Reply to the comments of RC2

RC2: General comment

The authors improved the dust simulation over East Asia based on a few extreme dust events by refining soil moisture factor, dust emission speciation profiles, and bulk soil density. They also examined dust removal by a typhoon. The particulate matter from model simulations were evaluated against observations, which confirmed an improvement. Overall, the paper is well written but require some minor edits before publication in ACP

Response: The authors wish to thank the reviewer for his compliments, positive and constructive comments of our work. All of the changes in the revised manuscript have been highlighted in <mark>yellow</mark>. Corrections (blue text) with line numbers indicated in this response document refer to the revised manuscript.

Our point-by-point responses to the reviewer's comments are given below:

Specific comment

Comment 1: Line 349-352: While the study showed an improved NMB with refined dust simulations, the authors should explain the possible causes of the remaining biases and offer suggestions on methods that will further reduce the NMB in future studies. After all, the statistics without refinement still satisfy the benchmark.

Response: The suggested discussion has been added. We included the sentence: "As the improved NMB with the refined dust simulation still shows a degree of model underestimation, a calibration process to resolve the aerosol removal mechanism may be the most impactful in closing this gap." **Page 14, Line 353-355.**

Comment 2: Line 589 – 590: How are the thresholds in the benchmark defined? A general statistical benchmark may not be appropriate for dust model evaluations. Even the default simulations satisfy the benchmark, which makes the refined simulation in this study less significant.

Response: Agree. Since there is no regular statistical benchmark to justify the dust model evaluation, the present modeling study is referring to the threshold suggested by Emery (2001). We added the following sentence: "The threshold of the statistical index is based on Emery (2001)." **Page 7, Line 161.**

Reference:
Emery, C., Tai, E., and Yarwood, G.: Enhanced meteorological modeling and performance evaluation for two Texas ozone episodes. prepared for the Texas Natural Resource Conservation Commission, prepared by ENVIRON International Corp, Novato, CA, 2001

Technical comments:
Comment 3: Line 15: Do you mean "dust radiative flux"?

Response: To avoid confusion, we modified the term from "dust flux" to "dust transport".
Page 1, Line 15.

Comment 4: Line 22: It should be either "higher" or "lower in magnitude" since they are negative values

Response: Agree. The term has been rephrased as "The Dust_Refined_3 normalized mean bias of PM10 was -30.65 % for the 2010 SDS event, which was lower in magnitude compared to Dust_Refined_1 (-41.18 %) and Dust_Refined_2 (-49.88 %)." **Page 1, Line 21-23**.

Comment 5: Line 27: "On 15-21 April 2021" => "During 15-21 April 2021"

Response: The term has been modified as **"During 15-21 April 2021, both CMAQ simulations and satellite data highlighted the influence of typhoon 'Surigae' on dust transport to downwind Taiwan and the Western Pacific Ocean (WPO)." Page 1, Line 27-29.**

Comment 6: Line 28: "Typhoon" should be capitalized

Response: The term has been capitalized as **"The CMAQ Dust_Refined_3 simulations further revealed a large fraction of dust aerosols were removed over WPO due to Typhoon 'Surigae'." Page 2, Line 29-31.**

Comment 7: Line 586: "bulb" => "bulk"

Response: The term has been changed. **Page 23, Line 583**.

Table 1 Summary of the design of the simulations used in the present study.

Scenarios	Descriptions
Dust_Off	Without in-line calculation of dust.
Dust_Default	With the new default wind-blown dust treatment (Foroutan et al., 2017).
Dust_Refined_1	Refined the soil moisture factor and the dust emission speciation profile for the Gobi Desert as suggested by Kong et al. (2021).
Dust_Refined_2	Refined the bulk soil density according to China's soil type as suggested by Liu et al. (2021).
Dust_Refined_3	Considering the both of Dust_Refined_1 and Dust_Refined_2.

Comment 8: Line 603: "dot representing" => "dots represent"

Response: The term in the caption has been changed as "Figure 1: (a) Modeling domain configuration used in the present study. The red dots represent the location of the observation sites at Shilin and Dongsha. (b) The blue lines represent the transects that the dust plumes travelled along in this studies that are discussed in Section 3." **Page 24, Line 605**.

Comment 9: Line 645 - 646: The caption needs to mention PM10 concentrations. The same applied to Figure 5.

Response: We thank the reviewer for the comment. In Figure 4 (now merged with Figure 5 from the previous manuscript), instead of PM_{10}, the transboundary process is explained based on dust mass concentration in order to emphasize purely mineral dust from northwest China. The caption has been modified. We changed the caption as "Spatial distribution of the simulated dust aerosol during the March 2010 episode over East Asia within domain 1 (d01) at (a) 06 UTC 18 March, (b) 12 UTC 19 March and (c) 15 UTC 20 March; and domain 2 (d02)

at (d) 15 UTC 20 March, (e) 23 UTC 20 March, (f) 04 UTC 21 March, (g) 08 UTC 21 March, (h) 06 UTC 22 March and (i) 12 UTC 22 March. Location of Dongsha is indicated with a black dot. The red arrows highlights the wind direction." **Page 27, Line 639-643**.

Comment 10: Supplementary Figure S2: "3-days" => "three-day". Which figures are based on MODIS? Please be more specific.

Response: The caption of the supplementary figure has been modified as "Figure S4: The three-day mean averaged AOD over East Asia region, for CMAQ (a1-a5, b1-b5, c1-c5, d1-d5) and MODIS (a6, b6, c6, d6) during 17-19 March 2005 (a1-a6), 18-20 March 2009 (b1-b6), 25-27 April 2009 (c1-c6) and 20-22 March 2010 (d1-d6)."