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Comment on acp-2022-490

Anonymous Referee #1

Referee comment on "Understanding day–night differences in dust aerosols over the dust belt of North Africa, the Middle East, and Asia" by Jacob Z. Tindan et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-490-RC2, 2022

The paper provides an analysis of many different data sets to try to extract differences in atmospheric dust content /altitude during day or night over the dust belt. To that extent, the idea is very interesting and a lot of work has certainly been done before compiling this manuscript. The manuscript is well-written and well-structured. However, the authors seem to lack in-depth understanding of the different types of measurement they analyse and compare, rendering some comparisons and conclusions a bit naïve. I think this is a common problem linked to data being more and more public to ease and promote their use. The users still have to bring effort in understanding what can or can't be done with the data, and the specificities of each data set, to avoid mis-interpretation. Of course, also data providers should make an effort in offering short and clear documentation but this is out of the scope of this review, just saying it's the usual providers-users information flow that does not work so well.

I have built my review with 4 sections. First, some general comments including on the data specificities that should not be ignored and some methodology points that do not fully convince me. Then some more specific major and minor comments and finally some purely technical corrections (typos, …)

Overall major comments

- "Dust activities" in the title and a bit everywhere in the manuscript: what does that mean precisely? My first thought was that it meant emissions / transport / deposition (the dust cycle – and I would then write in singular "dust activity"), but then mostly AOD/DOD and layer height are discussed, not the dust cycle. I think it would be more correct to replace dust activities by dust optical depth and layer height.
- Four IASI dust retrieval algorithms exist, all publicly available through the climate data store (cds.climate.copernicus.eu), directly as level 3 gridded products and containing

both the 10µm DOD and the converted 550nm DOD (very close to the 500nm value) following the best method defined by the data providers. Although I do not contest at all the use of the LMD product, maybe it should be made clearer why (only) this product was used in the analysis (and not just because it has good validation, at least 2 other products do also have good validation, check 10.1029/2018JD029701 and 10.5194/amt-12-3673-2019 for instance). In addition, it needs to be clear, from the beginning and all along, which IASI dust product is used (here it becomes clear only at section 2.2.1 but an annual IASI DOD map has been presented earlier in the manuscript). I strongly recommend using something like LMD IASI DOD instead of IASI DOD. Because different conclusions might arise if using different data sets (and that would actually be a very interesting comparison).

- The conversion between thermal infrared and visible DOD is very confusing and not consistent all along. Figure 1 shows IASI scaled to 500nm using an average ratio from all AERONET stations, while the validation uses a different ratio at each AERONET station, and even a (much) different ratio for solar and lunar observations. This means that the data used overall is not the same as the validated data, and that even at the same location, the conversion is done differently for day and night time data. Then from section 3.2 the AERONET data is now scaled to 10µm using the mean scaling factor (solar +lunar), so again not what was validated. Lines 350-351 do mention that "using individual ratios will slightly improve the consistency between AERONET CAOD and IASI DOD but may lead to some biases in the day-night differences". I agree to that, but then why for the validation a different ratio is used for each station, and even for solar and lunar at the same station ? Finally in Figure 7 no conversion at all is done and the plots show IASI DOD at 10µm and AERONET CAOD at 500nm, making it more difficult for the reader to compare values. My advice on this is to convert only once either to 500nm or to 10µm with, I guess, a constant value. Then use the data for the validation and all analyses. Even better would be to use the already converted IASI DOD at 550nm from the climate data store because then it is done according to what the data provider identified as the best way. This will most probably not change conclusions significantly, but will make the methodology more robust / logical / understandable.
- The local solar time of IASI observations as usually reported (about 9h30 and 21h30 equator crossing) is here considered as the actual truth for all IASI observations. I want to clarify that this crossing time is for the satellite / platform (or pure nadir observations). It does not mean that all observations occur at that precise local solar time, considering the large swath of IASI and also (less important here) that an orbit takes about 100 minutes. First of all, it is an approximate time at the equator. Second for example at 40°N the crossing times would be about 11 minutes earlier / later (100 minutes for 360° latitude). Finally and most importantly: the swath of 2200km (1100km of each side) means about 10° longitude if close to the equator (the orbit is polar, not exactly N to S but very close to it, so the swath is in the E-W direction) or 13° longitude at about 40°N latitude. For local solar time, this means respectively about 40 or 52 minutes local time difference between the extremities of the scan line and the pure nadir position, on each side. This might sound not so important, but it is when trying to compare IASI with local observations close to dust emission peak times. At the end, in an average of all IASI observations close to the Equator, one will have data from about 8:50 to about 10:10 (same pm) at the equator (and +/- 25 minutes at 40° latitude for example). This must be taken into account in all discussions, and also in selecting the data to be compared. (If needed, the real observation time of IASI is reported with the data, for each observation, in UTC time). It is already partly covered by taking an average from 9:00 to 10:00, but I think this average needs to be extended by at least a half hour earlier and later.
- Validation against AERONET: I am very sceptical in the way this validation is done, both because of the time averaging of AERONET around expected IASI observation time (instead of using real time co-locations based on IASI exact observing time) and because of the station-dependent conversion factor, even more because those are

different for day and night.

- A large effort is given in validating the IASI DOD and some information is provided for IASI dust layer height but no information is provided on the expected quality of other data sets used in this study.
- To study the impact of the winds / precipitation on DOD, one should not just look at those values at the moment of the IASI overpass (not forgetting it is not precisely 9:30) but also some time before. Indeed, for example if there was a strong wind/emission a few hours before the IASI overpass, the emitted dust would most probably remain in the air, at least partly. In addition, a larger mean wind speed is not enough to explain more emissions, and mean wind speed is not the right value to look at: a relatively low mean value could hide some very strong winds on specific days, while most days only present weaker winds. For precipitation: it will reduce the DOD for some time afterwards (due to wet scavenging, therefore removing dust from the air mass), and inhibit dust emission also for some time afterwards – depending on the amount of rain and how quickly the surface dries. It makes no sense to look at precipitation precisely at the IASI overpass times. Lines 608-610 mention an attempted analysis looking at precipitation two hours prior to IASI observations. This is a start, but again why specifically 2 hours prior to IASI observations? What is needed is to look during a few hours before IASI observations (if any precipitation took place during a time frame). These 2 sections need to be completely reworked.
- Please be advised (and mention in the text, and discuss especially in sections 3.3 and 3.4) a number of important information regarding the different data sets used. For both IASI and AERONET only cloud-free observations are possible, while (to be confirmed as I am not 100% certain) PM10 measurements occur under all meteo conditions. PM10 relates to the surface concentration, why DOD and CAOD are integrated along the whole column, making the comparison very difficult. Finally, IASI DOD contains only dust coarse mode, while AERONET coarse mode also contains other coarse particles (as sea salt – this is clearly stated in the manuscript), and PM10 contains all sorts of aerosols with size below 10µm – including for dust both fine and coarse particles (and other aerosol types).
- It is important to discuss the fact that PM10 / DOD is highly variable in time, including between different years (linked to the also variable meteo conditions). Therefore comparing the seasonal / diurnal cycles of dust using different years of data requires being very careful about the conclusions. The paper lacks that and the information of the time span (and data holes) for all ground-based AERONET and LISA stations.

Specific major comments:

- Lines 51-52: the radiative effects of dust also include the thermal infrared dust emissions, often forgotten by people working at short wavelengths, but that are also very important in the total radiative balance! Especially here the authors work with thermal IR observations so they should be aware and mention fully (i.e. not only absorption and scattering) the dust radiative effect at those wavelengths.
- Figure 1: stations names are very difficult to read; maybe a separate map with the stations would be clearer? In addition, the difference between teal and royal blue is not that obvious.
- Figure 2: I see, for some sites (e.g. Dak, Mez, Sol, Kar, …) more than others, a clear overestimation of IASI DOD (or underestimation of AERONET CAOD) for large DOD values. This should be discussed.
- Line 302 -> Could you be more specific than "close to" and "far from"? Is "far from" still in the area where a significant amount of dust is transported or do you mean so far

that those areas usually don't see much dust? In the latter case, I would understand why the correlation would be worse. In the first case, I do not understand why the correlation would be lower: at sites where mostly transported dust is observed, the situation is much less variable than closer to sources, and therefore the comparisons should be better, I think.

- Figure 3: I see here (opposite to Fig 2) some underestimation of low AOD by IASI (or overestimation by AERONET lunar), again for example in Dak, Mez, Sha, Kan. This should be
- Figures S1 and S2: one should not compare seasonal cycles over different years. Those cycles may be different from year to year, linked to local meteorological variability. I am aware that this makes the process more difficult, as some stations do not provide data for parts of some years, or do not span the same time frame, while IASI observations occur (almost) every day. But at least it should be mentioned that (or tested if) some differences might be due to sampling different years / months with the data that are compared. A possibility is, for these comparisons, to remove the IASI data when there is no data for the corresponding ground-based station.
- Lines 351-372: why differences are discussed while they are not significant? This means just discussing noise. Only the significant difference should be mentioned, i.e. only the LISA Cin data. For the comparison of the seasonal cycles between IASI and the stations, the next section 3.3 is much more precise and readable than the stars and dots in Figure 4.
- Lines 394-395: in addition to what the authors mention, I think that the very narrow swath of CALIOP also plays a role in the differences with IASI. With a repeat time of 16 days, a place is observed only twice per month (missing many events) and not the same day for afternoon and night observations (in addition occurring with a clearly different quality), all of it making the differences between CALIOP early afternoon and night very dubious, to my opinion.
- Line 398: only the old papers are mentioned here, the more recent dust layer height validation paper of Kylling should also be mentioned here, with its conclusions. (I see that it is mentioned lines 407-408 but only for its methodology, not the resulting bias of IASI versus CALIOP)
- Figure 6: please use the same vertical scale for the different stations to allow comparisons. Also I am confused now looking at those plots with errors bars: for example Ban DJF -> all day are significantly higher than night in Fig 6 but the difference is not significant in Fig 5. Again I think the station differences should be removed from Fig 5 where in any case they are very difficult to see and reported non-significant.
- Lines 420-422: the differences at MBour between IASI and PM10 can't be just because sea salt is included in the PM10. That explanation holds for a larger PM10 during the winter at that station but not for a lower PM10 at that station during spring and summer. Another explanation for the difference between IASI and PM10 would be that MBour is further from the sources, hence the dust is higher in the atmosphere and not recorded in surface PM10 while recorded in IASI column DOD. Or possibly that there is more wind, actively dispersing the dust therefore making the average PM10 smaller. Maybe those hypotheses could be checked.
- Figure 7: again please use the same vertical scale for all sub-figures to allow comparisons. In addition, it would be much more clear if IASI or AERONET was converted (using a once-decided standard way all along the paper) and then both plotted in the same plot for much easier comparison. Again the temporal range for the different stations, which does not match the full range, makes the comparisons more difficult. See also major comment 6.
- Figure 8: same comment about the vertical scale; in addition I think the text lacks some discussion about the differences e.eg. between MBour and Dakar which are very close and yet very different. Again, I think the key is in the fact that the observations are totally different and should actually not be compared without explanations. The sentence lines 472-473 should contain some discussions and not just a note of the

differences or similarities depending on the site.

- Line 522: please clarify (again) what is meant here by daytime and nighttime wind speed; it looks as if it is an average along the whole day (or night);
- Figure 11: I can't see the wind vectors properly (figures are too small)
- Line 574-576: I do not understand. Why here highlight the lack of match between maximum PM10 and minimum wind speed? We should not expect such a match, or should we? And what other factors would you suggest contribute to evening increase in PM10 than wind speed? Please elaborate.
- Paragraph lines 577 to 585 is largely unclear to me. The morning peaks and afternoon minima of wind speed do not occur at all stations. The comparisons are much confusing. In addition, again I would not expect a full match between surface wind speed and total column AOD / DOD (both because winds do not always lead to emissions, and because surface is different from column observation).
- Lines 631-633: please recall that AERONET does not provide observations under cloudy sky, so also not when there is precipitation. Therefore, the AERONET observations peaking at the times of the precipitation peaks simply most probably do not occur on the same days. This is, I guess, easy to check in the data.
- Lines 636-637: how can low winds enhance dust emissions? Or maybe low altitude winds is meant?
- Lines 640-642: "of solar radiation reaching the surface" -> technically, if the radiation has reached the surface it was not absorbed, so I would remove "reaching the surface"; in addition, the thermal emission effects is again lacking from the dust-radiation interactions. I think the impact on the PBL height is not so straightforward: it will depend on the local conditions, because the absorption and scattering of solar light tends to reduce the heat, while emission of thermal light tends to increase the heat.
- Line 715: events occurring before the passage of IASI would not be missed if they are large enough, as the dust will remain in suspension for at least a few hours, possibly up to days. Events occurring after the IASI observation then also occur before the next IASI observation and can be observed if they last long enough. They would however be "displaced" depending on the winds and the time between the event and the observation. I would rephrase and nuance that part of the discussion.
- Line 726: please elaborate. Do you mean a negligible impact of soil moisture difference between the different overpass times? This requires more than just a sentence. Indeed, if the soil moisture remains the same for morning and evening, then its impact on dust emission differences between morning and evening would be negligible. However, I would be very surprised if indeed the soil moisture does not show a diurnal cycle, depending on precipitation, surface type, temperature, solar heating, ….. Maybe it is just that ERA-5 is not able to reproduce these cycles?
- The discussion focuses mostly on IASI shortcomings, and should also contain the whole "problem" of comparing different data from different instruments observing different quantities at different times under different meteo conditions, and the reasons of uncertainties in the other data sets compared in this work
- Conclusions need to be modified according to other changes in the manuscript

Minor comments

- Abstract, lines 28-30 : this is confusing… only the morning hour time frames are provided, then for "late afternoon" no time frame is given; and the sentence is a bit long, making it difficult to read.
- The abstract is a bit too long, I think
- Line 40: "It is produced mainly by wind erosion …" -> why "mainly"? Is there another

mechanism?

- Line 50: "the effect of which" makes it unclear to me if it refers to only the latter (dust - cloud interaction) or both (dust – radiation and dust-cloud interactions)
- Line 51: could you add some more recent references about dust-induced uncertainties in modelling aerosol impacts on climate change ?
- Line 53: 4 of the citations (over 7) about the effects of dust on Monsoon are of the team writing the current publication, does it represent the full literature "statistics" (at first glance it feels like a way to increase the team's papers reference numbers; I would think only one reference is enough especially since the titles are relatively similar)
- Line 132, line 140; line 141: maybe add some more recent references for the most important dust sources in each part of the dust belt?
- Line 152: the section title needs to make clear which IASI data is used
- Lines 106 and 154: I suggest using the original IASI papers when describing the instrument, not the papers of one specific user of the data, which also cites the original papers when describing the instrument
- Line 155: the spectral resolution of 0.5cm-1 is after apodization, not the original resolution of the instrument (but indeed that of the data most commonly used) -> just add "after apodization" in the sentence
- Line 156: why only "onboard Metop-A"? I understand that here only data from Metop-A is used, but the general description is the same for all IASI instruments onboard the 3 Metop satellites
- Line 156: "at an angle of 48.5°" -> this is the maximum value, not a constant value.
- Line 157: the IASI swath is about 2200km and one IASI instrument leads to almost global coverage in 12 hours (not really global, some bands are missing between orbits at low latitudes)
- Line 158: "the satellite has a local equatorial crossing time" -> local solar equatorial crossing time
- Line 158: the availability mentioned here is indeed for IASI / Metop-A but it should be made clear that the other instruments have different time frames and the temporal series of consistent data is continued
- Line 160: missing some refs about the use of IASI for atmospheric composition
- Line 163: Météorologie (check the accents)
- Line 164: "with in situ observations" – please do not mix AERONET (ground-based remote sensing) with "in situ" (real local observations, such as PM10 if really obtained from local aerosols as the LISA measurements)
- Line 175: "CALIOP is a near-nadir": no, CALIOP is purely nadir
- Lines 176-177: I don't see how the 16 days repeat cycle "makes" the field of view what it is… Please rephrase
- Line 189: why provide the field of view only for the lunar observations?
- Line 191: formulation is weird, what means >+- ? Uncertainty is, by nature, a box around the value, so I would omit the +-. As for the > signs: do you mean that 0.01 is the maximum uncertainty for wavelengths larger than 0.44µm, while 0.021 is the minimum uncertainty for shorter wavelengths? This is very unclear, I do not know how to interpret minimum or maximum uncertainties in that context. Please rephrase.
- Line 292 and following: please explain why you used SDA (I agree with the choice, but the explanation is missing)
- Line 198: How do you remove missing values?
- Line 201: Six sites are supposedly blue dots in Fig. 1 – I only see 5 of them
- Line 226: Shifted to local time -> local solar time
- Title 2.3 -> should start with "validation of"
- Figure 4 caption vs text line 320: please also mention in the text that a mean scaling factor is used

Technical corrections

Abstract, line 7 : probably missing the word “data” after the end of the parenthesis

Abstract, line 9 : both … show (without the s)

Abstract, line 18, I think it misses “night time” before “dust emissions”

Lines 39-40: “it is produced […] their uplift” -> choose singular (“the dust” or plural “dust aerosols”; I would go for plural)

Line 41: “uplift […] occur” -> occurs

Line 254 “at” should be without capital letter

Line 264: AERONET is mis-spelled

Line 319: add for IASI that it is at 10µm (to avoid any possible confusion)

Line 349 “a uniform scaling factor […] is used” (instead of “are used”)

Line 358 AERONET is mis-spelled

Line 393: “in general” or “generally”

Line 444: “five to 15” -> “5 to 15”

Line 459: Maybe “at” is missing at the beginning of the sentence?

Line 474: two time steps (no -)

Line 521 Figure 11 showS

Line 566: weird formulation: what are dust activates?

Line 660: remove “the” before day-night

Line 719: I guess “orbital gaps”