# The importance of identifying dust sources in urban areas: HYSPLIT analysis and $PM_{2.5}$ measurements

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**Abstract.** The Mediterranean region has been prone to air quality and public health problems due to particulate matter originating from Sahara transboundary storms. In this study we combine information from World Air Quality Index platform, gravimetric sampling, and backward trajectory analyses via the NOAAH HYSPLIT model and data from MERRA 2, to identify the contribution of dust events in elevated particulate matter $PM_{2.5}$ concentrations in Albania. The highest value of measured concentrations during January 2022 were on 8 and 17 January 2022, respectively 44.92 µg/m³ 57.25 µg/m³. The WAQI-reported median PM2.5 concentration on January 8, along with the identification of individual trajectories and MERRA-2 (NASA Giovanni) reanalysis of dust-specific contributions, reached 35 µg/m³ on that day.

## 1 Introduction

Over the past ten years, Albania's population has increased and became denser. With 2,793,592 residents as of January 2022, Tirana was the most populous region in Albania, with 30% of the total population living there. This analysis was triggered by the WHO report (2016) on PM2.5 calculated fatalities and INSTAT statistics (2011–2023), which showed that, for the first time, deaths surpassed births between 2020 and 2023. This rise suggests causes other than COVID-19 [1, 2]. The air quality in the Mediterranean region, which includes Albania, is greatly impacted by Saharan dust. According to Querol et al. (2009) and Dai et al. (2022), Saharan dust contributes approximately 6 µg/m³ to $PM_{10}$ in the Eastern Mediterranean's yearly, with dust events reaching peaks of 31 µg/m³ [3, 4].

The geographic location and topography of Albania has always influenced air pollution and climate. Mountains block the dispersion of pollutants, accumulating them in urban valleys in several cities. In Tirana, Dajti Mountain serves as a natural barrier against winds coming from the east and northeast. Another factor is the city's proximity to the Mediterranean Sea and its location in the Balkans, which result in a high influence of dust coming from the African region. The Mediterranean climate is characterised with winds and varying weather patterns that increases $PM_{2.5}$ and $PM_{10}$ from sources such as traffic, wood heating, waste burning and industry.

The WAQI platform (World Air Quality Index) analysed $PM_{2.5}$ in 2022 from two stations in Albania [5]. They use sensors devices such as optical particle sensors (OPS), which use laser light scattering to count and determine the size of particles, and electrochemical sensors for gases. The platform receives the $PM_{2.5}$ and $PM_{10}$ concentrations measured by the stations and transforms them into a standard index. $PM_{2.5}$ levels of 35 µg/m³, for instance, are categorized as unhealthy for sensitive groups with indices ranging 101–150), but levels above 55 µg/m³ are characterised unhealthy and have indices ranging151–200. Comprehensive analysis is made possible by WAQI's complete data. Hourly updates in Tirana make it easier to monitor and identify peaks in wintertime pollution caused by local emissions or Saharan dust.

In January 2022, $PM_{2.5}$ was collected in centre of Tirana using a sampling instrument (LVS) that pumped 2.3 m³/h onto Whatman PTFE filters. The sampler was placed on the roof top of 17 m above the ground. Filters were weighted before and after sampling each time Premti et al. (2025) [6]. Values were compared with WAQI reported values in the corresponding days.

We also applied the NOAA HYSPLIT model (Hybrid Single Particle Lagrangian Integrated Trajectory) to track air masses during days with high $PM_{2.5}$ to detect whether they originated from the Sahara [1]. NASA MERRA-2 provided estimates of dust and $PM_{2.5}$ concentrations. MERRA-2 combines data from satellites, measurements, and models, using advanced assimilation techniques (Gelaro et al., 2017) [7]. From the Giovanni platform we collected time series and spatial distributions for January 2022, identifying dust episodes and their impact on air quality.

## 2 Results and discussion

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### 2.1 Mortality due to air pollution

Several studies are focused in connecting and quantifying particulate matter originating form Sahara dust to mortality and hospital admissions. Chen et al. (2020) evaluated a risk ratio of 1.08 for mortality coming from an $PM_{2.5}$ increase of every 10 µg/m³. Cakmak et al. (2016) and Gan et al. (2013) identified high risk for mortality in areas of Canada where concentration of PM2.5 was low suggesting no safe threshold for chronic exposure [8,9,10].

Mallone et al. (2011) and Alessandrini et al. (2013) evaluated the causes of increased cardiac and respiratory diseases. WHO has reported detailed calculated parameters based on observations of median annual $PM_{2.5}$ reported in 184 countries in the world [11, 12]. In Albania during 2016 it was reported an annual median $PM_{2.5}$ concentration of 20 µg/m³, which is higher than values reported for Greece 16 µg/m³ and Italy 15 µg/m³. Countries located north as Kosovo and Serbia reported higher values respectively 23 µg/m³ and 25 µg/m³. DALYs in Albania (21000) are much lower than in Italy (80000) but higher than Kosovo (12000) and YLLs (43000) surpass Monte Negro value (9000) but are much lower than Italy (720000). Deaths attributed to air pollution in Albania (AAP) are lower than those reported by surrounded countries (table 1).

**Table 1.** Information about calculated parameters regarding deaths from air pollution.

| Parameter | Value | Parameter description |
|---|---|---|
| AAP | 1900 | Deaths that are attributed to air pollution. |
| YLLs | 43000 | Years of life lost because of premature mortality by AAP. |
| DALYs | 21000 | All years lost from premature deaths and disability form AAP. |
| Age standardized death rate | 67 | Deaths per 100000 population from AAP. |
| Age standardized DALY rate | 750 | DALYs per 100000 population from AAP. |

### 2.2 Local measurements and WAQI data

Local sampling was performed in the centre of Tirana from 02.01.2022 to 29.01.2022 (12 $PM_{2.5}$ concentration values). Maximum value of 57.23 µg/m³ was observed on 17 January while minimum value was 12.7 µg/m³. On January 8, the second-highest value of 44.9 µg/m³ was measured, while other values were relatively low. This value corresponds to values reported by WAQI and described in figure 1.

Observation daily concentration reported by WAQI during 2021 showed that WHO daily limit of 15 µg/m³ were often excited in urban areas as Tirana, especially in winter when wood burning is the primary source for residential heating. Daily median values ranged from 30 to 52.3 µg/m³. During 2022 yearly median reported value was 15.44 µg/m³ while highest daily values were reported in January. On 8 January daily median value of $PM_{2.5}$ was 41.15 µg/m³ (figure 1).

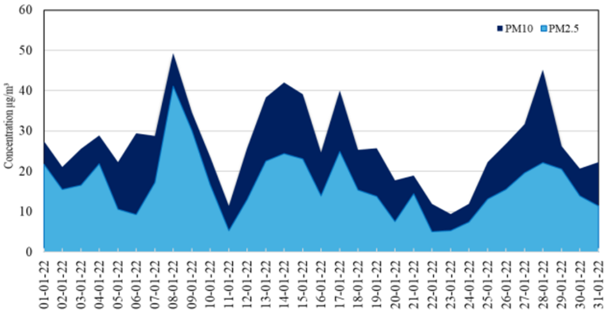


**Fig. 1.** Daily median $PM_{2.5}$ and $PM_{10}$ concentration reported for January 2022.

### 2.3 Hysplit analysis and MERA-2 modelling

We run the model NOAA HYSPLIT for several periods during winter. On January 8, 24 backward individual trajectories (72 hours, 500 m above ground level) were performed with Hysplit model. Each trajectory was during different hour of the day (00:00 to 23:00 UTC). This way we assessed the variability of the pathways of air masses. During the day there was a consistent pattern with air parcels arriving in Albania from central and western Sahara. This observation is linked to measured values reported which originate directly form these areas in Africa (figure 2).

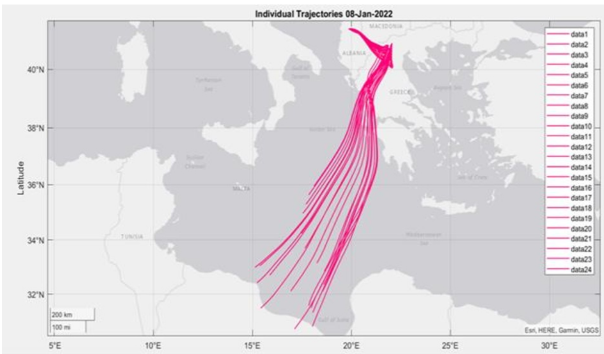


**Fig. 2.** Backward individual trajectories with air masses coming form Africa on January 8. 2022.

Gammouldi et al. (2024) determined that Sahara dust is transported in central Europe in very high which indicates that the second high value measured on 17 January is from local sources as wood burning [13].

In figure 3 is described the time series of averaged dust surface mass concentration daily, during January 2022. The data are modelled with MERRE-2 reanalysis. In figure 4 is given the time averaged map of dust concentration, where the intensity of Sahara dust and spatial distribution in the southwestern region is described.

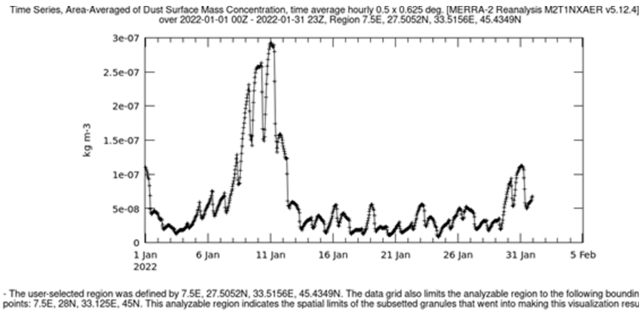


**Fig. 3**. Time series of averaged dust surface mass concentration (kg/m³), in January 2022.

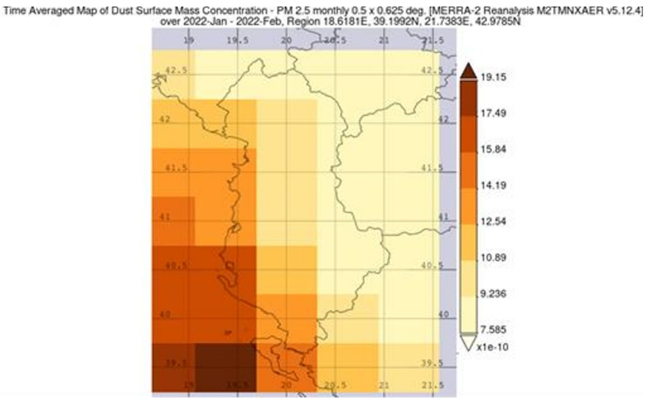


**Fig. 4.** Spatial distribution of dust surface mass concentration during January 2022

In figure 5 are described the time series for total mass concentration of $PM_{2.5}$ in green which includes dust and local sources. Time series of average dust concentration mainly coming form Africa in purple and time series of average dust mass concentration for fine $PM_{2.5}$ in blue.

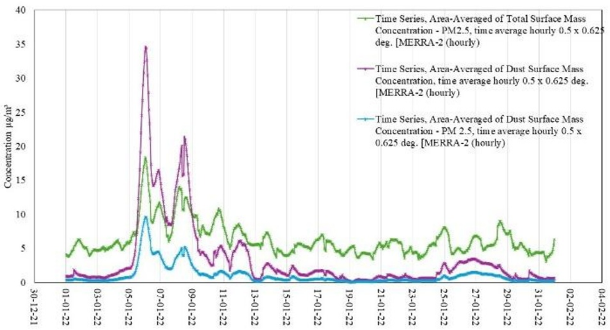


**Fig. 5.** Caption of the Figure 1. Below the figure.

We observe that on January 8 the main source of $PM_{2.5}$ comes form Sahara dust reaching 35 µg/m³ while on the 17th of January, there is not any influence form dust transport indicating that the highest measured value is due to local sources.

## 3 Conclusion

Combining different information of measurement on PM2.5 and modelling with HYSPLIT and MERRE-2, was fruitful in identifying the influence of a dust storm in Albania. Further analysis in distinguishing a local source as wood burning during winter, is essential for evaluation of mortality indicators.

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