

The paper “Large contribution of meteorological factors to inter-decadal changes in regional aerosol optical depth” presents and discusses the long-term global trends in AOD (1980–2016), based on MERRA-2, MODIS-Terra, MISR and Statistical Models on emission factors and meteorological parameters, driving the inter-decadal AOD changes. The study falls within the scope of ACP. The manuscript is well-written and structured, the presentation clear, the language fluent and the quality of the figures high. The authors have done a thorough job and the results support the conclusions. I recommend publication in ACP, however I recommend the following revisions before it can proceed to be published.

Comments:

- 1) The manuscript validates MERRA-2 against AERONET, MODIS-Terra and MISR. However the AERONET, MODIS-Terra and MISR datasets are used in the assimilation of MERRA-2, and therefore are not independent. From the used datasets only CARSNET is independent. Therefore, it is suggested to the authors to provide separately the comparison and discussion of MERRA-2 against CARSNET, and modify the manuscript in order to discuss the use of AERONET, MODIS-Terra and MISR only in terms of evaluation and not validation.
- 2) Page 2, lines 32: AERONET is not in-situ. Please rephrase.
- 3) Page 4, lines 130-134: The authors are argued to use MODIS-Aqua also in the analysis, despite the two years of less observations. MODIS-Terra has been documented to suffer from degradation issues, therefore the observed trends may be an artifact. In addition, please comment on the possible sensor effect on the presented results of the manuscript.
- 4) I think it would be beneficial for the manuscript to include a flowchart showing the methodology of the comparison followed by the authors. The entire process can be summarized there along with the methodology requirements followed e.g. the spatial - temporal constraints, screening requirements, wavelength, etc. The information exists in the manuscript but I feel like it is scattered among the sections. Furthermore, I suggest the authors to provide the collocation criteria (both spatial and temporal), the wavelength of AOD studied, since the datasets are very different. For instance how the analysis of MERRA-2 is gridded in 1x1 deg² resolution, why three-hourly MERRA-2 are compared to hourly AERONET and not three-hourly AERONET and how the dataset is gridded to ROIs? All these information should be gathered in a flow-chart.
- 5) Comparison methods: It would be interesting to show the Fractional Bias and the Fractional gross error. In addition, please include among the other equations the correlation coefficient equation.
- 6) Page 8, lines: 295-297: what about the cases of $0.05 < P < 0.1$?
- 7) Please include a table with as many rows as the number of ROIs to summarize and show simultaneously the following: MAE, RMSE, R, VIF, positive/negative trends (periods 1,2,3), and statistical significance (yes, no) at the 0.05 level.
- 8) The discussed methodology: How much the selected methodology affect the final trends (e.g. selected periods 1,2,3, boundaries of ROIs, collocated criteria...)?

9) The scientific methods and assumptions are valid, and the authors give proper credit to related work, especially in the introduction and methodology. In the "Results Section" though frequently results on AOD trends are presented, without any explanation/discussion on the observed trends and without the associated references on the discussion and the explanation on the results. The undervalue of the present work is not to simply provide the trends, but to comment on the physical and anthropogenic causes that the trends are associated with. Hereinafter, the authors will find indicative parts of the manuscript to improve by extending the associated parts with discussion and/or references, which I missing when reading the manuscript:

- Page 10, lines 353-355: "which indicates that MERRA-2 overestimates the AOD in these regions"? Where is the overestimation attributed to? (explanation and references)
- Page 12, lines 446-458: ""... global distribution of AOD also shows obvious seasonal differences, with global aerosol loading reaching its maximum in spring and summer." (explanation and references)
- Page 12, lines 449-458: References missing.
- Page 13, lines 465-469: References missing.
- Page 13, lines 487-492: Explanations and references missing.
- Page 14, lines 524-530: Explanations and references missing.
- Page 15, lines 546: "except for the positive trend that still existed in the marine area of the Southern Hemisphere, the fluctuations in other regions were smaller and relatively stable.": Explanations and references missing.
- Page 15, lines 549-552: Explanation missing.
- Page 15, lines 554-556: Explanations and references missing.
- Page 15, lines 557-558: Explanations and references missing.
- Page 15, lines 559-561: Explanations and references missing.
- Page 15, lines 561-564: Explanations and references missing.
- Page 16, lines 604-605: Explanations and references missing.
- Page 16, lines 607-619: The entire paragraph needs improvement. Results are presented, not explained. Explanations and references missing.
- Page 16, lines 629: Explanations and references missing.
- Page 16, lines 632: Explanations and references missing.
- Page 17, lines 634: References missing.
- Page 17, lines 634-635: References missing.
- Page 17, lines 635-637: References missing.
- Page 17, lines 638-640: References missing.
- Page 17, lines 640-643: References missing.
- Page 17, lines 645-646: Explanations and references missing.
- Page 17, lines 653-656: References missing.
- Page 17, lines 658-661: References missing.
- Page 17, lines 662-663: Explanations and references missing.
- Page 17, lines 667: Explanation missing.
- Page 17, lines 671: References missing.
- Page 17, lines 672-675: References missing.
- Page 18, lines 678-680: Explanations and references missing.
- Page 18, lines 683-684: References missing.
- Page 18, lines 687: References missing.
- Page 18, lines 709-710: Explanations and references missing.

- Page 18, lines 710-713: Explanations and references missing.
- Page 19, lines 750-755: References missing.