

PENNS^TATE



Airborne Dust and Aerosols Description Using Lidar Backscatter

Guangkun Li, Sachin J. Verghese and C. Russell Philbrick
Penn State University, Department of Electrical Engineering
and
Dennis Fitz and David Pankratz
University of California at Riverside, CERT

25th Annual Conference on Atmospheric Transmission and Radiance Models
The Museum of Our National Heritage
Lexington, MA
25-27 June 2002

PENNS^TATE



Outline

Introduction to the California Dust Investigation
Instruments Used
Chamber Tests
Measurement Result Examples
Model Calculations
Comparisons
Summary

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

Penn State University
Electrical Engineering Department
University Park, PA

Dr. Russell Philbrick

Pilot Study – Conducted 12-18 December 2000

Main Investigation – Conducted 10 - 20 December 2001

25-27 June 2002

25th Conference on Atmospheric Transmission

3



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

25-27 June 2002

25th Conference on Atmospheric Transmission

4

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

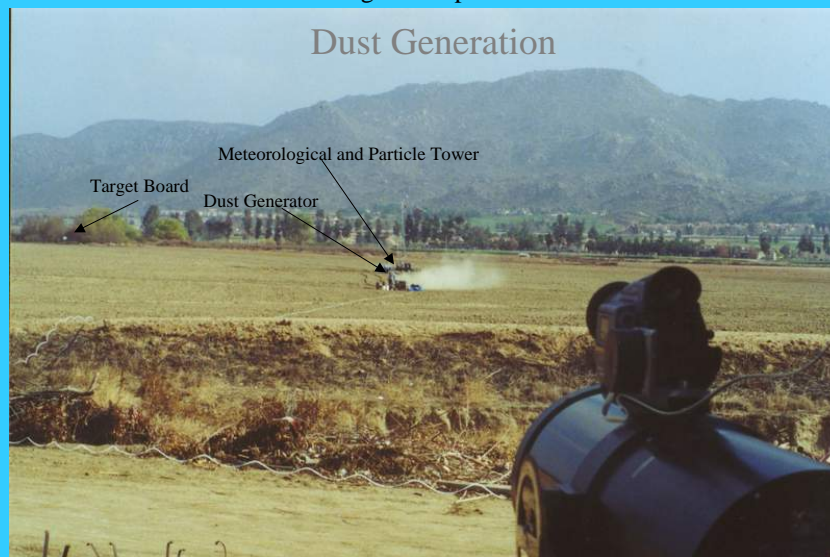
Operating Environment Controlled Indoor
Detection Range 30 - 60 km
Laser (dual wavelength) DPSS:Nd:YLF (523.5 nm/1047 nm)
Laser Control Remote Set or RS232
Average Energy VIS: >5 μ J/pulse NIR: >10 μ J/pulse
Pulse Repetition Rate (pulse duration) 1 - 10 kHz (10 ns)
Cassegrain Telescope Diameter (F.O.V.) 0.2 m (- 100 μ rad)
Detector APD Photon Counting Module
Scanning Mode Sweep or Stay and Stare
Horizontal Scanning (vertical swiveling) $\pm 90^\circ$ (0 $^\circ$ - 90 $^\circ$)
Scanning Speed per sec Variable from 0.1 $^\circ$ to 30 $^\circ$
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

25-27 June 2002

25th Conference on Atmospheric Transmission

5

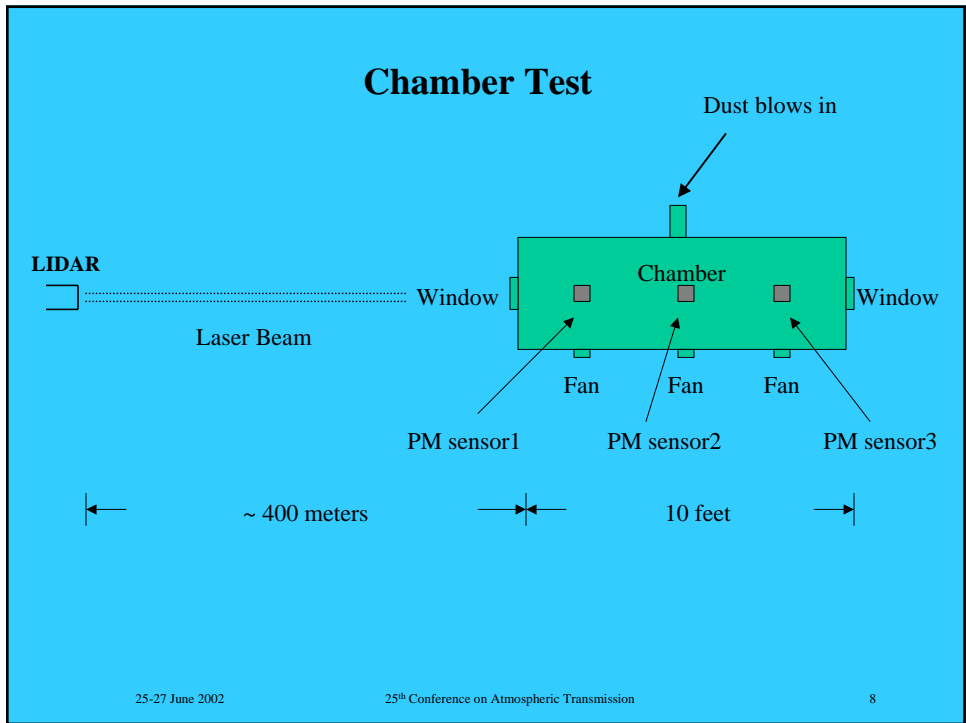
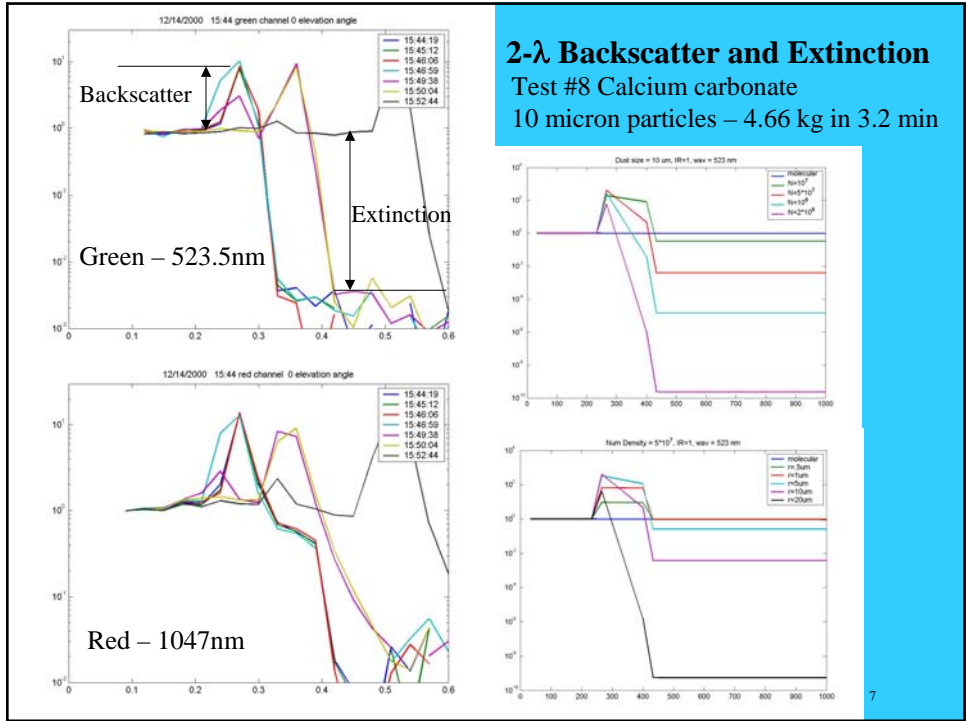
**Evaluation of Geologic Dust – California – Dec 2000
Scanning Micro-pulse Lidar**

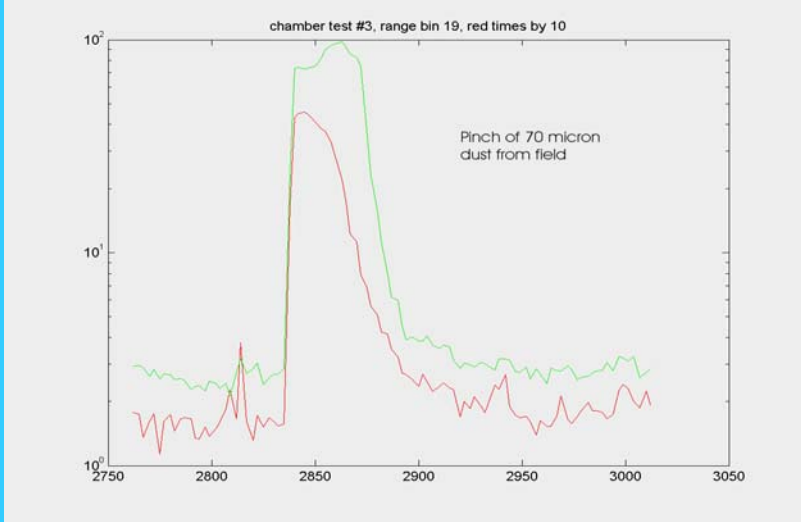


25-27 June 2002

25th Conference on Atmospheric Transmission

6

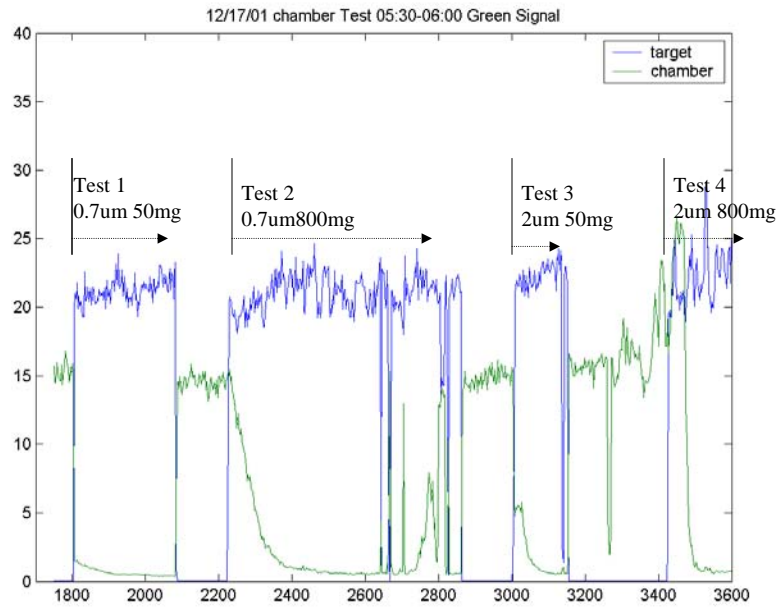




25-27 June 2002

25th Conference on Atmospheric Transmission

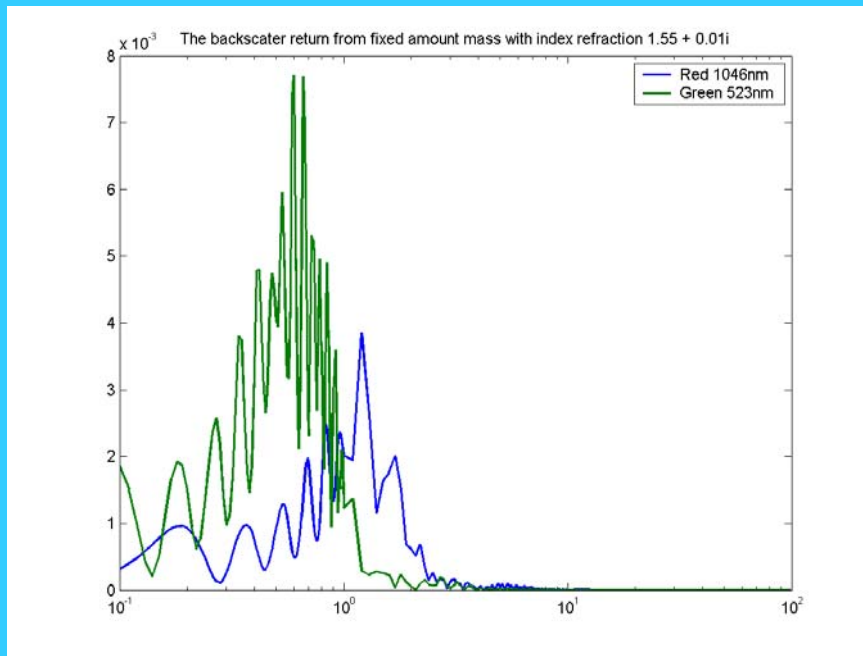
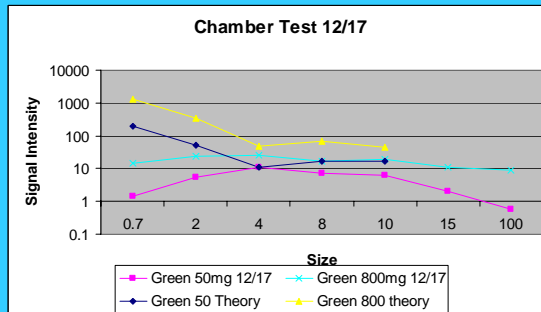
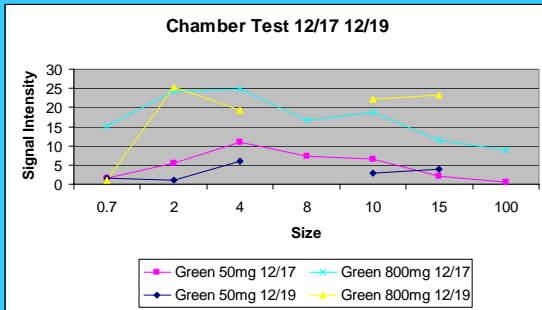
9

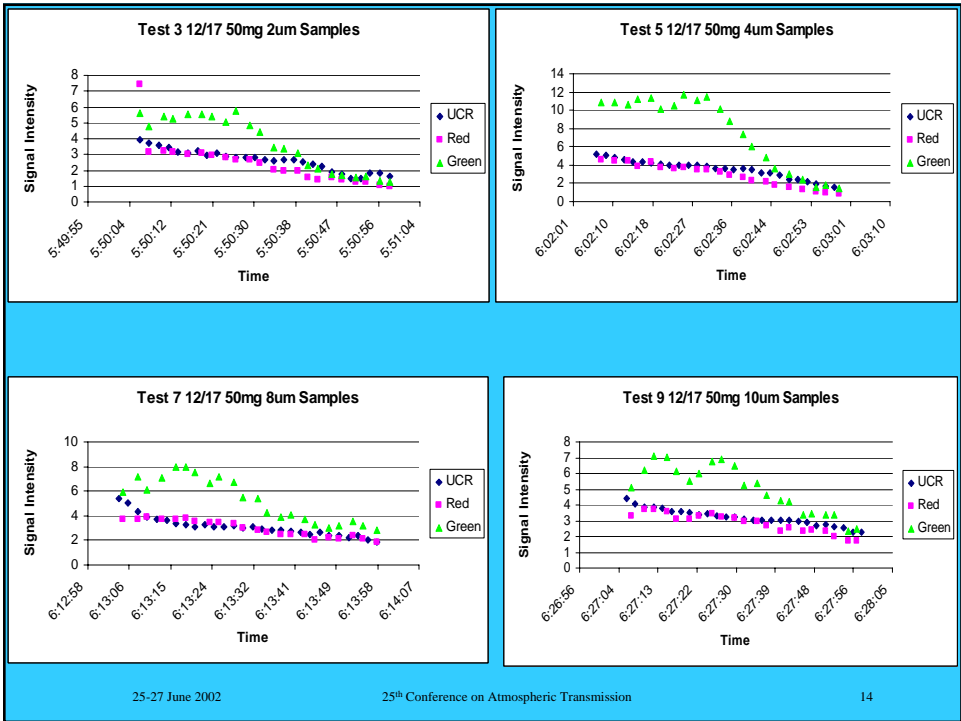
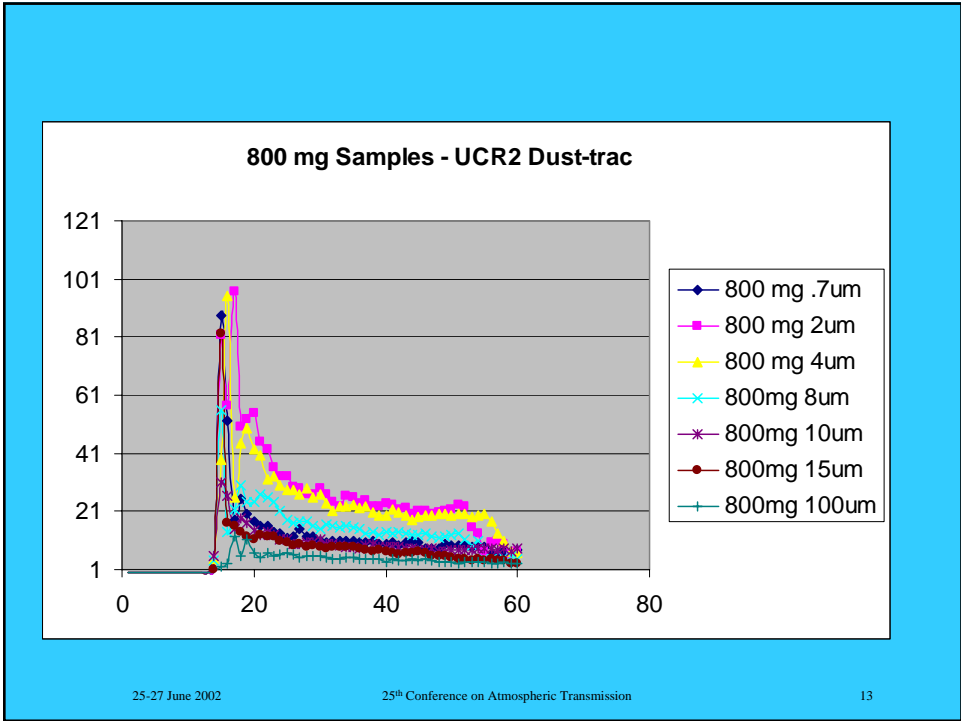


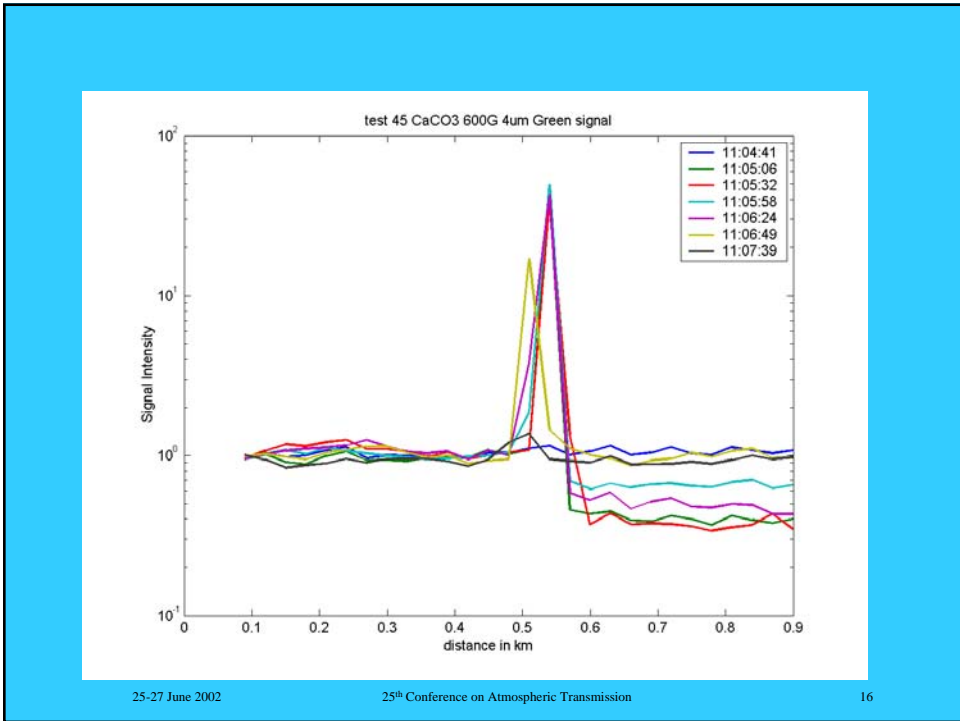
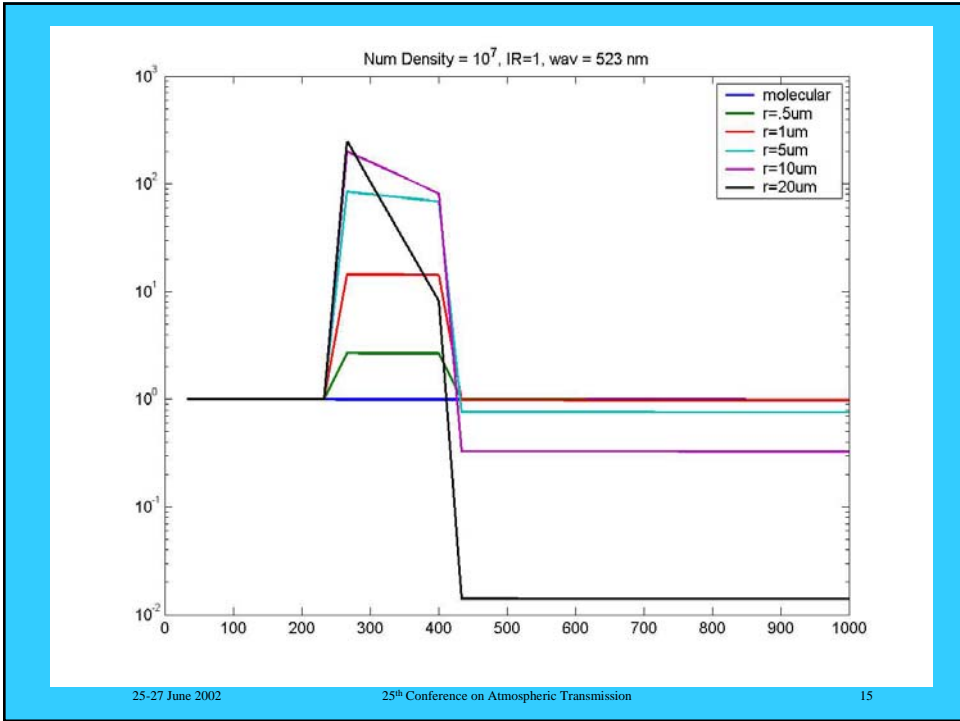
25-27 June 2002

25th Conference on Atmospheric Transmission

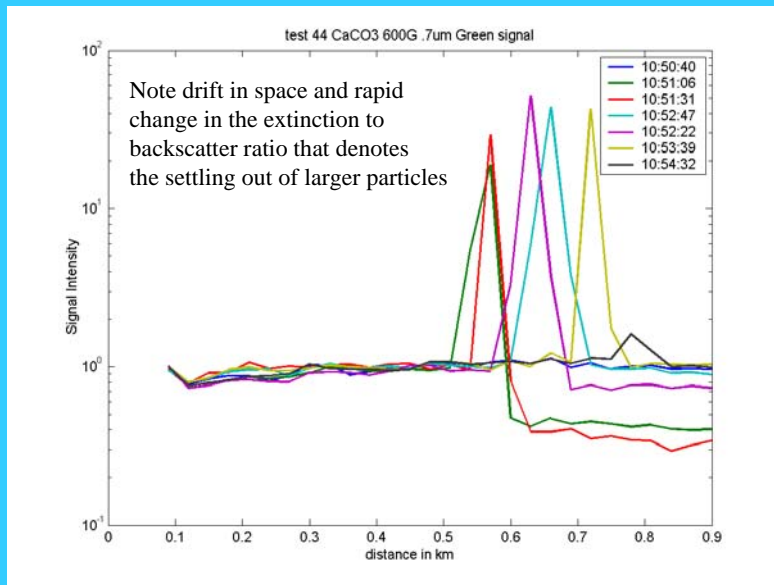
10



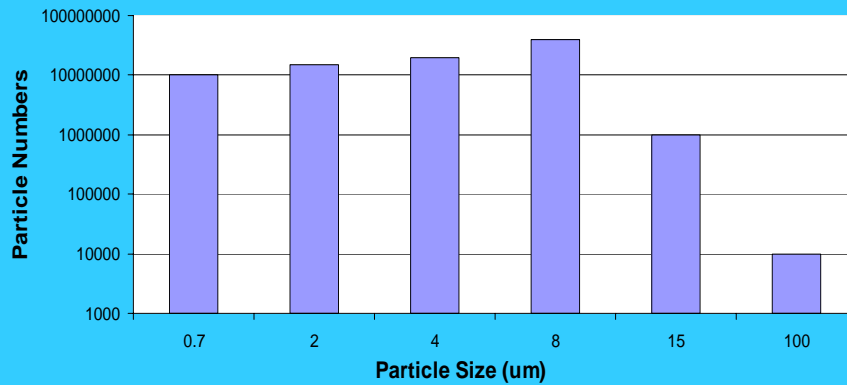




Time Evolution of Plume

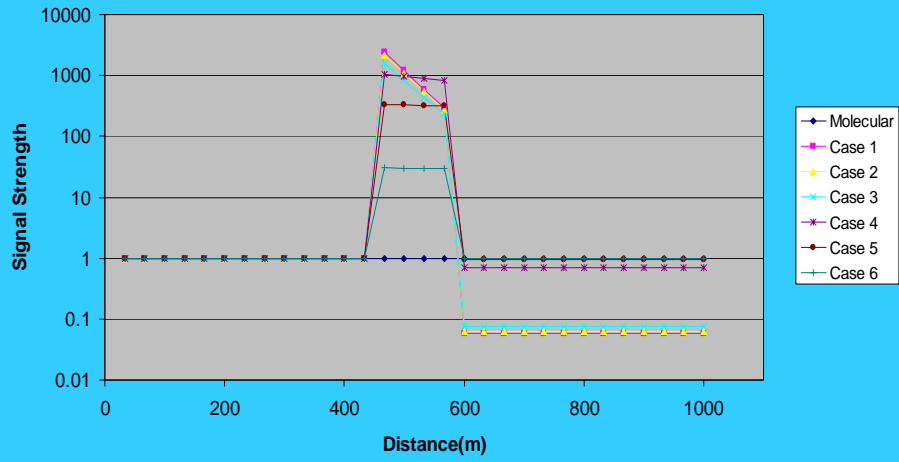


Particle Size Distribution



Case 1: Particle size distribution from 0.7um to 10um; Case 2: The 100um was settling out; Case 3: 15 um was settling out; Case 4: 8um was settling out; Case 5: 4um was settling out; Case 2 um was settling out

Simulated Results of Backscatter from LIDAR with Large Particles Settling Out Step by Step (Green Signal 523nm)

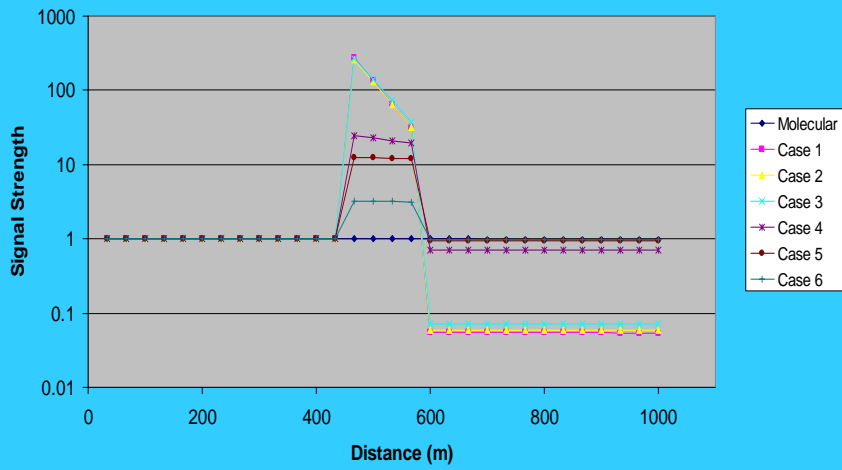


25-27 June 2002

25th Conference on Atmospheric Transmission

19

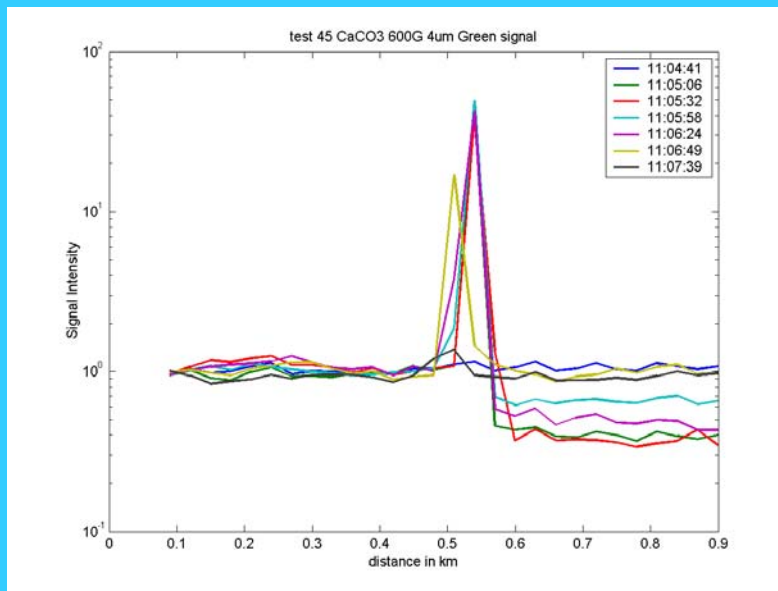
Simulated Results of Backscatter from LIDAR with Large Particles Settling Out Step by Step (Red Signal 1046nm)



25-27 June 2002

25th Conference on Atmospheric Transmission

20



25-27 June 2002

25th Conference on Atmospheric Transmission

21



Summary

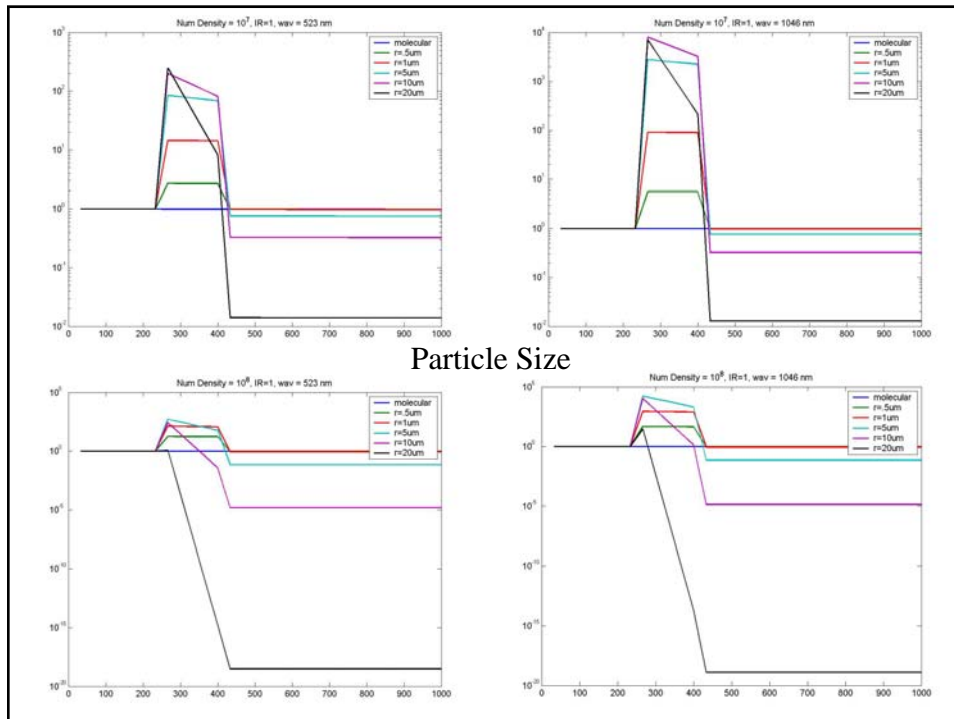
- Simple model for optical scattering compares favorably
- Extinction can be measured beyond the generated cloud
- Chamber Tests have been used to examine the backscatter versus particle size
- Lidar can be used to measure the settling rate and residence time for various components of the airborne particles in the atmosphere
- Investigations continue on the calculations needed to describe the scattering of dust with T-matrix and other approaches

22

25-27 June 2002

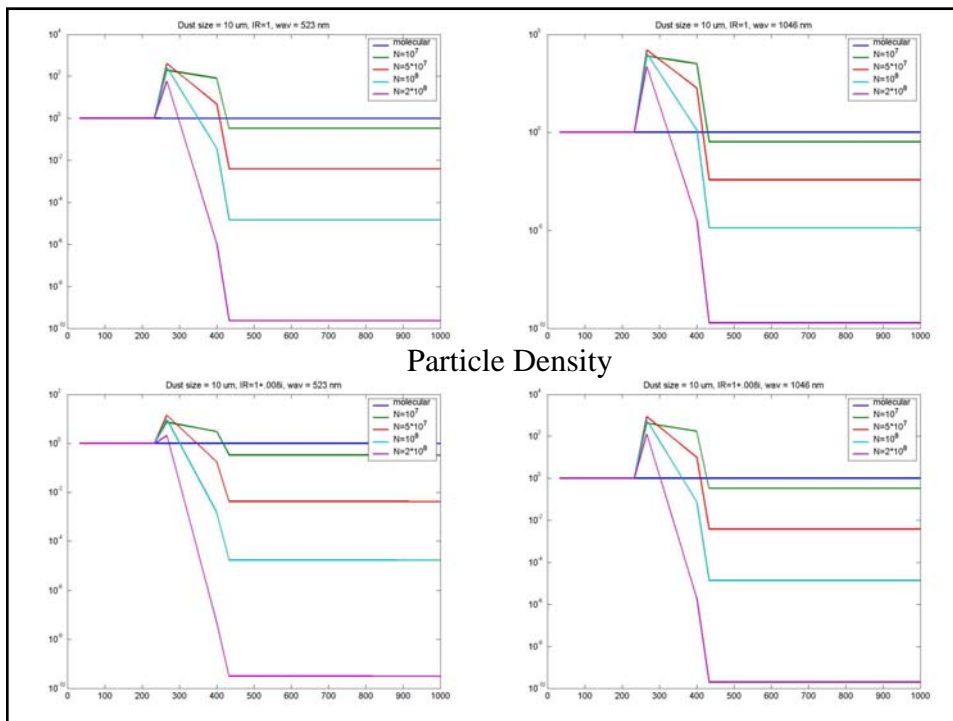
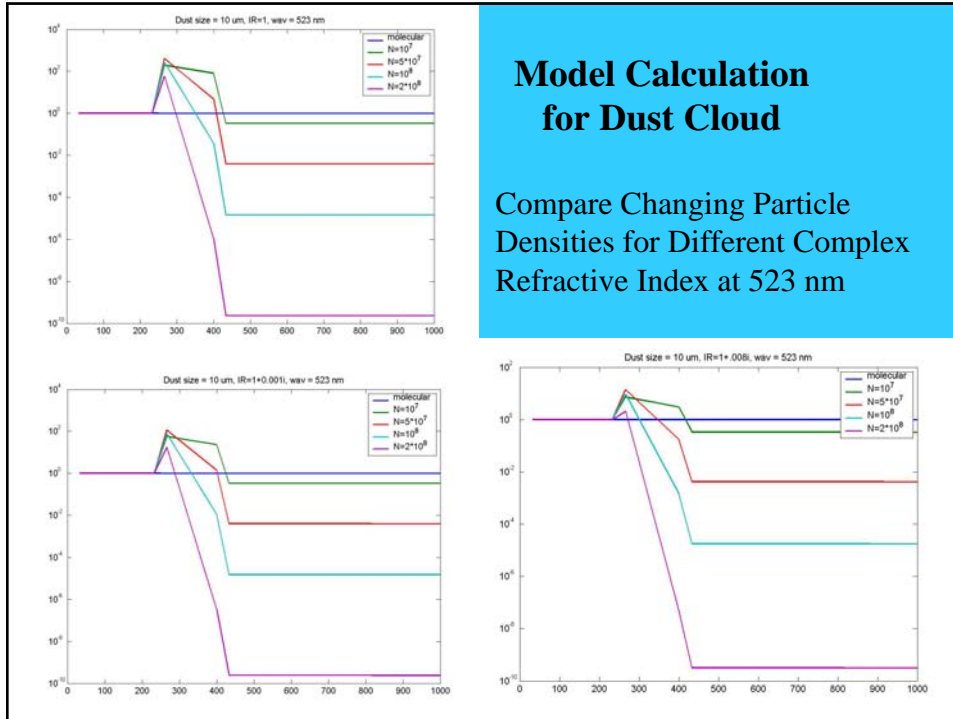
25th Conference on Atmospheric Transmission

22

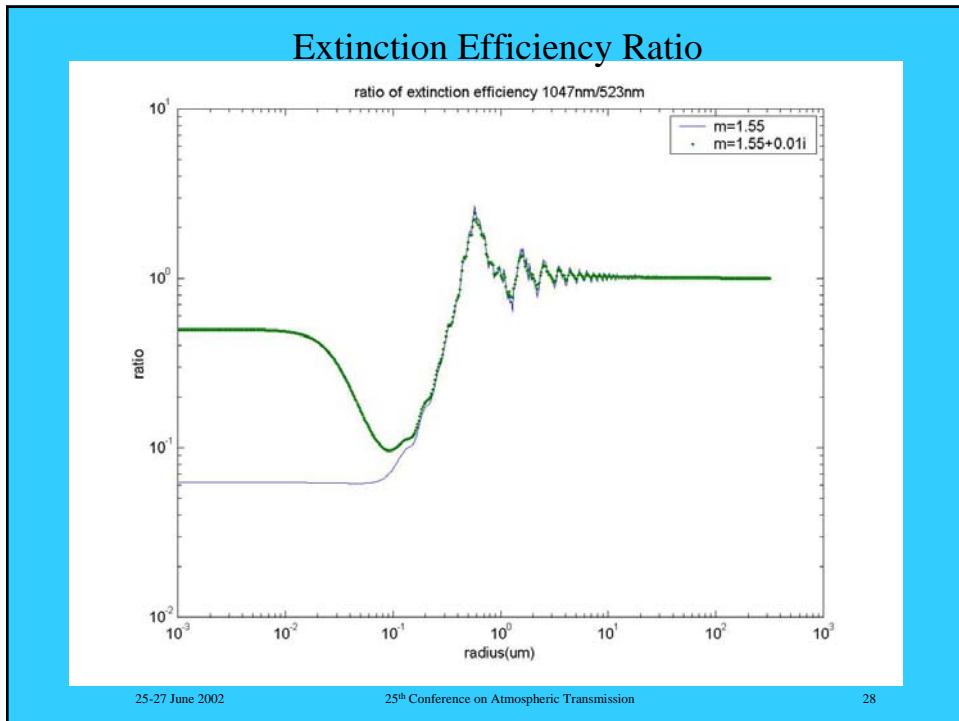
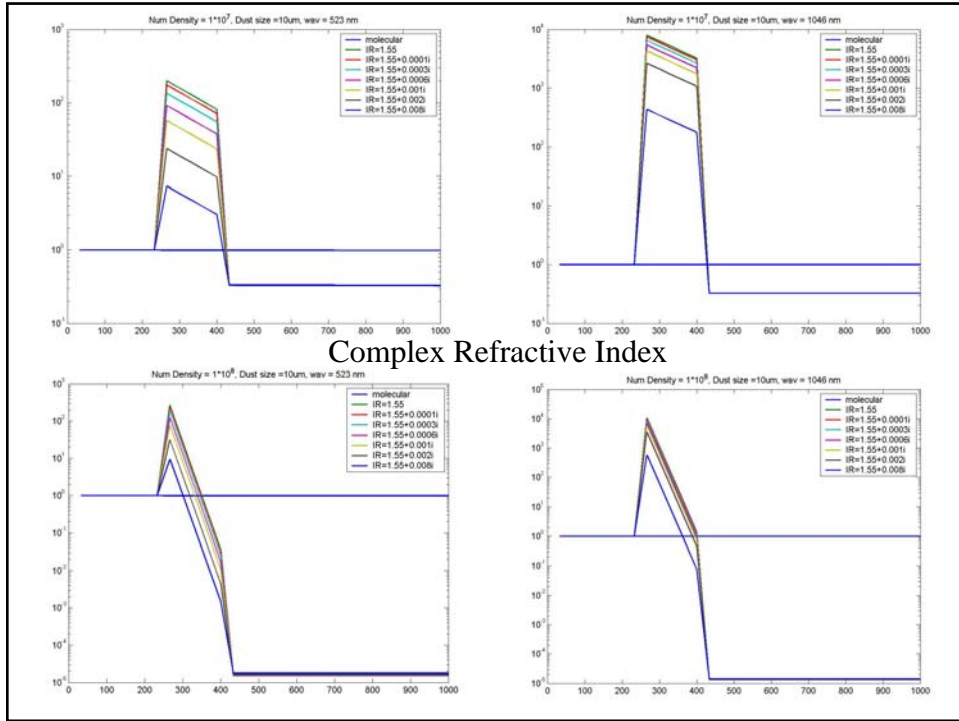


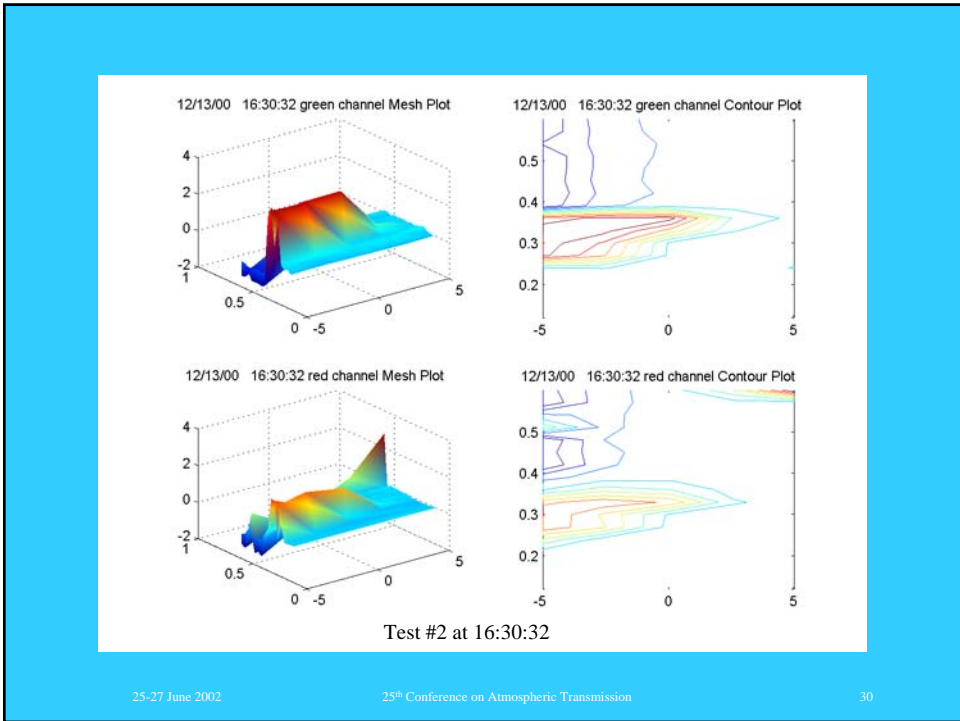
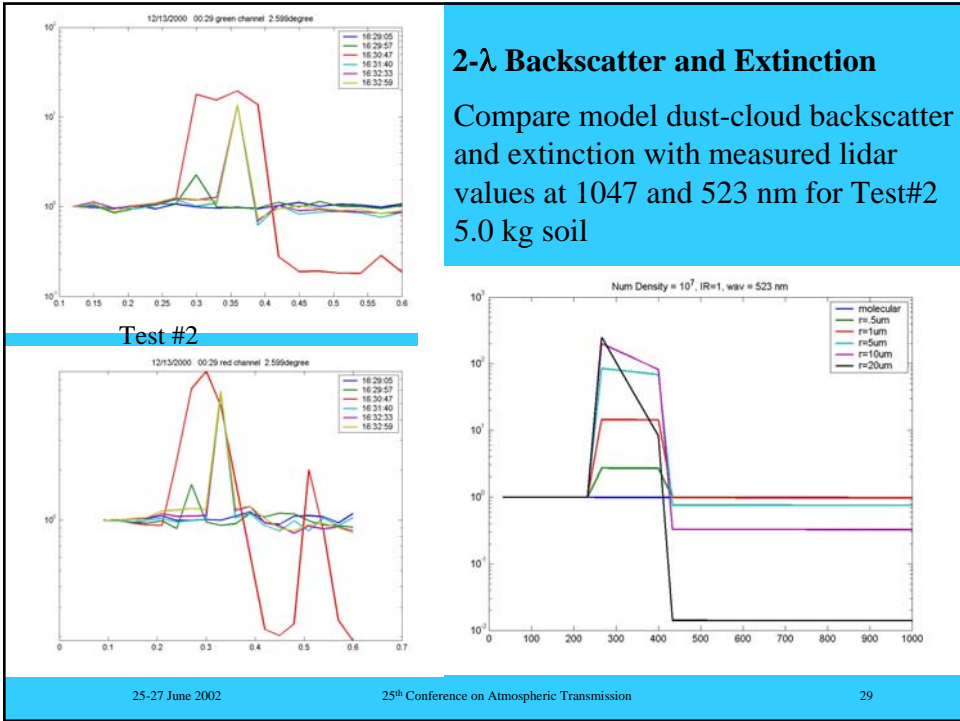
Model Calculation for Dust Cloud

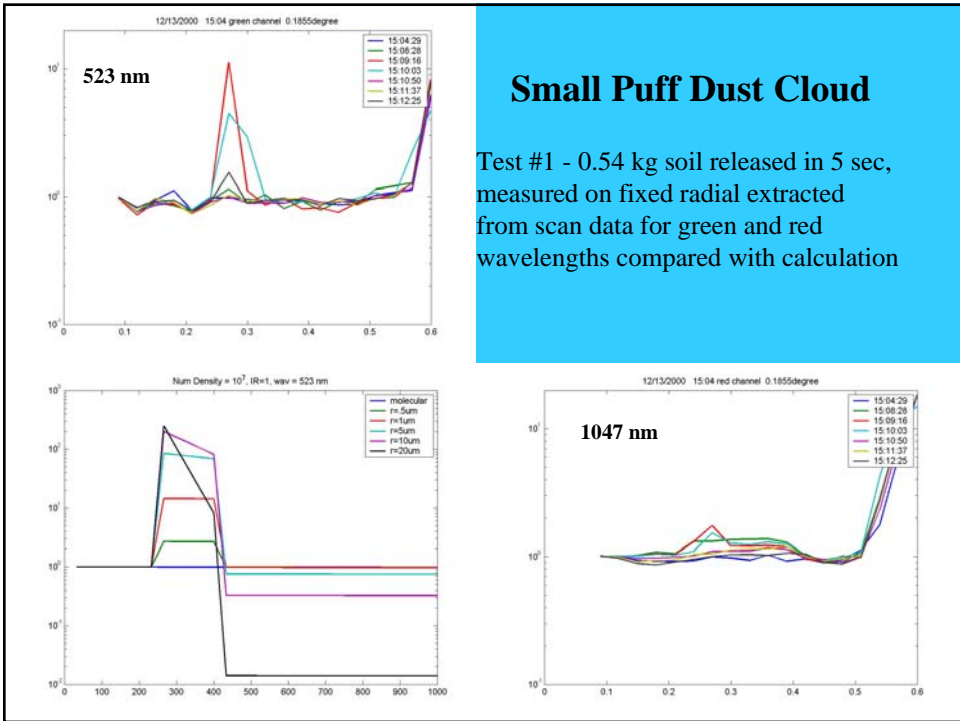
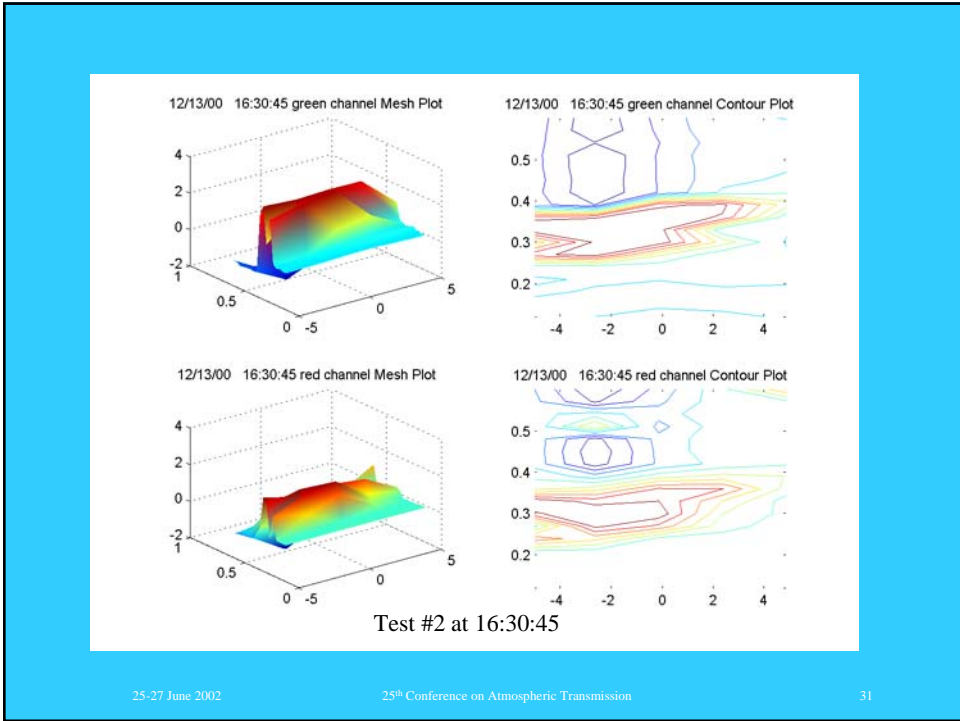
Compare Changing Particle
Densities for Different Complex
Refractive Index at 523 nm



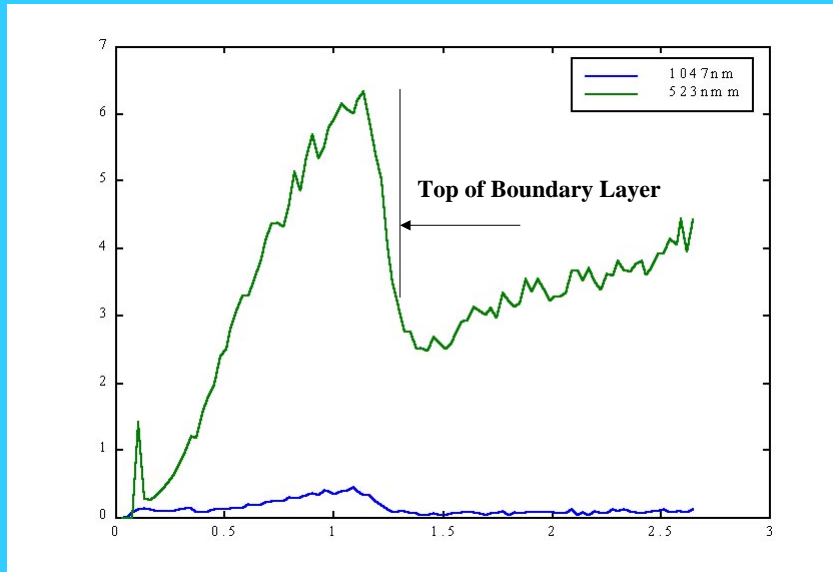
Particle Density







Vertical Extinction Profiles



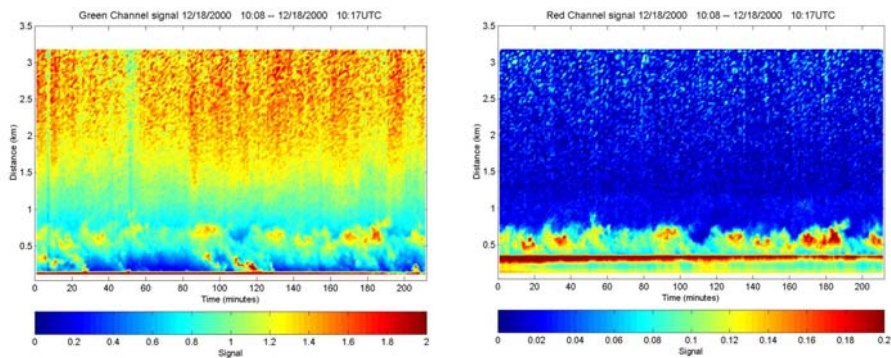
25-27 June 2002

25th Conference on Atmospheric Transmission

33

Vertical Profiles

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



25-27 June 2002

25th Conference on Atmospheric Transmission

34

