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Release Notes for the DPR Level 1 products

All users of DPR Level 1 data should keep in mind the following changes in Version 08A products.

<Major changes in the DPR Level 1 products from Version 07B to Version 08A>

1. Format change in the product

The product format was updated from HDF5 to NetCDF.

2. Deleted variables

The following two variables were removed because they are more accurately estimated within the DPR Level-2 algorithm and are therefore provided in the DPR Level-2 products under the same variable names.

- `mainlobeEdge` indicates the absolute distance between the detected surface and the upper edge of clutter originating from the mainlobe.
- `sidelobeRange` indicates absolute distance between the detected surface and the upper clutter position from the sidelobe.



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<Minor changes in the DPR Level 1 products from Version 07A to Version 07B>

The GPM Core Observatory satellite performed orbit boost maneuvers on Nov. 7 and 8, 2023 that raised its altitude from 400km to 435km. Details show at the following link.

<https://gpm.nasa.gov/missions/gpm/orbit-boost>

The orbits in which this operation was performed are shown operation status in the following link.

<https://gportal.jaxa.jp/gpr/information/product>

1. Changes of the sensitivity, the spatial resolution and the swath width

The sensitivity, the spatial resolution and the swath width in the DPR instrument were changed. See full descriptions by the following link.

<https://www.eorc.jaxa.jp/GPM/en/boost.html>

2. Update the VPRF table.

A new VPRF (Variable Pulse Repetition Frequency) table for the post-boost was installed in the KuPR and the KaPR. Corresponding VPRF table was implemented in the DPR Level 1 algorithm as well.

3. Update altitude information.

The DPR Level 1 product stores two altitude information that are `dprAlt` and `scAlt`. After the orbit boost, the altitude for DPR operation was stored in the `dprAlt` and real spacecraft altitude was stored in the `scAlt`. See full descriptions by the following link.

https://www.eorc.jaxa.jp/GPM/doc/algorithm/GPM_Orbit-boost_DPR-note_20240304A.pdf

4. Update the timing delay.

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.

<Major changes in the DPR Level 1 products from Version 05C to Version 07A>

1. Refinement of the scan angle table (KuPR)

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JAXA implements a small adjustment (about 0.024 deg) of the scan angle table used in the geolocation calculations based on a statistical analysis of KuPR's geolocation. Note that KuPR's hardware setting related to beam pointing does not change, and a parameter in the scan angle table for calculating the geolocation of beam is updated.

2. A new quality flag for mirror image (KuPR and KaPR)
`binMirrorImage` which notifies an unusual precipitation at high altitude by the mirror image of DPR is introduced.
3. Swath name change (KuPR)
A swath name in KuPR Level 1 product is changed from 'NS' to 'FS'.
4. Refinement of a table for gain of phase shifter (KaPR)
JAXA implements a small adjustment to a table for the gain of phase shifter which is one of the components in the receiver system and is responsible for the DPR's beam direction. This is expected to mitigate an angle bin dependency of the gain depending on the phase shifter setting after the change of KaPR's scan pattern on 21 May 2018. This adjustment results in a maximum change of about 0.5 dB in the received power and noise power of KaPR.
5. New variables related to geolocation (KuPR and KaPR)
New variables related to geolocation are newly added. They are `sunLocalTime`, `scHeadingGround`, `scHeadingOrbital`, `sunData` group. See full descriptions by the following link.
<https://www.eorc.jaxa.jp/GPM/en/archives.html>
6. Update correction values for `startBinRange` (KuPR and KaPR)
Correction values for the observation start distance is updated. This changes the estimated observation start distance by 16 m for KuPR, 5 m for KaMS, and 56 m for KaHS.
7. Variable definition changed. (KuPR and KaPR)
The definition of `noiseSampleNumber` is changed to store the actual number of samples measured by the instrument considering the number of independent sample.

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<Minor changes in the DPR Level 1 products from Version 05B to Version 05C>

JAXA and NASA implemented a small adjustment of the instrument alignments used in the geolocation calculations based on the beam matching adjustments in Version 05B. These shifts in pointing will occur in the V05A/B data once that data is reprocessed as well.

1. The KaPR roll alignment was adjusted so that the calculated beam locations on the surface better match those for KuPR in the cross-track direction. The adjustment changes the KaPR locations by about 100 meters cross track.
2. The KuPR pitch alignment was adjusted so that the calculated beam locations on the surface better match those for KaPR in the along-track direction. The adjustment changes the KuPR locations by about 40 meters along track.

<Minor changes in the DPR Level 1 products from Version 05A to Version 05B>

JAXA and NASA implemented a change of the scan pattern of the KaPR on 21 May 2018.

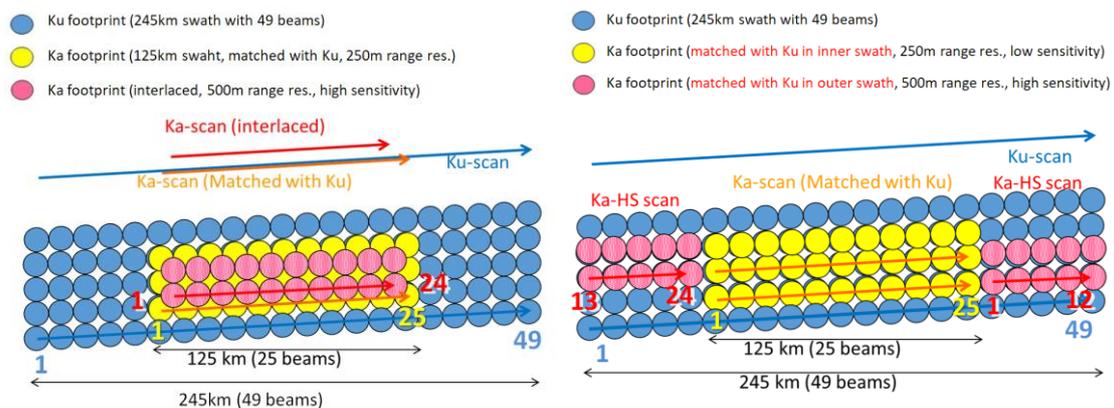


Figure 1. DPR’s scan pattern before May 21 2018 (left) and after May 21 2018 (right). KaHS beams scan in the inner swath before May 21 2018, but now they scan in the outer swath and match with KuPR’s beams. Numbers in color indicate angle bin numbers for KuPR (blue), KaMS (yellow), and KaHS (red).

According to this event, the DPR Level 1 product version has changed from 05A to 05B. Major effects were summarized as follows.

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1. Change of the scan pattern of the KaPR.

JAXA changed the scan pattern of the KaPR on 21 May 2018. As shown in Fig.1, the high sensitivity beams of KaPR, which is called KaHS, scanned in the inner swath and interlaced between the matched beams of KaPR, which is called KaMS, from the beginning of the mission until May 21. As of May 21, KaHS beams are moved to the outer swath and match with the KuPR beams there so that the dual-frequency algorithm can be applied over the full swath. The format of the product does not change in V05B. The first 12 elements in each of KaHS's scan data that consist of 24 angle bins correspond to the last 12 angle bins of the KuPR angle bins, and the remaining 12 elements correspond to the first 12 angle bins of the following KuPR scan. A warning flag is set in the variable called "dataQuality".

2. Improvement of beam matching between the KuPR and the KaPR.

JAXA has adjusted the beam directions of the KuPR and the KaPR in order to improve the beam matching between the KuPR scans and KaPR scans. The offset between the KuPR and KaMS footprint centers at nadir has reduced approximately from 300m to 30m since the adjustment on 21 May 2018,.

<Major changes in the DPR Level 1 products from Version 4 to Version 5>

1. Changes of the DPR's calibration parameters.

JAXA improved the DPR's calibration parameters in the Version 5 products based on the new calibration results on orbit. With the new parameters, the measured radar reflectivity factors increase by about +1.3 dB for the KuPR and by about +1.2 dB for the KaPR from the corresponding Version 4 data.

2. Changes of FCIF-LUT.

The temperature dependence of the FCIF input/output characteristic was improved based on the re-examination of calibration data. The re-examination revealed that the version 4 algorithm compensate the temperature changes too much. In V5, the gain adjustment due to the temperature change is nullified because the actual temperature of FCIF is very stable on orbit.

The FCIF-LUT for the KuPR near the saturation was improved so that the effect of saturation near the saturation level was mitigated. As for the KaPR, the modification was not made because saturations do not occur in the KaPR in a normal condition.

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3. Data format change

The following two new variables were added and one variable was modified.

- ‘receivedPulseWidth’ that indicates the received pulse width after passing through the band-pass-filter was added.
- ‘totalCoefVersion’ that indicates the total version, which consists of the version number of the calibration coefficients and the version number of the FCIF-LUT, was added.
- ‘transReceiverCoefVersion’ that indicates the version number of the calibration coefficients was modified.

4. Improvement in noise power calculation

The definition of the DPR’s noise power was changed. Since the effect of the band-pass filter to noise is different from that of the radar echoes (the former has a continuous flat spectrum while the latter has a non-flat spectrum defined by the transmitting pulse shape), the version 4 algorithm used a formula to calculate the noise power that differs from the formula to calculate the echo power. In version 5, the noise power is also calculated with the formula that is used to calculate the echo powers so that the noise power in V5 is the effective noise power that can be compared with echo powers directly.

< Caveats for the DPR Level 1 products >

1. Status of the DPR A-side operation

JAXA changed that the status of the DPR data obtained during the A-side operation in products Version5 (B-side is used in the current standard operation). The reasons for such handling are that the calibration parameters of the DPR A-side are not reliable, because no external calibration of the DPR A-side was carried out on orbit, and the ground test values of the DPR A-side before launch are not reliable either. Therefore, the corresponding scans were attached with identification flags in the DPR Level 1 products, and these scans were treated as missing scans in the DPR Level 2 products. The following table shows the periods of the DPR A-side nominal operation.

Operational mode	Period	Orbit number
SCDP-B/FCIF-A	2014/3/10~3/12, 5/25	171 - 205, 1351-1355
SCDP-A/FCIF-A	2014/3/14~16	232-262
SCDP-A/FCIF-B	2014/3/16~18	263-295

B-side (SCDP-B/FCIF-B) is used in the rest of the period.

2. Calculation of the DPR's noise power

The DPR has a special mode to measure background noise in which the average noise power is measured while the transmitter is turned off at each angle bin in the ordinary observation mode ('Noise-A'). This noise power is subtracted from the received power measured at each range bin to extract radar echo power profile. To calculate the echo profile, the effect of the band-pass filter assumes that the echo has the same power spectrum defined by the transmitted pulse shape. Since the received power is the sum of echo power and noise power, the noise power recorded in each profile is the effective noise ('Noise-B') that affect the echoes. In version 4, Noise-A was calculated by assuming that the noise has a flat spectrum. The difference in the conversion formulas to calculate Noise-A and Noise-B created some confusions to the users although the noise was properly subtracted in the products. In order to avoid the confusion, Noise-A is calculated with the same formula that is used to calculate the echo profile (and hence Noise-B) in version 5. (As a result, the noise power calculated by using the hardware design document is the lower than the power stored in the DPR

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L1 product. The magnitudes of difference are -2.11dB, -2.41dB and -2.13dB for the KuPR, the KaPR(MS) and the KaPR(HS), respectively.)

3. Beam directions of the KaPR

JAXA uploaded a proper set of phase code to the KaPR on August 6th, 2014. Until that time from April 8th, 2014, the beam pointing directions of the KaPR had small biases. The code error caused a beam match between the KuPR and the KaPR(MS) and affected the KaPR's total antenna gain slightly. After the proper code was uploaded, the beam scans in the proper directions and the bias error were resolved. The DPR Level 1 algorithm was modified to compensate this bias for the antenna gain in this period so that the antenna gain in the products is correct.

4. Reversal of DPR's scan direction

The beam scan direction of DPR had been reversed from the proper direction until JAXA uploaded a proper set of phase code to the DPR at 13:20 UTC on March 18th, 2014. After the proper code was uploaded, the beam has been scanned in the proper direction, i.e., from left to right with respect to the +X forward direction of the satellite.

The DPR Level 1 algorithm was modified to accommodate this change so that the geolocations in the products are correct from the beginning of the mission.

5. Special operations of DPR

The following caveats describe special operations of DPR. You can use these data with your discretion. You can also refer to the DPR invalid data lists at the following web site. <https://gportal.jaxa.jp/gpr/information/product>

5.1. Operation with the DPR transmitters off

JAXA carried out the receiving only mode to check the DPR receiver system. The orbits in which this operation was performed are shown Appendix-A and operation status in the following site.

<https://gportal.jaxa.jp/gpr/information/product>

5.2. Change of the DPR receiver attenuator (RX ATT) setting

JAXA has checked the dynamic range of the radar system by changing the attenuator setting in the DPR receivers. The received power in the DPR Level 1



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products is not affected, because the offset caused by the receiver attenuator is accounted for in the DPR Level 1 algorithm. The orbits in which this operation was performed are shown Appendix-A and operation status in the following site.

<https://gportal.jaxa.jp/gpr/information/product>

5.3. Operation of GPM satellite maneuver

NASA has carried out several maneuver operations such as a delta-V maneuver and a Yaw maneuver. In addition, pitch offset maneuvers have also been conducted to check the GPM satellite status. The orbits in which these operations were performed are shown Appendix-A and operation status in the

following site. <https://gportal.jaxa.jp/gpr/information/product>

5.4. Test operation for adjusting the phase code in the KuPR instrument

The JAXA DPR project team has conducted several test operations using different phase codes in the phase shifters in order to mitigate the effects of sidelobe clutter in KuPR. Please be cautious of the periods in these test operations. The orbits in which these operations were performed are shown Appendix-A and operation status in the following site.

<https://gportal.jaxa.jp/gpr/information/product>

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<Appendix A: Major DPR events >

Major DPR events until September 2, 2014 are as follows. After September 2, you can visit the following web site to check the DPR status.

<https://gportal.jaxa.jp/gpr/information/product>

Orbit No.	UTC	DPR Event
#144	2014/3/8 21:54	DPR observation start
#171	2014/3/10 16:29	Change DPR FCIF-B to A
#201	2014/3/12 14:24	GPM Delta-V Maneuver
#206	2014/3/12 22:43	DPR power OFF
#207-231	2014/3/13-14	GPM EEPROM change
#232	2014/3/14 14:14	DPR SCDP-A ON
#232	2014/3/14 14:41	DPR check out restart
#236	2014/3/14 20:02	DPR observation restart
#263	2014/3/16 14:08	Change DPR FCIF-A to B
	2014/3/16 14:59	DPR transmitters off (f1/f2 off) test
#264	2014/3/16 15:49	
#279	2014/3/17 15:10	GPM 180deg Yaw Maneuver (+X to -X)
#294	2014/3/18 13:20	Proper phase code upload
#296	2014/3/18 17:18	DPR SCDP-B ON Observation mode
#310	2014/3/19 14:21	GPM Delta-V Maneuver
#325	2014/3/20 13:41	DPR patch adaption
#328	2014/3/20 17:56	DPR observation restart
#374	2014/3/23 17:26	DPR transmitters off observation
#375	2014/3/23 19:05	
	2014/3/23 19:06	SSPA LNA analysis mode
#377	2014/3/23 22:35	DPR observation restart
#380	2014/3/24 2:11	DPR External calibration
#404	2014/3/25 15:07	DPR transmitters off observation
#418	2014/3/26 12:32	
#419	2014/3/26 14:20	GPM Delta-V Maneuver
#478	2014/3/30 9:53	DPR External calibration
#503	2014/4/1 0:00	DPR External calibration (Yaw + pitch)
#531	2014/4/2 19:47	GPM Delta-V Maneuver
#601	2014/4/7 7:37	DPR External calibration

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Orbit No.	UTC	DPR Event
#621	2014/4/8 14:10	Upload new test phase code of KuPR (#1)
#626	2014/4/8 21:46	DPR External calibration (Yaw + pitch)
#647	2014/4/10 6:36	DPR External calibration
#672	2014/4/11 20:43	DPR External calibration (Yaw + pitch)
#675	2014/4/12 1:45	GPM Delta-V Maneuver
#715	2014/4/14 15:28	Upload new test phase code of KuPR (#2)
#731	2014/4/15 15:44	Return to phase code (#1)
#675	2014/4/12 1:45	GPM Delta-V Maneuver
#747	2014/4/16 17:04	GPM Delta-V Maneuver
#748	2014/4/16 17:39	DPR transmitters off observation
#763	2014/4/17 17:07	
#770	2014/4/18 4:22	DPR External calibration (Yaw + pitch)
#795	2014/4/19 18:31	DPR External calibration (Yaw + pitch)
#795	2014/4/19 18:55	Ku/Ka RX ATT change 6dB to 9dB
#810	2014/4/20 17:59	Ku/Ka RX ATT change 9dB to 12dB
#824	2014/4/21 15:36	Ku/Ka RX ATT change 12dB to 6dB
#827	2014/4/21 20:34	GPM Delta-V Maneuver
#885	2014/4/25 13:05	GPM ST alignment and IRUCAL table updates
#886	2014/4/25 14:30	GPM +10 deg. roll slew
	2014/4/25 15:20	GPM +10 deg. pitch slew
#887	2014/4/25 16:10	GPM +10 deg. yaw slew
#901	2014/4/26 13:30	GPM 180deg Yaw Maneuver (-X to +X)
#907	2014/4/27 0:00	GPM -1 deg. pitch slew
#913	2014/4/27 8:20	GPM -2 deg. pitch slew (-4 deg. total)
#918	2014/4/27 16:20	
#923	2014/4/28 0:25	
#924	2014/4/28 1:10	Ku/Ka RX ATT change 6dB to 9dB
#933	2014/4/28 15:04	Upload new test phase code of KuPR(#3)
#935	2014/4/28 18:13	Return to phase code(#1)
#964	2014/4/30 15:50	GPM Delta-V Maneuver
#994	2014/5/2 13:20	Upload new test phase code of KuPR (#4)
	2014/5/2 13:21	Ku/Ka RX ATT change 9dB to 6dB
#996	2014/5/2 16:36	Upload new test phase code of KuPR(#5)
#998	2014/5/2 19:44	Ku/Ka RX ATT change 6dB to 9dB

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Orbit No.	UTC	DPR Event
	2014/5/2 19:45	Return to phase code (#1)
#1059	2014/5/6 17:35	GPS both A and B ON
#1103	2014/5/14 13:44	
#1073	2014/5/7 15:57	GPM Delta-V Maneuver
#1088	2014/5/8 14:15	Ku SSPA analysis mode (5min)
	2014/5/8 15:08	Ka SSPA analysis mode (5min)
#1089	2014/5/8 15:48	Ku LNA analysis mode (5min)
	2014/5/8 16:44	Ka LNA analysis mode (5min)
#1090	2014/5/8 17:23	Upload new test phase code of KuPR (#6)
#1092	2014/5/8 20:21	Ka SSPA analysis mode (5min)
	2014/5/8 21:12	Upload new test phase code of KuPR (#7)
#1094	2014/5/9 0:16	Return to phase code(#1)
#1150	2014/5/12 14:58	Ku/Ka RX ATT change 9dB to 12dB
#1182	2014/5/14 16:07	GPM Delta-V Maneuver
#1274	2014/5/20 13:30	GMI Deep Space Calibration
#1277	2014/5/20 18:44	
#1288	2014/5/21 11:30	Upload new test phase code of KuPR (#8)
#1290	2014/5/21 14:43	Upload new test phase code of KuPR (#9)
#1292	2014/5/21 17:59	Upload new test phase code of KuPR (#10)
#1294	2014/5/21 21:07	Upload new test phase code of KuPR (#11)
#1296	2014/5/22 0:16	Return to phase code(#1)
#1319	2014/5/23 11:38	Upload new test phase code of KuPR (#12)
#1322	2014/5/23 15:03	Upload new test phase code of KuPR (#13)
#1324	2014/5/23 15:03	Upload new test phase code of KuPR (#14)
#1326	2014/5/23 21:37	Upload new test phase code of KuPR (#15)
#1328	2014/5/24 0:57	Return to phase code(#1)
#1351	2014/5/25 11:44	Change DPR FCIF-B to A (For External Cal.)
		Ku/Ka RX ATT change 12dB to 6dB
#1354	2014/5/25 17:18	DPR External calibration (Yaw + pitch)
#1355	2014/5/25 17:54	Change DPR FCIF-A to B
		Ku/Ka RX ATT change 6dB to 12dB
#1414	2014/5/29 13:59	GPM Delta-V Maneuver
#1430	2014/5/30 13:50	Upload new test phase code of KuPR (#16)
#1431	2014/5/30 15:26	Upload new test phase code of KuPR (#17)

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Orbit No.	UTC	DPR Event
#1432	2014/5/30 17:01	Upload new test phase code of KuPR (#18)
#1433	2014/5/30 18:34	Upload new test phase code of KuPR (#19)
#1434	2014/5/30 20:07	Return to phase code(#1)
#1447	2014/5/31 16:06	Upload new test phase code of KuPR (#20)
#1448	2014/5/31 17:53	Upload new test phase code of KuPR (#21)
#1449	2014/5/31 19:59	Return to phase code(#1)
#1477	2014/6/2 15:06	DPR External calibration
#1502	2014/6/4 5:15	DPR External calibration
#1508	2014/6/4 14:13	Upload new test phase code of KuPR (#22)
#1508	2014/6/4 14:56	Upload new test phase code of KuPR (#23)
#1509	2014/6/4 16:39	Upload new test phase code of KuPR (#22)
#1511	2014/6/4 18:59	Return to phase code(#1)
#1539	2014/6/6 14:09	Upload new test phase code of KuPR (#22)
#1541	2014/6/6 17:26	Return to phase code(#1)
#1600	2014/6/4 5:15	DPR External calibration
#1603	2014/6/10 17:38	GPM 180deg Yaw Maneuver (+X to -X)
#1625	2014/6/12 2:58	DPR External calibration
#1646	2014/6/13 11:46	DPR External calibration
#1648	2014/6/13 14:08	Upload new test phase code of KuPR (#24)
#1649	2014/6/13 15:45	Upload new test phase code of KuPR (#25)
#1650	2014/6/13 17:36	Upload new test phase code of KuPR (#26)
#1651	2014/6/13 19:12	Upload new test phase code of KuPR (#27)
#1652	2014/6/13 20:54	Upload new test phase code of KuPR (#28)
#1653	2014/6/13 22:33	Upload new test phase code of KuPR (#29)
#1654	2014/6/14 0:21	Upload new test phase code of KuPR (#30)
#1655	2014/6/14 1:39	Return to phase code(#1)
#1726	2014/6/18 15:17	GPM Delta-V Maneuver
#1769	2014/6/21 9:33	DPR External calibration
#1794	2014/6/22 23:42	DPR External calibration (Yaw + pitch)
#1892	2014/6/29 7:18	DPR External calibration
#1917	2014/6/30 21:27	DPR External calibration
#1942	2014/7/2 12:42	Upload new test phase code of KuPR (#31)
#1944	2014/7/2 14:38	Upload new test phase code of KuPR (#32)
#1945	2014/7/2 16:30	Return to phase code(#1)

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Orbit No.	UTC	DPR Event
#1975	2014/7/4 15:07	Upload new test phase code of KuPR (#33)
#1976	2014/7/4 16:44	Upload new test phase code of KuPR (#34)
#1977	2014/7/4 18:24	Return to phase code(#1)
#2015	2014/7/7 5:01	DPR External calibration
#2040	2014/7/8 19:08	DPR External calibration (Yaw + pitch)
#2053	2014/7/9 16:17	GPM Delta-V Maneuver
#2163	2014/7/16 16:32	GPM 180deg Yaw Maneuver (-X to +X)
#2176	2014/7/17 13:22	Upload new test phase code of KuPR (#35)
#2177	2014/7/17 15:03	Upload new test phase code of KuPR (#36)
#2178	2014/7/17 16:37	Upload new test phase code of KuPR (#37)
#2180	2014/7/17 18:47	Return to phase code(#1)
#2184	2014/7/18 1:42	DPR External calibration
#2209	2014/7/19 15:51	DPR External calibration
#2286	2014/7/24 14:54	Change Ku timing delay
#2289	2014/7/24 19:11	Upload new test phase code of KuPR (#38)
#2290	2014/7/24 20:49	Return to phase code(#1)
#2304	2014/7/25 18:07	Upload new test phase code of KuPR (#39)
#2307	2014/7/25 23:26	DPR External calibration
#2332	2014/7/27 13:34	DPR External calibration
#2380	2014/7/30 16:04	GPM Delta-V Maneuver
#2430	2014/8/2 21:12	DPR External calibration (Yaw + pitch)
#2455	2014/8/4 11:21	DPR External calibration
#2455	2014/8/6 20:48	Upload new phase code of KaPR
#2599	2014/8/13 17:55	DPR External calibration
#2624	2014/8/15 8:03	DPR External calibration
#2706	2014/8/20 15:09	GPM Delta-V Maneuver
#2722	2014/8/21 15:40	DPR External calibration
#2747	2014/8/23 5:48	DPR External calibration
#2782	2014/8/25 12:15	Change DPR FCIF-B to A
#2782	2014/8/25 12:30	Upload new test phase code of KuPR (FCIF-A#1)
#2784	2014/8/25 14:34	Upload new test phase code of KuPR (FCIF-A#2)
#2785	2014/8/25 16:13	Upload new test phase code of KuPR



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Orbit No.	UTC	DPR Event
		(FCIF-A#3)
#2786	2014/8/25 17:51	Upload new test phase code of KuPR (FCIF-A#4)
#2787	2014/8/25 19:22	Change DPR FCIF-A to B
#2787	2014/8/25 19:24	Return to phase code(#39)