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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Diurnal cycle of clouds extending above the tropical tropopause observed by spaceborne lidar" *by* Thibaut Dauhut et al.

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We thank Anonymous Referee #2 for his/her comments. In the following we answer each of them. The line numbers refers to the version online since 8 October 2019. Note that we would like to slightly change the title for: "The diurnal cycle of the clouds extending above the tropical tropopause observed by spaceborne lidar". Also, to emphasize our results, a sentence will be added line 236: "These results highlight how much the evolution of stratospheric clouds can be undersampled by other spatial instruments restricted to 01:30 and 13:30 LT, that then miss for instance the first maximum and the deepest development of stratospheric clouds in the early night."

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Referee #2: General Impressions: This study uses the CATS lidar to estimate the stratospheric cloud fraction over tropics. The spatial distribution and the diurnal cycle of the stratospheric cloud fraction are analyzed and documented. The study also discusses the regional and seasonal differences of the stratospheric cloud fraction. The similarities and differences between their results and previous results are discussed as well. As this paper pointed out, it is a rare opportunity to study diurnal cycle of thin clouds based on the vertical cloud profiles. Therefore, I am overall supportive of the study. However, I feel the current manuscript needs a bit more detail (see some suggestions below).

Author Comment: Indeed the CATS observations provide us an unprecedented opportunity to study the diurnal cycle of the clouds above the tropopause. In the proposed changes, we will add several new paragraphs about: the diurnal cycle of high-altitude cirrus by ground-based lidar, the comparison between our results and ground-based lidar observations, the link between the diurnal cycle of very deep convection and stratosphere cloud faction (see Authors' changes in Manuscript in the response to Referee Comment 2 from Referee #1).

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Referee #2: Specific Suggestions: Figure 3: Comparisons between DJF and JJA are hard to interpret because the locations are differently selected by different seasons. Are the differences we see here due to the seasonal differences or due to the regional differences?

Authors' response: The objective is not to compare DJF and JJA but to characterise the cloud fraction in the stratosphere where and when they are the most present, as illustrated in Figure 1. So the differences are firstly due to regional differences. To be more explicit, the lines 196-198 are changed for the text below.

Authors' changes in manuscript: "To characterise the diurnal cycle of the cloud extent in the stratosphere, the cloud fraction is represented in terms of height above the

tropopause and local time (Fig. 3) over the tropical regions where the cloud fraction is the largest (Sect. 3.1). Each tropical region is considered either in DJF or in JJA to match the season when the stratospheric clouds are the most frequent (Fig. 1)."

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Referee #2: The paper concluded that the most of the findings are consistent with previous studies based on satellite observations, which means that the most of the findings are already known. I understand the uniqueness of this study is to use lidar instruments to understand the cloud fraction. However, the whole story feels a bit thin. Maybe compare the results with in-situ measurements to add more insight?

Authors' response: Thank you for the suggestion. However, most of our findings concern the diurnal cycle of the clouds in the stratosphere, which is not already known but unique and unprecedented. We will add some comparison with the ground based observations of the high-altitude cloud diurnal cycle, even though theses observations suffer from little spatial coverage and high lidar attenuation by convective clouds in troposphere (see Authors' Response to Referee #1).

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Referee #2: Also, more references are needed. For example, it would be nice to have some reference of in-situ measurements (line 23 to 24) and of decreasing low-stratospheric humidity (line 41-43).

Authors' response: Following Referee #2 recommendations, we added the following references: (we got these recommendations during the initial round of review, so the changes are already present in the version of the manuscript posted for interactive discussion)

- for in-situ measurements, l.24: Thomas et al., 2002; Jensen et al., 2013; Frey et al., 2014

- for decreasing low-stratosphere humidity, l.46: Jensen et al., 2013.

Thomas, A., Borrmann, S., Kiemle, C., Cairo, F., Volk, M., Beuermann, J., Lepuchov, B., Santacesaria, V., Matthey, R., Rudakov, V., Yushkov, V., MacKenzie, A. R., and Stefanutti, L.: In situ measurements of background aerosol and subvisible cirrus in the tropical tropopause region, J. Geophys. Res., 107, 4763, doi:10.1029/2001JD001385, 2002.

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