Validation of Hydrometeor Classification Products between EarthCARE CPR radar and GPM DPR radar

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Outline

- Hydrometeor profiling algorithm will be a new highlight feature for GPM DPR level2 algorithm in Version 8, planned to be released in year 2026.

- Validations for the algorithm have been successfully performed including sources from ground-based and satellite-based instruments.

- In this presentation, we first time show the validation of hydrometeor products between GPM DPR and EarthCARE CPR (baseline of BA).

Background

Main products for CPR level-2:

CPR_FMR_2A
CPR_CD_2A
CPR_CLD_2A
CPR_TC_2A

In level 2 product of CPR, the algorithm performed hydrometeor classification inherited from CloudSat and is extended to CPR. Information of doppler velocity is included for the hydrometeor type classification for CPR (EarthCARE JAXA level 2 Algorithm Theoretical Basis Document (ATBD) and Irbah et al. (2023)).

EarthCare CPR radar

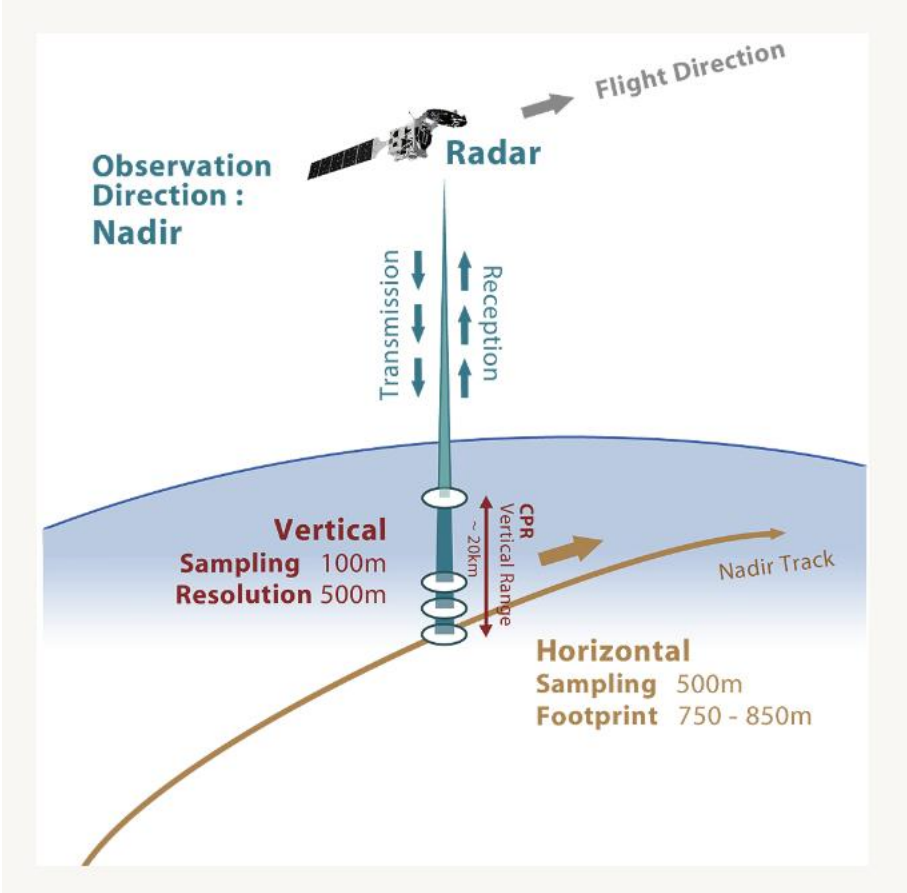


Image and table:
https://www.eorc.jaxa.jp/EARTHCARE/about/inst_cpr_e.html

Main Observation Parameters for CPR

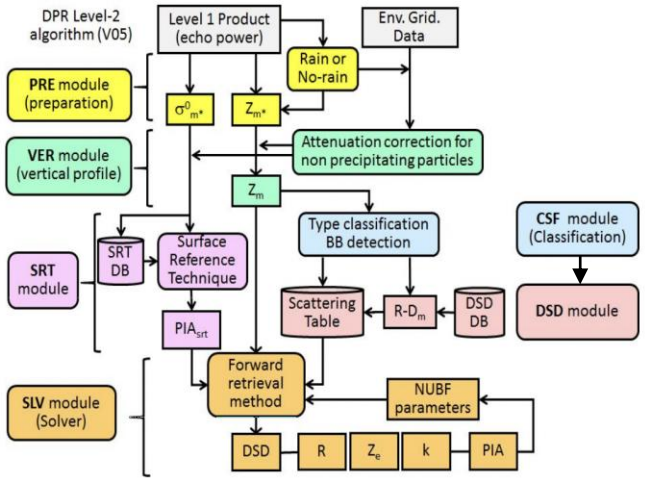
Sensor type	94 GHz (W-band) Doppler radar
Developer	Japan Aerospace Exploration Agency (JAXA) National Institute of Information and Communications Technology (NICT)
Center frequency	94.05 GHz
Pulse width	3.3 μs
Antenna beam width	< 0.095 deg.
PRF	6100 to 7500 Hz (variable)
Sensitivity	< -35 dBZ at atmospheric top (10 km integration)
Doppler accuracy	< 1.3 m/s (10 km integration)
Measurement range	-1 to 12/16/20 km (depending on latitude zone)
Measurement range	-1 to 12/16/20 km (depending on latitude zone)
Footprint (IFOV)(*2)	< 750 m (depending on satellite altitude)
Horizontal sampling	500 m
Vertical resolution	500 m
Vertical sampling	100 m (oversampling)

Background

Hydrometeor Profiling algorithm is a new feature of upcoming Version 8 for GPM-DPR level-2 algorithm.

The Implementation is complete. Earliest release of the product will be in year 2026.

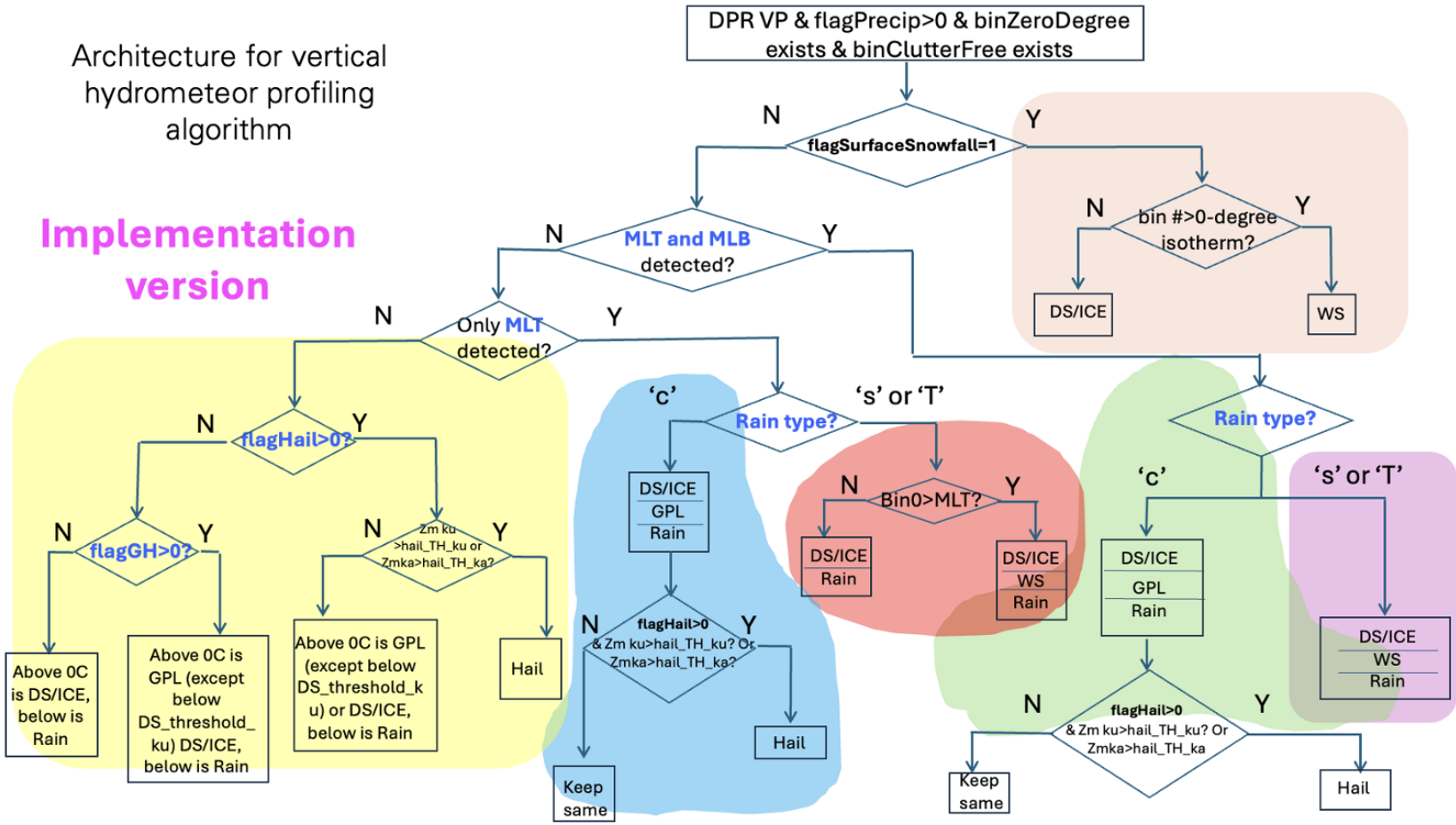
Algorithm is developed using products (Le and Chandrasekar 2017, 2020, 2021, 2022, 2023) our team have developed.



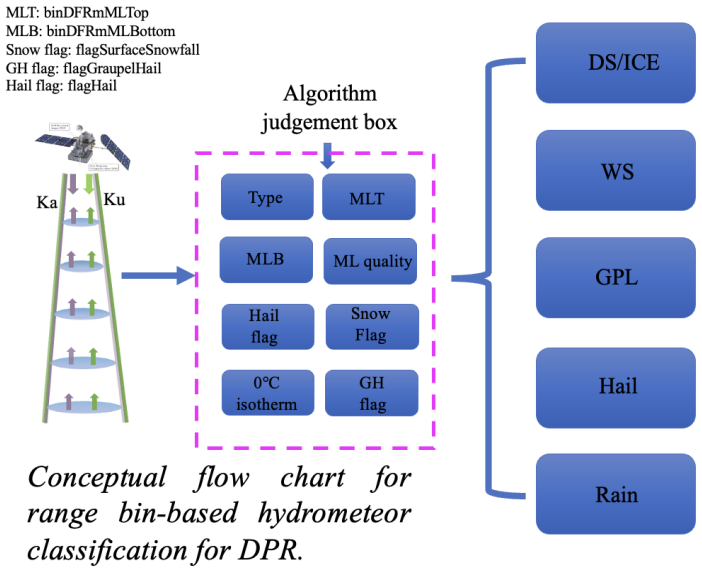
Flowchart of GPM DPR level 2 algorithm (from GPM DPR ATBD, 2021)

Architecture for vertical hydrometeor profiling algorithm

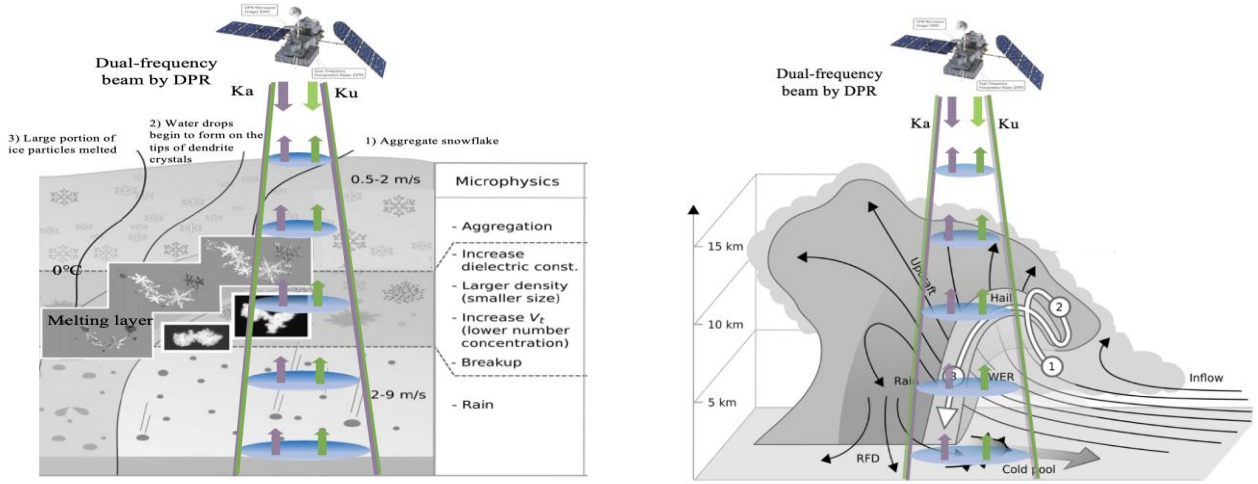
Implementation version



GPM DPR VERTICAL PROFILING ALGORITHM



Conceptual flow chart for range bin-based hydrometeor classification for DPR.



Conceptual plot for GPM DPR overlooking a Left: stratiform storm featuring snow, melting layer and rain on vertical profile. Right: hailstorm on vertical profile. (Chandrasekar et al. 2021)

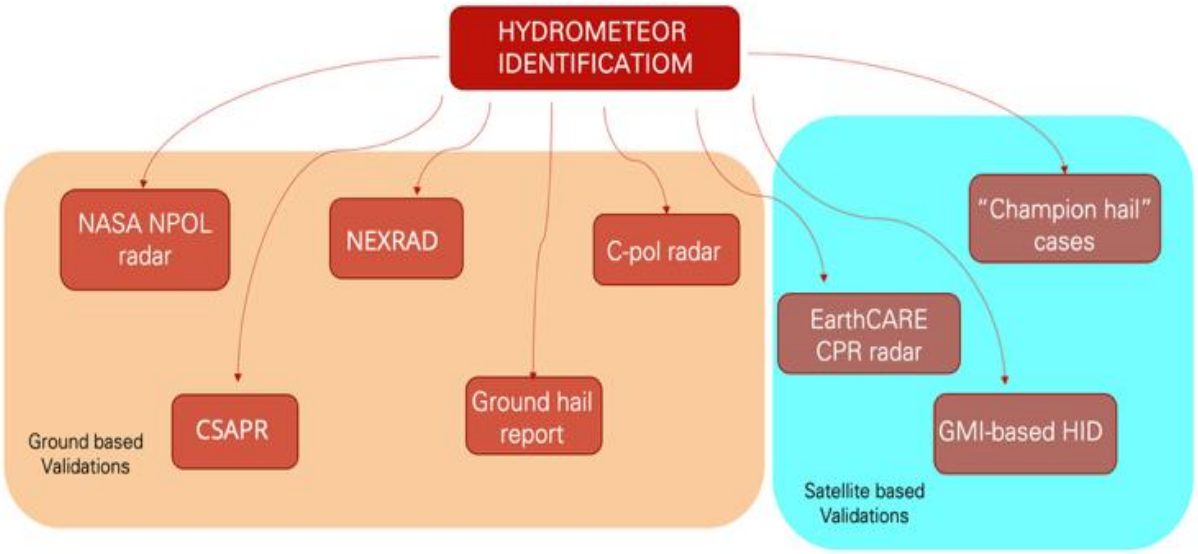
- In the initial phase, five hydrometeor types will be introduced. They are dry snow/ice crystal (DS/ICE), wet snow (WS), graupel (GPL), hail (Hail) and rain (Rain). DS/ICE, GPL and Hail represent low-density, medium-density, high-density particles respectively. Ground Clutter is also considered as a category.

Products developed by our team (till version 7)

1, “Precipitation Type”;
2, “MLTop”;
3, “MLBottom”;
4, “MLquality”;
5, “flagSurfaceSnowfall”;
6,“flagGraupelHail”;
7, “flagHail”

- Precipitation type index (PTI) is a good indicator of different hydrometeor types.

GPM DPR VERTICAL PROFILING ALGORITHM



Validations we have successfully performed.

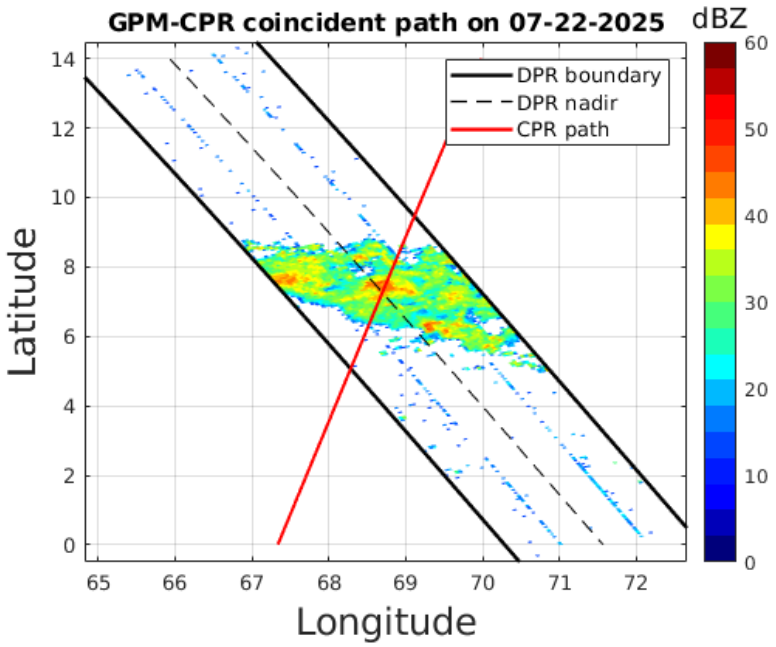
Criteria to choose cases:

- CPR has TC file (target classification)
- CPR and DPR have coincident overpasses
- Precipitation is observed

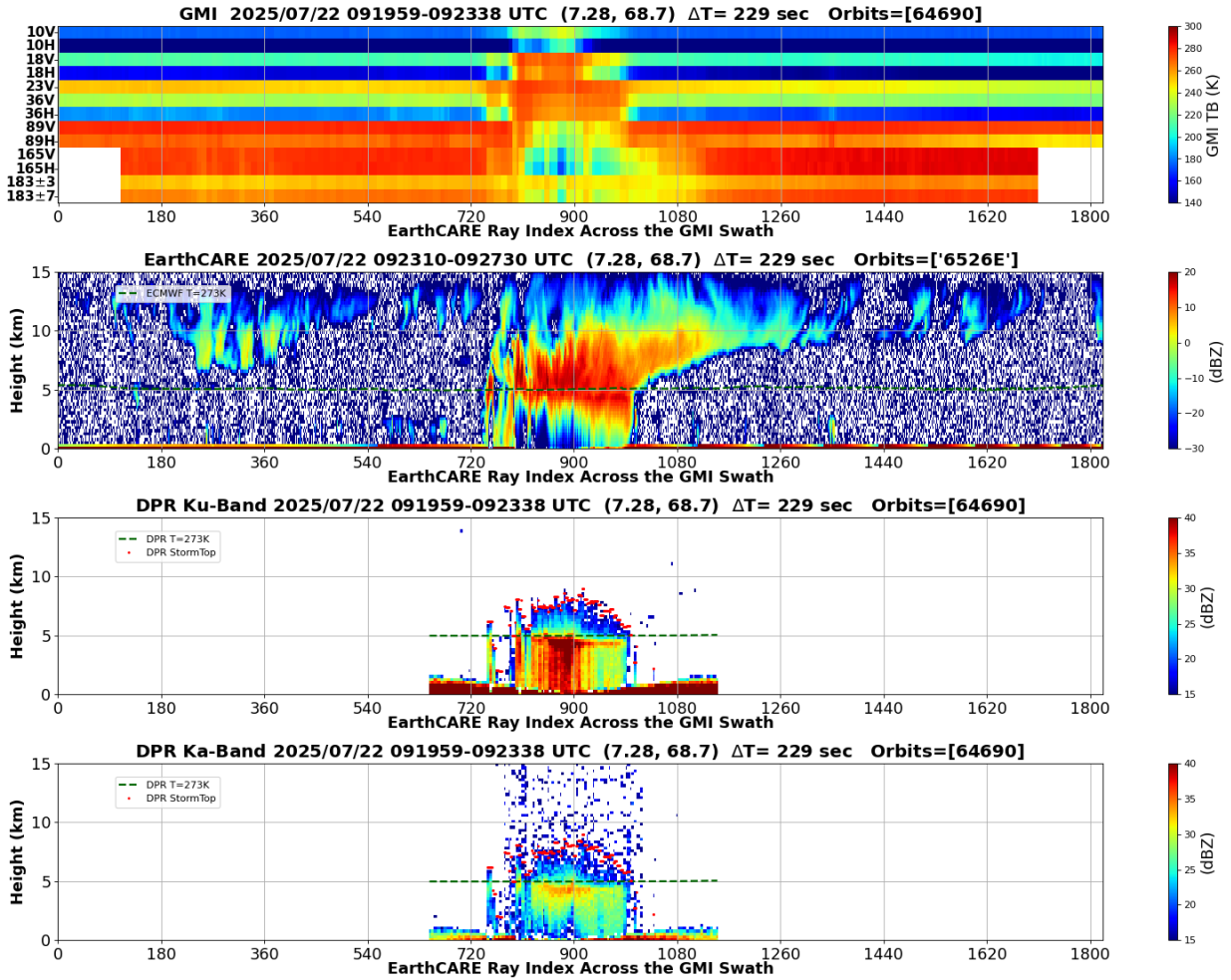
- **Key Research Results:** Cross validation of Hydrometeor products from EarthCARE CPR radar and GPM DPR radar. These cases illustrates promising comparison of hydrometeor types in various precipitation events between two different space radar system.
- **Significance:** GPM DPR hydrometeor profiling products are based on microphysics while the EarthCARE CPR hydrometeor products are using dynamics. Coming from different approaches, this kind of comparison and validation is incredibly meaning and convincing.
- **NASA Assets and Data:** GPM DPR data includes newly implemented hydrometeor products in Version 8 of L2 algorithm (will be released in 2026). EarthCARE data includes newly released CPR level 2 product of target classification.

Validation Example (case one)

2025-07-22 case

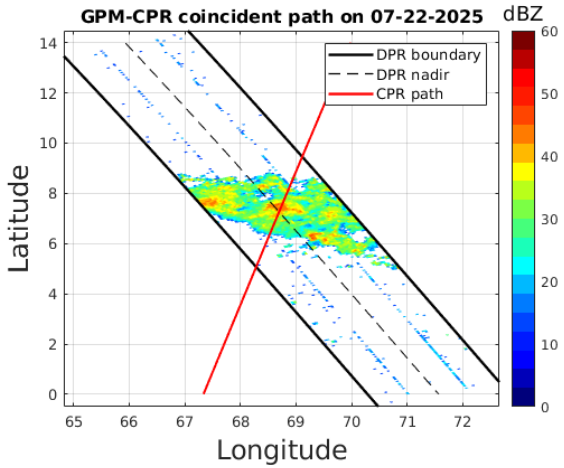


Precipitation event simultaneously observed by EarthCARE CPR radar and GPM DPR radar on July-22-2025 UTC 092730, in the Indian Ocean, east of the Indian subcontinent.



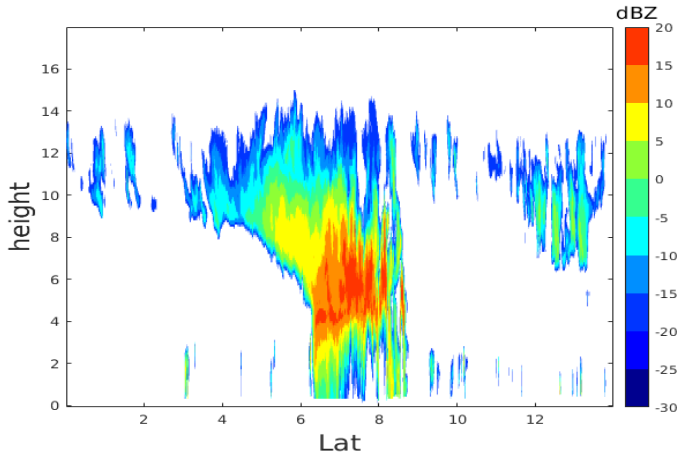
Curtesy EarthCARE-GPM coincident database.

Validation Example (case one)

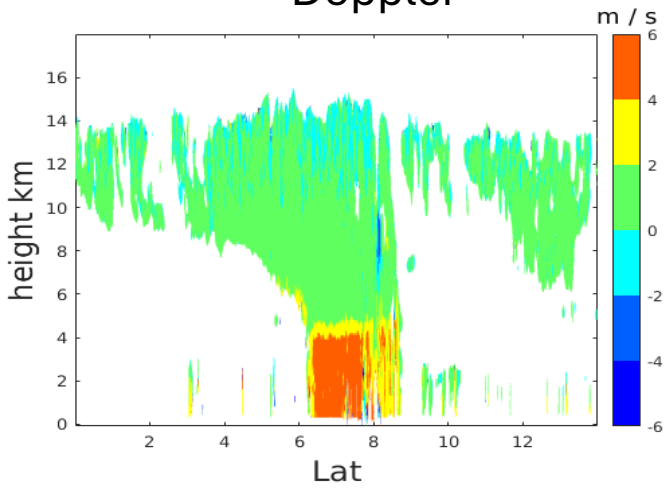


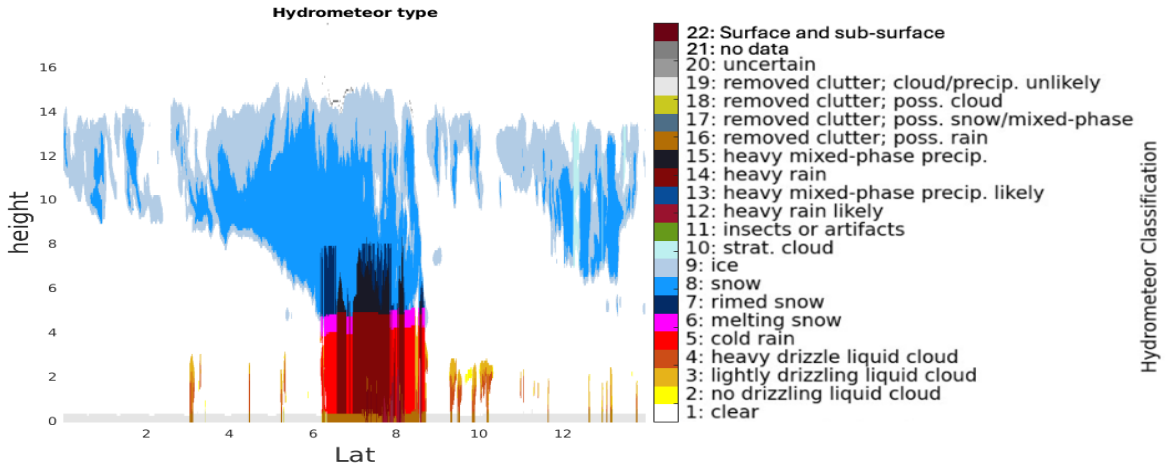
CPR observations

Ze (W)



Doppler

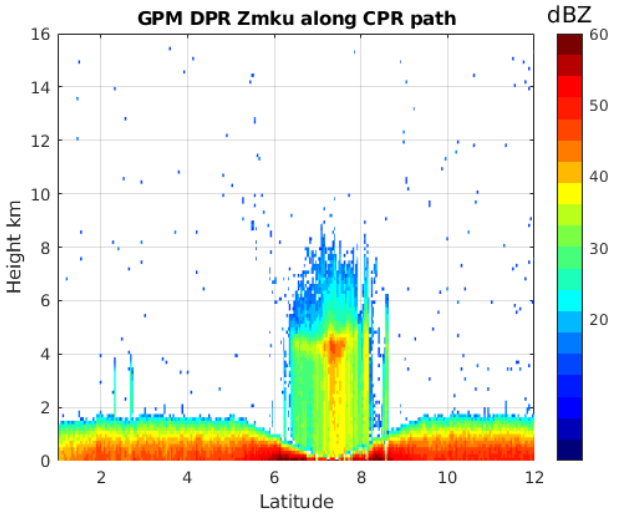


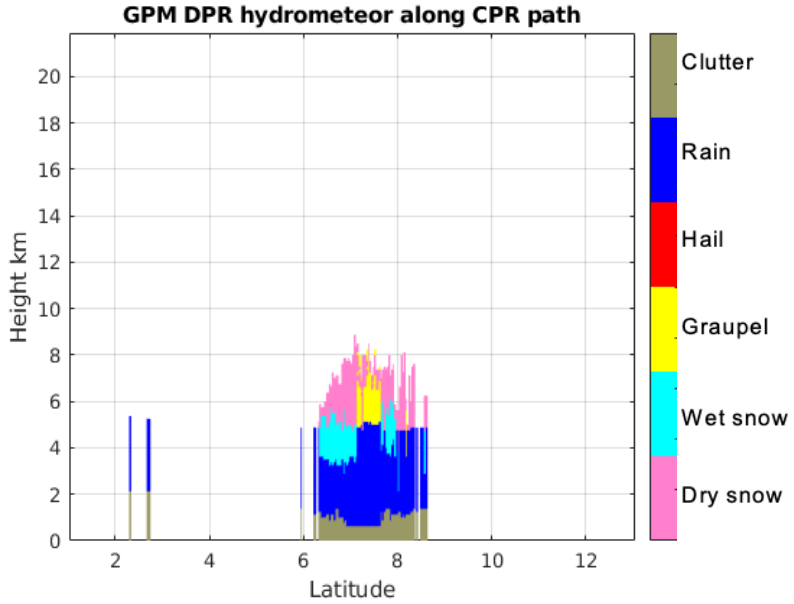


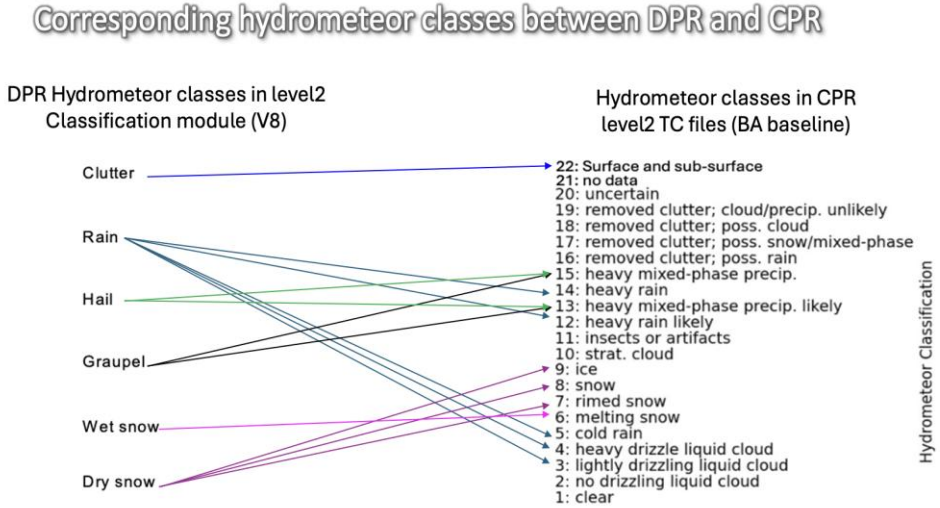
- Melting layer is around 4~5 km.
- Heavy precipitation is observed at latitude between 6~8 degree.

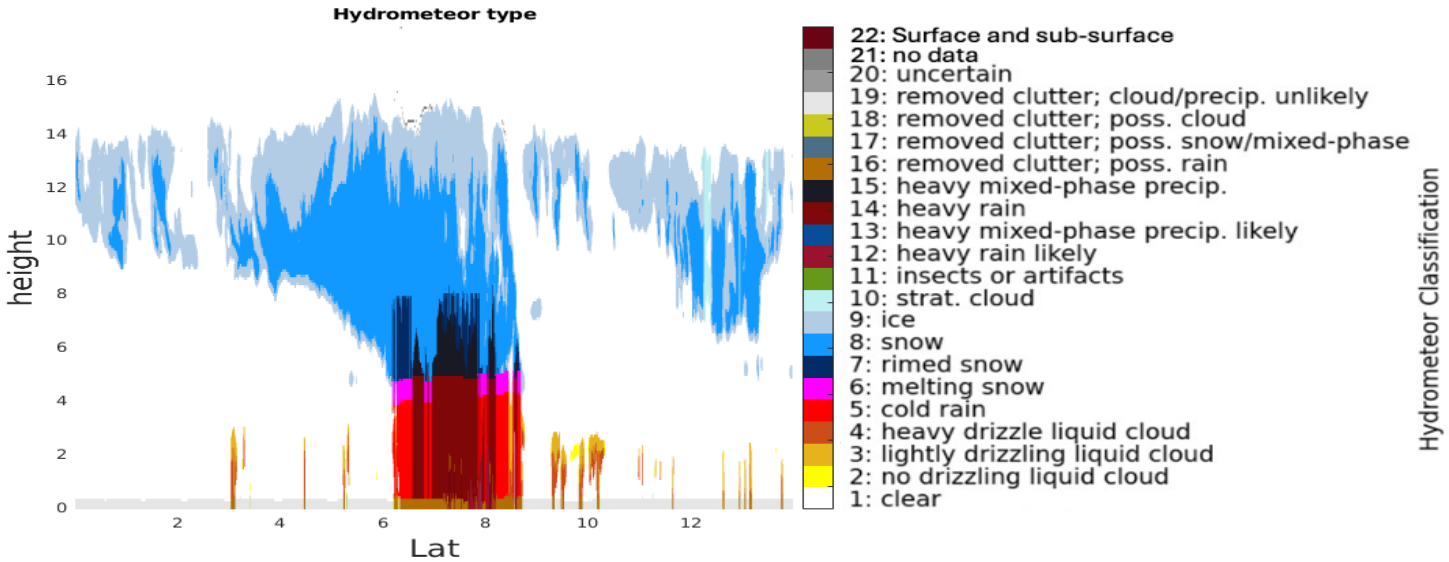
Validation Example (case one)

GPM DPR Zm (ku)





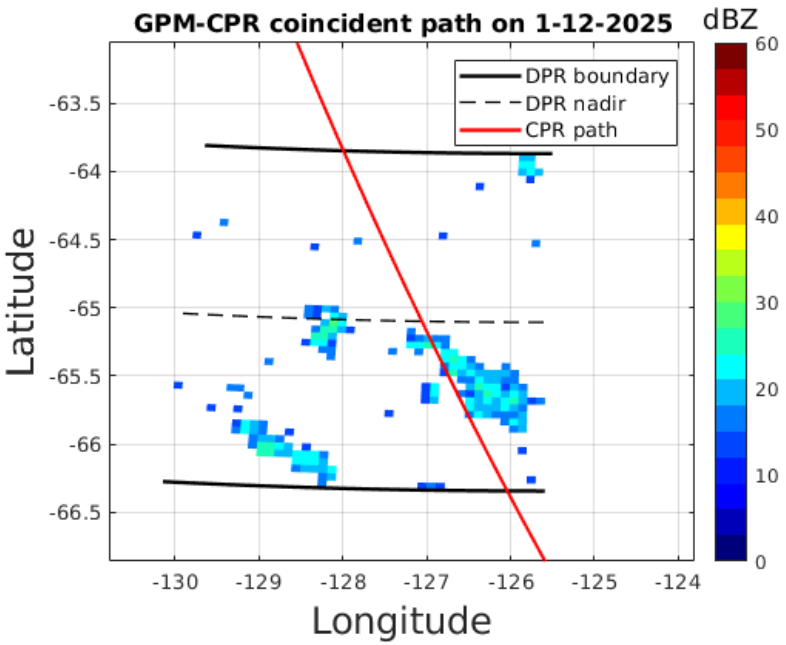




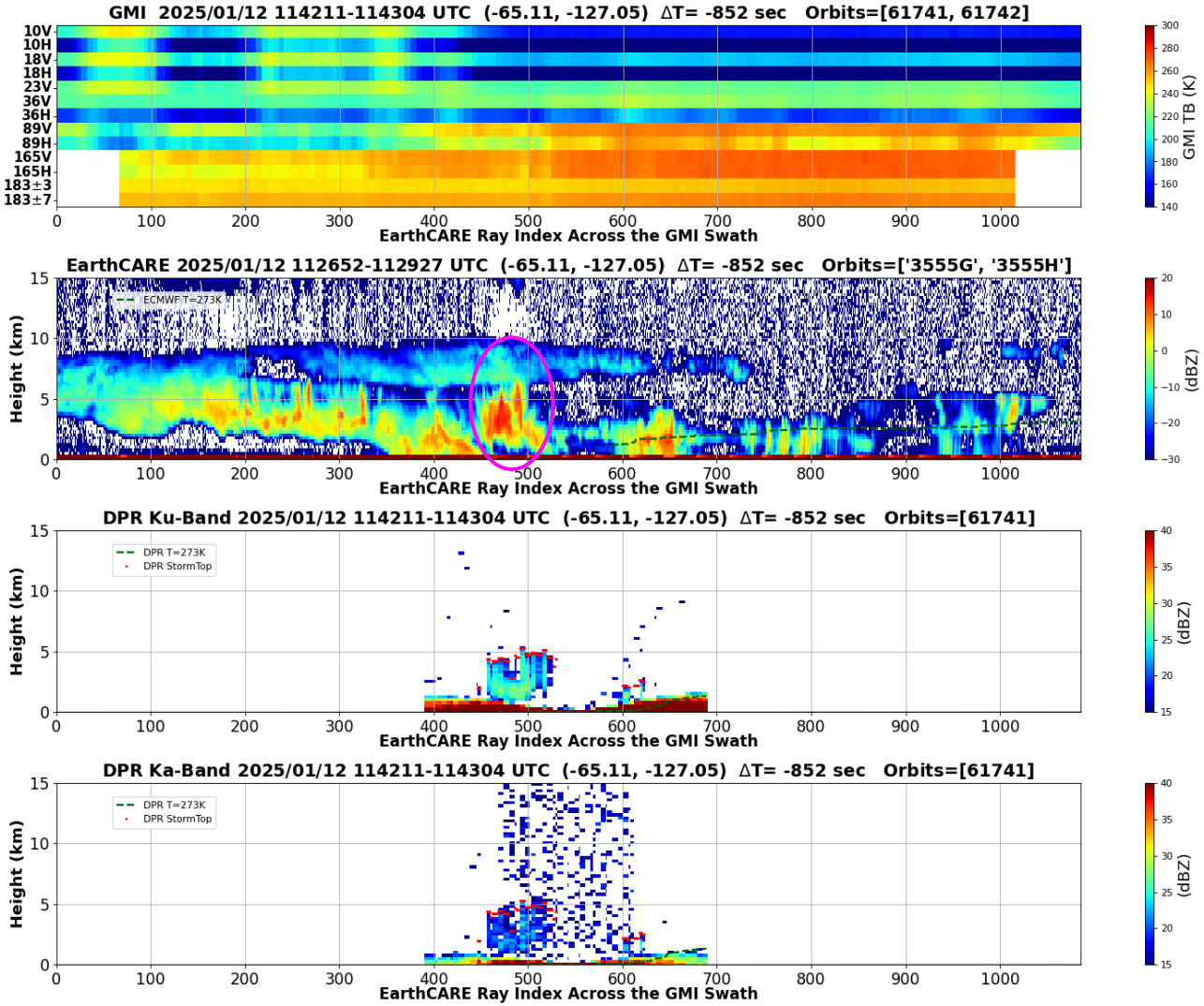
- Hydrometeor types from both radars identify melting layer around 4~5 km.
- Both radar detect heavy precipitation at latitude between 6~8 degree.

Validation Example (case two)

2025-01-12 snow case

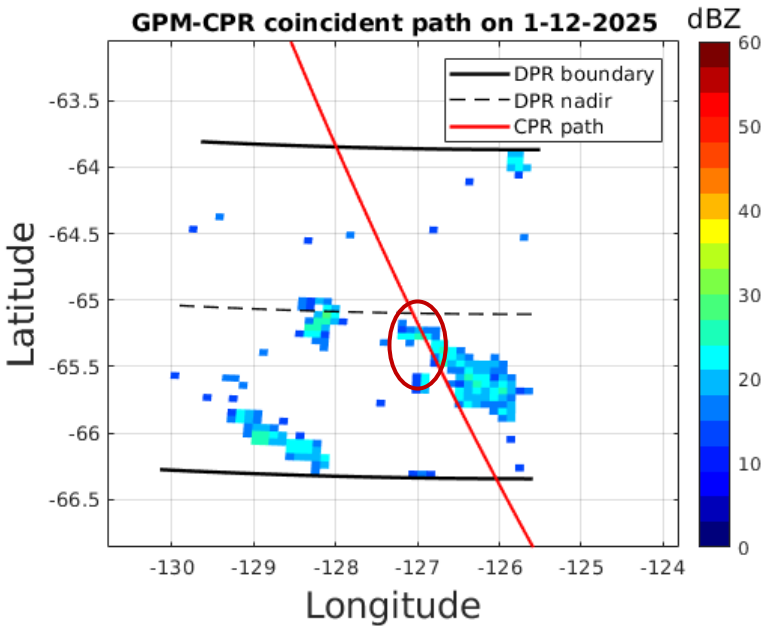


Precipitation event simultaneously observed by EarthCARE CPR radar and GPM DPR radar on Jan-12-2025 UTC 112652, at Southern Ocean, off the coast of Antarctica.



Curtesy EarthCARE-GPM coincident database.

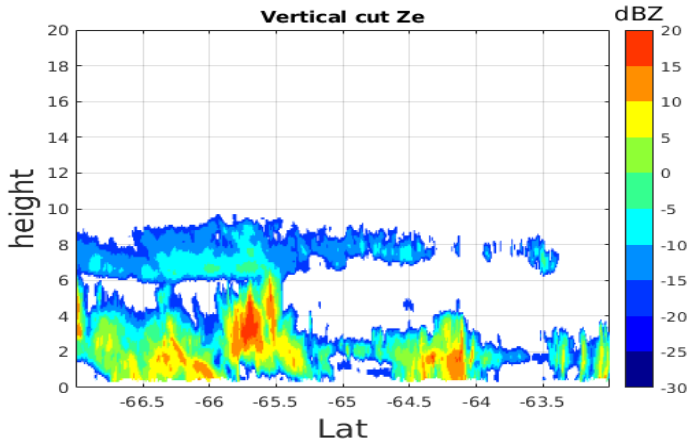
Validation Example (case two)



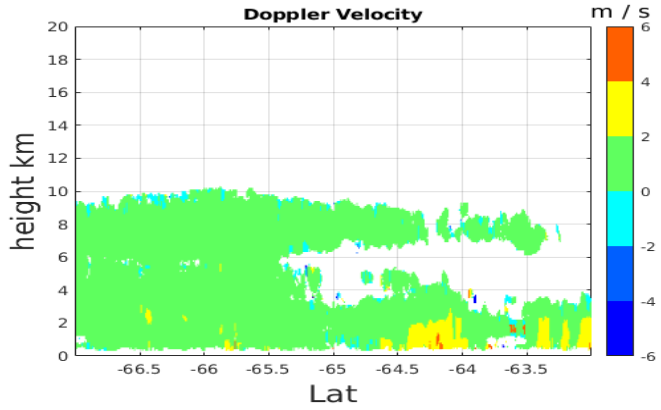
- Hydrometeor types is mainly snow, rimed snow and ice.
- Some melting happens at lower altitude around latitude –64.5 degree.

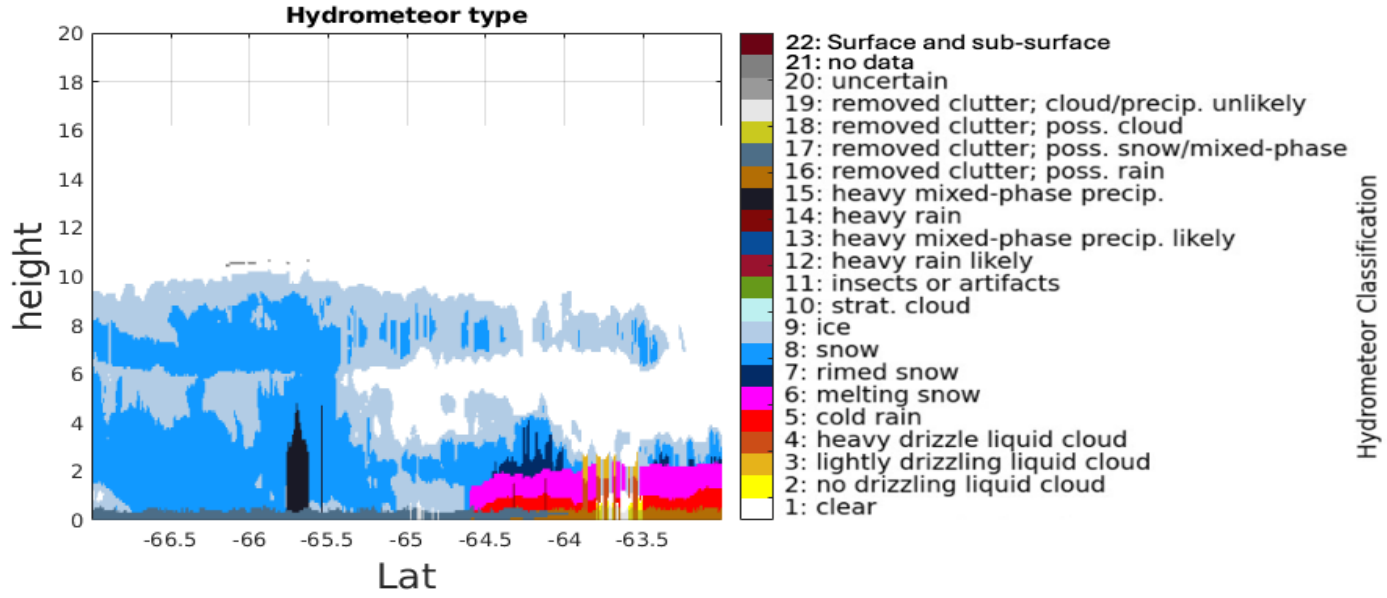
CPR observations

Ze (W)



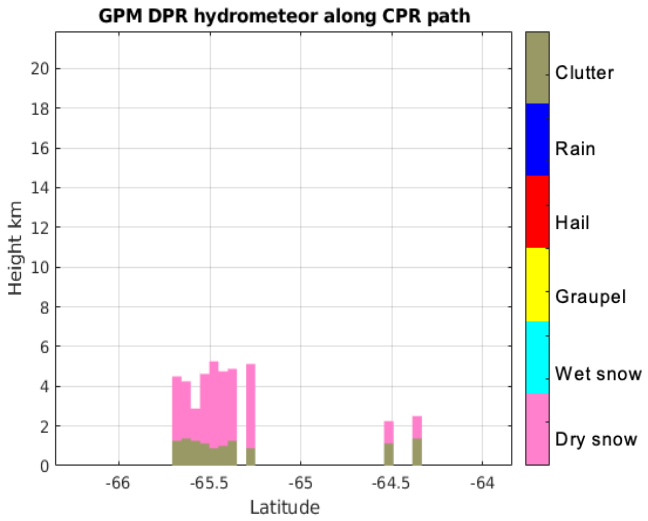
Doppler

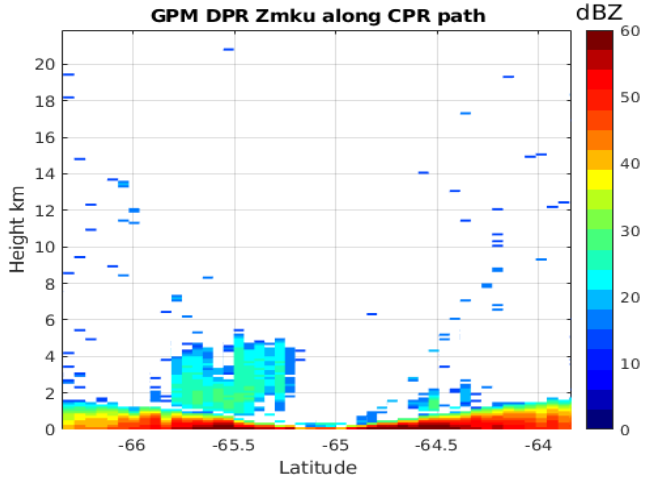


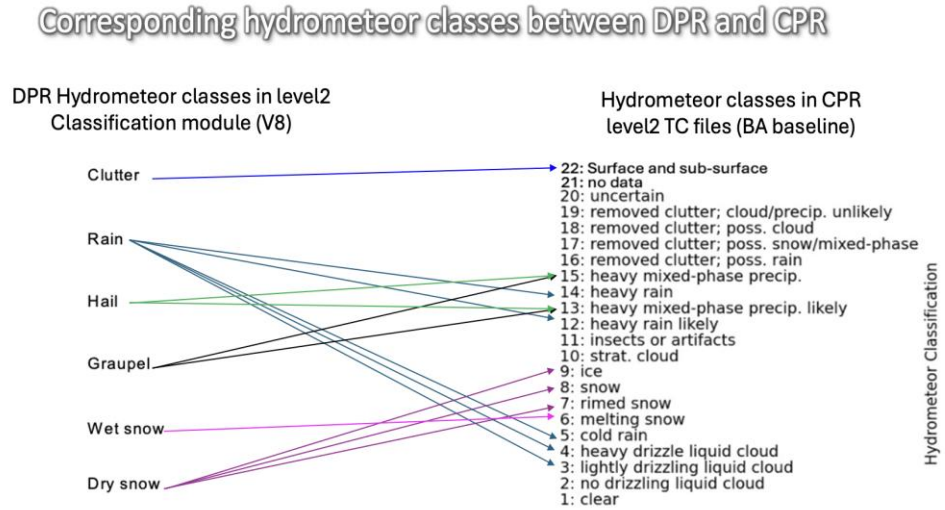


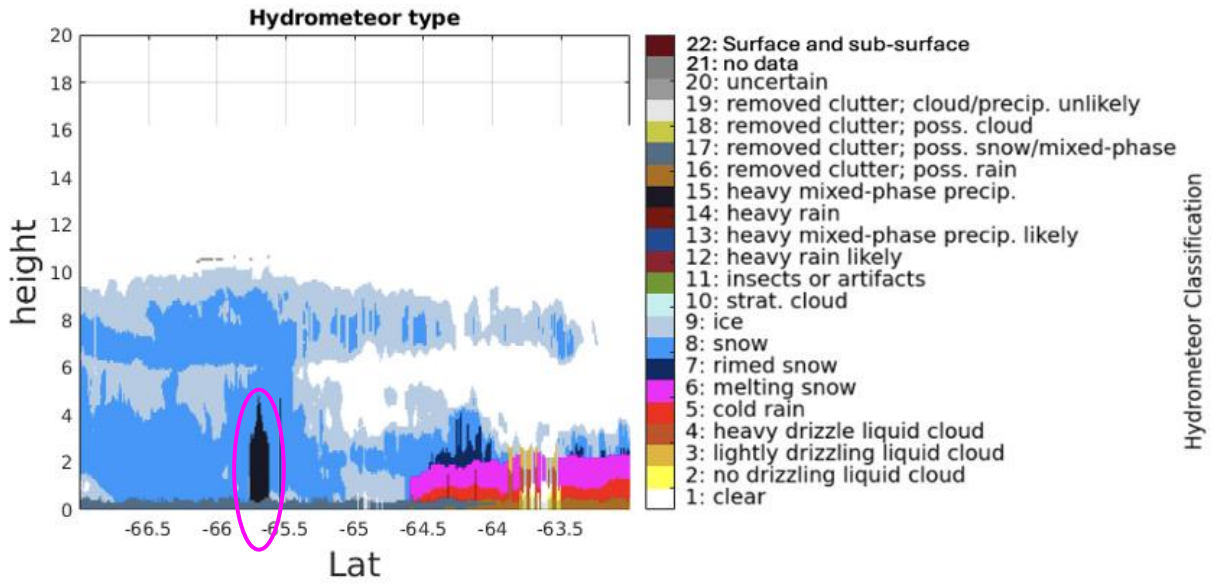
Validation Example (case two)

GPM DPR observations





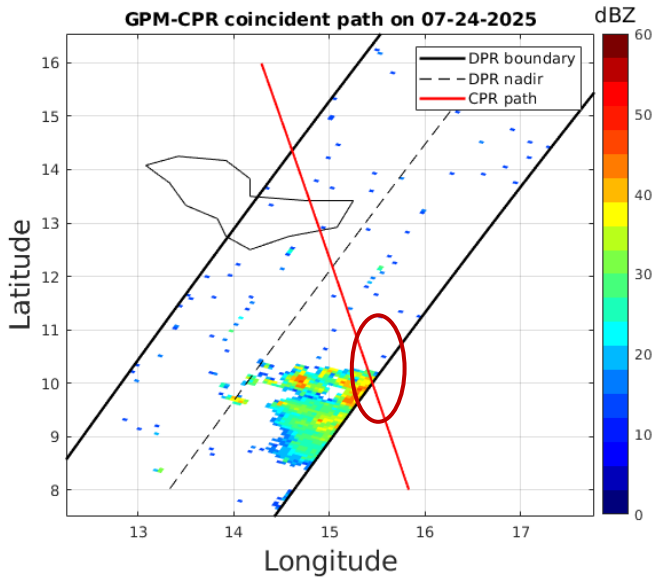




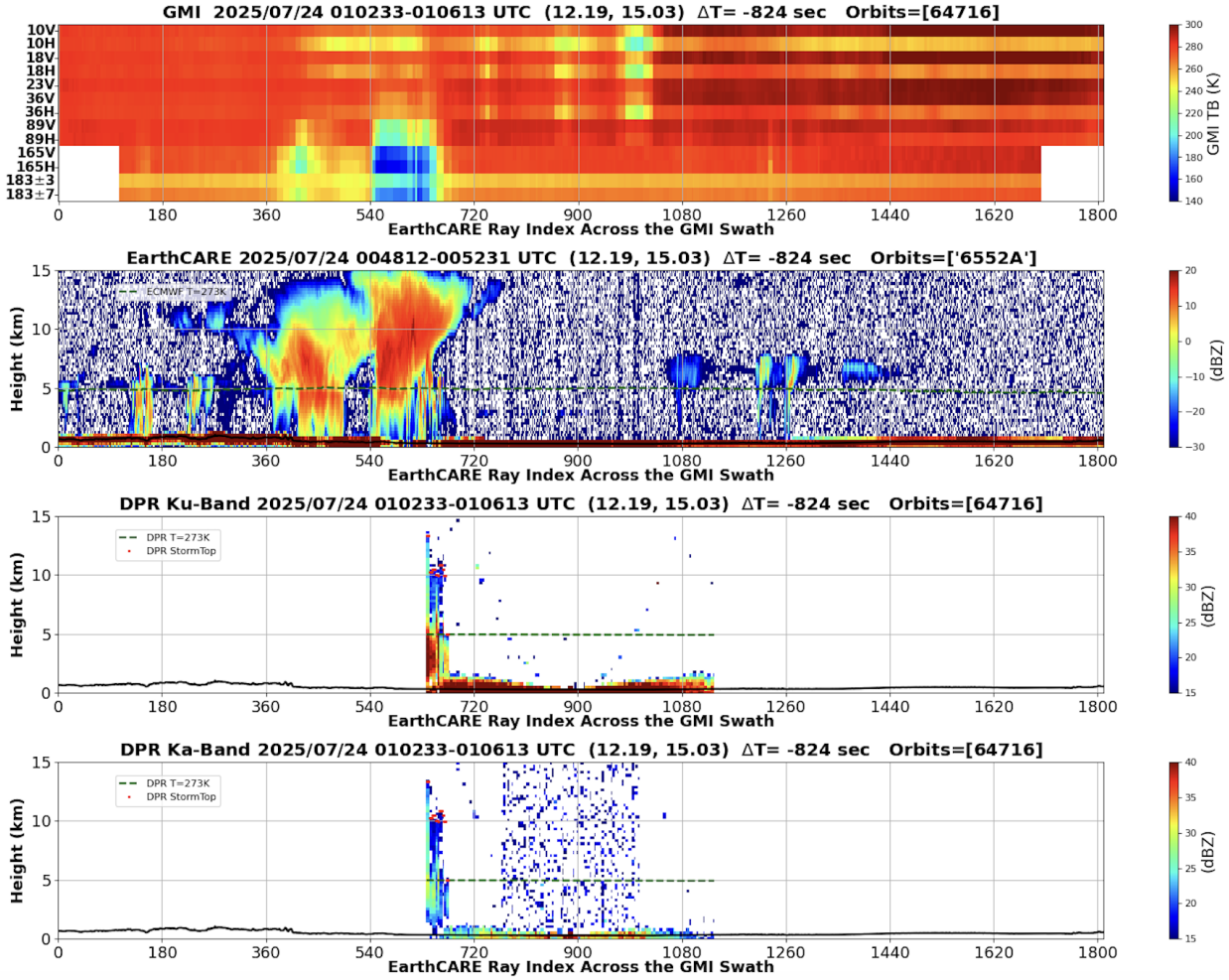
GPM DPR hydrometeor profiling algorithm and CPR TC products both detect dry snow for this case.

Validation Example (case three)

2025-07-24 case

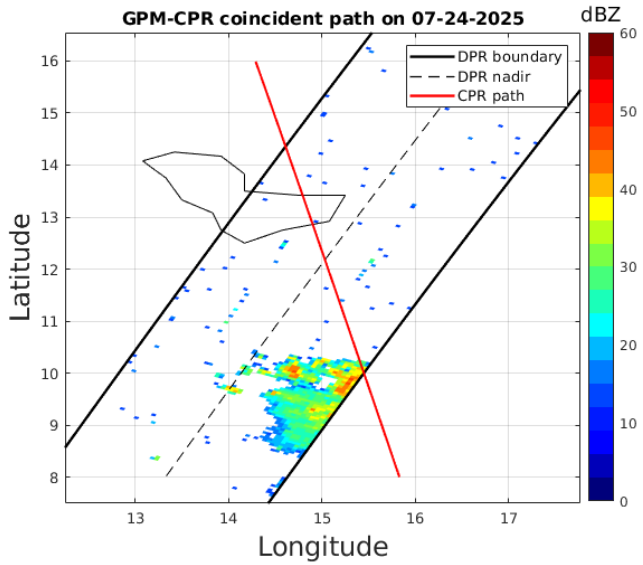


Precipitation event simultaneously observed by EarthCARE CPR radar and GPM DPR radar on July-07-2025 UTC 004812, east of the coast of Somalia and west of the island nation of Sri Lanka.



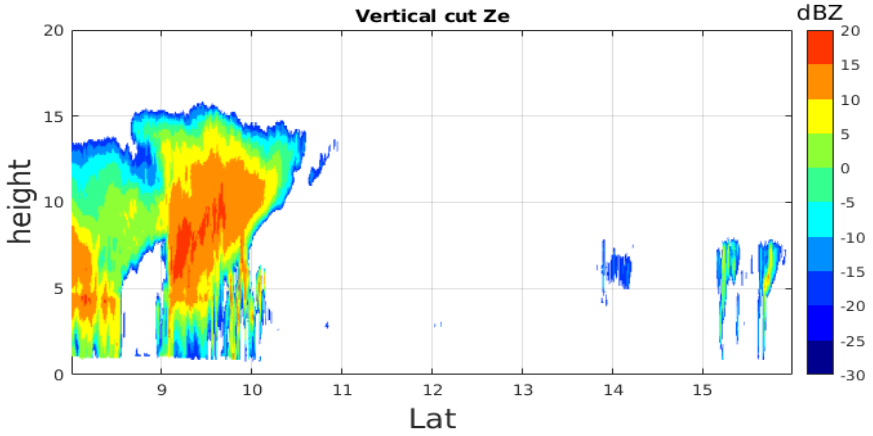
Curtesy EarthCARE-GPM coincident database.

Validation Example (case three)

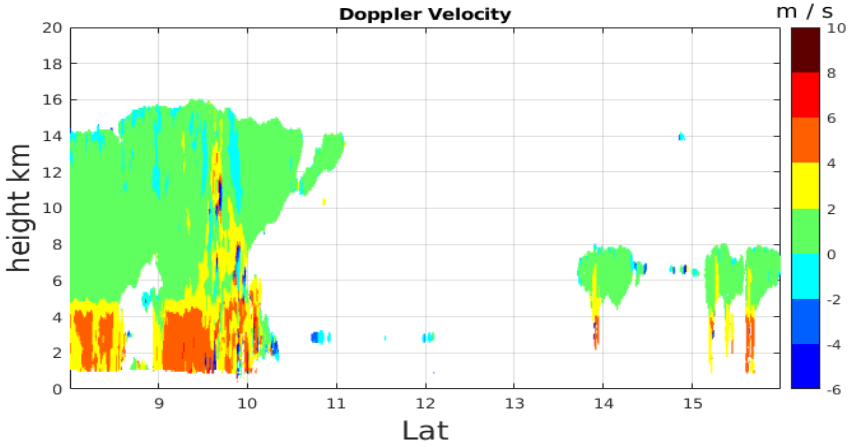


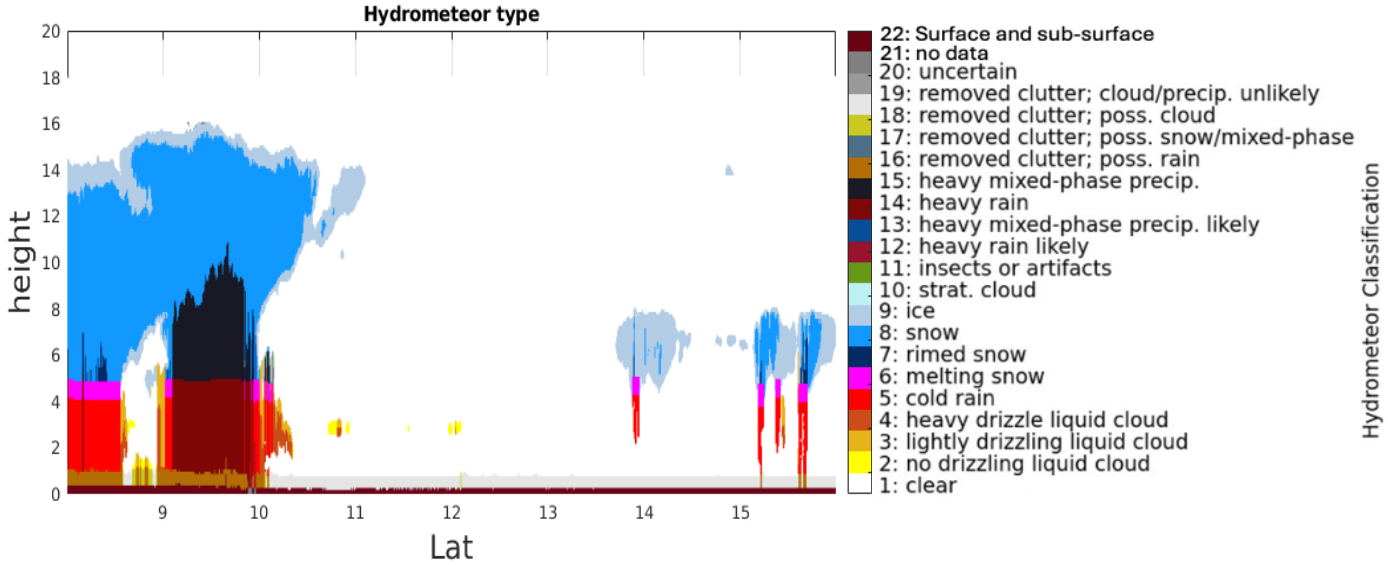
CPR observations

Ze (W)



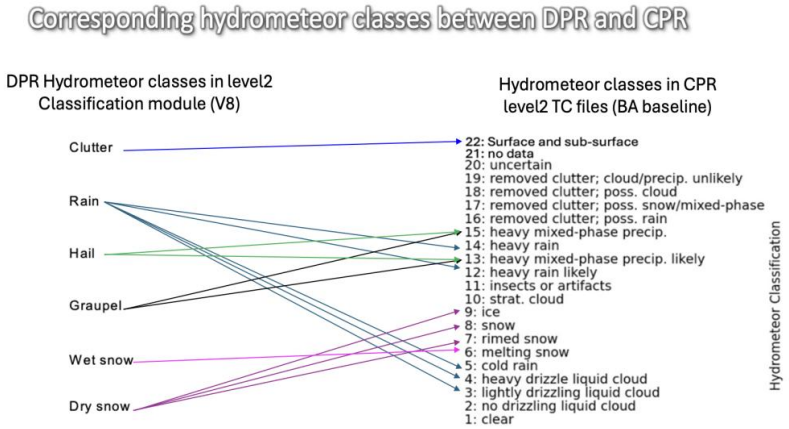
Doppler



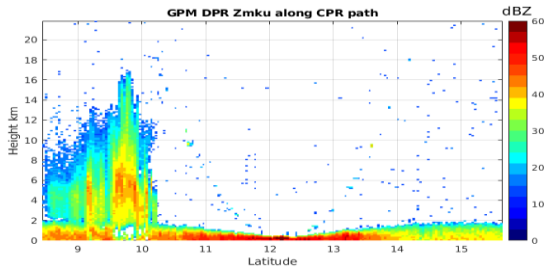


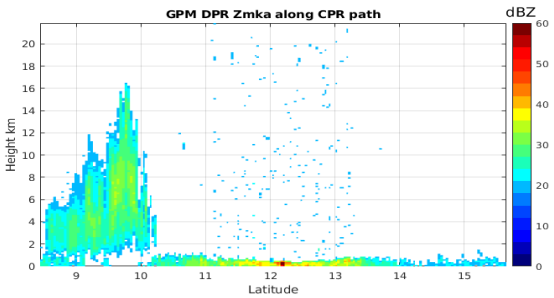
- Hydrometeor types is mainly heavy mixed phase precipitation.
- Some melting layer is detected at 4~5km.

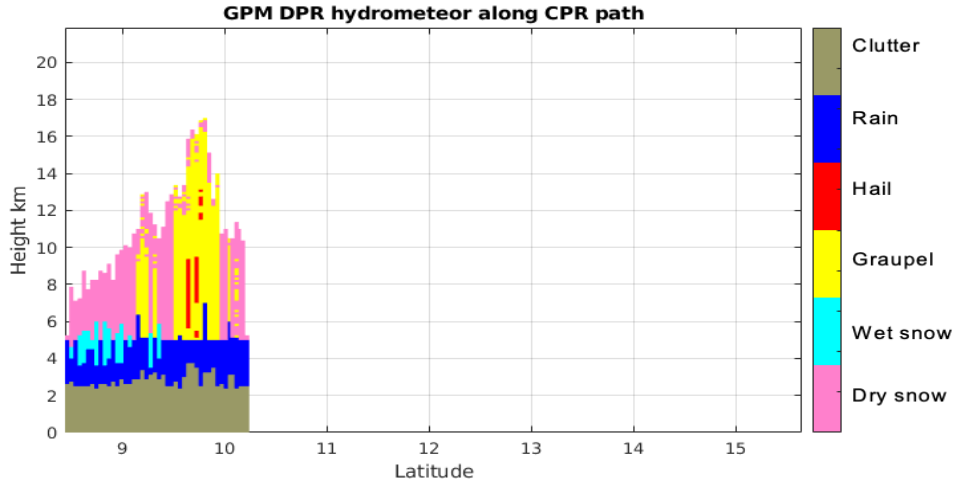
Validation Example (case three)

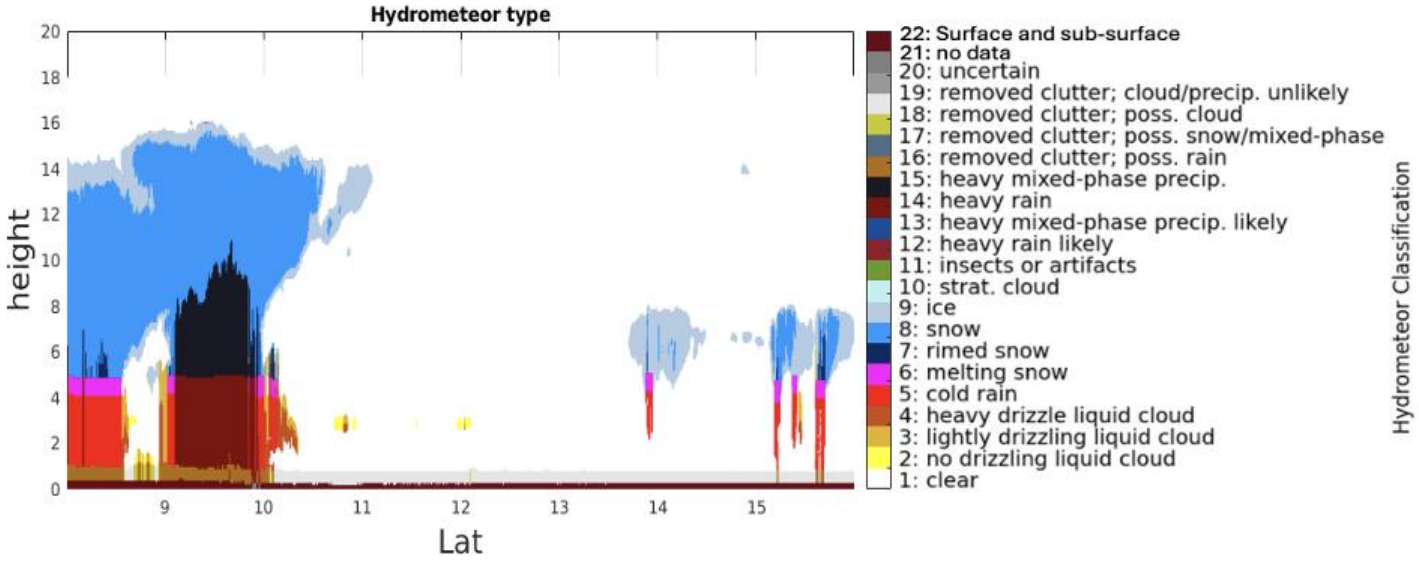


GPM DPR observations









Hydrometeor types identified from both radars illustrate promising comparisons. Graupel and a bit of hail are identified by GPM DPR at latitude between 9~10 degree. Melting layer is also identified at 4~5 km at latitude between 8~9 degree.

Summary

- Initial cross validation of hydrometeor products from EarthCARE CPR radar and GPM DPR radar are illustrated. These cases show promising comparisons of hydrometeor types in various precipitation events between two different space radar system.

- GPM DPR hydrometeor identification products are based on microphysics while the EarthCARE CPR hydrometeor products are using dynamics. Coming from different approaches, this kind of comparison and validation is incredibly meaning and convincing.

- Validations with more depth will be performed in the future including testing with different baseline products and quantitative analysis.

Thank you!