

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 $\mu\text{g}/\text{m}^3$ and monthly average concentration was measured between 40.2-66.3 $\mu\text{g}/\text{m}^3$ (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 PM₁₀ concentration. From annual monitoring report in 2006 revealed that daily PM₁₀ level in Dindaeng was in the range of 29.9-206.2 $\mu\text{g}/\text{m}^3$ and monthly average concentration was measured between 51.0-120.6 $\mu\text{g}/\text{m}^3$ (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

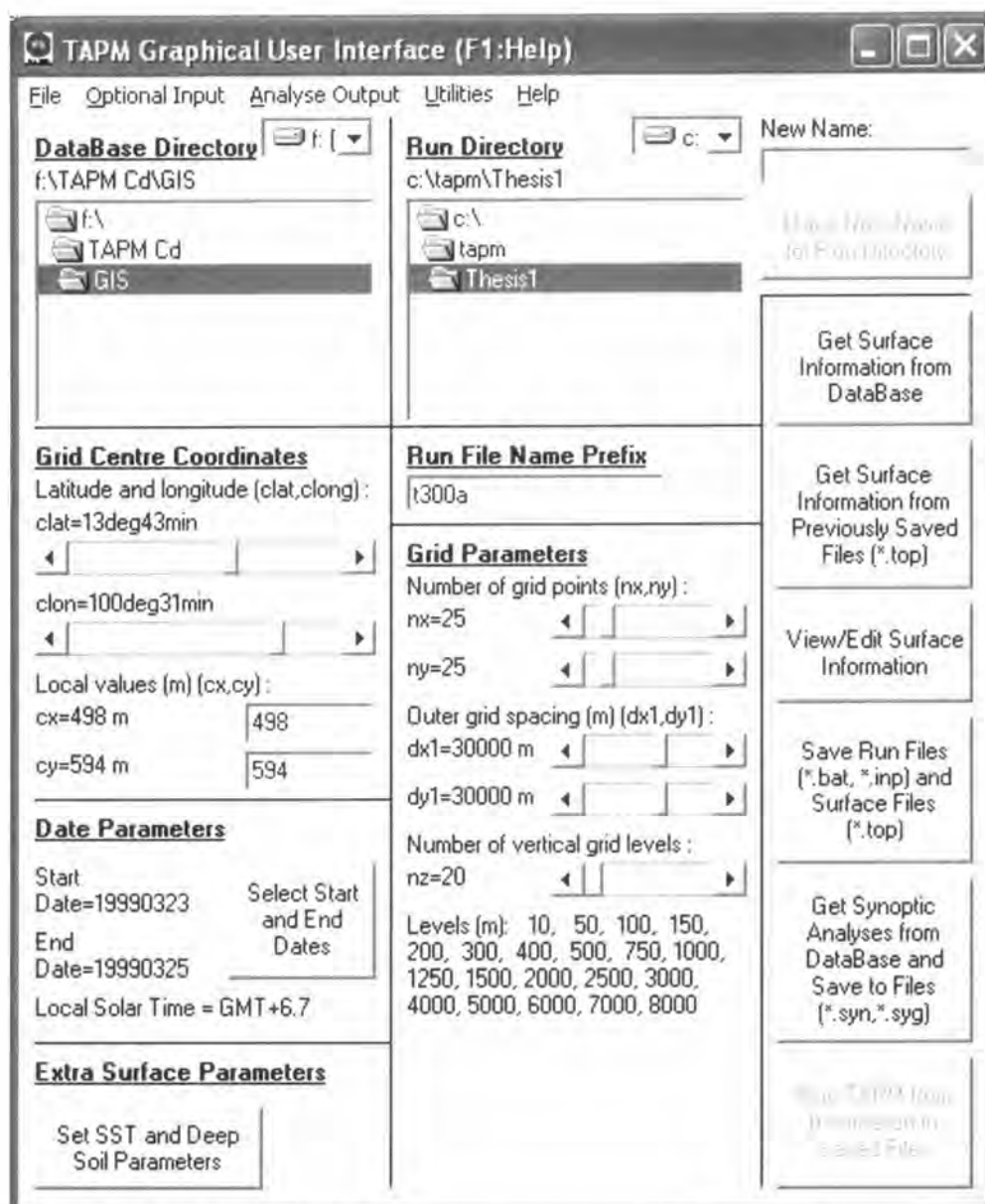


Figure 3.7: Main window of TAPM version 3.0

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 <i>Latitude and longitude</i>	
▪ Latitude (clat)	13 deg 43 min
▪ Longitude (clon)	100 deg 31 min
<i>Local values(m) (Cx,Cy)</i>	
▪ Cx	498
▪ Cy	594
2) Date parameters	Varied upon simulation date
3) Grid parameters	
<i>Number of grid points (nx,ny)</i>	
▪ nx	25
▪ ny	25
<i>Outer grid spacing (dxl,dyl)</i>	
▪ dxl	30,000
▪ dyl	30,000
<i>Number of vertical grid levels</i>	
▪ 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 ($^{\circ}$).

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.

The screenshot shows a Microsoft Excel spreadsheet with the following data structure:

Row	Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H	Column I	Column J	Column K	Column L	Column M	Column N	Column O
1	10000101	1	4000	7200											
2	10000101	1	11	200000											
3	10000101	1	25												
4	10000101	1	0	0											
5	10000101	2	0	0											
6	10000101	3	0	0											
7	10000101	4	0	0											
8	10000101	5	0	0											
9	10000101	6	0	0											
10	10000101	7	0	0											
11	10000101	8	0	0											
12	10000101	9	0	0											
13	10000101	10	1.542	70											
14	10000101	11	1.542	90											
15	10000101	12	2.066	90											
16	10000101	13	2.066	40											
17	10000101	14	0	0											
18	10000101	15	0	0											
19	10000101	16	0	0											
20	10000101	17	0	0											
21	10000101	18	0	0											
22	10000101	19	0	0											
23	10000101	20	0	0											
24	10000101	21	0	0											
25	10000101	22	0	0											
26	10000101	23	0	0											
27	10000101	24	0	0											
28	10000101	25	0	0											
29	10000102	1	0	0											
30	10000102	2	0	0											
31	10000102	3	0	0											
32	10000102	4	0	0											
33	10000102	5	0	0											
34	10000102	6	0	0											
35	10000102	7	0	0											
36	10000102	8	0	0											
37	10000102	9	0	0											
38	10000102	10	1.542	40											
39	10000102	11	2.07	90											
40	10000102	12	1.542	40											
41	10000102	13	2.066	100											
42	10000102	14	0	0											
43	10000102	15	2.066	90											
44	10000102	16	1.028	40											
45	10000102	17	0	0											

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

The screenshot shows a Microsoft Excel spreadsheet with the following data structure:

Row	Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H	Column I	Column J	Column K	Column L	Column M	Column N	Column O
1	10000101	1													
2	0	7826	-5575	25	0.5	1	0	0							
3	0	-3493	-5368	20	0.06	1	0	0							
4	0	7130	-5407	20	0.02	1	0	0							
5	0	-3316	-5364	20	0.02	1	0	0							
6	0	7113	-5261	20	0.09	1	0	0							
7	0	-3376	-5021	20	0.04	1	0	0							
8	0	7261	-5007	20	0.06	1	0	0							
9	0	-3249	-4854	20	0.02	1	0	0							
10	0	7230	-4825	20	0.03	1	0	0							
11	0	-6096	-3764	15	-0.5	1	0	0							
12	0	3076	330	20	0.03	1	0	0							
13	0	-3375	175	20	0.02	1	0	0							
14	0	-2500	-250	20	0.03	1	0	0							
15	0	-2500	350	20	0.06	1	0	0							
16	0	2307	960	20	-0.5	1	0	0							
17	0	2277	-21	23	0.5	1	0	0							
18	0	2113	1128	20	0.04	1	0	0							
19	0	1905	894	18	-0.5	1	0	0							
20	0	-2550	-3425	20	0.03	1	0	0							
21	0	2617	-2612	20	0.04	1	0	0							
22	0	2650	-3025	20	0.07	1	0	0							
23	0	2691	-3053	20	0.07	1	0	0							
24	0	2703	-3081	22	-0.5	1	0	0							
25	0	2723	-3050	20	0.08	1	0	0							
26	0	2727	-3501	20	0.08	1	0	0							
27	0	2737	-3721	20	0.02	1	0	0							
28	0	2745	-3272	20	0.12	1	0	0							
29	0	2747	-2945	20	0.02	1	0	0							
30	0	2750	-3025	20	0.06	1	0	0							
31	0	2752	-2944	20	0.11	1	0	0							
32	0	2752	-3079	20	0.06	1	0	0							
33	0	2800	-3476	20	0.02	1	0	0							
34	0	2850	-3125	20	0.07	1	0	0							

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;

<i>nsource</i>	is number of point sources.
<i>nhour</i>	is number of hours over which the time-varying emissions cycle (1=constant).
<i>mode</i>	is control the source mode (-1=OFF, 0=EGM, 1=EGM+LPM).
<i>x_pse</i>	is west-east (x) local coordinate of the stack (m).
<i>y_pse</i>	is south-north (y) local coordinate of the stack (m).
<i>h_pse</i>	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 NO₂).
- so2_pse* is emission rate of SO₂ (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).

<i>x0</i>	is west-east (x) local coordinate of the source (m) (start coordinate).
<i>y0</i>	is south-north (y) local coordinate of the source (m) (start coordinate).
<i>h0</i>	is source height above the ground (m) (start coordinate).
<i>x1</i>	is west-east (x) local coordinate of the source (m) (end coordinate).
<i>y1</i>	is south-north (y) local coordinate of the source (m) (end coordinate).
<i>h1</i>	is source height above the ground (m) (end coordinate).
<i>f_no</i>	is fraction of the NO _x emission that is NO (0 = no NO, 1 = all NO).
<i>f_fpm</i>	is fraction of the APM emission that is FPM (0 = no FPM, 1 = all FPM).
<i>tr1</i>	is emission rate of TR1 (g s ⁻¹).
<i>tr2</i>	is emission rate of TR2 (g s ⁻¹).
<i>tr3</i>	is emission rate of TR3 (g s ⁻¹).
<i>tr4</i>	is emission rate of TR4 (g s ⁻¹).
<i>apm</i>	is emission rate of APM (g s ⁻¹).
<i>nox</i>	is emission rate of NO _x (g s ⁻¹) (expressed as NO ₂).
<i>so2</i>	is emission rate of SO ₂ (g s ⁻¹).
<i>rs</i>	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.

A	B	C	D	E	F	G	H	I
1	0	2898	4106	0	3481	4278	0	0.5
2	0	2999	4107	0	3492	4279	0	0.5
3	0	3492	4269	0	4204	3896	0	0.5
4	0	4339	3991	0	4379	3800	0	0.5
5	0	4490	3968	0	4564	3608	0	0.5
6	0	4638	3467	0	4792	3437	0	0.5
7	0	4969	3437	0	5323	3417	0	0.5
8	0	4306	3890	0	4379	3709	0	0.5
9	0	4489	3967	0	4983	3607	0	0.5
10	0	4637	3466	0	4791	3436	0	0.5
11	0	4968	3436	0	5322	3416	0	0.5
12	0	3491	4358	0	4339	3895	0	0.5
13	0	6202	3819	0	4702	3691	0	0.5
14	0	6203	3818	0	4703	3692	0	0.5
15	0	4703	3691	0	9927	6796	0	0.5
16	0	9927	6794	0	11128	6127	0	0.5
17	0	12161	5649	0	12296	5488	0	0.5
18	0	13168	4979	0	13864	4576	0	0.5
19	0	14138	4606	0	13857	4568	0	0.5
20	0	13168	4979	0	12306	5480	0	0.5
21	0	11120	6127	0	3937	6803	0	0.5
22	0	6209	3811	0	6408	7628	0	0.5
23	0	6408	7634	0	6269	3811	0	0.5
24	0	12164	5654	0	12312	5564	0	0.5
25	0	12137	6254	0	11895	6058	0	0.5
26	0	12635	6095	0	12608	6206	0	0.5
27	0	13174	6246	0	14170	3642	0	0.5
28	0	4556	3922	0	4663	3980	0	0.5
29	0	4663	3982	0	4560	3927	0	0.5
30	0	6408	7626	0	3608	7001	0	0.5
31	0	3669	6993	0	6408	7626	0	0.5
32	0	9153	1902	0	9656	2508	0	0.5
33	0	9159	1796	0	9645	2508	0	0.5
34	0	9656	2508	0	9656	2508	0	0.5

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

A	B	C	D	E	F	G	H	I
1	0	1	0	0	0	0	0	0.5
2	0	8000	7000	0	8500	7500	0	0.5
3	0	8500	7000	0	9000	7500	0	0.5
4	0	9000	7000	0	9500	7500	0	0.5
5	0	8000	7500	0	8600	8000	0	0.5
6	0	8500	7500	0	9000	8000	0	0.5
7	0	9000	7500	0	9500	8000	0	0.5
8	0	8000	8000	0	8600	8500	0	0.5
9	0	8500	8000	0	9000	8500	0	0.5
10	0	9000	8000	0	9500	8500	0	0.5
11	0	3000	3500	0	3500	4000	0	0.5
12	0	3500	3500	0	4000	4000	0	0.5
13	0	4000	3500	0	4500	4000	0	0.5
14	0	3000	4000	0	3500	4500	0	0.5
15	0	3500	4000	0	4000	4500	0	0.5
16	0	4000	4000	0	4500	4500	0	0.5
17	0	3000	4500	0	3500	5000	0	0.5
18	0	3500	4500	0	4000	5000	0	0.5
19	0	4000	4500	0	4500	5000	0	0.5
20	0	10500	3000	0	11000	3600	0	0.5
21	0	11000	3000	0	11500	3600	0	0.5
22	0	11500	3000	0	12000	3600	0	0.5
23	0	10500	3600	0	11000	4000	0	0.5
24	0	11000	3600	0	11500	4000	0	0.5
25	0	11500	3600	0	12000	4000	0	0.5
26	0	10500	4000	0	11000	4500	0	0.5
27	0	11000	4000	0	11500	4500	0	0.5
28	0	11500	4000	0	12000	4500	0	0.5
29	0	3600	0	0	3000	500	0	0.5
30	0	3000	0	0	2500	500	0	0.5
31	0	2500	0	0	2000	500	0	0.5
32	0	3600	500	0	3000	1000	0	0.5
33	0	3000	500	0	2500	1000	0	0.5
34	0	2500	500	0	2000	1000	0	0.5

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

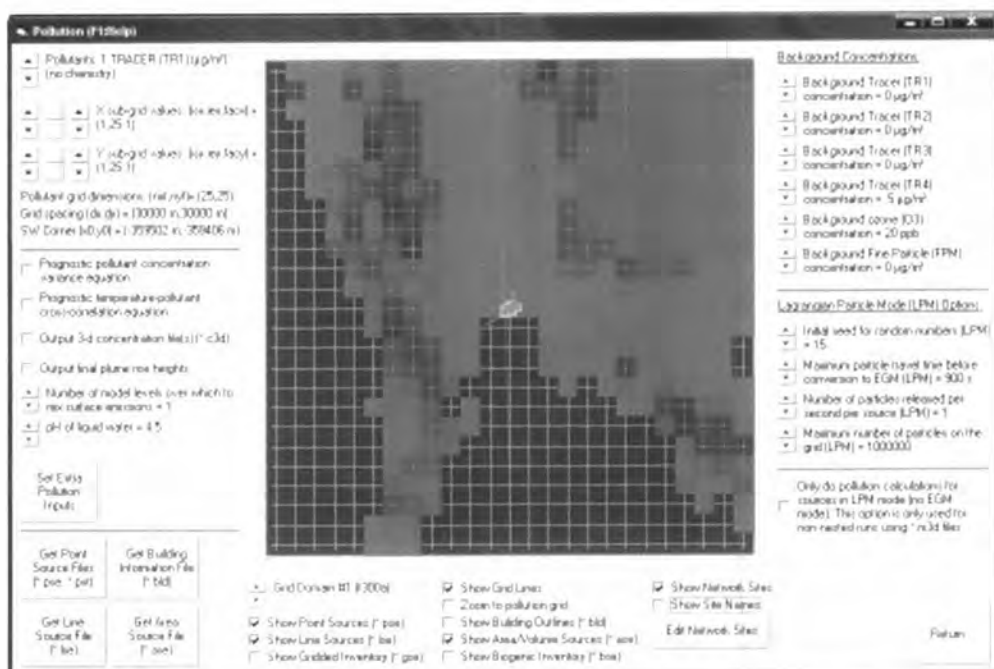


Figure 3.12: The outermost grid domain (30 km) in TAPM configuration

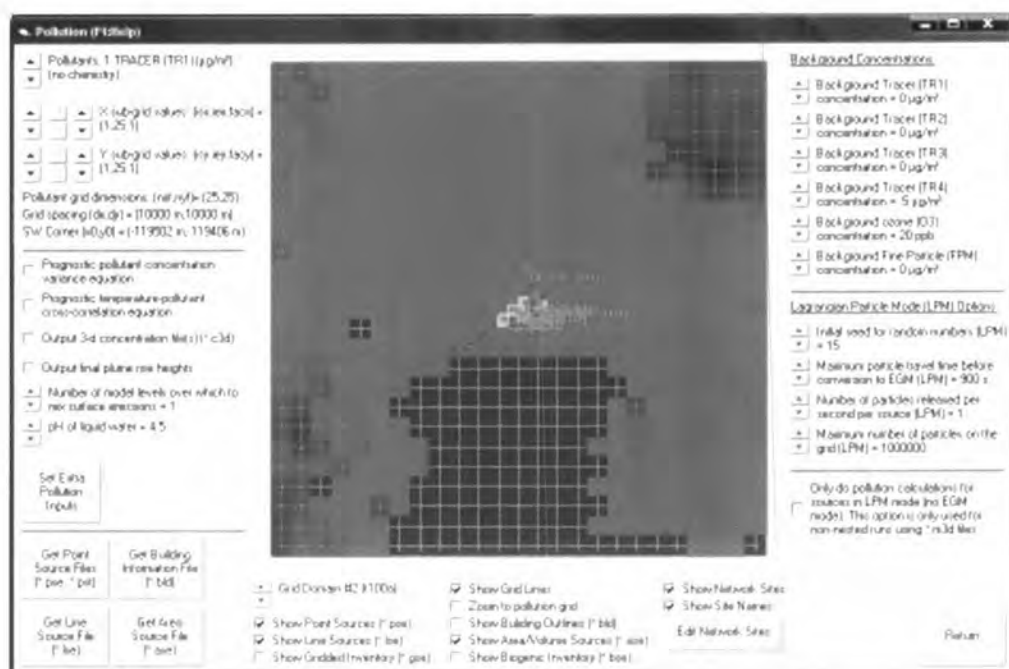


Figure 3.13: The second grid domain (10 km) in TAPM configuration

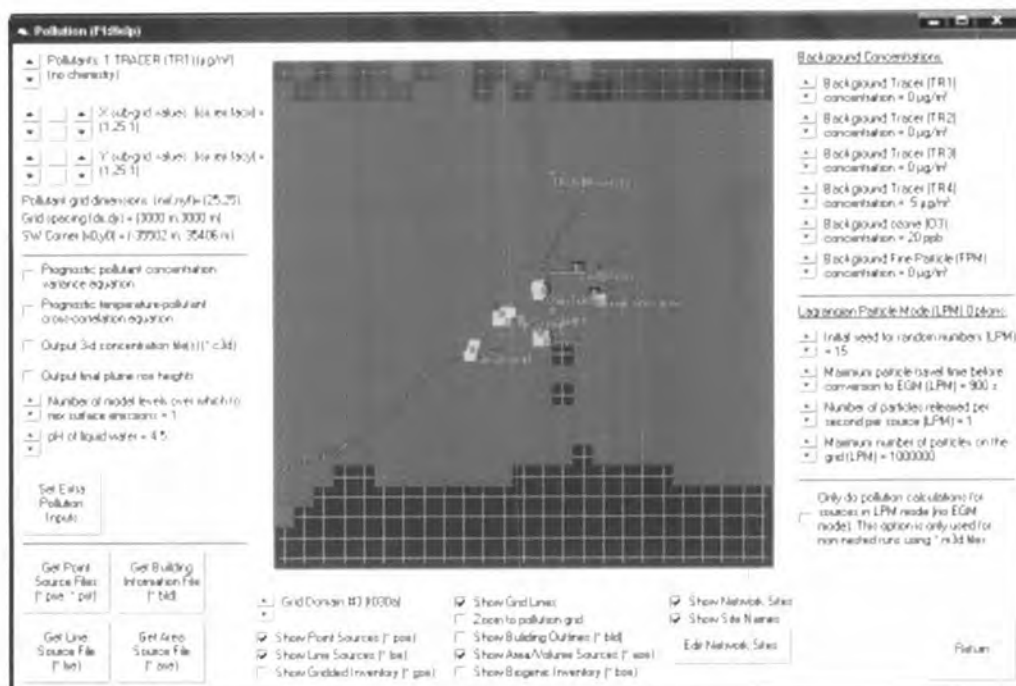


Figure 3.14: The third grid domain (3 km) in TAPM configuration

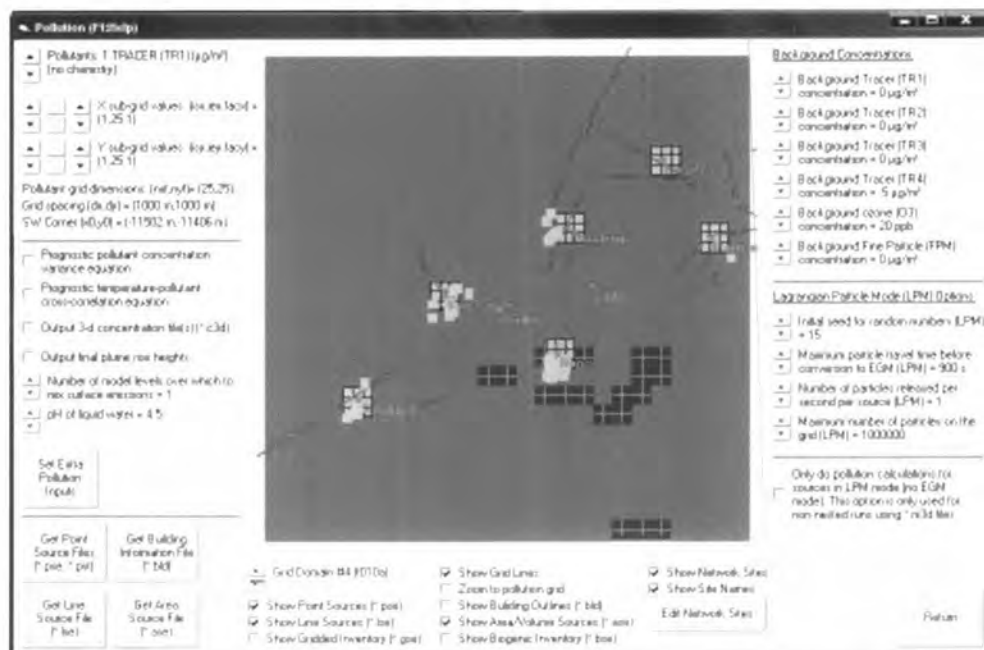


Figure 3.15: The innermost grid domain (1 km) in TAPM configuration