Atmos. Chem. Phys. Discuss., 8, S9493–S9501, 2008
www.atmos-chem-phys-discuss.net/8/S9493/2008/

Atmospheric Chemistry and Physics Discussions

ACPD

8, S9493–S9501, 2008

Interactive Comment

Interactive comment on "Large-scale planetary disturbances in stratospheric temperature at high-latitudes in the Southern Summer Hemisphere" *by* M. G. Shepherd and T. Tsuda

M. G. Shepherd and T. Tsuda

Received and published: 26 November 2008

Before addressing the Referee comments in detail we need to explain the changes in some of the figures presented in the revised version of this manuscript. Following the submission of the paper we found a numerical error in the routine selecting one of the data sets for analysis. This had affected the phase of the selected raw data shown and in turn the phase of the modeled harmonics, but not their amplitudes. This has now been corrected and the new plots are included in the revised version of the manuscript and in our response to the Referee report. However, the discussion provided earlier is still relevant. Corrections have been made wherever necessary to update the presentation in view of these new results. We are very sorry for all this and deeply apologize. As a result, the figures of the revised version have undergone the needed revision to

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

reflect the corrections made.

Changes summary:

1) Figure 1 now shows the temperature field at 20 km and 30 km height, instead of only at 30 km as in the original manuscript, in order to illustrate the variability with height and time. We still believe that this presentation of the data gives an idea of the range and pattern of variability observed. 2) We have added Fig. 2a, at 20 km. 3) Figure 3 - Hovmöller diagrams of the residual temperatures at 20 km. 4) We have removed the original Fig. 5 as not necessary in view of the spectral analysis that follows. 5) Figure 5 (formally Figure 4) - gives only the LS periodograms at 65°S and 40°E and 120°E as these are sufficient to illustrate the point made in the text. 6) Figure 6, referring to the zonally symmetric waves of the original version has been removed. Comments are provided in the text and in the response to the Referees. 7) Figure 7 is the Hovmöller diagrams of the restored model temperature field, calculated for the grid of the experimental data from Figure 4. It shows all four latitude bands considered, without the plots of the zonally symmetric wave contribution. 8) Figure 8 is a new figure illustrating the 'goodness' of the modeled results obtained.

Response to Anonymous Referee #1

"Only one height level is analysed (30km). The notion of a height range (10-40km) should be dropped (in the abstract and the main text), if no additional information is provided. It seems a missed opportunity, not to investigate other levels, but this should not be prohibitive for publication."

The actual analysis of the COSMIC data indeed included five altitude levels, at 20 km, 25km, 30km, 35 km and 40 km. We originally chose to present the data only from the analysis at 30 km as this level corresponding to ˜ 10 mb pressure level is often used for comparison between observations and model data assimilated fields. Also it was assumed that the magnitude of the planetary waves would increase with height and their manifestation at 30 km would be more distinct that at the lower altitudes.

ACPD

8, S9493–S9501, 2008

Finally, global lower stratosphere phenomena like the equatorial QBO peak at 30-35 km and any effect on the extra-tropical and high latitude temperature field should be most apparent at the 30 km level chosen. Thus that choice was made for our original presentation.

" When talking about the QBO the authors are confusing me: QBO/vortex relationships have quite a long tradition in stratospheric research (e.g. work by Holton and Tan). The Labitzke reference on page 16426 is not in the literature list and is quite likely not the most relevant here (I guess the reference is to the overview paper from 2006, but some detailed earlier/original work by Labitzke et al. and Gray et al. would be more suitable to cite here). In addition, there seems to be no clear distinction between Northern and Southern hemisphere (most work is based on NH data). The following description of the phase of the QBO during the observational period is confusing. The authors should rephrase this (16426) and the following paragraph after plotting and providing a figure for the paper from NCEP or ECMWF zonal wind data to illustrate the background state of the atmosphere clearly (two panels: zonal mean zonal wind at 30km as a function of time and latitude, zonal mean zonal wind at the equator as a function of time and height). Figure 1 could be dropped instead, I do not think this much detail about the sampling is required; it cannot be assessed by eye anyway."

We thank the Referee for the suggestions. The paragraph referring to the possible role of the QBO in the observed perturbations in the early Austral summer has been re-written and more relevant references have been considered as recommended. However, as we have provided a very up-to-date reference to work on the phase of the equatorial zonal mean flow we have chosen not to expand the analysis to zonal mean wind data at this instance, as this is a part of another study.

" The conclusions need to be adjusted to the work presented. A small snapshot study is very valuable, but should not be used to speculate about long-term changes or past exciting events that have no relation to the data base presented in the paper. A toned down outlook might be permissible, but foremost the presented findings should be summarised and discussed in the context of the common perception of a quiet Antarctic summer stratosphere. Maybe the authors should come back to figure 6 in this context. Looking at this figure for quite some time, I get the feeling that the (late) Antarctic summer is quiet, and the timing of the seasonal transition is most interesting (which might come back to a proper description of the seasonal evolution of winds, see above)."

Thank you. This has been done.

" Technical: colour scale in figure 4 was very low in contrast; maybe the authors could consider a colour scale similar to figure 3?"

Thank you. We have now changed the colour scale of the respective figures.

Response to Anonymous Referee #2

" It has been mentioned by the authors that the GPS COSMIC temperature data provide information for altitude range between 10 and 40 km at each kilometre and for latitudes between 55°S and 80°S. Therefore, I do not understand well why the authors miss the opportunity to study the spatial (altitude and latitude) structure of the considered in the paper planetary waves."

Indeed, the COSMIC observations present a unique opportunity to study planetary wave dynamics in the lower stratosphere for 10-40 km height with respect to both planetary wave vertical and latitudinal characteristics. As part of the analysis presented in this report we have investigated the planetary wave perturbations at other altitudes as well, namely at 20 km, 25 km, 30km, 35 km and 40 km. As the amplitude of the planetary wave increases with height due to the decreasing density it is expected that the amplitudes of the wave perturbations for which the data are examined would be stronger and more distinct at the upper part of the COSMIC observations range including the 30 km level. The level of 30 km altitude is also almost equal to the pressure level of 10 mbar, at which often comparisons are often made between observations and data assimilate fields from models like the UKMO and NCEP. In the original version of

ACPD

8, S9493–S9501, 2008

Interactive Comment

this report we elected to present and discuss only these results. To our knowledge this study is one of the first to use COSMIC temperature observations for planetary wave analysis and as such we needed a presentation of the data which can easily be related to other studies, employing data assimilated fields. Further analysis with regard to the planetary wave perturbations observed by COSMIC is currently underway including their vertical and latitudinal behaviour and the results obtained will be presented in a separate report in the near future. However, to illustrate the variability of the perturbations observed with height we have now also included plots at 20 km, accompanied by some relevant comments.

" In order to clarify not only the predominant periods but also the zonal structures (direction of propagation and zonal wave number) of the planetary waves it would be better the 2D Lomb-Scargle periodogram analysis instead of dynamic Lomb-Scargle periodogram analysis (whose results are shown in Fig. 4) to be utilized."

We agree with the Referee comments and we will consider this approach in our future investigations.

" How the 30-day peak seen at the LS periodogram could be related to the length of the used time segment (p. 16420 -15). "

Yes, this is certainly possible and is often the case. This was mentioned in the text. Therefore in the spectral decomposition following the Lomb-Scargle analysis we consider perturbations with periods of less than 25 days. New spectral analysis including the time period considered in the present report employs 45-day time-segments, which allows resolving the presence of a 23-day perturbation. This is work in progress and results will be reported in the near future.

" The authors may like to clarify the situation regarding the absence of a truncation term in (1) (p.16417 - 20)."

In our case the term T0 in Eq. (1) contains the background mean temperature field

ACPD

8, S9493–S9501, 2008

Interactive Comment

plus all other perturbations possibly present in the observations and not accounted for, e.g. perturbations with period of less than 11 days or greater than 23 days. This is a bit different from the approach considered by Pancheva et al. (2007), where a separate term is introduced in addition to the mean field (in their case zonal mean wind), to contain all harmonic perturbations not accounted for. Since we are interested in the contributions made by the 10-, 16- and 23-day waves to the observed temperature field and not the background field not having a separate 'residual' term does not affect the results obtained. Even a glance at the modeled and observation data plots show that the model has succeeded in mapping the main perturbations seen in the observations. We have explained this in the revised version and have also included a plot of the percentage error between the observation and modeled data. The error is less than +/- 100%, or less than a factor of +/- 2. The plots of the percentage error between the modeled and observed temperature fields at the respective latitudes of interest given herein indicate that except for few experimental outliers the rest of the model temperatures differ by a factor of 2 or less from the observations. Keeping in mind that the modeled parameters were obtained by fitting the longitude/UT binned observations and using a 30-day sliding time segments, a factor of 2 or less difference between the two datasets is considered very satisfactory.

The comparison of the two datasets was performed in terms of residual temperature, dTobs and dTmodel, which are defined in a different way. The observation dataset contains all available temperature observations with their respective UT and longitudes for the period from December 1, 2006 to March 1, 2007 in the respective 5° latitude bands. In order to reveal the perturbations pattern in the observed temperature field we have subtracted the seasonal mean temperature from these observations thus obtaining the residual dTobs, plotted in Figs. 3 & 4.

The model residual dTmodel simply represents only the contribution to the temperature field by the more significant planetary waves considered in the spectral decomposition, eastward -, westward-propagating and stationary planetary waves with wave numbers

ACPD
8, S9493–S9501, 2008

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

-2 to 2 and periods of 10, 16, 23 and 0 days, respectively. Therefore the two residuals are not exactly the same, which adds to the earlier statement that a factor of 2 or less difference between the model and experimental data is very satisfactory.

The modeled temperature field is restored into the UT/longitude coordinates of the raw observations and then the experimental values are subtracted from the model ones to produce the percentage errors. As there were some missing data at the edges of the observation plots those are still marked in the presentations that follow.

" The zonally symmetric waves rapidly amplify after day number 370 when the SPW1 and the zonally travelling planetary waves have modest or even small amplitudes (Fig. 6); does this situation support the coupling mechanism between the SPWs and the travelling waves in generating the zonally symmetric waves?"

The agreement between the observations and model was achieved without considering harmonics with wavenumber s=0. As we did not consider the analysis of wind data in this study we agree that any discussion on the zonally symmetric waves as the result of wave-zonal mean flow interaction cannot be appropriate. In addition, the phase of the QBO wind field at the equator indicates that such coupling is not likely to be taking place.

" Please, clarify what you mean suggesting that the results for the 16- and 23-day zonally symmetric waves shown in Fig. 6b "might be presenting the same oscillation" (p. 16421 - 25). What about the errors of the derived planetary waves; some amplitudes have magnitudes less than 0.3 K (Fig. 6)?"

The standard deviations of the amplitudes obtained from the wave spectral decomposition are well below 0.1. Thus they were not included in the amplitude plots in Figure 6. However, due to the very small amplitudes obtained for s= ś 3, only PW with s= +/- 1 and s = +/- 2 were considered in the restored temperature field shown in Fig. 7.

" Please, note that for altitudes below 20 hPa pressure level and during the period of

ACPD

8, S9493–S9501, 2008

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

time considered in the manuscript the zonal mean zonal wind over the equator was eastward (please, see Fig. 1 from the recently published paper by Wu et al., J. Geophys. Res., v. 113, A05308, 2008) - (p. 16427 - 4)."

We thank the Referee for bringing this reference to our attention. The observations of the zonal mean zonal wind at Singapore are consistent with the results of Alexander et al. (2008b) (their Fig. 1), a reference to which was given in the text. The fourth sentence in the first paragraph on page 15 should read:

'The period of December 2006 - February 2007 was marked by a decrease in the eastward phase of the stratospheric zonal mean wind before reversing to westward in mid-March, 2007. In January-February 2007 the equatorial QBO was in its eastward shear phase with the zero zonal mean flow line at 24 km height (Alexander et al., 2008b, Fig.1).'

We recognize the need of information on the stratospheric zonal mean flow for the period of interest in order to better understand the origin of the perturbations observed and in particular the potential wave-zonal mean flow interaction with the stationary waves obtained, which would lead to zonally symmetric waves. Because such analysis was not done as a part of the present report and because of the results obtained without the inclusion of s=0 waves in the restored temperature field, we have withdrawn any comments and plots, given in the original manuscript referring to zonally symmetric waves until further consideration.

This concerns Fig. 6b and Fig. 7, lower row. Instead the revised Fig. 7 contains the restored temperature field in the same coordinates as the observations, shown in Fig. 3 & 4. A new Fig. 8, showing plots of the percentage errors at 65°S and 70°S is now included with relevant discussion.

" Please, remove from the abstract "from 10 to 40 km altitude" because the planetary waves only at 30 km height are investigated."

ACPD

8, S9493–S9501, 2008

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

Thank you. This has been considered.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 16409, 2008.

ACPD

8, S9493–S9501, 2008

Interactive Comment