

Retrieval of polar ice cloud properties from IASI and EarthCARE observations

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Clouds in polar regions exert a strong influence on the Earth’s radiation budget, but the characterization of their vertical structure and microphysical properties from passive satellite observations alone remains challenging. The recent availability of EarthCARE cloud products provides a unique opportunity to evaluate and constrain cloud retrievals derived from hyperspectral infrared observations.

In this study, ice cloud properties are retrieved from observations of the Infrared Atmospheric Sounding Interferometer (IASI) collocated with EarthCARE Level-2 JAXA cloud products over polar regions. The retrieval is based on the IOTA inversion framework [1], an optimal estimation scheme designed to derive atmospheric thermodynamic parameters and vertically resolved cloud microphysical properties from hyperspectral infrared radiances. The method combines the fast all-sky radiative transfer model σ [2] with dimensionality reduction techniques and physically constrained prior statistics to retrieve cloud optical depth, effective particle size, and cloud vertical structure.

The analysis focuses on collocated IASI and EarthCARE observations acquired during year 2025 over Arctic and Antarctic regions (approximately 78° and 81° in both hemispheres). Although the final temporal coverage will depend on the availability of validated EarthCARE products, the current dataset already provides several thousands of collocated observations suitable for statistical analysis. Collocations are defined using strict spatial and temporal criteria to minimize uncertainties associated with cloud variability.

The synergy between hyperspectral infrared measurements from IASI and the active lidar-radar observations from EarthCARE enables a detailed assessment of the information content of passive infrared retrievals. In particular, EarthCARE geometrical cloud products are exploited to evaluate the capability of the IASI retrieval framework to reproduce cloud optical and ice microphysical structure under polar atmospheric conditions. The combined dataset also allows the investigation of regional differences between Arctic and Antarctic cloud properties and the characterization of optically thin cirrus clouds that are particularly relevant in the far-infrared.

This work demonstrates the potential of combining passive hyperspectral infrared observations with active cloud profiling measurements to improve the remote sensing of polar clouds. The results are particularly relevant in the context of the ESA 9th Earth Explorer mission FORUM (Far-infrared Outgoing Radiation Understanding and Monitoring), whose measurements will provide unprecedented sensitivity to upper tropospheric ice clouds.

References

- [1] Martinazzo et al. 2026: Retrieval of atmospheric and cloud profiles from high-spectral resolution infrared observations. Under review Journal of Quantitative Spectroscopy and Radiative Transfer.
- [2] Masiello, et al. 2024: The new σ -IASI code for all sky radiative transfer calculations in the spectral range 10 to 2760 cm⁻¹: σ -IASI/F2N. Journal of Quantitative Spectroscopy and Radiative Transfer. <https://doi.org/10.1016/j.jqsrt.2023.108814>

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