

## ***Interactive comment on “Transport of Saharan dust from the Bodélé Depression to the Amazon Basin: a case study” by Y. Ben-Ami et al.***

**Anonymous Referee #2**

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Ben-Ami, Koren, Rudich, Artaxo, Martin, and Andreae, Transport of Saharan dust from the Bodele Depression to the Amazon Basin: a case study, to be published in ACP

General

The paper contains original, very interesting material, is well written, and is thus appropriate for ACP.

However, major revisions are required. Many points remain to be clarified.

What is missing in the introduction are clear statements concerning: What has been done before in this field of research?

This point needs to be more properly and carefully elaborated in the introduction. The

C1997

submitted paper is obviously not the first one that reports on the transport of dust (AND OF SMOKE the authors should clearly mention that) towards South America. Kaufman et al. 2005 (JGR) demonstrated how dust and smoke is transported across the Atlantic based on MODIS observations. Liu et al 2008 (JGR, CALIPSO, long range transport paper) showed dust and smoke plumes over the tropical Atlantic. Ansmann et al. demonstrated how dust and smoke is transported to America during the winter season. The paper presented here is similar to the Ansmann paper.

Another essential point to be clarified and changed is: Schepanski et al. 2009 (JGR?) recently introduced a mechanism how dust is mobilized. Large amounts are emitted into the lower atmosphere when the nocturnal low level jet dissolves in the morning hours and hits the ground. And according to the Schepanski paper dust mobilization takes place almost everywhere in the southern Saharan area, not only in the Bodele area. Thus the statement ‘...Given the Bodele depression is the largest. ...’ cannot be interpreted as the only source of dust identified in the Amazon Basin. .

Details

Title has to be improved! The paper does not provide any solid data set (measurements, model simulations) that clearly shows a direct relationship between Bodele dust and the Amazon Basin particles. This is not acceptable. Speculation is not tolerable.

Page 4346, line 5: Abstract: ‘...Given the Bodele depression area ...is the main winter dust source. .... yes that may be true but is certainly not the only one.

Page 4346, line 8-13 must be rephrased according to the discussion above (...speculative argumentations are not tolerable in scientific papers). Provide unambiguous facts, or leave it out. More alternative positions are not acceptable.

Page 4347, line 18-27, in this paragraph one should review the literature, what has been done, what is known from previous work (Formenti, 2001, Kaufman 2005, Liu 2008, Ansmann 2009), before one introduces the new approach. To my opinion the

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approach here (use of CALIPSO lidar data to indicate WINTER TRANSPORT pattern, height dependent transport, depolarization ratio analysis) is similar to the Ansmann work (lidar in Africa and South America, WINTER SEASON transport pattern, dust and smoke transport, height dependent..., depolarization ratio). That needs to be mentioned in the introduction!

Page 4347, line 29: Koren... has suggested that the Bodele depression .... is the main source for the dust transport. ....

As mentioned above, Schepanski et al. 2009 show that this may not be true at all. So this phrase appears too speculative. Please rephrase (or better leave it out). Why not just stating, dust from the southern Saharan area is transported to South America (mixed with smoke..). Why do the authors try to emphasize 'Bodele' so much?? The message of the paper is clear and does not change if they remove their key word 'Bodele...'.

Page 4348, line 23 to Page 4349, line 4: Why do the authors not present a more relaxed, more realistic discussion, i.e., why do they not tell that dust and smoke plumes are transported (this is later clearly seen in the CALIPSO depol data). Why do they focus on dust only.

Page 4349, line 23: ..dust mass was estimated...over the Ocean....! Where over the Ocean? Provide exact location information, show trajectories that the dust at this oceanic site is linked to the Bodele depression area.

Page 4349, line 25... , Conversion of AOD to dust mass,... I speculate that 50% of the mass is smoke related! So, this conversion computation is rather uncertain! Must be mentioned.

Page 4350, line 9: I have not found any indication for biomass burning aerosols in Andreae 1986, why is that referenced here?

Page 4350, line 15 – line25: What is  $f$  (without index ) in the formula? How is it explicitly

C1999

related to  $f-m$ ,  $f-a$ ,  $f-d$ . Is Eq(2) ok? Is  $f$  always smaller than  $f-a$  (otherwise tau-du is becoming negative).

Page 4350, line 27: The use of CALIPSO depol to separate dust and smoke is similar to the approach presented by Tesche et al. (JGR, 2009), should be referenced!

Page 4351, line 6: use 'depolarization ratio' ... instead of 'depolarization signal'.

Page 4351, line 9: Add Freudenthaler et al., 2009 (Tellus, SAMUM special issue) to the reference list regarding dust depolarization ratios. Murayama (2001) reports observations that are frequently disturbed by anthropogenic particles over eastern Asia, and thus these values are much lower than the values for pure dust.

Page 4351, line 25... : I miss one point: Backtrajectories arriving at Amazonia (Manaus area),...clearly showing the link to the Bodele area! I can image why this point is left out... because such an analysis will show rather uncertain and not convincing results. But without such an analysis the hypothesis 'Bodele dust found in the Amazon Basin' is just speculation!

And looking at the bullet list in section 3... What about cloud effects, thunderstorms in the tropics during the winter season along the transport route, washout? Did you check the satellite images along the transport path for cloud clusters (indicating washout). There must be also significant washout over the Amazon Basin (during the wet season). Please discuss this impact.

Page 4353, line 17: I checked the AERONET web page...! So large aerosol optical depths up to 4(!), and obviously always a large contribution (30-50%) by biomass burning smoke. Can optical depths accurately be measured above AOD=3? Is the CIMEL still able to find the exact position of the sun? Over 14 days the optical depth was larger than 2!. The Angstrom exponents are always between 0.2 and 0.8 (clearly indicating a large contribution by smoke). Why did the observations stop on March 1, 2008? Multiple scattering effects must be large so that the single scattering AOD is

C2000

then obviously often larger than 5! More explanations are required here to convince readers that proper observations are presented!

Unfortunately there is no other AERONET site that shows such dramatically high AODs in that biomass burning area.

Page 4353, line 24. . . . It is demanding to provide information regarding the CALIPSO data quality (uncertainties) in such situations with so high AOD (larger than 2). How trustworthy are all the shown CALIPSO products. Can I trust the depolarization ratio profiles down to the ground? . . . at such high AOD values? What about multiple scattering by dust in such cases, must be large? CALIPSO lidar is not just a powerful lidar. I am surprised about the shown results. Please provide a bit larger discussion regarding uncertainties. Ask the CALIPSO people to provide uncertainty information for situations with such high AOD.

Figure 3 is one of the main figures and shows the full advantage of a spaceborne lidar! BUT Figure 3 is rather small (must be increased by at least factor of 2). Maybe it is then necessary to split the figures in two plots. Most parts of Figure 4 can be omitted. Concentrated on CALIPSO observations that are relevant for this paper. Then more details can be seen. Figure 4 is also too small!

Page 4354, line 20: Add Tesche et al (JGR, 2009, SAMUM results) to the references and compare their results with the CALIPSO findings. I guess, agreement is reasonable. This comparison will help to convince the reader that CALIPSO data are trustworthy!

Page 4355: Volume depolarization ratios are always not easy to explain. They are influenced by the strength of particle backscattering (in comparison with Rayleigh backscattering) and by the influence of the different scatterer types. So this complicates the discussion. On the other hand, it is certainly too difficult to show color plots in terms of particle depolarization ratios. But add some sentence and explain this. It must be clear to the reader why the depolarization ratio is so variable. According to the Tesche

C2001

(2009) paper dust particle depolarization ratio is obviously around 30-35% and the particle depolarization ratio of smoke (fine mode particles) is obviously close to 0%. That should be mentioned very clearly.

Page 4355, line 4: I can not believe that European haze can make it down to central Africa. There are many other sources of pollution, e.g., from northern Africa. Do the trajectories indicate such a haze transport? Please check, if yes, mention this (trajectories support this hypothesis), if no, remove the hypothesis.

Page 4355, line 24: The AOD is so large, and at such favourable conditions MODIS has difficulties, over the Ocean? Please explain!

Page 4356, line 14: After section 3.3.2 another subsection is required, not to say demanded. What do transport models show? Are DREAM model runs for this case? Please check!. What about HYSPLIT trajectories. We need support by air mass transport simulations! Without such a support, all statements that follow are (almost) pure speculation and are thus unacceptable to be presented in a scientific paper. Furthermore, the authors want to create a link from Bodele to Amazonia. That has to be shown!!! Demonstrated by air mass transport simulations!!! If such simulations are highly uncertain, then the hypothesis is highly uncertain, too. But even such a result would be a result worthwhile to be presented as a quality criteria for the highly speculative hypothesis.

Page 4356, line 17. . . : Arrival of dust. . . ? Please show that this hypothesis is supported by air mass transport simulations.

Brazil observations from 22-26 February are related to dust emissions from 18-27 February. This is nonsense, what went wrong? Please clarify.

Page 4356 line 22: Ok, large particles identified. Source: Sahara! Are there potentially other sources for large particles? Do the chemical analysis during AMAZE allow to identify smoke, too? Would be confusing, if you only identified the dust, but not the

C2002

smoke. Measurements are done during the wet season. Can you estimate the washout effect? Check satellite imagery for the last two days of the travel across the rain forest.

Page 4357, line 10: Ansmann et al (2009, GRL) provide similar conclusions (3-4 km top height). Should be mentioned, too

Page 4355, line 14: ... that closely follows dust emitted from the Bodele depression AND MANY OTHER AREAS OF THE SOUTHERN SAHARA. ....

Page 4361, line 25: Liu, D 2008a, Liu, Z 2008b, Liu D 2008b, better a,b,c? ignoring D or Z?

Page 4362, line 13: Martin et al. ... as long as the paper is not published (at least in press) it should not show up in the references.

Figures:

Fig1: Use star or closed circle symbol in Fig 1a to indicate the site

Fig2a: Use linear scale for Angstrom from 0. to 0.7 (presently one number, log scale?, is insufficient).

Fig2b: Use more contrasting colors for the trajectories. Hard to identify them in Fig 2b. Use yellow star or bullet to indicate the AERONET site.

Fig 3a,b top: Figures are too small, where is the equator?...indicate some latitudes! Symbols 'a' for Fig 3a and 'b' to indicate Fig 3b are missing.

Fig3a,b bottom: Figures are too small , unsufficient height and longitude information.

Enlarge the plots, use other colors to clearly indicate the areas and Bodele (with star or bullet symbol).

Fig4: Figure is too small , provide axis text and units. Vertical profile of WHAT (attenuated backscatter?). 60% of the data (latitudinal belt) shown are not needed here!

Fig 5: x-axis: Volume depolarization ratio, y axis: Occurrence frequency (Cases). Data C2003

set is based on 18-26 Feb 2008 (for the seven CALIPSO curtain like measurements)? Area from 20E-60W, 30N-30S?. Please provide this information!

Avoid ...depolarization signal. . .

Almost pure dust causes volume depolarization ratios of 25% at 532nm, pure dust causes more than 30%, what is the impact of multiple scattering here?

Fig6: Figure is too small, Occurrence frequency in percent? State that clearly, improve also: Volume depolarization ratio

Fig7: At least 30% of the AOD is caused by biomass burning smoke.

Fig7b x axis: Daily dust mass (Tonne) . . .what means Tonne, never heard!

Fig8, Provide proper x axis and y axis text and units

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Interactive comment on Atmos. Chem. Phys. Discuss., 10, 4345, 2010.