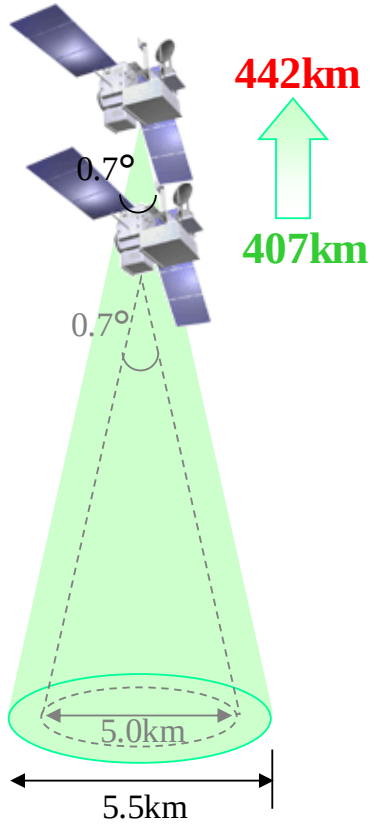
Status report on post-boost products for GPM/DPR L1 V07B, GPM/DPR L2/L3 V07C, and SLH L2/L3 V07C

JAXA
DPR algorithm development team
SLH algorithm development team

4th March 2024

Impacts of the DPR instruments due to the orbit boost

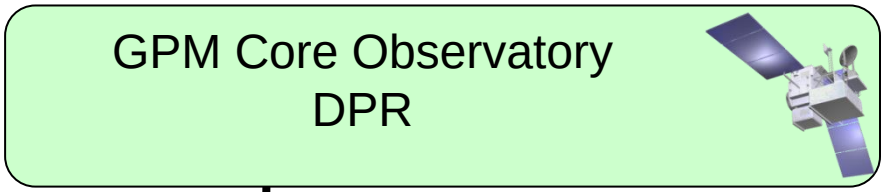
- The GPM Core Observatory orbit boost in Nov. 2023 can lead to extension of the mission lifetime.
- On the other hand, following Impacts on the GPM/DPR are expected.
  - Instrument footprints and swath widths increased proportionately with the altitude change.
  - Radar sensitivity was reduced slightly.



The following was estimated by the DPR manufacture company (NEC)

Satellite altitude	Swath width	Spatial resolution		Minimum Detectable Rain Rate (Actual)		
		Nadir (Angle-bin No. 25)	Scan edge (Angle-bin No. 1, 49)	Ku	Ka (Matched)	Ka (High-sensitivity)
407km	255.8km	5.04km × 5.04km	5.04km × 5.57km	0.30mm/hr	0.38mm/hr	0.16mm/hr
442km	277.9km	5.48km × 5.48km	5.48km × 6.05km	0.33mm/hr	0.42mm/hr	0.19mm/hr

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 for the DPR-L1 algorithm

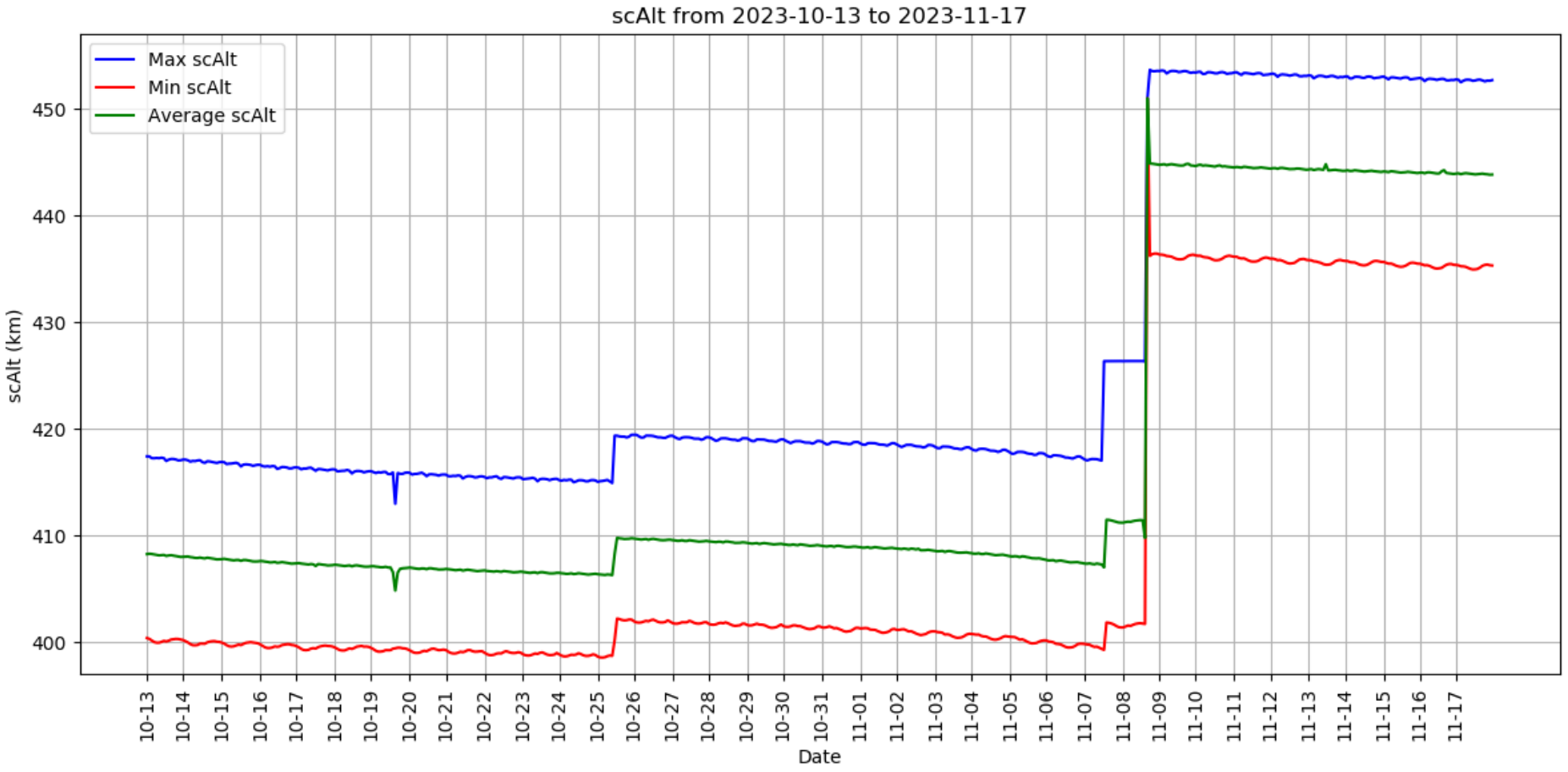
- The VPRF(Variable Pulse Repetition Frequency) table update
  - ➢ Installed a new VPRF table for post-boost in the DPR-L1 algorithm.
  - ➢ Changed the VPRF table version (V3 → V4).

- 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.

- Timing delay updates
  - ➢ The observation timings in the along-track direction of the KuPR and the KaPR were changed to adjust the beam matching of those footprints for the orbit boost.

Preliminary evaluation of the DPR-L1 product

scAlt (real spacecraft altitude)

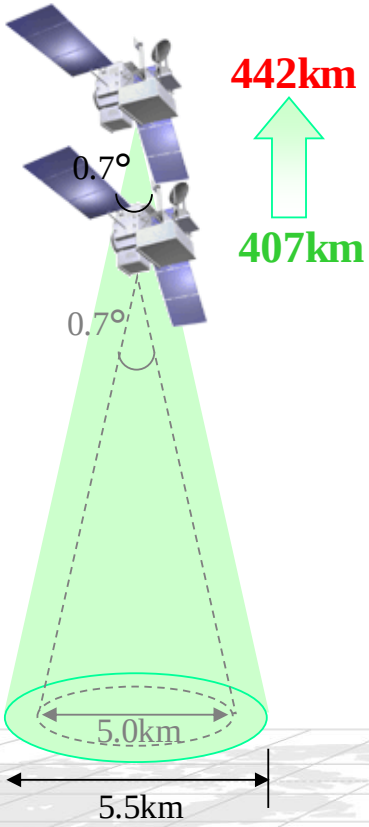


Time series of spacecraft altitudes during the period from 13rd Oct. to 17th Nov. 2023. Blue, red, and green lines denote maximum, minimum, and averaged altitudes within each orbit, respectively.

Preliminary evaluation of the DPR-L1 product

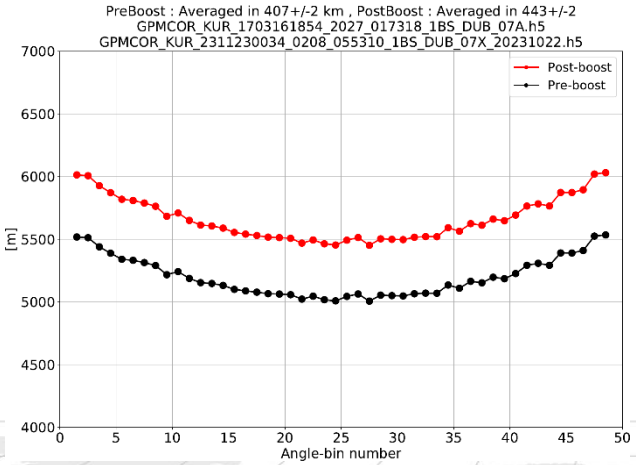
Geolocation

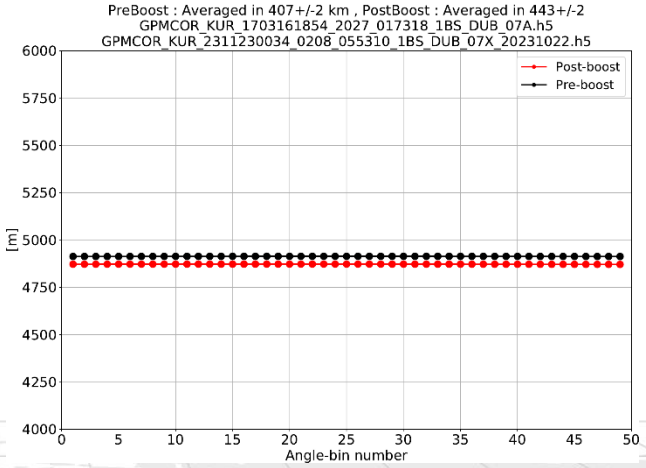
Specifications of the DPR in terms of spatial resolution and swath width for the pre-boost (altitude of 407km) and the post-boost (altitude of 442km).



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).

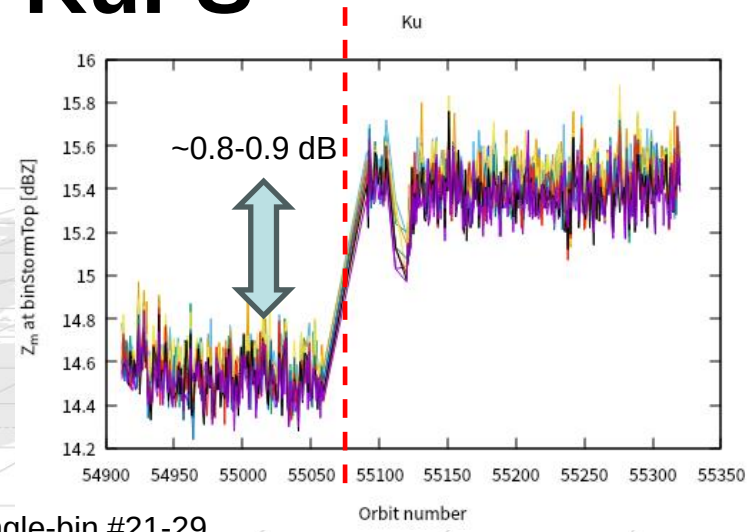
DPR-L2 algorithm development status

- Main developments of the L2 algorithm in V07C are related to 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 V07C in terms of the mainlobe clutter detection and the sidelobe clutter database.
- Preliminary evaluation of the DPR-L2 product, corresponding to V07C, is shown here using the revised algorithms.

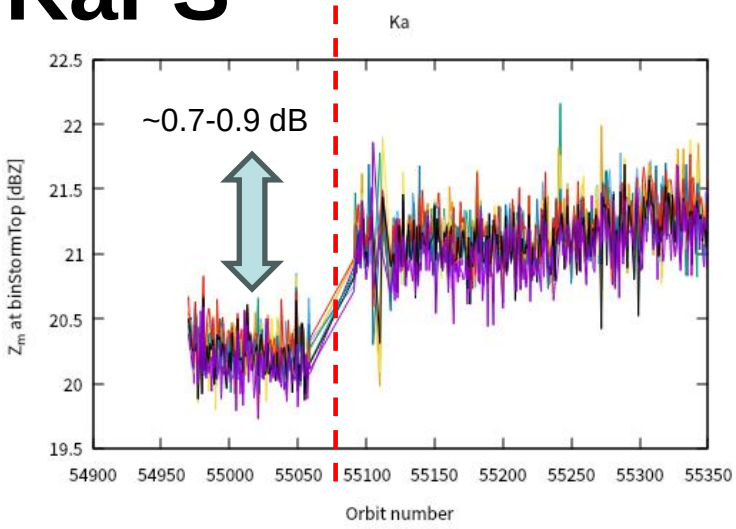
Preliminary evaluation of the DPR-L2 product

- 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

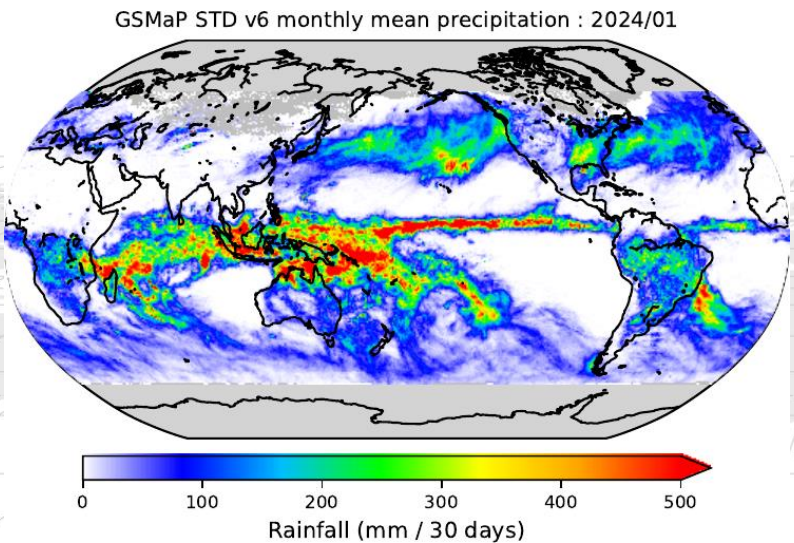


Angle-bin #21-29

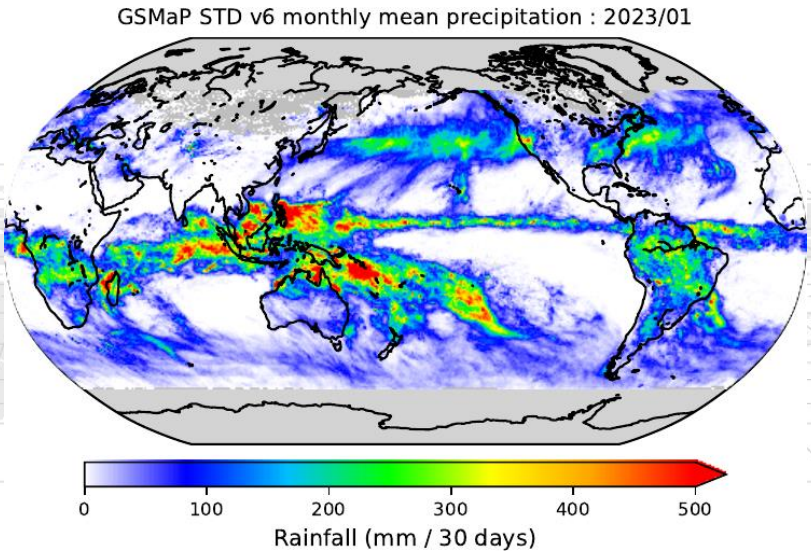
Preliminary evaluation of the DPR-L2 product

- We compared precipitation estimates between the pre-boost and the post-boost.
  - Pre-boost : Jan 1- Jan 31, 2023
  - Post-boost : Jan 1- Jan 31, 2024
- Please note precipitation distributions in Jan 2024 were affected by effects of the El Nino.

GSMaP (Jan. 2024)



GSMaP (Jan. 2023)

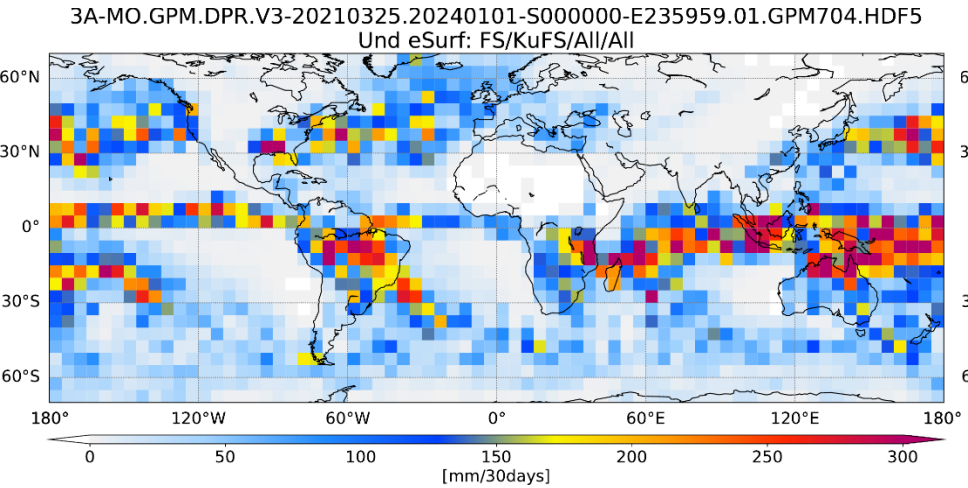


Horizontal distribution of surface precipitation: KuFS

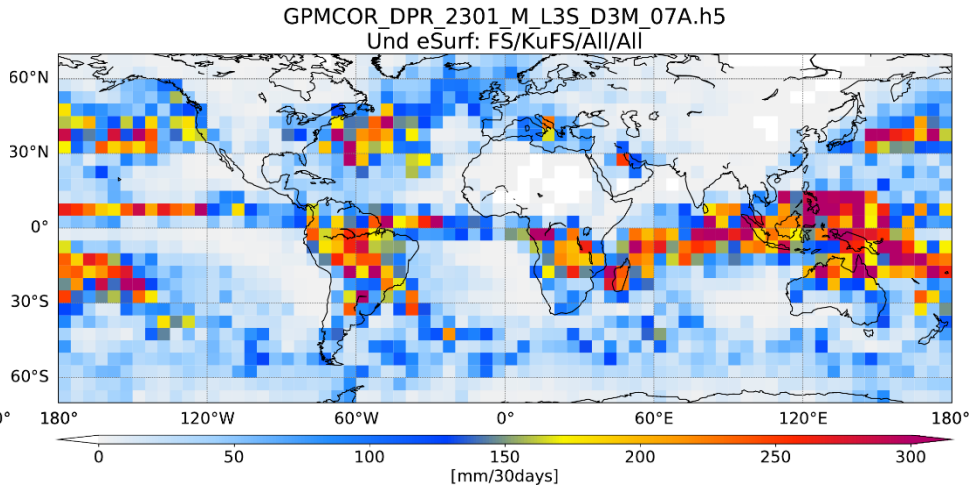
Post-boost :Jan 1- Jan 31, 2024

Pre-boost : Jan 1- Jan 31, 2023

Post-boost (GPM704)



Pre-boost (V07A)

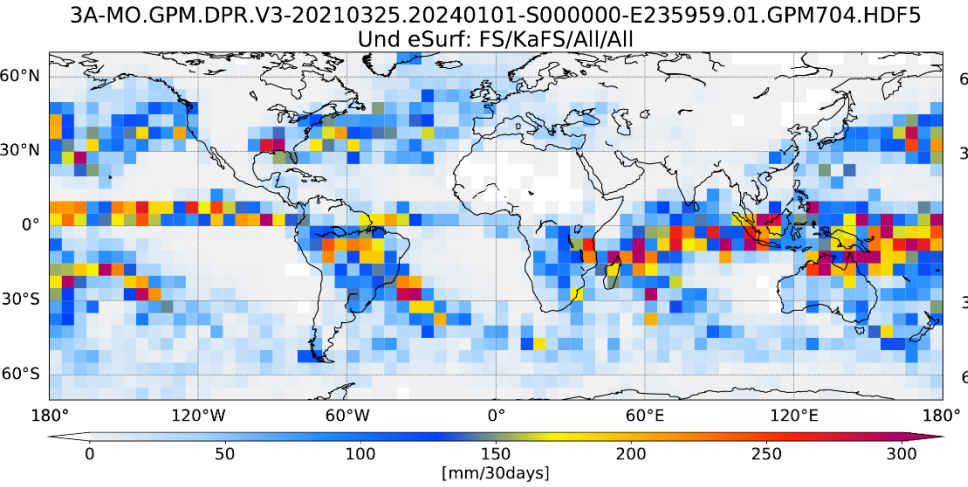


Horizontal distribution of surface precipitation: KaFS

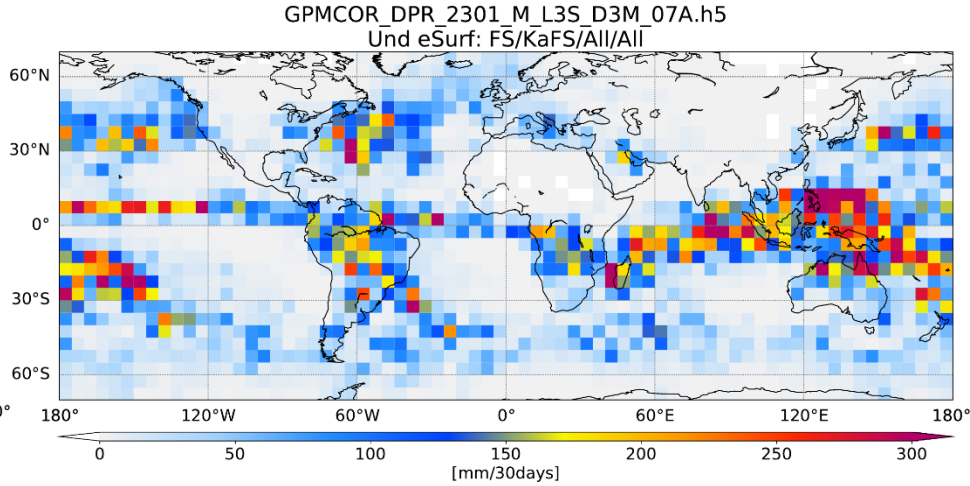
Post-boost :Jan 1- Jan 31, 2024

Pre-boost : Jan 1- Jan 31, 2023

Post-boost (GPM704)



Pre-boost (V07A)

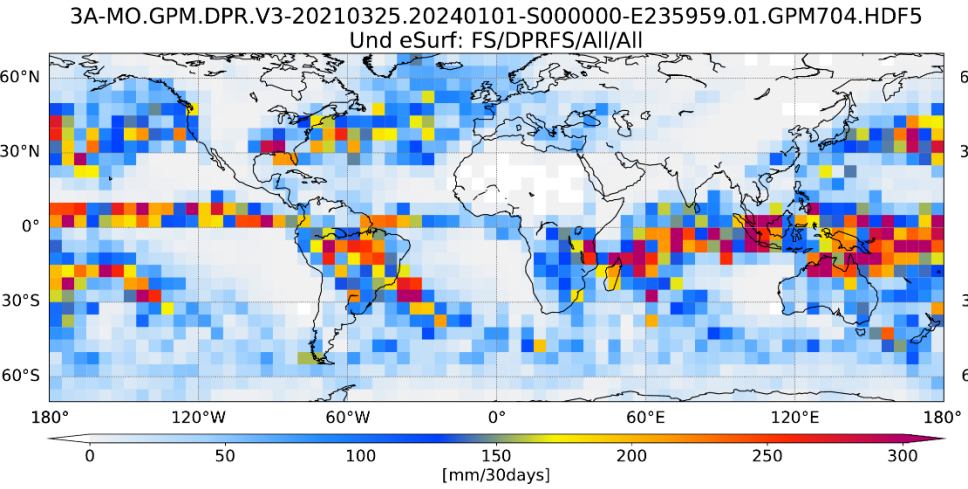


Horizontal distribution of surface precipitation: DPRFS

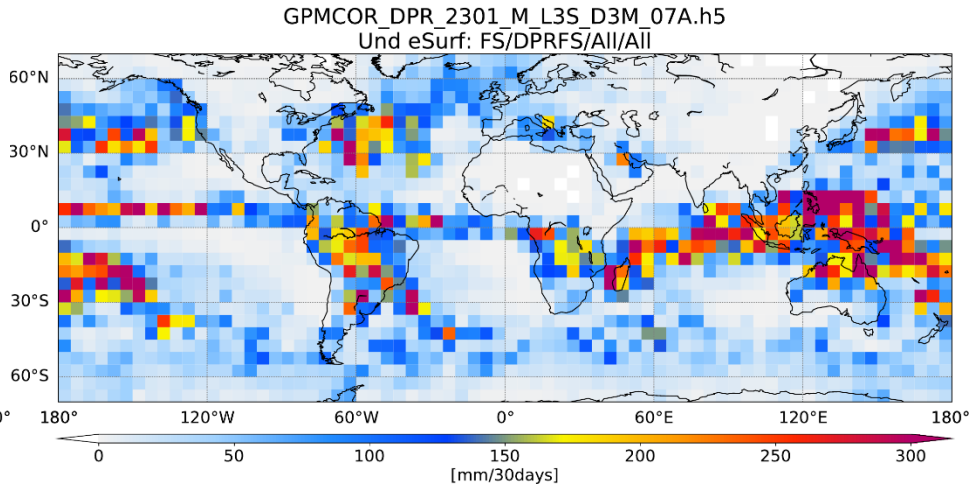
Post-boost :Jan 1- Jan 31, 2024

Pre-boost : Jan 1- Jan 31, 2023

Post-boost (GPM704)



Pre-boost (V07A)

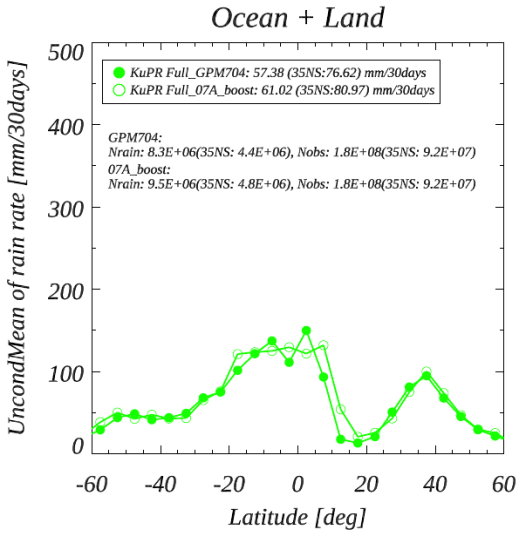


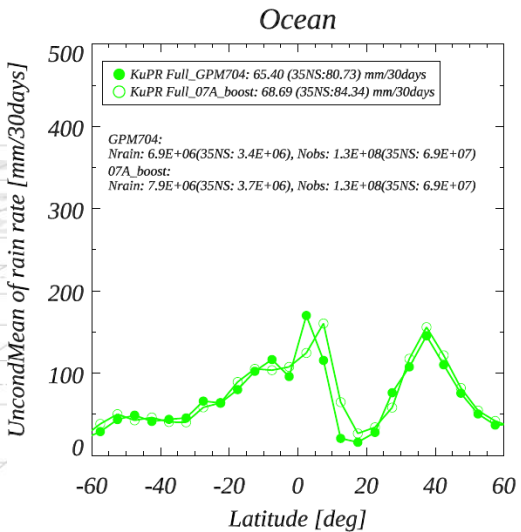
Zonal mean surface precipitation (KuFS)

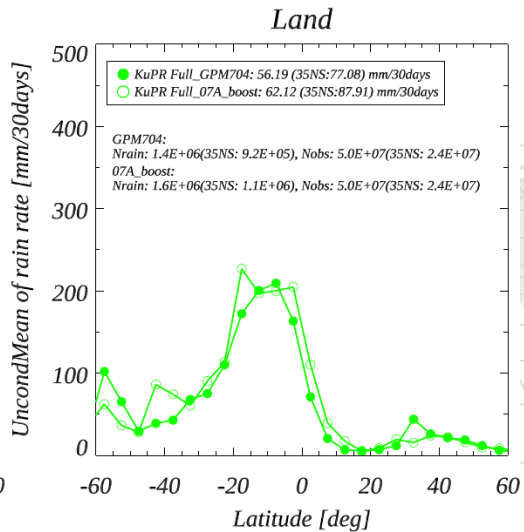
precipRateESurface

Full swath
KuPR

● : Post-boost
○ : Pre-boost





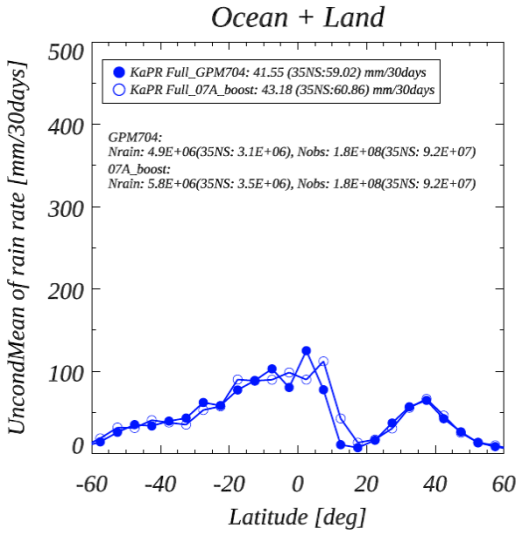


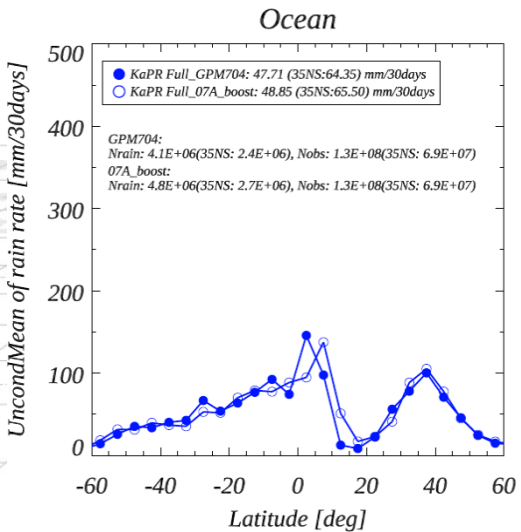
Zonal mean surface precipitation (KaFS)

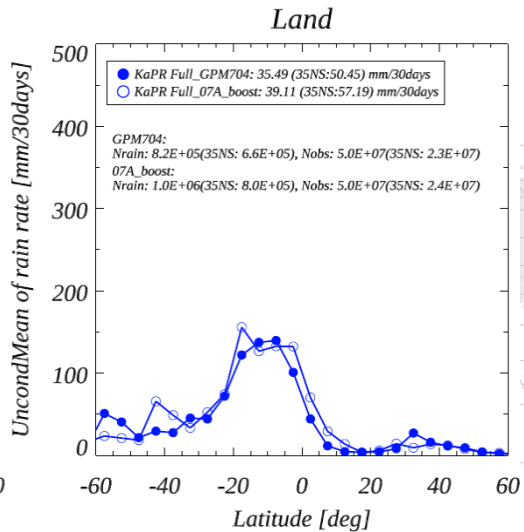
precipRateESurface

Full swath
KaPR

● : Post-boost
○ : Pre-boost





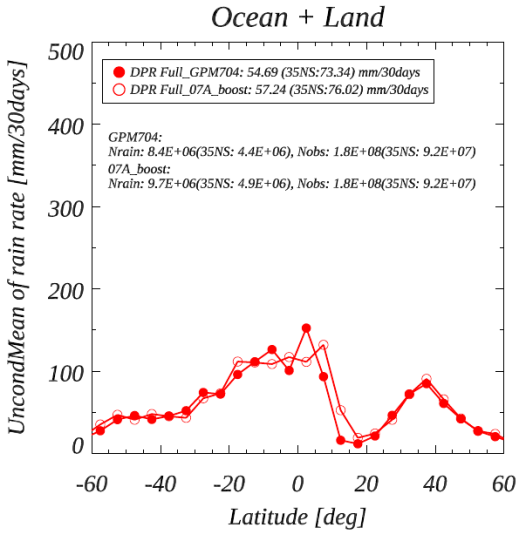


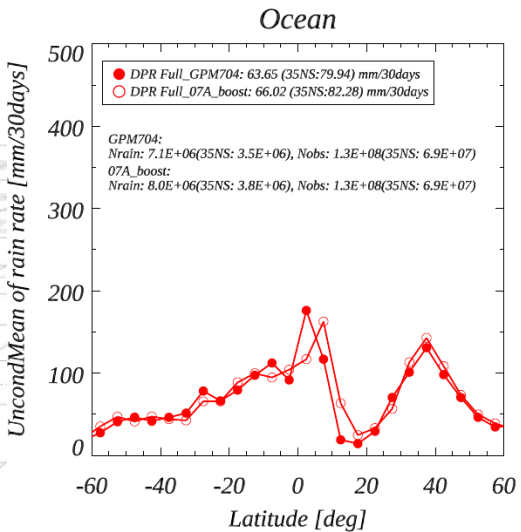
Zonal mean surface precipitation (DPRFS)

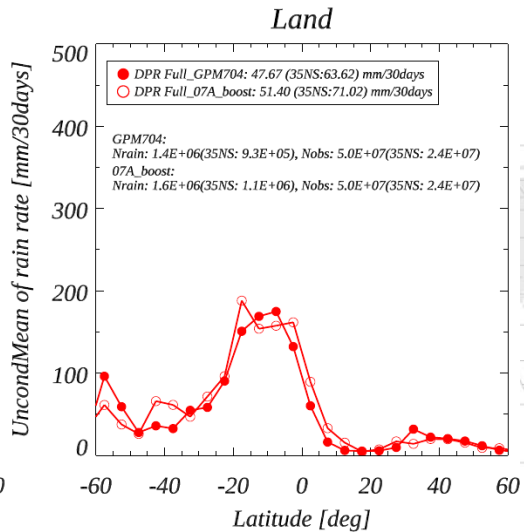
precipRateESurface

Full swath
DPR

● : Post-boost
○ : Pre-boost







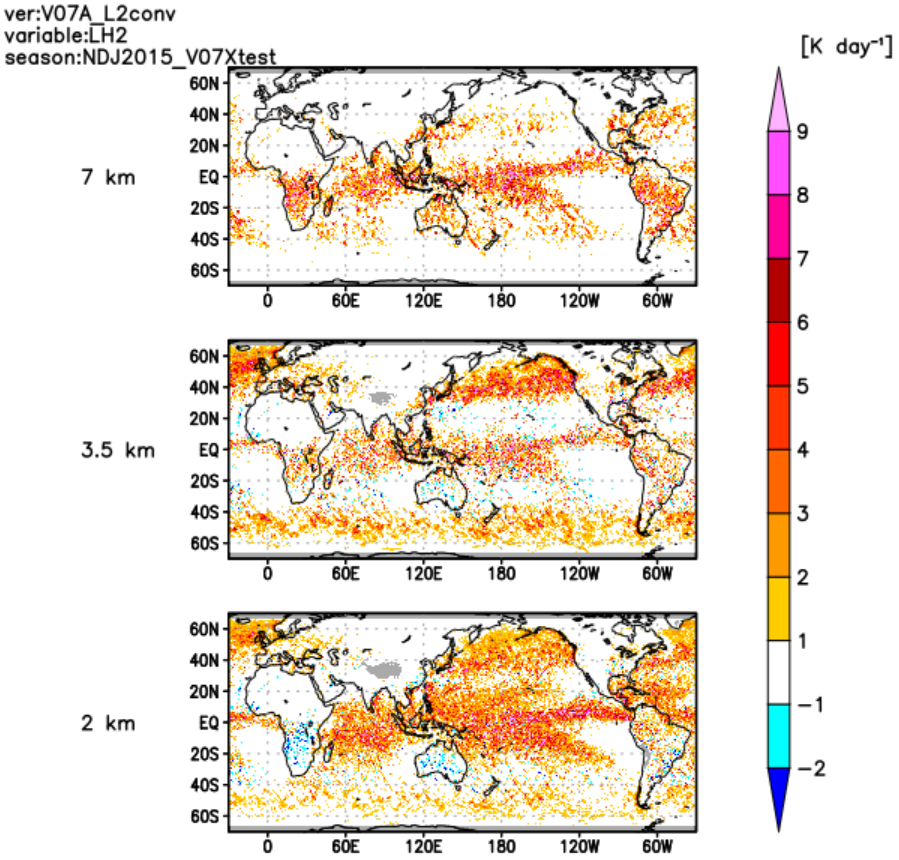
SLH algorithm development status

- The SLH team has not changed the algorithm related to the GPM Core Observatory orbit boost on Nov. 2023.
- While there are characteristics related to interannual changes in precipitation estimates, the SLH team has determined that there are no problems as SLH products.

Horizontal distribution of the LH

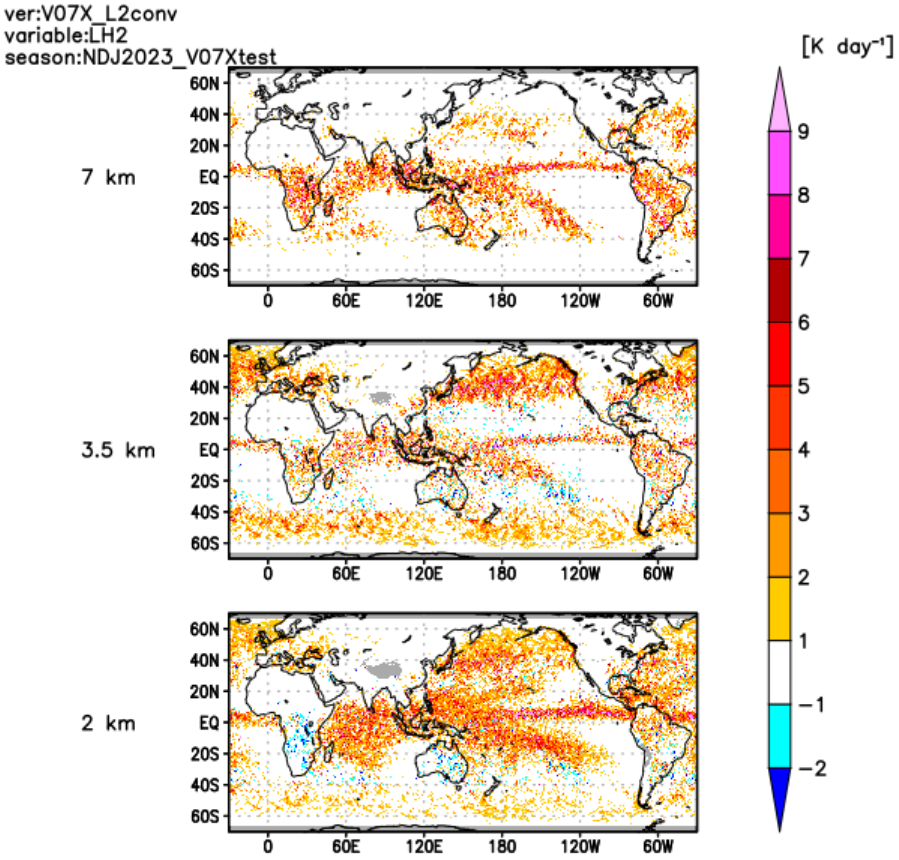
V07A

NDJ2015(V07Xtest)



V07X

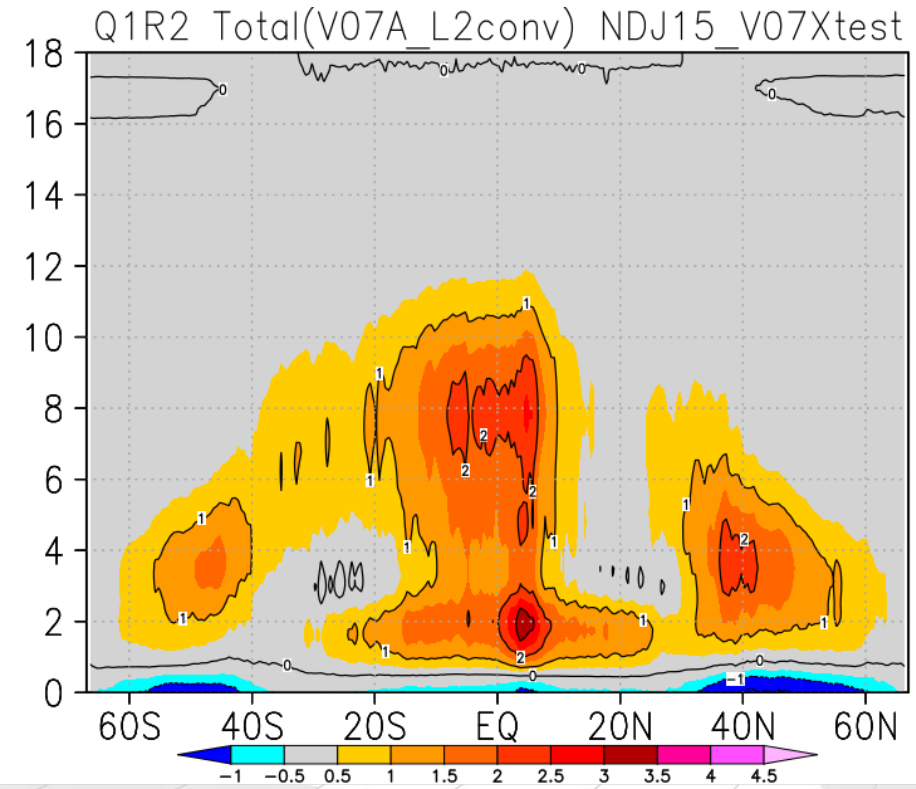
NDJ2023(V07Xtest)



Vertical distribution of the Zonal mean Q1R

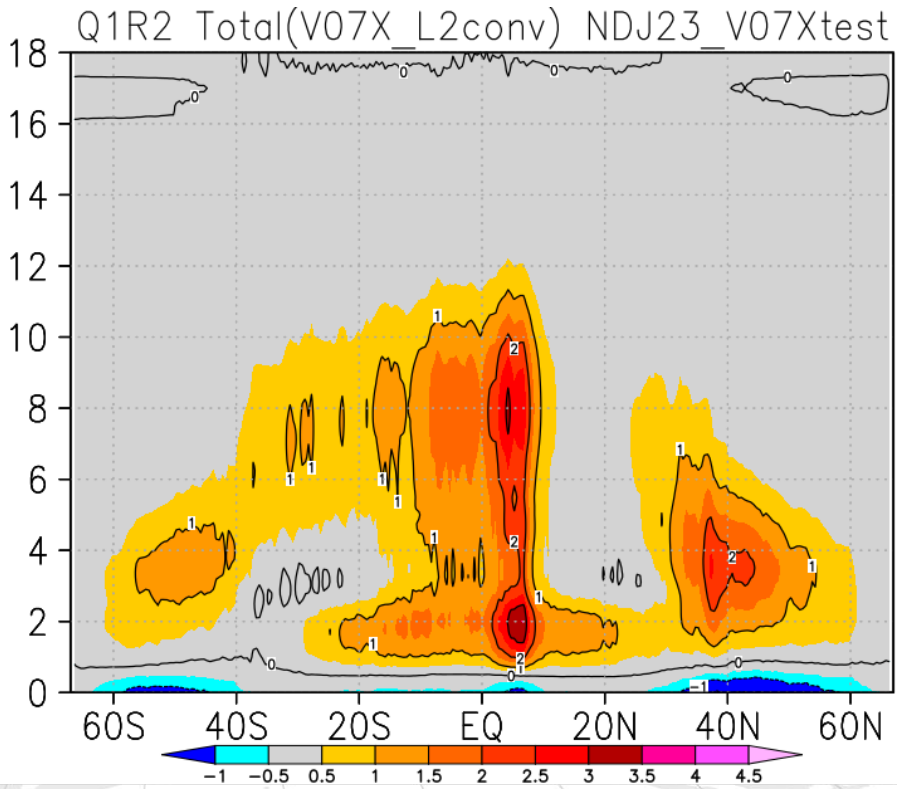
V07A

NDJ2015(V07Xtest)



V07X

NDJ2023(V07Xtest)



Summary

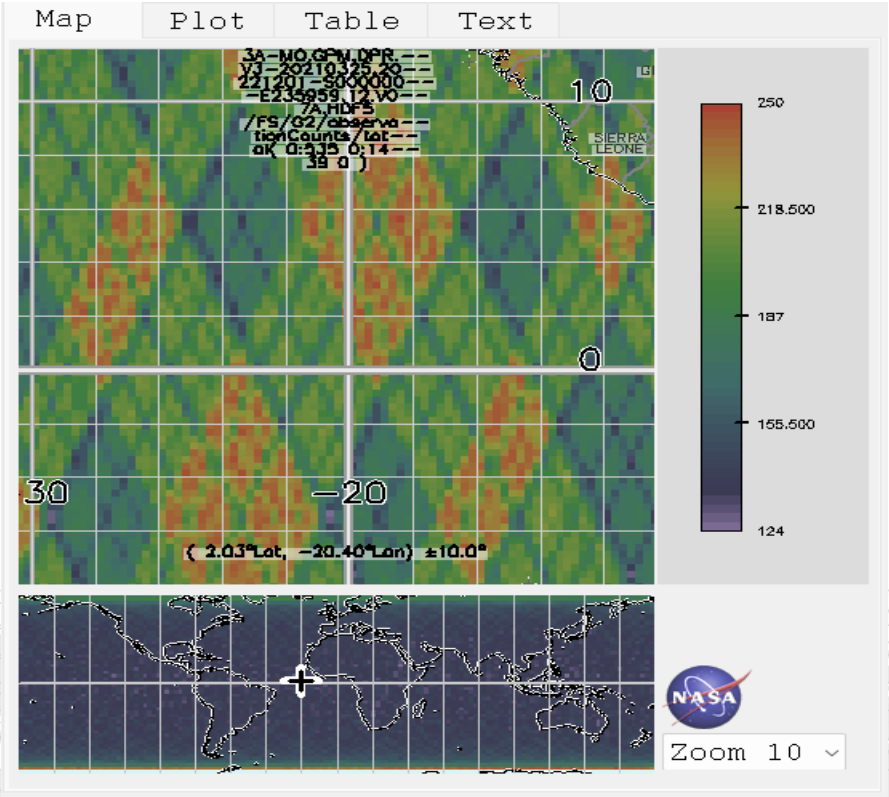
- This summarizes preliminary evaluations of V07C.
  - DPR L1 V0B, and DPR L2/L3 & SLH L2/L3 algorithms for V07C is working as expected.
  - DPR-L1 data confirmed that changes of the sampling were larger in the cross-track direction (about 5 km to 5.5 km at the nadir).
  - With analyzing measured radar 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.
  - Horizontal maps and zonal mean averages of DPR L2/L3 V07C and SLH L2/L3 V07C show reasonable ranges while there are characteristics related to interannual changes in precipitation estimates.
- Based on the above results, the DPR team and the SLH team suggest that there is no problem with the release of V07C.

Appendix:
Comparisons of the DPR observation coverage between the pre-boost and the post-boost

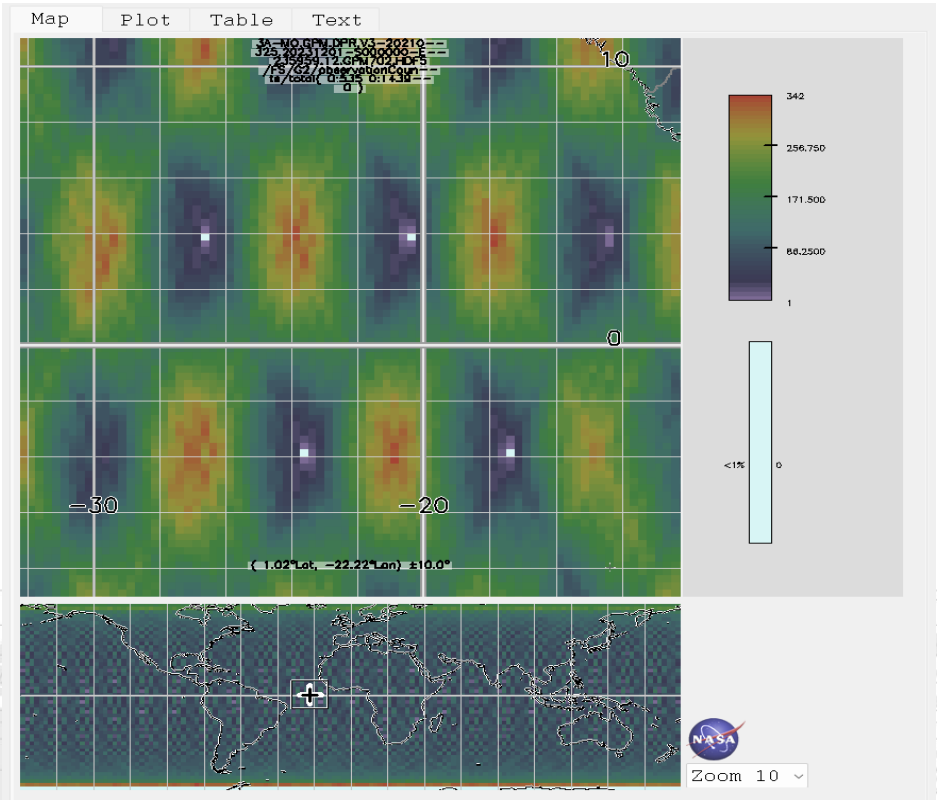
Comparison in the DPR-L3 products

Comparing Dec. 2022 and 2023, G2 All Observations Ku.
We have 0.25deg boxes now that have 0 counts in them for the month and some grids have many more counts then previously.
Note: Dec. 2023 had a few days missing due to GPM S/C anomaly.

Dec. 2022 before boost



Dec. 2023 after boost



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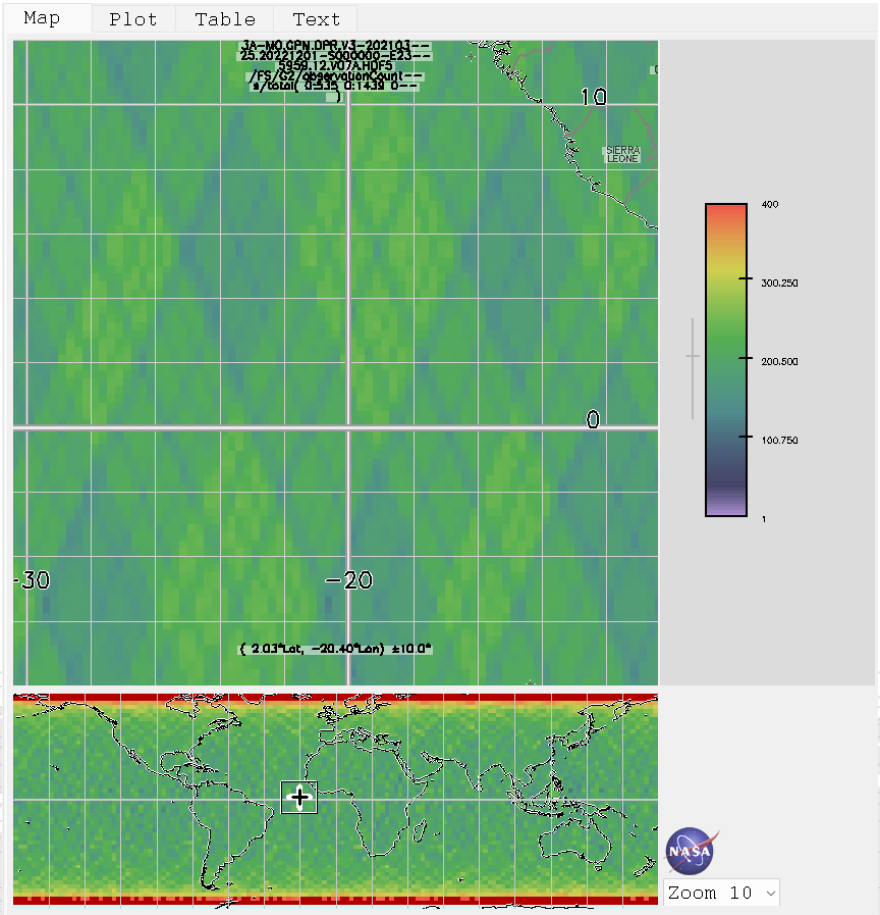
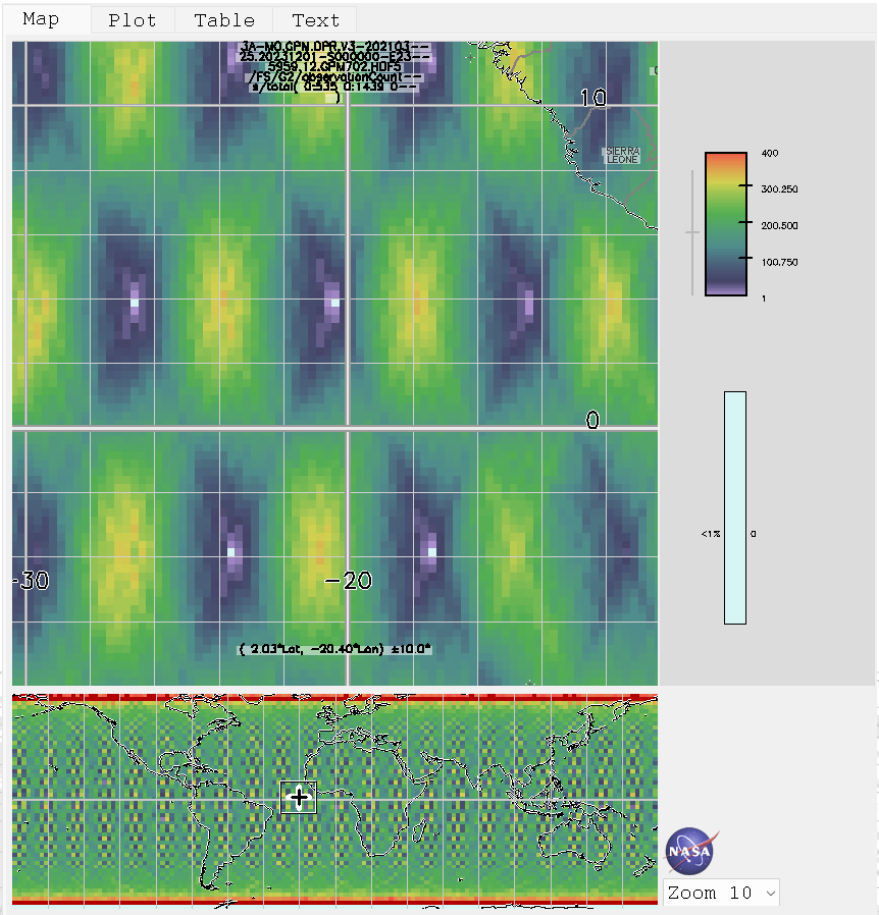
Comparison in the DPR-L3 products

Same data but with common color scales.

Dec. 2022 before boost



Dec. 2023 after boost



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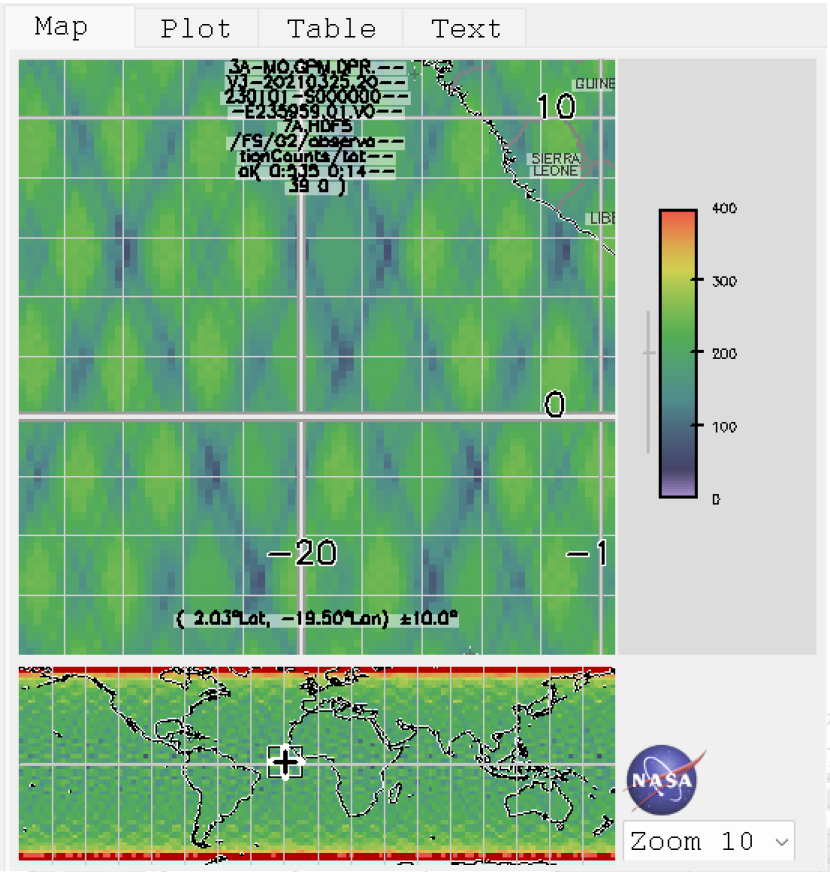
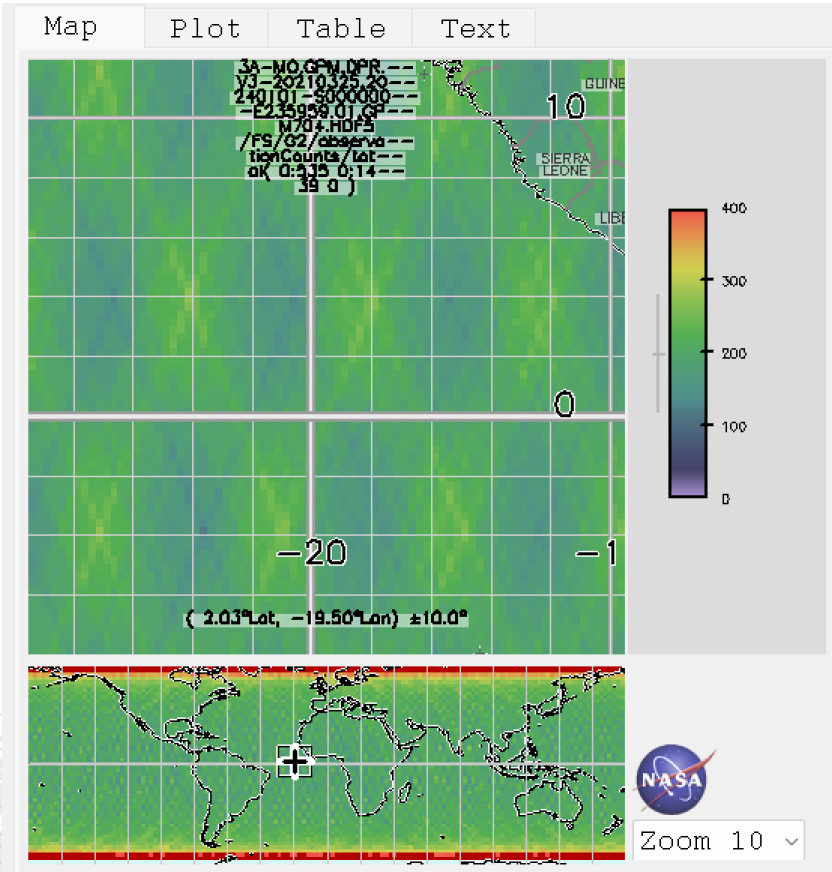
Comparison in the DPR-L3 products

Jan. 2023 before boost



Jan. 2024 after boost



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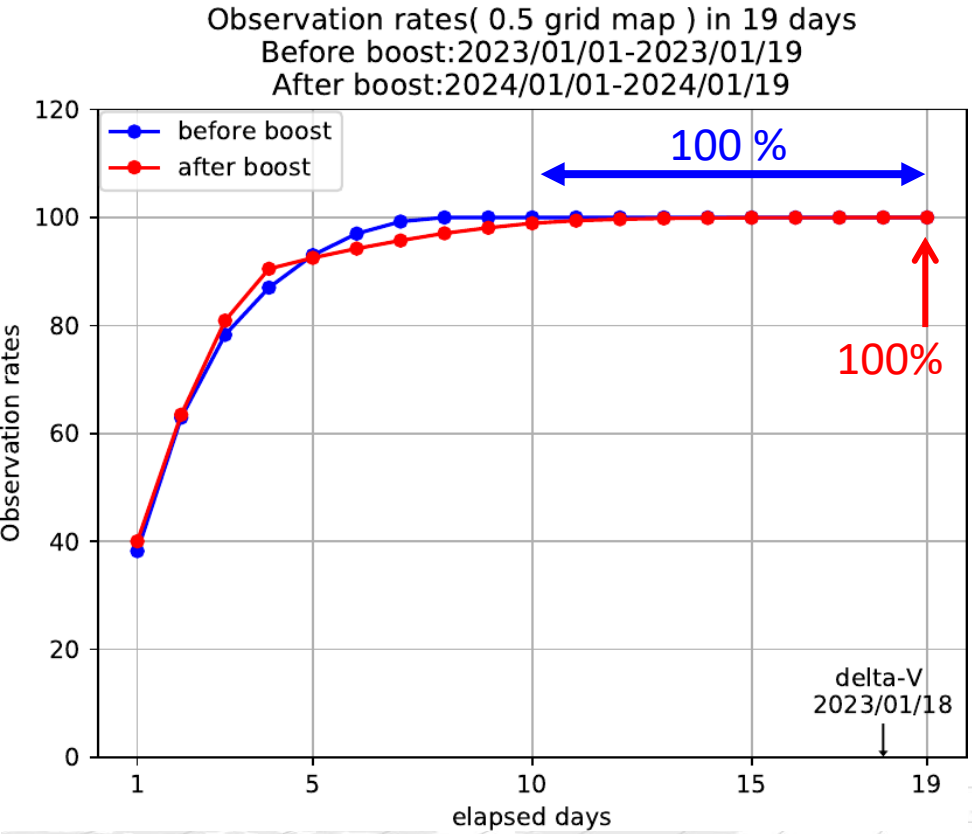
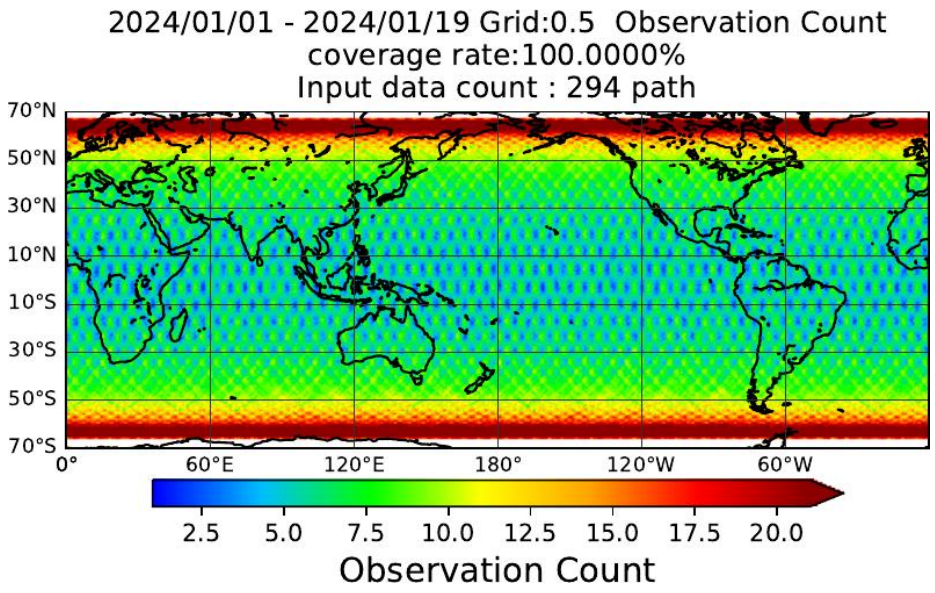
Preliminary evaluation of the DPR observation coverage

By RESTEC & JAXA





- In pre-bost, 100% coverage in 10 days.
- In post-bost, the coverage was reached to 100% in 19 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.