Referee #1

Based on model output of the GCM CMAM-sd for the years 1979-2010 the authors introduce a novel method to investigate the intermittent nature of parameterized orographic gravity wave forcing (OGWD). Three hotspot regions are investigated, the Himalayas, the Rocky Mountains, and East Asia. It is found that OGWD in the hotspot regions is very intermittent, as expected from previous simulations and observations. By means of a peak-detecting algorithm, a set of strong peak events is identified and investigated in more detail. Composite analysis shows that during peak events the effect on the upper stratosphere and mesosphere differs strongly between the different hotspot regions, and effects can even have opposite sign.

In summary, this is an interesting paper that provides new and unique information which is of interest to the readership of WCD. The paper is well written and the figures are of good quality. Therefore the paper should be published in WCD after addressing my major comment and my detailed comments.

We thank the reviewer for his/her thoughtful comments and suggestions. Our response including changes made to the manuscript is listed below.

Major comment:

My major concern is more of technical than of scientific nature. Part of the work has been published before in the first author's PhD thesis, and figures or parts of them are just reproduced. The PhD thesis, however, is not even listed among the references. This concern can easily be resolved by referring properly to the first author's PhD thesis, see the "specific comments".

Further, I want to state clearly that the scientific value of the paper is not affected because the duplications occur mainly in the "Data and methodology" part of the paper, and the figures are definitively needed as an introduction to the intermittency analysis that is new and not contained in the PhD thesis.

Link to the PhD thesis:

https://dspace.cuni.cz/bitstream/handle/20.500.11956/102077/140068896.pdf

We would like to thank you for the notice. We added "Adapted from Chapter 3 in Kuchar (2018)." to figures adapted from the first author's PhD thesis according to your comment #16. Furthermore, we added a mention that several parts of the Data and methodology section are adapted from PhD thesis (Kuchar, 2018) that originally inspired this study.

Kuchar, A.: Coupling processes of various timescales in the middle atmosphere, PhD dissertation, Charles University, Faculty of Mathematics and Physics, https://dspace.cuni.cz/handle/20.500.11956/102077, 2018.

Detailed comments:

(1) p.2, l.30/31: This statement is too specific! Perhaps because also the reference Hoffmann et al., 2013 is too specific as it covers only orographic and convective

hotspots and is very limited by the observational filter of the AIRS satellite instrument. In addition to the hotspots, there is also considerable background gravity wave activity, as can be seen from other gravity wave climatologies (for example, Ern et al., 2018), and also gravity waves emitted from other sources like jets and fronts (almost invisible for AIRS) can exhibit spatial asymmetries and can occur as hotspots. This becomes most obvious, for example, during sudden stratospheric warmings (see, for example Ern et al., 2016)

Ern, M., Trinh, Q. T., Kaufmann, M., Krisch, I., Preusse, P., Ungermann, J., Zhu, Y., Gille, J. C., Mlynczak, M. G., Russell III, J. M., Schwartz, M. J., and Riese, M.: Satellite observations of middle atmosphere gravity wave absolute momentum flux and of its vertical gradient during recent stratospheric warmings, Atmos. Chem. Phys., 16, 9983-10019, 2016.
Therefore I would suggest to modify the statement in l.30/31 as follows:
"From observations, GWs are known to be distributed spatially asymmetric around the globe in so-called hotspots (e.g. Hoffmann et al., 2013)."
->
"From observations, it is known that, in addition to relatively uniform background gravity wave activity, specific gravity sources like orography, convection, or jets and fronts, can occur as so-called hotspots and introduce strong spatial asymmetries around the globe (e.g. Hoffmann et al., 2013, Ern et al., 2016, 2018)."
Thank you for reading carefully and for providing a good suggestion. We revised the text accordingly.

(2) p.2, l.31/32: This statement is too unspecific! The statement may hold also for other models that do not use specified non-orographic gravity wave sources like convection, or jets and fronts. However, here and in Sacha et al. (2018) only CMAM-sd is investigated. Further, the step from the real observations that show also multiple features of non-orographic gravity waves to the parameterized gravity waves in CMAM-sd with a simple non-orographic source is too large. Suggestion:
resulting from the two parameterizations is well represented by the OGW parameterizations
->
resulting from the two parameterizations in CMAM-sd is mainly introduced by the OGW parameterization
Thank you for reading carefully and for providing a good suggestion. We revised the text accordingly.

(3) p5, l.113/114 How is area weighting performed? In terms of square-km areas assigned to each grid point? (This information is important because grid points at lower latitudes would be weighted more strongly.)
The area weighted uses the cosine of the latitudes as weights (see also the github code here). It was also specified in the revised manuscript.

(4) p.5, l.121: Not clear what "with minimum distance of 20 days" means. Has a detected peak event to be separated by more than 20 days from the next peak event? Please clarify!
We have revised the text to clarify that 20 days are needed to separate the peaks.

(5) p.7, l.153: In Geller et al. (2013) CMAM-sd is not mentioned, but the main statement still holds. Perhaps just rewrite the first part of the sentence: "Comparison with Fig.2 in Geller et al. (2013) reveals that CMAM-sd ..."
Thank you for reading carefully and for providing a good suggestion. We revised the text accordingly.

(6) p.8, l.183: Considering the changed shape seen in Fig. S2 after revision, why would you think that it is rather missing OGWD, and not NGWD, if the shape changes from a double-peak to a single peak?
The main argument is the coincidence with the model OGWD. Furthermore, we rephrased it in the following way: “which may stem partly from missing NGWs at lower latitudes but mainly from underestimated OGWD (Seviour et al., 2012).”

(7) About p.10, l.218/119 onward, and the supplement: please add some explanation! Strong intermittency in summer, in non-mountainous regions, or at higher altitudes does not necessarily indicate "strong OGWD", but could be the effect that OGWD occurs only very sporadically. In these cases, compared to the total GWD, OGWD could be just negligible.
The following sentence was added: “This does not necessarily indicate strong OGWD in boreal summer as shown in Fig. 3 but it rather indicates that moderate OGWD occurs very sporadically and the boreal summer climatological OGWD is weak.”

(8) p.11, l.229/230 Intermittency lost by zonal averaging could also happen if other GW sources are more dominant than the OGWs in the hotspots.
This is definitely a valid argument for the observational data where categorization of GWs on OGWs and NGWs is not straightforward. Nevertheless, the intermittency of model OGWs outside of the hotspots is lower. Therefore, we lose part of the intermittency due to zonal averaging. This test should encourage modeling centres to provide the GW diagnostics in 3D as stated in Section 4.

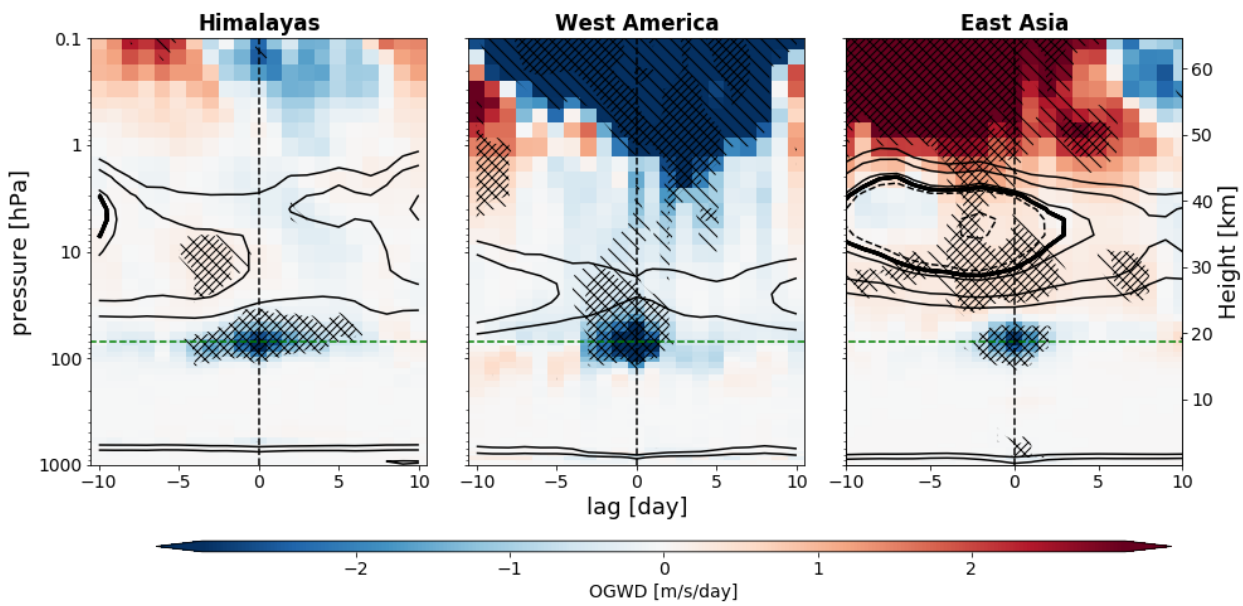
(9) p.11, l.232: Please state more clearly that during winter OGWs can permanently find favorable propagation conditions and act more continuously. Therefore OGW intermittency is reduced in winter, but probably OGWD more relevant.
We added the following sentence: “During winter OGWs can permanently find favorable propagation conditions and act more continuously. Therefore OGW intermittency is reduced in winter, when climatological OGWD is stronger and therefore more relevant in a traditional concept of stratospheric dynamics.”

(10) p.11, l.234: About multiple mountain ranges - what do you think is the mechanism? Could it be that if multiple mountain ranges are present (and have different orientations) there are more often favorable OGW propagation conditions for at least one of the ranges, with the effect of OGWs acting more continuously than in other regions with only a single mountain range?

We added the suggested mechanism in the manuscript in the following way: “This can be connected with the fact that it consists of multiple (relatively smaller) mountain ranges with different orientations, which may be favorable for a more frequent fulfilment of conditions prone to launch freely propagating GWs and therefore resulting in lower intermittency compared to only a single mountain range with uniform orientation.”.

(11) p.12, l.269 please repeat the information that the considered peak events are mainly in the winter season when winds are usually eastward (positive) throughout the stratosphere and lower mesosphere.

We added the following sentence: “Absolute winds are usually eastward (positive) throughout the stratosphere and lower mesosphere except westward winds between 10 hPa and 1 hPa for EA (not shown).” The sentence documents the adapted figure 8 below where we show absolute winds instead of anomalies as black contours.



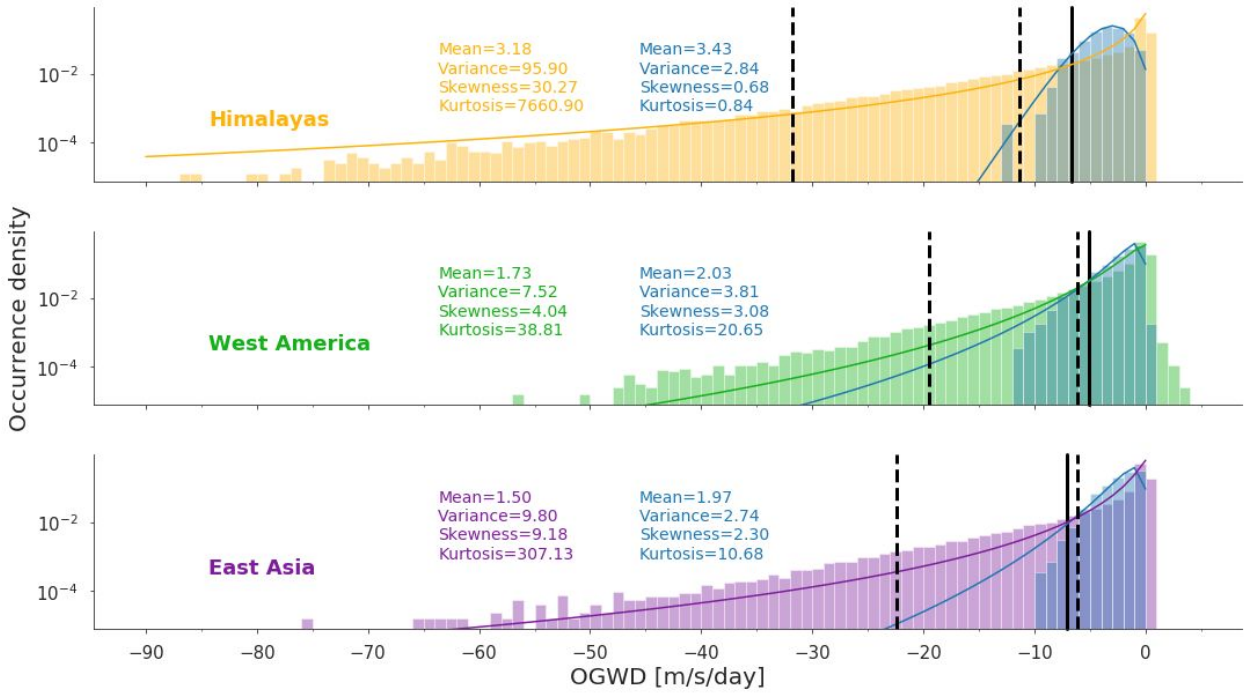
(12) p.12, l.276: Would this correspond to positive zonal wind anomalies on zonal average?

Yes, the common positive pattern in the zonal-mean composites of OGWD between the upper stratosphere and the lower mesosphere corresponds to the positive zonal mean zonal wind anomalies. We added this mention accordingly.

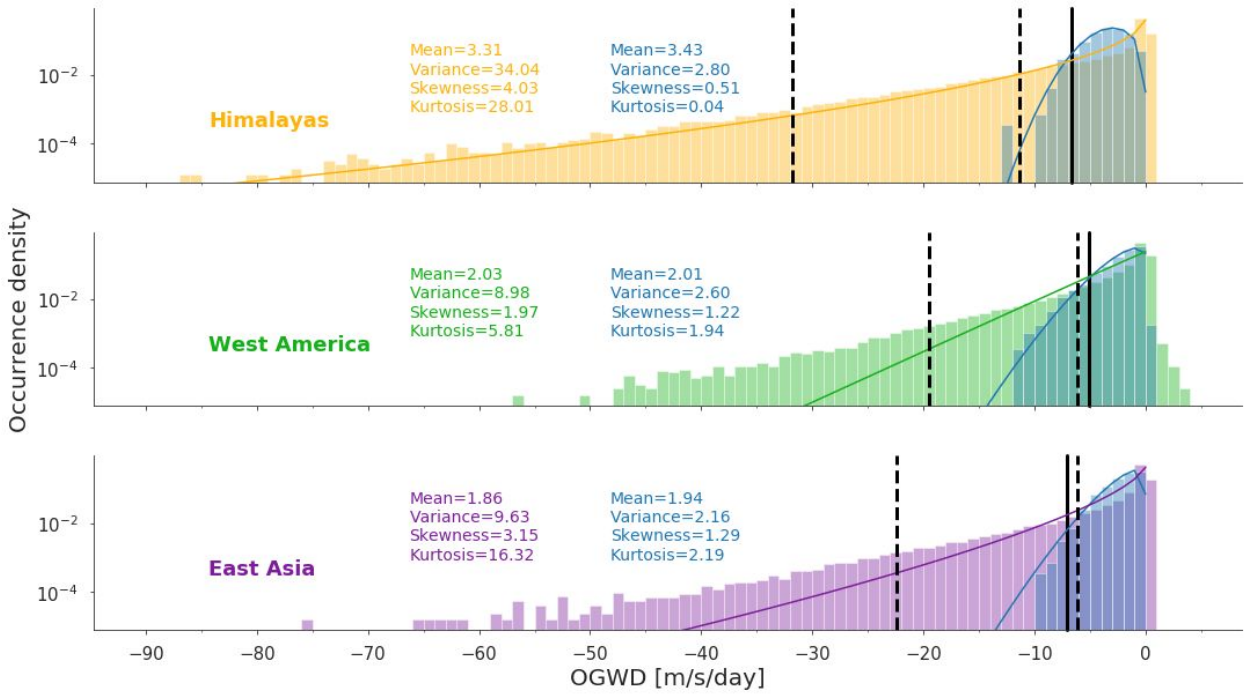
(13) Fig.6 If you want to make the statement that the OGWD pdf distributions are

log-normal, please add theoretical curves (the corresponding fits of log-normal distributions).

We added the corresponding fits of log-normal distributions and their corresponding moments into Fig. 6 (see below). Note that the negative values of OGWD were used as positive values for fitting (and the originally positive part of the OGWD spectrum was not fitted).



Furthermore, we enclosed the following figure into the supplement where fits of the Weibull Minimum Extreme Value distributions and their corresponding moments are added to document the fact that it fits more closely the spatially averaged values.



(14) In the caption of Fig.8, "p-values" are mentioned, but not explained. Please clarify: are these values significance values arising from t-tests?
These p-values arise from the bootstrap method based on 10000 samples as stated in Section 2.2. The following sentence was revised accordingly: “The statistical significance and corresponding p-values of the composites were derived through application of a bootstrap method based on 10000 samples.”

(15) p.15, l.322: Please clarify that "minima" means "strong negative values".
Thank you for reading carefully and for providing a good suggestion. We revised the text accordingly.

(16) p.4, Fig.1 contains 3 panels that were published before in the PhD thesis Kuchar (2018), Fig. 3.4 there. At least a reference to the thesis should be included. Perhaps something like "Adapted from Kuchar (2018)."
Thank you for reading carefully and for providing a good suggestion. We revised the text and figures accordingly.

(17) p.6, Fig.3 is almost exactly the same as in the PhD thesis Kuchar (2018), Fig. 3.7 there. Again, at least a reference to the thesis should be included.
Thank you for reading carefully and for providing a good suggestion. We revised the text and figures accordingly.

(18) p.13, also Fig.8 is similar to one of the figures in the thesis (Fig. 3.12)

Thank you for reading carefully and for providing a good suggestion. We revised the text and figures accordingly.

Technical comments:

p.2, l.51: CMAM simulation -> CMAM Done
p.5, l.121: beneath -> beyond Done
p.6, l142: satelite -> satellite Done
p.9, l.205: 6 -> -6 Done
p.14, l.283: hotspot composites can have an impact -> hotspot composites indicate potential impacts Done
p14, l.288: have been -> has been Done