Bridging the GPM+CloudSat and GPM+EarthCARE coincidence datasets for expanded observations of drizzle and snow

JAXA information
GPM+EarthCARE

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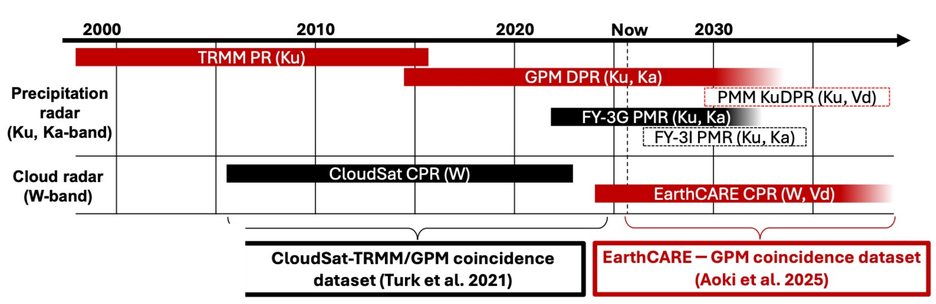
PPS information
GPM+CloudSat
TRMM+CloudSat

Multi-frequency Radar + Radiometer Profiling of Precipitation

Limited detection and large uncertainty in the quantification of light (i.e., rates less than 2 mm hr^{-1}) and frozen precipitation are a longstanding issue from space-based active and passive microwave observations. The Ku/Ka-band (14/35 GHz) Dual Frequency Precipitation Radar (DPR) onboard the joint NASA/JAXA Global Precipitation Measurement (GPM) spacecraft misses a significant fraction of light and frozen precipitation. As atmospheric opacity increases, the measured passive microwave (MW) radiances from the GPM Microwave Imager (GMI) are increasingly masked from the desired precipitation nearer the surface. Additional observations are needed to assess cold-season precipitation data products derived from passive MW radiometers such GMI and the latest JAXA Advanced Microwave Scanning Radiometer (AMSR-3).



The W-band (94 GHz) CloudSat Cloud Profiling Radar (CPR) operated during intermittent periods between 2006-2023. The increased backscattering efficiency at W-band reveals portions of rain and snow that are otherwise missed by current DPR and GMI products. Between 2006-2014, orbital intersections (coincidences) between the Tropical Rainfall Measuring Mission (TRMM) and CloudSat provided a 2-frequency (Ku+W) profiling radar and 9-channel (10-85 GHz) passive MW observations. From 2014-2020, GPM+CloudSat coincidences provided 3-frequency (Ku+Ka+W) profiling radar and 13-channel (10-183 GHz) passive MW observations (final CloudSat reprocessing at CSU/CIRA is underway). Numerous studies have utilized the GPM+CloudSat coincident dataset for developing and evaluating algorithms that invert passive MW radiances into rain and snow geophysical products. These datasets also provide unique observations for training machine learning algorithms.

EarthCARE

Radar Reflectivity, Z_w
+
Doppler velocity, V_d
$V_d = V_{air} + V_{tz}$

V_{tz}= reflectivity-weighted particle fall speed

GPM

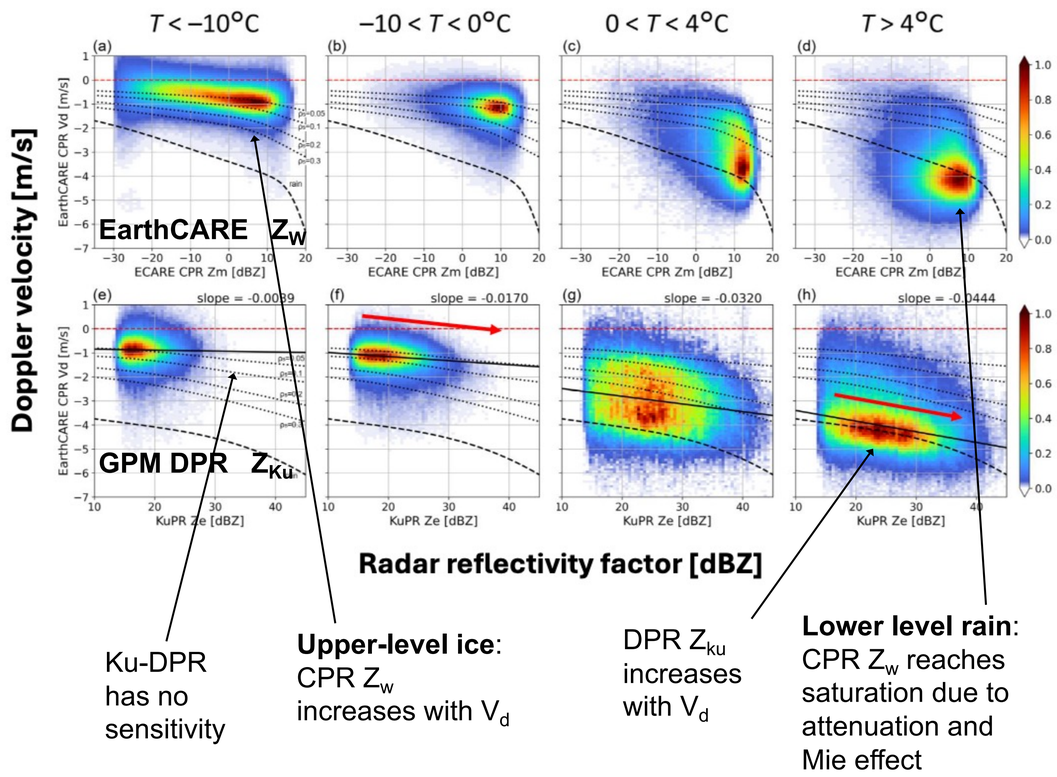
DPR
Radar Reflectivity, Z_{ku}, Z_{ka}
→ (N_w, D_m) → R

high N_w, low D_m → drizzle
low N_w, high D_m → heavy rain

GMI
MW Radiometric T_B
10-183 GHz

top-of-atmosphere upwelling radiances

GPM+EarthCARE observations Aug 2024-Jun 2025

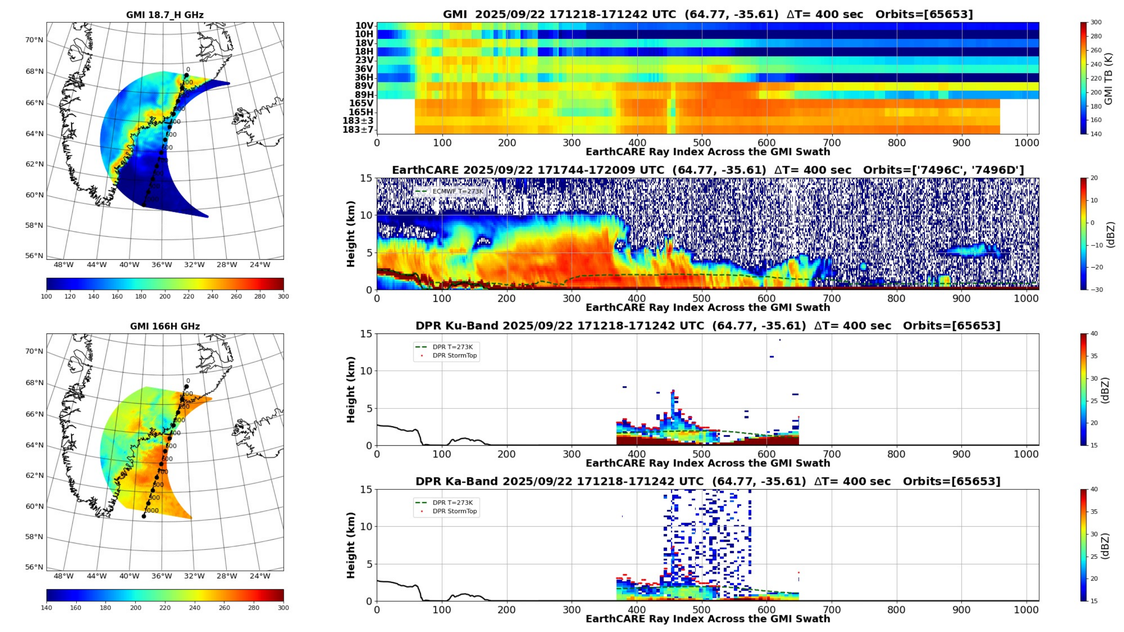


Figures courtesy S. Aoki, JAXA/EORC

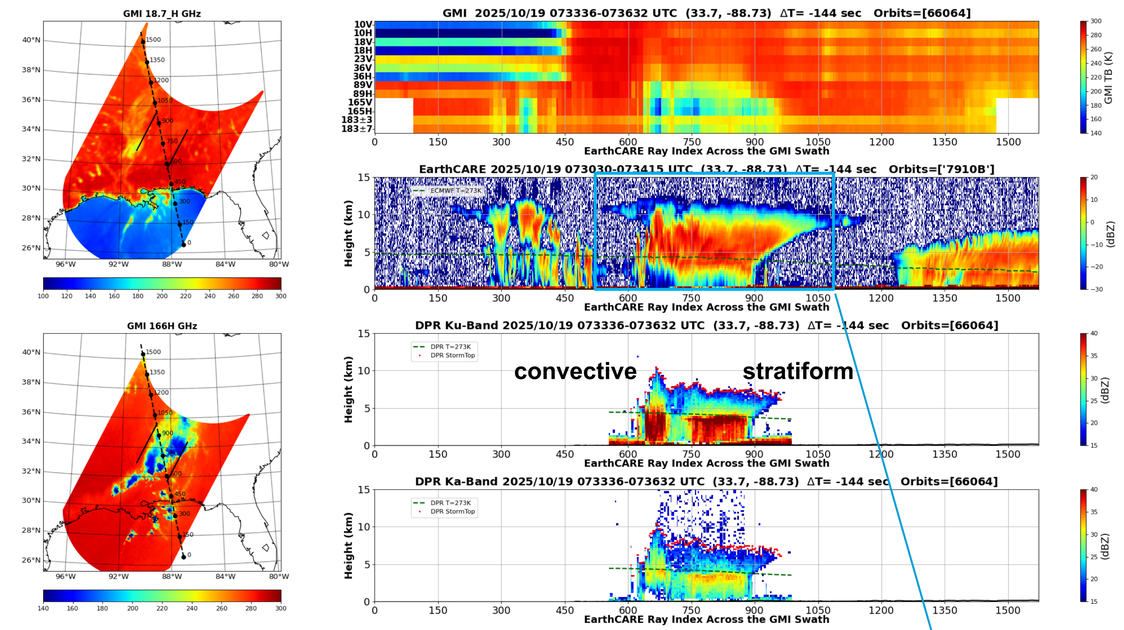
GPM+EarthCARE Dataset

In May 2024, the joint European Space Agency (ESA)/JAXA Earth Clouds, Aerosol and Radiation Explorer (EarthCARE) spacecraft was deployed as one of ESA's Earth Explorers. While similar to CPR, EarthCARE's CPR possesses increased sensitivity and a nadir Doppler profiling capability. While there is a gap between CloudSat and EarthCARE, the GPM+EarthCARE coincident dataset being processed by JAXA further extends these joint observations across more diverse conditions, especially the night-time observations that were unavailable from CloudSat after 2010. In June 2025, JAXA's GOSAT-GW spacecraft with AMSR-3 began operations, which has channels similar to GMI. With similar orbit planes, the AMSR3+EarthCARE coincidences are continuous.

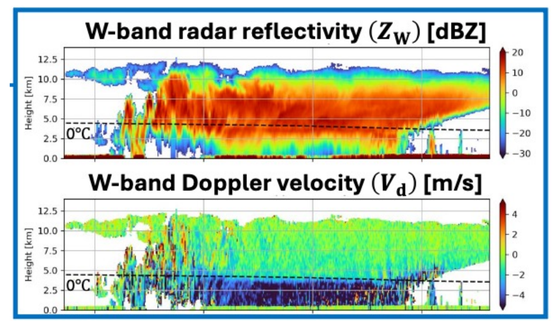
Edge of Greenland Ice Sheet 22 September 2025



Northern Mississippi USA 19 October 2025



The EarthCARE Doppler velocity differs significantly above and below the freezing level. Even with some attenuation occurring, the Doppler velocity can still be measured in the rain layers. The convective region is impacted by attenuation, more turbulent vertical air motion, and greater microphysical variability. The difference in Vd above and below the freezing level is unclear.



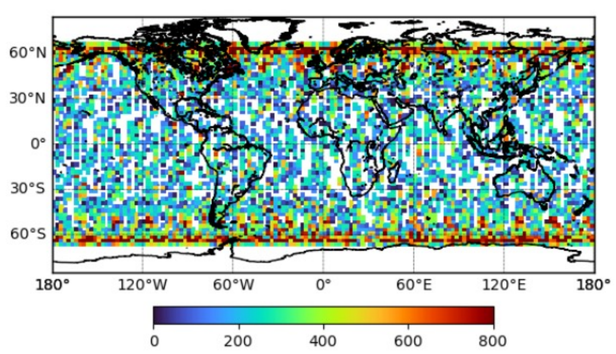
Dataset Content

The GPM+EarthCARE datafile contents are produced in a near-identical netCDF4 format to TRMM+CloudSat and GPM+CloudSat. Coincidence files contain all content from GPM 1C, 2A-DPR, 2B-CMB, 2A-GPROF, and many CloudSat or EarthCARE products and auxiliary datasets (e.g., ECMWF). At this time, data extend into 2026 (~4500 files). A future dataset update will append the JAXA Level-2 rain and snow (RAS) research products (CPR_RAS, AC_RAS, ACM_RAS) currently in development.

Dataset Content and ATBD:

JAXA EarthCARE product list:

GPM+EarthCARE observations Aug 2024-Feb 2026



References

Aoki, S., Kubota, T., and Turk, F. J., 2026: Exploring vertical motions in convective and stratiform precipitation using spaceborne radar observations: insights from EarthCARE and GPM coincidence dataset. *Atmos. Meas. Tech.*, 19, 79–100, https://doi.org/10.5194/amt-19-79-2026.

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