

Validating EarthCARE's CPR in the Arctic: Results from the COMPEX-EC Airborne Campaign

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Low-level Arctic clouds, especially mixed-phase clouds, strongly influence regional climate and Arctic amplification, yet remain poorly understood in data-sparse regions. EarthCARE measurements overall provide unique data in the Arctic to narrow down current uncertainties. However, for this purpose, a thorough assessment of EarthCARE performance with reference measurement is needed. Therefore, the COMPEX-EC (Clouds over cOMPIEX environment – EarthCARE) airborne campaign was conducted in April 2025, based in Kiruna, Sweden. During seven research flights, we obtained approximately 5.63 hours of along-track radar data collocated in space and time with EarthCARE (at least 30 minutes per flight). The campaign spanned diverse Arctic environments, from the Norwegian Sea to northern Scandinavia, and captured a wide range of meteorological conditions, including several marine cold-air outbreak events.

A key objective is to validate EarthCARE's Cloud Profiling Radar (CPR). The AWI Polar 5 aircraft carried a comprehensive suite of active and passive remote-sensing instruments, including: the 94 GHz Microwave Radar/radiometer for Arctic Clouds (MiRAC) with 18.3 m vertical and 1 s temporal resolution, a microwave radiometer channel for retrieving liquid water path (LWP), a lidar system for precise cloud-top height measurements, and additional sensors for cloud radiation properties.

Vertical profiles of radar reflectivity and Doppler spectrum, enabling us to distinguish between ice and liquid hydrometeors and to track the evolution of mixed-phase clouds and shallow precipitation layers. Due to aircraft velocity and the instrument being tilted by 25°, correction of the Doppler spectrum is still in progress. Furthermore, during the leg of the underflight, dropsondes provide us with vertical profiles of temperature, humidity, and wind. MiRAC has previously been used for CloudSat assessment, so these high-resolution airborne observations are crucial for evaluating EarthCARE CPR's vertical sensitivity, resolution, and blind zone characteristics.

Preliminary analysis from COMPEX-EC demonstrates strong potential for synergistic validation: EarthCARE overpasses during the campaign coincided with well-sampled atmospheric conditions, allowing for direct comparisons with radar reflectivity profiles and hydrometeor classification from MiRAC. Both MiRAC and EarthCARE's CPR indicate a median reflectivity of -10 dBZ (± 2 dBZ) at 1 km altitude for mixed-phase clouds over the open ocean. These comparisons are being used to quantify EarthCARE CPR's performance, identify biases or limitations, and guide algorithm development for improved Arctic cloud and precipitation retrievals.