Clim. Past Discuss.,
https://doi.org/10.5194/cp-2018-164-AC1, 2019

Climate of the Past Discussions
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Interactive comment on "Identifying teleconnections and multidecadal variability of East Asian surface temperature during the last millennium in CMIP5 simulations" *by* Satyaban B. Ratna et al.

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Received and published: 21 January 2019

Ratna et al., examined the relationships between AMO/PDO and surface temperature in East Asia (TAS) at multidecadal time scales based on models and reconstructions data, found that external forcing greatly strengthened the relationship between AMO and TAS but weakened relationship between PDO and TAS, and discussed the volcano influences. This is an interesting study on how external forcing influences on teleconnetions between AMO/PDO and TAS. However, I still have some concerns on this study.

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Reply: We thank the referee for their time and for their helpful suggestions.

Major concerns:

1) On the reliability of model and reconstruction data. Comparisons between modeled PDO/AMO from (CCSM4, MPI-ESM-P, BCC) with observed PDO/AMO index from HadISST/NCDC ERSST during the period of 1870-2000 should be added to evaluate the reliability of PDO/AMO index from model. There are several PDO/AMO reconstruction (such as, Gray et al., 2004; Shen et al., 2006). Although such PDO/AMO reconstructions are relatively short, the results seem more convincing by adding these records. In addition, there are published and robust Asian summer temperature reconstructions (e.g. Cook et al., 2013, Shi et al., 2015), such reconstruction data should be used. Comparisons among different reconstructions are as important as comparisons among the different models.

Shen, C., W.-C. Wang, W. Gong, and Z. Hao. 2006. A Pacific Decadal Oscillation record since 1470 AD reconstructed from proxy data of summer rainfall over eastern China. Geophysical Research Letters, vol. 33, L03702, 2006. Gray, S.T., L.J. Graumlich, J.L. Betancourt, and G.T. Pederson. 2004. A tree-ring based reconstruction of the Atlantic Multidecadal Oscillation since 1567 A.D. Geophysical Research Letters, 31:L12205, doi:10.1029/2004GL019932. Cook E R , Krusic P J , Kevin J. Anchukaitis et al. Tree-ring reconstructed summer temperature nomalies for temperate East Asia since 800 C.E. Climate Dynamics, 2013, 41(11-12):2957-2972. Shi F , Ge Q , Yang B , et al. A multi-proxy reconstruction of spatial and temporal variations in Asian summer temperatures over the last millennium. Climatic Change, 2015, 131(4):663-676.

Reply: Evaluation of model PDO/AMO. We have made a spatial comparison of the models' PDO/AMO signatures with those observed PDO/AMO, using HadISST and ERSST. Their spatial patterns are in Figs. 1 and 2 of this reply (see below). We have used the HadISST data for the period 1871-2000 and ERSST for the period 1854-2000 based on the availability of the data. It can be seen that the modelled PDO/AMO is agrees closely with observed PDO/AMO. We will use these extended figures (with the additional row showing the observations) in our revised manuscript.

Analysis of additional, shorter PDO/AMO reconstructions. The primary focus of this study is on the model simulations and the influence of external forcings, and on records of at least 1000-year length. While analysis of additional reconstructions is worth doing, that is more suited to another study examining shorter periods. We would prefer not to dilute our focus by analysis of additional reconstructions that are shorter (and, since our focus is also exclusively on multidecadal timescales and longer, having millennial-length timeseries is beneficial). Concerning the Gray et al. AMO reconstruction, we note the comments of Wang et al. (2017: disclosure, several authors are also authors of the current study): “The reconstruction of Gray et al. is based on a sparse tree-ring network, completely independent of our predictors; it has precise dating control, but its smaller network (only 12 sites) may compromise its representation of AMV if the centres of climate impact of AMV shift through time (also see the discussions in ref. 16).”

Wang J, Yang B, Ljungqvist FC, Luterbacher J, Osborn TJ, Briffa KR and Zorita E (2017) Internal and external forcing of multidecadal Atlantic climate variability over the past 1,200 years. Nature Geoscience 10, 512-517 (doi:10.1038/ngeo2962).

Analysis of individual Asian summer temperature reconstructions. The E Asian temperature reconstruction we used, from Wang et al. (2018), is a composite of seven published reconstructions that already includes the two suggested by the referee (Cook et al. 2013, Shi et al. 2015). The time series comparison of these three datasets can be seen in Wang et al (2018). Nevertheless, we have calculated the correlations between three of the individual summer temperature reconstructions (Cook et al. 2013, Shi et al. 2015, Zhang et al. 2018) and AMO (Wang et al. 2017, Mann et al. 2009), PDO (Mann et al. 2009, MacDonald et al. 2005), volcanic (GRA, Gao et al. 2008; CEA, Crowley et al. 2008; SIG, Sigl et al. 2015) and solar forcing (VSK, Vieira et al. 2011; SEA, Shapiro et al. 2011; SBF; Steinhilber et al. 2009) (Figs. 3 and 4 of this reply). They do show some interesting differences, perhaps related to how well they resolve the response to volcanic forcing, so we will include these additional results in our revised manuscript. However, with the exception of the correlations between E Asian temperature and the Mann et al. (2009) AMO index, the only significant correlations (with some solar forcing, PDO and AMO reconstructions) at the multidecadal timescales are with the Wang et al. (2018) composite reconstruction.

Vieira, L. E. A., Solanki, S. K., Krivova, N. A., and Usoskin, I.: Evolution of the solar irradiance during the Holocene, Astron.Astroph., 531, A6, doi:10.1051/0004-6361/201015843, 2011. Shapiro, A. I., Schmutz, W., Rozanov, E., Schoell, M., Haberreiter, M., Shapiro, A. V., and Nyeki, S.: A new approach to the long-term reconstruction of the solar irradiance leads to large historical solar forcing, Astron. Astrophys., 529, A67, doi:10.1051/0004-6361/201016173, 2011. Steinhilber, F., Beer, J., and FrÂĺohlich, C.: Total solar irradiance during the Holocene, Geophys. Res. Lett., 36, L19704, doi:10.1029/2009GL040142, 2009.

2) On PDO signal. PDO has clear decadal and inter-decadal signal. Figure 11 also showed significant 15-20 years periods for PDO. However, all the time series are passed through a 30-year low pass filter using the Lanczos filter, which may miss key information of PDO. 10-year low pass filter should be used for PDO analysis.

Reply: We agree that PDO has a decadal signal which can been identified in Figure 11. However, the specific purpose of our study is to look at variability on multidecadal timescales (title and first line of the abstract), not decadal timescales, which is why we have passed all timeseries (including the PDO) through a 30-year low-pass filter. Therefore we do not use a 10-year filter because that would conflict with the aim of our study.

3) On Volcano influences. Although previous studies showed that volcano eruptions affected decadal climate changes, it is equivocal that volcano eruptions affected multidecadal climate changes. For example, TAS reconstruction showed clear volcanic

forcing signal, and volcano eruptions resulting in pulses of cooler summer conditions that may persist for several years (See Figure 12 in Cook et al., 2013). However, this study showed that there were not significant correlations between TAS and volcanic forcing (Figure 8c). In addition, superposed epoch analysis (SEA) should be used to test the impact of explosive volcanism on temperature.

Reply: Again, we note the aim of our study is explicitly to look at multidecadal timescales, so a superposed epoch analysis would not add more to the results already found. However, as noted above, we have now also analysed two individual E Asian temperature reconstructions, including Cook et al. (2013). Although the correlations with volcanic forcing are slightly stronger for Cook et al. (2013) than for the other reconstructions (Fig. 3 of this reply), they are still not statistically significant at the multidecadal timescale. This contrasts with two of the three climate models (CCSM4 and MPI), which show significant multidecadal correlations between simulated E Asian T and volcanic forcing, a finding that we report in the paper. There is also evidence that volcanic eruptions affect heat content and SST on these longer timescales (e.g. Gleckler et al. 2006). As suggested by the referee, the volcanic influence on the reconstructed temperatures is probably limited to the interannual timescale – but this timescale is not the focus of our study.

Gleckler, P. J., T. M. L. Wigley, B. D. Santer, J. M. Gregory, K. AchutaRao, and K. E. Taylor, 2006: Volcanoes and climate: Krakatoa's signature persists in the ocean. Nature, 439, 675.

4) On time scales of external forcing. there are other external forcings (e.g. solar activity) that should be considered. Solar activity has multi-decadal periods.

Reply: We focussed on volcanic forcing because it had previously been established that this was the largest external influence on the last millennium simulations (see the first sentence of section 5 of our manuscript). However, since we are also looking at reconstructions, the referee is correct that we should not neglect solar forcing, because the reconstructions might show a significant association with solar forcing (indeed, as Wang et al. 2018 showed) even though the models may not. We have now included solar forcings in our analysis of the correlations between E Asian temperature and PDO/AMO/external forcing, both in model and reconstructions (right-hand column of Fig. 4 of this reply). We used three different solar forcing reconstructions (Vieira et al. 2011; Shapiro et al. 2011; Steinhilber et al. 2009). The only E Asian temperature reconstruction with significant multidecadal correlations to solar forcing is the composite reconstruction of Wang et al. (2018). We will include these additional results in our revised manuscript.

5) On influences of external forcing, external forcing greatly strengthened the relationship between AMO and TAS but weakened relationship between PDO and TAS. Do you think such results are related to definition and calculation of AMO and PDO? In simple terms, AMO reflects average SST, but PDO reflects spatial configuration of SST. So AMO may be related to external forcing while PDO may be related to internal variability.

Reply: Yes, the referee's explanation is correct. Minor Concerns: 1) Page 3, Line 20-22. For temperature over East Asia, TAS reconstruction is summer temperature, and TAS model data is summer, cold season temperature and annual temperature. It is confusing. Please clarify which season temperature used in Figure 3-8 in Figure caption.

Reply: The annual mean temperature is used in Figures 3-8. We will amend the figure captions to make this clear. 2) Page 13, Line 9, East Asiantemperature should be East Asian temperature.

Reply: We will correct this typo. 3) Figure 7a, the label for y axis for volcanic forcing should be added.

Reply: We will add the y-axis label for volcanic forcing: 'Radiative forcing (W m-2)' 4) Figure 8, confidence level explanation should be added.

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Reply: We will add 'The bars marked with 'star' marks are significance at 95% using a two-tailed student t-test'.

Please also note the supplement to this comment:
https://www.clim-past-discuss.net/cp-2018-164/cp-2018-164-AC1-supplement.pdf

Interactive comment on Clim. Past Discuss., https://doi.org/10.5194/cp-2018-164, 2018.

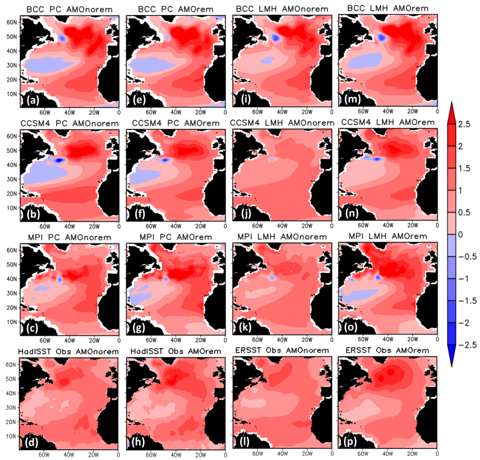

Figure 1: The AMO spatial patterns. Regression of annual-mean SST (K) on the AMO index for the three CMIP models for the LMH and PC experiments, compared with HadISST (d, h) and ERSST observation (i, p). (a-d) and (i-l) use the AMO index calculated without subtracting the global SST anomaly while (e-h) and (m-p) use the AMO index after subtracting the global SST anomaly.

Fig. 1.

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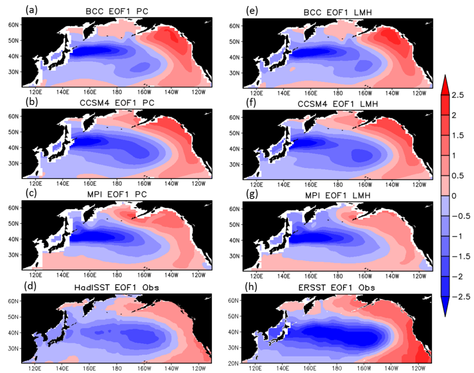

Figure 2: The PDO spatial pattern. The leading EOF of North Pacific SST anomalies for the three CMIP models, PC (a-c) and LMH (d-f) simulations, compared with HadISST and ERSST observation.

Fig. 2.

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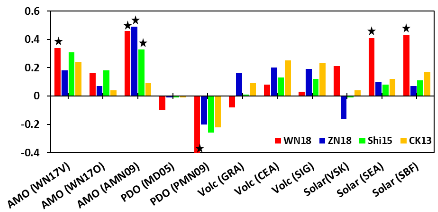

Figure 3: Correlation of TAS reconstructions with AMO, PDO, volcanic forcing and solar forcing reconstructions. The bars marked with 'star' are significance at 95% level using a two-tailed student t-test.

Fig. 3.

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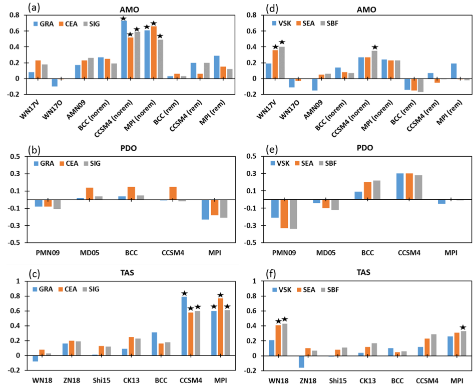

Figure 4: The correlations of (a) AMO, (b) PDO and (c) TAS with volcanic and solar forcing (models and reconstructions) data. (a-c) for volcanic forcing and (d-f) for solar forcing. The bars marked with 'star' are significance at 95% level using a two-tailed student t-test.

Fig. 4.