Cairo Air Improvement Project

Air Quality Monitoring Component

User's Guide for the Air Quality Early Warning System (AQEWS)

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1. INTRODUCTION

1.1 THE AIR QUALITY EARLY WARNING SYSTEM (AQEWS)

The air quality early warning system (AQEWS) program is a forecasting tool that produces particulate matter (PM) forecasts based on input data that includes past air quality and observed and forecasted meteorological conditions, plus forecaster knowledge. The PM of interest is PM_{10}, which corresponds to particles with sizes less than 10 microns. The program makes PM_{10} concentration forecasts using statistical equations that predict the current- and next-day PM_{10} concentrations in the Cairo area. It also makes PM_{10} trend forecasts for the next day, the second day, and the third day. The trend forecast provides an indication of whether PM_{10} concentrations are expected to increase, decrease, or remain about the same for each day. PM_{10} forecasts represent 24-hour averaged values of PM_{10}. The forecasts cover the central Cairo region from Fum al Khlig to Qualaly Square to El Abbassyia.

This manual provides information on how the AQEWS works, daily operations for using the AQEWS, and information on the development of the AQEWS. In addition, the table of contents and the flowcharts in Sections 2 and 3 can be used as a guide to find needed information or help on a given subject. Please note that some of the information found in this manual is also provided in the AQEWS program help text.

1.2 ABOUT PARTICULATE MATTER

Particulate matter (PM) is a general term for a mixture of solid particles and liquid droplets found in the air. Scientific studies have shown a link between PM concentrations and a series of significant health effects. Furthermore, PM effectively scatters and absorbs light; thereby, reducing visibility.

PM is composed of primary particles (particles emitted directly into the atmosphere) and secondary particles (gases that form PM in the atmosphere). Sources of primary PM include:

- Suspended dust
- Sea salt
- Elemental carbon
- Organic carbon
- Metals from combustion
- Small amount of sulfates and nitrates

Sources of secondary PM include:

- Sulfur dioxide (forms sulfates)
- Nitrogen dioxides (forms nitrates)
- Ammonia (forms ammonium compounds)

- Volatile organic compounds (forms organic carbon compounds)

Particulate matter naturally divides into to groups by particle size: fine PM, which comes from sources such as combustion and from the transformation of gaseous emissions and course PM, which comes from sources such as wind blown dust.

The AQEWS software forecasts the total concentration of fine particles and course particles (up to 10 ug/m^3 in diameter). This total is known as PM_{10}.

2. OVERVIEW OF THE DAILY PRODUCTION OF A PM_{10} FORECAST USING THE AQEWS PROGRAM

To produce a daily PM_{10} forecast, a forecaster completes the general steps shown in **Figure 2-1**.

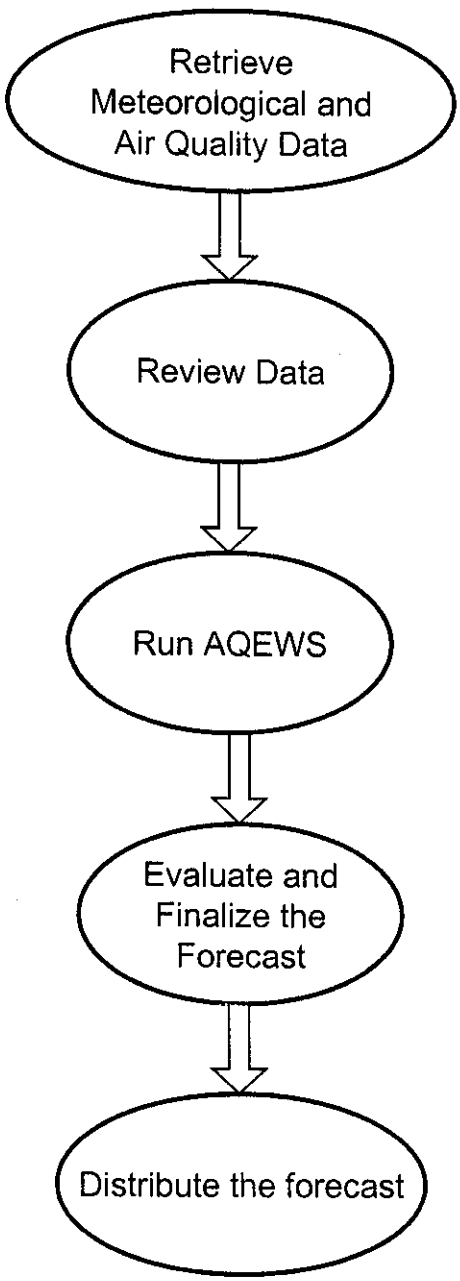


Figure 2-1. Daily forecast operations using AQEWS.

The general characteristics of the AQEWS program are shown in **Figure 2-2**. This figure contains ellipses that relate to the topics shown in the more detailed flowchart (in Section 3).

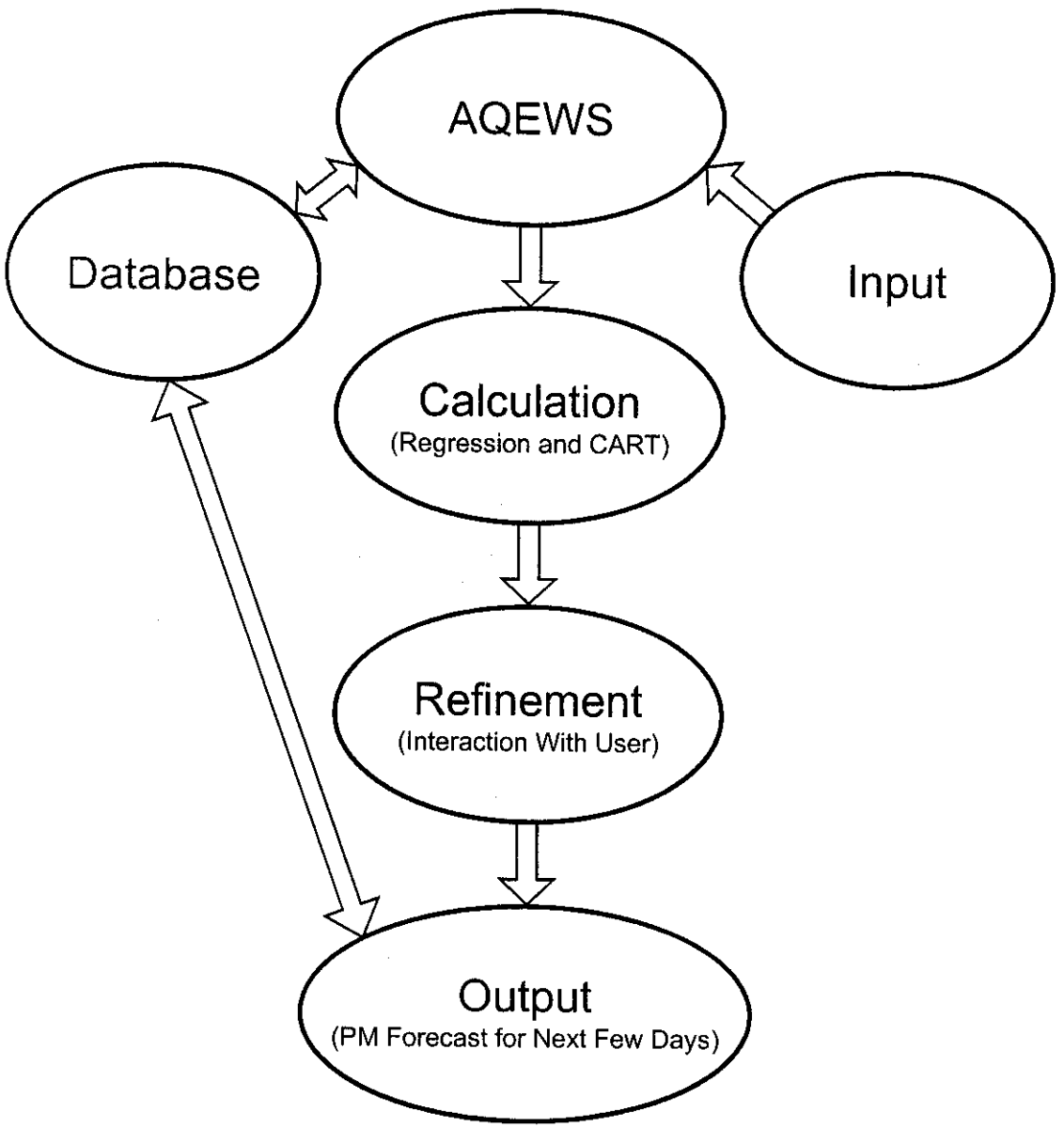


Figure 2-2. General characteristics of the AQEWS program.

The AQEWS uses a Microsoft Access database to store input data and output data, as well as other required information. Please do not alter the database except via the AQEWS.

The AQEWS requires air quality inputs including prior-day particulate matter concentrations measured at several monitoring sites and same-day particulate matter concentrations from one site, as well as meteorological inputs including both surface and aloft weather conditions and predictions of future weather. **Figures 2-3 through 2-5** show the three AQEWS input screens. Program inputs are described in detail in Section 3.1.

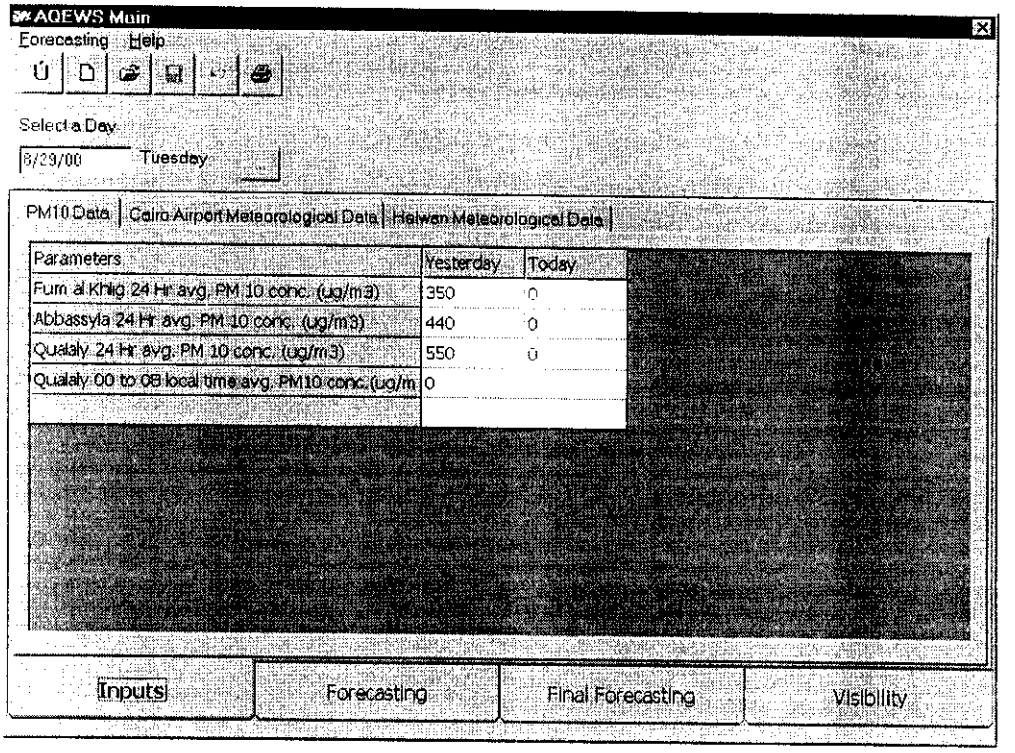


Figure 2-3. AQEWS air quality input screen.

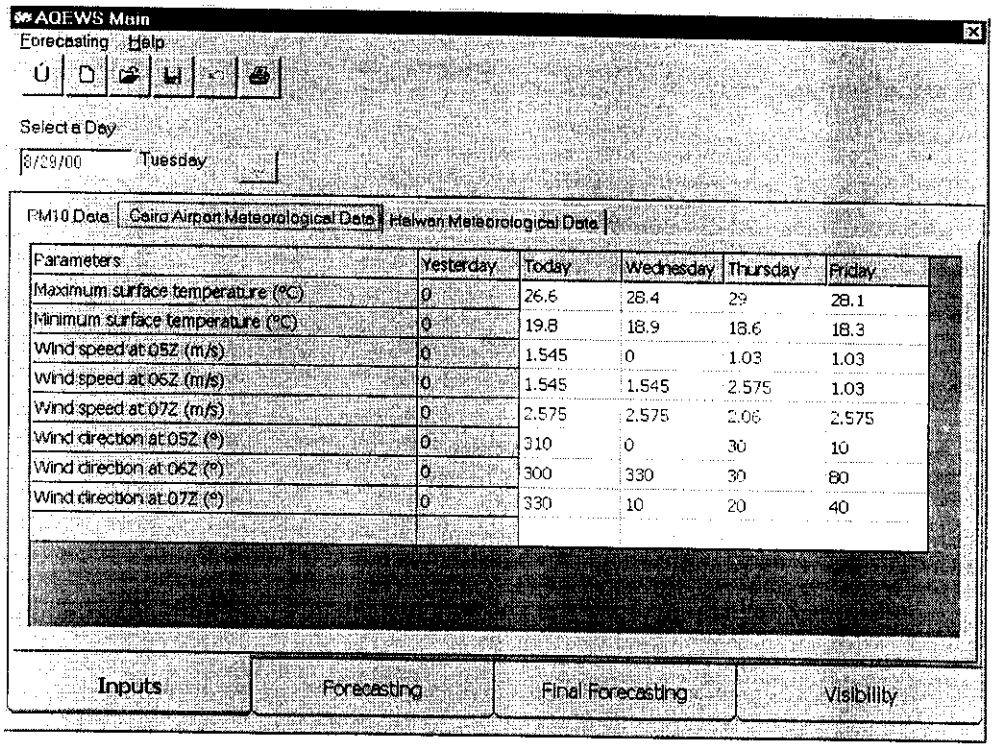


Figure 2-4. AQEWS Cairo Airport meteorological data input screen.

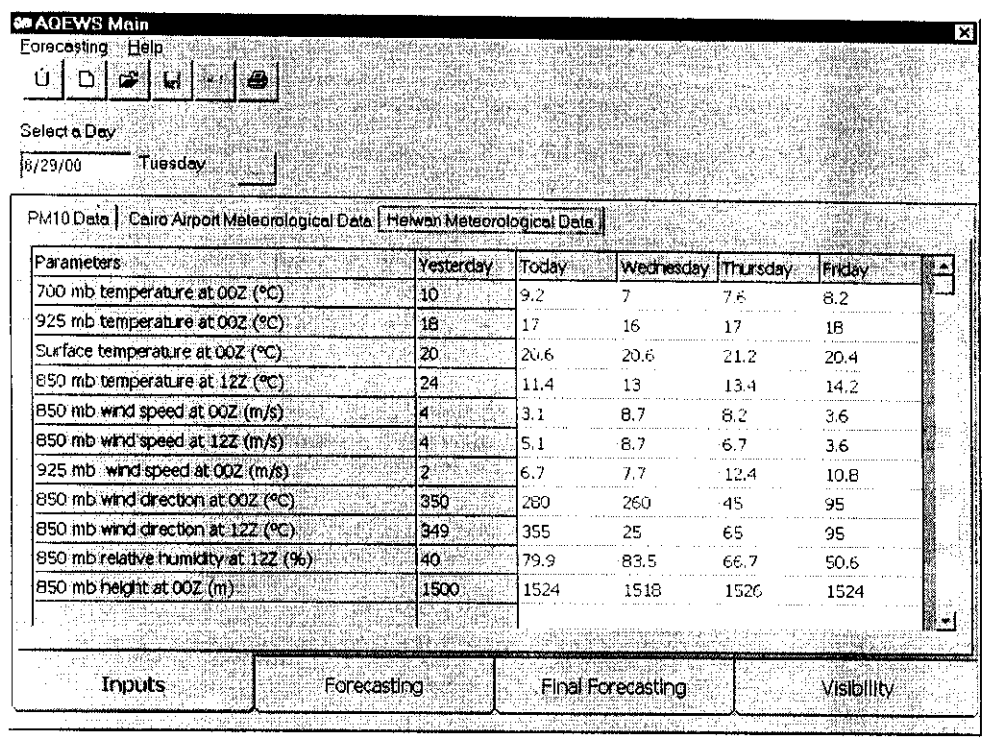


Figure 2-5. AQEWS Helwan meteorological data input screen.

The AQEWS uses a regression equation and CART (Classification and Regression Tree) to calculate particulate matter (PM_{10}) forecasts for the current and next day (**Figure 2-6**) based on the input data. The program also uses a regression equation to calculate a trend forecast for the next day and the two following days (Figure 2-6).

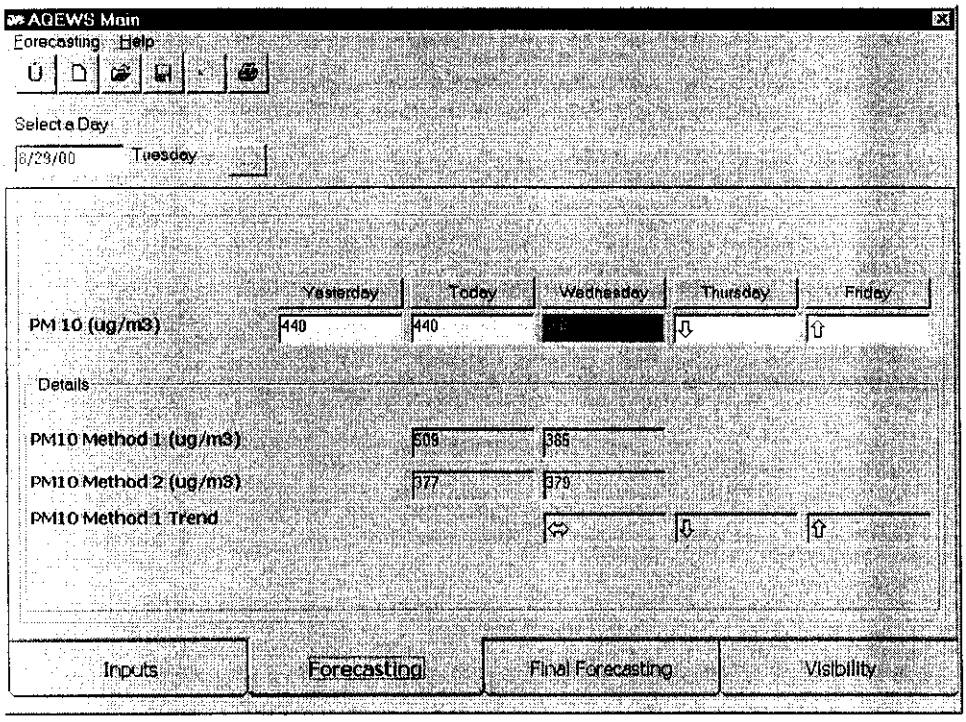


Figure 2-6. AQEWS initial forecast screen.

After the AQEWS calculates the PM_{10} forecast using regression and CART, the forecaster can use the system to refine or modify the forecast and add their own remarks (**Figure 2-7**). A final forecast is then produced and saved in the database; it can easily be printed out for distribution.

The AQEWS uses the PM_{10} forecast to simulate visibility in Cairo for the current day, prior day, or next day, or for past forecasts (**Figure 2-8**).

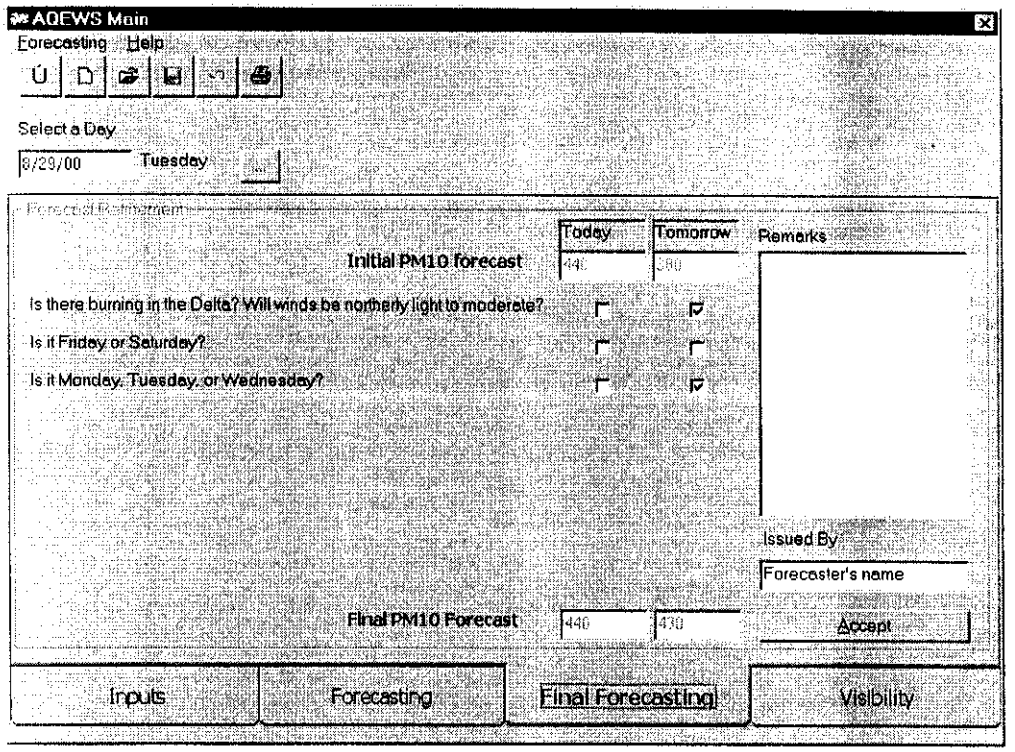


Figure 2-7. AQEWS final forecast screen.

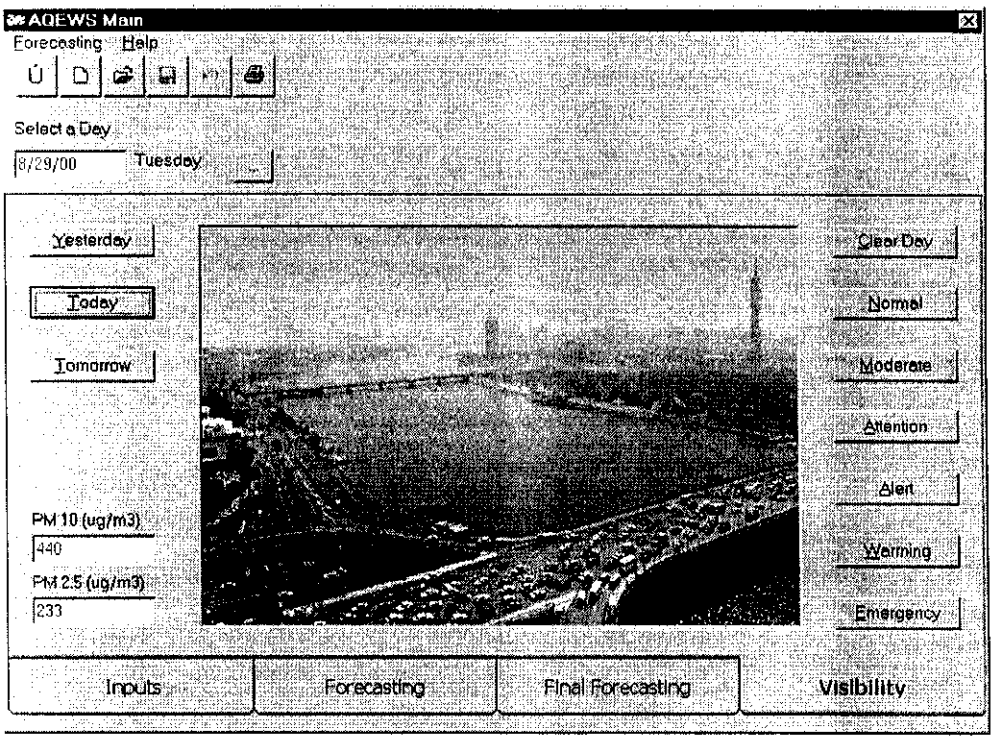


Figure 2-8. AQEWS visibility screen.

3. HOW THE AQEWS WORKS

This section presents details of how the AQEWS works including a description of the forecasting tools it uses to create PM_{10} forecasts. Some of the information in this section is also provided in the AQEWS program help text. Note that the forecasting algorithm is contained in Appendix A.

Figure 3-1 shows the process the AQEWS goes through to produce forecasts and visibility outcomes. Each box contains a reference to a section number in this training manual where more detailed information is provided.

As shown in Figure 3-1, the AQEWS:

1. Accepts meteorological and air quality data from a forecaster as inputs (see **Section 3.1**).

2. Applies a regression equation that uses only meteorological data to produce a PM_{10} trend forecast for "tomorrow", day 2, and day 3 (see **Section 3.2.4**).

3. Applies a regression equation that uses observed and forecasted meteorological and air quality data to produce a regression equation PM_{10} concentration forecast for "today" and "tomorrow" (see **Section 3.2.1**).

4. Applies a CART decision tree that uses observed and forecasted meteorological and air quality data to produce a CART PM_{10} concentration forecast for "today" and "tomorrow" (see **Section 3.2.2**).

5. Uses Fuzzy weighting to estimate an outcome across a discrete cutpoint by calculating a weighted average of two possible CART solutions (see **Section 3.2.3**).

6. Averages the CART and regression PM_{10} concentration forecasts (see **Section 3.2**).

7. Uses the trend forecast to adjust today's and tomorrow's PM_{10} concentration forecast (see **Section 3.2.5**).

8. Produces initial PM_{10} forecasts for "today" and "tomorrow."

9. Uses forecaster's input to refine the forecast and allows the forecaster to add remarks to produce a final forecast (see **Section 3.2.6 and 3.2.7**). The final forecast includes a PM_{10} concentration forecast for "today" and "tomorrow", and a PM_{10} trend forecast for "tomorrow", day 2, and day 3.

10. Allows the user to print a forecast form for distribution (see **Section 3.2.7**).

11. Simulates visibility using the final PM_{10} forecasts for "today" and "tomorrow" (see **Section 3.2.8**).

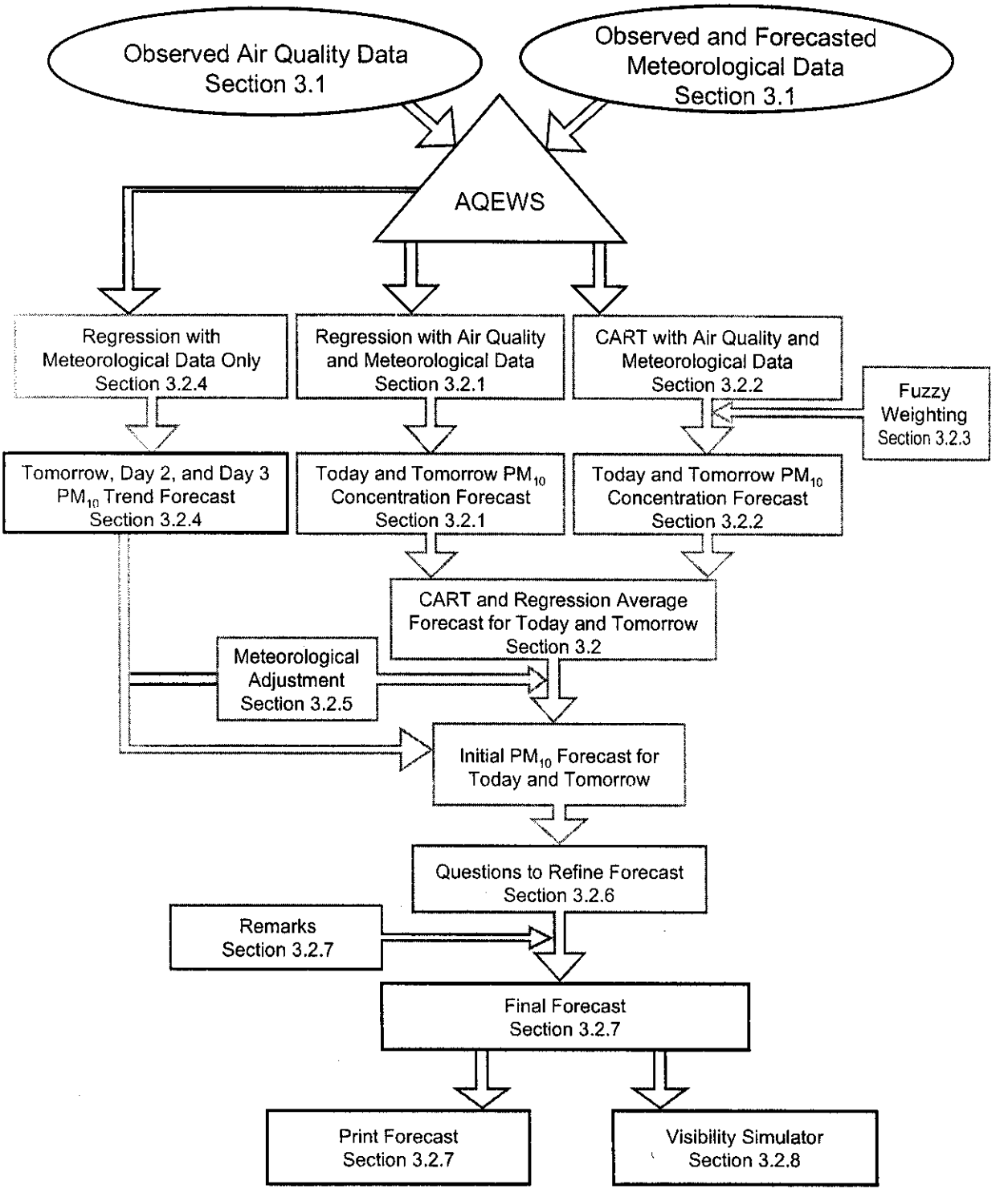


Figure 3-1. Flowchart showing how the AQEWS program produces forecasts and visibility information.

3.1 INPUT DATA

Input data used in the AQEWS are shown in **Table 3-1**. These data include observed PM_{10} and meteorological data and forecasted meteorological data. The meteorological data are both surface and upper-air data. The forecaster receives these data daily from various agencies. On a forecast basis, the meteorological data are produced by the Eta model.

It is not always possible to collect all of the necessary data. Under these circumstances, the forecaster must enter alternate data into the AQEWS program. Suggested alternate data are discussed in Section 4.7 and in the AQEWS help text.

Table 3-1. Input parameters and what they represent or are used for in PM_{10} forecasting.

Input Parameter	Represents/Used For
Fum al Khlig 24-hr avg. PM_{10} conc. (ug/m^3)	Persistence and carryover
Abbassyia 24-hr avg. PM_{10} conc. (ug/m^3)	Persistence and carryover
Qualaly 24-hr avg. PM_{10} conc. (ug/m^3)	Persistence and carryover
Qualaly 00 to 08 local time avg. PM_{10} conc. (ug/m^3)	Indication of today's 24-hour average PM_{10}
Maximum surface temperature (°C)	Strength of mixing
Minimum surface temperature (°C)	Strength of nocturnal inversion
Wind speed at 05Z (m/s)	Morning horizontal dispersion
Wind speed at 06Z (m/s)	Morning horizontal dispersion
Wind speed at 07Z (m/s)	Morning horizontal dispersion
Wind direction at 05Z (°)	Vector averaging
Wind direction at 06Z (°)	Vector averaging
Wind direction at 07Z (°)	Vector averaging
700-mb temperature at 00Z (°C)	Stability and vertical dispersion
925-mb temperature at 00Z (°C)	Stability and vertical dispersion
Surface temperature at 00Z (°C)	Strength of convection
850-mb temperature at 12Z (°C)	Stability and vertical dispersion
850-mb wind speed at 00Z (m/s)	Large scale wind and pressure patterns
850-mb wind speed at 12Z (m/s)	Large scale wind and pressure patterns
925-mb wind speed at 00Z (m/s)	Boundary layer dispersion
850-mb wind direction at 00Z (°C)	Large scale wind and pressure patterns
850-mb wind direction at 12Z (°C)	Large scale wind and pressure patterns
850-mb relative humidity at 12Z (%)	Subsidence
850-mb height at 00Z (m)	Subsidence and stability

3.2 "TODAY" AND "TOMORROW" PM_{10} CONCENTRATION FORECAST TOOLS

Two objective forecasting methods are used to provide the most accurate initial forecast possible: Classification and Regression Tree (CART), which is a decision tree, and multiple linear regression. The forecasts provided by each of these tools are averaged to produce an initial forecast value for PM_{10} concentrations for "today" and "tomorrow".

3.2.1 Regression

Regression is a statistical method for describing the relationship among variables. For PM_{10} forecasting, regression equations were developed to describe the relationship between PM_{10} concentration (referred to as the predictand, what is being predicted) and other predictor variables (e.g., temperature, wind speed, etc.). An excellent source of information regarding statistical methods is Wilks, 1995.[1]

How regression works

Multi-linear regression is used to forecast PM_{10}. If two variables are correlated, a line or a curve can describe the relationship between those variables using a mathematical equation. Using this equation and the input variables, AQEWS predicts PM_{10} concentrations.

$$PM_{10} = \text{constant} + c_1 V_1 + c_2 V_2 \ldots . c_n V_n$$

where:

PM_{10} = forecast variable
c = coefficients (weighting factors)
V = predictor variables

The specific regression equation for the "today" and "tomorrow" PM_{10} concentration forecasts used by the AQEWS is:

PM10 = -1112 - 1.125* HECADT-13.013*HECAWSAM +0.815*HGT8502AM + 3.973*V850_2AM+2.110*V850_2PM+3.419*DT925700_2AM- 310*RH8502PM+0.648*PM10YST

where:

PM_{10}	=	predicted PM_{10} concentration ($\mu g/m^3$)
HECADT	=	Cairo Airport maximum temperature - Cairo Airport minimum temperature (°C) for "today" or "tomorrow"
HECAWSAM	=	Cairo Airport average wind speed from 05Z to 07Z (m/s) for "today" or "tomorrow"
HGT8502AM	=	Height of the 850-mb level at Helwan at 00Z (m) for "today" or "tomorrow"

[1] Wilks D.S. (1995) *Statistical Methods in the Atmospheric Sciences*, Academic Press, NY.

V850_2AM = North-south component of the wind speed at 850-mb level at Helwan at 00Z (m/s) for "today" or "tomorrow"

V850_2PM10 = North-south component of the wind speed at 850-mb level at Helwan at 12Z (m/s) for "today" or "tomorrow"

DT925700_2AM = Difference in temperature from 925 mb to 700 mb at Helwan at 00Z (°C) for "today" or "tomorrow"

RH8502PM10 = Relative humidity at 850 mb at Helwan at 12Z (%) for "today" or "tomorrow"

PM10YST = Yesterday's average PM_{10} 24-hour concentration from Qualaly Square, El Abbassyia, and Fum El Khalig monitoring sites ($\mu g/m^3$) for "today" or "tomorrow", where "tomorrow's" forecast uses "today's" final PM_{10} forecast as "yesterday's" average PM_{10} 24-hour concentration.

The AQEWS uses the data inputs to calculate PM_{10} concentration forecasts based on this regression equation. For example, if the values of the input variables are 25°C, 2 m/sec, 1550 m, 2 m/sec, 4 m/sec, 14°C, 20%, and 500 $\mu g/m^3$, respectively, then the model would forecast a PM_{10} concentration of 486 $\mu g/m^3$.

Regression analysis strengths

- Regression analysis is well documented and widely used in a variety of disciplines.
- Regression software is widely available and runs on a personal computer. It is generally easy to use.
- Regression is an objective forecasting method that reduces potential biases arising from human subjectivity.
- Regression can properly weight relationships that are difficult to subjectively quantify.

Regression analysis limitations

- Regression equations require a modest amount of expertise and effort to develop.
- Regression equations tend to predict the mean better than the tails (i.e., the highest PM_{10} concentrations) of the distribution. They will likely underpredict the high concentrations and overpredict the low concentrations.

3.2.2 Classification and Regression Tree (CART)

CART is a statistical procedure designed to classify data into two distinct (or dissimilar) groups. It uses software to develop a decision tree by continuously splitting daily 24-hour average PM_{10} concentration data into two groups based on a single value of a selected predictor variable. The selected predictor variable and the threshold cutoff value are determined by the

CART software. The software identifies the variables with the highest correlation with PM_{10} and splits the data set into the two most dissimilar groups. The splitting of the data set and tree development continues until the data in each group are sufficiently uniform. An excellent source of information regarding CART is Breiman et al., 1984.[2] Predictor variables used in CART include meteorological data (i.e., temperature, wind speed, cloud cover, etc.) and air quality data.

Figure 3-2 shows the decision tree used in the AQEWS to forecast PM_{10} concentrations for "today" and "tomorrow". This decision tree was develop using 38 predictor variables, which include observed PM_{10} data and observed and forecasted meteorological data. Of the 38 predictor variables, yesterday's observed 24-hour average PM_{10} concentration describes the greatest amount of the variance in today's 24-hour average PM_{10} concentration; it was used as the first data split. This split resulted in the two most dissimilar groups: Group 1 (for 24-hour average PM_{10} concentration less than 375 $\mu g/m^3$) and Group 2 (for 24-hour average PM_{10} concentration greater than 375 $\mu g/m^3$). CART was then applied to Groups 1 and 2 using the same set of 38 predictor variables. The tree growth continued until there were nine distinct groups.

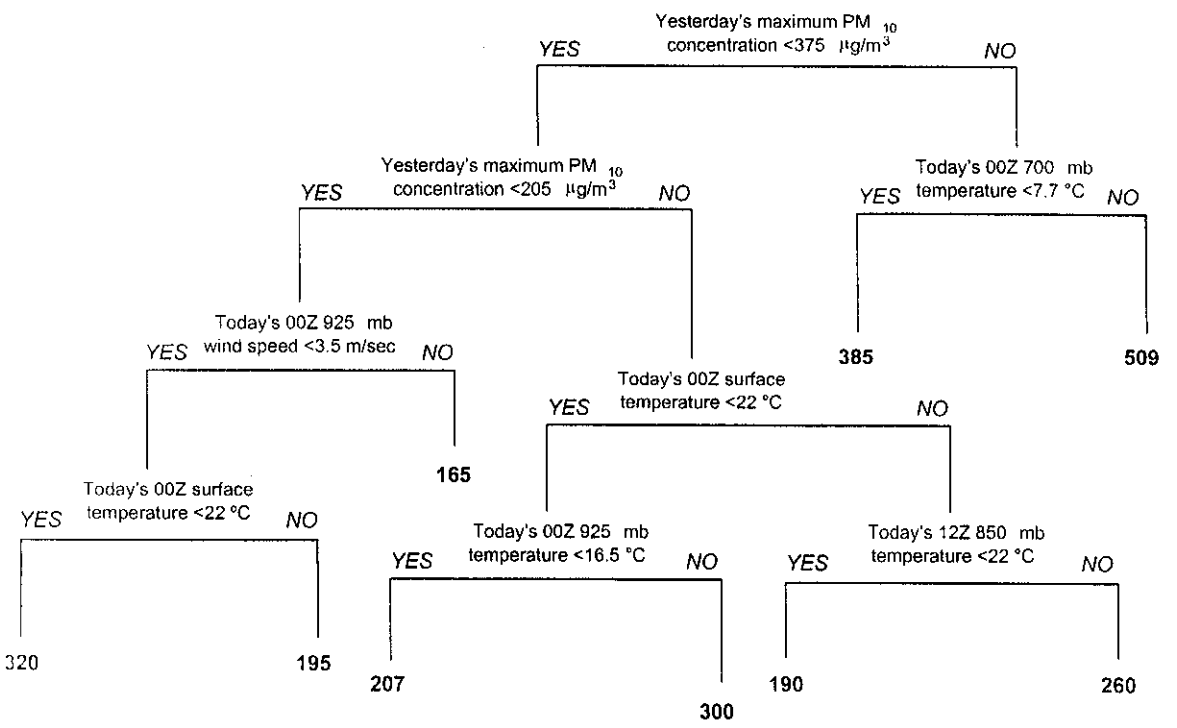


Figure 3-2. CART decision tree for forecasting "today's" and "tomorrow's" PM_{10} concentrations.

[2] Breiman L., Friedman J.H., Olshen R.A., and Stone C.J. (1984) *Classification and Regression Trees*, Chapman & Hall/CRC, Boca Raton, FL.

How the AQEWS uses CART to predict PM_{10} concentrations

The AQEWS uses data inputs to calculate PM_{10} concentration forecasts based on the CART decision tree. As shown in the tree, each question relates to whether a predictor variable is above or below a given value (a cutpoint). After following a particular path down the tree guided by the answers to the questions, AQEWS arrives at a PM_{10} concentration forecast. For example, if yesterday's maximum PM_{10} concentration was greater than 375 $\mu g/m^3$ and today's 00Z 700-mb temperature is greater than 7.7°C, the CART PM_{10} forecast for "today" is 509 $\mu g/m^3$.

Note that slight differences in the input variables can produce significant changes in the predicted PM_{10} concentrations. To help mitigate this issue, Fuzzy weighting is applied to the first cutpoint in the decision tree. Fuzzy weighting is discussed in Section 3.2.3.

CART strengths

- Requires little expertise to operate; runs quickly.
- Complements other subjective forecasting methods.
- Allows the forecaster to differentiate between days with similar PM_{10} concentrations if the PM_{10} concentrations are a result of different processes.

CART limitations

- Requires a modest amount of expertise and effort to develop.
- Slight changes in predicted variables may produce large changes in the predicted PM_{10}.
- Can only predict PM_{10} concentrations based on information contained within the observed and forecasted data. Changes in the predicted weather conditions may not be reflected in the predictor variables and may cause uncertainty in the PM_{10} predictions.
- May not predict PM_{10} concentrations during periods of unusual emissions patterns due to holidays or other events; however, human forecasters can account for these changes and their potential impact on PM_{10} concentrations.

3.2.3 Fuzzy Weighting

Fuzzy weighting helps estimate an outcome across a discrete cutpoint. The AQEWS uses fuzzy weighting when the input PM_{10} data are ±40 $\mu g/m^3$ of the 375 $\mu g/m^3$ cutpoint in the CART decision tree. Here is an example of how it works:

If the observed PM_{10} is 365 $\mu g/m^3$ (i.e., within 40 $\mu g/m^3$ of 375 $\mu g/m^3$), then the AQEWS calculates two PM_{10} forecasts:

1. For PM_{10} of less than 375 $\mu g/m^3$
2. For PM_{10} greater than 375 $\mu g/m^3$

The AQEWS calculates a weighted average of the two solutions. For example, if the input data include:

PM_{10} = 365 μg/m^3

00Z surface temperature = 19°C

00Z 700-mb temperature = 9°C

00Z 925-mb temperature = 18°C

then according to the tree shown in **Figure 3-3**, the two CART solutions calculated by the AQEWS are 300 μg/m^3 and 509 μg/m^3.

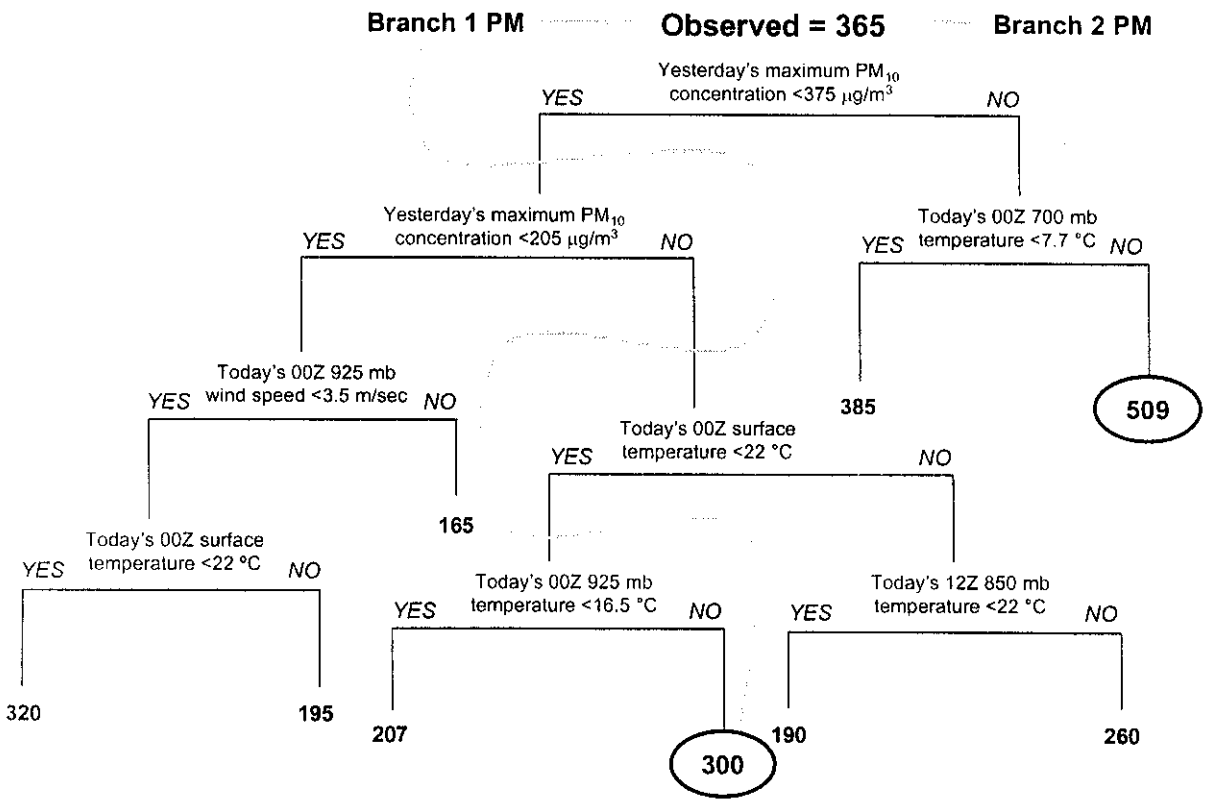
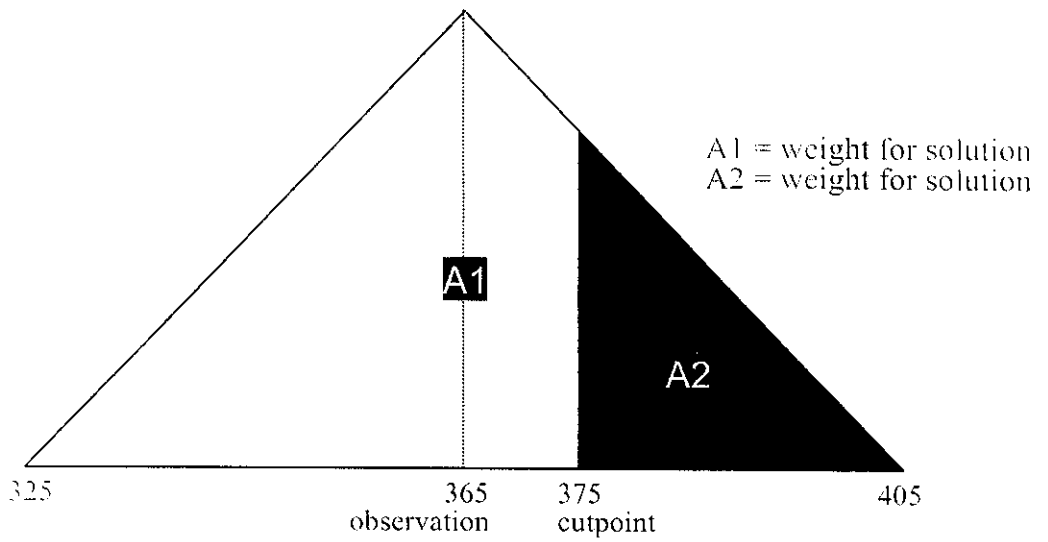


Figure 3-3. Decision tree showing the two outcomes for the example case.

Next, the AQEWS calculates a weighted average of the two solutions as demonstrated in **Figure 3-4**. For this example, the AQEWS forecast using Fuzzy weighting is 355 μg/m^3.



$$Branch\,1\,PM \times (\frac{A1}{(A1+A2)}) + Branch\,2\,PM \times (\frac{A2}{(A1+A2)}) = (Fuzzy\ weighted\ \ forecast)$$

$$(300)\ (.71) + (509)\ (.28) = 355 \mu g/m^3$$

Figure 3-4. Schematic of how the AQEWS calculates a weighted average of the two PM_{10} forecast solutions.

3.2.4 Trend Forecasts

A trend forecast provides an indication of whether PM_{10} concentrations are expected to increase, decrease, or remain about the same tomorrow and on the second and third days.

How trend forecasts are computed

The process for computing a PM_{10} trend forecast is shown in **Figure 3-5**. PM_{10} trend forecasts are computed using a regression equation that uses only meteorological data for inputs and no air quality data. After the AQEWS generates a PM_{10} forecast for each day, the program objectively reviews day-to-day relative changes between the PM_{10} forecasts to determine the PM_{10} trend. If the forecasted PM_{10} concentrations increase by 50 $\mu g/m^3$ from one day to the next, then the PM_{10} trend is deemed to be increasing for the next day. Likewise, if the forecasted PM_{10} concentrations decrease by 50 $\mu g/m^3$ from one day to the next, then the PM_{10} trend is deemed to be decreasing for the next day. Otherwise, the PM_{10} trend is deemed unchanged.

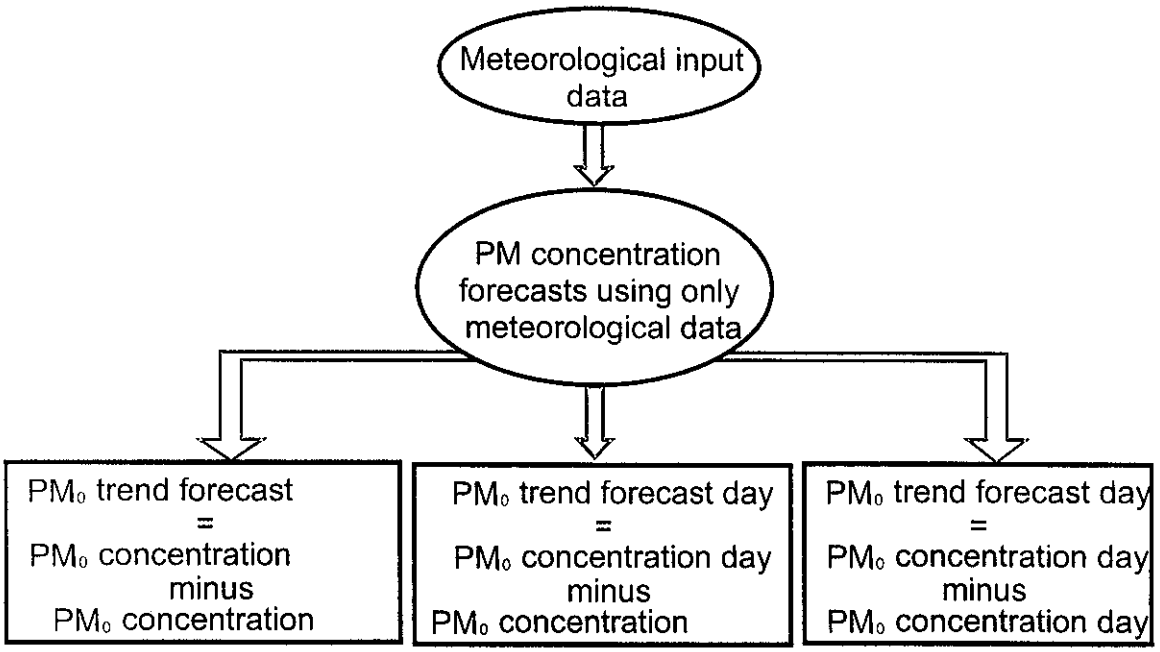


Figure 3-5. Process for computing a PM_{10} trend forecast.

The regression equation used for AQEWS trend forecasting is:

PMMET_1 = (-1) * 2146 + (0.973 * HECADT) + (-46.29 * HECAWSAM) + (1.599 * HT850_1) + (7.586 * V850_2AM) + (0.833 * V850_2PM) + (10.416 * DT925700_1A) + (-0.476 * RH850_1)

where:

PM10	=	predicted PM_{10} concentration (ug/m^3) used in the trend calculation
HECADT	=	Cairo Airport maximum temperature - Cairo Airport minimum temperature (°C) for "today, tomorrow, day2, or day 3"
HECAWSAM	=	Cairo Airport average wind speed from 05Z to 07Z (m/s) for "today, tomorrow, day2, or day 3"
HGT8502AM	=	Height of the 850-mb level at Helwan at 00Z (m) for "today, tomorrow, day2, or day 3"
V850_2AM	=	North-south component of the wind speed at 850-mb level at Helwan at 00Z (m/s) for "today, tomorrow, day2, or day 3"
V850_2PM	=	North-south component of the wind speed at 850-mb level at Helwan at 12Z (m/s) for "today, tomorrow, day2, or day 3"
DT925700_2AM	=	Difference in temperature from 925 mb to 700 mb at Helwan at 00Z (°C) for "today, tomorrow, day2, or day 3"
RH8502PM	=	Relative humidity at 850 mb at Helwan at 12Z (%) for "today, tomorrow, day2, or day 3"

What a trend forecast represents

A trend forecast indicates if PM_{10} concentrations are expected to increase, decrease, or remain about the same due to changes only in the meteorology. No persistence information is used in this forecast (i.e., yesterday's PM_{10} concentration). Since the PM_{10} trend forecast is generated differently than the PM_{10} concentration forecast, these forecasts may contradict one other. For example, a PM_{10} concentration forecast may indicate that the PM_{10} concentration is going to increase by 60 $\mu g/m^3$ from "today" to "tomorrow"; whereas, the PM_{10} trend forecast may indicate no change in PM_{10} concentration from "today" to "tomorrow". If such a situation occurs, the PM_{10} forecast has a greater uncertainty compared to when the two forecasts agree.

3.2.5 Meteorological Adjustment

Because today's and tomorrow's PM_{10} concentration forecasts are heavily dependent on yesterday's observed PM_{10} and today's PM_{10} forecast, respectively, it is necessary to adjust these forecasts when large changes in the weather are expected. The adjustment of today's and tomorrow's PM_{10} concentration forecasts is called the "meteorological adjustment".

How it works

Today's and tomorrow's PM_{10} concentration forecasts are adjusted using the information from today's and tomorrow's PM_{10} trend forecasts, which are computed using the regression equation that only uses meteorological data as inputs. The adjustments to today's and to tomorrow's PM_{10} forecasts are summarized in **Table 3-2.**

Table 3-2. Meteorological adjustment to today's and tomorrow's PM_{10} concentration forecast.

PM_{10} concentration trend from yesterday to today or from today to tomorrow calculated by the meteorological regression equation		Adjustment to today's or tomorrow's PM_{10} forecast
Increase of more than 100 $\mu g/m^3$	then	Increase by 80 $\mu g/m^3$
Increase between 80 and 100 $\mu g/m^3$		Increase by 60 $\mu g/m^3$
Decrease more than -70 $\mu g/m^3$		Decrease by -70 $\mu g/m^3$
Change between –70 and +80 $\mu g/m^3$		Make no adjustment

For example, if the PM_{10} concentration forecast for "tomorrow" produced by the meteorological regression equation is 400 $\mu g/m^3$ and the PM_{10} concentration forecast for "today" produced by the meteorological regression equation is 200 $\mu g/m^3$, then the PM_{10} concentration

trend is for a 200 $\mu g/m^3$ increase; therefore, AQEWS increases tomorrow's PM_{10} concentration forecast by 80 $\mu g/m^3$.

3.2.6 Refining the Initial Forecast

To refine the PM_{10} forecast for "today" and "tomorrow", the forecaster must enter answers to a few objective questions in the AQEWS. The questions, the rationale for the questions, and the effect on the PM_{10} forecasts are presented below. Note that new questions can be added to the program as new information becomes available regarding PM_{10} in Cairo.

Question #1: Is there burning in the Nile Delta and are winds expected to be northerly light to moderate?

If yes, then the PM_{10} forecast is increased by 30 $\mu g/m^3$.

This question captures the influence of PM transport from fires in the delta into the Cairo area on PM_{10} concentrations in Cairo. The 30 $\mu g/m^3$ increase was subjectively determined. Future refinement to this concentration increase may be needed.

Question #2: Is it Friday or Saturday?

If yes, then the PM_{10} forecast is decreased by 20 $\mu g/m^3$.

Question #3: Is it Monday, Tuesday, or Wednesday?

If yes, then the PM_{10} forecast is increased by 20 $\mu g/m^3$.

Questions 2 and 3 capture the changes in emissions throughout the week and the resulting influence of those changes on PM_{10} concentrations. Analysis has shown that PM_{10} concentrations in Cairo were about 20 $\mu g/m^3$ lower on Friday and Saturday and about 20 $\mu g/m^3$ higher on Monday, Tuesday, and Wednesday compared to the weekly average PM_{10} concentration. See Appendix C for details.

3.2.7 Final Forecast

After answering the above questions, the forecaster can add any remarks regarding the forecast and then accept the final forecast. See Appendix E for example remarks. The forecast can then be printed and distributed.

3.2.8 Visibility

The AQEWS uses computer imaging to simulate visibility changes in Cairo due to different PM_{10} concentrations. In the program, you can view visibility simulations for "yesterday" (based on "yesterday's" PM_{10} concentrations) as well as "today's" and

"tomorrow's" forecasted visibility. For comparison, you can view the visibility associated with various episode levels by clicking on the buttons on the right side of the Visibility screen.

4. USING THE AIR QUALITY EARLY WARNING SYSTEM (AQEWS)

The following topics are presented in this section:

- Installing AQEWS (Section 4.1)
- Generating and saving a new forecast (Section 4.2)
- Viewing an old forecast (Section 4.3)
- Simulating visibility (Section 4.4)
- Printing reports (Section 4.5)
- Exiting the program (Section 4.6)
- Handling missing data (Section 4.7)

This information is also available in the AQEWS help text.

4.1 INSTALLING AQEWS

The AQEWS package contains a compact disk (CD) with program installation files. Complete the following steps to install the software:

1. Insert the CD into the CD drive.
2. Click **Start** from the Windows task bar, then select **Run**.
3. Select **Setup.exe** on the CD drive.
4. Follow the instructions that appear on each screen and click **Finish** to complete the installation.
5. Remove the CD and store it in a safe place.

The AQEWS program will create a program group called "AQEWS". From the Windows Start/Programs menu click on **AQEWS** to start the program.

4.2 GENERATING AND SAVING A NEW FORECAST

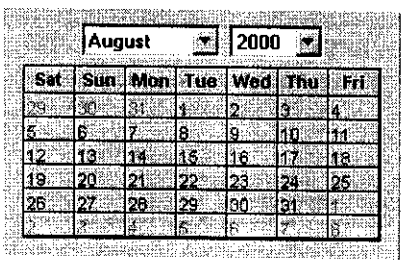
To create a new forecast:

1. Select **New** from the **Forecasting** menu or press the **New Forecast** icon.
2. Enter all values in each of the three input screens or use the **Get Data** function to automatically import the meteorological data. To use the Get Data function, the meteorological and air quality data must be in the format provided by the EMA and EEAA, respectively. Also, the data must reside in the "csv" subdirectory of the directory where the AQEWS program resides. The meteorological data file needs to be named weaenv.csv and the air quality file needs to be named eimp.csv. Finally, the meteorological and air quality data files must be over written with the latest data files each day.

3. Select **Save** from the **Forecasting** menu or press the **Save** icon.
4. Click on the **Forecasting tab** to compute and save the forecast. At this point, if you need to change an input value, click on the **Inputs tab** and select **Open** from the **Forecasting** menu or press the **Open an existing forecast** icon. This will re-open the database and allow you to change input values. After changing any values, click on the **Forecasting tab** to compute and save the updated forecast. This new forecast will overwrite the previous forecast. Note that only one forecast per day can be saved in the database.
5. Answer the questions on the **Final Forecasting tab** to complete the forecast. Click **Accept** to save the final forecast. At this point, if you want to change any input variables, click on the **Inputs tab** and select **Open** from the **Forecasting** menu or press the **Open an existing forecast** icon as discussed above.

4.3 VIEWING AN OLD FORECAST

You can view old forecasts by selecting **Open** from the **Forecasting** menu or by pressing the **Open an existing forecast** icon. Then, click on the calendar icon to select the date. You can view the input parameters, forecasts, and visibility simulations by clicking on the appropriate tab. Note that you cannot change the values of input parameters when viewing an old forecast.



4.4 SIMULATING VISIBILITY

The AQEWS uses computer imaging to simulate visibility changes in Cairo due to different PM_{10} concentrations. You can view visibility simulations for "yesterday" (based on "yesterday's" PM_{10} concentrations) as well as "today's" and "tomorrow's" forecasted visibility. For comparison, you can view the visibility associated with various episode levels by clicking on the buttons on the right side of the Visibility screen.

4.5 PRINTING REPORTS

To print a report of the current forecast, select **Print** from the **Forecasting** menu or press the **Print** icon on the toolbar. The printed report shows the PM_{10} forecast and any remarks made by the forecaster.

To print a report from another day, follow the procedures for **View an old forecast**. Then select **Print** from the **Forecasting** menu. Or press the **Print** icon on the toolbar.

4.6 EXITING THE PROGRAM

Exit the program by clicking the X in the upper-right corner of the screen or selecting **Exit** from the **Forecasting** menu. When you exit, all windows will be closed and the last saved data will be stored in the database.

4.7 HANDLING MISSING DATA

Match your cells with missing data to the examples shown in **Figures 4-1 through 4-3**. Guidelines for handling missing data are described according to the reference number in each cell.

PM_{10} Data

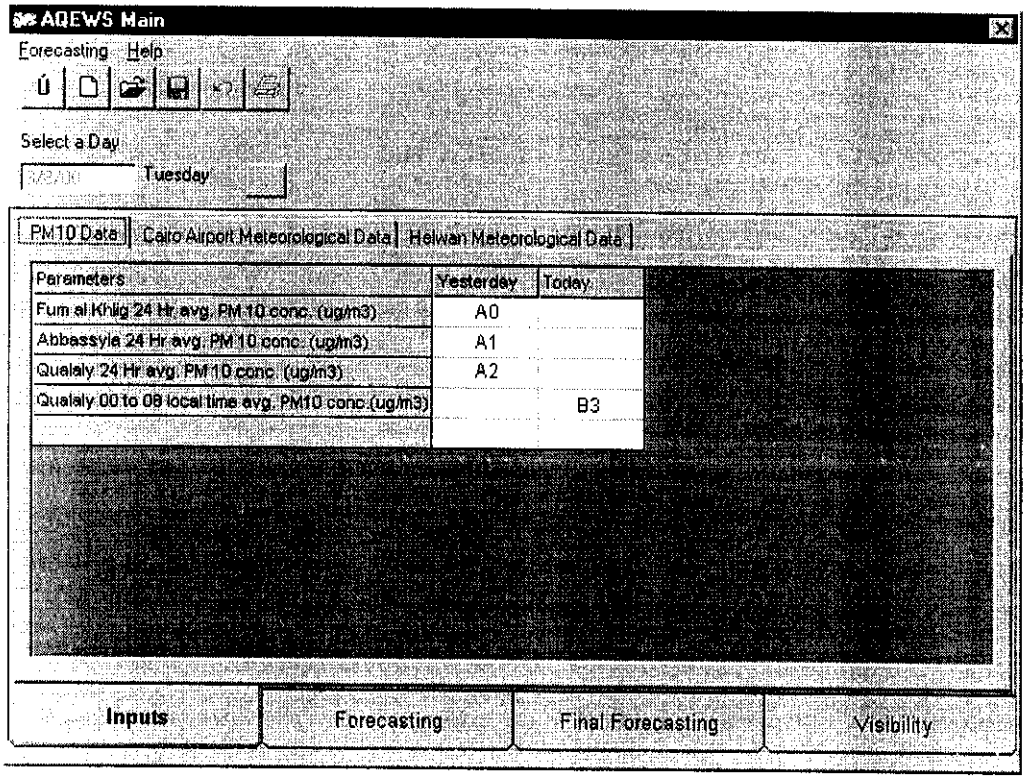


Figure 4-1. AQEWS air quality input screen.

A0: If missing, leave it blank.

A1: If missing, leave it blank.

A2: If missing, leave it blank.

However, if **A0, A1, and A2** are all missing, use yesterday's forecasted 24-hour average concentration.

B3: If missing, leave it blank.

Cairo Airport Meteorological Data

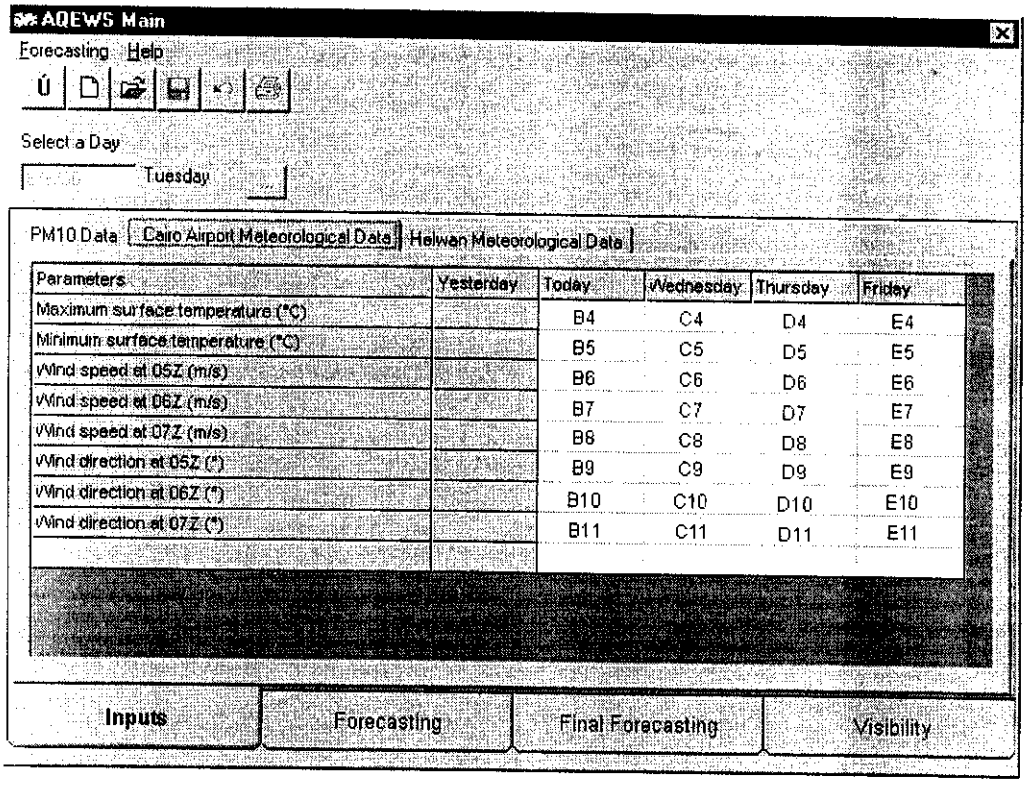


Figure 4-2. AQEWS Cairo Airport meteorological data input screen.

B4, C4, D4, E4: If missing, use the maximum surface temperature forecast from the prior model run.

B5, C5, D5, E5: If missing, use the minimum surface temperature forecast from the latest model run.

B6, B9: If missing, use Cairo Airport's observed wind speed and direction at 04Z.

B7, B10: If missing, use Cairo Airport's observed wind speed and direction at 05Z or 07Z.

B8, B11: If missing, use Cairo Airport's observed wind speed and direction at 06Z or 08Z.

B6, B7, B8, B9, B10, B11: If Cairo Airport's observed surface wind speeds and directions at 03Z, 04Z, 05Z, 06Z, 07Z, 08Z are all missing, use the Cairo Airport's forecasted wind speeds and directions for 05Z, 06Z, and 07Z from the prior model run.

C6, C7, C8, C9, C10, C11, D6, D7, D8, D9, D10, D11, E6, E7, E8, E9, E10, E11: For any missing values, use Cairo Airport's forecasted 05Z, 06Z, or 07Z wind speeds and directions from the prior model run for that value.

Helwan Meteorological Data

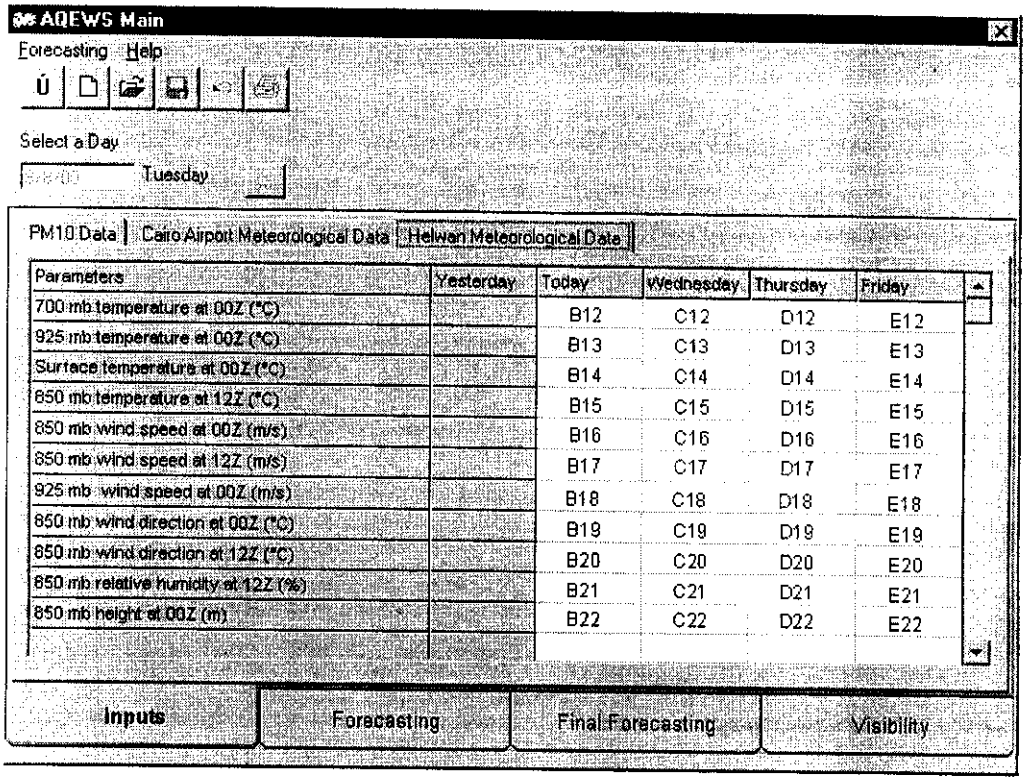


Figure 4-3. AQEWS Helwan meteorological data input screen.

B12: If missing, use the Helwan 00Z 700-mb temperature forecast from the prior model run or use the Helwan 00Z 700-mb temperature observation for 12Z from yesterday.

C12, D12, E12: If missing, use the Helwan 12Z 700-mb temperature forecast from the prior model run.

B13: If missing, use the Helwan 00Z 925-mb temperature forecast from the prior model run or use the 00Z 925-mb temperature observation from yesterday.

C13, D13, E13: If missing, use the Helwan 00Z 925-mb temperature forecast from the prior model run.

B14: If missing, use the Helwan 00Z surface temperature forecast from the prior model run or use Cairo Airport's 00Z surface temperature observation.

C14, D14, and E14: If missing, use the Helwan 00Z surface temperature forecast from the prior model run.

B15: If missing, use the Helwan 12Z 850-mb temperature forecast from the prior model run or use the Helwan 12Z 850-mb temperature observation from yesterday.

C15 and D15: If missing, use the Helwan 12Z 850-mb temperature forecast from the prior model run.

B16 and B19: If missing, use the Helwan 00Z 850-mb wind speed and direction forecast from the prior model run or use the Helwan 00Z 850-mb wind speed and direction observation from yesterday.

C16, C19, D16, D19, E16, and E19: If missing, use the Helwan 00Z 850-mb wind speed and direction forecast from the prior model run.

B17 and B20: If missing, use the Helwan 12Z 850-mb wind speed and direction forecast from the prior model run or use the Helwan 12Z 850-mb wind speed and direction observation from yesterday.

C17, C20, D17, D20, E17, and E20: If missing, use the Helwan 12Z 850-mb wind speed and direction forecast from the prior model run.

B18: If missing, use the Helwan 00Z 925-mb wind speed forecast from the prior model run or use the Helwan 00Z 925-mb wind speed observation from yesterday.

C18, D18, and E18: If missing, use the Helwan 00Z 925-mb wind speed and direction forecast from the prior model run.

B21: If missing, use the Helwan 12Z 850-mb relative humidity forecast from the prior model run or use the 12Z 850-mb relative humidity observation from yesterday.

C21, D21, and E21: If missing, use the Helwan 12Z 850-mb relative humidity forecast from the prior model run.

B22: If missing, use the Helwan 00Z 850-mb height forecast from the prior model run or use the 00Z 850-mb height observation from yesterday.

C22, D22, and E22: If missing, use the Helwan 12Z 850-mb height forecast from the prior model run.

5. DAILY OPERATIONS

To produce a daily PM_{10} forecast, a forecaster completes the general steps shown in **Figure 5-1**. Procedural details by time and activity are shown in **Figure 5-2**.

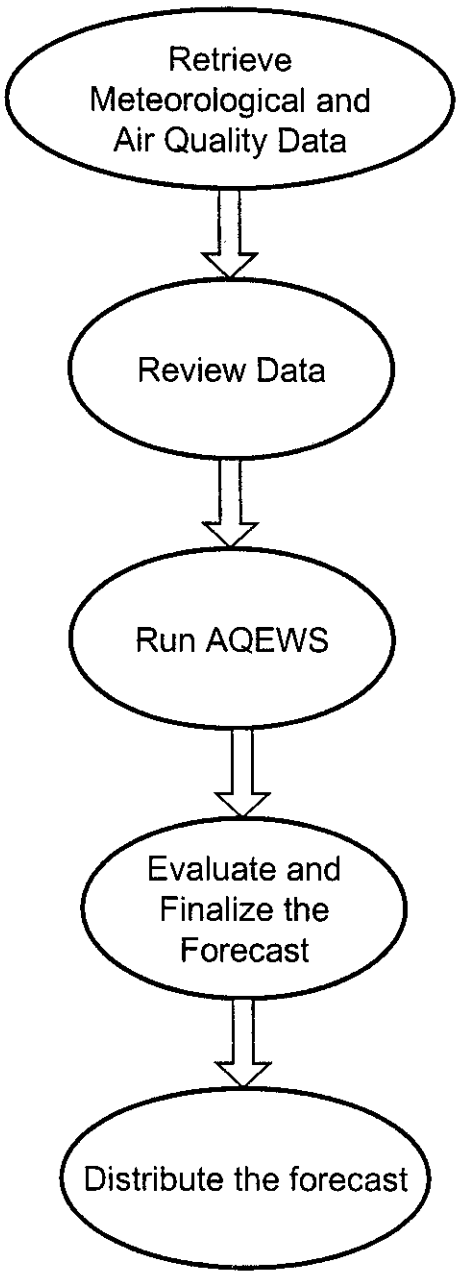


Figure 5-1. Daily forecasting operations using AQEWS.

Daily Forecast Activities

Task *(time)*

Receive Data *(0900)*

Check that all EIMP data have been received.
Check that all EMA data have been received.
Are any data missing? Please explain.

_____

_____

If data have not been received, use alternate data delivery method such as FAX.
If data are missing, follow the missing data procedure in the training manual or AQEWS Help.

Review Data *(1000)*

Evaluate yesterday's forecast accuracy using the accuracy verification spreadsheet.
Was the forecast missed by more than one category or 100 ug/m^3? If so, please explain and complete the missed forecast form.

_____

Review today's weather observations, forecasts charts, and upper-air observations from Helwan to determine the general meteorological conditions and forecast trend.

Have forecasted weather conditions changed since yesterday? Please explain.

_____

_____

_____

Are large weather changes expected over the next few days? Please explain.

_____

_____

_____

Is the inversion strength expected to change? Please explain.

_____

_____

Are surface and aloft winds expected to change? Please explain.

_____

_____

How might the weather conditions influemce the PM concentrations over the next several days? Please explain.

_____

_____

Evaluate the input data quality.
Do the input data reflect the general weather conditions? Please explain. If not, the input data may be old or wrong and the data needs to be replace as described in the missing data protocol in the AQEWS Help.

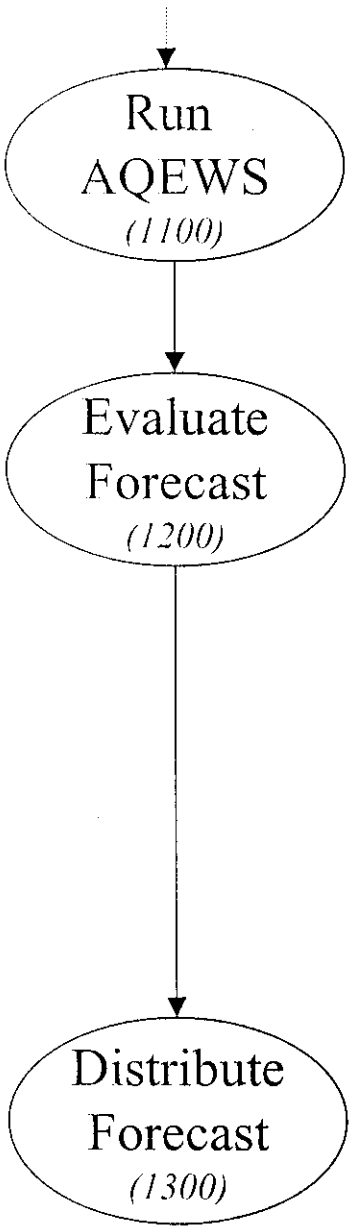
_____

_____

Figure 5-2. Detailed list of daily forecast activities.

Daily Forecast Activities Continued

Task *(time)* — Action and Questions



Run AQEWS (1100)

Enter the input data.
Run the initial forecast
Input remarks.
Produce the final AQEWS forecast.
Review the final forecast form.

Evaluate Forecast (1200)

Compare the AQEWS forecast to the weather trend.

Is AQEWS forecast consistent with the trend? Please explain. If not, reevaluate the input data and forecast trend. Rerun the AQEWS forecast as needed..

_____

_____

_____

Run other forecasting methods (if available).

Do the other methods agree with the AQEWS forecast? Please explain. If so, the forecast certainty is high. If not, reevaluate the input data used in all models and re-run the models as needed. If the forecast still disagree, then forecast certainty is lower than when the forecasts agree.

_____

_____

_____

Review the final forecast.
Add qualifiers to the forecast discussion.
Add uncertainty discussion to forecast

Distribute Forecast (1300)

Copy the forecast and post it on the wall.
Distribute the forecast.
Run verification statistics
Backup database on the other computer and on a floppy disk.

6. SUBJECTIVE FORECAST INPUT

Although the AQEWS can produce a final PM_{10} forecast without subjective input, subjective input can be used to understand or improve the final AQEWS PM_{10} forecast. This section presents examples of information obtained from weather forecast charts and rawinsondes that can be used for subjective input. It is important to note that the information presented in this section is derived from only two high PM_{10} episodes in Cairo, October 20-25, 1999, and November 17-24, 1999. These episodes do not represent all of the different types of PM episodes.

October 20-25, 1999 PM Episode

Figure 6-1 shows PM_{10} concentrations during a PM episode in Cairo from October 20 to 25, 1999. As shown in the figure, the highest PM_{10} concentrations of this episode occurred on October 23. The important meteorological characteristics of this episode include the following:

- Weak upper-level troughs passed over and north of Egypt (**Figure 6-2**).
- The troughs lowered surface pressures north of Egypt, thereby weakening the northerly winds; but the winds still remained moderate from the north (Figure 6-2).
- Aloft temperatures warmed, the capping inversion lowered, and the vertical mixing was limited (**Figure 6-3**).
- Despite the moderate northerly winds, the reduced vertical mixing allowed for high PM_{10} concentrations.
- It is likely that northerly winds transported any smoke in the Delta into the Cairo region.
- The episode ended when a ridge of high pressure moved into Egypt increasing the northerly winds and weakening the temperature inversion (Figure 6-3 and **Figure 6-4**).

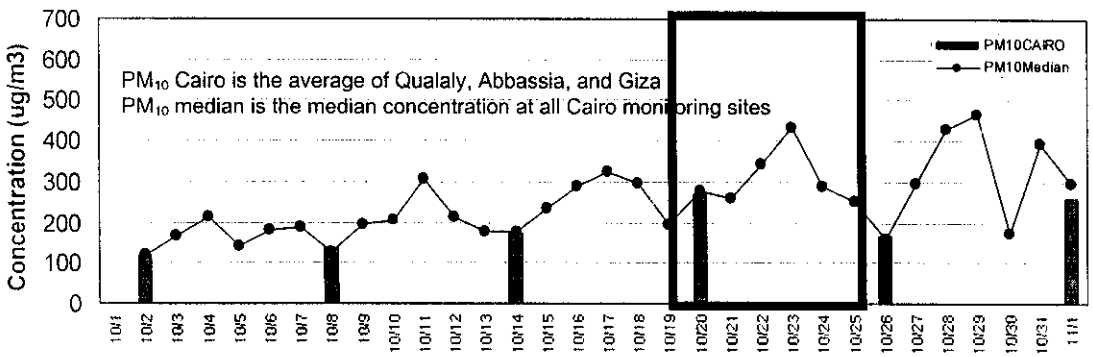


Figure 6-1. Time-series plot of PM_{10} concentrations in Cairo in October 1999. The October 20-25, 1999, episode is outlined.

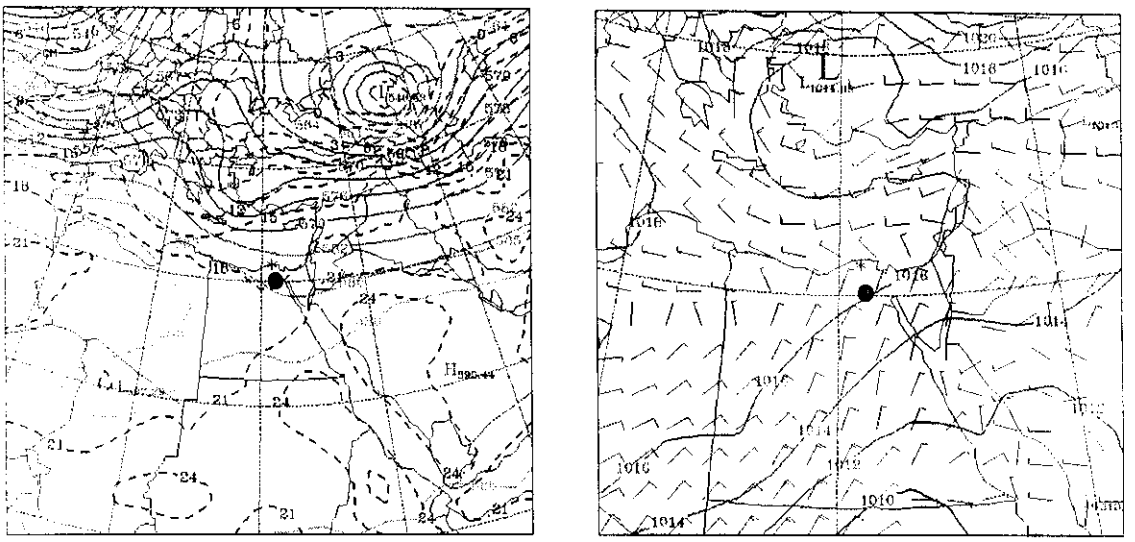


Figure 6-2. 500-mb heights (dm) (solid) and 850-mb temperatures (°C) (dashed) (left), and sea level pressure (mb) and surface wind flags (right) on October 23, 1999, at 1400 LT.

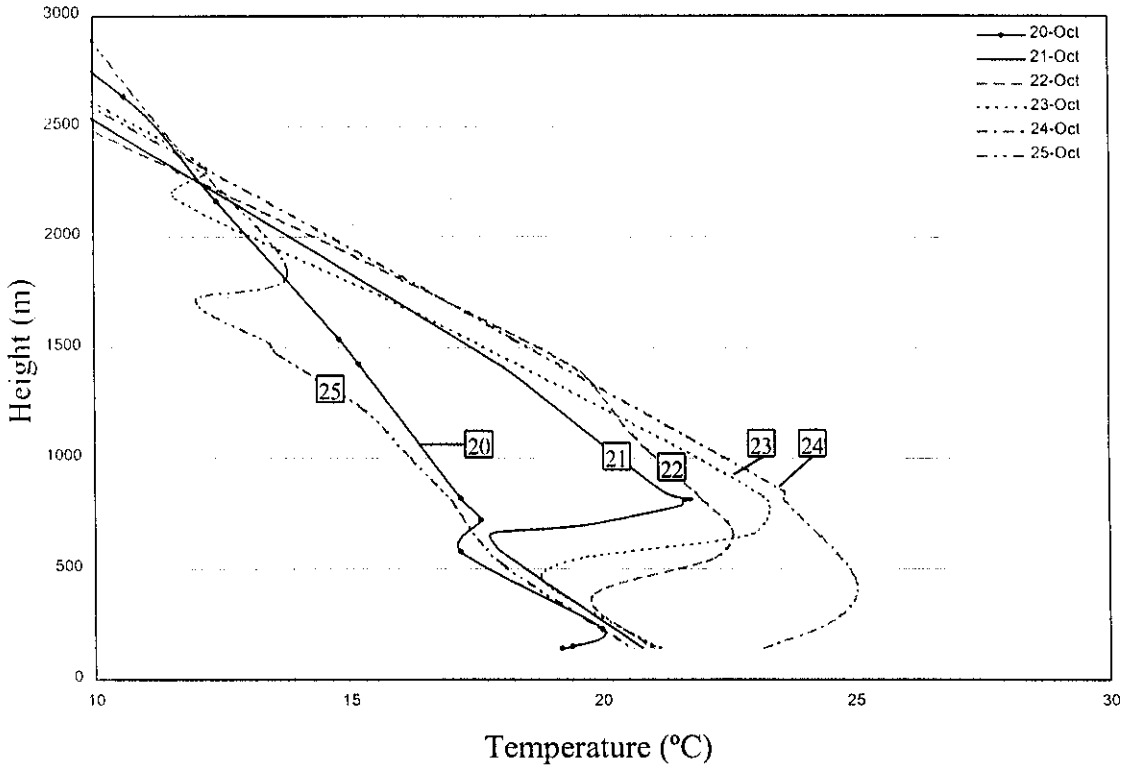


Figure 6-3. 0200 LT temperature soundings taken at Helwan from October 20 to 25, 1999.

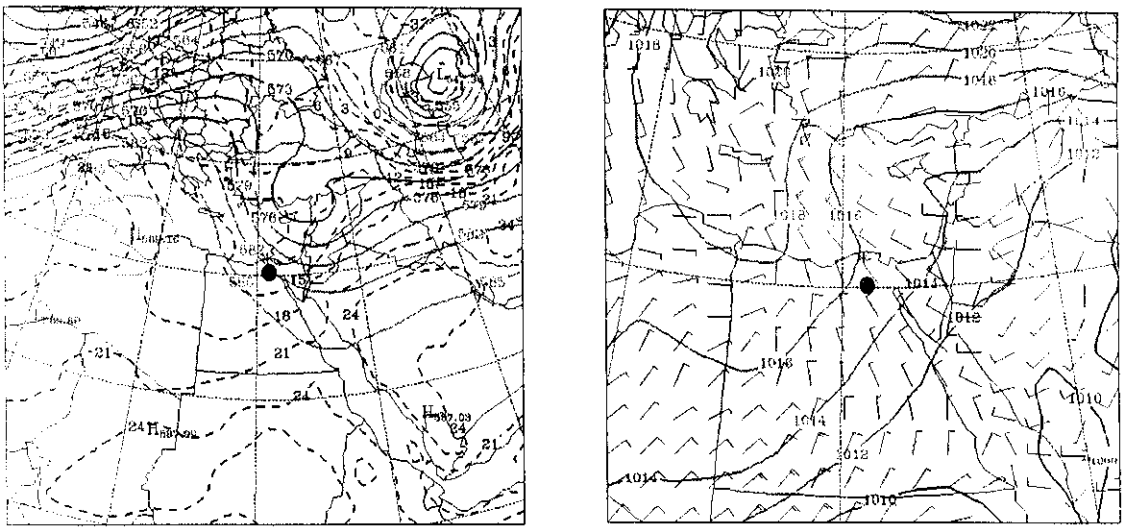


Figure 6-4. 500-mb heights (dm) (solid) and 850-mb temperatures (°C) (dashed) (left), and sea level pressure (mb) and surface wind flags (right) on October 25, 1999, at 1400 LT.

November 17-24, 1999 PM Episode

Figure 6-5 shows PM_{10} concentrations during a PM episode in Cairo from November 17 to 24, 1999. Note that the highest concentrations occurred on November 21. The important meteorological characteristics of this episode include the following:

- A strong upper-level high moved over Egypt from the south (**Figure 6-6**).
- The strong high increased surface pressures south of Egypt, thereby stopping the northerly winds and causing light southerly winds and recirculation (Figure 6-6).
- Aloft temperatures warmed and the vertical mixing was reduced (**Figure 6-7**).
- The light winds and reduced vertical mixing allowed for high PM_{10} concentrations.
- The episode ended when a strong trough passed north of Egypt, and a ridge of high pressure moved northwest of Egypt. This pattern increased the northerly winds and dissipated the inversion (Figure 6-7 and **Figure 6-8**).

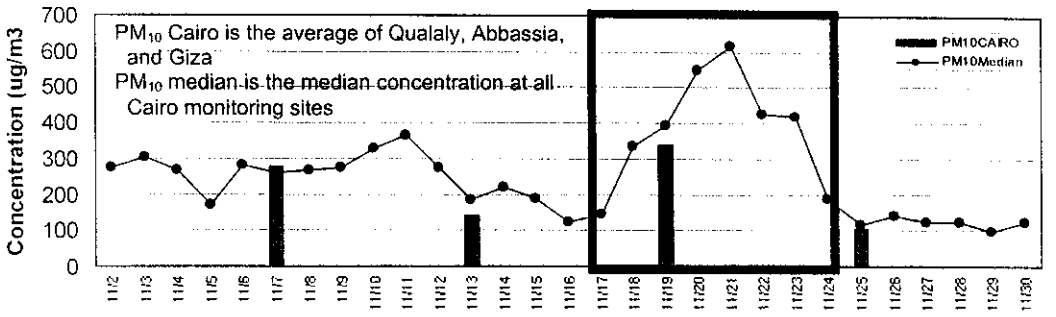


Figure 6-5. Time-series plot of PM_{10} concentrations in Cairo in November 1999. The November 17-24, 1999, episode is outlined.

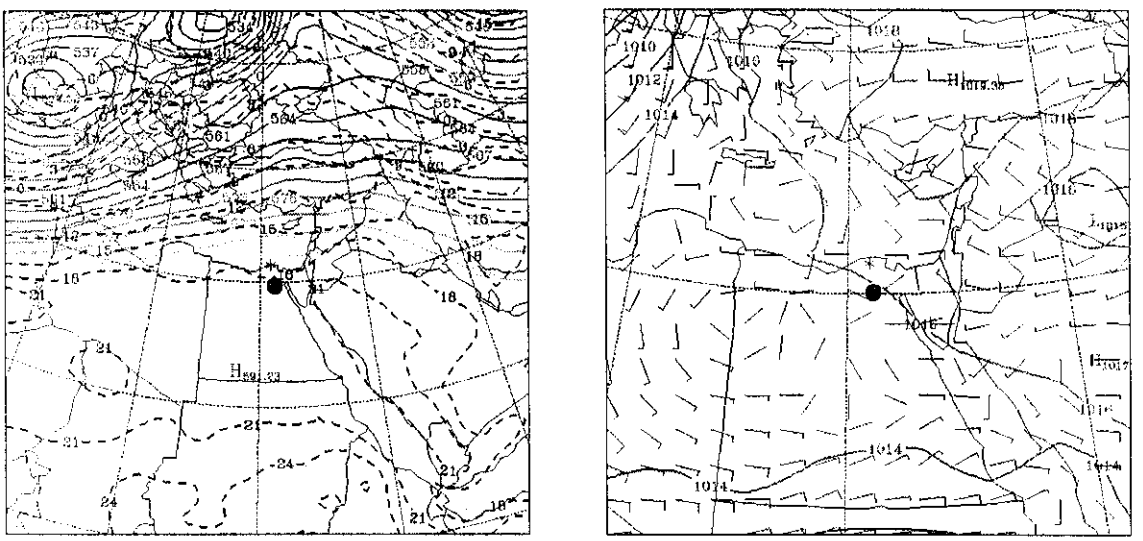


Figure 6-6. 500-mb heights (dm) (solid) and 850-mb temperatures (°C) (dashed) (left), and sea level pressure (mb) and surface wind flags (right) on November 21, 1999, at 1400 LT.

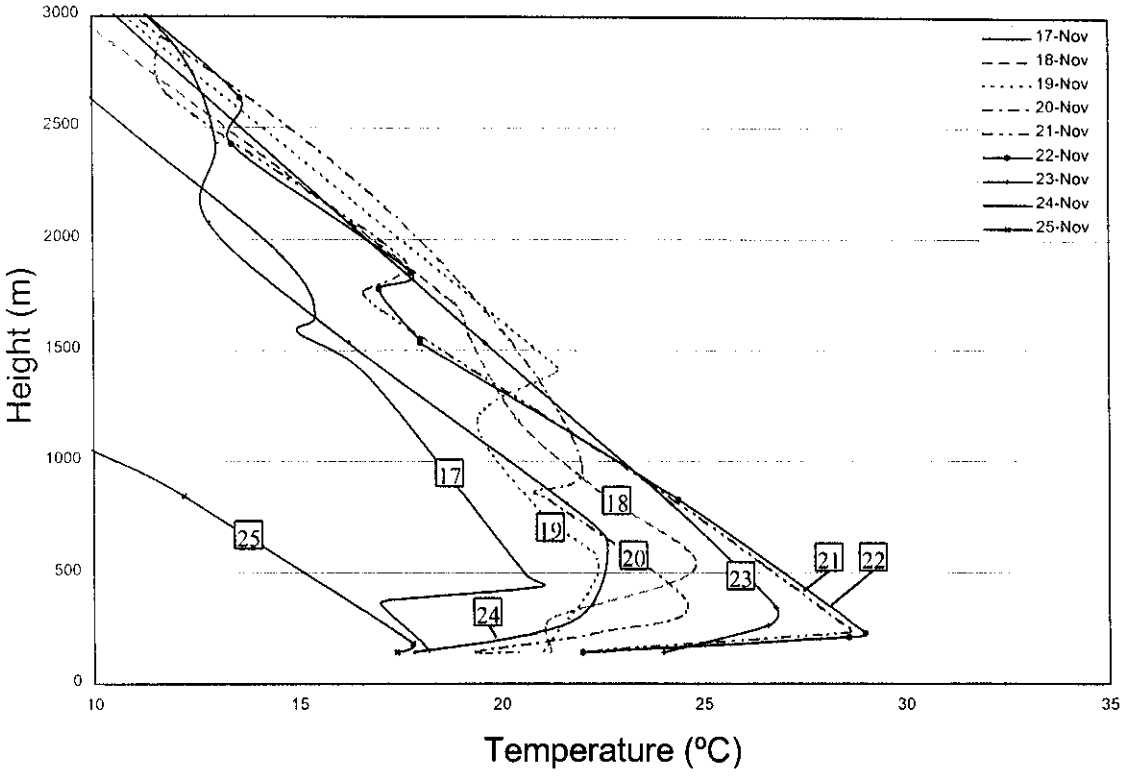


Figure 6-7. 0200 LT temperature soundings taken at Helwan from November 17 to 25, 1999.

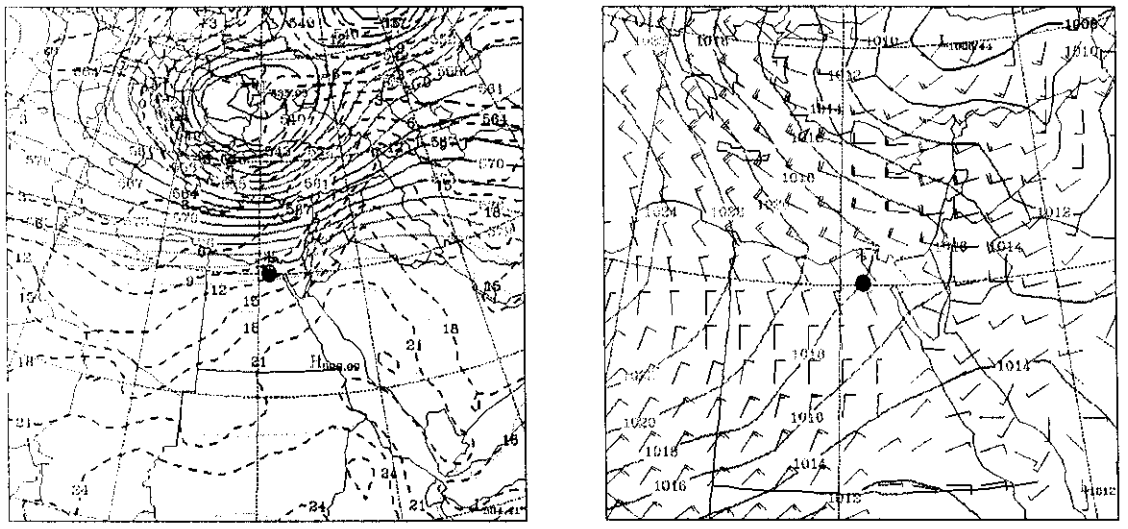


Figure 6-8. 500-mb heights (dm) (solid) and 850-mb temperatures (°C) (dashed) (left), and sea level pressure (mb) and surface wind flags (right) on November 24, 1999, at 1400 LT.

7. FORECAST VERIFICATION

Forecast verification is the process of evaluating the quality of forecasts by comparing the predicted PM_{10} concentrations to the observed PM_{10} concentrations. The verification process can be complex since there are many ways to evaluate a forecast including, accuracy, false alarm rate, bias, and more. No one statistic can fully reflect the performance of a program so you need to compute many verification statistics in order to evaluate completely the quality of the forecasting program.

There are two basic ways to evaluate a forecast program: Discrete and Categorical. Discrete verification is based on specific concentrations (250 ug/m3). Categorical verification is based on concentration categories (good, moderate, attention, etc.)

To verify the AQEWS PM_{10} forecasts, use the verification spreadsheet: *Verification.xls*. This spreadsheet consists of two tabs: Data Entry and Forecast Performance. Each day the forecaster should input the forecasted values and the previous day's observed PM_{10} concentrations into the Data Entry tab enter the data, the spreadsheet automatically calculates forecast performance statistics. To view the forecast performance you can print the Forecast Performance tab.

The **Discrete Statistics** in the verification spreadsheet include:

Average closeness	Measures the "closeness" between the forecasted and observed values averaged for all forecasts.
Bias	Indicates, on average, if the forecasts are under or over-predicted. A negative bias indicates that the forecasts are under predicated. A positive bias indicates that the forecasts are over predicted.
Correlation	Measures if the forecasted and observed PM_{10} values change together.

The **Categorical Statistics** are computed by first selecting a concentration cut point as shown in Figure 7-1. The Categorical Statistics in the verification spreadsheet include:

Accuracy	Percent of forecasts that correctly predict the concentrations above or below the cut point.
Probability of Detection	Percent of time the forecasts correctly predicted the observed high PM_{10} days.

False Alarm Rate — Percent of time the forecasts incorrectly predicted high PM_{10} concentrations that did not actually occur.

Bias — Indicates, on average, if the forecasts are under predicted or over predicted. Values less than 1 are under-predicted; values greater than 1 are over-predicted.

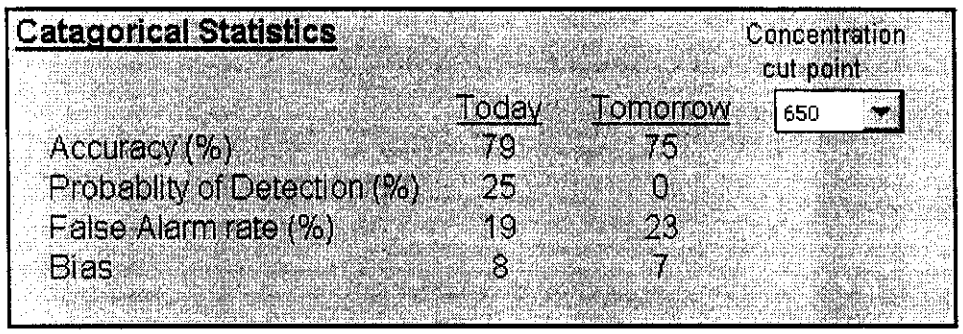


Figure 7-1. Example of categorical forecast statistics for a specific concentration cut-point.

8. DEVELOPMENT OF THE FORECAST TOOLS

The AQEWS uses regression equations, a decision tree, and subjective input to forecast PM_{10} concentrations. This section discusses how these tools were developed.

8.1 THE PROCESS OF DEVELOPING FORECASTING TOOLS

The overall process of developing the forecasting tools for the AQEWS is shown in **Figure 8-1**. As shown in the figure, the process of developing the regression equations and decision trees relies on the identification and selection of key predictor variables using our understanding of air quality and meteorological processes and statistical techniques. The process of developing the subjective input relies on data analyses designed to help forecasters understand what and how meteorological and chemical processes influence PM_{10} in the Cairo area.

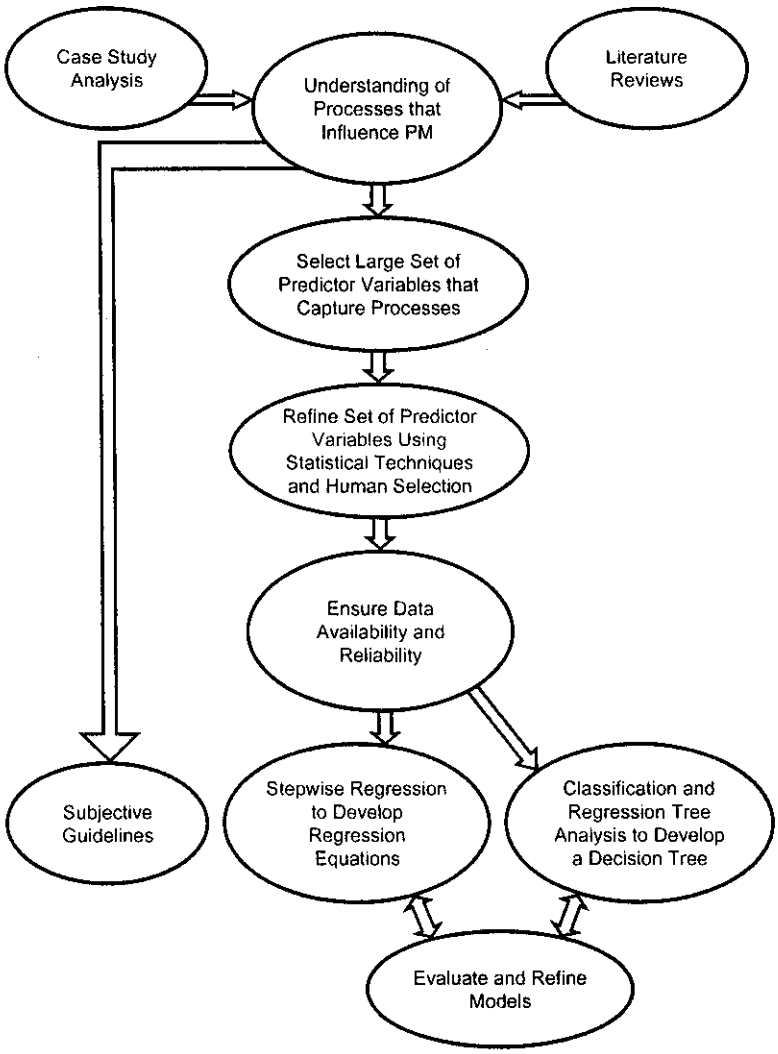


Figure 8-1. The forecasting tool development process.

The process used to produce the forecasting tools upon which the AQEWS is based are as follows:

- **Understand the important phenomena.** Literature reviews and analyses using historical meteorological and air quality data were used to understand the important phenomena that influence PM_{10} concentrations in Cairo. For example, data analysis showed that high PM_{10} concentrations are associated with warm aloft temperatures. The literature reviews and analyses helped in the development of subjective input and variable selection. The subjective input is presented in Section 6.
- **Capture the important phenomena.** One hundred forty predictor variables were selected that capture the important phenomena that influence PM_{10} concentrations in Cairo. For example, data analysis showed that high PM_{10} concentrations from "yesterday" are associated with high PM_{10} concentrations "today". Thus, yesterday's PM_{10} concentration was selected as a predictor variable.
- **Use statistical techniques and human knowledge to decrease the number of variables.** Correlation analyses, cluster analyses, step-wise regression, and our understanding of PM_{10} were used to refine the set of predictor variables to about 40. Section 8.2 discusses these techniques.
- **Ensure data availability and reliability.** The data selected needed to be easily obtainable and available from reliable source(s). The data also needed to be available at a specified time every day so that the forecast can be issued on time every day.
- **Use step-wise regression and CART to develop the tools.** Using the final set of about 40 predictor variables, step-wise regression was used to develop preliminary regression equations, and CART was used to develop preliminary decision trees.
- **Evaluate the models using an independent data set and the developmental data set.** The preliminary regression equations and decision trees were evaluated using the independent and developmental data sets. The developmental data set includes all available data from 1999 and 2000 and the independent data set only contains 6 days of data from 1998. The developmental data set was used because the independent data set was too small to complete an adequate evaluation of the model. Using the results from the evaluation, the regression equations and CART tree were refined and finalized.

The finalized tools were then integrated into the AQEWS, and accuracy statistics were calculated. **Table 8-1** shows forecast statistics for tomorrow's PM_{10} forecast produced by the AQEWS.

Table 8-1. AQEWS forecast statistics for the developmental and independent data sets.

Data Set	Probability of Detection[2]	Same Category[3]	Forecast within 100 $\mu g/m^3$	Forecast within 75 $\mu g/m^3$	Forecast within 50 $\mu g/m^3$
Developmental	66% (12 of 18)	73%	90%	89%	72%
Independent[1]	50% (1 of 2)	67%	67%	50%	50%

[1] Six days of data from 1998.
[2] The percentage of time the AQEWS correctly predicted observed PM_{10} episodes (≥350 $\mu g/m^3$).
[3] Three categories were calculated from the PM_{10} forecast (0-199 $\mu g/m^3$, 200-349 $\mu g/m^3$, and 350+ $\mu g/m^3$). The percentage of time that the forecast was in the same category is shown.

8.2 TECHNIQUES USED FOR DEVELOPING FORECASTING TOOLS

Statistical analysis techniques and human selection were used to identify the most important predictor variables. **Figure 8-2** and the following discussion describe the statistical analyses performed.

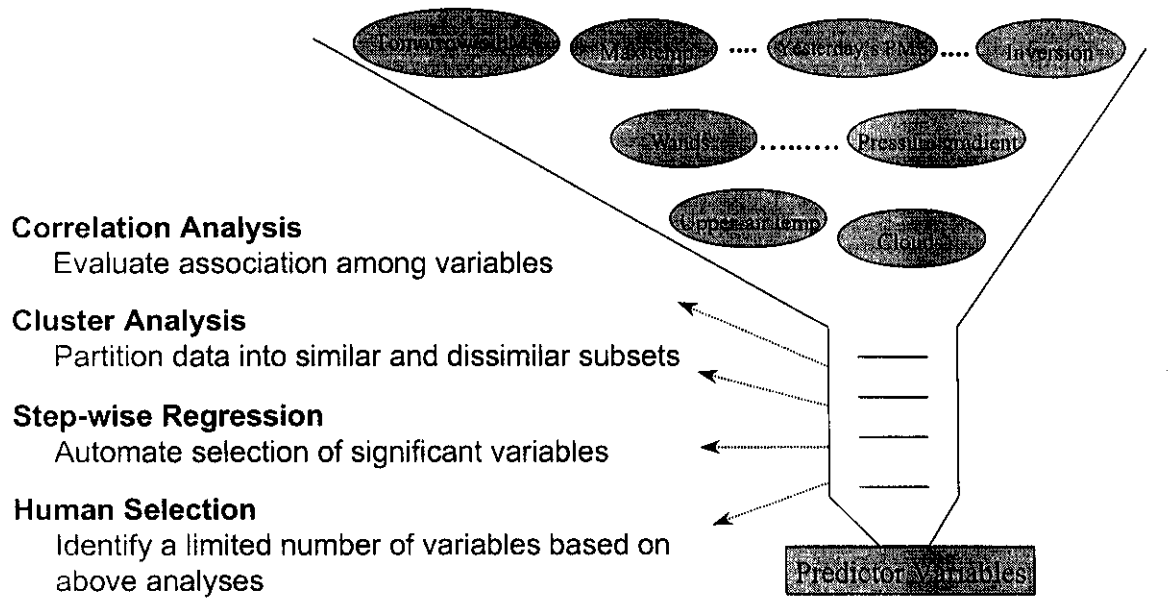


Figure 8-2. Statistical analyses and techniques.

Correlation analysis is used to evaluate the relationship between the predictand (i.e., PM_{10} concentrations) and various predictor variables. Correlations range from +1 (high-positive relationship) to 0 (no relationship) to -1 (high-negative relationship). Selected variables for the forecast model development have a high-positive or high-negative correlation. A high-positive correlation indicates that increases in the variable are associated with increases in the PM_{10} concentrations. Appendix B contains a summary of the correlation statistics between PM_{10} and candidate predictor variables.

Cluster analysis is a method used to partition data into similar and dissimilar subsets. Many of the variables may be somewhat similar (e.g., maximum surface temperature and 900-mb temperature), and cluster analysis identifies these similarities. Sometimes, one variable represents a whole set of similar variables.

Step-wise regression is an automatic procedure that allows the statistical software (SAS, Statgraphics, Systat, etc.) to select the most important variables and generate the best regression equation. When using this approach, it was important to question and evaluate the results. A common problem with this technique is that the resulting regression equations may contain too many variables that cause them to "over fit" the data, producing inaccurate predictions. When developing the final regression equation and decision tree, the number of predictor variables were limited to avoid this problem.

Human selection is another means of selecting the most important predictor variables. Forecasters visually evaluated the relationship among variables using scatter plot matrices, for example.

APPENDIX A

FORECASTING ALGORITHMS

This appendix contains the forecasting algorithms used in the AQEWS program. The algorithms calculate particulate matter (PM) forecasts based on input data that include observed air quality and observed and forecasted meteorological conditions. The algorithms include statistical equations that predict the current- and next-day PM_{10} concentrations. They also make PM_{10} trend forecasts for the next day, the second day, and the third day.

```
Sub Forecast_Calulation()
If BadData = True Then Exit Sub
'On Error Resume Next
'c  3 site average pm yesterday
'*****************************
Dim x1, x2, x3 As Double
Dim z1, z2, z3 As Integer

'Averaging yesterday's PM data
If PM1_0 <> 0 Then z1 = 1
If PM2_0 <> 0 Then z2 = 1
If PM3_0 <> 0 Then z3 = 1
If PM1_0 + PM2_0 + PM3_0 = 0 Then
  BadData = True
  Exit Sub
End If
PM_0 = (PM1_0 + PM2_0 + PM3_0) / (z1 + z2 + z3)
'*******************************
'Calculating today's PM10 forecast
'CART
'PM_1Cart calculation
'*************************************************************\
'Fuzzy Calculation for cart if within 40 ug/m3 of 375 cut
If Abs(PM_0 - 375) <= 40 Then

  'Calculate area of triangles and percent of area over and under 375ug/m3 for weighting of the 2
solutions
  'Equal lateral triangle area = 80*69.2*.5=2738
  If PM_0 <= 375 Then

   ' Small triangle is base2 *height2*.5
```

```
    x2 = ((40 - (375 - PM_0)) * (1.73 * (40 - (375 - PM_0))) * 0.5)
  ' remaining area
    x1 = 2768 - x2
    X1FACTOR = 100 * (x1 / 2768)
    X2FACTOR = 100 * (x2 / 2768)
    PM_0_AA = PM_0
    PM_0_BB = PM_0 + 40
  Else
    ' small trianglel is base2 *height2*.5
    x1 = ((40 - (PM_0 - 375)) * (1.73 * (40 - (PM_0 - 375))) * 0.5)
    ' remaining area
    x2 = 2768 - x1
    X1FACTOR = 100 * (x1 / 2768)
    X2FACTOR = 100 * (x2 / 2768)
    PM_0_BB = PM_0
    PM_0_AA = PM_0 - 40
  End If
' Calculate solution for path 1
If PM_0_AA > 375 Then
  If T700_1 > 7.7 Then
    PM_1CartAA = 509
  Else
    PM_1CartAA = 385
  End If
Else
  If PM_0_AA > 205 Then
    If TS_1 < 22 Then
      If T925_1 < 16.5 Then
        PM_1CartAA = 207
      Else
        PM_1CartAA = 300
      End If
    Else
      If T850_1 < 22 Then
        PM_1CartAA = 190
      Else
        PM_1CartAA = 260
      End If
    End If
  Else
    If WS925_1 < 3.5 Then
      If TS_1 < 22 Then
        PM_1CartAA = 320
      Else
        PM_1CartAA = 195
      End If
```

```
      Else
        PM_1CartAA = 165
      End If
    End If
  End If

' Calculate solution for path 2

  If PM_0_BB > 375 Then
    If T700_1 > 7.7 Then
      PM_1CartBB = 509
    Else
      PM_1CartBB = 385
    End If
  Else
    If PM_0_BB > 205 Then
      If TS_1 < 22 Then
        If T925_1 < 16.5 Then
          PM_1CartBB = 207
        Else
          PM_1CartBB = 300
        End If
      Else
        If T850_1 < 22 Then
          PM_1CartBB = 190
        Else
          PM_1CartBB = 260
        End If
      End If
    Else
      If WS925_1 < 3.5 Then
        If TS_1 < 22 Then
          PM_1CartBB = 320
        Else
          PM_1CartBB = 195
        End If
      Else
        PM_1CartBB = 165
      End If
    End If
  End If

'WEIGHTED AVERAGE BY TRIANGLE AREA

PM_1Cart = (PM_1CartAA * X1FACTOR + PM_1CartBB * X2FACTOR) / 100
```

```
'**********************************************End fuzzy for pm_1cart
' Cart with no fuzzy weighting
Else


 If PM_0 > 375 Then
   If T700_1 > 7.7 Then
     PM_1Cart = 509
   Else
     PM_1Cart = 385
   End If
 Else
   If PM_0 > 205 Then
     If TS_1 < 22 Then
        If T925_1 < 16.5 Then
          PM_1Cart = 207
        Else
          PM_1Cart = 300
        End If
      Else
        If T850_1 < 22 Then
          PM_1Cart = 190
        Else
          PM_1Cart = 260
        End If
     End If
    Else
      If WS925_1 < 3.5 Then
        If TS_1 < 22 Then
          PM_1Cart = 320
        Else
          PM_1Cart = 195
        End If
      Else
        PM_1Cart = 165
      End If
   End If
 End If
End If
'*****************************************************************
'PM_1Regression Calculation
'*****************************************************************
'Remark  Need to calculate some variables
Hecadt = (MaxST_1) - (MinST_1)
US_5 = -1 * WS5_1 * Sin(0.01744 * WD5_1)
```

```
US_6 = -1 * WS6_1 * Sin(0.01744 * WD6_1)
US_7 = -1 * WS7_1 * Sin(0.01744 * WD7_1)
VS_5 = -1 * WS5_1 * Cos(0.01744 * WD5_1)
VS_6 = -1 * WS6_1 * Cos(0.01744 * WD6_1)
VS_7 = -1 * WS7_1 * Cos(0.01744 * WD7_1)
Hecawsam = Sqr(((US_5 + US_6 + US_7) / 3) ^ 2 + ((VS_5 + VS_6 + VS_7) / 3) ^ 2)
V850_2am = (-1) * (WS850_1a) * Cos(0.01744 * WD850_1a)
V850_2pm = (-1) * (WS850_1b) * Cos(0.01744 * WD850_1b)
DT925700_1A = (T925_1) - (T700_1)


PM_1Regression = (-1) * 1112 + (-1.125 * Hecadt) + (-13.013 * Hecawsam) + (0.815 *
HT850_1) + (3.973 * V850_2am) + (2.11 * V850_2pm) + (3.419 * DT925700_1A) + (-0.31 *
RH850_1) + (0.648 * PM_0)



PM_1 = (PM_1Cart + PM_1Regression) / 2
'PM_1 = ((PM_1 * 2) + PM_1a) / 3

'*************************************************************************

'PM_2 Calculation - --Tomorrow 's forecast


'PM_2Cart Calcualtion
'*****************************************************************

'*****************************************************************
'Fuzzy Calc. for cart if within 40 ug/m3 of 375 cut

If Abs(PM_1 - 375) <= 40 Then

'Calculate area of triangles and percent of area over and under 375 for weighting of the 2
solutions

If PM_1 <= 375 Then
' small triangel is base2 *height2*.5

    x2 = ((40 - (375 - PM_1)) * (1.73 * (40 - (375 - PM_1))) * 0.5)

' remaining area

    x1 = 2768 - x2
    X1FACTOR = 100 * (x1 / 2768)
    X2FACTOR = 100 * (x2 / 2768)
```

```
    PM_1_AA = PM_1
    PM_1_BB = PM_1 + 40

  Else

' small triangel is base2 *height2*.5

    x1 = (40 - (PM_1 - 375)) * (1.73 * (40 - (PM_1 - 375)) * 0.5)

' remaining area

    x2 = 2768 - x1
    X1FACTOR = 100 * (x1 / 2768)
    X2FACTOR = 100 * (x2 / 2768)
    PM_1_BB = PM_1
    PM_1_AA = PM_1 - 40

  End If

'  Calculate solution for path 1

 If PM_1_AA > 375 Then
   If T700_2 > 7.7 Then
     PM_2CartAA = 509
   Else
     PM_2CartAA = 385
   End If
 Else
   If PM_1_AA > 205 Then
     If TS_2 < 22 Then
        If T925_2 < 16.5 Then
          PM_2CartAA = 207
        Else
          PM_2CartAA = 300
        End If
      Else
        If T850_2 < 22 Then
          PM_2CartAA = 190
        Else
          PM_2CartAA = 260
        End If
     End If
   Else
      If WS925_2 < 3.5 Then
        If TS_2 < 22 Then
          PM_2CartAA = 320
```

```
        Else
          PM_2CartAA = 195
        End If
      Else
        PM_2CartAA = 165
      End If
  End If
End If

' Calculate solution for path 2

If PM_1_BB > 375 Then
  If T700_2 > 7.7 Then
    PM_2CartBB = 509
  Else
    PM_2CartBB = 385
  End If
Else
  If PM_1_BB > 205 Then
    If TS_2 < 22 Then
      If T925_2 < 16.5 Then
        PM_2CartBB = 207
      Else
        PM_2CartBB = 300
      End If
    Else
      If T850_2 < 22 Then
        PM_2CartBB = 190
      Else
        PM_2CartBB = 260
      End If
    End If
  Else
    If WS925_2 < 3.5 Then
      If TS_2 < 22 Then
        PM_2CartBB = 320
      Else
        PM_2CartBB = 195
      End If
    Else
      PM_2CartBB = 165
    End If
  End If
End If

'WEIGHTED AVERAGE BY TRIANGLE AREA
```

```
PM_2Cart = (PM_2CartAA * X1FACTOR + PM_2CartBB * X2FACTOR) / 100


' ***********************************************End fuzzy for pm_1cart
' Cart with no fuzzy weighting

Else
 If PM_1 > 375 Then
   If T700_2 > 7.7 Then
    PM_2Cart = 509
   Else
    PM_2Cart = 385
   End If
 Else
   If PM_1 > 205 Then
     If TS_2 < 22 Then
       If T925_2 < 16.5 Then
         PM_2Cart = 207
        Else
         PM_2Cart = 300
       End If
      Else
       If T850_2 < 22 Then
         PM_2Cart = 190
        Else
         PM_2Cart = 260
       End If
    End If
   Else
     If WS925_2 < 3.5 Then
       If TS_2 < 22 Then
         PM_2Cart = 320
       Else
         PM_2Cart = 195
       End If
      Else
       PM_2Cart = 165
     End If
  End If
End If
End If
'*************************************************************
```

'PM_2Regression Calculation

'**********

'Remark Need to calculate some variables

Hecadt = (MaxST_2) - (MinST_2)
US_5 = -1 * WS5_2 * Sin(0.01744 * WD5_2)
US_6 = -1 * WS6_2 * Sin(0.01744 * WD6_2)
US_7 = -1 * WS7_2 * Sin(0.01744 * WD7_2)
VS_5 = -1 * WS5_2 * Cos(0.01744 * WD5_2)
VS_6 = -1 * WS6_2 * Cos(0.01744 * WD6_2)
VS_7 = -1 * WS7_2 * Cos(0.01744 * WD7_2)
Hecawsam = Sqr(((US_5 + US_6 + US_7) / 3) ^ 2 + ((VS_5 + VS_6 + VS_7) / 3) ^ 2)
V850_2am = (-1) * (WS850_2a) * Cos(0.01744 * WD850_2a)
V850_2pm = (-1) * (WS850_2b) * Cos(0.01744 * WD850_2b)
DT925700_2A = (T925_2) - (T700_2)

PM_2Regression = (-1) * 1112 + (-1.125 * Hecadt) + (-13.013 * Hecawsam) + (0.815 * HT850_2) + (3.973 * V850_2am) + (2.11 * V850_2pm) + (3.419 * DT925700_2A) + (-0.31 * RH850_2) + (0.648 * PM_1)

PM_2 = (PM_2Cart + PM_2Regression) / 2

'**********

'trend forecast

'Remark Based on regression and met only
'Remark Need to first calculate today met only PMmet_0

Hecadt = (MAXST_0) - (MINST_0)
US_5 = -1 * WS5_0 * Sin(0.01744 * WD5_0)
US_6 = -1 * WS6_0 * Sin(0.01744 * WD6_0)
US_7 = -1 * WS7_0 * Sin(0.01744 * WD7_0)
VS_5 = -1 * WS5_0 * Cos(0.01744 * WD5_0)
VS_6 = -1 * WS6_0 * Cos(0.01744 * WD6_0)
VS_7 = -1 * WS7_0 * Cos(0.01744 * WD7_0)
Hecawsam = Sqr(((US_5 + US_6 + US_7) / 3) ^ 2 + ((VS_5 + VS_6 + VS_7) / 3) ^ 2)
V850_2am = (-1) * (WS850_0A) * Cos(0.01744 * WD850_0A)

V850_2pm = (-1) * (WS850_0B) * Cos(0.01744 * WD850_0B)
DT925700_0A = (T925_0) - (T700_0)

PMmet_0 = (-1) * 2146 + (0.973 * Hecadt) + (-46.29 * Hecawsam) + (1.599 * HT850_0) + (7.586 * V850_2am) + (0.833 * V850_2pm) + (10.416 * DT925700_0A) + (-0.476 * RH850_0)

'Remark Need to first calculate today met only PMmet_1

Hecadt = (MaxST_1) - (MinST_1)
US_5 = -1 * WS5_1 * Sin(0.01744 * WD5_1)
US_6 = -1 * WS6_1 * Sin(0.01744 * WD6_1)
US_7 = -1 * WS7_1 * Sin(0.01744 * WD7_1)
VS_5 = -1 * WS5_1 * Cos(0.01744 * WD5_1)
VS_6 = -1 * WS6_1 * Cos(0.01744 * WD6_1)
VS_7 = -1 * WS7_1 * Cos(0.01744 * WD7_1)
Hecawsam = Sqr(((US_5 + US_6 + US_7) / 3) ^ 2 + ((VS_5 + VS_6 + VS_7) / 3) ^ 2)
V850_2am = (-1) * (WS850_1a) * Cos(0.01744 * WD850_1a)
V850_2pm = (-1) * (WS850_1b) * Cos(0.01744 * WD850_1b)
DT925700_1A = (T925_1) - (T700_1)

PMmet_1 = (-1) * 2146 + (0.973 * Hecadt) + (-46.29 * Hecawsam) + (1.599 * HT850_1) + (7.586 * V850_2am) + (0.833 * V850_2pm) + (10.416 * DT925700_1A) + (-0.476 * RH850_1)

'Remark Need to first calculate tomorrow met only PMmet_2

Hecadt = (MaxST_2) - (MinST_2)
US_5 = -1 * WS5_2 * Sin(0.01744 * WD5_2)
US_6 = -1 * WS6_2 * Sin(0.01744 * WD6_2)
US_7 = -1 * WS7_2 * Sin(0.01744 * WD7_2)
VS_5 = -1 * WS5_2 * Cos(0.01744 * WD5_2)
VS_6 = -1 * WS6_2 * Cos(0.01744 * WD6_2)
VS_7 = -1 * WS7_2 * Cos(0.01744 * WD7_2)
Hecawsam = Sqr(((US_5 + US_6 + US_7) / 3) ^ 2 + ((VS_5 + VS_6 + VS_7) / 3) ^ 2)
V850_2am = (-1) * (WS850_2a) * Cos(0.01744 * WD850_2a)
V850_2pm = (-1) * (WS850_2b) * Cos(0.01744 * WD850_2b)
DT925700_2A = (T925_2) - (T700_2)

PMmet_2 = (-1) * 2146 + (0.973 * Hecadt) + (-46.29 * Hecawsam) + (1.599 * HT850_2) + (7.586 * V850_2am) + (0.833 * V850_2pm) + (10.416 * DT925700_2A) + (-0.476 * RH850_2)

'Remark Need to calculate met only PMmet_3

```
Hecadt = (MaxST_3) - (MinST_3)
US_5 = -1 * WS5_3 * Sin(0.01744 * WD5_3)
US_6 = -1 * WS6_3 * Sin(0.01744 * WD6_3)
US_7 = -1 * WS7_3 * Sin(0.01744 * WD7_3)
VS_5 = -1 * WS5_3 * Cos(0.01744 * WD5_3)
VS_6 = -1 * WS6_3 * Cos(0.01744 * WD6_3)
VS_7 = -1 * WS7_3 * Cos(0.01744 * WD7_3)
Hecawsam = Sqr(((US_5 + US_6 + US_7) / 3) ^ 2 + ((VS_5 + VS_6 + VS_7) / 3) ^ 2)
V850_2am = (-1) * (WS850_3a) * Cos(0.01744 * WD850_3a)
V850_2pm = (-1) * (WS850_3b) * Cos(0.01744 * WD850_3b)
DT925700_3A = (T925_3) - (T700_3)


PMmet_3 = (-1) * 2146 + (0.973 * Hecadt) + (-46.29 * Hecawsam) + (1.599 * HT850_3) +
(7.586 * V850_2am) + (0.833 * V850_2pm) + (10.416 * DT925700_3A) + (-0.476 * RH850_3)



'Remark   Need to calculate met only PMmet_4

Hecadt = (MaxST_4) - (MinST_4)
US_5 = -1 * WS5_4 * Sin(0.01744 * WD5_4)
US_6 = -1 * WS6_4 * Sin(0.01744 * WD6_4)
US_7 = -1 * WS7_4 * Sin(0.01744 * WD7_4)
VS_5 = -1 * WS5_4 * Cos(0.01744 * WD5_4)
VS_6 = -1 * WS6_4 * Cos(0.01744 * WD6_4)
VS_7 = -1 * WS7_4 * Cos(0.01744 * WD7_4)
Hecawsam = Sqr(((US_5 + US_6 + US_7) / 3) ^ 2 + ((VS_5 + VS_6 + VS_7) / 3) ^ 2)
V850_2am = (-1) * (WS850_4a) * Cos(0.01744 * WD850_4a)
V850_2pm = (-1) * (WS850_4b) * Cos(0.01744 * WD850_4b)
DT925700_4A = (T925_4) - (T700_4)


PMmet_4 = (-1) * 2146 + (0.973 * Hecadt) + (-46.29 * Hecawsam) + (1.599 * HT850_4) +
(7.586 * V850_2am) + (0.833 * V850_2pm) + (10.416 * DT925700_4A) + (-0.476 * RH850_4)



'Trend forecast
'------------------
 If (PMmet_1) - (PMmet_0) > 50 Then
   PMTrend_1 = 1
  Else
   If (PMmet_1) - (PMmet_0) < -50 Then
```

```
      PMTrend_1 = -1
    Else
      PMTrend_1 = 2
   End If
 End If
'----------------
 If (PMmet_2) - (PMmet_1) > 50 Then
   PMTrend_2 = 1
  Else
   If (PMmet_2) - (PMmet_1) < -50 Then
     PMTrend_2 = -1
    Else
     PMTrend_2 = 2
   End If
 End If
'-----------------------
 If (PMmet_3) - (PMmet_2) > 50 Then

   PMTrend_3 = 1
  Else
   If (PMmet_3) - (PMmet_2) < -50 Then

     PMTrend_3 = -1
    Else
     PMTrend_3 = 2
   End If
 End If

 If (PMmet_4) - (PMmet_3) > 50 Then

    PMTrend_4 = 1
  Else
   If (PMmet_4) - (PMmet_3) < -50 Then

     PMTrend_4 = -1
    Else

     PMTrend_4 = 2
   End If
 End If
' Need to adjust PM_1 based on met trend today to tomorrow
' This met adjustment increases the influence of met compared to persistence

 If (PMmet_1) - (PMmet_0) > 100 Then
   PM_1 = PM_1 + 80
```

```
  Else

If (PMmet_1) - (PMmet_0) > 70 Then
    PM_1 = PM_1 + 60
  Else


     If (PMmet_1) - (PMmet_0) < -70 Then
      If (PM_1 > 200) Then
      PM_1 = PM_1 - 70
      End If
    Else
     PM_1 = PM_1

End If
End If
End If


' Need to adjust PM_2 based on met trend today to tomorrow
' This met adjustment increases the influence of met compared to persistence

If (PMmet_2) - (PMmet_1) > 100 Then
  PM_2 = PM_2 + 80

  Else

If (PMmet_2) - (PMmet_1) > 70 Then
    PM_2 = PM_2 + 60
  Else

     If (PMmet_2) - (PMmet_1) < -70 Then
     If (PM_2 > 200) Then
      PM_2 = PM_2 - 70
      End If
    Else
     PM_2 = PM_2

End If
End If
End If

End Sub
```

APPENDIX B

CORRELATIONS

This appendix contains correlations between Cairo's daily PM_{10} concentration and daily meteorological and air quality parameters. Cairo's daily PM_{10} concentration is the average PM_{10} 24-hour concentration from the Qualaly Square, El Abbassia, and Giza monitoring sites. Data from October 1998 through February 2000 were used in the correlation calculation. The actual number of data points used for each correlation varies depending upon each parameters data availability.

Parameter	PM10CAIRO
PM10CAIRO	1.000
JDAY	0.375
COSJDAY	0.254
SINJDAY	-0.246
DOW	-0.055
COSDOW	-0.113
SINDOW	0.100
AQ01SO2	0.632
AQ02SO2	0.397
AQ03SO2	0.249
AQ04SO2	0.355
AQ05SO2	0.223
AQ06SO2	0.377
AQ07SO2	-0.234
AQ08SO2	0.492
AQ10SO2	0.233
AQ11SO2	0.257
AQ13SO2	0.296
AQ14SO2	0.243
AQ38SO2	0.492
AQ01NO2	0.335
AQ02NO2	0.604
AQ04NO2	0.097
AQ05NO2	0.255
AQ06NO2	0.739

Parameter	PM10CAIRO
AQ08NO2	0.465
AQ10NO2	0.397
AQ11NO2	0.388
AQ13NO2	0.218
AQ38NO2	0.386
AAUPM10	0.835
ABZPM10	-1.000
AMPPM10	0.883
APCPM10	0.743
ATIPM10	0.788
AUCPM10	0.874
BISPM10	0.850
BLBPM10	0.654
CACPM10	0.846
CAIPM10	0.831
CEHPM10	0.795
CYCPM10	0.886
DRCPM10	0.809
EGSPM10	0.914
EQSPM10	0.878
ERAPM10	0.896
FAKPM10	0.722
GEMPM10	0.874
HDMPM10	0.835
HFSPM10	0.716

Parameter	PM10CAIRO
HTIPM10	0.734
KFCPM10	0.790
LRCPM10	0.822
MAYPM10	0.645
METPM10	0.763
MICPM10	0.493
NRCPM10	0.803
OCTPM10	0.524
OLSPM10	0.897
RAMPM10	0.717
SBHPM10	0.774
TBSPM10	0.399
TESPM10	0.731
TTIPM10	0.711
UHCPM10	0.817
AQ01PM10	0.953
AQ02PM10	0.692
AQ06PM10	0.413
AQ35PM10	0.639
AQ37PM10	0.773
AQ05PM10	0.549
AQ13PM10	0.746
AQ14PM10	0.606
ABZPM25	-1.000
APCPM25	0.566
AUCPM25	0.757
BISPM25	0.729
BLBPM25	0.506
CACPM25	0.684
CAIPM25	0.647
CEHPM25	0.662
DRCPM25	0.642
EGSPM25	0.812
EQSPM25	0.676
GEMPM25	0.769
HFSPM25	0.583
KFCPM25	0.600
METPM25	0.753

Parameter	PM10CAIRO
MICPM25	0.291
NRCPM25	0.717
OCTPM25	0.377
OLSPM25	0.758
RAMPM25	0.564
SBHPM25	0.747
TBSPM25	0.324
TESPM25	0.641
TTIPM25	0.465
UHCPM25	0.802
AQ03O3AVG	-0.382
AQ11O3AVG	0.156
AQ03O3MAX	-0.227
AQ11O3MAX	0.241
AQ01TSP	0.559
AQ06TSP	-0.120
AQ07TSP	-0.270
AQ10TSP	-0.191
HECAMAXT	-0.090
HECAMINT	-0.176
HECADT	0.168
WSAMSQR	-0.335
HECAWSAM	-0.402
HECAAMWD90	0.131
HECAWSPM	-0.254
HECAPMWD90	0.187
HECA_DP_5AM	-0.031
THK5102AM	-0.031
HGT8502AM	0.266
HGT7002AM	0.150
HGT5002AM	0.035
TEMPSFC2AM	0.007
TEMP9252AM	0.093
TEMP8502AM	0.049
TEMP7002AM	0.007
TEMP5002AM	-0.067
TDSFC2AM	-0.092
TD9252AM	-0.053

Parameter	PM10CAIRO
TD8502AM	-0.108
TD7002AM	-0.052
TD5002AM	0.162
WSSFC2AM	-0.066
WS9252AM	-0.126
WS8502AM	-0.172
WS7002AM	0.014
WS5002AM	0.026
WDSFC2AM90	0.084
WD9252AM90	0.223
WD8502AM90	0.229
WD7002AM90	0.018
WD5002AM90	0.023
USFC_2AM	-0.131
VSFC_2AM	0.099
U925_2AM	-0.141
V925_2AM	0.276
U850_2AM	-0.183
V850_2AM	0.212
U700_2AM	-0.055
V700_2AM	0.103
U500_2AM	0.017
V500_2AM	-0.051
DTSFC9252AM	0.230
DTSFC8502AM	0.102
DTSFC5002AM	-0.142
T850_DT2AM	0.104
T700_DT2AM	0.027
T500_DT2AM	-0.025
DH850_2AM	0.151
DH700_2AM	0.144
DH500_2AM	0.091
THK5102PM	-0.164
HGT8502PM	0.277
HGT7002PM	0.102
HGT5002PM	-0.081
TEMPSFC2PM	-0.135
TEMP9252PM	-0.081

Parameter	PM10CAIRO
TEMP8502PM	-0.024
TEMP7002PM	-0.128
TEMP5002PM	-0.253
TDSFC2PM	-0.092
TD9252PM	-0.253
TD8502PM	-0.237
TD7002PM	-0.032
TD5002PM	0.047
WSSFC2PM	-0.173
WS9252PM	-0.038
WS8502PM	-0.015
WS7002PM	0.013
WS5002PM	0.117
WDSFC2P	0.166
WD9252PM	0.356
WD8502PM	0.299
WD7002PM	0.165
WD5002PM	0.050
USFC_2PM	-0.100
VSFC_2PM	0.084
U925_2PM	-0.134
V925_2PM	0.265
U850_2PM	-0.062
V850_2PM	0.325
U700_2PM	0.021
V700_2PM	0.167
U500_2PM	0.110
V500_2PM	0.066
DTSFC9252PM	0.139
DTSFC8502PM	0.237
DTSFC5002PM	-0.124
T850_DT2PM	0.136
T700_DT2PM	0.043
T500_DT2PM	-0.061
DH850_2PM	0.067
DH700_2PM	0.064
DH500_2PM	0.029
LOGPM10	0.947

Parameter	PM10CAIRO
LOGPM10MAX	0.901
PM10CAIRO2D	0.452
PM25CAIRO	0.824
PM10MAXCAI	0.943
PM10MAXYST	0.719
AMDT925850	0.120
AMDT925700AM	0.169
PMDT925850	-0.177
PMDT925700	0.054
RHSFCAM	-0.153
RH925AM	-0.159
RH850AM	-0.138
RH700AM	-0.085
RH500AM	0.156
RHSFCPM	0.064
RH925PM	-0.128
RH850PM	-0.212
RH700PM	-0.017
RH500PM	0.158
AMAVGRH9258	-0.173
PMAVGRH9258	-0.202

Parameter	PM10CAIRO
MAXPMSO2AQ1	0.423
MAXPMNO2AQ1	0.170
MAXPMPM10AQ1	0.748
MAXPMSO2AQ2	0.283
MAXPMNO2AQ2	0.546
MAXPMPM10AQ2	0.308
MAXPMSO2AQ6	0.157
MAXPMNO2AQ6	0.495
MAXPMPM10AQ6	0.118
MAXPMSO2	0.446
MAXPMNO2	0.378
MAXPMPM10	0.460
MAXPMPM10YST	0.366
MAXAMPM101D	0.547
MAXAMPM10AQ1	0.738
MAXAMPM10AQ2	0.248
MAXAMPM10AQ6	0.029
WSHEAR2AM	0.009

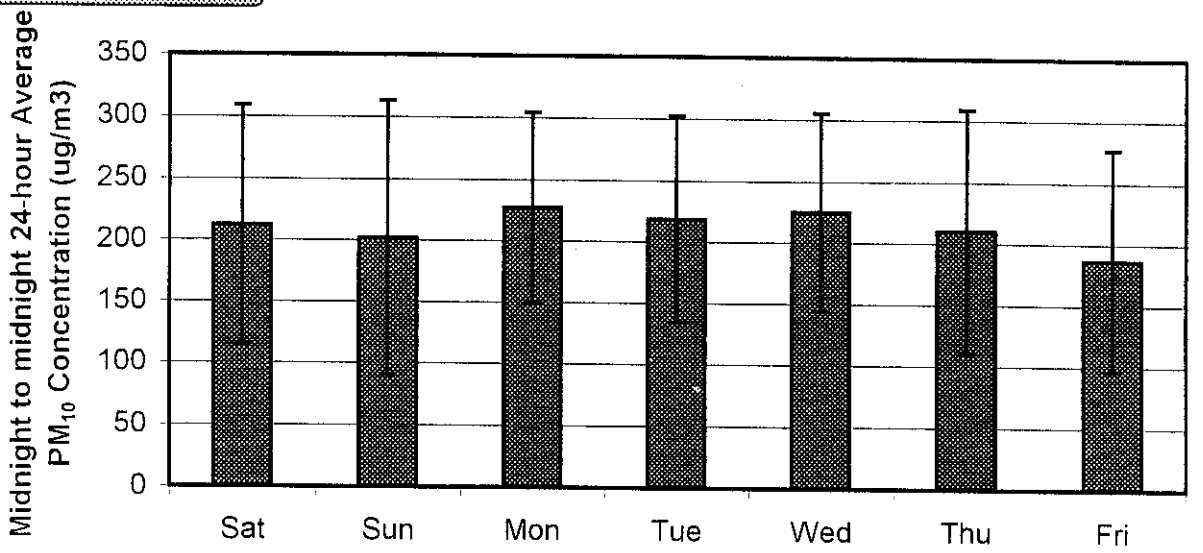
APPENDIX C

CENTRAL CAIRO PM_{10} CHARACTERISTICS

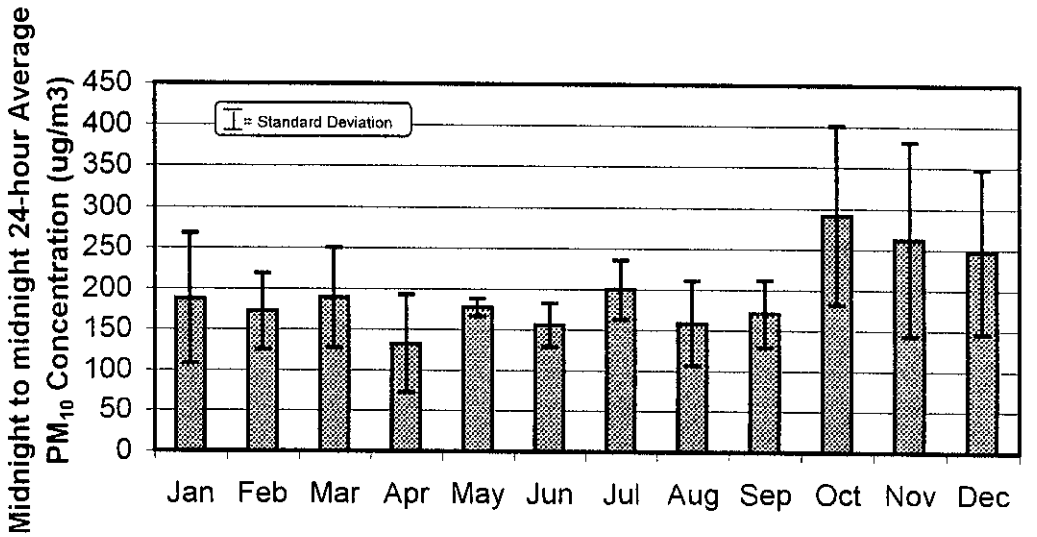
Central Cairo PM_{10} Characteristics

Based on PM_{10} data from January 1, 1999 to Feburary 28, 2000
Represents PM_{10} concentrations in Central Cairo

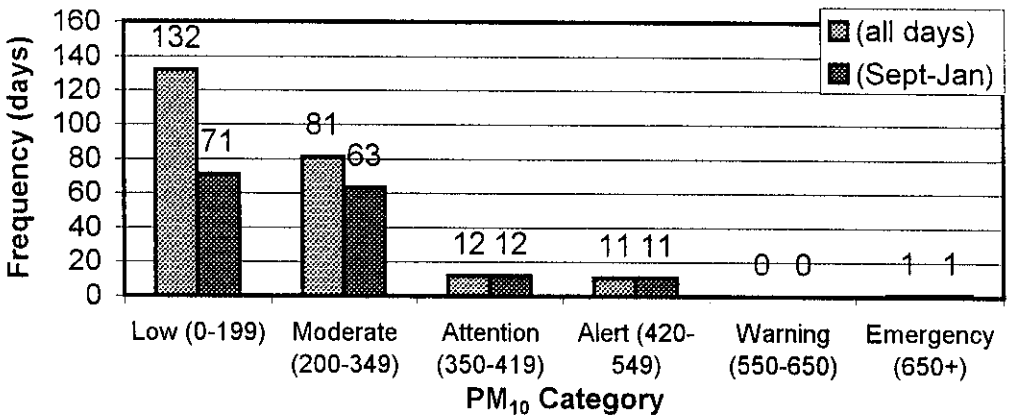
Day of Week Distribution



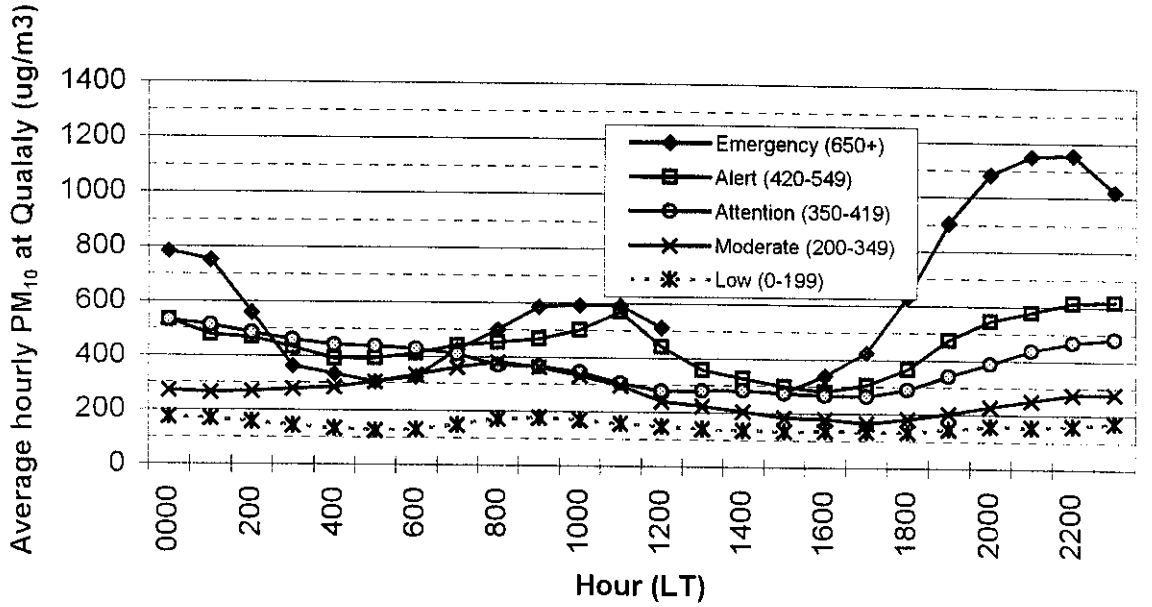
Seasonal Distribution



Frequency Distribution



Diurnal Profile by Catagory



PM_{10} Statistics

Metric	Sites		
	Qualaly	Fum al Khlig	Abbassyia
Maximum (ug/m3)	619	416	458
Minimum (ug/m3)	83	78	72
Average (ug/m3)	221	170	153
Median (ug/m3)	197	145	137
Number days	201	58	58

APPENDIX D

FORECASTING FORMS

Missed Forecast Form

Today's Date _____ Forecast Reviewer _____

Air Quality Information

Yesterday's observed PM_{10}	**Today's** PM_{10} forecast issued yesterday	**Tomorrow's** PM_{10} forecast issued 2 days ago	Difference (**Yesterday's** Observed – **Today's** Forecasted)	Difference (**Yesterday's** Observed – **Tomorrow's** Forecasted)

Input Variables	**Miss Forecast**
Air Quality Data	
Fum al Khlig 24-hr avg. PM_{10} conc.	☐
Abbassyia 24-hr avg. PM_{10} conc.	☐
Qualaly 24-hr avg. PM_{10} conc.	☐
Qualaly 00 to 08 local time avg. PM_{10} conc.	☐
Surface Data	
Maximum surface temperature	☐
Minimum surface temperature	☐
Wind speed and direction	☐
Upper-air Data	
700-mb temperature at 00Z	☐
925-mb temperature at 00Z	☐
Surface temperature at 00Z	☐
850-mb temperature at 12Z	☐
850-mb winds at 00Z	☐
850-mb winds at 12Z	☐
925-mb winds at 00Z	☐
850-mb relative humidity at 12Z	☐
850-mb height at 00Z	☐

Comments

_____

_____

_____

_____

_____

Daily Forecast Activities

Task *(time)*

Action and Questions

Receive Data *(0900)*

Check that all EIMP data have been received.
Check that all EMA data have been received.
Are any data missing? Please explain.

_____

_____

If data have not been received, use alternate data delivery method such as FAX.
If data are missing, follow the missing data procedure in the training manual or AQEWS Help.

Review Data *(1000)*

Evaluate yesterday's forecast accuracy using the accuracy verification spreadsheet.
Was the forecast missed by more than one category or 100 ug/m³? If so, please explain and complete the missed forecast form.

_____

Review today's weather observations, forecasts charts, and upper-air observations from Helwan to determine the general meteorological conditions and forecast trend.

Have forecasted weather conditions changed since yesterday? Please explain.

_____

_____

_____

Are large weather changes expected over the next few days? Please explain.

_____

_____

_____

Is the inversion strength expected to change? Please explain.

_____

_____

Are surface and aloft winds expected to change? Please explain.

_____

_____

How might the weather conditions influemce the PM concentrations over the next several days? Please explain.

_____

_____

Evaluate the input data quality.
Do the input data reflect the general weather conditions? Please explain. If not, the input data may be old or wrong and the data needs to be replace as described in the missing data protocol in the AQEWS Help.

_____

_____

Daily Forecast Activities Continued

Task *(time)*	Action and Questions
Run AQEWS *(1100)*	Enter the input data. Run the initial forecast Input remarks. Produce the final AQEWS forecast. Review the final forecast form.
Evaluate Forecast *(1200)*	Compare the AQEWS forecast to the weather trend. *Is AQEWS forecast consistent with the trend? Please explain. If not, reevaluate the input data and forecast trend. Rerun the AQEWS forecast as needed..* _____ _____ _____ Run other forecasting methods (if available). *Do the other methods agree with the AQEWS forecast? Please explain. If so, the forecast certainty is high. If not, reevaluate the input data used in all models and re-run the models as needed. If the forecast still disagree, then forecast certainty is lower than when the forecasts agree.* _____ _____ _____
Distribute Forecast *(1300)*	Review the final forecast. Add qualifiers to the forecast discussion. Add uncertainty discussion to forecast Copy the forecast and post it on the wall. Distribute the forecast. Run verification statistics Backup database on the other computer and on a floppy disk.

PM_{10} Forecast for Cairo
Air Quality Early Warning System - Forecast Tool

Date 17/09/2000
Issued By Mahmoud & usama

PM_{10} Forecast

	Yesterday 16/09/2000	Today 17/09/2000	Tomorrow 18/09/2000	Tuesday 19/09/2000	Wednesday 20/09/2000
PM_{10} (ug/m3)	120	220	180		
PM_{10} Category	Low	Moderate	Low		
PM_{10} Forecast Trend				⇧	⇔

Remarks

Qulaly is still missing.

PM forecast is for central Cairo, average 24 hour concentration.
Forecast valid for 17/09/2000 to 20/09/2000

APPENDIX E

Guidelines for the Forecast Remarks

The "Final Forecast" page in the AQEWS program contains a "Remarks" section, where the forecaster inputs comments regarding the daily AQEWS forecast. The comments need to include information on the quality of the input data and the amount of confidence in the PM forecast. The forecast confidence levels are high, medium, or low. The confidence level chosen by the forecaster will usually depend on the quality of the AQEWS air quality and meteorological input data.

The following are example remarks:

"All input data where available and forecast confidence is high."

"Yesterday's observed PM data where only available from Qualaly. However, the forecast confidence is high"

"Yesterday's observed PM concentrations from Abbassyia were 500 ug/m3, which is 300 ug/m3 higher then PM concentrations from Qualaly and Fum Khaglig. Given that the meteorology yesterday was favorable for low PM concentrations, the Abbassyia data appear to be wrong. Therefore, Abbassyia's PM data were not used to produce the forecast. However, the forecast confidence is high.

"The latest meteorological forecast data used as input for the AQEWS where not available and yesterday's meteorological forecast data were used instead. Because other meteorological forecast models indicate rapid changes in the meteorology over the next 2 days, the forecast confidence is low"

"The latest meteorological forecast data used as input for the AQEWS where not available and yesterday's meteorological forecast data were use instead. Because other meteorological forecast models indicate only small changes in the meteorology over the next 2 days, the forecast confidence is medium"

"There is burning in the delta region and there is uncertainty on whether the smoke will be transported to Cairo today or tomorrow. Given this uncertainty, the forecast confidence is medium for today and tomorrow."