The paper entitled "Arctic spring and summertime aerosol optical depth baseline from long-term observations and model reanalyses, with implications for the impact of regional biomass burning processes" by Peng Xian and coauthors presents a comprehensive view on long-term measurements and modelling of aerosol optical depth (AOD) in the Arctic. They consider ground-based AERONET sun photometer measurements, observations by three spaceborne instruments, and results from three aerosol reanalyses as well as their composite to investigate (i) the consitency of the different data sets, (ii) the annual and seasonal variation as well as the long-term trend in AOD together with the importance of biomass-burning smoke, and (iii) statistics on the occurrence of extreme AOD events.

While the work is of interest to the readers of ACP, it is far to much material for one publication. This review is late, also because it is impossible to read the manuscript in one sitting. In fact, the content could be split in as much as three papers according to the list of topics provided above. Such an approach would lead to very good papers that could be much more reader-friendly than the current submission. This reviewer therefore recommends to reject the paper in its current form and to re-submit after a thorough revision of content and readibility. Alternatively, the work requires major revisions, shortening, and a decision on which of the three topics to focus in this particular submission.

Reply: We thank the reviewer for the comments on this manuscript. We intend to link remote sensing, ground observations, and reanalyses to provide comprehensive information on the Arctic AOD so that readers can have a consistent picture of the Arctic AOD status. It is known that the Arctic has far fewer observations compared to other regions of the world, so a single dataset or aspect (remote sensing vs modeling) is challenged to provide a true and comprehensive view of the Arctic AOD. We think it is essential to present the reanalyses results along with remote sensing and ground observations so that these complimentary data can be inter-supportive and comprise a rich and reliable picture of Arctic AOD. Surface-based AOD measurements stand for “accuracy”, and satellite products provide “coverage”, while model reanalyses provide information of “aerosol processes” that can help explain what’s observed. We think missing either one of the three components would greatly degrade the strength of the study.

The consistency of the different data sets is discussed in the manuscript with a highlight on the effect of quality control of the remote sensing datasets. We highlight the importance of quality control because our climatological AOD (less than 0.1 near 70N) is quite different from some other studies using off-the-shelf MODIS and MISR products (specifically Tomasi et al., 2015 of AOD value of 0.2 near 70N; our result is more in line with AERONET measurements; see section 6 discussion). The requirement of quality control on the remote sensing data for data assimilation, climate/trend analysis (our case here) purposes is demonstrated in numerous studies (e.g. citations within the manuscript for MODIS, MISR, CALIOP products, Zhang et al., 2006; 2010; 2017; Shi et al., 2011, 2013; Toth et al., 2018; Hyer et al., 2015). So we think quality control is necessary but it does not need to be further addressed as the methods used here are common.

In response to the reviewer’s concern on the length of the manuscript, we have split the manuscript into two separate manuscripts. One focuses on AOD climatology and trend (now Part 1) and the other focuses on statistics of extreme AODs (now Part 2). Part 1 has 55 pages, including 13 figures and 4 Tables (and references). Part 2 has 34 pages including 10 figures and 3 tables (and references). Part 1 is similar to the original manuscript, except for

the removal of the extreme AOD events and with marginal changes incorporating reviewers' and coauthors' comments. Part 2 focuses on extreme AOD events and with four additional figures and one additional table providing in-depth analyses of extreme AOD events (e.g., the geographical distribution of AODs at the 95th percentiles, a figure illustrating the trend of extreme AOD events). The added table (Table 1) is to provide AERONET site information and basic AOD statistics (similar to Part 1). We thank the reviewer's suggestion for splitting the paper into more than 1 papers.

Please find some more specific comments below:

- The paper is rather lengthy and would benefit from trimming the text and content to what's really needed. A start would be a shorter title such as, e.g. to Arctic spring and summertime aerosol optical depth baseline from long-term observations and model reanalyses.

Reply: The paper is split into two manuscripts as mentioned above. The titles are shorter than before.

- Entire paragraphs could be omitted as they are repeating points made earlier or are just redundant, e.g. lines 24-31 (not needed in the Abstract), 141-148, 176-182, 299-303 (why mention if the statement end with "is not used here"),...

Reply: Line 24-31: We think the inclusion of the discussions in the abstract is a personal preference. We prefer abstracts to be stand-alone with sufficient info for readers. Therefore, we kept the discussions in the abstract.

Line 141-148: The advantage of high temporal resolution biomass burning emissions used in the aerosol reanalyses was mentioned in two places in the manuscript: One in the introduction (listed line numbers), and the other in the discussion. We'd really like to highlight this point so we've kept it in the introduction as well as in the discussion.

Line 176-182, 299-303: These lines are removed following the reviewer's suggestion.

- The entire part about FLAMBE (description and results) could be omited. In fact, the point made here could be condensed down to something along the lines of "findings are also supported by burning emissions from FLAMBE" later in the discussion.

Reply: The FLAMBE biomass burning (BB) emission climatology and the trend, which are derived based on satellite observations, are a critical data source for revealing changes in BB aerosol patterns in the Arctic region. Thus, we would like to include an introduction of FLAMBE for the benefit/convenience of readers. The FLAMBE-related information is only one figure and it is kept in the manuscript.

- There are way too many figures for one publication. In addition, some information in these figures could be moved to the supplement to improve the discussion of the findings. For instance, the main figures could stick to the Multi-Reanalysis Concensus and their discussion could link to more detailed figures including the specific findings of the three models in the supplement. The authors should re-evaluate if a figure that isn't thoroughly discussed in the text is needed in the manuscript.

Reply: See our reply to the first comment on the length of the manuscript. Regarding the usage of reanalyses, many of the figures contain AOD information from all three reanalyses and their consensus, because we intend to show the diversity and similarity of these reanalyses and avoid the consensus being dominated by any specific reanalysis product. We think this makes our result more convincing while providing information for readers interested in the difference of the reanalyses. We think every figure is discussed thoroughly except for some aspects that are supportive of other results in the manuscript (where we stated something like, for example, for the trend in reanalyses "consistent with the trend in remote sensing AOD").

- *The study makes use of height-resolved measurements from CALIOP and considers detailed aerosol re-analyses fields. The work would be even stronger of this information was to be used to also investigate the vertical distribution of Arctic aerosols. Such an attempt would partly compensate for the disadvantage of AOD to refer to column aerosol load.*

Reply: As the reviewer commented earlier, the current manuscript is already long, so we prefer to focus on AOD only for this submission. We mentioned that the vertical distribution of aerosols for extreme events "is the topic for another manuscript" in the original submitted manuscript. We are working on that aspect and will report our findings in another manuscript. Thank you.