ITALIAN ADJUSTMENT OF NATURAL CONTRIBUTION OF DESERT DUST IN PM10

Background

In 2014, the EC-LIFE+ DIAPASON project coordinated by CNR-ISAC tested innovative detection methods to provide direct evidence of Saharan dust presence in observation sites (Gobbi et al., 2019). In parallel, the European Guidelines methodology to quantify dust contribution to PM10 was revised to overcome some limitations encountered in its application on Italian territory and beyond. The revised 'DIAPASON methodology' (Barnaba et al., 2017) allows the quantification and deduction of the desert dust contribution to daily averages PM10 in an automatic way, combining numerical data from desert dust model simulations and PM10 measurements from national monitoring stations. This method was also used at the European scale as part of the EC-ERA4CS DustClim project[1], and recently shared within the European working group on air quality modelling FAIRMODE. From a multi-annual analysis conducted for the period 2006-2012 (Barnaba et al., 2022), it has been estimated that desert dust intrusions impact air quality in Italy on approximately 10% (north) to 30% (south) of the year's days. These events carry an average of approximately 10 µg/m³ of PM10 per day, with an impact on the average annual concentration ranging between 1 and 3 µg/m³. In Sicily, there are peaks of over 10 µg/m³. The significance of this data is better understood considering the recent World Health Organization (WHO) "safety" threshold for human health, which has been lowered from an average annual value of total PM10 (including anthropic and natural components) from 20 to 15 µg/m³ (WHO, 2021). Starting from the ongoing reporting in 2024, the Diapason methodology is being used by the italian Ministry of Environment and Energetic Safety (MASE) to estimate the contribution of desert dust throughout the entire national territory. This estimation involves the National Research Council-Institute of Atmospheric Sciences and Climate (CNR-ISAC), the Italian Institute for Environmental Protection and Research (ISPRA), and the national network system for environmental protection (SNPA).

Methods

The methodology quantifies the portion of PM10 that is due to the desert dust natural component. The Italian territory is divided into 81 different zones. Within the methodology, numerical data from the BSC-Monarch model are firstly used to identify the monitoring-site-resolved dates affected by desert dust outbreaks, based on a threshold of model dust-PM10 of 5 µg/m³.

To determine the fraction of PM10 levels not attributed to the desert dust outbreak on the days with identified influence, the six-day moving percentile 50 is calculated for each day in the station's time series, excluding the days with identified desert influence. The calculated moving 50th percentile value is then subtracted from the daily average of PM10 measured at the station for the days affected by the African contribution. Full details about the procedure are provided in Barnaba et al., (2017).

Model data are downloaded from the operational dust service at the WMO Barcelona Dust

[1] https://www.isac.cnr.it/projects/dustclim-dust-storms-assessment-development-user-oriented-climate-services-northern-africa

Regional Center[2] and python scripts are used for subsequent calculations. The process consists of two steps: a) identification of the site-resolved dates affected by Saharan events and b) site-resolved quantification of the dust load for each dust-affected date.
At the end of the year, a data series of the natural contribution is generated for each individual station, containing statistics for compliance with legislation after discounting the natural contribution. A summary of the estimated contribution is then calculated for each zone. Output statistics are calculated using R-software scripts. Additionally, a shapefile of points has been generated, in which the estimates of the natural contribution to PM_{10} are shown, both in terms of annual average and in terms of number of exceedances, for each monitoring station.

Summary results for 2023

The most recent analysis, referring to the year 2023 at a national level, confirms the previous findings regarding the impact of desert dust on air quality in our country. This impact shows a decreasing gradient from south to north, which can be attributed to the proximity to African desert areas and the loss of dust load along the path of air masses towards Europe through dry and wet deposition.
In 2023, air quality (AQ) monitoring sites in Italy were found to be affected by desert dust transport on 44 days on average (range 16 - 107). Here we do not consider desert dust events occurring at elevated atmospheric levels and thus not affecting air quality. Dates in which AQ is deteriorated due to desert dust therefore represent 12% of the total (with a range of 4% to 29%). The average duration of these events was 2.4 days, with the longest event lasting approximately 18 days. On these event days, the contribution to the daily PM10 concentration was, on average, 8.9 µg/m³ (ranging from 1.0 to 24 µg/m³).
The number of deductible days, which represents the additional contribution to PM10 from desert dust, was, on average, 3.7 days per monitoring station (ranging from 0 to 28). In fact, in 2023 66 monitoring stations exceeded the daily PM10 limit value of 50 µg/m³ (not to be exceeded more than 35 times in a year). After subtracting the desert contribution, only 59 stations remained in violation, meaning that in 7 station the desert dust contribution was critical in producing the exceedances.
The average annual concentration of total PM10, before the deduction, was 22.3 µg/m³ (ranging from 6.0 to 39.0 µg/m³). After deducting the desert contribution, the average concentration was 21.0 µg/m³ (ranging from 6.0 to 38.0 µg/m³). Therefore, the average annual concentration of PM10 attributed to the desert contribution was estimated to be approximately 1.2 µg/m³ (ranging from 0.0 to 6.0 µg/m³).
It is important to note that compliance with legal limit values is assessed at the zone level. Thus, even if just one station in a given area exceeds the limit value, the area as a whole is considered non-compliant. Based on the desert contribution estimates for 2023, after subtracting the dust contribution, 18 out of 20 zones that initially exceeded the daily limit value remained non-compliant. Regarding the two zone IT0893 (Emilia-Romagna region, zone name:Pianura est) and IT1612 (Apulia region, zone name: Pianura) the exceedance of PM10 daily limit value was attributable to natural sources, i.e. desert dust advection, thus that exceedance shall not be considered as an exceedance for the purposes of Directive 2008/50/EC.
In conclusion, the analysis for the year 2023 confirms the significant impact of desert dust on air quality in our country. The frequency and duration of desert sand transport events are relatively

[2] https://dust.aemet.es/products/data-download

high, leading to significant contributions to PM10 concentrations. However, after deducting the desert contribution, the number of monitoring stations exceeding the daily limit value decreases, indicating that desert dust is a major factor affecting air pollution in these areas. Although the average annual concentration of PM10 due to desert dust is relatively low, it still contributes to overall air pollution levels. Thus, it is crucial to consider the impact of desert dust on air quality and implement appropriate measures to mitigate its effects.

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