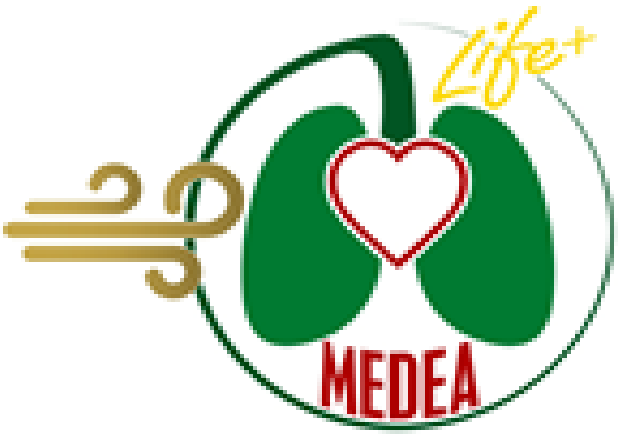

Sub-Action C.4.1

Deliverable C4.1. Report on Forecasting preparation and feasibility assessment

Beneficiary responsible for implementation: UCY

Date: 01/08/2018

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Introduction

The aim

The main objective of Action C.4 was to tune the efforts of all stakeholders of all three partner countries, to enhance their forecasting system's capacity for the purposes of public warning disseminations, as these will be tested during the study periods. Following the first tested period, the forecasting performance will be assessed using real monitoring particulate matter (PM) data of the study areas and improved. The forecasting group of all three partner countries for this action, are listed in Table 1:

Table 1: Stakeholders

Forecasting Group	*Cyprus*	*Greece*	*Israel*
Atmospheric forecasters (AtFor)	CyMet Dep. (Filippos Tymvios)	University of Crete (Stavros Solomos)	Ben-Gurion University of the Negev (Itai Kloog)
Air Quality Monitoring (AirQ)	DLI (Chrysanthos Savides)	University of Crete (Nicos Kalivitis)	Ben-Gurion University of the Negev (Itzhak Katra)
Clinicians (Clin)	Medical School (Panayiotis Yiallouros, Panayiotis Kouis)	University of Crete (Lena Demetriou, Manolis Galanakis)	Soroka Clinical Research Center (Victor Novak, Shaked Yarza)

UCY (Cyprus) will be responsible for coordination and will work with CyMET (Cyprus), UOC (Crete) and SCRC (Israel) for the implementation of this Action.

The first milestone

In the preparatory stage of the forecasting activities, the existing forecasting capacities per country partner were investigated, in conjunction with the established practises that each country follows for Desert Dust Storm (DDS) warnings. Under the responsibility of Action Coordinator, several meetings took place (either in person or via SKYPE/Teleconferencing), in order to present progress, and make proposals for updates of the work plan and actions. At this starting point of C.4 action, the forecasting group of all three countries, came up with a common and consistent process that should be followed. An important outcome of this coordinated effort was the ability given to the atmospheric forecasters of Greece, Cyprus and Israel, for collaboration and exchange of information about Desert Dust Storm Events. This capability for easy and quick exchange of information, is given to the partners, via the online e-Platform which is already established through other actions of the project.

Correlation between regional scale dust forecasts and urban scale PM_{10} concentrations

The primary objective of C.4 action was to derive the correlation between regional scale forecasts of dust concentration (derived from regional scale models) and urban-scale PM_{10} concentrations (collected from air quality monitoring systems) to guide the DDS forecasting.

The feasibility assessment

First, it was decided that each country partner would use its own current established capacities and practises in regional scale dust load modelling. Cyprus and Crete are already in the position to run the forecasting Advanced Research Weather forecasting model (WRF) in their baseline mode, whereas Israel is still in the process of the development of an Israel-based WRF model which will follow a similar methodology to the set-ups of Cyprus and Greece. However, in light of the technological development and rapid growth of other numerical models, for the first year of project implementation, it was decided to follow an assessment study of the predictions of the online dust regional Atmospheric Model (BSC-DREAM), using regional scale dust predictions and urban-scale PM_{10} measurements. The BSC-DREAM provides daily forecasts of the desert dust concentrations in the Mediterranean region and the predictions of this model cover geographically all three country-partners of project. For the purposes of this preliminary study, Cyprus was used as a case study. The data that were used, concern (i) hourly average data of urban-scale PM_{10} concentrations for the period between 2012-2016, (ii) predictions from the DREAM model and (iii) backwards trajectory analysis results from the Hysplit model for the same period. The ground level measurements were recorded by the local air quality monitoring partner, the Air Quality Section, from the Department of Labour Inspection (DLI, https://www.airquality.dli.mlsi.gov.cy/), Ministry of Labour, Welfare and Social Insurance of Cyprus and concerned the Monitoring Stations of traffic at Nicosia and the EMEP background station at Ayia Marina Xyliatou.

The measurements of the abovementioned period were compared with results from the predictive models, DREAM and Hysplit. The results of the comparison between predictions of the models with the urban-scale PM_{10} concentrations lead to the conclusion that DREAM and Hysplit can reliably provide qualitative forecasting warnings about DDS event at least one day beforehand. Also, by using statistical methods for control and monitoring of a process, it was confirmed that the practice of DLI to issue public warnings is trustworthy. In addition, the results of this feasibility study showed that different regional scale models can be used instead of the WRF

forecasting model, which was described in the project proposal, as the main forecasting tool. Moreover, the importance of local-scale effects in the spatiotemporal distribution of dust particles near the surface has been illustrated by the use of high resolution atmospheric models for Cyprus and Middle East (Mamouri et al., 2016; Solomos et al., 2017) and for Crete (Solomos et al., 2018a, Solomos et al., 2018b). An example of the forecasting operational systems that are used for the issuing of DDS warnings is shown in Appendix A.

The assessment of PM_{10} measurements in the study area

The results of the conducted analysis show that the highest annual intensity of PM_{10} concentration in the EMEP station (26.4 μg/m^3) and the Nicosia (Traffic) station (47.2 μg/m^3) were observed in 2013. Also, according to the official data, in 2013, DLI issued 14 warnings for DDS. In contrast, in 2016, DLI issued 20 warnings for DDS, which is the highest number of warnings in the study period. At the same time the lowest annual intensity of PM_{10} concentration for both stations, were observed in 2016. Specifically, the annual average value of PM_{10} concentration from EMEP station was 19.9 μg/m^3 and the corresponding value for Nicosia (Traffic) station was 40.8 μg/m^3. The key results of the up to now analysis, are presented in Appendix A.

Description of warning practise for Desert Dust Storm

In order to come out with a common process between the Life-MEDEA project partners, for DDS event warnings, the existing experience and knowledge of the partners were exploited. The purpose of the practice is to have timely but mainly reliable warning of participants for upcoming DDS events in a consistent way. This process will be carried out and controlled by the forecasting groups of each country through an online platform that has already been created, tested and is fully operational. The complete description of the forecast alerts to participants about upcoming DDS events through e-platform can be found in Appendix B.

A. feasibility assessment of applying models for early forecasting of DDS events

Table 1: Warning issues for *Desert Dust Storms* from the *Department Labour Inspection (CY)*

Year	# of Days
2012	5
2013	14
2014	4
2015	13
2016	20

Table 2: The annual average values and the corresponding standard deviation of the urban-scale PM_{10} concentrations for (a) the background station EMEP at Ayia Marina Xyliatou and (b) traffic monitoring station at Nicosia.

Year	EMEP		Nicosia (Traffic)	
	Annual Aver. [µg/m^3]	Std.	Annual Aver [µg/m^3]	Std.
2012	21.7	14.3	43.8	21.6
2013	26.4	34.5	47.2	25.2
2014	23.5	23.7	45.0	22.5
2015	22.5	30.0	46.3	67.5
2016	19.9	12.8	40.8	15.0

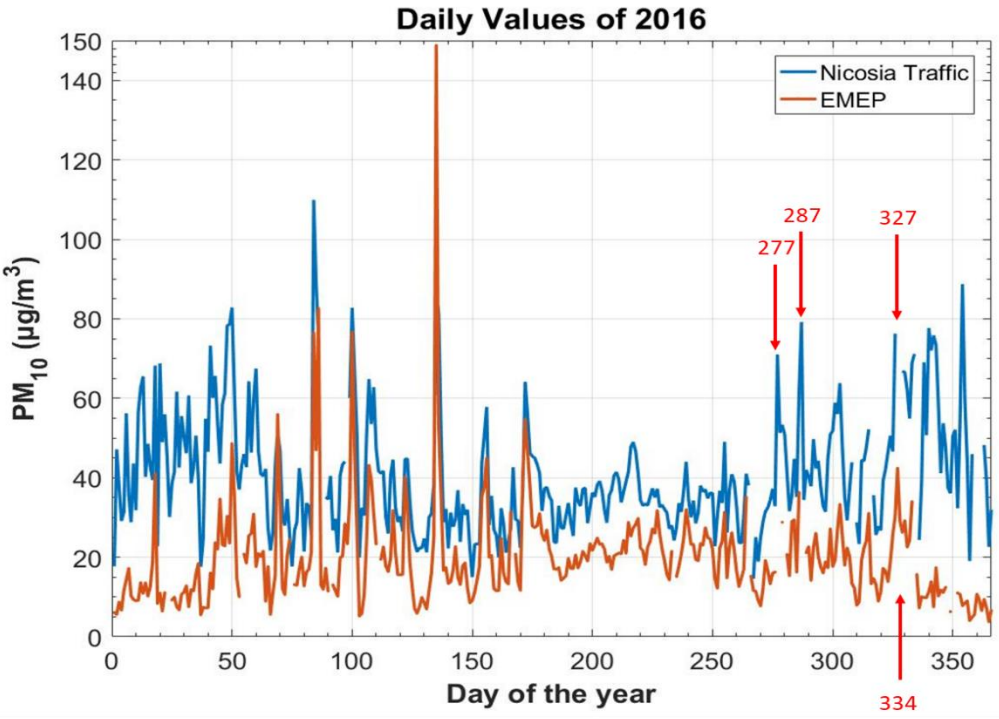


Figure 1: The time-series plot of PM_{10} concentrations measurements, using collected data from the Air Quality Monitoring stations (a) EMEP and (b) Nicosia (Traffic), for the year of 2016.

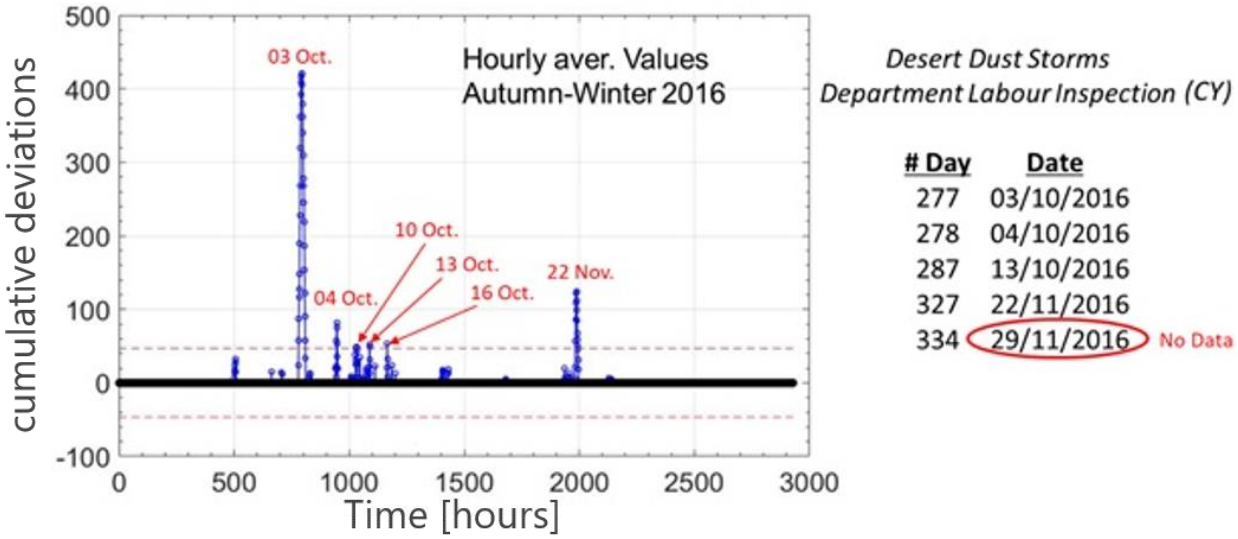
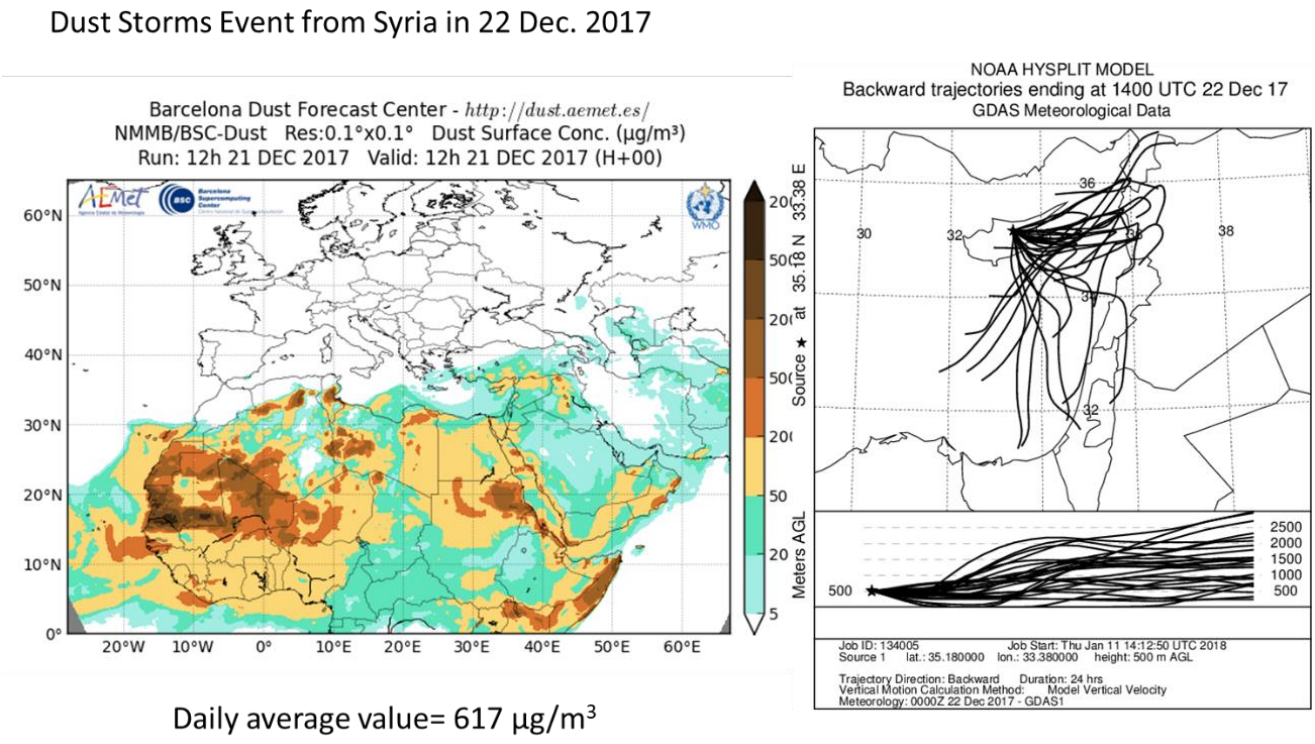


Figure 2: The collected measurements of PM_{10} concentrations from the background monitoring station EMEP (Ayia Marina Xyliatou), were analysed using statistical methods for control and monitoring of a process. It was confirmed that the practice of DLI to issue public warnings is trustworthy.



(a) (b)

Figure 3: The predictions of (a) DREAM model and (b) Hysplit model, were compared with PM_{10} concentration measurements in Cyprus. This comparison provides qualitative correlation between regional scale dust-load predictions and urban-scale PM_{10} measurements to guide the DDS forecasting.

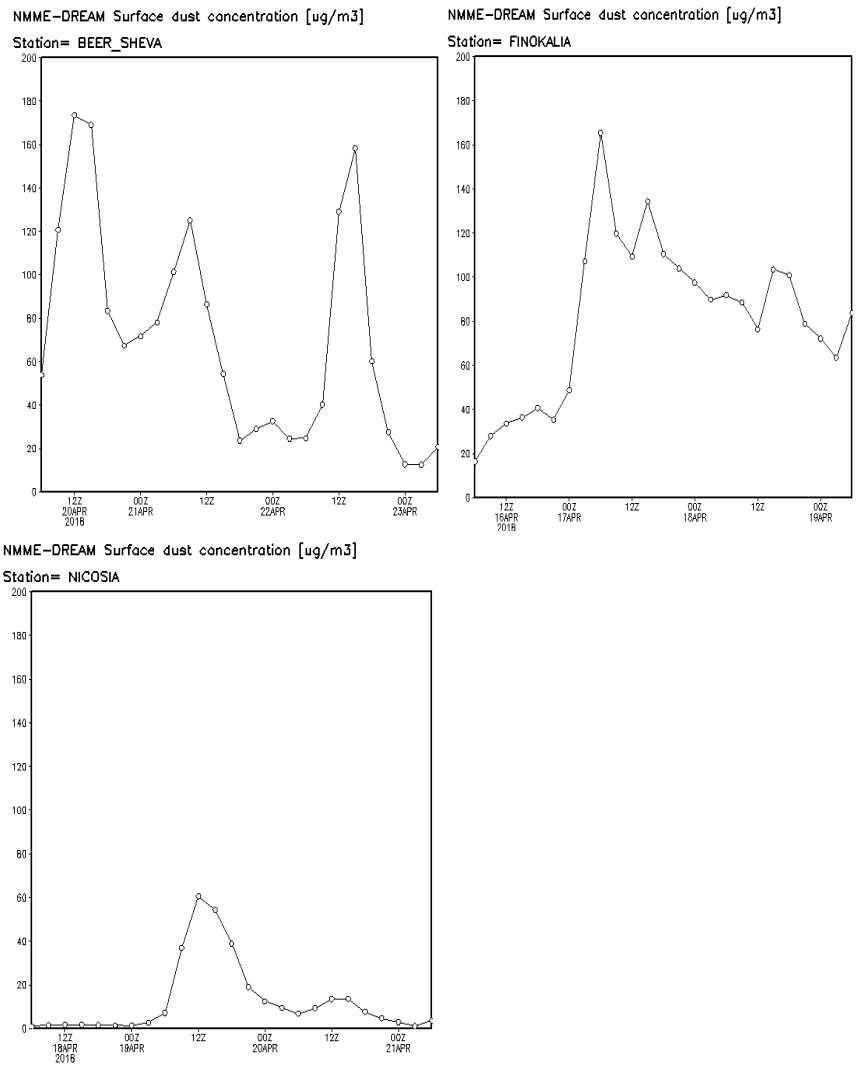
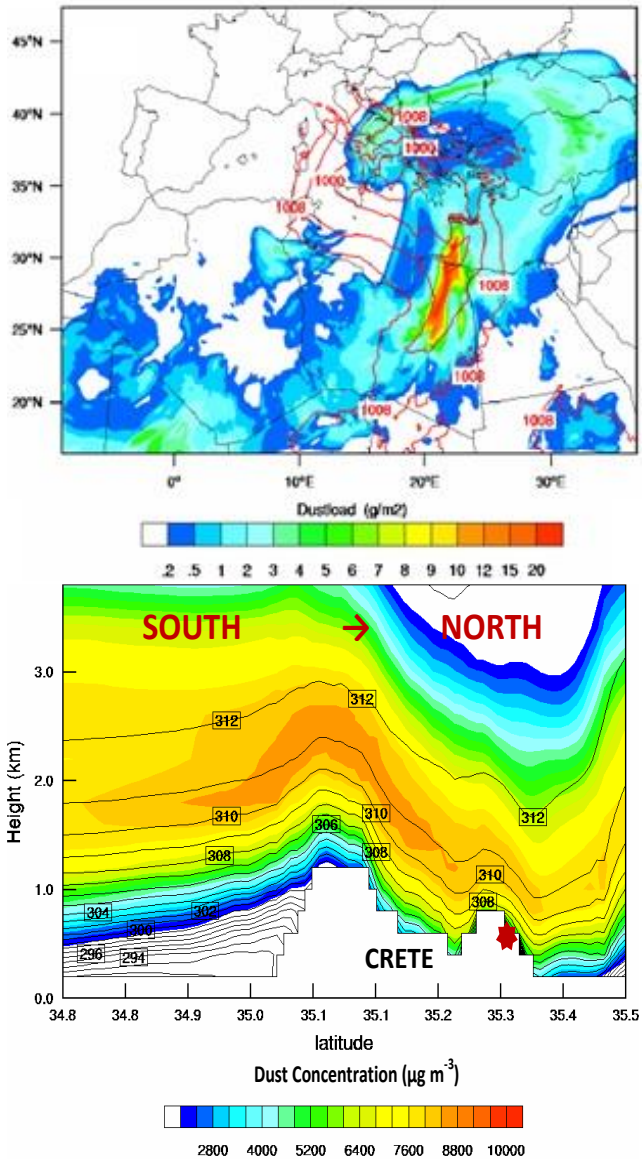
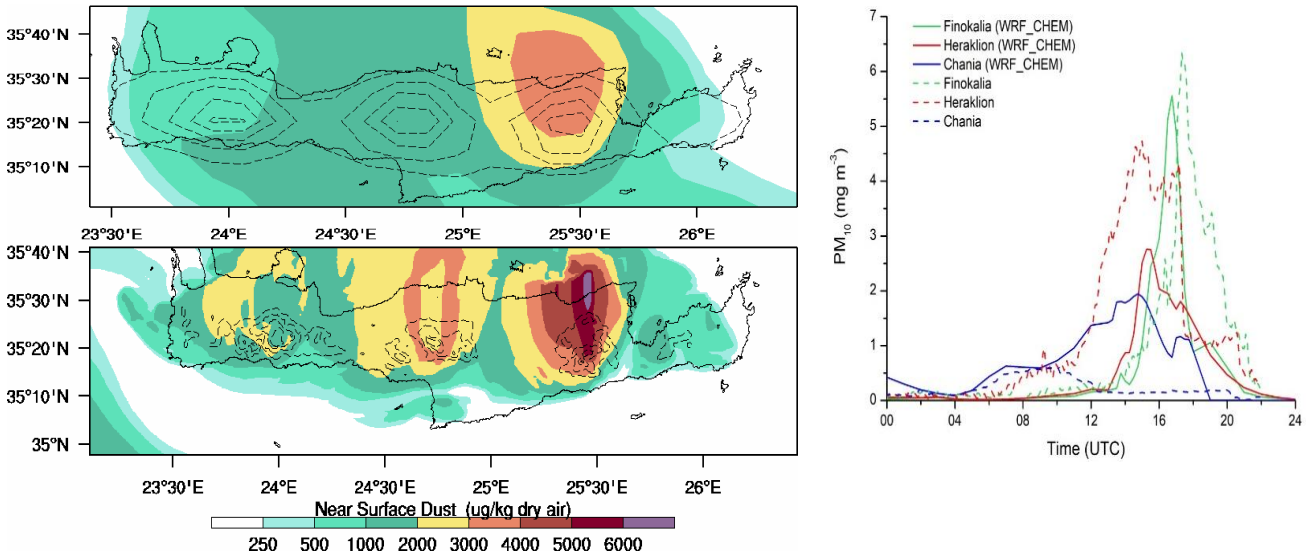


Figure 4. Examples of surface dust concentration forecasts (μg m^{-3}) at the stations of Beer Sheva in Israel, Finokalia in Greece and Nicosia in Cyprus from the operational NMM-DREAM model of the BEYOND center of excellence of the National Observatory of Athens (http://beyond-eocenter.eu/).



(a) (b)

Figure 5: (a) WRF-CHEM dust load (g/m^2) on 22 March 2018, 1200 UTC and (b) the vertical cross-section of dust concentration over Crete at 1700 UTC showing the downwards mixing of dust over the lee side of the island due to downslope Foehn winds (from Solomos et al., 2018).



(a) (b)

Figure 6: (a) WRF-CHEM surface dust concentration (μg m^{-3}) on 22 March 2018, 1500 UTC at 12×12 km grid space (up) and at 1×1 km grid space (down). (b) Evaluation of model results with PM_{10} measurements at the stations of Chania, Heraklion and Finokalia. Only the high resolution runs managed to reproduce a realistic distribution of the dust particles maxima at the surface (from Solomos et al., 2018a, b)

B. The Description of the practise of the forecast alerts about upcoming DDS events through e-platform

The format of the portal will be as follows:

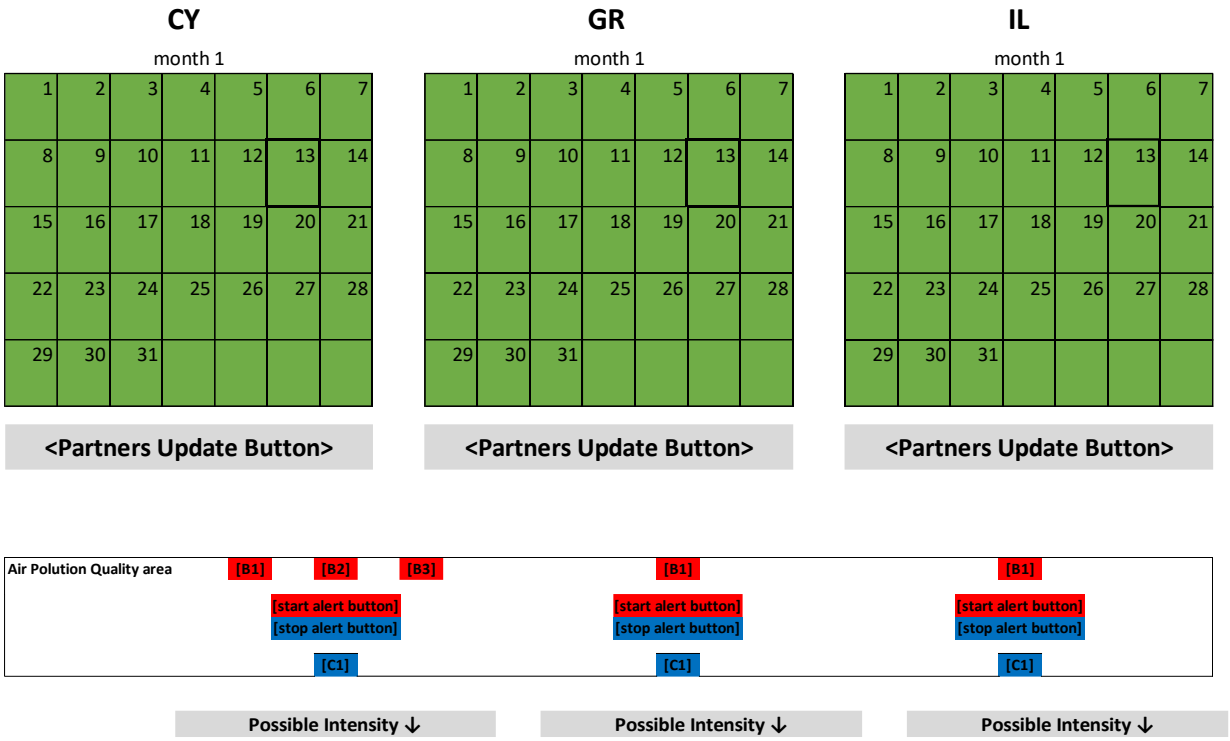


Figure 1: The calendar for Desert Dust Storm forecasting, that the estimation will be projected for the 5 following days.

On a webpage the current calendar month will appear (with the option of displaying also the next upcoming month as well) for each partner from the three countries (Cyprus, Greece, Israel). Each participating authority* from all countries will be able to see what is happening in the other countries but they will only be able to change the different fields of the calendar for their own country.

For example, the partners from Cyprus (CyMet Dep, DLI, Medical schools) will be able to monitor the calendar of Greece and Israel, but they will not be able to modify any information in the portal. Any modifications or changes will be made on their own portal relating to Cyprus.

First Action

Who acts: Atmospheric Forecasters

Who are informed (through app message, SMS and/or email): Monitoring Services, Clinicians

The calendar by default presents all days of the month in green color, which according to the color code of Table 2 means that the dust levels in the atmosphere are expected to be normal and within the permitted limits (No alert-severity 0). Therefore, if the forecasting does not predict any episodes of desert dust storms (DDS), then AtFor (e.g CyMet Dep.) does not need to make any changes to the portal.

Table 2: Color Code which describes the Desert Dust Storm forecasting severity:

	No prediction
	No alert - Severity 0
	Dust load in the atmosphere due to regional and local phenomena or human activity - Severity 1
	Dust event with high values of PM_{10} concentrations - Severity 2
	Severe Dust event, unusual high PM_{10} concentrations - Severity 3

*Participants/patients will not have access to the portal but will also be receivers of the meteo/air alerts

The Atmospheric Forecasters (AtFor) of each country member are responsible to forecast the upcoming episodes of DDSs. The AtFor partners, based on the predictions of their models, are responsible to inform the portal based on the color code (Table 2). Only AtFor have permission to change the color code of each day and press the "Partners Update Button".

If the forecasts of AtFor (e.g CyMet Dep.) predict that in the following days there is a possibility of dust in the atmosphere (e.g of Cyprus), then the corresponding participating authority (e.g CyMet Dep.) should logged in to the portal using its individual password and change the color of each day individually (through drop down menu), depending on the severity of the phenomenon that is expected. Once the AtFor (e.g CyMet Dep.) has assured that the correct color codes for the next 5 days have been chosen, then the "Partners Update Button" has to be pressed, in order to send a relevant SMS and/or email to the other stakeholders of his country (e.g Monitoring Service and Clinicians) to warn them that there may be a DDS in the

upcoming days. The warning will be given to alert all interested partners in the country.

Hypothetical scenario (e.g region of Cyprus):

Day of study: 10th March

The forecast of the Cyprus Meteorological Service indicates that

- on March 11 there will be moderate DDS
- on March 12 there will be severe DDS
- on March 13 there will be very severe DDS
- on March 14 there will be severe DDS
- on March 15 there will be moderate DDS

the CyMet (the AtFor partner of the country), selects through drop down menu of each day, the corresponding colors for the aforementioned dates as shown in Figure 2.

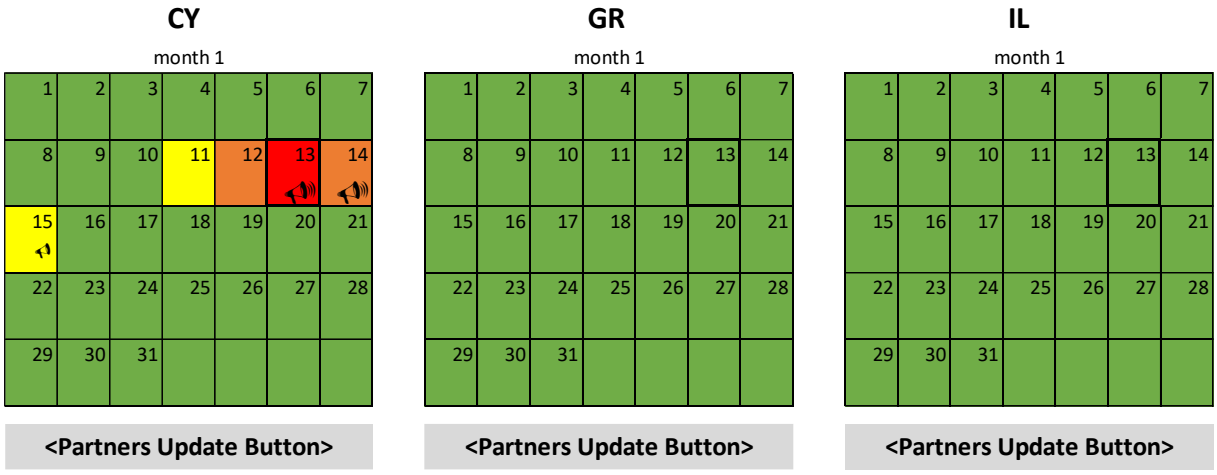


Figure 2: The calendar for Desert Dust Storm forecasting, which presents the predictions for five consecutive days from 11th to 15th of March.

Then AtFor partner presses the "Partners Update button" to send to the Monitoring Services and Clinicians the following message: "Predictions for a possible Desert Dust Storm episode in the coming days have changed".

Predictions have changed based on the 12th of March forecasting. Therefore, the AtFor partner must log in again in the portal where the colouring from the current date

onwards must change, see (Figure 3). The coloring for 10 and 11 March will not be able to change (since the log in is done in 12th of March). Then the AtFor partner presses the "Partners Update button" to send to the Monitoring Services and Clinicians the following message: "Predictions for a possible Desert Dust Storm episode in the coming days have changed".

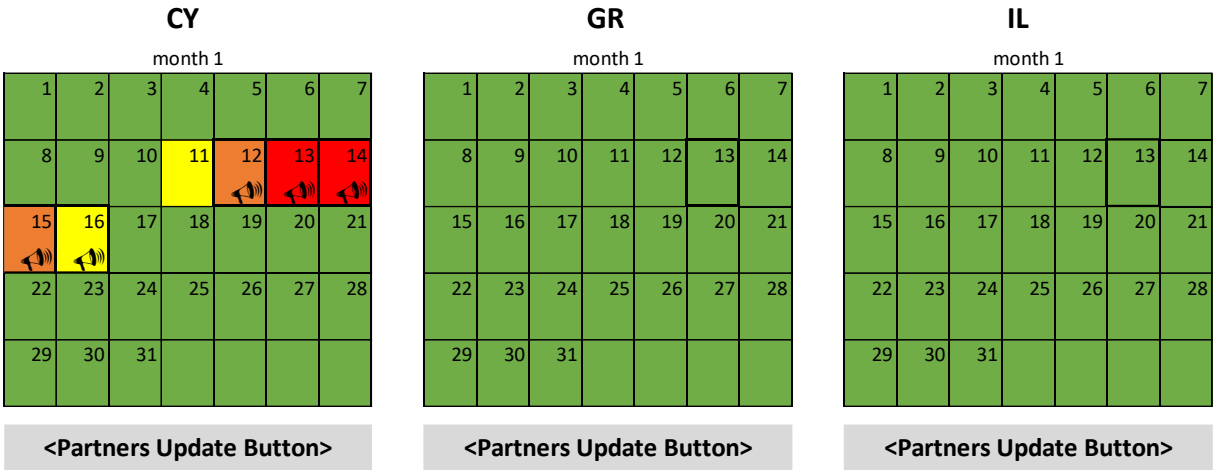


Figure 3: The calendar for Desert Dust Storm forecasting for 11th to 16th of March, which presents the predictions after change.

Important Note!

The AtFor partners of each country will be able to click on the Abbreviation Name of each other country (above the corresponding calendar), in order send an automated app message, SMS or/and email to the AtFor partner of the other country, in the case where the predictions of AtFor partner-A are different from the predictions of the AtFor partner-B for the country-B.

Second Action

Who acts: Monitoring Services

Who are informed (through app message, SMS or/and email): Atmospheric Forecasters, Clinicians, Participants

The Monitoring Services (AirQ) partners will be already on guard for DDS phenomenon based on the warnings they already received from the portal. AirQ partners in each country, through the portal, are responsible to inform timely and reliably the clinicians and participants (and their parents, teachers if applicable), that a DDS is occurring.

Depending on the conditions and the established practices that each country follows for DDS warning (see Table 3), the AirQ partners of each country must update the portal.

Note!

Each country may have as many internal criteria as it considers necessary, according to the established practice it has followed to date for the determination of DDS. Only AirQ partner can enable and press the "Start alert Button".

Table 3: Internal criteria for each partner

Cyprus

If at least 2 out of 3 internal criteria are met for 3 consecutive hours the [start alert button] should be pressed

[B1] Ag. Marina Xyliatou (EMEP - background station) exhibits hourly-averaged concentrations of $PM_{10} > 50$ μg/m^3

[B2] Any AQMS exhibits hourly-averaged concs of $PM_{10} > 100$ μg/m^3

[B3] Any 3 stations exhibit hourly-averaged concs of $PM_{10} > 50$ μg/m^3

Greece

If the internal criterion [B1] is met for 3 consecutive hours, the [start alert button] should be pressed

[B1] Heraklion station exhibits hourly-averaged concentrations of $PM_{10} > 50$ μg/m^3

Israel

If the internal criterion [B1] is met for 3 consecutive hours, the [start alert button] should be pressed

[B1] Beer Sheva station exhibits hourly-averaged concentrations of $PM_{10} > 100$ μg/m^3

For all countries

If the internal criteria are not met for 2 consecutive hours the [stop alert button] should be pressed

[C1]

Note!

The [B_i] and [C1] buttons are on/off buttons. The user must click [B_i] buttons in order to unlock the [start alert button]. The portal must not allow the user to press [C1] – condition for [Stop Alert button]-before 2 hours.

Hypothetical scenario (e.g region of Cyprus):

Day of study: 13th March

For example, in the entire territory of Cyprus, 9 Air Quality monitoring stations (AQMS) are installed. DLI (AirQ partner) has defined the following internal criteria as a practical procedure for DDS warning:

[B1] If Ag. Marina Xyliatou AQMS (EMEP) as background station exhibits hourly-averaged concentrations of PM_{10} > 50 μg/m^3

[B2] If any AQMS exhibits hourly-averaged concentrations of PM_{10} >100 μg/m^3

[B3] If any 3 stations exhibit hourly-averaged concentrations of PM_{10} > 50 μg/m^3

If at least 2 out of 3 internal criteria are met for 3 consecutive hours, DLI partner should choose the corresponding [B_i] buttons in order to unlock the [start alert button]. The portal should record this selection for statistical reasons and data meta-analysis. Then the DLI partner must press the [start alert button] in order to send the default warning messages to all interested members, depending on the participant category they are.

For statistical reasons, through a drop-down menu, the AirQ partner should choose from the "Possible Intensity" button, the pollution level of PM_{10} concentration in the atmosphere (see Table 4). The pollution level of PM_{10} concentration should be referred to the area where the patients are located and to the time where the SMS or/and email was sent (again for statistical reasons and data analysis).

Table 4: Pollution Level:

	Low (0-50) μg/m^3
	Moderate (50-100) μg/m^3
	High (100 - 200) μg/m^3
	Very High (>200) μg/m^3

Then if the internal criteria of the AirQ partner stop to be met for 2 consecutive hours, the AirQ partner (and only the AirQ partner), has to press "Stop Alert button"

to end the alarm. An automated app message, SMS or/and email will be sent to patients and other partners in the country in order to stop their precaution measures. If after 48 hours the alarm is still on, the portal will automatically send a reminder to the AirQ partner about the stop alert. The reminder will be repeated every 24 hours, until the alarm is stopped.