Reply to the comments to the discussion of the preprint.

My general comments were provided already in the previous review phase:

The research questions and methods are novel. However, the biggest issue is that, at its current state, the manuscript does not fulfil one of the main aims of ACP: "The journal scope is focused on studies with general implications for atmospheric science rather than investigations that are primarily of local or technical interest." Currently, the manuscript is very Bergen specific and resembles a project report to the municipality. Hence, for the manuscript to fit into the scope of ACP, a major review is needed.

We are glad to read about the reviewer appreciation of our study. It encourages us to push harder in advancing research in this direction. We also agree that the case study in the manuscript is perhaps too extensive and too specific. However, we think that our arguments are also worth to consider. We want to advance the numerical modeling technique to realistic applications. How would one achieve that without reporting success and failure with a specific case? We all rely on peer-review process to correct and solidify the research. Understandably, the Bergen municipality does not have proper competence to evaluate the work against the research standards. So, we are interested in open and honest discussion of the case study as well, not only the general part of the study. Besides this point, it was and still is rather routinely accepted in the community journals, including the ACP journal, to publish insides into seemingly specific but by the mater of fact useful case studies. Let us look at ACP publications. Among the most downloaded articles you may find the *following case specific studies*:

93,433 downloads: Christoudias, T. and Lelieveld, J.: Modelling the global atmospheric transport and deposition of radionuclides from the Fukushima Dai-ichi nuclear accident, Atmos. Chem. Phys., 13, 1425–1438, https://doi.org/10.5194/acp-13-1425-2013, 2013.

63,272 downloads – very close to our subject of study - Benton, A. K., Langridge, J. M., Ball, S. M., Bloss, W. J., Dall'Osto, M., Nemitz, E., Harrison, R. M., and Jones, R. L.: Night-time chemistry above London: measurements of NO3 and N2O5 from the BT Tower, Atmos. Chem. Phys., 10, 9781–9795, https://doi.org/10.5194/acp-10-9781-2010, 2010.

31,941 downloads – very close to our subject of study - Zhang, R., Jing, J., Tao, J., Hsu, S.-C., Wang, G., Cao, J., Lee, C. S. L., Zhu, L., Chen, Z., Zhao, Y., and Shen, Z.: Chemical characterization and source apportionment of PM2.5 in Beijing: seasonal perspective, Atmos. Chem. Phys., 13, 7053–7074, https://doi.org/10.5194/acp-13-7053-2013, 2013.

and among the most recent such publications (1,900 downloads): Hellén, H., Kangas, L., Kousa, A., Vestenius, M., Teinilä, K., Karppinen, A., Kukkonen, J., and Niemi, J. V.: Evaluation of the impact of wood combustion on benzo[a]pyrene (BaP) concentrations; ambient measurements and dispersion modeling in Helsinki, Finland, Atmos. Chem. Phys., 17, 3475–3487, https://doi.org/10.5194/acp-17-3475-2017, 2017.

Those arguments support out conclusion that our study is well fitted to the ACP journal and will be interesting for the larger community of readers. In any case, however, we would suggest leaving the final decision on the topical editor. We hope that the reviewer will agree with that.

Some general comments:

1. As mentioned above, the manuscript is now only focused on the city of Bergen and hence the results are lacking general implications. For instance, no comparison with previous studies applying more simplified geometries or real topographies is given. Furthermore, there is rather a lot of discussion about the funding of these kinds of studies by cities, which I think does not fit the scope of ACP.

We hope that we answered to this concern above. As for previous studies, there are no such studies directly comparable with our results either by method or by subset of input data.

As for "the funding discussion", we believe that this is a matter of certain misunderstanding. We do not discuss funding of studies in the published preprint. We discuss how our modeling methodology might help to optimize socio-economic policy scenarios. To our view, this is important aspect of the science published by ACP, just look at the list of the most influential relevant papers given above.

2. Now the manuscript is difficult to follow. This is partly related to the language and partly to the structure of the manuscript. At least these points require improvements:

- The aims of the study must be stated clearly

- Sections 1 & 2 should be merged because they overlap a lot regarding the content.

- The language requires revision. Firstly, the paragraphs are lacking coherence and the text is missing flow. Secondly, the application of articles (a/the) and prepositions must be double-checked.

The required corrections have been introduced. We disagree that the paper is difficult to follow. It is written in plain language checked by the English speaker. The structure complies with the IMRAD standard for research papers. We will provide further revision in the final version of the manuscript if any.

Thank you for your minor but very important corrections. We have now included all of them into the text.

I hope these comments will be answered in this review phase. Another general comment:

- What boundary conditions are applied for the passive PM2.5?

We specified the PM2.5 boundary conditions in more details now. The lateral and upper boundary conditions are non-periodic. It means that the substance leaving the domain does not recycled on the other side. The bottom boundary conditions are non-penetrative.

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

P1 L7: "emission" --> "emissions"

It is changed now.

P1 L17-18: I would leave this definition of LES out of the abstract

We removed this sentence.

P1 L20-21: "with the worst air pollution" --> "that typically lead to the weakest air quality"?

We do not agree that "the weakest air quality" will improve the text. But we reformulated the sentence as "Such complex geography is expected to favour local air quality hazards, which makes this study of general interest. "

P1 L21: "Bergen" --> "Bergen, Norway"

It is changed now.

P1 L21: "True laser" sounds wrong. I understand that you are meaning "topography from laser scanning" here

It is changed now in the text to "The topographic data for the approximation are taken from a laser-scan digital elevation model (DEM) of 1 m resolution provided by the Norwegian mapping authority (Statens Kartverk, 2018).", and removed from the Abstract.

P2 L22: "at the regular mesh" is unnecessary detailed here

We removed this specification.

P2 L28: "limited incentives" --> "limitation incentives"? "limited incentives" --> "limitation incentives"?

We disagree. The proposed changes would alter the meaning.

P2 L38: "in short run" --> "in the short run"

We disagree. Our use of language is correct.

P3 L46 – P4 L79: This paragraph is long and difficult to follow. You could split it up into two or more parts.

We agree. It was a too long text. We made two paragraphs instead.

P3 L47-48: “with the meteorological background set up by shifting weather” sounds peculiar. How about: “with the temporally varying prevailing meteorological conditions”?

We agree. We removed the sentence.

P3 L48: I would move "e.g. in Bergen, Norway" to the end of this phrase: “... stagnation zones, as shown in Bergen, Norway”

Perhaps, but we did not find it optimal.

P3 L51: “(Chandler, 1976), (Bai, 2018).” --> “(Chandler, 1976; Bai, 2018).”

This is a typesetting issue for technical editing.

P3 L55: “That is likely true”. I would not be so sure. Low-cost sensors are not the most reliable data sources.

We do not understand this comment. In this sentence we are talking about dense networks of sensors. Each sensor could be less reliable, but when there are hundreds of them, statistical methods are able to recover reliable information.

P3 L58: “Locked within silo”. What does this mean?

“Silo” or “siloed structure” is a standard term from social science, which describes such an organization where information flow is allowed only between directly subordinated units, but not between units operating at the same level of hierarchy. In its application to meteorological information, it allows only for use of information/models approved by the higher levels. Any information collected around, whatever relevant or reliable it is, won’t be taken up and considered in such an organization.

P3 L60-61: I do not think that information about project funding belongs here.

We removed this information.

P4 L75: “massive-parallel”? You mean “supercomputers that can be applied to run massively parallelized simulations”?

We disagree, our use of computing terminology is correct.

P4 L83: “by Wolf et al. (Wolf-Grosse et al., 2017a; Wolf et al. 2020)” --> “by Wolf-Grosse

et al. (2017a) and Wolf et al. (2020)"

This is a typesetting issue for technical editing.

Section 2: A general figure of the area of interest (i.e., Bergen) and its districts would be useful.

We do not understand this comment. Figure 1 is such a figure of the area of interest.

P5 L 104: "Bergen has clean air brought to the city with westerlies from the Atlantic Ocean" sounds wrong. Why not simply: "the prevailing westerly wind provides clean from the Atlantic Ocean to Bergen"?

We agree. The sentence is now "As in many Nordic cities, westerly winds bring clean air into Bergen from the Atlantic Ocean."

P5 L113: "There is a strong anti-correlation between air quality and air temperature in Bergen (Wolf and Esau, 2014)." This is not Bergen-specific but applies to maybe most of the cities?

This is not true. Air quality in temperate and tropical many cities positively correlates with air temperature. See e.g., Ramsey, N. R., Klein, P. M., & Moore, B. (2014). The impact of meteorological parameters on urban air quality. *Atmospheric Environment*, **86**, 58–67.

Moreover, Chudnovsky et al. (2014) used MODIS data product to show that the corellations change sign when temperature cross a threshold of about 7^{o}C.

Chudnovsky, A., Lyapustin, A., Wang, Y., Tang, C., Schwartz, J., & Koutrakis, P. (2014). High resolution aerosol data from MODIS satellite for urban air quality studies. *Central European Journal of Geosciences*, **6**(1), 17–26.

A study in Seoul (seo et al., 2018) revealed positive correlations between PM10 and temperature for short term pollution episodes.

Seo, J., Park, D.-S. R., Kim, J. Y., Youn, D., Lim, Y. Bin, & Kim, Y. (2018). Effects of meteorology and emissions on urban air quality: a quantitative statistical approach to long-term records (1999–2016) in Seoul, South Korea. *Atmospheric Chemistry and Physics*, **18**(21), 16121–16137.

Yet another study in Nagasaki (Wang et al 2015) clearly revealed positive correlations between PM2.5 and temperature in all months.

Wang, J., & Ogawa, S. (2015). Effects of meteorological conditions on PM2.5 concentrations in Nagasaki, Japan. *International Journal of Environmental Research and Public Health*, **12**(8), 9089–9101.

P5 L 114: "calm weather periods" --> high-pressure systems leading to weak winds?

We prefer to keep our formulation.

P6 L141: “PALM resolves” --> “LES resolves”

We are working with a specific code PALM. There is no need to generalize here.

P6 L141-142: “PALM explicitly resolves a part of relevant three-dimensional atmospheric turbulence dynamics as well as turbulence”. I do not understand the meaning of this phrase. Yes, LES directly resolves the turbulence structures that are larger than the grid and parametrises the rest.

Yes, we tell this to our reader.

P7 L150: “runs”

It is changed now.

P7 L 156: “chemical processes”. Aerosol dynamics can also have an impact.

We agree.

P7 L 164: Open “NO2”

Sorry, but we did not understand this comment.

P7 L167: “The domain includes buffer zones used for linear interpolation between the opposing period boundaries of 1000 m width”. The meaning of this phrase is not clear to me.

The sentence was replaced with “Therefore, this domain includes buffer zones with a width of 1000 m each, which are needed for linear interpolation between the opposing periodic boundaries.”

P8 L169: “the largest achieved urban simulations so far”. Are you sure?

Yes, we are still sure.

P8 L179-184: Are the temperatures applied just some generic values or have you taken them from measurements or model simulations?

The temperatures were taken from analysis of direct observations during the weather episodes corresponding to the simulated scenarios.

P8 L191-192: “We have already identified the typical meteorological conditions that correspond to the high urban pollution episodes (Wolf et al., 2014).” --> I would write "The typical meteorological conditions that correspond to the high urban pollution episodes in Bergen have been identified in a previous study by Wolf et al. (2014)"

Since journals recommend using active voice, we prefer to keep our sentence.

P9 L194-196: These side comments about the boundary conditions applied for PALM are a bit confusing.

We changed this comment to “This setup reflects conditions of winter temperature inversions with radiative surface cooling over land and warmer sea surface temperatures.“

P9 L215: “Since 1995 installation only the new ovens are allowed”. Something missing here?

We changed it to “Since 1995, only new stoves are allowed.”

Section 4: please refer more to the figures. I will make it easier to follow the text.

Thank you. We tried to follow this advice now.

P11 L252: “the actual local conditions”. Which conditions?

We changed this to “This pattern is however significantly distorted by intricate interplay of local air circulations and turbulent diffusion in the lower parts of the atmosphere.”

P11 L253: “in more densely populated districts”. This can be expected only if the emissions correlate with the population density.

This is a good point. Indeed, districts with more high-rise buildings, and hence population, are not necessarily those with the largest emission. However, in Bergen, population density does not vary significantly at the district level. High-rise buildings are dispersed and embedded into the areas of low-rise houses.

P11 L255: “in some stagnation zones”. It would be easier to follow the manuscript if you indicated these areas in the respective figures.

We agree, this is one of possible ways to organize the figures. Other approaches are possible as well. We tried to reduce use of local toponymics to focus on more general applicability of the study.

P11 L262: "e.g., over Nordåsvannet at 60.32 N and 5.32 E." You could mark this in the respective figure.

We will do this on high resolution Figure.

P12 L281-282: "Artificially defining emissions…" This belongs to the methods section.

We agree. These sentences were moved to the Methods section.

Figures 4-6: I find it difficult to distinguish different districts on the figures. How about 1) combining the figures to one figure and always showing the same area in the map OR 2) adding a smaller map to each figure to show the location of the specific district on the big map?

We tried that and several other methods, but it makes Figures overloaded with geographical information. Perhaps, a reservation of the whole page for an infographics-like illustration would help, but we are not experts in the graphical design. So far, we decided to keep figures as they are.

P14 L329: a dot missing after "Table 1"

We changed this.

P14 L330: is the limit 40 ug/m3 for the daily average or temporal values?

This is a limit for hourly averaged values.

P14 L332: "households are under the current distribution of ovens exposed to high air pollution." The word order is confusing.

We agree. We changed the sentence to "Nevertheless, a total of 4031 (scenario 1) and 5986 (scenario 2) households are still exposed to high air pollution under the current distribution of stoves."

P15 L362: "Felius et al. study (Felius et al., 2019) however" --> "Felius et al. (2019), however,"

This is a typesetting issue for technical editing.

P16 L385: I guess the user-code modifications should be provided as well?

We agree. The modifications are described and provided.