

## ***Interactive comment on “Monitoring and tracking the trans-Pacific transport of aerosols using multi-satellite aerosol optical depth retrievals” by A. R. Naeger et al.***

### **Anonymous Referee #2**

Received and published: 20 January 2016

The paper “Monitoring and tracking the trans-Pacific transport of aerosols using multi-satellite aerosol optical depth retrievals” by Naeger et al. describes a new merged AOD product, which integrates different existing and new Level 2 products from LEO and GEO satellite instruments. This merged AOD product is applied to monitor and track a trans-Pacific aerosol outbreak event from Asia to the US. The topic of the paper fits well with the aims and scopes of AMT. Nevertheless, I have found this paper far too technical. The scientific significance of the manuscript, in the present form, is not clear to me. The individual AOD products are merely put together on a common grid. The description of the methodology, both for the derivation of the new AOD observations from GEO instruments (GOES-15 and MTSAT-2) and how this is merged with the exist-

C4998

ing LEO observations (MODIS VIIRS), is extremely confusing. In addition, the added value brought by using this new merged product, with respect to the individual LEO and GEO products alone, is not really shown. The validation is very limited and not convincing.

For these reasons, I think that the manuscript, as it is at present, is of a limited interest for the AMT readership. Here in the following I give several suggestions to improve the manuscript and I am willing to re-review it when the major and specific comments are seriously tackled.

### **Major revisions:**

1) The general direction of the scientific community in this field is to synergistically combine observations and modeling. In this paper the modelling of aerosols (e.g., transport, processes, etc), as well as data assimilation is not even mentioned. It is crucial to discuss how this new merged observation product contributes to the larger context of the synergy observations/modeling.

2) This work is based on the development of a composite NRT product. The need of NRT products to track trans-Pacific transports of aerosols pollutants must be justified. In my opinion, this temporal criterion is not as crucial as it seems to emerge from this manuscript. Can one just study the transport process after the events occurred and then characterize US air quality in terms of internal production and external pollution income a posteriori? Please justify why NRT tracking of abroad pollution is important for air quality in the US.

3) US standard atmospheric profiles are used in this method (P10328), not accounting for parameters variability. Using standard climatological profiles is a crude approximation, because the real atmosphere can deviate significantly from standard conditions on, e.g., water vapour, temperature and ozone profiles. I think that this methodology should benefit using more specialized information, e.g., from reanalysis or complementary satellite observations. At least, the uncertainties introduced using this crude

C4999

approximation must be estimated and discussed.

4) Same thing for the aerosol models used in this work. Why selecting 6SV continental and desert aerosol models? It is possible to quantify the uncertainties if other aerosols types are observed while using these models?

5) “Multi-satellite AOD retrievals”, in the title, seems to indicate that a multi-instrument retrieval is made, i.e. a Level 2 product based on the inversion of Level 1 spectra from more than one instrument. This is not at all the case because the Authors merely “compose” different Level 2 products from different instruments. Please, reformulate the title to account for this (e.g., using the word “composite” and putting a less marked accent on “retrievals” - the basis of this method is to combine retrievals produced by other people + new “mono-instrument” products using GOES-15 and MTSAT-2). Please change the Abstract, Introduction and Conclusions accordingly.

6) The validation is very superficial and must be extended. The comparison with AERONET observations should be conducted on the individual and merged products, to show, if it is the case, that the merged product brings added value with respect to the individual products.

7) Even if I’m not a native English speaker, I have found that English need to be improved throughout the text. In addition, the article is very long and sometimes hard to read (e.g., section 3 is very long and need to be improved in terms of readability). I provide several suggestions to improve the text but this is not exhaustive and I’m not the good person to go more deep than that, as I’m not a native English speaker. Finally, several technical aspects of the method should be eliminated, as they are of limited interest for the AMT readership.

#### **Minor revisions and specific comments:**

1) P10320 L4: “Ocean in order” → “Ocean, in order”

2) P10320 L17-18: “where the new product can encounter significant uncertainties due

C5000

to the inclusion of the geostationary AOD retrievals”, do you mean that your GOES-15 and MTSAT-2 products have significant uncertainties there? Please reformulate.

3) “The uncertainties associated with geostationary AOD retrievals are expected to be minimized after the successful launch of the next-generation advanced NOAA GOES-R 20 and recently launched JMA Himawari satellites. Observations from these advanced satellites will ultimately provide an enhanced understanding of the spatial and temporal distribution of aerosols over the Pacific”, have you any evidence to affirm that (e.g., sensitivity analyses based on synthetic observations)? In addition, I’m not sure that this sentence is pertinent in the Abstract (that’s more a perspective to be put in the Conclusions).

4) P10321 L3-4: “biomass burning activities” → “biomass burning”, “release” → “releases”

5) P10321 L15-17: “western United States where they can be transported from the free troposphere towards the ground, which can increase the risk of lung cancer and cardiopulmonary mortalities (Pope et al., 2002)”, like this it seems that the transport causes mortality, while the (transported) aerosols do. Please reformulate (making a separate sentence, starting from “which can increase”)

6) P10321 L18: is “inadequate” adequate here? “Does not assure” is better maybe?

7) P10321 L21: “effects” → “radiative effects”

8) P10321 L24: “continually” is OK? “continuously”?

9) P10321 L24: “across the Earth” is nice but is “at the global scale” more pertinent here?

10) P10322 L9: “solve some of” → “reduce”

11) P10322 L18-19: “spatial distribution of aerosols”, at which spatial scale?

12) P10322 L19-20: “near-real time (NRT) CALIPSO measurements are unavailable”,

C5001

this may be true but can you please give a justification for this?

13) For the discussion about the exclusion of CALIOP-CALIPSO, please refer to my major revision 2

14) P10322 L27: please consider to use “merged AOD” instead of “AOD” here and in the whole text, as a reply to my major revision 5

15) P10323 L2: “MODIS”, please check if all acronyms are defined at their first occurrence.

16) Data section: maybe a list of products and instruments used (or a table) before beginning to discuss them individually would be useful

17) P10323 L7: “High quality”, how do you estimate that quality is high?

18) P10323 L11: “as of January 2015”, still unavailable?

19) P10323 L13: is the uncertainty or the uncertainty of the uncertainty multiplied by the AOD?

20) P10323 L14-15: “MODIS AOD...numerous spectral bands”, why? Please develop the discussion about why the presence of a lot of spectral bands improves the accuracy of AOD retrievals.

21) P10324 L17: “...but not into our 6 hourly composite product”, define before your products (60 hours, daily, ...)

22) P10324 L27-P10325 L1: “Because...coverage”, the sentence is clumsy. Please reformulate.

23) P10325 L2: “only have 5 spectral bands”, why not mentioning their spectral resolutions and nominal wavelengths?

24) P10325 L7-8: “Note that easily accessible archives containing AOD data are unavailable”, isn't it better “Note that easily accessible archives containing AOD data are

C5002

not available”?

25) P10325 L9-11: “The GOES AOD ... (2008)”, and what about the MTSAT-2 algorithm?

26) P10325 L20-22: “We utilize...exponent”, why not directly comparing to the optical properties at 500 nm, by keeping in mind that a (small, due to the only 50 nm spectral distance) difference exists due to the different wavelengths? And if you really want to derive the AOD at 550 nm, please characterise the uncertainty arising from this conversion (error propagation using the Ångström law).

27) P10326 L1: “earth” → “Earth”

28) P10326 L7-9: “The level 2 AODs retrieved in 17.6 km X 17.6 km spatial resolution at 0.56  $\mu\text{m}$  have been gridded to 0.5 X 0.5 resolution for the comparison purpose. A detailed description of the aerosol algorithm is given in Kahn et al. (Kahn et al., 2005)”, please invert the two sentences

29) P10326 L14: “energy”, I personally don't have problems in talking about energy and expressing it in wavelength units in this context, but it might be unclear for a more general atmospheric sciences readership. Please reformulate (you can say “pulses of light” or “of radiation” or something)

30) P10326 L15: “curtain-like”, maybe you can simply talk of “profiles”

31) P10326 L18: “height of aerosols”, you mean “the altitude where aerosols are located”?

32) Methodology section: this section is exceedingly long and very hard to follow. Isn't it possible to sub-divide it in different sub-sections? In the following a series of comments and suggestions to improve this section are given but I encourage the authors to carefully re-look, restructure and rewrite this section to improve readability. As it is now, I cannot judge if your paper is acceptable for publication or not because I cannot thoroughly understand your methodology. This is in connection with my major review 7.

C5003

- 33) P10326 L25: “tasks”, you mean “steps”, “phases”, “stages”? Same thing for other occurrences of “task”
- 34) P10327 L4: “large amount of effort to complete”, you mean it is the most critical step in terms of the computational cost?
- 35) Figure 1 is OK but isn't it possible to produce a similar figure about the overall methodology, i.e., from the individual products to the merged final product?
- 36) P10327 L7: why this date/time (18/03/2014, 05:01)?
- 37) P10327 L12: “demonstrates” → “shows”
- 38) P10327 L 16: “solar zenith angle”, isn't it the “cosine of the solar zenith angle”?
- 39) All this part linked to Eq. 1 is not clear at all to me. Maybe you can try to reformulate?
- 40) P10328 L10-13: please refer to my major revision 3
- 41) P10328 L16-18: please refer to my major revision 4
- 42) P10329 L5: as for comment 41, please refer to my major revision 4
- 43) P10330 L15-18: “However...Naeger et al., 2013b)” what do you mean with “dust has a unique spectral signature in the 10.8 and 12.0 microns bands”? To me, dust particles can have variable mineralogical composition and, as such, variable spectral signatures. Please explain.
- 44) P10331 L15-16: “sunglint regions cause high biased AOD retrievals”, and then are screened out?
- 45) P10331 L17-18: what do you mean with “special”?
- 46) P10331 L26-27: “due to the non existent...”, you mean that the test is not performed?

C5004

- 47) P10332 L7-13: “our automated scripts continually search for...”, this is more a technical detail, and is of limited interest for an AMT paper.
- 48) P10333 L3-on: with reference to my major comment 7 and specific comment 32, e.g. isn't this paragraph a good candidate for a specific and separate sub-section?
- 49) P10333 L3-on: you give reasons why these different Level 2 products are “compatible” (including supporting references) but an estimation of the uncertainties introduced by merging different products seems to me still necessary. For example, what is the impact of using instruments with different spatial resolution and observation geometry and timing? How does each compare with the others? As your paper introduces a new merged product, these questions are pertinent and need a clear and more precise answer than “we do not expect significant issues when averaging the MODIS and VIIRS AOD retrievals for generating our AOD composite product”: this is not convincing
- 50) P10334 L6-8: “The product is valid...18 March”, the word “valid” here looks a little bit strange. You would want to say that you impose that the central time in the time interval of the used products is chosen as the “nominal time” of the merged product?
- 51) P10335 L7: “the much finer”, finer than...?
- 52) The section 4.1 is sensibly more readable than section 3 but the discussion on the differences between the two LEO and GEO products and between them and the merged product might benefit from the identification, on Fig. 4, of the area discussed in the inherent text (e.g., “around 38°N, 165°E”, P10334 L14 and P10335 L4, etc)
- 53) P10335 L 9-11: “Furthermore...VIIRS”, the reader is asked to see these biases using the very small subfigures. It is very hard. Can you maybe provide a small further subfigure with the comparison of these estimations, or a more precise description of the areas you look at and a calculated, quantitative, bias value?
- 54) P10335 16-18: “Note that...product”, has this information been given before?
- 55) Figures 4 and 5: the small grey rectangles in Fig. 4c, which are referred to, as well,

C5005

in Fig. 5 are hardly visible. Isn't it possible to arrange Fig 4 differently to enlarge the individual panels?

56) Does the comparison with CALIOP-CALIPSO show that the merged AOD product is a significant improvement in describing this plume with respect to the individual LEO and GEO products? For me, it is not actually this evident...

57) P10337 L 15: "The height is provided as an important input into the NOAA HYSPLIT model...", you want to say that the start altitude of the trajectory simulations is a necessary input and it must be given to HYSPLIT when making these simulations? Please reformulate.

58) Figures 6 and 7 are referenced to in quite a strange way: between parentheses. Why not a traditional sentence like "Figure 6 shows..." or so? Please look through the whole manuscript if the figures are introduced before citing them.

59) Section 4.2: you never mention possible sink and evolution processes for the aerosols during transport. The fact that the trajectories initialised at one spatio-temporal location go towards one specific direction at the end of a HYSPLIT run of x days does not mean that you'll find the same aerosols there, after x days of trajectory run. A fraction of the aerosol population might have been removed by sink processes or transformed by evolution processes. More aerosols might reach the final location due to other sources. This absolutely needs to be discussed here.

60) P10338 L1: "Google Earth", please say somewhere that you show your trajectories on Google Earth visualisation, if you really need to use Google Earth (why not using a map like those of Fig 4 instead?)

61) P10338 L9-12: "However, the HYSPLIT model was too aggressive in predicting the transport of the aerosol plume as indicated in Fig. 6 where the aerosol plume is already over the landmass of North America by 22 March at 05:00 UTC.", I'm pretty sure that it was not really aggressive, you just don't consider possible sink and evolution

C5006

processes but just transport. This leads certainly to an overestimation of the aerosol plume at distal locations.

62) P10338 L22-24: isn't it useful to be shown?

63) Paragraph from P10339 L11 to the end of section 4: why do you calculate and discuss the statistics of the number of pixels here? The spatial coverage improvement of the merged product should be discussed before, maybe even in the Methodology section.

64) The "Uncertainties" section should appear before and is incomplete in the present version. The uncertainties introduced by the merging process itself, which is the most interesting to be discussed in such a manuscript, is not even mentioned. The discussion on the uncertainties introduced by the use of one fixed aerosol model is only superficially tackled. It should be discussed, e.g., how microphysics (aerosol size distribution), chemical (composition and then refractive index) and vertical distributions prescribed affect the AOD retrievals.

65) I suggest to separate the "Uncertainties" part from the "Validation" part (last paragraph) of section 5. Validation is OK at the end of the paper, while the uncertainties estimation should be discussed before, like mentioned in the specific comment 64.

66) P10341 L12: the correlation coefficient you refer to is R or R<sup>2</sup>? How the value 0.93 compares with correlations of AERONET data with individual LEO and GEO products?

67) The discussion on the outliers: can you justify why you think that these outliers are linked to the choice of the aerosol model? Using a different aerosol model the correlation improves?

68) P10341 L21-24: "Although the MODIS and VIIRS...can be made", this sentence is far too strong: it seems that you're arguing that MODIS and VIIRS never make usable measurements due to clouds and sun glint (globally? Over the Pacific Ocean?). This is in contradiction with what you show in Figs. 4-5b, for example. Please reformulate

C5007

this sentence.

69) P10342 L2-5: "Overall, when combining...Pacific Ocean", this improvement must be better justified and quantified in the text and in the conclusions.

70) P10342 L7-8: "were able to be recognized" is a clumsy expression. Please reformulate.

71) P10342 L14: "aerosol activity" → "aerosol distribution"

72) P10342 L28 – P10343 L2: it is a strange choice not to show the 6 hours merged product when we all agree that the use of the new GEO products, due to its fine temporal resolution, has a greater impact on this merged product than that shown in this paper.

73) P10343 L 2-8: finally you mention data assimilation. A discussion about this must be included in the introduction as well.

74) Please mention the spectral resolution of the next-generation GEOs as well.

75) Table 3: what is the meaning of the "time" subscript?

---

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 10319, 2015.