This paper compares the nighttime observations of mid- and high-level clouds from balloon-borne microlidars BeCOOL obtained from October 2021 to January 2022 near the equator from Indian to Central Pacific Oceans with the observations collected by the space-borne lidar CALIOP. Three collocated (in space and time) case studies are first presented followed by a statistical comparison of the cloud optical and geometrical properties from all observations performed during the campaign with those obtained by CALIOP over the same region during the flight time of the balloons. A last section analyze the link between Tropical Tropopause Layer (TTL) clouds and temperature anomalies provided by GPS-Radio Occultation.

BeCOOL is a system designed for TTL cirrus and convective overshoot monitoring. The study demonstrates the very good agreement between BeCOOL and CALIOP and the superiority of BeCOOL to detect ultrathin clouds, validating its usefulness for the study of TTL cirrus. However, it also suggests that obtaining BeCOOL observations of overshooting convective cloud tops would require steerable balloons as their occurrences are rare and the sampling during such campaign too small.

The article is well-organized, easy to read and clear. The figures perfectly illustrate the main results and are of the highest quality. I would recommend its publication after taking into account the comments below.

My only main concern is that the descriptions of the processing of Level 1 and Level 2 products are not yet available, making the reviewing somewhat difficult as we are not informed by potential bias and errors in the cloud detection and optical properties retrieval methods. It would be great that the authors provide information on the detection method and the optical depth retrieval.

Below is a list of minor comments.

Line 13: “~~T~~tropics”

Lines 81–83: “For the cloud classification, in order to focus on the main part of clouds, top and base altitudes are slightly modified so that 15 % of the cloud optical depth lay above the new top altitude, and 15 % below the new base altitude.” – What is the rationale for doing this? I understand it decreases cloud top altitude and increases cloud base altitude. How this relate with the results from Sect. 4.2 where such manipulation is not performed?

Figs. 2g and 4e: Use “° S” instead of “-°N” for consistency with other plots and text.

Line 143: “along the 570-km track”

Lines 189–191: “Regarding backscattered power, the contrast between the cloud and the surrounding clear sky is higher at 808 than 532 nm (due to the strong wavelength dependency of Rayleigh scattering, emphasized by Peter et al. (2003)). This is why, in addition to a lower absolute noise level, very thin features are more easily detected with BeCOOL.” – In what proportion play the wavelength and the noise?

Line 211: “7.5 m·s^{-1}”

Line 220: “Over the Maritime ~~c~~Continent and during the campaign, about 1 % of the pixels of the BT maps have ~~BT~~values lower than” – Are you considering the collocated 5°×5° BT maps only or the BT maps of the whole Maritime Continent region?

Line 223: “all 17 Strateole-2 campaign balloons” – Please explained here, in the Introduction, or in Sect. 2.1, that this Strateole-2 campaign releases many balloons whose three with a BeCOOL lidar (if this is correct).

Table 3: Mention in the caption this is for BeCOOL observations.

Line 232: “(0.6 %)” – 1 % in Table 3. 0.6 % is for the Mid-level cloud only over Maritime Continent. Keep same decimal notation (at least for value < 1 %) in the Table.

Line 233: “Maritime ~~c~~Continent”

Lines 241–242: “which are detected in 39 % of the profiles over the Maritime Continent” – Table 3: Maritime Continent = 47 %; Indian Ocean = 39 %

Table 4: “Frequency of occurrence of cirrus (cloud base > 10 km) in BeCOOL profiles with different thresholds on optical depth, percentage of 10-minute profiles. Bold font stands for TTL cirrus (cloud base > 14 km).”

Lines 242–243: “The thresholds on optical depth show what would be detected by less sensitive instrument: CALIOP ($\tau > 0.002$), human bare eye (visible cirrus, $\tau > 0.03$), passive radiometers ($\tau > 0.1$).” – It would be interesting to add figures (in Appendix?) of the BeCOOL mask color-coded with those OD thresholds corresponding to Figs. 1, 2b, 3b, and 4b. This would allow to better see the BeCOOL’s enhanced detection capability.

Line 249: “Optical and geometrical properties of mid- and high-level clouds”

Lines 250–251: “for all BeCOOL Level 2 profiles from the 2021 Strateole-2 campaign” – Does it represent more data than the 3 flights shown in previous sections?

Lines 252–253: “All clouds with a reported base altitude below 5 km have been removed from both datasets to focus on free-tropospheric and TTL clouds.” – Why this is not directly a condition for the cloud classification (Sect. 2.1)?

Lines 254–255: “Unlike the previous section, we use here the actual lidar-determined top and base altitude instead of the modified altitudes used for the cloud classification.” – I don’t understand the rationale for this. See comment for Lines 81–83.

Fig. 5b: It shows that 82 % of the lidar profiles show clouds with OD > $2\cdot10^{-3}$. In Table 4, it was 75 %. What explains that the percentage is now higher? I might have understood if the value was lower since you removed mid-level clouds with base below 5 km from datasets (for some reasons I don't understand). Could it be due to the fact you don't use the same definition for cloud top and base altitudes in both sections (for some reasons I don't understand)?

Line 269: "and between 17 and 17.5 km for the base."

Lines 279–282: "For CALIOP, according to Yorks et al. (2011), multiple scattering effects due to the large size of the lidar footprint tend to lower the apparent cloud base altitude, enhancing the apparent geometrical depth of the cloud. This explains the differences between base altitude distributions and geometrical depth, while top altitude distributions show an excellent agreement." – Actually, this effect is mainly due to a non-ideal transient response of the PMTs (Lu et al. 2013, 2020). The effect is more visible in liquid clouds. I suspect the "Geometrically thin (a few hundred meters), horizontally extensive mid-level clouds are often found above, below 10 km, mainly between 5 and 8 km; they typically have large backscatter and are likely pure liquid or mixed-phase clouds." (Lines 68-70), to play a significant role in the geometrical depth difference you observed. Another reason for this effect comes from the difference in horizontal averaging in the detection algorithms. Compare to the detections performed at ~5-km horizontal resolution in the BeCOOL data, the detections performed at 20- and 80-km horizontal resolution in the CALIOP data can introduce a low bias in the cirrus cloud base retrieval when the cloud base altitude fluctuates at smaller scales. This does not affect the cirrus cloud tops very much are they appear flatter at those scales.

- Lu, X., Hu, Y., Liu, Z., Zeng, S., and Trepte, C.: CALIOP receiver transient response study, SPIE Optical Engineering + Applications, San Diego, California, United States, https://doi.org/10.1117/12.2033589, 2013.
- Lu, X., Hu, Y., Vaughan, M., Rodier, S., Trepte, C., Lucker, P., and Omar, A.: New attenuated backscatter profile by removing the CALIOP receiver's transient response, J. Quant. Spectrosc. Radiat. Transfer, 255, 107244, https://doi.org/10.1016/j.jqsrt.2020.107244, 2020.

Line 289: "GPS-RO" – Define here (where first mentioned).

Table 5: Mention in the caption this is for BeCOOL observations.

Line 336: "~~could~~cloud base"

Lines 338–339: "Ultrathin TTL cirrus, with optical depth below the detection threshold of CALIOP ($\tau < 2\cdot10^{-3}$), are reported in 16 % of the lidar profiles" – Is 16 % coming from Table 4? My understanding is that this value corresponds to profiles containing ultrathin TTL cirrus only. In Sect. 4.2, you mentioned that clouds with $\tau < 2\cdot10^{-3}$ appear in 26 % of the profiles, but this is not limited to TTL cirrus. I would guess that the ultrathin TTL cirrus are detected in the lidar profiles with a fraction between 16 % and 26 %.

Fig. A2: "for case study 2"