

# Introduction to AIM/Enduse[Air]

AIM APEIS TWS in NIES

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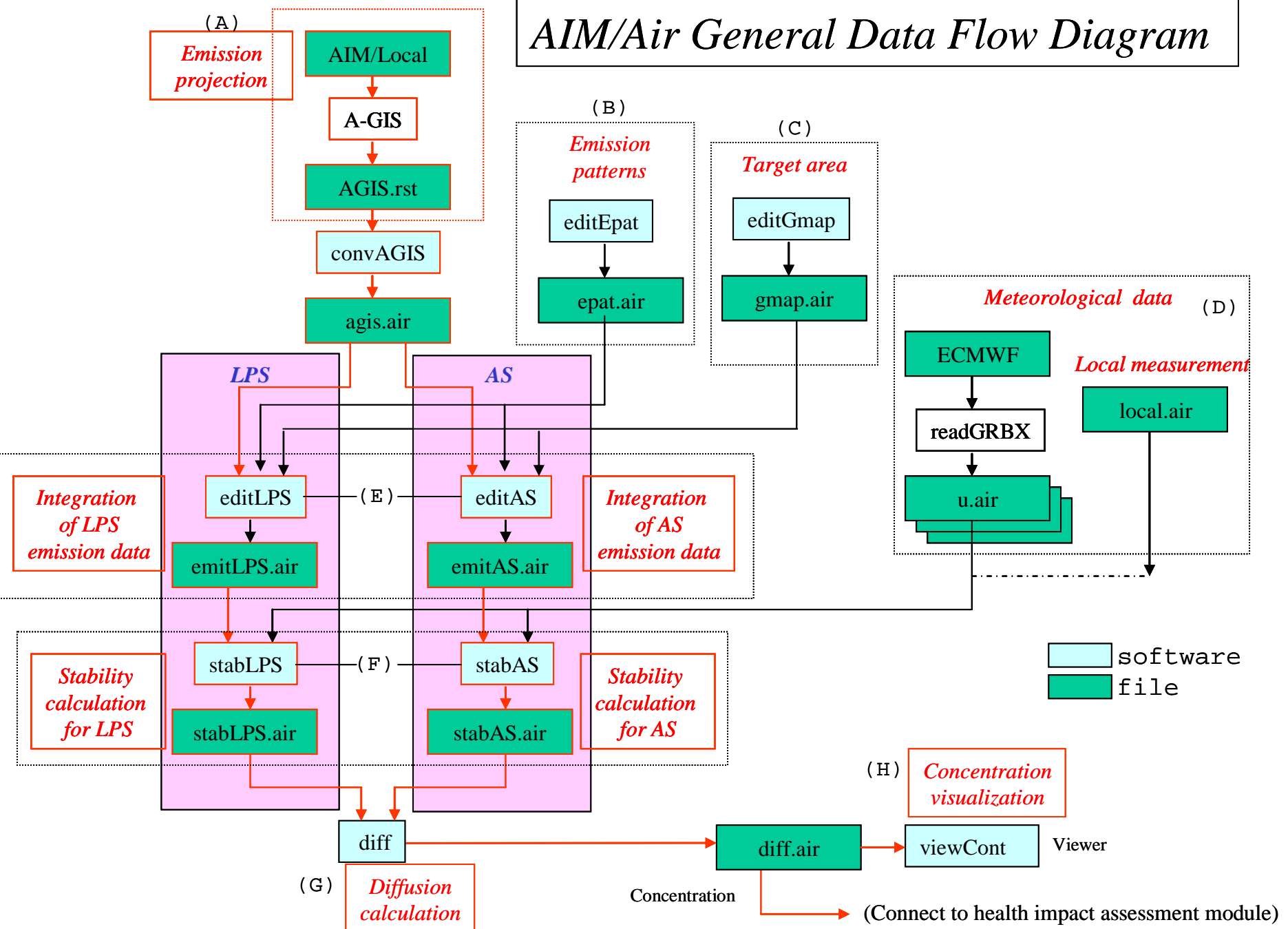
# Purpose

- To calculate diffusion of air pollutant emitted from three kinds of sources:
  - LPS: emission from large point source which has a tall stack, such as power plant, boiler or reactor in factory, waste incinerator, and so on.
  - AS: area source having a lower emission point, such as factory having a low stack, transporters, houses, fields, and so on.
  - LS: line source such as traffic road.

# Characteristics

- Air quality modeling in the framework of AIM family
- One of supplementary models of AIM/Enduse
- SO<sub>2</sub>, NO<sub>x</sub>, are target pollutants.. (SPM is the third target of pollutant)
- Pollutant concentration in every hour during specified period is calculated.
- Evaluation of health risk related to energy use through calculation of air pollutant concentration.

# AIM/Air General Data Flow Diagram



Edit large point source (LPS) data. Select an emission pattern of the LPS from the defined patterns. Moreover, edit area source (AS) data. Select an emission pattern of each point source from the defined patterns.

Develop a database of emission patterns representing hourly, daily, and monthly changes in emission, sector by sector.

Program

GIS.rst

vA GIS

editEpat

epat.air

Target area

editGmap

gmap.air

Meteorological data

(D)

ECMWF

Local measurement

Calculate the index of atmospheric stability for each LPS and each cell of AS. Diffusion parameters corresponding to the index is calculated

Interpolation of AS emission

The interface between AIM/Enduse and AIM/Air. Convert the pollutant emission from each district into the grid matrix data of emission by using the converter software, A-GIS (on IDRISI), sector by sector.

LPS

AS

stabLPS

(F)

stabAS

Stability calculation for LPS

Make grid map corresponding to the target area. A cell in the grid means a unit of area source and a receptor position where the pollutant concentration is calculated.

Cut out the meteorology data of the target area from the worldwide meteorology data ECMWF, and interpolate and form the data. Another meteorology data measured by local observation sites are also available.

(G)

Diffusion calculation

Concentration

(Connect to health impact assessment module)

# Emission pattern generator (1)

Form1

**AIM/Air**  
**EMISSION PATTERN GENERATOR**

Load Master      No. of Patterns

Emission Table

NO	Color	Name
1	***	
2	***	
3	***	
4	***	
5	***	
6	***	
7	***	
8	***	
9	***	
10	***	
11	***	
12	***	
13	***	
14	***	
15	***	
16	***	
17	***	

Add   Ins   Del   Clear

Load Epat   Save Epat   Quit

Emission Condition

Emission | Hourly | Daily | Monthly | Special |

Emission Condition

Annual Emission Intensity

☒ Mt/(year m2)    ☐ t/(year m2)  
☐ kg/(year m2)    ☐ g/(year m2)

Emission Specification

	Value
Stack Height (m)	0
Gas Flow (m3N/s)	0
Gas Temperature (K)	0
Density at 273K (kg/m3)	1.293
Spec.Heat on CP (cal/K/g)	0.24

# Emission Pattern generator (2)

GUI to input emission pattern.

Emission Condition

Emission ☒ Hourly ☐ Daily ☐ Monthly ☐ Special

Emission Condition (Hourly)

☒ Constant emission pattern  
☐ Switching On and Off pattern

On is from  o'clock to  o'clock

☐ Changing by hour

Weight Table (Min is 0.0, Max is 1.0) :

	AM	PM
0 - 1 o'clock	0	0
1 - 2 o'clock	0	0
2 - 3 o'clock	0	0
3 - 4 o'clock	0	0
4 - 5 o'clock	0	0
5 - 6 o'clock	0	0
6 - 7 o'clock	0	0
7 - 8 o'clock	0	0
8 - 9 o'clock	0	0
9 - 10 o'clock	0	0
10 - 11 o'clock	0	0
11 - 12 o'clock	0	0

Hourly pattern

Emission Condition

Emission ☐ Hourly ☒ Daily ☐ Monthly ☐ Special

Emission Condition (Daily)

☒ Constant emission pattern  
☐ Switching On and Off pattern

On is from  to

☐ Changing by day

Weight Table (Min is 0.0, Max is 1.0) :

	Weight
Monday	0
Tuesday	0
Wednesday	0
Thursday	0
Friday	0
Saturday	0
Sunday	0

Daily pattern

Emission Condition

Emission ☐ Hourly ☐ Daily ☒ Monthly ☐ Special

Emission Condition (Monthly)

☒ Constant emission pattern  
☐ Changing by month

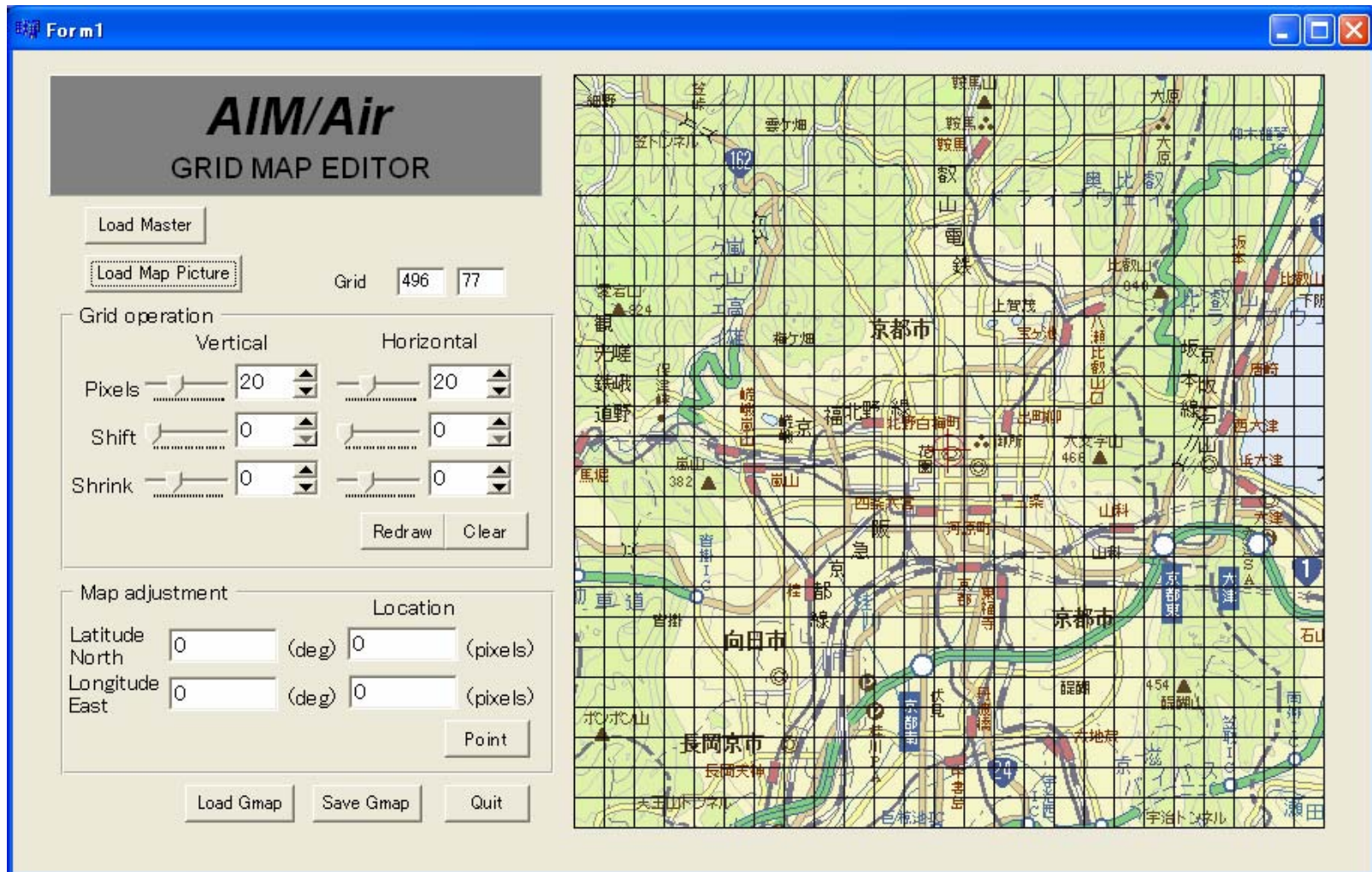
Weight Table (Min is 0.0, Max is 1.0) :

	Weight
Jan	0
Feb	0
Mar	0
Apr	0
May	0
Jun	0
Jly	0
Aug	0
Sep	0
Oct	0
Nov	0
Dec	0

Monthly pattern

Note: Term of special holidays is also taken into account.

# Grid map editor





# AS Emission Editor (1)

Form1

**AIM/Air**  
AS EMISSION EDITOR V1.0

Load Master Load\_Gmap Load Epat Load MapPic

Emission Patterns

NO	Color	Name
1	Red	Standard Pattern 1
2	Yellow	5 Days Working
3	Light Green	Half Emission in Week End
4	Light Blue	Shutdown in August
5	Dark Blue	Holiday in New Year
6	***	
7	***	
8	***	
9	***	

Set All

AS Cell Information

Cell 4,2 -----> [ ]

Code 0 [ ] OK

Height 0 [ ] (m)

Emit 0 [ ] (kg/cell)

Load EmitAS Combine EmitAS Save EmitAS Quit

# AS Emission Editor (2)

Form1

**AIM/Air**  
AS EMISSION EDITOR V1.0

Load Master Load\_Gmap Load Epat Load MapPic

Emission Patterns

NO	Color	Name
1	Red	Standard Pattern 1
2	Yellow	5 Days Working
3	Green	Half Emission in Week End
4	Cyan	Shutdown in August
5	Blue	Holiday in New Year
6	***	
7	***	
8	***	
9	***	

Set All

AS Cell Information

Cell 2,2 ----> 2,2

Code 8421631 8421631 OK

Height 1 1 (m)

Emit 1 1 (kg/cell)

Load EmitAS Combine EmitAS Save EmitAS Quit

# LPS Emission editor

**AIM/Air**

# LPS EMISSION EDITOR

Load Master      Load Epat

Emission Patterns

NO	Color	Name
1	[Blue]	Standard Pattern
2	[Red]	Day Time Pattern
3	[Green]	Week Day Pattern

Load EmitLPS      Save EmitLPS      Quit

NO	Name	Lati.	Long.	Height	Emit.	GFlow.	GTemp.	Patt.
1	IK01	35.43	139.63	8	0.87	0.87	573	[Blue]
2	IS01	35.85	139.63	13	0.68	0.68	573	[Red]
3	IS02	35.6	140.1	10	0.75	0.75	573	[Green]
4	IT01	35.68	139.75	15	0.7	0.7	573	[Blue]
5	IT02	35.68	139.35	6	0.85	0.85	573	[Red]
6	***							
7	***							
8	***							
9	***							
10	***							
11	***							
12	***							
13	***							
14	***							
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21	***							
22	***							
23	***							
24	***							
25	***							

Add      Ins      Del      Clear      The number of LPS [ 5 ]

# Specification of AIM/Air software

- **Grid size:** fineness of the grid is restricted by the limitation of CPU power and memory size.
  - Ex 1) the size of the target area is 100km x 100km, and cell size of the grid is 1 km x 1 km
  - Ex.2) the size of target area is 10km x 100km, and cell size of the grid is 100m x 100m. The balance of the target size and cell size are flexibly adjustable.
- **Emission pattern** of LPS should be designed according to the actual operation schedule in the factory. That of AS cell should be designed by considering land use, several kinds of industrial area, residential area, traffic path, agricultural field, and so on.
- **Hourly, weekly and monthly change** in emission intensity can be defined.
- The meteorology data locally corrected at observation sites are available for the diffusion calculation.
- **Pollutant concentration in every hour during specified period** is calculated.
- **Effective computational algorithm** to calculate plume-type diffusion from AS cells is implemented.
- **GUI** is available on PC computer, and software can run on both PC and Linux.

# Plume model

This diffusion equation is used when the wind velocity is more than 1(m/s).

$$C(x, y, z) = \frac{Q_p}{2\pi\sigma_y\sigma_z u} \exp\left(-\frac{y^2}{2\sigma_y^2}\right) \exp\left\{\left(-\frac{(z-H_e)^2}{2\sigma_z^2}\right) + \left(-\frac{(z+H_e)^2}{2\sigma_z^2}\right)\right\}$$

$x$ : downstream coordinate,  $y$ : horizontally transverse coordinate,  $z$ : vertical coordinate (representative height=1.5m),  $Q_p$ : emission from point source (kg/year),  $u$ : wind velocity (m/s),  $\sigma_y$ ,  $\sigma_z$ : diffusion coefficients of coordinate  $y$  and  $z$  (m)

Diffusion parameters

$$\sigma_y = \gamma_y \cdot x^{\alpha_y}, \quad \sigma_z = \gamma_z \cdot x^{\alpha_z}$$

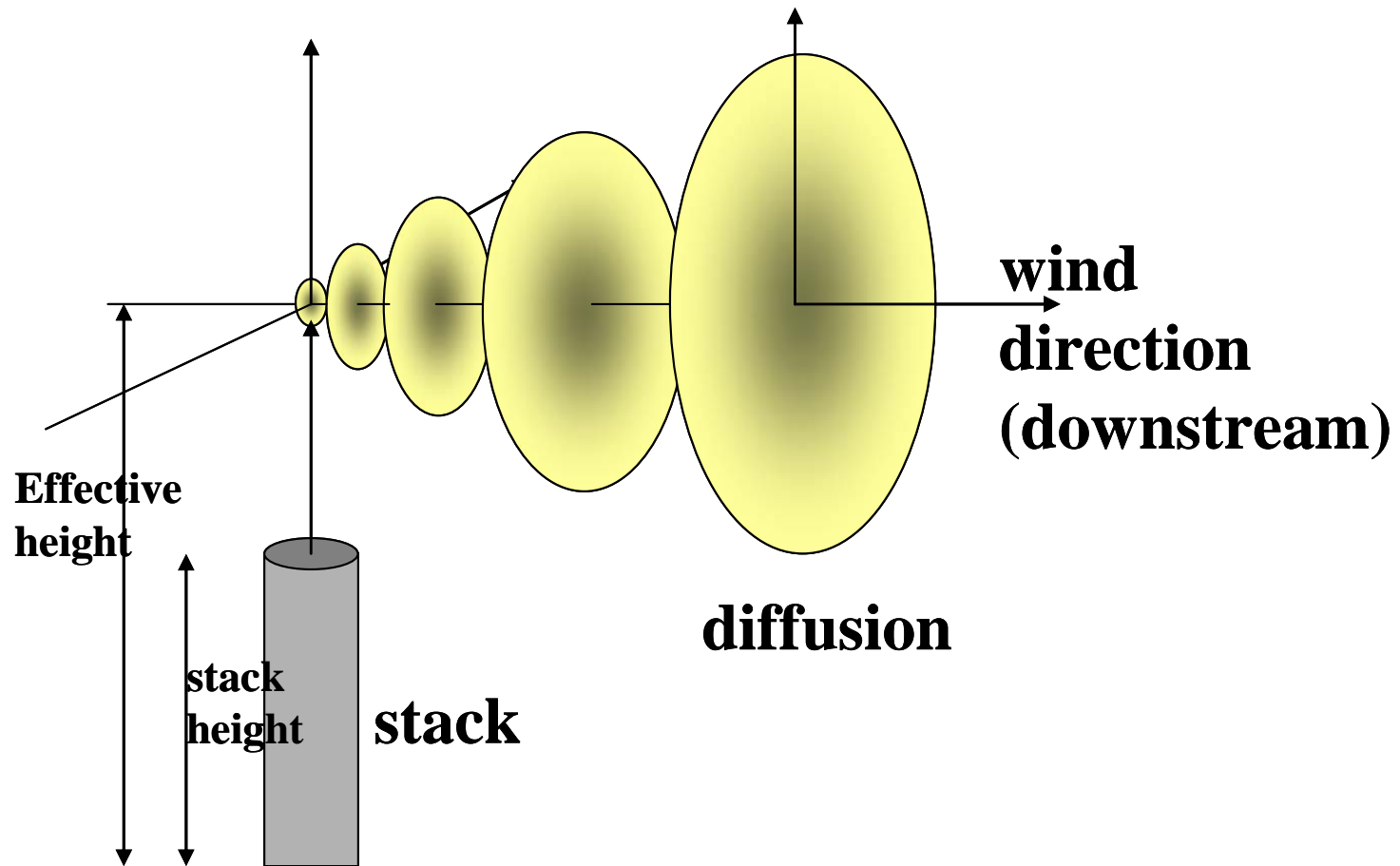
Effective stack height

$$H_e = H + \Delta H$$

$$\Delta H = 0.175 Q_H^{1/2} u_h^{-3/4}$$

$$Q_H = \rho C_p q_g (T_g - T_0)$$

# Image of plume diffusion



# Puff model

This diffusion model is used in the case of no wind or very weak wind.

$$C(x, y, z) = \frac{Q_P}{(2\pi)^{3/2} \gamma} \exp\left(-\frac{u^2}{2\alpha^2}\right) \left[ \frac{1}{\eta_-^2} \left\{ 1 + \frac{\sqrt{\pi/2} \cdot ux}{\alpha \eta_-} \exp\left(\frac{u^2 x^2}{2\alpha^2 \eta_-^2}\right) \operatorname{erfc}\left(-\frac{ux}{\sqrt{2}\alpha \eta_-}\right) \right\} + \frac{1}{\eta_+^2} \left\{ 1 + \frac{\sqrt{\pi/2} \cdot ux}{\alpha \eta_+} \exp\left(\frac{u^2 x^2}{2\alpha^2 \eta_+^2}\right) \operatorname{erfc}\left(-\frac{ux}{\sqrt{2}\alpha \eta_+}\right) \right\} \right]$$

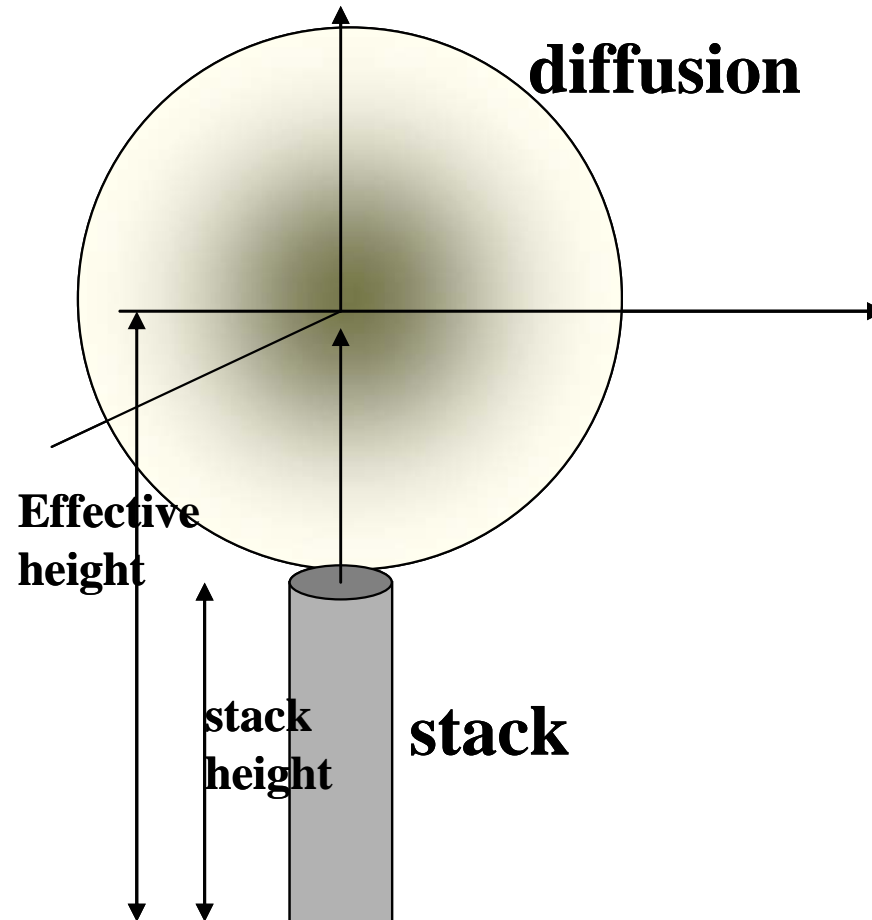
$$\eta_-^2 = x^2 + y^2 + \frac{\alpha^2}{\gamma^2} (z - H_e)^2$$

$$\eta_+^2 = x^2 + y^2 + \frac{\alpha^2}{\gamma^2} (z + H_e)^2$$

$$\operatorname{erfc}(W) = \frac{1}{\sqrt{\pi}} \int_W^\infty e^{-t^2} dt$$



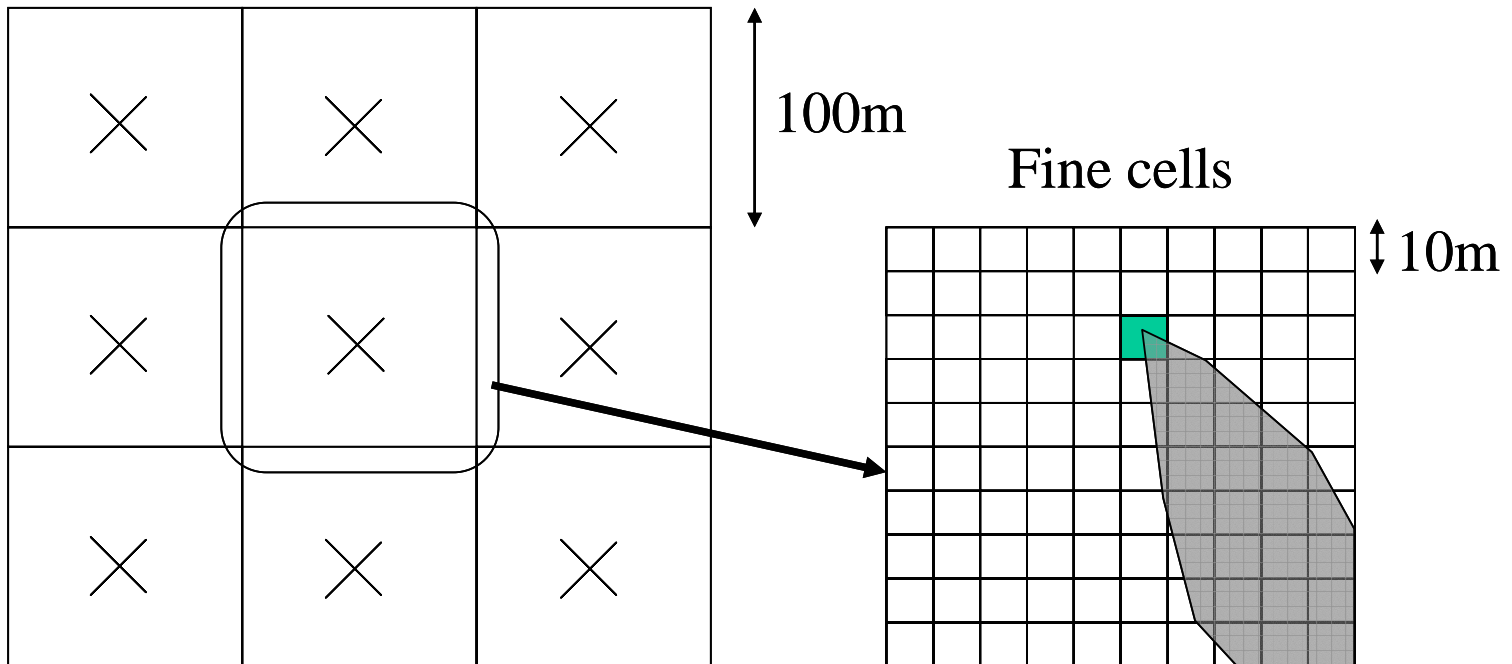
# Image of puff diffusion





# Method for AS

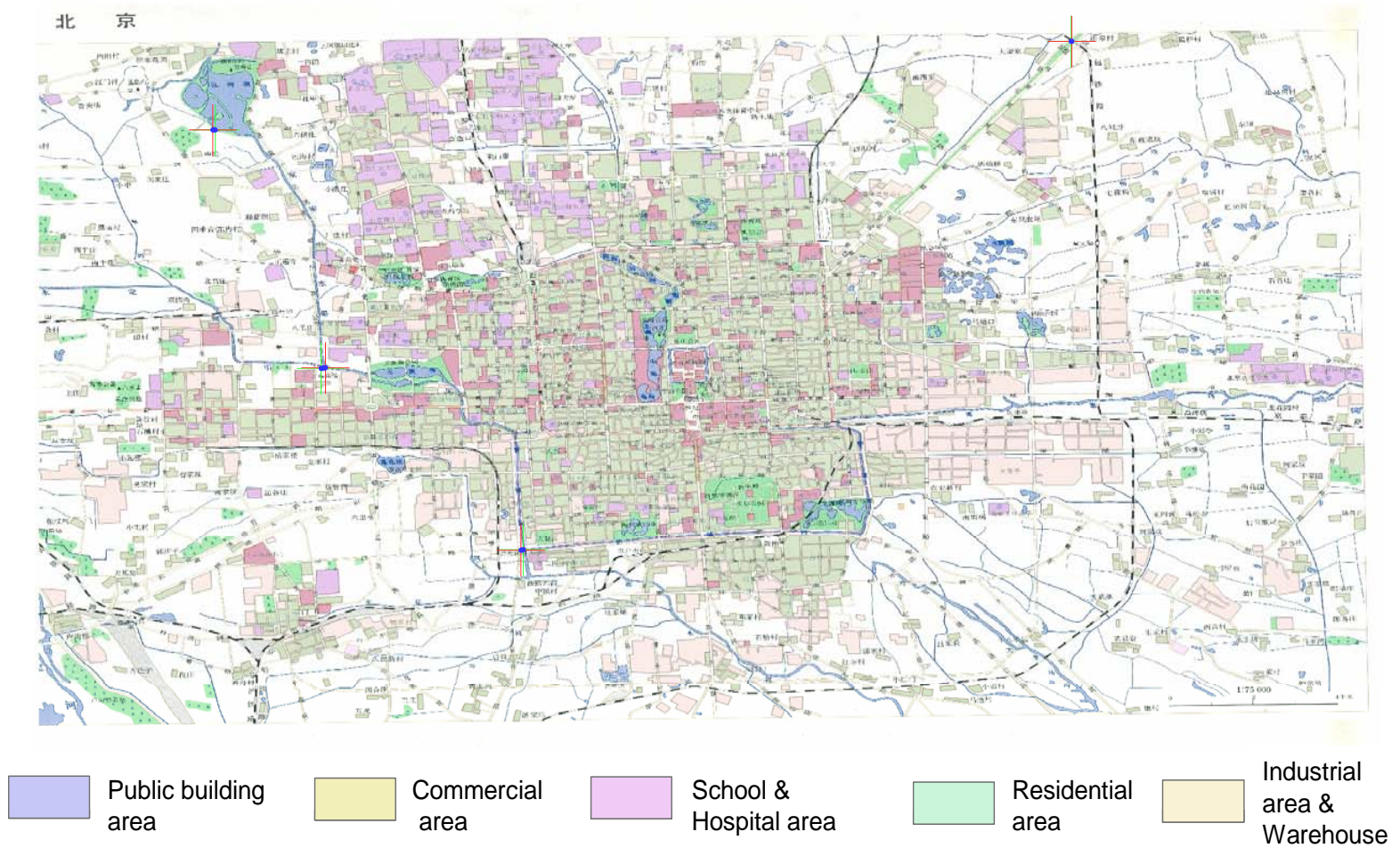
AS and Receptor cells



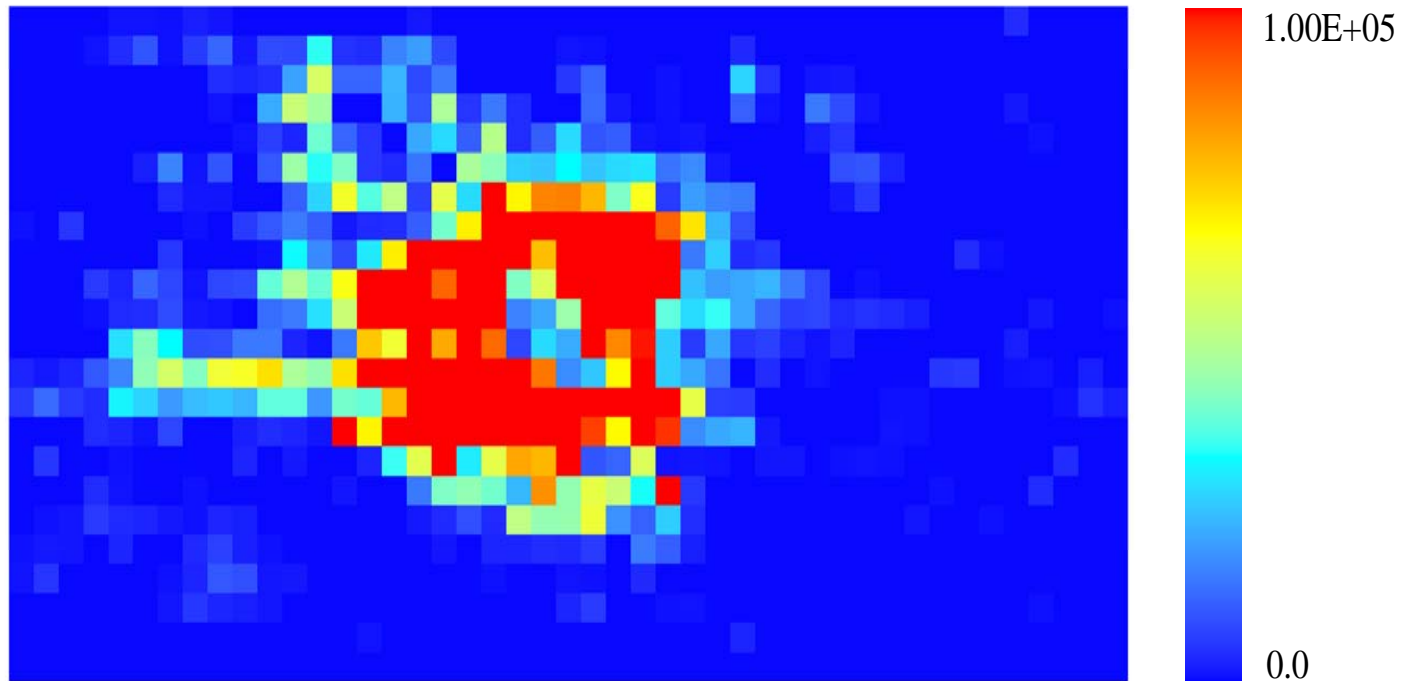
# Required data in AIM/Enduse[Air]

Emission quantity	Annual quantity (kg/year), sector by sector, output from Enduse model.
Emission pattern	daily, weekly, and monthly change in emission, sector by sector
LPS	location (latitude and longitude), stack height, gas(flow, temperature, specific heat)
AS	land-use map, emission height, gas(flow, temperature, specific heat)
LS	road map, traffic volume by transporter-type, emission factor (kg/m) by transporter-type
Meteorology data	wind direction and velocity, air temperature, solar radiation, cloud cover

# Land use in Beijing city



# Emission from residential area (grid map data)



# Contribution to Air Pollution in Beijing

