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Comparison Study Between using Statistical Method and BSC-DREAM8b Model to Determine the Contribution of Mineral Dust on PM10 in Constantine, Algeria

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ABSTRACT

Saharan dust is mainly composed of mineral dust due to the proximity of the Sahara to the study site. This work aims to identify Saharan dust intrusions and evaluate their contribution to annual and daily PM10 at a suburban background site located in the city of Constantine in Algeria using two methods. The first method employs the BSC-DREAM8b model which is a regional model designed to simulate and/or predict the atmospheric aerosol cycle of mineral dust, and the second one, use a statistical method which is based on an original methodology called revised methodology proposed by [1] and revised by [2]. The latter is used in the absence of chemical analysis. The results obtained display a certain consistency between the two methods used. The observed average PM10 during the study period was $57.12 \pm 21 \mu\text{g}/\text{m}^3$. Using BSC-DEAM method, the mineral dust concentration was $34.7 \pm 42 \mu\text{g}/\text{m}^3$ with a contribution of 60.73% to PM10. However, it was about $25.63 \pm 29 \mu\text{g}/\text{m}^3$ using the revised methodology with a contribution of 45% to PM10.

Keywords: Mineral dust, PM10, BSC-DREAM model, Revised methodology.

1 Introduction

PM10 are inhalable particles of the order of $10\mu\text{m}$ but not only that. These particles include smaller and more harmful particles that can cause cardiovascular and cerebrovascular accidents, asthma, etc. the study of the contribution of mineral on PM10 dust in Algeria is an innovative study in the country, However, the high cost of chemical analyzes prevents the development of many of them. It is for this reason that we chose this more accessible and less expensive approach to determine the contribution of mineral dust to PM10.

2 Experimental

2.1 Site description

The sampling site was located south of Constantine within the university of Mentouri brothers at camus of Chaab Ersas area ($36^{\circ}34'36''\text{N}$, $6^{\circ}37'29''\text{E}$, 565 m.a.s.l.). The sampling device is located approximately 14 m above the ground and approximately 120 m from an active traffic lane.

2.2 PM10 sample collection

Sampling was scheduled at midnight for 24 h every 3 days during one year from 20 June 2017 to 13 June 2018. A total of 117 samples were collected during the measurement campaign. A mini vol TAS sampler (Tactical air sampler) was used with a flowrate in the range 5 L/min. Hourly meteorological data from the nearby meteorological weather station of Ain-El-Bey which is located 4 km to the south of the sampling site were used. PM10 samples were trapped by quartz microfiber filters (47 mm of diameter). Before and after each sampling interval, the collection media were humidity and temperature stabilized for 48 h before weighing them.

2.3 Determination of dust episodes

In order to identify the days affected by Saharan dust intrusions in Constantine during the study period, we used the same methodology proposed and employed by [3] based on prior studies.



2.4 BSC-DREAM8b model

Aerosol maps: BSC-DREAM8b (Dust REgional Atmospheric Model) dust maps: <https://ess.bsc.es/bsc-dust-daily-forecast>); Simulation with this system was carried out for all sampling days.

2.5 Revised methodology

A statistical method was suggested by [4] to know the net daily contributions of Saharan dust to particle concentrations. This method does not require chemical speciation data and is much less expensive. This approach was adopted by the European Commission (EC) regarding natural events, in accordance with Directive 2008/50/EC [5]. This method is easier to apply given that only the days impacted by saharan dust must be identified to be excluded from calculations. [2] modified some points of the method proposed by the EC, 2011 using each site of measurement as a reference site (so-called self-calibration method). This means that the equation (1) is applied to each site on the basis of the data recorded there, making it possible to deduce the “PM10net_dust” values specific to the study site.

$$\text{PM10net_dust} = \Delta\text{PM10} = \text{PM10 background (in presence of saharan dust)} - \text{PM10 background (in the absence of saharan dust)} \quad (1)$$

3 Results and Discussion

3.1 Statistical methodology

From 117 sampling days, we obtained 58 days with Saharan dust intrusion. The methodology revised by [2], was applied to statistically estimate the contributions of Saharan dust to PM10. After excluding the days affected by Saharan dust intrusions, the 40th percentile value was calculated on the basis of the remaining days and its value is $31.5 \mu\text{g}/\text{m}^3$. This value represents the background pollution concentration which appears to be quite high. This per urban background concentration is mainly linked to road traffic below the measurement site at a distance of 120m. Equation (1) results in an annual average concentration of Saharan dust with a value of $25.63 \mu\text{g}/\text{m}^3$ representing a contribution of 45% to PM10 ($57.12 \mu\text{g}/\text{m}^3$).

3.2 BSC-DREAM8b model

For the whole study, we obtained an annual average concentration of $34.7 \mu\text{g}/\text{m}^3$ for mineral dust which appears to be significant, with a contribution of 60.73% to PM10.

3.3 Comparison between the two methods

Figure 1 represents the temporal variation of PM10 concentrations with that of mineral dust estimated by the BSC-DREAM8b model and the statistical method. The histograms show the comparison between the seasonal variation of Saharan mineral dust intrusions estimated by the two methods.

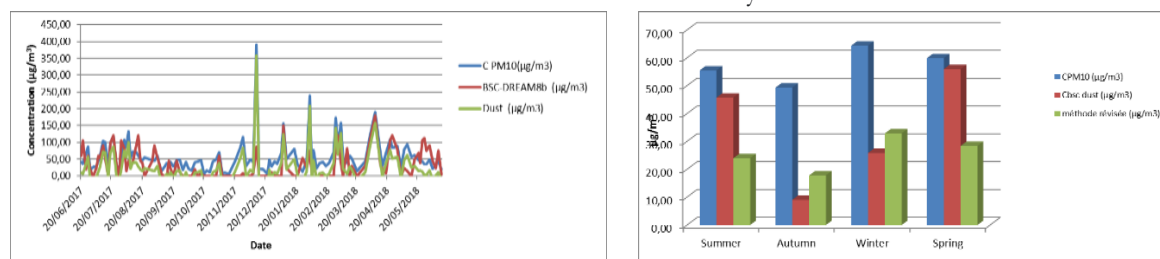


Figure1: a) Temporal variation of PM10 and mineral dust concentrations estimated by the BSC-DREAM8b model and the statistical method, b) Histograms comparing the seasonal variation of Saharan dust intrusions estimated by the BSC-DREAM8B model and the statistical method.

According to Figure 1.a, the temporal variations of mineral dust estimated by the two methods follow the same pattern of temporal variation for the majority of sampling days. However, the BSC-DREAM8b prediction model would tend to overestimate the concentrations of mineral dust where the latter would exceed those of PM10 during the spring and summer seasons. However, it appears that the two methods used in Figure 1.b differ in their seasonal estimation of Saharan mineral dust concentrations. Indeed, the BSC-DREAM8b model produces an overestimation of Saharan dust concentrations in the summer and

spring seasons compared to the statistical method, with a concentration of Saharan dust during the entire study period equal to $34.7 \mu\text{g}/\text{m}^3$. According to [6], the use of the BSC-DREAM8b model gives an overestimation of mineral dust in the hot months, due to the overestimation of the AOD by the model. The BSC-DREAM8b model depends on other parameters for forecasting and estimating the Saharan dust cycle which may be more or less close to reality. On the other hand, the statistical calculation method used gives an overestimation of mineral dust in the winter and autumn seasons with a concentration of Saharan dust throughout the study period equal to $25.63 \mu\text{g}/\text{m}^3$. This may be due to the fact that the statistical method essentially depends on the concentrations of PM₁₀ which were significant in the months of December, January and February.

4 Conclusions

This approach is done for the first time in Algeria. The results show a similitude in some points but are quite different. The results obtained using the BSC_DREAM model seems to be more

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