Reply to Reviewer's Comments

We would like to first thank the editor and two anonymous reviewers for their comments to help improve our manuscript. Below we give a point-to-point response to address the reviewers' comments. The original comments are in black and our responses are in blue.

Comments from Anonymous Referee #1

The paper presents an interesting analysis of dust storm in the Yangtze River Delta based on the simulation from the CMAQ air quality model. The manuscript is well written and easy to understand and is an interesting contribution to the scientific literature. I recommend it for publication in ACP after the authors provided additional clarifications and addressed the comments given below. I hope the authors are able to address these comments, perform the requested changes and revise the manuscript within a couple of weeks.

The comments:

1. In general, the simulations are much higher than the observations for the wind speed because of the low resolution of the terrain and land-use, especially in the coarse domain. Therefore, the nearly perfect comparison between simulations and observations in the manuscript is not reasonable. Please clarify it.

Response: Thank you for the comments. We agree that there should be differences between the simulated wind speeds and the observations. Firstly, to improve the simulations, we have used carefully Data Assimilation(FDDA) techniques in this study. FDDA is a technique by which the observations are combined with the first guess fields and their respective error statistics to provide an improved estimate (the analysis) of the atmospheric state. It is proved that FDDA can significantly improve our ability to forecast the meteorological conditions. Secondly, although the bias and gross error (GE) between the simulations and observations for wind speed are small, other statistical indicators, for example, the root mean square errors (RMSE),1.82, 1.69, and 1.35 for Domain 1, Domain 2 and Domain 3, respectively, indicate that our simulation is not "perfect". In fact, similar model performance for wind speed can also be found in previous studies for China (Zhao et al., 2013; Wang et al., 2010).

2. Wind direction is strange parameter. 360 and 0 is the same for the wind direction. However, when you want to calculate the average of the wind direction, you will get a result of nearly 180. When you calculate the average of the wind direction in a period or a region, mostly you will get a result from 90 to 270. Please clarify the method you used to calculate the wind direction in your manuscript.

Response: Thank you for your comments. In this study, the range of wind direction was $0 \le wind\_direction < 360$ degree. It was calculated based on U-wind speeds (uu) and V-wind speeds (vv) and had a unique value. The simulated wind direction was calculated according to the following method,

(1) when U-wind speed is larger than 0,

$$wind\_direction = 270 - \frac{180}{\pi}\arctan(vv/uu)$$

(2) when U-wind speed is smaller than 0,

$$wind\_direction = 90 - \frac{180}{\pi}\arctan(vv/uu)$$

(3) when U-wind speed is equal to 0,

$wind\_direction = 180$ (if vv is larger than 0)

$wind\_direction = 0$ (if vv is smaller than 0)

$wind\_direction =$ missing value (if vv is equal to 0)

To clarify, we have added some description in the manuscript (see Page 7, Line 22-24).

3. In the manuscript, the authors compared the simulations and observations of the PM10. Could you please give us the comparison of the spatial distribution for the PM10 concentrations? In this way, more information will be illustrated, such as the comparison in different days, the pathway of the dust storm and so on.

Response: Thank you for your suggestion. **Figure R1** shows the comparison of the spatial distribution for the PM_{10} concentrations. In general, the spatial distribution of the observations was consistent with the simulations, especially near the source region (like that on 29 and 30 April). We can also see some overestimations at the downwind regions. The possible reason is that the shown simulated results are average values for 36km grid and it's difficult to capture the specific concentration for every point accurately for some time.

We have added the discussion to section 3.2.1 and supplementary materials. The transport path of dust has been illustrated in section 4.3, so we don't discuss this based on **Fig.R1**.

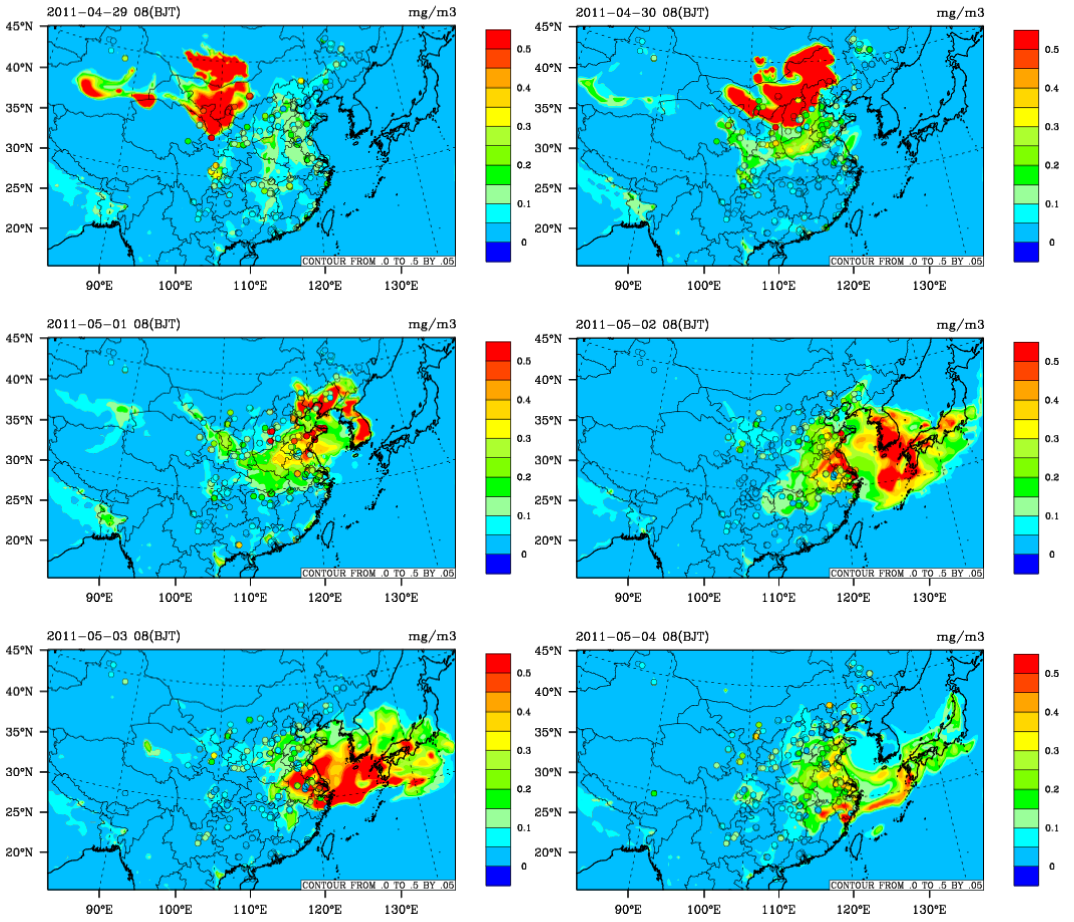
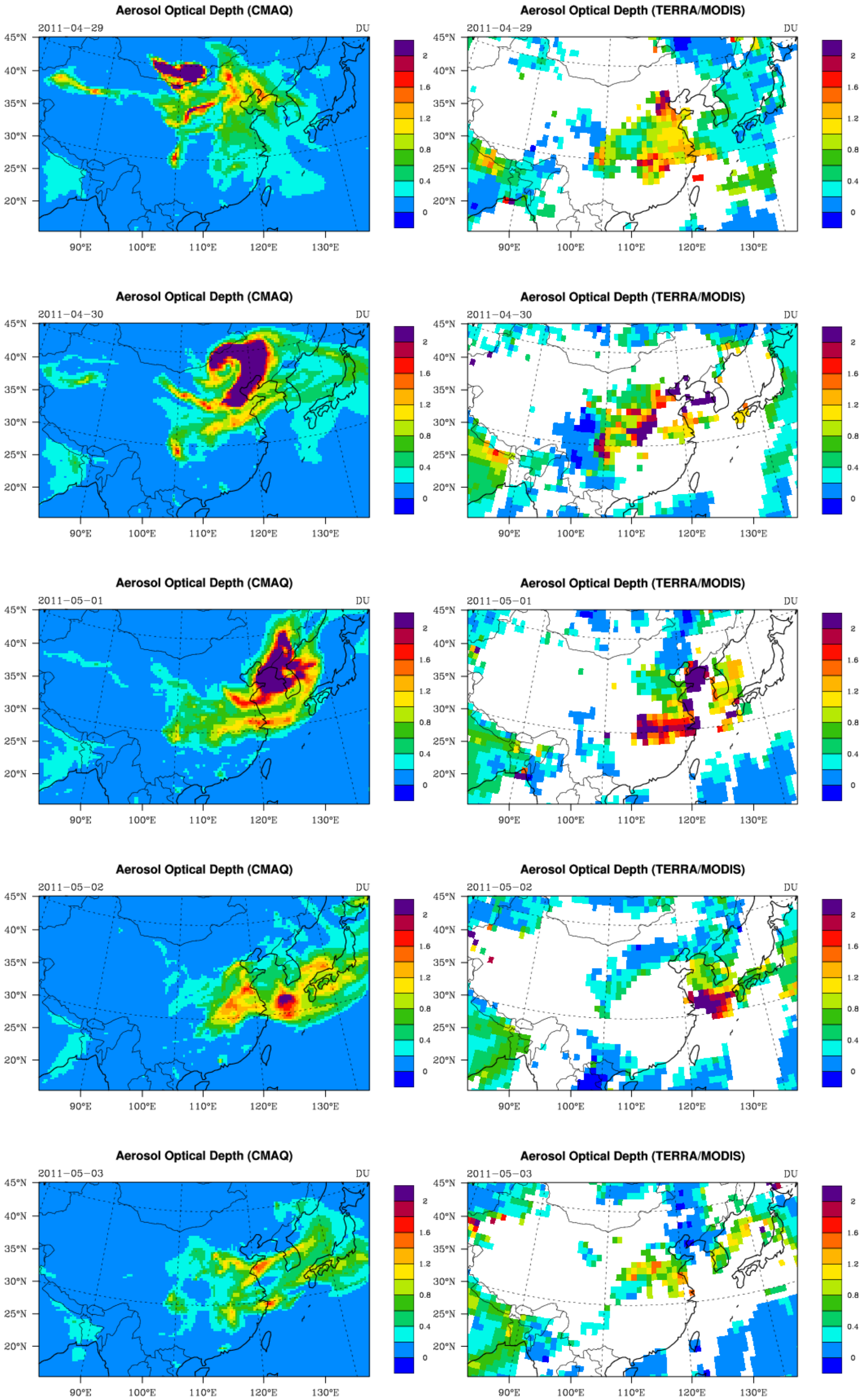


Fig.R1. Spatial distribution of the observed (the dots) and simulated (the contour) PM_{10} concentrations.

4. As for the dust storm, except for the ground observations downloaded in the website MEP, satellite data also should be used to do the comparison, such as AOD and AAI(absorbing aerosol index). As shown in the figure in 29 April, there are two points of the highest concentration of the PM10. However, you can only get one maximum point in the simulation. In addition, no dust storm was observed in 28 April and the spatial distribution of the AAI was also not consistent with the simulations. Please clarify it.

Response: Thank you for the comments. We have added the comparison between the simulated AOD and MODIS product in section 3.2.2 of the revised manuscript and supplementary materials. The comparison is shown in **Fig.R2**. We can see that the agreement between simulated and observed AOD is reasonably acceptable, demonstrating the ability of DUST_REVISED in capturing both the day-to-day variations and the spatial patterns of aerosols.

We also tried to compare the simulations with AAI. The overpass time of GOME-2 is 9:30 BJT, so the AAI images you showed presented the picture of China at that moment. We compared it with the simulated PM_{10} concentration at 9:00 BJT (shown as **Fig.R3)**.It can be seen that the spatial distribution of the AAI was generally consistent with the simulations.



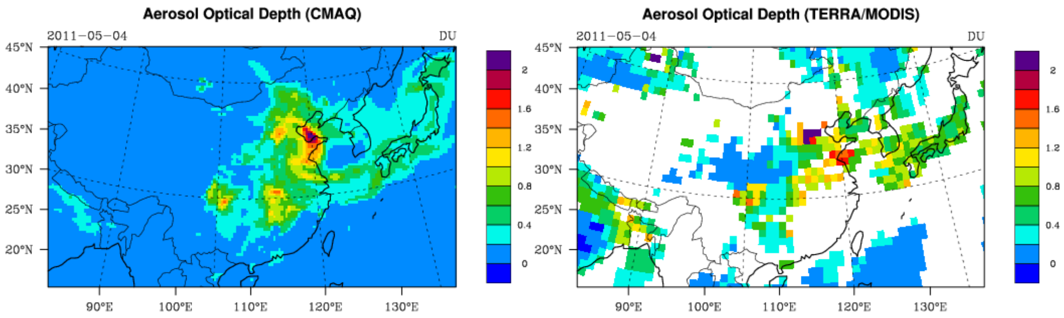


Fig.R2. Aerosol optical depth at 550 nm in 29 April to 4 May from model simulations (left) and from satellite measurements (right)

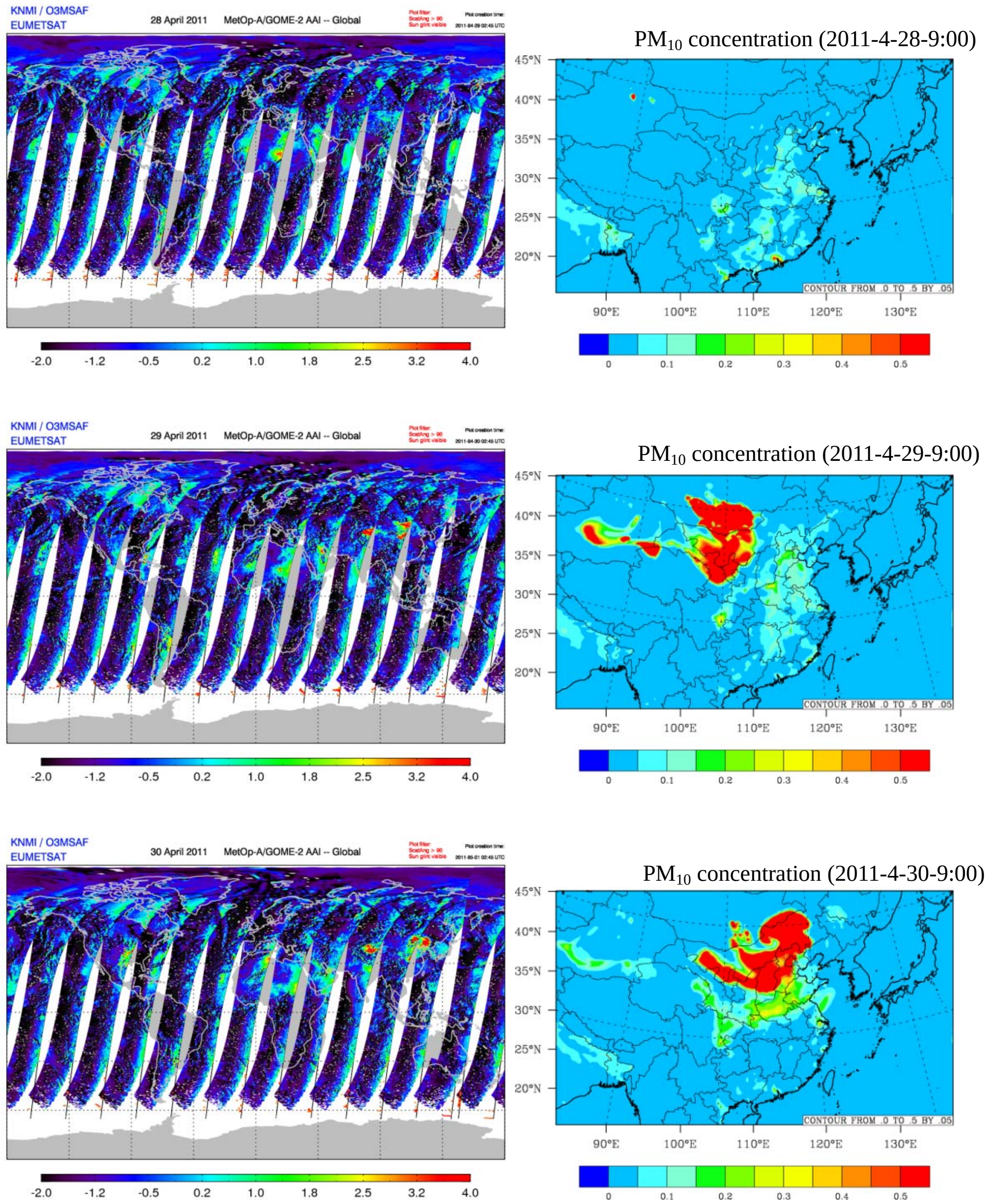


Fig.R3. Absorbing aerosol index (AAI) from GOME-2 (left) and the simulated PM_{10} concentration (right)

5. I noticed the wet deposition was much higher than the dry deposition for the PM10.The authors illustrated that the wet deposition was main occurred over the sea. However, even in the mainland of China, the wet deposition was also the main loss compared to the dry deposition. Why? Could you please give us some description of the cloud fraction and precipitation?

Response: Thank you for your comments. We agree with you that the wet deposition was a main loss compared to the dry deposition in the mainland of China averagely. But in our study, the dry deposition and wet deposition for PM_{10} were 184.7kt and 172.6kt, respectively. The total dry deposition is a little higher than the total wet deposition of PM_{10}.The major reason is that wet depositions are associated with precipitation and dust concentrations. Only 0.03cm precipitation was observed in Shanghai during 1 to 6 May. The distribution of simulated cloud fraction and precipitation during 1 to 6 May is shown as **Fig.R4**. It can be seen that there was little precipitation in the domain. The high values of cloud fraction and precipitation only occurred at the bottom of the domain. As the description in section 4.3, dust particles were transported from north to south, and then from sea to mainland, so the dust concentration was relatively low at the bottom of the domain. The distribution of wet deposition was generally similar with the distribution of precipitation. We have added some description in the revised manuscript (see Page 13, Line 23-24).

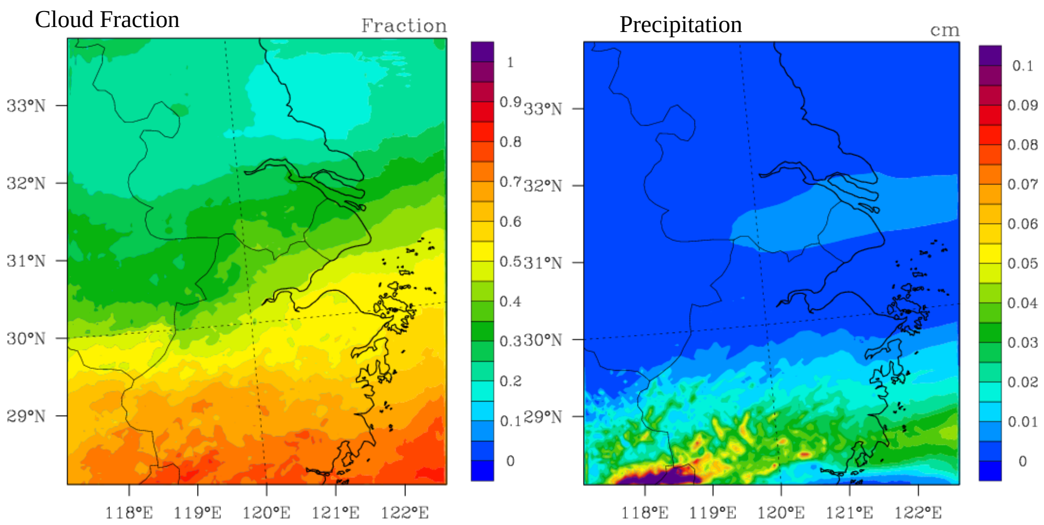


Fig. R4 Average cloud Fractionand precipitation distribution from 1 to 6 May

References cited in this response:

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Zhao, B., Wang, S. X., Wang, J. D., Fu, J., Liu, T. H., Xu, J. Y., Fu, X., Hao, J. M.: Impact of national NO_X and SO_2 emission control policies on particulate matter pollution in China, Atmospheric Environment, 77, 453-463, 2013.