Response to referee #2

General Comments: The authors present an original method to retrieve cloud and drizzle vertical profiles. Although they focus on marine boundary-layer clouds, their technique is in general very valuable to characterize drizzle in low-level clouds. Thus, I find the paper suitable for publication in AMT. However, I have some concerns with the methodology as described in the text and summarized in Figure 1. The details of the method are sometimes confusing and not clear. Please see the list of specific comments.

- Thank you for your comments.

Specific comments: 1. In order to decide if a profile includes drizzle or not, a threshold of -17 dBZ is used (p6 l29-p7 l1) If a cloud has been identified as drizzling, it is further checked in which height exactly drizzle has to be retrieved: first cloud and drizzle boundary heights are identified. However, drizzle is not retrieved, "where the observed radar reflectivity is less than or equal to Zc." I have some problems here: Zc has not been introduced yet (first explained in l20 ff). Do you mean the threshold of -17 dBZ here? Or Z related to cloud droplets only? But then how do you know, if also drizzle is present and the measured Z is a sum of both, Zc and Zd?

- We agree the wording is slightly confusing here. We have changed p6 ln20 to say 'the forward modelled drizzle reflectivity is set to zero when the forward modelled cloud reflectivity is greater than the observed reflectivity, thus forcing no drizzle to be retrieved'. Hopefully this is also clearer in the updated figure 1 (see response to question 3).

2. p 9, l 8 ff: Can you explain in more detail how the gradient is calculated?

- The gradient is simply the gradient between the fourth last gate below cloud base and the last gate below cloud base.

3. Figure 1: a) What is Z_cb? Z at cloud base? I supposed that you check each cloudy bin for drizzle using the threshold of -17 dBZ.

- We have updated the figure, the drizzle threshold is determined where the maximum observed radar reflectivity in the column exceeds –17 dBZ.

3b) Why is y=Z_d in constrained mode above cloud base? And how do you know Z_c? (see comment 1) Anyhow, I have problems with this notation: cloud radar only provides Z and it does not distinguish between Z_c and Z_d. So y = Z, always. I am not sure if I got it right but I try to summarize: Depending on the presence of drizzle the forward model for Z changes: relaxed mode (cloud droplets only): Z=Z(Z_c)=Z(N_c,W_c) constrained mode (below cloud base, drizzle drops only): Z=Z(Z_d)=Z(N_W,r_0,ν) constrained mode (above drizzle top, cloud droplets only): Z=Z(Z_c)=Z(N_c,W_c) constrained mode (between cloud base and drizzle top, cloud droplets and drizzle drops): Z=Z(Z_c,Z_d)=Z(N_c,W_c,Z_obs) So in this case Z does not depend on N_W, and r_0,ν at all because Z_d is described as max(0,Z_obs-Z_c)? It would be helpful to include such kind of overview of the forward models in this flowchart.

- We have updated Figure 1 so that it now includes all the forward models. Specifically we have clarified that if the forward modelled cloud radar reflectivity exceeds the observed radar reflectivity, the forward modelled drizzle reflectivity is set to zero and no drizzle is retrieved (Nw is set to zero)

3c) I have assumed that the shortwave zenith radiances are part of the observation vector. However, they are not part of y in Figure 1. It is not clear to me how exactly they are used in the retrieval framework.

- The radiances are part of the observation vector, figure 1 now reflects this.

3d) Since you are using "relaxed mode" and "constrained mode" in the text, I would also include these terms in the figure.

- The two modes are now included in figure 1.

4) p 12, l15 ff: Can you explain in more detail how the initial ensemble is generated (which values)? Shouldn't you here also refer to Table 1?

- Yes, thanks for the suggestion, we have updated the text to refer to Table 1. The values used to generate the initial ensemble are those given in Table 1.

5) Can you also include one or two sentences on how the convergence criterion is defined? Do all ensemble members always converge? If not, what is the percentage of converged members?

- We have added 'The convergence criterion is set such that the difference between the ensemble mean of the forward modelled observations and the observations is less than the observation uncertainty' on pg 12, ln 22-23. The number of converged ensemble members will depend on the uncertainty of the solution, but generally all ensemble members will converge or be close to convergence when the stopping criterion is met.

6) Figure 6 and Figure 10: Do the error bars represent the variability of cloud properties within the column (since column-averaged values are shown). Or are they the retrieved uncertainty based on the spread of the converged ensemble members? If the latter is the case, then I don't understand p18, l 5: "As the retrieval uncertainty for drizzle within cloud is comparable to the uncertainty for drizzle below cloud base,...": The error bars for drizzle above cloud base are much larger and thus the retrieval uncertainty.

- Yes, we agree this was not clear. The sentence is meant to refer to retrieval errors – i.e. the bias and rmse, not the uncertainty. The manuscript has therefore been updated to 'As the retrieval errors for the drizzle within cloud are comparable to the errors for the drizzle below cloud base…'

Technical corrections 1) p.5, l7: underlying 2) Figure 1: please set vectors in bold, e.g. Wc (that should be a profile, right?)

- Changed.