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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Long-range transport of Asian dust and air pollutants to Taiwan: observed evidence and model simulation" *by* C.-Y. Lin et al.

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We greatly appreciate the constructive comments from the anonymous referee #1. We have carefully considered his comments and have the revision finished, accordingly. Our responses to his comments are as follows:

1. Page 10184 lines 11: Are the dust and pollutant air masses really transported separately? Judging from the observation results described in this paper, the peak concentration times differ, but are they already mixed when they arrive to Taiwan ?

Response: The composition analysis in the text showed that pollutants are the major component of the first PM10 peak (00UTC, Mar. 18) while dust is the major composition of the second peak (04UTC, Mar.18). From the backward trajectory analysis starting from 00UTC (Fig. 3) and 04UTC (We will add a backward trajectory analysis started

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from 04 UTC in the revised version) in northern Taiwan showed that these two peaks come from quit different sources areas. The air masses of the first peak mainly come from anthropogenic area while the masses of the second peak originate from desert areas. Although the mixing takes place on the way to Taiwan, it mixes slightly when they arrived Taiwan. Thus we are able to separate their paths by trajectory analysis.

2. Page 10184 lines 18: which is more important: transport paths or atmospheric boundary conditions ?

Response: Both are equally important. However, the intensity of separated high pressure and its location determine the transport paths. Actually, the source of the cold air comes from northern of China with dry weather condition. Under dry and stable atmospheric boundary conditions, the dust and air pollutants are usually transported below the mixing level (nearly 2.0 km in this study). Under these conditions, the transport paths determine whether the air masses pick significant air pollutants or not. For example, if the air masses mainly pass over anthropogenic pollution areas, they will occasionally pick up air pollutants. On the contrast, if most of the path over ocean, turbulence will let the masses of dust and air pollutants much well mixing.

3. Page 10185 Second paragraph: The authors mention that the results by Prospero et al. and Uno et al. are always mixed but in this paper's case, they are decoupled. This statement might lead to a misunderstanding. What is most important, is the transport path and location of the receptor (such as Midway)? A more detailed description is necessary for the case in which they are de-coupled and /or mixed.

Response: As replied in questions #1 and #2, the transport paths would be the most important factor if under the same weather condition. This is probably the result from a boundary layer, the turbulence mixing because of the cold winter monsoon winds over the relatively warm Kuroshio Current, over the East China Sea upwind of Taiwan.

4. Page 10186 lines 22: what is inconsistent?

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Response: Text amended in revised version, It is mean “separately transport between Asian dust and air pollutants”.

5. Page 10188 lines 11: Is NAQPMS used in a nesting grid structure ? if not, please mention it.

Response: Even NAQPMS model can employ multiple level nested grid only one domain was employed with 81 km resolution in this study.

6. Page 10189 line 18 Equation (1) What are W and R ? C1 must be a grid-size dependent parameter, what is the unit

Response: Text amended in revised version. W is the humidity factor and assumed to be linearly dependent on the relative humidity. C1 is an empirical constant set as 2.9x10-11 (Hu and Qu 1997, Wang et al. 2000).

7. Page 10189 section 4 This section has only Section 4.1. Do you need another subsection ? if not, remove the line of ‘Section 4.1’ designation and include your text into section 4 instead.

Response: We do have specific sections as “section 4.2 simulation result and discussion” in Page 10193, line1.

8. Page 10190 lines 13-29: The authors reported that the peak concentration time difference between dust and air-pollution is approximately 3 h. How do you explain this time lag ? Based on the location of main sources of dust and air-pollutants, can you explain this difference? Reader will require more quantitative analysis of this lag.

Response: In the text, we stated the first peak occurred around 0800LST (0000UTC, Fig. 3) and the major contribution is pollutants because the sources of air mass come from rich anthropogenic areas. However the second peak occurred at about 1200LST(0400UTC) (We will add a backward trajectory analysis started from 04 UTC in the revised version), with the source of air masses originated from higher altitude ($>$ 4000 m). Therefore, the air masses follow high pressure system with much faster

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speed to Taiwan. For example, the back trajectory started at 0400 UTC showing the air masses is located in Inner Mongolia while trajectory started at 0000UTC showing the air masses is located in nearby Beijing on March 16.

9. Figure 5 may not be necessary. See Comments in 16 below.

Response: The figure dropped in the revised version.

10. Figure 6: This figure shows the high backscatter for the air-pollution component, but for the dust component, the backscatter is small (depolarization is also small). Does this mean that the level of dust is less than that of the air pollution ?

Response: No, The total depolarization ratio is a non-unit while the unit for attenuated backscattering coefficient is “steradian” (Measures 1984). In general, the total depolarization ratio is greater than 0.05 in Taiwan (Chen et al., 2006) representing significant dust particle contribution.

11. Page 10193 Second paragraph: Figure 10: I can read that the peak times of SLUF and HNO3 are different. Why ? From my perspective, from Fig. 9 and 10, the peak concentration times for dust and air pollutants are separated, but are they already mixed when they arrive in Taiwan ?

Response: We agree that dust and air pollutants have already mixed in some extent before they arrived Taiwan but not serious at all.

12. Page 10194: First paragraph: The description is very poor. Why is the emission inventory by Streets et al. an underestimation ? Readers will need reasons explained here, supported by appropriate references.

Response: Text amended in revised version. The emission inventory by Street et al. (2003) is based on year 2000. It could be underestimated of the emission apply to our case in 2005 not the study of Street et al.

13. Page 10194 Second paragraph: (a) Based on the trajectory analysis shown in

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Fig.3. Beijing is not located upstream of Taiwan. Therefore. Fig. 12 (Lidar result of Beijing) might not be necessary for the main thrust of this paper (See comments in 16 below for figure restructuring). (b) Insert the location of Miyakojima into Fig.3. (c) it might be wrong to assert that Miyakojima is not the upstream of Taiwan. In this case study, both Miyakojima and Taiwan might be located on the same front line of the pollutant outbreak. If so, add the trajectory from Miyakojima in Fig. 3. (d) Figure 11 and Fig.6: The polarization level of dust in Miyakojima and Taiwan shows a difference of almost two times. Why ? Does this arise from a difference of the measurement technique?(e) Figure 13: Again, the Beijing Lidar result is not essential in this paper.

Response: (a) We agree that Beijing is not directly located on the upstream of Taiwan based on Fig. 3. However, the trajectory of air masses location on 3/16 is quite close to Beijing, we consider it is reasonably with the resolution of the HYSPLT model is nearly 100 Km. Due to lack of observation data, lidar in Beijing is employed to examine the performance of our model in the upstream area. (b) Figure amended in Figure 3. (c) We added the back trajectory analysis started from Miyakojima. Apparently, air masses over Taiwan and Miyakojima are from the similar sources area. (d) In theory, Miyakojima is quite close to Taiwan; it is expected to have the same level depolarization ratio. However, local emission is significant in northern Taiwan while Miyakojima's local emission can be ignored almost. Therefore, the result of total depolarization ratio in Miyakojima is more evident than that of Taiwan. (e) The lidars network employed by NIES such as Beijing and Miyakojima provided important information for the dust event. The detected results can provide us to examine the model outputs as for there is not enough observation available. Although the Beijing lidar is not right on the way of back trajectory route which started at 0000 UTC 18 March., the trajectory of air masses location on 3/16 is close enough to Beijing. Therefore, the comparison between Beijing and model output is another boundaries to examine the model performance under the limitations of observation data.

14. Page 10195 Last paragraph: The authors have mentioned that this study is an

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exceptional case of dust and air pollutant transport to Taiwan. To identify the transport pathway and meteorological conditions for coupling and re-decoupling of dust and air pollutants to Taiwan, I recommend the inclusion of additional analysis for review here.

Response: We will conduct another detail analysis in a separate paper for the cases of the coupling of dust and air pollutants cases as for there is no researcher paper discus this phomenona over this region.

15. Page 10196 line 25-26: Streets emission part = same as comment #12.

Response: Text amended in the revised version.

16. The overall flow of this paper is not well organized because of the many similar figures (some of which are unimportant). I suggest major restructuring of figures and discussion using only necessary figures. Figure 2 is unclear. Redraw it to clarify its main points. Into Fig.3, insert the location of Miyakojima and the back-trajectory from there. Remove Fig.5. The location of inversion explainable by the text. Mege the information in Figs. 7, 9 and 11 into Fig. 6 as (c), (d), and (e). Remove Fig.10(if necessary, add a SULF concentration contour using dashed lines into Fig. 9). Remove Figs. 12 and 13 because they are not pertinent to the major thrust of this paper.

Response: According to the suggestions by the reviewer, Figures are amended in the revised version.

Technical corrections 17. Page 10195 lines 2 and 3: costal must be coastal (typo)

Response: Text amended in the revised version.

18. Page 10198 lines 19: Mematsu must be Uematsu

Response: Text amended in the revised version.

19. Table 2: what is MSU%

Response: Text amended in table 2 in the revised version. It means the fraction of

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Mass Size Distribution in the model.

20. Figure 2: Why did you insert NOx+O3. It is not used in the paper.

Response: Text dropped in the revised version.

References:

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Interactive comment on Atmos. Chem. Phys. Discuss., 6, 10183, 2006.