Wind Engineering Joint Usage/Research Center
FY2015 Research Result Report

Research Field: Outdoor Environment
Research Period: FY2015 ～ FY2016
Research Number: 152010
Research Theme: Preliminary investigation on the influence of planning factors on the near-field PM2.5 dispersion within urban areas

Representative Researcher: Prof. Xiaofeng Li

Budget [FY2015]: 357,000 Yen

*If the research was not continuous, this will be the Final Result Report, so the contents of the report has to be detailed.
*There is no limitation of the number of pages of this report.
*Figures can be included to the report and they can also be colored.
*Submitted reports will be uploaded to the JURC Homepage.

1. Research Aim

This research mainly focuses on the influence of planning factors on the pollutant dispersion in built-up urban areas. Due to the inhomogeneous distribution of urban pollution sources and the influence of urban morphology on urban flow and dispersion, highly inhomogeneous pollution levels in neighborhood scale (~1 km) can be found in built-up areas. Epidemiological studies also showed that cardiopulmonary mortality was highly associated with living near a major road or an industrial area. It is thus evident that urban planning is highly related to the distribution of urban pollution. Therefore, this research aims to evaluate the urban dispersion, try to provide better living environment by optimizing urban planning, including road, community, and green area arrangements.

2. Research Method

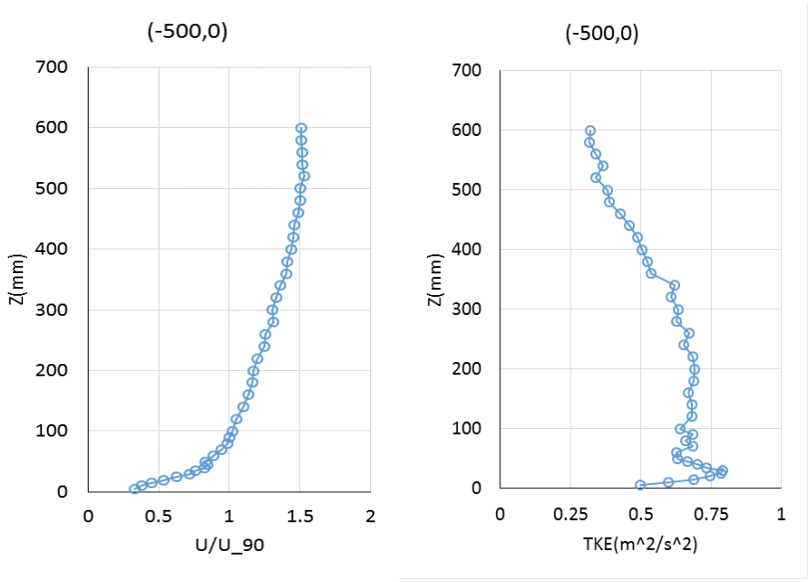
To investigate the influence of different planning factors on the pollutant dispersion in urban areas, wind tunnel experiments were performed to study the pollutant dispersion characteristic. Cubic blocks were used to represent simplified building groups and tested in the Boundary Layer Wind Tunnel of TPU. The wind tunnel experimental results were used to calibrate the CFD model. The optimal turbulent Schmidt number were determined according to the wind tunnel experiments.

3. Research Result

3.1 Wind tunnel experiments

In the wind tunnel experiments, six dispersion scenarios in four different flow fields were

tested in the boundary layer wind tunnel, 1,476 concentration points and 72 velocity vector points in total were measured. The results are as follows. Fig. 1 shows the inlet profiles. The horizontal wind speed is normalized by the reference speed U_{90}=3.74 m/s at the reference height H=90 mm.



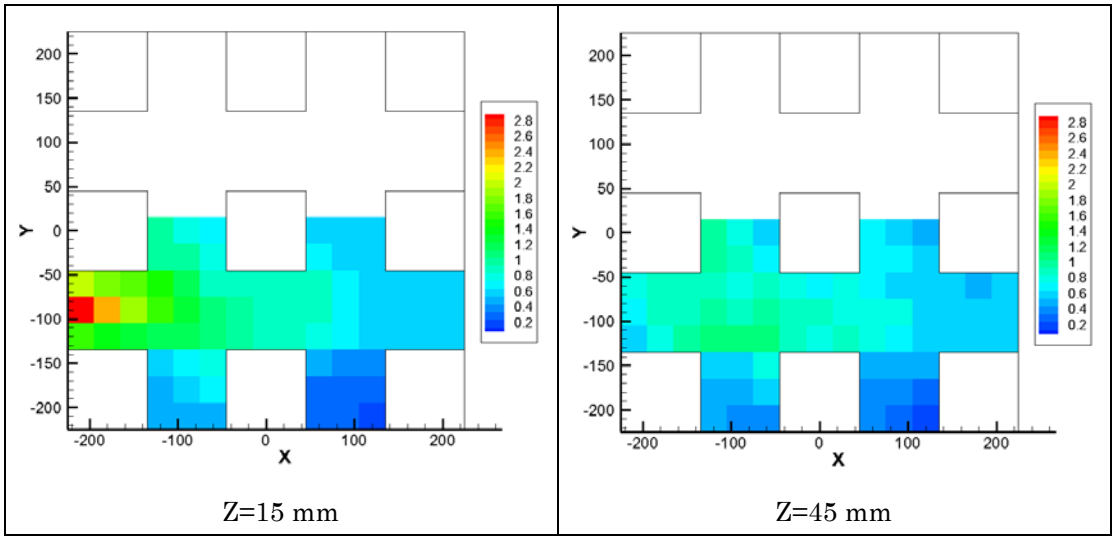
(a) (b)

Fig. 1 Inlet profiles. (a) Horizontal wind speed (b) Turblent kinetic ernergy

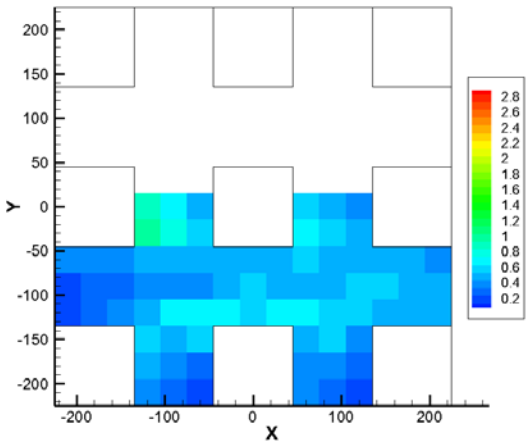
Fig. 2 shows the concentration distributions of all six scenarios, with wind coming from the left side (upper left for the two 45 degree cases). The points at three horizontal planes (Z=15, 45, 75 mm) were measured. Due to the symmetrical air flow fields, only half of the points were sampled. The concentration data were normalized according to Eq. (1).

$$C^{+}=CU_{90}H^{2}/C_{release}q \quad (1)$$

where, C is the measured concentration, U_{90}=3.74 m/s is the wind speed at the reference height H=90 mm, $C_{release}$=100% the release concentration, q=0.001667 m^3/s the release rate.



Z=15 mm Z=45 mm



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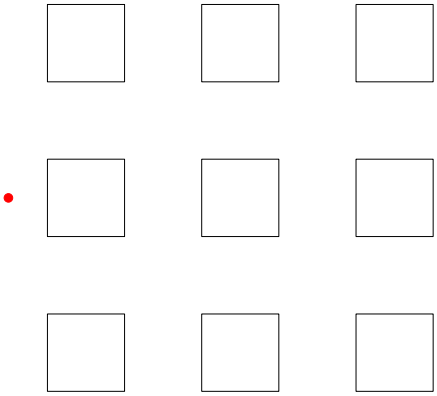
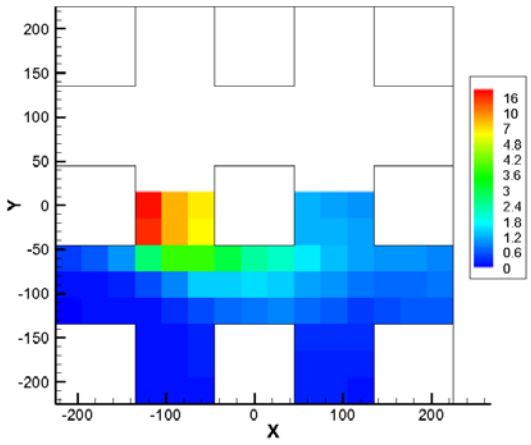
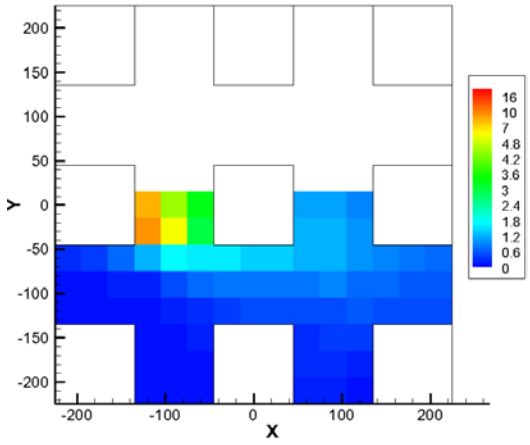


Layout, red dot is the release point

Scenario 1



Z=15 mm



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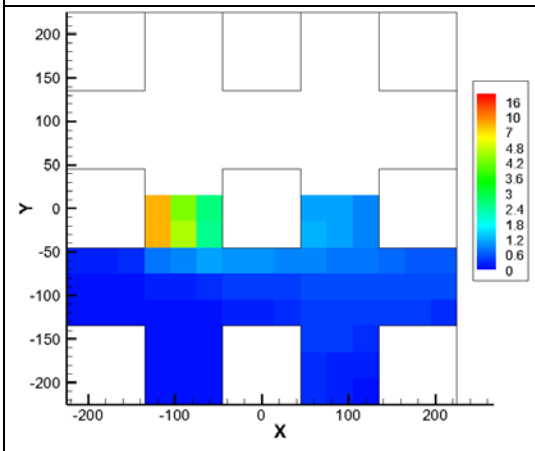

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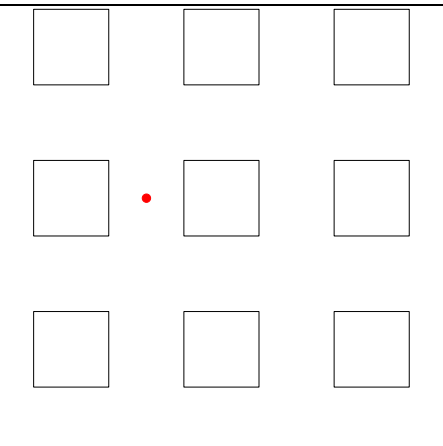
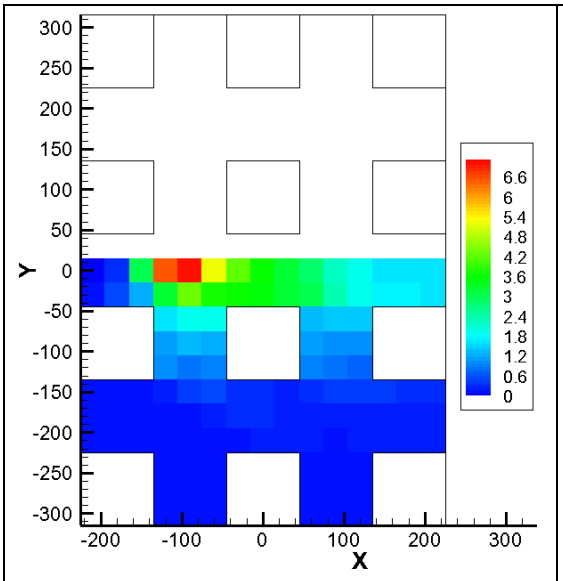


Layout

Scenario 2



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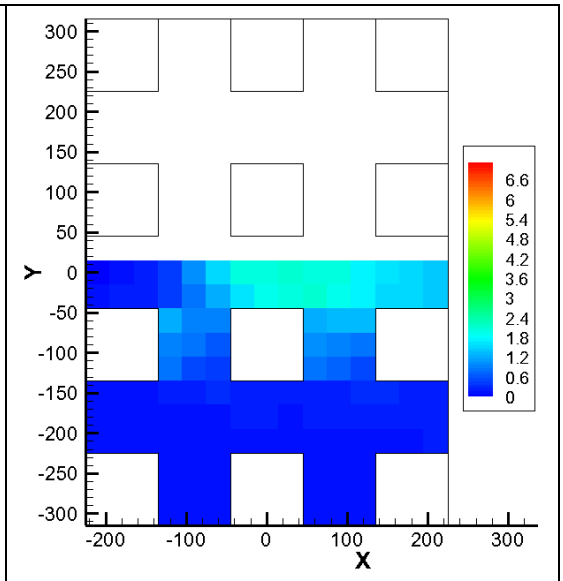

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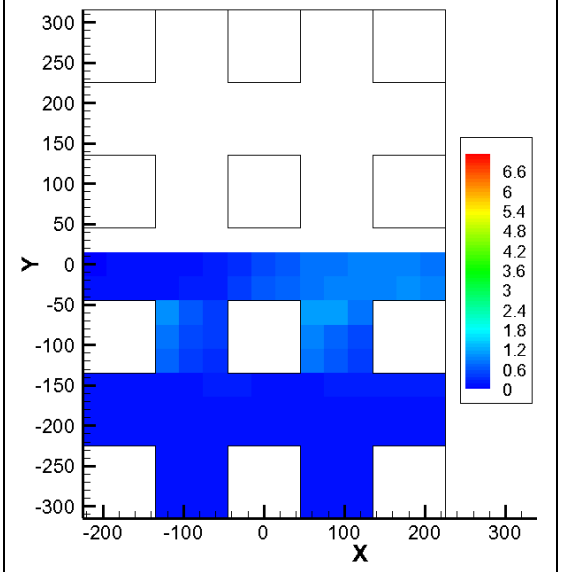

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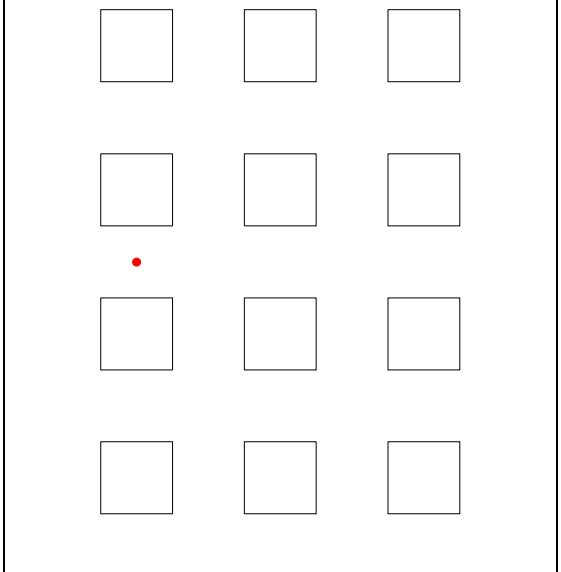
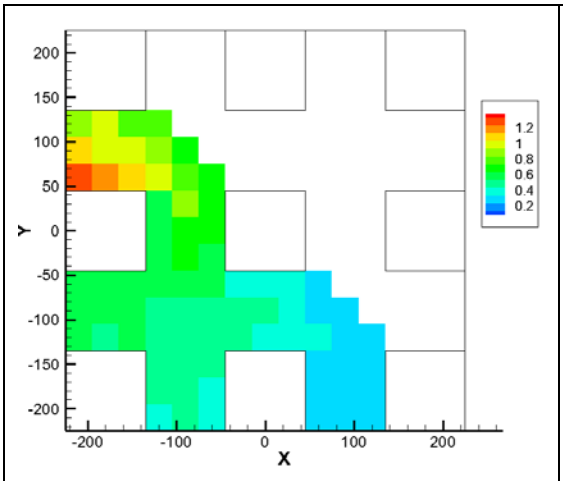


Layout

Scenario 3



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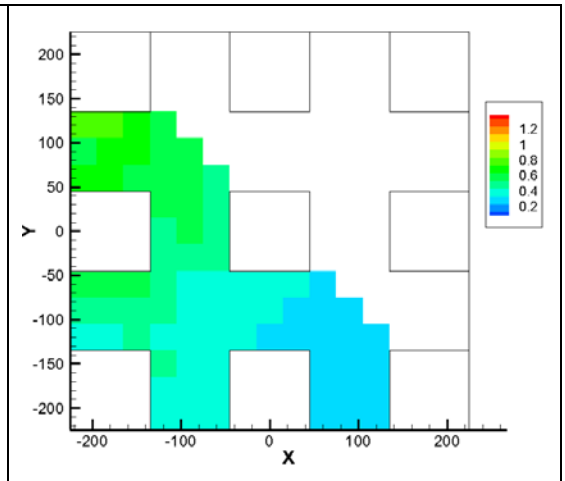

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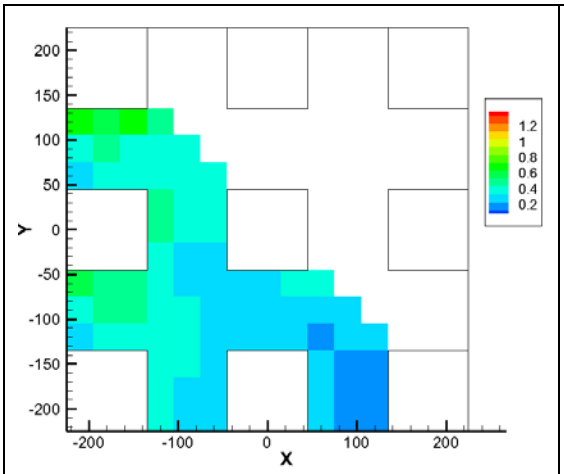

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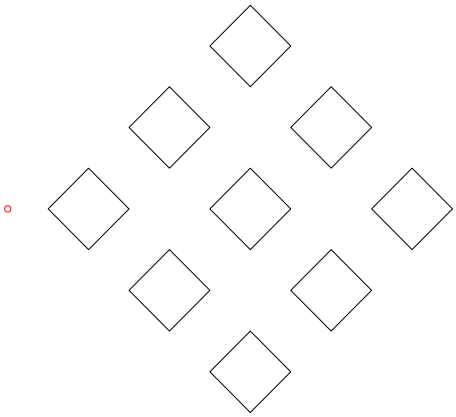
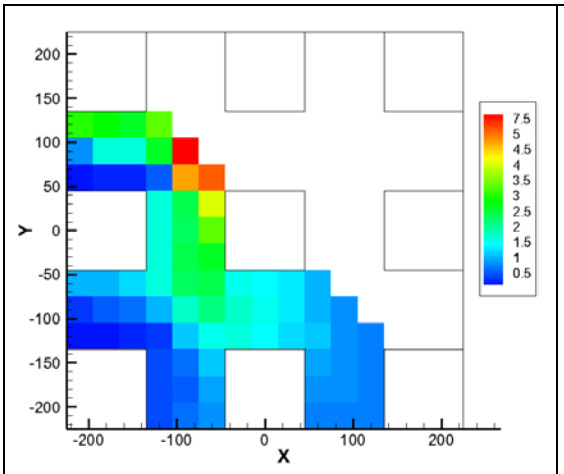
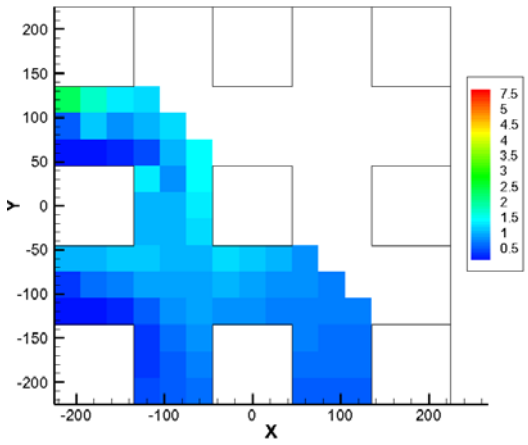


Layout

Scenario 4



Z=15 mm



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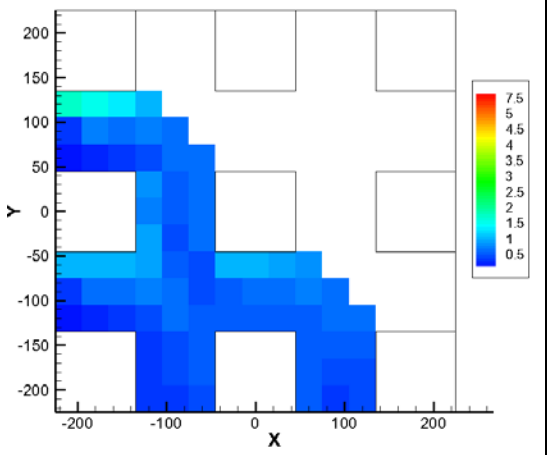

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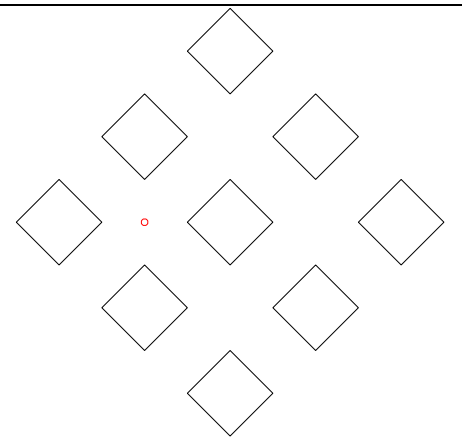
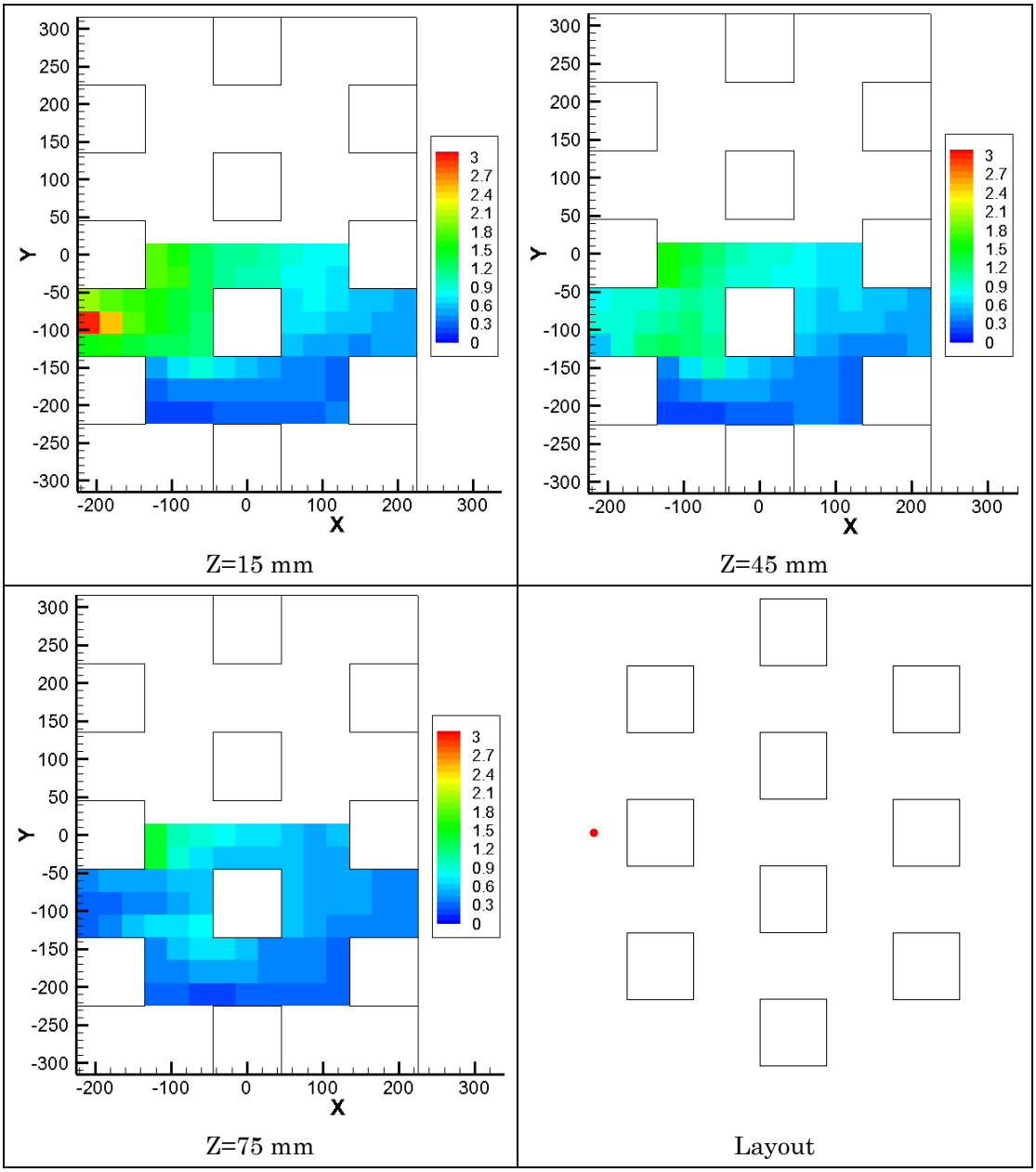


Layout

Scenario 5



Scenario 6

3.2 Two of all six scenarios were simulated and the simulation method was determined, in which the optimal turbulent Schmidt number is 0.5~0.7.

4. Published Paper etc.

[Underline the representative researcher and collaborate researchers]

[Published papers]

[Presentations at academic societies]

[Published books]

[Other]

Intellectual property rights, Homepage etc.

5. Research Organization

1. Representative Researcher

Xiaofeng Li	Tsinghua University, China, Associate Professor

2. Collaborate Researchers

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Fei Xue	Tsinghua University, China, PhD Candidate
Jie Ma	Tsinghua University, China, PhD
Lihai Wang	Tsinghua University, China, Research Assistant