Review of “A novel method for objective identification of 3-D potential vorticity anomalies,” by Christoph Fisher et al.

**General Comments**

This paper provides a novel technique for identifying the 3-D structure and temporal evolution of potential vorticity anomalies. Using a morphological image processing technique on a stereographic projection they identified PV candidates and filtered them for further analysis. Extension of the technique to 3-D is presented using a case study of a large precipitation event in Vietnam in 2015. The paper is generally well written and suitable for publication in Geoscientific Model Development. Below are some suggestions for improvement. The main issue is that more clarity is required in explaining the 3-D extension of the algorithm and description of the 3-D analyses.

**Specific Comments**

Line 23: May want to list some of these nonconservative processes. Also, what do you mean by “large-scale”?

Lines 163-165: How do you merge the data at the equator? Is it possible to get different results from the two mappings? Or do you just ignore this region for this study and leave the boundary problem for future work?

Line 173: Is this angle measured with respect to the center point point $(x_c, y_c)$?

Line 177: Should the exponent be 2 rather than -2. Otherwise, what does $\cos^{-2}$( ) represent?

Line 184: I don’t understand how $\Delta s(x_c, y_c)$ is calculated. Can you give an example or show this distance on Figure 3?

Line 196: Does *z* represent an infinitesimal line segment between any two arbitrary points?

Line 201: What is the gradient used here? Is it a spatial gradient along the projection plane?

Figure 4 caption: I know this is an illustrative figure, but it would be helpful to know what dataset, time, vertical level, as in Figure 5, in case a reader may want to try to reproduce these results.

Lines 240-1: The threshold PV value (2 PVU) could possibly be classified as an input parameter. You don’t show any sensitivity to the choice of this parameter, but clearly it could have a significant impact on your analysis. You may want to comment on this.

Line 255: What about features that are disconnected from the main part of the region, like the small filaments in the Atlantic Ocean. How do you calculate their distances since no path from the inner boundary is available that stays within the domain?

Line 254: Is the contour here defined as the boundary of the object? If the object is connected to the main reservoir do you include the line segments where the object and the reservoir intersect?

Section 4.4: This is a nice description of various metrics, but it seems that they are not really used much in the paper. It would be nice to have some examples of these calculations for different features in one of the 2-D examples.

Figure 6: It is interesting that this figure is based on pressure layer-averaging rather than isentropic level. Is there a reason for this? Also, it is unclear how the individual objects are distinguished here. For example, the feature over the Atlantic Ocean appears to have two distinct PV anomalies. Are they both part of one object?

Lines 327-328: Regarding the length calculation, is this only for features that are connected to the main reservoir? What about the cutoff features in the ocean? How do you calculate the length of those features for the filtering algorithm to use, since they are disconnected? This is related to an earlier question.

Lines 320-323: I don't understand this sentence. How does their algorithm identify a broad trough? Are your referring to the 2 PVU contour on Figure 8b? And what is the tropospheric air encapsulated in the stratospheric reservoir? Can you point to that in the figure?

Line 367: The first sentence seems to be missing some words "extend the in Section 4"

Line 370-379: The description of the 3-D extension of the algorithm seems to be lacking important information for the reader. Here are a few questions and comments.

- In 2-D you have boundary defined by the 2 PVU contour and domain defined by the area enclosed by that contour, which includes PV values greater than 2 PVU. In 3-D the boundary is now the 2 PVU surface, but what is the domain? Is it the 3-D region where the PV value is greater than 2 PVU? So generally you are calculating distance upwards from the 2 PVU surface?
- In 2-D you calculate the distances constrained by lines that remain in the domain. But in 3-D are the distances still required to stay in the domain? How is that done?
- This 3-D calculation takes into account both vertical and horizontal displacements, and in the vertical you use a scaling between potential temperature and height. Couldn't you use the geopotential height as the approximate vertical position of each grid point?
- Are there complications in your algorithm when there are multiple tropopauses in one vertical column? How does the algorithm handle these?
- It could be that one additional figure showing how the process works in 3-D with a simpler shape than in Figures 9 and 10 would help the reader to understand this extension. Could you make plots similar to Figure 4, but with the 3-D domain? For 3-D, it is not obvious what is the domain, the two boundaries, the direction for which the distances are calculated, etc.

Figure 9: It looks like the anomalies are above the dynamical tropopause, extending into the higher PV stratosphere. Is this an optical illusion? Also, I wondered why the long streamer in the central lower part of Figure 9a is not identified as an anomaly. Is this too thin in the vertical to meet the 6 K threshold?

Line 382: Would this be analogous to $\Gamma_1$ in Figure 4a? What would $\Gamma_2$ look like?

Line 389-390: Centroid and area don't seem to be calculated anywhere. Can you give an example?

Line 400: This says you filter the areas to get detached and separated objects. It seems arbitrary that the 6K cutoff would actually separate the regions into dynamically distinct features. Won't this artificially cut off certain features that should be connected?

Line 469-470: The yellow anomaly is an equatorward intrusion of stratospheric air. Since tropopause height increases equatorward, wouldn't the anomaly lie under the tropopause, like a tropopause fold?

Figure 13 gives the appearance that the anomaly is above the tropopause. Maybe it would help to explain exactly what the isosurfaces of the anomalies represent in your 3-D diagrams.

**Technical Corrections**

Figure 2 caption: Do you mean “FMM” here, not “FFM”. Also, do you want to capitalize “marching method”?

Line 246: replace “is” with “are”, since the noun is plural (distances)

Line 281: Do you mean distance d emerging “from” ...

Line 305: Should “form” be “forms”, since the noun is singular (shape)

Line 323: “spot” should be “spots”