Raman Lidar Retrievals

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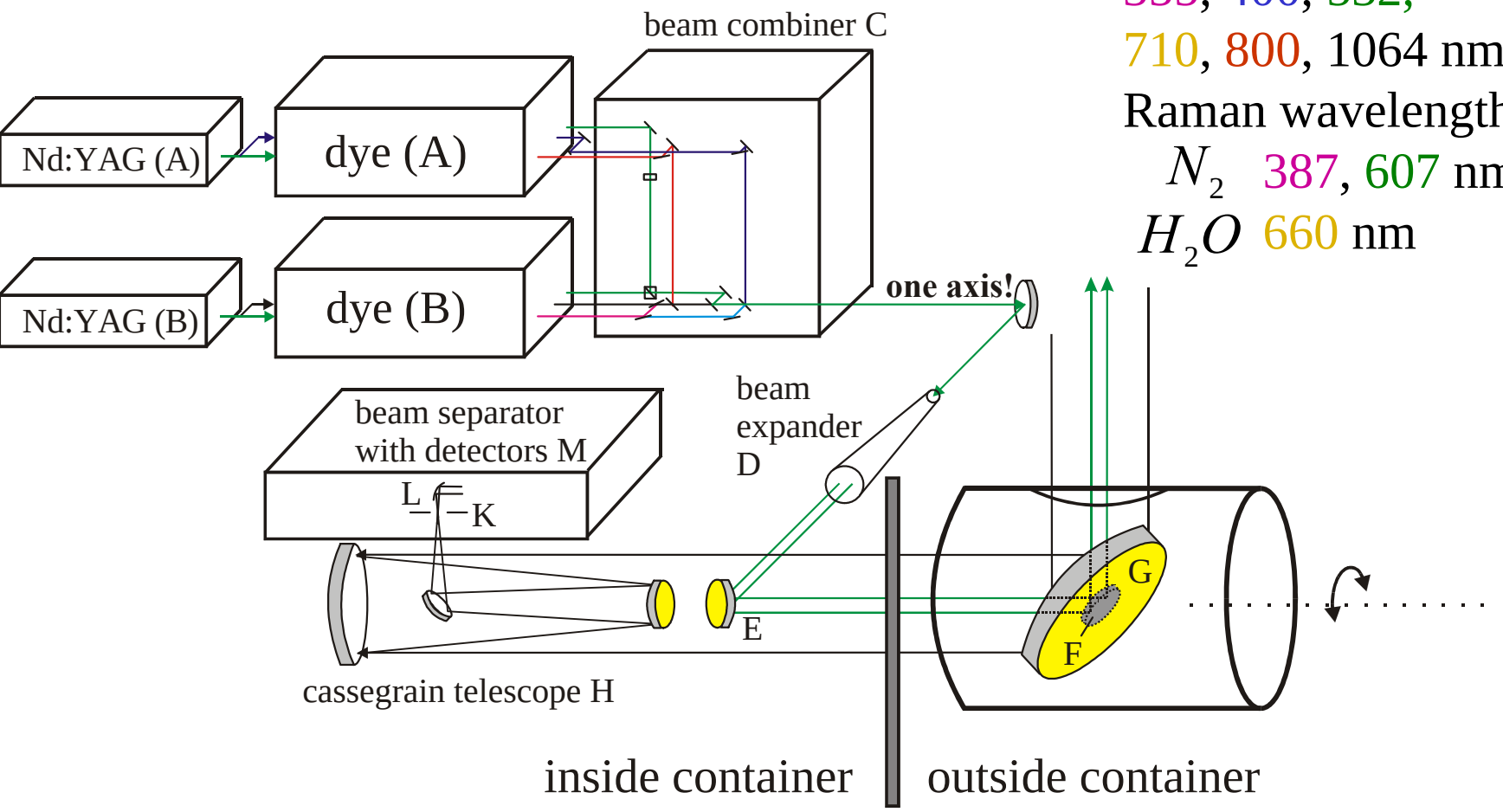
Six-Wavelength Lidar

(Althausen et al., J. Atmos. Oceanic Technol., 17, 1469-1482, 2000)

laser wavelengths:
355, 400, 532,
710, 800, 1064 nm
Raman wavelengths:
N_2 387, 607 nm
H_2O 660 nm



RETRIEVAL OF PHYSICAL PARTICLE PARAMETERS

INPUT

- backscatter coefficients at: 355, 400,532, 710, 800, 1064 nm
- extinction coefficients: 355, 532 nm
- base functions
- MIE backscatter and extinction efficiencies

INVERSION WITH REGULARIZATION

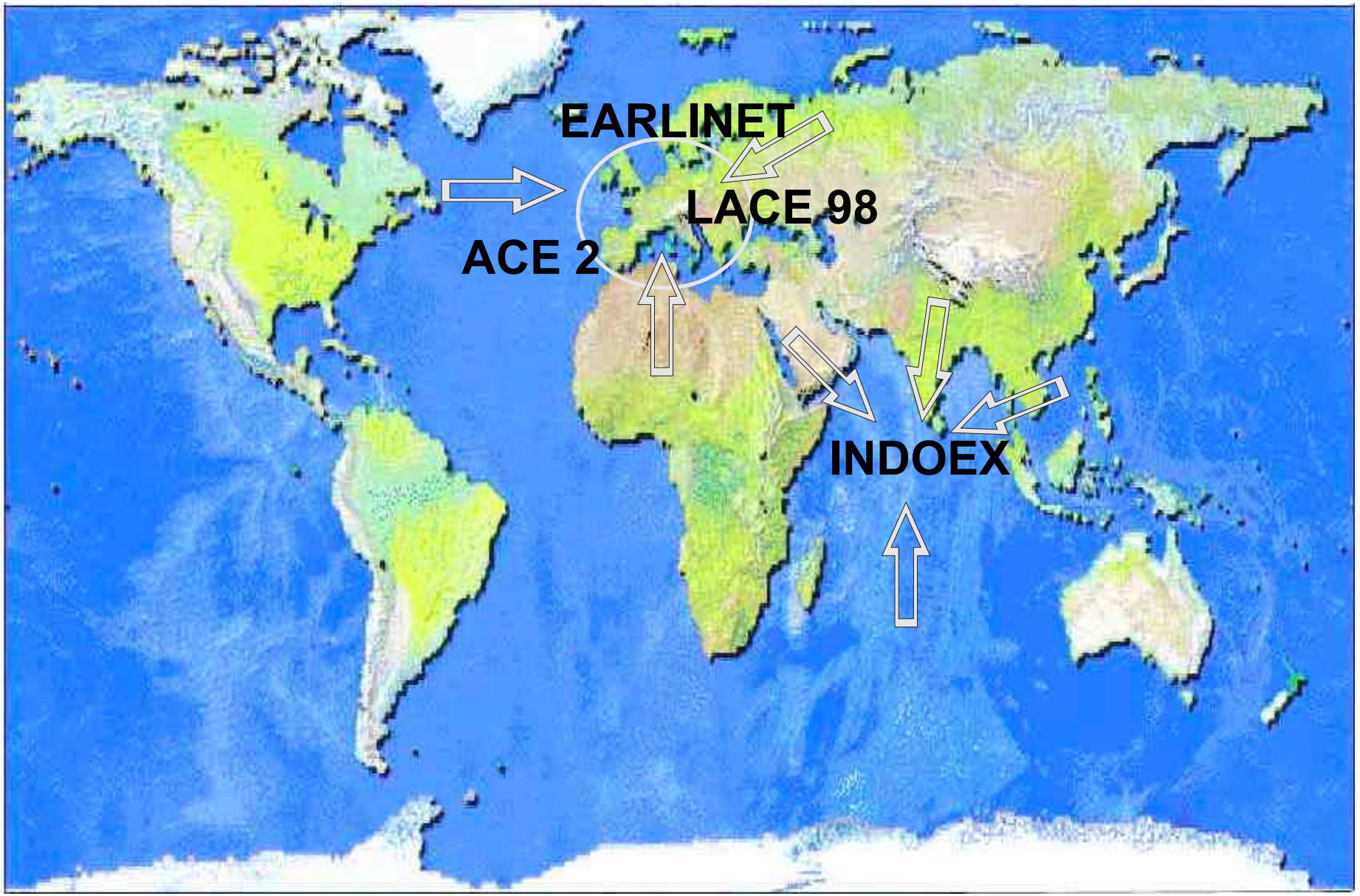
- independent of shape of particle size distribution
- no knowledge on refractive index necessary
- works for wide range of particle parameters: 0.1 μm < r_{eff} < 1.5 μm

OUTPUT

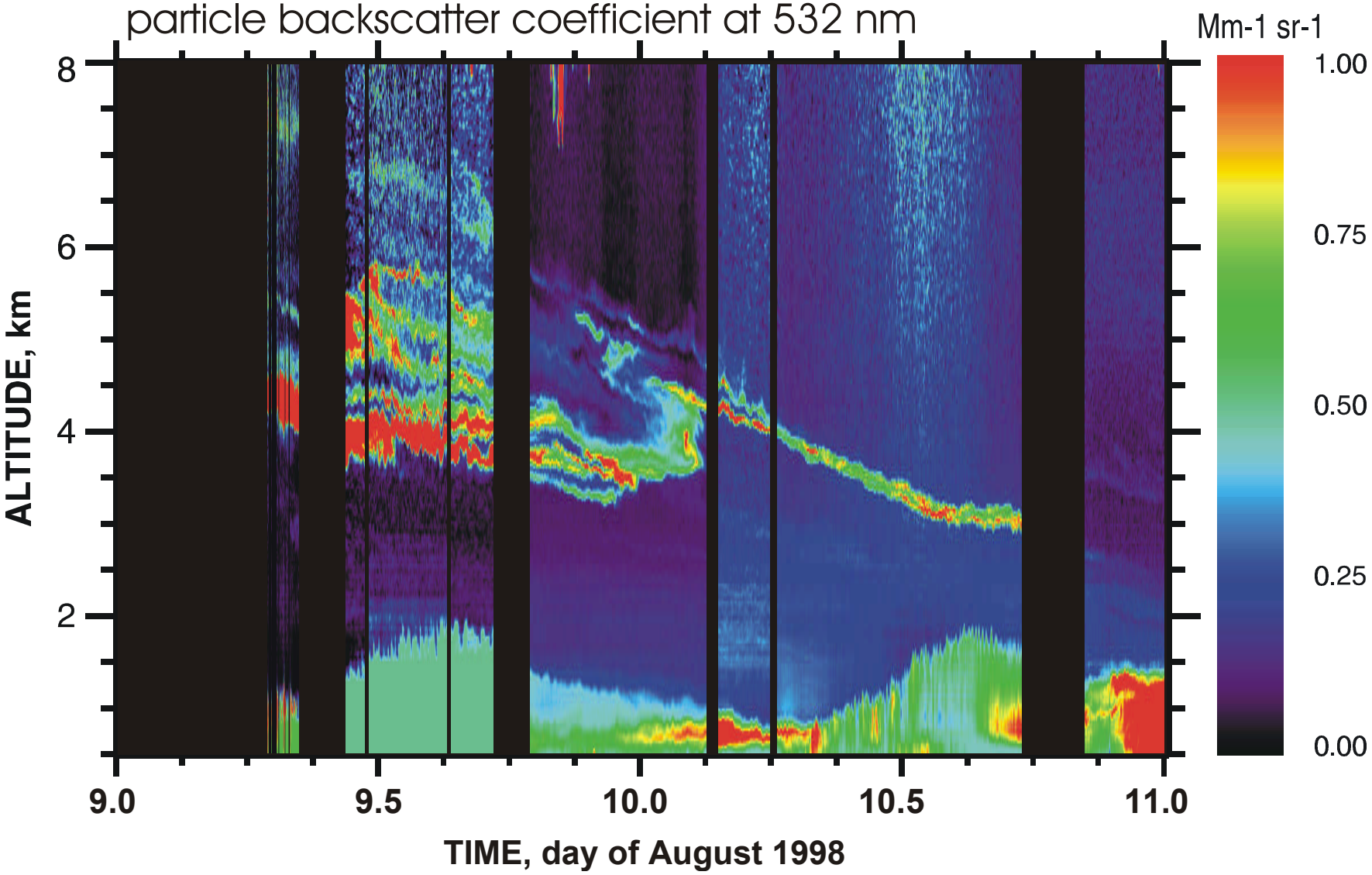
- approximation of volume concentration distribution
- effective radius,
- volume, surface-area, (number) concentration
- complex refractive index
- single-scattering albedo

Müller et al., 1999a: Microphysical particle parameters from extinction and backscatter lidar data by inversion with regularization: theory
Müller et al., 1999b: ..... : simulation
Müller et al., 2000 : ..... : experiment

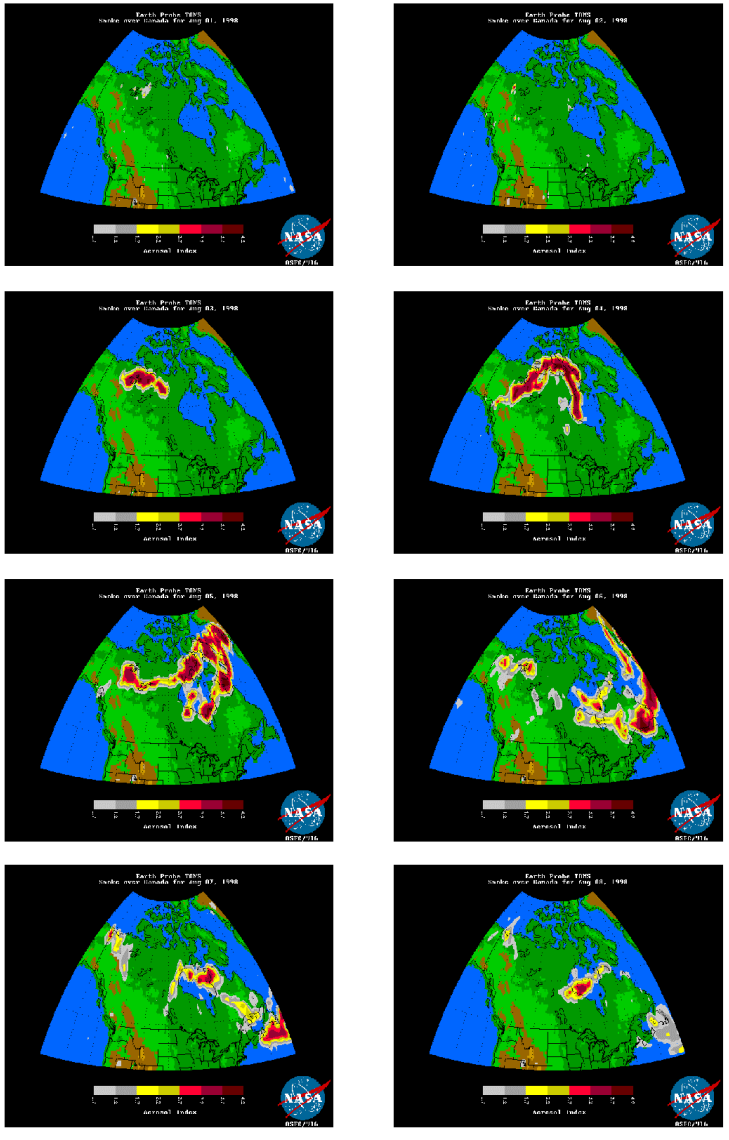
Applied Optics


EARLINET
LACE 98
ACE 2
INDOEX

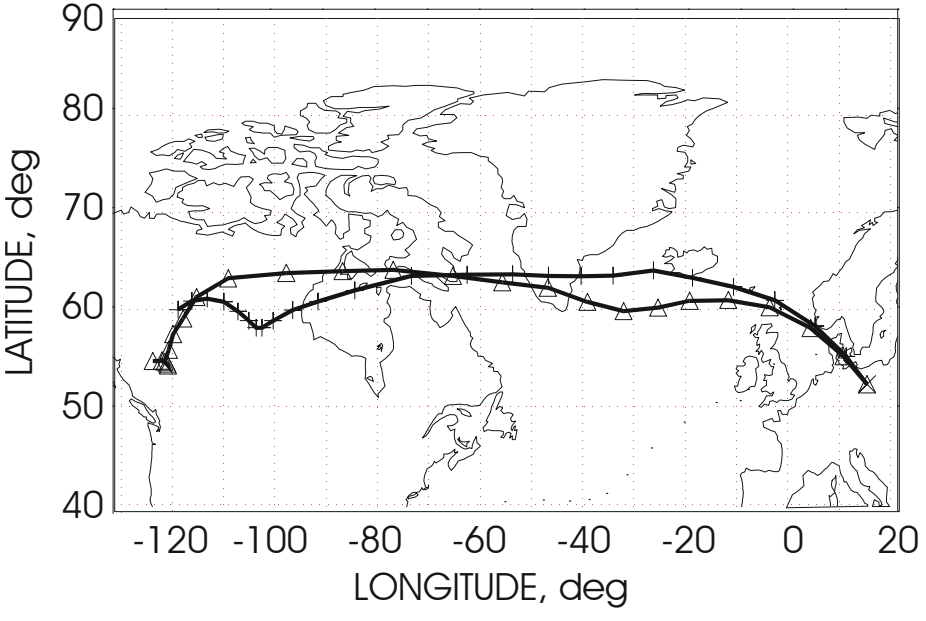
Aerosol layer from biomass burning in Canada



TOMS aerosol index, North America, Aug 1-8 1998



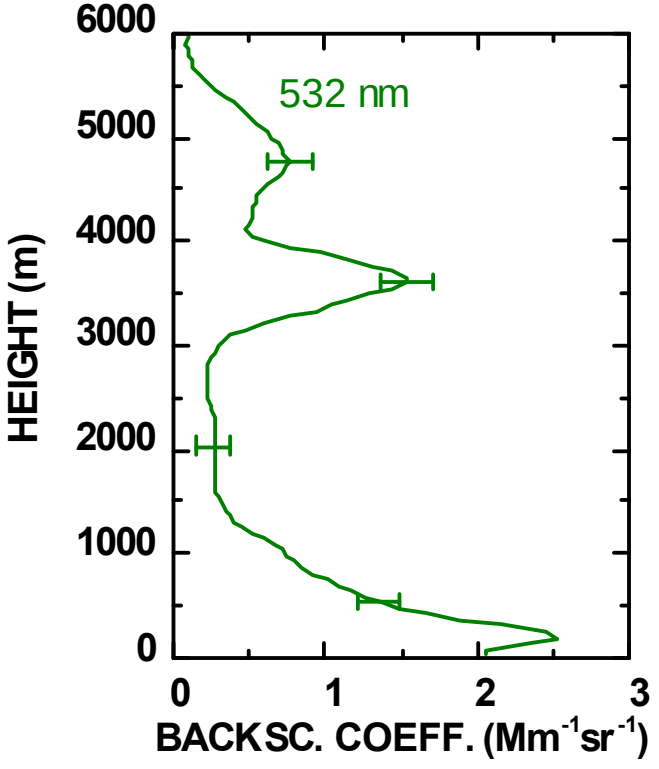
ANALYTICAL 8-DAY BACKTRAJECTORIES
(1 AUG - 9 AUG 1998)



Andreas Stohl,
Technische Universität München

VALIDATION OF INVERSION RESULTS WITH AIR-BORNE IN-SITU MEASUREMENTS

9 AUG 1998, 22:00 - 24:00 UTC

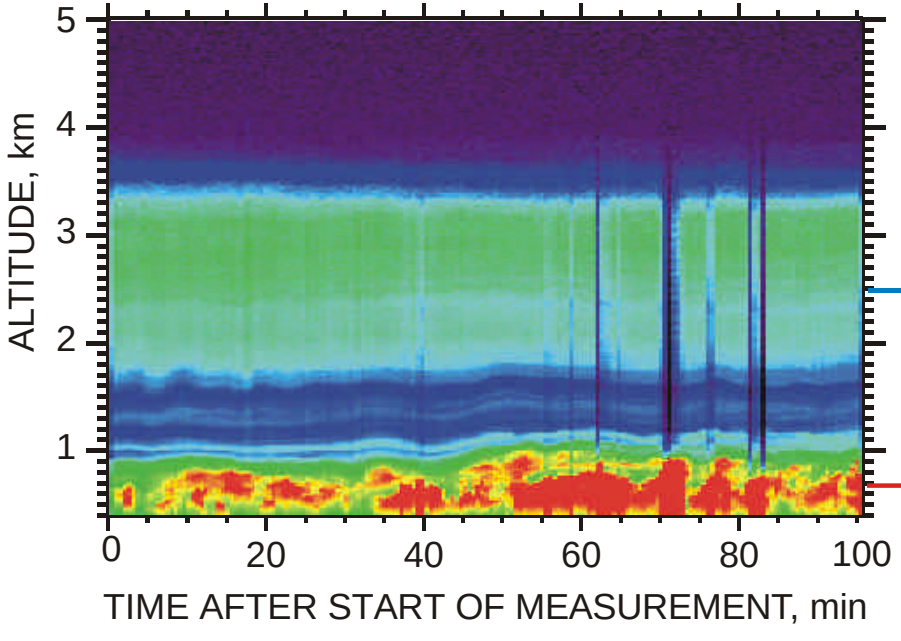


	3500-4000 m inversion	3400-3900 m in-situ (r > 50 nm)
eff. radius (μm)	0.27 ± 0.04	0.25 ± 0.07
v ($\mu m^3/cm^3$)	13 ± 2	8 ± 5
s ($\mu m^2/cm^3$)	139 ± 7	95 ± 55
n ($1/cm^3$)	291 ± 70	271 ± 74
real part	1.64 ± 0.09	1.56
imag. part	0.05 ± 0.02	0.07
single-scat. albedo (532nm)	0.83 ± 0.06	0.79 ± 0.02

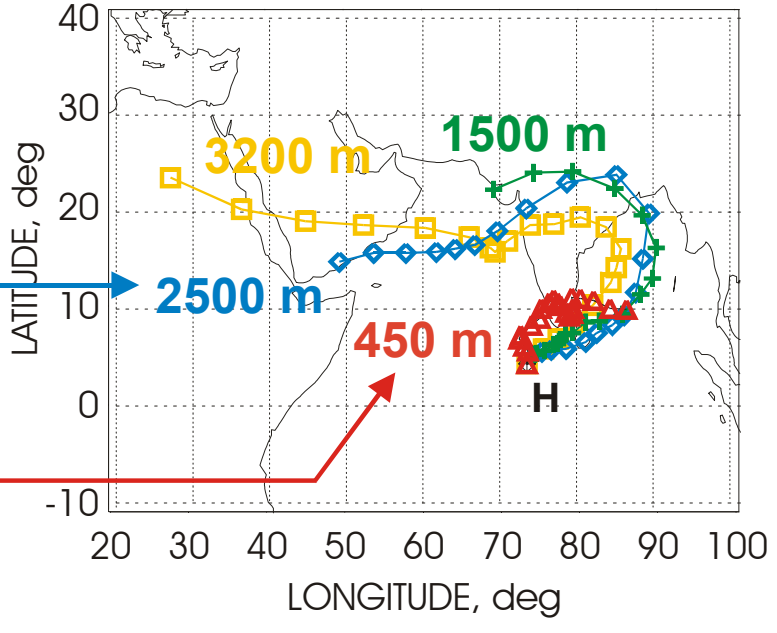
25 Mar 1999: Elevated Particle Layer
Long-Range Transport From India

BACKSCATTER COEFFICIENT (532 nm) - RES.: 15 m, 30 s

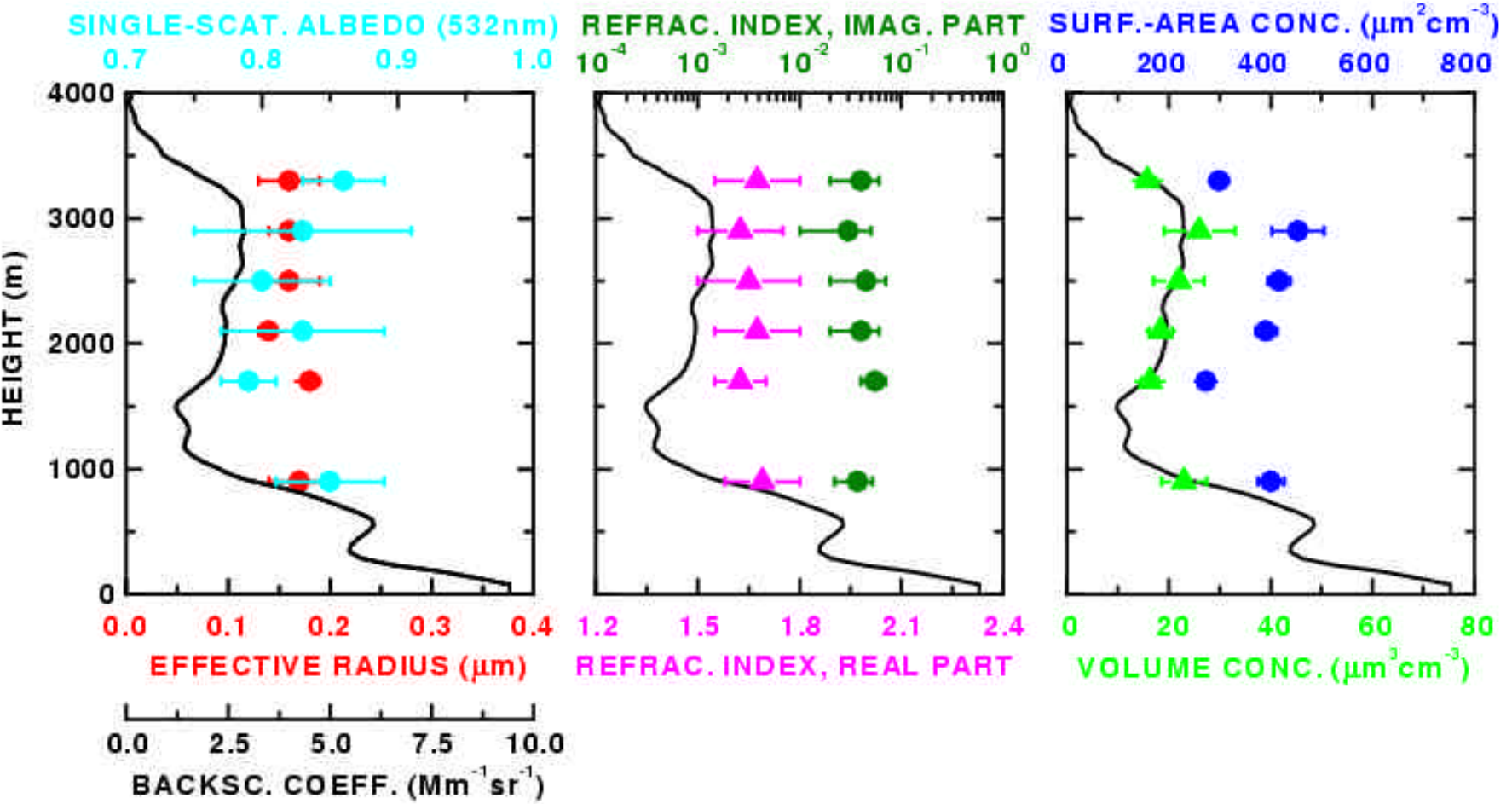
INDOEX, Maldives (4.2 N, 73.5 E) , 25/03/99, 13:30 UTC

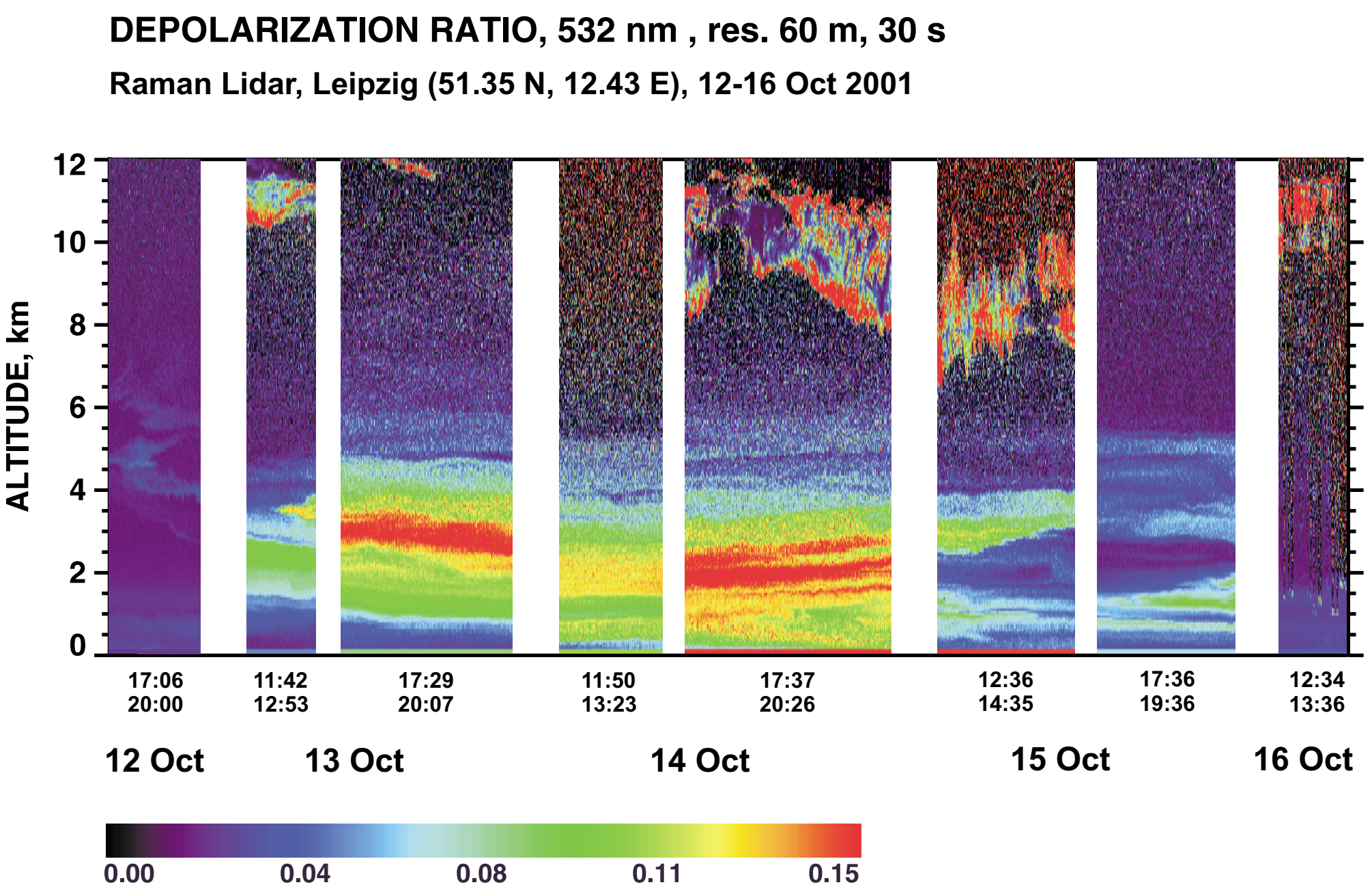


10 Day Backtrajectories

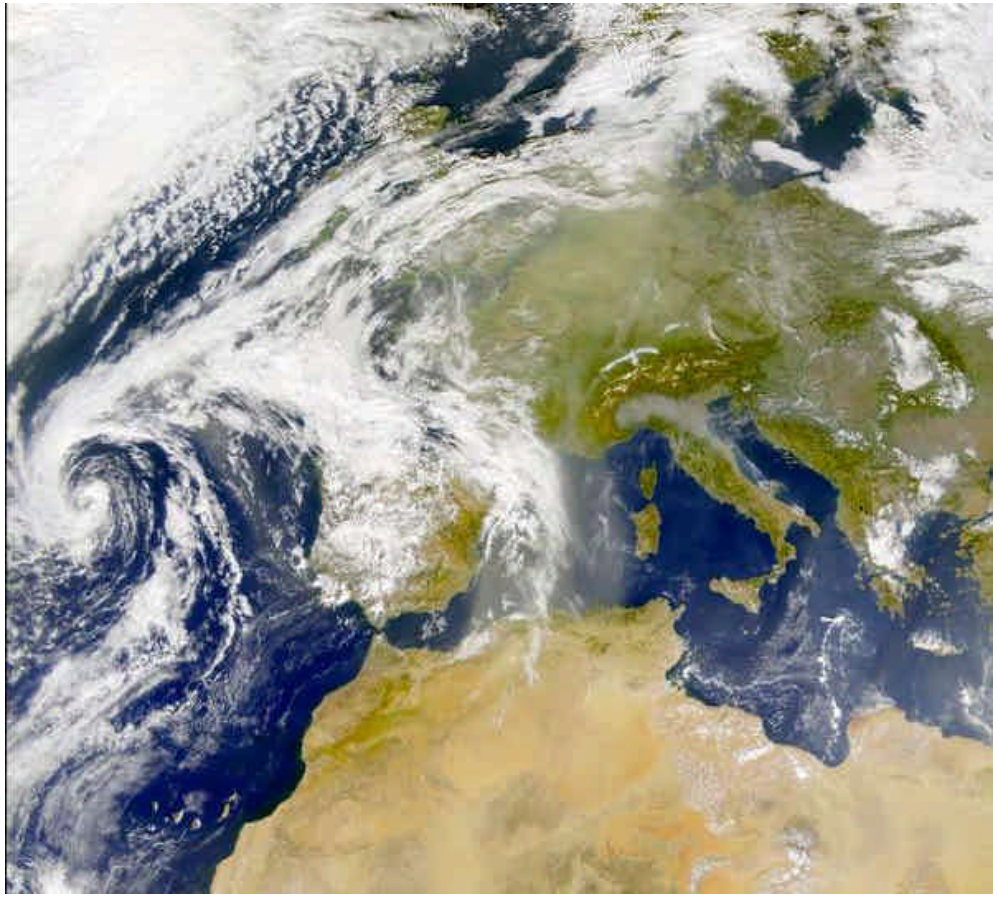


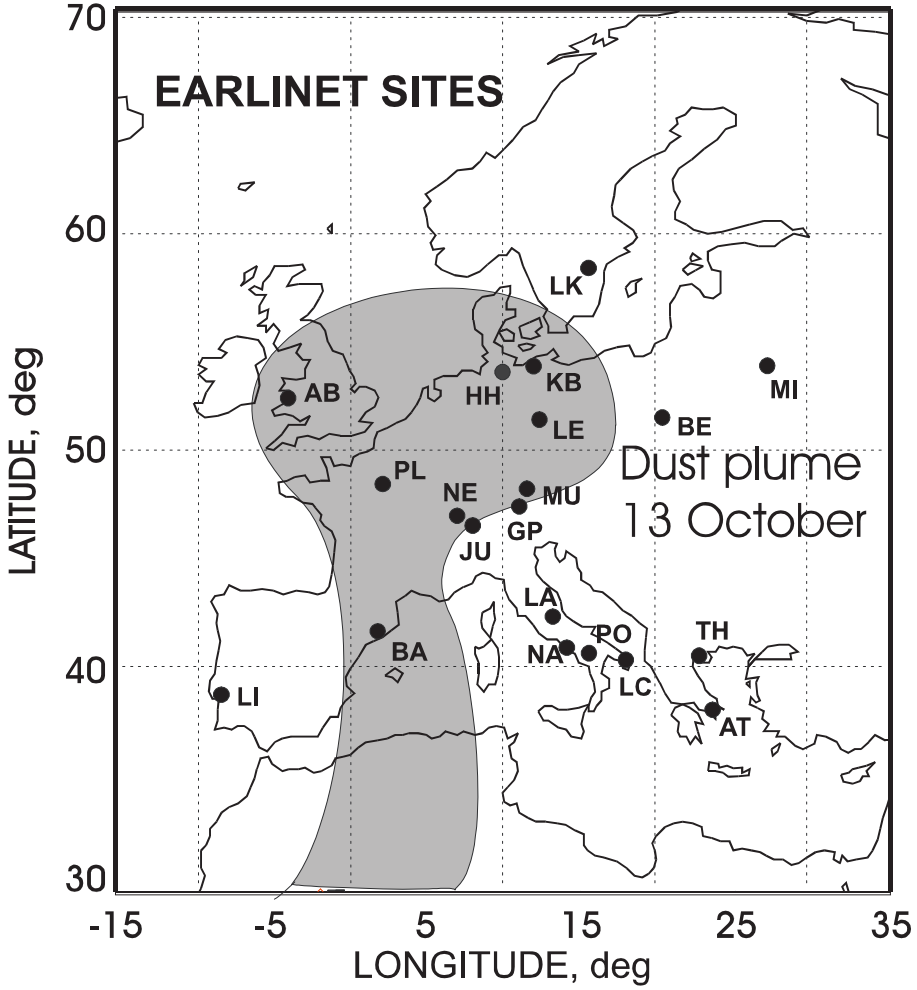
25 MARCH 1999: Physical Parameters



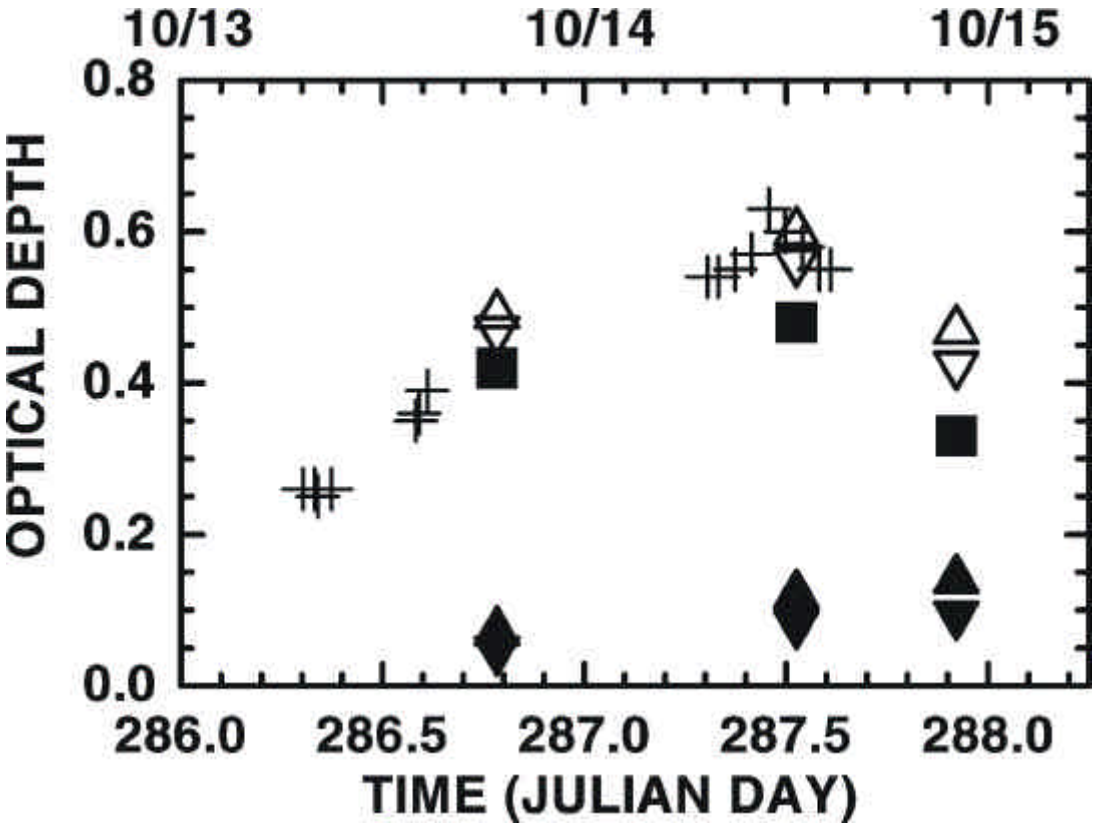

DEPOLARIZATION RATIO, 532 nm , res. 60 m, 30 s
Raman Lidar, Leipzig (51.35 N, 12.43 E), 12-16 Oct 2001
ALTITUDE, km
12
10
8
6
4
2
0
17:06
20:00
11:42
12:53
17:29
20:07
11:50
13:23
17:37
20:26
12:36
14:35
17:36
19:36
12:34
13:36
12 Oct
13 Oct
14 Oct
15 Oct
16 Oct
0.00
0.04
0.08
0.11
0.15

Saharan Dust Outbreak
SeaWiFS, 13 October 2001



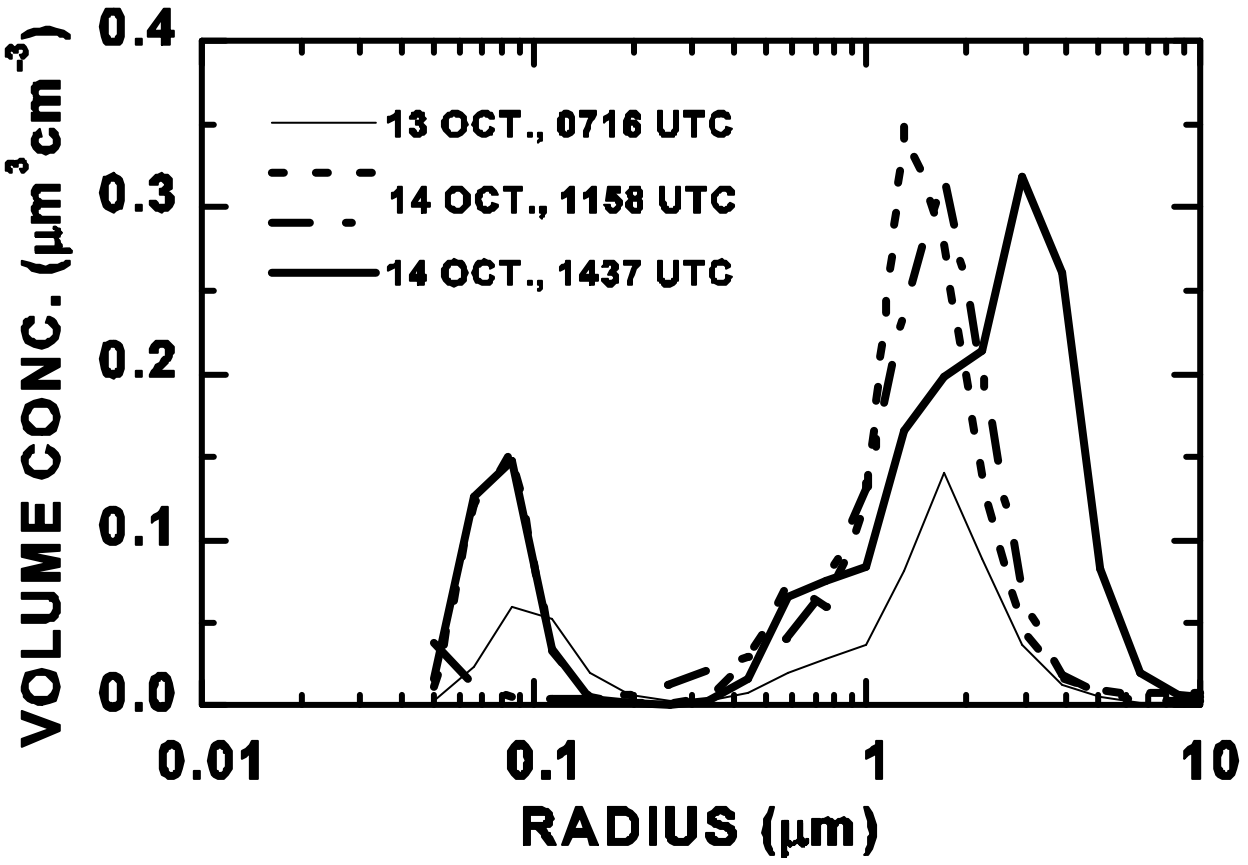


Optical depth at 532 nm from lidar and Sun photometer



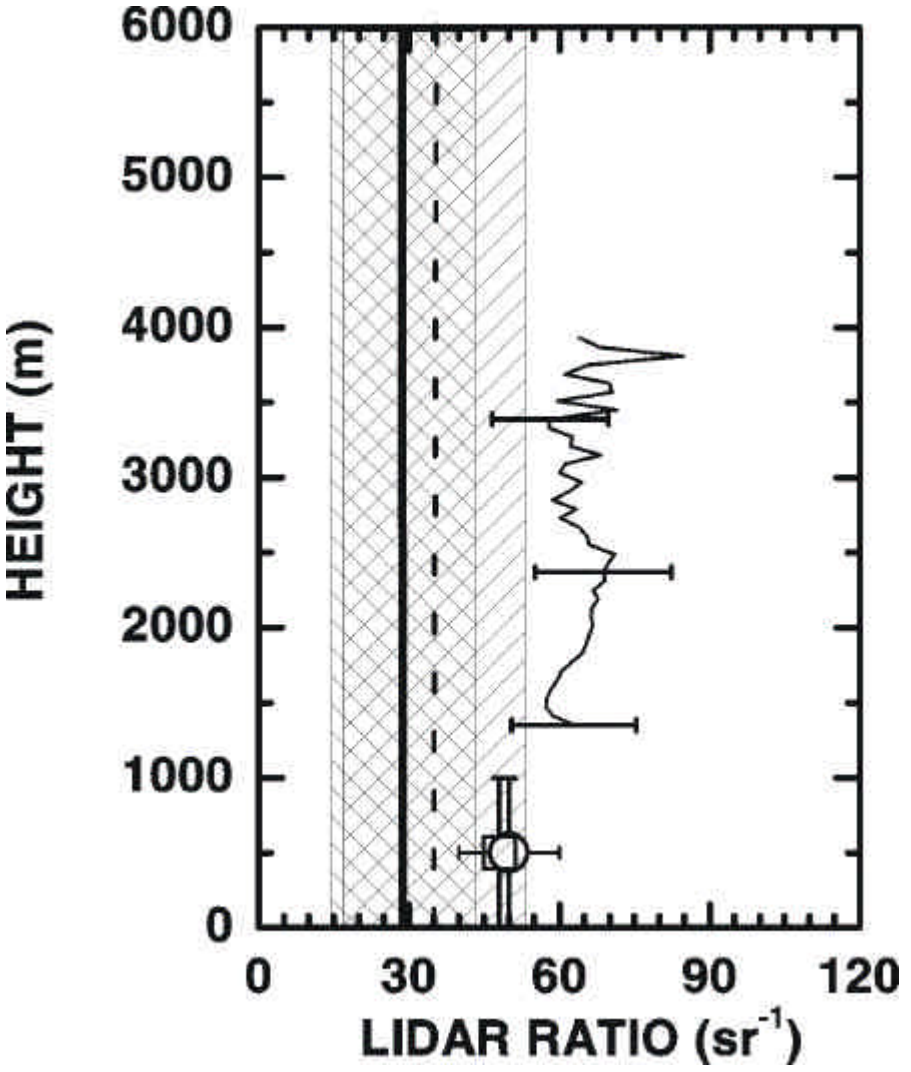
+ Sun photometer
▼ lidar <1000 m, S=40 sr
▲ lidar <1000 m, S=60 sr
■ lidar >1000 m
▽ lidar total, S=40 sr (<1000 m)
△ lidar total, S=60 sr (<1000 m)

Particle size distribution from Sun photometer



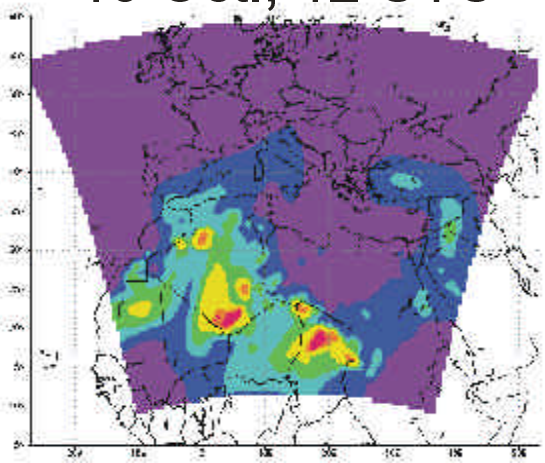
From spheroidal particle model:
effective radius: 0.6–0.7 μm
refractive index (670 nm): real part 1.5–1.6, imaginary part 0.0014–0.0039
single-scattering albedo (670 nm): 0.93–0.96

Lidar ratio from measurement and model

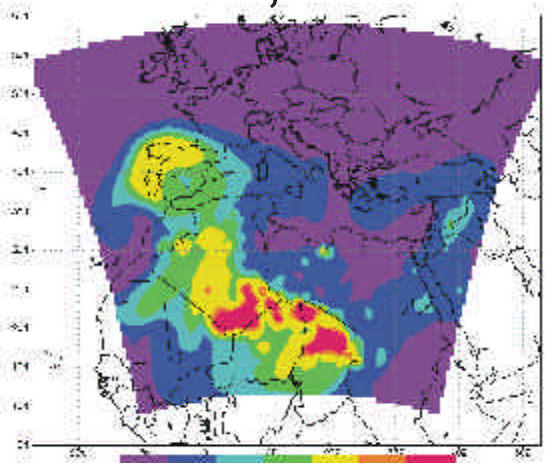


Saharan Dust Outbreak, Oct. 2001
Horizontal Dust Load Over Europe
DREAM Model

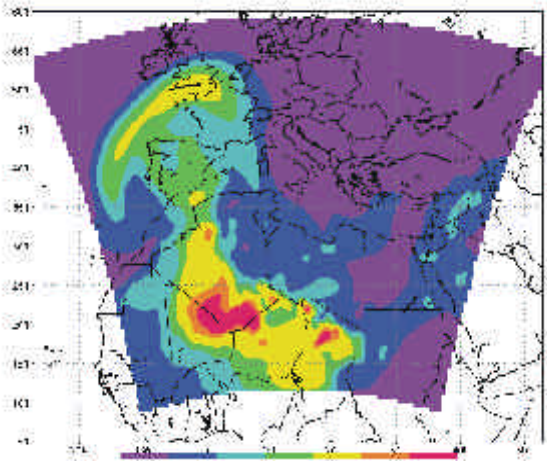
10 Oct., 12 UTC



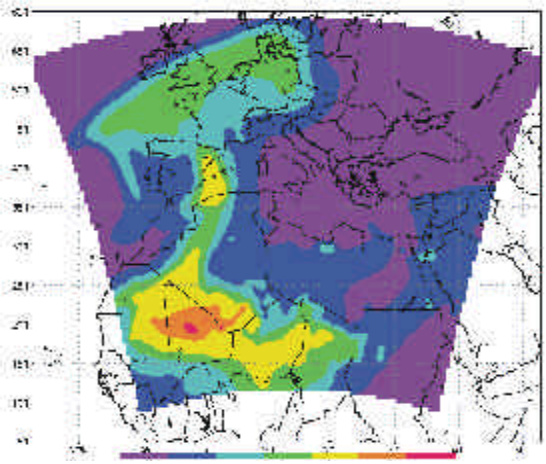
11 Oct., 12 UTC



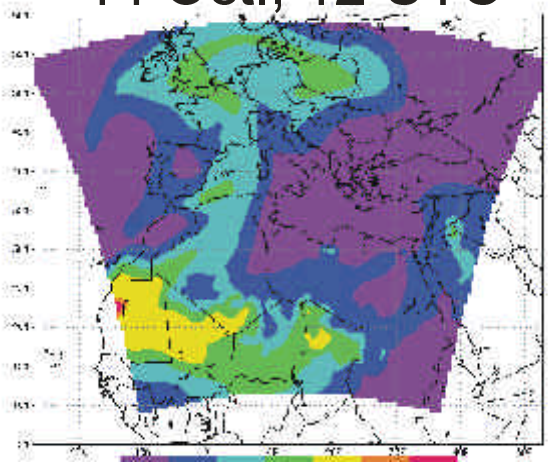
12 Oct., 12 UTC



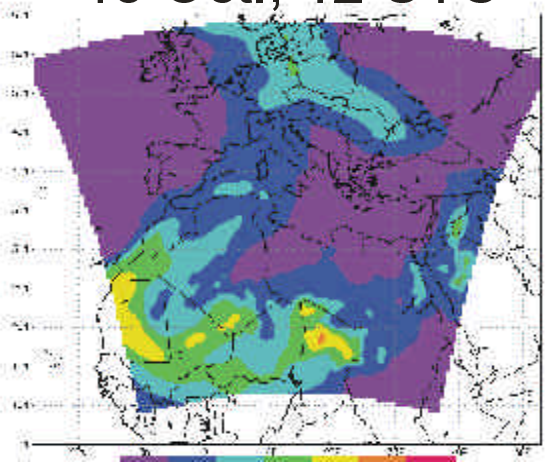
13 Oct., 12 UTC



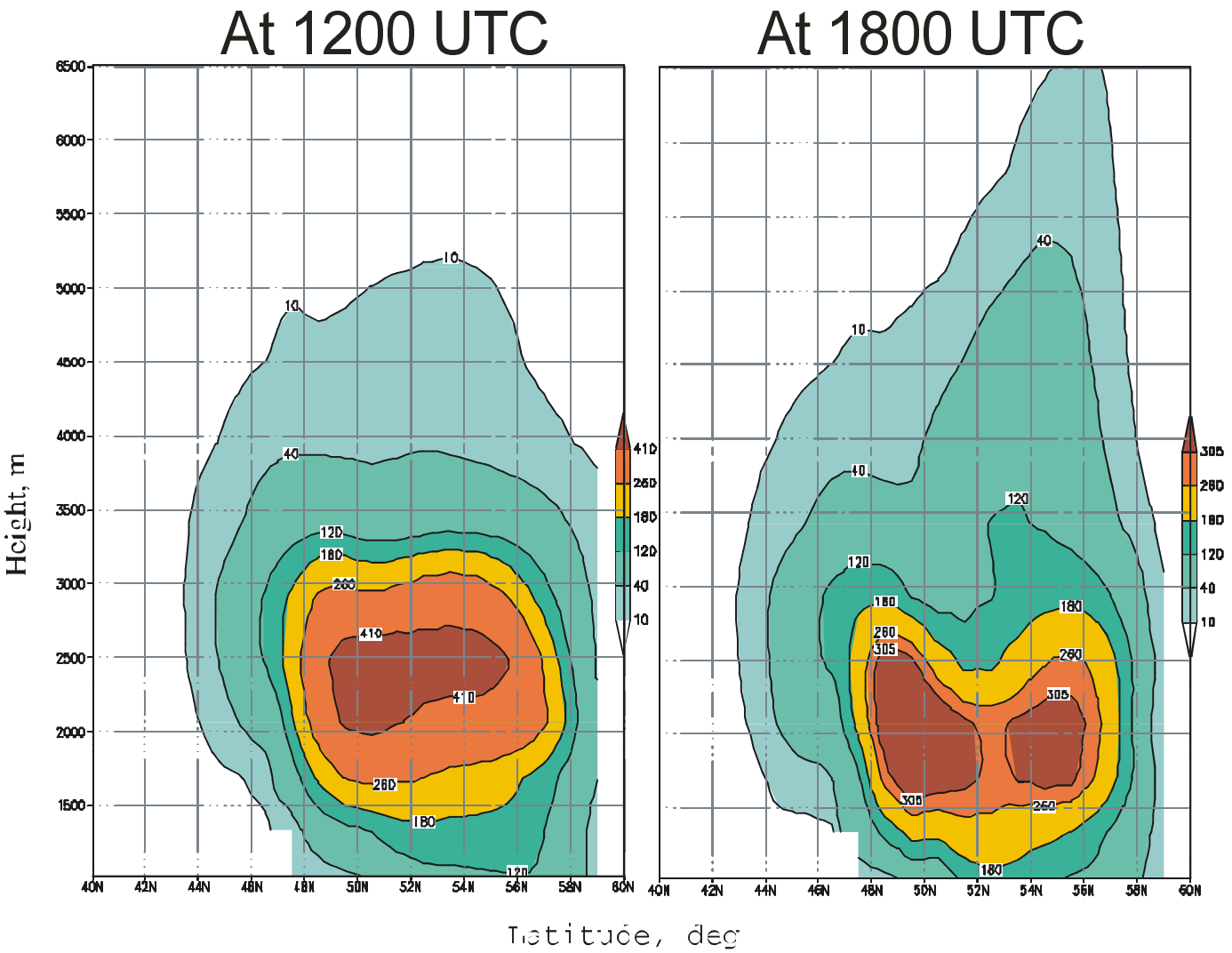
14 Oct., 12 UTC



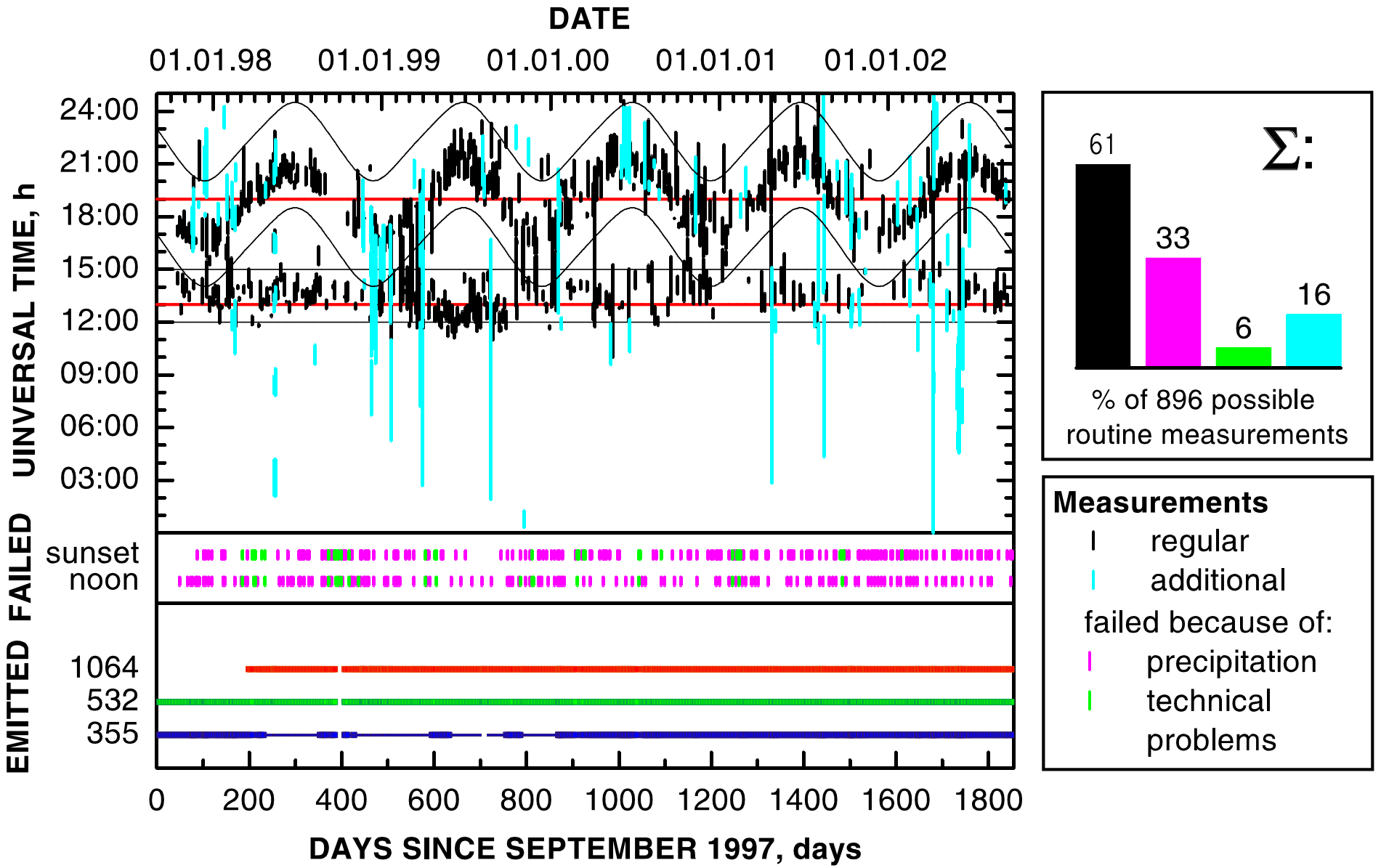
15 Oct., 12 UTC



Saharan Dust Outbreak, 14 Oct. 2001
Dust Load Over Leipzig (51.3 N, 12.4 E)
DREAM Model

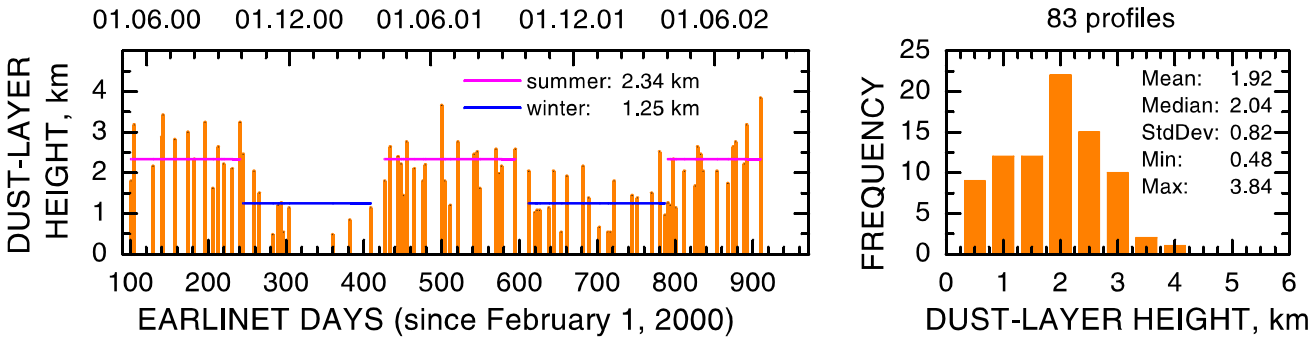


Raman Lidar Measurements at Leipzig: September 1997 - September 2002

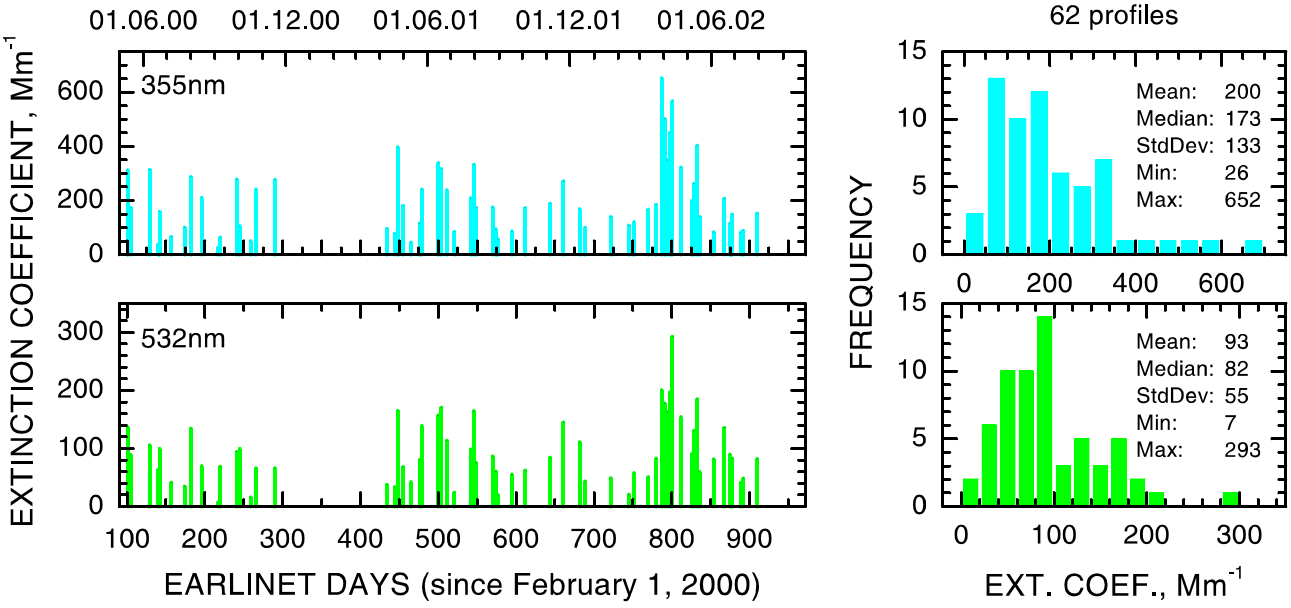


Measurement Statistics
Raman Lidar, Leipzig

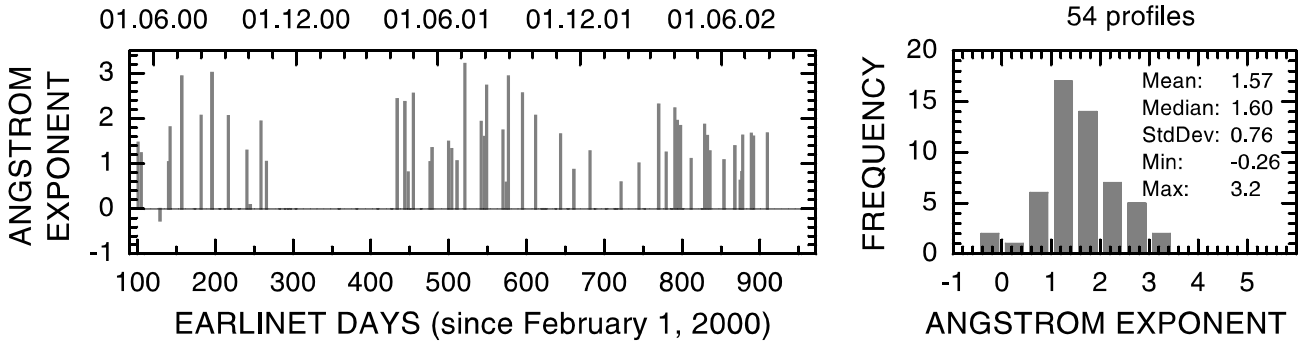
Dust-Layer Height



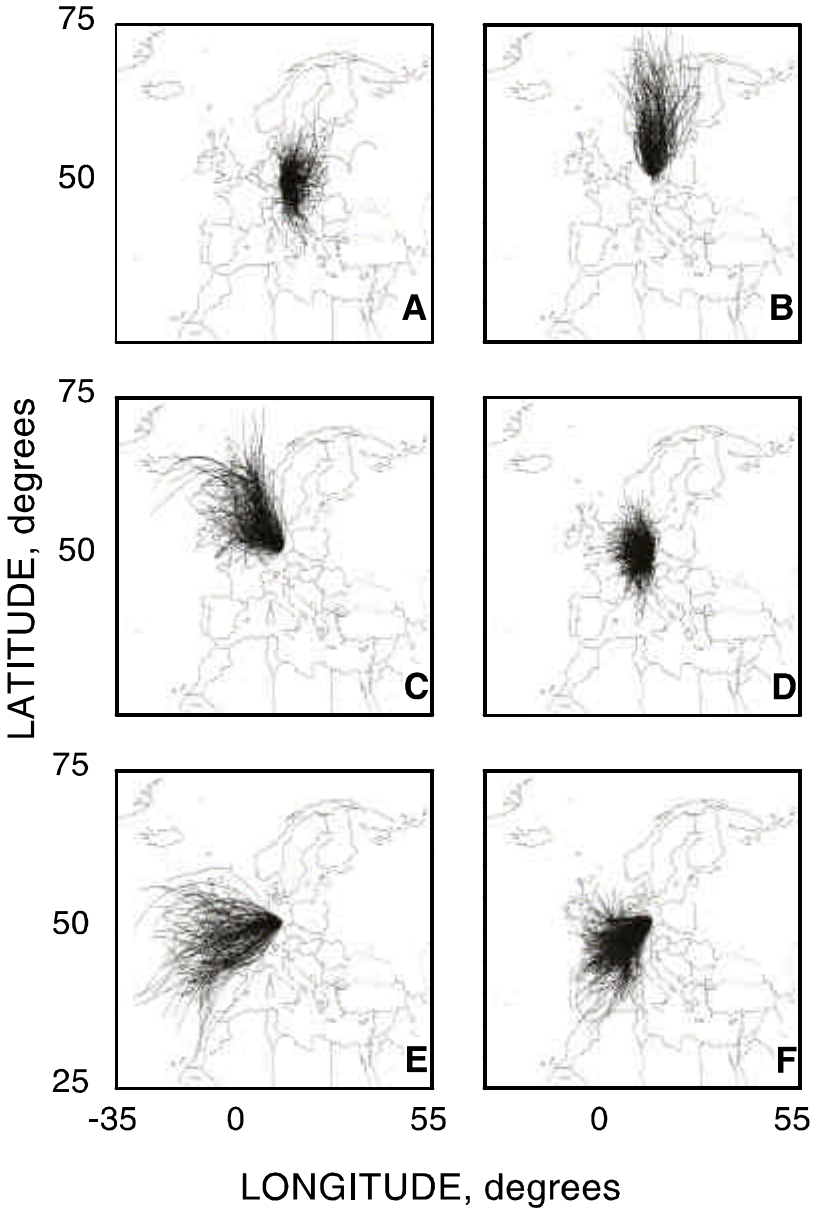
Extinction Coefficients (355nm, 532 nm)

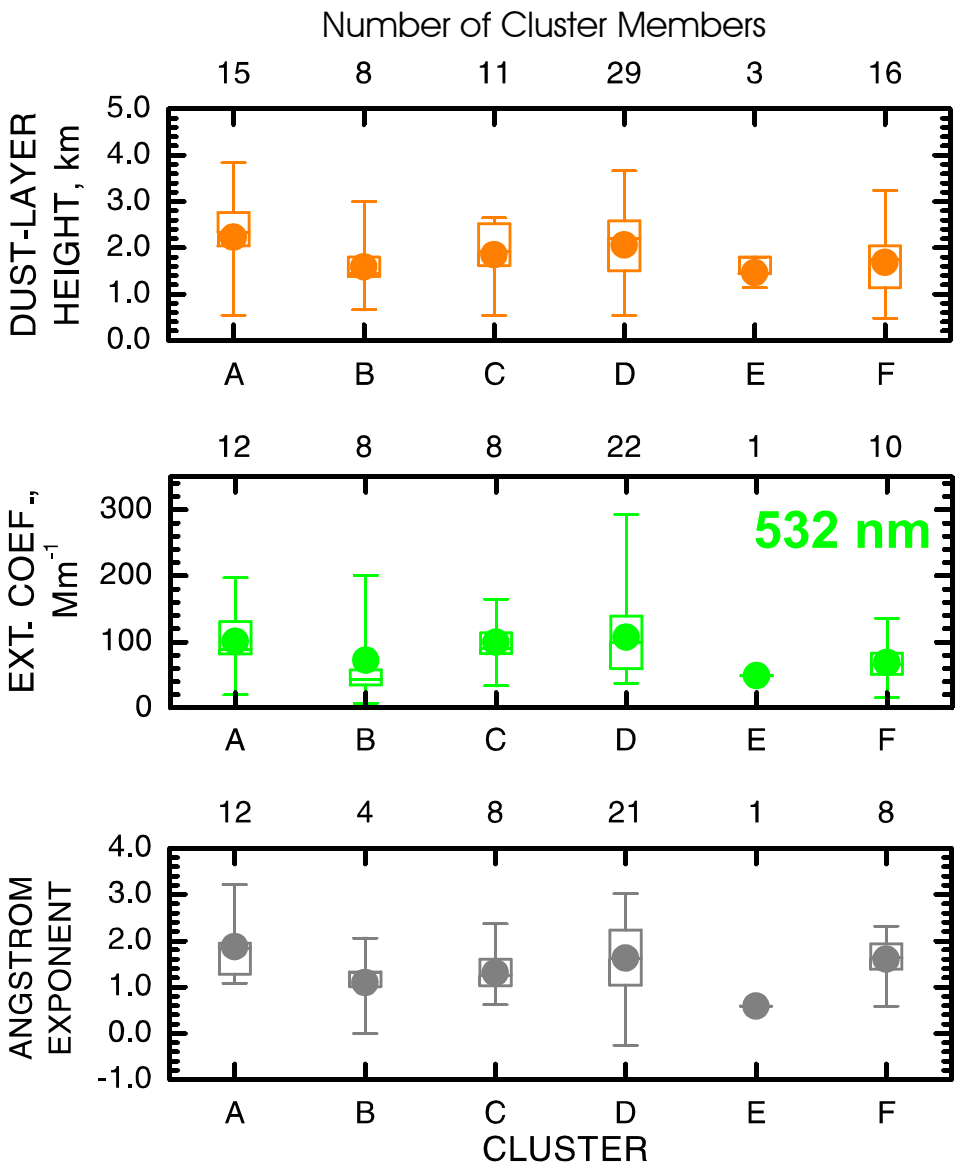


Angström Exponent



EARLINET, Raman Lidar, Leipzig
Cluster-Mean Properties





INDOEX	NE-Monsoon Feb/Mar 1999, Mar 2000 SW-Monsoon Jul/Oct 2000
ACE 2	Jun/Jul 1997
LACE 98	Jul/Aug 1998
German Lidar Network	1997-2000
EARLINET	since 2000