Atmos. Chem. Phys. Discuss., 11, C13257–C13265, 2011
www.atmos-chem-phys-discuss.net/11/C13257/2011/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "The impact of channel effect on Asian dust transport dynamics: a case in southeastern Asia" *by* C.-Y. Lin et al.

C.-Y. Lin et al.

yao435@rcec.sinica.edu.tw

Received and published: 16 December 2011

Reviewer 2:

Major comment: 1. The impacts of topography on the dust storm transport: a. Both Hysplit trajectories and GFS wind fields show that this dust storm moved toward Taiwan from northeast direction. Intuitively, the northern tip and east-side of the island should be affected more than the west side. As shown in the previous study by this author, Lin et al. (2005, Atmos. Environ.), the ground sites on the east side of Taiwan (all the way to the HC site at the southern tip) are affected by dust storms much more frequently (Fig 7 there), which I think represent the climatology of the dust impacts on Taiwan's air quality.

R: The backward trajectory may indicate the source and pathway of the air parcel well, but it cannot show how the dust be transported in detail. Generally speaking, it is true that the northeasterly monsoon prevails during winter and spring, and hence the wind direction mostly is northeasterly. However, the wind direction varies, in fact, strongly related to the location and movement of continental high pressure system. Sometimes wind direction over northern Taiwan could be northwesterly, northerly and northeasterly according to the location of continental high pressure system (Please refer to Figure A1 as following).

Our previous paper indicated the spatial PM10 distribution due to the long-range transport of continental Asian dust storms and their significant impact at eastern and south tip of Taiwan It is because at eastern Taiwan locations such as HL and HC (Figure 1 of this manuscript), the seasonal mean PM10 concentration (local emission), are quite low, about 30-40 ug/m3. On the other hand, average PM10 concentration could be as high as 80-100 ug/m3 at western and southwestern Taiwan due to the elevated local emissions. Also, as estimated by our previous paper (Lin et al. 2005) the average inflow concentration on the day after frontal passage could be as high as 71$\pm$34 ug/m3 during the DS event. Therefore, even though the average impact calculation is significant over eastern and south tip Taiwan, it is not necessary to say that those places are affected by dust storms much more frequently than the west, so as to the air quality impact.

b. While the 2010 March dust storm is a signiïňĄcant event, its transport pathway is someÂňhow special. I think the large spatial difference of dust concentration on both sides of the island is mainly due to the location of the PaciïňĄc high-pressure system. The high-pressure centered to the east of Taiwan prevented the strong dust storm sweep though the whole island, i.e. only north and southwest of Taiwan is affected by this strong storm. The mountain range may help to enhance the dust transport along the Taiwan Strait through the channel effects, while it seems not the main reason for the large east-west spatial gradients.

ACPD

11, C13257–C13265, 2011

R: This dust storm event was the highest Asian dust concentration event ever recorded in Taiwan. However, the transport path is not unique. The transport path is to follow the movement of continental high pressure system and the processes as shown in the schematic figures (Figure A1 as following). This point also can be identified from the back trajectory analysis. Thus the air mass is dominated by the continental outflow. Actually, we did study a few significant dust cases with this similar uneven PM10 concentration distribution and will be discussed later in a separate paper.

We agree the reviewer's comment that the mountain range may help to enhance the dust transport along the Taiwan Strait, and, in fact, this is one of our major points in the conclusion. However, if we revisited the evolution of the continental outflow (Figure A1) and data analysis in Figure 4, those processes can be clearly identified. After frontal passage at stage II, the dust concentration in the northern Taiwan is at the level about 1000-1500 ug/m3 (Figure 3a) and then high concentration dust could easily transport to the south over western Taiwan due to the channel effect we proposed. This point can be well illustrated from Figures 3b and 4. After the continental high pressure system moves to the Ocean, it gradually merges into the already existing Pacific high pressure system, and environmental wind direction then gradually changes from northeasterly to easterly (Stage III in Figure A1). In other words, at this final stage, say, after 12 UTC, 21 March (Figure 4d, Figure 7d), the high pressure center moves to the east of Taiwan and it blocks the dust southward transport. The simulation results (Figures 7 and 10-13) also support our points.

2. Model and observation comparison is lacking: a. Ground PM10 observations show very good spatial and temporal movement of this storm, we are wondering how well model can capture those features. The cross-session of the model in Fig 13 suggest that the gradient in model is less than that in observation. For example, Fig. 13 'd', the PM10 concentration around 600km line is pretty low, while at the 'CH' site, the observed PM10 is quite high.

R: The comparison between ground monitoring and simulation has been included in

ACPD

11, C13257–C13265, 2011

Interactive Comment

this revised version (Page18 L18-Page19 L7). Figure 8 in this revision, shows the time series of the comparison between observation and simulation PM10 concentration around Taiwan at stations, SL, CH, MG, HL and HC(Figure 8a-b) from 21 LST, 20 March to 07 LST 22 March, 2011. In the northern Taiwan at station SL, the peak concentration simulated quite well only with 2-h late for the peak occurrence. The variation of simulation dust concentration underestimated over western Taiwan at station HC. This is probably due to our model resolution still not good enough to simulate local distribution in detail. However, the model captures the characteristics of the dust transport at station HL, HC and MG even though observation data missing for station MG after 19 March, 2010.

b. Topography impacts on the simulated wind ïňĄeld: can authors show the comparison of control and QT vs. observations (at representative TEPA ground stations)? Since you used the data assimilation with GFS data (in both control and QT runs?), it would be interesting to see how they compare with the observations made at air quality sites as a relatively independent check.

R: Figure A2 shows the comparison of control (red), case QT(green) and observation (blue) at TC station (46730) as following. The simulation results showed that the V-component with the significant different after 21 March. As the topographic reduced to a quarter of its original height, the simulation of northerly wind (negative v-component) wind speed reducing by 3-5 m/s than control run during 21-22 March. The channel effect can be clearly identified from this experiment.

3. Please see attached CALIPSO curtain plots (2010-03-21) along two tracks close to Taiwan, which show both composition and elevation of the aerosol types. It seems dust mixed with anthropogenic aerosols (polluted dust) and smokes, and they came to Taiwan in a descending motion. It is not very clear how authors averaged the CALIPSO observation to get the vertical proïňĄle show in their paper, the aerosols in high altitude is somehow removed.

ACPD

11, C13257–C13265, 2011

R: What we really concern in this paper is the high dust concentration transport dynamic in the low boundary. Figure A3 shows the vertical distribution of extinction and depolarization from surface to7 km. In fact, the extinction coefficient of the aerosols layer above 5 km is significant lower than that in the low boundary. We agree that dust would be mixed with anthropogenic pollutants. However, the anthropogenic aerosols are the minor contributors according to our results in Figure A3. In this study, extinction and particle depolarization profiles are averaged along the selected CALIPSO tracks in order to avoid the signal influence from cloud. Moreover, the particle depolarization is vertically smoothed for every 300 meters owing to signal intensity consideration.

Other comments: 1. Page 26445, line 9, mentioned FGGE data, while author didn't speciïňĄed how those data were used in this study? To drive the model? Validate the model?

R: The FGGE data is the reported by the ground stations. In this study, we used those data to roughly validate the dust transport with the simulation results. (Page 6, L20)

2. Page 26449, line 6, 'In other word, ...', it is not clear how could author reach this conclusion from the HYSPLIT result. Air mass reached HC site went through very similar pathways as other sites.

R: We agree the reviewer's comment and this sentence already dropped.

3. Page 26541, line 4, mountain channeling effect can explain the timing of the dust peak concentration at different sites, while it can't explain the large spatial gradient.

R: As response in the major comment #1, we further presented the relationship between continental outflow and the movement of high pressure system to identify our points.

4. Page 26452, line 19, it should be 'As mentioned'.

R: Text has been amended (Page 17 L16).

ACPD

11, C13257–C13265, 2011

Interactive Comment

5. Page 26457, line 20, we didn't see the comparison between model with ground observation, CALIPSO, and MODIS.

R: The description has been amended in this revision because we only compared in qualitatively between simulation and MODIS (Page25 L14-18). The comparison between model and ground observation has been included in this revision as response in major comment #2.

6. Fig. 3, those results are based on the WRF simulation or observations?

R: For Figure 3, those results are based on the observations (Page 34 L9)

7. In Fig. 4, please outline the location of Taiwan Island and coastline. In other 2d maps, it would be nice if the island is outlined more clearly.

R: Figure quality has been improved. We integrated the original Figures 4 and 5 as shown in this revision Figure 4.

8. Line dust region is not used in other discussion

R: The discussion of the observation from CALIPSO in Figure 6 is to identify our major point, the uneven distribution of PM10 concentration. For example, in Figure 6, along CALIPSO orbit tracks 06Z and 06Zs are different in extinction and PM10 concentration. Also, please refer to the response of major comment #3.

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/11/C13257/2011/acpd-11-C13257-2011-supplement.pdf

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 26441, 2011.

ACPD

11, C13257–C13265, 2011

Interactive Comment

Response to Reviewer#2: Figures supplement

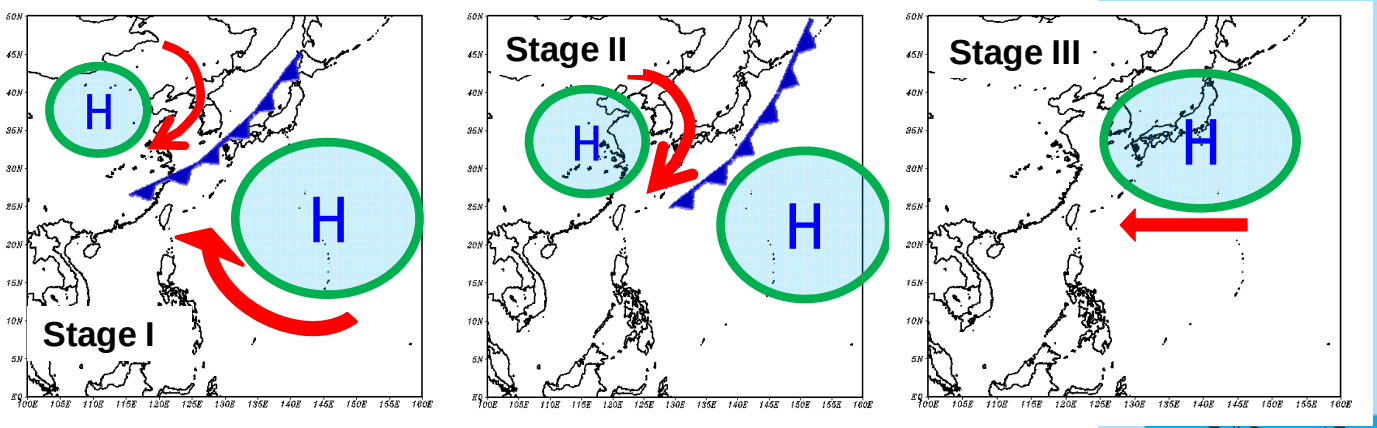

Figure A1: Schematic of the relationship between the movement of continental highs and associated wind direction around Taiwan. Stage I: Taiwan is covered in a warm air while a front is approaching. Stage II: continental cold air outflow after frontal passage. Stage III: the outflow rebound by the high pressure

ACPD

11, C13257–C13265, 2011

Interactive Comment

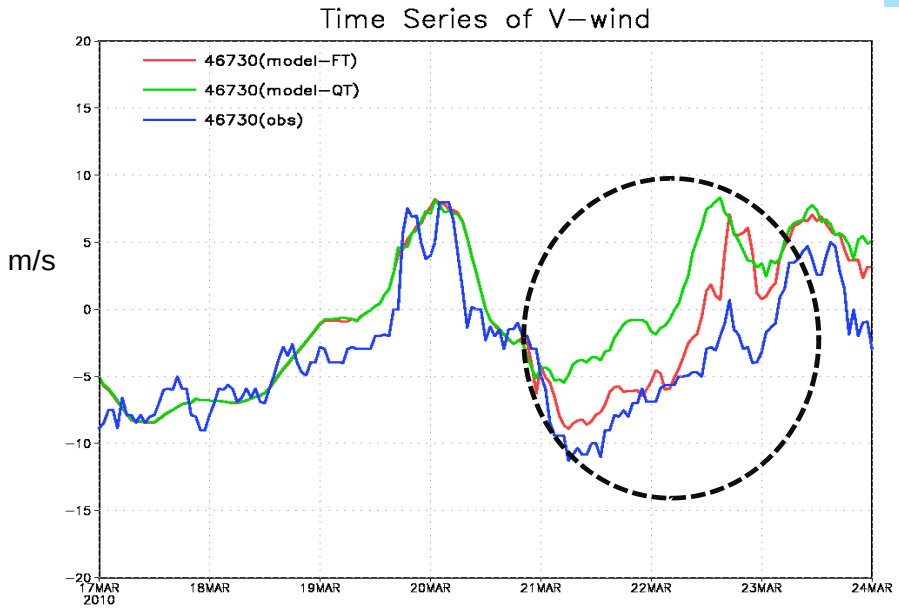

Figure A2: The N-S component of wind speed at station TC (46730) for observations (blue), for simulation case QT(green) and control run (red) during 17-24 March, 2010.

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

ACPD
11, C13257–C13265, 2011

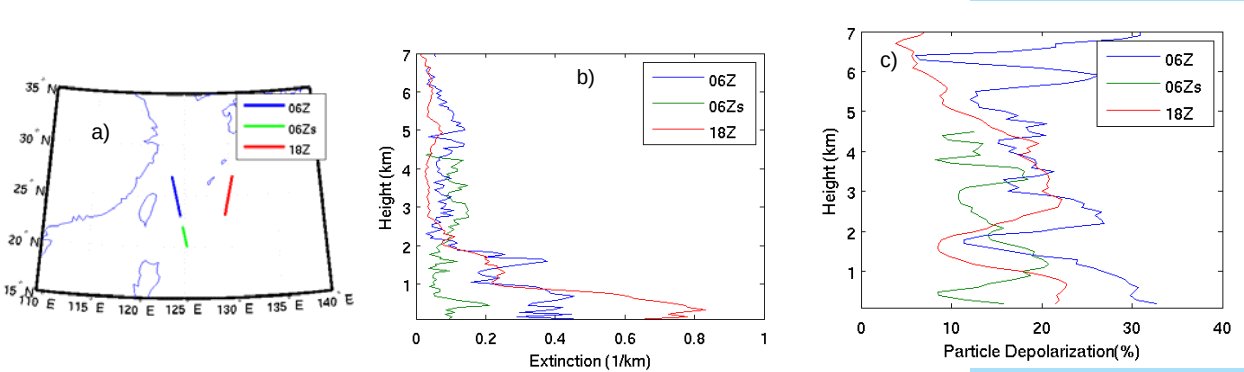

Figure A3 (a) The CALIPSO orbit tracks around Taiwan at 06:00 UTC (blue and green), and 18:00 UTC (red), 21 March 2010. (b) The vertical distribution of extinction coefficient deduced from CALIPSO Lidar at orbit tracks in (a) around Taiwan. (c) The vertical distribution of the percentage of depolarization ratio from CALIPSO Lidar at orbit tracks in (a) around Taiwan.