Aerosol and Water Vapor Measurements Acquired by the Upgraded SGP Raman Lidar During ALIVE

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1. Background

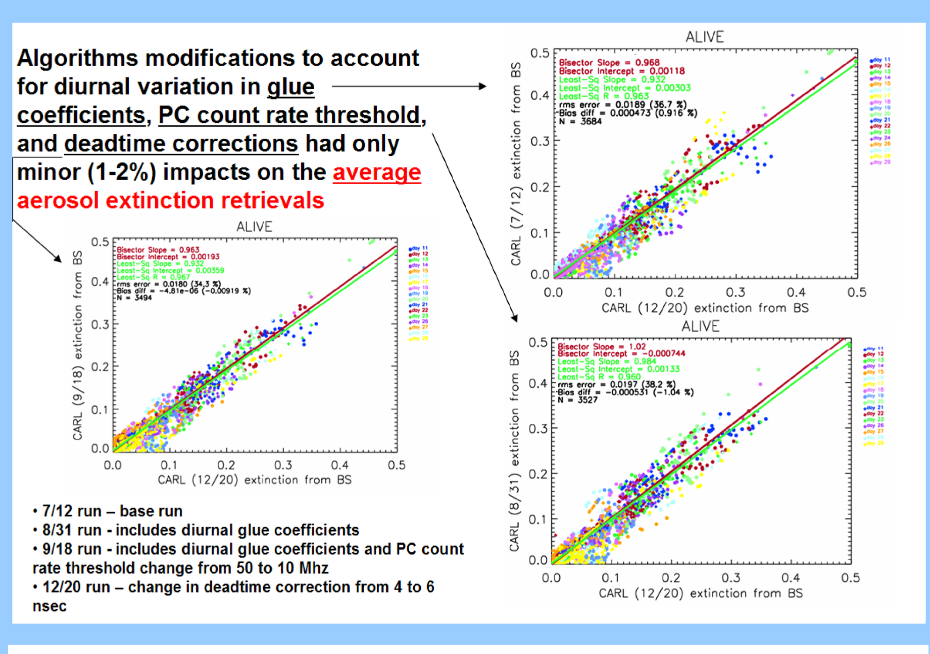
During 2004, the SGP Climate Research Facility (CRF) Raman lidar (CARL) was upgraded and modified in several ways to increase its sensitivity and improve and/or extend the aerosol extinction and water vapor retrievals. A major objective of the DOE ARM Aerosol Lidar Validation Experiment (ALIVE), which was conducted during September 2005, was to evaluate the impact of these modifications and upgrades on the CARL measurements of aerosol extinction and water vapor. The computation of the CARL aerosol extinction and water vapor profiles required extensive modifications to the CARL algorithms and software as a result of these modifications and upgrades. These modifications and their impacts on the aerosol and water vapor profile retrievals are presented here.

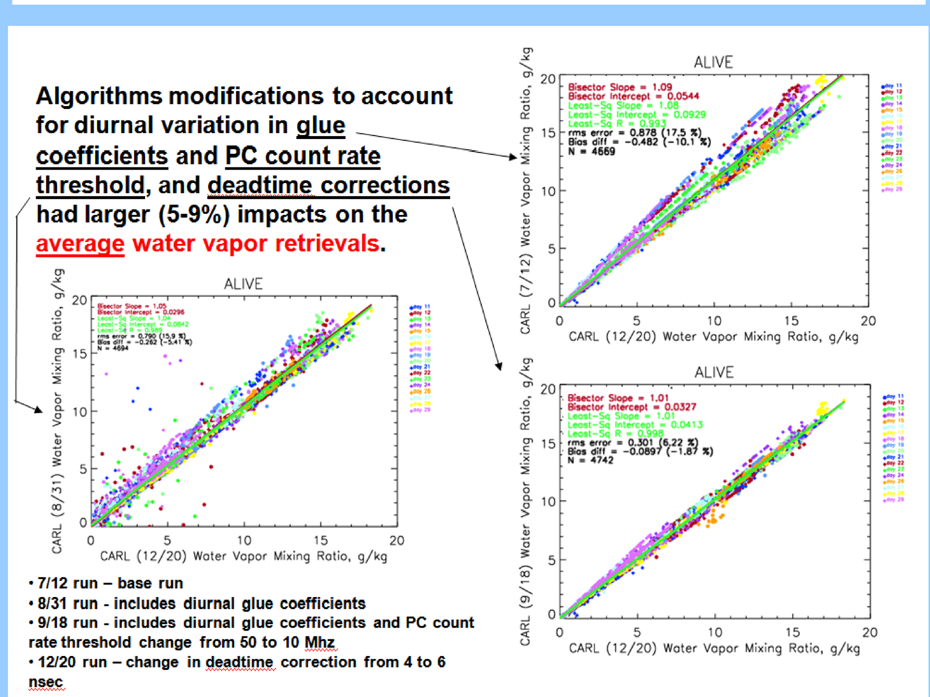
2. CARL Algorithm Modifications

Computation of CARL aerosol and water vapor profiles for ALIVE required extensive modifications to CARL algorithms to account for changes/upgrades made to CARL hardware. Changes were made to:

- Combine analog-to-digital (A/D) and photon counting (PC) mode data via "glue" coefficients. This required:
  - determine appropriate range of PC data rate
  - remove cloud contamination
  - remove long term trends
  - account for diurnal variation
  - determine appropriate PC count thresholds
- Modify water vapor calibration methods
- Determine aerosol and water vapor overlap functions for low altitude measurements
- Modify cloud screening

➢ Algorithm modifications
- ➢ significantly affected <u>instantaneous</u> aerosol & water vapor profiles
- ➢ caused only minor (1-2%) impacts on the <u>average</u> aerosol extinction profiles
- ➢ caused more significant (~10%) impacts on the <u>average</u> water vapor profiles



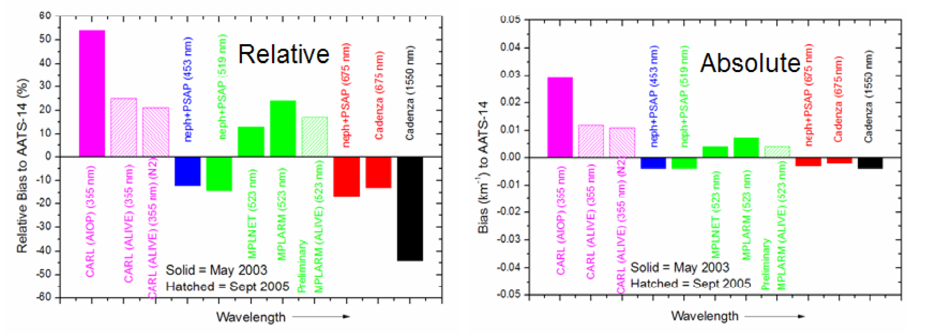


3. Key Findings from ALIVE Comparisons

Upgrades and modifications significantly improved the accuracy of the CARL aerosol measurements

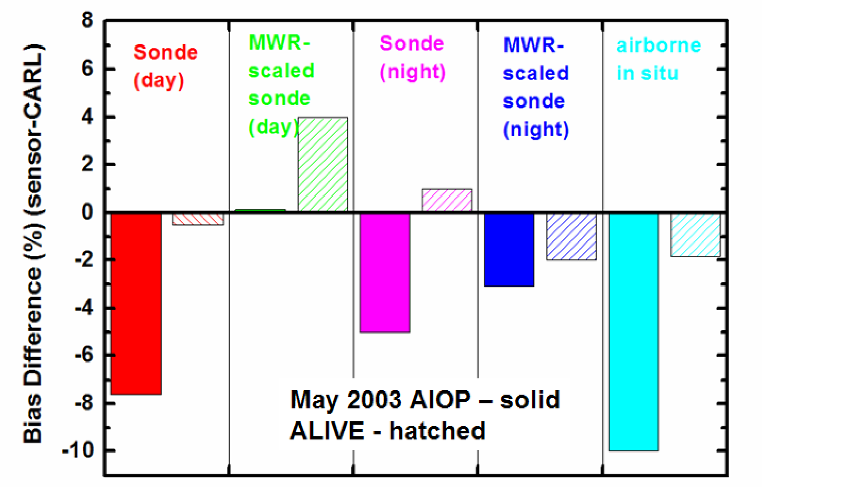
ALIVE: Better Agreement in Aerosol Extinction

- CARL modifications significantly improved accuracy and temporal resolution of aerosol measurements
- CARL aerosol extinction bias was about a factor of two lower than the bias derived from May 2003 Aerosol IOP
  - Bias was 0.011-0.014 km-1 (20-30%) higher than AATS14 aerosol extinction (355 nm)
  - This bias is about 10% of the annual median value of aerosol extinction within the lowest kilometer



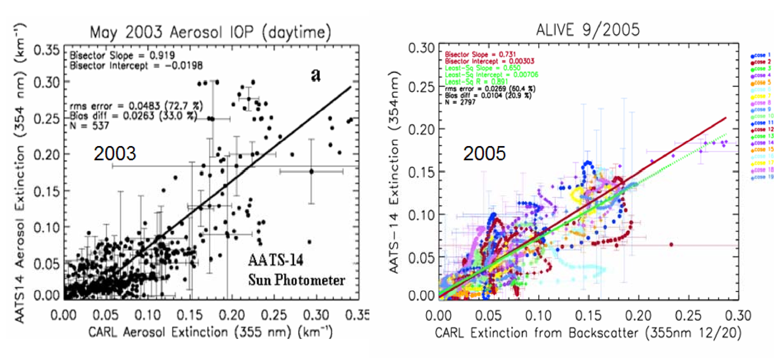
ALIVE: Better Agreement in Water Vapor

- General improvement in water vapor measurements
- CARL water vapor within +/- 3 % of scaled or unscaled sondes
- Diurnal differences remain
- Airborne in situ sensor still slightly drier (~2%) drier than MWR scaled CARL or sonde



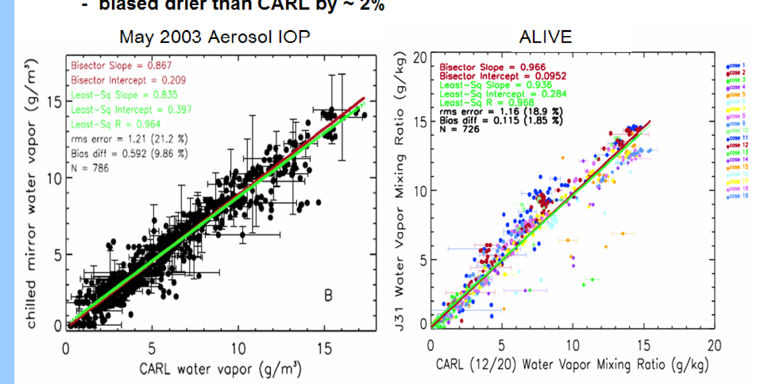
CARL vs. AATS14 aerosol extinction (May 2003 AIOP and September 2005 ALIVE)

During ALIVE, bias errors reduced by 30-50% to about 0.015 km-1



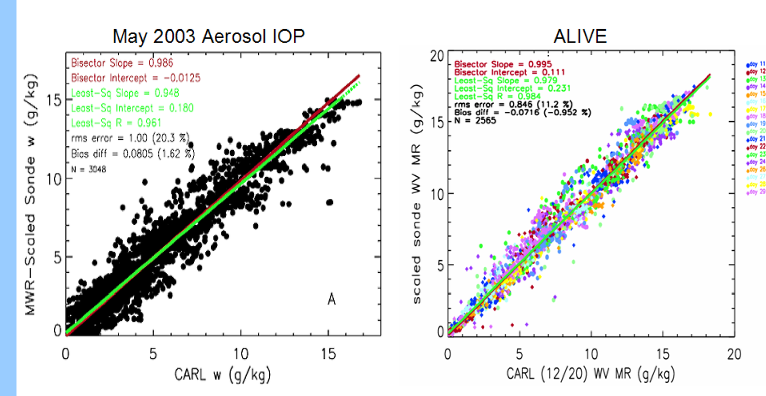
CARL vs. airborne in situ water vapor (May 2003 AIOP and September 2005 ALIVE)

- May 2003 Aerosol IOP – Edgetech chilled mirror on CIRPAS Twin Otter - biased drier than CARL by ~10%
- ALIVE – Vaisala HMP243 capacitive sensor on Sky Research J-31 - biased drier than CARL by ~ 2%



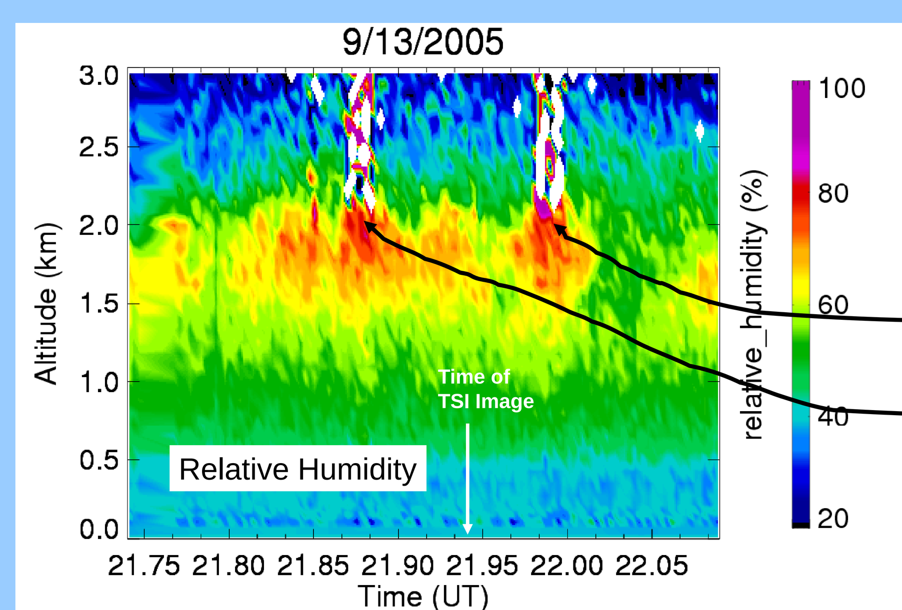
CARL vs. MWR-scaled sonde (May 2003 AIOP and September 2005 ALIVE)

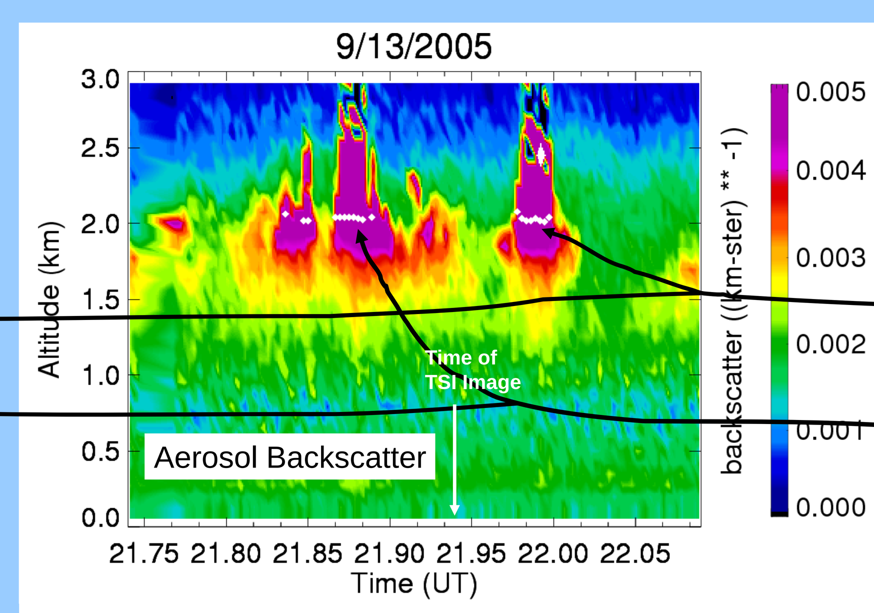
ALIVE – comparable bias error (~ -0.07 g/kg or -1%) and smaller rms error (0.85 g/kg, ~ 11%) than May 2003 Aerosol IOP

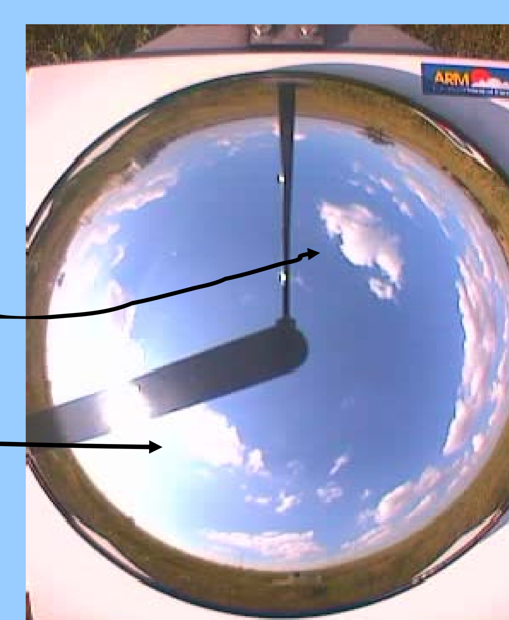


4. CARL High Temporal Resolution Aerosol and Water Vapor Measurements

The higher temporal and spatial resolution measurements from the upgraded CARL system permit more detailed investigations of aerosol hygroscopicity and the behavior of aerosols and water vapor near clouds.

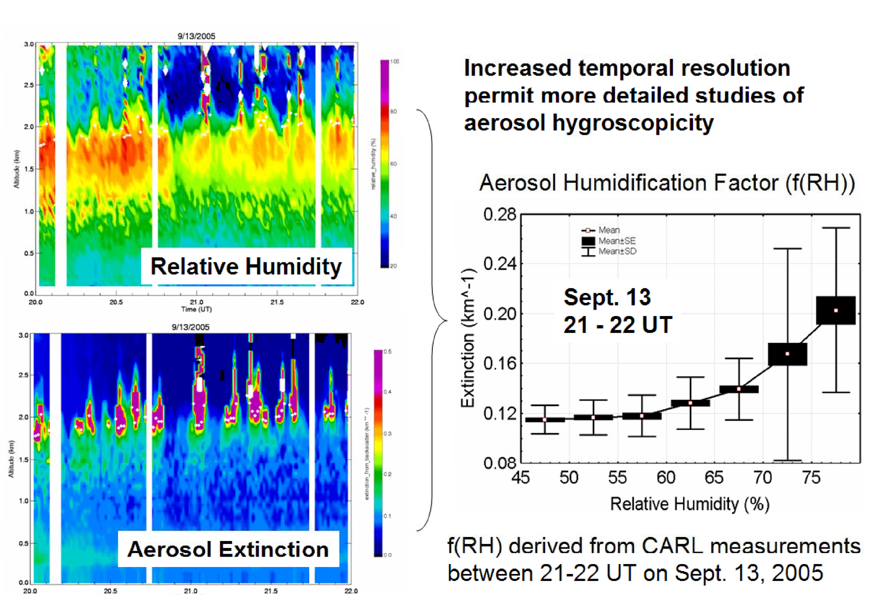






Relative humidity (left) and aerosol backscatter (center) between 21:45-22:05 UT on September 13, 2005 derived from CARL 10 second profiles. White dots in backscatter image show cloud base derived from CARL. TSI image at 21:56:30 UT (right) shows location of clouds relative to CARL measurements. CARL measurements show variability of relative humidity and aerosol backscatter near clouds.

CARL observations of aerosol hygroscopicity



5. References

Ferrare R. et al., (2006) JGR, 111, D05S08, doi:10.1029/2005JD005836
Schmid B. et al. (2006) JGR, 111, D05S07, doi:10.1029/2005JD005837

6. Acknowledgements

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