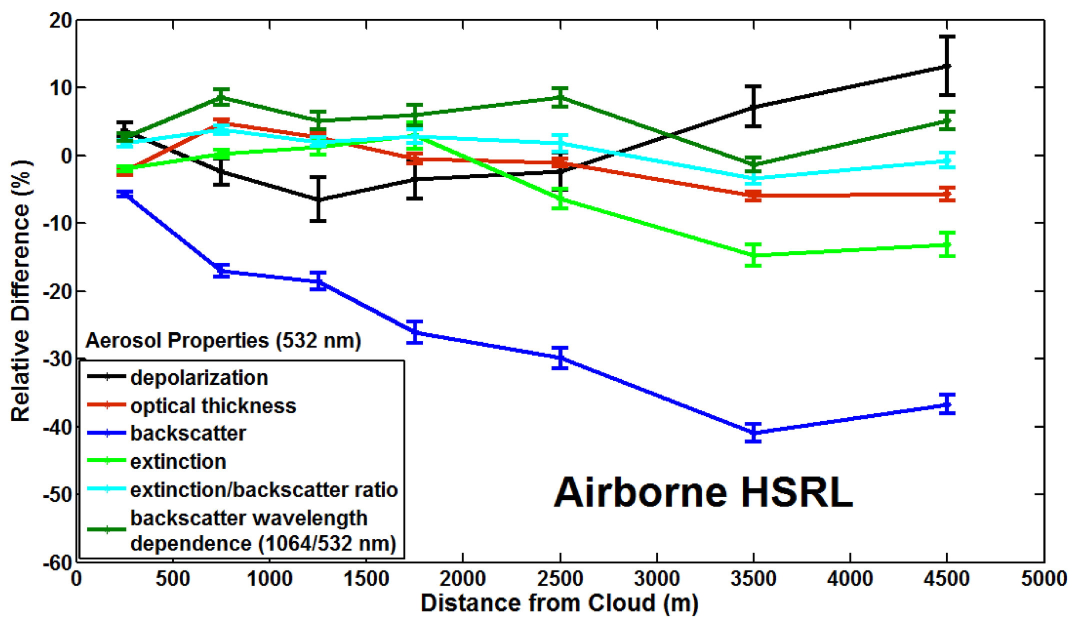
Variations in Aerosol Properties Associated with Changes in Relative Humidity

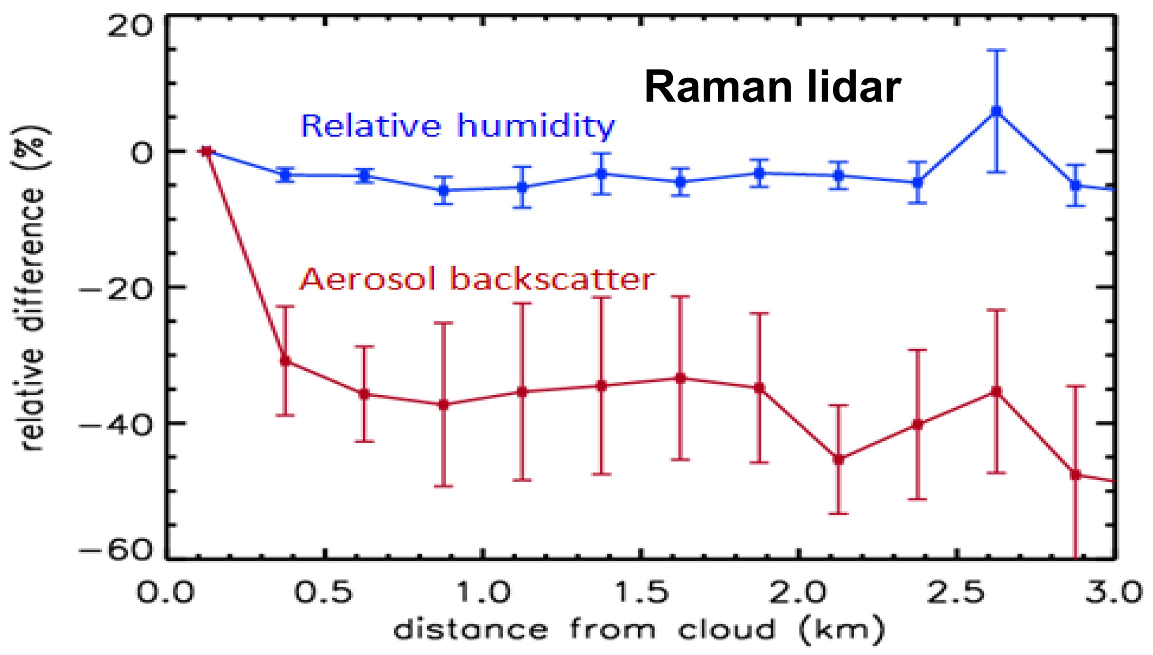


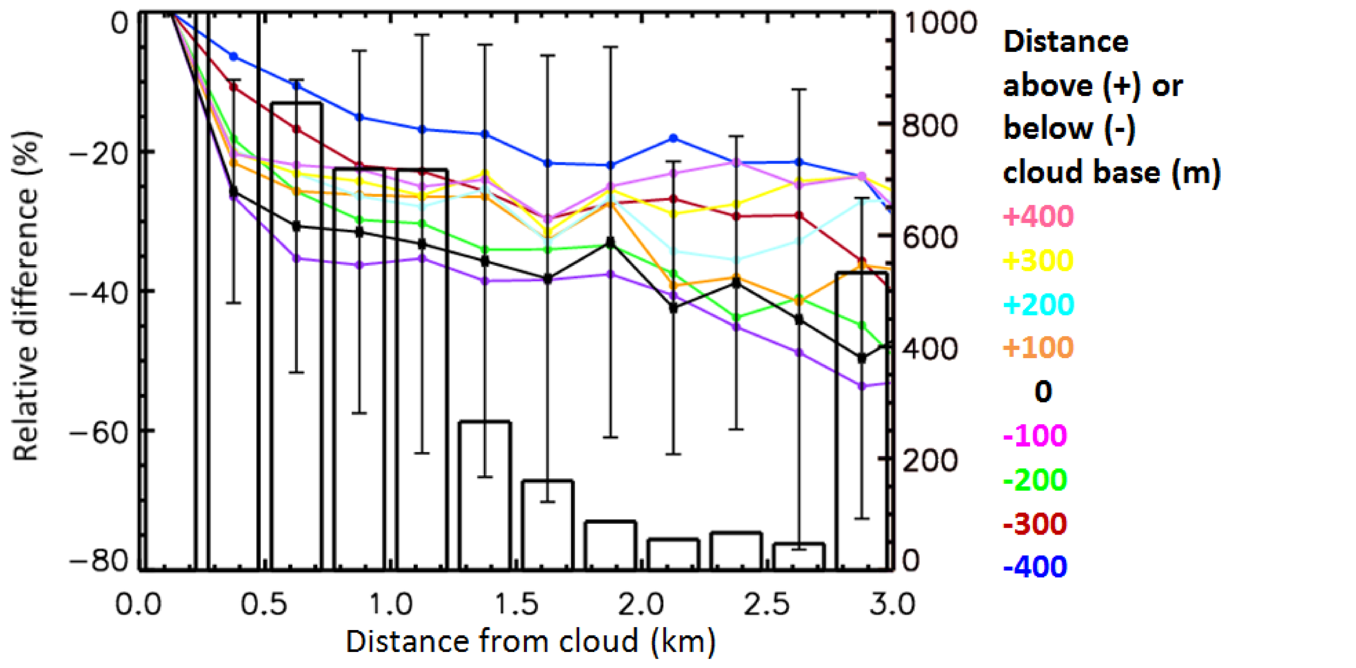


- Increases in aerosol backscatter with RH near the top of the boundary layer
- Aerosol humidification factor, f(RH), appears consistent with measurements made by surface in situ instruments
- HSRL measurements suggest that as the RH increases, aerosols become more spherical and that a larger fraction of scattering comes from accumulation mode aerosols.

Aerosol and Water Vapor Variability Near Clouds







- Variations in aerosol properties and relative humidity near clouds measured by airborne HSRL (top left) and Raman lidar (bottom left). Raman lidar data show increases in relative humidity (5-10%) near clouds. Raman lidar and HSRL measurements show increases in aerosol extensive parameters (backscatter (20-40%), AOT (5-10%)) near clouds.
- Decreases in aerosol depolarization near clouds (10-20%) suggest that aerosols become more spherical with higher RH near clouds
- Variations in aerosol properties and RH are largest at or within about 200 m below cloud base (top right)

Acknowledgements

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