

## Comment on wcd-2022-34

Alison Ming

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Community comment on "The stratosphere: a review of the dynamics and variability" by  
Neal Butchart, Weather Clim. Dynam. Discuss.,  
<https://doi.org/10.5194/wcd-2022-34-CC3>, 2022

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These comments were generated during the SPARC stratospheric dynamics journal club\*  
that met over two 1.5h sessions to discuss this paper.

The paper reviews the current state of understanding of dynamical variability in the  
stratosphere. Overall it is well written and provides good coverage of what is a broad and  
rapidly evolving topic. In some places, there is a bit too much detail given which lengthens  
the paper and in other places, we have felt there were some important omissions.

We very much enjoyed reading this paper and it generated some good discussions. Our  
comments are below.

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Corwin Wright, Simchan Yook

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Comments:

Title: Add the word "review". It helps put the review in the right frame of mind.

Figures could be bigger. Some are not easily readable.

Line 47: typo 'an induced a mean meridional...'

Line 54: "...is not associated with the changing season". The QBO does have some  
seasonal phase locking. See Coy et al. (2020) and references therein.

Figure 2: Maybe combine T and zonal wind plots with coloured/greyscale contours for T  
and lines for u.

Figure 3: "Horizontal" typo. Caption should say that the left column is N Hemisphere and  
that the right column is SH. The colour bar should be changed from a divergent scale to a  
linear one to reflect the data being plotted.

Figure 4: Confusing to have Equator-direction on the left-hand side of both panels. Add a note in the caption.

Line 161: Should probably include a word of warning on the choice of scaling for the horizontal and vertical EP flux arrow. Jucker paper is relevant here. Figure 4 caption. Mention that the Equator is on the left in (b).

Line 165: "relatively" typo.

Section 2.2: Lots of gravity waves (GWs) break in the stratosphere! They are a major driver of many processes. This whole section underplays the role of GWs which are only mentioned briefly in the last paragraph.

The distinction between wave types is often not made clear when talking about the extratropics in Section 2 in general. This needs clarifying when "wave" is mentioned or clearly at the start of the section. In contrast, in Section 3 on the Tropics, the type of wave is clearly stated.

Figure 4 and Line 160: It is worth adding a word of caution on the visualisation of EP fluxes. We are aware that choosing various research papers choose to scale  $F(z)$ . When an arbitrary factor is picked (100 in this case), we do not think it necessarily leads to "a clearer visualisation". Jucker (2021) has a particularly good discussion of this issue and would be worth citing.

Figure 5 caption: Of course at least some of the extra detail comes from the model - the statement "it is possible" undersells this.

Figure 6: lines are so dense that when zoomed out to page-scale it generates Moiré patterns on my screen! Would suggest using colour instead/as well or making the figure itself bigger.

Figure 6(a): add some vertical guides for Jan 17 and Jan 27?

Line 225: [Caveat. We have not read the Hardiman et al. (2020) paper in detail but will be doing so.] Stratospheric vacillations are interesting and worth mentioning. Is the 120-day period sine wave a noteworthy result that should be included in this review? It feels like too much detail. Since 120 days is the length of winter, it does not seem surprising that such a sine wave can be fitted. My understanding of this topic is that there are some winters which start showing this periodic behaviour but the picture is far from clear.

Line below 259, footnote 3, typo: "locally rapid temperatures rises" - remove S from the end of "temperature"

Line 272: A reference discussing sudden warming definitions would be good here. For example, Butler and Gerber (2018) would be a good one.

Line 303: Albers and Birner (2014) is about preconditioning from BOTH planetary and gravity waves. Worth mentioning both types of waves here.

Line 305: Tim Palmer (1981) to Palmer (1981)

Line 376, typo: "display variability from cycle-to-cycle" - remove hyphens

Line 404: It may be worth including some more references on chemistry-QBO interactions. For example: Tian et al. (2006) looks at variations in NO<sub>x</sub> driving O<sub>3</sub> and Naoe et al. (2017) looks at changes in the future O<sub>3</sub> QBO.

Line 407, typo: "which is the principle reason" - change to "principal reason"

Line 423, syntax: "A corollary (...) is the occurrence of an SSW is " - perhaps insert "that" to make the text clearer: "A corollary (...) is that the occurrence of an SSW is"

Line 465, syntax: as above, alleviate the very long sentence beginning with "One consequence", for instance "One consequence (...) is that the paradigm", and set off the clause "and thereby provide a mechanism for interannual variability" with commas. Or break those four lines of text into several sentences.

Figure 11: It would be good to guide the reader to what they are looking for in terms of the QBO disruptions. This plot is not obvious since the eastward jet during the Dec/Jan 2019/2020 is not visible in this plot. We suggest using the Singapore sonde data instead that is available from here: [https://acd-ext.gsfc.nasa.gov/Data\\_services/met/qbo/qbo.html](https://acd-ext.gsfc.nasa.gov/Data_services/met/qbo/qbo.html). Indeed their plot of zonal winds does show the relevant feature. [The Kawatani et al. (2020) paper about the SAO has few relevant plots to the QBO. The spread between reanalysis is still large over the Equator, although it is improving, and it may be best to use the Singapore sonde data.]

Section 5 begins with a general historical introduction of stratospheric modelling, referring to the early studies in this domain. As such, Section 5.1 down to about line 495 seems better suited as a part of the general introduction of the paper. Section 5 could be re-titled simply "Predictability", without internal subsections.

Line 498 typo: "absence" -> "absent"

Line 510, typo: "despite been able to simulate" - change to "despite being able to simulate"

Line 530: reference to obs of ssw

Figure 16: I can see why you have grey-ed out the red line for a single ensemble member but I am not sure if this figure on its own is informative without the description in Scaife et al. (2016). The summary of Scaife et al. (2016) in the text is sufficient to illustrate the point.

Line 624: why should there be only one? Omit this sentence?

Line 646 typo: "Peninsular" -> "Peninsula"

Line 706: Domeisen 2019 is <https://doi.org/https://doi.org/10.1029/2018JD030077> (line 950), but it might need to be <https://doi.org/https://doi.org/10.1029/2019JD030920> or <https://doi.org/https://doi.org/10.1029/2019JD030923> (lines 952, 956), which are labelled as 2020a and 2020b in the references.

Figure 18: You should alert the reader to non-linear colour scale. Is there a more recent illustration of the increase in predictive skill since more recent papers are cited on Line 705?

Final paragraph of Section 7: "high altitude leisure flights by dangerously polluting rocket powered hobby aeroplanes" and "could increase the risk of disastrous extremes" does not seem like the right way to end this good review paper on. We would suggest re-visiting this paragraph.

References:

Coy, L., Newman, P. A., Strahan, S., & Pawson, S. (2020). Seasonal variation of the quasi-biennial oscillation descent. *Journal of Geophysical Research: Atmospheres*, 125, e2020JD033077. <https://doi.org/10.1029/2020JD033077>

Butler, A. H., & Gerber, E. P. (2018). Optimizing the Definition of a Sudden Stratospheric Warming, *Journal of Climate*, 31(6), 2337-2344. DOI: <https://doi.org/10.1175/JCLI-D-17-0648.1>

Jucker, M. Scaling of Eliassen-Palm flux vectors. *Atmos Sci Lett*. 2021; 22:e1020. <https://doi.org/10.1002/asl.1020>

Kawatani, Y., Hirooka, T., Hamilton, K., Smith, A. K., and Fujiwara, M.: Representation of the equatorial stratopause semiannual oscillation in global atmospheric reanalyses, *Atmos. Chem. Phys.*, 20, 9115–9133, <https://doi.org/10.5194/acp-20-9115-2020>, 2020.

Tian, W., M. P. Chipperfield, L. J. Gray, and J. M. Zawodny (2006), Quasi-biennial oscillation and tracer distributions in a coupled chemistry-climate model, *J. Geophys. Res.*, 111, D20301, doi:10.1029/2005JD006871.

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\* The SPARC stratospheric dynamics journal club consists of a group of about 25 members ranging from first year PhD students to more senior researchers who meet online every 2 weeks to discuss a paper. The size of the group varies depending on the paper being discussed and the various interests of individuals but typically between 6 to 10 people will be present.