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Interactive comment on "A Mechanistic Analysis of Tropical Pacific Dynamic Sea Level in GFDL-OM4 under OMIP-I and OMIP-II Forcings" *by* Chia-Wei Hsu et al.

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We thank the reviewer's useful comments and suggestions. The questions in the general comments are all listed out separately below. The necessary figures and explanation will be added to the paper to provide robust evidence and makes the paper easier for the reader to follow.

- Cause of the absence of the observed DSL trough around 9N in simulations is made using zonally averaged zonal wind (e.g., Fig.4b). Considering the slanting distribution of the wind convergence zone in the eastern tropical north Pacific, two-dimensional

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distribution of wind stress curl anomaly might be more illustrative.

A: A 2D plot of wind stress curl mean state is shown below [figure1] to demonstrate that the main zonal bias seen in figure 4c (manuscript) is located in the north-eastern tropical Pacific. The stronger dipole wind stress curl bias in the north-eastern tropical pacific in CORE might be related to the poorer representation of the slanted feature of ITCZ. However, the DSL mean state bias is not significantly improved in JRA55-do even with the slanted feature (manuscript figure4a, figure3b). This result shows that JRA55-do still has a bias in wind stress which is consistent with the zonal mean analysis in figure 4 (manuscript).

- The seasonal variation of NECC might be more clearly explained by using seasonal evolution of horizontal distribution of DSL in the tropical north Pacific.

A: Agreed. In the original manuscript, we describe that the better seasonal DSL simulation forced by JRA55-do is associates with better timing of NECC. However, we did not show the DSL gradient Hovmöller which can provide a better visual explanation. We will add the following explanation and figure in the updated manuscript. "Due to the better simulation of the Rossby wave propagation which affects the DSL seasonal variation in the narrow zonal bend in JRA55-do, the seasonal variation of meridional DSL gradient is also better represented in the simulation which affects the timing of the NECC. At 180o, the positive anomaly of meridional DSL gradient in CORE during the second half of the year creates an anomalous counter-force which counter-acts the negative meridional DSL gradient that supports NECC strength (figure 2 below). This effect can also be seen in figure19c where NECC in CORE forced simulation decreases in the second half of the year that deviates from the more accurate NECC simulation forced by JRA55-do."

- Add some paragraphs that give quantitative guidance about how the simulated biases may compromise practical assessments of sea level variability based on the OMIP simulations. For example, are the biases of DSL trend comparable to global mean sea level rise observed in recent years?

A: Giving quantitative guidance on practical sea level variability is a good suggestion. We will add the following basin-scale analysis into the manuscript. “Pacific trend bias over the tropics in CORE is the largest across all three major basins. JRA55-do significantly reduces the bias over the tropical Pacific but has a negative bias in the extra-tropical region and other basins in both northern and southern hemispheres.” The OMIP simulated DSL cannot be used to evaluate the global mean sea level rise due to the definition of DSL does not contain the global mean sea level rising signal, which is stated in line 97-98 of the manuscript.

– Specific comments

- L129: "DSL correlates well with the surface wind stress in the mean state". I think that this expression is somewhat inappropriate. I would suggest something like, "distribution of DSL can be explained well by the surface wind stress in the mean state", if I understand the authors’ intention correctly.

A: Correct. We will rephrase as suggested.

- Figures 3 and 4: Given that the locations of wind stress convergence are slanting from southwest to northeast in the eastern north Pacific as shown in Figure 3a, contribution of zonal derivative of the meridional component to wind stress curl might not be neglected and the horizontal distribution of wind stress curl bias would be of interest. Is the bias pattern of either wind stress curl or Sverdrup stream function comparable with the DSL bias shown in Figures 3b and 3c? A bit more detail would clarify the point that should be improved in the forcing dataset.

A: In figure 4c (manuscript), we show both the total wind stress curl (solid line) and contribution of the meridional derivative of the zonal component to the wind stress curl (dashed line). The two lines show little difference for both CORE and JRA55-do (also in the 2D maps shown below). Therefore, we think the zonal derivative of the meridional component to the wind stress curl is small. Figure4 and 5 below also show the dominating role of zonal wind on wind stress curl and biases. Despite the small contribution, we use the total wind stress curl for all analyses in the study. As for the DSL bias related to the wind stress curl bias, the explanation is included in the response to the first question above and figure 1.

- L.213-215: "We hypothesize that the key reason for the weak NECC is due to both the underestimated zonal wind stress in JRA55-do and a flattening of the DSL trough due to the wind stress curl bias in the northern tropical Pacific found in both CORE and JRA55-do [figure 4b,c]." I think that a bit more detailed explanation is required about how the underestimated zonal wind stress in JRA55-do is related to the weak NECC.

A: The referee is correct. Our original statement of underestimated zonal wind stress in JRA55-do affecting NECC is not explained in detail and cannot be quantified to show the contribution. Since that contribution is not the focus here in the study, we update the sentence by removing the part about zonal wind stress to avoid any confusion.

- L.251: Does the excessive westerly wind trend in CORE and JRA55-do affect simulated features of the global warming hiatus?

A: Since there is no output of surface temperature from OMIP simulation, it is hard to perform a direct comparison between model and observation regarding the hiatus. Based on Kosaka and Xie 2013, sea surface temperature (SST) evolution over the tropical Pacific plays an important role in the global warming hiatus. We compare OISST SST observation with SST in both JRA55-do and CORE forced simulations over the same region used in the study. We find little differences between observation and the two simulations. Therefore, the global warming hiatus should be implicitly included in the simulation.

Kosaka, Yu, and Shang-Ping Xie. "Recent Global-Warming Hiatus Tied to Equatorial Pacific Surface Cooling." Nature 501, no. 7467 (September 2013): 403–7. https://doi.org/10.1038/nature12534.

- L.374-375: How does the improved seasonal variation of DSL in JRA55-do result in the better seasonal variation of NECC?

A: This is explained in detail in the response to the second question above with figure 2.

- L.493-495: "the bias in the wind stress forcing causes biases in the geostrophic current that leads to the flattening of the DSL gradient in the meridional direction". I think that the flattening of the DSL leads to the biases in the geostrophic current. For example, "the bias in the wind stress forcing causes flattening of the DSL gradient in the meridional direction that leads to biases in the geostrophic current".

A: Correct. We will rephrase the sentence as suggested. Technical comments

- L58-59: It would be worth noting here that baroclinic deformation radius in the tropics can be resolved by the 0.25-degree resolution used by GFDL-OM4 as also noted in L.122-123.

A: Agreed. We will add the description about baroclinic deformation radius here, too.

- L180-181: "the heat is not stored in the eastern tropical Pacific but flushed to the western tropical Pacific". I think this is worth noting here that "details are discussed in the next paragraph".

A: Agreed. We will add the sentence to make it easier for readers to follow.

- L.218-220: I think discussion about trend can be moved to somewhere around the paragraphs that discuss DSL trend using Figure 8 in section 4.

A: This arrangement of placing the discussion about trends associated with the mean state of current here is intentional. This is written in a way so the reader can connect the following section (section 4) with the current section (section 3).

- L.252: "extends" should read "extending".

A: Agreed.

- L.266: "(called offsetting factor)". That is actually used as an offsetting factor to correct JRA-55 wind.

A: Agreed. We will change the sentence to avoid the parenthesis.

- L.314: "off" should perhaps read "offset" or "delayed".

A: Agreed. The word will be changed to “delayed”.

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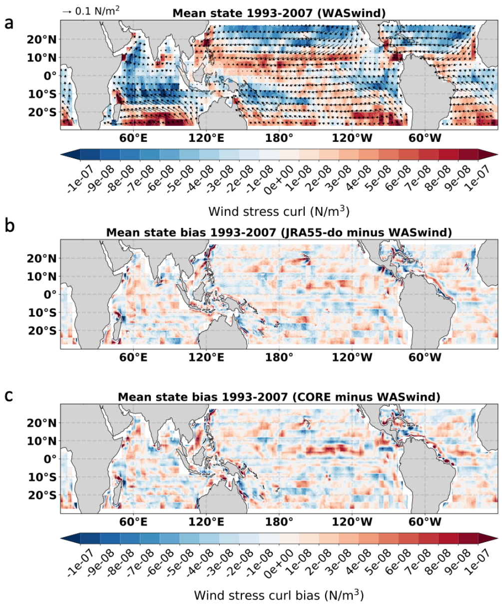

Fig. 1. (a) The wind stress curl (shading) and wind stress (vector) time mean from WASwind. The wind stress curl bias in (b) the JRA55-do and (c) the CORE.

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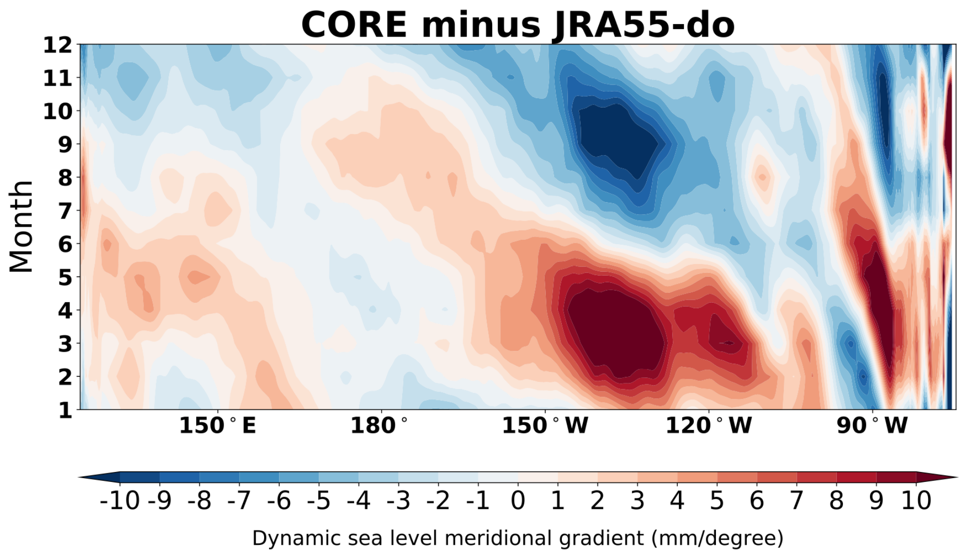

Fig. 2. Hovmöller diagram of monthly climatology showing the meridional mean (2âŮęN to 10 âŮęN) DSL gradient difference by subtracting JRA55-do forced simulation from CORE.

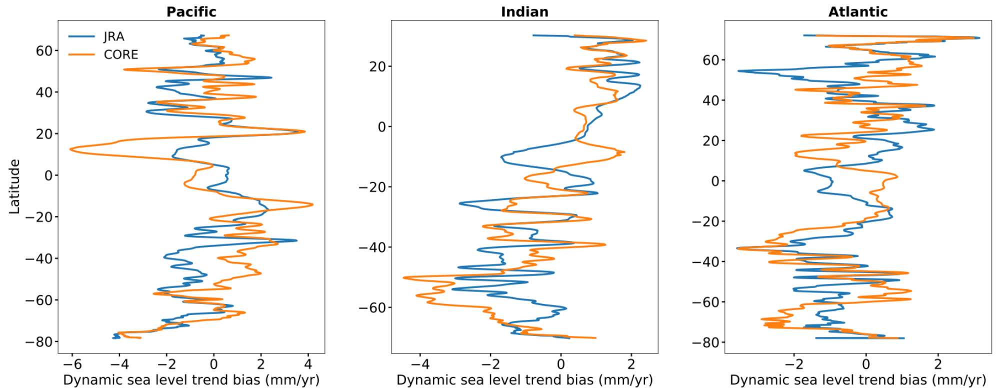

Fig. 3. The zonal mean DSL trend bias at all three major basins from JRA55-do (blue) and CORE (orange) forced simulations during 1993-2007.

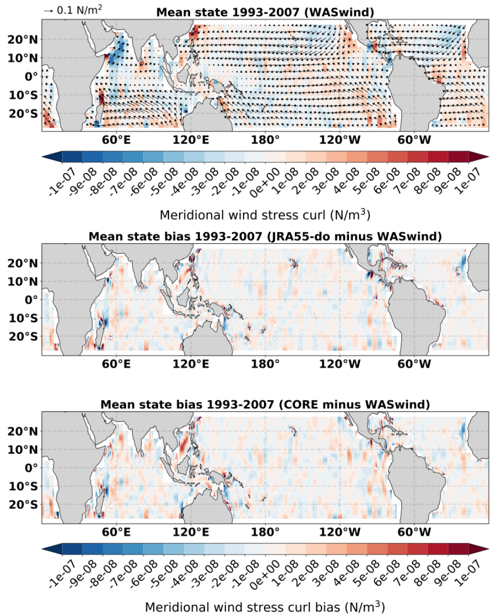

Fig. 4. same as figure 1 with only meridional component.

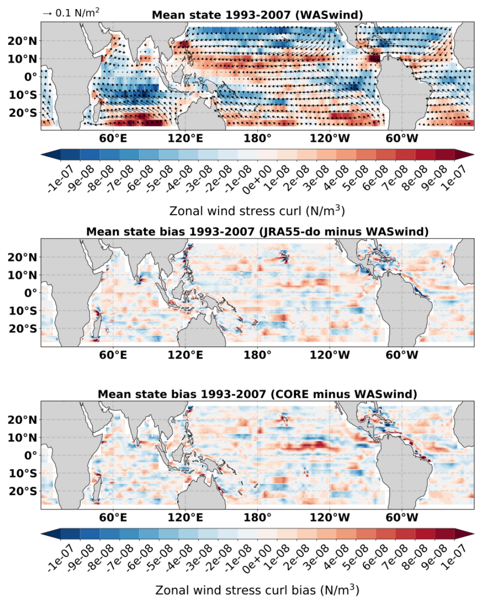

Fig. 5. same as figure 1 with only zonal component

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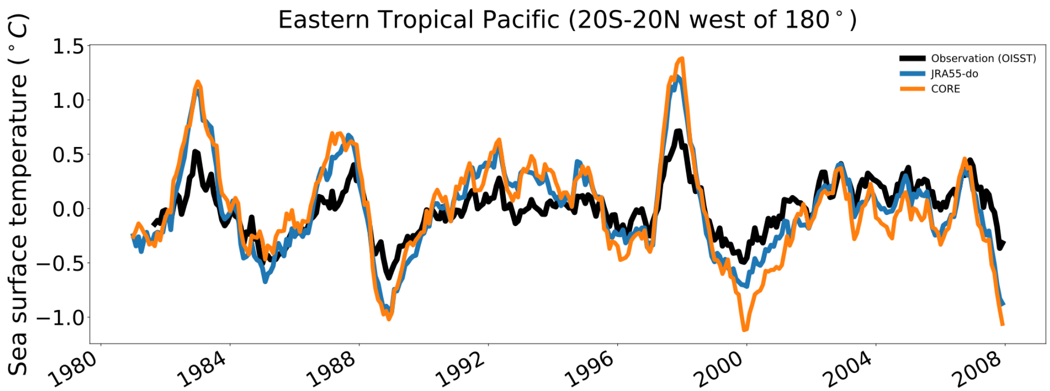

Fig. 6. Sea surface temperature mean in the box (20S-20N and west of 180o – eastern boundary) used in the Kosaka and Xie, 2013 study to test the factor affecting the global hiatus.