Review of “Aerosol as a potential factor to control the increasing torrential rain events in urban areas over the last decades” submitted to ACP for publication by Lee et al.

The authors examine the roles played by aerosol concentration and spatial distribution in torrential rain that occurred in Seoul, using cloud-system resolving model simulations. The model results show that the inhomogeneity of the spatial distribution of aerosol concentrations or loading causes the inhomogeneity of the spatial distribution of evaporative cooling and the intensity of associated outflow around the surface. This inhomogeneity generates a strong convergence field in which torrential rain forms. The effects of the increases in the inhomogeneity play a much more important role in the increases in torrential rain than the much-studied effects of the increases in aerosol loading.
The study provides new understanding about aerosol effects on convection and precipitation over large cities, which warrants a publication in ACP. However, many clarifications are needed before the paper can be accepted as shown below, particularly in the introduction, model description and the model results on the section of convergence. In addition, if aerosol radiative effects are included (it seems to be that way, but not very sure), then the results shown are not only the indirect effects. When you change aerosol concentration or inhomogeneity, aerosol radiative effects also change, and this impact could be more significant. The could impact the standpoint of your analysis in Section 4 (currently, your standpoint is purely from aerosol indirect effect).

Section 1,
1. Line 80-86, The description here mixes the cloud cell dynamics with synoptic-scale dynamics. It is true that synoptic-scale dynamics may be homogenous for MCS. However, the convective cells are affected by many small-scale dynamics such as cold pool, rear-inflow, wind shear, vortex, etc. Those small-scale cloud dynamical processes are generally inhomogeneous even with the same aerosol loading everywhere because they are complexly impacted by small-scale environment such as land-surface, microphysics, etc. Aerosol inhomogeneity could only be one of these factors. Therefore, the description here needs to be rewritten.

2. Line 92-94, similar comment as above. The inhomogeneity of the convective cell and precipitation occurs everywhere, not only just over urban area. Many other factors could contribute to the inhomogeneity. For the urban area, there is effect of urban heat, which is so relevant and should be discussed in the introduction.

3. Line 106-108, Are you talking about observed studies here? If so, then need to be clear about it. If not, you should cite the symbolic papers illustrating the invigoration through enhanced latent heat induced by freezing such as Khain et al. 2005 and Rosenfeld et al. 2008.
4. The description about literature studies in aerosol indirect effects on convective clouds are one-sided. Many studies showed that the enhanced or suppressed precipitation by aerosols could be very dependent on RH, wind shear, CAPE, etc., which should be clearly delivered to readers.

Section 3,

1. Section 3.1, first paragraph, what are the domain sizes? Where is Seoul in Domain 3?

2. Line 165, Domain 1 is 4.5 km. Does the cumulus parameterization work for this resolution?

3. About the RRTMG scheme you used, did you use the effective radius calculated from microphysics in the radiation calculation?

4. Line 192: need some details about the aerosol module you developed. What was included in the module and is there any reference? Is aerosol formation excluded? If so, how are aerosol properties (SD, composition, vertical distribution) specified? How are the aerosol optical properties calculated? Is aerosol module similar to the idea used in Fan J. et al. 2008, JGR? If so, providing references would help readers understand better about what the aerosol module is.

5. Line 222-223, how did you convert PM10 to aerosol number concentration? Theoretically you can not do this since PM10 is only contributed by the very large aerosol particles. Do you have any reference for what you did here?

6. Line 237-238, the aerosol generation is not included in the SBM released in WRF. The reference Fan et al. 2009 shown here indeed had it for that study, but it was not included in the WRF releases. Did you make your own code to do this or you assumed this process was included in the released version?

7. Description of model simulations and Table 1 are confusing currently. Need clear description about how the aerosol concentration and inhomogeneity are changed, respectively, from one to other simulations. For example, in Line 279-280, “The repeated simulation has the “low” inhomogeneity and concentrations of “aerosol” as compared to the control run and thus is referred to as the low-aerosol run”, if both aerosol number and inhomogeneity are changed as described here, then how do you distinguish the effect by changing aerosol number from changing aerosol inhomogeneity? What are the other simulations you ran to help you distinguish? As I read along, I found much of the description is at the different result parts. So, the description should be moved to here to help people clearly understand the purpose of the simulations and how the simulations were set up.
In addition, Table 1, the two columns “Contrast in aerosol spatial distribution” (Column 2) and “The homogeneous aerosol distribution” (Column 4) mean the similar thing to me. The content in Column 2 “reduced by a factor of 2”, does not make sense if it is for “Contrast in aerosol spatial distribution”. Did you mean “Contrast in aerosol number concentration”?

8. It is not clear if you excluded aerosol radiative effect or not? If so, please be very clear about it. If not, then the effects we see are not only the indirect effects. When you change aerosol concentration or inhomogeneity, aerosol radiative effects also change, and this impact could be more significant. The could impact your analysis in Section 4.

Section 4,

1. Sections 4.1.1 and 4.1.2, the comparison of precipitation with observations does not seem to be fair since there is a significant fraction of the domain over ocean where no measurements are available.
In addition, how about the evaluation of meteorological fields with observations? There should be a lot sounding measurements over Seoul.

2. It seems that there is an inconsistency between Figure 5 and Figure 6a for the differences between low aerosol and control runs. Figure 5 does not show that the precipitation in low-aerosol case has significantly smaller precipitation. However, Figure 6a suggest the rain should be much lower in that case because the total precipitation is mainly determined by the moderate and heavy rain rates.

3. Line 338-341, Figure 7, the figure caption is very long and confusing. The light blue contours represent precipitation rates, but they are hard to see and the values for contour line are not clearly shown or described. Also, there could be timing shift between the convective developments in two simulations so comparison between the two simulations at a particular time may not be meaningful.

4. Figure 8, I guess the plots are for the control run? I did not find such information in the figure caption or text. I had a trouble to understand what was plotted. Compared with Figure 7c and e, Figure 8a and 8b correspondingly have the same spatial domain for the same time, but I do not understand why the blue line and the green boxes are totally different.

5. Please mark the city boundary or the boundary between the high/low boundaries in Figures 7-9.

6. Section 4.2.1, the long text of the first 4 paragraphs can be simplified with just a few sentences since most of the description here is just the basic text book knowledge about the relationship of convergence, condensation, and precipitation. What's interesting here should be just the differences between the control and low-aerosol runs. Then the text that follows it should be explaining the reasons for the differences in convergence, condensation, and precipitation. The long text in this section makes readers very hard to get what the main points are.

7. Line 670-675, very long sentence and the meaning does not make sense based on the results shown. For example, "the absence of the strong convergence field in the control-homoge run results in the situation where the increase in the frequency of heavy precipitation in the control-homoge run" is opposite to the results shown above.