Justification report on the contribution of natural events to the PM_{10} limit values for 2024

Environment and Resources Authority

September 2025

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 PM_{10} 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 paper[1]. This document is being submitted with the assessment of attainment of the environmental quality objectives with respect to PM_{10} for the reporting year 2024 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 images[2] and NOAA HYSPLIT single-particle backward trajectories[3], the ensemble forecasts of the WMO and SDS-WAS[4] 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 new station remains classified as a traffic station and is situated approximately 300m from its original location in Msida. According to the Ambient Air Quality Directive requirements, this relocation necessitates the station to be treated as new, now identified under a new station code, MT00011, for this and future 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. During the construction phase, higher concentration peaks of pollutants are anticipated and will be meticulously documented for further analysis.

In 2024, two stations of the Maltese monitoring network, namely the re-located traffic station in Msida (MT00011) and the urban station in Attard (MT00008), were non-compliant with regards the daily PM_{10} limit value objective with 42 and 38 exceedances, respectively. Msida station has registered an annual average PM_{10} concentration of 36.8 $\mu g/m^3$, whilst Attard station registered an average of 32.7 $\mu g/m^3$ (prior to correction for natural sources), both of which comply with the Annual Limit Value. In comparison, Malta's rural background station experienced 13 days exceedances of the daily PM_{10} limit value, which is higher than the number recorded in 2023. The annual average concentration of PM_{10} at Għarb was similar to the previous year being 19.3 $\mu g/m^3$. 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

[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

data capture of 98.9% was achieved for PM_{10} in 2024. The data capture for PM_{10} at the Msida station was 94.8% and 95.4% in Attard. The excellent level of data capture achieved at all three monitoring stations permitted a more significant and realistic measure of the amount of exceedances experienced by the Maltese Islands.

Msida and Attard stations are about 33 and 30 kilometres from Għarb station, respectively. Due to the fact that the Maltese territory comprises only of 316 km^2, 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 PM_{10} daily averages measured in Għarb (MT00007), Msida (MT00011) and Attard (MT00008) in 2024. 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.

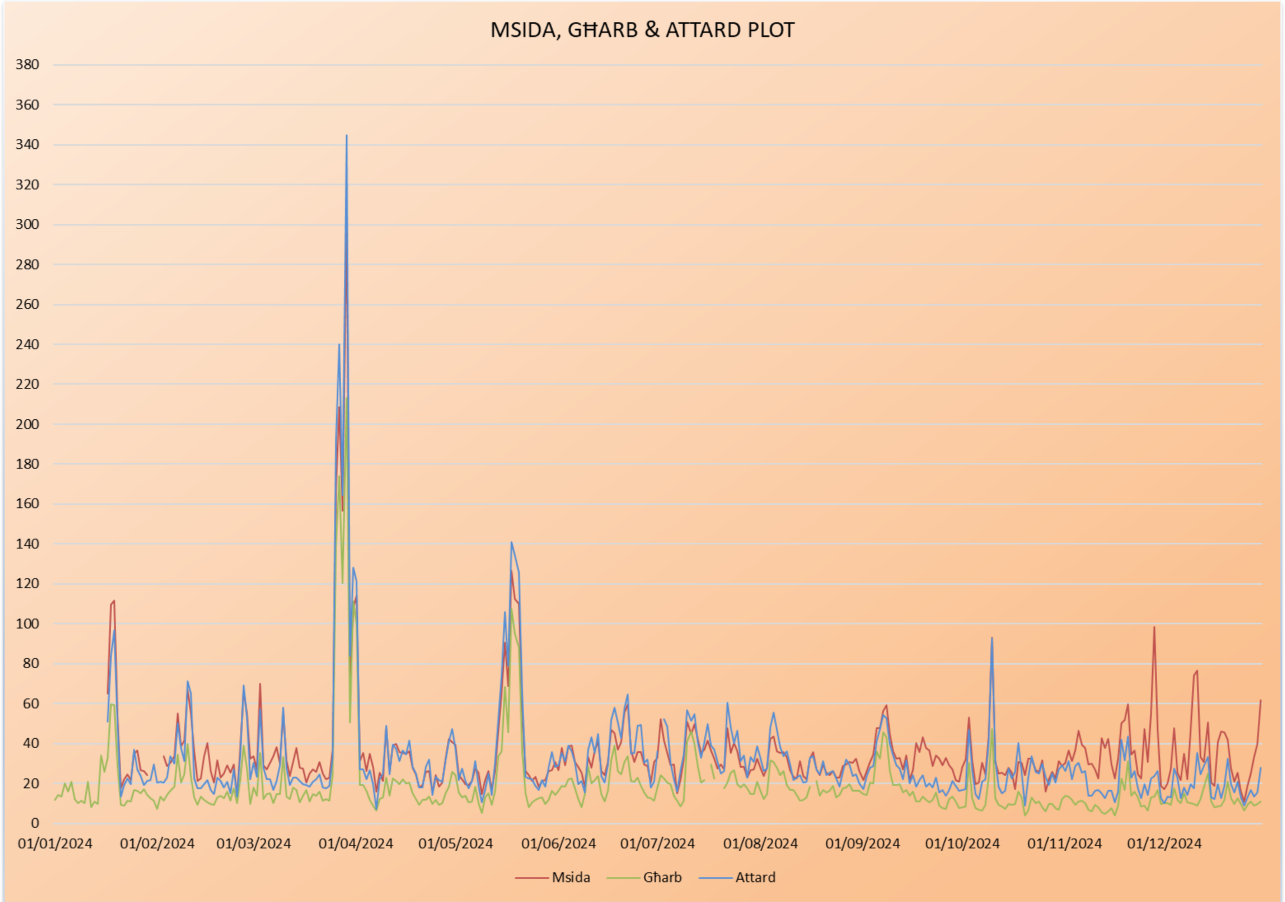

Figure 1: Daily averages of PM_{10} measured at the background rural station in Gharb (station code: MT00007), the traffic station in Msida (station code: MT00011) and the urban station in Attard (MT00008) in 2024.

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 PM_{10} concentrations recorded at our background monitoring station in Għarb, which is modelled using Hidden Markov Models (HMMs), which express the PM_{10} time-series as a number of Gaussian distributions (this number is determined by the model). These Gaussian distributions are also called PM_{10} 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.[5]
PM_{10} levels in Għarb were described by a four-regime HMM, with 14 days from regime 4 (see Figure 2 and Table 1) primarily attributed to Saharan dust events.

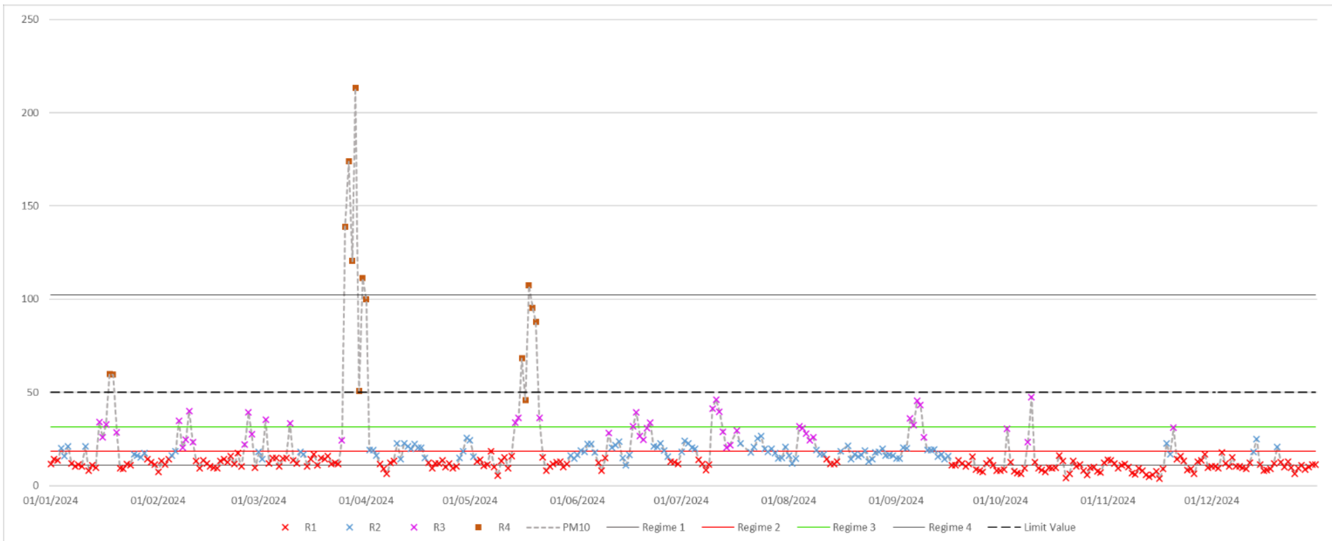

Figure 2: PM_{10} time series for MT00007 (Għarb) in 2024 and the four PM_{10} concentration regimes.

		Concentration in µg/m³		
Regime	**Number**	**Range**	**Average**	**Standard Deviation**
1	198	3.9 - 18.5	11.090	2.743
2	107	11.1 - 26.6	18.461	3.176
3	47	20.5 - 47.5	31.611	6.989
4	14	45.9 - 213.3	102.329	48.119
Full data set	366		15.257	

Table 1: Basic statistical data for the four PM_{10} concentration regimes for the MT00007 station in 2024.

[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. All 14 days from Regime 4 have been identified as Saharan dust intrusions and therefore, acceptable for deduction. 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 Għarb station as well as those of Msida and Attard stations. Table 2 lists all the above mentioned 14 days, which had been identified clearly to be influenced by African dust. 13 out of the 14 days also exceeded the daily limit value at the rural background station in Għarb, whilst all the identified Saharan dust days resulted in an exceedance at both Msida and Attard stations.

In the case of Għarb station, all 13 exceedance days were below the daily limit value after this reduction process was performed. In case of Msida, four days (denoted in Table 2 in italic) remained above the daily limit value after contribution of African dust was subtracted, while ten days went below the DLV. Furthermore, in relation to Attard, 8 days (denoted in Table 3 in italic) remained above the daily limit value after the deduction of the Saharan dust portion, while 6 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**
18/01/2024	*59.9*	*44.48*	*109.5*	*65*
19/01/2024	*59.4*	*43.98*	*111.9*	*68*
26/03/2024	138.8	123.16	167.5	44
27/03/2024	173.9	158.26	208.5	50
28/03/2024	*120.4*	*104.76*	*156.5*	*52*
29/03/2024	*213.3*	*197.66*	*304.4*	*107*
30/03/2024	50.8	35.16	68.6	33
31/03/2024	111.3	95.66	108	12
01/04/2024	99.8	84.16	114.2	30
16/05/2024	68.3	52.21	90.8	39
17/05/2024	45.9	29.81	68.8	39
18/05/2024	107.4	91.31	126.7	35
19/05/2024	95.4	79.31	112.5	33
20/05/2024	88	71.91	110.2	38

Table 2: Days which were identified to be influenced by Saharan dust and the resulting PM_{10} concentrations at Msida station following deduction of African dust contribution.

Date	Measured concentration at rural background station MT00007	Contribution of African dust	Measured concentration at traffic station MT00008	Resulting concentration at the traffic station after deduction of African dust and rounding to the nearest integer
18/01/2024	*59.9*	*44.48*	84.1	40
19/01/2024	*59.4*	*43.98*	*96.9*	*53*
26/03/2024	138.8	123.16	*191.3*	*68*
27/03/2024	173.9	158.26	*239.9*	*82*
28/03/2024	*120.4*	*104.76*	*164.4*	*60*
29/03/2024	*213.3*	*197.66*	*344.6*	*147*
30/03/2024	50.8	35.16	84.1	49
31/03/2024	111.3	95.66	128.2	33
01/04/2024	99.8	84.16	121.0	37
16/05/2024	68.3	52.21	*106.0*	*54*
17/05/2024	45.9	29.81	79.3	50
18/05/2024	107.4	91.31	140.8	50
19/05/2024	95.4	79.31	*134.3*	*55*
20/05/2024	88	71.91	*125.7*	*54*

Table 3: Days which were identified to be influenced by Saharan dust and the resulting PM_{10} concentrations at Attard 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 42 to 32 and in Attard, the number of days reduced from 38 to 32.

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 PM_{10} 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 PM_{10} values, which might hinder Malta’s compliance to the Daily Limit Value.

This described methodology has resulted in an annual average of PM_{10} at Msida reduced from 36.8 µg/m^3 to 33.3 µg/m^3 and from 32.7 µg/m^3 to 29.3 µg/m^3 in Attard, 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 PM_{10} 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 PM_{10} 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 PM_{10} 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:

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

Figure 3 shows the correlation between the sea salt concentration determined from sodium and chloride concentration on the PM_{10} 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:

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

The respective formula for data sets from Msida is:

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

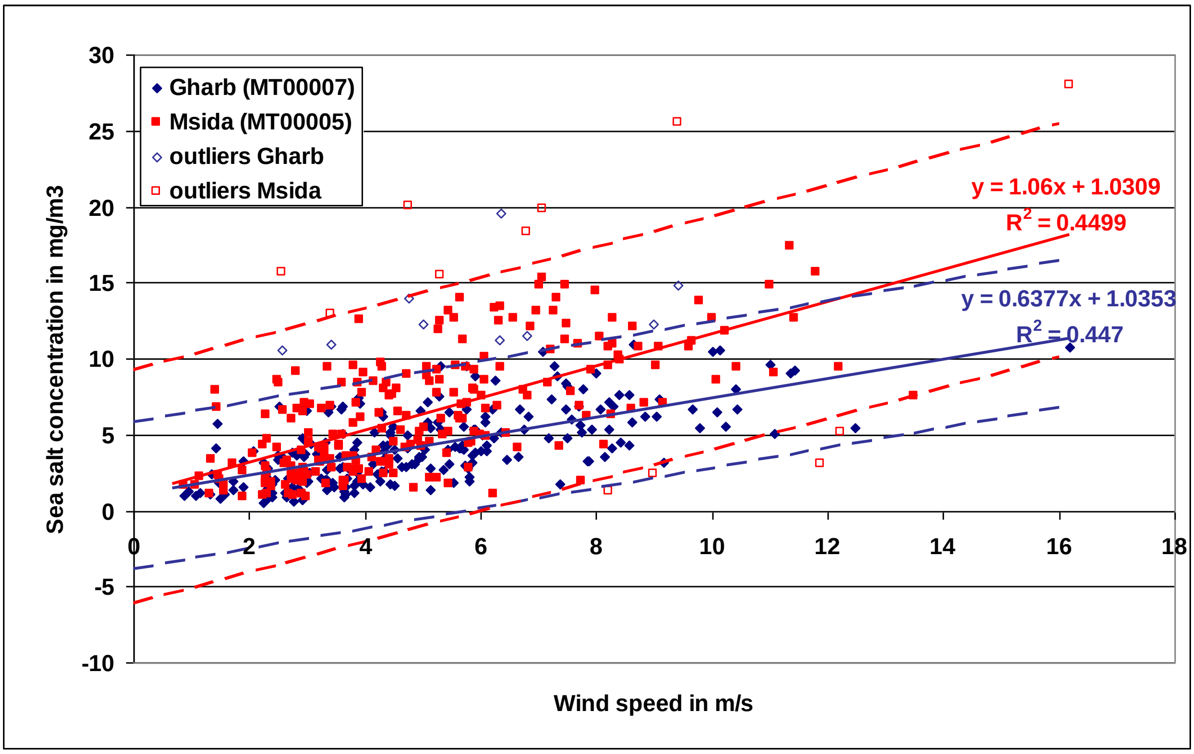

Figure 3: Correlation between daily average wind speed and sea salt concentration in PM_{10} at the background station in Gharb and the traffic station in Msida. The dashed lines represent the 2σ confidence intervals of the respective data sets. Data points outside the confidence intervals have not been considered for the regression calculation.

For the year 2024, no ion data is available at the time of reporting in order to determine the sea salt concentration directly from the PM_{10} measurements at Msida as well as from Għarb. 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 4 lists the days at Msida station, which were not identified as Saharan dust events and which have decreased below the daily limit value for PM_{10} after the sea salt contribution had been deducted and after rounding to integer values. The table also includes one Saharan dust-influenced day which was still exceeding the DLV after the deduction of Sahara dust contribution, but has gone down below 50 µg/m^3 after additional sea salt deduction calculations using formula [2].

In Msida, 11 days not identified as Saharan dust events have been reduced below the DLV after sea salt deduction, whilst out of the identified days, only 1 day has reduced below the DLV.

In Msida, these reductions have further reduced number of daily exceedances to 20, while the annual PM_{10} concentrations decreased further from 33.3 µg/m^3 after Sahara dust deduction to 27.6 µg/m^3 in Msida.

The average sea salt concentration in 2024 was 5.7 µg/m^3 which is slightly lower than that of the previous year with a difference of just 0.2 µg/m^3.

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
20/01/2024	54.0	7.23	47
07/02/2024	55.2	6.91	48
11/02/2024	55.1	7.22	48
28/02/2024	55.0	6.77	48
10/03/2024	55.7	12.90	43
28/03/2024	*51.7*	*6.59*	*45*
21/05/2024	56.5	7.30	49
02/07/2024	52.1	9.72	42
10/07/2024	50.9	3.75	47
03/10/2024	53.1	8.81	44
19/11/2024	51.8	5.53	46
14/12/2024	50.5	6.26	44

Table 4: 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.

In 2024, the number of days exceeding the Daily Limit Value in Attard fell below the 35-day threshold, eliminating the need to adjust concentrations for sea salt content at this station. During the time when the correlation study between wind speed and sea salt was carried out, Attard station was not yet launched, therefore, such a correlation is absent. Additionally, as noticed, 2024 stood out as an outlier year for this station, attributed to significant roadworks nearby that impacted PM concentrations. Moving forward, additional investigations into sea salt correlations at Attard are planned, aligning with preparations for the stringent limits outlined in the revised Directive (2024/2881).

4.0 Conclusion

In 2024, the relocated traffic station in Msida and urban station in Attard exceeded the allowed number of exceedances of the PM_{10} daily limit value with 42 and 38 days, respectively. The number of exceedances at the rural background station in Għarb was quite low in comparison with Msida station, with 13 days exceeding the limit value. There were a number of days with relatively high PM_{10} values for a rural background station, which were not classified in Regime 4 but were potentially influenced by Sahara dust. In comparison, the, number of days exceeding the DLV at Msida station in 2024 was much lower than in 2023. 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 regime during the summer or early winter months. Moreover, the good data capture recorded at Għarb station for both PM_{10} and wind speed facilitated a more accurate deduction process for natural dust. In this regard, the number of exceeding days went from 42 to 32 and from 38 to 32 in Msida and Attard, respectively.

The contribution of sea salt to the PM_{10} fraction in 2024 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 PM_{10} concentration resulted in a deduction of 12 more exceeding days in Msida, reducing the number of the remaining exceedances in Msida to 20. The deduction of sea salt contribution was not calculated for Attard station given that no correlation was done for this station and it complies with the DLV after the deduction of Saharan dust. This means that Malta is compliant with regards the daily PM_{10} limit value objective for 2024.

In Għarb, the annual average PM_{10} concentration is well below the annual limit value with19.3 µg/m^3. The annual PM_{10} concentration at Msida and Attard stations were also below the ALV, however further reduced from 36.8 µg/m^3 to 27.6 µg/m^3 and 32.7 µg/m^3 to 29.3 µg/m^3, respectively, 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 (µg/m^3)	Justification and comment on Sahara dust intrusion* **The time stated in these descriptions is to be considered as approximate.*
18/01/2024	59.9	The backward trajectories reveal extensive paths, indicating strong southeast winds carrying sand from the African continent. Both the 500 and 1500 meter trajectories pass over regions such as Western Sahara, Morocco, and Algeria, with the blue trajectory descending below 1500 meters, which explains the observed event on that day. This can be observed faintly in the satellite image, which clearly shows the beginning of the event with a noticeable mass of sand moving towards Malta. The dust forecast further confirms the intrusion of dust over a large area in the Mediterranean.
19/01/2024	59.4	All trajectories continue following the same path, with the highest trajectory consistently staying around 3000 meters for most of its course. Satellite images remain inconclusive due to cloud cover, hindering detailed observations. However, forecast models indicate that the influence will remain strong in the Malta area.
26/03/2024	138.8	The trajectories all pass deeply into the Sahara Desert for a significant duration before reaching Malta. This explains the strong influence visible in the satellite image. Despite some areas being obscured by cloud cover, it is evident that there was a pronounced impact from Saharan dust. The forecast indicated a substantial influence across the islands, extending to Sicily as well.
27/03/2024	173.9	The trajectories remain equally conclusive as the previous day, showing a very long path passing over the Sahara Desert. The satellite images clearly depict a strong event with significant impacts. Despite some areas being obscured by cloud cover, the strong influence can still be observed as forecasted, moving northwards and covering all of Malta and its surrounding areas.

28/03/2024	120.4	The trajectories shifted towards the coastline on this day, which explains the weakening of this event. Additionally, it is clear that there were high wind speeds given the long trajectories. In the satellite image, the Saharan dust is not directly above Malta, but the event is still notably active with high concentrations observed. Overall, there is less influence shown compared to previous days, but there is still a relatively strong presence over Malta.
29/03/2024	213.3	The trajectories shifted inward from the coastline, which appeared to strengthen the event, with high concentrations reported on this day. Despite the satellite image not directly aligning with the presence of Saharan dust over Malta, the trajectory path and the peaks in concentration are sufficient to confirm the ongoing Saharan dust event during this period. Additionally, there were high wind speeds along these long trajectories. The clear satellite image does not show a distinct influence of Saharan dust. However, the forecast indicates a weakened sand intrusion, still considered part of the event, supported by sustained recorded concentrations.
30/03/2024	50.8	The trajectories have continued to shift further south of the Sahara Desert, picking up a large sand mass and transporting it towards Malta, as evident in the satellite image. The event remains very clear and strong, with persistent influence observed.
31/03/2024	111.3	The backward path of the trajectories remained unchanged throughout the day. The satellite image indicates reduced influence from Saharan dust compared to previous observations. However, a moderately strong influence was forecasted for this day.
01/04/2024	99.8	The trajectories continue to pass over the Sahara Desert region before reaching Malta, indicating that this day remains part of the 7-day event. This is supported by the high daily average recorded. The satellite image shows a slight influence, marking the potential end of the event. Forecast

		models indicate less influence expected, aligning with other parameters, and this day is considered to be the final day of the event.
16/05/2024	68.3	All trajectories pass predominantly over Algeria and Libya for their entire path, confirming a significant influence from Saharan dust. The satellite images clearly show this influence, confirming its presence. The forecast for Saharan dust influence is strong for this day, marking the beginning of another significant event.
17/05/2024	45.9	The highest and lowest trajectories both traverse the African continent, primarily over Algeria. The middle trajectory remains near the coastline, yet a strong influence was recorded, evident in the satellite image. Despite some cloud cover, a significant influence is observed across the surrounding areas. The forecast indicates a somewhat diminished influence compared to other parameters, but it is still confirmed.
18/05/2024	107.4	The higher trajectories consistently pass over the African continent throughout the day. Although the lowest trajectory hovers just over the Tunisian coastline, an event can still be confirmed for this day, supported by the satellite image and high concentration levels. Despite some cloud cover, the influence remains visible. The forecast predicts a northward movement of the sand mass, resulting in a stronger intrusion, which explains the higher concentration compared to the previous day.
19/05/2024	95.4	The trajectories for this day show a similar pattern. A weak influence could be considered, but the daily average remains relatively high. Despite reflections and cloud cover, a slight influence can be inferred. The forecast predicts a moderate influence for this day, which aligns with the other two parameters.
20/05/2024	88	All trajectories, including the lowest one, pass through Libya and predominantly Algeria, clearly indicating an influence as evident in

		the satellite image. The influence is clear throughout the day. As observed by other parameters, Saharan dust influence was present on this day as part of the 5-day event.

<u>1st Episode on the 18th January, 2024.</u>

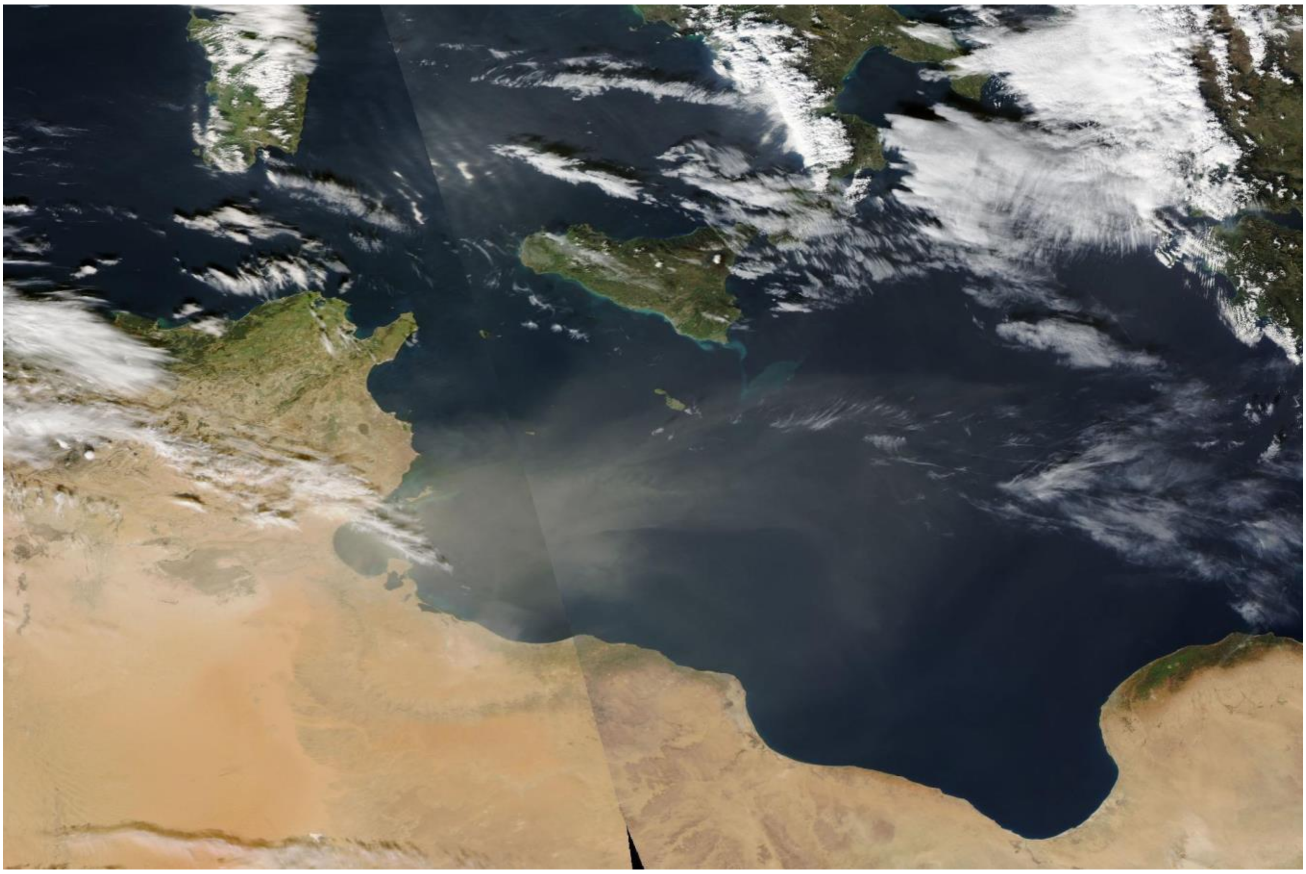

Figure A.1.1: Satellite image of the episode on 18.01.2024.

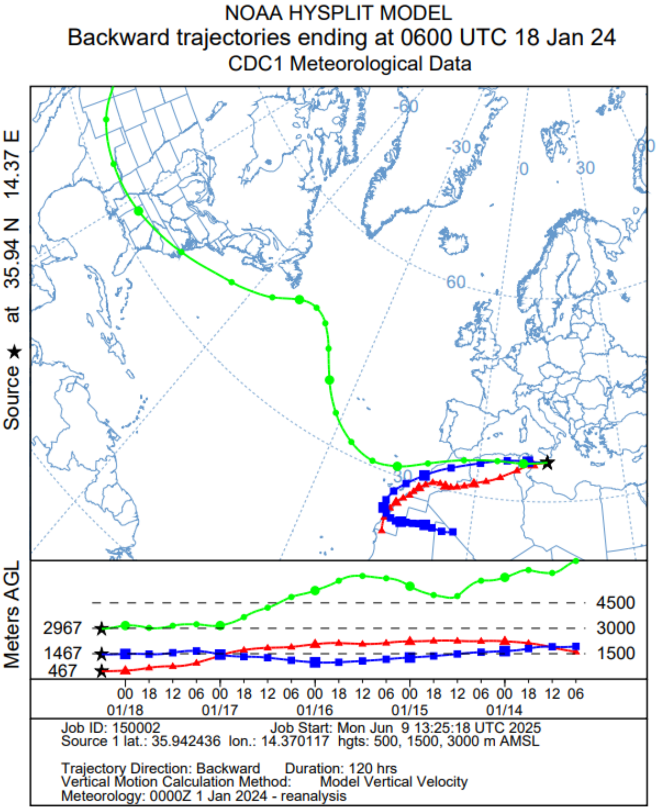

Figure A.1.2: Hysplit back trajectories for the episode on 18.01.2024 (0700h UTC+1).

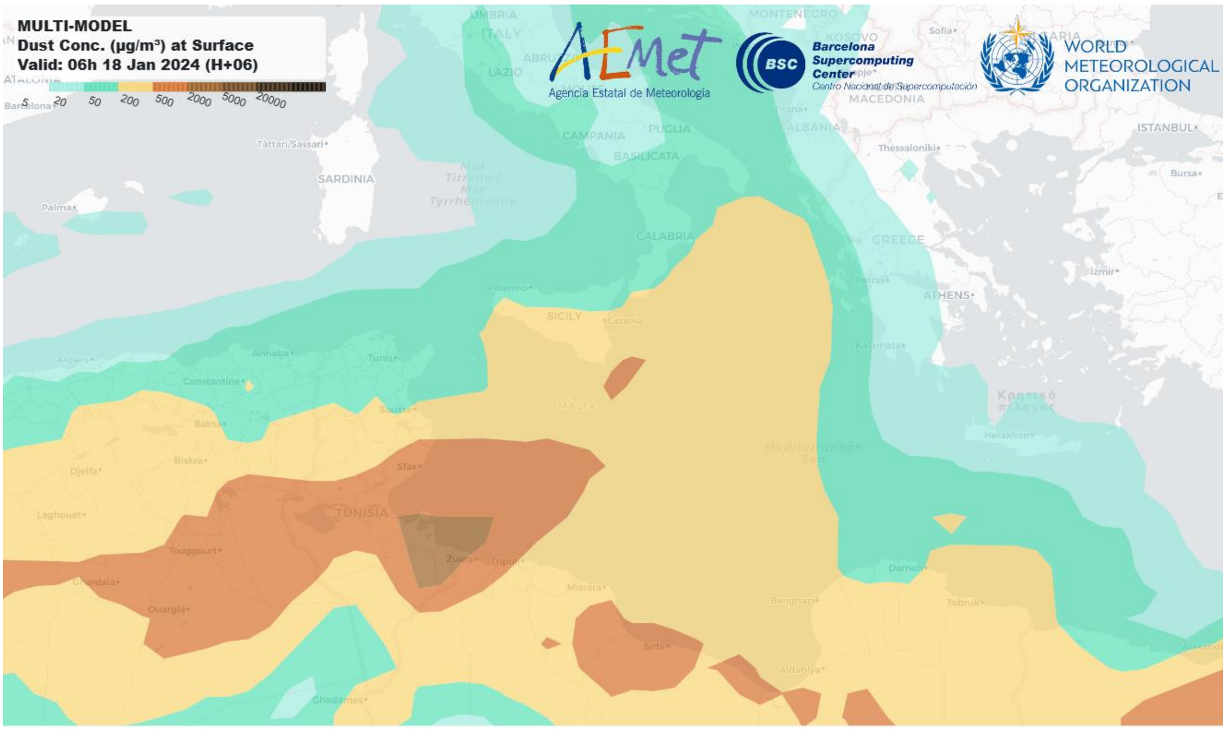

Figure A.1.3: PM_{10} levels forecasted by the ensemble model on 18.01.2024.

2nd Episode on the 19th January, 2024.

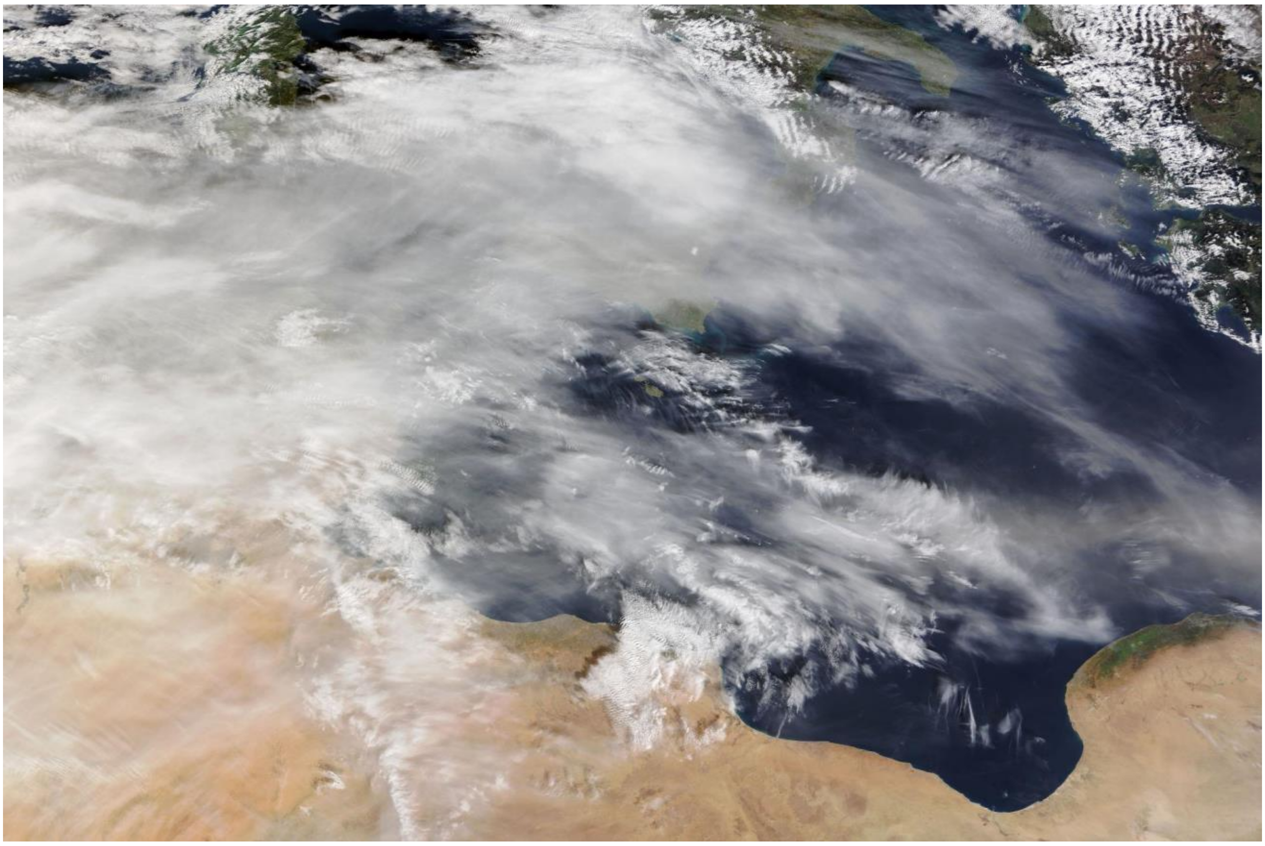

Figure A.2.1: Satellite image of the episode on 19.01.2024.

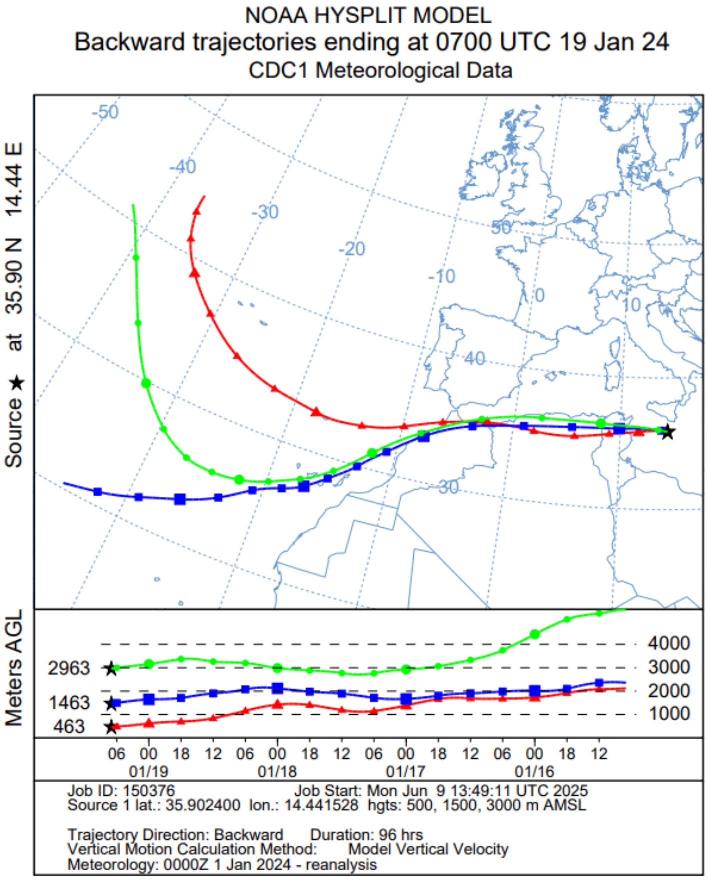

Figure A.2.2: Hysplit back trajectories for the episode on 19.01.2024 (0800h UTC+1).

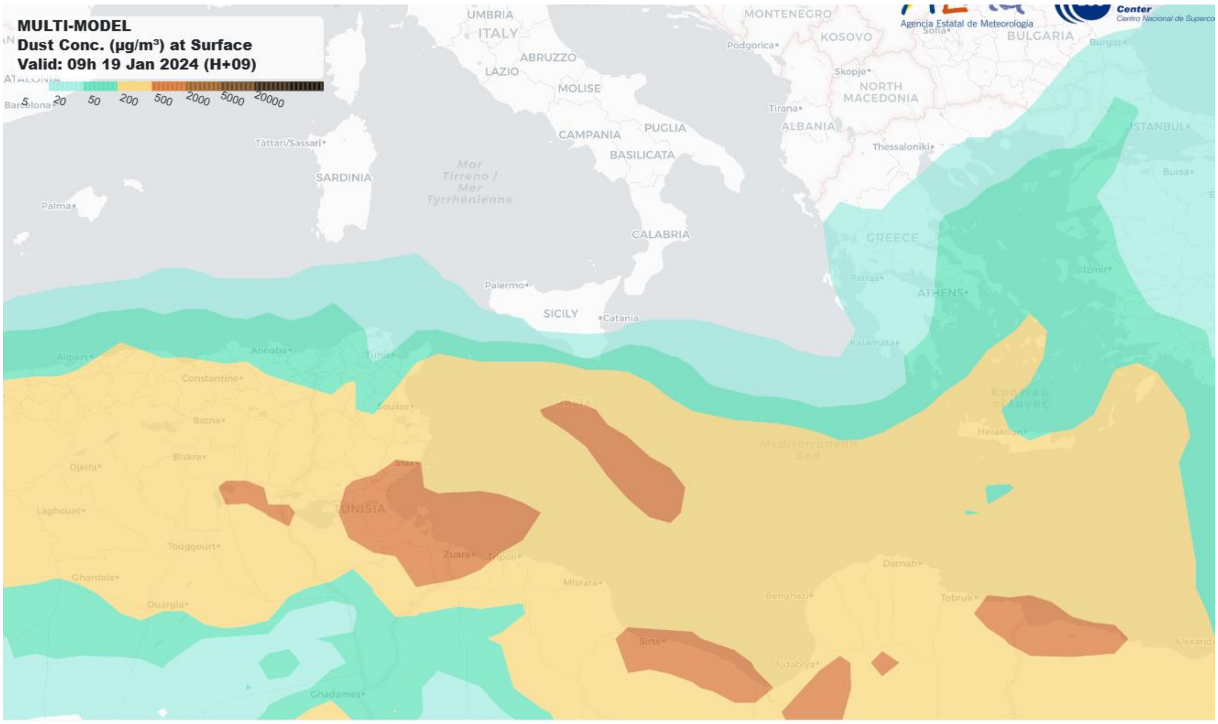

Figure A.2.3: PM_{10} levels forecasted by the ensemble model on 19.01.2024.

3rd Episode on the 26th March, 2024

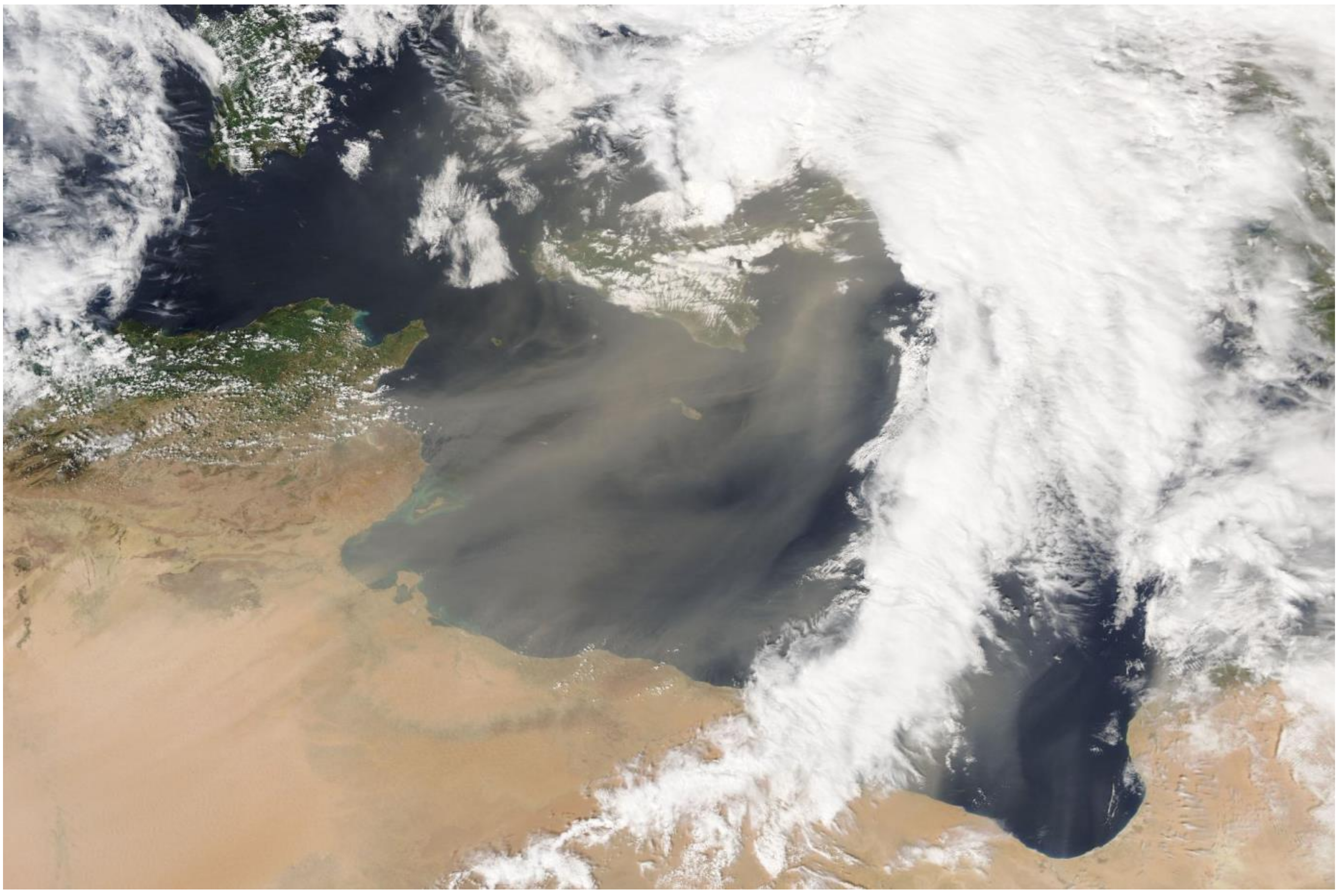

Figure A.3.1: Satellite image of the episode on 26.03.2024.

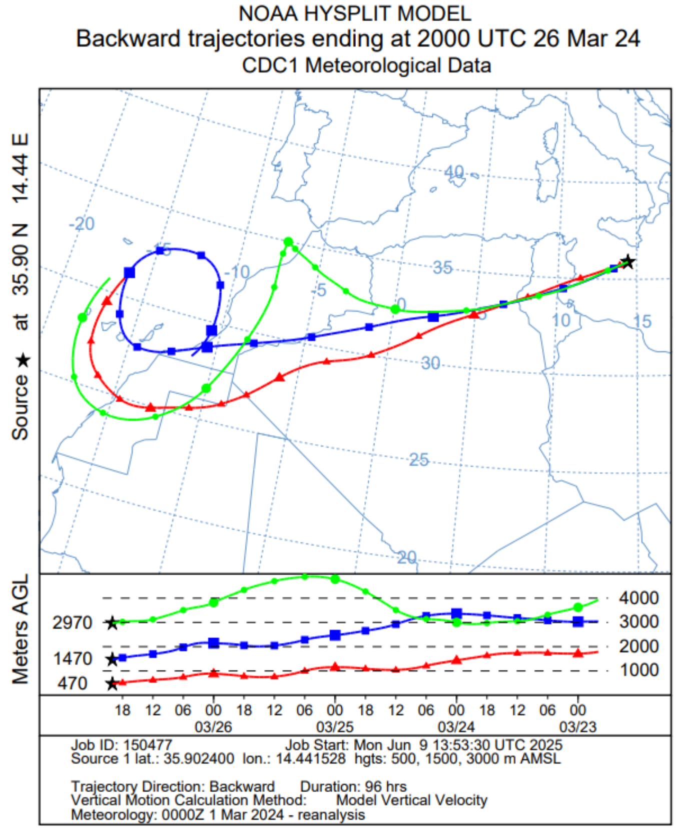

Figure A.3.2: Hysplit back trajectories for the episode on 26.03.2024 (2100h UTC+1).

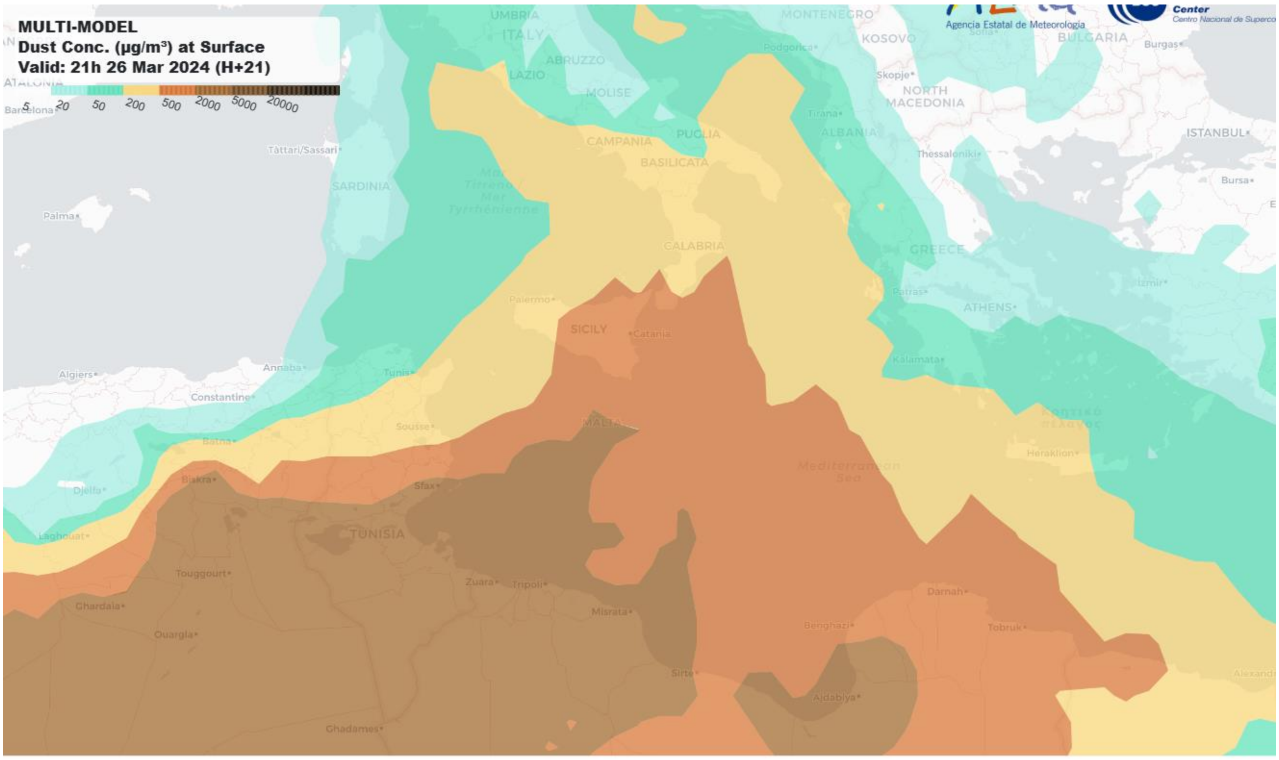

Figure A.3.3: PM_{10} levels forecasted by the ensemble model on 26.03.2024.

4th Episode on the 27th March, 2024.

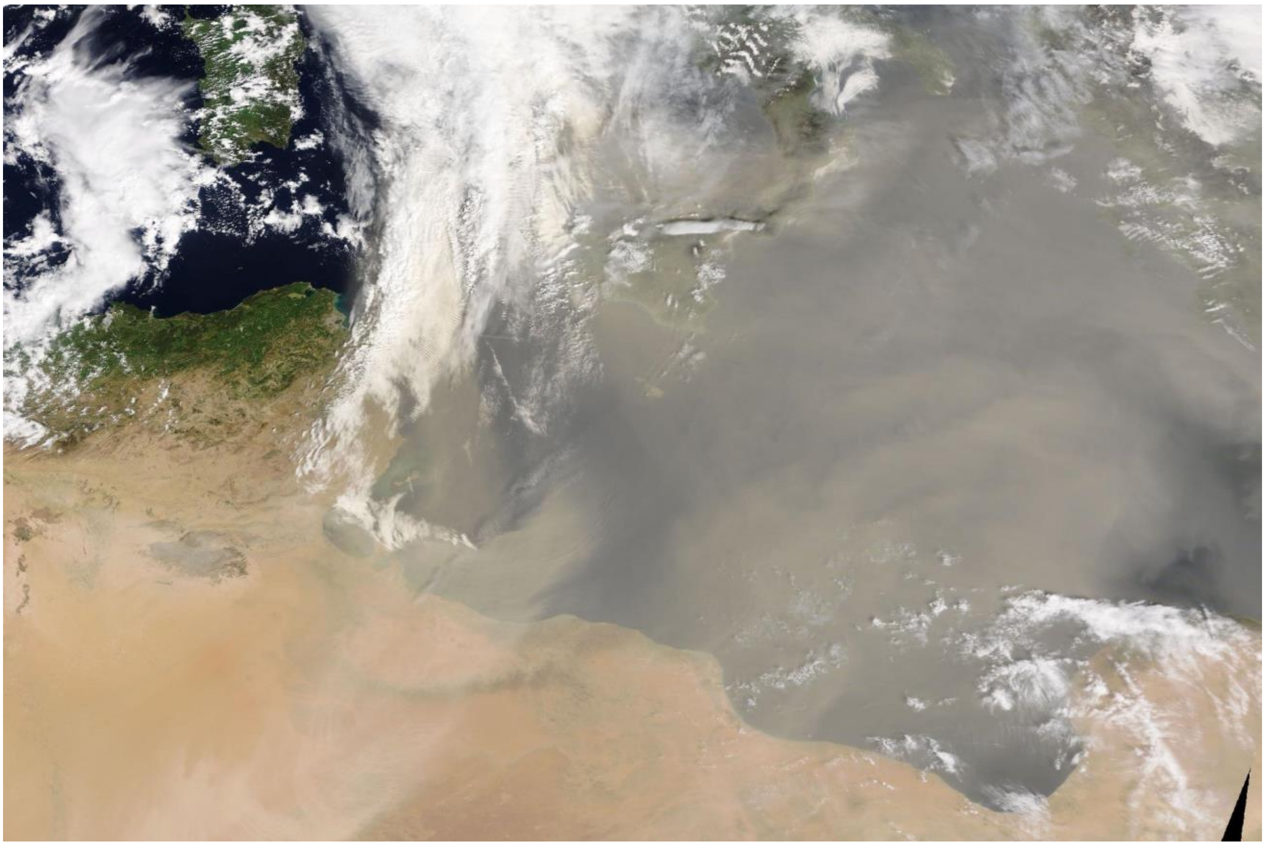

Figure A.4.1: Satellite image of the episode on 27.03.2024.

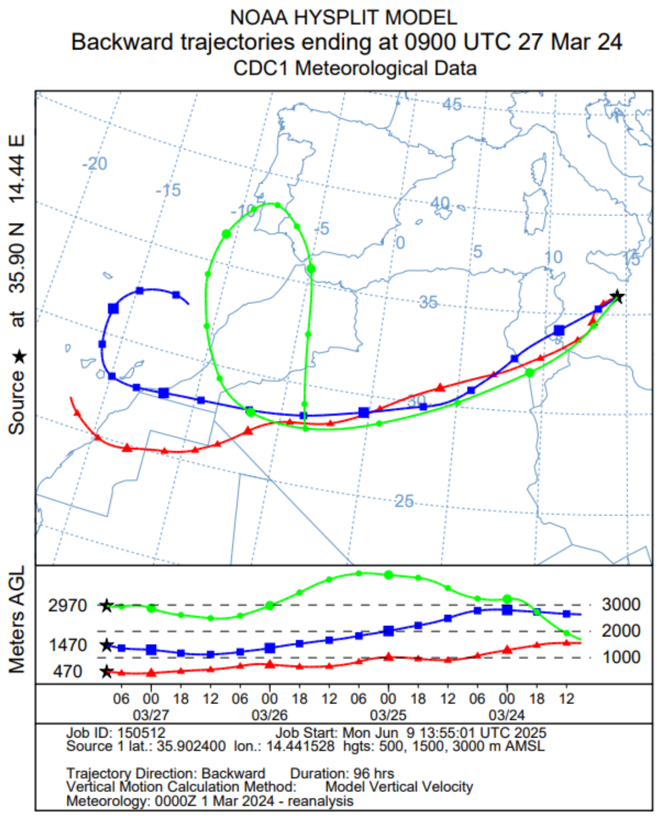

Figure A.4.2: Hysplit back trajectories for the episode on 27.03.2024 (1000h UTC+1).

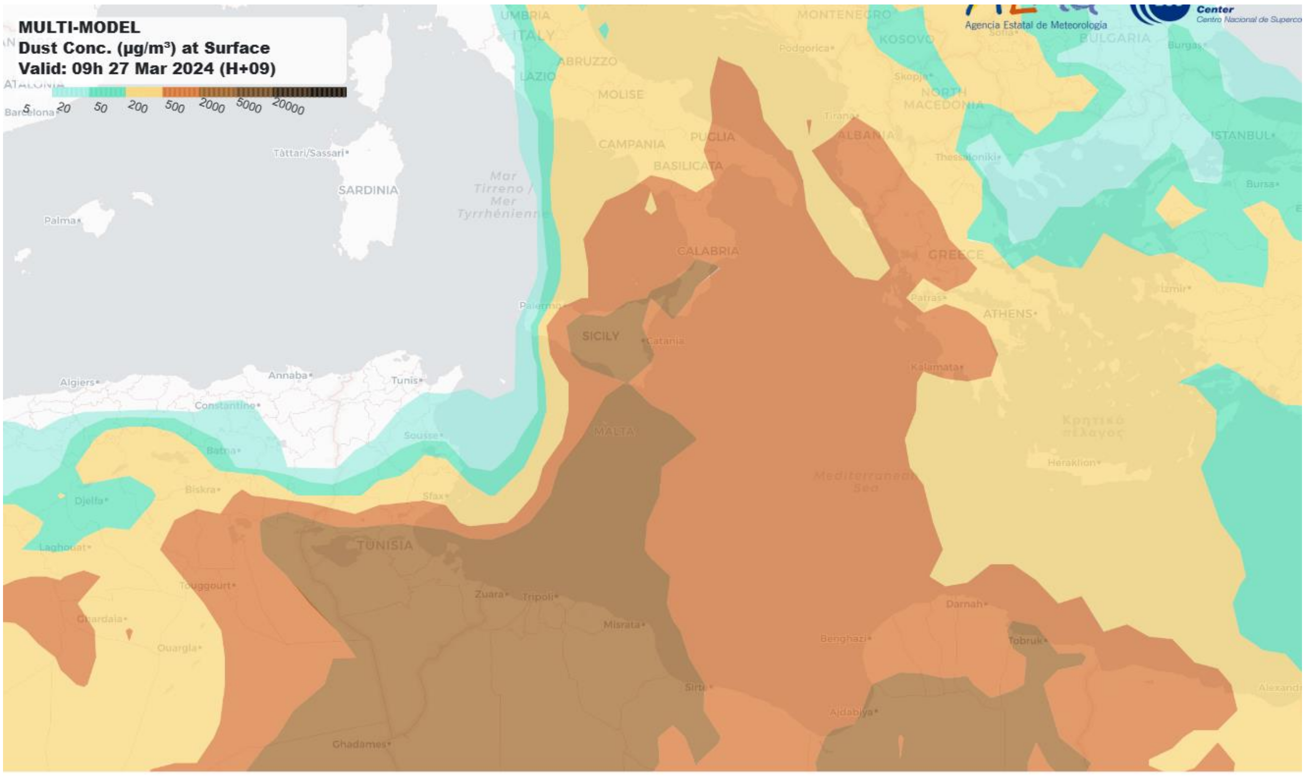

Figure A.4.3: PM_{10} levels forecasted by the ensemble model on 27.03.2024.

5th Episode on the 28th March, 2024.

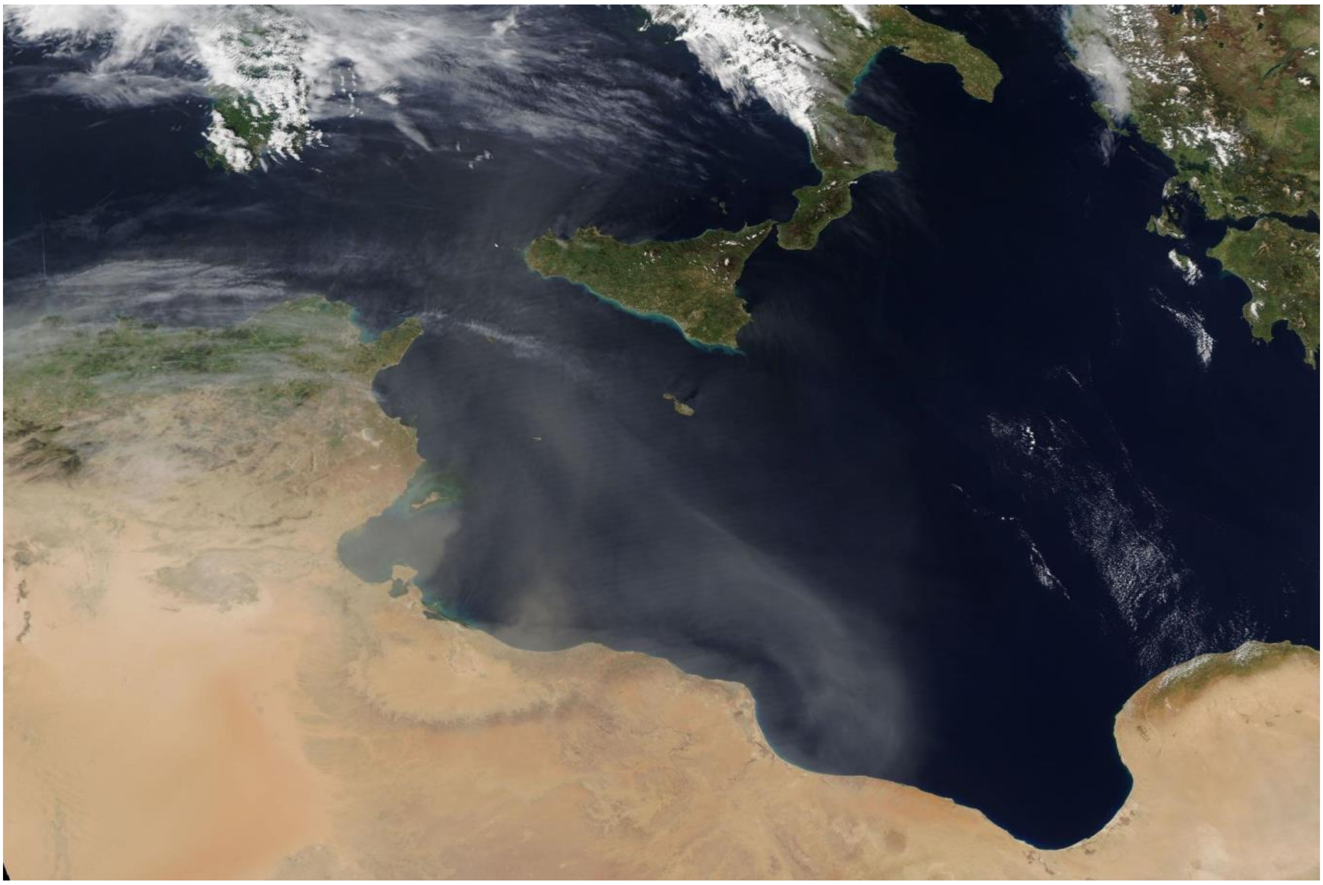

Figure A.5.1: Satellite image of the episode on 28.03.2024.

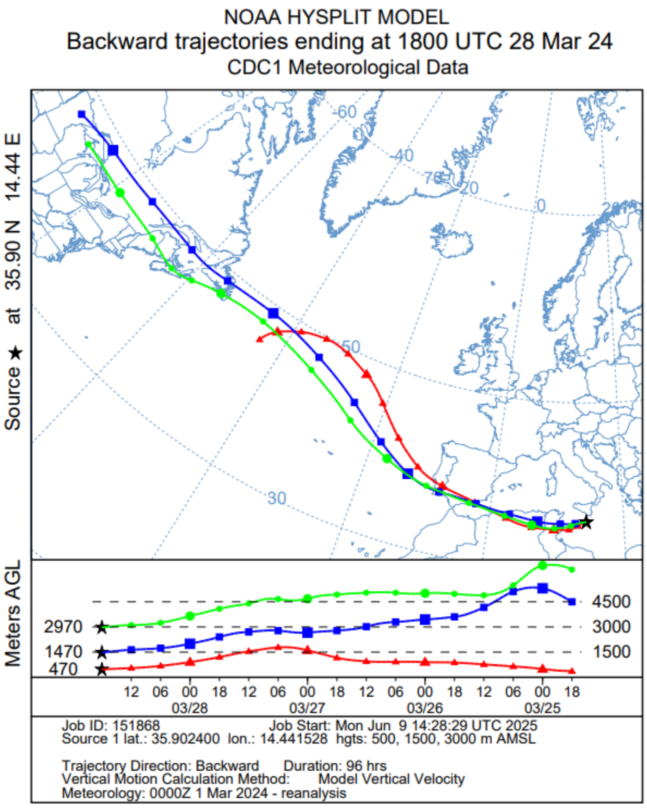

Figure A.5.2: Hysplit back trajectories for the episode on 28.03.2024 (1900h UTC+1).

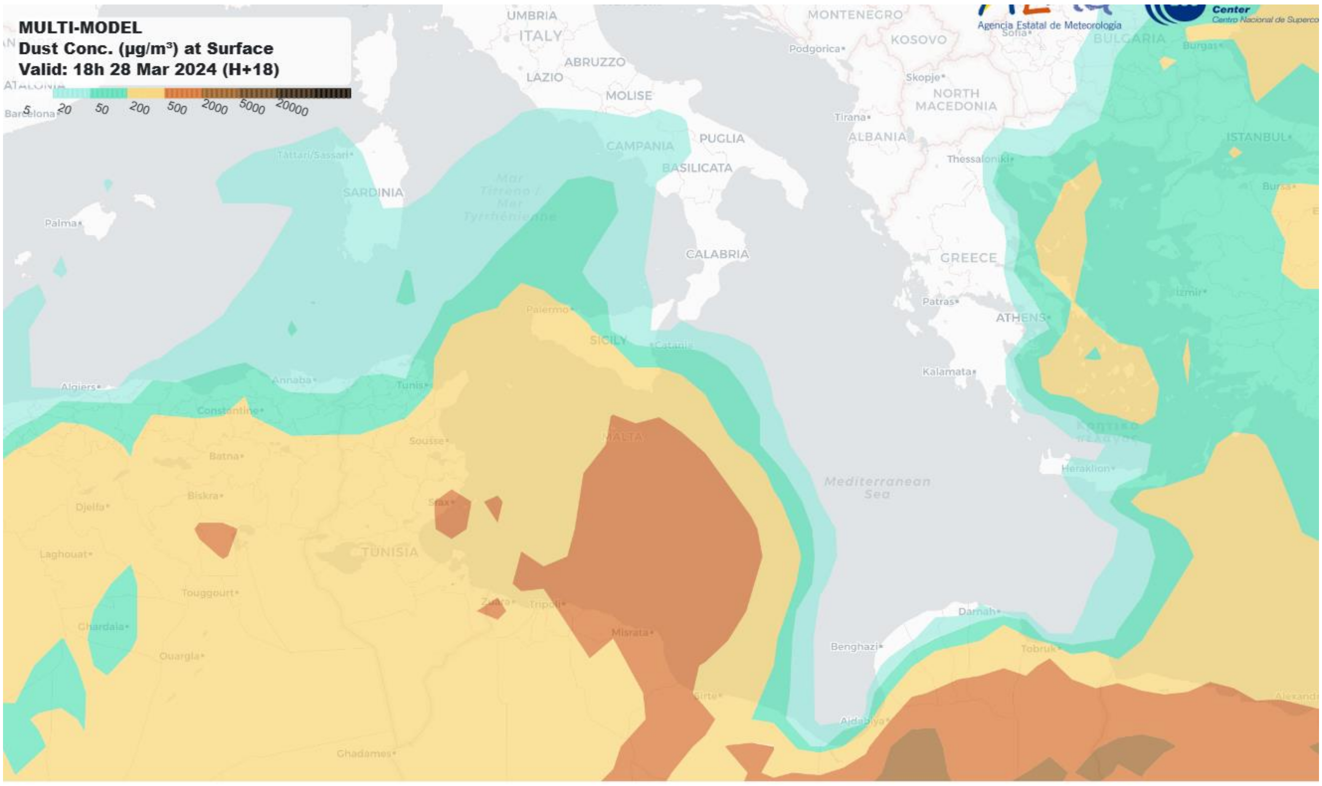

Figure A.5.3: PM_{10} levels forecasted by the ensemble model on 28.03.2024.

6th Episode on the 29th March, 2024.

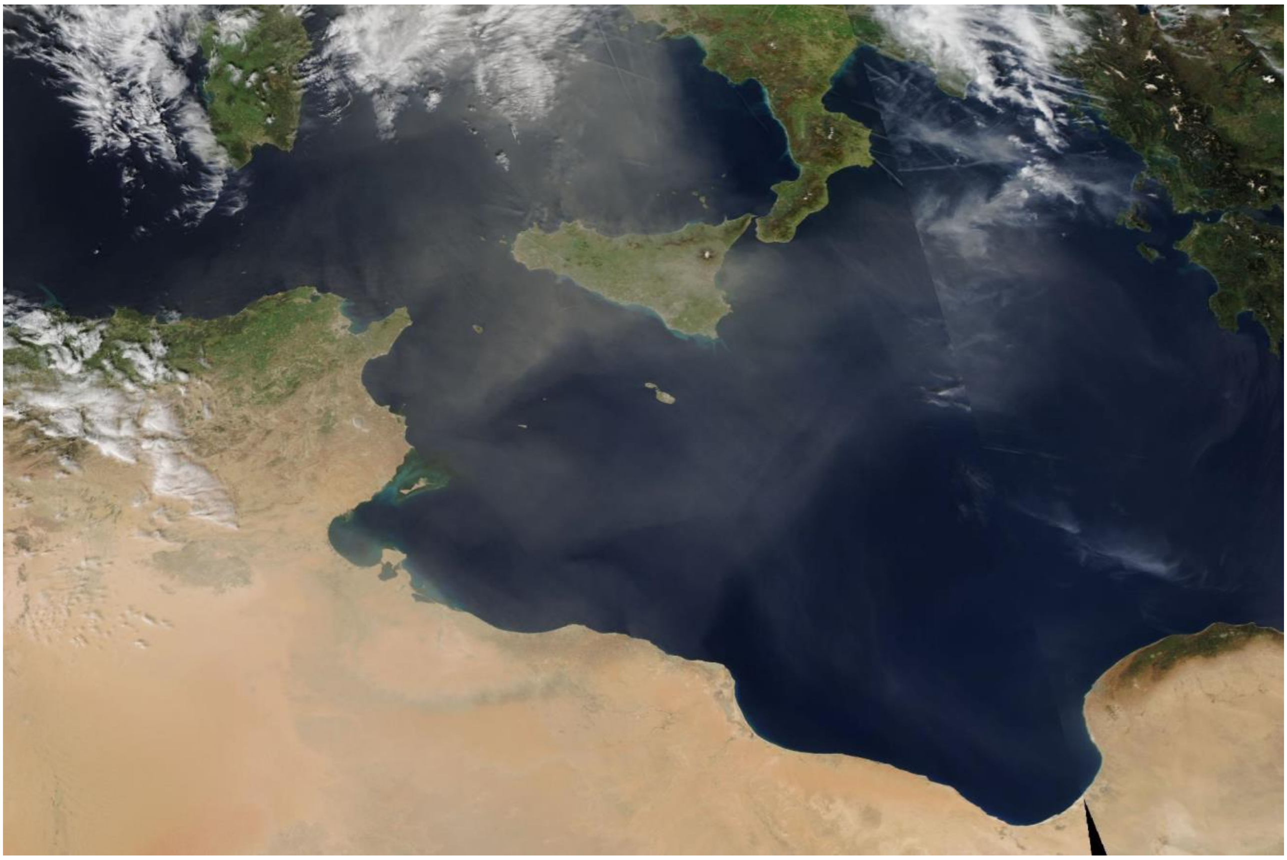

Figure A.6.1: Satellite image of the episode on 29.03.2024.

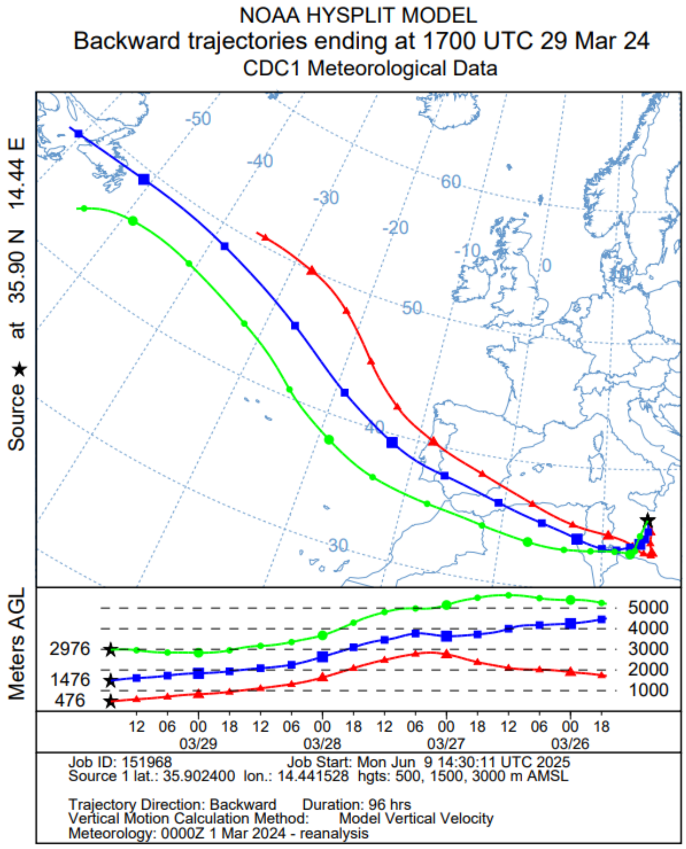

Figure A.6.2: Hysplit back trajectories for the episode on 29.03.2024 (1800h UTC+1).

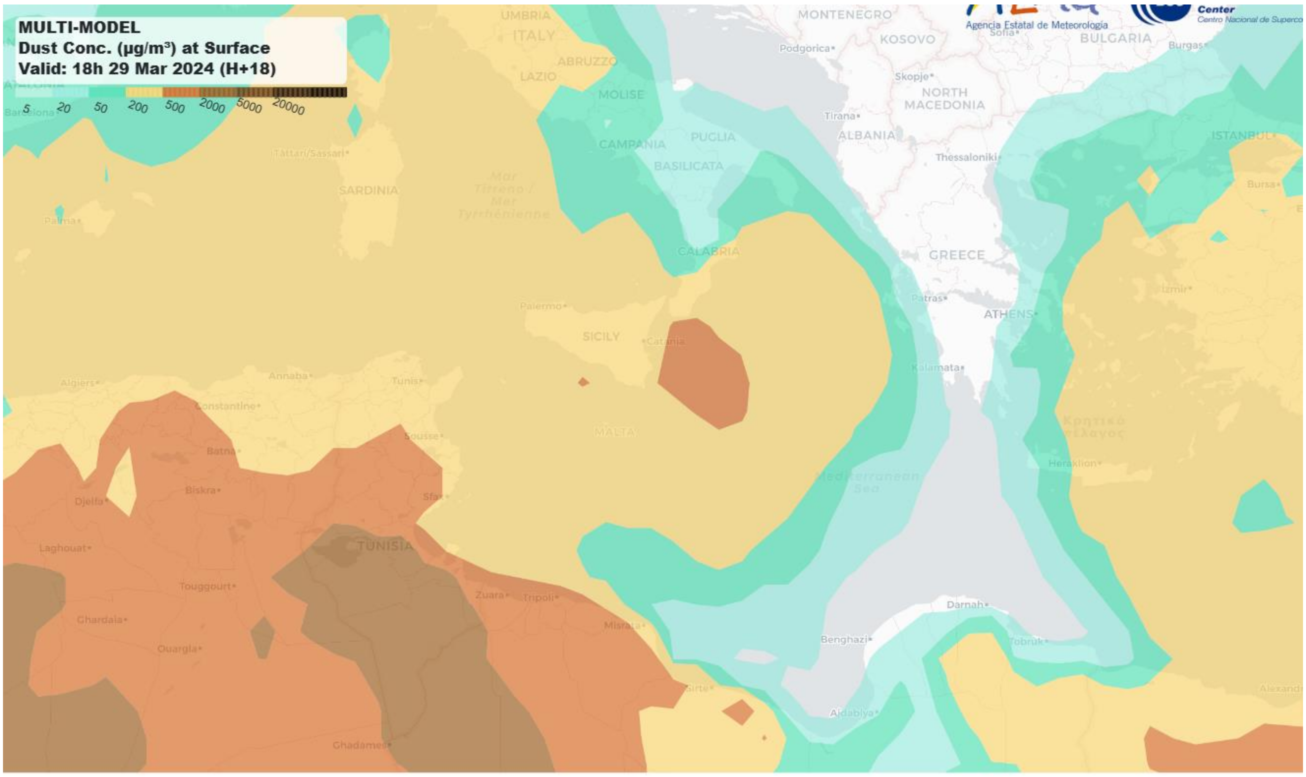

Figure A.6.3: PM_{10} levels forecasted by the ensemble model on 29.03.2024

7th Episode on the 30th March, 2024.

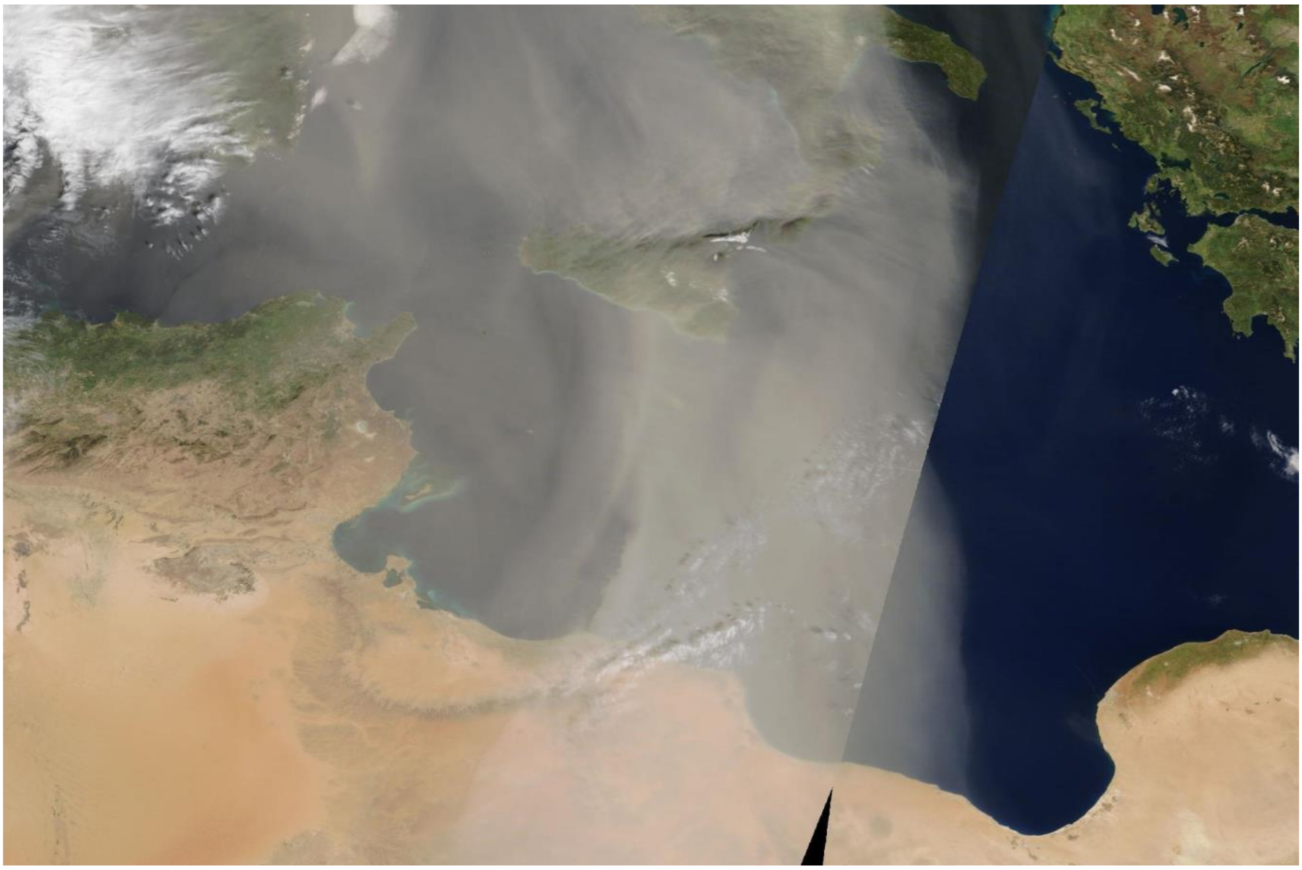

Figure A.7.1: Satellite image of the episode on 30.03.2024.

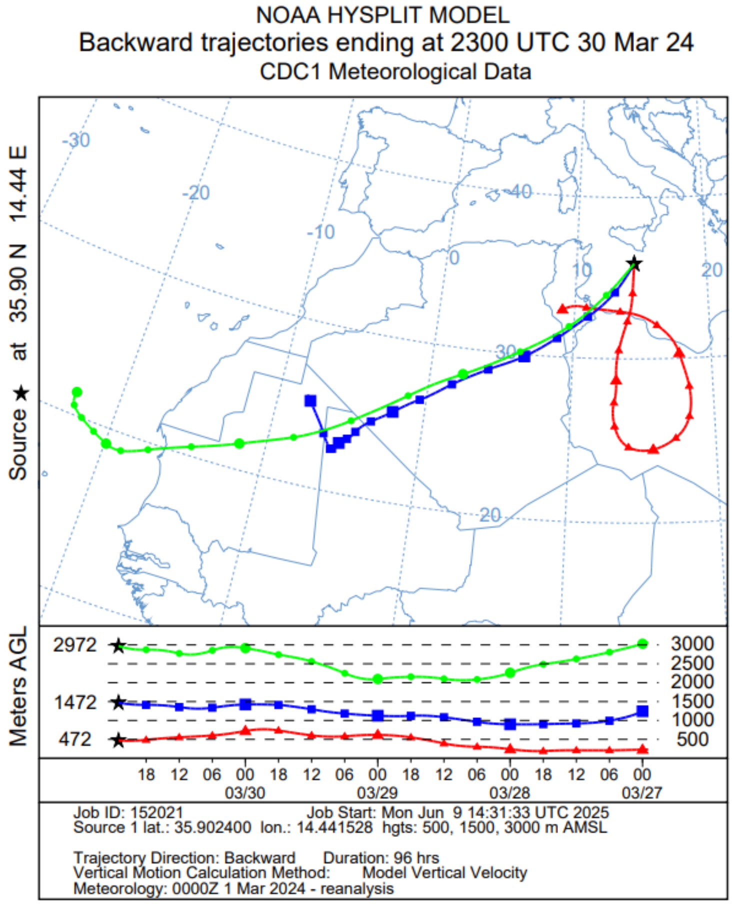

Figure A.7.2: Hysplit back trajectories for the episode on 30.03.2024 (0000h UTC+1).

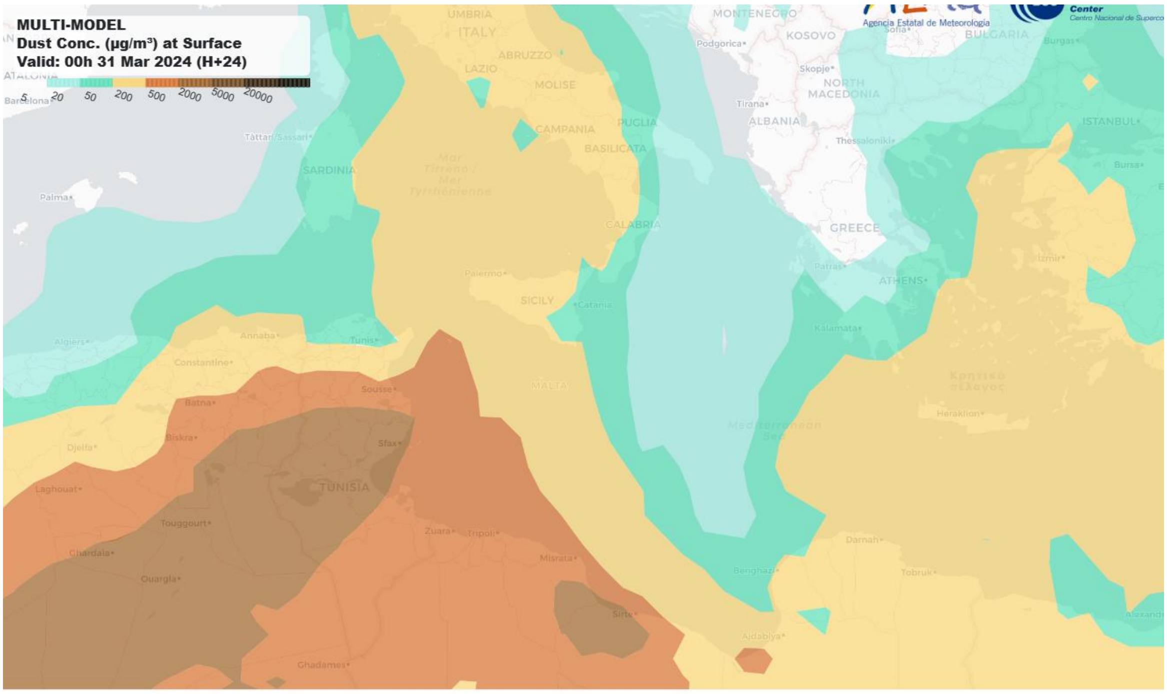

Figure A.7.3: PM_{10} levels forecasted by the ensemble model on 30.03.2024.

8th Episode on the 31st March, 2024.

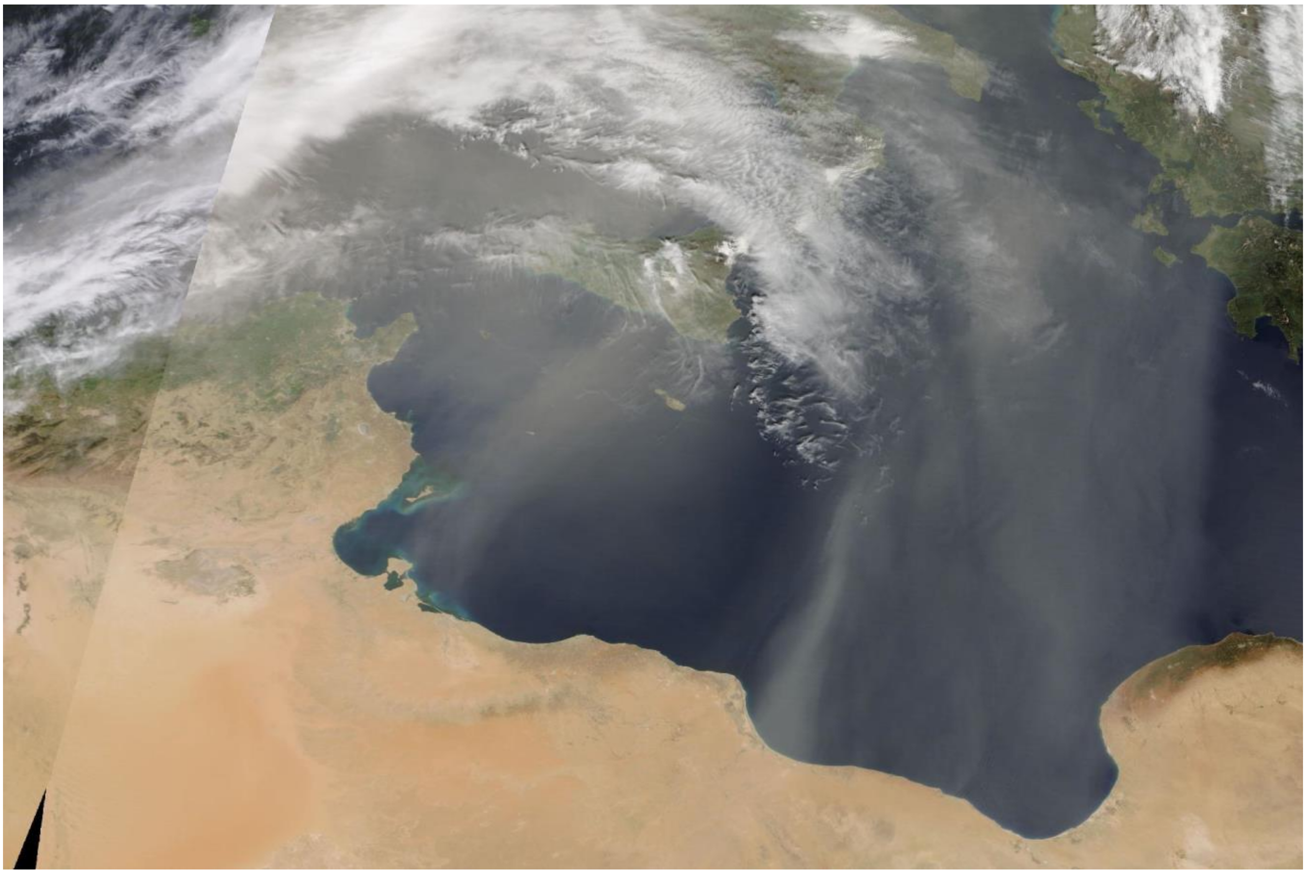

Figure A.8.1: Satellite image of the episode on 31.03.2024.

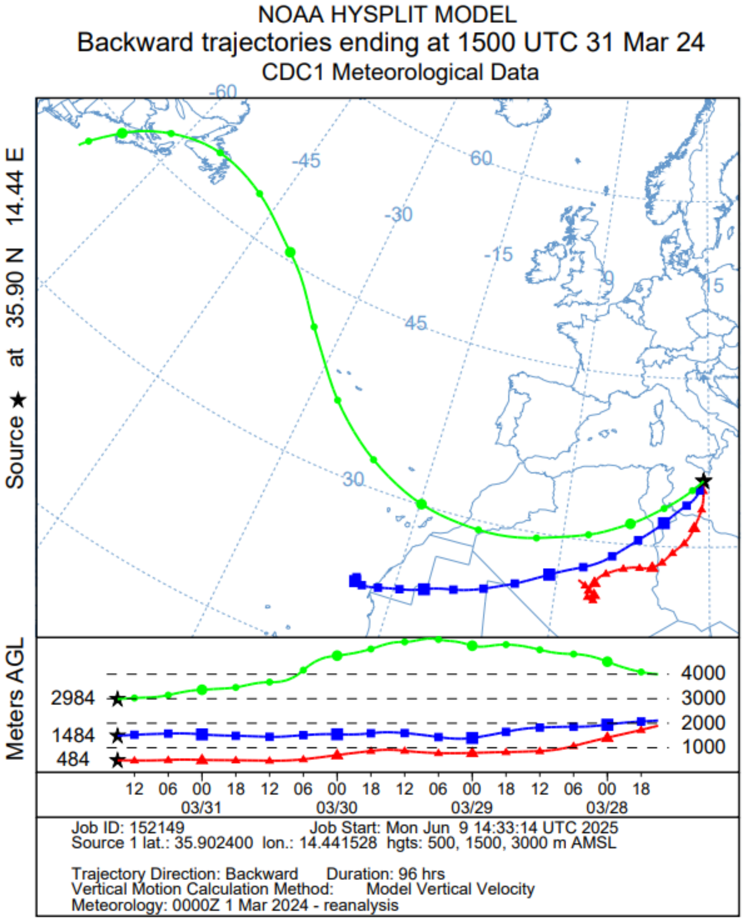

Figure A.8.2: Hysplit back trajectories for the episode on 31.03.2024 (1600h UTC+2).

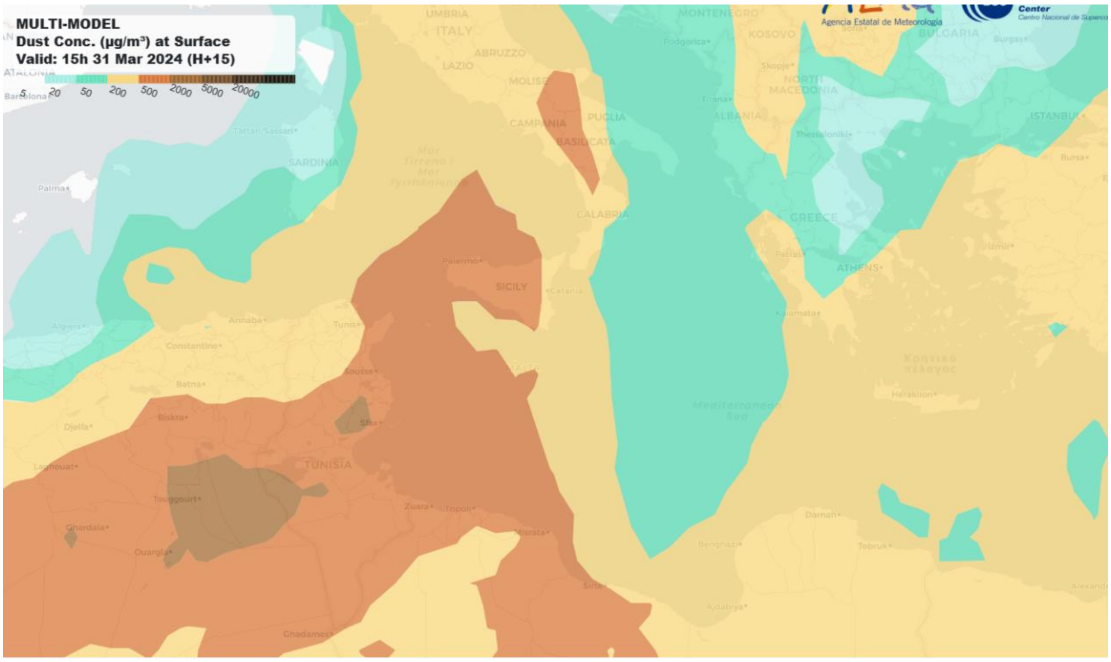

Figure A.8.3: PM_{10} levels forecasted by the ensemble model on 31.03.2024.

9th Episode on the 1st April, 2024.

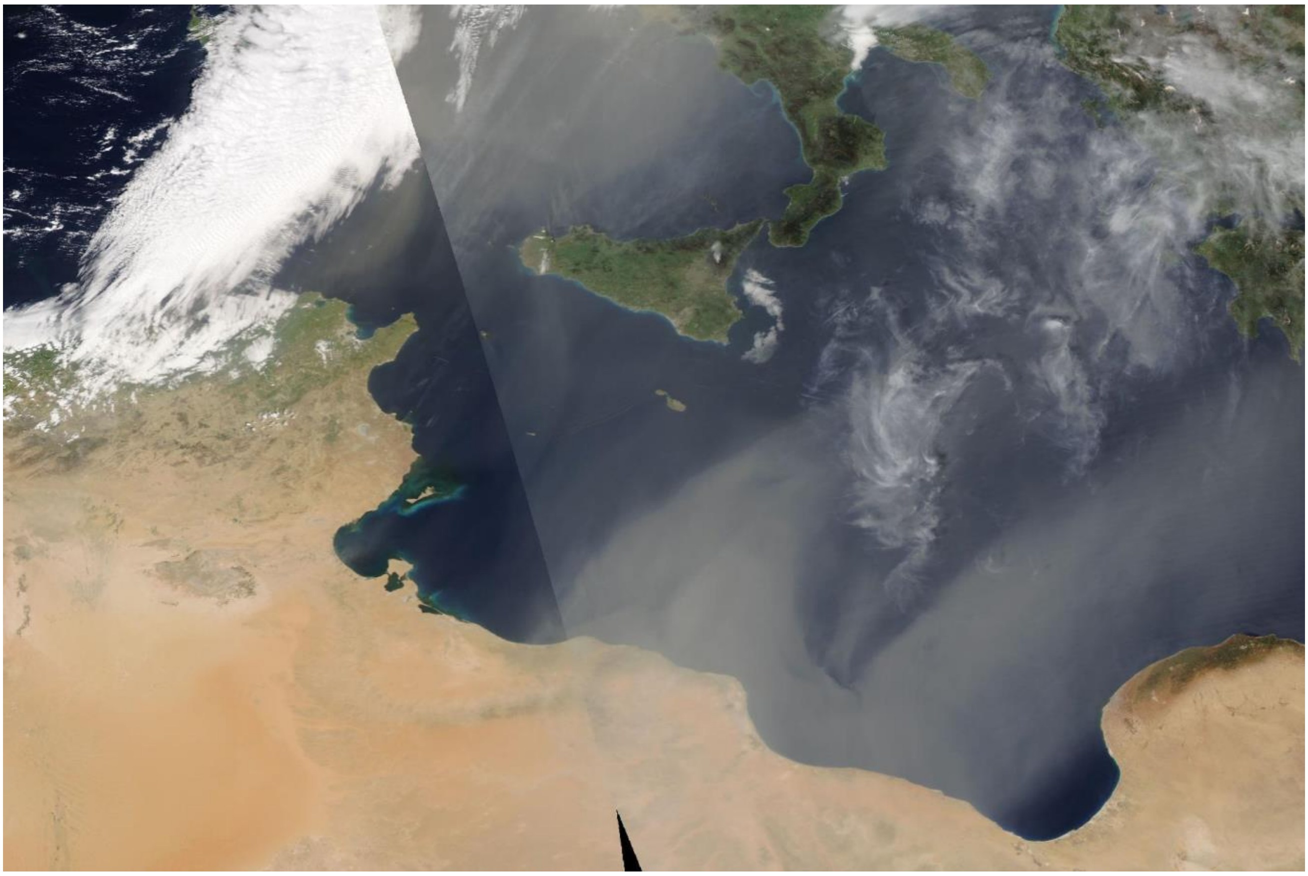

Figure A.9.1: Satellite image of the episode on 01.04.2024.

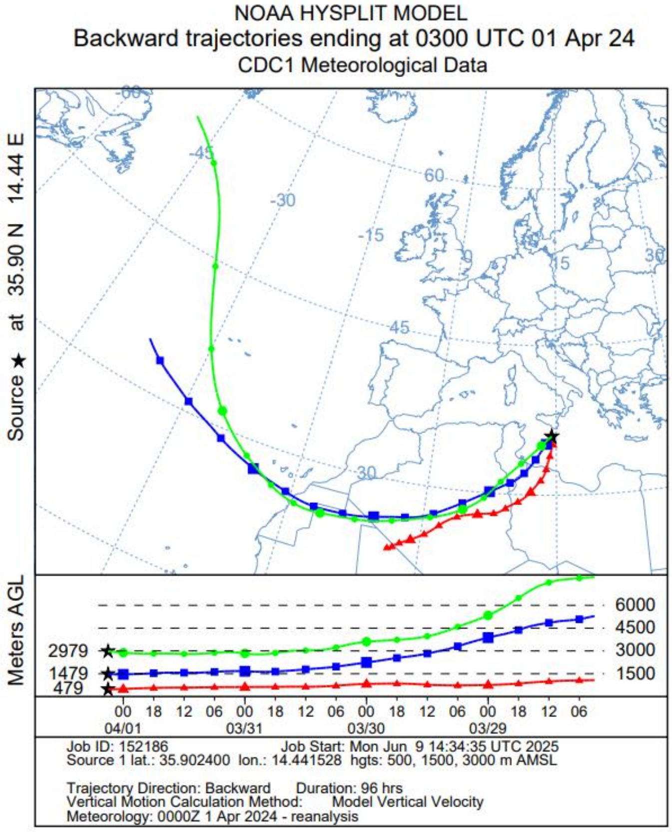

Figure A.9.2: Hysplit back trajectories for the episode on 01.04.2024 (0400h UTC+2).

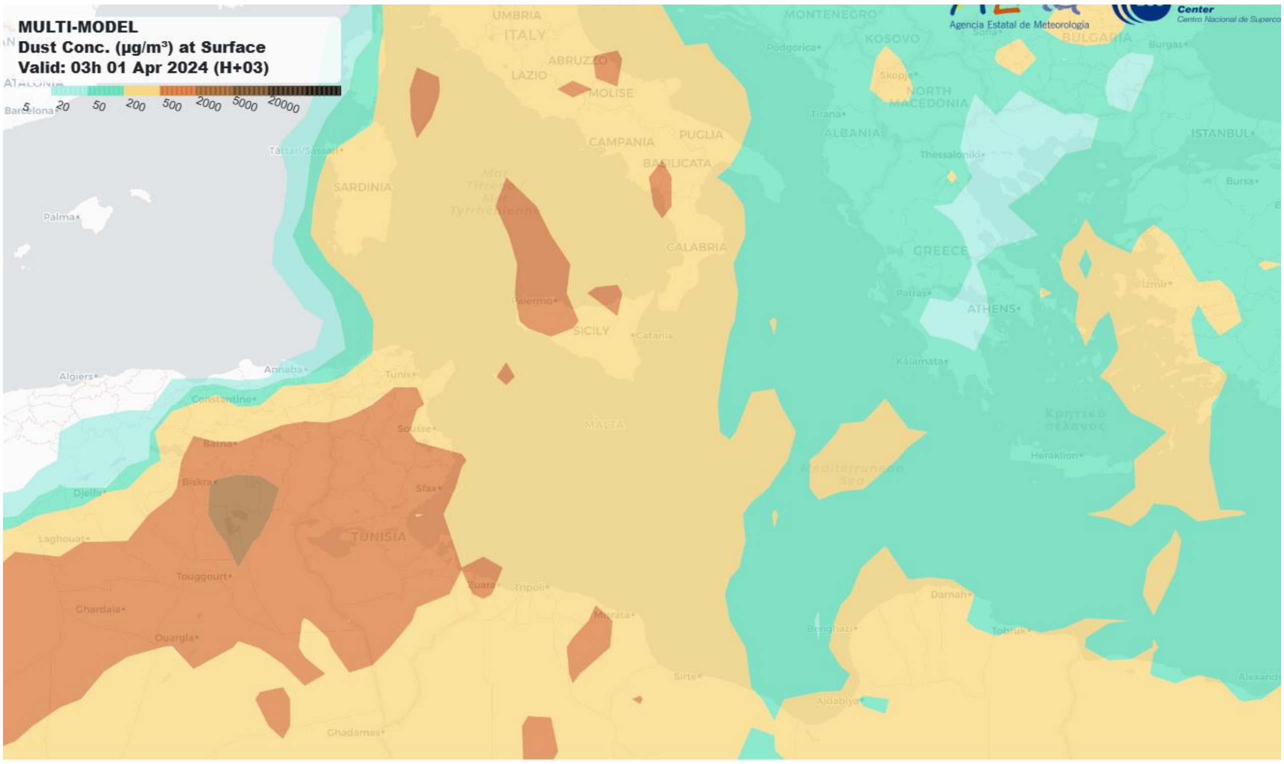

Figure A.9.3: PM_{10} levels forecasted by the ensemble model on 01.04.2024.

<u>10th Episode on the 16th May, 2024.</u>

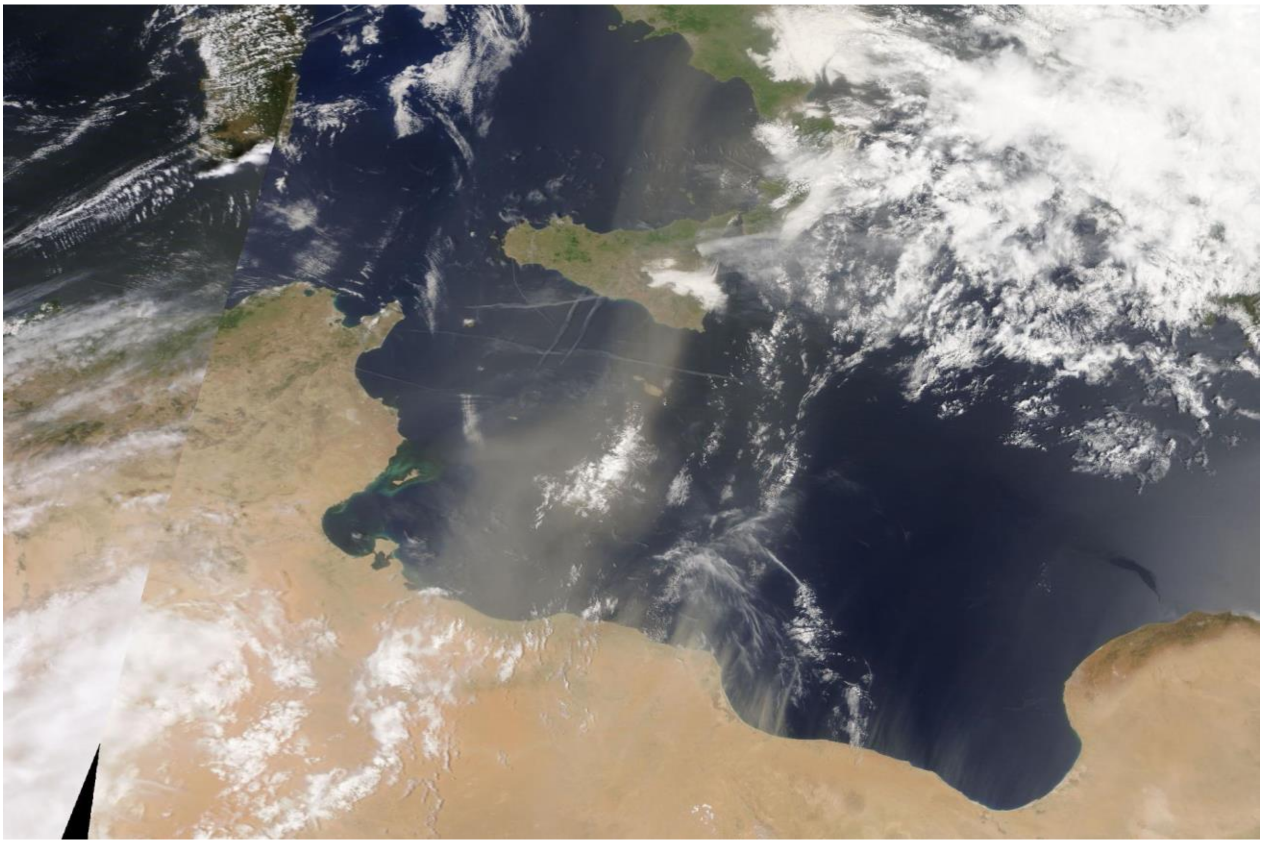

Figure A.10.1: Satellite image of the episode on 16.05.2024.

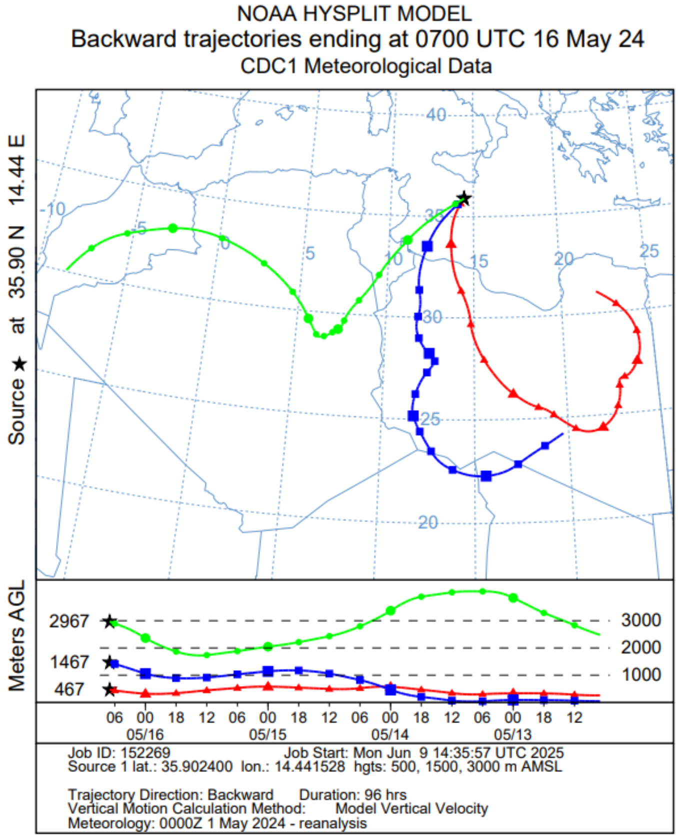

Figure A.10.2: Hysplit back trajectories for the episode on 16.05.2024 (0800h UTC+2).

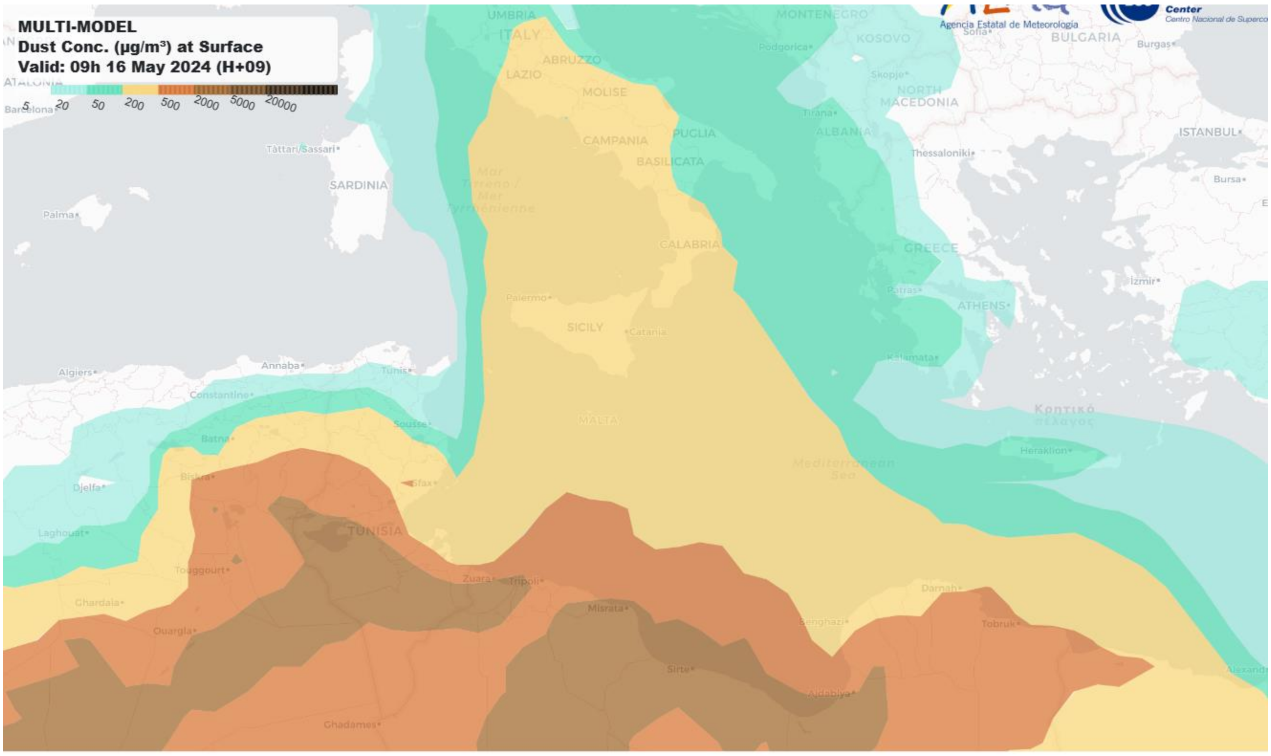

Figure A.10.3: PM_{10} levels forecasted by the ensemble model on 16.05.2024.

11th Episode on the 17th May, 2024.

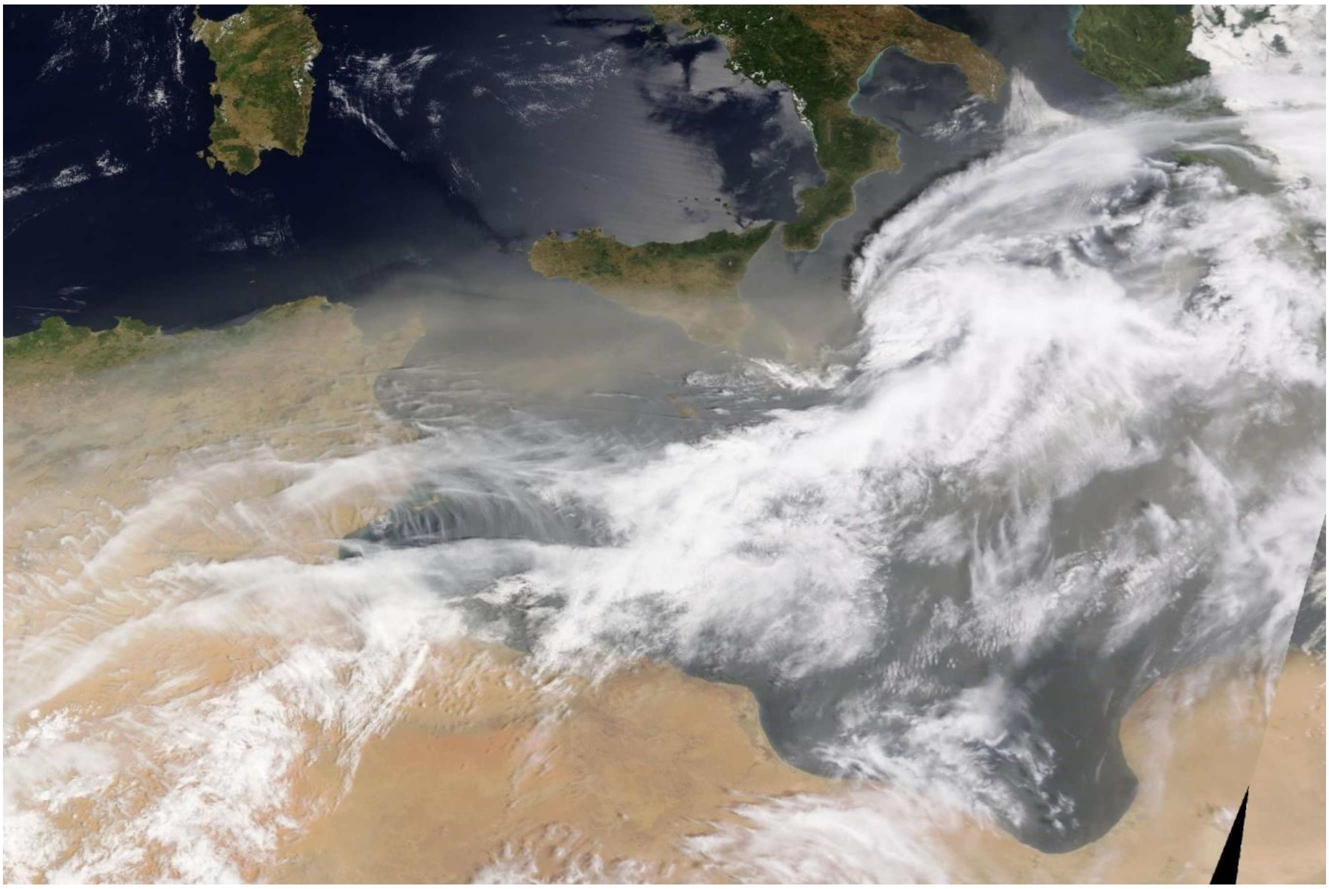

Figure A.11.1: Satellite image of the episode on 17.05.2024.

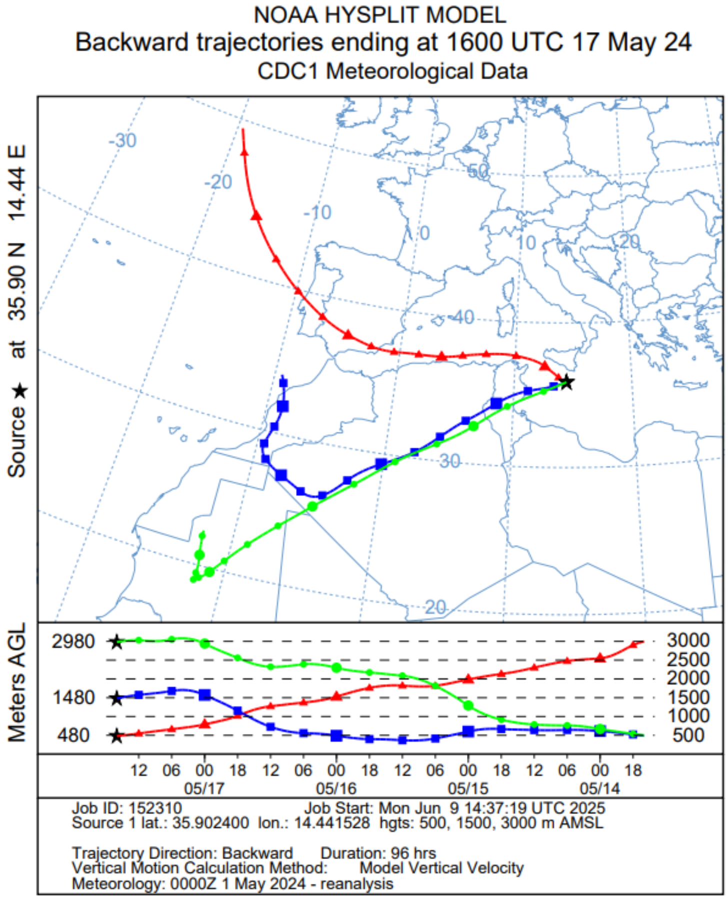

Figure A.11.2: Hysplit back trajectories for the episode on 17.05.2024 (1700h UTC+2).

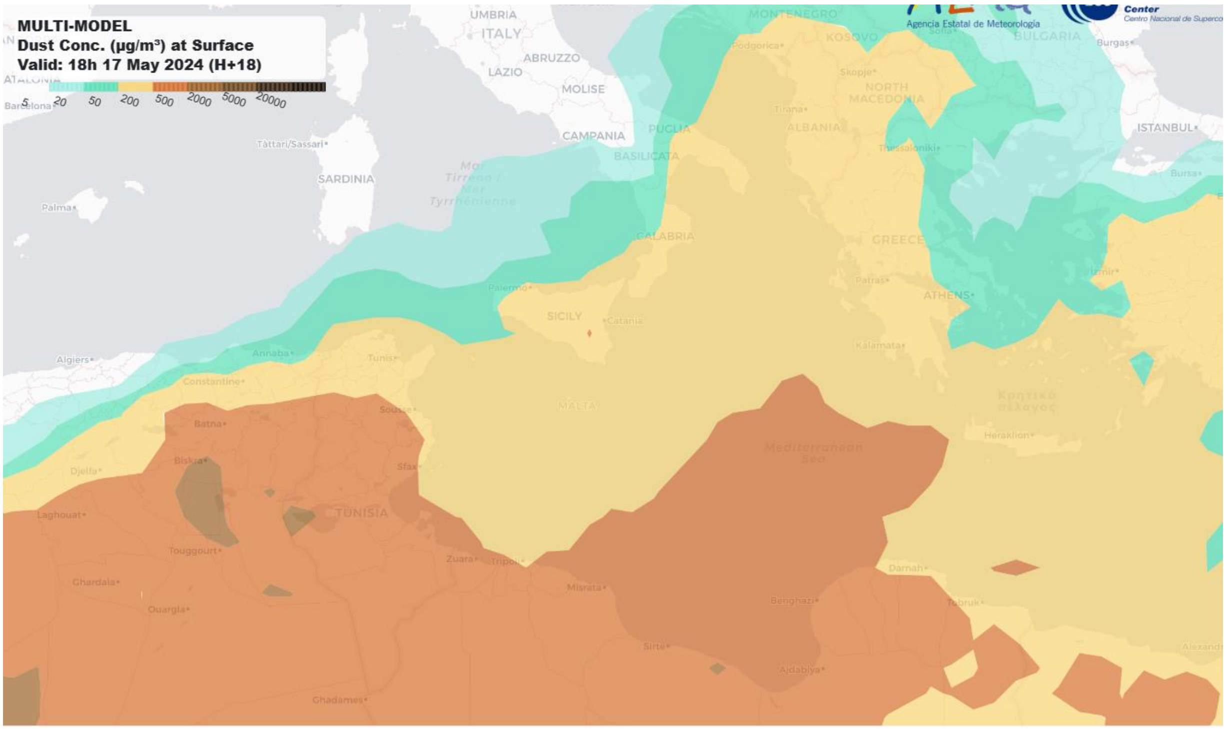

Figure A.11.3: PM_{10} levels forecasted by the ensemble model on 17.05.2024.

12th Episode on the 18th May, 2024.

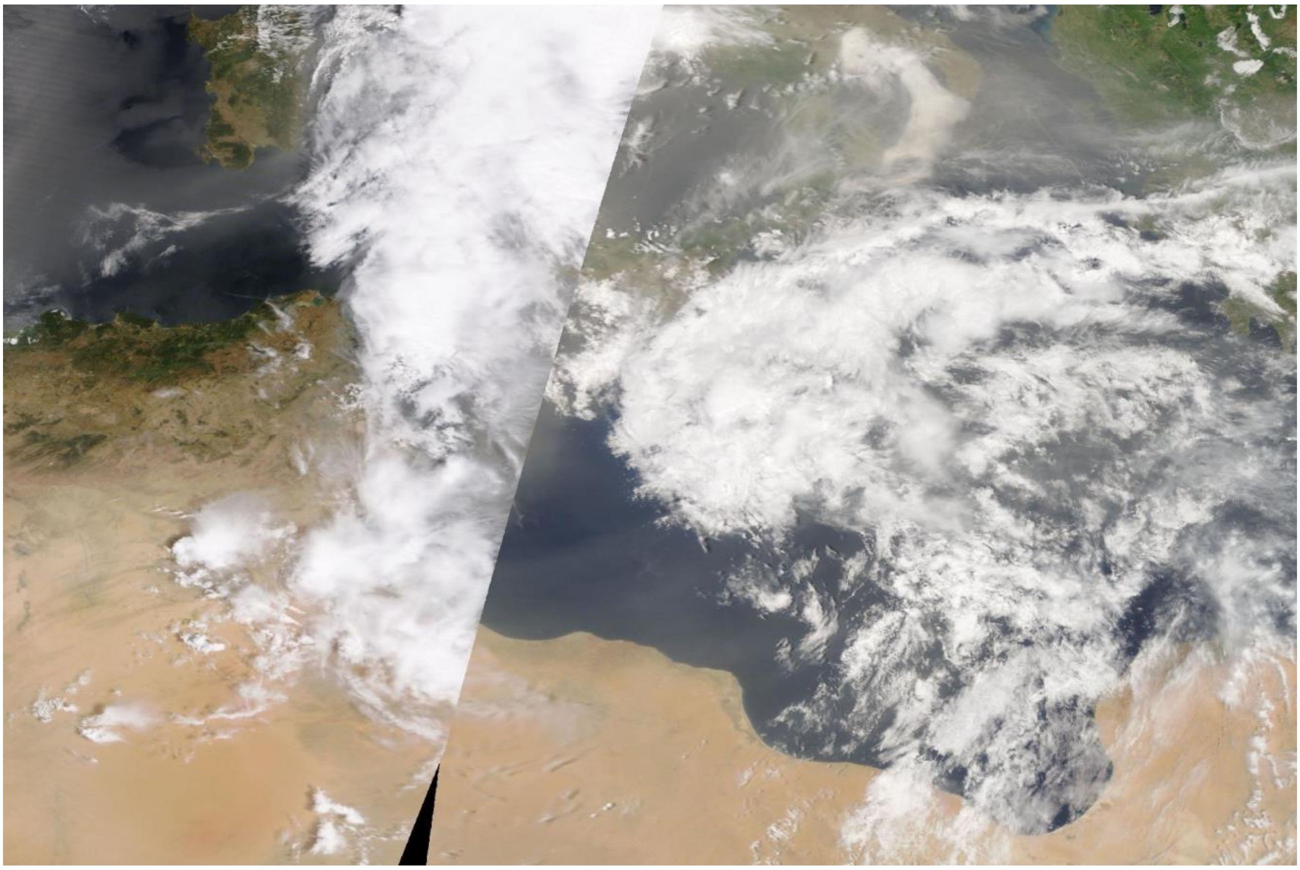

Figure A.12.1: Satellite image of the episode on 18.05.2024.

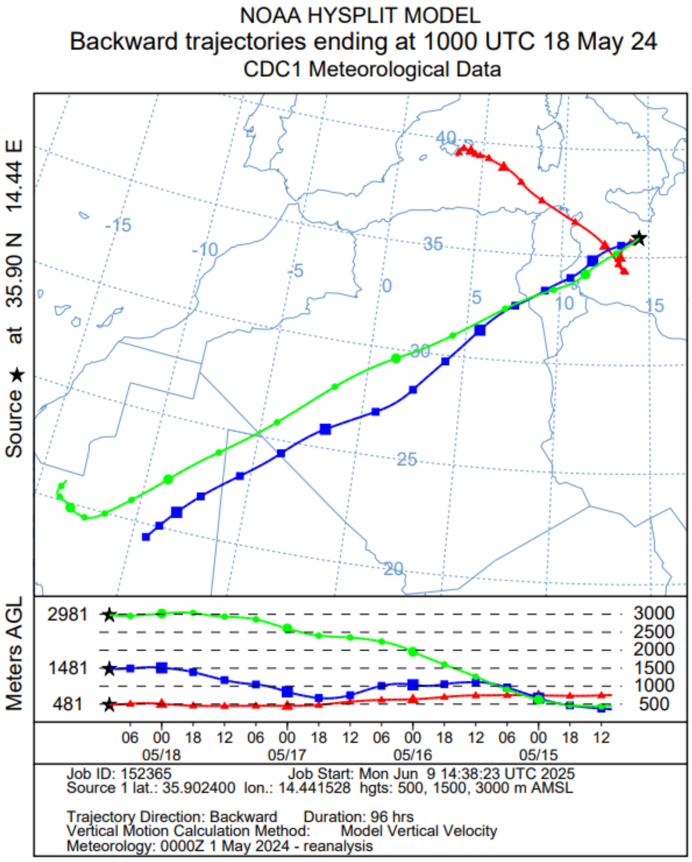

Figure A.12.2: Hysplit back trajectories for the episode on 18.05.2024 (1100h UTC+2).

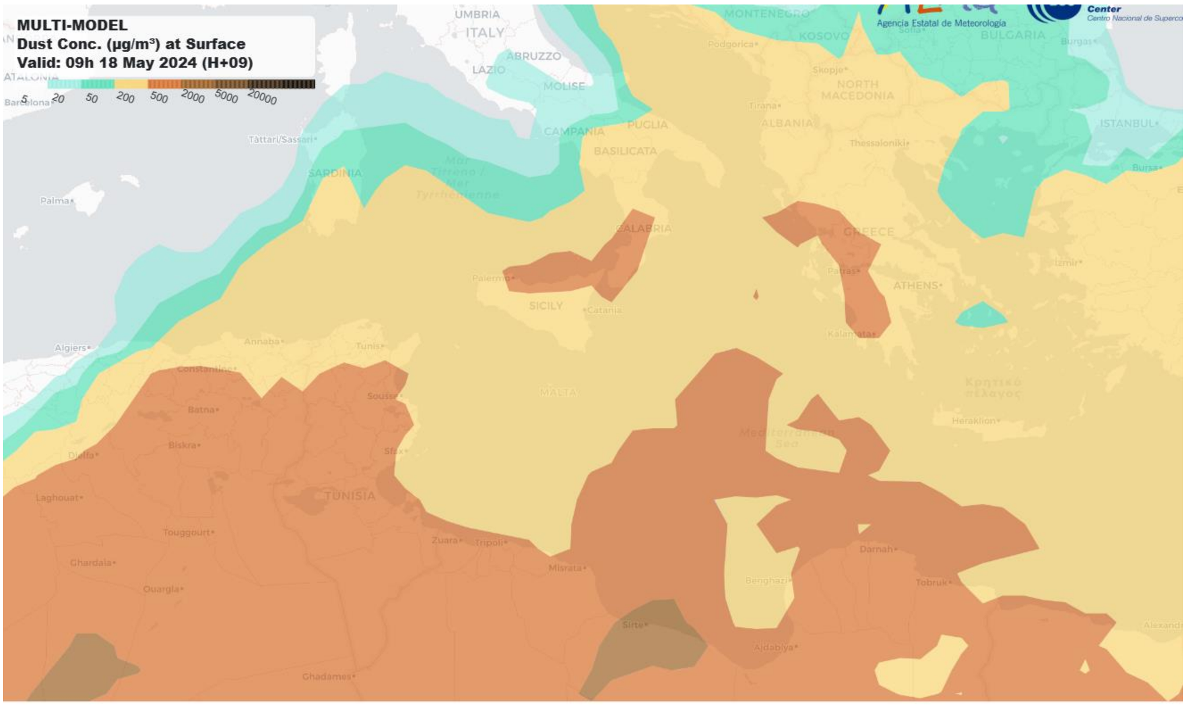

Figure A.12.3: PM_{10} levels forecasted by the ensemble model on 18.05.2024.

13th Episode on the 19th May, 2024.

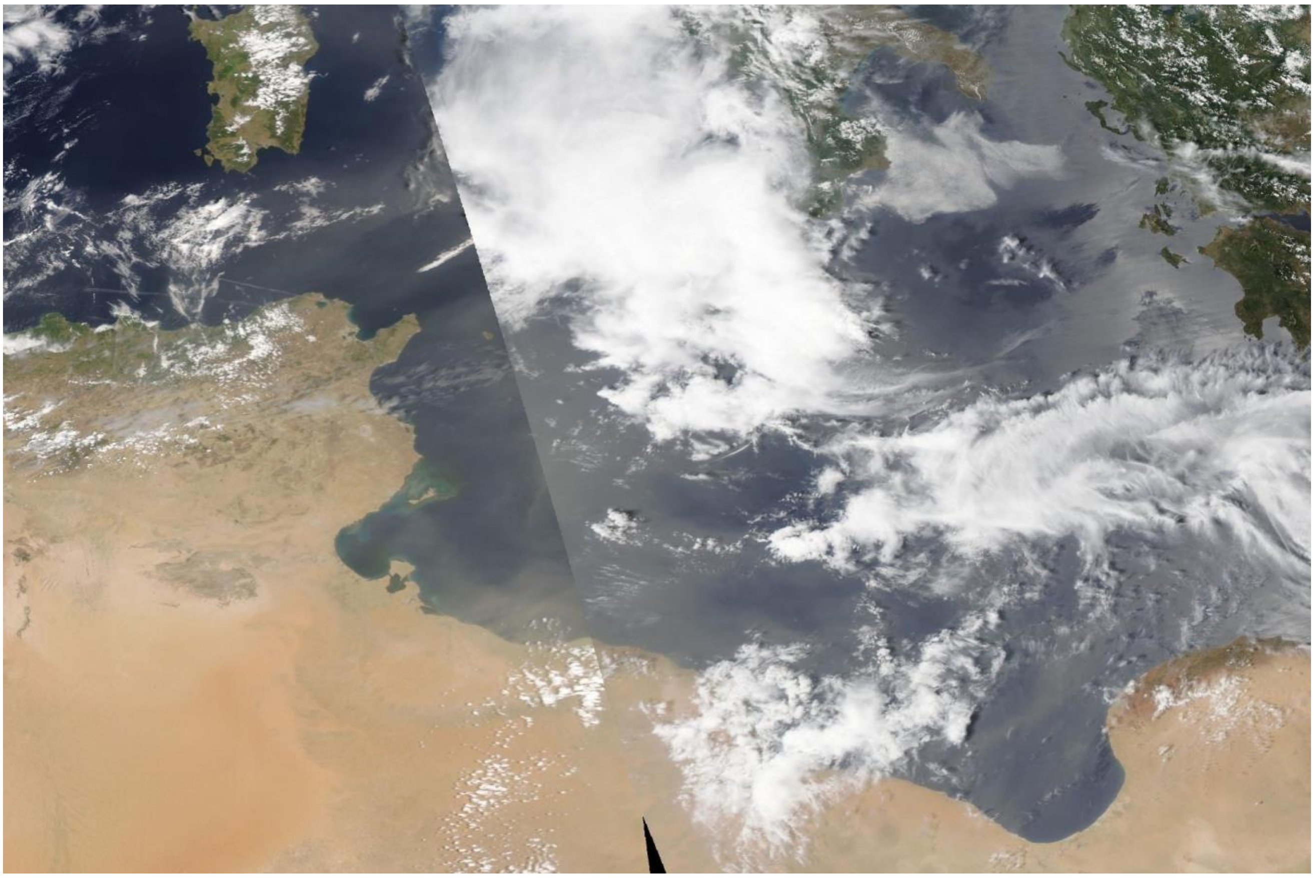

Figure A.13.1: Satellite image of the episode on 19.05.2024.

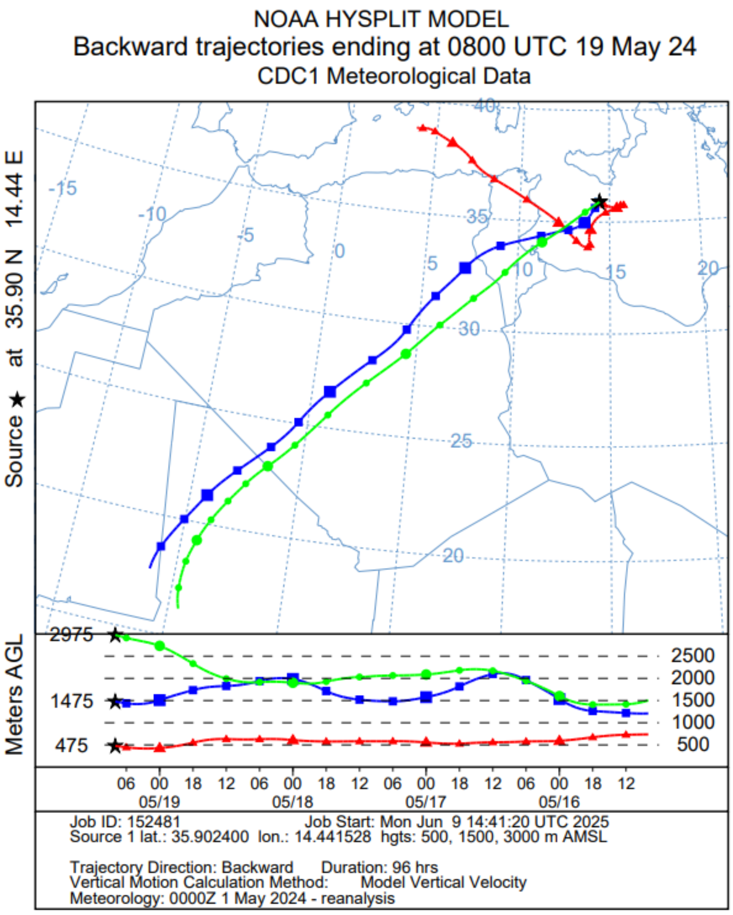

Figure A.13.2: Hysplit back trajectories for the episode on 19.05.2024 (0900h UTC+2).

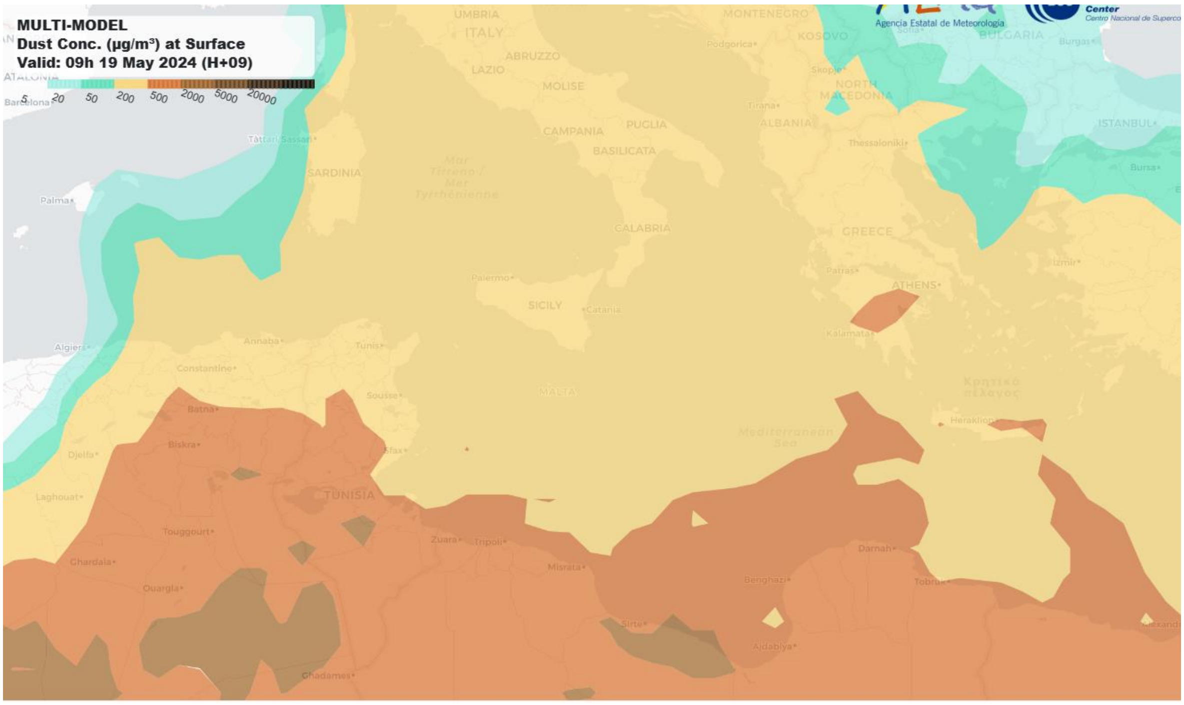

Figure A.13.3: PM_{10} levels forecasted by the ensemble model on 19.05.2024.

<u>14th Episode on the 20th May, 2024</u>

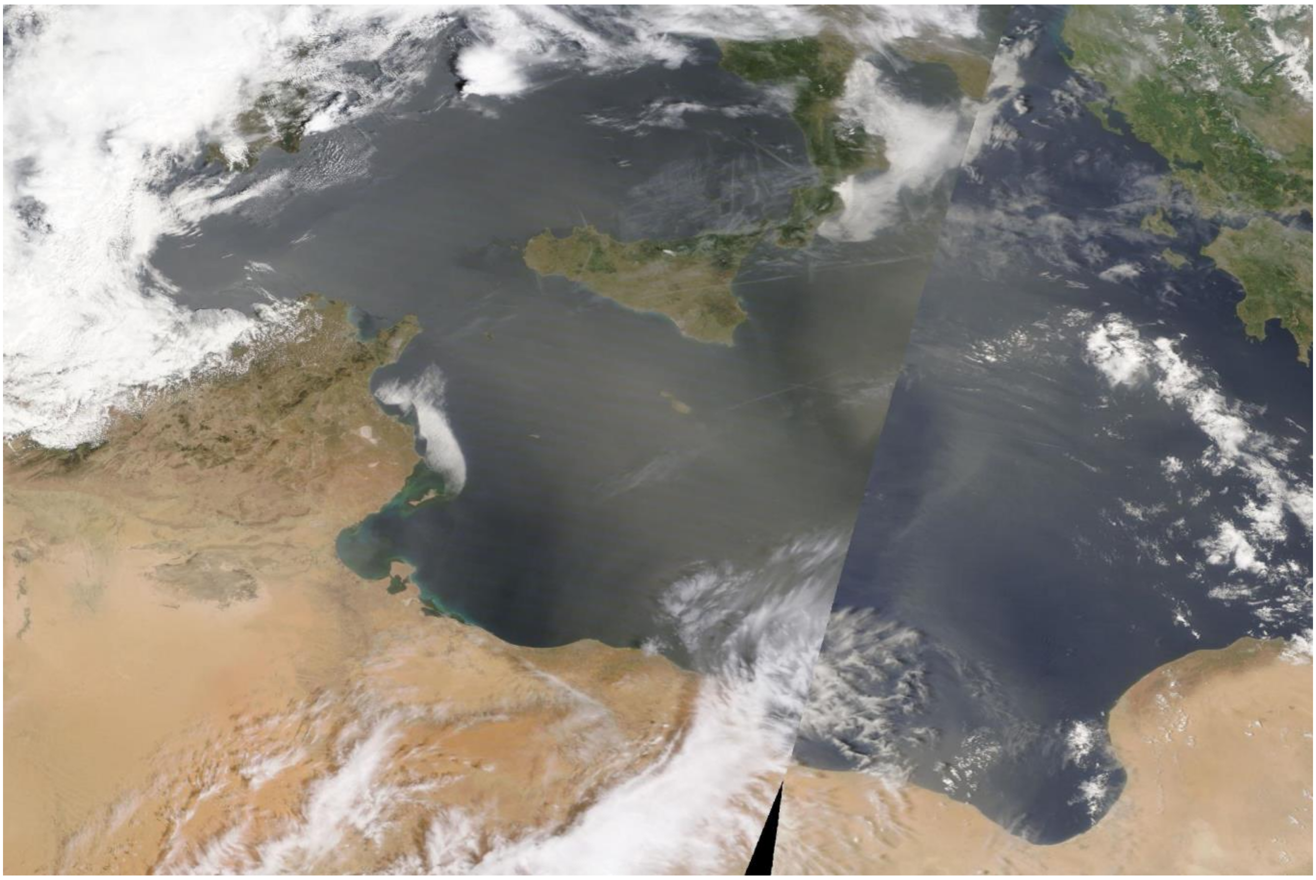

Figure A.14.1: Satellite image of the episode on 20.05.2024.

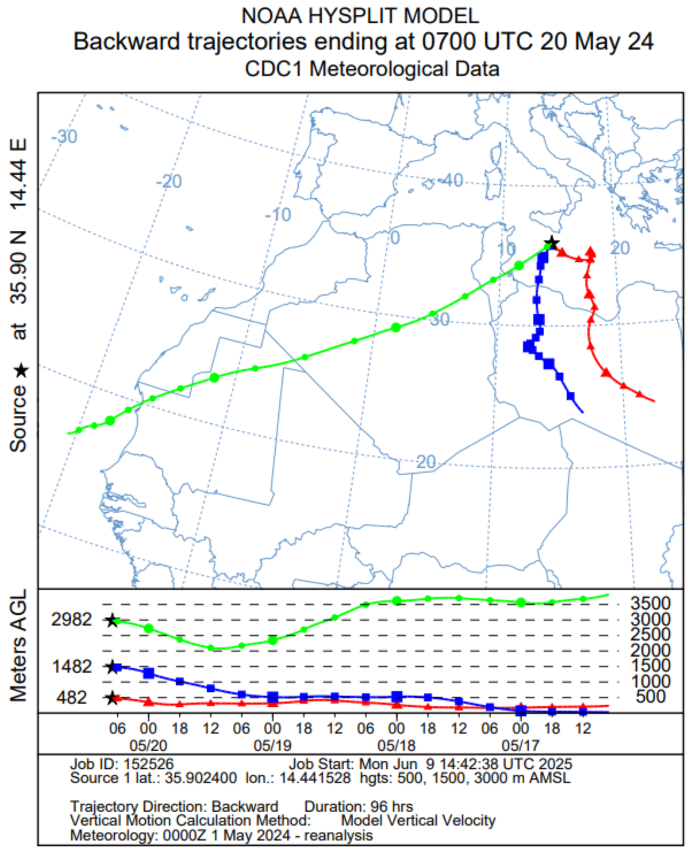

Figure A.14.2: Hysplit back trajectories for the episode on 20.05.2024 (0800h UTC+2).

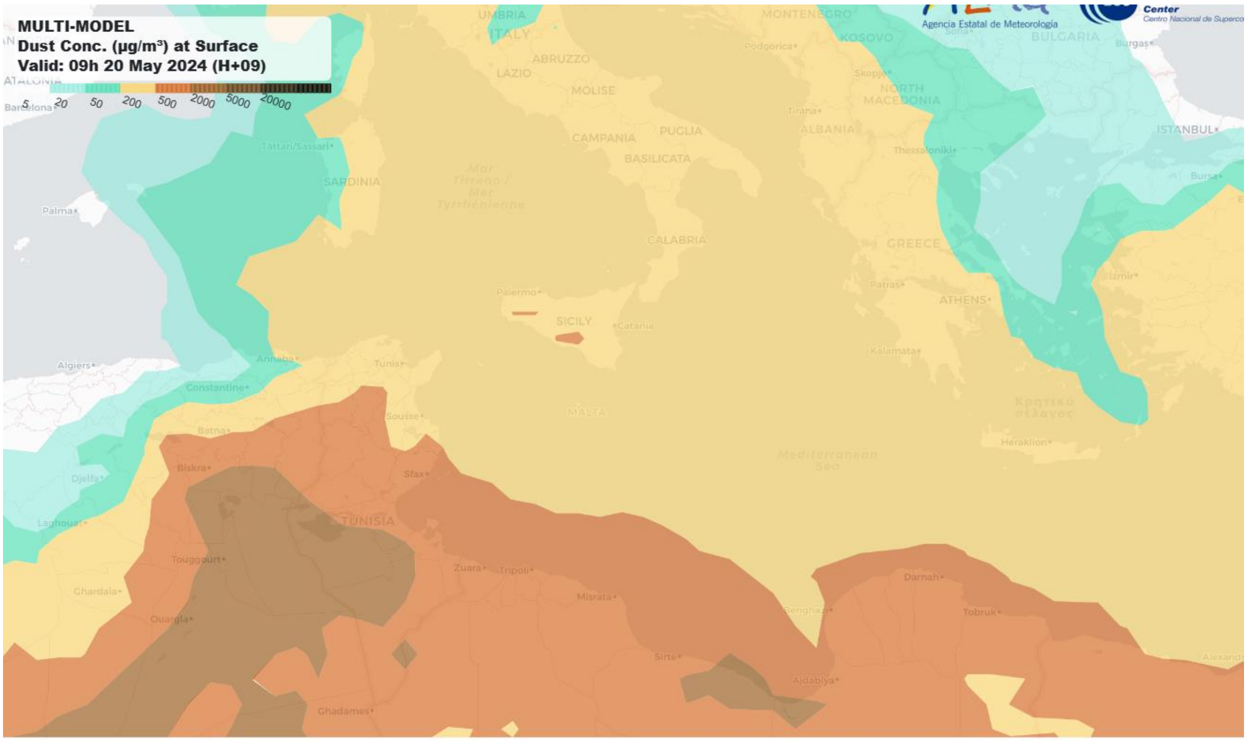

Figure A.14.3: PM_{10} levels forecasted by the ensemble model on 20.05.2024.

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.