Using collocated Arctic Weather Satellite (AWS) and EarthCare radiometer data over polar latitudes to investigate cloud effects on sub-millimeter wavelengths

Gunnar Behrens, Anqi Li, Eleanor May, Peter McEvoy, and Patrick Eriksson

1. Introduction

Swedish Ice Clouds are the most beautiful in the world… but can we investigate them by collocating EarthCARE and the Arctic Weather Satellite?

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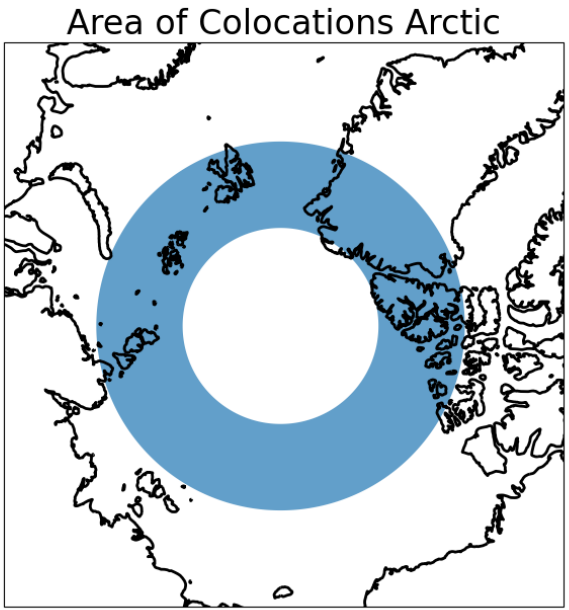
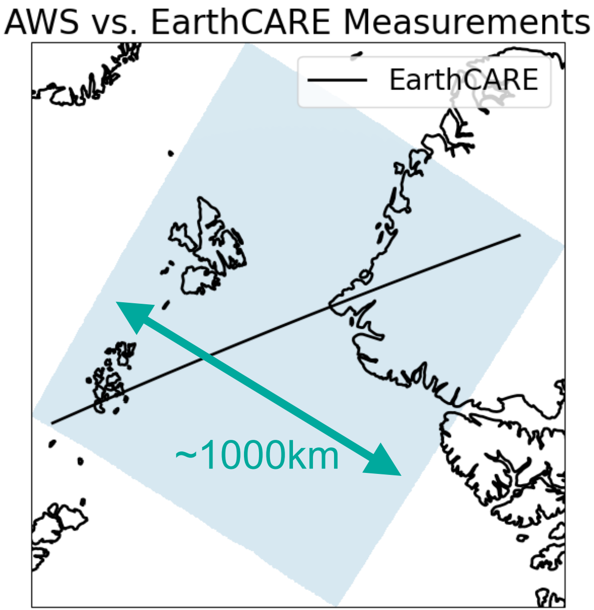


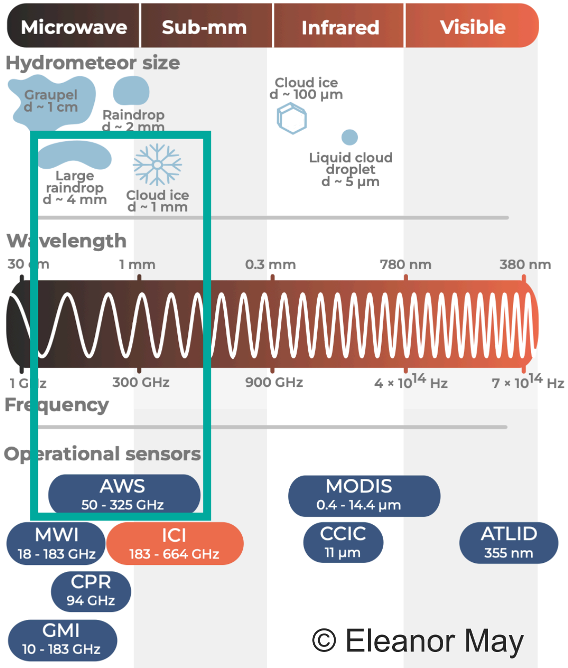


Sadly not … But we can study a large portion of convective processes in the Arctic between 77°N and 83°N combining EarthCARE and AWS

2. Arctic Weather Satellite (AWS)

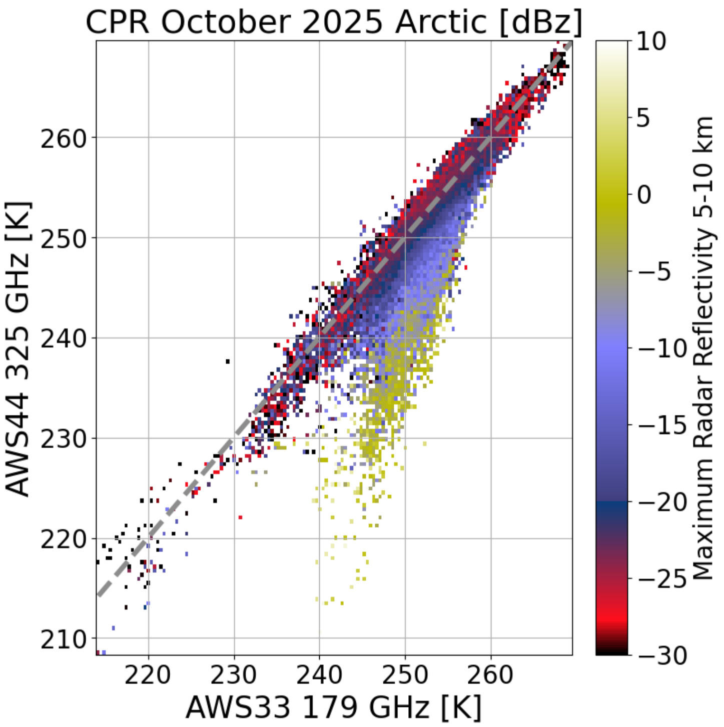
AWS radiometer (Eriksson et al. 2025):

- 3 microwave bands at 50, 89, 175 GHz with in total 15 channels
- 4 sub-millimeter channels (>300 GHz)
- Sub-millimeter = higher sensitivity to cloud ice compared to lower frequencies
- Footprint size of 89, 175 and 325 GHz bands ~10 km



4. Results

Cloud signal = difference in brightness temperatures between AWS channels caused by presence of cloud



Behrens et al., in prep

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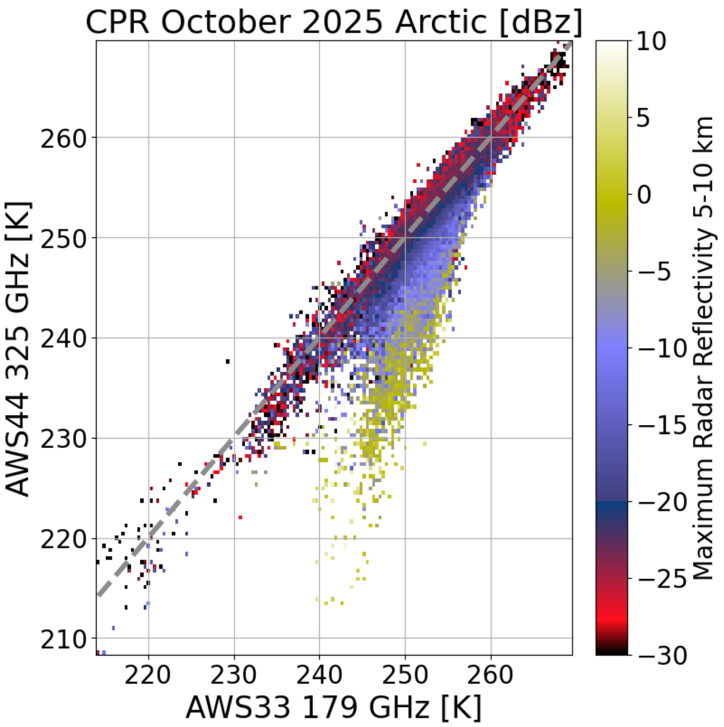

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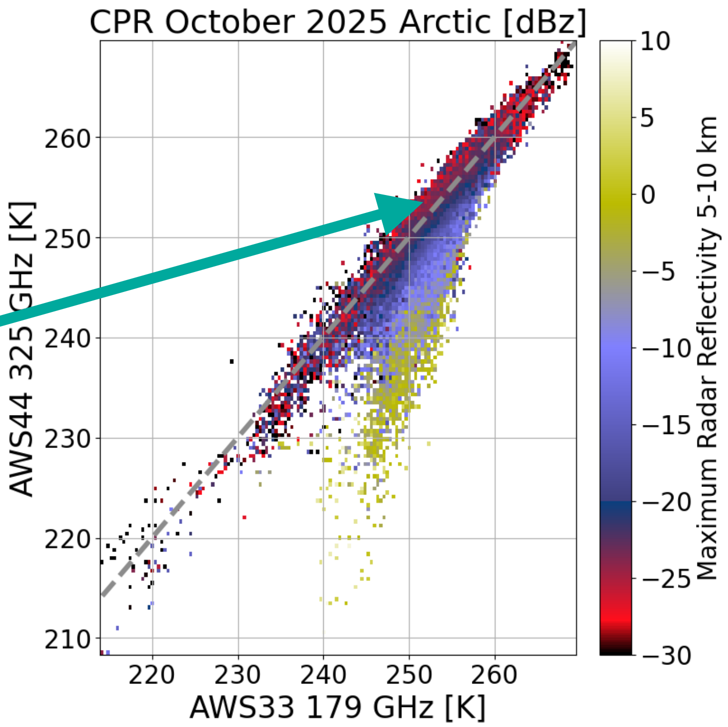

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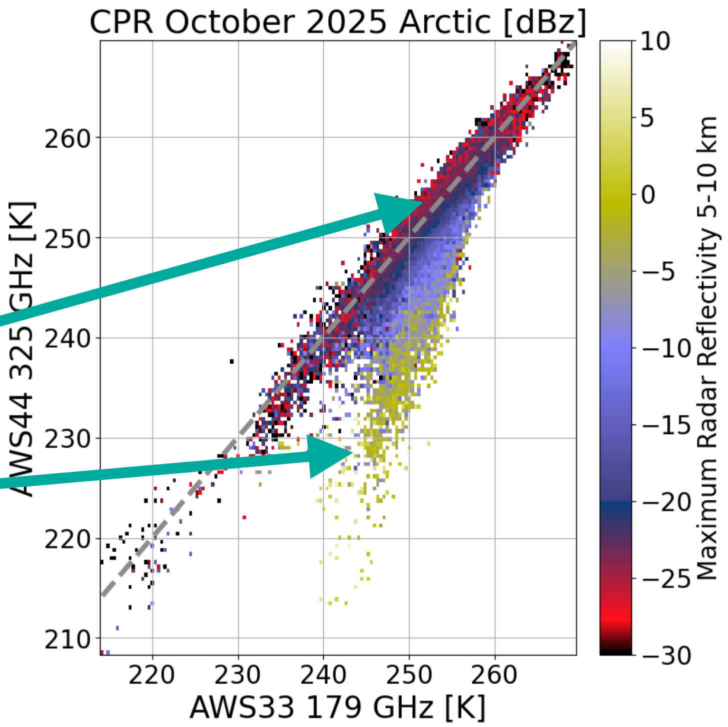
- Samples along 1:1 ratio of AWS33 vs AWS44 (cloud free), maximum CPR < -20 dBZ
- „Cloud arm“:
  - AWS44 << AWS33 indicates cloud
  - Increasing dBz with growing cloud signal



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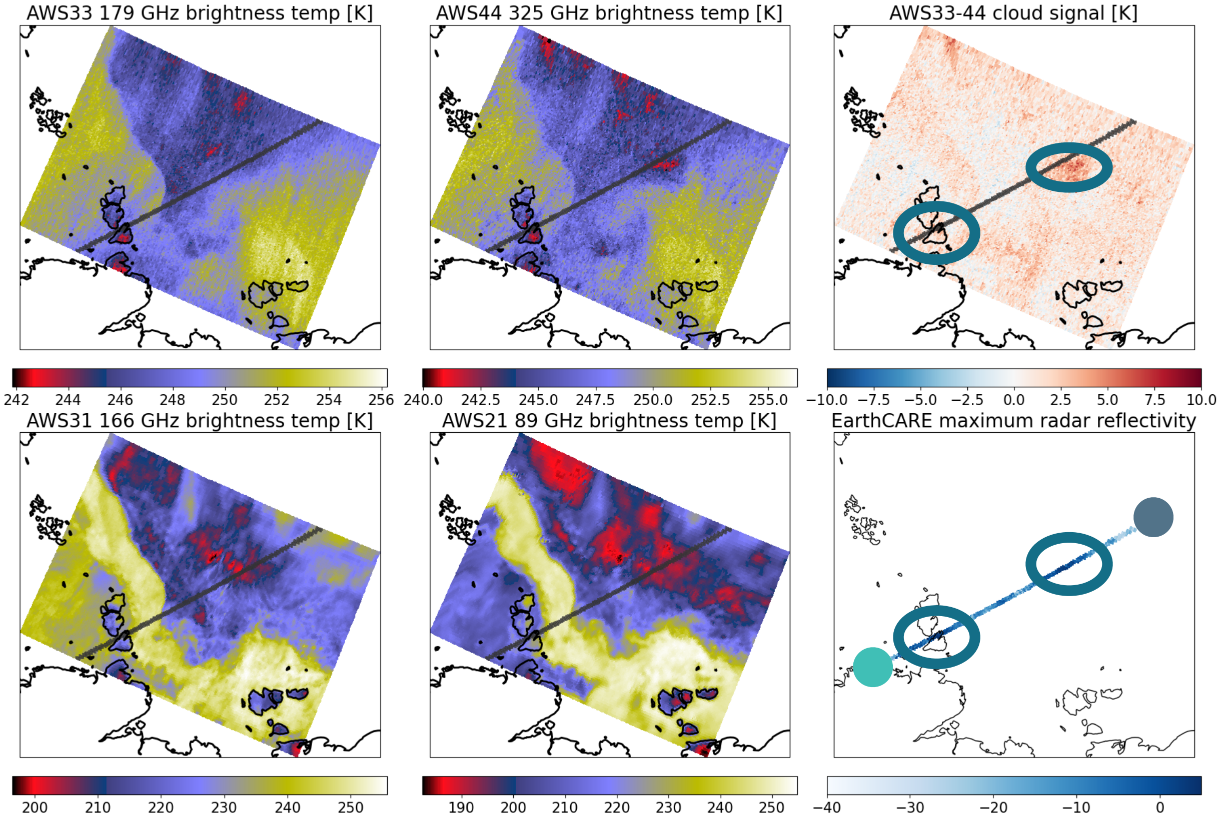
4. Results

31 October 2025, Laptev Sea:

AWS perspective:

- Good agreement between cloud signal („cloud arm") in AWS (AWS33-44) and averaged max. CPR radar reflectivity
- Sharp boundaries in AWS31, AWS21 related to sea-ice edges

How does the situation look like from the EarthCARE perspective?



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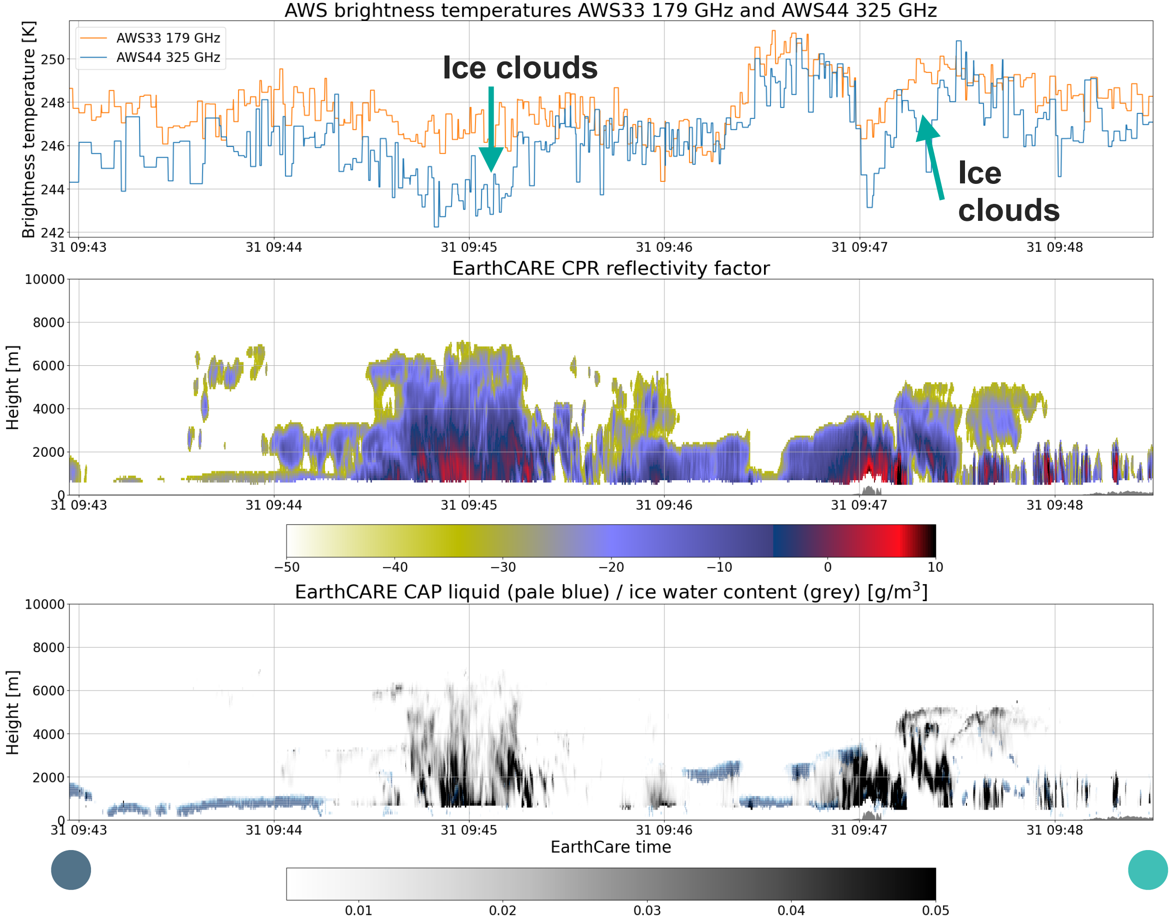
31 October 2025, Laptev Sea:

- Enhanced AWS cloud signals („cloud arm“) if ice clouds are present



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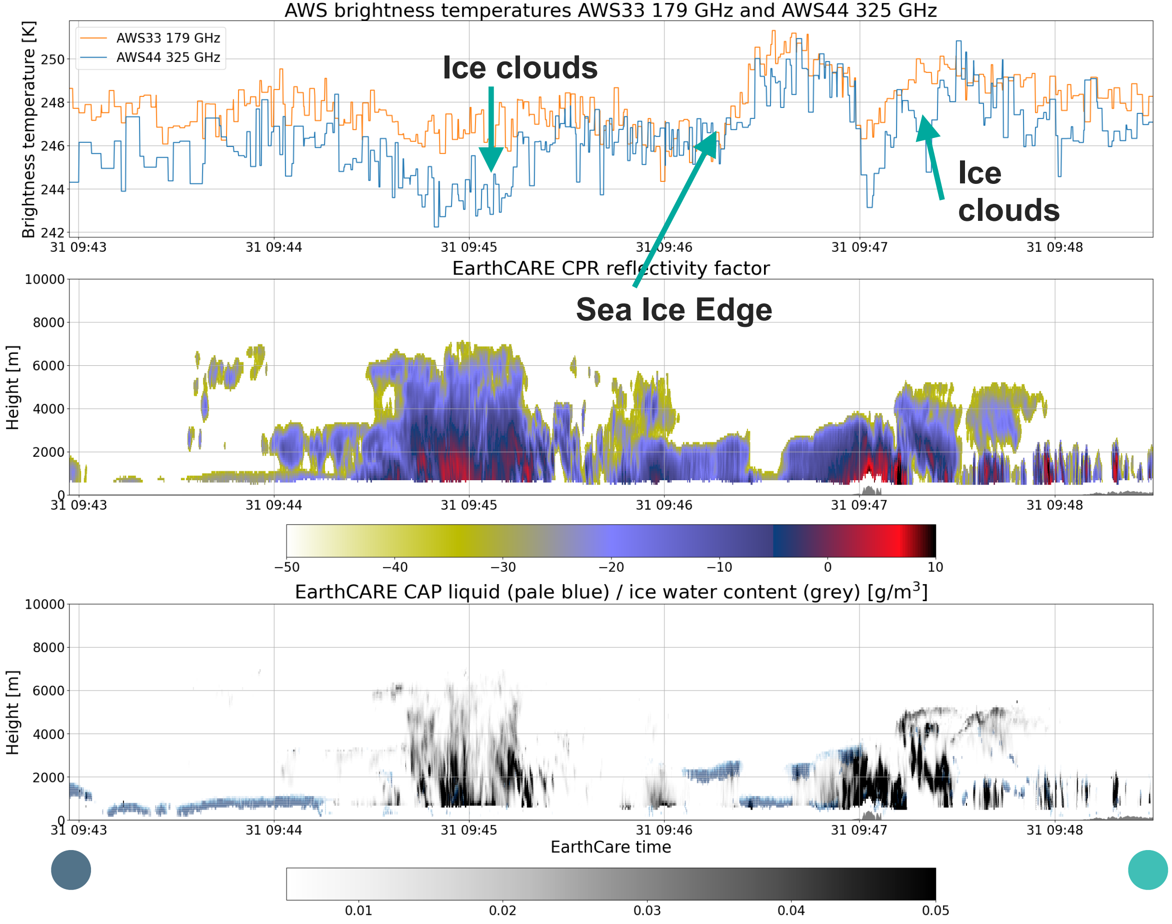
- Strong influence of surface albedos on AWS brightness temperatures (thin sea ice, open water and topography)



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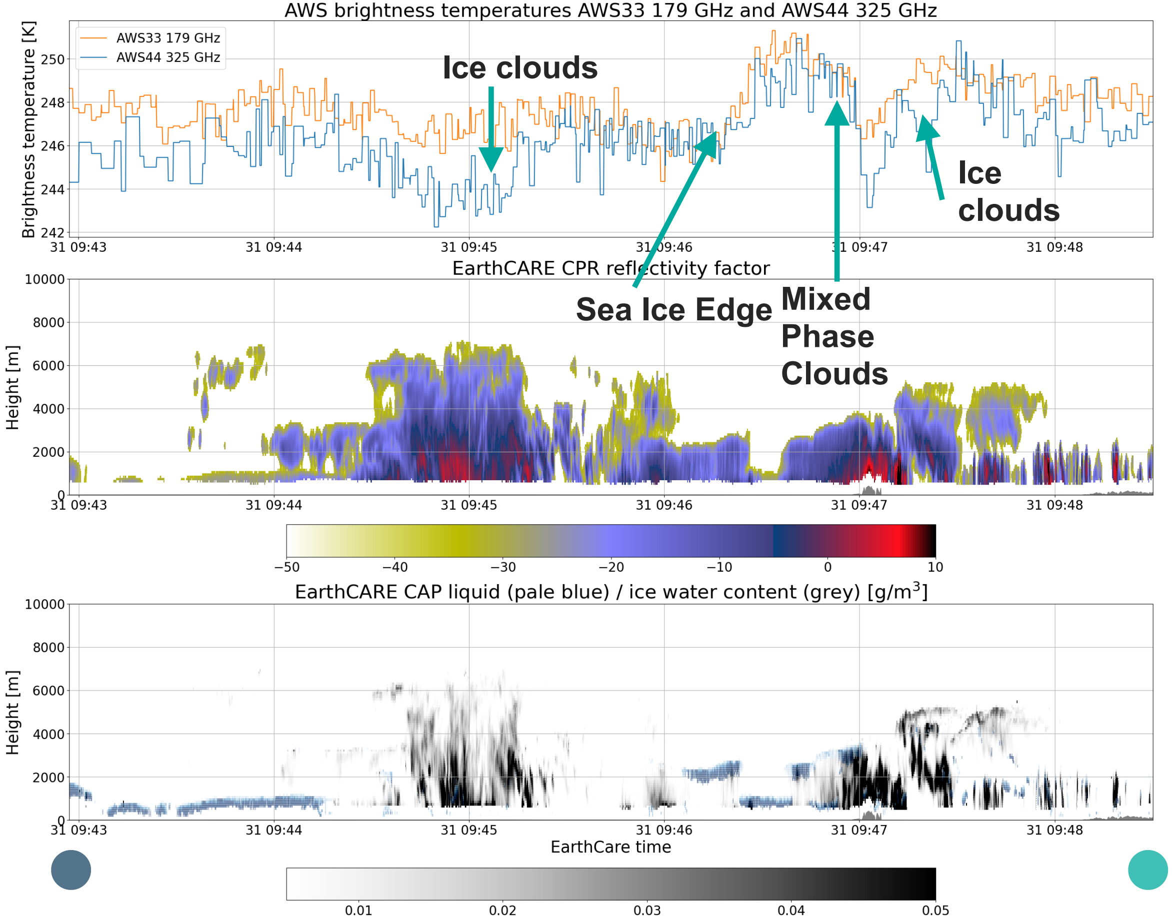
- Mixed phase and liquid clouds damp AWS cloud signals as expected



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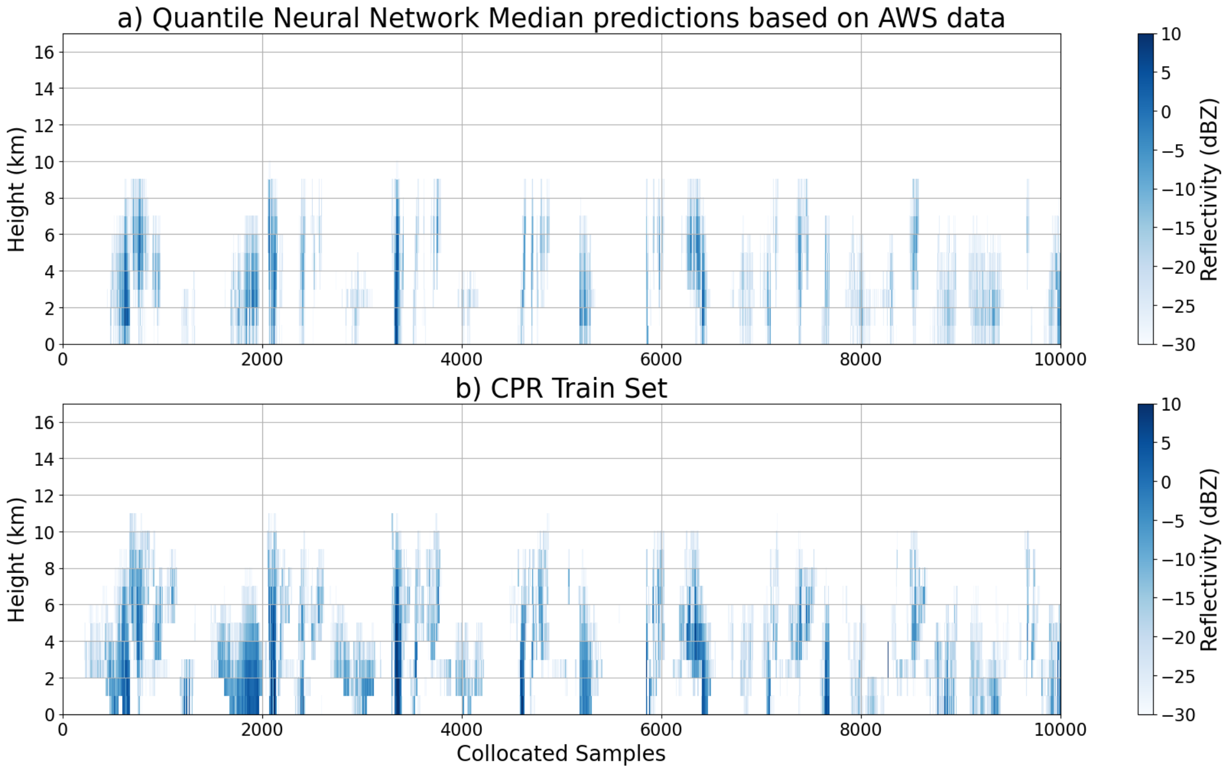
- Initial tests show potential to retrieve CPR features down to -20 dBZ

- Surprising potential to retrieve radar reflectivities also near the ground (retrieving snow?)



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5. Summary and Outlook

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- Agreement between AWS cloud signals and CPR radar reflectivities in statistical sense
- Higher thicker ice clouds in CPR visible in AWS raw data
- Weaker cloud signals for mixed-phase clouds and sensitivity of AWS wrt surface emissivity changes
- Initial ML experiments: ML retrieval could predict CPR reflectivities until -20 dBZ based on AWS data
- **Next steps: Expand colocation look-up table, colocation data base and develop a final version of ML retrieval over the Arctic as part of ESA CCI cloud**

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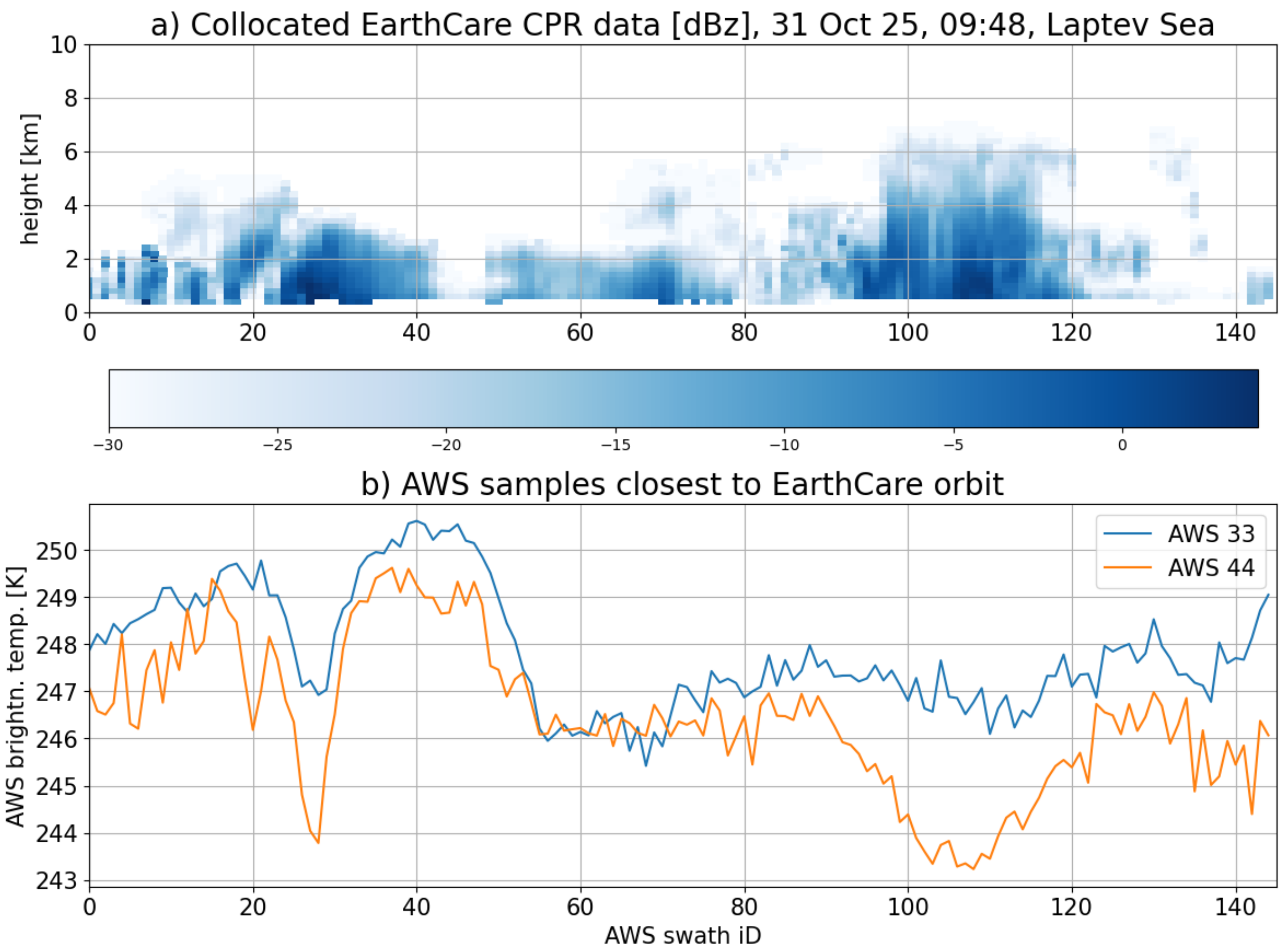
References

Eriksson, P., Emrich, A., Kempe, K., Riesbeck, J., Aljarosha, A., Auriacombe, O., Kugelberg, J., Hekma, E., Albers, R., Murk, A., Møller Pedersen, S., John, L., Stake, J., McEvoy, P., Rydberg, B., Dybbroe, A., Thoss, A., Canestri, A., Accadia, C., Colucci, P., Gherardi, D., and Kangas, V.: The Arctic Weather Satellite radiometer, Atmos. Meas. Tech., 18, 4709–4729, https://doi.org/10.5194/amt-18-4709-2025, 2025.

Laptev Sea:

averaged CPR based on AWS footprint, outer swath ~30km, inner swath ~10km



3. Colocation Database

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1) Simulate crossings of AWS and EarthCare orbits based on Two-Line-Elements (April 25-Ongoing)

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2) Generate look-up tables based on AWS, EarthCARE CPR* and CAP* data July 25 - March 26

3) Generate Colocation Database:
- AWS 89, 175, 325 GHz channels
- averaged EarthCARE CPR radar reflectivities

July 25, October 25

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July 25, October 25

4) Build of CPR machine learning emulator / retrieval based on AWS data

*use of version BA and BC

Test data:

Predicting CPR based on AWS channels (July, October 25)