

## Reply to Reviewer #2

Thank you for your valuable comments. We modified the manuscript according to your comments.

1. - Page 2270, line 1 from bottom: it is not clear in which way the inclusion of boundaries may generate errors related to topography (the boundaries are based on the observed residual mean vertical velocity)

**Reply:** For calculation of  $\overline{v'\theta'}$ , we did not exclude the region under the land surface. Thus  $\overline{w}^*$  near the lowest level has some errors. By use of Laplacian for solving TEM model, the errors of  $\overline{w}^*$  near the lowest level affect upper levels.

2. - Page 2271, line 1 from bottom: The anomalies are calculated w.r.t. a climatology of 4 months (DJFM) or 3-months as indicated in the caption of Figure 1? In case it is for the 3-months, which ones?

**Reply:** We miswrote the caption of Figure 1. Correctly, the anomalies are calculated mean of 4 months (DJFM). The figure caption was corrected.

3. - page 2273, line 9 from top: could you clarify the role of the boundary effect?

**Reply:** Boundary effect means just giving the observed residual mean vertical wind at the top

and bottom. It means  $\frac{1}{a \cos \phi} \frac{\partial}{\partial \phi} \left( \cos \phi \frac{\overline{v'\theta'}}{\overline{\theta}_z} \right)$  at the bottom and

$\overline{w} + \frac{1}{a \cos \phi} \frac{\partial}{\partial \phi} \left( \cos \phi \frac{\overline{v'\theta'}}{\overline{\theta}_z} \right)$  at the top. Usually, we determine boundary value as zero at the

top and bottom. As you pointed out, this expression is somewhat confusing. Thus we modify the sentence as follows;

*When the boundary value is zero at the top and bottom,-*

4. - page 2274, lines 1-4 from bottom: Not clear, from Figure 5 it appears that the main contributor to the ascent on 18 Jan is still the diabatic heating.

**Reply:** As you pointed out, the diabatic heating term is the main driver of tropical upwelling through January 2009. We would state that wave forcing is the main contributor of time change of the residual mean vertical wind in the tropics.

5. - Page 2275, line 11 from top: 'decays with decreasing altitude'. Not clear from the Figure

**Reply:** In the mid latitudes, residual mean vertical wind does not decay with decreasing altitude in all levels. We added following words in the sentence:

*In the tropics and high latitudes, the anomaly of residual mean vertical wind decays with decreasing altitude.*

6. - Page 2275, lines 8-10 from bottom: the eddy forcing term in the SH troposphere has an insignificant effect on the TTL: but it induces a positive anomaly even a bit below 200 hPa. Do you mean that it is too small to be significant at 95%? Then, this insignificant effect is occurring on the 18 January only. Things would have been different on January 9 if we refer to Figure 4. Any comment?

**Reply:** We did not mean what you stated. We would state that the SH forcing was not the main driver of tropical upwelling between 150 and 100 hPa because of its smallness. The expression "insignificant" is not appropriate at this case, and thus, we used another expression in the sentence.

7. - Page 2277 and discussion of Figure 10. Looking at the vertical component of the wave activity flux at 100-125 hPa, on January 18 and January 21 there are large values (red contours) over the North Atlantic. Could this be a source region of wave activity relevant for the SSW occurrence and duration? (For example, at 500 hPa (well below), these regions appear to coincide with the Greenland blocking area - Jan 18 - and European blocking area - Jan 21). See for example: Woollings et al. 2010 - Associations between stratospheric variability and tropospheric blocking). Could you add a comment?

**Reply:** We also think that the blocking causes the upward-propagating waves related to the SSW and the equatorward-propagating waves related to cooling in the upper TTL. However, we think the relationship between tropospheric blocking and stratospheric sudden warming is beyond the main scope of our paper.

8. - Page 2279, lines 6-9: sentence not clear, there is a verb missing?

**Reply:** Thank you for pointing out. We modified the sentence as follows:

*Our results accord with several studies. Ahead of the cyclonic anomaly in the westerly duct, ascent occurs and static stability is reduced, which is consistent with the interpretation that equatorward-propagating waves force the convection (Kiladis, 1998; Matthews and Kiladis, 2000).*

9. - A question: Could this interesting analysis be extended (in a next work) to other strong

SSW events and make some statistics?

**Reply:** As you said, we think further analysis is needed especially about statistics. We will examine what type of SSW event makes influence on the TTL temperature and circulation statistically in future study.