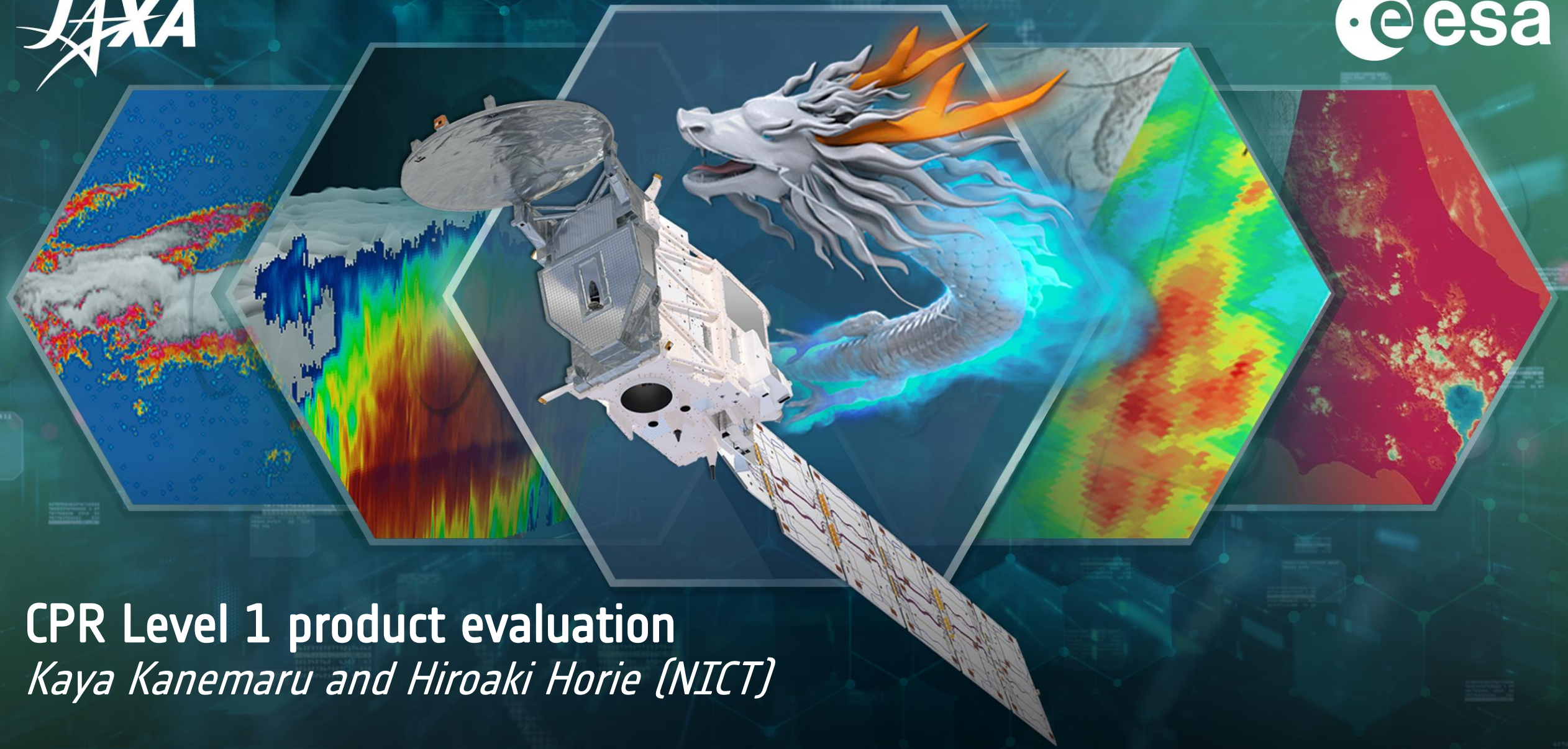


# CPR Level 1 product evaluation

*Kaya Kanemaru and Hiroaki Horie (NICT)*

1st ESA-JAXA EarthCARE In-Orbit Validation Workshop
14 – 17 January 2025 | VIRTUAL EVENT

# Background and purpose

2006/06 – 2023/12
CloudSat CPR

Gap

2024/06 – NOW
EarthCARE CPR

2013 – 2019

2012/07 – NOW
GCOM-W AMSR2

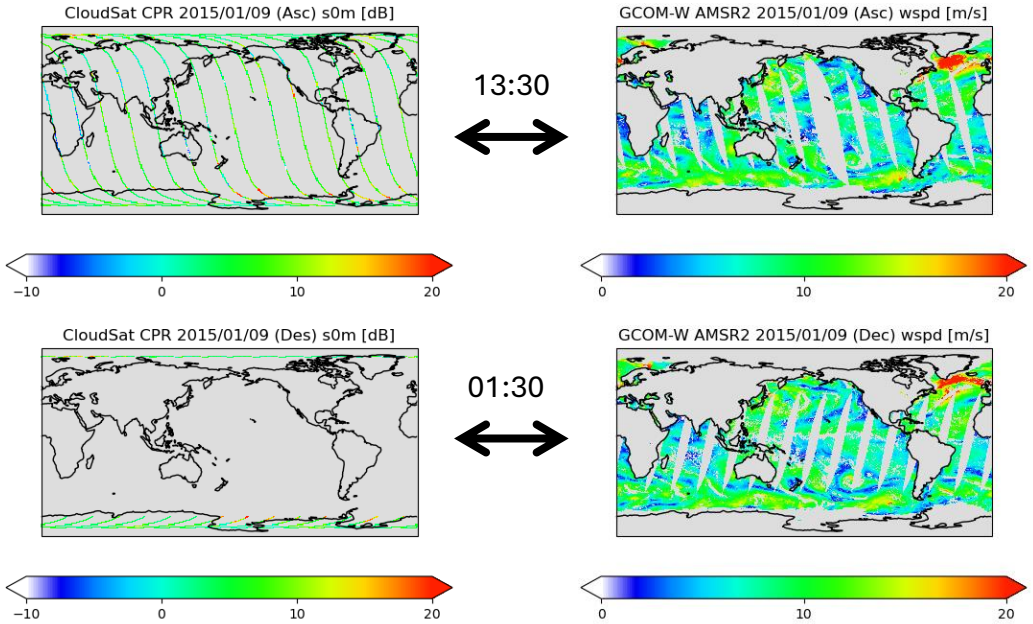
Evaluation of EarthCARE CPR (EC-CPR) data with CloudSat CPR (CS-CPR) data is useful for checking data quality. It is, however, since CloudSat mission was ended at 2023/12, **EarthCARE CPR data cannot be directly compared by CloudSat CPR data**. Here, intercomparison of CPRs between CloudSat and EarthCARE is conducted with GCOM-W AMSR2 sea surface wind (SSW) data as a reference.

| | CloudSat | GCOM-W | EarthCARE |
|---|---|---|---|
| Equatorial crossing time | 13:30 (asc) | 13:30 (asc) | 14:00 (des) |

# Method: Matchup between $\sigma_m^0$ and SSW

## 2015/01/09

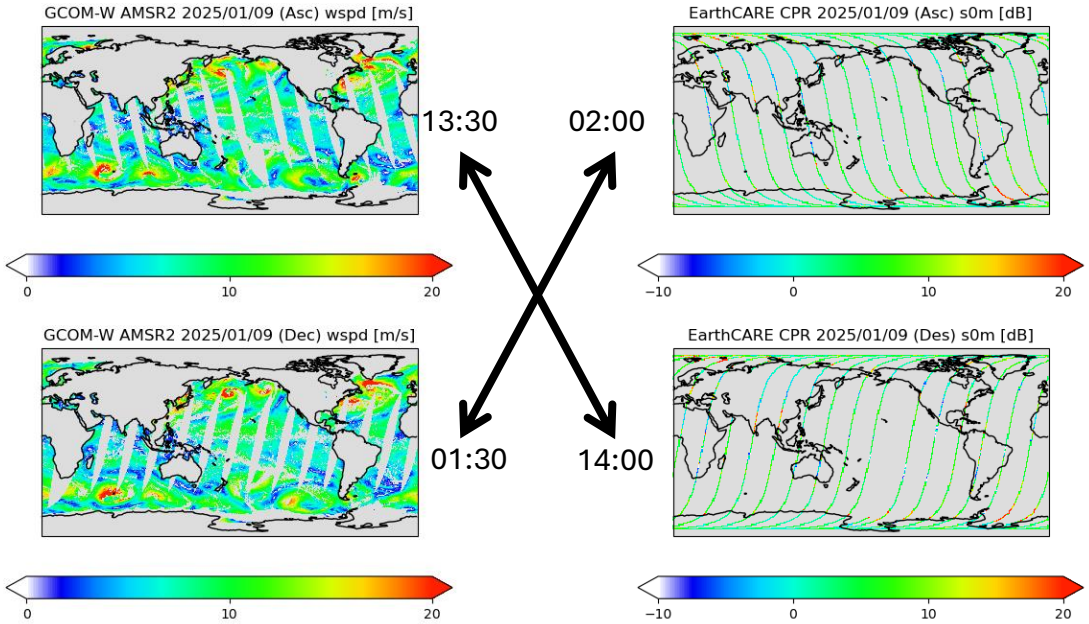
CloudSat CPR s0m [dB] — GCOM-W AMSR2 SSW [m/s]




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

## 2025/01/09

GCOM-W AMSR2 SSW [m/s] — EarthCARE CPR s0m [dB]



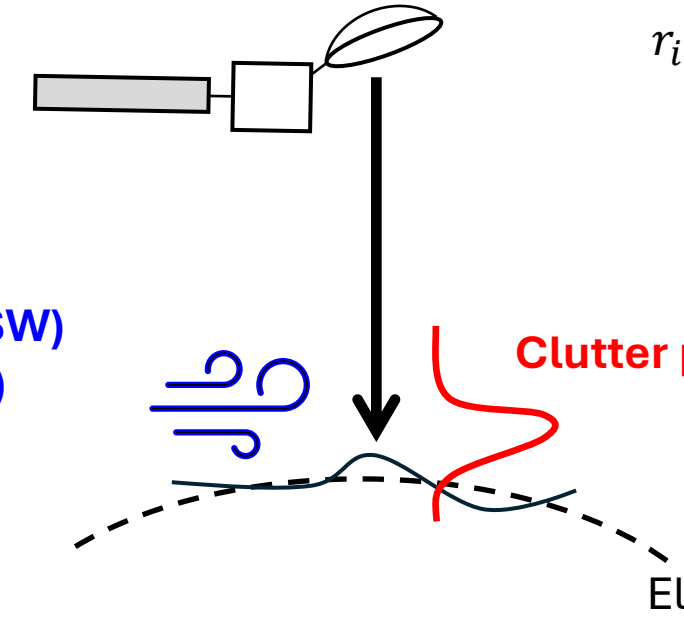

AMSR2 AS-ECV in V8.2 (Remote Sensing Systems)
CS-CPR L1B in R05 (CloudSat DPC)
EC-CPR L1B in vCa (JAXA/NICT)

# Method

## Monitoring stability of radar calibration

$$\sigma_m^0 \approx \sigma^0(\theta_z, \lambda, U_{10})$$

$\theta_z$: incidence angle
$\lambda$: wavelength
$U_{10}$: sea surface wind




Kanemaru et al. (2024, JTECH)
https://dx.doi.org/10.1175/JTECH-D-23-0151.1

## Reconstruction of clutter pattern $P_{sfc}$

$$P_{\mathrm{sfc}}(r_i - r_{\mathrm{DEM}}) = P_r(r_i)$$

$$r_i = \mathrm{rangeToFirstBin} + (i-1) \times \mathrm{rangeBinSize}$$

i: range-bin # (1 start)

$$r_{\mathrm{DEM}} \simeq \mathrm{rangeToIntercept} - \frac{\mathrm{elevation}}{\cos\theta_z}$$

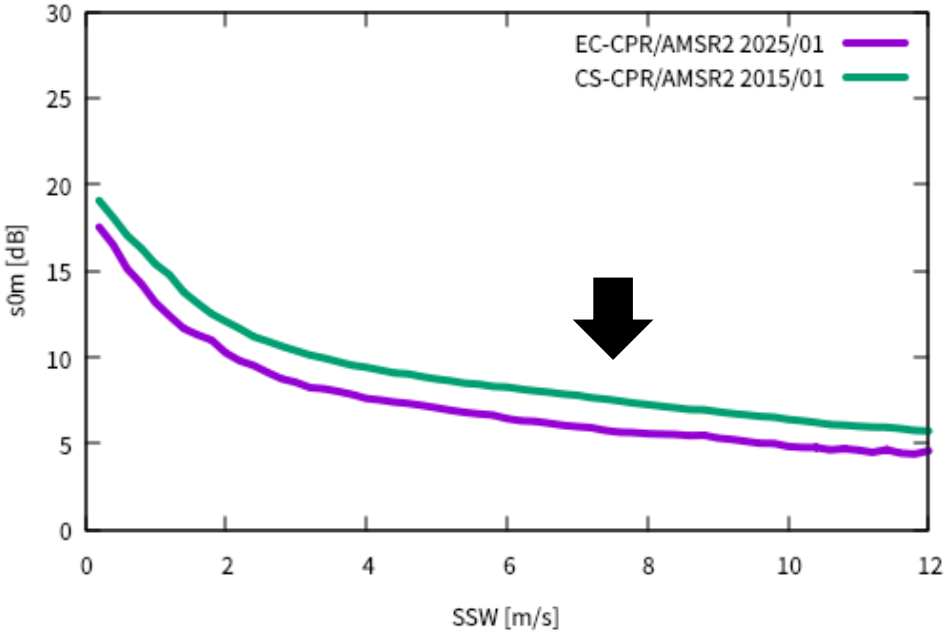
Kanemaru et al. (2020, TGRS)
https://dx.doi.org/10.1109/TGRS.2019.2963090

# Results: $\sigma_m^0$ vs. SSW

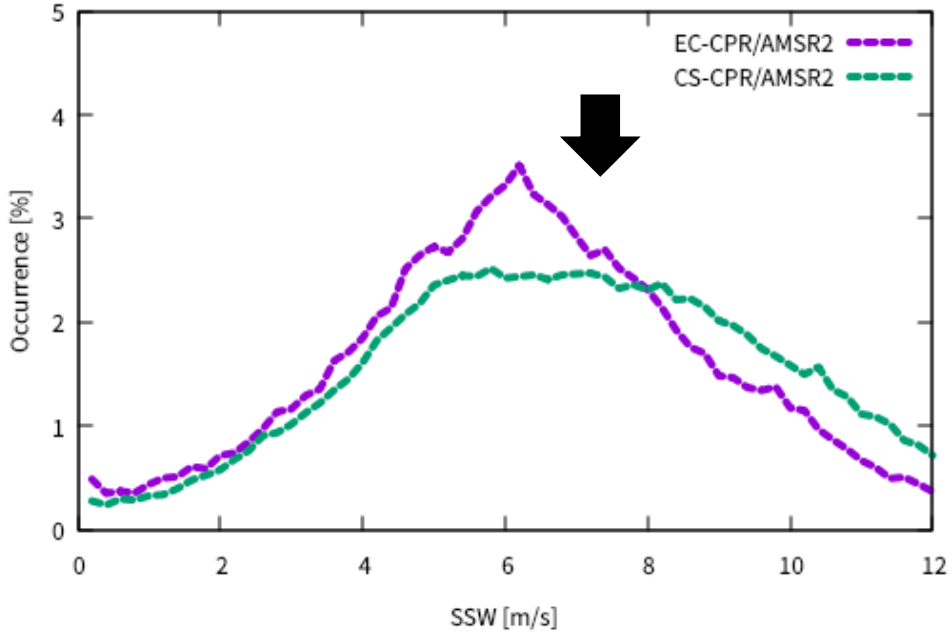
EarthCARE(EC)-CPR: 2025/01/01-2025/01/14 (vCa)
CloudSat(CS)-CPR: 2015/01/01-2015/01/31 (R05)

Clear-sky is defined as a simple judgement using $P_r$ and $P_n$

AMSR-2 SSW vs. s0m in clear-sky



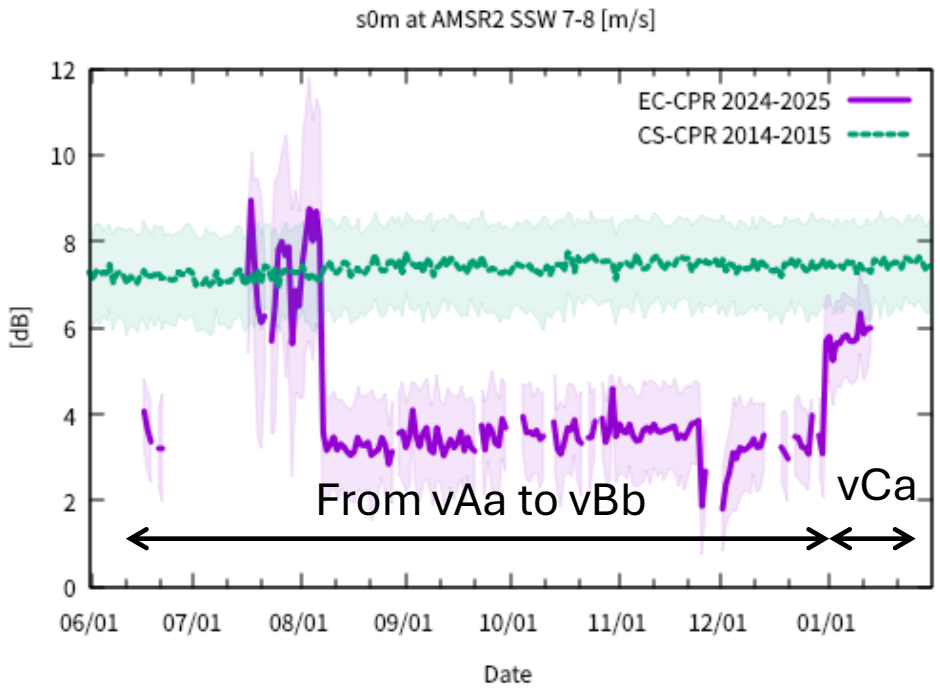

Collocated number




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

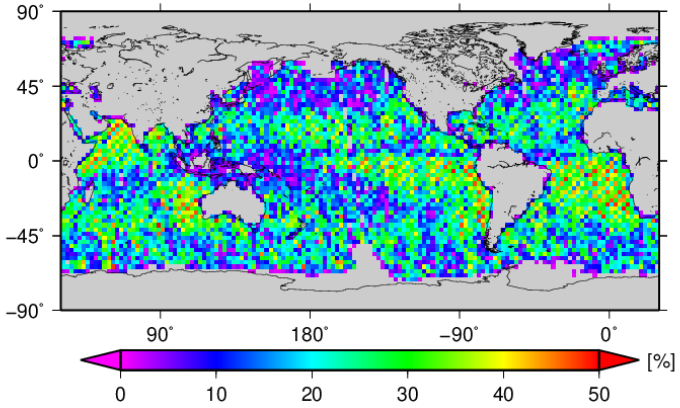
# Results: Timeseries of $\sigma_m^0$ at SSW 8 m/s

Except for change in version, $\sigma_m^0$ level of EC-CPR is stable with time.

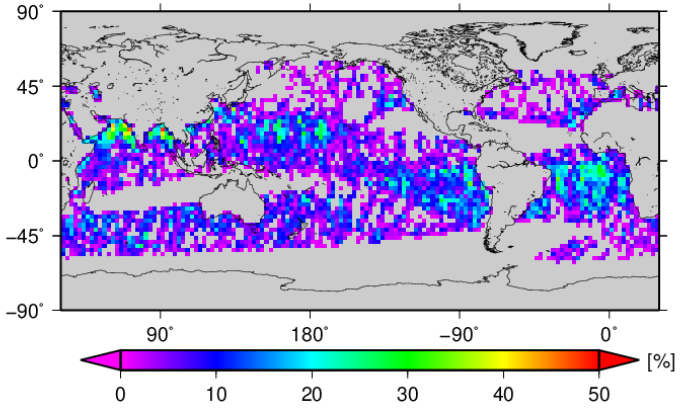



Solid line: mean
Shaded: ± 1 stdv

Collocated occurrence at SSW 7-8 m/s (2025/01/01-31)

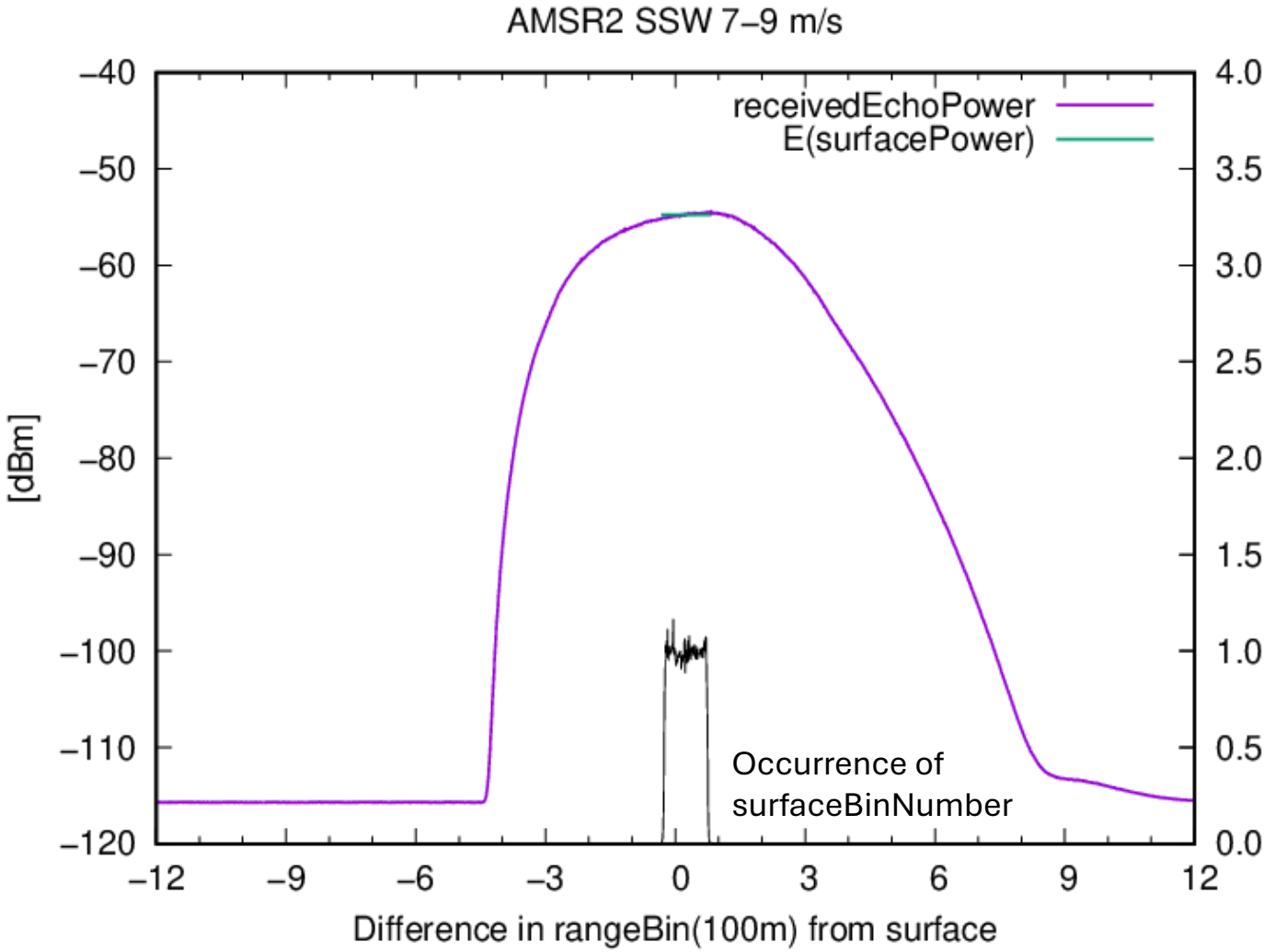



Collocated occurrence at SSW 7-8 m/s (2025/01/01-14)




SSWs from 7 to 8 m/s are frequently observed over subtropical and mid-latitude oceans.

# Results: Reconstructed clutter pattern




2025/01/10-2025/01/14 (14 days)

AMSR2 sea surface wind: 7-9 m/s
AMSR2 column water vapor : < 40 mm
Latitude: -40 to 40 (avoid sea ice)

$E[P_r(r_{i,\mathrm{sfc}})]$ = -54.77 [dBm]

$\mathrm{Max}[P_r(r_i - r_{\mathrm{dem}})]$ = -54.47 [dBm]

CS-CPR algorithm adopts peak miss bias correction. But, EC-CPR algorithm may not adopt the bias correction.
The bias for EC-CPR is estimated to be -0.3 dB

# Summary

EC-CPR L1 products in public version (vCa) are intercompared with CS-CPR products by using GCOM-W AMSR2 data as a reference.

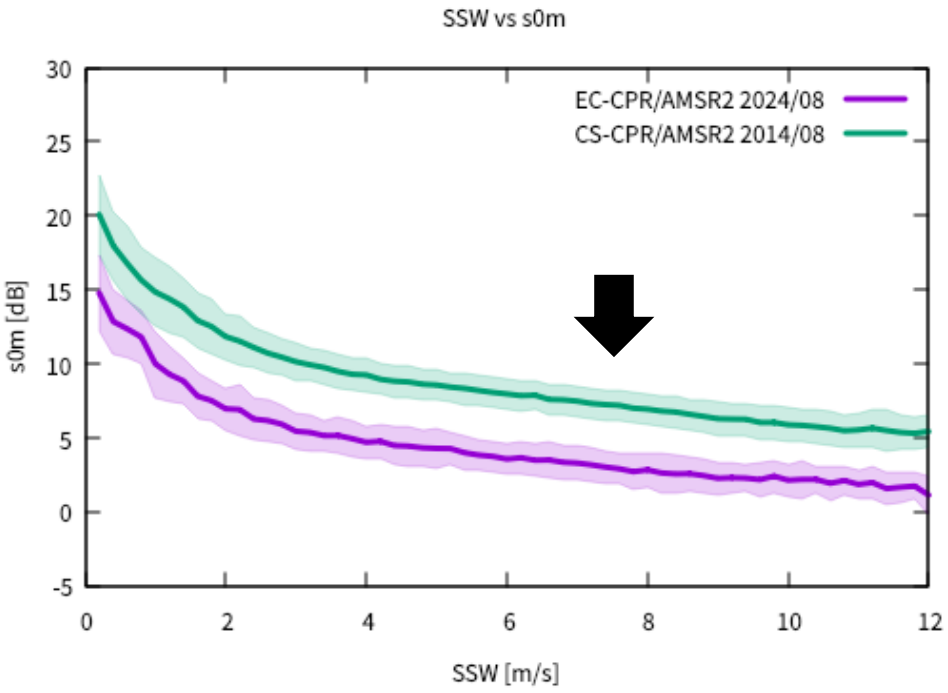
- $\sigma_m^0$ of EC-CPR in vCa is slightly (~1.7 dB) lower than that of CS-CPR in R05
- Except for change in version, $\sigma_m^0$ level of EC-CPR is stable with time.
- 1.7 dB difference in $\sigma_m^0$ between EC-CPR and CS-CPR may be caused by:
  - Peak bias due of coarse discrete range sampling for EC-CPR is ~-0.3 dB
  - Difference in atmospheric gas attenuation, which can be evaluated in L2 products.
  - Residual error of calibration factor

# References

EarthCARE(EC)-CPR: 2024/08/08-2024/08/30 (vAc)
CloudSat(CS)-CPR: 2014/08/01-2014/08/31 (R05)

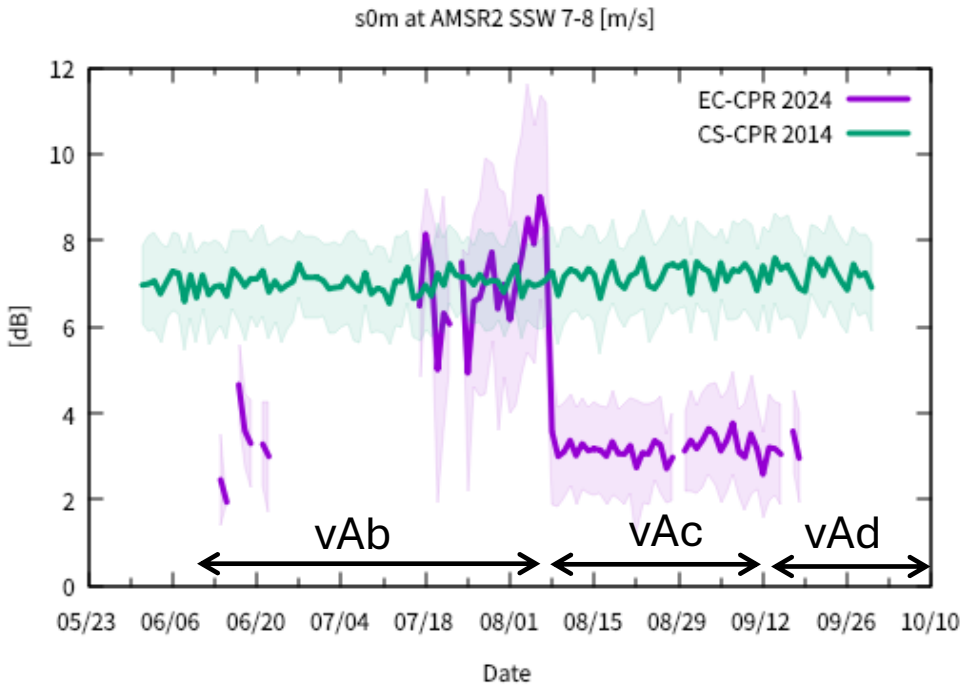
AMSR-2 products are provided from Remote Sensing Systems

AMSR-2 SSW vs. s0m in clear-sky




EC-CPR (vAc/vAd) is ~4 dB lower than CS-CPR.
Standard deviation is almost the same.

Daily time series of s0m in clear-sky when SSW 7-8 m/s



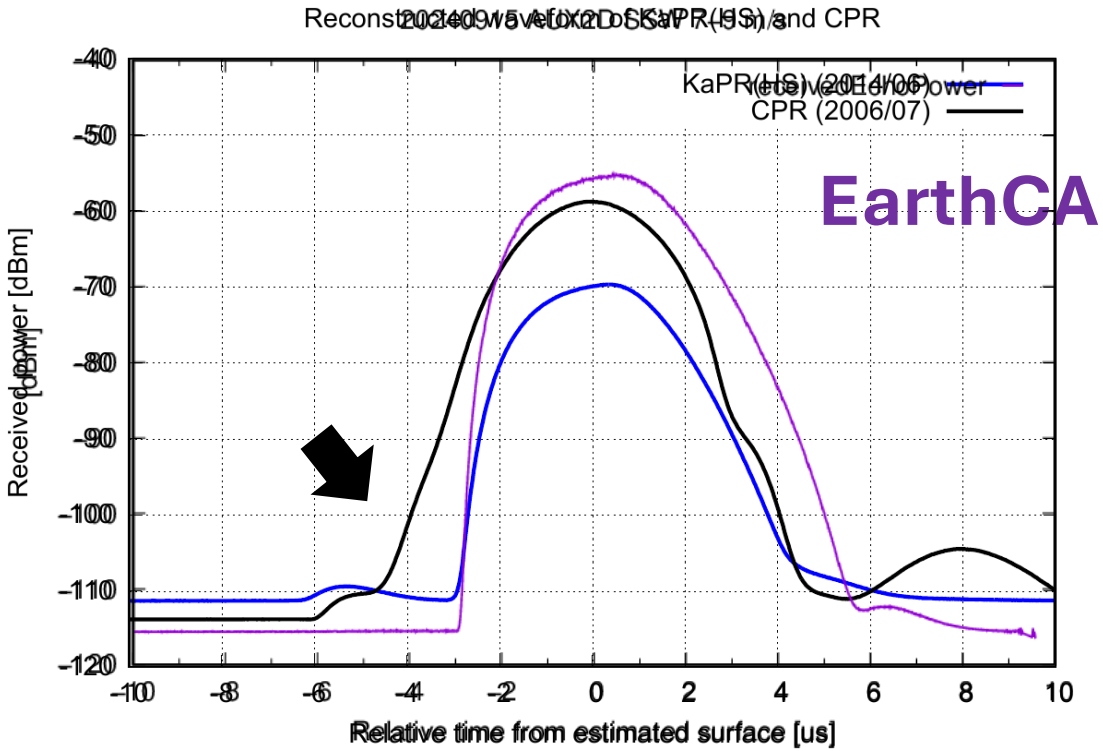

~7 dB

~3 dB

L1B in vAb had large temporal variability.
After vAc, quality of data is stable.

# CloudSat CPR

## KaPR (HS) (plusewdith = 3.2 us)




600m

Fig. 9 in Kanemaru et al. (2020)

**EarthCARE CPR**

Clutter contamination of CloudSat CPR due to the feed-through problem is not seen in clutter pattern of EarthCARE CPR

(KaPR is caused by inference due to two-frequency agility)