Atmospheric Chemistry and Physics Discussions

Atmos. Chem. Phys. Discuss., referee comment RC1
https://doi.org/10.5194/acp-2021-139-RC1, 2021
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Comment on acp-2021-139

Mona Kurppa (Referee)

Referee comment on "The effect of BC on aerosol–boundary layer feedback: potential implications for urban pollution episodes" by Jessica Slater et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-139-RC1, 2021

Dear authors,

This study investigates the impact of black carbon (BC) aerosols on the dynamics of the planetary boundary layer (PBL) and aerosol-PBL feedback mechanism in wintertime Beijing. The study applies a large-eddy simulation (LES) model coupled with a radiative transfer and an aerosol model (SALSA). The influence of BC concentrations is investigated from different angles and the results of different sensitivity studies support each other. The method and research questions are novel and overall, the study has been designed and conducted well. However, some points require further attention before publication.

General comments:

- As mentioned above, the study is well planned and conducted. However, it seems that finalizing the manuscript lacks some effort. For instance, sometimes sections and figures are incorrectly referred to and the language does not always sound professional. I would also double-check the usage of articles (a/an and the).
- In this study, you investigated three different kinds of model setups described in Sections 2.3-2.5. Each setup investigates different model sensitivities. You end up using the word "case" a lot. For instance, you use the word "case" for different setups (Sections 2.3-2.5), but you also use it e.g., in Table 2 ("BC case and No BC case"). Maybe you could try to come up with some more indicate words to make it easier to follow the text? For example, scenario, sensitivity, simulation etc. Different “cases” (i.e., setups described in Sections 2.3-2.5) could also have some more indicative names, e.g., case_aerosol_loading, case_met and case_BC_loading.
- The Discussion section now contains conclusions and most of the content in Conclusions should be moved to Discussions. Please review the content of these sections. For instance, Conclusions should not introduce any new arguments, while now the novel mechanism is presented for the first time there.
- Regarding Conclusions, the research questions should be restated there.

- Limitations of the study have not been discussed anywhere.
- Applying LES in this type of study is very novel and I think you should stress more in the text. Furthermore, visualising the simulation setup would be very useful for the readers. Now you are only showing one-dimensional vertical profiles while LES resolves the three-dimensional flow and concentration fields.
- Figures 2- 4 and 6-10: Gridlines would be useful. Also, add the variable names to the x-labels in addition to the units and get rid of "^" in the units.

Specific comments (P=page, L=line):

P1 L1: Is it correct to say "to various degrees"? I would remove it.

P1 L8-9: "a high resolution coupled large eddy simulation-aerosol-radiation model" --> "a high-resolution model that couples an aerosol and a radiative transfer model with large-eddy simulation (LES)"?

P1 L10: black carbon --> BC

P1 L22: give the WHO exposure limit

P2 L28: 10% --> 10% of ?

P2 L49: Is it a positive feedback if an increase in concentrations leads to a shallower PBL?

P3 Fig. 1: This figure nicely illustrates the concept of BC aloft and surface BC. However, I do not think it shows the effect of BC layer height on PBL interactions as said in the caption.

P2 L59-60: This phrase is partly a repetition of the first phrase of the previous paragraph.

P2 L72: "through synoptic scale winds" --> "by synoptic-scale winds"?

P3 L83: remove “a” before “polluted”

P4 L90: The dome effect is being discussed a lot in the introduction but not later in the manuscript.

Section 2.1: I would mention somewhere that LES resolves the three-dimensional turbulent field of wind and scalar concentrations and that it directly resolves most of the energy and parametrises only the smallest scales.

P4 L102: I would not use the expression “is based on”. These are just numerical methods applied in UCLALES to resolve the flow and dispersion.

P4 104: I would open “doubly periodic” to “periodic in both horizontal directions”

P4 L104-105: the surface scheme for moisture and heat, right?

P4 L104-107: I think the urban surface scheme I rather essential, so I suggest you give some more information about it here. Especially when Slater et al. (2020) is not an open-access publication.

P4 L109: How many size bins do you use?

P5 L116: “feed back” --> “feedback”

P5 L117: “size” --> “aerosol size”?

P5 L118: What do you mean by “set refractive indices”? Constant, pre-computed values?

P5 L119: define lambda and Dp in the equation

P5 120: “apart from BC” --> “apart from that of BC”?

P5 L121-123: Are these two phrases repeating each other?

P5 L121: “simply” --> “in a simple way”?

P5 Section 2.2: Could you add an illustration of the modelling domain and add the location of the sounding station to that?

P5 L128: Where are the radiosonde profiles from? Beijing International Airport?

P5 L129: You could open “APHH”

P5 L132: “km“ --> “km^2”

P5 L135-P6 L142: Overall, this paragraph is difficult to follow as the reader is not yet familiar with different “cases”

P6 L141: “Section 2.3” --> “Section 2.5”

Section 2.3-2.5: These sections belong under section 2.2. Therefore, I would make them subsubsection 2.2.1-2.2.3.

P6 Fig. 2: Here and elsewhere: use BC and SO42- for black carbon and sulphates.

P6 L153: numbers smaller than 10 are usually written out (here 3 --> three)

P7 L154: “table”-->”Table” and “figure”-->”Fig.” (throughout the manuscript)

P7 L163: I would change: “to a base case which was simulations not including” --> “... to a reference simulation (hereafter "base case") which did not include”

P7 L166: “inversion” --> “temperature inversion” (throughout the manuscript)

P7 L166-167: Indicate the height that you define as the free troposphere.

P7 L167-169: Repetition to the first phrase of this paragraph.

P7 L170: “different initial meteorological profiles and surface values” --> “the different initial meteorological conditions”

P8 L174-176: This phrase is very long.

P8 L179: You use both “set up” and “setup”

P8 L182: “section 3.1” --> “section 2.3”?

P8 L183: “Figure 5 (a)” --> “Fig. 4a”? (throughout the manuscript)

P9 L196: How much does it decrease?

P9 L197: “layer” --> “air layer above the surface”

P9 L197: How large increase?

P10 L 199: “calculates” --> “calculated”

P10 L203: remove the comma after “inversion”

P10 L204: remove “of 1.6-2 K” since it is already clear from the previous phrase

P10 L204: Remember that the prevailing synoptic meteorological conditions also influence the PBL height tendency

P10 L207: How small?

P10 L212: add “in case 1” after “for all three simulations”

P10 L215: Refer to Fig. 5a-c as you say that the absorption of SW radiation causes heating.

P11 Fig. 5: Add variable names to the colour bar labels and the aerosol layer height to the subplot titles.

P11 L222: “This is” --> “This leads to”?

P11 L225: Can you further explain this? Above you say that PBL is 4.2 % lower when the BC layer is at 700-1150m compared to the BC layer at 500-950m.

P12 L227: “to” --> “in”?

P12 L230: “400 m above the PBL top” so specifically at which height?

P12 L231: add a reference to Fig. 8.

P13 Fig. 8: How is this vertical integral of TKE calculated? Where do the units kg/s come from?

P15 L268-269: “This was done as proxy…” is repetition.

P15 L274: “the low level of SWR available”. Give the value.

P16 L287: Give the height for the bottom of the PBL.

P17 L295: “the largest” --> “larger”?

P17 L299: “works out at” --> “leads to”?

P17 L303: Give the height of PBL top

P17 L305: “this” --> “which”

P17 L307: “slightly less” --> “a slightly lower”

P17 L315-316: “… suggesting the importance…”. I do not understand this sentence.

P17 L320: Temperature inversions can also exist e.g., at the surface

P17 L324: “at the PBL top” --> “from the PBL top”

P17 L327: “… Beijing, are “ --> “… Beijing, and they are”

P18 L328: This information belongs to the methods section.

P18 L336: weaker capping inversion?

P18 L336: “a small effect” --> “only a small effect”?

P18 L337: remove “that” after “Beijing”

P18 L338: remove “in Beijing”

P18 L345: Should it be explained somewhere how a night-time stable boundary layer is formed? The word "collapsing" might be misleading for someone who is not familiar with PBL dynamics.

P19 L364-365: “When the PBL…” is repetition to the lines 344-345.

P19 L368: The illustration in Fig. 11 is helpful but you have referred to it only here and then in Conclusions. I would use it to support the text in the Discussion.

P20 L381: “saddle type pressure field” has not been mentioned in the text before this.