

## Responses to Reviewer#1

1. The manuscript reads well and is convincing until section 4.2. In this section looks into the spectral characteristics of the correlation between the EASM and precipitation in the model simulations. It claims that there exist a 60-year quasi periodicity is almost all PMIP3 simulations and the CESM ensemble. I have two main concerns. One is that the spectra of the running correlations in the CESM ensemble do not really look similar in the different ensemble members. This ensemble has been conducted with the same forcing and with the same model, so that the spectra - if they represent a real signal- should look, in my opinion, much more similar. For instance, the simulation in left column middle row shows a spectrum that is very different from the simulation in the right column middle row. This means that either the statistical significance of the spectral peaks is not really well estimated: the peak at about 130 years that appears in this latter simulation as significant does not appear in any other ensemble member. This may be due to the construction of the time series. The running correlation are calculated with a 31-year filtered applied to the EASM and precipitation time series. I suspect that this filtering may introduce spurious peaks in the spectrum, although it is difficult ascertain before hand. I suggest to calculate the spectrum of a time series resulting from calculating the running correlation of random time series and see in how many cases spurious spectral peaks arise. I found a bit suspicious that the spectral peaks that the authors claim are twice and four times the period of the running window width.

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Thank you very much for the insightful comments.

1. We acknowledge that there are some differences among the spectra derived from CESM ensemble members. On one hand, we focus on the spectra of RPC/PC, which depends not only on variations of the winds and precipitation but also on their relationship. This makes the spectra more complicated than a simple index, such as a precipitation index. On the other hand, the key factor affecting the fluctuation of the PRC/RC may be different among the CESM simulations. As you mentioned, the correlation shown in Fig. 11 is relatively low, though it is statistically significant. This result suggests that other factors except for the AMO may also contribute to the RC fluctuation, but they are not robust signs among the ensemble members. In other words, although the model employs the same external forcings, the temporal evolution of internal variability of climate system (e.g., PDO) is not the same due to different initial conditions. As listed in Table S1 and S2, the SST over North Pacific is more sensitive to the initial conditions than that over the North Atlantic in the CESM-LME simulations, resulting in the complex phase combinations of the AMO and PDO (Fig. S7). Therefore, the combination of different phase of internal variabilities may enhance or damp the relationship between the winds and precipitation, hence leading to the complexity of the spectra. In the revised manuscript, we add some discussions on this point (Page 8, Line 1-8).

2. Following your suggestions, we verified the significance of the spectrum with a Monte Carlo simulation (Page 4, Line 9-14). Specifically, we generated two random arrays with the same length of the original data, and then calculate the spectrum of their 31-year running correlation. Repeat previous steps 10,000 times and get 10,000 spectra, then the fifth (tenth) percentile at each timescale is set as threshold for  $\alpha = 0.05$  ( $\alpha = 0.1$ ). As shown in Fig. 10, the running correlation between the original data could induce some spurious spectral peaks on short timescales (i.e., 22-year) but not on a longer timescale. Thus, in some ensemble members, the spectral that peaks around twice and four times of the running window width is unrelated to the application of running correlation.

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2. The explanation of the involvement of the North Atlantic SSTs on the link between EASM and precipitation is actually very weak. It is based on a statistical result without any physical explanation. This is a reflection of another weakness in the study. The authors clearly show that there are multi-decadal periods where the link EASM-precipitation breaks down. This must have a local and immediate reason, for instance that in those periods other local patterns of variability vary more strongly, or that the sources of moisture in the Western Pacific become colder or other similar reason. But if there is a long-distance effect of the North Atlantic SSTs, this has to be mediated by a regional mechanism, add this is not explored at all in the study. In addition, the correlations displayed in Figure 11 are really low. This figure also shows the area where at least 7 of the nine ensemble members show the same sign of the correlation. However, this result may not be that significant as it seems at first sight. On average 4 or 5 simulations will show the same sign, so that 7 can be not that unusual when considering that this test is applied to all grid cells of the simulation at the same time (this is the simultaneous multiple test problem or field significance). In other words, the chances that one single region in the world passes the 7-over-nine-same-sign test are probably not that low.

1. We add some discussions on the possible mechanisms about how the AMO affected the EASM-precipitation relationship (Page 7, Line 23-31).

The formation of precipitation is not only affected by the moisture but also related to the local thermal condition. When the temperature gets lower, the moist air gets easier to saturate if the moisture is constant. Previous studies have shown that the AMO could influence the temperature over East Asia positively (Lu et al., 2006; Wang et al., 2013). During the cold (warm) phase of the SST anomalies over North Atlantic, the temperature over East Asia tends to be colder (warmer) (Fig. S6). As the EASM strengthens, the moisture transported to monsoon region increases, which is propitious to improve precipitation. Meanwhile, the lower (higher)-than-normal temperature condition over East Asia is helpful (unhelpful) to the saturation of the air and thus promote (hamper) the formation of precipitation, which results in a more (less) robust positive EASM-precipitation relationship.

2. We applied the Monte Carlo simulations to demonstrate that the SST variation over the North Atlantic is a significant sign connecting with the EASM-precipitation relationship. Nevertheless, other potential influence factors, such as the PDO, are more sensitive to the initial conditions. This result indicates that the PDO plays different roles in modulating the connection between the AMO and EASM-precipitation relationship among CESM-LME, which may be responsible for the low variance explained by the PDO shown in Fig. 11.

3. Figure R1 shows that most anomalous SSTs around the world only passed the 4- or 5-over-9-same-sign-test, except over the North Atlantic region, where can passed the 7-over-9-same-sign-test. The result of 7-over-9-same-sign-test is similar to that of the Monte Carlo simulation test (Fig. 11), proving the rationality of the 7-over-9-same-sign-test.

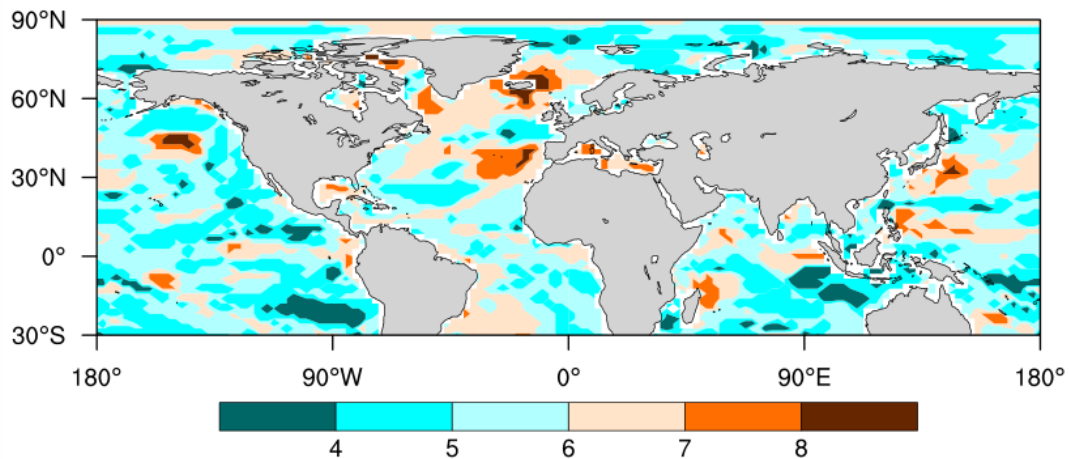


Figure R1. Numbers of ensemble members in CESM-LME full-forcing experiments that agree with the MEM result in the connection between the AMO and EASM-precipitation relationship (shown in Fig. 11).

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#### References

Wang, J., Yang, B., Ljungqvist, F. C., Zhao, Y.: The relationship between the Atlantic Multidecadal Oscillation and temperature variability in China during the last millennium, *J. Quaternary Sci.*, 28, 653-658, 2013.

10 Lu, R., Dong, B., and Ding, H.: Impact of the Atlantic Multidecadal Oscillation on the Asian summer monsoon, *Geophys. Res. Lett.*, 33, 2006.

3. Page 2, line 5: 'aforementioned EASM-precipitation relationship is possibly changeable over recent decades (e.g., Shi and Zhu, 1998; Li et'

15 Perhaps, changeable -> not stable

Corrected.

4. Peng et al. (2014) also implied that several severe droughts that occurred over eastern China were. Peng et al is not in the reference list

20 We add the reference of Peng et al. (2014). (Page 11, Line 23-24)

5. page 3, line 21: 'ESM because of its climate drift in long-term simulations (Gupta et al., 2013). These simulations have a rough time span'

rough time scape -> approximately cover a span

25 Corrected.

6. Page4, line2: Specifically, we calculate the geological distributions of the correlation between the EASM strength and summer precipitation geological -> spatial

30 Corrected.

7. Page 4, line 11: ' CGCM3) to 0.79 (GISS-E2-R), all passing the 95% significance test. The centered root-mean-square errors range from 0.99 (MRI-CGCM3) to 1.55 (HadCM3),

are over the 95% significance level.

units for RMSE are missing - I guess they are m/sec

The RMSE has been normalized by the standard deviation of the observation, thus it is a dimensionless quantity.

## Anonymous Referee #2

1. These conclusions are based on a thorough analysis of the multi-model PMIP3 past1000 ensemble. The authors first establish the performance of individual models in representing present-day climate variations and base the selection of models on this evaluation. The results could be more robust if the authors included also the CESM single-model ensemble in the analyses of section 4.1 (see below). I am much less convinced about section 4.2, where the authors claim that a roughly 60yr oscillation in some teleconnections to the North Atlantic causes the variations in the EASM-precip relation. I don't find the collection of spectra very convincing and strongly recommend not to derive spectra from heavily-smoothed time series.

Thank you very much for the constructive comments.

1. We include the CESM-LME results in [Page 6, Line 31-34](#), and attach the corresponding figure in the supplement ([Fig. S3](#)).

2. The multi-decadal periodicity of PRCs/PCs differs among different models. On one hand, the RPC/PC depends not only on variations of the winds and precipitation but also on their relationship. This makes their spectra more complicated than a simple index, such as a precipitation index. Thus, the different parameterizations relevant to precipitation and winds among PMIP3 models may lead to the diversity of their spectra. On the other hand, the key factor affecting the fluctuation of the PRC/RC may vary even among the same model simulations (i.e., CESM-LME). The correlation between the AMO and EASM-precipitation relationship is relatively low, though it is statistically significant ([Fig. 11](#)). This result suggests that other factors except for the AMO may also contribute to the RC fluctuation, while not robust among the ensemble members. Take the PDO for example, we show that the SST variation over the North Pacific is more sensitivity to the initial conditions than that over the North Atlantic ([Table S1 and S2](#)), making their phase combinations differ among CESM-LME ([Fig. S7](#)). In other words, the connection between the AMO and EASM-precipitation relationship is affected by the PDO in different ways among the CESM-LME, making the spectra of RC/PRCs more complex. We add some discussions on this point ([Page 8, Line 1-8](#)) in the revised manuscript. Considering these reasons, we modified the "roughly 60-year periodicity" into the "multi-decadal periodicity" throughout the manuscript.

3. It is possible that heavily-smoothed time series could induce spurious peaks in the spectrum. To avoid this problem, we applied a Monte Carlo simulation to verify the significance of the spectral. Specifically, we generated two random arrays with the same length of the original data, and then calculate the spectrum of their 31-year running correlation. Repeat previous steps 10,000 times and get 10,000 spectra, then the fifth (tenth) percentile at each timescale is set as threshold for  $\alpha = 0.05$  ( $\alpha = 0.1$ ). As shown in [Fig. 10](#), the running correlation will induce some spurious spectral peaks on the short timescales (i.e., 22-year) but not on the timescale we concerned (i.e., around 60-year). We introduce the Monte Carlo simulation in [Page 4, Line 9-14](#).

2. The connection with the Atlantic Multidecadal Oscillation is also not well established. The correlations shown in [Fig.11](#) show extremely low explained variance, even though they may pass a statistical significance test. In an earlier paper (Shi et al., *Clim. Dyn.*, 2016) the principle author did a much better job in identifying teleconnections influencing precipitation patterns in a particular model. If the AMO-China precip connection is as robust as the authors claim, the multitude of realisations from the CESM ensemble should make it possible to nail down the pathway how and to

which amount the AMO influences the eastern China rainfall in comparison to the EASM.

We add some discussion on the possible mechanisms about the possible mechanisms that AMO affected the EASM-precipitation relationship (Page 7, Line 23-31).

5 The formation of precipitation is not only affected by the moisture but also related to the local thermal condition. When the temperature gets lower, the moist air gets easier to saturate if the moisture is constant. Previous studies have shown that the AMO could influence the temperature over East Asia positively (Lu et al., 2006; Wang et al., 2013). During the cold (warm) phase of the SST anomalies over North Atlantic, the temperature over East Asia tends to be colder (warmer) (Fig. S7). As the EASM strengthens, the moisture transported to monsoon region increases, which is propitious to improve precipitation. Meanwhile, the lower (higher)-than-normal temperature condition over East Asia is helpful (unhelpful) to the saturation of the air and thus promote (hamper) the formation of precipitation, which results in a more (less) robust positive EASM-precipitation relationship.

15 Minor issues:

1. Page1, line 23 have == has Page 2, line18: do you mean “combing” or “combining”?  
Corrected. We mean “combining”.

20 2. Page 2, lines32ff and general: I recommend to reduce (increase) the wording in parenthesis in order to improve (deteriorate) the clarity of the argument.  
We modified the manuscript as you suggested. (Page2, Line 19-21)

25 3. Page 3, line 5: Peng et al., 2014: for which time period?  
During the last millennium (Page 3, Line 6).

4. Line 6: the previous work by Shi et al is important and you should give a brief summary of their findings.  
We add a brief summary of Shi et al. (2016b). (Page 3, Line 6-10)

30 5. Also for the later part: In Shi et al. 2016 it is concluded that only one model is able to adequately reproduce the precipitation patterns over China in the last millennium context. Why is that not so important for the present study?

35 In Shi et al. (2016a), they mainly focused on the divergent response of annual precipitation/humidity condition between arid Asian inland and Eastern China (monsoonal region), and select the models based on the annual humidity difference between the MCA and LIA in comparison with multi-proxies. In this study, we concentrated on the relationship between summer precipitation and winds over China. We choose models based on their performance in simulating the EASM strength and EASM-precipitation relationship, which is difficult to compare with the proxies. Thus, in Shi et al. (2016a), their models selection was stricter than that in this study. In addition, their result further  
40 agreed with one of our main conclusions that the EASM-precipitation relationship is positive and stable on multi-centennial timescale.

6. Line 21: the PMIP3 definition is exactly 850 to 1850 A.D.  
Corrected.

7. Page 4, line 2, page 5, line 11: why geological? Geographical, spatial?

Corrected to “spatial”

5 8. Page 5, line 11, figures 1,4: the “observations” are from a relatively short period (1979- 2000). In the light of the later results on the non-stationarity: How does one know that this period is representative for the 20th century or longer?

We modified the observational EASM and EASM-precipitation relationship calculated from 1948-2000, and the simulated EASM and EASM-precipitation relationship are derived from 1901-2000.

10 (Fig. 1 and 4; Fig S2)

9. Page 6, lines 6ff: The results could be made more robust if the CESM LM Ensemble simulations would be included. For example, in figure 2c one could have another entry for CESM LME including an estimate of the ensemble spread. So you would provide both a multi-model ensemble and a single-model ensemble.

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Thanks for your suggestion and we have added a CESM results (Page 6, Line 31-33) and corresponding figure in the supplement (Fig. S3).

10. Page 6, lines 14ff: I don’t find the periodicity so obvious. If one requires 95% significance, only 5 out of 14 PMIP models and 3 out of 9 LME simulations meet the criterion, hardly a very robust feature. Again, the spectra should not be calculated from smoothed data.

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First, as you suggested, we applied a Monte Carlo simulation to avoid the possible spurious spectral peaks caused by filtered time series. We acknowledge that in some of these simulations, the spectral peaks are significant at 90% significance level, not robust compared to the 95% significance level.

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Nevertheless, almost all multi-decadal spectral peaks among these simulations pass the 90% significance test, which possibly indicates that it is a common and robust sign among climate models, thus increasing its credibility to some extent.

11. Line 15, and page 7, line 13: There is only one Shi et al., 2016 in the reference list.

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References Shi et al. (2016a) and Shi et al. (2016b) are added. (Page 11, Line 32- Page 12, Line 2)

12. Line 29: I would say there are as significant peaks between 120 and 150 years in several of the individual forcing runs (e.g., 10 b, f,I,n)

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As shown in Fig. 10, the CESM control run has a significant 120~150-year periodicity besides the multi-decadal periodicity. It indicates that the similar 120~150-year occurring in some CESM single-forcing runs may also result from the internal variability of the climate system. The lack of the 120~150-year periodicity in the remaining single-forcing runs possibly implicates that this periodicity is sensitive to the initial condition. We add some discussions on this point in the revised manuscript (Page 7, Line 4-7 and Line 17-18).

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13. Page 7, line 29: “geological evidence” better: from proxy data

Corrected.