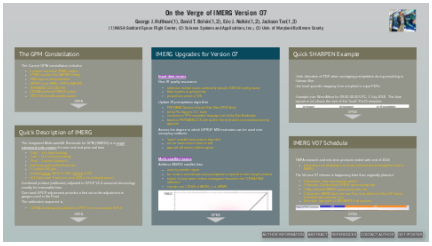
On the Verge of IMERG Version 07



George J. Huffman(1), David T. Bolvin(1,2), Eric J. Nelkin(1,2), Jackson Tan(1,3)

(1) NASA Goddard Space Flight Center; (2) Science Systems and Applications, Inc.; (3) Univ. of Maryland Baltimore County

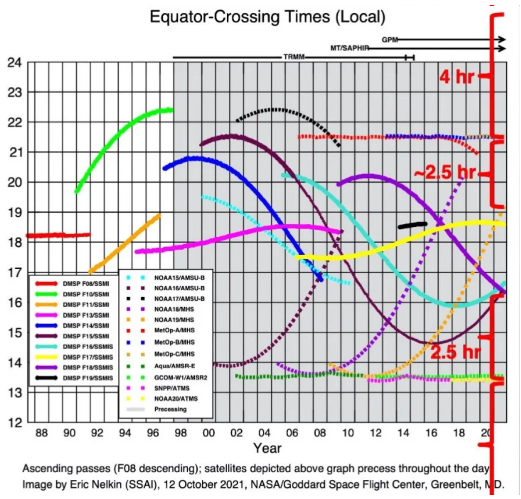
THE GPM CONSTELLATION

The Current GPM constellation includes

- 5 passive microwave (PMW) imagers
- 6 PMW sounders (but SAPHIR ending)
- PMW input as precip estimates
- GPROF (most PMW) + PRPS (SAPHIR)
- PERSIANN-CCS (GEO IR)
- CORRA (combined PMW-Ku radar)
- GPCP SG (monthly satellite-gauge)

Presently the interval between observations is < 3 hr >90% of the time, globally

- there are still significant gaps in coverage by the polar-orbit satellites
- the precessing satellites only occasionally fill these gaps
- the constellation is evolving
- the next challenge is coping with short-lived smallsats



Ascending passes (F08 descending); satellites depicted above graph precess throughout the day
Image by Eric Nelkin (SSAI), 12 October 2021, NASA/Goddard Space Flight Center, Greenbelt, MD.

QUICK DESCRIPTION OF IMERG

The Integrated Multi-satellitE Retrievals for GPM (IMERG) is a single integrated code system for near-real and post-real time

- "Early" – 4 hr (flash flooding)
- "Late" – 14 hr (crop forecasting)
- "Final" – 3 months (research)
- half-hourly and monthly (Final only)
- 0.1° global CED grid
- morphed precip, 60° N-S in V05, 90° N-S in V06
- all 3 (Early, Late, Final) cover June 2000 to the (delayed) present

Combined product (calibrator) adjusted to GPCP V2.3 seasonal climatology zonally for reasonable bias

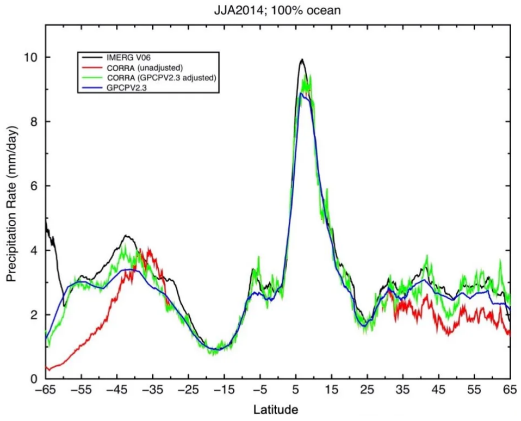
Over land GPCP adjustment provides a first cut at the adjustment to gauges used in the Final

The calibration sequence is

- CORRA climatologically calibrated to GPCP over ocean outside 30°N-S
- GMI calibrated to monthly CORRA
- GPM constellation climatologically calibrated to GMI

Adjustments working roughly as intended

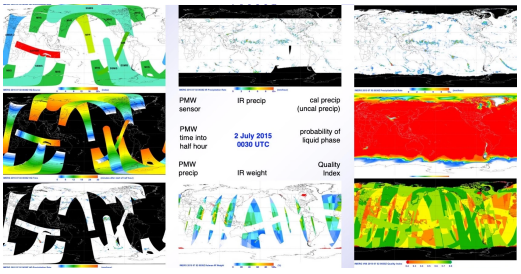
- CORRA is low at higher latitudes
- adjustments in Southern Ocean are large and need analysis
- IMERG subsetted to coincidence with CORRA is much closer to (adjusted) CORRA



D. Bolvin (SSAI; GSFC)

Data fields in IMERG

	V06 Half-hourly data file (Early, Late, Final)
1	[multi-sat.] precipitationCal
2	[multi-sat.] precipitationUncal
3	[multi-sat. precip] randomError
4	[PMW] HQprecipitation
5	[PMW] HQprecipSource [identifier]
6	[PMW] HQobservationTime
7	IRprecipitation
8	IRkalmanFilterWeight
9	[phase] probabilityLiquidPrecipitation
10	precipitationQualityIndex
	V06 Monthly data file (Final)
1	[sat.-gauge] precipitation
2	[sat.-gauge precip] randomError
3	GaugeRelativeWeighting
4	probabilityLiquidPrecipitation [phase]
5	precipitationQualityIndex



IMERG UPGRADES FOR VERSION 07

Input data issues

New IR quality assurance

- addresses multiple issues, particularly episodic GOES-W cooling issues
- likely requires on-going tuning
- pressed into service in V06

Update IR precipitation algorithm

- PERSIANN Dynamic Infrared–Rain Rate (PDIR-Now)
- led by Phu Nguyen, U.C. Irvine
- conversion to PPS-compatible language code led by Dan Braithwaite
- based on PERSIANN-CCS with another threshold and a new machine-learning approach

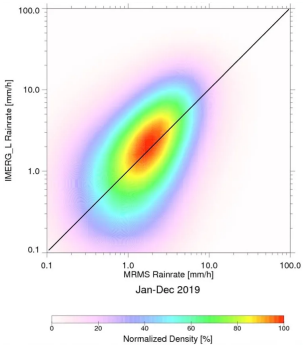
Assess the degree to which GPROF MW estimates can be used over snowy/icy surfaces

- "warm" snowfall cases seem to have skill
- sea ice cases seem to have no skill
- gaps will still exist in coldest regions

Multi-satellite issues

Address IMERG satellite bias

- varies by weather regime
- but, tends to overestimate mean precipitation compared to other merged products
- subject of (very) active, tedious investigation focused on the CORRA-PMW calibration
- example over CONUS of IMERG_L vs. MRMS



GPM GV Office

MW and IR precipitation limits raised to 200 mm/hour across the code

- currently 120 mm/hour and 50 mm/hour, respectively

Compute precipitation motion vectors using multiple numerical analysis fields

- improve behavior near orography
- Precipitation (PRECTOT) ➔ Total Precipitable Liquid Water (TQL) ➔ Total Precipitable Water Vapor (TQV)
- V06 was just TQV

Change some variable names

- intended to reduce confusion
- yes, this will break some current code; sorry!
- SHARPEN changes meaning of IRWeight

	V07 Half-hourly data file (Early, Late, Final)
1	*[multi-sat.] precipitation~~Cal~~*
2	[multi-sat.] precipitationUncal
3	*[multi-sat. precip] randomError*
4	[PMW] ~~HQ~~MWprecipitation
5	[PMW] ~~HQ~~MWprecipSource [identifier]
6	[PMW] ~~HQ~~MWobservationTime
7	IRprecipitation
8	IR~~influencekalmanFilterWeight~~
9	*[phase] probabilityLiquidPrecipitation*
10	*precipitationQualityIndex*
	V07 Monthly data file (Final)
1	*[sat.-gauge] precipitation*
2	*[sat.-gauge precip] randomError*
3	GaugeRelativeWeighting
4	*probabilityLiquidPrecipitation [phase]*
5	*precipitationQualityIndex*

Modify selection of the (single) satellite used when there are multiple PMW estimates for a given time/grid box

- Yalei You's work showed that conical "imagers" out-perform cross-track "sounders" over ocean

Run Kalman Filter on PMW overpasses

- even with SHARPEN (see top right box), using PMW overpasses "as is" causes ripples in the animations
- skill measures are maintained or modestly improved

Address averaging effects on PDF of precipitation introduced by Kalman Filter

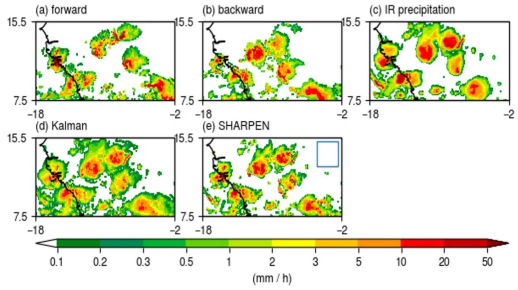
- Ed Zipser and Mani Rajagopal showed increased occurrence of rain and reduced maximum values in morphed values (*JHM*, 2021, doi:10.1175/JHM-D-20-0226.1)
- Scheme for Histogram Adjustment with Ranked Precipitation Estimates in the Neighborhood (SHARPEN) (*JHM*, 2021, doi:10.1175/JHM-D-20-0225.1)
- see the top right panel for more information and the poster https://agu.confex.com/agu/fm21/meetingapp.cgi/Paper/829783 (https://gcc02.safelinks.protection.outlook.com/?url=https%3A%2F%2Fagu.confex.com%2Fagu%2Ffm21%2Fmeetingapp.cgi%2FPaper%2F829783&data=04%7C01%7Cgeorge.j.huffman%40nasa.gov%7C3c2f3f4bf77a4d2b73ef08d9b8ba8fcb%7C7005d45845be48ae8140d43da96dd17b%7C0%7C0%7C637743933672455130%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLC%3D%7C3000&sdata=QUc%2BMOq%2Bw3B6c1htDB6mALNv4EjzVRDtV4wtNpKYHxg%3D&reserved=0)

QUICK SHARPEN EXAMPLE

Undo distortion of PDF when averaging precipitation during morphing in Kalman filter

Use local quantile mapping from morphed to input PDFs

Example over West Africa for 00:00-00:30 UTC, 1 July 2018. The blue square in (e) shows the size of the "local" 25x25 template.



J. Tan (UMBC)

The datasets input to the Kalman filter have similar PDFs (top row)

The Kalman-filtered result (d) has larger coverage, lower maximum rates because it's a weighted average

The SHARPEN'ed precipitation PDF (e) is closer to the input precipitation PDFs

For more information, see https://agu.confex.com/agu/fm21/meetingapp.cgi/Paper/829783 (https://gcc02.safelinks.protection.outlook.com/?url=https%3A%2F%2Fagu.confex.com%2Fagu%2Ffm21%2Fmeetingapp.cgi%2FPaper%2F829783&data=04%7C01%7Cgeorge.j.huffman%40nasa.gov%7C3c2f3f4bf77a4d2b73ef08d9b8ba8fcb%7C7005d45845be48ae8140d43da96dd17b%7C0%7C0%7C637743933672455130%7CUnknown%7CTWFpbGZs%3D%7C3000&sdata=QUc%2BMOq%2Bw3B6c1htDB6mALNv4EjzVRDtV4wtNpKYHxg%3D&reserved=0)

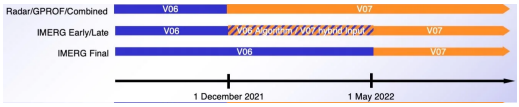
IMERG V07 SCHEDULE

TMPA research and real-time products ended with end of 2019

- the products are still getting a lot of use, but users are encouraged to move to IMERG

The Version 07 release is happening later than originally planned

- 6 December: radar reprocessings started
- 1 February: Combined and GPROF reprocessings start
- 1 May (notional): IMERG reprocessing starts, but
- 1 December: IMERG Early and Late Runs must shift from V06 to V07 hybrid Combined near-real-time input
- November: last month of V06 IMERG Final products



AUTHOR INFORMATION

After a B.S. in Physics at The Ohio State University (1976) and a Ph.D. in Meteorology at Massachusetts Institute of Technology (1982), Dr. Huffman was an Assistant Professor at University of Maryland, College Park, then moved to NASA Goddard Space Flight Center (GSFC) in 1988, where he consulted until entering government service in 2012, now as a Research Physical Scientist. Dr. Huffman focuses on combined (satellite-gauge) estimates of global precipitation. The resulting data sets include the Global Precipitation Climatology Project (GPCP) monthly and daily products (a contribution to the World Climate Research Program, WCRP); the NASA Tropical Rainfall Measuring Mission (TRMM) Multi-satellite Precipitation Analysis; and the NASA Global Precipitation Measurements (GPM) mission's Integrated Multi-satellitE Retrievals for GPM. Allied work includes estimating errors and extreme precipitation event statistics. Dr. Huffman is the Deputy Project Scientist for GPM, and the GPM Multi-satellite Algorithm Team lead. He has 145 publications, 15 as first author, and numerous presentations. As well, he is the Chief for the Mesoscale Atmospheric Processes Lab at GSFC. Recent awards include NASA/GSFC Robert H. Goddard Group Honor Award for Science, 2019; Fellow of the American Meteorological Society, 2019; and NASA Exceptional Service Medal, 2018.

ABSTRACT

Development is well-advanced for the next version of the Integrated Multi-satellitE Retrievals for the Global Precipitation Measurement (GPM) mission (IMERG), labeled Version 07. IMERG is a key output of the U.S. GPM Science Team, and V07 will be the second generation in which data from both the Tropical Rainfall Measuring Mission (TRMM) and GPM projects are combined into a single, uniformly processed record, currently starting in June 2000. This presentation will show several examples of successes and challenges in V06, and use these to illuminate the upgrades that have been pursued for V07. For example, the V06 IMERG near-real-time products (Early and Late Runs) show regional biases because they do not have climatological calibration (despite the documentation), and this will be done in V07. As well, the time series of precipitation-rate histograms shows a seam in the transition from TRMM calibration to GPM Core Observatory calibration at the start of June 2014. V07 will benefit from better continuity in the input calibration datasets across that boundary. A third issue is that the Kalman filter used in IMERG a) introduces a variable amount of smoothing, and b) depends on relatively simple measures of input data quality. Both of these are revisited in V07.

We will report the status of IMERG Version 07 processing as of the conference time, and introduce some topics that are being considered for the future, including improved uncertainty estimates, addition of sub-monthly gauge information, and strategies for incorporating precipitation estimates from multiple, relatively short-lived small satellites.

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