The paper introduces soil texture variability and more complexity into the Dust Entrainment and Deposition scheme (DEAD) within the atmospheric model ALADIN. 0-D sensitivity experiments for different types of soils and a 3-D simulation of a dust storm are presented. The model is evaluated with a few observations (AOD and dust surface concentration) during a dust storm in Northern Africa and compared to the previous model set-up.

We would like to thank the anonymous referee for their constructive comments. The syntax of new version of the paper has been completely corrected by a native English speaker.Our response is detailed below.

General comments:
While there are some interesting aspects in the paper, such as the attempt to use soil texture information in the dust emission scheme, there seems to be several inconsistencies in the development of the scheme, or at least the text is rather confusing and needs further clarification. On the other side, to my opinion, the results shown do not sufficiently support a main conclusion of the paper, which is the better behavior of the developed scheme compared to the previous set-up. An English native speaker may revise the text.

We excuse ourselves for the English. The final version of the manuscript will be revised by an English native speaker and we point to make our explanations clearer.
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.

Detailed comments:
-Throughout the paper, the terms "soil" and "surface" are used indistinctively. Please be precise in the use of both terms. Dust emission is affected by both soil and surface characteristics.

We agree the comment. Dust emission is affected by both soil and surface characteristics. And we will take into account of this distinction in the revised version of the manuscript. So, we revised page 2895 line 9-10 "…influenced by surface characteristics" as "….influenced by soil and surface characteristics".
We revised Page 28 line 10 "the surface features …" as "The soil and the surface features…"

- Emission scheme:
It is not clear how the relative surface of the soil particles is used in the scheme. Why do you calculate the average relative surface? How is this used? Is the E parameter in equation 7? If yes, E is defined as the fraction of erodible surface: : : why the fraction of erodible surface is determined by the average relative surface of the particles in the soil? If not, where is the relative surface area used in the scheme?

The total average surface of the four populations (Fig.5) represents the new map of the potential dust source utilized in the revised version of DEAD. So, the purpose to calculate this parameter is to show the difference compared to that used in the original version.
The E parameter defines the fraction of erodible surface and it is given by COVER004 related to the bare soil fraction. This last (COVER004) is provided by ECOCLIMAP databases (Masson et al., 2003).

Equation 7 is from White (1979) and used in Marticorena and Bergametti (1995), so please correct/add the reference accordingly. The originality of Marticorena's paper partly resides *on determination of the Reynolds number (in the threshold velocity equations) based only on the particle diameter (since the relationship is implicit) and also on the specification of the horizontal to vertical flux ratio.*

It is right, the basis of the Equation 7 is from White (1979), as mentioned in Marticorena and Bergametti (1995), but Marticorena and Bergametti introduce the contribution of each soil particles to the horizontal saltation flux by theirs relative surfaces. So, in our work we used the formulation proposed in MaB95.

*Since you assume a particle diameter of 75 µm in the soil for the calculation of the U*t, the terms (1+U*t/U*)(1-U*tˆ2/U*ˆ2) are not dependent on Dp and can be out of the integral in equation 7. Finally the integral of the relative surface over particle size should be always 1. Which means that equation 7 becomes the one used in Zender et al. (2003), and (strangely) means that no explicit influence on soil particle size on saltation is taken into account as claimed in the text. My understanding (although it is not clear in the text) is that the soil texture information in equation 7 is introduced through the parameter E, which is defined as the erodible surface (represented in this case by the relative surface area). As mentioned before, why should the relative surface area represent the erodible surface? The main question here is why the authors don't use the soil information to explicitly model saltation in equation 7? Why do they use a U*t independent of the size of the saltator. Why is equation 7 is presented in such a way given the comments above?*

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_p= 75 µm. So that saltation is initiated whenever $u_* > u_{*t}(D_p)$. In our work, we assume all soils in erodible regions contain particles of size D_p. This detail has been added in the revised text.

Alpha in equation 8 is not introduced in Shao et al. (1993) but in Shao et al. (1996). However, from the text it appears to be constant (no spatial variability) since all the parameters are constant (Beta, gamma, g, U, Dd, Ds). If I am wrong with my understanding of the text, the text should be clarified. If it is constant, what is the sense of introducing a constant alpha?*

The reviewer is right, α is introduced in Shao et al. (1996). But is not constant because u_{*t} depends on the soil moister and surface roughness. The spatial variability of α is shown in Fig. S1b (see the supplement below). This correction has been added in the revised text.

Which aerodynamic roughness lengths are used in the model for the drag partition correction? Are these satellite estimates, or derived from the atmospheric model used in the surface layer scheme?

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.

In summary, the previous aspects related to the emission scheme need to be clarified and justified by the authors. Whether the emission scheme is more or less complex, the options used need to be clearly explained and consistent, and the assumptions justified.

The clarifications of the revised dust emission scheme have been given into the supplement (see below) which will be introduced in the final version of the manuscript.

What are the three modes following the AMMA parameterization? Is it table 3? It should be referred in the text.

The three modes following the AMMA distribution is shown in Table 3. The detailed of this distribution is given in the supplement.

O-D simulations:
In table 4, the different set-ups of the experiments are listed. When it comes to EXP4 the authors define the dust source intensity as the relative surface for each population. Again this is confusing. In section 2.2, line 13 you talk about average relative surface area as the potential dust source emission and in equation 7 you talk about fraction of erodible surface. In table 4, it is relative surface for each population. Please homogenize and explain.

We agree that this section is not clear enough.
In table 4, the relative surface for each population refers to each of the four populations. This table will be modified and is given in the supplement by Table S2.
Section 2.2 and Section 2.3 are reformulated and are given into the supplement.

Concerning the 0-D experiments, how can EXP4 have different threshold friction velocity if, as you claim in section 2.3 (lines 20 to 24), you assume particles of size 75 µm?

The threshold friction velocity is corrected by the moisture effect and the roughness effect, therefore it is not constant.
3-D simulations
As stated in the abstract, the goal of the paper is to develop a global mineral dust emission parameterization. The main conclusion is that the developed scheme improves the previous one. However, I have two main concerns.

First, the results are based on a single event and a specific region. If the aim is the global scale, the evaluation may be global. Also it is difficult for me to accept that the comparison of different model set-ups for a specific event and a specific region, we can conclude than a scheme is better than the other. Only with longer term simulations covering at least a seasonal cycle and different regions (even within the North African domain) one may conclude that the developments represent a improvement.

On the other hand, I have some concerns with the evaluation performed and the discussion of the results:

- The evaluation is qualitative. There are no skill scores and is quite subjective. What are the biases, RMSE, and correlation of each experiment?

In the revised DEAD, the surface and soil parameters input are provided by the global database such as: FAO soil type database, USDA texture classification and ECOCLIMAP land surface parameters. The choice of the relations and parameterizations used in the revised version is subjected to a compatibility examination with these databases. The revised DEAD represents better dust source area, the sandblasting efficiency and the threshold friction velocity compared with the original version. For this reason which we said that it is a global parameterization. The results obtained for the 7-13 march, 2006 dust storm event over North African domain, support our conclusion.
Nevertheless, we agree with the reviewer and we cannot prove that this parameterization increases globally the simulation of dusts with just one simulation and only in a specific region of the world. In the new version we will be more careful with conclusion about the performance of the new version of DEAD in 3D.
Otherwise, this is not the main object of the paper to make scores. For that (as you say) we need to make a long term simulation. It is the objective of future works by simulating 5 years over west Africa. The main objective of this paper is to present the new formulation and indicate which process and impact it gave over a severe dust storm over west Africa.

- *The period of March is affected by biomass burning in the Sahel region. The total AOD measured by the sun-photometers may include contributions from these aerosols, so the comparison of the different experiments and the conclusions reached may be affected by it.*

The 7-13 march, 2006 dust storm event is very intense, it is generated by the Harmattan flux coming from the desert region (see Fig.8). So, the contribution of the aerosol biomass burning on the total AOD measured is neglected compared with the dust aerosol contribution. Black Carbon is, probably, present in the atmosphere from March 10 and on the south of the domain. When one is in northern flux, Black Carbon which comes from the Guinea gulf cannot go up until the Sahel (Tulet et al., 2008). Therefore, our conclusion is not considerably affected.
Tulet, P., Mallet, M., Pont, V., Pelon, J., and Boon, A.: The 7-13 March 2006 dust storm over West Africa: Generation, transport, and vertical stratification, J. Geophys. Res , 113, D00C08, doi:10.1029/2008JD009871, 2008.

- *The authors do not explain how and to which extend the different experiments are tuned (parameter a in equation 7). A different tuning can derive into different results. This is even more certain when the models are tuned with observations in one region and for a specific event. How were the experiments tuned? For example, in figure 10 it seems to me that EXP_THR is strongly underestimated in all the stations used. If the tuning constant is increased, the results would be much closer to the other experiments.*

The reviewer is right for the adjustment of the models according to their specificities related to the vertical and horizontal resolution. But the adjustment is homogeneous horizontally and we think that this version improves the geographical distribution of the emissions in bond with the soil properties. The choice of the constant “a” is made starting from several simulations of calibration in 3-D for the two versions of DEAD, original and revised. Concerning the underestimation of the AOD by EXP_THR, that is due to the sandblasting efficiency which is too weak above the dust source area (see Fig.S1a in the supplement) and at the threshold erosions which are very important (see Fig.S3a in the supplement).

- It is argued that EXP3 and EXP4 give reasonable results for the AOD (Figure 10) but EXP3 overestimates the surface concentrations in Banizoumbou and Mbour (Figure 12). If we look in detail into the comparison of both experiments with the AOD in Banizoumbou and Mbour (Figure 10), we clearly see that also there EXP3 overestimates in the same way as in the case of surface concentrations (in the period 9-15 in Banizoumbou and 9 to 10 in Mbour). With this, I finally come back to the previous tuning issues and the influence of other aerosol. Depending on the tuning, the results may be different; also the effect of biomass burning is not clear. These effects can change the discussion of the results and the conclusions of the paper given the low amount and specific locations of the observations used in the evaluation.

Yes, we are completely of agreement with the reviewer concerning the over-estimates of the AOD by the configurations EXP3 and EXP4 for the stations Banizoumbou and Mbour and this, we had announced it in the chapter 3.2.3 page 2909 line 20-28 and page 2910 line 1-8. However in the conclusion we gave the general behaviour of our results obtained by these two experiments over all stations used for validation. We think that the two experiments present well the dominant features of the event, especially, the beginning of the dust storm event, the evolution in the time and space of the dust storm and finally the transport towards the south towards the Guinea gulf. What shows well our adjustment and calibration of these experiments. Concerning the effect of biomass burning, we agree that these aerosols influence the AOD in the Sahel area, but in the case of a north flux (Harmattan) and such extensiveness, like our case, we think that this effect is marginal compared to the dust aerosols effect.

Figures:

- I believe that Figure 1 is not needed since it is very general and well known. - Why is MODIS used in Figure 9? There is no data over sources and there are other satellite estimates providing information there (OMI and MODIS Deep Blue for example). Why not to show the differences between EXP3 and EXP4 in a map? It would help to understand the potential different patterns from both experiments.

Figure 1 is very important. We think it is important to put this figure, although it is well known for a specialist. By the combination with the maps of clay fraction and sand fraction (Fig.5), allow the elaboration of the soil textures map given by Fig.3.

MODIS with DEEP BLUE algorithm (based on MODIS and Seawifs) gives information without holes but which can be problematic above the deserts where the surface albedo is near to that of the dusts. We made the choice not represent these areas. That can be debatable but it is the choice which makes us. OMI does not restore AOD but an Aerosol index. MSG_SEVERI gives the same information such as OMI with in addition to weather information (clouds). The objective to show this figure is to see the capability of the Aladin model to reproduce the synoptic situation and the spatial distribution of the AOD.

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 $M^T\left(D_p\right)$ 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:

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

The total basal surface S_{total} is

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

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

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

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 $dS_{rel}\left(D_{bin}\right)$ 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:

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

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:

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

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:

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

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):

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

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

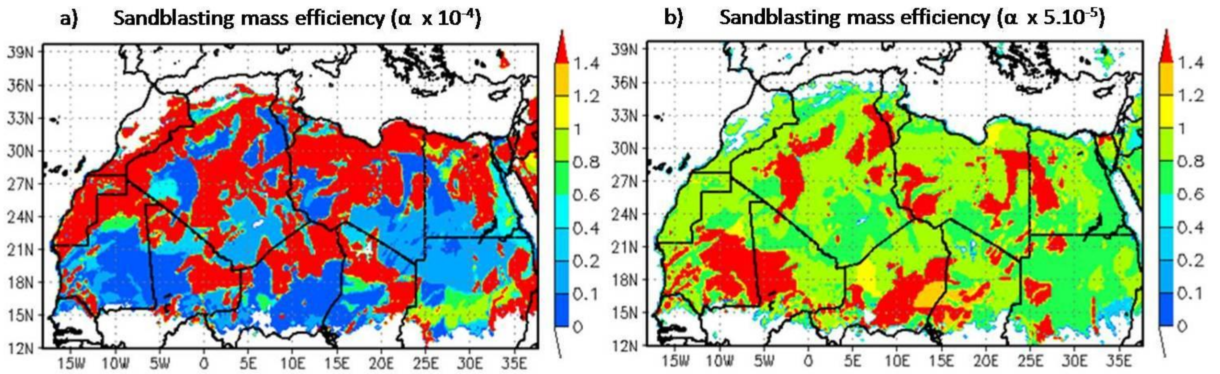

Fig. S1. Sandblasting mass efficiency (α) in m^{-1} calculated by: a) MaB95 with 0< %clay<20% and b) Shao et al. (1996)

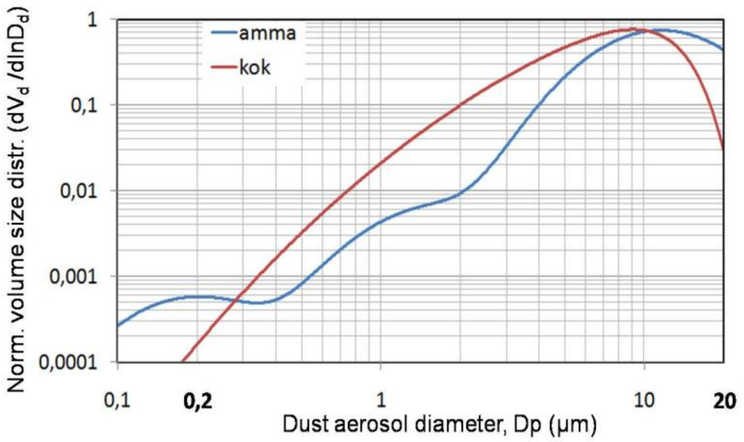

Fig. S2. The normalized volume size distribution of emitted dust aerosol given by: AMMA distribution (blue line) and Kok theory (red line).

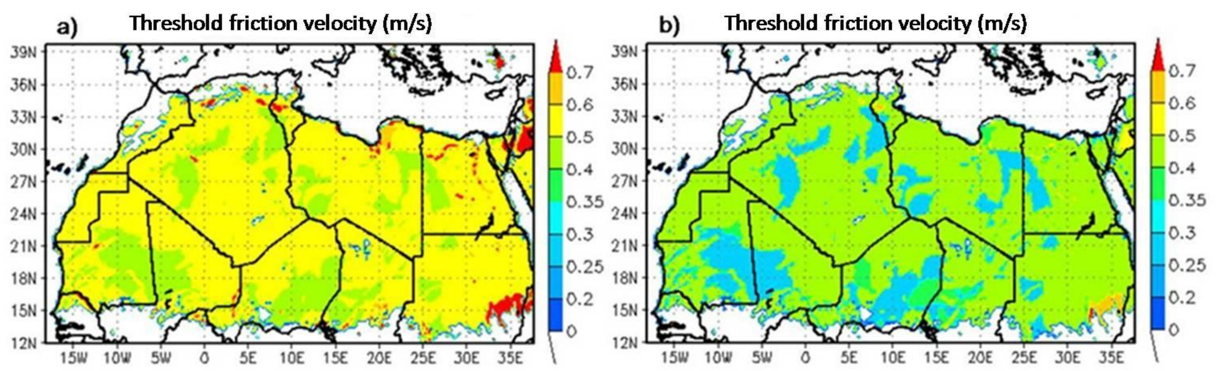

Fig. S3. Threshold friction velocity in m/s calculated by MaB95, introducing the soil moister effect following: a) Fecan at al (1999) and b) adapted Fecan formulation (Eq.S7)