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Optical Scattering by Airborne Dust Particles

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ARFL Transmission Meeting

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Outline

Introduction to the California Dust Investigation

Instruments Used in Pilot Study

Horizontal and Vertical Profiles

Measurement Result Examples

Model Calculations

Concentration

Size

Complex Refractive Index

Comparisons

Summary

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Introduction

Research Project: Evaluation of Geologic Dust Entrainment, Removal and Transport Mechanisms

Objective: Investigate the discrepancies between ambient geologic dust measurements and the contributions to source inventories for PM10 and PM2.5.

University of California
College of Engineering
Center for Environmental Research and Technology (CECERT)
Riverside, CA

Dr. Dennis Fitz

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Electrical Engineering Department
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Dr. Russell Philbrick

Pilot Study – Conducted 12-18 December 2000

Main Investigation – Planned 29 July – 17 August 2001

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Field Site

Field site located 5 miles east of Riverside CA – university farm station

Instrumented Tower

Meteorology properties and particle density and size
Measured at several locations

LIDAR

Scanning Lidar measures particle distributions

Nd:YLF 1047 nm – 523 nm

5-10 μ j pulses 1-10 kHz

30 meter range resolution

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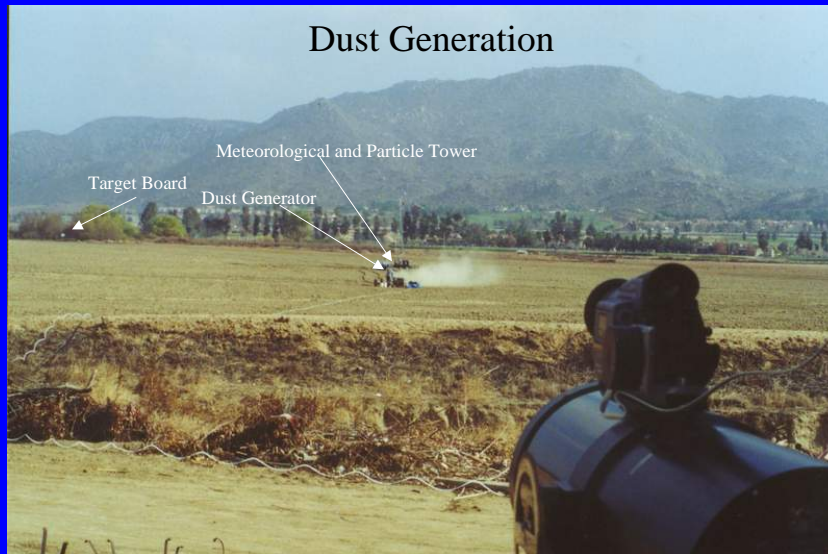
**Portable Digital Lidar (Dual Wavelength with Scanner)
System Specifications**

Operating Environment Controlled Indoor
Detection Range 30 - 60 km
Laser (dual wavelength) DPSS:Nd:YLF (523.5 nm/1047 nm)
Laser Control Remote Set or RS232
Average Energy VIS: >5 :J/pulse NIR: >10 :J/pulse
Pulse Repetition Rate (pulse duration) 1 - 10 kHz (10 ns)
Cassegrain Telescope Diameter (F.O.V.) 0.2 m (- 100 :rad)
Detector APD Photon Counting Module
Scanning Mode Sweep or Stay and Stare
Horizontal Scanning (vertical swiveling) $\pm 90^\circ$ (0/ - 90/)
Scanning Speed per sec Variable from 0.1/ to 30/
Optical Transceiver Dimensions (weight) 33" x 14" x 12" (40 lbs)
Computer Desktop or Laptop PC
Software Windows 95/98 based software
Dual Multichannel Scaler (dimensions) Rack-mountable (19" x 14" x 7")
Data Averaging Time Adjustable from 1 sec to 1 hour
Range Resolution 30 m, 75 m, 150 m, 300 m

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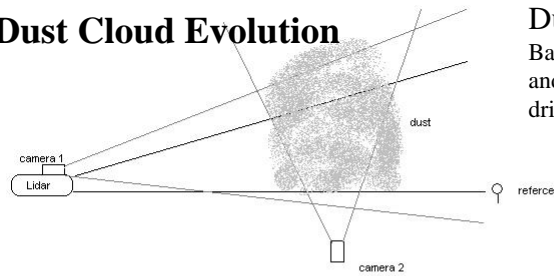
**Evaluation of Geologic Dust – California – Dec 2000
Scanning Micro-pulse Lidar**



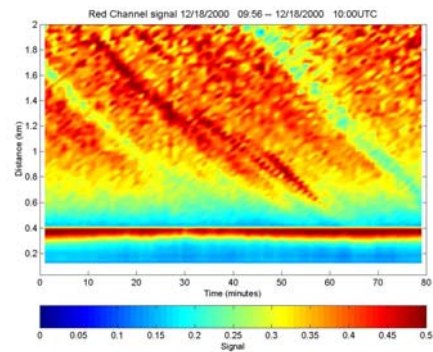
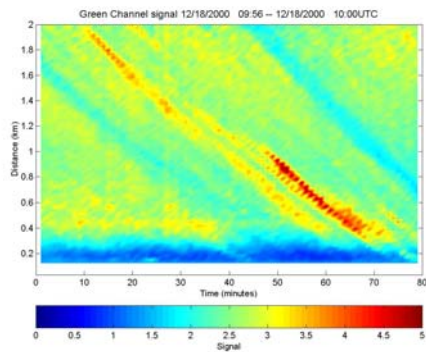
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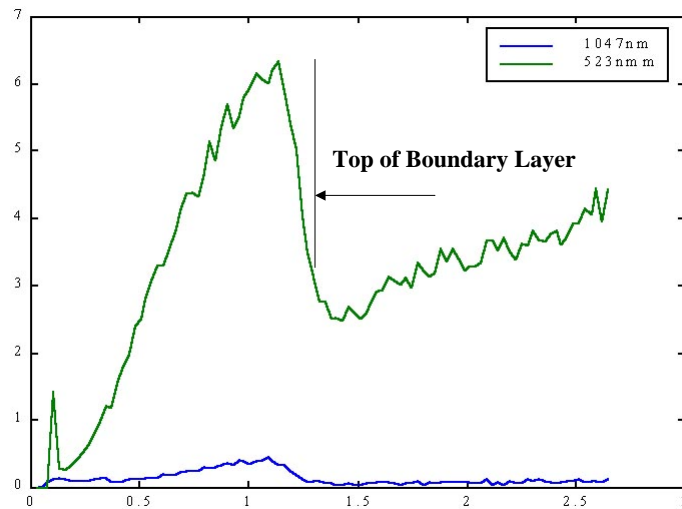
Dust Cloud Evolution



Dust Cloud Evolution
Backscatter from Green (523 nm)
and Red (1047 nm) during 1 hour
drift



Vertical Extinction Profiles

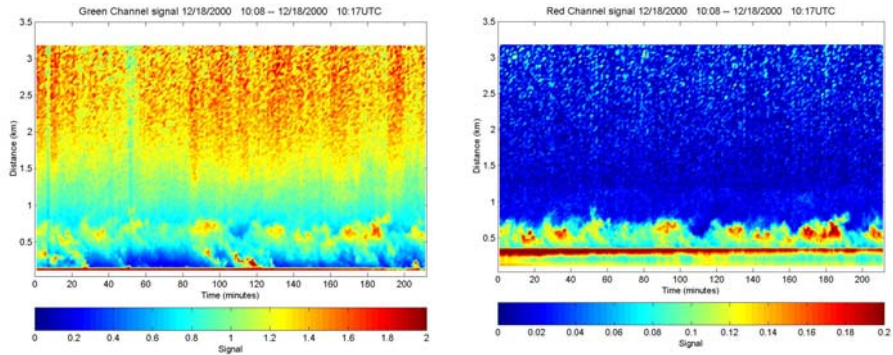


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Vertical Profiles

Time sequence of vertical profile (75 degree elevation) during wind storm on 18 December 2000



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T = 1 sec



T = 30 sec

California Dust Generation Experiment – Dec 2000
Dust Generation Test #2 – 5.5 kg soil

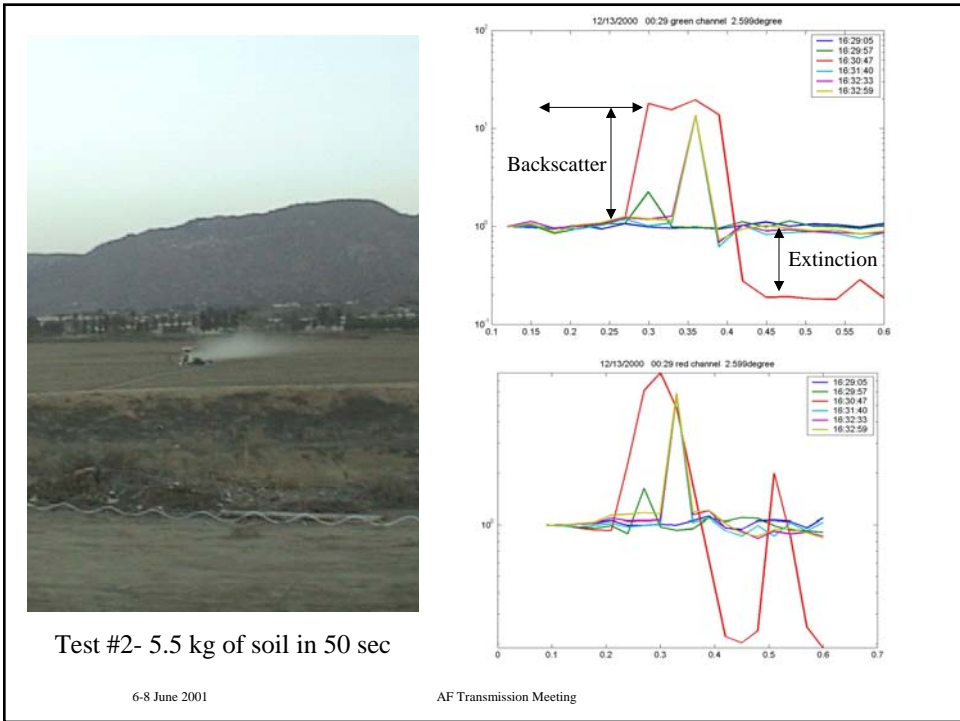
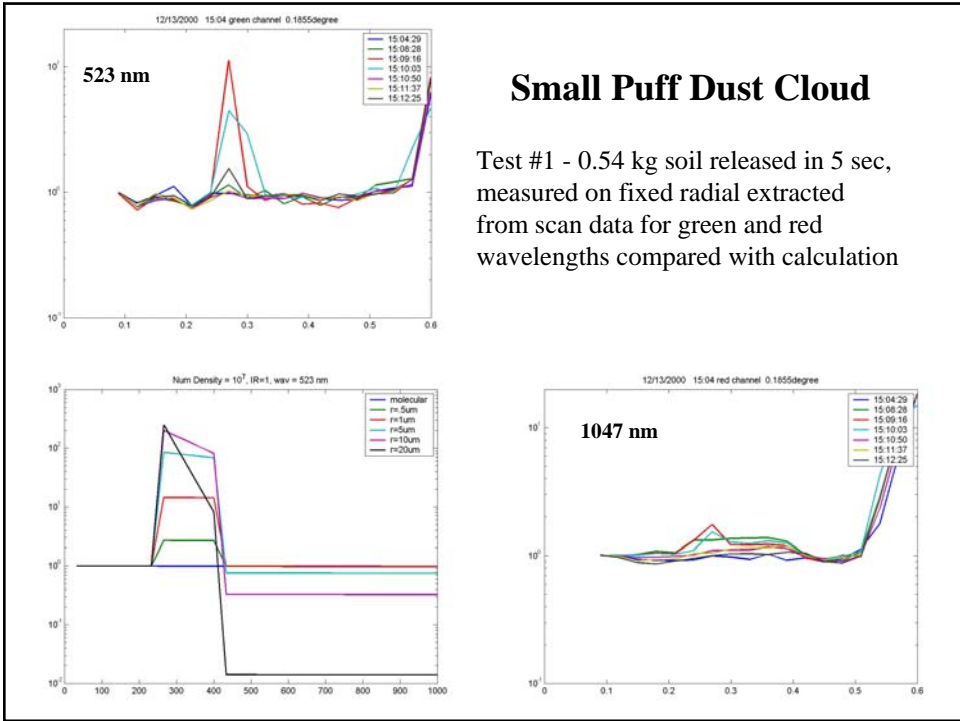
T = 60 sec



T = 90 sec

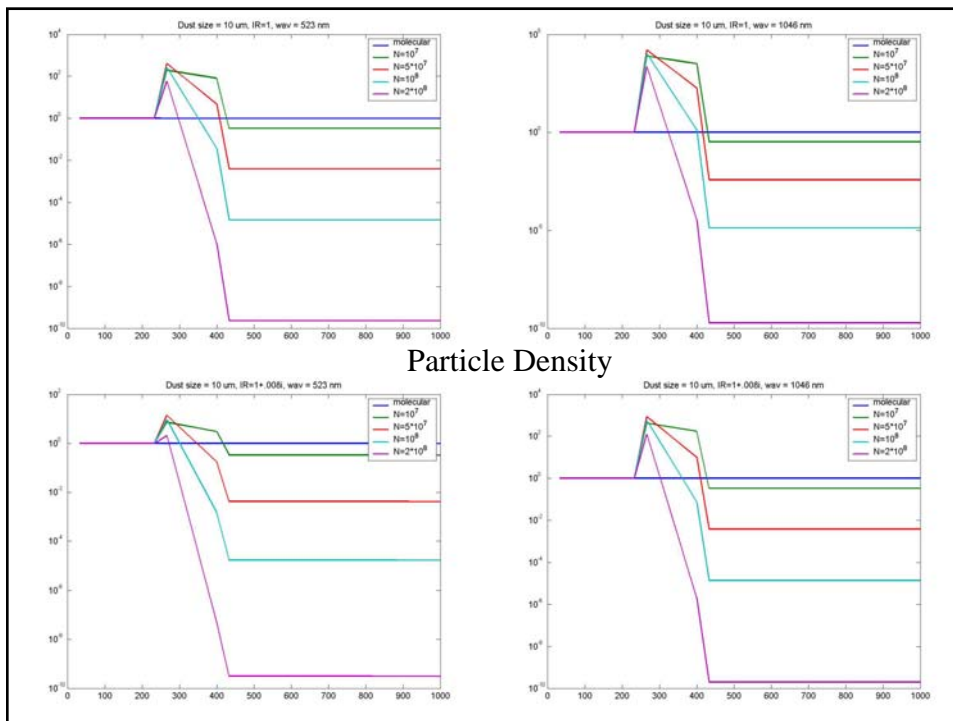
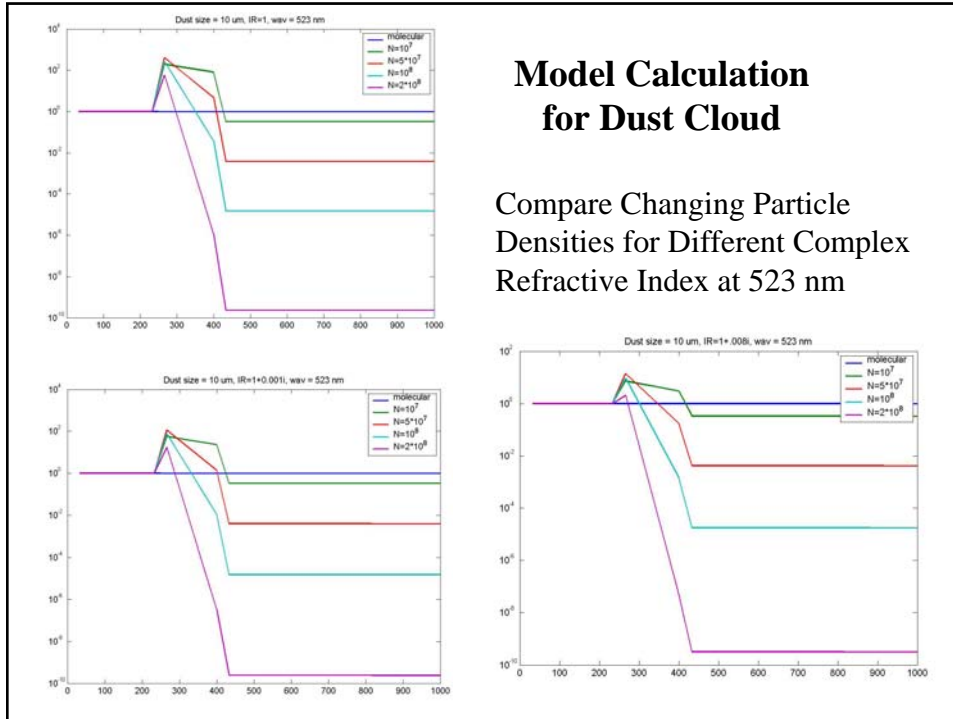
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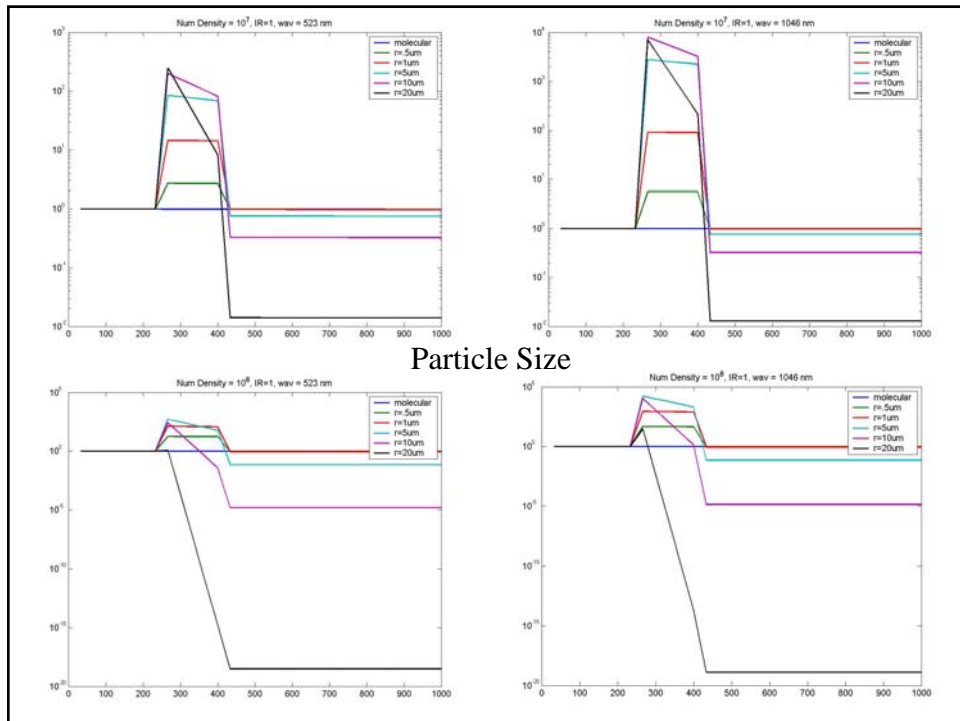
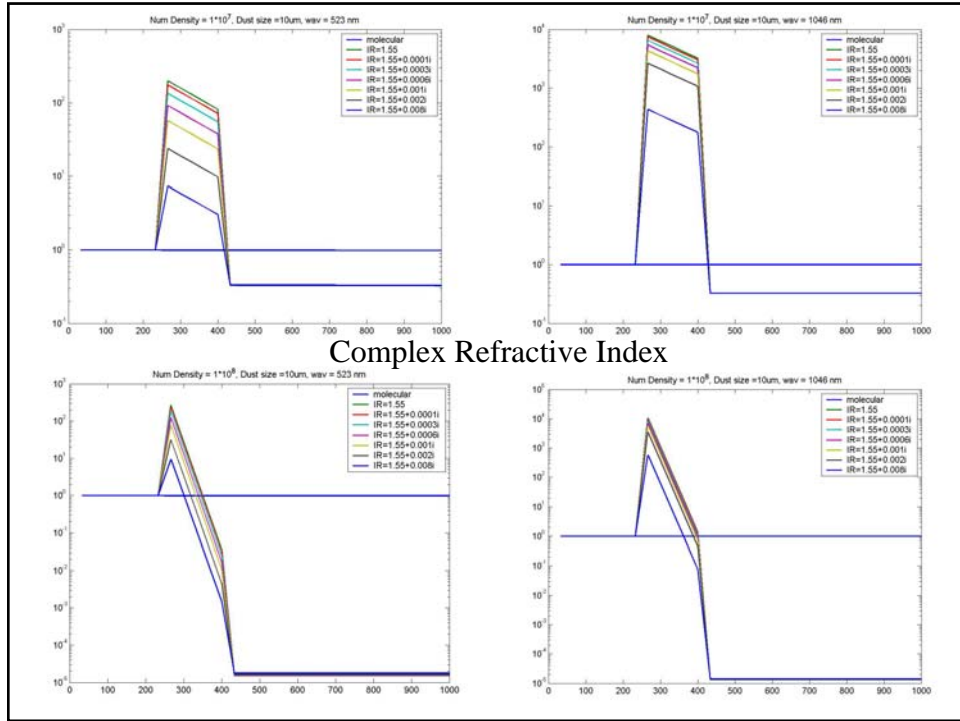


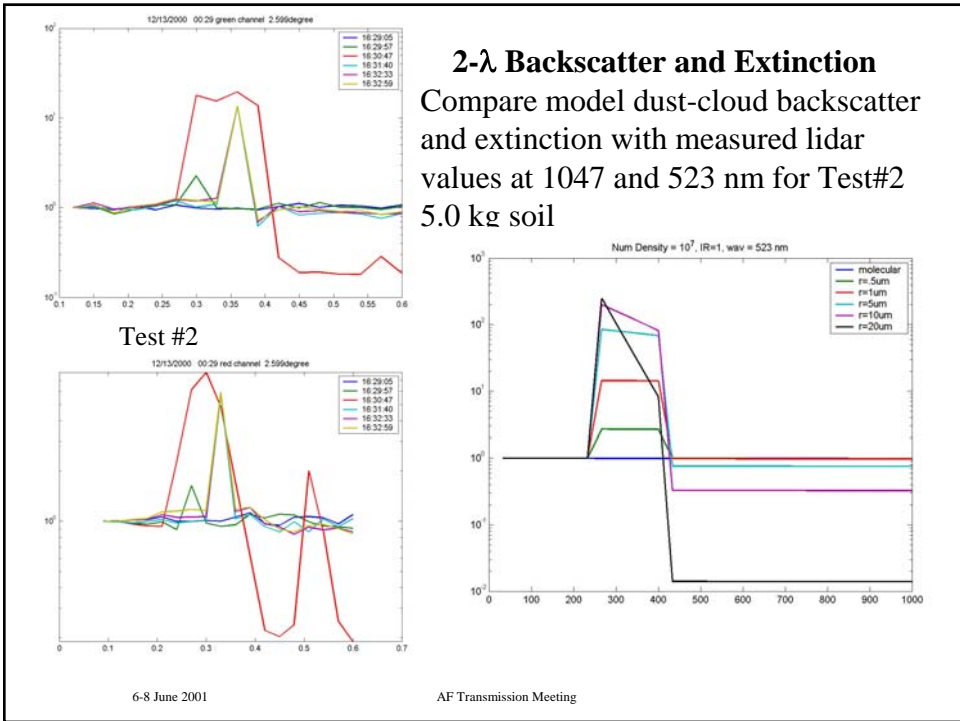
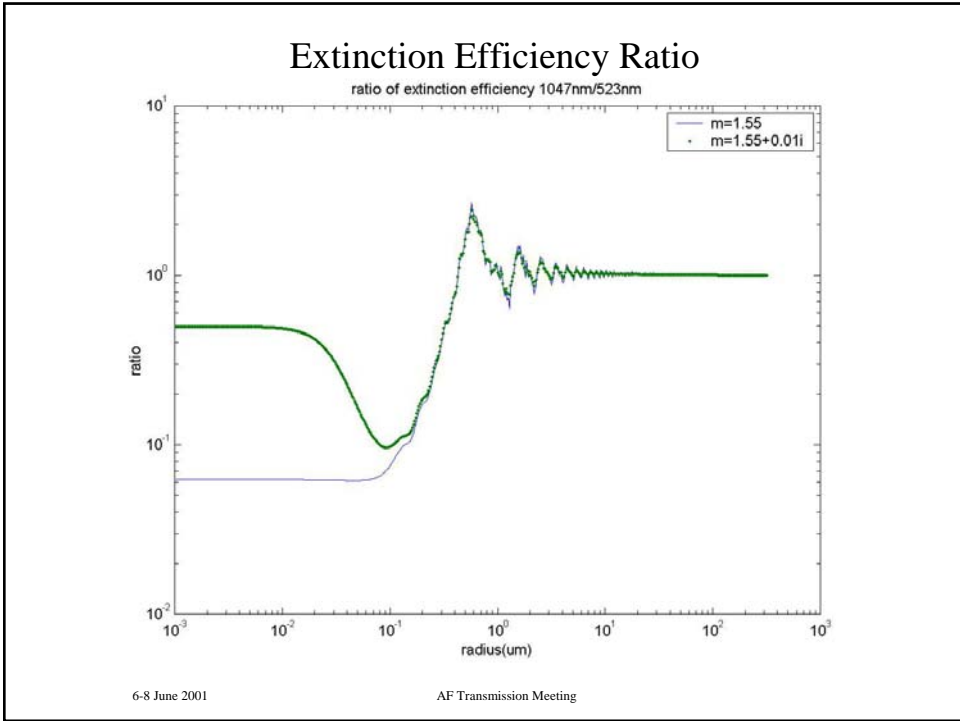
Model Calculation for Dust Cloud

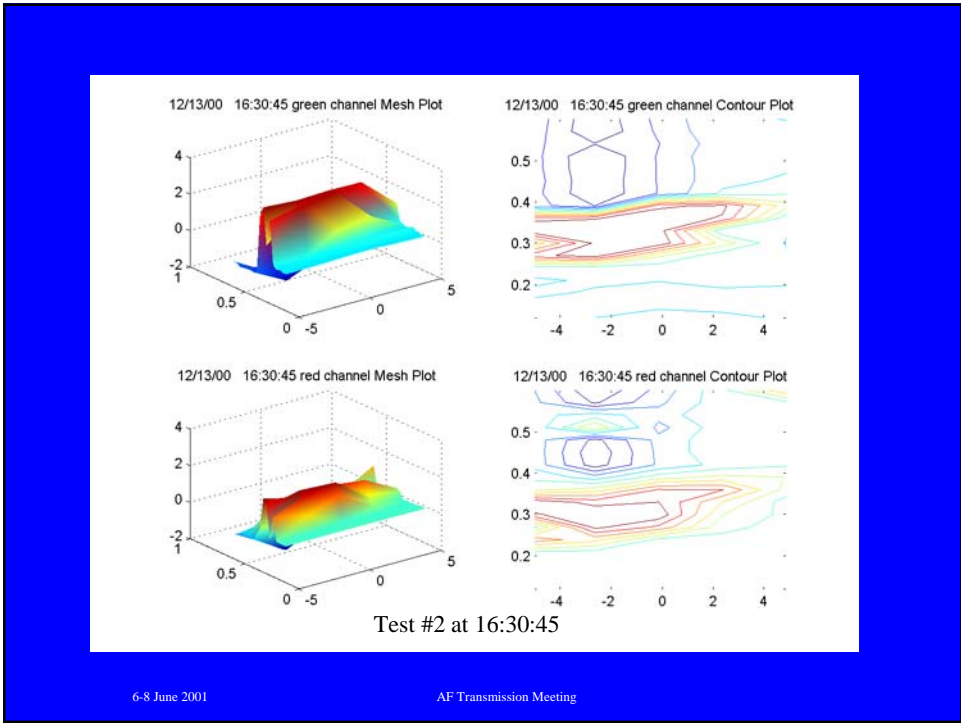
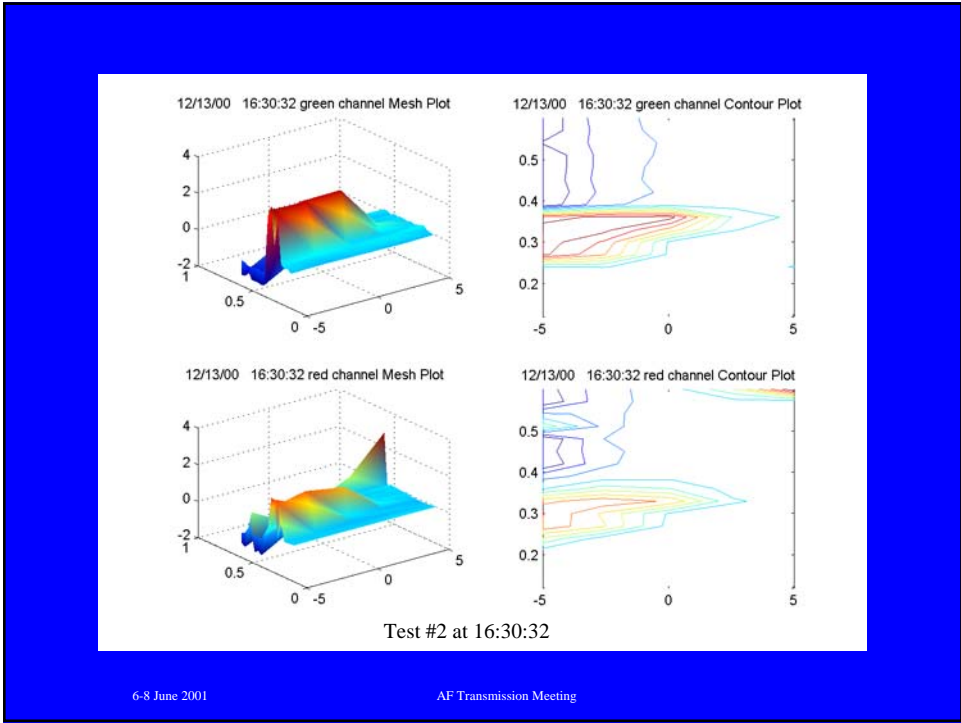
Compare Changing Particle
Densities for Different Complex
Refractive Index at 523 nm

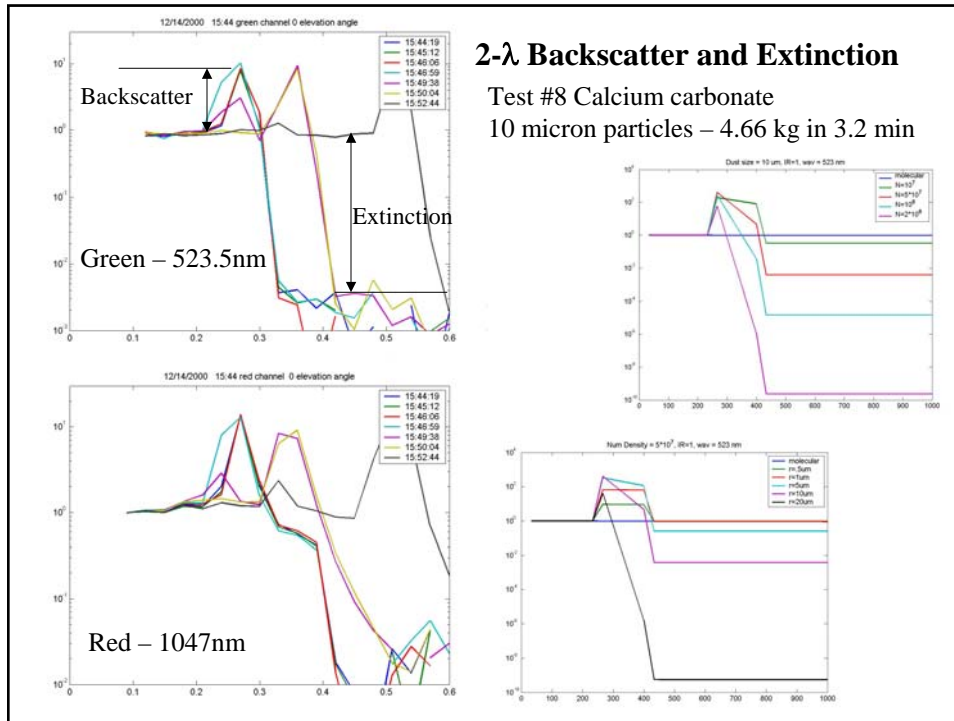



Particle Density











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Summary

- Simple model for optical scattering compares favorably
- Extinction can be measured beyond the generated cloud
- Backscatter/Extinction sensitive to size in 0.1-1.0 μ
- August 2001 tests are planned to confirm optical scattering analysis and describe dust cloud evolution
- Investigations continue on the calculations needed to describe the scattering of dust with T-matrix and other approaches

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