# Response to referee and editor

The impact of mesh size and microphysics scheme on the representation of mid-level clouds in the ICON model in hilly and complex terrain

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Dear editor and referee,

We would like to thank the editor and the referee for their careful evaluation of the revised manuscript. We address the raised points below.

Best regards, Nadja Omanovic, Brigitta Goger, and Ulrike Lohmann

## Response to referee

### Comments to the Author

> The authors addressed my comments with great care, and their additional explanations provided important insights. Thank you! I only have two minor comments left below.

Thank you for carefully re-reading our revised manuscript.

### Minor comments

> Tabs. 3 and 4: Could the authors comment on the assumed 'cloud mask' they used to determine the LWC, IWC, LWP, and IWP? Since most modeled mean values are substantially smaller than the observed values, it might be the case that more almost non-cloudy columns are considered in the calculation of the modeled mean values. Since the LWC also strongly depends on the height above the cloud base, I wonder at which height level the LWC is determined. Lastly, I suggest showing histograms of LWC, IWC, LWP, and IWP.

Thank you for your question. Double-checking our analysis lead to the finding of a missing mask in the analysis of the simulated water contents and paths. We applied now a mask of LWC / IWC $> 0.01\,\mathrm{g\,m^{-3}}$ (as we have done already for the observations). We included now that the values are based on a mask in the table captions as well as in the methods part (line 189): *"For comparing the cloud characteristics, we apply a threshold value of 0.01 g m$^{-3}$ for liquid and ice water content to the observations and simulations to only consider in-cloud values."*. With the mask, we obtain a better agreement between the observed and simulated values. We adapted the discussion as well to account for that. LWC and IWC are calculated for the entire cloud not at a specific height, we also clarified that in the table captions.

Thank you for suggesting to add histograms of the water quantities. We created a summary figure (now Fig. 14) depicting the histograms and included it in the discussion as it provides a great summary of the differing performances of the model setups.

> Fig. 5: Since the two-moment microphysics predict very low droplet concentrations, I wonder if autoconversion/accretion are affecting these simulations. Those processes should be absent in the one-moment microphysics simulations.

Autoconversion/ accretion are present both in 1M and 2M. The 1M takes the prescribed cloud droplet number concentration (or diagnosed ice crystal number concentration), and calculates the collection kernels. In 2M, this is done more realistically, because of the prognostic cloud droplet and ice crystal number concentration. In 1M, the autoconversion rate should be small given the low simulated LWC and higher cloud droplet number concentration,

hence the cloud droplet sizes are so small that autoconversion is not efficient. For 2M we have low cloud droplet number concentrations and low LWC, hence also here the autoconversion rate is small. We added the following text to the discussion for Fig. 5 (line 249): *"In both schemes, the collision and coalescence of cloud droplets (i.e., autoconversion) may be low. In 1M the high CDNC and low LWC lead to small cloud droplets limiting collisions and in 2M low CDNC and low LWC also yield small autoconversion rates."*.

# Response to editor

## Comments to the Author

My further request is to add units of LWP/IWP to the Figures 3 and 7 (or captions). Please also double check the observed LWC of 2.40 and LWP of 0.17 in Table 3, one of which looks like a mistake.

Thank you for spotting the missing units. We added them in the figure caption.

The liquid water path measurements are based on the microwave radiometer, while the observed liquid water content is based on the Cloudnet algorithm, that cominbes several instruments and model data to classify clouds. In this case, there are only a few areas in the cloud, that the algorithm classifies as liquid, hence the LWCs are very high. We added the following text in the manuscript (line 236): *"In Table 3, the observed LWP is smaller than the observed LWC. The LWP measurements are based on a microwave radiometer. The LWC is based on the Cloudnet algorithm, which combines several instruments and model data to classify the cloud. In this case, the areas for a liquid cloud occur only sporadically, leading to a very high LWC given the measured LWP. Hence, the interpretation of the LWC should be done with care."*.