CPR session summary

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1st ESA-JAXA EarthCARE In-Orbit Validation Workshop

14 – 17 January 2025 | VIRTUAL EVENT

General summary 1: CPR performance and Level 1 algorithm

- Generally, CPR performs as expected:
  - Better sensitivity than CloudSat/CPR (Ze < -35dBZe) Nakatsuka Horie
  - Doppler velocity observation and its accuracy are satisfactory Imura Pfitzenmaier
  - Different performance for different PRF (pulse repetition frequency) settings (e.g. 16, 18 and 20 km modes) as expected --- **proposal of 18km operation-mode, instead of 20km-mode, for 60S – 60N .** Imura
  - Geolocation is within the required range Treserras and Kollias Horie Nakatsuka
  - There were several issues recognized during the commissioning phase (see below). Nakatsuka
- Issues solved (causes are confirmed):
  - HPT switch-off by body current (decreasing trend and JAXA will improve the system to reduce the unobservable period) Nakatsuka
  - I, Q offset (rainbow color Doppler velocity field). Now good with SPU-B (primary side). Nakatsuka

General summary 2: CPR performance and Level 1 algorithm

- Issues solved (continued)
  - Calibration was improved by ARC. Horie
  - Bug fixed in Doppler spectrum calculation in Level 1
  - mirror images appear as 2nd trip echo ---Methods are established. (The algorithm is currently applied in Level 2, Will these be applied to Level 1?). ESA-JAXA also need to discuss (if overlapping, the mirror Z should be subtracted).
- Issues unsolved
  - The differences in calibration of Ze still exist against CloudSat (~2dB).
  - Beam pointing correction (critical for capturing zonal climatology of Doppler signal)
  - Surface detection were sometimes incorrect for heavily attenuated profile (NICT will investigate)
  - Artificial echo at 2.5 km altitude (JAXA will investigate)
  - PRF dependency of Doppler spectrum width (JAXA-NICT will investigate)
  - Noise floor underestimation (JAXA-NICT will investigate)

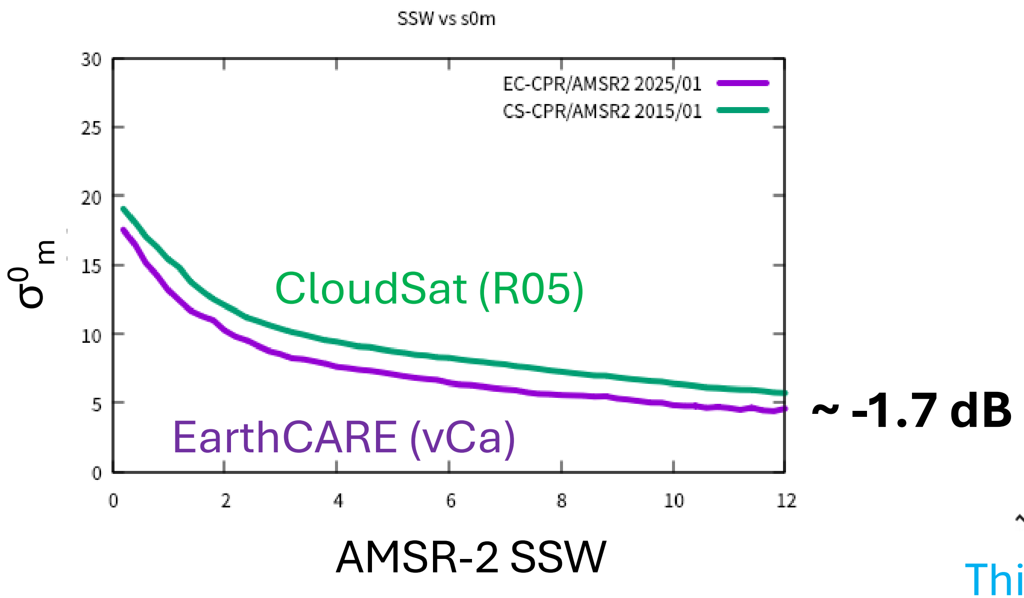
Nakatsuka
Aoki
Kollias
Pfitzenmaier
Kanemaru
Feilding
Borque
Ewald
Kollias
Kollias
Nakatsuka
Kollias
Kollias

Radar reflectivity factor (Z) validation

Current CPR's reflectivity factor (Z) bias is about ~ -1.7 dB (after reflecting the external cal. result) or -4 dB (without external cal. result)

Comparison of σ_m^0 with CloudSat data

σ_m^0 measured by EC-CPR (vCa) is slightly (~1.7 dB) lower than to that by CS-CPR

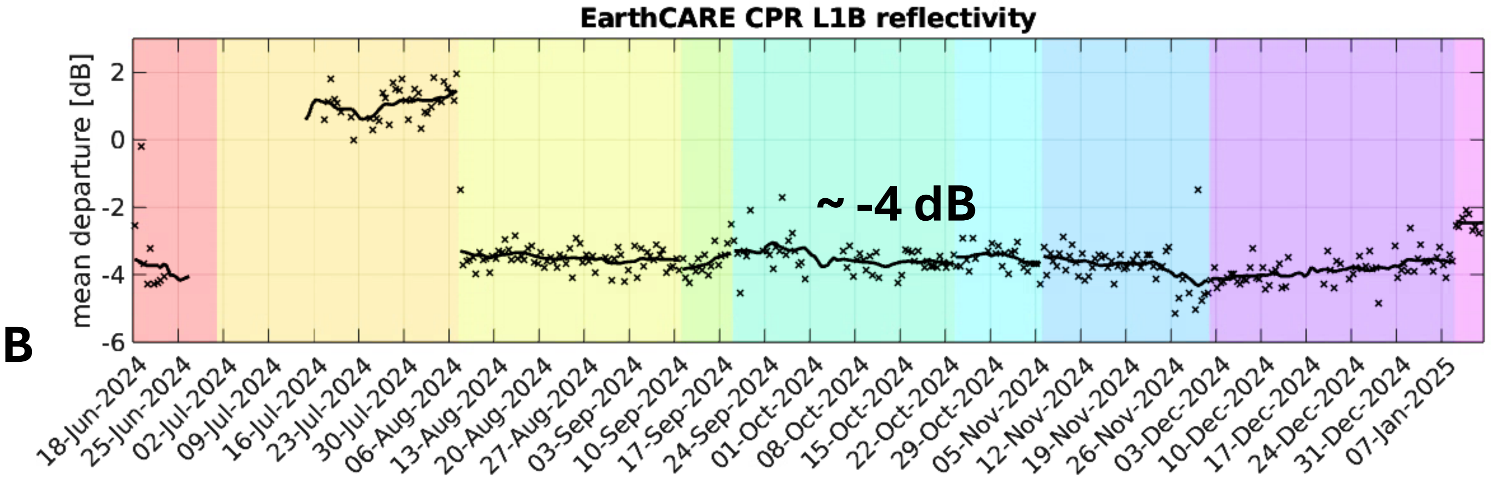


EarthCARE(EC)-CPR: 2025/01/01-2025/01/14 (vCa)
CloudSat(CS)-CPR: 2015/01/01-2015/01/31 (R05)

Kanemaru

Comparison with ECMWF radar reflectivity

(without external cal. result)



This method has the advantage of being applicable on very short time scales!

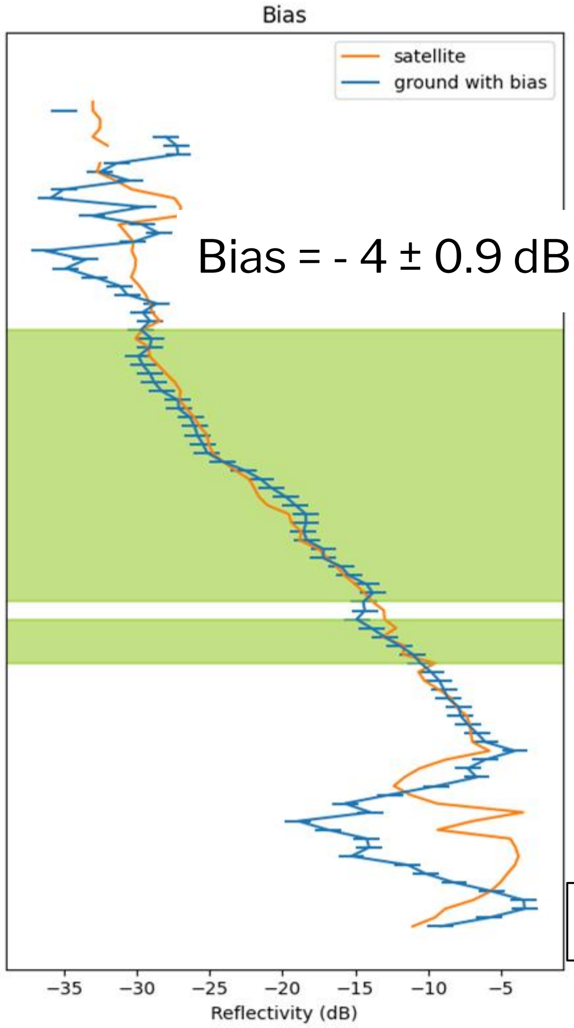
Feilding

Radar reflectivity factor (Z) validation
comparison with ground-based and aircraft obs.

JAXA esa

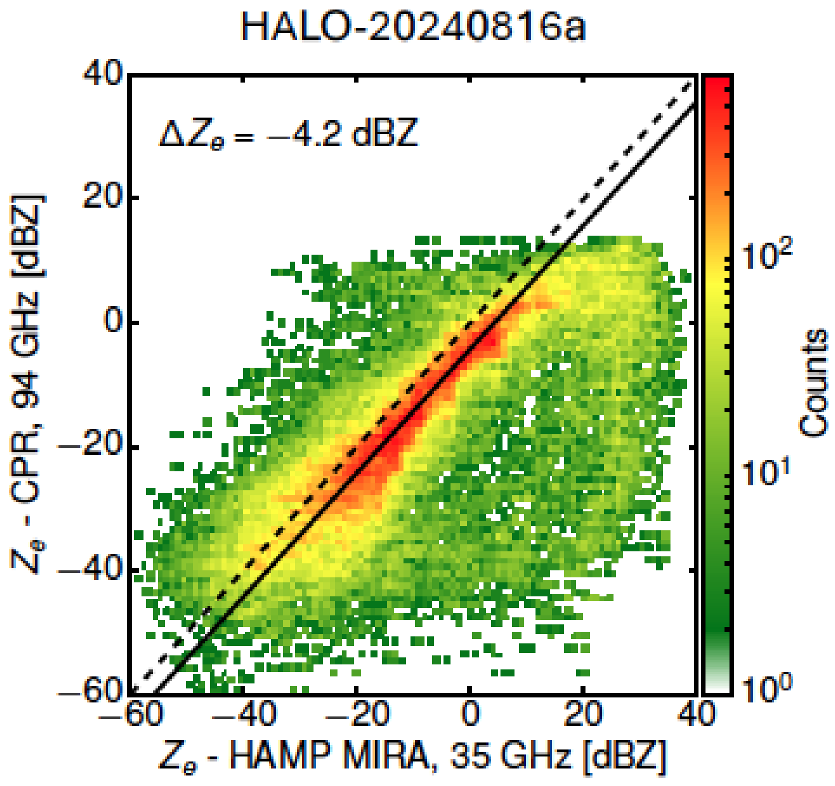
Comparison with ground-based/airborne observation shows about -4 dB bias (w/o external cal. result)

ACTRIS' ground-based radar network



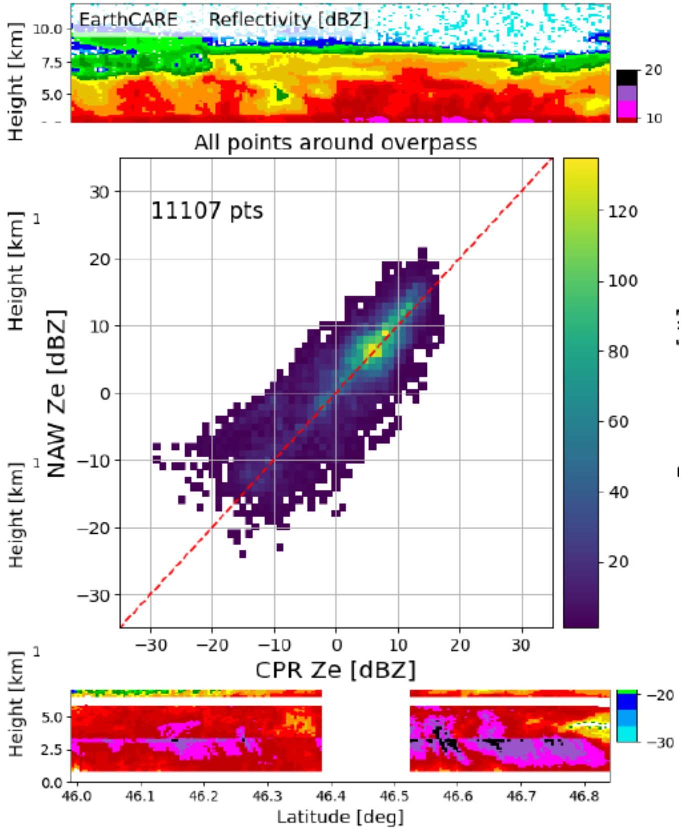
Pfitzenmaier

Comparison with MIRA onboard HALO



Ewald

Comparison with NAW
(after +5 dB offset for CPR)



Borque

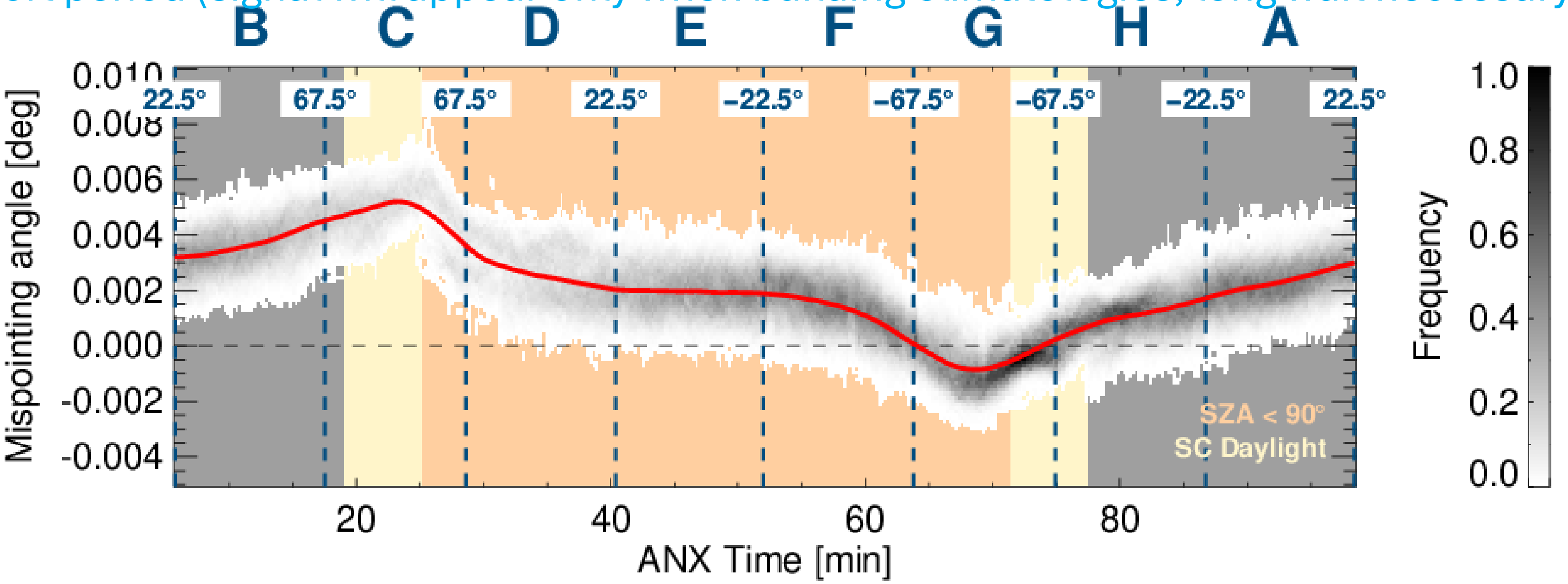
CPR antenna mispointing

- **Mispointing trends influenced by solar illumination cycles and thermoelastic distortions on the antenna.**
- **JAXA is almost ready to update the antenna distortion model.**

Kollias

Nakatsuka

This error can introduce biases in zonal climatology of Doppler signal. Note that it will be very challenging to use any ground based or airborne system to calibrate the Doppler to this level of accuracy in a short period (signal will appear only when building climatologies, long wait necessary).



Satellite line-of-sight velocity contamination

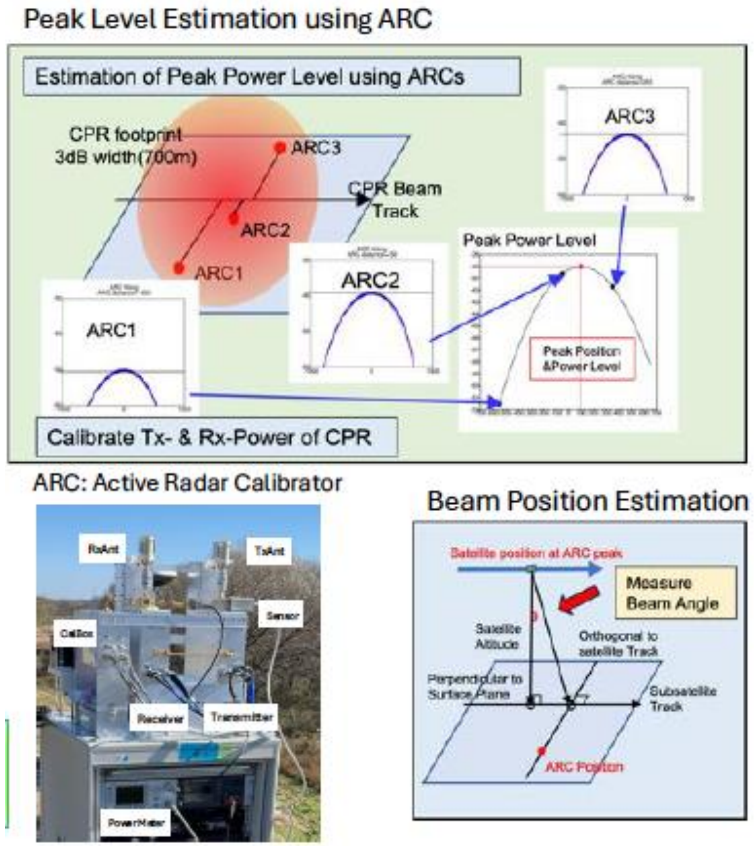
0.01°$_{(7.6km/s)}$ → 1.32m/s

Geolocation evaluation

Both external calibration with ARCs and coastline/geographical gradient detection methods confirmed that the **CPR geolocation is within the required range**.

Horie

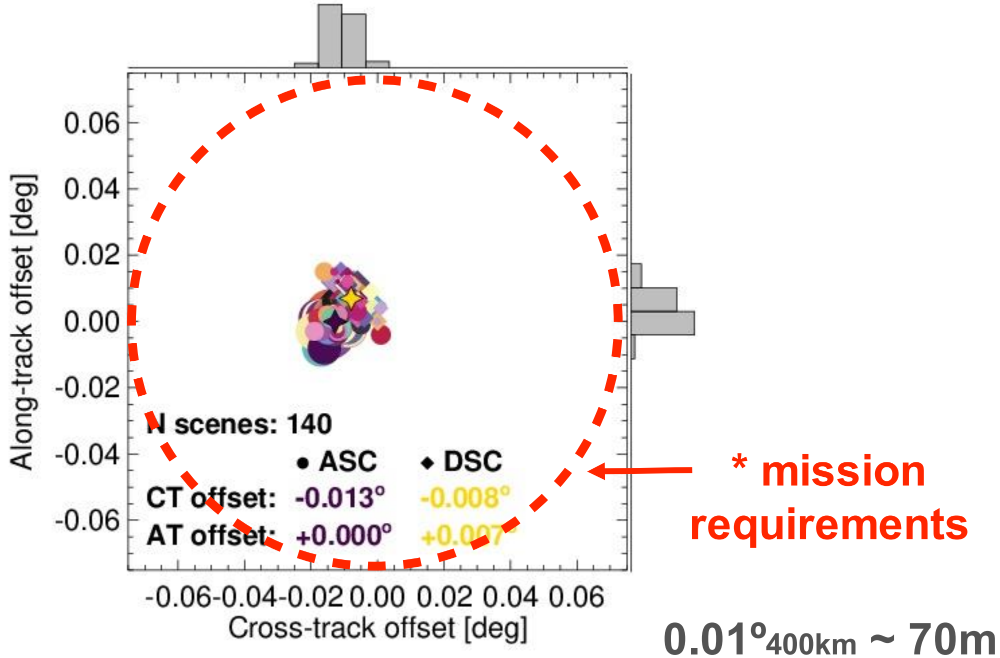
Treserras and Kollias (by van Zazelhoff)



Horie

Combined statistics

Dec 2024



0.01^{o}_{400km} ~ 70m

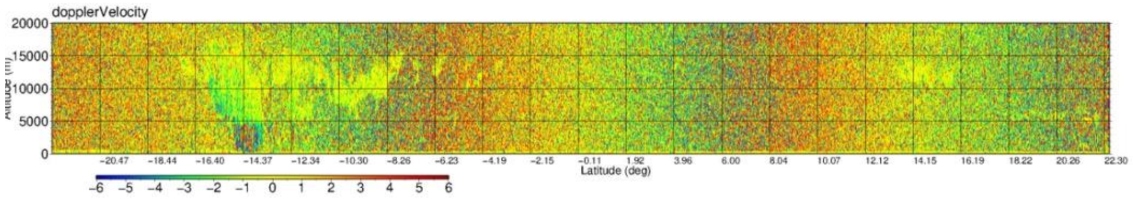
Treserras and Kollias (by van Zazelhoff)

I, Q bias correction (Top)
Artificial echo at 2.5 km altitude (Bottom)

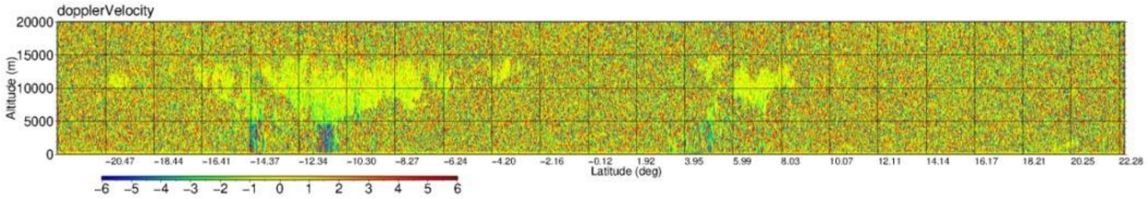
I, Q bias correction for SPU-B clearly reduces the Doppler bias of weak echo. (solved)

Nakatsuka

(Before IQ offset correction)

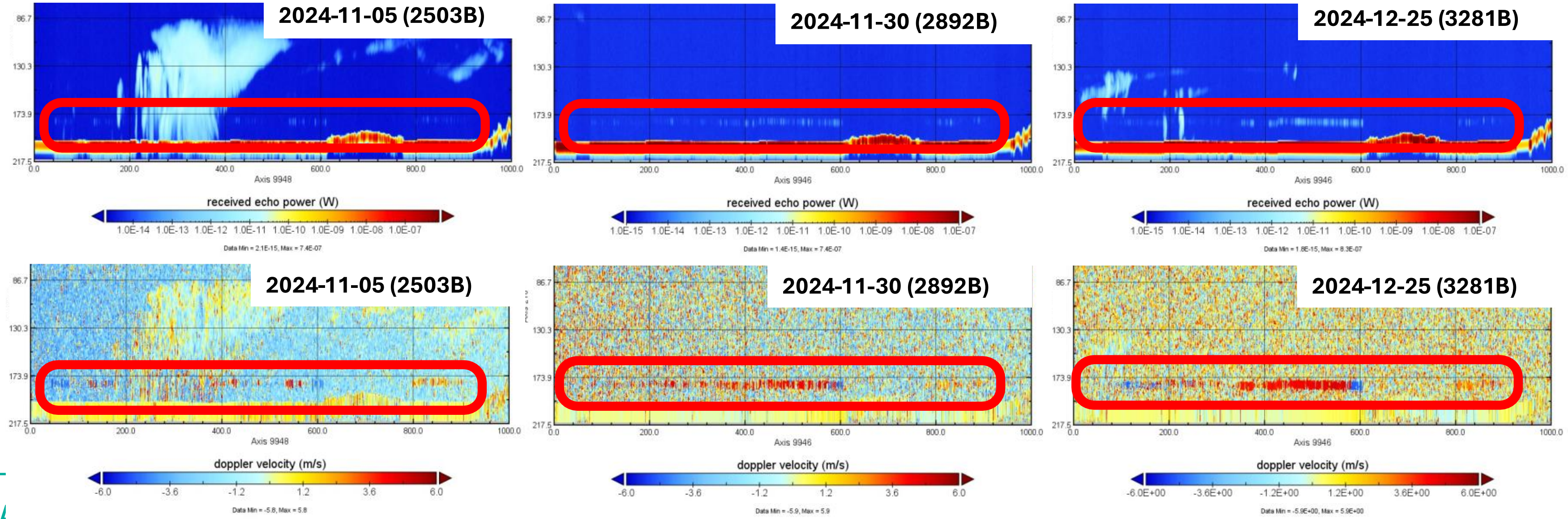


(After IQ offset correction)



Unexpected weak echo (Z and Doppler) appears when the surface return is very strong. JAXA continues to investigate the cause. Needs to be solved.

Nakatsuka | Kollias

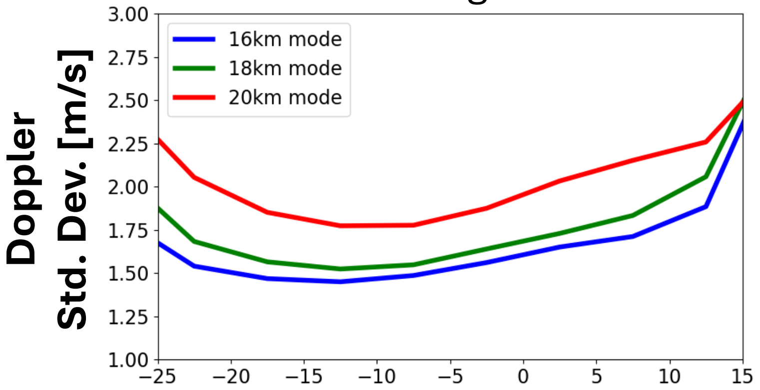


Doppler accuracy evaluation

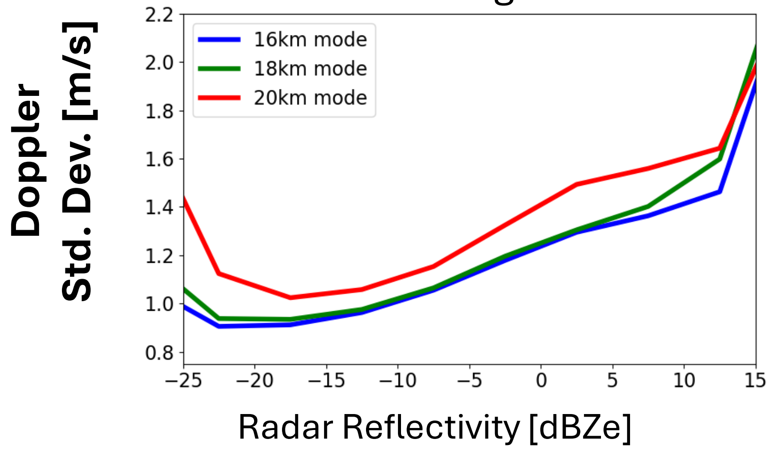
post-launch evaluation

Imura

500 m integration

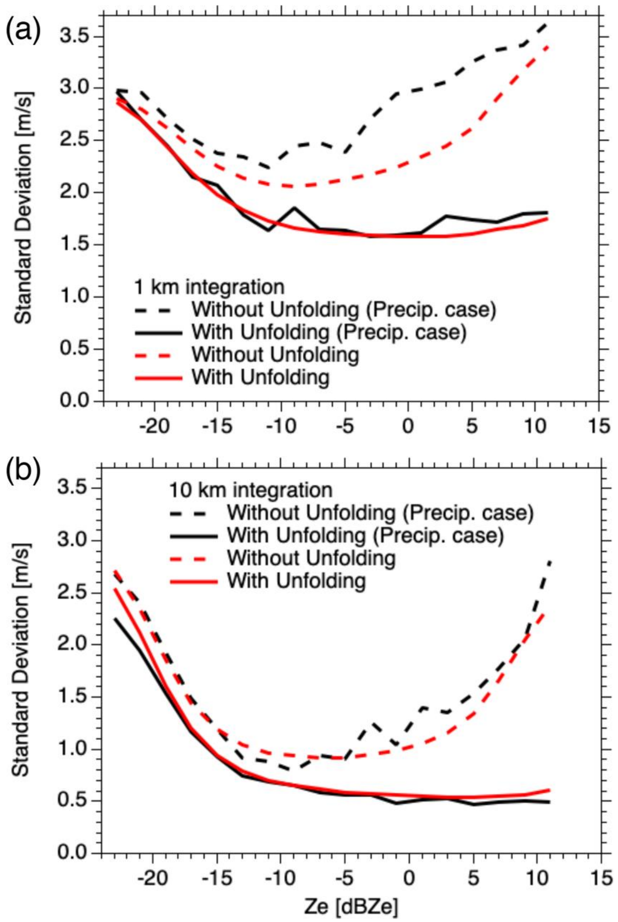


10 km integration



- Variability of Doppler velocity significantly reduced from 20 km mode (low PRF) to 18 km mode (high PRF almost comparable to that of 16km-mode).
- Very few cloud fraction appear above altitude of 18km.
- Comparing with pre-launch estimation, post-launch estimation shows larger variation for higher reflectivity regions caused by the natural variabilities.
- Provided that the natural variability components would be similar among three modes, the **18km-mode operation is proposed instead of 20km-mode in 60S-60N**.

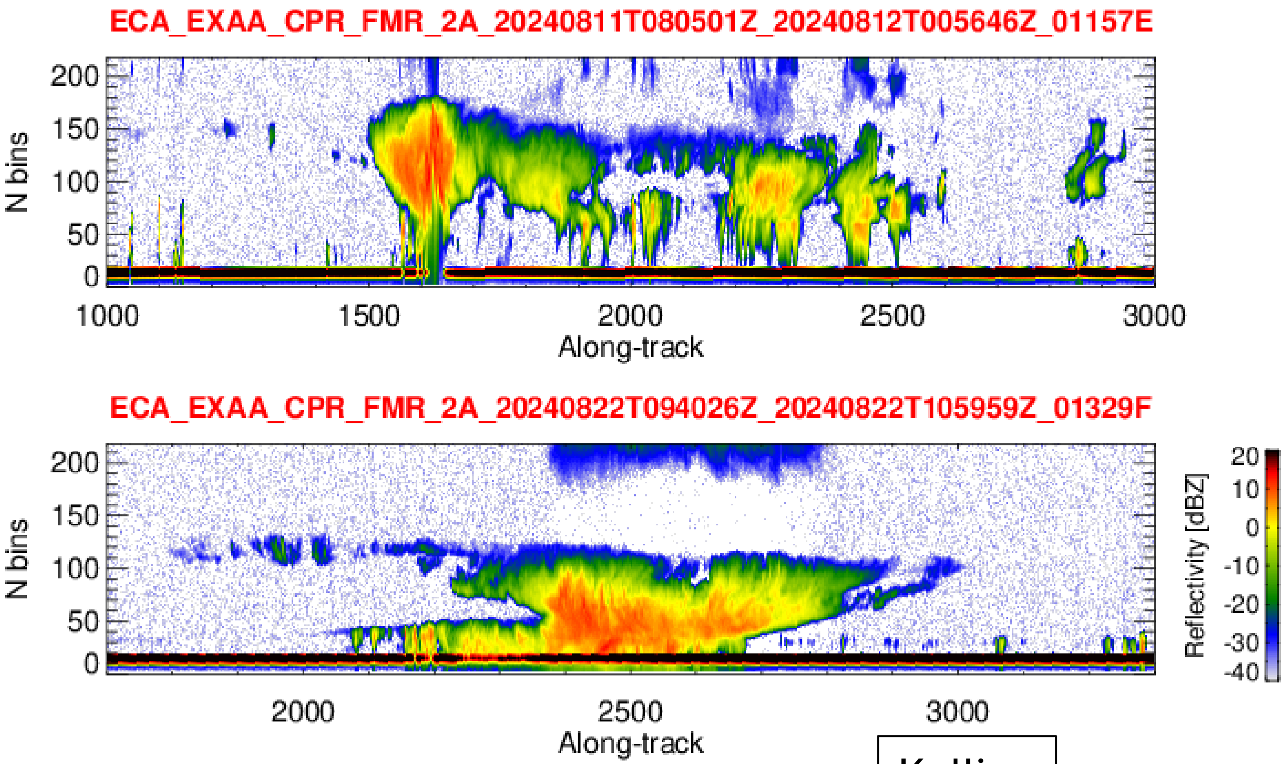
pre-launch estimation (20 km mode)



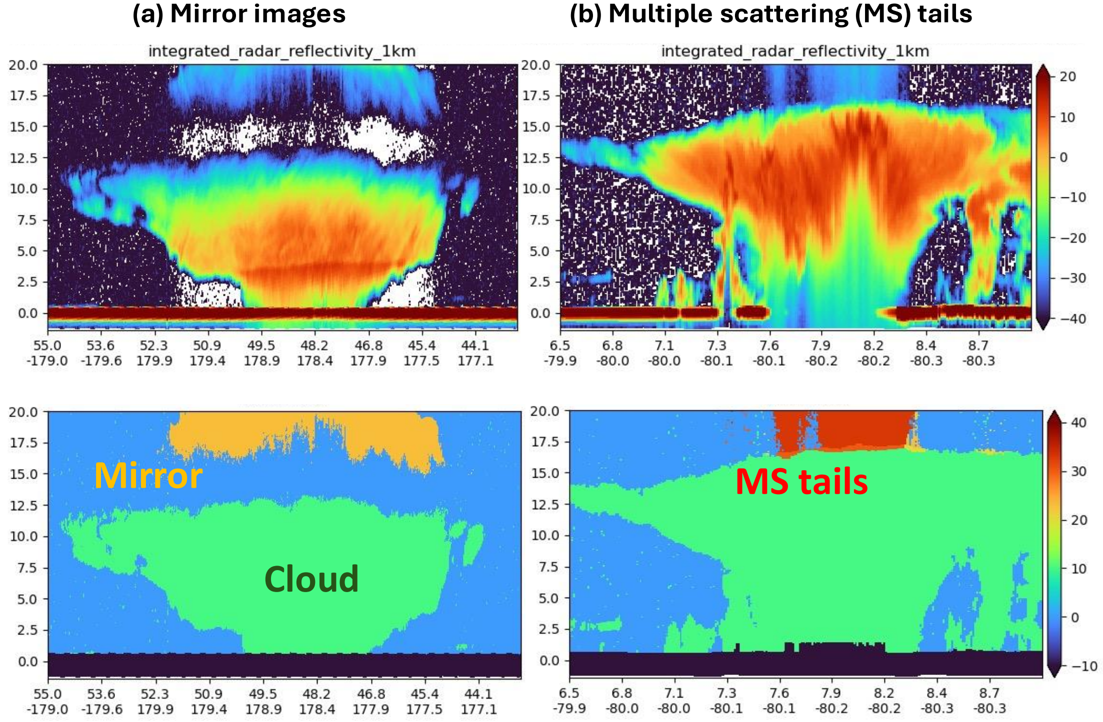
Hagihara et al. (2023)

Mirror image & MS tail detection/masking

- Methods to mask mirror image and multiple scattering tails are established. Kollias Aoki



Kollias



Height-distance diagrams of radar reflectivity and cloud mask of mirror images and MS tails in EarthCARE CPR observation.

Aoki

Underestimation of **noise floor** affects the Level-2 Cloud Mask and Tb estimation

Kollias

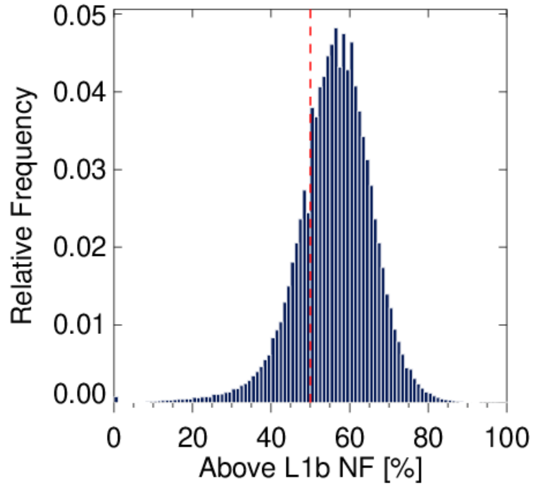
Noise Floor

- Underestimated
- Affected by second-trip echoes
- Reported only every 14 profiles

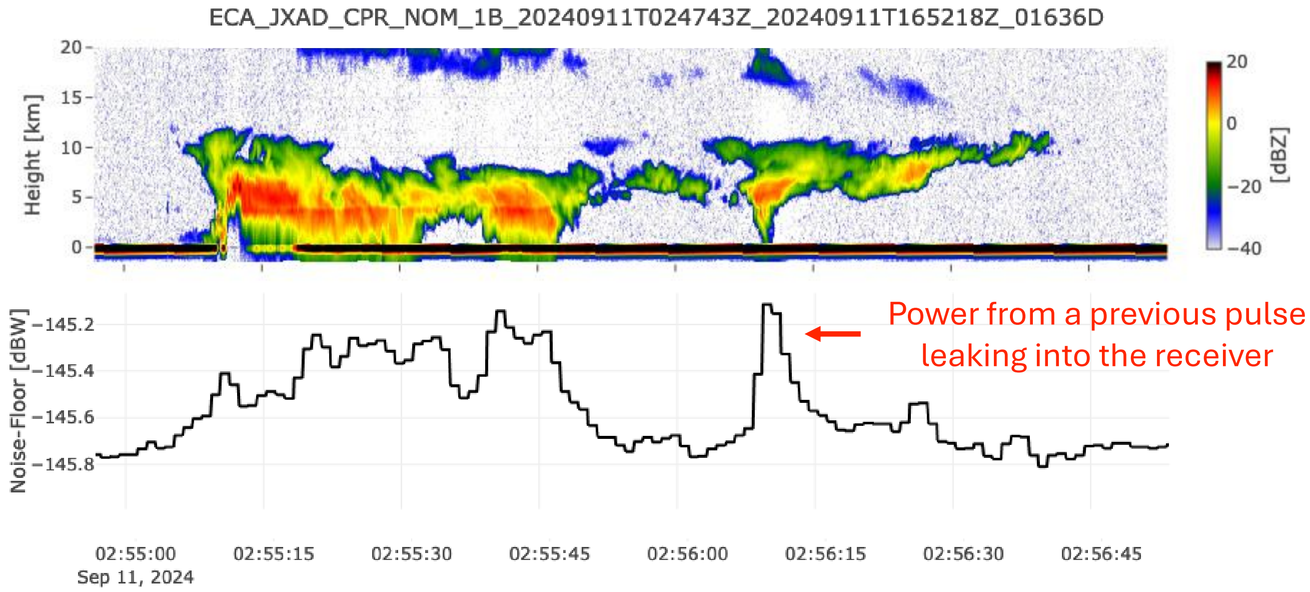
Impacts →

L2a Cloud Mask

L2a Brightness temperatures



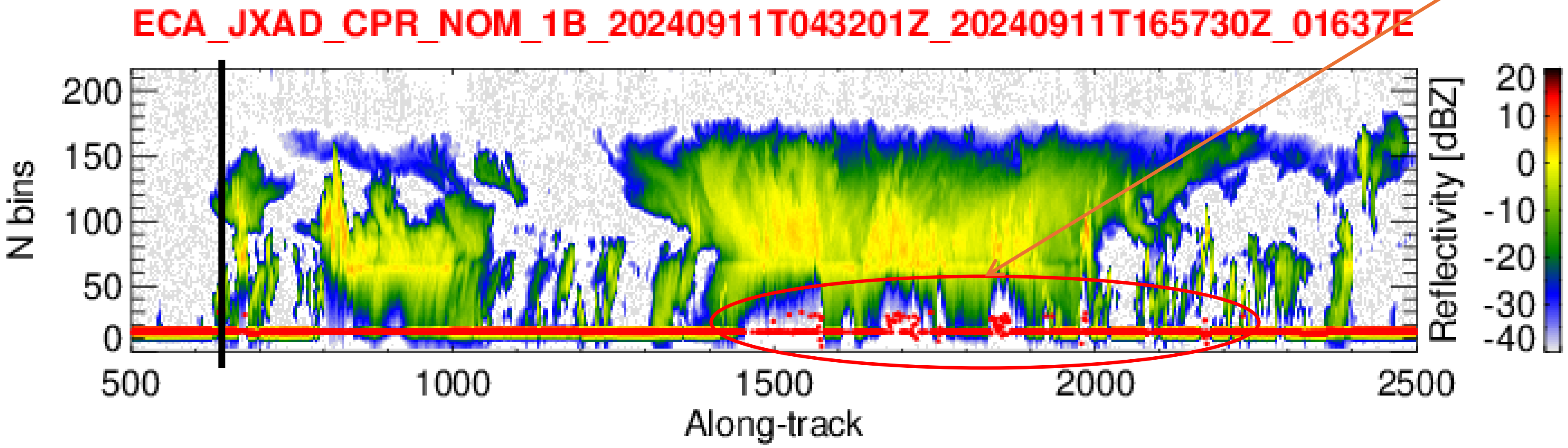
Percentage of values above the L1b NF in clear-sky conditions

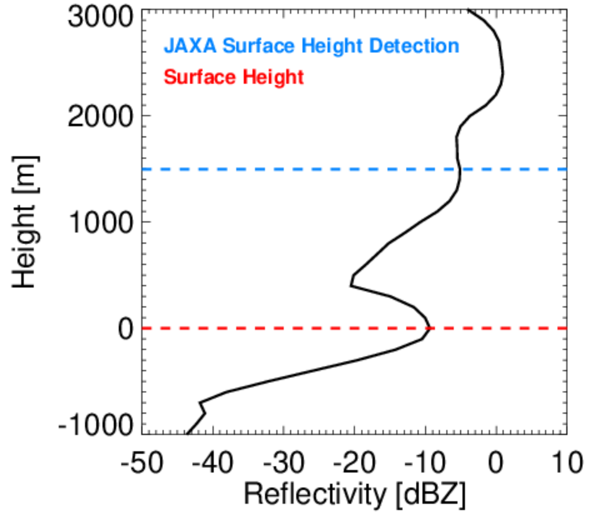


Surface Height Detection

Kollias

The L1b surface height detection, defined by the C-NOM variable *surfaceBinNumber*, is sometimes incorrect in profiles **with strong attenuation.**





Other considerations

- Calibration activity
  - sea surface calibration (expecting the final calibration result)
  - Proper space and time averaging strategy in ground-based radar comparisons
- Attenuation estimation (comparison of profile)
  - comparison of downward looking radar vs. upward looking radar
  - comparison with longer wavelength radar (e.g. MIRA)
- Doppler velocity unfolding method has already established?
- Expectation of future validation activities
  - validation of geophysical products from Level 2
  - comparison with other satellites (e.g. GPM, CloudSat)

Horie

Pftzenmaier

Ewald

Delanoe

Borque

Topics for discussion

1. **What are the positive aspects about the data, processors that can be highlighted from validation team results?**

Outstanding results. Any public communications with highlights? Press release

2. What has been identified by validation team as aspects to improve and are there clear/proposed way to address that?

- There is general consensus on the Z calibration (with some procedure being capable to provide feedbacks at almost the daily scale) with all cal/val methods converging (still 2dB discrepancy between instrument and cal/val apprroaches),

- Doppler cal/val is more challenging (seasonal and zonal variations!!), make sure correlation of I and Qs and range weighting is properly is accounted for).

Validation team suggestion for 16-18 km mode operations (*16km-mode in polar as current and 18km in other regions (<60deg) and no more 20km mode*) ➔ Imura-san's work. Is there consensus of the validation team on this recommendation?

3. What should be noted to public about the quality of the released L1 data?

Need to be crystal clear from the users point of view which calibrations have been applied to Z and Doppler signal.

Also flags for artifacts needed (mirror, anomalous 2.5 km height feature)

Topics for discussion

4. What are aspects that for the validation team are yet to be validated?

NUBF, aliasing corrections? Multiple scattering flags? Cloud boundary stretching?

Anything else we have missed?

5. What recommendations/suggestions for future L1 / L2 validation activities (e.g. needs/gaps) and for mission planning

L2 is generally more challenging (both JAXA and ESA products to be intercompared), workshop in March.

Remember that in addition to products it is important to validate assumptions underpinning algorithms