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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Impact of the East Asian summer monsoon on long-term variations in the acidity of summer precipitation in Central China" *by* B. Z. Ge et al.

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Reply to Referee 1: We thank referee 1 for reviewing our paper and giving valuable comments. The following are our detailed responses to the comments:

General Comments: In this paper, the authors investigate the impact of East Asian summer monsoon on the variations of acidity in China. The target of this paper is quite interesting and appropriate to this journal. It seems this paper should be published in ACP, but I think the authors should do more analysis of data (especially model output) for the evidence of their results. In addition, I am wondering why the authors use

off-line model output for the analysis of relationship between precipitation and aerosol property. The concentration of aerosols might strongly affect to the cloud properties and precipitations via indirect effects. On-line models such as WRF/Chem should be useful for analysis of precipitation-aerosol interactions.

Reply to general comments: We agree that the concentration of aerosols could affect the cloud properties and precipitations. But in this paper, we do not focus on the correlation between precipitation and aerosol property. We just try to figure out how the changes in East Asia summer monsoon can affect the changes of precipitation sulfate and nitrate concentration in Central China. WRF/Chem performs well in analyzing precipitation-aerosol interactions. However, our work focuses more on the climatologic differences and CMAQ, as one of widely used air pollution models, is a suitable tool. In addition, model period is from 1992 to 2003. For such a long period huge calculations need to be done and using an on-line model needs resources beyond our limitation.

Detailed comment 1: Page 19596, line 17: Please write clearly the period for analysis. It seems the authors use data from June to August, because East Asian summer monsoon has been used for analysis in section 3.2.1. Is it true?

Reply to comment 1: Yes our analysis period is from June to August during 1992∼2006. It is mentioned at Page 19596, line 17, "we choose to focus on summertime and study the contributions . . .. . .". This sentence is changed to " we choose to focus on summertime (from June to August) and study the contributions . . .. . ."

Comment 2: Page 19579, section 2.2, The authors should show the figure for model domains. Are figures 8, 11-12 from the output of domain 2?

Reply to comment 2: The model domains are provided in Figure 2 in our revised manuscript (for more details see Yamaji,et al., 2006). We revised the manuscript in page 19597, line 12-13, "The horizontal resolution of the model is 80km for the mother domain and 20 km for the nested domain", to "The horizontal resolution of the model is 80km".

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Comment 3: Page 19597, section2.2 : The latest version of CMAQ is 4.7.1. Why did the authors use version 4.4? It seems the concentration of nitrates is improved in the latest version by considering N2O5 reactions and NH3 emissions (cf. http://www.cmascenter.org/conference/2010/slides/bhave_simulating_annual_2010.ppt). Figure 1 shows that the concentration of nitrates calculated by the model tend to underestimate in summertime by the factor of 10 or higher. The deficit of nitrates clearly affects to pH, and the authors should explain the cause of this underestimation of nitrates, or focus on the concentration of sulfate, not pH.

Reply to comment 3: Our model simulations were done before the latest version of CMAQ 4.7.1 was issued. The underestimation of nitrates may be caused by the model's horizontal resolution (80*80km/grid), which is too coarse to perform well for urban sites. We have compared our simulation results (CMAQ 4.4) with the observation data from rural sites of EANET which can reflect the larger area and the results are closer than that from cities (See Figure 1 and Table 1 in our revised manuscript). In Chongqing area, the differences of modeled and observed concentrations are -16.1% and 4,0% for sulfate at urban and rural sites, respectively, and 29.3% and -23.2% for nitrate at urban and rural sites, respectively. In Xiamen area, the differences of modeled and observed concentrations are 10.9% and 69.1% for sulfate at urban and rural sites, respectively, and -11.8% and 2.8% for nitrate at urban and rural sites, respectively (see Table 1 in our revised manuscript for details). All modeled concentrations for rural sites except sulfate in Xiaoping-Xiamen are closer to the observation data than for urban sites. The exception in Xiaoping-Xiamen may be due to the very low observed sulfate concentration. Since rural sites often represent larger regions and urban sites are more easily influenced by local emissions, we believe the poorer model performance for the urban sites is resulted from the coarse horizontal model resolution. In spite of this drawback, the model results are acceptable and can answer our purposes in this paper as almost all the relative biases are below 30%.

Comment 4: Page 19600, section 3.1.1: The authors should show how to make the

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spatial pattern of VWA pH from the observation data of 74 stations. Was the spatial pattern simply made by the distance from the stations?

Reply to comment4: We used Cressman interpolation method to make the spatial pattern of VWA pH from the observation data of 74 stations. Details about the Cressman interpolation can be found in "http://iridl.ldeo.columbia.edu/dochelp/StatTutorial/Interpolation/".

Comment 5: Page 19602, section 3.2.1: There might be a relationship between the pattern of pressure system in East Asia and EAMI, but it is not clear that there is a clear relationship between the precipitation in Central China and EAMI. It seems there is a negative relationship between precipitation in Central China region and EAMI in June and August, and almost no correlation in July (cf. http://www.lasg.ac.cn/staff/ljp/data-monsoon/EASMI.html). This negative correlation can explain the high precipitation in 1998, in spite of low EASM in that year. I wonder why the authors show the relationship between EAMI and pH.

Reply to comment 5: We agree that there is no clear relationship between the precipitation in Central China and EAMI. In our manuscript, we focus on the relationship between the precipitation acidity in Central China and EAMI. East Asia monsoon may strongly influence the wind field of almost half of China's land area, from the southeast coast to the North China Plain. Due to higher mountains northern and western China, larger amount of air pollutants emitted in southeastern coast regions would be transported to Central China under stronger East Asia monsoon, resulting in increased concentrations of acidic pollutants in Central China (see Fig. 8 in our revised manuscript) and lower precipitation pH. Stronger East Asia monsoon can also cause lower rainfall in MLYR (Middle and lower reaches of the Yangtze River) (Fig. 10a in our revised manuscript), so that more pollutants can be transported to Central China by northwesterly winds in summer. As a result, the concentrations of acidic pollutants in Central China will increase further and influence the pH finally.

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Comment 6: Page 19604, section 3.2.2: The authors mentioned about 'teleconnection' between pH in Central China and rainfall in the MLYR, but it seems this result is not so surprising. In summertime, northerly wind is dominant in the Central China region. If the humidity is low in Central China region, pH can be higher because of low activity of wash out process. That air mass will be transported from the Central China to MLYR by the northerly, and finally, precipitation in MLYR might be low. Why you want to mention this 'teleconnection'?

Reply to comment 6: We use "teleconnection" because that as we mentioned monsoon, "teleconnection" between monsoon and precipitation came into our mind. Many investigations find out that the changes of East Asia summer monsoon have some effects on the changes of rainfall in the MLYR (Li and Zeng, 2005). However, southeastern wind is dominant (Figure 3 in attachment) in Central and southeastern China in summertime. As the East Asia summer monsoon is very strong, the rainfall in MLYR will be decreased and large amount of air pollutants will be transported from southeastern to Central China, finally increases the precipitation acidity in this area. So this "teleconnection" between pH in Central China and rainfall in the MLYR shows the pattern of this mechanism.

Comment 7: Page 19616, Figure 1: The caption of figure 1 is insufficient. What does 'sulfate and 2000-2003' mean for?

Reply to comment 7: We apologize that some words in the caption of Figure 1 was missing. In the revised manuscript the caption reads like "Time series of modeled and observed monthly volume-weighted mean concentrations of sulfate and nitrate for EANET sites and GAW background stations"

Comment 8: Page 19617, Figure 2: There is no stations in Spratly islands. Why did you show these islands in the map? (also in Figure 3-5, 8-12)

Reply to comment 8: Actually, there is no station in Spratly islands, and they are shown in our maps because it is required by the financial supporter of this study.

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[1] Yamaji K, Ohara T, Uno I, et al. Analysis of the seasonal variation of ozone in the boundary layer in East Asia using the Community Multi-scale Air Quality model: What controls surface ozone levels over Japan? Atmospheric Environment, 2006, 40(10): 1856-1868. [2] Li, J. and Zeng, Q.: A new monsoon index, its interannual variability and relation with monsoon precipitation, Clim. Environ. Res., 10, 42–46, 2005.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 19593, 2010.