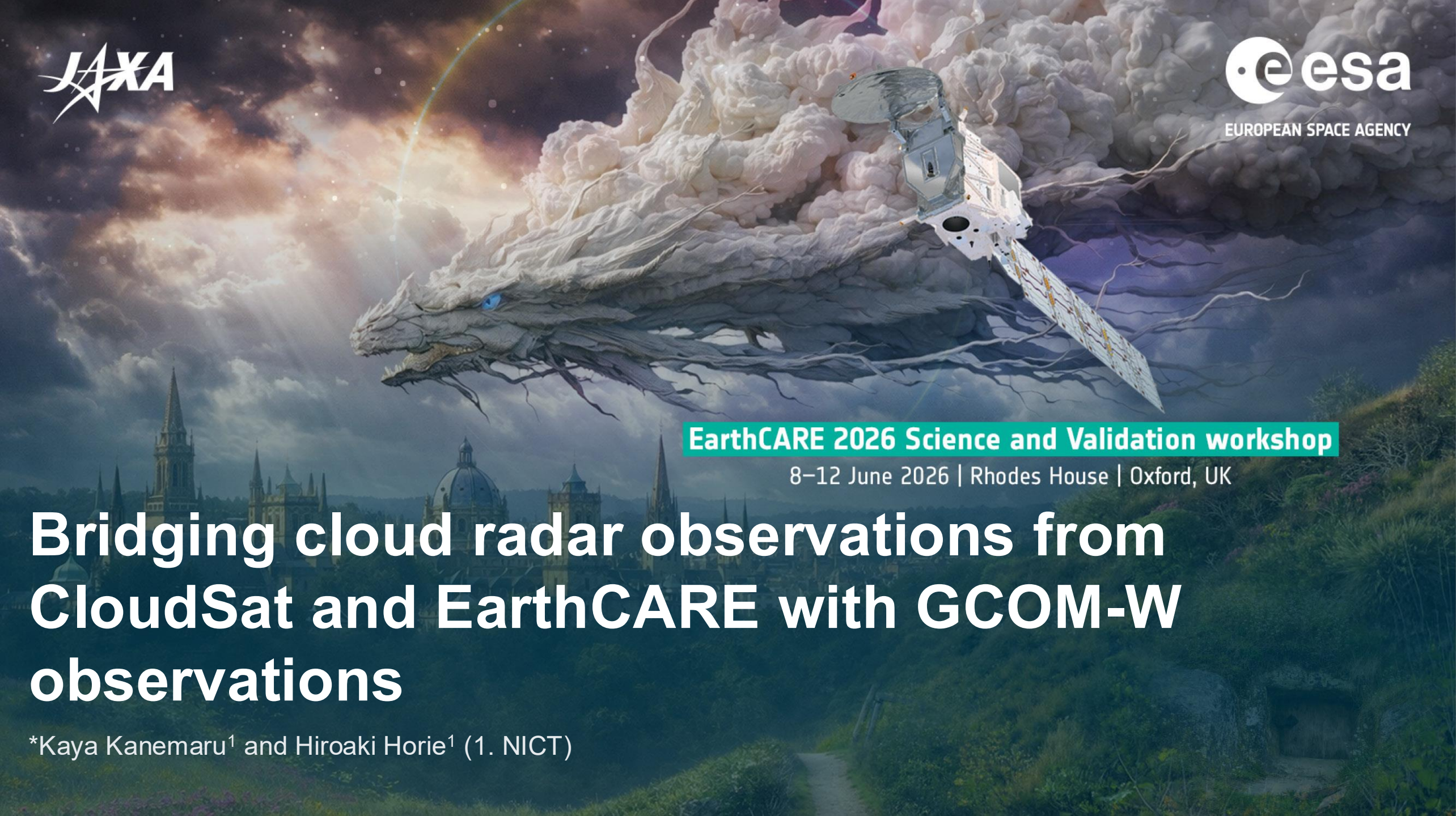
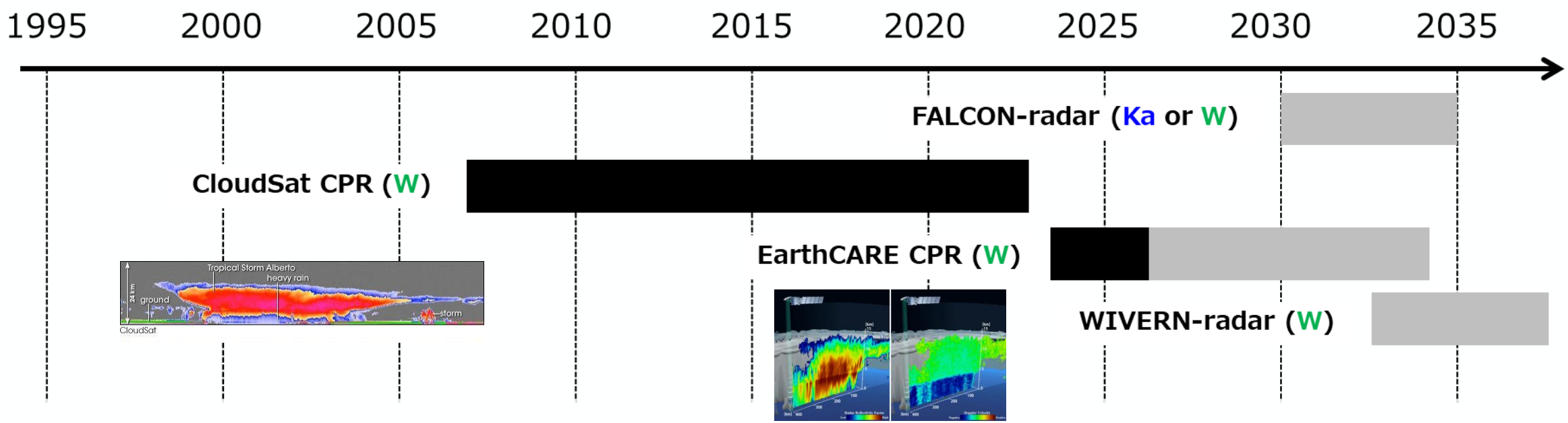


Bridging cloud radar observations from CloudSat and EarthCARE with GCOM-W observations

*Kaya Kanemaru[1] and Hiroaki Horie[1] (1. NICT)

Background



Since the launch of CloudSat satellite in 2006, cloud radar observations have continued by CloudSat and EarthCARE missions. The EarthCARE mission is expected to be extend to ~2034. Moreover, following cloud radar satellite missions are planning.

Those cloud radar records have a potential for detecting long-term change of vertical structure of cloud due to the global warming.

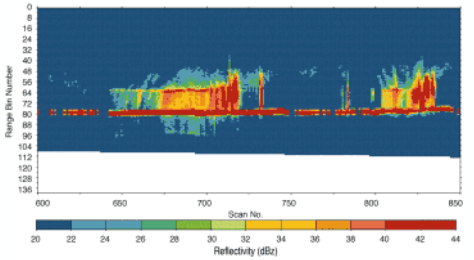
Background

Radar ideally measures radar reflectivity (Z)

To estimate rain rate (R), Z-R relationship is required

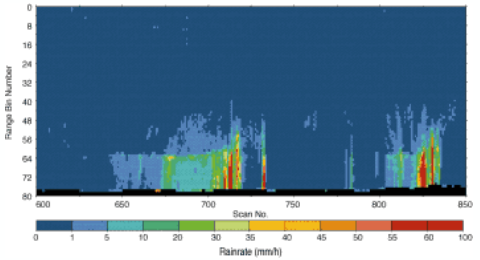
$$Z = aR^b$$

a & b : parameters depending on rain events



Attenuated Z

Correction & Conversion

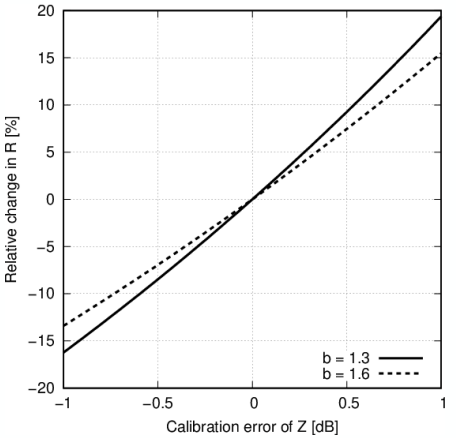


Estimated R

Calibration error of Z propagates estimation error of R.

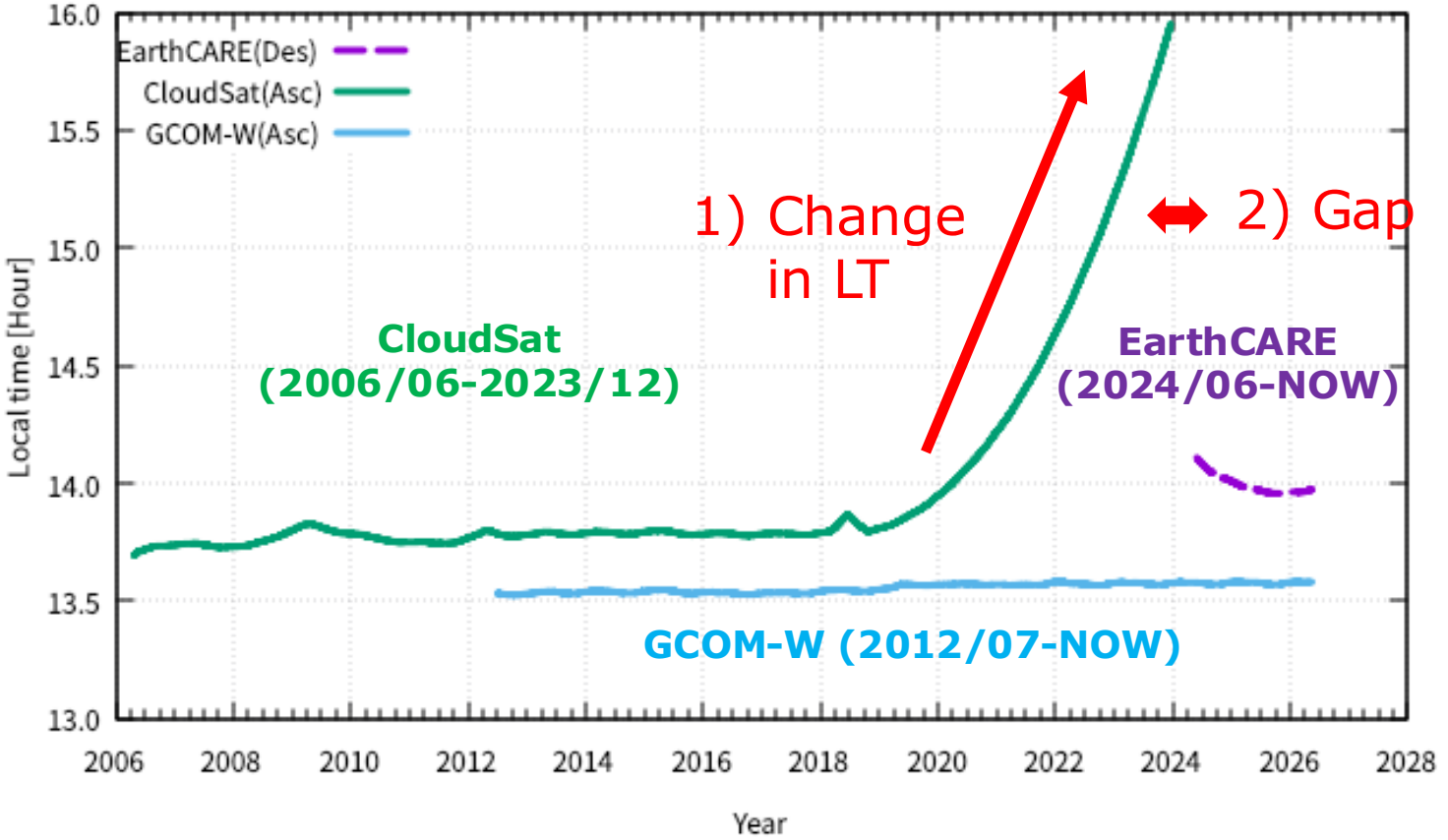
Relative change in R [%] due to the calibration error δ [dB]

$$\Delta R = 10^{0.1\delta/b} - 1$$



Background

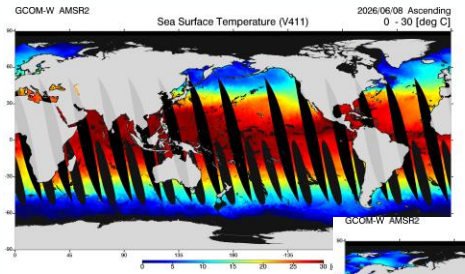
Timeseries of Local Time crossing equator (LT)



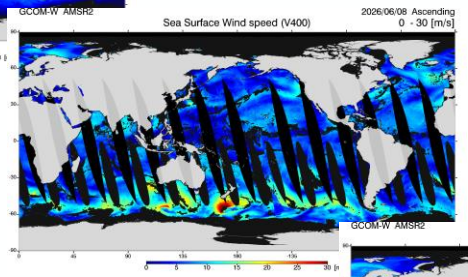
Calibration consistency between CPRs between CloudSat and EarthCARE is essential.
Unfortunately, CloudSat and EarthCARE missions does not operate in the same period.
GCOM-W satellite may solve this difficulty.

GCOM-W AMSR2

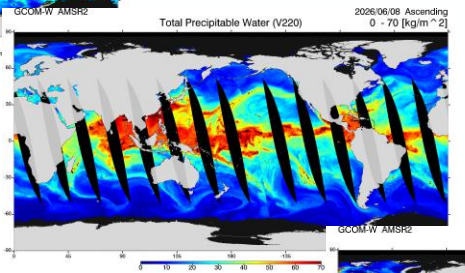
https://kuroshio.eorc.jaxa.jp/JASMES/WC_j.html



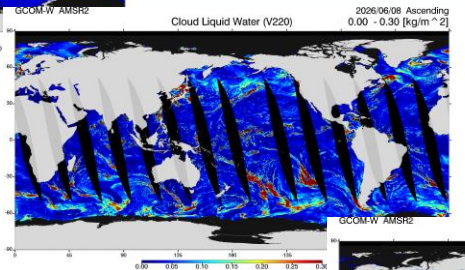
Sea surface temperature



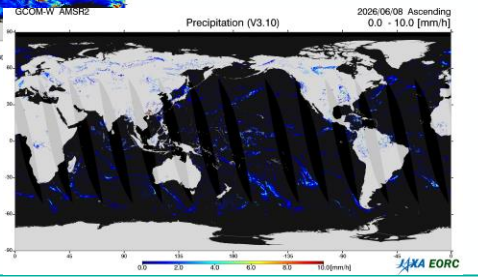
Sea surface wind



Colum water vapor

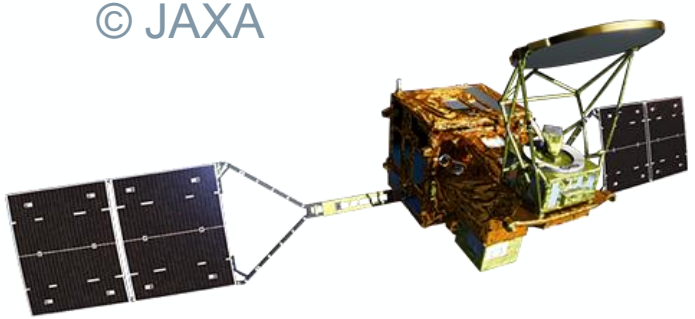


Cloud liquid water path



Surface precipitation

© JAXA



Frequency: 6.925 GHz to 89.0 GHz

Purpose

2006/06 – 2023/12
CloudSat CPR

Gap

LT change

2024/06 – NOW
EarthCARE CPR

2012 – 2020

2012/07 – NOW
GCOM-W AMSR2

2024 – NOW

To bridge cloud radar observations from CloudSat CPR (CS-CPR) to EarthCARE CPR (EC-CPR), intercomparison between CS-CPR and EC-CPR is conducted with GCOM-W AMSR2 data as a reference.

This study intercompares CPR data with two approaches:

1) Surface echoes with AMSR2 sea surface wind (SSW)
2) Hydrometeor echoes with AMSR2 cloud liquid water path (CLWP)

Method

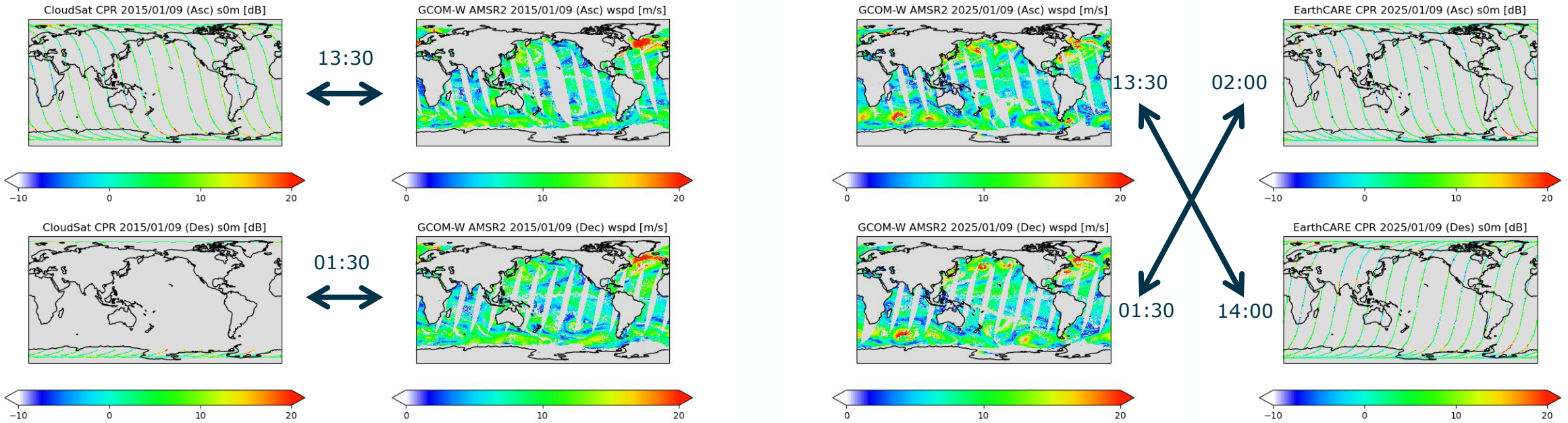
2015/01/09

2025/01/09

CS-CPR s0m [dB]

GCOM-W AMSR2 SSW [m/s]

EC-CPR s0m [dB]



After 2012, CPR was DO-Op (Daylight-Only Operations) mode

Note that σ_m^0 is gridded onto 0.25 deg 0.25 deg.
Collocation is within ± 45 mins

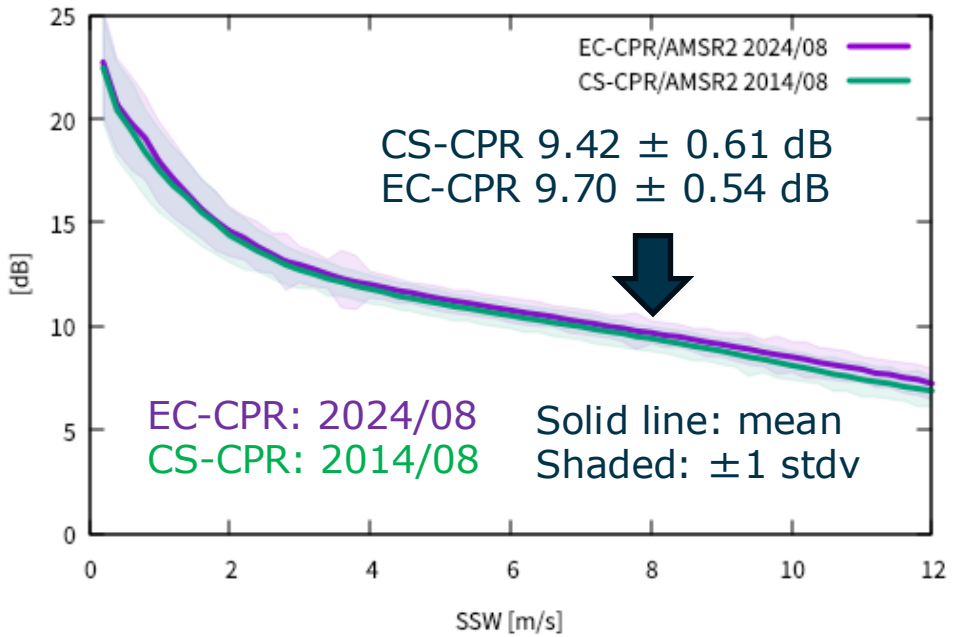
AMSR2: AS-ECV in V8.2 (Remote Sensing Systems)
CS-CPR: 2B-GEOPRF in R05 (CloudSat DPC)
EC-CPR: L2ECO in vCc (JAXA G-portal)

1) Intercomparison of surface echoes

EarthCARE(EC)-CPR: L2ECO vCc
CloudSat(CS)-CPR: 2B-GEOPROF R05

*Clear-sky is defined as AMSR2 CLWP < 0.5 mm

AMSR-2 SSW vs. s0 in clear-sky*

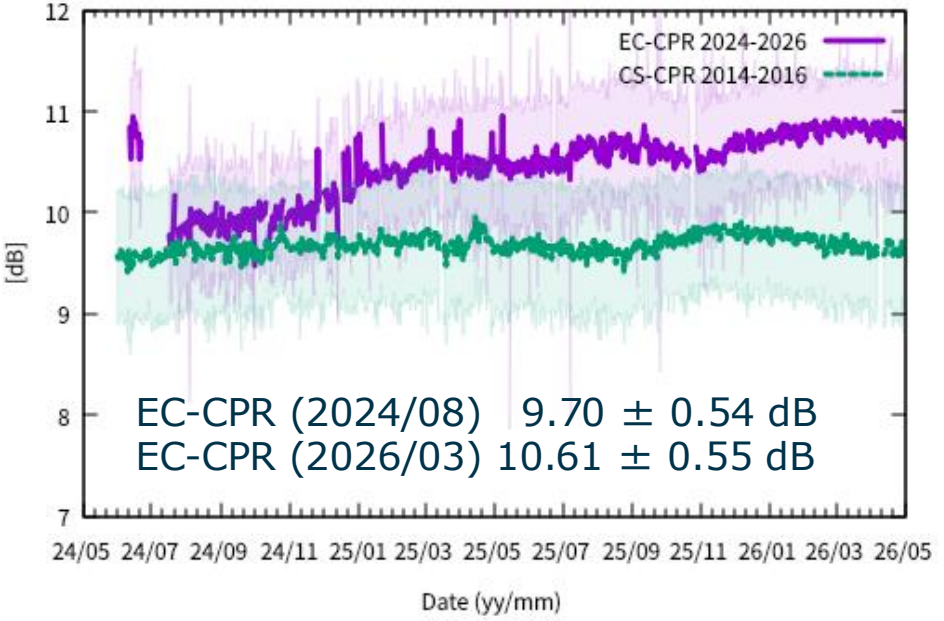


σ^0 by EC-CPR is 0.28 dB higher than to that by CS-CPR.

σ^0 is corrected due to atmospheric gas attenuation with simple equation below

$$\sigma^0 = \sigma_m^0 + \mathrm{PIA}_{\mathrm{gas}} \approx \sigma_m^0 + (0.0815 \times \mathrm{CWV}_{\mathrm{AMSR2}} + 0.220)$$

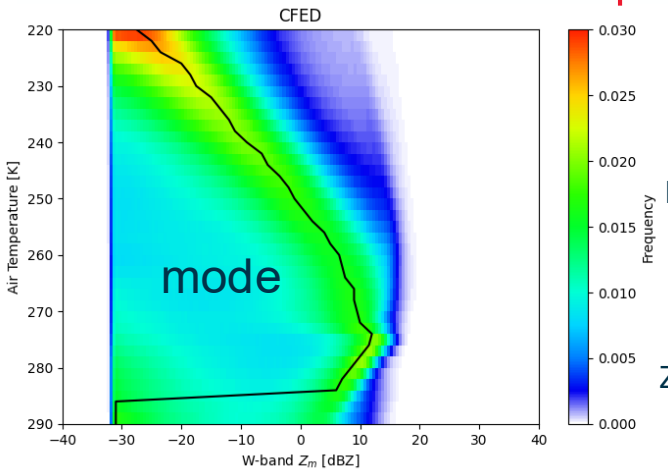
Time series of σ^0 in clear-sky at AMSR2 SSW 7-8 m/s



EC-CPR's σ^0 changes over time by 0.9 dB from 2024/08 to 2026/03 (20 months).

2) Intercomparison of hydrometeor echoes

EC-CPR day-time

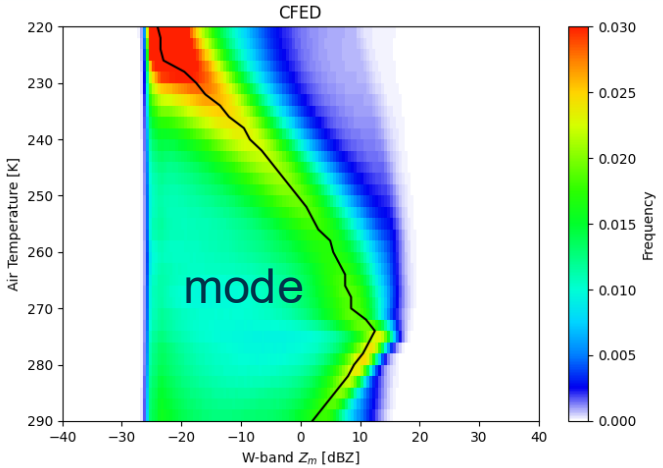


2025/01-2026/04

Bin 2 K & 0.5 dB

SNR > -8 dB
$Z_{m,min}$ ~-32 dBZ

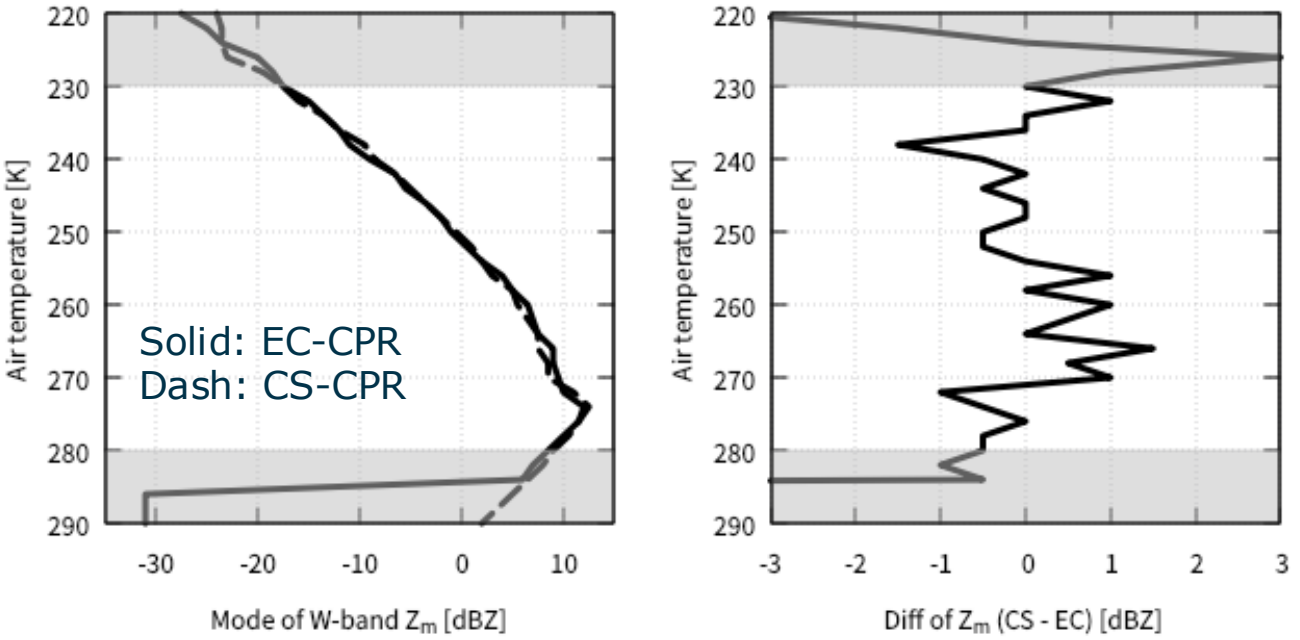
CS-CPR day-time



2015/01-2016/04

Cloud_mask > 30
$Z_{m,min}$ ~-27 dBZ

EC > CS EC < CS



From global statistics, mode between EC-CPR and CS-CPR is almost same. But, EC-CPR of hydrometeor echoes tends to be higher than CS-CPR.

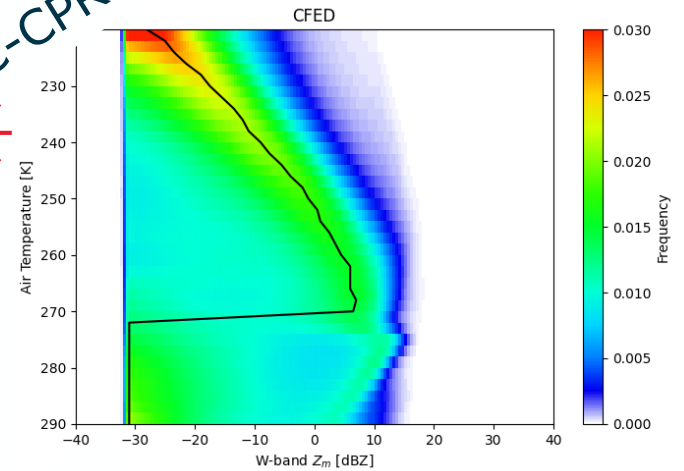
2) Intercomparison of hydrometeor echoes

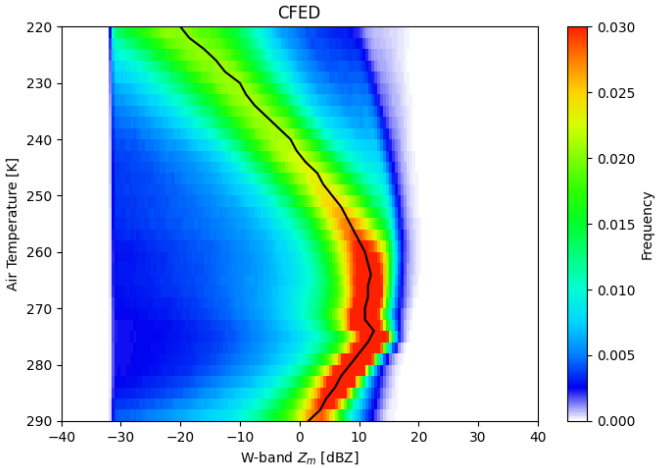
AMSR2 CLWP 0.0-0.5 mm

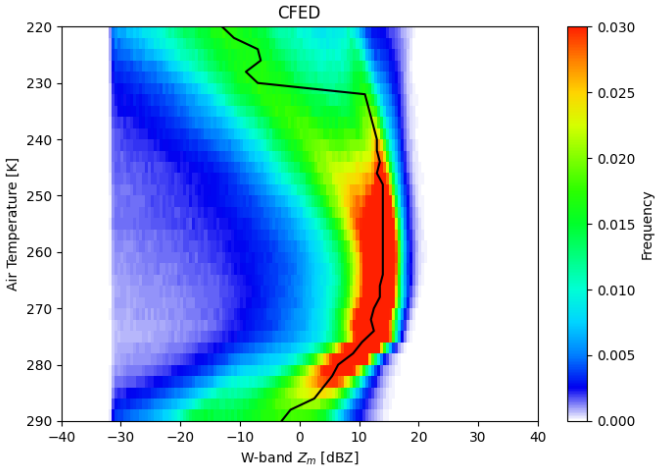
AMSR2 CLWP 0.5-1.0 mm

AMSR2 CLWP 1.0-1.5 mm

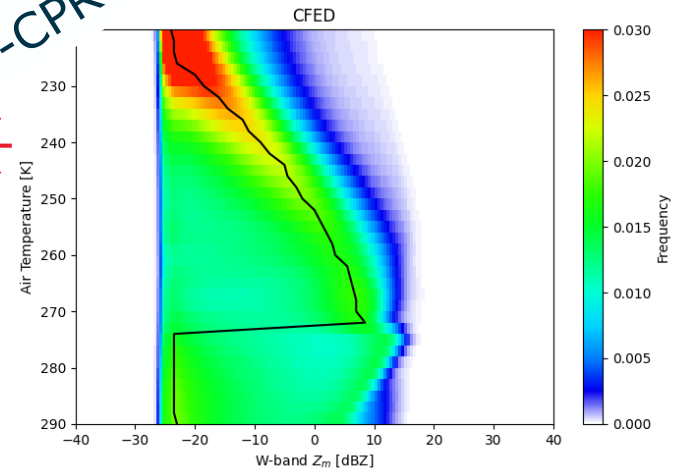
EC-CPR

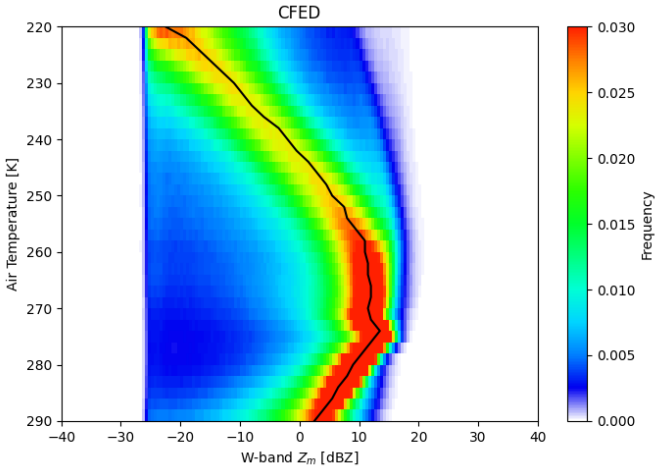


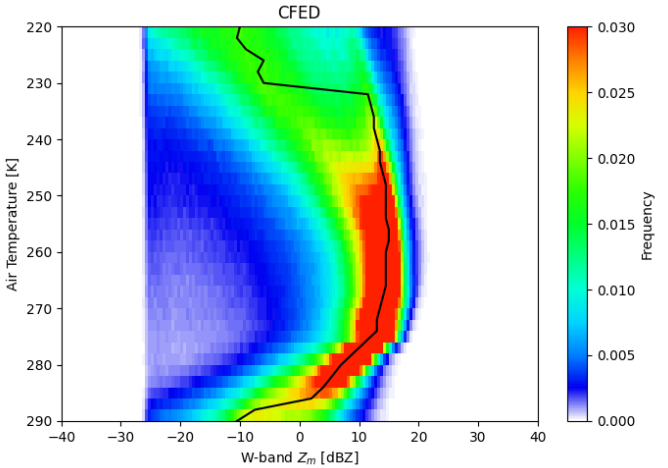




CS-CPR



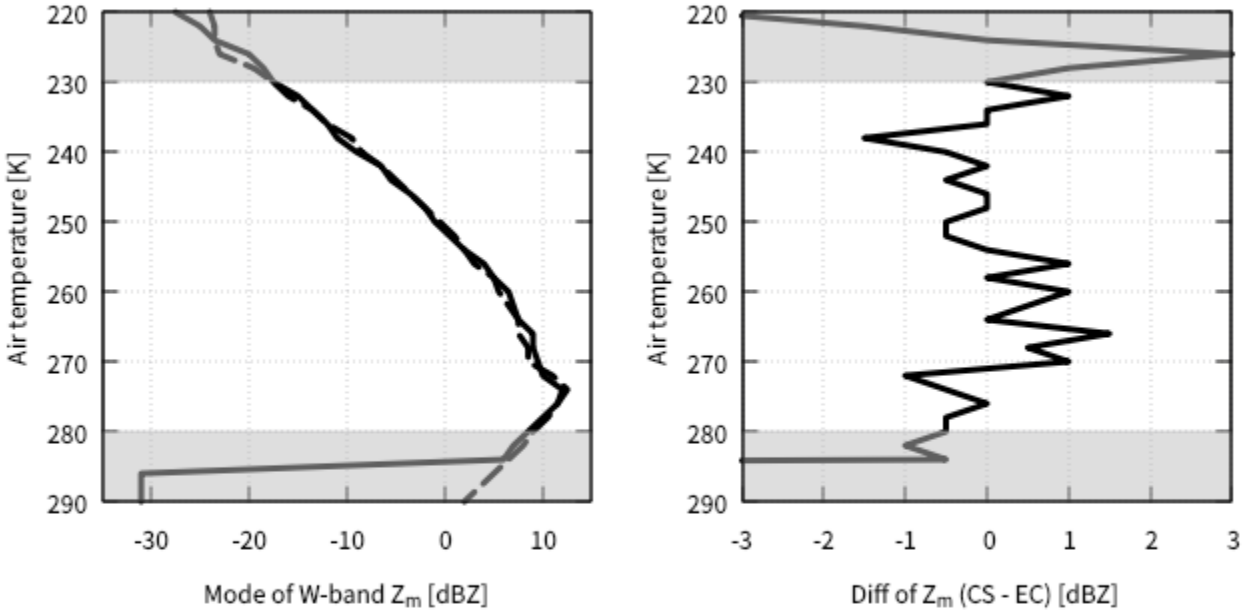




2) Intercomparison of hydrometeor echoes

Solid: EC-CPR (2025/01-2026/04)
Dash: CS-CPR (2015/01-2026/04)

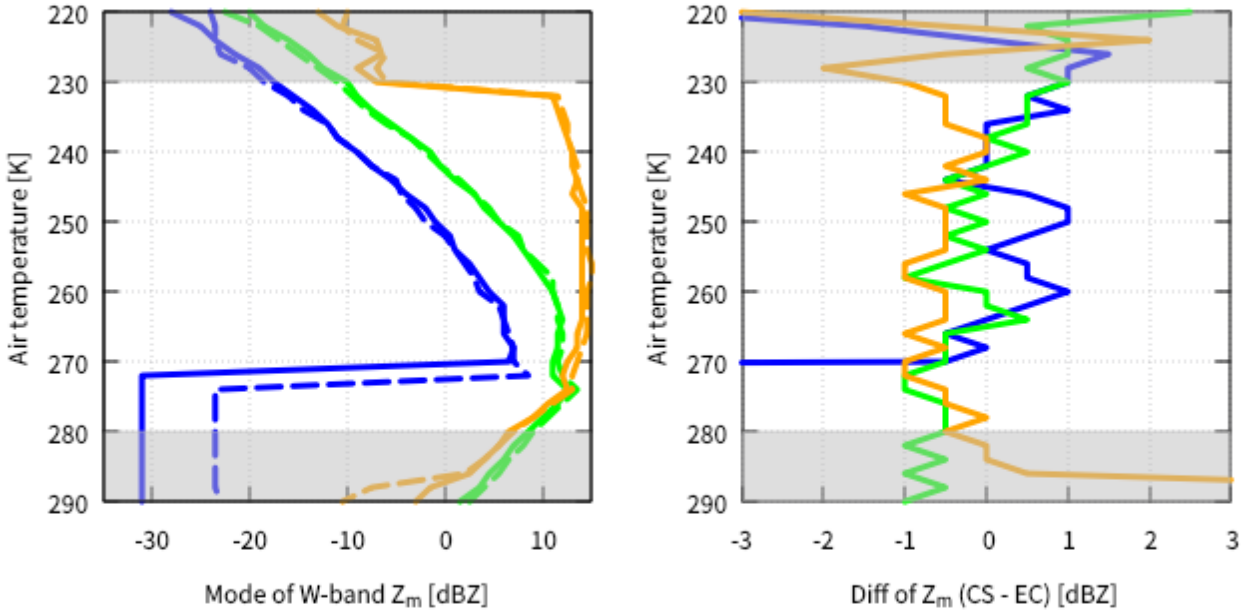
EC > CS EC < CS



All (match up only)

From global statistics, mode between EC-CPR and CS-CPR is almost same. But, EC-CPR of hydrometeor echoes tends to be higher than CS-CPR.

EC > CS EC < CS



AMSR2 CLWP 0.0-0.5 mm, 0.5-1.0 mm, 1.0-1.5 mm

EC-CPR somewhat tends to be higher than CS-CPR.

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Summary

EC-CPR products in public version are intercompared with CS-CPR products by using GCOM-W AMSR2 data as a reference. Good agreement is obtained, but small difference of σ^0 and Z_m are found.

Surface echoes:

- σ^0 of EC-CPR in 2024/08 is 0.3 dB higher than CS-CPR.
- σ^0 of EC-CPR changes over time by 0.9 dB from 2024/08 to 2026/03 (20 months).

Hydrometeor echoes:

- Agreement of mode between EC-CPR and CS-CPR is within ± 1 dB.
- EC-CPR somewhat tends to be (0.5-1.0 dB) higher than CS-CPR.

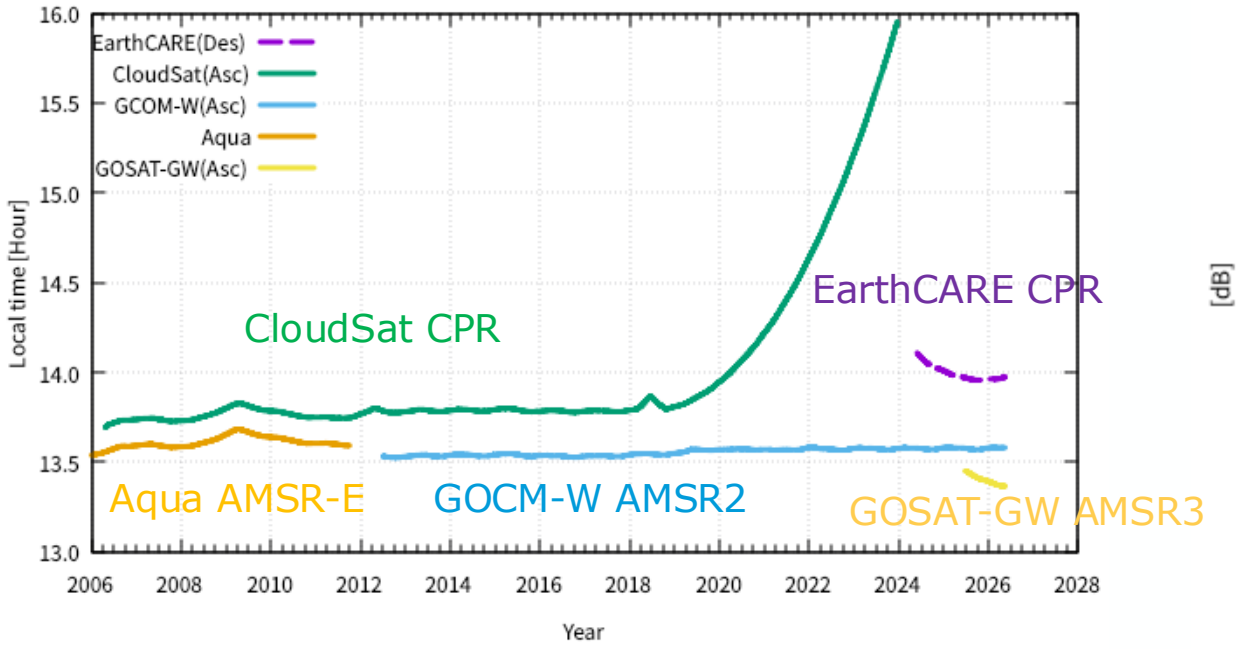
Acknowledge
This work was supported by the 'Promotion of observation and analysis of radio wave propagation fund of the Ministry of Internal Affairs and Communications, Japan.

Next step

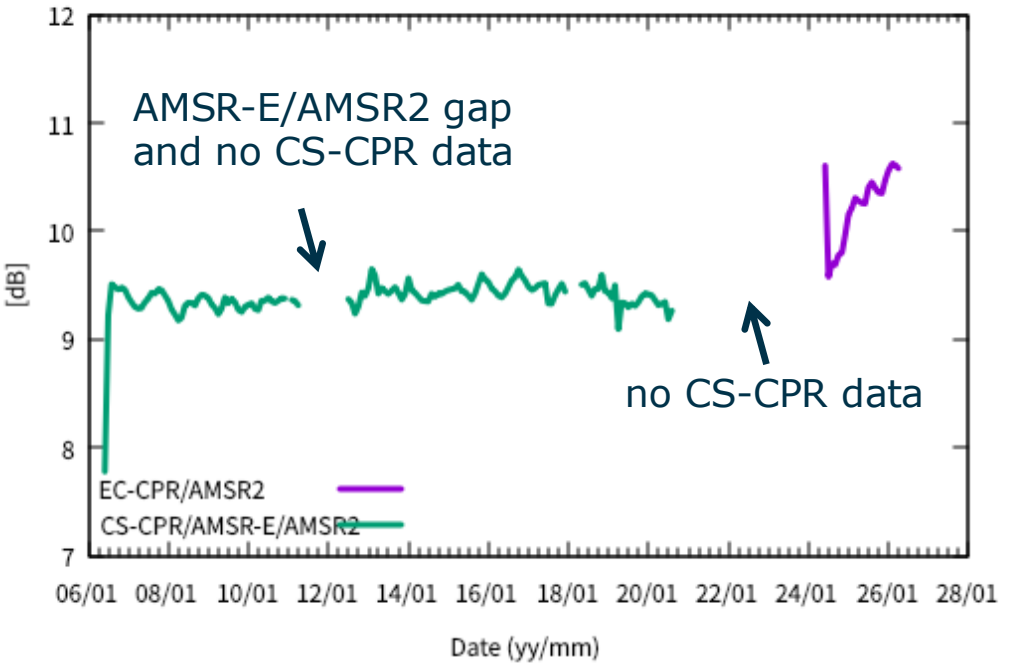
- Revise calibration parameters
- Categorize cloud types by LEO imagers (MODIS/VIIRS) and/or GEO imagers (Himawari-8/9), and precipitation types by spaceborne precipitation radar (DPR)

AMSR series for monitoring cloud radar

Time series of local time crossing the equator



Time series of σ^0 in clear-sky at AMSR-E/AMSR2 SSW 7-8 m/s



I hope maintain of AMSR2 observations and seamless transition GCOM-W AMSR2 to GOSAT-GW AMSR3 in the near future.