

Reviewer #1

The authors would like to thank the reviewer for carefully reading the manuscript and critically analyzing the results. Based on the useful suggestions of the reviewer, the manuscript is now much improved. In the following, we provide point-by-point responses to reviewer's comments, which are italicized and typed in brown.

Specific comments:

1- In page 5, line 6, the uncertainty level (σ) is mentioned for the first time. It would be helpful if the authors provided the value of σ , since it is very difficult to estimate it from the figures. Furthermore, it seems that the uncertainty level of the phase is larger than that of the amplitudes of the tides. Maybe, it's the type of plotting that confuses me and in reality, the uncertainty levels of both amplitude and phase are similar. But, if the phase uncertainty level is indeed larger, do the authors know why? In the case of the phase of S2, it concerns me that the authors can really state there is a shift of 1-2 h given that σ appears to be of 1-1.5 h. I mean, from the figures, except in the case of 2009 and maybe in 2006 around the 10th of January, the shift in the phase of S2 may be completely embedded within the uncertainty level. Hence, one could say that the phase has not changed. Or, did I overlook something?

Response: The reviewer has correctly pointed out this error in the analysis. The uncertainty levels have been recalculated and the error has been corrected. The values of the uncertainty levels are now provided in the updated manuscript and the literature that have been followed for these calculations have also been included in page 6 lines 17-19 in the tracked changes file. The shift in the phase of S2 after recalculation is now not embedded within the uncertainty levels.

2- Plots of the phase of SW2 and M2 are presented in Figs. 6, 7 and 8. However, they are never discussed in the manuscript. Besides, I strongly recommend changing the colorbar to "hsv" or any other cyclic color bar, and use 0 and 12 (12.4) as lower and upper boundaries, respectively. In that way, one can clearly see if there are (or not) changes in the phase of the simulated tides.

Response: The phase of the simulated SW2 and M2 are now discussed in detail in the updated manuscript. The upper boundaries of the color bars have been changed for the simulated tides in the updated plots.

3- To extract the tides from the model simulations, I guess the authors used a similar fitting technique as in the case of the observations. If so, please mention that explicitly in the manuscript. Further, did the authors only fit SW2 and M2 or did they consider more wave numbers as well as other tides such as DW1?

Response: The process for extracting the tides from model simulations have now been included in the revised manuscript. In page 9 of the tracked changes file, we now describe the process in detail.

4- Page 9, lines 7-8. Can one really expect that tides in temperature behave in the same way as in the winds? This reviewer has had the opportunity to study thermal tides in different model simulations and has found that they can behave quite differently in temperature and in the winds. Maybe the authors could show some results in the simulated winds to clarify this issue.

Response: The reviewer has raised an important point regarding the tides in the neutral temperature and winds. As both the reviewers have been concerned about this issue, we have now included the SW2 and M2 tides from the simulated zonal winds in addition to tides from the neutral temperature for the 2003, 2009 and 2013 SSW events in the revised manuscript.

A comparison between the tides in zonal wind and neutral temperature for the three SSWs is presented as follows:

2003 SSW event

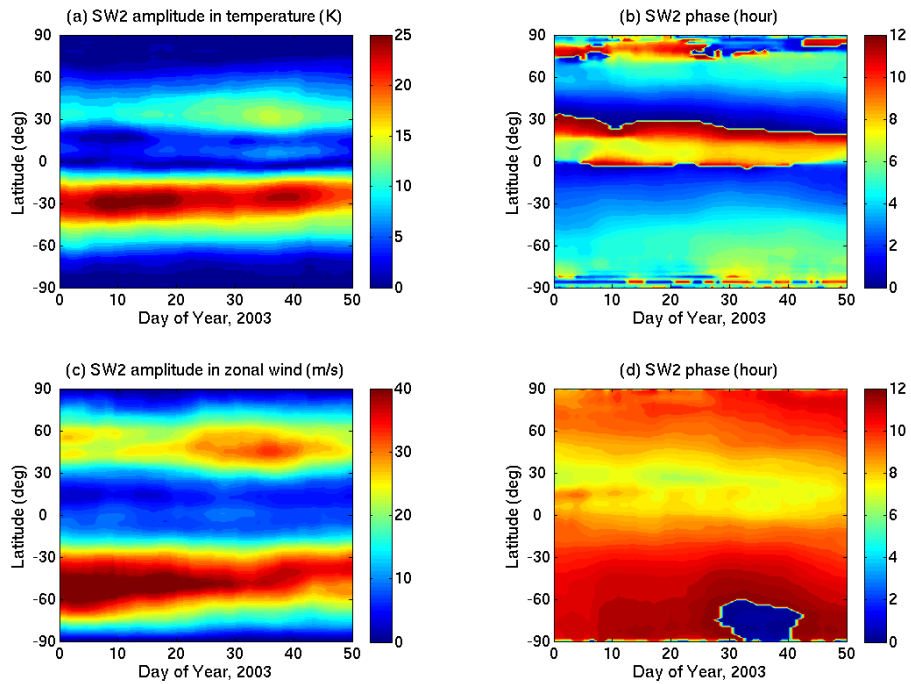


Figure 1: The SW2 tidal amplitude in (a) neutral temperature and (c) zonal wind at ~120 km of altitude during the 2002-2003 SSW event. (b) and (d) present the corresponding SW2 phase in neutral temperature and zonal wind, respectively.

2009 SSW event

Tides in neutral temperature

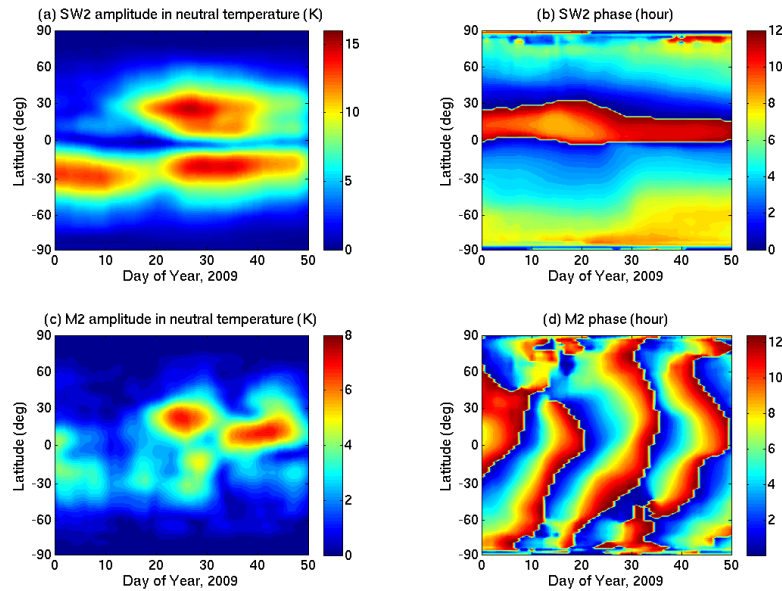


Figure 2: The amplitude (a) and phase (b) of the SW2 tide in neutral temperature at ~120 km of altitude during the 2008-2009 SSW event. The amplitude and phase of the M2 tide during the same period are presented in (c) and (d), respectively.

Tides in zonal wind

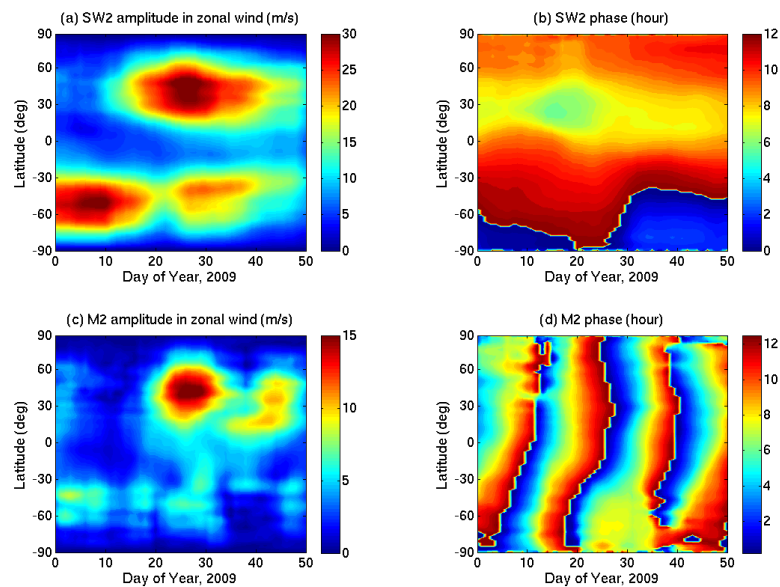


Figure 3: Same as Figure 2 except that the tides from zonal wind are presented in this figure.

2013 SSW event

Tides in neutral temperature

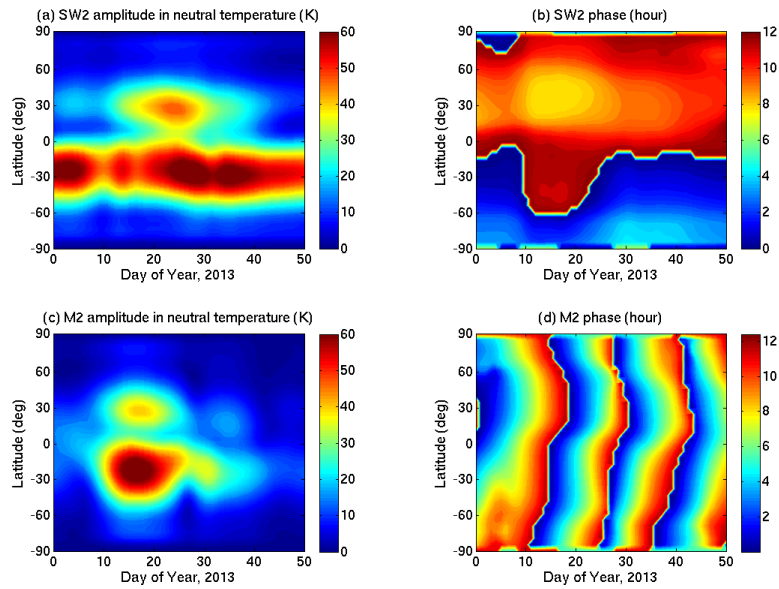


Figure 4: Same as Figure 2 but for the 2012-2013 SSW event.

Tides in zonal wind

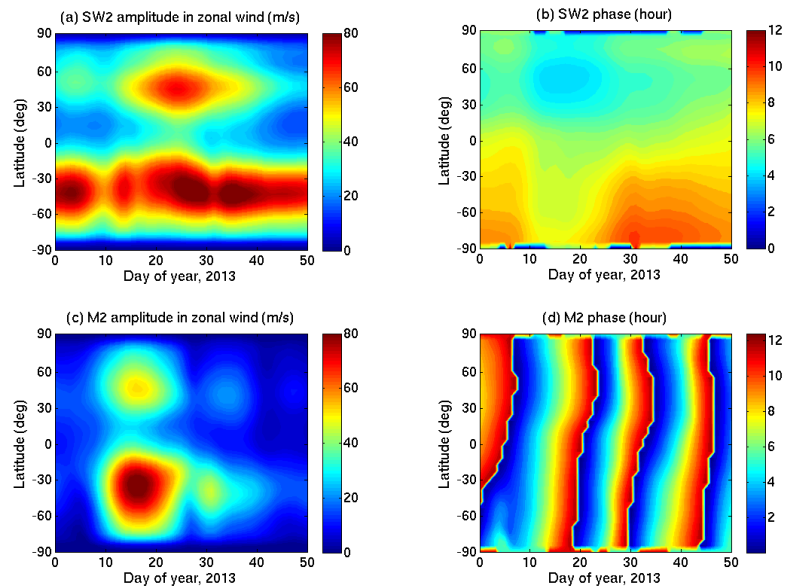


Figure 5: Same as Figure 2 except that the tides from zonal wind are presented in this figure for the 2012-2013 SSW event.

From the analysis of the tides in zonal wind and neutral temperature during these three SSWs, it is found that the SW2 and M2 tidal enhancements in zonal winds are comparably similar to the SW2 enhancements in neutral temperature in temporal terms for all the three SSWs but a difference in the latitudinal tidal structures can be observed. The amplification in SW2 and M2 in zonal winds occur at slightly higher latitudes in both hemispheres as compared to the amplification of SW2 and M2 in neutral temperature. In the updated version of the manuscript, we have discussed the tidal amplitudes and phase in both neutral temperature and zonal wind in more detail.

5- Page 12, lines 9-10. Please correct me if I am wrong, but when the authors write about the relative amplification of the tides, I understand that they mean relative to pre-SSW conditions. If that is the case then, at least for the eye of this reviewer, it is not clear that the relative amplification of L2 is larger than that of S2 for the 2013 SSW event.

Response: Compared to the 2003, 2006 and 2009 SSWs, the greater relative enhancement of L2 over S2 is not so clear for the 2013 SSW event. For this reason, the minimum and maximum values of L2 and S2 have now been added in the updated manuscript. The first enhancement of L2 starts during the second week of December when the L2 amplitude increases from 5 nT on the 12th December to a peak tidal amplitude of 19 nT on the 28th December. A stronger second enhancement starts on the 6th January and a peak tidal amplitude of 27 nT is then estimated on the 15th January. The S2 enhancements also start during the same period with its amplitude increasing from 13 nT on the 12th December to a peak amplitude of 41 nT on the 7th January. If the relative enhancement is calculated then the L2 amplitude increases by a factor of 4.4 and the S2 amplitude increases by a factor of 2.1. This point has now been clarified in the revised tracked changes file (see page 9, lines 14-15).

Response for technical comments:

The author thanks the reviewer for carefully reading the manuscript and pointing out the grammatical errors. The errors have been corrected in the updated version of the manuscript.