

ACP review:

This is a point to point response to the **Ref#1** comments.
Referee comments are in italic.

We would like to thank the referee for his/her numerous comments, suggestions and technical corrections that made the paper so much better. We really appreciate the enormous amount of time you spent with our manuscript.

P1L31: Please specify "and other global datasets"

- *P1L38: Specify "changes of the middle atmosphere"*
- *P2L25: What other phenomena cause abrupt changes of MA circulation? If not relevant, please rephrase.*
- *P2L32: Explain here (shortly) again why. Mention again PW generation by IGW if relevant.*
- *P2L39: processes such as e.g. ...? List shortly.*

Answer: The introduction underwent minor changes based on you and Ref#3 comments.

P4L2: What do you mean with "introduce"? Do you mean prescribe? Nudge? "prescribe" is the right word, it is changed (P3L29)

P4L8: How long is the spin-up period?

330 model days, has been added in the text (P3L36)

P4L10: Mean January conditions? Of what period? Or a specific January? In this context, take into account the comments of referee #3

Decadal mean January means are used and this is now mentioned in the text (P4L9).

P4L25-26: Can this abrupt change lead to dynamic instabilities during the transition?

Answer: Yes. The build up of the response is to see in Hovm. diagrams (Figs. 3, 4 and 9).

P4L22-28: Should this GWD modification be understood as rather a change in orographic or non-orographic GWs or as a mixture? Can you estimate that from the observations in Sacha et al. 2015?

Answer: Based on Šácha et al. 2015 and on analysis of CMAM-sd GW parametrization output (not shown) we argue that the majority of GWs in the stratosphere in the EA/NP region in January are of orographic origin (P5L24).

P4L37: Please explain why you are not smoothing the boundaries and if that could have any effect.

Answer: To simulate the sudden and localized GW breaking effect and also to mimic the EA/NP hotspot given the coarse resolution of the model. It is very likely that the sharp boundaries will determine some patterns of the response (e.g. the lee wave pattern in Fig. 10b)-P16L2-4. In the Box0.1 simulation the boundaries are not as sharp due to the background GWD from the reference simulation.

Table 1: Please explain better the systematic behind these experiments. Many values of the table cannot be found in the text. Are these values random guessing (trial and error) or is there a particular science question behind every combination of values?

Answer: We are describing the choices of the GWD components P5L12-30. To sum up, we are varying the GWD along the rough observational constraints (or estimates) for the GWD above the EA/NP region.

Sect. 2.2: It should be made a lot clearer in this section what can be compared here. The model does not seem to calculate interactive chemistry for ozone and methane, and these tracer distributions do not reflect purely dynamical effects (which is mentioned). At this point I do not see how 30 day model simulations (with only January conditions) are supposed to be compared with 30 year annual climatologies of satellite observations. Moreover, are these satellite observations in well enough resolution (temporal and spatial) to hold for comparisons with the effects studied in the model?

Answer: The comparison has been removed and the tracer related information is now given in the supplement only for motivation of research in the EA/NP region.

P6L6: Explain why you analyse the 6.25hPa level.

Answer: It is the second level above the artificial GWD and nudging upper boundary. The first level above can be influenced by some interface effects. We have added a clarification of this choice at P6L15-18.

P6L13: The SSW simulations have not been explained before (only in the table). There should be information in the main text about those.

P6L21-33: This paragraph should be revised comprehensively. Fig. 2 should be split into two or three figures, in the print-out version, the wind vectors are hardly visible and also the other features are not clear. The meaning of the mentioned results are not clear (particularly line 24-26) and the sentence from line 27-30 should be split to make the points one by one. Also, the word "quite" in line 28 should be removed or specified.

P7L26-28: This mechanism should be explained better and/or citations included.

P7L30-32: This should be in the discussion and outlook section, maybe the entire paragraph.

Answer: The SSW simulations are now introduced in Fig.4 and related discussion. Wind vectors in Fig. 5 (former Fig.2) have been enlarged and the subsection related to Fig. 5 has been rewritten.

P8L5: over how much time is that strengthening and shift taking place?

P8L11-12: This statement should be constrained further in such way that the robustness of this behaviour has not been tested in other vortex situations.

P8L15: How can I see that this vortex displacement is more rapid?

Answer: Fig. 4 has been added to give additional information about SSWs and the description of results is now more precise and clear P8L24-P9L12.

In general: At many places, line breaks should be used instead of blank lines everywhere. This would help to divide the respective sections into individual units of meaning.

Answer: We are using the ACP template where blank lines seem to be the only way to divide paragraphs. But we agree that this would be helpful.

Fig 4: You do not discuss Fig. 4d in the text here, instead you mention one "not shown" figure and one figure from the Supplement. You should consider to restructure this. Also, I would appreciate the contoured lines for the box of enhanced GW drag, as in 4f, in all panels. However, why are there 3 lines, is it not always the same box?

Answer: Fig. 7 (former Fig.4) as well as other figures has been newly created and the choice of subplots now fits better to the direction of the text.

P10L12: This (rather abstract) figure should be introduced with some motivation why you plot this and/or what you expect to learn from plotting this.

Answer: The motivation for Fig. 9 is at P11L15-18 and its results are newly described.

P12L18: What else can it be? And what does that mean for the simulations?

Answer: After the comment from Ref#3 we have made a much deeper analysis with the outcome that this pattern is most likely caused by nonlinear interaction of inertia GWs with tides (P12L5).

P13L13-21: This comparison does not seem sensible to me. CH4 is influenced by much more than only vertical velocity (chemistry, advection, diffusion) and thus the comparison does not hold. Also, the patterns you describe in the plots are hardly visible and the motivation for this comparison is not clear to me either. I am not sure if the comparison is crucial for your results anyway, since you do not conclude any vital points here, but if so, the comparison should be made much more carefully.

Answer: This subsection has been deleted.

Section 4: I think this section should be revised comprehensively. Now, it is some mishmash of discussion, outlook (partly irrelevant like P16L36), conclusions and literature review (partly with only little relation to the results of this study, e.g. P17L8-12). It should be structured more thoroughly around the results of this study and link the findings more clearly to the literature (e.g. P15L26-32: It feels like there lacks a (half) sentence at the end that integrates your results into the ones from the references mentioned). The second paragraph is a literature re- view without any clear connection to the results, rather, it raises questions that cannot be answered with this setup; that seems out of place. The second paragraph discusses some insufficiencies of the idealistic modelling approach. This is indeed very important, but it is not made clear, what that means for the conclusions that can be drawn from the model experiments (what can/could still be learned out of the vortex displacement simulation even though it is not reliable?). The connection of your results with the PDO should be discussed more thoroughly because from your model setup (mean January) you cannot compare different PDO phases. Moreover, the PDO had never been mentioned before in the paper.

There should be a separate and concise conclusions section that lists the main findings of this study (one of which e.g. an extract of the last paragraph of the paper, this is a very important point).

Answer: We absolutely agree and the Discussion and conclusions section has been restructured, rewritten and a summary of results is now given at P14L30-P15L24.

All of the following technical corrections have been implemented and the animations are now created according to ACP guidelines.