

3-rd Year Lab course: Mineral Desert Dust

Comparison between the Tel-Aviv University dust forecasts and PM10 data

1. Introduction

Airborne mineral dust from the world's deserts makes a major contribution to the global tropospheric aerosol budget, with dust concentrations being particularly high over arid regions. The dominant sources of mineral aerosols are the arid regions of North Africa, the Arabian Peninsula, Central Asia, China, Australia, North America, and South Africa. The Sahara is the world's most important dust source; it is thought that northern Africa is responsible for up to half of the global mineral dust emissions. Once in the atmosphere, dust particles interact with solar and thermal radiation, modulating the Earth radiation balance. Mineral dust could also affect cloud formation and precipitation.

Desert dust storms are significant seasonal atmospheric phenomena in the Eastern Mediterranean region, which periodically dominate weather conditions in the region, particularly in spring. Desert dust is one of the main natural air pollutants affecting air quality. It could directly affect human health for people who suffer from asthma, allergy, and other breathing diseases. It is reasonable to suggest that the dust effect depends on dust particle size, or, in other words, that there is some relationship between dust particle size and allergy diseases. Near dust sources, dust particle size ranges from 0.1 to about 20 μm . Large particles fall down near dust sources, while a percentage of fine particles with size less than 1 micron increases with distance from dust sources. It is worth mentioning that a short-distance dust transport from the Eastern Sahara, through Egypt, into Israel brings both coarse and fine fractions. A long-distance dust transport from the Western Sahara, through Southern Europe, into the Eastern Mediterranean brings mainly fine fraction with size less than 1 micron. For days, when the Saharan dust is transported over Israel, dust aerosols dominate ground-based measurements of PM10 concentrations. In particular, PM10 concentrations higher than 100 $\mu\text{g}/\text{m}^3$ for the most part relate to dust events, with rare exceptions due to human-related accidents accompanied by a release of anthropogenic air pollution.

A history of the TAU dust prediction system started from MEIDEX, - Mediterranean Dust Experiment with a participation of the first Israeli astronaut Ilan Ramon, in winter 2003. Within the framework of MEIDEX, the one-particle-size dust prediction system was put in operational use in Tel-Aviv University in November 2000. In the year 2006, in order to improve 3D-dust forecast, the modified version of DREAM model with more detailed set of 8 dust particle size classes between 0.1 and 7 microns was put in operational use. The dust prediction system produces daily forecasts of 3-D distribution of sea-salt aerosol concentration over the Mediterranean, North Africa, Europe, and the Atlantic Ocean (<http://wind.tau.ac.il/dust8/dust.html>). The model has 0.3 degrees horizontal resolution and 24 vertical levels. Forecasts are made once every day, starting from 12:00 UTC and providing forecasts up to 72 hours ahead. The Israeli Ministry of Environmental Protection uses the forecasts to distinguish between natural and anthropogenic aerosols.

2. Objectives of the lab course.

a) The main goal is to evaluate TAU 24-hour dust forecasts by using Israel PM10 data. This will help to better understand the model's capabilities for providing reliable dust forecasts. Provided by the Israeli Ministry of Environment Protection, the PM10 measurements at the Tel-Aviv University site (Yad Avner Building, 32.1N, 34.8E) will be used for model evaluation.

b) To distinguish between different routes of desert dust transport into Israel by using the on-line archive of dust forecasts: from the eastern part of the Sahara, through Egypt, into Israel; and from the western part of the Sahara, through Southern Europe, into the Eastern Mediterranean and Israel.

c) To estimate seasonal variations and a long-term tendency of desert dust events in Tel-Aviv by using PM10 data.

3. Data and Methodology

PM10 measurements, taken at several monitoring sites in Israel by the Israeli Ministry of the Environment Protection, are available on-line (Fig. 1). The data can be downloaded from the following site: <http://www.sviva.gov.il>



Fig. 1. The on-line data base of the Israeli Ministry of the Environment Protection.

The time in the monitoring stations is always Israel (Jerusalem) winter time. PM10 measurements include all kinds of atmospheric aerosols both natural and anthropogenic with size less than 10 microns. On the contrary, the dust model does not include any local aerosols, but only mineral desert dust. To compare correctly PM10 versus model data, we have to distinguish between mineral dust, transported from the Sahara, and local PM10 aerosols. Without conducting some chemical analysis this is not a simple task. To get around this problem, threshold of local PM10 aerosols should be determined. When PM10 data taken at one monitoring station are highly correlated with those taken at other monitoring site, this is the evidence that we deal with a large-scale aerosol event, i.e. with the desert dust transport. As estimated, for example, for days with $PM_{10} > 100 \mu g/m^3$, the correlation is higher than 0.5 between the PM10 records in Tel-Aviv and Carmiel. The number of days with $PM_{10} > 100 \mu g/m^3$ can be used to estimate seasonal variations and a long-term tendency of desert dust events. On the contrary, low correlation between PM10 data taken at different sites is the evidence of local aerosols. In particular, for days when $PM_{10} <$

100 $\mu\text{g}/\text{m}^3$, the correlation is about 0.2 between the PM10 records in Tel-Aviv and Carmiel. Therefore, for those days without significant dust, i.e. when $\text{PM}_{10} < 100 \mu\text{g}/\text{m}^3$, we can characterize an average level of local aerosols by estimating their mean. As found, the average level of local aerosols in Tel-Aviv is approximately 40 - 50 $\mu\text{g}/\text{m}^3$.

Tel-Aviv University desert dust forecasts are available via the Internet.

You can get the animation of dust transport (i.e. dust time evolution in the atmosphere over the model domain) for some specific date by using the following link:

<http://wind.tau.ac.il/dust8/YMMMDD/dust.html>

where YY stands for year, MM for month, and DD for day. For example, in order to see the model-predicted dust transport on March 13, 2006, (Fig. 2) one can use the following link to the forecast of March 12, 2006 (the previous date):

<http://wind.tau.ac.il/dust8/060312/dust.html>

Examining dust forecasts day after day will help you to distinguish between different routes of dust intrusions.

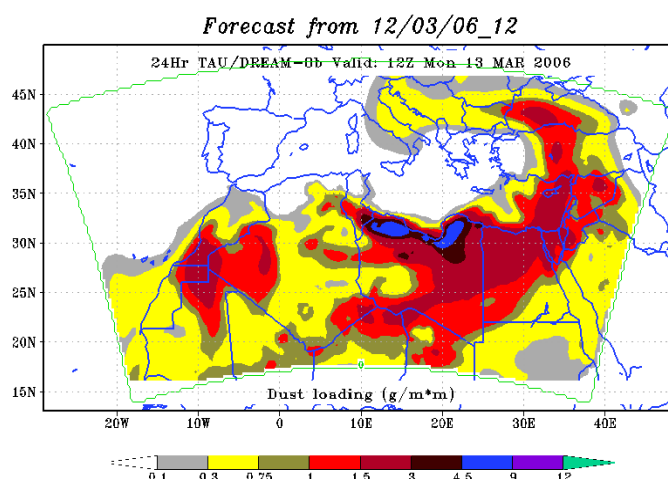


Fig. 2. The model-predicted dust transport over the Eastern Mediterranean on March 13, 2006.

You can also get surface dust concentrations in the ASCII format in Tel-Aviv by using the following links:

<http://wind.tau.ac.il/dust8/YMMMDD/surface-PM10-ramat-aviv-ascii.dat>

Here is some explanation of those files:

Within each file you will see 13 numbers of predicted surface dust concentrations (X_1, X_2, \dots, X_{13}) started from 12:00 UTC of the forecast day for consecutive intervals of 6 hours up to 72 hours ahead: see the table below with all details.

#	UTC	Forecast time	Model data [microgram/m ³]
1	12:00	0	X1
2	18:00	6	X2
3	24:00	12	X3
4	06:00	18	X4
5	12:00	24	X5
6	18:00	30	X6
7	24:00	36	X7
8	06:00	42	X8
9	12:00	48	X9
10	18:00	54	X10
11	24:00	60	X11
12	06:00	66	X12
13	12:00	72	X13

The model-predicted concentrations for the next day after the date of forecast, i.e. X4, X5, X6, and X7, will be compared with PM10 data. Note that the time in the dust forecast is always Universal Time (UTC), while for PM10 data in the monitoring stations they use Israel (Jerusalem) winter time. Therefore, X4 should be compared with PM10 taken at the Tel-Aviv site at 08:00, X5 with PM10 taken at 14:00, X6 with PM10 taken at 20:00, and X7 with PM10 taken at 02:00.

For example, using the following link

<http://wind.tau.ac.il/dust8/060312/surface-PM10-ramat-aviv-ascii.dat>

we can see the model-predicted surface dust concentrations based on the model forecast of March 12, 2006, as shown below:

2.721e+02
2.370e+02
2.417e+02
1.740e+02
2.628e+02
3.248e+02
3.958e+02
4.371e+02
6.355e+02
4.843e+02
2.938e+02
1.396e+02
7.612e+01

The model-predicted data for March 13, 2006, are marked by the yellow color. These model data correspond to the following PM10 data taken at the Tel-Aviv site:

יד אבנר - רמת אביב

חלקיקים נשימים (PM10) שעה תאריך

מיקרוגרם/מטר קוב

13/03/2006	08:00:00	29.95
13/03/2006	14:00:00	475.07
13/03/2006	20:00:00	369.82
14/03/2006	02:00:00	308.73

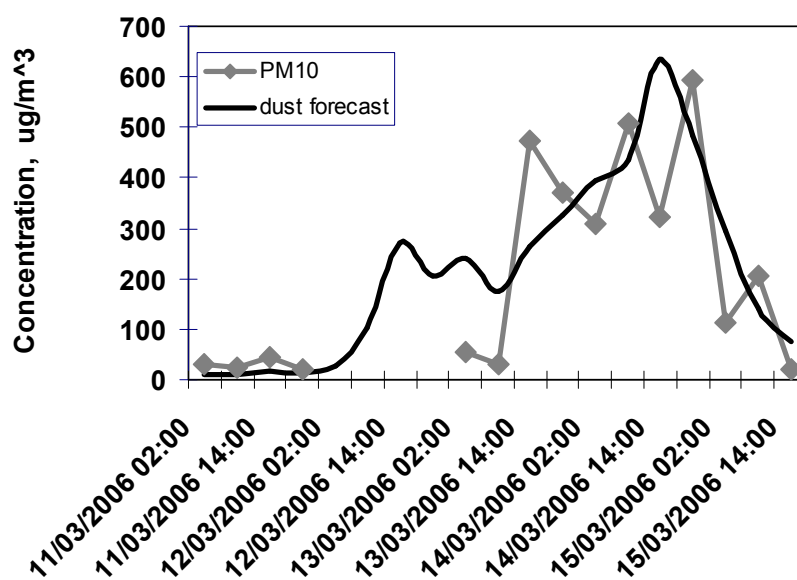


Fig. 3. The comparison between PM10 measurements (the grey line), taken at the Tel-Aviv site during the dust event on March 13 – 14, 2006, and model-predicted surface dust concentrations (the black line).

4. Lab work realization

1. Download daily PM10 data taken at the Tel-Aviv site (Yad Avner Building) from March 30, 1999, to the present. Use the following link to the web-site of the Israeli Ministry of the Environment Protection: <http://www.sviva.gov.il>
2. Obtain seasonal variations of desert dust by analyzing monthly numbers of days with $PM_{10} \geq 100 \mu g/m^3$, averaged from 1999 - 2011.

3. Obtain year-to-year variations of annual numbers of days with $PM_{10} \geq 100 \mu\text{g}/\text{m}^3$ and their linear fit, which illustrates a long-term tendency of desert dust over Tel-Aviv during the period from 1999 to 2011.
4. Determine some examples of different routes of desert dust intrusions into Israel, by using the on-line archive of TAU dust forecasts:
<http://wind.tau.ac.il/dust8/YMMMDD/dust.html>
5. As illustrated in Fig. 3, compare model-predicted surface dust concentrations with PM_{10} data taken at the Tel-Aviv University site for two dust events in Israel, February 23 – 26, 2007, and March 10 – 14, 2007.
6. Compare model-predicted surface dust concentrations for all consecutive days from February to April 2006 with corresponding PM_{10} data and estimate a correlation coefficient.

5. Report

A report includes five Excel work sheets with the following five figures and their data:

Fig. 1. Seasonal variations of desert dust over Tel-Aviv based on monthly numbers of days with $PM_{10} \geq 100 \mu\text{g}/\text{m}^3$, averaged over the period from 1999 - 2011.

Fig. 2. The long-term tendency of desert dust over Tel-Aviv based on annual numbers of days with $PM_{10} \geq 100 \mu\text{g}/\text{m}^3$ during the period from 1999 to 2011.

Fig. 3 and 4. Comparisons between model-predicted surface dust concentrations and PM_{10} data taken at the Tel-Aviv University site for two dust events, February 23 – 26, 2007, and March 10 – 14, 2007.

Fig. 5. Comparison between model-predicted surface dust concentrations and PM_{10} data taken at the Tel-Aviv University site for all consecutive days from February to April 2006.

Attention! Two important comments.

Comment 1.

To make model-vs.-measurement comparisons, i.e. February 23 – 26, 2007, March 10 – 14, 2007, and for all consecutive days from February to April 2006, you should use model-predicted data from the previous day (18 – 36 hour forecasts) and not from the current day. (See examples of model-vs.-measurement comparison for March 13, 2006, in the guidelines).

From the model output file for previous day, you take numbers from four to seven (X4, X5, X6, and X7), which correspond to 18-hour forecast, 24-hour forecast, 30-hour forecast, 36-hour forecast respectively. These model forecasts from the previous day you should compare with measured PM10 concentrations on the current day.

Use the aforementioned approach to all days, for which you make model-vs.-measurement comparisons.

Comment 2.

For model-vs.-measurement comparison, you will compare two data sets in Universal Time (UT): the first data set includes PM10 measurements and the other data set includes model data.

First, download hourly PM10 from the site of the Ministry of Environment Protection.

Then, create the first data set by selecting PM10 data for 2, 8, 14, and 20 LT (local Israel time), which corresponds to 0, 6, 12, and 18 UT (Universal Time).

Finally, create the data set of model-predicted dust concentrations.

Model data are in UT time. Use model data from the previous day where

number 3 corresponds to 0UT,

number 4 corresponds to 6UT,

number 5 corresponds to 12UT,

number 6 corresponds to 18UT.

Technical note.

You don't need download model data. You can just copy from the screen the aforementioned four numbers every day and paste them into the data set of model data in your Excel file.