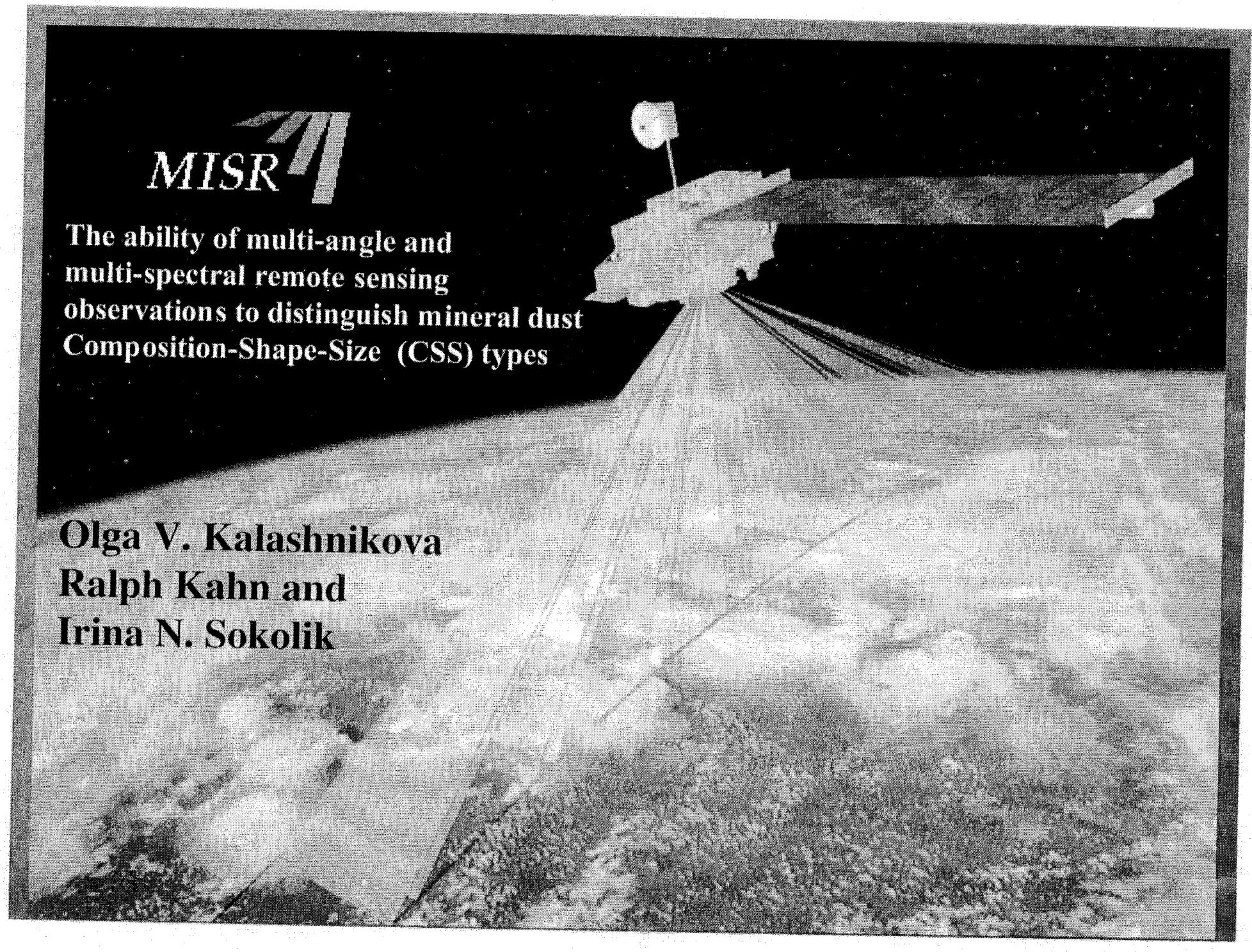
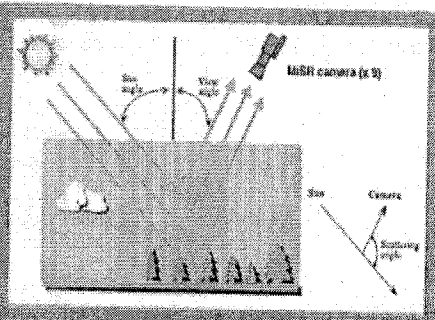
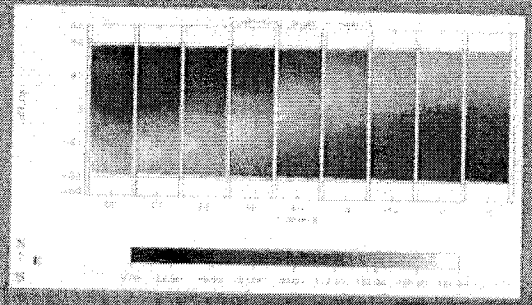

MISR
The ability of multi-angle and multi-spectral remote sensing observations to distinguish mineral dust Composition-Shape-Size (CSS) types
Olga V. Kalashnikova
Ralph Kahn and
Irina N. Sokolik

MISR sensitivity to aerosol optical properties





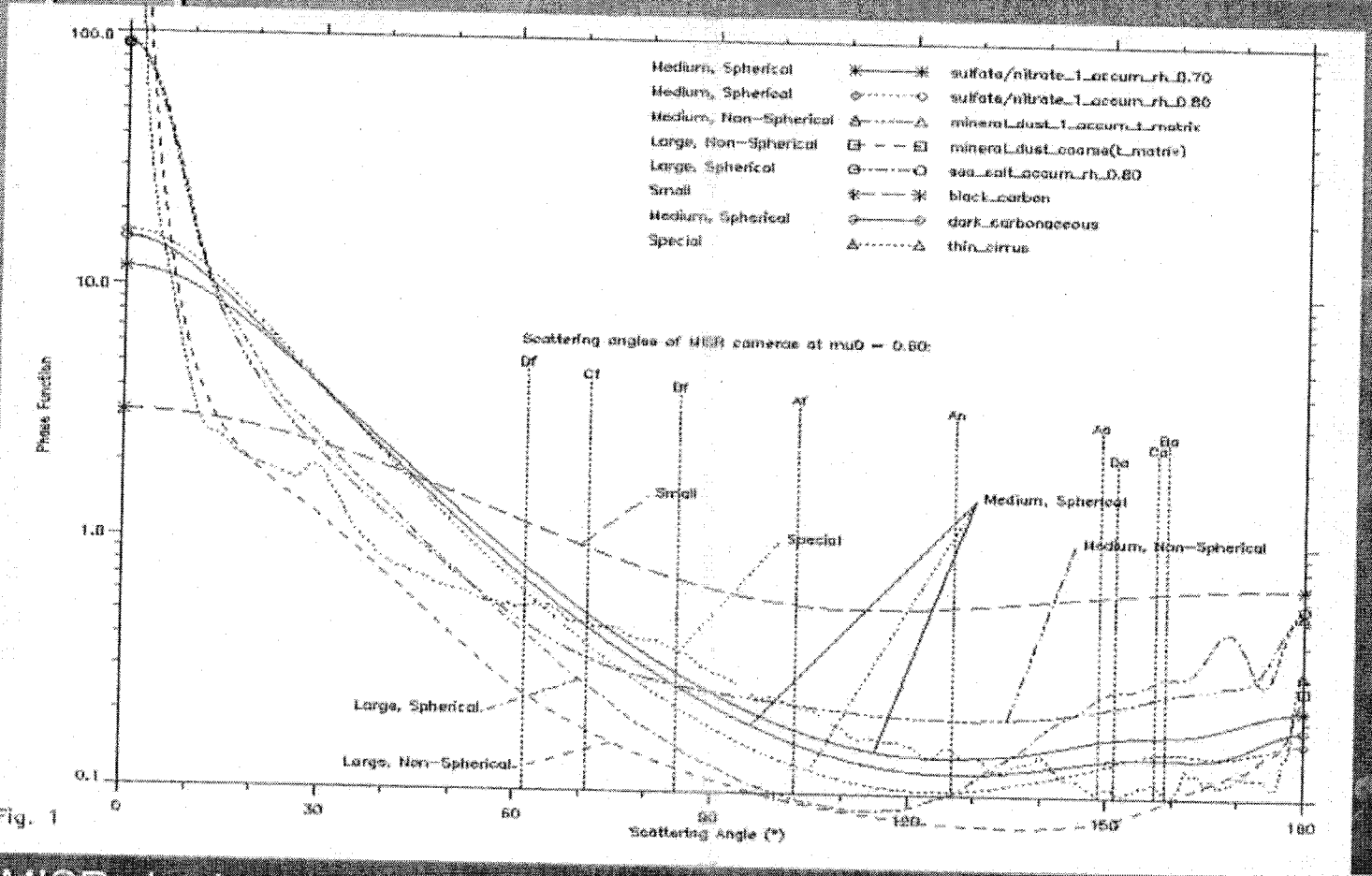


Fig. 1

The MISR viewing geometry allows discrimination of aerosol air mass types, represented by climatologically probable, external mixtures of aerosol components having prescribed optical properties

Motivations

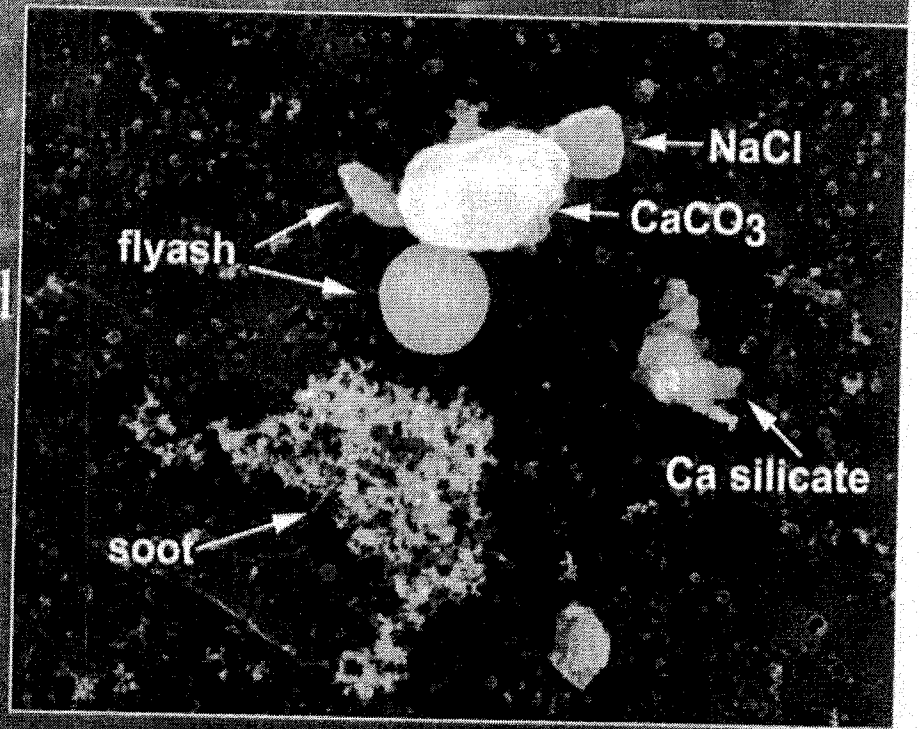
Required parameters for aerosol retrievals:

- Scattering phase function, $P(\Theta;\lambda)$
- Single scattering albedo, $\omega_0(\lambda)$
- Extinction coefficient, $k_{ext}(\lambda)$

MISR is very sensitive to the phase functions used in retrievals

Mineral dust particles:

- Mostly nonspherical
- Externally and internally mixed
- Size-dependent shapes
- Size-dependent compositions
- Complex wavelength dependence; $m_r = f(\lambda)$



Composition-Shape-Size distribution of realistic dust mixtures is required to model optics

Approach

Reconstruct CSS distributions

- -Determine representative sizes
- -Determine range of refractive indices
- -Determine representative shapes

Calculate optics (DDA And T matrix)

- Calculate P(Θ), ω, and k_{ext} for reconstructed CSS distributions

MISR sensitivity studies

Provide new dust models for MISR retrievals

Representative size distributions and refractive indices

Size Mode1

(number distribution)

R0=0.5um, σ=1.5

Size Mode2

(number distribution)

R0=1.0um, σ=2.0

Composition mode 1

(weakly absorbing)

Composition mode 2

(strongly absorbing)

Wavelength μm	Type 1 Asian analog	Type2 Saharan analog
0.550 (green)	(1.51, 0.0021)	(1.61, 0.0213)
0.672 (red)	(1.51, 0.0011)	(1.60,0.0064)
0.866 (near-IR)	(1.51, 0.0007)	(1.59, 0.0032)

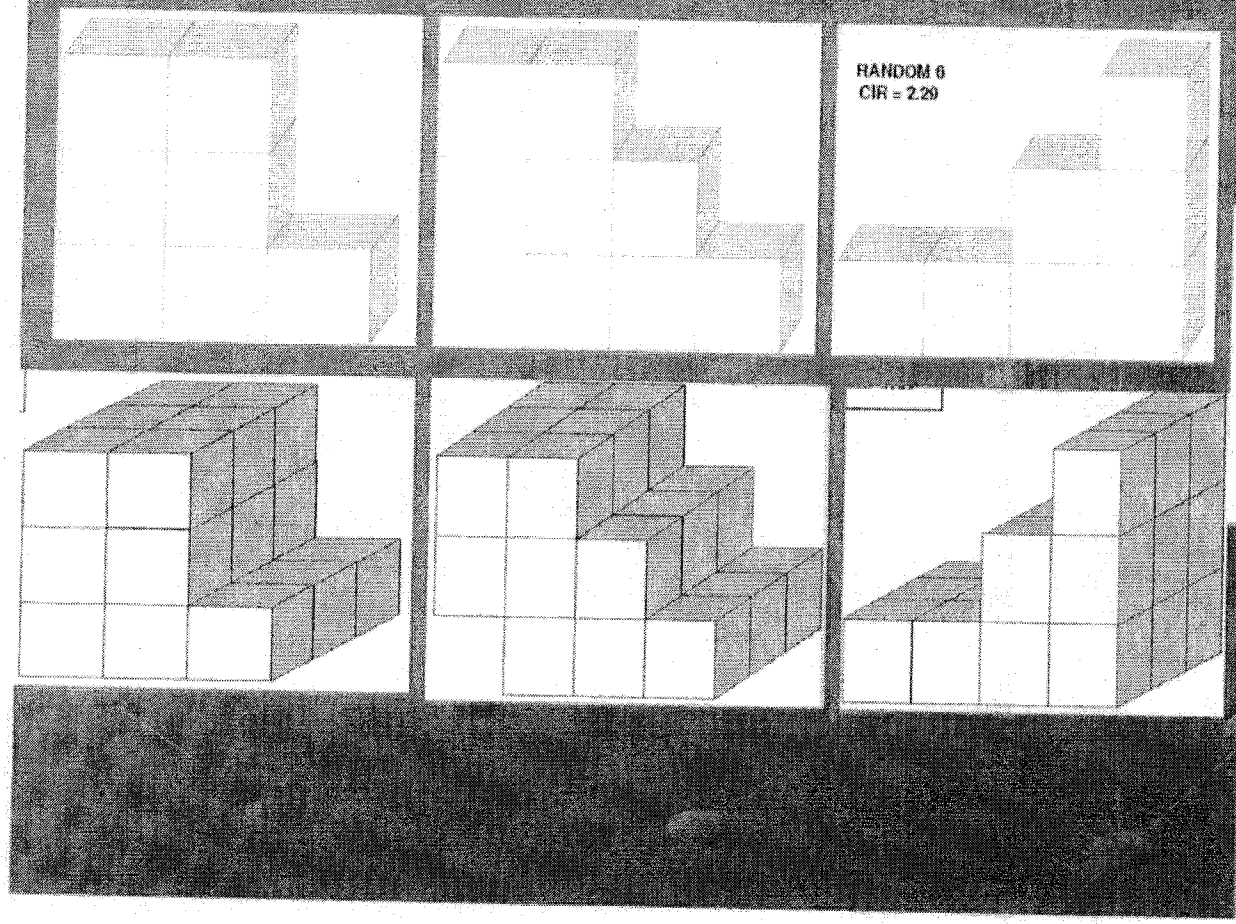
Representative shapes

Irregular plates and grains:

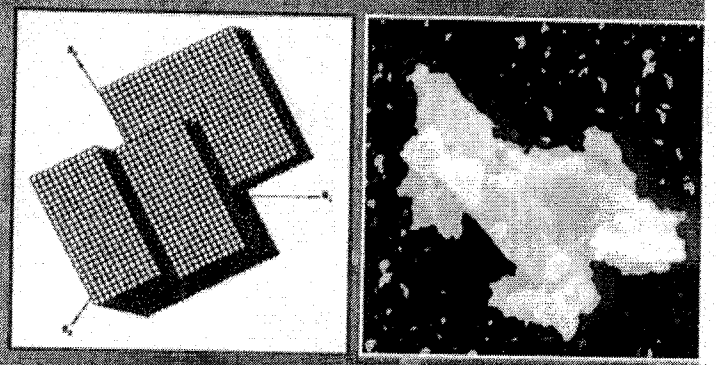
Random4,
CIR=1.64

Random5,
CIR=1.93

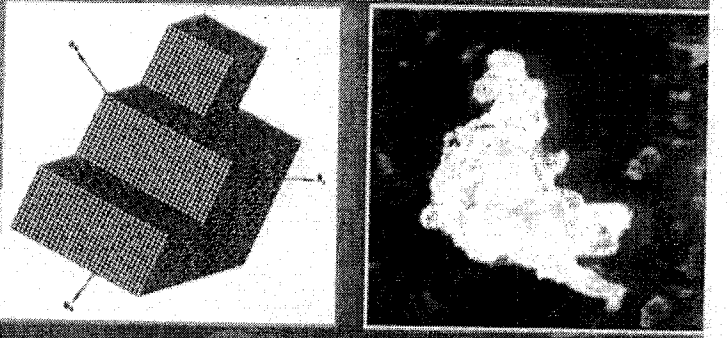
Random6,
CIR=2.29



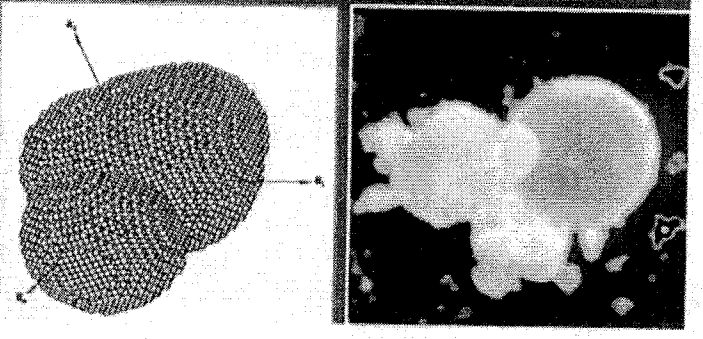
Random1



Random2

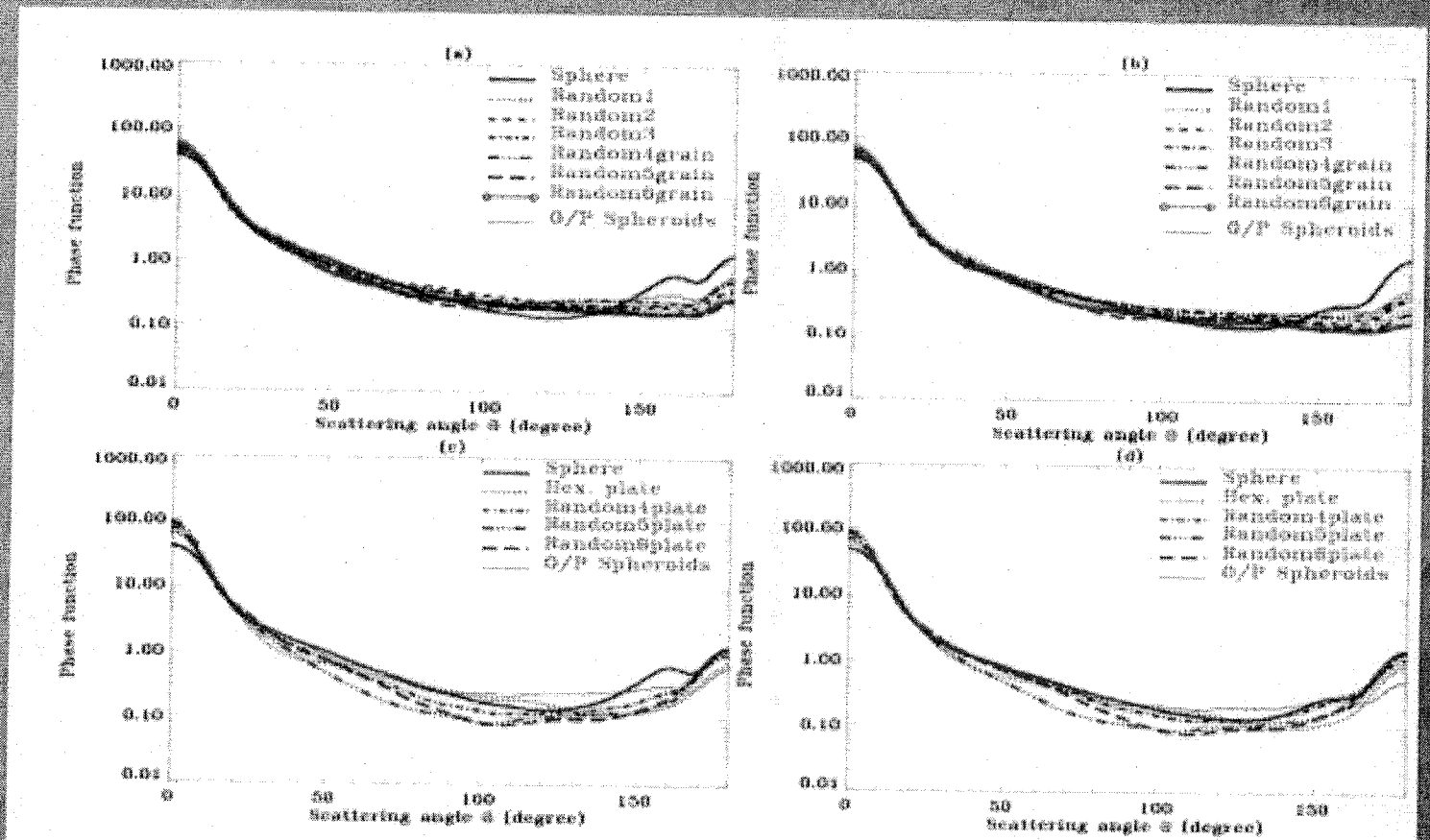


Random3



Sensitivity of phase function to particle shape
(DDA calculations for the Size Mode 1, λ=0.550μm)

Composition type 1 | Composition type 2



- P(Θ) different for irregular plates and for grains having same CIR
- P(Θ) (backscattering) of irregular grains is less than for O/P spheroids
- P(Θ) of grains decreases and get flatter as CIR increases

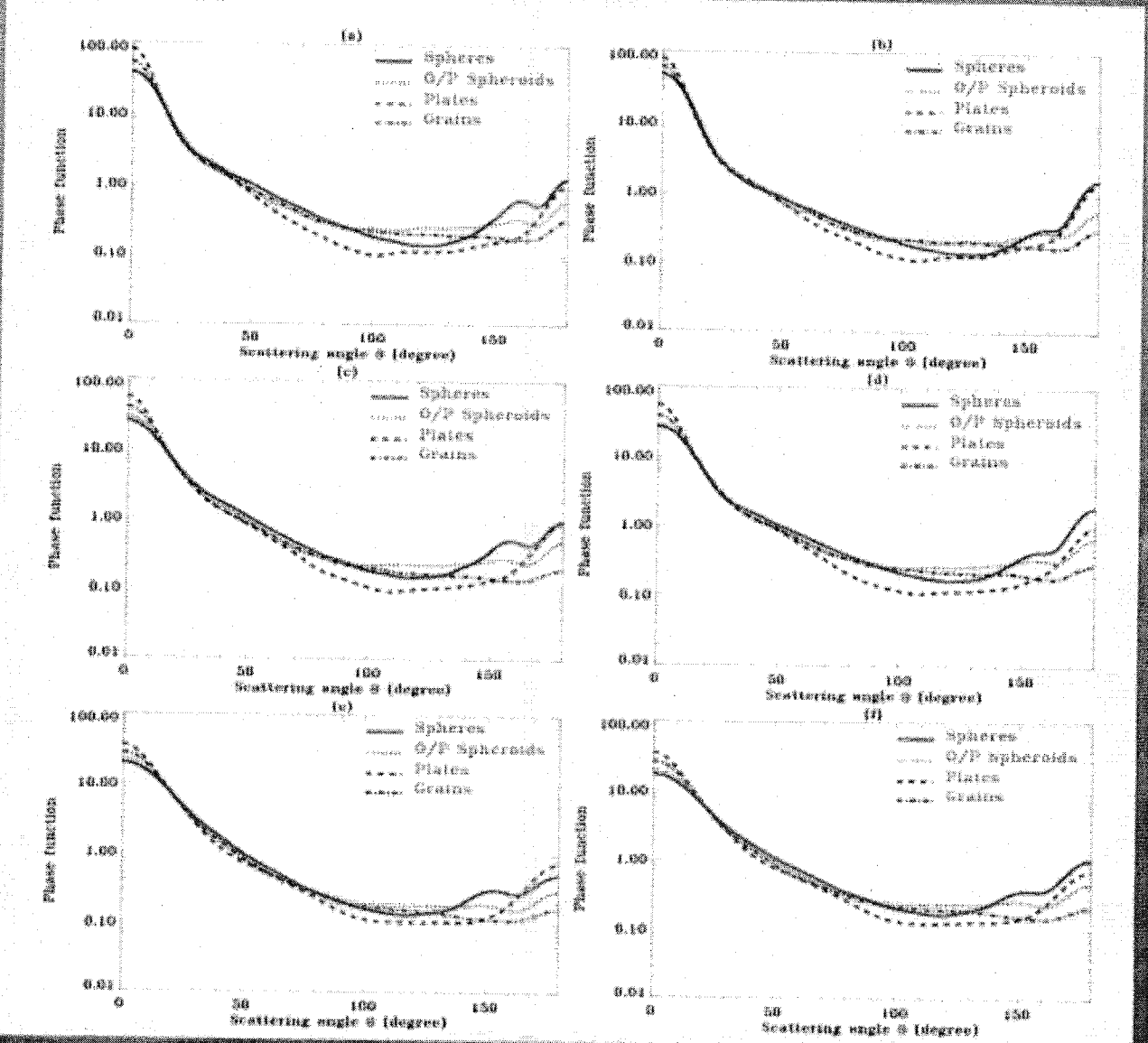
Phase functions of size-shape mixtures used for MISR dust sensitivity studies, Size Mode 1

Composition type 1 | Composition type 2

λ=0.550μm

λ=0.672μm

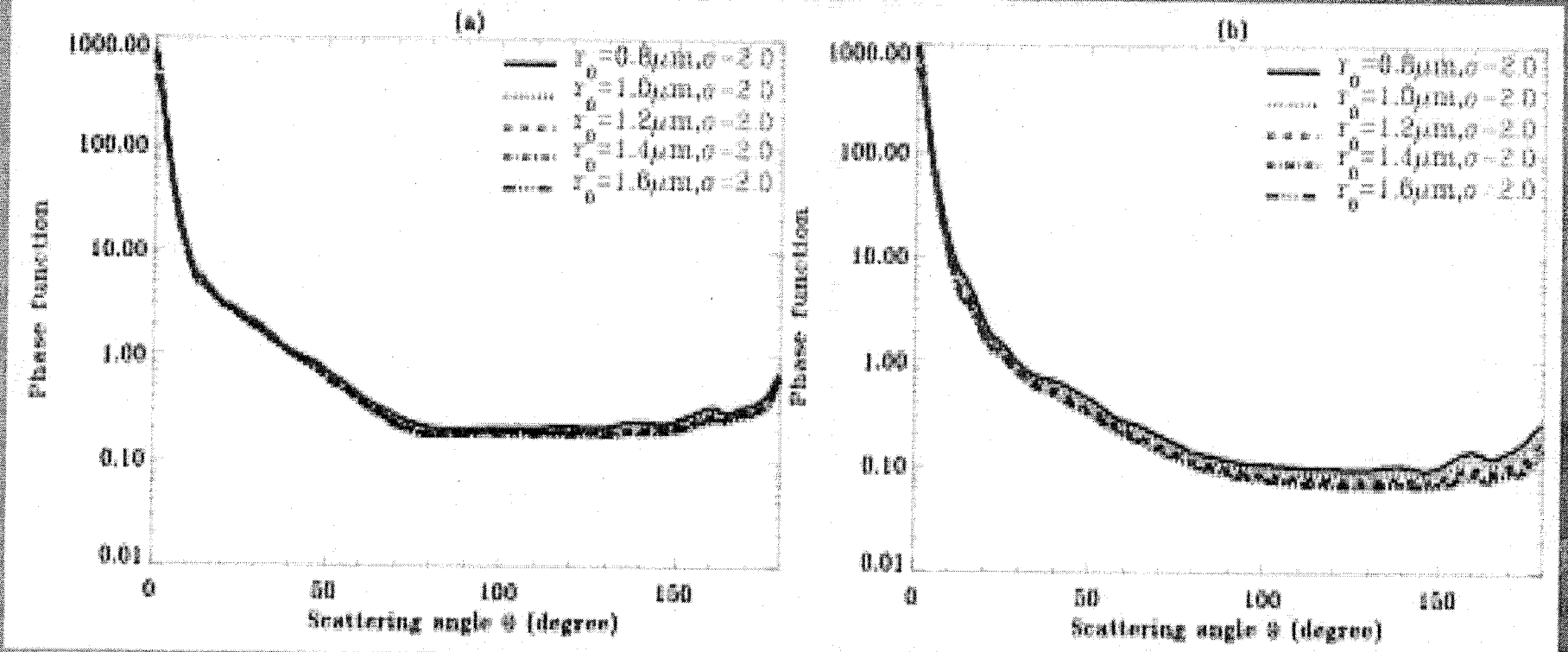
λ=0.865μm



Phase function sensitivity to size
(T-matrix calculations for Size Mode 2)

Composition type 1

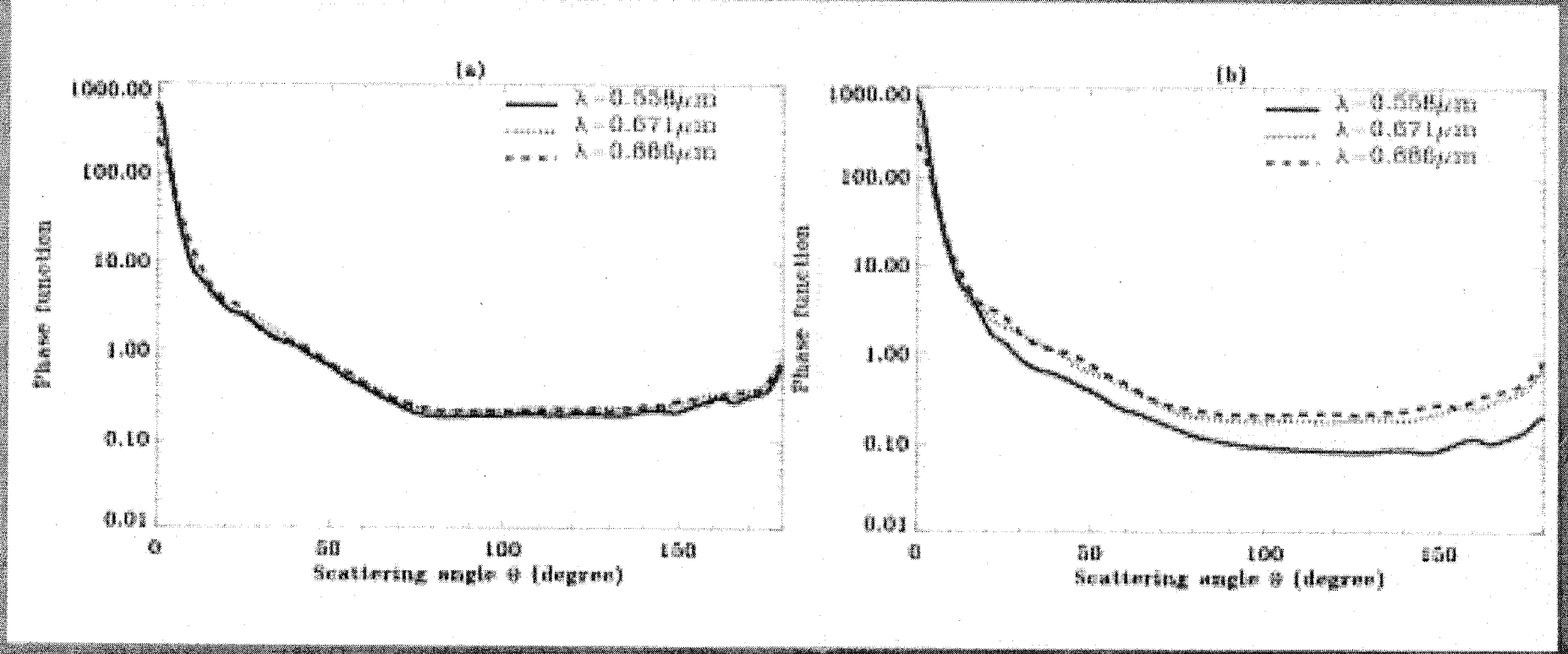
Composition type 2



➢ P(Θ) of grains decreases and get flatter as size increases

Phase functions of size-shape mixtures used for MISR dust sensitivity studies, Size Mode 2

Composition type 1 Composition type 2



CSS mixtures

- CSS1: Type 1 Mode 1 Plates + Type 1 Mode 2 O/P spheroids
- CSS2: Type 1 Mode 1 Grains + Type 1 Mode 2 O/P spheroids
- CSS3: Type 1 Mode 1 O/P spheroids + Type 1 Mode 2 O/P spheroids
- CSS4: Type 2 Mode 1 Plates + Type 2 Mode 2 O/P spheroids
- CSS5: Type 2 Mode 1 Grains + Type 2 Mode 2 O/P spheroids
- CSS6: Type 2 Mode 1 O/P spheroids + Type 2 Mode 2 O/P spheroids
- CSS7: Type 1 Mode 1 Plates + Type 2 Mode 2 O/P spheroids
- CSS8: Type 1 Mode 1 Grains + Type 2 Mode 2 O/P spheroids
- CSS9: Type 1 Mode 1 O/P spheroids + Type 2 Mode 2 O/P spheroids
- CSS10: Type 2 Mode 1 Plates + Type 1 Mode 2 O/P spheroids
- CSS11: Type 2 Mode 1 Grains + Type 1 Mode 2 O/P spheroids
- CSS12: Type 2 Mode 1 O/P spheroids + Type 1 Mode 2 O/P spheroids

- Scenario A: 30% Mode 1 +70% Mode 2
- Scenario B: 50% Mode 1 + 50% Mode 2
- Scenario C: 80% Mode 1 + 20% Mode 2

Type 1 = Less Absorbing; Type 2 = More absorbing; Mode 1 = smaller; Mode 2 = Larger; O/P = oblate/prolate

Conclusions

- At least for the limiting cases, differences in $P(\vartheta)$ for more and less absorbing mineral dust are large enough to be detected by MISR under good viewing conditions
- Mode 1 and Mode 2 size distribution differences should be detected by MISR, and some characteristics of the Mode 1 distribution may be detectable
- Among non-spherical particle types, at least two, and possibly more broad shape classes should be detected by MISR