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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Anthropogenic forcing of shift in precipitation in Eastern China in late 1970s" *by* T. Wang et al.

T. Wang et al.

wangtao@mail.iap.ac.cn

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Response to the comments on "Anthropogenic forcing of shift in precipitation in Eastern China in late 1970s" of referee 1

This study used a coupled AOGCM to decipher the causes of interdecadal summer precipitation shifts in Eastern China. The authors stated that the westward shift of the WPSH induced by rapidly increasing GHGs led to increasing precipitation in the YRV, while the reduced summer land-sea thermal contrast caused by aerosol cooling contributed to weakened EASM and drought in Northern China. Together, the effects of GHGs and aerosol led to the interdecadal shift in Eastern China in the 1970s. Overall, this paper contains some interesting parts, but the results/conclusions are not convincing. It seems that some statements in the manuscript were not based on the facts shown in the figures, but were based on the desire of the authors. Additionally, whether the interdecadal shift in Eastern China in the 1970s was caused by GHGs and aerosols or the internal climate variability was not clearly analyzed. I have some comments which the authors need to address adequately and faithfully, if they wish their paper to be considered for publication in ACP. Details of my comments are listed below:

1) Four sets of historical simulations (ALL150, ANT150, NAT150 and CTL150) covering 1850-1999 were carried out in this study. The effect of greenhouse gases (GHGs) and the tropospheric sulphate aerosol were considered together in ANT150. There were no specific simulations to isolate the impacts of GHGs and aerosols. Your Fig.10d clearly suggested an increasing land-sea thermal contrast (stronger warming in the land compared to the ocean), which does not support the dimming effect of the aerosols and reducing land-sea thermal contrast (see page 12007, last paragraph). The slightly cooling in land shown in ALL150 is actually caused by natural forcing (NAT150, see Figs. 10c and 10e). Therefore, your statements and conclusions that the cooling effect of the anthropogenic aerosols led to weakened EASM and drought in the Northern China is incorrect, or at least is not supported by your results.

Response to the comment 1: We partly agree with the reviewer on this point. The present model results can not support the conclusion that the slightly cooling in land in ALL150 is caused by aerosols, particularly when we lack of an only aerosols ensemble. In the revised manuscript, we attribute these cooling and less pronounced warming over eastern China partly to the natural forcing (i.e. volcano), and partly to the responses of land surface to enhanced precipitation (surface evaporative cooling) and convection (reflecting more shortwave radiation). At the same time, we also point out that the cooling effects from anthropogenic aerosols are not negligible either, which could contribute to these cooling or less pronounced warming over eastern China in ALL150 and ANT150. The detail analysis please see P14,L15-32. Thank you for this comment.

2) Based on your reasoning, the drought in Northern China and the flood in the YRV should persist in recent 10 years given the rapid increases in GHGs and aerosols. However, the 'southern flood and northern drought pattern' was reversed in recent years. Similar precipitation shifts like the 1970s can be found in the early half of the twentieth century and the past 500 years (Qian and Zhu, 2001, Climatic Change, 50, 419-444; Zhu and Wang, 2002, GRL, 2001GL013997; Qian et al., 2003, Clim Dyn, 21, 77-89). Those shifts occurred when the impacts of GHGs and aerosols were weak. Therefore, the interdecadal shift in Eastern China in the 1970s may be caused by internal climate variability not the anthropogenic forcings.

Response to the comment 2: At first, thanks very much for this comment. In the revised manuscript, we have added more analysis both on the model results and observations and associated mechanisms, further confirming that the anthropogenic agents play a dominant role in shaping the East Asian climate changes and anomalous precipitation pattern over eastern China in the second half of the 20th century. In addition, we also make the discussion on the reason of the reversed precipitation trend over eastern China during the resent 10 years. As follows in the revised manuscript (P16, L19-30):"In recent 10 years, the annual-mean global temperature has not risen (Fig. 20a; Easterling and Wehner, 2009; Foster and Rahmstorf, 2011), despite the continued increased anthropogenic forcing. A recent study tied this current hiatus in global warming specifically to a La-Niña-like decadal cooling, a strong intrinsic climate variability, in the eastern tropical Pacific (Kosaka and Xie, 2013). This decadal cooling could further regulate the Indian Ocean SST through air–sea interaction (Du et al., 2009). Thus, a similar hiatus in SST warming can also be seen in the Indian Ocean (Fig. 20a). However, the warming caused by greenhouse gases in the mid- and high latitude regions (Kosaka and Xie, 2013) and East Asian continent (Fig. 20b) continued in the boreal summer during this period. That means the heat forcing over the Indian Ocean will be relatively weak during this period, in contrast to the strong heat forcing that is seen in the second half of the 20th century. This is one potential explanation for why the southern flood and northern drought pattern is reversed in the recent 10 years." As the reviewer mentioned, in the early 20th century, the similar precipitation pattern indeed existed during the 1920s-1940s (also see Fig. 7 in the revised manuscript). Although the impacts of GHGs and aerosols were weak during this period, the external natural forcing played an important role in heating the Indian Ocean SST (Fig. 11c in the revised manuscript), which could have further resulted in the similar shift in precipitation during the early 20th century. In fact, we are preparing another manuscript to address this related question, therefore not be discussed further in this revised manuscript. On the other hand, it is also implied that the similar precipitation pattern in eastern China in the past climate may be caused by the natural external forcings, even the intrinsic variability of the climate system. They are not paradoxical with our present conclusion, focusing on the shift in the late 1970s.

3) The observations from 740 weather stations contain data from 1951 to nowadays and the CRU data was updated to 2010. Why you restrict your analysis to the period of 1958-1995? Can you obtain the same conclusions by including the data in recent 10 years?

Response to the comment 3: There have been some previous studies to address this shift in summer precipitation in the late 1970s, usually restricting their analysis from mid-1950s to late 1990s. It can be seen in the CRU results (Fig 7 in the revised manuscript), in fact, this interdecadal shift happened during the period from mid-1950s to mid-1990s. Since 1995, the summer precipitation began to increase over the NC (also see Fig 6 in the revised manscript), implying a beginning of the reversed shift in recent 10 years. Thus, we restrict our analysis to 1995. On the other hand, changes in circulation are direct factors to affect precipitation. In this study, we really want to use as much data as possible to evaluate our model results. Particularly for the reanalysis data, there are still some uncertainties between them, as shown in Fig 17 and Fig 18 in the revised manuscript. Because the ERA40 data begins from 1958, we restrict our analysis from 1958. In fact, the analysis on the periods 1955-1995 and 1958-1995 shows the same results. Because we focus on the shift in climate changes on an interdecadal timescale in this study. In the recent 10 years, the precipitation pattern reversed, the possible reasons have been addressed in the Response 2 and discussion part in the revised manuscript.

4) Page 12005, 2nd paragraph. Did you calculate the correlations between observations and the modeled precipitations after 3-yr running means (see the caption of your Fig. 6)? If so, you should consider the reducing degree of freedom in the observed and modeled precipitation time series when testing the significant level of their correlations.

Response to the comment 4: Thanks very much for this comment. We indeed neglected the changes of degree of freedom after 3-yr running means in Fig. 6. The P-value is only about 0.2, not significant after considering the reduced degree of freedom. Therefore, we have deleted the related statements in the revised manuscript.

5) Fig.11. You are analyzing the EASM and the anomalous temperature pattern in Eastern Asia. So it is more appropriate to analyze the surface air temperature anomalies averaged over Eastern Asia.

Response to the comment 5: Thanks very much for this suggest. We have added the corresponding figure in the revised manuscript (Fig. 20b)

6) To better compare the land-sea thermal contrast, it might be better to include the observed SST changes in Figs. 10ab.

Response to the comment 6: Thanks very much for this suggestion. Modify accordingly (Fig. 19a and 19b in the revised manuscript).

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