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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Saharan dust infrared optical depth and altitude retrieved from AIRS: a focus over North Atlantic – comparison to MODIS and CALIPSO" *by* S. Peyridieu et al.

S. Peyridieu et al.

sophie.peyridieu@lmd.polytechnique.fr

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First, we would like to warmly thank the two anonymous reviewers for their positive comments and suggestions. Changes introduced to the manuscript following their review are listed below.

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1 Response to Anonymous Referee # 1

Page 21200

- l. 5 : *Look-up-Tables* → *look-up-tables* ⇒ Changed.
- l. 21 : *sounders at low altitudes* → *sounders for low altitudes* ⇒ Changed.
- l. 21 : *These results however... ==there is no contradiction. Please remove the "however".* ⇒ "However" has been removed.
- l. 26 : *if aerosol forcings* → *although aerosol forcings* ⇒ "if" changed to "although"

Page 21202

- l. 7 : *Aqua train* → *A-train* ⇒ Changed.

Page 21203

- l. 3 : *"Look-up-Tables"* → *LUTs (no apostrophes)* ⇒ This sentence has been rewritten as : "Both steps use look-up-tables (LUTs) computed..."
- l. 13 : *herein* → *therein (several times in manuscript)* ⇒ Changed.
- l. 20–24 : *This instrument... measurements (...). ==This is a very long, confusing sentence in which the word "sun-photometer" appears twice (with different spelling). Please rephrase* ⇒ This sentence has been rephrased to:
  "This instrument is considered as a key sensor for satellite retrieval of aerosol properties. MODIS AOD retrievals have been widely validated with the ground-based sun photometers network AErosol RObotic NETwork (AERONET) data

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and compared to other satellite retrievals and model simulations (Remer et al., 2002, 2005; Kinne et al., 2003)."

- l. 26 : *How may sampling artefacts influence the comparison of monthly averages? For example, MODIS aerosol retrieval uses a very strict cloud filter.* ⇒ Cloud detection for AIRS is already mentionned in section 2.1. (p. 21202, line 22).
  We have added, about the comparison between AIRS and MODIS products in section 2.2 (p. 21203, line 27) : "MODIS and AIRS flying onboard the same platform Aqua, there are no temporal artefacts on the observed scene. Both products compared here have passed strict cloud filtering tests. Moreover, for the comparison of monthly averages, MODIS 1×1 grid elements corresponding to AIRS cloudy or non-retrieved grid elements have been removed. We thus have the same number of items averaged for both AIRS and MODIS AOD products."

- l. 27 : *Let us remind* → *Please note* ⇒ Changed.

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- l. 10–13 & l. 20 : *Please mention here the poor global coverage of CALIOP* ⇒ We have replaced the present sentence (l. 10–13) by: "CALIOP has been flying (...) over the globe, with high vertical resolution from space (Winker et al., 2007; Kim et al. 2008)."
  Then, when mentioning the Level-2 product (l.20): "(...) of each layer, at a spatial horizontal resolution of 5 km."
  Finally, we introduce the poor global coverage of CALIOP in the next paragraph (l.24) : "The lidar has a high horizontal resolution of 5 km for detecting cloud or aerosol features. However, CALIOP only makes nadir measurements, and so the global coverage of CALIOP is poorer than a scanning instrument like AIRS due

to the distance between two successive orbits (more than 1000 km). This is why comparing CALIOP and AIRS products is not straightforward."

- l. 13 : *from space = not necessary, please leave it out.* ⇒ Changed.
- l. 16 : *At the time we are writing this paper* → *At the time of writing* ⇒ Changed.
- l. 20 : *at a spatial resolution* → *at a horizontal spatial resolution (as apposed to vertical)* ⇒ See our answer about lines 10–13.

Page 21205

- l. 1 : *with low sensitivity to a complex layering of the dust. ==What is meant here? "Low" sensitivity or "no" sensitivity? Doesn't the algorithm assume only one aerosol layer? In that case I think "no sensitivity" would be more accurate here.* ⇒ We mean that the limited vertical resolution of infrared sounders does not allow disentangling separate aerosol layers particularly when their mean altitudes lie within this vertical resolution. Change made: "... of the dust due to the limited vertical resolution of the sounder."
- l. 11 : *"highly" confident* → *"highly confident"* ⇒ Changed.
- l. 21–24 : *(Various comments)* ⇒ We have rephrased the block from lines 19 to 24 into : "Over ocean, the inversion algorithm is able to discriminate small spherical particles (accumulation mode) from large spherical or non-spherical particles (coarse mode) (Herman et al., 2005). In the following, the non-spherical component is assumed to be directly related to the presence of dust particles."

Page 21206

- l. 10 : *"atmosphere-Look-Up-Tables"* → *atmosphere LUTs* ⇒ Changed.

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- l. 20 : *situations with N<5 are rejected ==why?*
  ⇒ Some changes have been made to the manuscript about this rejection. See answer to reviewer #2 for more details.

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- l. 20 : *"aerosol-Look-Up-Tables" → aerosol LUTs* ⇒ Changed.
- l. 25 : *(linearly or not) ==please be more specific – if not linear, then what? Otherwise leave this bit out.* ⇒ Calculations are made only for the values of Table 2 in bold font. Other values are interpolated: BTs for other AOD values are interpolated linearly ; BTs for other viewing angles and altitudes are interpolated quadratically. Errors associated with the interpolation have been calculated. We have changed the "(linearly or not)" into "(linearly or quadratically)" and we have consequently modified the layout of Table 2 :

Parameter	Values	Interpolation mode	Maximum error
View angles (°)	**0**, 5, 10, **15**, 20, 25, **30**	quadratic	0.22 K
AOD	**0.0**, 0.10, 0.20, 0.30, **0.40**, 0.50, 0.60, 0.70, **0.80**	linear	0.15 K
Altitude (4A layer)	**757 m (38)**, **1258 m (37)**, 1756 m (36), **2411 m (35)**, **3254 m (34)**, **4116 m (33)**, 4965 m (32), **5795 m (31)**	quadratic	0.20 K

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Pages 21207 through 21209

- p.21207(l.27–28), p.21208(l.1–24), p.21209(l.1–2) : *(Various comments)*

  ⇒ The description of the calculation of D$_{pixel}$ and of the selection of AOD-altitude bins (section 2.3.2) has been reformulated :

  " For each AIRS spot (instantaneous field of view, ifov), the aerosol LUT with the view angle the closest (±2.5) to the real view angle is selected. The set of observed BTs from the eight AIRS channels is compared to calculated sets extracted from this LUT. This comparison is restricted to the N atmospheric situations selected as in Sect. 2.3.1. So, the number of such calculated sets, P, is equal to N times the number of AODs and altitudes sampled in the LUT (N×9×8; see Table 2). Then, a distance, D_{spot}, is defined between the observed set and each of these P calculated sets:

$$D_{\text{spot}}(\text{AOD},\text{alt}) = \frac{1}{N}\sum_{atm=1}^{N}\left(\alpha\sum_{j=1}^{8}\frac{\left(BT^{j}_{\text{calc}}-BT^{j}_{\text{obs}}\right)^{2}}{\sigma_j^2}+\beta\sum_{k=1}^{5}\frac{\left(\Delta BT^{k}_{\text{calc}}-\Delta BT^{k}_{\text{obs}}\right)^{2}}{\sigma_k^2}\right) \quad (1)$$

  where the first term of the sum stands for the normalized distance between the observed and the LUT BTs channel sets. The second term stands for the normalized distance between the observed and the LUT BT differences (gradients) for five couples of channels chosen as 313–177, 177–134, 315–177, 166–135 and 140–134 (Pi2004). The coefficients α and β (α=0.8, β=0.2) weight the respective contributions of the individual channels and of the channel differences.
  D_{spot} values are then filtered (see below) and averaged over 1×1 grid boxes (pixel) :

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$$D_{\text{pixel}}(\text{AOD}, \text{alt}) = \frac{1}{N_{\text{spot}}} \sum_{1}^{N_{spot}} D_{\text{spot}}(\text{AOD}, \text{alt}) \quad (2)$$

where N_{spot} stands for the number of AIRS spots kept in the corresponding 1×1 grid box (pixel) after each individual distance D_{spot} has passed successfully a threshold test based on the internal variability of the LUT.
Figure 3 illustrates, for a 1×1 grid box located near Cape Verde, the values of D_{pixel} in function of AOD (x-axis) and altitude (y-axis). Finally, AOD and altitude bins with a value of D_{pixel} verifying $D_{\text{pixel}} \leq min(D_{\text{pixel}}) \times 1.1$ are averaged over a month giving the retrieved monthly mean AOD and altitude of the grid box. The standard deviation provides an estimate of the dispersion of the retrieval, keeping in mind that part of this dispersion is due to the natural variability of aerosols."

Page 21209

- l. 12–14 : *I am not familiar with the Volz or MITR models. How large are the differences in refractive index between those models? In other words, how sensitive is the AIRS retrieval to errors in refractive index? It is also intriguing that the errors in aerosol layer altitude and AOD – which are very different quantities with different effects on BTs – are the same for all studied cases. Is this a coincidence?*
  ⇒ The sensitivity of AIRS retrievals to refraction indices has been investigated by Pierangelo et al. (2004, see their section 3.3). Refractive indices used here (OPAC-MITR model) actually come from measurements made by Volz in the Barbados in 1973 and is a revision of the refractive indices published by d'Almeida (1991).
  We have modified in the text the sentence about the errors induced by Volz or

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MITR refractive indices (lines 23–25) : it has been replaced by "Pi2004 studied the impact of different refractive indices on the retrieval of aerosol properties. For example, for an input AOD of 0.30, the errors on the retrieved AOD are of about +13 % and -13 % using MITR or Volz indices, respectively ; for an input altitude of 2424 m, the errors on the retrieved altitude are of about -1 % and +14 % using MITR or Volz indices, respectively.

Page 21210

- l. 8–13 : *Point (3) is not ... last five days (Reid et al., 2003). ==What do the findings of Reid et al. have to do with point (3), the frequent occurrence of clouds?* ⇒ There is actually a direct relation between Reid findings and the clouds : If during these "last five days", clouds obscure the scene, the satellite won't see the aerosols in the Saharan Air Layer. We have added on sentence : "During such a short period, the presence of clouds could obscure this event from the satellite view."
- l. 27 : *herein* → *therein* ⇒ Changed.

Page 21211

- l. 4 : *herein* → *therein* ⇒ Changed.

Page 21212

- l. 1–22, Figure 4 : *The shape of the plume coming from the Sahara also looks different (straight from west to east for MODIS, bending southward for AIRS). Is that due to particle size, to MODIS cloud mask, AIRS removal of low-lying aerosol layers, or something else?* ⇒ The difference in the "bending" of the

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plumes is however rather small. Fig. 4 being a climatology over 6 years, potential differences in the cloud masks cannot explain this. The different sensitivity of the two instruments to dust aerosol modes is also to be considered as well as the sensitivity of MODIS to other aerosol types (low-lying marine aerosols, for example).
We added one sentence on line 6 : "Differences observed in the shape of the plume (straight from west to east for MODIS, bending southward for AIRS) could have the same origin."

- l. 10 : *indicating these particles -> indicating that small particles* ⇒ The full sentence originates from Maring et al., 2003b, and states that "the normalized mineral dust size distributions of particles smaller than 7.3 μm over the Canary Islands 10 and Puerto Rico were indistinguishable, indicating these particles were not preferentially removed during atmospheric transport." These particles, which refer to particles with a diameter smaller than 7.3 μm, include a large part of the mineral dust coarse mode, which is retrieved by AIRS. The fact that AIRS AOD remains significant over the Caribbean might be due the presence of these large particles.
⇒ Change made: "(...) indicating that coarse mode particles were not preferentially removed (...)"

- l. 14 : *by roughly one month =looks more like three months to me (March vs. June)* ⇒ Your question has led us to comment into more details figure 5d : "Over the Indian Ocean, MODIS and AIRS AOD peaks are in good agreement. As for region (a), MODIS baseline AOD remains relatively high (~0.20) and starts increasing later, by about two months, than does AIRS AOD. For the four last years (2006–2009), AIRS shows two peaks, the main one in July and the secondary one in April/May. This is compatible with Léon and Legrand (2003) results who report observed maxima of activity in dust sources during pre-monsoonal (spring) and monsoonal (summer) periods, with active areas during spring time between

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17N–22N and 42E–58E. Also, Li and Ramanathan (2002) show monthly variation of the AVHRR-retrieved AOD averaged over the 5 years from 1996 to 2000 for the Arabian Sea with an early start of the season in April (see their Fig. 7). However, the AIRS AOD results should be taken with care because of the simultaneously retrieved aerosol layer mean altitude approaching the limit of reliability of 1 km (see Section 2.4)."

- l. 25 & Figure 5 (& Table 3) : *It would be helpful if the regions were drawn on a map.* ⇒ A figure has been added with a map, showing the four boxes and the location of La Parguera AERONET station used in Section 3.1.

Page 21213

- l. 23 : *tendancy* → *tendency* ⇒ Changed.

- l. 26–29 : *The transition... sensitive to dust. ==This is not a very convincing explanation, because AERONET (Fig. 7) only shows one peak corresponding to the MODIS maximum, not a broad or a secondary peak.*
⇒ The original sentence (l.22–29) has been rephrased to :
"AERONET measurements made at La Parguera (18 N, 67 W) station, which is close to the center of the box, show the same tendency (Fig. 7); In May, values of the visible optical depth at 550 nm and Angström exponent from AERONET measurements are 0.19 and 0.69, respectively. This is in agreement with MODIS mean optical depth, which ranges from 0.18 to 0.24 throughout the years 2003 to 2009. These values show that although the visible optical depth is already high in May, it is only due to small particles. On the contrary in June and July, AERONET 0.55 μm AOD series is highest when the corresponding Angström exponent is lower than 0.40, indicating the presence of coarse mode particles. This peak of the visible optical depth corresponds to the peak of our AIRS-retrieved

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infrared optical depth. The transition between two aerosol modes in May/June may explain the time lag seen between MODIS and AIRS observations."

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- l. 5 : *Altogether, during the dust season, ... ==is this only for area (d), or for all?* ⇒ Our statement was unclear. Replaced by : "(...) between the two products : R^2=0.65 for both regions (a) and (b), R^2=0.52 for region (d); for region (c), as expected from the difference in the phase of the two products, the correlation is substantially lower : R^2=0.31."

- l. 8 : *For region (a)...dust compositions (Koven and Fung, 2006). What are the implications for particle size? Could this be a reason for the variability found between the different sites? Are the found particle sizes in agreement with assumptions?*
  Lines 6-14 have been rewritten and additional information given to answer the reviewer's questions :
  "Using the AERONET retrievals over Capo Verde (effective radius and width of coarse and accumulation modes, Dubovik and King, 2000), the refractive indices at 0.55 μm used by MODIS retrieval, and the refractive indices at 10μm from the MITR model, Pi2004 computed with a Mie radiative transfer code the infrared to visible extinction ratio. The calculated ratio, 0.4 to 0.55 according to the month, compares well with the AIRS to MODIS AOD ratio of 0.40 to 0.52 for a small area over Capo-Verde (JJA). However, it must be underlined that AERONET size distribution retrievals are available only 2 to 5 days each month, whereas the AIRS to MODIS ratio is a season average. We also find a slight decrease of this ratio when the distance to the sources increases: 0.50 for region (b), which may reveal a small loss in coarse size particles due to gravitational settling. This ratio then increases to 0.64 for region (c) manifesting again the difference in phase

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between the fine and the coarse modes during this season (later arrival of the coarse mode). These numbers also compare well with the results of Highwood et al. (2003)."

- l. 20 : *As for the AODs... Indian Ocean. =This is a very confusing sentence, please rephrase. Do not start the sentence with "As for..."* ⇒ "Altitude results are first presented spatially, from the northern tropical Atlantic to the western Indian Ocean."
- l. 26 : *These results bring into evidence:* → *Fig. 8 shows:* ⇒ Changed to "Results of Fig. 8 [now Fig. 9] show : (...)"

Page 21215

- l. 1 : *herein* → *therein* ⇒ Changed.
- l. 10 : *the blank areas south of the SAL ==are these gaps due to persistent cloud cover?* ⇒ Yes, in presence of clouds (detected by a specific cloud mask) AIRS spots are not processed. Because of the persistent cloud cover, especially in the ITCZ, some areas don't have enough retrievals available for averaging over one month of data.
  Sentence on line 10 has been changed to : "On the AOD and altitude maps of Figs. 4 and 8 [now Fig. 9] , the blank areas south of the SAL are mostly due to persistent cloudiness and precisely correspond to the location of the ITCZ."
- l. 26 : *in the statistics* → *for the statistics* ⇒ Changed.

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- l. 8 : *AIRS altitudes are lower than CALIOP altitudes ==what could be the reason? Sampling differences?*

⇒ The main reason of this low bias lies in the definition of the IR-retrieved altitude. As said p.21209, lines 18–21, "Intrinsically, the AIRS-retrieved altitude is an "infrared-equivalent" altitude, i.e. the altitude at which half of the dust optical depth is below and half of the optical depth is above. If the layer is homogeneous, it is the middle of this layer." It may however be expected that such layers are not homogeneous and that half of the AOD is concentrated in a layer geometrically thinner below the "infrared-equivalent altitude" and thicker above.
We added, line 9, after "... and agree better outside." :
"This low bias likely results from the difference in the definition of the "mean aerosol layer altitude" used by CALIOP (the so-called "centroid" that we verified being very close to the mean of the top and base altitudes, at least for the single-layer cases processed here) and AIRS. For the latter, the altitude retrieved is an "infrared-equivalent" altitude, i.e. the altitude at which half of the dust optical depth is below and half of the optical depth is above (see section 2.4). If the layer is homogeneous, it is the middle of this layer, as for CALIOP. It may however be expected that such layers are not homogeneous and that half of the AOD is concentrated in a layer geometrically thinner below the "infrared-equivalent altitude" and thicker above. Moreover, it must be kept in mind that CALIOP is also sensitive to high level fine mode dust particles."

- l. 9 : *about 500 m and agree better outside.* → *about 500 m; better agreement is found outside of the main dust season.* ⇒ Changed.
- l. 16 : *particularly satisfactory -> do you mean "good"?* ⇒ Yes. See also page 21217,l.28
- l. 24–25 : *not obviously adapted -> do you mean "not ideally suited"?* ⇒ Yes. Change made.
- l. 25 : *AOD do not show* → *AOD does not show* ⇒ Changed.

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- l. 8-9 : *AIRS mean altitude although the comparison* → *AIRS mean altitude when the comparison* ⇒ We have split this sentence into two sentences : "(...) good agreement with the AIRS mean altitude. This comparison was limited to (...)"
- l. 15–16 : *Here, retrieved altitudes lower than 1 km have been discarded. ==What fraction of all cases have altitude < 1km?*
  ⇒ Change made on p.21217, lines 15–16 : "(...) to sound close to the surface. As a consequence, retrieved altitudes lower than 1 km (less than 5% of all cases in dusty regions) have been discarded."
- l. 19 : *are to be conducted* → *will be conducted* ⇒ Changed.
- l. 23 : *LMD ==abbreviation is not explained in the text* ⇒ LMD = Laboratoire de Météorologie Dynamique. The full meaning is already mentionned P.21202, but the acronym is not. This is now corrected.

Page 21218

- l. 1 : *datasets from several satellite-based observations* → *datasets from different satellite-based instruments* ⇒ Changed.
- l. 3 : *algorithm do not make exception* → *algorithm is no exception* ⇒ Changed.
- l. 3 : *condition* → *conditions* ⇒ Changed.

Tables and figures

- Table 2 : *Look-Up Table* → *look-up-table* ⇒ Changed.

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- Table 3 : *A map would be more illustrative* ⇒ See comment of P.21212 line 25.
- Figs. 4, 5, 8 : *Several figures (in particular Figs. 4, 5, and 8) are too small; the details and the text are mostly lost to the reader.* ⇒ Agreed. Unfortunately the ACPD version (landscape page) does not allow much changes to the layout of the figures. In the ACP version, figures 4 and 5 [now Fig. 6] will appear on a full page ; figure 8 [now Fig. 9] will be displayed on a full column.
- Fig. 6 : *Please show region (c) from Fig. 5 as a box in Fig. 6 (or zoom in on it), and add the location of the AERONET site* ⇒ AERONET site and region boxes will be shown in a separate new figure, as explained above. Change made on 21212 line 28 : "Limits of these regions are shown on Figure 5."
- Fig. 9 : *Please explain in the figure caption what the magenta error bars are, this is now only mentioned in the text. And why are the CALIOP lines dotted in winter as well?*
  ⇒ This figure has been redrawn, with respectively gray and magenta enveloppes representing standard deviations of both instruments. For clarity purposes, we dotted CALIOP data in winter as well as AIRS data. In winter, the number of items retrieved for AIRS is not statistically representative ($\leq$100) because of the limit in AOD (altitude is shown only when AOD$\geq$0.10). Caption has been changed.

2 Response to Anonymous Referee # 2

Minor comments

- Fig. 3 : *Figure 3 is not particularly clear. The caption should be increased to explain the figure better.*
  ⇒ Figure caption changed to: "Representation of the distance calculated for

each AOD(8 values on the x-axis)–altitude(9 values on the y-axis) situation of the aerosol-LUTs. Selected values of $D_{pixel}(AOD, alt)$ around $D_{pixel}(AOD, alt)_{min}$ (square) are shown with a '+' sign and used for averaging aerosol properties. Here is shown the example of a 1×1 pixel south of Cape Verde Islands in July 2003."

- Fig. 6 : *In Figure 6, change "Aerosol optical thickness" to "Aerosol optical depth" for consistency with the rest of the manuscript.* ⇒ Changed.
- References : *Herman et al: replace POLDER//ADEOS by POLDER/ADEOS* ⇒ Changed.

Specific comments

- *It is not clear to me why situations where less than 5 atmospheres satisfy the criterion on the distance d0 are rejected. If just a few atmospheres (strictly less than 5) provide a very good fit to the observations, then why should they be excluded? How often does this happen? Why is this an improvement to the method of Pierangelo et al.?*
  ⇒ Cases where less than 5 atmospheres satisfy the criterion on the distance d_0 represent about 15% of all cases and they are usually located in the margins of the aerosol plumes. Thus, cases with a satisfying number of retrieved atmospheres (5≤N≤10) processed in our study represent more than 80% of all cases. Observations leading to less than 5 atmospheres recognized in the atmosphere-LUTs are considered as potentially too marginal and are consequently not processed.
  Two modifications have been introduced :

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In section 2.1 (p.21202 line 26 and p.21203 lines 1–3) : "(...) follows two main steps. In the first step, the observed atmospheric situation is determined as accurately as possible; in the second step, dust properties are retrieved. Both steps use look-up-tables (...)"

In section 2.3.1 (p.21206, lines 19–22) : "... are rejected as potentially corresponding to too marginal situations (about 15% of all cases). This first step, aiming at selecting a reduced set of atmospheric situations corresponding to AIRS observations, is an important improvement added to the method originally published by Pi2004. Incidentally, it also greatly reduces the second step computation time."

- *What are the other improvements ?*
  ⇒ The main other improvement of the method, not detailed in the text, concerns a better treatment of the viewing angle.

- *I accept it is difficult to validate the retrieval of the aerosol optical depth at 10 μm as there is no ground measurement for this quantity. However it might be worth speculating what sort of ground-based measurements might be suitable to document the accuracy of the satellite retrieval.*
  ⇒ Even if there is no routine measurements of dust from ground in the infrared, and no network of such instruments, the CLIMAT radiometer (by CIMEL company) has been used in many campaigns (Sahel, Sahara, China, Guadeloupe). It has one wide spectral band (8-13 μm) and several narrow channels within (Brogniez et al. 2003). During the AMMA campaign, a CLIMAT radiometer has been working without interruption from February to November 2006, and proved that information on the mineralogical composition can be remotely retrieved.

Brogniez, G., C. Pietras, M. Legrand, P. Dubuisson, and M. Haeffelin, A High-Accuracy Multiwavelength Radiometer for In Situ Measurements in the Thermal

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Infrared. Part II: Behavior in Field Experiments., *J. Atmos. Oceanic Technol., 20, 1023–1033*, 2003.

- *The PARASOL data should be reprojected on the same grid as the MODIS and AIRS data in Figure 4 and the same color scale should be used. It is difficult to see consistency (or lack of) between the AIRS and PARASOL data with the current figure. Also it would be good to know if the non-spherical AOD has been (can be) validated against observations and what the limitations of the product are.*

  ⇒ Figure 6 [now Fig. 7] has been replotted on the same projection and with the same color scale as AIRS.

  The non-spherical AOD has not yet been validated using coincident ground-based measurements. There is a good consistency, temporal and spatial, between the percentage of non-spherical particles derived from AERONET stations located around the Atlantic ocean and the detection of non-spherical particle plume from PARASOL.

3 Added reference

Dubovik, O., and King, M.D., A flexible inversion algorithm for retrieval of aerosol optical properties from sun and sky radiance measurements., J. Geophys. Res., 105, 20673-20696, doi:10.1029/2000JD900282, 2000.

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4 Figure captions

- **Figure 1.** Effect of mineral dust on AIRS brightness temperatures for 324 AIRS channels: **(a)** for three values of the 10 μm AOD; **(b)** for three values of the mean layer altitude. "Reference" values: AOD=0.2, altitude=2411 m.

- **Figure 2.** Sensitivity of channel 140 (at 10.36 μm, 965.4 cm^{-1}) to AOD for various mean altitudes of the aerosol layer (left), and to mean layer altitude for various AODs (right). Sensitivity to AOD corresponds to a variation of 0.1 around the AOD value considered; sensitivity to altitude corresponds to a variation of one layer of the 4A radiative transfer model layering ($\sim$500 m below 2400 m and $\sim$800 m above) around the altitude value considered. The instrumental noise for this channel is 0.12 K.

- **Figure 3.** Representation of the distance calculated for each AOD(8 values on the x-axis)–altitude(9 values on the y-axis) situation of the aerosol-LUTs. Selected values of D_{pixel}(AOD,alt) around D_{pixel}(AOD,alt)$_{min}$ (square) are shown with a '+' sign and used for averaging aerosol properties. Here is shown the example of a 1$\times$1 pixel south of Cape Verde Islands in July 2003.

- **Figure 4.** Monthly climatology (1$\times$1 resolution) of the aerosol layer mean optical depth seen by AIRS and MODIS over the period 2003–2008. Left: 10 μm AIRS-retrieved AODs; right: 0.55 μm MODIS-retrieved AODs. January: top; December: bottom.

- **Figure 5.** Regions of study and location of the La Parguera AERONET station (18N, 67W).

- **Figure 6.** **(a)** to **(d)** Time series of 10 μm AIRS (red line, left ordinate) and 0.55 μm MODIS (green line, right ordinate) optical depths for the regions of Table

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3: **(a)** east Atlantic, **(b)** middle Atlantic, **(c)** west Atlantic, and **(d)** south of the Arabian peninsula. **(e)** Time series of the number of items found in the corresponding regions.

- **Figure 7.** Aerosol optical depth of the non-spherical coarse mode at 0.55 μm observed by PARASOL in May (top), June (center) and July (bottom) 2007.
- **Figure 8.** Aerosol optical thickness (y-left axis) and Angström Exponent (y-right axis) as a function of the month (x-axis). The data are averaged over 8 years of measurements, from 2000 to 2008 (2003 is missing).
- **Figure 9.** Monthly climatology (1$\times$1 resolution) of the aerosol layer mean altitude retrieved by AIRS over the period 2003–2008. For significance purposes (see text, Sect. 2.4), altitude is shown only for pixels with 10 μm AOD$\geq$0.10.
- **Figure 10.** Time series of AIRS-retrieved monthly mean aerosol layer altitude (thick black line, solid if the number of items is statistically representative, dotted otherwise) over Atlantic region (a) of Table 3. The thin dashed line shows on the right ordinate the corresponding number of items in the region. The 1-σ envelope of the AIRS retrieval over the region is shown in grey. CALIOP mean (centroid) altitudes are shown in magenta for the period June 2006–December 2008, with associated 1-σ envelope.

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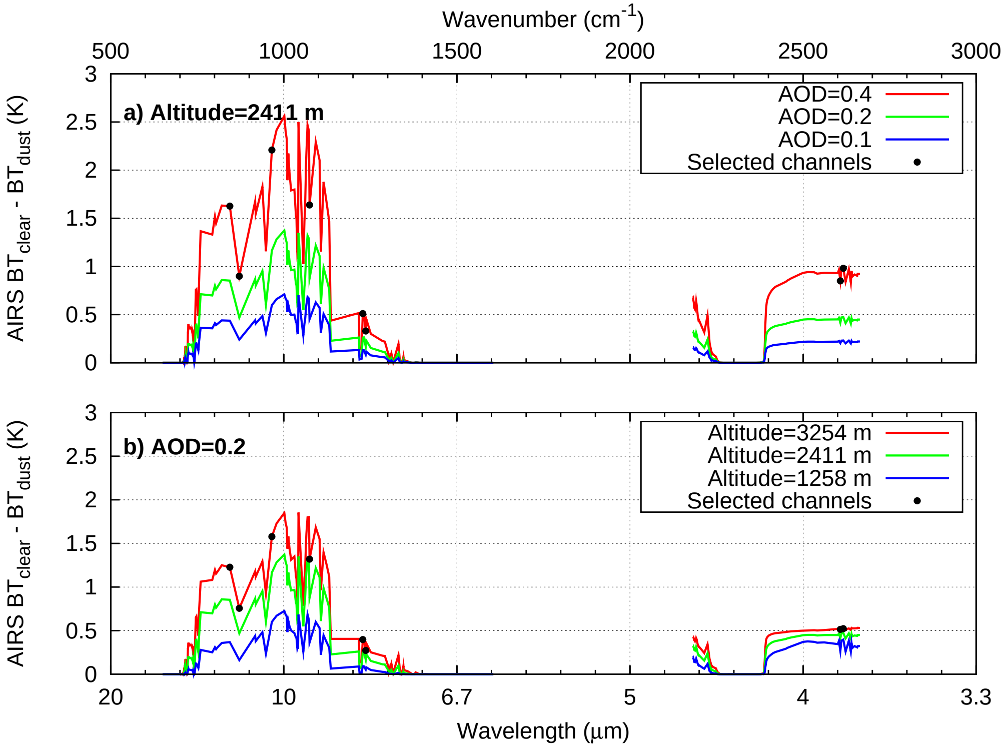

Fig. 1.

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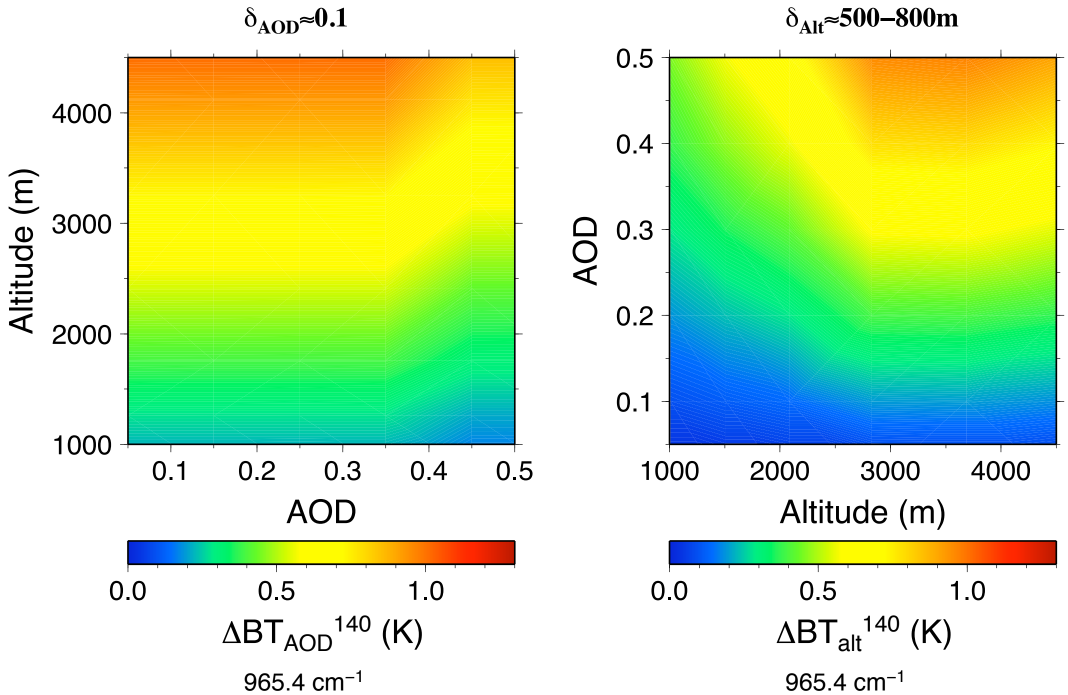

Fig. 2.

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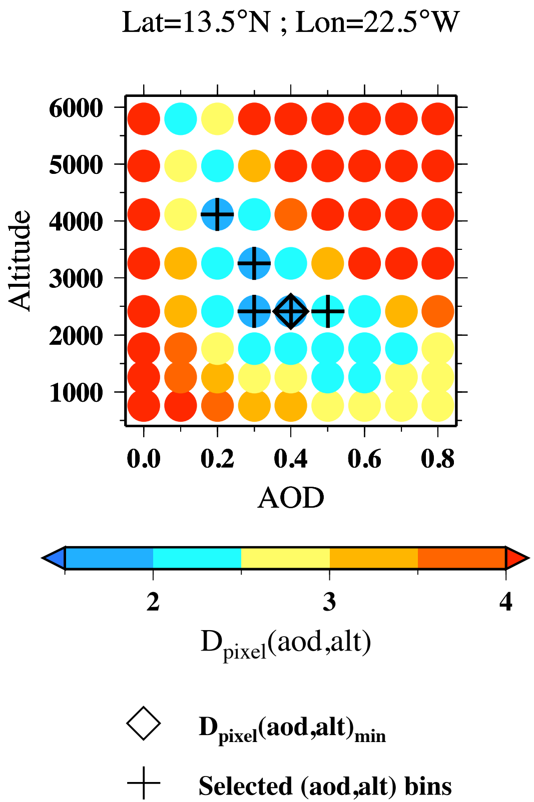

Fig. 3.

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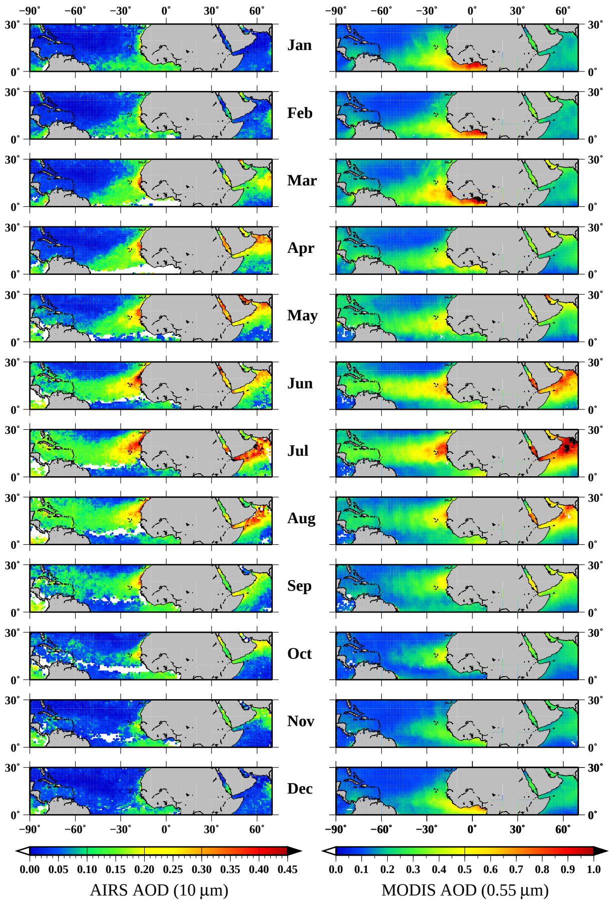

Fig. 4.

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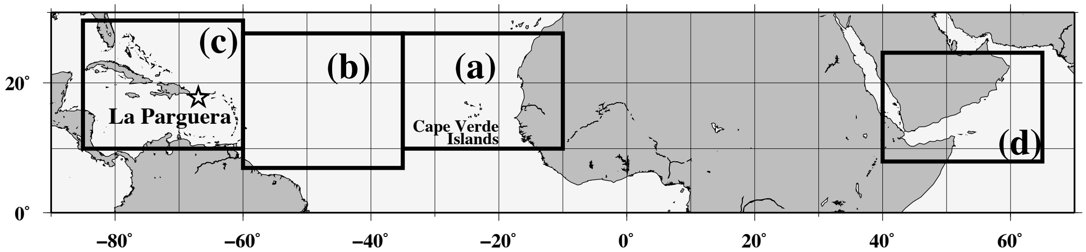

Fig. 5.

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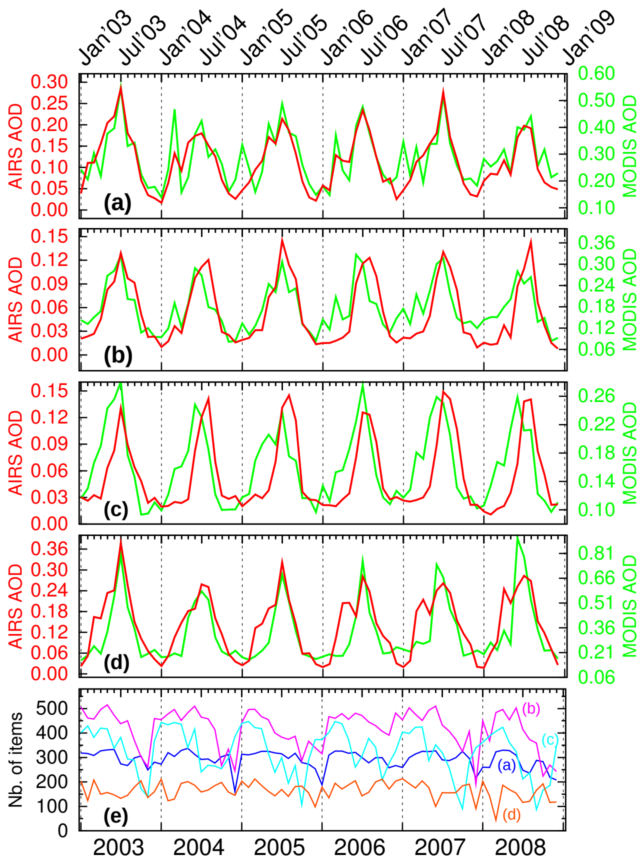

Fig. 6.

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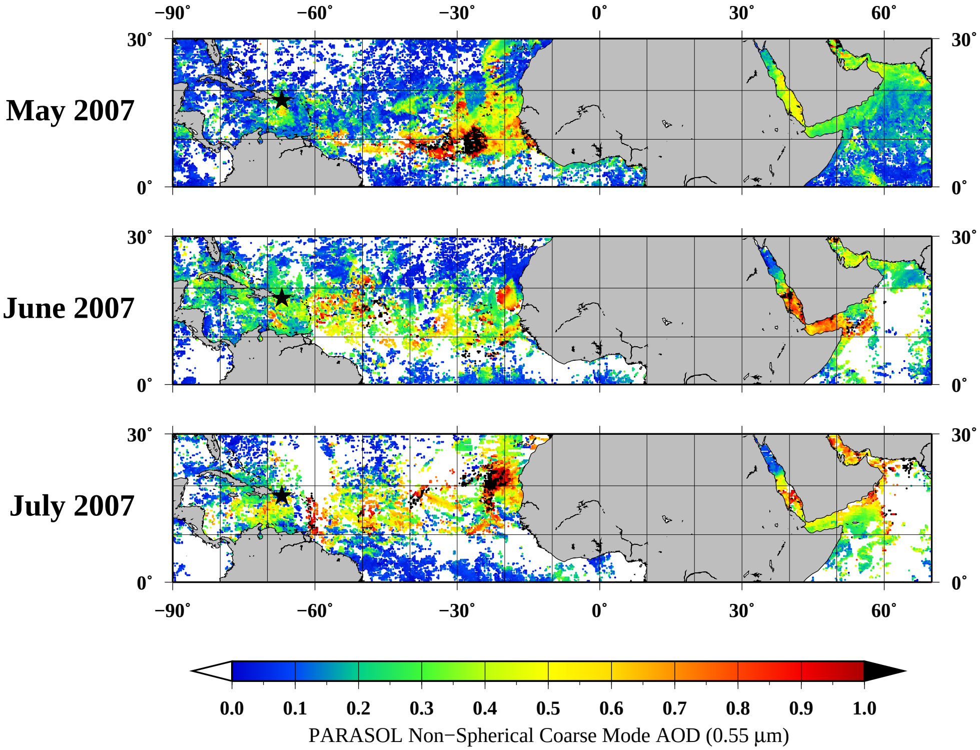

Fig. 7.

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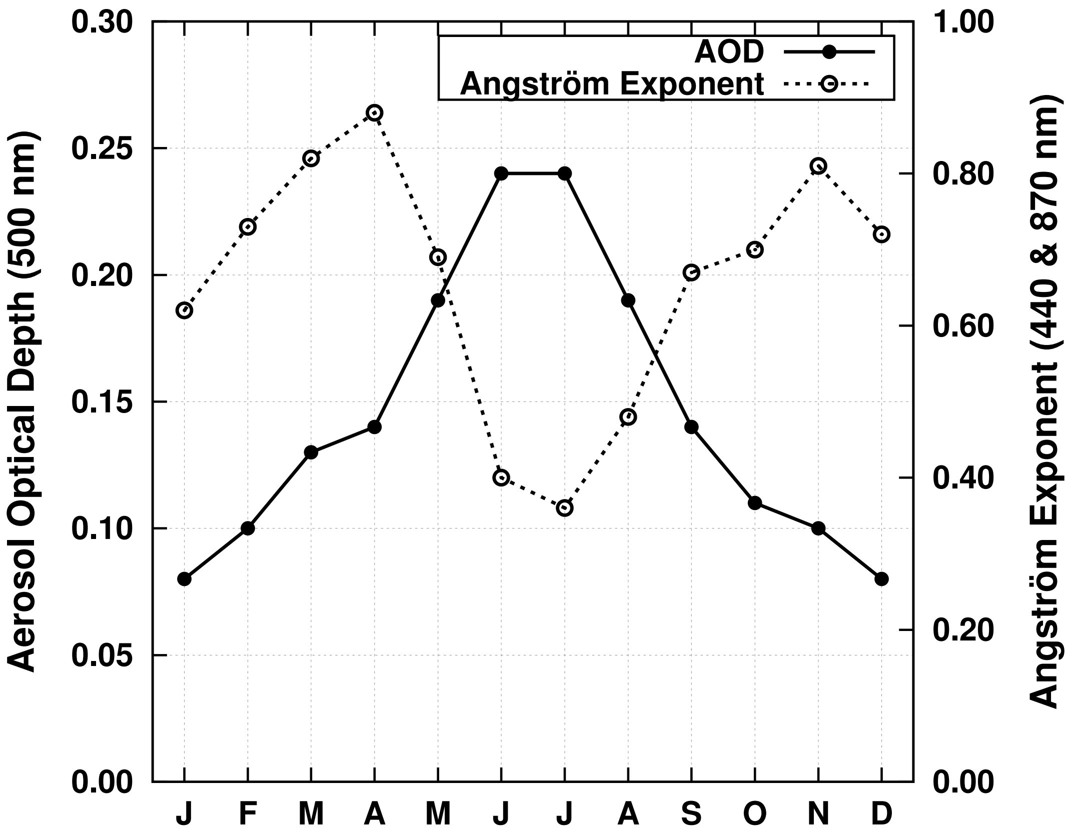

Fig. 8.

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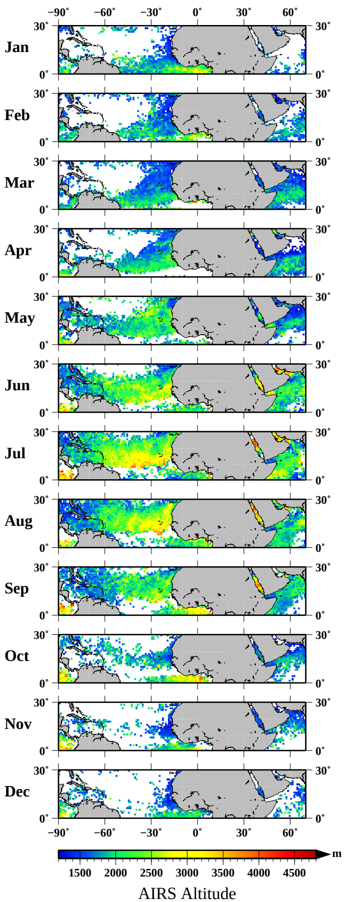

Fig. 9.

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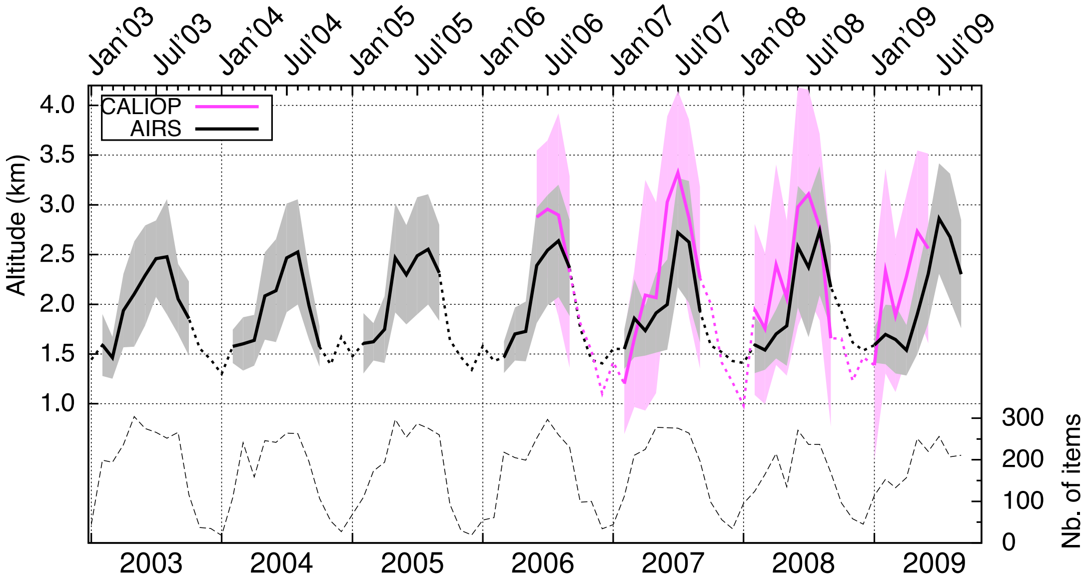

Fig. 10.

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