We thank the referee for a very thoughtful review and detailed suggestions to our manuscript. Incorporation of these suggestions helps to improve the quality of our manuscript significantly. Following are the responses to the reviewer's comments, and related revises have been incorporated into the updated manuscript.

(1). **Comment**: The main issue with the manuscript is the lack of a clear and detailed explanation of the methodology. The authors referred to the work of Tong et al. (2015) in various places in the Methodology section. This is not a published manuscript (under review in journal?) which makes it impossible for a reader to understand the details of the dust emission algorithm that the authors have used.
Response: The methodology of our study includes three major parts as described in the manuscript: first, section 2.1 introduces the development of the values of initial threshold friction velocity constant based on reanalysis of field measurement data; second, section 2.2 introduces the development of the source-dependent speciation profiles for Gobi and Taklamkan Desert; third, section 2.3 introduces the implementation of the dust heterogeneous chemistry. The reviewer's major concern is about the section 2.1. We agree with the reviewer that more details are necessary to clearly describe how the reanalysis of field data is performed, so the manuscript is revised according to this comment. Tong et al. (2015) is still under preparation to give an explicit description about the dust emission model and field measurement data. So in this manuscript, the fundamental equations and algorithms are briefly introduced. In the revised manuscript more necessary details are added to help readers to clearly understand the dust emission model (see the last paragraph of section 2.1).

(2). **Comment**: It is unclear how the double-counting of the soil moisture was addressed in this study. What was the procedure for revising the original threshold velocities? It is obvious from Fig. 1(c) that the process of modifying the threshold velocities are different for different soil and land use types. What value of the soil moisture was used for each soil and land use type to modify the threshold velocities? The whole procedure needs to be presented and scientifically justified.
Response: In the original field measurements, the value of the soil moisture in each sample was provided (e.g., see Table 2 of Gillette et al., 1980). These data were used to feed the Fecan formula to derive the would-be threshold velocity under dry condition. We have reprocessed the data for the soil and land use types measured by Gillette 1980 and 1982. In case of missing data for certain soil types, we have chosen the values with the soil composition closest to a measured type following the USDA soil composition diagram (Fig 1 of Gillette et al., 1980). We have now added the information in the revised manuscript (see the last paragraph of section 2.1).

(3). **Comment**: How (quantitatively) is the presence of non-erodible elements accounted for in calculating the threshold friction velocity and what value of the surface roughness was used?
Response: Non-erodible elements mainly include pebbles, rocks, and vegetation, while in this study only vegetation is considered. The land cover types (accompanied by soil types) determine the threshold friction velocity as calculated in Eq.(5) in section 2.1. The erodibility and roughness length used in this model only represents the potentially erodible particles such as slit, clay and sand by following the fundamental algorithm of Marticorena et al. (1997). So with this algorithm, only three land cover types are considered for erodible potential, include shrubland, mixed

shrub/grassland, and barren/sparsely vegetated land. Surface roughness length (Z_{ruf}) is calculated in WRF based on vegetation fraction, while the surface roughness factor is calculated based on Z_{ruf}) (see response for comment#5)

(4). Comment: What is the value of coefficient A (scaling factor) in Eq. (1)?
Response: The value of A is set as 32.0 in this study.

(5). **Comment**: How is the surface roughness adjusting factor ($Z_{i,j}$) calculated?
Response: The surface roughness adjusting factor *Z* is calculated as:

$$Z = \frac{C_1}{C_1 \times lnZ_{ruf} - C_2}$$

The constants $C_1 = 32$ and $C_2 = -5$ used in this equation are derived from field measurement data from Gillette et al. (1980) and the relationship between roughness length and friction velocity described in Marticorena et al. (1997).

(6). **Comment**: The new dust speciation profiles are different for Gobi and Taklamakan. How does ONE default profile in CMAQ is replaced by these TWO profiles? Does user need to pre-define the regions where each profile is being applied?
Response: In the standard CMAQ, the default speciation profile is applied to the entire simulation domain. The two new profiles developed in this study are assigned separately to Gobi and Taklamkan based on a pre-defined map of these deserts. Yes, users need to pre-define the region where which profile should be applied.

(7). **Comment**: The vertical-to-horizontal dust flux ratio in Eq. (2) is based on the linear fitting of the measurements of Gillette (1979) by Marticorena and Bergametti (1995). The authors should note that the value of K based on this equation has the unit of [1/cm], while the rest of the formulation in the manuscript is in SI units. It seems that a factor of 100 is missed in the present calculations. Also, what would be the justification of using K=0.0002 for clay%>20%? Please comment.
Response: The unit of K is [1/cm] in Marticorena and Bergametti (1995) equation, and the factor 100 is implicitly reflected in the scaling factor A. The value of K (0.0002) for clay%>20% is used here following the recommendation of Marticorena and Bergametti (1995). We notice that this value may be subject to further changes when more measurements are made available.

(8). **Comment**: Eq. (5) is not from Fecan et. al (1999). There is no surface roughness study in their work.
Response: The reviewer is right, the Fecan et al. (1999) should be cited to support the calculation of soil moisture adjusting factor in Eq.(6), not for Eq.(5). We have correct this in the updated manuscript.

(9). **Comment**: Based on Eq. (6), the soil moisture factor is 999.9 for Sm > Wmax. I think it should be the case only when Sm > Sl. Furthermore, the third relation should be used when Wmax < Sm < Sl. Please go through the conditions in Eq. (6) and revise them. Also, how is Sl (saturation soil moisture limit) determined?

Response: The reviewer is right about the conditions in Eq.(6). In fact the soil moisture S_m shall not exceed the saturation soil moisture limit S_l. We set the soil moisture adjustment factor f_{soilm} as 999.9 in the code of the model only to avoid computational abnormal values, thus it is not necessary to show this condition in the manuscript. So there are only two conditions considered, and the Eq.(6) has been revised in the manuscript as:

$$f_{soilm,i,j} = \begin{cases} 1.0, & for\ S_m \leq W_{max} \\ (1.0 + 1.21 \times (S_m - W_{max})^{0.68})^{0.5}, & for\ W_{max} < S_m \leq S_l \end{cases} \quad (6)$$

The value of S_l is determined based on a predefined lookup table for different landcover categories and soil types as shown below. The values in the table are mainly based on documentation of the North American Mesoscale (NAM) model.

Table Saturation soil moisture limit

Landcover Soil Type	Shrubland	Mixed shrub/grass land	Barren or sparsely vegetated
Sand	0.395	0.135	0.068
Loamy sand	0.410	0.150	0.075
Sandy loam	0.435	0.195	0.114
Silt loam	0.485	0.255	0.179
Silt	0.476	0.361	0.084
Lam	0.451	0.240	0.155
Sandy clay loam	0.420	0.255	0.175
Silty clay loam	0.477	0.322	0.218
Clay loam	0.476	0.325	0.250
Sandy clay	0.426	0.310	0.219
Silty clay	0.482	0.370	0.283
Clay	0.482	0.367	0.286

(10). **Comment**: The results deteriorate for Ca_2^+ when the new dust profile is used (Table 5). Please comment on the possible reasons.

Response: The evaluation statistics suggest that total $PM_{2.5}$ is underestimated at Duolun and Yunlin, but Ca_2^+ is overestimated under the default profile. So although the NMB value changse from 36.69% by default profile to -53.12% for Ca_2^+ by revised profile, it is highly possible that the revised profile provides a better estimation of the calcium mass contribution since the evaluation statics for trace metals should be consistent with that for total $PM_{2.5}$. The overall underestimation for $PM_{2.5}$ and trace metals should be due to the underestimation of fine mode aerosol mass contribution (20%) in total dust emission. No solid conclusion is made at this point because the PM_{10} data is not available at Duolun or Yulin, although the total suspended particles (TSP) is measured and indicate the fine mode aerosol should have larger mass contribution (about 40% in TSP).

(11). **Comment**: In general, the information and texts in figures are very small and hard to read.

Response: The figures are revised to make the text bigger and easier to read in the updated manuscript. Figure 1 uses larger text font, and we also reduce the number of landcover categories shown in Figure 1(a), because only three categories will generate dust in the model. Figure 2 is revised to add text indicating the locations of Fudan Univ. observational sites and TAQMN site. Figure 7 and Figure 10 has added description in the subtitles to help illustrate the information of the figures. The rest of the figures have smaller font due to limited page size, but they are all drawn as vector graphics so readers can enlarge them to have a clear view.

(12). **Comment**: Please delete the repeated word “revised” on P. 35593 line 24.
Response: It is changed in the updated manuscript, thanks to the notification of the reviewer.

(13). **Comment**: In Eq. (3), the values of clay, silt, and sand should be in fraction not percentage.
Response: Yes, they should be in fraction. We have revised the text and Eq.(3) in the updated manuscript.

(14). **Comment**: In Fig. (2), the orange rectangle (Fudan observation) and the purple diamond (TAQMN) are hard to find. Please consider marking them within the figure.
Response: Figure (2) is revised to add text and larger markers to indicate the locations of observational sites.