

Response to Reviewers' comments

We agree with majority of comments made by the Reviewer which we find useful and helpful and accept with thanks. We have made the recommended changes and these are outlined below.

1. Reviewer expressed concerns about the description of methods of geochemical analysis stressing the absence of standards.

A paragraph explaining the methods and a reference to a publication describing the geochemical standards we used have been added:

“Bulk chemistry of the LTD and control samples was characterised by X-ray fluorescence analysis (Beckhoff et al., 2006), producing weight percentages of the major elemental composition as oxides, and trace elements as parts per million. Prior to the analysis, samples were crushed and ground in a Fritch planetary ball mill. Pressed powder pellets were prepared from the ground samples and major and trace elements were measured on the pellets. Samples were analysed using a Panalytical MagixPro X-Ray fluorescence spectrometer with a Rb 4 kW X-ray tube. The spectrometer was calibrated and the unknown samples are measured using Panalytical SuperQ analytical software. A wide range of international reference standards were used for calibration (Govindaraju, 1989) and GSP-1 and DR-N standards were analysed at the same time as the collected samples to act as internal check standards (Supplement 1). The nominal detection limit of trace elements measurements was 5 ppm.”

We have added values of GSP-1 and DR-N standard measurements (as an average of several measurements for each element and standard) and published standard values to the data on elemental composition of the analysed samples. We will present the data in tabular format as a supplement to the paper showing results in graphical format in the main text. The table is presented at the end of this document.

2. Reviewer suggested that SEM data should be compared to ‘standard’ methods of particle size analysis.

We have added the following paragraph to the paper to address this comment:

“Electron microscopy is currently one of the most widely used methods of particle size analysis in application to both airborne aerosol (e.g. Reid et al., 2003 a, b; Abed et al., 2009; Kandler et al., 2011) and mineral dust deposited on ice and snow (e.g. Li et al., 2011). An

advantage of this method is in its ability to identify unusual particle shapes, deposition patterns and presence of such material as diatoms and pollen which may provide further insight into the origin of dust. One of the limitations is undersampling of ultrafine particles due to both the filter pore size and uncertainties in calculation of their parameters. However, a comparison of different methods of particle size characterization by Reid et al. (2003 b) has shown that bias towards coarser particles is lower when using SEM in comparison with optical particle counters in application to atmospheric aerosol. Similarly Roeyr et al (1983) used both SEM and Coulter Counter to derive particle size distributions from samples of dust contained in an Antarctic ice core and found that while both methods generated distributions that are similar in shape, SEM measurements produced lower modal values than Coulter Counter measurements.”

3. Reviewer stated that the geochemical data presented in the paper is only useful to describe the elemental composition of dust but cannot be used for dust provenancing. Reviewer also suggested that there are few dust samples from the potential source regions.

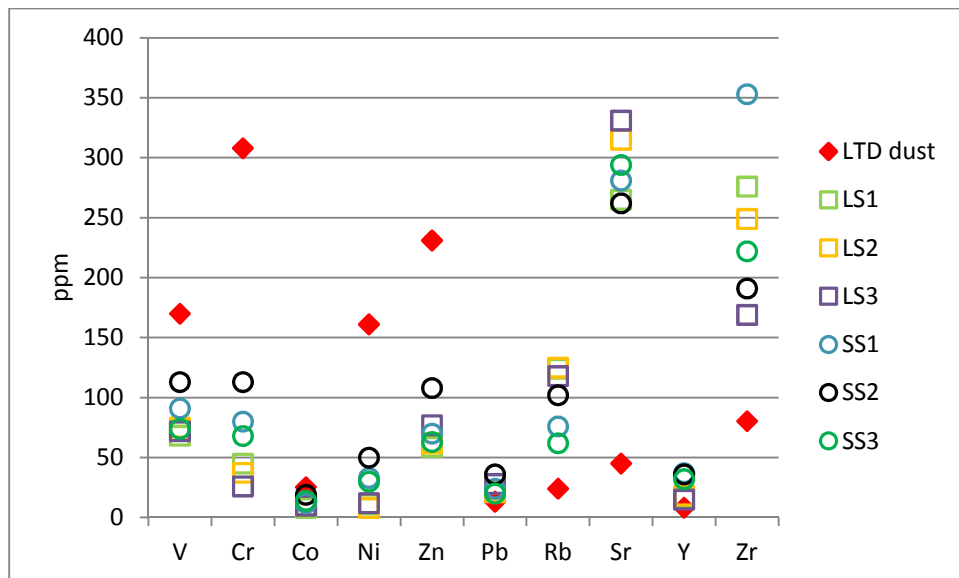
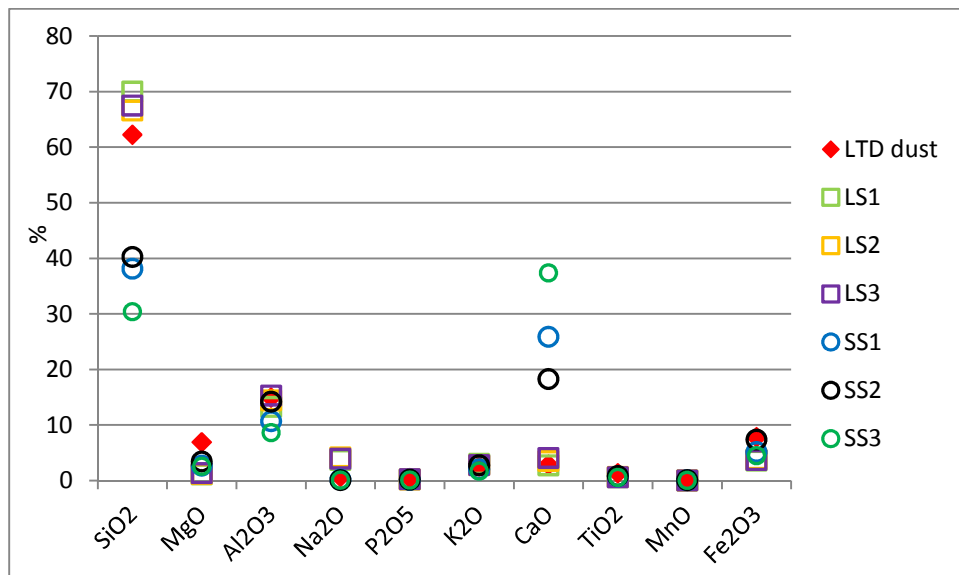
We agree with these comments and accept (and stress it in the text) that a small number of samples is a limitation of the paper. We have removed all references to sedimentological and geochemical analyses as provenancing techniques and modified objectives of the paper. We included new objective “to characterise elemental composition of deposited dust in compare it with that of locally produced dust and dust samples from the potential source region” as a more appropriate one than geochemical provenancing. We consider it important to retain the section on elemental composition of the dust as currently there are no publications at all on elemental composition of desert dust transported to the Caucasus Mountains and on pollutants which can be carried by the desert dust.

We used three samples from the potential source region of the transported dust in Sahara as determined using SEVIRI data. The small number of samples was used because of a good match between the areas of sample collection and source area in Sahara as indicated by SEVIRI and while we can potentially add more samples from this location, this addition may not provide information which will further enhance data interpretation. Samples from Mesopotamia will certainly be more valuable, however, there is little literature on this region currently, and fieldwork in Syria, which SEVIRI indicates as a secondary source, is not feasible at the present time.

4. Reviewer suggested that geochemical data should not be presented in tabular form.

The data will be presented in graphical format; see below. We will submit a table containing geochemical results as a supplement so that it shows standards data too.

(a) Chemical analysis of major elements (%) and (b) trace elements (ppm) in the LTD dust sample from the Garabashi Glacier compared to local sediments (LS) and the Saharan soils from the source region (SS), derived from XRF analysis. Data for copper and analyses of GSP-1 and DRN standards are presented in the Supplement.



Supplement 1. Chemical analysis of major elements (%) and trace elements (ppm) in the LTD dust sample from the Garabashi Glacier compared to local sediments (LS) and the Saharan soils from the source region (SS), derived from XRF analysis. Averages of several measured values for GSP-1 and DR-N standards are presented alongside the published values (Govindaraju, 1989).

Major elements	SiO ₂	MgO	Al ₂ O ₃	Na ₂ O	P ₂ O ₅	K ₂ O	CaO	TiO ₂	MnO	Fe ₂ O ₃
LTD dust	62.25	6.93	14.97	0.66	0.44	2.57	2.89	1.35	0.10	7.83
LS1	70.03	1.13	13.28	3.72	0.25	3.03	2.77	0.62	0.05	3.60
LS2	66.61	1.21	14.45	4.21	0.23	2.79	3.56	0.7	0.06	3.90
LS3	67.51	1.36	15.32	3.97	0.27	2.81	4.1	0.62	0.05	3.72
SS1	38.15	2.72	10.71	0.21	0.15	2.08	25.9	0.78	0.09	5.18
SS2	40.27	3.47	14.24	0.11	0.2	2.79	18.3	0.85	0.12	7.4
SS3	30.42	2.6	8.66	0.11	0.13	1.74	37.4	0.6	0.08	4.51
GSP-1 measured	67.59	0.92	14.0	2.97	0.27	5.43	2.21	0.60	0.03	3.68
GSP-1 published	67.32	0.97	15.28	2.81	0.28	5.51	2.03	0.66	0.04	4.30
DR-N measured	54.83	4.84	16.42	2.70	0.27	1.68	7.14	1.08	0.22	9.55
DR-N published	52.85	4.4	17.52	2.99	0.25	1.7	7.05	1.09	0.22	9.7

Trace elements	V	Cr	Co	Ni	Cu	Zn	Pb	Rb	Sr	Y	Zr
LTD dust	170	308	25	161	1656	231	13	24	45	8	80
LS1	68	45	8	11	7	59	22	124	265	17	276
LS2	75	37	10	8	7	62	21	125	315	18	249
LS3	72	26	10	12	19	77	28	118	331	15	169
SS1	91	80	12	33	20	70	24	76	281	37	353
SS2	113	113	19	50	25	108	36	102	262	36	191
SS3	74	68	14	30	19	63	20	62	294	32	222
GSP-1 measured	57	6	8	6	29	96	49	233	209	26	455
GSP-1 published	54	12	8	9	33	105	54	250	240	29	500
DR-N measured	156	40	34	15	51	144	47	73	400	30	128
DR-N published	220	45	35	22	52	150	65	75	400	-	125