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AUTOMATIC ALERT SYSTEM FOR TROPOSPHERIC PARTICULATE POLLUTION MONITORING

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ABSTRACT

An automatic alert system is implemented in order to detect atmospheric pollution layers and establish the degree of pollution load. When such layers are heavily loaded, automatic alerts are sent towards designed scientists in order to further analyze the event and inform the relevant stakeholders. The alert system is based on continuous measurements taken by a ceilometer supplemented by a photometer. Backtrajectory model is used to establish the pollution source.

1. INTRODUCTION

Atmospheric particulate pollution can impact human health [1] and safety, and to a larger extent, the biosphere. Heavily loaded pollution layers in troposphere can affect aviation [2], and when reaching the ground, they can diminish air quality [1], while they also affect agriculture areas or important infrastructure [3].

Within this context, we pursued to implement an automated system for pollution layers detection in near real time (NRT) where the degree of pollution is evaluated. When the pollution is high, we issue automated alerts towards designated scientists. The scientist can then perform dedicated measurements to gather additional information to get a thorough image of the pollution event. If the final assessment reveals a strong pollution event, alerts will be sent towards the national bodies in charge with emergency situations. Here we present the main methodology and the implementation of the system for Bucharest, Romania.

2. METHODOLOGY

2.1 Instruments

This methodology is based on measurements by continuously operating instruments, namely a CHM15k ceilometer from Lufft [4] and a CE318 photometer from Cimel [5]. In addition, Hysplit [6] back trajectory analysis is performed when strong pollution layer is detected, in order to gather information about the source of the event.

2.1 Procedure

The main steps of the procedure are the following:

- Ceilometer data are processed every 15 minutes. Time-height plots (quicklooks) based on range corrected signal (RCS), displaying the last 24h, are updated. Example images are shown on our website (http://liverali.inoe.ro/Ceilometer/). Furthermore, the lofted aerosol layers are detected. Currently, the algorithm developed by Lufft is used to identify up to three layers of aerosol layer height (ALH). Note that the algorithm does not perform above ~ 4000 m. An algorithm to evaluate ALH over the whole troposphere is under development in our department.
- When an aerosol pollution layer is detected by ceilometer over the last 15min, above 2500m, the system downloads the NRT Cimel sun photometer data to further characterize the aerosol situation. Specifically, aerosol optical depth (AOD) data and Spectral Deconvolution Algorithm (SDA) files are used. The current values of AOD, Ångström exponent (AE) at 440 nm / 870 nm, fine mode fraction (FMF) / course mode fraction (CMF) at 550 nm and the AOD for FMF/CMF at 550 nm are compared with the climatological values (monthly means) at our station [7]. The current photometer data refers to Version 3 level 1.5, which are cloud-screened and quality controlled and are provided by Aeronet [8].
- If one of the parameters exceed 90^{th} percentile of the climatological values, the Hysplit backtrajectory is performed over 10 days. In addition, AE bellow 10^{th} percentile is considered as well.

Specifically, the criteria to define the values outside the climatological range are:

- AOD > 90th percentile
- AE < 10th percentile or > 90th percentile
- AOD FMF, AOD CMF > 90th percentiles
- FMF > 90th percentile

A document is created containing overview information of the detected event, in order to help scientists quickly evaluate all available information. The document contains the RCS from ceilometer with the location of the ALH, the photometer values along with the monthly means from climatology and the Hysplit backtrajectory. An email is sent to designated scientists who will analyze the results. Also, the events are stores in a log file (contains the same information as that issued by email).

3. RESULTS

3.1 Current alert system

The implementation of the algorithm started in February 2018. The Hysplit feature was added at a later stage.

The following alerts types are issued:

a) When there is no photometer data, the aerosol load can not be evaluated through the optical properties given by photometer. An alert is sent by email where it is mentioned the presence of the ALH, while there is no photometer data available.

b) When the optical properties are evaluated w.r.t. climatological values but the current values are within expected limits.

c) When the optical properties are evaluated w.r.t. climatological values and the current values are outside the expected limits. A document is created showing the results.

An example of the information included in the document is shown in Figs 1-3. In Fig. 1 (slide 1) we observe that the current values (shown by black squares) are below the 90th percentiles (shown by filled triangles). However, AE is above the 90th percentile. Similar, the FMF and CMF AODs are below 90th percentile (Fig. 2). FMF is slightly larger than the 90th percentile. Figure 3 shows the RCS with overlapped ALH (also shown RCS with overlapped cloud base height – CBH). We can observe that in the last 15 min there are ALH (IInd or IIIrd layers) above 2500 m. The right plot shows the Hysplit backtrajectory. We observe that the backtrajectory reaches the ground level (shown by the black curve on the lower panel) after ~30 h back in time, close to Pristina in Kosovo. Apart from these images, the document includes numerical values of the parameters which are outside climatological values (in this case, AE). Large values of AE correspond to a small mean size of the aerosol and consequently to a larger FMF and AOD FMF. Small particles are associated with pollution due to smoke fires for example.

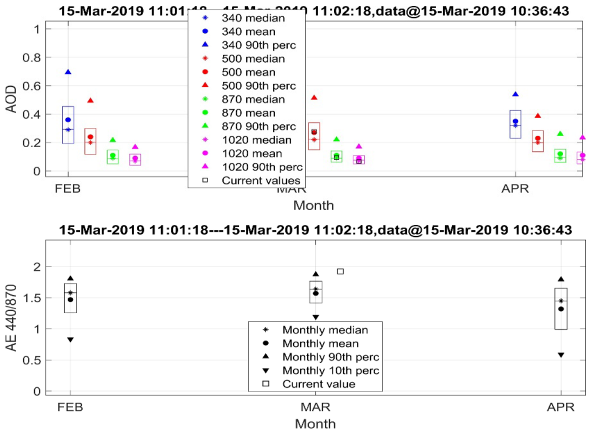

Fig. 1. AOD and AE (current values versus climatological monthly values).

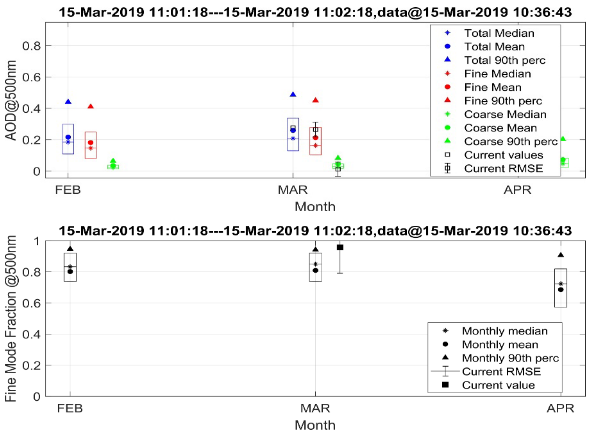

Fig. 2. AOD FMF and AOD CMF, FMF at 500nm.

A quick search in FIRMS [9] shows the fires which occurred 48h before. Figure 4 shows a screen shot of the area.

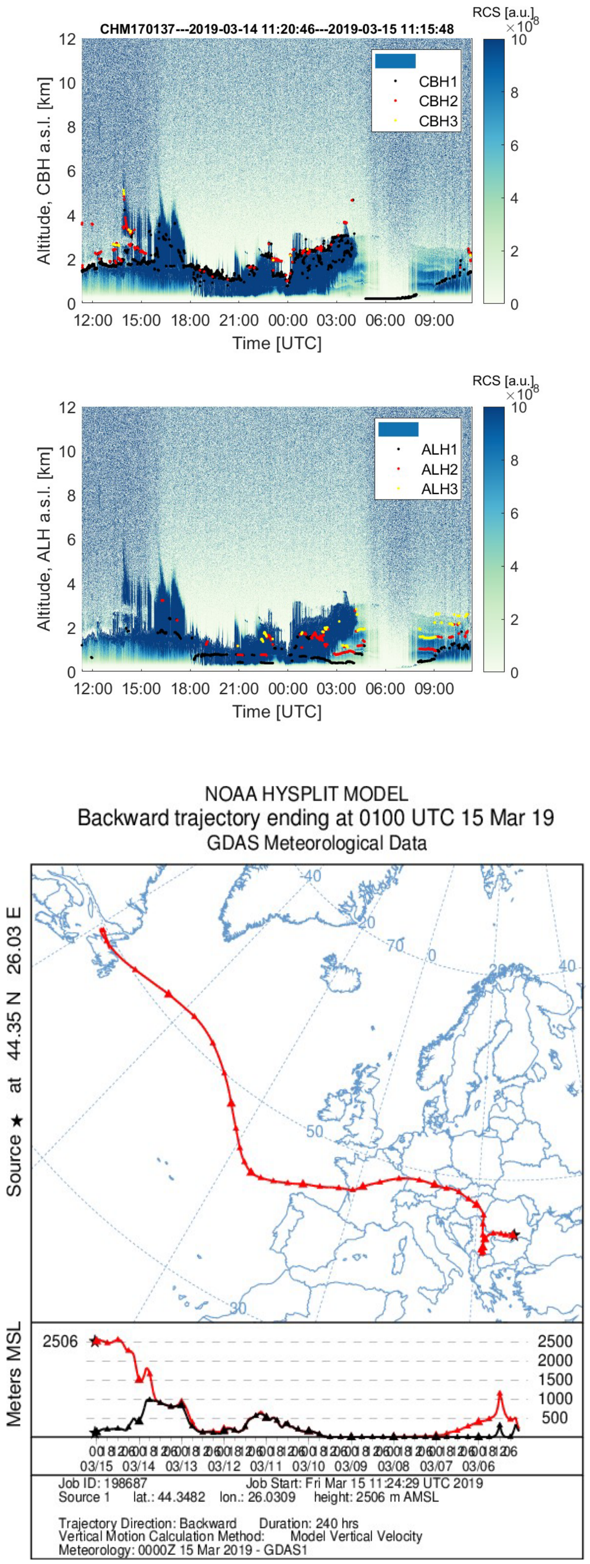

Fig. 3. RCS with overlapped CBH and ALH (upper) and Hysplit backtrajectory (lower).

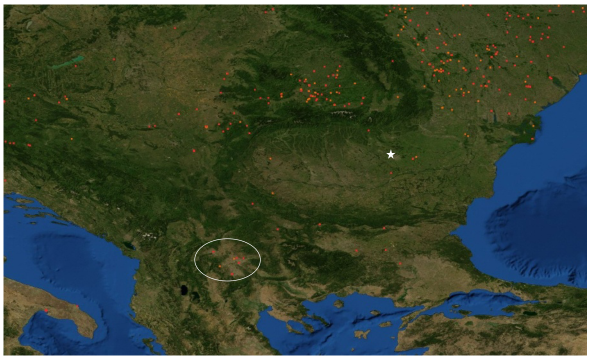

Fig. 4. Screenshot of the fires seen by MODIS 48h before the event run by Hysplit. The star shows INOE location and the eclipse shows the region with fires along backtrajectory.

CONCLUSIONS

The current alert system is implemented at INOE 2000 in Magurele (Romania). It is based on continuous measurements taken by a CHM15k ceilometer and a CE318 photometer. Climatological values (based on ten years measurements) of the aerosol optical properties revealed by photometer are used to determine the degree of the current pollution. Thus, alerts are sent when optical properties are above the 90th percentile of the climatological values plus value of AE below 10th percentile. Hysplit backtrajectory is performed to determine the pollution source.

Limitations:

- The algorithm works when photometer data is available (cloud free). Currently, only the day time measurements are used.
- ALH is determined by the manufacturer's algorithm. It focuses on ALH below ~ 4000m.

Further implementations:

- Use day and night photometer data. Use of Photons retrievals are envisaged [10].
- In-house algorithm to determine ALH in whole troposphere.

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