The NOAA/ESRL Airborne Aerosol Observatory: Climatology and Seasonal Variation of Aerosol Properties Over Central Illinois

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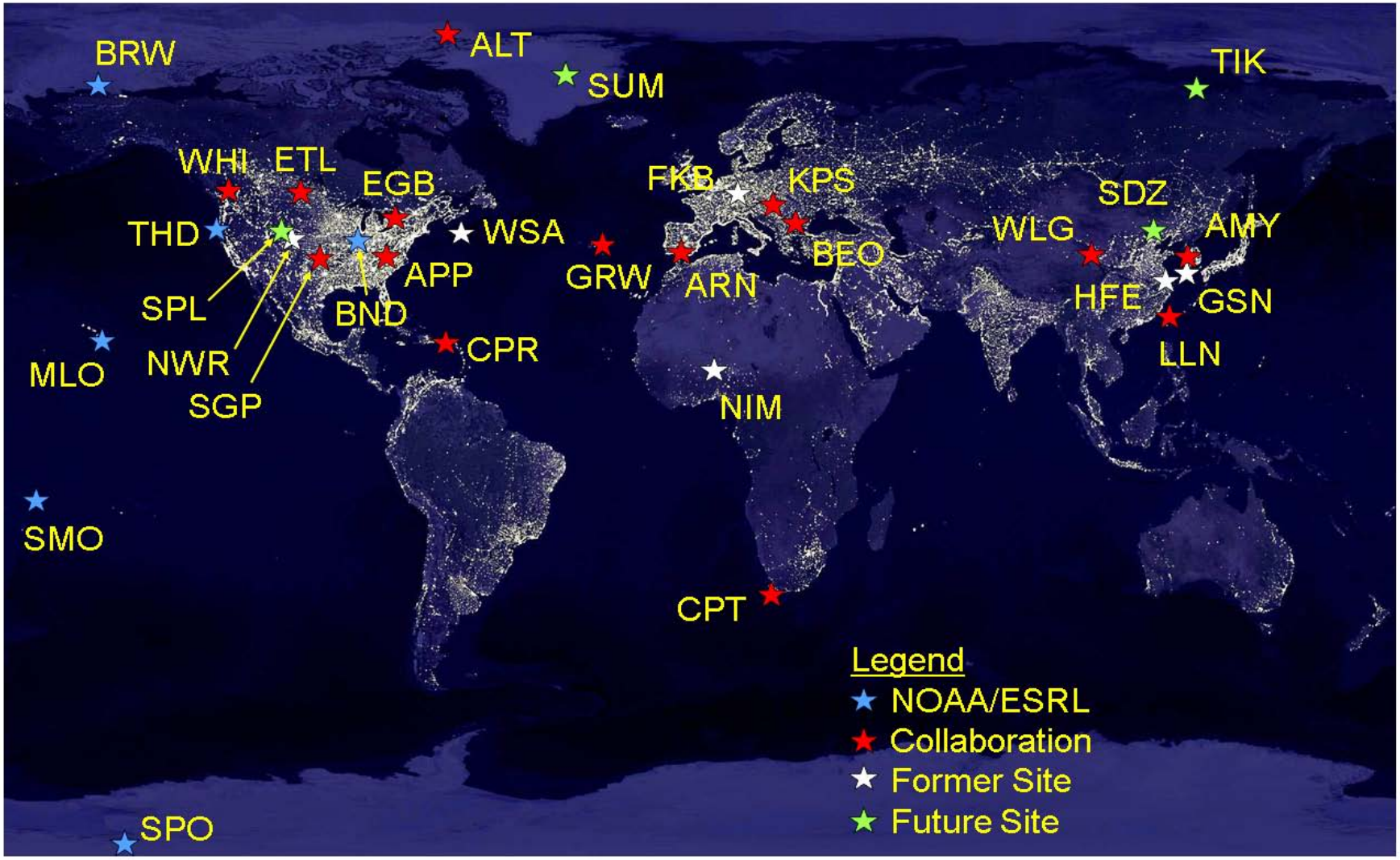
[4]Institute of Aviation, University of Illinois, Champaign-Urbana, Illinois, USA

Photo courtesy of Yin-Nan Lee, BNL

NOAA/ESRL Collaborative Surface Aerosol Monitoring Network



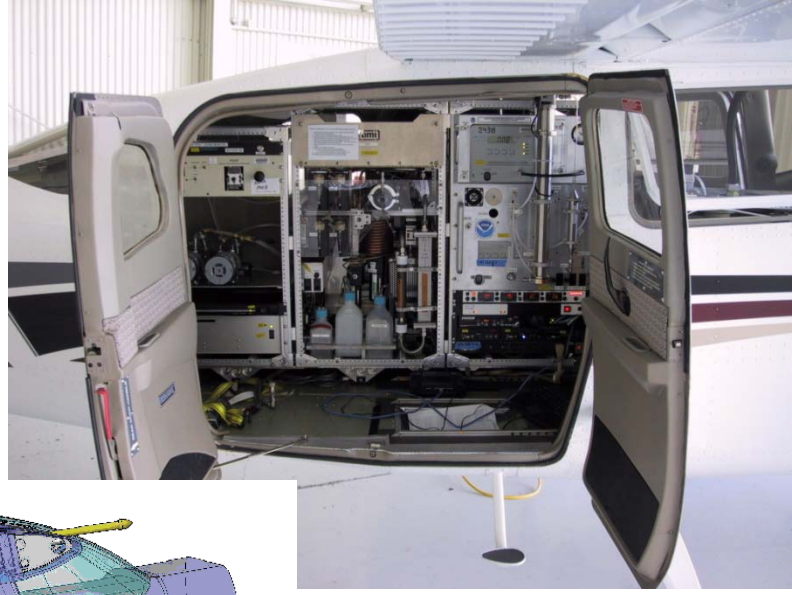
Very few long term measurement efforts have been made above the surface.

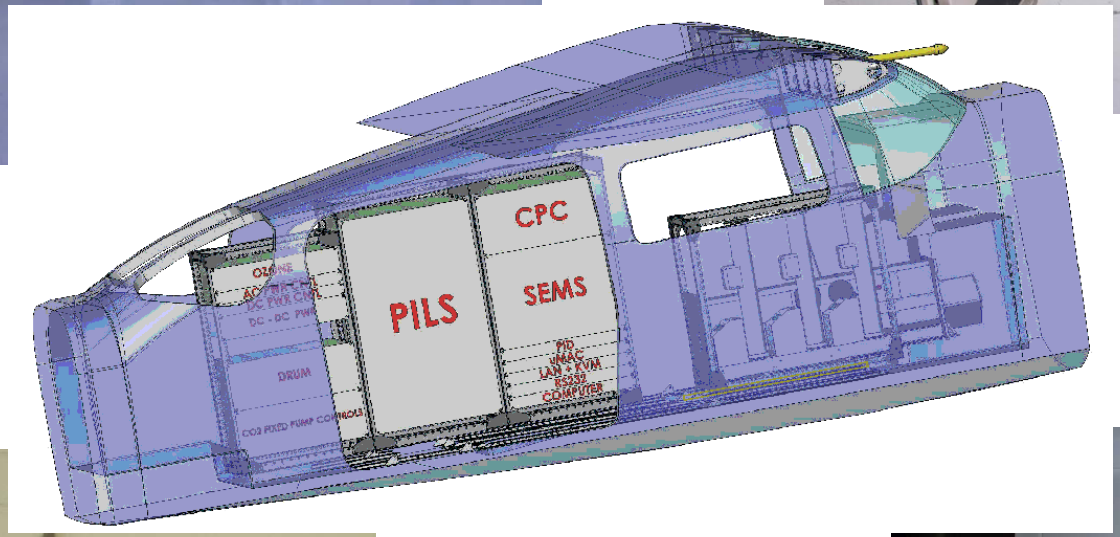
ESRL initiated regular aircraft measurements over two heavily instrumented surface sites: The DOE/ARM Southern Great Plains Central Facility near Lamont, Oklahoma, and the NOAA Surface Aerosol Monitoring Station near Bondville, Illinois.

- **Oklahoma program: 2000-2007 (~7.7 years, 742 profiles)**
- **Illinois program: 2006-2009 (~3.25 years, 401 profiles)**

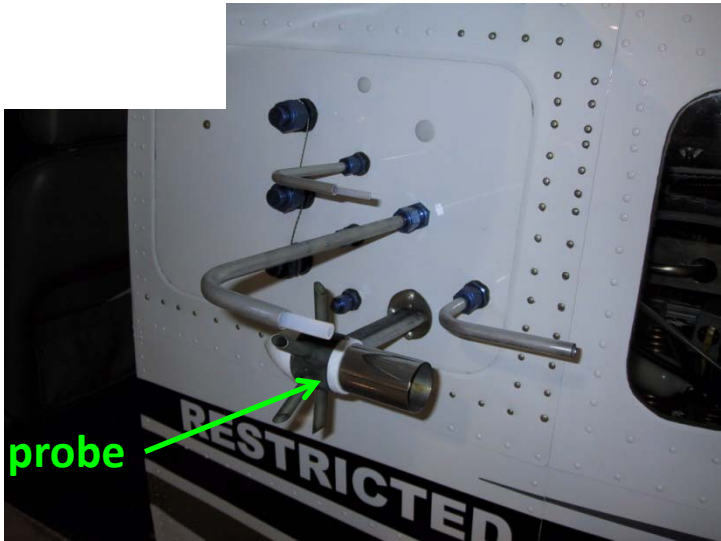
AAO Program Objectives

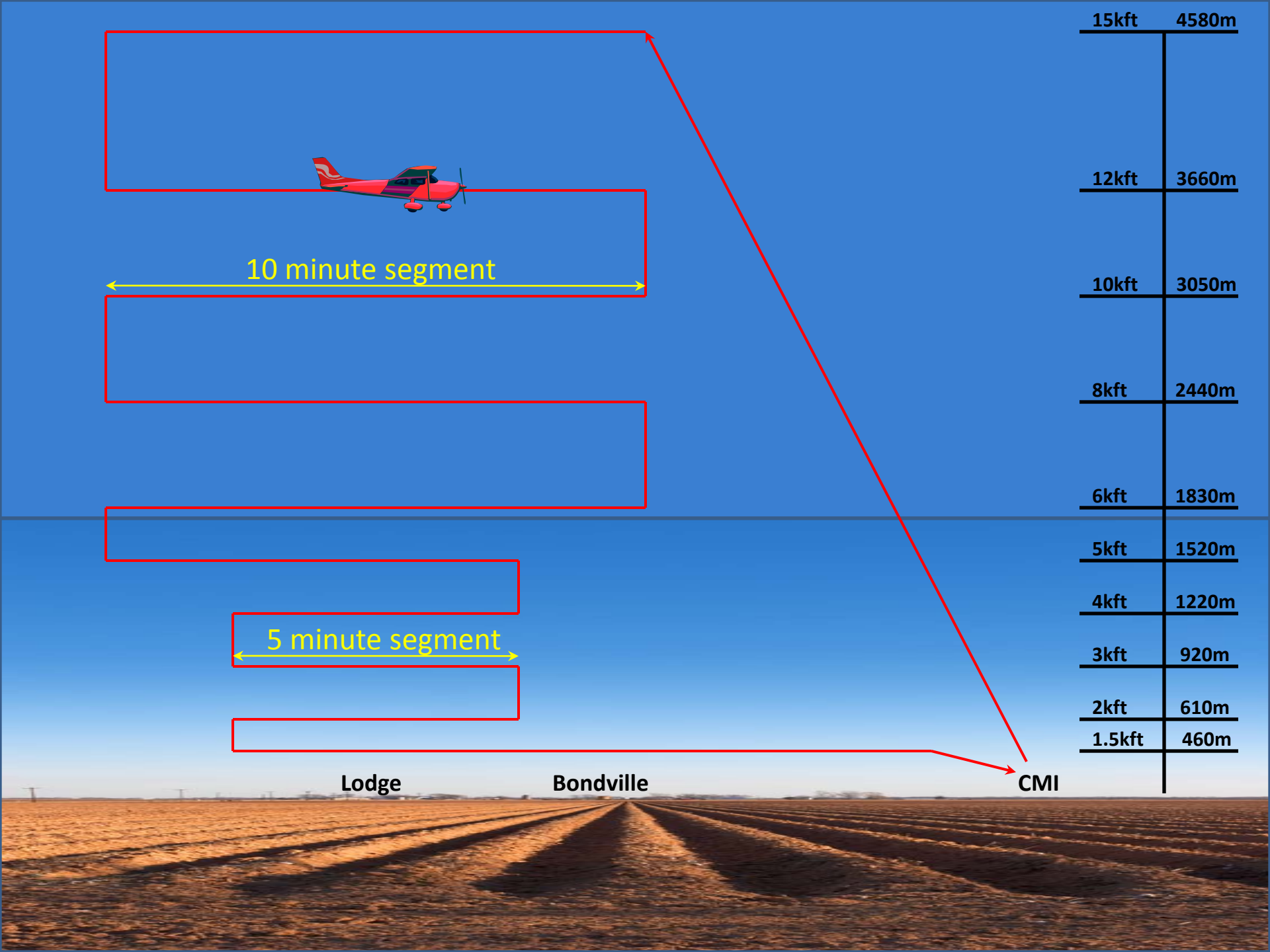
- **Build a statistically-significant database of the extensive and intensive aerosol properties of the lower atmosphere (surface → 4.6 km/15kft) over central Illinois.**
- **Characterize *when*, *how often*, and *under what conditions* the surface aerosol measurements are representative of the lower column**
- **At times of opportunity, conduct flights during TERRA and A-Train satellite overpasses for comparison with satellite measurements**
- **Compare with co-located AERONET AOD measurements**
- **Platform for NOAA flask and continuous ozone sampling**

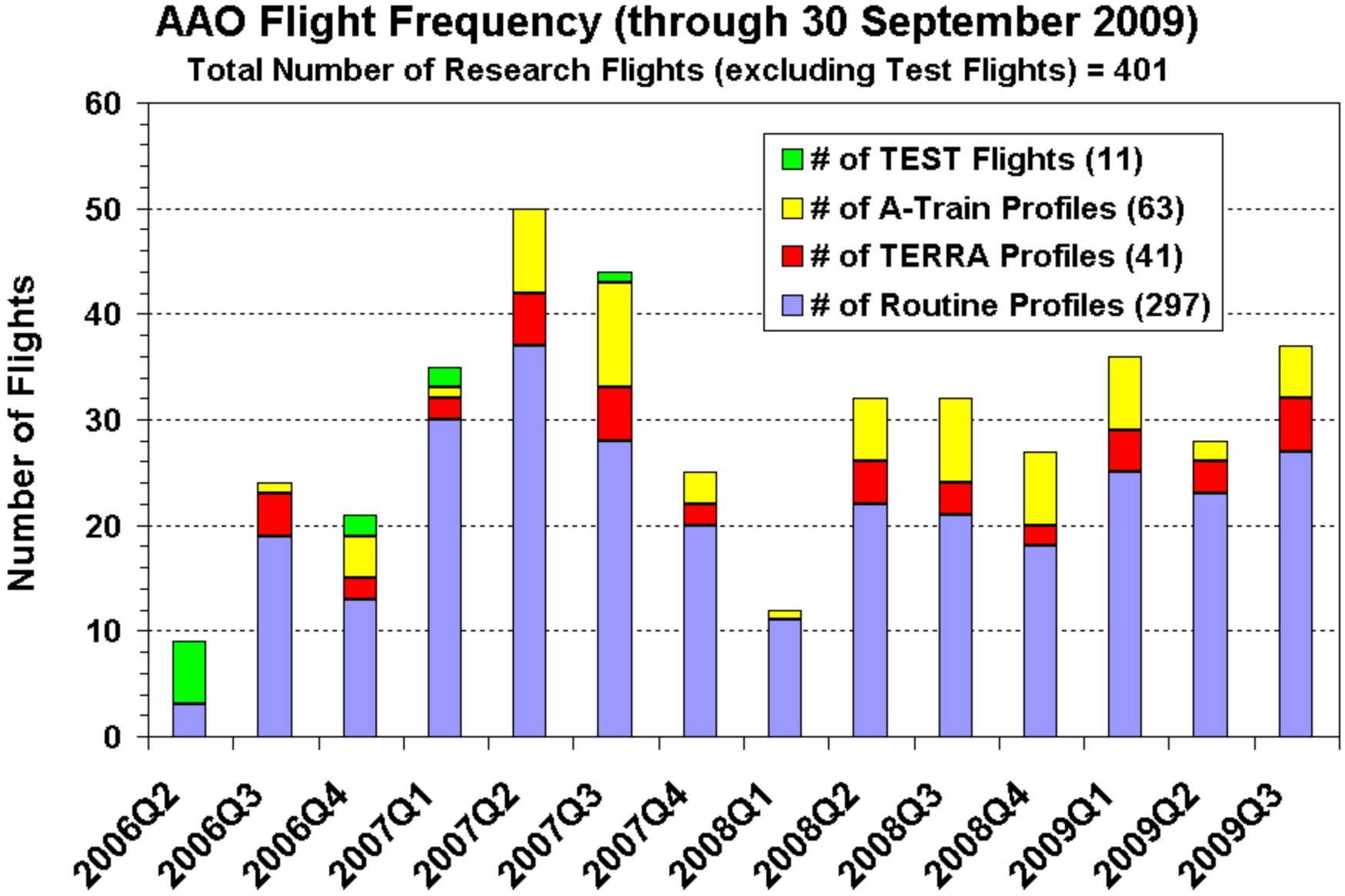


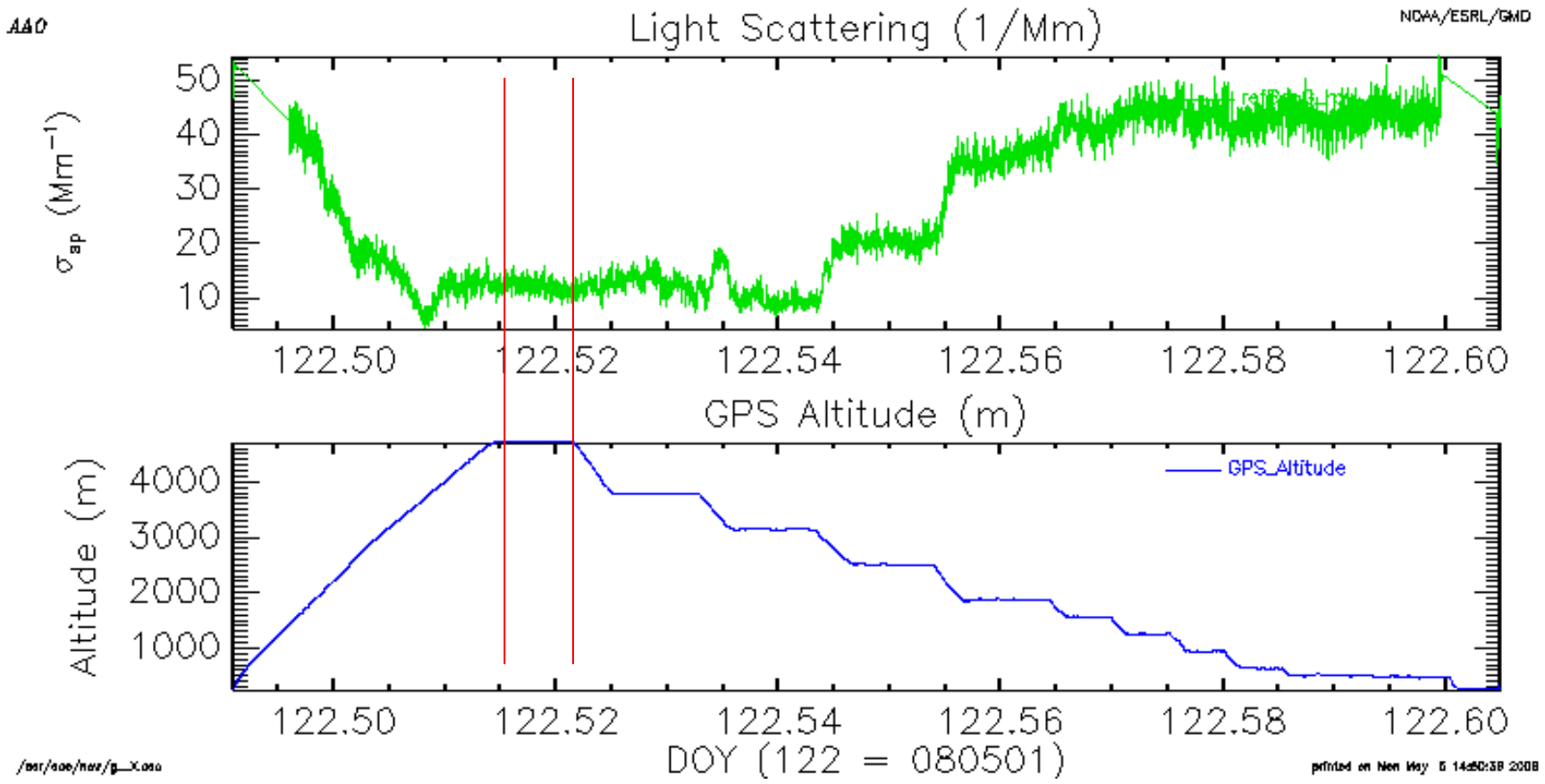


Trace gas inlets




15kft
4580m
12kft
3660m
10kft
3050m
8kft
2440m
6kft
1830m
5kft
1520m
4kft
1220m
3kft
920m
2kft
610m
1.5kft
460m
10 minute segment
5 minute segment
Lodge
Bondville
CMI

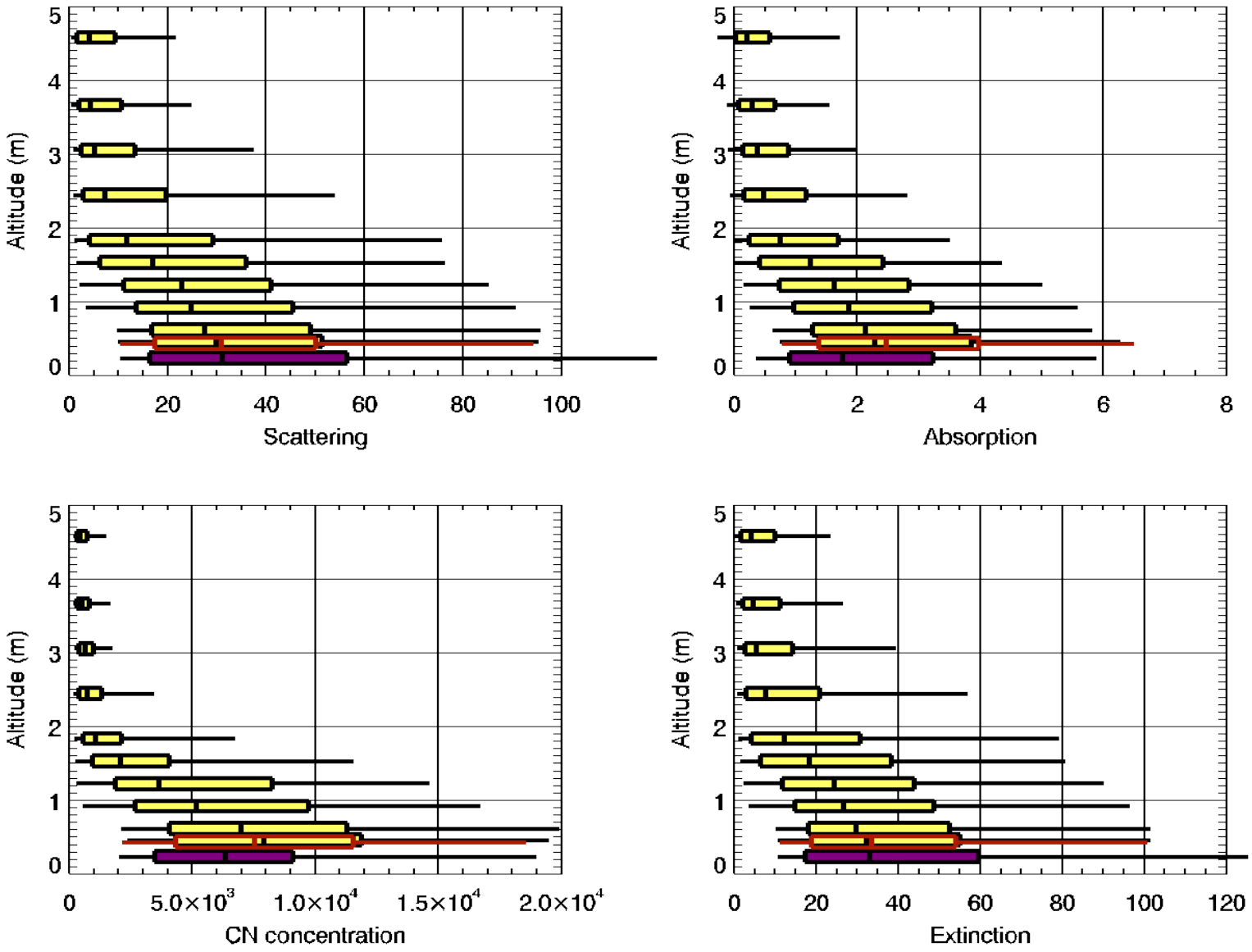

AAO Flight Frequency (through 30 September 2009)
Total Number of Research Flights (excluding Test Flights) = 401
Number of Flights
60
50
40
30
20
10
0
# of TEST Flights (11)
# of A-Train Profiles (63)
# of TERRA Profiles (41)
# of Routine Profiles (297)
2006Q2
2006Q3
2006Q4
2007Q1
2007Q2
2007Q3
2007Q4
2008Q1
2008Q2
2008Q3
2008Q4
2009Q1
2009Q2
2009Q3


AAO
Light Scattering (1/Mm)
NOAA/ESRL/GMD
σ_{sp} (Mm^{-1})
50
40
30
20
10
122.50
122.52
122.54
122.56
122.58
122.60
GPS Altitude (m)
Altitude (m)
4000
3000
2000
1000
GPS_Altitude
122.50
122.52
122.54
122.56
122.58
122.60
DOY (122 = 080501)
/ser/sce/nsr/g_X.ctl
printed on Mon May 5 14:50:38 2008

All measurements are for dry aerosol adjusted to Standard T and P conditions.

Red outline box = low altitude fly-bys of BND site.

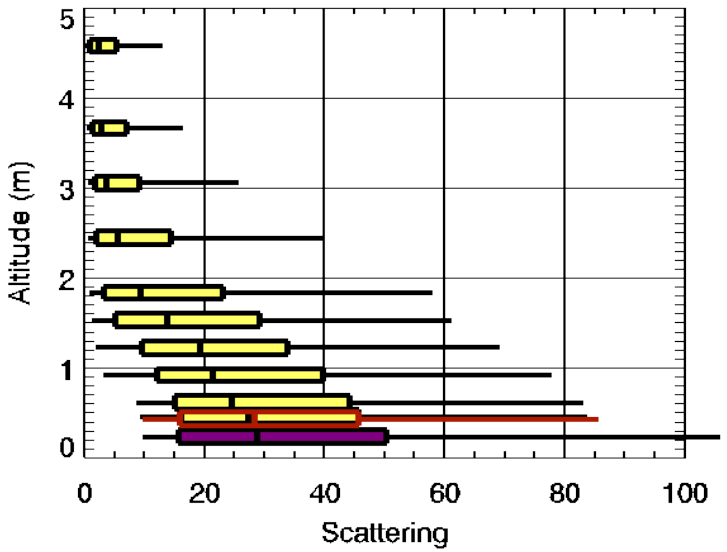
Purple fill box = BND surface data averaged over each profile duration (~2 hrs)

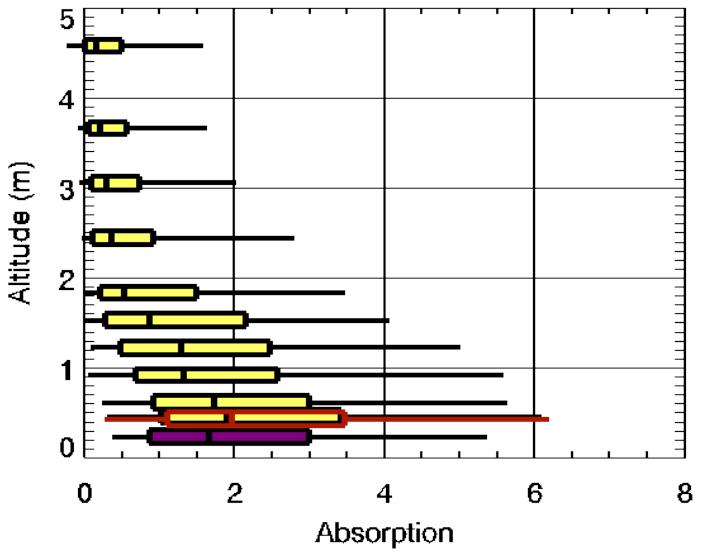


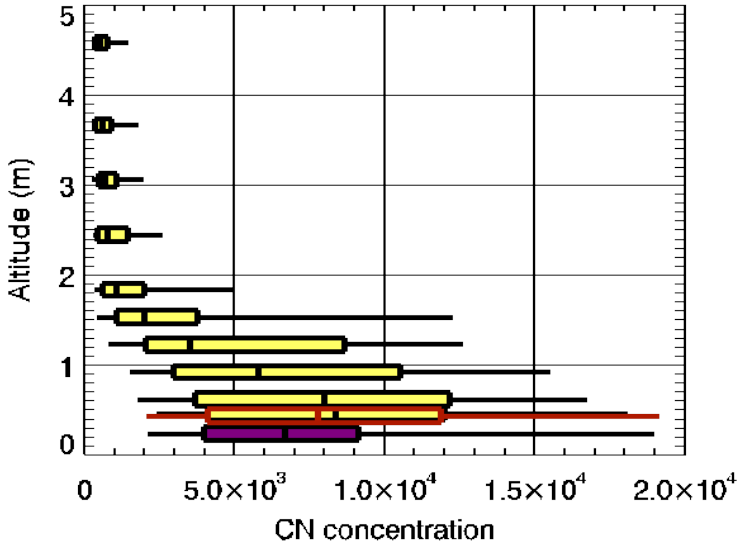
All measurements are for dry aerosol adjusted to Ambient T and P conditions.

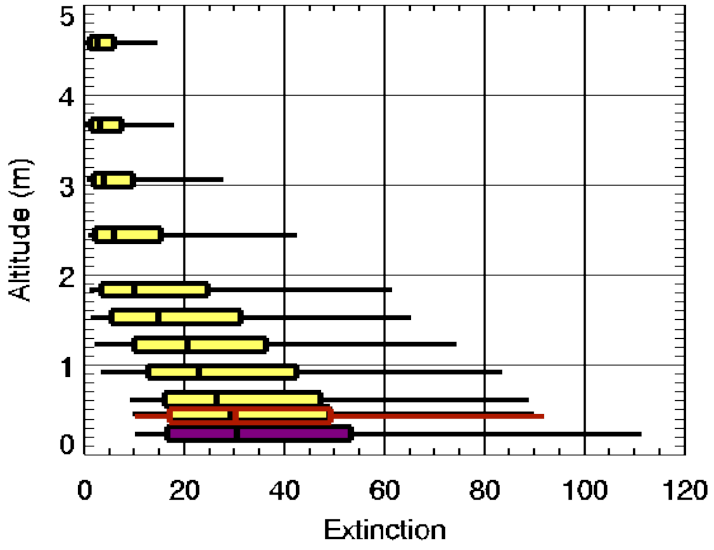
Red outline box = low altitude fly-bys of BND site.

Purple fill box = BND surface data averaged over each profile duration (~2 hrs)

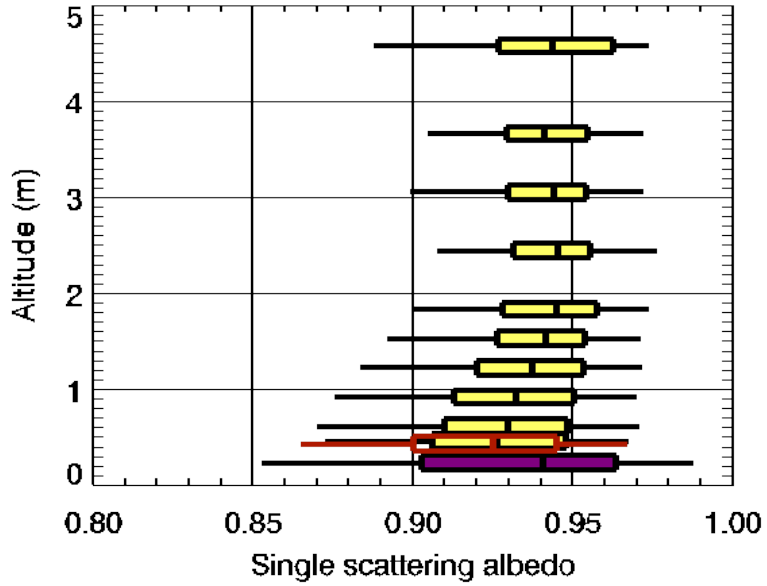


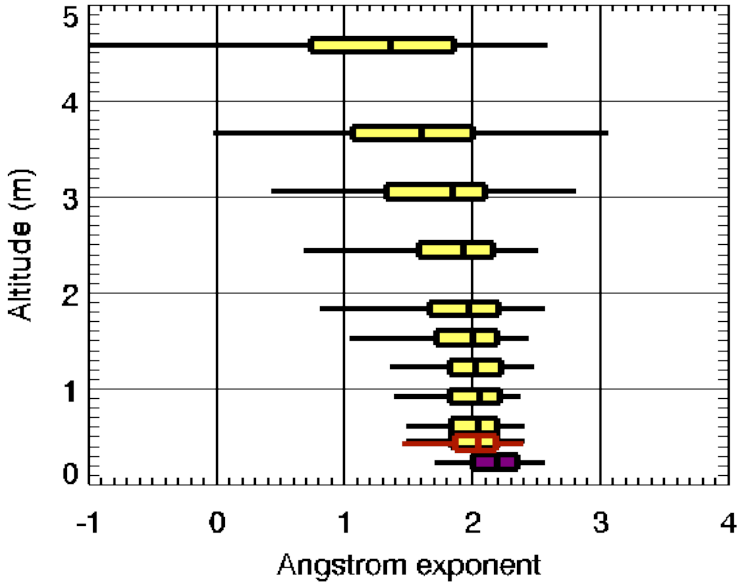


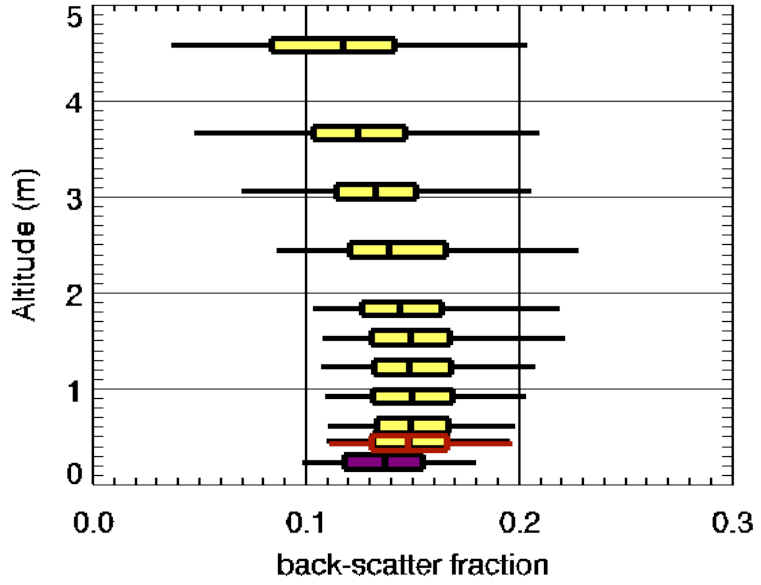


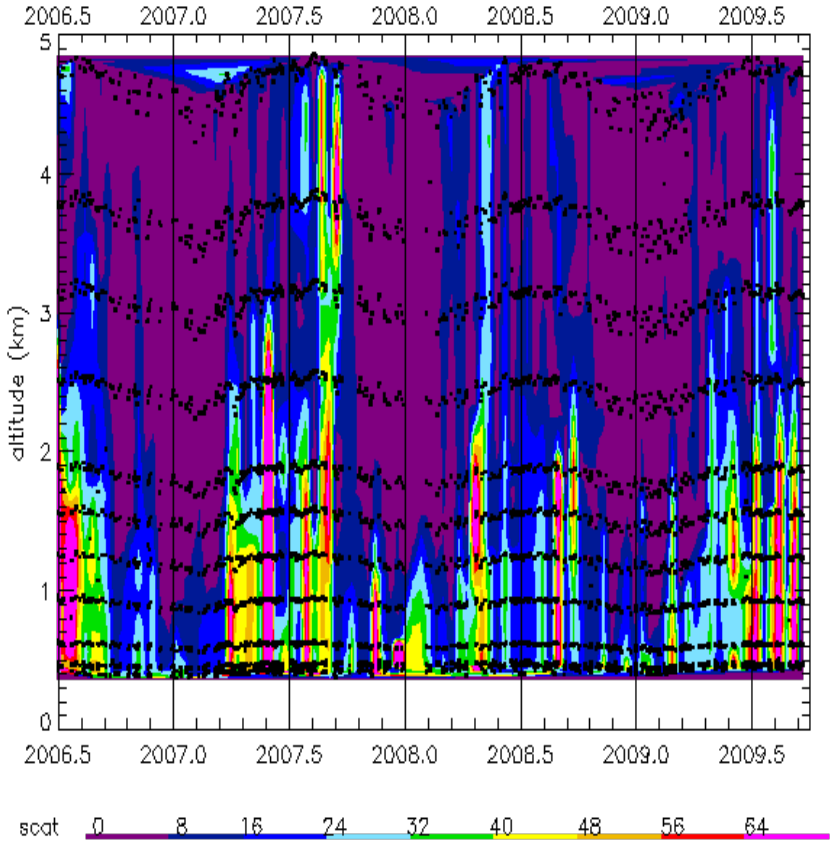


Measurements are for dry aerosol adjusted to STP conditions.

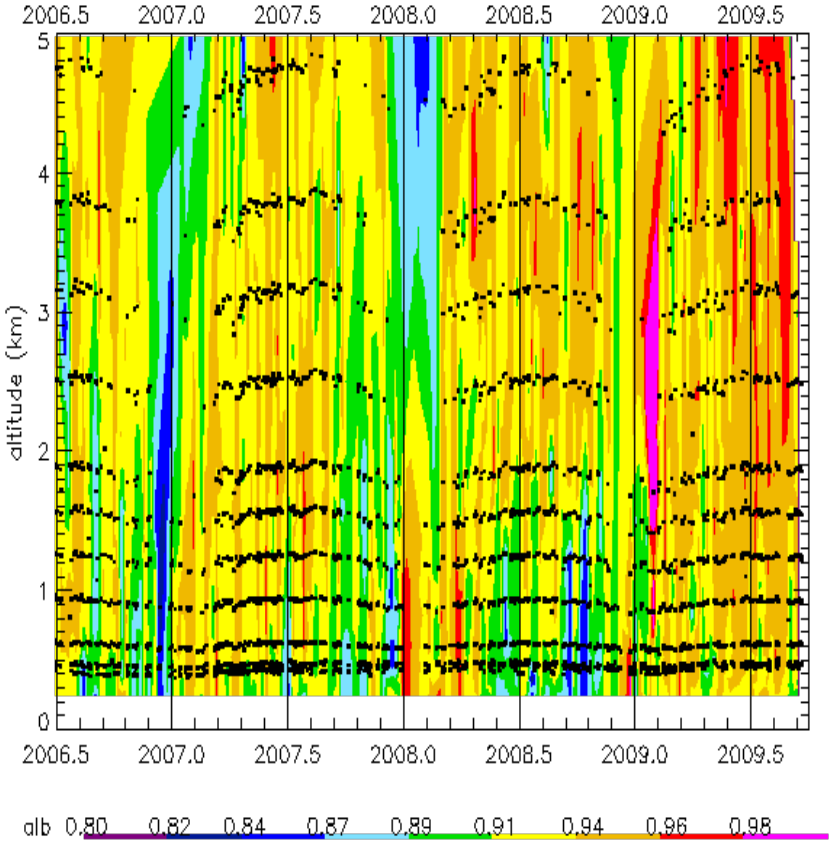




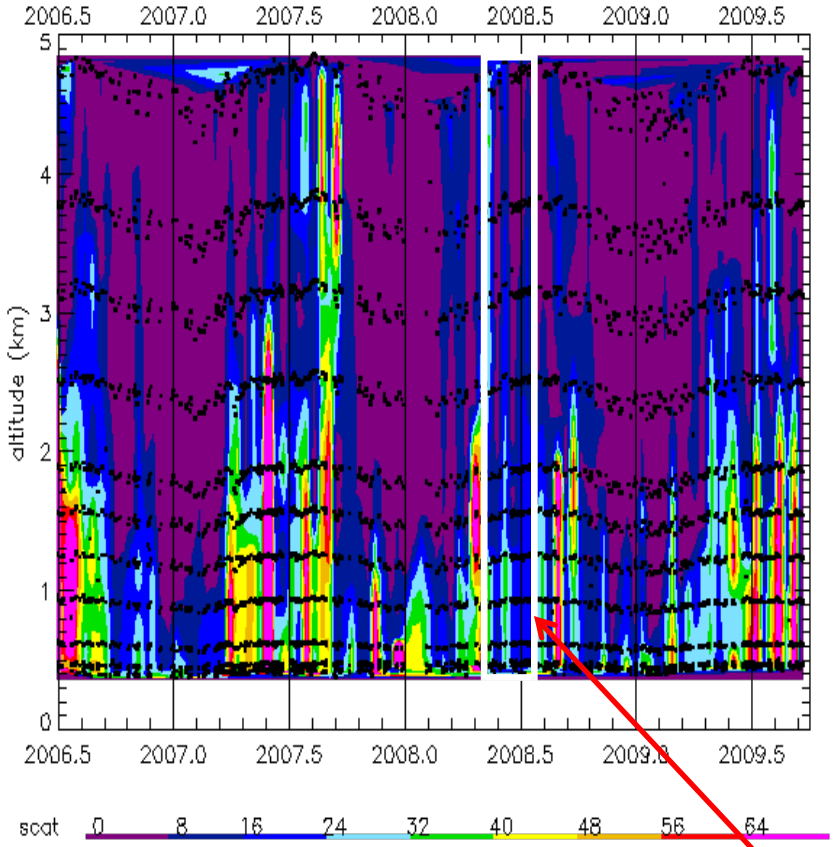




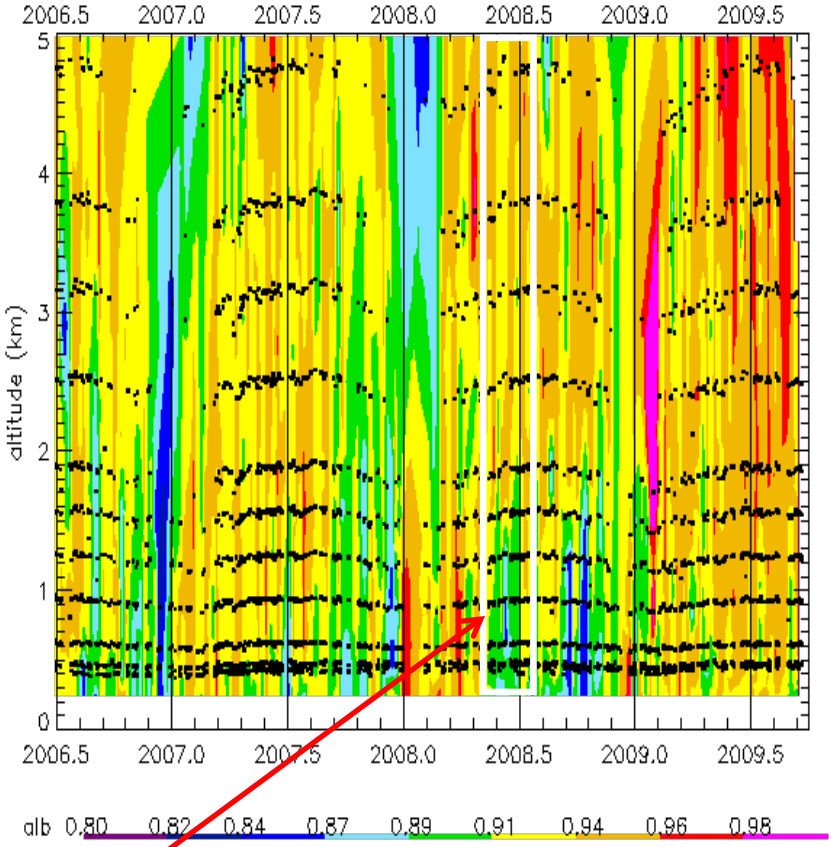
Scattering, 550nm (Mm^{-1})



Single-scattering Albedo (550nm)



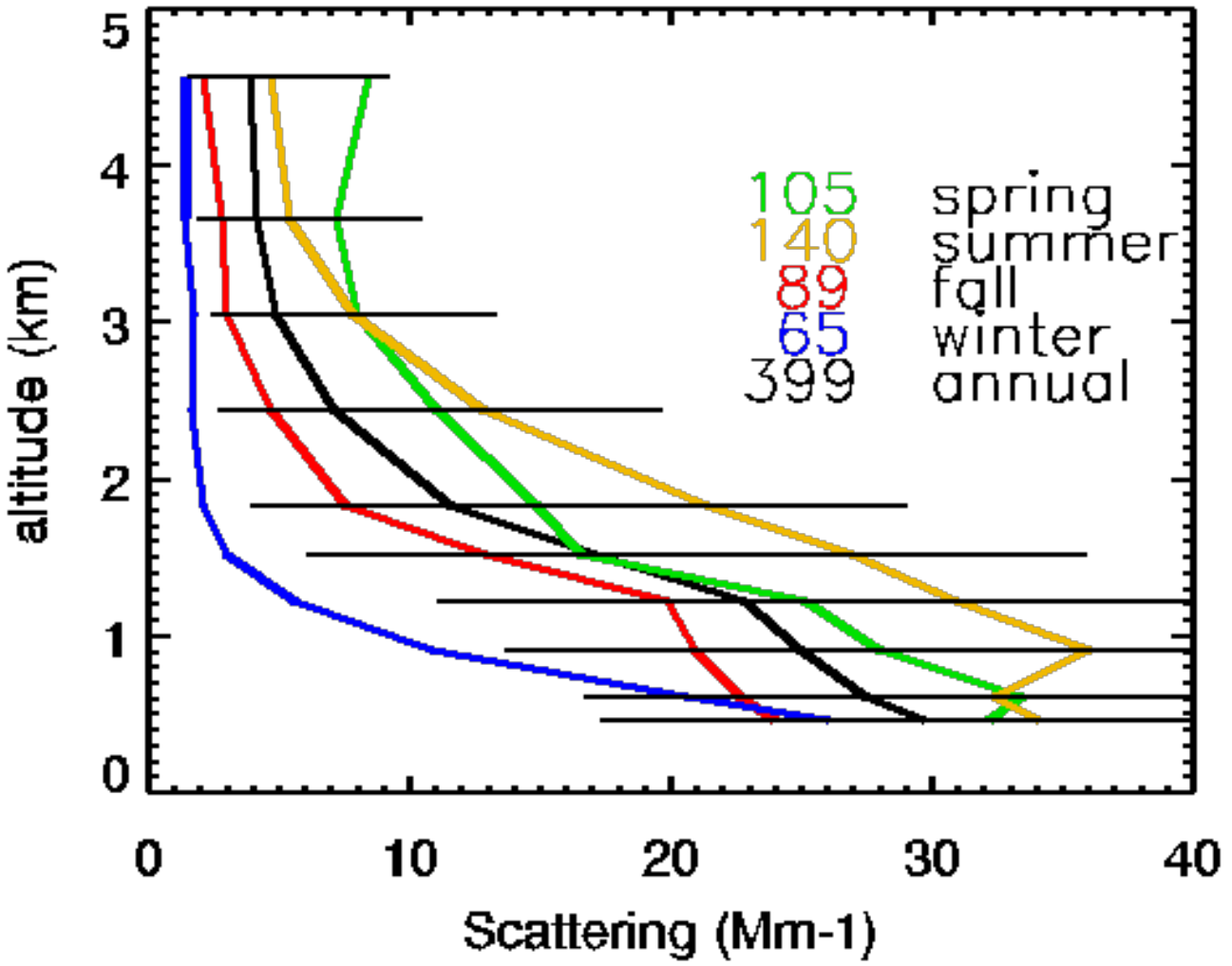
Scattering, 550nm (Mm^{-1})



Single-scattering Albedo (550nm)

Anomalously wet period in late-spring → summer 2008. Rainfall well above average. Measurable rainfall at BND site no less frequently than every three days during this period.

All measurements are for dry aerosol adjusted to STP conditions.



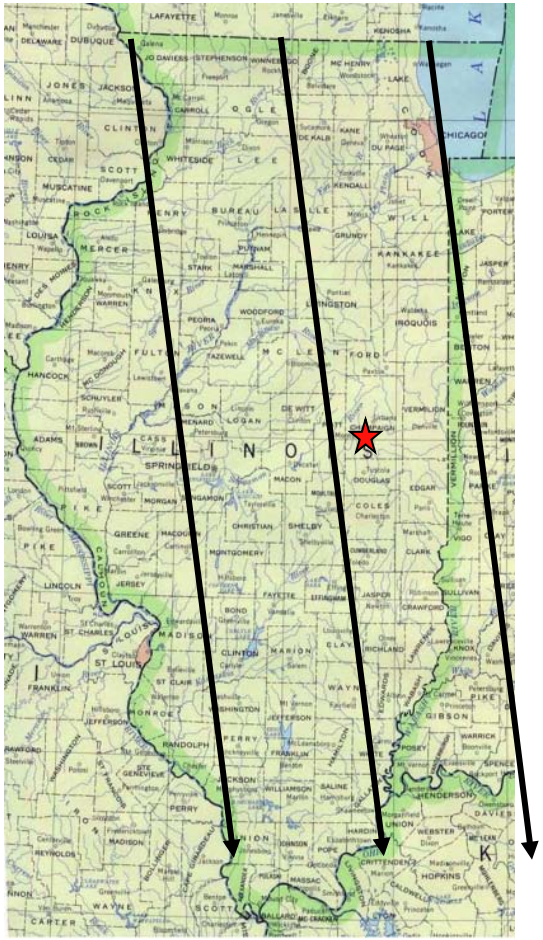
Spring: M, A, M

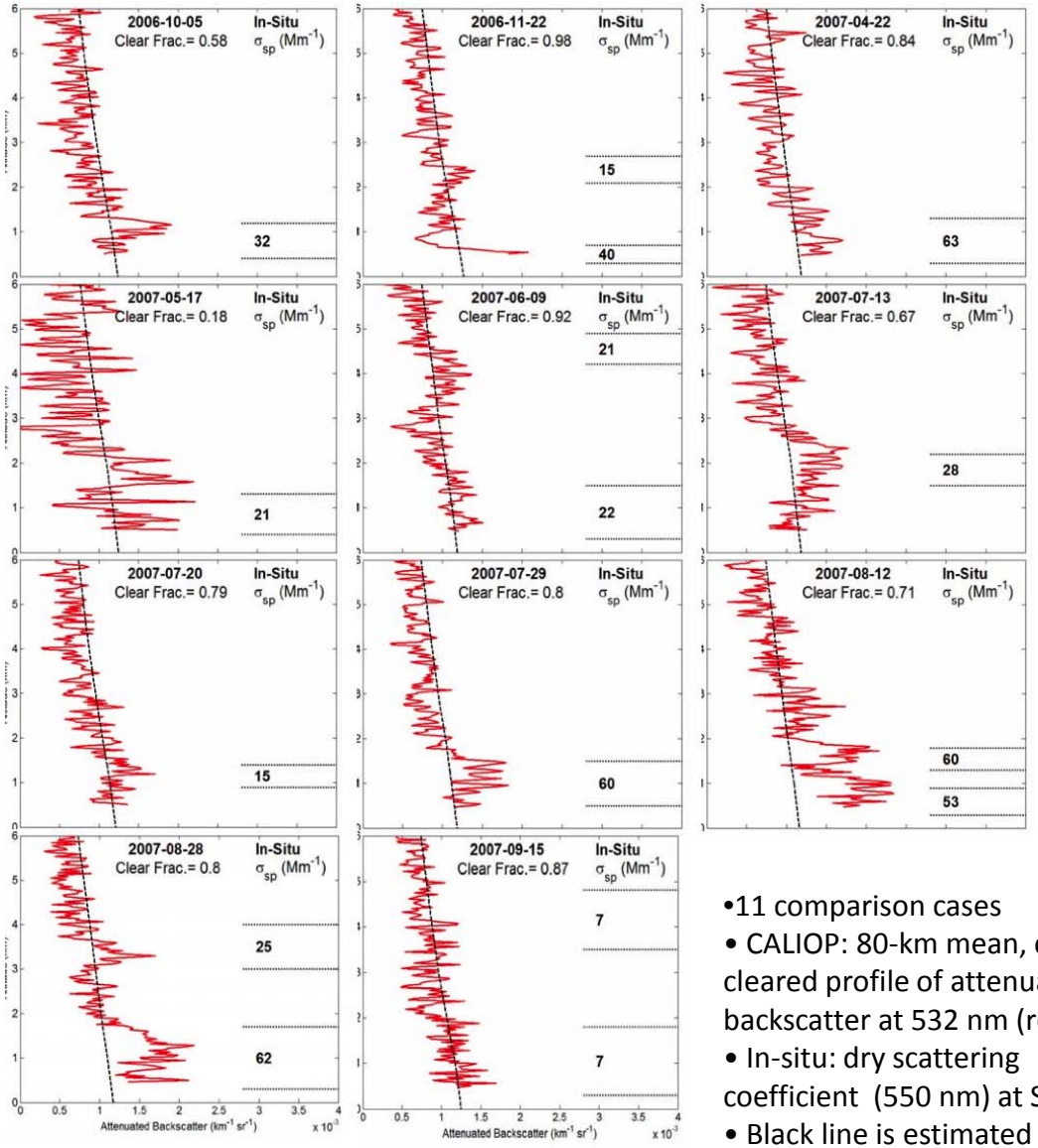
Summer: J, J, A

Fall: S, O, N

Winter: D, J, F

A-Train Overpass Tracks





- 11 comparison cases
- CALIOP: 80-km mean, cloud-cleared profile of attenuated backscatter at 532 nm (red line)
- In-situ: dry scattering coefficient (550 nm) at STP.
- Black line is estimated profile of molecular backscatter.

Future Work:

1) **Determine f(RH) for AAO measurements and adjust aerosol measurements to ambient RH.**
2) **Comparison of AAO measured aerosol optical properties and optical properties calculated from aerosol microphysical (i.e., size distribution data).**
3) **Comparison of AAO data with similar vertical profile data from 8-year Oklahoma flight program.**
4) **Evaluation of horizontal inhomogeneity (i.e., patchiness) in the aerosol.**
5) **Comparison of AAO in situ data with satellite-based remote sensors (e.g., CALIPSO lidar measurements of extinction, MISR aerosol optical thickness, etc.).**
6) **AERONET comparisons (significant progress already)**
7) **Model comparisons**

Future Work (model comparisons):

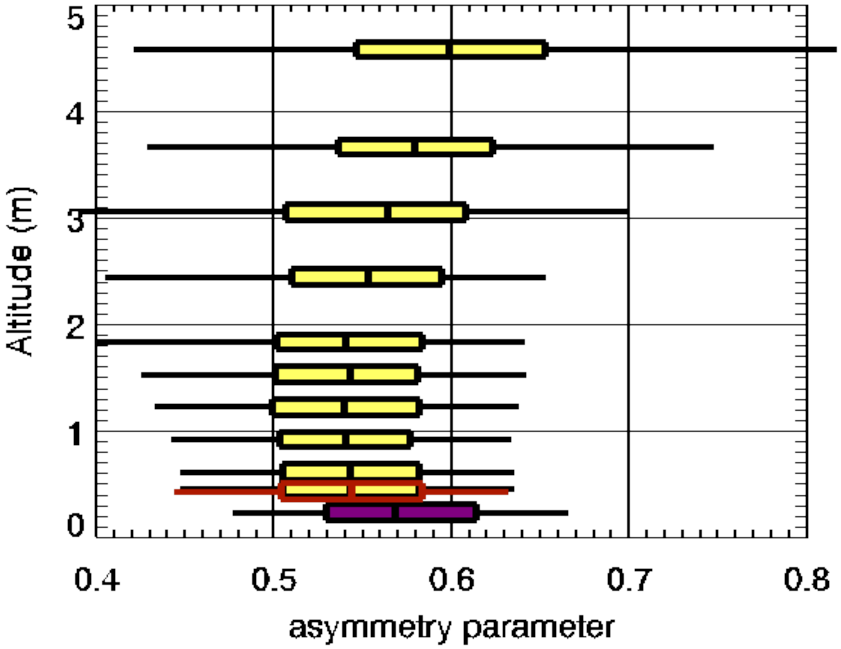
1. **Paul Ginoux - GFDL/AM2 model**

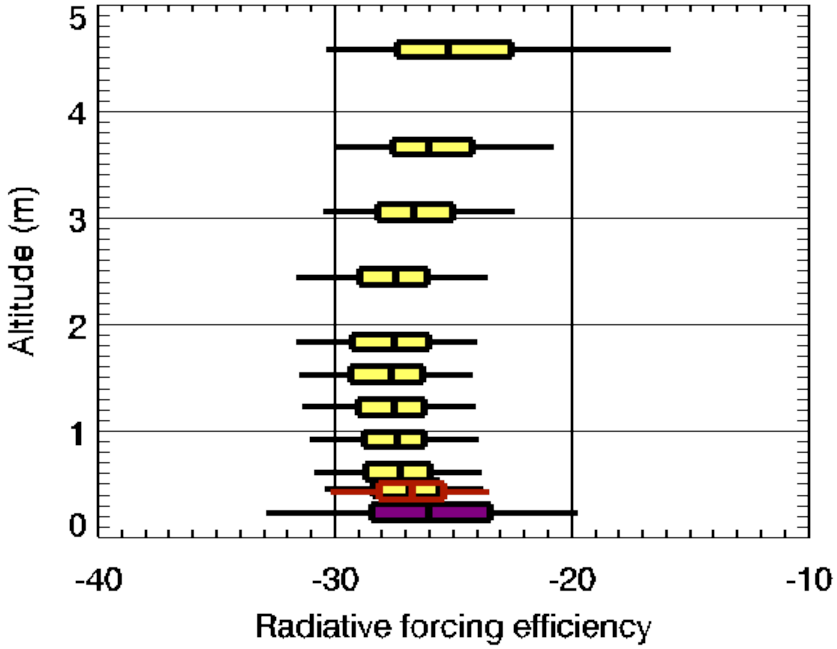
2. **Ragnehild Bieltvedt Skeie - CICERO—Center for International Climate and Environmental - Oslo CTM2**

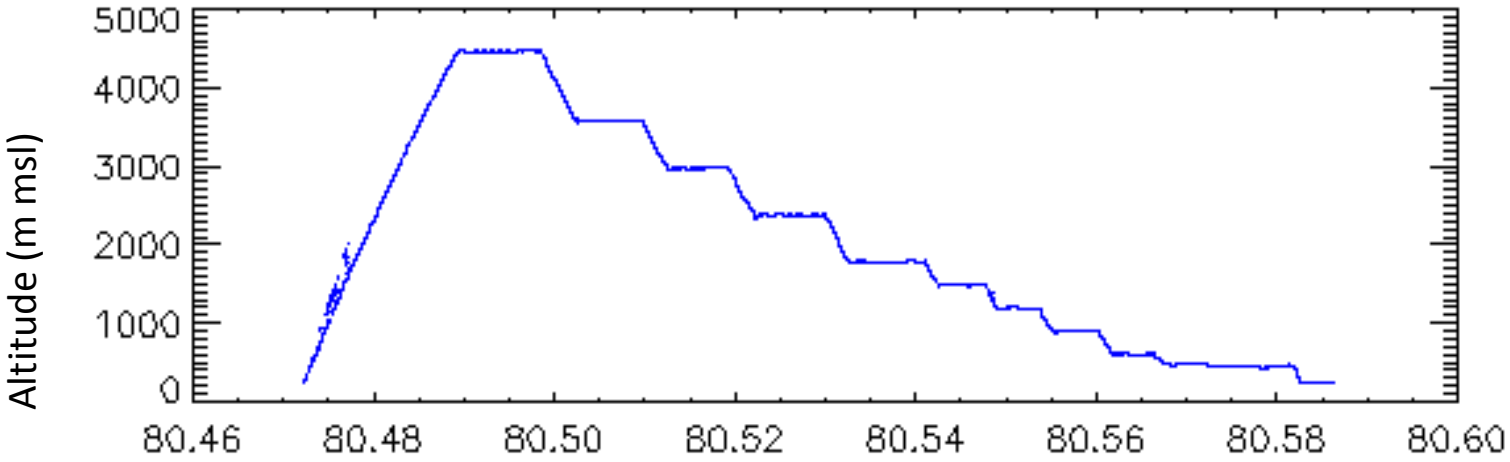
3. **Gill-Ran Jeong – MIT 3-D global aerosol-climate model**

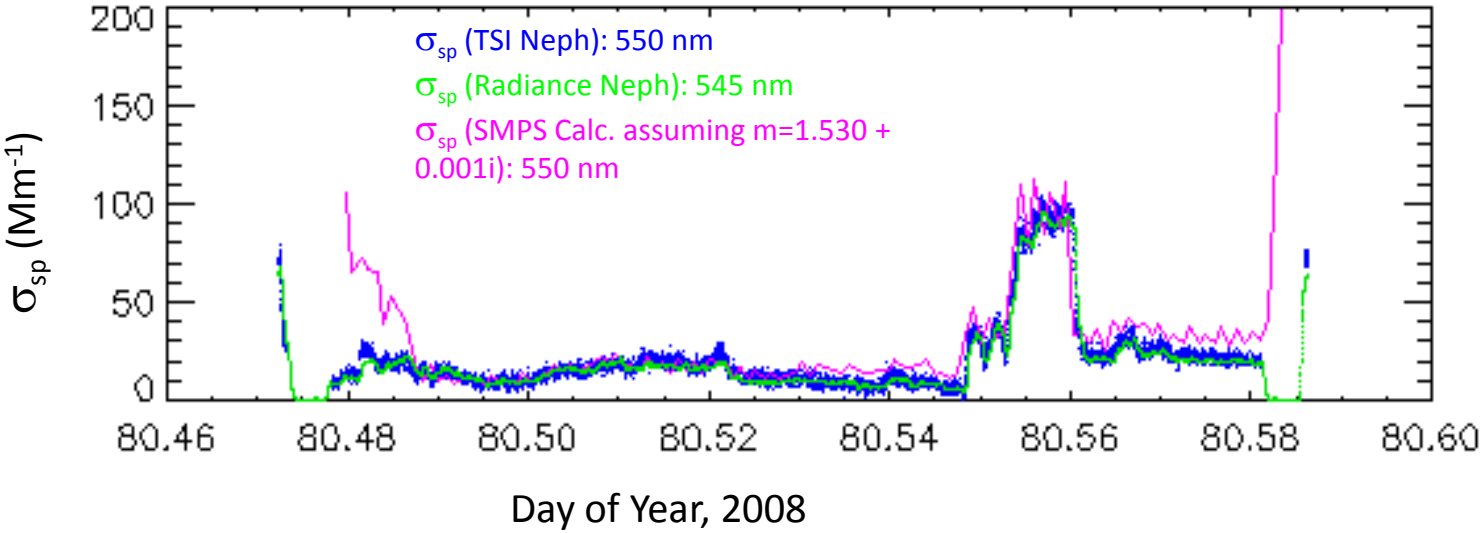

Thank you for your attention!
Photo courtesy of Yin-Nan Lee, BNL

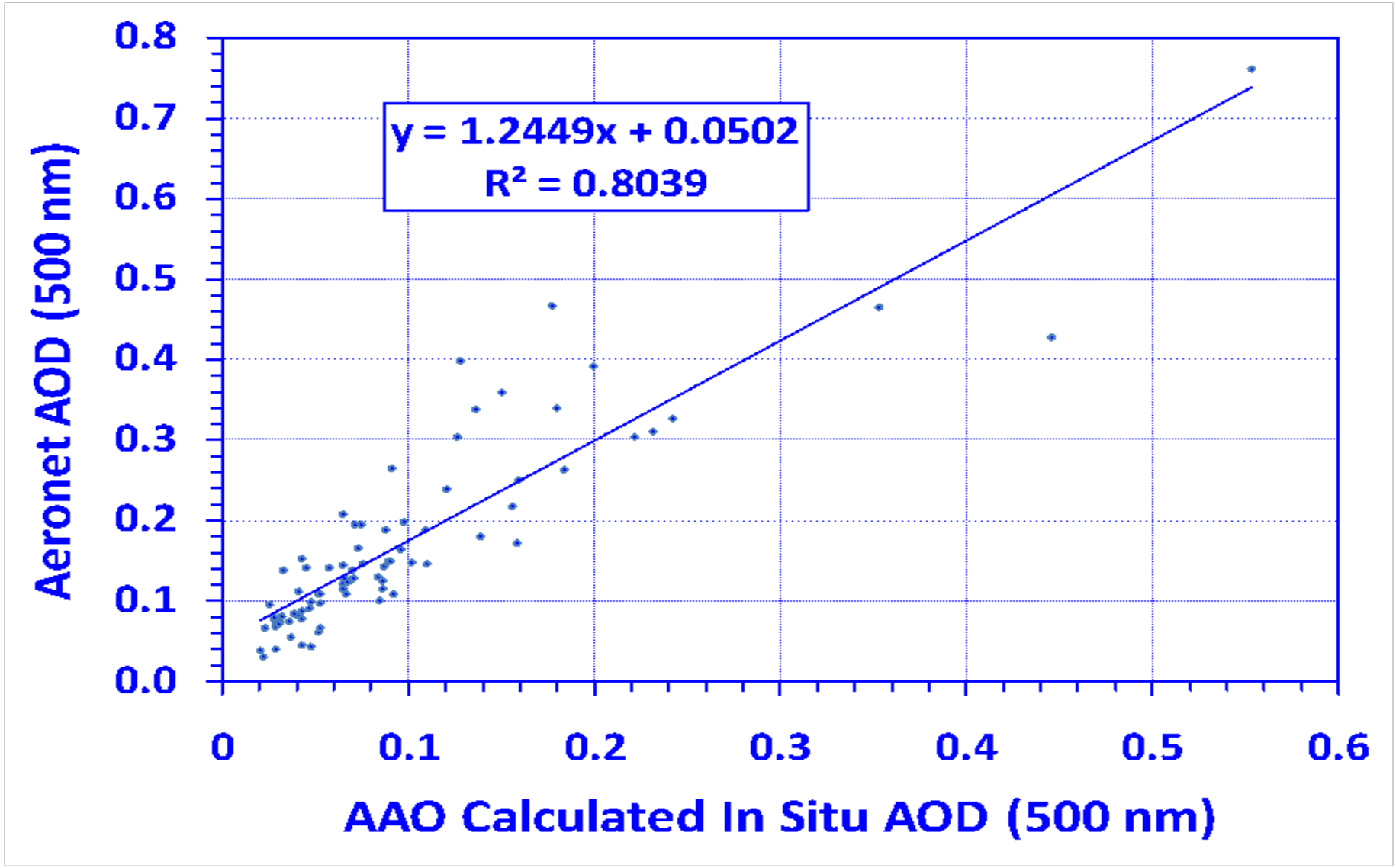
All measurements are for dry aerosol adjusted to STP conditions.






Altitude (m msl)
5000
4000
3000
2000
1000
0
80.46
80.48
80.50
80.52
80.54
80.56
80.58
80.60
Day of Year, 2008


σsp (Mm-1)
σsp (TSI Neph): 550 nm
σsp (Radiance Neph): 545 nm
σsp (SMPS Calc. assuming m=1.530 + 0.001i): 550 nm
200
150
100
50
0
80.46
80.48
80.50
80.52
80.54
80.56
80.58
80.60
Day of Year, 2008


y = 1.2449x + 0.0502
R² = 0.8039
Aeronet AOD (500 nm)
AAO Calculated In Situ AOD (500 nm)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
0.1
0.2
0.3
0.4
0.5
0.6

Paul Ginoux - Geophysical Fluid Dynamics Lab (GFDL), NOAA, Princeton, NJ

The GFDL AM2 model calculates the mass distribution and optical properties of aerosol based on their emission,
chemical production, transport, and dry and wet removal.

Ragnehild Bieltvedt Skeie - CICERO—Center for International Climate and Environmental Research

Oslo CTM2 is an off-line chemical transport model driven by meteorological data from the Integrated Forecast System (IFS) model at the ECMWF centre.

Gill-Ran Jeong - Dept. of Earth, Atmospheric, and Planetary Sciences
MIT, Cambridge, MA

Our model is 3-D global aerosol-climate model developed from the Community Atmospheric Model version3 (CAM3) of NCAR. The aerosol modules describe size-and mixing state- dependent physiochemical and hygroscopic processes of seven aerosol modes using two-moment scheme.