SEC-2024068

CPR Integrated Commissioning Team Activities

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European Space Agency (ESA), Japan Aerospace Exploration Agency (JAXA)

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

Overall CPR Integrated Commissioning Team Activities

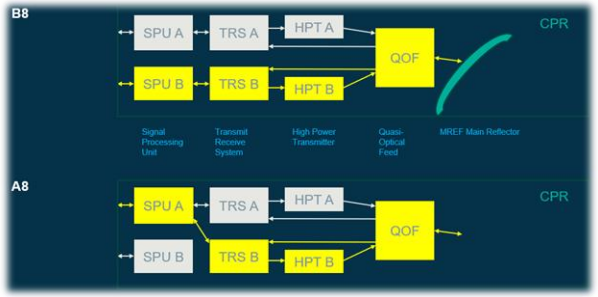
The CPR Integrated Commissioning Team is a joined team of JAXA and ESA including scientists (CARDINAL)

Highlights:

Successful Deployment of MREF Deployment at LEOP
CPR First Observation Mode 12. June 2024 including first data
CPR First Product published by ESA and JAXA on 27. June
CPR L1b Data Formal Release on 20. Sept.
All commissioning Tasks have been successfully executed ----------
Full science data performance achieved after last reconfiguration end November 24
Some calibration activities will be continued as part of the commissioning till March 25

No severe anomalies

An anomaly related to HPT-B switch-off lead to a re-configuration ----------
from B8 (all B-chain) to A8 (all B-chain except SPU-A used) in July 24,
return to original nominal configuration end November 24.

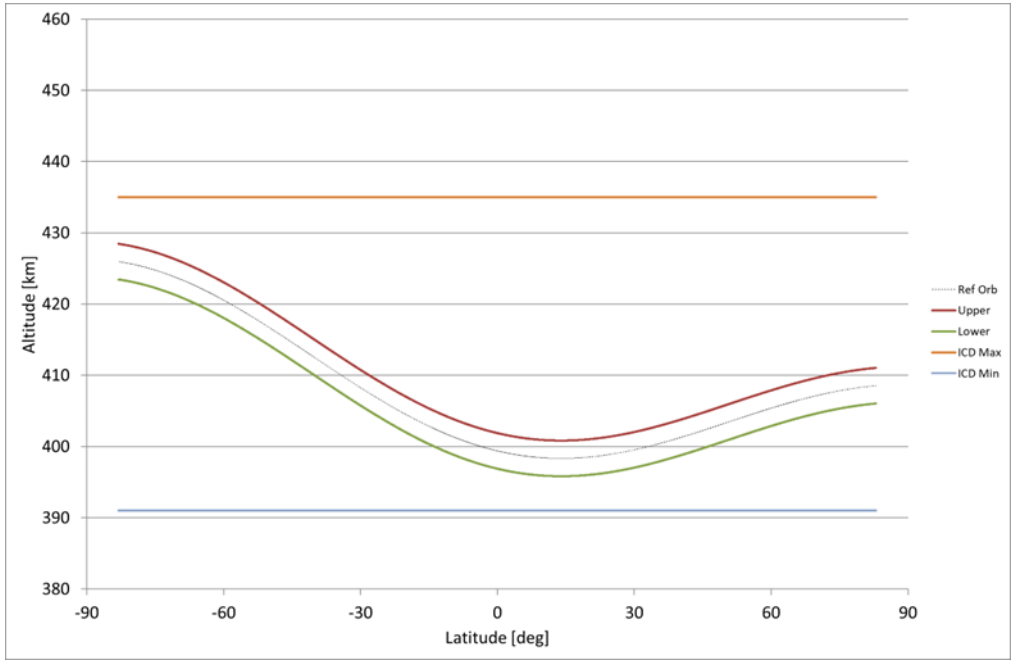


This anomaly is meanwhile understood as “natural behaviour” of the HPA (High Power Amplifier) amplifying the 94 GHz radar signal of CPR – leading sporadically to data gaps due to manual restart needed through the ground segment. Automatization is aimed to reduce data gaps.

EarthCARE Orbit evolution

- Initial orbit injection:
  - ✓ The result of the initial orbit insertion was about +5km compared to the originally planned nominal orbit altitude of +3km. Furthermore, due to an S/C RCS system problem during the initial test maneuver, the orbit altitude was 6km (perigee) to 10km (apogee), which is higher than the nominal orbit altitude.
- Orbit altitude:
  - ✓ While waiting for natural altitude decay, the semi-major axis and eccentricity were adjusted and the nominal orbit altitude was reached around 26 Aug 2024.
- Ground track positioning:
  - ✓ The nominal orbit is defined by two conditions: 1) orbit altitude (maintained within ±2.5km) and 2) ground track positioning (maintained within ±25km), and adjustments to ensure that 2) the sub-satellite track passes at the designated ascending node (0.6 degree) have completed before 10 October 2024 when routine revisit cycle started.

(Nominal Orbit Altitude)



CPR commissioning results

CPR Initial Phase (CPR B8 configuration)

- CPR Initial check out with B8 configuration (all nominal side) was performed from 7 June to 21 June 2024.
- All functional and performance check were completed except for the data evaluation of External calibration and Sea surface calibration because of the timing (No external calibration and sea surface calibration in June)

Issue	+ Create issue	Target start D	Target end D	Status
ECCOMMIS-24	CPR Instrument and Data E2E Commissioning Tasks	10/Jun/24		IN PROGRESS
ECCOMMIS-43	CPR Initial phase (CPR B8 configuration)	10/Jun/24		CLOSED
ECCOMMIS-47	[CPR-01] CPR Switch-ON	10/Jun/24	10/Jul/24	CLOSED
ECCOMMIS-76	[CPR-02A] CPR IQ Offset Verification through "Internal Calibration 1" with HPT ON	12/Jun/24	14/Jun/24	CLOSED
ECCOMMIS-63	[CPR-02B] "3-steps Internal Calibration 1" with SOR.	12/Jun/24	14/Jun/24	CLOSED
ECCOMMIS-60	[CPR-03] SPU Temperature checks through the « Internal Calibration 2 » sequence with HPT OFF	20/Jun/24	10/Jul/24	CLOSED
ECCOMMIS-61	[CPR-04] "Fixed sub-mode (Highest PRF)" Verification for height of 20Km, 18Km and 16Km	12/Jun/24		CLOSED
ECCOMMIS-64	[CPR-05] Automatic PRF change against latitude and attitude are verified	12/Jun/24	10/Jul/24	CLOSED
ECCOMMIS-45	[CPR-09] Health Status and Functional Check	10/Jun/24	10/Jul/24	CLOSED
ECCOMMIS-217	[CPR-14] Rx ATT Check	18/Jun/24	10/Jul/24	CLOSED
ECCOMMIS-218	[CPR-15] Check HPT Stabilization after silent state	18/Jun/24	10/Jul/24	CLOSED
ECCOMMIS-219	[CPR-16] Check the effectiveness for range-bin spurious countermeasures.	17/Jun/24	10/Jul/24	CLOSED
ECCOMMIS-220	[CPR-17] Check the soundness of Power Monitor	17/Jun/24	29/Nov/24	CLOSED

(CPR A8 configuration)

- CPR Initial check out with A8 configuration (SPU: redundant, others: nominal) was performed from 16 July to 17 September 2024.
- Only [CPR-18] is under evaluation by JAXA/NEC for the beam pointing error correction equation (**OPEN item**).

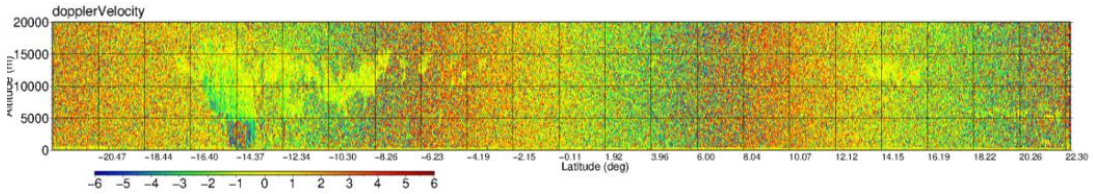
Issue	+ Create issue	Target start D	Target end D	Status
ECCOMMIS-331	CPR Initial phase (CPR A8 configuration)	22/Jul/24	30/Nov/24	IN PROGRESS
ECCOMMIS-337	[CPR-01] CPR Switch-ON (A8)	22/Jul/24	28/Aug/24	CLOSED
ECCOMMIS-341	[CPR-02A] CPR IQ Offset Verification through "Internal Calibration 1" with HPT ON (A8)	25/Jul/24	26/Jul/24	CLOSED
ECCOMMIS-342	[CPR-02B] "3-steps Internal Calibration 1" with SOR. (A8)	25/Jul/24	02/Aug/24	CLOSED
ECCOMMIS-338	[CPR-03] SPU Temperature checks through the « Internal Calibration 2 » sequence with HPT ON (A8)	02/Aug/24	09/Aug/24	CLOSED
ECCOMMIS-339	[CPR-04] "Fixed sub-mode (Highest PRF)" Verification for height of 20Km, 18Km and 16Km (A8)	30/Jul/24	28/Aug/24	CLOSED
ECCOMMIS-340	[CPR-05] Automatic PRF change against latitude and attitude are verified (A8)	29/Jul/24	09/Aug/24	CLOSED
ECCOMMIS-343	[CPR-09] Health Status and Functional Check (A8)	24/Jul/24	02/Aug/24	CLOSED
ECCOMMIS-344	[CPR-14] Rx ATT Check (A8)	30/Jul/24	09/Aug/24	CLOSED
ECCOMMIS-345	[CPR-15] Check HPT Stabilization after silent state (A8)	30/Jul/24	02/Aug/24	CLOSED
ECCOMMIS-346	[CPR-16] Check the effectiveness for range-bin spurious countermeasures. (A8)	24/Jul/24	09/Aug/24	CLOSED
ECCOMMIS-347	[CPR-17] Check the soundness of Power Monitor (A8)	24/Jul/24	29/Nov/24	CLOSED
ECCOMMIS-221	[CPR-18] Check the Beam Pointing error correction equation	22/Jul/24	30/Nov/24	IN PROGRESS

CPR commissioning results

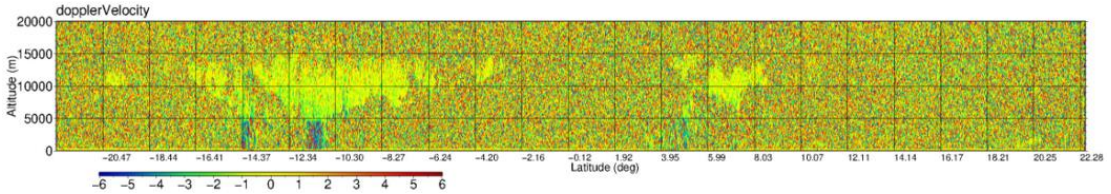
CPR Calibrations

- **[CPR-06] CPR Internal calibration**: IQ offset values has been updated on 8th October 2024, and the criteria was passed. Process for the nominal operation phase has been confirmed. Regarding Internal calibration-2 process, the process via CPR planning rule has been confirmed with PDGS.

(Before IQ offset correction)



(After IQ offset correction)

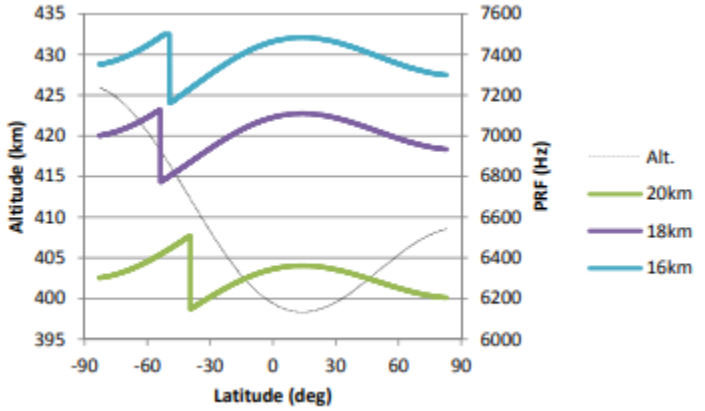


- **[CPR-07] External Calibration, [CPR-08] Sea Surface Calibration**: Process for the nominal operation phase has been confirmed. The calibration will be continuously performed during the nominal operation phase. Because the opportunities of the calibration in initial phase were reduced because of the unexpected orbit, it was agreed that the frequency of the calibration will be kept till the end of March 2025.
  - The detailed activities and analysis results will be presented in “CPR calibration” by H. Horie-san/NICT.

CPR commissioning results

CPR Performance Task

- **[CPR-10] High PRF activity**: The activity was performed from 5 November to 12 November. The possible sub-mode (18km mode) operation in the nominal operation phase should be discussed with the science team.
  - As there is a trade-off relationship between Doppler accuracy and observation height, the detailed analysis results will be presented in “Comparison between CPR observation modes” by Y. Imura-san.
  - In this study potential cloud echo contamination due to mirror image also needs to be considered and will be presented in “CPR mirror image analysis” by S. Aoki-san.



- **[CPR-11] CPR Performance Verification**: Because of the IQ offset performance, JAXA has switched over the SPU back to B(nominal) from A(redundant) for the better CPR performance especially for Doppler measurement accuracy. The acquired data has already been evaluated.

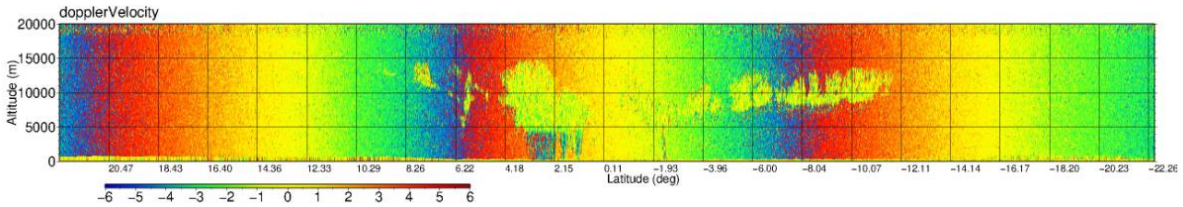
CPR commissioning results

CPR Performance Task (cont.)

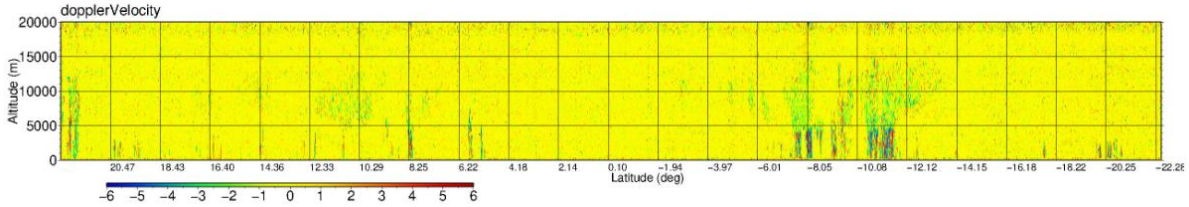
The following tasks still need to be evaluated, however, no major issues have been identified.

- **[CPR-12] CPR Standalone Alignment performance verification**: The Launch alignment report has been confirmed with no significant alignment errors, but is now being re-evaluated without antenna beam correction.
- **[CPR-13] ATLID-CPR Co-Alignment**: The Airbus assessment report has provided good results in terms of geolocation and co-registration, but is now being re-evaluated without antenna beam correction.
- **[CPR-19] Zero Doppler Mode**: The activity was performed on 15 November 2025. According to the preliminary assessment result there are no significant difference in Doppler bias removal. However the effect can be seen in noise signal because the satellite velocity compensation is not necessary in this mode.

(Yaw Steering Mode)



(Zero Doppler Mode)



- **[CPR-20] Small DV manoeuvres**: This operation concept has been descoped for commissioning by ESA.

Major open issues

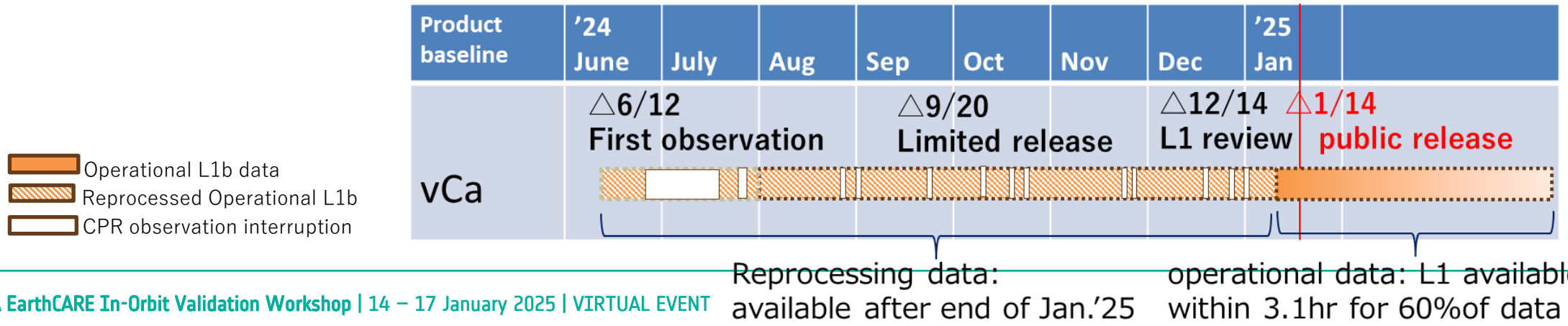
The following anomalies are still open, however, the way forward has already been determined through the IOCR.

- **[IOC-AR-23] CPR mispointing leading to low Doppler accuracy**:
  - As the result of initial check-out in orbit, it has revealed that the correction formula prepared before launch must be modified. In the IOCR collocation, it was agreed that un-corrected product without antenna beam correction will be released at the timing of public release of CPR L1b product (vCa) in January 2025.
  - The revised formula has already been prepared. However, the seasonal change should be verified using the measurement results in January 2025. The actual implementation of revised correction formula to L1b processor is planned coordinating with the subsequent L2 processes.
- **[IOC-AR-24] CPR Power Calibration Corrections**:
  - After the evaluation results of CPR external calibration, the correction has been implemented in CPR L1b processor (vCa). As a result, the level of radar reflectivity of CPR is approximately 2 dB lower than the ones for Cloudsat.
  - The further calibration would be evaluated during the nominal operation phase by using the results of CPR external calibration, and the sea surface calibration.

CPR L1b product

➢ CPR L1 Product release plan

- CPR observation started from June 12 2024, and CPR Level 1 product has been generated since then.
- Since Sep.20 2024, CPR L1b (vAe to vBb) product have been released to the validation team for its initial validation.
- In December, JAXA including Japanese Scientists have confirmed that CPR L1product can be released to public.
  - ✓ L1product satisfies the requirements to release public.
  - ✓ Ground system is ready to release the product to public.
- JAXA have released CPR L1 product to public 14th January.
  - ✓ From Jan.9th data(#3502C) is available as forward processing data.
  - ✓ The reprocessed data from June 12(#227F) is available after end of January, and it will take one month for reprocessing campaign.

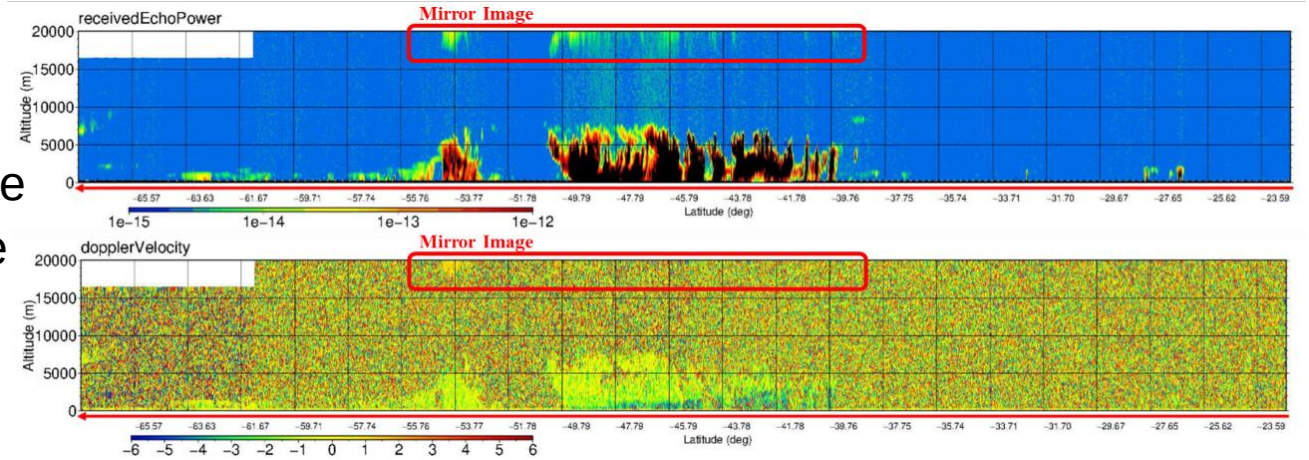


CPR L1b product

Caveats of the CPR L1b product (ver. vCa) was described in the release note (SEC-2024057)

- **Mirror Image**

The “Mirror image” is a phenomenon in which an upside-down cloud pattern appears in a vertical symmetrical form to the direct echo from the target, due to backscattering from the target via reflection from the surface.
The mirror image will be indicated by flag in the CPR L2 product (CPR_ECO_2A).



- **Radar reflectivity and received echo power (Comparison with the CloudSat)**

The released EarthCARE/CPR L1b product reflects the results of calibrations during the commissioning phase. Comparing with the CloudSat/CPR data, it is confirmed that the level of radar reflectivity of the EarthCARE/CPR data is about 2dB lower than that of the CloudSat/CPR data.

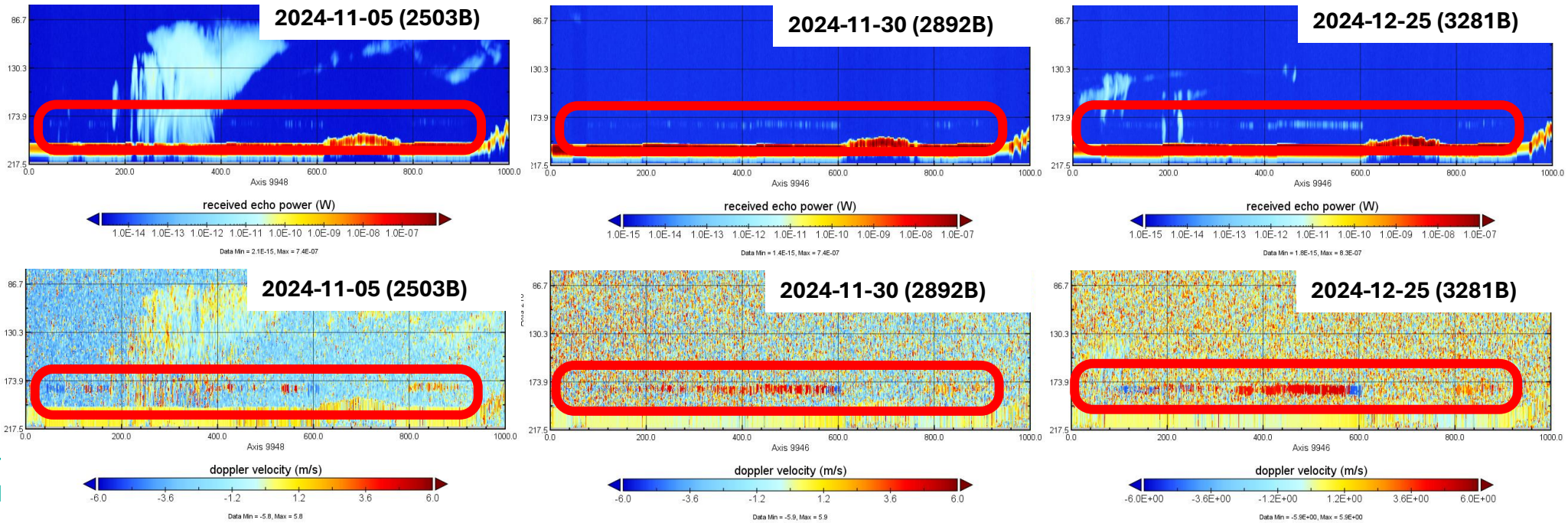
CPR L1b product

Caveats of the CPR L1b product (ver. vCa) was described in the release note (SEC-2024057)

- **Anomalies observed over specific areas**

JAXA found some echo/doppler anomalies that are not clouds in a specific area at the same relative orbit pass*. Here, two examples of the anomaly are shown. The mechanism by which the anomaly occurs is still under investigation. And it is possible that other similar anomalies may be occurring in other area.

<Example of anomalies over Bangladesh area on the flame-B of the relative orbit pass no.=028>



CPR L1b product

➢ Major event history

- The CPR off-nominal operations such as on-board parameter updates and some operation that would affect data quality are listed in the Table-1 of the release note as below.

Event	UTC(From)	To	Duration		Obs. Data		SPU	Orbit/	Note
			Days	Time	Yes	No		Frame	
CPR First Turn-on	2024-06-07T13:02:00	-				✓	B		
Observation with SPU-B	2024-06-12T12:02:24	2024-07-16T11:44:28	33d	23h42m04s	✓		B	00226A-00386A	Start of CPR Observation.
Observation with Initial IQ offset values	2024-06-12T12:02:24	2024-07-16T11:44:28	33d	23h42m04s	✓		B	00226A-00386A	Initial IQ offset values were passed the criteria.
Mode Transition Test	2024-06-13T09:51:58	2024-06-14T12:00:02	1d	02h08m04s		✓	B	00241H-00258G	For initial Checkout. Internal Calibration is included.
Sub-mode Fix (Middle)	2024-06-14T12:00:03	2024-06-14T16:37:32	0d	04h37m29s	✓		B	00258G-00261G	For initial Checkout.
Sub-mode Fix (HIGH)	2024-06-14T16:37:33	2024-06-14T21:15:01	0d	04h37m28s	✓		B	00261G-00264G	For initial Checkout.
Sub-mode Fix (LOW)	2024-06-14T21:15:02	2024-06-17T12:45:26	2d	15h30m24s	✓		B	00264G-00305G	For initial Checkout. Long Silent State (10min.) is included.
Rx ATT Change Operation	2024-06-17T13:57:57	2024-06-18T17:43:19	1d	03h45m22s	✓		B	00306F-00324E	For initial Checkout.

- Observation data loss may occur during planned operation, such as CPR Calibration Operations, Silent State Operation Over Radio Astronomy Sites (RAS), Satellite maneuvers, GS outage etc. Please refer the followings;
  - ✓ CPR L1b Data Missing List (CPR Operation Status):
    https://www.eorc.jaxa.jp/EARTHCARE/data/operational_status_e.html
  - ✓ RAS overpasses:
    https://ec-pdgs-monitor.eo.esa.int/flyover/passes/
  - ✓ Overview of CPR Calibration Plan :
    https://www.eorc.jaxa.jp/EARTHCARE/data/calibration_e.htm/