Gridded

Erich Franz Stocker
Erich.F.Stocker@nasa.gov
NASA/GSFC, Code 610.2
Greenbelt, MD
Text

Owen Kelley
Owen.A.Kelley@nasa.gov
George Mason University
Fairfax, VA
Products
Abstract

TRMM has many products that contain instantaneous or gridded rain rates often among many other parameters. However, these products because of their completeness can often seem intimidating to users just desiring surface rain rates. For example one of the gridded monthly products contains well over 200 parameters. It is clear that if only rain rates are desired, this many parameters might prove intimidating. In addition, for many good reasons these products are archived and currently distributed in HDF format. This also can be an inhibiting factor in using TRMM rain rates. To provide a simple format and isolate just the rain rates from the many other parameters, the TRMM product created a series of gridded products in ASCII text format. This paper describes the various text rain rate products produced. It provides detailed information about parameters and how they are calculated. It also gives detailed format information. These products are used in a number of applications with the TRMM processing system. The products are produced from the swath instantaneous rain rates and contain information from the three major TRMM instruments: radar, radiometer, and combined. They are simple to use, human readable, and small for downloading. They are available from anonymous ftp on trmmopen.gsfc.nasa.gov.
Background

During the first 3 years of the Tropical Rainfall Measuring Mission (TRMM), all data was produced in Hierarchical Data Format (HDF) only. This is an extremely useful format that is self-describing, standardized, and provides a large set of useful tools for reading, creation, browsing, and displaying. Importantly for TRMM, HDF was also the standard format for NASA’s Earth Observing Systems (EOS) missions.

However, HDF is complex. For people used to simple formats (e.g. GIS) or using other tools based on other formats, HDF appears to be difficult to use. The user must spend the time to learn the tools and their interaction with the underlying physical format.
Additionally, the TRMM data products themselves contain many parameters. For example, the monthly gridded Precipitation Radar (PR) product contains over 200 different science parameters. While other products do not have as many parameters, they nevertheless still contain more parameters than many scientists need.

This led the modeling community to request a simple format that contained just a few key parameters dealing with surface precipitation. They wanted a format which anyone could use without learning a complex set of tools or rules. They also wanted the physical format to be easy to use without worrying about byte-swapping, floating point formats, etc. Lastly, they wanted the data products to be small enough to retrieve quickly even over less than stellar internet connections.
This led the TRMM Project Scientist to organize a small group to develop the desired data products that met as many of the modeling community needs as possible. The group was composed of both scientists and computer scientists.

The working group determined that files using ASCII representation would be the most universally understood format. To ensure that the contents would be easily understandable only a small number of parameters would included. Finally, a simple data “compression” scheme was adopted.

In 2002, all the TRMM data was put in the gridded text format and made publicly available on the TRMM anonymous ftp server.
This is the most used of the TRMM gridded text products. It contains the surface rain rates from the swath level 2 products from the TRMM Microwave Imager (TMI), the PR, and the Combined (PR & TMI).

A number of different suggestions were made by the working group for the base temporal aggregation. All could easily be accommodated by using a one hour grid. Additionally, each of these one hour grids would be packaged into a daily product.

Because of the TRMM coverage, it was determined that the best geographical gridding would be accomplished using $0.5^\circ \times 0.5^\circ$ spatial gridding. This was used by many of the standard TRMM gridded products.
3G68 Format:

All TRMM 3G products report their data on a universal grid where 90S, 180W is grid matrix ID (0,0) and 90N, 180E is grid matrix ID (360,720). While TRMM data is only collected from approximately 38S to 38N, reporting grid IDs based on the universal grid should permit easier combination with data from other satellites. The first 5 lines in the file contains header information. Some of these are intended only for visual scanning while other lines can be used by software to assist in setting up memory automatically.

Header Lines
Line 1:  Product_ID (3G68),
       Algorithm Version,
       Adjustment Algorithm ID (if any applied else NONE)
       Adjustment Algorithm Version (if any else NONE)
TRMM Data Credit (NASA/NASDA/CRL)
Date/Time  Product Produced (in local time)

Line 2:  Maximum Grid rows (Latitude)
Maximum  Grid columns (Longitude)
Minimum Latitude represented in Grid
Minimum Longitude represented in Grid
Grid cell resolution
Date of data in Product

Line 3:  (TRMM specific information -- all numeric)
Minimum Latitude for TRMM data
Maximum Latitude for TRMM data
Minimum Longitude for TRMM data
Maximum Longitude for TRMM data

Line 4:  keyword identified grid information
Grid_First_Row
Grid_Center_Latitude
Grid_First_Column
Grid_Center_Longitude
Grid_Cell_Resolution
Line 5: Data line column identifications (exact strings)

hour
minute
row
column
tmi_total_pixels
tmi_rain_pixels
tmi_mean_rain
tmi_conv_%
pr_total_pixels
pr_rain_pixels
pr_mean_rain
pr_conv_%
comb_total_pixels
comb_rain_pixels
comb_mean_rain
comb_conv_%

Sample Header lines from 3G68: word line does not appear in file
Data Lines

Each data line contains the following information:

- Hour, min, row of global .5 x .5 grid, column of global grid
- Total pixels from 2A12 (TMI) in cell
- Rainy pixels from 2A12 (TMI) in cell
- Mean rain rate from 2A12 (TMI) in mm/hr
- Percentage of rain from 2A12 (TMI) calculated to be convective

- Total pixels from 2A25 (PR) in cell
- Rainy pixels from 2A25 (PR) in cell
- Mean rain rate from 2A25 (PR) in mm/hr
- Percentage of rain from 2A25 (PR) calculated to be convective

- Total pixels from 2B31 (Combined) in cell
- Rainy pixels from 2B31 (Combined) in cell
- Mean rain rate from 2B31 (Combined) in mm/hr
- Percentage of rain from 2B31 (Combined) calculated to be convective

The mean rain rate is an unconditioned mean. This is the total rain (including zero rain) divided by the total pixel count but not including missing pixels.
Compression Approach Used

In the event that a cell has a value for TMI but no PR pixel covered that cell, a 0 will be included for pr_total_pixels field but no other values appear for PR or Combined. This situation indicates that no PR pixel covered that grid box. This approach is taken to keep the file small because it does not print out missing values for the remainder of the PR or Combined fields.

In the event that a cell has no TMI value but does have PR values, the TMI total-pixels field will be set to 0 and rain-pixels set to 0. The mean rain and the convective percentage will be set to -9 to indicate that these are missing.

If neither the TMI nor the PR swath covered an hourly grid box, then no information is written to the file. This means that values in the file represent grid boxes that had data from at least 1 of the TRMM instruments. Users may safely assume that grid boxes with no values listed in the file did not contain data.
Sample Data Line

A. (Case when there is no PR pixel in cell)
   0 5 106 59 24 24 0.87 0 0

B. (Case when a line has both TMI and PR data)
   0 10 109 109 48 0 0 0 133 32 0.39 34 133 32 0.35 28

C. (Case when a line has no TMI but has PR)
   2 0 157 196 0 0 -9 -9 33 3 0.04 0 33 3 0.03 0

Explanation of Case A:
Hour 1(0 base), 5 mins [time of first pixel in grid box]
Grid box row 106 (0 base), column 59 (0 base) of global grid
24 total pixels, 24 rainy pixels, 0.87mm/hr, 0% convective

The last 0 indicates that there are 0 PR pixels in the grid box
3G68 Global View of TRMM Coverage Area

Precipitation Rate (mm/h)

no observations

0.1 1 10 100
3G68

Heavy rains fell across the central United States in mid-March of 2008.

For more information: http://trmm.gsf.c.nasa.gov/publications_dir/midwest_flooding_13-20mar08.html
3G68 Land

In 2003, scientists requested that a finer geospatial resolution be used to create 3G68 products over 3 land masses: Africa, South America, and Australia. They desired that these products continue to be hourly grids packaged as daily files but they wanted the grid box to be $1^\circ \times 1^\circ$.

Three separate daily files are produced--one for each of the three land masses. The format for each of these files is EXACTLY the same as that described for the 3G68 global product. However, there are, naturally, more grid boxes. Once again, the TRMM coverage area is placed within a global grid. So, the row and columns are displacements in the global $1^\circ \times 1^\circ$ grid.
Tropical Cyclone Jokwe on March 10, 2008 between the African Nation of Mozambique and the Island of Madagascar. The tropical cyclone had category 3 winds of 125 mph winds.

http://trmm.gsfc.nasa.gov/publications_dir/midwest_flooding_13-20mar08.html
Tropical Cyclone Jokwe on March 10, 2008 between the African Nation of Mozambique and the Island of Madagascar. The tropical cyclone had category 3 winds of 125 mph winds.

http://trmm.gsfc.nasa.gov/publications_dir/midwest_flooding_13-20mar08.html
Africa
Precipitation Radar

Tropical Cyclone Jokwe on March 10, 2008 between the African Nation of Mozambique and the Island of Madagascar. The tropical cyclone had category 3 winds of 125 mph winds.

http://trmm.gsfc.nasa.gov/publications_dir/midwest_flooding_13-20mar08.html
3G68

Africa

Precipitation Radar –

% Convective

Tropical Cyclone Jokwe on March 10, 2008 between the African Nation of Mozambique and the Island of Madagascar. The tropical cyclone had category 3 winds of 125 mph winds.

http://trmm.gsfc.nasa.gov/publications_dir/midwest_flooding_13-20mar08.html
Tropical Cyclone Jokwe on March 10, 2008 between the African Nation of Mozambique and the Island of Madagascar. The tropical cyclone had category 3 winds of 125 mph winds.

http://trmm.gsfc.nasa.gov/publications_dir/midwest_flooding_13-20mar08.html
Heavier than normal precipitation fell in South American during February of 2008, which caused flooding.

For more information: http://trmm.gsfc.nasa.gov/publications_dir/south_america_flooding_feb-mar08.html
With the success of the rain retrieval 3G68 and 3G68Land gridded text files, the science community asked for an analogous text format for 2 channels from the Visible Infrared Scanner (VIRS). They requested the two infrared channels with units in $T_b$: channel 4, the 10.8 micron channel, and channel 5, the 12 micron channel. Each channel was put in its own daily text file: 3G01-4 and 3G01-5.

The radiances contained in the L1B VIRS swath files are converted to brightness temperature. The data are gridded on a global grid of $0.5^\circ \times 0.5^\circ$. 
Format
The 3G01 product provides:

- mean brightness temperature
- maximum brightness temperature
- minimum brightness temperature
- standard deviation

A lookup table is used to convert VIRS channel 4 radiances to brightness temperature. While the table is calculated in 0.5 deg steps, the conversion applies a linear interpolation to provide the actual printed value.

All TRMM 3G products report their data on a universal grid where 90S, 180W is grid matrix ID (0,0) and 90N, 180E is grid matrix ID (360,720). While TRMM data is only collected from approximately 38S to 38N, reporting grid IDs based on the universal grid should permit easier combination with data from other satellites.
Header Lines
Line 1:  Product_ID (3G01),
   Algorithm Version,
   Adjustment Algorithm ID (if any applied else NONE)
   Adjustment Algorithm Version (if any else NONE)
   TRMM Data Credit (NASA/NASDA/CRL)
   Date/Time (local time)  Product Produced

Line 2:  Maximum Grid rows (Latitude)
   Maximum  Grid columns (Longitude)
   Minimum Latitude represented in Grid
   Minimum Longitude represented in Grid
   Grid cell resolution
   Date of data in Product

Line 3:  (TRMM specific information -- all numeric)
   Minimum Latitude for TRMM data
   Maximum Latitude for TRMM data
   Minimum Longitude for TRMM data
   Maximum Longitude for TRMM data
Line 4:  keyword identified grid information
    Grid_First_Row
    Grid_Center_Latitude
    Grid_First_Column
    Grid_Center_Longitude
    Grid_Cell_Resolution

Line 5:  Data line column identifications
    hour
    minute
    row
    column
    VIRS_total_pixels
    VIRS_Channel4_mean_Tb
    VIRS_Channel4_max_Tb
    VIRS_Channel4_min_Tb
    VIRS_Channel4_sigma_Tb

    These header lines are almost identical with those contained in the 3G68 products but modified to represent the VIRS data and the fact that each data line contains only a single channel value for the hour and grid location.
An outbreak of tornadoes struck the southern United States on February 5 of 2008. The 3G01 image shows the minimum 10.8 micron infrared brightness temperature observed in each grid box. Values below 230 K are sometimes associated with intense convective storms, such as tornado-producing storms.

For more information: http://trmm.gsfc.nasa.gov/publications_dir/6aug08_tornado.html
An outbreak of tornadoes struck the southern United States on February 5 of 2008. The 3G01 image shows the minimum 12 micron infrared brightness temperature observed in each grid box. Values below 230 K are sometimes associated with intense convective storms, such as tornado-producing storms.

For more information: http://trmm.gsfc.nasa.gov/publications_dir/6aug08_tornado.html
Conclusions
The gridded text products contain only the rain related parameters, are in a simple universal format, and greatly reduce the volume of data that must be retrieved to get basic surface precipitation information.

These products are available via anonymous ftp from trmmopen.gsfc.nasa.gov in the directories pub/3G68, pub/3G68Land, pub/3G01-4, and pub/3G01-5. The pub directory contains README files for 3G68, 3G68Land, and the 3G01 products. These describe the file structure and calculations used in greater detail.

The gridded text products are extensively retrieved and used. They are among the most requested TRMM products.
TRMM gridded text products

E. Stocker (1)
(1) NASA/GSFC Code 610.2

TRMM has many products that contain instantaneous or gridded rain rates often among many other parameters. However, these products because of their completeness can often seem intimidating to users just desiring surface rain rates. For example one of the gridded monthly products contains well over 200 parameters. It is clear that if only rain rates are desired, this many parameters might prove intimidating. In addition, for many good reasons these products are archived and currently distributed in HDF format. This also can be an inhibiting factor in using TRMM rain rates. To provide a simple format and isolate just the rain rates from the many other parameters, the TRMM product created a series of gridded products in ASCII text format. This paper describes the various text rain rate products produced. It provides detailed information about parameters and how they are calculated. It also gives detailed format information. These products are used in a number of applications with the TRMM processing system. These products are produced from the swath instantaneous rain rates and contain information from the three major TRMM instruments: radar, radiometer, and combined. They are simple to use, human readable, and small for downloading. They are available from anonymous ftp on trmmopen.gsfc.nasa.gov.