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# *Interactive comment on* "Investigation on the abnormal quasi-two day wave activities during sudden stratospheric warming period of January 2006" *by* Sheng-Yang Gu et al.

**Anonymous Referee #2**

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Referee report on "Investigation on the abnormal quasi-two day wave activities during sudden stratospheric warming period of January 2006"

This paper examines the unusual quasi two-day wave (QTDW) behavior during sudden stratospheric warming (SSW) period of January 2006, and reaches two main conclusions:

1. The unusually strong W2 QTDW is identified during the 2006 Austral summer, along with the conventional W3 component. 2. The strongest W2 signal occurs due to: (a) a manifestation of the summer easterly jet instability induced by SSW event via inter-hemispheric coupling and (b) a nonlinear interaction between W3 QTDW and wave

number 1 stationary planetary waves (SPW1).

Neither of these findings is new and the first is definitely not new. One can find a similar description in Limpasuvan and Wu (2009) and other previous studies by the same first author (e.g., Gu et al., 2016a,c). In particular, the unusual QTDW behavior during the 2006 Austral summer has been well documented in Limpasuvan and Wu (2009), where they showed that the conventionally dominant mode of QTDW with zonal wavenumber 3 (W3) is followed by a strong W2 component traveling westward (at nearly the same phase speed). In addition, the characteristic features of the QTDW (W2 and W3) found in this study are very similar to the previous findings of Gu et al. (2016c), who considered a large number of SSW events (including the warming episode of 2006). This also includes interpretation related to W2 generation by a nonlinear interaction between W3 and SPW1 during SSW events (Gu et al., 2016c). The authors will need to argue the significance of their work, with an emphasis on their novel findings. Because of these concerns, the manuscript requires a major and mandatory revision. If these concerns cannot be addressed, I would not recommend publishing this manuscript in ACP.

Other major points:

1. The interpretation of Fig. 7, regarding the source of W2 is not convincing. The EP flux vectors associated with W2 QTDW in the summer hemisphere are far from the instability source and the critical layers. Therefore, the argument for the amplification of QTDW via wave-mean flow interaction near the critical layer seems flimsy and requires further investigation. In addition, the QTDW activity in the winter branch seems to be partly originating from the tropical (0-20ËŽN) mesosphere. Can the authors explain this?

2. The authors also argued that the stronger W2 QTDW in austral summer 2006 is due to enhanced inter-hemisphere coupling induced by SSW in the winter hemisphere; however, such evidence is not clear from Fig. 9 and Fig. 10. I would suggest the authors prove it quantitatively, e.g., by calculating the residual mass-stream function

induced by resolved planetary wave drag (via downward control principle), as outlined by Lubis et al. (2016, Eq. 5), and the associated diabatic heating ($d\theta/dz\ w^*$). If the authors' argument is correct, hence, after the SSW event, we do expect an enhanced residual (inter-hemispheric) circulation in the summer hemisphere along with increased diabatic heating near the austral mesospheric jet.

3. Based on Figs 10-11, it is clear that the regions where the PV gradient is negative are potentially baroclinically or barotropically unstable, and thus represent potential sources of QTDW activity; however, it is still unclear which types of instability are more dominant for such processes; is it barotropic or baroclinic mode? Also, what causes the negative PV gradient in that region? Is this associated with changes in vertical shears or wind curvature? Please clarify.

4. The interpretation of Figs 13-14 is very confusing. The results shown in Figs 13 and 14 do not indicate that the W2 QTDW is generated via nonlinear advection interaction between W3 and SPW1. This is due to the fact that enhanced meridional nonlinear advection in the summer hemisphere (Fig. 13) is not accompanied by enhanced SPW1 activity (in u and v) in the same region (Fig. 14), rather only a prominence of W3 activity. Therefore, the generation of W2 QTDW via meridional nonlinear advection seems to be unlikely.

Specific points:

L47: Delete "to exist"

L57-58: Missing references

L59-L60: A similar finding was also reported by Lossow et al. (2015) and Lubis et al. (2016).

L87-L99: In addition to inter-hemispheric coupling induced by SSW events, a strengthening of summer mesospheric easterlies can also be induced by stratospheric ozone depletion in spring, leading to an increased instability of the summer mesospheric easterly jet and, thus, enhanced QTDW activity (see Lossow et al., 2015; Lubis et al., 2016).

L206-L207: Why is the latitudinal structure of W2 more symmetrical, compared to W3? Is this due to the characteristic of the instability-normal mode of the wave? Please explain.

L236-L237: Please clarify this result by plotting a latitude-height structure of the refractive index associated with W2?

L287: Why does positive EP flux divergence indicate the source of planetary waves?

L293: Please provide the nonlinear advection equation that you used in the manuscript.

Some references:

Limpasuvan, V., and D. L. Wu (2009), Anomalous two-day wave behavior during the 2006 austral summer, Geophys. Res. Lett., 36(4), L04807.

Lossow, S., C. McLandress, A. I. Jonsson, and T. G. Shepherd, 2012: Influence of the Antarctic ozone hole on the polar mesopause region as simulated by the Canadian Middle Atmosphere Model. J. Atmos. Sol.-Terr. Phys., 74, 111–123.

Lubis, S.W., N. Omrani, K. Matthes, and S. Wahl, 2016: Impact of the Antarctic Ozone Hole on the Vertical Coupling of the Stratosphere-Mesosphere-Lower Thermosphere System. J. Atmos. Sci., 73, 2509–2528.

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