AEROSOL PROPERTIES FROM MISR MULTI-ANGLE IMAGING OVER OCEAN

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MISR
Multi-angle
Imaging
Spectro-
Radiometer

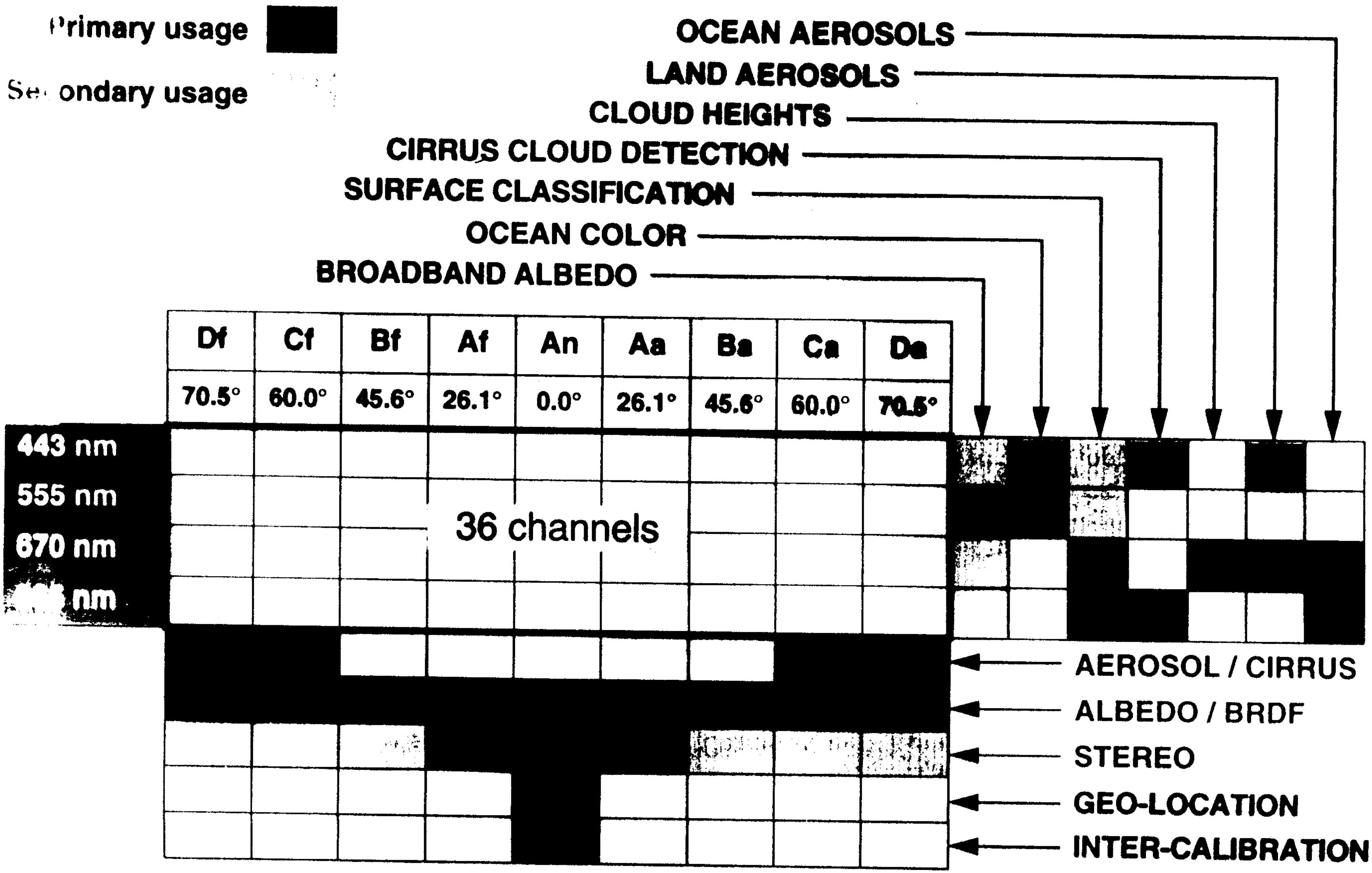
MISR DESCRIPTION

Parameter	Value
Camera View Zenith Angles at Earth Surface	0.0° (nadir) 26.1°, 45.6°, 60.0°, and 70.5° (both fore and aft of nadir)
Swath Width	360 kilometers (9-day global coverage)
Cross-Track x Along-Track Pixel Sampling (Commandable)	275 meters x 275 meters 550 meters x 550 meters 1.1 kilometers x 1.1 kilometers 275 meters x 1.1 kilometers
Spectral Bands (solar spectrum weighted)	446.4, 557.5, 671.7, 866.4 nanometers
Spectral Bandwidths	41.9, 28.6, 21.9, 39.7 nanometers
CCD (Charge-Coupled Device) Sensor Architecture	4 lines x 1504 active pixels (each of 9 cameras)
Absolute Radiometric accuracy	3% (1σ) at maximum signal
Instrument Mass	149 kilograms
Instrument Power (worst case)	83 Watts (avg.), 131 Watts (peak)

JPL

HOW WE WILL USE OUR NINE CAMERAS and FOUR BANDS

MISR



To account for the effects of aerosols in Climate Models:

- Need the column extinction **optical depth** (τ_a)

  -- Currently the state-of-the-art for operational satellite retrievals

- Need mean effective aerosol **microphysical properties**

  -- Single scattering **phase function** and **albedo**

  -- These map to **Size Distribution** (r_a), **Shape**, and **Indices of Refraction** (nr, ni)

- Need aerosol **vertical distribution**

Summary: Need constraints on [τ_a, r_a, **nr, ni**] & shape

NEW MULTIANGLE CAPABILITY -- MORE INFORMATION ABOUT AEROSOLS

How will MISR contribute to the global aerosol picture needed for climate change studies?

Based on simulations over cloud-free, calm ocean, for pure particle types:

- **Aerosol Extinction Optical Depth (τ_a)**

  -- Determined to at least 0.05 or 20%, whichever is larger, for common aerosol types except soot, even when the particle microphysical properties are poorly known.

- **Particle Size (r_a)**

  -- "Small," "Medium," and "Large" size discrimination across Accumulation Mode sizes -- key for vis spectrum

- **Indices of Refraction (nr, ni)**

  -- Two to four compositional groups

- **Spherical vs. Nonspherical** for Sahara dust indices

- **Poorer Sensitivity for ni >~ 0.008 (Black Carbon)**

How can MISR contribute?

- **Can not** in general **nail down everything** we need to know to model the effects of aerosols, even over cloud-free, calm ocean, without introducing other information

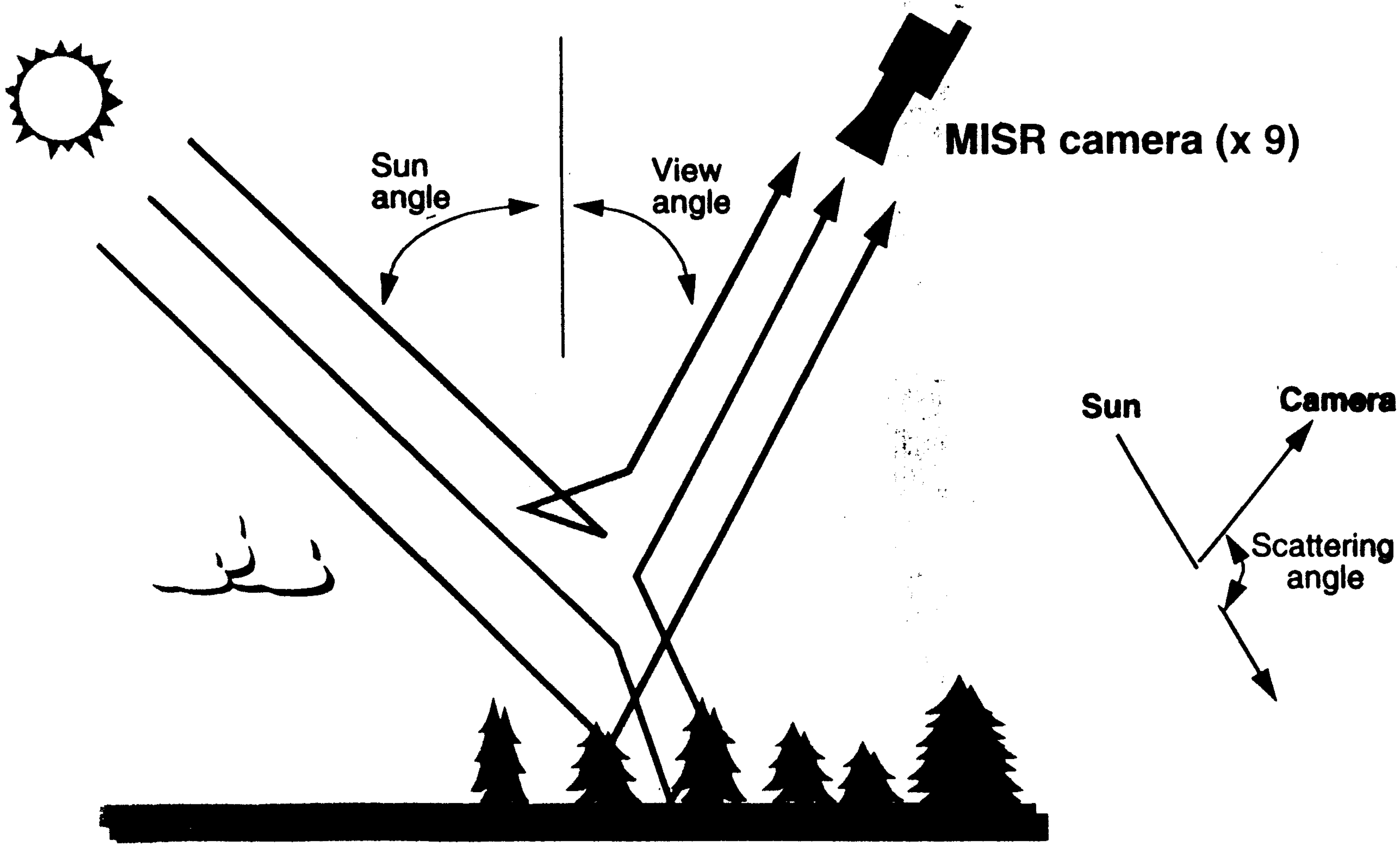
- **Can distinguish air masses** containing different aerosol types – a major step beyond current operational satellite aerosol retrievals, which obtain only optical depth, based on entirely assumed particle properties

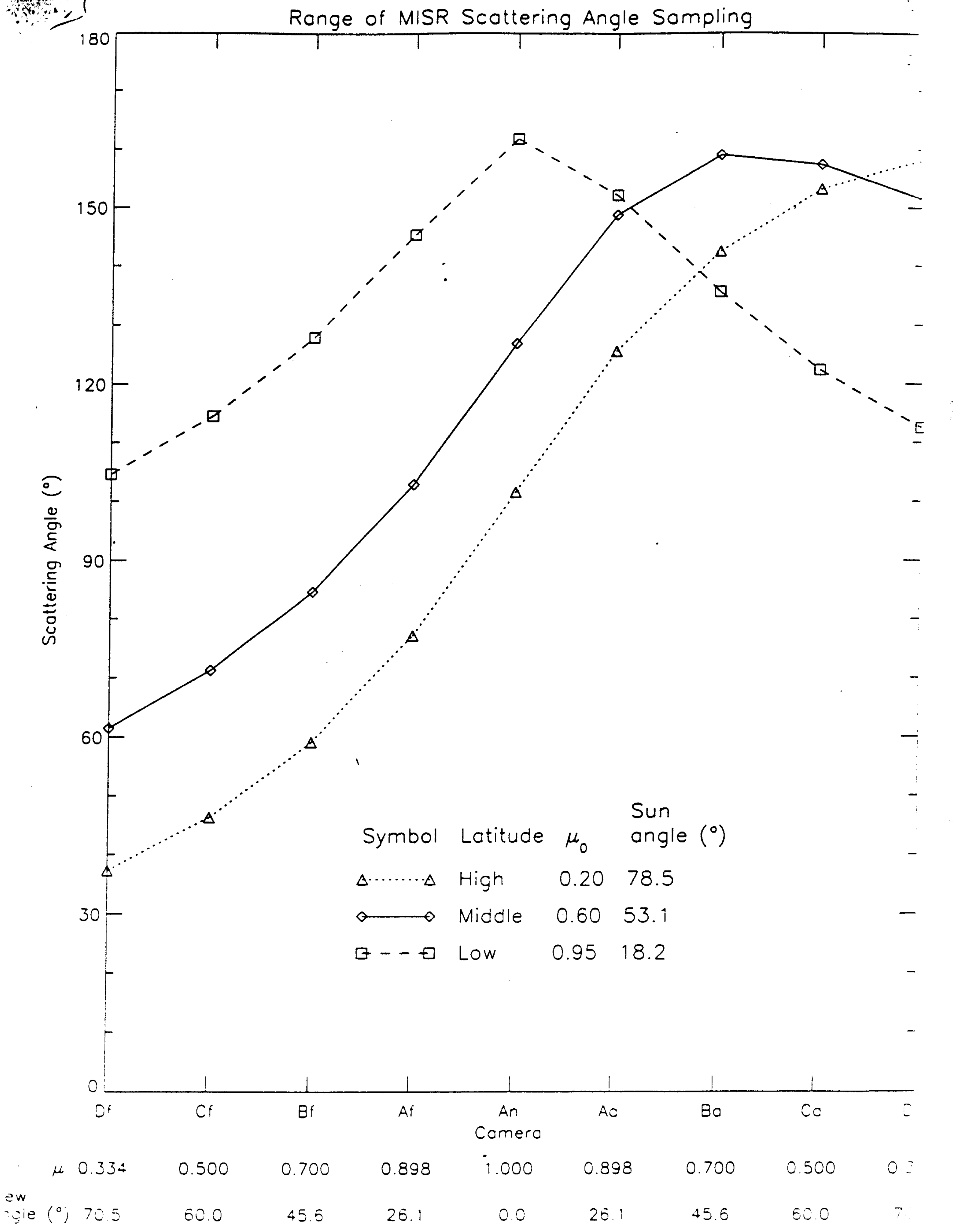
Use **MISR to get the large-scale, time-varying picture** of air masses containing different aerosol types

Rely on **field measurements to give detailed microphysical properties** of aerosol within each air mass

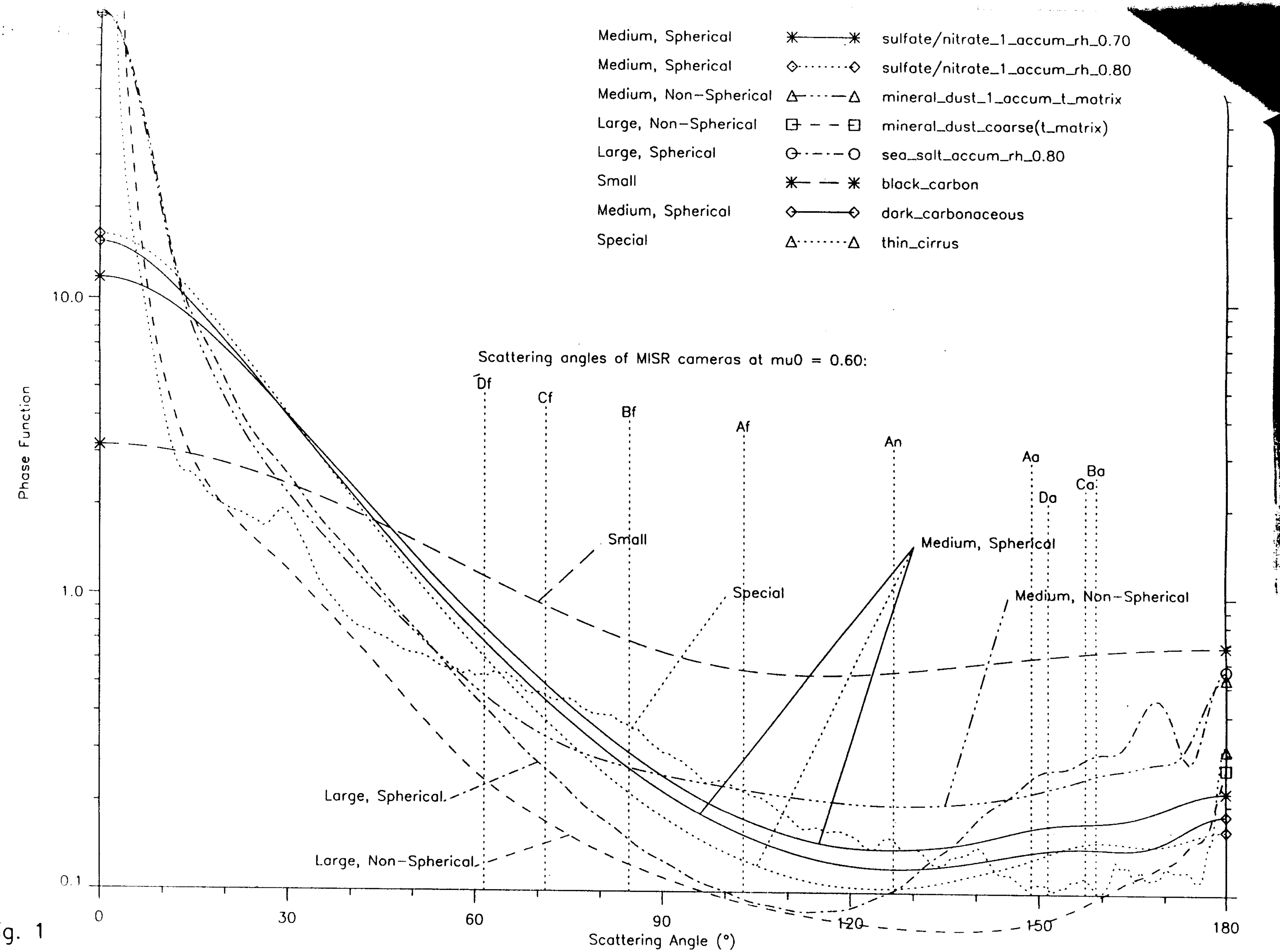
====> **Complementary Efforts**

ATMOSPHERE AND SURFACE CONTRIBUTIONS TO MISR IMAGERY





Range of MISR Scattering Angle Sampling
Scattering Angle (°)
180
150
120
90
60
30
0
Df
Cf
Bf
Af
An
Ac
Ba
Ca
Camera
Symbol
Latitude
μ_0
Sun angle (°)
High 0.20 78.5
Middle 0.60 53.1
Low 0.95 18.2
μ 0.334 0.500 0.700 0.898 1.000 0.898 0.700 0.500
60.0 45.6 26.1 0.0 26.1 45.6 60.0



Medium, Spherical
sulfate/nitrate_1_accum_rh_0.70
Medium, Spherical
sulfate/nitrate_1_accum_rh_0.80
Medium, Non-Spherical
mineral_dust_1_accum_t_matrix
Large, Non-Spherical
mineral_dust_coarse(t_matrix)
Large, Spherical
sea_salt_accum_rh_0.80
Small
black_carbon
Medium, Spherical
dark_carbonaceous
Special
thin_cirrus
Scattering angles of MISR cameras at mu0 = 0.60:
Df
Cf
Bf
Af
An
Aa
Ba
Ca
Da
Small
Special
Medium, Spherical
Medium, Non-Spherical
Large, Spherical
Large, Non-Spherical
Phase Function
10.0
1.0
0.1
0
30
60
90
120
150
180
Scattering Angle (°)

Fig. 1

Evaluating Agreement Between Comparison Models and Measurements

4 Variables summarize the information in **18 Measurements**

$$\chi^2_{abs} = \frac{1}{N\langle w_k \rangle} \sum_{l=3}^{4} \sum_{k=1}^{9} \frac{w_k [\rho_{meas}(l,k) - \rho_{comp}(l,k)]^2}{\left(\sigma^2_{abs.cal}(l,k;\rho_{meas}) + \sigma^2_{abs.\mathrm{var}}(l,k)\right)} \qquad (1a)$$

where ρ_{meas} is the simulated "measured" radiance, ρ_{comp} is the simulated radiance for the "assumed" comparison model, l and k are the indices for wavelength band and camera, N is the number of measurements included in the calculation,w_k is the weight for terms related to camera k, and $<w_k>$ is the average of the weights for all the cameras included in the sum. The absolute calibration uncertainty is:

$$\sigma^2_{abs.cal}(l,k) = \rho^2_{meas}\left[\left(\varepsilon_{abs\_sys}(l,k;\rho_{meas})/100\right)^2 + \left(SNR_{am}(l,k;\rho_{meas})\right)^{-2}\right] \qquad (1b)$$

The variance of all (M) pixels in a patch is:

$$\sigma^2_{abs.\mathrm{var}}(l,k) = \frac{1}{M}\sum_j \left[\rho_{meas}(j;l,k) - \langle \rho_{meas}(l,k)\rangle\right]^2 \qquad (1c)$$

χ^2_{geom} is defined as:

$$\chi^2_{geom} = \frac{1}{N\langle w_k \rangle} \sum_{l=3}^{4} \sum_{\substack{k=1 \\ k \neq nadir}}^{9} \frac{w_k \left[\frac{\rho_{meas}(l,k)}{\rho_{meas}(l,nadir)} - \frac{\rho_{comp}(l,k)}{\rho_{comp}(l,nadir)}\right]^2}{\left(\sigma^2_{geom.cal}(l,k;\rho_{meas}) + \sigma^2_{geom.\mathrm{var}}(l,k)\right)} \qquad (2a)$$

With:

$$\sigma^2_{geom.cal}(l,k;\rho_{meas}) = \frac{\sigma^2_{cam}(l,k;\rho_{meas})}{\rho^2_{meas}(l,nadir)} + \frac{\sigma^2_{cam}(l,nadir;\rho_{meas})\rho^2_{meas}(l,k)}{\rho^4_{meas}(l,nadir)} \qquad (2b)$$

Also, χ^2_{spec} (similar to χ^2_{geom}, but normalized to band 3) and χ^2_{maxdev}, which is largest term in (1).

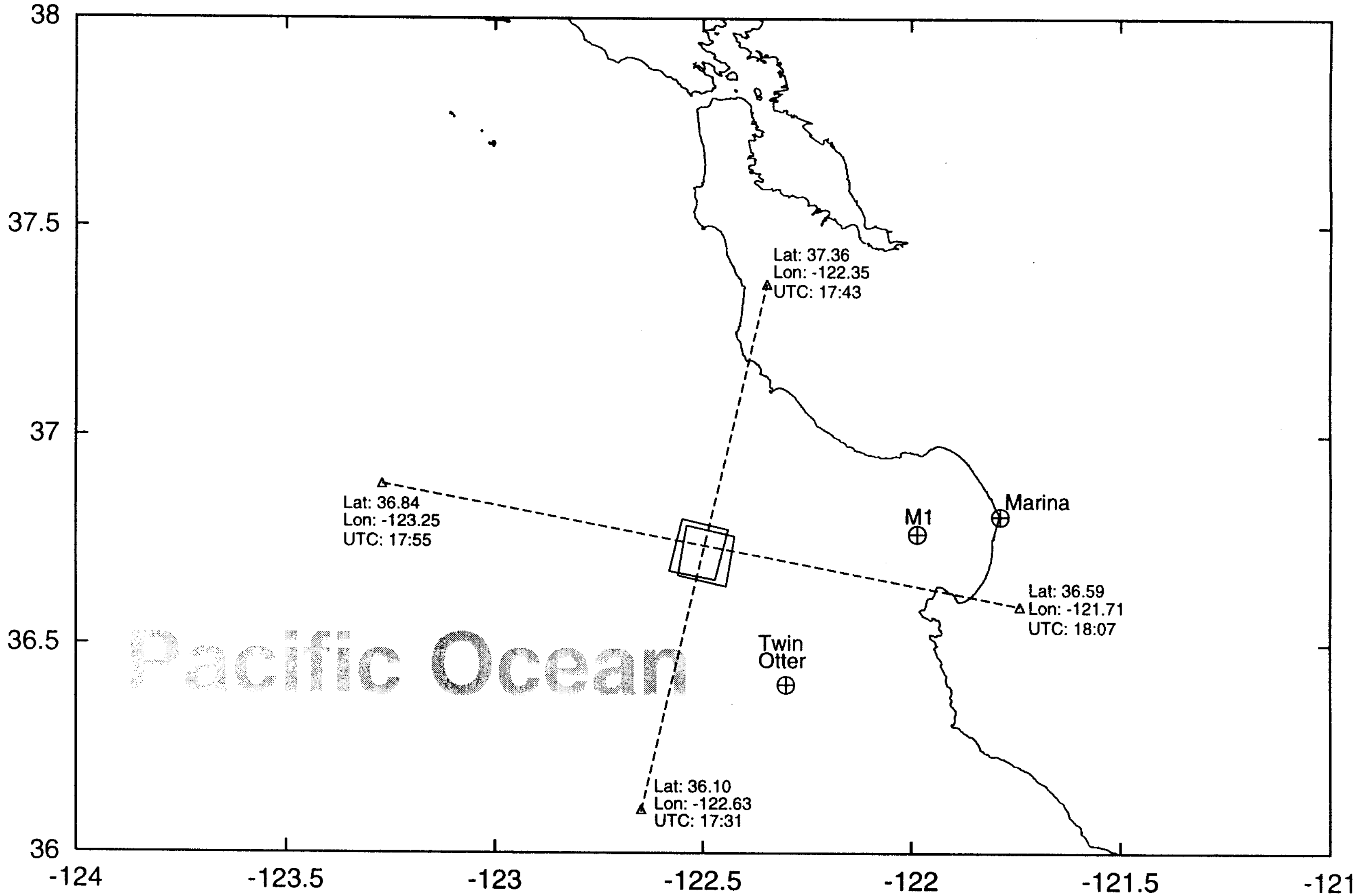

38
37.5
37
36.5
36
-124
-123.5
-123
-122.5
-122
-121.5
-121
Lat: 37.36
Lon: -122.35
UTC: 17:43
Lat: 36.84
Lon: -123.25
UTC: 17:55
Marina
M1
Lat: 36.59
Lon: -121.71
UTC: 18:07
Pacific Ocean
Twin
Otter
Lat: 36.10
Lon: -122.63
UTC: 17:31

Fig. 1

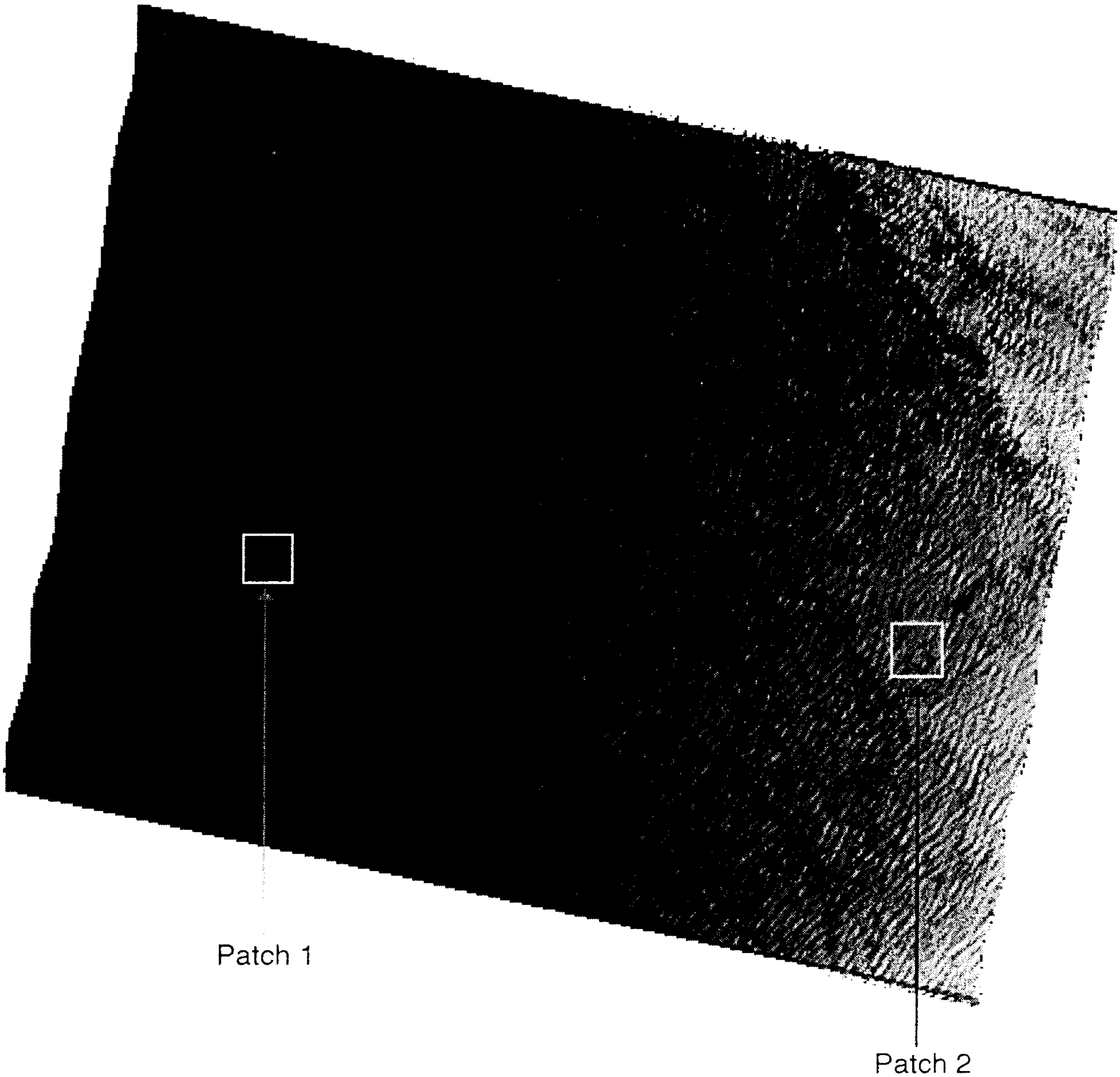


Fig. 2

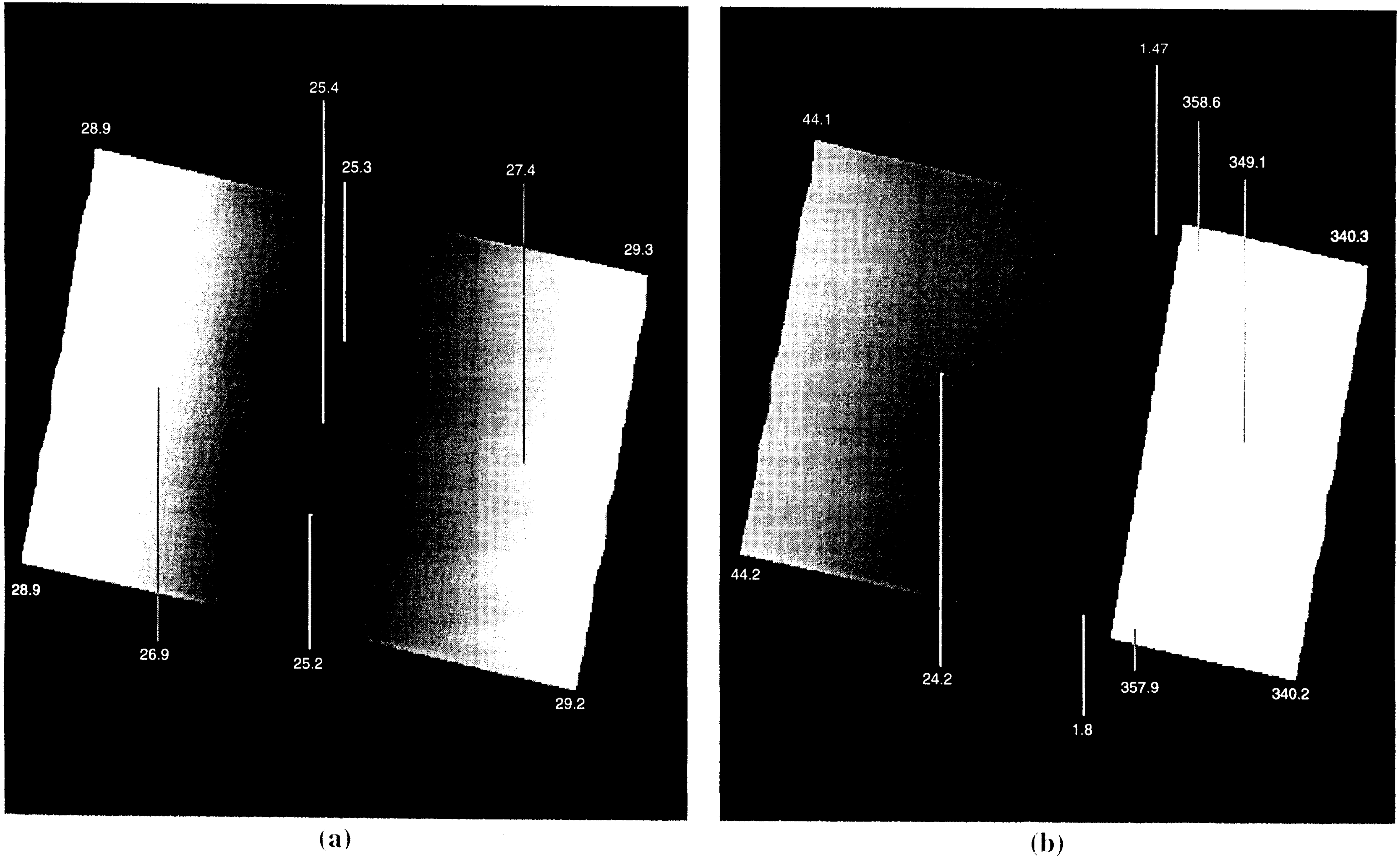
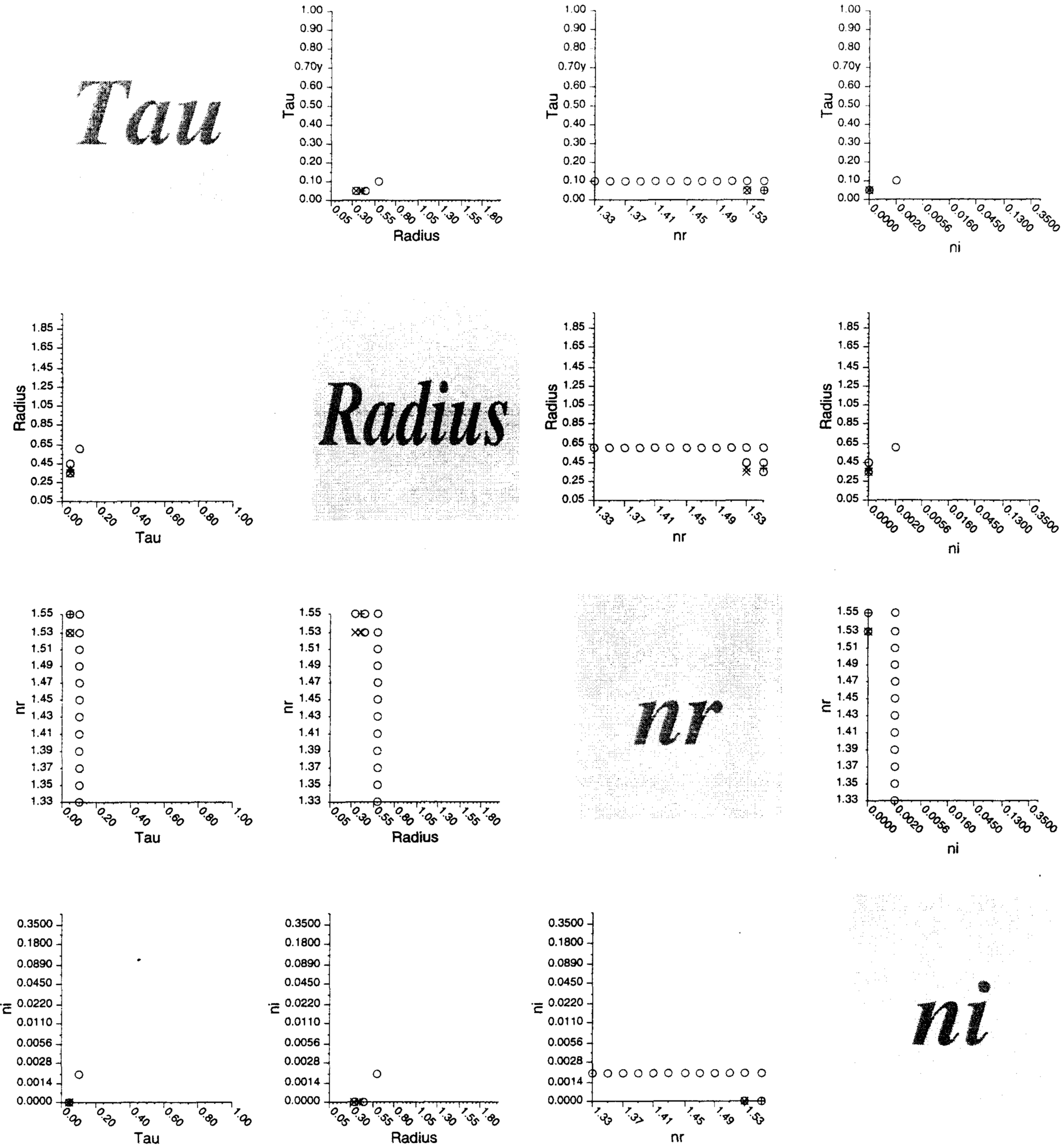

25.4
28.9
25.3
27.4
29.3
28.9
26.9
25.2
29.2
(a)
1.47
358.6
44.1
349.1
340.3
44.2
24.2
357.9
340.2
1.8
(b)

Fig. 3

atm_stats index = 0, windspeed index = 1



× chisq < 17.5
\+ 17.5 <= chisq < 20.0
○ 20.0 <= chisq < 22.5
▵ 22.5 <= chisq < 25.0
∘ 25.0 <= chisq < 27.5

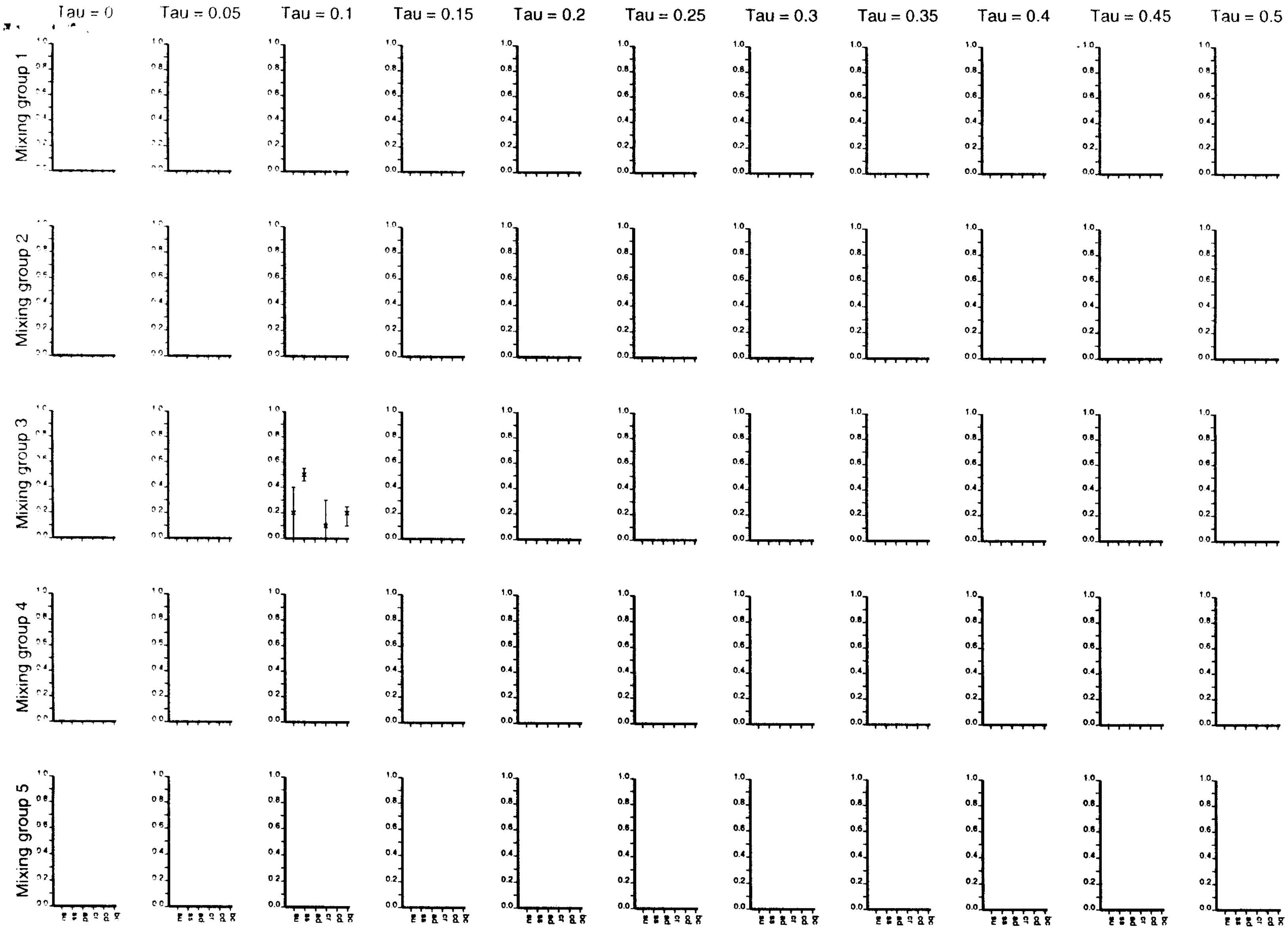
Assumed Physical Properties of Component Particles[§]

	n_r	n_i	r_c	ω_0	Size / Shape Category
Thin Cirrus	1.31	0.0	>50.	1.0	Special
Sea Salt	1.35	0.0	0.61	1.0	Large Spherical
Sulfate (Land)	1.46	0.0	0.08	10.	Medium Spherical
Sulfate (Ocean)	1.39	0.0	0.10	1.0	Medium Spherical
Carbonaceous	1.50	0.025	0.13	0.87	Medium Spherical
Mineral Dust (Accumulation Mode)	1.53	0.0045	0.47	0.91	Medium Nonspherical
Mineral Dust (Coarse Mode)	1.53	0.0045	1.90	0.73	Large Nonspherical
Black Carbon	1.75	0.440	0.012	0.17	Small

[§] Optical properties reported for MISR Band 3 (670 nanometers). For hygroscopic particles, the hydrated values are shown.

Major Climatological Particle Mixing Groups

Classification	Component 1	Component 2	Component 3	Component 4	Color
1. Carbonaceous + Dusty Maritime	Sulfate	Sea Salt	Carbonaceous	Accumulation Mode Dust	Blue
2. Dusty Maritime + Coarse Dust	Sulfate	Sea Salt	Accumulation Mode Dust	Coarse Dust	Yellow
3. Carbonaceous + Black Carbon Maritime	Sulfate	Sea Salt	Carbonaceous	Black Carbon	Green
4. Carbonaceous + Dusty Continental	Sulfate	Accumulation Mode Dust	Coarse Dust	Carbonaceous	Red-Brown
5. Carbonaceous + Black Carbon Continental	Sulfate	Accumulation Mode Dust	Carbonaceous	Black Carbon	Gray



su := sulfate; ss := sea salt; ad := accumulation dust; cr := caronaceous; cd := coarse dust; bc := black carbon

File id: /data/science/explorer/dsm/sites/Mon990629/chisq/clim/run_1_patch_1/tau_water_0.002/s02R06M0*.111111111.bin
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