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## **Comment on acp-2021-676**

Anonymous Referee #1

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Referee comment on "Evolution of the intensity and duration of the Southern Hemisphere stratospheric polar vortex edge for the period 1979–2020" by Audrey Lecouffe et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-676-RC1>, 2021

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**Comments on "Evolution of the stratospheric polar vortex edge intensity and duration in the Southern hemisphere over the 1979 – 2020 period" by Lecouffe et al. (2021)**

### **Summary**

Using the ERA-Interim reanalysis, ENSO index, QBO observations, and solar cycle index, Lecouffe et al. calculated the metrics of the southern hemispheric stratospheric polar vortex at 50 hPa using the vortex elliptical diagnostics. The variable PV is used in the study due to its conservation property on the isentropic surface in the free atmosphere. The paper is interesting and provide some useful information to the community. However, I also found some minor shortcomings in the paper. The authors might need to well review the most recent publications in the literature, and build their work on the existing results in literature. For example, previous studies have confirmed that the ENSO does not have significant impact on the Southern Hemisphere polar vortex. But this paper still discusses the weak impact of the ENSO on the vortex edge. Due to those problems in the manuscript, I suggest a substantial revision before the paper could be published.

### **Major comments**

- Lack of a sufficient review on the most recent publications.

The impact of ENSO, solar cycle, and QBO on the polar vortex in both hemispheres has been widely and exhaustively studied in literature. However, this manuscript fails to provide a sufficient review on the most recent publications. The impact of the canonical ENSO on the SH polar vortex is insignificant in both observations and modeling studies (Rao and Ren 2020 <https://doi.org/10.1007/s00382-019-05111-6>; Hurwitz et al. 2011 <https://journals.ametsoc.org/view/journals/atasc/68/4/2011jas3606.1.xml>). The impact of QBO on the stratosphere is also reported in the latest literature (Rao et al. 2020 <https://doi.org/10.1175/JCLI-D-19-0663.1>; Butchart et al. 2019 <https://doi.org/10.5194/gmd-11-1009-2018>). As the solar cycle's impact on the SH stratospheric polar vortex, it is also discussed most recently in Figure 3 of Rao et al. 2020JGR (<https://doi.org/10.1029/2020JD032723>). I suggest the authors to explore more of recent publications to see what has been done and what has not.

- Discussion on the 2002 SSW but lack of the 2019 SSW

Ample evidence has reported the similarity of the 2002 and 2019 SSWs in the SH. The paper discusses the main characteristics of the polar vortex edge in 2002 but fails to mention the 2019 SSW. Related studies are also ignored in the paper. The main characteristics of the SH polar vortex during the 2019 SSW have also been reported in Rao et al. 2020JGR (<https://doi.org/10.1029/2020JD032723>), Shen et al. 2020GRL (<https://doi.org/10.1029/2020GL089343>). The background of this study is still lacking and the references can be further improved.

- Start date of the SH polar vortex and the final warming date

In my understanding, the start date of the stratospheric polar vortex in both hemispheres are mainly forced radiatively due to the annual cycle, and it should be very stable. I checked the start date of the polar vortex in the NH using the zonal mean zonal wind at 60N and 10hPa as the threshold. I found that the start date of the NH polar vortex is very stable. In contrast, the final warming date in both hemispheres differs from year to year due to the dynamics associated with planetary wave activities. However, this study shows that both the start date and end date of the SH polar vortex have a large interannual variability. What forces such a strong variation of the start date of the stratospheric polar vortex. The authors also failed to mention the most recent studies on the final warming

date in the SH (Rao and Garfinkel 2021CD, <https://doi.org/10.1007/s00382-021-05647-6>). They also discussed the possible impact of the ozone depletion and recovery on the polar vortex final warming date.

### **Minor comments**

- P1L18: This sentence should be supported by some citations. Please insert.
  
- L24: The most recent report by Rao and Garfinkel 2021CD checked the interannual variation of the final warming date from CMIP5/6 models and JRA55 reanalysis. Explore if you missed more recent reports.
  
- P2L1: The reference put too much on the ozone depletion, but review on other aspects of the stratospheric polar vortex is insufficient.
  
- L13: The ozone depletion events are also existing in the NH. The AUG organized one special issue for the NH ozone loss event in the 2019/2020 winter:

[https://agupubs.onlinelibrary.wiley.com/doi/toc/10.1002/\(ISSN\)1944-8007.ARCTICSPV](https://agupubs.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)1944-8007.ARCTICSPV). Choose several references and discuss the ozone depletion in the NH (e.g., Garfinkel 2020, 2021; Feng et al. 2021). The authors really should read more to enrich the introduction of the paper. This version is really not satisfactory.

- L17-19: The future recovery of the ozone and its possible impact on the vortex in both hemispheres are also discussed in Rao and Garfinkel 2021CD.
  
- L28: What is wind module? Please specify.
  
- P3L2-3: The impact of QBO, ENSO, and solar cycle on the polar vortex in both hemispheres have been widely studied in literature. Please be more exhaustive when you mention the most recent studies. Please see my major comments.
  
- L9-10: This conclusion is also reported by Rao et al. 2020JGR when they checked the possible impact of the QBO phase on the 2019 SSW in SH.
  
- L12-19: This part should be moved to the method section. Or I suggest to remove or shorten.
  
- L24: You might emphasize the novelty of this study, because the possible impact of

QBO, ENSO, and solar cycle have been widely reported.

- P4L7-12: This sentence is toooooo... long. Can you split this sentence and clearly describe the model MIMOSA. Please tell readers what MIMOSA consist of and how it can predict the PV. Is it a forecast model?
  
- L18: Rao et al. 2019 JGR also used this index to select the solar max and min years. Please refer to Table 3 in Rao et al. 2019 JGR (<https://doi.org/10.1029/2019JD030826>)
  
- L20: 21th => 21<sup>st</sup>
  
- L23: If you read Rao et al. 2019 JGR (supplementary material), please mention that they also consider the intensity change for each solar cycle.
  
- L27-30: This index is not reasonable, because it can not distinguish between Eastern and Central Pacific ENSO events. Only CP ENSO can impact the SH polar vortex. Previous studies (Hurwitz et al. 2011; Rao and Ren 2020) have reported that EP ENSO is not related with the SH stratosphere. Please change to use Nino3 and Nino4 index and revisit the possible impact of ENSO on the SH polar vortex edge.

- L31: This sentence can be removed. It has been mentioned earlier.
  
  
- L33: This classification of ENSO state is also weird. 21 warm ENSO and 21 cold ENSO. Why is there no neutral ENSO state? Rather weird and unacceptable.
  
  
- P5 Table 1: ENSO index should be changed.
  
  
  
- L5: The position of the edge is in the unit of EL, rather than as a function of EL degree. Please correct throughout the paper. The authors might misunderstand the function. The edge is a single value, independent of the EL.  $Edge = edge(\theta, \text{time})$ . But  $PV = PV(EL, \theta, \text{time})$ . Mathematically, the description is incorrect.
  
  
- L11-12: PV is not an output for the NCEP/NCAR reanalysis. I do not think the authors clearly know and understand what they read. If the PV is also obtained from MIMOSA driven by the NCEP/NCAR reanalysis, please clarify.

- P6L6: I did not see any special value of using so many thresholds. The results are different for those thresholds. Which one should readers believe?
- L11: See above. What is function?
- P7L6: Add discussion for the 2019 SSW in SH. Please inserted relevant references.
- Figure 2: See above. Function is misleading.
- P8L4: Those are factors which might control the interannual variation of the polar vortex. This sentence should be rephrased.
- P9L10: How did you test the difference for the medians? The difference for the mean can be tested using the t-test. Which test is used for the medians? Please clarify.

- P10L1: delete “statistical”
  
- L8: How did you test the difference for the medians?
  
- Section 4.2.2, 4.2.3: The two subsections still focused on the impact of solar cycle on the polar vortex edge. I prefer to seeing the results for the composite for ENSO and QBO directly. Can you also show?
  
- P14L5: In my understanding, the maximum day is different from year to year. But you fixed from 15 September to 15 October. If so, remove this sentence as is misleads readers.
  
- L9-11: The discussion is useless. Those so-called decrease and increase reflect the interannual variation, rather than any trend.
  
- L19-20: The final solar cycle is weak, mention in Rao et al. 2019 JGR.



