Dear Reviewer and Editor,

here below our answers to your comments (reported for your convenience) are presented as a one-to-one reply and highlighted in yellow. We would like to warmly thank the Reviewer for the revision of our work and in particular the detailed analysis of the spectral radiance signal.

Please note that a new version of the Article accounting for the Reviewers comments, is also attached as a reply in the discussion section.

This paper presents a comprehensive analysis of four years of far-infrared and mid- infrared spectral measurements of downwelling radiation at the Dome C site in Antarctica. Nearly 88,000 spectra comprise the database. These spectra are analyzed with a machine learning code to identify scenes as clear or comprised of ice-phase or mixed-phase clouds. The method of training the machine learning algorithm using coincident lidar data is described.

The infrared spectral observations are automated and are taken throughout the year. Analyses of the occurrence of the different scene types are presented in various ways (by year, by time of year (season)). Comparisons against observations of cloud type made by satellites are also presented. The paper also presents an analysis of the occurrence of cloud type against the meteorological conditions.

The paper is very exhaustive in its analyses and I would recommend publication after these minor comments are addressed.

Line 101 – are the effects of the air in the 1.5 m chimney significant at any wavelength? My team found it necessary to account for the "chimney effect" in analysis of our ground- based, uplooking data. See https://doi.org/10.1016/j.jqsrt.2015.10.017 and http://dx.doi.org/10.1016/j.jqsrt.2017.04.028

We are aware of the "chimney effect" on localized spectral intervals characterized by large gaseous optical depths and short photon paths: such as the CO_2 Q-branch and the water vapor most absorbing lines associated to rotational transitions in the FIR, typically below 400 cm-1 for the considered atmospheric conditions. This effect is related to the calibration process as explained in the replies to the next 2 comments regarding figure 2 and 5. In previous research, such as in Rizzi et al 2016 (See Section 4 and 5 in this regard.), we have applied corrections to chimney effect since the goal was the study of the radiance signal along the REFIR-PAD spectrum. Also, the effect is considered when we retrieve the atmospheric profiles and cloud properties as in Di Natale et al. (2020).

In the present research, we don't use the spectral interval from 620-670 cm-1 (a note is added to the text) and the CIC optimization selects the 380-1000 cm^{-1} band (again with the exclusion of the 620-670 cm-1) as the reference interval for the classification. Thus, the chimney effect does not interfere with the classification analysis.

Di Natale, G.; Bianchini, G.; Del Guasta, M.; Ridolfi, M.; Maestri, T.; Cossich, W.; Magurno, D.; Palchetti, L. Characterization of the Far Infrared Properties and Radiative Forcing of Antarctic Ice and Water Clouds Exploiting the Spectrometer-LiDAR Synergy. *Remote Sens.* 2020, *12 (21)*, 3574. https://doi.org/10.3390/rs12213574

Rizzi, R., C. Arosio, T. Maestri, L. Palchetti, G. Bianchini, and M. Del Guasta (2016), One year of downwelling spectral radiance measurements from 100 to 1400 cm^{-1} at Dome Concordia: Results in clear conditions, J. Geophys. Res. Atmos., 121, 10,937–10,953, http://dx.doi.org/10.1002/2016JD025341

Line 116 – what is meant by (1928)?

Rephrased: "A subset of REFIR-PAD data, comprising 1928 spectra, is co-located with LiDAR measurements."

Figure 2 – The 150 K brightness temperature in the red (clear sky) curve is interesting. This is at the very core of the 15-um band, the strongest part of the band, so the line should be saturated almost immediately within the atmosphere, and thus, 150 K appears to be too small. Is there a suspected reason for this anomalous feature? Or is it perhaps a microwindow saturating in the polar summer mesosphere where the temperatures can be well below 150 K? These are January (summer) spectra, so the polar mesosphere is quite cold at that time.

Actually, the brightness temperature peak at 15-um is a calibration artefact due to the noise amplification (due to calibration process) present at this wavenumber caused by the strong air absorption inside the interferometric path. Since the noise is not shown in the figure, for a better clarity, we will remove this spectral point in the revised figure. The noise figures of REFIR-PAD measured in the Antarctic campaign are reported in https://doi.org/10.5194/amt-12-619-2019. As said, the band 620-670 cm^{-1} is excluded by the CIC identification process which relies only on brightness temperatures spanning over the 380-620 and 670-1000 cm^{-1} bands. This is clarified in the new version of the paper.

Figure 5 – Similarly, the 300 K brightness temperature seem a bit high for such a saturated part of the spectrum. In the summer season the polar stratopause temperature can approach 300 K, but in the winter season this seems too warm. In addition, the brightness temperatures near 1300 cm-1 and the standard deviations approaching 350 K are non-physical. To what extent does the cloud classification system (CIC) depend on these regions of the spectrum in which the brightness temps appear to be incorrect?

As for the 150 K peak at 15-um (667 cm^{-1}), these features are due to the noise amplification caused by the low efficiency of the interferomenter due to strong absorption present inside the interferometer at specific wavenumbers. Below 300 cm^{-1} they are caused by H_2O, at 667 cm^{-1} by CO^2 and around 1100 and 1270 cm^{-1} by the absorption of the Mylar beam-splitter. Note that also these spectral intervals are not accounted for in the CIC analysis.

Figures 8 and 11. The legends in these figures are difficult to read as the font is very small. I am looking at the figures on my computer screen that projects each manuscript page at full size. The labeling of the axes of these figures is also difficult to read. Please re- plot these figures with larger axis labels and please use a larger font on the figure legends.

The Figures are generated again using larger font sizes for the axes labels and legends.