Atmospheric
Chemistry
and Physics
Discussions

Interactive comment on "Multi-decadal variations of atmospheric aerosols from 1980 to 2009: sources and regional trends" *by* Mian Chin et al.

Anonymous Referee #2

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This manuscript documents the results comparing the aerosol variations and trends simulated by GOCART model during 1980–2009 against the observations from multiple satellite sensors and ground-based networks. Results show that the AOD and surface aerosol concentration reduced in Europe, Russia and North America, but increased in East Asia and South Asia, while the global mean AOD shows little changes over land and ocean in the past three decades because of the concealing of opposite trends in different regions. The study highlights the need of regional-scale assessment for aerosol, including its concentration, optical properties and radiative forcing.

Overall the results are interesting and evaluation for AOD and aerosol concentrations are valuable to the GOCART and even a boarder community. The analysis on dust emission and loading is insightful. While I believe this study merits to be published in

ACP, the manuscript can be much better organized and presented in a more condensed way. The current version of manuscript is very lengthy but poorly organized, which make it very difficult for readers to catch up the major points of this paper. Here below are some comments that may help authors to better organize the paper and present the data in a context that would yield more scientific insights.

(1) Usually we first have initial science issues we want to address and major points we want to make in mind before we formally start writing a paper, then we only select the relevant results that serve to address those issues or points to be included in the paper. The authors often tend to present whatever they have evaluated and analyzed, but the reality is that readers often only quickly go through the conclusions and abstracts, and read the relevant figures/tables. For this paper, it is not clearly to me what are new progress and insights? Is this a first 30-year simulation of GOCART? And a newer version of GOCART? If yes, what aspects are new? How is the model performance comparing with previous version and other AeroCom models? I would suggest significantly refine and shorten the paper (see my other comments 2 and 3) by removing the results that are not relevant to the key points you want to make. Instead, more clearly list the major findings and progress in the Conclusions and other related parts.

(2) Too many subregions. While I understand the rationale using 27 sub-regions in the study, some regions show very similar variability and trend and some regions are not mentioned at all in the discussion. It might be too much work if I am asking to regroup subregions and redo analysis, but it may make sense to suggest only selecting those typical regions (you really mentioned in the discussion) over land and ocean to present in related figures/tables. 8-9 regions over land and 4-6 regions over ocean probably will make the presentation much clearer and quality of figures (e.g. Figure 5) much better.

(3) AERONET data. Section 4.3, including Figures 7 and Table 3, present the evaluation of model AOD with AERONETS data. It's not clear to me what the major conclusions are obtained from this part. Authors provided a Table 3 and ask readers to summarize based on this table, but I believe this should be authors' job. The model

significantly underestimates the AOD over the Mexico City and Kanpur, authors suggest this is because of missing aerosol types, emissions, PBL, or coarse resolution, etc., which are just very general suspects. In fact, it should be one of objectives of this study to narrow-down the suspicious list with further in-depth analysis. Given the great spatial variability of aerosol over those polluted regions with complex terrain, I don't think it is so meaningful or insightful to compare the in-situ point measurement with the coarse-resolution model results. I would suggest remove this section, unless authors can wrap up some insightful and solid conclusions after further in-depth analysis are done.

(4) Table 4. Given the reality that fewer readers can have patience to read such a detailed table and find the main conclusions from it, I would suggest to use a smartly-designed figure to replace the Table 4 to facilitate to capture the major information that authors want to delivery.

(5) Global pattern change. Section 4.2.3 (figure 6) uses the difference of two 2–year averages to represent the global change of AOD. Due to the large inter-annual variability of AOD mainly resulting from the inter-annual variability of meteorology, it is not possible to quantify the statistical significance of the differences for both model and satellite data if only two years of data are used. The comparison of model and observation over the regions where the difference between two periods is not statistically significant for either model or satellite data is not meaningful, that's why in climate community the simulations have to be run for decades or ensemble simulations are needed. So I suggest select at least 5 years to get an average and do the statistical test for difference, and discussion only focus over the region where the difference is statistically sigifcant.

(6) Multiple satellite datasets. To highlight the uncertainty associate with the observations, this paper (e.g. Figure 4) provides several AOD datasets from different satellite sensors, which is something that should be encouraged. However, the challenging for this approach is it will become more difficult to obtain an assertive conclusion (whether model underestimates or overestimates) if the model result is located within the bounds

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of observations (e.g. model AOD is smaller than MODIS but larger than MISR). I don't have a perfect idea to figure out this issue, one suggestion that authors could do, is to identify the regions with higher confidence (smaller standard deviation among multiple datasets), which can be done by calculating the inter-observation datasets standard deviation (e.g. Figure 4). If the subregion discussed is located in the high-confidence area, then the conclusions can be more assertive and reliable. Otherwise we have to be more conservative for the discussion over the regions with lower-confidence (larger inter-satellite disparity).