Review of "Extended validation and evaluation of the OLCI-SLSTR Synergy aerosol product (SY_2_AOD) on Sentinel-3" by Sogacheva et al.

Summary:

This paper presents the synergy AOD product from Sentinel-3 and its evaluation against a set of other global AOD products. This is obviously product of a thorough comparison, from the use of validations against AERONET, MAN (and SURFRAD and SKYNET in supplement), and MODIS datasets, and the breadth and level of detail of the manuscript shows it. This is a high-quality manuscript and should be published in AMT, and will likely be used as reference for many other validation of satellite aerosol products. While this manuscript is long, it is obviously needed, and the quality of the work is appreciated.

I recommend this paper to be published, but after addressing these issues:

- The linear fitting scheme is not well identified, or may not be appropriate for AOD fitting, and by the manuscript's own analysis (section 6.1.5), this matters for quantifying the overall fit. See the general comment #6. This would not be brought up as major concern except for the fact that it is highlighted in the manuscript already.
- There are numerous errors in formatting throughout the manuscript which detracts from the quality.
- The description of the retrieval methodology is unclear. How does the retrieval of AOD at multiple wavelength and single scattering albedo is achieved through fitting of AOD at only wavelength (550 nm)?

General Comments:

1. Several language issues are found within the abstract, and there is need for more quantitative indication in the abstract instead of the subjective descriptions (see specific comments below)
2. Throughout the document the date format does not seem to meet the AMT standard of "Date and time: 25 July 2007 (dd month yyyy), 15:17:02 (hh:mm:ss)", particularly evident in the paragraph at line 79-89. See the guidelines: https://www.atmospheric-measurement-techniques.net/submission.html#math
3. How much time is passed between measurements in the oblique and nadir view? And how does that impact the aerosol retrieval, particularly near clouds?
4. The retrieval dictates the retrieval of AOD and its fine mode at 550 nm, however returns many more parameters, including single scattering albedo, at various wavelengths. This is poorly described, and is both referred to as 'aerosol properties retrieved' and 'intended as diagnostics' (section 2.2.2). Please clarify what these properties are, and how they are retrieved, especially when only fitting to AOD and fine mode AOD at 550 nm.
5. Many references and citations are only links to websites, many of which should be replaced by the appropriate citation, and many are missing the date accessed.
6. The type of linear regression is not identified, and this matters for AOD comparisons. Reference to a 'linear regression' between the aAOD and syAOD is presented, however it seems to imply

the use of the Ordinary-Least-Squares (OLS) commonly-used fitting routine. This is unlikely to be suitable for this data as the 'independent' variable (aAOD) is subject to uncertainties, and AOD typically do not have gaussian error profiles, which are needed for the OLS. Other fitting routines are recommended to be used, like the 'Yorkfit' (York et al., 2004) or a bivariate regression (e.g., Shinozuka et al., 2015). Similarly, some considerations to the "R" parameter should be mentioned – is it the common Pearson linear correlation coefficient or the Spearman's rank correlation as suggested for use in Sayer et al., 2018. It seems uncertain what is used in Matlab's linear model, or how uncertainty is weighted.

7. There seems to be a significant reduction in error statistics when using the Single Oblique angle, than the single nadir view and even the dual views, however this is not mentioned much, and leads the reader to question the validity of the nadir viewing measurements as a result. (see table 1)
8. There seems to be lower discrepancy between syAOD and aAOD in regions of significant biomass burning aerosol (higher AOD Bor, NAW, AOb for example). This raises the question on what type of single scattering albedo is used, and how does the selection of this model impact the AOD retrievals.
9. Throughout the conclusions section there is a significant amount of qualitative wording such as 'agreement is good' This is subjective and not always supported by the comparisons presented in this manuscript. Either give comparison values to what it is expected to be, or refrain from these subjective statements.
10. There is no mention of potential impact of varying single scattering albedo on the AOD retrieval in the conclusion. Is this a solved issue?

Specific Comments:

11. Title: 'Extended' seems to be slightly overexaggerating for a year and half in terms of satellite data comparisons. Suggest to remove that word from the title.
12. Line 14: The word 'synergy/synergistic' is used twice in the first sentence.
13. Line 24: The use of double +/- is confusing, is this the error of the error based on AOD, or the potential range of the error?
14. Line 29: Use of "Angström" should be consistent throughout the manuscript, the "ö" is missing on this line.
15. Line 30: AE is not defined .
16. Line 28-35: use of subjective descriptions should be made more quantitative e.g., "good correlation", "agreement is better", "often slightly better". By how much, how often, and compared to what?
17. Abstract: the extent of the evaluation is not introduced. How many days, years, or number of comparison points are used here?
18. Line 108, and throughout the manuscript: there should be a space between the number and the unit '500m'
19. Line 102 and 105, please reference the proper citations for SENTINEL-3 OLCI and SLSTR instead of the websites.
20. Line 102 and subsequent, is it capital case SENTINEL-3, Sentinel-3, Sentinel 3? Please select one and use is consistently throughout the manuscript.

21. Line 113, is there a better reference than this website document for the aerosol retrieval? Seems like this is an important publication for better understanding the material presented in this manuscript. Particularly to support the statement “is of variable quality, with higher uncertainty in retreievals in the oblique backscattering direction.” (which has a typo at line 114).
22. Does the shift vectors (section 2.2.1) also have a rotational portion, or is it only translational shifts?
23. Lines 137 and 145 seem to be repeated “at least 50% of valid pixels”
24. Line 147, it is unclear what is meant by ‘direction’. Is it viewing direction or viewing angle?
25. Line 151, Does 442.5 spectral band refer to 442.5 nm ?
26. Line 186, What is “Copernicus C3S_Lot2” ?
27. Line 214, why the shift in multiplication symbol from “x” to “*”?
28. Figure 2 is too small.
29. Line 297, How big are the bins in Figure 2?
30. Line 311, GCOS is not defined.
31. Table 1 – decimal point is comma “,” instead of point “.”
32. Line 342, typo “bind”
33. Line 380, sentence is unclear, is syAOD550 different to S3B syAOD$_{550}$?
34. Line 446, equation 1 does not seem well formatted
35. Line 448, use of * instead of multiplication symbol (×)
36. Line 452, Latitude in [-30 -20] is not well defined, are these degrees south? Is the range inclusive?
37. Line 453-457 , formatting error? dAODrel or is it dAOD$_{rel}$ or dAOD,rel (in figure 8, 9)
38. Line 453, typo? What is “ca”
39. Figure 8, Units on x-axis not identified (Degrees?)
40. Line 547, What is Aerosol_cci+?
41. Line 595, these distribution don’t look very Gauss-like, they seem clearly skewed, particularly singleN.
42. Line 617, second apostrophe is not the right side.
43. Line 672-673, portion of this sentence is in red.
44. Figure 22, AOd region is missing a portion of the red dashed curve. (similarly in Figure S10 AsN, and S11 AOb)
45. Line 698, Isn’t AERONET reported at 440 -870 nm? What is a personal estimation? AE difference when using a difference in wavelength has been reported in multiple other papers, e.g., LeBlanc et al., 2020, Yoon et al., 2012
46. Figure 24, There seems to be a common clustering of high syAE, at or just above 2.0. Is this a default limit of AE from the retrieval? Or is this a real behavior of the aerosol?
47. Line 735, “good quality” is subjective, but an rms of greater than 0.5, and R often lower than 0.5, with biases often exceeding 1.0 does not seem to be of ‘good quality’.
48. Table 7, the decimal notation is a comma “,” not a dot “.”
49. Figure 28, labels of map regions is too small and of bad quality to read.
50. Line 785, second time AOI is defined.
51. Supplement 1, there is an “Error! Reference source not found.” At the 4th to last line of the first page.

52. Supplement section 1 and 2, there seems to be no mention of the singleO – oblique angle viewing in the comparison to SURFRAD and Skynet

References:

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Shinozuka, Y., Clarke, A. D., Nenes, A., Jefferson, A., Wood, R., McNaughton, C. S., Ström, J., Tunved, P., Redemann, J., Thornhill, K. L., Moore, R. H., Lathem, T. L., Lin, J. J., and Yoon, Y. J.: The relationship between cloud condensation nuclei (CCN) concentration and light extinction of dried particles: indications of underlying aerosol processes and implications for satellite-based CCN estimates, Atmos. Chem. Phys., 15, 7585–7604, https://doi.org/10.5194/acp-15-7585-2015, 2015.

Yoon, J., Von Hoyningen-Huene, W., Kokhanovsky, A. A., Vountas, M. and Burrows, J. P.: Trend analysis of aerosol optical thickness and ngström exponent derived from the global AERONET spectral observations, Atmos. Meas. Tech., 5(6), 1271–1299, doi:10.5194/amt-5-1271-2012, 2012.

York, D., Evensen, N. M., Martınez, M. L., & De Basabe Delgado, J. Unified equations for the slope, intercept, and standard errors of the best straight line. *American journal of physics*, *72*(3), 367-375., https://doi.org/10.1119/1.1632486, 2004.