Evaluation of Terra MODIS Aerosol and Water Vapor Measurements Using ARM SGP Data

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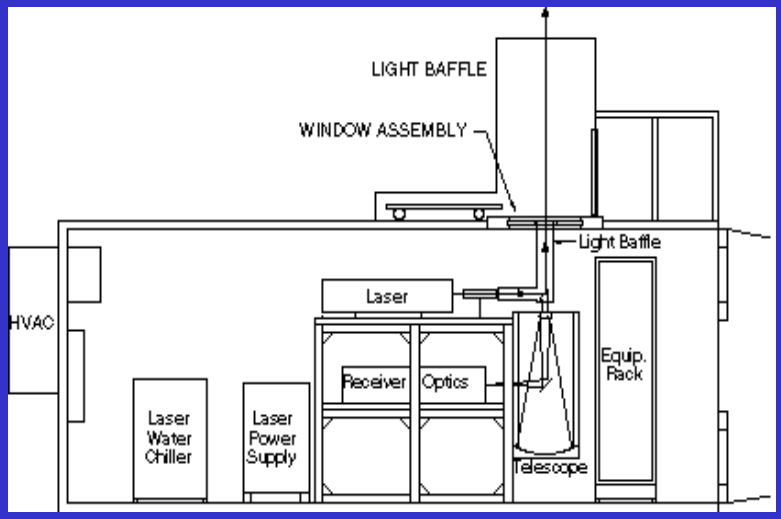
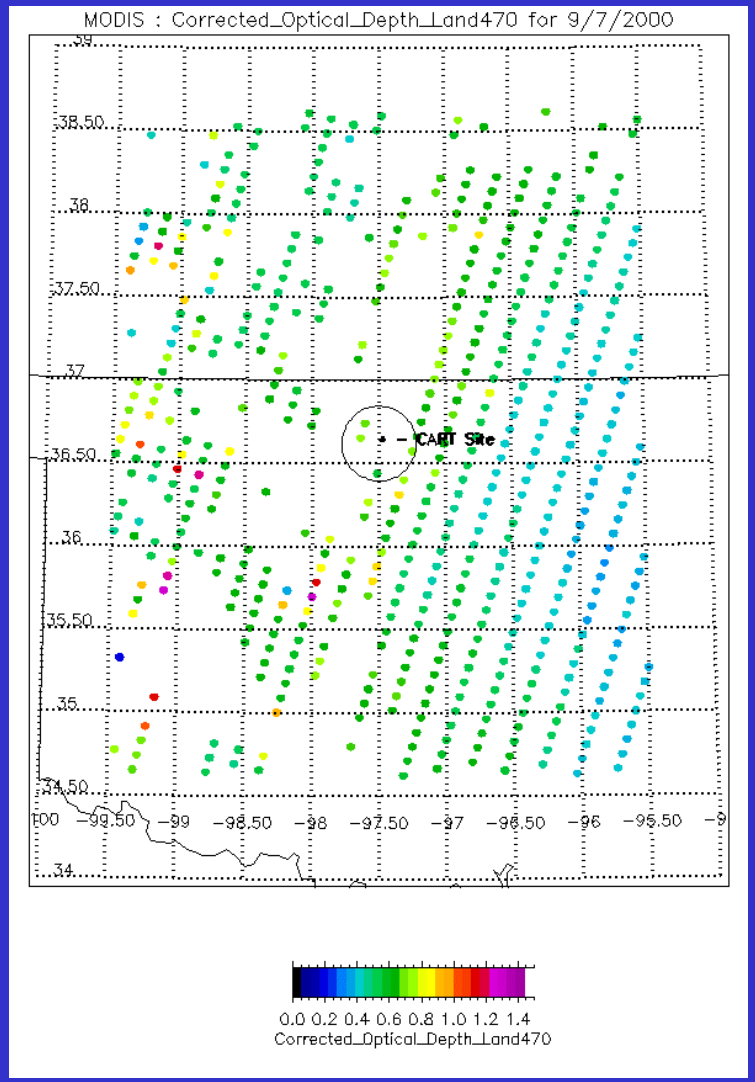
Southern Great Plains (SGP) CART Raman Lidar (CARL)

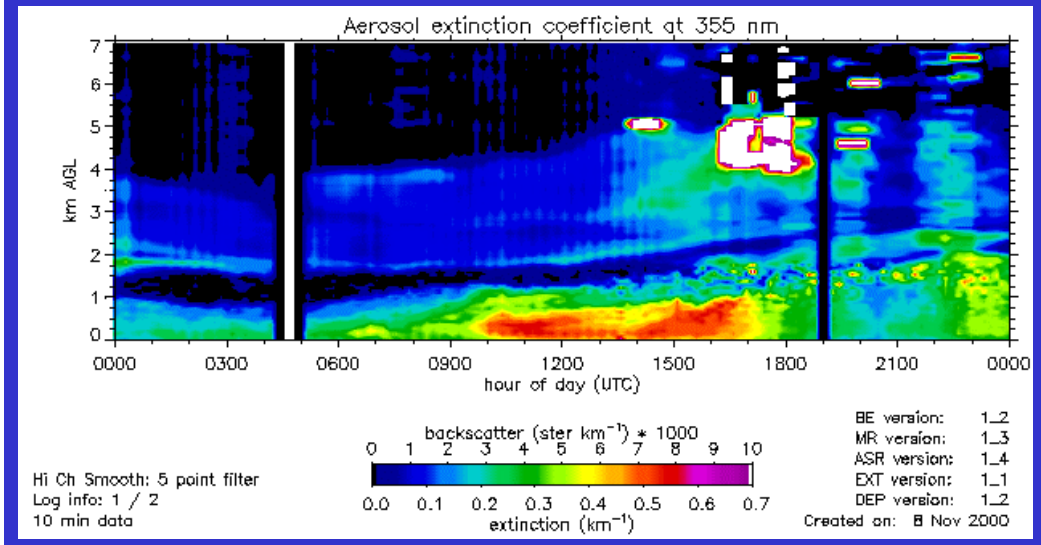
- Nearly Continuous Operation
- Nd:YAG (355 nm) (day/night)
  - 12 W
- 61 cm telescope
- Wavelengths
  - Rayleigh/Aerosol (355 nm)
  - Depolarization (355 nm)
  - Raman water vapor (408 nm)
  - Raman nitrogen (387 nm)
- 39 meter range resolution
- low, high sensitivity channels
- measures
  - water vapor and aerosol profiles
  - precipitable water vapor and aerosol optical thickness
  - aerosol and cloud depolarization

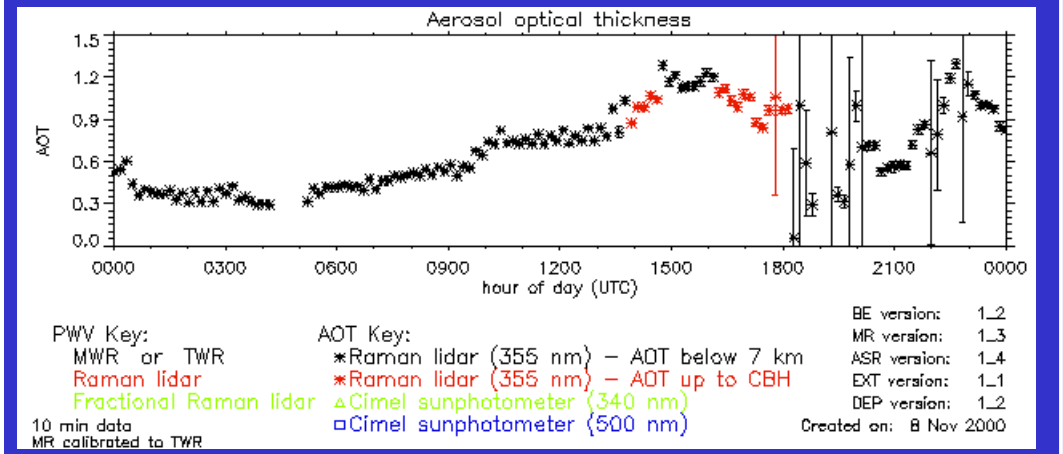


Additional information: http://www.arm.gov/docs/instruments/static/rl.html

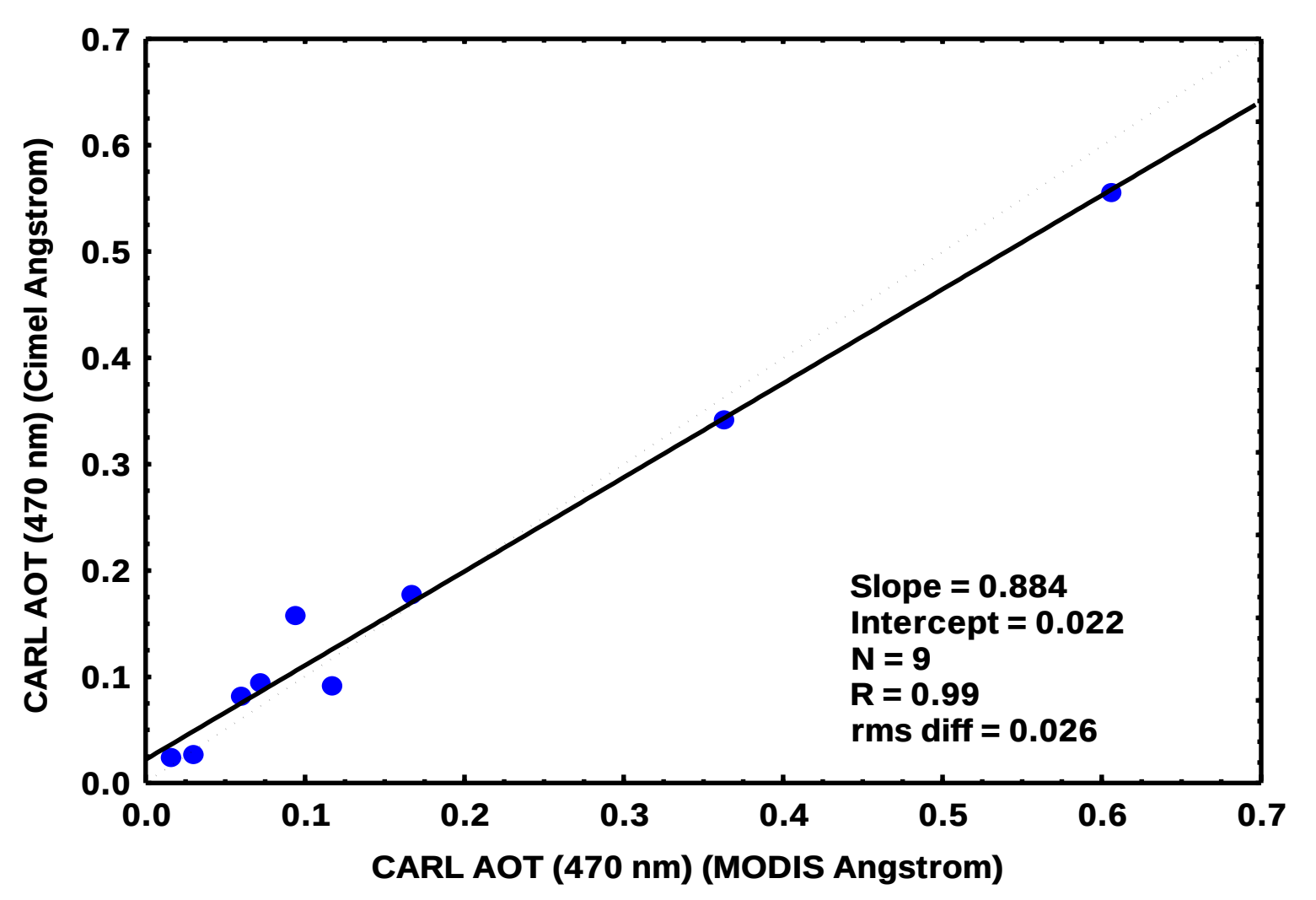
MODIS and Raman Lidar Aerosol Measurements over DOE ARM SGP Site



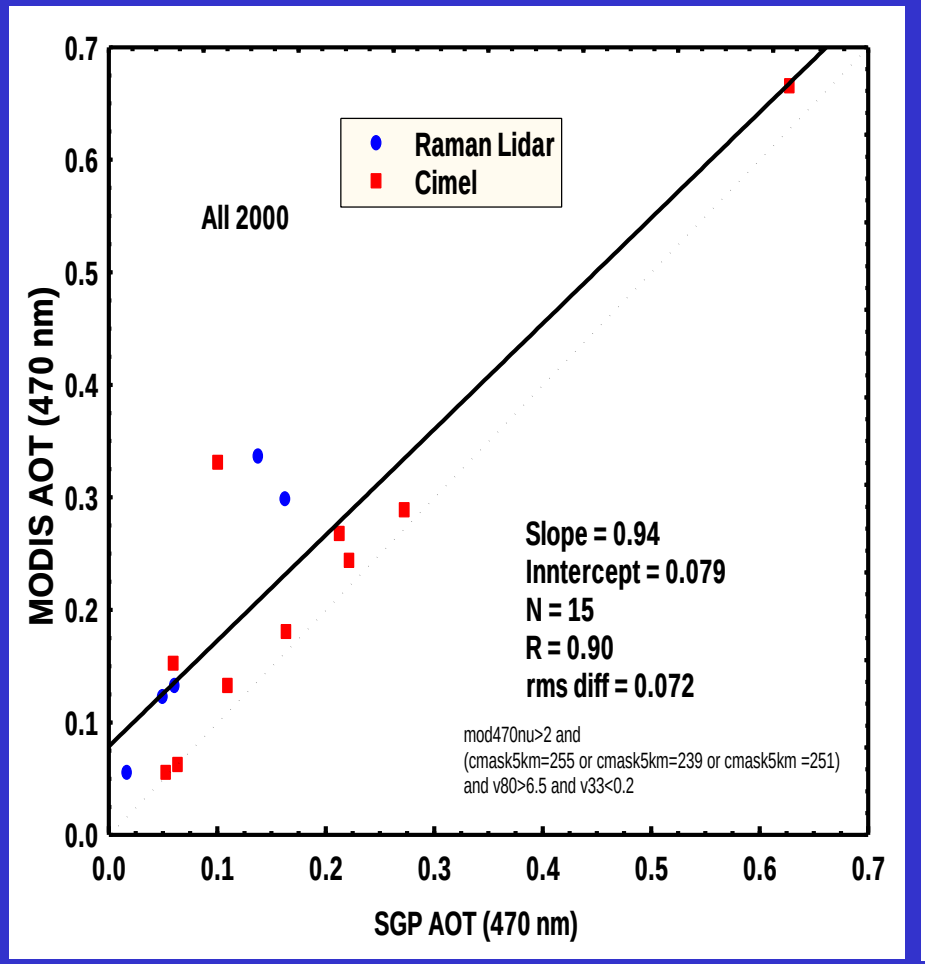


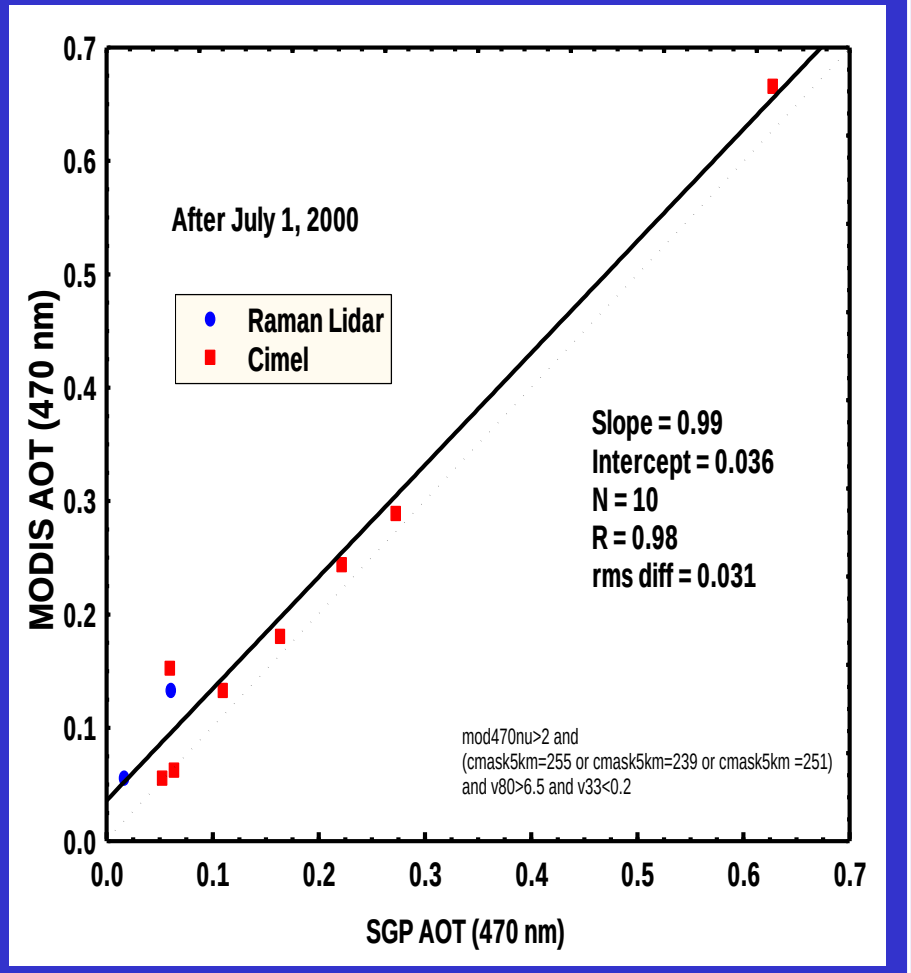


- Convert CARL AOT (355 nm) to AOT (470 nm)
- Use Angstrom exponent from Cimel or MODIS AOT

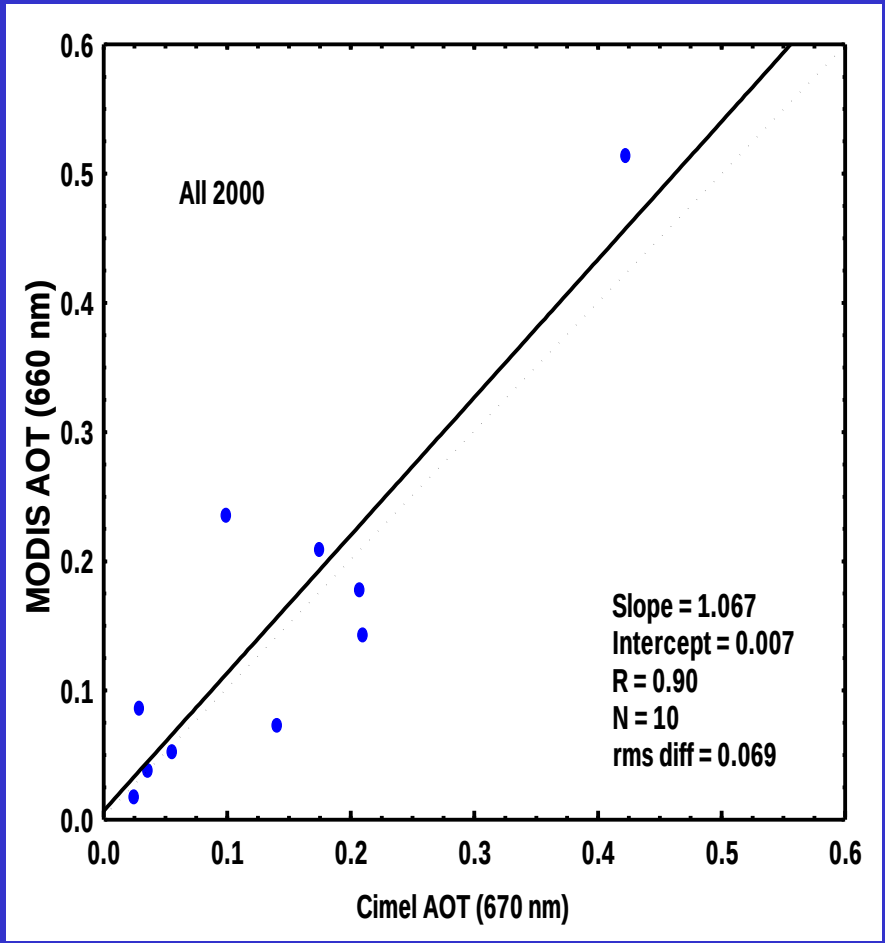


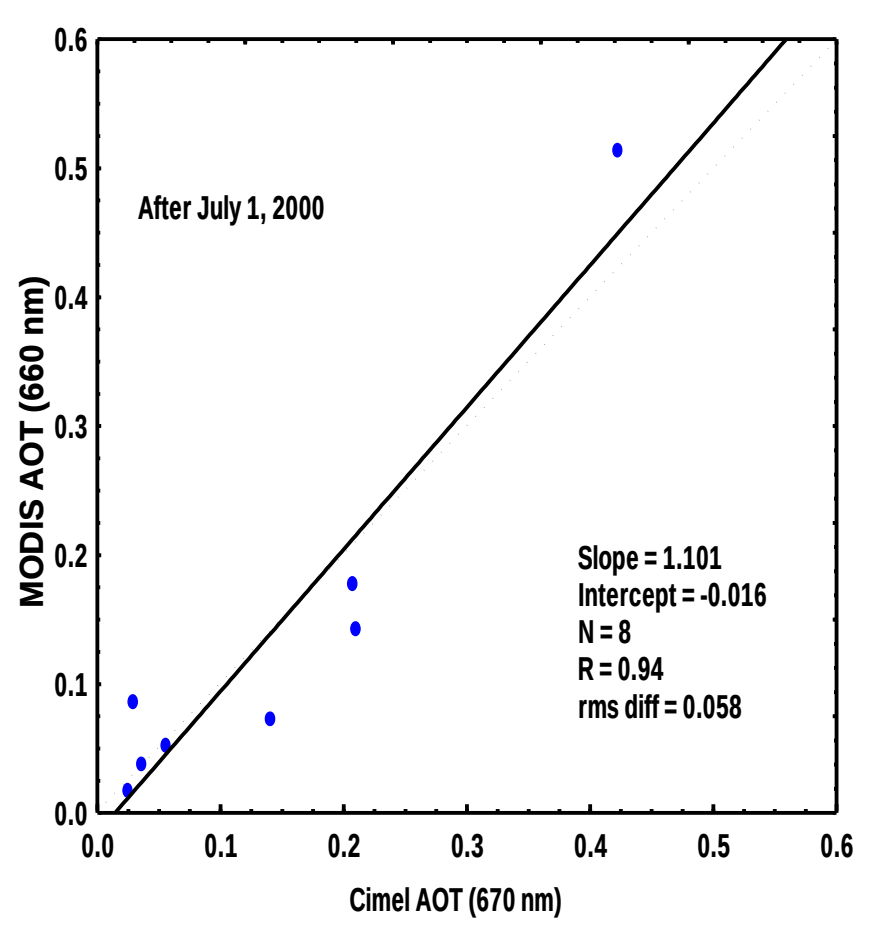
AOT Comparison at 470 nm



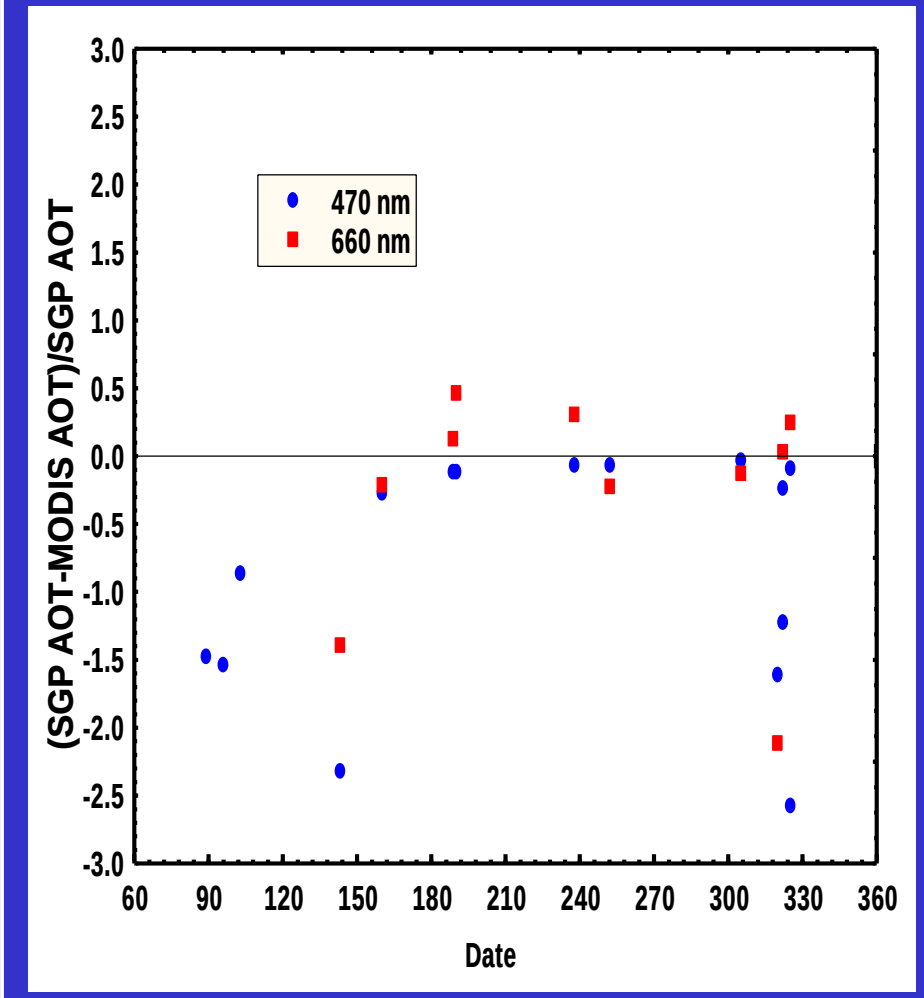


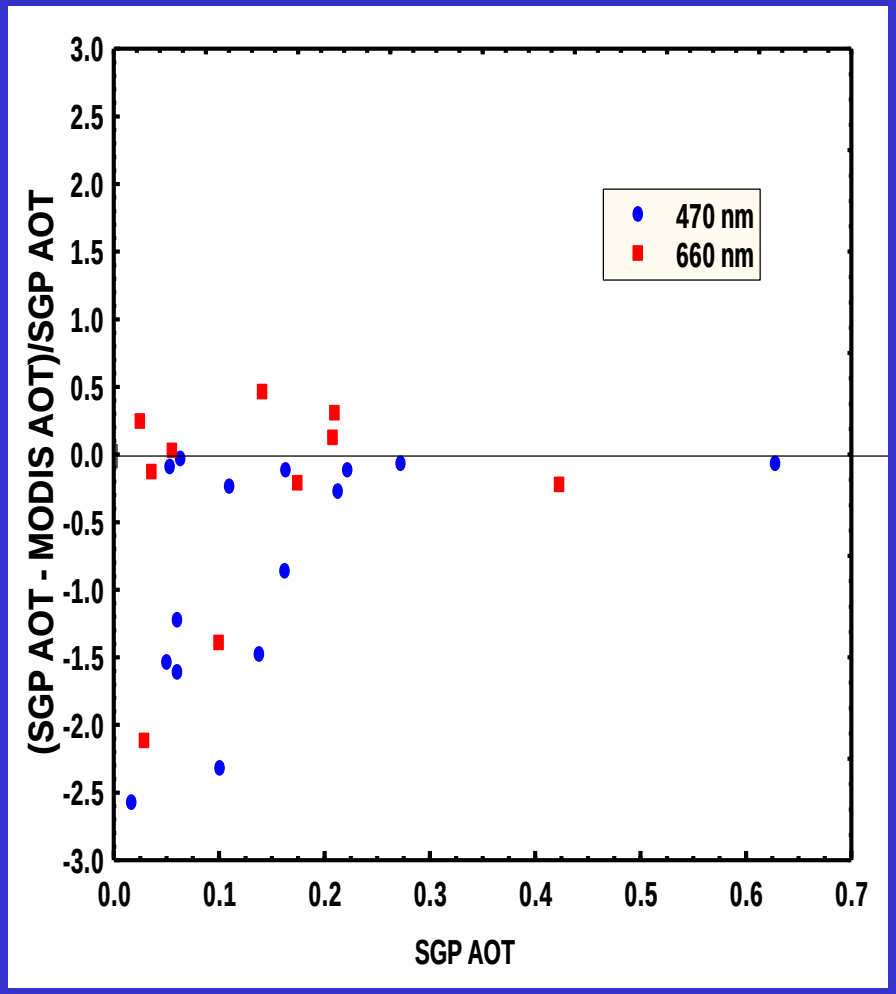
AOT Comparison at 670 nm

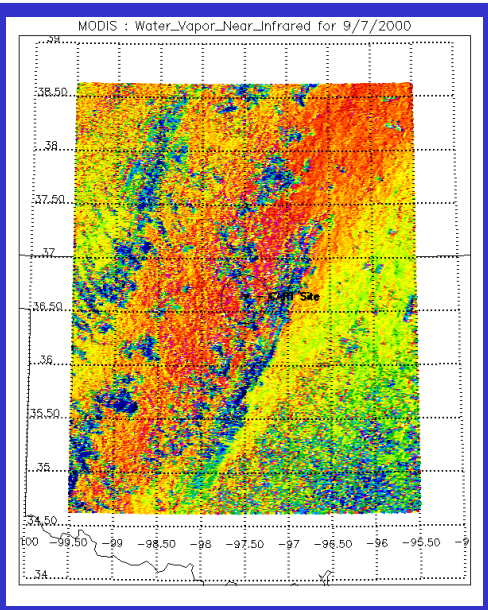


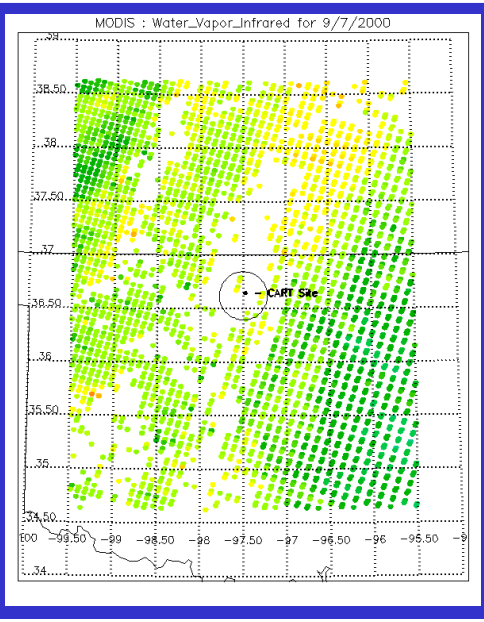


AOT Differences






MODIS : Water_Vapor_Near_Infrared for 9/7/2000
CART Site


MODIS : Water_Vapor_Infrared for 9/7/2000
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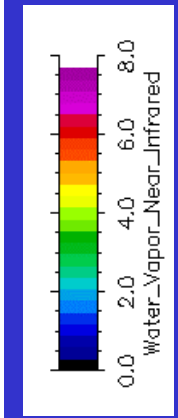
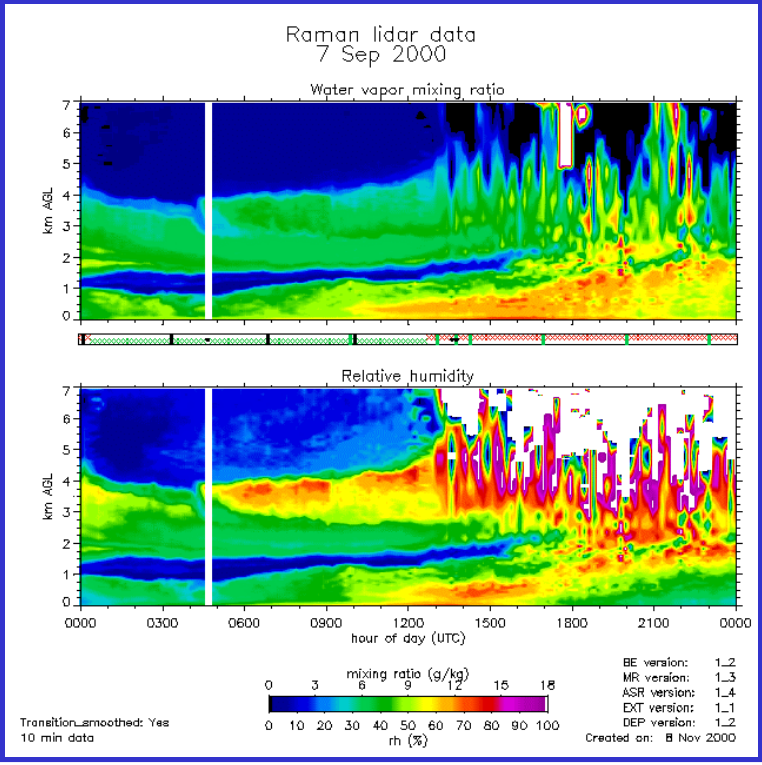
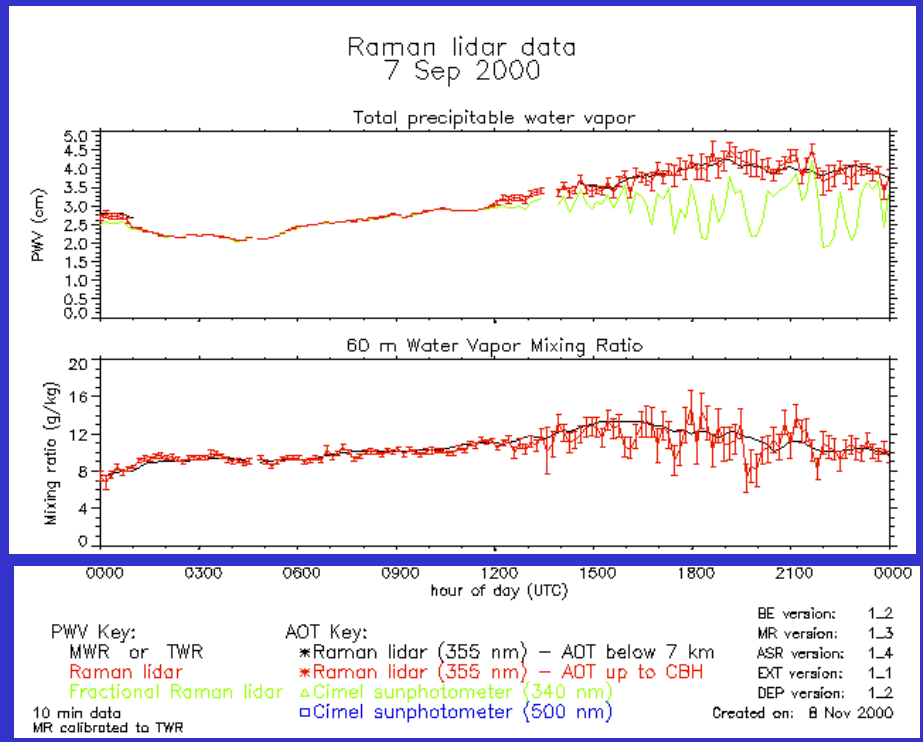
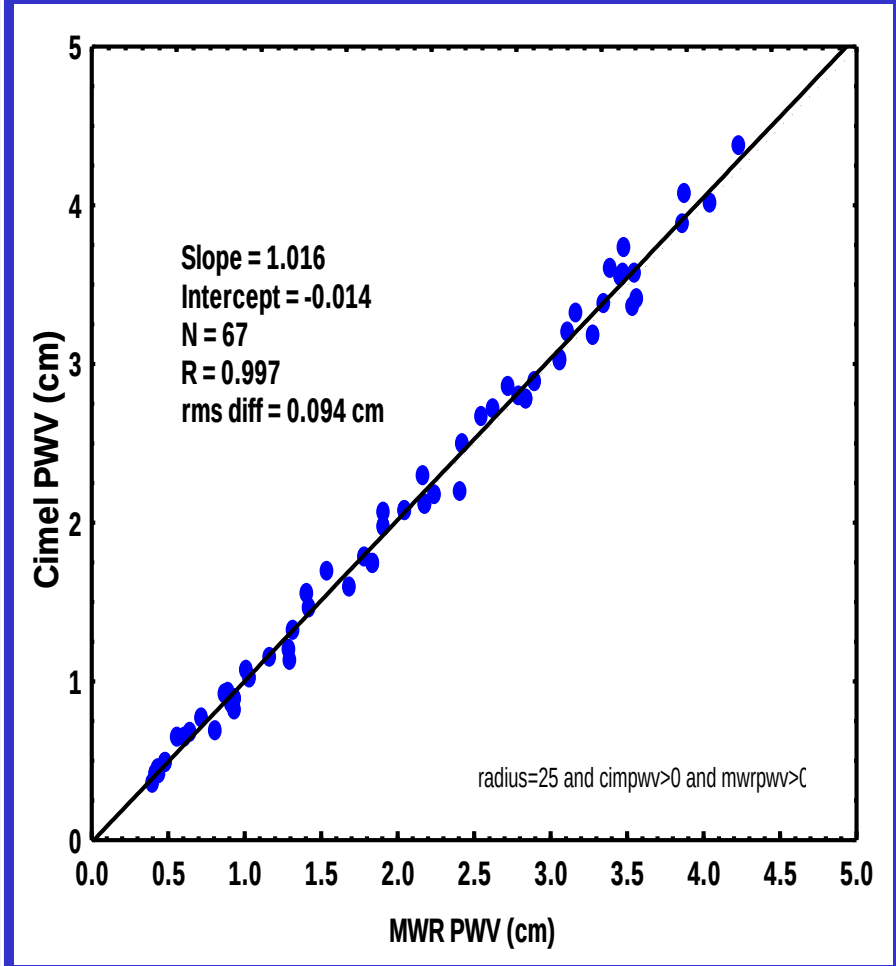
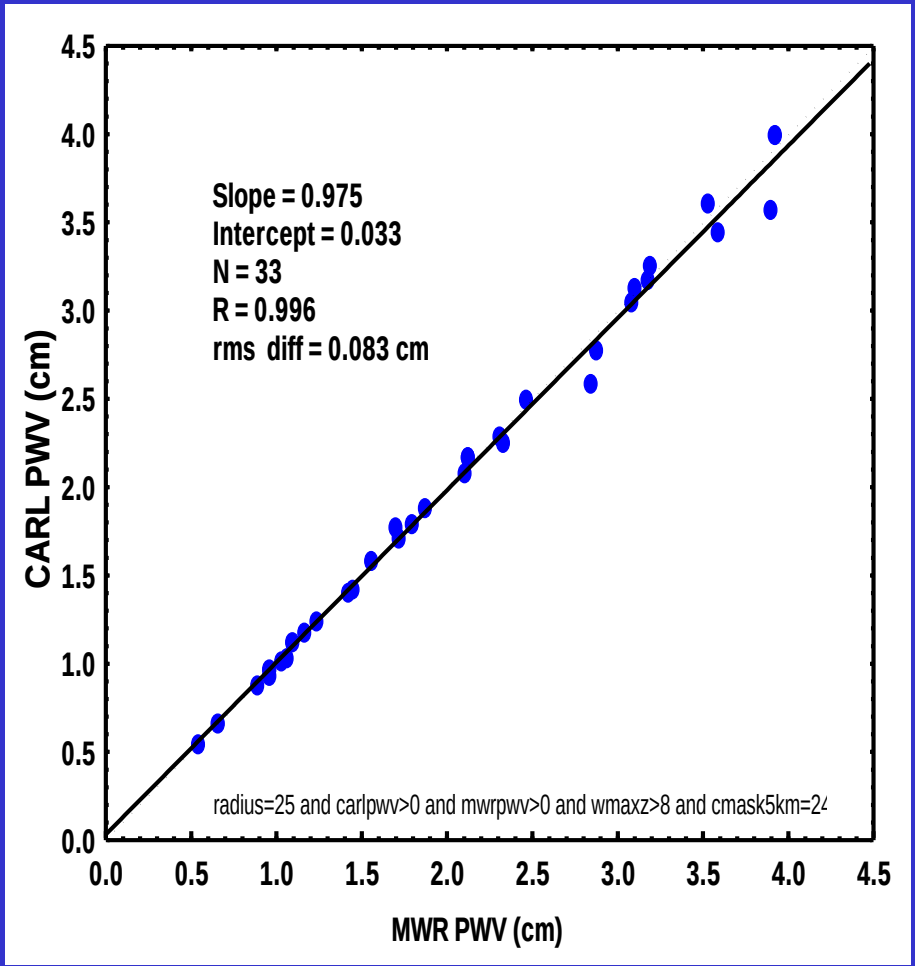

Water_Vapor_Near_Infrared
0.0
2.0
4.0
6.0
8.0


Raman lidar data
7 Sep 2000
Water vapor mixing ratio
km AGL
Relative humidity
hour of day (UTC)
mixing ratio (g/kg)
rh (%)
Transition_smoothed: Yes
10 min data
BE version: 1_2
MR version: 1_3
ASR version: 1_4
EXT version: 1_1
DEP version: 1_2
Created on: 8 Nov 2000

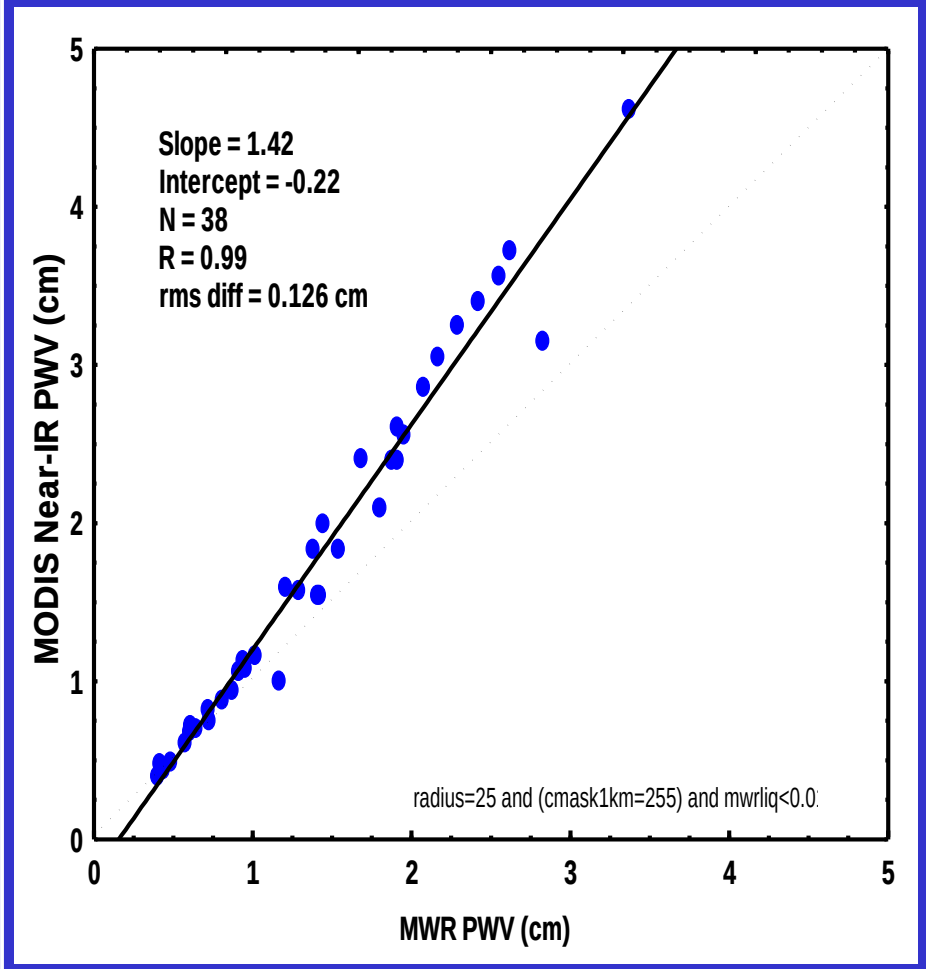

Raman lidar data
7 Sep 2000
Total precipitable water vapor
PWV (cm)
60 m Water Vapor Mixing Ratio
Mixing ratio (g/kg)
hour of day (UTC)
PWV Key:
MWR or TWR
Raman lidar
Fractional Raman lidar
AOT Key:
Raman lidar (355 nm) – AOT below 7 km
Raman lidar (355 nm) – AOT up to CBH
Cimel sunphotometer (340 nm)
Cimel sunphotometer (500 nm)
10 min data
MR calibrated to TWR
BE version: 1_2
MR version: 1_3
ASR version: 1_4
EXT version: 1_1
DEP version: 1_2
Created on: 8 Nov 2000

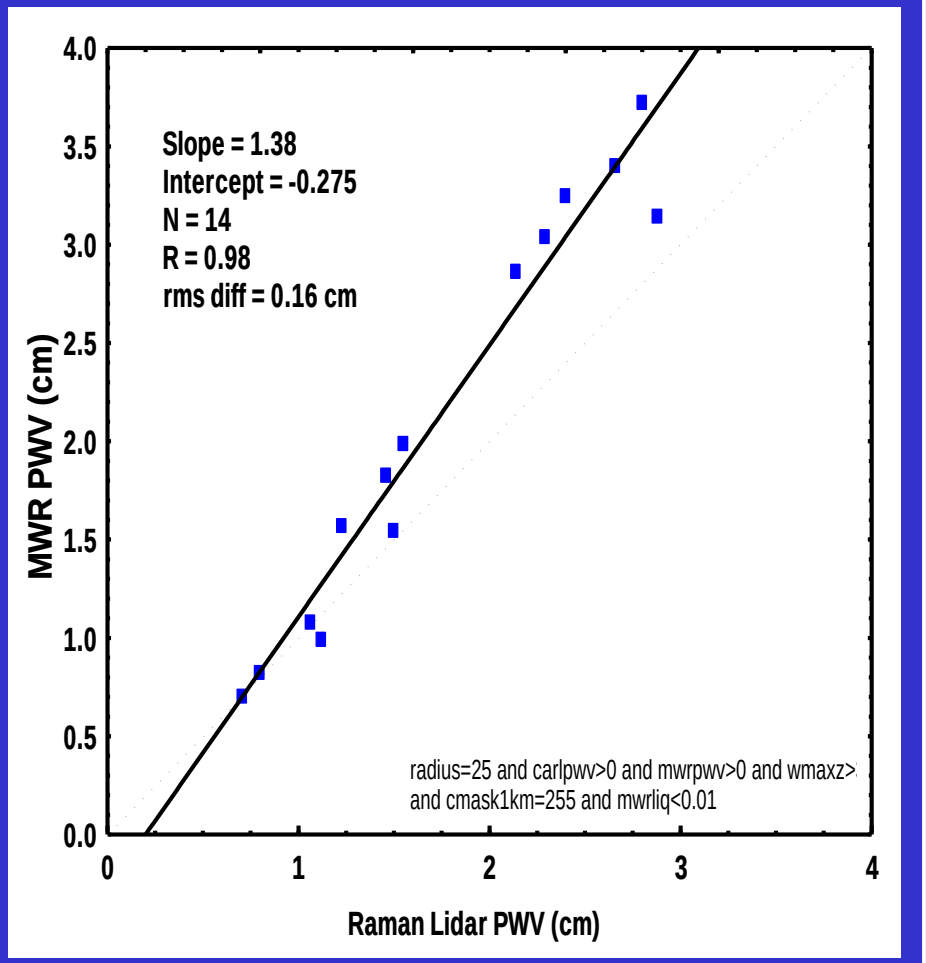
MWR, Raman Lidar, Cimel PWV comparisons



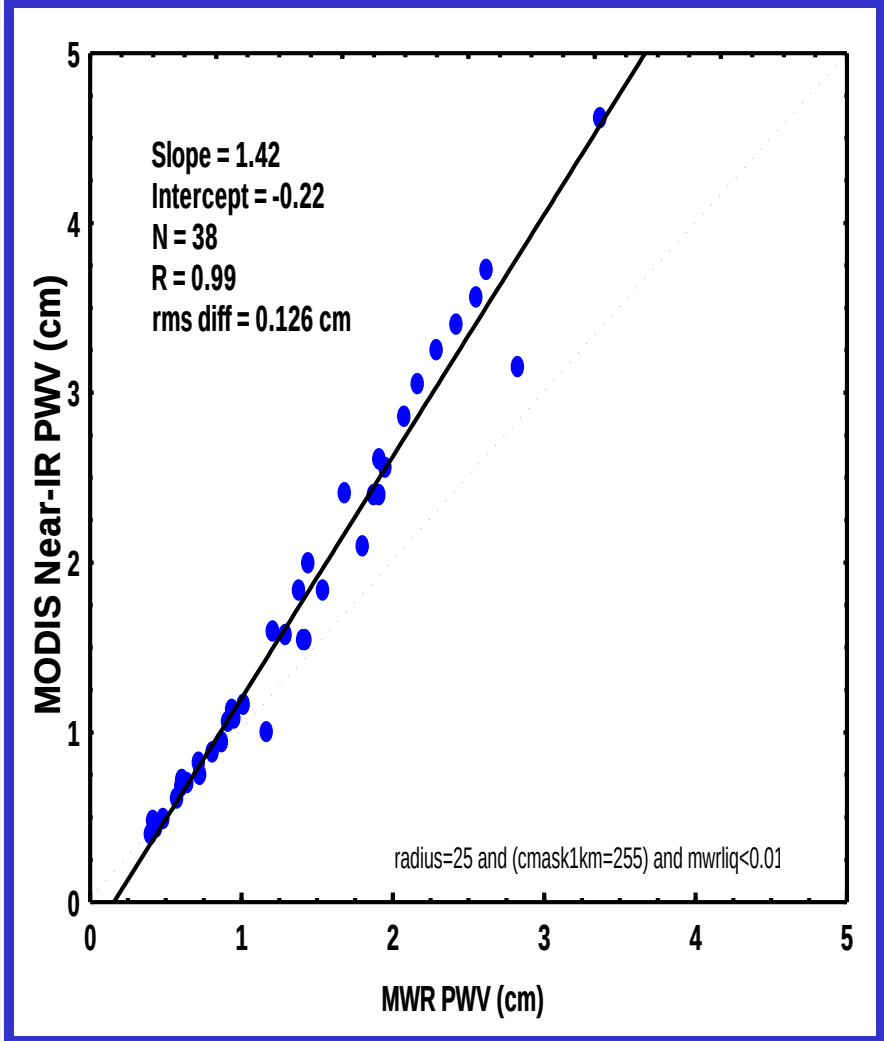


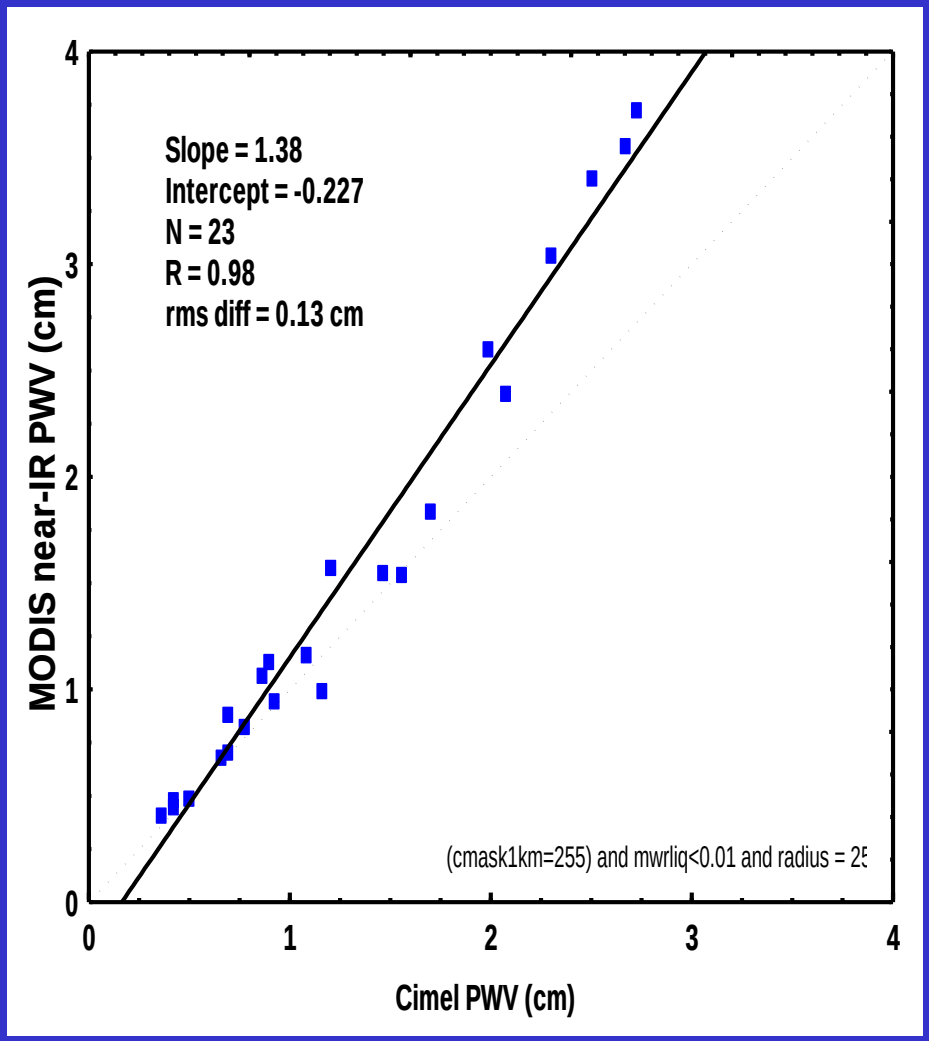
MWR, Raman Lidar, MODIS near-IR PWV comparisons



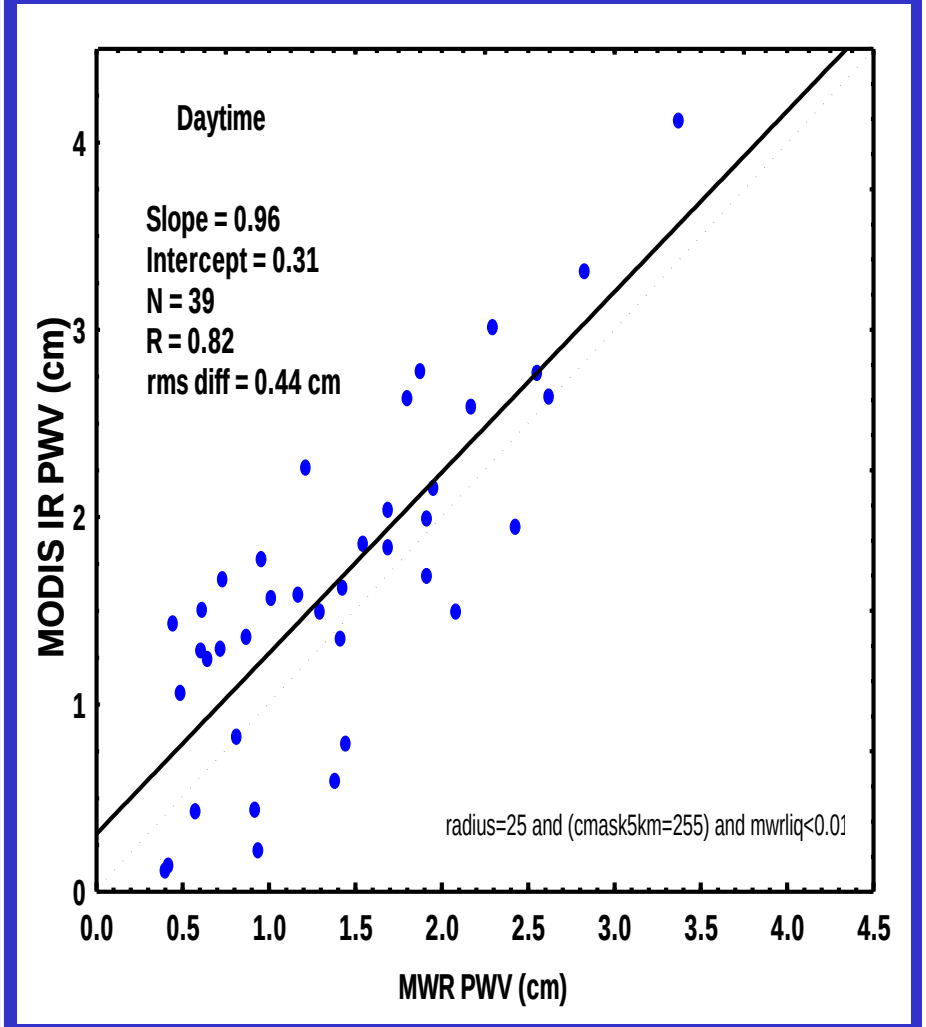


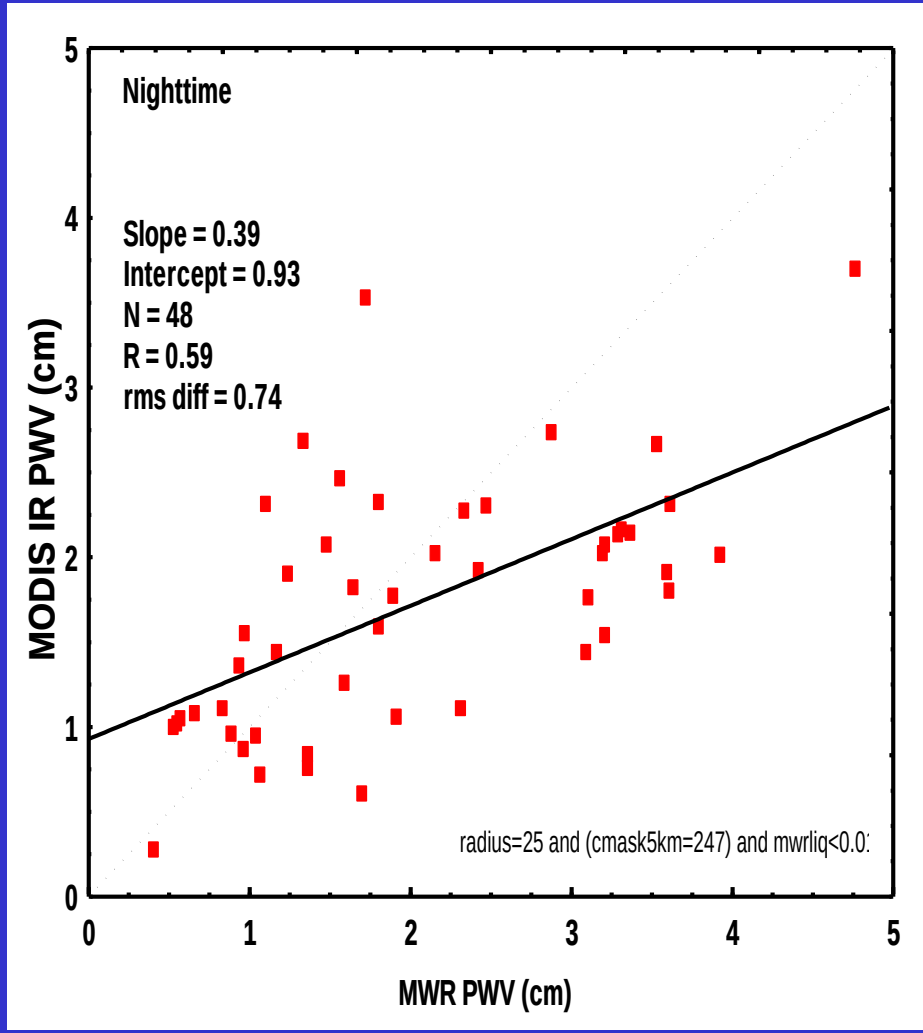
MWR, Cimel, MODIS near-IR PWV comparisons





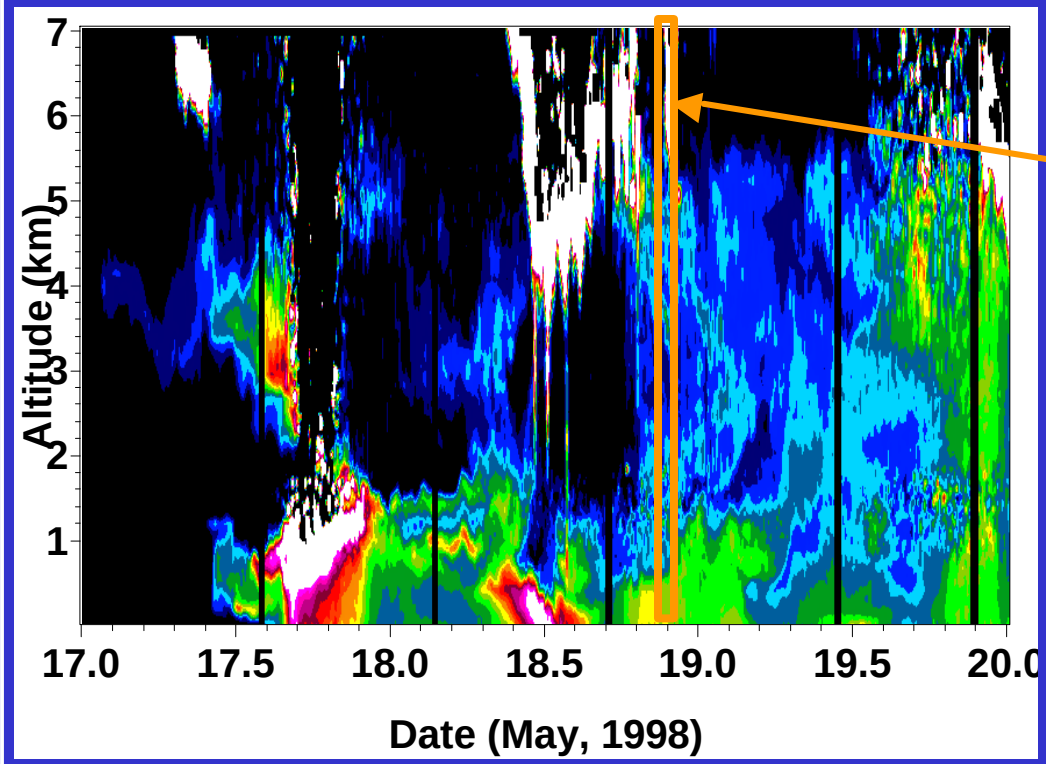
MWR, MODIS IR PWV comparisons

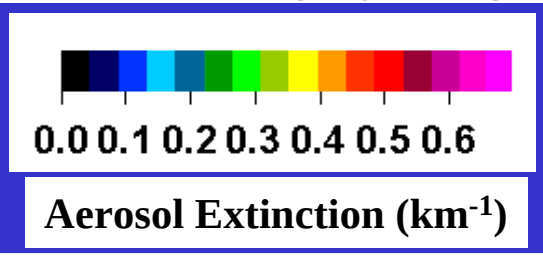


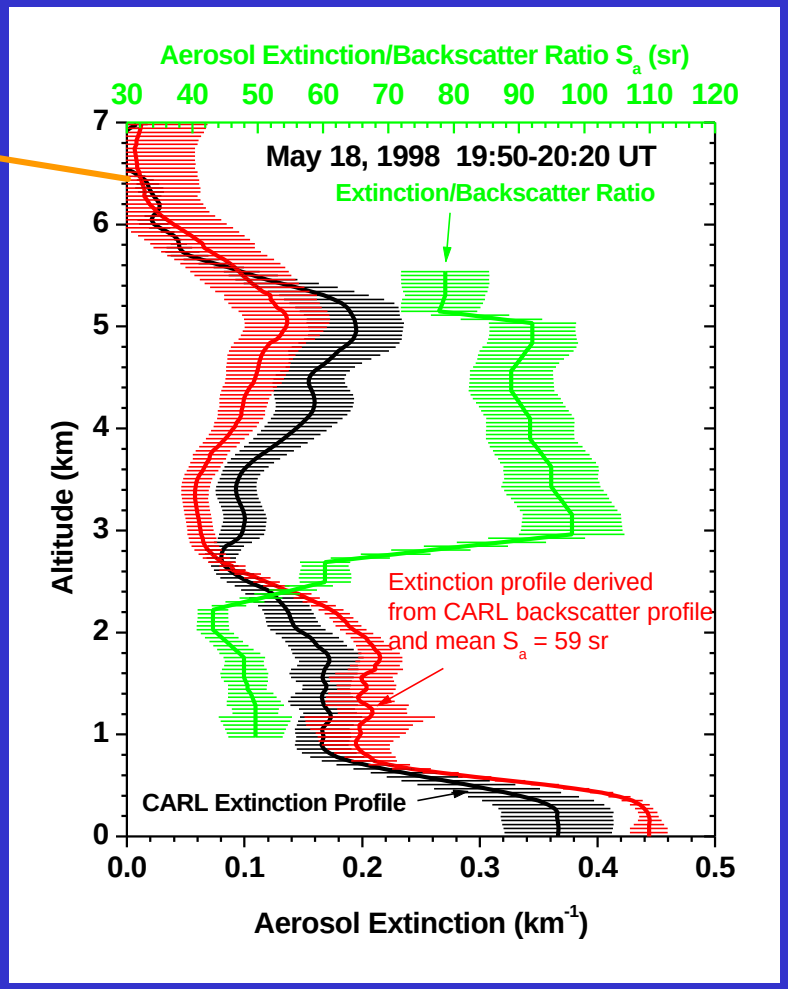


Raman lidar observations of the aerosol vertical variability

- measures vertical variability in aerosol extinction/backscatter (S_a)
- variability due to changes in size, composition of aerosols

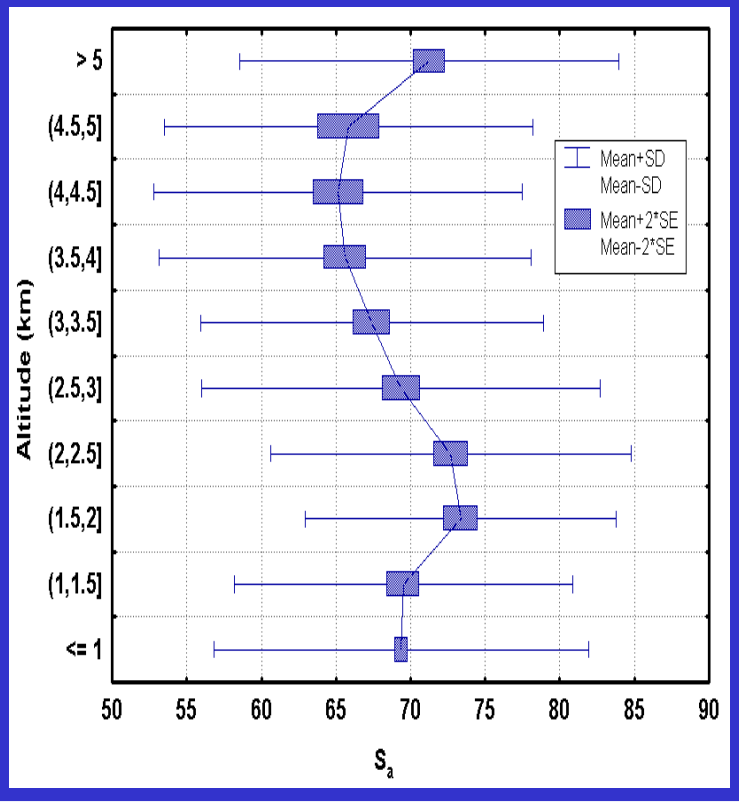


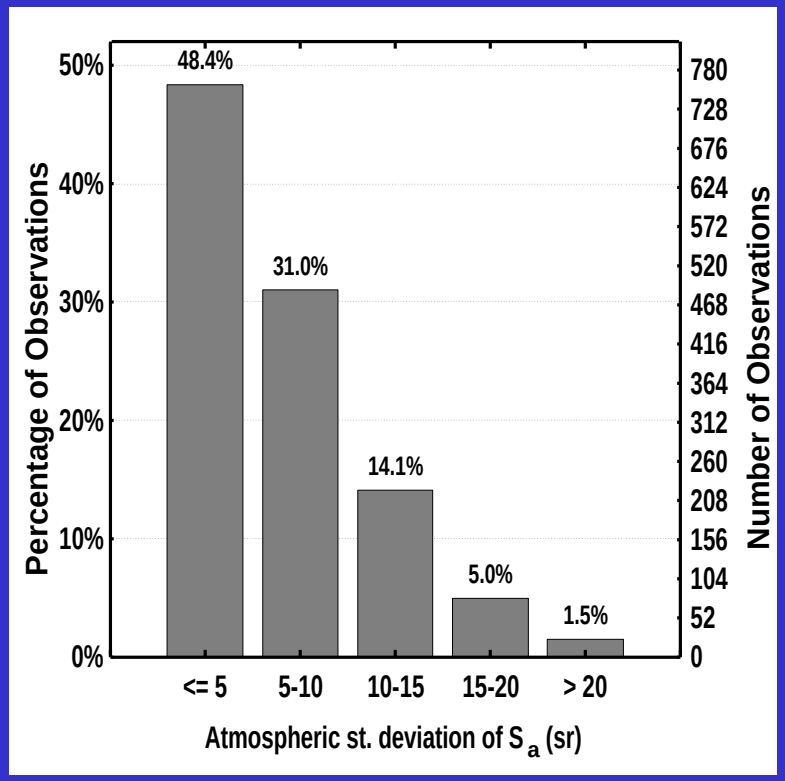




Raman lidar measurements of aerosol extinction/backscatter ratio S_a

- Average values show increase at top of BL, then a slight decrease with altitude
- Large (>20% or >10 sr) variations in S_a vertical profile occur about 20% of time



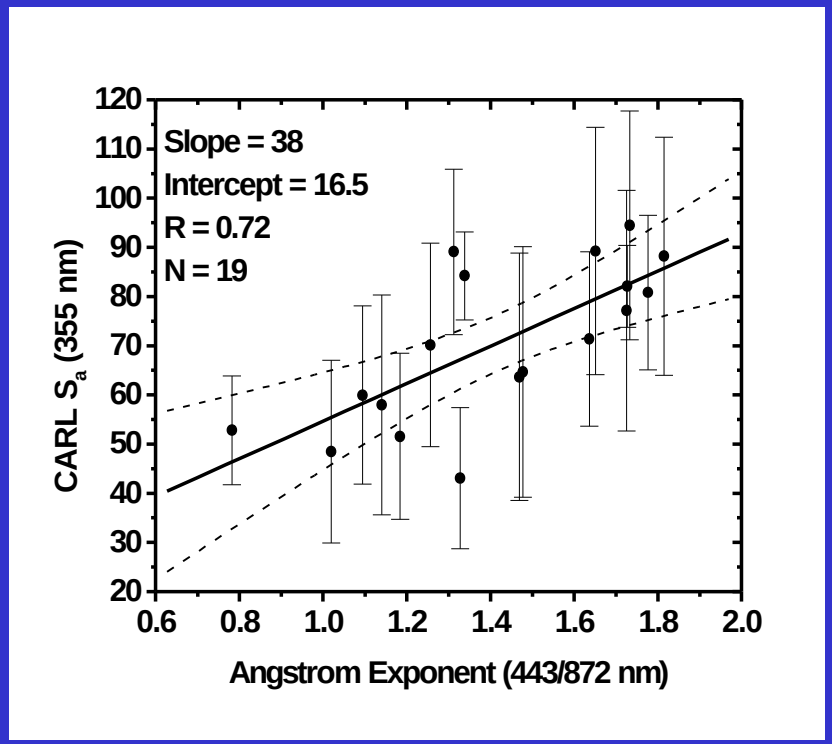


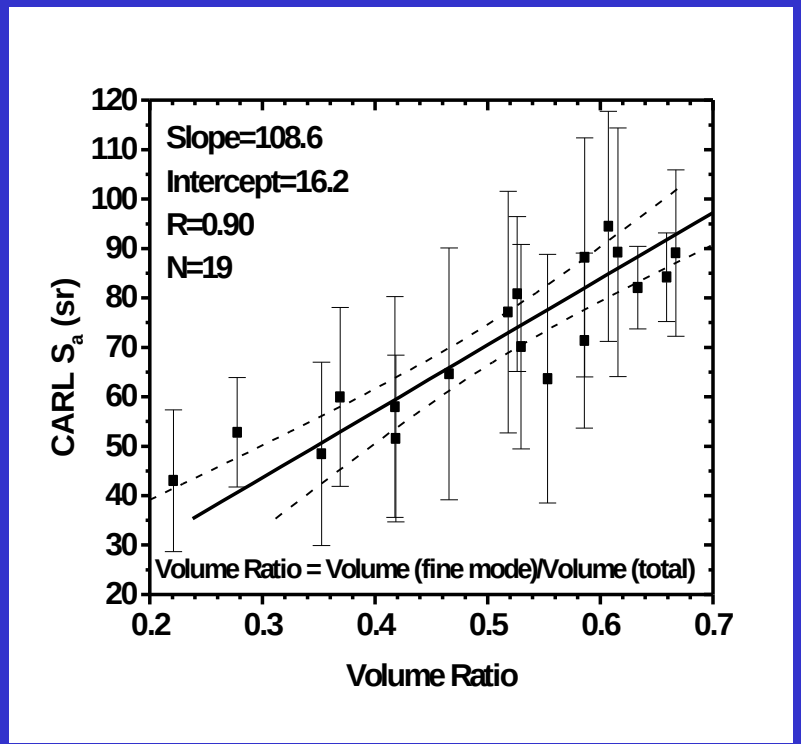
Comparison of Raman lidar S_a with Cimel aerosol measurements

- Sa increases with accumulation mode aerosol
- limited to cases with small Sa vertical variability and large AOT (>0.4)

How does Sa profile correlate with IAP measurements of

- Angstrom exponent profile
- single scattering albedo profile



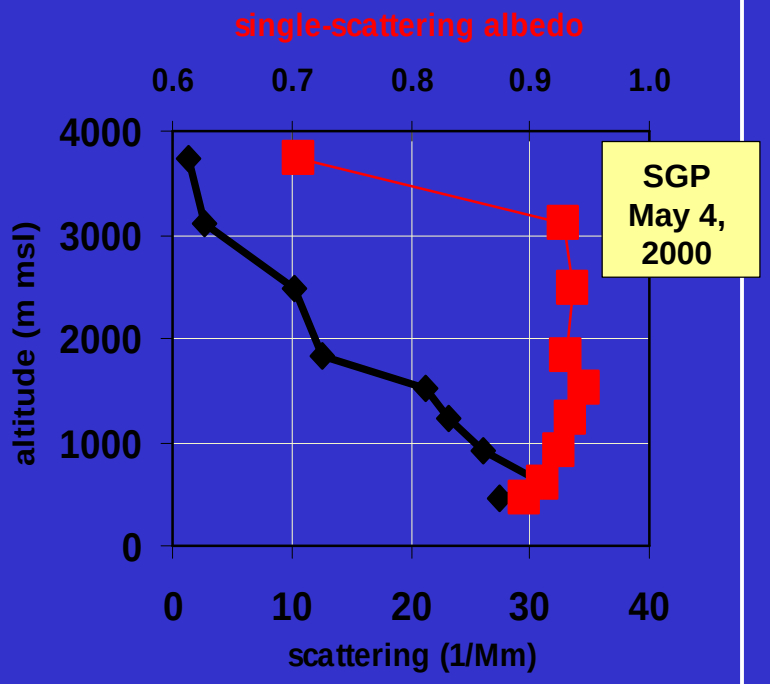


In-Situ Aerosol Prof

Objective: Obtain a statistically-significant data set of vertical distribution of aerosol properties

Measurements: aerosol scattering and absorption, plus chemical composition, above a similarly instrumented surface site

2-3 profiles/week for 1 year



Sample Inlet

Port view of rack

John Ogren

Betsy Andrews

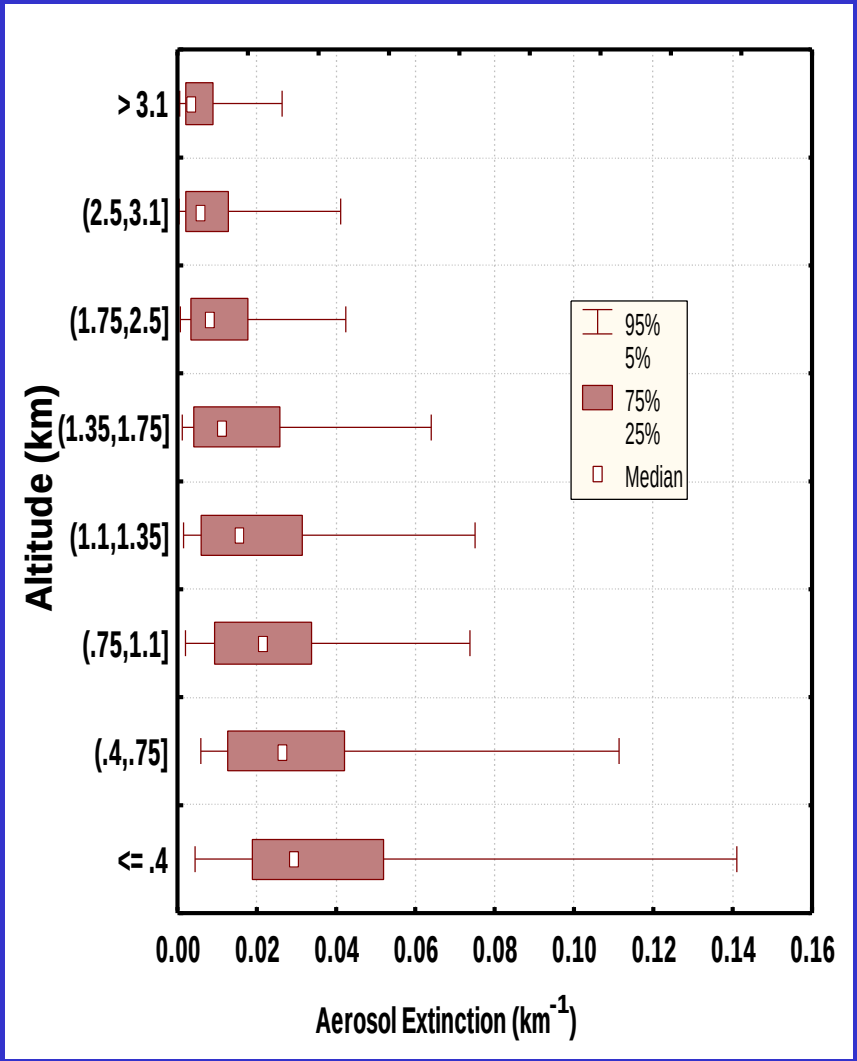
NOAA/CMDL

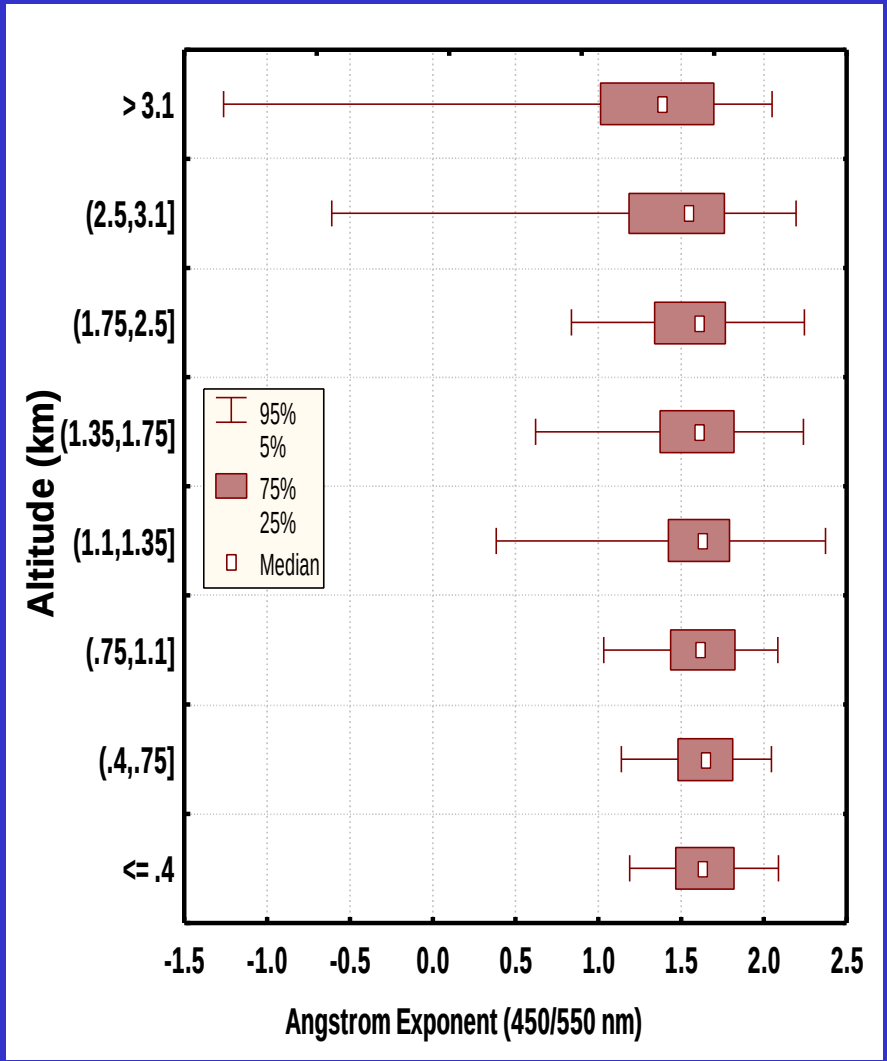
Summary of

Flight period	March 25 – December 31, 2000
Total days	98 flight days/ 280 day period
Total flights	104 flights
Total flight time	215 hours
Average flight duration	2.1 hours
# complete profiles -over CART site -with SGP data	96 75 93

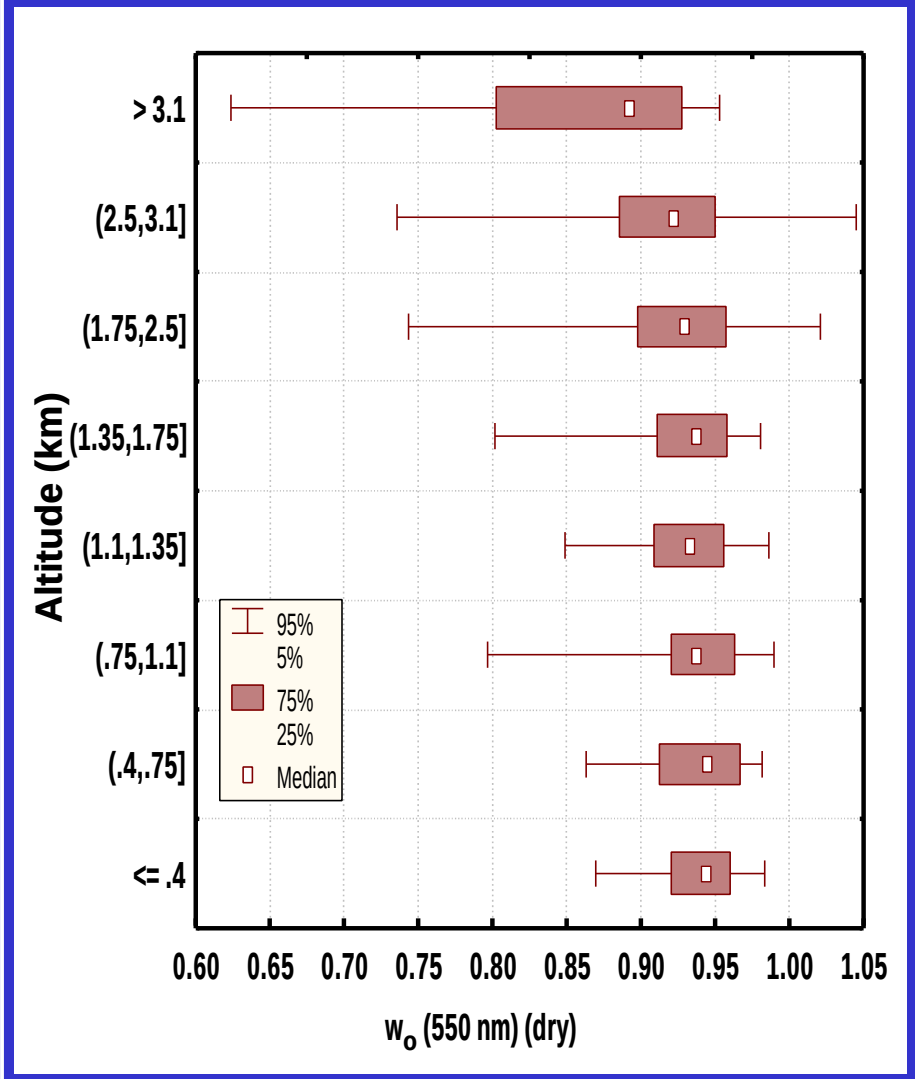
John Ogren
Betsy Andrews
NOAA/CMDL

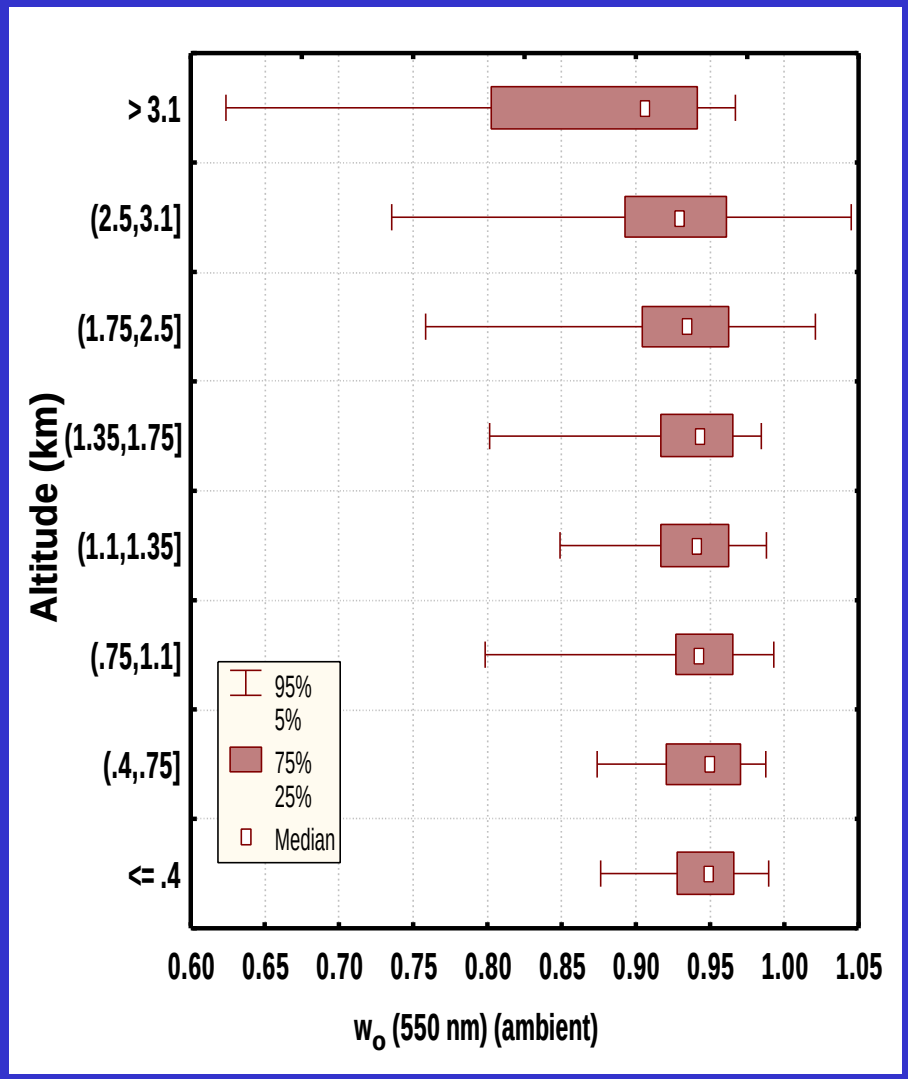
SGP IAP measurements

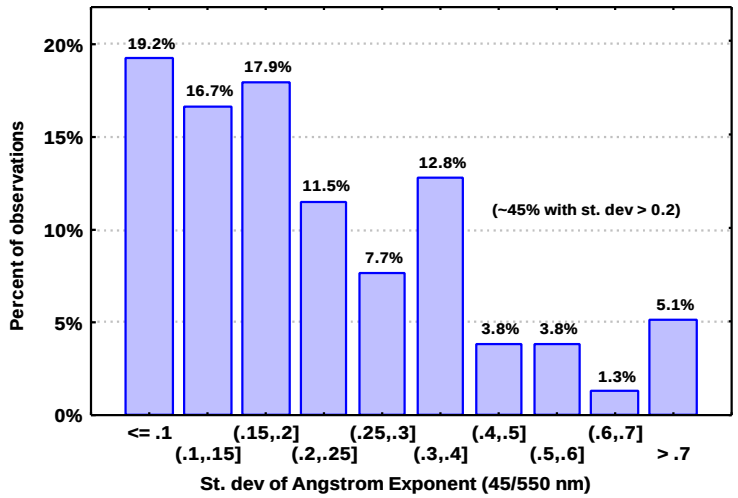


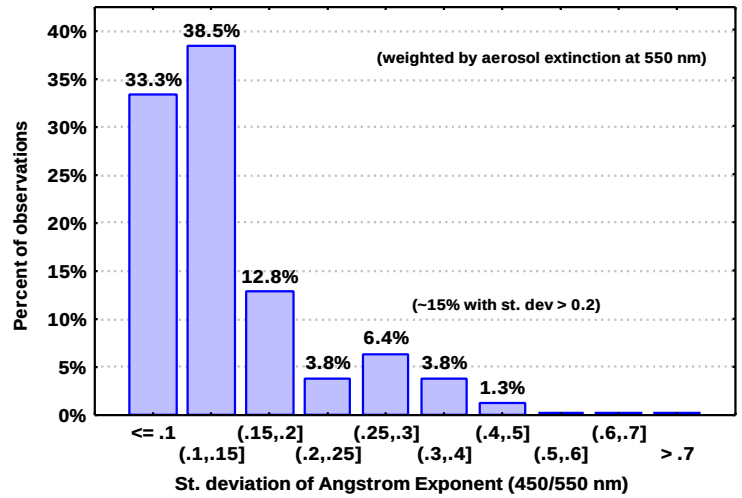


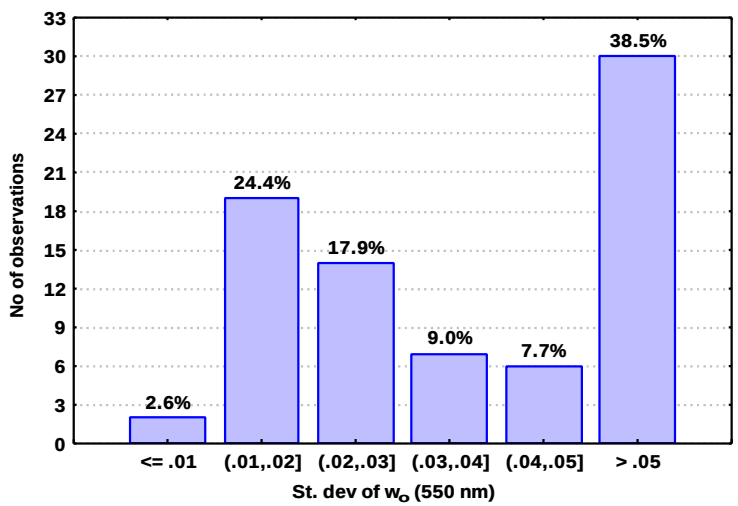
SGP IAP measurements

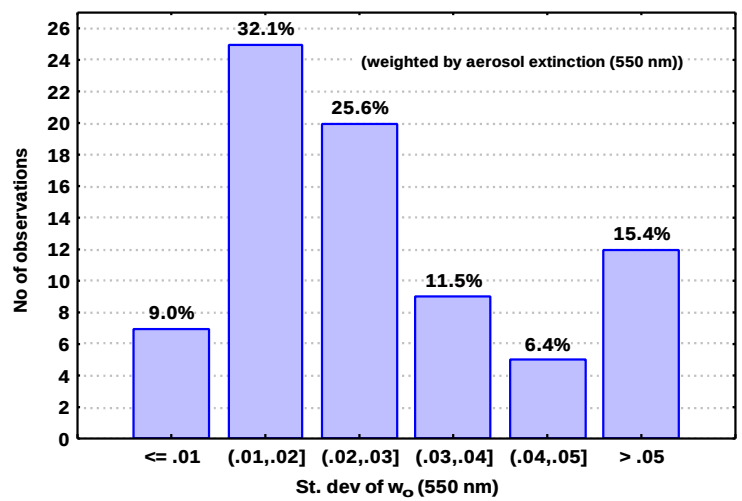





Percent of observations
20%
15%
10%
5%
0%
19.2%
16.7%
17.9%
11.5%
7.7%
12.8%
3.8%
3.8%
1.3%
5.1%
(~45% with st. dev > 0.2)
<= .1
(.1,.15]
(.15,.2]
(.2,.25]
(.25,.3]
(.3,.4]
(.4,.5]
(.5,.6]
(.6,.7]
> .7
St. dev of Angstrom Exponent (45/550 nm)


Percent of observations
40%
35%
30%
25%
20%
15%
10%
5%
0%
33.3%
38.5%
12.8%
3.8%
6.4%
3.8%
1.3%
(weighted by aerosol extinction at 550 nm)
(~15% with st. dev > 0.2)
<= .1
(.1,.15]
(.15,.2]
(.2,.25]
(.25,.3]
(.3,.4]
(.4,.5]
(.5,.6]
(.6,.7]
> .7
St. deviation of Angstrom Exponent (450/550 nm)


No of observations
33
30
27
24
21
18
15
12
9
6
3
0
2.6%
24.4%
17.9%
9.0%
7.7%
38.5%
<= .01
(.01,.02]
(.02,.03]
(.03,.04]
(.04,.05]
> .05
St. dev of w_o (550 nm)


No of observations
26
24
22
20
18
16
14
12
10
8
6
4
2
0
9.0%
32.1%
25.6%
11.5%
6.4%
15.4%
(weighted by aerosol extinction (550 nm))
<= .01
(.01,.02]
(.02,.03]
(.03,.04]
(.04,.05]
> .05
St. dev of w_o (550 nm)

Summary

- Aerosol Optical Thickness
  - MODIS AOT in generally good agreement with Cimel/Raman lidar AOT
  - Additional comparisons required for better statistics
- Precipitable Water Vapor
  - MODIS near-IR biased high by about 35-40%
  - MODIS IR daytime small bias but large (30-40%) rms difference
  - MODIS IR nighttime in poor agreement with SGP data
- Vertical Variability of Aerosols
  - Raman lidar and IAP data show large vertical variability about 15-25%
  - additional studies underway to investigate vertical variability