Review of:
Effect of deep convection on the TTL composition over the Southwest Indian Ocean during austral summer.

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Anonymous Reviewer

1 General Comments

The authors present a study focussed on the origin of convective signatures on two balloon-borne water vapour profiles observed in the vicinity of tropical storms in January 2016 (TS Corentin) and March 2017 (TC Enawo). Additional ozone sondes, ground- and space-based Lidar data as well as Meteosat 7 IR images and AURA-MLS water vapour data have been utilized and compared to the balloon data as well as model results from FLEXPART trajectory studies based on regular and nested high-resolution ECMWF analysis data. Therefore quite a suite of tools has been deployed in order to corroborate and interpret the measurements. Significant hydrations have been identified in the upper troposphere (UT) for both flights which based on the back trajectories could be traced to convective activity of the respective tropical storms. One dehydrated layer slightly below the cold point was identified. A slight moistening signal in the lower stratosphere (LS) has been found for the 2016 measurement and could be related to horizontal transport from the SE-Indian ocean which was still humid in response to the strong ElNino. These major results are in-line with previously published results so no new or rare types of signatures are reported. Also, quite a number of modelling and experimental studies on this topic have been published over the years based on balloon-borne, airborne as well as satellite data. However, the availability of reliable and spatially well resolved data to discriminate different convective models and represented processes still seems not sufficient which raises the value of each new dataset being studied and published. The study presented here focusses on the region of the South-West Indian Ocean which has not received a lot of attention with this respect.

As the role of moistening and drying effects of tropical storms on the UT, TTL, and LS are still under discussion this is a relevant and well suited topic for publication in ACP. The manuscript is well written, however the structure needs improvement. Data validation and interpretation are mixed up at places which makes the argumentation quite hard to follow. The number of figures could also be reduced. As discussed in detail below, the data presented are not sufficient to conclusively support several of the topics discussed in length in the manuscript. As a result I recommend to focus the discussion to the conclusively identified source-signature relations mentioned above and submit a revised and more focussed manuscript taking into account the comments below.

2 Detailed Comments

l.100: Apart from the CFH specifications the altitude dependent temperature measurement accuracy of the radio sonde must be given in order to judge the reliability of the relative humidity (RH) used later. Derivation and specifications of the measured vertical coordinate(s) should also be mentioned briefly.

Structure of the Data/Results sections: I recommend to move all validations (instrument intercomparisons) and derivations of climatological differences to one dedicated section where they are derived and presented without discussing them along with interpretational details. The argumentation would be much easier to follow when giving/deriving temperature differences, water vapour intercomparisons, RH, differences to monthly mean MLS H_2O profiles first and then later discuss them all together with respect to the FLEXPART trajectory model results for the consecutive atmospheric layers and flights. Also I propose to discuss the possible CFH lower strat. dry bias on 3.March 2017 in this early section and just mention it later in the interpretation. In this last aspect it is also important to point out the reliability of the CFH results up into the UT supported by the good agreement with the lidar.

CFH-MLS intercomparison: The efforts to validate and intercompare the data employed for the study are very welcome! The few (6 and 10) MLS profiles selected employing the given criteria and presented in Fig.9 may, however, not be the best to compare to the CFH data since temporal and/or spatial vicinity alone doesn't really help. These single MLS profiles may very closely resemble the air masses probed by the CFHs on some altitudes but have very different origin for others. Therefore a low number of profiles will not be representative even when regarding the std.devs. I wonder if searching for matches for the measured air particles in the CFH profiles with previous or later MLS measurements in a given time window employing the Flexpart trajectories wouldn't do a much better job and provide at least a similar number of satellite measurements with less 'variability'. On a related issue: The stirring provided by the storms generates a quite inhomogeneous atmosphere up into the TTL (Cairo et al. (2008) and references therein). The spot measurement by CFH may by just hitting a fresh tropospheric filament yield humidities much higher than any MLS point ever could, and the other way around. Employing the averaging kernel of MLS on such an in-situ profile in a very inhomogeneous atmosphere will with low probability yield a good comparison even with a good spatial match. This applies also to Fig.12 and the discussion. I think the significance of any features can only be discussed within an at least $3\times\sigma$ uncertainty in mixing ratio differences (or relative difference, Fig. 12). Therefore some of the smaller features presented may be somewhat over interpreted in the lengthy discussions that at the end do not yield a firm conclusion (wherever there are 'mays'. These parts should be severely shortened or even cut out. Also for the intercomparison and discussions the selection of MLS profiles is somewhat intransparent, e.g. for Fig. 12. This procedure should be detailed. For the calculation of the monthly climatological average the proper way would be to exclude all MLS profiles which are probably affected by convection. Low UTLS ozone values could provide an indicator for those (e.g. Paulik and Birner, 2012).

Flexpart simulations: Why are the back trajectory studies for both flights limited to (or just only shown for?) the same two altitude layers? They are not particularly well chosen for either of the flights, e.g. for 25.Jan the 14-15km layer coincides with the crossover of ΔH_2O from moistening to drying in Fig.12. Why isn't a trajectory parcel initiated e.g. for each data point shown in Fig. 12. Then the percentage of trajectories originating from certain altitude regimes in the vicinity or away from the active storm influence regions could be shown. Figs. 10 and 11 present an interesting way of doing a visual analysis but this is extremely hard to relate to the observations. I think at least a proper adjustment of the analysis layers must be done/shown.

l. 696ff: Since the need for accurate and spatially well resolved data on tropical storm events is stressed later in the summary I would like to recommend adding ozone sondes and possibly backscatter sondes to the CFH payloads for future measurements as deployed in e.g. Li et al. (2017). Inclusion of BS sondes would certainly be a major additional cost and weight factor (reagrding that the instruments will be lost) but give very valuable information on the condensed water phase which here can only be approximated from the CALIPSO tracks. However, also regarding the major efforts in flight planning, ozone sondes would offer a very cost effective option yielding really parallel profiles which would help to better identify air mass origins. Here independent ozone profiles from sondes launched on different dates are utilized which is generally a good add-on but can't replace parallel ozone measurements for the interpretation of observed signatures (in absence of other tracer information). E.g. RH shows a very structured profile which is obviously driven by the temperature profile for 25.Jan.2016, however the RH structure on 03.Mar.2017 is not as obvious from the observed temperature (Fig.7). Here an online ozone profile would be extremely valuable to discriminate on air mass origin signatures. The 4.Feb. ozone profile nicely shows the remaining signatures of Corentin in contrast to 18.Jan. but is useless to discuss detailed dynamical features of the H_2O profile.

3 Figures

Fig.1: I think it would be worthwhile to also show the actual flight tracks of the CFH sondes.

Fig.2: This figure is trivial and could be dropped. The explanation given in the text is sufficient. The nested region could still be given by a rectangle in Fig.1.

Figs.3+4: The climatological fields in the top panels of Figures 3 and 4 are not really needed as the respective climatologies for the actual profiles are given and discussed later on. The bottom panels are useful giving insight into the monthly mean situations at UT and TTL levels and could be combined into one figure then.

Fig.5: It might be useful to indicate (shade) the most important signatures/layers and name them to help in the discussion (possibly also in other related figures...). Caption: Is the std. dev. shown 1sigma? Please specify.

Fig 6.: It would be sufficient to show the CALIPSO track only up to 22-23S (this would enable to blow up the figure in the vertical). Please align the vertical axes on left and right panels, possibly also show the CPT as a line on the left panels!

Fig.7: The upper panels do not give essential additional information over the text and the derived temperature differences to the climatology could be integrated into the left panels of Fig.6.

Figs. 10.+11.: See general comment above ...

4 Typos etc.

l.95: ...Frostpoint...

l.242: ... at 215hPa in for ..., remove ”in”

l.282: The lidar smoothes ...

l.303: ...north of Madagascar ...

l.502: ... due to the 0.5x0.5 ...

l.517: ”Figure 10b”, harmonize with the caption (either ”upper right, etc.” or a, ,b, c, d)

l.525: On 23 January ...

l.626: ... on the water vapour mixing ratio at 100hPa ... (slang)

l.634: ... and the ... is less important ... (meaning unclear)

l.650: ... impact of the ...

References

Cairo, F., Buontempo, C., MacKenzie, A. R., Schiller, C., Volk, C. M., Adriani, A., Mitev, V., Matthey, R., Di Donfrancesco, G., Oulanovsky, A., Ravegnani, F., Yushkov, V., Snels, M., Cagnazzo, C., and Stefanutti, L.: Morphology of the tropopause layer and lower stratosphere above a tropical cyclone: a case study on cyclone Davina (1999), Atmos. Chem. Phys., 8, 3411–3426, https://doi.org/10.5194/acp-8-3411-2008, 2008.

Li, D., Vogel, B., Bian, J., Mueller, R., Pan, L. L., Gunther, G., Bai, Z., Li, Q., Zhang, J., Fan, Q., and Voemel, H.: Impact of typhoons on the composition of the upper troposphere within the Asian summer monsoon anticyclone: the SWOP campaign in Lhasa 2013, Atmos. Chem. Phys., 17, 4657–4672, https://doi.org/10.5194/acp-17-4657-2017, 2017.