

GPM/DPR Level-3 for V06X

Algorithm Theoretical Basis Document

Revised May 2020

The Level-3 radar products provide daily and monthly global statistics of the Level-2 Ku, Ka and DPR products on a latitude-longitude grid. High and low spatial resolution grids are defined such that the high-resolution grid (G1) is $0.25^{\circ} \times 0.25^{\circ}$ (lat \times lon) while the low-resolution grid (G2) is $5^{\circ} \times 5^{\circ}$. For the variables defined on the low-resolution grid, the statistics include mean, standard deviation, counts and histogram. For variables defined on the high-resolution grid, the same statistics are computed with the exception of a histogram, which is omitted.

The level 3 code is written so that the 15 or 16 orbits of Level-2 DPR data produced daily can optionally be processed in two runs, where one output file contains statistics from the ascending orbital passes while the other file contains statistics from the descending passes. Since all orbits for the day are processed in each run, there is no need for intermediate files. What is produced are two daily level 3 HDF files. Nominally, the standard level 3 product will be obtained by processing the twice-daily HDF files over a calendar month; however, this is not required. In particular, output products can be generated from any set of daily HDF files. It should be noted that the daily files will contain a mean square statistic rather than the standard deviation. For the monthly (or multi-day) file, however, the mean square statistic will be replaced with the standard deviation.

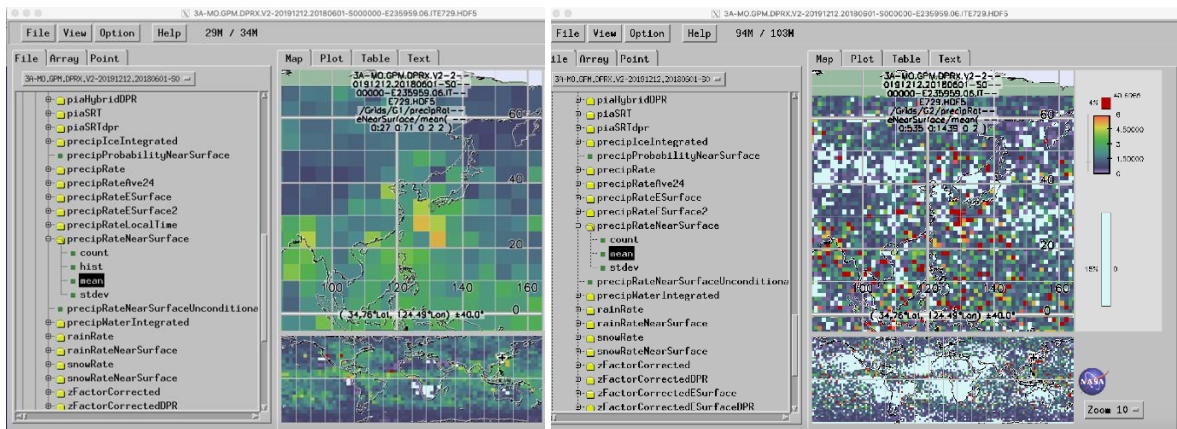


Figure 1. These plots in orbit viewer (Thor) for June 2018 show the structure of Level-3 products in HDF5. Global products include the monthly mean of near surface precipitation rate (mm/hr) on the G1 grid (Left) and on the G2 grid (Right).

Unlike Level-2 data that are stored in separate HDF files for Ku, Ka, and DPR products, the Level-3 file combines all products and stores them under the channel dimension array in a single HDF file. As of 21 May 2018, the scan pattern of the Ka radar was changed by redirecting the 24 interleaved FOVs (fields of view) of the high sensitivity channel to the outer swath so that the 49 beams of the Ku- and Ka-band became approximately matched in space and time. (Figure 2).

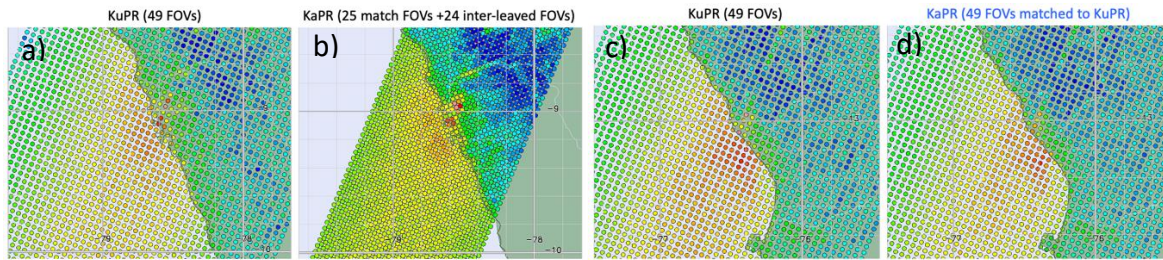


Figure 2. The left 2 panels show FOVs before the scan pattern change (a) Ku and (b) Ka band where the Ka scanned only over the inner swath. The right 2 panels show the FOVs at (c) Ku and (d) Ka after the scan pattern change. The swath width of the Ka radar is now matched to that of the Ku-band radar but, where the FOVs in the outer swath are those from the high sensitivity mode, previously used in the interleaved scan pattern.

The channel combinations before the Ka-band scan pattern change consisted of KuNS, KaMS, KaHS, DPRMS, and KuMS. (In the notation adopted for versions 6X and above, ‘normal swath’ NS has been replaced by ‘full swath’ FS; these are identical and both refer to the set of 49 FOVs. In particular, KuNS=KuFS.) Two channels are used for Ku-band statistics: KuNS consists of level 2 products from the full swath of 49 FOVs while KuMS consists of the same products but obtained from the inner swath of 25 FOVs. Two channels are also used to store the Ka-band statistics from the 25 matched FOVs (KaMS) and from the 24 interlaced FOVs (KaHS). One channel, DPRMS, is used for the DPR products generated from the 25 matched FOVs (DPRMS). Since most of the DPR products are frequency independent, only one channel is assigned. There are, however, some frequency dependent DPR products such as path attenuation related variables (piaSRT, piaFinal, etc.) that are saved separately; for example, piaSRT(5 channels) and piaSRTdpr (2 channels, DPRKuMS and DPRKaMS).

After the scan pattern change, the total number of channels increased from five to seven. The two additional channels are needed to store the Ka full swath (KaFS) and the DPR full swath product (DPRFS). Table 1 shows in more detail the channel index information and the array dimensions before and after the scan pattern change. Note that frequency dependent DPR products like piaSRTdpr also require two additional DPR channels for full swath (DPRKuFS and DPRKaFS) along with the existing DPR channels for the inner swath (DPRKuMS and DPRKaMS). To store these data, we use the following convention for the channel dimension array: DPRKuMS(DPRchn=1), DPRKaMS(DPRchn=2), DPRKuFS(DPRchn=3) and DPRKaFS(DPRchn=4).

Table 1. The channel combination of products from Ku, Ka and DPR and the order of product

| Number of FOVs | Freq. | Before Scan Pattern Change (V6) | After Scan Pattern Change (V6X) | Name of Channel |
|--|-------|---------------------------------|---------------------------------|-----------------|
| Full Swath (FS/NS) 49 FOVs | Ku | KuNS | KuFS | chn 1 |
| | Ka | - | KaFS | chn 6 |
| | DPR | - | DPRFS | chn 7 |
| Match Swath (MS) 25 FOVs | Ku | KuMS | KuMS | chn 5 |
| | Ka | KaMS | KaMS | chn 2 |
| | DPR | DPRMS | DPRMS | chn 4 |
| High Sensitivity Swath (HS) 24 Interleaved FOVs | Ka | KaHS | KaHS (Empty) | chn 3 |

Seven basic variable types have been identified. Type 1 variables are channel-dependent; type 2 variables are channel- and height(range)-dependent; type 3 are channel- and angle-dependent; type 4 variables are independent of channel-, height- and angle. Two additional types have been defined to store observation counts (type 5) and time dependent variables (type 6). A final type (type 7) is used to store products suitable for a general user.

Type-1A variables (channel-dependent):

heightBB, heightBBnadir, BBwidth, BBwidthNadir, heightStormTop, precipIceIntegrated, precipWaterIntegrated, precipRateNearSurface, precipRateESurface, precipRateESurface2, precipRateAve24, zFactorCorrectedNearSurface, zFactorCorrectedESurface, zFactorMeasuredNearSurface, rainRateNearSurface, snowRateNearSurface, mixedPhNearSurface, flagHeavyIcePrecip, epsilon, zeta

The low-resolution structure for ***heightBB*** variable (and others) is:

G1%heightBB%count(*ltL,lnL,chn,rt,st*)
 G1%heightBB%mean(*ltL,lnL,chn,rt,st*)
 G1%heightBB%stdev(*ltL,lnL,chn,rt,st*)
 G1%heightBB%histogram(*ltL,lnL,chn,rt,st,nbin*)

The high-resolution structure for ***heightBB*** variable (and others) is:

G2%heightBB%count(*ltH,lnH,chn,rt*)
 G2%heightBB%mean(*ltH,lnH,chn,rt*)
 G2%heightBB%stdev(*ltH,lnH,chn,rt*)

Type-1B variables (channel-dependent):

zFactorCorrectedNearSurfaceDPR,zFactorCorrectedESurfaceDPR

The low-resolution structure for ***zFactorCorrectedNearSurfaceDPR*** variable (and others) is:

G1%zFactorCorrectNearSurfaceDPR%count(*ltL,lnL,DPRchn,rt,st*)
 G1%zFactorCorrectNearSurfaceDPR%mean(*ltL,lnL,DPRchn,rt,st*)
 G1%zFactorCorrectNearSurfaceDPR%stdev(*ltL,lnL,DPRchn,rt,st*)
 G1%zFactorCorrectNearSurfaceDPR%histogram(*ltL,lnL,DPRchn,rt,st,nbin*)

The high-resolution structure for ***zFactorCorrectedNearSurfaceDPR*** variable (and others) is:

G2%zFactorCorrectNearSurfaceDPR%count(*ltH,lnH,DPRchn,rt*)
 G2%zFactorCorrectNearSurfaceDPR%mean(*ltH,lnH,DPRchn,rt*)
 G2%zFactorCorrectNearSurfaceDPR%stdev(*ltH,lnH,DPRchn,rt*)

Indices:

ltL: 28 (-70 to 70 deg; 5 deg grid)
 lnL: 72 (-180 to 180 deg; 5 deg grid)
 ltH: 536 (-67 to 67 deg; 0.25 deg grid)
 lnH: 1440 (-180 to 180 deg; 0.25 deg grid)
 chn: 7 {KuFS, KaMS, KaHS, KuMS,KaFS,DPRFS}
 DPRchn: 4 {DPRKuMS,DPRKaMS,DPRKuFS,DPRKaFS}
 rt: 3 {stratiform, convective, all}
 st: 3 {ocean, land, all}
 nbin: 30 (number of bins in histogram)

| Type | product | Resolution | variable | ltL | lnL | chn | rt | st | bin |
|---|---|------------|----------|---------|----------|----------|------|------|--------|
| Type-1A | heightBB, heightBBnadir, BBwidth, BBwidthNadir, heightStormTop, precipIceIntegrated, precipWaterIntegrated, precipRateNearSurface, precipRateESurface, precipRateESurface2, precipRateAve24, zFactorCorrectedNearSurface, zFactorCorrectedESurface, zFactorMeasuredNearSurface, rainRateNearSurface, snowRateNearSurface, mixedPhNearSurface, flagHeavyIcePrecip, epsilon, zeta | G1 | count | 28 ltL | 72 lnL | 7 chn | 3 rt | 3 st | |
| | | | hist | 28 ltL | 72 lnL | 7 chn | 3 rt | 3 st | 30 bin |
| | | | mean | 28 ltL | 72 lnL | 7 chn | 3 rt | 3 st | |
| | | | stdev | 28 ltL | 72 lnL | 7 chn | 3 rt | 3 st | |
| 7chn : KuFS, KaMS, KaHS, DPRMS, KuMS, KaFS, DPRFS | | G2 | count | 536 ltH | 1440 lnH | 7 chn | 3 rt | | |
| | | | mean | 536 ltH | 1440 lnH | 7 chn | 3 rt | | |
| | | | stdev | 536 ltL | 1440 lnH | 7 chn | 3 rt | | |
| | | | | | | | | | |
| Type-1B | zFactorCorrectedNearSurfaceDPR, zFactorCorrectedESurfaceDPR | G1 | count | 28 ltL | 72 lnL | 4 DPRchn | 3 rt | 3 st | |
| | | | hist | 28 ltL | 72 lnL | 4 DPRchn | 3 rt | 3 st | 30 bin |
| | | | mean | 28 ltL | 72 lnL | 4 DPRchn | 3 rt | 3 st | |
| | | | stdev | 28 ltL | 72 lnL | 4 DPRchn | 3 rt | 3 st | |
| 4 DPRchn : DPRKuMS, DPRKaMS, DPRKuFS, DPRKaFS | | G2 | count | 536 ltH | 1440 lnH | 4 DPRchn | 3 rt | | |
| | | | mean | 536 ltH | 1440 lnH | 4 DPRchn | 3 rt | | |
| | | | stdev | 536 ltH | 1440 lnH | 4 DPRchn | 3 rt | | |
| | | | | | | | | | |

Type-2A variable (channel- and height(range)-dependent):

zFactorCorrected, zFactorMeasured, precipRate, rainRate, snowRate, mixedPhRate, dm, dBNw

Low-resolution structure for ***zFactorCorrected*** variable (others are the same):

G1%zFactorCorrected%count(ltL,lnL,chn,hgt,rt,st)
G1%zFactorCorrected%mean(ltL,lnL,chn,hgt,rt,st)
G1%zFactorCorrected%stdev(ltL,lnL,chn,hgt,rt,st)
G1%zFactorCorrected%hist(ltL,lnL,chn,hgt,rt,st,nbin)

High-resolution structure for ***zFactorCorrected*** variable (others are the same):

G2%zFactorCorrected%count(ltH,lnH,chn,hgt,rt)
G2%zFactorCorrected%mean(ltH,lnH,chn,hgt,rt)
G2%zFactorCorrected%stdev(ltH,lnH,chn,hgt,rt)

Type-2B variable (channel- and height(range)-dependent):

zFactorCorrectedDPR, epsilonDPR

Low-resolution structure for ***zFactorCorrected*** variable (others are the same):

G1%zFactorCorrectedDPR%count(ltL,lnL,DPRchn,hgt,rt,st)
G1%zFactorCorrectedDPR%mean(ltL,lnL,DPRchn,hgt,rt,st)
G1%zFactorCorrectedDPR%stdev(ltL,lnL,DPRchn,hgt,rt,st)
G1%zFactorCorrectedDPR%hist(ltL,lnL,DPRchn,hgt,rt,st,nbin)

High-resolution structure for ***zFactorCorrected*** variable (others are the same):

G2%zFactorCorrectedDPR%count(ltH,lnH,DPRchn,hgt,rt)
G2%zFactorCorrectedDPR%mean(ltH,lnH,DPRchn,hgt,rt)
G2%zFactorCorrectedDPR%stdev(ltH,lnH,DPRchn,hgt,rt)

Indices:

ltL: 28 (-70 to 70 deg; 5 deg grid)
lnL: 72 (-180 to 180 deg; 5 deg grid)
ltH: 536 (-67 to 67 deg; 0.25 deg grid)
lnH: 1440 (-180 to 180 deg; 0.25 deg grid)
chn: 7 {KuFS, KaMS, KaHS, KuMS, KaFS, DPRFS}
DPRchn: 4 {DPRKuMS, DPRKaMS, DPRKuFS, DPRKaFS}
hgt: 5 {2 km, 4 km, 6 km, 10 km, 15 km}
rt: 3 {stratiform, convective, all}
st: 3 {ocean, land, all}

nbin: 30 (number of bins in histogram)

| Type | product | Resolution | variable | ltL | lnL | chn | hgt | rt | st | bin |
|---------|---|------------|----------|----------|----------|----------|------|------|------|--------|
| Type-2A | zFactorCorrected,zFactorMeasured,precipRate,rainRate,snowRate,mixedPhRate,dm,dBNw | G1 | count | 28 ltL | 72 lnL | 7 chn | 5hgt | 3 rt | 3 st | |
| | | | hist | 28 ltL | 72 lnL | 7 chn | 5hgt | 3 rt | 3 st | 30 bin |
| | | | mean | 28 ltL | 72 lnL | 7 chn | 5hgt | 3 rt | 3 st | |
| | | G2 | stdev | 28 ltL | 72 lnL | 7 chn | 5hgt | 3 rt | 3 st | |
| | | | count | 536 ltH | 1440 lnH | 7 chn | 5hgt | 3 rt | | |
| | | | mean | 536 ltH | 1440 lnH | 7 chn | 5hgt | 3 rt | | |
| Type-2B | zFactorCorrectedDPR,epsilonDPR | G1 | count | 28 ltL | 72 lnL | 4 DPRchn | 5hgt | 3 rt | 3 st | |
| | | | hist | 28 ltL | 72 lnL | 4 DPRchn | 5hgt | 3 rt | 3 st | 30 bin |
| | | | mean | 28 ltL | 72 lnL | 4 DPRchn | 5hgt | 3 rt | 3 st | |
| | | G2 | stdev | 28 ltL | 72 lnL | 4 DPRchn | 5hgt | 3 rt | 3 st | |
| | | | count | 536 ltH | 1440 lnH | 4 DPRchn | 5hgt | 3 rt | | |
| | | | mean | 536 ltH | 1440 lnH | 4 DPRchn | 5hgt | 3 rt | | |
| G2 | stdev | 536 ltH | 1440 lnH | 4 DPRchn | 5hgt | 3 rt | | | | |

Type-3A variables (channel and angle dependent):

piaSRT, piaHB, piaHybrid, piaFinal, piaFinalSubset

Low-resolution structure for ***piaSRT*** variable:

G1%*piaSRT*%count(*ltL,lnL,chn,ang,rt,st*)
 G1%*piaSRT*%mean(*ltL,lnL,chn,ang,rt,st*)
 G1%*piaSRT*%stdev(*ltL,lnL,chn,ang,rt,st*)
 G1%*piaSRT*%histogram(*ltL,lnL,chn,rt,st,nbin*)

High-resolution structure for ***piaSRT*** variable:

G2%*piaSRT*%count(*ltH,lnH,chn,ang,rt*)
 G2%*piaSRT*%mean(*ltH,lnH,chn,ang,rt*)
 G2%*piaSRT*%stdev(*ltH,lnH,chn,ang,rt*)

Type-3B variables (channel and angle dependent):

piaSRTdpr, piaFinalDPR, piaFinalDPRSubset, piaHybridDPR

Low-resolution structure for ***piaSRTdpr*** variable:

G1%*piaSRTdpr*%count(*ltL,lnL,DPRchn,ang,rt,st*)
 G1%*piaSRTdpr*%mean(*ltL,lnL,DPRchn,ang,rt,st*)
 G1%*piaSRTdpr*%stdev(*ltL,lnL,DPRchn,ang,rt,st*)
 G1%*piaSRTdpr*%histogram(*ltL,lnL,DPRchn,rt,st,nbin*)

High-resolution structure for ***piaSRTdpr*** variable:

G2%*piaSRTdpr*%count(*ltH,lnH,DPRchn,ang,rt*)
 G2%*piaSRTdpr*%mean(*ltH,lnH,DPRchn,ang,rt*)
 G2%*piaSRTdpr*%stdev(*ltH,lnH, DPRchn,ang,rt*)

Indices:

ltL: 28 (-70 to 70 deg; 5 deg grid)
 lnL: 72 (-180 to 180 deg; 5 deg grid)
 ltH: 536 (-67 to 67 deg; 0.25 deg grid)
 lnH: 1440 (-180 to 180 deg; 0.25 deg grid)
 chn: 7 {KuFS, KaMS, KaHS, KuMS, KaFS, DPRFS}
 DPRchn: 4 {DPRKuMS,DPRKaMS,DPRKuFS,DPRKaFS}
 ang: 7 {0°, ±3°, ±6°, ±9°, ±12°, ±15°, ±18°}
 rt: 3 {stratiform, convective, all}
 st: 3 {ocean, land, all}
 nbin: 30 (number of bins in histogram)

The *ang* index is taken to be 7 for full swath channels (*chn1*, *chn6*, *chn7*, *DPRchn3*, *DPRchn4*,) whereas only 4 are needed for half (*chn2*, *chn4*, *chn5*, *DPRchn1*, *DPRchn2*) and KaHS(*chn3*) swath. Taking a 4 angle-bin increment (3°), beginning with nadir (0°) gives the following incidence angles: 0°, ±3°, ±6°, ±9° for half swath. For full swath, this series is continued with samples at ±12°, ±15°, ±18°.

$ang=\{1, 2, \dots, 7\} \Rightarrow$ angle bins {25, (21,29), (17,33), (13,37), (9,41), (4,45), (1,49)}

In other words, *ang* index 1 is used to store the nadir data at Ku-band, index 2 is used to store Ku-band data from angle bins 21 and 29 ($abs(21-25) * 0.75^0 = (29-25) * 0.75^0 = 3^0$), index 3 to store data from angle bins 17 and 33 ($abs(17-25) * 0.75^0 = (33-25) * 0.75^0 = 6^0$), and so on. Finally, index 7 is used to store data from the farthest angles of the outer swath ($abs(1-25) * 0.75^0 = (49-25) * 0.75^0 = 18^0$).

For the half swath channel (*chn2*, *chn4* and *chn5*) using the same increment (4 angle bins or 3°) but noting that the center angle bin (counting from 1 to 25) is 13 then:

$ang=\{1, 2, 3, 4\} \Rightarrow$ angle bins {13, (9,17), (5,21), (1,25)}

For the KaHS channel (*chn=3*), we begin with the two beams closest to nadir so that:

$ang=\{1, 2, 3, 4\} \Rightarrow$ angle bins {(12,13), (8,17), (4,21), (1,24)}

which correspond to incidence angles of ±0.375°, ±3.375°, ±6.375° and ±8.625°.

It will often be the case that the PIA from the SRT is considered unreliable. Since the statistics of *piaSRT* and *piaSRTdpr* are taken only for those data that are considered marginally reliable or reliable, then comparisons between the PIA(SRT) and PIA(Final) statistics will be taken over different sets of data. To restrict the statistics of PIA(final) to only those cases for which the *piaSRT* and *piaSRTdpr* are reliable or marginally reliable, we introduce the subsetted statistics: *piaFinalSubset* and *piaFinalDPRSubset*.

| Type | product | Resolution | variable | ltL | lnL | chn | ang | rt | st | bin |
|---------|---|------------|----------|---------|----------|----------|------|------|------|--------|
| Type-3A | piaSRT, piaHB, piaHybrid, piaFinal, piaFinalSubset | G1 | count | 28 ltL | 72 lnL | 7 chn | 7ang | 3 rt | 3 st | |
| | | | hist | 28 ltL | 72 lnL | 7 chn | 7ang | 3 rt | 3 st | 30 bin |
| | 7chn : KuFS, KaMS, KaHS, DPRMS, KuMS, KaFS, DPRFS 7ang : 0deg, ±3deg, ±6deg, ±9deg, ±12deg, ±15deg, ±18deg | G2 | mean | 28 ltL | 72 lnL | 7 chn | 7ang | 3 rt | 3 st | |
| | | | stdev | 28 ltL | 72 lnL | 7 chn | 7ang | 3 rt | 3 st | |
| | | | count | 536 ltH | 1440 lnH | 7 chn | 7ang | 3 rt | | |
| | | | mean | 536 ltH | 1440 lnH | 7 chn | 7ang | 3 rt | | |
| Type-3B | piaSRTdpr, piaFinalDPR, piaFinalDPRSubset, piaHybridDPR | G1 | count | 28 ltL | 72 lnL | 4 DPRchn | 7ang | 3 rt | 3 st | |
| | | | hist | 28 ltL | 72 lnL | 4 DPRchn | 7ang | 3 rt | 3 st | 30 bin |
| | 4 DPRchn : DPRKuMS, DPRKaMS, DPRKuFS, DPRKaFS 7ang : 0deg, ±3deg, ±6deg, ±9deg, ±12deg, ±15deg, ±18deg | G2 | mean | 28 ltL | 72 lnL | 4 DPRchn | 7ang | 3 rt | 3 st | |
| | | | stdev | 28 ltL | 72 lnL | 4 DPRchn | 7ang | 3 rt | 3 st | |
| | | | count | 536 ltH | 1440 lnH | 4 DPRchn | 7ang | 3 rt | | |
| | | | mean | 536 ltH | 1440 lnH | 4 DPRchn | 7ang | 3 rt | | |
| | | | stdev | 536 ltH | 1440 lnH | 4 DPRchn | 7ang | 3 rt | | |

Type-4 variables (channel, height- and angle independent):

DFRNearSurface, *DFRmNearSurface*

Low-resolution structure for *DFRNearSurface* variable:

G1%DFRNearSurface%count(ltL,lnL,rt,st)
 G1%DFRNearSurface%mean(ltL,lnL,rt,st)
 G1%DFRNearSurface%stdev(ltL,lnL,rt,st)
 G1%DFRNearSurface%histogram(ltL,lnL,rt,st,nbin)

High-resolution structure for *DFRNearSurface* variable:

G2%DFRNearSurface%count(ltH,lnH,rt)
 G2%DFRNearSurface%mean(ltH,lnH,rt)
 G2%DFRNearSurface%stdev(ltH,lnH,rt)

Type-5 variables, Total number of observations

ObservationCounts (This structure has 4 elements to store the observation counts with respect to total, local time, angle/pia, and shallow rain)

G1%ObservationCounts%total(*ltL,lnL,chn,st*)
G1%ObservationCounts%localTime(*ltL,lnL,chn,time,st*)
G1%ObservationCounts%pia(*ltL,lnL,chn,ang,st*)
G1%ObservationCounts%shallowRain(*ltL,lnL,chn,st*)

where the index *time* (=24) represents local time binned by hour. The high-resolution ObservationCounts structure is the same except the surface type *st* is omitted and the element 'localTime' is not computed.

G2%ObservationCounts%total(*ltH,lnH,chn*)
G2%ObservationCounts%pia(*ltH,lnH,chn,ang*)
G2%ObservationCounts%shallowRain(*ltH,lnH,chn,st*)

Note that **ObservationCounts%total** is equal to the number of observations at a particular lat/lon box for each channel and, in the case of the low-resolution grid, for each surface type. The probability of rain at a particular height level, for a particular rain type and surface type, over the low-resolution grid is computed by:

$$\text{Probability of Rain}(ltL,lnL,hgt,chn,rt,st) = \frac{G1\%precipRate\%count(ltL,lnL,hgt,chn,rt,st)}{G1\%ObservationCounts\%total(ltL,lnL,hgt,chn,rt,st)}$$

Note that all rain types and all surface types are obtained by setting *rt*=3 and *st*=3. The unconditioned mean can be calculated from the conditioned mean by multiplying by the probability of rain. The unconditioned standard deviation can also be computed from the conditional mean, conditional standard deviation and the probability of rain.

Type-6 variables (time-dependent rain rate):

precipRateLocalTime

Low-resolution structure for **precipRateLocalTime** variable:

G1%precipRateLocalTime%count(*ltL,lnL,chn,time,st*)
G1%precipRateLocalTime%mean(*ltL,lnL,chn,time,st*)
G1%precipRateLocalTime%stdev(*ltL,lnL,chn,time,st*)

where all indices are defined as before and where
time: 24 {corresponding to hourly grid of the local time}

Note that a height index or rain type index is not included since only the near-surface precipRate is used for this product. Both stratiform and convective rain are included – i.e., no rain type classification is used.

A high-resolution grid for these variables has not been defined.

Type-7 variables (general user products):

precipRateNearSurfaceUnconditional, PrecipProbabilityNearSurface

Since most users will not need the detailed statistics described above, a subset of the mean, near-surface unconditional rain rate is defined which is independent of rain type or surface type, i.e., all rain types and surface types are included.

G1%precipRateNearSurfaceUnconditional(*ltL,lnL,chn*)

along with the high-resolution counterpart:

G2%precipRateNearSurfaceUnconditional(*ltH,lnH,chn*)

Since these rain rates will be unconditional, there is no need for a separate count variable. However, the user might want a rain probability:

`G1precipProbabilityNearSurface(ItL,InL,chn)`

with the corresponding high-resolution variable:

`G2precipProbabilityNearSurface(ItH,InH,chn)`

Definition of Variables (see level 2 documentation for detailed definitions)

(Unless otherwise indicated, the variables below are such that the mean and standard deviations are 4-byte real, the counts and histograms are 4-byte integers. With the exception of `ObservationCounts` and `precipRateNearSurfaceUnconditional`, all statistics are conditioned on the presence of precipitation. Unless otherwise noted, all variables are defined on both low and high-resolution grids.)

BBwidth: width of bright-band (m) [classification]

BBwidthNadir: width of bright-band (m) at nadir incidence [classification]

DFRNearSurface: $Z(Ku)-Z(Ka)$, in dB, evaluated near the surface [solver]

DFRmNearSurface: $Z_m(Ku)-Z_m(Ka)$, in dB, evaluated near the surface [preparation]

dB_{Nw}: $10 \log_{10}$ of the particle number concentration (m^{-3}) [solver]

dm: mass-weighted diameter (mm) [solver]

epsilon: dimensionless scale factor on α in $k=\alpha Z^\beta$ (where k is the specific attenuation in dB/km) [solver]

epsilonDPR: same as above except height dependent using dual-freq data [solver]

flagHeavyIcePrecip: flag to indicate the presence of hail or graupel in the column [solver]

heightBB: height from ellipsoid to 'bright-band' (m) [classification]

heightBBnadir: height from ellipsoid to 'bright-band' for nadir incidence (m) [classification]

heightStormTop: height from ellipsoid to storm top (m) [preparation]

mixedPhRate: precip rate of mixed phase particles as a function of height (mm/h) [solver]

mixedPhRateNearSurface: precip rate of mixed phase particles near surface (mm/h) [solver]

ObservationCount%localTime: total number of observations categorized into local hour. Note that this variable is only computed on the low-resolution grid.

ObservationCount%pia: total number of observations categorized into incidence angle

ObservationCount%shallowRain: number of observations of shallow rain [classification]

ObservationCount%total: total number of observations

piaFinal: path-integrated attenuation (dB), obtained from single-freq methods [solver]

piaFinalDPR: path-integrated attenuation (dB), obtained from dual-freq method [solver]

piaFinalDPRSubset path-integrated attenuation (dB), obtained from dual-freq method using only those observations for which the SRT-derived pia is considered reliable or marginally reliable [SRT, solver]

piaFinalSubset: path-integrated attenuation (dB), obtained from single-freq methods using only those observations for which the SRT-derived pia is considered reliable or marginally reliable [SRT, solver]

piaHB: path-integrated attenuation (dB) derived from the Hitschfeld-Bordan method

piaHybrid: path-integrated attenuation (dB) derived from the weighted sum of the HB and SRT

piaHybridDPR: path-integrated attenuation (dB) derived from the weighted sum of the HB, SRT, and the standard dual-wavelength method

piaSRT: path-integrated attenuation (dB), obtained from single-freq methods [SRT]

piaSRTdpr: path-integrated attenuation (dB), obtained from dual-freq method [SRT]

precipIceIntegrated: precipitation ice content integrated along the column (g/m^2) [solver]

precipProbabilityNearSurface: probability of rain near surface, low-resolution only [preparation]
precipRate: height-dependent precipitation rate (mm/h). Note that all 'precipRate' variables include all types of precipitation [solver] (note that precipRate is the sum of rainRate, mixedPhrate, and snowRate.)
precipRateAve24: average precipitation rate (mm/h) between 2-4 km above ellipsoid [solver]
precipRateESurface: estimated precip rate at surface (mm/h) [solver]
precipRateESurface2: estimated precip rate at surface (mm/h), using a statistical approach [solver]
precipRateLocalTime: near-surface precip rate (mm/h) categorized into local hour; low-resolution only [solver]
precipRateNearSurface: precip rate (mm/h) near surface [solver]
precipRateNearSurfaceUnconditional : unconditional rain rate (mm/h) near surface, low-resolution only [solver]
precipWaterIntegrated: precipitation water content integrated along the column (g/m²) [solver]
rainRate: height-dependent rain rate (mm/h) [solver].
rainRateNearSurface: rain rate near the surface (mm/h) [solver]
snowRate: height-dependent snow rate (mm/h) [solver].
snowRateNearSurface: snow rate near surface (mm/h) [solver]
zFactorCorrected: height-dependent radar reflectivity factor (mm⁶/m³) in dB, using single-freq attenuation correction [solver]
zFactorCorrectedDPR: height-dependent radar reflectivity factor (mm⁶/m³) in dB, using dual-freq attenuation correction [solver]
zFactorCorrectedESurface: estimated at-surface radar reflectivity factor (mm⁶/m³) in dB, using single-freq attenuation correction [solver]
zFactorCorrectedESurfaceDPR: estimated at-surface radar reflectivity factor (mm⁶/m³) in dB, using dual-freq attenuation correction [solver]
zFactorCorrectedNearSurface: near-surface radar reflectivity factor (mm⁶/m³) in dB, using single-freq attenuation correction [solver]
zFactorCorrectedNearSurfaceDPR: near-surface radar reflectivity factor (mm⁶/m³) in dB, using dual-freq attenuation correction [solver]
zFactorMeasured: height-dependent measured radar reflectivity factor (mm⁶/m³) in dB [preparation]
zFactorMeasuredNearSurface: measured radar reflectivity factor near surface (mm⁶/m³) in dB [preparation]

Histogram Bin Definitions

! mm/h (logarithmic steps) used for all rain rate & related variables

```
cat_rain = [ 0.01, 0.10, 0.13, 0.17, 0.23, 0.30, 0.40, 0.52, 0.69, 0.91, 1.20, 1.58, 2.08,
            2.75, 3.62, 4.77, 6.29, 8.29, 10.92, 14.40, 18.97, 25.00, 32.95, 43.43, 57.24,
            75.44, 99.43, 131.04, 172.71, 227.63, 300.00 ]
```

! dBZ, used for all radar reflectivity-related variables

```
cat_Z = [ 0.01, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0, 22.0, 24.0, 26.0, 28.0, 30.0,
          32.0, 34.0, 36.0, 38.0, 40.0, 42.0, 44.0, 46.0, 48.0, 50.0, 52.0, 54.0, 56.0, 58.0,
          60.0, 62.0, 64.0 ]
```

! kg/m²

```
cat_integratedWater = [ 0.0, 200.0, 400.0, 600.0, 800.0, 1000.0, 1200.0, 1400.0, 1600.0, 1800.0,
                       2000.0, 2200.0, 2400.0, 2600.0, 2800.0, 3000.0, 3200.0, 3400.0, 3600.0,
                       3800.0, 4000.0, 4200.0, 4400.0, 4600.0, 4800.0, 5000.0, 5200.0, 5400.0,
                       5600.0, 5800.0, 6000.0 ]
```

! meters

```
cat_bbhgt = [ 10.0, 250.0, 500.0, 750.0, 1000.0, 1250.0, 1500.0, 1750.0, 2000.0, 2250.0, 2500.0,
              2750.0, 3000.0, 3250.0, 3500.0, 3750.0, 4000.0, 4250.0, 4500.0, 4750.0, 5000.0,
              5250.0, 5500.0, 5750.0, 6000.0, 6250.0, 6500.0, 6750.0, 7000.0, 7500.0, 20000.0 ]
```

! meters

```
cat_bbwidth = [ 0.0, 125.0, 250.0, 375.0, 500.0, 625.0, 750.0, 875.0, 1000.0, 1125.0, 1250.0,
                1375.0, 1500.0, 1625.0, 1750.0, 1875.0, 2000.0, 2125.0, 2250.0, 2375.0, 2500.0,
                2625.0, 2750.0, 2875.0, 3000.0, 3125.0, 3250.0, 3375.0, 3500.0, 3625.0, 3750.0 ]
```

! km (convert m > km)

```
cat_stormh = 1000.0*[ 0.01, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0,
                      6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0, 11.5, 12.0,
                      12.5, 13.0, 14.0, 15.0, 16.0, 20.0 ]
```

```
cat_epsilon = [ 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3,
                1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7,
                2.8, 2.9, 3.0 ]
```

```
cat_nubf = [ 1.0, 1.05, 1.1, 1.15, 1.2, 1.25, 1.3, 1.35, 1.4, 1.45, 1.5, 1.55, 1.6, 1.65,
             1.7, 1.75, 1.8, 1.85, 1.9, 1.95, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7,
             2.8, 2.9, 3.0 ]
```

```
cat_pia = [ 0.01, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.5,
            3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 7.0, 8.0, 9.0, 10.0, 15.0, 20.0, 25.0,
            30.0, 100.0 ]
```

```
cat_dBNw = [ 0.1, 1.0, 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0, 22.0,
             24.0, 26.0, 28.0, 30.0, 32.0, 34.0, 36.0, 38.0, 40.0, 42.0, 44.0, 46.0,
             48.0, 50.0, 52.0, 54.0, 56.0, 60.0 ]
```

! mm

```
cat_Dm = [ 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5,
           1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.0,
           4.0 ]
```

Appendix

1. Level 3 Data Format Structure (Monthly)

1.1. Data Format Structure

3DPR, "DPR Monthly Product" compute statistics of the DPR measurements at both a low horizontal resolution (G1, 5° x 5° latitude/longitude) and a high horizontal resolution (G2, 0.25° x 0.25° latitude/longitude).

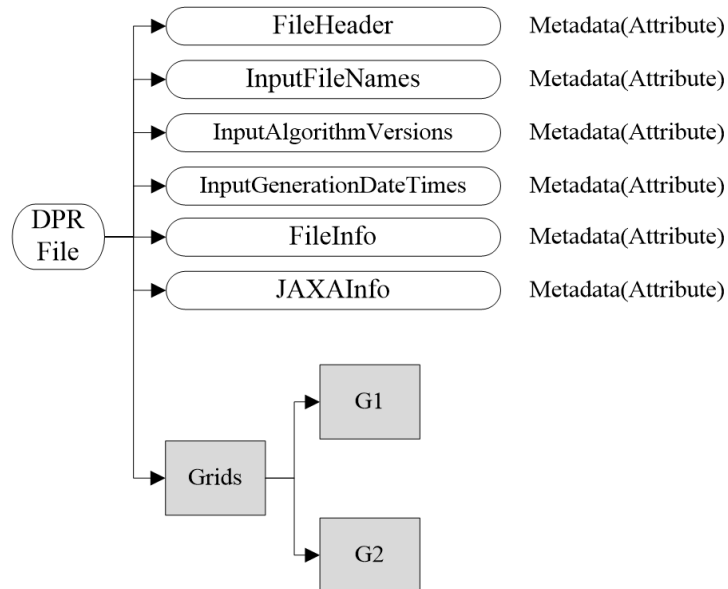


Figure 1.1-1 Data Format Structure for 3DPR

Dimension definitions:

- ltL
 - 28 Number of low resolution 5° grid intervals of latitude from 70°S to 70°N.
- lnL
 - 72 Number of low resolution 5° grid intervals of longitude from 180°W to 180°E.
- ltH
 - 536 Number of high resolution 0.25° grid intervals of latitude from 67°S to 67°N.
- lnH
 - 1440 Number of high resolution 0.25° grid intervals of longitude from 180°W to 180°E.
- chn
 - 7 Number of channels: KuFS(49), KaMS(25), KaHS(24), DPRMS(25), KuMS(25), KaFS(49), DPRFS(49).
- DPRchn
 - 4 Number of DPR channels: DPRKuMS(25), DPRKaMS(25),
- hgt
 - 5 Number of heights above the earth ellipsoid: 2, 4, 6, 10, and 15 km.
- tim
 - 24 Number of hours (local time).
- ang
 - 7 Number of angles. The meaning of ang is different for each channel.
For Ku channel all indeces are used with the meaning 0, 1, 2, ..., 6 = angle bins 24, (20,28), (16,32), (12,36), (8,40), (3,44), and (0,48).
For Ka channel 4 indeces are used with the meaning 0, 1, 2, 3 = angle bins 12, (8,16), (4,20), and (0,24). For KaHS channel 4 indeces are used with the meaning 0, 1, 2, 3 = angle bins (11,2), (7,16), (3,20), and (0,23).
- rt
 - 3 Number of rain types: stratiform, convective, all
- st
 - 3 Number of surface types: ocean, land, all.
- bin
 - 30 Number of bins in histogram. The thresholds are different for different variables. See the introduction to this algorithm.

1.2. Metadata

Metadata has seven elements. Figure 1.2-1 shows metadata structure.

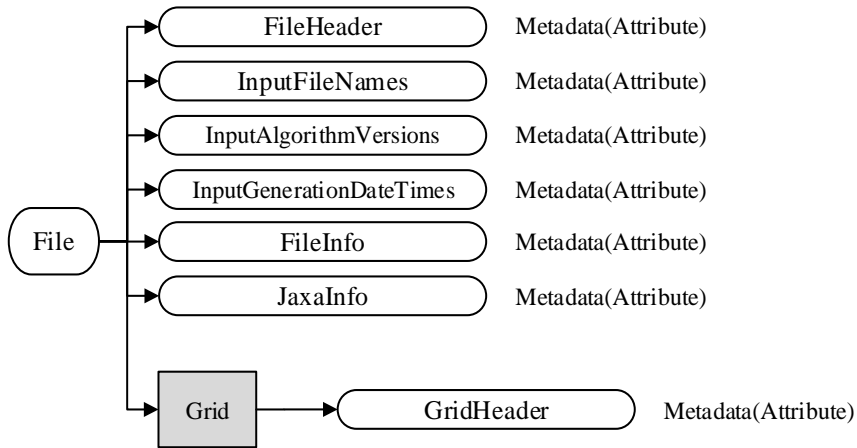


Figure 1.2-1 L3 Metadata

1.2.1. FileHeader

FileHeader contains metadata of general interest. This group appears in all data products. Details are shown in Table 1.2-1 FileHeader Elements.

Table 1.2-1 FileHeader Elements

| No | Element | Description | Data size (bytes) |
|----|------------------|---|-------------------|
| 1 | DOI | Digital Object Identifier. *Value is blank currently. | 256 |
| 2 | DOIauthority | Digital Object Identifier Authority. | 256 |
| 3 | DOIshortName | Digital Object Identifier Short Name. *Value is blank currently. | 256 |
| 4 | AlgorithmID | The algorithm that generated this product, e.g., 2A12. | 50 |
| 5 | AlgorithmVersion | The version of the algorithm that generated this product. | 50 |
| 6 | FileName | The file name of this granule. | 50 |

1.2 Metadata

| No | Element | Description | Data size (bytes) |
|----|----------------------|--|-------------------|
| 7 | SatelliteName | Values are: TRMM GPM MULTI F10 ... F18 AQUA GCOMW1 CORIOLIS MT1 NOAA15 ... NOAA19 METOPA NPP. More values will be added as they are known. | 10 |
| 8 | InstrumentName | Values are: PR TMI VIRS PRTMI KU KA DPR GMI DPRGMI MERGED SSMI SSMIS AMSRE AMSR2 WINDSAT MADRAS AMSUA AMSUB SAPHIR MHS ATMS. More values will be added as they are known. | 10 |
| 9 | GenerationDateTime | The date and time this granule was generated. The format is YYYY-MM-DDTHH:MM:SS.sssZ, where YYYY is 4-digit year, MM is month number, DD is day of month, T is "T", HH is hour, MM is minute, SS is second, sss is millisecond, and Z is "Z". All fields are zero-filled. The missing value is constructed by replacing all digits with 9, i.e., 9999-99-99T99:99:99.999Z. | 50 |
| 10 | StartGranuleDateTime | The start time defining this granule. The format is the same as GenerationDateTime. DETAILS: An orbital granule starts when the satellite is at the position defined by GranuleStart. Thus the start time is not the first scan time. Some algorithms have overlap scans in the file before the start time as defined in SwathHeader. A monthly granule starts on the first ms of the month, for example March 1998 would be 1998-03-01T00:00:00.000Z. | 50 |
| 11 | StopGranuleDateTime | The stop time defining this granule. The format is the same as GenerationDateTime. DETAILS: An orbital granule stops when the satellite is at the position defined by GranuleStart. Thus the stop time is not the last scan time. Some algorithms have overlap scans in the file after the stop time as defined in SwathHeader. A monthly granule stops on the last ms of the month, for example March 1998 would be 1998-03-31T23:59:59.999Z. | 50 |
| 12 | GranuleNumber | The number of this granule, which starts as in GranuleStart. If the GranuleStart is identical to the orbit start, then the GranuleNumber will be the same as the orbit number. The GranuleNumber will have 6 digits, including leading zeroes, for example 001234. | 50 |
| 13 | NumberOfSwaths | The number of swaths in this granule. | 50 |
| 14 | NumberOfGrids | The number of grid structures in this granule. | 50 |
| 15 | GranuleStart | The starting place in the orbit of this granule. Currently defined values are "SOUTHERNMOST LATITUDE" and "NORTHBOUND EQUATOR CROSSING". | 50 |
| 16 | TimeInterval | The time interval covered by this granule. Values are "ORBIT", "HALF ORBIT", "HALF HOUR", "HOUR", "3 HOUR", "DAY", "DAY ASC", "DAY DES", "MONTH", "CONTACT". | 50 |
| 17 | ProcessingSystem | The name of the processing system, e.g., "PPS", "JAXA". | 50 |
| 18 | ProductVersion | The data version assigned by the processing system. | 50 |
| 19 | EmptyGranule | Whether a granule is empty. Values are "EMPTY" or "NOT EMPTY". | 50 |
| 20 | MissingData | The number of missing scans. | 50 |

1.2.2. InputFileNames

InputFileNames contains a list of input file names for this granule. Since some algorithms may have 2000 input files, this group is a “Long Metadata Group”, which has no elements. This group appears in Level 3 time averaged products.

1.2.3. InputAlgorithmVersions

InputAlgorithmVersions contains a list of input algorithm versions for this granule. Since some algorithms may have 2000 input files, this group is a “Long Metadata Group”, which has no elements. This group appears in Level 3 times averaged products.

1.2.4. InputGenerationDateTimes

InputGenerationDateTimes contains a list of input generation datetimes for this granule. Since some algorithms may have 2000 input files, this group is a “Long Metadata Group”, which has no elements. This group appears in Level 3 times averaged products.

1.2.5. FileInfo

FileInfo contains metadata used by the PPS I/O Toolkit. This group appears in all data products. This group appears in L2 Metadata. Please see Table 1.2-2 FileInfo Elements.

Table 1.2-2 FileInfo Elements

| No | Element | Description | Data size (bytes) |
|----|--------------------|---|-------------------|
| 1 | DataFormatVersion | The version of the data format used to write this file. This version is separate for each AlgorithmID. The order is: "a" "b" ... "z" "aa" "ab" ... "az" "ba" "bb". | 50 |
| 2 | TKCodeBuildVersion | Usually TK CodeBuildVersion is "1". If the I/O routines built by TKIO change even though the DataFormatVersion is unchanged, then TK CodeBuildVersion increments to "2", "3", ...If subsequently DataFormatVersion changes, TKCodeBuildVersion becomes "1" again. | 50 |
| 3 | MetadataVersion | The version of metadata used to write this file. This version is separate for each AlgorithmID. The order is: "a" "b" ... "z" "aa" "ab" ... "az" "ba" "bb" ... | 50 |
| 4 | FormatPackage | The underlying format of this granule. Values are “HDF4”, “HDF5”, “NETCDF”, “TKBINARY”. | 50 |
| 5 | BlueprintFilename | The filename of the primary blueprint file that defined the format used to write this file. | 50 |
| 6 | BlueprintVersion | The BlueprintVersion of the format definition. | 50 |
| 7 | TKIOVersion | The version of TKIO used to create I/O routines to write this file. TKIOVersion does not define the format used to write this file. | 50 |

1.2 Metadata

| No | Element | Description | Data size (bytes) |
|----|---------------|--|-------------------|
| 8 | MetadataStyle | The style in which the metadata was written, e.g., "PVL". "PVL" means < parameter >=< value >. | 50 |
| 9 | EndianType | The endian type of the system that wrote this file. Values are "BIG ENDIAN" and "LITTLE ENDIAN". | 50 |

1.2.6. JAXAInfo

JAXAInfo contains metadata requested by JAXA. Used by DPR algorithms and GSMaP. This group appears in L2 Metadata. Table 1.2-3 shows TotalQualityCode in JAXAInfo.

Table 1.2-3 TotalQualityCode Elements

| No | Element | Description | Data size (bytes) |
|----|------------------|--|-------------------|
| 1 | TotalQualityCode | <p>The total quality of product is defined based on the quality of input data or missing pixels ratio.</p> <p>Quality meaning are</p> <p>(a) GPM DPR L3 and PR L3 product Good: missing pixels ratio \geq 50% Fair: missing pixels ratio $<$ 50%</p> <p>(b) GPM DPR SLH L3 and PR SLH L3(Gridded orbit) product Good: The total quality of input data (L2) is Good. Fair: The total quality of input data (L2) is Fair. EG (Empty Granule): The total quality of input data (L2) is EG</p> <p>(c) GPM DPR SLH L3 and PR SLH L3 product Good: missing pixels ratio \geq 50% Fair: missing pixels ratio $<$ 50%</p> | 50 |

1.2.7. GridHeader

GridHeader contains metadata defining the grids in the grid structure. This group appears in Level 3 products. Table 1.2-4 shows each metadata elements in GridHeader.

Table 1.2-4 GridHeader Elements

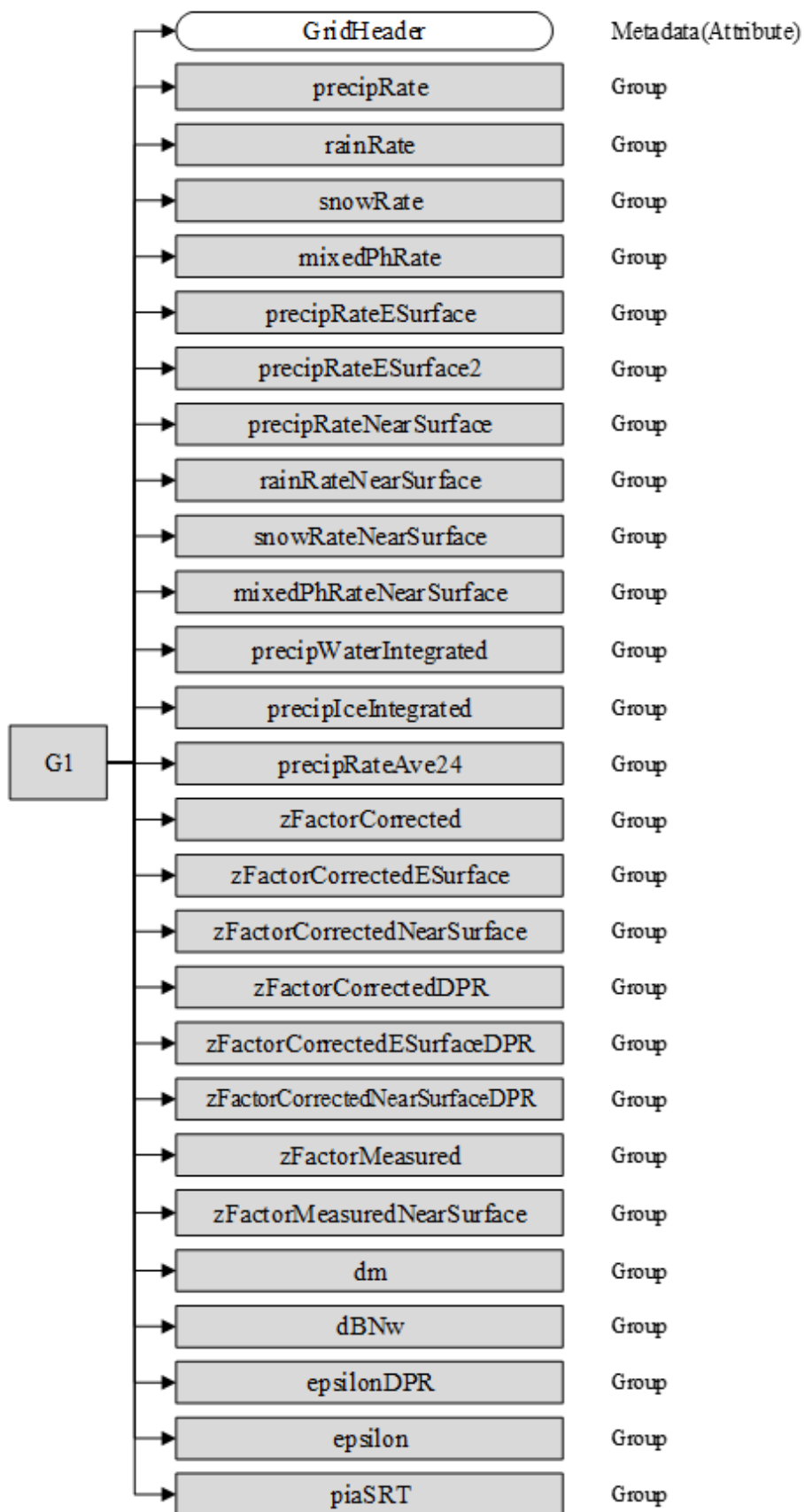
| No | Element | Description | Data size (bytes) |
|----|--------------------|--|-------------------|
| 1 | BinMethod | Method used to obtain the value in each grid box. The only defined value is "ARITHMEAN". | 50 |
| 2 | Registration | Representative location within the grid box. The only defined value is "CENTER". | 50 |
| 3 | LatitudeResolution | North-south size of a bin (degrees latitude). | 50 |

1.2 Metadata

| No | Element | Description | Data size (bytes) |
|----|-------------------------|---|-------------------|
| 4 | LongitudeResolution | East-west size of a bin (degrees longitude). | 50 |
| 5 | NorthBoundingCoordinate | Northern-most latitude (degrees) covered by the grid. | 50 |
| 6 | SouthBoundingCoordinate | Southern-most latitude (degrees) covered by the grid. | 50 |
| 7 | EastBoundingCoordinate | Eastern-most longitude (degrees) covered by the grid. | 50 |
| 8 | WestBoundingCoordinate | Western-most longitude (degrees) covered by the grid. | 50 |
| 9 | Origin | Origin of the grid indices, e.g., "SOUTHWEST". | 50 |

1.3. Data Group

Elements of data group are explained in detail in this section. G1 grid and G2 grid have same structure commonly. エラー! 参照元が見つかりません。 shows the data group structure.



Continued on next figure

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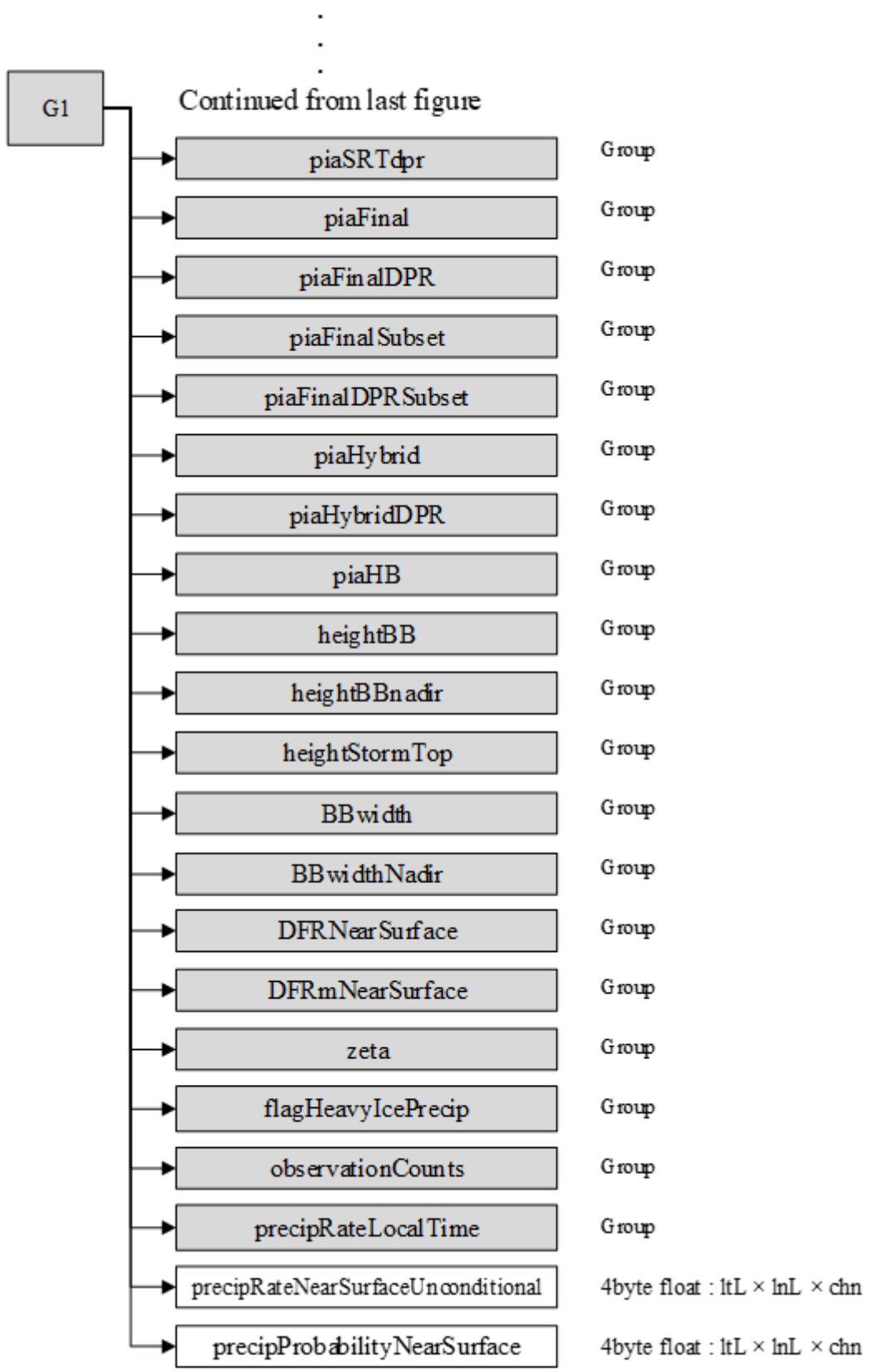


Figure 1.3-1 Data Format Structure for 3DPR

1.3.1. precipRate (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * hgt * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * hgt * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * hgt * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Conditional Precipitation Rate.

1.3.2. rainRate (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * hgt * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * hgt * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * hgt * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Conditional liquid water Rain Rate.

1.3.3. snowRate (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * hgt * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * hgt * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * hgt * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Conditional Snowfall Rate.

1.3.4. mixedPhRate (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * hgt * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * hgt * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * hgt * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Conditional Mixed Phase Precipitation Rate.

1.3.5. precipRateESurface (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Conditional Estimated Surface Precipitation Rate.

1.3.6. precipRateESurface2 (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * rt | -9999 | |

| | | | | | |
|--|-------|--------------|--|---------|--|
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Alternate Conditional Estimated Surface Precipitation Rate.

1.3.7. precipRateNearSurface (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Conditional Precipitation Rate at Near Surface Level.

1.3.8. rainRateNearSurface (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Unconditional liquid Rain Rate at Near Surface Level.

1.3.9. snowRateNearSurface (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

| | | | | | |
|----|-------|----------------|---------------------------------|---------|--|
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Conditional Snow Rate at Near Surface Level.

1.3.10. mixedPhRateNearSurface (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Conditional Mixed Phase Precipitation Rate at Near Surface Level.

1.3.11. precipWaterIntegrated (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------------------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | g/m ² |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Integrated Precipitable Water.

1.3.12. precipIceIntegrated (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|------|-------|---------------|------|
|------|----------|------|-------|---------------|------|

| | | | | | |
|----|-------|----------------|---------------------------------|---------|-----|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Integrated Precipitable Ice.

1.3.13. precipRateAve24 (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Average Precipitation Rate in 24hrs.

1.3.14. zFactorCorrected (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * hgt * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * hgt * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * hgt * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Vertical profile of corrected reflectivity factor with attenuation correction.

$10 \log_{10}(Z)$ where Z is in mm^6/m^3 .

1.3.15. zFactorCorrectedESurface (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Corrected Reflectivity at the Estimated Surface.

1.3.16. zFactorCorrectedNearSurface (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Corrected Reflectivity at the Near Surface Level.

1.3.17. zFactorCorrectedDPR (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|------------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * DPRchn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * DPRchn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * DPRchn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Corrected Reflectivity from DPR.

1.3.18. zFactorCorrectedESurfaceDPR (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|------------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * DPRchn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * DPRchn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * DPRchn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Corrected Reflectivity from DPR at Estimated Surface.

1.3.19. zFactorCorrectedNearSurfaceDPR (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|------------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * DPRchn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * DPRchn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * DPRchn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Corrected Reflectivity from DPR at the Near Surface Level.

1.3.20. zFactorMeasured (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * hgt * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * hgt * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * hgt * rt | -9999 | |

| | | | | | |
|--|-------|--------------|--|---------|--|
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Vertical profile of reflectivity factor (Z) without attenuation correction (as measured).

$10\log_{10}(Z)$ where Z is in mm^6/m^3 .

1.3.21. zFactorMeasuredNearSurface (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

zFactorMeasured near surface.

1.3.22. dm (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * hgt * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * hgt * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * hgt * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

1.3.23. dBNw (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * hgt * rt * st | -9999 | N/A |

| | | | | | |
|----|-------|----------------|----------------------------|---------------------------------------|--|
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | | ltL * lnL * chn * hgt * rt * st * bin | |
| G2 | count | 4-byte integer | ltH * lnH * chn * hgt * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

1.3.24. epsilon (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Epsilon is the indication of the adjustment away from the initial drop size distribution, epsilon = 1 is no adjustment.

1.3.25. epsilonDPR (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|--|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * DPRchn * hgt * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * DPRchn * hgt * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * DPRchn * hgt * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Epsilon of DPR.

1.3.26. piaSRT (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * ang * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * ang * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * ang * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Path Integrated Attenuation from SRT.

1.3.27. piaSRTdpr (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|--|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * DPRchn * ang * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * DPRchn * ang * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * DPRchn * ang * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Path Integrated Attenuation from SRT DPR.

1.3.28. piaFinal (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * ang * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * ang * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * ang * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |

| | | | | | |
|--|-------|--------------|--|---------|--|
| | stdev | 4-byte float | | -9999.9 | |
|--|-------|--------------|--|---------|--|

The final estimates of path integrated attenuation caused by precipitation particles.

1.3.29. piaFinalDPR (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * DPRchn * ang * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * DPRchn * ang * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * DPRchn * ang * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Final Path Integrated Attenuation from DPR.

1.3.30. piaFinalSubset (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * ang * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * ang * rt * st * bin | -9999 | |

Final Path Integrated Attenuation Subset. G1 only.

1.3.31. piaFinalDPRsubset (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|------------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * DPRchn * ang * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

| | | | | | |
|--|------|----------------|---|-------|--|
| | hist | 4-byte integer | ltL * lnL * DPRchn * ang * rt * st * bin | -9999 | |
|--|------|----------------|---|-------|--|

Final Path Integrated Attenuation from DPR Subset. G1 only.

1.3.32. piaHybrid (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * ang * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * ang * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * ang * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Weighted Hybrid PIA between the HB solution and the SRT PIA.

1.3.33. piaHybridDPR (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * DPRchn * ang * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * DPRchn * ang * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * DPRchn * ang * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Weighted Hybrid PIA between the HB solution and the SRT PIA for DPR.

1.3.34. piaHB (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * ang * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |

| | | | | | |
|----|-------|----------------|---------------------------------------|---------|--|
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * ang * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * ang * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

The 2-way attenuation of Hitchfield-Bordan Path Integrated Attenuation for the slant range path.

1.3.35. heightBB (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Height of bright band.

1.3.36. heightBBnadir (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |

Height of Bright Band from Nadir. G1 only.

1.3.37. heightStormTop (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |

| | | | | | |
|----|-------|----------------|----------------------|---------------------------------|--|
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | | ltL * lnL * chn * rt * st * bin | |
| G2 | count | 4-byte integer | ltH * lnH * chn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Height of storm top.

1.3.38. BBwidth (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

The width of bright band.

1.3.39. BBwidthNadir (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |

BBwidth at nadir. G1 only.

1.3.40. DFRNearSurface (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|------|-------|---------------|------|
|------|----------|------|-------|---------------|------|

| | | | | | |
|----|-------|----------------|---------------------------|---------|-----|
| G1 | count | 4-byte integer | ltL * lnL * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

DFR at the Near Surface level.

1.3.41. DFRmNearSurface (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

DFRm at the Near Surface level.

1.3.42. zeta (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * ang * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * ang * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * ang * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Integral of $0.2 * \ln(10) * \alpha * Z_m^{\beta}$ over the slant range path where alpha and Z_m are

functions of range.

1.3.43. flagHeavyIcePrecip (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|---------------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * rt * st | -9999 | N/A |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |
| | hist | 4-byte integer | ltL * lnL * chn * rt * st * bin | -9999 | |
| G2 | count | 4-byte integer | ltH * lnH * chn * rt | -9999 | |
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

This flag denotes detection of solid ice hydrometeors which cause severely strong Z factor or huge DFRm in the sky less than -10 degree C temperature. Counts of the occurrence of flagHeavyIcePrecip. Mean and std. dev. are set to missing. The histogram contains counts of the integer flag values, with bins from 1 to 30.

1.3.44. observationCounts (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|-------------|----------------|----------------------------|---------------|------|
| G1 | total | 4-byte integer | ltL * lnL * chn * st | -9999 | N/A |
| | localTime | 4-byte integer | ltL * lnL * chn * tim * st | | |
| | pia | 4-byte integer | ltL * lnL * chn * ang * st | | |
| | shallowRain | 4-byte integer | ltL * lnL * chn * st | | |
| G2 | total | 4-byte integer | ltH * lnH * chn | | |
| | pia | 4-byte integer | ltH * lnH * chn * ang | | |
| | shallowRain | 4-byte integer | ltH * lnH * chn | | |

Observation Counts of each data.

1.3.45. precipRateLocalTime (Group)

| Grid | DataName | Type | Array | Missing Value | Unit |
|------|----------|----------------|----------------------------|---------------|------|
| G1 | count | 4-byte integer | ltL * lnL * chn * tim * st | -9999 | N/A |

| | | | | | |
|--|-------|--------------|--|---------|--|
| | mean | 4-byte float | | -9999.9 | |
| | stdev | 4-byte float | | -9999.9 | |

Precipitation Rate by Local Time. G1 only.

1.3.46. precipRateNearSurfaceUnconditional

| Grid | Type | Array | Missing Value | Unit |
|------|--------------|-----------------|---------------|------|
| G1 | 4-byte float | ltL * lnL * chn | -9999.9 | |
| G2 | 4-byte float | ltH * lnH * chn | -9999.9 | |

Rain not conditioned on rain.

1.3.47. precipProbabilityNearSurface

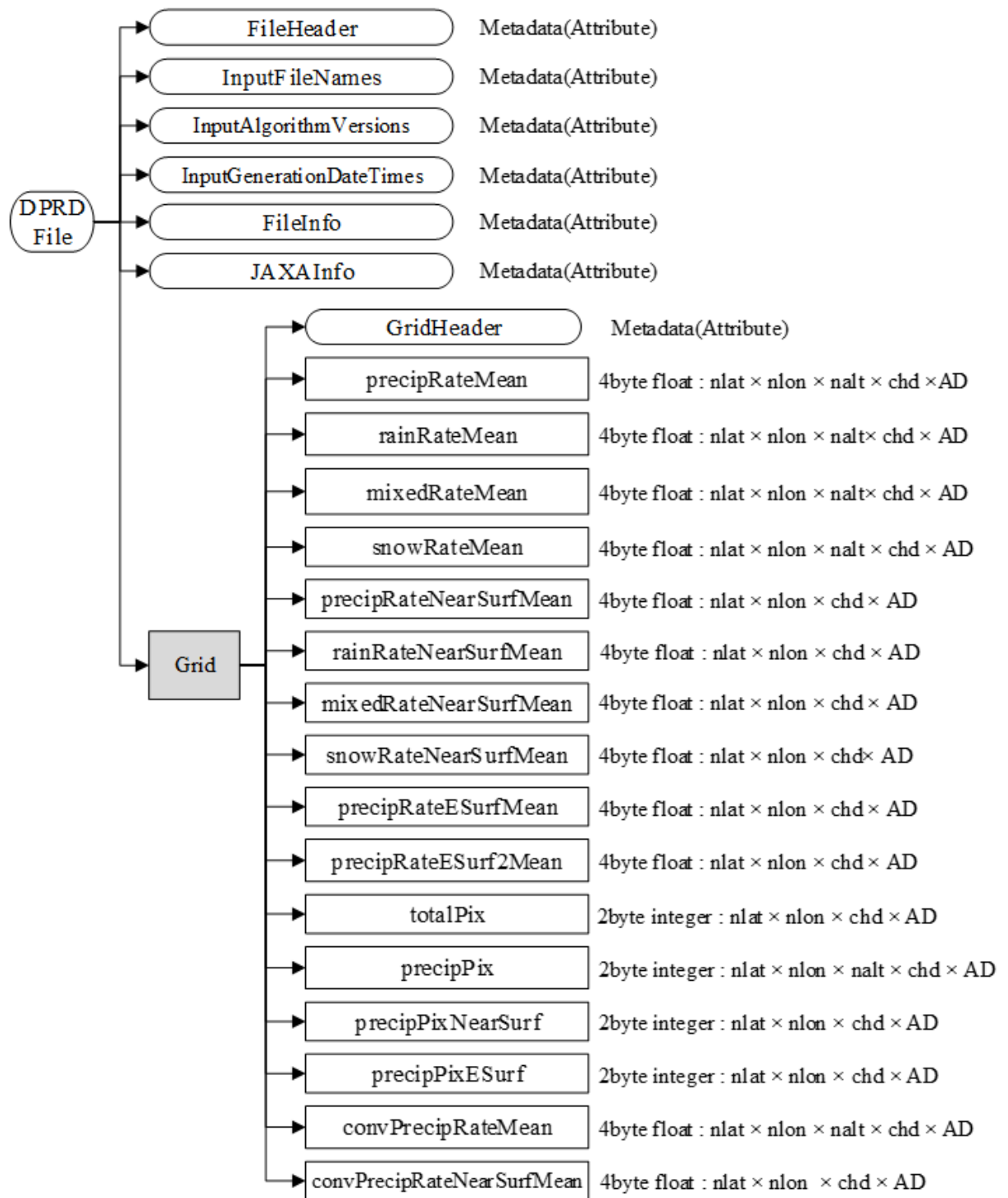
| Grid | Type | Array | Missing Value | Unit |
|------|--------------|-----------------|---------------|------|
| G1 | 4-byte float | ltL * lnL * chn | -9999.9 | |
| G2 | 4-byte float | ltH * lnH * chn | -9999.9 | |

Probability of Rain.

2. Level 3 Data Format Structure (Daily)

2.1. Data Format Structure

3DPRD, “DPR Daily Product”, compute daily statistics of the DPR measurements at a high horizontal resolution ($0.25^\circ \times 0.25^\circ$ latitude/longitude). Details of the data format structure are shown in Figure 2.1-1. This product can be downloaded from JAXA and NASA download site. An additional product, which is not a GPM standard product, is published by NASA download site. It separates ascending (ASC) and descending (DES) products for L3 daily. The data format structure is identical that of 3DPR, DPR Monthly Product (See 1.1).



Continued on next figure

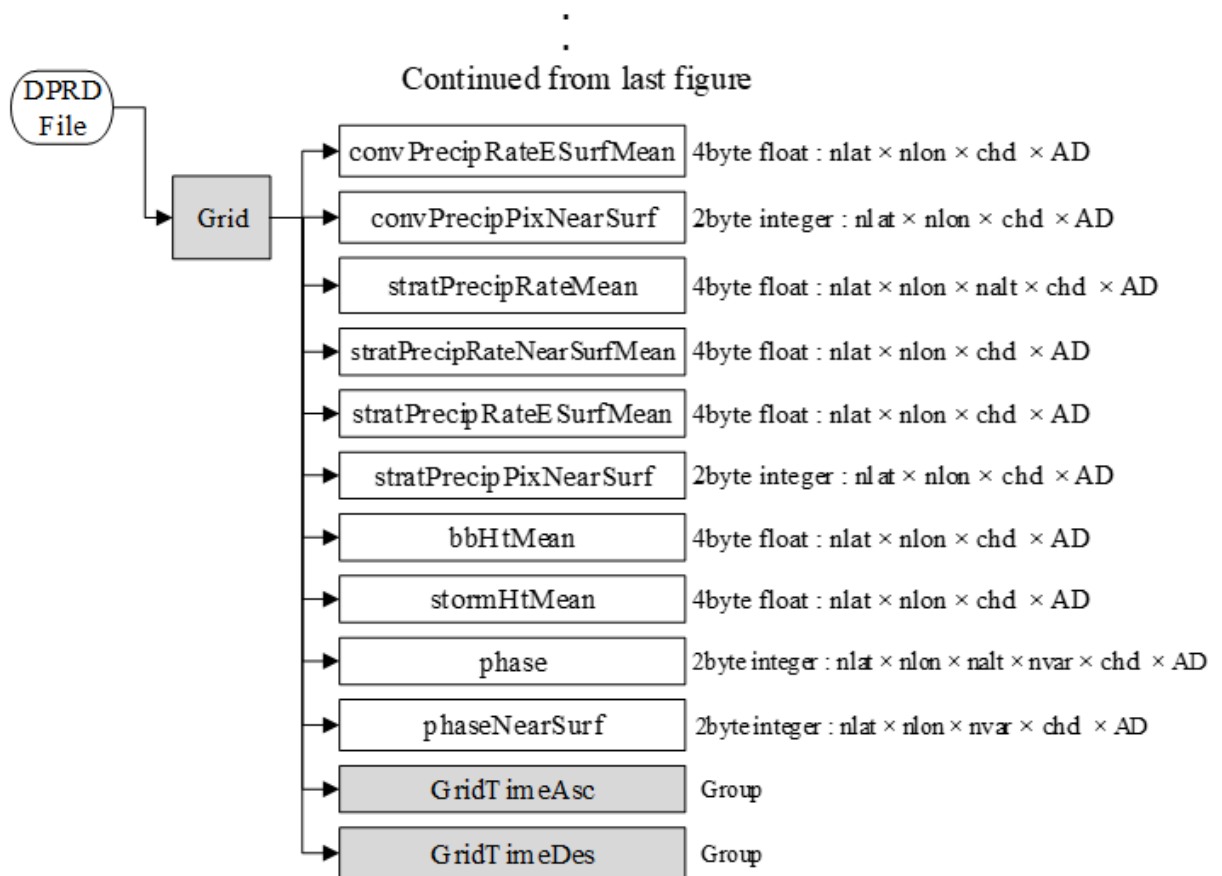


Figure 2.1-1 Data Format Structure for 3DPRD

Dimension definitions:

- nlat
 - 536 Number of high resolution 0.25° grid intervals of latitude from 67°S to 67°N.
- nlon
 - 1440 Number of high resolution 0.25° grid intervals of longitude from 180°W to 180°E.
- nalt
 - 5 Number of heights above the earth ellipsoid: 2km, 4km, 6km, 10km, and 15km.
- nvar
 - 3 Number of phase bins. Bins are counts of phase less than 100, counts of phase greater than or equal to 100 and less than 200, counts of phase greater than or equal to 200.
- chd
 - 2 Number of channels for 3DPRD: KuNS, DPRMS.
- AD
 - 2 Ascending or descending half of the orbit.

2.1. Metadata

See Figure 1.2-1.

2.2. Data Group

2.2.1. precipRateMean

(1) precipRateMean

| Type | Array | Unit |
|--------------|----------------------------------|-------|
| 4-byte float | nlat * nlon * nalt * chd * AD | mm/hr |

Mean Precipitation rate, includes both liquid and solid phases at various height levels.

First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.2. rainRateMean

(1) rainRateMean

| Type | Array | Unit |
|--------------|----------------------------------|-------|
| 4-byte float | nlat * nlon * nalt * chd * AD | mm/hr |

Mean rainfall rate, excludes solid precipitation at various height levels.

First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.3. mixedRateMean

(1) mixedRateMean

| Type | Array | Unit |
|--------------|----------------------------------|-------|
| 4-byte float | nlat * nlon * nalt * chd * AD | mm/hr |

Mean rainfall rate of the mixed phase precipitation at various height levels. First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.4. snowRateMean

(1) snowRateMean

| Type | Array | Unit |
|--------------|----------------------------------|-------|
| 4-byte float | nlat * nlon * nalt * chd * AD | mm/hr |

Mean rainfall rate of solid precipitation at various height levels. First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.5. precipRateNearSurfMean

(1) precipRateNearSurfMean

| Type | Array | Unit |
|--------------|---------------------------|-------|
| 4-byte float | nlat * nlon * chd * AD | mm/hr |

Mean precipitation rate in a grid box using only the Near Surface location along the slant path for each radar ray. First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.6. rainRateNearSurfMean

(1) rainRateNearSurfMean

| Type | Array | Unit |
|--------------|---------------------------|-------|
| 4-byte float | nlat * nlon * chd * AD | mm/hr |

Mean rainfall rate of liquid precipitation in a grid box using only the Near Surface location along the slant path for each radar ray. First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.7. mixedRateNearSurfMean

(1) mixedRateNearSurfMean

| Type | Array | Unit |
|--------------|---------------------------|-------|
| 4-byte float | nlat * nlon * chd * AD | mm/hr |

Mean rainfall rate of mixed phase precipitation in a grid box using only the Near Surface location along the slant path for each radar ray. First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.8. snowRateNearSurfMean

(1) snowRateNearSurfMean

| Type | Array | Unit |
|--------------|---------------------------|-------|
| 4-byte float | nlat * nlon * chd * AD | mm/hr |

Mean rainfall rate of solid precipitation in a grid box using only the Near Surface location along the slant path for each radar ray. First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.9. precipRateESurfMean

(1) precipRateESurfMean

| Type | Array | Unit |
|--------------|---------------------------|-------|
| 4-byte float | nlat * nlon * chd * AD | mm/hr |

Mean precipitation rate in a grid box using only the Estimated Surface location along the slant path for each radar ray. First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.10. precipRateESurf2Mean

(1) precipRateESurf2Mean

| Type | Array | Unit |
|--------------|---------------------------|-------|
| 4-byte float | nlat * nlon * chd * AD | mm/hr |

Mean precipitation rate in a grid box using only the Estimated Surface 2 location along the slant path for each radar ray.

First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.11. totalPix

(1) totalPix

| Type | Array | Unit |
|----------------|---------------------------|------|
| 2-byte integer | nlat * nlon * chd * AD | N/A |

The total number of measurements in each grid box. First index is Ascending node, second index is Descending.

Missing Value :

-9999

2.2.12. precipPix

(1) precipPix

| Type | Array | Unit |
|----------------|----------------------------------|------|
| 2-byte integer | nlat * nlon * nalt * chd * AD | N/A |

The number of measurements in each grid box that included detectable precipitation at various height levels. First index is Ascending node, second index is Descending.

Missing Value :

-9999

2.2.13. precipPixNearSurf

(1) precipPixNearSurf

| Type | Array | Unit |
|----------------|---------------------------|------|
| 2-byte integer | nlat * nlon * chd * AD | N/A |

The number of measurements in a grid box that included detectable precipitation at the Near Surface level. First index is Ascending node, second index is Descending.

Missing Value :

-9999

2.2.14. precipPixESurf

(1) precipPixESurf

| Type | Array | Unit |
|----------------|---------------------------|------|
| 2-byte integer | nlat * nlon * chd * AD | N/A |

The number of measurements in a grid box that included detectable precipitation at the Estimated Surface level. First index is Ascending node, second index is Descending.

Missing Value :

-9999

2.2.15. convPrecipRateMean

(1) convPrecipRateMean

| Type | Array | Unit |
|--------------|----------------------------------|-------|
| 4-byte float | nlat * nlon * nalt * chd * AD | mm/hr |

The mean precipitation rate of convective type at various height levels. First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.16. convPrecipRateNearSurfMean

(1) convPrecipRateNearSurfMean

| Type | Array | Unit |
|--------------|---------------------------|-------|
| 4-byte float | nlat * nlon * chd * AD | mm/hr |

The mean precipitation rate of convective type at the Near Surface level along the radar ray. First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.17. convPrecipRateESurfMean

(1) convPrecipRateESurfMean

| Type | Array | Unit |
|--------------|---------------------------|-------|
| 4-byte float | nlat * nlon * chd * AD | mm/hr |

The mean precipitation rate of convective type at the Estimated Surface level along the radar ray. First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.18. convPrecipPixNearSurf

(1) convPrecipPixNearSurf

| Type | Array | Unit |
|----------------|---------------------------|------|
| 2-byte integer | nlat * nlon * chd * AD | N/A |

The number of convective precipitation measurements in a grid box at the Near Surface level. First index is Ascending node, second index is Descending.

Missing Value :

-9999

2.2.19. stratPrecipRateMean

(1) stratPrecipRateMean

| Type | Array | Unit |
|--------------|----------------------------------|-------|
| 4-byte float | nlat * nlon * chd * nalt * AD | mm/hr |

The mean precipitation rate of stratiform type at various height levels. First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.20. stratPrecipRateNearSurfMean

(1) stratPrecipRateNearSurfMean

| Type | Array | Unit |
|--------------|---------------------------|-------|
| 4-byte float | nlat * nlon * chd * AD | mm/hr |

The mean precipitation rate of stratiform type at the Near Surface level along the radar ray. First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.21. stratPrecipRateESurfMean

(1) stratPrecipRateESurfMean

| Type | Array | Unit |
|--------------|---------------------------|-------|
| 4-byte float | nlat * nlon * chd * AD | mm/hr |

The mean precipitation rate of stratiform type at the Estimated Surface level along the radar ray. First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.22. stratPrecipPixNearSurf

(1) stratPrecipPixNearSurf

| Type | Array | Unit |
|----------------|---------------------------|------|
| 2-byte integer | nlat * nlon * chd * AD | N/A |

The number of stratiform precipitation measurements in a grid box at the Near Surface level. First index is Ascending node, second index is Descending.

Missing Value :

-9999

2.2.23. bbHtMean

(1) bbHtMean

| Type | Array | Unit |
|--------------|---------------------------|------|
| 4-byte float | nlat * nlon * chd * AD | m |

The mean bright band height in a grid box. First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.24. stormHtMean

(1) stormHtMean

| Type | Array | Unit |
|--------------|---------------------------|------|
| 4-byte float | nlat * nlon * chd * AD | m |

The mean storm height in a grid box. First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.25. phase

(1) phase

| Type | Array | Unit |
|----------------|--------------------|------|
| 2-byte integer | nlat * nlon * nalt | N/A |

| Type | Array | Unit |
|------|----------------------|------|
| | * nvar * chd * AD | |

The precipitation phase type in a grid box a various heights. First index is Ascending node, second index is Descending.

Missing Value :

-9999.9

2.2.26. phaseNearSurf

(1) phaseNearSurf

| Type | Array | Unit |
|----------------|----------------------------------|------|
| 2-byte integer | nlat * nlon * nvar * chd * AD | N/A |

The precipitation phase type in a grid box. First index is Ascending node, second index is Descending.

Missing Value :

-9999

2.2.27. GridTimeAsc (Group)

(1) Year

| Type | Array | Unit |
|----------------|-------------|------|
| 2-byte integer | nlat * nlon | year |

4-digit year, e.g., 1998. Values range from 1950 to 2100 years.

Missing Value :

-9999

(2) Month

| Type | Array | Unit |
|----------------|-------------|-------|
| 1-byte integer | nlat * nlon | month |

Month of the year. Values range from 1 to 12 months.

Missing Value :

-99

(3) DayOfMonth

| Type | Array | Unit |
|----------------|-------------|------|
| 1-byte integer | nlat * nlon | day |

Day of the month. Values range from 1 to 31 days.

Missing Value :

-99

(4) Hour

| Type | Array | Unit |
|----------------|-------------|------|
| 1-byte integer | nlat * nlon | hour |

UTC hour of the day. Values range from 0 to 23 hours.

Missing Value :

-99

(5) Minute

| Type | Array | Unit |
|----------------|-------------|--------|
| 1-byte integer | nlat * nlon | minute |

Minute of the hour. Values range from 0 to 59 minutes.

Missing Value :

-99

(6) Second

| Type | Array | Unit |
|----------------|-------------|------|
| 1-byte integer | nlat * nlon | s |

Second of the minute. Values range from 0 to 60 s.

Missing Value :

-99

(7) MilliSecond

| Type | Array | Unit |
|----------------|-------------|------|
| 2-byte integer | nlat * nlon | ms |

Thousandths of the second. Values range from 0 to 999 ms.

Missing Value :

-9999

(8) DayOfYear

| Type | Array | Unit |
|----------------|-------------|------|
| 2-byte integer | nlat * nlon | day |

Day of the year. Values range from 1 to 366 days.

Missing Value :

-9999

2.2.28. GridTimeDes (Group)

(1) Year

| Type | Array | Unit |
|----------------|-------------|------|
| 2-byte integer | nlat * nlon | year |

4-digit year, e.g., 1998. Values range from 1950 to 2100 years.

Missing Value :

-9999

(2) Month

| Type | Array | Unit |
|----------------|-------------|-------|
| 1-byte integer | nlat * nlon | Month |

Month of the year. Values range from 1 to 12 months.

Missing Value :

-99

(3) DayOfMonth

| Type | Array | Unit |
|----------------|-------------|------|
| 1-byte integer | nlat * nlon | day |

Day of the month. Values range from 1 to 31 days.

Missing Value :

-99

(4) Hour

| Type | Array | Unit |
|----------------|-------------|------|
| 1-byte integer | nlat * nlon | hour |

UTC hour of the day. Values range from 0 to 23 hours.

Missing Value :

-99

(5) Minute

| Type | Array | Unit |
|----------------|-------------|--------|
| 1-byte integer | nlat * nlon | minute |

Minute of the hour. Values range from 0 to 59 minutes.

Missing Value :

-99

(6) Second

| Type | Array | Unit |
|----------------|-------------|------|
| 1-byte integer | nlat * nlon | s |

Second of the minute. Values range from 0 to 60 s.

Missing Value :

-99

(7) MilliSecond

| Type | Array | Unit |
|----------------|-------------|------|
| 2-byte integer | nlat * nlon | ms |

Thousandths of the second. Values range from 0 to 999 ms.

Missing Value :

-9999

(8) DayOfYear

| Type | Array | Unit |
|----------------|-------------|------|
| 2-byte integer | nlat * nlon | day |

Day of the year. Values range from 1 to 366 days.

Missing Value :

-9999

3. Level 3 (Text) Data Format

3.1. Record Structure for Level 3 (Text) data

The level 3(Text) data are stored away with the record structure such as the table below by a text file.

Table 3.1-1 Record structure of level 3 (Text) data

| | |
|-----------------|----------|
| Header (1 line) | Record 1 |
| Data (N lines) | Record 1 |
| | Record 2 |
| | ... |
| | ... |
| | Record N |

3.2. Header Structure for Level 3 (Text) data

The header structure for level 3 (Text) contains like the table below in one line.

Table 3.2-1 Header Structure of level 3 (Text) data

| No. | Item | Contents |
|-----|------------------------------------|--|
| 1 | Longitude | “Lon” Fixed string |
| 2 | Separator | “, ”(one comma + single-byte spaces). Applies to all separators below. |
| 3 | Latitude | “Lat” Fixed string |
| 4 | Separator | |
| 5 | Precipitation intensity of surface | “precip” Fixed string |
| 6 | Separator | |
| 7 | Hour | “H” Fixed string |
| 8 | Separator | |
| 9 | Minute | “M” Fixed string |
| 10 | Separator | |
| 11 | A/D flag | “A_or_D” Fixed string |
| 12 | Line break | 0x0A |

3.3. Data Structure for Level 3 (Text) data

The data structure for level 3 (Text) contains like the table below in N line.

Table 3.3-1 Data structure of level 3 (Text) data

| No. | Item | Contents |
|-----|------------------------------------|---|
| 1 | Longitude | NNN.NN Arbitrary real number of 2 decimal places Unit: degree |
| 2 | Separator | ","(one comma). Applies to all separators below. |
| 3 | Latitude | (-)NN.NN Arbitrary real number of 2 decimal places Unit: degree |
| 4 | Separator | |
| 5 | Precipitation intensity of surface | NNN.NN Arbitrary real number of 2 decimal places Unit: mm/hr |
| 6 | Separator | |
| 7 | Hour | HH Arbitrary integer(00-23) Unit: Hour(UTC) |
| 8 | Separator | |
| 9 | Minute | MM Arbitrary integer(00-59) Unit: Minute(UTC) |
| 10 | Separator | |
| 13 | A/D flag | X "A" or "D" (A=Ascending D=Descending) |
| 14 | Line break | 0x0A |
