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Caveats for the DPR Level 1 and Level 2 products

DPR Level 1 and Level 2 products have been released to public users.

Caveats for these products are described as follows. All users can keep them in mind when they use the data.

＜Caveats for DPR Level 1 products by JAXA＞

1. Calibration of DPR

   The analysis of surface normalized radar cross section (sigma^0) of DPR shows that the current calibration coefficients that were determined before launch give consistent values of sigma^0 with those from TRMM/PR. Although some gain offsets of the DPR transmitter and receiver powers are detected by the external calibrations after launch, JAXA has decided not to adapt the gain offsets.

2. Scan flip of DPR

   JAXA uploaded a proper set of phase code to the DPR on March 18th, 2014 at 13:20 UTC. Until that time, the beam scan direction of DPR had been reversed from the proper direction. 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 geolocation in the products is correct from the beginning of the mission.

3. Special operations of DPR

   The following caveats describe special operations of DPR. You can use these data with your discretion. And you can also refer DPR invalid data lists as normal observation data at following web site, which caused by the satellite maneuver, DPR operation mode change or the other special events.
   <DPR operation status (data missing list)>
   https://www.gportal.jaxa.jp/gportal_file/qty/GPM/gpmom_vrfy_DPR_ope_status_make_2014.csv

3.1 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 in Appendix-A.

3.2 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 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.

3.3 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 this operation was performed are shown Appendix-A.

3.4 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 this operation was performed are shown Appendix-A.

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＜Caveats for DPR Level 2 products by DPR Level 2 algorithm development team＞

1. Preparation module (PRE)

   Mainlobe clutter may be occasionally misjudged as a strong precipitation echo in some areas, in particular in Greenland and in Antarctica where the accuracy of the digital elevation map (DEM) used in the algorithm is not good. It is expected that such misjudgment is very infrequent.

   Sidelobe clutter contamination has been reduced to a satisfactory level at most occasions. However, significant sidelobe clutter remains at exceptional places such as over a very calm sea and some ice-covered land, for example, in Northern Canada.

   “flagEcho” provides information related to the mainlobe and sidelobe clutter. Please see Appendix B for details.

2. Classification module (CSF)

   (1) Bright band (BB) detection has angle bin dependence because of the smearing of the shape of BB peak near the antenna scan edges.

   (2) In the outer swath of Ku-band data, BB detection is not very effective yet. The performance of BB detection in the outer swath is expected to be improved in the next algorithm revision.

   (3) BB quantities of MS mode of DPR algorithm are derived by combining the results obtained by the measured dual frequency ratio (DFRm) method and conventional method (i.e., the method similar to the one used by the TRMM 2A23 algorithm). When BB is detected, binBBTop and binBBBottom are obtained by examining the Ku-band Z profile. Thus obtained binBBTop and BBBottom are different from binDFRmTop and binDFRmBottom determined by the DFRm method.

   (4) BB quantities of HS mode of DPR algorithm are derived by the DFRm method alone; binBBTop and binBBBottom are equal to binDFRmTop and binDFRmBottom in a rigorous sense. In the next algorithm revision, BB

quantities of HS mode of DPR algorithm are planned to be derived by combining the results obtained by the DFRm method and the conventional method.

(5) Rain type is obtained by using two different methods: one is the V-method and the other the H-method. In the DPR algorithm, a new DFRm method is used instead of the conventional V-method. The CSF module outputs a unified rain type. Major categories of the unified rain type are stratiform, convective, and other.

(6) The unified rain type is expressed by 8-digit numbers; the most significant digit indicates the major rain type as follows:

Stratiform - 1xxxxxxx,
Convective - 2xxxxxxx,
Other - 3xxxxxxx,

where xxxxxxx depends on the details.
In C language, the major rain type can be obtained by the following equation:

```
Type = typePrecip[i] / 10000000;
```

where typePrecip[i] is the rain type flag at the i-th angle bin. Type=1, 2, and 3 means rain type is stratiform, convective, and other, respectively.
The second most significant digit of the unified DPR rain type indicates the rain type obtained by the DFRm method.

(7) All the shallow rain is classified as convective in the unified rain type.

(8) Sidelobe clutter influences the Ku-band shallow rain statistics significantly. When taking rain type statistics such as the dependence of each type count on the angle bin, you should treat the shallow rain count separately. (This suggestion applies to the Ku-only products and DPR NS products.)

(9) The parameters in the DFRm method need further fine tuning.

3. Solver module (SLV)

Hitschfeld-Bordan's attenuation correction method is not applied for range bins with mainlobe clutter, strong attenuation and abnormally large Zm. For those range bins, Ze is assumed to be constant along the beam.

In the KaPR algorithm, surface precipitation rates may be underestimated when precipitation echo and surface echo are severely attenuated by heavy precipitation.

In solid precipitation layers, partly because particle characteristics are not assumed well, precipitation rates may be overestimated, in particular in the KaPR products.

Since the dual-frequency attenuation correction method (HB-DFR method) has not been well evaluated after the launch, the range of epsilon is limited in this method.

In the Dual-frequency algorithm, if KaPR's surface echo is missing, PIA estimates by single-frequency SRT are used instead of those by dual-frequency SRT. However, this transition may not perfectly work. As a result, precipitation rate estimates by the Dual-frequency algorithm are systematically lower than those by the Single-frequency (KuPR) algorithm in the case of heavy precipitation.

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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://www.gportal.jaxa.jp/gportal_file/qty/GPM/gpmom_vrfy_DPR_ope_status_make_2014.csv

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

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Orbit No.	UTC	DPR Event
#601	2014/4/7 7:37	DPR External calibration
#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 -1 deg. pitch slew (-2 deg. total)
#918	2014/4/27 16:20	GPM -2 deg. pitch slew (-4 deg. total)
#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)

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Orbit No.	UTC	DPR Event
#998	2014/5/2 19:44	Ku/Ka RX ATT change 6dB to 9dB
	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)
#1160	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)

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Orbit No.	UTC	DPR Event
#1431	2014/5/30 15:26	Upload new test phase code of KuPR (#17)
#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)

Orbit No.	UTC	DPR Event
#1945	2014/7/2 16:30	Return to phase code(#1)
#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)

Orbit No.	UTC	DPR Event
#2785	2014/8/25 16:13	Upload new test phase code of KuPR (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)

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＜Appendix B:　Details of "flagEcho"＞

flagEcho is a 1-byte integer variable, and its array size is nbin x nray x nscan. Here, nbin is the number of range-bins, nray is the number of angle bins, and nscan is the number of scans in the granule.

The meaning assigned to each bit in the flagEcho is summarized in Table 1.

flagEcho provides the following information.

- Classification of precipitation/no-precipitation at each range-bin (bit 0-3). However, the final judgment of precipitation/no-precipitation in the L2 product is provided by flagSLV (bit6-7).
- Detection of mainlobe clutter (bit 4-5).
- Application of a routine to reduce the sidelobe clutter (bit 6-7)

Figure 1 shows an example of a vertical cross section of the flagEcho.

Table 1. Meaning assigned to each bit in flagEcho

Bit	0	1
bit 0	-	precipitation @ DPR or Ku or Ka
bit 1	-	precipitation @ DPR
bit 2	-	precipitation @ Ku
bit 3	-	precipitation @ Ka
bit 4	-	mainlobe clutter @ Ku
bit 5	-	mainlobe clutter @ Ka
bit 6	-	sidelobe clutter @ Ku
bit 7	-	sidelobe clutter @ Ka

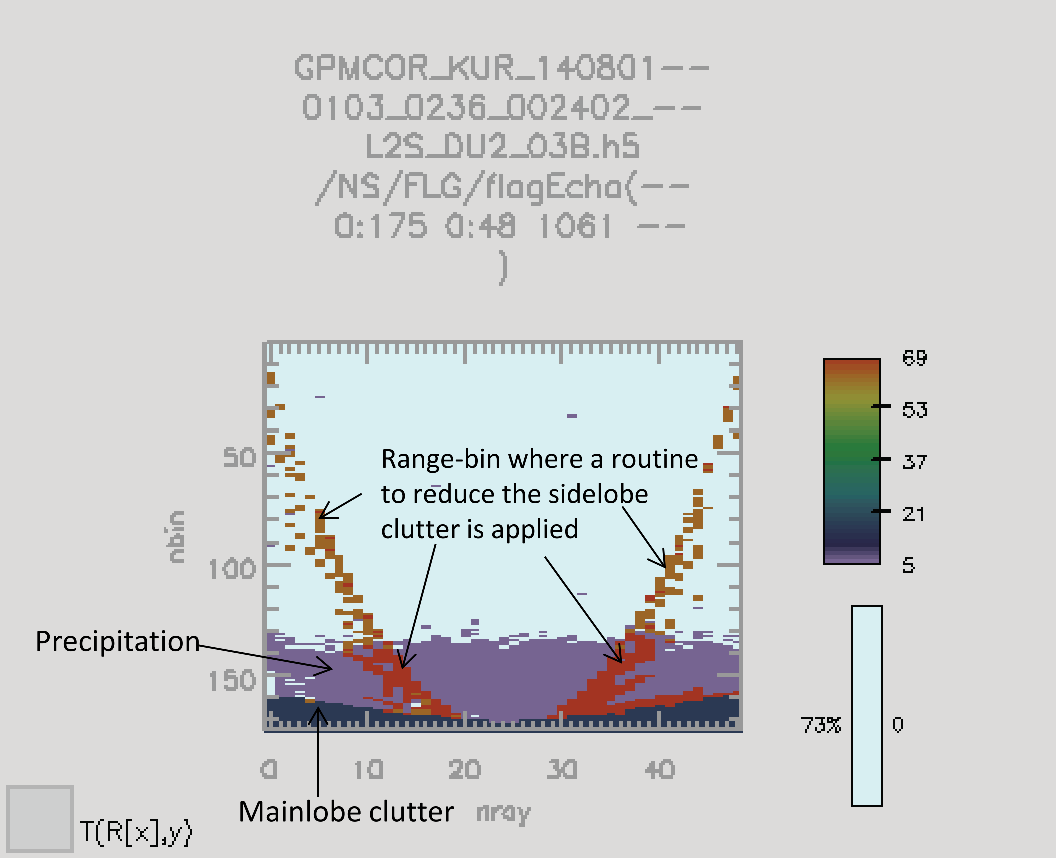

Figure 1. An example of a vertical cross section of flagEcho. The horizontal axis denotes the angle bin number and the vertical axis denotes the range-bin number.

The precipitation/no-precipitation bits (bits 6 and 7) in flagSLV are defined by using a spatial filtering that includes the condition that "the number of successive range bins in which flagEcho (bit 0-3) is set along the range is larger than or equal to 6 (for KuPR and KaMS) or 3 (for KaHS)". flagSLV shows the existence of precipitation when bit 6 or bit 7 of flagSLV is set (non-zero).

While sidelobe clutter remains at some places, the bits in flagEcho that indicate the existence of possible sidelobe clutter may be useful for analyses of KuPR radar reflectivity.