We would like to thank the Reviewer for carefully reading of manuscript and for numerous useful suggestions.

1) I found that the main interesting point of the paper is Figure (4), which depicts the variation of the advection of mineral dust, can affect the single scattering albedo. However the explanations given by the authors are rather confusing, e.g. L177 "stronger contribution of dust over the ocean than over the continent".
This statement is counter-intuitive because dust sources are located over the continent and AOD over the continent is also higher.

We agree that this sentence is counter-intuitive. AOD is indeed stronger above the continent than over the ocean because the atmosphere also contains aerosols issued from biomass burning occurring south of our region of interest. As transport follows a NE-SW direction in winter, dust coming from the NW of Mauritania is partially seen over the continent (in AOD and SSA) and its main signature should be seen over the ocean. Hence, we attribute the high SSA values encountered over the Ocean to dust originated from this NW Mauritanian source which should exclusively be composed of mineral dust.
We have modified the text L225-227 (in the new version) to clarify our explanation.

2) *As well in the conclusion L324, "MAM is being closer to the summer situation": this is not the case for the SSA for which we observe a gradient between land and ocean while the vertical distribution is similar. You must clarify this point.*

L324 (in the previous version), we were referring to the vertical distribution when stating that "MAM is being closer to the summer situation". However, SSA over the ocean is indeed higher than over the continent (Figure 4). The same reason as mentioned above applies here. Over the continent, AOD is high in the southern part of our domain (Figure 3b) where aerosols from biomass burning mix with aerosol dust giving SSA values lower than 0.9 (Malavelle, 2011). As the transport is still NE-SW, SSA over the ocean still records a higher contribution of mineral dust over the ocean than the continent. This explains the higher SSA over the ocean. Comment was added in the text L391.

3) *Although it could be interesting to use a different zonal area for summer and winter because the dust transport follows a E-W direction during summer while it is NE-SW during winter as depict by Figure (3).*

Our objective was to study the vertical distribution of mineral dust and to better understand the fate of dust through the land-ocean transition. We therefore tried to prevent the influence of other aerosols coming from biomass burning because they have different optical and chemical properties and hence have a different fate. As biomass burning occurs south of 12°N in winter and spring time (Engelstaedter et al., 2007), we decided to take this latitude as southern limit. We also wanted to keep a coastline oriented as "north-south" as possible in order to be able to locate the continent-ocean transition before looking at the aerosol properties above the ocean and land. As the coastline is oriented northeast/southwest north of Cape Blanc, we chose 21°N as northern limit. But indeed, winter and summer main transport directions are different but we believe the choice of this latitude band allows to capture most of the mineral dust signal.

4) - L44. Clarify this sentence and add relevant references. Explain how the AOD retrieval depends on vertical extent of the dust layer.

Based on perturbations induced by the Rayleigh scattering for the detection of absorbing aerosols, Chiapello et al., (1999) showed that TOMS AI is most sensitive to aerosols at high altitudes. We have added the a sentence to clarify this statement in the text L55-57.
The results of these authors were also related by Kaufman et al. (2005).

5) Provide information on the quality level (level 1.5 or level 2) and temporal resolution (daily mean or temporal window around satellite overpass). It appears later in the text that you have used monthly means.

AERONET is available under three different products: Level 1.0, 1.5 and 2.0. In this study, we have used Level 1.5 for Cape Verde and Level 2.0 for the other stations. We used Level 1.5 product for Cape Verde due to a lack of sufficient Level 2 data for this station.
Level 1.5 data are raised to Level 2.0 (quality-assured) after final calibration values are applied and manual data inspection is completed (http://aeronet.gsfc.nasa.gov/new_web/man_data.html; Smirnov et al., 2000a). At Level 1.5, the minimum aerosols optical depth ($\tau_{ai\ min}$) is identified at each wavelength (τ_{ai}) and for each station. If the difference $\tau_{ai} - \tau_{ai\ min}$ is less than the maximum of ($0.05*\tau_{ai\ min}$, 0.02) for each channel, then cloud is affected to this record. If this screening removes all but one point from a series then an additional criterion is applied to the spectral channels. If the Angström parameter computed using all available channels between 440 and 870 nm is greater than -0.1, then the point is considered cloud and pointing error free.
The final post-deployment calibration values are applied to the data set for producing Level 2.0 products. The spectral channels are evaluated for data anomalies, filter degradation or other possible instrument failures. The data are also inspected for possible cloud contaminated outliers.
Concerning the temporal resolution of AERONET observations, we computed a "daily" mean based upon data collected between 10am and 3pm in order to use observations collected during the same time window as satellite overpass. We then used these 10am-3pm daily averages to compute monthly 10am-3pm AOD.
The complementary information is added to the text L100-102.

6) L65. AE is an optical parameter. Extensive (AOD) and intensive (SSA, AE) parameters are more appropriate.

We took this remark into account and modified the text accordingly L82.

7) L78. Improve the description of uncertainties on aerosol parameters.

The uncertainty we are talking about L79 (in the previous version) concerns AERONET data. This uncertainty is inherent in the algorithm inversion used to retrieve aerosol characteristics. Some approximations are used in the numerical inversion algorithm which produce errors named relative errors having a standard deviation of 0.01 (Dubovik et al., 2000). A comment was added in the text L96-98.

8) L125. Clarify what is MDOF and what is p(x,y,z). Please refer to Adams et al (2012 and clearly define equation (1) and explain all the terms.

We are not sure to properly understand Reviewer's comment. MDOF is the Mineral Dust Occurrence Frequency (L151). In equation (1), p(x,y,z) is equivalent to MDOF. Indeed, it is not a probability of occurrence but a frequency of occurrence. L159
We added the following explanation of equation (1) .
The Occurrences in the longitude (x) are summed and normalized by the total valid satellite passes in a given longitudinal range (35°W-20°E).
p is the resulting occurrence frequency at the grid point, s the number of valid satellite passes at the same grid point, and N the number of grid points in a specified longitudinal range. It was now clarify in the text L160-161.

9) Figure 1 and related text starting L145. Compare AOD for the same wavelength. You can interpolate the sun photometer AOD at 500 nm from AOD at 440 and 675 nm.
Comment the regression coefficients you have obtained. In particular, explain why the regression for M'Bour site is significantly different from the others.

We agree with Reviewer. We now have interpolated (L176-177) AERONET AOD at 500 nm from AOD at 440 and 675 nm (new Figure 1). The correlations between AERONET and satellite data did not change significantly, nor the slopes or intercepts of the linear regression. L180-181
Indeed, the regression of AOD for M'bour site is not as good as for the other sites. M'bour is located at the shore at the interface between land and sea. The satellite algorithm retrieval is not the same over the land and over the ocean. As M'bour experiences both oceanic and continental influences (notably through wind diurnal cycles), we believe the AOD retrieval at the shore is more complexe than in land (Banizoumbou and Agoufou) or at sea (Cape verde). L183-185

10) L165. Correct sentence. The http link must be in the data description section.

This sentence was corrected accordingly L197
The link was now moved in the data and methodology section. L125

11) L167 and Figure (2). It is unclear which wavelength you have used for the comparison.
Please rewrite Figure (2) caption and avoid unnecessary information on site location. Why did you use daily data rather than monthly data as for the AOD validation ?

The right wavelength which used in this work is now written in the text L199
Figure 2 caption was wrong, we have now corrected it. The right wavelength is indicated on the x- and y- axes in the figure. We also removed unnecessary information about site location.

For the evaluation of the performance of satellite SSA retrievals we indeed used daily AERONET SSA using observations between 10am and 3pm. We used these daily observations to obtain significant correlations and robust regressions (see also our response to comment number 15 of Reviewer #2).

11) Figure 3. It is not possible to read the SSA contour lines. Provide an additional figure with SSA regional pattern.

We believe the superimposition of SSA contour levels onto AOD is better since they both represent mineral dust characteristics. We have improved the quality of our Figure 3. We hope this new Figure 3 will indeed be easier to read.

12) L232. Rewrite sentence and defined correctly which layer you are talking about.

According to Reviewer's remark, we reformulated the sentence as follow:
"Unlike winter, dust are concentrated between the higher layers of the ABL, from one to 5-6 km (Fig. 5C; Gamo, 1996), in response to intense convective mechanisms that are more common in the region at this season (Cuesta et al., 2009)." L282-283

13) L230. How do you use the AE ? Please clarify and clearly state this in the data and method section.

We agree with Reviewer. We now have clarified our use of AE in the data and method section.
Here we use aerosols optical thickness larger than 0.2 when Ångström Exponent is lower than 0.7 (see L116). This methodology is based on AOD and AE to characterise mineral dust and has already been used by Ben-Ami et al., (2010) and Drame et al., (2015).

14) L240. Explain the link between gravitational settlement and SSA. This whole paragraph is unclear. However it is of highly importance to get your point on the link between the dynamic of the dust transport and the optical properties. Consider also revising L298.
We did not intend to link the settlement of large particles to SSA properties. SSA remains high and roughly constant throughout the continent and over the ocean. We believe summer AOD in northern Africa is largely dominated by mineral dust which could explain the high SSA values encountered at this season. L294
We understand that the paragraph starting L298 (in the previous version) could be misleading. We therefore clarify this point in the manuscript. L364

Technical comments:
- Avoid use of "desertic aerosol". Prefer desert aerosol or better mineral dust
We have changed "desertic aerosol" expression accordingly throughout the manuscript (in the title and in the whole text)
- L42: correct sentence between brackets
Corrected accordingly (L53)
- L125: Adam must be outside brackets
Corrected accordingly (L154)

We would like to thank the Reviewer for having carefully read of the manuscript and for having made numerous useful suggestions.

1) In this paper, the authors present an analysis of the seasonal evolution of desert aerosol properties (AOD, SSA in particular) along a longitudinal band covering a part of Sahel and of the Eastern Atlantic Ocean. They use a combination of passive and active space-borne remote sensing observations, together with meteorological data and numerical weather prediction analyses. In spite of some merit, the paper contains too many inaccuracies. The authors do not really have a solid knowledge the dynamics/thermodynamics features of the WAM system impacting the atmospheric boundary layer over the Sahara, the dust emission and transport over the region. I have made numerous comments along these lines in the following.

No mention is made to previous projects/campaign that have taken place in the area and contributed to advance knowledge on dust-dynamics interactions: GERBILS, FENNEC, SAMUM. Some AMMA results are discussed.

We agree that very interesting knowledge was collected during the field campaigns carried out in the region. The FENNEC and the African Monsoon Multidisciplinary Analysis (AMMA) campaigns were used in Ryder et al., (2013), Cuesta et al., (2009) and Marticorena et al., (2010) which were cited (in the previous version). Saharan Mineral Dust Experiment (SAMUM) was also indirectly mentioned through Petzold et al., (2011). Please see the previous version (L287,L233,L190 L62 etc).
Puerto Rico Dust Experiment (PRIDE) campaign was also used in Reid et al. (2002) which was also cited L62 and L274 (in the previous version).
To this respect, we believe we took these observation campaigns into account to highlight the gain of knowledge that they implied, although we indeed didn't mention explicitly name them.
However, we acknowledge the interest of results issued from other field studies and we added a reference to Weinzierl et al. (2016) who published results from the SALTRACE experiment and McConnell et al.'s (2008) associated to the Dust Outflow and Deposition to the Ocean (DODO) project. L72-L75 etc, L349
The Saharan Dust Experiment (SHADE) and the Geostationary Earth Radiation Budget Intercomparison of Longwave and Shortwave radiation (GERBILS) were indirectly cited through Highwood et al., (2003) and Johnson and Osborne (2011), respectively. See the manuscript (L351 and L207)

2) I also think that the authors should discuss also to what extent the change in aerosol properties at land-sea transition has an impact on air-sea interactions or even the radiative budget in the region.

We agree with the Reviewer that the changes in aerosol properties will have an impact on the surface heating and hence on the heat fluxes at the interface and probably on winds at a regional scale. We added sentences to highlight this aspect but note that the paper aims at describing the seasonal changes of aerosol distribution and properties at the land-sea transition and does not pretend to answer about the climate effect of these changes.

Liao and Seinfeld (1998) or Kok (2011) showed that the radiative interactions are sensitive to the size of the mineral dust aerosols and their optical properties. These aerosols properties change during their transport along which they are affected by sedimentation and other processes.
We mentioned in the manuscript "During transport from North Africa to the Atlantic Ocean, very large amounts of coarse dust (Fig. 4c of the manuscript) are deposited along the path with a rapid change in the size distribution of aerosols near the west African coast (Ryder et al., 2013)" (L286-287 in the previous version). The changes of the aerosol size and properties during their transport will indeed impact the climate system (Huneeus et al., 2011, Mahowald et al., 2014).
McConnell et al. (2008) suggested that the variation in the aerosol profiles over the ocean has an impact on the radiative effect. Indeed, Highwood et al. (2003) showed that the radiative effect of the mineral dust aerosols is correlated with the altitude of the dust layer. Our Figure 5 clearly shows the seasonal variation of the vertical distribution. Hence, we added a sentence to discuss the fact that this seasonality will impact the radiative budget.
The modification of the Single Scattering Albedo across the land-sea transition also affect significantly the radiative budget. Having a higher SSA over the ocean than over the continent implies a stronger dust-induced cooling of the ocean relative to the continent. This differential cooling impacts the temperature gradients across the land-sea transition and hence might affect the wind. We added this discussion in the manuscript (L348-351)

3) Abstract
NCEP, CALIOP, OMI and SeaWIFS have to be defined.

The acronyms NCEP (National Center for Environmental Prediction), CALIPSO (Cloud Aerosol Lidar and Infrared Pathfinder Satellite Observations), CALIOP (Cloud-Aerosol Lidar with Orthogonal Polarization), OMI (Ozone Monitoring Instrument) and SeaWiFS (Sea-Viewing Wide Field-of-View Sensor) are now defined in the abstract.

4) L21-25: not only America. . . Transport pathways also include EU and the Mediterranean, depending on the season. Please correct.

This paragraph was corrected as follow (L27-30):

The mineral dust aerosols emitted from the Sahara desert can be transporter over long distances in the atmosphere and can be detected as far as Americas (Prospero et al., 1981; Swap et al., 1992; Formenti et al., 2001; Kaufman et al., 2005; Ansmann et al., 2009b; Ben–Ami et al., 2010), Mediterranean region (Bergametti et al., 1989; Moulin et al., 1998; Hamonou et al., 1999; Gobbi et al., 2000; Ansmann et al., 2003; Papayannis et al., 2008, Schmechtig et al., 2010) and Asia (Ganor and Mamane, 1982; Israelevich et al., (2003), Ganor et al., 2010).
But here, the study of dust transport focuses on the main corridor of their transport Westward Africa (Formenti et al., 2001).

5) L31: even larger particles have been found close to source regions: see the work of Ryder et al. during FENNEC

We added Ryder's (2013) reference and corrected the sentence as follow (L37):
The mineral particles suspended in the atmosphere come from different sources and have a nature similar to the nature of the soil from which they arise (Claquin et al., 1999, Formenti et al 2008) with a broad spectrum of particle sizes ranging between 0.01 µm and 300 µm (Wagener, 2008; Ryder et al., 2013).

6) *L37-38: no, the Observatory in Barbados set up by J. Prospero goes back to the 1960s*

In this sentence, we refer to the study of the transport from satellite information. In order to clarify the eventual amibiguity, we reformulate the sentence as follow:
Although the transport of mineral dust across the Atlantic Ocean started to be investigated in the 60s, it started to be studied from satellite observations in the 1970s (Kaufman et al., 2005, Taghavi et al., 2008). L44-46

7) L39-40: also cite the work of Shepanski et al. who have used the high temporal resolution of SEVIRI to analyze emission hot spots location and frequency

We agree with the Reviewer. This sentence was modified by adding Schepanski et al., (2007, 2009 and 2012) studies (L48). These authors have done a very interested work on the mineral dust based on SEVERI sensor to analyze emission hot spots location and frequency. Their work was cited in the previous version (L43,L49,L206,L227,L238).

8) *L43-44: not true. MODIS or MISR allow identifying dust using SSA deep blue is almost exclusively a dust product. . .*

We agree with Reviewer's remark and hence decided to remove the following sentence L52
“These satellite products also present some limitations since they are unable to differentiate aerosols and particularly those from desertic origin.”

9) *L46-47: what signal. . . be more specific*

We clarified that by writing L55-57:
“Moreover AOD estimated by satellite integrates the contribution of every kind of particles and this latter estimation also depends on the altitude at which aerosols are located. Based on perturbations induced by the Rayleigh scattering in the detection of absorbing aerosols, Chiapello et al. (1999) showed that TOMS AI is more sensitive to aerosols present at high altitude than at low altitude. In other words the signal changes with the height of the aerosol plume for a given aerosol content.

10) L48: the SAL is defined L52
It was now corrected accordingly L59

11) L48-49: The vertical disconnection of dust layers between land and ocean: I do not understand this. The SAL is an emanation of the Saharan ABL which is undercut by the low level flow from the Atlantic. . . this flow penetrates over the continent during the day.. so that the disconnection is not necessarily appearing at the land-sea transition..

First, we want to mention that we used disconnection instead of discontinuity and we apologize for this misuse (L60).
This discontinuity has already been mentionedin Chiapello et al. (1995) and Tsamalis et al., (2013) who used bothground measurements and satellite observations in their study. The satellite observation from CALIPSO was used in this work and results show a clear seasonal discontinuity of the dust layer at the land-ocean transition (see Figure 5 of the manuscript).

12) L55-56: are those elements part of the composition of dust? Otherwise where do they come from ?

Indeed, we did not relate theses elements to dust in this sentence. We reformulated the sentence as follow L66-67:
"In winter, the SAL is characterized by the transport of dust containing chemical elements such as aliminum (Al), silicon (Si), iron (Fe), titanium
(Ti) and manganese (Mn) (e.g., Formenti et al., (2001); Ben-Ami et al., (2010); and is located between 5°N and 10°N (e.g., Tsamalis et al., (2013))."

13) L57: not true, see the recent BAMS paper on the SALTRACE campaigns
"The studies relating aerosols to their transport are generally a simple description of the vertical distribution of aerosols in the SAL (Generoso et al., 2008; Liu et al., 2008; Ben-Ami et al., 2009; Braun, 2010; Yu et al., 2010; Adams et al., 2012; Ridley et al., 2012; Yang et al., 2012) or a description of the seasonality of the SAL in connection with large-scale dynamics (Liu et al., 2012; Tsamalis et al., 2013)."

We would like to mention that our work was initiated before the availability of the mentioned reference. However we took into account Reviewer's suggestion by adding a sentence to the former one L71-76:
"Some of studies relating aerosols to their transport are generally a simple description of the vertical distribution of aerosols in the SAL (Generoso et al., 2008; Liu et al., 2008; Ben-Ami et al., 2009; Braun, 2010; Yu et al., 2010; Adams et al., 2012; Ridley et al., 2012; Yang et al., 2012) or a description of the seasonality of the SAL in connection with large-scale dynamics (Liu et al., 2012; Tsamalis et al., 2013). However, the dust field campaigns, AMMA, SAMMUM-1 and 2, FENNEC or SALTRACE (see Table 1 of Weinzierl et al., (2016) carried out in West Africa and over the Atlantic Ocean improved our understanding of dust-dynamics interactions. During SALTRACE, a linear depolarization ratio of particles and a relative humidity threshold of 50% were used for differentiating different types of aerosol (Weinzierl et al., 2016). Authors showed that sea salt aerosol were restricted to the lower layer

superposed by biomass-dust mixtures. They also showed that the altitude of the mineral dust layer decreased westward."

14) L67: CALIOP and CALIPSO need to be defined.

All acronyms have now been defined.

15) Section 2: methodology and data What stations did you use? They should be listed here. . . Are you using level 2 data only ?

This following paragraph was added in the methodology and data section to clarify the data which have been used in this study L100-104.
"These data are used to validate remotely sensed AOD and SSA measurements. AERONET is available under three different products: Level 1.0, 1.5 and 2.0. In this study, we use Level 1.5 product for Cape Verde, due to a lack of sufficient Level 2 data for this station and Level 2.0 for the other stations (Banizoumbou, Agoufou and M'bour). Concerning the temporal resolution of AERONET observations, we compute a "daily" mean based upon data collected between 10am and 3pm in order to use observations collected during the same time window as satellite overpass. We then use these 10am-3pm daily averages to compute monthly 10am-3pm AOD."

16) L171-173: can you explain why the SSA-related correlations with ARONET stations are so low compared to the AOD-related correlations which are quite good. . .? Is this link to the threshold of 0.9 that you have selected? Changing this threshold to a higher value may improve the correlations. . . Also, it is unclear why the SSA correlations a better near the coast (M'Bour) where I would expect greater mixing of dust with other particles) than over the continent where dust should be present almost exclusively. .

We agree with the Reviewer. A comment was added in the text (L205-209).
The SSA-related correlations with AERONET stations are low compared to the AOD-related correlations for the same stations. Both quantities (AOD and SSA) are computed from AOD and its absorption since SSA=[AOD-absorption(AOD)]/AOD. This uncertainty can then be related to the fact that AOD used for AOD or for SSA comes from two different sensors (SeaWIFS and OMI respectively) and processing. As seen in the calculation of SSA, its computation uses two quantities (AOD and its absorption) and hence introduces different sources of errors.
We don't believe that this uncertainty is related to our threshold of 0.9. This value has already been used in previous studies in this region and it seems to be a good threshold for differentiating dust aerosols from biomass burning aerosols (Léon et al., 2009, Jethva et al., 2014).
During the GERBILS campaign over West Africa, Johnson and Osborne (2011) showed that there was no obvious relationship between the observed SSA and the geographic location of the measurement.
The better correlation of SSA at M'bour station could be due to different reasons.
It can be due to the strong contribution of dust transport from the northwest flow which advects important dust amounts from Mauritanian sources in winter (Figure 6a).
The OMAERUV algorithms of OMI retrievals could provide another

explanation. Indeed, cloud contamination of thin cirrus in the OMI footprint can cause the overestimation of SSA retrieval (Jethva et al., 2014).
During the GERBILS campaign over West Africa, Johnson and Osborne (2011) found that AERONET SSA retrievals show significantly lower SSAs at Banizoumbou than Dakar (averaging 0.91 and 0.94, respectively). These authors suggested that this discrepancy could be due to the smaller amount of sampling in Dakar. In agreement with the later authors, we have fewer sampling in our case at M'Bour than over the continent (see caption of Figure 2).
A comment was added in the text to clarify that discrepancy on SSA correlations (L205-L209).

Also you are saying that the SSA correlation in Cape Verde is better than over the continent, which is not true based on the numbers given in the text: 0.3 in Cape Verde Vs 0.47 and 0.5 in land.

We apologise for the wrong formulation, this sentence has been reformulated as follow (L203-204):
"The agreement between the two inversions is better over the continent (Banizoumbou station, r=0.47 and Agoufou station: r=0.50) and at the shore of West Africa (M'bour station: r=0.66) than over the ocean (Capo Verde station: r=0.30)".

17) Figure 3: To what dust hot spot are the largest AOD values observed related to? From your map this looks to be the Aïr region? What is happening there? In your domain you are not including the Bodélé depression, arguably the largest dust source in the world, why? Why are the largest AOD values observed in MAM? What are the dynamical processes related to these emissions?

We do not completely understand Reviewer's point. The Bodélé depression is located at 17°N-18°E and hence is part of our domain (12°N-21°N and 35°W-20°E).
Concerning the largest AOD encountered in MAM, Figure 3b shows a large AOD south of 21°N at this season. These large AOD values result from a mixing of aerosols of dust and biomass burning origin. The presence of biomass burning aerosols is indicated by SSA values lower than 0.90 south of 15°N. Léon et al., (2009) were also surprised to find low values of SSA at Mbour coastal station (~14°N) in March during which strong dust events occur. On the other hand, the presence of dust north of 15°N is also highlighted. It is in agreement with the map of dust emissions showed by (Weinzierl et al. 2016; Fig.5). Figure 6b also shows the convergence of cold flow from ocean and the warm flow from North Africa which results in highly variable winds which is at play in the dust emission in this region. All together, biomass burning and dust emissions occurring at the end of the dry season are responsible for the largest AOD values encountered in MAM.
Comment was added in the text (L211-214).

18) L187: unclear what is meant here by "largest dust particles are mobilized *and raised above the continent by convective systems".. Are you referring to dust mobilization at the leading edge of cold pools? This is a very efficient mechanism for sure, but only when soil moisture is low and vegetation has not grown yet, i.e. May and June over Sahel. . . Please be more explicit what is meant here. Do you refer to Fig. 4c of Rajot et al?*

We understand that this sentence was unclear. It was replaced (L234-235) by: In boreal summer important quantity of dust can be lifted up and vertically transported in the upper atmosphere by convective systems.

19) Generally speaking, I think this Figure should be better described with more insights into the processes and hot spot regions leading to the observed distribution of AOD and SSA.

We agree with the Reviewer. Hence, the following comment was added to the text (L210-219):

Figure 3 shows the seasonal distribution of SSA superimposed on AOD in West Africa. Together, high AOD and high SSA indicate the dominance of dust aerosol in the atmosphere. In winter, the main dust source in West Africa, i.e. the Bodélé depression, is depicted with AOD greater than 0.5 and SSA higher than 0.9 around 16°N-18°E (Fig.3a). This persistent dust hot spot is activated all along the year and exhibits a maximum of dust emission in spring (Fig.3b), in agreement with Engelstaedter et al. (2007). In summer, the intense surface heating from solar radiation (Heat Low) induces the development of a near-surface thermal low pressure system over northern Mali, southern Algeria, and eastern Mauritania (Lavaysse et al., 2009; Messager et al., 2010) and controls the dry convective processes which contribute to about 35% of the global dust budget (Engelstaedter et al., 2007; Fig.3c). Over the Northwest Saharan region (16N-24N,0-12W), AOD is higher than 0.5 and SSA is around 0.95 indicating a large area of dust emission at this season already mentioned by Engelstaedter et al., (2007).

20) L202: "ABL develops vertically to reach the level of the SAL." No! The SAL is an emanation of the SABL has explained above. . . the fact that the aerosol layer is detached from the surface is related to the flow from the Atlantic penetrating over the continent. One way to show that would be to add zonal winds (in the form of arrows) in the cross-section: you would see westerly winds where the there is no or littles dust in the low levels and easterly winds in the upper levels where dust is observed.

We agree with the Reviewer that the SAL is an emanation of the SABL. This sentence was modified as follow (L250):
"The ABL is developed vertically to reach up to 5 km of altitude."
Indeed, we could have added the zonal winds as arrows in the cross-section in Figure 5. Kaufman et al. (2005) showed good correlations between NCEP zonal wind and AOD in West Africa all along the year. Here, we have used NCEP horizontal wind at 925 hPa (Figure 6c) and radiosounding data over Dakar to discuss the effect of the atmospheric circulation on the vertical aerosol distribution. Both figure 6 and 7 show that the flow below 1 km comes from the Atlantic Ocean while above 1 km. It comes from the West African continent.

21) L218: "[. . .] and the vertical distribution of aerosols is not supported by a favorable wind regime ascending particles." What do you mean? This is very unclear. . .

Referring to the large-scale dynamics, the deep vertical dust transport is mainly controlled by the Inter-tropical Convergence Zone (ITCZ). The ITCZ exhibits a clear seasonal latitudinal migration and is located around 5°N (e.g. Sultan et al., 2000) in winter. In terms of general circulation, the subsiding branch of the Hadley cell blocks the vertical transport of dust by dry convection in the region (Lavaysse et al., 2009).
Engelstaedter et al., (2007) showed that in North Africa the strong surface convergence, associated dry convection and increased vertical wind velocity create conditions that favor dust emission and transport into higher altitudes.
We reformulated the sentence to clarify our point (L265-268):
"(Schepanski et al, 2007) found that over the Sahara sources of dust emissions are less active in winter than in summer season. The southward migration of the ITCZ and the subsiding branch of the Hadley cell also prevents the vertical distribution of aerosols to develop (Lavaysse et al., 2009)."

22) L222: "These West African emission zones participate actively to the transport of mineral aerosols in the near Atlantic Ocean.": this is lame, please rephrase

We agree with the Reviewer that this sentence does not bring any insight. Hence we decided to remove (L272) this sentence and the next one which does not bring information either.

23) L233-236: It is the dry convection related to the solar heating that drives the development of the Saharan boundary layer and hence the fact that dust aerosols are seen up to 6 km or more in the summer. What is happening in the region of the ITD is marginal in this process. . . The dust layer overpassing the monsoon flow maybe be slightly elevated due to the cold air undercutting the warmer dust-laden air, but the monsoon flow is not deep enough to account for the change in elevation of the top of the SAL.

We are agree with the Reviewer that this sentence was misleading.
Indeed, on one side, the solar heating drives the development of the Saharan boundary layer and on the other side, the low pressures located over North Africa around 23°N (Lavassy et al., 2009) induces the increase of dust activity (Choobari et al., 2014). We amended this sentence as follow (L284-289):
"Indeed, the summer solar heating drives the development of the Saharan boundary layer which reaches up to 6 km while the convergence of hot dry air (Harmattan) from the Sahara with fresh moist air (monsoon) from the ocean generates intense convective cells which are responsible for the suspension of large amounts of dust which will be distributed in the ABL."

24) L241: "In summer, atmospheric dynamics raise large dust particles that are subject to the law of universal gravitation of Newton," Tell me something that is not!! How pompous and meaningless is that?

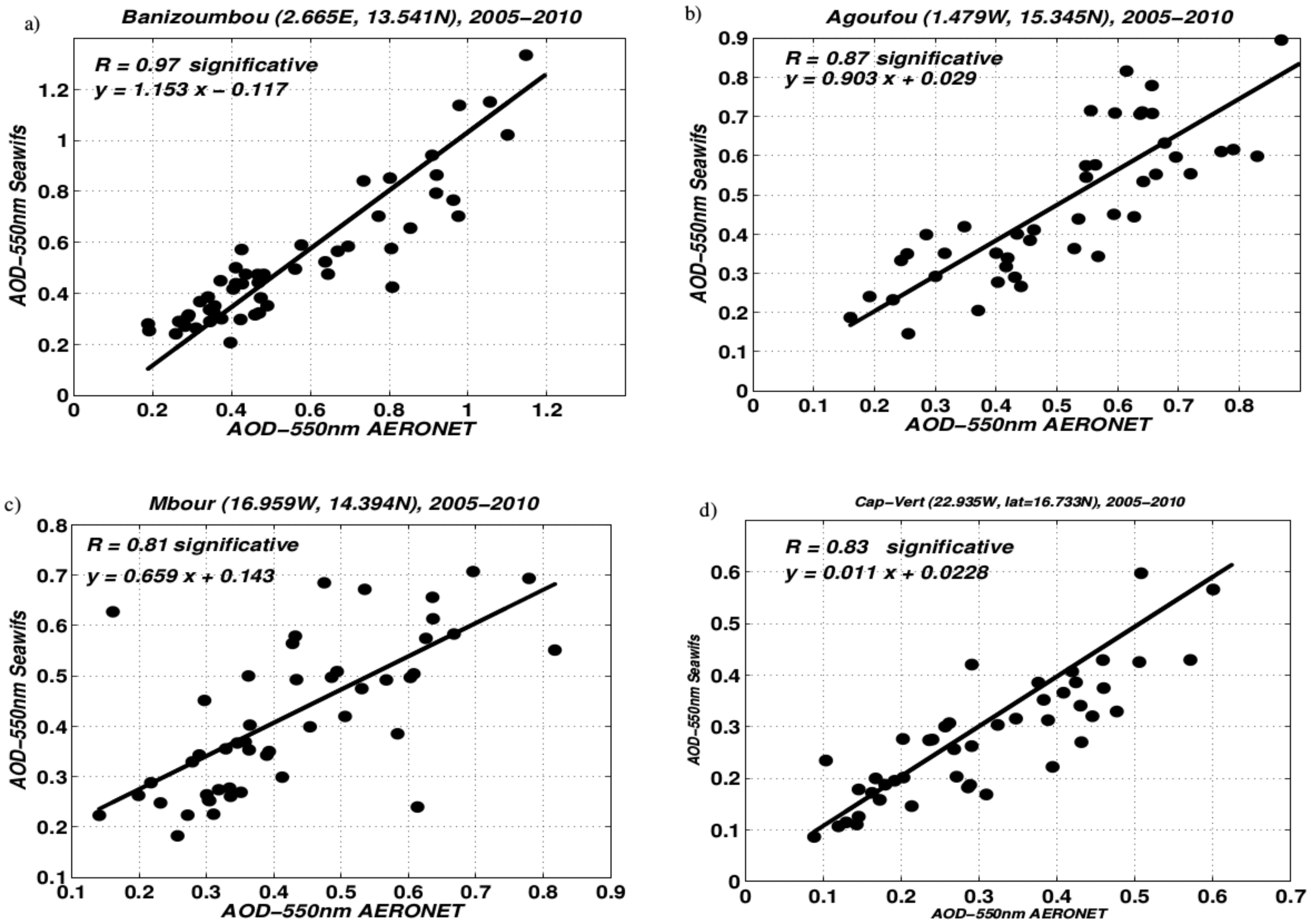
This sentence was modified as follow (L294-295):
“In summer, atmospheric dynamics raise large dust particles that are settling down much closer to the source regions than the rest of the year (Shao, 2000). ”

25) Section 4.2: I feel this section should be better tied up with the discussion of Figures 4, 5 and 6 as it brings essential dynamics and thermodynamics information to the reader not familiar with West African weather.

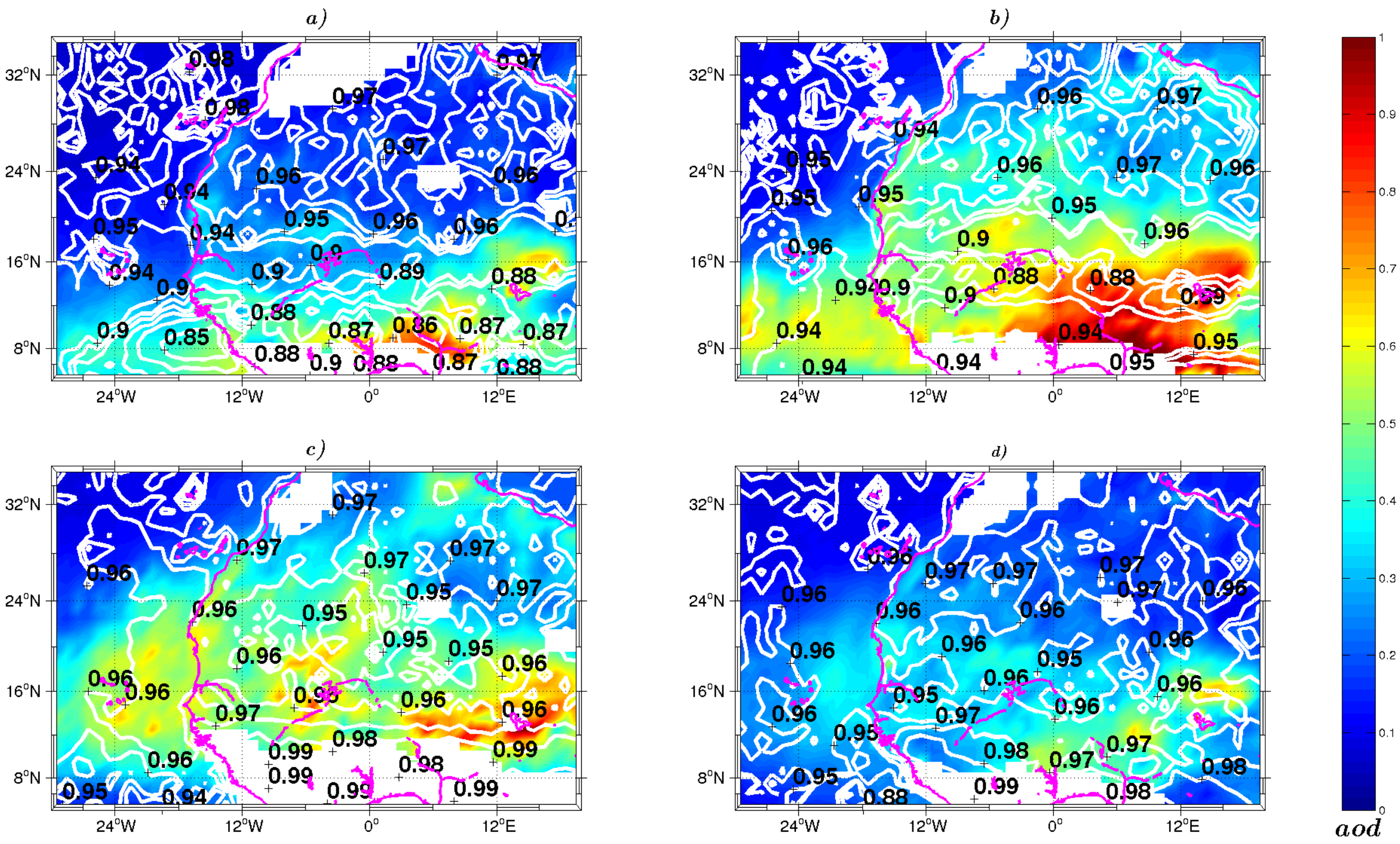
We have chosen to structure the manuscript to discussing the seasonality before describing the influence of dynamics and thermodynamics on the vertical distribution at the interface between land and ocean. Hence we took into account Reviewer's comment and tried to tie up better section 4.2 to compile the information contained in Figures 4, 5 and 6 but we believe the final scheme of what is observed in the different Figures is well synthesized in the conclusion section that is made for it.

26) L320: “In summer, convection associated with structures that develop at the ITCZ distribute dust over 6 km height and create a thicker AOD.” I totally disagree.. It is dry convection over the Sahara and northern Sahel that controls the height of the top of the SAL and the altitude at which the dust from eastern sources towards the west.

This sentence was modified as follow (L384-387):
In summer dry convection located north of 10°N and associated with structures that develop at the Inter-Tropical discontinuity (ITD) distribute dust up to 6 km height and create a thicker AOD. Above 6 km altitude over the Saharan-Sahel areas, the vertical distribution of dust is blocked by the strong subsiding branch of the Hadley cell (Lavaysse et al., 2009).



a)
Banizoumbou (2.665E, 13.541N), 2005–2010
R = 0.97 significative
y = 1.153 x – 0.117
AOD–550nm Seawifs
AOD–550nm AERONET
b)
Agoufou (1.479W, 15.345N), 2005–2010
R = 0.87 significative
y = 0.903 x + 0.029
AOD–550nm Seawifs
AOD–550nm AERONET
c)
Mbour (16.959W, 14.394N), 2005–2010
R = 0.81 significative
y = 0.659 x + 0.143
AOD–550nm Seawifs
AOD–550nm AERONET
d)
Cap–Vert (22.935W, lat=16.733N), 2005–2010
R = 0.83 significative
y = 0.011 x + 0.0228
AOD–550nm Seawifs
AOD–550nm AERONET


a)
b)
c)
d)
32°N
24°N
16°N
8°N
24°W
12°W
0°
12°E
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
aod

Seasonal cycle of ~~desertic~~ desert aerosols in West Africa : Analysis of the Coastal transition with passive and active sensors

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Abstract. The impact of ~~desertic~~ desert aerosols on climate, atmospheric processes and the environment is still debated in the scientific community. The extent of their influence remains to be determined and particularly requires a better understanding of the variability of their distribution. In this work, we studied the variability of these aerosols in West Africa using different types of satellite observations. SeaWiFS ~~and OMI~~ (Sea-Viewing Wide Field-of-View Sensor) and OMI (Ozone Monitoring Instrument) data have been used to characterize the spatial distribution of mineral aerosols from their optical and physical properties over the period 2005-2010. In particular, we focused on the variability of the transition between the West African continent and the Eastern Atlantic Ocean. Data provided by the Lidar scrolling CALIOP (Cloud-Aerosol Lidar with Orthogonal Polarization) onboard the satellite CALIPSO (Cloud Aerosol Lidar and Infrared Pathfinder Satellite Observations) for the period 2007-2013 were then used to assess the seasonal variability of the vertical distribution of ~~desertic~~ desert aerosols. We first obtained a good representation of Aerosol Optical Depth (AOD) and Single Scattering Albedo (SSA) by satellites ~~(~~SeaWiFS and OMI ~~, respectively)~~ respectively in comparison with AERONET estimates, both above the continent and the ocean. Dust occurrence frequency is higher in spring and boreal summer. In spring, the highest occurrences are located between the surface and 3 km above sea level, while in summer the highest occurrences are between 2 and 5 km altitude. The vertical distribution given by CALIOP also highlights an abrupt change at the coast from spring to fall with a layer of ~~desertic~~ desert aerosols confined in an atmospheric layer uplifted from the surface of the ocean. This uplift of the aerosol layer above the ocean contrasts with the winter season during which mineral aerosols are confined in the atmospheric boundary layer. Radiosondes at Dakar Weather Station (17.5°W, 14.74°N) provide basic thermodynamic variables which partially give causal relationship between the layering of the atmospheric circulation over West Africa and their aerosol contents throughout the year. A SSA increase is observed in winter and spring at the transition between the continent and the ocean. The analysis of mean NCEP (National Center for Environmental Prediction) winds at 925 hPa between 2000 and 2012 suggest a significant contribution of coastal sand sources from Mauritania in winter which would increase SSA over the ocean.

1 Introduction

The Sahara is the largest source of mineral aerosols in the world, with a contribution of almost 40% compared to the overall emissions from natural sources (Ramanathan et al., 2001; Tanaka et al., 2005). ~~These minerals and desert aerosols are emitted in arid and semi-arid North Africa and transported across the Atlantic Ocean to the American continent, the Caribbean islands, Florida (Chiapello et al., 1995; Dunion and Marron, 2008) , South America (Prospero et al., 1981; Liu et al., 2008, 2012) and North America (Tsamalis et al., 2013)~~ The mineral dust aerosols emitted from the Sahara desert can be transported over long distances in the atmosphere and can be detected as far as Americas (Prospero et al., 1981; Swap et al., 1992; Formenti et al., 2001; Kaufman Mediterranean region (Bergametti et al., 1989; Moulin, 1997; Ansmann et al., 2003) and Asia (Ganor and Mamane, 1982; Israelevich et al But here, the study of dust transport focuses on the main corridor of their transport Westward Africa (Formenti et al., 2001) . They play a very important role on the climate and the various processes involved in the climate system (Kaufman et al., 2005; Teller and Levin, 2006; Stith et al., 2009) through their direct impact in the visibility, in the infrared (Sokolik and Toon, 1999) or the earth radiation budget (Andreae et al., 1996; Solomon, 2007) which is still poorly known. The difficulty of understanding the impact of aerosols on the Earth's radiation balance is due to the large spatial and temporal variability of their concentration and composition in the atmosphere. The mineral particles suspended in the atmosphere come from different sources and have a nature similar to the nature of the soil from which they arise (Claquin et al., 1999; Formenti et al., 2008) with a broad spectrum of particle sizes ranging between 0.01 ~~and 100 micrometers (Wagener, 2008)~~ μm and 300 μm (Wagener, 2008; Ryder et al., 2013) . Their impact on the marine ecosystem and particularly on oceanic primary production (Duce and Tindale, 1991; Baker et al., 2003; Mills et al., 2004; Jickells et al., 2005; Mahowald et al., 2009) remains still uncertain and difficult to assess because of the composition of these particles and of physico-chemical processes affecting them (e.g., Friese et al., 2016). Mineral dust deposition also have a negative impact on human health and are responsible for meningitis epidemics or cardiac deseases (Thomson et al., 2006; Martiny and Chiapello, 2013; Diokhane et al., 2016; Prospero et al., 2005; Griffin, 2007).

~~The desert aerosols and their large-scale transport began to be studied in the 90s~~ Although the transport of mineral dust across the Atlantic Ocean started to be investigated in the 1960s, it started to be studied from satellite observations ~~(?Moulin, 1997)~~ since 1970s (Kaufman et al., 2005; Taghavi and Asadi, 2008) . Passive sensors have the advantage of providing daily data on the state of the atmosphere with good spatial and temporal coverage. The satellite products have improved our knowledge of the source regions and dust transport pathways in recent years ~~(Engelstaedter et al., 2006)~~ (Engelstaedter et al., 2006; Schepanski et al., 2007, 2009b, However, studies of their spatial and temporal variability are mainly based on indices such as the Aerosol Optical Depth (AOD) or the Aerosol Index (AI) which provide vertically integrated information on the ~~Atmospheric~~ atmospheric aerosol contents (passive space derived observations: ~~(Cakmur et al., 2001; Chiapello and Moulin, 2002; Kaufman et al., 2005; Engelstaedter et al., 2006; S These satellite products also present some limitations since they are unable to differentiate aerosols and particularly those from desertic origin.~~ Cakmur et al. (2001); Chiapello and Moulin (2002); Kaufman et al. (2005); Engelstaedter et al. (2006); Schepanski et al. (Moreover AOD estimated by satellite integrates the contribution of every kind of particles and this latter estimation also depends on the altitude at which aerosols are located. Based on perturbations induced by the Rayleigh scattering in the detection of absorbing aerosols, Chiapello et al. (1999) showed that TOMS AI is more sensitive to aerosols present at high altitude than at low altitude. In other words the signal changes with the height of the aerosol plume for a given aerosol content~~(Chiapello et al., 1999)~~.

Recently, the vertical structure of the ~~SAL~~ Saharan Air Layer (SAL) has been analyzed from CALIPSO satellite observations. The vertical ~~disconnection~~ discontinuity of dust layers between land and ocean strongly impacts the atmospheric deposition rates of mineral matters (Schepanski et al., 2009a) and dust concentration at the oceanic surface which has important consequences on the primary biological productivity of surface waters (Martin, 1992; Arístegui et al., 2009).

In boreal summer, ~~the Saharan Air Layer (SAL)~~ SAL is characterized by hot, dry air, very dust-laden and is located between 10°N and 25°N (Dunion and Marron, 2008; Tsamalis et al., 2013). This SAL is marked by very strong potential temperatures up to 40°C and a radon presence (radon-222) indicating the desert origin of air masses (Carlson and Prospero, 1972).

In winter, the SAL is characterized by the transport of dust containing chemical elements such as aliminum (Al), silicon (Si), iron (Fe), titanium (Ti) and manganese (Mn) (e.g., ~~Ben-Ami et al., 2010~~ Formenti et al., 2001; Ben-Ami et al., 2010) and is located between 5°N and 10°N (e.g., Tsamalis et al., 2013). ~~The~~ Some of studies relating aerosols to their transport are generally a simple description of the vertical distribution of aerosols in the SAL (Generoso et al., 2008; Liu et al., 2008; Ben-Ami et al., 2009; Braun, 2010; Yu et al., 2010; Adams et al., 2012; Ridley et al., 2012; Yang et al., 2012) or a description of the seasonality of the SAL in connection with large-scale dynamics (Liu et al., 2012; Tsamalis et al., 2013). However, the dust field campaigns, AMMA, SAMMUM-1 and 2, FENNEC or SALTRACE (see Table 1) of Weinzierl et al., (2016) carried out in West Africa and over the Atlantic Ocean improved our understanding of dust-dynamics interactions. During SALTRACE, a linear depolarization ratio of particles and a relative humidity threshold of 50% were used for differentiating different types of aerosol (Weinzierl et al., 2016) . Authors showed that sea salt aerosol were restricted to the lower layer superposed by biomass-dust mixtures. They also showed that the altitude of the mineral dust layer decreased westward. The effects of small-scale dynamics and thermodynamics for controlling the vertical structure of desert aerosols in coastal West Africa remain unknown, and efforts made in this direction are restricted to very sporadic case studies (Gamo, 1996; Reid et al., 2002; Petzold et al., 2011).

In this study, in-situ and satellite observations are used to describe the seasonal time-scale of mineral dust distribution. We first used complementary information, provided by ~~Sea-viewing Wide Field Sensor (SeaWiFS) and Ozone Monitoring Instrument (OMI) which deliver optical (AOD: Aerosol Optical Depth; SSA: Single Scattering Albedo) and physical (AE: Angstrom Exponent) properties of desertic~~ SeaWiFS and OMI which deliver extensive (AOD) and intensive (SSA, AE) parameters of desert aerosols, to analyse the spatial variability of the ~~desertic~~ desert aerosol dust. Then we used CALIOP lidar on board CALIPSO to investigate the vertical distribution of these ~~desertic~~ desert aerosols.

We finally analyze meteorological data to explain the impact of the atmospheric variables on the seasonal cycle of the vertical distribution of ~~desertic~~ desert aerosols at the transition zone between the continent and the ocean. We conclude the present work by summarizing all the results which are reflecting our common knowledge on mineral dust discrimination and spatio-temporal distribution.

2 Methodology and Data

2.1 AErosol RObotic NETwork (AERONET)

We first used data of AOD from AERONET between January 2005 and December 2010. AERONET is a global network of in-situ observations developed by the NASA Earth Observing System (NASA's EOS) (Dubovik et al., 2000). AERONET consists of solar photometers Cimel providing measures of AOD every 15 minutes, refractive index and also allows inversions such as particle size distribution of aerosols and single scattering albedo (SSA) at 440nm, 670nm, 870nm and 1020nm wavelengths (Holben et al., 1998) with an accuracy of $\pm$ 0.01 (Slutsker and Kinne, 1999; Dubovik et al., 2000; Holben et al., 2001). This uncertainty is inherent in the algorithm inversion used to retrieve aerosol characteristics. Some approximations are used in the numerical inversion algorithm which produce errors named relative errors having a standard deviation of 0.01 (Dubovik et al., 2000) . AERONET's SSA are computed for favorable atmospheric conditions (AOD 440 nm > 0.4 and solar zenith angle $>45°$) using an algorithm which performs almucantar inversions (Jethva et al., 2014). These data are used to validate remotely sensed AOD and SSA measurements. AERONET is available under three different products: Level 1.0, 1.5 and 2.0. In this study, we use Level 1.5 product for Cape Verde, due to a lack of sufficient Level 2 data, for this station and Level 2.0 for the other stations. Concerning the temporal resolution of AERONET observations, we compute a "daily" mean based upon data collected between 10am and 3pm in order to use observations collected during the same time window as satellite overpass. We then use this 10am-3pm daily averages to compute monthly 10am-3pm AOD.

2.2 Sea-viewing Wide Field-of-view Sensor (SeaWiFS)

We then used DeepBlue-SeaWiFS monthly mean AOD at 550 nm and AE products derived from SeaWiFS developed by NASA to study ocean color. SeaWiFS measures the solar radiation reflected at the top of the atmosphere in the wavelengths 412 nm, 443 nm, 490 nm, 510 nm, 555 nm, 670 nm, 765 nm and 865 nm. Satellite measurements carried out between October 1997 and December 2010 (Jamet et al., 2004; Hsu et al., 2012) have a value of signal-to-noise and uncertainty of 2%-3% for the different spectral bands (for details see (Eplee et al., 2007; Franz et al., 2007; Eplee Jr et al., 2011)). In this paper, we use the Level 3 version 4 products (Bettenhausen and Team, 2013) for years 2005 to 2010. The SeaWiFS AOD provided at 550 nm is available both over the land and over the ocean (Hsu et al., 2004; Sayer et al., 2012). The products used here are land-ocean estimates generated and made available to the scientific community by NASA (Wang et al., 2000). Regarding the contribution of the aerosols types in the AOD, the studies of Dubovik et al. (2002); Schepanski et al. (2009b) or Tegen et al. (2013) suggested that the coarse mode fraction of mineral dust dominates the atmospheric mixture when AE values, associated with AOD values greater than or equal to 0.3, are below 0.7. Here, we consider aerosols optical thickness larger than 0.2 when the Ångström Exponent is lower than 0.7 (figure 4) to monitor the evolution of coarse (upper and lower bounds respectively) and fine (lower and upper bounds) modes of mineral aerosols.

2.3 Ozone Monitoring Instrument (OMI)

OMI is a passive sensor on board the Aura satellite launched on 15 July 2004 by NASA's EOS Aura space-craft which released its first observations in October 2004. Like all satellites in the A-Train constellation, OMI scans the entire Earth in 14 to 15 orbits with a nadir ground pixel spatial resolution of 13 × 24 km^2 (Jethva et al., 2014). In addition to the ozone content in the atmosphere OMI provides information on aerosols, clouds, gases (NO2, SO2, HCHO, BrO, and OClO) and irradiance in the ultraviolet (Levelt et al., 2006). We use Aura/OMI SSA at 500 nm taken from https://ozoneaq.gsfc.nasa.gov/data/lance-browse/, the OMAERUV Level 3 Collection 003 aerosol product processed in March 2012 with a spatial resolution of 1° x 1° to quantify the scattering of the aerosol types with passive sensors. The OMAERUV algorithm assigns flag to each pixel which carries information on the quality of the retrieval (Jethva et al., 2014).

The SSA represents the ratio (ranging between 0 and 1) of scattering coefficient to extinction coefficient and provides information about the absorbing properties of the aerosols. SSA of 0.9 indicates that 90% of the total extinction of solar light is caused by scattering and 10% by absorption effects (Jethva et al., 2014). This parameter depends on the wavelength, size and the complex refractive index of particles (Léon et al., 2009). The closer this value is to one the more desert aerosols dominate (Johnson et al., 2008; Léon et al., 2009; Ialongo et al., 2010; Malavelle, 2011).

OMI data were interpolated on the grid of SeaWiFS data to superimpose the products (AOD and SSA).

2.4 Cloud Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)

The first polarization lidar in space so-called CALIPSO is a sun-synchronous satellite developed by NASA as part of the Earth System Science Pathfinder program (ESSP) and launched on April 28, 2006 (Winker et al., 2007; Hunt et al., 2009) in order to provide a global coverage of the vertical distribution of the properties of clouds and aerosols (Winker, 2003). The CALIOP lidar (LIght Detection and Ranging) ~~Cloud-Aerosol Backscatter Lidar with Orthogonal Polarization (CALIOP)~~ onboard CALIPSO acquires vertical profiles of the atmosphere at 30 m resolution in the lower layers (from the two orthogonal components that result from depolarization of a signal backscattered laser at 532 nm and vertical profiles of a total laser at 1064 nm signal backscattered at nadir). The final level-2 product is reduced to a uniform resolution calculated from averaging and/or interpolating different resolutions for generating intermediate products (Winker et al., 2006). We use the Vertical Feature Mask (VFM; stage 1 Version 3) for which the processing algorithm is described in CALIOP Algorithm Theoretical Basis, Part 3: Scene Algorithms Classification (Liu et al., 2005). VFM allows to separate aerosols from clouds but also the desert aerosols from other types of aerosols (Omar et al., 2009). This methodology of discrimination by CALIOP of aerosol types gives results close to another method of distinction between mineral dust made from inversions (SSA and AE) of AERONET level 2 products (Mielonen et al., 2009). The mix of layers of desert aerosol and other types of aerosols (i.e. biomass burning) is very rare (Chou et al., 2008; Heese and Wiegner, 2008) in our region of interest. During the dry season, mineral aerosols are observed in the atmospheric surface layer ranging 0.5 to 1 km while the aerosol emitted through biomass burning are carried to higher levels up to 5 km altitude (Cavalieri et al., 2010). Nevertheless, classification errors are possible for low values of the Mineral Dust Occurrence Frequency (MDOF) and at frontal zones between layers of different substances (Adams et al., 2012). For this reason we only consider here the values of MDOF above 10%. Our method for determining the mineral dust by a calculation of the MDOF is equivalent to ~~(Adams et al., 2012) expressed by the following~~ Adams et al. (2012) and follows the equation:

$$p(x,y,z) = \frac{\sum_{n=0}^{N} p(x+n,y,z)}{\sum_{n=0}^{N} s(x+n,y,z)} \quad \forall \quad x,y,z \tag{1}$$

where p is the ~~probability~~ frequency of occurrence of dust at a grid point, s the total number of valid satellite passing the same grid point and N the total number of grid points. The Occurrences in the longitude (x) are summed and normalized by the total valid satellite passes in a given longitudinal range (35°W-20°E). Data were gridded with a near-uniform horizontal resolution of 0.5° x 0.5° and a vertical resolution of 30 m for 290 vertical levels between 0.5 and 8.2 km above sea level. The CALIOP lidar on CALIPSO (also in the A-train) has a 90 m instantaneous footprint which is smeared to 333 m in the along track direction by orbital motion over the lidar pulse duration. All satellites of the A-train constellation, such as CALIPSO, fly in a sun-synchronous orbit with a 16 days coverage cycle consisting of 233 orbits separated by 1.54 degrees longitude or about 172 km at the equator. Each satellite completes 14.55 orbits per day with a separation of 24.7 degrees longitude between each successive orbit at the equator. These CALIPSO orbits are controlled to cover the same ground with cross-track errors of less than ±10 km (Winker et al., 2007). This drastically reduces the spatial coverage of the satellite. Consequently, we use a mesh of 0.5° longitude to cover the area between 10°W-24°W and 12°N-21°N. The choice of this band of latitude is driven by one of the objectives of the paper which is to study the transition of aerosol distribution between the continent and the ocean. Dust occurrences are averaged over latitudes 12°N to 21°N and are then smoothed over 30 points longitudinal running mean and 50 points vertical running mean.

3 Results

3.1 Horizontal dust distribution

SeaWiFS AOD (estimated at wavelength 550 nm) represents an average value of the optical Depth of the atmosphere. It has first been compared to the monthly AOD given by AERONET photometers (given at the wavelength 675 nm and interpolated at 550 nm) by calculating the correlation between the two measurements at different selected stations (Fig. 1). Our choice focused on the stations Banizoumbou (2.665°E-13.541°N), Agoufou (1.479°W-15.345°N), M'bour (16.959°W-14.394°N) and Capo Verde (22.935°W-16.733°N) to assess the quality of satellite information obtained accross the land-ocean continuum. A very good correlation is calculated between SeaWiFS and in-situ measurement given by the photometer at Banizoumbou (R=~~0.95~~0.97; Fig. 1a). The photometer Cimel at Agoufou (Mali) also shows a very good correlation with SeaWiFS (R=~~0.92~~0.87; Fig. 1b).

The correlation between the two measures is equal to 0.81 at the shore in M'bour (Fig. 1c). It is close to the one in Capo Verde (R=0.83; Fig. 1d). All these correlation values of AOD are significant at 95% using a student statistical test. The regression for M'bour site is not as good as for the other sites. This site is located at the shore at the interface between land and sea and the satellite algorithm retrieval is not the same over the land and over the ocean. We also studied the structure of the cloud of points between the two datasets to assess the quality of the satellite measurements as a function of the aerosol concentration. The regression line obtained by the least squares method shows a linear relationship between satellite and in-situ monthly mean measurements of AOD at the selected stations.

The horizontal transport of desert aerosols can be followed by considering the key and complementary parameters that distinguish them. To better characterize the ~~desertic~~ desert aerosols, we combined AOD (SeaWiFS) with SSA (OMI) to specify the contribution of the latter compared to other types of aerosols in the atmosphere. A threshold of 0.90 in monthly averaged SSA is used to define regions dominated by desert aerosols. This value is chosen in agreement with the threshold value given in previous studies (Léon et al., 2009; Malavelle, 2011; Jethva et al., 2014). This method allowed us to define the Sahelo-Saharan region as the one which is the most influenced by dust plumes composed of desert aerosols throughout the year (between 12°N and 21°N; Fig. 3).

The comparison of the daily SSA of Aura/OMI versus AERONET is achieved to validate satellite SSA which provides a better spatio-temporal coverage of our region of interest. OMI SSA retrievals are taken between ~~10 and 15 am ,~~ 10am and 3pm time range which cover AERONET measurements. As emphasized by Jethva et al. (2014), this comparison is done at the original wavelengths of each independent measurement (388 nm for OMI and ~~438~~ 440 nm for AERONET) in order to avoid uncertainties induced by the interpolation at other wavelengths. Good correlations are retrieved between the two datasets at the different ground stations in West Africa for the period 2005-2010 within root mean square (RMS) difference of 0.03 in the selected region (Fig. 2). Globally, the OMAERUV SSA is well correlated with ground measurements. The correlation at all selected sites for this study is significant. The agreement between the two inversions is better over the continent (Banizoumbou station, r=0.47 and Agoufou station: r=0.50) and at the shore of West Africa (M'bour station: r=0.66) ~~and~~ than over the ocean (Capo Verde station: r=0.30)~~than over the~~ . The discrepancy between the AERONET SSA retrievals over continent (Banizoumbou ~~station, r=0.47 and Agoufoustation: r=0.50)~~ and Agoufou) and at the shore of West Africa (M'bour) was already found by (Johnson and Osborne, 2011) during GERBILS campaign over West Africa. These authors suggested that a lack of sampling may affect the results. Their results are in agreement with our results which show 449 retrievals in Banizoumbou againts 178 retrievals in M'bour site.

Figure 3 shows a seasonal distribution of the AOD which supperposed onto SSA in West Africa region. Both, large AOD and strong SSA indicate that mineral dust is the dominant component in the aerosol in the atmosphere. In winter, the main dust source in West Africa, Bodélé depression, is showed in figure. 3a with AOD larger than 0.5 and SSA larger than 0.9 around (17N-18E). This most persistent dust hot spot is activated along the year and provides a maximum dust emission in spring (Figure 3b), in agreement with Engelstaedter and Washington (2007) . In summer, the intense surface heating from solar radiation (Heat Low) induces the development of a near-surface thermal low pressure system over northern Mali, southern Algeria, and eastern Mauritania (Lavaysse et al., 2009; Messager et al., 2010) and controls the dry convective processes which contribute to about 35% of the global dust budget (Engelstaedter and Washington, 2007) . Over Northwestward Sahara region (Fig. 3c), the AOD is larger than 0.5 and SSA is stronger than 0.9, both variables indicate together the most hot spot mineral dust source in West Africa in summer which already showed by Engelstaedter and Washington (2007) .

Figure 3 and Figure 4 show that horizontal monthly average of AOD is stronger above the continent than over the ocean throughout the year. The weakest AOD is given for winter months (DJF for December-January-February) with a mean value of 0.33 ± 0.07 (standard deviation). At this season, the SSA values are higher in the northeast tropical Atlantic than on the West African continent with a SSA maximum reaching 0.95. This indicates a stronger contribution of dust over the ocean than over the continent in the latitude range 12°N-21°N. Note that sources of dust aerosols are also indicated by high SSA values north of 21°N. The air masses advection in the lower atmosphere (925 hPa) follows a NorthEast-SouthWest direction in winter (figure 6a), dust coming from the NorthWest of Mauritania is partially seen over the continent (in AOD and SSA) and its main signature should be seen over the ocean. In spring (MAM for March-April-May), the increase of the monthly mean AOD compared to winter is indicated by a stronger mean value (0.50 ± 0.08). The mean optical depth indicates that the dust sources are becoming more active with an atmosphere more charged than in winter. The coarse mode dominates in the mixed atmosphere boundary layer over the continent with lower values of AE less than 0.7 (not shown). Nevertheless, the reflectance properties of aerosols (given by the SSA) is higher over the ocean than over the continent and vary weakly compared to winter. In summer (JJA for June-Jully-August), the maximum mean AOD is 0.52 ± 0.05. AOD values are associated with higher SSA above 0.96. It indicates that aerosols are clearly dominated by desert dust in boreal summer. At this season, ~~the largest dust particles are mobilized and raised above the continent~~ important quantity of dust can be lifted up and vertically transported in the upper atmosphere by convective systems ~~(e.g., ?, Fig. 4c)~~ and near-surface convergence (Engelstaedter and Washington, 2007) . In autumn (SON for September-October-November), the monthly mean AOD is 0.34 ± 0.05. AOD is decreased compared to spring but the SSA values are much higher than in spring despite the fact that uplift occurrences are larger in spring than in fall in west Africa (Marticorena et al., 2010; Diokhane et al., 2016).

Changes of AOD and SSA are seen at the transition between the continent and the ocean (Fig. 4). Understanding these changes requires a thorough analysis of the vertical distribution of dust during transportation from east to west in North Africa.

3.2 Vertical dust distribution

The vertical distribution of desert aerosol indicates a strong presence of dust concentrations between the surface and 6 km in agreement with the results of Léon et al. (2009) who studied the vertical distribution of dust in the North-East Tropical Atlantic (Fig. 5).

In DJF, desert aerosols are mainly concentrated in the atmospheric boundary layer (ABL) between the surface and 2 km (Fig. 5a) both over the continent and the ocean. At this season, we also noted a homogeneous dust aerosol transition between Western Africa and the Eastern part of the Atlantic Ocean.

In MAM, there is an elevation of the SAL with a maximum altitude of 5 km on the continent and between 4 and 5 km above the ocean (Fig. 5b). The MDOF over 50% above the continent shows that dust emissions are much greater than in winter. ~~ABL develops~~ The ABL is developed vertically to reach ~~the level of the SAL~~up to 5 km of altitude. It results in an atmospheric layer well mixed between the surface and 5 km of altitude above the continent (10°W-15°W). Above the Ocean we see a detachment of the SAL from the ocean surface which occurs at the coast (around 18°W).

JJA is the busiest season of the year in terms of dust rising in the northern hemisphere of Africa. It is characterized by the development of density currents that intensify the mobilization of terrigenous aerosols (e.g., Bou Karam et al., 2008; Schepanski et al., 2009b, Fig. 5c).

Unlike DJF, we note a clear separation of the dust layer above the Eastern Atlantic Ocean where dusts are confined between 1 and 6 km altitude.

In SON, dust emissions decrease in intensity compared to JJA but the detachment from the surface of the ocean remains clear at the coast although less marked than in JJA (Fig. 5d). According to Adams et al. (2012), the heart of the SAL is located about 5 km above sea level in SON, whereas Liu et al. (2012) shows a maximum altitude of 4 km.

4 Discussion

4.1 Seasonal variability

The desert aerosols in the band of latitude 12°N-21°N are mainly emitted in the Saharan and Sahelian regions. Emissions and transport processes are mainly controlled by meteorological variables (Brooks and Legrand, 2000; Joseph, 1999).

~~In the Sahara , the~~ Schepanski et al. (2009b) found that over the Sahara sources of dust emissions are less active in winter than during ~~the other seasons and the~~ summer season. The southward migration of the ITCZ and the subsiding branch of the Hadley cell over the dry convection can also prevents the deep vertical distribution of aerosols ~~is not supported by a favorable wind regime ascending particles~~in north Africa (Lavaysse et al., 2009) . The maximum altitude of this distribution is 3 km above the continent and 2 km at the West African coast in agreement with the studies of (Léon et al., 2009) and (Vuolo et al., 2009). Compared to other seasons, DJF show an important role played by the shallower atmospheric layers on the dust transported from source regions located in the Northwestern part of Mauritania and more generaly in the West African coastal region (Fig. 6a).~~These West African emission zones participate actively to the transport of mineral aerosols in the near Atlantic Ocean.~~ This high occurrence is shown by the inter-seasonal variability derived from NCEP Reanalysis. Figure ~~.~~ 6 highlights that the Northwest region of Mauritania has the highest standard deviation of horizontal wind intensity between 18°N-24°N and that wind is very intense in winter compared to the other seasons (Fig. 6a). Hence this region represents an important sand source in winter as mentioned by previous studies (Bertrand et al., 1979; Ozer, 2000; Tulet et al., 2008; Laurent et al., 2008; Mokhtari, 2012; Hourdin et al., 2015).~~During this period, the studies of Dubovik et al. (2002); Schepanski et al. (2009b) or Tegen et al. (2013) suggested that the coarse mode fraction of mineral dust dominates the atmospheric mixture as AE values are below 0.7 (not shown) and are associated with AOD values greater than or equal to 0.3. Here, we have considered thresholds of 0.7 for AE and 0.2 for AOD to monitor the evolution of coarse (upper and lower bounds respectively) and fine (lower and upper bounds) modes of mineral aerosols.~~

Unlike winter, ~~summer dust emissions are more concentrated in~~ as shows in figure 5c, dust are concentrated between the higher layers of the ABL~~up to 6 km (Gamo, 1996) ,~~ , from one to 5-6 km (Gamo, 1996) , in response to intense convective mechanisms that are more common in the region at this season (Cuesta et al., 2009). Indeed, the summer solar heating drives the development of the Saharan boundary layer which reaches up to 6 km while the convergence of hot , dry air (HarmatanHarmattan) from the Sahara and fresh , with fresh moist air (monsoon) from the ocean causes the raising and maintenance of aerosol layers between 1 and 6 km at the thermal front area of the inter-tropical discontinuity (ITD) for which the northern edge is located around 16°N (Fig. 6c). generates intense convective cells which are responsible for the suspension of large amounts of dust which will be distributed in the ABL. Transport is also growing between 3 and 4 km above the ocean with a MDOF greater than 70%, i.e. more than 30% higher than that observed in DJF. This sharp increase of MDOF from DJF to JJA is in agreement with the results of (Schepanski et al., 2009b) who estimated an increase of more than 20% of the activity of dust sources in summer compared to winter in West Africa in the observations of Meteosat Second Generation (MSG) Spinning Enhanced Visible and Infrared Imager (SEVIRI). In summer, atmospheric dynamics raise large dust particles that are subject to the law of universal gravitation of Newton, thus settle much faster on the continent settling down much closer to the source regions than the rest of the year (Shao, 2000) . However, their reflectivity of solar radiation becomes larger and reaches a maximum value indicated by a SSA of 0.97 (Fig. 4c).

In autumn, SSA values are comparable to spring values but these high values are not due to high reflectance of desert aerosols like in spring because the southern migration of the Inter-Tropical Convergence Zone (ITCZ) reduces the activity of convective systems and causes a reduction of dust emissions shown by a decreasing of the AOD (Fig. 4d). These high SSA values can be attributed to atmospheric conditions seen through the relative humidity which is much higher than in spring (Fig. 7d). Indeed, OMI measures the atmospheric properties of the aerosols which are know to be hygroscopic (Jethva et al., 2014).

4.2 Continent-Ocean transition

To better understand the factors responsible for the high variability of the vertical transition of desert aerosols from the continent to the ocean, we placed ourselves at a coastal point (Dakar) to study the variation of meteorological variables and their potential influence on the distribution of aerosols. Seasonality of vertical distributions of winds, relative humidity and potential temperature from radiosounding conducted at the weather station (GOOY) of Dakar (at West African shore) are shown in Figure . 7.

In DJF, continental winds are very strong at the surface with a maximum of 22 m/s at 500 m (Fig. 7a). The north-east direction of the winds in the first thousand meters explains the homogeneity of the vertical distribution of dust from the continent towards the ocean. This north-east wind applies to all West Africa at the surface (Fig 6a). Their intensity also explain the strong values of MDOF (up to 50%) observed by CALIOP in wintertime above the continent. Between 1 and 2 km height, winds weaken and change direction (south to south-east) while MDOF observed by satellite decreases (Fig. 5a). Between 2 and 5 km height, the winds turn to the southwest and west. These dust-depleted air masses of oceanic origin are wetter than from the land, and limit the development of the ABL. The air masses of continental origin are located between the surface and 2000 m height (Fig. 7a). In Figure. 7a, the relative humidity is around 20% (between 500 and 2000 m) and it corresponds to a very dry air mass of Saharan origin. Between 2 and 5 km the potential temperature indicates a stable atmospheric layer. This season is associated with an intermediate AOD value which decreases from 15°E to 10°W. SSA reflects mineral dust properties across its westward transportation (>0.9) but is higher by 0.2 over the ocean than the continent. We believe it could reflect the transport of dust emitted along the coastline which is only partly taken into account in dust properties derived from the continent.

Compared to the DJF situation, MAM surface winds (Fig. 7b) are intensifying to 25 m/s at 500 m height and are from the east. They are associated with MDOF above 50% in the ABL around 14°W. Surface winds (Fig 6b) shows the near-surface convergence of northward and southward flows along 16°N which is associated with a well-mixed distribution of dust in the first 5 km of the atmosphere (Fig 5b) and higher AOD values than in winter (Fig 4). There is an inversion of easterly winds between 1 and 3 km and a second southerly wind peak (15 m/s) appears between 3 and 4 km. It corresponds to the dust layer (SAL) detected by CALIOP. The vertical profile of potential temperature indicates a stable thick layer, well mixed between the surface and 3 km (Fig. 7b). Beyond this altitude there is a stable stratification of the atmosphere indicated also by the potential temperature. Between 3 and 5 km height, the air masses coming from the South to the South-Southwest are also of oceanic origin and their interaction with a more consistent amount of dust than in winter could explain the better marked transition between the ocean and the continent in terms of SSA (increase) and AOD (decrease) for this season (Fig. 4b). Indeed, in general, increasing the relative humidity is likely to increase the SSA and size hygroscopic aerosols with dry to wet passage inducing a larger diameter even when humidity is below the saturation level (Hervo, 2013; Howell et al., 2006).

In JJA, surface winds (0-1 km) decrease and are from the West to the Southwest (West African Monsoon) (Fig. 7c). This corresponds to lower values of MDOF (Fig. 5c) but to relative humidity values well above DJF or MAM (Fig. 7). Reid et al. (2002) presented a conceptual model of Saharan dust transport in the middle troposphere describing an evolution of relative humidity profile in agreement with the observations made in Dakar. These authors describe a moistening of the surface layers due to monsoon flow which penetrates up to 1.5 km above this layer. Figure 6c shows deep intrusion of air masses coming from the Golf of Guinea which brings humidity into the continent. The dry convection taking place over the continent favors the vertical transport of dust to high altitudes (Engelstaedter and Washington, 2007) .

Between 2 and 6 km, winds are from the East and above 15 m/s. These wind velocity maxima reach 25 m/s in the range 3.5-5 km and are associated to the African Easterly Jet (AEJ) (Wu et al., 2009; Lafore et al., 2011). The co-localization of the AEJ and the SAL between 2 and 5 km height (Fig. 5c and Fig. 7c) causes the westward SAL transport by AEJ in summer (Karyampudi et al., 1999). These strong winds correspond to the layer of dust detected by satellite at this altitude (Fig. 5c). Above the continent, the mesoscale features associated with the convergence between Harmattan and the West African Monsoon at the ITCZ cause strong updrafts that allow lifting and transport of dust particles throughout the air column (Tulet et al., 2008). The dynamics of the monsoon described by the conceptual scheme of mechanisms controlling the dust vertical redistribution in Cuesta et al. (2009) explain the wide occurrence of dust found between 2 and 5 km rather than at the surface. During transport from North Africa to the Atlantic Ocean, very large amounts of coarse dust (Fig. 4c) are deposited along the path with a rapid change in the size distribution of aerosols near the west African coast (Ryder et al., 2013). The changes of the aerosol size and properties will impact the climate system (Huneeus et al., 2011; Mahowald et al., 2014) . McConnell et al. (2008) suggested that the variation in the aerosol profiles over the ocean have an impact on the radiative effect, a statement confirmed by Highwood et al. (2003) who showed that the radiative effect of mineral dust is correlated with the altitude of the dust layer.

The signing of the SAL is evidenced by relative dryness of the atmosphere (Dulac et al., 2001) between 1.5 and 5 km (Fig. 7c).

At this altitude, the vertical profile of potential temperature indicates Saharan origin of air masses with temperatures between 35°C and 45°C (Carlson and Prospero, 1972). The wind direction (east) given in Figure . 7c between 1.5 and 5 km altitude confirms the origin of the Saharan air masses. The presence of dust in the SAL causes both warming and drying of the atmosphere between 1.5 and 5 km and a cooling below this layer (Tulet et al., 2008).
In SON, winds are weak and from the East at the surface (FigFigs. 7ed and 6d). Between 1 and 5 km, it is increasing but is less intense than in JJA between 3 and 5 km and it is associated with a decrease of the MDOF (Fig. 5d). The moisture profile in SON (Fig. 7d) is close to that of JJA, but has a more humid atmosphere in the layer between 1.5 and 5 km where maximum relative humidity of the year occurs (60%; Fig. 7d). The analysis of the vertical distribution of thermodynamic variables like relative humidity, potential temperature and wind measured at the Dakar weather station shows that the thermodynamical conditions control the dust vertical distribution as well as the depth of the dust layer depending on the season. This analysis also explains the unintuitive differences between spring, when the low values of SSA are associated with a strong AOD, and autumn characterized by high values of SSA associated with comparable AOD low AOD values.

5 Conclusions

Studies of processes involved in the vertical distribution of aerosols at the transition between continent and ocean are very rare. Here, we took advantage of a weather station ideally located on the main pathway of desert aerosols from Northern Africa (Léon et al., 2009; Marticorena et al., 2010; Mortier et al., 2016) to explain the effect of meteorological variables on this transition in a region of primary importance worldwide. The interaction of air masses of oceanic origin with dust aerosols are crucial for understanding their fate (e.g., Friese et al., 2016). This study constitutes the first attempt to relate the seasonal dynamic of the atmosphere and the vertical distribution of dust aerosol in this region and provides the first dynamical explanation of a counterintuitive deposition pattern over the Atlantic ocean. Indeed, it explains the role of the local atmospheric circulation in driving a higher AOD and dust content in summer over west Africa in phase with dust deposition in Barbades islands but in opposition with Cape Verde islands where deposition is more intense in winter (Chiapello et al., 1995).
We have studied the seasonal variability of the distribution of desert aerosols in West Africa (continental and oceanic) from their optical and physical properties. First of all we have been able to show a good estimate of physical properties (AOD and SSA) of aerosols by satellite when compared with AERONET ground measurements on the mainland, the coast and the ocean. Space observations then allowed us to show the predominant presence of Saharan dust in the atmosphere north of 12°N throughout the year and an additional significant contribution of sandy sources from the Mauritanian coast in winter. The MDOF indicates a change in the vertical distribution of dust at the transition between the continent and the ocean, the largest differences occurring in spring and summer seasons. In DJF, the ABL is shallow (∼ 1km) and strong winds from North-East transport the dust in a dry atmosphere from the continent to the ocean continuously. This surface layer is superimposed by a stable atmospheric layer which inhibits the vertical development of this surface layer rich in dust aerosols. The decrease from east to west of the AOD requires material deposition during the transit. In summer, convection In summer dry convection located north of 10°N and associated with structures that develop at the ITCZ distribute dust over Inter-Tropical discontinuity (ITD) distribute dust

up to 6 km height and create a thicker AOD. Above 6 km altitude over the Saharan-sahel areas, the vertical distribution of dust is bocked by the strong subsiding branch of the Hadley cell (Lavaysse et al., 2009) . In the lower layers, the westward oceanic moistly entries which are opposite to the higher eastward winds generate very different distributions above the continent or the ocean. On the mainland, the dust is dominated by coarse mode and have a homogeneous vertical distribution while above the ocean, lower layers are poor in dust and are superimposed by the SAL which is highly enriched. The SSA remains constant at this transition. MAM and SON represent transition periods~~, MAM~~ . For the vertical dust distribution, MAM is being closer to the summer situation.

Future modeling experiments should bring further insights into ocean-atmosphere processes involved in explaining this transition and the dust deposition along this pathway. It also seems that a more tailored approach to ocean-atmosphere interactions including higher frequencies of variability and notably the diurnal cycle is needed to make more apparent the role of local circulation on the vertical distribution of aerosols in coastal areas.

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References

Adams, A. M., Prospero, J. M., and Zhang, C.: CALIPSO-derived three-dimensional structure of aerosol over the Atlantic Basin and adjacent continents, Journal of Climate, 25, 6862–6879, 2012.

Alizadeh-Choobari, O., Sturman, A., and Zawar-Reza, P.: A global satellite view of the seasonal distribution of mineral dust and its correlation with atmospheric circulation, Dynamics of Atmospheres and Oceans, 68, 20–34, 2014.

Andreae, M. O. et al.: Raising dust in the greenhouse, Nature, 380, 389–390, 1996.

Ansmann, A., Bösenberg, J., Chaikovsky, A., Comerón, A., Eckhardt, S., Eixmann, R., Freudenthaler, V., Ginoux, P., Komguem, L., Linné, H., et al.: Long-range transport of Saharan dust to northern Europe: The 11–16 October 2001 outbreak observed with EARLINET, Journal of Geophysical Research: Atmospheres, 108, 2003.

Ansmann, A., Baars, H., Tesche, M., Müller, D., Althausen, D., Engelmann, R., Pauliquevis, T., and Artaxo, P.: Dust and smoke transport from Africa to South America: Lidar profiling over Cape Verde and the Amazon rainforest, Geophysical Research Letters, 36, 2009.

Arístegui, J., Barton, E. D., Álvarez-Salgado, X. A., Santos, A. M. P., Figueiras, F. G., Kifani, S., Hernández-León, S., Mason, E., Machú, E., and Demarcq, H.: Sub-regional ecosystem variability in the Canary Current upwelling, Progress in Oceanography, 83, 33–48, 2009.

Baker, A., Kelly, S., Biswas, K., Witt, M., and Jickells, T.: Atmospheric deposition of nutrients to the Atlantic Ocean, Geophysical Research Letters, 30, 2003.

Ben-Ami, Y., Koren, I., and Altaratz, O.: Patterns of North African dust transport over the Atlantic: winter vs. summer, based on CALIPSO first year data, Atmospheric Chemistry and Physics, 9, 7867–7875, 2009.

Ben-Ami, Y., Koren, I., Rudich, Y., Artaxo, P., Martin, S., and Andreae, M.: Transport of North African dust from the Bodélé depression to the Amazon Basin: a case study, Atmospheric Chemistry and Physics, 10, 7533–7544, 2010.

Bergametti, G., DUTOT, A.-L., BUAT-MÉNARD, P., Losno, R., and Remoudaki, E.: Seasonal variability of the elemental composition of atmospheric aerosol particles over the northwestern Mediterranean, Tellus B, 41, 353–361, 1989.

Bertrand, J., Cerf, A., and Domergue, J.: Repartition in space and time of dust haze south of the Sahara, The Long-Range Transport of Pollutants and its Relation to Gen. Circulation Including Stratospheric/Tropospheric Exchange Processes p 409-415(SEE N 80-26888 17-45), 1979.

Bettenhausen, C. and Team, G. D. M.: Consistent Long-Term Aerosol Data Records over Land and Ocean from SeaWiFS, in: Goddard Space Flight Center Greenbelt, Maryland, pp. 1–19, http://disc.sci.gsfc.nasa.gov/dust/documentation/README.DeepBlueSeaWiFS.pdf, 2013.

Bou Karam, D., Flamant, C., Knippertz, P., Reitebuch, O., Pelon, J., Chong, M., and Dabas, A.: Dust emissions over the Sahel associated with the West African monsoon intertropical discontinuity region: A representative case-study, Quarterly Journal of the Royal Meteorological Society, 134, 621–634, 2008.

Braun, S. A.: Reevaluating the role of the Saharan air layer in Atlantic tropical cyclogenesis and evolution, Monthly Weather Review, 138, 2007–2037, 2010.

Brooks, N. and Legrand, M.: Dust variability over northern Africa and rainfall in the Sahel, in: Linking climate change to land surface change, pp. 1–25, Springer, 2000.

Cakmur, R. V., Miller, R. L., and Tegen, I.: A comparison of seasonal and interannual variability of soil dust aerosols over the Atlantic Ocean as inferred by the TOMS AI and AVHRR AOT retrievals, Journal of Geophysical Research: Atmospheres, 106, 18 287–18 303, 2001.

Carlson, T. N. and Prospero, J. M.: The large-scale movement of Saharan air outbreaks over the northern equatorial Atlantic, Journal of applied meteorology, 11, 283–297, 1972.

Cavalieri, O., Cairo, F., Fierli, F., Donfrancesco, G. D., Snels, M., Viterbini, M., Cardillo, F., Chatenet, B., Formenti, P., Marticorena, B., et al.: Variability of aerosol vertical distribution in the Sahel, Atmospheric Chemistry and Physics, 10, 12 005–12 023, 2010.

Chiapello, I. and Moulin, C.: TOMS and METEOSAT satellite records of the variability of Saharan dust transport over the Atlantic during the last two decades (1979–1997), Geophysical Research Letters, 29, 2002.

Chiapello, I., Bergametti, G., Gomes, L., Chatenet, B., Dulac, F., Pimenta, J., and Santos Suares, E.: An additional low layer transport of Sahelian and Saharan dust over the north-eastern tropical Atlantic, Geophysical Research Letters, 22, 3191–3194, 1995.

Chiapello, I., Prospero, J., Herman, J., and Hsu, N.: Detection of mineral dust over the North Atlantic Ocean and Africa with the Nimbus 7 TOMS, Journal of Geophysical Research: Atmospheres, 104, 9277–9291, 1999.

Chou, C., Formenti, P., Maille, M., Ausset, P., Helas, G., Osborne, S., and Harrison, M.: Size distribution, shape and composition of dust aerosols collected during the AMMA SOP0 field campaign in the northeast of Niger, January 2006, J. Geophys. Res, 113, D00C10, 2008.

Claquin, T., Schulz, M., and Balkanski, Y.: Modeling the mineralogy of atmospheric dust sources, Journal of Geophysical Research: Atmospheres, 104, 22 243–22 256, 1999.

Cuesta, J., Marsham, J. H., Parker, D. J., and Flamant, C.: Dynamical mechanisms controlling the vertical redistribution of dust and the thermodynamic structure of the West Saharan atmospheric boundary layer during summer, Atmospheric Science Letters, 10, 34–42, 2009.

Diokhane, A. M., Jenkins, G. S., Manga, N., Drame, M. S., and Mbodji, B.: Linkages between observed, modeled Saharan dust loading and meningitis in Senegal during 2012 and 2013, International journal of biometeorology, 60, 557–575, 2016.

Dubovik, O., Smirnov, A., Holben, B., King, M., Kaufman, Y., Eck, T., and Slutsker, I.: Accuracy assessments of aerosol optical properties retrieved from Aerosol Robotic Network (AERONET) Sun and sky radiance measurements, Journal of Geophysical Research: Atmospheres, 105, 9791–9806, 2000.

Dubovik, O., Holben, B., Eck, T. F., Smirnov, A., Kaufman, Y. J., King, M. D., Tanré, D., and Slutsker, I.: Variability of absorption and optical properties of key aerosol types observed in worldwide locations, Journal of the atmospheric sciences, 59, 590–608, 2002.

Duce, R. A. and Tindale, N. W.: Atmospheric transport of iron and its deposition in the ocean, Limnology and Oceanography, 36, 1715–1726, 1991.

Dulac, F., Chazette, P., Gomes, L., Chatenet, B., Berger, H., and Dos Santos, J. V.: A method for aerosol profiling in the lower troposphere with coupled scatter and meteorological rawindsondes and first data from the tropical Atlantic off Sahara, Journal of aerosol science, 32, 1069–1086, 2001.

Dunion, J. P. and Marron, C. S.: A reexamination of the Jordan mean tropical sounding based on awareness of the Saharan air layer: Results from 2002, Journal of Climate, 21, 5242–5253, 2008.

Engelstaedter, S. and Washington, R.: Atmospheric controls on the annual cycle of North African dust, Journal of Geophysical Research: Atmospheres, 112, 2007.

Engelstaedter, S., Tegen, I., and Washington, R.: North African dust emissions and transport, Earth-Science Reviews, 79, 73–100, 2006.

Eplee, R. E., Patt, F. S., Barnes, R. A., and McClain, C. R.: SeaWiFS long-term solar diffuser reflectance and sensor noise analyses, Applied optics, 46, 762–773, 2007.

Eplee Jr, R. E., Sun, J.-Q., Meister, G., Patt, F. S., Xiong, X., and McClain, C. R.: Cross calibration of SeaWiFS and MODIS using on-orbit observations of the Moon, Applied Optics, 50, 120–133, 2011.

Formenti, P., Andreae, M., Lange, L., Roberts, G., Cafmeyer, J., Rajta, I., Maenhaut, W., Holben, B., Artaxo, P., and Lelieveld, J.: Saharan dust in Brazil and Suriname during the Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA)-Cooperative LBA Regional Experiment (CLAIRE) in March 1998, Journal of Geophysical Research: Atmospheres, 106, 14 919–14 934, 2001.

Formenti, P., Rajot, J. L., Desboeufs, K., Caquineau, S., Chevaillier, S., Nava, S., Gaudichet, A., Journet, E., Triquet, S., Alfaro, S., et al.: Regional variability of the composition of mineral dust from western Africa: Results from the AMMA SOP0/DABEX and DODO field campaigns, Journal of Geophysical Research: Atmospheres, 113, 2008.

Franz, B. A., Bailey, S. W., Werdell, P. J., and McClain, C. R.: Sensor-independent approach to the vicarious calibration of satellite ocean color radiometry, Applied optics, 46, 5068–5082, 2007.

Friese, C. A., van der Does, M., Merkel, U., Iversen, M. H., Fischer, G., and Stuut, J.-B. W.: Environmental factors controlling the seasonal variability in particle size distribution of modern Saharan dust deposited off Cape Blanc, Aeolian Research, 22, 165–179, 2016.

Gamo, M.: Thickness of the dry convection and large-scale subsidence above deserts, Boundary-Layer Meteorology, 79, 265–278, 1996.

Ganor, E. and Mamane, Y.: Transport of Saharan dust across the eastern Mediterranean, Atmospheric Environment (1967), 16, 581–587, 1982.

Ganor, E., Osetinsky, I., Stupp, A., and Alpert, P.: Increasing trend of African dust, over 49 years, in the eastern Mediterranean, Journal of Geophysical research: atmospheres, 115, 2010.

Generoso, S., Bey, I., Labonne, M., and Bréon, F.-M.: Aerosol vertical distribution in dust outflow over the Atlantic: Comparisons between GEOS-Chem and Cloud-aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO), Journal of Geophysical Research: Atmospheres, 113, 2008.

Griffin, D. W.: Atmospheric movement of microorganisms in clouds of desert dust and implications for human health, Clinical microbiology reviews, 20, 459–477, 2007.

Heese, B. and Wiegner, M.: Vertical aerosol profiles from Raman polarization lidar observations during the dry season AMMA field campaign, Journal of Geophysical Research: Atmospheres, 113, 2008.

Hervo, M.: Etude des propriétés optiques et radiatives des aérosols en atmosphère réelle: Impact de l'hygroscopicité, Ph.D. thesis, Université Blaise Pascal-Clermont-Ferrand II, 2013.

Highwood, E. J., Haywood, J. M., Silverstone, M. D., Newman, S. M., and Taylor, J. P.: Radiative properties and direct effect of Saharan dust measured by the C-130 aircraft during Saharan Dust Experiment (SHADE): 2. Terrestrial spectrum, Journal of Geophysical Research: Atmospheres, 108, 2003.

Holben, B., Tanre, D., Smirnov, A., Eck, T., Slutsker, I., Abuhassan, N., Newcomb, W., Schafer, J., Chatenet, B., Lavenu, F., et al.: An emerging ground-based aerosol climatology: Aerosol optical depth from AERONET, Journal of Geophysical Research: Atmospheres, 106, 12 067–12 097, 2001.

Holben, B. N., Eck, T., Slutsker, I., Tanre, D., Buis, J., Setzer, A., Vermote, E., Reagan, J. A., Kaufman, Y., Nakajima, T., et al.: AERONET—A federated instrument network and data archive for aerosol characterization, Remote sensing of environment, 66, 1–16, 1998.

Hourdin, F., Gueye, M., Diallo, B., Dufresne, J.-L., Escribano, J., Menut, L., Marticoréna, B., Siour, G., and Guichard, F.: Parameterization of convective transport in the boundary layer and its impact on the representation of the diurnal cycle of wind and dust emissions, Atmospheric Chemistry and Physics, 15, 6775–6788, 2015.

Howell, S., Clarke, A., Shinozuka, Y., Kapustin, V., McNaughton, C., Huebert, B., Doherty, S., and Anderson, T.: Influence of relative humidity upon pollution and dust during ACE-Asia: Size distributions and implications for optical properties, Journal of Geophysical Research: Atmospheres, 111, 2006.

Hsu, N., Gautam, R., Sayer, A., Bettenhausen, C., Li, C., Jeong, M., Tsay, S., and Holben, B.: Global and regional trends of aerosol optical depth over land and ocean using SeaWiFS measurements from 1997 to 2010, 2012.

Hsu, N. C., Tsay, S.-C., King, M. D., and Herman, J. R.: Aerosol properties over bright-reflecting source regions, IEEE Transactions on Geoscience and Remote Sensing, 42, 557–569, 2004.

Huneeus, N., Schulz, M., Balkanski, Y., Griesfeller, J., Prospero, J., Kinne, S., Bauer, S., Boucher, O., Chin, M., Dentener, F., et al.: Global dust model intercomparison in AeroCom phase I, Atmospheric Chemistry and Physics, 11, 2011.

Hunt, W. H., Winker, D. M., Vaughan, M. A., Powell, K. A., Lucker, P. L., and Weimer, C.: CALIPSO lidar description and performance assessment, Journal of Atmospheric and Oceanic Technology, 26, 1214–1228, 2009.

~~Husar, R. B., Prospero, J. M., and Stowe, L. L.: Characterization of tropospheric aerosols over the oceans with the NOAA advanced very high resolution radiometer optical thickness operational product, Journal of Geophysical Research: Atmospheres, 102, 16889–16909, 1997.~~

Ialongo, I., Buchard, V., Brogniez, C., Casale, G., and Siani, A.: Aerosol Single Scattering Albedo retrieval in the UV range: an application to OMI satellite validation, Atmospheric Chemistry and Physics, 10, 331–340, 2010.

Israelevich, P., Ganor, E., Levin, Z., and Joseph, J.: Annual variations of physical properties of desert dust over Israel, Journal of Geophysical Research: Atmospheres, 108, 2003.

Jamet, C., Moulin, C., and Thiria, S.: Monitoring aerosol optical properties over the Mediterranean from SeaWiFS images using a neural network inversion, Geophysical Research Letters, 31, 2004.

Jethva, H., Torres, O., and Ahn, C.: Global assessment of OMI aerosol single-scattering albedo using ground-based AERONET inversion, Journal of Geophysical Research: Atmospheres, 119, 9020–9040, 2014.

Jickells, T., An, Z., Andersen, K. K., Baker, A., Bergametti, G., Brooks, N., Cao, J., Boyd, P., Duce, R., Hunter, K., et al.: Global iron connections between desert dust, ocean biogeochemistry, and climate, science, 308, 67–71, 2005.

Johnson, B. and Osborne, S.: Physical and optical properties of mineral dust aerosol measured by aircraft during the GERBILS campaign, Quarterly Journal of the Royal Meteorological Society, 137, 1117–1130, 2011.

Johnson, B., Osborne, S., Haywood, J., and Harrison, M.: Aircraft measurements of biomass burning aerosol over West Africa during DABEX, Journal of Geophysical Research: Atmospheres, 113, 2008.

Joseph, M.: Long-term measurements of the transport of African mineral dust to the southeastern United States: Implications for regional air quality, 1999.

Karyampudi, V. M., Palm, S. P., Reagen, J. A., Fang, H., et al.: Validation of the Saharan dust plume conceptual model using lidar, Meteosat, and ECMWF data, Bulletin of the American Meteorological Society, 80, 1045, 1999.

Kaufman, Y., Koren, I., Remer, L., Tanré, D., Ginoux, P., and Fan, S.: Dust transport and deposition observed from the Terra-Moderate Resolution Imaging Spectroradiometer (MODIS) spacecraft over the Atlantic Ocean, Journal of Geophysical Research: Atmospheres, 110, 2005.

Lafore, J.-P., Flamant, C., Guichard, F., Parker, D., Bouniol, D., Fink, A., Giraud, V., Gosset, M., Hall, N., Höller, H., et al.: Progress in understanding of weather systems in West Africa, Atmospheric Science Letters, 12, 7–12, 2011.

Laurent, B., Marticorena, B., Bergametti, G., Léon, J., and Mahowald, N.: Modeling mineral dust emissions from the Sahara desert using new surface properties and soil database, Journal of Geophysical Research: Atmospheres, 113, 2008.

Lavaysse, C., Flamant, C., Janicot, S., Parker, D., Lafore, J.-P., Sultan, B., and Pelon, J.: Seasonal evolution of the West African heat low: a climatological perspective, Climate Dynamics, 33, 313–330, 2009.

Léon, J.-F., Derimian, Y., Chiapello, I., Tanré, D., Podvin, T., Chatenet, B., Diallo, A., and Deroo, C.: Aerosol vertical distribution and optical properties over M'Bour (16.96 W; 14.39 N), Senegal from 2006 to 2008, Atmospheric Chemistry and Physics, 9, 9249–9261, 2009.

Levelt, P. F., van den Oord, G. H., Dobber, M. R., Malkki, A., Visser, H., de Vries, J., Stammes, P., Lundell, J. O., and Saari, H.: The ozone monitoring instrument, IEEE Transactions on geoscience and remote sensing, 44, 1093–1101, 2006.

Liu, D., Wang, Z., Liu, Z., Winker, D., and Trepte, C.: A height resolved global view of dust aerosols from the first year CALIPSO lidar measurements, Journal of Geophysical Research: Atmospheres, 113, 2008.

Liu, D., Wang, Y., Wang, Z., and Zhou, J.: The three-dimensional structure of transatlantic African dust transport: a new perspective from CALIPSO LIDAR measurements, Advances in Meteorology, 2012, 2012.

Liu, Z., Omar, A., Hu, Y., Vaughan, M., Winker, D., Poole, L., and Kovacs, T.: CALIOP algorithm theoretical basis document. Part 3: Scene classification algorithms, NASA-CNES document PC-SCI-203, 2005.

Mahowald, N., Albani, S., Kok, J. F., Engelstaeder, S., Scanza, R., Ward, D. S., and Flanner, M. G.: The size distribution of desert dust aerosols and its impact on the Earth system, Aeolian Research, 15, 53–71, 2014.

Mahowald, N. M., Engelstaedter, S., Luo, C., Sealy, A., Artaxo, P., Benitez-Nelson, C., Bonnet, S., Chen, Y., Chuang, P. Y., Cohen, D. D., et al.: Atmospheric Iron Deposition: Global Distribution, Variability, and Human Perturbations*, Annual Review of Marine Science, 1, 245–278, 2009.

Malavelle, F.: Effets direct et semi-direct des aérosols en Afrique de l'ouest pendant la saison sèche, Ph.D. thesis, Université Paul Sabatier-Toulouse III, 2011.

Marticorena, B., Chatenet, B., Rajot, J.-L., Traoré, S., Coulibaly, M., Diallo, A., Koné, I., Maman, A., NDiaye, T., and Zakou, A.: Temporal variability of mineral dust concentrations over West Africa: analyses of a pluriannual monitoring from the AMMA Sahelian Dust Transect, Atmospheric Chemistry and Physics, 10, 8899–8915, 2010.

Martin, J. H.: Iron as a limiting factor in oceanic productivity, in: Primary productivity and biogeochemical cycles in the sea, pp. 123–137, Springer, 1992.

Martiny, N. and Chiapello, I.: Assessments for the impact of mineral dust on the meningitis incidence in West Africa, Atmospheric Environment, 70, 245–253, 2013.

McConnell, C., Highwood, E., Coe, H., Formenti, P., Anderson, B., Osborne, S., Nava, S., Desboeufs, K., Chen, G., and Harrison, M.: Seasonal variations of the physical and optical characteristics of Saharan dust: Results from the Dust Outflow and Deposition to the Ocean (DODO) experiment, Journal of Geophysical Research: Atmospheres, 113, 2008.

Messager, C., Parker, D. J., Reitebuch, O., Agusti-Panareda, A., Taylor, C. M., and Cuesta, J.: Structure and dynamics of the Saharan atmospheric boundary layer during the West African monsoon onset: Observations and analyses from the research flights of 14 and 17 July 2006, Quarterly Journal of the Royal Meteorological Society, 136, 107–124, 2010.

Mielonen, T., Arola, A., Komppula, M., Kukkonen, J., Koskinen, J., de Leeuw, G., and Lehtinen, K.: Comparison of CALIOP level 2 aerosol subtypes to aerosol types derived from AERONET inversion data, Geophysical Research Letters, 36, 2009.

Mills, M. M., Ridame, C., Davey, M., La Roche, J., and Geider, R. J.: Iron and phosphorus co-limit nitrogen fixation in the eastern tropical North Atlantic, Nature, 429, 292–294, 2004.

Mokhtari, M.: Amélioration de la prise en compte des aérosols terrigènes dans les modèles atmosphériques à moyenne échelle, Ph.D. thesis, Université de Toulouse, Université Toulouse III-Paul Sabatier, 2012.

Mortier, A., Goloub, P., Derimian, Y., Tanré, D., Podvin, T., Blarel, L., Deroo, C., Marticorena, B., Diallo, A., and Ndiaye, T.: Climatology of aerosol properties and clear-sky shortwave radiative effects using Lidar and Sun photometer observations in the Dakar site, Journal of Geophysical Research: Atmospheres, 2016.

Moulin, C.: Transport atmosphérique des poussières africaines sur la Méditerranée et l'Atlantique: climatologie satellitale à partir des images Météosat VIS(1983-1994) et relations avec le climat, Ph.D. thesis, 1997.

Omar, A. H., Winker, D. M., Vaughan, M. A., Hu, Y., Trepte, C. R., Ferrare, R. A., Lee, K.-P., Hostetler, C. A., Kittaka, C., Rogers, R. R., et al.: The CALIPSO automated aerosol classification and lidar ratio selection algorithm, Journal of Atmospheric and Oceanic Technology, 26, 1994–2014, 2009.

Ozer, P.: Les lithométéores en région sahélienne: un indicateur climatique de la désertification, Ph.D. thesis, Université de Liège Faculté des sciences Liège Belgique, Liège, Belgique, 2000.

Petzold, A., Veira, A., Mund, S., Esselborn, M., Kiemle, C., Weinzierl, B., Hamburger, T., Ehret, G., Lieke, K., and Kandler, K.: Mixing of mineral dust with urban pollution aerosol over Dakar (Senegal): impact on dust physico-chemical and radiative properties, Tellus B, 63, 619–634, 2011.

Prospero, J., Glaccum, R., and Nees, R.: Atmospheric transport of soil dust from Africa to South America, Nature, 289, 570–572, 1981.

Prospero, J. M., Blades, E., Mathison, G., and Naidu, R.: Interhemispheric transport of viable fungi and bacteria from Africa to the Caribbean with soil dust, Aerobiologia, 21, 1–19, 2005.

Rajot, J.-L.: Wind blown sediment mass budget of Sahelian village land units in Niger, Bulletin de la SocitGologique de France, 172, 523–531, 2001.

Ramanathan, V., Crutzen, P., Kiehl, J., and Rosenfeld, D.: Aerosols, climate, and the hydrological cycle, science, 294, 2119–2124, 2001.

Reid, J. S., Westphal, D. L., Livingston, J. M., Savoie, D. L., Maring, H. B., Jonsson, H. H., Eleuterio, D. P., Kinney, J. E., and Reid, E. A.: Dust vertical distribution in the Caribbean during the Puerto Rico Dust Experiment, Geophysical research letters, 29, 2002.

Ridley, D., Heald, C., and Ford, B.: North African dust export and deposition: A satellite and model perspective, Journal of Geophysical Research: Atmospheres, 117, 2012.

Ryder, C., Highwood, E., Lai, T., Sodemann, H., and Marsham, J.: Impact of atmospheric transport on the evolution of microphysical and optical properties of Saharan dust, Geophysical Research Letters, 40, 2433–2438, 2013.

Sayer, A., Hsu, N., Bettenhausen, C., Ahmad, Z., Holben, B., Smirnov, A., Thomas, G., and Zhang, J.: SeaWiFS Ocean Aerosol Retrieval (SOAR): Algorithm, validation, and comparison with other data sets, Journal of Geophysical Research: Atmospheres, 117, 2012.

Schepanski, K., Tegen, I., Laurent, B., Heinold, B., and Macke, A.: A new Saharan dust source activation frequency map derived from MSG-SEVIRI IR-channels, Geophysical Research Letters, 34, 2007.

Schepanski, K., Tegen, I., and Macke, A.: Saharan dust transport and deposition towards the tropical northern Atlantic, Atmos. Chem. Phys, 9, 1173–1189, 2009a.

Schepanski, K., Tegen, I., Todd, M., Heinold, B., Bönisch, G., Laurent, B., and Macke, A.: Meteorological processes forcing Saharan dust emission inferred from MSG-SEVIRI observations of subdaily dust source activation and numerical models, Journal of Geophysical Research: Atmospheres, 114, 2009b.

Schepanski, K., Tegen, I., and Macke, A.: Comparison of satellite based observations of Saharan dust source areas, Remote Sensing of Environment, 123, 90–97, 2012.

Shao, Y.: Physics and modelling of wind erosion (atmospheric and oceanographic sciences library), 2000.

Slutsker, I. and Kinne, S.: Wavelength dependence of the optical depth of biomass burning, urban, and desert dust aerosols, J Geophys Res, 104, 00 093–5, 1999.

Sokolik, I. N. and Toon, O. B.: Incorporation of mineralogical composition into models of the radiative properties of mineral aerosol from UV to IR wavelengths, Journal of Geophysical Research, 104, 9423–9444, 1999.

Solomon, S.: Climate change 2007-the physical science basis: Working group I contribution to the fourth assessment report of the IPCC, vol. 4, Cambridge University Press, 2007.

Stith, J., Ramanathan, V., Cooper, W., Roberts, G., DeMott, P., Carmichael, G., Hatch, C., Adhikary, B., Twohy, C., Rogers, D., et al.: An overview of aircraft observations from the Pacific Dust Experiment campaign, Journal of Geophysical Research: Atmospheres, 114, 2009.

Swap, R., Garstang, M., Greco, S., Talbot, R., and Kållberg, P.: Saharan dust in the Amazon Basin, Tellus B, 44, 133–149, 1992.

Taghavi, F. and Asadi, A.: The Persian Gulf 12th April 2007 dust storm: observation and model analysis, in: EUMETSAT Meteorological Satellite Conference, Darmstadt, Germany, pp. 8–12, 2008.

Tanaka, T. Y., Kurosaki, Y., Chiba, M., Matsumura, T., Nagai, T., Yamazaki, A., Uchiyama, A., Tsunematsu, N., and Kai, K.: Possible transcontinental dust transport from North Africa and the Middle East to East Asia, Atmospheric Environment, 39, 3901–3909, 2005.

Tegen, I., Schepanski, K., and Heinold, B.: Comparing two years of Saharan dust source activation obtained by regional modelling and satellite observations, Atmospheric Chemistry and Physics, 13, 2381–2390, 2013.

Teller, A. and Levin, Z.: The effects of aerosols on precipitation and dimensions of subtropical clouds: a sensitivity study using a numerical cloud model, Atmospheric Chemistry and Physics, 6, 67–80, 2006.

Thomson, M. C., Molesworth, A. M., Djingarey, M. H., Yameogo, K., Belanger, F., and Cuevas, L. E.: Potential of environmental models to predict meningitis epidemics in Africa, Tropical Medicine & International Health, 11, 781–788, 2006.

Tsamalis, C., Chédin, A., Pelon, J., and Capelle, V.: The seasonal vertical distribution of the Saharan Air Layer and its modulation by the wind, Atmospheric Chemistry and Physics, 13, 11 235–11 257, 2013.

Tulet, P., Mallet, M., Pont, V., Pelon, J., and Boone, A.: The 7–13 March 2006 dust storm over West Africa: Generation, transport, and vertical stratification, Journal of Geophysical Research: Atmospheres, 113, 2008.

Vuolo, M. R., Chepfer, H., Menut, L., and Cesana, G.: Comparison of mineral dust layers vertical structures modeled with CHIMERE-DUST and observed with the CALIOP lidar, Journal of Geophysical Research: Atmospheres, 114, 2009.

Wagener, T.: Le fer à l'interface océan-atmosphère: Flux et processus de dissolution dans l'eau de mer., Ph.D. thesis, Université de la Méditerranée-Aix-Marseille II, 2008.

Wang, M., Bailey, S., Pietras, C., McClain, C., and Riley, T.: SeaWiFS aerosol optical thickness matchup analyses, The Sea-WiFS Postlaunch Technical Report Series, 10, 39–44, 2000.

Weinzierl, B., Ansmann, A., Prospero, J., Althausen, D., Benker, N., Chouza, F., Dollner, M., Farrell, D., Fomba, W., Freudenthaler, V., et al.: The Saharan Aerosol Long-range Transport and Aerosol-Cloud-Interaction Experiment (SALTRACE): overview and selected highlights, Bulletin of the American Meteorological Society, 2016.

Winker, D.: Accounting for multiple scattering in retrievals from space lidar, in: Proc. of SPIE Vol, vol. 5059, p. 129, 2003.

Winker, D. M., Hostetler, C., Vaughan, M., and Omar, A.: CALIOP Algorithm Theoretical Basis Document, Part 1: CALIOP Instrument, and Algorithms Overview, Release, 2, 29, 2006.

Winker, D. M., Hunt, W. H., and McGill, M. J.: Initial performance assessment of CALIOP, Geophysical Research Letters, 34, 2007.

Wu, M.-L. C., Reale, O., Schubert, S. D., Suarez, M. J., Koster, R. D., and Pegion, P. J.: African easterly jet: structure and maintenance, Journal of Climate, 22, 4459–4480, 2009.

Yang, W., Marshak, A., Várnai, T., Kalashnikova, O. V., and Kostinski, A. B.: CALIPSO observations of transatlantic dust: vertical stratification and effect of clouds, Atmospheric Chemistry and Physics, 12, 11 339–11 354, 2012.

Yu, H., Chin, M., Winker, D. M., Omar, A. H., Liu, Z., Kittaka, C., and Diehl, T.: Global view of aerosol vertical distributions from CALIPSO lidar measurements and GOCART simulations: Regional and seasonal variations, Journal of Geophysical Research: Atmospheres, 115, 2010.

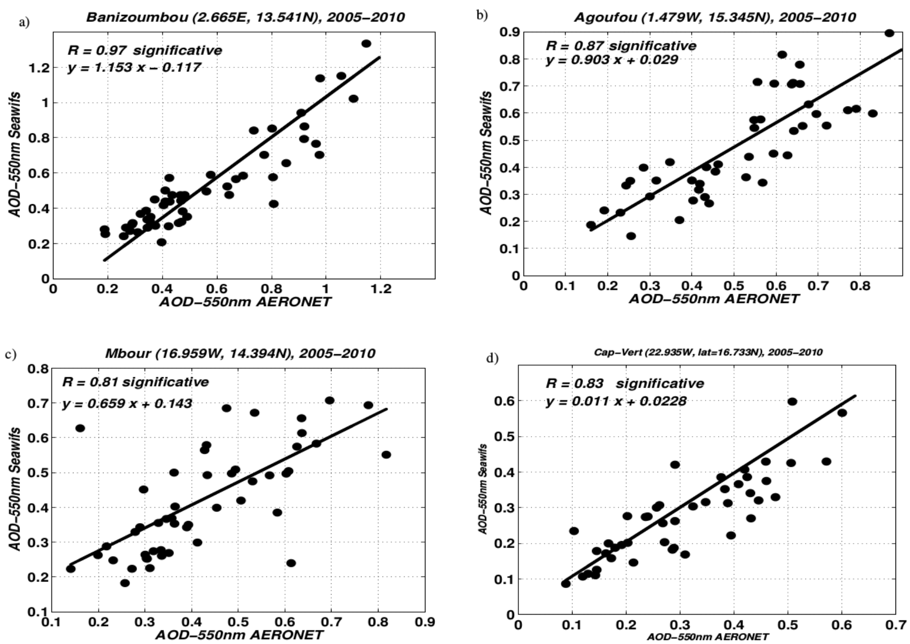

Figure 1. Comparison of monthly mean aerosol optical depth (AOD) between SeaWiFS (550 nm) and ground measurements from AERONET (675 nm) from January 2005 to December 2010. This comparison is done at the following stations : a) Banizoumbou (53 points), b) Agoufou (47 points), c) M'bour (50 points) and d) Cape verde (47 points). The red solid line represents the regression between both dataset

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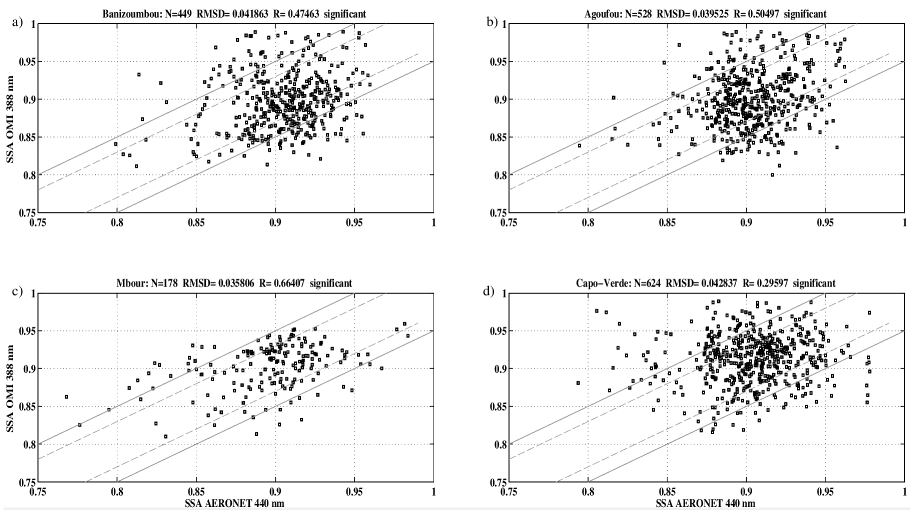

Figure 2. OMAERUV SSA at ~~440~~ 388 nm wavelength as a function of AERONET SSA at 440 nm at a) Banizoumbou (~~lon=~~2.665E,~~lat=~~13.541N; ~~a total of~~ 449 retrievals~~are plotted, yielding a root mean square difference (RMSD) of 0.04~~); b) Agoufou (~~lon=-1.479~~1.479W, ~~lat=~~15.345N; 528 retrievals~~with a RMSD of 0.04~~); c) Mbour (~~lon=-16.959~~16.959W, ~~lat=~~14.394N; 178 retrievals~~with a RMSD of 0.04~~) and d) Capo Verde (~~lon=-22.935~~22.935W, ~~lat=~~16.733N; 624 retrievals~~with a RMSD of 0.04~~). The solid lines indicate the domain where the two retrievals agree with each other within 0.03 and the dashed lines indicate agreement within 0.05.~~The AERONET's data used here are Level 2, quality assured for Banizoumbou, Agoufou and M'bour sites. For Cape Verde Level 1.5, is used to get a significant number of retrievals.~~

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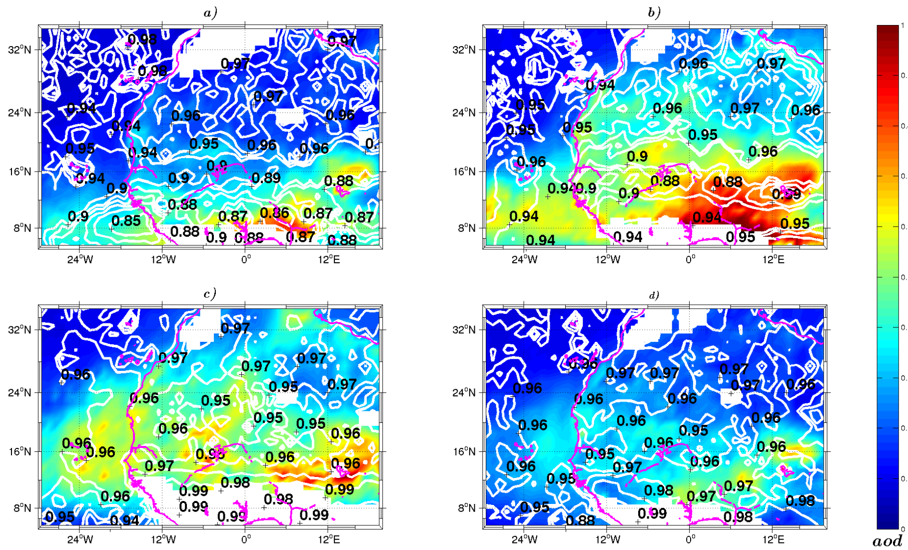

Figure 3. Seasonal distribution of aerosol optical depth (average between 2005 and 2010) at 550 nm wavelength (colours) from SeaWiFS for a) winter (DJF); b) spring (MAM); c) summer (JJA) and d) fall (SON). Single scattering albedo (SSA) from OMI is superimposed with white contour lines. The box delimited by brown dashed lines represent the band of latitude averaged in Fig. 4 (12°-21°N) where dust aerosols have the strongest contribution to AOD.

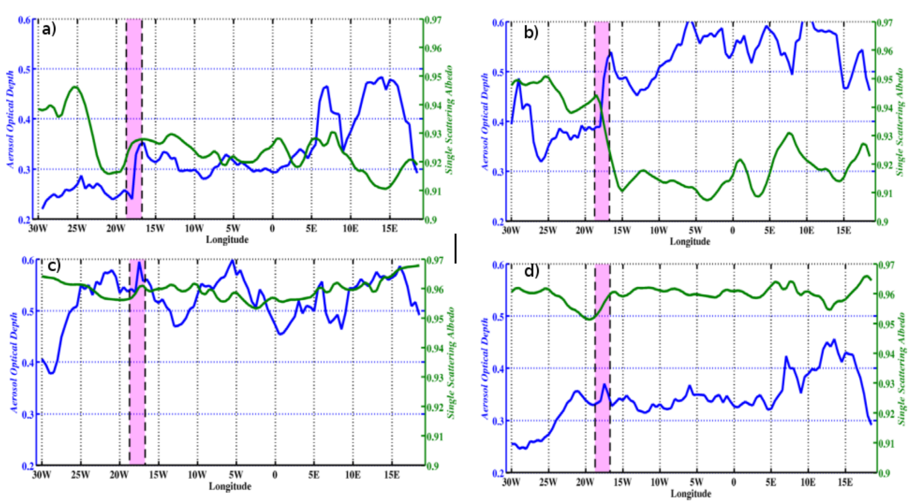

Figure 4. Seasonal SeaWiFS AOD at 550 nm (bleu), Aura/OMI SSA (green) zonally averaged between 12° and 21°N and from 2005 to 2010: a) DJF; b) MAM; c) JJA; and d) SON. The black dashed lines indicate the continent-ocean transition for the latitude range 12°-21°N.

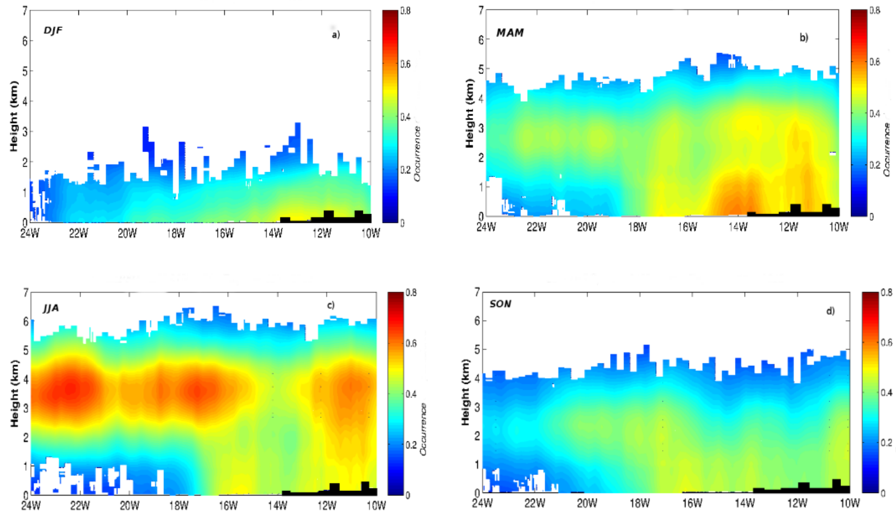

Figure 5. CALIOP daytime seasonal vertical distribution of the frequency of mineral dust aerosol occurrence zonally averaged between 12° and 21°N over the period 2007-2013: a) winter; b) spring; c) summer; and d) fall.

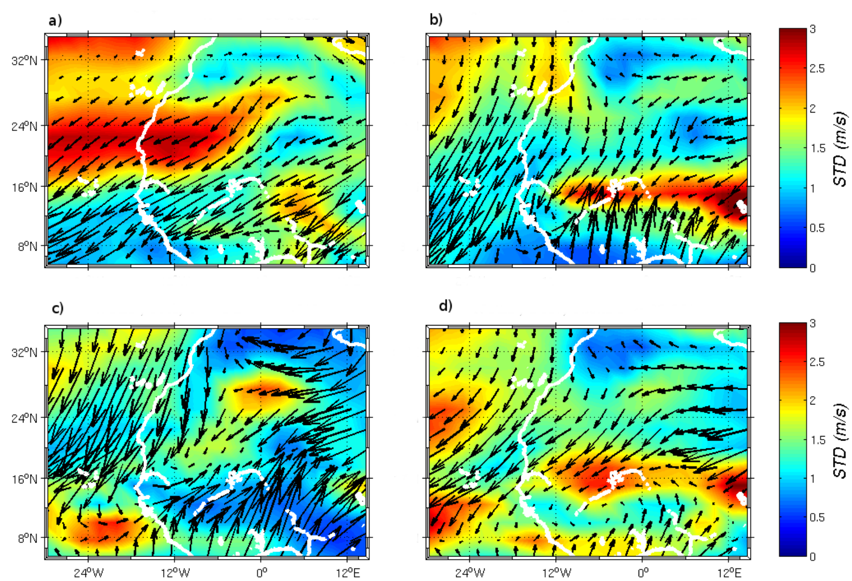

Figure 6. Seasonal mean zonal wind field at 925 hPa over West Africa from NCEP Reanalysis between 2000 and 2012: a) winter (DJF); b) spring (MAM); c) summer (JJA); and d) fall (SON). The vectors show wind direction while colors indicate the standard deviation of wind velocity (m.s^{-}1).

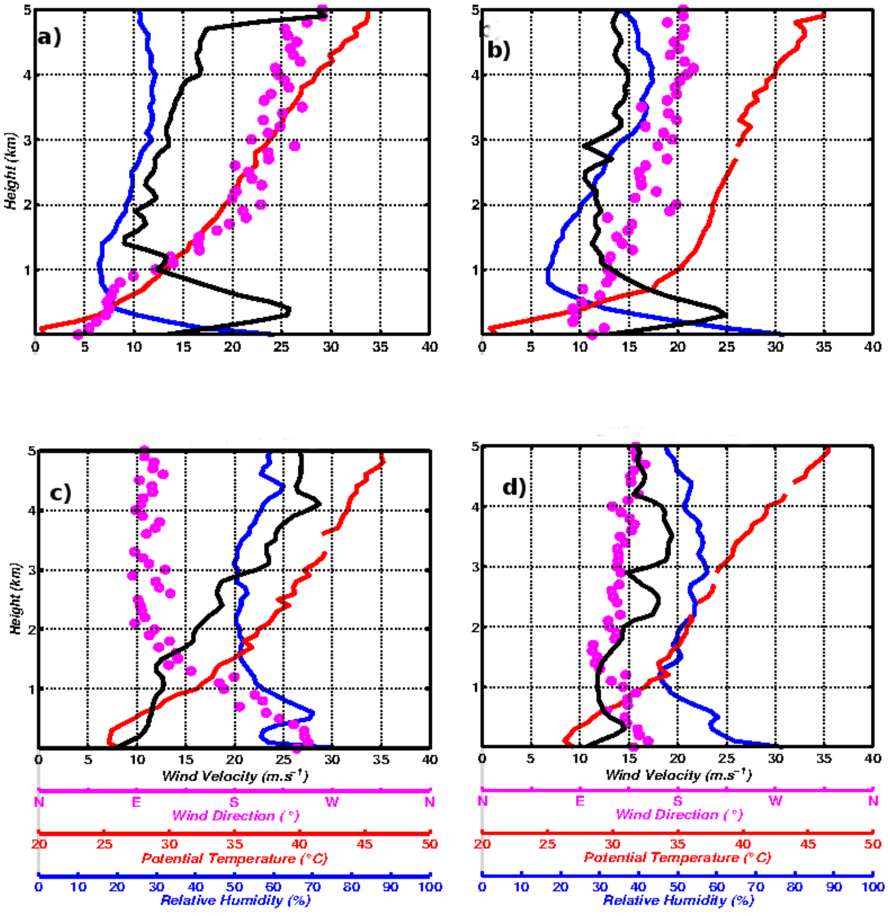

Figure 7. Mean seasonal vertical profiles of wind velocity (black line), wind direction (pink dots), potential temperature (red line) and relative humidity (blue line) at Dakar weather station (14.73°N, 17.51°W) for a) winter; b) spring; c) summer; and d) fall. Observations correspond to weather balloon launched daily at 12UTC for years 2012 to 2014.

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