# Raman Lidar Measurements During ALIVE

**Ferrare, Turner, Clayton, Petty, Schmid, Flynn**

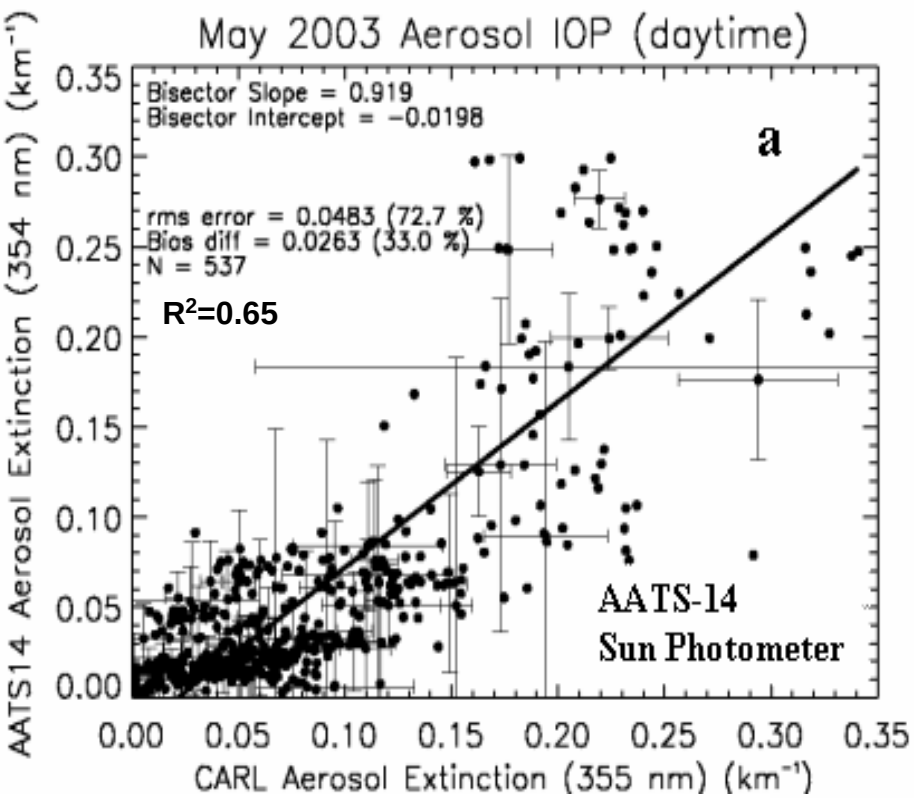
# Background

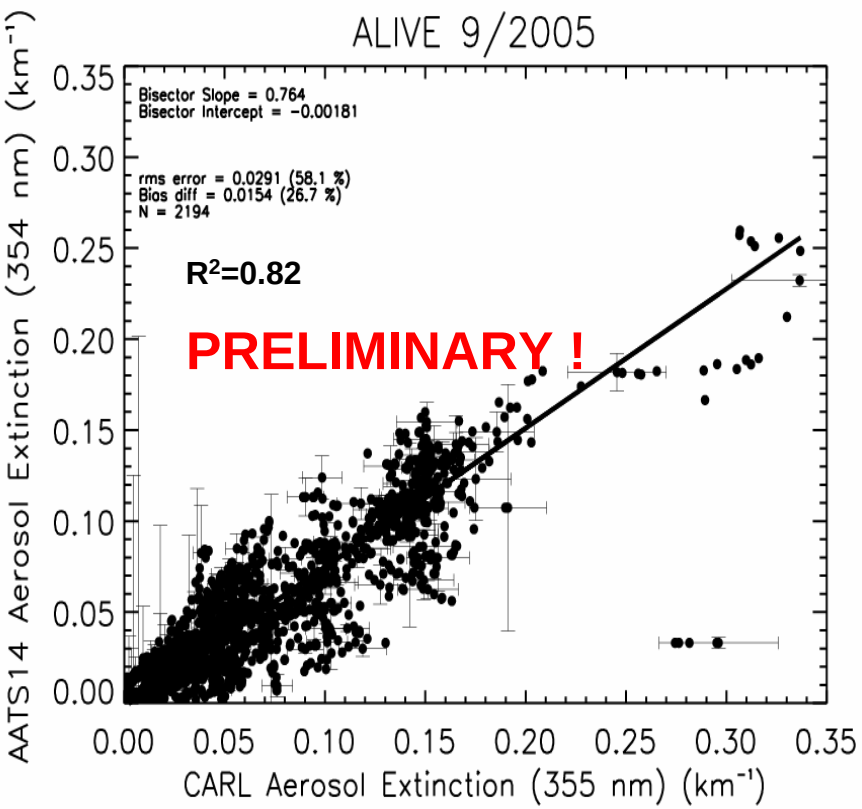
**ALIVE – Aerosol Lidar Validation Experiment – conducted in Sept. 2005 to evaluate upgraded SGP Raman Lidar (CARL) and MPL**

**At our last AWG meeting (March 2006), we presented preliminary comparisons of CARL aerosol extinction profiles with AATS14 to gauge performance of upgraded CARL during ALIVE…**

# CARL vs. AATS14 (AIOP and ALIVE)

**During ALIVE, bias errors reduced by 30-50% to about 0.015 km$^{-1}$**




Data limitations: alt, 0.00000–5.00000;

# Algorithm Modifications

**Computation of "final" CARL aerosol extinction and water vapor profiles for ALIVE required extensive modifications to CARL algorithms and software (recall Diana Petty's presentation).**

**Several changes/upgrades were made to account for upgraded hardware…**

- **Addition of new Licel detection electronics requires:**
  - **combining analog-to-digital mode (A/D) and photon counting (PC) mode data via "glue coefficients". Algorithms to determine glue coefficients were developed to:**
    - **determine appropriate range of PC data rate**
    - **remove cloud contamination much earlier in processing**
    - **remove long term trends**
    - **account for diurnal variation**
  - **determining appropriate PC count threshold values**

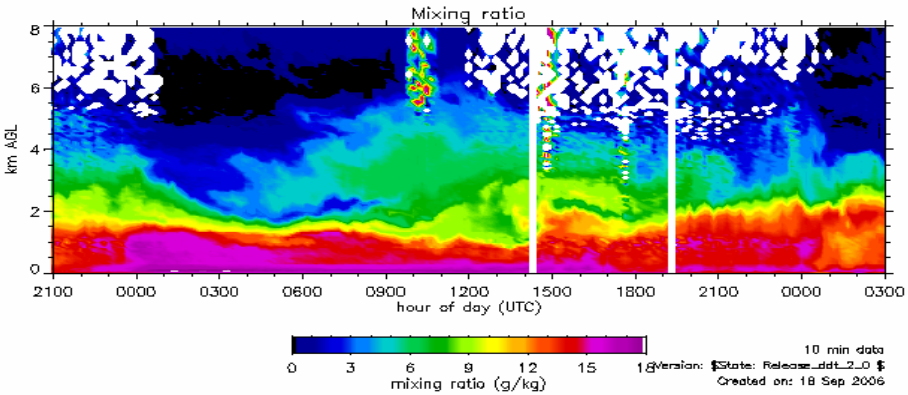
**Several other changes were made to aerosol and water vapor algorithms…**

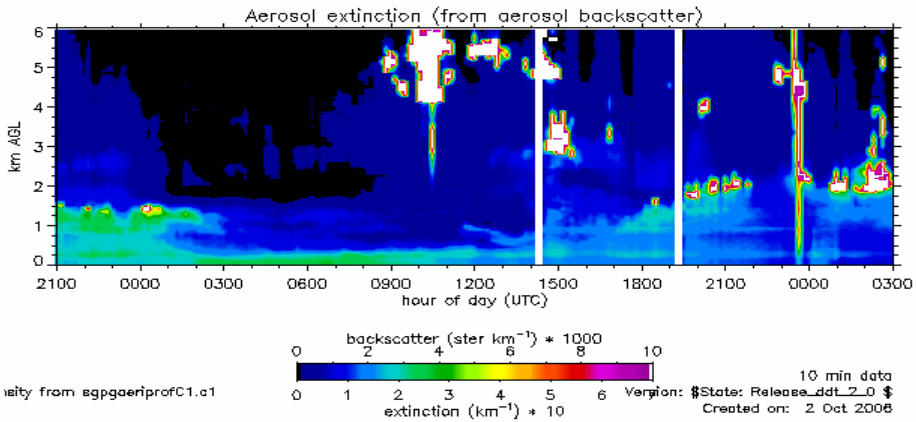
- **water vapor calibration**
- **aerosol and water vapor overlap functions for low altitude measurements**
- **cloud screening**

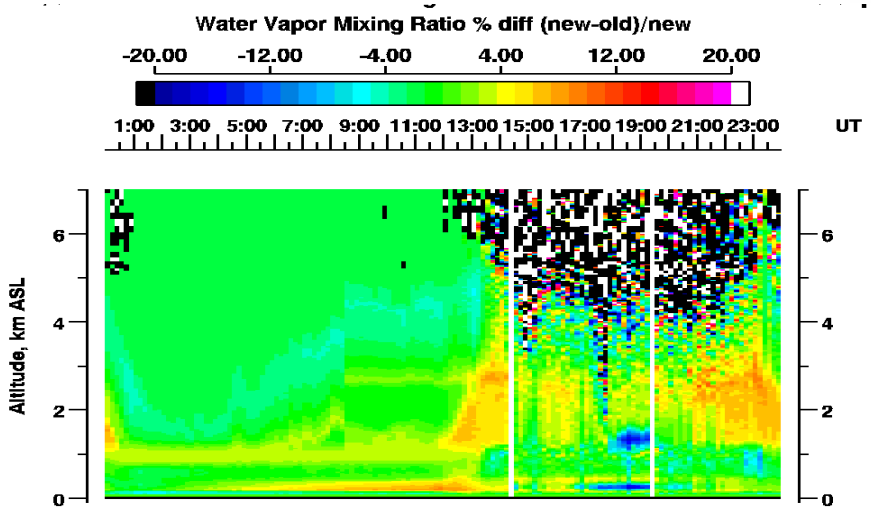
**Since our science proposal depends on accurate CARL measurements, we have had to devote considerable time to developing these CARL algorithm modifications and testing via comparisons with previous results and other datasets…**

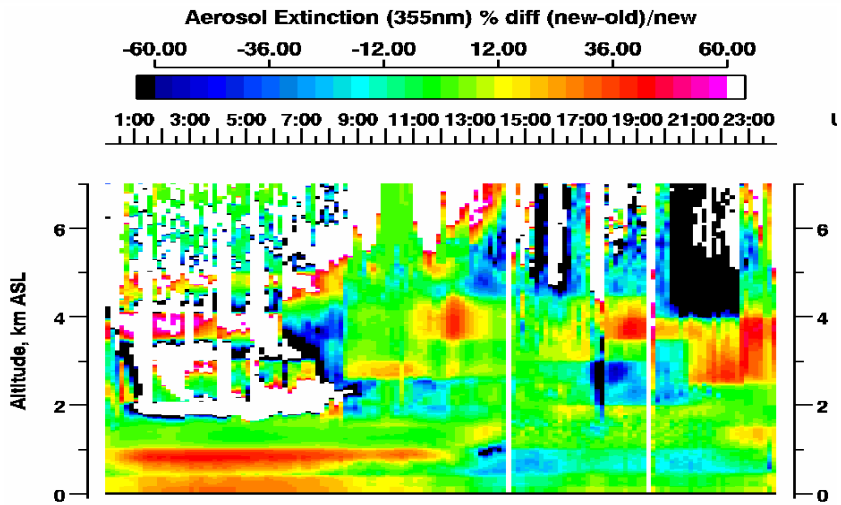
# Impacts of “glue coefficients”

- **Algorithm modifications were required to account for diurnal variation in <u>glue coefficients</u>**
- **Water vapor and aerosol retrievals were impacted by these retrievals**



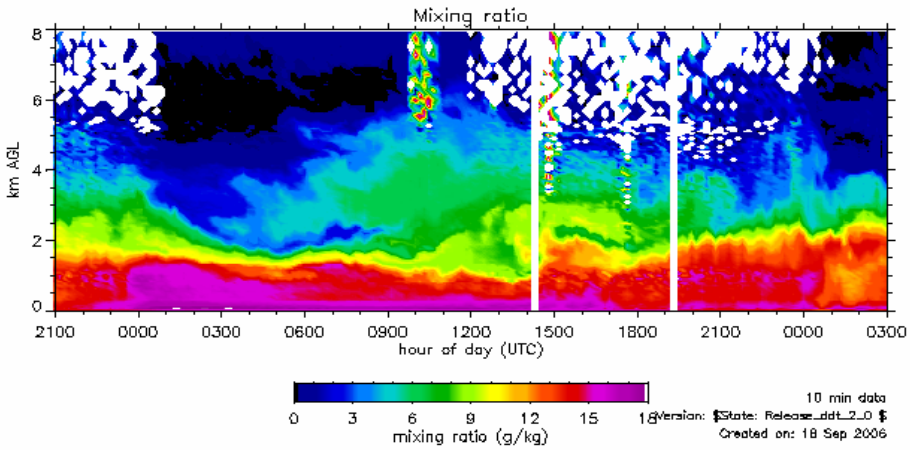



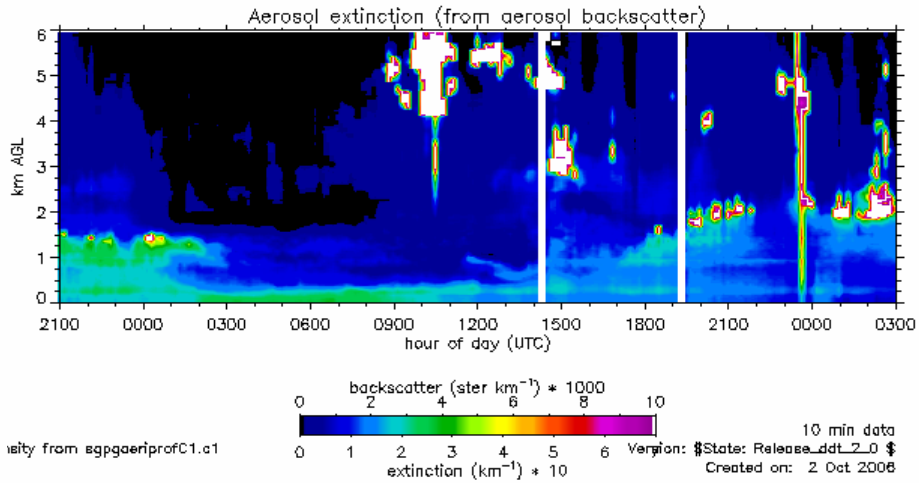



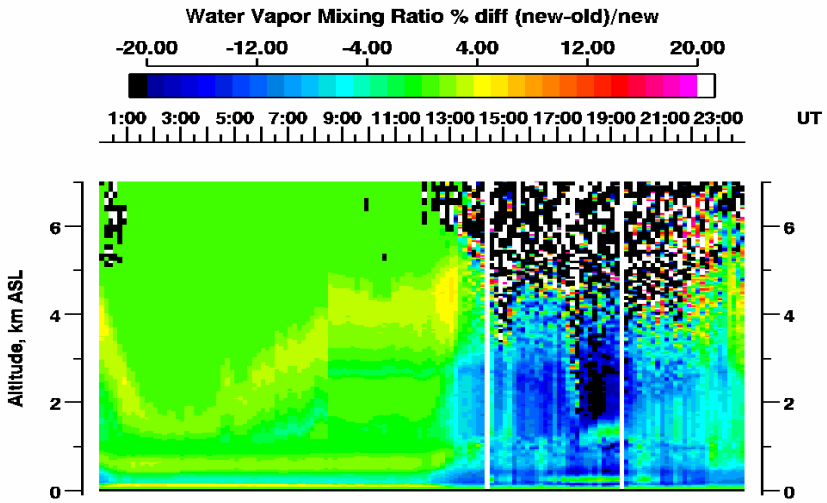



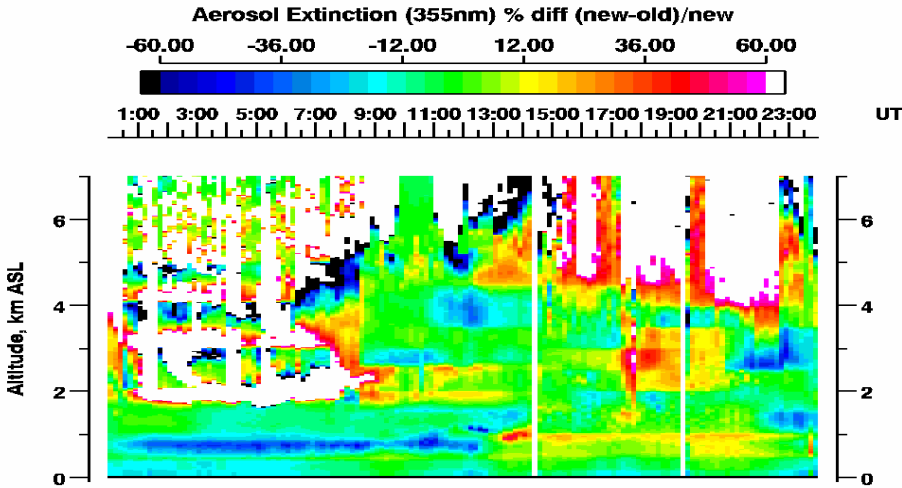
# Impacts of PC count rate threshold

- **Algorithm modifications were required to account for <u>PC count rate threshold</u>**
- **Water vapor and aerosol retrievals were impacted by these retrievals**



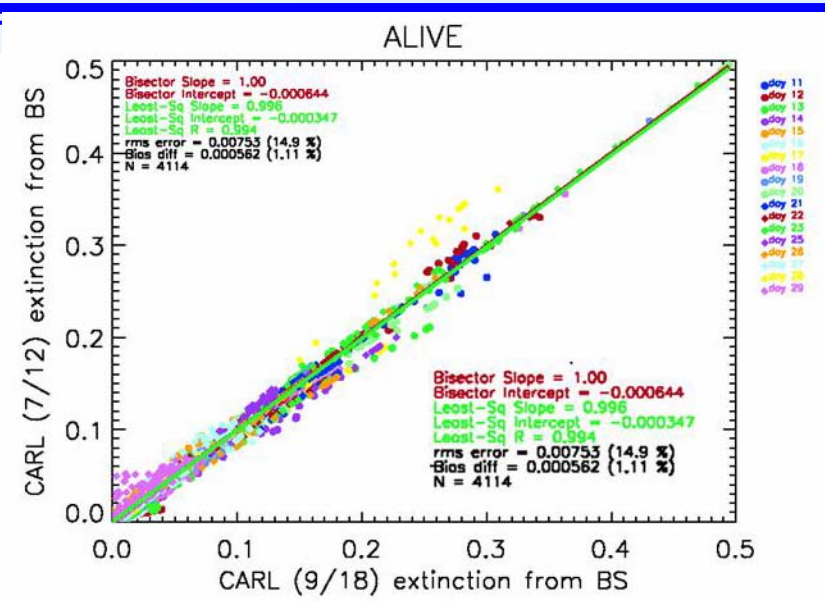



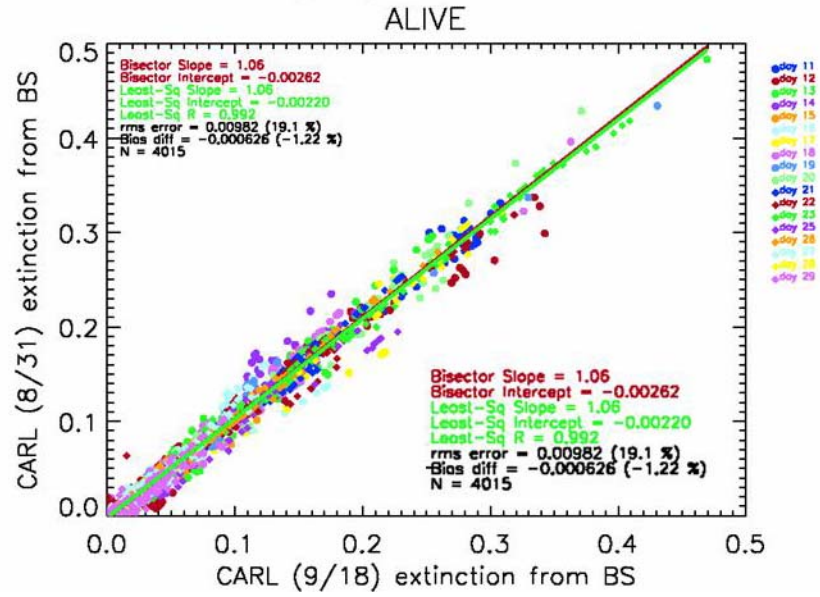



# Impacts on aerosol extinction

**Algorithms modifications to account for diurnal variation in <u>glue coefficients</u> and <u>PC count rate threshold</u>, had only minor (1-2%) impacts on the average aerosol extinction retrievals**

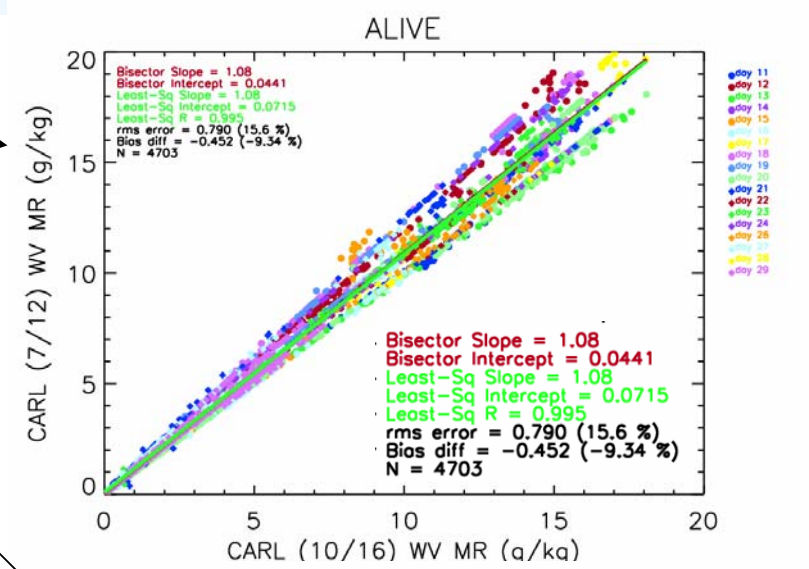


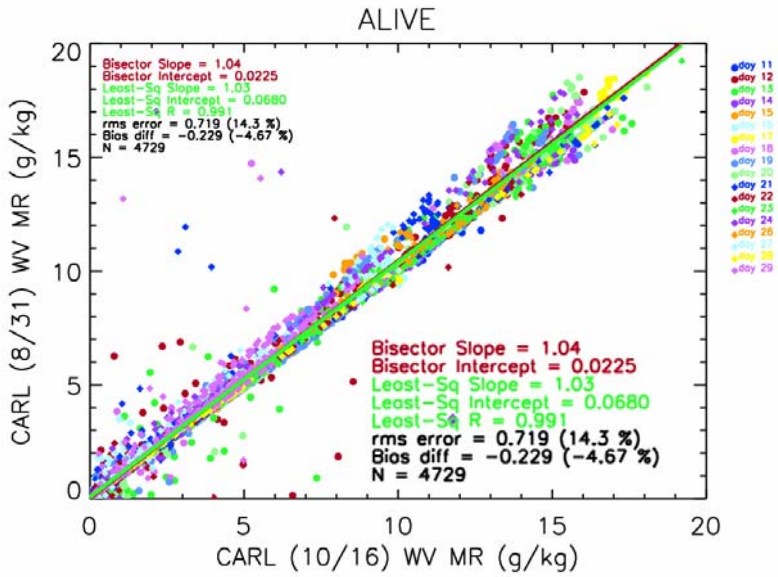



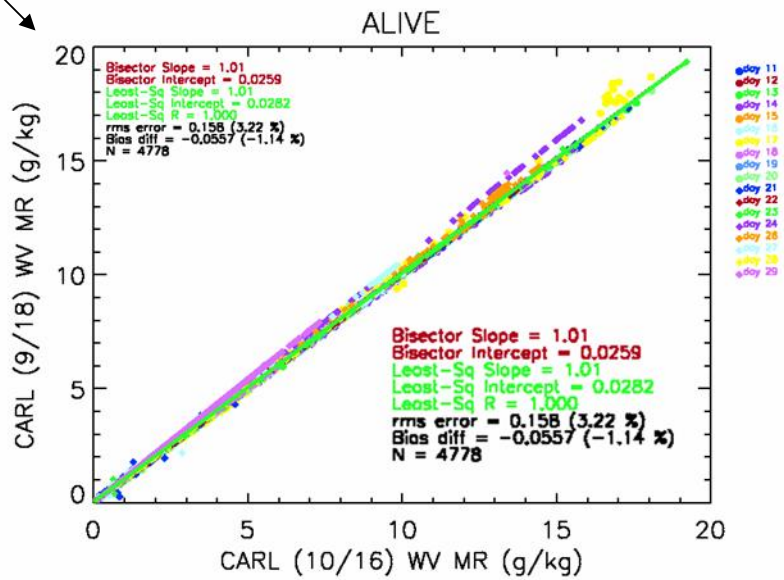

- **7/12 run – base run**
- **8/31 run - includes diurnal glue coefficients**
- **9/18 run - includes diurnal glue coefficients and PC count rate threshold change from 50 to 10 Mhz**

# Impacts on water vapor

**Algorithms modifications to account for diurnal variation in <u>glue coefficients</u> and <u>PC count rate threshold</u>, had larger (5-9%) impacts on the average water vapor retrievals. Impact of <u>infrequent tower calibration</u> had only minor (~1%) impact.**



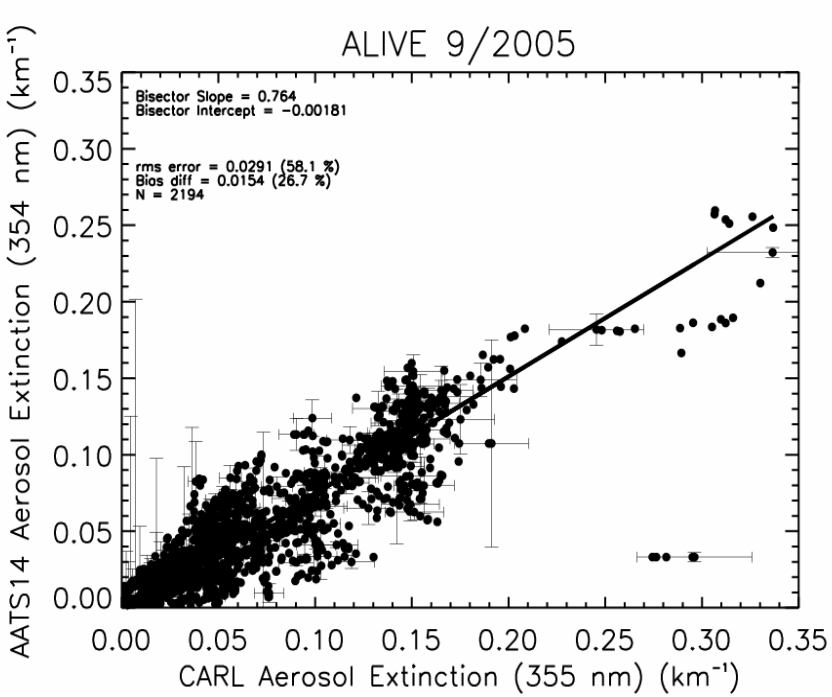



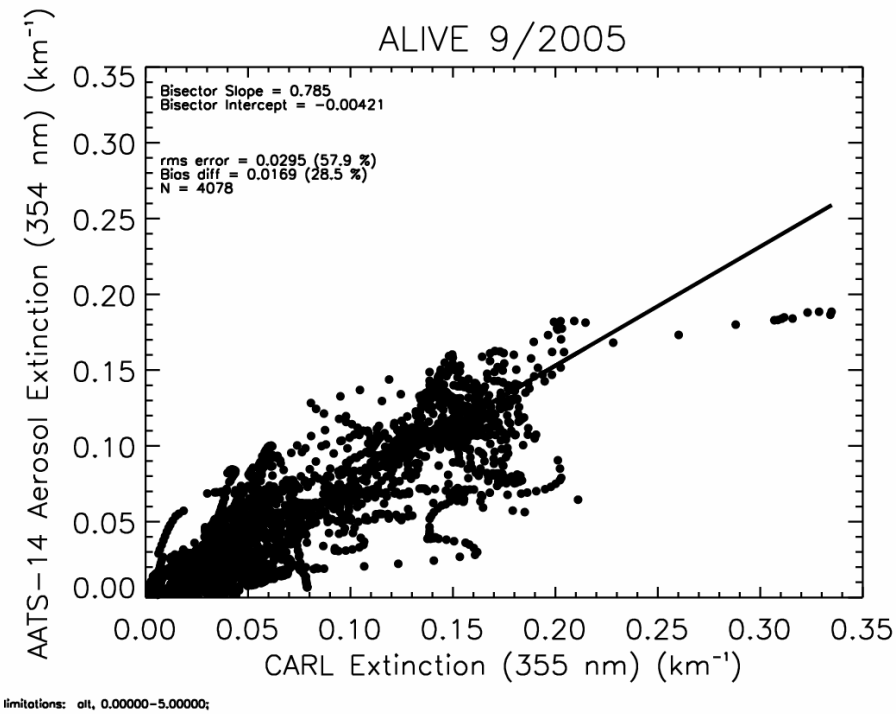
# CARL vs. AATS14 aerosol extinction (ALIVE)

**Algorithms modifications to account for diurnal variation in glue coefficients and PC count rate threshold, had only minor (1-2%) impacts on the average aerosol extinction retrievals. Therefore, aerosol extinction comparisons relative to AAT14 are essentially unchanged from what was shown in March.**

**Preliminary (March 2006)**



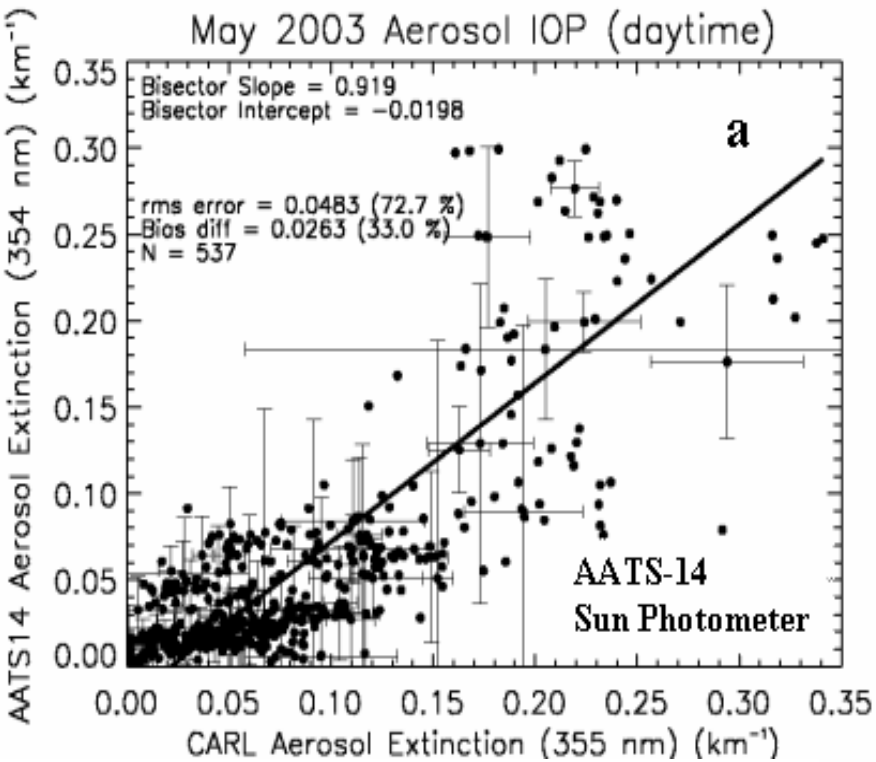

**"Final?" (September 2006)**

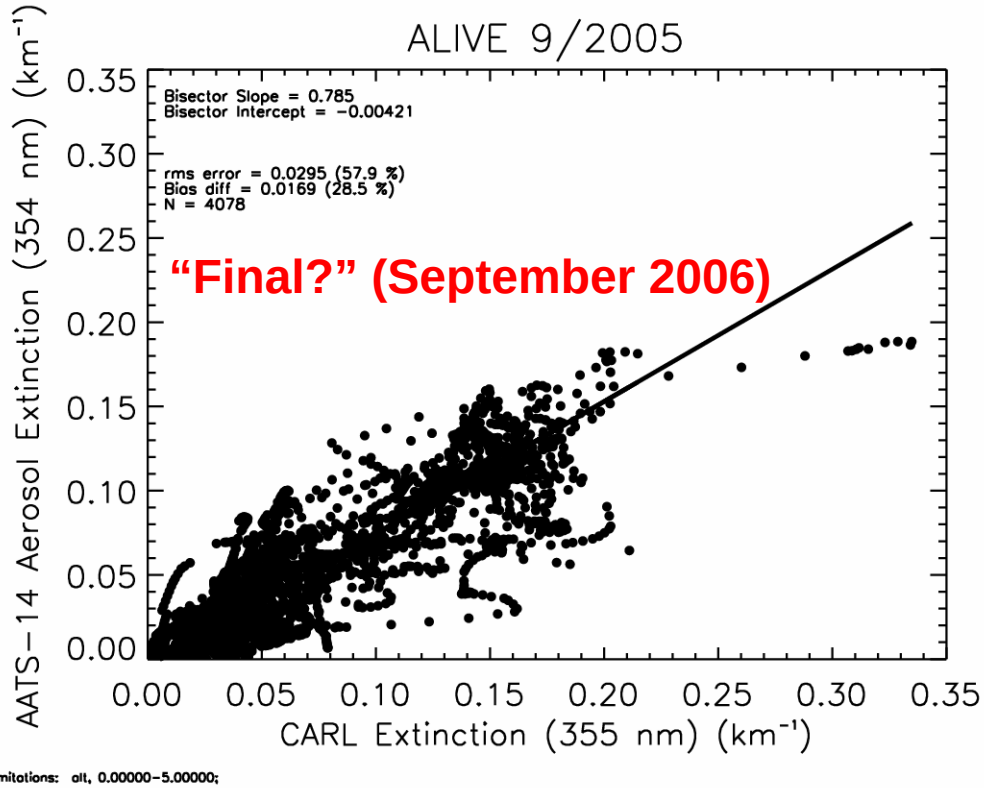



Data limitations: alt, 0.00000−5.00000;

# CARL vs. AATS14 aerosol extinction (AIOP and ALIVE)

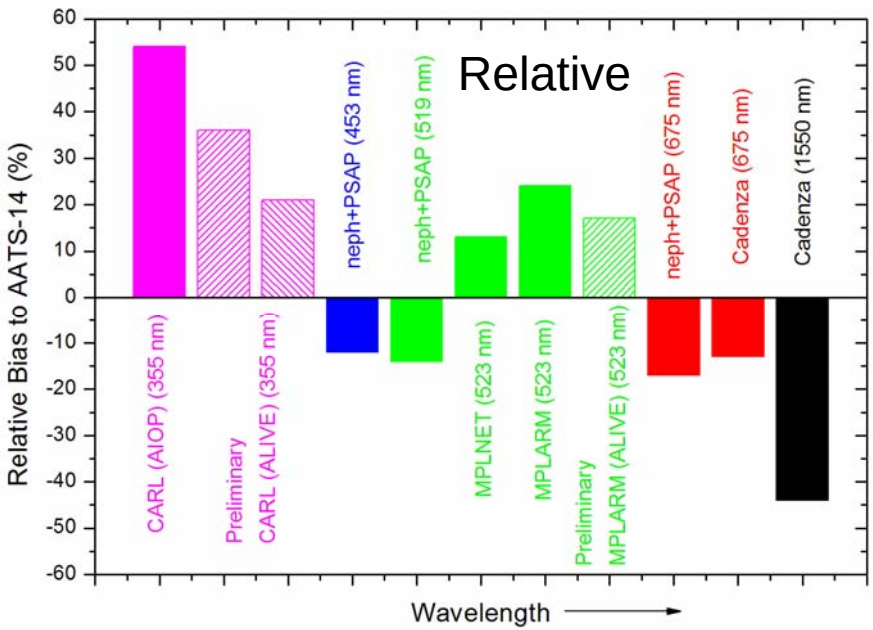
**During ALIVE, bias errors reduced by 30-50% to about 0.015 km$^{-1}$**

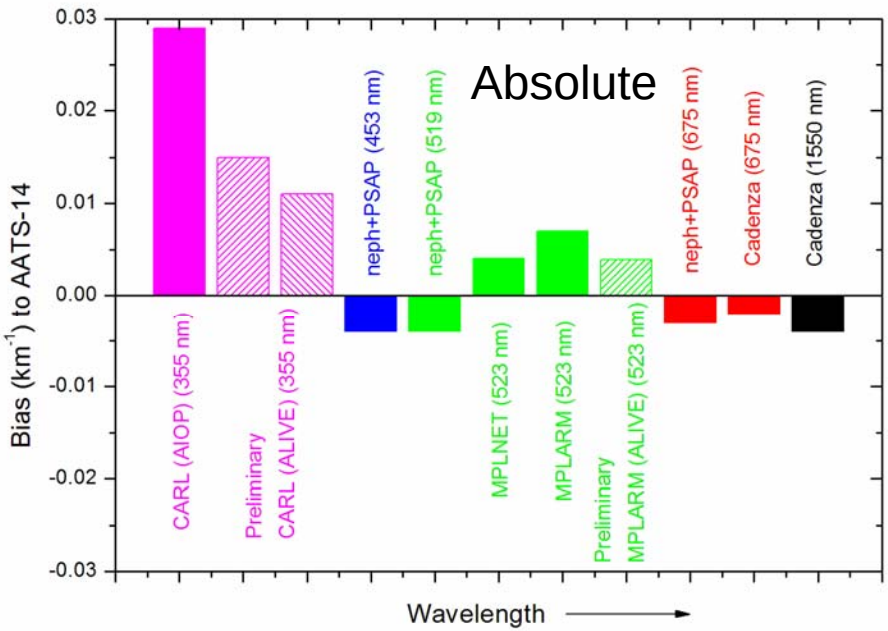


# ALIVE: Improvement in CARL Extinction

- **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 0.011-0.015 km-1 (21-36%) higher than AATS14 aerosol extinction (355 nm)**
  - **This bias is about 10% of the annual median value of aerosol extinction within the lowest kilometer**

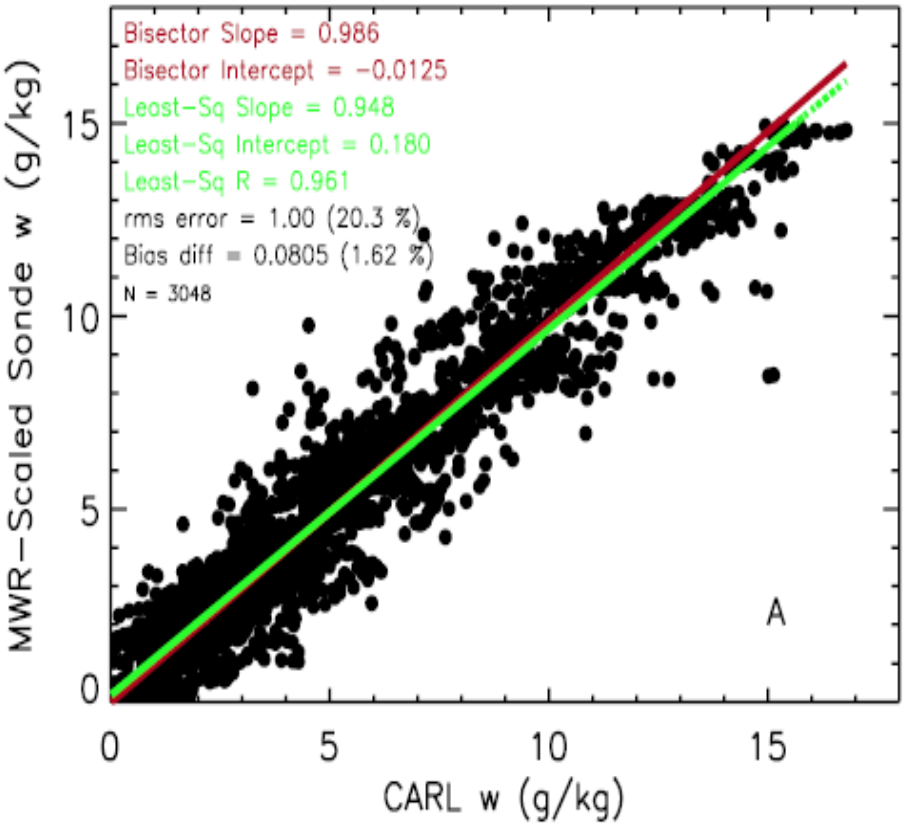


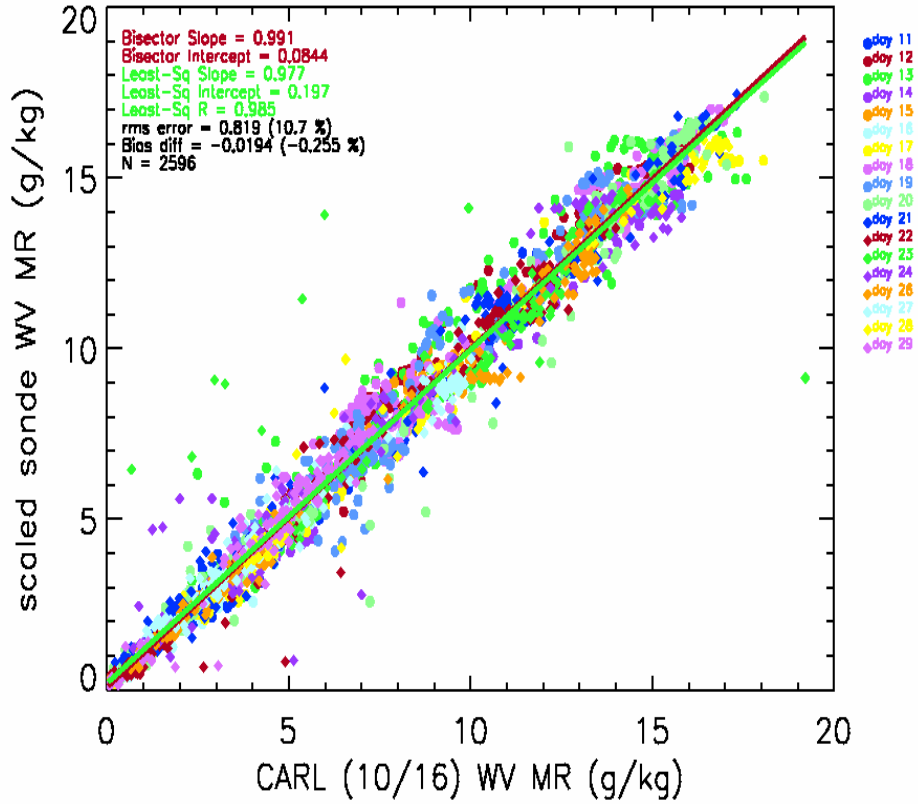
# CARL vs. MWR-scaled sonde (AIOP and ALIVE)

**ALIVE – much smaller bias error (~ -0.02 g/kg or -0.3%) and smaller rms error (0.8 g/kg, ~ 10%) than May 2003 Aerosol IOP**

May 2003 Aerosol IOP

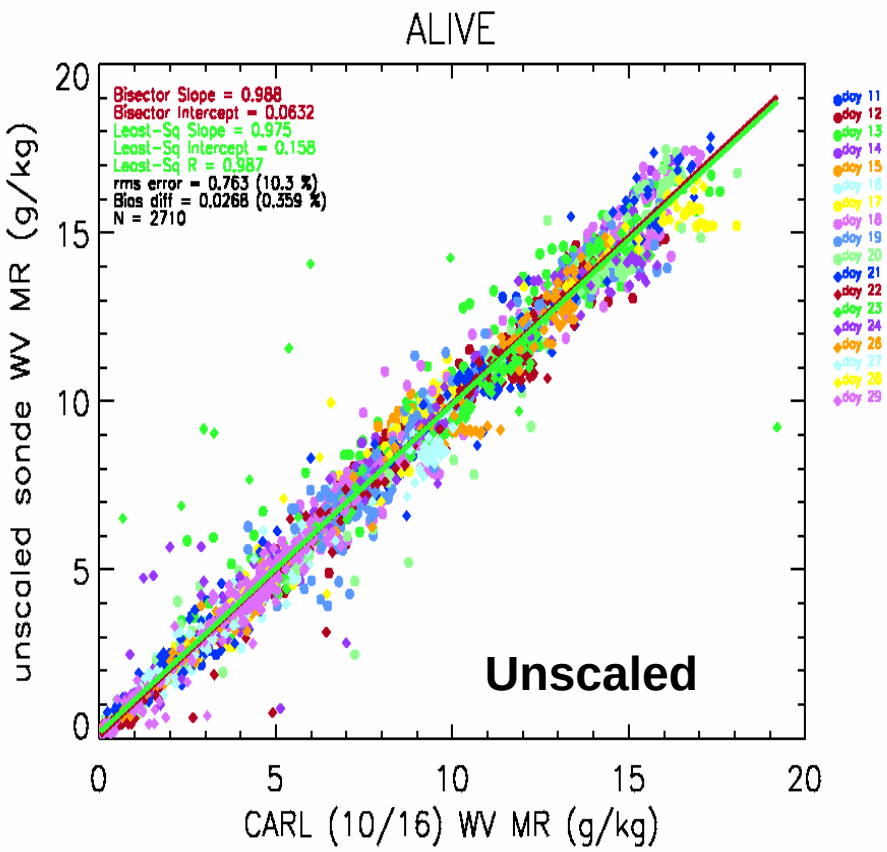


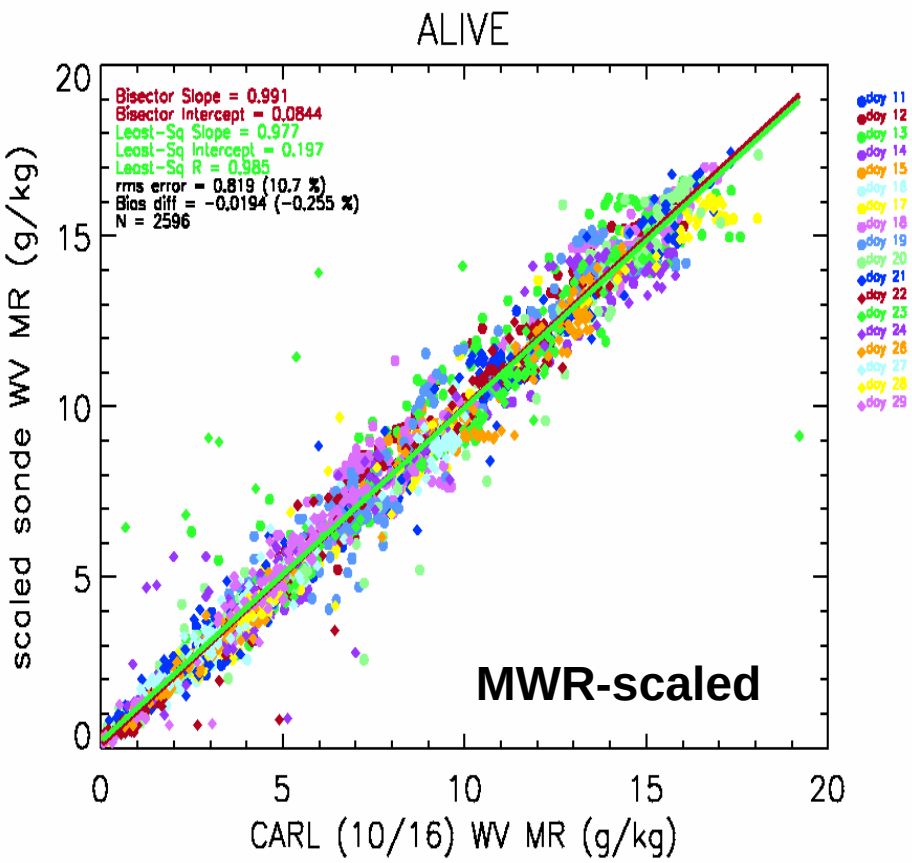

ALIVE



# CARL vs. sondes (unscaled & scaled)

- **Overall (night+day)**
  - **negligible bias differences and 10% rms differences between CARL and sondes**
  - **not much difference when comparing with unscaled or scaled sondes**



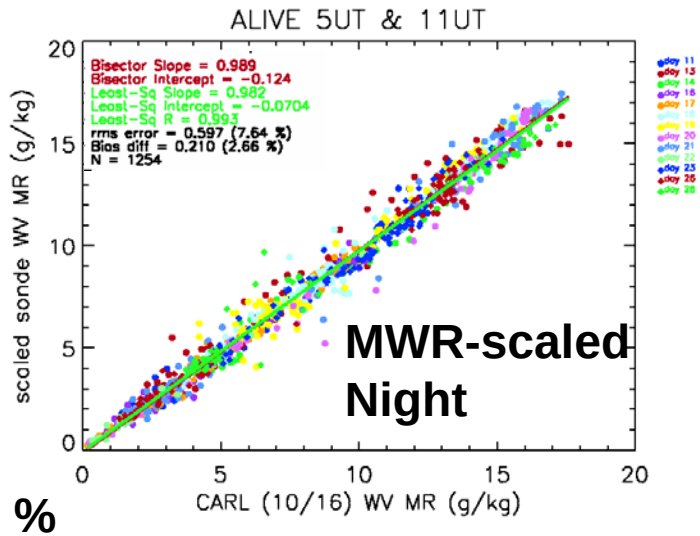

Data limitations: alt, 0.00000–4.00000;

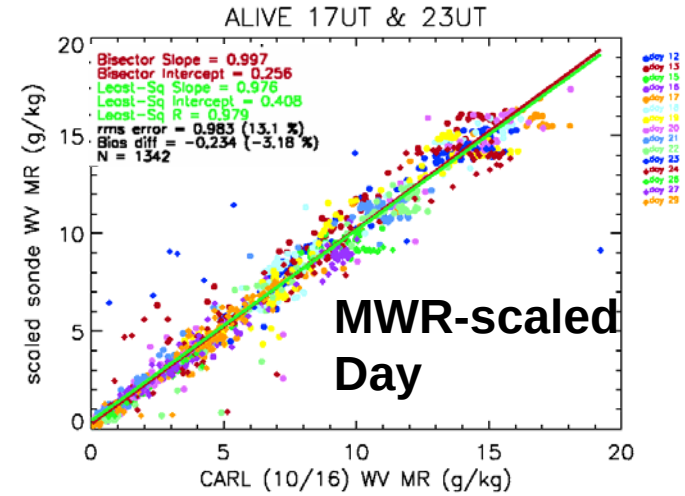
# CARL vs. radiosonde (diurnal)

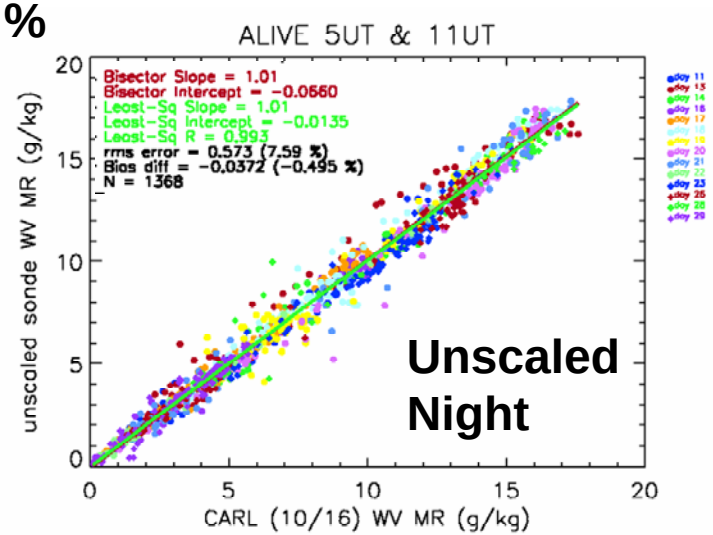
**Comparison depends on time of day**

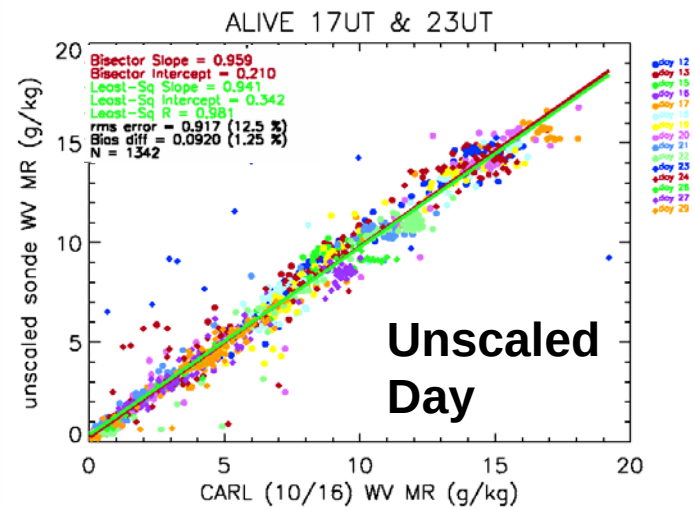
**Bias differences (CARL-sonde)**
**Scaled (night) 3 %**
**Scaled (day) -3 %**
**Unscaled (night) -0.5 %**
**Unscaled (day) 1 %**

**Either CARL and sondes have diurnal bias (drier in day, wetter at night) and/or MWR has diurnal bias (drier at night, wetter in day)**



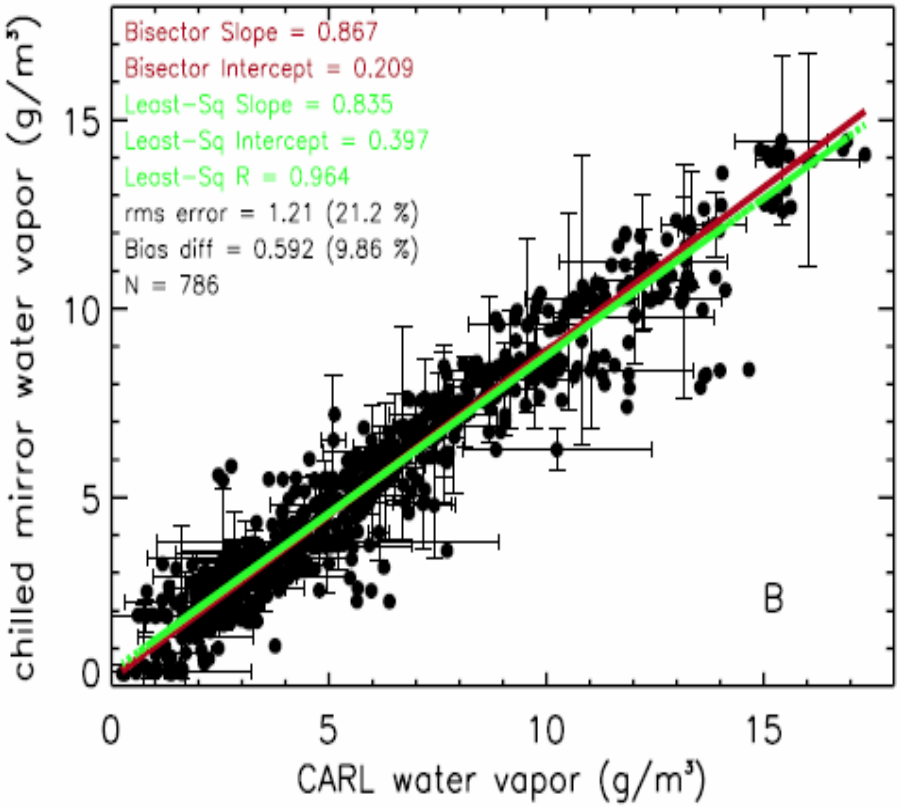



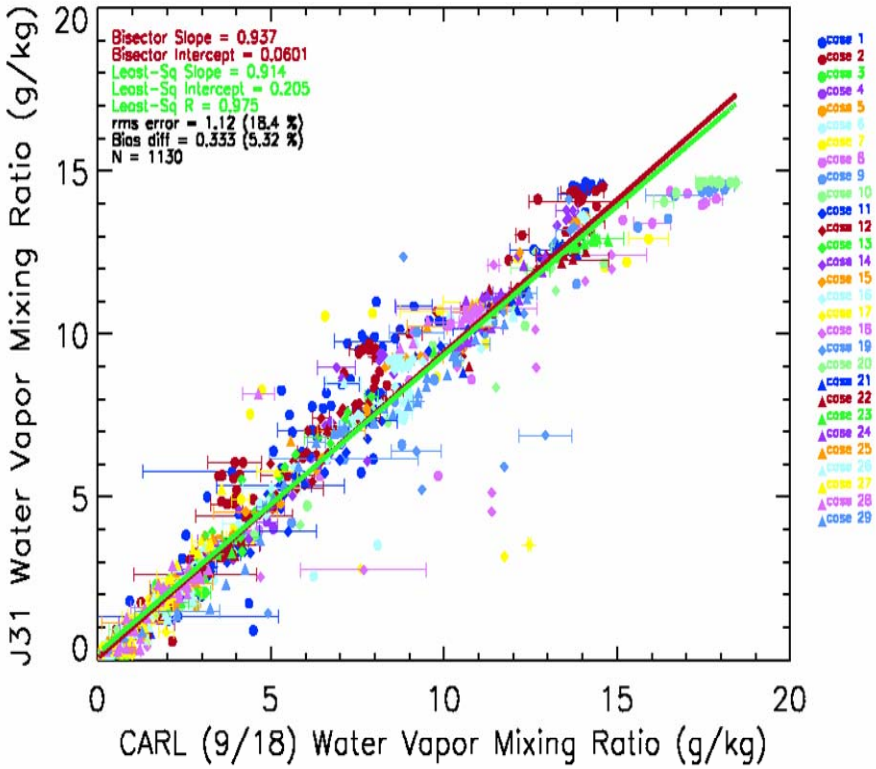
# CARL vs. airborne in situ water vapor (AIOP and ALIVE)

- **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 ~ 5%**

May 2003 Aerosol IOP

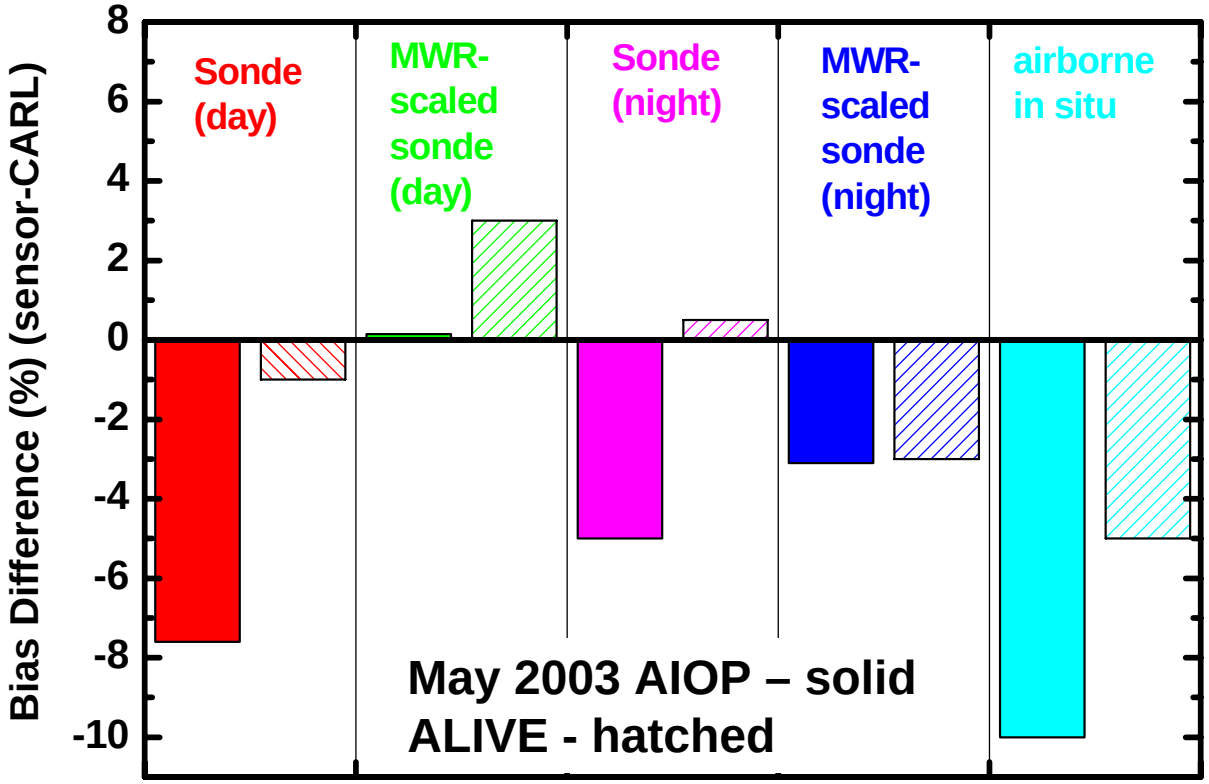



ALIVE



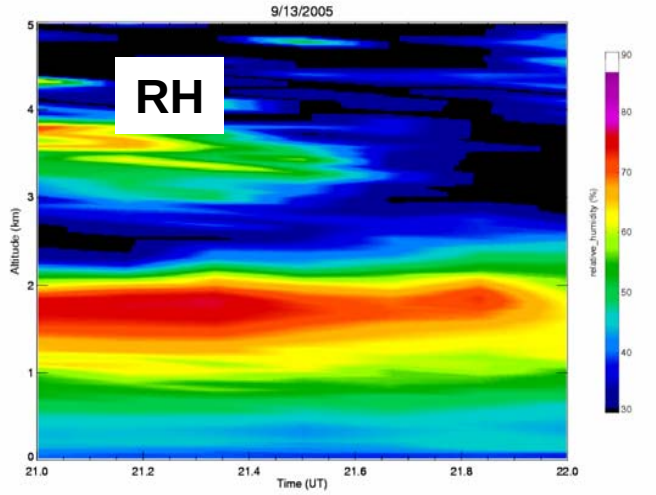
# ALIVE: Improvement in Water Vapor

- General improvement in water vapor measurements
- CARL water vapor within +/- 3 % of scaled or unscaled sondes
- Diurnal differences remain
- Airborne in situ sensor still drier (~5-8%) drier than MWR scaled CARL or sonde



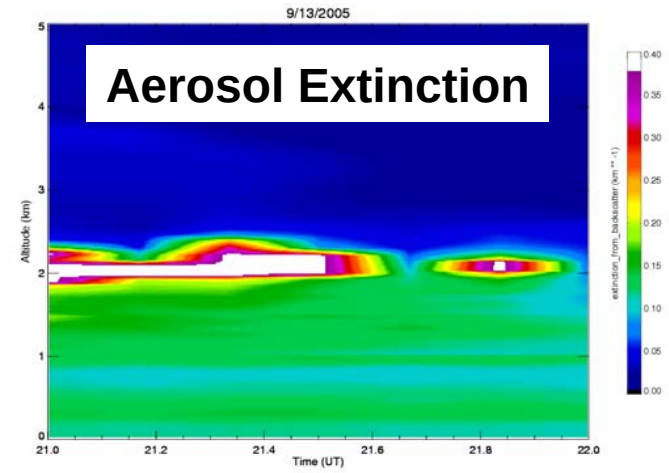
# CARL High Temporal Resolution Data

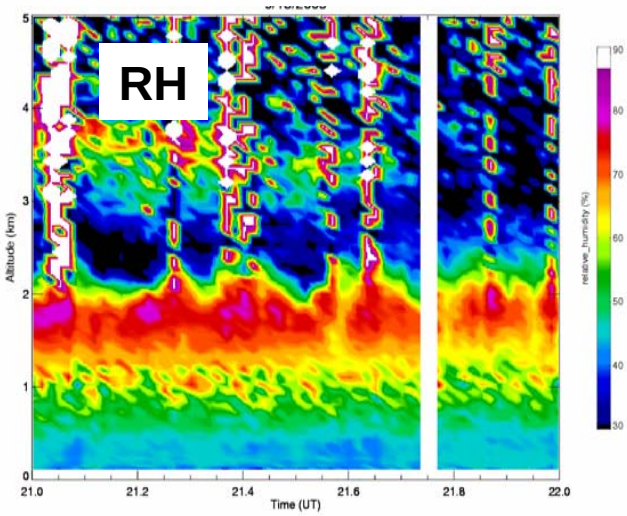
**Increased temporal resolution should permit more detailed analyses near clouds**



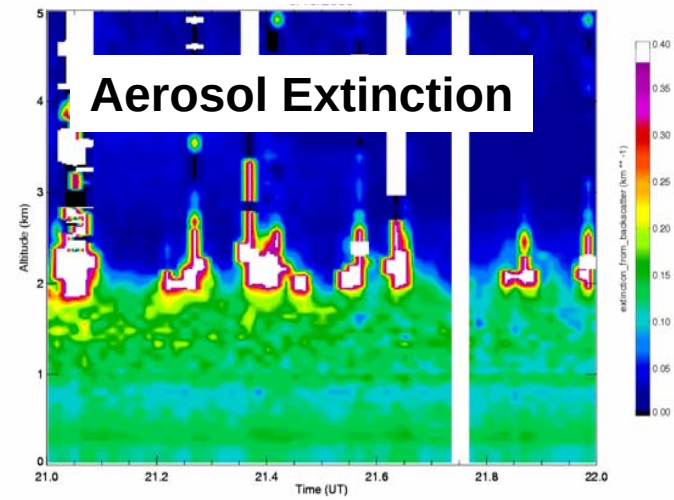

**Sept. 13**
**21 - 22 UT**

**10 min**

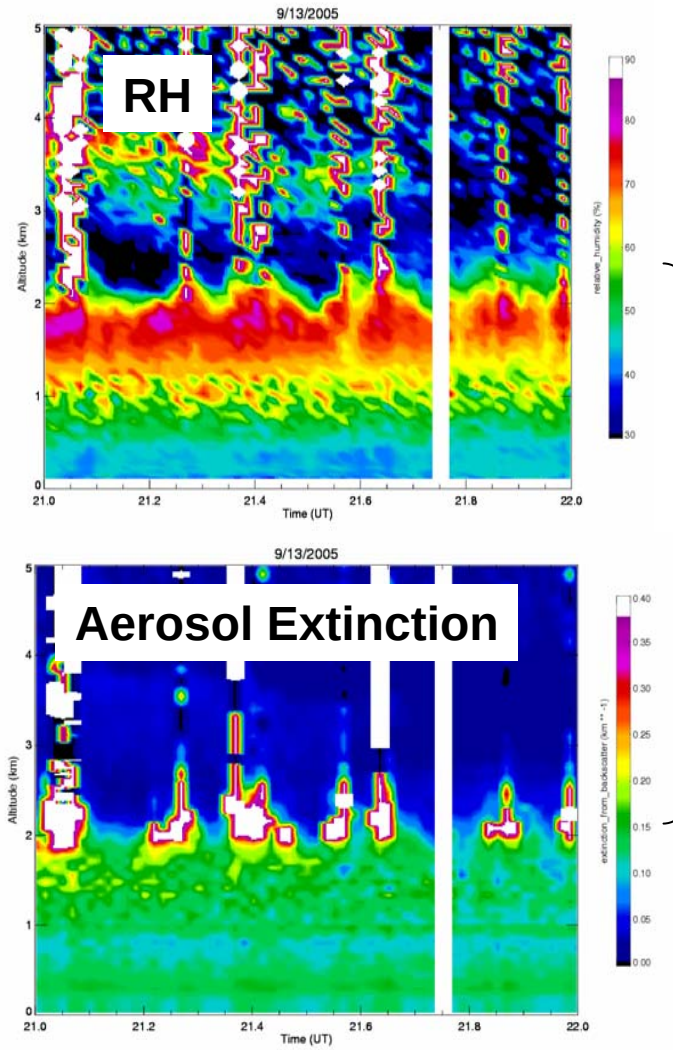


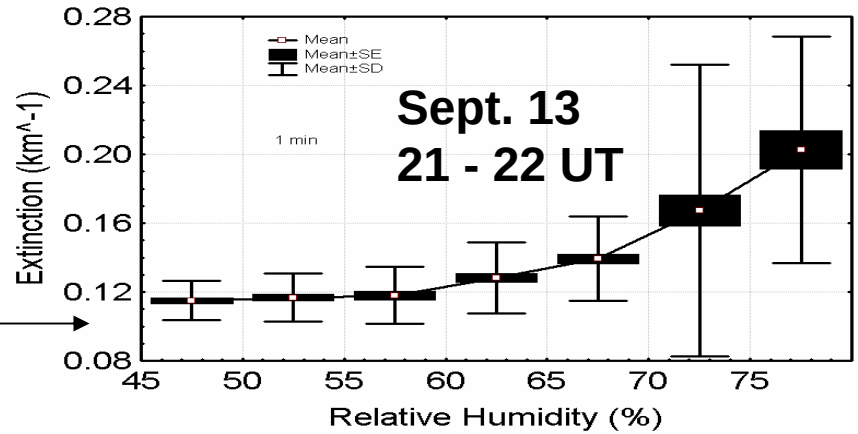

**1 min**

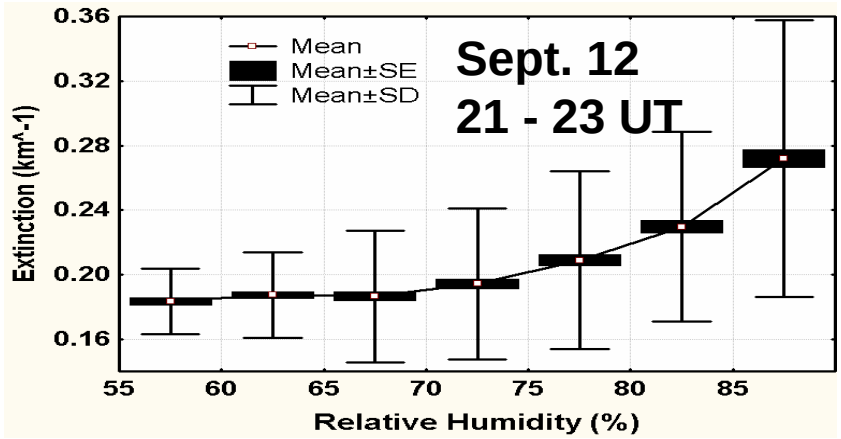


# CARL observations of aerosol hygroscopicity




**Increased temporal resolution should permit more detailed studies of aerosol hygroscopicity**



# Summary

- Computation of final CARL ALIVE aerosol and water vapor profiles required extensive modifications to CARL algorithms
- Initial vs. final CARL profiles:
  - Individual profiles showed considerable differences
  - On average: final water vapor profiles were 5-10% drier than initial profiles
  - On average: final aerosol extinction profiles were within about 1-2% of initial profiles
- Impact of CARL upgrades as determined from ALIVE:
  - Aerosol extinction performance displayed significant improvement
  - Water vapor performance showed small improvement
- CARL data acquired since the upgrade must be processed with modified algorithms to avoid large uncertainties
- CARL upgrades should significantly benefit aerosol-cloud studies
- Recommendation: increase (or at least maintain current) CARL mentor support