[Research Article # ESD]: "Synchronized spatial shifts of Hadley and Walker circulations" by Kyung-Sook Yun, Axel Timmermann, Malte F. Stuecker

We thank the reviewers for their constructive and helpful comments. We carefully revised the manuscript "Synchronized spatial shifts of Hadley and Walker circulations" and provide a point by point reply to the individual comments below.

Reply to the comments of Reviewer #2

General Remarks:
This paper shows that warm pool SST anomalies in the decaying El Niño event gen- erate a meridionally asymmetric Walker circulation response, which couples the zonal and meridional atmospheric overturning circulations. I think their results are overall novel and reasonable, and I would be happy to see this work on Earth System Dynamics after some minor revisions, particularly regarding discussions. Specific comments are as follows.

[Ans] Authors are grateful to the reviewer for very constructive comments which were helpful to improve this work. The manuscript has been largely revised according to the reviewer's comments as listed below.

Specific Comments:
Q. 1. *The authors focus on NINO 3 regions to explore the relationship between SST anomalies and Walker circulation. Recently, Central Pacific El Nino events tend to increase and also some papers suggested the increase of CP El Nino in a warm climate. I think that the relationship may be changed if we concentrate on the NINO4 region. The authors need to discuss the sensitivity of the NINO region on the relationship somewhere.*

[Ans] The relationship between ENSO and WC&HC shift modes is only manifest in Nino3 but not in Nino4 even during the boreal spring (CC with WC2 ~ 0.09 and CC with HC1 ~ 0.03). This reflects the phase-synchronization is more associated with eastern Pacific-type El Niño events than with central Pacific-type El Niño events. We added the description in the revised text [line 140-142].

Q. 2. *In figure 1, the temporal evolution of normalized PC from WC or HC almost coincides with the NINO3 index from 1979-2000. However, the relationship between the two indexes seems to be weakened after 2000. I would know possible reasons. I think that many reasons may be discussed – ENSO diversity, mult-idecadal variability (IPO or AMO), and even global warming.*

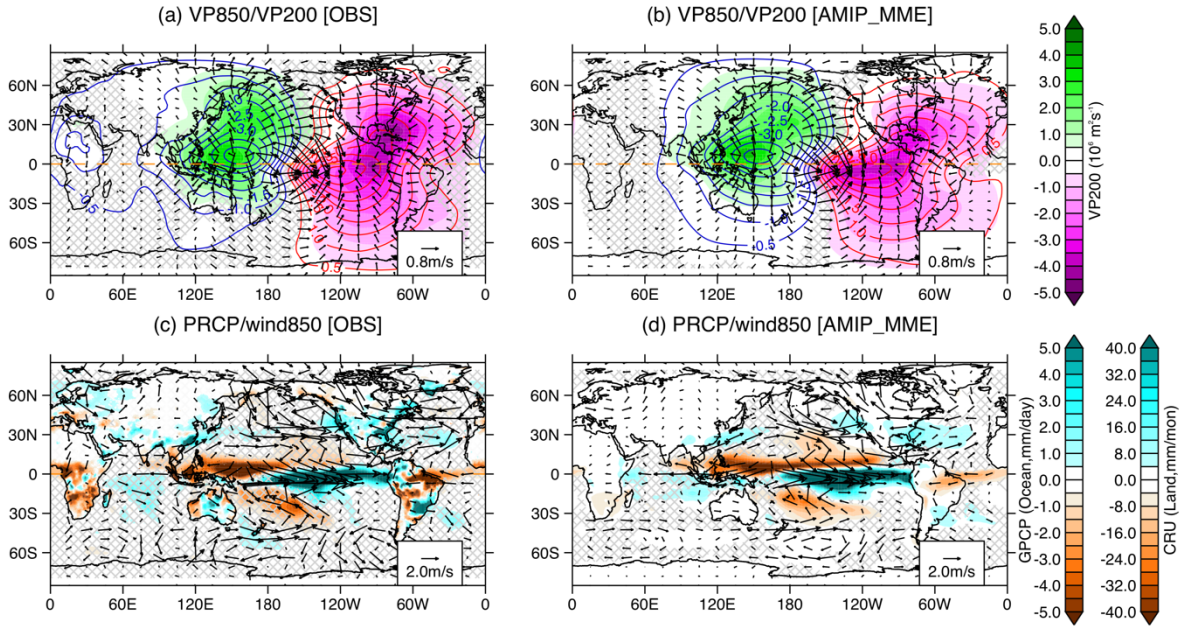
[Ans] The weakened relationship may be a consequence of the Pacific WC intensification by Atlantic warming and Pacific cooling (England et al., 2014;McGregor et al., 2014) associated with multi-decadal climate variability (e.g., Atlantic Multi-decadal Oscillation and Inter-decadal Pacific Oscillation), zonal shifts in ENSO's center (Sohn et al., 2013). We added more discussion on the possible reason for the changing WC-HC relationship in the revised text [line 188-191].

Q. 3. *In figure 2, it is well known that the AMIP run tends to overestimate the atmospheric response given SST forcing. How much does the strength or duration length of phase synchronization may be changed in a coupled model?*

[Ans] The CMIP5 models show considerable diversity in occurrence probability of SYN event. Compared to nine SYN event from AMIP MME, the number of SYN event from CMIP5 models is ~ 5.7 ± 3.2SD (see Supplementary Fig. S4). We added the explanation in the revised text [line 183-184].

Q. 4. *In Figures 4 and 5, I would see the circulation pattern in the upper troposphere (200 hPa). If the authors think the upper-level circulation change is not relevant to this study, please mention the reason in the main text.*

[Ans] We added the 200 hPa circulation pattern as shading in Fig. 4. Basically, the upper-level circulation pattern is consistent with the lower circulation pattern: e.g., anomalous lower-level divergence and upper-level convergence over the WNP. The NW-SE asymmetric circulation feature is slightly clearer in 850 hPa than 200 hPa, likely due to larger impact of SST forcing. We present the 850 hPa circulation pattern only in Fig. 5, to reduce the complexity in plotting.



Ref_Fig 4 Global pattern of phase synchronized spatial shifts of HC and WC. Composite anomalies during PSYN months (i.e., the absolute tendency of phase difference is less than 0.3) with February-March-April (FMA[1]) extreme El Niño (FMA[1] Niño3 > 1.5SD), obtained from the observations (left column) and the AMIP MME (right column): (a, b) 850 hPa velocity potential (VP850; contour) and 200 hPa velocity potential (VP200; shading) anomaly; (c-d) precipitation (GPCP for ocean and CRU for land; shading) and 850hPa wind (vector) anomaly. The hatching shows the area where the difference is statistically insignificant at the 99% confidence level.

Q. 5. *In figure 4, the 95 % significance level may be too low to show a strong shift of HC and WC. Why don't you use 99% or other higher criteria?*

[Ans] We changed the significance criteria to the 99% confidence level and obtained very similar results. The text was accordingly changed in the caption of Figures.