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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Observational evidence of moistening the lowermost stratosphere via isentropic mixing across the subtropical jet" *by* J. Langille et al.

Anonymous Referee #1

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Observational evidence of moistening the lowermost stratosphere via isentropic mixing across the subtropical jet J. Langille et al.

The authors present results from a new remote sensing instrument designed for satellite-borne high-vertical resolution limb soundings o f water vapor in the upper troposphere/lower stratosphere. The instrument was mounted on board a high-altitude research aircraft and a single cross section obtained of an intrusion of tropospheric air into the lowermost stratosphere, just above the substropical jet is presented. The cross section provides evidence of a moist filament of tropospheric air being mixed poleward into the lower most stratosphere.

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Such events are of physical and climatic interest given the role of these events in moistening the extratropical lower stratosphere and thus determining water vapor concentrations in a region important for climate forcing. The observations reveal features at very fine vertical length scales (< 1 km) which are difficult to observe and to model, although the MLS observations do seem to capture the filament in question to some extent. This filament of elevated water vapor coincides with the (upper) tropopause near the 400 K isentropic surface. The authors suggest tentatively that there may be a bias in the ECMWF reanalysis in the form of a vertical offset of the dynamical fields, in that there is a similarly located region of low potential vorticity air somewhat lower in altitude.

Regardless of this suggestion, this observation of a fine filamentary structure extending into the lowermost stratosphere is certainly worthy of publication, but since the scope of the paper is, as set out by the authors, primarily to present the scientific value in these test observations (not simply to validate them) I think it is appropriate to ask for a bit more follow up analysis on some of the details.

Firstly, the newer ERA 5 reanalysis should be used instead of ERA Interim. It has substantially higher vertical and horizontal resolution, and the data is easily available. It would be also worth looking at model level data which is much finer than the data provided on the 37 pressure-level grid. I am not convinced of the inferred vertical (see below), but in any case, the comparison would be much more relevant in the context of the more modern product.

Secondly, emphasis has been placed on the vertical and meridional structure of this filament, but the only synoptic details we are given is in the form of an isobaric wind map at 175 hPa. It could be very enlightening to see some maps of potential vorticity on the 400 K and the 380 K isentropic surfaces with a domain comparable to Figure 1, in order to distinguish the filament from the layer of air between the double tropopause structure highlighted in Fig. 3a. These may have quite different horizontal structures that could shed light on the fine vertical structure of the observed water vapor. On a

related note, I don't think the text includes a discussion of the line-of-sight resolution of the measurements (i.e. in the longitudinal direction in the current geometry).

With regards to the suspected offset in the reanalysis output, this is certainly a difficult region to capture correctly and so it seems plausible to me that such an offset could exist. However, it's also possible that the water vapor transport is not aligned with the lowest PV anomaly, or that the layer of most effective intrusion is not where the PV gradients are strongest (after all the meridional PV gradients act as a horizontal mixing barrier that discourages such intrusions). The requested figures should provides some clarity on this point. A related dynamical point is that the potential temperature lapse rate is not a materially conserved quantity, while PV is (up to diabatic processes); this point should probably be stressed more clearly in the text.

One final minor comment: on line 168 reference is made to orange contours in Figure 3 that I think are in fact dark gray; the orange contours only show up in Figure 4.

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