

# **The Transition in Multi-Satellite Products from TRMM to GPM (TMPA to IMERG)**

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The transition from the Tropical Rainfall Measuring Mission (TRMM) data products to the Global Precipitation Measurement (GPM) mission products is well underway. This document specifically addresses the multi-satellite products, namely the TRMM Multi-satellite Precipitation Analysis (TMPA), the real-time TMPA (TMPA-RT), and the Integrated Multi-satellitE Retrievals for GPM (IMERG).

## 1. TRMM Status and Future

The TRMM satellite reentered the Earth's atmosphere on 17 June 2015, and whatever debris survived landed in the southern Indian Ocean well west of Australia. The terminal phase began when fuel was exhausted in July 2014. On 7 October 2014 the satellite descended to an altitude that precluded useful TRMM Precipitation Radar data, with a brief revival as TRMM descended past the original altitude of 350 km. Meanwhile, the TRMM Microwave Imager (TMI) continued to function with slowly changing characteristics until it was shut down on 8 April 2015 as part of the decommissioning, or "passivation" of the satellite. The actual demise of TRMM is not the substantive issue for the TMPA and TMPA-RT.

## 2. TMPA Future

Starting with data for October 2014, the intercalibration of the passive microwave precipitation estimates had to change for production 3B42, and this created at least a slight inhomogeneity, primarily over the oceans. We already know that calibrations involving PR have a different interannual behavior than calibrations based solely on passive microwave. In addition, as a legacy product, shifts in input data, such as new algorithms, might make continuation of 3B42 problematic faster than we want. The NOAA MSPPS sounder data are a particular flash point. The character of the 3B42 has changed somewhat, since the calibrator no longer involves radar data, so it is recommended that projects that require the best homogeneity only use 3B42 for the period January 1998 to September 2014. Nonetheless, we will run 3B42 in parallel with IMERG through December 2019. [Note that this is much later than some early planning called for; see the IMERG timeline, below.] One unavoidable issue is that the loss of TMI data reduces the amount of conical-scan imager data going into the TMPA and TMPA-RT. All of the TMPA datasets continue to be called TRMM Version 7 despite these changes.

## 3. TMPA-RT Future

Meanwhile, the 3B42RT system was already computed with a climatological intercalibration for the passive microwave precipitation estimates (i.e., they are not calibrated with current data), so 3B40RT, 3B41RT, and 3B42RT continue to function as they have. As with 3B42, 3B42RT's status as a legacy product means that shifts in input data might make continuation problematic faster than we want. One unavoidable issue is that the loss of TMI data reduces the amount of conical-scan imager data going into both the TMPA and TMPA-RT. We recognize the

application focus for 3B42RT, and are running it for several months after the equivalent IMERG products are satisfactory. Completion of a satisfactory retrospective processing was completed in August 2019 (again, much later than stated in earlier versions of this document), and we plan to cease producing TMPA products at the end of December 2019. We suppose that some users will want the old product forever, but changing IR security rules, aging computer hardware and software, and declining availability of satellites from the TRMM era necessitate this timing.

#### 4. IMERG Timeline

- The “Day 1” Version 03 IMERG Final Run data sets (for the GPM era, mid-March 2014 to the present, delayed about 3 months) were released in late December 2014.
- In Version 03, the IMERG Late Run data sets began 7 March 2015, while the Early Run started 1 April 2015.
- The first retrospectively processed GPM-era IMERG data sets were released as GPM Version 04 in Spring 2017 (somewhat later than previously announced).
- Another retrospectively processed GPM-era IMERG data set was released as Version 05 in November 2017.
- Initial Processing (i.e., with new data) for Early and Late Runs were upgraded to V06 as of 00 UTC 1 May 2019.
- The extension of IMERG back to the TRMM era happened in Summer 2019 as part of Version 06.
  - Final Run retrospective processing for the GPM era (first release is June 2014) began 4 June 2019 (after two starts that revealed processing errors) and the complete record from June 2000 to early 2019 finished on 3 July.
  - The Early and Late were retrospectively processed for the entire record, with completion on 20 August 2019.

The goal is to start the IMERG record at the beginning of 1998, but at the present the appropriate geo-infrared data are not available before mid-February 2000. This issue affects all runs, including the Final, and it’s being worked.

Given the sea change in algorithms from TRMM to GPM, the project chose to use the retrospective processing for IMERG in place of a final reprocessing for the TMPA/TMPA-RT. [This final reprocessing would have been labeled “TRMM Version 8”.]

#### 5. Further Information

The IMERG Algorithm Theoretical Basis Document (ATBD) is currently the best technical reference for IMERG. It is accessible at

[https://pmm.nasa.gov/sites/default/files/document\\_files/IMERG\\_ATBD\\_V6.pdf](https://pmm.nasa.gov/sites/default/files/document_files/IMERG_ATBD_V6.pdf)

The technical document is located at

[https://pmm.nasa.gov/sites/default/files/document\\_files/IMERG\\_doc\\_190909.pdf](https://pmm.nasa.gov/sites/default/files/document_files/IMERG_doc_190909.pdf)

The PMM web site

<https://pmm.nasa.gov/>

is the right general source for news, and its IMERG data access page contains hot links to the latest versions of these documents, as well as release notes. Specific IMERG announcements will be posted to the IMERG mailing list, and you're always free to ask if you think we're too quiet or you hear a rumor. If you wish to be added to the IMERG mailing lists, please e-mail

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Together with all GPM and TRMM data sets, IMERG data set locations are posted on the consolidated GPM data access pages, available through

*<https://pmm.nasa.gov/data-access/>*

The best place to ask questions (because they go to more than one person), is the “contact us” link at the bottom of the GPM web page

*[https://pmm.nasa.gov/contact?edit\[cid\]=3](https://pmm.nasa.gov/contact?edit[cid]=3)*

Finally, two GPM Applications Workshops held in November 2013 and June 2015, the Agriculture Workshop in August 2017, the GPM Disease Initiative Workshop in May 2018, and the GPM Weather and Air Quality Forecasting Workshop in July 2019 proved very useful for exchanging information and feedback to users and developers alike. Another workshop on numerical models and GPM data is being planned for the future.

## TMPA-IMERG Comparison

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algorithm	TRMM Multi-satellite Precipitation Analysis	Integrated Multi-satellite Retrievals for GPM
basic acronym	TMPA	IMERG
data sets	<ul style="list-style-type: none"> <li>• 3B42/3B43 production multisatellite-gauge combination</li> <li>• 3B40RT/3B41RT/3B42RT real-time merged microwave, microwave-calibrated IR, multisatellite</li> </ul>	<ul style="list-style-type: none"> <li>• 3IMERGHH/3IMERGM Final Run multisatellite-gauge combination</li> <li>• 3IMERGL Late Run near-real-time</li> <li>• 3IMERGE Early Run near-real-time</li> </ul>
spatial grid; coverage	0.25°x0.25° lat/lon; 50°N-S	0.1°x0.1° lat/lon; 90°N-S
current version	7 (7A for parts, but this is a technicality)	06A
time interval; span	<ul style="list-style-type: none"> <li>• 3 hr centered at 00, 03, ..., 21 UTC; 1 Jan 1998-present (production), 15 Feb 2000-present (real-time)</li> <li>• monthly; Jan 1998-present (production)</li> <li>• other value-added products in data centers</li> </ul>	<ul style="list-style-type: none"> <li>• 30 min; June 2000-present (delayed for corresponding latencies), to be extended to Jan 1998 when feasible</li> <li>• monthly; June 2000-(delayed) present (Final), to be extended to Jan 1998 when feasible</li> <li>• other value-added products in data centers</li> </ul>
latency	<ul style="list-style-type: none"> <li>• 3B42/3B43 2.5 mo after the month's end</li> <li>• 3B40RT/3B41RT/3B42RT 8 hr after obs. time</li> </ul>	<ul style="list-style-type: none"> <li>• Final 3.5 mo after the month's end</li> <li>• Late 14 hr after obs. time</li> <li>• Early 4 hr after obs. time</li> </ul>
native format	<ul style="list-style-type: none"> <li>• HDF4 (production)</li> <li>• binary (RT)</li> <li>• other value-added products in data centers</li> </ul>	<ul style="list-style-type: none"> <li>• HDF5</li> <li>• other value-added products in data centers</li> </ul>
algorithm summary	<ul style="list-style-type: none"> <li>• calibrate microwave precip rates to TRMM Combined Instrument</li> <li>• merge microwave (HQ), giving preference to conical-scanners</li> <li>• compute VAR microwave-calibrated IR precip rates</li> <li>• fill holes in HQ merged microwave with IR estimates</li> <li>• include gauge data by <ul style="list-style-type: none"> <li>- computing monthly satellite-gauge and then scaling 3 hr data to sum to the monthly in each grid box (production)</li> <li>- scaling 3 hr to 3B42 with climatological coefficients (RT)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• calibrate microwave precip rates to GPM Combined Instrument, which are climatologically calibrated to GPCP V2.3</li> <li>• merge microwave (HQ), giving preference to conical-scanners</li> <li>• compute PERSIANN-CCS microwave-calibrated IR precip rates</li> <li>• use CMORPH-style motion vectors based on vertically integrated water vapor (from numerical analyses) to forward/backward propagate microwave maps, then use a Kalman filter to combine these and the IR estimates into a weighted estimate (Early is forward-only)</li> <li>• include gauge data by <ul style="list-style-type: none"> <li>- computing monthly satellite-gauge and then scaling 30 min data to sum to the monthly in each grid box (Final)</li> <li>- scaling 30 min to Final with climatological coefficients (Late and Early)</li> </ul> </li> </ul>
input microwave algorithms	<ul style="list-style-type: none"> <li>• GPROF versions 2010v2 and 2004v for various conical scanners</li> <li>• NOAA MSPPS for cross-track scanners</li> </ul>	<ul style="list-style-type: none"> <li>• GPROF2017, except</li> <li>• PRPS V2 for SAPHIR</li> </ul>

plan	<ul style="list-style-type: none"> <li>continue running for several months after IMERG is retrospectively processed for the TRMM era to allow a transition for users</li> <li>Planned termination is end of 2019</li> </ul>	<ul style="list-style-type: none"> <li>V06 retrospectively processed back through the TRMM era, initially starting with June 2000; this stands in for the TRMM V8 last processing</li> </ul>
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Data Fields in TMPA V7 (top left), TMPA-RT V7 (top right), and IMERG V06 (bottom)

<b>3-hourly data file (3B42)</b>	
1	Multi-satellite precipitation
2	Multi-satellite precipitation error
3	Sat. obs. time
4	PMW precipitation
5	IR precipitation
6	Satellite source identifier
<b>Monthly data file (3B43)</b>	
1	Satellite-Gauge precipitation
2	Satellite-Gauge precipitation error
3	Gauge relative weighting

<b>Merged microwave data file (3B40RT)</b>	
1	Merged PMW precipitation
2	Merged PMW precipitation error
3	# pixels
4	# ambig. pixels
5	# rain pixels
6	PMW source identifier
<b>IR data file (3B41RT)</b>	
1	PMW-cal. IR precipitation
2	PMW-cal. IR precipitation error
3	# pixels
<b>Multi-satellite data file (3B42RT)</b>	
1	Calibrated precipitation
2	Calibrated precipitation error
3	Satellite source identifier
4	Uncalibrated precipitation

<b>Half-hourly data file (IMERG Early, Late, Final)</b>	
1	Calibrated multi-satellite precipitation
2	Uncalibrated multi-satellite precipitation
3	Calibrated multi-satellite precipitation error
4	PMW precipitation
5	PMW source identifier
6	PMW source time
7	IR precipitation

8	IR KF weight
9	Probability of liquid-phase precipitation
10	Quality Index
<b>Monthly data file (IMERG Final)</b>	
1	Satellite-Gauge precipitation
2	Satellite-Gauge precipitation error
3	Gauge relative weighting
4	Probability of liquid-phase precipitation
5	Quality Index