

## Response to Reviewer 2

We thank Reviewer 2 for the careful assessment of the manuscript and valuable suggestions.

Please note that, in the reviewed manuscript, the data have been reprocessed to take into account the remarks made by the Reviewer 1. For the sake of completeness, I report here an extract of my response to Reviewer 1. Please refer to that for further explanation on the impact of the reprocessing on the data:

The main changes have been:

- i. The data are now averaged over 10 minutes instead of 5 (line 253 now changed to "... data are from 10 min averages...")
- ii. The BR threshold value to detect cirrus clouds (above 10 km) clouds has been increased from 1.15 to 1.2; moreover, an additional threshold on the SNR has been used, so that a cirrus cloud is now identified as (line 254 now changed: "... a cloud is defined as an altitude interval not thinner than 150 m where the condition  $BR > 1.2$ , and SNR lower than 0.5 on the parallel channel is continuously met.")

This reprocessing has brought some changes in the overall results of the study:

1. The number of data points with particle depolarization below 10% has been greatly reduced, and are now basically restricted to a layer between 16 and 17 km.
2. The number of clouds with very low optical thickness is reduced.
3. The LR values greater than 29, previously reported mainly at high altitudes and low temperatures, which were associated with low depolarization and low values of optical thicknesses, are no longer massively apparent.

Figure 6 has been deleted from the main text and moved to the Supplementary Material (now fig. S1), and the text from line 260 to the end of the paragraph 3.2 has been changed as follows: "The vertical distribution of backscattering inside the cloud was investigated (see fig. S1 in Supplementary Material for further details). In many cases, the lower and upper parts of the cirrus appear to produce the same scattering effect for small to medium values of tau, indicative of an even distribution of backscatter inside, which we may take as a proxy for the distribution of IWC. Conversely, the thickest clouds tend to have lower backscatter in their bottom part with respect to the top part, with few exceptions for the highest ones; this is arguably due to mass redistribution by sedimentation."

Please note that to meet the suggestion of Reviewer 1, paragraphs 3.2 and 3.3 are now merged.

According to the reviewer's suggestion, figs 9, 10, and 11 have also been deleted from the main text and moved to the Supplementary Material (now figs S2, S3, S4). As a result, the discussion from line 281 to 294 has been changed to: "The analysis of the LR obtained with the Young procedure shows that in the majority of cases LR is distributed between 20 and 40 sr, with a peak around 30 sr and without showing particular dependencies on the mean depolarization, temperature or optical thickness of the cloud (see figs. S2, S3 and S4 in Supplementary material)."

Similarly from line 348 onward there is no reference to LR and now it reads: "It is worthwhile noting that the high level SVC with low optical thickness and depolarization have the highest potential temperature difference along..."

Following the Reviewer's suggestion, all arguments using LR as support have been removed from the manuscript. In particular, in previous line 349, 359, 372, 381,

Paragraph 5. "Discussion" has been deeply restructured and expanded (please refer to the revised manuscript), with the intention of placing the work in the more general context of studies on tropical

clouds and their seasonality. Additional references to satellite studies have been quoted, namely Massie et al., 2010; Sassen et al., 2008; Sassen et al, 2009; Nazaryan et al., 2008; Virts and Wallace, 2010; Virts and Wallace , 2014; Zou et al., 2020; Luo and Rossow 2004, Wang et al., 2020; Sunilkumar et al., 2005. Every consideration on the LR have been eliminated.

Supplementary Material has been deeply reshaped and reduced as suggested, now hosting only the previous figures 6,9,10,11, now removed from the manuscript. The study on the dependence of optical parameters on the backtrajectory analysis has now been summarized in the manuscript.

Detailed suggestions:

Line 13: acronym explained.

Line 83-84: modified as: "Kremser et al. (2009), by following Lagrangian trajectories from the Troposphere until their entering the Stratosphere, have demonstrated that..."

Line 122: corrected.

Line 166: corrected.

Line 176: optical Thickness  $\tau$  defined for the first time in line 29.

Line 209: corrected.

Line 224: A reference to the data source has been added in the text (line 223-225 now reads: " ... two empirical orthogonal function RMM1 and RMM2 [...]. RMM1 and RMM2 data are from the Australian Bureau of Meteorology website <http://www.bom.gov.au/climate/mjo/>") and in the figure caption.

Line 254: corrected.

Line 298: corrected.

Line 377: corrected.

The fonts of all figures have been enlarged.

Fig 3 caption has been corrected, as well as old figure 6, now in the Supplementary Material as fig S1.