Investigating mixed phase clouds using a synergy of ground based remote sensing measurements

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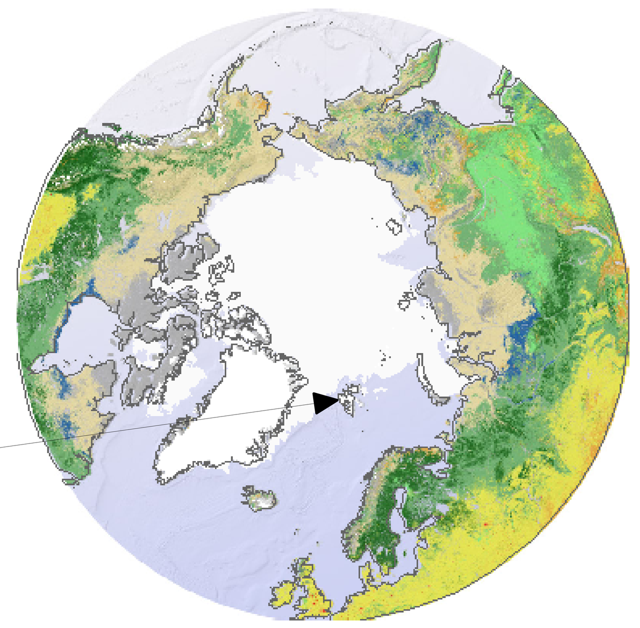
Arctic Amplification and Clouds

Arctic Amplification: Climate Relevant Atmospheric and Surface Processes and Feedback Mechanisms (AC)[3]

- Project to investigate the key processes contributing to Arctic Amplification
- Comprehensive cloud observations carried out at AWIPEV station in Ny Ålesund



Arctic mixed phase clouds

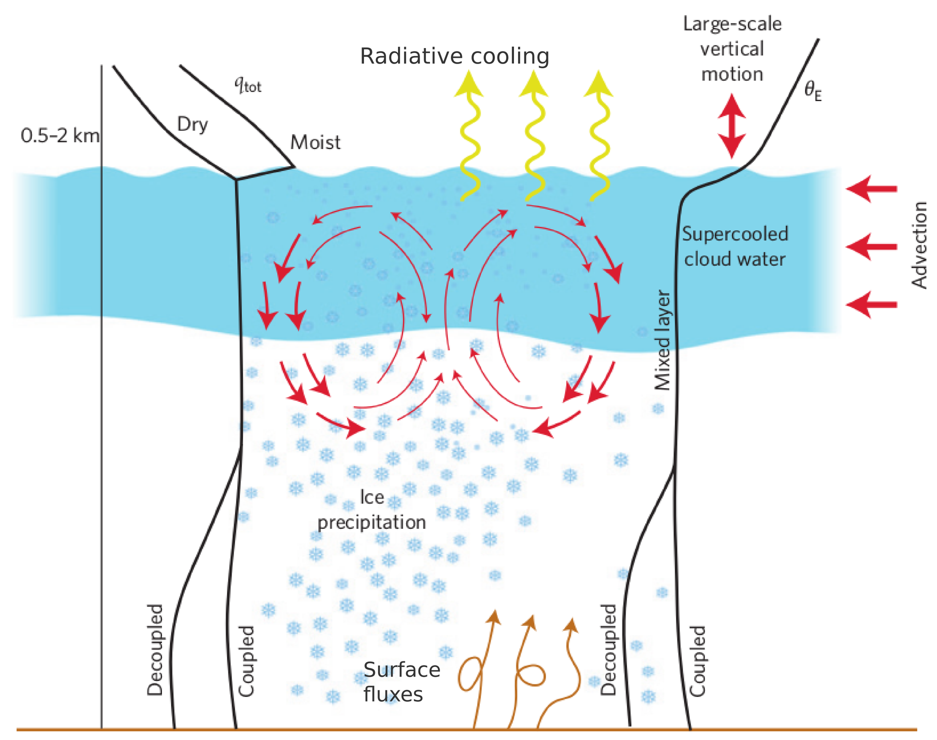


Fig 1. Structure and key processes[1].

"Low-level stratiform liquid and mixed-phase clouds are found to be the most important contributors to the Arctic surface radiation balance."[2]

Mixed Phase Cloud – A Case Study

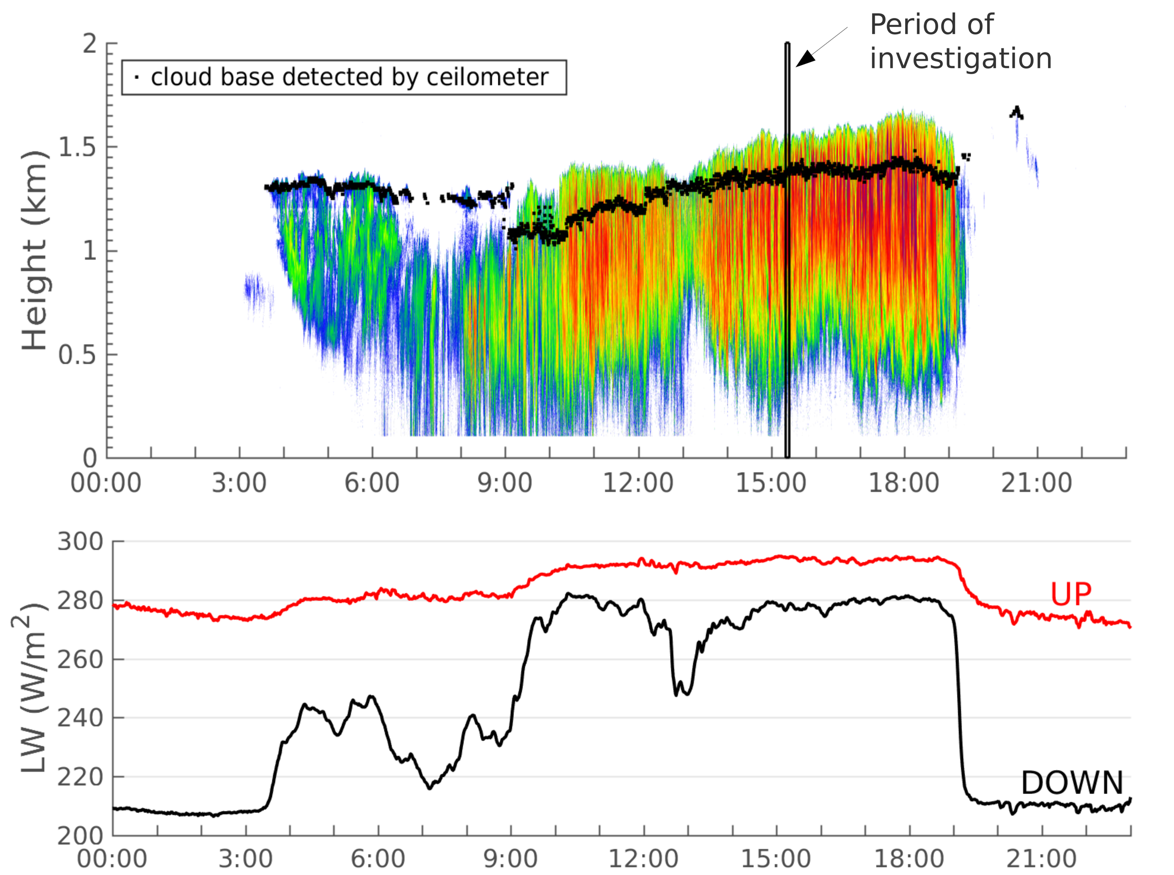
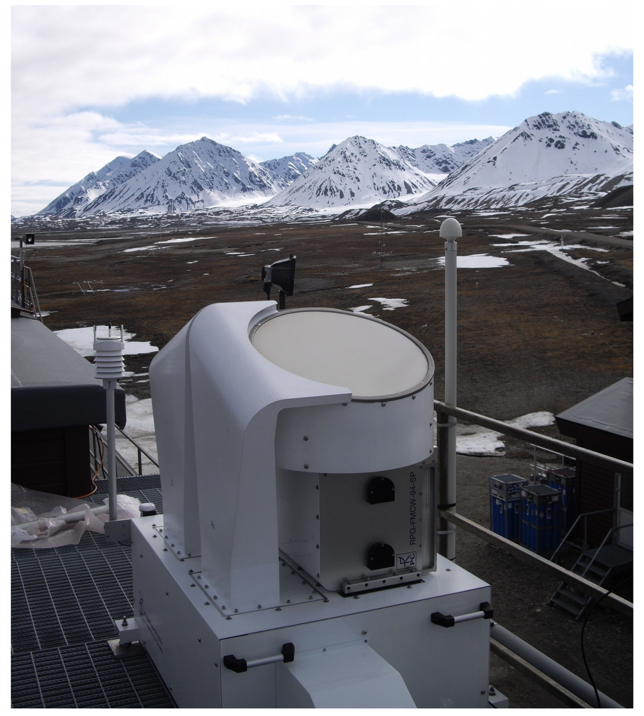


Fig 2. A mixed phase cloud observed on the Nov 23th 2016: radar reflectivity and cloud base detected by ceilometer (upper panel); long-wave surface radiation measurements (lower panel).

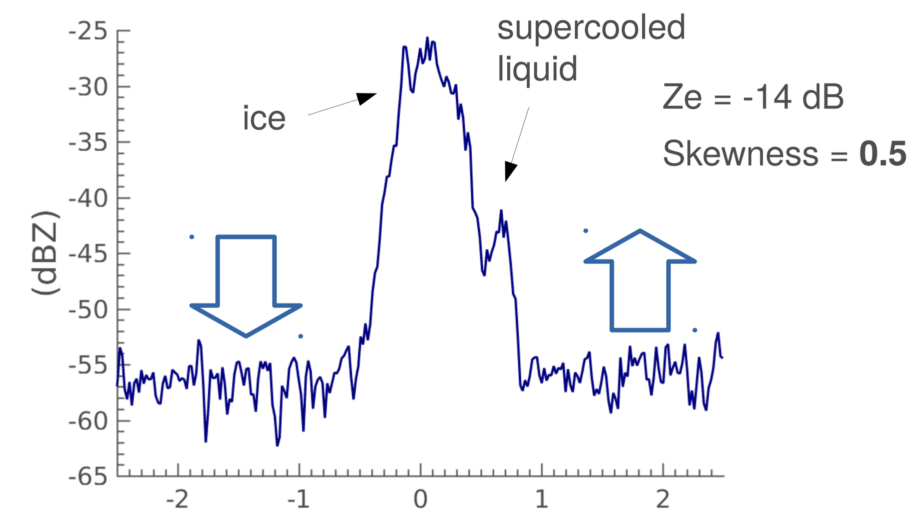
Instruments

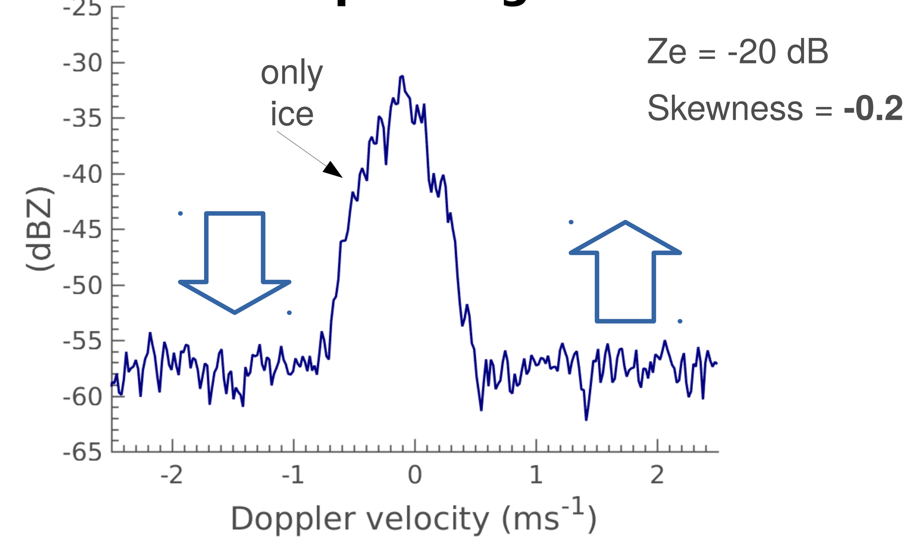


94 GHz FMCW radar (with up to 5 m vertical resolution) combined with a 89 GHz radiometric channel.

Hatpro (passive microwave radiometer): 7 channels at 22 GHz and 7 channels at 60 GHz.

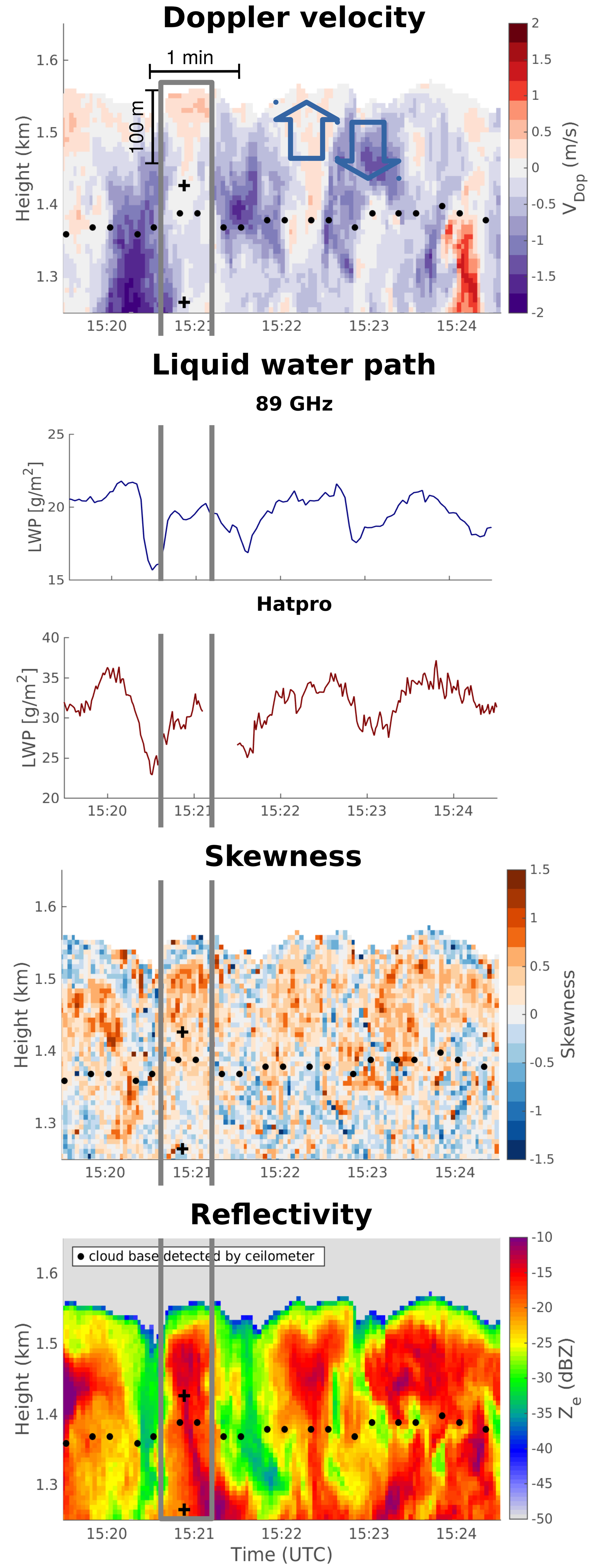
Utilizing Doppler Spectra





- Ze is dominated by ice ($Ze \sim D^6$)
- Mean Doppler velocity $V_{Dop} = V_{Terminal} + V_{Air}$ → since $V_{Terminal}$ is always down (negative), a positive V_{Dop} is caused by upwind
- Super-cooled droplets are floating with the air ($V_{Terminal} \approx 0$ m/s) → ice particles separate from super-cooled liquid in the Doppler spectra (if low turbulence) → if both super-cooled liquid and ice present, spectra becomes positively skewed

Small scale variability



Vertical air motion driven by cloud top radiative cooling

Supercooled liquid water and dynamics connected:

Updraft → increase in LWP and skewness

Downdraft → decrease in LWP

Ice growth connected to presence of cloud liquid:

More liquid → more ice

Fig 5. Cloud top structures revealed by different radar moments. Liquid water path is retrieved from the radar's 89 GHz passive channel[3] and the Hatpro

References

1- Figure 3 in Morrison, H., de Boer, G., Feingold, G., Harrington, J., Shupe, M.D. and Sulia, K., 2012. Resilience of persistent Arctic mixed-phase clouds. Nature Geoscience, 5(1), pp.11-17.
2- Shupe, M.D. and Intrieri, J.M., 2004. Cloud radiative forcing of the Arctic surface: The influence of cloud properties, surface albedo, and solar zenith angle. Journal of Climate, 17(3), pp.616-628.
3- N. Küchler, S. Kneifel, P. Kollias and U. Löhnert, A W-band radar-radiometer system for accurate and continuous monitoring of clouds and precipitation, Journal of Atmospheric and Oceanic Technology, under review

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