Validation Recommendations: Cloud and Precipitation

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Highlight and Recommendation on Cloud and Precipitation (Mason and Takahashi, EC WS Dec. 2025) (1)

Calibration

- long term monitoring of CPR calibration constant by independent approach (external calibration, roll maneuver, σ_0)

Radar reflectivity factor validation

- further combination with other satellites
- utilization of multi-frequency radar (W, Ka, Ku, and X-band radar)

Doppler velocity (air motion and/or sedimentation velocity)

- Add flag on reliability (e.g. multiple scattering region, folding region)
- How can we inform Doppler velocity unfolding? i.e. first-guess as structure of vertical air motion in deep convective clouds
- Effects of ice processes on Doppler features: dendritic growth & riming; representation in models

Highlight and Recommendation on Cloud and Precipitation (Mason and Takahashi, EC WS Dec. 2025) (2)

- Target classification
  - more validation activities incl. in-situ observation (macrophysical structure & phase: supercooled layers, cloud-base, etc.)
  - validation activities on non-meteorological target (e.g. insect) for future classification categories
  - Continue capitalizing on long record of ground-based sites and networks (e.g. CloudNet) to answer specific questions needed to inform EarthCARE algorithms:
    - Thickness of melting layer & melting layer attenuation
    - Cloud-base height (when precipitating)
    - Sublimation/evaporation of precipitation near surface
    - *Can these be expressed as a function of X-MET variables?*
- Geophysical products
  - Always need more in situ flights in regimes of interest:
    - Ice clouds (& mixed-phase, supercooled layers): validating PSD assumptions to satisfy both ATLID and CPR
    - Warm liquid clouds & drizzle (stratocumulus, trade cumulus, southern ocean): *porpoising flight pattern to sample profile*
  - LWP comparison with ground-based microwave radiometer: *how to vertically distribute liquid water content given LWP?*
  - vertical air motion with atmospheric radars (e.g. MU radar, EAR, PANSY)
  - use of polarimetric information of ground-based/airborne radars (e.g. rain rate over water)
- Support the development of cloud synergistic products with observations from other missions (e.g., MTG, PACE, 3MI)

Target variables to be validated

targets, variables	method	presentations in this WS
Various types of clouds	remote sensing	contrail: Marjani (T324), Dimitropoulou (T325) ship tracks: Smith (T310) near surface processes: Roversi (P050)
Cloud particle type, incl. mixed phase	in situ obs. (aircraft) remote sensing (ground) ground based pol. radar Radiative closure	Kim (T120), David (T423) & Carlsen (T424) Marinou (T323), Phillips (P020) Chandrasekar (T202), Takahashi (P006) Pery (T319), Ewald (T322)
drop size distribution	in situ obs. (ground)	Adirosi (P010)
LWC (LWP), IWC (IWP)	in situ obs. (aircraft) remote sensing (aircraft)	Francois (T302), David (T423) & Carlsen (T424) Francois (T302)
vertical air speed / sedimentation velocity	in situ obs. (aircraft) remote sensing (aircraft) remote sensing (ground) Comp. with GPM	Okamoto (S115), Kim (T120), Ohno (T204), Takahashi (P006) Aoki (T501)
Precipitation	comp. with GPM Virga/evaporation/sublimation	Various authors (ECWS Dec. 2025) Roversi (T422, P050)
non-meteorological target	in situ (ground)	Mason (ECWS Dec. 2025)
global 3D distribution	comp. with CloudSat model comp.	Okamoto (S115) Mason (T118)

see “**Highlight and Recommendation on Cloud and Precipitation**” **(EC WS Dec. 2025)**

Recommendations

The verification of clouds and precipitation is proceeding smoothly

- Results from the analysis of aircraft experiments and ground observation data have been presented during this WS.
- In addition, analyses on various kinds of clouds (e.g. ship tracks and contrail) were presented.
- Algorithm developers requested more validation results on particle categories, strongly related to radiative closure studies comparing ice particle properties.
- Iterative feedback from workshops has been instrumental in improving L2 products
- Radiative closure studies reveal the importance of cloud macrophysical structure at cloud-top and at cloud-base.

In light of these circumstances, we recommend the following:

1. validation of particle categories (in situ observation) to inform scattering properties for retrievals, forward models, radiative transfer modelling
2. provide QCed observational data available to the community.