Vertical Profiles of Aerosol Optical Properties Over a Continental US site

Anne Jefferson
Patrick Sheridan, Betsy Andrews and John Ogren

NOAA Climate Monitoring and Diagnostics Laboratory
Boulder, Colorado, USA

http://www.cmdl.noaa.gov/aero

Questions on surface vs vertical in-situ measurements

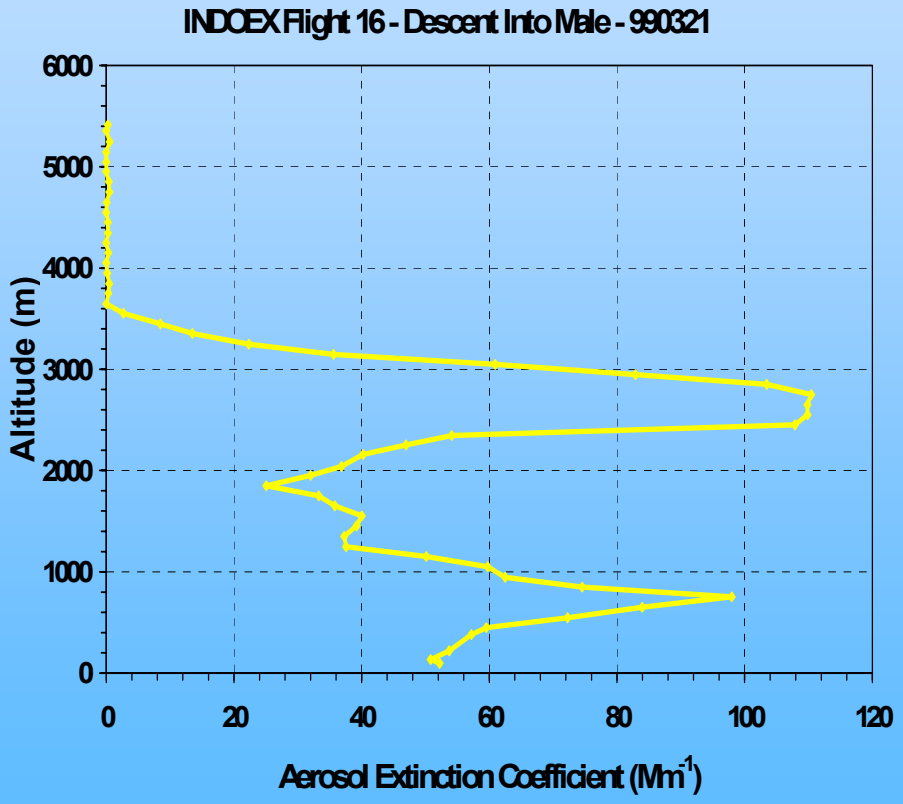
- How representative are the optical properties of surface aerosols to the column properties?

- What is the variability of the aerosol optical properties above and below the mixed layer?

- Under what circumstances can the surface data be used to validate satellite data?

- How well can short term aircraft measurements characterize the regional and seasonal variability of aerosol properties?

Observations of elevated layers with high aerosol extinction over the Indian Ocean



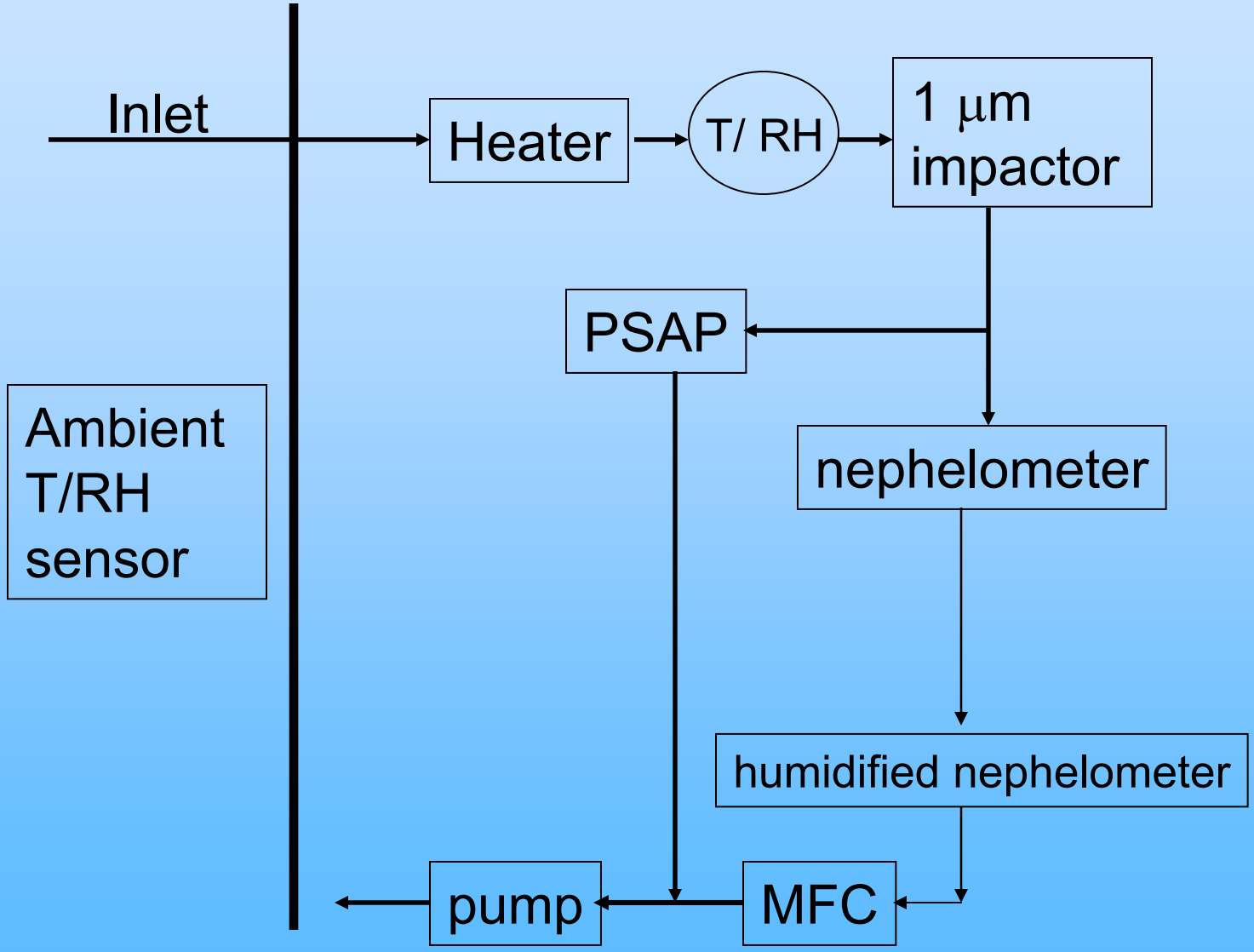
NOAA/CMDL In-situ Aerosol Profiling

- Information on aerosol properties aloft is scarce, satellites and surface stations give limited data.
- Light airplanes can be used to monitor vertical profiles of key aerosol properties at modest cost.
- Objectives:
  - obtain aerosol climatology aloft
  - determine relevance of surface climatology
- Summary: Cessna 172 (4-seat), profiles to 3.7 km asl, aerosol light scattering and absorption, automated operation.

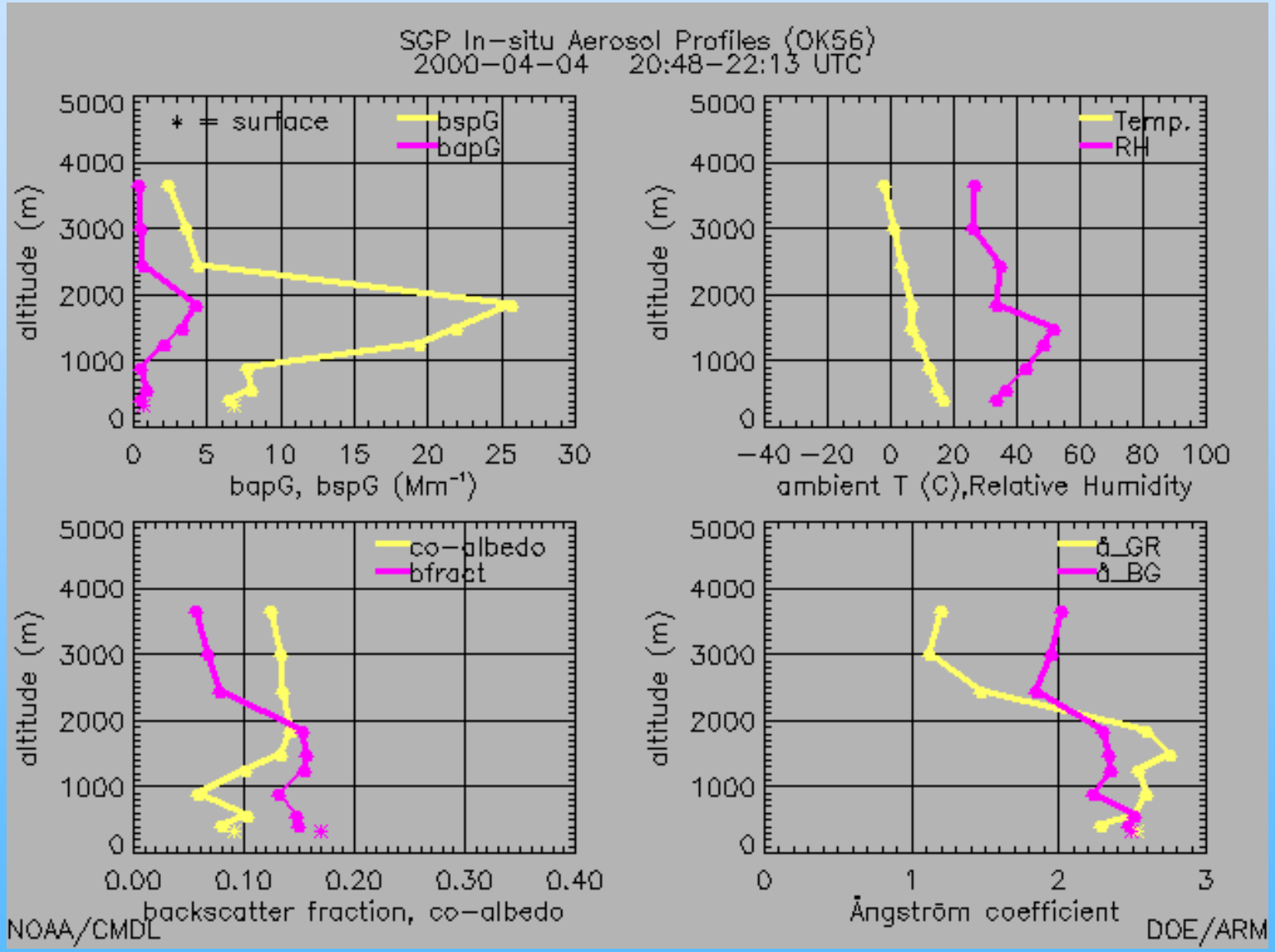
- DOE/ARM funding for Oklahoma project, >500 flights since 3/2000

- NOAA funding starting 2003 to begin sampling over another site with an enhanced payload. Start flying fall 2005.

Sampling System

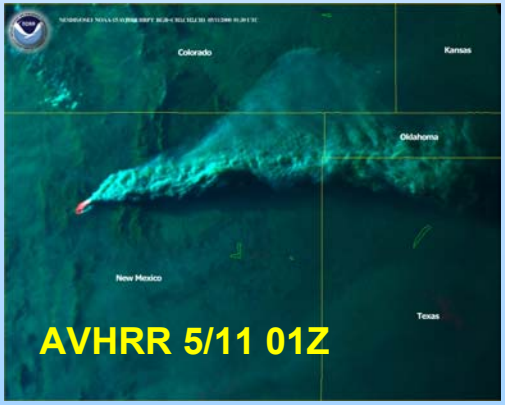


Vertical profiles of aerosol properties for an elevated aerosol layer

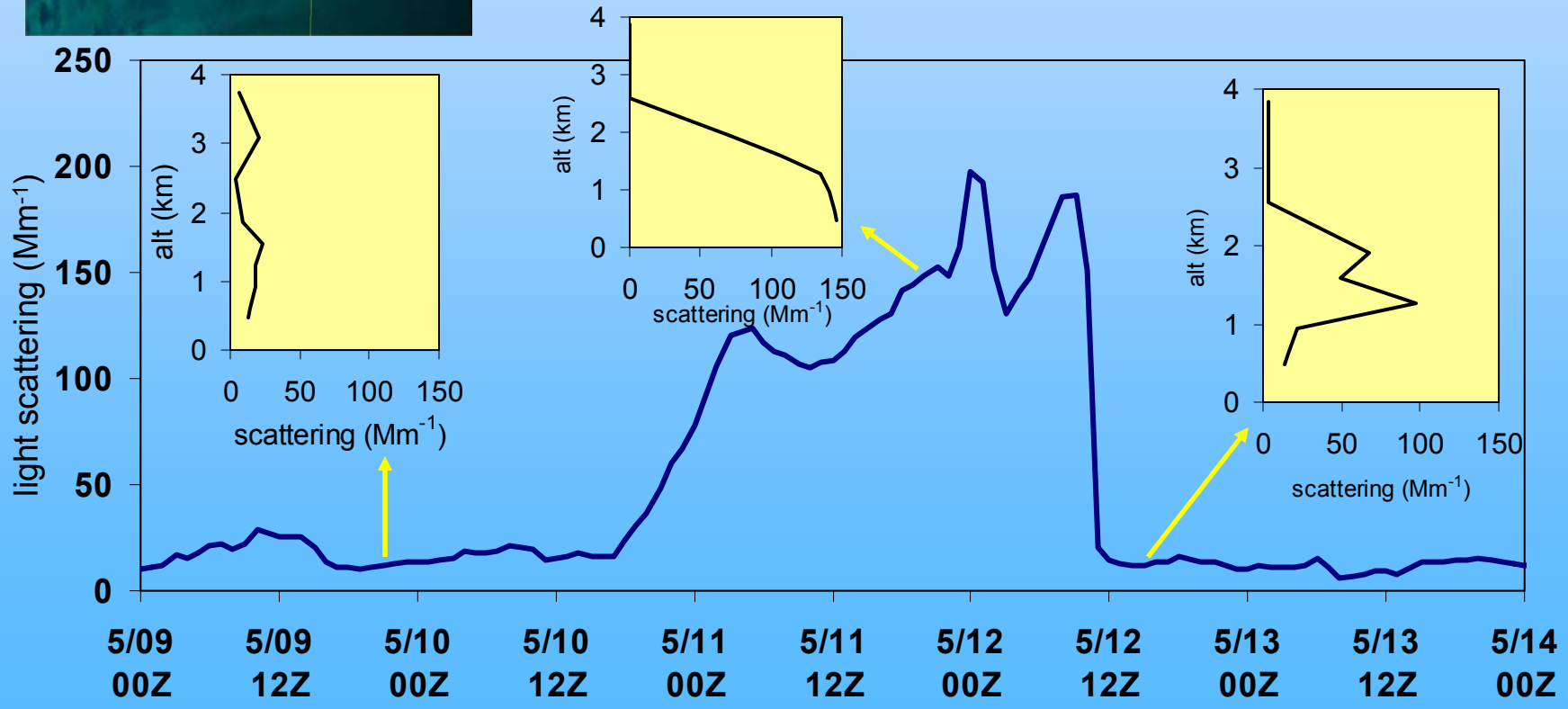


www.cmdl.noaa.gov/aero/net/iap/profiles.html

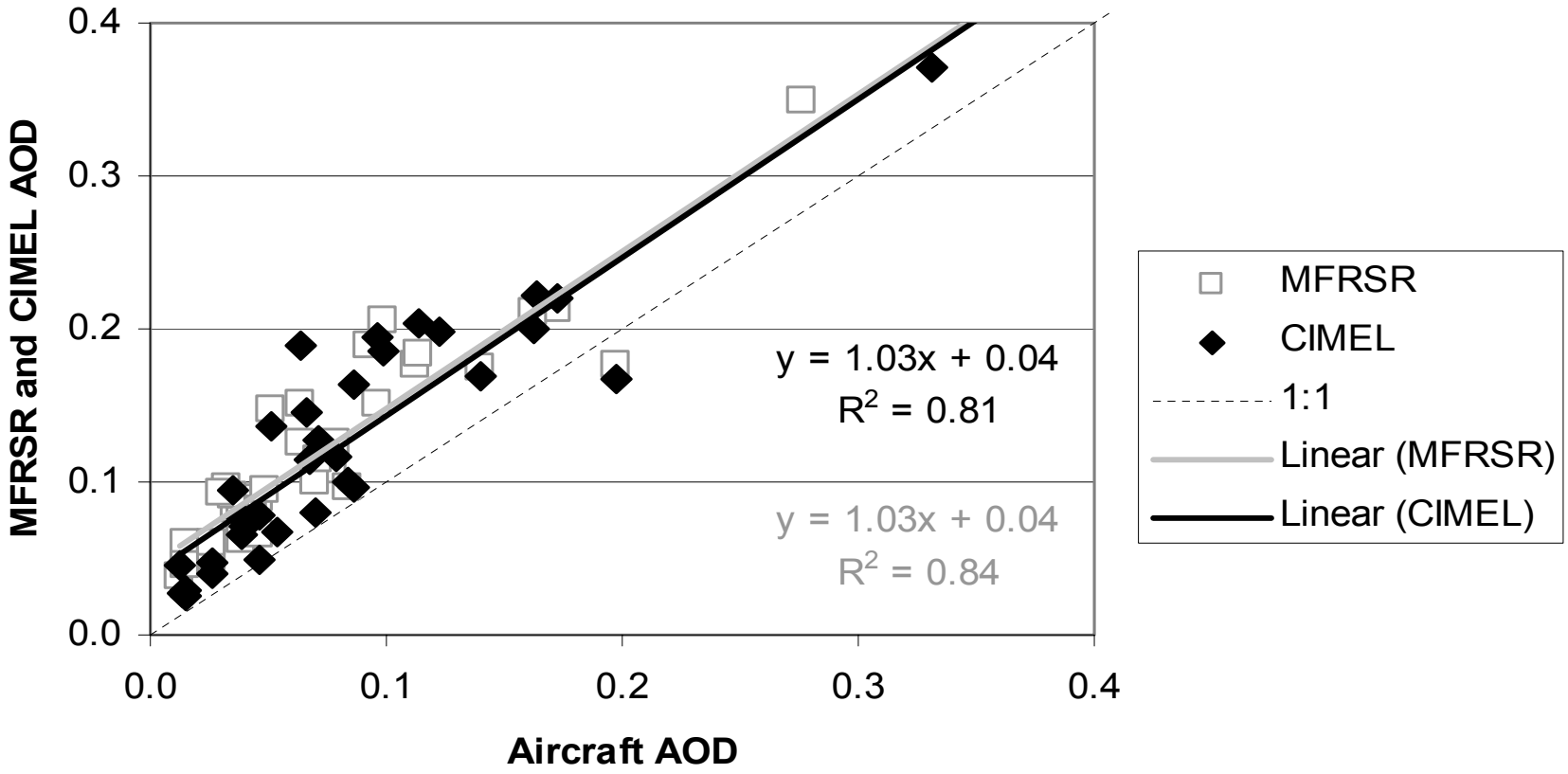
Long-range transport of smoke aerosol from Los Alamos to Oklahoma, May 2000



Smoke plume reached DOE+NOAA aerosol monitoring site (star) around 16Z on May 10 (blue line). Vertical profiles from aircraft profiling flights (insets) show that the smoke layer aloft persisted after a cold front passed on May 12 at 11Z.

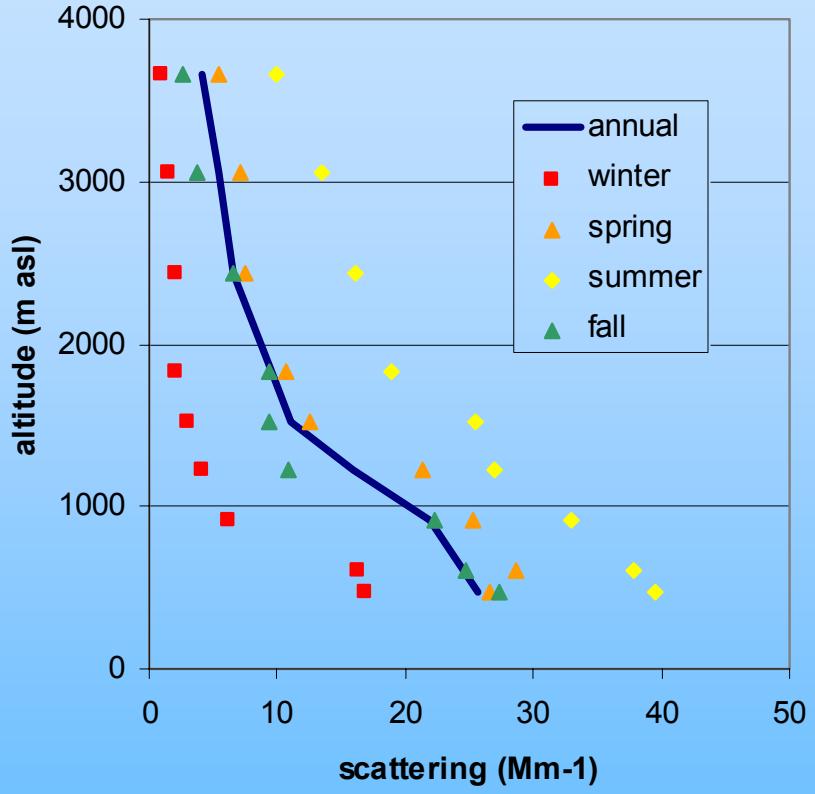


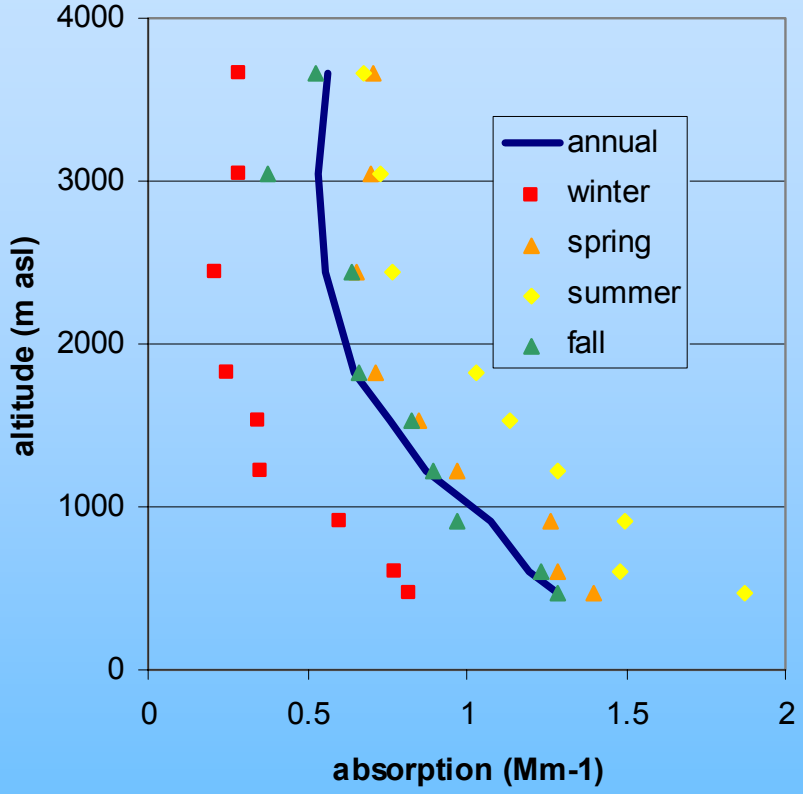
Comparison with AOD measurements



Values are adjusted to ambient T,P & RH, for λ = 0.55 μm, and Dp < 1 μm, for 32 flights between March 28 and September 1, 2000. Additional adjustments are made for supermicron and stratospheric aerosol.

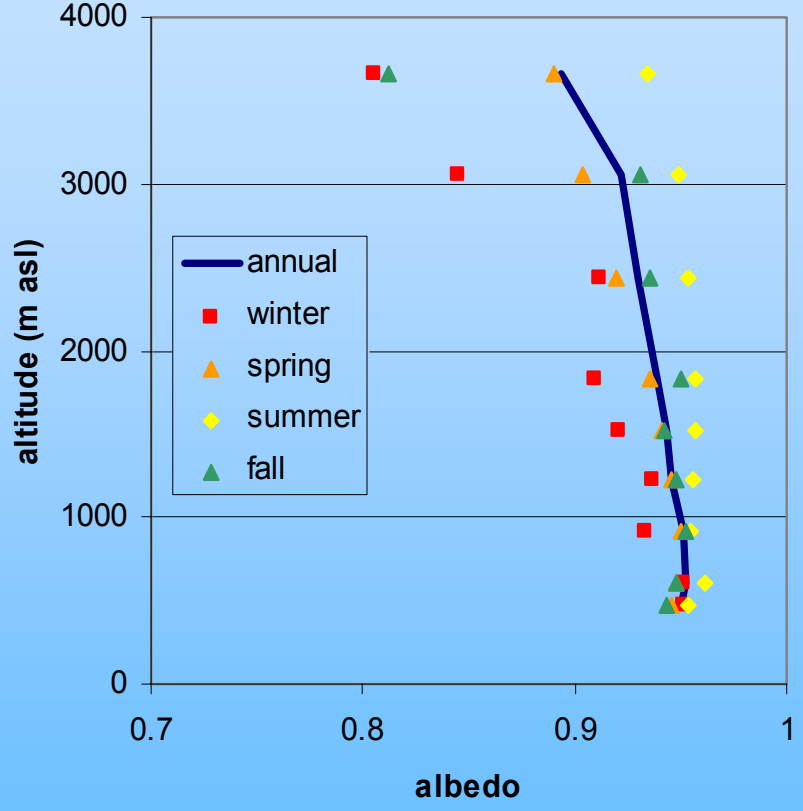
Seasonal Variation of Average Aerosol Profiles over Oklahoma: Aerosol Amount

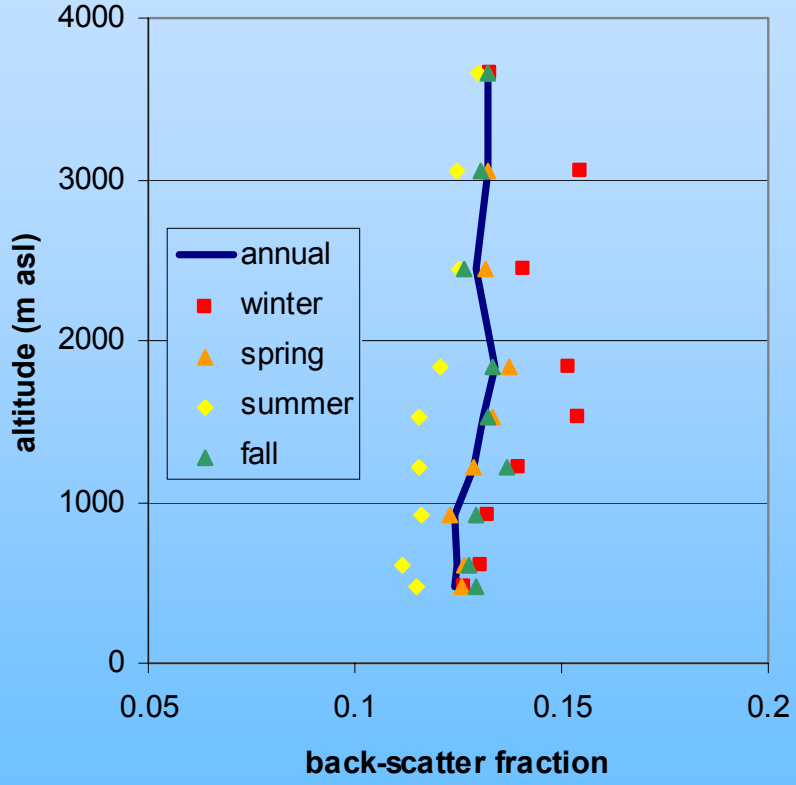




Notes: Results are for 324 profiles from March, 2000 – March, 2003 over the DOE/ARM site. Aerosol radiative properties reported at 550 nm wavelength, RH<40%, and particle diameter below 1 μm.

Seasonal Variation of Average Aerosol Profiles over Oklahoma: Aerosol Character





Notes: Results are for 324 profiles from March, 2000 – March, 2003 over the DOE/ARM site. Aerosol radiative properties reported at 550 nm wavelength, RH<40%, and particle diameter below 1 μm.

How well do surface properties reflect those of the column?

- Delle Monache et al. (*JGR 2004)* looked at the ratio of the aircraft/surface aerosol properties for 10 days with a “well-mixed” atmospheric boundary layer of constant potential temperature and a capped inversion.
- He found a good correlation with surface and aircraft measurements in the mixed layer and a poor correlation above the mixed layer.
- aerosol single scattering albedo declines above the mixed layer

ratios of aircraft/surface aerosol optical properties with altitude

absorption 550 nm

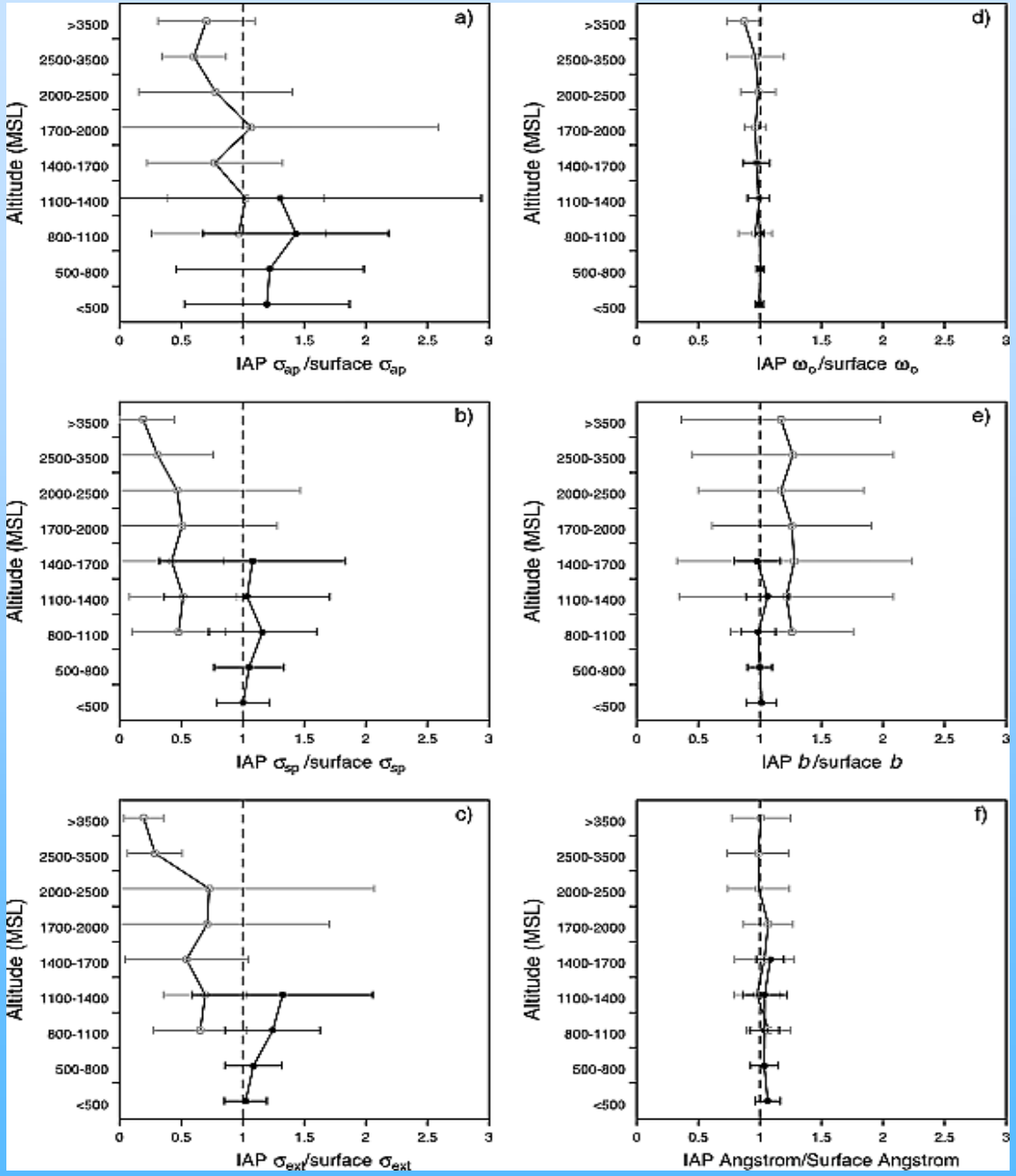
scattering 550 nm

extinction 550 nm

single scattering albedo 550 nm

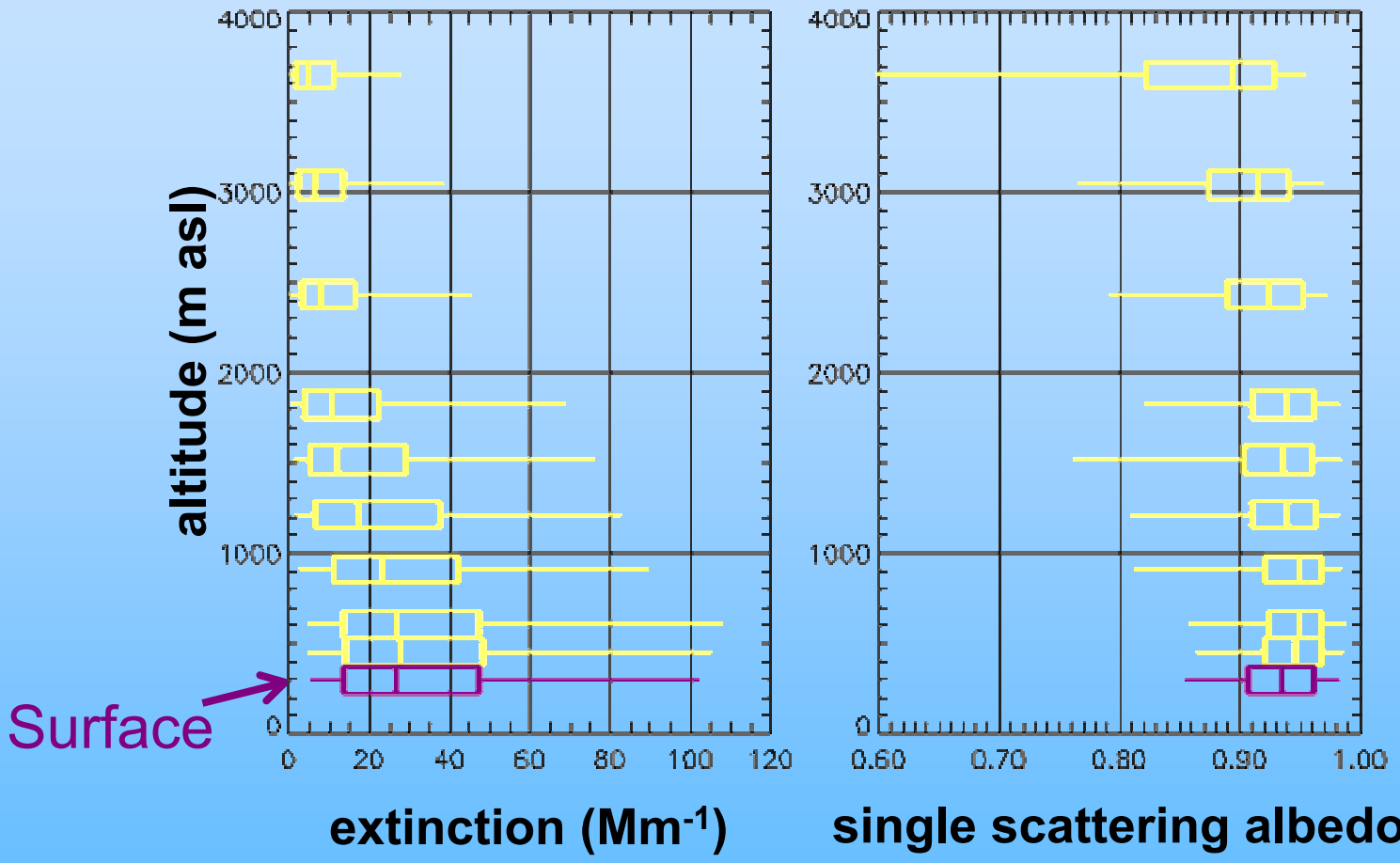
back scatter fraction 550 nm

Ångstrom exp 450/550 nm



Delle Monache et al, JGR 2004. Bars represent 1 standard deviation of the data.

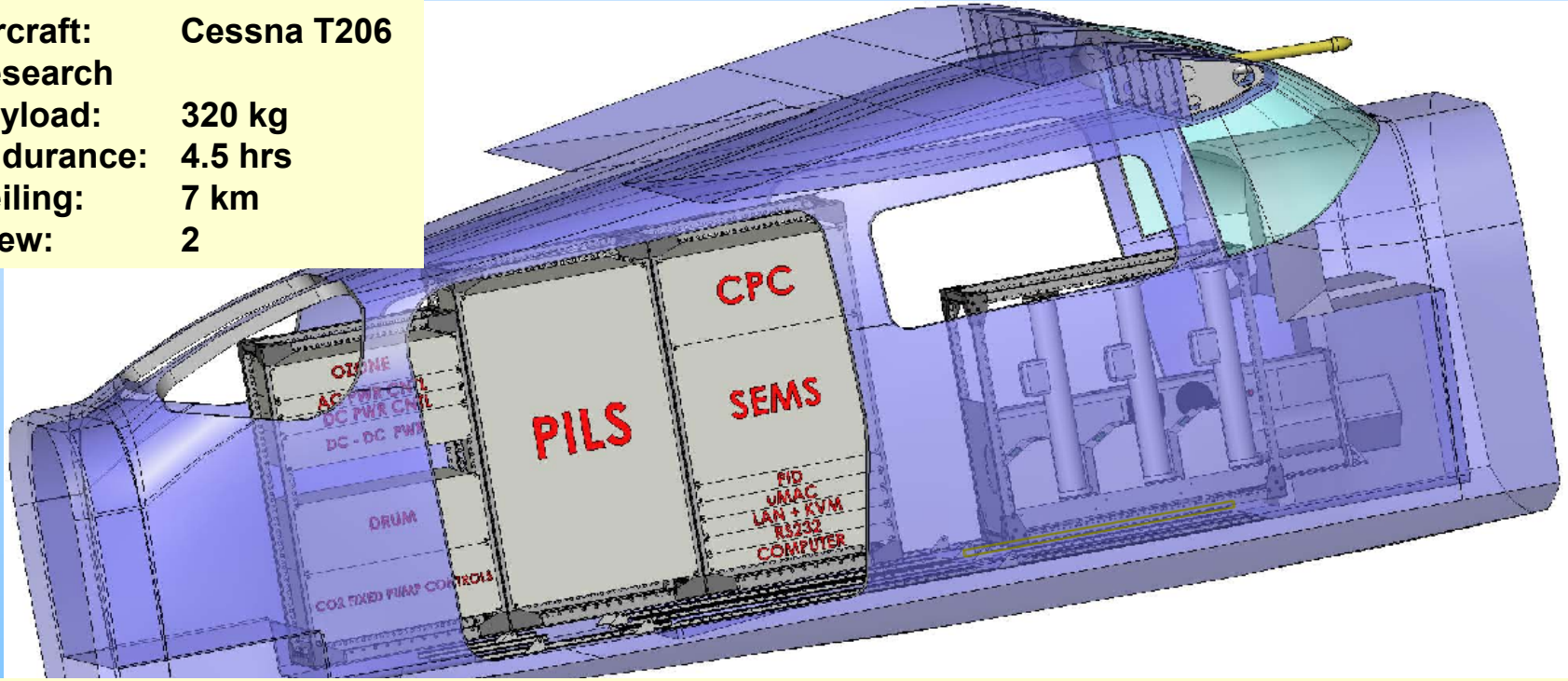
Vertical Profiles of σ_{ext} and ω at SGP



Values are adjusted to STP and at RH < 40%, for λ = 0.55 μm and Dp < 1 μm, for 339 flights between March 25, 2000 and February 22, 2003.

NOAA Airborne Aerosol Observatory

Aircraft:	**Cessna T206 Research**
Payload:	**320 kg**
Endurance:	**4.5 hrs**
Ceiling:	**7 km**
Crew:	**2**



Chemical Properties

- Major ions
  - PILS sampler
  - analysis by IC
- Trace elements and total mass
  - DRUM sampler
  - analysis by PIXE, β-attenuation
- Gases (O3, carbon-cycle flasks)

Microphysical Properties

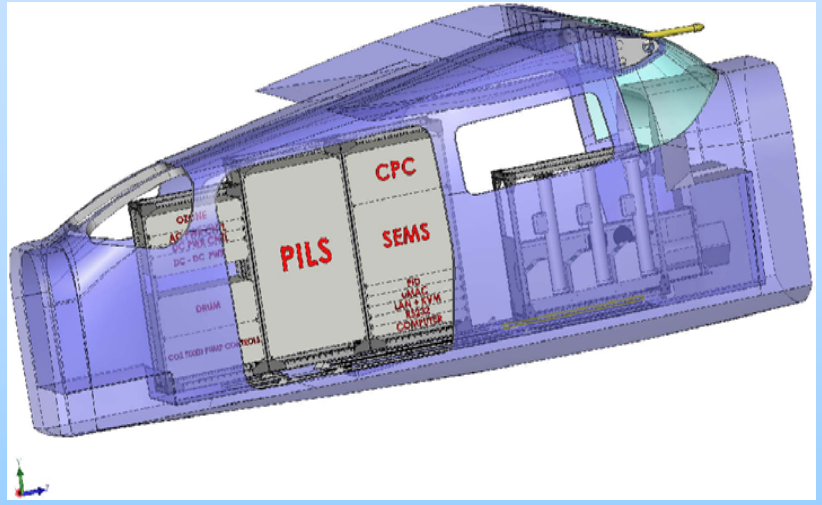
- Number concentration **D > 10 nm**
- Size distribution **20 < D < 500 nm**

Radiative Properties

- Light scattering. backscattering, and absorption **3 wavelengths, no size cut, 40% RH**
- Scattering vs. RH **1 wavelength, 1 μm size cut, 40%, 65%, 85% RH**

NOAA Airborne Aerosol Observatory

- Objective: Obtain a climatology of aerosol properties aloft for testing models and satellite retrievals
- Stair-step flight patterns from surface to 12k' (occasionally 18k'), 2-3 flights per week
- Underfly satellites when possible (A-Train)
  - requires clear sky and overpass nearby
- Most profiles in vicinity of CMDL aerosol monitoring station near Bondville, IL
  - possibly relocate to Trinidad Head, CA for springtime maximum in transport from Asia



- Aerosol chemistry
  - major ions, trace elements, gravimetric mass
- Aerosol size distribution, number concentration
- Aerosol optics
  - light scattering, absorption, hygroscopic growth
- Gases
  - continuous O_3, carbon-cycle flasks