Reply to the comments of RC2

RC2: General comment

This study describes an improvement to the CMAQ dry deposition over Western Pacific using various dry deposition schemes. It also addressed the performance of a model-simulated long dust-black carbon belt along 15N. The study indicated improvements in the results, but it is unclear how the improvements are statistically relevant. The impact of other processes could affect the dry deposition scheme but was not addressed. A statistical rather than a visual comparison between CMAQ and satellite/assimilated AOD would be more convincing to demonstrate modeling performances. Also, the manuscript contains numerous grammatical and technical errors that require thorough proofreading before resubmission.

General Comment Response: The authors wish to thank the reviewer for the constructive comments on our work. The present research purposely investigates how the various types of dry deposition schemes embedded within CMAQv5.4 could help improve the latest refined dust model proposed by Kong et al. (2024). The other processes that could impact the dry deposition scheme efficiency, such as resistance, land surface, roughness length …, which is not our research scope. However, we thank the reviewer for pointing out the possible research question. We will consider the idea proposed to minimize the research gap. The manuscript has been proofread through Grammarly (version Premium) online text editor

All of the changes in the revised manuscript have been highlighted in yellow. Corrections (blue text) with line numbers indicated in this response document refer to the revised manuscript.

RC2: Specific comments and responses

Comment 1: The abstract should not include references.

Response: The references has been removed. We modified the sentence as "By utilizing the CMAQv5.4 with the refined dust emission treatment, the East Asian dust (EAD) simulation during January 2023 was constructed to evaluate the performance of four dry deposition parameterizations, namely PR11, E20, S22, and P22." **Page 1, Line 14-17**.

Comment 2: L 82. What is "LABS"?

Response: "LABS" refers to "Lulin Atmospheric Background Station." The abbreviation has been included on **Page 1, Lines 22**.

Comment 3: L 115. Where is Vs in the equation?

Response: V_s as one of the functions in the physical formulation of V_d. We corrected the formula as below: "

$$V_d = V_s + \frac{1}{R_a + R_s} \quad (3)$$

where V_s is the gravitation settling velocity, R_a is the resistivity aerodynamic and R_s is the surface resistivity. The V_s is calculated according to Stokes's Law as:

$$V_s = \frac{\rho_p D_p^2 g C_c}{18\eta} \quad (4)$$

where, p_p is the density of the particle; D_p is the diameter of the particle; g is gravitational acceleration; C_c is the Cunningham correction factor for small particles; and, η is the dynamic viscosity of air." **Page 6, Line 137-142**.

Comment 4: L 168. The sentence is unclear. Clouds always induce biases in modeled and assimilated aerosols.

Response: The sentence has been revised. We modified the sentence as "The Modern Era Retrospective-analysis for Research and Application version 2 (MERRA-2) reanalysis data was used to demonstrate the spatiotemporal distribution of dust, compared with the air quality model, irrespective of the influence of clouds." **Page 8, Line 190-193.**

Comment 5: L 170. MERRA-2 is a data-assimilated system rather than a remotely sensed data.

Response: The sentence has been revised. We changed the sentence to "MERRA-2 (Gelaro et al., 2017) is a NASA reanalysis product utilizing Goddard Earth Observing System Data Assimilation System Version 5 (GEOS-5) and covering the data-assimilated system at a native spatial resolution of 0.5 ◦ × 0.625 ◦." **Page 8, Line 193-195.**

Comment 6: L 227. MERRA-2 is a data-assimilated product rather than a pure observational product. It's unclear how this sentence fits in with Figure 4.

Response: The sentence has been removed.

Comment 7: Fig S1. The link in the caption does not show these synoptic maps.

Response: The link in the caption has been revised. We corrected the caption as "Figure S2: Surface weather maps for the weather pattern obtained by Taiwan Central Weather Bureau (https://www.cwa.gov.tw/)." **Supplementary, Page 3, Line 33.**

Comment 8 Fig S2. A statistical comparison between collocated CMAQ and MODIS AOD with a scatterplot is needed to quantify their agreements.

Response: We thank the reviewer for the comment. MODIS AOD retrieved consisted of the missing value due to the cloud cover. Hence, the visualized qualitive comparison between CMAQ and MODIS can be more appropriate instead of a statistical comparison. However, we agree that using a scatter plot is needed for the evaluation quantification. A detailed model evaluation between CMAQ and the observed dataset over mainland China has been delivered to carry out the statistical comparison, which is more reliable in testing the model efficiency (Table 5). We added the discussion as "Figure 5 shows the scatter plot of simulated and observed PM across mainland China. The correlation coefficient (R), a factor of two (FAC2), and the mean observed and simulated PM are marked in Figure 5. The modeled PM_{10} without the dust scheme had the lowest correlation, followed by Dust_PR11. Among all of these simulations, Dust_E20 performed the best (R > 0.3) compared to Dust_PR11, Dust_S22 and Dust_P22. However, for $PM_{2.5}$, the correlation between the model and measured values was similar for all the dry deposition schemes. The statistical index of FAC2 was used in the present work since either low or high outliers less influence it (Chan and Hanna, 2004). The dataset is reliable for FAC2 values between 0.5 and 2.0, with the ideal model of 1.0. The simulated PM_{10} by E20 performed well, with a nearly perfect value of 1.1. Meanwhile, the $PM_{2.5}$ by S22

simulation was slightly better than E20 but much better than the other experiments." **Page 11, Line 275-284.**

Comment 9: Fig S3. A statistical comparison is also needed by using the MERRA-2 AOD as well, not just the dust column. MERRA-2 provides AOD for each species.

Response: We thank the reviewer for the comment. Fig S5 aims to demonstrate the consistency of the transport pattern between dust and black carbon over the western Pacific Ocean, as shown by MERRA-2. Please see **Comment 8** for the detailed scatter plot analysis.

An explanation regarding the transport pattern consistency is included. We added the sentence as "Such consistency has been verified by the MERRA-2 dust and black carbon mass column over the region (red dash rectangular in Fig. S5)." **Page 15, Line 383-384.**

Also, Fig. S5 has been modified to emphasize the transboundary over the western Pacific Ocean. We change the figure as:

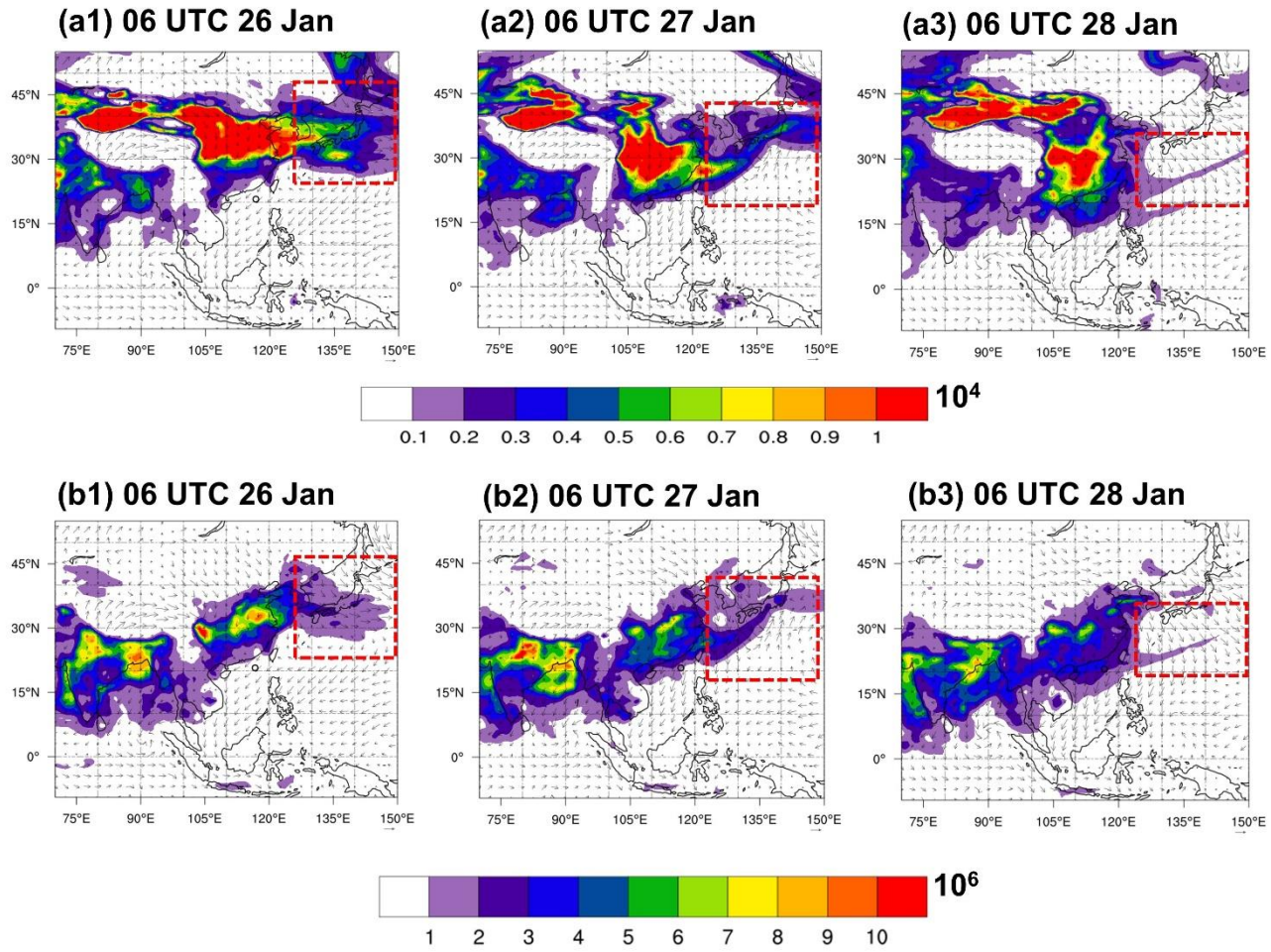

Figure S5: MERRA2 dust mass column (a1-a3) and black carbon mass column (b1-b3) during 06 UTC (a1, b1) 26 January, (a2, b2) 27 January and (a3, b3) 28 January 2023.