Dust is a most abundant atmospheric aerosol component in terms of aerosol dry masses. Yet, dust, as well as sea salt, simulation has a higher uncertainty among major primary aerosol components due to its interactive parameterizations of the emissions and contrasting particles sizes concluded by a study of multi-model comparison within AeroCom [Textor et al., 2006]. This paper addresses this weak link in dust simulation by improving dust emission with a better description of the surface soil size distribution of erodible material. The topic of the paper is suitable for Geoscientific Model Development. I recommend publishing the paper after the authors address the following comments.

Textor, C., Schulz, M., Guibert, S., Kinne, S., Balkanski, Y., et al.: Analysis and quantification of the diversities of aerosol life cycles within AeroCom, Atmos. Chem. Phys., 6, 1777-1813, doi:10.5194/acp-6-1777-2006, 2006.

We would like to thank the reviewer for their constructive comments and its help to perform our English.

Our response is detailed below.

General Remarks:

The paper adopts a theory that each soil texture class is linked to a specific soil aggregate particle size distribution. Does the change of soil aggregate distributions due to a change of texture classes translate to a change of emitted dust size distribution? This further discussion is important since dust size distributions not only affect dust simulation but also the role of dust in air quality and climate. If the dust emitted size distribution remains the same with various texture classes, which is consistent with the conclusion of a recent study by Kok (2011), please show the comparison of the distribution between this work and Kok's. Can you use Kok's distribution instead to revisit the study? If the dust emitted size distribution changes with texture classes, do you have any explanations for contradictory results between yours and Kok's?

Kok, J.,: Does the size distribution of mineral dust aerosols depend on the wind speed at emission? Atmos. Chem. Phys., 11, 10149–10156, 2011 www.atmos-chemphys.net/11/10149/2011/ doi:10.5194/acp-11-10149-2011.

There are a lot of terms, phrases, and sentences that require clarification. Some examples of these unclear definitions are given in the following specific comments. In addition, there are a number of grammar issues and awkward sentences. It would be good to ask someone for a careful "copy editing" read through.

I specify, through our paper, we proposed a new map of dust source emission based on the surface soil size distribution which replaces the map of the sand fraction utilized in DEAD. And we introduced, in the revised version of DEAD, the Shao (1996) formulation to calculate the sandblasting efficiency (α). The experiments and results exposed in the manuscript show well the interest of these modifications on the intensity of the surface dust fluxes (not emitted size distribution) and its dependence with soil textures. The variation of the soil texture is used in our work, only to quantify the saltation dust fluxes, because texture influences much the soil moisture-inhibition effects and the soil potential of fine particles. Thus, influence the saltation dust fluxes. Generally, the surface soil size distributions given by literature are very coarse, as our case. And also contain very large soil particles which is not participating in dust transport but it is important for dust mobilization. So, in my opinion it is very difficult to make a corresponding between surface soil size distribution and size distribution of emitted

dust aerosol. For this reason in our work, we chose the uniform size distribution of emitted flux for all textures; which is in agreement with Kok's theory. The difference between the Kok's distribution and the AMMA distribution (Fig.S2) is very perceptible and is clear that Kok's distribution is coarser and neglects the fine mode which is confirmed by the AMMA observations. This is related to the fact of this theory which is based on the measurements taking near the surface. However the AMMA distribution is based on the aircraft measurements taking at an altitude around 700 m above mean sea level between Niamey (Niger) and Cotonou (Benin). These regions are far from dust source and the dust fine particles are more dominant, because they have a weak sedimentation velocity and an important atmospheric residence time. For this reason the AMMA distribution is finer than Kok's. This fine mode is very important and thus acts as Ice Nuclei. So, we adopt this distribution for the revised DEAD version in order to represent well the transportable dust particles in the west Africa.
We excuse ourselves for the English. The final version of the manuscript will be revised by an expert in English.

We note that, a supplement for clarify the section 2 is given at the end of these responses. This supplement was introduced in the revised version of the manuscript.

Specific comments:
1. Page 2894 line 17: Can you indicate which approach gives better AOD simulation?

The Aerosol Optical Depth is defined as the integrated extinction coefficient over a vertical column of unit cross section. This parameter depends on the emission, transport, dry and wet deposition processes, and optical parameters of dusts. However, both approach utilize the same aerosol scheme (ORILAM) (Tulet and al. 2005) and the same SCAVenging scheme (Tost et al., 2006). For this reason the difference in AOD of the both simulation is small. But locally, the revised version gives better results, over M'bour and Djougou.

2. Page 2896 line 8: Please change "surface size distribution" to "surface soil size distribution" throughout the paper.
Thanks for this correction; It has been changed throughout the text.

3. Page 2897 line 12: Why is '(in situ or after transportation)' needed here?

"in situ or after transportation" describe the two types of formation of soil texture. The first type, mean the rock and minerals that has decomposed in place (in situ), the second refers to the material that has been deposited by wind, water, or ice (after transportation). This distinction will be clarified in the text.

4. Page 2898 equation 1: Mj, Dmedj, and j should have p in their subscripts since they are also the function of soil texture classes as shown in Table 2.
The reviewer is right; mass fraction M_j , median diameter D_{medj} and standard deviation σ_j depend on soil texture. So, the Eq.1 will be reformulated. The relation is given in the supplement by Eq.S1.

5. Page 2898 line 23: What does "each particle" mean? Does it refer to a texture class, a specific texture, or other?
« each particle » refers to « each soil particle with diameter (D_p) ». A sentence has been added in the text to clarify (see the supplement below).

6. Page 2899 equations 3-4: It is hard to understand section 2.2. Need to clarify Stotal and Sp. Is Stotal a total surface of texture class P or is a total surface of all texture classes? What's Sp? Is it same as Stotal? Need to change 'dSrel' as 'dSrel,p'. Please explicitly indicate that this upgraded DEAD model uses four dust bins and the emitted dust size distribution over each model grid box depends on its erodible fraction (i.e. soil texture classes) of that box.
We agree, the section 2.2 is unclear. It has been reformulated. The revised version of this section is given in the supplement (see below).

7. Page 2899 line 13-14: What's the purpose of calculating the average relative surface of the four populations?
The new map of the potential dust source is represented by the total average surface of the four populations (Fig.5). However, the old map of the potential dust source used in original DEAD is given by sand fraction. So, the purpose is to show the difference between the new and the old map.

8. Page 2899 line 20: Please define 'This last'.
"This last" define "threshold friction velocity". It has been clarified in the revised version of the text.

9. Page 2900 line 18: Please clarify 'each class size'. Does it refer to each of 12 texture classes or each of four populations?
" each class size" refers to "each of four population"
As for section 2.2, the Section 2.3 has been modified. The revised version of this section is given in the supplement (see below).

10. Page 2902 table 4: Elaborate on the motivation of designing the four experiments. Why is it important to test the influence of Moisture effect? Why does it not need to examine the influences separately from the formulation of horizontal saltation flux and the formulation of sandblasting efficiency α?
We introduced a correction within the Fecan (1999) formulation and we judged that it is necessary to give the contribution of this correction on the threshold friction velocity. The difference between the threshold friction velocity obtained by the Fecan (1999) and the adapted Fecan formulation is shown in the supplement Fig.S3.
One objective of this work is to examine the vertical dust flux (not the horizontal saltation flux). Concerning the sandblasting efficiency (α), it is constant in the original version of DEAD, since the percentage of clay is constant and equal to 20%. But in the revised DEAD it is variable. The difference between the sandblasting efficiency (α) calculated by MaB95 and Shao et al. (1996) is shown in the supplement by Fig.S1.

11. Page 2903 line 3-14: I do not understand the discussion. A figure or table to address the content of the discussion would be helpful. Similarly, please show results for the discussions on Page 2903 line 18-22, Page 2904 line 2-10, Page 2904 line 15-20, and Page 2904 line 25 to Page 2905 line4.
The main objective of the four configurations EXP1, EXP2, EXP3 and EXP4 is to quantify the different processes over soil types in particular the vertical dust flux and the threshold friction velocity. Fig. 6 shows well the evolution of the vertical dust fluxes depending on the friction velocity for the four configurations tested over clay soil (Fig. 6a), loamy soil (Fig.6b), sandy loam soil (Fig.6c), loamy sand soil (Fig. 6d) and sand soil (Fig. 6e). Concerning the

spatial variation of the threshold friction velocity we add the figure Fig.S3 which represents the Threshold friction velocity calculated by MaB95, introducing the soil moister effect following: a) Fecan at al (1999) and b) adapted Fecan formulation (Eq.S7) and also we add Table S3 (see the supplement below), to clarify our discussion.

12. Page 2906 line 13: Where is the table 5?
Thanks, it is an error, it correspond to table 4.

13. Page 2907 line 24-25: What is the time interval between the previous and the next model runs?
The time interval between the previous and the next model runs is 48h. This information has been added in the revised version of the text.

14. Page 2908 line 20: Please clarify 'Different AOD maxima'. Different from what?
The sentence will be reformulated as follows: "Various AOD intense were simulated in Chad (3), ..."

15. Page 2910 line 15-16: I am not convinced by the reason given by the authors that salt aerosols have less influence on the AOD due to their property of weakly diffused. Sea salt could enhance AOD significantly such as over Southern hemispheric storm track. The concentration of salt aerosols and the ambient RH are also potential reasons.
The sea salts can play a role of very important Cloud Condensation Nuclei (CCN), and can modify, with difficulty, the AOD beyond 0.2 (what is not negligible). This is due to the fact that these aerosols are little absorbing in comparison with the dusts or pollution aerosols. In ORILAM, the indexes of refractions give, at 550 nm and for an aerosol of diameter of 2 µm, Single Scattering Albedo (SSA) of 0.998 for salts and 0.93 for the dusts. These SSA are in conformity with the literature. If one compares the masses of dusts emitted at the time of the dust storms like that of 7-13 Mars 2006, one shows that the strong AOD are primarily due to the dusts. Also let us note that (but this is not the case here), fires of biomass can also play a big role to modulate the AOD in the West African.

16. Page 2911 line 3: This work applies a regional model to examine an improved DEAD model over Africa only, thus 'globally' should be changed to 'over Africa'.

The reviewer is right. We revised as "over Africa".

17. Page 2912 line 1: There is no cause-result relationship between the observation and the EXP4 and EXP3 predictions over Mbour. Therefore please delete 'therefore' in the sentence and add '.' Before 'EXP4'.

The reviewer is right. It has been changed.

18. Page 2912 line 22: What is 'That' referring to?

"that" refer to "the intense dust flux emission over Bodélé"
The sentence has been modified as: "The studies based on simulations (Laurent et al., 2008 ; Tegen, 2002) and satellite observations (Brooks and Legrand, 2000; Prospero et al.,2002 ; Washington et al.,2003) show that the Bodélé region is a very intense dust source. Which is fortify our results relating to the intense dust flux emission over this region simulated by EXP4"

19. Page 2912 line 22: What is the purpose of this sentence? Why should the dust event on March 9-11, 2006 agree with climatology average?

The march 9-11, 2006 dust storm is a synoptic event, touches the most region of North Africa. The wind speeds during this event exceeding the erosion thresholds into major part of the Sahara. Thus it is a favourable situation to identify and locate the essential of the dust source emission areas over North Africa. This situation shows that the Bodélé region emits much aerosol compared to the other regions, which is in agreement with the studies of Laurent et al. (2008), Tegen (2002), Brooks and Legrand (2000) and Prospero et al. (2002) ; Washington et al., (2003). This clarification has been added in the section 3.2.5.

Brooks, N.P.J., Legrand, M., Dust variability over northern Africa and rainfall in the Sahel, in Linking climate change to landsurface change, McLaren S.J. and Kniveton D. (Eds), Chapter 1,Kluwer Academic Publishers, 1-25, 2000.

Prospero, J.M., Ginoux, P., Torres, O., Nicholson, S.E., Gill, T.E., 2002. Environmental characterization of global sources of atmospheric soil dust identified with the Nimbus 7 Total Ozone Mapping Spectrometer (TOMS) absorbing aerosol product, Rev. Geophys., 40, 1, 1-31, 2002.

Laurent, B., Marticorena, B., Bergametti, G., Léon, J. F., and Mahowald, N. M.: Modeling mineral dust emission from the sahara desert using new surface properties and soil database, J. Geophys. Res., Vol. 113, D14218, doi:10.1029/2007JD009484, 2008.

Tegen, I., S. P. Harrison, K. Kohfeld, I. C. Prentice, M. Coe, and M. Heimann (2002), Impact of vegetation and preferential source areas on global dust aerosol: Results from a model study, *J. Geophys. Res.*, *107*(D21), 4576, doi:10.1029/2001JD000963, 2002.20.

20. Page 2913 line 6: You are not developing the DEAD model, but improving the model.

The reviewer is right. We proposed a revised version of DEAD. So, this remark will be taken into account in the revised text.

21. Page 2913 line 12: I think the Fecan formulation uses a high threshold (with lower moisture) so that Earth surface often can not meet this threshold to allow dust produced (e.g. dust underestimated in EXP 1).

Fecan formulation increases strongly the threshold friction velocity. Fig.S3, in the supplement, shows the difference between the threshold friction velocity calculated by MaB95, introducing the soil moisture effect following: a) Fecan at al (1999) and b) adapted Fecan formulation (Eq.S7).

Technical corrections

Authors greatly thanks the reviewer for all these syntax or grammatical errors

1. Page 2894 line 7-8: delete 'based on both : : :.'.

Revised accordingly.

2. Page 2894 line 8: change 'arrangement" to "improvement'.

Yes. We revised as "improvement".

3. Page 2894 line 13: change 'realized" to "conducted" or "performed'.

Yes. We revised as "conducted".

4. Page 2895 line 25: change 'not known" to "unknown'.

Yes. We revised as "unknown".

5. Page 2896 line 22: change '7-13 March' to 'March 7-13, 2006'. You need to indicate which year for the event when you mention it at first time.

Yes. We revised as “March 7-13, 2006”.

6. Page 2896 line 25: change ‘Sect. 2’ to ‘Section 2’ to be consistent with your writing following.

Yes. We revised as “Section 2”.

7. Page 2896 line 27: change ‘study’ to ‘studies’.

Yes. We revised as “studies”.

8. Page 2897 line 25: I don’t understand the word ‘messing’. Is it a typo of ‘missing’?

We revised as:

9. Page 2897 line 25-26: The sentences “Silt is ...equals 1” has been changed by: “The silt fraction is the portion which complements the two portions of sand and clay for having the sum of the three portions is equal to 1”

10. Page 2899 line 17: Please move ‘(hereinafter referred to as MaB95)’ to the first time it is mentioned in the text. Please use MaB95 hereinafter such as Page 2899 line 20, Page 2900 line 17, Page 2902 line 10, etc.

Revised accordingly.

11. Page 2900 line 14-15: change ‘: : : due to the Oven effect and U10, U10,t are, respectively, the wind speed and : : :’ to ‘due to the Oven effect. U10 and U10,t are the wind speed and the threshold wind speed at 10m, respectively’.

It is “Owen” not “Oven”. So, we revised as : “…due to the Owen effect. U_{10} and $U_{10,t}$ are the wind speed and the threshold wind speed at 10 m, respectively”.

12. Page 2902 line 20: Please define ‘ISBA’.

Thanks for this remark, ISBA mean Interaction Soil Biosphere Atmosphere (ISBA) (Noilhan and Planton,1989)

13. Page 2907 line 3: change ‘have’ to ‘with’.

Yes. We revised as “with”.

14. Page 2907 line 7: Please move ‘the externalized surface scheme (SURFEX)’ to the first time you refer it in the text and use SURFEX afterword. Same for ISBA.

Revised accordingly.

15. Page 2907 line 17: What does ‘MesoNH’ mean?

Thanks for this remark, MesoNH mean mesoscale non-hydrostatic atmospheric model

16. Page 2910 line 11: delete “we register”

Revised accordingly.

17. Page 2910 line 21: missing ‘.’ after ‘14 March’.

Revised accordingly.

18. Page 2912 line 11: change ‘repartition’ to ‘distribution’.

Yes. We revised as “distribution”.

Supplement

Importance of the surface size distribution of erodible material: an improvement of the Dust Entrainment And Deposition (DEAD) Model

2. Developed dust emission scheme coded in SURFEX

The representation of dust emission processes is very important in a dust model. It depends on wind conditions, surface characteristics and soil type. The revised DEAD scheme is based on parameterizations of soil aggregate saltation and sandblasting processes. The main steps for this scheme are: the calculation of soil aggregate size distribution for each model grid cell, the calculation of a threshold friction velocity leading to erosion and saltation processes, the calculation of the horizontal saltating soil aggregate mass flux, and finally the calculation of the vertical transportable dust particle mass fluxes generated by the saltating aggregates.

2.1 Soil texture methodology

Soil texture is the result of physicochemical processes acting on rocks and minerals that has decomposed in place or that has been deposited by wind, water or ice, influenced by external factors like climate, topography, and living organisms. The knowledge of the soil texture is necessary to determine the soil potential of the fine particles and to control the soil water contents. In order to characterize the erodible fraction of different types of soils, soil aggregate distributions are provided to the DEAD scheme. These distributions rely upon the USDA (United States Department of Agriculture) textural classification (Table 1), for which different types of soil are classified according to an index referring to the classic sand/clay/silt triangle of texture composition (Fig. 1) (Buckley, 2001). Sand particles range in size from 0.05–2.0 mm, silt ranges from 0.002–0.05 mm, and the clay is made up of particles less than 0.002 mm in diameter. Gravel or rocks greater than 2 mm in diameter are not considered when determining texture. The combined portions of clay and sand in SURFEX scheme are provided by the global FAO database at 10 km resolution (Masson et al., 2003). These portions are shown in Fig. 2a and Fig. 2b, respectively, for the north Africa domain. The silt fraction is the portion which complements the two portions of sand and clay for having the sum of the three portions is equal to 1.

Once, the percentage of sand, clay and silt are known in the soil, the textural class can be read from the textural triangle. For example, a soil with 40% of sand, 40% of silt and 20% of clay would be classified as a loamy soil. Therefore, a map of soil texture can be created (Fig. 3).

The analysis of Fig. 3 shows that North Africa is dominated by a medium texture represented by loamy and sandy loam soil. These types of soil correspond to the Aridisols and Entisols in the Global soil region map classification (USDA/NRCS 1999). In second position, we find sand and loamy sand soil; these soils correspond to shifting sands region in USDA classification (USDA/NRCS 1999). This region, essentially constituted by a continuous substratum of coarse sands producing stable dunes made of coarse sands (median diameter 700µm) and active dunes made of fine sands (median diameter 250µm) (Callot et al. 2000). Silt loam occupies the major part of Hoggar and extreme eastern of Egypt toward red sea. Finally, clay and clay loam occupies very limited area in north Africa especially near Nil river and south-east of Sudan.

2.2 Soil aggregate distribution

A three-mode lognormal soil mass size distribution $M^T(D_p)$ is related with each texture class following Zobler (1986):

$$\frac{dM^T(D_p)}{d\ln(D_p)} = \sum_{j=1}^{n} \frac{M_j^T}{\sqrt{2\pi}.\ln(\sigma_j^T)}.\exp\frac{\left(\ln D_p - \ln D_{medj}^T\right)^2}{-2.\ln^2\sigma_j^T} \qquad \text{(S1)}$$

where j refers to the mode, T refers to the texture, M_j^T is the mass fraction of particles for mode j, D_{medj}^T is the mass median diameter, and σ_j^T is the geometric standard deviation.

Table 2 shows the mass fraction of particles M_j^T, the mass median diameter D_{medj}^T, standard deviation σ_j^T, and soil texture composition used to characterize each textural class (Zakey et al., 2006).

Following MaB95, the surface covered by each soil particle is assimilated to its basal surface. Thus a size distribution of the basal surfaces can be computed from the mass distribution, assuming spherical particles with the same density ρ_p:

$$dS^T(D_p) = \frac{dM^T(D_p)}{\frac{2}{3}.\rho_p.D_p} \qquad \text{(S2)}$$

The total basal surface S_{total} is

$$S_{total} = \int_{D_p} dS^T(D_p)dD_p \qquad \text{(S3)}$$

and the normalized continuous relative distribution of basal surfaces $dS_{rel}^{T}(D_p)$:

$$dS_{rel}^{T}(D_p) = \frac{dS^{T}(D_p)}{S_{total}} \tag{S4}$$

In our study, the process which we adopted to calculate the relative surfaces for each soil particle is based on a soil sample containing 1000 particles with a diameter ranging between $0.01 < D_p < 2000$µm. So, we consider all soil particles which contribute in saltation and sandblasting processes.

In order to increase the computation efficiency of the model and reduce the number of variables which are related to soil particles, we divided the particles of our sample soil into four populations according to their size: a) clay-size $D_p < 2\ \mu m$, b) small silt-size $2\mu m < D_p < 10\ \mu m$, c) large silt-size $10\ \mu m < D_p < 60\ \mu m$ and d) sand-size $D_p > 60\mu m$. And we calculated the average relative surface of each population according to the relative surfaces of the soil particles in the four size domains considered. The average relative surfaces of each of the four populations $dS_{rel}(D_{bin})$ are shown in the Fig.4 superimposed with the cover "COVER004" related to the fraction of erodible surface.

Then, the potential dust source map obtained for the revised DEAD version is represented by the total average relative surface of the four populations (Fig. 5).

2.3 Dust mobilization

The physical basis of the revised DEAD scheme is based globally on the MaB95 scheme, where dust is calculated as a function of saltation and sandblasting. Fine soil particles are not directory mobilized by wind, but they injected into the atmosphere during the sandblasting caused by saltation bombardment. Following Zender et al. (2003), the optimal size for saltation is $D_0 = 75\ \mu m$. So that, the dust mobilization starts when the friction velocity u_* exceeds a threshold value named threshold friction velocity u_{*t}. This threshold friction velocity is parameterized following MaB95 and is obtained for a particle $D_0 \approx 75$µm of diameter. Following MaB95, we assume all soils in the erodible region contain particles of size D_0. The threshold friction velocity depends on drag partitioning (MaB95) and soil moisture (Fécan et al., 1999).

The drag partition ratio f_d is calculated following MaB95:

$$f_d = \left[1 - \left(\frac{\ln\left(Z_0 / Z_{0s} \right)}{\ln\left\{ 0.35 \left[\left(0.1 / Z_{0s} \right)^{0.8} \right] \right\}} \right) \right]^{-1} \qquad \text{(S5)}$$

where $Z_0(cm)$ and $Z_{0s}(cm)$ are the roughness length for momentum and the smooth roughness length, respectively.

The smooth roughness length Z_{0s} is estimated following MaB95:

$$Z_{0s} = D_{med} / 30 \qquad \text{(S6)}$$

where D_{med} is the median diameter of the coarser mode for the twelve soil textures given in the Table 2.

The roughness lengths used by the ISBA scheme are derived from the ECOCLIMAP data bases. The value of Z_0 associated to bare soil (COVER004) is equal to 13 mm (Masson et al., 2003). Value used to quantify the momentum exchanges. But this value is very important and influences considerably the drag partition factor (F_d) and gives very important threshold friction velocity. What penalizes the dust emissions. For that, DEAD adopts a uniform value Z_0 = 100 µm and Z_{0s} = 33.3 µm. However, in our case the smooth roughness length are derived from the relation of MaB95 and varies according to the soil texture of from 33.3 µm for Sand to 3µm for the clay soils. The difference between Z_{0s} derived by MaB95 and Z_0 used in DEAD is significant. What gives important F_d factors. To keep the same value for the F_d factor for both version of DEAD original and new, we chose for the revised version of DEAD a roughness length Z_0 = 30 µm which is appropriate for Z_{0s} used.

Soil moisture generates a capillary force which is allowed to suppress dust deflation when the soil gravimetric water content (*w*) exceeds threshold soil moisture (*w'*). This threshold is defined in the revised DEAD scheme by the following relationship:

$$w' = b\,(0.17\, M_{clay} + 0.0014\, M_{clay}^{2}) \quad \text{and} \quad 0.053 < w' < 0.15 \qquad \text{(S7)}$$

It was established, empirically, that setting *b* = 3 in Eq. (S7) is better adapted to *w* predicted by the Interaction Soil Biosphere Atmosphere (ISBA) scheme (Noilhan and Planton, 1989) and provides a reasonable value of the erosion threshold velocity compared with that obtained by Fecan et al., (1999).

The factor that accounts for the effect of soil moisture content on the threshold friction velocity f_w is calculated following the relationship (Fecan et al., 1999):

$$f_w = \begin{cases} 1 & for \quad w \leq w' \\ \sqrt{1+1.21[w-w']^{0.68}} & for \quad w > w' \end{cases} \tag{S8}$$

w and w' having units of *kg/kg*

The Owen effect is calculated using the following relationship (Zender et al., 2003):

$$u_{*s} = u_* + 0.003\left(U_{10} - U_{10,t}\right)^2 \tag{S9}$$

where u_{*s} is the corrected friction velocity due to the Owen effect. U_{10} and $U_{10,t}$ are the wind speed and the threshold wind speed at 10 m, respectively.

The total horizontal saltating mass flux G is calculated following MaB95:

$$G = a.E.c.\frac{\rho}{g}.u_*^3\left(1+\frac{u_{*t}}{u_*}\right)\left(1-\frac{u_{*t}^2}{u_*^2}\right)\int_{D_{bin}} dS_{rel}\left(D_{bin}\right)dD_{bin} \tag{S10}$$

where E is the fraction of the erodible surface is represented by the COVER004, a is the global mass flux tuning factor determined at posterior through the model experiments, $c=2.61$, g is the gravitational constant, ρ is the atmospheric density and $dS_{rel}(D_{bin})$ is the average relative surface for each populations.

In the original DEAD version, the horizontal saltating mass flux G is converted to a vertical dust mass flux F with a sandblasting mass efficiency α which is parameterized following MaB95. This efficiency depends on the clay fraction in the parent soil is restricted to $M_{clay}<20\%$. At the local scale, this parameterization yields reasonable results (Marticorena et al., 1997) but at the global scale, it proves to be overly sensitive to M_{clay}. For this reason, Zender et al. (2003) assigns a constant value for clay fraction ($M_{clay}=20\%$). However, this assumption provides a uniform value of α over all dust source emissions and degrade the representativeness of the spatial variation of this efficiency. In order to turn out of this flaw in the revised DEAD, we adopt the Shao et al. (1996) sandblasting efficiency relationship:

$$\alpha = \frac{F}{G} = \frac{2}{3}\times\frac{\rho_p}{\rho}\times\frac{\beta\gamma g}{\left[u_{*t}(D_d)\right]^2} \tag{S11}$$

$\gamma = 2.5$

and

$$\beta = \left[0.125\times10^{-4}\ln(D_s) + 0.328\times10^{-4}\right]\exp\left(-140.7 D_d + 0.37\right) \tag{S12}$$

where D_d et D_s in mm and $\beta > 0$.

D_s: average diameter of the particles in saltation ($\sim 75 \mu m$), D_d: average diameter of the suspended particles ($\sim 6.7 \mu m$).

2.4 Size distribution of dust transportable particles

In the original DEAD, the emitted dust flux distribution is parameterized following Alfaro and Gomes (2001) sandblasting theory. This theory allows the distribution of emitted dust fluxes in three modes, according to the friction velocity. The measurements taken during the Special Observation Period (SOP) of June 2006 (Crumeyrolle and al. 2011) of AMMA, confirm the existence of a mode of particles centred around 0.64 µm but indicate that almost 99% of the number concentration is included in other particle modes finer than that centred around 0.64 µm. So, based on the AMMA measurement and the Alfaro and Gomes (2001) sandblasting theory, Crumeyrolle et al. (2011) proposed a new tri-modal size distribution (AMMA) for the emitted dust fluxes in the DEAD coupled to SURFEX. The parameters related to the AMMA distribution are given in Table S1.

Based on many published measurements of size-distributed dust flux, Kok (2011) argued that the size distribution of mineral dust emissions is independent of the wind speed and found little sensitivity of the emitted dust size distribution to soil textures. Furthermore, Kok (2011) proposed a theoretical emitted dust distribution depend on one median diameter ($D_s = 3.4\ \mu m$) and geometric standard deviation ($\sigma_s = 3.0$). The difference between the Kok's distribution and the AMMA distribution (Fig.S2) is very perceptible and is clear that Kok's distribution is coarser and neglects the fine mode which is confirmed by the AMMA observations. This is related to the fact of this theory which is based on the measurements taking near the surface. However the AMMA distribution is based on the aircraft measurements taking at an altitude around 700 m above mean sea level between Niamey (Niger) and Cotonou (Benin). These regions are far from dust source and the dust fine particles are more dominant, because they have a weak sedimentation velocity and a long atmospheric residence time. For this reason the AMMA distribution is finer than Kok's. This fine mode is very important and thus acts as Ice Nuclei. So, we adopt this distribution for the revised DEAD version in order to represent well the transportable dust particles in the west Africa.

Dry deposition and sedimentation of dust aerosols are driven by the Brownian diffusivity and by gravitational velocity (see Tulet et al. (2005) and Grini et al. (2006) for details).

Table S1. Log-normal parameters of the AMMA size distribution used in the DEAD coupled to SURFEX.

Dust mode	Mode 1	Mode 2	Mode 3
Number fraction (%)	97.52	1.95	0.52
Mass fraction (%)	0.08	0.92	99
Geometric standard deviation	1.75	1.76	1.70
Number median diameter (µm)	0.078	0.64	5.0
Mass median diameter (µm)	0.20	1.67	11.6

Table S2. Definition of the four configurations tested for five types of soils.

Compared elements	EXP1	EXP2	EXP3	EXP4
Geographic size distribution	Uniform texture	Uniform texture	Uniform texture	USDA textures
Moisture effect	Fecan (1999)	Fecan (1999) with w' is given by Eq.S7	Fecan (1999) with w' is given by Eq. S7	Fecan (1999) with w' is given by Eq. S7
Drag partition effect	MaB95 with Z_0=100 µm , Z_{0s} =33.3 µm	MaB95 with Z_0=100 µm, Z_{0s} = 33.3 µm	MaB95 with Z_0=100 µm, Z_{0s} =33.3 µm	MaB95 with Z_0=30 µm, Z_{0s} =D_{med}/30 µm
Saltation fluxes	White (1979)	White (1979)	White (1979)	MaB95
Sandblasting efficiency $\alpha = F/G$	MaB95 with $M_{clay} = 20\%$	MaB95 with $0 < M_{clay} < 20\%$	MaB95 with $M_{clay} = 20\%$	Shao (1996)
Dust source intensity	M_{sand}	M_{sand}	M_{sand}	Relative surface $dS_{rel}(D_{bin})$ for each of the four populations

Table S3. Threshold friction velocity *(u_{*t})* in m/s obtained with EXP1, EXP2, EXP3 and EXP4 configurations over clay soil, loamy soil, sandy loam soil, loamy sand soil and sand soil.

Soil type	EXP1	EXP2	EXP3	EXP4
Clay soil	0.6	0.5	0.5	0.5
Loamy soil	0.55	0.45	0.45	0.45
Sandy loam soil	0.5	0.42	0.42	0.42
Loamy sand soil	0.48	0.37	0.37	0.37
Sand soil	0.43	0.28	0.28	0.28

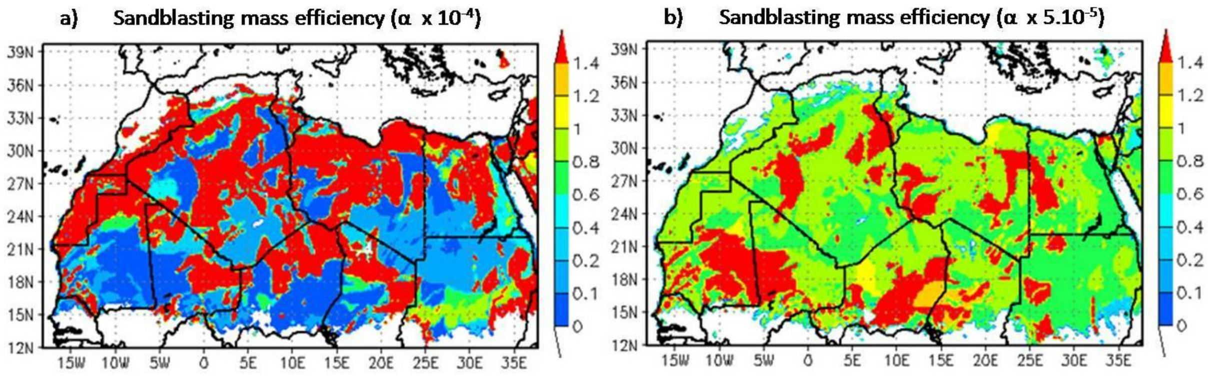

Fig. S1. Sandblasting mass efficiency (α) in m^{-1} calculated by: a) MaB95 with 0< %clay<20% and b) Shao et al. (1996)

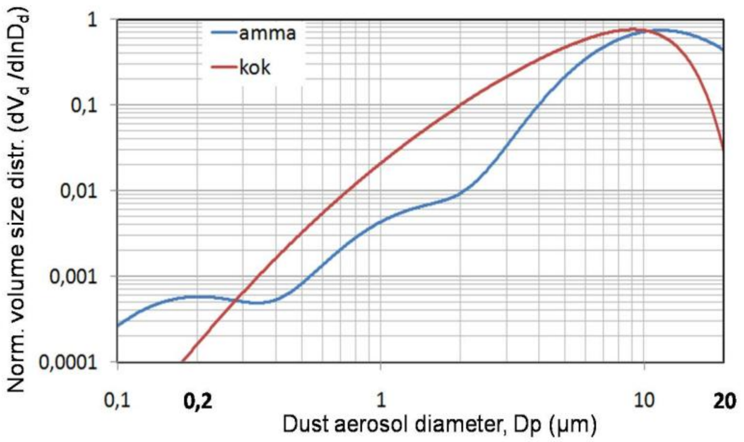

Fig. S2. The normalized volume size distribution of emitted dust aerosol given by: AMMA distribution (blue line) and Kok theory (red line).

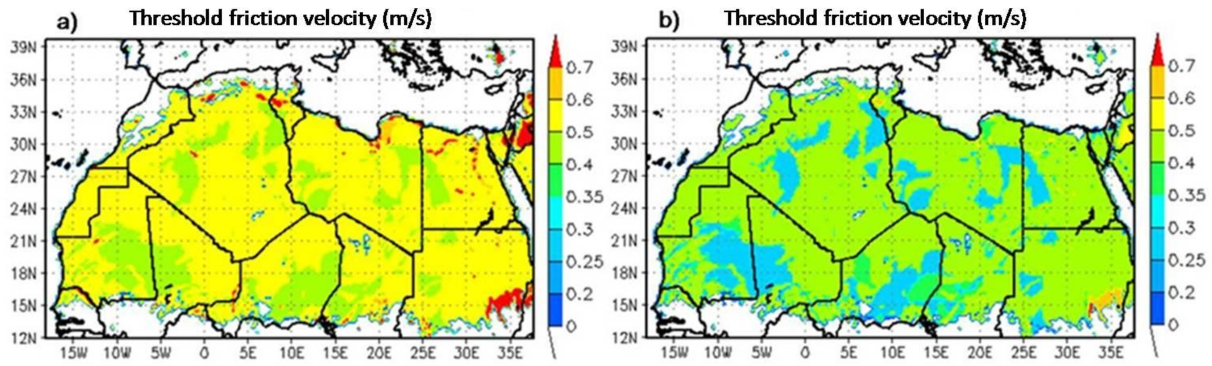

Fig.S3. Threshold friction velocity in m/s calculated by MaB95, introducing the soil moister effect following: a) Fecan at al (1999) and b) adapted Fecan formulation (Eq.S7)