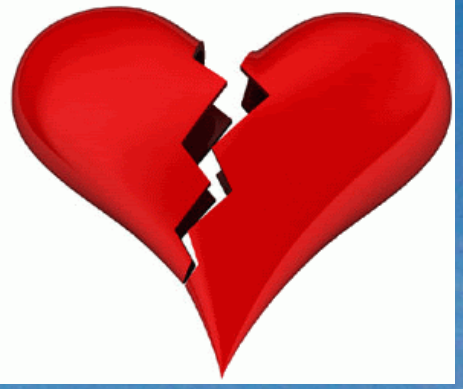
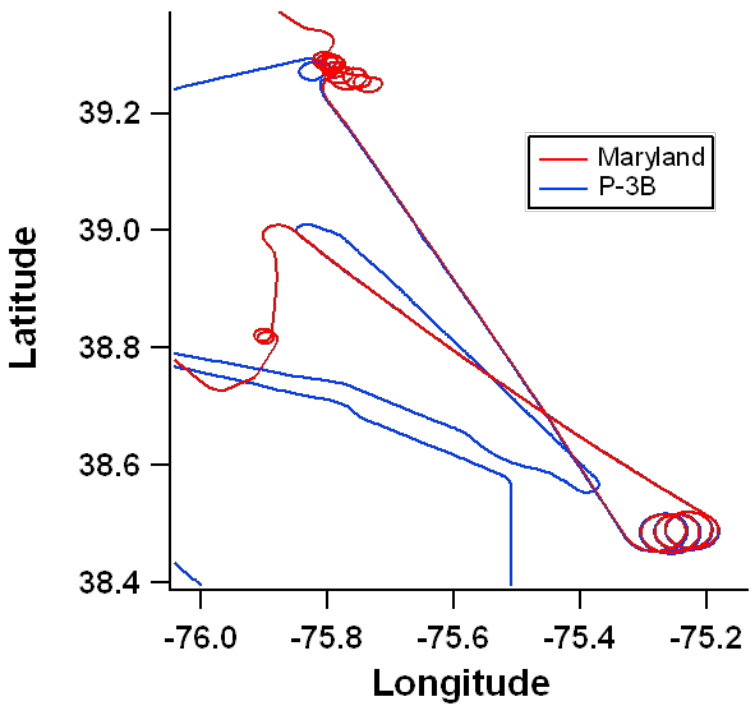


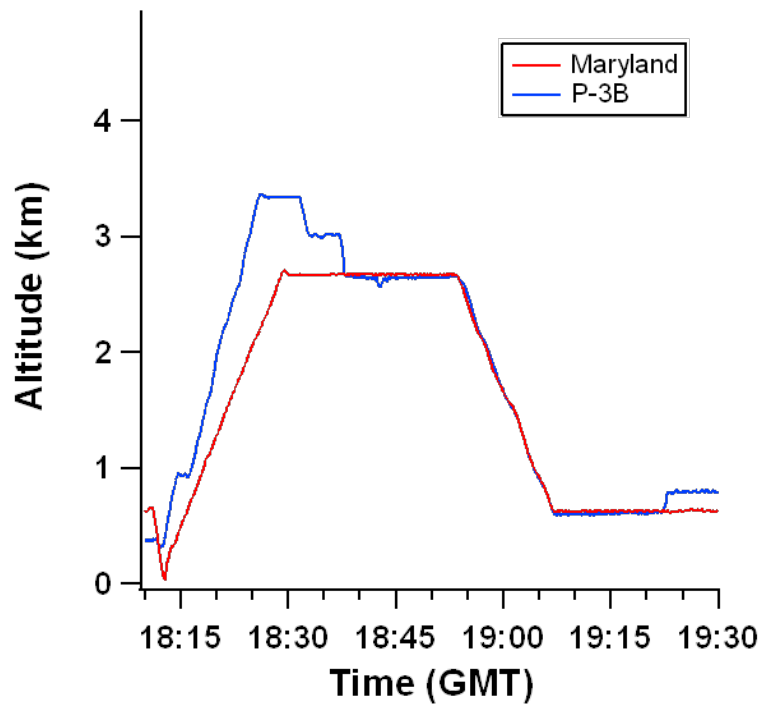
P3 vs. Cessna 402B Comparisons

Jeff Stehr, Gao Chen, Amy Thornhill
Hao He, Lacey Brent, Heather Arkinson, Russ Dickerson
And a cast of thousands!
University of Maryland and NASA Langley

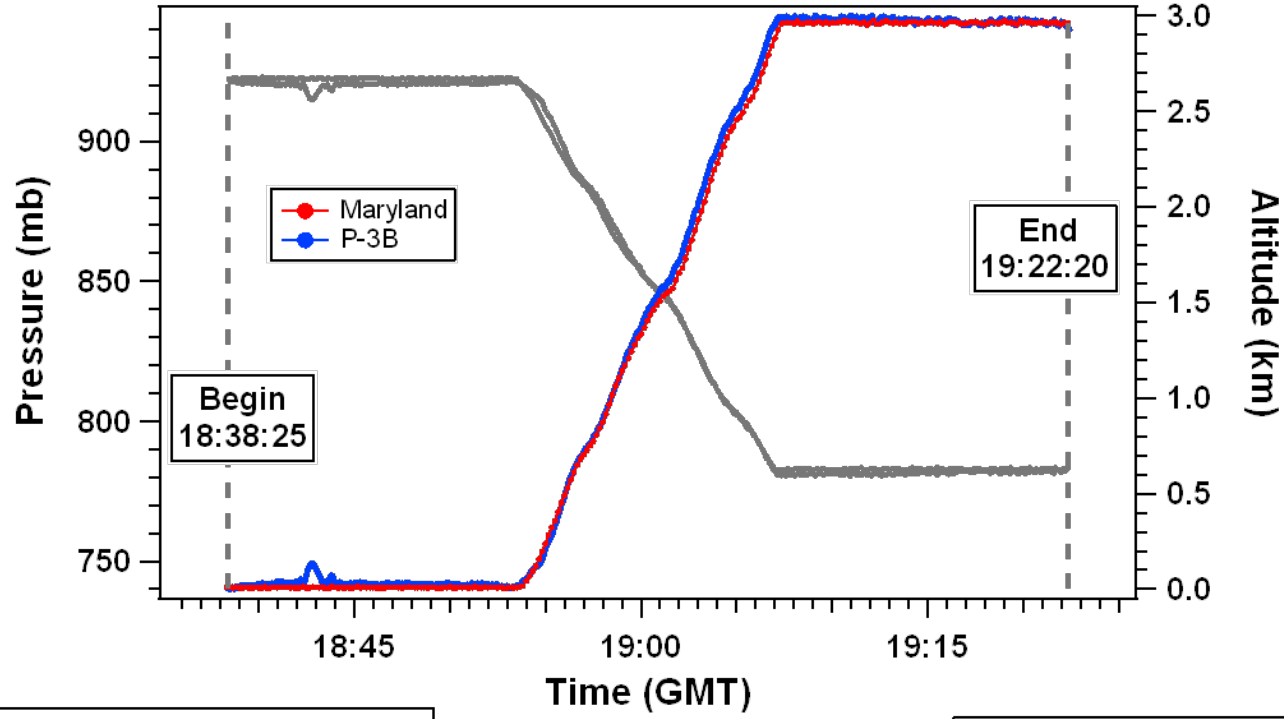
DISCOVER-AQ Data Workshop
February 14, 2012
Newport News, VA

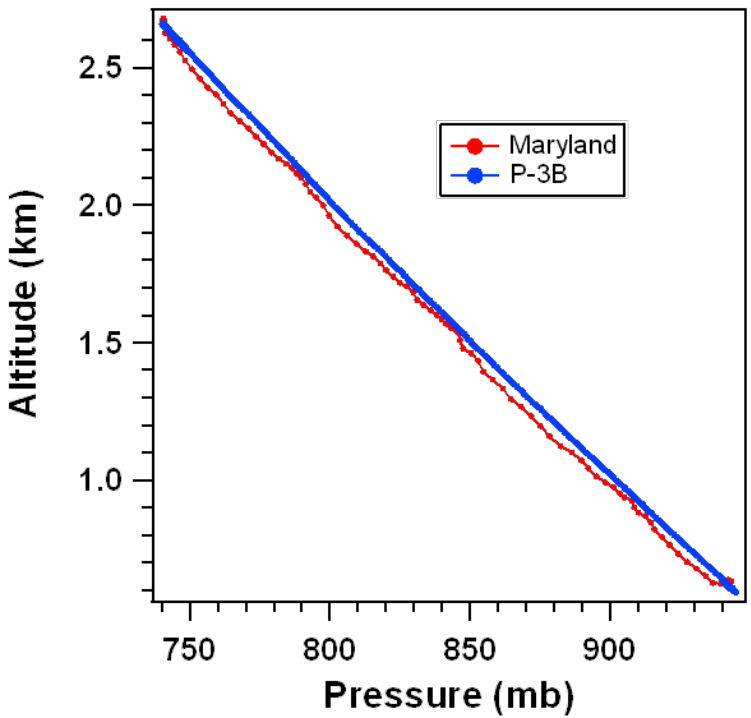
Maryland and NASA Intercomparison on 7/27/2011

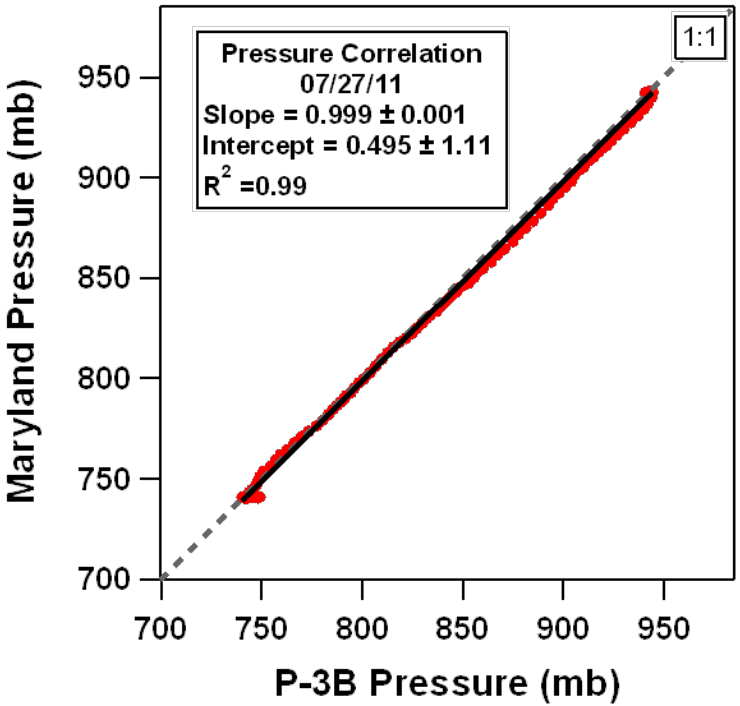




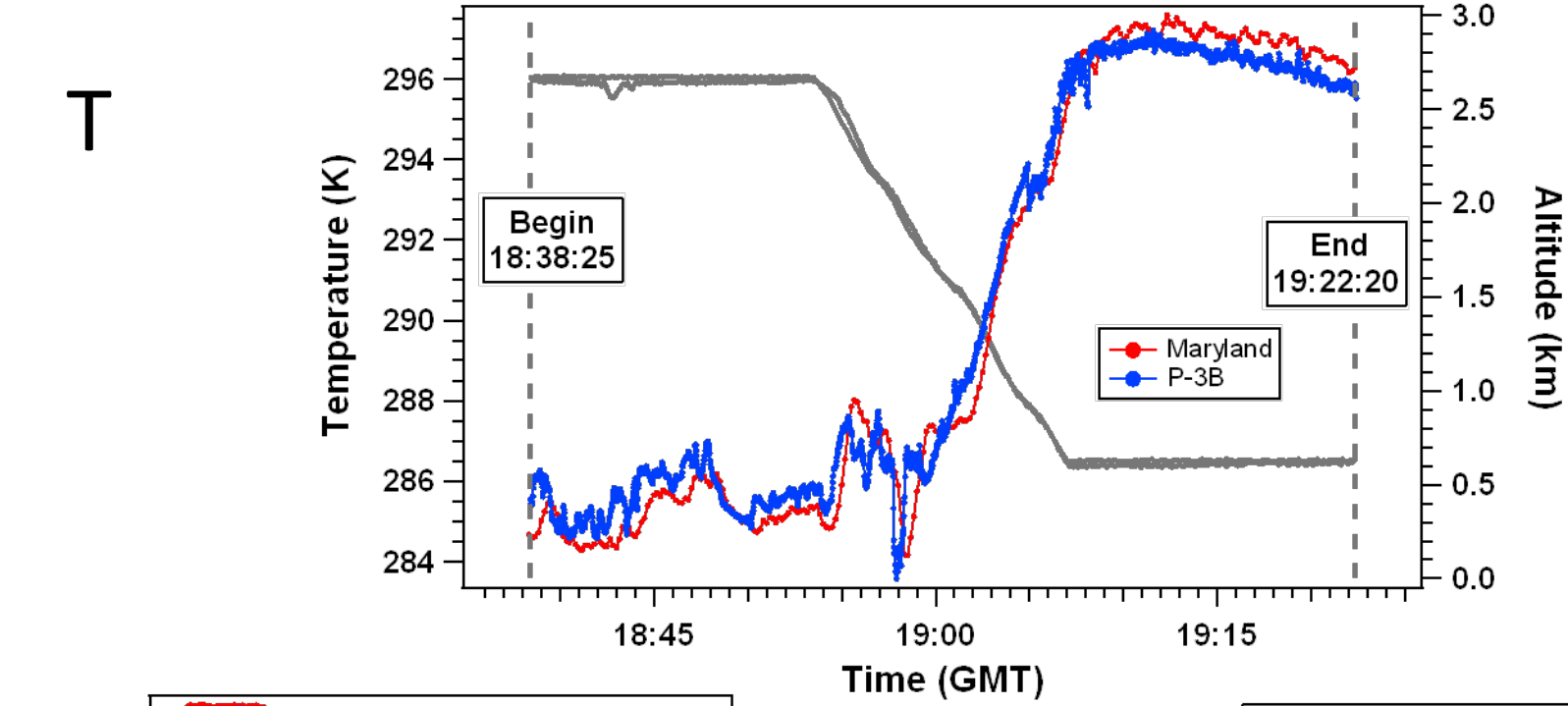
P

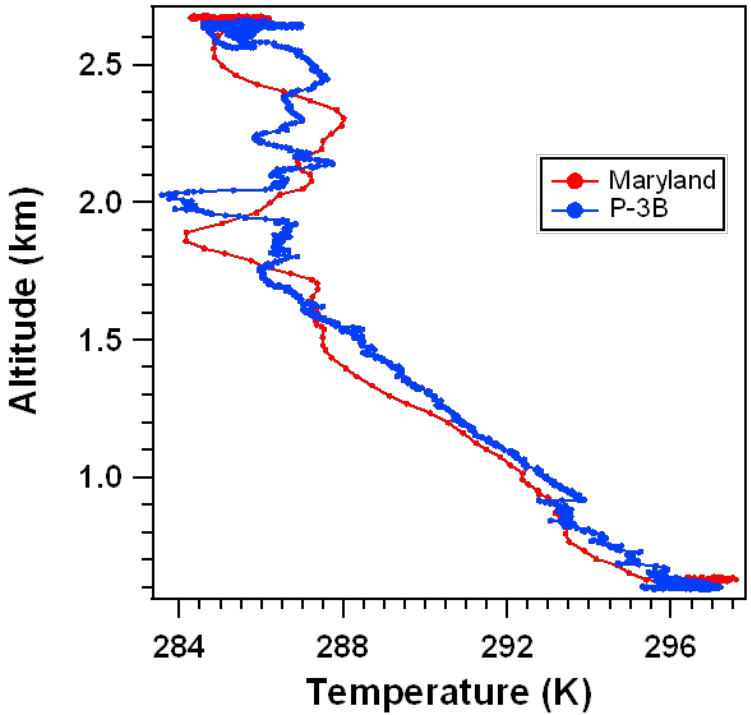

Pressure (mb)
Altitude (km)
Time (GMT)
Maryland
P-3B
Begin
18:38:25
End
19:22:20
18:45
19:00
19:15
900
850
800
750
3.0
2.5
2.0
1.5
1.0
0.5
0.0

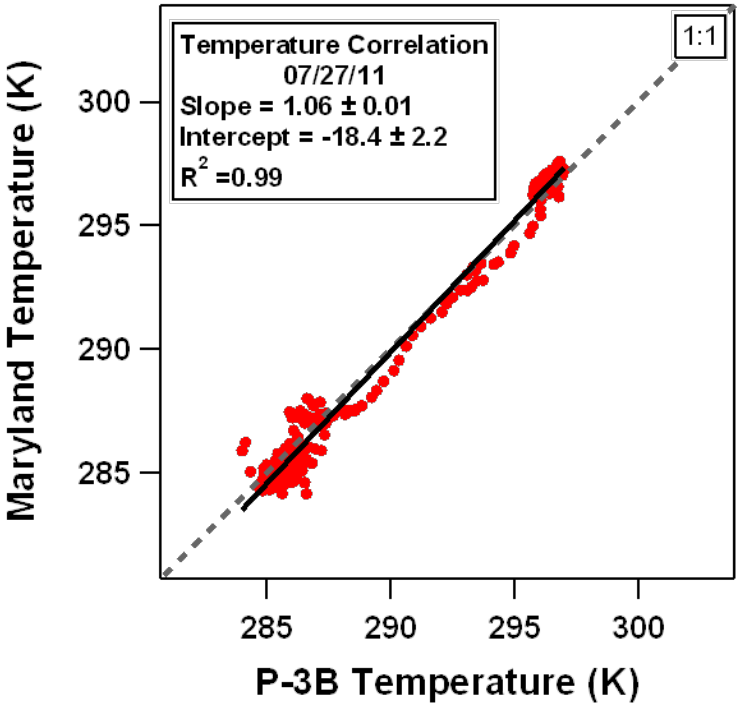

Altitude (km)
Pressure (mb)
Maryland
P-3B
2.5
2.0
1.5
1.0
750
800
850
900

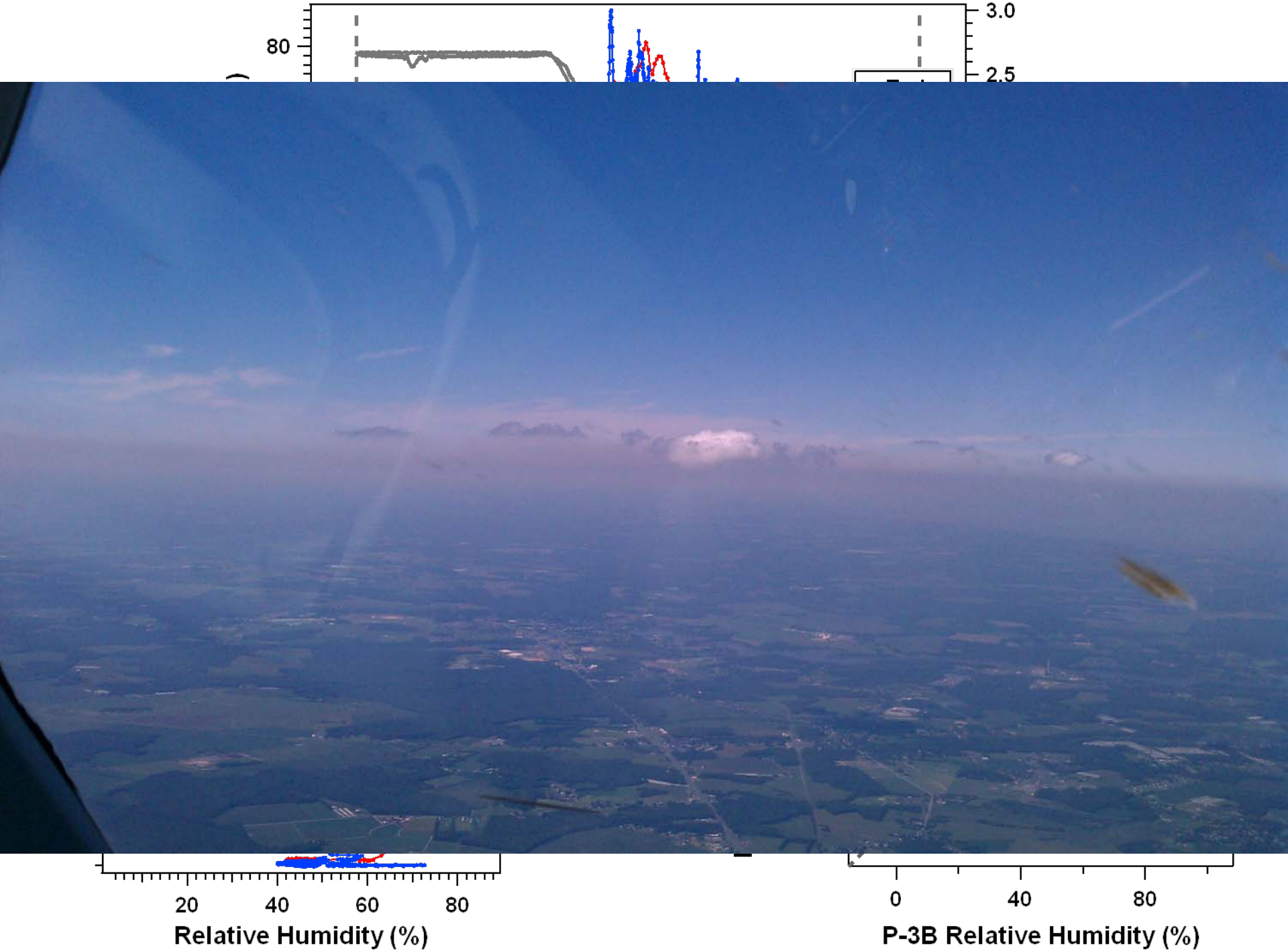

Pressure Correlation
07/27/11
Slope = 0.999 ± 0.001
Intercept = 0.495 ± 1.11
R2 =0.99
1:1
Maryland Pressure (mb)
P-3B Pressure (mb)
950
900
850
800
750
700

T

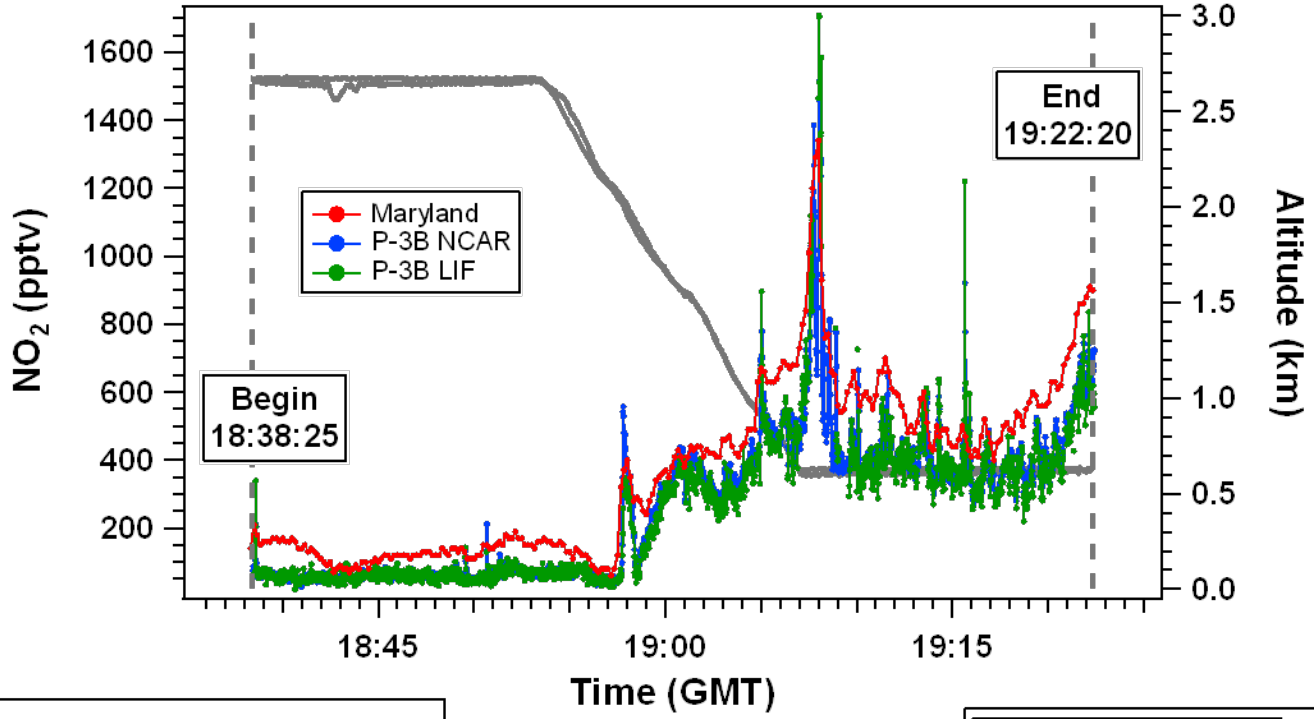

Begin
18:38:25
End
19:22:20
Maryland
P-3B
Temperature (K)
Altitude (km)
Time (GMT)
18:45
19:00
19:15
284
286
288
290
292
294
296
0.0
0.5
1.0
1.5
2.0
2.5
3.0

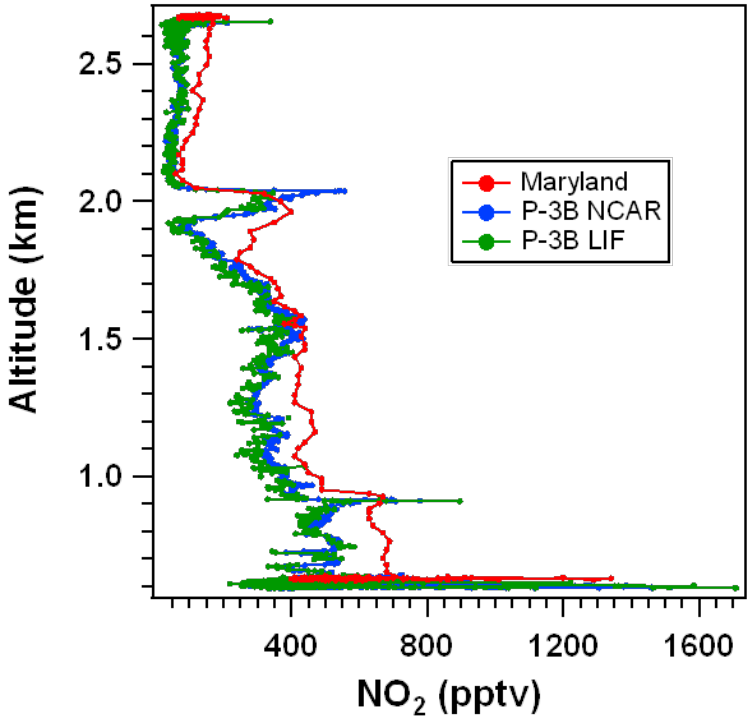

Maryland
P-3B
Altitude (km)
Temperature (K)
1.0
1.5
2.0
2.5
284
288
292
296

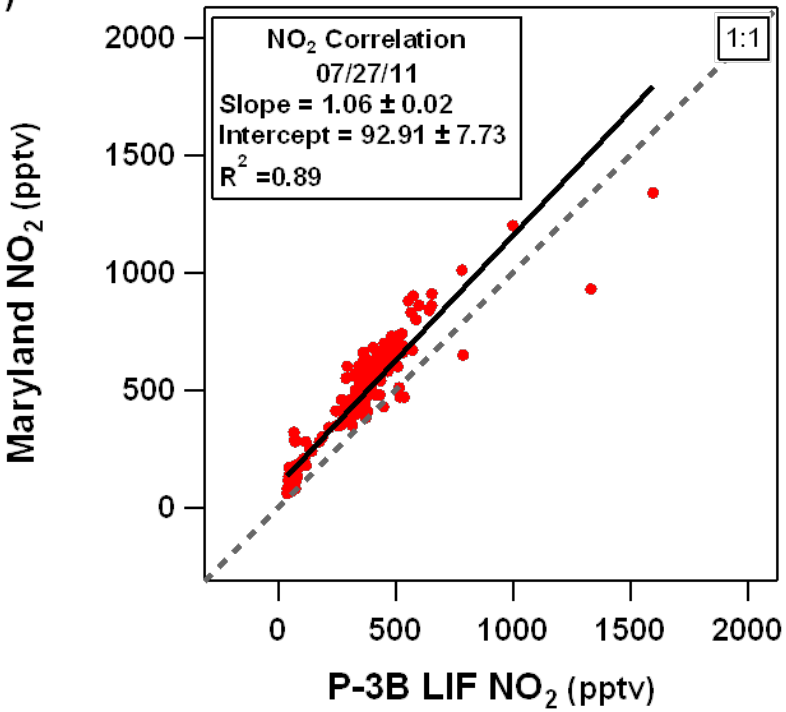

Temperature Correlation
07/27/11
Slope = 1.06 ± 0.01
Intercept = -18.4 ± 2.2
R2 =0.99
1:1
Maryland Temperature (K)
P-3B Temperature (K)
285
290
295
300

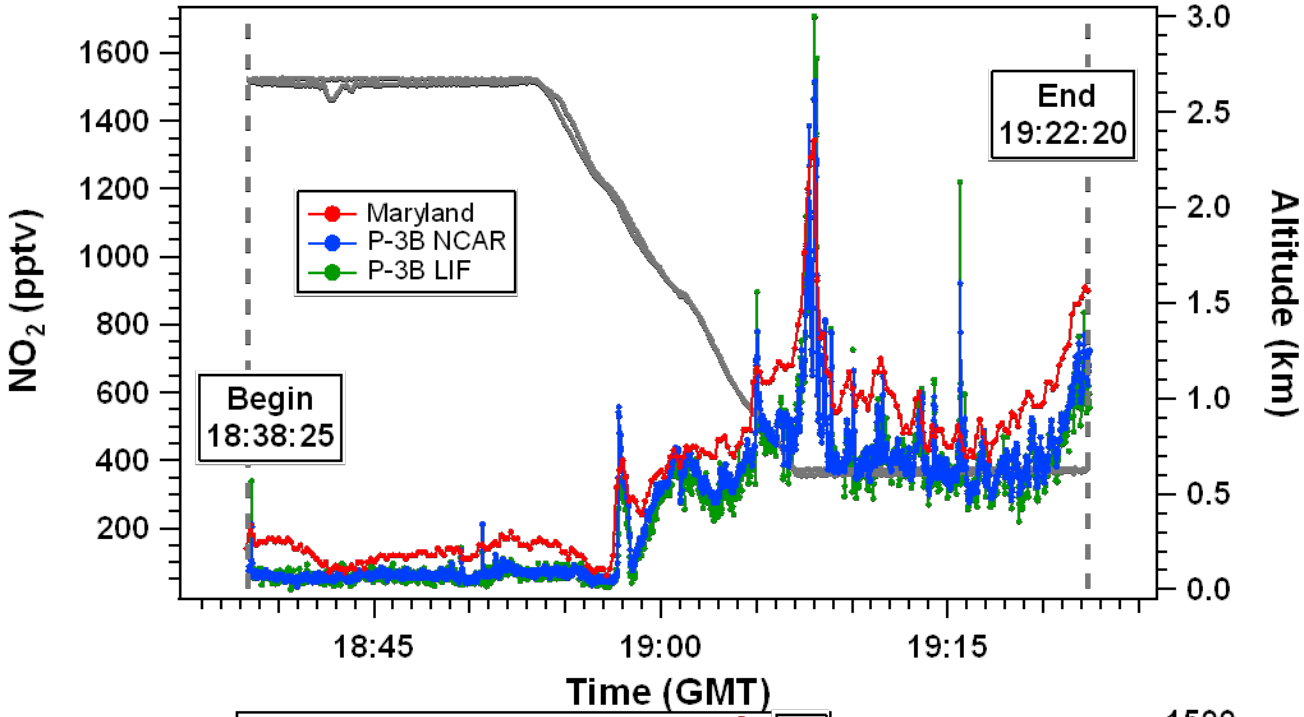

80
3.0
2.5
20
40
60
80
Relative Humidity (%)
0
40
80
P-3B Relative Humidity (%)

NO_2

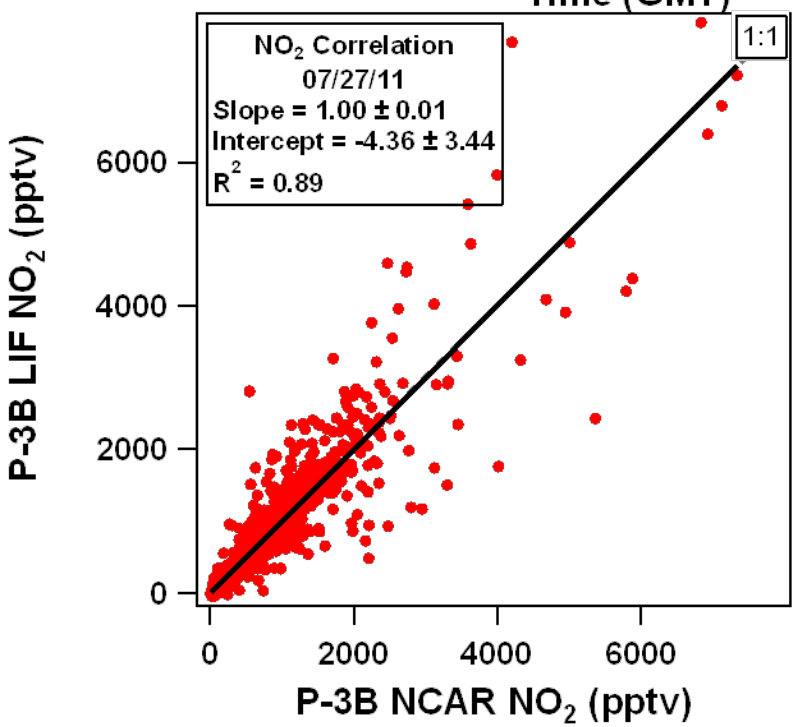

Begin
18:38:25
End
19:22:20
Maryland
P-3B NCAR
P-3B LIF
NO2 (pptv)
Altitude (km)
Time (GMT)
18:45
19:00
19:15

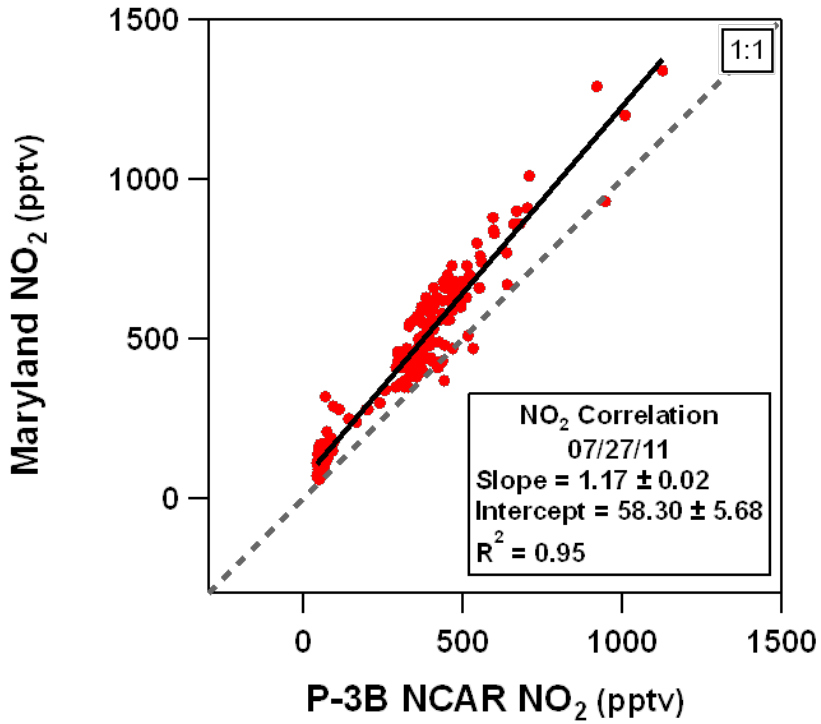

Maryland
P-3B NCAR
P-3B LIF
Altitude (km)
NO2 (pptv)


NO2 Correlation
07/27/11
Slope = 1.06 ± 0.02
Intercept = 92.91 ± 7.73
R2 =0.89
1:1
Maryland NO2 (pptv)
P-3B LIF NO2 (pptv)



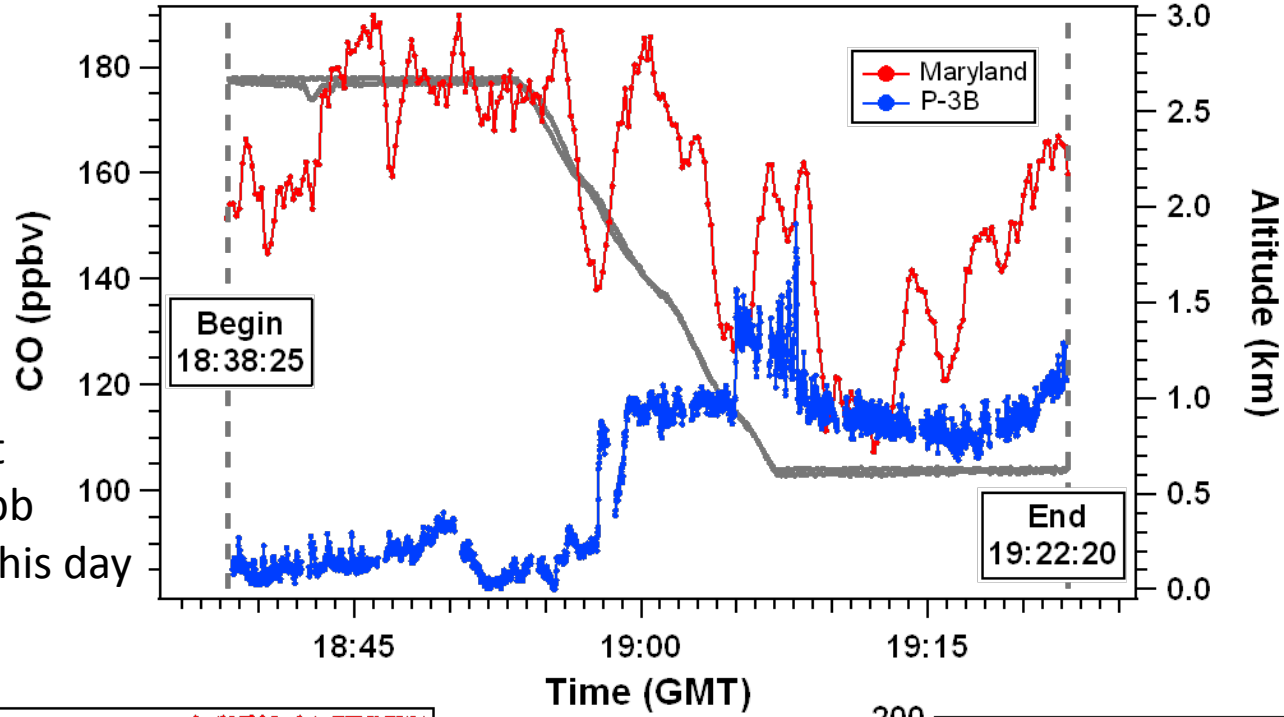
UMD NO_2 detection Limit ~100 ppt

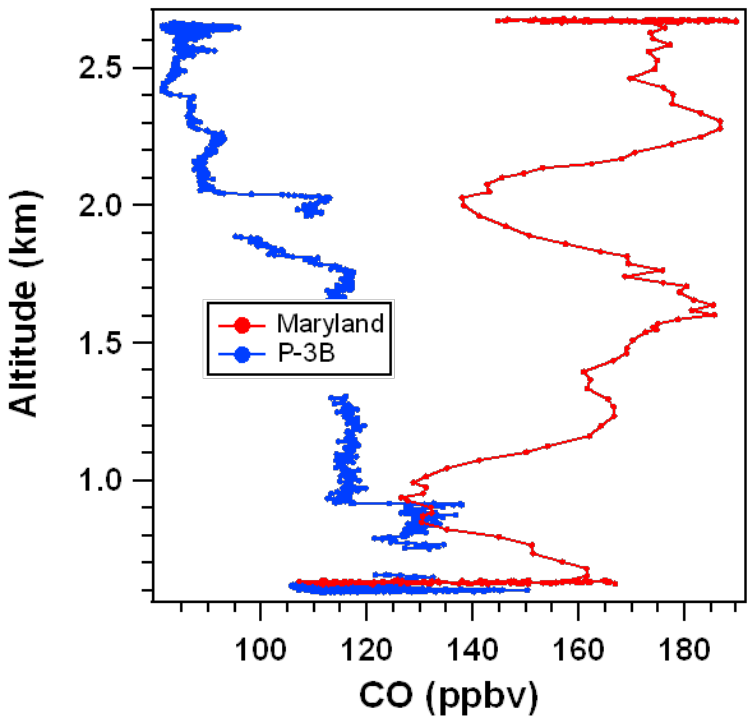


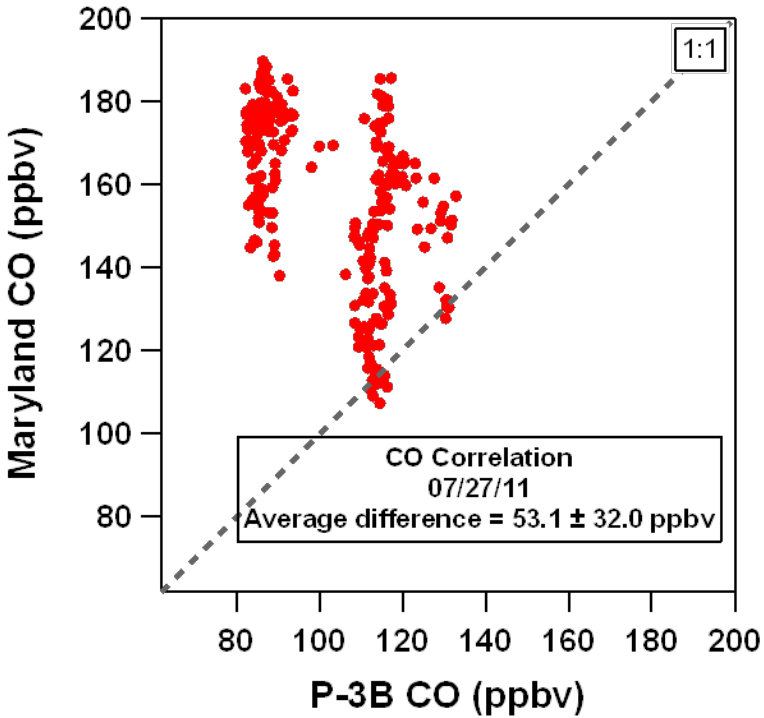


CO

Detection Limit
TECo 48 ~20 ppb
Zero problem this day
Others better



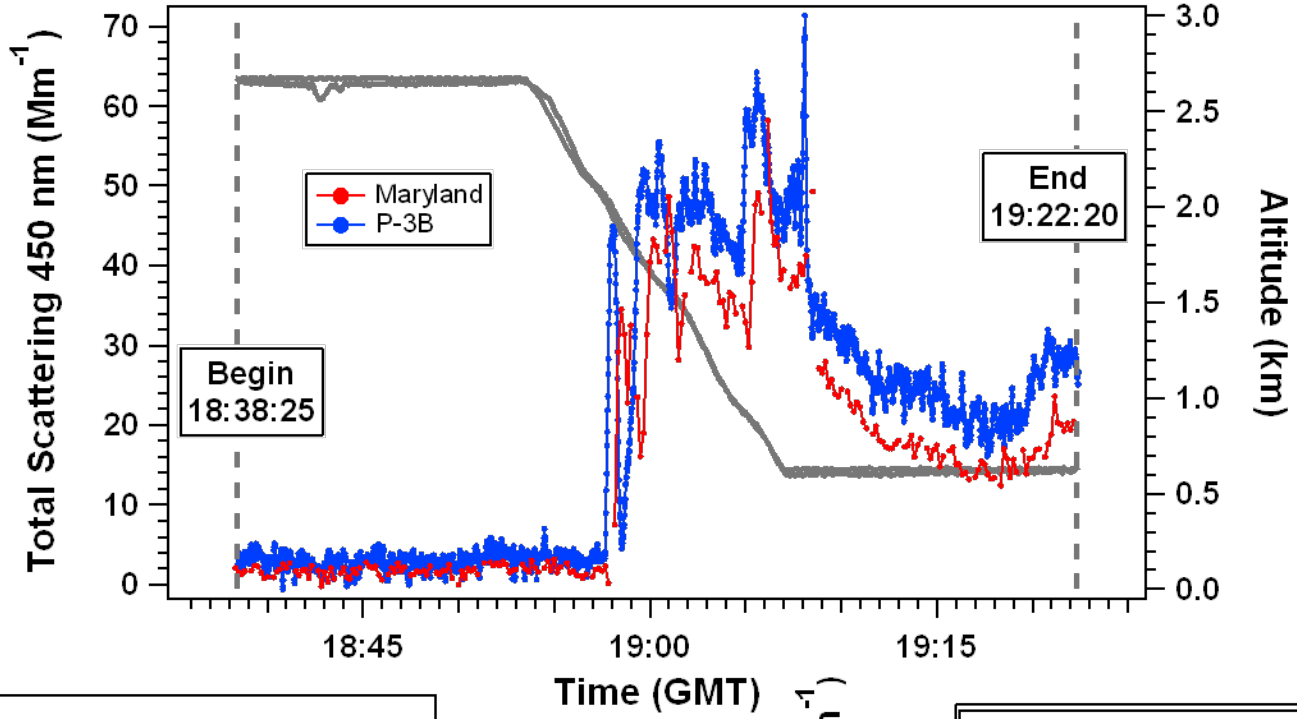


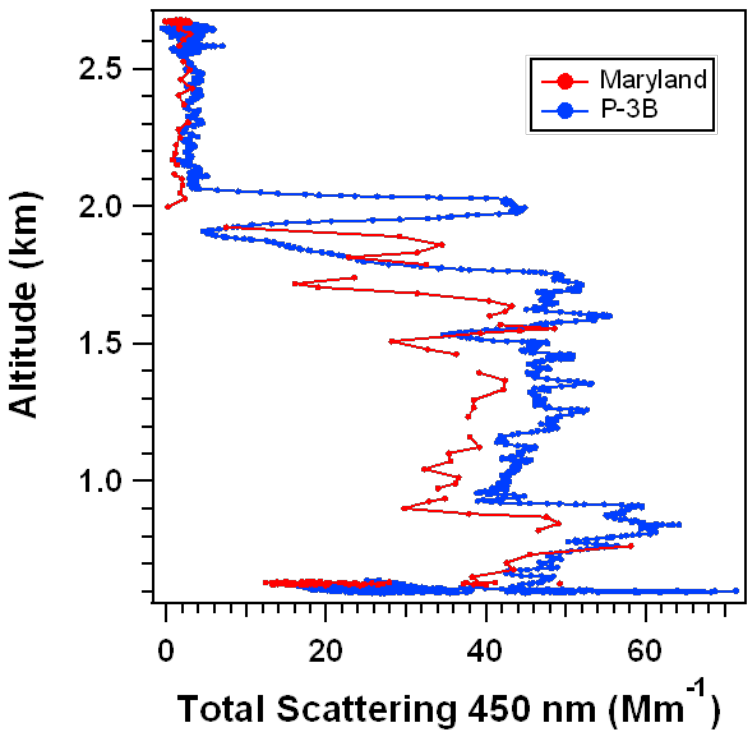


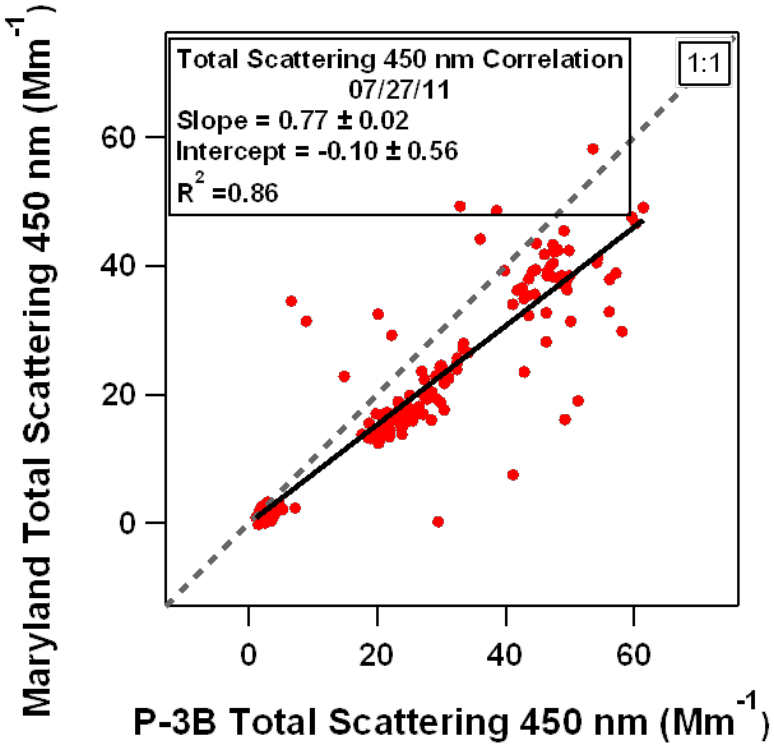
Scattering Correction

- Nephelometer interior warmer than ambient
- RH much lower in instrument chamber
- $B_{scat} = B_{scat} \times f(RH)$
- $f(RH) = [(100\text{-}RH_{neph})/(100\text{-}RH_{ambient})]^{\gamma}$
- We used a fixed gamma and get a correction of ~ +50 ± 16%
- Corrected scattering is higher

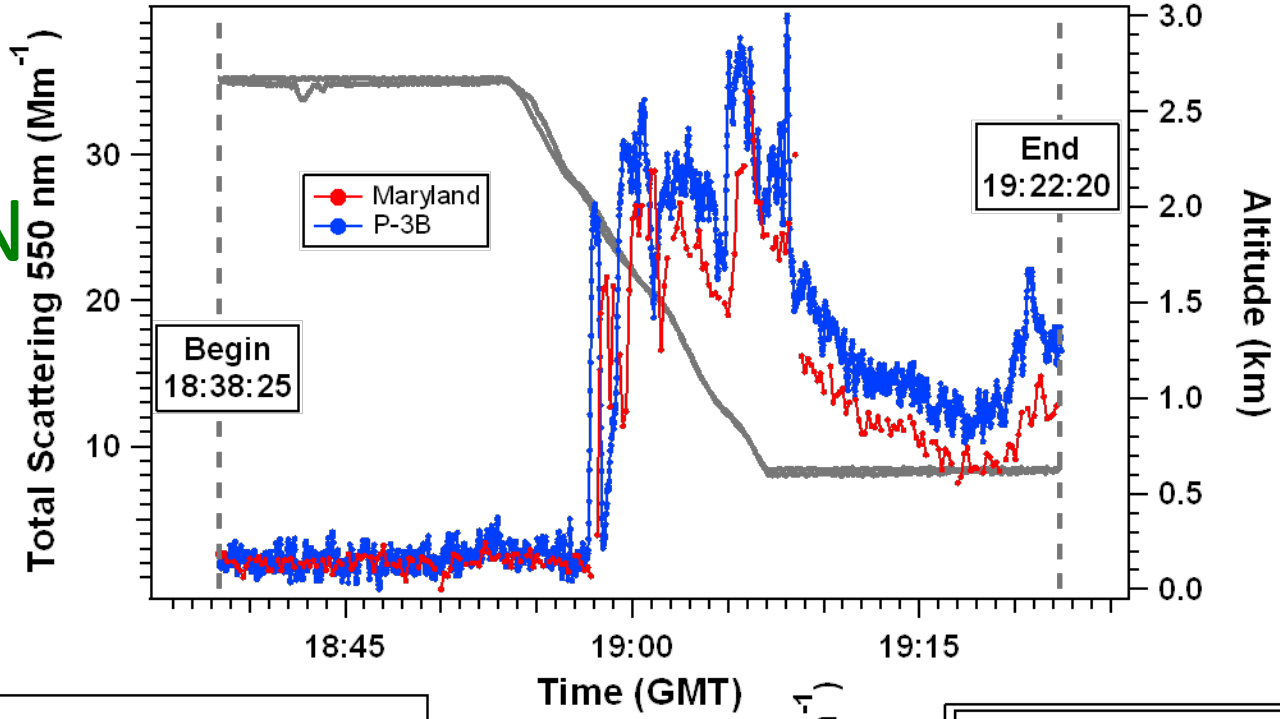
BLUE

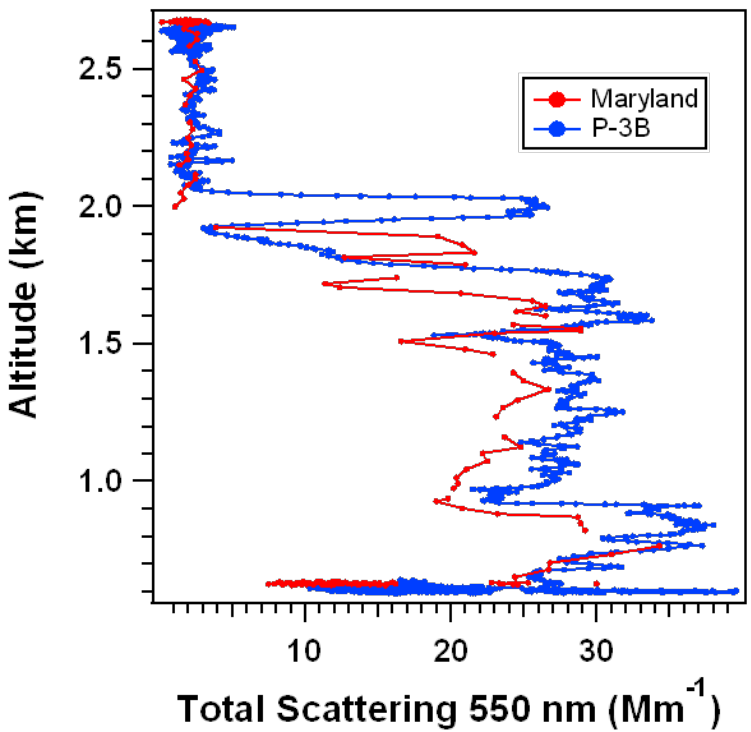

Total Scattering 450 nm (Mm^{-1})
Altitude (km)
Time (GMT)
Maryland
P-3B
Begin
18:38:25
End
19:22:20
18:45
19:00
19:15

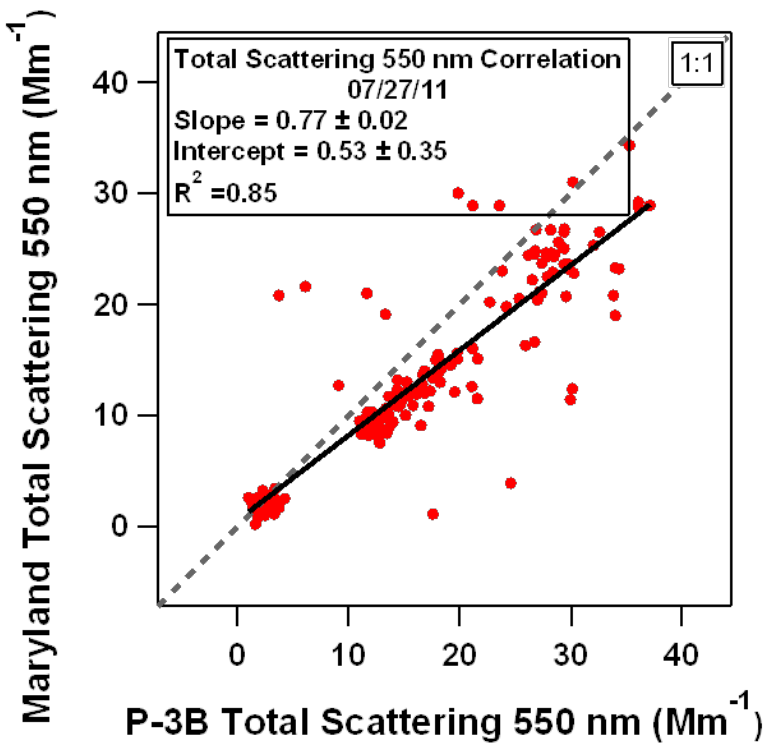

Altitude (km)
Total Scattering 450 nm (Mm^{-1})
Maryland
P-3B


Total Scattering 450 nm Correlation
07/27/11
Slope = 0.77 ± 0.02
Intercept = -0.10 ± 0.56
R^2 =0.86
1:1
Maryland Total Scattering 450 nm (Mm^{-1})
P-3B Total Scattering 450 nm (Mm^{-1})

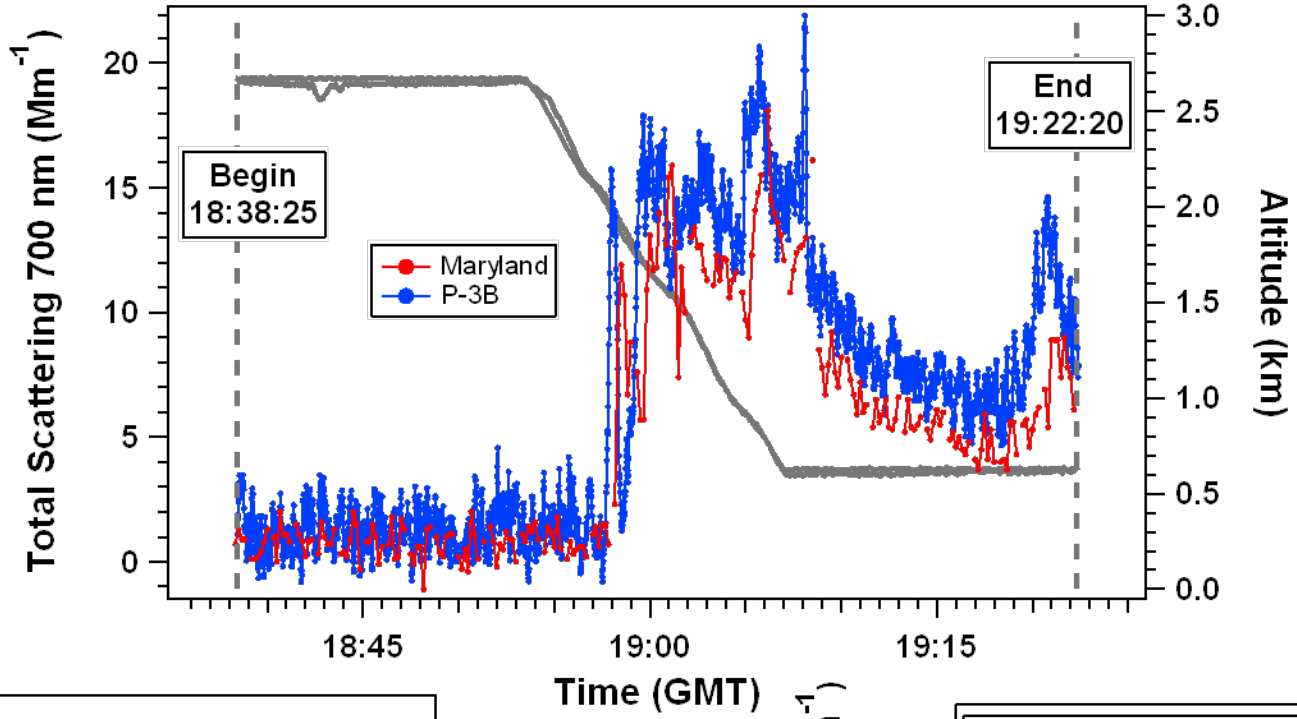
GREEN

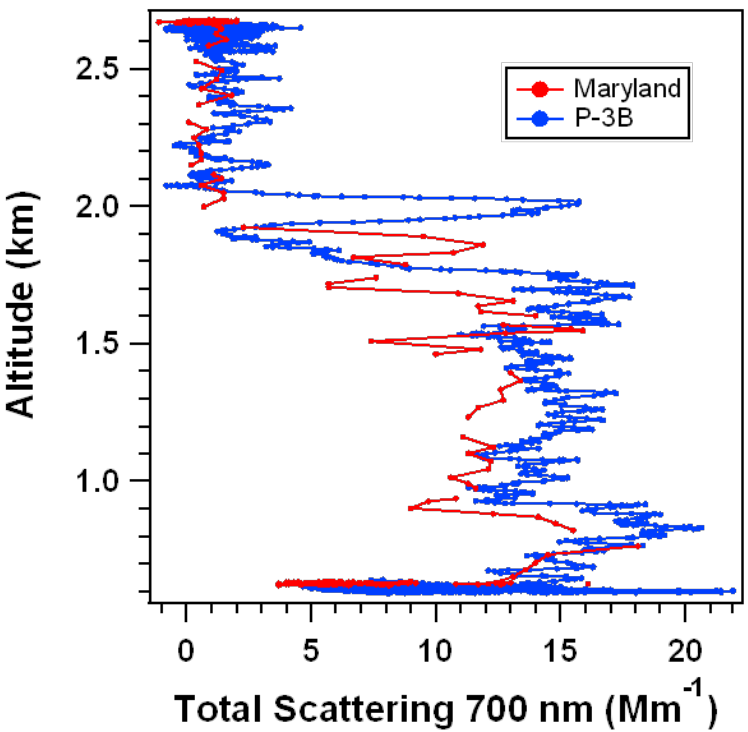

Total Scattering 550 nm (Mm^{-1})
Altitude (km)
Time (GMT)
Maryland
P-3B
Begin
18:38:25
End
19:22:20
18:45
19:00
19:15

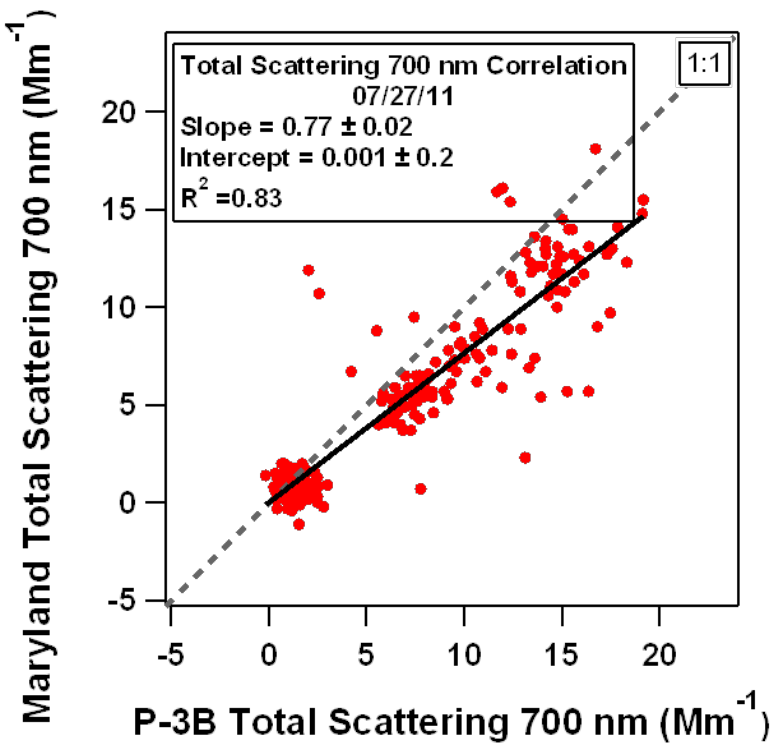

Altitude (km)
Total Scattering 550 nm (Mm^{-1})
Maryland
P-3B


Total Scattering 550 nm Correlation
07/27/11
Slope = 0.77 ± 0.02
Intercept = 0.53 ± 0.35
R^2 =0.85
1:1
Maryland Total Scattering 550 nm (Mm^{-1})
P-3B Total Scattering 550 nm (Mm^{-1})

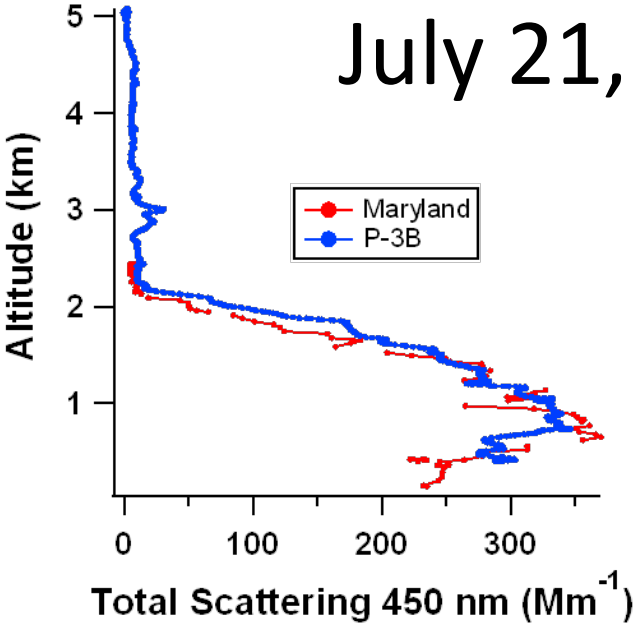
RED

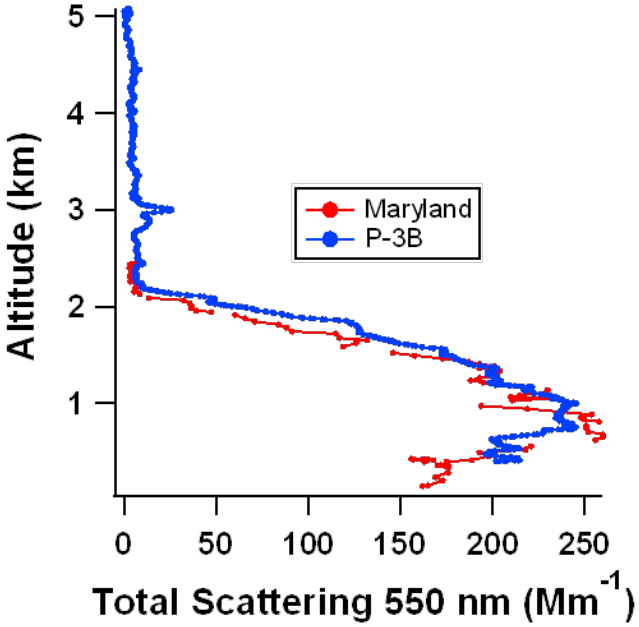

Begin
18:38:25
End
19:22:20
Maryland
P-3B
Total Scattering 700 nm (Mm^{-1})
Altitude (km)
Time (GMT)
18:45
19:00
19:15

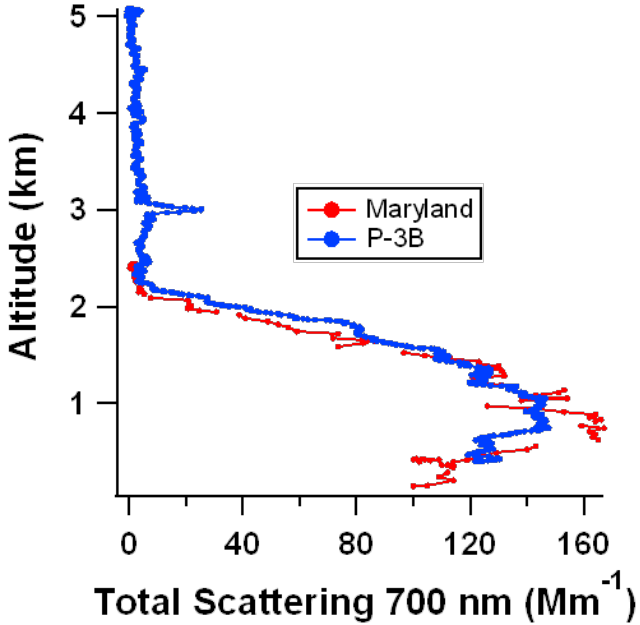

Maryland
P-3B
Altitude (km)
Total Scattering 700 nm (Mm^{-1})

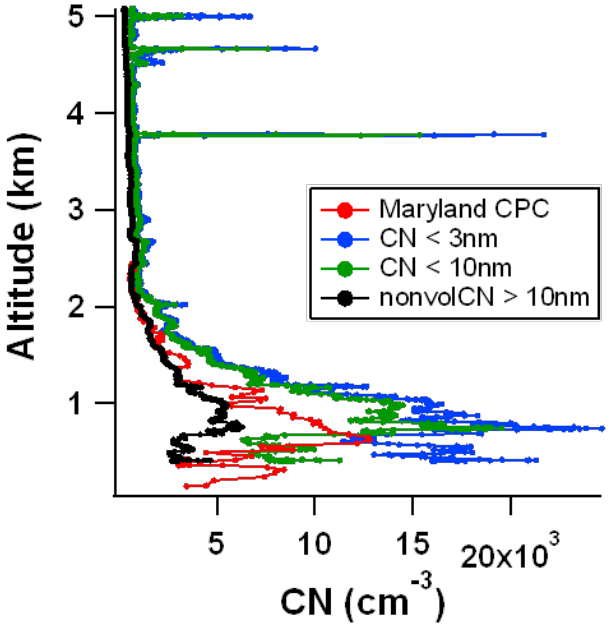

Total Scattering 700 nm Correlation
07/27/11
Slope = 0.77 ± 0.02
Intercept = 0.001 ± 0.2
R^2 =0.83
1:1
Maryland Total Scattering 700 nm (Mm^{-1})
P-3B Total Scattering 700 nm (Mm^{-1})

July 21, 2011

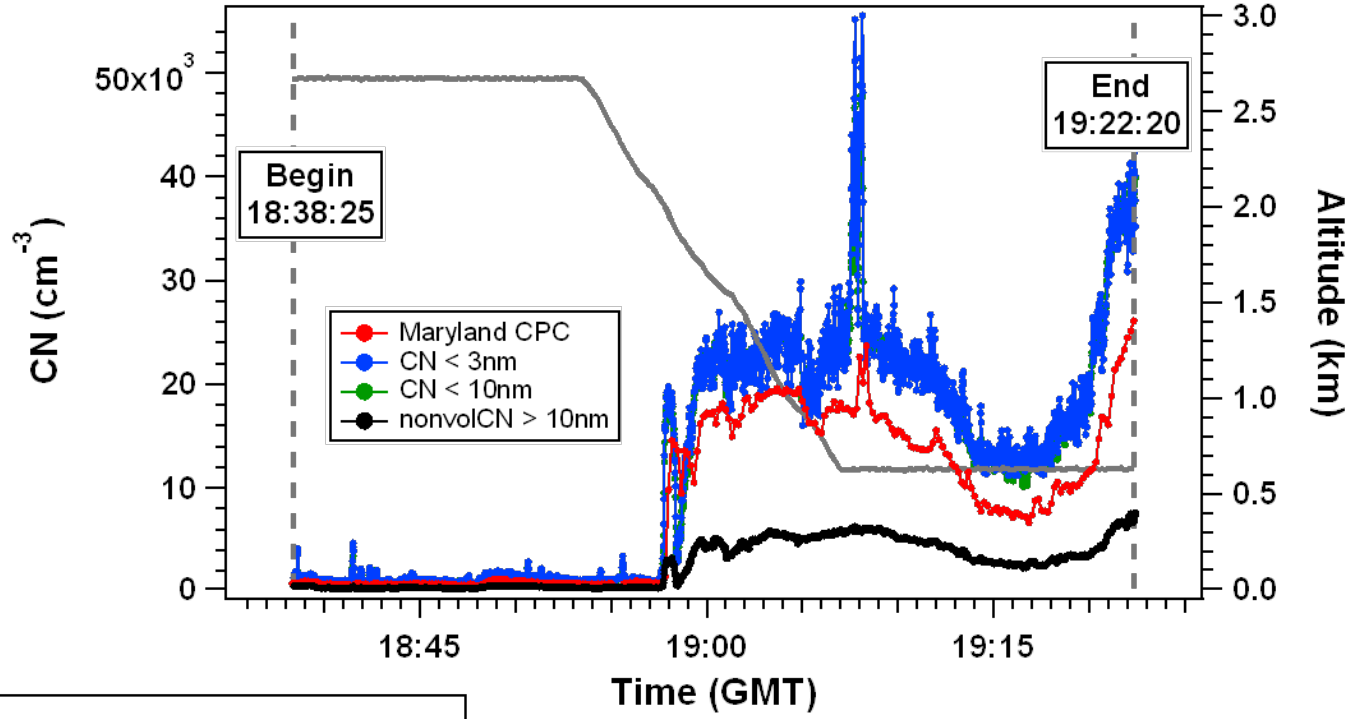

Altitude (km)
Total Scattering 450 nm (Mm^{-1})
Maryland
P-3B

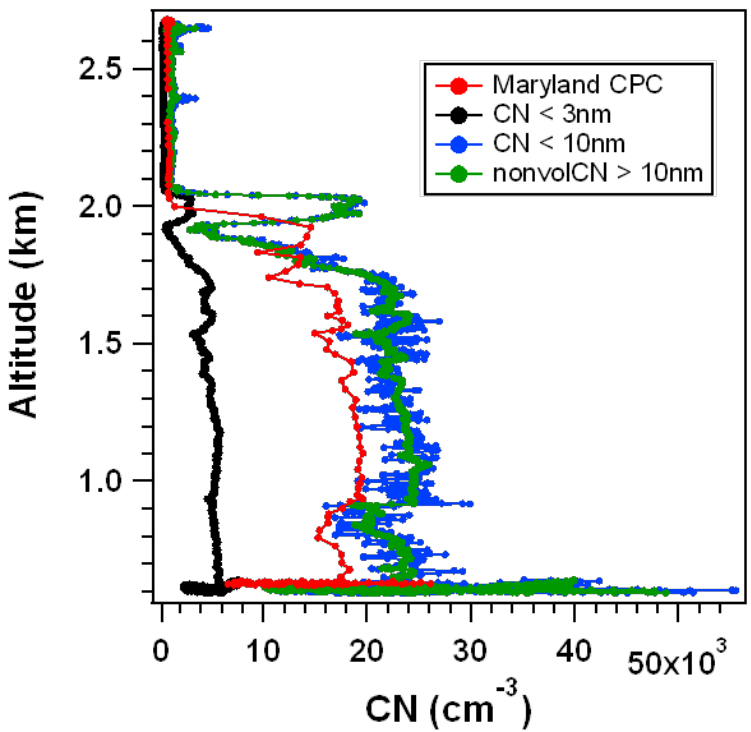

Altitude (km)
Total Scattering 550 nm (Mm^{-1})
Maryland
P-3B


Altitude (km)
Total Scattering 700 nm (Mm^{-1})
Maryland
P-3B


Altitude (km)
CN (cm^{-3})
20x10^{3}
Maryland CPC
CN < 3nm
CN < 10nm
nonvolCN > 10nm

CPC



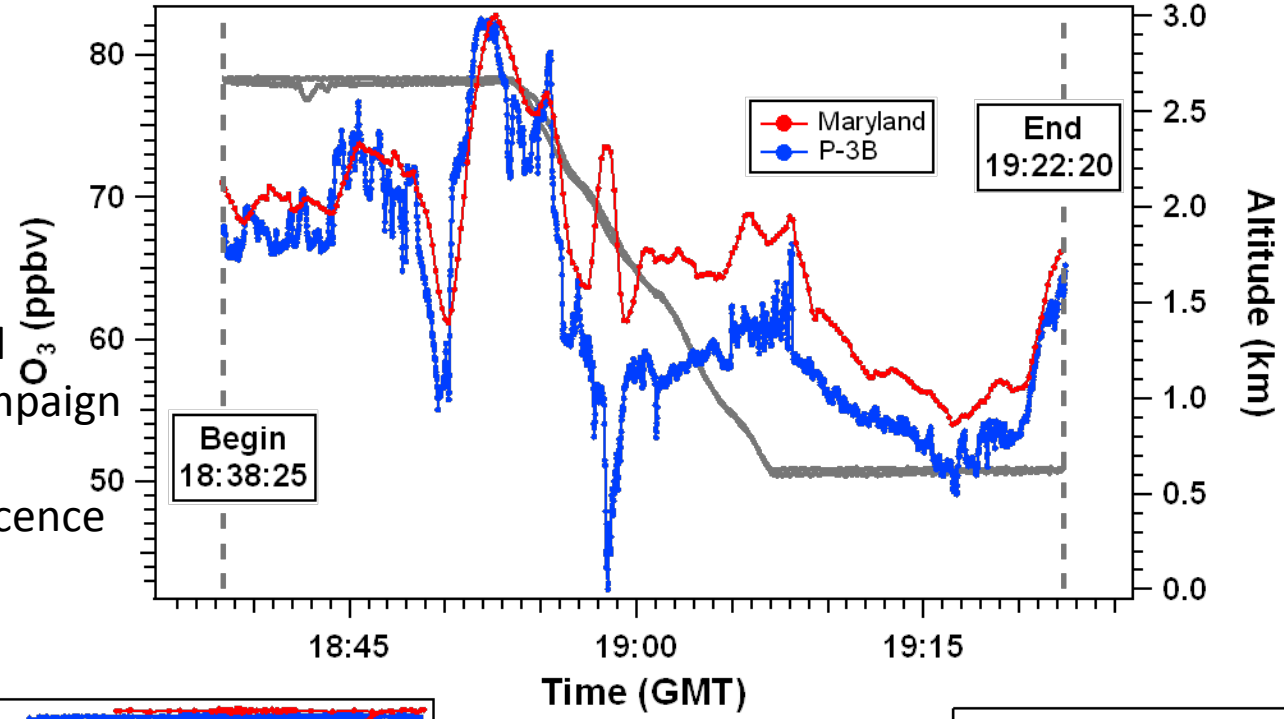


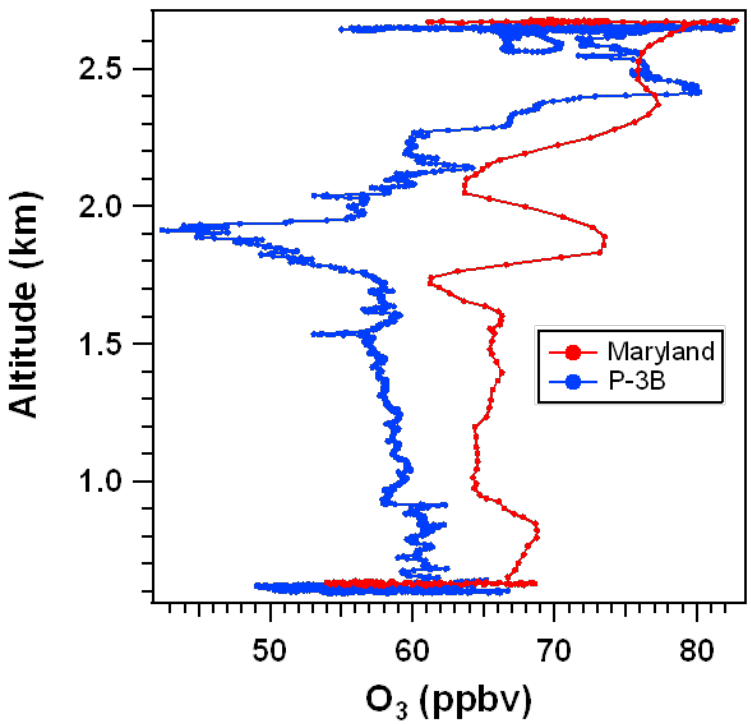
CPC # are not CN!!

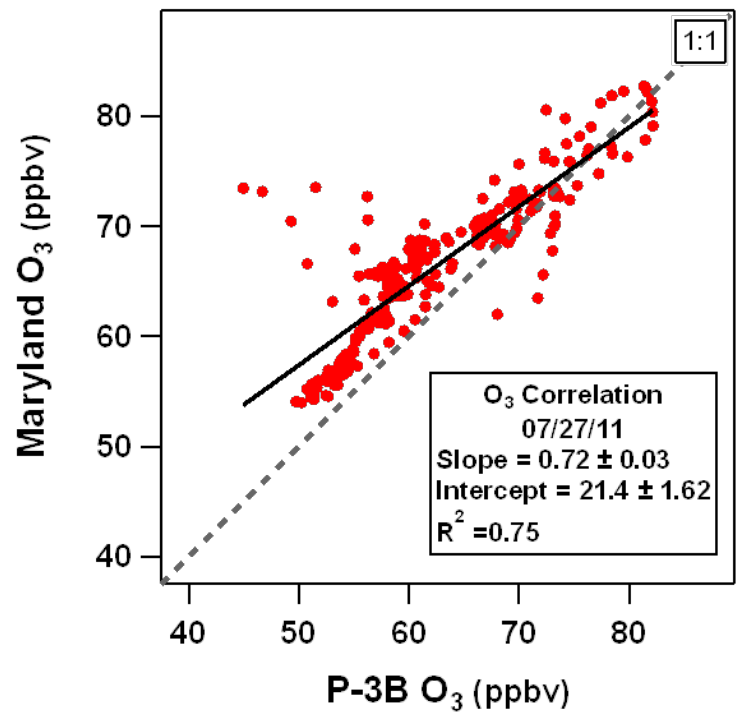
TSI 3007 has a 50% detection threshold at 10 nm

O_3

TECo 49
NIST calibrated
Pre & Post Campaign
NCAR
Chemiluminescence







Conclusions

- T, RH, P All in good agreement
  - T, RH corrections added since summer worked well
- NO_2 UMD, NCAR and UC Berkeley instruments in good agreement. NCAR and UCB especially close
- UMD ozone UV absorption instrument v. chemi
  - 49C NIST-calibrated pre and post-campaign, within 2%
  - NCAR ozone chemiluminescence instrument does not agree
- UMD CO suffers from background drift and has a higher detection limit—use with caution
  - ~20 ppb in the lab

Conclusions(2)

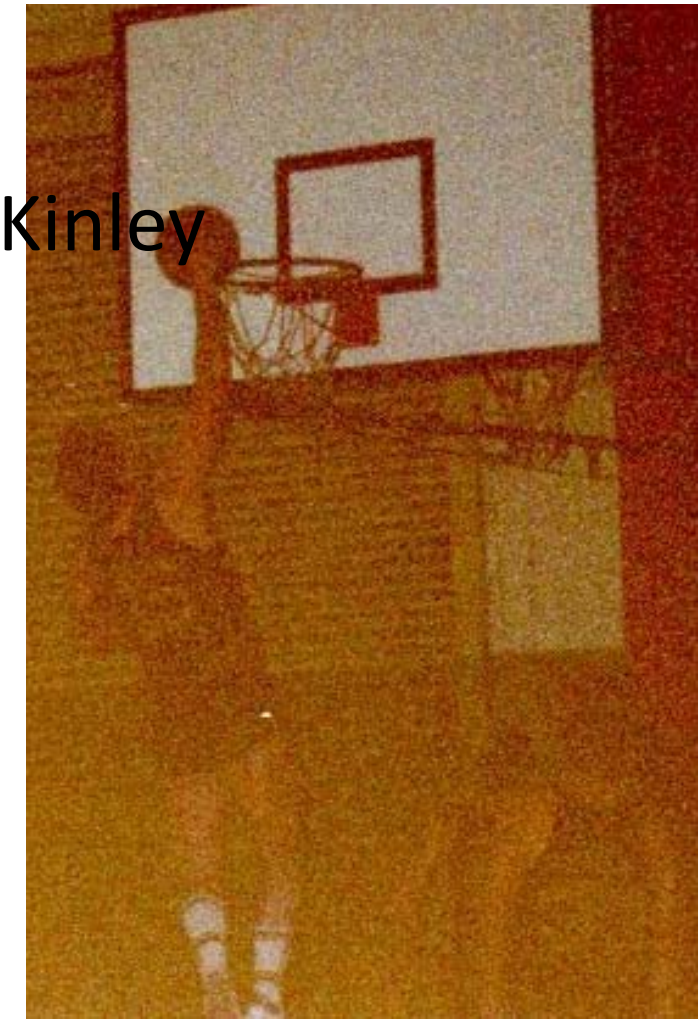
- Scattering Comparison OK
  - Use of fixed gamma for f(RH) brings UMD instruments into better agreement
  - Shape of profiles the same, absolute values not identical
  - Most days very comparable
    - 1 sigma error is 16% (fixed gamma on P3 data)
- UMD CPC is not the same as the CN counters!
  - Similar results, but CN ≠ CPC
  - CPC 50% detection threshold ~10 nm particles

Time lags

- Correlation analysis reveals some time lags (and two leads) between UMD data and P3 data.
- Still investigating these, though they make physical sense.

Acknowledgements

- Everyone in this room!
- NOAA, NASA, MDE, M-DNR
- URF: Jim Cramer and John McKinley



Correction for ram heating

- Temperature correction:

  $AT = (T_m + 273.15) / (1.0 + 0.2 * rf * M^2) - 273.15$

  T_m = measured temperature in °C

  M = mach number of aircraft speed

  RF = empirically determined factor

  AT = actual temperature in °C

  Ambient temperature is lower than ram-heated air

RH Correction

- $RH = P(H_2O)/P_{sat(H2O)}$
- Need to correct RH to the proper temperature
- $RH_{proper} = RH_{indicated} \times P_s(T_{measured})/P_s(T_{corrected})$
- So ambient RH is higher than that measured with ram heating