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Annales Geophysicae Discussions

Interactive comment on "Comparative Analysis of MODIS, MISR and AERONET Climatology over the Middle East and North Africa" *by* Ashraf Farahat

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Response to Anonymous Referee # 1 Dear Referee, Thank you very much for your feedback about our article. We greatly appreciate the comments. We have addressed all your comments and we have revised the manuscript accordingly. For your consideration, we have included a copy of the revised article with track changes.

Please find below our response to your comments. Regards,

Ashraf Farahat

Comments from Referees The author presents an analysis of collocated MISR and MODIS satellite AOD retrieval data over seven AERONET sites for a 16-year period. These sites are located in or next to the desert regions of North Africa and the Middle

East, hence many (but not all) of these sites have aerosol conditions dominated by desert dust. It is a straightforward study, which seeks to analyse the behaviour of the various AOD products with respect to each other Author's response We agree with the reviewer's comment that not all sites covered by this study are dominated by desert dust. It has been reported by Farahat et al. 2016 (Farahat, A., El-Askary, H., Adetokunbo, P., and Fuad, A.-T.: Analysis of aerosol absorption properties and transport over North Africa and the Middle East using AERONET data, Ann. Geophys., 34, 1031-1044) that dominated aerosols over these sites are seasonal and location dependent. They also depend on local pollution and aerosols transport.

Comments from Referees The histograms in figures 6-12 are the most useful depiction here of the collocated datasets, displaying the distributions of AOD values over the various AERONET sites as retrieved by AERONET and the satellite products. It is interesting that the MISR AOD retrieval does not appear to capture the very low AODs observed by AERONET. However the trend analysis provides a rather weak discussion and conclusion, only hinting at significant values for the Solar Village site with AERONET and MISR, as far as I can see from the figure. Author's response It is important to mention that the goal of this study is to assess the consistency in aerosol trends between spaceborne sensors and AERONET data. The study tried to investigate which satellite data can better describe ground-based measurements over certain geographic locations in the Middle East and North Africa. Our analysis mainly focused on how data availability, topography, and water areas can affect satellite's measurements from one region to another. Aerosols categorization and sources are not the major focus of this study. Having this in mind, following the reviewer's comment we have revised the discussion as below: The following paragraphs have been added to section 4.2 p.11, lines 286-288 new paragraph added Trends of aerosol loading from 2000 to 2005 are analysed by plotting fitting lines of monthly mean AOD retrievals by MISR and MODIS/Terra and Aqua. The AOD retrieved by different instrument shows different trends. p.11, lines 290-293 new paragraph added Terra depicts a negative correlation coefficient with time while Aqua shows a positive one. Terra AOD decreases

0.0071/year, while Aqua increases 0.0015/year. Aqua have lower correlation coefficient for AOD compared to Terra, which indicates Aqua performed more stable during the study period. p.11, lines 298-300 new paragraph added In order to understand whether the discrepancy temporal trend of Terra and Aqua is a result of regional conditions or if it exists in all sites, we investigated Terra, Aqua, MISR, and AERONET over other sites. p.11, lines 302-303 paragraph has been modified Both MODIS/Aqua and MODIS/Terra AOD show a stable trend over time at Mezaria site (not shown in the figure) with a correlation coefficient of 0.11 and 0.04 respectively. Both Terra and Aqua AOD increase 0.008 and 0.001/year, respectively. p.12, lines 310-314, new paragraph added where Terra AOD decreases 0.0027/year, while Aqua increases 0.0066/year. Although Solar Village, Mezaria, and Bahrain are all located in or next to a desert region, the inconsistency between Terra and Aqua measurements is subject to the regional conditions. For example, the large water body surrounding Bahrain could mean that the great majority of the MODIS retrievals are from Dark Target algorithm. p.12, lines 316-327, new paragraph added Over Cairo, MODIS/Terra, MODIS Aqua, and MISR measurements agree on AOD increase by 0.001, 0.0007, and 0.0007/year respectively with correlation coefficients 0.10, 0.04, and 0.22 respectively. Despite the deviation between the three aforementioned sensors, they all agree on AOD temporal trend increase over Cairo. This could be attributed to the high pollution level at the mega city of Cairo due to high population, vehicle emission, and biomass burning. Taman site (Fig. 4c): MISR AOD agrees with Taman AERONET on a positive trend indicating the efficiency of MISR V22 algorithm over green areas with less black carbon particles. Aqua measurements show temporal AOD decrease of 0.0079/year with a correlation coefficient of 0.81 and Terra show AOD decrease of 0.0043/year with a correlation coefficient of 0.35. Meanwhile, MISR shows AOD increase of 0.0014/year with a correlation coefficient of 0.19.

Comments from Referees I noticed the short comment by Andrew Sayer (I usually try to avoid reading other reviews in discussion journals, but as a comment on data versions this seemed to be a particularly relevant point), and I agree that it is vital that the most up-to-date data versions are used for all three of the datasets. If the

current versions are not used then the analysis in this paper is of only minimal historical interest. Therefore please make sure that you are using the new Version 3 AERONET products, for example. I do not know how much difference to the results re-performing the analysis will cause, but presumably there will be differences in almost all of the figures and tables. Author's response We would like to confirm that we have used Level 2.0 Version 3 AERONET data available at https://aeronet.gsfc.nasa.gov. This has been highlighted in the paper at p.6, lines 48-49. For MODIS data, we have used Collection 6.1. Both dark target and deep blue algorithms have been used. Dark target retrievals were used over water regions while deep blue data were used over land. Data are available at https://giovanni.gsfc.nasa.gov/giovanni. For MISR data, we have choose to use V22 rather than V23, released on February 12, 2018, in our analysis because of few know issues know with this product that are still under formal validation. Some of these known issues are directly related to data reliability over bright surfaces compared to dark water, which is significant for our study. We have responded to Andrew Sayer through public discussion to explain that for the results reliability we should not use V23 MISR data for this study. Only after these known issues are resolved, it will be more feasible to relay on the new data product. Below please find our detailed response to Andrew Sayer Dear Andrew, Thank you very much for the short comment regarding the data version used in the article.

MISR Indeed, we are aware of version 23 (V23) MISR data released on February 12, 2018, however few known issues with the new product are still under formal validation. Some of these known issues are related to data reliability over bright surfaces compared to dark water, which is significant for our study. Moreover, we have found that changes in the new product has no significant impact on the results presented in our article as explained below in major and minor differences between V23 and V22 MISR product. To ensure data reliability based on known issues and insignificant impact of the new product on our results, we preferred to use the most recent V22 in our analysis.

Major differences between V23 and V22 MISR products 1- Initial assessments of the

results from the 4.4 km resolution V23 retrieval algorithm show that V22 AOD retrievals perform similar to V23 relative to AERONET. V23, however perform significantly better than V22 only relative to high spatial density AERONET Distributed Regional Aerosol Gridded Observation Network (DRAGON) deployments which is out of the scope of our study. 2- V22 has similar performance as V23 in reporting non-spherical aerosols in places where they are climatologically expected, particularly when the AOD is large. Both versions effectively discriminates small, medium, and large particles in exactly similar pattern. 3- Although V23 added AOD grid points below 0.025, which eliminates gap at low AODs, observed relative to AERONET, this update should not affect the results in our article, as we are not dealing with such low AOD values. 4- V23 changes in the snow-ice mask source by applying a more conservative cloud screening logic. This should have no effect on the results presented in our paper as we have performed our comparative analysis mostly over an arid/semi-arid region. 5- V23 change in near-surface wind speed source has no significant effect on our results as only the total wind speed is used in the dark water aerosol retrievals; this change does not affect the Aerosol Product. 6- V23 added a correction factor to take into consideration the effect of chlorophyll ("underlight") on MISR red and NIR bands over Dark Water. This reduces AODs retrieved over dark water; however, its significantly affect low AODs values only. Minor differences between V23 and V22 MISR products 1- Significant field name and content changes in V23 relative to V22, which makes the product significantly more accessible. This however has no effect on the results discussed in our article. 2- Switch from HDF4, stacked-block format to NetCDF-4 conventional format. This however has no effect on the results discussed in our article. 3- Provide per-retrieval geolocation and time information to make product easier to use. This also has no effect on the results presented. If you still believe that the new data product could significantly change the results taking into consideration possible AOD range at the study region, please let me know and we can definitely check the results against the new version. AERONET For the AERONET data, we have used Level 2.0 Version 3 available at https://aeronet.gsfc.nasa.gov. We will highlight this in the article. MODIS For MODIS

data, we have used Collection 6.1. Both dark target and deep blue algorithms have been used. Dark target retrievals were used over water regions while deep blue data were used over land. Data are available at https://giovanni.gsfc.nasa.gov/giovanni. We will highlight this in the article. p.4 Lines 110 – 114 have been added. Comments from Referees Please also clarify whether you are using the Dark Target (DT) and/or the Deep Blue (DB) AOD retrievals, since these use very different retrieval methods and it is a vital distinction to make. Presumably, the MODIS AODs over central desert sites such as Solar Village or Tamanrasset would be from the Deep Blue algorithm, while coastal sites such as Bahrain would have a greater prevalence of DT retrievals. It would perhaps make more sense to discriminate the MODIS AODs further, between retrievals using the DT and the DB algorithms. A possible question might be whether the DB or the DT algorithm performs better in the vicinity of Bahrain or other such sites on the desert margins? Author's response Both dark target and deep blue algorithms have been used. Dark target retrievals were used over water regions while deep blue data were used over land. Data are available at https://giovanni.gsfc.nasa.gov/giovanni. For regions like Bahrain where large water body surrounds land, a combined Dark Target and Deep Blue AOD product for land and Ocean has been used. The product is available through https://giovanni.gsfc.nasa.gov/giovanni. p.6, Lines 145- 149 was added.

Specific Comments Comments from Referees p.2, lines 36-37: why is this in italics? Author's response Italics format has been removed. Author's changes in manuscript p.2, lines 36-37: Italics format has been removed.

Comments from Referees Section 2.2: if MODIS Deep Blue retrievals are used (and they should be), please also describe them here Author's response The author would like to confirm that both dark target and deep blue algorithms have been used. Dark target retrievals were used over water regions while deep blue data were used over land. Data are available at https://giovanni.gsfc.nasa.gov/giovanni. The Deep Blue retrievals have been described on section 2.2 P5 L 127 - 132 The Deep Blue is a NASA developed algorithm to calculate AOD over land using MODIS data. Bu measuring

contrast between aerosols and surface features, Deep Blue retrieves AOD. Over bright land, Deep Blue uses (0.412, 0.470/0.490 μm) and dark land (0.470/0.490, 0.650 μm) for AOD retrievals. Over water, the Deep Blue algorithm is not used. The MODIS dark-target algorithm is designed aerosol retrieval from MODIS observations, over ocean (dark in visible and longer wavelengths) and dark land surfaces (low values of surface reflectance) (e.g., dark soil and vegetated regions) in parts of the visible (VIS, 0.47 and 0.65 μm) and shortwave infrared (SWIR, 2.1 μm) spectrum (Kaufman et al., 1997). Author's changes in manuscript New paragraph has been added to section 2.2 to describe Deep Blue algorithm P5 L 127 - 132

Comments from Referees Throughout the manuscript there are language issues which should be corrected Author's changes in manuscript Thank you for the comment. We have carefully reviewed the English through the manuscript and the following corrections have been made: Line 11: comma inserted after MISR Line 15: grammar correction: MODIS/terra AOD indicates instead of indicate Line 33: sentence revised to: "that has major effects on human activities in the Arabian" Lines 42-43: revised for clarity. Line 121: sentence rephrased for clarity Line 136-137: sentence rephrased for clarity Line 147-149: sentence rephrased for clarity Table 2 caption has been modified p.28 Lines 838-840

Comments from Referees p.14, line 330: do you know what these peaks indicate? On brief speculation I might imagine that the first peak is indicative of industrial aerosol and the second peak might be indicative of dust. Ångström coefficient values may give some evidence as to what these might be. Author's response P14, lines 332-335 have been added Ångström exponent (AE), dependency of the AOD on wavelength, can also be used to determine particles' size where the smaller the particle the larger the exponent. AE analysis show that the first peak at 0.25 is indicative of industrial particles with high AE values and the second peak at 0.35 indicates dust aerosol. High anthropogenic loading could be attributed to rapidly growing aluminum industry in Bahrain (Farahat 2016).

Comments from Referees p.15, lines 397-400: if the MODIS retrievals are preferentially coming from the Gulf, does that mean that the great majority of the retrievals over Bahrain are from DT?

Author's response The MODIS matched AERONET data are averaged from measurements that are within a radius of about 27.5 km from the AERONET station and within 30 min of the satellite flyover the station. For such a small country like Bahrain surrounded with a large water area, MODIS retrievals are preferentially coming from the water. Combined Dark Target and Deep Blue products are used for Bahrain the majority of the measurement are from DT.

Comments from Referees p.14, line 253: 'topology'. I think you mean 'topography'?

Author's response Thank you. 'topology' has been replaced with 'topography'

Author's changes in manuscript p.16, line 419

Please also note the supplement to this comment:
https://www.ann-geophys-discuss.net/angeo-2018-79/angeo-2018-79-AC2-supplement.pdf

Interactive comment on Ann. Geophys. Discuss., https://doi.org/10.5194/angeo-2018-79, 2018.