Response to anonymous referee #2's interactive comment on the manuscript "LES study on turbulent dust deposition and its dependence on atmospheric boundary-layer stability"

General comments: The authors use large-eddy simulation (LES) to investigate the influence of turbulent shear stress / momentum flux on dust deposition. Using a shear-stress weighted average of dry deposition velocity, they derive a modified version of a dust deposition scheme and obtain improved results compared to the LES dust deposition.
The subject of investigation is important and tests of the impact of the improved parameterization on the spatial distribution of dust deposition in a regional or global model are desirable in a future study. The manuscript is well structured. I therefore recommend publication of the manuscript after consideration of the following comments, which are overall minor.

Response: We are most grateful to Referee #2 for the time and effort he/she put into reading the manuscript, and for his/herhelpful comments and constructive suggestions. We fully agree with the Referee #2's suggestion about further investigation and tests of the improved parameterization of dust deposition in a regional or global model. There are several suggestions we will consider and modify the text accordingly.

Minor comments:
1) How is dust deposition (velocity and fluxes) calculated in the LES? Is the deposition scheme from Zhang and Shao (2014) used here as well? This does not become clear in the text.
Response: *Yes, the deposition scheme from Zhang and Shao (2014) is used for each grid of the lowest layer in the LES to calculate the deposition flux on the ground. In the revision, we will add a line of explanation to make it clear.*

2) Apart from the two different roughness lengths, the LES simulation design (domain configuration, simulation setup, cases) seem to be exactly as in Klose and Shao (2013), as are components of the analysis of the shear stress distribution. It should be made clear in the text that parts of the study design follow Klose and Shao (2013).
Response: *Sorry about this. We will try to clarify that parts of this study design follow Klose and Shao (2013).*

3) Data used in the paper is made available online, which is great. Ideally, I think a format which is independent of the programming language used would be preferable. Currently npy is used, which requires python. This is only a recommendation.
Response: *Thanks for the suggestion. We will try to convert the data from npy format to a csv format that is independent of the programming language.*

4) Line 9-10 While there are studies on the effects of atmospheric boundary layer stability (ABLS) on dust emission, I do not agree that they are as clearly documented as the sentence suggests. Stability is not typically considered in dust emission schemes. I propose to revise the sentence.
Response: *Indeed, this sentence is not accurately expressed. We will revise the sentence to 'While the effects of ABLS on particle emission have received more attention, those on particle deposition have rarely been explored' in the revision.*

5) Line 26 When stating that several dust deposition schemes have been proposed, I recommend listing more than two.
Response: *Thanks for the suggestion. We will give more dust deposition schemes in the revision.*

6) Line 43-44 Please add reference.
Response: *Thanks. We will add the reference in the revision.*

7) Line 50-53 This is (almost entirely) a direct citation from Klose and Shao (2013) and should be indicated as such.
Response: *Thanks. We will indicate this in the revision.*

8) Line 56-57 Sentence (current dust-deposition schemes only consider the mean wind) needs reference.
Response: *Thanks. We will correct this in the revision.*

9) Line 60 to accurately model
Response: *Thanks. We will correct it in the revision.*

10) Line 77 What do you mean with “reasonably well-established”?
Response: *Indeed, this is a bit sloppy. We will try to be more precise in the revision.*

11) Line 82 “nonlinear backscatter and anisotropic” – please check grammar
Response: *Thanks. We will check and correct it in the revision.*

12) Line 92-95 I presume the description of tau_ij is inherent to WRF, in which case a reference should be added.
Response: *Thanks. We will list the reference in the revision.*

13) Line 99 divided by
Response: *Thanks. We will correct it in the revision.*

14) Line 107 where K_m is eddy viscosity and phi_m is the MOST stability function
Response: *Thanks. We will correct it in the revision.*

15) Line 112 with “on grand” do you mean grid-resolved or grid-scale?
Response: *This comment is similar to Referee 1’s comment. The ‘grand’ will be changed to ‘ground’ in the revision.*

16) Line 114/115 as the change of dust concentration close to the surface
Response: *Thanks. We will correct it in the revision.*

17) Line 117 The combination of the two references given for dust emission is a little confusing, as the Shao (2004) paper deals with a dust emission scheme (without consideration of turbulence effects) and the paper from Klose and Shao (2013) deals with turbulent dust emission, but is no dust emission scheme (the corresponding references would be Klose and Shao (2012) and Klose et al. (2014)). Please clarify what the intention is here and update the references accordingly.
Response: *Indeed, this is a bit confusing. The purpose of the combination is to show the dust emission schemes have been studied with and without considering turbulence effects. We will try to be more precise and change Klose and Shao (2013) to Klose and Shao (2012) and Klose et al. (2014) accordingly.*

18) Line 118 settling instead of settlement
Response: *Thanks. We will correct it.*

19) Line 134 r_g should be defined at its first occurrence directly after Equation 10.
Response: *Thanks. We will correct it in the revision.*

20) Line 137 Please indicate the particle-size regime for which the Stokes assumption of a linear dependence of drag coefficient on particle Reynolds number, which is used here, is appropriate.
Response: Thanks. *According to* Malcolm and Raupach (1991)*, the Stokes regime is restricted to* D_p*<20 μm for quartz spheres falling freely in the air. We will give the corresponding particle-size regime in the revision.*

21) Line 141 assumption that dust concentration is zero
Response: *Thanks. We will correct it in the revision.*

22) Line 156 with beta … being the ratio…
Response: *Thanks. We will correct it in the revision.*

23) Line 158 for particles with diameter
Response: *Thanks. We will correct it in the revision.*

24) Line 160 gravitational settling
Response: *Thanks. We will correct it in the revision.*

25) Line 189 remove "below"
Response: *Thanks. We will correct it in the revision.*

26) Line 207 Do you mean "decreases with increasing wind speed"?
Response: *Sorry about this. Indeed, this line is a bit confusing. As Referee #2 pointed out, we had hoped to convey that 'decreases with increasing wind speed'. We will correct it in the revision.*

27) Line 211 ABLs, buoyancy
Response: *Thanks. We will correct it in the revision.*

28) Line 226 fluctuating behavior
Response: *Thanks. We will correct it in the revision.*

29) Line 287 performance
Response: *Thanks. We will correct it in the revision.*

30) Line 291-292 Check grammar
Response: *Thanks for Referee #2's kind reminder. We will change Line 291-292 to 'On this basis, by further evaluating the performance of the scheme of ZS14, we found that the accuracy of the ZS14 scheme decreases with increasing instability. As examples, we compared the deposition velocities* $V_{d,LES}$ *from Exp (5,9,17) and Exp (24, 27,33) with the deposition velocities* V_{d,τ_r} *calculated by the ZS14 scheme using each corresponding* τ_r*.' in the revision.*

31) Line 295 To predict
Response: *Thanks. We will correct it in the revision.*

32) Fig. 5 Check and use consistent labels (e.g. scatter/line versus circle/line)
Response: *Thanks. We will check and correct the inconsistent labels.*

33) Line 316 while it becomes
Response: *Thanks. We will correct it.*

34) Line 326 Please state how you calculated the Richardson number.
Response: *The Richardson number is derived from the transformed form of the formula* $R_i = \frac{g}{\overline{\theta}} \frac{\partial \overline{\theta}}{\partial z} \left(\frac{\partial V}{\partial z} \right)^{-2}$. *According to Li et al. (2014), the formula can be rewritten as* $R_i = -\frac{kz\varphi_h}{z_i \varphi_m^2} \left(\frac{w_*}{u_*} \right)^3$. *As* $w_* = \left(\frac{g}{\overline{\theta}} \overline{w'\theta'}_0 z_i \right)^{1/3}$, *$R_i$ can be estimated by using* $R_i = -\frac{g}{\overline{\theta}} kz \frac{\varphi_h}{\varphi_m{}^2} \frac{\overline{w'\theta'_0}}{u_*{}^3}$. *In the equation, z used is the center height of the lowest layer in this study,* φ_h *and* φ_m *are the Monin-Obukhov similarity functions*

for heat and momentum, respectively, which can be calculated by referring to Shao (2009), and $\overline{w'\theta'}_0 = \frac{H_0}{\rho_a c_p}$. *We will give the calculated formula in the revision.*

35) Line 328 associated with
Response: *Thanks. We will correct it in the revision.*

36) Line 338 In principle the deficiencies have only been shown for one dust-deposition scheme, even though from a conceptual point of view, this means that it applies for other schemes as well. I suggest to rephrase the sentence slightly to account for this nuance.
Response: *Thanks for the suggestion and we agree with Referee #2. We will modify this sentence to 'Through a series of numerical experiments, we have shown the turbulent characteristics of dust particle deposition velocity caused by the turbulent wind flow and pointed out the scheme of ZS14 has deficiencies in representing particle deposition under convective conditions.'*

37) Line 342 embedded
Response: *Thanks. We will correct it in the revision.*

38) Line 346 can be approximated with a Weibull distribution
Response: *Thanks. We will correct it in the revision.*

39) Line 351 on regional or global scales
Response: *Thanks. We will correct it in the revision.*

40) Line 352 the variation of tau may be changed (or affected) by surface roughness
Response: *Thanks. We will correct it in the revision.*

References

Klose, M. and Shao, Y.: Stochastic parameterization of dust emission and application to convective atmospheric conditions, Atmos. Chem. Phys., 12(16), 7309–7320, doi:10.5194/acp-12-7309-2012, 2012.

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Klose, M., Shao, Y., Li, X., Zhang, H., Ishizuka, M., Mikami, M. and Leys, J. F.: Further development of a parameterization for convective turbulent dust emission and evaluation based on field observations, J. Geophys. Res., 119(17), 10441–10457, doi:10.1002/2014JD021688, 2014.

Li, X. L., Klose, M., Shao, Y. and Zhang, H. S.: Convective turbulent dust emission (CTDE) observed over Horqin Sandy Land area and validation of a CTDE scheme, J. Geophys. Res. Atmos., 119, 9980–9992, doi:10.1002/2014JD021572.Received, 2014.

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Shao, Y.: Physics and Modelling of Wind Erosion., Springer Verlag, 2008.

Zhang, J. and Shao, Y.: A new parameterization of particle dry deposition over rough surfaces, Atmos. Chem. Phys., 14(22), 12429–12440, doi:10.5194/acp-14-12429-2014, 2014.