We thank Referee #1 for the review of the manuscript. We really appreciate the general and specific comments. Our responses are given hereafter.

Referee's comment: The paper could become scientifically more relevant when the more than 5 years of data, KCICLO corrected, were included in the time series.

Authors' response: We fully agree with the Referee. However, obtaining long AOD data series with the minimum required quality is a very difficult task in remote stations, as Tamanrasset, in which the annual exchange of instruments is difficult (this annual exchange is recommended by AERONET for calibration and maintenance of each instrument). Moreover, intense dust storms dirty the optics sometimes very quickly, sometimes progressively. This and other instrumental issues make some data sets not to achieve AERONET level 2.0.
This is the case of Tamanrasset in which, from February 2009 to October 2011 (983 days), the same sun photometer was installed. Socio-political problems prevent the exchange of the instrument on time. Moreover, the SUN and the SKY channels of the photometer contained variable amounts of dirtiness at different times, which is very difficult to correct for a very long time series (please, see the KCICLO method requirements in Appendix 1 of the present response: *Authors' response to Referee #2 about KCICLO method*).
Moreover, the sun photometer installed from October 2011 to October 2012 had severe electronic troubles due to a battery power failure. This situation leads to a lack of measurements (due to robot or filter errors) or to wrong measurements (no counts or saturated counts). A new battery was installed in May 2012 after solving many problems in the customs clearance. However, the quality of the data series was already compromised.
As a consequence, data for the period February 2009-October 2012 will be likely never promoted to AERONET Level 2.0, and what is worse, Level 1.5 data in this period do not have the sufficient quality to be properly corrected even with KCICLO method. It should be taken into account the requirements that should be fulfilled to successfully apply this method (Appendix 1 of the present response).
Finally, the sun photometer installed from November 2012 to December 2013 is now under evaluation and post-calibration.
Hopefully, data after November 2012 will achieve AERONET level 2.0 and might be incorporated in the future to perform relatively long term analysis, but there is no chance for the moment.
In any case, the time series analysed in the paper has been long enough to characterise the main features of the station such as the seasonal variation, the relation to the Convective Boundary Layer thermodynamic features, and the identification of the dust sources potentially impacting Tamanrasset.
A brief explanation about the lack of a longer time series will be incorporated into the text.

Referee's comment: The detailed discussion of AOD statistics and aerosol characteristics presented in Chapter 3.1 is mostly a repetition and confirmation of results already given in the 2011 work by Guirado et al.

Authors' response: We do not agree with this assessment. Guirado et al. (2011) briefly showed very preliminary results about aerosol characteristics at Tamanrasset that have been enlarged and improved in the present study:

1. Annual statistics provided by Guirado et al. (2011) were partly affected by fictitious diurnal cycle. After KCICLO correction, the annual AOD and AE mean values provided in the present paper (Sect. 3.1.1) are globally lower (around 8% and 17% respectively). More accurate and extended monthly and seasonal statistics are shown in the present paper (Sect. 3.1.1).
2. The same methodology of Guirado et al. (2011) is used to identify aerosol types at Tamanrasset but an in-depth analysis is provided here (Sect. 3.1.2).
3. Specific characterizations have been made for the first time in the present paper: fine mode fraction (Sect. 3.1.1), aerosol microphysics (Sect. 3.1.3), aerosol optical properties (Sect. 3.1.4), and annual evolution and seasonal features of precipitable water vapour (Sect. 3.1.5).
4. The aerosol vertical distribution has been characterised by the analysis of monthly and seasonal CALIOP aerosol extinction profiles at 532 nm (Seasonal profiles are shown in Fig. 8c-d in Sect 3.2).
5. Dust sources potentially impacting Tamanrasset have been identified applying the Concentration Weighted Trajectory (CWT) method (Sect. 3.2).
6. The impact of MCS (haboobs in many cases) on Tamanrasset will be incorporated in the text (please, see Appendix 2 of the present response: *Second response to John Marsham's Short Comment*).

<u>Referee's comment:</u> The observational basis (No days 25 to 90) for statistical analysis in terms of monthly and seasonal means remains rather poor and the addition of KCICLO corrected data since February 2009 would make it much more robust and informative. Most other AOD climatologies are based on much longer time series because of the large annual and inter-annual variations of aerosol concentrations.

<u>Authors' response:</u> It is not our intention to provide an AOD climatology at Tamanrasset site given the short data series available. However, we pretend to characterise aerosols by analysing a time series as accurate as possible by including the KCICLO correction to available AERONET level 2.0 data since Tamanrasset is a key station in the Sahara quite suitable for dust models and satellite based sensors evaluation.

<u>Referee's comment:</u> The scientific goal behind this analysis of this time series remains somewhat vague. I would like to learn about the long-term AOD climatology at this Saharan site, or about how the successful recovery of degraded observations did modify the previous 2011 results.

<u>Authors' response:</u> As mentioned before, the AOD and AE recovered data series show lower annual mean values (around 8% and 17% respectively) than the results presented by Guirado et al. (2011). As a consequence, more accurate and extended monthly and seasonal statistics have been provided. However, and as said before a long-term AOD data series at Tamanrasset is, unfortunately, not available.
Our scientific goal is associate the specific aerosol characteristics of Tamanrasset site with atmospheric features of the region. We have related the AOD, AE, FMF and PWV time series with the Convective Boundary Layer (CBL) and air transport pathways. We have found main seasonal patterns in terms of both aerosol distribution and air mass trajectories. Furthermore, and following the suggestions of Dr. Marsham, we provide information about the impact of Mesoscale Convective Systems affecting Tamanrasset

dust records during the wet-hot season (from April to September) by using NMMB/BSC dust model and MODIS-Aqua (Deep Blue) data. Please, see Appendix 2 of the present response: *Second response to John Marsham's Short Comment*.

Referee's comment: It remains unclear to me how the CWT method is applicable to vertically resolved trajectories when the observed weight at the receptor site is represented by a column integrated observation?

Authors' response: For this reason, we analysed CALIOP aerosol extinction profiles at 532 nm (Fig. 8c-d) to link aerosol extinctions and air mass pathways at certain heights. According to averaged CALIOP profiles, HYSPLIT back-trajectories at several end-point heights were calculated and analysed. We verified that major differences were shown when the end-point heights varied with respect to the CBL top height during both the dry and the wet seasons (Fig. 4a). As a consequence of this analysis, we selected three representative height levels: Ground level, 2600 m a.g.l. (above the CBL top in the dry season and within the CBL during the wet season), and 5600 m a.g.l. (above the CBL all year long). Furthermore, the suitability of the method is proved by incorporating the impact of MCS (haboobs in many cases) on Tamanrasset (please, see Appendix 2 of the present response: *Second response to John Marsham's Short Comment*). We can see how air masses come from areas where MCS have developed impacting severely the AOD records from Tamanrasset.

Referee's comment: My ignorance about CWT apart, the paper should more clearly point out any new findings from this study. I got the impression that both dust sources were already identified by d'Almeida and later works cited in text. The results presented here could then, e.g. be used to argument that the main source regions did not change over 30 years.

Authors' response: We do not pretend to identify general dust sources of mineral dust. Our goal is to identify which dust sources (previously identified by other authors) potentially impact Tamanrasset. Since the hydrological cycle over the Sahara is very poor and does not seem to have undergone changes in recent centuries, we do not expect changes in dust sources. However, a good knowledge of the dust sources affecting Tamanrasset could help elucidate changes in atmospheric patterns if appreciable interannual changes in AOD at Tamanrasset are recorded. For example, they could be subject to changes in the position of the Intertropical convergence zone (ITCZ) and/or its intensity, or to changes of wind regime on the Sahara, driven by changes of major pressure systems.

Referee's comment: This paper is well written and was apparently subjected to skilled proof reading and language editing. All figures are clearly labelled and described in captions, so are the tables. Their number is adequate to support the analysis presented in text. I appreciate the explicit omission of additional figures 'for the sake of brevit'.

Authors' response: The authors thank Referee #1 for the positive comments and assessment on edition aspects.

Referee's comment: Most of the many acronyms are properly introduced, but some, as e.g. KCICLO or NMMB/BSC are apparently too common within the group of authors. They are however readily found by Google.

Authors' response: Due to the word "KCICLO" is not exactly an acronym we did not introduce it in the paper. The name of the method is a combination of words corresponding to K (name of a constant) and "ciclo" (cycle in Spanish). This explanation will be incorporated into the text.
NMMB/BSC acronym corresponds to "NCEP Non-hydrostatic Multiscale Model (NMMB) Barcelona Supercomputing Center (BSC)". It will be properly introduced in Section 3.2. (Potential source regions) where we will include a short analysis of MCSs.

Referee's comment: Sect. 3.1.1 Line 18: absorption should probably read *extinction*

Authors' response: We will remove the following part of the sentence (Lines 18 and 19 in Sect. 3.1.1): "…and the strongest dust absorption from May to August at Tamanrasset station" because it refers to optical properties of aerosols over Tamanrasset which is addressed in the corresponding section 3.1.4.

Appendix 1: Authors' response to Referee #2 about KCICLO method

<u>Referee's comment:</u> Apparently, KCICLO method is a feasible way to correct the data when the current instrument calibration is for some reason over or down estimated. I would like to read more careful justification why the method is applicable specifically under conditions where the instrument window is contaminated.

<u>Authors' response:</u> The KCICLO method is used to detect, evaluate and correct possible calibration problems, after discarding a real atmospheric effect or instrument malfunctions (Cachorro et al., 2004, 2008). Particularly, the obstruction in the optical path, due to dirtiness on the sun photometer front windows, leads to a distinct diurnal cycle pattern that can be corrected using the KCICLO method. This fictitious diurnal cycle is due to the systematic absolute error in the AOD measurements as a consequence of the calibration errors: the magnitude of this absolute error is greatest at midday because varies as the inverse of the solar air mass (Cachorro et al., 2008). Equivalent effects, such as moderate filter degradation can be also corrected (Cachorro et al., 2008).

However, only certain stations fulfil a set of weather requirements to apply this ''in situ'' correction-calibration procedure: a sufficient number of clear-sky and stable days are needed for a given period to be corrected. In the context of measurements affected by a calibration problem, stable days mean that the retrieved AOD should show an ideal cosine convex or concave shape of the diurnal cycle (Cachorro et al., 2004, 2008).

Furthermore, the selected days must fulfil another set of requirements about air mass range (higher than 0.4 and typically between 1.7 and 6), turbidity (AOD (440 nm) < 0.12 and variability lower than 5% in the specified air mass range), number of data points (at least 12 per day), and standard deviation of the fit to quantify the calibration factor error (lower than 0.01) (Cachorro et al., 2008).

Therefore, the successfully application of the KCICLO method over a given period is associated with a sufficient number of days (5–10%) fulfilling all the above mentioned requirements. As a consequence, the application of the method it is not always feasible at all stations or at all periods of time.

At Tamanrasset, a sufficient number of days from 18 November 2007 to 20 June 2008 were available to properly apply the KCICLO method. Only two different corrections were performed, i.e. only two different types of contamination (amount of dirtiness and lenses affected) were detected.

This point will be also further clarified into the text.

Appendix 2: Second response to John Marsham's Short Comment

The authors thank Dr. Marsham for his interesting remarks and suggestions concerning the impact of cold pool outflows ("haboobs") from moist convection over Tamanrasset in summertime. Based on these suggestions we have performed some additional analysis will improve the paper results.

We have analysed 21 episodes of Mesoscale Convective Systems (MCSs) to understand their influence over Tamanrasset. The events have been selected through comparison between observed AERONET AOD and NMMB/BSC-Dust model AOD over Tamanrasset (Fig. SC-2). NMMB/BSC-Dust model properly reproduces dust transport associated with synoptic-scale meteorological processes observed during most part of the year. However, from June to September the model is not capable to capture strong and fast dust outbreaks. As indicated by Marsham et al. (2011), Mesoscale Convective Systems (MCSs) cannot be well captured by global meteorological models or regional dust models. The summertime observation-model discrepancies have been used to identify potential MCSs affecting Tamanrasset. High temporal and spatial SEVIRI-MSG-2 RGB dust composites combined with ECMWF meteorological analysis have been also analysed using McIdas to assess the convective origin of each event.

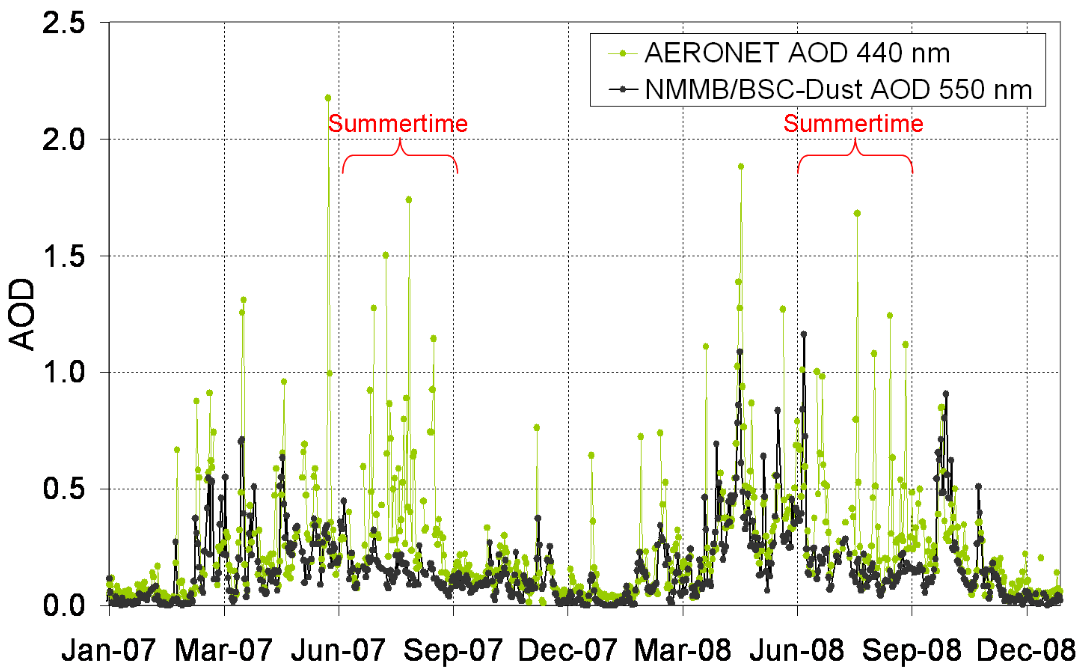

Fig. SC-2. AERONET and NMMB/BSC-Dust AOD daily mean values for the period 2007-2008.

Once identified and confirmed the MCS events impacting Tamanrasset, a similar approach to Roberts (2014) and Roberts et al. (2014) has been followed. The MODIS Deep Blue composite AOD and AOD anomaly have been analysed for the 21 daily episodes of maximum AOD during MCSs events (Fig. SC-3). The AOD anomaly has been calculated over the 2007-2008 summertime mean value.

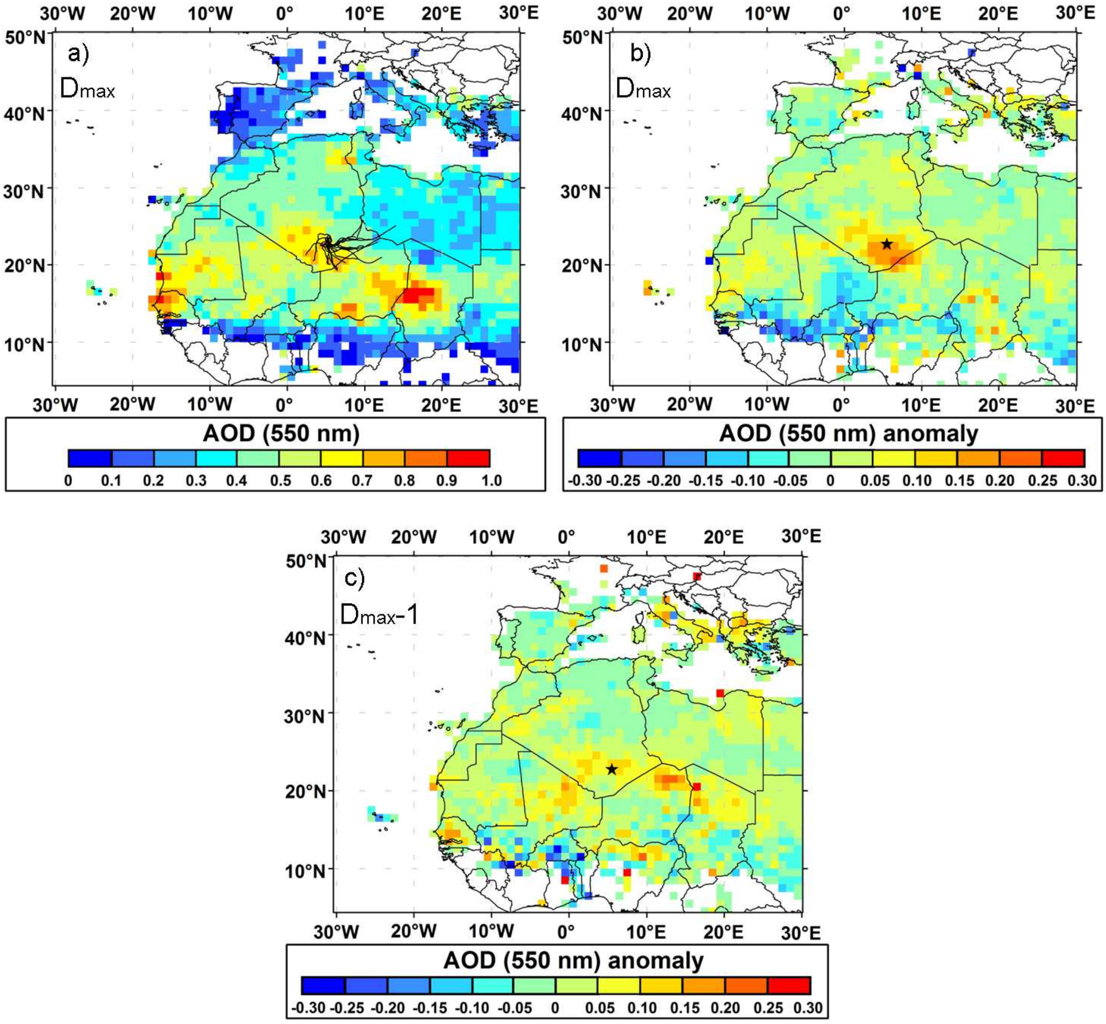

Fig. SC-3. Composite Moderate Resolution Imaging Spectrometer (MODIS) Deep Blue 550 nm (a) aerosol optical depth (AOD) and (b and c) AOD anomaly at Tamanrasset (black star). The maps are shown for (a and b) the 21 days of maximum AOD (Dmax) during Mesoscale Convective Systems (MCSs) events and (c) the 21 days before these maxima (Dmax-1). Two-day HYSPLIT (Hybrid Single Particle Lagrangian Integrated Trajectory Model) back-trajectories arriving at Tamanrasset at ground level (black solid lines) are also displayed in panel (a).

Several regions of high AOD, including the surrounding area of Tamanrasset, are shown in the MODIS Deep Blue averaged AOD map (Fig SC-3a). However, a strong positive AOD anomaly (above 0.20) is only shown south Tamanrasset (Fig SC-3b) as a consequence of dust uplift associated to MCSs in this area driven by northward displacement of the intertropical discontinuity (ITD). The HYSPLIT back-trajectories show that air flow getting Tamanrasset during these events comes from the positive AOD anomaly south of Tamanrasset. Simultaneously, a negative AOD anomaly observed over eastern Mali is probably caused by rainfall associated to MCSs, since on Dmax-1 this anomaly is located to the east, south Tamanrasset (Fig SC-3c). These results are in good agreement with Roberts (2014) and Roberts et al. (2014) who analysed 31 anomalously rainy episodes in the Sahara and northern Sahel linked to dust uplift in the area.

This short analysis and the corresponding results and references will be included in Section 3.2 (Potential source regions) of the paper as a complementary analysis of MCSs affecting Tamanrasset which are not properly parameterized by HYSPLIT back-trajectories. Furthermore, a short description of the NMMB/BSC-Dust model and MODIS Deep Blue AOD product will be provided.

Short Comment References

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