CHAPTER 3

METHODOLOGY

3.1 Characteristic of Study Site

The study roads are chosen based on high density of daily traffic passing the road at during 12 hours of day time (7.00 am -7.00 pm), including that having permanent roadside PCD monitoring station located not over 5 meters away from curbside. Furthermore, the history record of daily traffic counting should be in place and must be operated by Traffic and Transport Department of Bangkok Metropolitan Authority (BMA), all these have taken in account for selection criteria.

According to the criteria has been described; Ladphrao and Dindaeng road were qualified; because there are PCD roadside air monitoring to obtain hourly concentration and the daily traffic data are annually monitored by BMA to ensure quality of data using in this research.

3.1.1 Ladphrao Road

Located in Wangtonglank district, this 6 lanes road and 10.5 km in length has connected inner district and eastern district of Bangkok together, at which the record of densely traffic volume have been recorded for many years. The recent record of daily traffic counted by traffic and transport department (TTD, 2005) indicated that more than 50,000 vehicles per day were detected through all road links. There is PCD's air monitoring station placed near Chok-chai police station at approximately 4 meters away from curbside of the road. From annual monitoring report in 2006 revealed that daily PM10 level in Ladphrao was in the range of 27.2-96.7 $\mu g/m^3$ and monthly average concentration was measured between 40.2-66.3 $\mu g/m^3$ (PCD, 2006). The location and photograph of station illustrated on figure 3.1 and 3.2.

3.1.2 Dindaeng road

Locating in Dindaeng district, this road is 7 lanes and approximately 4 km in length, at which the victory monument and Rama IX conjunction has connected together by this road. The PCD monitoring station placed on 4 meters away from curbside behind the bus stops and the Prachanukul School is located on the opposite side of the road to this station. The daily traffic of Dindaeng road was found about 86,508 vehicles per day in year 2005 (TTD, 2005) and causing high PM_{10} concentration. From annual monitoring report in 2006 revealed that daily PM10 level in Dindaeng was in the range of 29.9-206.2 $\mu g/m^3$ and monthly average concentration was measured between 51.0-120.6 $\mu g/m^3$ (PCD, 2006). The photographs of the station are shown in figure 3.3 and 3.4.

3.2 On-site Traffic Count

The volume of daily traffic has been recorded continuously during 7.00 am to 19.00 pm in Ladphrao and Dindaeng road by Video Camera (Sony Handycam) which placed at position approximately 2.5 meters high for ensuring all lanes have been properly recorded. The period of traffic recording was operated in January 2006, when as daytime traffic movement was determined. To identify and number particular vehicle types, all video tapes of study road traffic have been re-viewed and counted through video player. The illustrations of Video Camera Setup have been shown in figure 3.5 and 3.6. The considered vehicle types, which must be identify and number by manual counters, were categorized into 8 groups as follow;

(1) Sedan, described as light-duty gasoline vehicles weighted less than 6,000 lbs (or 2,718 kg.)

(2) Pick-up and Van, described as light-duty diesel vehicles weighted less than 6,000 lbs (or 2,718 kg.)

(3) Tuk-tuk and small 4-wheel taxi, described as light-duty diesel vehicle registered as one type of non-fixed route taxi particularly in Bangkok.

(4) Motorcycle, described as 2-wheel vehicles powered by gasoline.

(5) Minibus, described as light heavy-duty diesel bus registered as one types of fixed route bus cooperated with Bangkok Mass Transit Authority (BMTA).

(6) Medium-truck, described as medium heavy-duty diesel truck weighted at 19,500-33,000 lbs (or 8,833-14,949 kg.)

Figure 3.1: Ladphrao monitoring station (aerial photograph)

Figure 3.2: Ladphrao monitoring station

Figure 3.3: Dindaeng monitoring station (aerial photograph)

Figure 3.4: Dindaeng monitoring station

Figure 3.5: Video Camera Setup

Figure 3.6: Traffic Recording

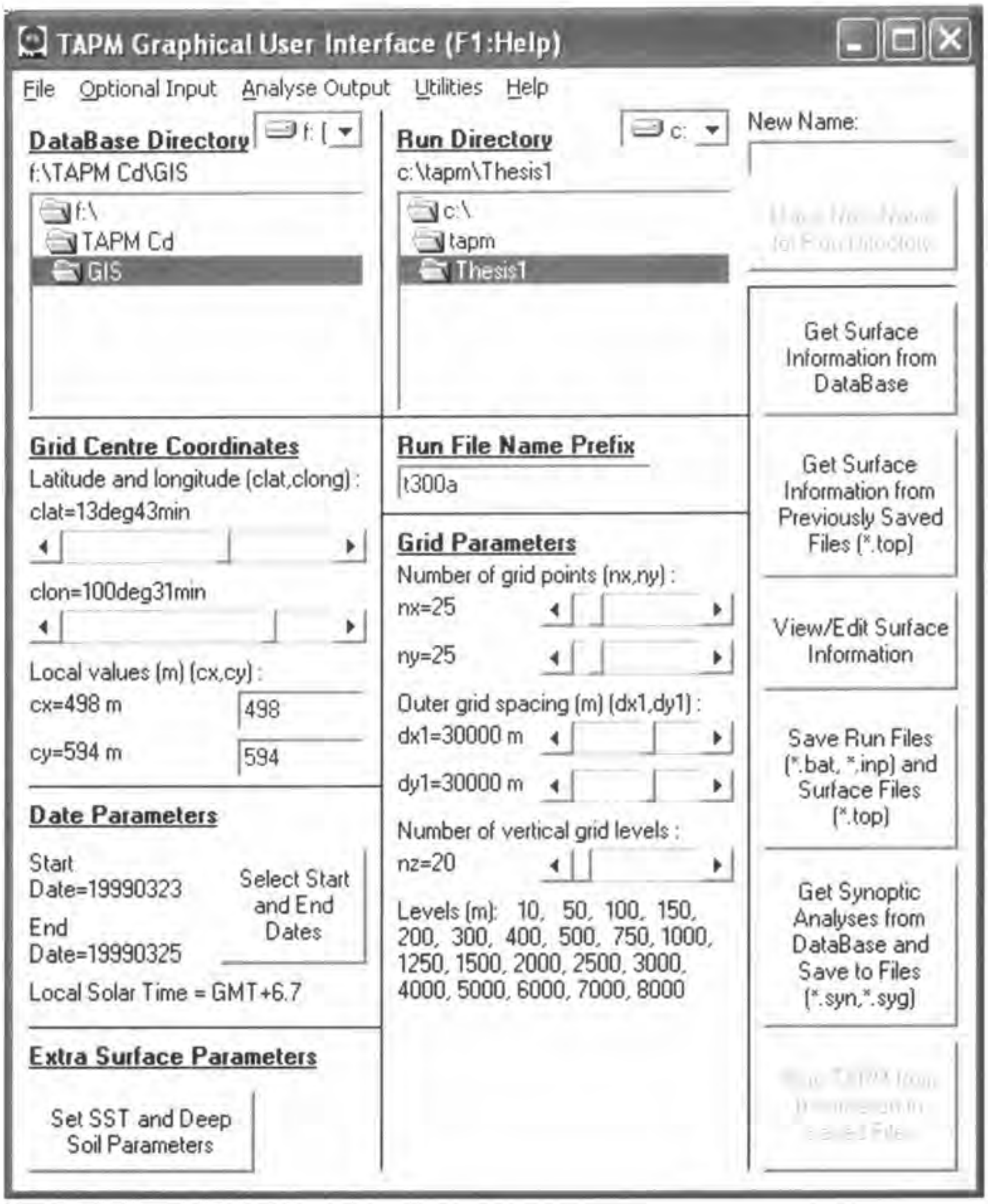

Figure 3.7: Main window of TAPM version 3.0

b) Grid Centre Coordinates

This section requires selection of latitude and longitude coordinate corresponding to the centre of the grids that are set up in the Grid Parameters section. This position is used in the database retrieval process to locate the correct position for extraction of input information. A local coordinate system can also be set up; the default system has the origin at the centre latitude and longitude. The local system uses units of meter in the usual (x, y) Cartesian system where the x is positive from west to east and y is positive from south to north, and specifies the centre of the local system with respect to the latitude/longitude grid centre.

c) Date Parameters

This section sets the start and end dates for the simulation in the form year-month-day (yyyymmdd) for example, 19970608 corresponds to the 8 June 1997. The value of the Local Solar Time (LST) relative to Greenwich Mean Time (GMT) is also displayed for information (calculated from the selected grid centre longitude). For example, Thailand Standard Time is EST = GMT + 7 and Australia Standard Time in Western Australia is WST = GMT + 8.

d) Grid Parameters

The section specifies the number of west-east (x) and south-north (y) grid points, the outer grid spacing (m) in these directions, and the number of pre-set staggered vertical grid points. The same number of grid points and the same vertical model levels are used for each grid nest. Generally, any outer grid spacing or number of points can be chosen, as long as the outer grid domain is typically somewhere between 400 km by 400 km and 1000 km by 1000 km, in order to remove the boundary regions as far away as possible from the central region of interest. It is also recommended that a minimum number of grid points for a realistic simulation should be $20 \times 20 \times 20$ points in the x, y, z directions respectively. The a grid of $25 \times 25 \times 25$ points or more is taken in this study.

e) Get Surface Information from Database

This button extracts terrain height, vegetation type and soil type from files contained in the currently selected database directory. Alternatively, this information may be recalled using the next following button.

f) Get Surface Information from Previously Saved Files (*.top)

This button if files (*.top and *.inp) exist in the current Run Directory with the Run File Name Prefix that matches the current GUI selections. Once this information has been obtained, it can be viewed and edited in the Surface Window by pressing the View/Edit Surface Information button.

g) Save Run Files (*.bat, *.inp) and Surface Files (*.top)

This button saves these files in the Run File Directory using the Run File Name Prefixes for each grid. For example, if there are three grids selected (see Section 3.1.1) with file name prefixes for the outer to inner grids of t300a, t100a and t30a respectively, then the files t300a.bat, t300a.inp, t300a.top, t100a.top and t30a.top will be saved.

h) Get Synoptic Analyses from Database and Save to Files (*.syn, *.syg)

This button accesses synoptic meteorological and sea-surface temperature analyses from the currently selected Database Directory and outputs this information to files using the Run File Name Prefix (e.g. t300a.syn and t300a.syg).

i) Save Run Files (*.bat, *.inp) and Surface Files (*.top) and Get Synoptic Analyses from Database and Save to Files (*.syn, *.syg)

This two buttons have to be pressed, and then the model can be run using the saved files.

j) Run TAPM from Information in Saved Files

Once this button is pressed, the model would start to run. However, the user is also prompted to save the GUI Default File (*.def) before model initially start to calculate.

3.3.2 Basic Model Configuration

As described above, before performing model running the fundamental parameter need to be selected properly while any other necessary input files have to be prepared for model. Table 3.1 below showing fundamental parameters configured for TAPM in order to forecast meteorological variables and air pollution level matched with Bangkok's conditions.

Table 3.1: Fundamental parameter required for TAPM simulation

Model Controls	Parameter required
1) Grid Center Coordinate	
Latitude and longitude	
▪ Latitude (clat)	13 deg 43 min
▪ Longitude (clon)	100 deg 31 min
Local values(m) (Cx,Cy)	
▪ Cx	498
▪ Cy	594
2) Date parameters	Varied upon simulation date
3) Grid parameters	
Number of grid points (nx,ny)	
▪ nx	25
▪ ny	25
Outer grid spacing (dx1,dy1)	
▪ dx1	30,000
▪ dy1	30,000
Number of vertical grid levels	
▪ nz	25

3.3.3 Input Files

Since TAPM has been configured appropriately before undergo calculation, there are two important parts of input files that need to be created. The meteorological data assimilation file (*obs) and emission file (*pse, *lse or *ase) are importantly created which is needed to be properly saved and placed into corrected folder under Run Directory as referred in section 3.3.1.

a) The meteorological data assimilation file

Assimilation of winds can optionally be included in a model simulation. The existence of an extra file with name: Run File Name Prefix plus a *.obs extension (e.g. if the outer grid Run File Name Prefix is t300a, then the wind observations need to be in a file called t300a.obs) turns on the assimilation option. The wind speed and direction observations are used to nudge the predicted solution towards the observations. The file format for the wind data assimilation *.obs files is as follows (free format)

READ: nsite

READ: sdate, shour, (x_site(i),y_site(i),i=1,nsite)

READ: sdate, shour, (z_site(i),r_site(i),i=1,nsite)

READ: sdate, shour, (k_site(i),q_site(i),i=1,nsite)

Repeated for each simulation hour

READ: idate, ihour, (ws_site(i),wd_site(i),i=1,nsite)

Where;

nsite	is number of observation sites.
sdate	is start date of simulation (yyyymmdd).
shour	is start hour of simulation (1–24).
x_site	is west-east (x) site location in local coordinates (m).
y_site	is south-north (y) site location in local coordinates (m).
z_site	is vertical (z) site location above the ground (m).
r_site	is radius of influence (m) for each site.
k_site	is number of vertical model levels to assimilate each side of the nearest model level to the observation.
q_site	is data quality indicator (0.0–1.0) (0.0 = ignore, 1.0 = reliable).
idate	is date of observations (yyyymmdd).
ihour	is hour of observations (1–24).
ws_site	is site wind speed (m s^{-1}).
wd_site	is site wind direction (°).

To create *.obs file, EXCEL program is easy-to-use program to preliminarily develop the meteorological data assimilation file at first place and then the preliminary file must be saved as type 'text (tab delimited)' with extension *.obs following the file name. (e.g.t300a.obs, t100a.obs or t030a.obs) It's should be note that the *.obs file must be placed at corrected folder where model propose to run. The example of *.obs file initially developed in EXCEL is shown in figure 3.8.

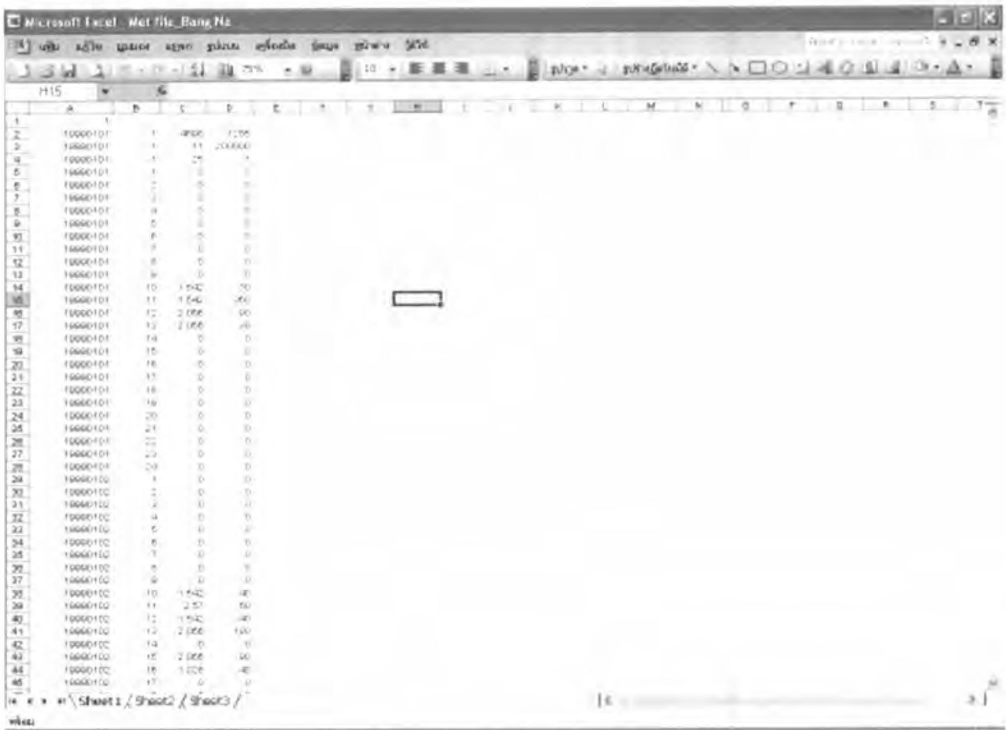

Figure 3.8: The preparation of meteorological data assimilation file (*.obs) by EXCEL program.

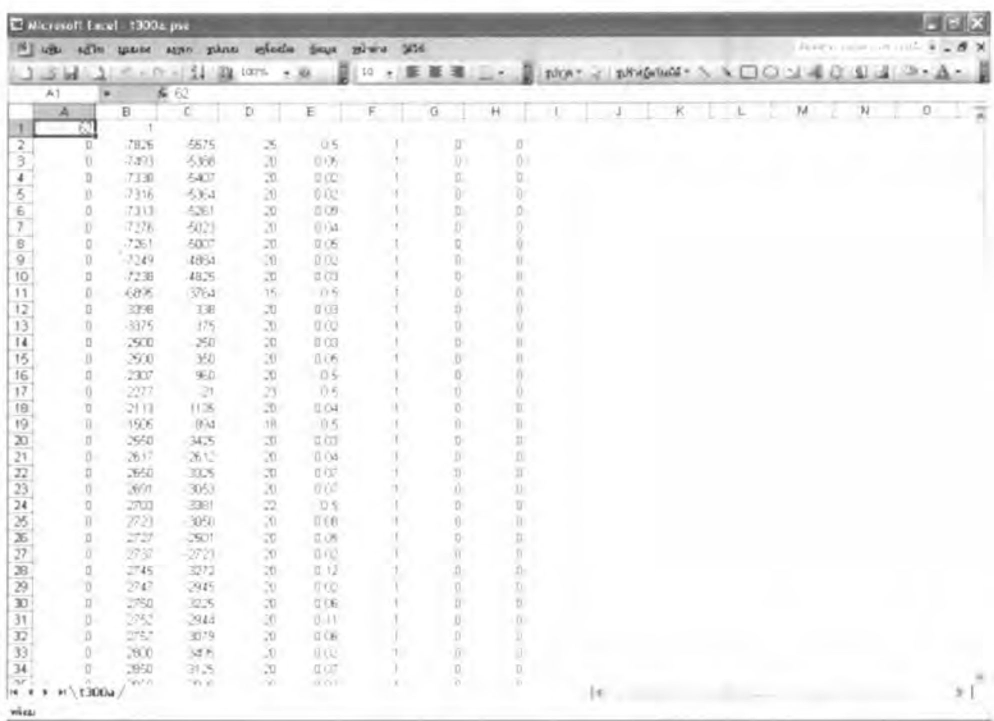

Figure 3.9: The preparation of point source emission file (*.pse) by EXCEL program.

b) The emission file

Hourly varying emission information can optionally be read by the model for files with point source emissions (*.pse), line source emissions (*.lse), area source emissions (*.ase). The model assumes that the file names of these files for a particular run use the Run File Name Prefix of the outer grid with the corresponding extension (e.g. t300a.pse, t300a.lse, t300a.ase, t300a.gse, t300a.bse, t300a.whe, t300a.vpx, t300a.vdx, t300a.vlx, and t300a.vpv). The model can be run with any combination of these files, or no emission files at all, but care should be taken when changing pollutant mode (tracer or chemistry). The listing file (*.lis) will indicate what types of emission information is being used by the model. If generated by the user, these files should be in ASCII, free format, and should be placed in the Run Directory. If the end of file is reached before the end of the TAPM run, the file is rewound and read again (i.e. the emissions cycle over time). The required format for the *.pse file can be seen from the following explanation.

READ: nsource, nhour

do i = 1, nsource

READ: mode, x_pse, y_pse, h_pse, r_pse, e_pse, f_no_pse, f_fpm_pse

enddo

do Until End of File

do i = 1, nsource

IF TRACER MODE, READ: w_pse, t_pse, tr1_pse, tr2_pse, tr3_pse, tr4_pse

IF CHEMISTRY MODE, READ: w_pse, t_pse, apm_pse, nox_pse, so2_pse, rs_pse

enddo

enddo

where;

nsource	is number of point sources.
nhour	is number of hours over which the time-varying emissions cycle (1=constant).
mode	is control the source mode (-1=OFF, 0=EGM, 1=EGM+LPM).
x_pse	is west-east (x) local coordinate of the stack (m).
y_pse	is south-north (y) local coordinate of the stack (m).
h_pse	is stack height above the ground (m).

r_pse is internal stack radius (m).

e_pse is buoyancy enhancement factor (1=no enhancement due to near-by stacks).

f_no_pse is fraction of the NO_X emission that is NO (0 = no NO, 1 = all NO).

f_fpm_pse is fraction of the APM emission that is FPM (0 = no FPM, 1 = all FPM).

w_pse is stack exit velocity ($m\ s^{-1}$).

t_pse is stack exit temperature (K).

tr1_pse is emission rate of TR1 ($g\ s^{-1}$).

tr2_pse is emission rate of TR2 ($g\ s^{-1}$).

tr3_pse is emission rate of TR3 ($g\ s^{-1}$).

tr4_pse is emission rate of TR4 ($g\ s^{-1}$).

apm_pse is emission rate of APM ($g\ s^{-1}$).

nox_pse is emission rate of NO_X ($g\ s^{-1}$) (expressed as NO_2).

so2_pse is emission rate of SO_2 ($g\ s^{-1}$).

rs_pse is emission rate of Rsmog ($g\ s^{-1}$).

The required format for the *.lse or *.ase file can be seen from the following

```
READ: nsource, nhour
do i = 1, nsource
READ: mode, x0, y0, h0, x1, y1, h1, f_no, f_fpm
enddo
do Until End of File
do i = 1, nsource
IF TRACER MODE, READ: tr1, tr2, tr3, tr4
IF CHEMISTRY MODE, READ: apm, nox, so2, rs
enddo
enddo
```

where;

nsource is number of sources.

nhour is number of hours over which the time-varying emissions cycle (1=constant).

mode is controls the source mode (-1=OFF, 0=EGM).

x0 is west-east (x) local coordinate of the source (m) (start coordinate).

y0 is south-north (y) local coordinate of the source (m) (start coordinate).

h0 is source height above the ground (m) (start coordinate).

x1 is west-east (x) local coordinate of the source (m) (end coordinate).

y1 is south-north (y) local coordinate of the source (m) (end coordinate).

h1 is source height above the ground (m) (end coordinate).

f_no is fraction of the NO_X emission that is NO (0 = no NO, 1 = all NO).

f_fpm is fraction of the APM emission that is FPM (0 = no FPM, 1 = all FPM).

tr1 is emission rate of TR1 ($g\ s^{-1}$).

tr2 is emission rate of TR2 ($g\ s^{-1}$).

tr3 is emission rate of TR3 ($g\ s^{-1}$).

tr4 is emission rate of TR4 ($g\ s^{-1}$).

apm is emission rate of APM ($g\ s^{-1}$).

nox is emission rate of NO_X ($g\ s^{-1}$) (expressed as NO_2).

so2 is emission rate of SO_2 ($g\ s^{-1}$).

rs is emission rate of Rsmog ($g\ s^{-1}$).

Note that although the format is the same for both line and area/volume source files, line sources have emissions uniformly distributed along a straight line using the start and end points specified, whereas area/volume sources have emissions uniformly distributed within a volume (or x-y plane area, if heights are the same) with sides aligned along the Cartesian coordinate axes and side lengths $|x1-x0|$, $|y1-y0|$ and $|h1-h0|$, in the x, y, z directions respectively. Same as meteorological data assimilation file (*.obs file), the EXCEL program need to be firstly created *.pse, *.lse and *.ase file and then transform to particular emission file, the example of file developed on EXCEL has been given in figure 3.9 - 3.11 for point source emission file, line source emission file and area source emission file, respectively. The illustration showed 4 domains setting with point source emission file (*.pse), line source emission file (*.lse), area source emission file (*.ase) and location of 6 monitoring stations have been shown in figure 3.12 - 3.15, respectively.

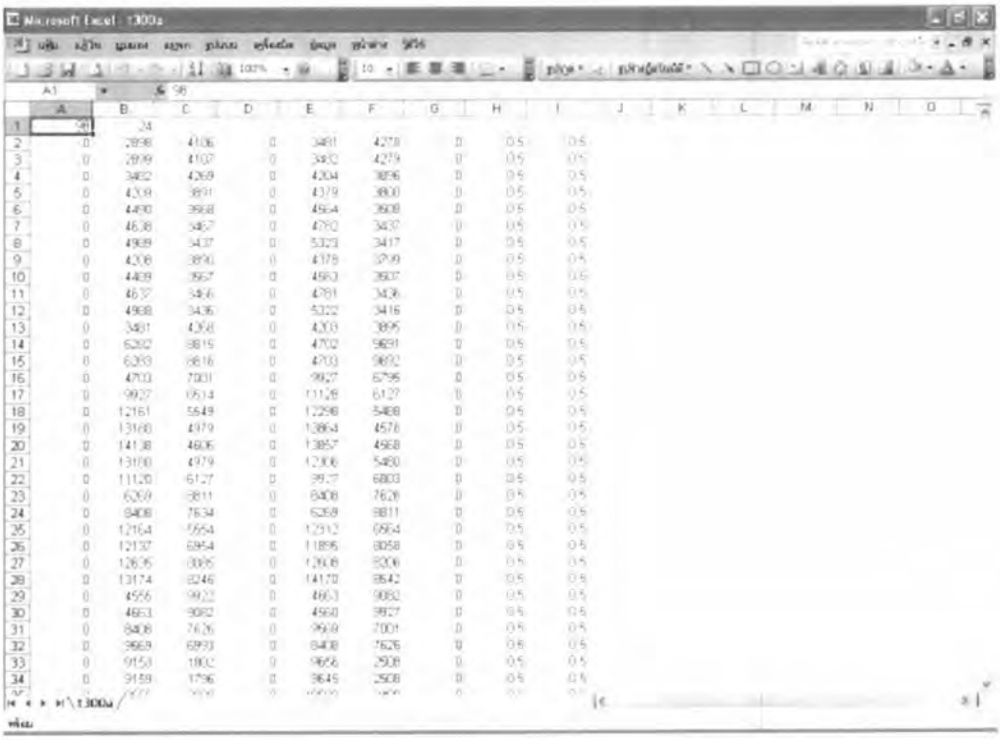

Figure 3.10: The preparation of line source emission file (*.lse) by EXCEL program.

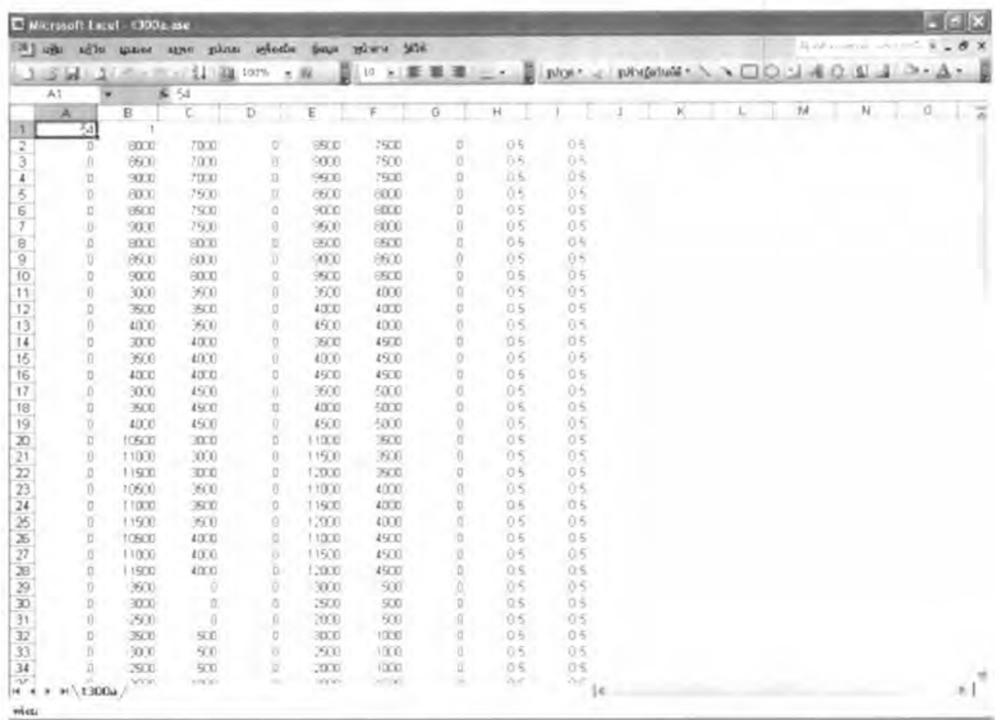

Figure 3.11: The preparation of area source emission file (*.ase) by EXCEL program.

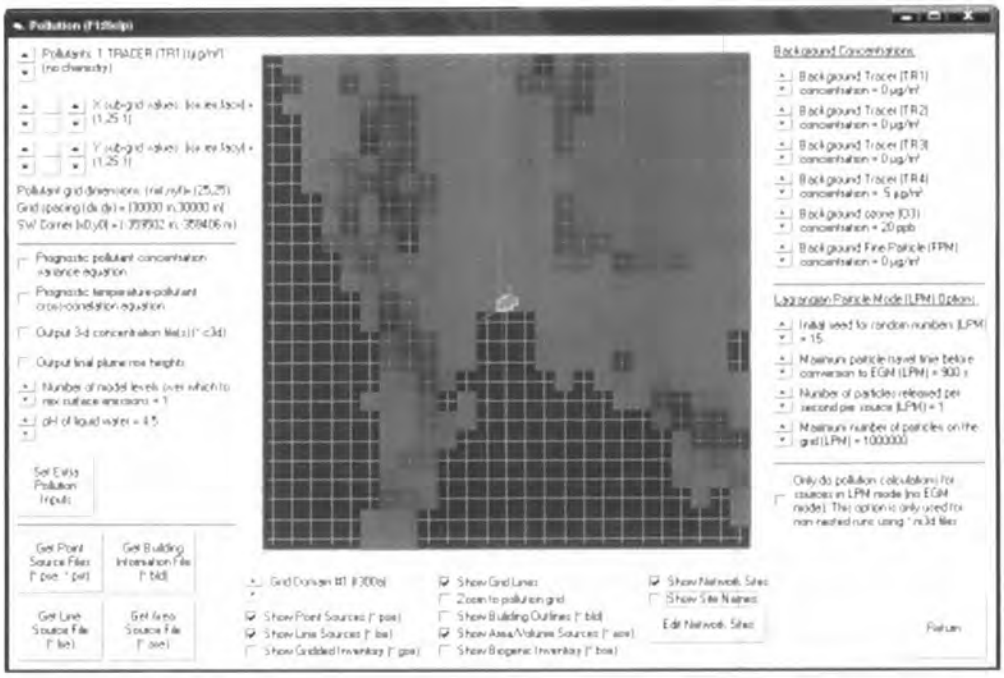

Figure 3.12: The outermost grid domain (30 km) in TAPM configuration

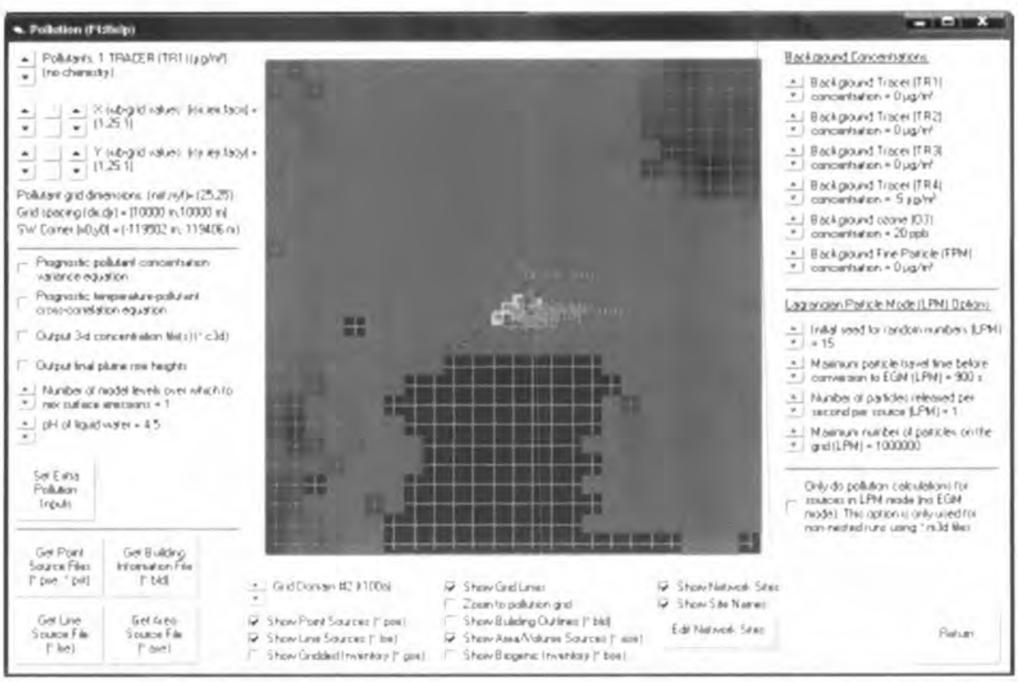

Figure 3.13: The second grid domain (10 km) in TAPM configuration

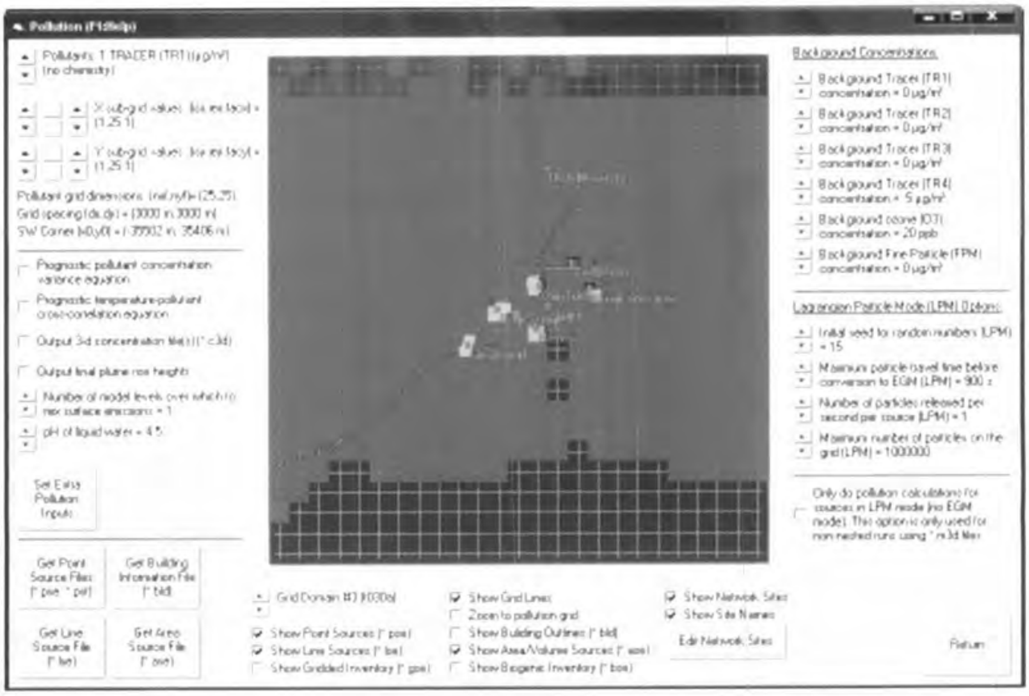

Figure 3.14: The third grid domain (3 km) in TAPM configuration

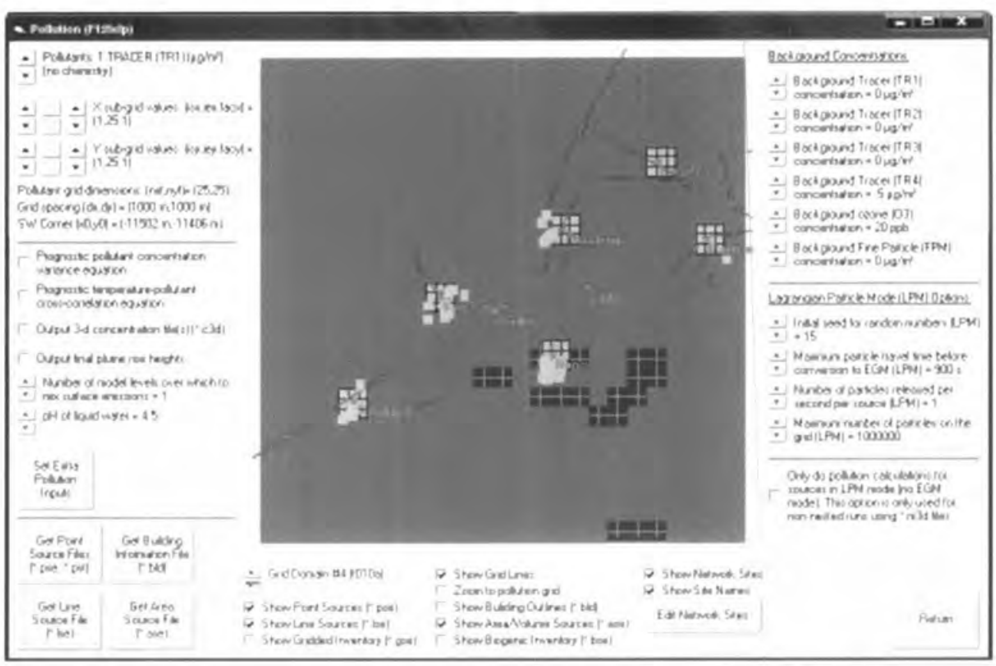

Figure 3.15: The innermost grid domain (1 km) in TAPM configuration