Aerosol Variability Near Clouds During CLASIC/CHAPS

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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?

Background

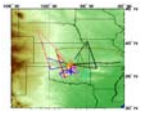
- Satellite, airborne, and surface sensors have noted significant changes in aerosol properties in transition zones near clouds ("Twilight Zone", Koren et al., 2007)
- 3D radiative effects can hamper passive remote sensing retrievals of aerosols near clouds (Wen et al., 2007)
- Satellite-derived estimates of direct aerosol radiative forcing will 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 (Twohy et al., JGR, 2009)

Lidars

DOE ARM SGP Raman Lidar

- Water vapor, aerosol, depolarization profiles
- Precipitable water vapor and aerosol optical thickness (355 nm)
- Continuous, autonomous (24/7) operation
- Hardware (2004) and software (2006-2007) upgrades permit rapid (10 sec – 1min) water vapor and aerosol profiles
- Temporal resolution: 10 sec (RH, backscatter)
- Vertical resolution: 75 m (possible to go to higher resolution)

NASA LaRC Airborne High Spectral Resolution Lidar (HSRL)

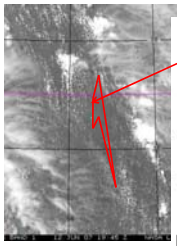


- Deployed on NASA B200 King Air (~9 km)
- Independently measures aerosol backscatter, extinction, and optical thickness
- Nadir "curtain" files of aerosol backscatter and depolarization (532, 1064 nm) and extinction (532 nm)
- Temporal resolution: 2 sec
- Vertical resolution:
  - 30 m backscatter
  - 300 m extinction
- Averaged data within +/- 60 m of cloud top

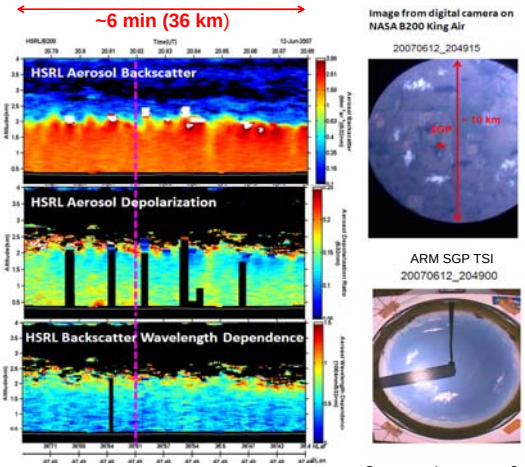
Approach

- Use combination of advanced ground (SGP Raman Lidar) and airborne (NASA/LaRC HSRL) lidars, and airborne in situ measurements (G-1, Twin Otter) acquired during CLASIC/CHAPS to investigate aerosol properties near clouds
- Aerosol properties and RH adjacent to cloud edge are compared with properties some distance away from cloud edge

HSRL measurements acquired over SGP Raman lidar on June 12, 2007 during DOE CHAPS/CLASIC mission to investigate changes in aerosol optical properties

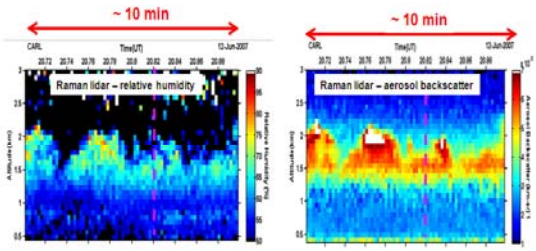


B200 flight track color coded by AOT from HSRL



HSRL measurements show variations in aerosol properties near top of PBL over SGP site

Camera images of clouds over SGP on June 12

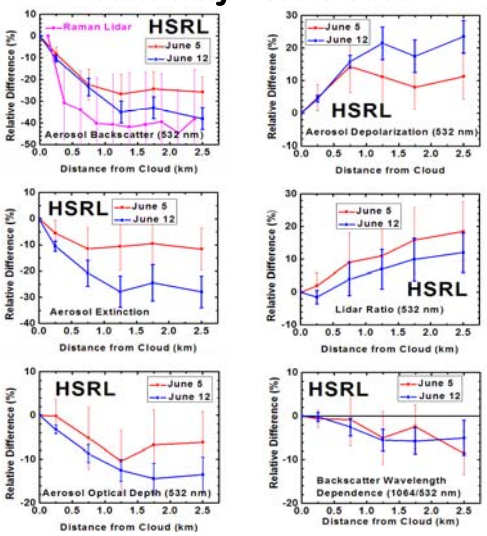


Raman lidar measurements show increases in aerosol backscatter and RH at top of PBL near clouds

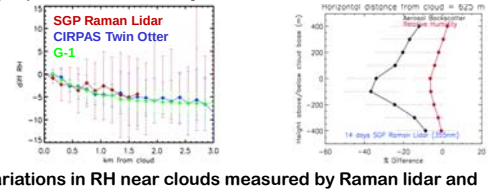
Summary

- Lidar measurements show increases in aerosol extensive parameters near clouds; these increases appear consistent with observed increase in RH near clouds
- Increases in relative humidity (5-10%) near clouds
- Increases in aerosol backscatter (20-40%) and optical depth (8-17%) near clouds (within few km)
- Decreases in aerosol depolarization near clouds (10-20%) consistent with aerosols becoming more spherical with higher RH near clouds
- Aerosol humidification can not explain decrease in lidar ratio near clouds
- Variations in aerosol properties and RH confined to altitudes between ~200-400 m above/below cloud base
- Aircraft in situ measurements show small increases in coarse mode particles near clouds

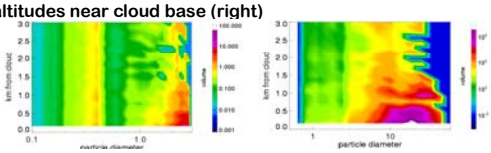
Variability Near Clouds



Variations in aerosol extensive (left) and intensive (right) properties measured by HSRL and Raman lidar



Variations in RH near clouds measured by Raman lidar and airborne in situ are consistent (left); variations are confined to altitudes near cloud base (right)



Particle volume size distribution as a function of distance from cloud measured by PCASP (left) and CAS (right) on G-1

Acknowledgements

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