

# Response to Reviewer 1

**Manuscript title:** *Non-monotonic response of net dust deposition kinetics to low wind speeds*

**Manuscript No.:** egusphere-2026-261

Dear Reviewer,

We sincerely thank you for your careful reading of the manuscript and for your constructive comments. Your central observations concerning secondary re-entrainment, collector representativeness, wind-profile characterization, and the interpretation of the fitted kinetic parameters led us to substantially revise the manuscript. In particular, we now distinguish gross downward deposition from the experimentally measured cumulative tray-retained net accumulation; explicitly document the unsuppressed rebound/re-entrainment processes; correct and fully reanalyse the wind-profile data; provide the monitor position and the available concentration time series; add an auxiliary threshold-screening test; and revise the interpretation, limitations, figures, equations, and terminology throughout.

**Note on page and line references:**

The page and line numbers cited in the author comments posted during the interactive discussion referred to the revised manuscript before it was transferred to the official Copernicus Word template. Reformatting changed the pagination and line numbering but did not alter the scientific content of the revisions. The page and line references below have therefore been updated to correspond to the final revised manuscript submitted for peer-review completion.

## General assessment

### Reviewer comment:

Dry deposition of atmospheric dust is a key process controlling the atmospheric lifetime of dust, source-region removal, and long-range transport. This is particularly important in the post-dust-storm low-wind phase, where its behavior directly affects the accuracy of global dust cycle simulations and climate radiative forcing estimates. For a long time, dust deposition processes under low wind speeds have remained difficult to quantify accurately, and most models adopt monotonically wind-speed-dependent parameterization schemes. This study utilized a closed-circuit recirculating wind tunnel and employed a two-stage experimental protocol (high-wind loading followed by low-wind deposition). Combined with laser diffraction particle size analysis and a first-order exponential kinetic model, the study systematically quantified the deposition kinetic parameters ( $a$ ,  $k$ ,  $\tau$ ,  $J_0$ ) for different particle sizes under wind speeds of 0–6 m s<sup>-1</sup>. The results revealed a non-monotonic response in the net deposition of fine-to-medium particles, with a peak at approximately 2 m s<sup>-1</sup>, leading to the proposal of a potential “low-wind window”. This work provides important process-based experimental constraints for improving the parameterization of dry deposition in atmospheric models.

The manuscript is generally well written and logically structured. The experimental design is systematic, and the kinetic model fits the data well, providing valuable measured data and physical interpretations for low-wind dust deposition research. However, I have the following suggestions for improvement regarding the experimental design, particle physics processes, and the physical interpretation of net deposition.

### Response:

We appreciate the reviewer’s positive assessment and the clear identification of the issues that required further qualification. The revision retains the central empirical result: a size-dependent, non-monotonic response of the mass stably retained by the trays, but narrows the claim to the quantity that was actually measured. The title now refers to “net dust deposition kinetics,” and the Abstract defines the observations as cumulative retained mass and the fitted quantities as an asymptotic retained mass, an effective net-accumulation rate coefficient, a characteristic time scale, and an initial net accumulation flux. Throughout the manuscript, “dry deposition” is retained when referring to the established atmospheric process or existing parameterizations, whereas the experimental observations are described as “tray-retained net accumulation,” “effective surface retention,” or “net accumulation flux.” We also make clear that the measurements provide benchmark behaviour for coupled deposition–retention–re-entrainment treatments rather than a direct measurement of gross deposition velocity.

## Major Comments

### Major Comment 1: Separation of deposition and secondary re-entrainment

#### Reviewer comment:

In practical scenarios, the dry deposition of dust is almost always accompanied by secondary resuspension. For this reason, previous studies on dust dry deposition mechanisms, especially experimental research, have generally suppressed or eliminated the influence of secondary resuspension to investigate the pure mechanism of dust dry deposition. Since no measures were adopted in this experiment to inhibit secondary resuspension, the final results reflect the combined effect of two physical processes: deposition and re-entrainment. The non-monotonic variation of dust dry deposition with wind velocity observed in this study arises from the competition between these two mechanisms, which is not inconsistent with existing physical models of dust dry deposition. It is suggested that the author revise the relevant statements to avoid misleading readers.

#### Response:

We agree with this interpretation and have revised the manuscript accordingly. No water, beads, grease, adhesive coating, or other retention medium was present in the collection trays. The recorded tray mass therefore cannot be interpreted as gross downward deposition alone. We now define it explicitly as cumulative tray-retained net accumulation, which integrates particle arrival at the tray surface and subsequent losses through rebound, local re-entrainment, and removal from the tray. The original soil source was completely covered with steel plates before the low-wind phase, preventing continued direct emission or re-erosion from that source; however, the steel cover did not suppress particle loss from the trays or deposition onto other tunnel surfaces.

The kinetic notation has been revised to match this measurement. The fitted parameter  $a$  is now the asymptotic retained mass,  $k$  is the effective net-accumulation rate coefficient,  $\tau$  is the corresponding characteristic time, and  $J_0 = ak$  is the initial net accumulation flux. We removed the preprint's derivation and reporting of an "equivalent deposition velocity," because the experiment did not measure a vertical concentration gradient or a gross downward particle flux. The manuscript now states explicitly that  $M(t)$ ,  $a$ , and  $J_0$  are tray-based net-accumulation metrics and are not normalized by the time-varying concentration.

We also revised the conceptual comparison with model parameterizations. The non-decreasing reference curve is now introduced only as a simplified deposition-only expectation, in which deposition velocity increases or remains unchanged with wind or friction velocity while resuspension is treated separately. Departures from this reference are used as a diagnostic measure of the combined net-retention response; they are not presented as evidence that established deposition physics is internally inconsistent. The Discussion now interprets the  $2 \text{ m s}^{-1}$  maximum as the outcome of favourable particle delivery and stable retention under the present collector configuration, whereas the smaller retained masses at  $4\text{--}6 \text{ m s}^{-1}$  reflect increasing persistence in suspension, horizontal redistribution, reduced stable retention. At  $6 \text{ m s}^{-1}$ , local re-entrainment may also have contributed because this wind speed was within the apparent mobilization threshold range identified in the auxiliary test. The revised Implications section therefore recommends coupling conventional deposition with wind- and size-dependent stable retention and a surface-specific, threshold-dependent re-entrainment term.

Finally, the Abstract, Results, Discussion, Conclusions, figure captions, and terminology were revised to avoid presenting the response as pure dry deposition or a direct deposition-velocity measurement. The main empirical finding is now framed as a "low-wind window" in net retention under the present experimental configuration.

*Location in the final revised manuscript: Title (p. 1, lines 1–2); Abstract (p. 1, lines 15–26); Introduction (pp. 2–4, lines 53–104); Methods (pp. 5–8, lines 127–220); Results (pp. 9–13, lines 223–333); Discussion (pp. 13–17, lines 334–465); and Conclusions (p. 18, lines 466–486).*

## Major Comment 2: Rationality and representativeness of the tray measurements

### Reviewer comment:

Furthermore, it should be noted that since the experimental results incorporate the effect of secondary resuspension, which is closely correlated with surface properties, the shape and size of the trays used in the experiments will exert a direct impact on the findings. The author is advised to conduct in-depth analysis and discussion on the rationality and representativeness of the experimental results.

### Response:

We agree that collector geometry and surface properties are integral to the measured net-retention response. We have therefore expanded both the Methods and the limitations discussion. Each collector was a cylindrical acrylic tray with a radius of 10 cm (20 cm diameter), a 3 cm rim, and a smooth, untreated collection surface. Twenty-five trays were installed at predefined floor positions at the start of every low-wind run. Five trays were assigned to each sampling time and removed after 30, 60, 90, 120, or 180 min. The same initial positions, time-specific assignments, and retrieval sequence were used for every wind-speed treatment. Thus, the tray configuration at a given sampling time was matched among treatments, although the number of trays progressively decreased within each run.

The wind profiles were measured with the complete initial array of 25 trays installed, so they include the collective aerodynamic influence of the array at the profile-measurement station. At the same time, the revised manuscript now states explicitly that the available profile measurements do not resolve flow separation, recirculation, or wakes immediately adjacent to individual 3 cm rims, nor changes in the local flow field caused by progressive tray removal. We removed the comparison between the fitted roughness length and bare sand and no longer report independently fitted aerodynamic roughness length or displacement height, because the tray array is a non-uniform roughness field and the vertical resolution is insufficient for robust simultaneous estimation of these quantities.

The revised limitations section now distinguishes internal comparability from external representativeness. The identical collector and matched sampling protocol support comparisons among the four wind-speed treatments. However, the absolute retained masses and fitted parameters are configuration-specific: the 20 cm diameter, rim height, smooth acrylic surface, local wakes, particle rebound, and progressive tray removal may all affect capture and subsequent loss. The results should therefore not be transferred directly to natural soil, vegetation, or collectors of different geometry without further calibration. We now present the measurements as controlled, surface-specific constraints on effective near-surface retention rather than universal deposition efficiencies.

*Location in the final revised manuscript: p. 6, lines 134–144 and 155–160; p. 7, lines 161–173; and p. 17, lines 446–452.*

## Specific Comments

### 1. Definitions of $u_*$ and $\delta$ in Figure 1

#### Reviewer comment:

It is suggested to define  $u_*$  and delta in the caption of Figure 1 to help readers quickly understand the information presented.

#### Response:

We thank the reviewer for this suggestion. The caption of Fig. 1b now identifies  $u_*$  as the friction velocity estimated from the slope of a log-linear near-surface wind-profile regression and identifies  $\delta$  as the boundary-layer thickness obtained from the 99% upper-profile velocity criterion. The Methods provide the complete definitions:  $U(z) = A \ln(z/z_{\text{ref}}) + B$ ,  $u_* = \kappa A$  with  $\kappa = 0.4$  and  $z_{\text{ref}} = 1$  m;  $\delta$  is the first height at which the shape-preserving interpolated profile reaches  $0.99U_\infty$ , with  $U_\infty$  defined as the mean velocity at 0.80, 1.20, and 1.60 m. The corresponding  $R^2$  values are shown directly in Fig. 1b.

*Location in the final revised manuscript: p. 5, lines 120–125; and pp. 6–7, lines 155–168.*

### 2. Wind-profile measuring position and consistency of the tray layout

#### Reviewer comment:

It is recommended to specify the measuring position for the wind velocity profile.

The trays, with a height of 3 cm, are obviously higher than the surface roughness length  $z_0$  provided in the paper. Thus, the trays act as surface roughness elements under experimental conditions and exert a notable influence on the near-ground wind field. Given that the development of a turbulent boundary layer requires a certain fetch length, the measuring location of the wind velocity profile should be clearly stated. In addition, it needs to be clarified whether the trays were reset after each test run, so as to ensure consistent layout of the trays across all experimental tests.

#### Response:

We really thank the reviewer for identifying this issue. Wind profiles were measured at nominal speeds of 2, 4, 6, and 8 m s<sup>-1</sup>. During preparation of the wind-profile dataset for the original analysis, however, the profiles measured at 4, 6, and 8 m s<sup>-1</sup> were inadvertently selected and presented as corresponding to the 2, 4, and 6 m s<sup>-1</sup> treatments. We sincerely apologize for this oversight. We have now reanalyzed the wind-profile data using the correct profiles measured at 2, 4, and 6 m s<sup>-1</sup>, recalculated the associated profile-derived parameters, and replaced Fig. 1b accordingly. This error was confined to the wind-profile analysis. The deposited masses, particle-size distributions, and kinetic parameters were determined independently from the tray samples and are therefore unchanged, including their wind-speed ranking.

The revised Methods now specify that profiles were measured on the longitudinal centreline, 9 m downstream of the test-section entrance and immediately downstream of the collection-tray array. The complete initial array of 25 trays was present during profile measurement. Trays were positioned at predetermined locations with 20 cm spacing, and the initial layout was restored before each run. During an actual deposition run, however, five trays were removed at each scheduled sampling time. We now state this progression explicitly and clarify that the same time-specific tray assignments and removal sequence were used across treatments, ensuring a matched configuration at each sampling time.

The wind-profile analysis was also revised to avoid treating the array as a uniform bare-sand roughness surface. Apparent friction velocity was estimated from a two-parameter regression,  $U(z) = A \ln(z/z_{\text{ref}}) + B$ , over the common height range 0.05–0.40 m. This supplies four measurement points above the 0.03 m rims for all three treatments. With  $\kappa$  and  $z_{\text{ref}}$  fixed,  $u_*$  is calculated from  $\kappa A$ ; roughness length and displacement height are not fitted independently. The corrected apparent friction velocities are 0.063, 0.089, and 0.154 m s<sup>-1</sup> at nominal speeds of 2, 4, and 6 m s<sup>-1</sup>, with  $R^2 = 0.921, 0.933, \text{ and } 0.883$ ,

respectively. The corresponding operational boundary-layer thicknesses are approximately 0.88, 0.73, and 0.48 m.

All derived quantities were recalculated. The nominal near-wall viscous length scale is now approximately 1.20, 0.85, and 0.49 mm, and the Rouse number for 2–10  $\mu\text{m}$  particles ranges from approximately 0.006 to 0.32. The manuscript also states that the profiles represent profile-scale mean flow under the complete initial tray array but do not resolve local wakes around individual rims or flow changes caused by tray removal.

*Location in the final revised manuscript: p. 5, lines 120–125; p. 6, lines 134–141 and 155–160; p. 7, lines 161–173; p. 14, lines 339–346; and p. 17, lines 446–452.*

### 3. Tray dimensions and absence of a resuspension-suppression medium

#### Reviewer comment:

With a diameter of 10 cm, the trays are prone to particle resuspension. Please clarify whether small beads or water were placed at the bottom of the trays to suppress resuspension.

#### Response:

We thank the reviewer for raising this important point. We clarify that 10 cm is the radius, not the diameter; each cylindrical acrylic tray had a diameter of 20 cm and a rim height of 3 cm. No water, glass beads, grease, adhesive coating, or other material was placed in the trays. We added this information explicitly to Sect. 2.2.

This clarification also prompted a substantive change in interpretation. Because rebound and re-entrainment were not suppressed, the collected mass is now defined as cumulative tray-retained net accumulation rather than gross deposition. The fitted  $a$ ,  $k$ ,  $\tau$ , and  $J_0$  parameters are described as effective net-retention descriptors. We also added a limitation stating in Sect. 4.4 that tray diameter, rim height, the smooth acrylic surface, local flow separation, particle rebound, and progressive tray removal can influence the absolute retained mass. The matched collector type and sampling sequence allow controlled comparison among wind speeds, but the absolute values are specific to the present configuration.

*Location in the final revised manuscript: p. 6, lines 134–144; p. 8, lines 197–205; and p. 17, lines 446–452.*

### 4. Dust-concentration monitor position and absence of vertical concentration gradients

#### Reviewer comment:

Please specify the installation position and height of the dust concentration monitor. Given that the gradient of dust concentration is key environmental data for this experiment. Why relevant measurements were not conducted?

#### Response:

We thank the reviewer for this constructive suggestion. The sampling inlet of the real-time concentration monitor was located on the longitudinal centreline of the test section, 7.5 m downstream of the test-section entrance and 1.0 m above the tunnel floor. These details have now been added to Sect. 2.2.

We agree that multi-height concentration measurements would be required to characterize a vertical concentration gradient and, together with appropriate turbulence or direct-flux measurements, would be needed to resolve downward and upward particle fluxes and derive a deposition velocity. The original experiment was designed around time-dependent mass retained by the tray array; the single fixed-point monitor was installed as a quality-control instrument to compare the initial suspended loading among runs and to follow the persistence of airborne dust during the low-wind phase. A vertical concentration profile was not part of the original experimental design and cannot be reconstructed retrospectively. We now state this limitation directly and do not use the concentration record to infer a vertical flux, re-entrainment flux,

or deposition velocity. Consistent with this limitation, the “equivalent deposition velocity” derivation in the manuscript was removed.

To make full use of the available data, we added the complete normalized 180 min concentration time series as Fig. S2 and summary values as Table S1. The recorded initial concentrations ( $C_0$ ) were 191.35, 178.20, 186.36, and 189.44  $\text{mg m}^{-3}$  at 0, 2, 4, and 6  $\text{m s}^{-1}$ , respectively (range 178.2–191.4  $\text{mg m}^{-3}$ ; coefficient of variation 3.1%). A sensitivity analysis rescaled retained mass by  $C_{\text{ref}}/C_0$  and confirmed that the principal wind-speed ranking was unchanged. The mean concentration during the final 20 min was 5.32%, 0.15%, 9.27%, and 4.24% of  $C_0$  at 0, 2, 4, and 6  $\text{m s}^{-1}$ . Thus, the 2  $\text{m s}^{-1}$  treatment had the lowest late-stage residual concentration, whereas the 4 and 6  $\text{m s}^{-1}$  treatments retained more airborne dust, especially at 4  $\text{m s}^{-1}$ . These data support initial-condition comparability and the interpretation of airborne-dust persistence.

*Location in the final revised manuscript: p. 6, lines 145–153; p. 8, lines 197–205; and p. 10, lines 258–265. Supplement, Table S1 and Fig. S2.*

## 5. Number of wind-profile points, fitted parameters, and $R^2$

### Reviewer comment:

Line 171: When the boundary layer thickness is 0.48 m, there appear to be only three valid wind velocity measurement points. Since the adopted fitting function contains three unknown parameters, the fitting results are not meaningful. Please provide the coefficient of determination for each wind velocity profile fitting.

### Response:

We agree that the original three-parameter fit was not adequately constrained. We therefore replaced it rather than retaining the original formulation. As noted in our response to Comment 2, we also identified and corrected the profile column-indexing error before reanalysis.

The revised analysis uses  $U(z) = A \ln(z/z_{\text{ref}}) + B$  with fixed  $z_{\text{ref}} = 1$  m and  $\kappa = 0.4$ , followed by  $u_* = \kappa A$ . Only  $A$  and  $B$  are fitted. A common interval of 0.05–0.40 m was used at all wind speeds, providing four points above the 0.03 m tray rims, including for the profile with  $\delta \approx 0.48$  m. Aerodynamic roughness length and displacement height are no longer independently estimated or reported. The corrected apparent friction velocities are 0.063, 0.089, and 0.154  $\text{m s}^{-1}$  for 2, 4, and 6  $\text{m s}^{-1}$ , and their coefficients of determination are  $R^2 = 0.921$ , 0.933, and 0.883, respectively. These  $R^2$  values are now reported both in Sect. 2.3 and directly in Fig. 1b.

Boundary-layer thickness was calculated independently of the friction-velocity regression. For each profile,  $U_\infty$  was defined as the mean wind speed measured at 0.80, 1.20, and 1.60 m. Minor non-monotonic reversals across the eight measured heights were adjusted using isotonic regression, after which shape-preserving interpolation was used to identify the first height at which the profile reached  $0.99 U_\infty$ . This yielded  $\delta \approx 0.88$ , 0.73, and 0.48 m for the 2, 4, and 6  $\text{m s}^{-1}$  profiles, respectively. This suggestion has helped us improve the clarity of the manuscript.

*Location in the final revised manuscript: p. 5, lines 120–125; pp. 6–7, lines 155–173; and p. 14, lines 339–346.*

## 6. Equation numbering

### Reviewer comment:

It is recommended to number all equations for ease of citation.

### Response:

Thank you for this helpful comment. We have numbered all displayed equations used in the analysis and updated the text to refer to them consistently. These are the log-linear wind-profile relationship [Eq.

(1)], the apparent-friction-velocity calculation [Eq. (2)], the first-order accumulation model [Eq. (3)], the initial net accumulation flux [Eq. (4)], and the ratio to the non-decreasing benchmark [Eq. (5)].

*Location in the final revised manuscript: p. 6, lines 155–160 and Eqs. (1)–(2); and p. 8, lines 197–220 and Eqs. (3)–(5).*

## 7. Scope of the monotonic deposition–wind relationship

### Reviewer comment:

Line 230: Generally, a monotonic relationship between deposition velocity and wind velocity is only recognized when solely considering dry deposition and ignoring the effect of resuspension.

### Response:

We agree and have revised the text so that this distinction is explicit. The old manuscript stated too broadly that dry-deposition parameterizations assume a strictly monotonic relationship. The revised manuscript now states that many schemes describe deposition velocity for a fixed particle size and surface as increasing or remaining unchanged with wind speed or friction velocity while treating resuspension separately. The isotonic reference is therefore described as a non-decreasing, simplified deposition-only expectation.

The observed ratio  $R(U) = J_0(U)/J_{0, \text{mono}}(U)$  now quantifies only how the measured tray-retained net accumulation departs from that reference. It is not interpreted as showing that a deposition-only model is physically inconsistent; rather, it illustrates the additional influence of stable retention and particle loss when deposition, rebound, and re-entrainment act together. Correspondingly, the revised Discussion recommends a coupled treatment containing conventional deposition, wind- and size-dependent retention, and a surface-specific re-entrainment term.

*Location in the final revised manuscript: pp. 2–3, lines 53–61 and 75–79; p. 8, lines 214–220; and pp. 15–16, lines 381–423.*

## 8. Critical wind speed for dust mobilization

### Reviewer comment:

The critical wind velocity for dust emission from the surface can be readily obtained. Please discuss its relationship with the three wind speeds adopted in the experiment, as this will effectively support the analysis of resuspension effects in the paper.

### Response:

We agree with the reviewer's suggestion and have incorporated it into the revised manuscript. We conducted an auxiliary threshold-screening test using the same dust in the same wind tunnel. Inverted glass dishes bearing double-sided adhesive tape were positioned at the dust tray edge to capture mobilized particles. The upper surfaces of the inverted dishes were approximately level with the top of the dust tray. Wind speed was increased stepwise, and three replicate collectors were used at each speed. Captured mass remained low from 5.59 to 5.87 m s<sup>-1</sup> and increased sharply at 6.01 m s<sup>-1</sup>, defining an apparent critical range of 5.87–6.01 m s<sup>-1</sup> for marked particle mobilization under this tray configuration. We use the term “apparent” because the result is configuration-specific and is not presented as a universal threshold for the source soil.

This screening clarifies the interpretation of the deposition treatments. The 2 and 4 m s<sup>-1</sup> treatments were below the apparent critical range, whereas 6 m s<sup>-1</sup> was close to or within it. Rebound and local re-entrainment are therefore physically plausible contributors at 6 m s<sup>-1</sup>. By contrast, the reduced tray-retained mass at 4 m s<sup>-1</sup> should not be attributed primarily to active threshold exceedance. Its combination of lower retained mass and the highest late-stage airborne concentration is more consistent with continued suspension, recirculation, horizontal redistribution, and reduced stable retention. However, because vertical fluxes were not measured, the relative magnitude of these mechanisms cannot be partitioned quantitatively.

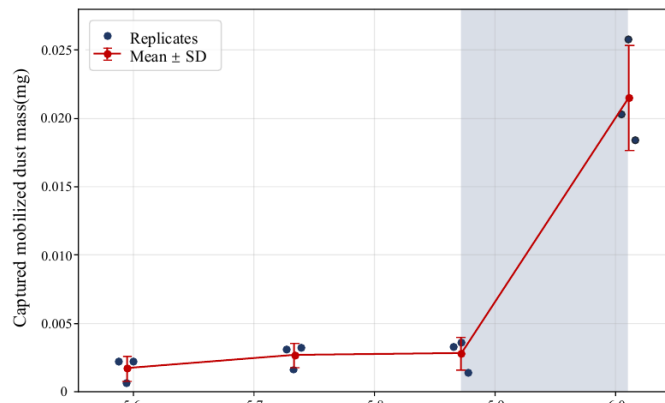


Figure S1. Auxiliary threshold-screening result. Captured mobilized mass increased sharply between 5.87 and 6.01  $\text{m s}^{-1}$ .



Photograph of the auxiliary threshold-screening arrangement used to capture mobilized particles at the tray edge.

*Location in the final revised manuscript: p. 10, lines 253–254; and pp. 14–15, lines 363–371. Additional information is provided in Fig. S1 of the Supplement.*

## 9. Closing parenthesis in the y-axis label of Figure 3b

### Reviewer comment:

The y-axis label of Figure 3b is missing a closing parenthesis.

### Response:

Corrected. The y-axis label in Fig. 3b now reads “ $J_0$  ( $\text{mg m}^{-2} \text{h}^{-1}$ )”, including the closing parenthesis, and the associated caption consistently defines  $J_0$  as the initial net accumulation flux.

*Location in the final revised manuscript: p. 11, Fig. 3b and lines 267–271.*

## 10. Italic formatting of $a$

### Reviewer comment:

Line 274: Please set  $a$  in italic.

### Response:

Corrected. The parameter  $a$  is now italicized at its definition and throughout the equations, figure captions, Results, Discussion, Conclusions, and supplementary tables. We also checked the formatting of the other mathematical variables ( $k$ ,  $\tau$ ,  $J_0$ ,  $U$ ,  $U_{\text{opt}}$ ,  $C_0$ , and  $D_{50}$ ) for consistency.

*Location in the final revised manuscript: p. 1, lines 20–24; p. 8, lines 197–220; and pp. 9–11, lines 229–285. Additional results are provided in Tables S2–S4 of the Supplement.*

## 11. Capitalization and consistency of “Peak”

### Reviewer comment:

In lines 329–330, “peak” should be corrected to “Peak”. Please check the entire manuscript and ensure consistent formatting and capitalization of related symbols and terms for better readability.

### Response:

Corrected. The modal-diameter annotations in Fig. 4 now consistently use “Peak” with an initial capital, and the caption explicitly defines the label as the modal diameter. We also reviewed the figure labels, captions, mathematical symbols, units, and capitalization of the related terms across the manuscript and Supplement for consistency.

*Location in the final revised manuscript: p. 12, Fig. 4 and lines 287–293.*

## 12. Consistency of the $k$ value and the text describing its maximum

### Reviewer comment:

In Figure 3(a), the  $k$  value for  $\text{PM}_{2.5}$  at  $4 \text{ m s}^{-1}$  is shown as 4.03, whereas the text describes that  $k$  reaches or approaches its maximum at  $2 \text{ m s}^{-1}$ . Please check the data for consistency with the description and make corrections or provide clarification.

### Response:

We thank the reviewer for identifying this inconsistency. We rechecked the fitted parameters against the source results and confirmed that the value shown in Fig. 3a was correct; the description in the old manuscript was inaccurate. For  $\text{PM}_{2.5}$ ,  $k$  is 0.24, 3.03, 4.03, and  $3.61 \text{ h}^{-1}$  at 0, 2, 4, and  $6 \text{ m s}^{-1}$ , respectively, so its maximum occurs at  $4 \text{ m s}^{-1}$ . The revised text now gives the size-specific maxima correctly: the largest  $k$  occurs at  $2 \text{ m s}^{-1}$  for  $\text{PM}_{10}$ , at  $4 \text{ m s}^{-1}$  for  $\text{PM}_{2.5}$  and  $\text{PM}_{30}$ – $\text{PM}_{63}$ , and at  $6 \text{ m s}^{-1}$  for  $\text{PM}_{20}$ .

We also clarified the distinction between  $k$  and  $J_0$ . The coefficient  $k$  measures how rapidly the fitted curve approaches its asymptotic retained mass, whereas  $J_0 = ak$  is the initial net accumulation flux. Consequently, the wind speed that maximizes  $k$  need not maximize  $J_0$ . Among the tested speeds,  $J_0$  is highest at  $2 \text{ m s}^{-1}$  for  $\text{PM}_{2.5}$ – $\text{PM}_{30}$  and at  $4 \text{ m s}^{-1}$  for  $\text{PM}_{40}$  and  $\text{PM}_{63}$ . The Abstract, Fig. 3 caption, and Results now report these rankings explicitly. No fitted values were changed in response to this comment; the correction was to the explanatory text.

*Location in the final revised manuscript: p. 1, lines 20–24; and p. 11, lines 267–285. Additional results are provided in Table S2 of the Supplement.*

**We again thank the reviewer for all these comments. They substantially improved the precision of the experimental description and ensured that the conclusions are aligned with the measured quantity and the limitations of the collector-based design.**

## Response to Reviewer 2

**Manuscript:** *Non-monotonic response of net dust deposition kinetics to low wind speeds*

**Manuscript No.:** egusphere-2026-261

Dear Reviewer,

We sincerely thank you for your careful reading of the manuscript, your positive assessment of the experimental framework, and your constructive comments. Your questions led us to clarify the distinction between gross dry deposition and the cumulative net mass retained by the trays; document the steel-plate isolation of the original dust source; use the available concentration records to test initial-condition comparability and describe suspended-dust persistence; expand the treatment of tunnel-wall losses, recirculation, dust type, moisture, and particle shape; fully revise the wind-profile analysis; correct the median-diameter calculation and the temporal interpretation of Fig. 4; and add a detailed discussion of how the kinetic descriptors can inform numerical parameterizations. The line numbers below refer to the current clean revised manuscript supplied with this response. For clarity, we have numbered the previously unnumbered soil-type comment as Comment 4 and renumbered the subsequent comments consecutively.

### Note on page and line references:

The page and line numbers cited in the author comments posted during the interactive discussion referred to the revised manuscript before it was transferred to the official Copernicus Word template. Reformatting changed the pagination and line numbering but did not alter the scientific content of the revisions. The page and line references below have therefore been updated to correspond to the final revised manuscript submitted for peer-review completion.

### General assessment

#### Reviewer comment:

The present study investigates the quantification of size-resolved dust deposition kinetics in a large closed-circuit wind tunnel. Overall, the manuscript is well written, well organized, and strongly motivated, addressing a genuine and insufficiently constrained problem: the behavior of dry dust deposition under weak, post-storm background wind conditions, where existing parameterizations show large discrepancies and typically assume a monotonic response. The experimental facility is impressive, the kinetic framework provides a sensible and concise approach for summarizing the experimental runs, and the size-resolved analysis represents a notable strength of the study. The finding that deposition rates at  $2 \text{ m s}^{-1}$  exceed those observed at 0, 4, and  $6 \text{ m s}^{-1}$  for fine- to medium-sized particles is particularly interesting and may prove valuable for the development and improvement of deposition parameterizations. I have only a few minor comments that should be addressed by the authors before the manuscript is considered for publication.

#### Response:

We appreciate the reviewer's encouraging assessment. In response to the detailed comments, we retained the central empirical finding but tightened its definition and scope. The experiment measures cumulative mass remaining in untreated floor trays after particle arrival, rebound, local re-entrainment, and removal have all acted; it does not isolate gross downward deposition or directly determine a deposition velocity. Accordingly, the revised title and manuscript describe the experimental quantity as cumulative tray-retained net accumulation. The fitted parameters are now defined as the asymptotic retained mass  $a$ , effective net-accumulation rate coefficient  $k$ , characteristic time  $\tau = 1/k$ , and initial net accumulation flux  $J_0 = ak$ . We removed the old manuscript's equivalent deposition velocity calculation, added the concentration-based sensitivity analysis and the missing experimental details, and reframed the modelling implication as a need to couple conventional deposition with stable retention and re-entrainment.

## Specific Comments

### Comment 1: Isolation of the source bed and interpretation of reduced retention at 4–6 m s<sup>-1</sup>

#### Reviewer comment:

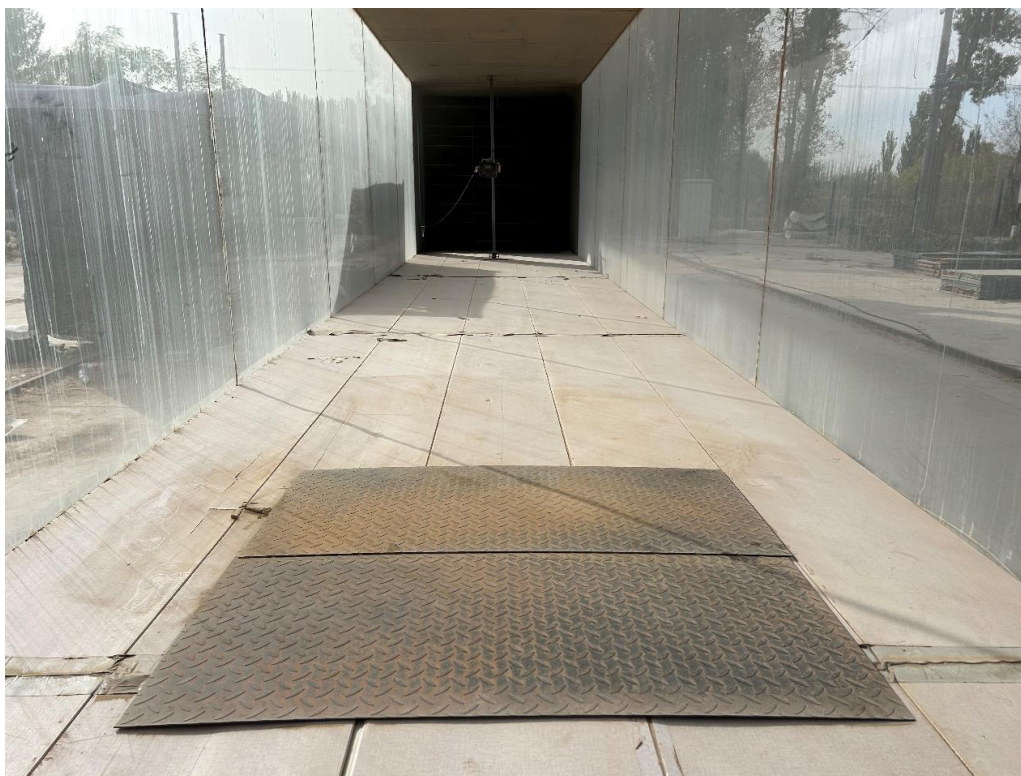
Dust is generated through erosion of the soil source at a wind speed of 14 m s<sup>-1</sup>, while the source bed remains present on the tunnel floor during the subsequent deposition phases conducted at 2, 4, and 6 m s<sup>-1</sup>. Under the higher deposition wind speeds, the source bed may continue to emit particles or undergo re-erosion. Consequently, the observed suppression of net deposition at 4–6 m s<sup>-1</sup> may partly reflect ongoing source emissions rather than the re-entrainment of previously deposited particles. The manuscript attributes this behavior to “resuspension and horizontal export”; however, it does not clearly distinguish between continued emissions from the source bed and the re-entrainment of deposited material. Could the authors please comment on the relative importance of these two processes and discuss how they may affect the interpretation of the results?

#### Response:

We thank the reviewer for identifying an important procedural detail that was omitted from the manuscript. Immediately after the approximately 5 min loading phase at 14 m s<sup>-1</sup> and before the target low-wind condition was established, the exposed soil source bed was completely covered with steel plates. The plates remained in place throughout the 0, 2, 4, or 6 m s<sup>-1</sup> accumulation period. Therefore, continued direct emission or re-erosion from the original source bed was deliberately prevented and should have been negligible during the low-wind measurements. We have added this sequence explicitly to Sect. 2.2.

This source isolation does not eliminate all particle-removal or redistribution processes. The collection trays contained no water, beads, grease, adhesive, or other retention medium. Consequently, particles already suspended in the tunnel could arrive at a tray and subsequently rebound or be locally re-entrained, while other particles could remain suspended, recirculate through the closed loop, move horizontally past the collection area, or deposit on unmeasured internal surfaces. We therefore define the measured quantity as cumulative tray-retained net accumulation, not total deposition.

We also revised the process interpretation to separate the 4 and 6 m s<sup>-1</sup> cases. An auxiliary tray-scale screening test identified an apparent critical wind-speed range of 5.87–6.01 m s<sup>-1</sup> for marked particle mobilization. The 6 m s<sup>-1</sup> treatment lies close to this range, so rebound and local re-entrainment from deposited material are physically plausible contributors to its reduced retention. In contrast, 4 m s<sup>-1</sup> is well below the apparent mobilization range. At 4 m s<sup>-1</sup>, the combination of lower tray-retained mass and the highest late-stage residual airborne concentration is more consistent with continued suspension, recirculation, horizontal redistribution, and reduced transfer into stable retention than with new emission from the covered source or threshold-driven re-entrainment alone. Because the experiment did not measure vertical fluxes or separately quantify every internal surface reservoir, we cannot assign numerical fractions to these pathways; the revision now states this limitation rather than attributing the response to a single process.



*Photograph of the test section after the original soil source bed was covered with steel plates. The plates remained in place throughout the low-wind accumulation phase.*

*Location in the final revised manuscript: pp. 5–6, lines 127–144; p. 10, lines 253–265; and pp. 14–15, lines 363–371. Additional information is provided in Fig. S1 of the Supplement.*

## Comment 2: Concentration normalization and interpretation of the kinetic quantities

### Reviewer comment:

A deposition velocity is defined as  $V_d = J/C$ . However, the quantities  $M(t)$ ,  $a$ , and  $J_0$  appear to be reported as absolute values without dividing by the suspended concentration  $C(t)$ , which both decays during a run and may differ between runs. The manuscript states that  $C_0$  was recorded “to calibrate the initial-condition comparability across wind-speed treatments” (Lines 155–157) but does not state whether the fitted quantities are normalized by  $C_0$ . Could the authors please clarify this point and discuss its implications for the interpretation and comparison of the reported deposition kinetics?

### Response:

We thank the reviewer for this kind reminder. We agree that the tray-derived quantities must not be confused with a deposition velocity strictly defined by  $V_d = J/C$ . The revised manuscript now states explicitly that  $M(t)$  is the measured areal cumulative tray-retained mass;  $a$  is the fitted asymptotic retained mass;  $k$  is the effective rate coefficient governing the approach to that fitted asymptote;  $\tau = 1/k$  is the characteristic adjustment time; and  $J_0 = ak$  is the initial slope of the fitted retained-mass curve. The units are  $\text{mg m}^{-2}$  for  $M$  and  $a$ ,  $\text{h}^{-1}$  for  $k$ ,  $\text{h}$  for  $\tau$ , and  $\text{mg m}^{-2} \text{h}^{-1}$  for  $J_0$ .

None of these primary fitted quantities was divided by the time-varying airborne concentration  $C(t)$ . In particular,  $J_0$  is an initial net accumulation flux into stable tray retention, not a concentration-normalized dry-deposition velocity. A defensible deposition velocity would require concentration at the relevant flux-reference height and an independently resolved downward surface flux or vertical concentration/flux structure. The experiment had only one fixed-point concentration monitor and did not measure a vertical concentration profile. For this reason, we removed the equivalent-deposition-velocity derivation and the associated  $V_d$ -based interpretation in the revised manuscript.

The concentration data serve two more limited but useful purposes. First, they establish that the low-wind runs began with comparable suspended dust loading:  $C_0$  was 191.35, 178.20, 186.36, and 189.44  $\text{mg m}^{-3}$  at 0, 2, 4, and 6  $\text{m s}^{-1}$ , respectively. The range was 178.2–191.4  $\text{mg m}^{-3}$  and the coefficient of variation was only 3.1%. Second, we performed an initial-loading sensitivity check by multiplying each retained-mass series by  $C_{\text{ref}}/C_0$ , where  $C_{\text{ref}} = 186.3 \text{ mg m}^{-3}$  is the mean  $C_0$  across treatments. This rescaling did not change the principal wind-speed ordering of the net-accumulation response. It therefore shows that the observed non-monotonic ranking is not an artefact of the small initial-loading differences. The complete 180 min normalized concentration curves and the concentration summary have been added as Fig. S2 and Table S1.

*Location in the final revised manuscript: p. 6, lines 145–153; p. 8, lines 192–220; and p. 10, lines 258–265. Additional information is provided in Table S1 and Fig. S2 of the Supplement.*

### Comment 3: Wall losses, internal deposition, and recirculation

#### Reviewer comment:

In the wind tunnel, a wind-speed-dependent fraction of dust may be lost to the walls, ceiling, turning vanes, and fan assembly through inertial impaction, while recirculated air may continue to resupply dust to the test section. At higher wind speeds, deposition may plausibly shift toward vertical or internal tunnel surfaces, meaning that the observed reduction in floor deposition could partly reflect a redistribution of deposited material rather than a reduction in total deposition. The authors are therefore encouraged to address, at least qualitatively, the potential influence of wall losses and recirculation on the reported deposition patterns and their interpretation.

#### Response:

We agree. The floor-tray measurements are not a closed whole-tunnel deposition budget. The facility is a closed-circuit wind tunnel, so particles that are not retained by the trays may continue to circulate and repeatedly pass through the test section. At the same time, particles may be lost to the side walls, ceiling, turning vanes, fan assembly, steel cover plates, or other internal surfaces. None of those surface reservoirs was measured, and their relative contributions may vary with wind speed and particle size. We have therefore revised the terminology and limitations to make clear that the measured quantity is effective near-surface retention by the floor trays under the present tunnel and collector configuration, rather than total deposition to all tunnel surfaces.

The concentration record helps constrain the interpretation. Initial  $C_0$  values were comparable among treatments (178.2–191.4 mg m<sup>-3</sup>; coefficient of variation 3.1%), so the relatively high retained mass at 2 m s<sup>-1</sup> cannot be explained by a higher initial dust loading. During the final 20 min of the 180 min experiment, mean  $C(t)/C_0$  was 5.32%, 0.15%, 9.27%, and 4.24% at 0, 2, 4, and 6 m s<sup>-1</sup>, respectively. Thus, 2 m s<sup>-1</sup> had the lowest late-stage residual concentration, whereas 4 and 6 m s<sup>-1</sup> retained more airborne dust, especially at 4 m s<sup>-1</sup>. In combination with the tray data, this pattern is consistent with greater suspended-dust persistence and reduced effective transfer into stable floor retention at 4–6 m s<sup>-1</sup>.

We have also moderated the conclusion drawn from this pattern. Lower tray-retained mass at 4–6 m s<sup>-1</sup> does not demonstrate a proportional reduction in whole-tunnel total deposition. It may reflect a combination of continued suspension, recirculation, horizontal redistribution, local re-entrainment, and deposition onto unmeasured internal surfaces. The single-point concentration series cannot distinguish those pathways or provide a spatial mass balance. The revised manuscript now states both what the concentration data support and what they cannot resolve.

*Location in the final revised manuscript: p. 4, lines 107–114; p. 6, lines 145–153; p. 10, lines 258–265; pp. 14–15, lines 363–380; and p. 17, lines 446–452. Additional information is provided in Table S1 and Fig. S2 of the Supplement.*

## Comment 4: Dependence on dust or soil type

### Reviewer comment:

The experiments were performed using a cropland/agricultural soil. How different might the results be if other dust soil types had been used? The authors acknowledge this limitation in Section 4.4; however, it would be useful to include some further discussion, or at least qualitative estimates, of how soil type, mineralogy, texture, particle-size distribution, and aggregation state may influence the reported deposition kinetics.

### Response:

We thank the reviewer for this helpful suggestion. We have expanded Sect. 4.4 from a brief general limitation into a process-based discussion of how dust properties could affect each aspect of the observed response. The tested material was a single local cropland soil, sampled from 0–5 cm depth and sieved to  $<63\ \mu\text{m}$ . Therefore, the measured values should not be assumed to apply quantitatively to desert crust, loess, construction dust, or other mineral aerosol sources.

The revised manuscript now gives the following directional expectations. A coarser or denser airborne population would generally have larger gravitational settling velocities and could produce a larger initial net accumulation flux  $J_0$ , a shorter characteristic time  $\tau$ , and a more gravity-dominated response. Finer, lower-density, or more porous particles would tend to remain suspended longer. Mineral composition, specific surface area, surface chemistry, and texture can indirectly affect the kinetics through cohesion, particle morphology, and the initial aggregation state. A material with a stronger tendency to aggregate under weak shear could acquire a larger effective settling size and show enhanced retention at an intermediate wind speed. Conversely, breakup of weak aggregates under stronger shear could reduce the retained mass and alter the high-wind response. These material differences could therefore change not only the magnitude of  $a$ ,  $k$ ,  $\tau$ , and  $J_0$ , but also the height and wind-speed location of the observed low-wind maximum.

Because only one material was tested, a numerical correction factor would be speculative and is not supported by the present data. We therefore provide physically based qualitative expectations and explicitly call for comparative experiments using dusts with contrasting particle-size distributions, mineralogy, density, morphology, cohesion, and aggregation states.

*Location in the final revised manuscript: p. 4, lines 114–117; and p. 17, lines 434–445.*

## Comment 5: Treatment and implications of soil moisture

### Reviewer comment:

I was not able to fully understand whether, and to what extent, the role of soil moisture was considered in the experimental design and analysis. Since soil moisture can influence particle cohesion, threshold friction velocity, dust emission rates, and potentially deposition behavior, its treatment may have important implications for the interpretation of the results. Could the authors please clarify whether soil moisture was measured or controlled during the experiments and discuss its potential impact on the reported deposition kinetics?

### Response:

Thank you for this helpful suggestion. Soil moisture was not varied as an independent experimental factor, but the material was subjected to a common dry pretreatment. After air drying and dry sieving to obtain the  $<63\ \mu\text{m}$  fraction, the dust was oven-dried at  $105\ ^\circ\text{C}$  for 8 h. The same soil material and drying procedure were used for all wind-speed treatments. This procedural control was intended to minimize run-to-run differences in moisture-related cohesion and emission threshold.

Residual gravimetric water content was not measured after oven drying. We therefore describe moisture as operationally standardized by drying, rather than quantitatively measured or set to a specified water content. Within the experiment, the common treatment makes moisture differences unlikely to explain the contrasts among 0, 2, 4, and  $6\ \text{m s}^{-1}$ . The reported kinetics should nevertheless be interpreted as applying to dry dust conditions.

We have expanded the limitations to explain why moist field conditions could behave differently. Water can strengthen capillary and cohesive forces, alter the threshold for initial particle release, change the airborne size distribution and aggregation state, increase particle-surface adhesion, and increase resistance to rebound or re-entrainment. These effects act in competing directions: moisture may suppress source emission but enhance aggregation and stable surface retention. Consequently, moisture could alter the fitted retained mass  $a$ , response rate  $k$ , characteristic time  $\tau$ , initial net flux  $J_0$ , and potentially the magnitude or location of the low-wind maximum. The direction and size of the net change cannot be inferred from this dry dust experiment, so we now limit the conclusion accordingly and identify controlled-moisture experiments as necessary future work.

*Location in the final revised manuscript: p. 4, lines 114–117; and p. 17, lines 453–459.*

## Comment 6: Revision and clarification of the wind-profile methodology

### Reviewer comment:

Lines 166–178: I suggest rephrasing this section and providing a more detailed explanation to help the reader better understand the methodology and interpretation of the results.

### Response:

We agree and have completely rewritten Sect. 2.3. During re-examination of the source data, we found an error in the manuscript: profiles measured at speeds of 4, 6, and 8 m s<sup>-1</sup> had inadvertently been associated with the 2, 4, and 6 m s<sup>-1</sup> deposition treatments. We corrected the assignment, replaced Fig. 1b with the correct 2, 4, and 6 m s<sup>-1</sup> profiles, and recalculated every profile-derived quantity. The deposited masses, particle-size distributions, kinetic fits, and wind-speed rankings were obtained independently from the tray measurements and are therefore unaffected by this correction.

The revised section now specifies the measurement geometry and array state. Profiles were measured on the longitudinal centreline, 9 m downstream of the test-section entrance and immediately downstream of the collection-tray array. All 25 trays were present in their complete initial layout, with 20 cm spacing between adjacent trays; this layout was restored before each run. Wind speed was measured at  $z = 0.02, 0.05, 0.10, 0.20, 0.40, 0.80, 1.20$ , and 1.60 m.

We also replaced the poorly constrained roughness-length formulation used in the old manuscript with a transparent two-parameter log-linear regression over the same height interval for all three treatments:

$$U(z) = A \ln(z/z_{\text{ref}}) + B, \text{ and } u_* = \kappa A,$$

where  $\kappa = 0.4$  and  $z_{\text{ref}} = 1$  m. The common fitting range was 0.05–0.40 m, which supplies four points above the 0.03 m tray rims and below the upper quasi-uniform part of the profile. The corrected profile-derived apparent friction velocities are 0.063, 0.089, and 0.154 m s<sup>-1</sup> at nominal speeds of 2, 4, and 6 m s<sup>-1</sup>, respectively, with  $R^2 = 0.921, 0.933$ , and 0.883.

Boundary-layer thickness  $\delta$  was estimated independently. We first removed minor local reversals using isotonic regression, applied shape-preserving interpolation, and then identified the first height reaching  $0.99U_\infty$ , where  $U_\infty$  is the mean measured velocity at 0.80, 1.20, and 1.60 m. The resulting operational  $\delta$  values are approximately 0.88, 0.73, and 0.48 m. The 0.03 m tray rim therefore corresponds to about 3.4%, 4.1%, and 6.3% of  $\delta$ . The text now states that these profiles include the collective influence of the complete tray array on the downstream mean profile but do not resolve individual-rim wakes or changes caused by progressive tray removal.

Finally, the corrected  $u_*$  values were propagated into the mechanistic discussion. The corresponding nominal near-wall viscous length scales are approximately 1.20, 0.85, and 0.49 mm, and the Rouse numbers for 2–10  $\mu\text{m}$  particles span approximately 0.006–0.32. These values support an important role for turbulent mixing relative to gravitational settling, especially for the finer particles.

*Location in the final revised manuscript: p. 5, lines 120–125; p. 6, lines 134–141 and 155–160; p. 7, lines 161–173; and p. 14, lines 339–346.*

## Comment 7: Particle shape and definition of the PM classes

### Reviewer comment:

Figure 2: How important is the shape of mineral particles for the sedimentation process? Was particle shape considered in the analysis? Since particle shape can influence aerodynamic properties and settling velocities, a brief discussion of its potential impact on the results would be helpful. Lines 193–197: Are the PM classes cumulative or differential?

### Response:

We thank the reviewer for raising these two related points.

First, particle shape was not independently characterized and no shape-dependent correction was applied. Laser diffraction reports a volume-equivalent diameter; it does not provide particle-level aspect ratio, sphericity, flatness, elongation, or orientation. Non-spherical mineral particles can experience drag and settling velocities that differ from those of equivalent spheres, with the magnitude depending on shape, orientation, density, and Reynolds number. Shape can also influence interception, rebound, and stable retention at the tray surface. Accordingly, the Stokes–Cunningham settling-velocity calculation in the mechanistic discussion is a nominal spherical-equivalent estimate based on a representative mineral density, not a particle-specific aerodynamic calibration.

The kinetic curves in Fig. 2 were fitted directly to measured tray-retained mass and therefore did not require an assumed shape to calculate  $M(t)$ ,  $a$ ,  $k$ ,  $\tau$ , or  $J_0$ . Nevertheless, the unmeasured shape distribution may affect the absolute transport and retention within each size class. Use of the same soil batch and preparation procedure limits systematic differences in the initial shape distribution among wind-speed treatments, but wind-dependent shape-selective transport or retention cannot be excluded. We added this methodological clarification and a dedicated limitation, including the need for future microscopic measurements of aspect ratio and sphericity.

Second, all PM classes in Fig. 2 are cumulative, nested diameter-threshold classes, not mutually exclusive differential bins. They are defined from laser-diffraction volume-equivalent diameter as PM<sub>2.5</sub>:  $D_v < 2.5 \mu\text{m}$ ; PM<sub>10</sub>:  $D_v < 10 \mu\text{m}$ ; PM<sub>20</sub>:  $D_v < 20 \mu\text{m}$ ; PM<sub>30</sub>:  $D_v < 30 \mu\text{m}$ ; PM<sub>40</sub>:  $D_v < 40 \mu\text{m}$ ; and PM<sub>63</sub>:  $D_v < 63 \mu\text{m}$ . Thus, PM<sub>2.5</sub> is included in PM<sub>10</sub>, PM<sub>10</sub> is included in PM<sub>20</sub>, and so forth. For each threshold, the total retained tray mass was multiplied by the cumulative laser-diffraction volume fraction below that diameter and divided by tray area. The definition is now stated both in Sect. 2.5 and in the Fig. 2 caption so the nested structure is visible at the point of interpretation.

*Location in the final revised manuscript: pp. 7–8, lines 175–196; p. 9, lines 229–233; pp. 13–14, lines 336–346; and p. 17, lines 460–465.*

**Comment 8: Recalculation and interpretation of the median particle diameter in Figure 4****Reviewer comment:**

Figure 4: I may have misunderstood the calculation, but it appears that there could be an issue with the reported median value. Could the authors please check the calculation and clarify this point?

**Response:**

Thank you for drawing our attention to this issue. We returned to the normalized source particle-size distributions and recalculated every  $D_{50}$  value. In the old manuscript,  $D_{50}$  had been assigned to the discrete measurement channel whose cumulative volume fraction was closest to 50%. The revised calculation first normalizes the differential volume fractions to 100%, constructs the cumulative volume distribution, and then uses linear interpolation on the logarithmic diameter scale between the two adjacent channels that bracket 50%. This procedure avoids the channel-selection bias in the original annotations.

The corrected  $D_{50}$  values at 0.5 and 3 h are, respectively: 13.4 and 10.8  $\mu\text{m}$  at 0  $\text{m s}^{-1}$ ; 7.1 and 9.8  $\mu\text{m}$  at 2  $\text{m s}^{-1}$ ; 6.3 and 7.5  $\mu\text{m}$  at 4  $\text{m s}^{-1}$ ; and 29.3 and 17.9  $\mu\text{m}$  at 6  $\text{m s}^{-1}$ . The vertical  $D_{50}$  lines and annotations in Fig. 4 have been updated. The differential PSD curves and modal-diameter channels were not altered by the recalculation.

The revised text reports the observed temporal changes without over-interpreting them. At 2  $\text{m s}^{-1}$ ,  $D_{50}$  increases from 7.1 to 9.8  $\mu\text{m}$  (approximately 38%), the modal channel moves from 4.3 to 18.3  $\mu\text{m}$ , and the volume fraction at 18.3  $\mu\text{m}$  increases from 5.3% to 8.6%. We describe this as progressive enrichment of medium-sized effective diameters. Aggregation is discussed only as one plausible contributor, because size-selective transport and retention could produce a similar change.

*Location in the final revised manuscript: p. 8, lines 194–196; pp. 12–13, lines 287–314; p. 13, lines 327–330; and p. 14, lines 351–357.*

**Comment 9: Use of the results in numerical simulations and deposition parameterizations****Reviewer comment:**

The authors should briefly discuss how the results of this study could be exploited in numerical simulations, particularly with respect to the development or improvement of dust deposition parameterizations.

**Response:**

We agree and have substantially expanded Sect. 4.3. The revision first separates the standard model quantity from our experimental quantity. Existing size-resolved schemes generally calculate a dry-deposition velocity from particle size, friction velocity, surface roughness, land-cover type, and surface collection processes, while particle rebound or resuspension is often represented separately. Our experiment does not provide a universal replacement deposition velocity. Instead, it supplies empirical constraints on the transient net surface-retention response after a matched initial airborne dust loading.

The four fitted quantities provide complementary constraints that can be used in model development or evaluation. The asymptotic mass  $a$  characterizes the fitted stable retained-mass level for a specified initial loading and collector surface. The effective coefficient  $k$  and its reciprocal  $\tau$  specify how rapidly the surface reservoir approaches that level. The initial slope  $J_0 = ak$  constrains the early net surface flux. Thus, a model can be tested not only against the amount retained after a fixed time, but also against the adjustment timescale and the initial response for each size threshold. The empirical kernel  $M(t) = a [1 - \exp(-kt)]$  can be used as a compact benchmark for a surface-reservoir component, provided that its configuration-specific nature is retained and that concentration normalization is handled separately in the atmospheric model.

To make the non-monotonicity quantitatively useful, we compared the observed  $J_0$  values with a non-decreasing wind-speed benchmark representing a simplified deposition-only expectation. For  $\text{PM}_{2.5}$ – $\text{PM}_{40}$ , observed  $J_0$  at  $2 \text{ m s}^{-1}$  exceeds that benchmark by approximately 15–72%. At  $6 \text{ m s}^{-1}$ , it is approximately 45–91% below the benchmark, equivalent to benchmark-to-observation factors of about 1.8–11 for the affected size classes. The deviation is smaller for  $\text{PM}_{63}$ . These values provide a direct low-wind test case for determining whether a model that treats deposition alone produces too much stable surface retention when particle rebound, persistence, and re-entrainment become important.

On this basis, we recommend a coupled parameterization rather than applying a single monotonic multiplier to deposition velocity. Conventional particle delivery to the surface should be coupled to (i) wind- and size-dependent stable retention or rebound and (ii) a surface-specific, threshold-dependent re-entrainment term. The high  $J_0$  near  $2 \text{ m s}^{-1}$  and its decline toward  $6 \text{ m s}^{-1}$  provide benchmark behaviour for the coupled response. Extension to field or global simulations will require calibration for natural roughness, vegetation, soil moisture, dust composition, and vertically resolved concentration/flux conditions; the present values are process-level constraints, not universally transferable coefficients. The conclusion now explicitly identifies targeted observations and simulations of near-surface particle exchange as the next step for transferring this framework to realistic boundary layers.

*Location in the final revised manuscript: pp. 15–16, lines 381–433; and p. 18, lines 483–486. Additional results are provided in Tables S2–S4 of the Supplement.*

**We again thank the reviewer for these constructive comments. They helped us clarify the definition and scope of the measured quantity, strengthen the methodological description and limitations, and better articulate how the experimental results may inform numerical parameterizations.**