NATIONAL TECHNICAL UNIVERSITY OF ATHENS - APPLIED MATHEMATICS AND PHYSICAL SCIENCES - PHYSICS DEPARTMENT

AEROSOL PROPERTIES

RELATED TO SAHARAN DUST REGIONAL EVENTS AS OBSERVED OVER ATHENS USING A

MULTI-WAVELENGTH RAMAN LIDAR SYSTEM

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OUTLINE

NTUA'S LIDAR SYSTEM

CASE STUDY OF SAHARAN DUST OUTBREAK

5 YEARS ANALYSIS OF THE SAHARAN DUST OUTBREAKS OVER ATHENS

- SEASONAL [GEOMETRICAL & OPTICAL PROPERTIES]
- REGIONAL [OPTICAL PROPERTIES]

CONCLUSIONS

AEROSOLS & CLIMATE

Aerosols perturb the energy balance of the Earth-atmosphere system:

→by *scattering* & *absorbing*
solar [shortwave] & terrestrial [longwave] radiation [direct radiative forcing]

→by *modifying cloud properties* [e.g. cloud lifetime, cloud albedo]
[indirect radiative forcing] – mostly the BC/OC particles

Estimates of aerosol forcing mostly rely on computational modeling and still contain significant uncertainties due to the challenges of representing aerosol microphysics, optical properties, and their spatial and temporal variability over the globe.

Evaluation of aerosol models with range-resolved aerosols observations is required

NTUA' S LIDAR SYSTEM

Athens, Greece

37.93N, 23.8 E

200m

Member of the EARLINET since 2000

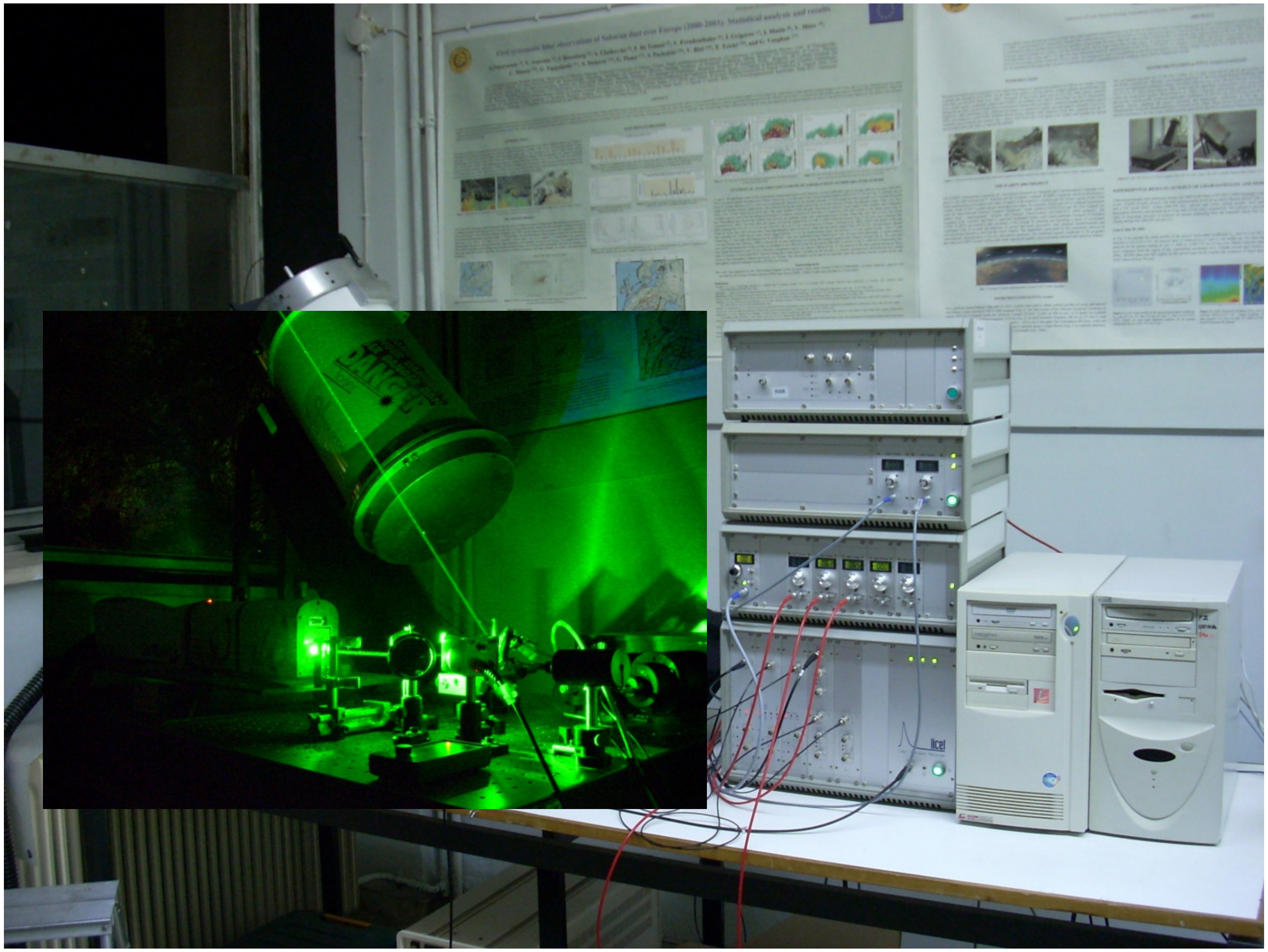
NTUA' S LIDAR SYSTEM

Athens, Greece

37.93N, 23.8 E
200m

Raman LIDAR

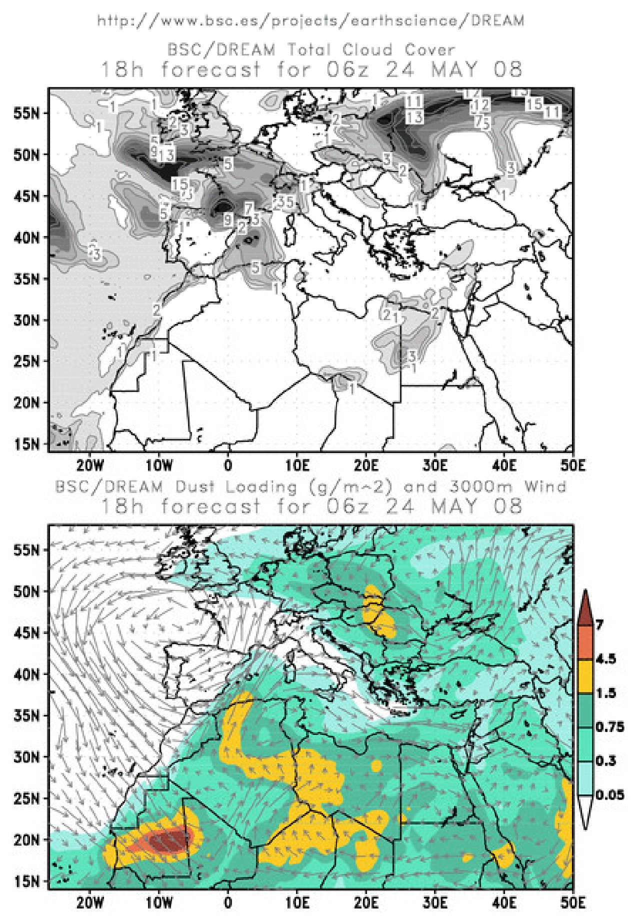
Nd:YAG laser
UV, Vis, IR
Telescope
300mm



SAHARAN DUST OUTBREAK

Forecast by DREAM model

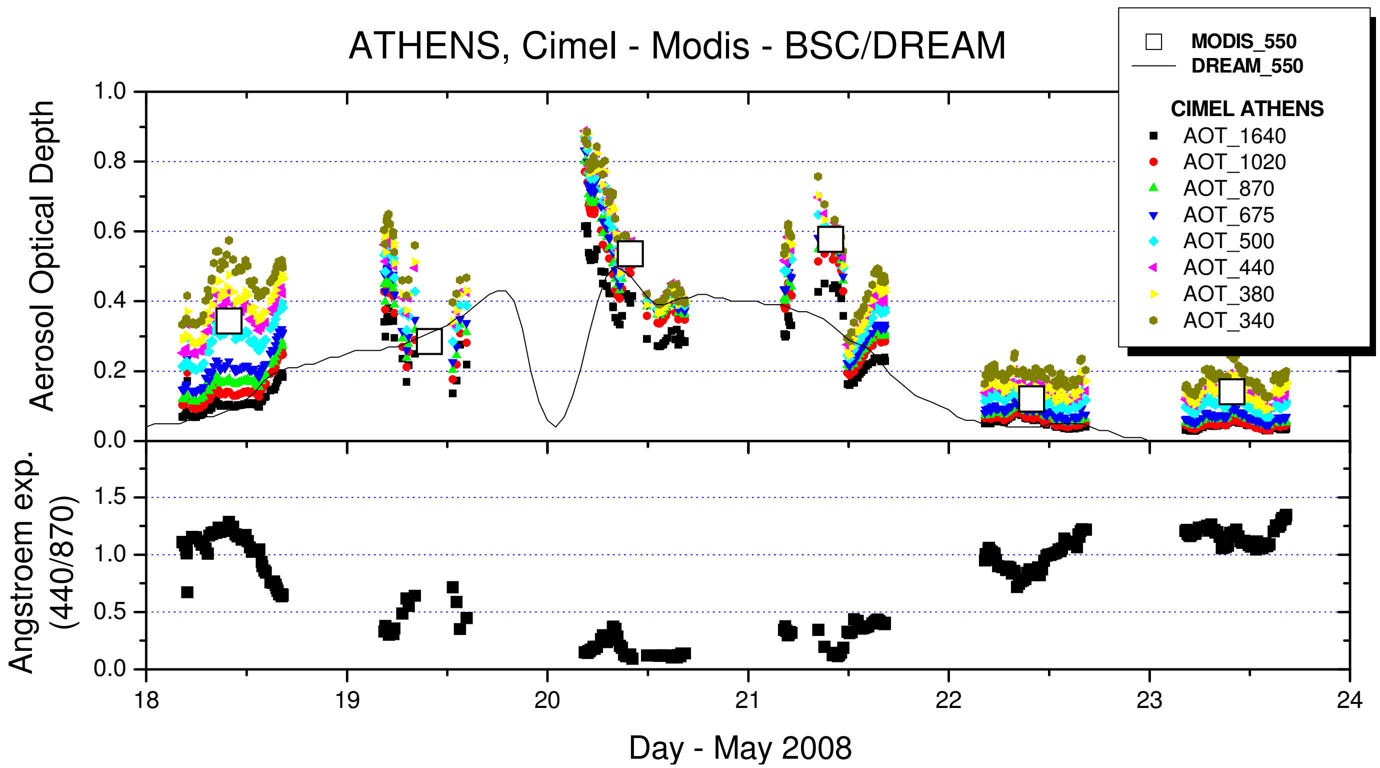
18-23 May 2008



SAHARAN DUST OUTBREAK

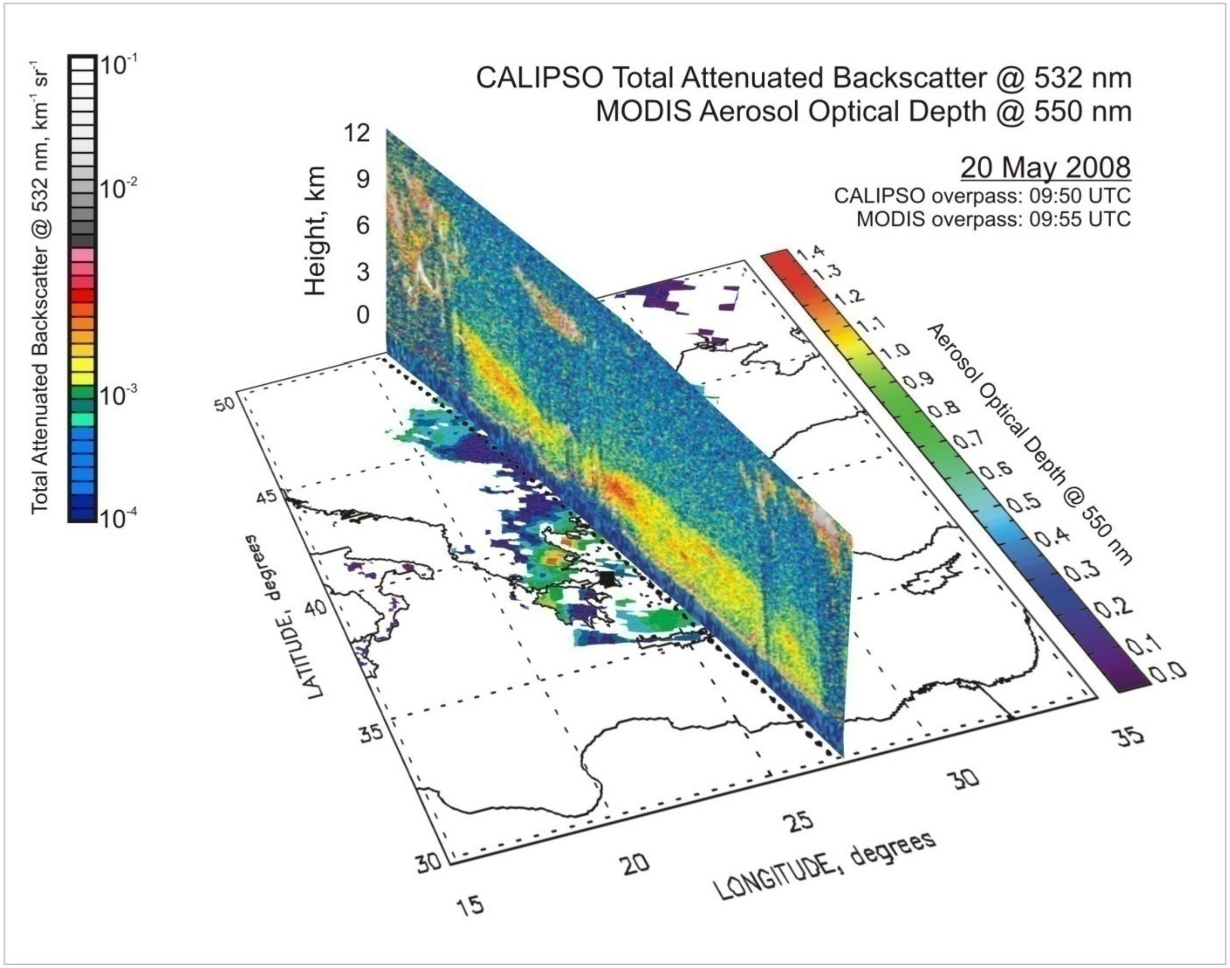
Sun-photometer data

18-23 May 2008



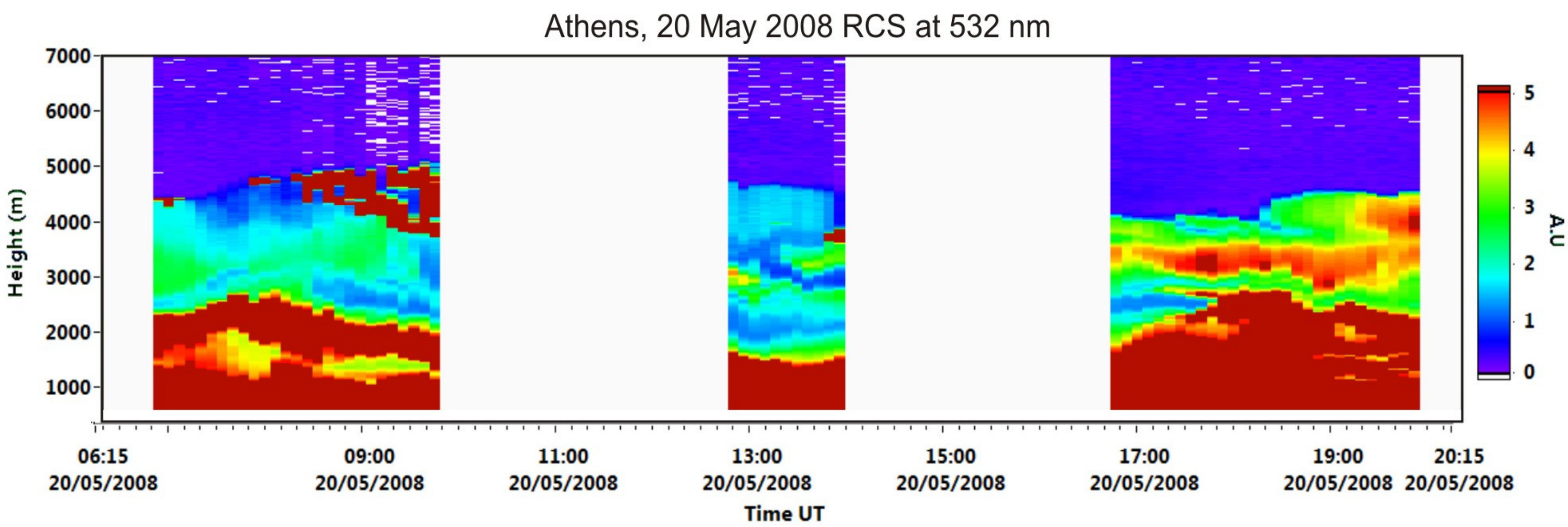
SAHARAN DUST OUTBREAK

Passive & Active Satellite sensors



SAHARAN DUST OUTBREAK

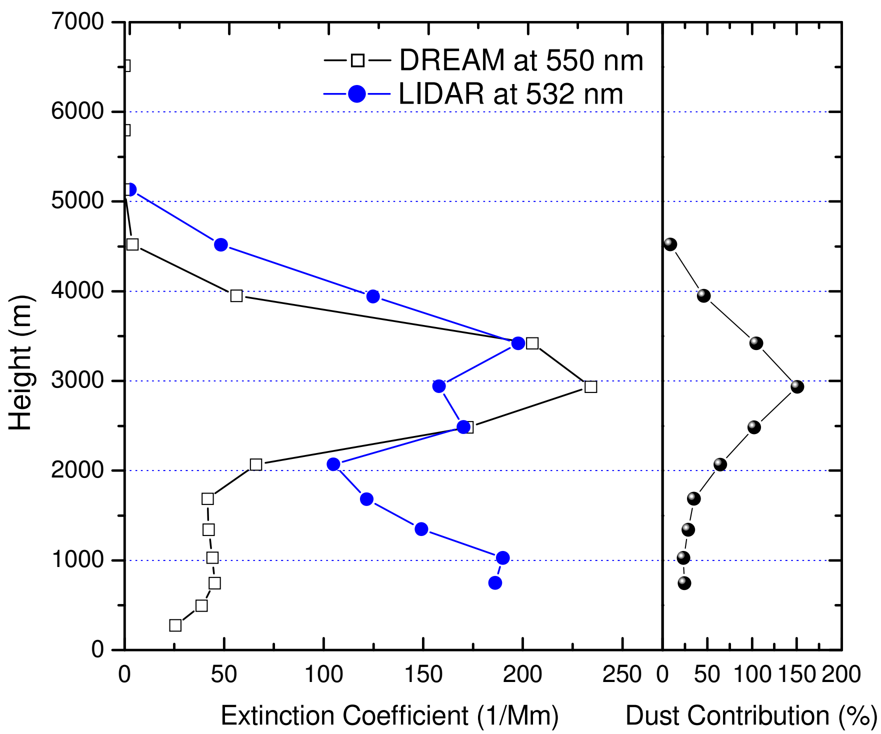
Temporal evaluation of the dust outbreak on 20 May 2008



SAHARAN DUST OUTBREAK

DREAM Model VS Raman-LIDAR NTUA

20 May 2008



Dust distribution characteristics

•Maximum value of extinction

DREAM modal: 2933m

NTUA's Raman-lidar: 3045m.

AOD [-6%]

DREAM Model: 0.34

NTUA Raman-lidar : 0.36

General comments

• The disagreement of the prediction of the model from the measured geometrical and optical properties with lidar, stay below the statistical errors of the lidar measurements.

•The performance of the BSC/DREAM model for the presented case study is quite satisfied.

SAHARAN DUST OUTBREAK

Radiative Forcing Model

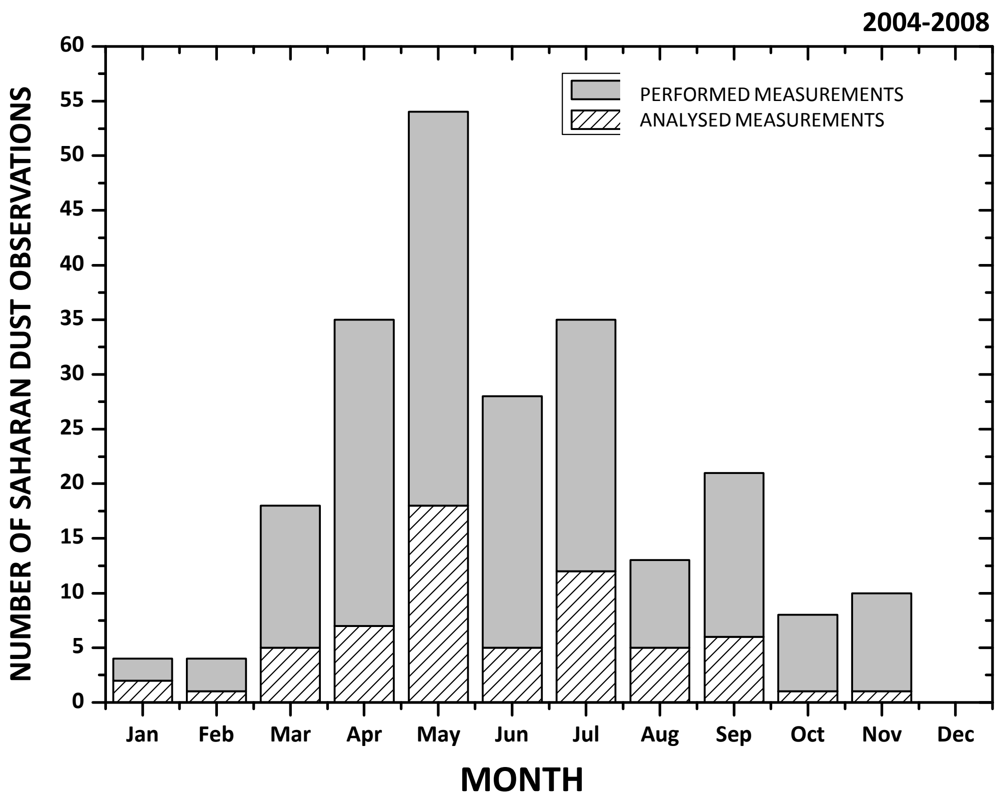
Application on period 18-23 May 2008

Day	Month	Year	RF scattered [W/m²]	RF absorption [W/m²]
18	5	2008	-1.8556	0.1431
19	5	2008	-3.1493	0.2092
20	5	2008	-3.7016	0.2042
21	5	2008	-2.4731	0.1992
22	5	2008	-0.6814	0.0649
23	5	2008	-0.4589	0.1267

TM 5 RADIATIVE FORCING MODEL

SYSTEMATIC OBSERVATIONS OF SAHARAN DUST OUTBREAKS OVER ATHENS

2004-2008



63 backscatter
22 Raman [extinction + backscatter]

3 criteria to characterize the aerosol lidar data as "Saharan dust" profiles 2004-2008:

[1] presence of a distinct aerosol dust layer using the first derivative of the lidar signal,
[2] aerosol layer's origin is the Saharan region
[3] and forecast by the BSC/DREAM model.

+ Verification by satellite data [MODIS, SeaWiFS]

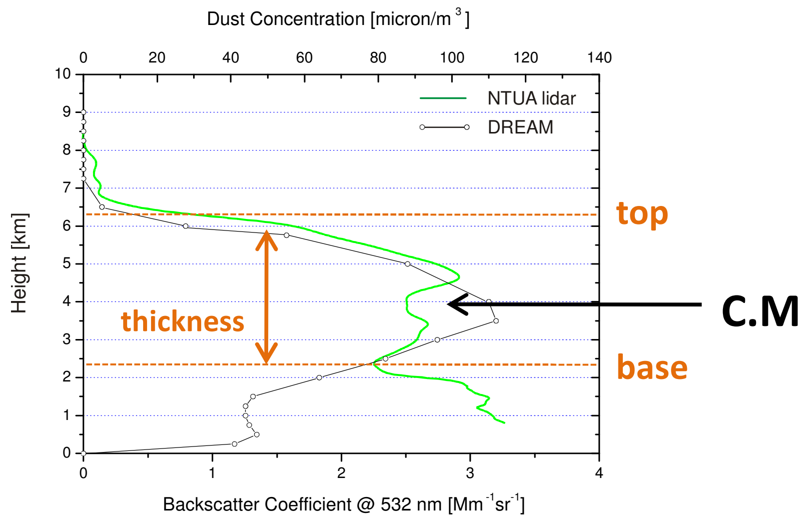
Measurements during Saharan dust outbreaks

Only strong dust events are considered [AOD>0.5 at 550 nm]

Geometrical Parameters

Calculations . Top – Base – Center of Mass

Geometrical characteristics of the dust layers



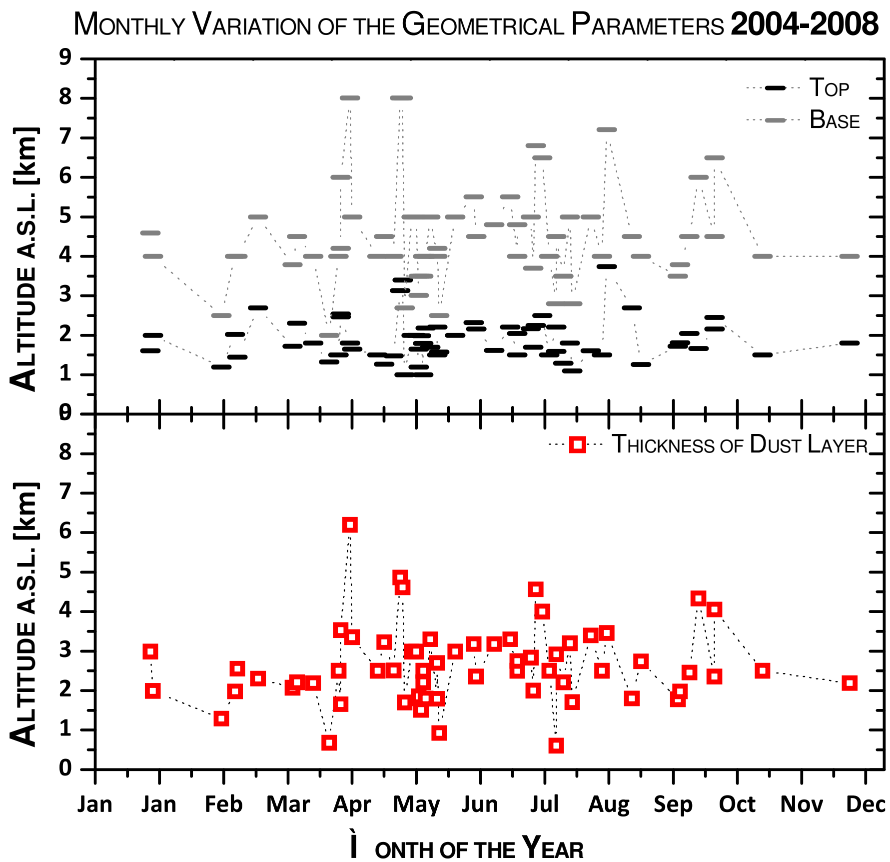
Center of mass

$$z_c = \frac{\int_{z_b}^{z_t} z \cdot \beta(z)dz}{\int_{z_b}^{z_t} \beta(z)dz}$$

Geometrical parameters of the dust layer	Mean value[m]	Maximum[m]	Minimum[m]
Base	1881.66± 539.50	3741.75	1001.91
Top	4510.56 ±1286.96	8005.22	2004.29
Thickness	2628.89 ±996.42	6201.41	601.43
Center of mass	2881.37 ±873.92	5758.03	1562.22

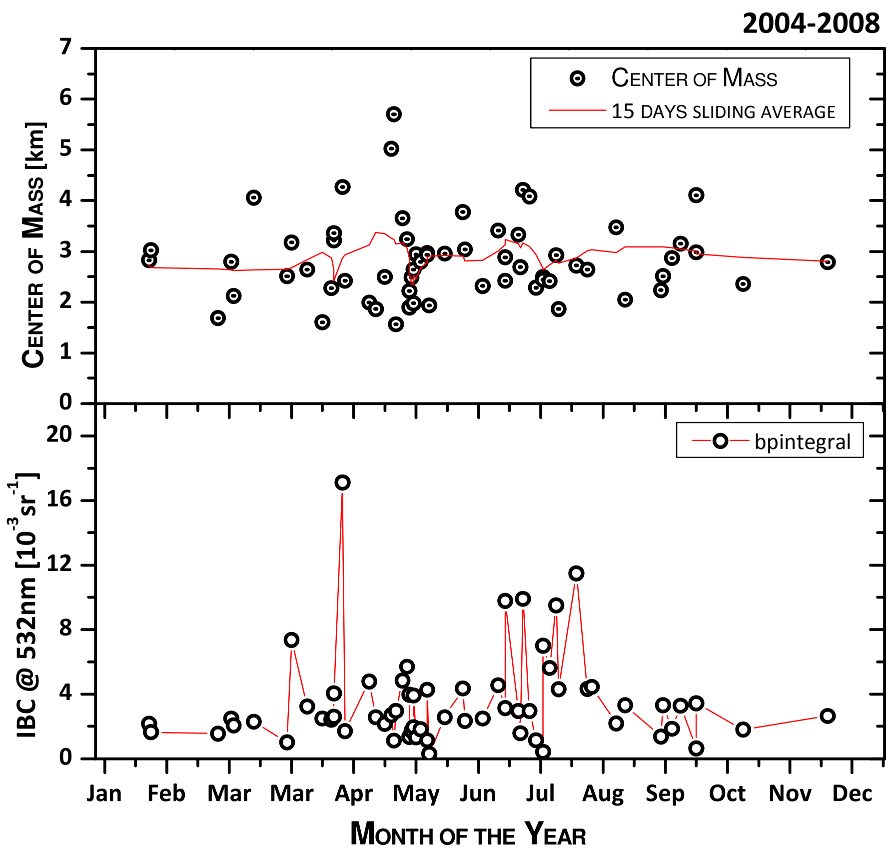
GEOMETRICAL PARAMETERS

STATISTICS . Top – Base – Center of Mass



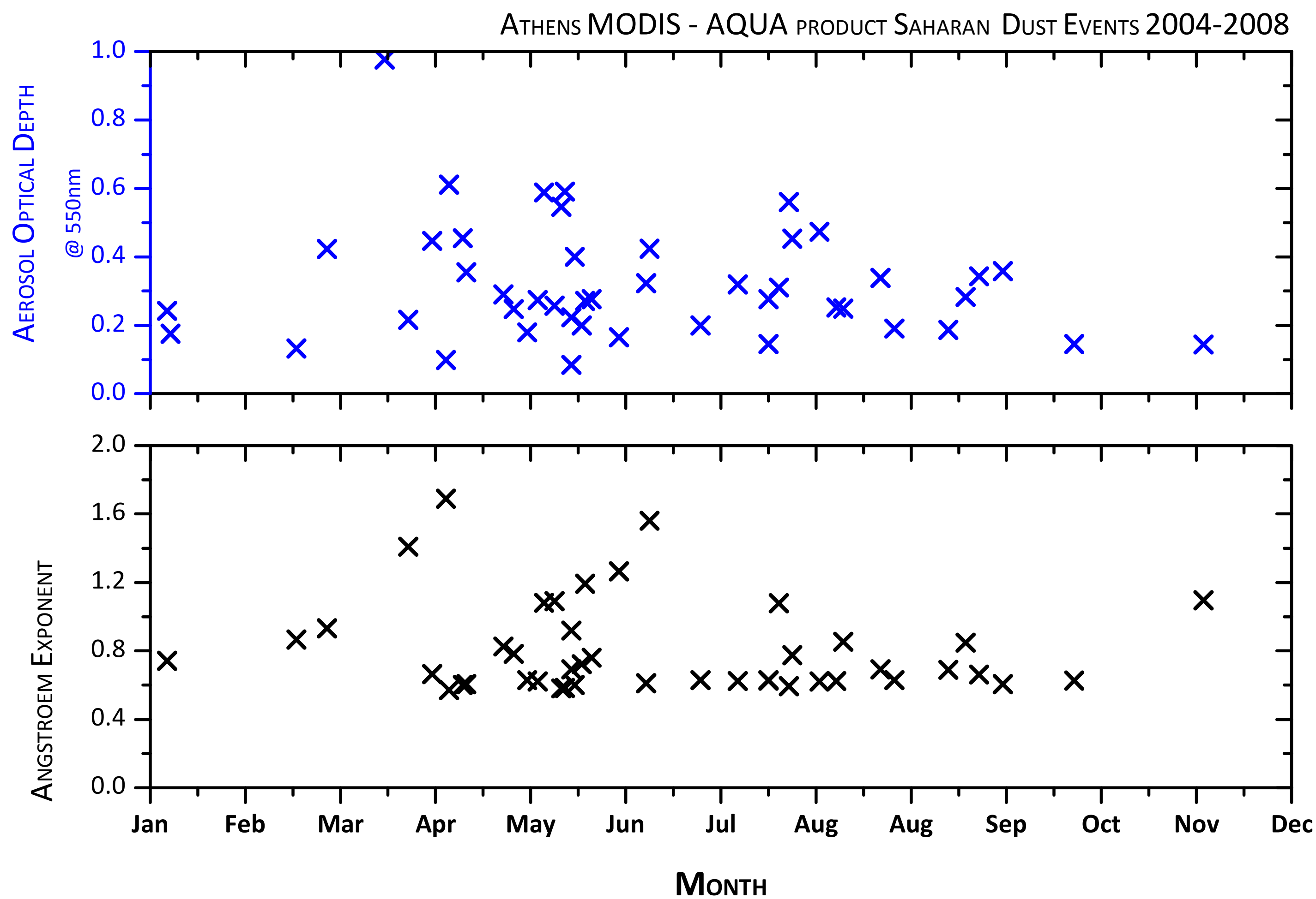
GEOMETRICAL PARAMETERS

STATISTICS . Top – Base – Center of Mass



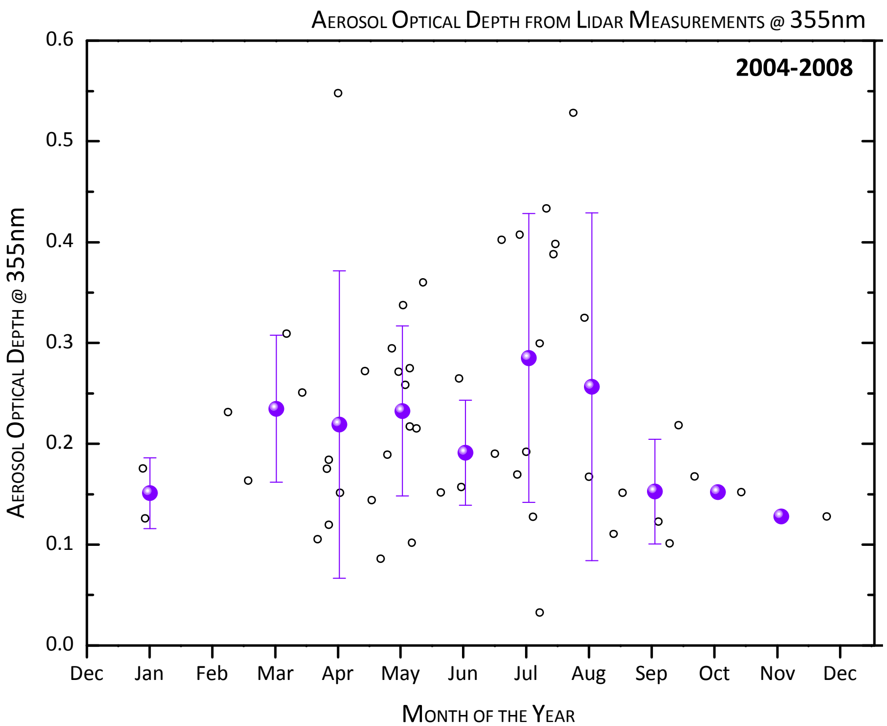
Optical Properties

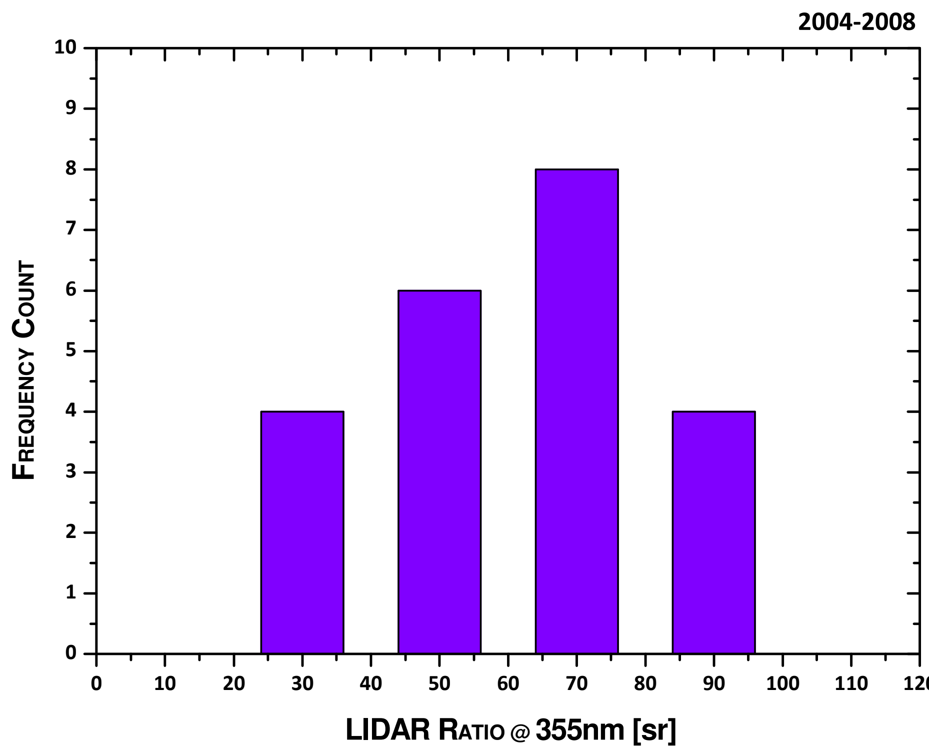
MODIS Data



OPTICAL PROPERTIES

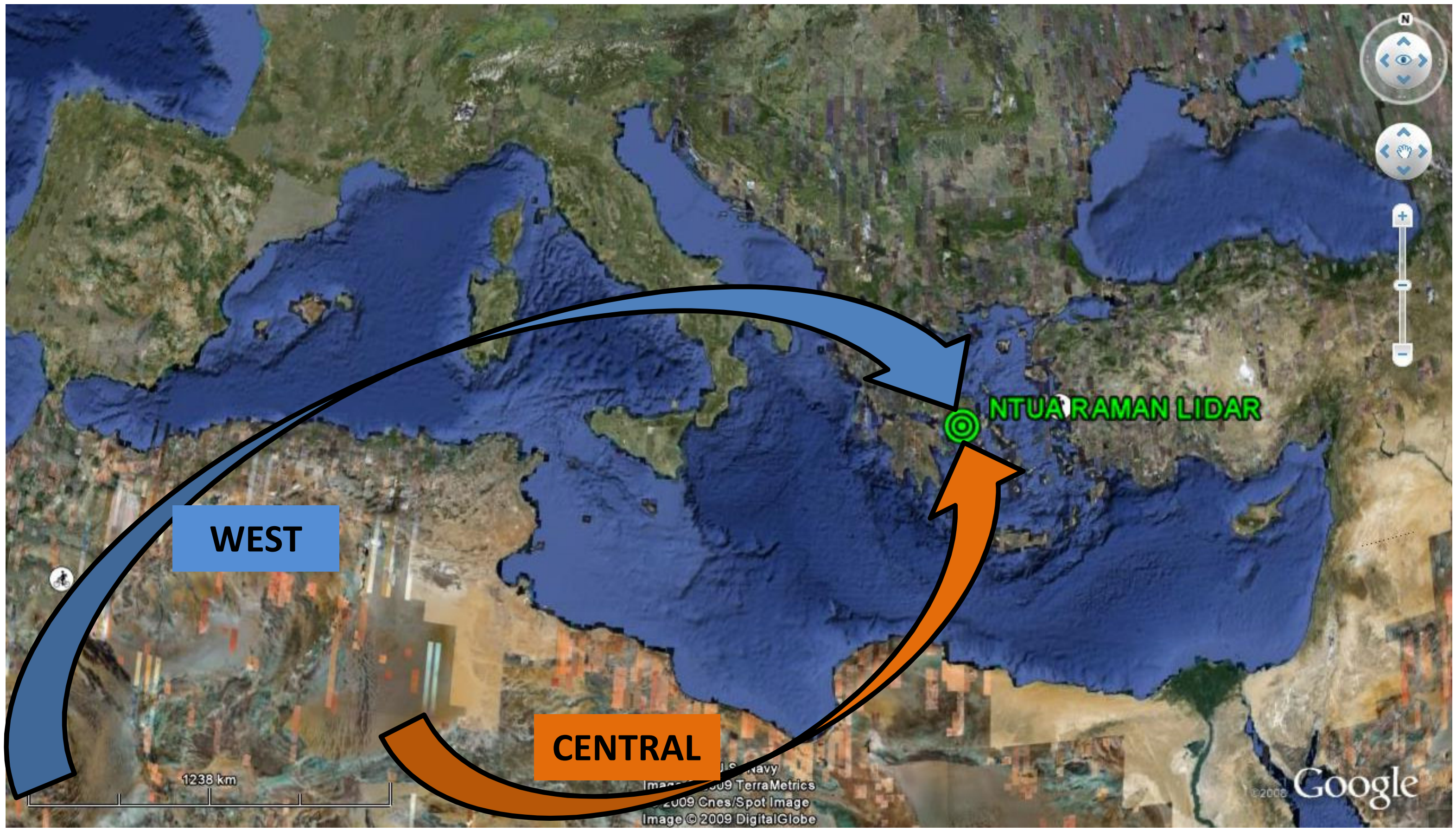
AOD & LIDAR Ratio





Optical properties of Saharan dust aerosols

Clusters Analysis

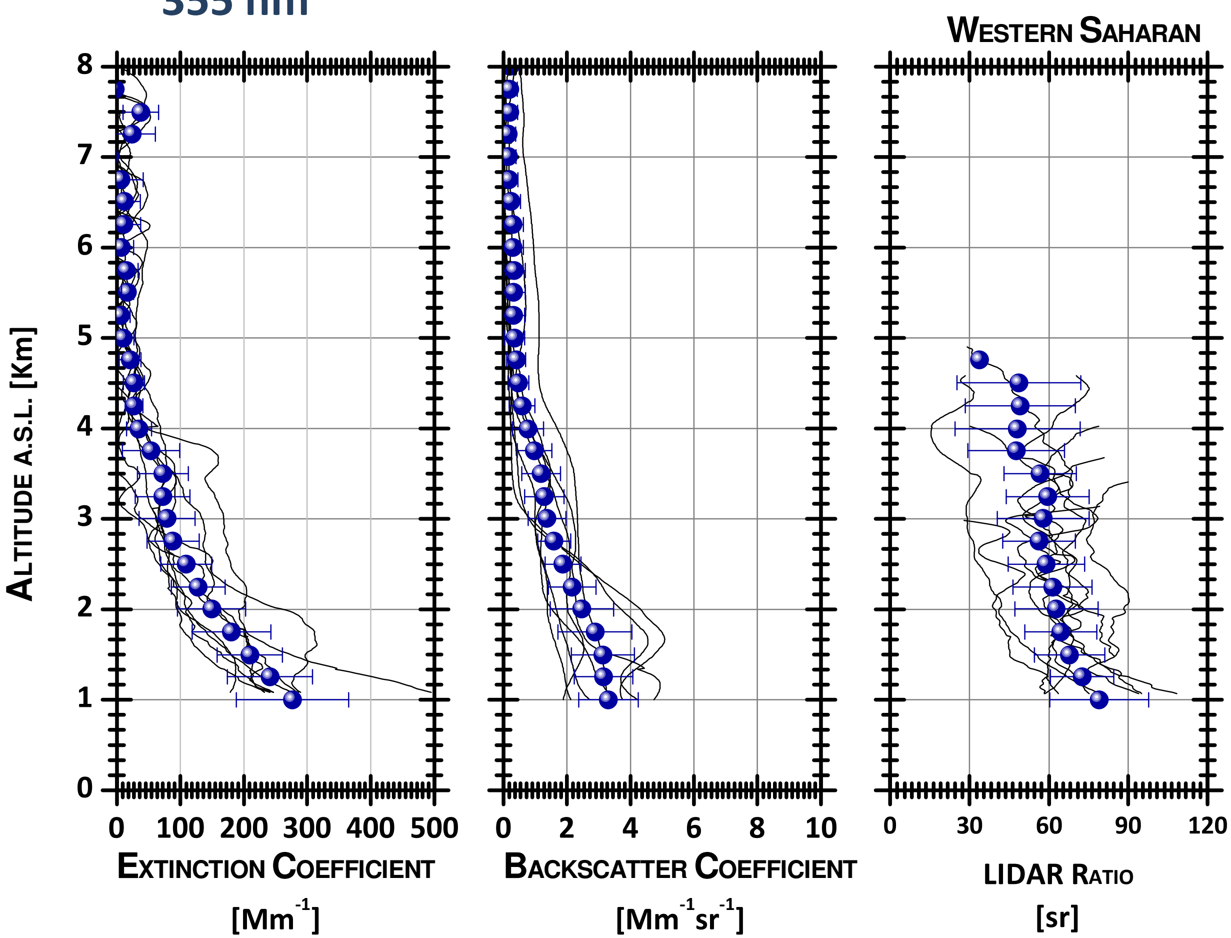


2 major regions of the Saharan desert

OPTICAL PROPERTIES OF SAHARAN DUST AEROSOLS

Western Saharan desert region

355 nm



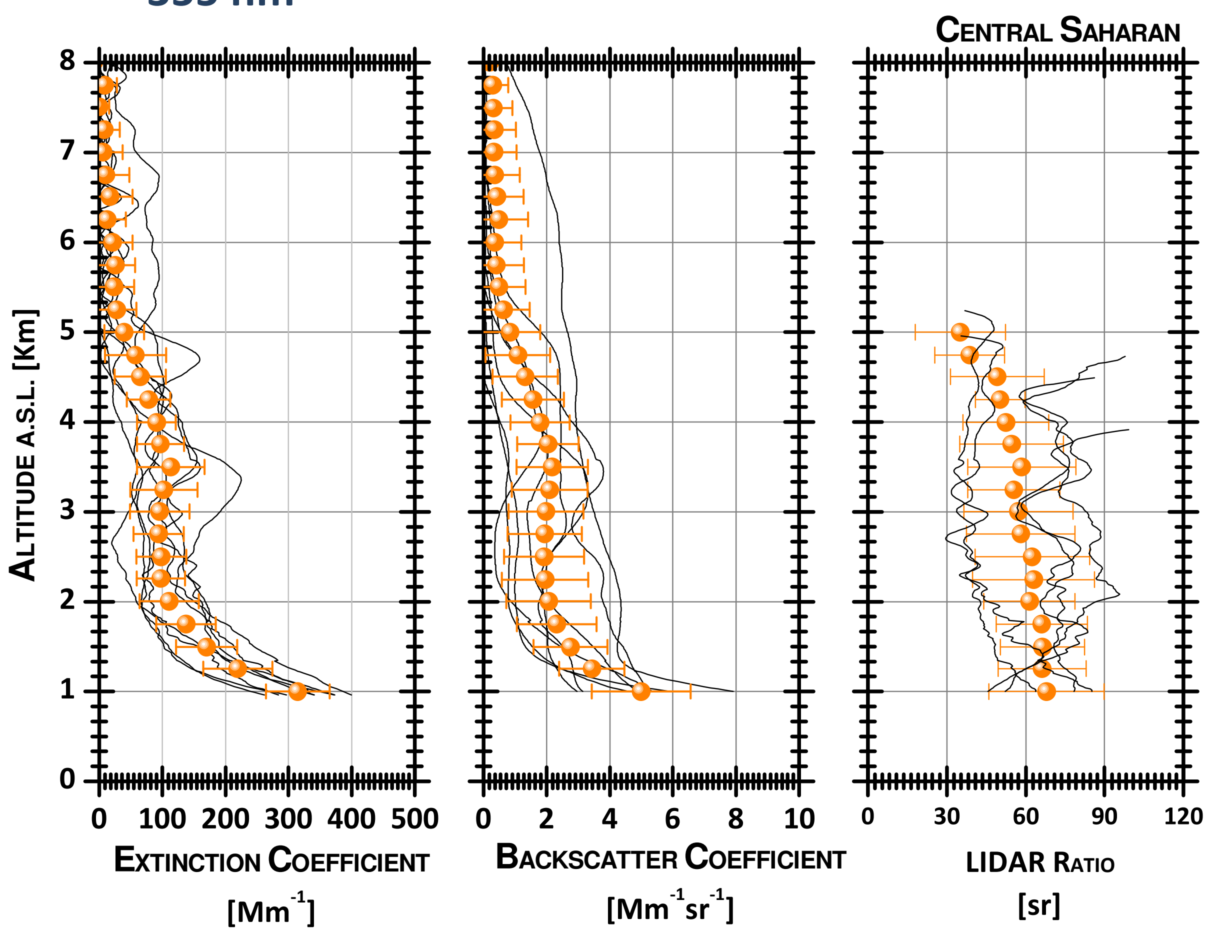
Summer & Early Autumn

- The mineral dust is mostly observed between 2.5-3.5km.
- The dust load is mostly present to the lower troposphere [inside the Planetary Boundary layer].
- Mean value of the lidar ratio: 60 sr [1.5 και 3.7 km].

OPTICAL PROPERTIES OF SAHARAN DUST AEROSOLS

Central Saharan desert region

355 nm



Winter & Spring

- The mineral dust is mostly observed to the free troposphere.
- The dust layer is usually lifted to the free troposphere, at heights above the PBL .
- Mean value of the lidar ratio: 65 sr [1.5 και 3.7 km] bigger distribution.

CONCLUSIONS

The main aim of this work was to present a statistical analysis on the geometrical properties of Saharan dust vertical distribution over Athens, Greece, for a 5 year period lidar measurements [2004-2008].

- Springtime (April-May) is the period of the maximum dust event occurrence as indicated both from lidar and MODIS measurements.
- Lidar observations reported multiple aerosol dust layer and variable thickness (680-6000 m) appearances.
- The mean center of mass of these layers was approximately calculated at 2800 m, with limited cases of events reaching altitudes over 5000 m.
- In addition, mean layer thickness was found to be 2900 m and mean top of the layer at 4500 m.

BSC/DREAM model aerosol dust climatology showed also predominant dust events for April and May periods. In addition, comparison of lidar retrieved backscatter coefficients and model calculated dust load showed fairly good agreement comparing the vertical profiles of dust aerosols. Trying to quantify the dust contribution to the Athens area, except from the obvious facts of its contribution to the spring months but also to the June-September period, we have to keep in mind that lidar dust analysis becomes difficult with the presence of clouds.

Using only lidar or sun-photometric dust climatology data, this leads to an underestimation of the dust effect especially in the winter months were the presence of clouds is more often. In the present study only 4 dust cases have been reported from lidar measurements during the winter period.

ACKNOWELEGMENTS
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BARCELONA SUPERCOMPUTING CENTER [DREAM MODEL]

END OF PRESENTATION

THANK YOU FOR YOUR ATTENTION