Response to anonymous referee's #1

General comments

This study presents a new particle dry deposition scheme applying to rough surfaces and provides an alternative for the community to deal with an important process in air quality sciences. It is worth to be published after considering the following concerns.

Response: we much appreciate the critical and insightful comments from anonymous referee. This critique has motivated us to examine and revise the manuscript. The details of responses are shown as following.

Specific comments

1. The study states that the new scheme is an improvement compared to existing ones and compared the model results with Slinn and Slinn (1980) and Slin (1982). Note that the model of Slinn and Slinn (1980) was developed for water surfaces, not for smooth or rough land surfaces. Thus, the comparison of Slinn and Slinn (1980) shown in Figure 1 does not make sense to me.

Response: our paper focuses on the study of physical mechanics of dry deposition processes. For Slinn and Slinn (1980) scheme, it was indeed developed for water surface. But in theory, the work has no difference from that for smooth surface, except for particle-growth process. So, for predicting deposition velocity on smooth surface, such as sticky wood and sand surface, we employ Slinn and Slinn (1980) scheme.

2. The study stated that earlier models predict reasonable deposition velocity over smooth surfaces but underpredict over rough surfaces. Note that the model of Zhang et al. (2001) actually predicts reasonable deposition velocity over rough surfaces and possibly overprecits deposition velocity over smooth surfaces (as shown in Petroff and Zhang, 2010). If the study really wants to demonstrate that earlier models are not suitable for rough or smooth surface, it should include comparisons with some of these earlier models (codes of these models should be available from those authors).

Response: the conclusion comes from the comparison between experimental data and schemes of Slinn. We also note that Zhang et al. (2001) and Petroff and Zhang (2010) actually predict comparable deposition velocity over rough surfaces and possibly over-predict deposition velocity over smooth surfaces (Zhang et al., 2001), through adjusting the coefficient of relevant collection efficiency but more physical explanation for the surface collection process. We believe that it could achieve good agreement between scheme results and measurements, by appropriately selecting of the adjustment coefficient. That is an efficacious method to improve the prediction precision for a certain surface. But if the surface condition changes, the relevant coefficients should also change. We add the comparison of Zhang et al. (2001), Petroff and Zhang (2010) and our wind tunnel measurements in Fig. 1. The results show the schemes cannot predict dust deposition velocity very well, which may be caused unsuitable adjustment coefficients. Actually, is it is no possible to get right adjustment coefficients for all surface conditions. Instead, we should expose the physical reason behind the change of surface collection efficiency which has been point out in Petroff and Zhang (2010). According to our proposal, the collection efficiency of isolated obstacle and the collection of whole surface should be distinguished. And one of the purposes of our work is to propose the relationship between these two variables. We have improved the expressions and added comparisons with Zhang et al. (2001), Petroff and Zhang (2010) in the revised version.

3. The study took wind-tunnel measurements as the basis for evaluating their new scheme and a few existing schemes. Field flux measurements suggested much higher deposition velocity than chamber or wind-tunnel measurements, especially over rough tall surfaces (e.g., forests). This study should first assess if the wind-tunnel measurements used here represent the real-world situation. Are the deposition velocities values from wind tunnel measurements similar to filed generated ones under similar (canopy, friction velocity) conditions? This should be briefly discussed in the paper. 4. Most collection efficiencies proposed in this new scheme are the same as or similar to those used in literature. But the final formulas in this scheme are actually more complex. It should be realized that a more complex scheme does not warrant more accurate results due to more input parameters involved (which had potential of introducing more uncertainties).
Response: the wind-tunnel measurements only can partly represent the real-world situation. But the situation in wind-tunnel is simple and is known well. We firstly test the schemes under this simple situation and then will extend to complex field situation in future. Actually, we briefly discussed the limitations of the wind-tunnel work and stated the further work which is desirable, in page 8080, line 9-15.
We knew that the collection efficiencies of obstacle are normally based on studies on particle collection by isolated obstacle. But in dust deposition model, the thing we really interested in is the collection efficiencies for whole surface. And these two variables are generally confused in existing model. The work of Petroff and Zhang (2010) actually pointed out the collection efficiency of surface is influenced by not only the size of obstacles but also the distribution of these surface collectors. But the relevant physical mechanisms are not exposed in that work. To obtain the relationship between collection efficiency of whole surface and collection efficiency of isolated obstacle, we reveal the interactions for the surface roughness elements in analogy to the drag partition theory. That is the main improvement of our new scheme. The new input parameters required by our scheme, such as frontal area index and basal area index could be estimated well from the wind profile, based on the drag-partition theory. These two parameters are necessary to describe more physical processes and to improve the rationality and precision of dust dry deposition scheme.

4. “Dust” is typically referred to road or soil derived particles in literature and is mostly in coarse particles. Secondary aerosol particles do not belong to dust. The scheme developed here applies to all sizes of particles and is not limited to dust particles. I would recommend replacing “dust” by “aerosol” or “particle” throughout the text.
Response: we have replaced “dust” by “particle” in the revised version.

5. Editorial comments.
Only some examples are given and the authors should proofread the whole paper.
P8064. L1: the first sentence of the abstract is not appropriate and does not reflect the status of all the existing schemes. Abstract: The abstract could summarize some quantitative results to demonstrate it improvement to exiting schemes.
Response: accepted.

L15: “in the absence of precipitation” should be deleted since dry deposition happens all the time even (and generally faster) during precipitation.
Response: it is indeed that, dry deposition happens all the time. But generally, we discuss dry deposition process in the absence of precipitation (Seinfeld and Pandis, 2006).

L17-18: the method is commonly called “inferential method”, dry deposition velocity (or resistance) are parameters of this method.
Response: accepted.

P8065. L1: first sentence repeats information in previous page and is not needed.
Response: accepted.

L9 and L16: use “firstly”, “secondly”.
Response: accepted.

P8067. L10 repeats L23 in the previous page.
Response: L10 has been deleted.

Response to anonymous referee # 3's interactive comment on the manuscript "A new parameterization of dust dry deposition over rough surfaces"

General comments

This paper investigates the question of the representation of dry deposition processes for dust particles and the influence of surface roughness on the deposition velocity. This is an important topic since the mass budget in 3-D dust model is largely under-constrained due to uncertainties in both emissions and deposition. The proposed parameterization is compared to the parameterizations proposed by Slinn (1980) and Slinn and Slinn (1982), that are widely used in 3-D aerosol models, and with experimental data, showing the improvement brought by this new parameterization. On original aspect of this work is to explicitly describe the relative influence of the roughness elements and of the bare fraction of the surface on the different terms involved in the deposition processes by analogy with the drag partition theory widely used to describe the erosion threshold over rough surfaces. The second original aspect is the comparison of this new parameterization with deposition velocity measurements performed in wind-tunnel for different surfaces with contrasted roughness properties. The paper is in general well written and well organized. In particular, the very detailed description of the main assumption is extremely valuable. Figures are clear and well described. A few clarifications on the assumptions made to establish the parameterization and on the sensitivity study (listed below) would make the results even more convincing. I recommend the publication of the manuscript after minor revisions.

Response: we'd like to thank the anonymous referee for the critical and insightful comments to our manuscript. Our reply is as follows.

Specific comments

1. -Page 8065 lines 10-16: the author argued that existing approaches have two deficits. It is not clear how or if the new parameterization provides a solution to the first deficit (gravitational settling).

Response: actually, the first deficit (gravitational settling) is taken into consideration by solving Eq. (1) analytically. The result is shown as Eq. (3), which also includes the resistances (r_a, r_g, r_s), but is not based on electrical-circuit theory and r_g is not considered as a parallel resistance anymore. The following comments will be added at the end of part 2.1:

"Here, the expression of w_d [i.e. Eq. (3), an analytical solution of Eq. (1)] is not based on electrical-circuit theory and r_g is not considered as a parallel resistance anymore. So the first deficit we described in the introduction has been dealt with."

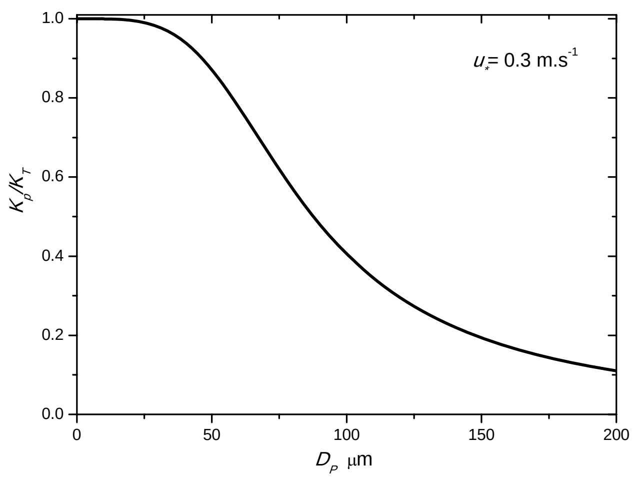
2. - Page 8065 lines 26-28: the comment on the results of the SS80 and S82 seems too severe

regarding the figure 1...

Response: we have a somewhat different view. The results of SS80 and S82 are comparable with the experimental data for smooth surfaces (such as wood surface). That is because the deposition processes over smooth surface are relatively simple, and these physical processes are well represented in the SS80 and S82 schemes. But over rough surfaces, dust deposition is complex. The difference between the predicted data and experimental results is obvious, if the input parameters are evaluated according to the practical situation. The shortage of the existing schemes is caused by ignoring some physical processes, such as the lacking of surface parameterization. Although the difference between the scheme and experiment can be reduced by adjusting some input parameters, the adjustment is often unreasonable and has no physical basic. That is why the existing schemes perform relatively poorly for rough surfaces.

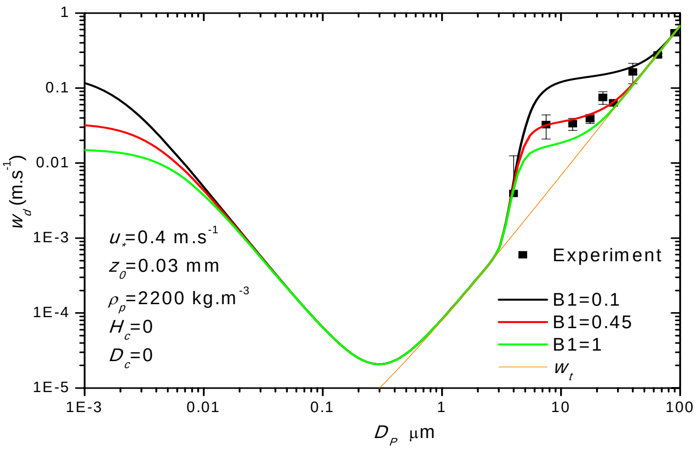
3. - Page 8068 line 9: the choice of the value of 1 for α and σ as u_* should be further justified.

Response: α and σ are the parameters for Eq. (6) which is proposed by Csanady (1963) to describe the trajectory-crossing effect of heavy particles in the atmosphere. α is considered as a constant, but the precise value of α is not certain. α is normally set to 1 in the discussions of Csanady (1963), Shao (2008) etc. σ is originally defined as the standard deviation of the turbulent velocity. If the turbulence is isotropic, it is acceptable to consider σ as the friction velocity u_*. For simplicity, we take the choice of the value of 1 for α and σ as u_*, which is not very precise but can describe the behave of K_p/K_t well (close to 1 for small particles which can follow the air stream well and reduced for large particles which are hard to follow the air movement because of particle inertia, as shown in the following figure).



4. - Page 8069, line 1-4: B1 has been determined from the wind-tunnel measurements. Is it a sensitive parameter?

Response: B1 only applies to smooth surface. The value of B1 is determined from the wind-tunnel measurements over sticky-wood surface. As shown in the following figure, B1 is sensitive for the particle less than 0.01 µm and for the particle with size from 3-50 µm.



5\. - Page 8071 line 10: the impaction efficiency is taken from Petroff et al. (2008) and is assumed constant whatever the roughness elements. Should it vary depending on the type of surface, for example, stone versus vegetation?

Response: the impaction efficiency E^{im} proposed by Petroff et al. (2008) is based on the results of three measurement campaigns on isolated cylinders (Ranz and Wong, 1952; May and Clifford, 1967; Starr, 1967). E^{im} represents the probability for the particles collected by the roughness element (normally considered as a cylinder in scheme). E^{im} is not constant. It is depended on the size of roughness elements and is of course varied for different surface types. Additionally, the surface type also affects the other parameters in the scheme, such as R which relates to surface texture, A_{in} which relates to surface micro-roughness and so on.

6\. - Page 8071 line 13: is it really relevant to take into account particle growth for mineral dust? Are the parameterization from Fitzgerald (1964) and Gerber (1985) appropriate for such particles?

Response: we take into account particle growth to the make the new scheme have a potential to describe the deposition for other kind of particles, such as sea-salt and sulphate aerosols. If the particles do not satisfy the requirement of particle growth mechanism, we should set RH=0% or $D_{p,\delta}$=D_p to exclude the effect of particle growth.

7\. - Page 8075 line 8: the definition of β, that can be found in table A1, should be given here. In addition, arguments on the choice of a unique value should be given. Based on wind tunnel measurements, Walter et al (Boundary Layer Metorol., 2012) estimated this value to 137 for blocs and 93 for vegetation elements.

Response: accepted. We will add the definition of β and add the arguments on the choice of a unique value in the revised version.

8\. - Page 8076-8077: in the description of the comparison between the new parameterization and the measurements, more details on what parameters really makes the difference from one surface to the other should be given, in particular for the parameters that will further used in the sensitivity analysis.

Response: we will improve the presentation of this part to highlight the reasons (about input parameter) for the difference of deposition velocity from one surface to the other.

9. - Page 8076 line 5-15 : it is quite surprising to read that sand grains are treated as individual obstacles, since they does not really fits the representation of figure 2, and especially when the final sentence states that sand grains are smooth. The size of the sand grains should be given explicitly. It is stated that in this case hc=30.Z0 and three values of Z0 are given. I cannot imagine that the size of the sand also changes.

Response: in our opinion, the sand surface fits the representation of figure 2, just the height of the obstacles is a little small (half of the diameter of sand particle, $h_c= D_{sand}/2$). Comparing to dust particles, the size of sand is relative big and the sand particle could be treated as a roughness element (or collector). We states that sand grains are smooth, which means there is no micro-roughness-element, such as hair, over sand particle and the surface of sand particle is supposed smooth (doesn't mean sand surface is smooth). In this case, we set $h_c=D_{sand}/2$. "$h_c=30.Z_0$" is applied on water surface but sand surface.

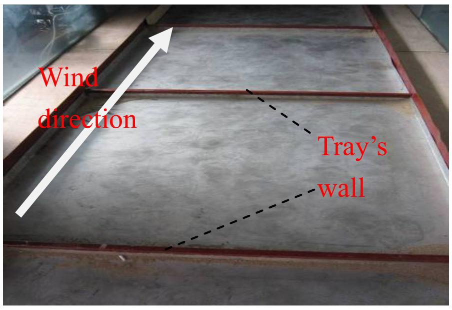
10. - Page 8076 line 22: it is difficult to imagine trees in a wind tunnel. May be "Shrubs" or "plants" would be more appropriate.

Response: we'd like to change it to "plants".

11. - Page 8076 line 27 - page 8077 line18: this part of the discussion is not clear, in particular concerning the role of bubbles and spay droplets. Are the wind tunnel measurements made at such wind velocity that it creates waves on the water surface that produce such bubbles and sprays? In this case, there would be a change in the roughness length (mentioned as constant and low in table 3). So even if the parameterization fits very well the measurements, I am not convinced by the discussion and by the final sentence ("We have shown ... droplets".

Response: this was a question puzzled us in the experiment. Finally, we find the bubbles and spay droplets or constant roughness length both relates to the trays (shown as the following picture) used to fill the water in the experiment. Actually, the bubbles and spay droplets are caused by the hitting of the water waves on the wall of the trays. And actually, the wind profile is mainly affected by the wall of the trays. That's the reason why roughness length is almost a constant.

We will add this information in the discussion to make it convincing.



12. - Page 8077: this sensitivity analysis is very welcome at this point of the manuscript and very interesting. However, it would be more convincing with some arguments on the selected range of values for the different parameters. As an example, the roughness element size vary from 1 to 10 mm, which is very low, especially compared to the height of the roughness elements fixed to 150 mm. This makes very long and thin obstacles: what kind of surface can is it supposed to represent? On the opposite, the range of roughness density is very large. Similarly, particle density has been taken from 1000 to 5000 kg.m^{-3}: Is it realistic compared to the density of typical minerals composing mineral dust?

Response: we'd like to add some arguments on the selected range of values for the different parameters (or change some selected range).

Fig. 3 is only a conceptual picture. h (or h_c) is actually the height of collection layer in where surface collects exist. d_c is the typical size the surface collect. As an example of plants, it is possible that h_c is several meters (the height of the plant) and the size of d_c (the size of branches or leaves) is several millimeter. The purpose of taking a large range of roughness density is to illustrate the whole change of surface roughness with increasing λ, from smooth to rough, and then back to smooth. We take particle density from 1000 to 5000 kg.m^{-3} to extend the application of the scheme to some other aerosol, including the heavy metal aerosol.

13. - Page 8079 line 20-21: please, comment the figures or remove them.

Response: we will remove Fig. 6 which looks unnecessary here.

14. - Page 8010 line 5-7: Additional test on different or larger range of roughness element dimensions could also be mentioned to treat deposition on urban surfaces or forest.

Response: we will add test of roughness element dimensions in larger range.

Technical corrections:

1. - page 8068 line 3: does "neutral particle" refer to their electrical charge?

Response: yes

2. - Page 8073 line 20: "depended" should be replaced by "dependent"

Response: accepted

3. - Page 8075 line 24: "absence" should be replaced by "absent".

Response: accepted

4. - Page 8078 line 8: in the sentence "dust deposition is suppressed ..", replace "suppressed by "negligible", for example.

Response: accepted

5. - Page 8078: line 13-16 : It should be clearly stated that it is not very sensitive.

Response: accepted

List of changes

Page 8063

In the title: “dust” is changed to “particle”

The name of the first corresponding affiliation is modified to “*Key Laboratory of Mechanics on Disaster and Environment in Western China of the Ministry of Education of China, Lanzhou University, 730000 Lanzhou, China*”

Page 8064

In the abstract: the first sentence is changed to “In existing particle dry deposition schemes, the effects of gravity and surface roughness elements on particle motion are often poorly represented.”

Line 4: “Particle deposition velocity is a function of aerodynamic, surface-collection and gravitational resistances. In this study, the effect of gravitation settling is treated analytically.” is added after “deficiencies”.

Line 4: “the scheme” is changed to “More importantly, the new scheme”.

Line 5: “dust” before “diffusion” and before “collection” are changed to “particle”.

Line 8: “dataset” is changed to “data set”.

Line 14-25: all “dust” are changed to “particle”.

Line 15: “(Seinfeld and Pandis, 2006)” is added after “precipition”.

Line 16-18: “To estimate … is widely used” is changed to “The inferential method is widely used to estimate particle deposition flux in terms of particle concentration and deposition velocity (or its inverse, the resistance)”.

Line 22: “the” is added before “aerodynamic”.

Line 23: “collection” is added after “surface”.

Page 8065

Line 1: the first sentence is deleted.

Line 2: “usual” is added before “approach” and “to estimating deposition velocity” is added after “approach”.

Line 3: “of” is added after “comprises”.

Line 4: “collection” is added after “surface”.

Line 5: “2012” is changed to “2006”.

Line 6: “dust” before “deposition” and before “concentration” are changed to “particle”.

Line 9: “First” is changed to “Firstly”.

Line 15: “2012” is changed to “2006”; “dust” is changed to “particle”.

Line 16: “Second” is changed to “Secondly”.

Line 17: “dust” is changed to “particle”.

Line 18: “for particle dry deposition” is added after “scheme”.

Line 20: “dust” is changed to “particle”.

Line 23: “dust” is changed to “particle”.

Line 24-25: “Slinn and Slinn … S82 hereafter” is changed to “Slinn and Slinn (1980, SS80 hereafter), Slinn (1982, S82 hereafter), Zhang et al. (2001, Z01 hereafter) and Petroff and Zhang (2010, PZ10 hereafter”.

Line 26-Line 2 (page 8066): “Shows that … physically unrealistic” is changed to “shows that the performances of existing deposition schemes are unsatisfactory, especially for rough surfaces (e.g. surface with plants). Considering that the Z01 and PZ10 schemes are based on field observation data sets and their model coefficients may have included the effects of certain factors (such as atmospheric convection and complex surface conditions) which cannot be well simulated in our wind-tunnel experiments, we will use SS80 and S82 as reference schemes in this study. As shown in Figure 1c, the model-observation discrepancies can be reduced by tuning some input parameters of S82, but the tuned parameters are physically unrealistic”.

Page 8066

Line 3，4，7: “dust” are changed to “particle”.

Line 3: “the” is changed to “this”.

Line 12: “dust” is changed to “particle”.

Line 18, 22, 23: “dust” are changed to “particle”.

Line 21: “above the collection layer” is deleted.

Line 24: “(Shao, 2008)” is added after “equation”.

Page 8067

Line 1, 2, 18: all “dust” are changed to “particle”.

Line 3: “under the transfer layer” is added after “lower part”.

Line 7: “roughness” is added after “the top of the”.

Line 10: “Equation (1) … condition” is deleted.

“Here, the expression of w_d [i.e. Eq. (3), an analytical solution of Eq. (1)] is not based on electrical-circuit analogy and r_g is no longer treated as a parallel resistance. So the first deficiency we described in the introduction has been dealt with.” is added at the end of this page.

Page 8068

Line 2: “much smaller than K_p and thus” is added before “negligible”; “the” before “eddy” is deleted.

Line 3: “for neutral particles” is deleted; “K_p/K_T” is changed to “K_T/K_p”.

Equation (6) is changed to $Sc_T = \frac{K_T}{K_p} = \left(1 + \frac{\alpha^2 w_t^2}{\sigma^2}\right)^{1/2}$

Line 10: “2012” is changed to “2006”.

Equation (8) is changed to $r_a(z) = \frac{Sc_T}{\kappa u_*}\left\{\left[\varphi(\varsigma)\cdot \ln(z-z_d)\right]_h^z - \int_h^z \ln(z-z_d)d(\varphi)\right\}$

Equation (9a) is changed to $r_a(z) = \frac{Sc_T}{\kappa u_*}\ln\left(\frac{z-z_d}{h_c-z_d}\right)$

Equation (9b) is changed to $r_a(z) = \frac{B_1 \cdot Sc_T}{\kappa u_*}\ln\left(\frac{z}{z_0}\right)$

Page 8069

Line 2: “B_1/Sc_T” is changed to “$B_1 \cdot Sc_T$”.

Line 17, 22: “dust” is changed to “particle”

Line 19: “rough” is changed to “roughness”;

Line 19-20: “element roof areas” is changed to “roof of roughness elements”

Line 20: “roughness” is added before “elements”.

Page 8070

Line 5, 13: all “dust” are changed to “particle”.

Line 7: delete “a” before “roughness” , after which “element” is changed to “elements”.

Line 12: “element” is changed to “elements”.

Line 25: “dust” is deleted.

Equation (13) is changed to $\tau_c = C_d \cdot [\rho_a |u_a(h)| \cdot u_a(h)] \cdot \lambda$.

Equation (14) is changed to $F_{d,c} = -E \cdot |u_a(h)| \cdot c(h) \cdot \lambda$

Page 8071

Line 5: add “air” before “kinematic”.

Line 8: “dust” is changed to “particle”.

Line 13: “the” is changed to “wet”.

Line 22: “tree” is changed to “plant”.

Page 8072

Line 2: “flow” is changed to “airflow”.

Line 7: “dust” is changed to “particle”; “the element roof” is changed to “the roof of roughness element”.

Line 9: “20” is changed to “20a”.

Line 10: “21” is changed to “20b”.

Line 15: “22” is changed to “21a”.

Line 16: “23” is changed to “21b”.

Line 18: delete “dust”.

Line 20: “24” is changed to “22”.

Line 22: delete “dust”.

Line 23: “dust” is changed to “particle”.

Line 24: “Dust particles” is changed to “Particles”.

Line 26: “dust” is changed to “particle”.

Page 8073

Line 2: “25” is changed to “23a”.

Line 3: “26” is changed to “23b”.

Line 5: “25” is changed to “23a”; “26” is changed to “23b”.

Line 6: “27” is changed to “24”.

Line 10: “28” is changed to “25”.

Line 17: “29” is changed to “26”.

Line 19: “Dust” is changed to “Particle”.

Line 20: “depended” is changed to “dependent”.

Line 21: “dust” is changed to “particle”

Line 23: “30” is changed to “27”.

Page 8074

Line 2: “31” is changed to “28”.

Line 4: “31” is changed to “28”.

Line 5: “32” is changed to “29”.

Line 6: add “collection” before “resistance”.

Line 9: “33” is changed to “30”.

Line 12: “34” is changed to “31”.

Line 15: “33” is changed to “30”.

Line 16: “35” is changed to “32”.

Line 20: “36” is changed to “33”.

Page 8075

Line 4: “37” is changed to “34”.

Line 6: “38” is changed to “35”.

Line 8-9: “and β ... surface drag coefficient” is changed to “β is the ratio of the pressure-drag coefficient to friction-drag coefficient, which varies with surface type. Here, we set β to 200 following the study of Shao and Yang (2005)”.

Line 11: “dust” is changed to “particle”.

Line 13: delete “or” before “if”; add “then only” before “two”.

Line 14: “namely, h_c and λ” is changed to “(h_c and λ) are necessary”

Line 21: “dust” is changed to “particle”.

Line 22: “prediction using” is changed to “results of”.

Line 24: “absence” is changed to “absent”; “Dust” is changed to “Particle”.

Line 26: “does not occur” is changed to “should be very low”.

Page 8076

Line 3: “a Phase Doppler Anemometry” is changed to “the PDA”.

Line 6: delete “that”.

Line 10: add “(D_{sand} = 0.2 mm)”after “sand particles”; add “(i.e., d_c = 0.2 mm, h_c = 0.1 mm)” after “half that diameter”.

Line 14: “As sand grains are smooth” is changed to “For smooth sand grains”.

Line 19: add “(related to d_c)” after “interception”.

Line 21: “dust” is changed to “particle”.

Line 22: “tree” is changed to “plant”.

Line 23: “tree” is changed to “branch”.

Line 26: “Compared with the sand surface, the deposition velocity over plant surface is increased, which may be mainly caused by the enhanced friction velocity u_*.” is added at the end of the paragraph.

Line 28: add “(RH=100%)” after “assumed”.

Page 8677

Line 1-2: “Silicon Dioxide” is changed to “fused silica”.

Line 5: delete “waves”; “emitted from the surface” is changed to “caused by the hitting of the water waves on the wall of the trays used as water containers in the experiment”.

Line 6: “dust” is changed to “particle”.

Line 7: add “and bubbles” after “waves”.

Line 11: delete “Bubbles and/or”.

Line 12: “tree” is changed to “plant”.

Line 15: “5d” is changed to “4d”.

Line 21, 26: “dust” is changed “particle”.

Line 22: delete “. As the scheme”.

Page 8078

Line 1-2: “frontal area … fraction of cover” is changed to “frontal and basal area indexes”.

Line 5: “dust” is changed to “particle”.

Line 7: “it” is changed to “deposition velocity”.

Line 8: “Dust” is changed to “Particle”; “suppressed” is changed to “negligible”.

Line 14: add “We take particle density from 1000 to 5000 kg m^{-3} to extend the application of the scheme to some special aerosol, such as heavy metal aerosol.” before “as shown in Fig 5a”; add “particle deposition is not very sensitive to particle density, because” before “the variability”; “mainly” is changed to “only slightly”.

Line 20: “predominantly” is changed to “predominant”.

Line 24: “Finally” is changed to “Then”.

Line 25: “element collection” is changed to “surface collection”.

Line 26: “element size” is changed to “surface characteristics”; add “roughness” before “element”.

Line 28: add “roughness” before the first “element”; “element collection” is changed to “surface collection”.

Line 29: “For smooth elements (A_{in}=1)” is changed to “For a certain micro-roughness feature (A_{in} = constant)”.

Page 8079

Line 2: “0.1” is changed to “0.01”.

Line 3: “in the range of 0.1 to 5 μm” is changed to “with size in this range”.

Line 4: “for small element size” is changed to “with decreasing d_c”.

Line 5: “5” is changed to “10”; add “slightly” before “increases”; add “roughness” before “element”.

Line 10-11: the sentence “The influence of … (Fig. 5e)” is changed to “and particle rebound may reduce surface collection effect. As shown in Fig. 5e, the influence of R on particle deposition is not obvious. Only for coarse particles larger than 5 μm, the deposition velocity slightly decreases with increasing R.”

Line 13: “used” is changed to “which is also employed”.

Line 14: “dust” is changed to “particle”.

Line 15: add “increasing” after “with”; “of all sizes” is changed to “smaller than 50 μm”

Line 19-21: delete the sentence “The influence of … in Fig. 6.”.

Line 23: “dust” is changed to “particle”; add “by adequate treatment of the gravitational settling effect and” after “proposed”.

Line 26: “dust” is changed to “particle”.

Page 8080

Line 6, 16, 24, 28: all "dust" are changed to "particle".

Line 10: add "and" after "sufficiently".

Line 20: add "significantly" before "influences"; "of all size" is changed to "smaller than 10 μm"; add "roughness" before "element".

Line 22: "of all size" is changed to "smaller than 50 μm"

Page 8081

Line 2: "2012" is changed to "2006".

Line 3, 6, 7, 9: all "dust" are changed to "particle".

Line 8: add "roughness" before "element".

Line 10: add "side area of the roughness" before "elements".

Line 11: "element collection efficiency" is changed to "collection efficiency of roughness element".

Line 12: "elements" is changed to "obstacles".

Page 8082

Line 28: "John … 2012" is changed to "second edition, John Wiley & Sons, Inc., Hoboken, 900–929, 2006".

Line 29: "2 edn … 2008" is changed to "second edition, Springer-Verlag, Berlin, 2008".

Line 14: "2010" is changed to "2012".

Page 8083

Line 12: "2014 (companion paper)" is changed to "Atmos. Chem. Phys., 14, doi:10.5194/acp-14-8869-2014, 8869–8882, 2014".

Page 8085

In the caption, "dust" is changed to "particle".

The equations of r_a are changed to

$r_a(z) = \frac{Sc_T}{\kappa \cdot u_*} \ln\left(\frac{z - z_d}{h_c - z_d}\right)$ for rough surface and $r_a(z) = \frac{B_1 \cdot Sc_T}{\kappa \cdot u_*} \cdot \ln\left(\frac{z}{z_0}\right)$ for smooth surface.

Page 8086

"Tree" is changed to "Plant".

The parameter of sand surface, h_c is changed from 0.2 to 0.1; d_c is changed from 0.1 to 0.2.

Page 8087

All "Dust" are changed to "particle".

Page 8089

Fig. 1, is changed to

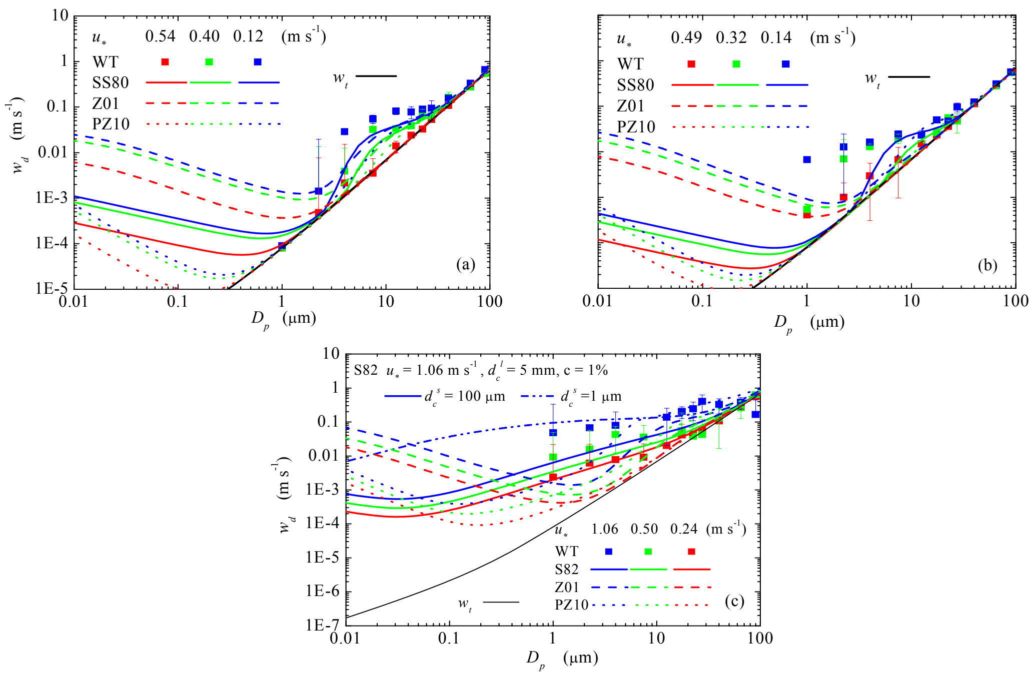


Fig. 1: Comparison of deposition velocity predicted by the SS80, S82, Z01 and PZ10 schemes (lines) with the wind-tunnel measurements (dots) over three different surfaces. (a) Sticky wood; (b) Sand; (c) Plant. The wind field parameters of the schemes are consistent with the relevant wind-tunnel experiments.

Page 8091

In the caption of Fig. 3, all "dust" are changed to "particle".

Page 8092

In the caption of Fig. 4, “symbols” is changed to “dots”; “tree” is changed to “plant”.

Page 8093

Some modifications are carried out for Fig. 5c and 5d.

Page 8094

Fig. 6 is deleted.