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Interactive comment on "Global analysis for periodic variations of gravity wave squared amplitudes and momentum fluxes in the middle atmosphere" *by* Dan Chen et al.

Dan Chen et al.

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Dear Dr Pisoft,

We would like to sincerely thank both reviewers for their positive and helpful comments. Please find below a point to point reply. We have all points taken into account in the new revised version of the paper.

Thank you very much for handling this manuscript.

Dan Chen

Anonymous Referee #2 Received and published: 3 April 2019

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Discussion paper

The paper by Dan Chen et al. presents the temporal variation of square-root zonal average gravity wave squared temperature amplitudes (GWSTA) and the GW momentum flux (GWMF) based on 13 years of satellite data of the SABER instrument. A spectral analysis is done focusing on the annual, semiannual, terannual oscillation up to quasi-biennial periods. The origin of these oscillations is interpreted in terms of different GW sources and the propagation pathways using a data set based on the combination of ECMWF data with GROGRAT ray-tracing. The paper is well written, the methods are adequately described and the results are properly discussed, therefore a publication in Annales Geophysicae is highly recommended. But nevertheless, some minor concerns should be addressed as indicated below before publishing.

Reply: We thank the reviewer for the very favorable recommendation and the comments which helped to improve the manuscript. Please find the original comment in black, the response in blue.

Specific comments: 1) The authors focus on the annual, semiannual, terannual oscillation up to quasi-biennial periods as dominating oscillations. From Fig. 1a it can be seen that there are also oscillation with periods around 7 and 13 years visible. Please have a short discussion on that topic as these oscillations have even larger amplitudes than the QBO signal. Due to the length of the time series of 13 years, those peaks should be discussed in terms of the possible resolution within the FFT.

Also reviewer 1 commented on the 7 and 13 year spectral content. In Fig. 1a there is indeed a peak at around 6-7 years and also a peak at 13 years higher than QBO. From the horizontal axes in Fig.1a, it can be seen that the high resolution of periods analyzed by FFT concentrates below 3 years, while low resolution exists in 3-13 years. In addition, Fig. 1b shows the significant periods: in particular these are found for values below 3 years over a wide range of latitudes. For this reason, we only focus on the annual, semiannual, terannual, quasi-biennial periods as dominating oscillations.

Based on your suggestions, we have added a short discussion about this peak in our

revised paper: 'In addition to the above-mentioned four major frequencies there are two peaks at around 6-7 years and 13 years. Due to the length of the time series of 13 years (156 months dataset), these are the two lowest frequencies (longest periods) which potentially could be resolved by FFT. These lowest frequencies are more likely to be influenced by leakage and aliasing. Therefore, we focus on the periods of 2.167, 1.0, 0.5 and 0.333 years, which are contained for several cycles and hence well constrained by our data. Potential explanations for the longer periods are ENSO which is an interannual oscillation of 2-7 years and the 11-year solar cycle.' on page 7, line29.

2) The difference of the variance based on the dominating periods between the northern and the southern hemisphere is related to SSW by the authors. It would be worth to discuss also the influence of planetary waves here as there are in general huge differences on both hemispheres due to the different land sea distribution.

Also this point was raised by Reviewer 1 in her/his comment 5. Please note that we are here considering monthly zonal means which have already removed a part of the intermittency. Still, planetary waves may contribute and we have noted this in the revised manuscript.

Based on your suggestion and also based on comment 5 of the first reviewer we have added a short discussion about this effect in our revised paper: '... is higher in the southern than in the northern hemisphere. Several effects may play a role. First, planetary wave activity is much higher in the northern than in the southern hemisphere. This results in higher variability in GW filtering. Likely more important for our time series of monthly zonal means is that this higher PW activity also frequently induces sudden stratospheric warmings, which terminate the ...' on page 15, line 22.

Technical comments:

-Page 7, line 28: Spectral amplitudes in Fig. 1b different compared to Fig. 1a, for a reader it would be more intuitive to use the axes as the color bar.

As we compare with the median, a linear axis seems more suited in Fig 1a. For the color plots we need a logarithmic axis to have sufficient contrast. In addition, the panels are for different altitudes. Therefore we will retain this figure as is.

-Please improve the figure captions. Suggestion: Add labels GWSTA and GWMF for Fig. 2, 3, 5, 7, 11.

As suggested, we have added the labels 'GWSTA' and 'GWMF' for Fig. 2, 3, 5, 7, 11 in our revised paper. Please see the modified figures in the revised paper.

-Page 35, Fig 11: The colorbars in Figure 11 are very different. For a better comparison between each oscillation the color scale should be adjusted as equal as possible.

According to your suggestion, we have adjusted the color bar. However, the spectral amplitudes of TAV and QBO are much smaller than those of AV and SAV. Therefore we now use the same color bar for TAV and QBO, and the other color bar for AV and SAV, respectively. Please see the revised manuscript for the adapted figures.

Please also note the supplement to this comment:
https://www.ann-geophys-discuss.net/angeo-2019-31/angeo-2019-31-AC2-supplement.zip

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