Review of paper:

Evaluation of IASI derived dust aerosols characteristics over the tropical belt

by Capelle et al.

Positives

- needed comparisons to demonstrate the capabilities of a new promising aerosol retrieval
- use of the right evaluation data (although for CALIPSO the nonsph. extinction should be used)
- sensitivity test to examine retrieval limitations (although size was not among them)
- nice overall structure of the paper

Concerns

- use of monthy coarse gridded matches is limiting (daily matches are way better)
- NO evaluation of the AOD bias – due to adjustment to AERONET AOD
- correlations are only meaningful, in case of sufficient variability
- correlations should distinguish between spatial and temporal applications
- correlating all data over a year confirms foremost seasonality (and not variability)
- the arguments for the elimination of outliers is not convincing
- retrieval of coarse effective radius is encouraged (could be validated against AERONET inv.data)

@@ Authors to Reviewer :
- please see answers to the Editor.
- the time period covered in the paper has been extended to June 2013.
- minor : IASI sounds from the thermal to the near infrared, not in the "far-IR".

General comments

The paper evaluates retrievals of (coarse size) dust aerosol over lower latitudes via the high spectral resolution far-IR IASI sensor data. This new IASI retrieval method complements common solar reflection aerosol retrievals. Although, this method is only sensitive to larger aerosol sizes, the retrieval offers, aside from data on coarse mode aerosol amount, also (at least over oceans) data on coarse mode aerosol altitude. In this presentation, these retrieved IASI aerosol products are compared to trusted coarse mode AOD reference data of AERONET sun-photometry and to altitude information of the active space-borne lidar sensor of CALIPSO.

The evaluation concept is great, only the offered content disappoints. There is no evaluation of the AOD bias. As I understand it, the evaluated IASI AOD is corrected by multiplying multi-annual ratios of IASI (far-IR) AOD to AERONET(vis) AOD. What is the IASI AOD, if there is no AERONET station to scale to?

Then there are these very coarse scales (monthly and 1.5*1.5deg), which brings up contaminating issue with regional representivity or averaging. I had hoped for daily data, which via more numerous samples would be also more meaningful.

Then there is the use of correlations to demonstrate skill without really looking into the meaning of such correlations.
When a satellite product is evaluated, then answers are expected for data coverage and data accuracy, where the accuracy should address bias, spatial and temporal variability. Unless these elements (preferably at smaller scales) are addresses I consider this an incomplete effort.
@ - Several aspects of the retrieval algorithm: robustness to aerosol model (size distribution, shape, and refractive indices), possible contamination by other aerosol species, radiative transfer model bias removal, or cloud mask including discrimination between clouds and aerosols, etc., were investigated and details may be found in Pierangelo et al., 2004.

- Spatial and temporal variability of the IASI-derived products is illustrated on the site-by-site time series shown in the Supplementary Material. More details are now given on the biases (see below and answers to Reviewer 2).

Minor comments

tables and figures (I started here, because they need to be self-explanatory)
Table 1
The table lists 38 used AERONET sites. I wonder if this table is necessary, as location information and quality information (level 1.5 or level 2.0) could be directly incorporated into the other Tables 2/3/4
@ doing so would also complicate Tables 2 to 4 and degrade the readability of their main content. We would prefer keeping them as they are.

Table 2/3/4
These tables summarize correlation scores of coarse AOD over ocean and land (vs. AERONET) and of 'central' (?) AOD altitude over oceans (vs CALIPSO). If I evaluate I certainly would be interested in correlations. But I also would be interested in bias. Why are average biases not listed? Also correlations have a temporal (time-series) and spatial aspect (distribution). The listed station correlations are apparent temporal correlations (which should be mentioned). In order to summarize, these temporal correlations could be averaged over all stations. Aside from temporal correlations, there are also spatial correlations, which investigate the skill to reproduce spatial patterns. Once you merge all data you mix spatial and temporal aspects, so that the 'all site merged' correlation is not directly comparable to the individual temporal correlations (and it is on average much higher than individual correlations). In addition, the 'all merged correlation' are biased towards the performance at stations with more data-points. Finally a word of caution regarding correlations: Correlations are only meaningful, if there is variability. Thus, some info on the local variability could be nice.
@ The bias issue is now extensively addressed. Temporal correlations, together with the normalized standard deviation of IASI (representative of the amplitude of the seasonal cycle at each site), are given and discussed throughout the paper. The latter has been added to the results presented in Tables 2-4. Moreover, the time series, given as Supplementary Material, inform on the space (sites) and time (period covered) variability of the IASI results compared to that of the

AERONET measurements. As suggested by the Reviewer, and if the Editor recommends it, we will move this material to the main paper.

Figure 1

This is far from perfect, since the 3-letter labels are really difficult to distinguish (even though a separate inset id offered for the Arabian peninsula (maybe the location crossed can be increased to much bigger black dots and possibly the station labels can be removed). It also would be nice to show by different (larger) symbols or colors, which data are used for ocean, for land and for altitude evaluations.

@ We tried several other configurations with advantages and drawbacks and finally came to this presentation. Some sites are used both over land and over sea… Not "perfect" perhaps…

Figure 2

These are fairly wide size-distributions (but all least all are smaller than the assumed size in the look-up table). I also prefer to use (number) mode radius and std deviation, which are common input variables in MIE simulations … rather than effective radius and variance. I also wonder why there is only the link to 10um data. IASI has a lot of spectral information, so dust size could be of the retrieval

@ The values displayed Figure 2 (now Fig A.3) for the effective radius and the standard deviation of the distribution are taken from the AERONET database for the 38 sites analysed over the IASI period (2007-2013). These values, displayed Fig. A.1, vary from about 0.5 to about 0.8 for the coarse mode. Moreover, it is shown in the Appendix that the impact of the distribution size on the normalized extinction efficiency, and finally on the brightness temperature, is negligible (in agreement with Sokolik et al, JGR, 1998 and Pierangelo, 2005, PhD thesis: see above reference). This is why we kept the OPAC value of 0.8.

Regarding the variables we use, the suggestion of the reviewer, more familiar with different, but equivalent variables, won't change the figure.

Finally, regarding the link to 10µm data, we agree with the reviewer that IASI has a lot of spectral information; this is why, in order to use the whole potential of this instrument, we use in the retrieval channels distributed along the whole infrared spectrum (indicated by vertical black lines on Figs. A2 and A4). The final AOD, expressed at 10µm, corresponds to the different AOD of each channel, expressed at 10µm using the extinction coefficient. Concerning the use of IASI to determine dust size, Fig. A4 of the Appendix shows that, between 9 and 10µm, brightness temperatures are only slightly sensitive to the size of the aerosol (the sensitivity is of second order compared to the sensitivity to AOD; therefore size has only a very small impact on the AOD retrieval, for which all the channels, except a few, are not sensitive at all to the radius (see Peyridieu et al., 2013 for more details on the effective radius retrieval.

Figure 3/5/7

It would be nice, if some basic information on the Taylor diagram could appear in the captions (and not only the text). Say for instance that standard deviation ratios are the radial component and temporal correlation is show on the circular component.

I am puzzled why in Table 3 CapeVerde and Dakar, stations affected by significant dust, are doing so poorly?… but it probably has to do with the scales (when starting with the figures, I expected daily matches rather than monthly average matches). I also wonder about lower variability of IASI over land in Figure 5 … are scales again an explanation?

@ - Figure legends completed.

- Capo_Verde(11), which appears in Table 2, with a correlation of 0.86 and a normalized standard deviation of 0.85 behaves quite well. The problem of Dakar, appearing both in Table 2 and Table 3, is detailed in section 4.1.2. There is, in particular, a problem with the phase of the seasonal cycle.
- In Fig. 5 (now, Fig. 4), the main problem, as said in the text, is undoubtedly that of the refractive index.

Figure 4/6/8
Aah, finally! Bias and difference statistics. Please include details on the boxes and whiskers in the captions.
… after reading later the document more carefully: This is NO\T the bias. The bias is not even investigated! But, it should.
@ Bias issue : please see answers to the Editor

Figure 9
Spectral dust absorption features in the far-IR *[thermal IR]* are important to be considered in the IASI retrievals (and it might be nice to indicate agreement or even include data suggested by Sukolik)
@ - refractive index impact is detailed in the Appendix. Four refractive index models are considered. We intend to use other refractive index models in the future.
- Reference has been made to Sokolik's paper.

Figure 10
This is quite a mess and not really convincing that red (assumptions) are better than blue (assumptions)… other than that there is variability. Do not use lines from station to station (as I automatically thought of a time-series) but rather use lines between red and blue symbols or just only symbols.
@ - This is clearly not a time series as the site codes appear on the x-axis. The suggestion with the lines would not really change the appearance of this figure.
- Figure caption has been clarified and now reads :
"Differences, site by site and total, found between the "MITR" and "Revisited" evaluations (see text) for the AOD (IASI versus AERONET) and for the sites over land (see Table 3). Differences in correlation are shown in red; differences in amplitude (normalized standard deviation) are shown in blue. Positive (resp. negative) values mean better correlation and amplitude closer to 1 (amplitude of the AERONET reference) for "MITR" (resp. "Revisited"). "

Now to the text:

Abstract
you "mention normalized standard deviation" ? Better explain what is means so the associated value of 0.96 is better understood (are you saying that the standard deviation is on the order of the mean). If so, it seems unfair since a large portion of it may be related to seasonality and not to local variability. … later in the text I found out that your normalized std.deviation is, just the ratio between the standard deviation of the test data (IASI) and that of the reference data (AERONET) and then a value close to 1.0 is desired.

@ modified; now reads : "…normalized standard deviation (i.e., ratio of the standard deviation of the test data (IASI) to that of the reference data (AERONET)) is of 0.93, close to the desired value of 1."

I also miss in the abstract on what scales the IASI data are evaluated. That has to be in the abstract.
@ "the overall correlation" replaced by "the overall temporal correlation"

The sentence starting with "To the reasons listed above … " does not make sense to me
@ paragraph concerned changed to:
"Altitude results over land, essentially over deserts, are not satisfactory for a majority of sites. The smaller sensitivity of IASI to altitude compared to its sensitivity to AOD, added to the difficulties met for the determination of the AOD over land (surface heterogeneities), explain this result. Work is in progress to solve this difficulty."

When mentioning the importance to climate, there should be also mentioned that IASI data could be very important to constrain IN concentrations in modeling as information on dust (the main ice nuclei) and altitude (distribution) is given. Certainly, if in addition also dust size could be addressed (e.g. 2um reff of 4um reff?) that would be an even better constraint.
@ The relationship with ice nuclei is not straightforward because of the mean altitude of the dust coarse mode, rarely exceeding 5 km. It is more the accumulation mode which is concerned. Dust size is also an IASI product (Pierangelo et al., 2005, Peyridieu et al., 2013, section 3.5), out of the scope of the present paper

Introduction
What is meant with "particles in the coarse mode are less efficient in their interaction with visible wavelength … " this is very unfortunately phrased, as coarse mode aerosol has the same or even larger AOD in the visible (compared to the far infrared). If a comparison to fine-mode aerosol was meant, then it still depends on the AOD involved for fine-mode and coarse mode … please rephrase.
@ Rephrased. Now reads :
"Visible wavelengths are sensitive to both fine and coarse mode particles when infrared wavelengths are essentially sensitive to the coarse mode. Associating these two spectral domains should help improving our knowledge of the impact of aerosols on climate, its variability and evolution."

IASI
The second step of the method determines the 10um AOD and the AOD central altitude. Does this mean only the far-IR *[thermal-IR]* spectral data (and dust refractive indices) are only used at 10um?
@ Obviously not. They are used at all the wavelengths entering the retrieval process (see Peyridieu et al. 2010-2013 for details). See also Figs. A1-A4 of the Appendix, marking the IASI channels used here.

Give some more detail how the coarse mode effective radius is determined … as apparently only one (wide) dust distribution is given.

@ This has been done in Pierangelo et al., 2005 and in Peyridieu et al., 2013, section 3.5. This was out of the scope of this paper. As already said, the sensitivity to the size is of second order compared to the sensitivity to AOD (see Fig A.4 of Appendix) and so the effective radius used doesn't significantly affect the retrieval (see also Peyridieu et al., 2013).

I am disappointed that only monthly averages are used (I had hoped for daily data matches). This makes the comparison rather general. But when already using monthly average, have you given a thought on comparing the 'retrieved' coarse mode aerosol effective radii to those of the AERONET inversion?
@ Many papers, including recent ones, still deal with monthly means and their results prove being helpful for climate variability and evolution studies. Moreover, comparisons with CALIOP are not possible at daily scale. However, work is in progress to analyze IASI results (AOD) at daily scale. One sentence has been added at the end of the paper.

AERONET
The temporal mismatch (daytime AERONET and 9.30pm IASI) is a handicap. Also how are the monthly SDA data determined (I only can hope that coarse mode AOD of individual samples is averaged).
@ This is less a handicap for monthly means than for daily means. Aeronet SDA data are desarchived from the Aeronet site, heading : " Spectral Deconvolution Algorithm (SDA) Retrievals -- Fine Mode AOD, Coarse Mode AOD, and Fine Mode Fraction ". Use is made of the "daily average"; no significant differences seen with the "weighted average".

CALIOP
It would have been much better to use from CALIOP data the non-spherical extinction data as they relate directly to dust.
@ Indeed, the use of the standard CALIOP (provided by the NASA/CNES teams) dataset is another option. However, we did not consider this option for the reasons mentioned in Tsamalis et al. (2013). The most important of them is the uncertainty about the lidar ratio. CALIOP, as an elastic lidar, cannot retrieve the extinction coefficient profile without an assumption about the lidar ratio. The value used in the CALIPSO algorithm is 40 sr. For dust aerosols, the lidar ratio can vary between 30 and 70 sr according to statistical studies, with case studies reporting values between 20 and 100 sr, while even within the Sahara and Middle East, where the majority of aerosols are dust, the lidar ratio varies significantly. Note also, that CALIPSO AOD does not account for the multiple scattering, which is non-negligible in the case of dust aerosols. More details can be found in Tsamalis et al. (2013). Recent studies further confirm our choice, by finding significant AOD differences between CALIOP and other instruments. For example, Ma et al. (2013) used the Level 3 CALIOP monthly mean gridded AOD products (daytime and nighttime) for cloud-free conditions (which is the product suggested by the Reviewer) to compare with MODIS monthly AOD: they report that CALIPSO AOD is significantly lower than MODIS AOD over dust regions (Sahara and northwest China). Similar underestimation has been found by Tsamalis and Chédin (2013) when comparing the CALIOP Level 2 layer product AOD (both for daytime and nighttime) with MODIS Deep Blue and MISR AOD over Sahara and Arabian Peninsula. In order to reduce the bias of CALIOP AOD in case of dust over northern Africa and Europe, Amiridis et al. (2013) proposed the application of a lidar ratio of 58 sr (instead of the present value of 40 sr) to individual Level 2 dust related backscatter products. Over the ocean, AOD comparison of CALIOP with MODIS for the case of dust aerosols (as characterised by

CALIOP) shows a relative underestimation of 13% for CALIOP (Kim et al., 2013). Regarding the extinction coefficient at 532 nm, Tesche et al. (2013) report an underestimation of up to 30% for observations over the Capo Verde region (mostly dust aerosols). Finally, the comparison of CALIOP daytime AOD with AERONET observations revealed a median relative difference (underestimation by CALIOP) of 25% (Omar et al., 2013).
Another issue is the misclassification of dust layers as polluted dust (e.g. Tesche et al. (2013)) or even as marine aerosol into the marine boundary layer, which modifies the AOD, as the lidar ratio of polluted dust or marine aerosols is different from the one of dust aerosols. Note also that for CALIOP Level 3 the Data Product Maturity is beta (http://www-calipso.larc.nasa.gov/resources/calipso_users_guide/data_quality/index.php#lidar), while we are using information from the Vertical Feature Mask of which the Data Product Maturity is Validated Stage 1 (same link as previously).
We however agree with the Reviewer that, ideally, one should compare the mean altitude from IASI (given its dependence on the AOD) with an extinction coefficient (or AOD)-weighted altitude from the lidar. This could be the case for the forthcoming mission EarthCARE, where the ATLID lidar has both high-spectral resolution (HSRL) and depolarisation capabilities, which can provide directly the extinction coefficient for dust aerosols (independently of the lidar ratio).
Finally, the bias between mean altitude (used here) and mean weighted (by the extintion coefficient) altitude cannot be estimated as the true lidar ratio for every dust layer is unknown.

Added in the text, p. 30147, line 29 : "and the possible misclassification of dust layers as polluted dust or marine inside the marine boundary layer, which in turns affects the assignment of the lidar ratio. These issues, already discussed in Tsamalis et al. (2013), are related to the fact that CALIOP is an elastic lidar, meaning that it needs an assumption about the lidar ratio to retrieve the extinction coefficient. Recent studies further corroborate our choice, by finding significant AOD differences between CALIOP and other instruments (Amiridis et al., 2013; Ma et al., 2013; Omar et al., 2013; Tesche et al., 2013). "

Method

I do not get the 1.5*1,5 grid … I thought it is 1*1?
@ From a review of papers dealing with remote sensing of aerosols, the 1.5°x1.5° resolution cannot be called "very coarse". Here, the aim is to somewhat increase the signal to noise ratio with the risk, the Reviewer is right, to bring some contamination, potentially masking the real performance of the method. One has, however, to keep in mind the fact that AERONET data are obtained daytime, when IASI data are obtained nighttime (at present). Research advancing step by step, we are already starting working on the daily issue, at a higher spatial resolution. It must also be pointed out that monthly results at such a space resolution (current IASI aerosol products resolution is 1°x1°) are still considered as very useful for climate research (study of climate variability and evolution). These data need being evaluated.
See also answer to the Editor.

What defines a valid month value for each data-set (give the minimum # of samples) ?
@ Valid month : A valid month has an AOD>0.02 and an altitude>1.0km; these values have been added. The number of items, as well as the quality of the AERONET observations are addressed in 2.2.

I am confused about the ratio between AERONET coarse mode AOD and IASI AOD. The plan here (as I understand) is to evaluate the IASI skill to determine coarse AOD, size from spectral information and altitude. Now if you prescribe the local conversion factor this does NOT test the skill of IASI to get reliable coarse mode AOD data. And what will you do in cases that there is not matching AERONET sample? Then also all these box and whisker plots address monthly variability but NOT bias. I hope this is not true. If so, please do NOT prescribe a ratio based on AERONET, as your LUT already uses (based on size assumption and refractive indices) such a ratio…. and the paper should evaluate the retrieval skill (without cheating). In any case you should your LUT make a function of size (assuming one size or size distribution will not work, since especially over the Sahara effective dust sizes are often larger) and there is sufficient spectral info in the IASI sample to address size.
@ - That part of your sentence is not clear to us : "…is to evaluate the IASI skill to determine coarse AOD, size from spectral information and altitude" ; we here determine AOD and altitude from the IASI spectral observations.
- bias issue : please see also answers to the Editor.
- the important issues raised here by the Reviewer are now detailed in the new Appendix A, in section 3, etc.
- size : answer already given.
- A. Chedin and co-Authors to Reviewer n°1:We cannot accept the word "cheating" .

With respect to IR/vis AOD ratios larger than 1.0: This is possible, if sizes are larger (ca 5um radius) and narrower in the width (the assumed 2.2 std deviation of the LUT is way too large and will smooth spectral detail). To make proper use of IASI spectral information you should use narrower size distributions variances between 0.3 and 0.5.
@ As already said, IASI-retrieved AOD is not significantly impacted by the size distribution parameters, whereas the IR/Vis ratio is impacted (see Fig. A3). From this figure, the large ratio found at Tenerife might indeed be interpreted as being due to a large effective radius or a small width of the size distribution, independently from the AOD we have estimated.

Why are outliers removed? Is this not cheating? Although you offer potential reasons for outliers, how do you know that these reasons apply? If you cannot proof it you have to keep the outliers.
@ - We won't comment the new "is it not cheating"...
- As explained in this paragraph, this procedure allows eliminating cases which would otherwise mask the real performance of the evaluation. This is common practice. Obviously, such outliers (7 out of 100) can "contaminate" further use of the data (although methods actually exist to detect them), as it is the case for all retrieval processes… Moreover, statistics including the "outliers" are given throughout the text. One sentence added :
" This procedure allows eliminating cases which would otherwise mask the real performance of the evaluation."

Results
(reminder: Just add the explanation of Taylor and Box plots in the figure caption)
@ What does the Reviewer recommend ?

The box plots show difference between "AERONET/IASI average scaled" IASI AOD and AERONET AOD. By leaving the " …" aspect out, there may be misunterpretations.

@ added to legends of Figs. 3 and 5 : "…and AERONET 500 nm coarse mode AOD (scaled by the site-ratio as explained in Section 3)"

The mixing should not be a problem … if the SDA method work. Of course if other particles cling to coarse aerosol the refractive indices could be affected but given the uncertain impact from changing refractive indices, I am not sure if the mixing has a big impact on the retrieval.
I agree that the temporal mismatch near sources could be a problem on a daily basis - but not so much on a monthly basis unless there are regular repeating wind-strength cycles.
@ We have shown that changing the refractive index may have an important impact. OK for the other comments.

In the sensitivity studies changes in the assumed refractive indices are one aspect and size assumptions (which are not investigated) are another. I am not so sure we learn so much from a different refractive index if the size-assumption is incorrect.
@ As said above, the size assumption is not a relevant problem in the infrared. The new Appendix details the sensitivity of brightness temperature to the size assumption.

If you think that time-series are important for a subchapter you should at least present a figure (I do not like references to supplements) either at least a figure or remove the text.
@ If the Editor recommends it, we will move this material to the main paper.

Discussion
The bias issue is side-stepped … at least problems with the multi-annual IR/vis AOD ratio are acknowledged.
@ Bias issue already discussed.

One problem may be the refractive index assumption … but a bigger problem is the fixed size and an unrealistic wide size-distribution. Any retrieval improvement should make size a flexible parameter.
@ Answer already given.

If you use daily data (despite the exact temporal mismatch) … there will be many more matches and the evaluation will be more meaningful.
@ Answer already given

The last paragraph mentioned "the overall agreement for AOD". This is an overstatement, as the paper only shows a reasonable temporal correlation. Spatial correlation and bias skill have not been demonstrated.
@ OK for the correlations (temporal); an overall value of 0.93 (38 sites, 6 years) is perhaps better than "reasonable"… In addition, we have shown the time series (IASI vs. AERONET) and their spatial variability from one site to another. The bias issue is now discussed in detail. The presence of important biases seems incompatible with the correlation results. Altitude biases are also given.

Atmos. Chem. Phys. Discuss., 13, C11711–C11715, 2014
www.atmos-chem-phys-discuss.net/13/C11711/2014/

Atmospheric Chemistry and Physics Open Access Discussions

Interactive comment on "Evaluation of IASI derived dust aerosols characteristics over the tropical belt" by V. Capelle et al.
Anonymous Referee #2

Received and published: 31 January 2014

The paper by Capelle et al provides information on the evaluation of IASI derived dust aerosol properties. It appears that the IASI data have already been shown to give dust properties as published in Peyridieu et al. 2013. The publication of the data and the retrieval method itself is thus not original here. This present study submitted to ACP does not contain new data on science problems associated with dust, something of typical interest for the readers of ACP. While a documentation of the evaluation is useful, I do not think ACP is the appropriate journal and recommend resubmission to a more technical journal, such as AMT. I recommend thus rejection for ACP.

Furthermore the paper still misses several quantifications, which make the work in the presented detail not very useful. It will require major revision. The authors conclude: "The present results demonstrate the usefulness of IASI data as an additional constraint to a better knowledge of the impact of aerosols on the climate system.". Sorry to say, I am not more convinced by the results presented here. However, I believer the authors have the data at hand to quantify the bias and provide an uncertainty estimate for the IASI dust related data. I am sure the data will then become useful.

Smaller comments and suggestions for revision:

Quite some editing of the english, inclusion of more comma, removal of vague statements would help the reader.

@@ Authors to Reviewer:
- please see answers to Editor's comments
- the time period covered in the paper has been extended to June 2013.

p30145

"disinterest" I don't think this is the right word..
@ changed to : ' lack of interest '

"have a high impact in the infrared when aerosols more typical of pollution or biomass burning usually have smaller size and affect less infrared radiation." please rephrase
@ Sentence rephrased :

‘ Aerosols in the coarse mode much affect infrared radiation contrary to aerosols in the fine mode. Dust and sea-salt particles are the main components of the coarse mode, the latter usually remaining in the bottom of the planetary boundary layer, to which infrared radiances collected at satellite level are poorly sensitive. ‘

p30146

"the domain remains largely unexplored and is still poorly understood" please omit, a little too general.
@ omitted

p30148

"at 9.30 p.m. LT" explain LT
@ changed to : ‘ at 9.30 p.m. Local Time (LT)

"except in the presence of a strong, recurrent, local diurnal cycle affecting the free troposphere to which IASI is most sensitive." please rephrase. not clear.
@ rephrased : ‘except in the presence of a strong, well established, local diurnal cycle affecting the free troposphere ‘

p30149

"The CALIOP mean altitude is calculated in this way in order to avoid the critical influence of the lidar ratio on the estimation of the extinction coefficient (and the optical depth), which might impact a mean altitude estimation" I do not totally agree. I am not convinced the authors make best use of the CALIOP products. In dust dominated regions it should be possible to compare the extinction profile from CALIOP to the dust occurrence frequency from IASI. I believe this is important to better understand the differences between the IASI and CALIOP profiles. At the very least this discussion needs to be extended to the point that a hypothesis is put forward how the bias would look like. As discussed here and later in the text, it sounds more like an excuse, which leaves the reader with no conclusion.
@ Please, see the (extensive) answer to Reviewer 1.
Added in the text, p. 30147, line 29 : “and the possible misclassification of dust layers as polluted dust or marine inside the marine boundary layer, which in turns affects the assignment of the lidar ratio. These issues, already discussed in Tsamalis et al. (2013), are related to the fact that CALIOP is an elastic lidar, meaning that it needs an assumption about the lidar ratio to retrieve the extinction coefficient. Recent studies further corroborate our choice, by finding significant AOD differences between CALIOP and other instruments (Amiridis et al., 2013; Ma et al., 2013; Omar et al., 2013; Tesche et al., 2013). “

p30150

vary according TO the characteristics of the terrain
@ done

"presence of high relief" => relief ?? orography, terrain is probably meant
@ changed to : ‘ high orography ‘

"For each site, a month of the period ... " please rephrase
@ rephrased : ‘ For each site, all the couples of monthly mean IASI AOD and AERONET AOD available over the period considered are included in the evaluation.’

"on a two dimensional plot" not clear. In contrast: what would be a one or even three dimensional plot.
@ ‘on a two dimensional plot‘ has been suppressed.

p30151

"To overcome this difficulty, a fit is done, site by site, including all the available items (monthly IASI-AERONET bins) over the period studied, resulting in an IR 10um AOD/500nm coarse mode AERONET AOD “site ratio”." This procedure removes any bias, if I understand the procedure correctly. Firstly, this should be made more clear, outspelled, explained. Secondly, its not clear how the large scale IASI product shall be used, e.g. by modellers, since one would not know which ratio to apply locally. Any recommendation for users? Can this be translated in an error estimate?
@ See answers to the Editor. Because translating infrared AOD into visible coarse mode AOD requires accurate knowledge of variables as the infrared refractive index, or the particle size distribution, quantifying the bias between these two sources of AOD is not straightforward. This problem is now discussed in detail in section 3 (Method) and in the new Appendix to this paper. The problem of the bias is also addressed throughout the text (Abstract, Method, Results, and Conclusion). The altitude bias is now given and discussed.

p30152

"Here, the test distance has been chosen so that about 7% of the items are eliminated." How much do the IASI results change if the 7% items are included. If one would use the IASI product one would not have the chance to see which 7% of the cases should be removed. Any recommendation for users? How shall the IASI be used as a constraint by climate modellers?
@ As explained in this paragraph, this procedure allows eliminating cases which would otherwise mask the real performance of the evaluation. This is common practice. Obviously, such outliers (7 out of 100) can “contaminate” further use of the data (although methods actually exist to detect them), as it is the case for all retrieval processes… Moreover, statistics including the “outliers” are given throughout the text.

p30152

Results, first paragraph: While it is useful to have an explanation of possible errors, the text as such is rather trivial and not very useful. It may be shortened to 2-3 sentences. However, a quantification of the estimated error in AOD and height would be very useful and would certainly deserve more explanation and text.

@ paragraph shortened. Now reads :
‘A few remarks are necessary to a better understanding of the following analysis. First, the signal induced on IASI observations by each variable of interest, here AOD or altitude, depends on the intensity of the variable. This is however less trivial for the altitude but, generally, the higher the altitude the larger the signal. This is due to the decreasing thermal contrast between the surface and the atmosphere when approaching the surface. For that reason, infrared sounders show a limited sensitivity to the boundary layer. Second, the signal induced by altitude is intrinsically smaller than that induced by AOD: retrieving accurate altitude is more difficult, even more for low AOD. Third, IASI, a remarkably accurate and stable instrument, has a drawback with the larger noise of its short wavelength channels used for a good disentangling of the AOD and altitude respective signals; this difficulty has more impact on the altitude than on the AOD.

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"These parameters varying from one site to another (and, often, from one day to the next), there is no one common factor reconciling the two observation metrics." There is no reason to believe that the ratio is stable at a given site. Dust properties will change with time considerably even at one site. Utilizing one ratio for all sites would be better, since it would be simpler and more reproducible. Unless more sophisticated modelling would be involved.
@ As the reviewer knows, in the infrared as in the visible, the variability of aerosol optical properties depends on that of their microphysical properties. In the infrared, the largest source of variability is that of the refractive index, followed by the size distribution. The shape of the particles has a minor influence. This is different in the visible. In the two cases, assumptions are necessary. Here, the lack of measurements of the refractive index in the infrared, for a variety of representative aerosol types, is the dominant problem. Using one ratio for all sites would mask this problem. In the Appendix, we now show that the IR/Vis coarse-mode AOD ratio may vary from 0.9, using the MITR refractive index model, to 0.5, using the so-called “Fouquart” model. A very large range of variation which forbids taking one unique value for the ratio. Results presented in the paper roughly follow the theory: mean ratios are different over sea, far from the sources (larger) and over land (smaller); over sea, ratios for sites far from the sources are (more or less…) different from the ratios for sites close to sources. New measurements should be available in a foreseeable future and will undoubtedly improve the situation.

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"The box and whiskers results (Fig. 5) are significantly degraded / The Taylor diagram for the altitude over sea" please rephrase
@ sorry, we do not clearly understand what the Reviewer wants. The first part of the sentence quoted is end of §5.1(AOD) and the second part concerns §5.2 (altitude), line 6…

AOD discussion: The site ratio used, removes the bias between aeronet and iasi. However, it would be interesting where bias exists, if a best guess ratio of AOD@IR and AOD@500nm would be applied. How big is the bias and thus error in the IASI AOD estimate. Which part of the bias may be attributed to the coarse mode AOD from Aeronet. This has to be discussed quantitatively to make the work more useful.

@ The AOD bias issue is now addressed in Section 3 (Method) and detailed in the new Appendix to this paper. Please see also answers to the Editor.

Altitude discussion: It is not clear which altitude differences exist between the two datasets. Correlation and amplitude do not inform about bias, which is a very basic description for a comparison. How much are IASI and CALIOP disagreeing? Which part of the bias may be attributed as error to both methods. Or ff the two datasets describe different properties, why are they compared at all? I believe the authors can be a bit more quantitative. How does the mean height distribution look like in the two datasets, displayed in a histogram?
@ In the revised Figure 7 (Box-and-Whiskers plot; formerly Figure 8), the difference between the median and zero is the bias observed between IASI and CALIOP. An overall systematic bias of -0.4 km (IASI-CALIOP) has been observed; site by site biases are shown. These differences are discussed. Section 5.2 has been modified accordingly.

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refractive index discussion: Please be more quantitative.
@ This paragraph has been modified and completed.

tables 2-4 :

If the authors believe that only correlation is of interest, then the correlation columns could be integrated in table 1, saving space. However, one could also argue for more statistical info on the comparison, such as mean, median values from aeronet and from iasi, rmse, mean normalised bias, std. The correlation numbers given are not reproducible, so they are not very informative for further work. Scatterplot for land and ocean data might be useful.
@ Indeed, Taylor diagrams give more infos than the Tables. Clearly, the normalized standard deviation of IASI ("amplitude") is as important as the correlation: it has been added in Tables 2-4 and is discussed in the text.

Fig 3,5,7:

It would be more readable if the station identifiers are used on the taylor diagrams.
@ we tried this with a poor result due to overlapping.

Fig 4,6,8:

The figure caption is not sufficient. What is really shown here? Ratios? bias in percent?
The plot title does not need to explain the plots as box-and-whisker plot.
@ Figure captions (now Figs. 3,5,7) changed to :
"Box-and-Whiskers plot (ends of the whiskers exclude the outliers) for the difference between IASI and AERONET 500 nm coarse mode AOD (scaled by the site-ratio as explained in 3.) over sea. "

fig 10:

the amplitude curve is not well explained in the caption. It might be useful to mention in the caption that this is for stations over land.

@ The caption has been clarified :

“ Differences, site by site and total, found between the “MITR” and “Revisited” evaluations (see text) for the AOD (IASI versus AERONET) and for the sites over land (see Table 3). Differences in correlation are shown in red; differences in amplitude (normalized standard deviation) are shown in blue. Positive (resp. negative) values mean better correlation and amplitude closer to 1 (amplitude of the AERONET reference) for “MITR” (resp. “Revisited”). “

Atmos. Chem. Phys. Discuss., 13, C12222–C12223, 2014

www.atmos-chem-phys-discuss.net/13/C12222/2014/

Atmospheric Chemistry and Physics Open Access Discussions

Interactive comment on "Evaluation of IASI derived dust aerosols characteristics over the tropical belt" by V. Capelle et al.

YB Balkanski (Editor)

yves.balkanski@lsce.ipsl.fr

Received and published: 14 February 2014

The major points raised by the reviewers that will need to be addressed are listed below:

- Provide an evaluation of the AOD bias.

@ The bias issue is now addressed in several sections of the paper:
- Abstract,
- 3. Method (a ~1 page paragraph added),
- 4. Results (new paragraph : «4.1.1 IR/Vis AOD coarse-mode site ratios»)
- 5. Discussion).

- An Appendix (5 pages: 3 pages text, 4 figures) has been added to explain the difficulty of addressing the AOD bias. For the AOD, such a comparison raises the problem of the difference between the two spectral domains used: infrared (IASI) and visible (AERONET). The IR (10 µm) /Vis (500 nm) AOD coarse-mode ratio essentially depends on the refractive index, on the width of the size distribution and on the effective radius. All these parameters, varying from one site to another (and possibly throughout the time period for a given site), there is no one common factor reconciling the two observation metrics. Size distribution parameters are not a serious issue for this evaluation because they are provided, at each site, by the AERONET database. We show, in Appendix A, that the crucial parameter governing the conversion of the AOD from the visible domain to the infrared domain, is the refractive index, substantially varying with the type of aerosol considered. Unfortunately, an obvious lack of measurements of dust refractive index in the infrared precludes determining an accurate theoretical IR/Vis AOD coarse-mode site ratio. However, it is also shown that the "empirical" IR/Vis AOD coarse-mode ratio determined a posteriori follows relatively well the theoretical ratio and can still be interpreted as a marker of the aerosol situation observed.
- Altitude biases are now given and discussed.

Answer the following remarks from the reviewers:

" - As I understand it, the evaluated IASI AOD is corrected by multiplying multi-annual ratios of IASI (far-IR) AOD to AERONET(vis) AOD. "

@ It is the AERONET coarse mode AOD which is scaled by a site ratio prior to the evaluation of the IASI AOD. The IASI AOD is left unchanged. The scaling ratio is detailed and discussed in Section 3 (Method) and in the Appendix. It is somewhat analogous to the "Angstrom exponent" used in the visible, allowing to "translate" AOD at one frequency into AOD at another one. The problem here is that this site-ratio strongly depends on the refractive index, in particular, its infrared part, much less smooth than in the visible, and still quite poorly known.
Minor point: IASI measures in the thermal and near infrared; not in the far-IR as said by Reviewer 1.

" - What is the IASI AOD, if there is no AERONET station to scale to? "

@ IASI AOD is given at 10 µm, globally, for the whole period covered here, exactly as are given MODIS, MISR or PARASOL visible AODs at several wavelengths. This is an important point for climate studies.

" - Then there are these very coarse scales (monthly and 1.5*1.5deg), which brings up contaminating issue with regional representativity or averaging. "

@ Answer to Reviewer 1:
From a review of papers dealing with remote sensing of aerosols, the 1.5°x1.5° resolution cannot be called "very coarse". Here, the aim is to somewhat increase the signal to noise ratio with the risk, the Reviewer is right, to bring some contamination, potentially masking the real performance of the method. One has, however, to keep in mind the fact that AERONET data are obtained daytime, when IASI data are obtained nighttime (at present). Research advancing step by step, we are already starting working on the daily issue, at a higher spatial resolution. It must also be pointed out that monthly results at such a space resolution (current IASI aerosol products resolution is 1°x1°) are still considered as very useful for climate research (study of climate variability and evolution). These data need being evaluated.

" - Issue of daily data, which via more numerous samples would be also more meaningful."
@ Certainly yes for aerosol research, and this is the reason why we are actively working in that direction. Less obvious for climate research.

" - Use of correlations to demonstrate skill without really looking into the meaning of such correlations. "
@ Answer to Reviewer 1 :
This remark is surprising: there is no mystery in the meaning of a correlation. However, to avoid any ambiguity, mention is now made of the "temporal correlation".

" - When a satellite product is evaluated, then answers are expected for data coverage and data accuracy, where the accuracy should address bias, spatial and temporal variability."

@ Answer to Reviewer 1 :
We agree. The bias issue is now extensively addressed. Temporal correlations, together with the normalized standard deviation of IASI (representative of the amplitude of the seasonal cycle at each site), are given and discussed throughout the paper. The latter has been added to the results presented in Tables 2-4. Moreover, the time series, given as Supplementary Material, inform on the space (sites) and time (period covered) variability of the IASI results compared to that of the AERONET measurements. As suggested by the Reviewer, and if the Editor recommends it, we will move this material to the main paper.

@@ All other questions/comments by the Reviewers have been answered

Yves Balkanski

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 30143, 2013.

normalized standard deviation of IASI (last column). In the following, the normalized standard deviation will be referred to as “amplitude”, as often representative of the amplitude of the seasonal cycle.