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Supporting Information for

[The importance of rare, high-wind events for total dust uplift in northern Africa]

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Introduction

The following supporting information contains details of the maximum wind-speeds recorded from recent field campaigns in northern Africa and discussion on the sensitivity of the results in the main paper to; changing thresholds, normalizing data, different averaging methods and inclusion of winds > 55 kn.

Text S1 – Maximum wind-speed in SYNOP observations

In order to investigate a plausible range of wind-speeds, selected cases of high winds associated with dust emission reports during 2006 – present were explored using Spinning Enhanced Visible and Infrared Imager (SEVIRI) satellite imagery alongside alternative surface reports such as METARS and reanalysis data. SEVIRI pink dust imagery was used to look for evidence of large-scale dust storms, or any other large scale meteorological feature which could have created a particularly high wind-speed and dust emission. The highest plausible wind-speed found was 54 kn.
This value is largely consistent with maximum wind-speeds of only 47 kn observed in recent shorter-term field activities such as IMPETUS (An Integrated Approach to the Efficient Management of Scarce Water Resources in West Africa) in Morocco, Fennec in southern Algeria and AMMA (African Monsoon Multidisciplinary Analysis) in Mali, see Table S1. In SYNOP observations several examples were found where wind-speeds above 60 kn were most likely due to typographic errors.

Text S2 - Choice of Thresholds

Two different thresholds, T_{25} and T_{mean}, are taken from the grouped thresholds calculated in CKM14 (Table S2 , rows 1 and 7). These thresholds are based on the relationship between frequency of observed dust emission events as a function of all observations: T_{25} is the wind-speeds at which 25% of all reported observations contained a dust emission report (CKM14). This was computed for each station and then averaged over the six groups of stations also used in this study. T_{mean} is the mean of T_{25}, T_{50}, and T_{75}. Both T_{25} and T_{mean} are used to calculate DUP, testing the sensitivity of the results to the choice of threshold.

Text S3 - Different averaging methods

SYNOP observation records were grouped using the six regions defined in CKM14: North Algeria, Central Sahara, Egypt, West Sahel, Central Sahel, and Sudan. Different methods can be used for averaging over the groups of stations. The “best estimate” method averages stations in a grouped region after the TDUP curve is calculated and is used for the results of the main article. Row 4 (Table S2) takes the calculations one step further for each individual station before averaging over the stations in a group: stations are averaged in regional groups after the frequency pdf is calculated from the total DUP pdf (purple, Fig. 1). Row 5 does not average over the group until the three TDUP terms have been calculated for each individual station. Sensitivity to these three methods is discussed in the next section.

Text S4 - Sensitivity to data processing and methods

Normalizing the data to account for reporting frequency bias through the day did not alter the TDUP results by more than 0.5 ms^{-1} (not shown). To investigate the sensitivity of results to inclusion of data which is suspected to be false, the “best estimate” method (described in section 2.2.1) is applied to all observations, including those over 55 kn (initially excluded for reasons outlined in section 2.2.1 of the main paper). As the investigation of these very rare events was limited to the time period of SEVIRI imagery availability it is possible that the years previous do contain a number of real reports over 55 kn and is therefore worth

calculating. Including winds > 55 kn did not change the results in C Sahara and Sudan and only by up to 1 ms^{-1} in the other regions (Table S2).

When using the averaging methods in rows 4 and 5, $TDUP_{50}$ does not vary more than 1 ms^{-1} from the "best estimate" in five of the six regions, and not at all in the 3 northern regions.

The $TDUP_{75}$, $TDUP_{50}$, and $TDUP_{25}$ wind-speeds are sensitive to the dust uplift threshold used to calculate DUP. In Table S2, the difference is greatest between rows 2 and 8 where the same method is used, but a different uplift threshold is applied. This explains most of the regional variations in $TDUP_{75}$, $TDUP_{50}$, and $TDUP_{25}$ in Fig. S1 (values plotted in Fig. 3 of main paper), as the regionally varying uplift thresholds vary from 10 ms^{-1} in N Algeria to 5 ms^{-1} in Sudan (first row, Table S2) and the maximum and minimum values for $TDUP_{75}$, $TDUP_{50}$, and $TDUP_{25}$ follow the same regional pattern. The advantage of T_{25} over T_{mean} is that it includes more data in the calculations and reduces the counting error in the pdfs.

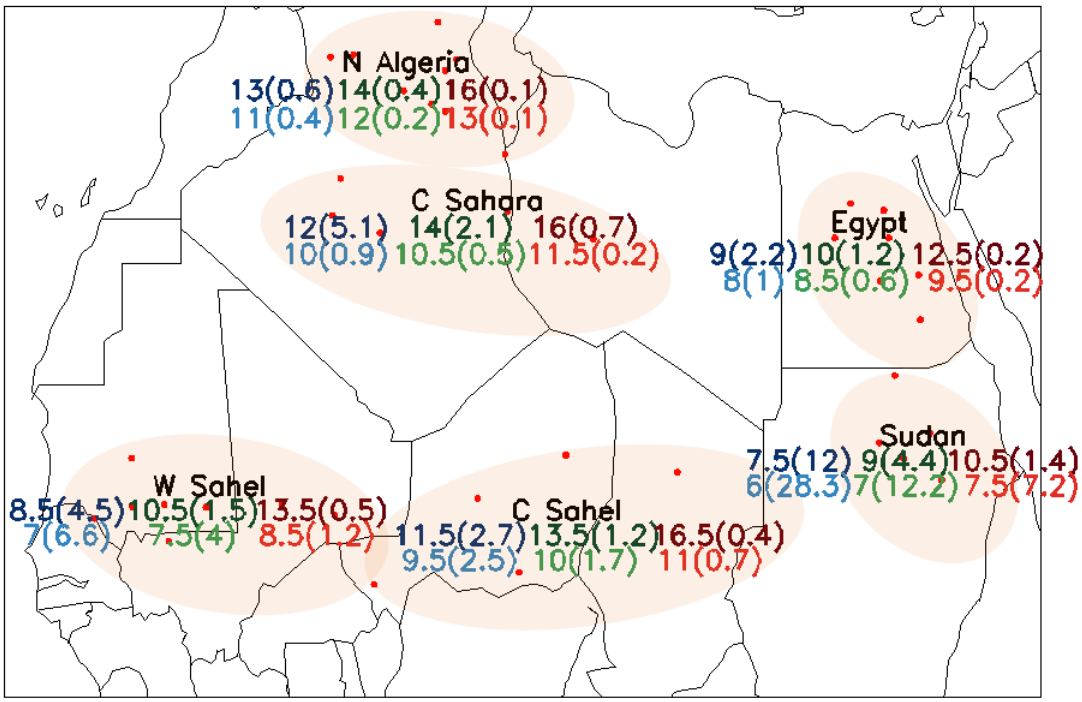

Figure S1. $TDUP_{75}$ (blue), $TDUP_{50}$ (green), and $TDUP_{25}$(red) wind-speeds in ms^{-1}, and their frequency of occurrence in brackets, for the 6 regions of grouped stations in northern Africa. Station locations are given by the red dots and the area covered by each group indicated by the shaded ovals. The equivalent values for ERA-Interim are given directly below in lighter colours. These values are plotted in Fig. 3 of the main paper.

Table S1. Field Campaign Station Metadata and Maximum Wind-speed*

Project	Station	Time Period	Data Res	Station Height	Max 10-min mean wind-speed (kts) at 10 m height*
IMPETUS	Lac Iriki	2001-2011	10min	3m	42.7
Fennec	Bordj Badji Mokhtar	June 2011	20 hz	10m	35.7
	AWS 134	June 2011	20 hz	2m	43.7
	AWS 138	June 2011	20 hz	2m	41.3
AMMA	Bamba	2005 - 2009	15min	3m	47
	Kobou	2008 - 2009	15min	3m	33.7
	Niamey	2006	1min	10m	38.8

*Maximum values in column six were converted to the equivalent values at 10 m height, assuming neutral stability for simplicity, and into knots from ms^{-1}.

Table S2. Thresholds for Dust Emission, Mean Frequency of Emission and Wind-speeds Above Which Give 50% of the total DUP ($TDUP_{50}$)*

			TDUP50 (m/s)					
			N Algeria	C Sahara	Egypt	W Sahel	C Sahel	Sudan
1	T_{25} threshold (m/s)		10	9	7	6	8	5
2	T_{25}	best estimate	14	14	10	10.5	13.5	9
3		incl. > 55 kn	15	14	11	11.5	14	9
4		average later	14	14	10	9.5	13	8.5
5		average last	14	14	10	9.5	12.5	8
6		occurrence winds above TDUP50	0.4%	2.1%	1.2%	1.5%	1.2%	4.4%
7	T_{mean} threshold (m/s)		12	11	9	8	10	6
8	T_{mean}	best estimate	16	15	13	12.5	15	9
9		occurrence winds above TDUP50	0.4%	2.4%	0.6%	2.2%	1.2%	1.4%
10	mean dust emission frequency obs		2%	12%	8.4%	12.5%	9%	27%
11	mean dust emission frequency ERA T25		1%	2.2%	3.4%	16%	6.6%	50%

*All results, apart those in row 3, exclude wind-speeds over 55 kn. Methods on rows 2,3 and 8 average stations in a group before calculating the cumulative frequency and subsequent $TDUP_{50}$. Methods in rows 4 and 5 average stations at later points in the calculations and are both explained further in section 3.1.3. T_{25} and T_{mean} are the different dust uplift thresholds used to calculate DUP, originally calculated from surface observations in CKM14.