MAIN SCENARIOS OF DESERT DUST INTRUSIONS OVER ALBANIA REGION

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Abstract

Mediterranean is one of the European regions which are mostly influenced by dust intrusions; from Saharan and Asian deserts. This fact is conditioned by the relatively short distance from these deserts and by the main characteristics of air mass circulation. Albania is mainly influenced by Saharan and Arabic dust intrusions, which contributes to the major aerosol concentrations at high altitudes, especially those of the coarse mode. Nowadays are world widely used several tools for this kind of investigation, like remote sensing techniques and forecasting models. In this paper is presented a study of statistical occurrences of dust intrusions over Albanian territory, during the summer seasons of the last two years; 2012-2013. The results obtained here are retrieved from the data of AERONET at some neighbor stations. We have also used the additional tools, like models NAAPS and DREAM, as well as the satellite images from MODIS/NASA. Conclusions about the scale of influence and the frequency of these intrusions in Albanian territory are obtained analyzing the altitude profiles of backscattering coefficients, the column integrated values of aerosol optical depth, fine to coarse mode fractions and their contribution on AOD, Angstrom exponent, the size spectrum, single scattering albedo, black carbon concentrations, global fire maps, etc. All the above mention parameters are retrieved at different laser wavelength, in order to estimate also their dependence on this parameter. The overall results show that the Albanian territory is strongly influenced by these kinds of intrusions, especially during the warm season. Because of its relatively small area compared to the dust source regions and their distances, dust intrusions display almost a same pattern over the entire territory. Despite of this, the values of AOD due to the coarse particles transported from the source regions are clearly higher than the values retrieved in the northern European countries.

***Keywords*:** *dust events, Albanian region, remote sensing techniques*

Introductıon:

Aerosols have direct and indirect effects on global climate IPCC (2007), altering the radiative balance of the Earth-atmosphere system Haywood and Boucher (2000), and changing the microphysical and the radiative properties of clouds Penner, et al., (2001). In fact, aerosol particles can act as cloud condensation nuclei, modifying cloud lifetime and amount Ramaswamy et al., (2001) and Lohmann and Feichter, (2005). The mineral dust from desert areas, which represent a great source of aerosol injected into the atmosphere, suppresses precipitation in thin low-altitude clouds Mahowald and L. M. Kiehl, (2003), Rosenlof (2001). In addition, dust deposition can modify the ocean biogeochemical cycle, providing an important source of micronutrients Jickells et al., (2005). It has also an impact on terrestrial ecosystems, providing nutrients as phosphorus to the soil (2004).

Saharan desert is one of the most important sources of aerosols, which has a considerable impact both at the global and at the regional scale, as the Mediterranean Basin Prospero et al., (2002). This desert is the most important dust source region in the world El-Askary et al., (2003). The occurrence of Saharan dust (SD) events above eastern Mediterranean has a marked seasonal cycle, with a spring maximum and a winter minimum, Barnaba and G. P. Gobbi (2004). In the summer, dust identification over the region is also frequent due to the longer duration of the dust particles favored by the stable weather conditions, the absence of depressions, and precipitation that favor their wet deposition. In this study a combination of active and passive remote sensing technologies are used.

Aim of study/research:

The principal goal of this study is putting into the evidence the dust events over Albanian region. Another problem revealed in this paper is the determination of principal optical properties of aerosols during these dust events. The final objective of this study is to analyze statistically the patterns of the aerosol optical properties.

Research topics:

The principal topics of this paper are;
The usage of remote sensing techniques for atmospheric research
Dust event analysis for a specific case.
Analysis of aerosol optical properties

Research questions:

Occurrences and frequencies of dust intrusions over Albanian territory.
Optical properties of these dust events.
Origins and trajectories of air masses.

Scientific methods:

In this study are used the remote sensing techniques for estimate the events of dust intrusions over Albanian territory. The study is focused on the summer seasons June-August of the last two years. This selection was done because the most frequent dust events over Mediterranean region are observed during the summer season.

In present work, we are focused on the investigation of dust event occurrences over the Albanian territory. The study consists on the analyses of two successive summer seasons; 2012-2013.

We have done cluster analysis, for the potential dust sources. The clusters include west, center and east desert of Sahara as well as the Arabian Desert.

Our analyses are based on the following tools;

Models; BSC-DREAM8b v2.0 8b (The Dust Regional Atmospheric Model), NAAPS (Navy Aerosol Analysis and Prediction System) and HYSPLIT (Hybrid Single Particle Lagrangian Integrated Trajectory Model). Satellite images from MODIS (NASA, Moderate Resolution Imaging Spectroradiometer) TERRA and AQUA. AERONET (Aerosol Robotic Network) data from sun/star photometer measurements of AOT, size distribution, fine/coarse fraction and Angstrom exponent.

The steps followed on this study are as follow;

Use of models, like BSC-DREAM8b v2.0 8b and NAAPS to evidence the dust intrusion events

- Verify the events using AERONET database
- Identify dust storms on by OMI and MODIS/NASA images
- Check HYSPLIT backward trajectories for eventually dust transport

Models BSC-DREAM8b v2.0 and NAAPS forecast the aerosol optical depth (AOD) in the study aeras.
OMI dhe MODIS/NASA images (500nm) give the real situation of aerosol load.
HYSPLIT backward trajectories model the air masses pathway, indicating their origins.
AERONET database consists on data of AOD (several wavelengths), AOD(coarse mode), fine mode fraction, Angstrom exponent (440-870nm).
In order to investigate better the Albanian region, are taken into consideration data from two neighbor stations; Lecce (Italy) and Thessaloniki (Greece).
The threshold values of optical properties for dust event are taken as follow;

- AOT(500nm) > 0.1
- Coarse mode fraction > 0.3
- Angstrom exponent < 1.5

Meanwhile "intensive dust events" have AOD(500nm) > 0.3

Data analysis:

7-days HYSPLIT backward trajectories (at the altitudes 1000m, 3000 and 5000m a.g.l.) indicate the predominant pathway of air masses during the summer season over Albania territory. These modeled trajectories suggest North Atlantic as the origin of lower layers and West Sahara as origin of highest layers. Thus dust transport take place on highest altitudes.
In figures 1 are presented backward trajectories over-passing our territory during some of the dusty events.

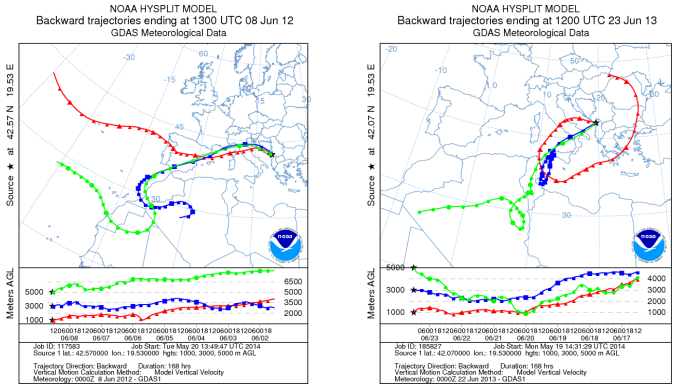

Figure 1. Dust intrusions; origin air masses west and central Sahara

Form back-trajectory cluster analysis we conclude that the principal source for dust intrusions over Albanian territory is West Sahara (27 back-ward trajectories). There are detected also dust intrusions originated on Central Sahara (8 backward trajectories). We haven't observed dust intrusions (based on backward trajectories) coming from the East Sahara or Arabic Desert. This fact can be argued by the air masses circulation during the summer season over this region.
We have evidenced 10 dust events over Albanian territory during periods June-August 12-13. There are encountered 17 dusty days, or 9.2% of the investigated period. 7 of these dust intrusions originate from the West Sahara and 3 have mixed origin from west and the center of Sahara desert. Dusty days occur mainly on June during the both summer seasons;

June 40%, July 30% and August 30% 2012
June 72%, July 14% and August 14% 2013

During summer seasons of 2013 and 2012, occurred 10 and 7 dust events respectively.

Table 1. Statistical distribution of the dust events

	duration	**AOT_{500}**	**Fine frac.**	**Anstr.exp.**	**AOTc**
6-aug-12	1	0.225	0.439	0.816	0.084
7-aug-12	3	0.336	0.631	1.226	0.188
11-jun-13	1.7	0.273	0.551	1.000	0.135

The calculations are based on the average values during each month. Minimal values of AOD and maximal values of nine mode fraction and Angstrom exponent fit the thresholds for dust event categorization.

Intensive dust events (AOD > 0.3) are observed only in three cases. Optical properties of the four extreme dusty days are given in table 2.

Table 2. Optical properties of intensive dust events

date	**AOD**	**fine frac.**	**Anstr.exp.**
6-aug-12	0.414	0.350	0.443
7-aug-12	0.432	0.303	0.354
11-jun-13	0.497	0.314	0.438
23-jun-13	0.786	0.491	0.877

The most intensive dust event was on 23 June 2013, while the most effective was during 6-8 August 2012. The dust event has 3 consecutive dusty days; two of them are characterized as intensive. These cases are related mostly to the dust intrusions from Central Sahara.

Other important tools on dust event identifications are the maps derived from models like BSC-DREAM8b v2.0 8b and NAAPS. The NAAPs maps of dust, smoke and sulfate concentrations forecast the dust intrusions. BSC-DREAM8b v2.0 8b despite of dust concentrations forecast also the altitude profiles. The model maps of some intensive days, days 6, 7, 11 and 23 June 2012 are presented in the figures 2-3.

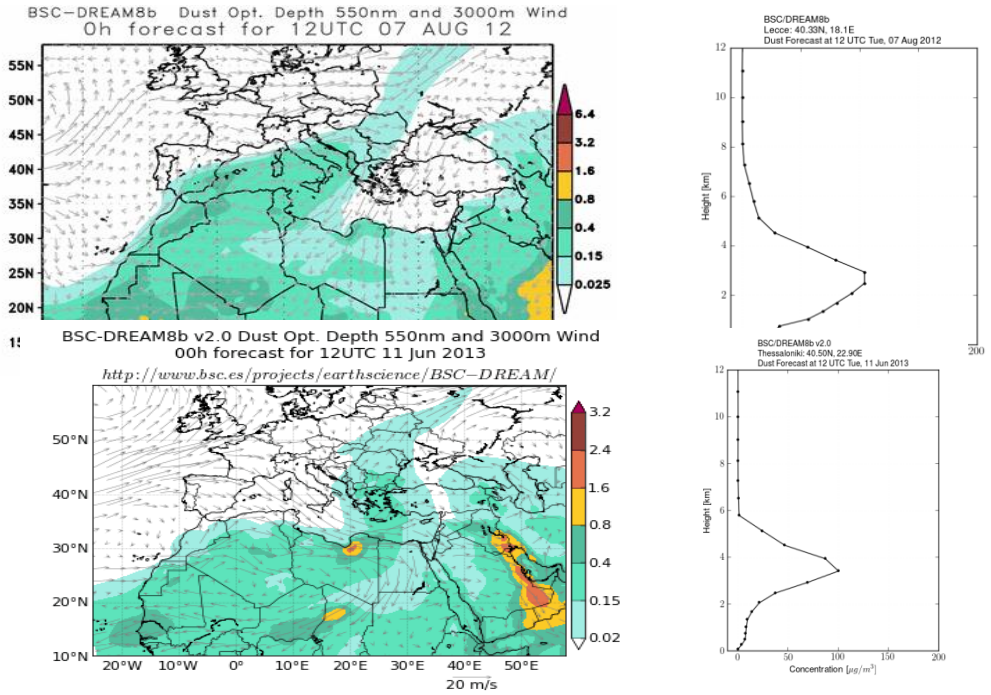

Figure 2. DREAM forecasts for intensive dust intrusions; from west and central Sahara

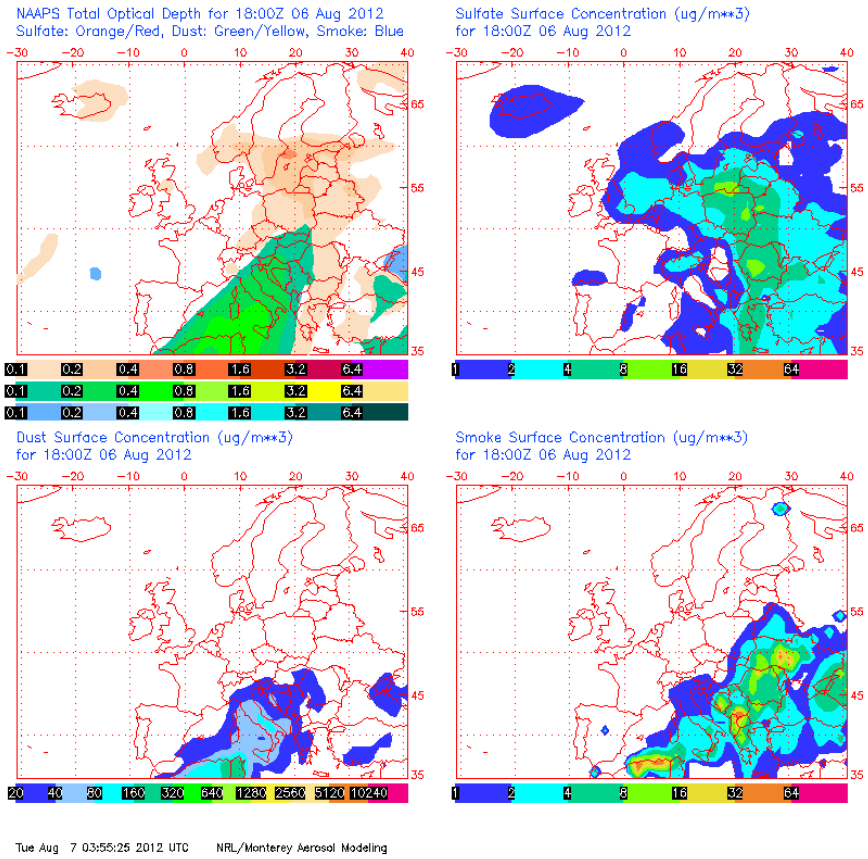

Figure 3. NAAPS forecasts for intensive one dust intrusion; from west Sahara

NAAPS model has the priority of giving except dust concentrations, also other components which give contribution on aerosol optical depth. Meanwhile DREAM model gives additional information about the layering.

One of the most important tools for estimation of aerosol optical are sun/star photometer data, provided by AERONET. From these data we can not only detect the dust events, but also estimate their optical properties. An illustration of the differences between aerosol size distribution during two extreme cases (clean and dusty days), are presented in figure 4.

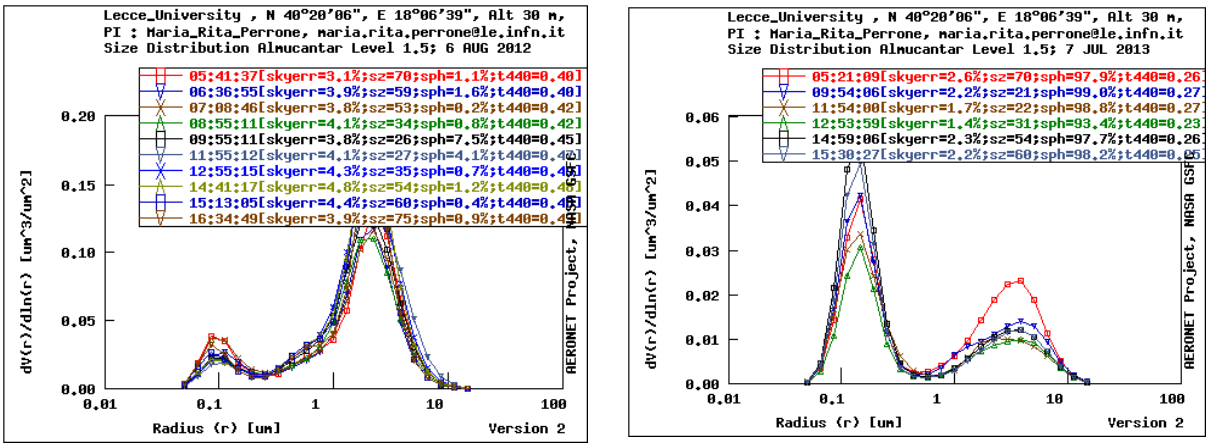

Figure 4. Aerosol size distributions during intensive dusty and clean days

From the fig.4 we can see that the peak of fine mode concentration doesn't change so much. It remains in the range of 0.04-0.05$\mu m^3/m^2$. On the other hand, the peak concentration of coarse mode is about 3-4 times lower during the clean case than during the intensive dust intrusion. Thus, we can state that anthropogenic activities are almost the same but the differences arise from the high presence of desert dust.
Origins, pathways and the concentrations over a specific site are analyzed also using the MODIS images. In figure 5 are presented the evolution of a casual dust intrusion over Balkan peninsula using MODIS images.

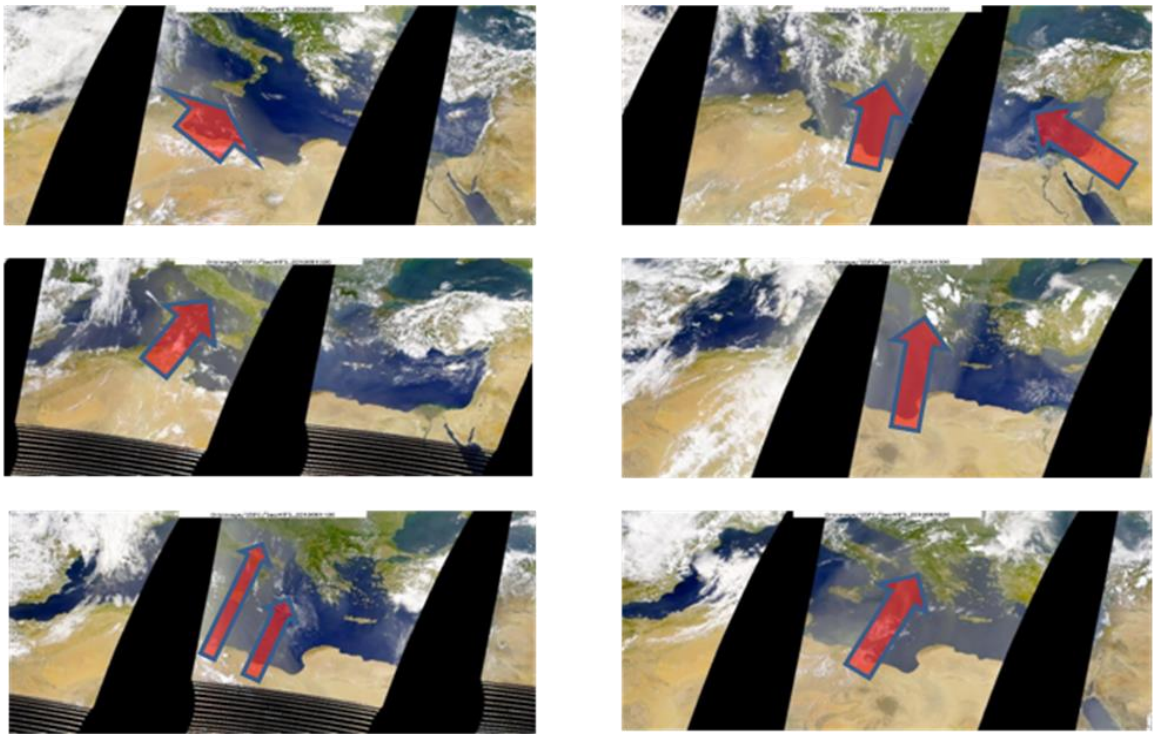

Figure 5. Satellite images of dust intrusion over Balkan Peninsula

During this dust event, the direction and intensity of dust transport as well as the origin sources continuously change.

Findings:

This analysis revealed 10 dust events which cover 17 days.
During June occur more than 50% of dust events.
The majority of dust intrusions originate from the West Sahara (77%), but all the intensive dust events are affected by air masses coming from the Central Sahara.
There are encountered also four intensive dust events; two during June and two during August.

Conclusions:

In this work are analyzed the dust events during summer season on two successive years, 2012-2013, over the Albania region.

We have used data from AERONET, satellite images, models like NAAPS, BSC-DREAM8b v2.0 8b, Hysplit, etc.

The optical parameters used in this analysis are; aerosol optical depth AOD, fine mode fraction, Angstrom exponent and the contribution of coarse mode to AOD.

As conclusion, must be mentioned that Albanian territory is often influenced by Saharan dust intrusion during summer seasons.

Recommendations:

As it a well known fact, the main component of Saharan dust is the coarse mode. So the presence of dust intrusions over Albanian territory influence on the increase of aerosol (coarse mode) concentration.

Thus, the environmental decisions about air quality must take into account also this fact, to consider that not all PM2.5 and PM10 comes from anthropogenic activities or local sources, but also from long range transport from Sahara Desert.

To have a more accurate estimation of dust intrusions over Albanian territory, the analysis must be based on the measurements situated in this country. But unfortunately the lidar and sun/star photometer instruments aren't available yet.

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