

Cloud water path detectability and retrieval accuracy from airborne passive microwave observations over Arctic sea ice

General remark

This manuscript describes an excellent experiment, possibly leading to an advancement in microwave remote sensing of the arctic ocean and atmosphere by a proper combination of forward models of microwave emission, SMRT and PAMTRA, for essential contributors, such as sea ice, snow, cloud liquid water, water vapour, and dry air. Due to the large number of physical parameters of the atmosphere and of the arctic ocean, the task required a delicate choice of observables, of variable and of fixed model parameters to get reasonable assessments. The observations consist of ERA5 data and of measurements from a large sensor package (HAMP) on a high-altitude aircraft (HALO) with microwave radiometers (and others) looking in nadir direction at frequencies between 22 and 190 GHz.

The complexity of this work required several days of reading and thinking to get a reasonable understanding. Finally, the gain of insight was great. But I might have been lost without my experience with microwave signatures of sea ice, snow and tropospheric water because basic signatures are missing in this manuscript.

Comments, questions and corrections

1 Change: CWP to ILW

The essential parameter is called Cloud Water Path (CWP). Unfortunately, this name is not clear, and it is misleading in three ways:

- a) The word, path, is irritating, as it may indicate which path a cloud may take on its way in the atmosphere. But this is not the case.
- b) Cloud water also consists of water vapour in the air between the cloud droplets. The mass of cloud droplets is usually smaller than the mass of the water vapour in the cloud.
- c) Clouds may also consist of frozen water.

Since the authors understand CWP as the liquid water mass per horizontal surface area, the name should be called vertically Integrated Liquid Water (ILW) mass of clouds in the atmosphere. This corresponds well to the vertically Integrated Water Vapour (IWV) mass of the atmosphere. This quantity is correctly used in the manuscript.

2 Line 4: "the variable sea ice and snow emission and scattering signatures partly mask the cloud signal..." In my view, the opposite is true: "the sea ice and snow emission and scattering signatures are partly masked by the atmosphere".

3 Line 53: What do you mean with "spatially resolved latent space representation of the sea ice"?

4 Figure 6d Simulated TB response: Shown are spectra of undefined quantities "DeltaTB". Please correct to TB values or define DeltaTB.

5 Line 418: "Crossing of the warm air intrusion from north to south": Correct to "crossing from north to south of a warm air intrusion" (from south)

6 Line 434: What do you mean with "artificial signals"

7 Line 439: To avoid misunderstandings, connect tails of linked adjectives in front of a substantive by hyphens, such as "very low wind-slab-correlation lengths". Also elsewhere.

8 Line 440: Correct or clarify (Fig. C1)

9 Appendix A: This is very limited information on atmospheric profiles. The limitation to ERA5 data is questionable, here. Warm and humid air inflows into the arctic area can change IWV by an order of magnitude within short time. Therefore, the example with 10% change of a rather dry troposphere is insufficient. Actual water vapour variations could be accounted for, e.g. by pattern differences and/or short-time variations at and between 22 and 31 GHz. Also, what I found from ground-based observations is that under advective conditions, the temporal decrease of IWV often corresponds to the precipitation in between.

10 Comment on the specularity parameter s : This parameter is most important at nadir view direction because of the largest difference between lambert scattering and specular reflection at a horizontal surface. On the other hand, there is no polarisation information in this case. Therefore, we need off-nadir observations, too, for real tests of the specularity.

I am open for direct discussion if needed to better interact.

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