**Dependence of particle size distribution at emission on friction velocity**

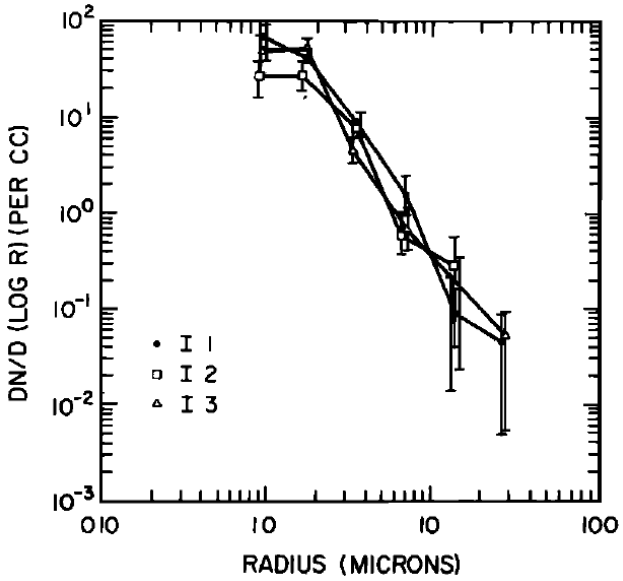
I thank the esteemed authors for writing this stimulating manuscript on a topic that has been of some controversy within the dust community: does the size distribution of emitted dust depend on wind properties and, if so, how? This manuscript aims to address two more specific sub-questions, namely (1) does the emitted dust size distribution depend on wind friction velocity and (2) does the emitted dust size distribution depend on atmospheric boundary layer stability? My colleague Sylvain Dupont submitted an excellent comment on this second part of the manuscript; my comment focuses on the first question.

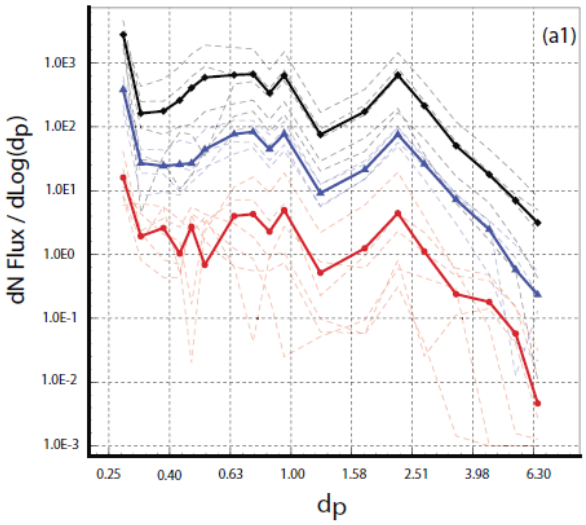
I value the contribution of this manuscript and hope that it can be published after revisions. The authors rightly identified that the question of whether emitted dust PSD depends on wind speed (and stability) should be investigated further as there is some contradictory evidence. After reading the paper carefully, I think there are a few issues in the present work that I would recommend addressing.

- As Sylvain Dupont also pointed out, a key methodological issue is that the authors equate airborne PSDs with the emitted dust PSD. This might be problematic because the size distribution of airborne aerosols is a sum of dust emitted at the measurement site, dust emitted upwind from the measurement site, and aerosols of any species advected to the measurement site. Additionally, the PSD of dust advected from upwind is known to depend on u* (see for instance Dupont et al., (2015)), so using the airborne PSD could create a change in the airborne PSD even if the emitted dust PSD remains constant. To avoid this problem that otherwise could shed doubt on the results, I recommend the authors either use the emitted dust flux inferred from the gradient method (Gillette, Blifford, and Fenster 1972) or should provide strong support in this paper that "In JADE, airborne-dust PSD […] well represent the emission-dust PSD" (line 57-8) and that this very strong match does not change with u*.
- Second, this work reanalyzes JADE data that was previously analyzed in an excellent paper by Shao et al. (2011). The present paper reaches rather different conclusions on the question of whether the emitted dust PSD depends on wind speed, yet does not note this seeming discrepancy anywhere that I could find. Indeed, Shao et al. (2011) report no dependence of the dust PSD on u* (their Fig. 12, copied below) and note that (their p. 15): "A clear and systematic dependency of psd on u* cannot be identified". I thus recommend that the revised paper (1) articulates the reasons why a reanalysis of the JADE data is necessary since these data were already analyzed in Shao et al. (2011), and (2) clearly explains why the present results are different from those reported in Shao et al. (2011) and why the authors think the analysis here is correct and, seemingly by implication, why the analysis and conclusion in Shao et al. (2011) is incorrect.
- Related to this previous point, I recommend that the authors use a broader range of data, similar to Shao et al. (2011). Their Figure 3 is similar to Figure 12 in Shao et al. (2011) in that it shows the dust PSD for different u* values, but it is subsetted to include only two events (10 and 11) whereas Figure 12 in Shao et al. (2011) presumably includes data from all measured events.

This might raise concerns that the conclusions of this study would change if more data than just the two events were considered.

- I think it would be beneficial to represent previous work better. As the authors are no doubt aware, the question of whether the emitted dust size distribution depends on wind friction velocity has been the subject of quite a number of studies, and several of those studies are not cited here. These include Fratini et al., 2007, Shao et al. 2011, and Huang et al., 2019. I'd also recommend noting more explicitly that the majority published measurements do not find a dependence of emitted dust size distribution on wind speed (see figure below and analyses in Kok (2011b) and Mahowald et al. (2014)). I think that context is important for the reader to interpret the opposite finding in this paper.



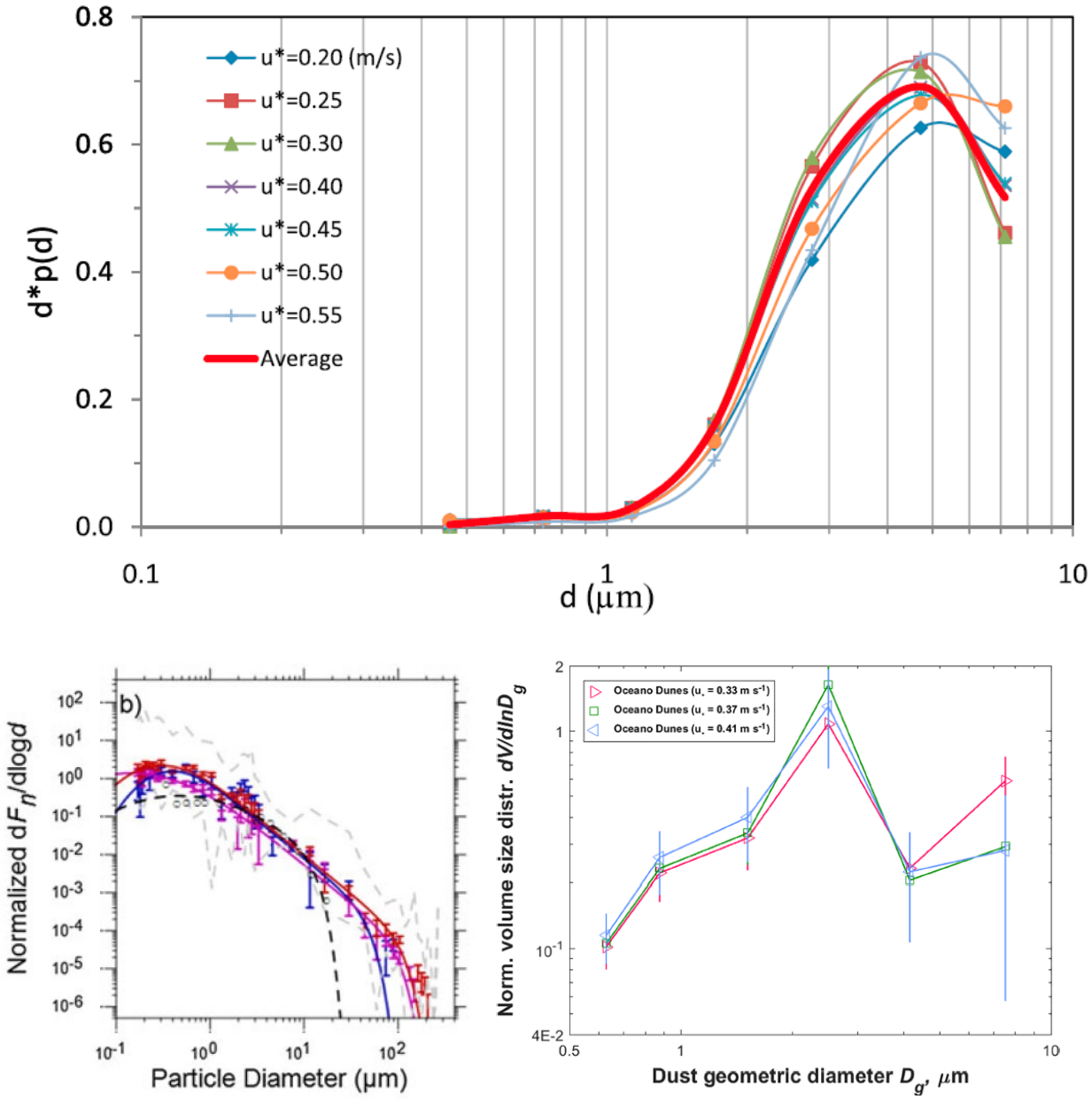



**Figure 1. Results from previous field measurements that investigated a dependence of the emitted dust particle size distribution (PSD) on wind friction velocity (u*).** Clockwise from the top, these results are from Gillette et al. (1974) (their Figs. 6 and 7), Fratini et al. (2007) (their Fig. 10), Shao et al. (2011; their Fig. 12), Rosenberg et al. (2014) (their Fig. 5), and Huang et al. (2019) (their Fig. 4).

- I recommend that the authors add a statistical analysis to determine whether the changes of the emitted dust PSD with u* are statistically significant. I think that's particularly important considering that the result here differs from what has been concluded in previous work.
- Line 30-32: "Since inter-particle cohesion depends on particle size, d, the fraction of dust emitted must also depend on d. Thus, for a given soil, the particle size distribution of dust at

emission (emission-dust PSD), $p_s(d)$, must depend on saltation bombardment or on friction velocity" and line 140-1 "u* is a descriptor of saltation bombardment intensity". This argument implicitly assumes that the impact speed of saltating particles increases with the friction velocity. It is highly intuitive that it would, but there is a very solid body of research that indicates that particle impact speed actually does not depend on friction velocity for transport-limited saltation. This lack of dependence of particle speed on wind speed was first proposed by Ungar and Haff (1987) because particle-wind feedbacks force an approximately constant saltator impact speed. It has since been confirmed by a large body of experimental (e.g., Namikas (2003), Rasmussen and Sorensen (2008), Creysells et al. (2009), Ho et al., (2011), Martin and Kok (2017)) and numerical (e.g., Duran et al. (2011), Kok et al. (2012)) work. The authors can of course present evidence to support their viewpoint counter to this literature, but I recommend acknowledging this extensive literature.

- Line 48-9: "Kok (2011a, 2011b) then proposed an emission-dust PSD and estimated its parameters from airborne-dust PSDs." That's actually not quite correct: Kok (2011a) only used emitted dust size distribution because airborne-dust PSDs are a convoluted sum of emission and advection (see comment above and by Sylvain Dupont). Also, the years on the references are incorrect (I corrected them in the quote above).
- I'm a bit confused how to interpret the 0-0.25 m/s u* category in the present paper's Figure 3, as this would include events without saltation where dust is not actively emitted but only advected. I suspect the authors are only using data for which saltation was occurring. If so, I recommend that the authors note that. And if not, I recommend the authors subset the data to only include active saltation data.

I thank the authors again for their stimulating paper. I'd be glad to discuss further with the authors offline, if desired.

Best wishes,

Jasper Kok

## References


Creyssels, M., P. Dupont, A. O. El Moctar, A. Valance, I. Cantat, J. T. Jenkins, J. M. Pasini, and K. R. Rasmussen. 2009. "Saltating particles in a turbulent boundary layer: experiment and theory." *Journal of Fluid Mechanics* 625:47-74. doi: 10.1017/s0022112008005491.

Dupont, S., S. C. Alfaro, G. Bergametti, and B. Marticorena. 2015. "Near-surface dust flux enrichment in small particles during erosion events." *Geophysical Research Letters* 42 (6):1992-2000. doi: 10.1002/2015gl063116.

Duran, O., P. Claudin, and B. Andreotti. 2011. "On aeolian transport: Grain-scale interactions, dynamical mechanisms and scaling laws." *Aeolian Research* 3 (3):243-270. doi: 10.1016/j.aeolia.2011.07.006.

Fratini, G., P. Ciccioli, A. Febo, A. Forgione, and R. Valentini. 2007. "Size-segregated fluxes of mineral dust from a desert area of northern China by eddy covariance." *Atmos. Chem. Phys.* 7 (11):2839-2854.

Gillette, D. A., I. H. Blifford, and D. W. Fryrear. 1974. "Influence of wind velocity on size distributions of aerosols generated by wind erosion of soils." *J. Geophys. Res.* 79 (27):4068-4075.

Gillette, D. A., Irving H. Blifford, and Charles R. Fenster. 1972. "Measurements of aerosol size distributions and vertical fluxes of aerosols on land subject to wind erosion." *J. Appl. Meteor.* 11:977-987.

Ho, T. D., A. Valance, P. Dupont, and A. O. El Moctar. 2011. "Scaling Laws in Aeolian Sand Transport." *Physical Review Letters* 106 (9). doi: 10.1103/PhysRevLett.106.094501.

Huang, Y., J. F. Kok, R. L. Martin, N. Swet, I. Katra, T. E. Gill, R. L. Reynolds, and L. S. Freire. 2019. "Fine dust emissions from active sands at coastal Oceano Dunes, California." *Atmospheric Chemistry and Physics* 19 (5):2947-2964. doi: 10.5194/acp-19-2947-2019.

Kok, J. F. 2011a. "A scaling theory for the size distribution of emitted dust aerosols suggests climate models underestimate the size of the global dust cycle." *Proceedings of the National Academy of Sciences of the United States of America* 108 (3):1016-1021. doi: 10.1073/pnas.1014798108.

Kok, J. F. 2011b. "Does the size distribution of mineral dust aerosols depend on the wind speed at emission?" *Atmos. Chem. Phys.* 11 (19):10149-10156. doi: 10.5194/acp-11-10149-2011.

Kok, J. F., E. J. R. Parteli, T. I. Michaels, and D. B. Karam. 2012. "The physics of wind-blown sand and dust." *Rep. Prog. Phys.* 75 (10):106901. doi: 10.1088/0034-4885/75/10/106901.

Mahowald, N., S. Albani, J. F. Kok, S. Engelstaeder, R. Scanza, D. S. Ward, and M. G. Flanner. 2014. "The size distribution of desert dust aerosols and its impact on the Earth system." *Aeolian Res.* 15:53-71. doi: 10.1016/j.aeolia.2013.09.002.

Martin, Raleigh L., and Jasper F. Kok. 2017. "Wind-invariant saltation heights imply linear scaling of aeolian saltation flux with shear stress." *Science advances* 3 (6):e1602569-e1602569. doi: 10.1126/sciadv.1602569.

Namikas, S. L. 2003. "Field measurement and numerical modelling of aeolian mass flux distributions on a sandy beach." *Sedimentology* 50 (2):303-326.

Rasmussen, K. R., and M. Sorensen. 2008. "Vertical variation of particle speed and flux density in aeolian saltation: Measurement and modeling." *Journal of Geophysical Research-Earth Surface* 113 (F2). doi: 10.1029/2007jf000774.

Rosenberg, P. D., D. J. Parker, C. L. Ryder, J. H. Marsham, L. Garcia-Carreras, J. R. Dorsey, I. M. Brooks, A. R. Dean, J. Crosier, J. B. McQuaid, and R. Washington. 2014. "Quantifying particle size and turbulent scale dependence of dust flux in the Sahara using aircraft measurements." *Journal of Geophysical Research-Atmospheres* 119 (12):7577-7598. doi: 10.1002/2013jd021255.

Shao, Y., M. Ishizuka, M. Mikami, and J. F. Leys. 2011. "Parameterization of size-resolved dust emission and validation with measurements." *Journal of Geophysical Research-Atmospheres* 116:D08203. doi: 10.1029/2010jd014527.

Ungar, J. E., and P. K. Haff. 1987. "Steady-state saltation in air." *Sedimentology* 34 (2):289-299. doi: 10.1111/j.1365-3091.1987.tb00778.x.