Response to anonymous Referee #2

We sincerely thank the reviewers for their constructive and thoughtful suggestions, which improve the quality of this paper. We have made the revisions and responses following your comments point by point.

The referee comments are shown in black.
The responses to the comments are shown in blue. The line numbers refer to the clean version of our revised manuscript.
The changes included in the revised manuscript are shown in red.

General comments:

General comment 1:

Section 4.2. Why is this comparison performed using different fluid properties for each solver? Has the flow reached the (quasi) steady-state conditions in the simulations using APreactingFoam and APsteadyReactingFoam after 90 minutes?

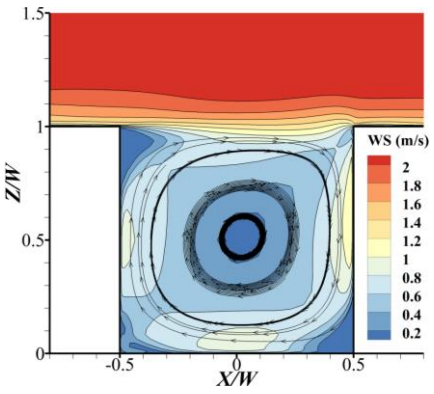
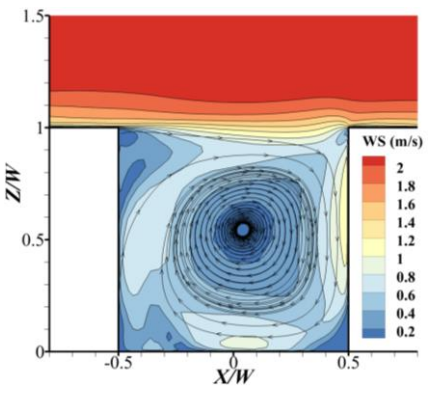
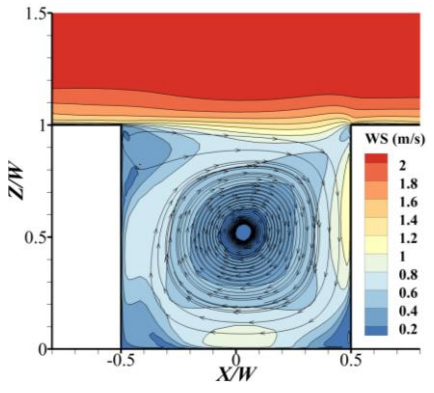
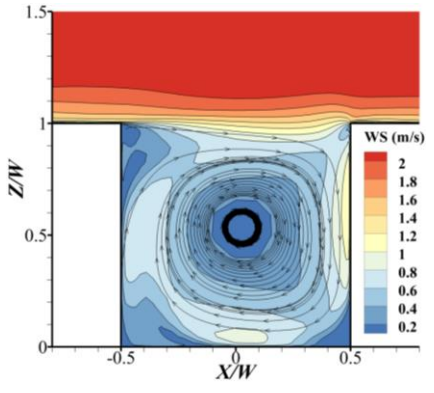
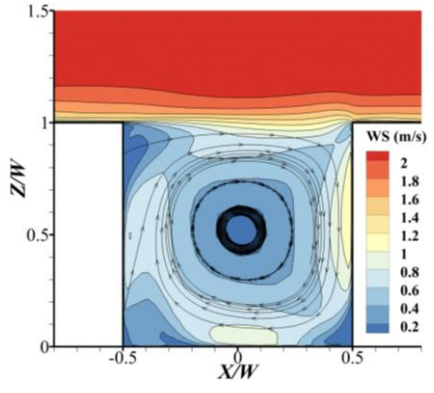
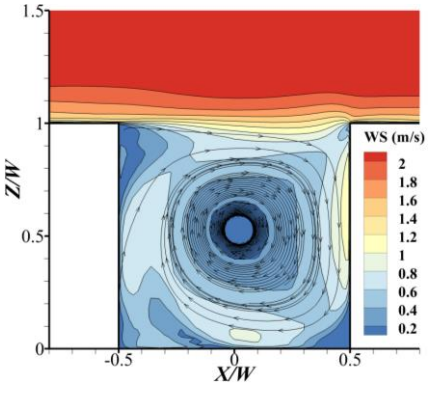
My suggestion is to use incompressible fluid for all cases to perform a proper comparison of these three solvers. After reaching the quasi-steady state, the wind pattern should approximately be the same using any of these solvers (if incompressible fluid is selected for all cases). The same applies for the dispersion of a non-reactive pollutant. Having the same wind pattern, it would make sense to compare the results from these solvers and provide the different computational time required to reach the quasi-steady state including chemical reactions as well. Based on this information (i.e. computational time require), users can select the appropriate solver for their simulations. If the same fluid properties cannot be applied, then each solver would need to be validated independently.

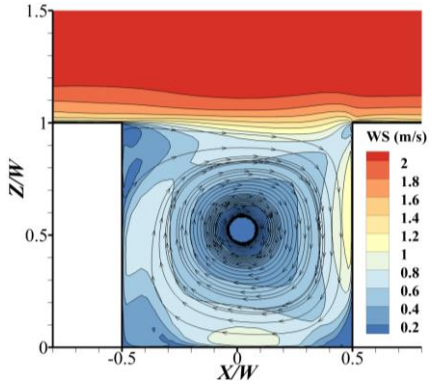
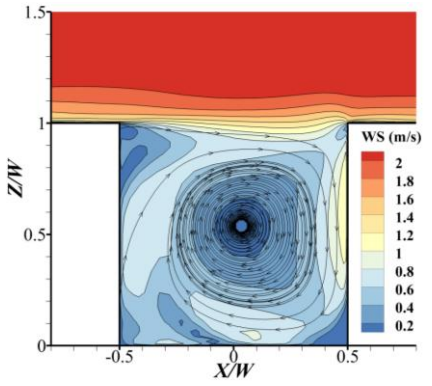
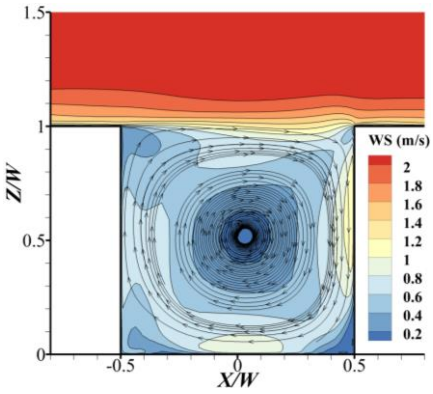
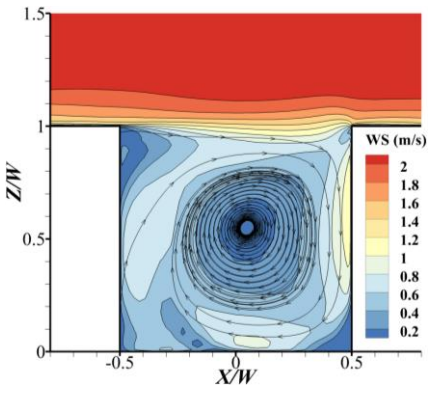
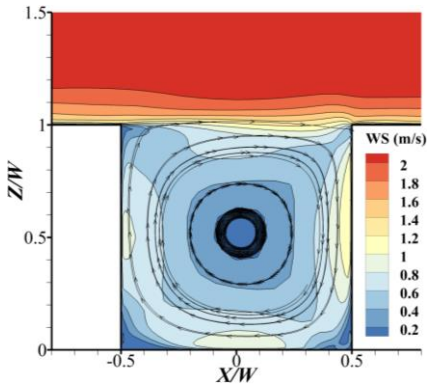
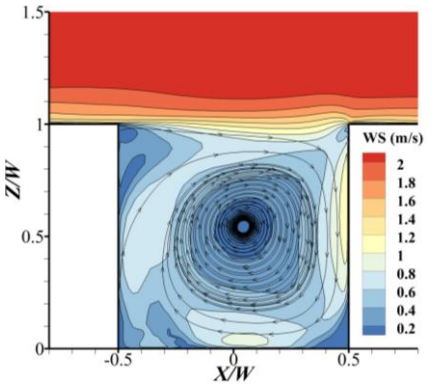
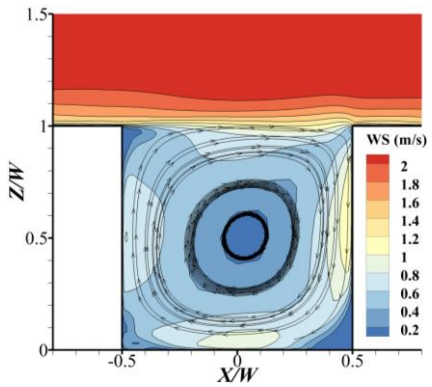
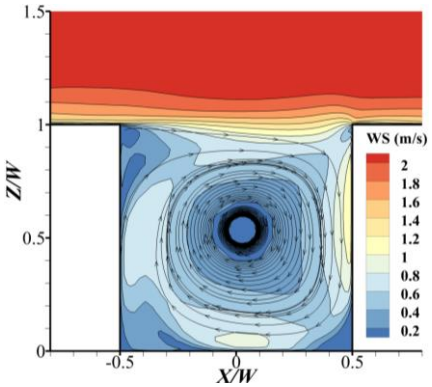
Response:

Thanks a lot for these useful suggestions. The APreactingFoam and APsteadyReactingFoam simulations have reached the (quasi) steady-state conditions after 90 minutes simulation. The wind patterns between 60 to 90 minutes are in Figure 1. As the figure shown, after 60-minute simulation, a stable single vortex structure has been formed in the street canyon. And after 80 minutes, the wind pattens has stabilized and hardly changed, which indicated that the simulations have reached quasi-steady state.

As for the comparison of the solvers, you are right and that is true that our simulated flows are incompressible. Actually, the density is almost constant in our simulation results even the compressible model is used. The reason for using the compressible fluid in APreactingFoam, APsteadyReactingFoam simulation is because that we found the calculation results can easily become unstable and divergent when the chemistry and flow field are solved simultaneously under the incompressible fluid model. It is the limitation of Openfoam code which is widely known by its users. Therefore, we designed the APreactingFoam and APsteadyReactingFoam to only solve the compressible fluid and the comparison is conducted under these conditions.

Figure 1 Wind patterns in APreactingFoam and APsteadyReactingFoam simulation

Time (minute)	APreactingFoam	APsteadyReactingFoam
At time of *t*=60 min		
At time of *t*=65 min		
At time of *t*=70 min		

At time of *t*=75 min		
At time of *t*=80 min		
At time of *t*=85 min		
At time of *t*=90 min		

Some details are added in the manuscript line 207-210 and line 218-219:

The APreactingFoam is only designed to solve compressible fluids because the simulation results are more likely to be unstable and divergent when the chemistry and flow field are solved simultaneously under the incompressible fluids. It is the limitation of OpenFOAM code which is widely known by its users.

This solver is only designed to solve compressible fluids for the same reason as APreactingFoam which is mentioned above.

General comment 2：

Conclusions. Please be precise in giving the details of the methodology used in this study.

Line 565. Please add that the validations presented in this paper are using APFoam with CS07A.

Response:

Thanks a lot for your attention. The revision was done in the manuscript line 563-565:

Additionally, to verify the model performance, several validations, including photochemical mechanism (CS07A) with SAPRC box modelling, flow field, 2D and 3D pollutant dispersion with wind tunnel experimental data have been conducted in this study.

Line 564-567. Please clarify that the validation of the photochemical mechanism (CS07A) is carried out against the *box* modelling SAPRC and flow and dispersion are performed against wind tunnel measurements.

Response:

Thanks a lot for your mention. The revision was done in the manuscript line 563-567:

Additionally, to verify the model performance, several validations, including photochemical mechanism (CS07A) with SAPRC box modelling, flow field, 2D and 3D pollutant dispersion with wind tunnel experimental data have been conducted in this study. The model results show a good agreement with the SAPRC box modelling and wind tunnel experimental data, indicating that the APFoam can be applied in the analysis of micro-scale urban pollutant dispersion.

Line 576. Please add in which conditions the NOx increases up to 98%, "…when wind speed is reduced to the half".

Response:

Thanks a lot for pointing out this. The revision was done in the manuscript line 576-579:

Ventilation condition is another reason for the NO_x concentrations increment, and the increase of NO_x can be up to 98% when the wind speed is reduced to the half. If no chemical reactions, NO_x concentration should rise 100% when the wind velocity decreases 50% (i.e. ventilation capacity reduces 50%) since the Re-independence requirement is satisfied.

Line 578-581. I suggest the authors include the percentage reduction of NO, NO2 and O3 for the most relevant scenarios (e.g. NOx50% and VOC30%) since the outcomes from the analysis in Section 4.7 are interesting to be highlighted in this section.

Response:

Thanks a lot for your mention. The revision was done in the manuscript line 579-582:

However, our results indicate that at least another 30% reduction in vehicle VOCs emissions can reduce the O_3 concentrations under the odd-even license plate policy with 24%-32%, 25%-28% and -6%-2% reduction rates of NO, NO_2 and O_3, respectively.

Specific comments:

Line 14. Please add "with SAPRC box modelling"
Line 259. Please add units "…10^-5 to 10^-6"
Line 296. This sentence "The air flow… " is repeated (line 273-274).

Response:

Thanks a lot for pointing out this. The revision was done in the manuscript.

Line 312. The acceptance criteria were originally defined in previous studies. Please see my previous comment and add the appropriate references.

Response:

Thanks a lot for pointing out this. The reference Chang and Hanna (2005) was added in the manuscript.

Line 332-333. Please remove this sentence. This section presents the evaluation of dispersion of a tracer (non-reactive pollutant), and therefore, chemical reactions are not solved in this simulation.

Line 355. Please remove "ODE solvers for chemistry". The same applies here since chemical reactions are not solved in this simulation.

Response:

Thanks a lot for your attention. The revision was done in the manuscript.

Line 394-400. Please use the same nomenclature for the simulated cases. For the same scenario, EMIS_zero_out is first used in Line 396 and Case_Emis_zero in the following line.

Response:

Thanks a lot for pointing out this. The revision was done in the manuscript. All the 'EMIS' were revised to 'Emis'.

Line 432. Which is the case setting? Please clarify this.

Response:

Thanks a lot for pointing out this. This case setting here refers to the simulation domain and time setting. The revision was done in the manuscript line 432:

Table 6 shows the elapsed time of these three simulations in same $H/W = 1$ street canyon for 90 minutes simulation.

Line 478. Based on what the authors stated in their responses to my previous comment. This sentence is therefore not correct. Please remove "background" since this statement applies to all VOC (background and emitted).

Response:

Thanks a lot for the hint. The revision was done in the manuscript.

References:

Chang, J. C. and Hanna, S. R.: Technical Descriptions and User's Guide for the BOOT Statistical Model Evaluation Software Package. [online] Available from: http://www.harmo.org/Kit/Download/BOOT_UG.pdf, 2005.