

Justification report on the contribution of natural events to the PM₁₀ limit values for 2025

Environment and Resources Authority

September 2026

1.0 Introduction

Being a Mediterranean country, Malta is frequently affected by dust loaded air masses advected from the African continent as well as from particles created from sea spray. The Directive on ambient air quality and cleaner air for Europe 2008/50/EC allows Member States to deduct the contribution of these natural sources from the measured PM₁₀ concentrations. Malta made use of this provision for the first time for the reporting year 2008. Since then, Malta had submitted a justification report outlining the methodology used to determine the contribution of natural sources of particulate matter, which was based on the Commission's working paper¹. This document is being submitted with the assessment of attainment of the environmental quality objectives with respect to PM₁₀ for the reporting year 2025 and consists of an update of similar previous reports required by the Ambient Air Quality Directive.

The same methodology has been applied as described in the justification reports for the previous reporting years for the satellite imagery and backward trajectories. Rapid Response MODIS satellite images² and NOAA HYSPLIT single-particle backward trajectories³, the ensemble forecasts of the WMO and SDS-WAS⁴ Center model and aerosol observations were used for the confirmation of the Saharan dust events, provided by the Barcelona Dust Regional Center.

The Maltese air quality monitoring network consists of 5 fixed monitoring stations. In 2024, the traffic station located in Msida (code MT00005) was relocated due to planned infrastructural developments in the area. The station remains operational at the relocated site for the 2025 reporting year and continues to be classified as a traffic station. The new site is situated approximately 300 m from the original location in Msida and, in accordance with the requirements of the Ambient Air Quality Directive, the station is treated as a new monitoring station under code MT00011 for this and subsequent reporting cycles. Efforts were made to select a site with similar characteristics to the original location in terms of pollution emissions and dispersion; however, certain differences exist, such as traffic flow patterns, proximity to curbsides, and the presence of trees. In addition, infrastructural and construction activities taking place in the vicinity of the monitoring station during the reporting period are considered to have influenced local particulate matter levels. A number of elevated concentration peaks were recorded during 2025, including episodes associated with construction-related dust emissions. The work logs of these occurrences have been provided to the Environment and Resources Authority and taken into consideration during the assessment of exceedance events and the natural dust deduction analysis.

¹ As available from http://ec.europa.eu/environment/air/quality/legislation/pdf/sec_2011_0208.pdf

² https://lance-modis.eosdis.nasa.gov/imagery/subsets/?subset=AERONET_Gozo

³ <https://ready.arl.noaa.gov/HYSPLIT.php>

⁴ <https://dust.aemet.es/products/daily-dust-products>

In 2025, the re-located traffic station in Msida (MT00011) was non-compliant with regards the daily PM₁₀ limit value objective with 50 exceedances. Prior to correction for natural sources, Msida station has registered an annual average PM₁₀ concentration of 37.9 µg/m³, which complies with the Annual Limit Value. In comparison, Malta's rural background station experienced just 9 days exceedances of the daily PM₁₀ limit value, which is lower than the number recorded in 2024 but in line with the trend seen in previous years. The annual average concentration of PM₁₀ at Għarb was also lower than in 2024 being 17.2 µg/m³. The location of the background station is well suited to monitor any transboundary air pollution arriving from outside the Maltese territory. At this station, a data capture of 98.1% was achieved for PM₁₀ in 2025, whilst the data capture for PM₁₀ at the Msida station was 97%. The excellent level of data capture achieved at these monitoring stations permitted a more significant and realistic measure of the amount of exceedances experienced by the Maltese Islands.

Msida station is about 33 kilometres from Għarb station. Due to the fact that the Maltese territory comprises only of 316 km², one can reasonably assume spatial consistency; and that the Maltese archipelago is fairly homogeneously affected in the case of a transboundary and/or natural contribution.

2.0 Contribution from Sahara dust events

Figure 1 depicts the PM₁₀ daily averages measured in Għarb (MT00007) and Msida (MT00011) in 2025. The homogeneity of these data sets is clearly illustrated here with the concentrations often closely following each other, in particular during high concentration Sahara dust events.

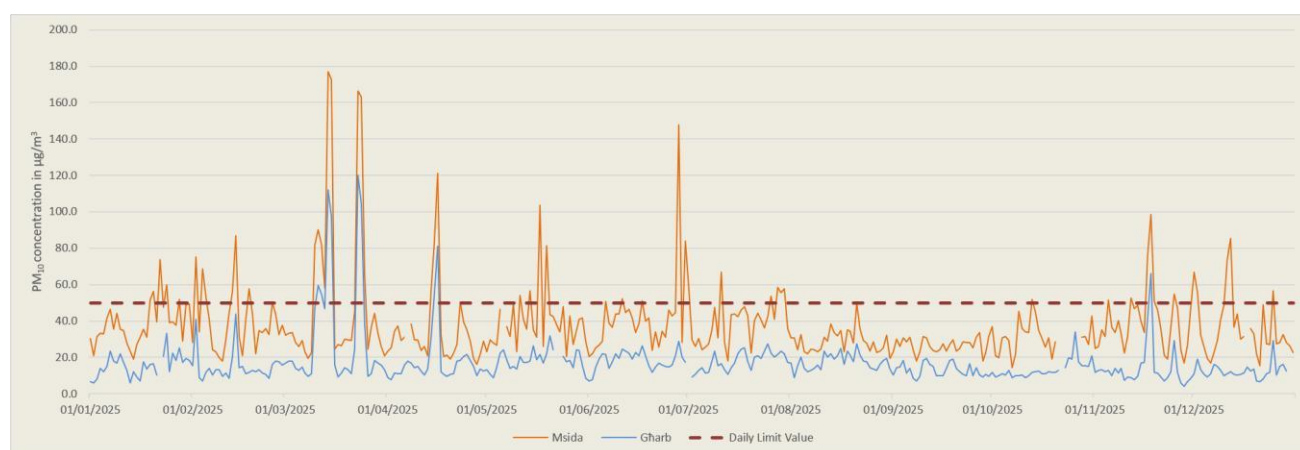


Figure 1: Daily averages of PM₁₀ measured at the background rural station in Għarb (station code: MT00007) and the traffic station in Msida (station code: MT00011) in 2025.

The Saharan episodes were identified using the method described by Gómez-Losada et al. (2016)⁵. This method includes a simple time series of annual hourly PM₁₀ concentrations recorded at our background monitoring station in Gharb, which is modelled using Hidden Markov Models (HMMs), which express the PM₁₀ time-series as a number of Gaussian distributions (this number is determined by the model). These Gaussian distributions are also called PM₁₀ concentration regimes, each with its mean level and standard deviation. The concentration regimes are attributed to different sources or groups of sources. The computational implementation of these concentration regimes is achieved using the open-source software R and the "Depmix S4" package. The validity of the results obtained by this package were checked by using two other packages called "Hidden Markov" and "HMM", which showed negligible differences in the parameter estimates.

PM₁₀ levels in Gharb were described by a three-regime HMM, with 15 days from regime 2 and 2 days from regime 1 (see Figure 2 and Table 1) primarily attributed to Saharan dust events.

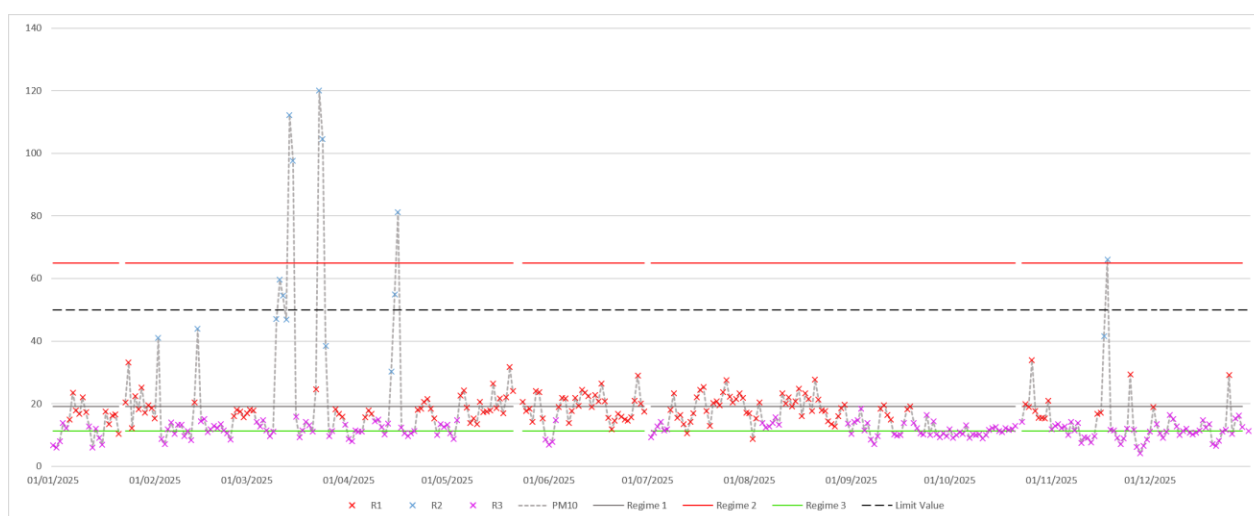


Figure 2: PM₁₀ time series for MT00007 (Gharb) in 2025 and the three PM₁₀ concentration regimes.

		$\mu\text{g}/\text{m}^3$				
Regime	Number	Range	Average	Standard Deviation	No. of days/366	Ans * Avg
1	160	8.8 - 33.9	19.109	4.256	0.438356164	8.376438356
2	16	30.2 - 120	64.988	28.876	0.043835616	2.848767123
3	183	4.2 - 18.3	11.274	2.416	0.501369863	5.652328767
Full data set	359			11.849	Sum	16.87753425

Table 1: Basic statistical data for the three PM₁₀ concentration regimes for the MT00007 station in 2025.

⁵ Gómez-Losada, Á., Pires, J.C.M, Pino-Mejías, R., 2016. Time series clustering for estimating particle matter contributions and its use in quantifying impacts from deserts. Atmospheric Environment 117, 271-281. <http://dx.doi.org/10.1016/j.atmosenv.2015.07.027>

The Saharan episodes identified using the HMM method were further analysed for Saharan dust intrusions by various means, such as $PM_{2.5}/PM_{10}$ ratio, backward trajectories, satellite pictures and forecast models. From the analysis done, 15 from 16 days from Regime 2 have been identified as Saharan dust intrusions. Historically, the deduction assessment has primarily focused on pollution regimes with average PM_{10} concentrations exceeding the daily limit value of $50 \mu g/m^3$. However, internal analyses have shown that a number of days with average PM_{10} concentrations between 30 and $50 \mu g/m^3$ can also be largely influenced by Saharan dust transport events on the Maltese Islands. Consequently, additional attention has recently been given to pollution regimes with average concentrations of $30 \mu g/m^3$ and above to ensure that Saharan dust contributions at lower concentration levels are not overlooked. Based on this assessment, 3 out of 164 days in regime 1 recorded concentrations above $30 \mu g/m^3$ and were therefore considered acceptable for deduction. Due to missing data on one of these days, Sahara dust deduction was performed on only 2 days from regime 1. The Appendix contains the satellite pictures and measurements, backward trajectory plots and model predictions of the days or episodes during which transboundary dust from the African continent was confirmed to have advected Malta.

As described in the Commission's working paper, the regional and temporary background concentration was determined by averaging the background measurements approximately 15 days before and after each particular episode. The average was chosen over the 40th percentile due to the absence of specific studies as recommended in the working paper. The resulting surplus was then subtracted from the respective episode values of Gharb station as well as those of Msida station. Table 2 lists all the above mentioned 17 days, which had been identified clearly to be influenced by African dust. 9 out of the 17 days also exceeded the daily limit value at the rural background station in Gharb, whilst 16 out of all the 17 identified Saharan dust days resulted in an exceedance at Msida station.

In the case of Gharb station, all 9 exceedance days were below the daily limit value after this reduction process was performed. In case of Msida, 6 days (denoted in Table 2 in *italic*) remained above the daily limit value after contribution of African dust was subtracted, while 10 days went below the DLV.

Date	Measured concentration at rural background station MT00007	Contribution of African dust	Measured concentration at traffic station MT00011	Resulting concentration at the traffic station after deduction of African dust and rounding to the nearest integer
24/01/2025	33.1	18.4	59.9	42
02/02/2025	41.1	26.8	75.2	48
14/02/2025	43.9	30.4	86.7	56
10/03/2025	47.0	33.2	81.7	49
11/03/2025	59.6	45.8	90.3	45
12/03/2025	54.6	40.8	82.3	42

13/03/2025	46.9	33.1	58.1	25
14/03/2025	112.2	98.4	176.8	78
15/06/2025	97.6	83.8	172.5	89
23/03/2025	120.0	106.4	166.5	60
24/03/2025	104.5	90.9	163.2	72
25/03/2025	38.5	24.9	65.9	41
14/04/2025	30.2	16.5	56.2	40
15/04/2025	54.9	41.2	83.6	42
16/04/2025	81.2	67.5	121.1	54
20/05/2025	31.7	13.5	43.4	30
18/11/2025	66.0	53.5	98.7	45

Table 2: Days which were identified to be influenced by Saharan dust and the resulting PM₁₀ concentrations at Msida station following deduction of African dust contribution.

Following the deduction of African dust events, the exceeding days at the traffic site in Msida reduced from 50 to 40.

It should be noted that this analysis mainly covers major and medium strong events at the background site. However, one can certainly and justifiably assume that the Mediterranean and therefore, the Maltese Islands are also affected by milder and less apparent forms of intrusion of dust from the African continent, which obviously add to the local anthropogenic contribution. Since the method used classifies the various concentrations into different regimes depending on their sources, some days with mild intrusions might be categorised in a different regime, which is not selected for further natural dust deduction analysis. However, it will be increasingly difficult to identify such milder events and accurately quantify them without further assessment and quantification tools.

Furthermore, Malta also experiences strong winds throughout the year, significantly contributing to the resuspension of dust particles following Sahara dust events. This resuspension process makes it quite challenging to quantify the natural Saharan dust portion in PM₁₀ concentrations, as the resuspended particles include various forms of dust which originate from other different sources. The methodology for natural dust deduction may not consistently capture this phenomenon, as mild to moderate resuspension events may fall outside the analytical regimes designated for analysis and deduction. This limits the accuracy of properly deducting natural Saharan dust from PM₁₀ values, which might hinder Malta's compliance to the Daily Limit Value.

This described methodology has resulted in an annual average of PM₁₀ at Msida reduced from 37.9 µg/m³ to 35.5 µg/m³ following deduction of the African dust events listed above.

3.0 Contribution from sea salt

Being surrounded by sea it is obvious that Malta is also affected by sea spray especially during strong wind conditions. In fact, a lot of salt can be found on the impaction plates of the sampling heads. It seems to be evident that the prevailing concentration of sea salt at a particular site is a complex phenomenon. On the other hand, one can also reasonably assume that once PM₁₀ is formed from sea spray, it will disperse rather uniformly over the Maltese territory due to the large scale weather conditions, which lead to its formation in the first place. However, key factors are certainly the distance from the shore and the wind speed. The contribution of sea salt to the PM₁₀ concentration was also considered and deducted, following the approach already outlined in previous justification reports.

As part of a baseline study, funded through the European Regional Development Fund (ERDF), a significant amount of PM₁₀ low volume sampler filters were collected from the traffic site in Msida (234) and the background site in Għarb (230) as well as from two other stations (Kordin, MT00003; Żejtun, MT00004) between March 2012 and May 2013. The filters were subsequently analysed for metals and ions.

During this campaign, sea salt correlation was calculated by using values provided in the Commission's guidance document for Chlorine and Sodium together and both separately. This was mainly done to reduce the uncertainty of the methodology. Since then, the results of this campaign have remained valid. This is due to the absence of anthropogenic sources of Sodium and Chloride in Malta, which makes us confident that the contribution is only related to sea spray. The only anthropogenic source of sea salt in Malta is potentially its resuspension as no winter road salting is done and dust suppression in the construction industry is solely water-based. However, quantification of this resuspended sea salt is challenging as the resuspended particles are often generated from different sources. Based on this formation of sea salt, which is a purely physical process, no changes happen with time and thus the methodology remains valid.

The daily sea salt concentration was determined according to the guidance document, by means of factorising the concentrations of chloride and sodium as follows:

$$[\text{Sea salt}] = 1.168 * ([\text{Na}^+] + [\text{Cl}^-]). \quad [1]$$

Figure 3 shows the correlation between the sea salt concentration determined from sodium and chloride concentration on the PM₁₀ filters at the respective station and the daily average wind speed at Għarb. The daily averages of wind speed at Għarb were also used for the correlation calculation at Msida. Għarb is situated in flat terrain, at an altitude of 114 metres and with an unrestricted airflow from all directions. Msida station on the other hand, is situated at sea level and at the base of a large valley, which could lead to channelling effects. The wind data from Għarb site is therefore considered more representative of the overall meteorological conditions over the Maltese Islands relevant for the production of sea spray.

The analysis reveals a linear relationship between sea salt concentration and wind speed in Għarb to:

$$\text{Sea salt} = 0.637 * \text{wind speed} + 1.0. \quad [2]$$

The respective formula for data sets from Msida is:

$$\text{Sea salt} = 1.06 * \text{wind speed} + 1.0. \quad [3]$$

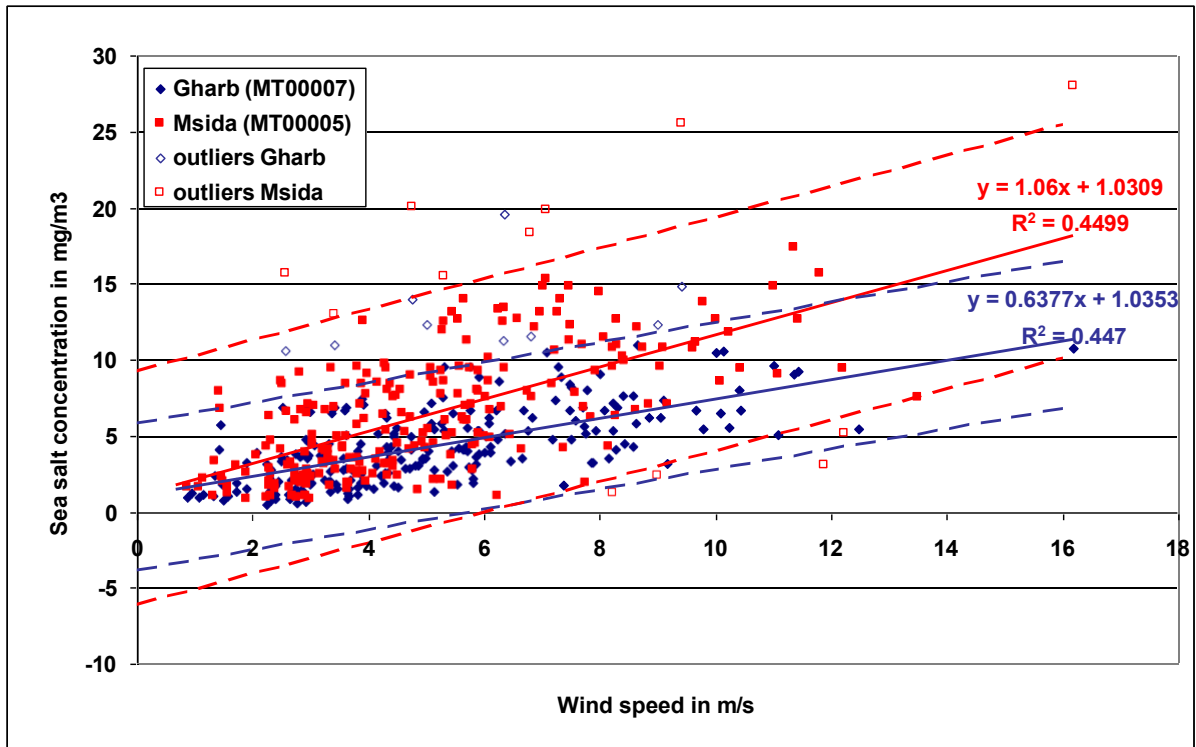


Figure 3: Correlation between daily average wind speed and sea salt concentration in PM₁₀ at the background station in Gharb and the traffic station in Msida. The dashed lines represent the 2σ confidence intervals of the respective data sets. Data points outside the confidence intervals have not been considered for the regression calculation.

For the year 2025, no ion data is available at the time of reporting in order to determine the sea salt concentration directly from the PM₁₀ measurements at Msida as well as from Gharb. Hence, the sea salt concentration was calculated using [3]. Additionally, a wind speed threshold of 2 m/s was applied, on the basis of which the sea salt concentration was calculated.

Table 3 lists the days at Msida station, which were not identified as Saharan dust events and which have decreased below the daily limit value for PM₁₀ after the sea salt contribution had been deducted and after rounding to integer values. The table also includes 2 Saharan dust-influenced days which were still exceeding the DLV after the deduction of Sahara dust contribution but have gone down below 50 µg/m³ after additional sea salt deduction calculations using formula [2].

In Msida, 14 days not identified as Saharan dust events have been reduced below the DLV after sea salt deduction, whilst out of the identified days, 2 days have reduced below the DLV.

In Msida, these reductions have further reduced number of daily exceedances to 23, while the annual PM₁₀ concentrations decreased further from 35.5 µg/m³ after Sahara dust deduction to 30.2 µg/m³ in Msida.

The average sea salt concentration in 2025 was 5.2 µg/m³ which is slightly lower than that of the previous year with a difference of just 0.5 µg/m³.

Date	Measured or Saharan dust corrected concentration at traffic station MT00005	Contribution of sea salt	Resulting concentration at the traffic station after deduction of sea salt and rounding to the nearest integer
19/01/2025	51.6	6.06	46
28/01/2025	52.0	6.37	46
05/02/2025	53.4	3.45	50
23/03/2025	<i>60.1</i>	<i>10.09</i>	50
16/04/2025	53.6	8.48	45
11/05/2025	54.0	6.55	47
06/06/2025	50.6	3.30	47
17/06/2025	51.2	5.02	46
26/07/2025	53.6	5.98	48
29/07/2025	55.6	7.94	48
13/10/2025	51.7	3.14	49
05/11/2025	51.5	3.75	48
12/11/2025	52.5	3.36	49
19/11/2025	50.7	5.19	46
25/11/2025	54.7	10.59	44
25/12/2025	56.7	8.32	48

Table 3: Days of exceedances at Msida station, which are below the daily limit value after deducting the sea salt contribution. Saharan dust corrected days are in italics.

4.0 Conclusion

In 2025, the new traffic station in Msida exceeded the allowed number of exceedances of the PM₁₀ daily limit value with 50 days. The number of exceedances at the rural background station in Għarb was quite low in comparison with Msida station, with 9 days exceeding the limit value. There were a number of days with relatively high PM₁₀ values for a rural background station, which were not classified in Regime 3 but were potentially influenced by Sahara dust. In this regard, Regime 1 was also considered for this analysis, particularly for days exceeding the 30 µg/m³. The number of days exceeding the DLV at Msida station in 2025 was slightly lower than in 2024. It was in fact the lowest since 2013, except for that recorded for 2020, which was influenced by a partial lockdown due to COVID-19. No strong influence was identified in the regimes during the peak summer months. Moreover, the good data capture recorded at Għarb station for both PM₁₀ and wind speed facilitated a more accurate deduction process for natural dust. In this regard, the number of exceeding days went from 50 to 40 in Msida.

The contribution of sea salt to the PM₁₀ fraction in 2025 was determined by calculation only as ion data was not available at the time of this analysis. However, the methodology described above gives very good and reliable estimation of the actual prevailing sea salt concentration. The consideration of sea salt contribution to the measured PM₁₀ concentration resulted in a deduction of 16 more exceeding days in Msida, reducing the number of the remaining exceedances in Msida to 23. This means that Malta is compliant with regards the daily PM₁₀ limit value objective for 2025.

In Għarb, the annual average PM₁₀ concentration is well below the annual limit value with 17.2 µg/m³. The annual PM₁₀ concentration at Msida was also below the ALV, however further reduced from 37.9 µg/m³ to 30.2 µg/m³, considering the impact of natural dust contributions on the monitored particulate matter concentration. Therefore, Malta is comfortably compliant for this objective as well.

Day of exceedance or suspected Saharan dust event	Daily concentration ($\mu\text{g}/\text{m}^3$)	Justification and comment on Sahara dust intrusion
24/01/2025	33.1	Satellite imagery indicates the presence of a Saharan dust plume over the central Mediterranean, while backward trajectories show that air masses reaching Malta originated from and passed over North Africa. Boundary layer height data confirms atmospheric mixing leading to dust transport, and dust forecasts further support Saharan dust influence over the Maltese Islands. Taken together, these lines of evidence clearly demonstrate the impact of long-range Saharan dust transport on air quality in Malta on this day.
02/02/2025	41.1	Satellite imagery and backward trajectory analysis clearly indicate a Saharan dust intrusion affecting the Maltese Islands, with air masses originating from North Africa and reaching Malta from the south. Dust forecast maps further show elevated dust concentrations over the central Mediterranean during the event. The combined evidence conclusively demonstrates that particulate matter levels on this day were significantly influenced by long-range transport of natural Saharan dust.
14/02/2025	43.9	Although the satellite imagery provides limited visual evidence of dust, a slight dust haze can still be observed over the central Mediterranean. Backward trajectory analysis provides stronger evidence, showing that air masses affecting Malta originated from North African regions, while the associated boundary layer height information indicates favourable conditions for dust transport. Dust forecast products further support the presence of

		Saharan dust over the area. Taken together, the available evidence indicates that air quality on this day was influenced by long-range transport of natural Saharan dust.
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10/03/2025	47.0	This day marks the onset of a five-day Saharan dust episode. Satellite imagery already shows a distinct dust haze over the central Mediterranean, indicating the presence of Saharan dust affecting the Maltese Islands. Backward trajectory analysis shows that air masses arriving at Malta passed over North African source regions, while dust forecast products indicate a dust intrusion over the area. Collectively, the evidence confirms the influence of long-range transport of natural Saharan dust on air quality on this day.
11/03/2025	59.6	On the second day of the Saharan dust episode, satellite imagery continues to show a visible dust haze over the central Mediterranean, indicating the persistence of Saharan dust in the region. Backward trajectory analysis shows that the lower air masses reaching Malta travelled over North African source regions at low altitudes before arriving over the Maltese Islands, favouring the transport of desert dust. Dust forecast products further confirm the presence of a Saharan dust intrusion affecting the area. Taken together, the available evidence demonstrates that particulate matter concentrations were

		influenced by long-range transport of natural Saharan dust.
12/03/2025	54.6	Despite substantial cloud cover in the satellite imagery, a dust haze remains visible over the central Mediterranean, indicating the continued presence of Saharan dust affecting the Maltese Islands. Backward trajectory analysis provides supporting evidence of dust transport, particularly for the lower air mass, which passed over North African source regions before reaching Malta, while the higher trajectories also originated from Africa at elevated altitudes. Dust forecast products show a clear Saharan dust intrusion over the area.
13/03/2025	46.9	Satellite imagery clearly shows the continuation of the Saharan dust event, with a widespread dust haze visible over the central Mediterranean and Malta. Although the backward trajectories are less conclusive due to their elevated transport heights, they remain consistent with air masses originating from North Africa. Dust forecast products continue to indicate elevated dust concentrations over the area. Overall, the available evidence confirms the continued influence of Saharan dust on air quality over the Maltese Islands.

14/03/2025	112.2	Satellite imagery shows a clear dust plume extending from North Africa towards the central Mediterranean, indicating the continued transport of Saharan dust towards the Maltese Islands. Backward trajectory analysis, particularly the lower trajectory, shows air masses travelling over North African source regions before reaching Malta. Dust forecast products further confirm the persistence of this Saharan dust event. Overall, the available evidence demonstrates the continued influence of long-range transport of natural Saharan dust on air quality.
15/03/2025	97.6	Satellite imagery provides strong evidence of Saharan dust influence, showing a dense dust plume extending from North Africa across the central Mediterranean and over the Maltese Islands. Backward trajectory analysis further supports this, particularly the 1500 m trajectory, which travelled at relatively low altitudes over North African regions before arriving at Malta. Dust forecast products also indicate elevated dust concentrations over the area, confirming the intensity of the intrusion. As the final day of this multi-day event, the combined evidence conclusively demonstrates a strong influence of long-range transport of natural Saharan dust on air quality.
23/03/2025	120.0	Despite the presence of cloud cover, satellite imagery shows a pronounced dust haze over the central Mediterranean, indicating a strong Saharan dust intrusion affecting the Maltese Islands. Backward trajectory analysis supports this, particularly the 1500 m trajectory, which travelled over North African regions at relatively low altitudes before reaching Malta. Dust forecast products also indicate elevated dust

		concentrations over the area. As part of a three-day dust event, the combined evidence confirms a significant influence of long-range transport of natural Saharan dust on air quality.
24/03/2025	104.5	During the second day of the dust episode, satellite imagery is largely obscured by cloud cover and therefore provides limited visual evidence of dust transport. Nevertheless, backward trajectory analysis confirms a strong Saharan dust influence, particularly the 1500 m and 3000 m air masses, which travelled at relatively low altitudes over North African regions before reaching the Maltese Islands. Dust forecast products also indicate elevated dust concentrations over the area, confirming the intensity of the intrusion. Taken together, the available evidence demonstrates a significant influence of long-range transport of natural Saharan dust on air quality.
25/03/2025	38.5	Due to extensive cloud cover, the satellite imagery provides limited visual evidence of dust transport on this day. However, backward trajectory analysis clearly indicates Saharan dust influence, with the air masses travelling over North African regions at relatively low altitudes before reaching the Maltese Islands. Dust forecast products further confirm the presence of elevated dust concentrations over the area.
14/04/2025	30.2	Due to extensive cloud cover, the satellite imagery provides limited visual evidence of dust transport. However, backward trajectory analysis shows that air masses affecting Malta circulated over North African regions before reaching the Maltese Islands, indicating Saharan dust transport. Dust forecast products further support this, showing the onset of a

		dust intrusion over the central Mediterranean.
15/04/2025	54.9	On the second day of the dust event, satellite imagery provides clearer evidence of Saharan dust transport, with a visible dust haze extending from North Africa across the central Mediterranean and affecting the Maltese Islands. Backward trajectory analysis further supports this, particularly the 1500 m trajectory, which travelled over North African regions before reaching Malta. Dust forecast products also indicate elevated dust concentrations over the area.
16/04/2025	81.2	On the third and final day of the dust event, both satellite imagery and dust forecast products provide clear evidence of Saharan dust influence over the Maltese Islands. Backward trajectory analysis further confirms this, particularly the 500 m and 1500 m air masses, which travelled over North African regions before reaching Malta. The combined evidence demonstrates the continued impact of long-range transport of natural Saharan dust on air quality during the final stage of this event.
20/05/2025	31.7	Although the satellite imagery is inconclusive, backward trajectory analysis indicates Saharan dust influence, with air masses reaching Malta after passing over North African regions. Dust forecast products also show dust concentrations extending into the central Mediterranean and affecting the Maltese Islands. Taken together, the trajectory and forecast evidence suggest a moderate influence of long-range transport of natural Saharan dust

		on air quality during this period.
18/11/2025	66.0	Although extensive cloud cover limits the interpretation of the satellite imagery, a light dust haze remains visible in cloud-free areas, suggesting the presence of Saharan dust over the central Mediterranean. Backward trajectory analysis provides stronger evidence, particularly the 1500 m trajectory, which shows air masses travelling over North African regions before reaching Malta. Dust forecast products further indicate a moderate dust intrusion affecting the area.

1st Episode on the 24th January, 2025

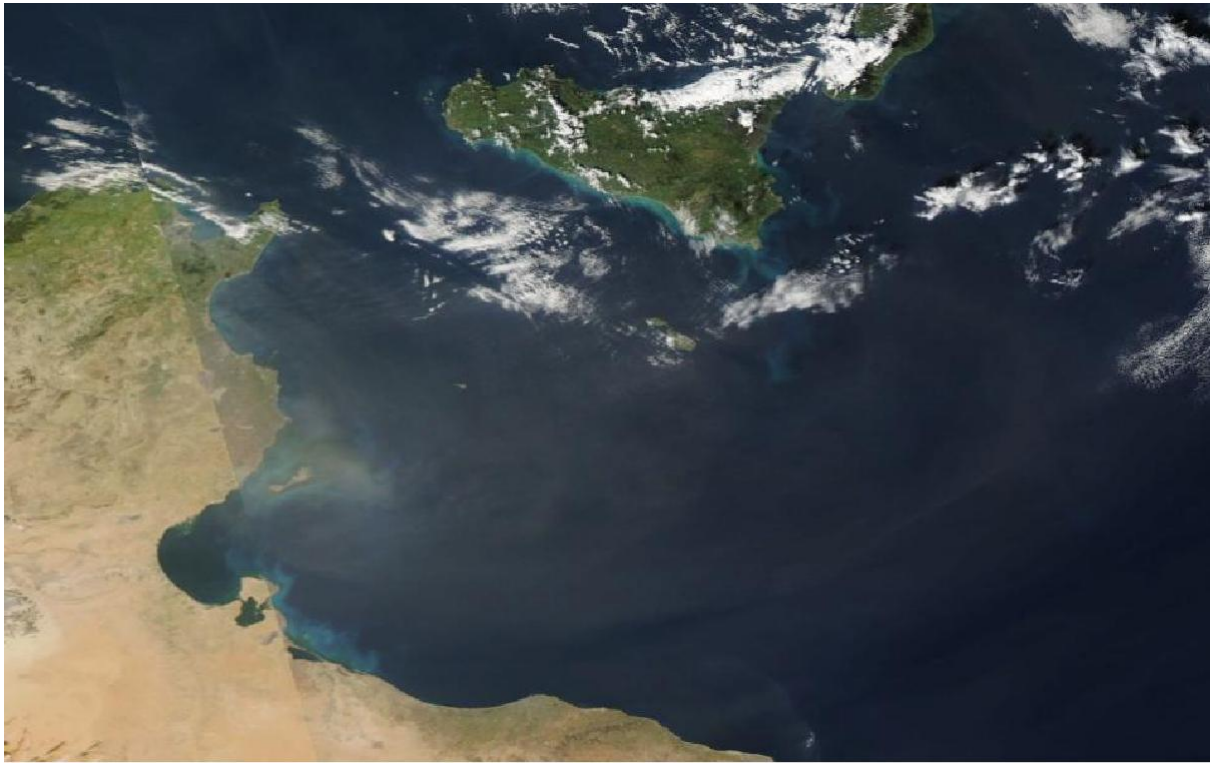


Figure A.1.1: Satellite image of the episode on 24.01.2025.

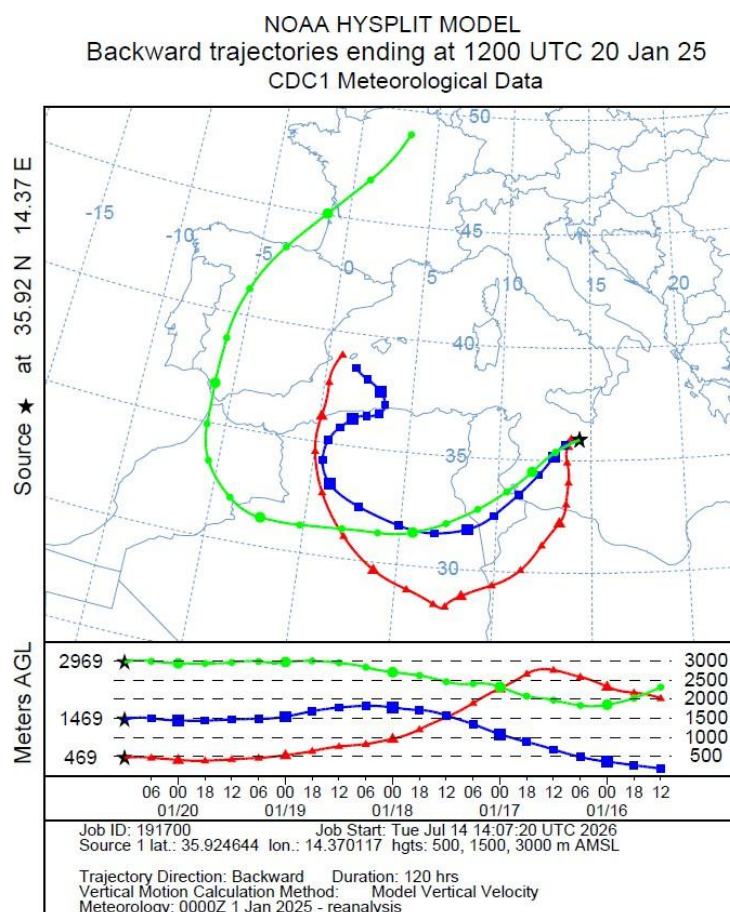


Figure A.1.2: Hysplit back trajectories for the episode on 24.01.2025 (1300h UTC+1).

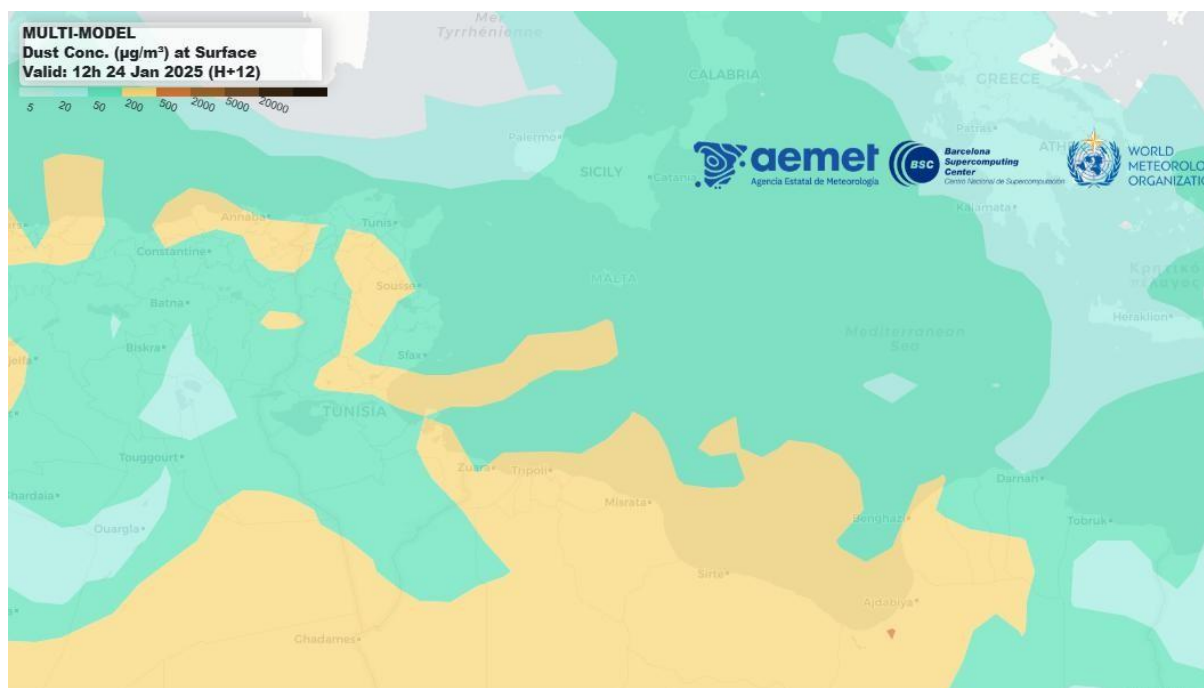


Figure A.1.3: PM₁₀ levels forecasted by the ensemble model on 24.01.2025.

2nd Episode on the 2nd February, 2025

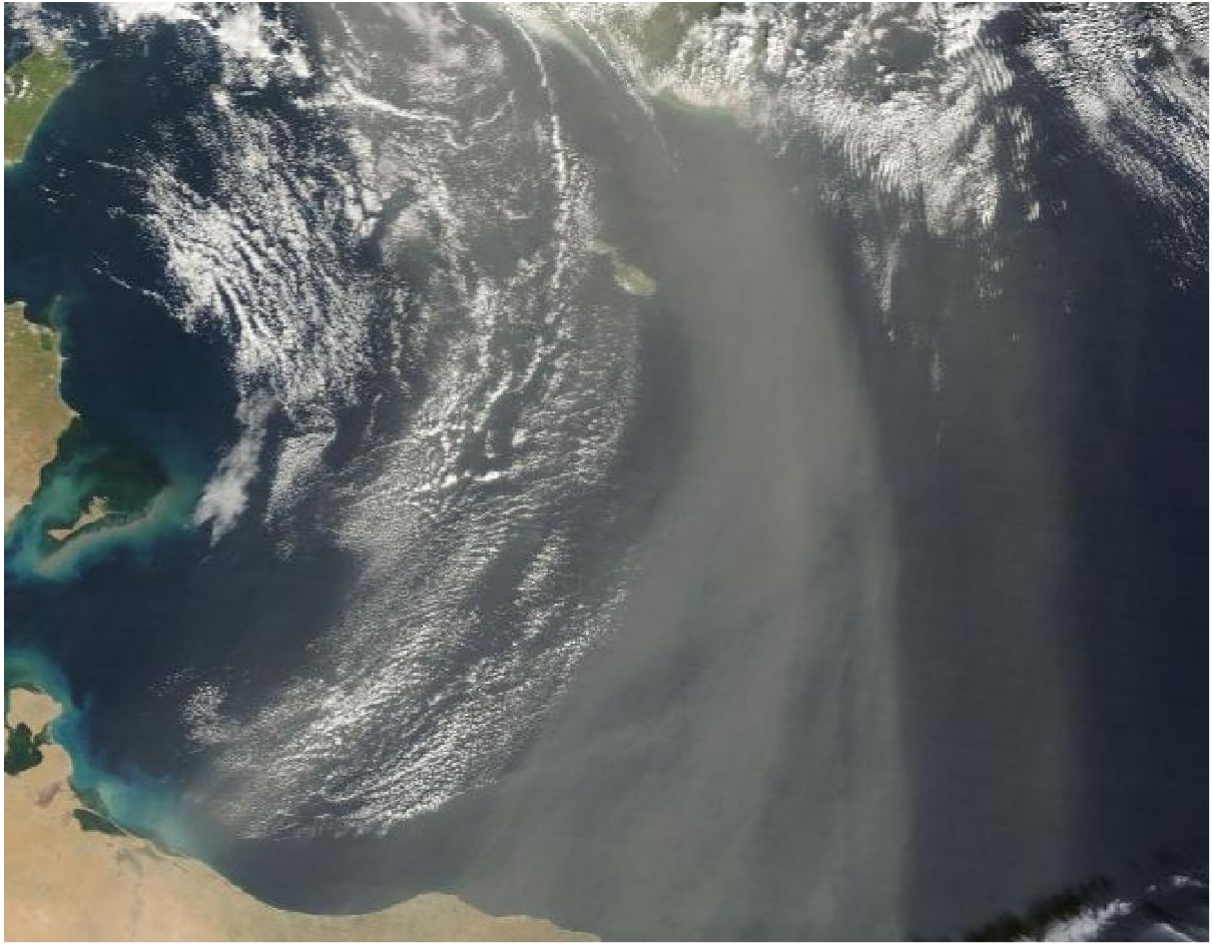


Figure A.2.1: Satellite image of the episode on 02.02.2025.

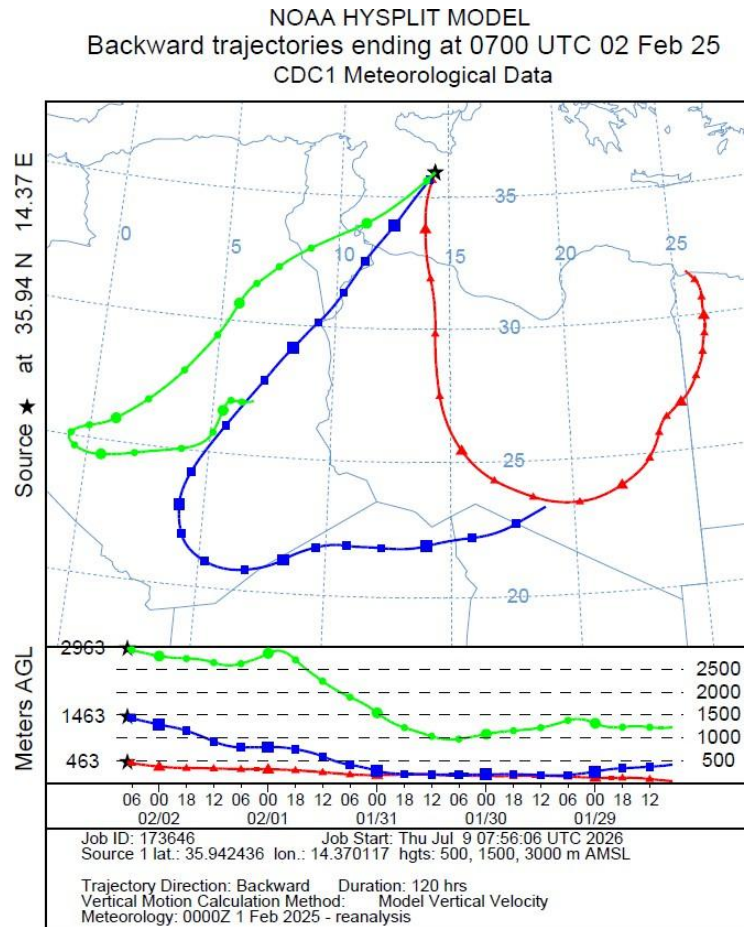


Figure A.2.2: Hysplit back trajectories for the episode on 02.02.2025 (0800h UTC+1).

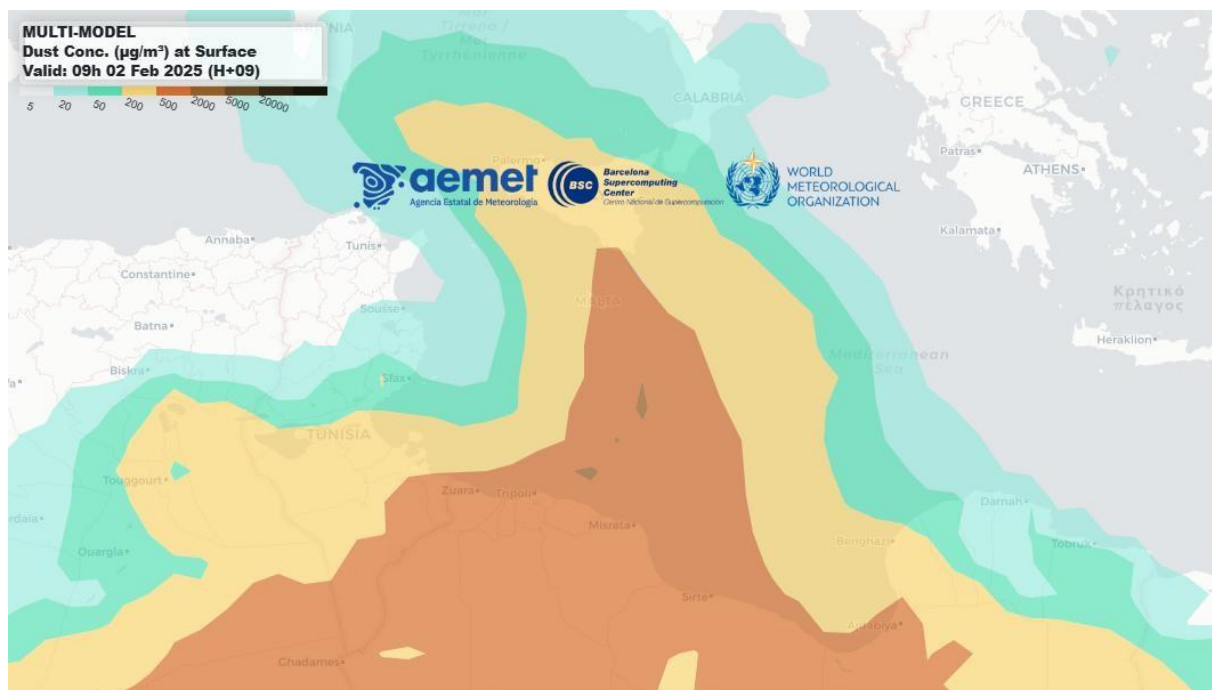


Figure A.2.3: PM₁₀ levels forecasted by the ensemble model on 02.02.2025.

3rd Episode on the 14th February, 2025

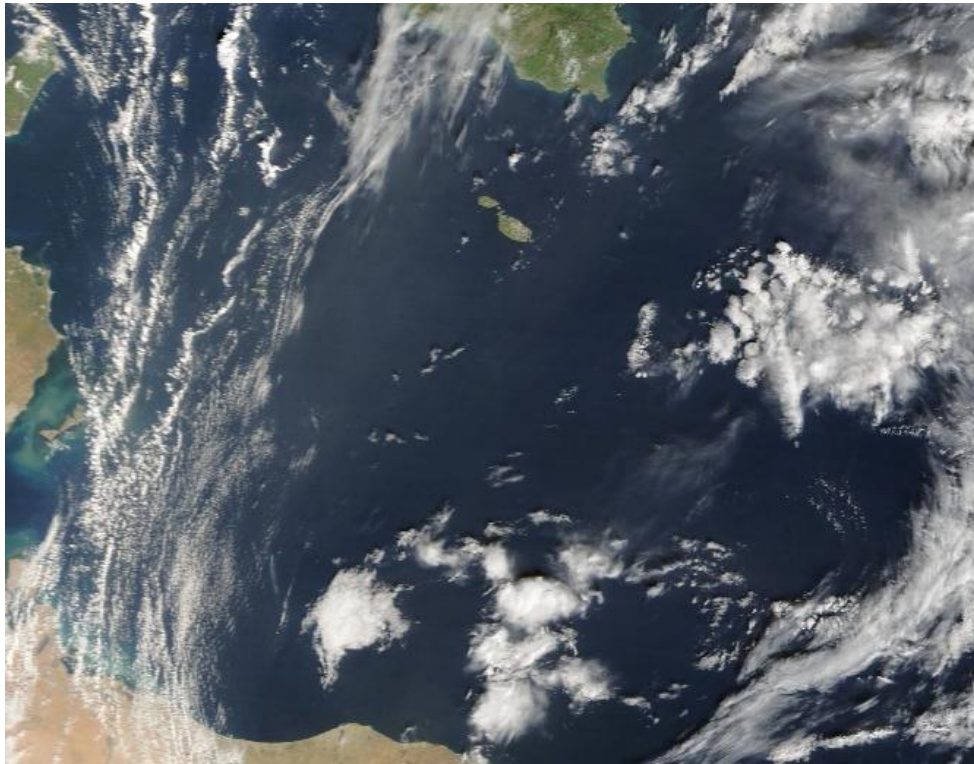


Figure A.3.1: Satellite image of the episode on 14.02.2025.

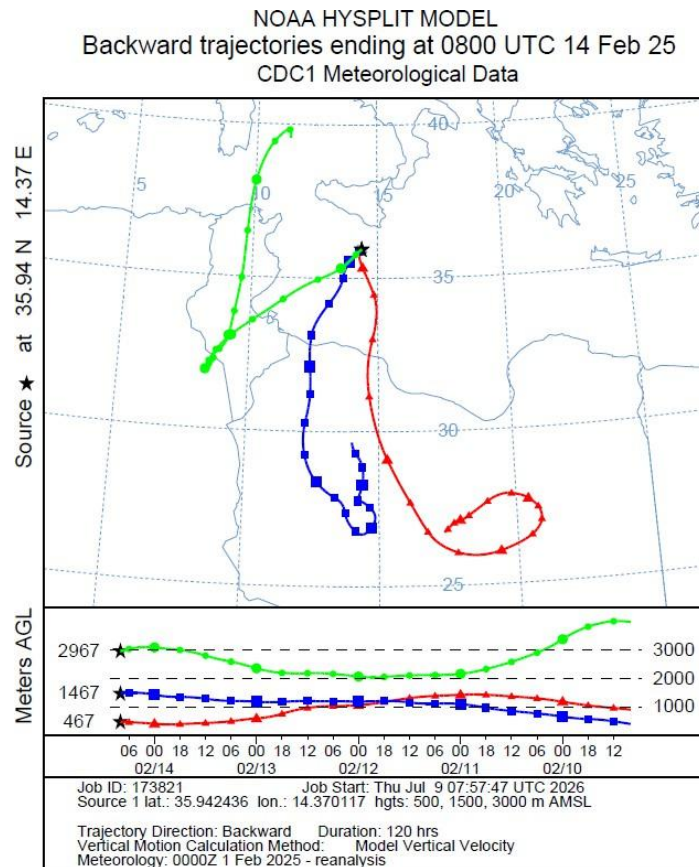


Figure A.3.2: Hysplit back trajectories for the episode on 14.02.2025 (0900h UTC+1).

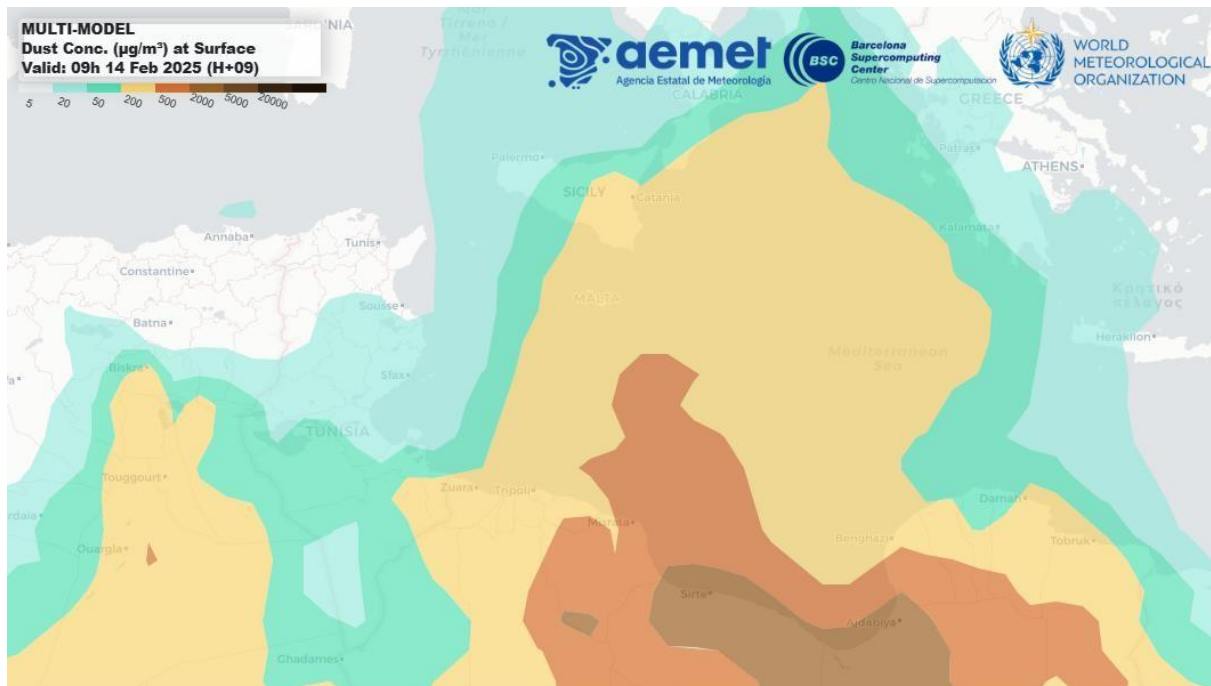


Figure A.3.3: PM₁₀ levels forecasted by the ensemble model on 14.02.2025.

4th Episode on the 10th March, 2025

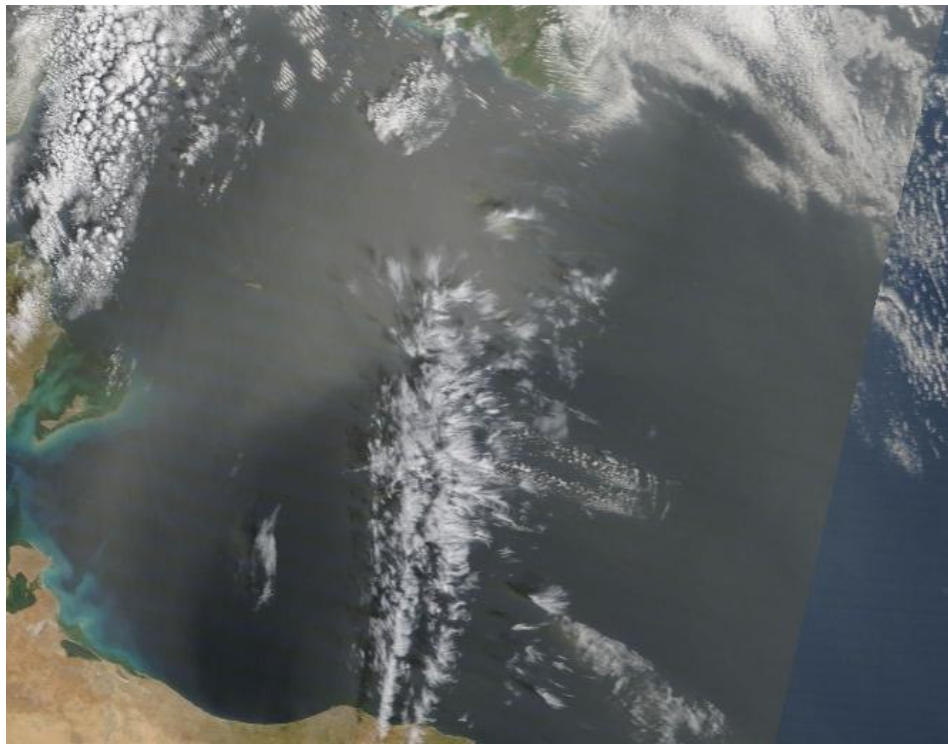


Figure A.4.1: Satellite image of the episode on 10.03.2025.

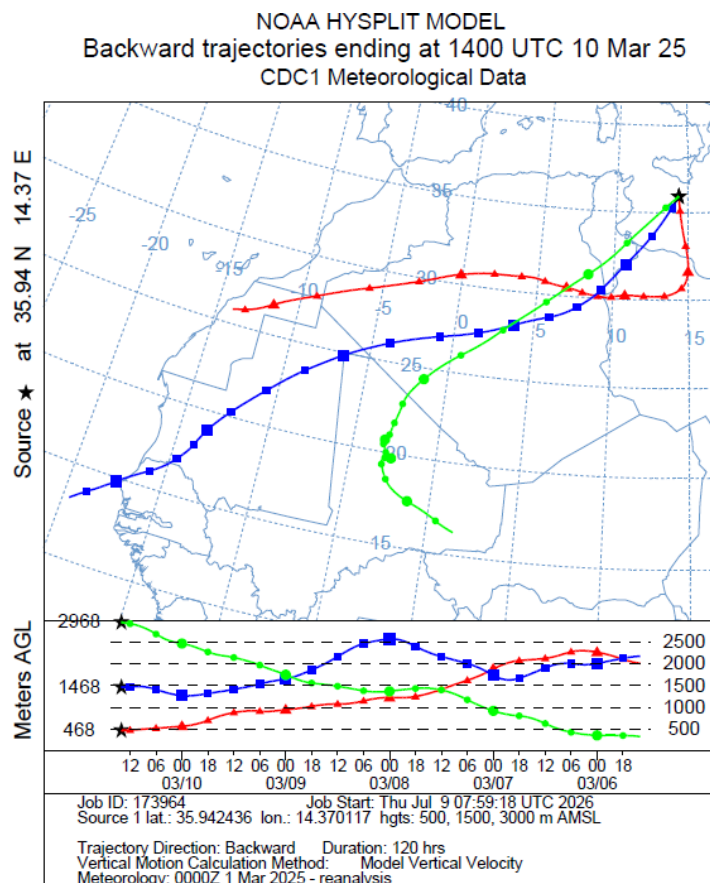


Figure A.4.2: Hysplit back trajectories for the episode on 10.03.2025 (1500h UTC+1).

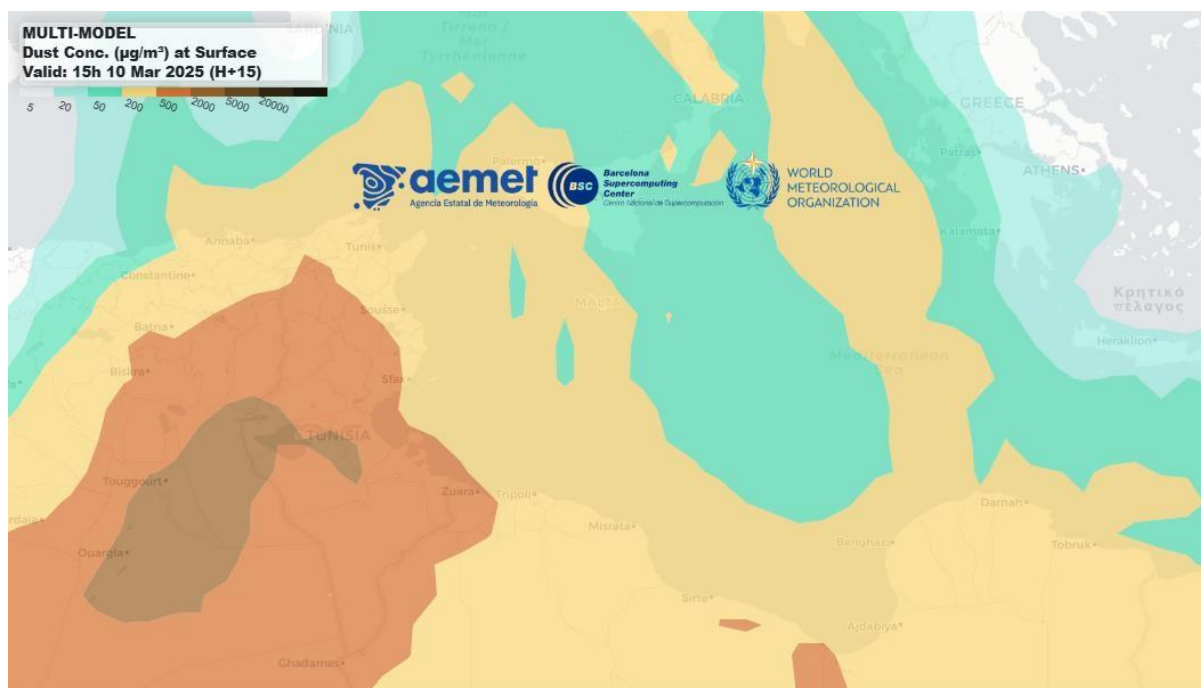


Figure A.4.3: PM₁₀ levels forecasted by the ensemble model on 10.03.2025.

5th Episode on the 11th March, 2025

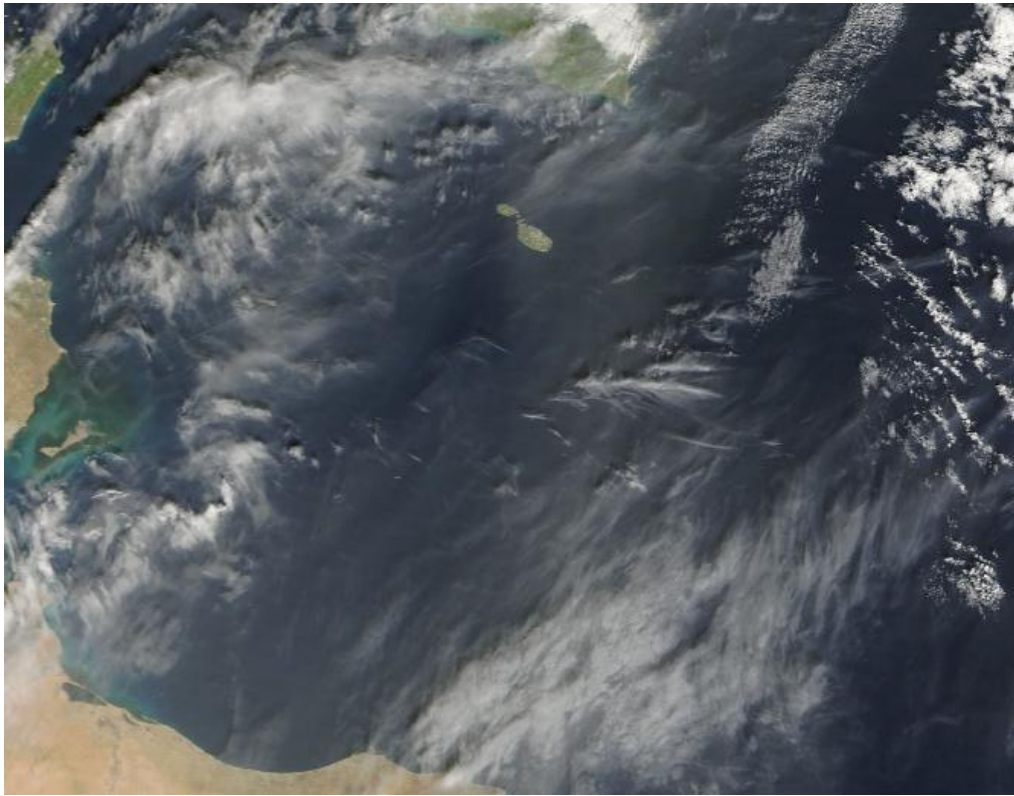


Figure A.5.1: Satellite image of the episode on 11.03.2025.

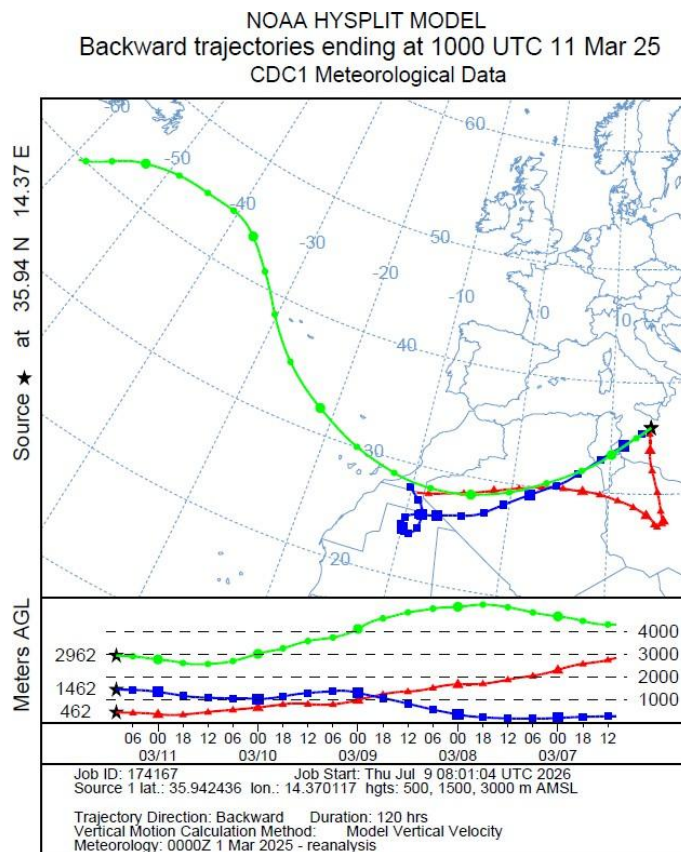


Figure A.5.2: Hysplit back trajectories for the episode on 11.03.2025 (1100h UTC+1).

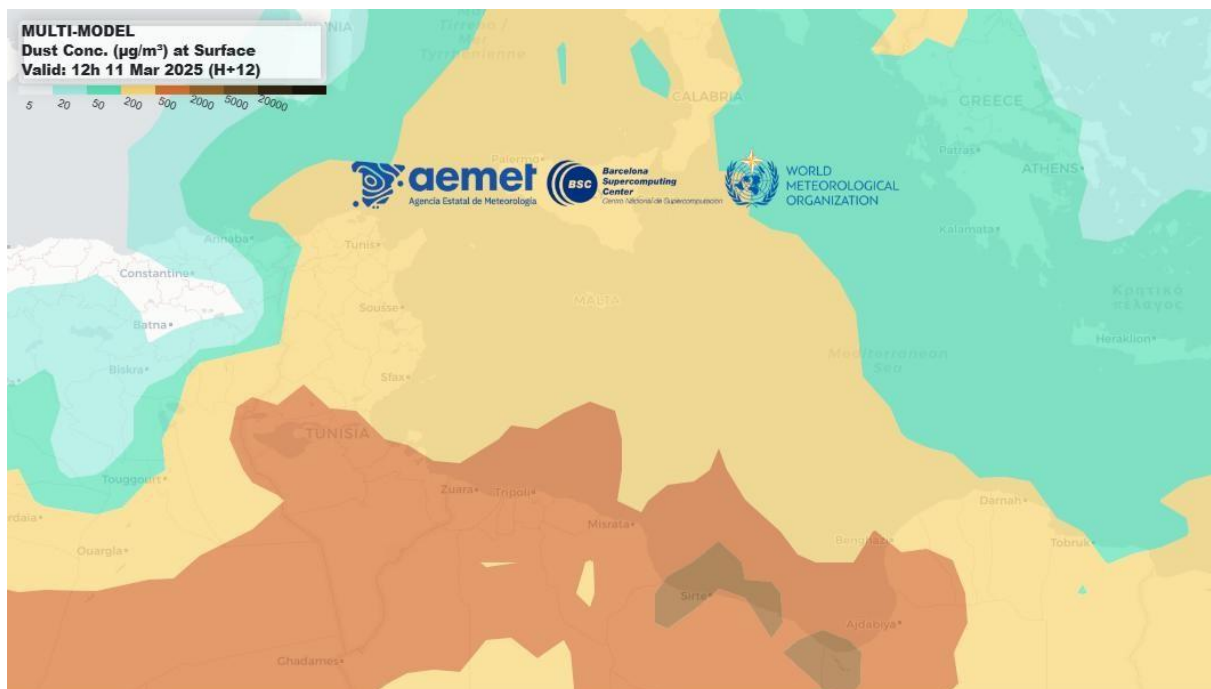


Figure A.5.3: PM₁₀ levels forecasted by the ensemble model on 11.03.2025.

6th Episode on the 12th March, 2025

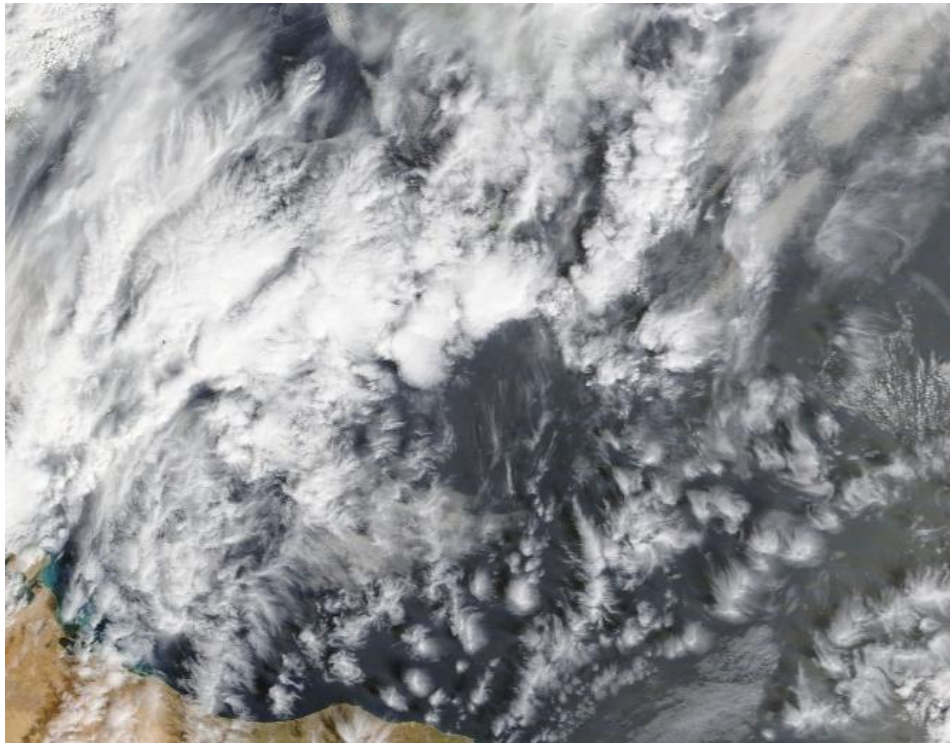


Figure A.6.1: Satellite image of the episode on 12.03.2025.

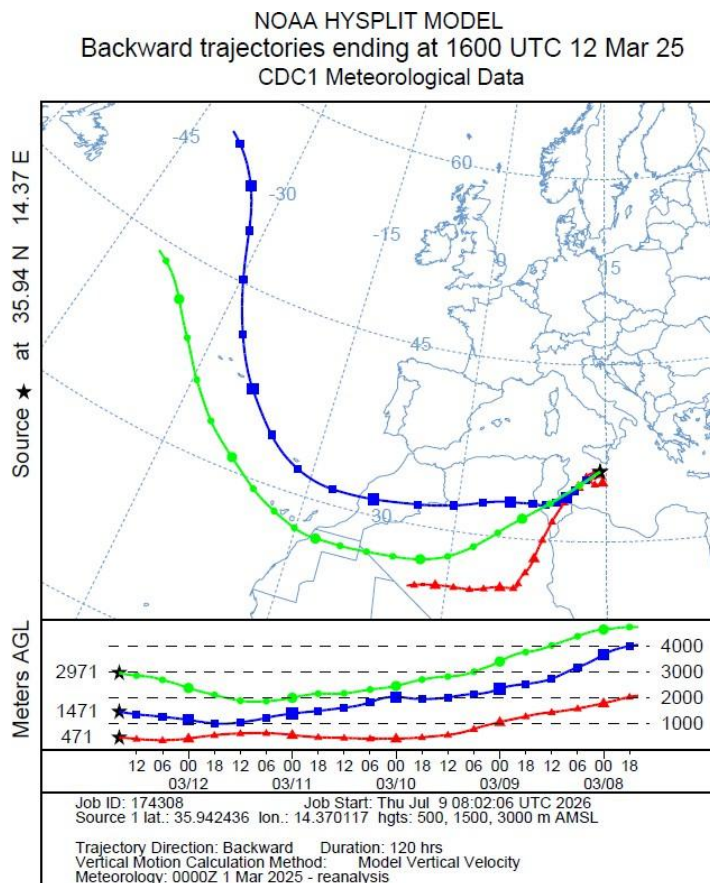


Figure A.6.2: Hysplit back trajectories for the episode on 12.03.2025 (1700h UTC+1).

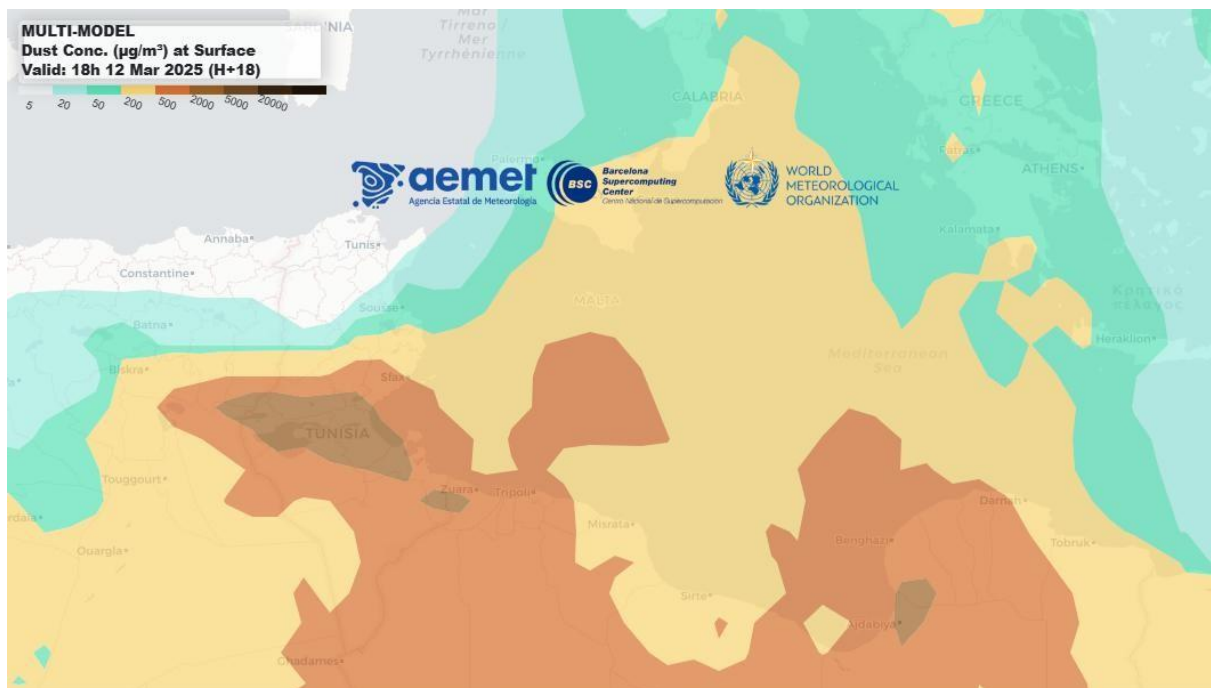


Figure A.6.3: PM_{10} levels forecasted by the ensemble model on 12.03.2025.

7th Episode on the 13th March, 2025

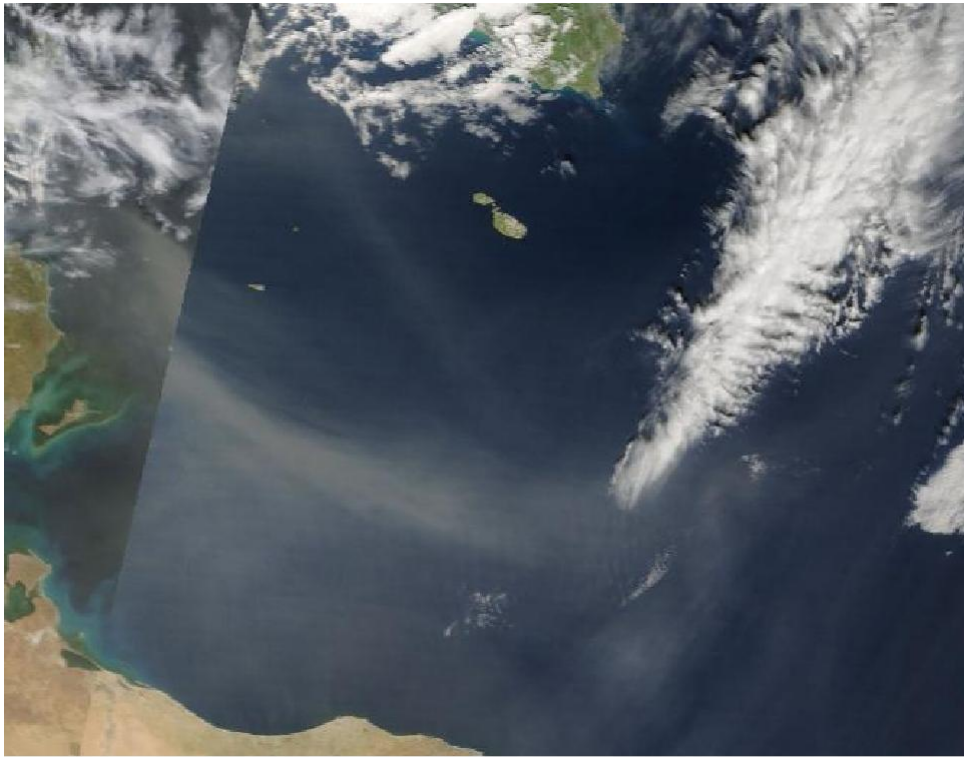


Figure A.7.1: Satellite image of the episode on 13.03.2025.

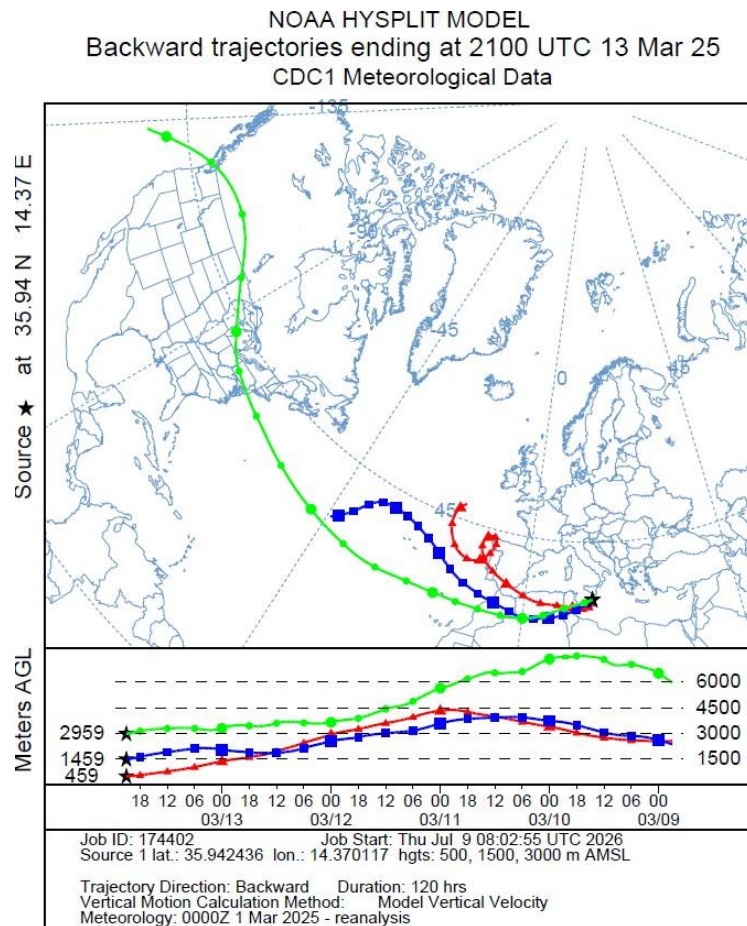


Figure A.7.2: Hysplit back trajectories for the episode on 13.03.2025 (2200h UTC+1).

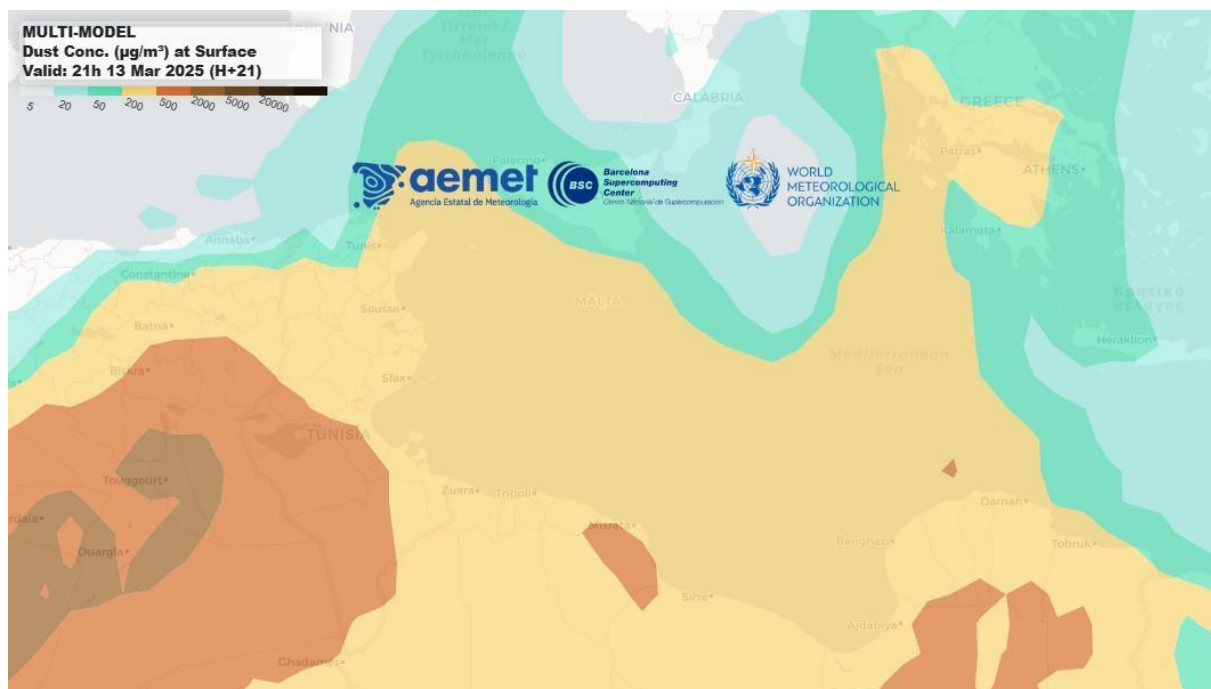


Figure A.7.3: PM₁₀ levels forecasted by the ensemble model on 13.03.2025.

8th Episode on the 14th March, 2025

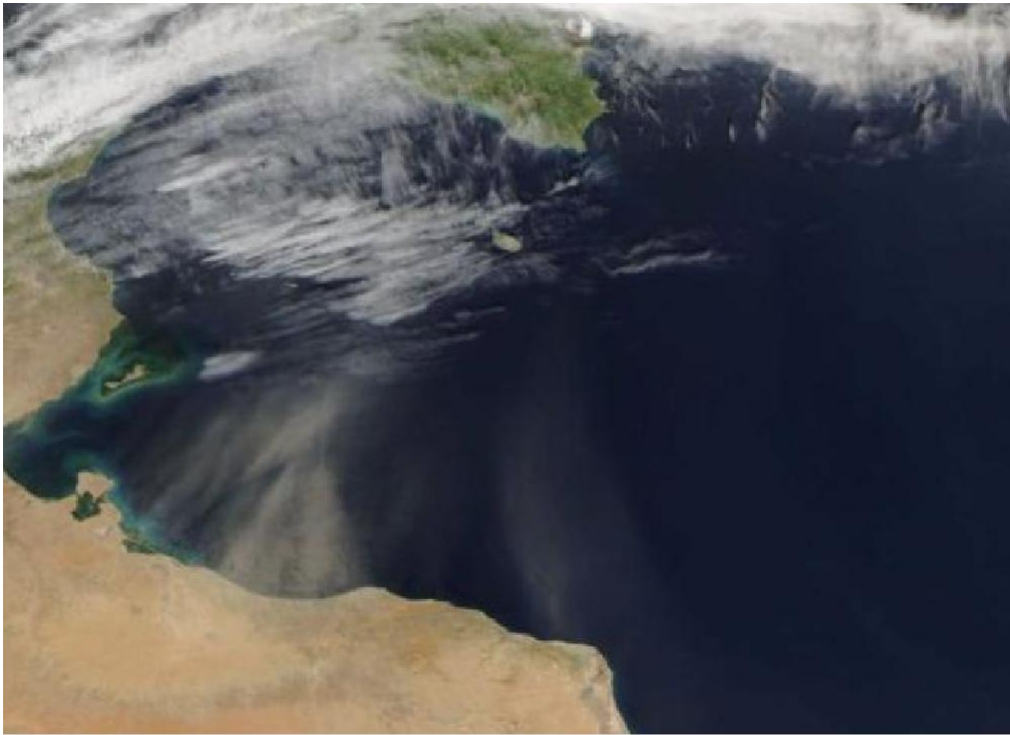


Figure A.8.1: Satellite image of the episode on 14.03.2025.

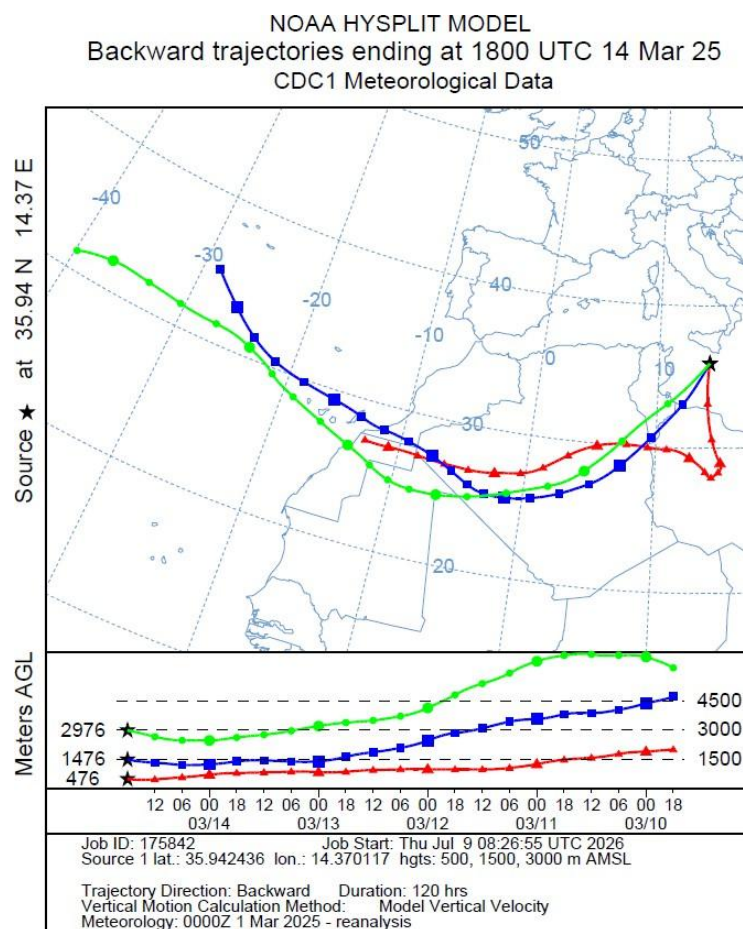


Figure A.8.2: Hysplit back trajectories for the episode on 14.03.2025 (1900h UTC+1).

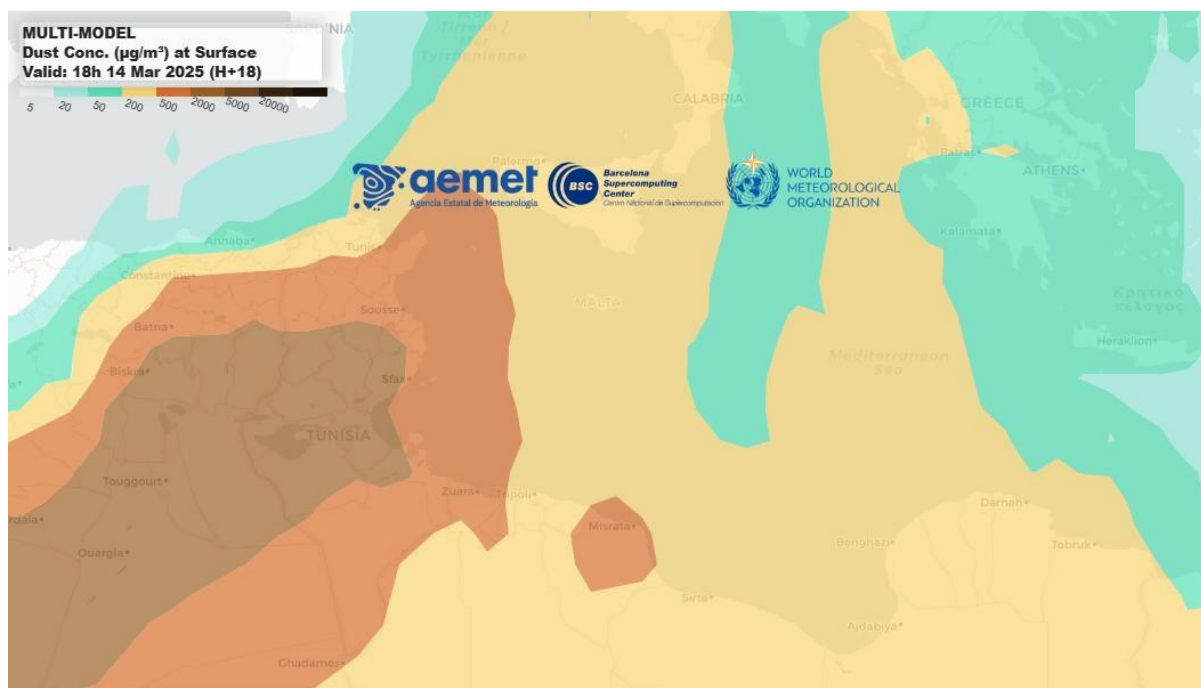


Figure A.8.3: PM₁₀ levels forecasted by the ensemble model on 14.03.2025.

9th Episode on the 15th March, 2025

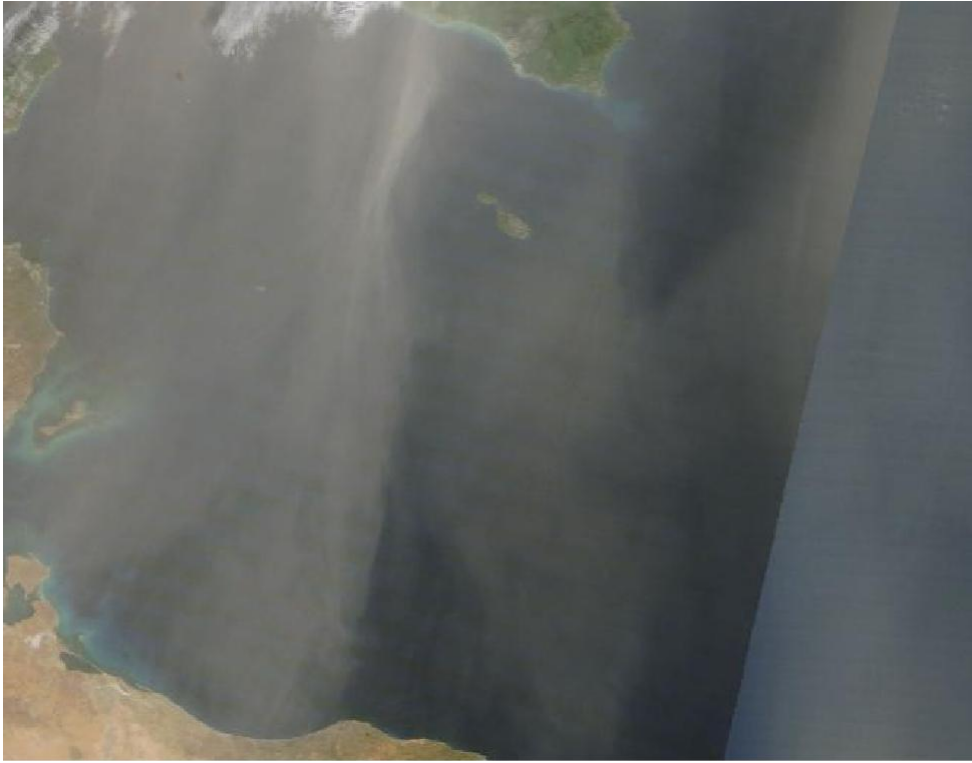


Figure A.9.1: Satellite image of the episode on 15.03.2025.

10th Episode on the 23rd March, 2025

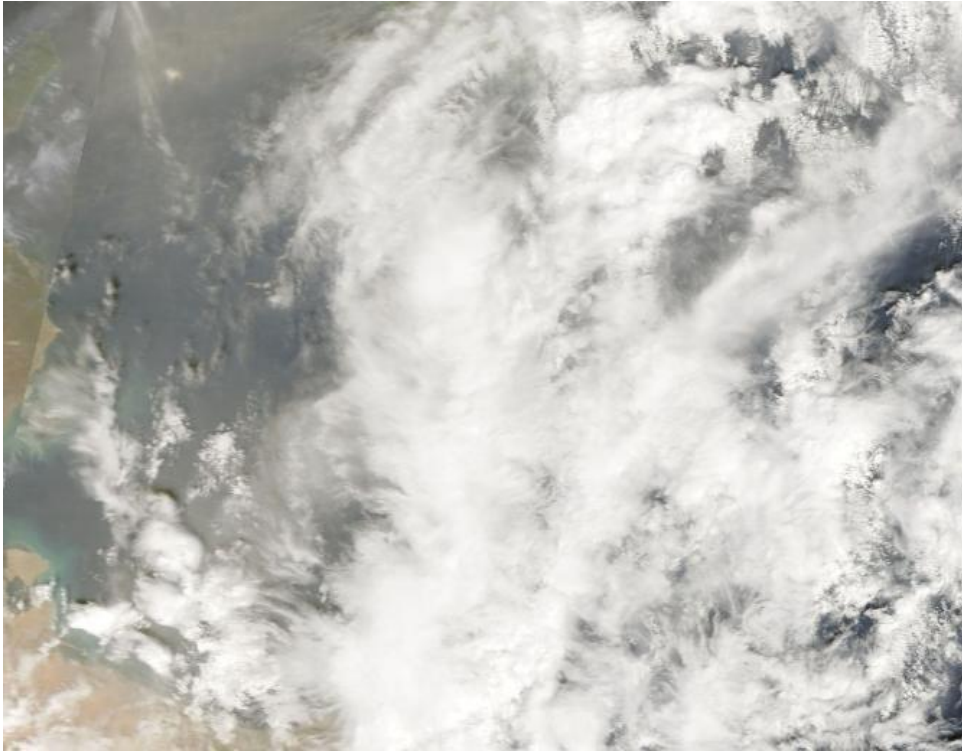


Figure A.10.1: Satellite image of the episode on 23.03.2025.

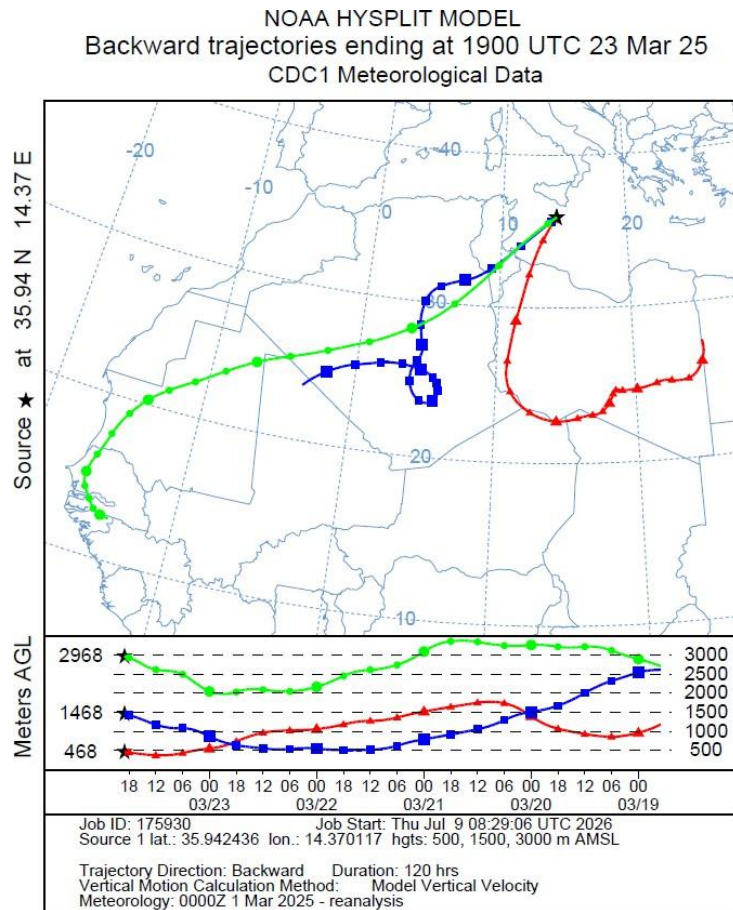


Figure A.10.2: Hysplit back trajectories for the episode on 23.03.2025 (2000h UTC+1).

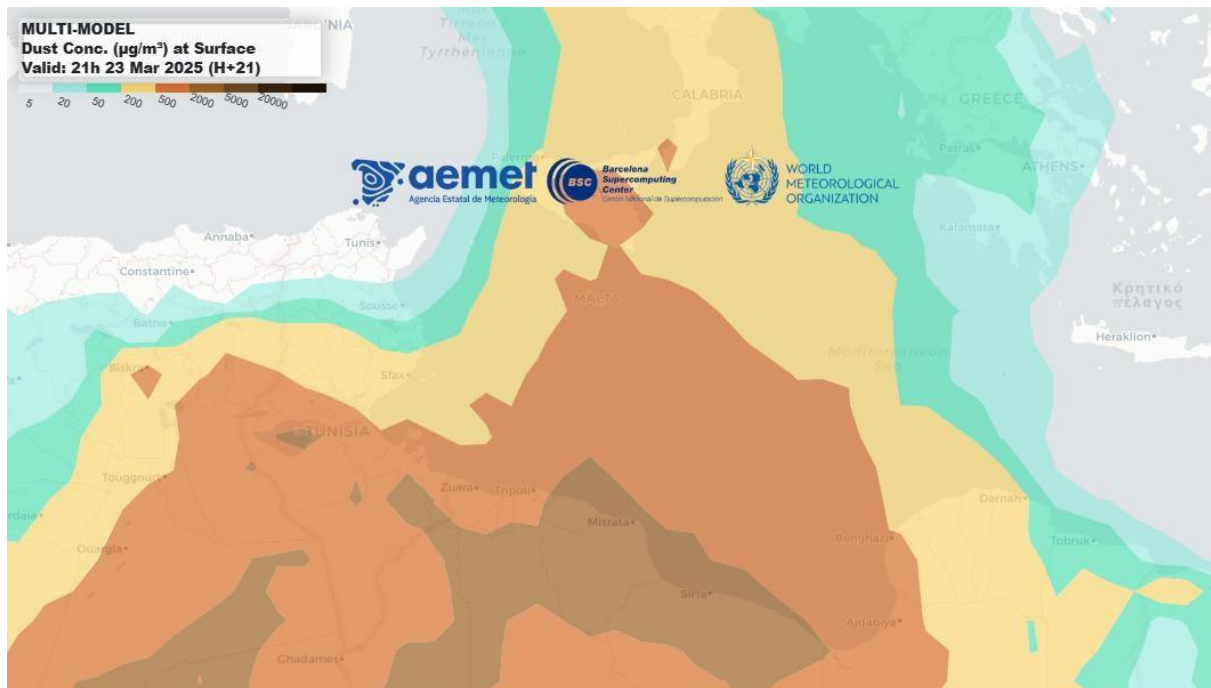


Figure A.10.3: PM_{10} levels forecasted by the ensemble model on 23.03.2025.

11th Episode on the 24th March, 2025

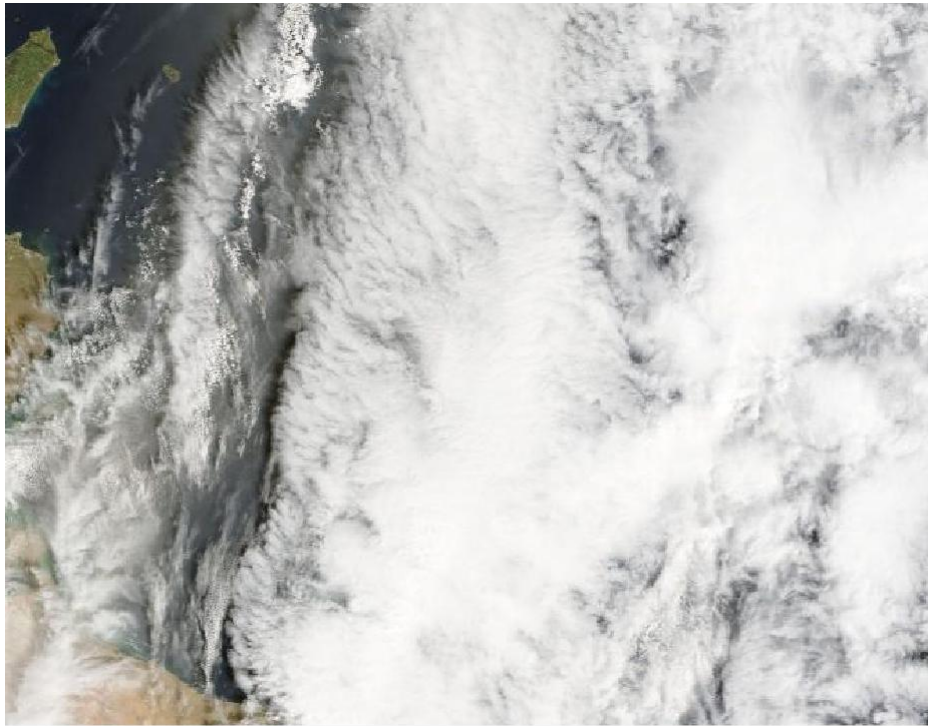


Figure A.11.1: Satellite image of the episode on 24.03.2025.

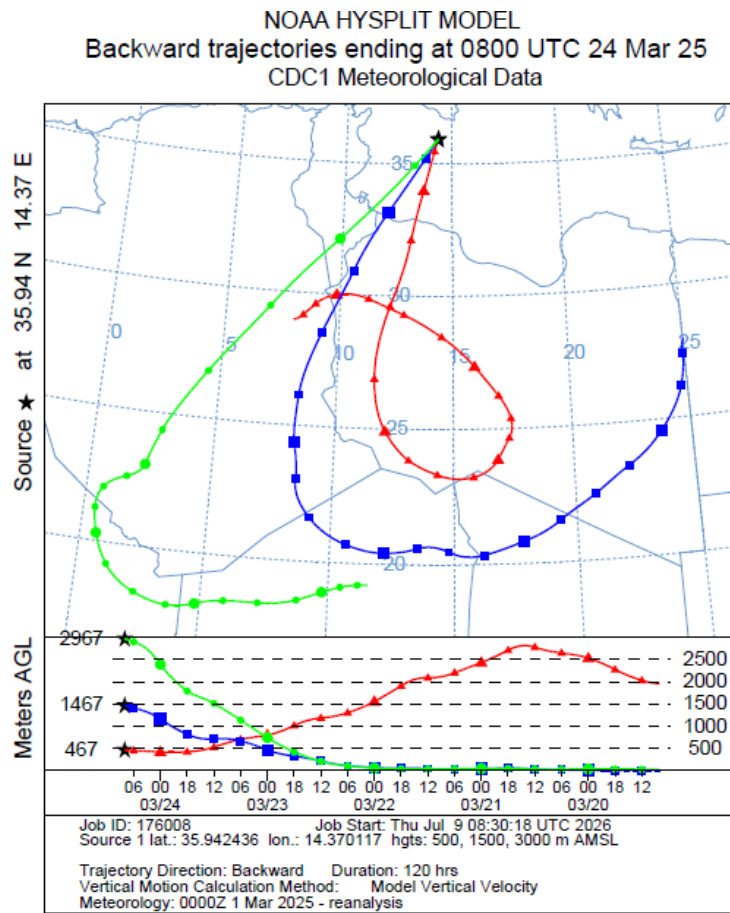


Figure A.11.2: Hysplit back trajectories for the episode on 24.03.2025 (0900h UTC+1).

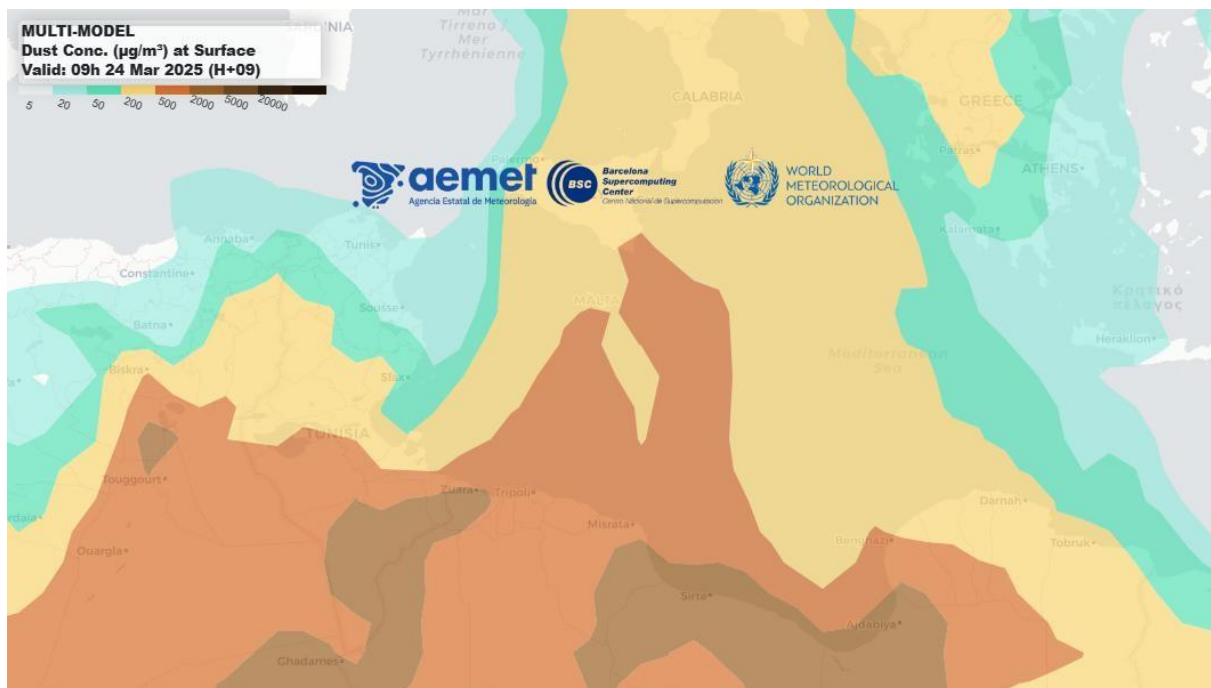


Figure A.11.3: PM₁₀ levels forecasted by the ensemble model on 24.03.2025.

12th Episode on the 25th March, 2025



Figure A.12.1: Satellite image of the episode on 25.03.2025.

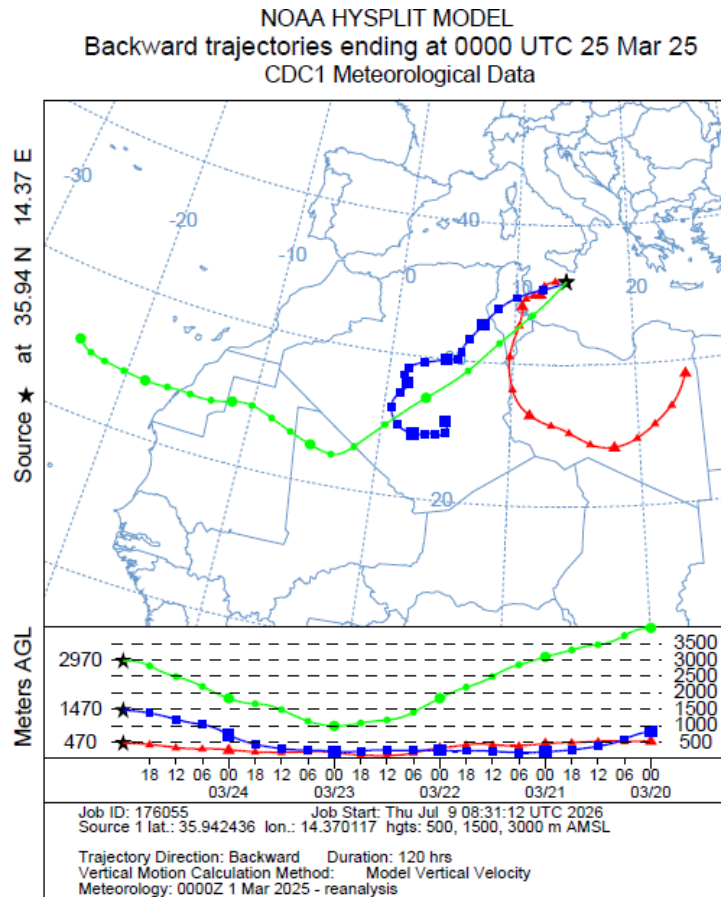


Figure A.12.2: Hysplit back trajectories for the episode on 25.03.2025 (0100h UTC+1).

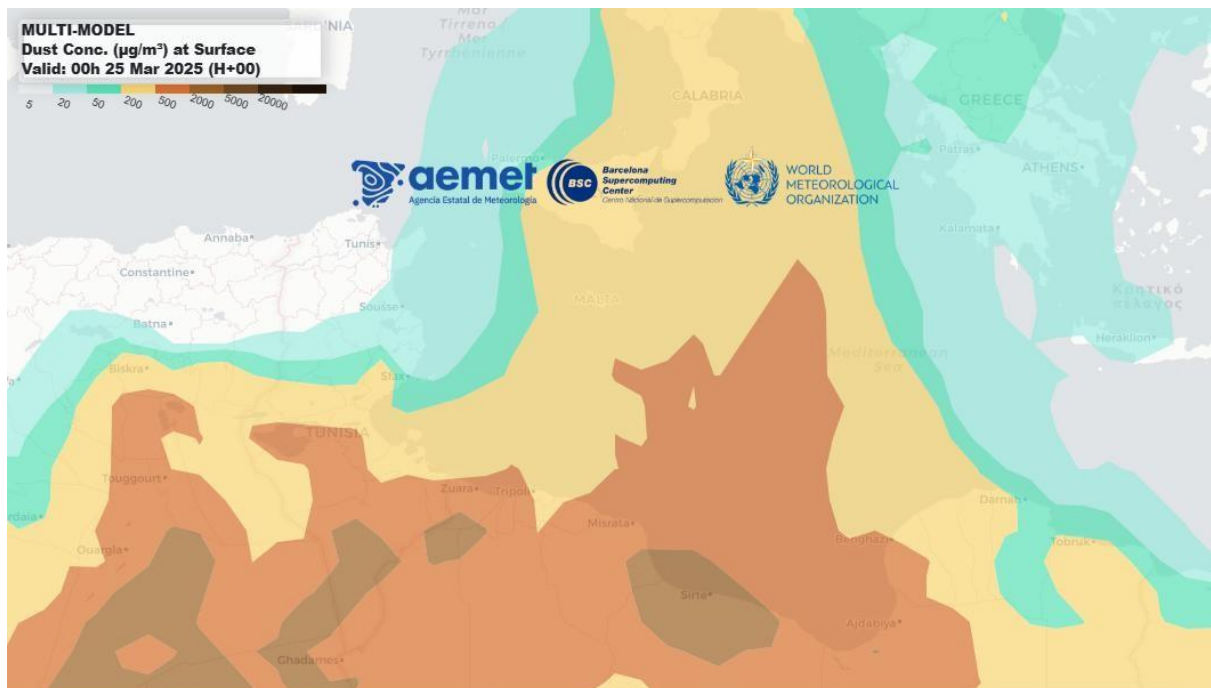


Figure A.12.3: PM₁₀ levels forecasted by the ensemble model on 25.03.2025.

13th Episode on the 14th April, 2025

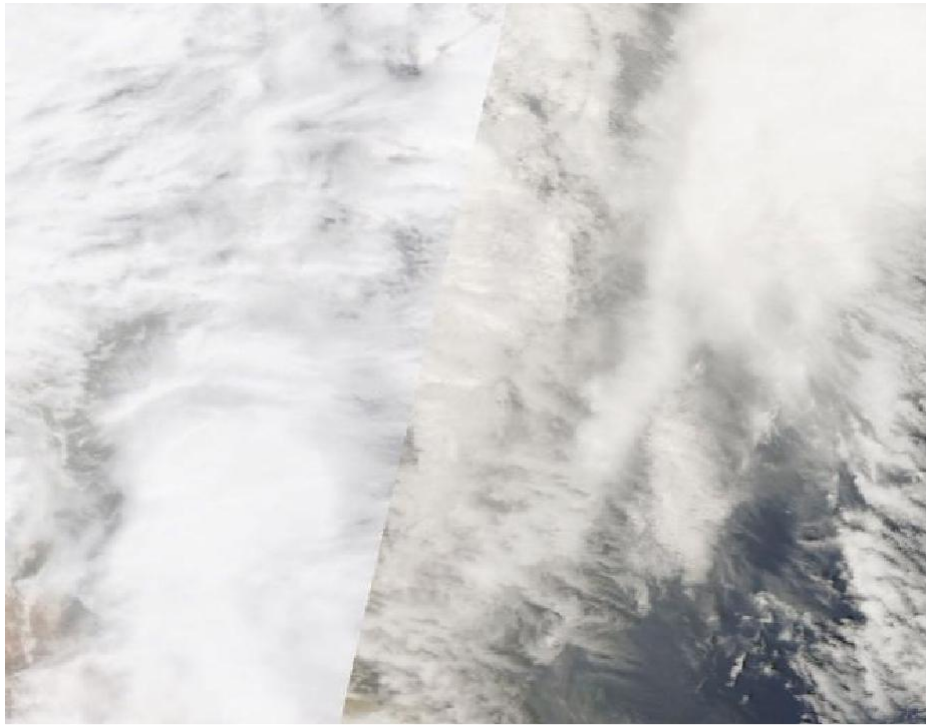


Figure A.13.1: Satellite image of the episode on 14.04.2025.

Source ★ at 35.94 N 14.37 E

Meters AGL

2979
1479
479

4000
3000
2000
1000

18 12 06 00 18 12 06 00 18 12 06 00 18 12 06 00 18 12 06 00

04/14 04/13 04/12 04/11 04/10

Job ID: 177077 Job Start: Thu Jul 9 08:59:50 UTC 2026
Source 1 lat.: 35.942436 lon.: 14.370117 hghts: 500, 1500, 3000 m AMSL

Trajectory Direction: Backward Duration: 120 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 1 Apr 2025 - reanalysis

MULTI-MODEL
Dust Conc. ($\mu\text{g}/\text{m}^3$) at Surface
Valid: 00h 14 Apr 2025 (H+00)

5 20 50 200 500 2000 5000 20000

aemet
 Agencia Estatal de Meteorología

BSC
 Barcelona Supercomputing Center
 Centre Nacional de Supercomputació

WORLD METEOROLOGICAL ORGANIZATION

Regions shown: TUNISIA, LIBYA, EGYPT, GREECE, ITALY (CALABRIA, SICILY), MALTA, CYPRUS.

Cities marked: Annaba, Constantine, Batna, Biskra, Touggourt, Zouara, Tripoli, Misrata, Benghazi, Darnah, Tobruk, Aydoyn, Heraklion, Athens, Patras, Kalamata.

Sea: Mediterranean Sea.

Figure A.13.3: PM₁₀ levels forecasted by the ensemble model on 14.04.2025.

14th Episode on the 15th April, 2025

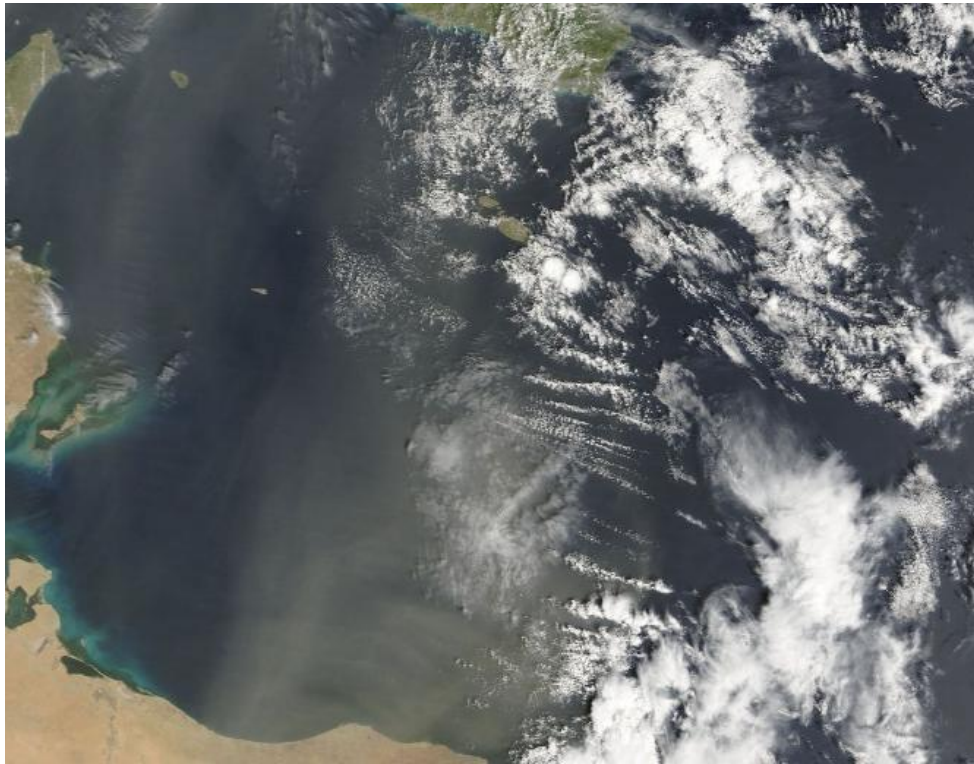


Figure A.14.1: Satellite image of the episode on 15.04.2025.

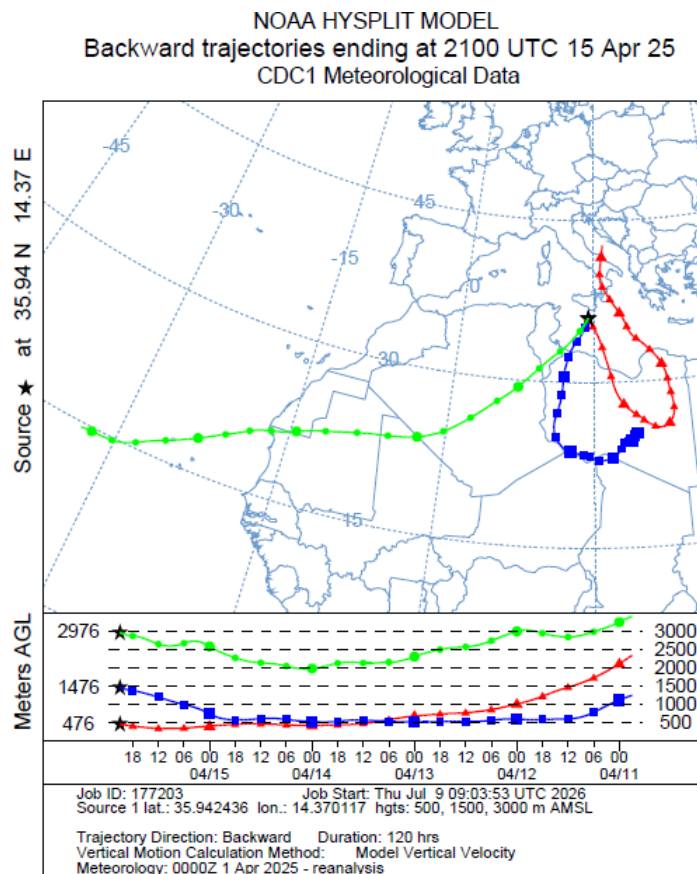


Figure A.14.2: Hysplit back trajectories for the episode on 15.04.2025 (2300h UTC+2).

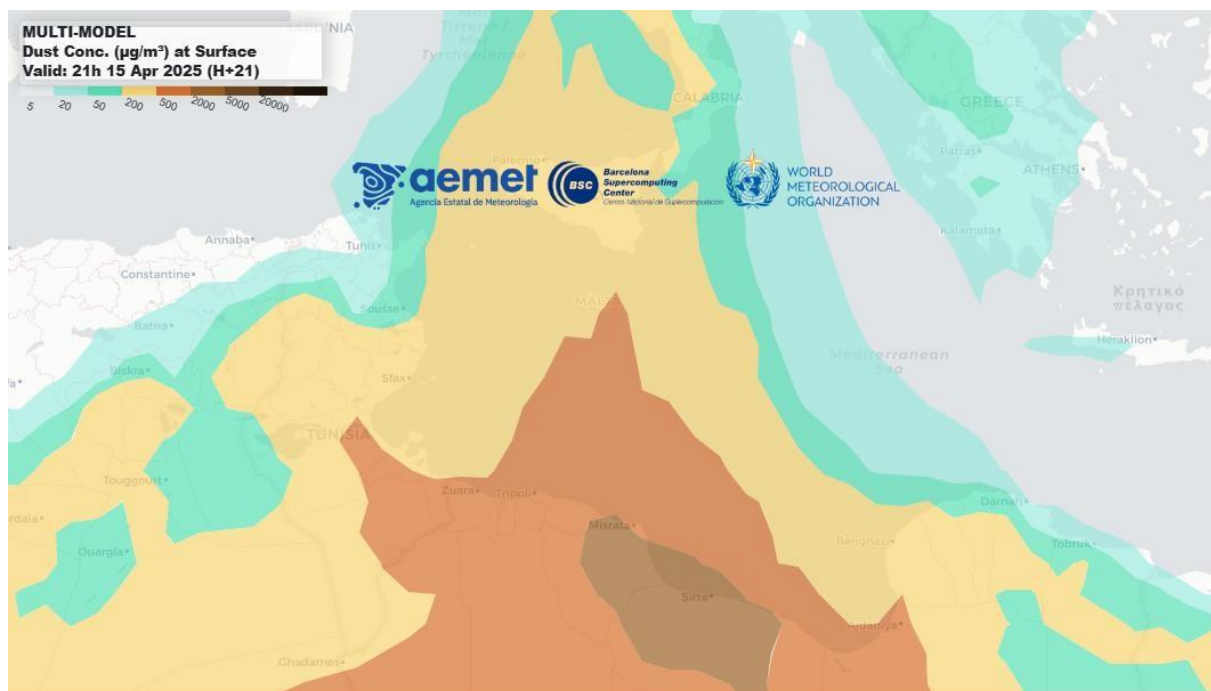


Figure A.14.3: PM_{10} levels forecasted by the ensemble model on 15.04.2025.

15th Episode on the 16th April, 2025

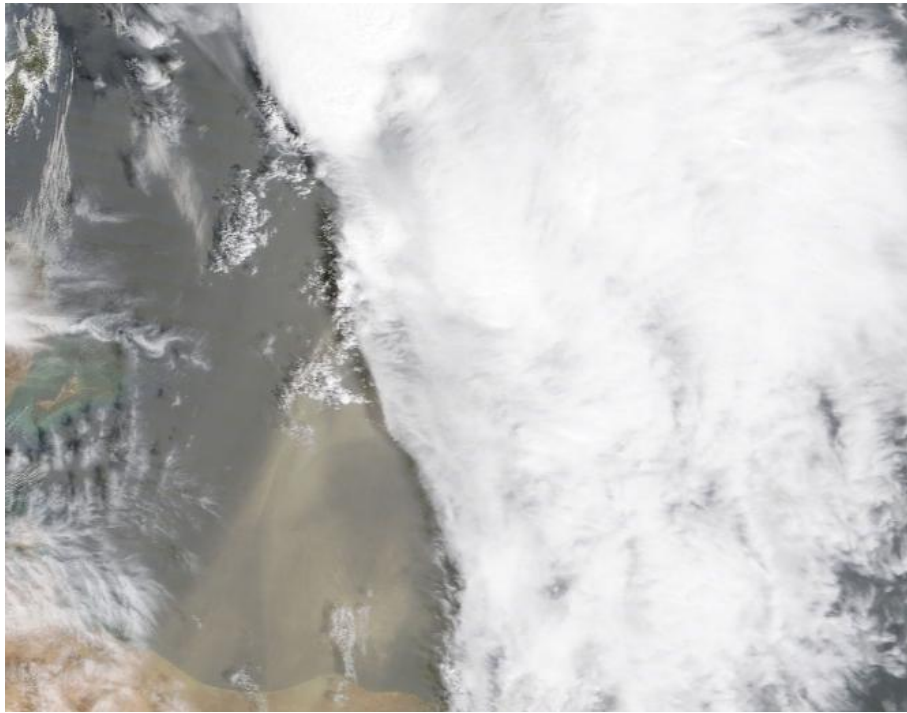


Figure A.15.1: Satellite image of the episode on 16.04.2025.

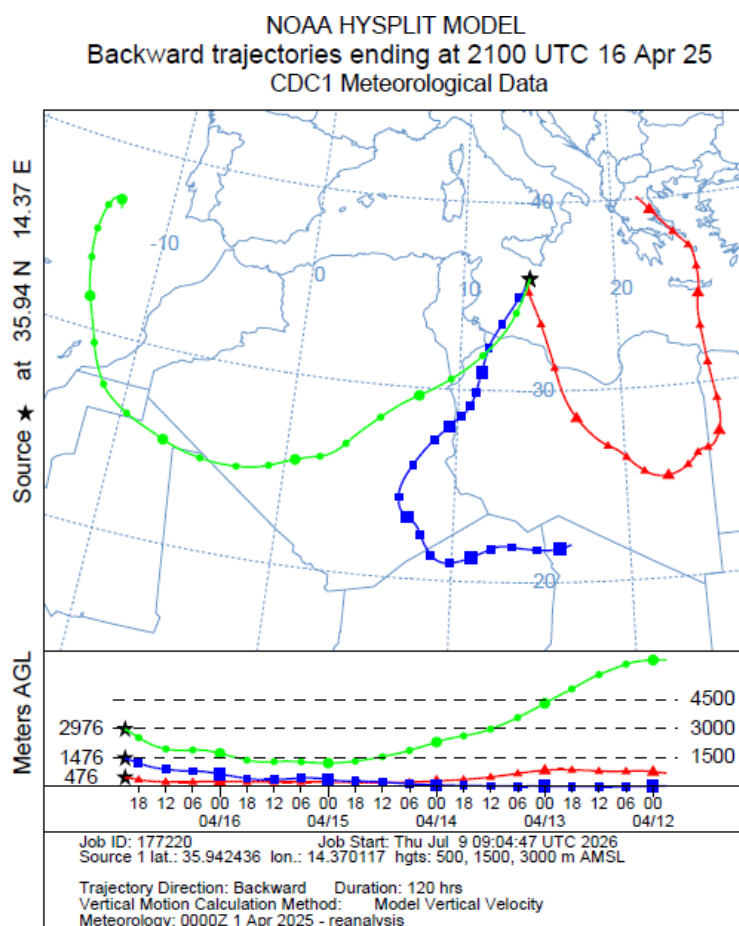


Figure A.15.2: Hysplit back trajectories for the episode on 16.04.2025 (2300h UTC+2).

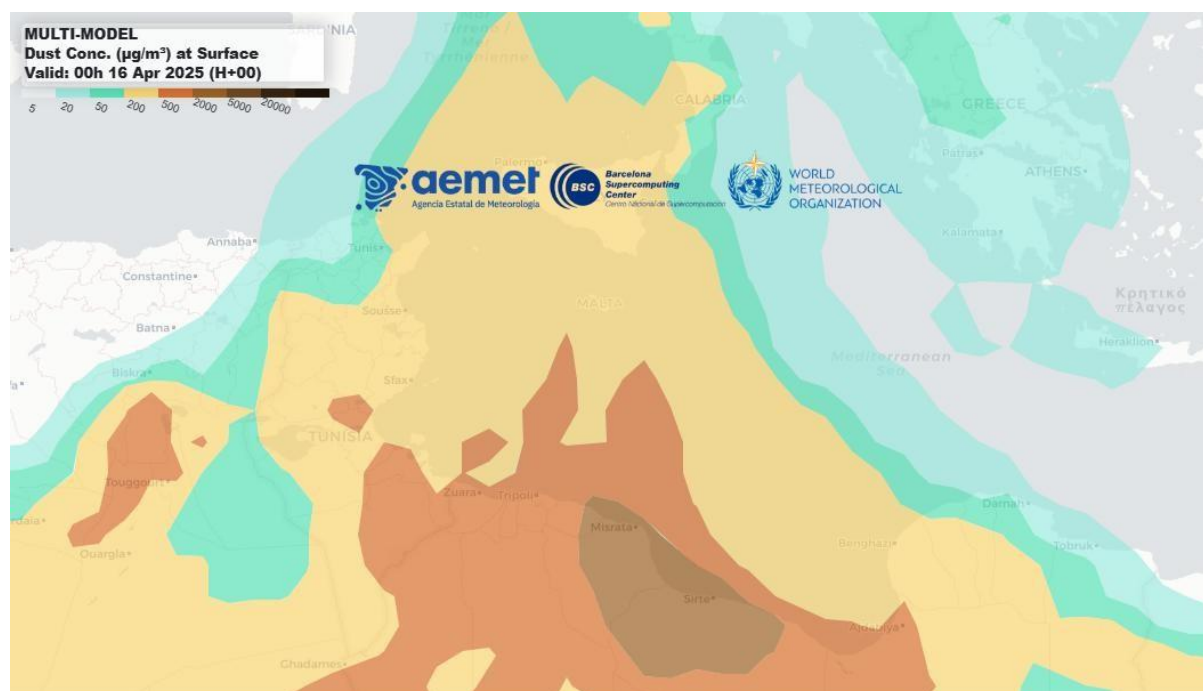


Figure A.15.3: PM₁₀ levels forecasted by the ensemble model on 16.04.2025.

16th Episode on the 20th May, 2025

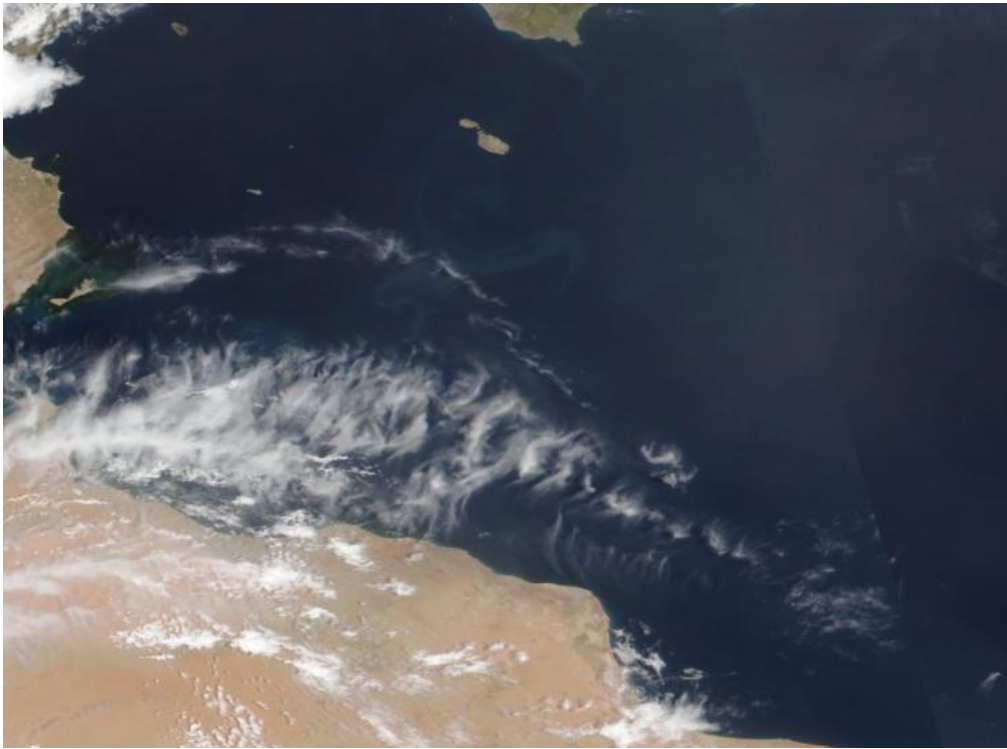


Figure A.16.1: Satellite image of the episode on 20.05.2025.

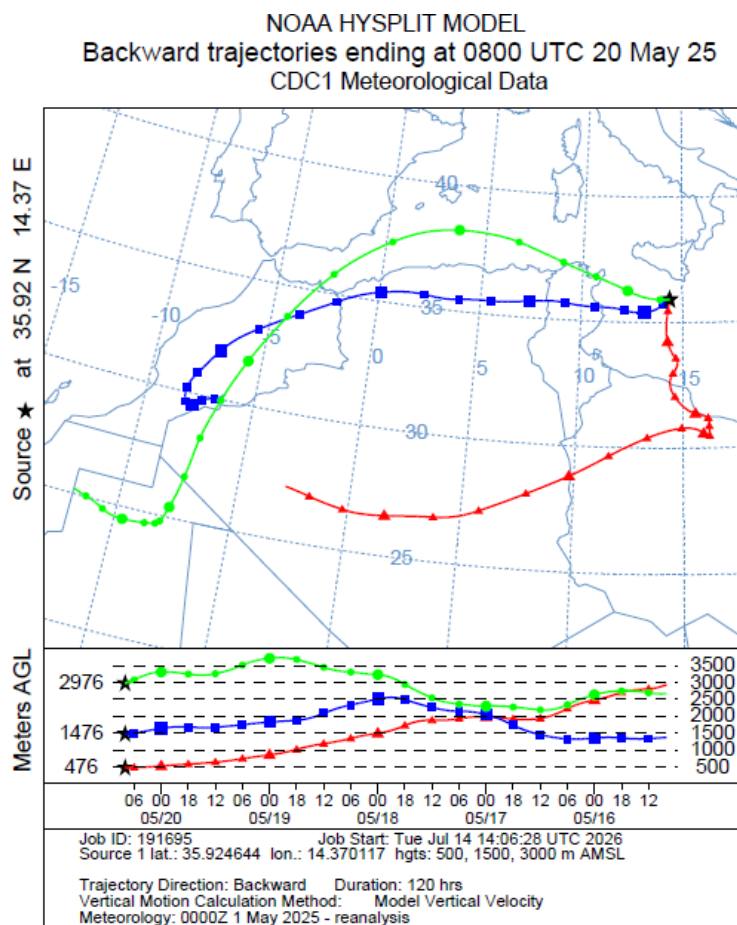


Figure A.16.2: Hysplit back trajectories for the episode on 20.05.2025 (1000h UTC+2).

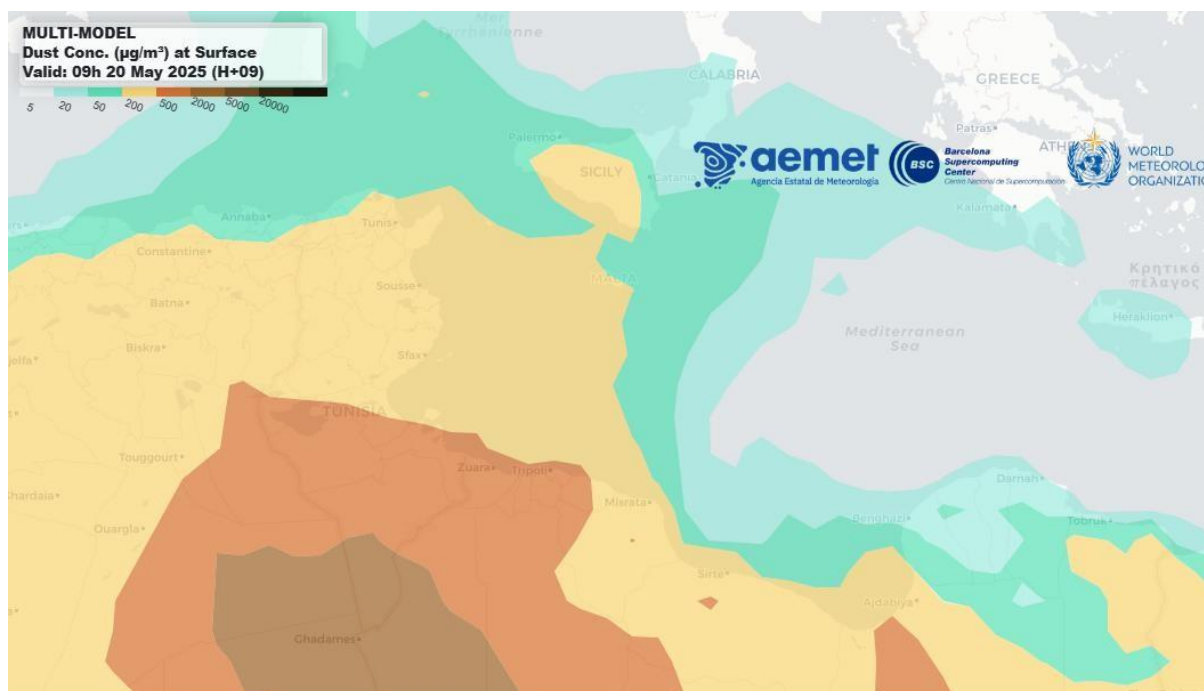


Figure A.16.3: PM_{10} levels forecasted by the ensemble model on 20.05.2025.

17th Episode on the 18th November, 2025

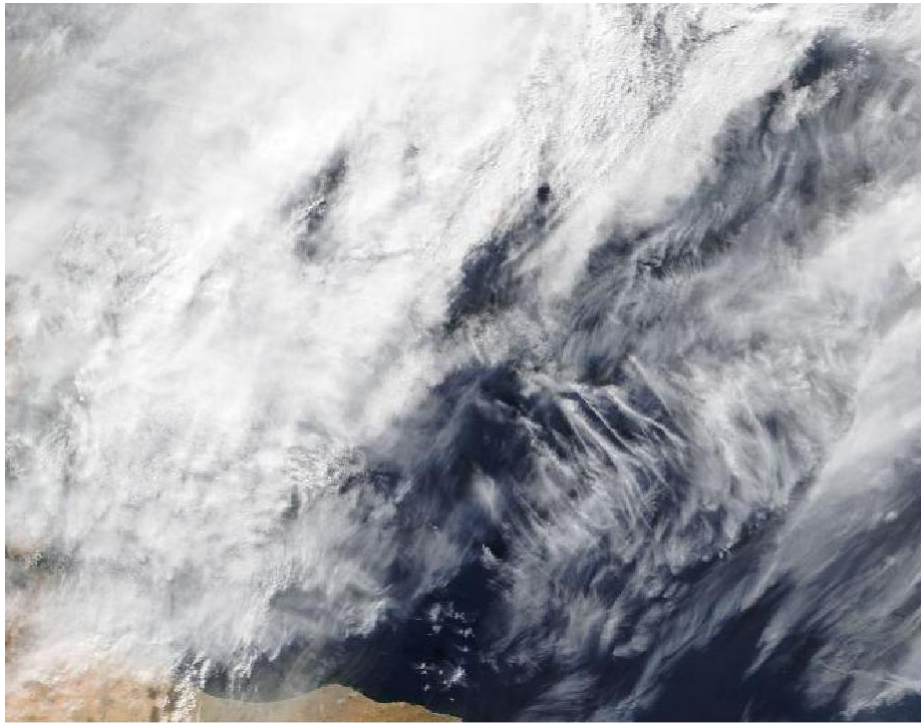


Figure A.17.1: Satellite image of the episode on 18.11.2025.

Source ★ at 35.94 N 14.37 E

Meters AGL

2972 ★
1472 ★
472 ★

12 06 00 18 12 06 00 18 12 06 00 18 12 06 00 18 12 06 00 18

11/18 11/17 11/16 11/15 11/14

Job ID: 177316 Job Start: Thu Jul 9 09:06:42 UTC 2026
Source 1 lat.: 35.942436 lon.: 14.370117 hghts: 500, 1500, 3000 m AMSL

Trajectory Direction: Backward Duration: 120 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 1 Nov 2025 - reanalysis

**MULTI-MODEL
Dust Conc. ($\mu\text{g}/\text{m}^3$) at Surface
Valid: 21h 18 Nov 2025 (H+21)**

5 20 50 200 500 2000 5000 20000

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Centro Nacional de Supercomputación

WORLD METEOROLOGICAL ORGANIZATION

Figure A.17.3: PM₁₀ levels forecasted by the ensemble model on 18.11.2025.

Note:

For all the figures with HYSPLIT back trajectories, the number in the brackets is the time at which the incoming air parcels reached Station MT00007 and recorded on average the highest values of PM10 concentrations. The trajectory in green represents the air parcel reaching Għarb at 3000m, the trajectory in blue represents the air parcel reaching Għarb at 1500m, while the trajectory in red represents the air parcel reaching Għarb at 500m.