RC3: 'Comment on acp-2021-341', Anonymous Referee #3, 25 Jun 2021 reply

This long review paper present the research progress of Pan Eurasian Experiment (PEEX) program, as well as that of urban air quality in China. It is an extremely comprehensive summary paper that includes the land ecosystem processes, thawing permafrost, ecosystem structural change, atmospheric composition and chemistry, urban air quality in megacities, weather and atmospheric circulation, changing water systems, snow, sea ice and ocean sediments, marine ecology, lake and rivers, anthropogenic and environmental impact on society, and natural hazards. Given its wide scope and my limited expertise, I focused mainly on the air quality part. In general, the review appropriately summarized the relevant work of PEEX, and it is well organized and presented. I only have some minor concerns. While it stressed the PEEX, however, some more information could be provided for **further explanation of changed air quality in mega cities. Relatively long-term trends in atmospheric composition should also be provided**.

We thank the reviewer for the apropos remarks. This paper, as the PEEX program (2012 -), is a multi-diciplinary research framework. This type of a framework is a relevant baseline if we, as a scientific community, aim to understand and find new feedbacks and interactions in the land-ocean-atmosphere continuum. For the future it is important to make perspective papers, where results from different disciplines are introduced to a wider scientific audience also with attempts to provide more holistic views on large-scale environmental challenges. The section structure of the paper follows the research agenda structure (land / atmosphere / aquatic / society systems and feedback & interactions) of the PEEX Science Plan. The result are reflected to this structure.

The geographical region discussed in this paper covers the Northern Eurasian region, in this case the boreal (taiga) forest zone, the Eurasian Arctic and China. China is identified as a relevant source area of the atmospheric pollution effecting the Arctic – boreal region, but also as one of a region of interest when discussing the global-scale environmental challenges and large-scale feedbacks. Referring to the so-called "Valeriepieris circle" map (2013) demonstrating that more people is "living inside a circle that outside it" (Danny Quah, London School of Economics and Political Science) concretizes the importance of China for the global climate change and air pollution challenge.

In addition to our responses to the specific comments, we have re-edited the abstract, added "table of contents" and a short description of our literature strategy to help the reader to understand better the chosen structure of the paper and our approach reporting the recent research results of the PEEX program. We frame our overview of the resent results by the PEEX community (including our co-authors), by the papers published in the ACP PEEX Part I special issue and by other relevant sources such as PEEX collaborating projects.

1. Section Northern Eurasian carbon monoxide (from line 566). Why was the CO elevated? As it is an indicator of energy efficiency, does it mean the energy efficiency went down in recent years?

Ratikin et al. (2018) concluded in their paper "Such pattern of changes in atmospheric composition especially in CO trends cannot be explained by growth of anthropogenic and/or wild-fires emissions. Possible reason of beginning of CO growth may be the change in the ratio of the natural sources and sinks with a significant role of atmospheric photochemical mechanisms."

2. Section Northern Eurasian Ozone (from Line 576). This paragraph stated the important chemical species of O3 formation in different regions. I would suggest the authors collect more information and provide a relatively long-term trend in O3 concentration in Northern Eurasia. Moreover, the driving forces of O3 change should also be analyzed.

We think this a relevant point, but such type of a trend analysis has not yet carried by the PEEX collaboration. We report and overview here only the existing results.

3. Section Black carbon and dust in the atmosphere and snow (from line 668). Similarly, could you reveal the long-term change of black carbon in Arctic and Northern Europe/Asia, and provide the main reasons for the changes.

Unfortunately, we do not have long-term black carbon data to make any trend analysis for the Russian part of the Arctic. BC trends for a few European and Northern America Arctic sites have been published in a scientific literature. We think it is not worth either repeating or trying to re-analyze those results here.

4. Section Air quality in China-recent observations (from line 846). There are a lot of studies stressing the changed air quality (i.e., reduced PM2.5 and increased O3) since 2013. However, very limited papers were selected in the review. The authors need to **explain their strategy in literature review**. Moreover, the reasons for the air quality change should also be well presented. For example, the implementation of national plan of air pollution control is considered to be the most important reasons for the improved air quality. It should be reviewed and presented here.

We have added a following description of our strategy in literature review: "*For the literature material, we have combined literature searches with summaries the scientific approach by the PEEX community. We used the following sources for demonstrating the results: (i) individual input sent by the PEEX research community, (ii) content of the scientific papers published in Atmospheric Chemistry and Physics (ACP) PEEX special issue in 2016-2019 (www.atmos-chem-phys.net/special_issue395.html), (iii) scientific output from PEEX labeled projects www.atm.helsinki.fi/peex/index.php/projects). For the individual input we asked the PEEX research community to identify the main published papers in peer reviewed journals for each question out of their own work and connect the work to one of the 15 science questions introduced in the PEEX science plan. Based on the abstracts we listed "addressed research themes" over last 5 years per PEEX key topical areas (Table 1), which we review in more detail in section 2.*"

5. The same section as Question 3. Why include only the NPF studies conducted at SORPES in YRD region? How about studies in other regions or sites? Is it because of the limited scope of PEEX?

The studies on NPF discussed in this paragraph have been conducted not only in SORPES and YRD, but also in Beijing. Furthermore, one of the studies made in PEEX (Chu et al., 2019), and also mentioned in this paragraph, reviewed practically all the NPF studies make in China prior to 2019.

6. Section anthropogenic emissions and environmental pollution in Russia (from 916). Given the different development stages and air pollution control plans between China and Russia, it would be interesting to compare the long-term trends in emissions and air quality for the two countries.

We think this a highly relevant point, but such analysis has not yet been carried out by the PEEX collaboration. It would need specific resources.

7. Some language errors need to be corrected. Line 501, section 3.1.1 or section 2.1.1? You don't need to give the full name of NPF as it appeared earlier.

We have corrected "section 3.1.1" to "2.1.1"

We have carefully checked the language and grammar of the latest version of the manuscript.

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