Read-me for Data Users

MEMORANDUM FOR: The Record
FROM: Patrick Meyers, GCOM Precipitation Team Lead
SUBJECT: GCOM Precipitation Rate/Type Validated maturity status and public release
DATE: 10/19/2016

Validated maturity status declaration for GCOM Precipitation Rate/Type
Maturity Review Date: **10/19/2016**
Effective Date: **mm/dd/yyyy**
Operational System: **GCOM-W1 AMSR2 Algorithm Software Processor, Version 2**

The JPSS Algorithm Maturity Readiness Review Board approved the release of the GCOM Precipitation Rate/Type to the public with a Validated maturity level quality as of mm/dd/yyyy (effective date), based on JPSS Validation Maturity Review held on 10/19/2016 (link to review artifacts).

1. Validated Maturity stage definition:
    - Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).
    - Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level.
    - Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.
    - Product is ready for operational use based on documented validation findings and user feedback.
    - Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.
    - More information at: http://www.star.nesdis.noaa.gov/jpss/AlgorithmMaturity.php

2. Algorithm Description

Overview

The Goddard Profiling Algorithm 2010 (GPROF) was originally developed for TMI (Gopalan et al. 2010; Kummerow et al. 2011; Meyers et al. 2015). The modular nature of GPROF allows the algorithm to be easily ported between different passive microwave imagers with comparable channels.

The GPROF ocean rain rate is derived from a Bayesian retrieval scheme, comparing observed AMSR2 brightness temperatures to an a-priori database of TMI and TRMM Precipitation Radar (PR) measurements. GPROF's observationally generated database improves upon previous Bayesian algorithms that relied on cloud resolving models and contained representiveness errors. TMI and AMSR2 observe at similar frequencies, allowing for portability between satellite platforms.

Rain rate retrievals over land are complicated by a dynamic and spatially variant surface emissivity, which precludes using a Bayesian inversion similar to the retrieval over oceans. Thus, an empirical approach dependent upon scattering of ice particles is necessary to calculate rain rates over land. First, each pixel is classified as raining / non-raining based on a series of screening procedures. Once a pixel has been determined to be raining, an empirically derived T89V – rain rate relationship is applied and combines the calculated contributions from stratiform and convective precipitation.

List of Products (Collection Short Name (CSN))

GCOM/AMSR2 Rain Rate

Product requirements (L1RDS)

Attribute	Threshold	Observed/validated
Applicable conditions		Delivered under "all weather" conditions
Horizontal cell size	5 km land (89 GHz FOV); 10 km ocean (37 GHz FOV size); 5-10 km sampling	5.0 km (land); 10 km (ocean)
Mapping uncertainty	< 5 km	~2.5 km
Measurement range	0 – 50 mm/hr	0 – 75 mm/hr
Measurement precision	0.05 mm/hr	0.01 mm/hr
Measurement uncertainty	2 mm/hr over ocean; 5 mm/hr over land	1.3 mm/hr (ocean) 3.6 mm/hr (land)
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)	91% every 20 h
Precipitation type	Stratiform or convective	Convective rain rate
Latency	25 minutes	8 minutes

EDR File Content Description

Variable	Type	Description	Dim	Units	Range
Across_Scan_High_Resolution	Short	FOV count across scan for High Resolution field	486	N/A	1-486
Across_Scan_Low_Resolution	Short	FOV count across scan for Low Resolution field	243	N/A	1-243
Along_Scan	Short	Scan count along scan	3960**Error!**	N/A	1-360

			Bookmark not defined.Error! Bookmark not defined.		
Earth_Azimuth_Angle	Float	Earth Azimuth Angle	3960**Error! Bookmark not defined.Error! Bookmark not defined.** x 243	Deg	-180.0 – 180.0
Earth_Incidence_Angle	Float	Earth Incidence Angle	3960**Error! Bookmark not defined.Error! Bookmark not defined.** x 243	Deg	-180.0 – 180.0
Latitude_ for_High_Resolution	Float	Latitude for the 89.0GHz-A channel's field of view	3960**Error! Bookmark not defined.** x 486	Deg	-90.0 – 90.0
Latitude_ for_Low_Resolution	Float	Latitude for the 89.0GHz-A channel's field of view thinned to just the odd values	3960**Error! Bookmark not defined.Error! Bookmark not defined.** x 243	Deg	-90.0 – 90.0
Longitude_ for_High_Resolution	Float	Longitude for the 89.0GHz-A channel's field of view	3960**Error! Bookmark not defined.**x 486	Deg	-180.0 – 180.0
Longitude_ for_Low_Resolution	Float	Longitude for the 89.0GHz-A channel's field of view thinned to just the odd values	3960**Error! Bookmark not defined.** x 243	Deg	-180.0 – 180.0
Probability_of_Precip	Float	Probability of Precipitation	3960**Error! Bookmark not defined.** x 486	%	0 – 100
QM_Avg_Rain_Land_Amt	Float	Quality Monitoring:	1	mm/hr	0 – 100
QM_Avg_Rain_Ocean_Amt	Float	Quality Monitoring:	1	mm/hr	0 – 100
QM_Cond_Rain_Land_Amt	Float	Quality Monitoring:	1	mm/hr	0 – 100
QM_Cond_Rain_Ocean_Amt	Float	Quality Monitoring:	1	mm/hr	0 – 100
QM_Num_Ambig_Land	Long	Quality Monitoring:	1	N/A	0-3960**Error! Bookmark not defined.**
QM_Num_Ambig_Ocean	Long	Quality Monitoring:	1	N/A	0-

					3960**Error! Bookmark not defined.**
QM_Num_Flagged_Land	Long	Quality Monitoring:	1	N/A	0-3960**Error! Bookmark not defined.**
QM_Num_Flagged_Ocean	Long	Quality Monitoring:	1	N/A	0-3960**Error! Bookmark not defined.**
QM_Num_Good_Land	Long	Quality Monitoring:	1	N/A	0-3960**Error! Bookmark not defined.**
QM_Num_Good_Ocean	Long	Quality Monitoring:	1	N/A	0-3960**Error! Bookmark not defined.**
QM_Num_Land_Pixels	Long	Quality Monitoring:	1	N/A	0-3960**Error! Bookmark not defined.**
QM_Num_Missing	Long	Quality Monitoring:	1	N/A	0-3960**Error! Bookmark not defined.**
QM_Num_Ocean_Pixels	Long	Quality Monitoring:	1	N/A	0-3960**Error! Bookmark not defined.**
QM_Num_Rain_Land_Pixels	Long	Quality Monitoring:	1	N/A	0-3960**Error! Bookmark not defined.**
QM_Num_Rain_Ocean_Pixels	Long	Quality Monitoring:	1	N/A	0-3960**Error! Bookmark not**

					defined.
QM_Sum_Rain_Land_Pixels	Float	Quality Monitoring:	1	mm/hr	0 – 1000000
QM_Sum_Rain_Ocean_Pixels	Float	Quality Monitoring:	1	mm/hr	0 – 1000000
Rain_Rate	Float	Surface rain rate	3960**Error! Bookmark not defined.** x 486	mm/hr	0 – 100
Rain_Rate_QC_Flag	Byte	Flag denoting precipitation quality flag	3960**Error! Bookmark not defined.**x 486	N/A	0 – 2
Scan_Angle	Float	Scan Angle	3960**Error! Bookmark not defined.**x 243	Deg	46.5 – 48.5
Scan_Time	Float	Scan line Start Time 6-D for (YYYY, MM, DD, HH, MM, SS.SSS)	3960**Error! Bookmark not defined.**x 6	GMT	YYYY = 2012 – 2032 MM = 1-12 DD = 1-31 HH = 0-23 MM = 0-59 SS = 0-59 .SSS = 000-999
convectPrecipitation	Float	Rain rate of convective clouds	3960**Error! Bookmark not defined.** x 486	mm/hr	0 – 100
surfaceType	Byte	Surface Type (Land, Coast, Ocean)	3960**Error! Bookmark not defined.** x 486	N/A	10 – 42

Quality flags

Value	Meaning
0	No quality issues
1	Over ocean: Extended bin search to reach minimum threshold of profiles for inversion. Over coast: Not confident in retrieval. Over land: Ambiguous cold temperature that could be surface emission or rainfall
2	Over ocean: Sea ice expected. Over land: climatological snow or desert; Tb screening for ambiguous cold surface, possible arid land, or snow contamination.

Product evaluation/validation

i. Global Precipitation Climatology Center (GPCC) Rain Gauges

The GPCC global network of rain gauges provides a ground-based system to validate GPROF retrievals (Schneider et al. 2011). Gauge estimates were compared to AMSR2 monthly rain retrievals from GPROF. Monthly estimates of rainfall from gauges were accumulated on a

2.5° x 2.5° grid for January to June 2013. Grid boxes with fewer than five gauges were removed from the sample. Observations were highly concentrated over the United States, Western Europe, the East Asia, and coastal Australia, with sparse observations through much of South America, Africa, and Central Asia. GPROF accurately diagnosed global rain patterns (Figure 1), with root mean-square error (RMSE) of 1.7 mm·day^{-1} (Figure 2). There was not an observed annual cycle in GPROF accuracy when compared to the tropical and subtropical GPCC gauges.

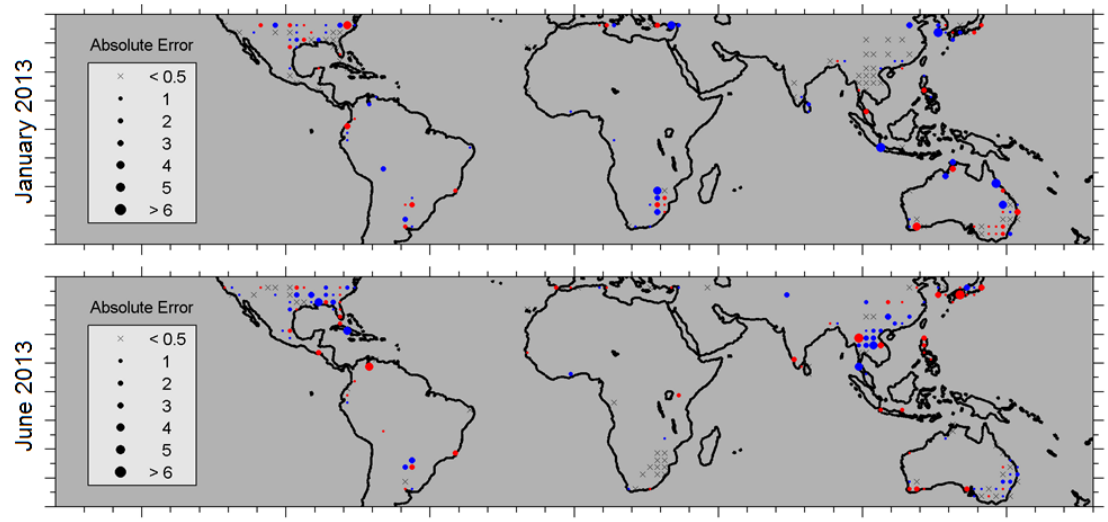

Figure 1: Overestimation (red) and underestimation (blue) of monthly accumulations of AMSR2 GPROF retrievals relative to monthly average GPCC measurements for January (top) and June (bottom) 2013.

ii. Global Precipitation Climatology Project (GPCP) Monthly Analysis

The GPCP Version 2.2 Combined Precipitation Set merges monthly rain estimates from the GPCC gauge network and microwave and infrared satellites (Adler et al. 2003; Huffman et al. 2009). GPCP rain rate measurements reduce regime-based systematic errors in satellite retrievals, such as in snowy regions. GPCP analysis provide global climate data to validate GPROF retrievals on monthly timescales (Figure 3). GPROF performed well in convective regimes, including over South America and Africa. It accurately identified the spatial extent of precipitation and locations of local maxima and minima. A persistent problem with microwave retrievals is overestimation of rainfall over Africa and underestimation over South America. Screening updates in GPROF enhanced summer rainfall totals South America, bringing measurements closer to GPCP analysis. A similar increase to rainfall occurred over India during the summer monsoon season. Over the oceans, GPROF identifies the ITCZ and mid-latitude cyclone tracks. The comparisons shown here were derived from GPROF for AMSR-E.

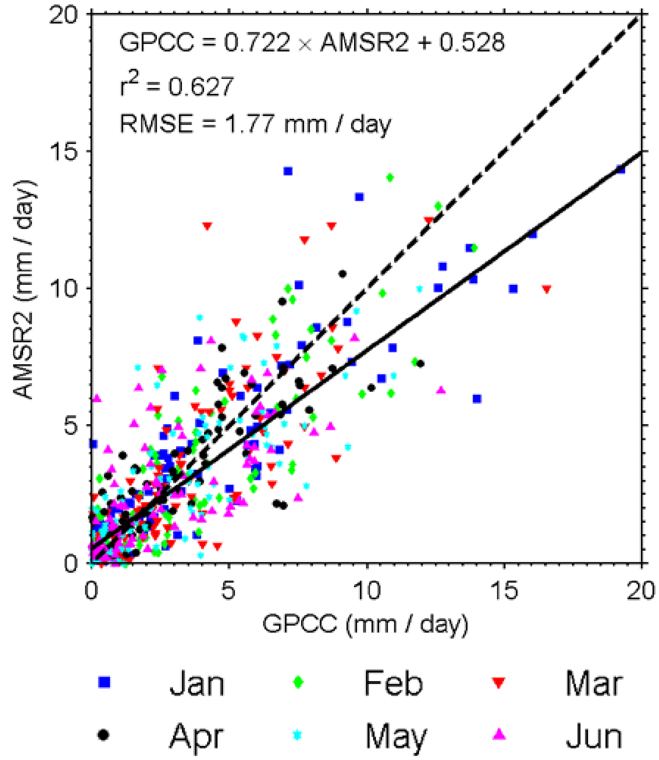

Figure 2: Comparison of GPCC and GPROF/AMSR2 monthly rain estimates for January to June 2013.

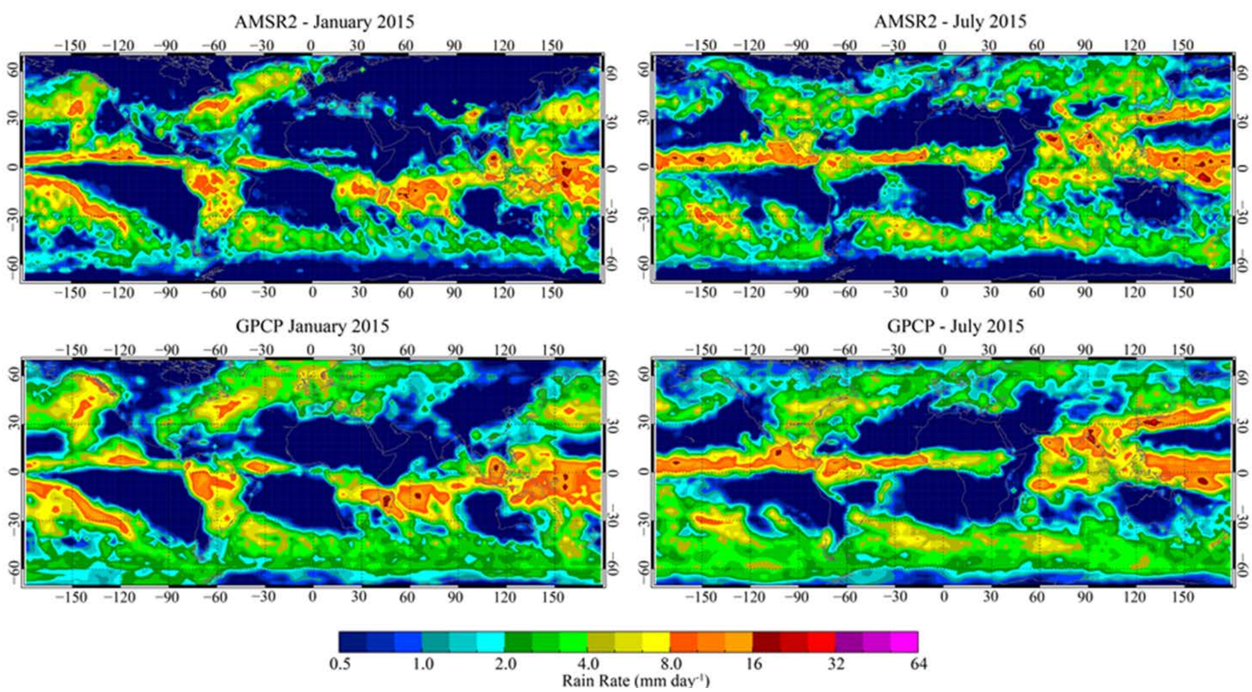

Figure 3: Comparison of GPCP monthly rain rate (bottom) and corresponding GPROF retrievals (top) for AMSR2 in January (Left) and July (Right) 2015.

iii.Tropical Rainfall Measurement Mission (TRMM) Comparisons

Given the lack of direct precipitation measurements over the open-ocean, satellite measurements drive the validation over ocean. The low-inclination orbit of TRMM allows for overlapping observations from the TMI and AMSR2 microwave imagers daily in the tropics. A previous version of GPROF is the operational algorithm for NASA's 2A12 Hydrometeor Profile product for TMI. Comparisons of collocated TMI and AMSR2 rain rate estimates (1 km, ± 30 minutes) show general agreement and similar histograms of rain rate distributions (Figure 4). Additionally, zonal means of TMPA, TMI, and AMSR2 show strong agreement between observational systems (Figure 5).

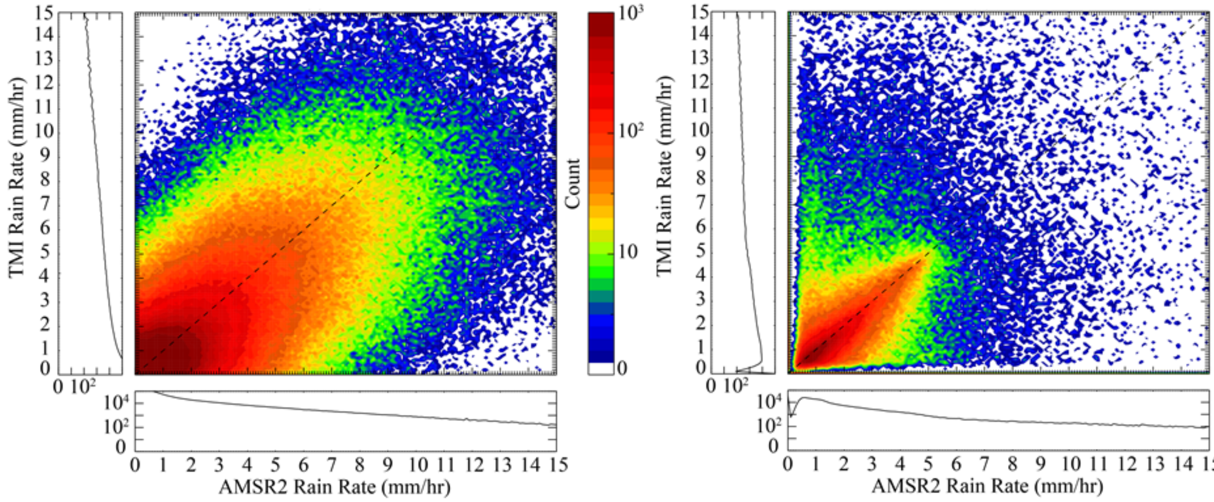

Figure 4: Density plot of collocated instantaneous rain rate estimates for TMI and AMSR2 for ocean (left) and land (right). Histograms along the axes show the rain rate distribution for each sensor. The root mean squared error is 1.3 mm/hr over ocean and 3.6 mm/hr over land.

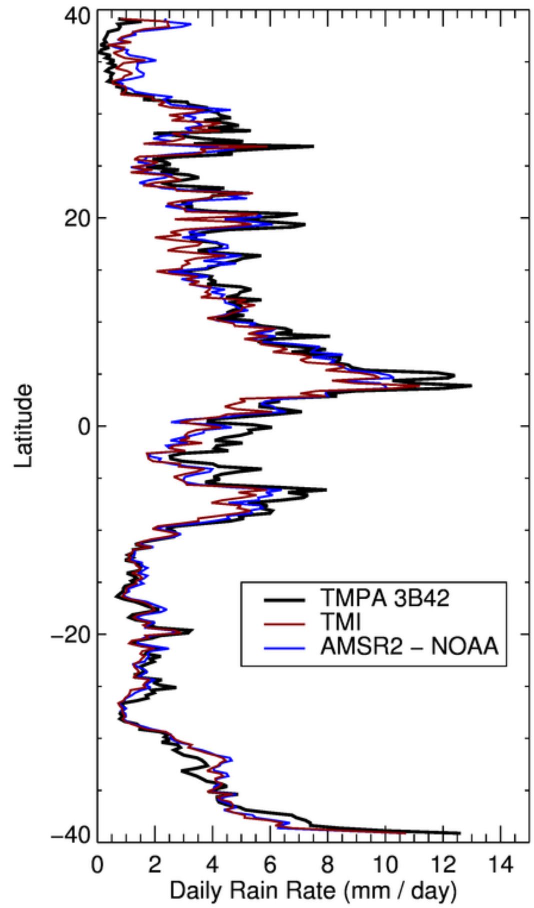

Figure 5: Zonal mean of collocated rain rates for TMPA (black), TMI (red), and AMSR2 (blue) for all surface classes.

Product availability/reliability

AMSR2 Precipitation EDR data were produced since mm/dd/yyyy. Routine product monitoring is available from OSPO: http://www.ospo.noaa.gov/Products/atmosphere/gpds/. Data is archived by the GCOM science team, and there is a 1-month archive of precipitation data available with authorization from http://manati.star.nesdis.noaa.gov/gcom/datasets/GCOM2Data.php.

Algorithm performance dependence

GPROF requires recent Reynolds sea surface temperature data for the ocean rain rate retrieval. All other ancillary data is static.

Known errors/issues/limitations

It has been established that AMSR2 precipitation retrievals are deficient in winter regions with frequent snow cover. Surface snow has a similar radiometric signal to falling precipitation, and brightness temperature relationships are sometimes insufficient to separate the two regimes. Additionally, GPROF tends to produce sporadic light precipitation in cold regions for the nighttime (descending) overpass.

3. Changes since last maturity stage: N/A

4. Review board recommendations

5. Path Forward/Future Plan

Currently in GPROF, a monthly climatology of snow cover automatically screens regions where snow can be expected. An updated precipitation algorithm should include a dynamic snow screen that incorporates the latest snow cover information from the Interactive Multisensor Snow and Ice Mapping System (IMS). Using dynamic information will reduce over-flagging of ice-contaminated pixels and account for rare snow events.

The NASA GPM program introduced a new version of GPROF which performs a Bayesian retrieval globally. The algorithm is still undergoing testing, validation, and refinement. As part of the proposed task, GPROF2014 for AMSR2 will be evaluated relative to the current AMSR2 EDR to determine if it is advantageous to replace the NOAA operational AMSR2 precipitation algorithm in the future.

6. Additional Items to note

Additional information is available in the GCOM-W AMSR2 precipitation rate/type algorithm theoretical basis document (ATBD) and validation maturity review briefing, which can be accessed at: http://www.star.nesdis.noaa.gov/jpss/Docs.php

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