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Discussions

Interactive comment on "Transport of Antarctic stratospheric strongly dehydrated air into the troposphere observed during the HALO-ESMVal campaign 2012" *by* C. Rolf et al.

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First major comment:

As author of a paper speculating about descent of Antarctic stratospheric air into the troposphere (Roscoe 2004, referenced by Rolf et al.), I was greatly looking forward to reading this work in detail. My earlier speculation was that some air should be descending over a broad area within the stratospheric vortex for a large part of the winter and early spring, based on various lines of circumstantial evidence. It would have been very pleasing for the speculation to be proven. If so, the implications for the

water vapour budget in the troposphere over the Antarctic Plateau, and for the isotopic composition of snow in ice cores there, would have been very significant.

Unfortunately, Rolf et al. do not indisputably show descent over a broad area, nor for a large part of the winter and early spring. Instead they show transport over a limited area (a few degrees latitude and longitude) on one day. They show how there is a strong probability that it is caused by a breaking Rossby wave, which suggests that the transport identified is unlikely to be widespread or frequent. Although their Figure 8 is interpreted as showing a widespread occurrence of such episodes, Figure 8 is based on trajectories of such long duration that their validity must be considered doubtful (see D below).

Hence, while the title, abstract and arguments within the bulk of the paper are factually correct, the importance of the discovery to the wider questions of water budget and isotopes in ice cores is probably rather limited.

Second major comment:

The authors consistently describe air at 8 to 9 km as though it were obviously tropospheric. This is often not the case in Antarctic winter and spring within the vortex. In the example shown in Figure 3 of Roscoe et al. (2004) of temperature and ozone structure at Halley (76°S) on 27 August 1987, the lapse rate becomes stable and the ozone amount increases sharply above about 290 hPa, which was at 8.4 km. On 1 September 1987 the ozone increase started at 300 hPa, which was at 8.2 km (Gardiner & Farman 1988). There are many more examples of such a low tropopause in Gardiner & Farman (1988), which contains convenient plots and tables for examining this issue.

One difficulty with the "thermal tropopause" calculation, from ECMWF and GLORIA data in Figures 1 and 3 is that such a calculation would normally define the tropopause as the height where the lapse rate changes sign. In the example in my Figure 3 (Roscoe et al. 2004) this would be at 30 hPa, clearly a long way into the stratosphere.

What matters is the height at which the atmosphere becomes ultra-stable, with a lapse rate less than, say, 3°C/km, which would always be at a much lower altitude than where the lapse rate changes sign. A tropopause defined by the discontinuity in ozone amount would also often be at a much lower altitude than where the lapse rate changes sign

Finally, most authors would assert that a potential temperature of 310 K in Antarctic winter and spring is in the lowest stratosphere, and 290 K is probably in the troposphere. In Figure 3, the 300 K contour would be at about 8.5 km within the vortex on the earlier flight leg, and down to 7.8 km during the dehydration event in the later flight leg. Again, much of the discussion about the dehydration in the later flight leg is about air that is very likely still in the stratosphere.

I do not argue that the premise of the paper is wrong because of these factors – Figure 3 shows clear transport of dehydrated air down to 7 km – merely that some of the analysis of data in the paper contains statements about tropospheric air that are contestable or over-emphasised.

Third major comment:

The transport event described in the paper is very reminiscent of a tropopause fold. These normally occur on the poleward side of the mid-latitude or the sub-tropical jet, and take stratospheric air sideways and equator-ward as they descend. But for Figure 1b, which shows no sign of the mid-latitude jet near the event at 47°S, we might easily have characterised the event described as a conventional tropopause fold.

Surely, this aspect of the discovery deserves comment, and perhaps some analysis of why it is more significant than a conventional tropopause fold?

Minor comments:

A. The last paragraph on page 7899 misses an important point identified by Lee et al. (2002): the lowest stratosphere below the vortex, from about 300 K to about 330 K, is

significantly mixed with mid-latitude air – the vortex barely exists at these altitudes as an isolating mechanism.

B. Page 7900 lines 6-8 describes my idea that katabatic winds provide a downward force over the Plateau, because of the expected paucity of re-supply to be expected as a result of the Coriolis force, as though it were a proven fact. It is not proven.

C. Possible rehydration after ice particles have fallen is an important topic. It would be very helpful to see the water measurements during the dive, which the authors say (page 7912 lines 3-4) confirm the absence of any rehydration features.

D. Most workers would regard back trajectories calculated for 50 days (Figure 4) or 150 days (Figure 8) as being of doubtful validity. Surely there should be some discussion about this?

E. The confusion about heights and potential temperatures discussed in the second major comment above continues on page 7915 line 27, where 5 km altitude is reported as being at 300 K. During the ozonesonde flight of 27 August 1987 (Figure 3 of Roscoe 2004), 5 km was at 286 K, and 300 K was at 8.9 km.

Editorial comments:

1. p7898 l3 – replace “extend” by “extends”.

2. p7898 l3 – replace “changing” by “changes”.

3. Fig1 caption l5 – replace “indicate” by “indicates”.

4. Fig1 caption l6 – surely the dots are blue-green (turquoise if you prefer), not blue?

References:

Lee, A.M., R.L. Jones, I. Kilbane-Dawe, J.A. Pyle, “Diagnosing ozone loss in the extratropical lower stratosphere”, J. Geophys. Res. 107, ACH 3-1–ACH 3-11, doi:10.1029/2001JD000538, 2002.

Gardiner, B.G., J.C. Farman, “Results of the 1987 ozonesonde programme at Halley Bay, Antarctica”, British Antarctic Survey, UK, ISBN 0-85665-128-1, 1988.

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