Supplement of

**Effects of three-dimensional electric field on saltation during dust storms: An observational and numerical study**

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**Introduction**

Text S1 describes the estimations of the size distribution of saltating particles, saltation mass flux, and saltation height based on the SPC-91 data. Text S2 describes the measurement uncertainties of VREFM sensor. The E-field data measured in our field campaign are provided as a CSV file in Dataset S1. Additional figures (i.e., Figs. S1-S5) that support the findings of this study are also included.

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**Text S1. Estimating the size distribution of saltating particles, saltation mass flux, and saltation height based on SPC-91 data**

Because SPC-91 sensors measure particle number passing through the measurement area (=2 mm in height and =25 mm in length) of SPC-91 per second in the range of 30-490 μm with 64 bins, the probability distribution function (PDF) of saltating particle size can be readily estimated by

where denotes the probability density of particle size in the range of ; and are the number and diameter of the -th particle bin, respectively. Examples of the PDF of saltating particle size are shown in Fig. S1. It can be seen that the size of saltating particles at different heights nearly obeys a log-normal distribution (with R2 of 0.85-0.96).

In our field campaign, we measured the saltating particle number flux at 6 heights from 0.05 to 0.7 m. Thus, the mass flux at each measurement height can be reasonably estimated by

As shown in Fig. S2, the measured mass flux data can be well fitted by the exponential functions (Shao, 2008):

where is the value of at =0 and is a positive empirical constant. Hence, the total mass flux can be determined by

Additionally, the saltation height is defined as the height below which 99.9 % of the total mass flux is present (Dupont et al., 2013; Kok et al., 2012); that is,

From Eq. s5, we can numerically determine , as shown in Fig. S2.

**Text S2. Measurement** **uncertainties of VREFM sensor**

Fig. S3 shows the calibration results of 3 representative VREFM sensors. It can be seen that there is an excellent linear relationship (R2=0.99-1) between the output voltage of VREFM and the applied E-field intensities. The uncertainties of VREFM sensor come primally from the fluctuation of output voltage of VREFM sensors under a constant applied E-field, as shown in Figs. S3a, S3c, and S3e. The uncertainties of a VREFM sensor under specific applied E-field can be defined as

where is the slope of the fitting line in Figs. S3b, S3d, and S3f; is the maximum fluctuation of output voltage of VREFM sensors; and is the applied E-field intensity in the parallel-plate E-field calibrator. From the calibration results, we found that the maximum uncertainties of VREFM ranged from ~1.38 % to ~2.24 %.

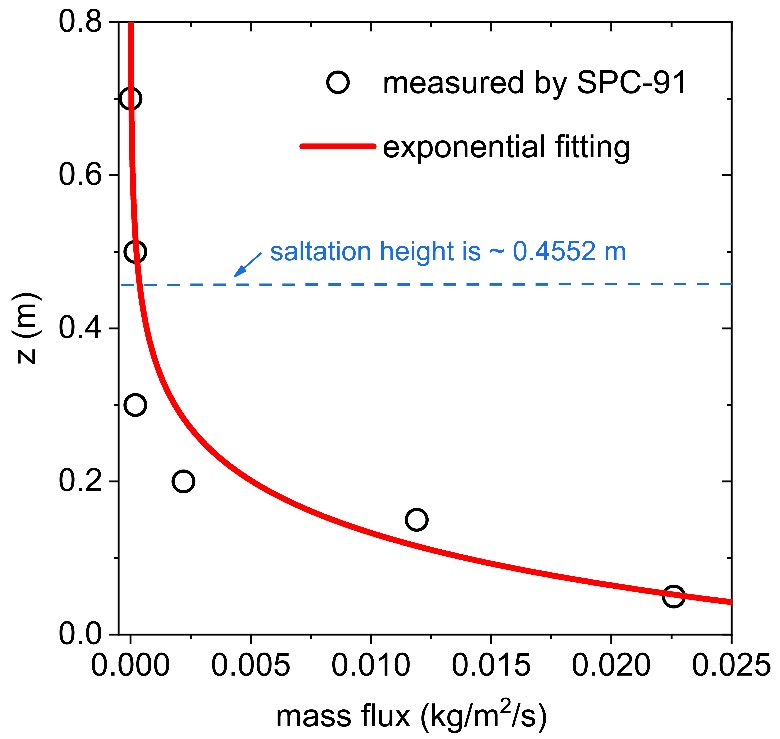
**Dataset S1.** (ds01.csv) A CSV file containing 3-D E-field data measured in our field campaign from 13:00 to 19:00 on May 6, 2014, at QLOA site. E1(1) to E1(5) represent the streamwise E-field at 0.05 to 0.7 m height, respectively; E2(1) to E2(5) represent the spanwise E-field at 0.05 to 0.7 m height, respectively; and E3(1) to E3(5) represent the vertical E-field at 0.05 to 0.7 m height, respectively. All data in the CSV file are shown in kV/m.



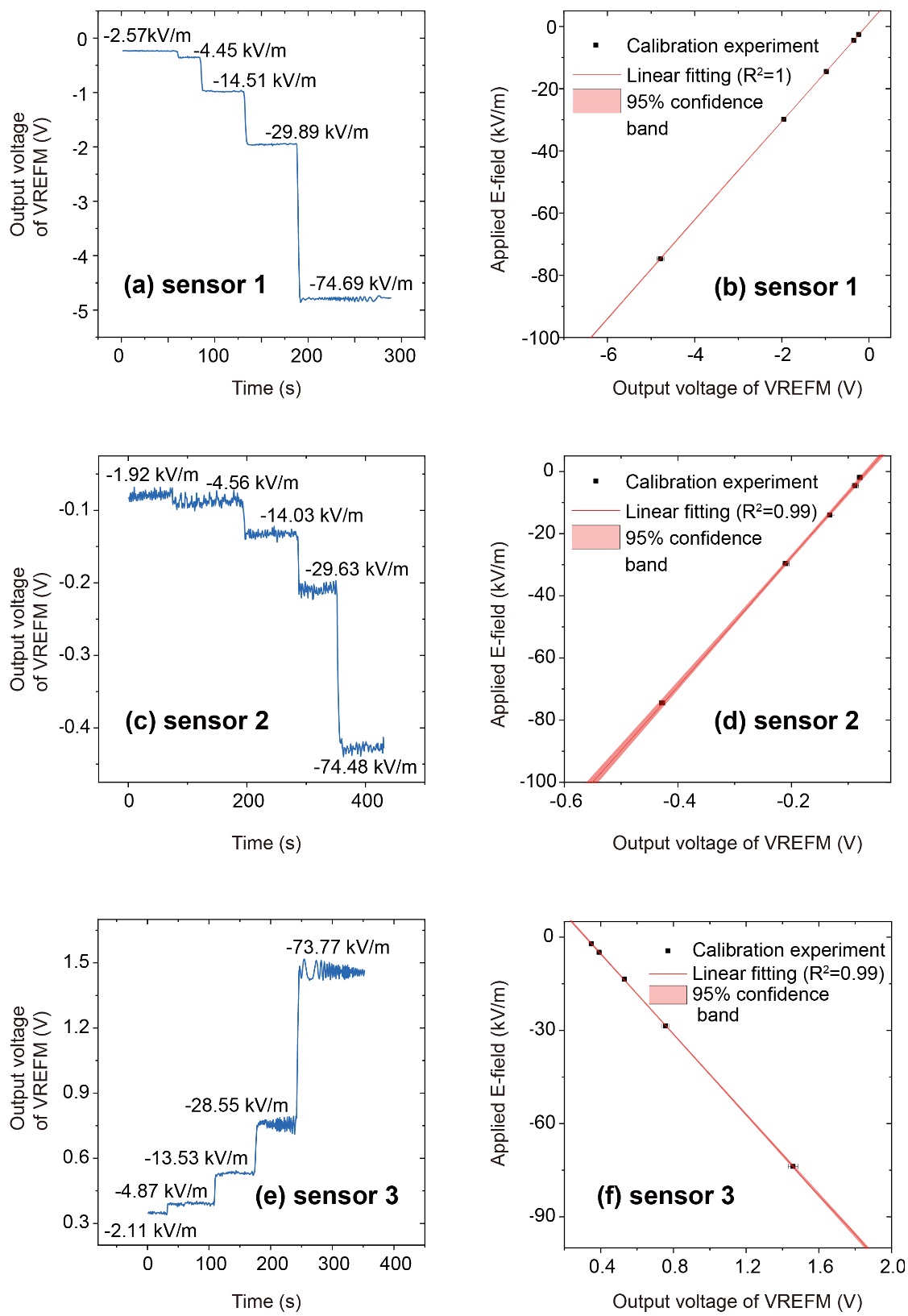




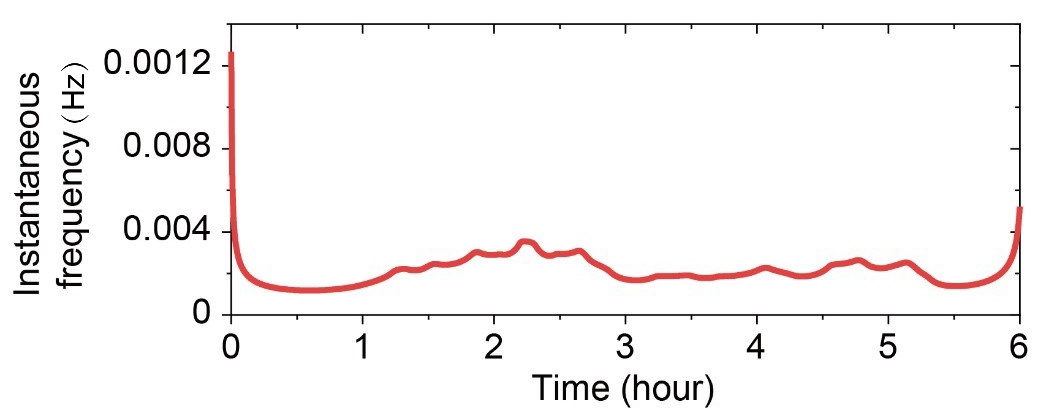
**Figure S1**. PDFs of the saltating particle size at different heights (from 0.05 to 0.7 m) in the relatively stationary period of the observed dust storm (shown as the shaded area in Fig. 4 of the manuscript). Open squares denote measured data by SPC-91 sensors, and lines denote log-normal (i.e. Eq. 7 in the manuscript) fitting.



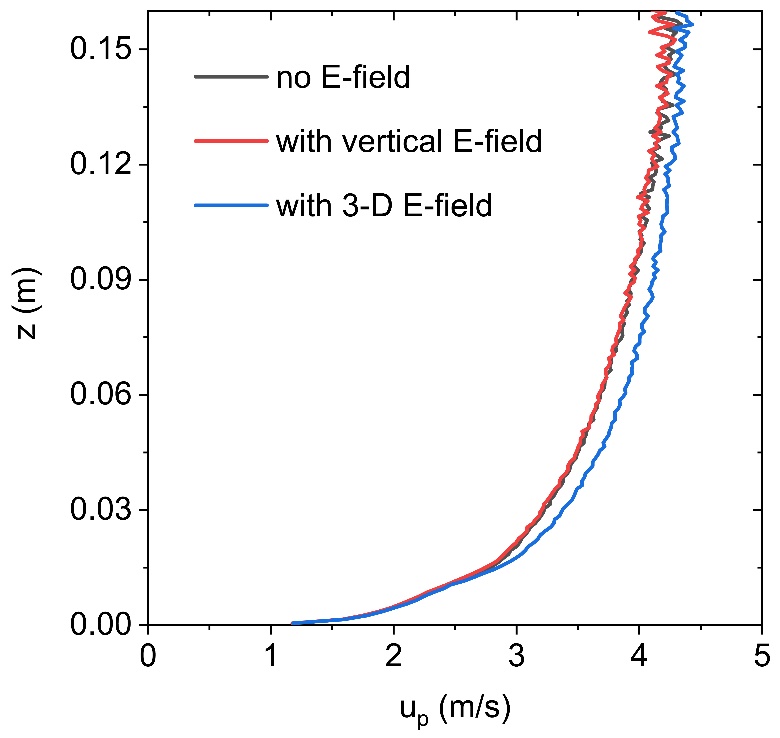
**Figure S2.** An example of the estimation of the total mass flux, , and saltation height, , in this study. The measured mass flux data are fitted by the exponential function , with =0.95. Thus, the total mass flux and saltation height can be estimated by Eqs. s4 and s5 in the Supplemental materials, respectively.



**Figure S3**. Examples of the calibration curves between the output voltage of VREFM sensor and the applied E-field in the parallel-plate calibrator. The subfigures (a), (c), and (e) are time series of output voltage of VREFM sensor at 5 different applied E-field levels (from ~2 kV/m to ~75 kV/m). The subfigures (b), (d), and (f) are the linear relationships between the output voltage of VREFM and the applied E-field intensity.



**Figure S4.** The instantaneous frequency of the intrinsic model function . The mean frequency of is 0.0021 Hz.



**Figure S5.** Vertical profiles of the mean horizontal particle speed for different cases, where =0.37 m/s, =200 μm, =exp(0.42), and=0.7.

**References**

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