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## ***Interactive comment on “Aerosol Climatology over Nile Delta based on MODIS, MISR and OMI satellite data” by H. S. Marey et al.***

**H. S. Marey et al.**

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Author reply to Anonymous Referee #1: We would like to extend our appreciation for your helpful response about our manuscript “Aerosol Climatology over Nile Delta based on MODIS, MISR and OMI satellite data”.

Abstract: P10449, L1: Why since 1999? Did these pollution events not occur before or were their simply no measurements available before 1999?

The black cloud phenomenon has been observed since 1999 and not before and the reason is not clear; however there are possibilities of some reasons. The first one explanation is that, the maximum harvested rice area has reached about 1999 (Marey et al., 2010) and it is plausible that this maximum represent the threshold of Cairo's air

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capacity which already has other anthropogenic pollution sources (e.g. vehicle emissions and industrial emissions). Hence the air could not convey the biomass burning emissions and consequently severe air pollution has occurred. Secondly, farmers in the past used to use the rice husks for cooking as a fuel and in the recent years they have switched over to use gas, so they no longer need the rice residuals for domestic use and they dispose of them by burning them in the open fields. Unfortunately, there is no comparable satellite data before 2000 to show the difference in the situation to help explain why the black cloud did not form before 2000.

P10449, L3: As described later, the desert dust is a different pollution event than the “black clouds” that occurs in spring and is of natural origin. In the abstract it sounds like that dust is also contributing to the black cloud events.

Yes, the desert dust is a different pollution event than the “black clouds” that occurs in spring and is of natural origin. However, the microphysical aerosol properties indicate that the aerosols at the time of the black cloud are mixed with some dust particles. This is not surprising, where Egypt suffers from dust particles all year long, which is indicated by the positive UVAI all year long.

P10449, L12-14: How high? Up to which altitudes are the dust layers found? The height of dust aerosols as seen by CALIPSO ranges from 2-5 km in altitude, whereas the smoke cloud layer heights are less than 1 km.

-Generally, I would suggest emphasizing in the abstract a bit more that data sets are used to get which information (e.g. AOD for deriving aerosol climatologies, CALIPSO for getting information on in which altitude are certain types of particles found).

For more emphasizing in the abstract a bit more about the data sets which are used, I would do that, but the abstract will be too long where used several data sets and I believe this is not accepted by the journal. Hence, I did that in more details in the second section of data.

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-When using AOD how do you differentiate between carbonaceous and dust aerosols?

Actually, I do not just use AOD to differentiate between carbonaceous and dust aerosols. I used UVAI as well as microphysical properties (size and shape) to perform this differentiation.

Introduction:

P10451, L13: What do you mean with spring wind events? Are these characterized by increased wind speeds or by a change of wind direction? What are the meteorological conditions behind these spring wind events?

The spring wind events are characterized by increased wind speeds and change of the dominant wind direction. The dominant wind direction usually comes from North or NW; however the wind direction in the spring during strong wind events comes from West or SW.

P10451, L18: “There are seasonal sources: : :.” Did you not just in the sentence before show that there is a seasonal cycle describing the concentrations found in different seasons?

We meant here to emphasize on the two air pollution episodes, which is not so clear in the last sentence. The two air pollution episodes are: the natural dust (“Khamsin” in spring) and the “black cloud” one in fall.

P10451, L20: Why since 1999? Did this event not occur earlier or were earlier no measurements available?

The black cloud phenomenon has been observed since 1999 and not before and the reason is not clear; however there are possibilities of some reasons. The first one explanation includes the maximum harvested rice area has reached about 1999 (Marey et al., 2010) and it is plausible that this maximum represent the threshold of Cairo’s air capacity which already has other anthropogenic pollution sources (e.g. vehicle emissions and industrial emissions). Hence the air could not convey the biomass burning

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emissions and consequently severe air pollution has occurred. Secondly, farmers in the past used to use the rice husks for cooking as a fuel and in the recent years they have switched over to use gas, so they no longer need the rice residuals for domestic use and they dispose of them by burning them in the open fields. Unfortunately, there is no comparable satellite data before 2000 to show the difference in the situation to help explain why the black cloud did not form before 2000.

P10451-P10452: You describe very nicely the health effects of black clouds. However, you do not say anything about the health effects concerning dust storms. Which effects do they have? Though they are a natural pollution event, there must be also some health effects or damage due to these.

You are totally right, however, where the particulate at the time of black cloud is finer (or smaller) than dust particulates, so they are more serious to study and more harm in their effect. Consequently most of the studies focus on black cloud event. Nevertheless, I did not find any record or article about health effect of dust air pollution health effects, so it may be a good point for the future research to investigate the health effects concerning dust storms.

P10452, I3-4: This needs some more clarification. How does that work? Do the particles not serve as CCN and produce more clouds and thus also more rain? This is part of Rosenfeld's study which revealed that both cloud droplet coalescence and ice precipitation formation are inhibited in polluted clouds (Rosenfeld, 2000) and hence change water cycle.

P10453, L20: How can one relate from fire counts to the source? Please clarify.

Marey et al. (2010) used MODIS fire counts to study the most probable causes of black cloud formation. They did monthly average of fire counts from 2001-2008, which showed a maximum fire counts number in fall each year. Also, they used GIS to illustrate the spatial distributions of those fire points. The GIS maps indicated that most of those fire locations are in the agricultural land (in the East and North of Cairo) that

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has the rice crops. Additionally MISR smoke plumes demonstrated that most of fire points are included in or headed the smoke plumes, indicating that the plumes originated from those fires. Actually it was very interesting study and you can find more details at Citation: Marey, H. S., J. C. Gille, H. M. El-Askary, E. A. Shalaby, and M. E. El-Raey (2010), Study of the formation of the “black cloud” and its dynamics over Cairo, Egypt, using MODIS and MISR sensors, *J. Geophys. Res.*, 115, D21206, doi: 10.1029/2010JD014384.

P10453, L8: This should be clarified a bit more. Why are you looking at the microphysical properties? Why is it important to know them? Are you using the microphysical properties to differentiate between dust and biomass burning compounds? Which properties are you exactly looking at?

Actually studying microphysical properties has multi-purposes; however in our study we exploited the microphysical properties to differentiate between dust and carbonaceous aerosol types. The microphysical properties that we exactly looked at are the size and shape.

P10453, L17: It should already in the introduction clearly be differentiated that deserts cause natural air pollution while biomass burning and the black clouds cause anthropogenic pollution.

Several studies have been conducted to understand the main reasons for the increased pollution levels in Cairo. However genesis of the fall episodes (the black cloud season) is still under discussion and needs more investigations like the present study. For example, Marey et al., 2010 indicated that biomass burning is the main contributor of the black cloud formation whereas Prasad et al., 2010 mentioned that dust storms are the main cause of the black cloud formation every year. Thus the nature of aerosols at the time of fall air pollution episode is ambiguous and still in debate. To solve this conflict we did optical and microphysical climatology to investigate the aerosol types of air pollution episodes, especially the fall one (black cloud).

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## Results:

P10457, L5-9: Which time period of precipitation data was considered? For what purpose is the precipitation data used?

The precipitation data used are from 1990-2009. They used to interpret and correlate with the AOD data.

P10457, L1-5: Please give some more details here. From where were the trajectories started and over which time period were they calculated?

This is already clarified in the result section P10462, L16-18, where it is mentioned that 5 day back trajectories originating from Cairo on 17 April 2007 at 10:00UTC are computed and the trajectories were initiated at 3000m and 4000ma.g.l.

P10458, L3-5: Are year to year variations not the same like inter-annual variations. Do you mean here that you see a trend? I indeed can see a slight decrease in max in the years 2007 to 2009.

Year variations are the same like inter-annual variations. We are as you, we can see a slight decrease in max in the years 2007 to 2009. However when we did trend analysis from 200-2009, we did not get statistically significant change and this we meant by no inter-annual variations.

P10458, L6: How do you know that the dust season is in April and the black clouds in autumn? Though you already describe in the introduction it would be worth to repeat it here once again.

As it is mentioned in the introduction, Cairo and some Nile delta cities suffers from two seasonal air pollution events, one of them in spring and usually it is called “Khamsin” and the other is in fall and it is accompanied by black haze covering Cairo and sometimes some delta cities and that is why , it is called “black cloud”. I added them again as you advised me.

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L10458, L19-end of paragraph: This is not clear. Please clarify what the connection between AOD and precipitation is and why?

We meant to say there is anti-correlation between AOD and precipitation. In other words the high precipitation rate will lead to low AOD by washing out the atmosphere and when the precipitation rate is low, the AOD will be high. This is demonstrated in Figure (3), however the precipitation rate is not the only factor and there are several factors that affect the amount of AOD. Thus in absence of other factors, the anti-correlation between AOD and precipitation rate will be obvious as the data in Figure 1 shown in summer and winter. P10458, L25: This sentence is not clear, I suggest rephrasing. We did rephrase of “As a result in winters, the AODs are minimum due to washing out of airborne particles by rain events”. To “the frequent occurrence of rain event in winter (which lead to high precipitation rate) decrease the airborne particles by washing them out and hence reduce the AODs to its minimum”.

P10458, L27-29: This sentence is also not clear. Sounds like that photochemical processes lead to low wind speeds. That makes no sense and I guess this is not what you mean. You rather mean that these processes act at the same time.

We did rephrase of “Moreover, in the summer season photochemical processes lead to slight increases in the values of aerosol optical characteristics.” To the photochemical processes in summer act at the same time (besides low precipitation rate) to slight increase the values of aerosol optical characteristics.

P10459, L5-7: Is that not simply due to the fact that there is more rain in winter than in summer in these regions?

This part of Papadimas et al. (2008) study and they showed that the precipitation rate is one of the strongest controlling factors in winter. However in summer emission rates of anthropogenic pollution are more important factors that vary the AOD values.

P10459, L10-12: This does not really explain why you get differences between Terra

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and Aqua. I agree that these differences are not significant, but still there must be an explanation why these are found.

The reason of the difference between Terra and Aqua is not known, however we suggest it is because the difference in their time picking the image. The Terra mission is in the morning (10.30) and the Aqua is in the afternoon (1.30). This may cause discrepancies in the AOD values. Because the differences are not statistically significant, we did not give it much attention to explain in our paper.

P10459, L23-end of paragraph: It is not clear from the text that data sets from different stations are used. In the figure captions, however, it is well explained. We did not mention in text that data sets from different stations are used because we did that in the data section (second section).

L23-end of paragraph: This should also be more clarified. It seems you split the data set to get two entire years. Is that correct?

Actually the data of AERONET are already divided between two stations. Both stations are in Cairo and are close to each other in location that is why I got all of them and represented them as two sequencing years. P10460, L3: Why is the AOD at 1020 nm higher? Is the following sentence giving the explanation? If yes, this should be said more clearly.

Actually at this line (P10460, L3) we said that “the AOD at 500 nm is considerably higher than those values at 1020 nm” and not the opposite. The wavelength dependence gives information about particle size, so when AOD at 500 nm is higher than those values at 1020 nm, it means that most of particles have small size. Because particle size analysis will be discussed in the following section (microphysical properties section), so we postponed explanation to the next section.

P10461, L2: Should not also the transport pattern play a role?

Yes you are right, it may play a role and I am going to add this point, thanks for that.

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P10461, L8: Up to which altitudes are the dust aerosols found? What is the reason that the aerosols during the black cloud events stay in the planetary boundary layer?

The dust aerosols are found up to 5 km altitude. The reason that the aerosols during the black cloud events stay in the planetary boundary layer is the frequent occurrence of temperature inversions at this time and this is discussed in more details at Marey et al. (2010).

P10461, L14-23: Can it be that the descriptions of the two panels are mixed up? Otherwise one would get the aerosol layers in the upper panel below the surface.

You are really right, I am so sorry; the descriptions of the two panels are mixed up. I did correct them, thanks for pointing this out to us.

Lxx: A general question, how do you differentiate between clouds and aerosol?

The CALIPSO level 2 has a product called vertical feature mask. This product has classified layers as aerosols or clouds. This classification based on the back scatter and the depolarization ratio values. Sometimes this classification has some errors and is not correct, so it is better to look at MISR MODIS or OMI UVAI images at the same time to assure the layer definition or classification.

P10462, L23: How does the NAO affect the "Cow" pattern? Does this really help to mention here? I would suggest adding some more details on this relationship.

During high NAO years a northward shift of the North Atlantic westerlies yields drier conditions over southern Europe and the Mediterranean Sea. This enhances both dust uptake and transport to the Mediterranean Basin. More details are found at Moulin et al. (1997).

P10462, L28 and following lines: It is not really clear which additional information you gain from size and shape of the particles.

We meant here to say that MISR will give us more detailed information about size and

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shape of aerosols, which lead to more information about aerosol types.

P10463, L27: add “(dust)” and “black cloud” after natural and anthropogenic, respectively. We added them accordingly.

P10463, L23: This is not clearly explained. How do you get information about the aerosol type from the microphysical properties?

We use microphysical properties to drive information about the aerosol type by using size and shape values. We know from literature that dust particles are large and have non-sphere shape while biomasses burning (carbonaceous or smoke) are small and spherical particles. Thus by investigating these two parameters (size and shape) as well as the optical properties, more information about aerosol type can be obtained.

Discussion and Conclusion:

P10464, L20: Which regions (lat/lon) are defined as Nile delta and Western desert? Nile Delta region is defined as 30°E to 32°E and 30°N to 32°N and this is mentioned in page 10457 L14. The Western desert is defined as 25°E–29°E and 25°N–29°N and this is mentioned at page 10457 L19.

P10465, L9-11: Why is it like this?

We believe that the frequent occurrence of temperature inversions is responsible for presence of the smoke aerosols in the PBL and this is discussed in more details at Marey et al. (2010).

P10465, L21: You already have known that and the measurements corroborate this.

Yes we knew that but not on scientific basis and now the scientific measurements corroborate this information.

P10465, L16-20: Why can large particles be related to dust? What are the typical characteristics of dust or carbonaceous particles?

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It is well known from literature that dust have large particles while carbonaceous are small particles.

P10465, L9-end of paragraph: These are also quite important results and could be mentioned also in the abstract.

Thanks for pointing this out and we included them in the abstract.

Figures:

Figure 1: Mark the Nile delta in the map.

The Nile delta mark is added accordingly

Figure 2: add titles to the Figures for (a) Nile delta and (b) Western desert.

The titles to the Figures for (a) Nile delta and (b) Western desert are added accordingly.

Figure 3: add titles as for Figure 2.

The titles are added accordingly.

Figure 4: It would be maybe helpful and more clearly if the symbols would be connected with lines.

There are missing monthly values and also the measurements did not start from Jan to Dec, so it will be confusing or misleading to connect them with lines.

Figure 5: I think the Figure would be more clearly if it would be shown in two Figures, one showing the daily UVAI and one showing the monthly UVAI. Caption: Are both data sets from OMI?

Yes both data sets are from OMI. We separated them into two figures, one for daily and one for monthly.

Figure 6: Please mark Cairo more clearly on the maps. The location of the Nile Delta is here somewhat different than it was described before in the text. In the text you said

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it is the area around 30 to 32 E and 30 to 32 N. It would also increase the readability of the figures if titles with the dates above the figures would be added.

We mentioned in the text that it is not easy to get CALIPSO image exactly over Cairo or Nile delta region. Thus one of the images (a) is west Cairo and not exactly over Nile delta and the other (b) is nearly passed over Cairo. The titles with dates are added to the figures accordingly.

Figure 9: The legend reads in both figures AOD fraction. It would be good to make it more visible also in the figure that one is for shape and one for size. Also here it would be good to add titles to the figures with the regions ((a) Nile delta and (c) Cairo). Is figure b also showing a climatology? If yes, that should be added to the caption.

Yes figure b is also climatology and we added it to the caption. We added size and shape fraction to the Y axis title to clearly identify the figures.

Technical corrections:

P10450, L7: : : ..10 yr period from (insert “period from”) We inserted “period from” at P10450, L7. P10450, L8: : : ..observed in the AOD: : : : :(insert “in the AOD”) P10454, L13: Are the numbers/plus-minus signs correct? We inserted “in the AOD” at P10450, L8. The first plus-minus signs at P10454, L13 is not correct, we are sorry, it is a typing mistake. P10456, L23-25: The comma should be after the coordinates and it should read “where the : : : :”. The sentence is corrected accordingly. P10458, L24: plotted is written twice, skip one. The word “plotted” is deleted accordingly. P10458, L24. P10460, L18: “data sets” instead of “datasets”. It is corrected accordingly. P10461, L16 and 17: “latitude” instead of “lat”. It is corrected accordingly. P10465, L20: Thus, this result : : : : :(insert this). The word “this” is inserted accordingly. P10465, L23: “black cloud” (small letters and in quotations as done before) instead of “Black Cloud” It is corrected accordingly. P10466, L4: skip “the” before fall. It is corrected accordingly. P10466, L11: skip “the” before fall. It is corrected accordingly. P10466, L13-14: These two sentences should be one or the first one needs to be rephrased. The second

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sentence is deleted at P10466, L14. Figure 6 caption: "CALIPSO" instead of "calypso".  
It is corrected accordingly.

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Interactive comment on Atmos. Chem. Phys. Discuss., 11, 10449, 2011.

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