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Interactive comment on "Sensitivity of spatial aerosol particle distributions to the boundary conditions in the PALM model system 6.0" *by* Mona Kurppa et al.

Anonymous Referee #2

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The manuscript (MS) deals with evaluating a new model system that couples an aerosol dynamics module (SALSA2.0) with a LES model system (PALM 6.0) for high-resolution urban air quality modeling. The main objective is to validate the horizontal and vertical distributions of aerosols in terms of particle number concentrations, size distributions and chemical compositions. In particular, authors investigate the model sensitivity to meteorological boundary conditions and aerosol background concentrations.

The authors simulated three periods in summer and winter with different meteorological conditions and compared them with the measurements conducted using a mobile

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laboratory and a drone in an urban neighborhood in Helsinki, Finland. The results highlight the high sensitivity of urban LES modeling to meteorological boundary conditions and the aerosol background concentrations.

The methods and assumptions are scientifically sound and well explained in the MS. The outcomes have important implications for future studies urban air quality modeling using LES. I consider the objectives of the MS interesting for the community and within the scopes of the journal. However, the presentation need improvements. Therefore, I recommend the MS for publication after minor revision. My major points are:

1- In the result section, there are extensive and detailed explanations (sometimes too wordy) about the plots but no discussion. There are few sentences in section 5 but it is not enough. The authors should move the discussions to section 4 and expand them. It is important to explain “what” we see in the plots. Nevertheless, more important than that is to know “why”.

2- The model somehow struggles with the mixing state of the atmosphere. I want to see direct quantitative measure of turbulence (e.g., TKE) at least between different runs. The vertical profile of the potential temperature or the Richardson number could be helpful too. Most importantly, the discrepancies are attributed to the mixing state in the simulations and observations. Thus, a direct measure of the atmospheric mixing state would be essential.

3- Several statistics are used in the MS but it is not clear what they represent. In the current form, they are rather confusing and make it hard to grasp the key message. For the horizontal distribution, I recommend SAL method.

4- I am a bit confused with the role of the aerosol dynamics and chemistry. It seems that the simulations differ in boundary conditions only. But the PSD and composition differ too. So is there a feedback from the atmospheric state to aerosol dynamics and chemistry? With the chemical boundary conditions fixed, these differences stem from the processes within the child domain only. Is that right? What are the individual roles

of aerosol dynamics, chemistry and meteorology? It would be helpful to elaborate on this.

Other comments:

P1L8: do you mean “are driven” instead of “are drawn”? This occurs several times in the MS.

P4L25: please explain in detail why you choose these dates. I assume it is based on the diurnal and seasonal variations in the mixing state of the atmosphere. What about the urban heat island?

P6L19: wouldn’t this be part of the reason why OC is well captured but not sulfate and Nitrate? What about the winter period?

P6L23: “at the same time”?

P6L23: “a high enough resolution is needed” is too generic. Please add a range. Table 2: the innermost domain has 1 m resolution. But later the results are aggregate a 5 m grid for comparisons. Then what is the point of this expensive simulation?

P9L22-26: this text is repetition of table 4.

P10L20: The boundaries of the innermost domain are fixed for the chemicals. This means that the air masses come and go without bringing or taking any pollutants. Does this make sense in the resolution you are dealing with?

P11L5: Most of the figures cited here are in the supplementary material. This is not helpful for the reader. I understand that the MS should not be lengthy. But perhaps with some reorganization

Figure 2: Adding the potential temperature to this plot would be helpful.

Figure 3: add name tags to each row and column so that the reader can navigate more easily.

Figure 4: I have problem understanding this type of figure. Perhaps because the purpose of each parameter is not well explained? What about SAL method?

Figure 5: It is difficult to have a solid conclusion here. Higher LDSA is (or should be) associated with higher number concentration. The model always fails to capture the profile in the morning hours. What are the individual contributions of MET and PSD?

P17L1-10: same as the previous comment.

P19L7-8: this is an odd sentence.

Figure 9: It might be that the coagulation (aerosol dynamics) is not fast enough. Is this a reason why fine particles are overestimated? This can be tested by aerosol dynamics on/off.

Figure 10 and Table S2: SAL might be a better method to compare these plots.

P24L26: replace “huge” with “large”.

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