Responses to the comments from Anyonymous Referee 3
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The original text from the Anonymous Referee is presented in colour grey and our responses in black. At the end there is a section specifying the changes to the manuscript after reading and answering each comment.

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Response to comments from Anonymous Referee #3

The paper, "Ice water path retrievals from Meteosat-9 using quantile regression neural networks," develops a new approach toward estimating cloud ice water path during any time of the day using a machine learning method. The technique is trained with matched SEVIRI pixels and DARDAR profiles using a quantile regression neural network that permits an estimate of the uncertainty for each retrieval. Two versions are applied, a single pixel method (MLP) and a single pixel plus surrounding pixel data, a convolutional neural net (CNN). The latter was found to be superior to the former in that the average uncertainty was reduced, although the CNN tends to "smear" the IWP signal across neighboring pixels. Three input datasets were tested: VISIR (daytime) using all but one SEVIRI channel, an infrared (IR) only method using all non-solar SEVIRI channel, and a subset IR case using only two channels to simulate an historical Meteosat imager. All were trained using DARDAR data and their results were compared to DARDAR data taken within the same time frame as the training set. The VISIR performed best, but is limited to daytime and would require training for various solar angles that are not available for the DARDAR. The IR input produced quite acceptable results that are consistent in relative terms with the daytime portions of diurnal cycles of IWP determined from other passive sensor methods. The IR subset input shows less skill but provides information that is not obtainable with more physically based retrievals. This approach shows promise for improving the estimation of IWP at all times of day.

We thank the referee for the nice summary of the paper, as well as for the comments and suggestions below.

I recommend publication with a few revisions.

1. It would help in section 2.3 to use the same terminology in the text and Figure 1 description of the collocation. "Cell" is only mentioned in the caption, not in the text. SEVIRI "pixel" is used in the text. Also, the caption should note the units used for lat and lon, as degree is the usual unit. Is it correct to assume that the SEVIRI pixels used for given image were at least 16 km apart?

   The assumption is not correct. We believe this question comes from confusing the limits of the abscissa in the plot with the size of a SEVIRI pixel in the projection used, delimited by the green lines. We are replacing "cell" with "pixel" in Figure 1, as suggested. This should reduce the risk of assuming that pixels are at least 16 km apart. We will also indicate in the Figure 1 caption that the units for the coordinates are kilometres.

2. The units of the statistical parameters in Figure 5 and 7 are given in kg m-3. That is good. But, the mean DARDAR value should be noted for each plot, or the values given in percent of the mean DARDAR value in the text.

   We are adding in the captions of Figure 5 and 7 the DARDAR mean of the observations in the test set.

3. Line 280: By stating that "CLAAS has been thoroughly validated" suggests that the CLAAS IWP values agreed well with actual IWP measurements. The cited studies showed that CLAAS agreed well with similar passive remote sensing techniques, but not particularly well with DARDAR, the "ground truth" used here. For the most part, the CLAAS values are significantly lower than their DARDAR counterparts, as indicated later in the discussion. As the results shown in the citations vary, and none arise from an actual comparison with any in situ data, "thoroughly validated" is a bit of an overstatement. I would suggest rewriting this line, so that it is no surprise to find the CLAAS mean running below that from the CNN in Fig. 9.

Thank you for this remark. Our original intention with the expression "CLAAS has been thoroughly validated" is to show that this dataset has works that compared IWP retrievals in the CLAAS dataset with other sources. We are updating the paragraph that starts that line to avoid this surprise, as well as removing "thoroughly validated" in the abstract, for consistency.

4. Figure 10. This plot is difficult to examine closely. I think it would be easier to compare the two methods by putting them on the same graph with the two scales, and maybe only using 4 months instead of all twelve, just to illustrate the relative consistency.

We assume the referee meant Figure 11 instead of 10. We have prepared Figure RC3.1 to replace Figure 11, and we are updating the text accordingly. Note that the choice of dashed and solid lines for the CLAAS dataset and CNN retrievals, respectively, and the colour choice for each month is only for the best clarity in the plot. For the curious reader, we are also including the current Figure 10 in supplementary material.
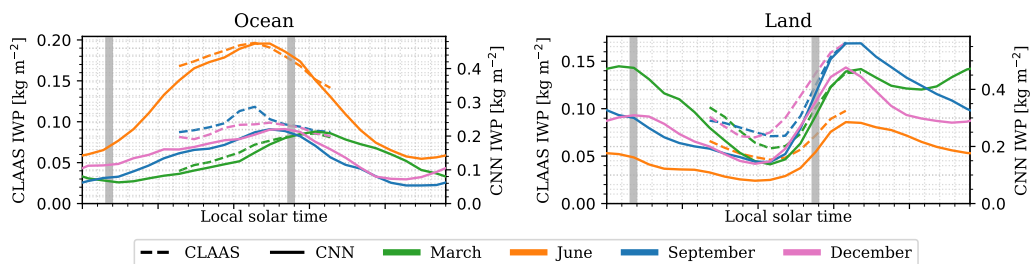

Figure RC3.1: Diurnal cycles for four arbitrary months in 2012. Note the different vertical ranges. The default matplotlib (Python library for plotting) method for determining the vertical limits was used. This Figure will replace Fig 10.

5. Mean mass height (Zm) and mean mass size (Dm) are derived with somewhat mixed results. It would be helpful if the authors could remind us of the importance of these parameters.

Ice water path (IWP) is an integrated value of the ice water content (IWC), but neither can we have any information about at what height IWC is located nor about the size of the ice crystals constituting the IWC. Estimating Z_m and D_m gives some information about these two problems and, therefore, can help to characterize better atmospheric ice. We are adding to the paper that these parameters help characterize better atmospheric ice.

Manuscript changes after the comments from Anonymous Referee #3

- Figure 1: "pixel" replaces "cell", and coordinate units remarked in the caption.

- Added mean of DARDAR IWP in the test set in Figs. 5 and 7. Also, added "daytime" to "test data" in Fig. 5, to clearly indicate that no nighttime observations were used there.

- Replaced the expression "CLAAS has been thoroughly validated" with "CLAAS IWP has been analyzed against DARDAR and compared with MODIS retrievals", and removed "thoroughly validated" from the abstract sentence "[in CLAAS], a thoroughly validated dataset based on a traditional approach.".

- Fig. RC3.1 replaces Fig 11, and Fig. 11 is moved to supplementary material. Text and captions adapted to match that four months are presented in the main text.

- Motivated the the importance of Z_m and D_m in the beginning of section 4.3, before presenting their retrieval results.