Earth Syst. Dynam. Discuss.,
https://doi.org/10.5194/esd-2018-52-AC2, 2018

Earth System Dynamics Discussions

Interactive comment on "North Pacific subtropical sea surface temperature frontogenesis and its connection with the atmosphere above" *by* Leying Zhang et al.

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Received and published: 19 December 2018

Responses to Reviewer #2

We appreciate the reviewer's comments and suggestions on our manuscript. Our replies follow each of Reviewer's comments or suggestions.

Comments:

1. Line 51: "respective"-> "perspective"

Response: Revised.

2. Line 187-188: Authors should give some explanations about how "the residual term (R) is mainly positive and facilitates an increasing SST" and how "the residual term acts to suppress SST decreasing tendency (Line 197)", since term R represents sub-scale process and dissipation.

Response: The residual term beneficial to an increasing SST may be associated with the meridional eddy heat fluxes over the subtropical North Pacific. Wunsch (1999) noted that eddy-induced heat fluxes are important relative to the total meridional heat fluxes in western boundary current regions of the North Atlantic and Pacific Oceans. Moreover, Qiu and Chen (2005) showed that the meridional eddy-induced heat fluxes over the subtropical North Pacific are both poleward for warm-core eddy detected in 11 Mar–3 Jun 2001 and cold-core eddy detected in 30 Dec 2001–24 Feb 2002. Accordingly, the poleward eddy-induced heat fluxes tend to transport the warm water from lower latitude to the subtropics, and benefit the warmer water there. These findings are consistent with our results that the residual term leads to the increasing SST over the NPSTF. Thus, the residual term beneficial to an increasing SST over the NPSTF is very likely due to the meridional eddy fluxes. However, it is still hard to confirm this process at this stage due to the relatively coarse resolutions of the data used in study. Thus, further exploration is needed when finer data becomes available to us. We add this discussion in our revised manuscript.

3. Line 203-204: Authors can not consider that "the GM tendency is mainly caused by the net heat flux term (Fig. 5e)". For example, at 26.5°N, GM tendency increases temporally from October to the middle of December, however, the net heat flux term experiences a decreasing period from October to the end of December. In fact, vadv term and R term also contribute to GM tendency especially in January and February.

Response: Although the magnitude of the net heat flux dominates the GM tendency from October to December, the tendency of GM tendency is not consistent with that of the net heat flux term at 26.5°N. However, the increasing of the GM tendency corresponds to that of meridional temperature advection, highlighting the important role of the meridional temperature advection in the frontogenesis. We add this discussion in our manuscript.

4. Authors should not cap the GM tendency at 100% in October and November in Fig. 6b.

Response: Revised.

5. Fig.7 could be omitted.

Response: The results from Argo data in Figure 7 is shown to confirm the conclusion that both the net heat flux and the meridional temperature advection are beneficial to the NPSTF frontogenesis from SODA. However, we also found that the meridional temperature advection in Argo data dominates the frontogenesis in January and February, highlighting the importance of the meridional temperature advection. Thus, results from SODA and Argo data exhibit some small differences. So we prefer to show this figure and move it into Figure 6.

6. Caption of Figure 8: It is the contribution of individual radiation component to the GM tendency.

Response: Fixed.

7. Line 269-270: How to estimate a 75% contribution of Ekman convergence to the meridional temperature in January and February.

Response: We separate the contribution of the Ekman convergence to the meridional temperature advection into the contribution of individual positive and negative values, because only positive values of the meridional temperature advection and Ekman convergence benefit the frontogenesis of the NPSTF. The contributions of positive values, regionally-averaged over 140°–190°E, 24°–28°N, are 78% and 84% in January and February, respectively. As for the negative values (i.e., suppressing the frontogenesis), the Ekman convergence is much smaller than the meridional temperature advection. Thus, we consider that the Ekman convergence accounts for at least 75% of the meridional temperature advection in January and February in terms of the contribution to the frontogenesis. However, this conclusion seems to be inadequate. Thus, this statement is revised as: “The Ekman convergence largely contributes to the meridional temperature advection in the frontogenesis in January and February.”

8. Line 334-338: “The thermodynamic calculation uses a specified mixed-layer depth, and the temperature of the slab is calculated based on the mixed-layer depth and surface fluxes. It means that the ocean dynamics processes can be ignored and the SST variation responds to the atmosphere.” Why? Since “The SST and meridional oceanic current velocity from the last 15 model years are used for analyses. (Line 342-343)” and “suggesting ocean dynamics may play an important role in the northward migration process (Line 354-355)”.

Response: The SST diagnosed in the slab ocean model is related to the surface heat fluxes among the atmosphere, ocean and ice model, without any oceanic internal dynamics process. Thus, the SST in the slab ocean model is considered irrelevant with the ocean process. As suggested in comment#9, results from the slab ocean model are no longer analyzed in our revised manuscript.

9. Section 4.3 about analysis with model outputs is unnecessary since no additional sensitivity experiment was carried out, the model output itself only provide misrepresented “observations”.

Response: As suggested, results from the slab ocean model are no longer analyzed in our revised manuscript.

10. Check the caption of Figure 13.

Response: Fixed.

Reference:

Qiu, B., and Chen Q. M.: Eddy-induced heat transport in the subtropical North Pacific from Agro, TMI, and Altimetry Measurements. J. Phys. Oceanogr., 35, 458-473, doi:

10.1175/JPO2696.1, 2005. Wunsch, C.: Where do ocean eddy heat fluxes matters? J. Geophys. Res., 104, 13235-13249, doi: 10.1029/1999JC900062, 1999.

Please also note the supplement to this comment:
https://www.earth-syst-dynam-discuss.net/esd-2018-52/esd-2018-52-AC2-supplement.pdf

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