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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Quantifying the contribution of anthropogenic influence to the East Asian winter monsoon in 1960–2012" *by* Xin Hao et al.

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1. Numerous studies have shown that the EAWM had been gone through a significant weakening in the past few decades. CMIP5 model output was often used to identify that the weakness of EAWM was the response to global warming in the current and future climate. Specifically, the change in the EAWM in future climate is considered to be a response to anthropogenic forcing. Compared to the previous studies, what is the new result from the current study?

Reply: Thank you for your comments. As you say, previous studies explored the response of the EAWM to global warming and revealed that the EAWM is weakened

under different global warming scenarios. These researches are qualitative descriptions of the influence of the global warming scenarios on the EAWM. Their results did not provide the exact influence of the anthropogenic forcing on the EAWM in the past few decades. To investigate the causes of the weakening of the EAWM in the past decades, we quantitatively estimate the contribution of the anthropogenic emissions to the change of the EAWM in this study. In the All-Hist scenario, HadGEM3-A-N216 model was forced by historical anthropogenic and natural external forcing plus observed sea surface temperature and sea ice. In the Nat-Hist runs, anthropogenic forcings and land cover/use were set to preindustrial levels, and anthropogenic contributions to the observed SSTs and sea ice were removed. By comparing with two experiments, the results reveal the responses of the EAWM to anthropogenic forcings which are close to the observation values over the past decades.

2. This study is aimed to quantitatively estimate the contribution of anthropogenic forcing to the change in EAWM by one model output. It is hard to trust the results from a quantitative analysis of this type of study. Are the results robust or sensitive to models, especially the result shown in Fig. 5?

Reply: Thank you for your comments. In the supplementary material, we provide performance assessment of the EAWM in All-Hist runs. In the All-Hist scenario, HadGEM3-A-N216 model was forced by historical anthropogenic and natural external forcing plus observed sea surface temperature and sea ice. The results show that each All-Hist run with different initial state can reproduce the climatology very well and capture the increasing trend of the EAWM in the past decades reasonably. Most of the All-Hist runs can reproduce the decadal variability of the EAWM. Moreover, the ensemble-mean of the runs number 1, 2, 5, 13, 14 and 15 show a good performance in simulating interannual, decadal and linear trend change of the EAWM. It turns out the HadGEM3-A-N216 model can reliably reproduce the EAWM in All-Hist runs. Thus, we think the quantitative analysis in this study is reliable. In this study, we define a threshold of 1.0 (-1.0) for the strong (weak) cases. Additionally, we also checked the results based on different thresholds (for example 0.8/-0.8 and 0.5/-0.5) and found that the conclusions are similar (Fig. 1 and 2).

3. The introduction is not comprehensive and a number of relevant works have not been cited. On decadal time scale, the EAWM weakened in the late 1980s, but reamplified after early 2000s (Wang and Chen 2014; Huang et al. 2014; Ding et al. 2014, 2015). For the causes of the decadal evolution of EAWM, many studies have shown that the changes in the Ural blocking and reduced Arctic sea ice are the main drivers (Wang and Chen 2014b; Mori et al. 2014; Luo et al. 2016).

Reply: Thank you for your comments. We have supplemented our introduction as follows:

The EAWM experienced remarkable transitions, with clear weakening since mid-1980s and re-amplification after mid-2000s (e.g., Yun et al., 2018; Wang and Chen 2014). The decadal oscillations in sea surface temperature (SST) are generally considered as the major source of the decadal variability of the EAWM, such as Pacific decadal oscillation and Atlantic multidecadal oscillation (Hao et al., 2017; Ding et al., 2014; Li and Bates, 2007). Jun and Lee (2004) suggested that the Arctic Oscillation may also contribute to the decadal variability in the EAWM. Additionally, above primary components of the EAWM system are subject to obvious changes under the influence of global warming (e.g., Li et al., 2018; Li et al., 2015; IPCC, 2013; Hori and Ueda, 2006; Kimoto, 2005; Zhang et al., 1997). Under different global warming scenarios, thermodynamic contrast between the East Asian continent and the Pacific Ocean is reduced uniformly characterized with weakening of the East Asian trough (EAT) as well as the East Asian jet, indicating a weakening of the EAWM (e.g., Xu et al., 2016; Kimoto, 2005). Previous studies based on Coupled models generally agree on the effect of global warming on the EAWM (Gong et al., 2018; Miao et al., 2018; Hong et al., 2017; Xu et al., 2016; Kimoto, 2005; Hu et al., 2000). Thus, Miao et al. (2018) deduced that global warming plays a key role in the interdecadal weakening of the EAWM since mid-1980s.

Minor points:

1.The caption of Fig. 1d should be “Model-HGT”.

Reply: Thank you for your comments. We have revised the mistake.

2. Model’s All-Hist runs can reproduce the climatology very well (Fig. 1), but fail to show the re-amplification of EAWM after early 2000s (Fig. 2a). It may lead to an overestimation of the contribution by anthropogenic forcing.

Reply: Thank you for your comments. As our results shown, HadGEM3-A-N216 can reproduce the climatology and decadal variability of the EAWM, including the re-amplification of EAWM after mid-2000s.

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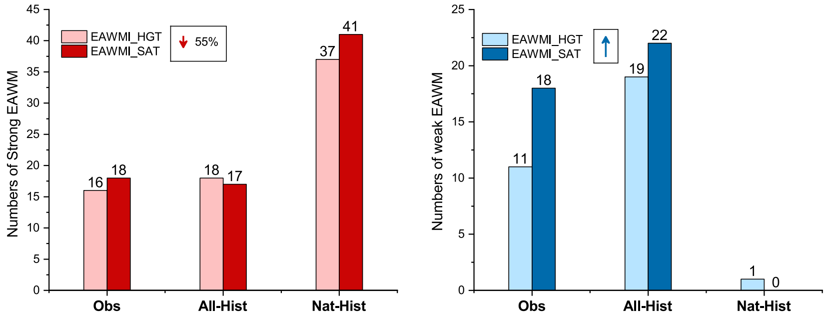

Fig. 1. Same as the Fig. 5 in paper, but based on the thresholds of 0.5/-0.5

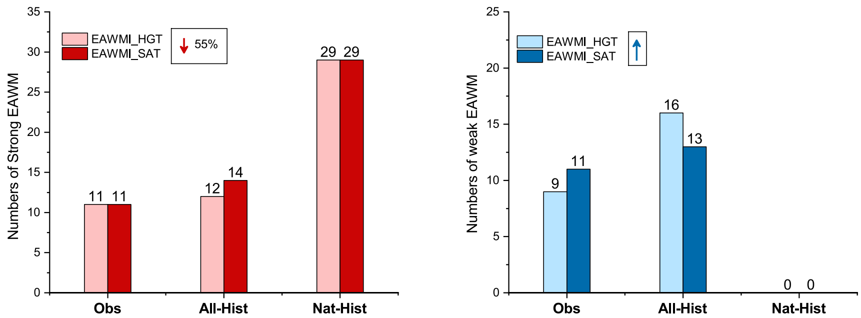

Fig. 2. Same as the Fig. 5 in paper, but based on the thresholds of 0.8/-0.8