

CHIRP: Toward Flight-Compatible Metasurface Polarimetry for Ice Cloud Observations

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Polarimetry in the 8–12 μm waveband is currently absent from NASA’s suite of spaceborne observing systems. Thermal polarimetry provides unique sensitivity to surface and ice crystal optical properties, offering a new pathway for constraining cloud microphysics and radiative effects. Ice clouds play a critical role in regulating large-scale atmospheric circulation, influencing high-impact phenomena such as the position and strength of the Northern Hemisphere jet stream and the variability of the El Niño–Southern Oscillation.

The goal of the CHanneled InfraRed Polarimeter (CHIRP) team is to establish a pathway toward achieving the polarimetric accuracy required for ice cloud remote sensing and to advance thermal polarimetry to higher technology readiness levels. CHIRP is a wavelength-channeled polarimeter designed for robustness and flight compatibility, with no moving parts. A single metasurface polarization grating enables simultaneous spectroscopy and polarimetry in a compact, common-path configuration. The first diffracted orders encode orthogonal polarization states, which are co-registered onto a single focal plane, simplifying calibration and enhancing system stability.

In this work, we present laboratory characterization of the CHIRP instrument alongside simulations of ice cloud top-of-atmosphere observations. Calibration accuracy and system stability requirements are driven by tropical ice cloud-top temperatures near 200 K, where the expected polarized radiance is only a few kelvin. To meet this performance goal, we develop an end-to-end calibration and validation framework spanning a broad temperature range. This framework includes methods for quantifying polarization sensitivity, assessing thermal stability, and identifying systematic error sources under mission-relevant environmental conditions.

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