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Interactive comment on "The vertical Structure and spatial Variability of lower tropospheric Water Vapor and Clouds in the Trades" *by* Ann Kristin Naumann and Christoph Kiemle

Anonymous Referee #1

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GENERAL COMMENTS

- Despite its importance many questions on water vapor characteristics are still poorly understood. The paper uses unique water vapor profile measurements from two campaigns in the North Atlantic trades to investigates how well numerical simulations at different resolution capture the water vapor variability and its subsequent impact on cloudiness. This topic as well as the evaluation metrics used to investigate the problem are interesting and innovative making the paper well suited for ACP.

- Water vapor variability includes both spatial and temporal changes acting on different scales. The paper does not explicitly discuss the scale of variability addressed by its

observations and the models and whether the same scales are captured. However, this is important as variability itself depends on the considered as shown by Steinke et al. (2015, www.atmos-chem-phys.net/15/2675/2015/, their fig. 4) for a convective boundary layer with ICON. Due to the nature of the airborne measurements it is not possible to disentangle spatial and temporal variations from the observations but this could be done in the model world. In fact in the observations I suspect that there will be more correlation as in the model as spatially neighbouring profiles are correlated while model profiles are randomly distributed. Maybe this issue can be assessed by checking different approaches to select the model data, e.g. along straight lines resembling flight paths?

- The water variability assessed by the paper (with 2.5 km grid size for ICON-SRM) is not on the same scale as the shallow clouds which have typically much shorter dimensions. There should be some information on cloud dimensions available from lidar or other measurements. The issue needs to be discussed and might be addressed in a follow-up analysis taking also cloud length into account which could be derived from backscatter lidar.

- When trying to connect water vapor and clouds it is also interesting to look at the water budget. Water vapor mixing ratio qv might not differ much for the max and min scenarios but this difference is likely in the order of the liquid water vapor mixing ratio qc. Therefore checking how this difference translates in the end to cloud fraction might give new insights as also the microwave radiometer should be able to provide LWP simultaneously with WVP. This analysis could support the conclusion that water vapor variability not necessarily needs to relate to an adequate representation of clouds as these live at the tail of the water vapor distribution. In this respect it is interesting to know how strong temperature variability is? Would it be possible to look at relative humidity?

- Being old fashion and looking at a printout several figures are very difficult to read and I make several suggestions for improvements in the technical section

SPECIFIC COMMENTS

L7 please avoid the term "humidity inversion" as this would point at the classic polar phenomena of increasing moisture with altitude which is not what you mean. Also in line 94 this should be rephrased to make clear that you talk about the temperature inversion.

L8 "but is less pronounced" than what?

L28 "with the decrease in subsaturation in the column" Is this true for all seasons. If you compare the different degrees of saturation in the free troposphere during the wet and dry season?

L27 "profiling moisture, aerosol, and clouds simultaneously with high accuracy and spatial resolution" is a bit overselling as there are limitations set by the strong lidar attenuation by clouds

L115 For LCL it would be good to say how good the lidar approach is compared to drop sonde profiles?

L133-135 I do not understand this sentence. How do you know that 1.5 % of the radiometer WVP data are affected by "saturation"?

L136: ICON has a complex grid such that resolution is not exactly the grid size, however, the true resolution of a model will always be coarser than the grid size. A discussion is needed.

L153 SST fixed for each simulation day. However, SST shows spatio-temporal variation. Does SST have an influence on water vapor variability or cloud fraction?

L184: Fig. 3 combines spatial and temporal variability. I would be good to split this up and check which limitation is imposed by the individual contributions. Just assuming a classical 10 m/s advection time scale gives an equivalent scale of 36 km for one hour time (ICON output frequency). That is of course a simplified view but could easily

explain why models with scale 20 km and below are so similar.

L210-218: Are the numbers given here for the whole campaign or as in Fig. 4 only for 11 Dec 2013? In fact it might be good to explain before how the stretched WVP scale is generated for days and campaign?

L329: Any idea why not? Are they to optically thick and thus as stratiform layers cover larger scales not in the data set?

L348: The paper shows the better representation of cloud fraction for the "higher resolution" simulation. This does not necessarily need to be a resolution effect but might be due to the different cloud schemes employed by the SRM and LEM. One possibility might be autoconversion which might be too weak in SRM allowing further vertical development of the clouds.

L395:" in the vicinity of deep convection" is a significant part of the data from this region?

L409: "..the major features of the vertical distribution"

TECHNICAL CORRECTIONS

Fig.1 is perfectly suited to add a fourth subplot with the difference between WVP_max-WVP_min which I find missing.

Fig. 2: I can't see anything in the water vapor plots. Maybe add a few contour lines. Wouldn't it make sense to show a microwave satellite field for WVP (from SSM/I, AMSR..)?

Fig. 4: I can't distinguish the different lines. Anyhow Fig. 4a already nicely shows both WVP scale so that I think that 4b could better show the difference of the models to values instead of repeating the full scale.

Fig. 7: similar to fig. 4 her b and c should be plotted as anomalies.

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