Earth Syst. Dynam. Discuss., 3, C621–C628, 2012
www.earth-syst-dynam-discuss.net/3/C621/2012/

Earth System
Dynamics
Discussions

Interactive comment on "Excitation of equatorial Kelvin and Yanai waves by tropical cyclones in an ocean general circulation model" *by* R. L. Sriver et al.

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Received and published: 9 November 2012

Authors' responses to comments by Referee C. Brierley:

Comment: "I feel that this paper presents some interesting results that could easily influence the direction of future research. As such, I feel it should be published pretty much as it is. I must confess that I am not overly familiar with the wave mechanisms under discussion, but none-the-less the evidence appears compelling that wave features do exist."

Response: We thank the reviewer for taking the time to review manuscript and for providing constructive and insightful comments.

Comment: "I felt the introduction provides a comprehensive summary of the literature already published in the field, and the authors were always open about the limitations of their methodology. I did wonder if the first sentence of the conclusion needed to also reflect that caution - perhaps they could note that is "a TC event" and that it is "in an oceanmodel".

Response: We agree and will make the necessary changes to the text.

Comment: "My only significant comment was about the 3x cyclone wind simulation. It is mentioned that such a simulation exists on p1004, yet figure 6B appears to contain results from the 2x simulation. Why is there no further discussion and information shown from this sensitivity study?"

Response: The reviewer raises a valid point. In the original model experiment, we performed multiple simulations in which we scaled the magnitude of the TC winds by factors 1x, 2x, and 3x. The general results of this sensitivity study, analyzing the effect of TC winds on the mean state of the upper ocean, are documented in an earlier paper (Sriver and Huber, 2010). We did not include the 3x case in the current manuscript, primarily for brevity and because the 3x case may represent a scenario which is too idealized or unrealistic. However, we agree with the reviewer that including results from the 3x case is useful for assessing the model's sensitivity to changes in surface forcing, thus in the revised version of the paper we will include an additional panel in Figure 6 showcasing the modeled wave for the 3x case.

Comment: "I was also left wondering if the authors had looked for wave features in the observational data for 1997, to show evidence that the features neither occur every year in data nor are associated with the non-cyclone forcing data."

Response: We did analyze the observational (TAO) upper-ocean heat content for 1997, in addition to the 2003 shown in the paper. During spring/summer of 1997, there is a basin-scale zonal redistribution of upper ocean heat from west to east in the tropical Pacific, which dominates the signal. This ocean heat readjustment has been documented

by McPhaden (1999) (see Figures 1 and 2) as a key indicator of El Nino transition. We also capture this variability in the ocean model experiments, which supports the robustness of the bulk forcing fields in capturing inter-annual variability. However, it is difficult to identify more transient intra-seasonal waves (as highlighted in this paper) in the observations, given the relatively slow 1997 temperature adjustment combined with the low-resolution of the TAO data. Because the observed 1997 evolution of tropical Pacific upper-ocean heat content has been previously documented (e.g. McPhaden 1999), we have not analyzed it in the present manuscript. However, in the revised manuscript we will provide a more thorough discussion about how the observed and model interseasonal variability in 1997 fits with our results and interpretations about the intraseasonal waves induced by TC wind forcing.

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Authors' responses to comments by Referee #2:

Comment: "This manuscript describes a numerical investigation on how tropic cyclones (TC) can generate the tropical Kelvin and Yanai ocean waves. The main approach of this study is to compare the two sets of numerical model simulation (i.e. model run with modified TC winds or without TC winds: the control run). By presenting model results with TC winds as anomalies relative to the control simulation with the mean difference being removed, the authors indicated the waves excited by TC winds as an eastward-propagating warm temperature anomaly compared to the control simulation.

In principle, this could be a very interesting manuscript. However, there are some fundamental shortcomings in the submitted manuscript: 1) personally, I don't feel confortable with the model configuration. i.e. modified the atmospheric forcing (years 1994–2000) to include TC wind fields between 2000-2006 and scale it by 2X, I feel it became too unrealistic and arbitrary. 2) Model results lack sufficient validations from observational data and the discussion on the dynamics regarding how the TC gener-

ated the ocean wave could be more in-depth. I therefore do not recommend publishing this manuscript in its present form. These flaws are noted in detail in the comments below."

Response: We thank the reviewer for carefully reviewing the manuscript and for providing constructive comments and feedback. Since the general concerns described above are also documented in more detail in the specific comments section, we address all points below to avoid redundancy.

Comment: "Specific comments: 1. Could you show a figure of modeled ocean status (e.g. temperature) rather than only the anomaly? It is important to convince the readers at the first that it is a "solid" model and able to capture the dominant characteristics of the studied region."

Response: The reviewer raises an important point about demonstrating model skill. While the version of the POP ocean model used in this study, along with the atmospheric forcing fields (Large and Yeager, 2004), have been previously documented and evaluated, it is important to demonstrate general model skill for our specific experimental design in the geographic region of interest (in this case the equatorial Pacific). Therefore, in the revised manuscript we will add one or two figures highlighting the model's performance in simulating the mean state of the tropical Pacific (including the annual cycle).

Comment: "2. What are the wave speed of the modeled "Kelvin" and "Yaina" wave, explicitly? Is it in accord with the analytic solution or realistic observation?"

Response: The modeled Kelvin and Yanai wave speeds shown in Figure 3A are roughly 3.1 m/s and 2.3 m/s, respectively. The observed Kelvin wave speed shown in Figure 3B is $\sim$2.9 m/s, which is consistent with documented wave speeds observed using the TAO array (e.g. Shinoda et al., 2008). We will add the explicit wave speeds of the modeled and observed waves into the revised version of the manuscript, as the reviewer suggested.

Comment: "3. In Figure 3, how much heat (not only temperature) anomaly was transported eastwards, is it comparable to TAO data?"

Response: For the modeled waves in Figure 3, the average anomalous ocean heat in the uppermost 300 meters is roughly $\frac{1}{4}$ of the observed ocean heat anomaly observed by TAO. We will include this calculation and discussion in the revised version of the manuscript.

Comment: "4. Instead of artificially “blending and scale” the wind forcing of 1994-2000 and 2000-2006 and just present the results, would be it possible to design some idealized cases by using more idealized TCs and even simplified ocean geometry in order to develop an analytic solution? Therefore you would have both model results and analytic solution so that you can show the mechanism of wave-generation by TC clearly, or even develop a theory and find critical value (how often or how strong the TC has to be to induce these waves from the theory)."

Response: We agree with the reviewer that the blending of the model's atmospheric forcing fields with TC records using the comprehensive POP ocean component of CCSM3 is not ideal. However, we chose to use a complex ocean model because it provides more realism than simpler box models , and this version of the model and forcing fields have been extensively documented and evaluated (Smith et al., 1992; Large and Yeager, 2004; Smith et al., 2004; Bryan et al., 2006; Danabasoglu et al., 2006; Yeager et al., 2006; Danabasoglu et al., 2008; Griffies et al., 2009). Further, multiple studies already exist seeking theoretical/analytic solutions to equatorial waves similar to those highlighted in the paper (e.g. Boyd, 1980; Giese and Harrison, 1990; Fedorov and Melville, 2000; Le Sommer et al., 2004; Ascani et al., 2010).

Overall, the goal of the current paper is primarily to provide a conceptual framework for illustrating how TCs may influence tropical Pacific ocean waves, and thus ENSO, using a comprehensive ocean model and idealized (though still based on real observations) TC surface forcing. We agree that more analysis is needed into examining the TC-wave

relationship, including using more idealized modeling/theoretical frameworks, and we hope these preliminary results will spark additional research in this area (including ongoing work by the co-authors). In the new version of the manuscript, we will highlight the reviewer's concerns in the text, by providing a more thorough discussion of the caveats associated with our methodologies and we will stress the need for additional research using different theoretical/modeling approaches.

Comment: "5. It would be scientifically interesting either going for a more in-depth theoretic research as mentioned above or a more realistically and solid model simulation, in this way you must a show a reliable model and good model-data comparison quantitatively, so that you could provide accurate information such as how much heat was transport; how much mixing was induced, how quick the wave could be induced or damped during different TCs etc."

Response: We generally agree with the reviewer about these points, which he/she has also raised in the previous comments. While a more in-depth theoretical approach is beyond the scope of this preliminary proof-of-concept study (for reasons outlined in point 4), we will address the reviewer's other points regarding model performance and wave characteristics in the revised manuscript. Specifically, we will: 1) highlight the reliability of the model in simulating the mean tropical state and interseasonal variability, 2) provide more complete quantification of the simulated wave characteristics, including wave speeds and ocean heat transport compared to observations, and 3) improve the descriptions and lists of caveats and limitations regarding modeling methodology employed in the study, and we will stress the need for additional work in the future.

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Interactive comment on Earth Syst. Dynam. Discuss., 3, 999, 2012.