Direct Aerosol Forcing of Climate

- **What are we after?**
  - Change in surface and top-of-atmosphere irradiances due to scattering and absorption of sunlight by anthropogenic aerosols, for the entire globe.
- **What do we need to measure?**
  - AEROSOL AMOUNT
    - Anthropogenic aerosol optical depth, δ_a
    - Chemical measurements to determine anthropogenic fraction
  - ABSORPTION vs. SCATTERING
    - Single-scattering albedo of anthropogenic aerosols, ϖ_o
  - SCATTERING vs. ANGLE
    - Angular scattering properties of anthropogenic aerosols (asymmetry parameter, backscatter fraction)
  - WATER UPTAKE
    - RH-dependence of scattering, absorption, angular scattering
- **What is our strategy?**
  - Models+satellites provide global distribution of AMOUNT
  - Monitoring from surface and airplanes gives
    - validation data for models and satellites
    - climatology of aerosol single-scattering albedo, angular scattering, and water uptake
  - Radiative transfer models derive forcing from AMOUNT and PROPERTIES

Observations of Direct Climate Forcing

- **Global mapping of anthropogenic aerosol optical depth (AOD) by satellites and models**
- **Regional climatology of radiative forcing efficiency (RFE) from in-situ measurements**
- **Direct Climate Forcing (W m^{-2})**
  DCF = AOD * f_f * f_{af} * RFE_a

f_f = fine mode fraction of AOD

f_{af} = anthropogenic fraction of fine mode AOD

In-situ profiling needed

In-situ Aerosol Profiling Aircraft

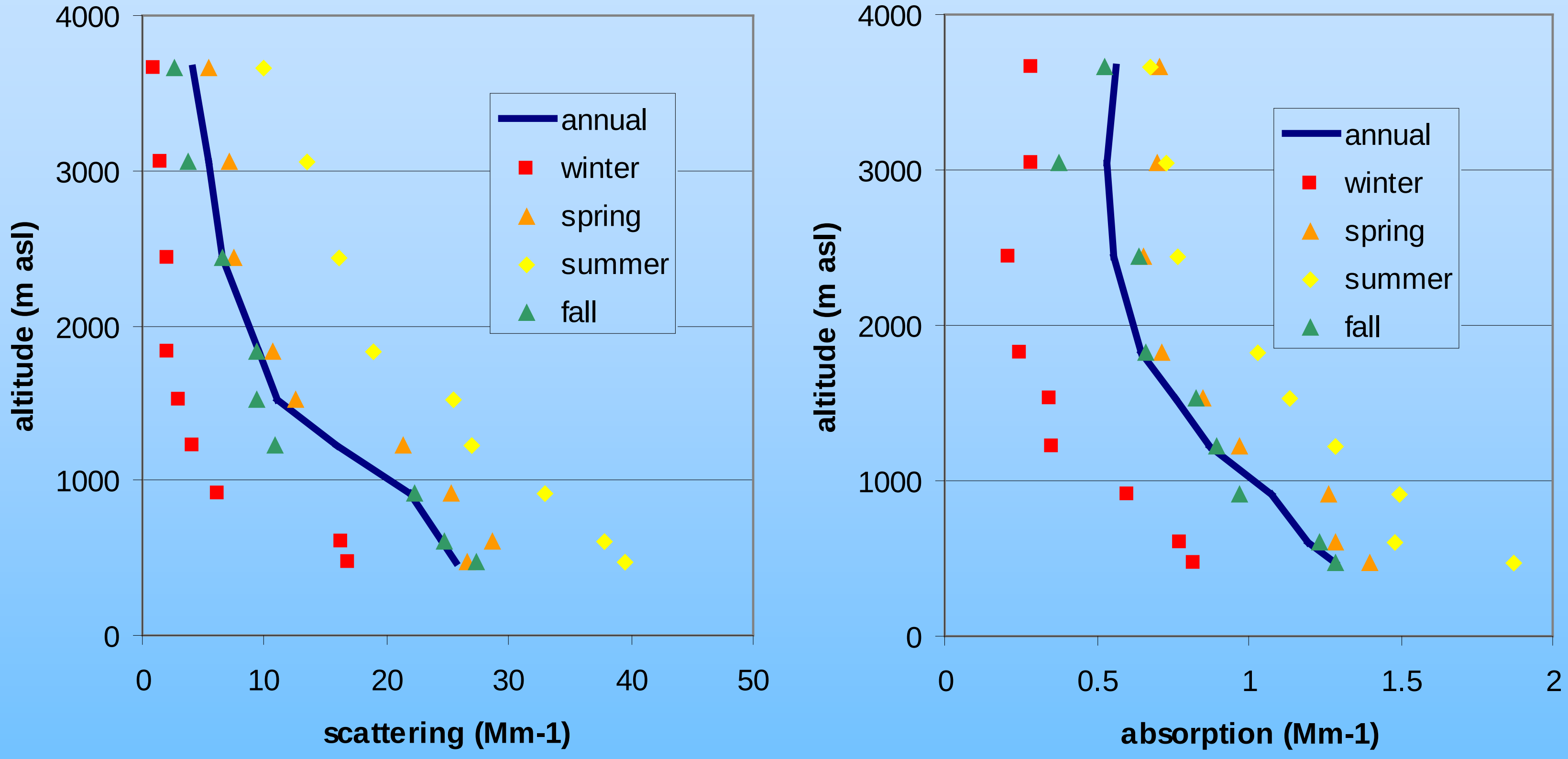
- **Information on aerosol properties aloft is scarce, satellites and surface stations give limited data.**
- **Light airplanes can be used to monitor vertical profiles of key aerosol properties at modest cost.**
- **Objectives:**
  - obtain aerosol climatology aloft
  - determine relevance of surface climatology
- **Summary: Cessna 172 or Cessna 206, profiles to ~4 km asl, aerosol light scattering and absorption, automated operation.**


Sample Inlet


Port view of rack

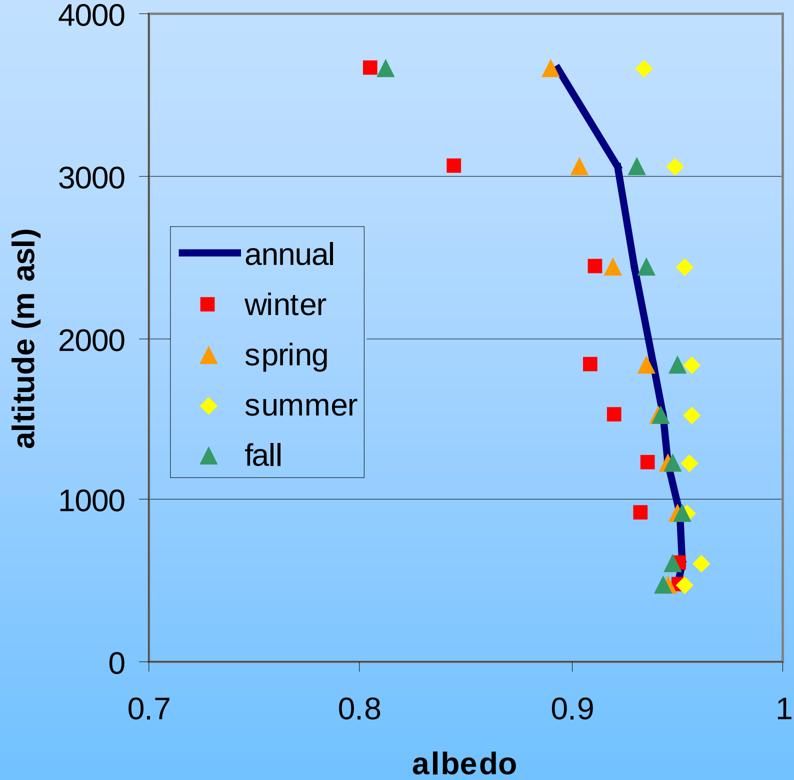
- DOE/ARM funding for Oklahoma project, >600 flights since 3/2000
- NOAA funding to sample over another continental U.S. site with an enhanced payload. Start flying June 2006.

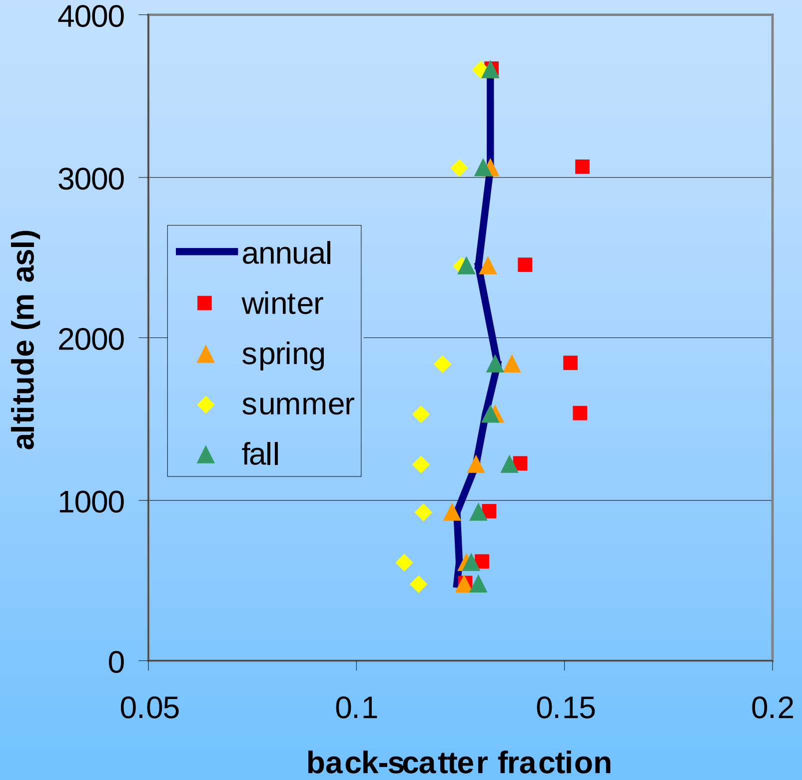
Seasonal Variation of Average Aerosol Profiles over Oklahoma: Aerosol Amount



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.

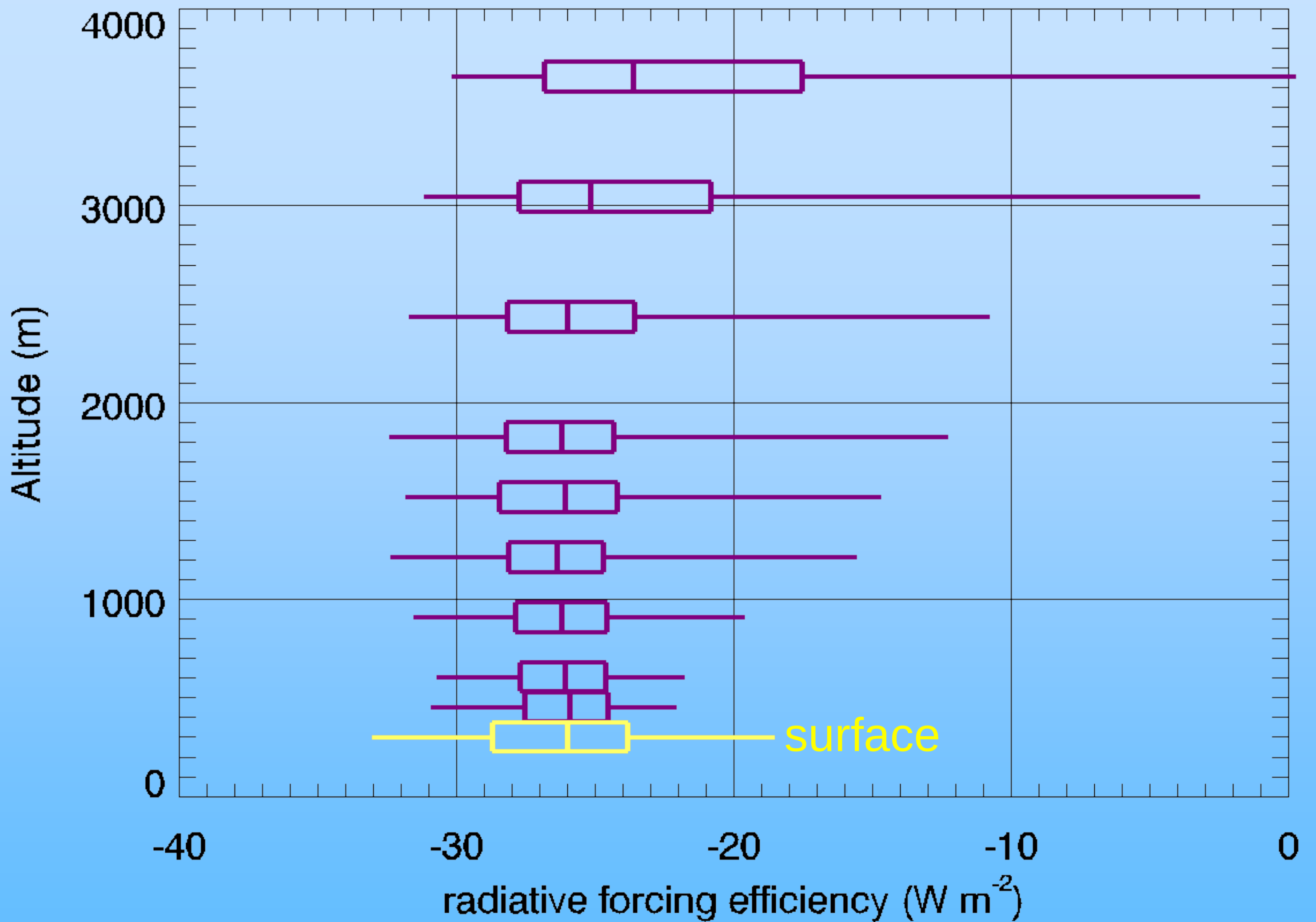
Seasonal Variation of Average Aerosol Profiles over Oklahoma





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.

Vertical Profile of RFE over Oklahoma



DOE/ARM funded research
March 25, 2000 - April 17, 2006, 616 flights

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 15k' (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
- **Status:** installation on Turbo Cessna 206 in May 2006, flights beginning June 2006

- **Aerosol chemistry**
  - major ions, water-soluble organic carbon
  - eventually add trace elements, gravimetric mass
- **Aerosol size distribution**
- **Aerosol optics**
  - light scattering, absorption, hygroscopic growth
- **Gases**
  - continuous O_3, carbon-cycle flasks

Variations in Radiative Forcing Efficiency