Hazard Projection System of Intentional Attack in Urban Area

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Motivation

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1. Background

- MHI developed the emergency response system (MEASURES) for Nuclear power plants, using RAMS/HYPACT.
- Nowadays the simulation system predicting NBC hazard becomes necesarry by the government and big cities.

2. Purposes of this study

- Improvement of RAMS building scheme, in order to simulate building effect more accurately with fine mesh.
- Development of hazard projection system ,applying RAMS/HYPACT.

Applications of MEASURES System

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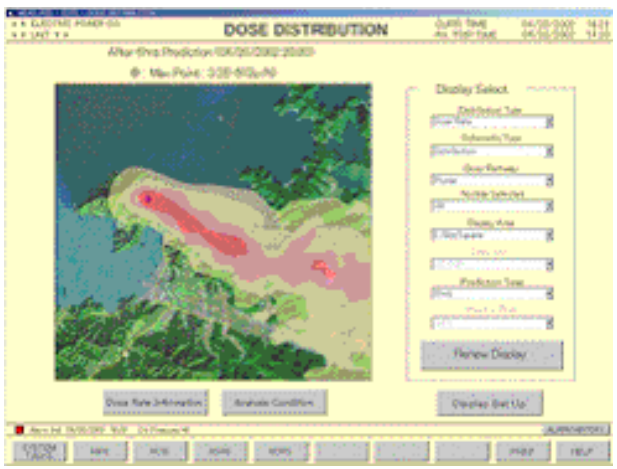
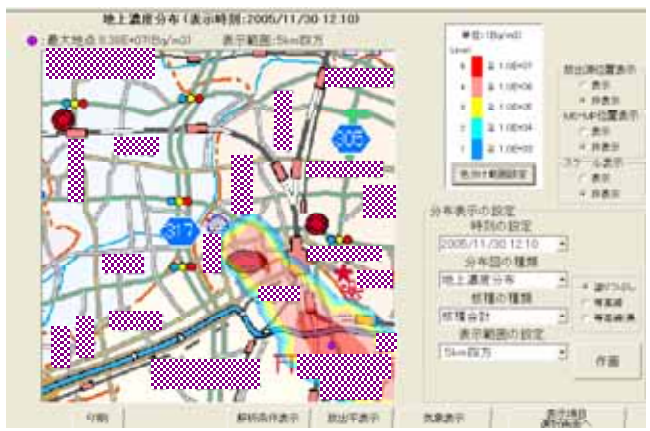
MEASURES (Multiple Radiological Emergency Assistance System for Urgent Response)

Objects	Nuclear P/S	NBC hazard
Users	Government Electric Power Companies	Government Municipals
Area	Few 10 km	Few 100 m
Time	Few hours	Few 10 minutes
Mesh size	Few 100 m	Few meters
Simulation	Terrain	Terrain & Buildings





Hazardous gas dispersion simulator

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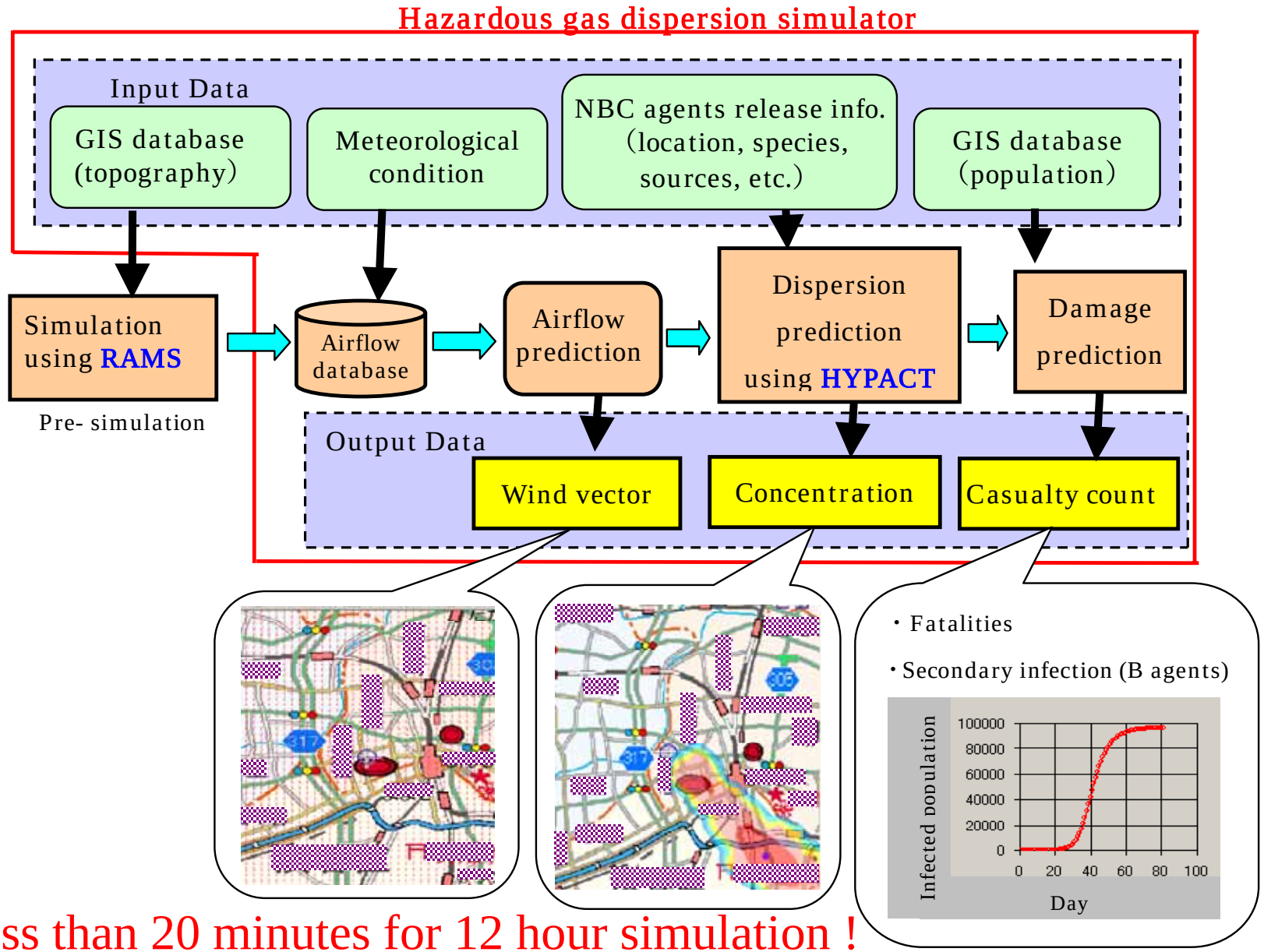
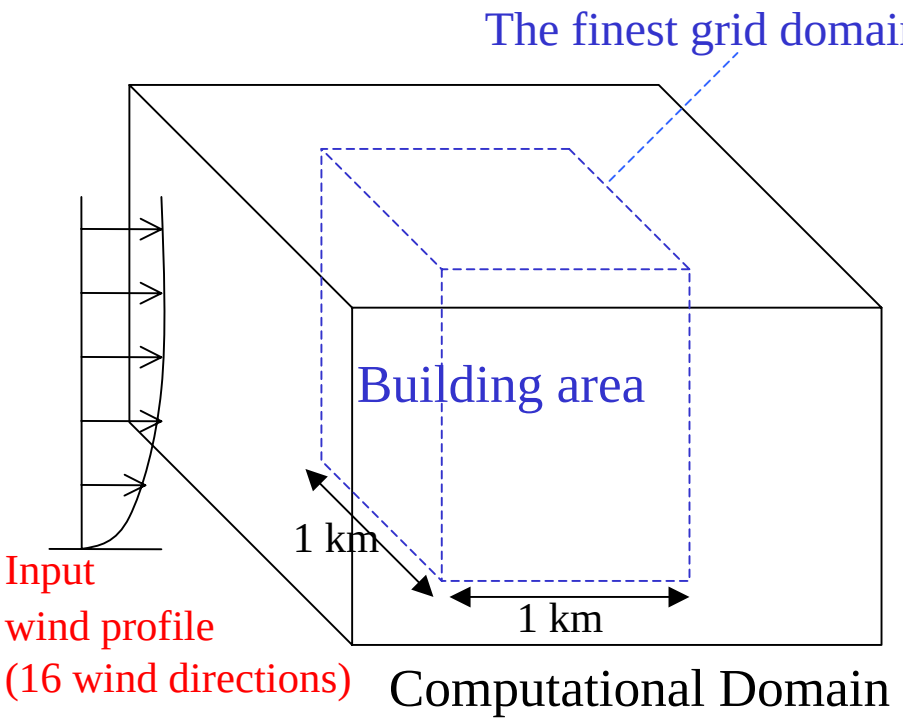
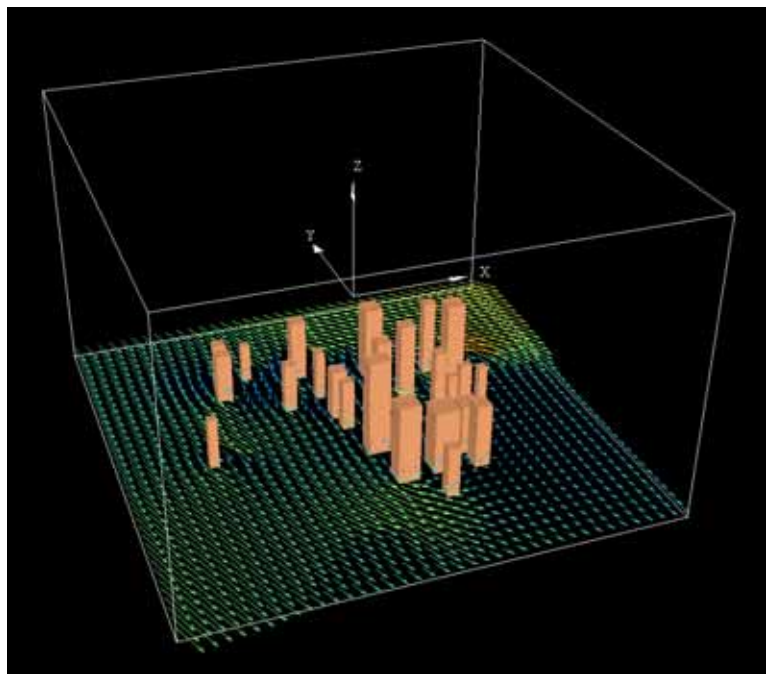


Less than 20 minutes for 12 hour simulation !

Airflow database

- Airflow data of 16 patterns corresponding 16 wind directions (N, NNE, NE, …., NNW) under neutral atmospheric conditions
- Pre-simulation using RAMS
- horizontal grid resolution : 10m
- buildings with more than 20 floors are set in the center area of the domain (1km squares)





Local 4D Assimilation Technique

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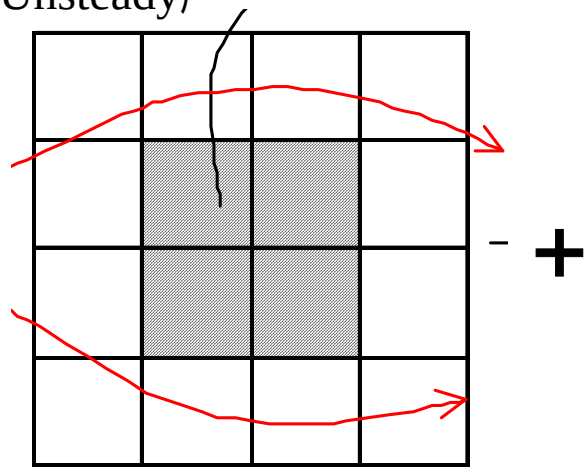
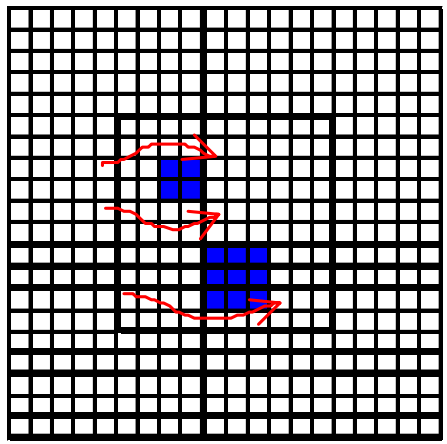
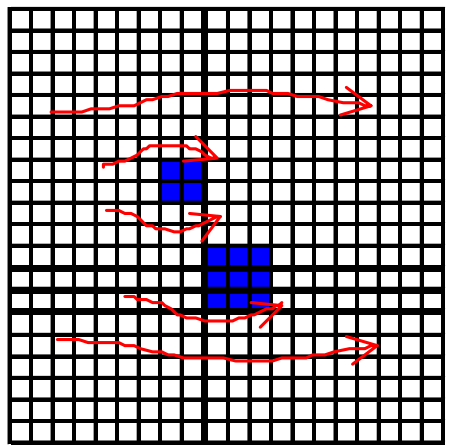
a) Few 100 m mesh
(Unsteady)

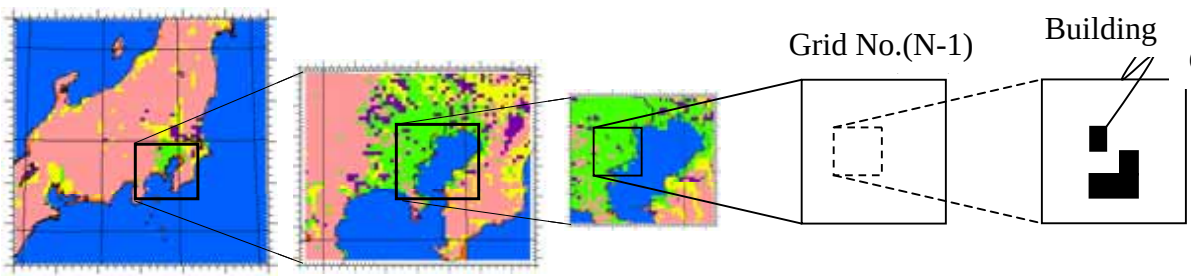
b)Few 10 m mesh
(Database of steady airflow)

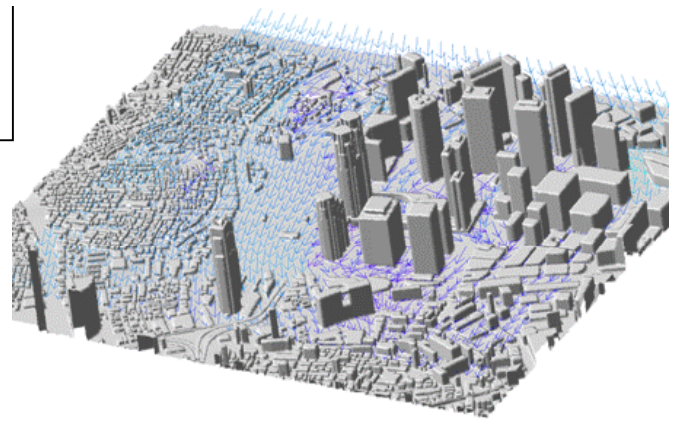
c) Local 4D Assimilation
(Nudging at boundary)











Air flow around tall buildings

Computational time of 12 hour simulation (24CPU×2GHz)

Model	100 m <	100 m >	Total
Present model	Few 10 min.	Few sec	Few 10 min.
Conventional	100 min.	2000 min.	Few 10 hrs

Parallel computing technique (1)

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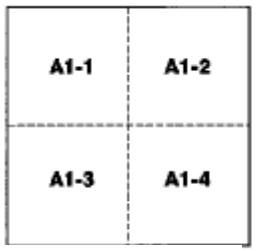
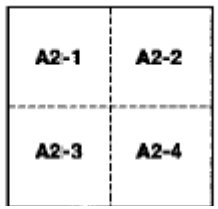
a) Conventional (Domain Decomposition Method : DDM)

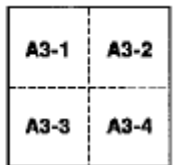
Each domain by Each CPU



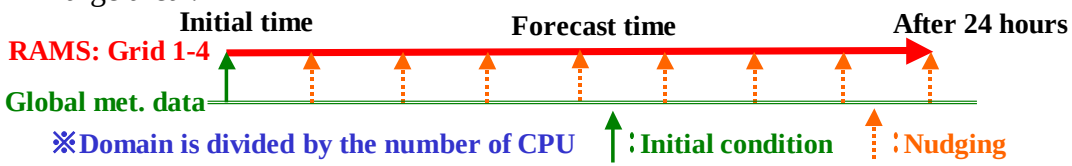
Large area : A1



Middle area : A2

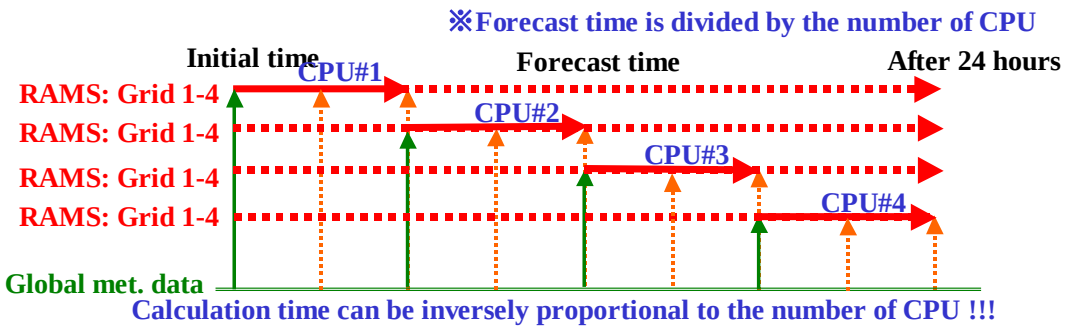


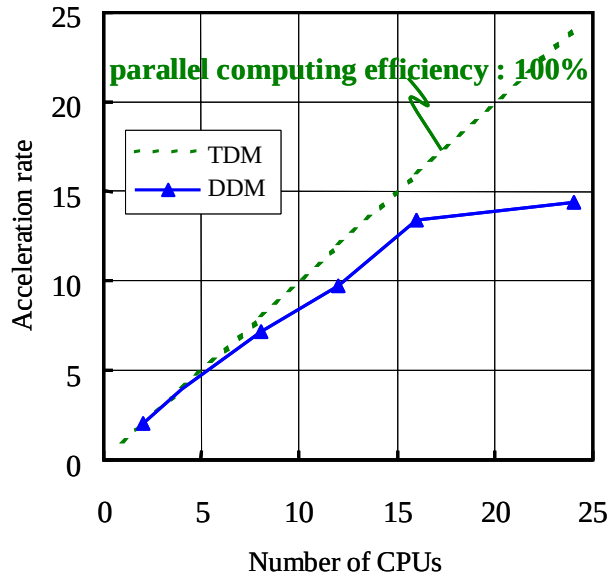
Small area : A3

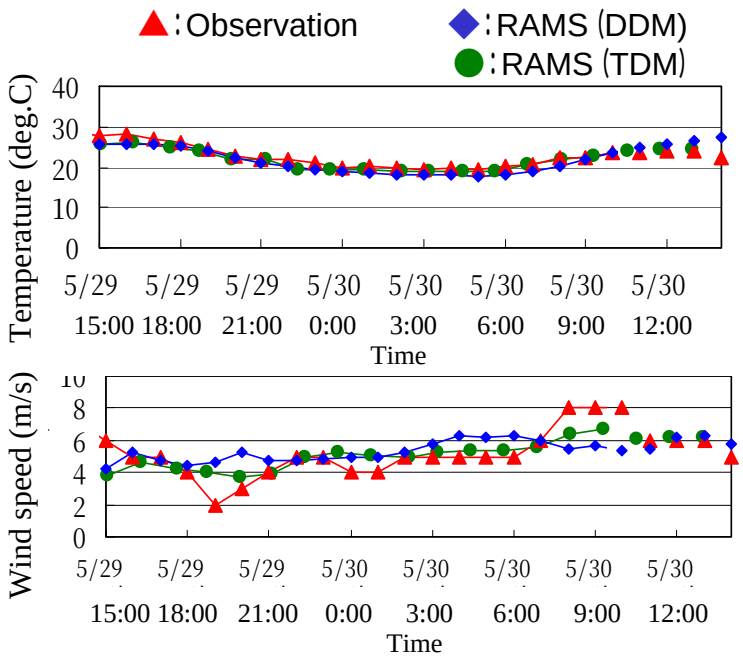


b) New-1 (Time Decomposition Method : TDM)

Each time by Each CPU





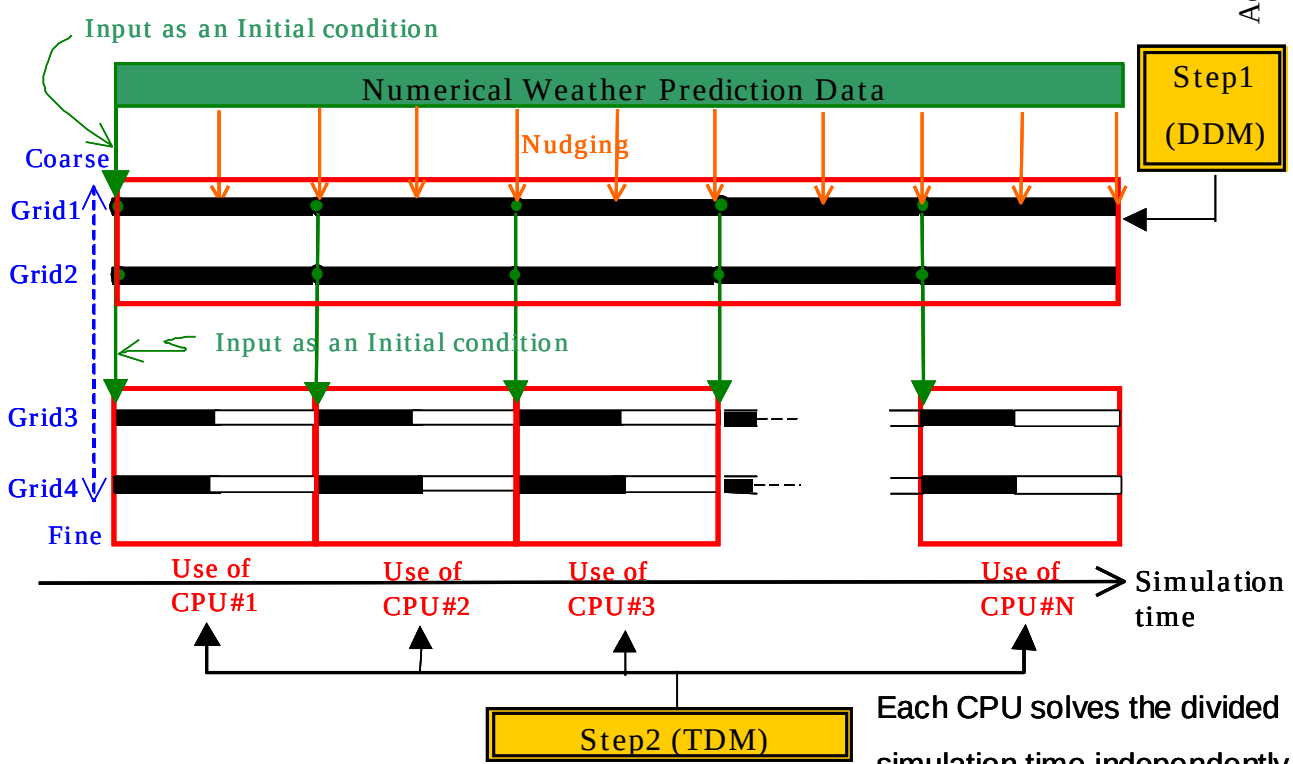


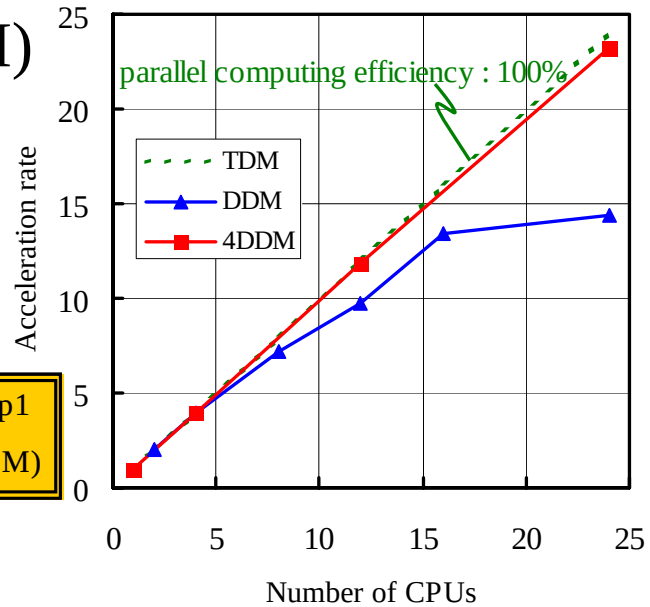
Parallel computing technique (1)

c) New-2 (4D Decomposition Method : 4DDM)

1st step: Domain Decomposition Method for coarse mesh

2nd step: Time Decomposition Method for fine mesh





Each CPU solves the divided simulation time independently.

US patent number：US6,801,856

Simulation of air flow around Mt. Tsukuba

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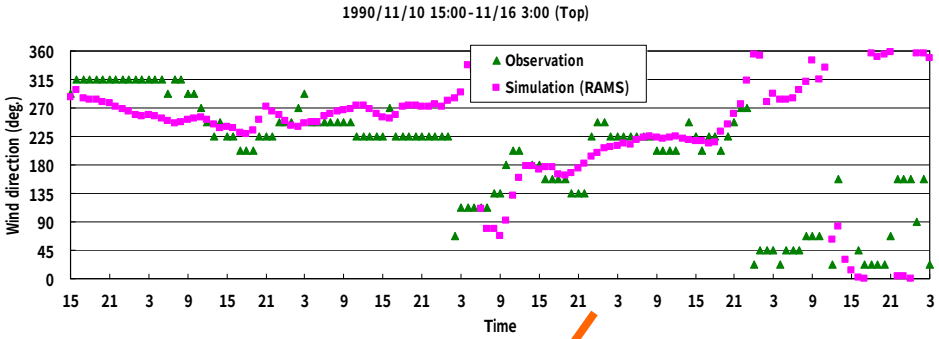
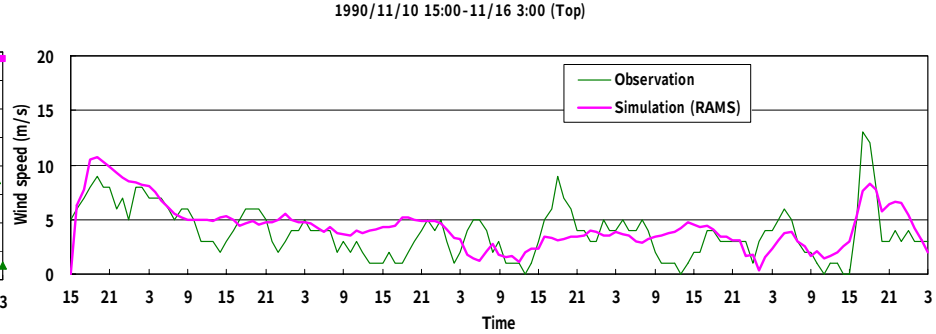
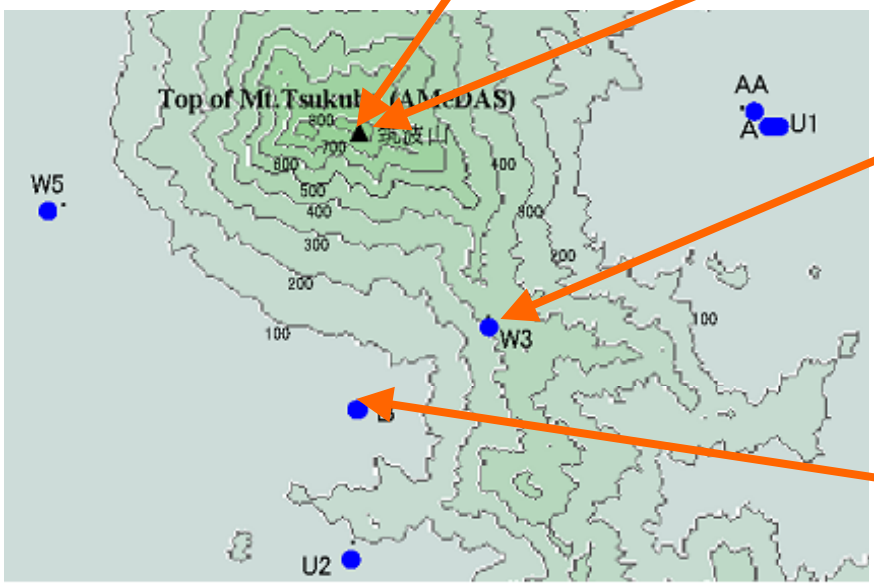
a)Wind Direction Top of Mt. Tsukuba

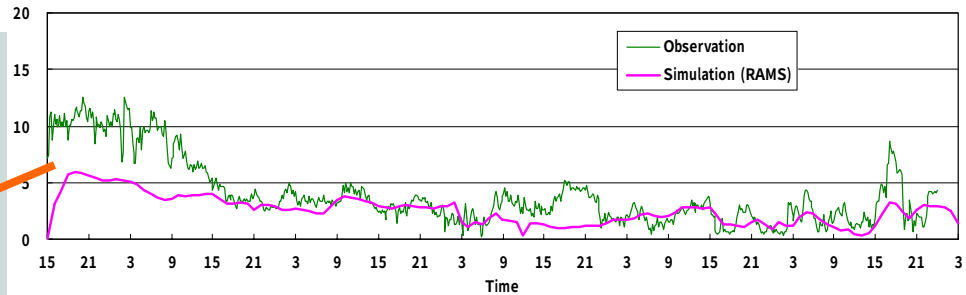


b)Wind Speed Top of Mt. Tsukuba

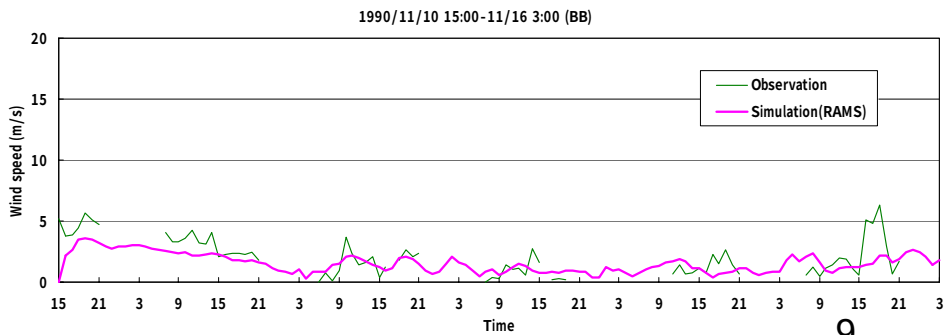




W3 station



BB station



Comparison of concentration (around Mt. Tsukuba)

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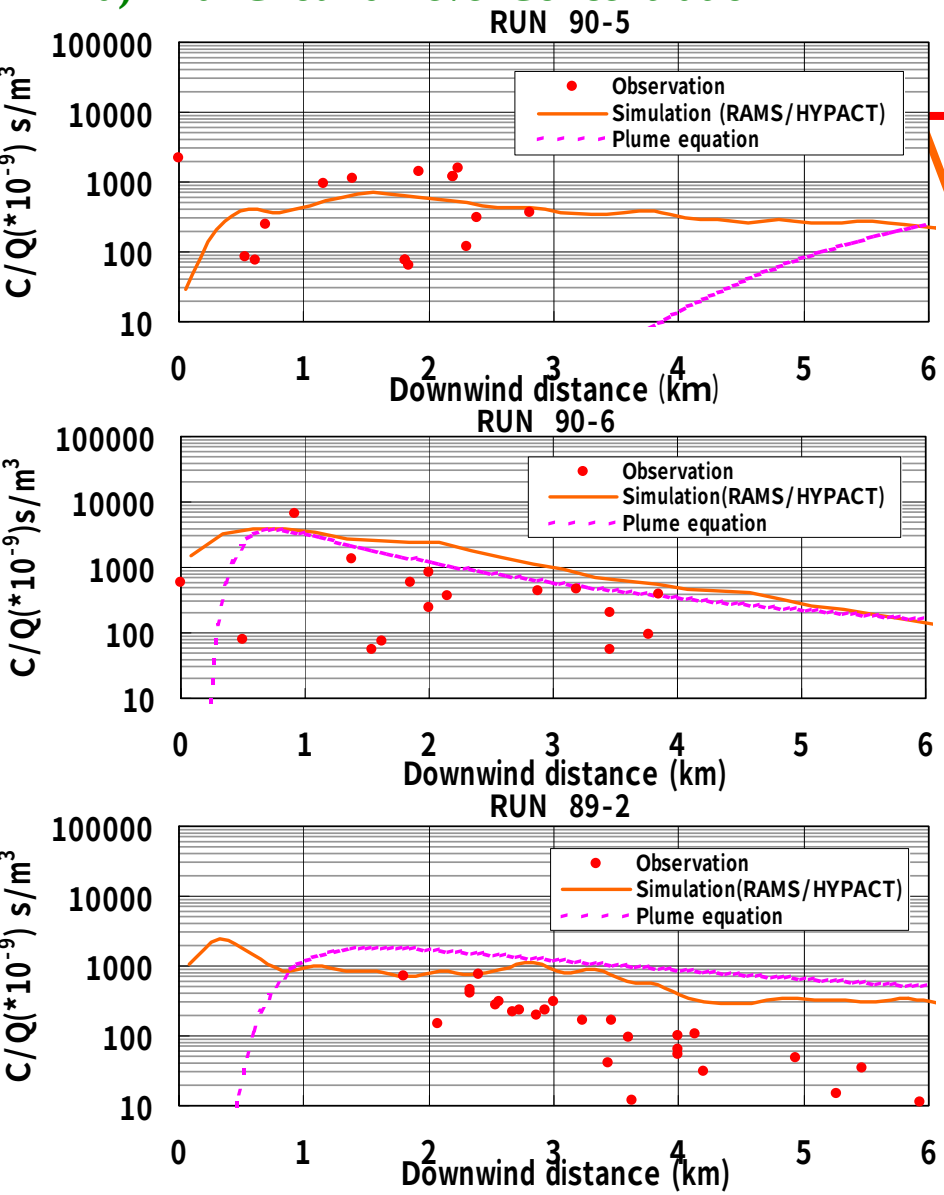
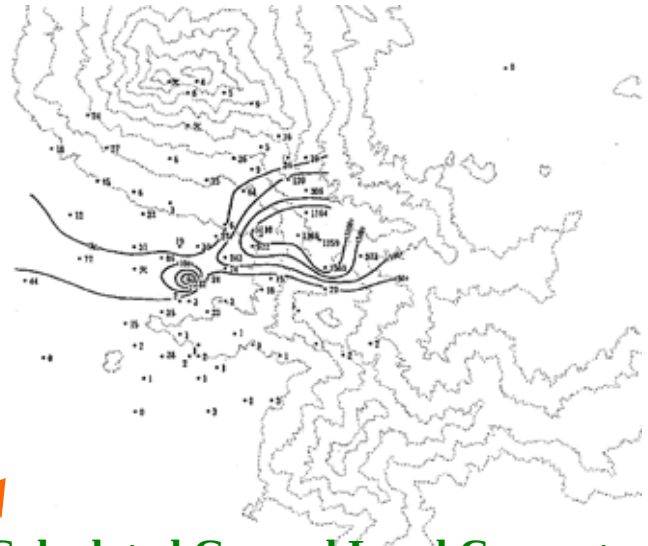
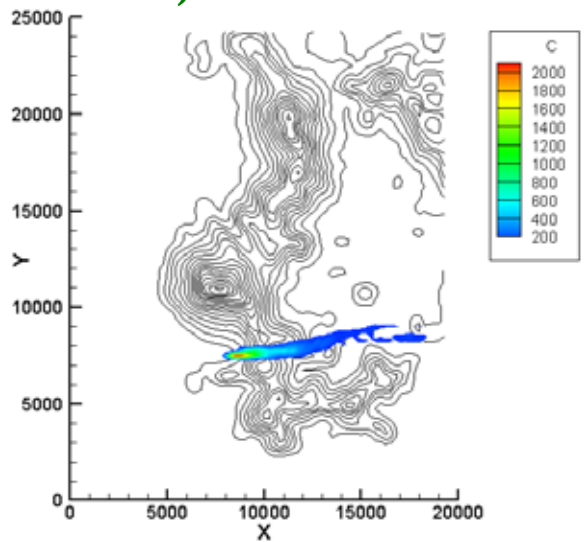
a)Axial Ground Level Concentration



b) Observed Ground Level Concentration (RUN 90-5)



c) Calculated Ground Level Concentration (RUN 90-5)



Comparison of Wind speed profile

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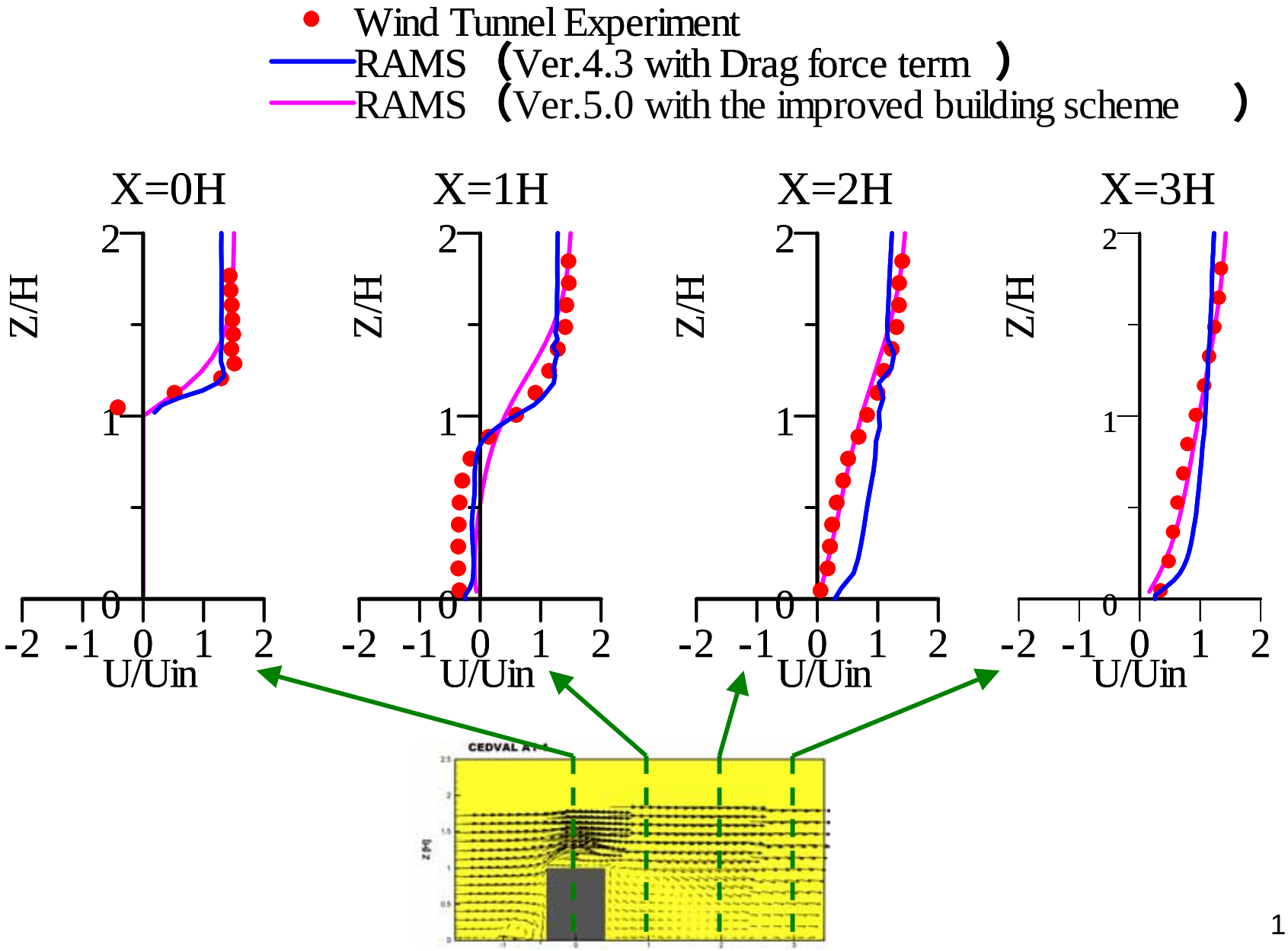
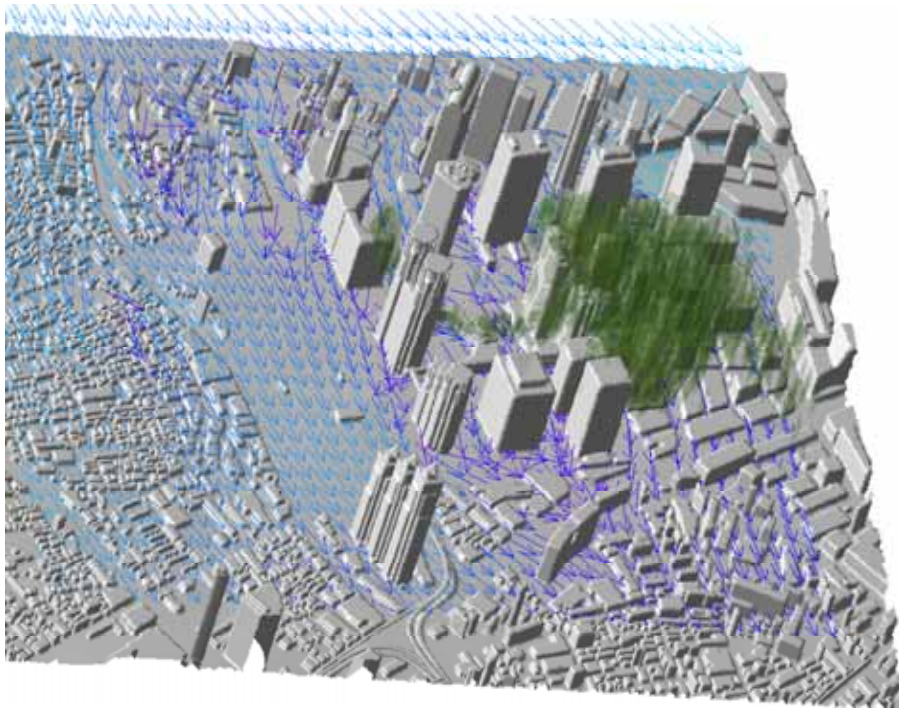
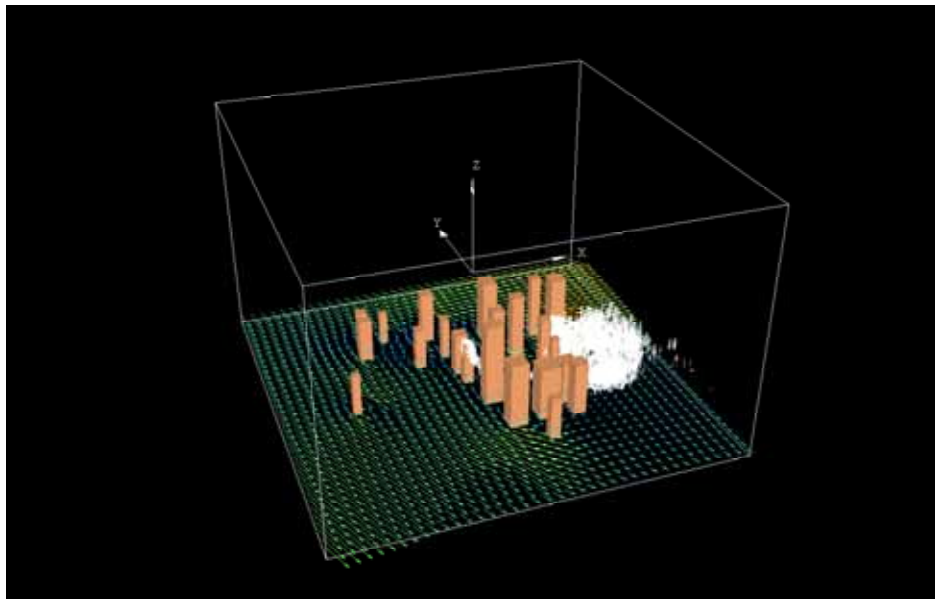


RAMS & HYPACT simulation



Building CAD data



Actual RAMS data

Examples of results from the dispersion simulator

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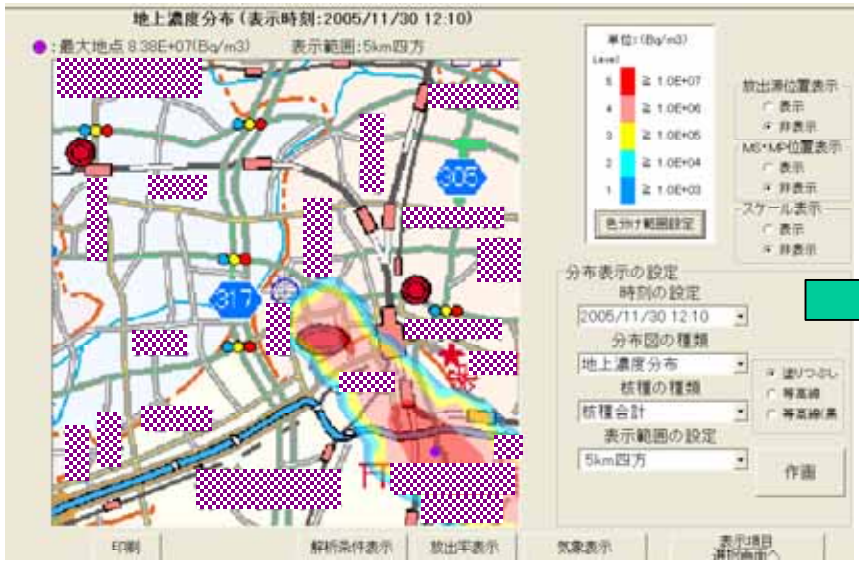
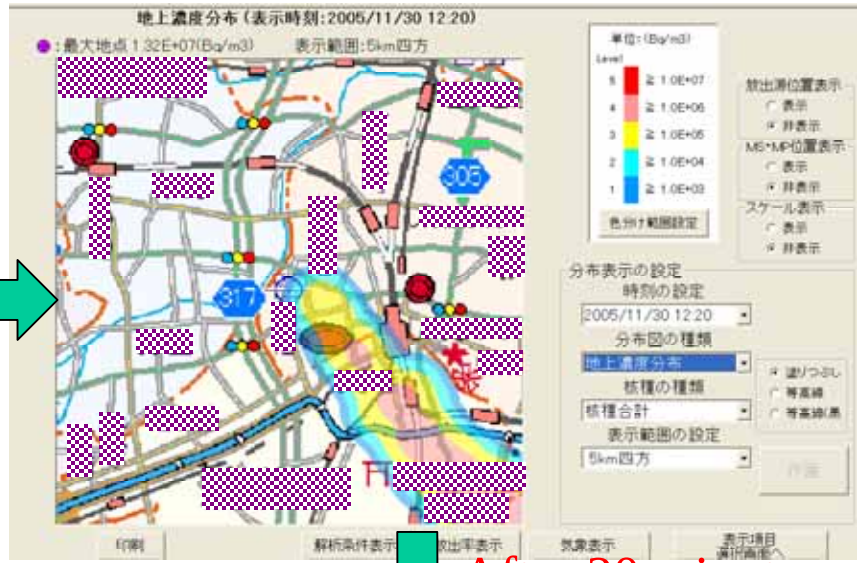




Gsa concentration: After 10 minutes

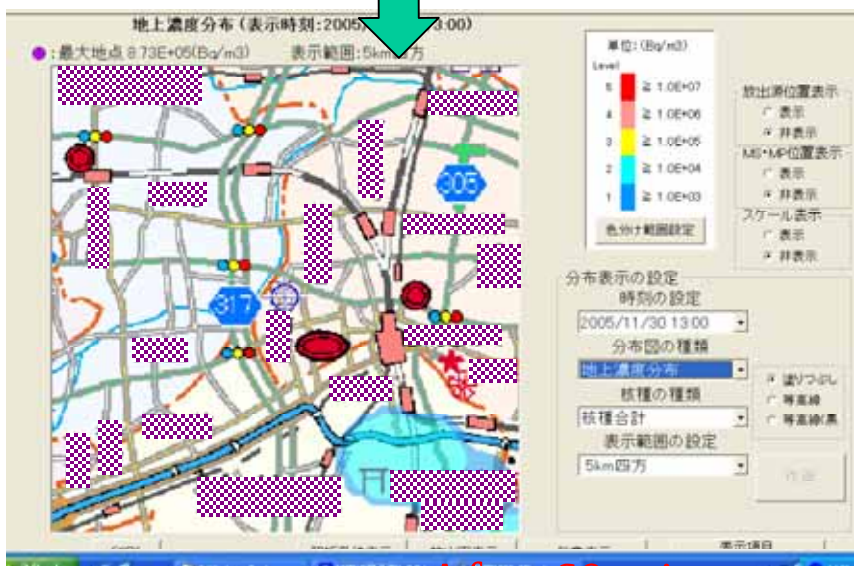
After 20 minutes

Release scenario

Wind : 5m/s (NW)

Species : Cs137 3kg

Source location : C hotel top
(137m AGL)



After 60 minutes

Roundtable drill of NBC hazard projection system

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In Tokyo metropolis office, Jan. 2008

Summary

- The improved building scheme were verified against wind tunnel experiments, and the simulated results showed good agreement with them.

- We developed dispersion simulator for NBC agents.
  This simulator can predict not only concentration of NBC agents but also number of casualties.

- The simulator attains less than 20 minutes for 12 hour prediction, by Local 4D Assimilation (L4DA) scheme .

Acknowledgements
This study is funded by MEXT (Ministry of Education, Culture, Sports, Science and Technology) of Japan.

ADAP coordinate in RAMS ver.5.0

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- Cartesian grid
- The “apertures” of grid cell faces are open or closed depending on the presence of topography or buildings
- Finite volume method are applied.

Ex.) horizontal advective term in the x-direction of an arbitrary scalar field.

$$-\frac{1}{\rho}\left(\frac{\partial \rho u \phi}{\partial x}+\phi\frac{\partial \rho u}{\partial x}\right)=-\frac{1}{\rho_j \Delta V_j}\left[\left(\left(\rho F A\right)_{j+1/2}-\left(\rho F A\right)_{j-1/2}\right)-\phi_j\left(\left(\rho u A\right)_{j+1/2}-\left(\rho u A\right)_{j-1/2}\right)\right]$$

A: grid cell apertures (m^2)

Ref.) C.J.Tremback, R.L. Walko, Implementing Very-High Resolution Capabilities into a Mesoscale Atmospheric Model: New Capabilities for the Regional Atmospheric Modeling System (RAMS)

Improved building scheme in ver.5.0

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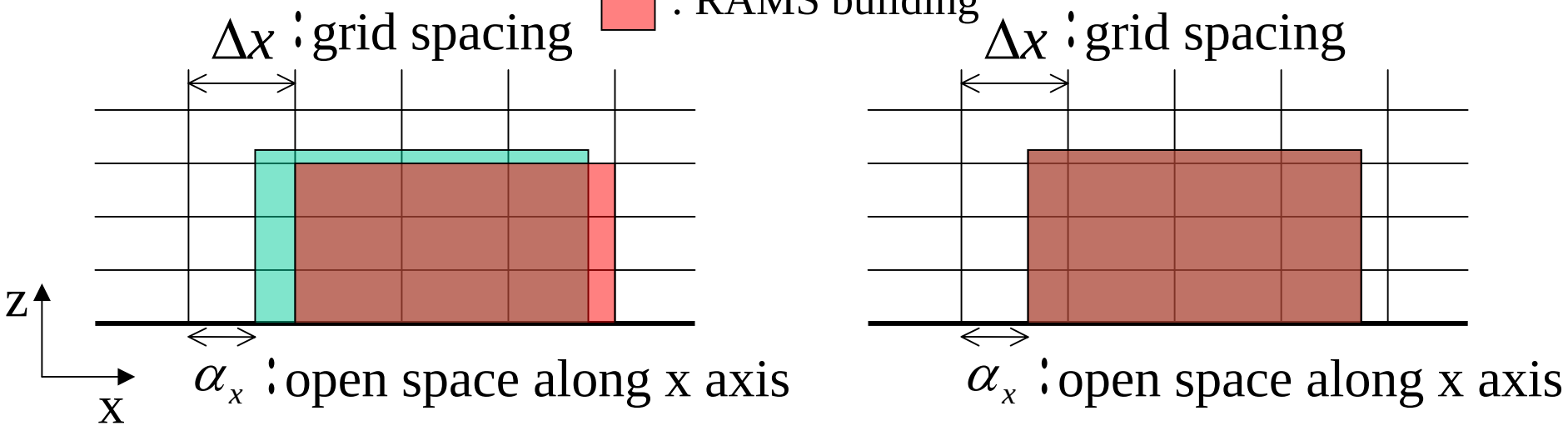
Original scheme

Improved scheme

: Actual building

: RAMS building



IF $\frac{\alpha_x}{\Delta x} \le 0.5$ *or* $\frac{\alpha_y}{\Delta y} \le 0.5$ *or* $\frac{\alpha_z}{\Delta z} \le 0.5$

THEN

Grid cell apertures (m^2) :Au=0, Av=0, Aw=0

Grid cell apertures (m^2) :

$Au = Au \times \frac{\alpha_x}{\Delta x}$, $Av = Av \times \frac{\alpha_y}{\Delta y}$

$Aw = Aw \times \frac{\alpha_z}{\Delta z}$

Test simulation with a single building

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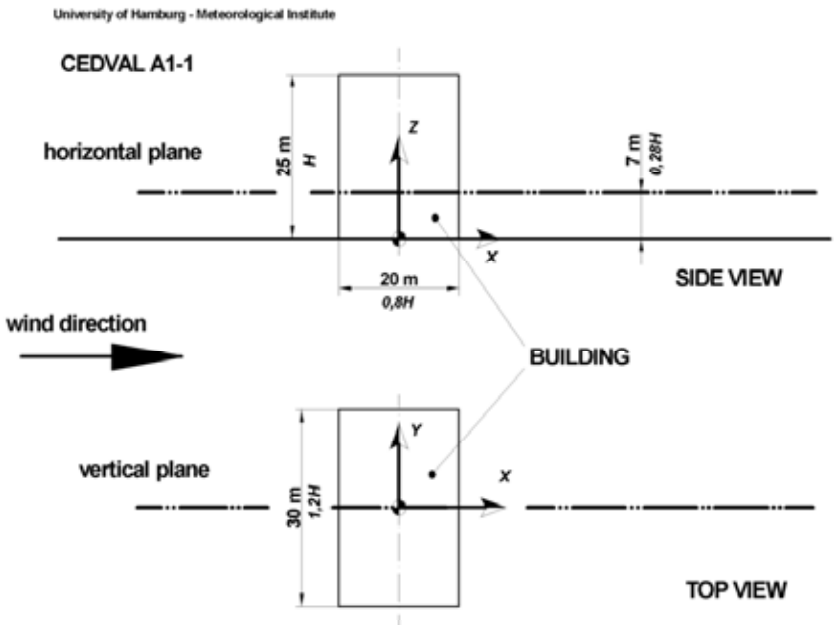
- Use of RAMS ver.5.0 with the improved building scheme
- Grid spacing of x, y, z : 2.0m
- Number of grid cells : 160 * 120 * 50 = 1 million
- Turbulent model: Isotropic E-l closure model implemented in RAMS ver.5.0 (Castelli, 2004)
- Comparison with Wind tunnel experiments carried out in Hamburg Univ. (http://



Comparison of Flow fields

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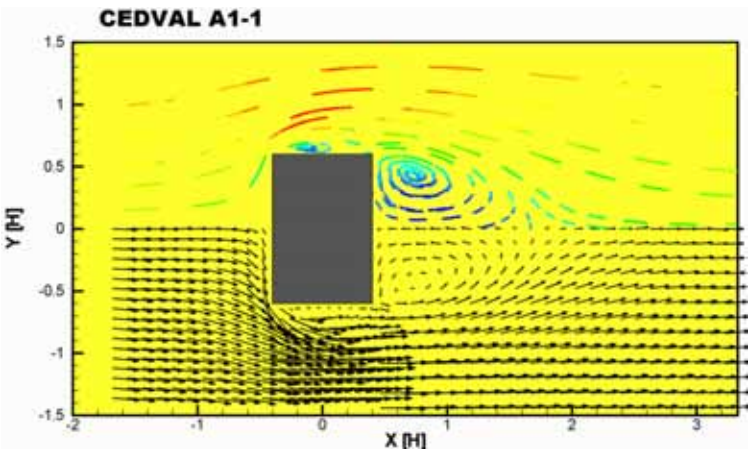
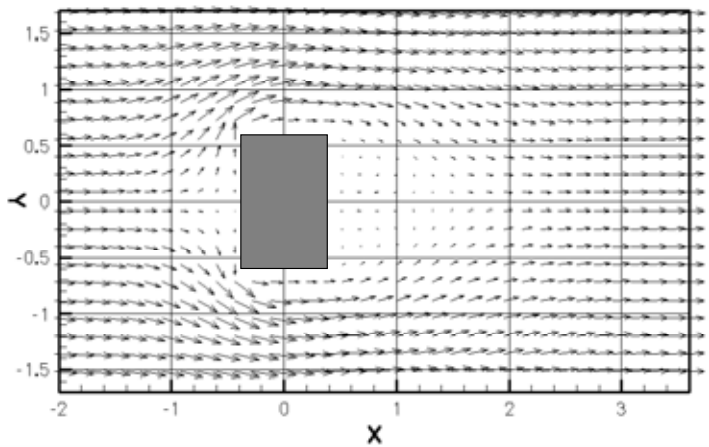
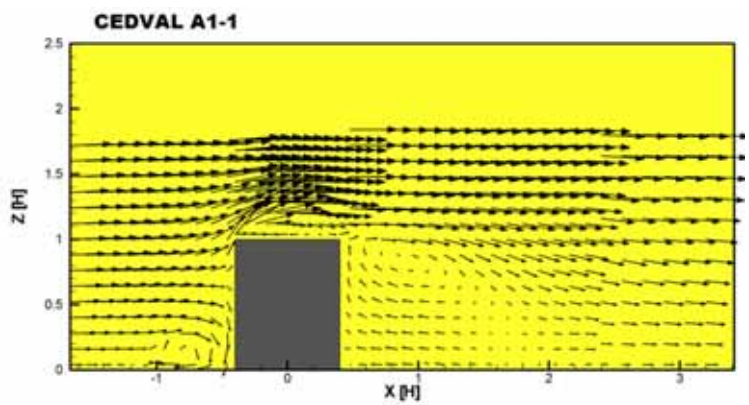
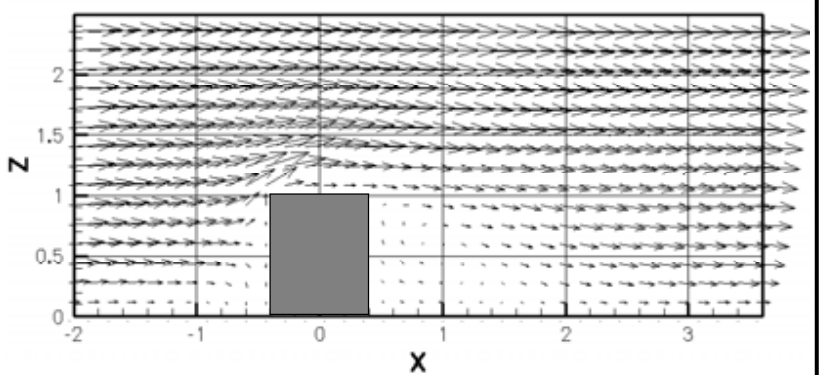
	Wind Tunnel experiment	Improved RAMS
Horizontal section		
Vertical section		

Simulation with Multi buildings

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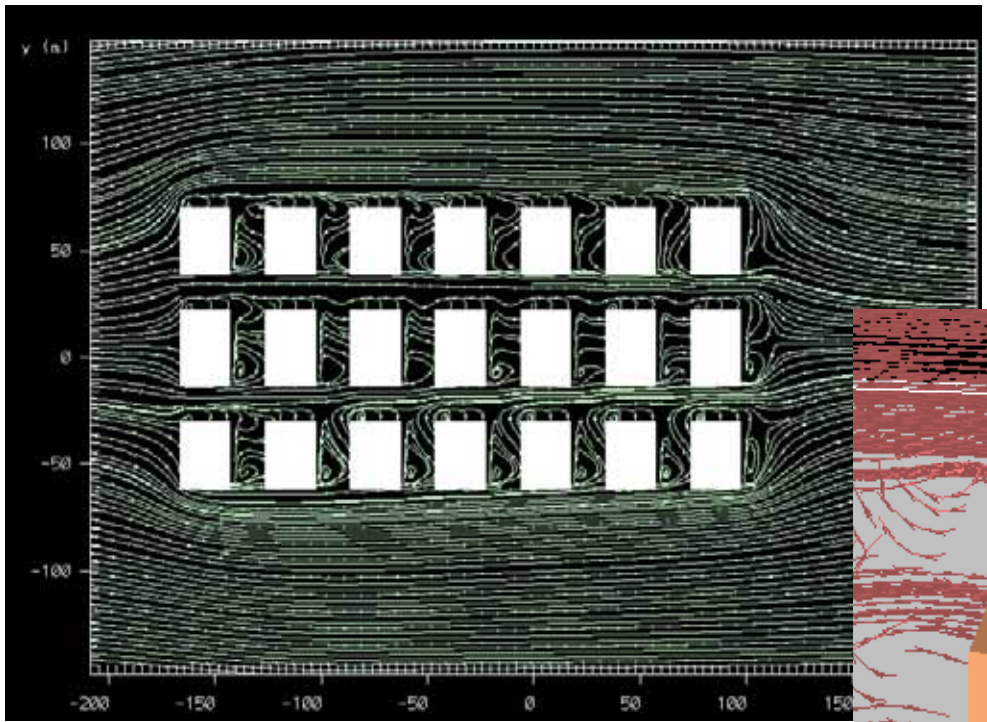
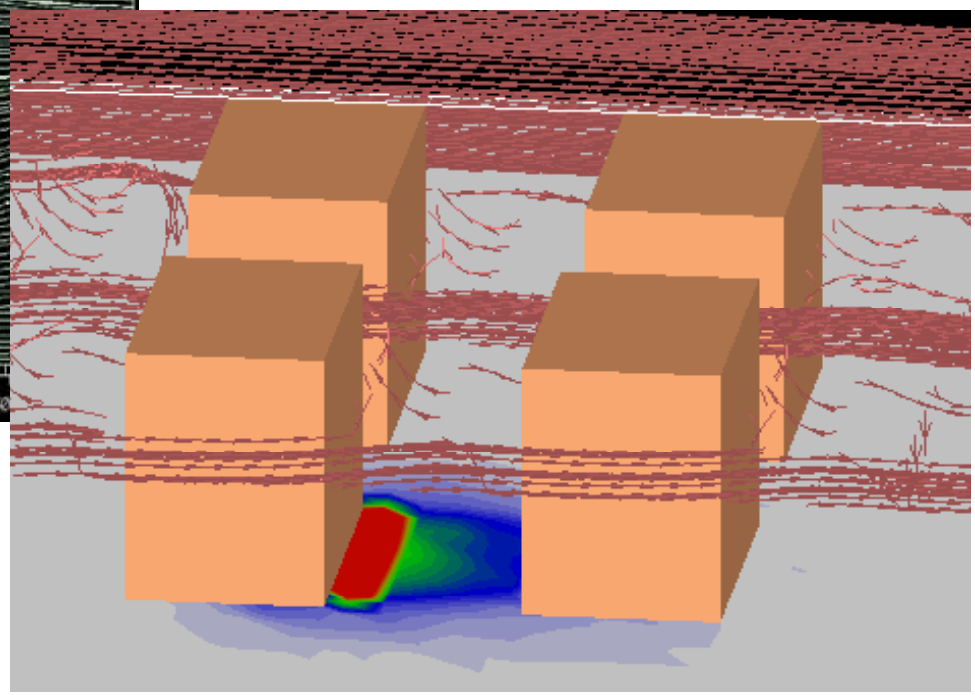
Stream lines in the horizontal section





Stream lines and Concentration field