Responses to Reviewer #2

We appreciate the valuable and insightful comments provided by the reviewer. We have revised the manuscript carefully according to these comments and suggestions. Our point-to-point responses are given below.

General Summary and Comments

This study explores the role of mean SST biases in simulating the observed characteristics of BSISO. The study is carried out using a suite of numerical experiments in which an atmospheric model (SPCAM3) is configured with observed boundary forcing (uncoupled) and coupled to a mixed-layer ocean model (coupled). Each of these configurations is branched out into further configurations. The mixed-layer ocean model (MC-KPP) is first constrained to an observed climatology and then to the climatology of a coupled GCM (SPCCSM3). The boundary forcing is constructed from the SST of the two coupled simulations. Based on these experiments, the authors suggest that ocean mean state determines the skill of BSISO simulation in a coupled model. The manuscript is well written, and it is worthy of publications subject to addressing the specific comments below.

1. One objective of the study is to "examine the role of […] and mean state bias in the simulated BSISO using a configuration of SPCAM3 coupled to a mixed-layer ocean model". To overcome the limitations of the 1D model, MC–KPP is constrained to an ocean mean state. Please explain what the advantage is of running the new simulations and not just analyze SPCAM3 and SPCCSM3. SST biases in SPCCSM3 and SPK-SPC are very similar.

Responses:

There are two differences between the atmosphere-only SPCAM3 and atmosphere-ocean coupled SPCCSM3 models: air-sea coupling and ocean mean-state bias. Thus, it is hard to tell which factor (air-sea coupling or ocean mean-state bias) mainly causes the differences in the simulated BSISO between SPCAM3 and SPCCSM3. To isolate the air-sea coupling effect and the ocean mean-state effect, we carried out four experiments by using SPCAM3 coupled to the MC-KPP ocean model (SPCAM-KPP; see Table 1 in the manuscript or see Table B1 below). For example, to study the effect of the ocean mean-state bias on the simulated BSISO, SPCAM3-KPP is constrained to either observed ocean state ("SPK-OBS") or by the cold climatological SPCCSM3 ocean state ("SPK-SPC"). Both experiments have air-sea coupling, but the ocean mean state differs. To isolate the effect of air-sea interaction on the simulated BSISO under the observed (SPCCSM3) ocean mean state, SPCAM3 is forced by the 31-day smoothed SST from SPK-OBS (SPK-SPC) in experiment "SPA-KOBS" ("SPA-KSPC"). We compare SPA-KOBS to SPK-OBS; we compare SPA-KSPC to SPK-SPC. In both comparisons, the two experiments have the same ocean mean state, but one has air-sea coupling while the other does not.

Table B1: List of simulations analysed, including the experiment name, model, ocean climatology condition used by the model to constrain (coupled model) or as forcing (atmospheric-only model), and design purpose.

Exp	Model	Ocean surface	Purpose
SPK-OBS	SPCAM3-KPP	SST climatology from observation	Understanding ocean mean-state effect (SPK-OBS vs. SPK-SPC)
SPK-SPC	SPCAM3-KPP	SST climatology from SPCCSM3	
SPA-KOBS	SPCAM3	31-day smoothed SST from SPK-OBS	Understanding air-sea coupling effect under observed mean state (vs. SPK-OBS)
SPA-KSPC	SPCAM3	31-day smoothed SST from SPK-SPC	Understanding air-sea coupling effect under SPCCSM3 mean state (vs. SPK-SPC)

2. L65-66: There are other studies (e.g., Waliser et al. 1999; Bernie et al. 2005, 2007; Danabasoglu et al. 2006; Misra et al. 2008; Stan 2018) showing that air-sea coupling improves the representation of diurnal cycle, which is relevant for intraseasonal variability. This other side of the argument should also be mentioned here.

Responses:

Thank you for pointing out these interesting studies. We have modified the related sentence as follows: "By comparing the results of coupled GCMs (CGCMs) with the results of the AGCMs prescribed with observed SSTs, many studies found that the inclusion of air-sea coupling could produce a more realistic intraseasonal variability via improving the representation of the diurnal cycle at the air-sea interface (Waliser et al., 1999; Bernie et al., 2005; Danabasoglu et al., 2006; Misra et al., 2008; Stan, 2018). Besides the air-sea coupling process, the differences between simulated results may also come from ocean mean-state differences between AGCM and CGCM, as incorporating air-sea interaction in CGCMs inevitably introduces atmospheric and ocean mean-state biases." (Lines 55–60).

References:

Bernie, D. J., S. J. Woolnough, J. M. Slingo, and E. Guilyardi, 2005: Modeling diurnal and intraseasonal variability of the ocean mixed layer. J. Climate, 18, 1190–1202.

Danabasoglu, G., W. G. Large, J. J. Tribbia, P. R. Gent, B. P. Briegleb, and J. C. McWilliams, 2006: Diurnal coupling in the tropical oceans of CCSM3. J. Climate, 19, 2347–2365.

Misra, V., L. Marx, M. Brunke, and X. Zeng, 2008: The equatorial Pacific cold tongue bias in a coupled climate model. J. Climate, 21, 5852–5869.

Stan, C., 2018: The role of SST variability in the simulation of the MJO. Clim. Dyn., 51, 2943–2964.

Waliser, D. E., K. M. Lau, and J.-H. Kim, 1999: The influence of coupled sea surface temperatures on the Madden–Julian Oscillation: A model perturbation experiment. J. Atmos. Sci., 56, 333–358.

3. L97: Since MC-KPP must be constrained to a reference ocean climatology, some tuning is involved in this process to ensure a realistic behavior in the ocean currents. Please clarify if MC-KPP is retuned when is constrained to SPC.

Responses:

Yes, we retune the ocean temperature and salinity corrections when MC-KPP is constrained to SPC, i.e., the reference ocean climatology. For both the SPK-OBS and SPK-SPC simulations, we first perform a 10-year simulation with relaxation, to compute the required climatological temperature and salinity corrections. In these 10-year simulations, the MC-KPP ocean is relaxed toward the ocean climatology (either from observations or from SPC) with a timescale of 15 days. The temperature and salinity relaxation tendencies from this simulation are stored, and then a daily climatology of corrections is calculated. This daily climatology is then smoothed with a 31-day running mean, to remove the high-frequency variability. Physically, this mean the seasonal cycles of the temperature and salinity relaxation corrections account for the effects of ocean advection and of bias in the surface fluxes. These mean seasonal cycles of the corrections are then imposed on the SPK-OBS or SPK-SPC simulation with no relaxation, which displays only small SST biases against the SPC ocean climatology (Fig. 1 in the manuscript).

We have clarified that: “For each SPCAM3-KPP simulation analysed here, a 10-year “relaxation” simulation is first performed, with a 15-day relaxation timescale toward the reference seasonal cycles of ocean temperature and salinity.” (Lines 100–101). We explain detailed tuning processes in Lines 98–104.

4. L98-99: MC-KPP has some limitations for the study of air-sea coupling because atmospheric variables can be modified by horizontal advection whereas ocean surface variables cannot. Physical mechanisms involved may not be representative of what happens in observations. Please discuss this limitation.

Responses:

We agree with the reviewer that MC-KPP, which is a simple one-dimensional ocean model, only has vertical mixing but lacks ocean dynamics, such as horizontal or vertical advection or wind-driven upwelling. Besides, the air-sea coupled modes of variability (such as the ENSO) and potential feedbacks from these modes to intraseasonal variability are also absent. These limitations of MC-KPP are emphasized in Lines 90–

92 in the revised manuscript.

5. Section 2.2 Please explain what the expected outcome for each experiment is. It's a lot of mix and match without a clear path why they are conducted.

Responses:

Sorry for the confusion. We have clarified the designs and purposes of these experiments in the revised Section 2.2 (Lines 110–121, Table 1). For convenience, see the text below and Table B1 (in our response to the first comment).

"To study the effect of mean-state biases on simulated BSISO, SPK is constrained to two ocean mean states: 1) the 1980–2009 climatology from the Met Office ocean analysis (Smith and Murphy, 2007); and 2) the climatology from the 20-year SPCCSM3 ("SPC" for short) simulation, which was analysed in Stan et al. (2010) and DeMott et al. (2014). The former is considered as the observed ocean state (Fig. 1c), against which SPC shows large cold SST biases throughout the Indo-Pacific in the boreal summer (Fig. 1f). These two coupled simulations are referred to as "SPK-OBS" and "SPK-SPC", respectively. Differences between the results of SPK-OBS and those of SPK-SPC can reveal the effect of SPC mean-state SST biases on the simulated BSISO. To investigate the effect of air-sea interaction on simulated BSISO under the observed ocean mean state, the time-varying SSTs from SPK-OBS are prescribed in an SPA simulation ("SPA-KOBS"). The 31-day smoothed SST is used to remove the high-frequency variability of SST and avoid erroneous positive feedbacks between SSTs, surface fluxes and precipitation (see DeMott et al., 2015 and references therein). Similarly, we prescribe the 31-day smoothed SST from SPK-SPC to SPA to understand the air-sea coupling effect under the SPC mean state ("SPA-KSPC") through the comparison with SPK-SPC."

Reference:

DeMott, C. A., N. P. Klingaman, and S. J. Woolnough, 2015: Atmosphere-ocean coupled processes in the Madden-Julian oscillation. Rev. Geophys., 53(4), 1099–1154.

6. L113: What is the resolution of the ocean model in SPCCSM3? Please add some details about the ocean model in SPCCSM3.

Responses:

The Parallel Ocean Program (POP; Danabasoglu et al. 2006), the ocean component of SPCCSM3, is a three-dimensional ocean model, which includes ocean dynamics. SPCCSM3 utilizes the low horizontal resolution version (~3°) of POP. POP has 40 vertical layers with the thickness of the top layers being 10 m, and exchanges SST and surface fluxes with SPCAM3 at 1-day coupling frequency.

Detailed description about POP was added in the revised manuscript (Lines 84–88).

Reference:

Danabasoglu, G., W. G. Large, J. J. Tribbia, P. R. Gent, B. P. Briegleb, and J. C. McWilliams, 2006: Diurnal coupling in the tropical oceans of CCSM3. J. Climate, 19, 2347–2365.

7. L117: Please explain the reasoning behind the 31-day smoothing. Why not using monthly data?

Responses:

Actually, prescribing either monthly or 31-day smoothed SST to the AGCM is efficient for removing the high-frequency variability in the boundary conditions. Considering the temporal resolution of the boundary forcing used in SPCAM3 is daily, we simply used 31-day smoothed data. This explanation about data resolution was added in Lines 117–119 of the revised manuscript. For further details about the need for using temporally smoothed SSTs in AGCM simulations to study tropical intraseasonal variability, please see Section 6 of DeMott et al. (2015).

Reference:

DeMott, C. A., N. P. Klingaman, and S. J. Woolnough, 2015: Atmosphere-ocean coupled processes in the Madden-Julian oscillation. Rev. Geophys., 53(4), 1099–1154.

8. L120-121: ERAI is not the common data set used for validation of precipitation and OLR. Why this choice? Fig. 2a shows a double ITCZ feature, which is not seen in other datasets used for validation of precipitation (CMAP, GPCP).

Responses:

Thanks for this useful comment. We have replaced the precipitation and OLR from the ERAI reanalysis dataset by the GPCP precipitation (Huffman et al. 2001) and NOAA OLR (Liebmann and Smith 1996) in the revised manuscript.

The summer (May–October) mean precipitation patterns from ERAI, GPCP and CMAP are shown in Fig. B1. Overall, the precipitation pattern from ERAI (Fig. B1a) resembles those from GPCP (Fig. B1b) and CMAP (Fig. B1c). With a focus on the tropical Pacific, the precipitation associated with the ITCZ and SPCZ in ERAI is indeed larger than GPCP and CMAP observations, as noted by the reviewer. Thus, we used the precipitation from GPCP 1DD instead of ERAI in the revised manuscript (and we revised Figs. 2–7).

We also compared the dominant modes of BSISO represented by convection from different datasets (ERAI vs. NOAA) and circulations (Fig. B2). The spatial distributions of the first four EOF patterns seem to be highly consistent, although the amplitude is slightly different. To enhance the reliability of the data analyzed, we used NOAA OLR rather than the OLR from the reanalysis in the revised manuscript (and we revised Figs. 9–12).

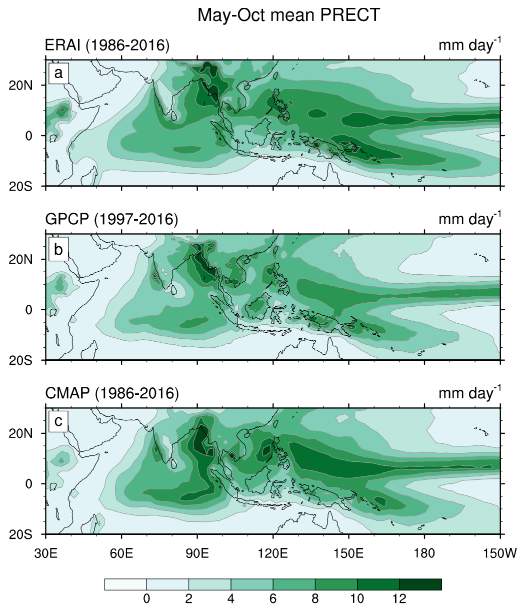

Figure B1. Summer (May–October) mean precipitation from (a) ERAI, (b) GPCP and (c) CMAP. The ERAI and CMAP data cover the period of 1986–2016 while the GPCP data is from 1997 to 2016.

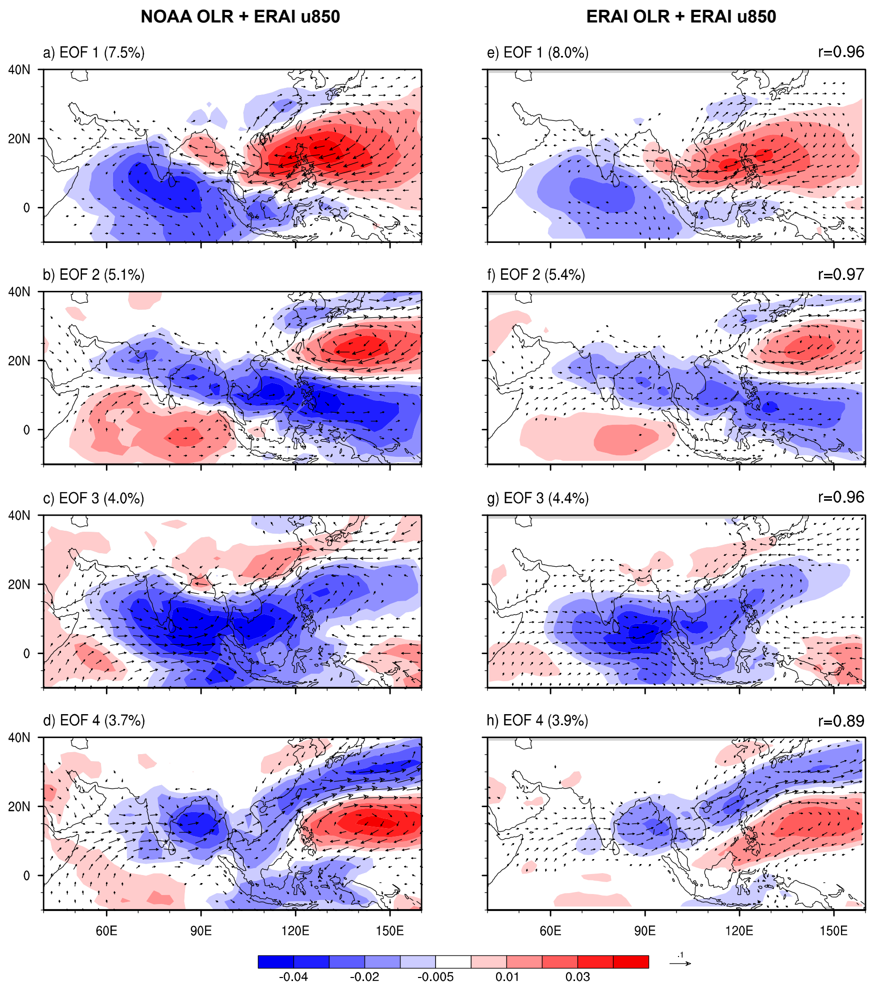

Figure B2. The first four leading MV-EOF modes of OLR (shading) and 850-hPa zonal wind (U850), derived from (a–d) NOAA OLR and ERAI U850, and from (e–h) ERAI OLR and ERAI U850. The meridional wind at 850 hPa was computed by regression onto the respective principal components. Numbers in parentheses indicate the percentage of variance explained. The pattern correlation of anomalous OLR in each MV-EOF mode derived from the two datasets is shown in the titles of (e–h).

References:

Huffman, G. J., Adler, R. F., Morrissey, M. M., Bolvin, D. T., Curtis, S., Joyce, R., McGavock, B., and Susskind, J., 2001: Global Precipitation at One-Degree Daily Resolution from Multisatellite Observations. J. Hydrometeorol., 2, 36–50.

Liebmann, B., Smith, C. A., 1996: Description of a complete (interpolated) outgoing long wave radiation dataset. Bull Am. Meteorol. Soc., 77, 1275–1277.

9. L127: OLR is generally viewed as a proxy of convective precipitation. This should be precipitation or OLR.

Response:

Revised accordingly.

10. L153-154: SPK-OBS displays the “bull’s eye” feature specific to most SPCAM simulations. This feature disappeared in the SPCCSM simulations and hence was explained by the lack of coupling which would compensate for some unrealistic features caused by the periodic domain of CRM. Can the authors comment on the nature of these features in SPK-OBS, which is used as a coupled model?

Responses:

Besides air-sea coupling, SST mean states between SPCAM3 and SPCCSM3 are also different, as a large cold SST bias can be identified over the Indo-Pacific regions in SPCCSM3. Consistent with the SPCAM3 simulation (DeMott et al. 2011; as shown in Figure B3), SPK-OBS simulates a zonally oriented band of excessively intense precipitation extending from 65ºE to 150ºE. In contrast, this enhanced precipitation band is largely suppressed in SPK-SPC. This suggests that the mean-state SST bias (rather than the air-sea coupling process) in SPCCSM3 may be the primary factor that causes the precipitation bias. Related discussion has been added in the revised manuscript (Lines 167–170).

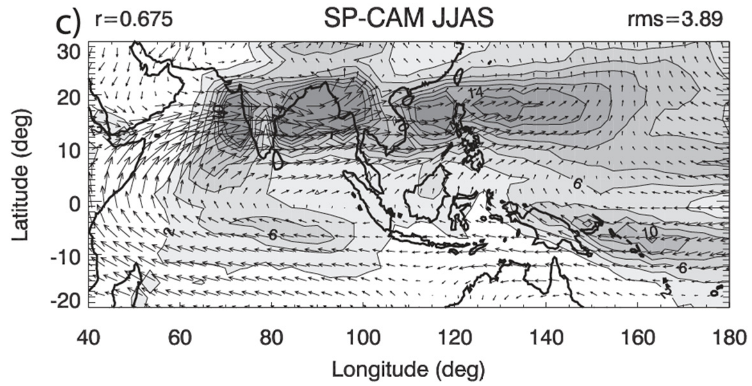

Figure B3. June–September mean precipitation and 850-hPa winds for SPCAM3. Precipitation contour interval is 2 mm day^{-1} starting at 2. (After Fig. 2c of DeMott et al. 2011)

Reference:

DeMott, C. A., Stan, C., Randall, D. A., Kinter, J. L. and Khairoutdinov, M., 2011: The Asian monsoon in the superparameterized CCSM and its relationship to tropical wave activity. J. Climate, 24(19), 5134–5156.

11. L162: The SST variability in SPC is lower than in OBS because the horizontal resolution of SPC is probably much coarser than in OBS.

Responses:

Thanks for this useful comment. As shown in Fig. B4, the deficient SST variability in SPK-SPC is largely associated with the deficient SST variability in SPCCSM3. POP in SPCCSM3 has a coarse horizontal resolution (~3º), which likely degrade the SST variability. We have added this in the revised manuscript (Lines 173–175).

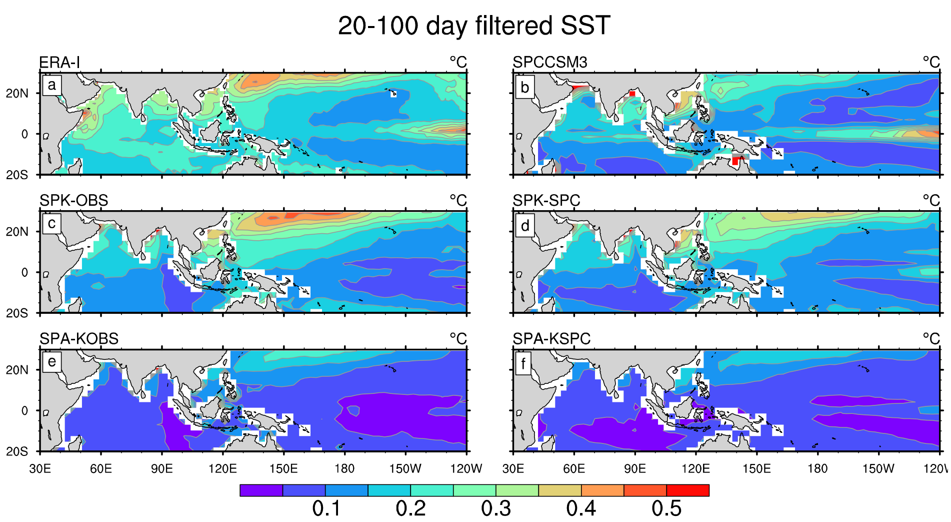

Figure B4. Standard deviations of 20–100-day-filtered SST during May–October derived from (a) ERAI, (b) SPCCSM3, (c) SPK-OBS, (d) SPK-SPC, (e) SPA-KOBS, and (f) SPA-KSPC.

12. L169-171: Without comparing the mean state of SPK-OBS (SPK-SPC) and SPA-KOBS (SPA-KSPC) we cannot say that coupling and mean biases have a negative feedback of BSISO. This would be true only if the mean precipitation remains the same.

Responses:

Excellent suggestion. The atmospheric mean state is often similar in atmosphere-only and atmosphere-ocean coupled models with the same oceanic mean state. As shown in Fig. B5, mean SST and precipitation in SPA-KOBS (SPA-KSPC) are almost the same as those in SPK-OBS (SPK-SPC). We added in the revised manuscript: "Mean precipitation fields in SPA-KOBS and SPK-OBS (SPA-KSPC and SPK-SPC) are nearly the same." Thank you.

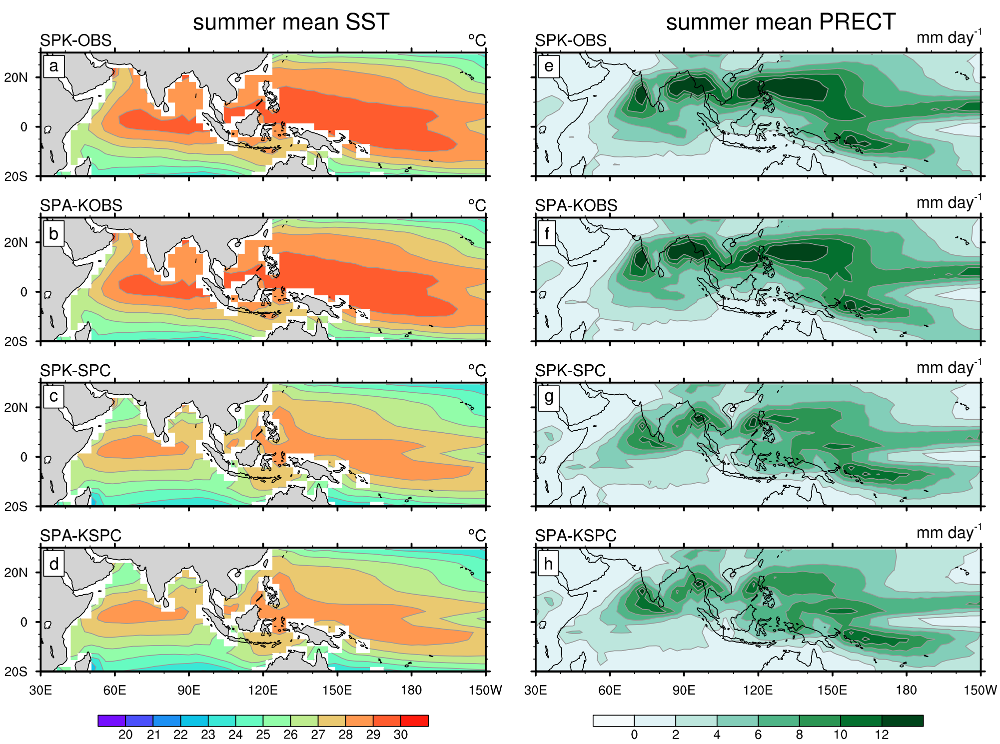

Figure B5. Summer (May–October) mean SST (left column) and precipitation (right column) from (a, e) SPK-OBS, (b, f) SPA-KOBS, (c, g) SPK-SPC, and (d, h) SPA-KSPC.

13. L175-181: Except for the southward propagation there is arguable any difference between observations and all simulations. Please revise these statements.

Responses:

Yes, all model simulations fail to capture the southward propagation of the BSISO. Other significant biases can be seen in the location of maximum BSISO convection.

The simulated convection center shifts northward (10ºN) relative to the observation (5ºN). We have modified these sentences. Please see Lines 191–193 in the revised manuscript.

14. L198-200: Please explain what features show the delay between the suppressed convection and warm SST.

Responses:

To reveal clearly the phase relationship between the convection and SST anomalies, we added the SST contours in Figures 4 and 5 in the revised manuscript. In the Indian Ocean (Fig. B6), SPK simulates well the observed near-quadrature phase relationship between the equatorial convection and SST anomalies. However, in the off-equatorial regions, the warm SST in the coupled models tends to shift toward the suppressed convective region. Over the western Pacific, the phase relationship between precipitation and SST seems to be properly represented in SPK simulations (Fig. B7).

We have carefully checked and modified the related sentences in the revised manuscript after the precipitation data were changed from ERAI to GPCP.

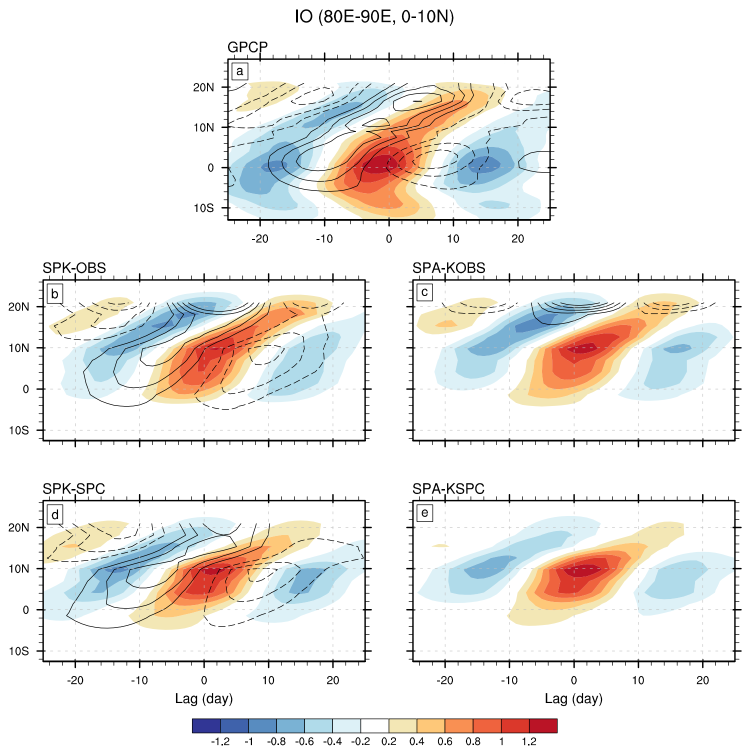

Figure B6. Lagged regression coefficients of 80º–90ºE averaged intraseasonal precipitation (shading; [mm day^{-1}]/[mm day^{-1}]) and SST (contour; [ºC]/[mm day^{-1}]) onto (80º–90ºE, 0º–10ºN) averaged intraseasonal precipitation for (a) GPCP precipitation and ERAI SST, (b) SPK-OBS, (c) SPA-KOBS, (d) SPK-SPC, and (e) SPA-KSPC. The contour interval is 0.001 [ºC]/[mm day^{-1}], and zero contour is omitted.

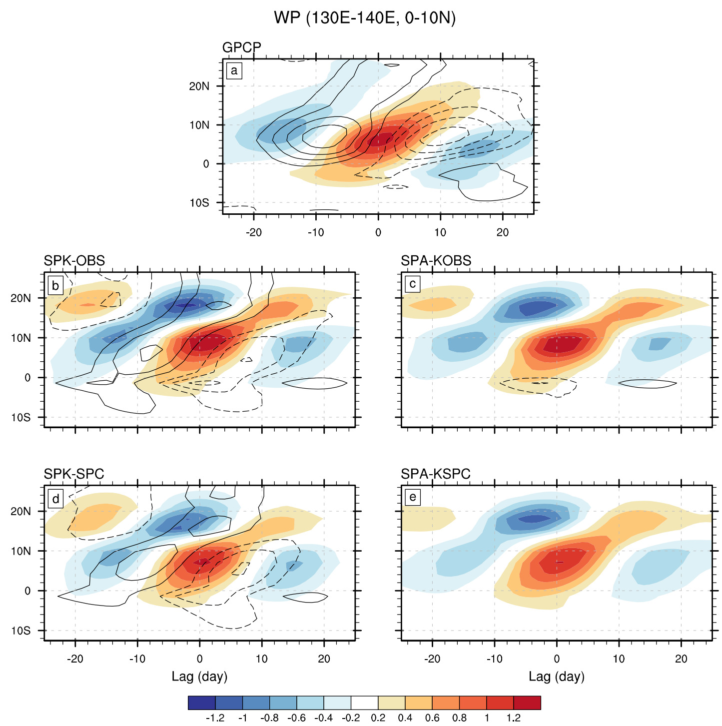

Figure B7. Same as Fig. B6, except for 130º–140ºE averaged intraseasonal precipitation and SST regressed onto (130º–140ºE, 0º–10ºN) averaged intraseasonal precipitation.

15. L202-204: The size of convective region is arguably different between observations and all model simulations. Please revise or show difference plots in support of a large difference.

Responses:

Yes, compared to GPCP precipitation, the size of the simulated convective region in all model simulations is smaller. We have revised the related sentences as follows: "The size of the convective regions in all model simulations is smaller than that in observations, which may imply a deficient BSISO propagation. Compared to SPK-OBS, the convective region reduces when either the SPC mean state is used (SPK-SPC) or air-sea coupling is removed (SPA-KOBS and SPA-KSPC)." (Lines 217–219)

16. L224: Please explain how one can use Fig. 8 (right column) to determine propagation of convection.

Responses:

As shown in Fig. B8, the temporal and spatial evolution of column-integrated moist static energy (MSE; $\langle m \rangle$) is highly consistent with that of anomalous precipitation (Figs. B8a and c). Positive values of the time change of $\langle m \rangle$ (i.e., $\partial\langle m \rangle/\partial t$) leads 90º ahead of the convection over both the Indian Ocean and western Pacific (Figs. B8b and d). Thus, the physical processes that modulate $\langle m \rangle$ (left column of Fig. B8) and

$\partial\langle m\rangle/\partial t$ (right column of Fig. B8) can be considered as the mechanisms responsible for the maintenance and propagation of convection, respectively. We have clarified the meaning of MSE diagnosis in the revised manuscript. Please see the text in Lines 138–142.

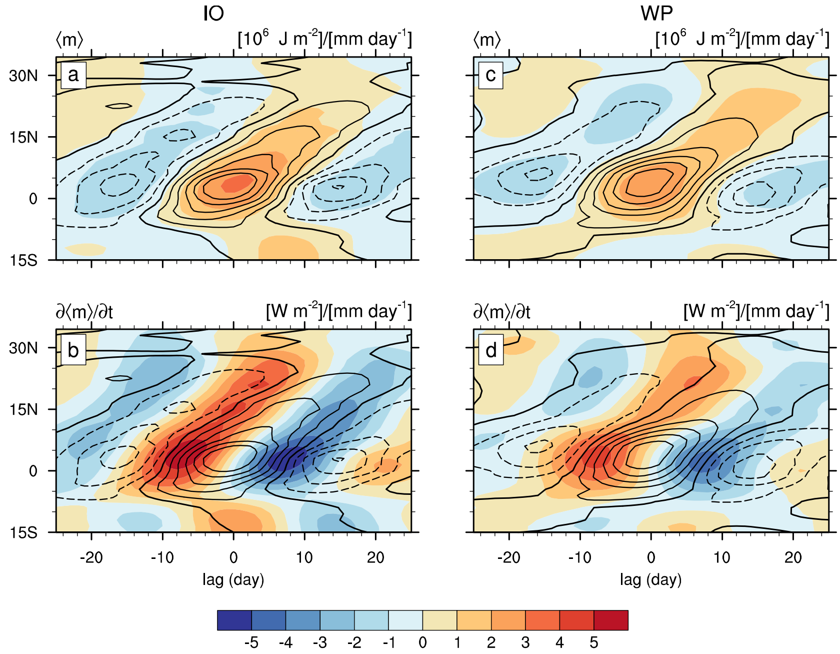

Figure B8. Lagged regression coefficients between longitudinal (75º–85ºE) averaged 20–100-day-filtered (a) $\langle m\rangle$ and (b) ($\partial\langle m\rangle/\partial t$) and area (75º–85ºE, 0º–10ºN) averaged 20–100-day-filtered precipitation over the Indian Ocean as a function of latitude. (c–d) Same as (a)–(b), except for the longitudinal (140º–150ºE) averaged variables regressed onto area (140º–150ºE, 0º–10ºN) averaged precipitation over the western Pacific (WP). Regression coefficients of precipitation are overlaid with an interval of 0.3 [mm day^{-1}]/[mm day^{-1}]; positive (negative) values are represented by solid (dashed) contours.

17. Section 3.4: The comparison between models and observations based on the BSISO indices can be very misleading because models can have their own BSISO with a different lifecycle than observations and this type of analysis will still consider 8 phases. A fair comparison can be done only if the phase compositing is constructed using PC1 and PC2 of observations for models as well. Here this is not possible because SST of the coupled model does not match an observed forcing. The only relevant analysis is to compare the lag-correlation of PC1 and PC2 for MISO 1 (with the 30-60 day period) and PC3 and PC4 for the MISO 2 (14-day period).

Responses:

It is true that models have their own BSISOs with different periods and evolutions, which lead to difficulties in comparing the features of simulated BSISO based on the same reference states. To ensure consistent analysis across all experiments, the anomalous OLR and 850-hPa zonal wind produced by each model experiment are projected, respectively, onto the observed EOF modes to obtain their respective PC time series. This approach helps assess fairly how well the model experiments simulate the observed BSISO because the projected results (modelled PCs) can be directly compared with the observations. If we used the EOF modes derived from the outputs of individual experiments, differences in the spatial patterns and periods would compromise direct comparison of PC time series. In fact, the approach of projecting anomalous fields onto observed modes has been widely used for model assessment of MJO and BSISO simulations (Sperber et al. 2008, 2013; DeMott et al. 2019).

The advantage of this approach has been added in section 2.3 (Lines 155–157).

References:

DeMott, C. A., Klingaman, N. P., Tseng, W.-L., Burt, M. A., Gao, Y., and Randall, D. A., 2019: The convection connection: How ocean feedbacks affect tropical mean moisture and MJO propagation. J. Geophys. Res. Atmos., 124(22), 11910–11931.

Sperber, K. R. and Annamalai, H., 2008: Coupled model simulations of boreal summer intraseasonal (30–50 day) variability, Part 1: Systematic errors and caution on use of metrics. Clim. Dyn., 31(2–3), 345–372.

Sperber, K. R., Annamalai, H., Kang, I.-S., Kitoh, A., Moise, A., Turner, A., Wang, B. and Zhou, T., 2013: The Asian summer monsoon: an intercomparison of CMIP5 vs. CMIP3 simulations of the late 20th century. Clim. Dyn., 41(9–10), 2711–2744.

18. L300-310: The SST gradients in MC-KPP have very little physical meaning (1D ocean model) and no analysis related to SST gradients is shown in the results. How realistic it is to base the interpretation of results on the SST gradients "simulated" by MC-KPP?

Responses:

Excellent question. It is true that the SST gradients in MC-KPP do not arise from oceanic processes (e.g., currents). However, substantial SST gradients can be forced by gradients in atmospheric surface fluxes, to which MC-KPP responds. Thus, we would argue that the SST gradients have physical meaning, though they may not be as intense or frequent as those in observations or in coupled models with a dynamical ocean.

To address this issue, we compare the differences in summer-mean SST and $\langle m \rangle$ between SPK-OBS and SPK-SPC (Fig. B9). The spatial pattern of $\langle m \rangle$ closely follows that of SST. Thus, we argue that the stronger BSISO variability in SPK-OBS than that in SPK-SPC may be related to the enhanced meridional gradients of SST and moisture (Fig. B9). Although the gradient of SST is underestimated in SPK-SPC, we still discuss the roles of horizontal moisture (or $\langle m \rangle$) advection induced by anomalous flows in ISO propagation because this physical process has been highlighted in several recent studies

(Jiang 2017; Jiang et al. 2018; Gao et al. 2019). Our results here also support the findings about the contribution of horizontal moisture advection to BSISO propagation.

Related sentences have been modified in the revised manscript (Lines 317–323).

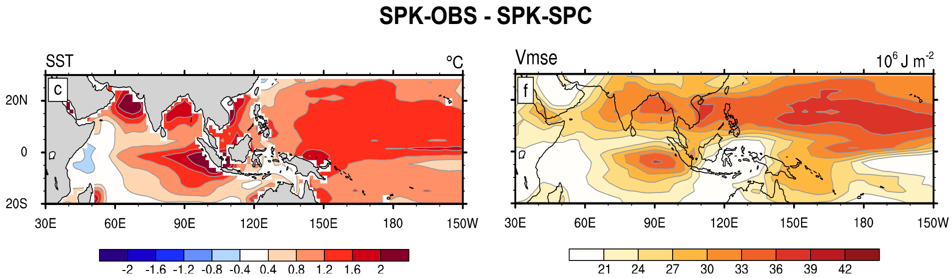

Figure B9. Differences in summer (May–October) mean (a) SST and (b) $\langle m \rangle$ between SPK-OBS and SKP-SPC (SPK-OBS minus SPK-SPC).

References:

DeMott, C. A., Klingaman, N. P., Tseng, W.-L., Burt, M. A., Gao, Y., and Randall, D. A., 2019: The convection connection: How ocean feedbacks affect tropical mean moisture and MJO propagation. J. Geophys. Res. Atmos., 124(22), 11910–11931.

Gao, Y., Klingaman, N. P., DeMott, C. A. and Hsu, P.: Diagnosing ocean feedbacks to the BSISO, 2019: SST-modulated surface fluxes and the moist static energy budget. J. Geophys. Res. Atmos., 124, 146–170.

Jiang, X., 2017: Key processes for the eastward propagation of the Madden-Julian Oscillation based on multimodel simulations. J. Geophys. Res. Atmos., 122, 755–770.

Jiang, X., Adames, A. F., Zhao, M., Waliser, D., and Maloney, E., 2018: A unified moisture moist framework for seasonality of MJO propagation. J. Climate, 31, 4215–4224.

19. Figure 1: The SST field is not an ERAI product.

Responses:

Yes, the ERAI is an atmospheric reanalysis dataset in which SST and sea ice concentration (SIC) were prescribed as boundary conditions for the atmospheric model. The SST and SIC used in the ERAI varied over different periods, which can be found in Table 1 of Dee et al. (2011).

We added: "Note that ERAI SST was the boundary condition prescribed for the ERAI." (Line 128).

Reference:

Dee, D. P., and Coauthors, 2011: The ERA-Interim reanalysis: Configuration and performance of the data assimilation system. Q. J. Roy. Meteorol. Soc. 137(656), 553–597, 2011.

20. Figure 8: Please add the statistical significance of regression coefficients.

Response:

The statistical significance of regression coefficients has been added in the revised Fig. 8 (or see Fig. B10 below).

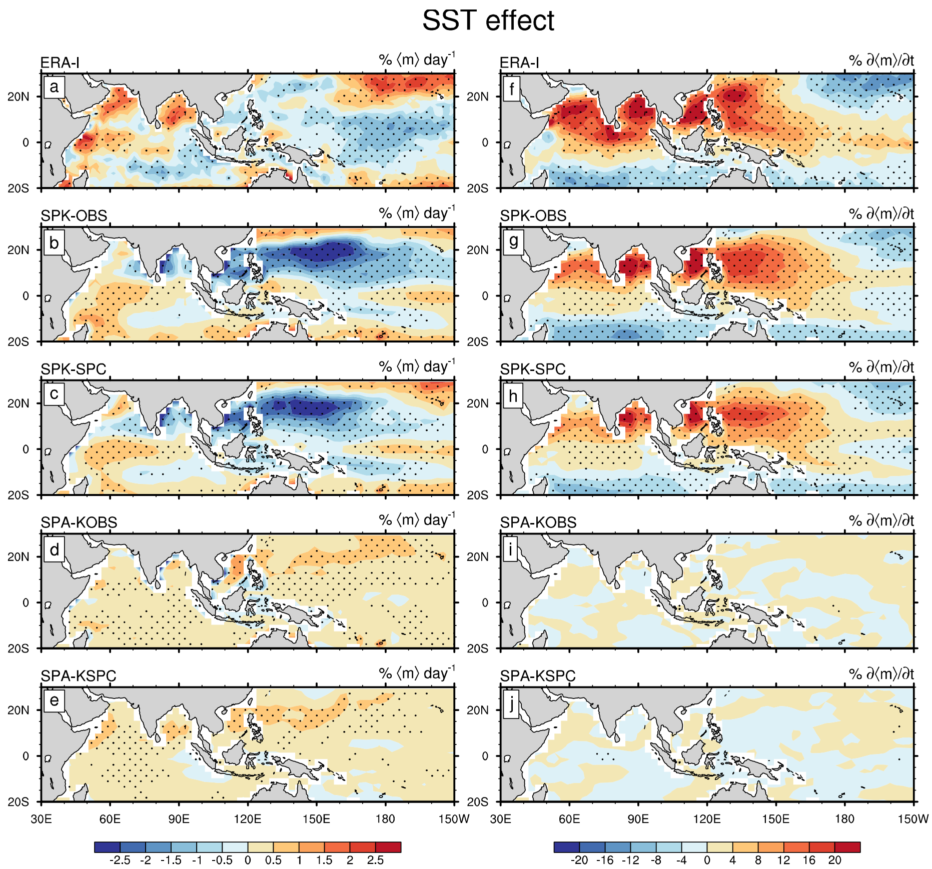

Figure B10. SST effect on (left column) $\langle \boldsymbol{m} \rangle$ and (right column) $\boldsymbol{\partial \langle m \rangle \partial t}$ through the modification of surface turbulent fluxes for (a, f) ERAI, (b, g) SPK-OBS, (c, h) SPK-SPC, (d, i) SPA-KOBS, and (e, j) SPA-KSPC. Stippling marks regression coefficient being significant at the 95% confidence level.