

We thank Dr. Knowland for her comments. Below are our responses in blue. The biggest change is that the update version includes new figures in the appendix showing root mean square (RMS) differences of the parameters studied to get an idea of the day-to-day variability. Brief text explaining these RMS differences was added throughout the manuscript.

#### Summary:

In this manuscript, the authors present a thorough intercomparison of reanalysis potential vorticity and diagnostics related to potential vorticity. One modern reanalysis product from four of the major global operational and research centers are selected: CFSR/CFSv2, ERAInterim, JRA-55 and MERRA2. As part of the SPARC Reanalysis Intercomparison Project, this paper provides clear advice to users of reanalysis PV diagnostics as well as recommends reanalysis centers to consider including PV on model levels in future products for optimal comparisons and scientific studies in the future. My one concern is the number (15) and size (multi-panel) of the figures relative to the text, however I do not see any that can be cut down in size or removed from the main text and included in a supplemental instead. Therefore, I recommend this paper for publication after my minor and technical comments below are addressed.

#### Comments:

Pg 1 Line 8, Pg 2 Line 32: Add "NASA" before "Modern" since the reanalysis center for the other three products is given. [We added NASA as requested](#)

Pg 2 Line 21: I think the comma after "Nash et al., 1996)," should either be a semi colon or a period. [We changed the comma to a semicolon](#)

Pg 3 Line 4: Update Table 1 MERRA2 reference to match Gelaro et al. 2017 reference used here.  
[Done](#)

Pg 3 Line 4: Is there a reason ERA-Interim is used instead of ERA-5, the latest ECWMF reanalysis? [When we were performing the analysis we did not have access to ERA-5, there were persistent problems downloading the data for an extended time period.](#)

Pg 3 Line 7: Why is the period 1980 through 2014 used? [CFSR/CSFv2 was only available on model levels for that time period That is why Long et al 2017 \(10.5194/acp-17-14593-2017\) or Manney and Hegglin 2018 \(10.1175/JCLI-D-17-0303.1\), and many others, also used that period.](#)

Pg 3 Line 11, Pg 5 Line 21: I checked the ERA-Interim website and I see "Vorticity (relative)" for ERA-Interim on Model Levels. <https://apps.ecmwf.int/datasets/data/interim-fulldaily/levtype=ml/>  
[Yes, we swapped by mistake which field was provided in which reanalysis, the sentence will now read: "CFSR/CFSv2 provides absolute vorticity while ERA-Interim provides relative vorticity, hence, for ..."](#)

Pg 3 Line 26: ERA-Interim and JRA-55 have coarser resolution than 0.5x0.5 degree. Could this impact your study?

[We used a bilinear interpolation to get to the 0.5°x0.5°grid so the only effects of interpolating to a finer grid should be minimal \(since no extrapolation is involved\), further, we did the same analysis at 2degrees resolution and the conclusions are the same.](#)

Pg 4 Line 9, Pg 5 Line 2: Correct me, but I do not see the different processing streams discussed or labelled on Figure 1 or 3, so do we assume that this does not impact PV anomalies? There is mention of a “CFSR to CFSv2 transition” on Pg 8 Line 6 but when this occurred is not stated.

The processing streams will be labeled in what were Figures 1,3,6,8,15 in the original manuscript, that is, in all the timeseries. The location of the CFSR/CFSv2 transition is mention in section 3.

Pg 4 Line 12: Should “regions” be singular since only the south pole is referenced here and not both poles? Yes, that is correct. It was changed to region.

Pg 4 Line 32: Can the authors comment on the fact that the CFSR differences are of opposite sign to the other reanalyses.

We will add: “In contrast, the other reanalyses are biased slightly high (only up to  $0.3 \times 10^{-4} \text{ s}^{-1}$ ) as an artifact of using the REM as a comparison tool. The similarities among these slightly high biases suggest good agreement among ERA-Interim, MERRA2, and JRA-55 at these levels.”

Pg 5 Line 11: Can the authors comment on what may cause this difference at CFSR at 2500K? Is this at all related to the model resolution or how the model treats the upper atmospheric levels? or that CFSR has the lowest Lid height (0.26 hPa, Table 1)?

Yes, this may/might/could be related to the lid height, which is right around that level. We will add: “This may be because this level is near the CFSR/CFSv2 lid height (0.26 hPa). “

In the EqL section we also added: “... however pronounced differences, greater than  $10^\circ$ , are seen near the poles around 2500 K, **which may be an artifact caused by the low CFSR/CFsV2 lid height.**”

Pg 5 Line 12: “near 850K” looks more like 850-1000K to me. Are the pixels centered on an isentropic level? No they are not, we will change to: “displays a discontinuity between 800 and 1000K. “

Pg 6 Line 1: UTLS is not defined. The phrase: “versus those on native model levels, e.g., for Upper Troposphere Lower Stratosphere (UTLS) studies” was added to this sentence.

Pg 6 Line 15: The lowest levels are not of interest to this study but can the authors comment on the “highest levels”. Does the top of the atmosphere change between the models that this criterion matters at all? By highest levels we actually meant above 2500K (the top of the model should not affect this except perhaps for CFSR/CFSv2), we will change the sentence to: “This criterion only affects the lowest levels studied in this analysis.”

Pg 6 Line 17: It is hard to see along the bottom of the figure. What is the lower limit on Figure 5? Is it 400 K?

Yeah, it is hard to discern, the lower limit is 330K as specified in section 2, which now includes the potential temperatures that we used.

Pg 6 Line 21: Suggest adding “; however” connecting these two sentences. Done

Pg 6 Line 31-Pg 7 line 2: Can the authors comment on why this might be? Not really ...

Pg 7 Line 4: This looks less evident for MERRA2 after 2005. That is correct, that was covered in the statement before that mentions that most of the time the differences are within 1°

Pg 7 Line 19: is altitude above sea level or above surface (ground-level)? Above sea level, we will change the sentence to: "Figure 8 shows climatological REM dynamical tropopause altitude (**above sea level**) maps for different seasons"

Pg 7 Line 26: "can be up to 1 km", does this have anything to do with the difference model resolution in the UTLS?

Yes it can be related to it. A column was added to Table 1 listing the UTLS vertical spacing around 1.2km for MERRA2 and 1.km for ERA-Interim, CFSR/CFSv2 and JRA55. We also added the following sentence at the end of the paragraph: "Part of these differences may be due to the slightly different spacing between model levels (1 to 1.2 km apart at these altitudes) and the actual location of such levels with respect to the tropopause."

We also added in Table 1: "the approximate vertical resolutions of the reanalysis fields for their entire vertical range can be found on Figure 3 of Fujiwara et al. (2017)"

Pg 8 Line 12: add "(not shown)" Added

Pg 8 Line 14: In general for this section, do the authors use the native resolution or the 0.5x0.5 degree interpolated resolution?

The sPV thresholds were computed on their native resolution, we change the text to: "we bin sPV (**from the native resolution of each reanalysis**) as a function of equivalent latitude, differentiate,..."

The rest was done using the 0.5x0.5 fields, we changed the text to: "To quantify such differences we identify vortices for each day and catalog the number of vortices as well as their area. To identify the vortices on a given isentropic surface (**in the 0.5° by 0.5° gridded fields**), we use a flood filling ..."

Pg 9 Lines 30-31: I suggest referencing Figure 11 here since later in this paragraph you reference Figure 12. The sentence was changed to: "In midwinter (see Figure 12), maximum differences .. "

Note that following a request by reviewer 2 we added a new figure hence the change in Figure number.

Pg 10 Line 3: Is there a reference for selecting this vortex area of  $0.15 \times 10^7 \text{ km}^2$ ? Not really this threshold was chosen somewhat arbitrarily by looking at the behavior of the plots.

Pg 10 Line 17: capitalize "southern" Done

Pg 10 Line 20: Looks to me CFSR is at 500K and 440K. Yes we will change the text to: "with the exception of CFSR/CFSv2 at 440 K (and to a lesser degree at 500 K), which shows a clear departure..."

Pg 10 Line 22: Suggest moving the sentence starting with "MERRA-2" to after "midwinter)." to keep the upper-level discussion together. The paragraph was changed to: "The greatest variability among the equivalent ellipses is seen at 1100 K and 1300 K, consistent with the variability in area seasonality (up to 20% in midwinter), with MERRA-2 showing slightly smaller ellipses than the other reanalyses at 1300 K. Most of the reanalyses agree remarkably ..."

Pg 10 Line 26: add "both" before "showing" Done

Pg 10 Line 26-27: Could the discontinuity in ERA-I be related to a change in processing streams?

The updated figure includes the processing streams; this discontinuity is not related to either data changes or processing streams.

Figures:

Figure 3: The y-axis has minor ticks which seem to be greater than the resolution of the pixels. I recommend reducing the minor ticks. Can annual minor ticks be added to the x-axis on this and the other figures?

The number of y-minor ticks was reduced as requested and we added annual x-minor ticks for figures 4, 7, 9, 16 (that is, figures 3, 6, 8 and 15 in the previous manuscript)

Figure 7: Can the y-axis include 30degree latitude interval labels since it is referenced several times on Page 7. We added a dashed line at 30S and 30N in every panel. The caption will be updated to include: "Dashed lines indicate the 30S and 30N latitudes."