

Interactive comment on “Mid-latitude cirrus classification at Rome Tor Vergata through a multi-channel Raman–Mie–Rayleigh lidar” by D. Dionisi et al.

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Major:

#1 - In Figure 3, the boundaries have been drawn following the results of HCM. The figure has been updated adding violet diamonds that represent the barycenter of each cluster (see the revised discussion paper). In HCM the number of clusters is, effectively, supplied a priori. For this reasons several tests were performed with different numbers of cluster and the final number of classes is selected choosing the most significant discriminative partition regarding the dendrogram of HCM (i.e. the level where there

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is a significant change of the aggregation index, based on the intra-classes variance using the Ward distance metric). Data was plotted in function of the two uncorrelated variables that describe the 87.21 % of the cirrus characteristics. Discriminant factor analysis is applied after HCM. A more detailed description of the method has been added in section 2.3 (see the revised discussion paper).

#2 - The statistics are derived from 532 and 387 nm data (elastic channel at 355 nm has been implemented only in 2012). This has been specified at the beginning of section 2.2: 'Using lidar data from the elastic channel at 532 nm (30-cm telescope) and the Nitrogen Raman upper channel at 387 (nine 50-cm telescopes)...'

#3 - This is correct. The lidar system does not have a depolarization capability and to screen out water clouds, the only step taken was thresholding data by temperature. In particular this uncertainty could affect class I and a small fraction of class IIb (the two classes where the cirrus could have a mid-height temperature between -25C and -40C). New text has been added in section 3.2.1 to mention this aspect: 'Since also supercooled water clouds could form between -25 and -40 °C, it is not possible, at this stage, to resolve the ambiguity about this class and its origin.'

#4 - Figure 4 has been modified to take into account the contribution of the lidar ratio errors (ΔLR) to the variability of LR distributions. This figure depicts the frequency distribution functions of LR calculated for the four classes fitted with Gaussian functions with the expected value μ equal to the mean of LR and the variance σ^2 equal to the square of the root mean square of ΔLR . The comparison between the spread of the LR distributions and of the superimposed Gaussian functions confirms that the distribution variability of LR is essentially due to lidar random noise, in particular for class I. New text has been added in section 3.2.1: 'To take into account the variability introduced by ΔL_{Reff} , these distributions are fitted with Gaussian functions (black curves in Figure 4) with the expected value μ equal to the mean of L_{Reff} and the variance σ^2 equal to the square of the RMS of ΔL_{Reff} . Classes IIa, IIb and III have the distribution centered between 20 and 40 sr (76%, 74% and 73% of the L_{Reff} are included

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in this range, respectively), with the latter differing from the two former classes for a less peaked shape. This characteristic is stressed in the class I that presents a more flattened shape. The comparison between the spread of the LReff distributions and of the superimposed Gaussian functions highlights that the distribution variability of LReff is due to lidar random noise. In particular, this effect is more visible for cirrus class I, which is characterized by larger errors (smaller values of τ_{Rm} , and then of LReff, are more affected to the signal fluctuations due to the statistical error noise than larger values of τ_{Rm}).

#5 -As mentioned at the beginning of section 3.2.1, the selection of cirrus with $\Delta\tau/\tau \leq 30\%$ allowed discarding cases with unlikely values of lidar ratio and limiting the effects of the signal noise error. This is confirmed by the fact that, for each class, mean values of LR are very similar to median values, However we agree with the reviewer: supercooled water clouds (see reply to comment #3), non-linear effects of signal noise, oriented plates and multiple scattering effects (see reply to comment #6) could have a significant impact on the trend in lidar ratio with temperature, in particular if this trend is weak. Thus, in section 3.2.1, new text has been added to the interpretation of the Figure 5: 'Similarly, we cannot exclude that low values of LReff ($\hat{\Delta}L_{ij}10$) in the lower left panel of Figure 5 could be due to the presence of oriented plates.' New text has also been added for Figure 6: 'However the amplitude of the standard deviation of the frequency distribution of LReff weighted means (black vertical lines in the second column of Figure 6) reduce the statistical significance of the retrieved results and do not permit to deduce any evident trends for these cirrus classes.'

#6 - We agree with the reviewer: multiple scattering effects due to the employment of two different channel, the elastic channel and the Raman upper channel (the Raman lower channel was used for less than 5% of the analyzed cases), could affect the variability of the lidar ratio, especially in case of weak trends. Although this aspect is already mentioned in section 4, new text has been added at the end of the new section 3.2.1, where the Figures 5 and 6 are discussed: 'Furthermore, MS could also affect the

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LReff trends. In fact, although these effects have been considered using a single value correction (see section 2.2), the employment of two different lidar channels (with different fields of view and wavelengths) to retrieve LReff could introduce another source of uncertainty on the LReff variability.' This effect, together with the other sources of uncertainty, is also discussed in the abstract and in the conclusions (please see the revised discussion paper).

Minor comments:

#1 - Corrected.

#2 - Corrected.

#3 - Corrected.

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