# Response to reviewer 2

We would like to thank reviewer 2 for a very thoughtful and detailed review. The review suggests that our paper still fails to convince that the contribution of meridional transport to the tropical seasonality of ozone is significant. The review also gives some hints on how to improve this point. So we followed these recommendations which, to some degree, agree with the recommendations given by the reviewer 2. Thus, we significantly changed the chain of reasoning although the main results and statements are the same. In particular, the points made by the reviewer 2 were taken into the account in the following way (the referenced lines in the revised manuscript are marked as L XXX - YYY):

1. "Vertical velocity"
   Yes, we agree that a quantitative understanding of the seasonality of ozone in the TTL strongly depends on the quality of the vertical velocities. That is what we also strongly emphasize in our paper where several scenarios of vertical velocity (diabatic with and without mass correction from operational ECMWF analysis and from ERA-Interim) are used. And indeed, the absolute values of in-mixing (Fig. 9) or of the fractional annual amplitude $\Delta O_3/\langle O_3\rangle$ or of its phase significantly depend on the used vertical wind. The only robust feature for all these scenarios is its seasonality with highest values of (passive) ozone in summer that, following CLaMS, is horizontally transported from the extratropical northern hemisphere into the TTL and mainly driven by the Asian monsoon anticyclone (see discussion L 596-617).

   Following the recommendation, we also included the reference Yang et al., JGR, 2008 (see L 580-583).

2. "zonal modulation"
   Following the idea described in the review, we included a new figure (Fig. 8) in the revised version showing the ozone climatology at two SHADOZ stations, Kuala Lumpur and Nairobi which are located downwind (in the climatological sense) of the Asian monsoon anticyclone. The analysis of these two local climatologies supports our arguments although the signatures of in-mixing in the model (decrease of the amplitude of the annual cycle with the distance from the Asian monsoon anticyclone or the phase shift of the ozone maximum) are slightly stronger than in the observations (see L 492-521).

3. "Vertical structure of the annual cycle"
   Yes, we agree that the vertical structure of the annual cycle derived from CLaMS, mainly the amplitude of the seasonal modulation is larger than the amplitude derived from the SHADOZ observations. On the other side the fast decrease of the amplitude of the fractional annual cycle, $\Delta O_3/\langle O_3\rangle$ discussed in Randel et al., 2007, above 70 hPa is not as pronounced if $\theta$ (instead of $p$) is used as the vertical axis (see Fig. 2 in the revised manuscript).

   Nevertheless, the qualitative decrease of $\Delta O_3/\langle O_3\rangle$ with altitude is reproduced by our simulations. However, the numerical values of the fractional annual amplitude $\Delta O_3/\langle O_3\rangle$ itself or of its phase significantly depend on the used transport scenario with vertical velocity and mixing having the strongest influence. In the revised version of our manuscript, we do both: analyze the quality of our simulations in terms of $\Delta O_3/\langle O_3\rangle$ and discuss the possible reasons for the diagnosed differences (see L 492-521 and L 612-617).

4. ”meridional exchange”
   Here, we also followed the recommendation and improved the following points:

   - improved figure 7 comparing MLS and CLaMS lat-lon climatologies by averaging CLaMS data in a way that mimics the MLS retrieval procedure (see L 445-459).
   - analyzed not only the Asian monsoon anticyclone but also the smaller anticyclones on the southern hemisphere (Bolivian high, Australian monsoon) with respect to their potential for in-mixing. Here, the reference Borchi et al, ACP, 2005 was included (see L 472-492).
   - looked at the MLS data at higher and lower levels than 380 K. Here, the analysis of MLS at 420 K confirms the importance of the Asian monsoon anticyclone and shows its dominance relative to other anticyclones. We mentioned this point in the revised version (see L 481-484).
   - included the climatology of two SHADOZ station which are directly influenced by the Asian monsoon (see above).