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Atmospheric Chemistry and Physics Discussions
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Interactive comment on "Balloon-borne measurements of temperature, water vapor, ozone and aerosol backscatter at the southern slopes of the Himalayas during StratoClim 2016-2017" *by* Simone Brunamonti et al.

Anonymous Referee #1

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General Comments

This manuscript presents the data and analyses of balloon-borne measurements from Northern India and on the southern slope of the Tibetan plateau during two Asian summer monsoon (ASM) seasons. The high vertical resolution profiles of temperature, water vapor, ozone, as well as the cirrus clouds and aerosol information are analyzed together to characterize the region's UTLS thermal and dynamical structure, transport characteristics, in particular the transport of water vapor into the stratosphere and the presence of the Asian tropopause aerosol layer (ATAL). This work is part of a larger

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Discussion paper

project involving the airborne campaign StratoClim. The data and the analyses are well documented in the manuscript. The result contributes important new information to the larger picture of ASM UTLS transport. The work is high quality and fits the scope of ACP well. I have a number of suggestions for improving the manuscript, mostly related to presentations and discussions of the results.

Major comments and suggestions:

1) Balloon-borne measurements have their strengths and weaknesses. When making interpretation, it is important to recognize the main weakness that the data is approximately one dimensional while the atmosphere in general is described in 3 (spatial) + 1 (time) dimensions. In this specific study, the location of measurements is uniquely situated in the region of steep elevation change. Associated with the terrain variation, the upper level anticyclone also creates a significant tropopause height variation. How the measurement location is relative to the horizontal structure of the tropopause height, especially the region of the highest tropopause, is very important for the conclusions. This consideration is largely missing in the discussion.

Suggestion: Discuss your results in contrast to the results from previously published work using data from balloon-borne measurements with similar payloads but launched from the Tibetan plateau (Bian et al., 2012). Identify the key differences and their implications to your conclusions in relation to the UTLS structure.

2) When concluding the role of ASM in moistening the stratosphere, it is important to recognize that the time scale changes at the level around the CPT. While the vertical transport up to the CPT is in general within the season, it becomes much slower above. The significant difference between the "confined layer" and the "background stratosphere (FLS)", defined to be above the level $\sim$ 65 hPa, is part of the "tape recorder" structure, i.e. the summer and winter difference. How does the ASM enhance this difference is the relevant question.

Suggestions: For the structure of the water vapor tape recorder, a good recent figure could be the Fig.2 of Glanville and Birner (2017). To estimate how much ASM is more effective in moistening the stratosphere compared to the tropical equatorial entry point in summer, you could possibly use the published result in Bian et al., 2012 (Fig 5) where soundings from Costa Rica (TC4) are used as a contrast to the ASM.

Additional comments:

3) This manuscript is desired to be more concise. For example, it is not clear how section 3 is contributing to the goal of the paper, since the discussion there are not related to particular scientific questions. The points made in that section may be better received when addressing particular questions in the later sections. Also suggest that you work to reduce the repetition of figures.

Suggestions: Be clear on the key objectives of the paper and focus on what serves these objectives. For example, is the comparison of the mean profiles with ECMWF necessary for the objective? Also note that some campaign specifics appeared three times (abstract, intro and campaign description) .

4) When describing the dynamical settings and seasonal changes, it is important to connect to the seasonal change of the ITCZ. See schematic in Lawrence and Lelieveld (2010) and Pan et al 2016 for related discussions. This will put the change from August to November into the right context. It is also more desirable to show the cold point tropopause in ECMWF in addition to PV, since CPT is what you use with the observation.

Specific comments and suggestions:

- References:

P2L13: consider replacing Park 2007 by Hoskins and Rodwell 1995.

P2l23: add Ungermann et al., 2013 before Fadnavis

- Wordings:

P1L22: “It is known to be enriched” -> “It is observed from satellite to contain enhanced”

P1L24: remove “very”

P2L4: reconsider “depletion” – the low ozone is not due to depletion but lofted low ozone air.

P3L11: rephrase “notoriously hardly accessible”

P5L2: rephrase “too high . . .” F. P. temperature and “too high” w.v. mxing ratio. Perhaps “w.v. mr derived by the f. p. t are too high to be physical”?

P14L26-28: A more accurate statement here should be “it is interesting to contrast the result from Pan et al. 2014, where a smaller variability of water vapor is found above the CPT ..."

Comparing the water vapor range of variability in Pan et al. 2014 (figs. 6&7, $\sim$ 3-5 ppmv) with results from this work (DK17 is $\sim$ 3.5-6.5 ppm, and NT16 is similar to the Kunming), the variabilities are qualitatively the same. Not sure where you found the "no variability above CPT" as a common concept.

- Figures:

Fig.2: (a) Consider adding easterly jet, which will show where the sounding location was in relation to the anticyclone. (b) Also consider adding simple dynamical field, GPH or tropopause 100 hPa contour to the maps on the right to indicate the anticyclone and possibly the region of highest tropopause. (c) it may be more insightful to color the trajectories by potential temperature.

Figs. 6-7: there is a strong discontinuity between the two figures when you changed from pressure to altitude. Suggest you consider using pressure altitude when you can label the profiles using both pressure and altitude. This can be consistently done throughout the paper.

Fig. 8. There is an error in the caption: FLS should not be CPT to CPT+5 km. By

definition, FLS is above the TOC. I hope this is only an error in description, not in the actual calculation.

- Additional References:

Glanville, A. A. and Birner, T.: Role of vertical and horizontal mixing in the tape recorder signal near the tropical tropopause, Atmos. Chem. Phys., 17, 4337-4353, https://doi.org/10.5194/acp-17-4337-2017, 2017.

Hoskins, B. J., and M. J. Rodwell (1995), A model of the Asian summer monsoon: IâĂŤThe global scale, J. Atmos. Sci., 52, 1329–1340.

Ungermann, J., Ern, M., Kaufmann, M., Müller, R., Spang, R., Ploeger, F., Vogel, B., and Riese, M.: Observations of PAN and its confinement in the Asian summer monsoon anticyclone in high spatial resolution, Atmos. Chem. Phys., 16, 8389-8403, doi:10.5194/acp-16-8389-2016, 2016.

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