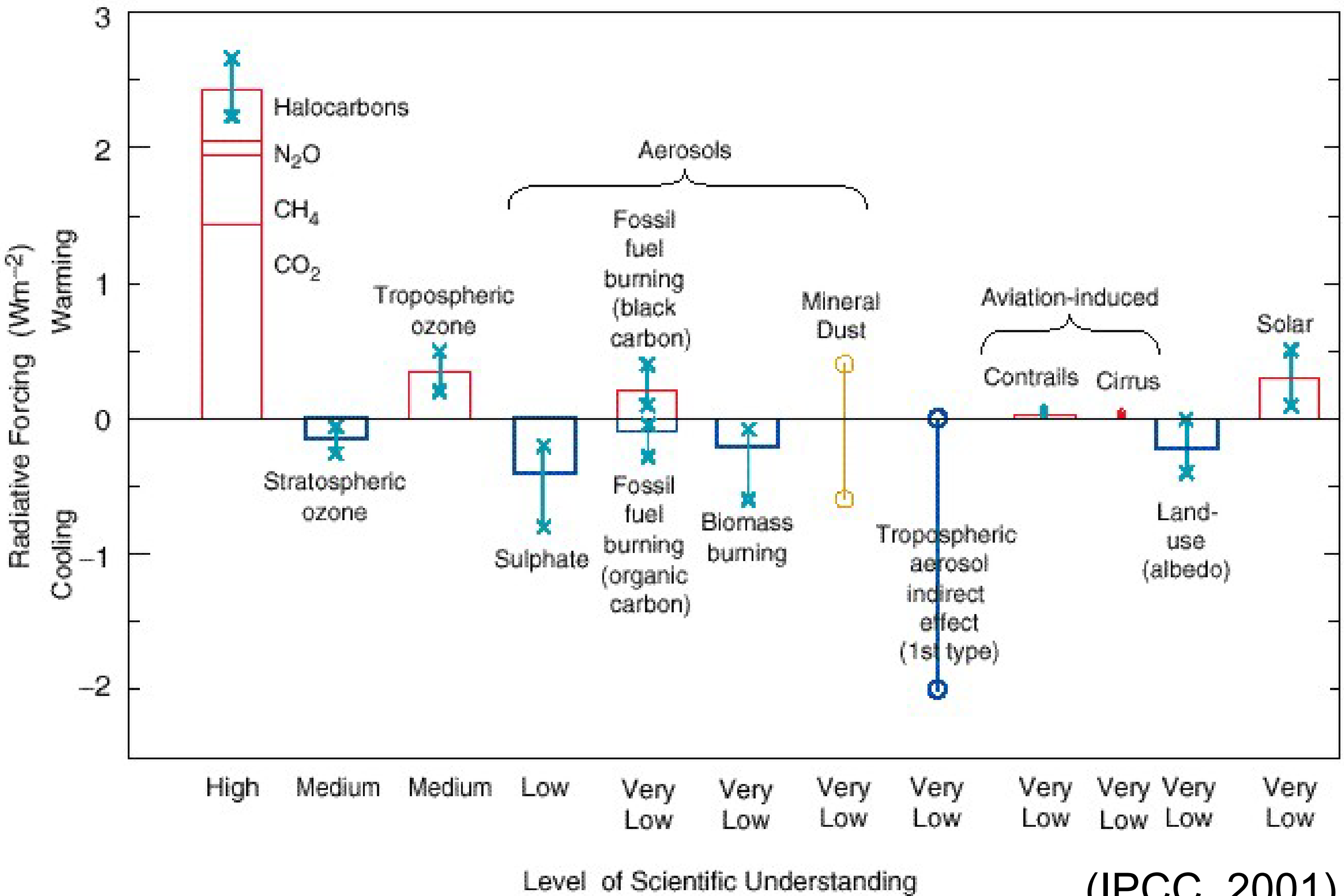
Aerosol Loading and Optical Properties during the May 2003 SGP ARM Aerosol IOP

Melissa Melvin – Northern Illinois University
V. Rao Kotamarthi – Argonne National Laboratory

August 16th, 2004
GCEP End-of-Summer Workshop

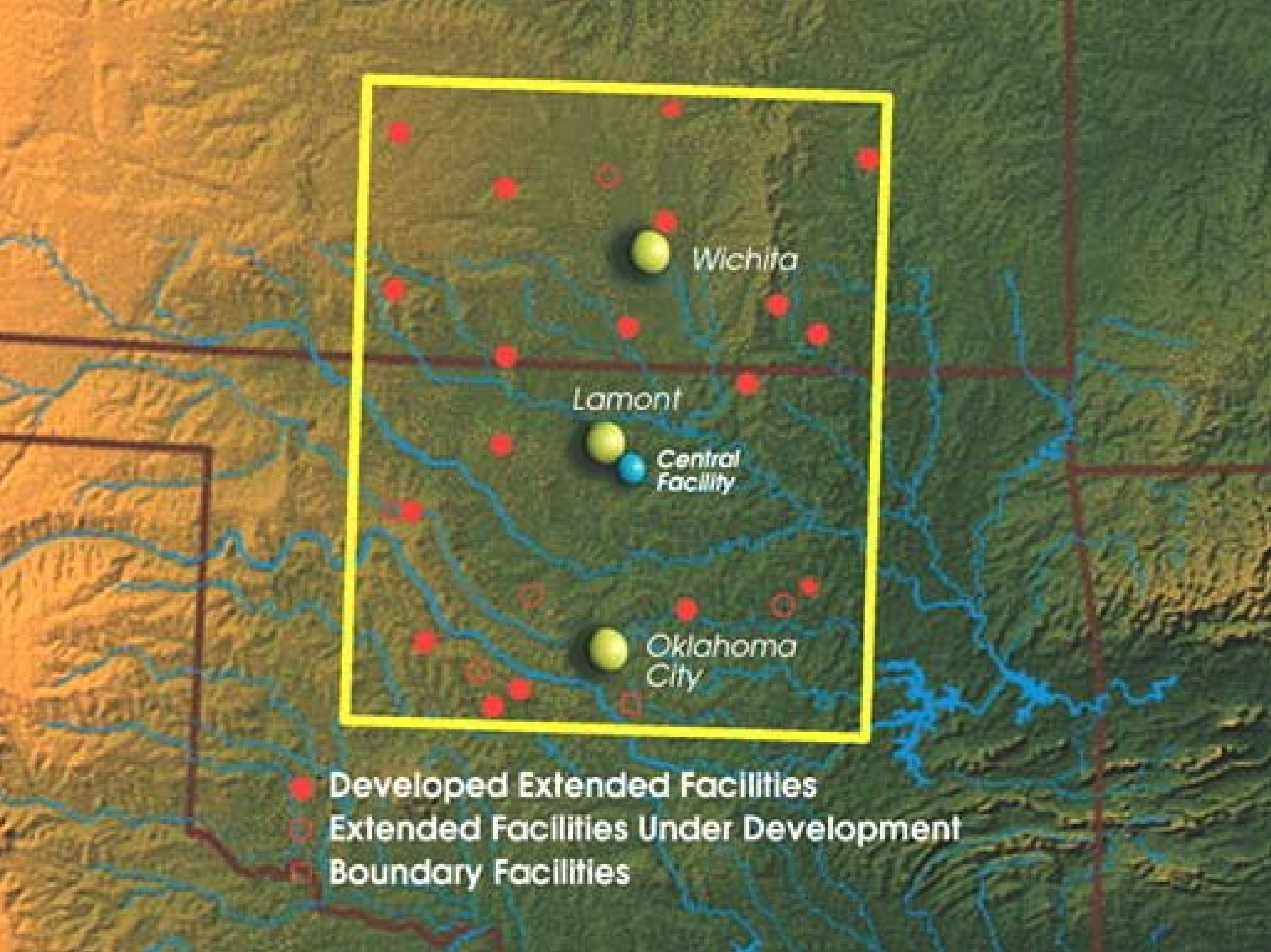
Why are aerosols so important?



(IPCC, 2001)

ARM Aerosol IOP 2003

- May 5 – May 31 at the Southern Great Plains (SGP) ARM site in north central Oklahoma.

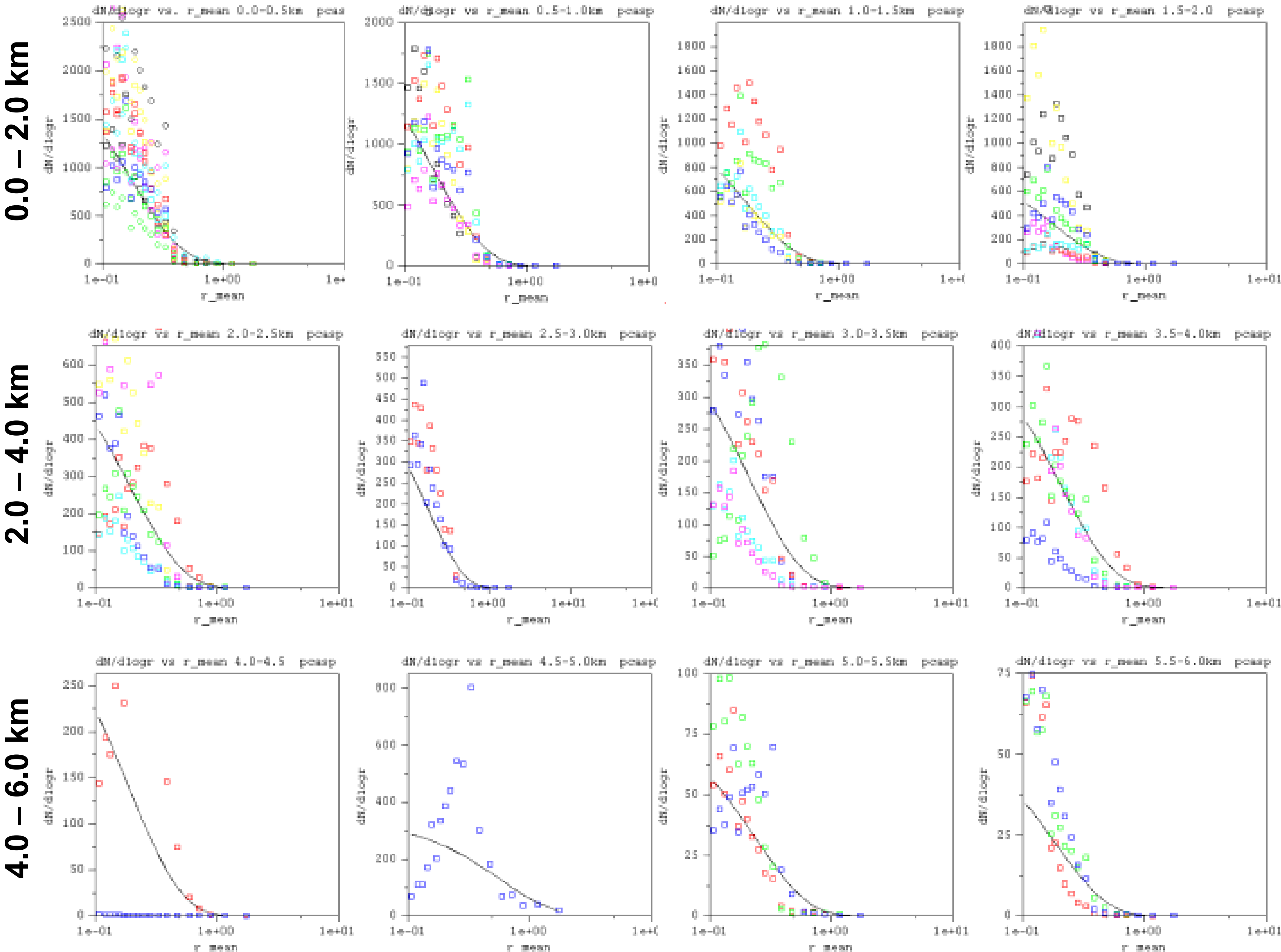

Wichita
Lamont
Central Facility
Oklahoma City
Developed Extended Facilities
Extended Facilities Under Development
Boundary Facilities

ARM Aerosol IOP 2003

- May 5 – May 31 at the Southern Great Plains (SGP) ARM site in north central Oklahoma.

- Enhanced ground based measurements
  - Optical properties (e.g. scattering, absorption, AOD)
  - Ozone and condensation particle concentrations
  - Particle chemical composition

- CIRPAS Twin Otter aircraft conducted 16 flights over 15 days totaling 60.6 flight hours.
  - In situ optical properties
  - In situ particle size and CCN concentrations
  - In situ vertical profiles of aerosol properties and WV


0.0 – 2.0 km
2.0 – 4.0 km
4.0 – 6.0 km
dN/dlogr vs r_mean 0.5-1.0km pcasp
dN/dlogr vs r_mean 1.0-1.5km pcasp
dN/dlogr vs r_mean 1.5-2.0 pcasp
dN/dlogr vs r_mean 2.0-2.5km pcasp
dN/dlogr vs r_mean 2.5-3.0km pcasp
dN/dlogr vs r_mean 3.0-3.5km pcasp
dN/dlogr vs r_mean 3.5-4.0km pcasp
dN/dlogr vs r_mean 4.0-4.5 pcasp
dN/dlogr vs r_mean 4.5-5.0km pcasp
dN/dlogr vs r_mean 5.0-5.5km pcasp
dN/dlogr vs r_mean 5.5-6.0km pcasp
dN/dlogr
r_mean

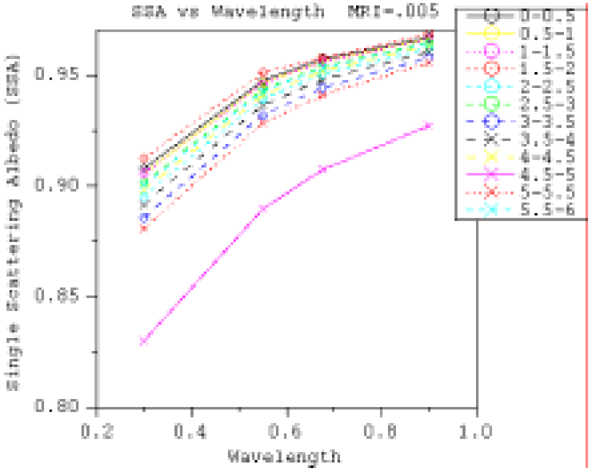
Aerosol Optical Properties Calculations

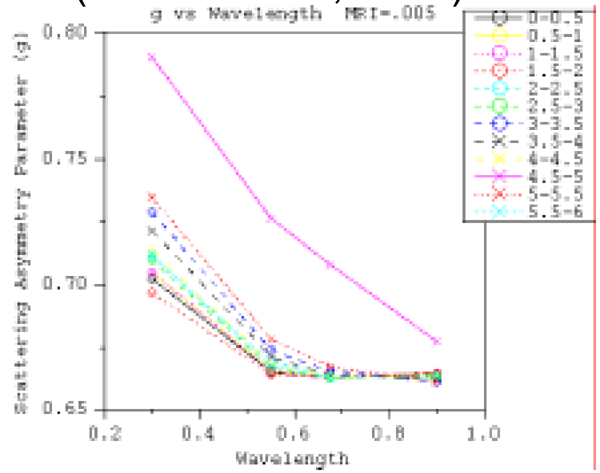
- Used Mie code developed by Michael Mishchenko at the NASA Goddard Institute for Space Studies, New York.

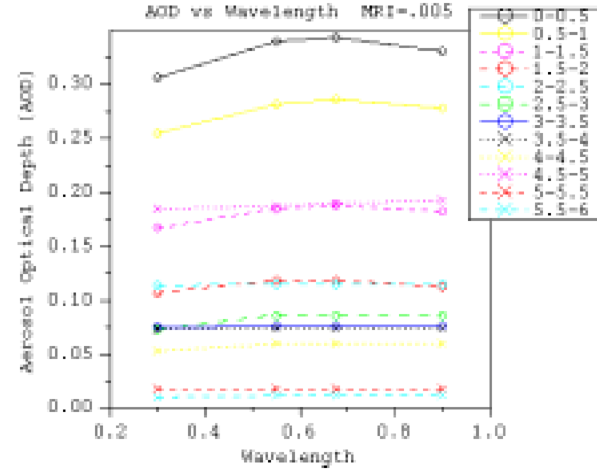
- Inputs
  - Distribution type
  - Particle size range
  - Wavelength
  - Refractive index

- Outputs
  - Single scattering albedo
  - Asymmetry parameter
  - Extinction cross section

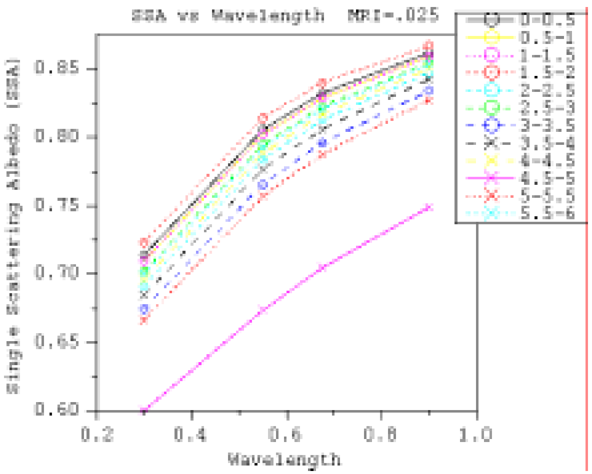
Refractive index 1.56 + .005i (Russell et al., 1997)

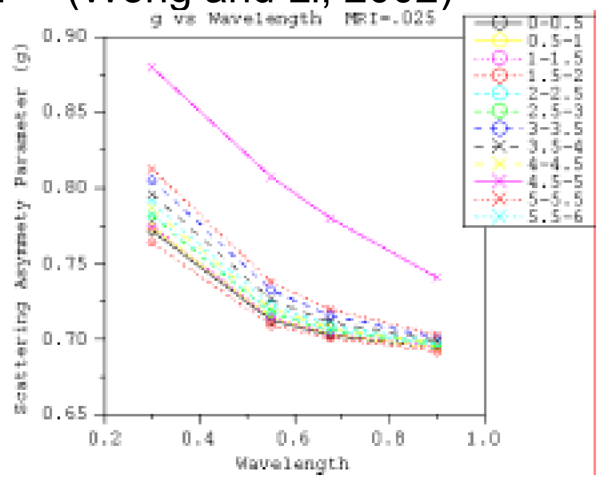


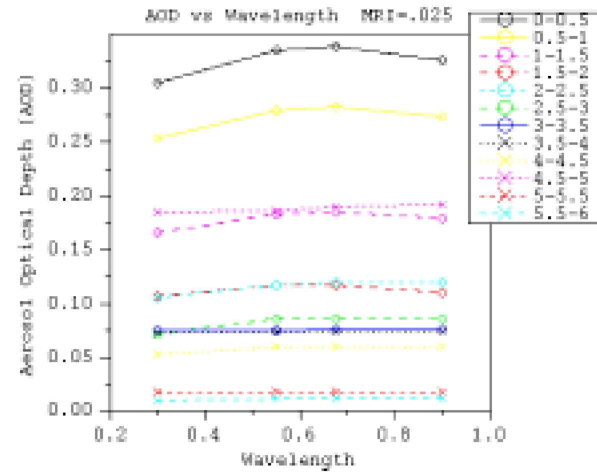




Refractive index 1.56 + .025i (Wong and Li, 2002)







0-6km AOD for MRI = .005 at λ = .55μm

	6.0 km
t = .012	
	5.5 km
t = .018	
	5.0 km
t = .189	
	4.5 km
t = .060	
	4.0 km
t = .074	
	3.5 km
t = .076	
	3.0 km
t = .086	
	2.5 km
t = .115	
	2.0 km
t = .119	
	1.5 km
t = .185	
	1.0 km
t = .282	
	0.5 km
t = .340	
	0.0 km

Aerosol Optical Depth

$$t = \int (C_{ext} * N)\, dz$$ (Liou, 1992)

C_{ext} = average extinction cross section per particle

N = particle density (# / m^3)

$$dN/d\log r = A\, r^{((1-3b)/b)} \exp(-r / ab)$$

where $0 < b < 0.5$ (Mishchenko et al., 1999)

A = constant

r = mean radius

a = coefficient

Column Radiative Forcing

$\Delta F = -\frac{1}{2} F_t \, T^2 (1-A_c)(1-R_s)^2 \, \beta \, \delta_a$ (Charlson et al., 1992)

- Ft = global mean TOA radiative flux
- T = fraction on incident light transmitted by atm. Above aerosol layer
- Ac = fractional cloud cover
- Rs = mean albedo of underlying surface
- β = fraction of radiation scattered upward by aerosol
- δa = mean optical depth of the aerosol

$\beta = \frac{1}{2}(1 - g)$ (Wiscombe and Grams, 1976)

- g = scattering asymmetry parameter

Column Radiative Forcing

For MRI = .005 with β = .191

Albedo	AOD	ΔF(w/m²)
0.4	0.3	-8.16
0.4	0.5	-13.61
0.4	0.8	-21.77
0.4	1.2	-32.65
0.4	1.5	-40.81

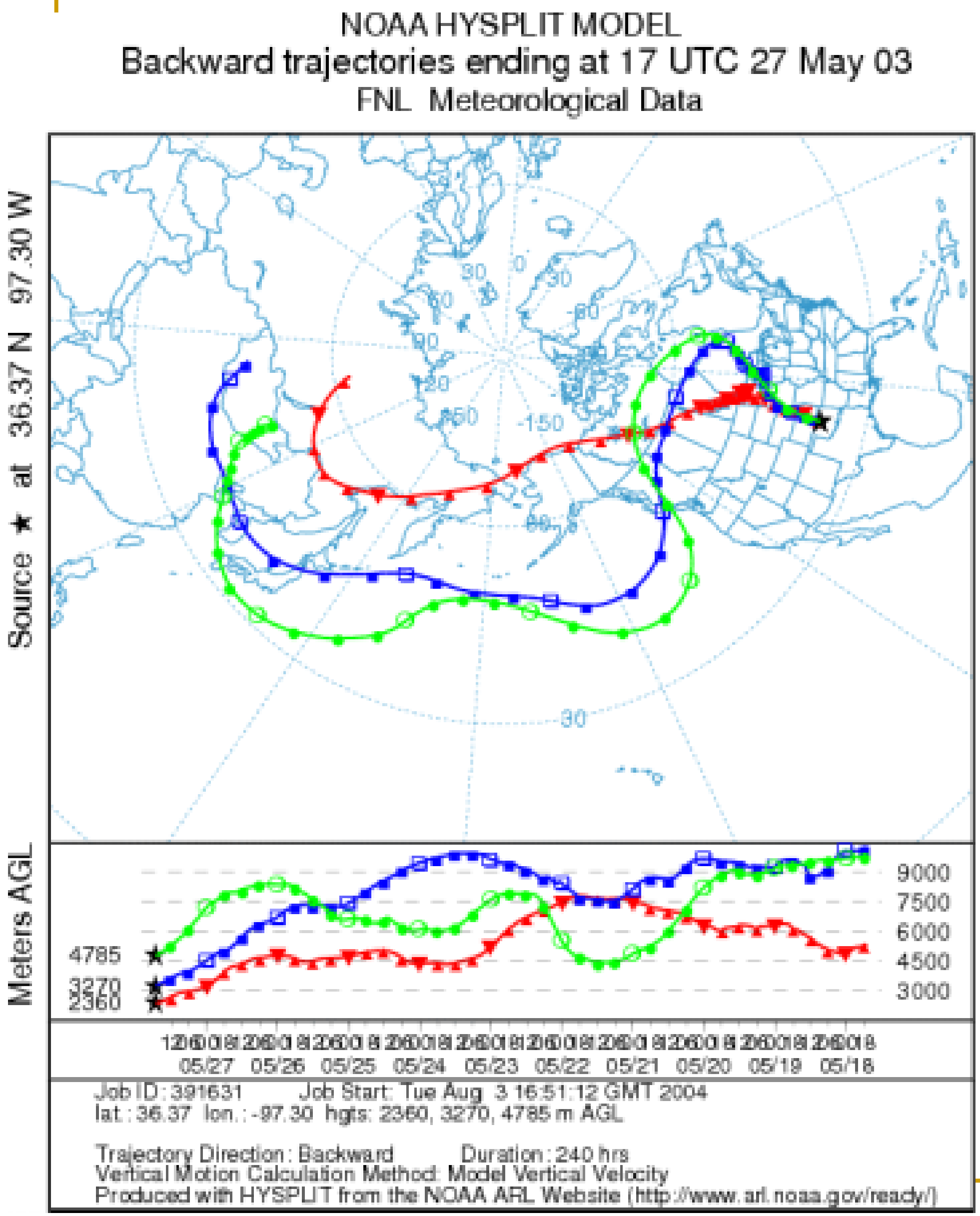
Albedo	AOD	ΔF(w/m²)
0.6	0.3	-3.63
0.6	0.5	-6.05
0.6	0.8	-9.67
0.6	1.2	-14.51
0.6	1.5	-18.14

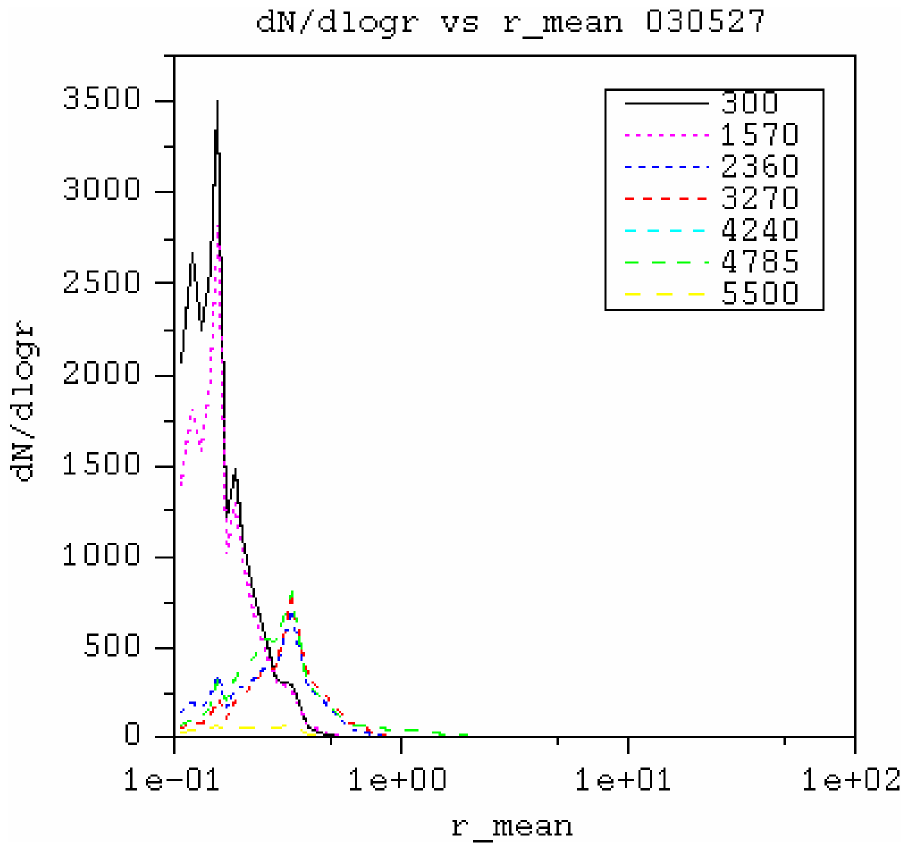
For MRI = .025 with β = .136

Albedo	AOD	ΔF(w/m²)
0.4	0.3	-5.81
0.4	0.5	-9.68
0.4	0.8	-15.49
0.4	1.2	-23.23
0.4	1.5	-29.05

Albedo	AOD	ΔF(w/m²)
0.6	0.3	-2.58
0.6	0.5	-4.30
0.6	0.8	-6.89
0.6	1.2	-10.33
0.6	1.5	-12.91

May 27th, 2003





Conclusions

- ARM aerosol IOPs are important in helping scientists improve climate models by increasing the process scale understanding of the aerosols and their impact on climate.
- Aerosol chemical (e.g. sulfate, black carbon) and physical properties (e.g. shape, age) are important as shown in the tables.
- The radiative forcing calculations we did indicate the importance of atmospheric aerosols on the radiative balance. For example the radiative forcing calculated is in the range of -2 to -10 w/m^2, the same order of magnitude as CO2 and other trace gas positive feedbacks.

Acknowledgements

- DOE – Global Change Education Program
- Argonne National Laboratory
- ARM Program

- V. Rao Kotamarthi, GCEP Mentor
- Jeff Gaffney and Milt Constantin