

COMPEX – Airborne remote sensing of Arctic clouds and precipitation in complex environments

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The Arctic climate continues to change rapidly, yet key processes governing cloud and precipitation feedbacks remain insufficiently constrained by observations. In particular, quantifying the contribution of low-level mixed-phase clouds and associated precipitation to the Arctic energy and water cycle remains challenging due to the scarcity of vertically resolved measurements in complex environments characterized by heterogeneous sea ice conditions and pronounced topography. Satellite retrievals at high latitudes are further complicated by low surface–cloud contrast and radar-blind-zone limitations. At the same time, atmospheric models exhibit substantial spread in their representation of shallow clouds and precipitation. Addressing these challenges requires coordinated active and passive remote sensing capable of resolving cloud microphysical structure together with atmospheric moisture profiles. The airborne campaign COMPEX (Clouds over COMPLEX environment), conducted in March–April 2026 from Longyearbyen (Svalbard), was designed to provide such observations over the Ny-Ålesund region and the sea ice and marginal sea ice zone North-West of Svalbard. The Polar 5 research aircraft of the Alfred Wegener Institute (AWI) was equipped with a combination of a novel G-band differential absorption radar and a W-band radar, complemented by a submillimeter microwave radiometer, backscattering lidar, broadband and spectral radiation measurements, hyperspectral imaging, and a dropsonde system.

This presentation provides a first look at the dataset collected during COMPEX and highlights its relevance for satellite validation and model evaluation. The dual-frequency Doppler radar configuration enhances sensitivity to small hydrometeors and improves phase discrimination, while the differential absorption technique enables profiling of water vapor within and below clouds. Targeted flight patterns document cloud and precipitation structures in

environments that are particularly challenging for spaceborne sensors, including low-level systems over sea ice. Coordinated underflights of EarthCARE allow direct comparison of radar reflectivity profiles, airborne derived cloud and precipitation quantities can be used to validate satellite based products, and passive microwave observations support improved characterization of sea ice emissivity for forward modeling and data assimilation. The COMPEX dataset thus provides a new high-quality Arctic reference for advancing precipitation retrievals and improving the representation of cloud-precipitation processes in atmospheric models.