Spectral Latent Heating (SLH) for GPM

Algorithm Theoretical Basis Document (ATBD)

Algorithm Ver.7

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1. General Summary for Spectral Latent Heating (SLH)

Convective latent heating plays essential roles for tropical convection, generating mesoscale circulations (e.g. Houze et al. 1989). Moreover, vertical profiles of diabatic heating, in which convective latent heating contributes largely, affects the general circulation of the atmosphere (e.g. Hartmann et al. 1984). For mid-latitude systems also, latent heating contributes to generations of PVs resulting in, for example, explosive intensifications of mid-lattitude storms (Boettcher and Wernli, 2011).

Previously, with TRMM PR, we developed SLH latent heating algorithm (Shige, Takayabu et al. 2004, 2007, etc) for tropical and subtropical TRMM observation region (35N-35S). With GPM DPR, the observation region extended to 65N-65S. Now we are to modify our latent heating retrieval algorithm (SLH) to be applicable from the tropics to mid-latitudes.

For GPM SLH algorithm, we retrieve latent heating variables utilizing two separate algorithms for tropics and for mid-latitudes. First, location of each GPM KuPR pixel is assigned to either tropics or mid-latitudes, depending on monthly maps of precipitation types determined in a similar manner as described in Takayabu (2008). Then, we retrieve three dimensional convective latent heating, Q1-QR (Q1R), and Q2, applying either tropical/mid-latitude algorithms to precipitation data observed from GPM DPR (KuPR). Here, Q1 and Q2 are apparent heat source and apparent moisture sink, respectively, introduced by Yanai et al. (1973), and QR is radiative heating of the atmosphere. In following subsections, we briefly describe the Spectral Latent Heating (SLH) algorithms for tropics and for mid-latitude precipitation.

1.1. Retrieval for the Tropics

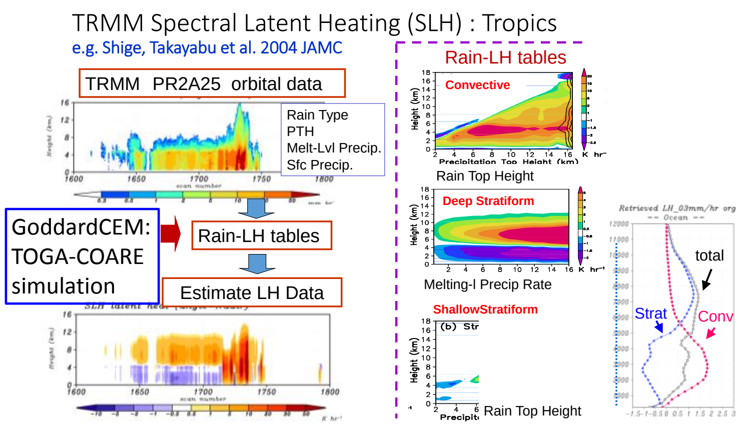

Fig.1: Summary of the SLH for tropics.

With the TRMM PR, we first developed the spectral latent heating (SLH) algorithm for the tropics as summarized in Fig.1, in a following manner. First, utilizing the Goddard Cumulus Ensemble Model, we simulated the TOGA-COARE precipitation, from which we made three spectral look-up tables (LUTs) of latent heating profiles in terms of precipitation top height (PTH) for convective and shallow stratiform rain, melting level precipitation rate (MLP) for deep stratiform rain. Utilizing TRMM PR precipitation profiles and these tables, we estimated the latent heating associated with the precipitation. Please refer to Shige et al. (2004, 2007, 2008, and 2009) for details.

Deep stratiform rain is now further divided into two new categories: deep stratiform with decreasing precipitation from the melting level toward the surface and deep stratiform with increasing precipitation from the melting level toward the surface. The SLH algorithm computes deep stratiform cooling magnitudes as a function of the precipitation rate at the melting level (Pm) – the precipitation rate at near surface (Pnsfc), assuming the evaporative cooling rate below the melting level in deep stratiform regions is proportional to the reduction in the precipitation profile toward the surface from the melting level (based on 1D water substance conservation). However, increasing precipitation profiles are found in some portions of stratiform regions, especially in regions adjacent to convective regions where 1D water substance conservation may be invalid. An LUT for deep stratiform with increasing precipitation toward the surface from the melting level (called "intermediate") is produced with the amplitude determined by Pnsfc.

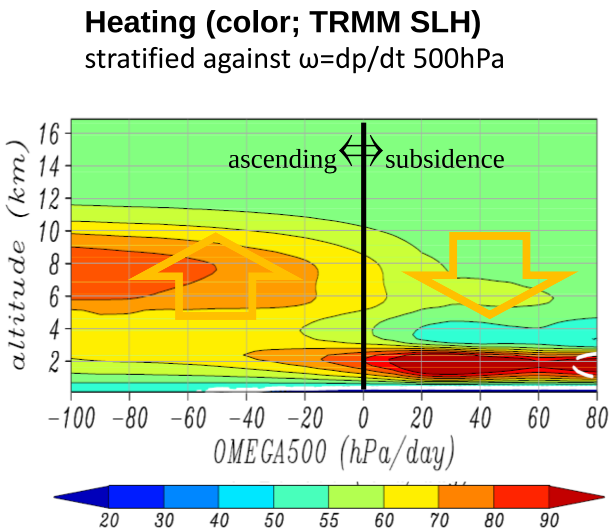

Fig.2: SLH-estimated Q1-QR profiles in 30N-30S at all longitudes over oceans, stratified with pressure velocity at 500hPa. Congestus regime is found in the large-scale subsidence region with Q1R peak at around 2km.

Utilizing these TRMM SLH, we found an existence of clear congestus regime with relatively high sea surface temperature with suppressed deep convection associated with large-scale atmospheric subsidence (Fig. 2). It was connected to solve the double ITCZ problem that climate model developers have long been plagued (Hirota et al. 2011).

1.2. Retrieval for mid latitudes

For mid-latitude systems, we employ the Japan Meteorological Agency (JMA)'s high resolution (horizontally 2km) local forecast model (LFM) to construct the LUTs. With collaborations of JMA's forecast group, 3hr and 4hr forecast data for 8 extratropical cyclone cases (16 shots) are collected and utilized for LUTs.

In treating mid-latitude systems, in contrast to the tropical systems, we first faced a "cloud base problem". In a tropical Mesoscale Convective System (MCS), we basically assume that freezing level coincides with its cloud base level for its stratiform precipitation area. For mid latitude stratiform precipitation, however, this assumption does not hold.

LH is closely related to various phase changes of water. Figure 3 shows the LH profiles associated with various phase change processes. Left panel is an example, where cloud base is below freezing level, melting and condensation occur at similar levels, and they cancel each other. While, when cloud base is above the freezing level, evapolation and melting occur together and result in a large cooling. So, we really need cloud base level information. But we only observe radar reflectivity profiles for precipitation with GPM DPR. Here, we tried to obtain the cloud base information from the precipitation profiles.

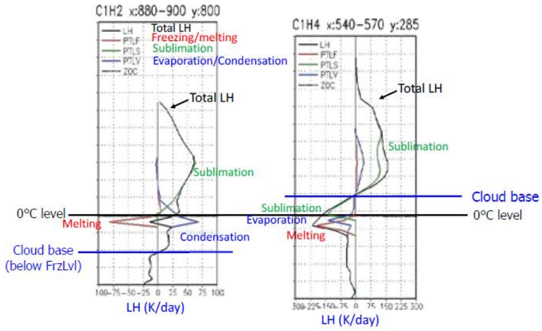

Fig.3: Latent heating associated with cloud processes for cloud base level below the freezing level case (left) and cloud base level above the freezing level (right).

Since precipitation should evaporate out of the cloud base, we may expect that precipitation maximum level (Pmax) can represent the cloud base. Figure 4 scatter the precipitation maximum heights against cloud base heights for stratiform precipitation: Downward Decreasing (DD) precipitation from the 0degC level, Downward Increasing (DI) precipitation, and others.

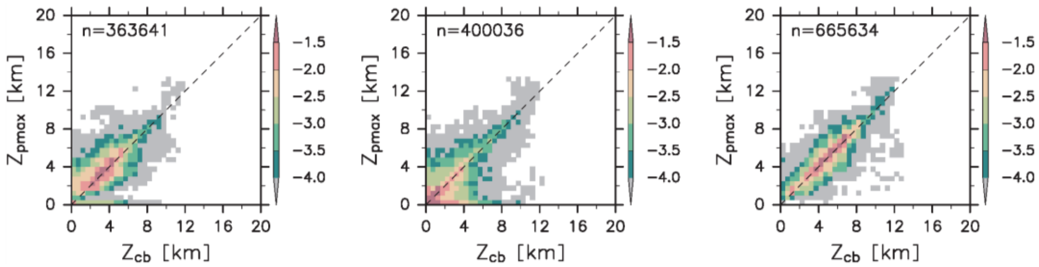

Fig. 4: Scatter histograms between cloud base levels (Zcb) and maximum precipitation heights (Zpmax). For DD, DI and other stratiform precipitation.

Finally, 6 tables, convective, shallow stratiform, 3 types of deep stratiform, and other were constructed for LH, Q1R, and Q2, respectively. Figure 5 shows the look up tables for LH. Convective and shallow stratiform tables are made against the precipitation top heights. Ordinate is the altitudes, and color shades are LH profiles for each bin. For deep stratiform and other precipitation, LUT are made against maximum precipitation (Pmax) chosen for the abscissa. In these LUTs, ordinate is the standardized altitude with zero at the Pmax level, and +1.0 and -1.0 correspond to PTH and the precipitation bottom height (PBH), respectively.

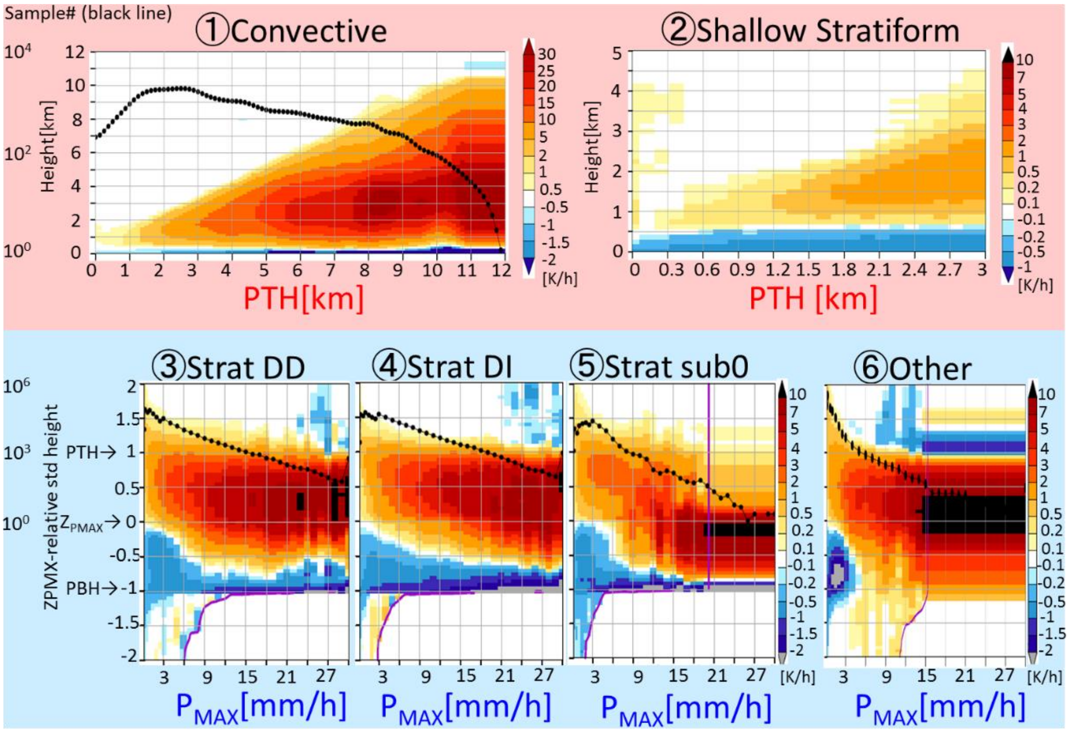

Fig.5: LUTs constructed from 8 extratropical cyclone cases simulated by JMA LFM. See text for details.

Utilizing the 6 LUTs and precipitation profile data from GPM 2AKu, LH is retrieved. Precipitation type (convective/ stratiform/ other), PTH, PBH, Pmax, and Pnsfc are utilized for input.

In order to see the performance of the retrieval, we first performed a consistency check. We compared LH retrieved from model precipitation and Model simulated LH along the red line of Fig. 6. Results are shown in Fig. 7. Left panels show the cross sections for precipitation, simulated LH and retrieved LH from top to bottom. We can confirm that retrieved LH looks very similar to simulated LH. Right panel show the averaged profiles for simulated LH in black and retrieved LH in red curves. Examining each sections separately (Fig. 8), we can confirm successful reconstruction of LH by this algorithm.

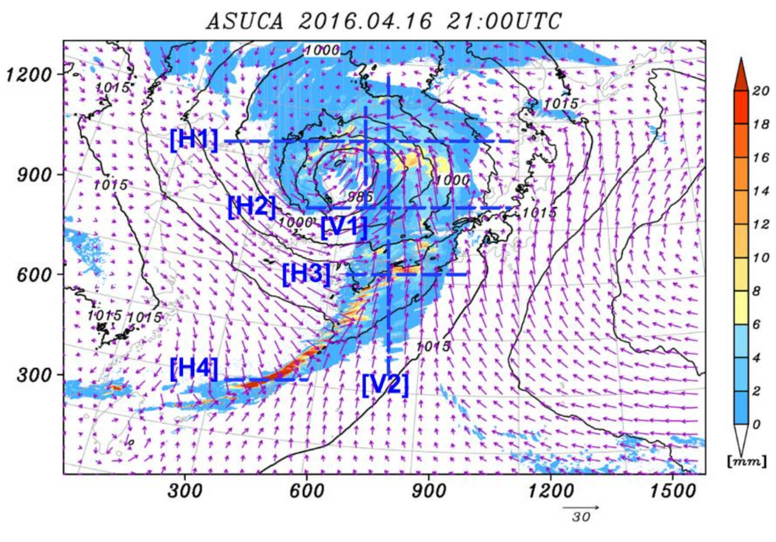

Fig. 6: LFM-simulated precipitation for extratropical cyclone case 1.

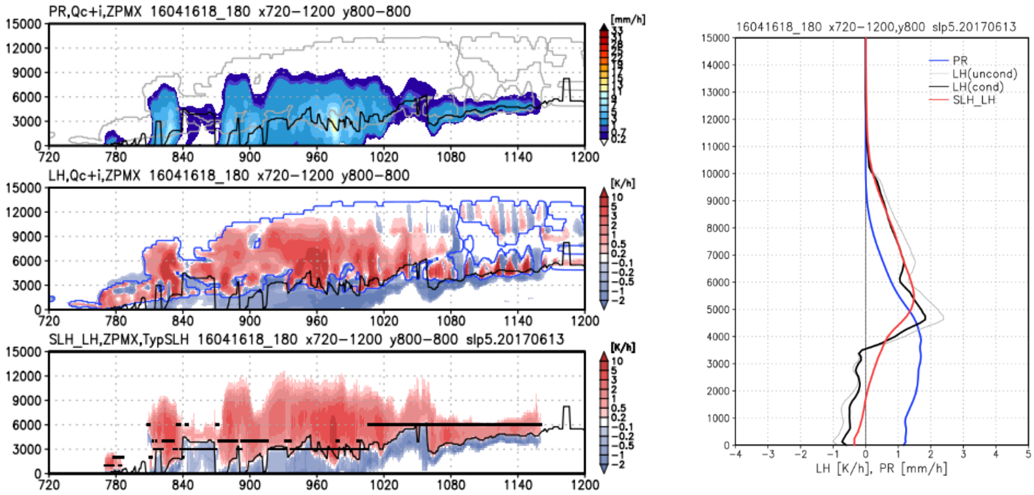

Fig. 7: Left: Precipitation, simulated LH, and SLH-retrieved LH using simulated precipitation, from top to bottom, respectively. Right: Averaged (in x-dir) profiles of precipitation (blue), simulated LH (black) and retrieved LH (red).

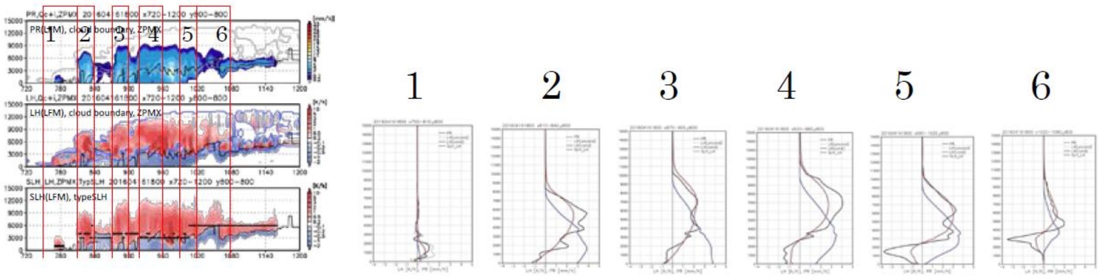

Fig. 8: Same as Fig.5 but the profiles are averaged for separate parts of the system numbered 1-6.

Finally, GPM KuPR is utilized for the retrieval. The left panels show precipitation and precipitation types from GPM KuPR. Note that there is no guarantee that the simulation corresponds well to the observation along a satellite orbit. But it seems to be a marvelous simulation (Fig.9).

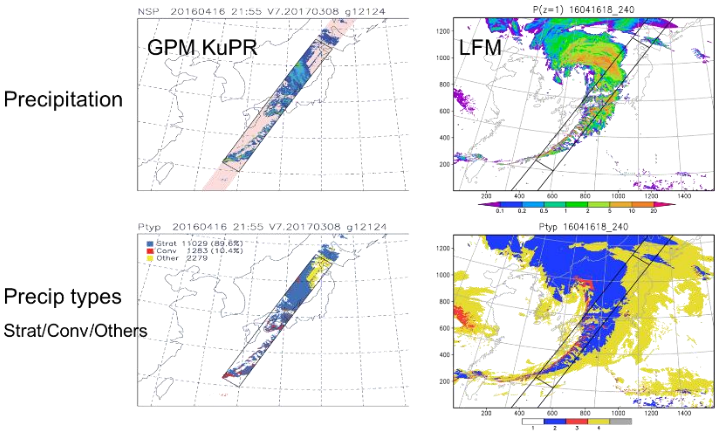

Fig. 9: Upper panels: GPM-observed precipitation and LFM-simulated precipitation at 18z 16Apr, 2016 (4hrF). Lower panels: Precipitation types

Figure 10 compare simulated and retrieved LH along the GPM orbit. Left panels are LFM-simulated precipitation and LH, middle are LFM precipitation and retrieved LH from LFM precipitation, Right panels show GPM-precipitation and retrieved LH. Precipitation simulation is very good, so we can compare these cross sections. The retrieval looks quite successful.

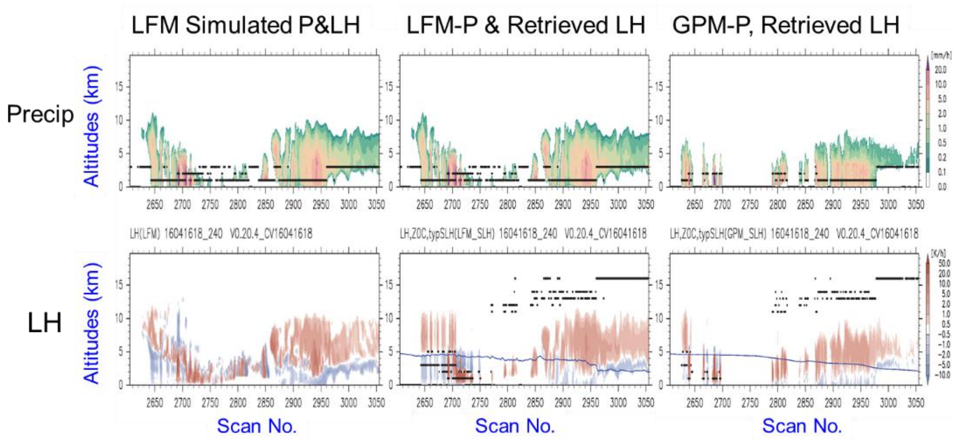

Fig. 10: Simulated and (LFM- & GPM-) retrieved LH along the GPM orbit shown in Fig. 9.

Finally average profiles of LH are compared for eight cases (Fig. 11). Red dashed are GPM retrieved profiles and Black is LFM-simulated LH, for total, convective, stratiform, and others. They are surprisingly consistent. Excellent correspondences are confirmed for cases with reasonable precipitation coverages (cases 1, 3, 5, 6, 8) in the evaluation regions of GPM swaths.

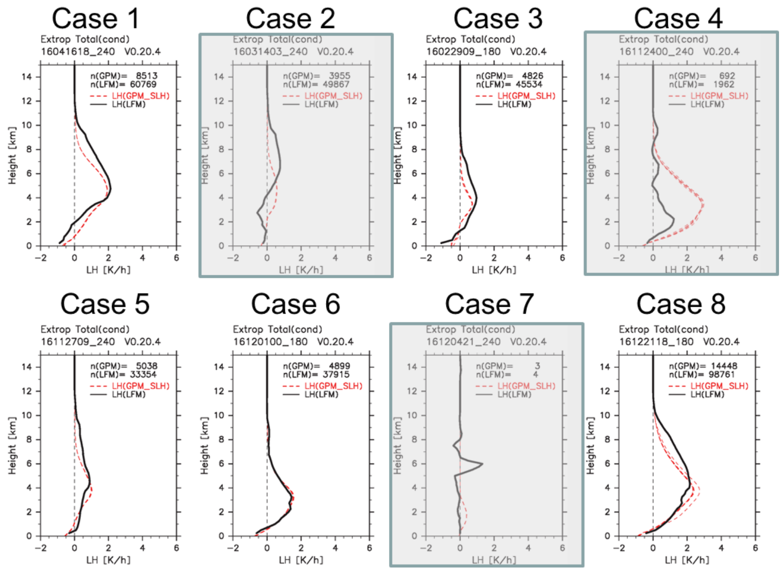

Fig. 11: Evaluations of GPM-retrieved LH for 8 cases. Red dotted curves represent retrieved GPM LH, and black curves are for simulated LH. Cases with mid-lat precipitation coverage are inefficient for evaluations are covered with gray shades.

We also confirmed a good continuities of LH distributions between tropics and midlatitudes in horizontal maps (Fig. 12) as well as in zonal mean vertical structure.

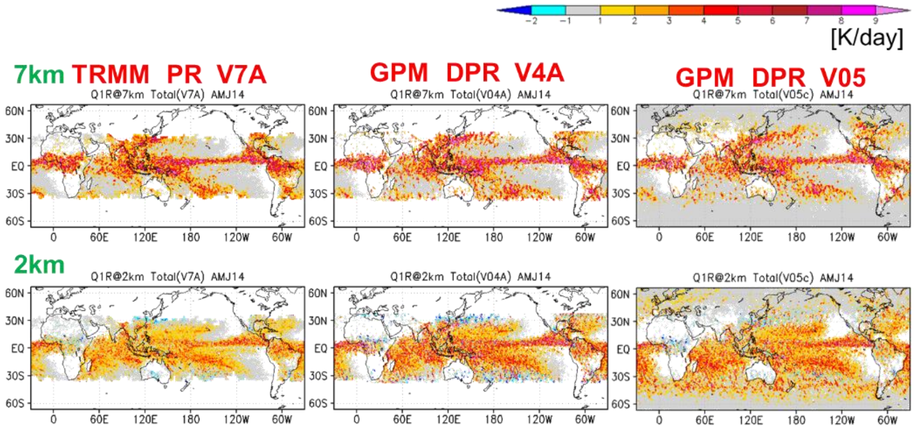

Fig. 12: Horizontal distributions of LH derived with GPM SLH V5 algorithm.

To summarize, we developed a new Spectral LH algorithm for mid-latitude precipitation, utilizing 8 extratropical cyclone cases simulated with JMA LFM. To this end, cloud Base vs Freezing Level relationship was an issue, for we utilize precipitation profiles observed from the GPM KuPR.

We found that precipitation maximum height can well represent the cloud base height. Six LUTs were constructed to retrieve LH from GPM KuPR. This new algorithm performed successfully: Consistency check and retrieval results were quite satisfactory.

2. INPUT DATA

GPM-SLH level-2 algorithm uses 2AKu product as input. Followings are summary of KuPR onboard the GPM core observatory. L2 algorithm also uses a precipitation regime database as an auxiliary data. GPM-SLH level-3 algorithms use SLP product as input.

Table 1 Major specification of GPM KuPR

Satellite	Height (km)	Instrument	frequency (GHz)	Data Period	Data Provider
GPM Core Observatory	407	KuPR	13.6	March 2014–present	

2.1. L2 product (SLP)

2.1.1. Input variables from 2AKu

scanStatus/dataQuality

scanTime

Latitude

Longitude

PRE/binClutterFreeBottom
PRE/binRealSurface
PRE/flagPrecip
PRE/landSurfaceType
PRE/localZenithAngle
VER/heightZeroDeg
CSF/typePrecip
SLV/binEchoBottom
SLV/precipRate
SLV/zFactorCorrected

2.2. L3 products (SLG)

2.2.1. Input variables from SLP

Swath/Latitude
Swath/Longitude
Swath/Q1minusQR
Swath/Q2
Swath/ScanTime/DayOfMonth
Swath/ScanTime/DayOfYear
Swath/ScanTime/Hour
Swath/ScanTime/MilliSecond
Swath/ScanTime/Minute
Swath/ScanTime/Month
Swath/ScanTime/Second
Swath/ScanTime/Year
Swath/latentHeating
Swath/rainTypeSLH

2.3. L3 products (SLD)

2.3.1. Input variables from SLP

Swath/Latitude
Swath/Longitude
Swath/Q1minusQR
Swath/Q2
Swath/ScanTime/Month
Swath/ScanTime/Year
Swath/latentHeating
Swath/rainTypeSLH

2.4. L3 products (SLM)

2.4.1. Input variables from SLD

Grid/LHDev

Grid/LHMean

Grid/Q1RDev

Grid/Q1RMean

Grid/Q2Dev

Grid/Q2Mean

Grid/allPix

Grid/convLHDev

Grid/convLHMean

Grid/convPix

Grid/convQ1RDev

Grid/convQ1RMean

Grid/convQ2Dev

Grid/convQ2Mean

Grid/otherLHDev

Grid/otherLHMean

Grid/otherPix

Grid/otherQ1RDev

Grid/otherQ1RMean

Grid/otherQ2Dev

Grid/otherQ2Mean

Grid/shallowLHDev

Grid/shallowLHMean

Grid/shallowPix

Grid/shallowQ1RDev

Grid/shallowQ1RMean

Grid/shallowQ2Dev

Grid/shallowQ2Mean

Grid/stratLHDev

Grid/stratLHMean

Grid/stratPix

Grid/stratQ1RDev

Grid/stratQ1RMean

Grid/stratQ2Dev

Grid/stratQ2Mean

3. OUTPUT DATA

As mentioned in previous section, we provides SLP, SLG, SLD, and SLM. Table 2 shows the brief description for them. Detail is explained in following subsections.

Table 2. Description for GPM SLH products

<table>
<tr><th>Products</th><th>Level</th><th>Descriptions</th><th>Temporal resolution</th><th>Horizontal resolution</th><th>Vertical resolution</th><th>Coverage</th><th>Output format</th></tr>
<tr><td>SLP</td><td>L2</td><td>Basic orbital SLH.</td><td>-</td><td>5km</td><td rowspan="4">80 layers*</td><td>-</td><td rowspan="4">HDF5 formats</td></tr>
<tr><td>SLG</td><td rowspan="3">L3</td><td>Gridded orbital SLH.</td><td>path</td><td rowspan="3">0.5-degree latitude/longitude grid.</td><td rowspan="3">180°W to 180°E/, 67°S to 67°N.</td></tr>
<tr><td>SLD</td><td>Daily averaged SLH</td><td>daily</td></tr>
<tr><td>SLM</td><td>Monthly averaged SLH</td><td>monthly</td></tr>
</table>

* at the fixed height of 0.00-0.25 km, 0.25-0.50 km0.0-0.5km, 0.5-1.0km, ..., 19.50-19.75 km, and 19.75-20.00 km.

3.1. L2 product (SLP)

3.1.1. Output Dimension Definition

- nscan
  - var Number of scans in the granule.
- nray
  - 49 Number of angle bins in each scan
- nlayer
  - 80 Number of layers at the fixed height of 0.00-0.25 km, 0.25-0.50 km, ..., 19.50-19.75 km, and 19.75-20.00 km.

3.1.2. Output variables

ScanTime/Year (2-byte integer, size: nscan)

4-digit year. Missing value is −9999.

ScanTime/Month (1-byte integer, size: nscan)

Month of the year. Missing value is −9999.

ScanTime/DayOfMonth (1-byte integer, size: nscan)

Day of the month. Missing value is −9999.

ScanTime/Hour (1-byte integer, size: nscan)

UTC hour of the day. Missing value is −9999.

ScanTime/Minute (1-byte integer, size: nscan)

Minute of the hour. Missing value is −9999.

ScanTime/Second (1-byte integer, size: nscan)

Second of the minute. Missing value is −9999.

ScanTime/MilliSecond (2-byte integer, size: nscan)

Thousandths of the second. Missing value is −9999.

ScanTime/DayOfYear (2-byte integer, size: nscan)

Day of the year. Missing value is −9999.

ScanTime/SecondOfDay (4-byte float, size: nscan)

Second of the day. Missing value is −9999.

Latitude (4-byte float, size: nray x nscan)

Latitude of the pixel center. Positive north, negative south. Missing value is −9999.9.

Longitude (4-byte float, size: nray x nscan)

Longitude of the pixel center. Positive east, negative west. Missing value is −9999.9.

latentHeating (4-byte float, size: nlayer x nray x nscan)

Latent heating. Unit is [K/h]. Missing value is −9999.9.

Q1minusQR (4-byte float, size: nlayer x nray x nscan)

Apparent heat source minus radiative heating rate; $Q_1 - Q_R$. Unit is [K/h]. Missing value is −9999.9.

Q2 (4-byte float, size: nlayer x nray x nscan)

Apparent moisture sink Q_2. Unit is [K/h]. Missing value is −9999.9.

rainTypeSLH (2-byte integer, size: nray x nscan)

Precipitation type decided by SLH algorithm. The values are listed below. Values 1–6 are tropical types, and values 110–160 are midlatitude types. For no precipitation or Masked out pixels (rainTypeSLH=0, 900, or 910), SLH values are not estimated.

Table 3. Description for rainTypeSLH

(a) Tropics and subtropics	**(b) Mid and higher latitudes**
0: No precipitation	0: No precipitation
1: Convective	110: Convective
2: Shallow stratiform	121: Shallow stratiform
3: Deep stratiform	122: Deep stratiform, downward decreasing
4: Deep stratiform with low melting level	123: Deep stratiform, downward increasing
5: Intermediary	124: Deep stratiform, subzero
6: Other	160: Other
Mask	
900: Tibet, winter mid-lat etc.	
910: Suspicious extreme	

rainType2ADPR (2-byte integer, size: nray x nscan)

Precipitation type copied from 2AKu. Missing value is −9999.

method (2-byte integer, size: nray x nscan)

Method copied from 2AKu. Missing value is −9999.

stormTopHeight (2-byte integer, size: nray x nscan)

For tropical types, height of storm top. For midlatitude types, precipitation-top height of the lowest precipitation layer. Unit is [m]. Missing value is −9999.

meltLayerHeight (2-byte integer, size: nray x nscan)

For tropical types, height of melting layer. All missing for midlatitude types. Unit is [m]. Missing value is −9999.

nearSurfLevel (2-byte integer, size: nray x nscan)

For tropical types, height of the near-surface level. For midlatitude types, precipitation-bottom height of the lowest precipitation layer. Unit is [m]. Missing value is −9999.

topoLevel (2-byte integer, size: nray x nscan)

Height of topography. Unit is [m]. Missing value is −9999.

climMeltLevel (2-byte integer, size: nray x nscan)

Climatological melting level. Unit is [m]. Missing value is −9999.

climFreezLevel (2-byte integer, size: nray x nscan)

For tropical types, climatological freezing level. All missing for midlatitude types. Unit is [m]. Missing value is −9999.

nearSurfPrecipRate (4-byte float, size: nray x nscan)

For tropical types, precipitation rate at the near-surface level. For midlatitude types, precipitation rate at the bottom level of the lowest precipitation layer. Unit is [mm/h]. Missing value is −9999.9.

precipRateMeltLevel (4-byte float, size: nray x nscan)

For tropical types, precipitation rate at the melting level. All missing for midlatitude types. Unit is [mm/h]. Missing value is −9999.9.

precipRateClimFreezLevel (4-byte float, size: nray x nscan)

For tropical types, precipitation rate at the freezing level. All missing for midlatitude types. Unit is [mm/h]. Missing value is −9999.9.

3.2. L3 products (SLG)

3.2.1. Output Dimension Definition

- nlat
  - 268 number of high resolution 0.5° grid intervals of latitude from 67°S to 67°N.
- nlon
  - 720 number of high resolution 0.5° grid intervals of longitude from 180°W to 180°E.
- nlayer
  - 80 number of layers at the fixed heights of 0.00-0.25 km, 0.25-0.50 km, ..., 19.50-19.75 km, and 19.75-20.00 km.

3.2.2. Output variables

GridTime/Year (2-byte integer, size: nscan)
 4-digit year. Missing value is -9999.

GridTime/Month (1-byte integer, size: nscan)
 Month of the year. Missing value is -99.

GridTime/DayOfMonth (1-byte integer, size: nscan)
 Day of the month. Missing value is -99.

GridTime/Hour (1-byte integer, size: nscan)
 UTC hour of the day. Missing value is -99.

GridTime/Minute (1-byte integer, size: nscan)
 Minute of the hour. Missing value is -99.

GridTime/Second (1-byte integer, size: nscan)
 Second of the minute. Missing value is -99.

GridTime/MilliSecond (2-byte integer, size: nscan)
 Thousandths of the second. Missing value is -9999.

GridTime/DayOfYear (2-byte integer, size: nscan)
 Day of the year. Missing value is -9999.

allLHMean (4-byte float, size: nlat x nlon x nlayer)
 All Conditional mean of latent heating . Unit is [K/h]. Missing value is -9999.9.

allPix (2-byte integer, size: nlat x nlon x nlayer)
 All (conditional) pixel counts. Missing value is -9999.9.

allQ1RMean (4-byte float, size: nlat x nlon x nlayer)
 All Conditional mean of Q_1-Q_R. Unit is [K/h]. Missing value is -9999.9.

allQ2Mean (4-byte float, size: nlat x nlon x nlayer)
 All Conditional mean of Q_2. Unit is [K/h]. Missing value is -9999.9.

convLHMean (4-byte float, size: nlat x nlon x nlayer)
 Conditional mean of convective latent heating. Unit is [K/h]. Missing value is -9999.9.

convPix (2-byte integer, size: nlat x nlon x nlayer)
 Convective pixel counts. Missing value is -9999.9.

convQ1RMean (4-byte float, size: nlat x nlon x nlayer)
 Conditional mean of convective Q_1-Q_R. Unit is [K/h]. Missing value is -9999.9.

convQ2Mean (4-byte float, size: nlat x nlon x nlayer)
 Conditional mean of convective Q_2. Unit is [K/h]. Missing value is -9999.9.

otherLHMean (4-byte float, size: nlat x nlon x nlayer)
 Conditional mean of other latent heating. Unit is [K/h]. Missing value is -9999.9.

otherPix (2-byte integer, size: nlat x nlon x nlayer)
 Other pixel counts. Missing value is -9999.9.

otherQ1RMean (4-byte float, size: nlat x nlon x nlayer)
 Conditional mean of other Q_1-Q_R. Unit is [K/h]. Missing value is -9999.9.

otherQ2Mean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of other Q_2. Unit is [K/h]. Missing value is -9999.9.

shallowLHMean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of shallow-stratiform latent heating. Unit is [K/h]. Missing value is -9999.9.

shallowPix (2-byte integer, size: nlat x nlon x nlayer)

Shallow-stratiform pixel counts. Missing value is -9999.9.

shallowQ1RMean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of shallow-stratiform Q_1-Q_R. Unit is [K/h]. Missing value is -9999.9.

shallowQ2Mean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of shallow-stratiform Q_2. Unit is [K/h]. Missing value is -9999.9.

stratLHMean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of stratiform latent heating. Unit is [K/h]. Missing value is -9999.9.

stratPix (2-byte integer, size: nlat x nlon x nlayer)

Stratiform pixel counts. Missing value is -9999.9.

stratQ1RMean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of stratiform Q_1-Q_R. Unit is [K/h]. Missing value is -9999.9.

stratQ2Mean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of stratiform Q_2. Unit is [K/h]. Missing value is -9999.9.

3.3. L3 products (SLD,SLM)

3.3.1. Output Dimension Definition

- nlat
  - 268 number of high resolution 0.5° grid intervals of latitude from 67°S to 67°N.
- nlon
  - 720 number of high resolution 0.5° grid intervals of longitude from 180°W to 180°E.
- nlayer
  - 80 number of layers at the fixed heights of 0.00-0.25 km, 0.25-0.50 km, ..., 19.50-19.75 km, and 19.75-20.00 km.

3.3.2. Output variables

LHDev (4-byte float, size: nlat x nlon x nlayer)

Conditional standard deviation of latent heating. Unit is [K/h]. Missing value is -9999.9.

LHMean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of latent heating. Unit is [K/h]. Missing value is -9999.9.

Q1RDev (4-byte float, size: nlat x nlon x nlayer)

Conditional standard deviation of Q_1-Q_R. Unit is [K/h]. Missing value is -9999.9.

Q1RMean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of Q_1-Q_R. Unit is [K/h]. Missing value is -9999.9.

Q2Dev (4-byte float, size: nlat x nlon x nlayer)

Conditional standard deviation of Q_2. Unit is [K/h]. Missing value is -9999.9.

Q2Mean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of Q_2. Unit is [K/h]. Missing value is -9999.9.

allPix (4-byte float, size: nlat x nlon x nlayer)

All (conditional) pixel counts. Missing value is -9999.9.

convLHDev (4-byte float, size: nlat x nlon x nlayer)

Conditional standard deviation of convective latent heating. Unit is [K/h]. Missing value is -9999.9.

convLHMean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of convective latent heating. Unit is [K/h]. Missing value is -9999.9.

convPix (4-byte float, size: nlat x nlon x nlayer)

Convective pixel counts. Missing value is -9999.9.

convQ1RDev (4-byte float, size: nlat x nlon x nlayer)

Conditional standard deviation of convective Q_1-Q_R. Unit is [K/h]. Missing value is -9999.9.

convQ1RMean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of convective Q_1-Q_R. Unit is [K/h]. Missing value is -9999.9.

convQ2Dev (4-byte float, size: nlat x nlon x nlayer)

Conditional standard deviation of convective Q_2. Unit is [K/h]. Missing value is -9999.9.

convQ2Mean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of convective Q_2. Unit is [K/h]. Missing value is -9999.9.

otherLHDev (4-byte float, size: nlat x nlon x nlayer)

Conditional standard deviation of other latent heating. Unit is [K/h]. Missing value is -9999.9.

otherLHMean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of other latent heating. Unit is [K/h]. Missing value is -9999.9.

otherPix (4-byte float, size: nlat x nlon x nlayer)

Other pixel counts. Missing value is -9999.9.

otherQ1RDev (4-byte float, size: nlat x nlon x nlayer)

Conditional standard deviation of other Q_1-Q_R. Unit is [K/h]. Missing value is -9999.9.

otherQ1RMean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of other Q_1-Q_R. Unit is [K/h]. Missing value is -9999.9.

otherQ2Dev (4-byte float, size: nlat x nlon x nlayer)

Conditional standard deviation of other Q_2. Unit is [K/h]. Missing value is -9999.9.

otherQ2Mean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of other Q_2. Unit is [K/h]. Missing value is -9999.9.

shallowLHDev (4-byte float, size: nlat x nlon x nlayer)

Conditional standard deviation of shallow-stratiform latent heating. Unit is [K/h]. Missing value is -9999.9.

shallowLHMean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of shallow-stratiform latent heating. Unit is [K/h]. Missing value is -9999.9.

shallowPix (4-byte float, size: nlat x nlon x nlayer)

Shallow-stratiform pixel counts. Missing value is -9999.9.

shallowQ1RDev (4-byte float, size: nlat x nlon x nlayer)

Conditional standard deviation of Q_1-Q_R. Unit is [K/h]. Missing value is -9999.9.

shallowQ1RMean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of shallow-stratiform Q_1-Q_R. Unit is [K/h]. Missing value is -9999.9.

shallowQ2Dev (4-byte float, size: nlat x nlon x nlayer)

Conditional standard deviation of shallow-stratiform Q_2. Unit is [K/h]. Missing value is -9999.9.

shallowQ2Mean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of shallow-stratiform Q_2. Unit is [K/h]. Missing value is -9999.9.

stratLHDev (4-byte float, size: nlat x nlon x nlayer)

Conditional standard deviation of stratiform latent heating. Unit is [K/h]. Missing value is -9999.9.

stratLHMean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of stratiform latent heating. Unit is [K/h]. Missing value is -9999.9.

stratPix (4-byte float, size: nlat x nlon x nlayer)

Stratiform pixel counts. Missing value is -9999.9.

stratQ1RDev (4-byte float, size: nlat x nlon x nlayer)

Conditional standard deviation of stratiform Q_1-Q_R. Unit is [K/h]. Missing value is -9999.9.

stratQ1RMean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of stratiform Q_1-Q_R. Unit is [K/h]. Missing value is -9999.9.

stratQ2Dev (4-byte float, size: nlat x nlon x nlayer)

Conditional standard deviation of stratiform Q_2. Unit is [K/h]. Missing value is -9999.9.

stratQ2Mean (4-byte float, size: nlat x nlon x nlayer)

Conditional mean of stratiform Q_2. Unit is [K/h]. Missing value is -9999.9.

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