Global Precipitation Climatology Project (GPCP)

The GPCP Climate Data Record (CDR)--Global Precipitation Monitoring and Trends

GPCP is a NOAA NCEI CDR generated at UMD (gpcp.umd.edu) and is also an international (WCRP/GEWEX) collaborative effort.

Robert Adler
Jian-Jian Wang, Guojun Gu (University of Maryland)
George Huffman (NASA Goddard Space Flight Center)
Ralph Ferraro (NOAA/NESDIS), Ping-Ping Xie (NOAA/NCEP), Long Chiu (GMU)
Udo Schneider and Andreas Becker (GPCC), Ali Behrangi (U. of Arizona)

Adler et al., 2017 Rev. Geophysics
Adler et al., 2018 Atmosphere
GPCP Climatology (1979-2018)  2.5º Lat./Long

Over ocean satellite-based estimates are critical

Over land gauges (adjusted for undercatch) dominate

40N-40S Ocean: Passive microwave from low-orbit (i.e., SSMI/SSMIS using METH/GMU algorithm) drives satellite estimates; Geo-IR estimates are used for diurnal adjustments and sampling

Tropics/Mid-latitude Land: Passive microwave from low-orbit (again SSMI/SSMIS using Ferraro algorithm) is combined with gauge analysis; gauges dominate where dense

Higher latitudes: Estimates from TOVS/AIRS sounders blended with gauges

Overall Quality: Very good, but with weaknesses...in polar regions, absolute value of satellite estimates over ocean, gauge undercatch estimates.

New version with improvements being developed (finer resolution, modern algorithms, TRMM/GPM/CloudSat data).
GPCP USAGE

Google Scholar search for “GPCP”: **16,300** (1310 in 2018)
Total Journal Citations for GPCP Products: **4925**

**GPCP MONTHLY**
Huffman et al., 1997: The Global Precipitation Climatology Project (GPCP) Combined Precipitation Dataset. *BAMS*  
Web of Science Citations: 223
Web of Science Citations: 2820
Huffman et al., 2009: Improving the global precipitation record: GPCP Version 2.1. *GRL*  
Web of Science Citations: 545
Web of Science Citations: 32

**GPCP PENTAD**
Web of Science Citations: 223

**GPCP DAILY**
Huffman et al., 2001: Global Precipitation at One-Degree Daily Resolution from Multi-Satellite Observations. *J. Hydrometeor.*  
Web of Science Citations: 1082

*From NCEI ftp log requests about 10 downloads a month for each of GPCP Monthly and Daily data sets ~ 200 data set downloads a year*

Connections to other NCEI CDRs and other data sets: RSS SSMI/SSMIS T_b’s CDR; Ferraro land rainfall; PERSIANN CDR
October 2019
Interim CDR (ICDR) available ~10 days after end of month

Heavy rain and flooding across central Africa from west to east coasts.

Asian summer monsoon ending with positive rainfall anomalies across the Arabian Sea and southern India and generally drier than normal conditions across Indochina and the Philippines

Tropical cyclone rain effects evident over Japan and Gulf of Mexico along U.S. coast

Dry conditions over southwest U.S. and Australia associated with wildfires
Global Mean Annual Water Cycle

Global mean water fluxes (1,000 km$^3$/yr) at the start of the 21st century

- **GPCP Land**
  - Value (2.2 mm/d)
  - 71.2 ±7.1
  - 70.6 ±5.0
  - Best guess estimates from observations and data integrating models
  - When water balance is enforced, uncertainty decreases

- **GPCP Ocean**
  - Value (2.9 mm/d)
  - 46.7 ±19.1
  - 45.8 ±6.7

From Rodell et al., 2015  J. Clim.
### How do TRMM and GPM-based estimates fit with GPCP?

**Tropical Ocean Mean Rainfall Estimates (25N-25S)**

<table>
<thead>
<tr>
<th></th>
<th>Passive Microwave</th>
<th>Radar</th>
<th>Combined</th>
<th>Composite (mean of 1st three)</th>
<th>GPCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean 25N-25S</td>
<td>3.44</td>
<td>3.36</td>
<td>3.35</td>
<td>3.37</td>
<td>3.18</td>
</tr>
</tbody>
</table>

- TRMM and GPM tropical ocean estimates in concert, a little larger (~6%) than current GPCP, smaller differences in subtropics/mid-latitudes
- Differences vary spatially and seasonally
- So, the next version of GPCP will have larger tropical ocean mean estimates
CloudSat-based Estimates vs. GPCP
High Latitude Ocean

Zonal Means (Ocean)
2007-2010

Generally mid-high latitude GPCP mean ocean values “validated” by CloudSat, except for southern ocean features

CloudSat analysis and figure from Behrangi (U. of Arizona)
Surface Temp., Pacific Decadal Oscillation, ENSO, Volcanoes (1979-Present)

"Forcings" on Precipitation

(a) Global mean surface temperature

(b) PDO index

(c) Nino 3.4

(d) Global mean stratospheric aerosol optical thickness

TS

PDO (Pacific Decadal Oscillation)

ENSO

Volcanoes

El Chicon
Pinatubo

- Standard deviation (σ) is .03 mm/d (~ 1%)
- Trend is slightly positive [.01 mm/d/decade; 1.3%/K] (larger over tropical ocean), sensitive to length of record
- Maximum anomalies for El Nino (1998, 2010, 2016) are +.04 mm/d (~ 1.5%), despite positive/negative anomalies over ocean/land.
- Maximum anomaly for volcano (-.09 mm/d [~ 3%]). Over both land and ocean.

*Adler et al., 2017 Rev. Geophysics*
Composite ENSO Precipitation Anomalies (1979-2017)

El Nino – La Nina Months
using Nino 3.4 index

Percentage of Mean
PDO-Related Precipitation Anomalies (Positive and Negative Phases)

(a) Precipitation anomalies (1993–1997)

(b) Precipitation anomalies (2014–2018)

(c) b–a

(d) Precipitation anomalies (2009–2013)

Trend? (with PDO removed)
Pattern of Global Trends

GPCP (v2.3; 1979–2018)

Trend Pattern related to Global Warming (GW) with a little inter-decadal signal on top
GPCP Observations and Climate Models

CMIP5/6 monthly precipitation from ensemble of multiple climate models:

1) **AMIP**: AMIP-type simulations (driven by observed SST, ice extent, and historical radiative forcings)  
   *Should simulate GW and PDO*

2) **CMIP**: Hist-Full; Coupled historical full radiative forcings simulations  
   *Should simulate only GW and other long-term effects*
Climate Models and GPCP

Global mean precipitation (mm day\(^{-1}\))
(1979-2014)

<table>
<thead>
<tr>
<th></th>
<th>GPCP</th>
<th>AMIP6</th>
<th>CMIP5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.69</td>
<td>3.02</td>
<td>2.97</td>
</tr>
</tbody>
</table>

*Climate Models ~ 10% higher than GPCP*
Trends in Precipitation
In terms of percentage change per degree of global warming (%/K)

CMIP scale is different (weaker by factor of ~2.5)
Trends in Rainfall Intensity at the Monthly Time Scale

**Percentile Changes/Trends:** GPCP  AMIP-5(SST)  CMIP-5

- For intense rain (90-95\textsuperscript{th} Percentile) trend is up for observations (GPCP) and both model types, with trend magnitude GPCP>AMIP>CMIP.
- For intermediate rain rates (e.g., 30\textsuperscript{th} Percentile) trend is down for observations and models, with trend magnitude again GPCP>AMIP>CMIP.
- Interpretations: 1) Models may be underestimating intensity changes related to warming; 2) AMIP>CMIP magnitudes may indicate relative GW+PDO vs. GW effects

Gu and Adler (2018) J. Climate
Global Monthly Precipitation Percentile Trends (%/K)

Area Weighted (1988-2014)
Trends in Tropical Monthly Rainfall Intensity

Mean tropical rainfall trend: 5.0%/C
95th Percentile rainfall trend: 13.3%/C
Summary

- **GPCP Monthly Analysis** provides high quality, long-term global precipitation information, including a “real-time” climate monitoring product.
- **Climatological mean values** reasonable, but may increase over tropical oceans when TRMM and GPM information are incorporated.
- **High-latitude information** generally good, but with some features and trends needing improvement—this is one focus of current NASA project.
- **Planetary mean precipitation** increasing slightly (significant?) with noticeable impacts of ENSO (1.5%) and volcanoes (3%).
- **ENSO-related pattern** of anomalies is dramatic and extensive.
- **Trend maps** show strong features over tropical oceans with increases along ITCZ, decreases in northern mid-latitudes.
- **GPCP-based trends** partially validate climate models and provide a “best” estimate from observations for evaluation of models.
- **Trends in Intensity** in tropics at the monthly scale have intense rains increasing, dry areas expanding, same in sign (but not magnitude) as models.
- **CMIP models** used for projections do not match well with observed pattern of trends or trends in intensity.
EXTRA SLIDES
Zonal-Mean Trends

Trend

Mean Profile

GPCP (1979–2017)
Pattern of Global Trends

Straight Trend

GPCP (v2.3; 1979–2018)

Later PDO+ minus Earlier PDO+

(c) b−a

mm/d/decade

mm/d