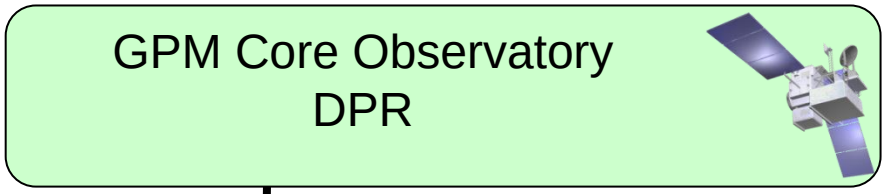
GPM/DPR V07X Product Note

JAXA and DPR algorithm development team

15th January 2024

GPM/DPR Data Processing Flow



Level 0

HK/Science Telemetry
- *DPR HK*
- *Observation data*
- *Satellite position*
- *Altitude*
- *Attitude*
- *Time*
- *DPR Temp. Monitor, etc*

Developed by JAXA

Level 1 algorithm

Ancillary Data
- *Satellite Orbital Elements*
- *CAL factors*
- *Scene information, etc.*

Level 1 Products

Engineering values
- *Transmit power*
- *Antenna beam direction*
- *Received power… etc.*

Physical values
- *Reflectivity factor*
- *Precip. rate*
- *Precip. type classification (Conv./Strat.)*
- *Particle type (Rain/Snow/Graupel)*
- *DSD (Drop Size Distribution) , etc.*

Developed by DPR Joint JAXA-NASA Algorithm Team

Level 2 algorithm

Level 2 Products

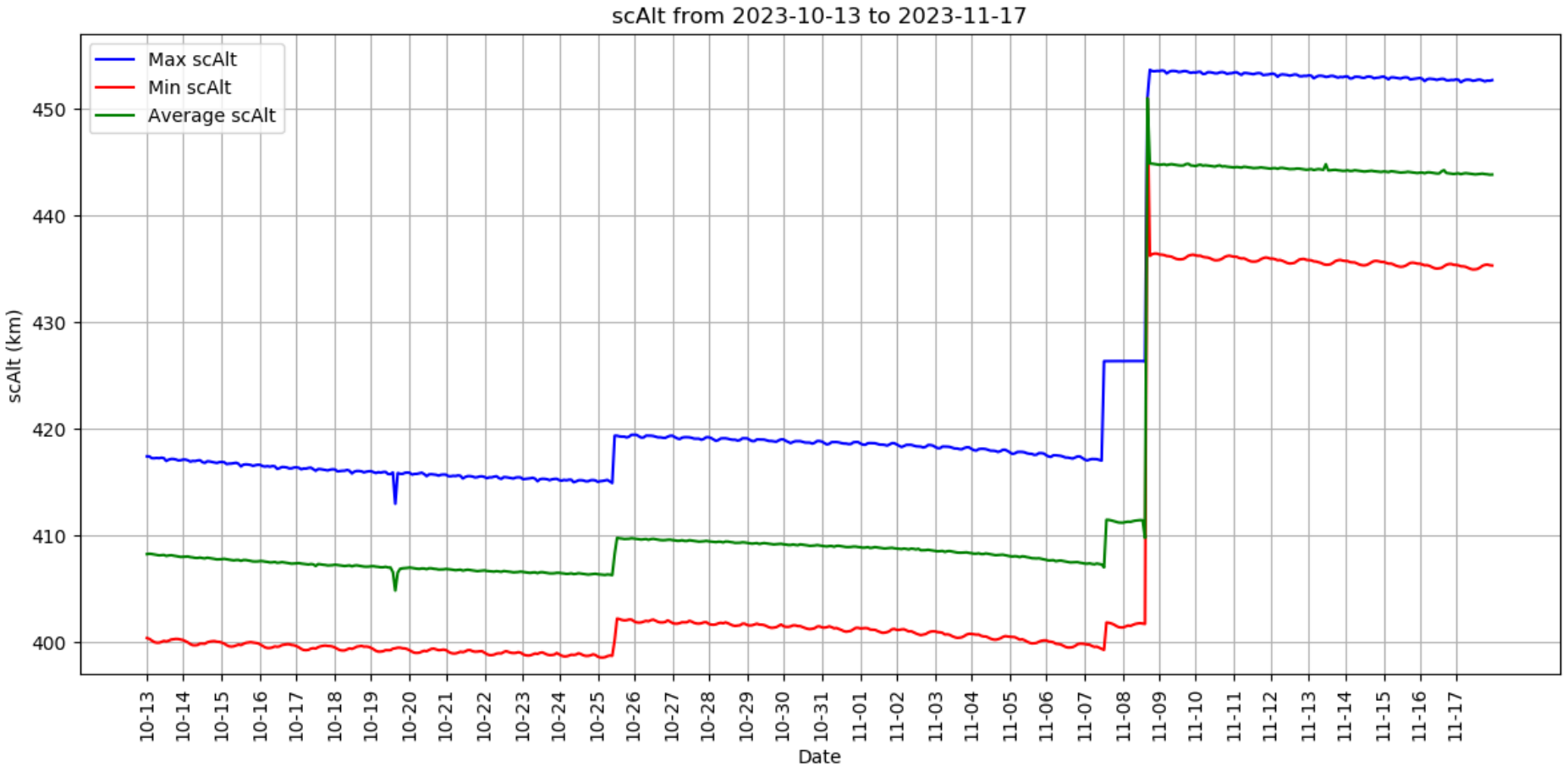
Updates of the DPR-L1 algorithm for post-boost operation

- Update the VPRF(Variable Pulse Repetition Frequency) table
  - ➢ Installed a new VPRF table for post-boost in the DPR-L1 algorithm.
  - ➢ Changed the VPRF table version (V3 → V4).

- Altitude information updates
  - ➢ DPR-L1 algorithms
    - ✓ Store altitude for DPR operation (dprAlt)and real spacecraft altitude (scAlt) in the DPR-L1 product.
      - /swath/navigation/dprAlt : altitude for DPR operation (offsetted to be between 396.5km and 419.5km)
      - /swath/navigation/scAlt : real spacecraft altitude
    - "scAlt" and "dprAlt" was almost same in the pre-boost.

Preliminary evaluation of the DPR-L1 product

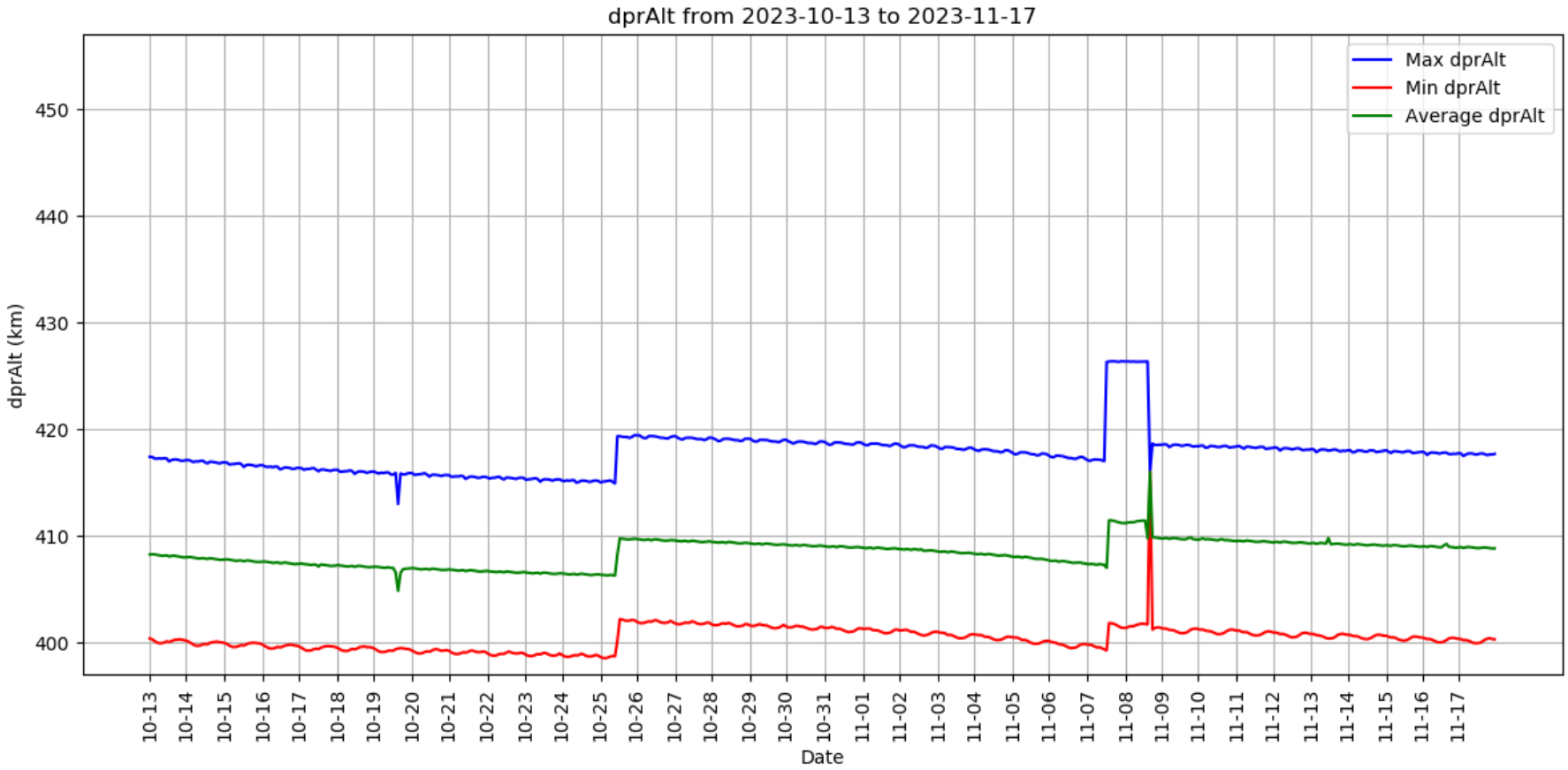
scAlt (real spacecraft altitude)



Time series of spacecraft altitudes during the period from 13rd Oct. to 17th Nov. 2023. Blue, red, and green lines denote maximum, minimum, and averaged altitudes within each orbit, respectively.

Preliminary evaluation of the DPR-L1 product

altitude for DPR operation (dprAlt)



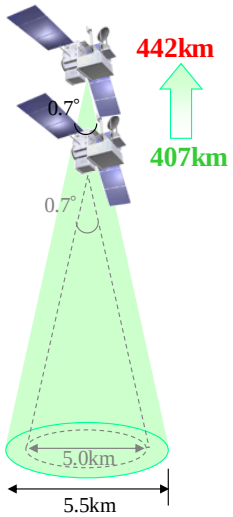
Time series of spacecraft altitudes during the period from 13rd Oct. to 17th Nov. 2023. Blue, red, and green lines denote maximum, minimum, and averaged altitudes within each orbit, respectively.

Preliminary evaluation of the DPR-L1 product

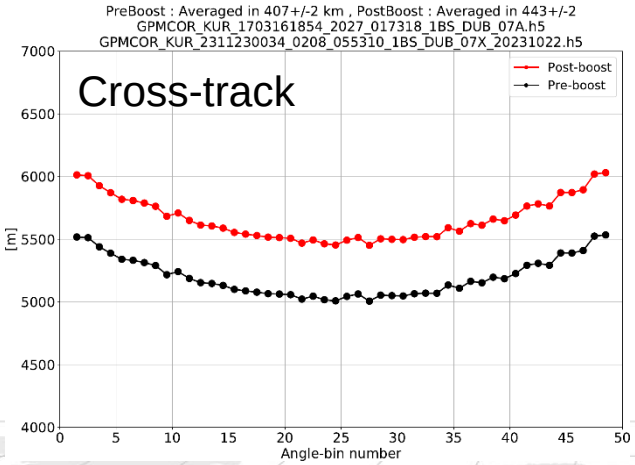
Geolocation

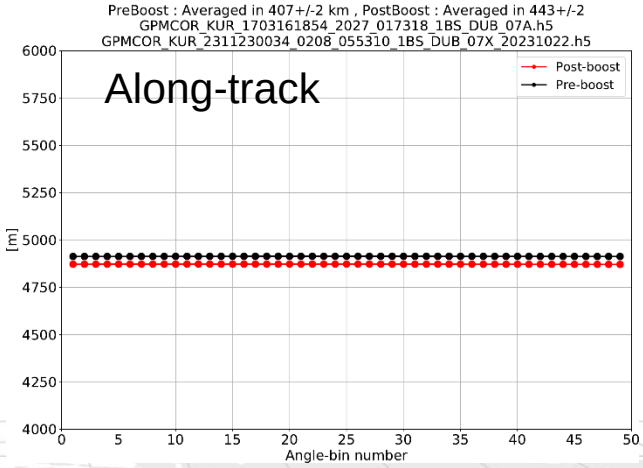
Specifications of the DPR in terms of spatial resolution and swath width for the pre-boost (altitude of 407km) and the post-boost (altitude of 442km), predicted by the DPR manufacture company (NEC).

Satellite altitude	Spatial resolution		Swath width
	Nadir	Scan edge	
407km	5.04km × 5.04km	5.04km × 5.57km	255.8km
442km	5.48km × 5.48km	5.48km × 6.05km	277.9km



Post:Nov. 23, 2023
Pre: Mar. 16, 2017





Distances between adjacent footprints in the cross-track direction (left) and the along-track direction (right) for the pre-boost(16th March 2017, Black marks) and the post-boost (23rd Nov. 2023, Red marks).

- Compared the footprint and swath width between similar orbits at pre/post boost.
- DPR-L1 data confirmed that changes of the sampling were larger in the cross-track direction (about 5 km to 5.5 km at the nadir).

Preliminary evaluation of the DPR-L1 product

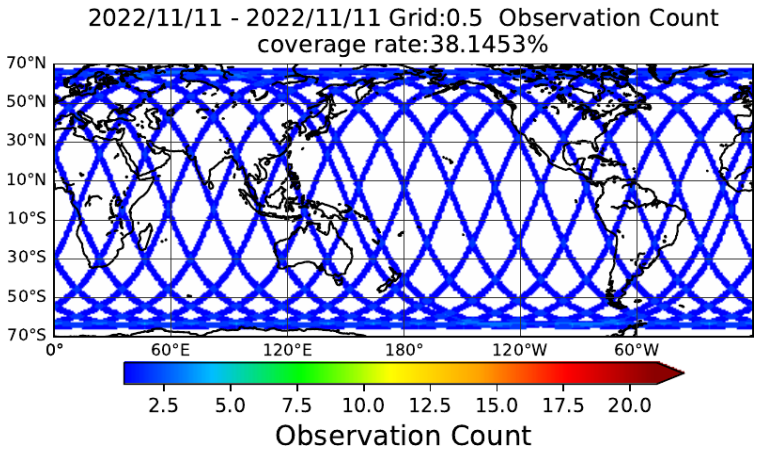
Comparisons of the DPR observation area for the pre-boost and the post-boost.

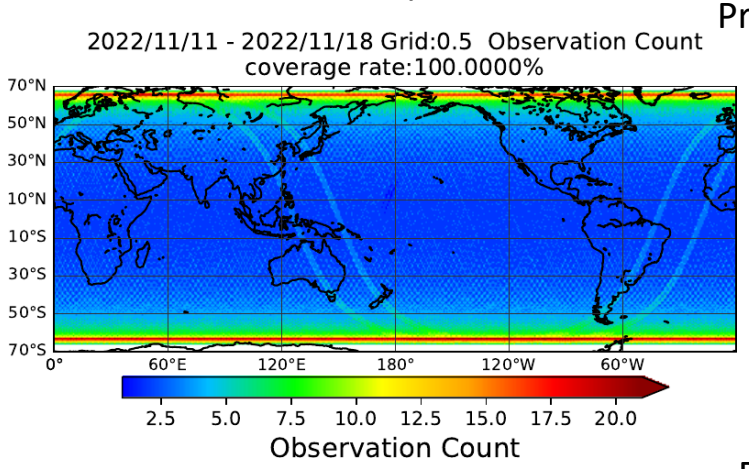
Coverage

One day

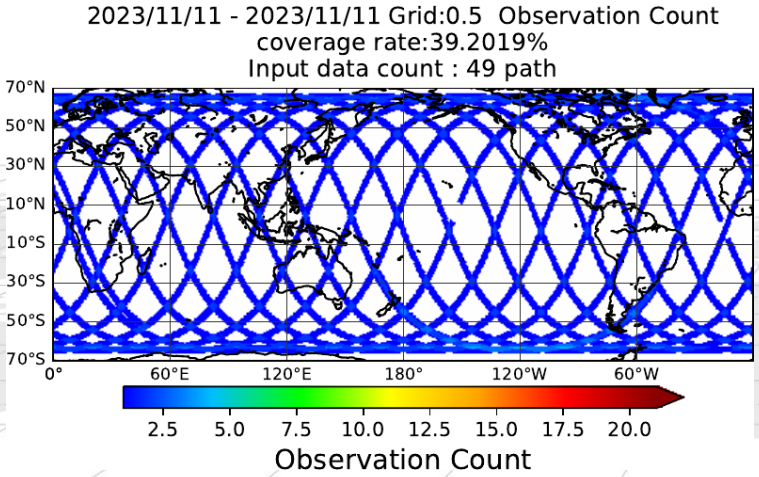
8 days

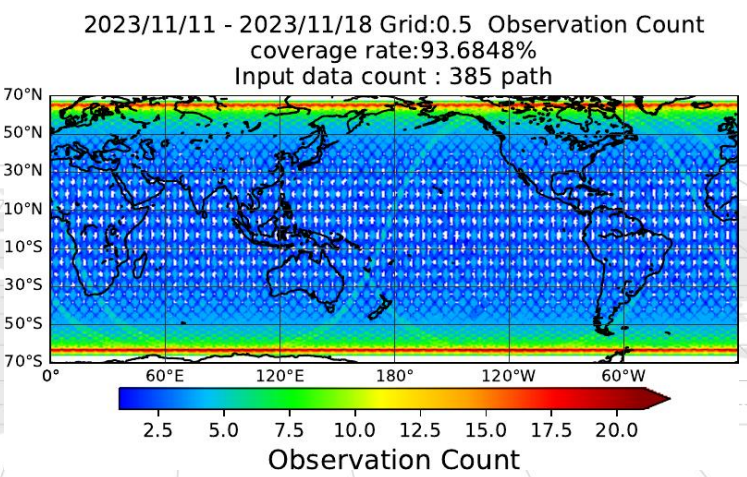
Pre-boost





Post-boost

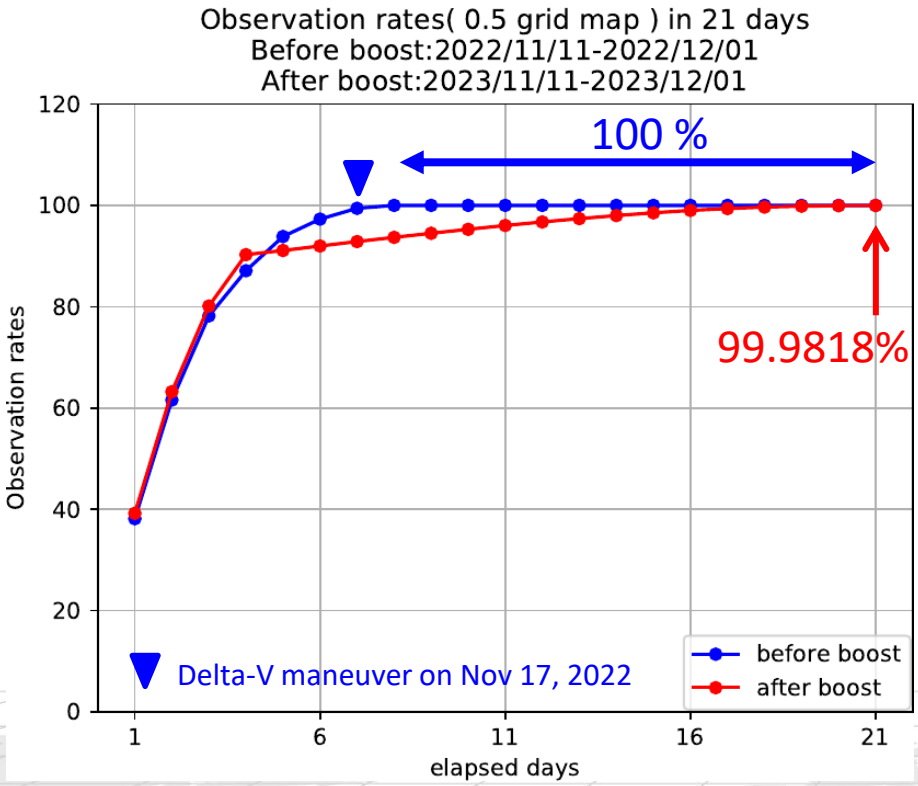


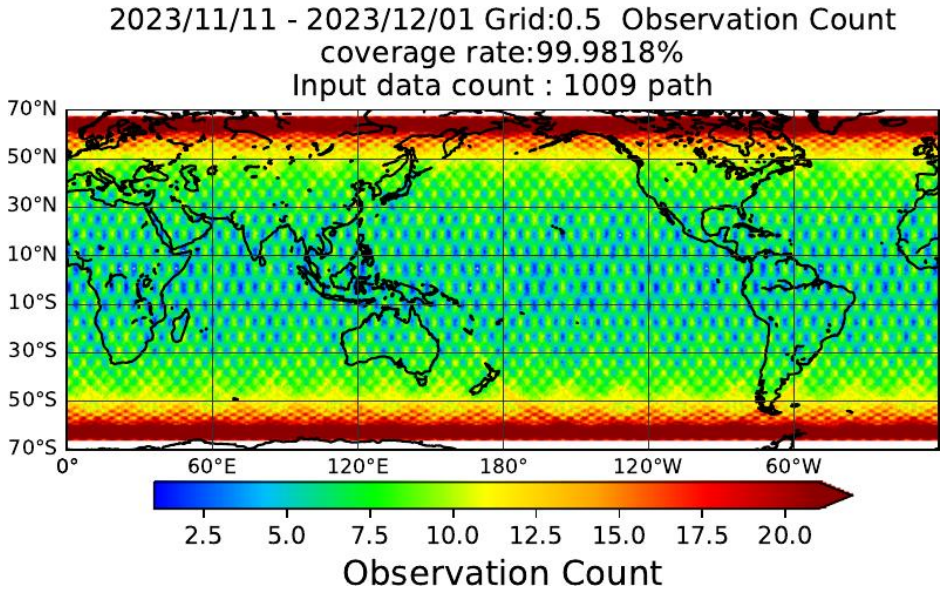


These observed DPR Coverage features were similar to those predicted by the NASA before the boost .

Preliminary evaluation of the DPR-L1 product

Comparisons of the DPR observation area for the pre-boost and the post-boost.





- In pre-bost, 100% coverage in 8 days.
- In post-bost, it has not reached 100% after 21 days.

- This coverage tendency is expected to change with satellite maneuvers.
- The maneuver is expected to change the orbit elements, thereby covering all locations.

These observed DPR Coverage features were similar to those predicted by the NASA before the boost .

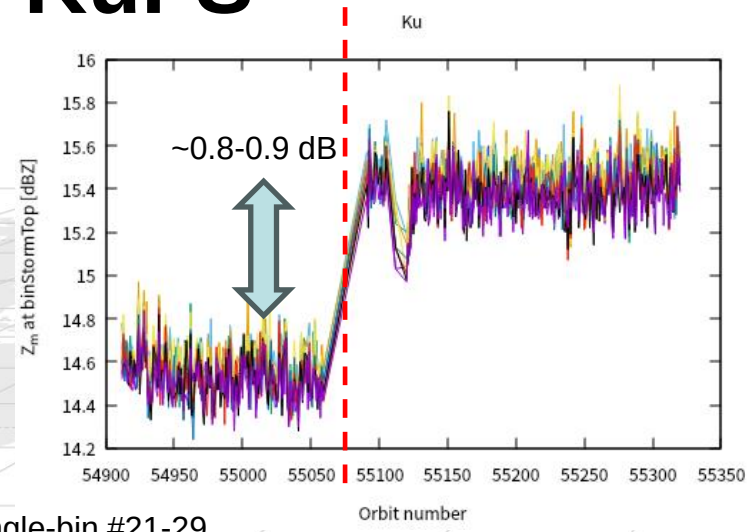
DPR-L2 algorithm development status

- Main developments of the L2 algorithm in V07X (Experimental version) are connected with Preparation (PRE) module.
  - The PRE module reads the received power data from L1 products, classifies each footprint into either rain or no-rain and converts the received power into measured reflectivity factor at each range bin and into apparent normalized surface cross section.
- DPR Joint JAXA-NASA Algorithm Team revised the PRE module in V07X in terms of the mainlobe clutter detection and the sidelobe clutter database.
- Preliminary evaluation of the DPR-L2 product, corresponding to V07X, is shown here using the revised algorithms.
- DPR team is also working for V07C (Standard version) which is expected to be released in March 2024.

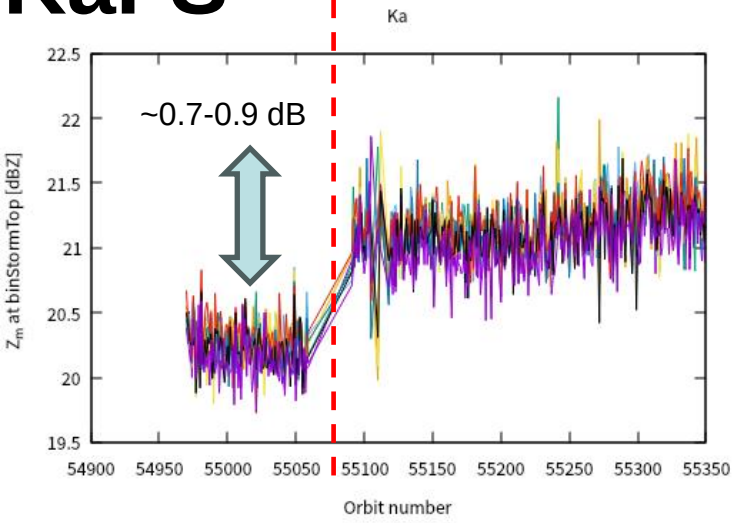
Preliminary evaluation of the DPR-L2 product

- The sensitivity degradation of the DPR is expected owing to the increase of satellite altitude.
- Figures below time series of measured radar reflectivity factor (Z_m) at storm top height (STH) over the ocean for the KuPR and the KaPR, respectively.
  - Z_m at STH is used as an indicator of the sensitivity (e.g., Toyoshima et al. 2015).
- They show the sensitivity degradation of about 0.8-0.9dB for KuPR, and about 0.7-0.9dB for KaPR, as expected.

KuFS Orbit boost



KaFS Orbit boost

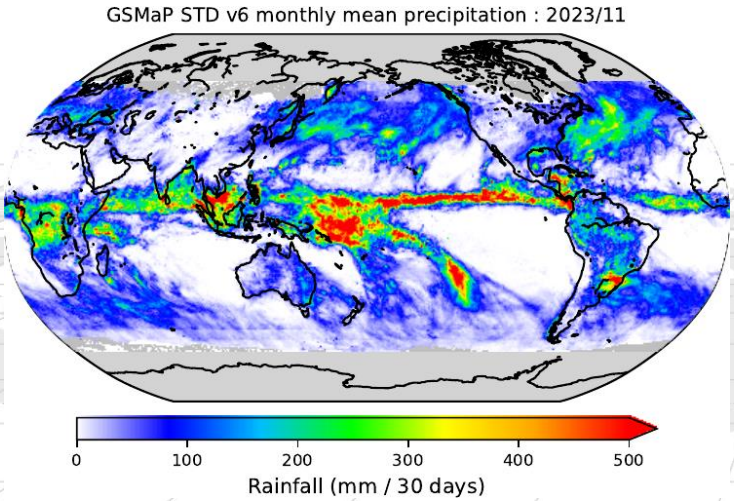


Angle-bin #21-29

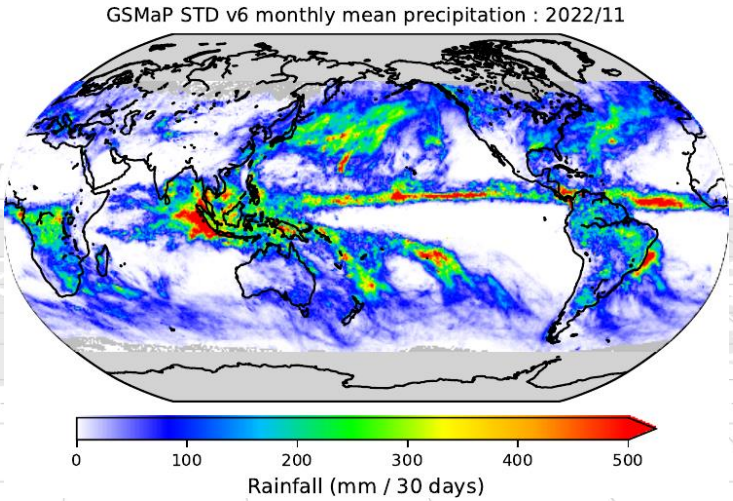
Preliminary evaluation of the DPR-L2 product

- We compared precipitation estimates between the pre-boost and the post-boost.
  - Pre-boost :Nov 12- Dec 12, 2022
  - Post-boost :Nov 12- Dec 12, 2023
- Please note precipitation distributions during Nov.-Dec. 2023 were affected by effects of the El Nino. Here we show GSMaP figures for references.

GSMaP (Nov. 2023)



GSMaP (Nov. 2022)

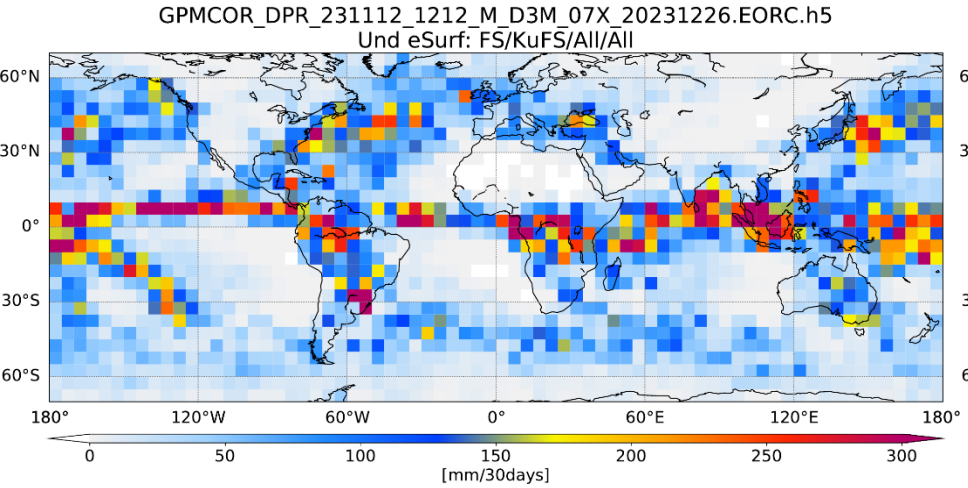


Horizontal distribution of surface precipitation: KuFS

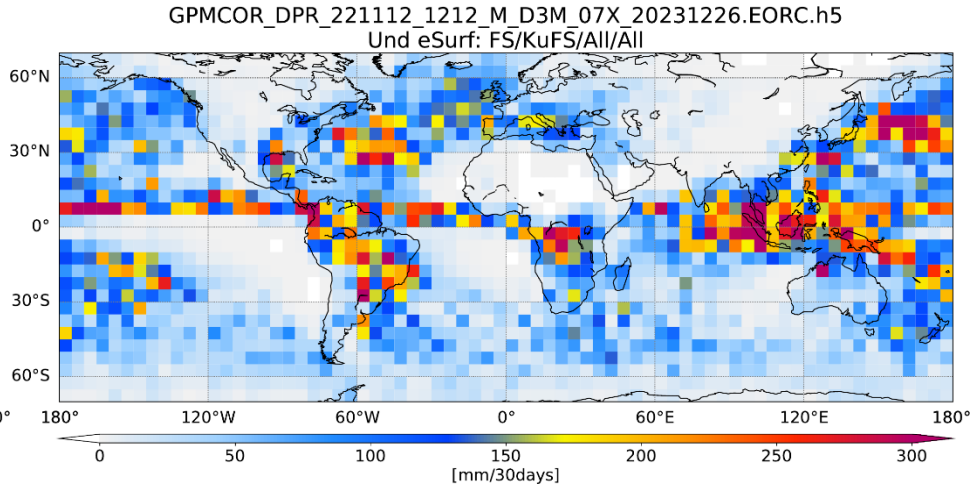
Post-boost :Nov 12- Dec 12, 2023

Pre-boost :Nov 12- Dec 12, 2022

Post-boost(07X_20231226)



Pre-boost(V07A)

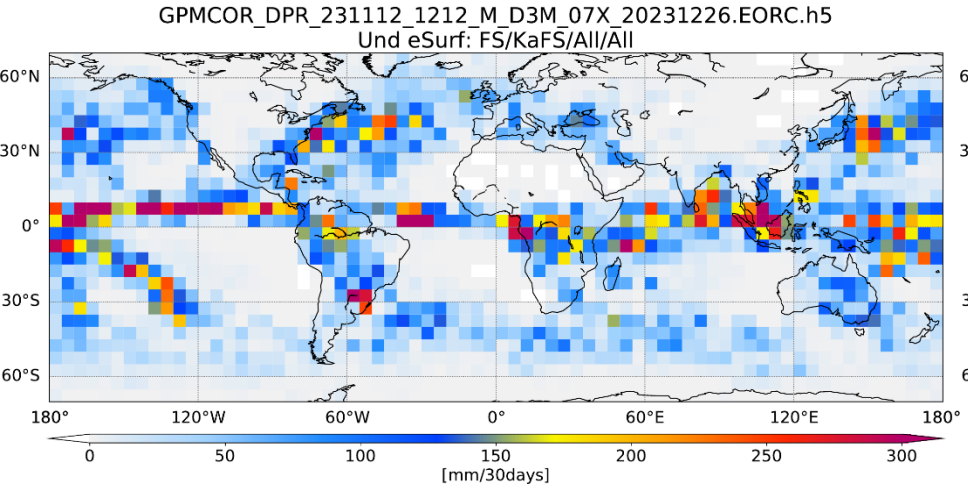


Horizontal distribution of surface precipitation: KaFS

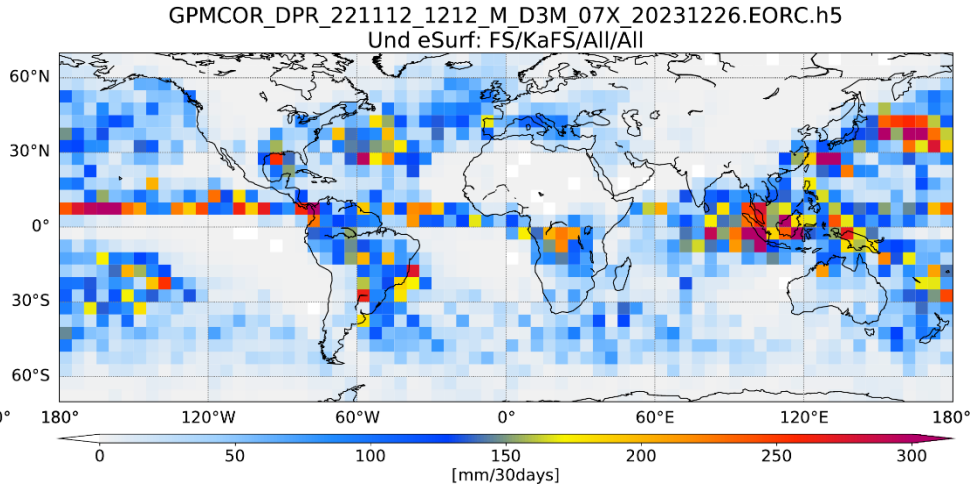
Post-boost :Nov 12- Dec 12, 2023

Pre-boost :Nov 12- Dec 12, 2022

Post-boost(07X_20231226)



Pre-boost(V07A)

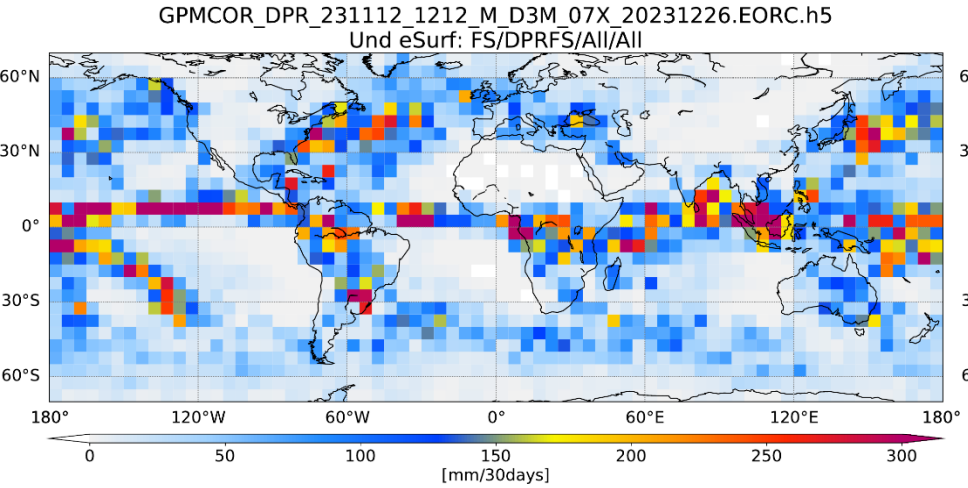


Horizontal distribution of surface precipitation: DPRFS

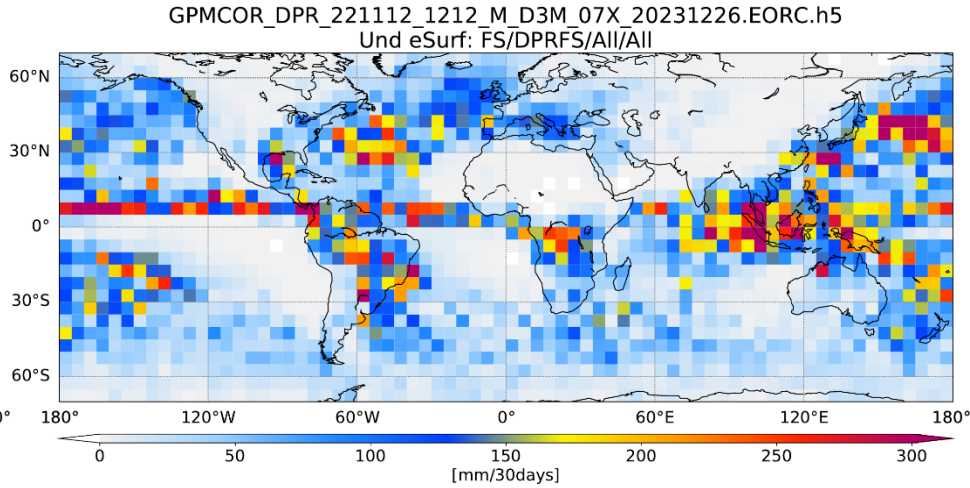
Post-boost :Nov 12- Dec 12, 2023

Pre-boost :Nov 12- Dec 12, 2022

Post-boost(07X_20231226)



Pre-boost(V07A)

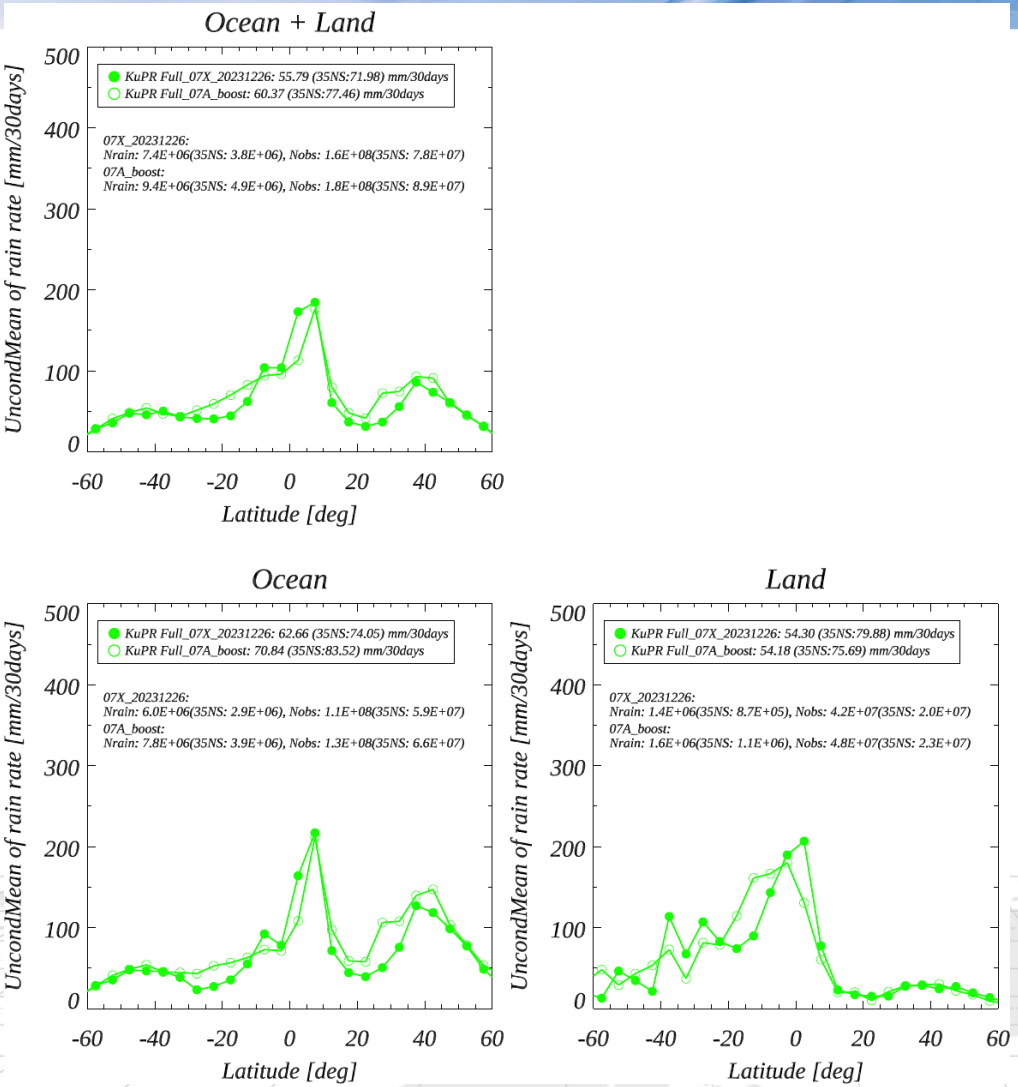


Zonal mean surface precipitation (KuFS)

precipRateESurface

Full swath
KuPR

● : Post-boost
○ : Pre-boost

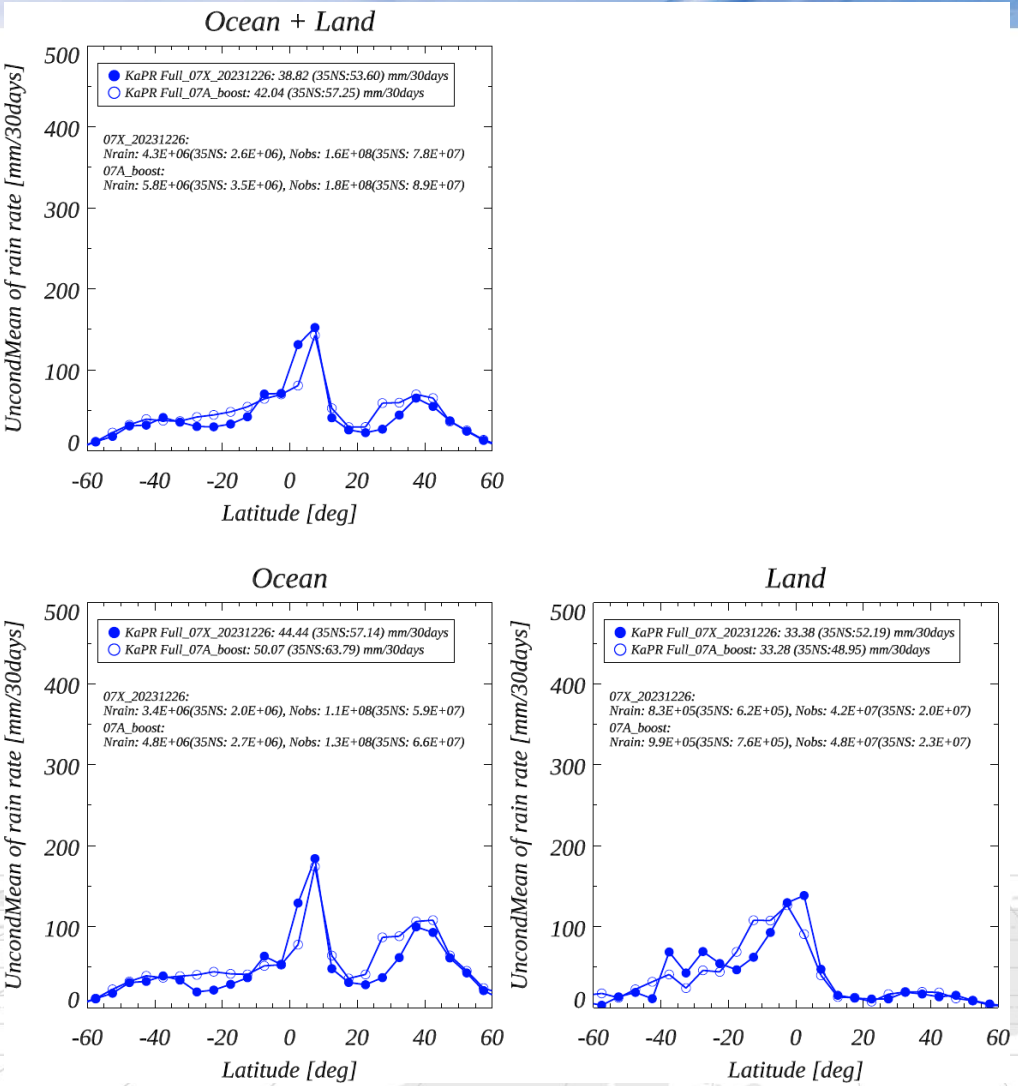


Zonal mean surface precipitation (KaFS)

precipRateESurface

Full swath
KaPR

● : Post-boost
○ : Pre-boost

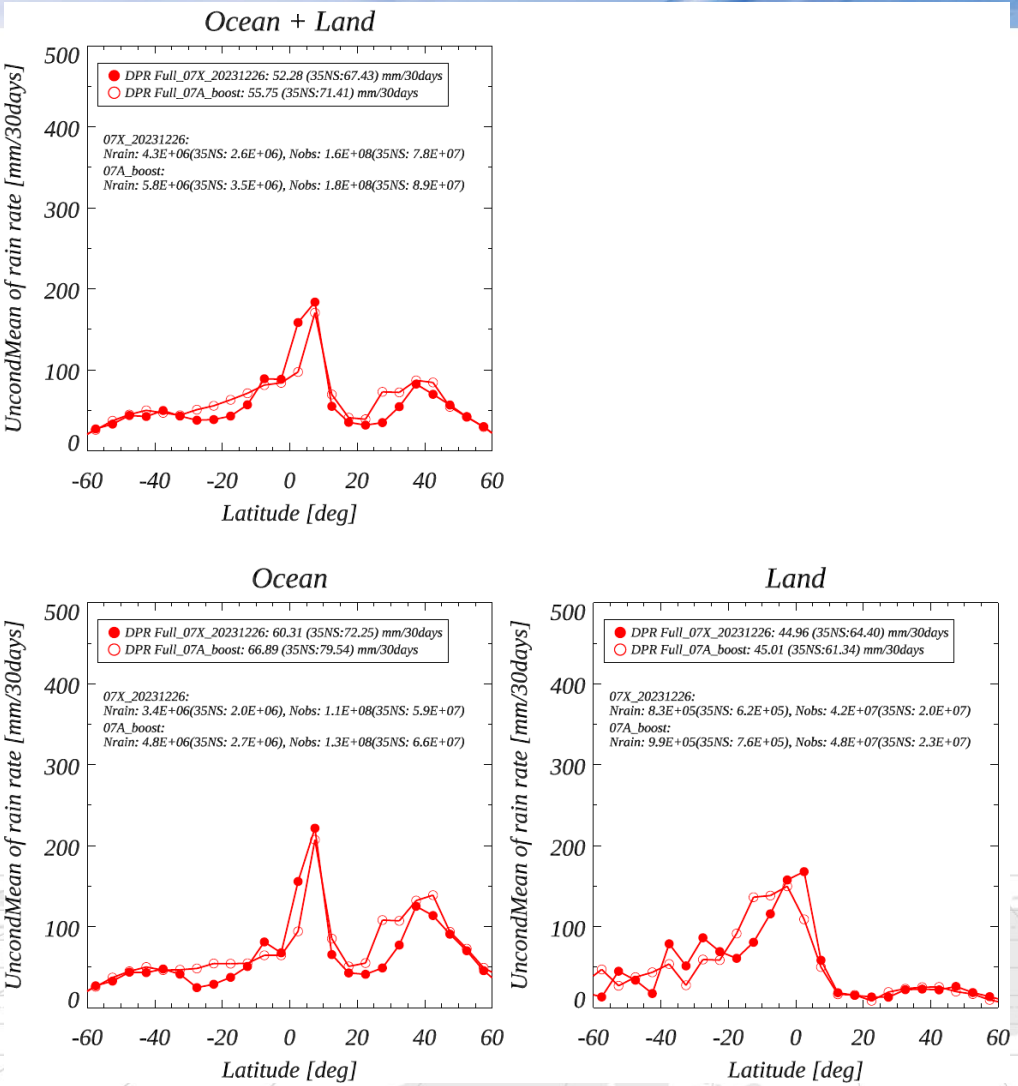


Zonal mean surface precipitation (DPRFS)

precipRateESurface

Full swath
DPR

● : Post-boost
○ : Pre-boost



Summary

- This summarizes preliminary evaluations of V07X.
  - DPR L1 and L2 algorithms for V07X are working as expected.
  - DPR-L1 data confirmed that changes of the sampling were larger in the cross-track direction (about 5 km to 5.5 km at the nadir).
  - Spatial bias was observed in DPR sampling during post-boost (11th Nov. to 1st Dec. 2023), but this is thought to be mitigated by the delta-V maneuver.
  - With analyzing measured radar reflectivity factor at storm top height over the ocean, the sensitivity degradation was found for about 0.8-0.9dB for KuPR, and about 0.7-0.9dB for KaPR.
  - Precipitation maps and zonal mean averages of V07X shows reasonable ranges while the strong El Nino may affect distributions during Nov.-Dec. 2023.
- Based on the above results, the DPR team suggests that there is no issue with the release of V07X.

Plan for DPR release in March 2024

- DPR V07X is the experimental version and to be expected to be used only for the near-real-time processing.
- JAXA and the DPR team is working for the final code for the standard version as following.
  - DPR L1 V07B
  - DPR L2&L3 V07C
- We’re targeting the above standard versions as the release in March 2024.
- We will develop algorithms and evaluate more DPR data before releasing the standard versions.

Reference

- T. Kubota, T. Masaki, G. Kikuchi, M. Ito, T. Higashiuwatoko, K. Kanemaru, N. Takahashi, K. Yamamoto, K. Furukawa, T. Nio, “Evaluation of effects on Dual-Frequency Precipitation Radar Observations due to the Orbit Boost of the GPM Core Observatory”, submitted to *Proc. IGARSS 2024*.