The latest Global Precipitation Climatology Project (GPCP) Daily and Monthly products (Version 3.2): Summary and Comparisons

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INTRODUCTION

The Global Precipitation Climatology Project (GPCP) products address the need for long-term precipitation products that emphasize homogeneity, following Climate Data Record (CDR) principles. Version 3.2 is the latest successor to both Version 2.3 Monthly and 1.3 Daily.

BUILDING THE NEW GPCP V3 *MONTHLY* DATASET

Summary of Upgrades from V2.3 Monthly to V3.2

- spatial grid improved from 2.5º to 0.5º
- Used recent satellite/mission capabilities (e.g., CloudSat, TRMM, GPM) to improve the product.
- consistent GEO-IR Tb datasets, expand area of use from 40ºN-S to 58ºN-S
- upgraded PMW (GPROF) and IR (PERSIANN-CDR) algorithms
- consistent AIRS-IR record
- shifted AIRS-to-TOVS calibration to improved TOVS-to-AIRS-IR
- added modern climatological calibrators (TCC over 20ºN-S, MCTG outside 35ºN-S, blended cross-over in between)
- new data fields: probability of liquid phase, Gauge Relative Weighting, Quality Index
- substitute climatological Fuchs gauge undercatch coefficients for Legates-Wilmott over Eurasia above 45ºN, using insights from GRACE (Behrangi et al. 2018).

To provide a CDR-like data set, we still prioritize

- consistent inputs
- careful inter-sensor calibration
- consistent processing over the entire record

BUILDING THE NEW GPCP V3 *DAILY* DATASET

The inputs are:

- Integrated Multi-satellitE Retrievals for GPM (IMERG)
- TOVS, AIRS-IR daily: Susskind cloud volume algorithm
- GPCP V3.2 Monthly

Approach:

- average IMERG Final (originally 0.1º, ½ hr) up to 0.5º daily
- histogram-calibrate TOVS, AIRS-IR to IMERG
- use IMERG in the band 55ºN-S and IMERG-calibrated TOVS/AIRS at higher latitudes
  - this is done for simplicity; future versions will extend to more latitudes
- "feather" the IMERG-AIRS difference just outside 55º to reduce seams
- scale the Daily to (approximately) sum to the Monthly product
- compute daily average of precipitation-weighted probability of liquid phase

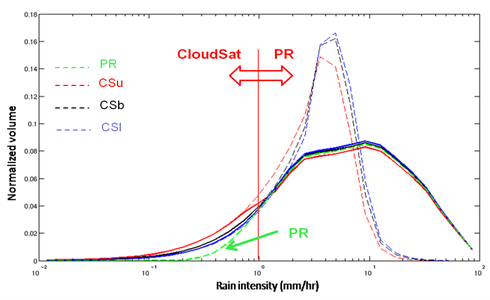
Period of record is June 2000 – December 2020 (currently)

(a) MONTHLY, (b) DAILY DATA FIELDS IN V3.2

a Monthly Data Field	Units/Indexing
merged satellite-gauge precipitation estimate	mm/d
merged satellite-gauge precipitation random error estimate	mm/d
satellite-only precipitation estimate	mm/d
satellite source field	IR = 0, IR/TOVS/AIRS blend = 2, TOVS/AIRS = 4
undercatch-corrected gauge analysis precipitation	mm/d
probability of liquid phase	%
gauge relative weighting	
quality index	
b Daily Data Field	**Units**
merged satellite-gauge precipitation estimate	mm/d
probability of liquid phase	%

The Merged CloudSat-TRMM-GPM (MCTG) to adjust oceanic precipitation rate

The heritage goes back to the Merged CloudSat TRMM AMSR-E (MCTA; Behrangi et al. 2014)
More recently we developed the Merged CloudSat TRMM, GPM over ocean (MCTG; Behrangi and Song 2020)



- The concept: Building on the strength of CloudSat for precipitation detection, the light precipitation captured by CloudSat is merged with the intense precipitation from TRMM/ GPM precipitation.
- MCTG is used for monthly adjustment of GPCP over the oceans.

RESULTS AND FINDINGS

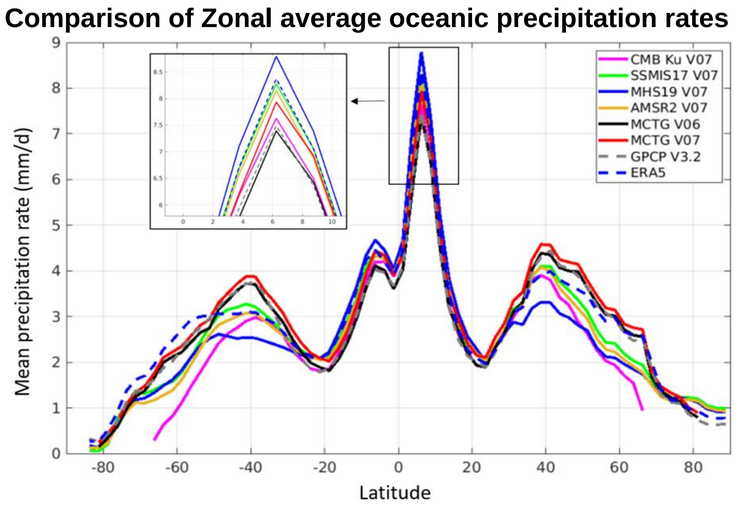
V3.2 CLIMATOLOGY STUDIES (1983-2020)

	Ocean			Land			Global		
GPCP	V3.2	V2.3	% change compared to V2.3	V3.2	V2.3	% change compared to V2.3	V3.2	V2.3	% change compared to V2.3
25°N-25°S	3.35	3.17	5.68	3.45	3.47	-0.58	3.38	3.25	4.00
60°N-60°S	3.26	3.05	6.89	2.52	2.54	-0.79	3.05	2.90	5.17
90°N-90°S	3.09	2.90	6.55	2.21	2.24	-1.34	2.81	2.69	4.46

Comparison of GPCP V3.2 and V2.3 for mean precipitation rate (mm/day) (1983-2020)

- global increase approximates recommendation of data assessment studies

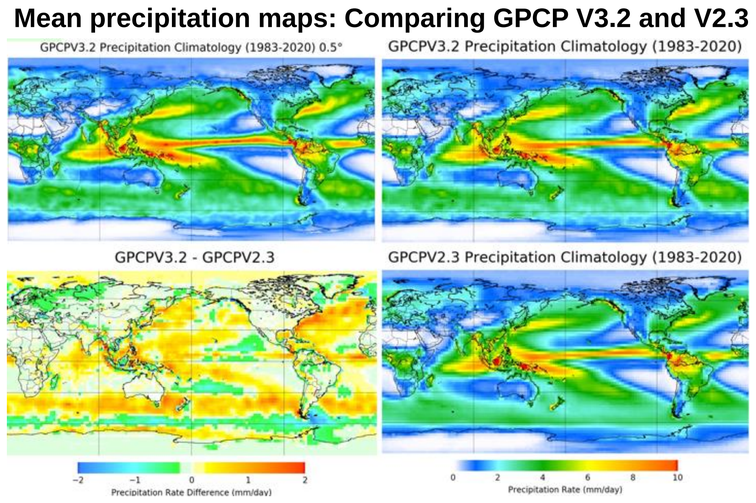
Comparison of Zonal average oceanic precipitation rates



Global/regional summary of products mean precipitation rates:

	Mean Oceanic precipitation (mm/d)				Relative change to previous version (%)				Relative change to MCTG V7 (%)		
	90º S/N	81º S/N	65º S/N	25º S/N	90º S/N	81º S/N	65º S/N	25º S/N	81º S/N	65º S/N	25º S/N
MCTG V7 *		**3.38**	**3.51**	**3.79**		**4.00**	**4.15**	**5.57**	**0.00**	**0.00**	**0.00**
MCTG V6 *		3.25	3.37	3.59					-3.85	-3.99	-5.28
CMB V7			**3.02**	**3.59**			**9.03**	**6.21**		**-13.96**	**-5.28**
CMB V6			2.77	3.38						-21.08	-10.82
GMI V7			**3.27**	**3.80**			**12.76**	**7.95**		**-6.84**	**0.26**
GMI V5			2.90	3.52						-17.38	-7.12
DPR V7			**2.62**	**3.15**			**-8.07**	**-9.48**		**-25.36**	**-16.89**
DPR V6			2.85	3.48						-18.80	-8.18
SSMIS V7	**3.21**	**3.23**	**3.34**	**3.90**	**18.01**	**17.88**	**15.97**	**10.48**	**-4.44**	**-4.84**	**2.90**
SSMIS V5	2.72	2.74	2.88	3.53					-18.93	-17.95	-6.86
MHS V7	**3.11**	**3.13**	**3.24**	**4.09**	**14.76**	**14.65**	**13.29**	**19.24**	**-7.40**	**-7.69**	**7.92**
MHS V5	2.71	2.73	2.86	3.43					-19.23	-18.52	-9.50
ATMS V7	**3.01**	**3.02**	**3.14**	**3.96**	**11.90**	**11.85**	**10.56**	**18.92**	**-10.65**	**-10.54**	**4.49**
ATMS V5	2.69	2.70	2.84	3.33					-20.12	-19.09	-12.14
AMSR2 V7	**3.11**	**3.13**	**3.25**	**3.83**	**12.68**	**12.59**	**11.68**	**8.19**	**-7.40**	**-7.41**	**1.06**
AMSR2 V5	2.76	2.78	2.91	3.54					-17.75	-17.09	-6.60
GPCP V3.2	**3.15**	**3.16**	**3.28**	**3.49**	**6.78**	**6.76**	**7.19**	**6.08**	**-6.51**	**-6.55**	**-7.92**
GPCP V2.3	2.95	2.96	3.06	3.29					-12.43	-12.82	-13.19
ERA5	**3.28**	**3.30**	**3.41**	**3.89**					-2.37	-2.85	2.64
GPM V07 μ:	3.11	3.13	3.13	3.76							
GPM V07 σ:	0.07	0.07	0.23	0.29							
μ -1σ:	3.04	3.06	2.90	3.47							
μ +1σ:	3.18	3.20	3.36	4.05							
μ -2σ:	2.97	2.99	2.67	3.18							
μ +2σ:	3.25	3.27	3.59	4.34							

Mean precipitation maps: Comparing GPCP V3.2 and V2.3



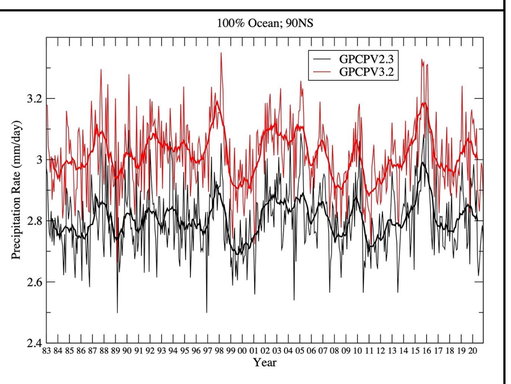
Gauges tend to dominate land areas in both V2.3 and V3.2
V3.2 tends to be higher over oceans

- largest increases in storm tracks
- decrease around 60ºS in V3.2 improves a perceived V2.3 issue
- increase in polar regions driven by CloudSat (in MCTG)

Full-resolution V3.2 (top left) has artifacts due to the IR in the Indian and Atlantic Oceans

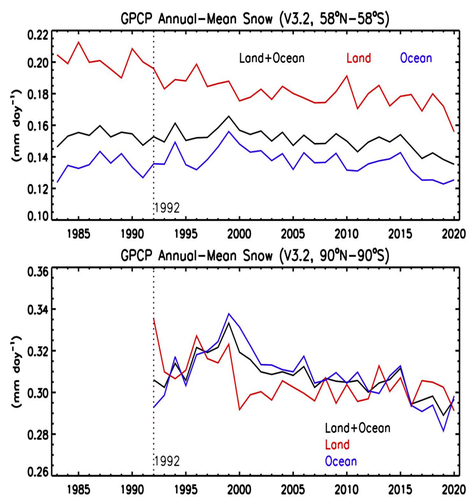
Time series variations in V3.2 and V2.3 global ocean average largely match

- interannual variation in the tropics is governed by METH in both
- calibration by TCC and MCTG sets the mean increase in V3.2



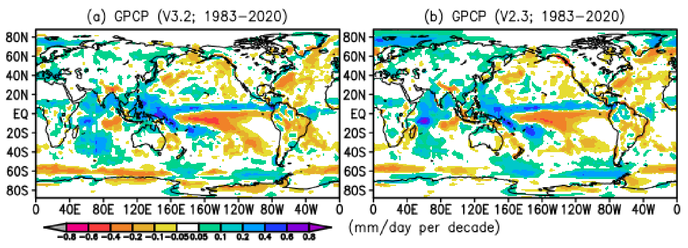
Time series of the global-average estimated snowfall for (top) 58°N-S (1983-2020), and (bottom) 90°N-S (1992-2020, due to dataset limitations)

- general downward trend over land, as expected due to global warming
- oceans increase to 2000, then decrease
- land shows a downward shift at 2000 when the polar regions are included (bottom)
- the V3.2 Daily shows the same trending (starting in mid-2000, of course), but with lower average rates



V3.2 trend pattern and magnitude are very close to V2.3 trends, but subtle differences exist

- Near-zero global trend, but significant regional trends
- ITCZ, W. Pacific, Indian Ocean increase; S. Pacific and mid-latitude storm tracks decrease



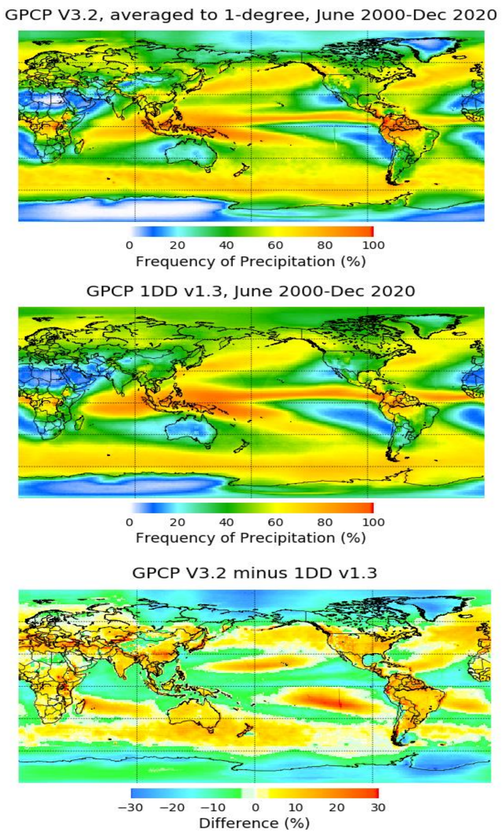
Daily product frequencies of occurrence differ

- V3.2 averaged to 1º to match V1.3 resolution
- V3.2 higher(lower) over ocean for lower(higher) values
- V3.2 mostly higher over land
- V3.2 lower in polar regions

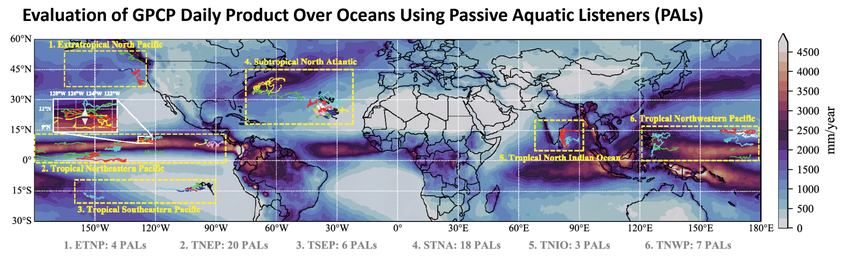
Algorithm differences matter

- IMERG has 48 samples/day, V1.3 IR has 8, TOVS/AIRS has 2-4
- both V3.2, V1.3 use daily (somewhat different) TOVS/AIRS in "high latitudes" with occurrence calibrated to the "low latitudes" at a mid-latitude point

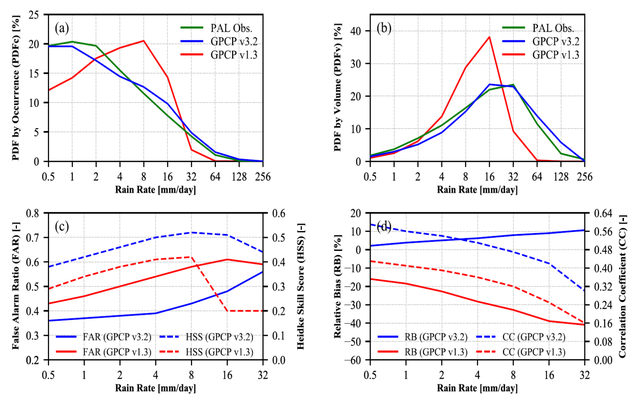
- the low latitude edge is 55º(40º)N,S for V3.2(V1.3)
- both are highly approximate
- AVHRR-based retrievals will be considered



Evaluation of GPCP Daily Product Over Oceans Using Passive Aquatic Listeners (PALs)



Comparison of (a) probability distribution function by occurrence (PDFc), (b) probability distribution function by volume (PDFv), (c) rainfall detection skills (false alarm ratio and Heidke skill score), and (d) estimation metrics (relative bias and correlation coefficient) as a function of daily rainfall intensity for Global Precipitation Climatology Project products. From Li et al. (2023)



- GPCP v3.2 shows substantial improvements in representing rain occurrence and rain intensity at daily scale.
- The results also highlight the challenge of precipitation measurement over certain regions such as the tropical Southeastern Pacific and extratropical North Pacific, compared to PAL observations.

FINAL COMMENTS, UPCOMING WORK, AND ACKNOWLEDGMENTS

GPCP Version 3.2 is designed for

- new satellite retrievals
- higher user expectations
- upgrades in dataset formats and archiving
- continued CDR standards
- consistency: submonthly (approximately) add up to the monthly values

GPCP has been funded for 5 more years under the 2022 MEaSUREs program, and will focus on:

- consistency and accuracy , by improving satellite and gauge analyses
- extending Daily back to 1983
- shifting to 0.1° resolution (from 0.5° in GPCP V3.2)
- shifting to 2-week latency using UCSB Climate Hazards Center (CHC) gauge analyses

Monthly and daily datasets are posted at NASA GES DISC

- V3.2 monthly DOI: *10.5067/MEASURES/GPCP/DATA304*
- V3.2 daily DOI: *10.5067/MEASURES/GPCP/DATA305*
- landing pages give access to data and documentation
- interactive analysis available through *https://giovanni.gsfc.nasa.gov/giovanni/*

Acknowledgments

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Reference:

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