Interactive comment on "All-sky Information Content Analysis for Novel Passive Microwave Instruments in the Range from 23.8 GHz up to 874.4 GHz" by Verena Grützun et al.

Anonymous Referee #2
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We thank Referee #2 for his or her time and effort, and for the very valuable comments. We have clarified and corrected the manuscript accordingly (the individual comments are addressed below). Note that due to some major comments of Referee #1 there were major changes in the manuscript. Especially, Referee #1 critisised the choices we made for the calculation of the a priori covariance error from ICON. We therefore recalculated it with more consistent and physically based assumptions. This changes the results for the information content. The general conclusions remain valid, but the liquid phase gains a greater share of the overall information content.

This is a comprehensive study on the idealized information content from microwave/sub-millimeter microwave channels that are relevant to the current instruments deployed in field and space missions.

I have three major comments:

1. I agree with the author that it is highly important to have consistent micro-physical parameterisations in the RTM and atmospheric model and appreciate the careful discussions on the comparisons between Seifer and Beheng 2006 and McFarquhar and Heymsfield (1997) schemes. However, the McFarquhar and Heymsfield (1997) parameterization is developed for tropical cirrus cloud using field campaign data collected during CEPEX, which may not be proper to apply to a midlatitude frontal cloud system. Besides, I don't see why it is necessary to have such long discussions in this article if two-moment scheme is used in both ICON and ARTS.

Thank you for this very valuable suggestion. We have reorganized the discussion of the microphysics. We have much more focused on the two-moment physics and removed the major part of the discussion of the McFarquhar and Heymsfield scheme, including the respective figure. We left a paragraph in, which points to the difference between the two schemes, but we added the information that the one-moment scheme is developed for the tropics (Sec. 3.1, esp. p6, l15-21).

2. In the calculation of Jacobians, the channel response function is not used and instead monochromatic radiative transfer simulations for the center frequencies of the side bands are carried out. For channels in the window region and sounding channels far from the absorption line center, the sensitivities or information content are sensitive to the width of the channel. And these channels are used to retrieve the hydrometeors.

We have added the following to the discussion:

"We do not use an explicit sensor response function but perform monochromatic radiative transfer simulations for the center frequencies of the side bands in each channel and use the mean of the two brightness temperatures. For clear sky, highly resolved (in terms of frequencies) tests showed that the error compared to using one monochromatic frequency per side band is less than 1 K (Brath et al., 2018). Because the scattering properties of the hydrometeors change only marginally within the band width, a further increase of this uncertainty in the cloudy case is unlikely."

Brath, M., Fox, S., Eriksson, P., Harlow, R. C., Burgdorf, M., and Buehler, S. A.: Retrieval of an IceWater Path over the Ocean from ISMAR and MARSS millimeter/submillimeter brightness temperatures, Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2017-167, 2018.

3. P10. Line 8: please explain in more detail: "the scattering solver for the perturbations gets the reference result as a first guess". Scattering is important since the focus of this study is to understand the information content in these channels to the different combination and types of hydrometers.

For clarity, we have rephrased this explanation as follows:
"In practice, we do not make a fully independent T_B calculation for each perturbation, since this is computationally very inefficient for the iterative scattering solver used (Emde et al., 2004). Instead, the scattering solver uses the result from the unperturbed scheme as a starting point. That result should be close to the result from the perturbed case already, because our profile perturbations are small. From that starting point, the perturbed Jacobians are calculated with far fewer iterations compared to a completely uneducated starting point, which makes the scheme far more computationally efficient." (p10, l11-16)

Minor comments:

1. In the abstract, Line 14: "however the information content is robust", this is right after the discussion on the little information on the profiles and microphysics. "robust" with respect to what?
We have rephrased to: "…the information content is surprisingly robust across different atmospheric compositions."

2. P2, Line 34: suggests to change to "low level clouds have only little effect on the "
We have rephrased to: "Low level clouds have only a marginal effect on…"

3. P3. Line 25: remove comma in 183GHz.
We have corrected this.

4. P3. Line 34: add "in" before "Sect.2".
We have corrected this and rephrased slightly.

5. P4. Line 24: Suggest to remove the first sentence in this paragraph, and state what kind of assumptions are made for surface emissivity and surface type.
We have rephrased the paragraph to:

"The radiative transfer simulations were performed with two different surface emissivities ε. In the first set of simulations, ε is equal to 0.6, which corresponds to an ocean surface. In the second set of simulations, ε is equal to 0.9, which corresponds to a land surface. Further, specular reflection is assumed. One should keep in mind though, that in reality ε depends strongly on the specific surface and to a smaller extent on the channel. However, the results differ only little for the different emissivities. Therefore, we use the simplified assumption of a constant emissivity for all channels, and the main part of the results shown in this article will be for the emissivity of the ocean, i.e., ε=0.6." (p5, l3-8)

6. P7, Line 4: "smaller smaller"
The respective section has changed much, and this phrase does not exist anymore.

7. P12, Line 19: "to choose them". Also, should it be "for each hydrometeor type"?
We have corrected both and slightly rephrased (now p13, l18-19).

Line 18: "amongst the extremes": does this mean extreme profiles are selected? If so, it is contradict with following statement that outliers are excluded. Please clarify.
We have rephrased to:
"To exclude unphysical outliers, which may be produced by the model, we disregard the profiles with a path larger than the 99th percentile." (p13, l19-20) Occasionally unphysical values may appear due to numerical issues. In order to only include valid profiles, we exclude the upper percentage of the extreme profiles.

8. P24, Line 8: "has to be paid"
We have corrected this (now p26, l11).