Determining Aerosol Single Scattering Albedo by Combining Measurements of Direct Solar Spectral Radiation and Broadband Short-Wave Flux

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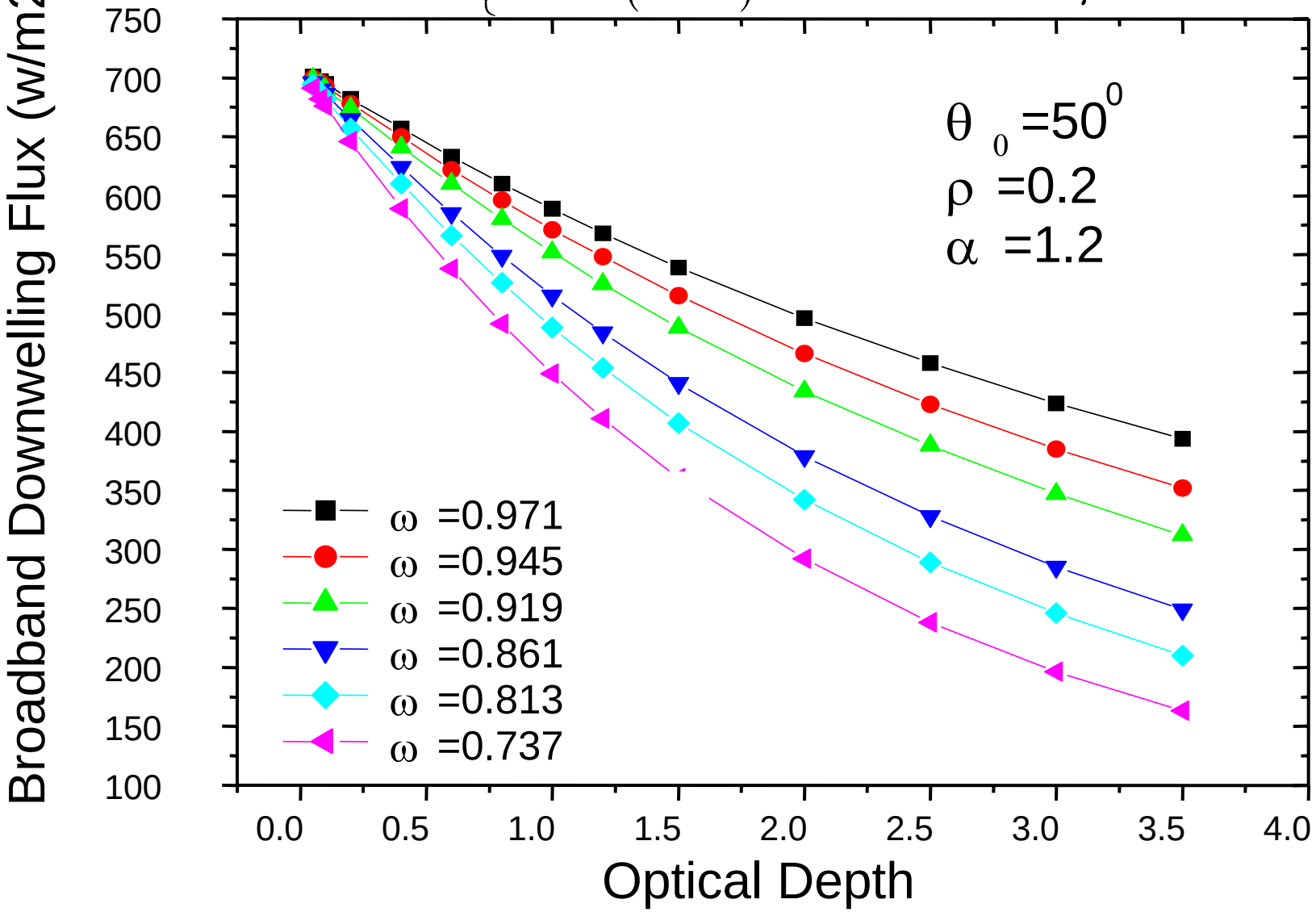
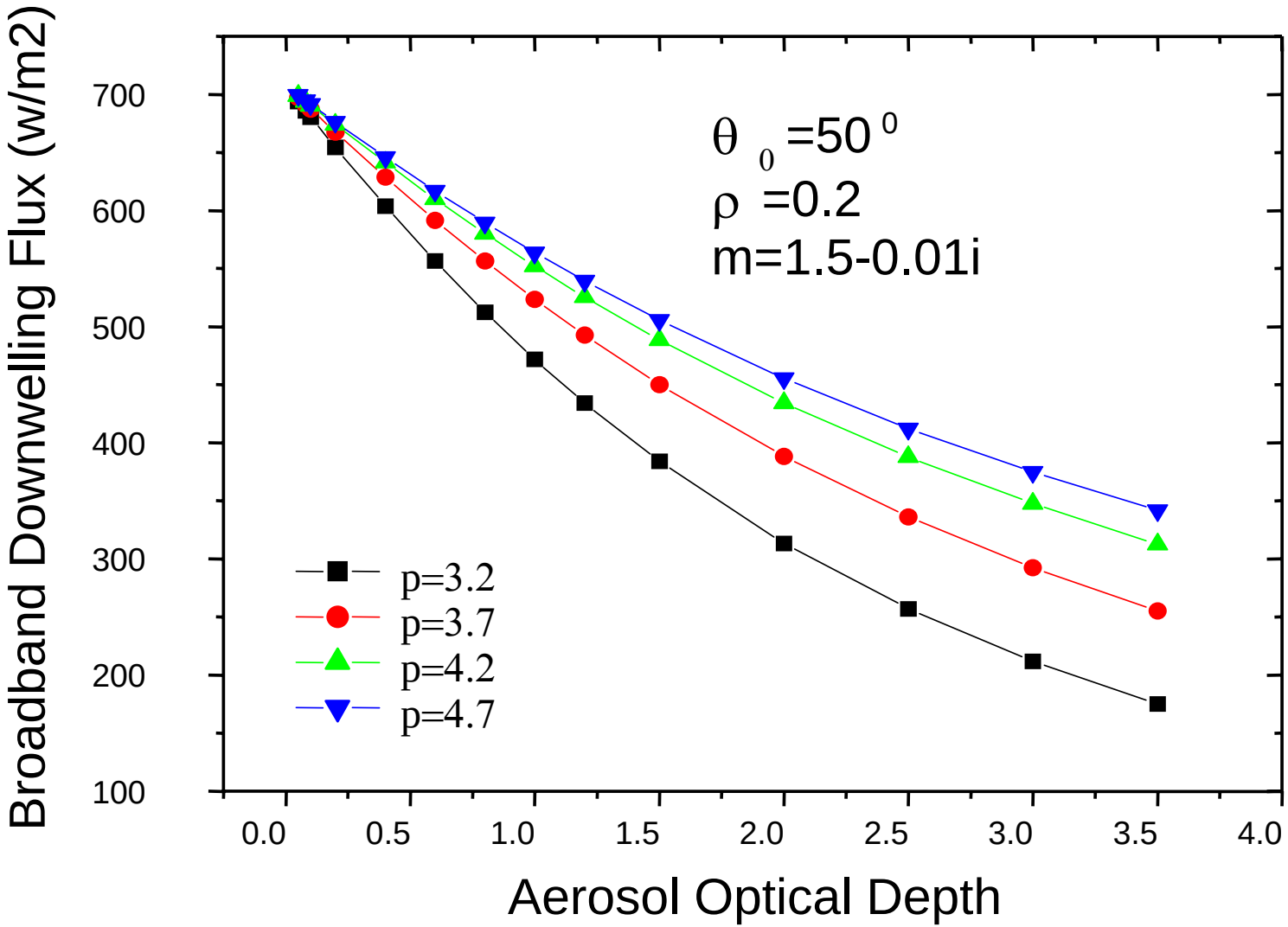
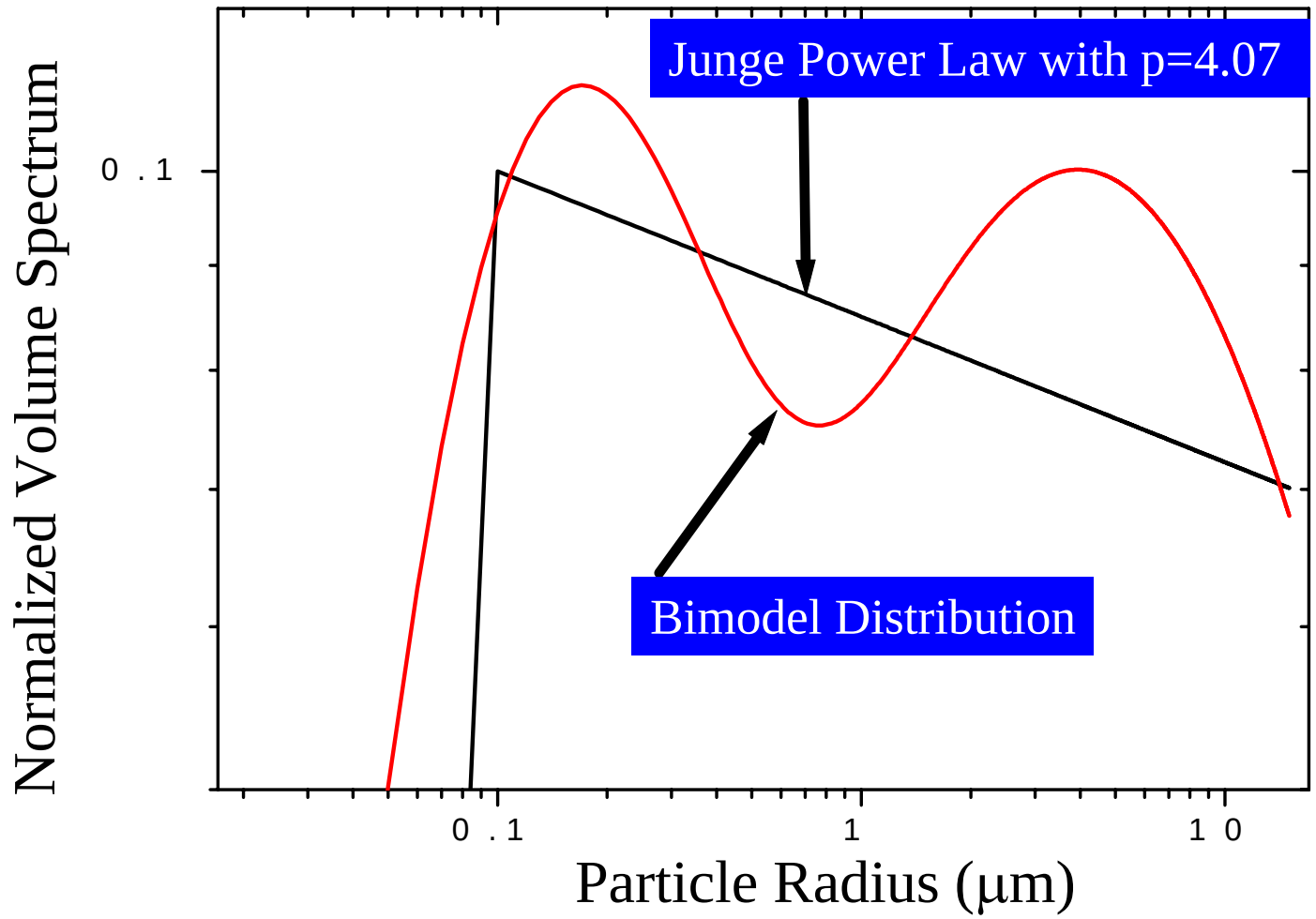
Purpose

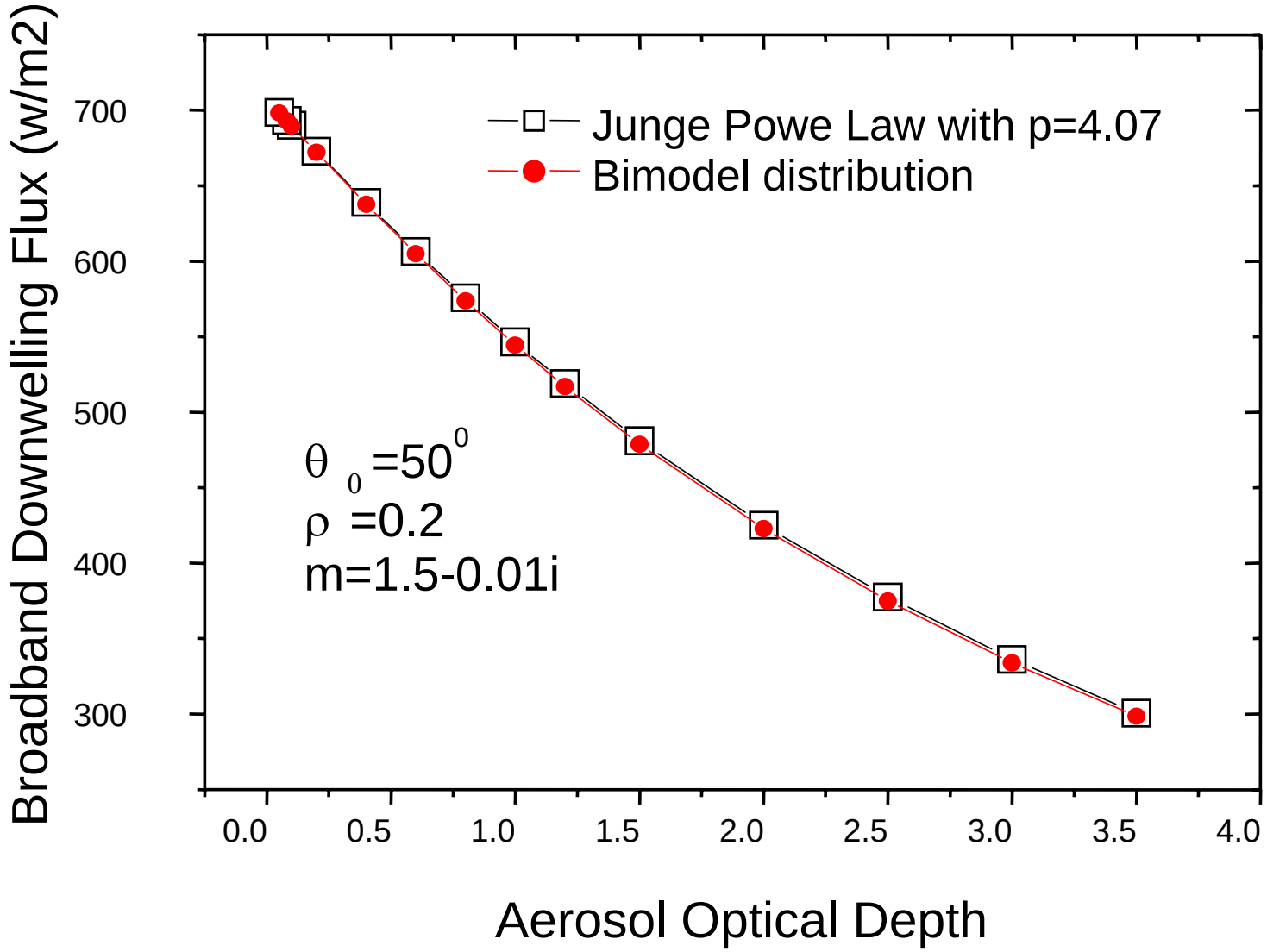
Estimate the aerosol single scattering albedo from combined measurements of spectral direct solar radiation and broadband downwelling SW fluxes.

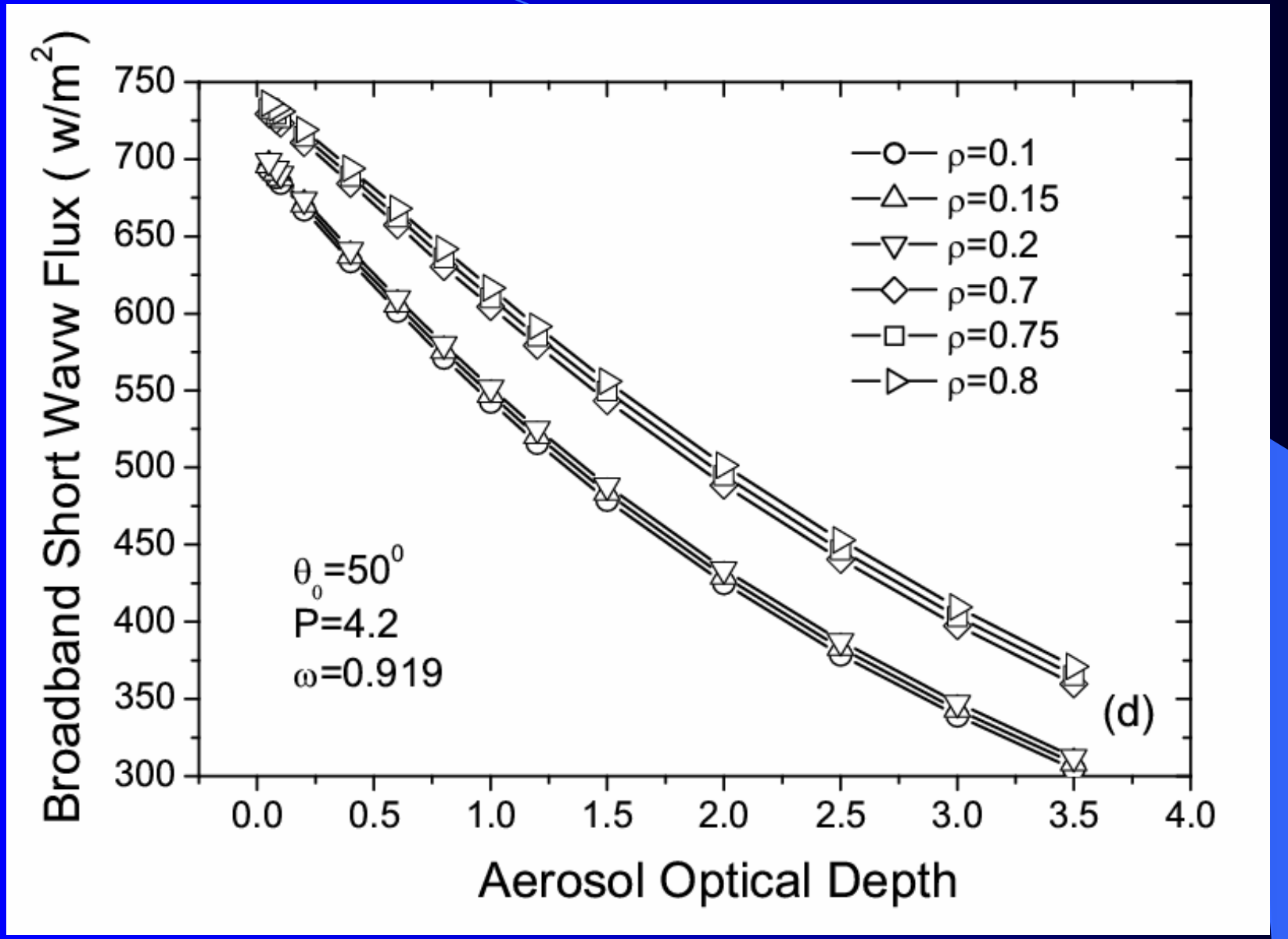
$$dv(r)/d\ln r = \begin{cases} c(r/0.1)^{4} & r \le 0.1\mu m \\ c(r/0.1)^{-(p-4)} & r \succ 0.1\mu m \end{cases} \quad (1)$$




Broadband Downwelling Flux (w/m2)
700
600
500
400
300
200
100
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Aerosol Optical Depth
θ 0 =50 0
ρ =0.2
m=1.5-0.01i
p=3.2
p=3.7
p=4.2
p=4.7

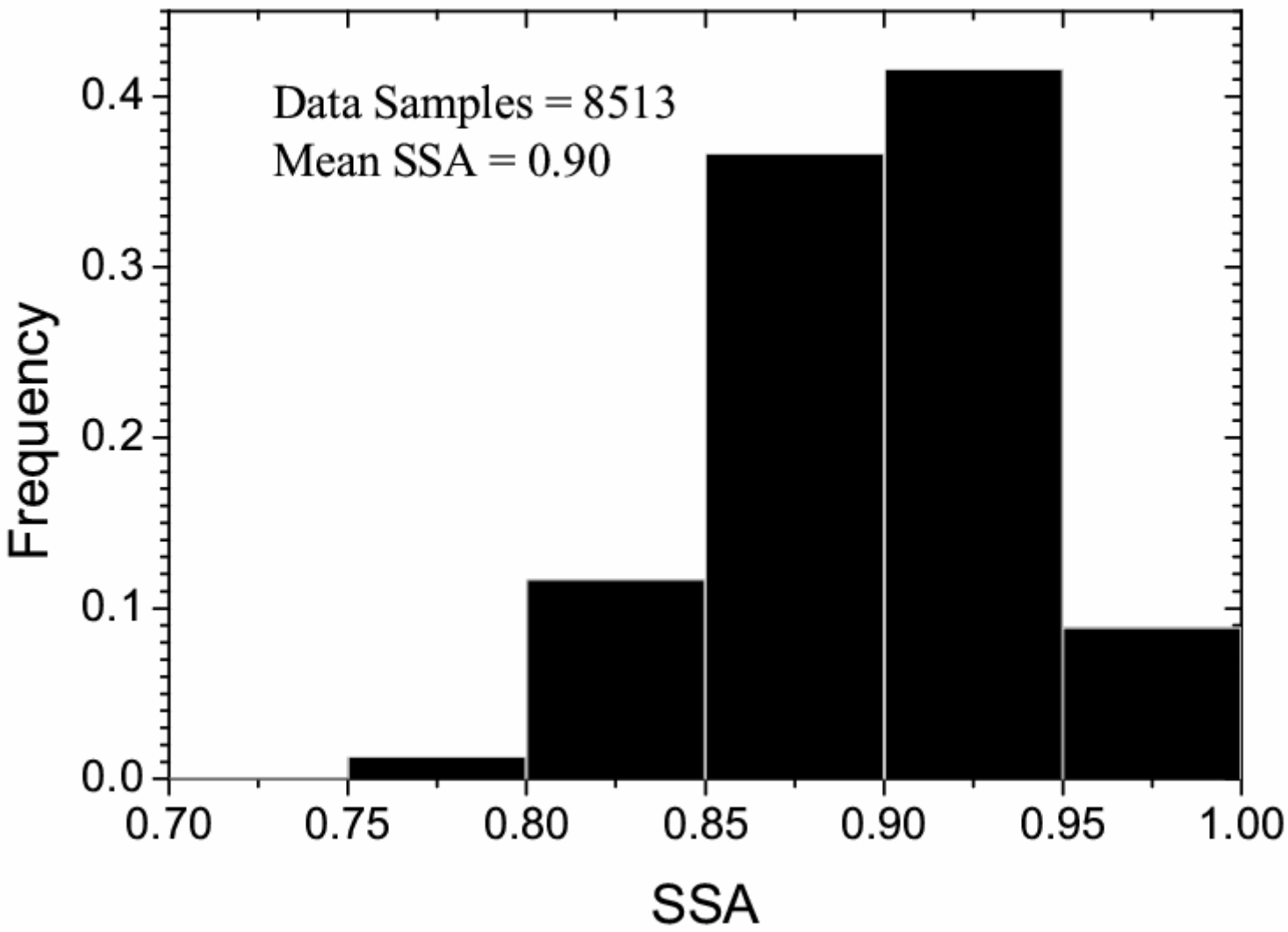

Junge Power Law with p=4.07
Bimodel Distribution
Normalized Volume Spectrum
0 . 1
0 . 1
1
1 0
Particle Radius (μm)

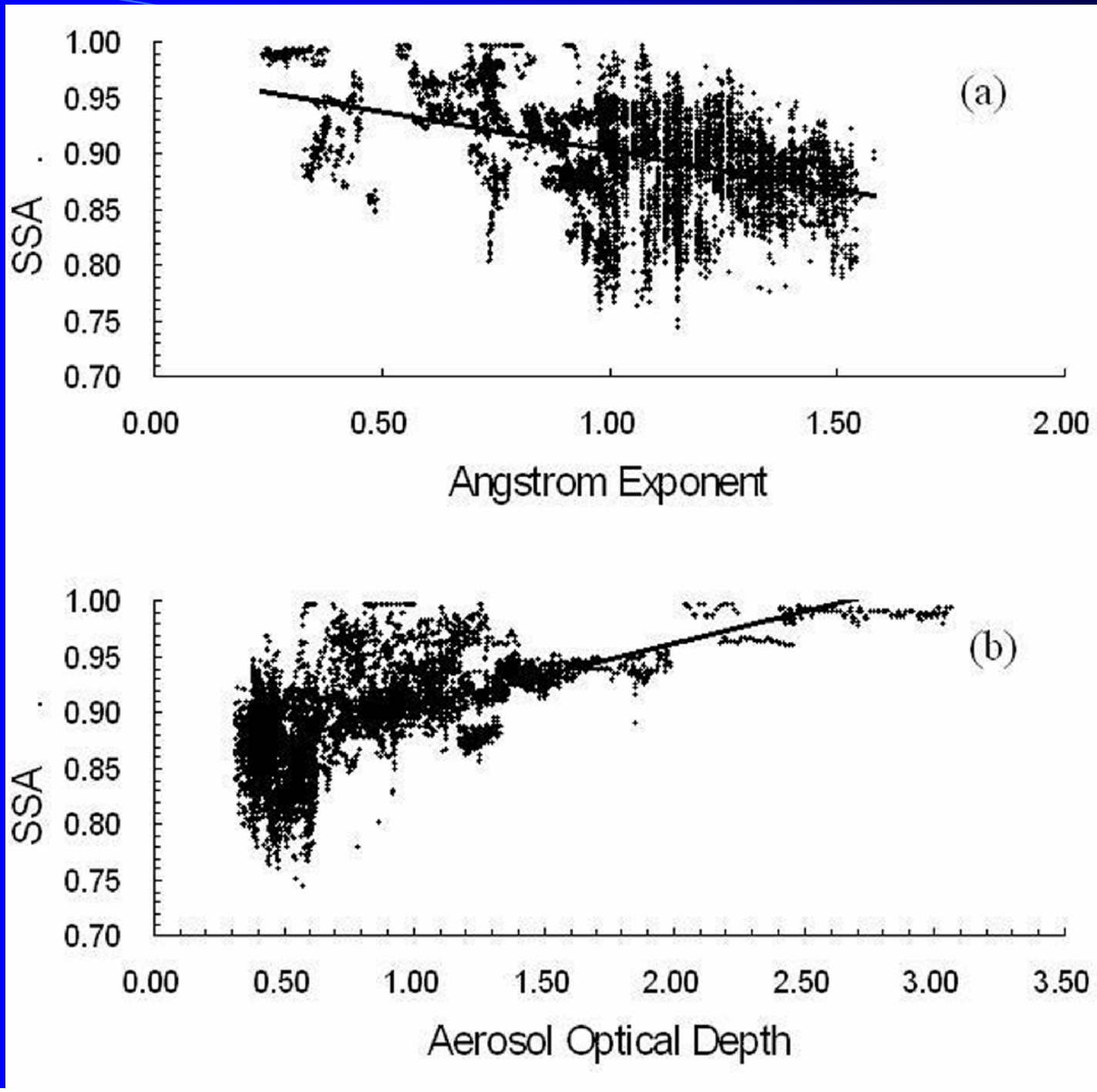

Broadband Downwelling Flux (w/m2)
700
600
500
400
300
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Aerosol Optical Depth
Junge Powe Law with p=4.07
Bimodel distribution
θ 0 =50 0
ρ =0.2
m=1.5-0.01i

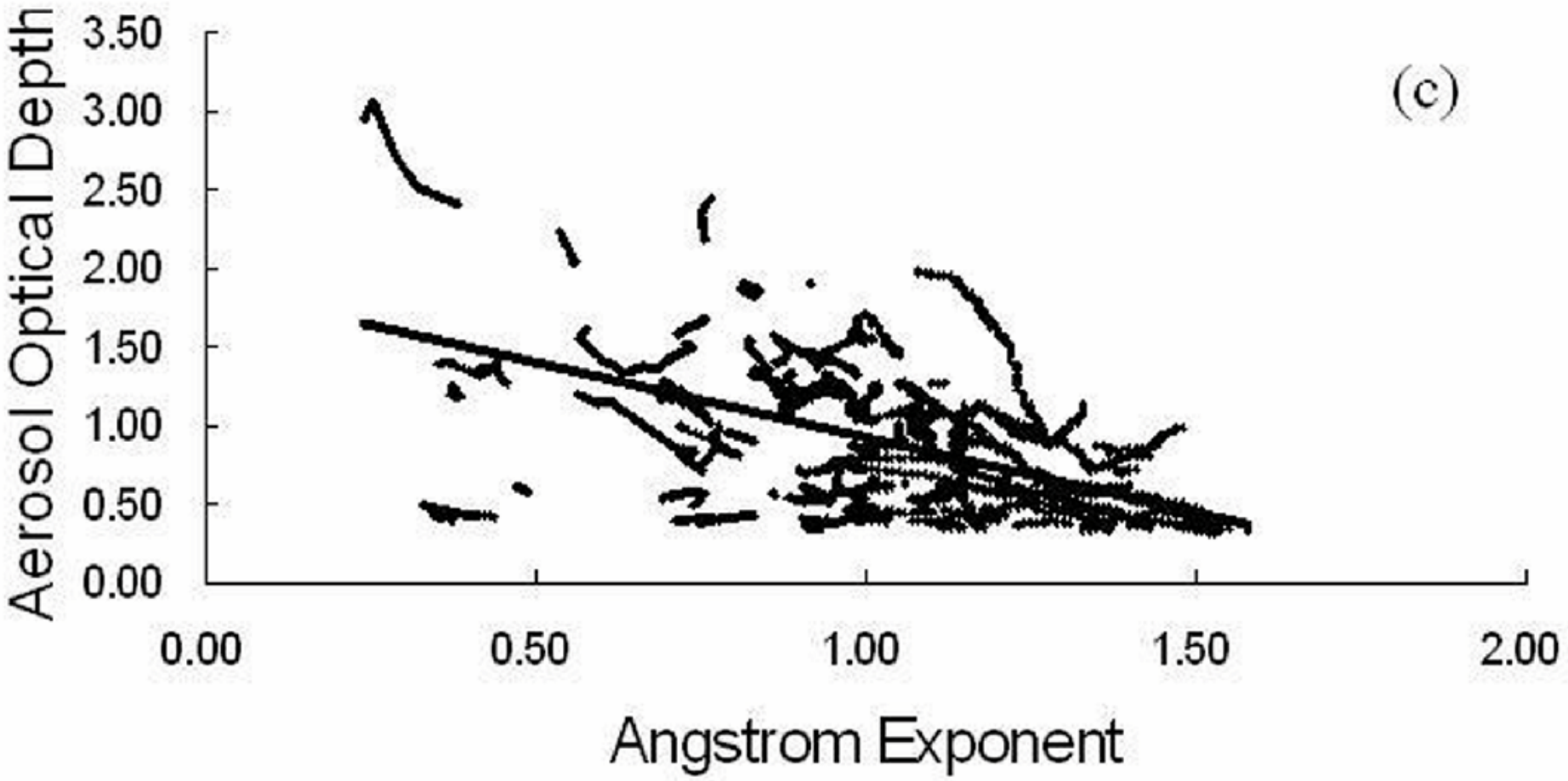

Broadband Short Wavw Flux (w/m^2)
750
700
650
600
550
500
450
400
350
300
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Aerosol Optical Depth
ρ=0.1
ρ=0.15
ρ=0.2
ρ=0.7
ρ=0.75
ρ=0.8
θ$_0$=50^0
P=4.2
ω=0.919
(d)

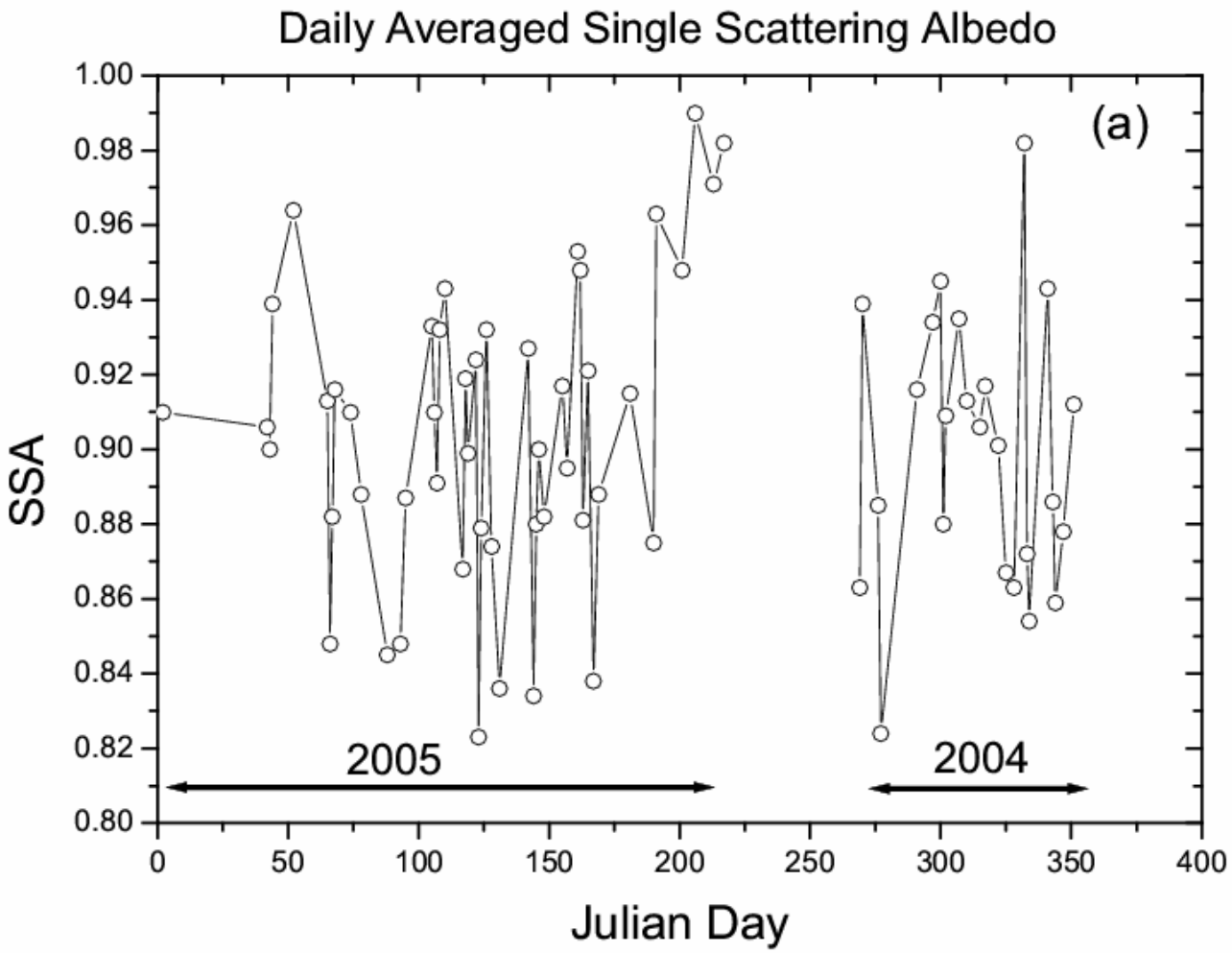
Application

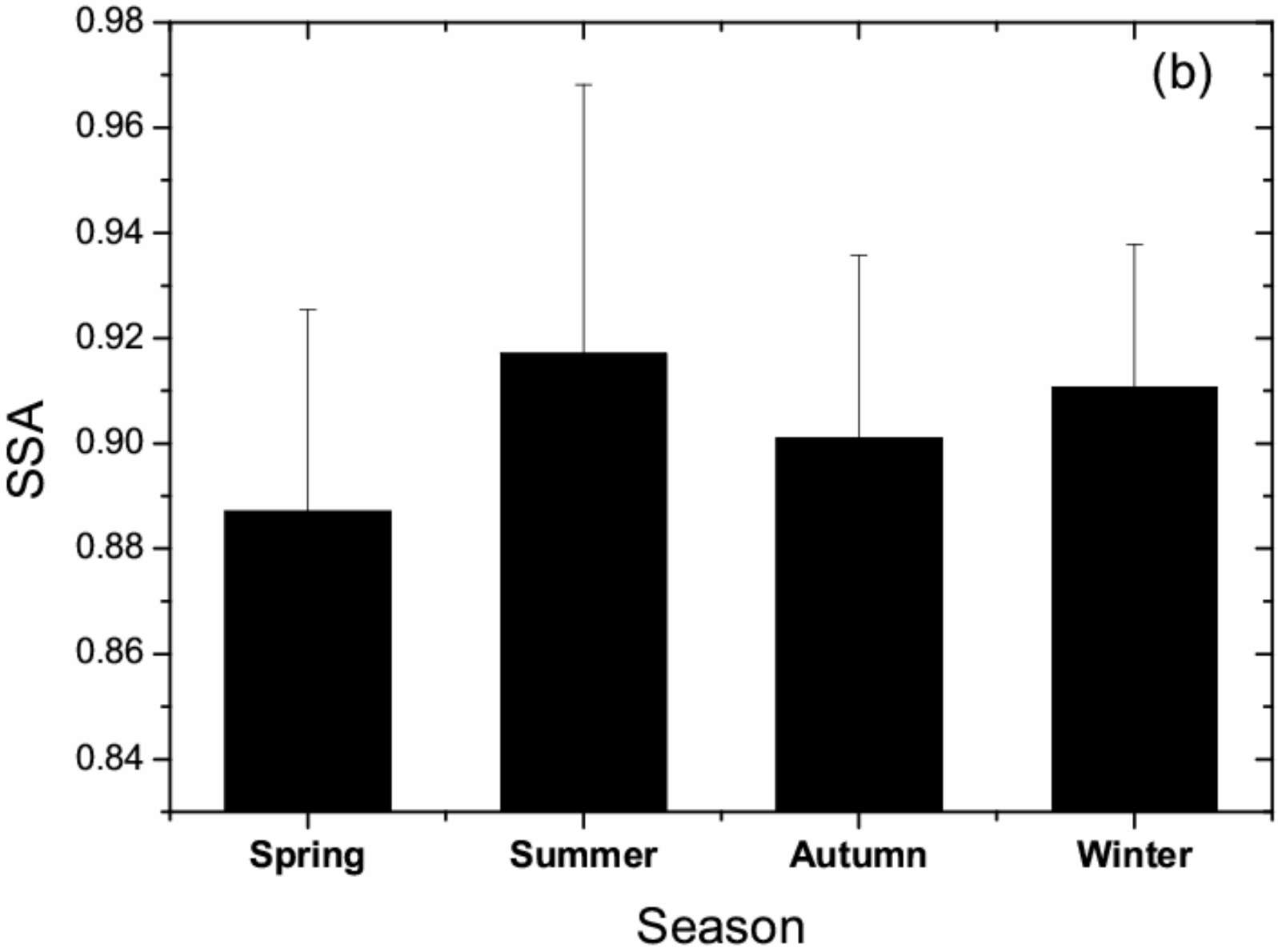
- Observation Site: Xianghe (39^0N,108^0E),China
- Sampling period: 2004-09----2005-08
- Instruments: CE-318, CM21
- Calibration: AERONET
- Cloud-screening: Digital Video Camera
- AOD and precipitable water: AERONET (from CE-318 measurements)

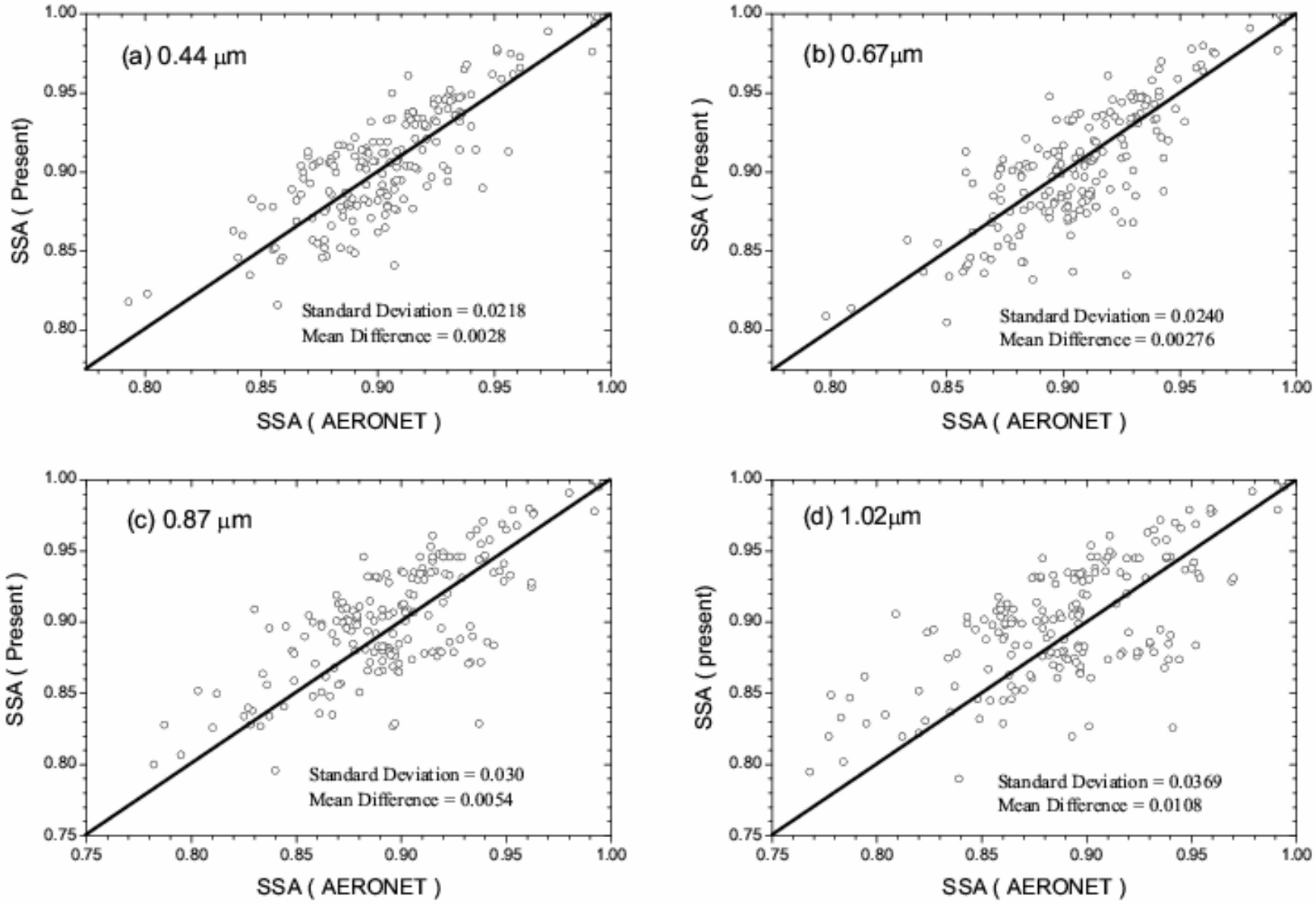

Data Samples = 8513
Mean SSA = 0.90
Frequency
0.0
0.1
0.2
0.3
0.4
0.70
0.75
0.80
0.85
0.90
0.95
1.00
SSA


1.00
0.95
0.90
0.85
0.80
0.75
0.70
SSA
(a)
0.00
0.50
1.00
1.50
2.00
Angstrom Exponent
1.00
0.95
0.90
0.85
0.80
0.75
0.70
SSA
(b)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Aerosol Optical Depth


Aerosol Optical Depth
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
(c)
0.00
0.50
1.00
1.50
2.00
Angstrom Exponent


Daily Averaged Single Scattering Albedo
(a)
SSA
1.00
0.98
0.96
0.94
0.92
0.90
0.88
0.86
0.84
0.82
0.80
0
50
100
150
200
250
300
350
400
2005
2004
Julian Day


(b)
SSA
0.98
0.96
0.94
0.92
0.90
0.88
0.86
0.84
Spring
Summer
Autumn
Winter
Season


(a) 0.44 μm
Standard Deviation = 0.0218
Mean Difference = 0.0028
SSA (Present)
SSA (AERONET)
(b) 0.67μm
Standard Deviation = 0.0240
Mean Difference = 0.00276
SSA (Present)
SSA (AERONET)
(c) 0.87 μm
Standard Deviation = 0.030
Mean Difference = 0.0054
SSA (Present)
SSA (AERONET)
(d) 1.02μm
Standard Deviation = 0.0369
Mean Difference = 0.0108
SSA (present)
SSA (AERONET)

Error Analysis

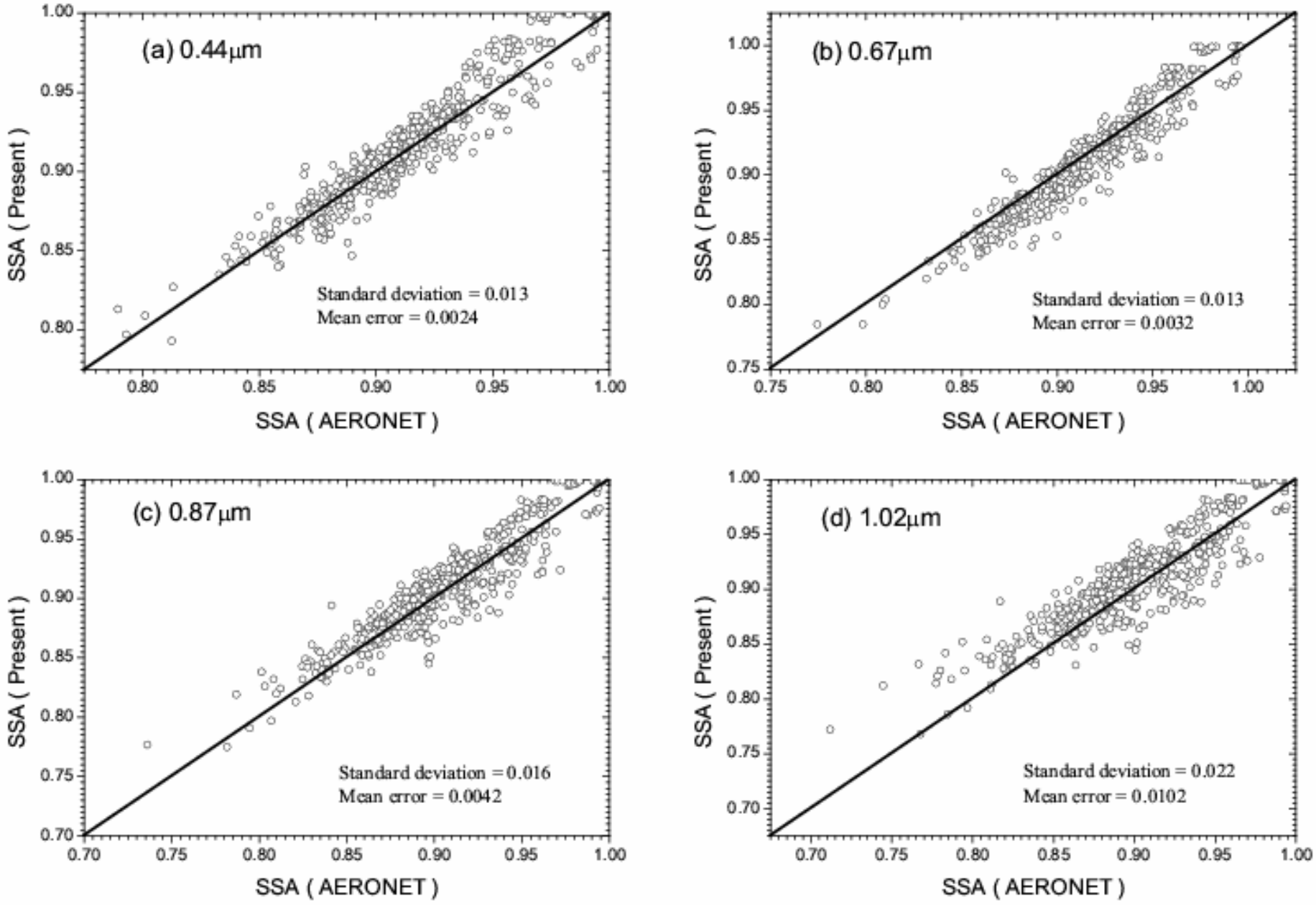
Assumption

- (1) size distribution assumption
- (2) spectral independent assumption of the complex index of refraction

(3) homogeneous sphere

Measurement error: within 10w/m2

retrieval error: less than 0.03


(a) 0.44μm
Standard deviation = 0.013
Mean error = 0.0024
(b) 0.67μm
Standard deviation = 0.013
Mean error = 0.0032
(c) 0.87μm
Standard deviation = 0.016
Mean error = 0.0042
(d) 1.02μm
Standard deviation = 0.022
Mean error = 0.0102
SSA (Present)
SSA (AERONET)

Summary

(1) The algorithm has accuracy comparable to AERONET

(2) The average value of SSA at 0.5mm is 0.9, with 50.4% of the retrieved values larger than 0.9, 48.3% between 0.80-0.9, and 1.3% smaller than 0.8.

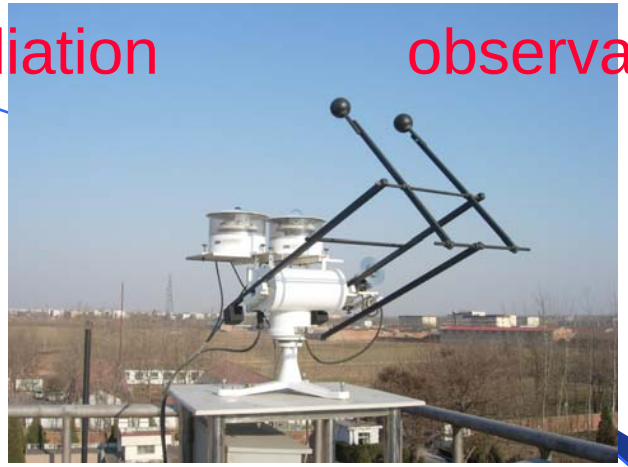
(3) SSA decreases as the Angstrom exponent increases, implying that the finer aerosol particles have stronger absorption than the coarser aerosol particles.

Near future plan of the observational study of aerosol radiative properties

Research purpose

- Study of aerosol radiative properties
- Evaluation of consistency among the methods which are widely used in the measurements of aerosol radiative properties

Radiation observation



Sun/Sky Radiometer

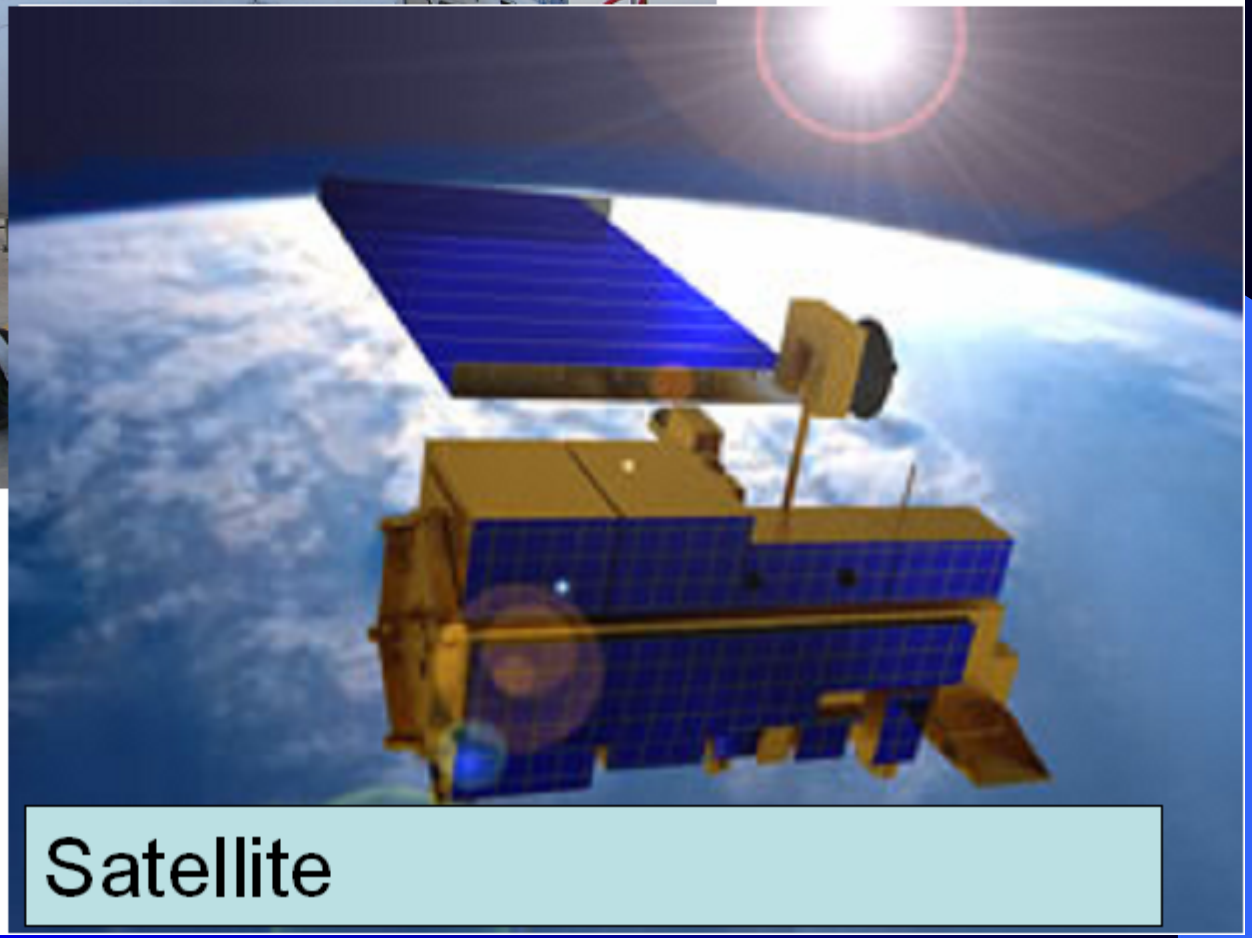
MFRSR

Lidar

Integrating nephelometer

Aethalometer

Airplane



Satellite

Thanks