Ocean Sci. Discuss., 11, C759–C766, 2014
www.ocean-sci-discuss.net/11/C759/2014/

Ocean Science Discussions
Open Access

Interactive comment on "Evaluation of the eastern equatorial Pacific SST seasonal cycle in CMIP5 models" *by* Z. Song et al.

Z. Song et al.

songroy@fio.org.cn

Received and published: 29 August 2014

article xcolor graphicx

Response to Referee #2

(Note: referee comments in black and our reply in blue)

General comments

Comment: The authors explored model bias for the seasonal cycle of SST in the eastern equatorial Pacific using CMIP5 CGCM outputs, and found that models tend to underestimate the amplitude of the seasonal cycle in the region near the eastern coast. Then, they concluded that the seasonal cycle of SST in the eastern equatorial Pacific

is generated by not only the local mean state, but also the remote effect. Their results must contribute to improvement of model bias of seasonal cycle, and thus ENSO. However, some points need clarification. From my point of view, the paper deserves to be published in the journal after major revision.

Reply: We would like to express our sincere thanks to the reviewer for the comments. The new manuscript will be modified according to the reviewer's suggestions. These comments and suggestions greatly help us improve the quality of this manuscript.

Specific comments

1. I cannot understand why the cold SST bias in the mean state causes the realistic simulation of amplitudes of seasonal cycle of EP2 SST.

Reply: Sorry for the misunderstanding. As we described in P1134 L19-L24, in the EP1 region, the amplitude of SST seasonal cycle is weaker than the amplitude in observation, because there is cold bias in the boreal spring at its peak and warm bias in the boreal autumn at its minimum. But, in the EP2 region, the amplitude is almost the same as in observation, because there is a quasi-constant cold bias along the year in this region.

Revision in paper:

Line 19 of P.1131: "and pointed that most of these model simulate two cold phases in the EEP SST rather than a single cold phases" was modified to "and pointed that 8 of these models simulate two cold phases in the EEP SST rather than a single cold phase"

2. Is EEP bias related to double ITCZ bias? Also, the explanation in P1135L15 L20 means the effectiveness of the Wind-Evaporation-SST positive feedback, which causes model bias of seasonal meridional migration of the Pacific ITCZ.

Reply: Thank you for your valuable suggestion. Yes, the EEP bias is related to double

ITCZ bias. In fact, the southward wind bias (Fig. 4a and b in paper) is associated with the double ITCZ bias, which weakens the meridional wind. So, in our revision, we add the discussion in the analysis section.

Revision in paper:

Line 20 of P.1135: In the texts P1135 L18-19: "Thus, a warm SST bias develops." is modified to "Thus, a warm SST bias develops. It should be noted that the southward wind bias is associated with the double ITCZ bias, which weakens the meridional wind through Wind-Evaporation-SST feedback (De Szoeke and Xie, 2008)".

3. P1134: Theoretically, the eastward Kelvin wave propagation is more important than the westward Rossby wave propagation on the equator. Could you explain more about Rossby wave propagation on the equator? Why can eastern EP1 region lead to central EP2 region by one to two monthly by most models (P1134L13)?

Reply: Sorry for the misunderstanding and thank you for your valuable suggestion. Yes, eastward Kelvin wave propagation is more important than the westward Rossby wave propagation on the equator. But, for the Pacific SST seasonal cycle, there're many observational analyses suggesting that the annual cycle in the equatorial Pacific is initiated in the east by monsoon and the induced signal propagates westward as the result of air-sea interaction (Bjerknes, 1961; Wyrtki, 1965; Horel, 1982; Mitchell and Wallace, 1992). In fact, in spring, the eastern EP1 region leads to central EP2 region by one to two months. The CMIP5 model can simulate such westward propagation property successfully. But, in August and September, both SST in the eastern EP1 region and EP2 region are in the same phase when the cold tongue grows. Unfortunately, 16 out of 18 CMIP5 models failed to reproduce such character, possibly due to the warm SST bias from southeastern tropical Pacific. In order to avoid misunderstanding, we rewrite this section and add some discussion of the model biases in the analysis section.

Revision in paper:

In the texts P1134 L10-L18: "Most models, including CanESM2, CCSM4, CSIRO-MK3-6-0, GFDL-CM3, GFDL-ESM2G, GISS-E2-H, GISS-E2-R, HadGEM2-CC, HadGEM2-ES, INMCM4, IPSL-CM5A-MR, IPSL-CM5B-LR, MPI-ESM-LR, and MPI-ESM-P, show that EP1 leads EP2 by one to two months during the course of one year, whereas two models, FIO-ESM and HadCM3, demonstrate that both EP1 and EP2 follow the same phase. A comparison of the results of multi-model ensemble (MME) mean and observation reveals that CMIP5 CGCMs can capture the annual cycle signal in both the EP1 and EP2 regions. In addition, the correlation coefficients between MME and observations are up to 0.9. " is modified to "In March and April, 16 out of 18 models, including CanESM2, CCSM4, CSIRO-MK3-6-0, FIO-ESM, GFDL-CM3, GFDL-ESM2G, GISS-E2-H, GISS-E2-R, HadCM3, HadGEM2-CC, HadGEM2-ES, INMCM4, IPSL-CM5A-MR, IPSL-CM5B-LR, MPI-ESM-LR, and MPI-ESM-P, show that EP1 leads EP2 by one to two months. But in August and September, only two models, FIO-ESM and HadCM3, demonstrate that both EP1 and EP2 follow the same phase. A comparison between multi-model ensemble (MME) mean and observation reveals that CMIP5 CGCMs can capture the annual cycle signal in both the EP1 and EP2 regions and westward propagation process in spring. In addition, the correlation coefficients between MME and observations can reach 0.9. But, CMIP5 models fail to reproduce the process that the SST in EP1 and EP2 regions are in the same phase in August and September when the cold tongue develops".

In the texts P1135L24, add "Moreover, the warm SST bias in the EP1 region in boreal summer may explain that most of CMIP5 models fail to reproduce the process that the SST in the EP1 and EP2 regions are in the same phase in August and September when the cold tongue develops." to the end of the paragraph.

In the texts P1136L6, add "And, CMIP5 models can simulate the EEP SST westward propagation character, SST in EP1 leading SST in EP2 by one to two months in spring. But, they fail to reproduce the process that the SST in EP1 and EP2 regions are in the same phase in August and September when the cold tongue develops." to the end of the paragraph.

4. P1130, L20: Can the mean EEP bias really cause ENSO simulation bias for amplitude, frequency, and seasonal phase-locking?

Reply: Yes. The properties of ENSO are highly sensitive to even slight changes in the mean state (Xie, 2004). For example, as described in this paper, the mean EEP bias is certain to affect the simulation of equatorial annual cycle, which is known to affect the properties of ENSO, most notably its seasonal phase-locking (Jin et al. 1994; Li and Hogan 1999).

5. P1131, L17: The EEP bias looks similar to eastern equatorial Atlantic SST bias. If the authors can add discussion about comparison with Atlantic SST bias, the paper will be more interesting.

Reply: Thank you for your suggestion. In this paper we mainly focused on the EEP SST seasonal cycle and will analyze the eastern equatorial Atlantic (EEA) SST bias in future, because the biases and its corresponding physical mechanisms in EEP and EEA regions are different. Firstly, the annual mean SST biases between EEP and EEA regions are different (Fig. 1 below). Secondly, the seasonal SST biases are also different (Fig. 2 below), such as the westward propagation can be simulated in EEP region but not in EEA region. Thirdly, the mechanisms of seasonal cycle between equatorial Pacific and Atlantic are different, although the northward displacement of the climatological ITCZ is the cause of the annual cycle in equatorial SST in both the Pacific and Atlantic (Xie, 1994). The annual cycle in the equatorial Pacific is initiated in the east by monsoon and propagates westward as the result of air-sea interaction (Mitchell and Wallace, 1992). In contrast to the equatorial Pacific where air-sea interaction is the leading mechanism for the annual cycle, the narrow width of the tropical Atlantic and the presence of strong continental convective zones mean that continental monsoons play a dominant role (Xie and Carton, 2004). So, to clearly analyze the EEP biases, it's better to discuss EEP and EEA biases separately.

Interactive comment on Ocean Sci. Discuss., 11, 1129, 2014.

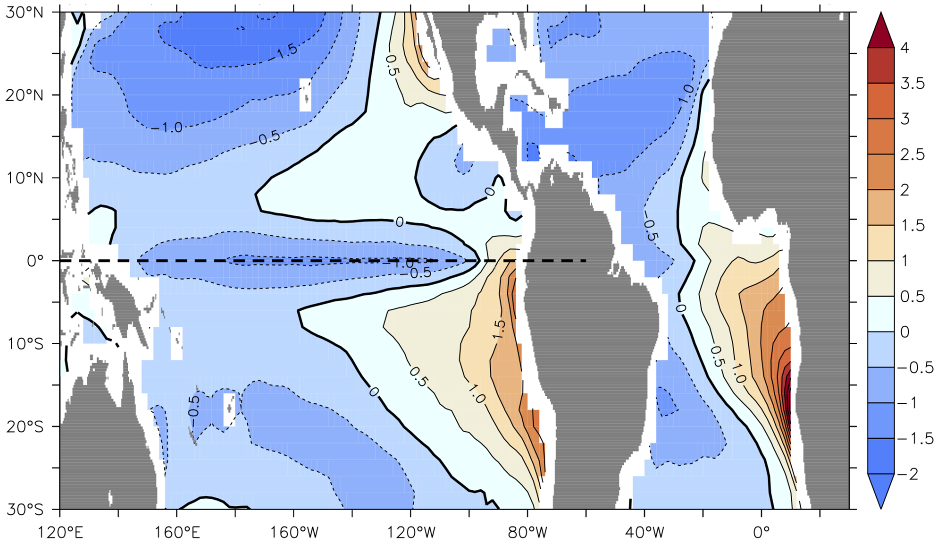

Fig. 1. CMIP5 Multi-Model Mean tropical Pacific and Atlantic annual mean SST bias

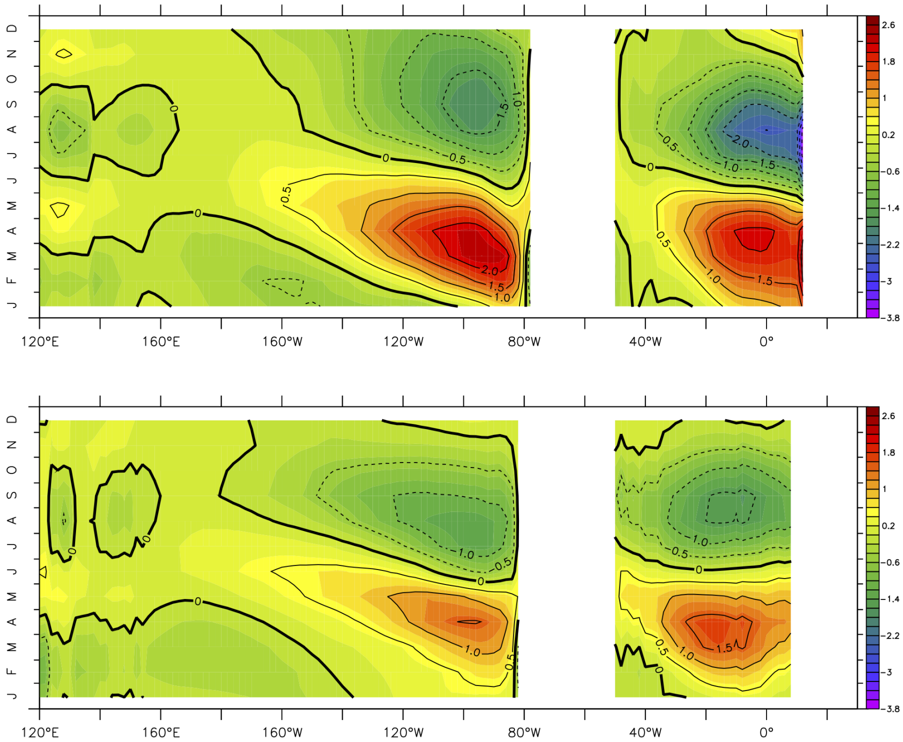

Fig. 2. Equatorial Pacific and Atlantic SST seasonal cycle (SST anomaly relative to annual mean) Upper: ERSST; Lower: CMIP5 Multi-Model Mean