The GPM Precipitation Gridded Text Product Set

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EGU 2018
Poster #10947

1. Introduction

Purpose—During the early days of the Tropical Rainfall Measuring Mission (TRMM), users requested that rainfall retrievals be available in a format simpler than the HDF4 format used for both L2 swath and L3 gridded products. Additionally, users indicated that they didn't need all the parameters (science products) that were contained in these standard files. The TRMM science project developed a series of gridded products stored in ASCII text files.

ASCII was the simplest and most universal format in which data could be stored. The gridded-text products produced in TRMM up until version 8 reprocessing were designated with the TRMM data type "3G68." The original grids were in hourly 0.5° × 0.5° boxes packaged into daily files. Later the TRMM project added 0.25° x 0.25° hourly grid products and 0.1° x 0.1° hourly grid products over Africa, South America, and Australia. These also were packaged as daily files.

The parameters in each of these 3G68 products were the same. The parameters within each grid box were rainfall retrievals taken from the TRMM Microwave Imager (TMI), TRMM Precipitation Radar (PR), and the TMI and PR combined products. This allowed the same software to access all three products with only changes in resolution required in the software. As all were stored in ASCII text with each line terminated by a newline (NL), many existing tools could easily ingest the products. From the beginning through the version 7 reprocessing, these gridded-text products contained some internal compression techniques that, while saving space, often made ingest more complicated than the compression warranted.

From the very beginning of Global Precipitation Measurement (GPM) mission, the decision was made that gridded products in text format analogous to the TRMM 3G68 products would be produced. But, no internal compression would be applied to the gridded-text products. Firstly, network throughput has greatly improved since the beginning of TRMM. Secondly, internal compression defeated the purpose of easy ingest using existing tools. As a result, each of the data lines in a GPM gridded-text product are the same length and contain the same number of parameters.

These GPM gridded-text products are summarized in the following sections. With the reprocessing of TRMM to version 8 (when TRMM products are incorporated into the GPM data suite), the TRMM gridded-text products will follow the GPM file-naming convention.

Products—GPM gridded-text products have the following characteristics. These products contain hourly grids at 0.25° × 0.25° resolution that are packaged in daily files. The first five lines of text in each file contain metadata about the file. The rest of the file consists of data lines containing the precipitation retrievals (the details are in the next section). Each text line is terminated by a NL. No internal compression is applied. However, to speed downloads, each of the daily files are gzipped using the standard Linux gzip utility.

GPM has three separate types of gridded-text products. The main gridded-text product contains precipitation information from the GPM core-satellite products: GPM Microwave Imager (GMI), the Dual-Frequency Precipitation radar Ku, the dual (Ku/Ka) frequency precipitation retrieval (DPR), and combined precipitation retrieval based on both the GMI and DPR information.

The second gridded-text product contains precipitation information from the GPM constellation conically scanning radiometers. The Goddard Profiling (GPROF) algorithm is used to retrieve precipitation from all of these radiometers. This second product contains the precipitation retrievals from GMI, AMSR2 on Japan's GCOM-W1 mission, and SSMI/S from the DMSP F16, F17, F18 satellites and for a while the F19 satellite.

The third gridded-text product contains the GPROF precipitation retrievals from the constellation cross-track scanners. Currently these instruments include MHS from the EUMETSAT satellites Metop-A and Metop-B in addition to NOAA MHS instruments on NOAA18 and NOAA19. The GPROF retrieval from ATMS on the NPP satellite is also included.

The basic data line format is the same in all the products (see section 2). Only the number and type of instrument groups varies by product type.

Current Version Information—The current version of the GPM core-satellite gridded-text product is V05B. Distribution of initial V05A had already started when an error in some of the precipitation-related parameters was found. While the precipitation values were correctly calculated based on the changes in the GMI GPROF retrieval parameters from V04, unfortunately not all the other precipitation-related parameters correctly made the change.

The GPM constellation conically scanning radiometer gridded-text products are at V05C. The conically scanning radiometer products started at V05B, but on 1 September 2017, GPROF processing of some of the F18 channels had to be changed. To document this change, the minor part of the version was changed from V05B to V05C. Generally, a change in the letter part of the data product version indicates that reprocessing back to the beginning of the GPM mission was not appropriate or necessary.

The GPM constellation cross-track scanning radiometer are at V05B. Again, V05B goes back to the beginning of the mission and was done because the original V05A had errors in some of the precipitation-related parameters.

2. File Format and Testing

The file begins with five lines of text that describe the file and the variables that it contains. The details of the metadata content can be found on the **https://pps.gsfc.nasa.gov** webpage. After the first five lines, each remaining line of the file contains data for a single 0.25° × 0.25° gridbox for a particular hour of the day. Each data line begins with the following four space-time parameters:

- Hour (0-23) indicating the UTC hour
- Minute (0-59) indicates the UTC minute of the first data item in the gridbox
- Row (0-719) where 0 would identify a gridbox whose southern boundary touches 90°S Latitude and 719 would identify a gridbox whose northern boundary touches 90°N Latitude (719 = 180°÷0.25° - 1).
- Column (0-1439) where 0 identifies the gridbox whose western boundary touches 180°W Longitude and 1439 identifies a gridbox whose eastern boundary touches 180°E Longitude (1439 = 360°÷0.25° - 1).

Following these four space-time parameters is the following set of parameters that is repeated for each sensor's precipitation information contained in this text file:

- Total number of pixels in the gridbox
- Number of precipitating pixels in the gridbox
- Mean unconditioned precipitation rate mm/hr (up to 5 decimal places)
- Mean unconditioned convection precipitation rate mm/hr (up to 5 decimal places)
- Mean unconditioned frozen precipitation rate mm/hr (up to 5 decimal places)
- An integer data quality indicator generally from 1 to 4. (For sensors where the retrieval does not provide a data quality, the data quality is -9.)

If a sensor does not have values for a particular hour in a particular grid box, then the total pixels are 0 but all the other values are set to -9 to indicate a missing value. The three GPM text grid products repeat the above-mentioned set of precipitation parameters for each of these kinds of retrievals.

Types of gridded-text Products

GPM Core Satellite
- GMI GPROF retrieval
- Ku Precipitation retrievals
- Ku/Ka Dual Frequency retrievals
- Combined GMI & Ku/K dual frequency retrievals

GPM Constellation, conically scanning
- GMI GPROF
- AMSR2 GPROF
- F16 SSMI/S GPROF for the F16, F17, F18, and F19 satellites (F19 available for only part of the processing period)

GPM Constellation, Crosstrack-scanning
- SAPHIR from Megha-Tropiques (currently all missing-value placeholder)
- MHS from the Metop-A, Metop-B, NOAA18, and NOAA19 satellites
- ATMS from Suomi/NPP

Figure 1. Text Grid vs. Daily L3 HDF5 (GMI)

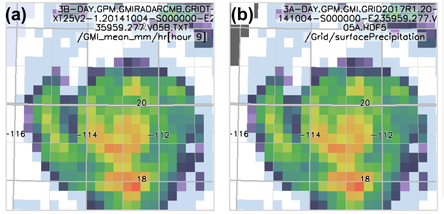


Figure 2. Text Grid vs. Monthly L3 HDF5 (AMSR2)

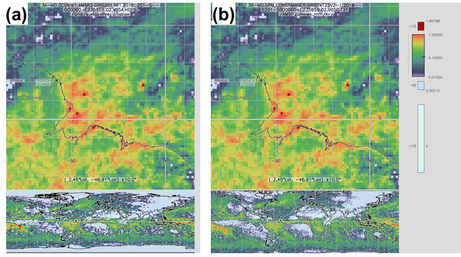
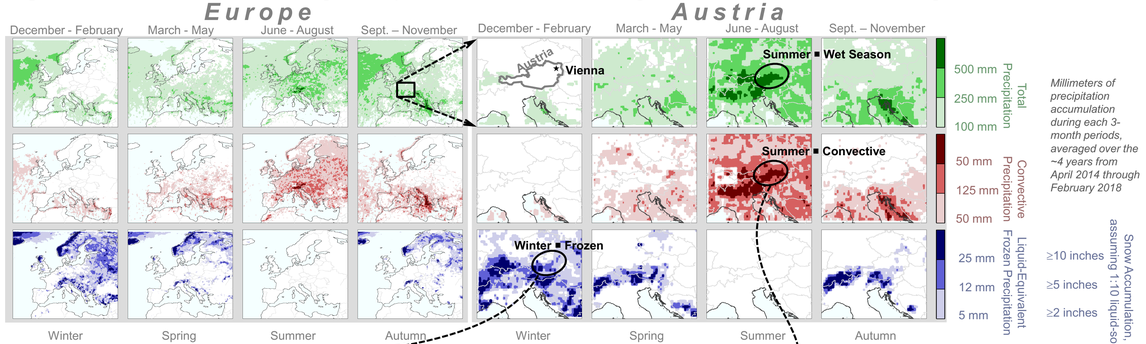


Figure 3. Text Grid GMI V05: Average Precipitation Accumulation During Each Three-Month Season using 3/2014 to 2/2018



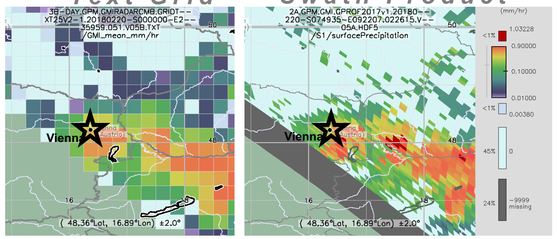


Figure 4. Example of a winter snow storm seen by GMI

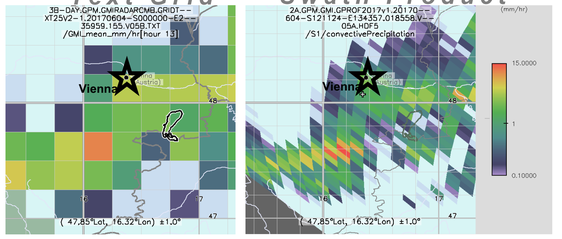


Figure 5. Example of a summer convective storm seen by GMI

Creating the Products—The data for each product comes from different sensors but the basic approach for generating the products is the same: Obtain a list of all the precipitation retrievals for the appropriate sensors for the day. With the exception of the core GPM gridded-text products, these retrievals are provided by the swath GPROF L2 HDF5 products. In the case of the core GPM product, the radar and combined L2 HDF retrievals are used along with GMI GPROF.

A .25° x .25° universal grid matrix is created for each of the 24 hours. As the level 2 products are read, the appropriate values are averaged into the target hourly quarter-degree bin. A count is maintained of the total pixels that were summed into the grid as well as a count of the pixels that contained precipitation, convective precipitation, and frozen precipitation. After all the L2 swath data for the hour has been read, the means are calculated. Any sensor that has no pixels in an hourly grid box has missing values. The same generic approach is used in creating each of the three different gridded-text products.

Testing the Products—PPS validates the 0.25° grids in the text products against 0.25° grids in PPS's daily and monthly sensor L3 HDF5 files. A first step in that process requires the rollup of all the hours of the gridded-text file into a single hour. Each sensor text grid aggregated product is compared to the daily L3 product for the same sensor. Verification is then made to ensure that the two products match within acceptable variations for round-off error. **Figure 1a** compares a summarized daily text-grid product against a L3 daily GMI GPROF product (**figure 1b**).

However, daily matchups don't necessarily provide enough data to verify that the gridded-text product faithfully contains the correct summarized retrievals. So, the next step is to summarize the gridded-text products for a month. These summarized results are then compared to the monthly level 3 retrieval products. **Figure 2a** shows a monthly summation of mean precipitation for the GCOM-W1 AMSR2 from the text grid and the same from the AMSR2 L3 HDF5 file (**figure 2b**). The same comparisons are done for the mean convection rate and the mean frozen precipitation rate. (***Note:*** PPS does make month rollup products available to users.)

Examples of use—By combining multiple daily text grids, one can examine precipitation patterns that occur diurnally, seasonally, or inter-annually. **Figure 3** shows how four years of GPM text grids can be combined to estimate the seasonal precipitation accumulation in Europe and the Mediterranean Sea. A zoom view of Austria is shown for the same data. Also shown is the accumulation of convective-type precipitation, and the accumulation of solid-phase precipitation. **Figure 4** uses a single, daily text grid to show an example of a snow-producing storm over Austria, while **Figure 5** shows an example of a convective-type storm over Austria.

3. Advantages of the Products

The universal nature of text and the ease of using a text-based product remain major advantages of these products since their production during the TRMM mission. Another advantage of the text grid is that the standard L3 HDF5 daily or monthly products do not maintain hourly time resolution. If the user were conducting diurnal precipitation research, they would need to retrieve the individual L2 swath products for each sensor instead of just a single gridded-text product for the day. Also, if the researcher wanted the precipitation retrievals from all of the sensors both on the GPM core satellite and constellation satellites, he or she would still need to download many files instead of just a single text-grid file. While the text grid is larger now that internal compression is no longer used, this expansion is offset by the improved storage and network capacity currently available.

4. Tools

PPS provides two important tools that work directly with gridded-text files. The THOR viewer is able to read and display any PPS gridded-text file that contains the appropriate five lines of metadata and that has the required data-line format. THOR can display the core-satellite gridded-text products as well as the products from the conically scanning and cross-track scanning radiometers.

PPS also provides software that can take a list of gridded-text products and combine all the information in the files into a single file with the same format as the original but that now contains the rolled-up data. The rollup may be done so that the hourly information is preserved (in the event that diurnal studies are to be undertaken), or all the hourly data can be rolled up into a single hour grid. For example, all the files for a month could be rolled up, either maintaining the hours or creating a monthly product where hour 0 contains the monthly data. There are no restrictions on how many files may be rolled up. The software expects a parameter file that lists all of the filenames that are to be used to calculate the summary.

Currently C-based software can be used to rollup the core-satellite gridded-text products and separate C-based software is available for the conically scanning radiometers and for the cross-track scanning radiometers. An initial Python 2.7 based program is available to allow users to rollup the core-satellite gridded-text products in any manner that they find useful. While not specifically a PPS tool, not using internal compression facilitates ingest by third-party tools (e.g., DBMS or spreadsheets).

5. Upcoming Changes

A major V06A reprocessing of the Ku, Ka, and DPR radar products and the combined GMI/radar product is planned by early Summer 2018. As a result, a version V06A of the GPM core-satellite gridded-text product will need to be produced. Reprocessed products will begin at the start of the GPM mission. However, the gridded-text products for the conically scanning and cross-track scanning radiometers do not need to be reprocessed and they will remain at V05.

In late Autumn or early Winter 2018, after the completion of the TRMM version 8 reprocessing, the TRMM gridded-text product will also be reprocessed and incorporated into the GPM data suite. A major objective of the TRMM version 8 reprocessing is to include TRMM-era data into the GPM data suite. As a result, the TRMM gridded-text product will be identified using GPM file naming conventions and have a V06 GPM product version designation.

As part of the TRMM reprocessing, gridded-text products for the TRMM-era constellation radiometers, both cross-track and conically scanning, will be created. A conically scanning radiometer gridded-text product will be added that includes AMSRE, SSMI, and pre-2014 SSMI/S. For the cross-track radiometers, the gridded-text product will include AMSUB and the pre-2014 MHS retrieval information.

At the next reprocessing, the crosstrack-scanning text file will likely add a sensor group for the ATMS sensor on the NOAA JPSS-1 satellite. A precipitation retrieval from the SAPHIR sensor on the French/Indian Megha-Tropiques satellite may also be added, but without mean rates for convective or frozen precipitation as the retrieval is not done via GPROF but uses another algorithm that does not provide this information.

6. Obtaining the Products

Before downloading a text grid or any other PPS data product, individuals must register with PPS by visiting **http://registration.pps.eosdis.nasa.gov**. The email address registered provides access using the following two methods for obtaining the text grid products:

- Use the STORM order interface: **https://storm.pps.eosdis.nasa.gov**
- Access the PPS FTP server using a web browser, an FTP utility, or an FTP script. Instructions are provided to registered users.

For questions or comments, email **erich.f.stocker@nasa.gov**