Review of

Observations of Tropical Tropopause Layer clouds from a balloon-borne lidar

by Lesigne et al.

General: This study reports on measurements of cirrus clouds using the new balloon-borne microlidar BeCOOL, operated during three flights onboard superpressure balloons as part of the Strateole-2 measurement campaign. From three collocated measurements of cirrus with different microphysical properties, BeCOOL was compared to CALIOP. The agreement between the instruments was very good and, moreover, BeCOOL was found to be significantly more sensitive to thin cirrus compared to CALIOP. A significant finding of the study is that a comparison of the frequencies of occurrence of cirrus with various optical depths reveals that CALIOP misses ~20% of the cirrus, all within the range of $\tau < 2 \cdot 10^{-3}$. Furthermore, all BeCOOL cirrus observations are statistically analyzed for different cirrus types in different regions and, in addition, TTL cirrus top heights and thicknesses, classified according to optical depth.

This is an excellent and exciting study, presenting new insights in the properties and distribution of high altitude tropical cirrus clouds, based on high quality observations from a new instrument.
The manuscript is well organized, fluently written and the figures are appropriate. It was a pleasure to read and review this article.

I have only a few minor comments, which are listed in the specific comments, that I would recommend to consider before publishing.
There is, however, one point on which the authors might have a second thought. To my feeling, the study sells itself a bit short - this is outlined in more detail in the specific comments to the abstract and title.

Specific comments:

Abstract: - I would include a sentence on the goal of the study after the first sentence,
see ACP guidelines for authors:
https://www.atmospheric-chemistry-and-physics.net/policies/guidelines_for_authors.html

- to my opinion it would be important to mention here that ~20% of the cirrus with $\tau < 2 \cdot 10^{-3}$ (cloud depth < 400m, cloud altitude > ~16km), which are mostly TTL cirrus, are not detected by CALIOP.
Would it be going too far to conclude that cirrus radiative-climate feedback estimates may therefore need to be reconsidered?

You have room to extend the abstrcat, it currently has 176 words and can be up to 250 words-

Title : Based on your exciting findings (and looking into the ACP guidelines for the title), you might think about changing the title, e.g. to something like:

‚Observations of an unexpectedly/surprisingly high portion of Tropical Tropopause Layer clouds from a balloon-borne lidar‘

Line 32ff: For space-borne lidar observations, it might be worth to cite Sourdeval et al. (2018).

Line 36ff: For airborne measurements of cirrus including TTL observations, Krämer et al. (2020) could be added.

Line 56: ‚fiels campaign' → field campaign

Line 71: ‚The clouds' vertical structure can be fully resolved up to an optical depth $\tau_{max} \simeq 3$, … ' Later, in Figure 10, optical depth up to 10 are shown ?

Line 173 ‚for such case' → for such a case

Line 315 ‚… placing almost half of the clouds in the wave phase in which both T' and dT'/dz are negative.'

If I understand it right, these are the conditions of cirrus formation and the other cases represent aged cirrus, where only the longer living cirrus are found, or ? If this is true, it could be mentioned in the discussion of this result in the following paragraph.

Table 3, caption**:** ‚BeCOOL main profile classification, percentages of 10 minutes averaged profiles. Details on this classification can be found in Sect. 2.1.'

References:

Sourdeval, O., Gryspeerdt, E., Krämer, M., Goren, T., Delanoë, J., Afchine, A., Hemmer, F., and Quaas, J.: Ice crystal number concentration estimates from lidar–radar satellite remote sensing – Part 1: Method and evaluation, Atmos. Chem. Phys., 18, 14327–14350, https://doi.org/10.5194/acp-18-14327-2018, 2018.

Krämer, M., Rolf, C., Spelten, N., Afchine, A., Fahey, D., Jensen, E., Khaykin, S., Kuhn, T., Lawson, P., Lykov, A., Pan, L. L., Riese, M., Rollins, A., Stroh, F., Thornberry, T., Wolf, V., Woods, S., Spichtinger, P., Quaas, J., and Sourdeval, O.: A microphysics guide to cirrus – Part 2: Climatologies of clouds and humidity from observations, Atmos. Chem. Phys., 20, 12569–12608, https://doi.org/10.5194/acp-20-12569-2020, 2020.