

## **Anonymous Referee #1:**

One general comment: I find the number of figures (and their complexity/number of panels) too generous and would encourage the authors to review if every figure/panel is necessary. My answer would be no!

We have decided to remove one figure (Figure 8) as suggested by Referee #2 and have reduced the number of total figure panels by 40 (from 166 to 126) according to the referee suggestions and as described below.

p4403, I19: It would be good if the authors could clarify how the earlier study (M06) was done. I assume the wind analyses were only available every 24 hours as an instantaneous field? If this is true, it would be good to distinguish the quality of the wind analyses and the information gained by using 6 hourly data

Yes, the study used the Met Office winds at once-daily (12 UT) resolution on a 2.5 x 3.75 lat x lon grid on UARS pressure levels (~2.5 km vertical spacing). So the resolution was much coarser than the present analysis both temporally and spatially. Also, the top analysis level was 0.1 hPa (a decade lower than the GEOS5 analyses). This will be discussed further in the Introduction.

Abstract and summary: Generally, I have the impression that the VITA scheme is given a too positive judgement. Some features seem to be numerical artefacts (e.g. Fig. 5 and 7) and should be assessed more critically; p4420, I26 is a good starting point.

We did mention in the abstract that "VITA eventually developed fine-scale N<sub>2</sub>O structure not observed in MLS data". We also indicated in the summary that "small-scale structures maintained by VITA that are not found in MLS are problematic..." We will review other VITA comments critically and try to use objective judgments.

Figure 4: Too many plots; are more than two dates really needed to make the point?

We reduced this to 4 dates (rather than 8) that we felt were necessary to make all important points.

Figure 7: Too many levels - pick 3 ...

We reduced this to 4 levels rather than 6.

Figure 10: as Figure 4

We reduced this to 4 dates (rather than 8) that we felt were necessary.

Figure 11: I am confused, is this plot just showing the benefit of reinitialising VITA on 1st April (p4420, I22) whereas the other runs are continuous? Please clarify.

Actually, the issue here is not the VITA reinitialization, but rather the unwanted diffusion caused by advection over the pole. The VITA model will not have this unwanted diffusion due to the triangular grid used. The VITA results were included in Figure 11 to show that there is no distortion of the N<sub>2</sub>O field.

Figure 15: the point made with this figure does not require 24 plots, I am afraid.

We reduced this to 4 dates (rather than 8) that we thought were necessary.

Minor: p4404, I14: avoid "shocking"; colloquial

We removed the part about "shocking".

p4405, I15: insert "the" before "van"

Done

p4418, I14: replace "destructive" with "eroding"

Done

## **Anonymous Referee #2**

The paper is a bit lengthy at times, and the number of figures is rather high. The authors should consider reducing the number of figures; I can only suggest two figures that are not really necessary, namely Figs. 1b and 8.

We have decided to remove one complete figure (Figure 8) as suggested and have reduced the number of total figure panels by 40 (from 166 to 126).

### **Minor comments**

1) P8, line 28: why do the authors consider that PV is noisy at 1300K, on APR 4? High PV remnants of the polar vortex are seen at all levels above 850K. Isn't that simply the case that this level is above the top of the FriAC?

Yes, this is likely the top of the FriAC and shouldn't necessarily be attributed to noise in PV.

2) P12, line 18: should be figure 3, not 4 (?).

Yes, you are correct. The change will be made.

3) P13, line 28: I don't understand why the authors say that the feature is not always identified by anticyclonic circulation. I can see that in the initial formation period (APR 1-7), the FriAC progresses eastwards. But it is still an anticyclone. Please clarify.

It is really the local anticyclonic circulation that we're talking about. During the anticyclonic phase there are height contours that are centered on and closed around the N2O maximum indicating a localized anticyclone. Later, the FriAC is embedded in the large-scale anticyclonic circulation of the summer easterlies, with the contours centered near the pole, not on the FriAC.

4) P17, line 26: the authors say that the elevated N2O in MLS on August 30 and 90E is not the FriAC last stage, but a new feature. Wasn't that feature already visible at earlier dates? Please relate the final evolution of the FriAC in July-August more clearly with what is seen on the maps of Fig. 15

Actually, we may have misinterpreted this feature. It isn't visible in the MLS daily maps for a few days leading up to 30 August, so we thought it was something new. But now we realize that it likely disappeared temporarily as it crossed over the pole, due to the MLS sampling limitations. We decided to blank out this region in the MLS data to avoid confusion and rewrote this discussion.

5) P20, line 19: it could equally be said that the MLS sampling and limited resolution degrades the filaments present in the real world, and that VITA has more realistic filamentation processes (?)

Yes, this is indeed possible for short-time integrations (~a few weeks). However, for long integrations (~months) the neglect of vertical mixing in VITA will result in unrealistic structures. This is what made it necessary to us to re-initialize.

6) General. What determines the depth (or vertical extent) of the FriAC ? Is it linked to the depth of the initial low-latitude intrusion?

We believe it is linked to the depth of the intrusion as well as the existence of significant PV gradients.

Wording Caption Fig. 3: there are no white lines, only black lines. I don't understand why the caption indicates geopotential only at 10 hPa ?

This has been corrected to read "black lines".

Caption Fig. 17: \*lines\*. They are several lines

Corrected.

Caption Fig. 18: define E/Up in full in the caption.

Done

Caption Fig. 14: more vertical tick marks are needed on the y-axis. Indicate latitude.

Done