

## Airborne validation of the EarthCARE Cloud Profiling Radar in Arctic cold-air outbreaks during the COMPEX-EC campaign

The COMPEX-EC airborne campaign was conducted in April 2025 from Kiruna, Sweden, to provide coordinated validation measurements for EarthCARE in the Arctic. The Alfred Wegener Institute's Polar 5 research aircraft carried a comprehensive remote-sensing payload including a Doppler W-band cloud radar, a microwave radiometer, backscatter lidar, spectral imagers, broadband radiometers, and a dropsonde system. This nearly one-to-one EarthCARE-like instrument suite enables detailed comparisons with EarthCARE observations, particularly for the Cloud Profiling Radar (CPR).

During the two-week campaign, we conducted seven successful EarthCARE underflights, most of which sampled cold-air outbreak conditions over the Norwegian Sea. These situations featured extensive boundary-layer cloud fields with embedded precipitation, a challenging regime for satellite observations and numerical models.

The primary focus of this study is the validation of CPR observations using airborne W-band radar measurements. Its higher sensitivity and spatial resolution allow investigation of the effects of satellite sampling characteristics, including horizontal and vertical averaging and the near-surface blind zone, on observed cloud and precipitation structures. We use airborne observations to assess the detectability of shallow mixed-phase clouds, their liquid water path, and snowfall in Arctic boundary-layer conditions.

Complementary measurements from the operated backscatter lidar, the derived cloud mask, top heights, and additional remote-sensing instruments provide independent constraints on cloud boundaries, phase, and radiative properties, supporting the interpretation of radar comparisons and the evaluation of selected EarthCARE Level-2 products.

The COMPEX-EC dataset provides a unique opportunity to evaluate the performance of EarthCARE observations in Arctic boundary-layer cloud regimes and to quantify the benefits of the mission's Doppler radar capability and improved near-surface sensitivity relative to previous spaceborne cloud radars.