Remote Sensing of Cloud Optical Thickness and Effective Particle Radius

Outline

- Status of the MODIS Airborne Simulator
- Remote sensing of cloud optical thickness and effective radius of water clouds
  - Physical principles of retrieval algorithm
  - Images of τ_c and r_e from ASTEX
  - Marginal probability density function of τ_c and r_e
  - Joint probability density function of τ_c and r_e
- Summary and conclusions
- Outstanding problems and future work

EOS

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Status of MODIS Airborne Simulator

Objectives

- Simulate the majority of atmosphere and land channels of *MODIS* prior to launch.
- Obtain measurements of reflected and emitted radiation with a single instrument under a wide variety of earth-atmosphere conditions.
- Compare retrievals of atmospheric and surface properties with nearly simultaneous *in situ* aircraft and surface observations.
- Perform calibration intercomparisons during *MODIS* overflights.

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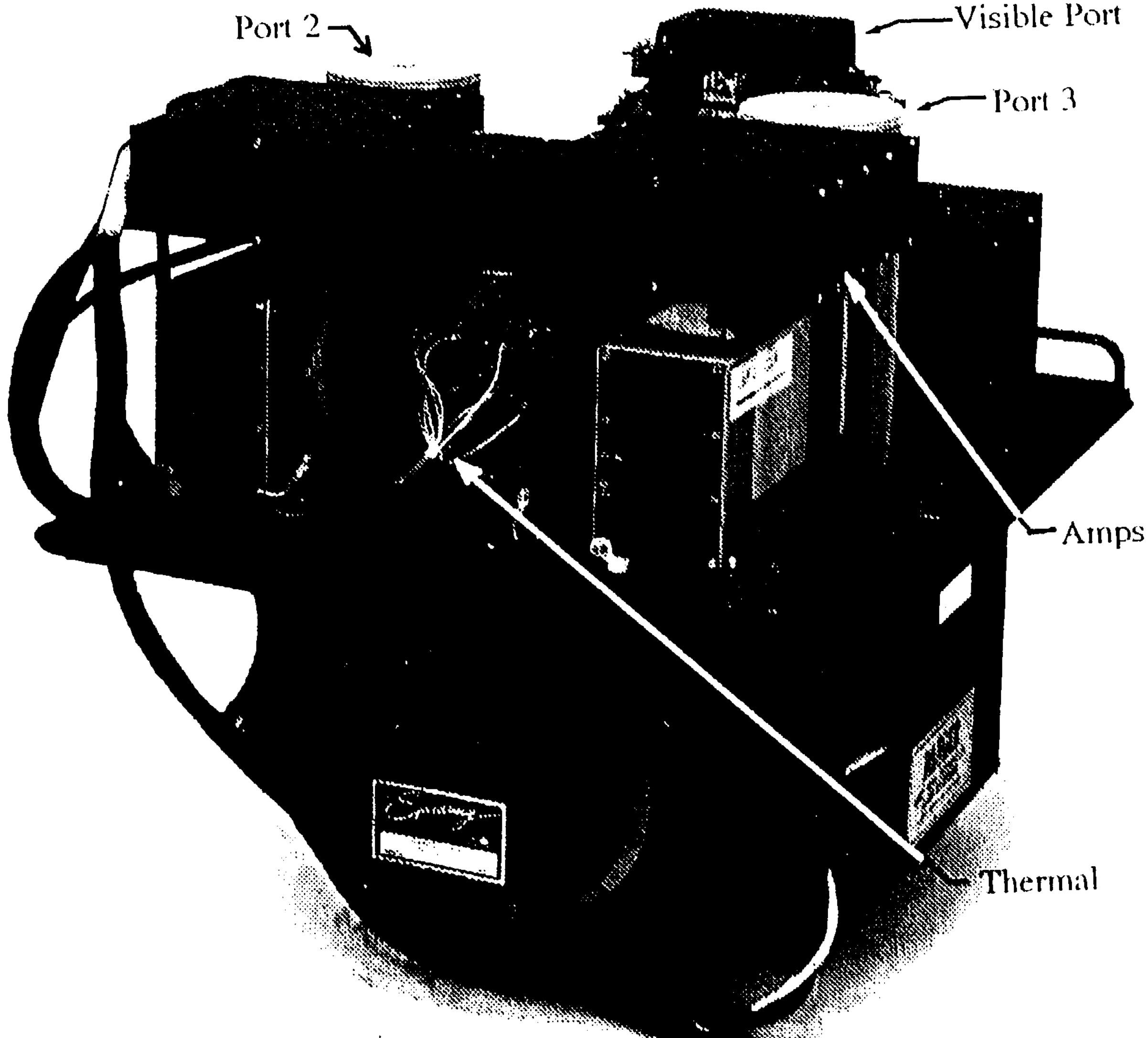
MODIS Airborne Simulator



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MODIS Airborne Simulator

Channels	50
Footprint	2.5 mrad
	45 m
Swath	±43°
	34 km
Spectral range	0.55-14.2 µm
Scan rate	6.25 scans/sec
Pixels in scan line	716
Data system	12 channels – 8 bit

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Wavelength (µm)	Bandwidth (µm)	Bits
0.547	0.043	8
0.664	0.055	8
0.875	0.041	8
0.905	0.030	8
0.945	0.043	8
1.623	0.057	8
2.142	0.047	8
3.725	0.151	8
4.500	0.150	10
4.650	0.150	8
8.563	0.396	10
9.650	0.5	10
11.002	0.448	10
12.032	0.447	10
13.186	0.352	10
13.952	0.517	8
14.300	0.5	8

ASTEX Configuration

Wavelength (μm)	Bandwidth (μm)	Bits	Channel
0.664	0.055	8	2
0.875	0.041	8	3
0.945	0.043	8	4
1.623	0.057	8	5
2.142	0.047	8	6
3.725	0.151	8	7
8.563	0.396	10	9
11.002	0.448	10	10
12.032	0.447	10	12
13.186	0.352	10	11
13.952	0.517	8	8

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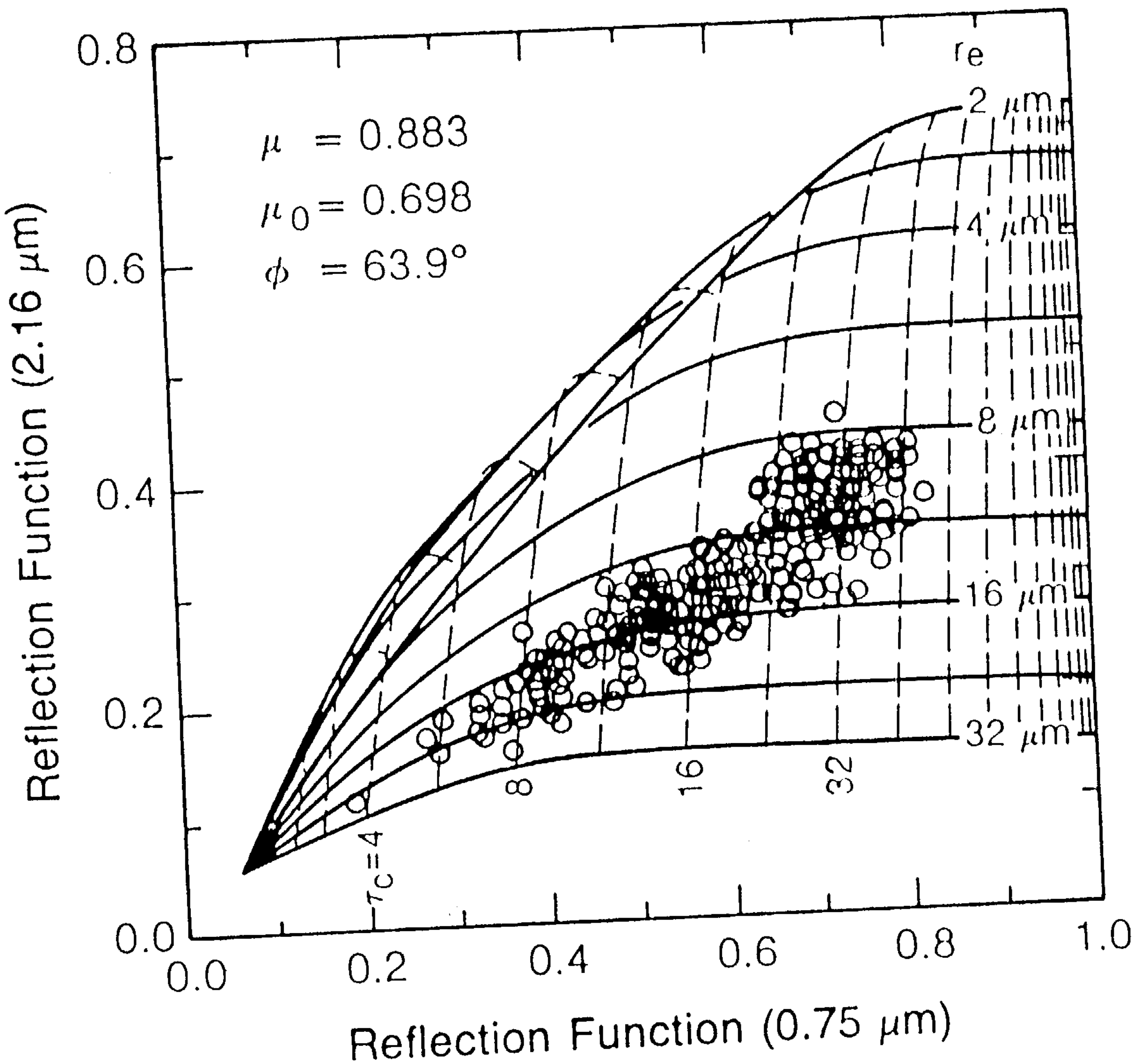
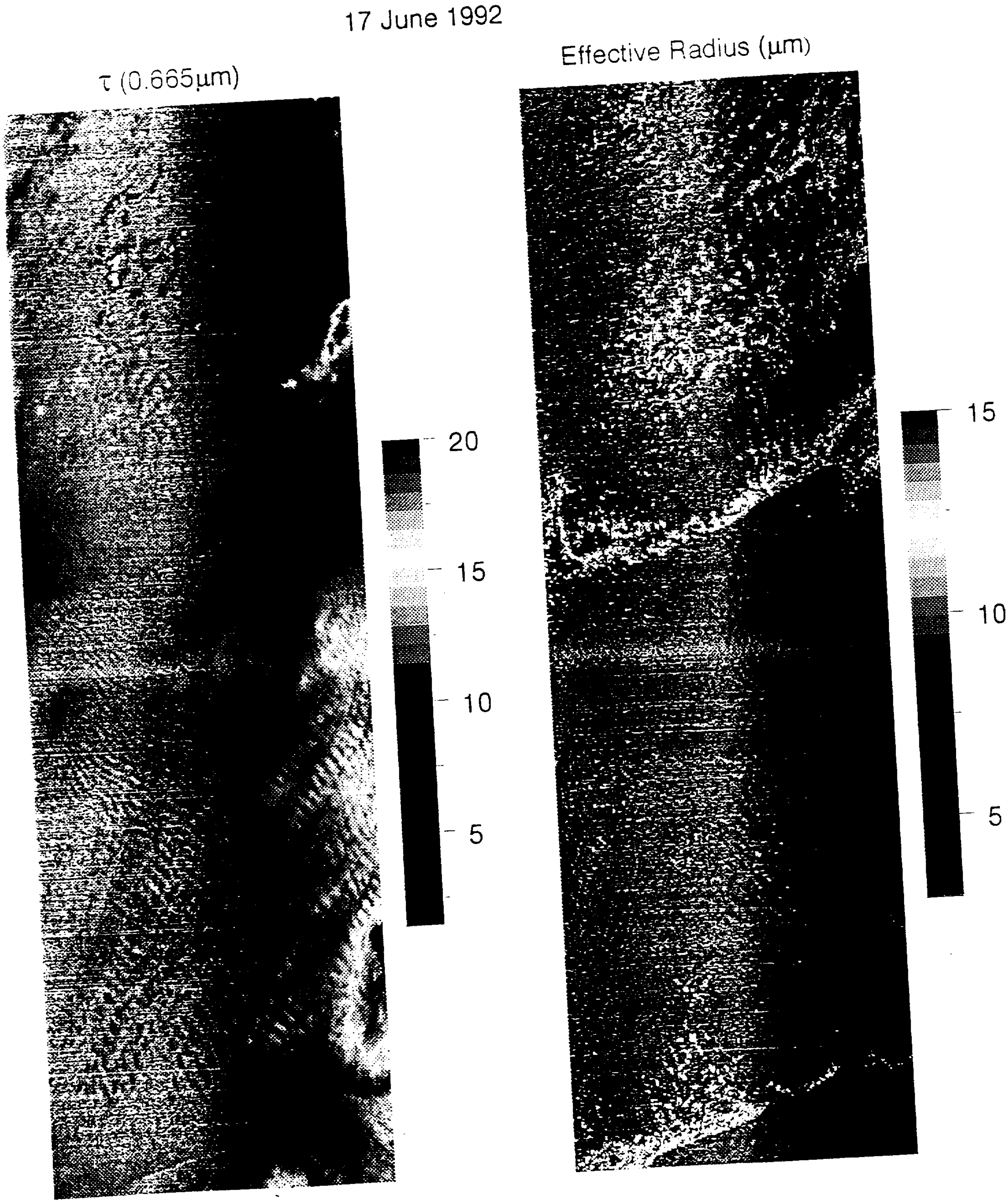
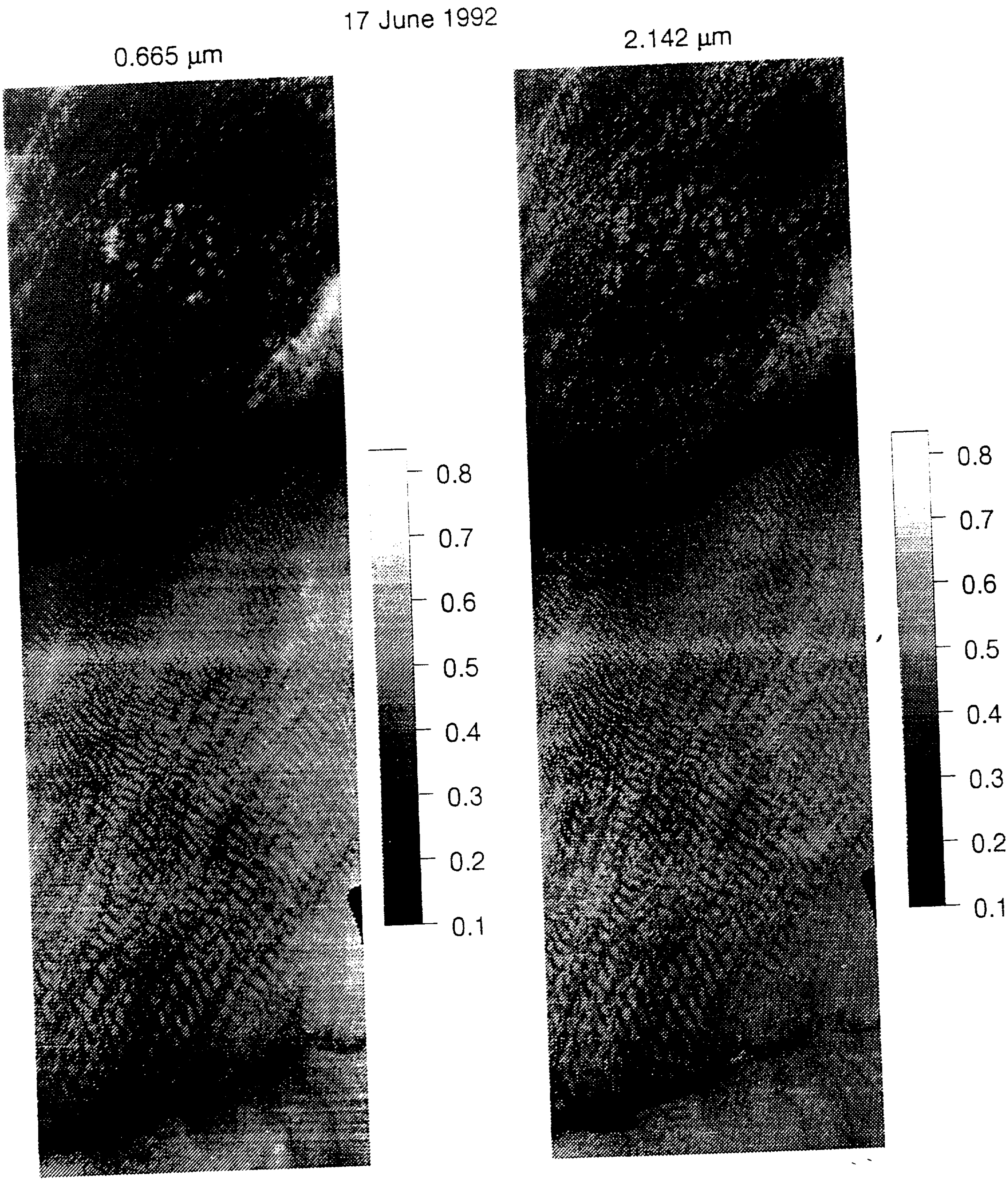
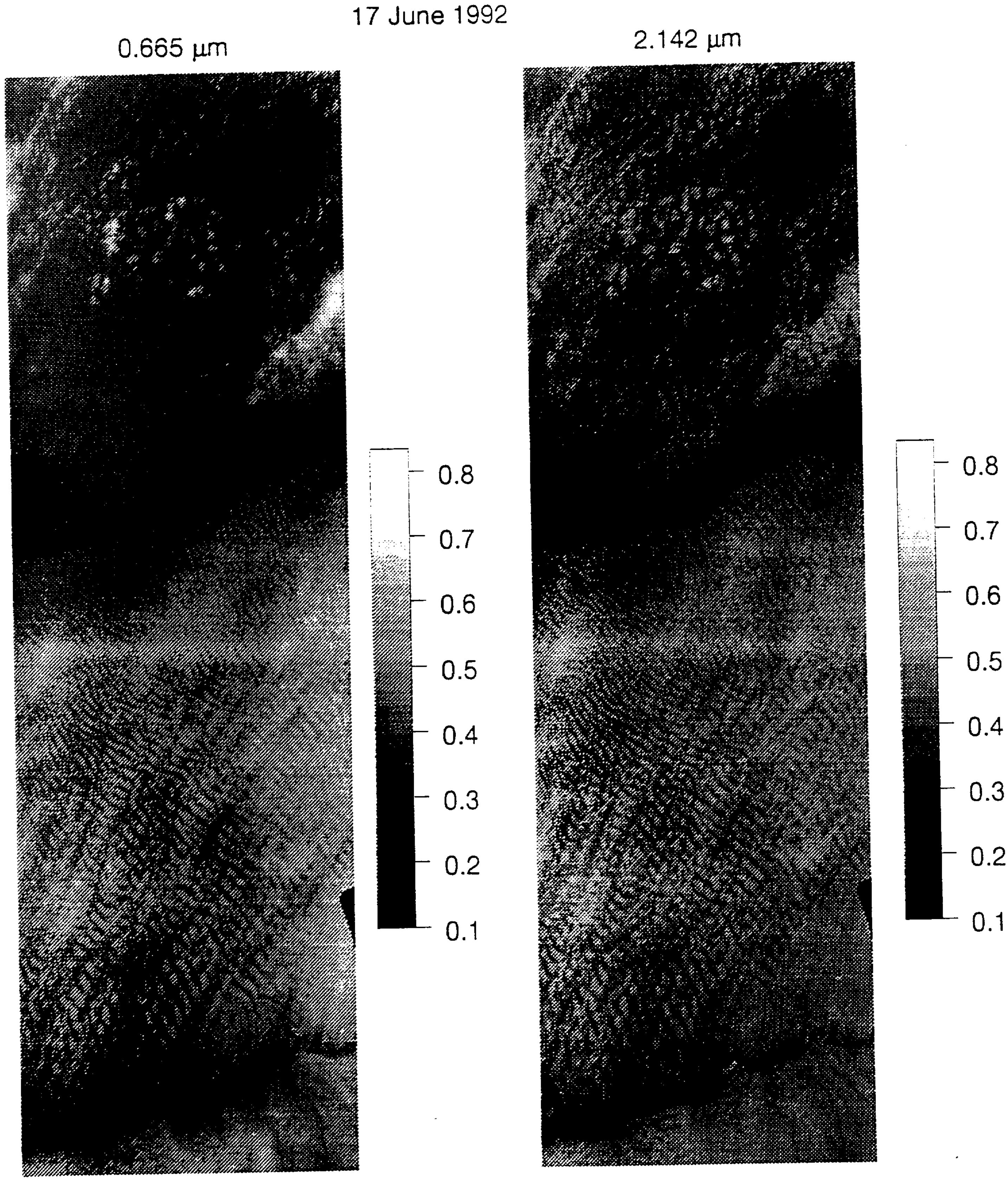


μ = 0.883
μ0 = 0.698
φ = 63.9°
re
2 μm
4 μm
8 μm
16 μm
32 μm
τc=4
8
16
32
0.0
0.2
0.4
0.6
0.8
1.0
Reflection Function (2.16 μm)
Reflection Function (0.75 μm)

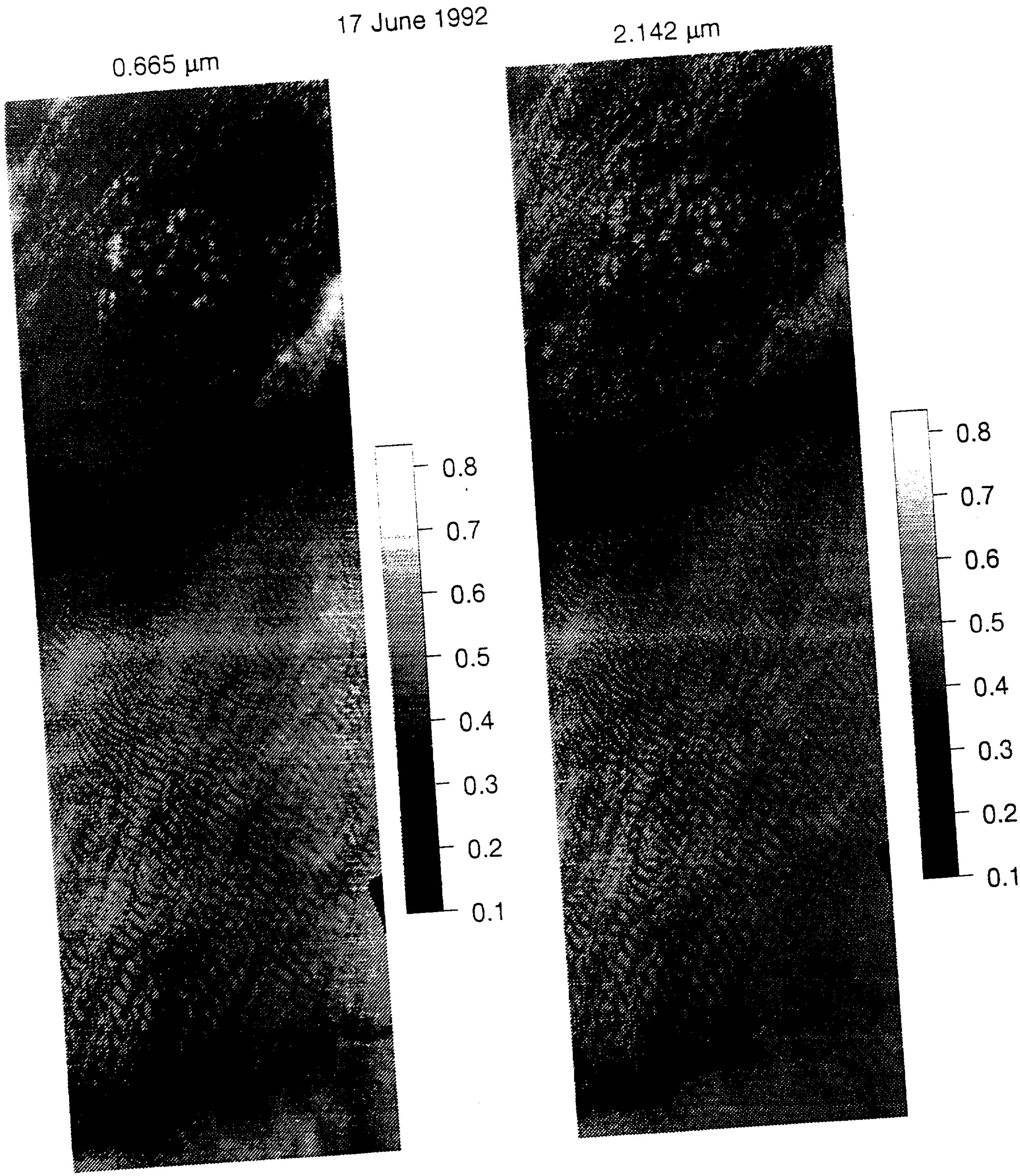


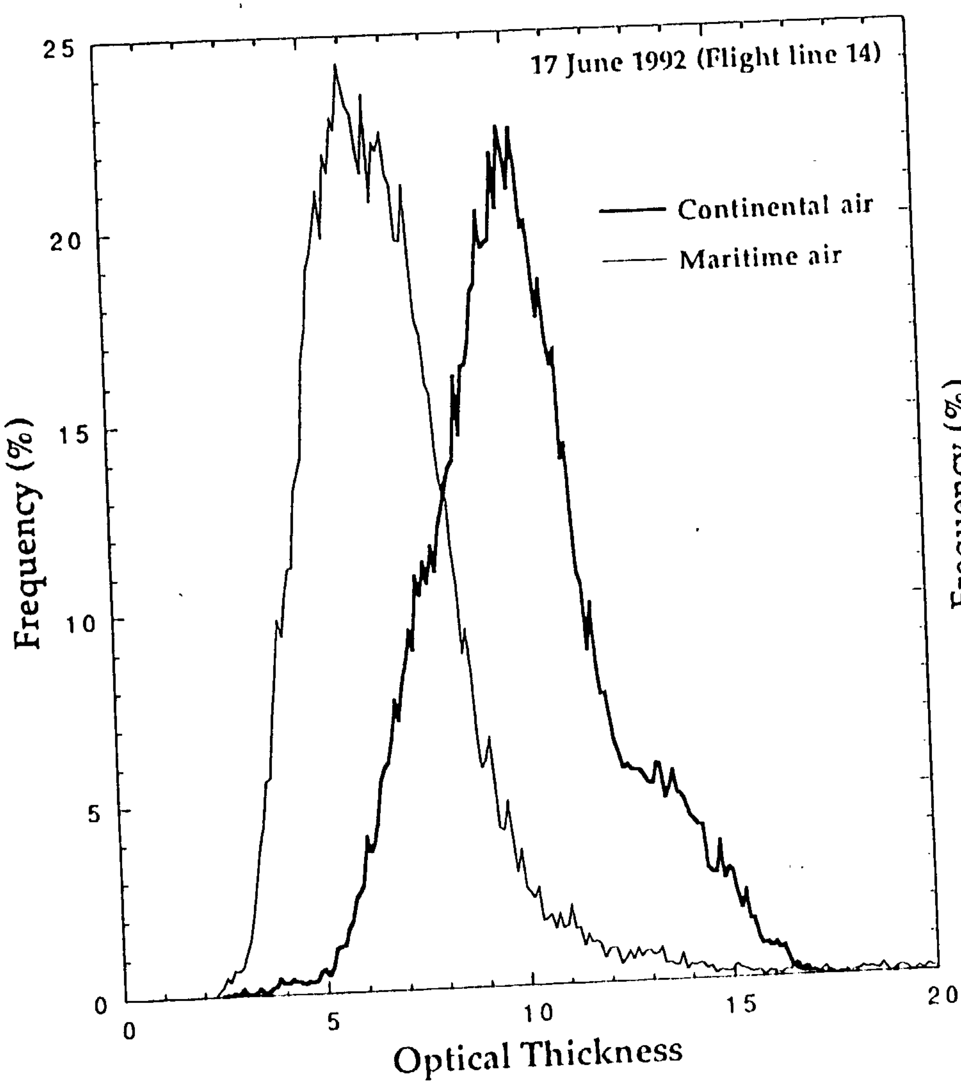
17 June 1992
τ (0.665μm)
20
15
10
5
Effective Radius (μm)
15
10
5


17 June 1992
0.665 µm
2.142 µm
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

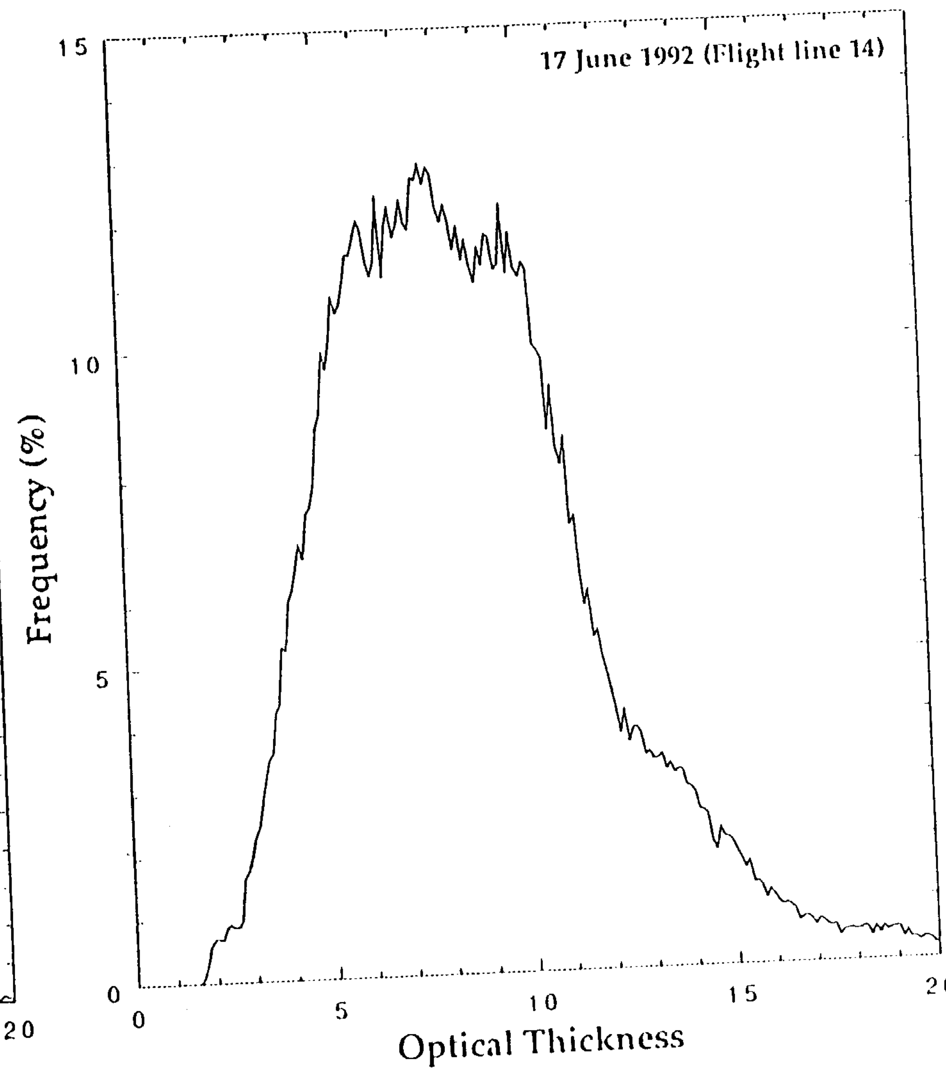


17 June 1992
0.665 μm
2.142 μm
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

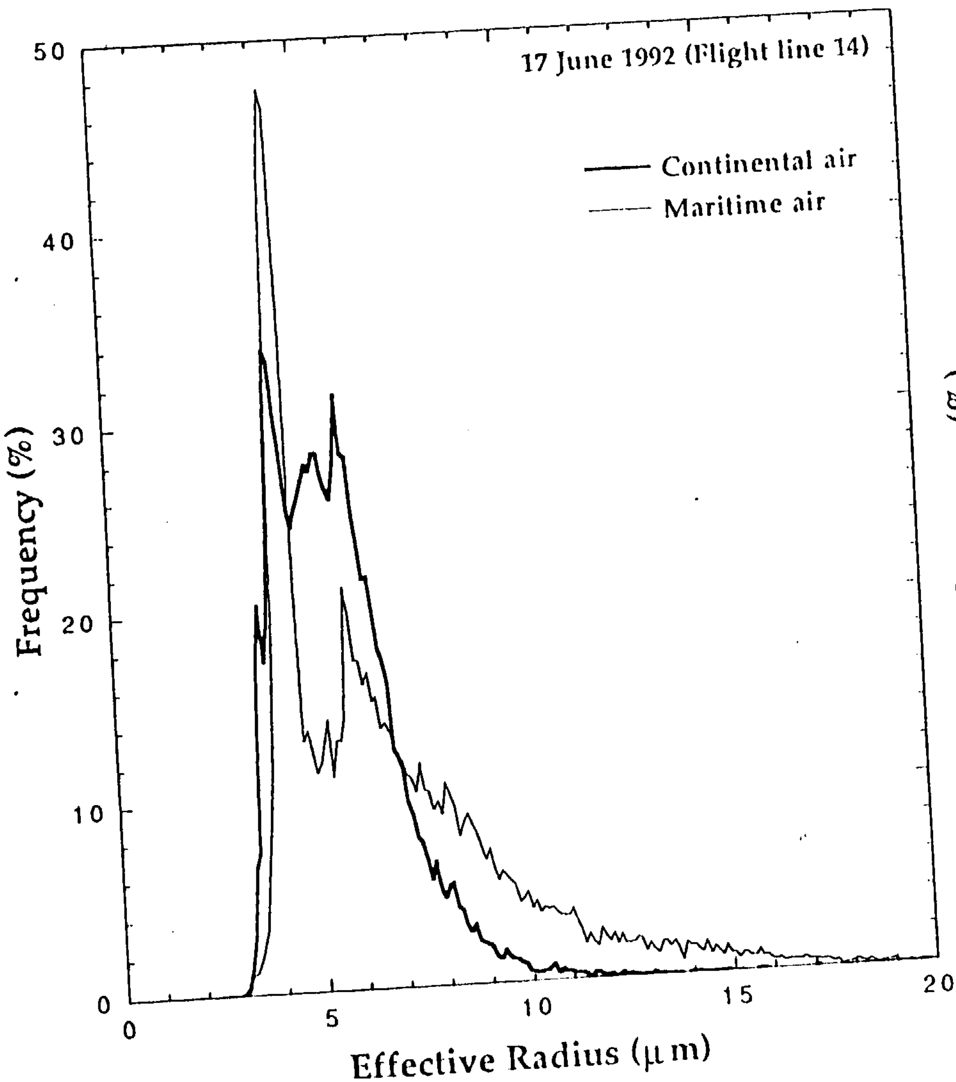

17 June 1992
0.665 µm
2.142 µm
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

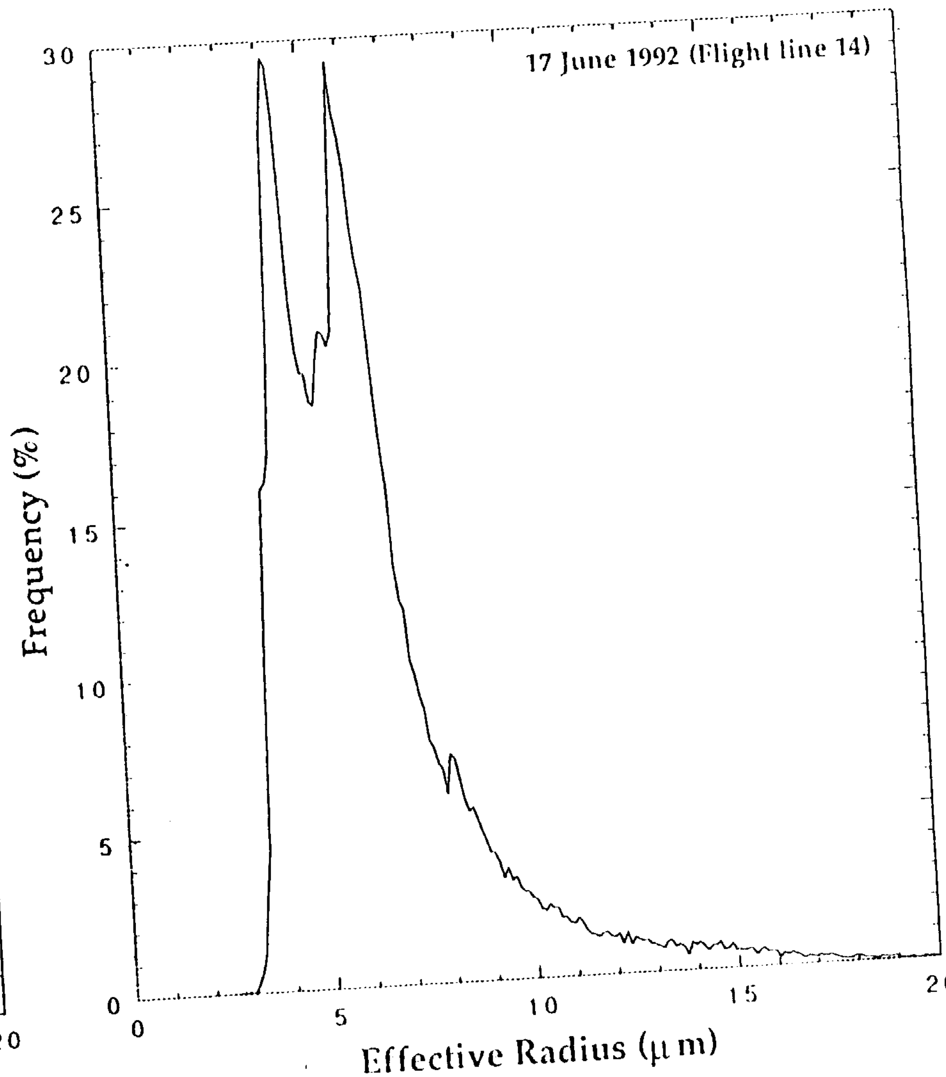


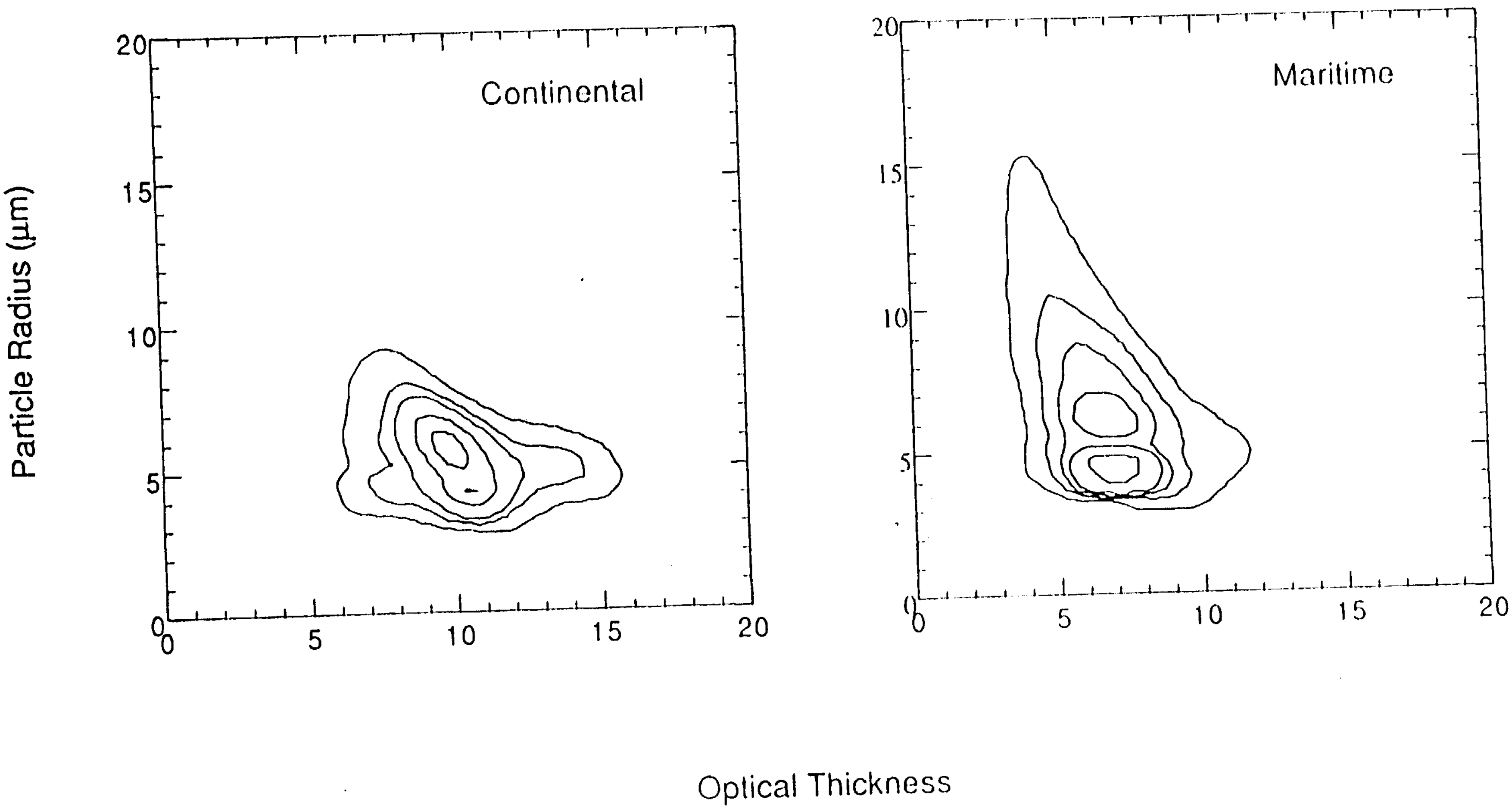
17 June 1992 (Flight line 14)
Continental air
Maritime air
Frequency (%)
Optical Thickness
0
5
10
15
20
25



17 June 1992 (Flight line 14)
Frequency (%)
Optical Thickness
0
5
10
15
20


17 June 1992 (Flight line 14)
Continental air
Maritime air
Frequency (%)
Effective Radius (μm)
0
10
20
30
40
50
0
5
10
15
20


17 June 1992 (Flight line 14)
Frequency (%)
Effective Radius (μm)
0
5
10
15
20
25
30
0
5
10
15
20



Continental
Maritime
Particle Radius (μm)
Optical Thickness
0
5
10
15
20

Summary and Conclusions

- The cloud optical thickness and effective radius can be estimated from reflected solar radiation measurements
- The remote sensing-derived optical thickness is larger in continental air than in maritime air
    - $\tau_c \sim 10$ for continental air
    - $\tau_c \sim 6$ for maritime air
- The remote sensing-derived effective radius decreases with increasing optical thickness in maritime air
- In continental air the relationship between optical thickness and effective radius is less well defined

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Outstanding Problems and Future Work

- Incorporate Rayleigh and aerosol corrections into retrieval algorithm
- Look into influence of boundaries on atmospheric retrievals
- Incorporate multiple channels into retrieval (including 1.64, 2.13, and 3.75 µm)
- Examine multiple layer clouds, using data collected during TOGA COARE and CEPEX
- Study impact of ice and mixed phase clouds on atmospheric retrievals of optical thickness and effective radius

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ER-2 Instrument Overview

SCAR-A (Wallops Flight Facility)

- MODIS Airborne Simulator (MAS)
  - Spectral intensity imagery in cross-track direction (11 of 50 bands between 0.55 and 14.30 μm)
- Airborne Visible and Infrared Imaging Spectrometer (AVIRIS)
  - High spatial resolution imagery in cross-track direction (224 bands between 0.4 and 2.5 μm)

SCAR-A Configuration

Wavelength (µm)	Bandwidth (µm)	Bits	Channel
0.547	0.043	8	2
0.664	0.055	8	3
0.875	0.041	8	4
0.945	0.043	8	5
1.88	0.05	8	6
2.142	0.047	8	7
3.725	0.151	8	8
8.563	0.396	10	9
11.002	0.448	10	10
12.032	0.447	10	12
13.186	0.352	10	11

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