Review of Global Precipitation for 2017

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Headlines: 1) La Nina effects continue into 2017 for global totals and pattern
2) Positive global mean precipitation trend becoming evident with GPCP
3) Global land precipitation at or near all-time high in 2017
4) 2017 contributes to ongoing trends in precipitation intensity in the tropics

The Global Precipitation Climatology Project (GPCP) monthly data set is a long-term (1979-present) analysis (Adler et al., 2003; Huffman et al., 2009: Adler et al., 2017) using a combination of satellite and gauge information. An interim GPCP analysis completed within 10 days of the end of the month allows for use in climate monitoring and, in this case, a quick look at the just completed year (2017). The current Version 2.3 of the GPCP Monthly analysis is a NOAA Climate Data Record (CDR) and is part of the Global Energy and Water EXchanges (GEWEX) project under the World Climate Research Program (WCRP).

Fig. 1 shows the GPCP climatology map (1979-2016), the annual mean map for 2017, and anomaly maps for 2017, for both rain rate magnitudes and percentages. The climatology map shows the usual maxima of the tropics and mid-latitudes, with similar features, of course, for 2017, but with fairly obvious greater magnitude of mean rainfall over the Maritime Continent and surrounding areas. The annual anomaly maps (Fig. 1c and 1d) emphasize those features, showing a definite La Nina pattern with the strong positive anomaly over the western Pacific and a rainfall deficit over the central and eastern Pacific near the Equator. Indeed, the seasonal anomaly patterns during 2017 (not shown) indicate that the La Nina features in the Pacific Ocean/Maritime Continent area existed in varying strengths during the entirety of 2017. This followed a transition from El Nino to La Nina during 2016. Typical La Nina anomaly features can also be seen in some other locations such as the tropical Atlantic, the negative anomaly off of Baja Mexico extending into the southwest corner of the U.S., and a typical La Nina pattern along the east coast of Africa. A negative anomaly feature across the very southern tip of the African continent can be seen, where Cape Town, South Africa experienced its driest year since 1933, probably due, in part, to La Nina. In Fig. 1d the Cape Town area is shown to have a spatially small, but very strong negative percentage feature, emphasizing the connection between large-scale features and local impacts. Northern California, Oregon and Washington show the strong positive anomaly related to heavy rain in the early part of the year. At higher latitudes, for example across northern Eurasia and Alaska, positive anomalies dominate the inter-annual changes, but also may be related to an estimated positive trend over the GPCP record in these areas.

Table 1 gives the estimated global mean rainfall rate for 2017 (2.72 mm/d) and the sub-totals for land and ocean. The global number is slightly (1%) higher than the 1979-2016 climatology, with land areas contributing a value about 4% higher than the land climatology. For this exercise the land precipitation values for years 2014-2017 from Version 2.3 have been adjusted upward 2%. This adjustment is based on a difference in the version of gauge analysis that is used for the recent period as compared to the pre-2014 era. This is a small, but significant adjustment, and is based on an inter-comparison of the gauge analyses for an overlapping period. However, the results could change slightly when updated, so should be considered carefully.

To put the global numbers for 2017 in context, Fig. 2a shows plots of the annual anomaly of the global total (and ocean and land totals) from 1979-2017, with Fig. 2c showing annual mean values for Nino 3.4 as a measure of ENSO for comparison with the annual anomaly values. The ocean and land values in Fig. 2a "flip-flop" between El Nino and La Nina years, with the global total value having smaller year-to-year variations, although larger during El Nino years (e.g., 1998, 2010, 2015-2016) (Adler et al. 2017). 2017, a weak La Nina year, has an estimated record-setting high GPCP land value, compensated by a relatively low ocean value. The global value for 2017 is not a record high value, although the combination of 2016 and 2017 has an estimated mean that is higher than any other sequential two-year mean. The estimated trend is calculated for the three curves in Fig. 2a and is a very slight positive for all three, with a value of 0.009 mm day^{-1} $decade^{-1}$ (0.33 % per decade) for the global trend (significant at the 5% level). The trend values for both land and ocean are very similar, but are not significant due to the larger inter-annual variations. The second panel (Fig. 2c) removes the ENSO effect on the annual anomalies, and results in reduced variations, but the trend values stay the same and the significance results are also unchanged relative to the 5% threshold. The small calculated global precipitation trend compared to the global surface temperature trend (0.16 K $decade^{-1}$) for the same period gives a 1.3% K^{-1} for the rate of increase in global precipitation in relation to global warming. This value is close to the value often quoted coming from climate models, but the GPCP-based value is very sensitive to the length (and homogeneity) of the record. As the length of record for analyses like GPCP increases, it is obvious that their value will increase dramatically.

Although the global trends in Fig. 2 are very small, the trends are larger and variable in the spatial domain (see Fig. 3), with the pattern showing an area of positive trend along most of the ITCZ, especially across the Pacific and Indian Oceans. Oceanic decreases north and south of the Pacific ITCZ are adjacent and weakly connected to decreases over land, as in the southwestern U.S. A general scenario of wet areas getting wetter, dry areas getting drier is evident. At high northern latitudes the positive trends noted across Eurasia and the Arctic Ocean to Alaska are similar to the positive anomaly features seen in Fig. 1 for 2017. Adding one year (2017) to the data set does not significantly change the pattern in Fig. 3, but also serves as a starting point for examining regional trends in relation to ENSO, inter-decadal variations and global warming (see Gu et al., 2016; Adler et al., 2017).

Data from 2017 have also been incorporated into the investigation of trends in rainfall intensity using the monthly GPCP analyses (Gu and Adler, 2018). Focusing on the tropics and the post-1987 period (the satellite microwave era) percentiles (and other parameters related to intensity) at each grid were derived and compared to the previous years (see Fig. 4). The mean tropical rainfall has a positive trend over the period (Fig. 4d), but it is also evident that there are even stronger positive trends in the higher percentiles (more intense rainfall), with significant trends at percentiles greater than 70% (see Fig. 4a). At intermediate percentiles (30-40%) a downward trend is noted (Fig. 4c). At low percentiles (not shown) trends were indeterminate, but defined "dry areas" showed increases during the period. The year 2017 results helped solidify the trend results, but an ENSO component is easily recognizable in the 95th percentile results with the El Ninos of 1998, 2010 and 2016. There is also a decadal shift evident around 1998 related to the shift in the Pacific Decadal Oscillation (PDO). Monitoring rainfall intensity changes, even on the monthly time-scale, will henceforth be a focus of our routine monitoring and research with the GPCP data.

References:

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Table 1. Global mean GPCP precipitation (mm day^{-1}) during 1979-2016 and in 2017. Also estimated are the annual anomalies in 2017 and corresponding percentage changes.

	Mean rain-rate during 1979-2016 (mm day^{-1})	Mean rain-rate in 2017 (mm day^{-1})	Annual anomaly in 2017 (mm day^{-1})	Percentage change in 2017 (%)
Land+Ocean	2.69	2.72	0.03	1.12
Land	2.24	2.34	0.10	4.46
Ocean	2.90	2.89	-0.01	-0.34

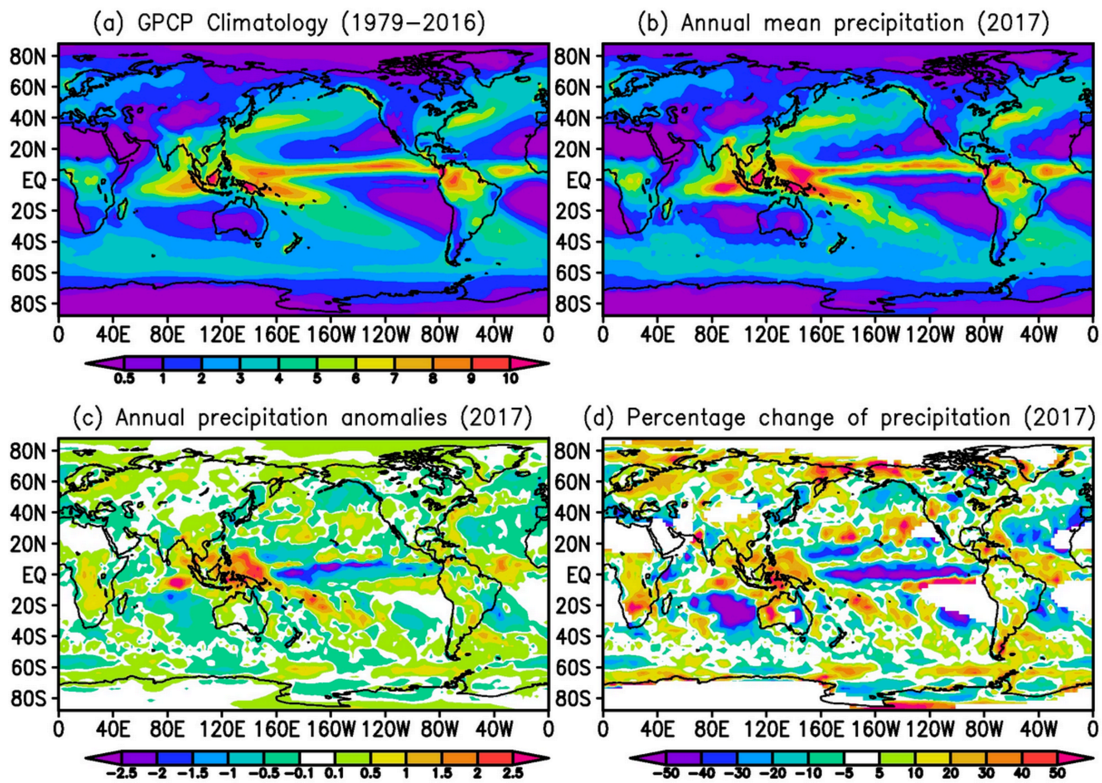

Figure 1. (a) GPCP climatological mean precipitation (mm day^{-1}), (b) annual mean precipitation in 2017, (c) annual precipitation anomalies (mm day^{-1}) in 2017, and (d) annual precipitation anomalies in percentages for 2017 (with areas having less than 0.5 mm day^{-1} of mean precipitation also shown in white).

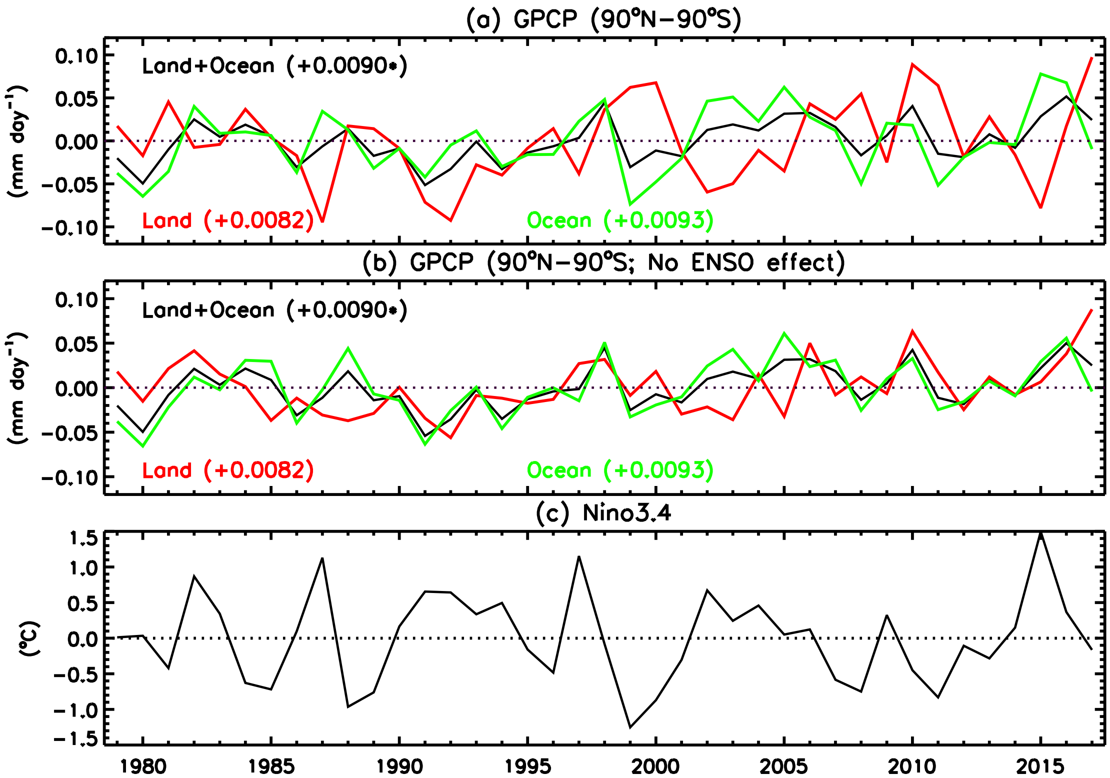

Figure 2. Time series of (a) global, annual mean precipitation anomalies, (b) no ENSO effect, and (c) annual mean Nino 3.4. Also shown in (a) and (b) are corresponding linear trends (mm day^{-1} per decade), and those followed by "*" are statistically significant.

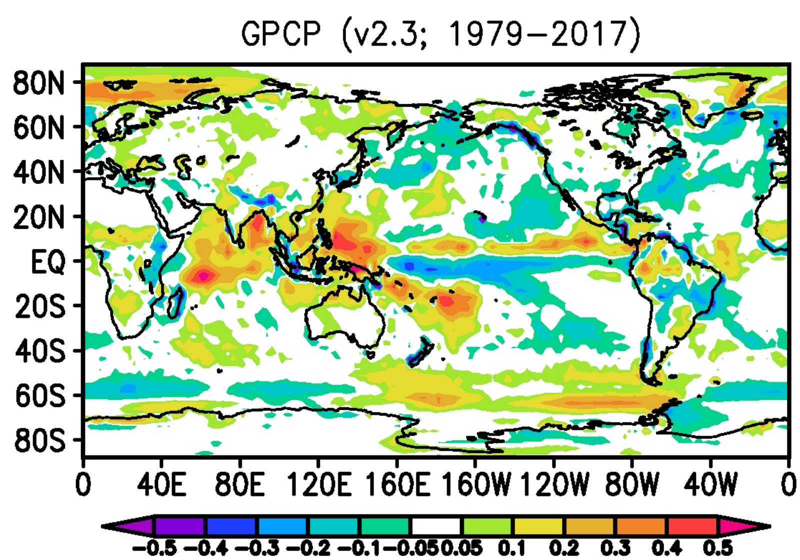

Figure 3. Linear trend of GPCP precipitation (mm day^{-1} per decade) during 1979-2017.

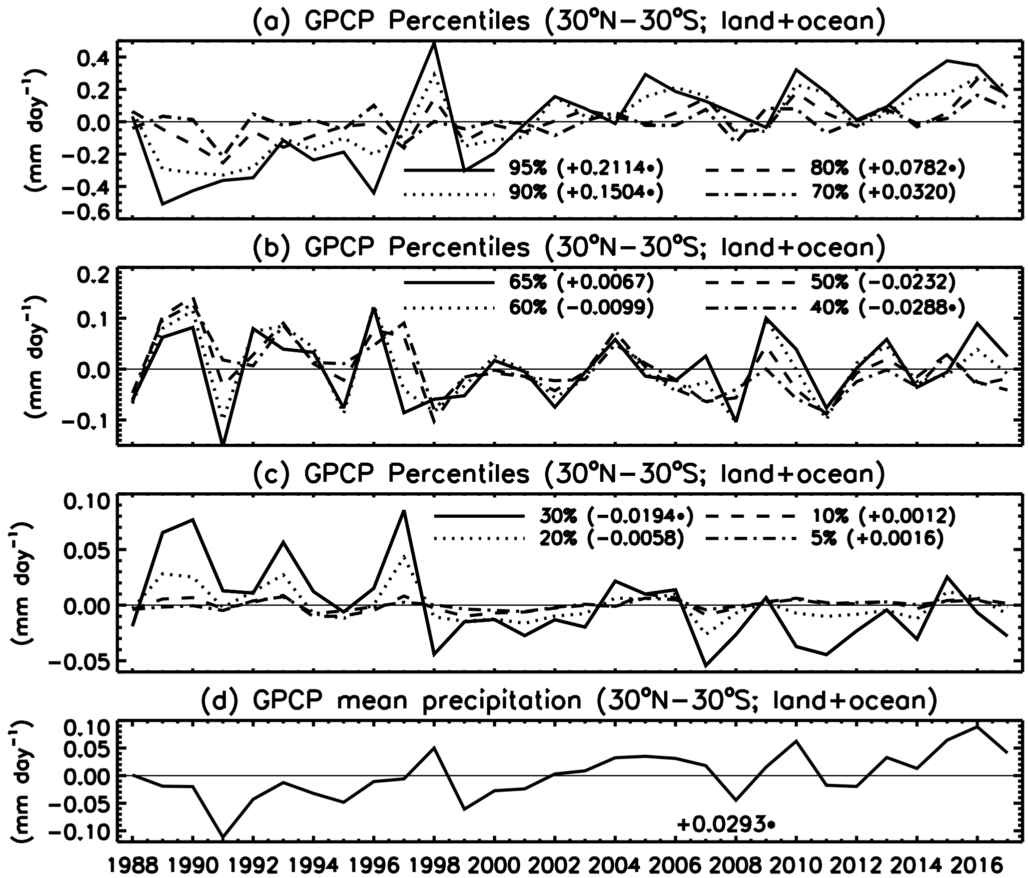

Figure 4. Annual anomalies of (a, b, c) precipitation percentiles and (d) mean precipitation determined by GPCP monthly rain-rates between 30°N-30°S (land+ocean). Also shown are their corresponding linear trends (mm day^{-1} per decade), and those followed by "*" are statistically significant.