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TECHNOLOGY DEVELOPMENTS ON ATMOSPHERIC MINERAL AEROSOL RESEARCH OVER THE WESTERN BALKANS

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ABSTRACT
Nowadays atmospheric research is supported by observation data and modelling products. AERONET and EARLINET network provides one of the most important networks on atmospheric observations over Europe Continent. Despite the ground-based measurement systems, satellite-based measurements provided by the sensors on-board of several satellites are of greatest interest. Moreover, the modelling forecast gives information in the areas not covered by the observations. Balkan Peninsula houses several ground-based systems, and it is covered by the satellite observations. However, these systems are absent in the western part of this peninsula. Thus, this study aims to assess the accuracy of the available data on aerosol loads over the Western.
Keywords: dust events, Western Balkans, observations, modelling.

1. INTRODUCTION
Nowadays, remote sensing research on atmospheric aerosol consists mainly on ground-based passive/active measurements and satellite observations. Moreover, modeling is another solution to forecast aerosol loading and their optical properties. Ground-based measurements are arranged in a series of installations containing passive instruments like sun/star-photometers, like the AERONET (AErosol RObotic NETwork), which is spread in many sites [1]. Moreover, active instruments like lidars, are incorporated in different networks. In Europe is active EARLINET (European Aerosol Research Lidar Network), but there are active also MPLNET (Micropulse Lidar Network) with stations spread over several locations over the world, LALINET (Latin American Lidar Network), SPALINET (Spanish and Portuguese aerosol lidar network), etc. Satellite-based observations utilize the satellites to retrieve radar and lidar data regarding to the aerosol properties. The sensors and satellite platforms for the aerosol properties retrieval are:
MODIS NASA Terra and Aqua satellites, OMI EOS-AURA (NASA), TOMS Nimbus-7 (1979-1993) & Earth Probe (1996-2000), CALIPSO CALIPSO (active sensor - Lidar), AVHRR NOAA series, GOES GOES (a geostationary satellite), POLDER PARASOL (developed by CNES), MISR NASA Terra and Aqua satellites, SeaWiFS NASA SeaStar, MERIS ENVISAT, ATSR (or AATSR) ERS-1, ERS-1 and (ENVISAT) and GOME ERS-2 SCIAMACHY ENVISAT. Some of the platforms have active sensors (Radar, CALIOP/CALIPSO, etc.) and other passive sensors (Landsat, MODIS, MISR, SeaWiFS, etc.).
In order to complete the aerosol assessment over the regions without observational data, also modelling is involved, like, The European Centre for Medium-Range Weather Forecasts model

ECMWF [2], Weather Research and Forecasting (WRF) model coupled with Chemistry WRF-Chem [3], Regional Climate Model RegCM [4], General circulation model GCM [5], NonHydrostatic SKIRON/Eta Modelling System [6], BSC_DREAM [7] and the European high-resolution gridded dataset E-OBS.

2. FACILITIES AT WESTERN BALKAN REGION

The region of Western Balkans has a lack of ground-based remote sensing installations for atmospheric aerosol research. AERONET and EARLINET networks don't operate in this region.
The nearest AERONET sites are those of Greece; Xanthi (08-15), Thessaloniki (03-17), Athens (08-17), Italy; Lecce_University (03-18), IMAA_Potenza (04-17), Rumania; Bucharest_Inoe (07-16), Timisoara (11-13, 16-17), Culj_UBB (10-17), Austria; Kanzelhohe_Obs (01-02, 08, 10-17), and several other sites with minor temporal coverage (fig. 1).
Nearest EARLINET sites are those of Greece - Athens and Thessaloniki, Romania - Bucharest, Bulgaria – Sofia, Italy – Lecce and Potenza [8].
Thus, the scarcity of the ground-based networks over the western Balkan region, obliges that the investigation of aerosol events over this region to be based only on the satellite observation data and modelling outputs.
Passive sensors on board of satellite platforms have coarse spatial resolutions. TOMS Total Ozone Mapping Spectrometer, 1978 -2000) and OMI (Ozone Monitoring Instrument, 2000-to present) have 100 km average resolution and 50 km resolution at nadir. They use UV radiation (330 nm, 360 nm).

Figure 1. Six western Balkan countries (Albania, Bosnia & Herzegovina, Croatia, Macedonia, Montenegro and Serbia), highlighted in the map of Europe continent. Here the regions (North Africa and Arabian Peninsula) with potential mineral dust sources are presented.

MODIS (Moderate Resolution Imaging Spectro-radiometer; on-board Terra and Aqua satellites) has 36 spectral channels: wavelength range: 0.405 μm to 14.25 μm, with spatial resolution 250-500 m.
Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) operates on two wavelengths (532 nm and 1064 nm).
MISR (Multi-angle Imaging SperctoRadiometer) operates on four spectral bands (0.45 μm (blue), 0.56 μm (green), 0.67 μm (red) and 0.87 μm (NIR).
SeaWiFS (Sea-viewing Wild Field of view Sensor) provides aerosol optical data in 8 channels (6 visible and 2 NIR) with 1 km spatial resolution.
There are developed several models which forecast mineral dust intrusions over the western Balkan region. Some of them are;
Atmospheric Dust Forecast System (BSC_DREAM8b), Navy Aerosol Particle Forecasting (NAAPS), The Hybrid Single Particle Lagrangian Integrated Trajectory Model (HYSPLIT), Copernicus Atmosphere Monitoring Service (CAMS) global forecasting system operated by ECMWF (The European Centre for Medium-Range Weather Forecasts (ECMWF), The Goddard Earth Observing System Model, Version 5 (GEOS-5), The Regional Climate Model system RegCM4, Weather Research and Forecasting (WRF) model coupled with Chemistry (WRF-CHEM)etc.

3. CASE STUDY

To investigate the available facilities for atmospheric aerosol research, here a specific desert dust intrusion event is taken into the analysis. In this case, the intense dust event occurred during April 2018 is analyzed in detail. To reach this goal, data taken synergically from satellite observations and model forecasting have been used. Mineral dust intrusions over Europe and especially over the Mediterranean basin are intensively investigated.

3.1. Satellite-based observations

Averaged maps of AOD550 during the whole dust event period are provided by the NASA's Earth Observing System Data and Information System (EOSDIS). The maps presented in the figure 2, show the spatial distribution of the AOD mean values over the investigated area.

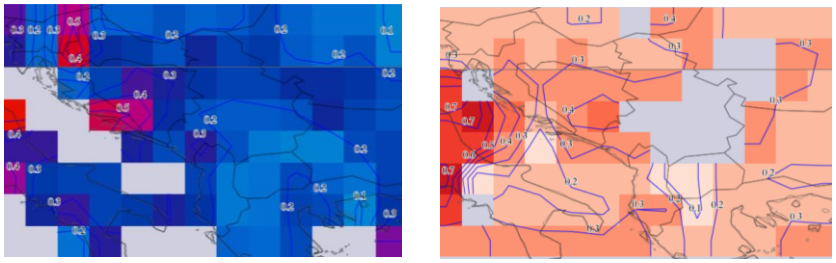

Figure 2. Maps of average AOD during dust event of April 2018 over western Balkan Peninsula, provided by NASA's Earth Observing System Data and Information System (EOSDIS). The upper map show MODIS-Aqua Deep Blue MYD08_D3 v6 (AOD_550), while the lower one show OMI OMAERUVd v003 (AOD_500).

The maps of figure 2, are averaged over the period from 11-17 April 2018. It is clearly seen the differences between the results obtained by the two sensors. However, both maps identify some of the maximums of AOD. The maximum AOD_{500}=0.5 around Montenegro provided by OMI coincides with the maximum AOD_{550}=0.3 provided by MODIS.

Data presented in the maps on the figure 3, show that MODIS has better spatial coverage than OMI. However, the correlation of their data is quite high. The differences between AOD_{500} and AOD_{550} provided respectively by OMI and MODIS are relatively low (fig. 3).

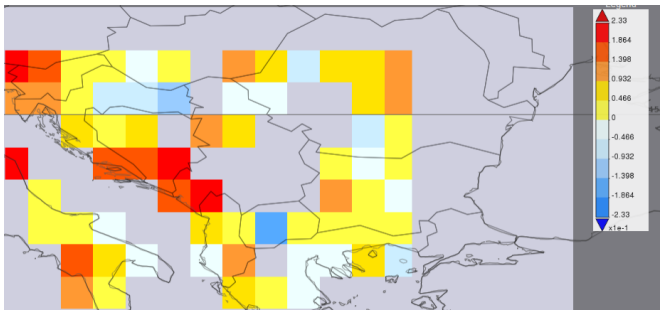

Figure 3. Time matched difference for 2018-04-11 - 2018-04-17 (Var. 1 - Var. 2)
Var. 1: AOD 500 nm daily 1 deg. [OMI OMAERUVd v003]
Var. 2: AOD 550 nm (Deep Blue, Land-only) daily 1 deg. [MODIS-Aqua MYD08_D3 v6].

3.2. Modelling forecast

For a better assessment of the dust intrusions over the western Balkan Peninsula, the datasets of four models are used. There are used, data provided by BSC_DREAM8b, CAMS-ECMWF and NASA-GEOS-5. Dust event starting and ending dates are forecasted slightly different from the four models; BSC-DREAM (12 – 18 Apr), CAMS-ECMWF (12 – 19 Apr) and NASA-GEOS-5 (10 – 19 Apr). However, the peaks of DUST_AOD550 are obtained during the same day (15 Apr), also differing slightly from one model to another (fig. 4).

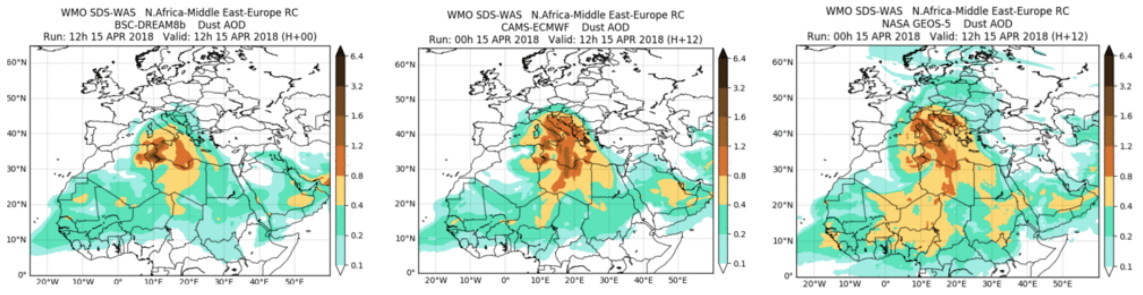

Figure 4. Dust event at its maximal intensity over western Balkan Peninsula, provided by three forecast models; BSC-DREAM8b, CAMS-ECMWF and GEOS-5 (15 April 2018).

Higher differences among the models arise in the case of the maximums of DUST_AOD550. BSC-DREAM gives AOD 0.4 over the west Croatia. CAMS-ECMWF forecasted much higher value; 1.2 spread over the southern Croatia, Montenegro and Albania. GEOS-5 forecast values up to 1.2 over the region of southern Croatia, BiH and Montenegro.

Dust surface concentrations provide useful information about the potential dust sources. Both models forecast dust source over the central Sahara (region of Tunisia and Libya), with maximal surface concentrations of 2000 μgm^{-3} (BSC-DREAM), 5000 μgm^{-3} (CAMS-ECMWF) and 1000 μgm^{-3} (GEOS-5). Much lower (up to 500 μgm^{-3}) concentrations over the Arabian Desert are forecasted by both models.

4. CONCLUSIONS

The absence of the availability of ground-based remote sensing installations for atmospheric research in the western Balkan countries, implied the necessity of the use of the auxiliary tools. The usage of the satellite-based observations gives accurate information about the aerosol optical properties. However, satellite products don't cover the whole the investigated area. For this purpose, the modelling techniques are adequate to investigate the regions with no data temporal/spatial coverage.

To perform aerosol research using remote sensing techniques over the region of western Balkan, passive and active sensors on several platforms and different models may be used. The results obtained from the analyses of these data give a detailed picture of the aerosol load and their optical properties over the region or its specific sites.

In this paper a case study was performed, taking into analysis the dust event which occurred during April 2018. Analysis was based on the satellite data retrieved from the sensors MODIS and OMI as well as from the models like BSC-DREAM8b, CAMS-ECMWF and GEOS-5. The results taken by different sensors and model coincide pretty well with each other, indicating the main properties of aerosol load over this region. Based on these data, the peak of this event occurred on 15 April, with AOD over than 1.0 is specific sites of the region.

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