Response to anonymous Referee #1

Response to the major comments:

- ✓ *"Comparisons with other datasets: The comparison with Claquin 1999 was shown in section 4.1 and Figure 14. To me, by looking at Figure 14, that the mineralogical composition from this work and the work by Claquin is significantly different for all 17 soil types, and yet, the authors think they are not that different (see section 4.1). I think the difference should be better, more quantitatively assessed and some explanations offered. There is no comparison with Nickovic 2012 at all in the text – why?"*

We have improved the comparison including new data from Nickovic et al. (2012) and paragraph of this section has been completely rewritten to take account of the comments.

"The Claquin et al. (1999) and Nickovic et al. (2012) data set provides mineralogical information for arid dust-source regions. The only difference between these two existing databases is the extension of the mineralogical table for 3 new soil units (Yermosols, Haplic Yermosols and Xerosols) by Nickovic at al. (2012) in comparison with Claquin et al., 1999. In the present paper, we recreated the whole database. We have extended this approach to cover soils over most of the world (with the exception of cold areas with permafrost), on the assumption that this will be useful for specifying dust mineralogy as dust sources change in response to climate changes. We have been able to capitalize on the much-expanded literature now available to provide mineralogical information of the clay fraction for 120 soils units described in the FAO classification. The number of minerals considered was also increased, compared to Claquin et al. (1999) and Nickovic et al. (2012), by addinginformation on chlorite, vermiculite, feldspars, goethite and hematite in the clay fraction. Although relatively unimportant by mass individually, together these minerals can be ca. 45% of the mass in some soil units (e.g. Humic Ferralsols). We have added mica and chlorite in the silt fraction, and attribute the iron oxide in this fraction to goethite (rather than hematite as in Claquin et al., 1999 and Nickovic et al., 2012). We have chosen not to normalize the distribution of individual minerals to 100% of the mass, in order to avoid artificially inflating the amount of an individual mineral recorded; up to 17% of the mass remains unidentified for some soils.

A comparison of databases has been established for 20 soils units that are listed Table 3. The average composition of the clay fraction obtained from the database of Nickovic et al. (2012) and from this work for the 20 soil units are shown Figure 14. Whatever the database, the major component of the clay fraction are clay minerals (kaolinite, illite and smectite), and the estimates of their cumulative abundance is almost always higher in the work of Nickovic et al. (2012) than in this work even if we add two additional clay minerals (chlorite and vermiculite). This can be partly explained by the fact that Nickovic et al. (2012) normalize the distribution of individual minerals to 100% of the mass unlike us. In both databases, the range in calcite content is the same, between 0 and 30% but in average the calcite content is higher in this work compared to the one obtained by Nickovic et al. (2012). We observe significant differences for calcite especially for Yermosols (3), haplic Yermosols (5), eutric Regosols (9), luvic Xerosols (11) and Sand Dune (4) where the difference can exceed 150%. We now discuss the evolution of the database between the two versions. The significant differences on calcite content result largely of the empirical relationship between the calcite content in the clay fraction and the total calcite and the amount of clay (Fig. 2) which is different between Claquin et al. (1999) and this work. The new relationship established in the present work leads to higher calcite content for the clay fraction for the same total calcite content and clay fraction content. In any database, quartz is a minor component of the clay fraction ranging from 0 to 15% with an average content of about 5%. In both database, hematite represents a minor fraction of the clay fraction, lower than 4.4%. Hematite abundance is lower in our work compared to Nickovic et al. (2012) but as we have added goethite, the comparison can be made on the total iron oxide minerals. When we take the total iron oxide fraction, the cumulative abundance of hematite and goethite from our database amounts to a larger mass fraction than the hematite content from Nickovic et al. (2012)."

Table 3: Soil units used for comparison of databases (see Fig. 14)

1	Arenosols	cambic
2	Arenosols	luvic
3	Fluvisols	calcic
4	Fluvisols	eutric
5	Lithosol	
6	Regosols	calcaric
7	Regosols	eutric
8	Salt flats	
9	Sand dune	
10	Solonetz	orthic
11	Solontchaks	gleyic
12	Solontchaks	orthic
13	Vertisols	chromic
14	Xerosols	calcic
15	Xerosols	haplic
16	Xerosols	luvic
17	Xerosols	
18	Yermosols	calcic
19	Yermosols	haplic
20	Yermosols	

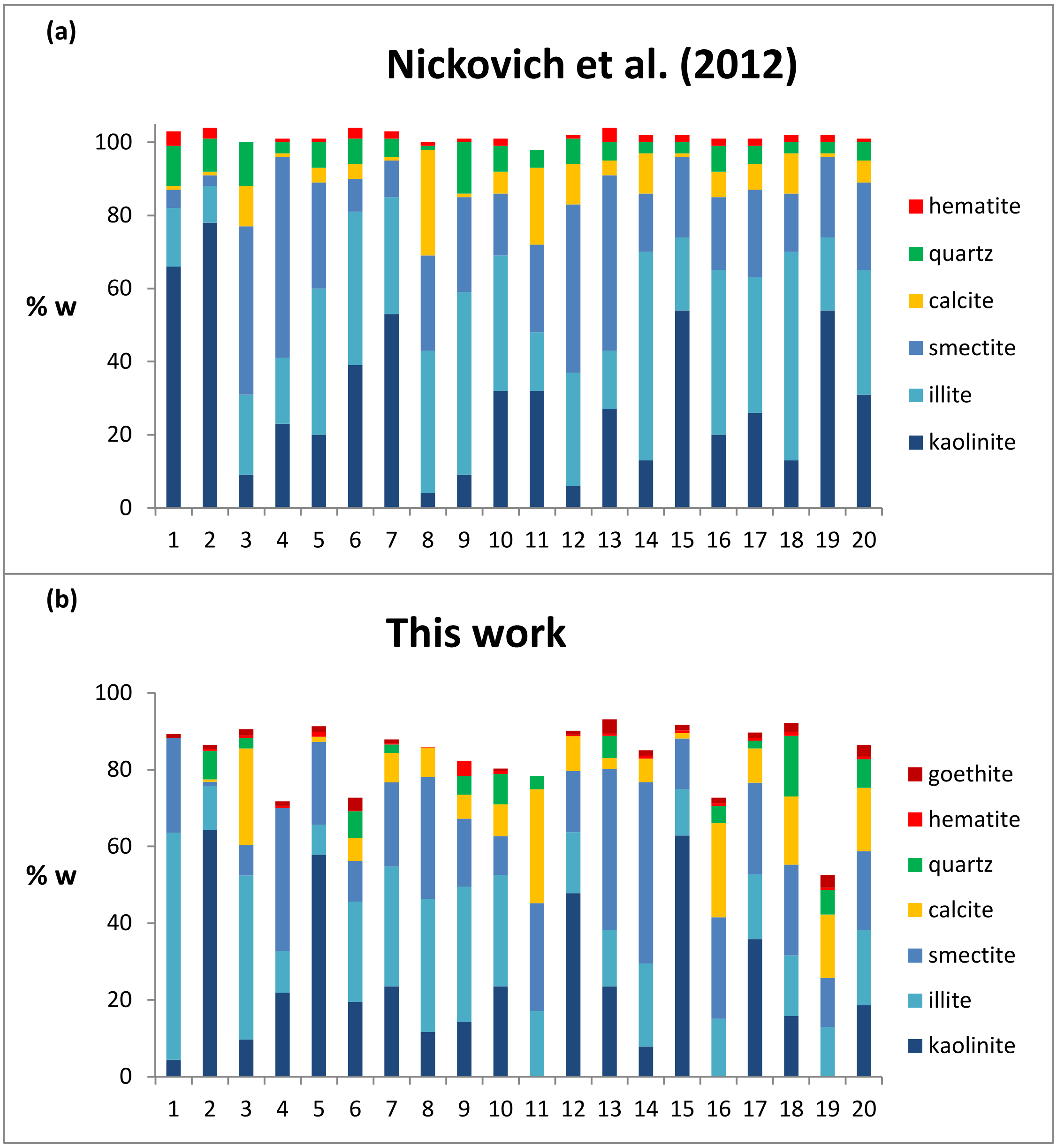

Figure 14: Mean mineralogical composition of 21 FAO soils types **(a)** According to the database of Claquin et al. (1999) and Nickovic et al. (2012) **(b)** According to this work.

✓ *"Difference between airborne and soil composition: It is quite informative that the authors take one step further to show the model simulation of airborne-dust mineral composition and compare that with the soil composition. But the explanation for the differences in composition between the airborne dust and soil was that the airborne dust was from the dust source area whereas the soil composition was for all soils. This is not convincing and not helpful. You should compare the soil composition in the dust source areas, since you know where they are as the model uses them, and then compare that with the airborne dust"*

The difference between the composition of airborne dust and the mean soil composition is informative. We wanted to contrast it with what the reviewer proposes, ie, the composition in the dust source areas which is quantified in the paper on Figure 9 for the main source regions as delimited in the revised version of the manuscript on Fig. 1. To illustrate that points, we assembled the following Table to contrast Saharan, Sahel and Asian dust source regions with the composition of transported dust.

	Transported Dust	Sahara	Sahel	Asia
Kaolinite	24.1	29.0	38.4	36.2
Illite	24.6	23.3	20.2	19.4
Smectite	15.3	19.4	15.9	16.0
Vermiculite	5.8	5.7	5.0	5.1
Calcite	8.9	8.8	4.0	5.7
Quartz	4.9	4.6	4.5	6.1
Chlorite	4.8	4.3	5.4	4.6
Goethite	1.9	2.0	3.5	3.4
Hematite	1.1	1.5	0.9	1.4
Feldspars	3.6	1.4	2.0	1.0

✓ *"Evaluation of dust aerosol single scattering albedo: It is not clear how the dust optical properties were calculated (dust particle size distributions, particle shape, complex refractive indices for different sizes). The resulting single scattering albedo (Fig. 16) should be compared with available measurements, such as AERONET at dust- dominated sites and some aircraft measurements (e.g., SAMUM). Although SSA from AERONET is a retrieved quantity, not directly measured, but comparisons is needed to see the degree of agreement (or disagreement)."*

We assume a spherical shape for particles in order to apply Mie theory. The dust particle size distribution is inferred from the model and we are currently studying the influence of these assumptions on optical parameters. This will be the topic of a whole paper that is coming up that also varies the mineralogy. As to the results presented in Fig. 16, there are backed up by many in-situ measurements of Single Scattering Albedo (SSA). These measurements include high values reported for accumulation mode of Saharan dust [Chen et al., 2011 ; Moosmüller et al. 2012; Osborne et al. , 2008; Dubovik et al. , 2002; Haywood et al 2003 ; Linke et al., 2006 ; McConnell et al. , 2008; Tegen et al. , 2006 ;] ranging from 0.95 to 0.99 (at approx. 550 nm). As reported very recently by Ryder et al. (2013) these measurements probably underestimate SSA as inlets tend to exclude particles from 3 to 300 µm.

Chen, G., Ziemba, L. D., Chu, D. A., Thornhill, K. L., Schuster, G. L., Winstead, E. L., Diskin, G. S., Ferrare, R. A., Burton, S. P., Ismail, S., Kooi, S. A., Omar, A. H., Slusher, D. L., Kleb,
M. M., Reid, J. S., Twohy, C. H., Zhang, H., and Anderson, B. E.: Observations of Saharan dust microphysical and optical properties from the Eastern Atlantic during NAMMA airborne field campaign, Atmos. Chem. Phys., 11, 723–740, doi:10.5194/acp- 11-723-2011, 2011.

Dubovik, O., B. Holben, T. F. Eck, A. Smirnov, Y. J. Kaufman, M. D. King, D. Tanre´, and I. Slutsker (2002), Variability of absorption and optical properties of key aerosol types observed in worldwide locations, J. Atmos. Sci., 59(3), 590–608. Haywood, J., Francis, P., Osborne, S., Glew, M., Loeb, N., Highwood, E., Tanre, D., Myhre, G., Formenti, P., and Hirst, E.: Radiative properties and direct radiative effect of Saharan dust measured by the C-130 aircraft during SHADE: 1. Solar spectrum, J. Geophys. Res.-Atmos., 108, 8577, doi:10.1029/2002jd002687,
2003.

Linke, C., Möhler, O., Veres, A., Mohácsi, Á., Bozóki, Z., Szabó, G., and Schnaiter, M.: Optical properties and mineralogical composition of different Saharan mineral dust samples: a laboratory study, Atmos. Chem. Phys., 6, 3315-3323, doi:10.5194/acp-6-3315-2006, 2006.

McConnell, C. L., E. J. Highwood, H. Coe, P. Formenti, B. Anderson, S. Osborne, S. Nava, K. Desboeufs, G. Chen, and M. A. J. Harrison (2008), Seasonal variations of the physical and optical characteristics of Saharan dust: Results from the Dust Outflow and Deposition to the Ocean (DODO) experiment, J. Geophys. Res., 113, D14S05, doi:10.1029/ 2007JD009606.

Osborne, S. R., Johnson, B. T., Haywood, J. M., Baran, A. J., Harrison, M. A. J., and McConnell, C. L.: Physical and optical properties of mineral dust aerosol during the Dust and Biomassburning Experiment, J. Geophys. Res.-Atmos., 113, D00C03, doi:10.1029/2007jd009551, 2008.
Tegen, I., B. Heinold, M. Todd, J. Helmert, R. Washington, and O. Dubovik (2006), Modelling soil dust aerosol in the Bode´le´ depression during the BoDEx campaign, Atmos. Chem. Phys., 6, 4345– 4359.

Response to the specific comments:

- ✓ *"Page 23949, line 20-21: This sentence has been said previously (page 23946). Probably the previous sentence should be revised to avoid repetition."*

We modified the sentence page 23946 "we specify the mineralogical composition of the clay (< 2 µm) and silt (between 2 and 63 µm) fractions independently", it is now replaced with "we specify the mineralogical composition of the finer textural classes of soils: the silt and the clay fraction."

- ✓ *Page 23949, line 24-25: This criterion is confusing – did you associate your information with the FAO soil unit, as you said in the previous section, or use the "alternative"classification"? What is the alternative classification?"*

We propose a simpler sentence that avoids any confusion: "3. The information is compiled for soil samples which can be identified according to the FAO soil classification"

- ✓ *Page 23951, line 16: If is not clear how RR and RF are determined from the Munsell color. How did you determine the soil color patterns? Is there a database on Munsell soil color so you can apply the relationship between RR, RF, and the Munsell color to estimate the hematite and goethite content globally?*

We propose to clarify this paragraph (line 13 to 16):

"Soil color is determined through visual comparison with the Munsell Soil Color Chart (Munsell Color Company, 1995). Color indices were developed on the basis of the Munsell notation: (i) the Redness Rating (RR) (Torrent et al., 1983) as a numerical index that could measure quantitatively the relationship between the redness and the hematite content in soil (ii) the Redness Factor (RF) (Fontes and Carvalho, 2005) as a numerical index that allows estimate the hematite to goethite ratio in soil."

- ✓ *Page 23951, line 23: Are you saying you are using the FAO soil units (total 211), not the "alternative classification" as you mentioned before?*

Yes, we only used the FAO soil units. We deleted the sentence (page 23949) that made the text confusing.

- ✓ *Page 23951, last paragraph: I am confused about these numbers of soil units: Total 211 soil units, 92 of which the composition is determined and 18 of which the composition is assumed, that gives a total of 110, not 120 (line 26 on page 23951), soil units with composition information. Then there should still be 111 soil units, not 90 (line 1 on page 23952) out of 211 total for which there is no information on composition. Please check the numbers.*

The total number for soil units is 211; 92 of these units have a determined composition, 28 have an assumed one, and no information exists for the 91 soil units left, for these 91 soils we could not associate any composition..

- ✓ *Page 23952, line 8: "divided equally" – should it be "divided proportionally" to make more sense?*

We chose to attribute half of the total mass of gypsum in dust to the silt fraction (considering that the other half is in the sand fraction). So we really meant "divided equally" in the case of gypsum.

- ✓ *Page 23953, line 1: "with that soil unit in the HWSD database" – replace this phrase with "with the soil unit corresponding to the HWSD database"*

The modification has been done.

- ✓ *Page 23953, line 3: Fig. 3 is not a mineralogical map. It is the % of soils with mineralogy.*

We deleted the reference to this Figure and we thank the reviewer for pointing this out.

- ✓ *Page 23953, line 7: 92 soil units? What is that number from?*

  There are 120 soil units (92+28), hence we replaced "92" with "120" (92+28)

- ✓ *Page 23954, line 7 and line 14-15: These sentences are contradictory. Is the highest illite amount in the NH high and mid-latitudes (line 7) or in the east and south of the Sahara (line 14-15)?*

There are two levels of description: line 7 is a description at the global level, while for line 14-15 is a description at the regional level (North Africa). To contrast these two descriptions, we added "in this region" in the last sentence line 14: " The highest amounts of illite *in this region* occur East and South of the Sahara, associated with Haplic and Cambic Arenosols."

- ✓ *Page 23955, line 13: Is illite "iron-rich"? I thought illite is non-absorbing therefore it is iron-poor. But I could be wrong. Just want to clarify.*

The term "iron-rich" is improper. The text is modified as follow:
"The total iron content reflects not only the presence of hematite and goethite but also the presence of clay minerals such as illite or smectite. These minerals contain substantial quantities of iron (around 3% according Journet et al., 2008). Due to their high abundance in dust, estimates of total iron in dust have to account for the iron associated with both illite and smectite ".

- ✓ *Page 23956, line 12: Sahara and Sahel definition: 0-20N is too wide for Sahel. Such defined region contains Sahara in the north and Savanna in the south, in addition to Sahel. If you have to use straight lines to define Sahel, 10N-16N is more correct. Definitely the Sahel northern border is not beyond 18N and the south border not much below 10N.*

We recomputed the mineralogy for the Sahel over the band 10N-16N.
This restriction of the latitudes that cover Sahel, has influence over the Sahara, where we have to change the range of latitudes from 20N-36N to 16N-36N. With these new definitions of regional bondaries, we recomputed the mineralogical composition for both the Sahel and the Sahara region, changed the text where the regions where defined and corrected Figures 9 & 10 accordingly.

- ✓ *Page 23956, line 27: What is the definition of "free iron"?*

In soil science, "free iron " is iron oxide and hydroxide. To make the text clearer, the term "free iron" is replaced by "iron (hydr-)oxides"

- ✓ *Page 23958, line 5, CASE 0, 1, and 2: What are the fundamental differences among the cases? Which case map you would recommend to use for global modeling?*

For global modeling, one would like to have information for all grid-points, hence CASE 0 for which no information is available on many grid points is not appropriate. Amongst CASE 1 or CASE 2 this will depend on the applications that the modeller is seeking. Presenting both cases and showing the illite composition in the transported dust showed that the differences in atmospheric dust composition are much less severe than the ones of in soil. This reflects the fact that source areas are in restricted regions and the largest emission fluxes occur over Sahara and over Asia.

- ✓ *Page 23958, line 23: now there is another number, 124, for soil units. What is this number? How many soil units you actually provide the information for? Should keep the number straight and consistent.*

The sentence line 23 is replaced by "We took advantage of the much-expanded literature now available to provide mineralogical information for 120 of the 211 soils units described in the FAO classification."

- ✓ *Page 23959, line 4: "We have chosen not to normalize the distribution of individual minerals to 100%...". But in Fig. 14 you showed the total 100% of mineral contents in each soil types (Fig. 14b)! On the contrary, the compositions do not add up to 100% in Claquin's work (Fig. 14a).*

We answer this point in the response to the first major comments

- ✓ *Page 23959, line 7: feldspars is not shown in Fig. 14 at all.*

This sentence commented on the differences for silt fraction, which are not illustrated by a figure. We decided to delete this sentence to make sure that the reader is not confused by it.

- ✓ *Page 23959, line 11: Confusing - you just said that quartz is the major components of the silt-sized fraction. But now it is only a small fraction of the mass? Does it mean that silt is only a small fraction of the dust mass?*

Quartz is the major components of the silt fraction but only a small fraction of the mass for the clay fraction. This sentence that comments on the peculiarities of the silt fraction (not shown in a Figure), will be deleted to make the text clearer.

- ✓ *Page 23959, line 12: What is the standard of being "similar"? I see that the calcite content is about 20% in "this work" for soil type 13 but only about 5% in Claquin's work. Are they similar?*

See the response to the first major comments

- ✓ *Page 23959, line 7-15: This comparison with Claquin is confusing. t seems to me that the composition are significantly different between this work and Claquin's in every soil types shown in Figure 14. The difference should better presented and explained. What about Nickovic's dataset?*

See the response to the first major comments

- ✓ *Page 23960, line 16: What is "R ratio"?*

The R ratio is defined in the text lines 3 and 4 and in the equation of line 5 page 23960. It is the relative proportion of hematite to the sum of hematite plus goethite

- ✓ *Page 23960, line 17: define "omega 0".*

Page 23960 has been changed to define ω_0 *as the single scattering albedo.*

- ✓ *Fig. 4: Add country lines on 4b to be consistent with 4a.*

Figure 4 and the section 2.7 was removed on the advice of reviewer 2.

- ✓ *Fig. 14: what are the 17 soil types?*

Table 3 was added. It give the relevant information about what those soil units are.