PACIFIC ENSO UPDATE

A Quarterly Bulletin of the Pacific El Niño-Southern Oscillation Applications Climate (PEAC) Center

3st Quarter, 2017 Vol. 23, No. 3 ISSUED: August 10, 2017

Providing Information on Climate Variability in the U.S.-Affiliated Pacific Islands for the Past 20 Years.

http://www.weather.gov/peac

CURRENT CONDITIONS

Abundant rainfall occurred throughout most of the United States-Affiliated Pacific Islands (US-API) during the first half of 2017, with almost all recording stations reporting above-average 1st-half totals (Fig. 1 and Fig. 2). Problematic dry conditions occurred in some isolated areas, including some of the northern atolls of Chuuk State, and some of the atolls of the northern RMI. Of all the recording stations shown in Figures 1 and 2, only Utirik was exceptionally dry. Utirik was the only recording station shown that had less rainfall in the first half of 2017 than it did during the first half of 2016 (Fig. 3).

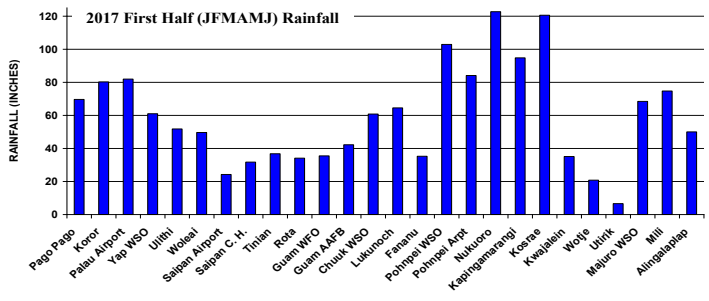


Figure 1. 2017 1st Half (JFMAMJ) rainfall amounts in inches at the indicated locations.

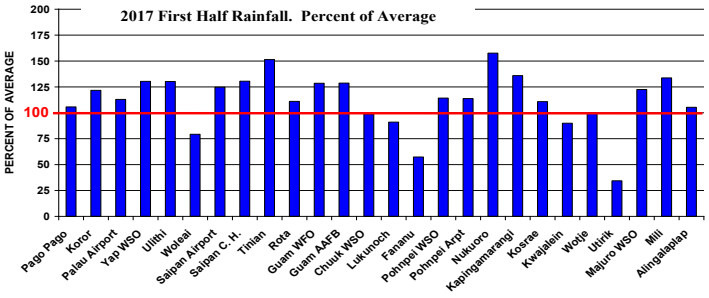


Figure 2. 2017 1st-half rainfall as a percent of average at the indicated locations. Note that most locations in Micronesia were above average, with the notable exceptions of Fananu (one of the northern-most atolls of Chuuk State), and the northern RMI atoll of Utirik.

Despite an abundance of rain at most locations during the first half of 2017, there were no reports of serious problems with flooding. The WSO Pohnpei had to issue flood statements for an occurrence of heavy rainfall of 7.17 inches over the 14th and 15th of June. This heavy rainfall resulted in high water in streams, and other nuisance ponding of water on roadways, but there were no reports of major damages or injuries.

As reported in the last ENSO Update, some of the atolls (e.g., Wotje, Utirik, Kwajalein) and Mejit Island of the northern RMI were very dry during the First Quarter of 2017, and continued to be dry into the 2nd quarter months. The RMI government shipped bottled drinking water supplies and reverse-osmosis units to some atolls to address water shortages. Drought information statements continue to be issued by the WFO Guam regarding dry conditions in the northern RMI and at some of the northern atolls of Chuuk State. Portions of the text of the statement issued by WFO Guam on 06 July 2017 are appended below.

Portions of the text of the Drought Information Statement issued by the WFO, Guam, on Thursday July 06, 2017 include:

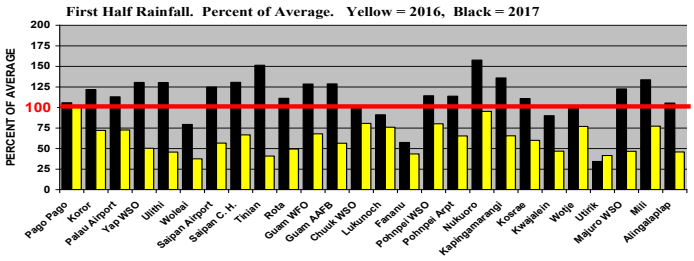


Figure 3. 2017 1st -half rainfall (black bars) versus 2016 1st -half rainfall (yellow bars) at the indicated locations. Values plotted are percentages of average rainfall totals at the indicated locations.

"...THE EXTREME DROUGHT CONTINUES IN THE NORTHERN AND NORTHWESTERN MARSHALL ISLANDS..."

"THE EXPERIMENTAL DROUGHT ASSESSMENT OF THE U.S. DROUGHT MONITOR INDICATES THAT UTIRIK OF THE NORTHERN MARSHALL ISLANDS IS IN SHORT-TERM AND LONG-TERM EXTREME DROUGHT (DROUGHT LEVEL 3 OF 4). WOTJE ATOLL AND NEARBY ATOLLS ARE IN LONG-TERM SEVERE DROUGHT (DROUGHT LEVEL 2 OF 4). KWAJALEIN AND NEARBY ATOLLS HAVE IMPROVED TO LONG-TERM ABNORMALLY DRY (DROUGHT LEVEL 0 OF 4)."

"SATELLITE IMAGES DURING THE LAST FEW DAYS SHOWED ONLY SPOTTY TRADE-WIND SHOWERS MOVING ACROSS THE NORTHERN MARSHALL ISLANDS. EXTREME DROUGHT IS AFFECTING UTIRIK AND OTHER NORTHERN AND WESTERN ATOLLS NORTH OF KWAJALEIN. THE FAR NORTHERN MARSHALLS WILL REMAIN DRY IN THE COMING WEEKS...BUT SOME IMPROVEMENT IS EXPECTED. ISLANDS ALONG AND NORTH OF 10N SUCH AS UTIRIK...RONGELAP...BIKINI...AILUK...AND ENEWETAK AT-

CURRENT CONDITIONS

OLLS AND MEJIT ISLAND WILL CONTINUE TO SUFFER FROM DROUGHT. RELATIVELY DRY CONDITIONS MAY ALSO AFFECT KWAJALEIN... WOTHO...MALOELAP...UJAE...WOTJE AND LIKIEP AND NEIGHBORING ATOLLS. ENOUGH RAINFALL HAS BEEN REPORTED FOR MAJURO... ARNO... NAMU... JALUIT AND AILINGLAPLAP...AND THESE LOCATIONS HAVE HAD ADEQUATE MONTHLY RAINFALL THROUGH JUNE TO AVERT DROUGHT."

CURRENT STATE OF ENSO

ENSO Alert System Status: Not Active

During the first few months of 2017, there was some indication that El Niño conditions might develop as early as the summer months, and even more likely to do so by the fall months. Indeed, the SST in the Niño 3.4 region of the central equatorial Pacific warmed to near the threshold of El Niño by the end of the 2nd Quarter (see Fig. 4). However, as the SST exhibited a warming trend, the atmosphere was unresponsive to it, and continued to exhibit behaviors consistent with ENSO-neutral or even with La Niña (e.g., a westward bias to TC formation and a delay-of-onset and westward shift of the western North Pacific monsoon trough). Please see CPC's latest ENSO advisory (appended below) wherein it is now thought that the odds now favor a continuation of ENSO-neutral through the remainder of 2017.

El Niño Diagnostic Discussion[1]
CLIMATE PREDICTION CENTER/NCEP/NWS
and the International Research Institute for Climate and Society
13 July 2017

Synopsis: ENSO-neutral is favored (~50 to 55% chance) into the Northern Hemisphere winter 2017-18.

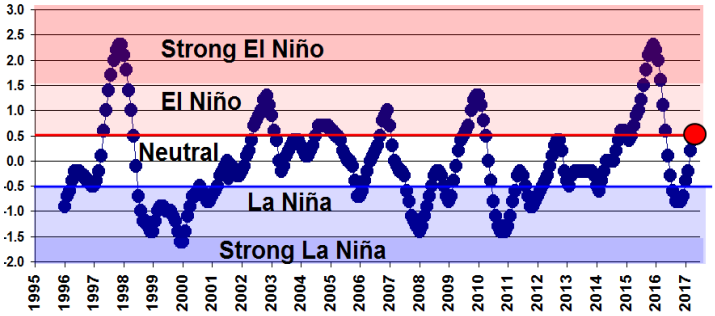


Figure 4. A plot of the CPC's Oceanic Niño Index (ONI) for the past two decades. The red dot indicates the latest three month average. Note that it is now near the El Niño threshold.

"During June, ENSO-neutral continued, although equatorial sea surface temperatures (SSTs) remained above average in the central and east-central Pacific Ocean. The latest weekly Niño index values were near +0.5°C in the Niño-4 and Niño-3.4 regions, and closer to zero in the Niño-3 and Niño-1+2 regions. The upper-ocean heat content anomaly was above average during June, reflecting above-average sub-surface temperatures across the central and eastern Pacific. In the atmosphere, tropical convection was suppressed over the west-central tropical Pacific and enhanced over the Maritime Continent. The lower-level and upper-level winds were near average over most of the tropical Pacific, and the Southern Oscillation Index (SOI) and Equatorial SOI were slightly negative to near-zero. Overall, the ocean and atmosphere system remains consistent with ENSO-neutral."

"Some models predict the onset of El Niño (3-month average Niño-3.4 index at or greater than 0.5°C) during the Northern Hemisphere summer. However, more than half of the models favor ENSO-neutral through the remainder of 2017. These predictions, along with the near-average atmospheric conditions over the Pacific, lead forecasters to favor ENSO-neutral into the winter (~50 to 55% chance). However, chances for El Niño remain elevated (~35-45%) relative to the long-term average. In summary, ENSO-neutral is favored (~50 to 55% chance) into the Northern Hemisphere winter 2017-18. (click CPC/IRI consensus forecast for the chance of each outcome for each 3-month period:
(http://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/?enso_tab=enso-cpc_plume).

CURRENT STATE OF ENSO

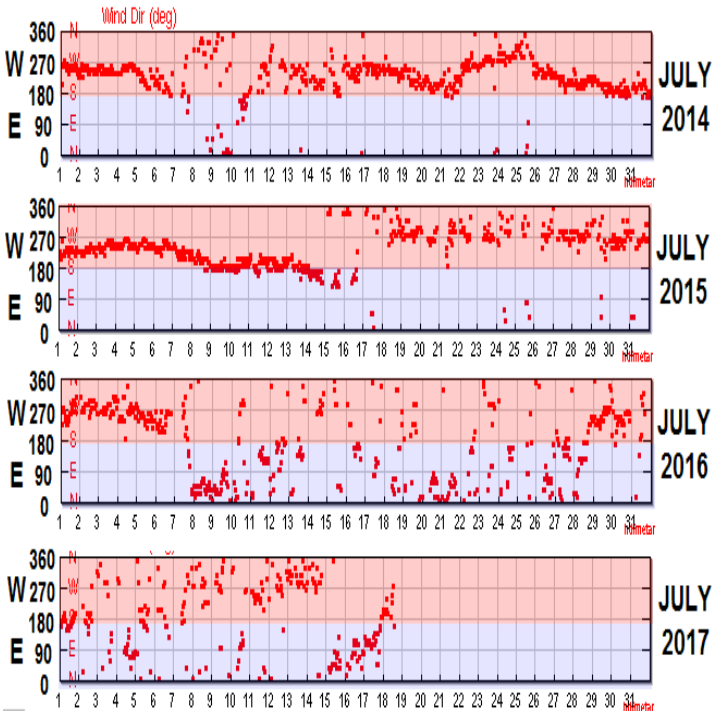


Figure 5. The 2017 onset of the western North Pacific monsoon has been delayed, with the monsoon trough remaining to the south and west of its typical location. The graphic above shows the E-W wind component at Koror, Palau, for July 2017 to-date and for the past three years. Note that during 2014 and 2015, the predominant wind at Koror during July was from the west and southwest. During July 2016 and July 2017 to-date, the wind has been light and highly variable in direction. Red shading indicates a westerly component to the wind, and light blue shading indicates an easterly component to the wind.

Sea Level

"As anticipated by the PEAC, the sea level across Micronesia returned to above average values during the 3rd Quarter of 2016. During the 4th Quarter of 2016, the sea level was above average across all of Micronesia and also at American Samoa (Fig. 6), and thereafter continued to be elevated above average values at all US-API recording locations through the first half of 2017. Note that the rise and fall of sea level closely tracks the strength of the low-latitude trade winds (Fig. 7), and hence the very strong connection of regional sea level with ENSO. Looking closely at Fig. 7, it appears that changes in trade wind strength tend to lead changes in sea level by about 1-2 months, suggesting that trade-wind strength may be a useful short-term (1-2 month) predictor of sea level behavior. See the sea level discussion for more details and specific forecasts.

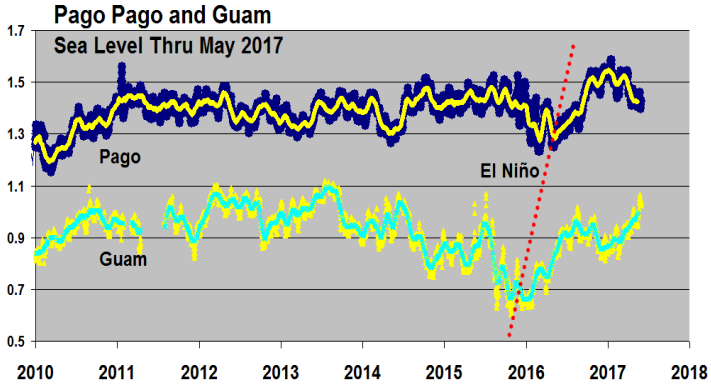


Figure 6. Sea level recorded at Guam and at American Samoa during 2010 to present. During El Niño, there is a sharp drop in sea level at most locations followed by a steep rise thereafter. The lowest sea level occurs at Guam a few months before the minimum is observed at American Samoa.

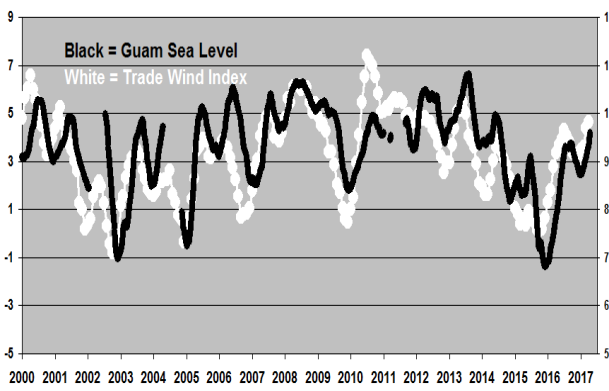


Figure 7. Time series of sea level at Guam (NOAA Sumay Cove tide gauge) from January 2000 through May 2017. Black line is a 12-month moving average of Guam's sea level, and the white line is a 5-month moving average of NOAA's trade wind index (5°S-5°N ; 135°E to 180°) The sea level at Guam and throughout the tropical western Pacific closely tracks the trade winds, with a small (1-2 month) lag that is perceivable in the diagram.

TROPICAL CYCLONE ACTIVITY

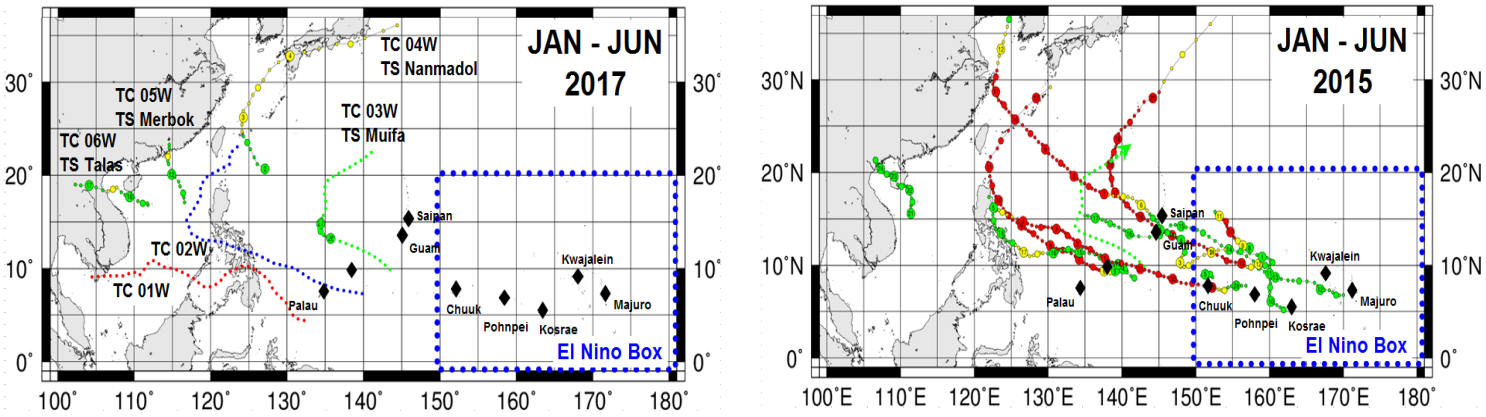


Figure 8: Tropical cyclone activity [(Source: North Pacific tropical cyclone (TC) information is taken from the 'Joint Typhoon Warning Center (JTWC)' of the U. S. Air Force and Navy, located at Pearl Harbor, Hawaii. Western North Pacific tropical cyclone information are taken from the 'Japan Meteorological Agency (JMA)/ World Meteorological Organization's Regional Specialized Meteorological Center (RSMC)' and South Pacific TCs information are taken from the ' Tropical Cyclone Warning Centers at Brisbane', Nadi,)

Western North Pacific

So far, the first half of the western North Pacific typhoon season has been relatively inactive, with only six tropical cyclones numbered by the JTWC through July 15 (Fig. 8). Only four of these TCs were named by the JMA. TCs 01W and 02W reached only the depression stage, and were not given names by the JMA. There have been no TCs of typhoon intensity to-date in the western North Pacific basin. There remains westward displacement of the early TCs of 2017 with all forming near Yap and Palau or even farther westward. As the outermost rainbands of Tropical Storm Muifa lingered near Guam, heavy rainfall (4-6 inches) was experienced there over the three-day period 24-26 April (see the LVS for Guam and the CNMI for more details). The westward displacement of the 2017 early-season TCs is not a harbinger of El Niño. See the plot of 2015 early season TCs in the bottom half of Fig. 8 to see a typical response to El Niño.

East Pac

This July was quite busy in the eastern North Pacific basin, with five named storms forming, four of which became hurricanes. Two of the hurricanes, Eugene and Fernanda, reached major hurricane strength. One unnamed tropical depression also formed in July. In terms of Accumulated Cyclone Energy (ACE), activity in July was more than 2.5 times the average activity for the month, making it the fifth most active July on record.

Southern Hemisphere

The 2016-17 Southern Hemisphere (SH) TC season (ending on 30 June 2017) was remarkably quiet! Only 17 TCs were numbered by the JTWC in the entire Southern Hemisphere. Of these, 13 were named by the responsible TC warning center. The 2016–17 South Pacific cyclone season is one of the least active South Pacific cyclone seasons on record, with only two tropical cyclones occurring within the South Pacific Ocean to the east of 160°E.

PEAC tropical cyclone assessment : *Western North Pacific and American Samoa*

Two official forecasts of 2017 typhoon activity have been released: (1) The Guy Carpenter Asia-Pacific Climate Impact Centre (GCACIC) at the School of Energy and Environment, City University of Hong Kong calls for a below-normal number of TCs between May 1 and October 31, resulting in a below-normal number of landfalling TCs in each of three East Asian regions (South China Sea/Philippines, east China/Taiwan and Japan/Korea); and (2) In their July Forecast Update for Northwest Pacific Typhoon Activity in 2017 issued on 06 July 2017, Dr Adam Lea and Professor Mark Saunders Dept. of Space and Climate Physics, UCL (University College London (http://www.tropicalstormrisk.com/) anticipate the 2017 Northwest Pacific typhoon season will likely see activity below the 1965-2016 climate norm. The TSR forecast has dramatically decreased since early May for three reasons: the anticipated development of El Niño has not happened, early-season typhoon activity has not occurred and May-June trade wind strength is consistent with a below-normal typhoon season.

TROPICAL CYCLONE ACTIVITY

Using all the above as guidance, the PEAC anticipates that TC activity will be below average in the western North Pacific basin through the remainder of 2017. In general, any movement of the state of the climate system in the direction toward El Niño (whether from La Niña to ENSO-neutral, ENSO-neutral to El Niño, or La Niña to El Niño) increases the likelihood for above-average typhoon activity. For the remainder of 2017, three or four TCs of tropical storm intensity or higher may pass within 180 n mi of each of Guam, the CNMI, Yap or Palau. These should move away to the west before acquiring major typhoon intensity. Eastward of Chuuk State, the risk of a tropical storm or typhoon is lower than at locations farther to the west. If the climate system makes a stronger push toward El Niño, the typhoon threat later in the year Sept-Oct-Nov-Dec (SOND) is thereby increased.

SEASONAL SEA LEVEL OUTLOOK FOR THE US-AFFILIATED PACFIC ISLANDS

The following sections describe: (i) the Canonical Correlation Analysis (CCA) forecasts for seasonal (mean and maxima) sea level anomalies (seasonal cycle removed) for the forthcoming seasons Aug-Sep-Oct (ASO), Sep-Oct-Nov (SON), and Oct-Nov-Dec (OND) of 2017 , (ii) ASO return values at 20 and 100-yr period, (iii) the observed monthly mean and maximum sea-level anomalies for the previous season May-June-July (MJJ) of 2017, and (iv) synopsis of last 2-years Sea Level variability and forecasts. *Note that, seasonal cycles have been removed for the data anomalies that are defined as 'deviations or departures from the normal' using the 1983 through 2001 mean sea level value computed at each station. Also note that CCA-forecasting technique adopted here does not account for sea level deviations created by other atmospheric or geological factors.*

Seasonal Sea Level Forecast (anomalies with respect to climatology) for ASO, SON, and OND of 2017

Forecasts of the sea-level anomalies in the USAPI (see http://www.weather.gov/peac/sealevel) are presented using CCA statistical model. Based on the independent SST and zonal wind (U) (SST-U) values in MJJ of 2017, the resulting CCA model has been used to forecast the sea level of three consecutive seasons: ASO, SON, and OND (see Table 1: left panel shows values for seasonal mean while the right panel shows the seasonal maxima). All the tide gauge stations (at 0 to 2-months lead time) provided skillful forecasts for these three consecutive seasons.

Table 1: Forecasts of sea level anomalies in inches (ASO, SON, and OND)

	Seasonal Mean Deviations [1]				Seasonal Max Deviations [2]				
Tide Gauge Station	**ASO**	**SON**	**OND**	**Seasonal Outlook[3]**	**ASO**	**SON**	**OND**	**ASO: Return Period[4]**	
Lead Time [5]	**0-M**	**1M**	**2M**	**Seasonal Outlook[3]**	**0-M**	**1M**	**2M**	**20- YR**	**100-YR**
Marianas, Guam	+3	+4	+4	**Normal**	+20	+20	+21	6.3	10.9
Malakal, Palau	+3	+3	+3	**Normal**	+40	+40	+40	8.1	10.2
Yap, FSM	+4	+4	+4	**Normal**	+32	+33	+33	8.4	11.3
Chuuk, FSM**	+4	+4	+4	**Normal**	+32	+32	+32	n/a	n/a
Pohnpei, FSM	+4	+4	+4	**Above**	+33	+34	+35	5.8	7.0
Majuro, RMI	+3	+3	+3	**Above**	+44	+44	+44	3.5	4.2
Kwajalein, RMI	+3	+4	+3	**Above**	+42	+42	+42	5.2	6.8
Pago Pago, Am. Samoa***	+5 (0)	+5 (0)	+5 (0)	**Normal**	+31 (+26)	+31 (+26)	+31 (+26)	4.1	5.2
Honolulu, Hawaii	+3	+2	+2	**Above**	+20	+21	+22	4.1	5.4
Hilo, Hawaii	+2	+2	+2	**Above**	+23	+23	+24	3.4	5.7

Table 1 and Supporting Statistics: : (-) indicate negative anomalies (fall of sea level from the mean), and (+) indicate positive anomalies (rise of sea level from the mean), n/a: data not available. Anomalies from -1 to +1 inches are considered negligible and anomalies from -2 to +2 inches are unlikely to cause any adverse climatic impact. Forecasts for Chuuk (**) are estimated subjectively based on information from WSO Chuuk and observations from neighboring stations of Pohnpei and Yap. *** There was a level shift (approximately 2-4 inches) in American Samoa at the time of September 2009 earthquake. So, -5 inches needs to adjust to the current tide-gauge values of Pago Pago. See PEAC website for the explanations of footnote (1 to 5). Also note that all information is based upon the 1983-2001 epoch.

The current sea level forecasts indicate that most of north and south Pacific stations are likely to be elevated in the forthcoming ASO, SON, and OND seasons. Current ENSO state displayed mixed signals—some atmospheric patterns have been recently leaning more towards weak La Niña conditions while the Oceanic pattern (SSTs) in the equatorial Pacific Ocean are slightly on the El Niño condition. The atmospheric impacts will therefore cause sea level to stay slightly elevated during the upcoming months. However, at any stage, no further rise is anticipated now. In Hawaii, both Honolulu and Hilo are likely to be moderately elevated.

There remains likelihood of high sea levels affecting the tropical northwestern Pacific islands during late summer and fall. The multi-model average forecast added to tide predictions is likely underestimating the potential high sea level stand due to unresolved processes in the statistical models.

SEASONAL SEA LEVEL OUTLOOK FOR THE US-AFFILIATED PACFIC ISLANDS

Observed Monthly Mean Sea Level Anomalies (with respect to climatology) for May-Jun-Jul (MJJ) of 2017

The monthly time series (January to March) for sea level anomalies have been taken from the UH Sea Level Center. The full time series (in mm) for monthly mean is available at: ftp://ilikai.soest.hawaii.edu/islp/slpp.anomaliess. Locations of all these stations can be found at http://www.prn.noaa.gov/peac/map.php.

Current Conditions/Impacts: A combination of the highest astronomical tides of the year ("King Tides"), global sea level rise, delayed sea level effects from the 2014-2016 El Niño, Pacific-wide climate and sea level variability, and localized eddies have caused record-breaking sea level heights in Hawai'i in May, which caused wave inundation in many parts of the state, in particular when large swell events coincided. However, the height of king-tides receded and no major inundation was observed in June and July. For islands in the northwestern Pacific, sea levels remained above normal during MJJ partly due to an equatorial Rossby wave, and to some recent atmospheric patterns leaning more towards weak La Niña conditions .

Table 2: Monthly observed mean/maximum sea-level anomalies in inches

Tide Gauge Station	Monthly Mean Deviations[1]				Monthly Max Deviations[2]			
	May	Jun	Jul	Standard Deviations	May	Jun	Jul	Sea level Trend
Marianas, Guam	+6	+5	+6	3.5	+23(5)	+22(4)	+22(4)	Above-Stable
Malakal, Palau	+1	+1	+1	4.4	+38(-2)	+37(-1)	+38(0)	Normal-Stable
Yap, FSM	+6	+7	+8	3.7	+36(6)	+37(7)	+33(3)	Above-Stable
Chuuk, FSM*	+4	+4	+4	3.9	**	**	**	Above-Stable
Pohnpei, FSM	+5	+5	+5	3.0	+34(4)	+35(5)	+35(5)	Above-Stable
Majuro, RMI	+4	+3	+3	2.3	+45(5)	+42(2)	+42(2)	Above-Stable
Kwajalein, RMI	+3	+3	+3	2.8	+41(5)	+40(4)	+36(3)	Above-Stable
Pago Pago, American Samoa***	+10 [5]	+10 [5]	+8 [3]	3.7	+34(4) [29]	+33(3) [28]	+33(3) [28]	Above-Stable
Honolulu, Hawaii	+8	+5	+4	1.8	+29(9)	+29(9)	+24(4)	Above-High-tides
Hilo, Hawaii	+7	+4	+6	2.1	+31(8)	+28(5)	+33(10)	Above-High-tides

Table 2. +/- indicate positive anomaly (rise) and negative anomaly (fall) respectively. Note that any changes between (0~ ±1) inch is considered to be negligible. Also note that changes within the range of (+/-) 2 inches are unlikely to cause any adverse climatic impact. * Experimental Satellite Aviso Altimetry data, ** Data currently unavailable; Figures in parenthesis ( ) are year-to-year seasonal anomaly. 1: Difference between the mean sea level for the given month and the 1983 through 2001 mean sea level value at each station (seasonal cycle removed); 2: Same as 1 except for maxima; SD stands for standard deviations. *** In Pago Pago, there was a level shift (approximately 5 inches) at the time of September 2009 earthquake (adjusted values are shown in parenthesis [ ].

Synopsis of 2-years Sea Level Variability and Forecasts

Starting from AMJ of 2015, a comparative perspective of two years of seasonal sea level variations is given below (Fig. 9). The sea lever in the western Pacific started to fall from AMJ of 2015. This falling trend continued up to JAS of 2015. Again it started to rise from OND of 2015 and, starting from JFM of 2016, sea level recorded an abrupt rise and remained high until OND of 2016. It started to fall from JFM of 2017 and stayed above normal since than. It is likely to stay marginally elevated in ASO of 2017.

See page 15 for sea level observations from Jason-2 satellite picture (Fig. 10).

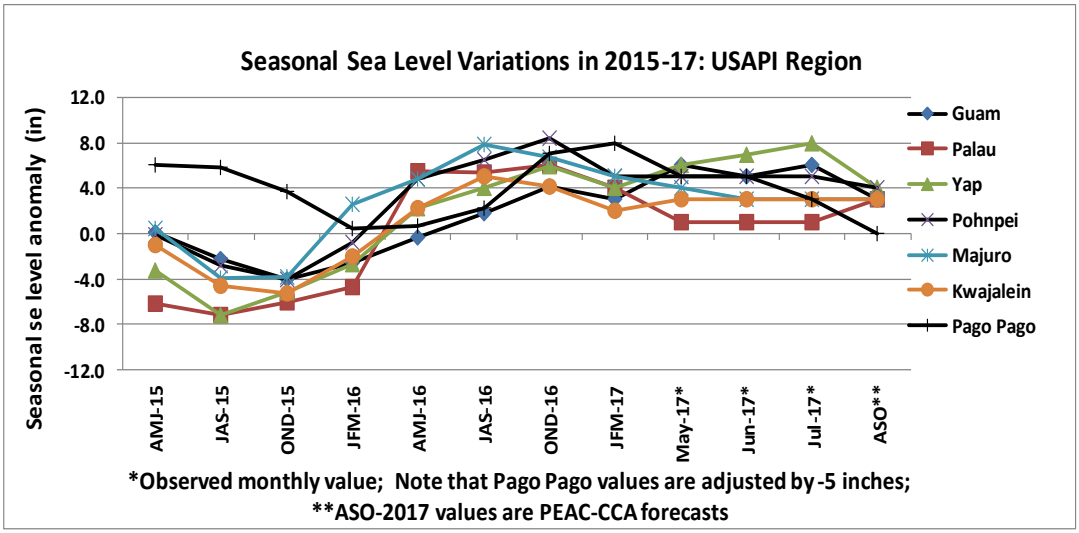


Figure 9. A comparative perspective of Island-wise seasonal sea level variations (AMJ 2015 to ASO 2017) (Note that Pago Pago data adjusted (approx. –5 inches) to 2009 level.

LOCAL SUMMARY AND FORECAST

American Samoa:

The monthly rainfall totals at American Samoa over the past two years have been mostly below average, with two peculiar exceptions: extreme rainfall (off-the-chart in Fig. AS-1) fell in April 2016, to be repeated with another off-the-chart extreme rainfall in May 2017. Dry conditions experienced in early 2016 were spectacularly interrupted during April 2016 when an incredible amount of rain was experienced. The 30.43 inches of rainfall at Pago Pago during April 2016 was by far the highest April rainfall in the historical record and the 2nd highest rainfall for any month in the 52-year climate record there. Extreme monthly rainfall occurred again in May 2017 (bounded fore and aft with dryness). The 23.23 inches of rainfall at Pago Pago during May 2017 was the 2nd highest May total in its modern historical climate record, with the highest May reading of 29.10 inches occurring in 1999. The May 2017 high rainfall amount included an extreme daily rainfall of 9.25 inches that occurred over a 24-hour period straddling the 10th to the 11th of May. This heavy daily rainfall event caused severe flooding across American Samoa and also in Samoa (formerly Western Samoa). The city of Apia in Samoa received 10.35 inches during the same heavy rain event. Details of the impacts of the flooding (from a Radio New Zealand post) are appended below. The widespread heavy rainfall over the 10th and 11th of May was associated with the passage to the south of American Samoa of Tropical Storm Ella (TC 19P) (Fig. AS-2). Ella was to be the final TC of the very quiet 2016-17 Southern Hemisphere TC season.

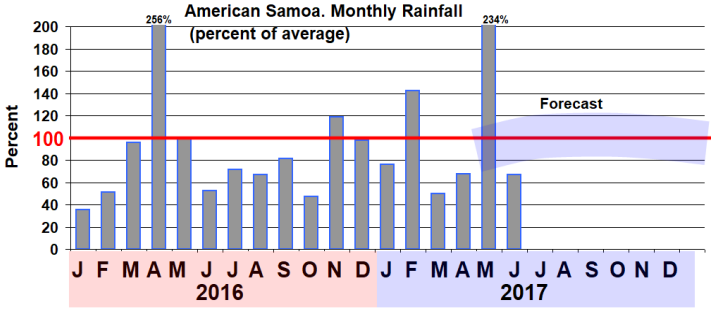


Figure AS-1. A time series of the monthly rainfall at Pago Pago from January 2016 through June of 2017. Note that most of the months plotted had below average rainfall with the spectacular exceptions of April 2016 and May 2017 that each rise beyond the upper 200% boundary of the chart! The forecast rainfall for the remainder of 2017 is shown by the light-blue band. It is the same band unaltered from the last Newsletter.

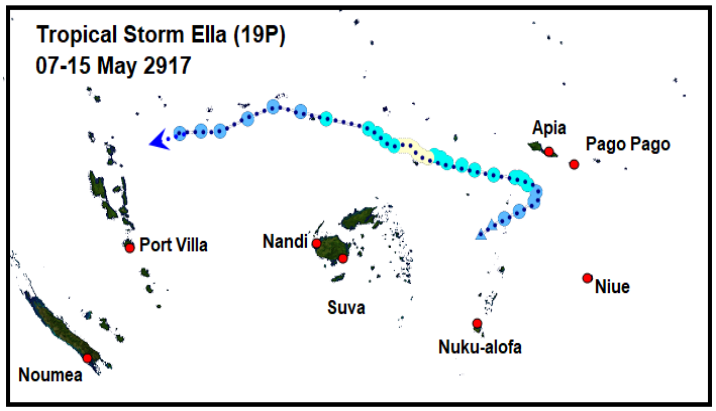


Figure AS-2. The track of Tropical Storm Ella (19P as per JTWC). Heavy rainfall associated with this TC caused damaging floods across Samoa (Apia) and American Samoa (Pago Pago). This was the final TC of the 2016-17 Southern Hemisphere TC season.

LOCAL SUMMARY AND FORECAST

News Item (Radio New Zealand -- http://www.radionz.co.nz/international/):

11:06 am on 12 May 2017

"Heavy rain in American Samoa has caused major flooding in the territory.

The Emergency Operations Center reports that some families were evacuated after water flowed like rivers through their homes.

According to the Center, affected areas include Mapusasga, and Mesepa, Kokoland, Fagaima, Leone and Amanave. Homeland Security sent out assessment teams last night to the affected families, some of whom have moved in with relatives and neighbors.

RNZI's correspondent said driving had been a nightmare along roads covered with water.

Monica Miller said that in some parts, rocks washed down from the mountainside were invisible to drivers.

Furthermore, new hazardous potholes were emerging in places which did not have them before.

The Meteorologist in charge at the National Weather Service, ***Hans Malala****, said the floodwaters came up to the window of his car as he was trying make his way to work last night.*

He said an active trough that is stationary over the Samoan islands was responsible for the incessant rain. …"

American Samoa Rainfall Summary: AMJ 2017, 2nd QTR & 1st Half

Station		Apr	May	Jun	2nd QTR	1st Half
Pago Pago WSO	Rain (in)	8.14	23.23	4.94	36.31	69.66
	% Avg.	68%	234%	67%	124%	106%
Siufaga Ridge*	Rain (in)	6.53	26.51	12.67	45.71	N/A
	% Avg.	50%	241%	141%	139%	%

* Station temporarily out of service, data resuming in 10 February 2017.

Climate Outlook:

Computer model forecasts are now indicating near average to above-average rainfall over the next three months at Pago Pago, and the PEAC concurs with these projections. With the current status of ENSO at ENSO-neutral, there are no compelling reasons at this time to manually intervene in the computer forecasts of rainfall for the region.

The very quiet 2016-17 Southern Hemisphere TC season ended on 30 June. American Samoa is now in its dry season, and no TCs are anticipated anywhere near American Samoa until at least until late October or November. At this time, the outlooks for 2017-18 TC season are uncertain, and will be updated in the next PEAC Newsletter.

Predicted rainfall for American Samoa from July 2017 through June 2018 is:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]
Jul - Sep 2017 (Heart of Next Dry Season)	100%
Oct - Dec 2017 (Onset of Next Rainy Season)	100%
Jan - Mar 2018 (Heart of Next Rainy Season)	100%
Apr - Jun 2018 (Onset of Next Dry Season)	100%

[1] Forecast rainfall quantities represent BEST ESTIMATES given the probabilistic forecast for each particular season and station.

LOCAL SUMMARY AND FORECAST

Guam/CNMI:

Rainfall throughout Guam and the CNMI was generally above average during the 1st half of 2017 (Fig. G1). During the first three months of 2017, slow-moving shear-lines brought several multi-day episodes of almost continuous drizzle, dark skies and misty rain showers, albeit with surprisingly low multi-day accumulations (< 1 inch). The weather in the 2nd Quarter gave way to persistent light to moderate trade winds with some light rainfall (generally below 0.25 inch) in showers almost every day. After three weeks of dryness in mid-April and then again during the first week of June, there were some wildfires occurring in the grass lands of southern Guam. The year's heaviest rainfall to-date occurred during the final week of April when 4-6 inches of rainfall fell across Guam over a three-day period. The island quickly turned green after the late April heavy rainfall event. Some drying occurred again after low rainfall in May and early June, but some heavier rain during mid and late June caused a general greening of lawns and roadside vegetation. A delay in the onset of the western North Pacific monsoon has been responsible for a prolonged period of unremarkable weather extending into July 2017 on Guam and in the CNMI with no extremes of rainfall, very hot days, cool nights, and persistent light trade winds. Not until July was there an episode on Guam and in the CNMI of southwesterly wind. The persistent trades bring with them an unusual haziness for this time of year. The haze originates, in part, from volcanic smog (VOG) that streams all the way in a ten-day trip from Hawaii's Big Island to Guam (Fig. G2).

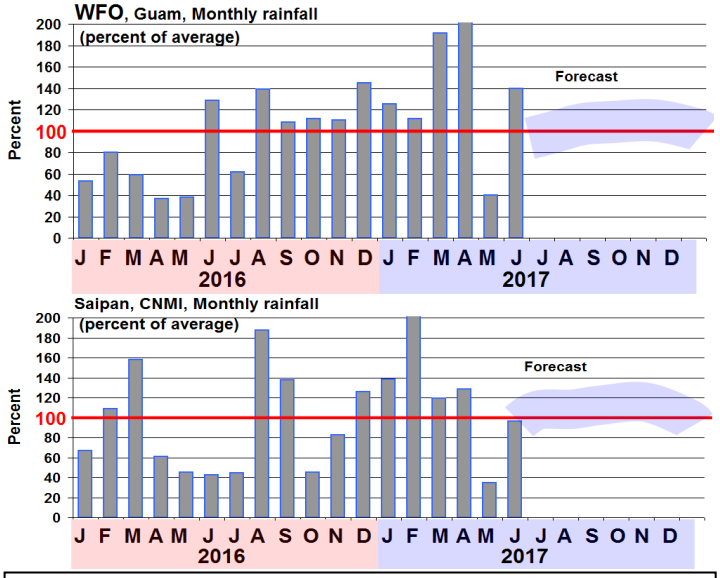


Figure G1. **Top**: **Top**: A time series of monthly rainfall percentages at the Guam WFO. Note how the persistent dryness through the middle of 2016 gives way to abundant rainfall into the 1st Quarter of 2017. **Bottom**: Same as the top panel, but for monthly rainfall percentages at the Saipan International Airport. Forecast rainfall for the remainder of the year is indicated by light blue band.

During a recent trip to Saipan by the UOG PEAC scientist, it was noted that the famous red-flowering flame trees lining the roadway to the Saipan International Airport were still recovering from severe typhoon damage in 2015 and the effects of severe defoliation from flame tree loopers (*Pericyma cruegeri,* Butler) in the fall of 2016. Note: many of the region's indigenous plant and animal species have gone extinct (or are now being damaged, threatened or endangered) from the introduction of non-native plant, animal, and insect pests. These include:

LOCAL SUMMARY AND FORECAST

(1) Brown tree snake – Of 18 species of native Guamanian birds, seven are extinct, two are extinct in the wild (the Guam Rail, and the Micronesian Kingfisher survive only in captivity), six are rare, and three are uncommon;

(2) Cycad scale and fly – 95% of all local cycad palms dead, species endangered, (*Cycas micronesica* went from being the most abundant tree on Guam in 2002 to endangered status in 2006, according to the International Union for Conservation of Nature & Natural Resources);

(3) Rhinocerous beetle – 50 % of coconut trees doomed;

(4) Asian Yellow Banded Hornet – in 2 years has spread across island, it is dangerous (they will someday kill someone);

(5) The Little Fire Ant – insect pest, irritating bites to humans, kittens blinded;

(6) Malaysian Brown Widow Spider – is dangerous, but hides well;

(7) Betel nut tree bud-rot fungus – possibly from Taiwan, killed thousands of trees early 2000s on Guam, all deplaning passengers arriving in Pohnpei from Guam had to walk through trays of bleach to kill the spores!

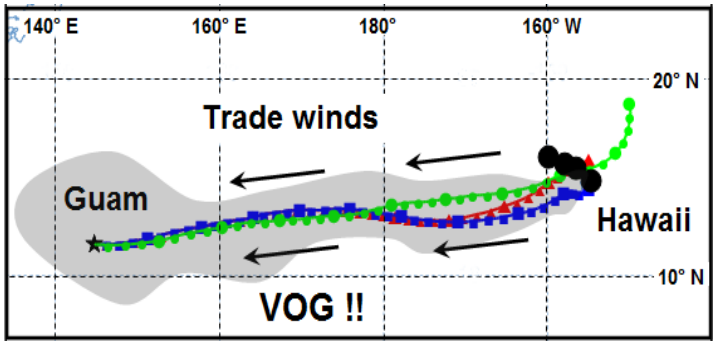


Figure G2. A backward trajectory from Guam on the morning of 17 July 2017 made using NOAA's HYSPLIT interactive web utility shows the origin of the hazy air over Guam at selected elevations of 1 m, 10 m and 100 m to be the Big Island of Hawaii. The travel time from Guam to Hawaii via the trade winds is 10 days. The light gray plume shows the movement and dispersion of the volcanic smog (VOG) that is emitted by the Big Island. Low sun angle satellite imagery (not shown) confirms the meandering plume of VOG drifting away to the west-southwest of its Big Island source. When the local winds are from the southeast across the State of Hawaii, VOG can be extensive in Honolulu and across the other islands of the State.

Climate Outlook:

Computer model forecasts are now indicating average to above average rainfall over the next three months, and the PEAC concurs with these projections. The climate is now in a state of ENSO-neutral, where it is anticipated to remain through the remainder of 2017. Earlier in the year, it was thought that there was a high probability for the onset of El Niño sometime in the latter half of 2017. The odds of El Niño onset have now fallen behind the odds for the continuation of ENSO-neutral, but remain above those for the emergence of La Niña. In general, any movement of the state of the climate system in the direction of El Niño (whether from La Niña to ENSO-neutral, ENSO-neutral to El Niño, or La Niña to El Niño) correlates well with average to above-average rainfall in our region. The stronger the move toward El Niño, the wetter and also the more serious the risk of a damaging tropical cyclone. The PEAC still gives assent to the forecast given two months ago to Saipan emergency managers by the Guam WFO Warning Coordination Meteorologist, Chip Guard:

"1. We expect more tropical cyclone activity than in 2016 but not quite as much activity as in 2015.

LOCAL SUMMARY AND FORECAST

Guam and CNMI Rainfall Summary: AMJ 2017, 2nd QTR & 1st Half						
Station		Apr	May	Jun	2nd QTR	1st Half
GUAM						
GIA (WFO)	Inches	8.60	1.89	8.40	18.89	35.47
	% Avg	220%	31%	130%	115%	129%
AAFB	Inches	1.67*	7.37	7.65	16.69	42.37
	% Avg	34%	112%	121%	94%	129%
Southern Mountain	Inches	11.31	2.06	7.22	20.59	39.87
	% Avg	232%	31%	114%	116%	121%
CNMI						
Saipan Intl. Airport	Inches	3.74	1.60	4.65	9.99	24.25
	% Avg	134%	36%	100%	84%	125%
Capitol Hill	Inches	2.61	2.25	7.85	12.71	31.71
	% Avg	75%	41%	135%	86%	130%
Tinian Airport	Inches	5.44	1.56	10.50	17.50	36.78
	% Avg	155%	28%	181%	118%	151%
Rota Airport	Inches	2.82	1.64	4.61	9.07	34.10
	% Avg	62%	26%	74%	53%	111%

2. The Northern Islands (i.e., those islands north of Saipan) could get a tropical cyclone as early as July, but more likely in August and September.

3. Saipan and Tinian could see a nearby tropical cyclone as early as July, but more likely in September, October and November.

4. Rota [and Guam] could see a nearby tropical cyclone as early as July, but more likely in October, November and December."

Later in the year (SOND), the odds of a typhoon strike (winds 65 kt or greater) are 1-in 7, or 15-20% for Guam and throughout the CNMI (these odds are near average). Despite a delay in the onset of the western North Pacific monsoon, we still anticipate that in August and continuing through October the effects of the monsoon will advance to Guam and the CNMI, brining plenty of rainfall, and two or three episodes of 25-30 kt SW winds. A stronger drift toward El Nino at any point heightens the odds of TC impacts all the way through to next January (2018).

Predicted rainfall for the Mariana Islands from July 2017 through June 2018 :

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]	
	Guam/Rota	Saipan/Tinian
Jul-Sep 2017 (Onset of next rainy season)	100%	110%
Oct-Dec 2017 (End of next rainy season)	120%	120%
Jan-Mar 2018 (1st half of next dry season)	110%	110%
Apr-Jun 2018 (2nd half of next dry season)	100%*	100%*

* This forecast for this time period is now very uncertain, and depends upon the developmental pathway of El Niño: If El Niño develops in 2017 so that it peaks in December 2017 or January 2018, then it could be dry early in 2018. If El Niño is delayed until 2018, then conditions are likely to be wet in the first half of that year.

LOCAL SUMMARY AND FORECAST

Federated States of Micronesia
Yap State:

Most locations on Yap Island were wet during the 1st Quarter of 2017, with February being particularly wet. Conditions became drier in the 2nd Quarter with the rainfall in both April and May falling below the 8-inch threshold for the adequate replenishment of municipal surface and groundwater supplies. In June, the rainfall recovered somewhat, but was still below average (Fig. Y1). Despite the relative dryness of April and May, there were no reports from Yap Island of any impacts to the municipal reservoir or any other supply of potable water. The dryness of the 2nd Quarter was unforeseen, and the PEAC 3-month outlook (made in early April) for the 2nd Quarter (AMJ) had called for near-average to above-average rainfall. The rainfall at other locations in Yap State, such as Ulithi and Woleai, followed a similar pattern to that seen at Yap Island: a wet 1st Quarter followed by a relatively dry 2nd Quarter. No reports of impacts to potable water supplies in the Yap State outer islands were received by the PEAC.

The 2017 onset of the western North Pacific monsoon was delayed. The axis of the monsoon trough remained south and west of its usual position with light easterly trade winds a dominant weather pattern in the region through June of the 2nd Quarter. The delayed and weak monsoon likely contributed to the dryness of the 2nd Quarter.

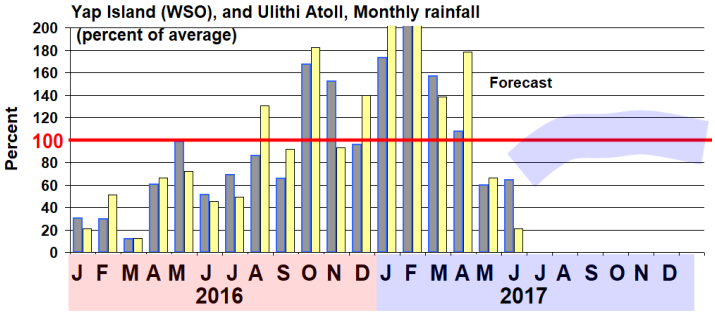


Figure Y1. Time series of monthly rainfall at the Yap Island WSO (gray bars) and Ulithi Atoll (yellow bars) for all of 2016 through June 2017. The continuous dryness at the end of 2015 through July of 2016 set a new historical record for low rainfall. Heavy rainfall in October 2016 began a 7-month run of persistent above-average rainfall, to be followed by an abrupt dry spell in May and June of 2017. Though recently dry, the rainfall across Yap State should rise to at-or -slightly above average through the remaining months of 2017. Note that Ulithi data from 24 through 29 June was missing. Rainfall at Ulithi during that period was likely at least 1.00 inch based on satellite data and data at Yap. This would place the rainfall at a more realistic 31% of normal.

Yap State Rainfall Summary: AMJ 2017, 2nd QTR & 1st Half						
Station		Apr	May	Jun	2nd QTR	1st Half
Yap State						
Yap WSO	Inches	6.19	5.40	8.16	19.75	60.96
	% Norm	107%	60%	64%	72%	130%
Ulithi	Inches	8.73	5.12	2.26*	16.11	51.77*
	% Norm	178%	66%	21%	69%	130%
Woleai	Inches	9.13	8.44	10.26	27.83	49.66
	% Norm	83%	69%	79%	77%	79%

* 5 missing days

LOCAL SUMMARY AND FORECAST

Climate Outlook:

Computer model forecasts made in April over-estimated the AMJ 3-month rainfall totals. However, despite dryness in May and June, the models still indicate average to above average rainfall over the next three months (JAS), and the PEAC concurs with these projections. Given that the dryness was likely a result of a delayed and weak western North Pacific monsoon, heavier rainfall should return to Yap State as the monsoon finally develops in late July or early August.

During July through September 2017, the basin TC activity should continue to exhibit a westward and northward shift, with a near average basin count of tropical cyclones. This should keep the tracks safely to the north of the State. Later in the year (late September through December), 2 or 3 named cyclones should track somewhere through Yap State. The PEAC assesses the risk of some damaging effects, such as high waves, gales or very heavy rainfall at 15-20% (a 1-in-7 to 1-in-5 chance) for each of the islands of Yap State, particularly from Yap Island northeastward through Fais and Ulithi.

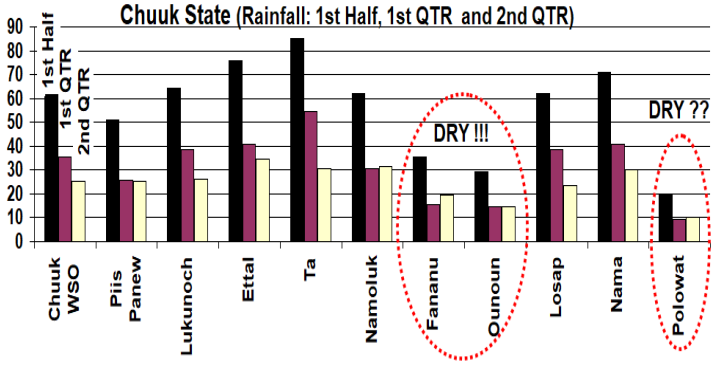
Predicted rainfall for Yap State from July 2017 through June 2018 is is:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]	
	Woleai	Yap & Ulithi
July-September 2017 (Heart of next Dry Season)	900%	100%
October-December 2017 (End of next Rainy Season)	100%	110%
January-March 2018 (Onset of next Dry Season)	90%*	100%*
April-June 2018 (End of next Dry Season)	95%*	100%*

* The uncertainty of the extended long-range forecasts will remain high until the next El Niño becomes established or its onset time is better established.

Chuuk State:

During the 1st Half of 2017, rainfall totals were mostly within plus-or-minus 10-15% of average across Chuuk State. There were two exceptions to the widespread near-average rainfall: it was very dry in the northern-most atolls of Chuuk State (e.g., at Fananu and Onoun) and also dry at Polowat in the west of the State (Fig. CH-1). Dryness in the northern atolls was of sufficient severity to impact the availability of potable water. The northern atolls of Chuuk State were mentioned in a series of Drought Impact Statements issued by the WFO Guam during the 1st Half of 2017. However, on account of a small (but very useful) increase of rainfall in June and early July, mention of the northern atolls of Chuuk State was dropped from the DIS issued on 20 July. The dryness at Polowat is thought to be an artifact of poor exposure of the rain gauge. No reports of impacts of low rainfall were received from this atoll.



LOCAL SUMMARY AND FORECAST

Fig. CH-1. Rainfall at selected locations across Chuuk State. The three bars for each site show (in order): the 1st-Half total, the 1st-QTR total and the 2nd QTR total. Note: (1) the big north-south differences in total rainfall; (2) the greater total during the 1st QTR vice the 2nd QTR; and (3) the dry conditions at the northern-most atolls of Fananu and Onoun. The dryness at Polowat may be an artifact of poor exposure of the rain gauge.

In a somewhat unusual (and unforeseen) evolution, the 1st Quarter rainfall totals were higher than the 2nd Quarter totals at most locations (Fig. CH-1). This caused the dry conditions in the northern atolls to persist longer than anticipated. In summary, the weather across Chuuk State during the 1st half of 2017 was generally unremarkable apart from dryness in the north. There were no early season tropical cyclones and no serious inundations from waves and/or high tide conditions.

Chuuk State Rainfall Summary: AMJ 2017, 2nd QTR & 1st Half

Station		Apr	May	Jun	2nd QTR	1st Half
Chuuk Lagoon						
Chuuk WSO	Inches	7.51	9.40	8.50	25.41	60.79
	% Avg	61%	77%	73%	70%	99%
Southern Mortlocks						
Lukunoch	Inches	9.61	9.41	6.97	25.99	64.50
	% Avg	73%	71%	57%	67%	91%
Northern Mortlocks						
Losap	Inches	9.15	10.40	3.83	23.38	62.14
	% Avg	74%	85%	33%	64%	101%
Northern Atolls						
Fananu	Inches	7.27	2.58	5.82	3.50	15.67
	% Avg	68%	42%	70%	28%	62%
Ounoun	Inches	5.60	3.47	5.67	14.74	29.34
	% Avg	28%	52%	83%	41%	48%
Western Atolls						
Polowat	Inches	3.04*	4.51*	2.55*	10.10*	19.37*
	% Avg	51%	50%	20%	37%	40%

* It is possible that persistent dryness at Polowat is exaggerated by an exposure problem with the rain gauge.

Climate Outlook:

The dryness of the 2nd Quarter of 2017 was unforeseen, and the forecast in the last newsletter indicating average to above-average rainfall for most of Chuuk State during AMJ was too high. The forecast therein for the northern atolls of Chuuk State fared better —

"*… except in the far north of the State (e.g., the Hall Island group), where the monthly rainfall may continue to be below average over the next two months before recovering to near average by July.*"

Looking forward over the next three months (JAS) and beyond, a blend of simple persistence with the computer forecasts will be used. Recent computer model forecasts indicate close to average rainfall for the next three months, so a slightly lower-than-average rainfall upfront will rise to near average by late August or early September and remain near average thereafter (see Fig. CH-2, and the table of forecast rainfall below). For the extended outlook beyond 3 months, the current state of ENSO and its anticipated evolution would continue to favor average to perhaps slightly above average rainfall.

LOCAL SUMMARY AND FORECAST

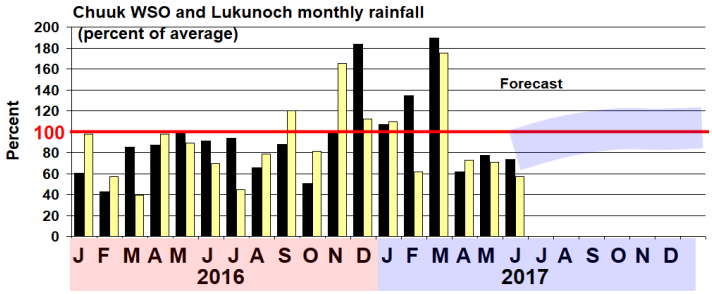


Figure CH-2. A time series of the monthly rainfall at the WSO Chuuk (black bars) and at Lukunoch (yellow bars) during 2016 and the first 6 months of 2017. The forecast (light-blue band) is for slightly below-average rainfall from July into August, rising thereafter to near-average rainfall for the rest of 2017.

For the remainder of 2017, the threat of a damaging TC anywhere within Chuuk State is anticipated to be near average: 2 or 3 named storms will track through State waters, with likely impacts of rough seas, large swells and heavy rainfall for most atolls. The risk of a direct passage of a typhoon over any atoll of Chuuk State is thought to be near average (about a 1-in-7, 15%) chance at each island location in the Chuuk Lagoon and northward (particularly during mid-September through December).

Predicted rainfall for Chuuk State from July 2017 through June 2018 is

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]			
	Chuuk Lagoon, Losap, & Nama	Polowat	Northern Is.	Southern Mortlocks
Jul - Sep 2017	90%	75%	85%	95%
Oct - Dec 2017*	100%	95%	95%	100%
Jan - Mar 2018*	100%	95%	100%	100%
Apr - Jun 2018*	100%	90%	95%	100%

* The onset of El Niño in late 2017 or during the first few months of 2018 could have a big impact on the rainfall amounts, so uncertainty at the long range is considered higher than average.

Pohnpei State:

In the words of Eden Skilling (station manger of the Pohnpei Weather Service Office), Pohnpei Island and most of the atolls of Pohnpei State have lately been, "Plenty wet!" Apart from the month of February 2017, the rainfall at the WSO Pohnpei Island has been at-or-above average since August 2016 (Fig. PN-1). The low-latitude atolls (Nukuoro and Kapingamarangi) were particularly wet during the first half of 2017, with Kapingamarangi's 6-month (JFMAMJ 2017) rainfall total of 94.76 inches the 2nd highest such total in that location's climate record for the years 2000 to 2017 (Fig. PN-2).

During the recent wet months, the Pohnpei WSO had to issue some flood statements for Pohnpei Island. A noteable high rainfall event occurred over the two days of 14 and 15 June, during which period the Pohnpei WSO recorded 7.17 inches of rainfall. Flood statements were issued, but the impacts were limited to nuisance flooding of streams and deep ponding on roadways. In general, dangerous flooding occurs on Pohnpei Island when the hourly rainfall is 2 inches per hour for 2 hours or 1 inch an hour for 5 hours and mudslides occur if the 24-hour rainfall reaches 10 inches or more. On the atolls of Pohnpei State, heavy daily

LOCAL SUMMARY AND FORECAST

rainfall of almost any threshold does not seem to bring about impacts worthy of complaint.

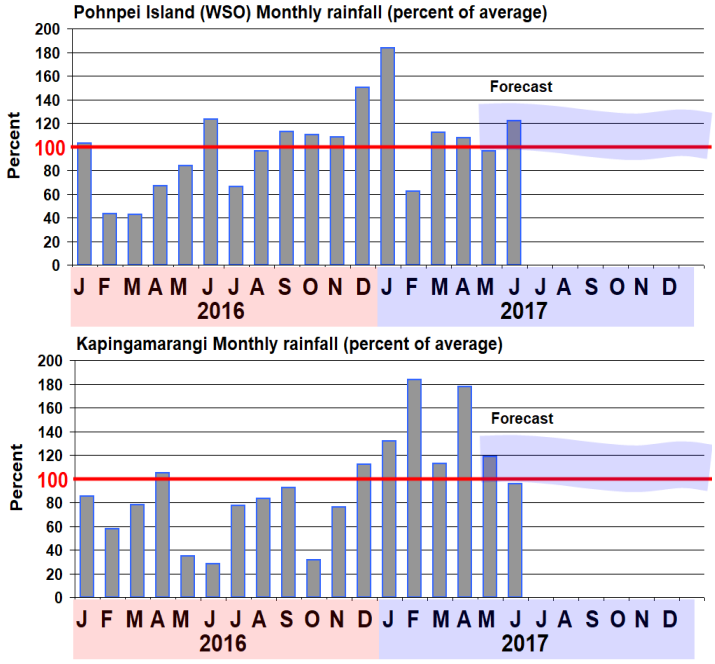


Figure PN-1. A bar chart of the monthly rainfall at WSO Pohnpei Island (top) and at Kapingamarangi (bottom) during the calendar-year 2016 through the 1st half of 2017. The forecast for AMJ rainfall made by the PEAC in April of 2017 (light blue band in each chart) was reasonable for those three months, and the forecast made then for an extended continuation of average-to-above-average rainfall still applies.

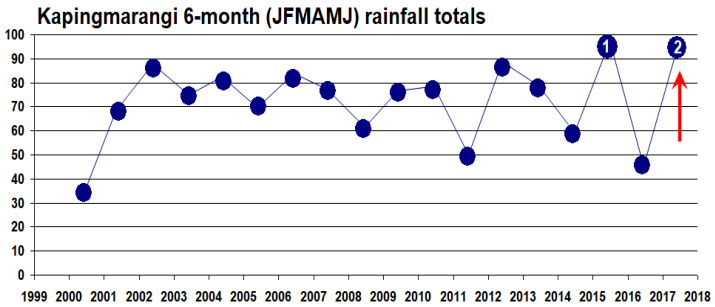


Figure PN-2. A time series of the 6-month first-half-of-the-year rainfall totals at Kapingamarangi for the years 2000 to present. The 94.76 inches of rainfall at Kapingamarangi during the first half of 2017 (red arrow) was the 2nd-highest in the time series.

Climate Outlook:

While simple persistence would indicate a continuation of above average rainfall across Pohnpei Island and the outer atolls of Pohnpei State, recent computer model forecasts have trended closer to average for the next three months. In consultation with Pohnpei partners, the PEAC has settled on a forecast favoring average to slightly above average rainfall over the next few months. For the extended outlook beyond 3 months, the current state of ENSO and its anticipated evolution would continue to favor average to above average rainfall.

The climate is now in a state of ENSO-neutral, where it is anticipated to remain for the remainder of 2017. At any time over the next several months should the state of the climate system begin to shift toward El Niño, the odds for above-average rainfall across most of Pohnpei State increase. Also, the stronger the move toward El Niño, the higher the risk becomes for a damaging tropical cyclone.

LOCAL SUMMARY AND FORECAST

Pohnpei State Rainfall Summary AMJ 2017, 2nd QTR & 1st Half						
Station		Apr	May	Jun	2nd QTR	1st Half
Pohnpei WSO	Rain (Inches)	17.68	18.45	20.85	56.98	102.90
	% of Average	108 %	96%	122%	108%	114%
PNI Airport	Rain (Inches)	13.68	15.93	18.04	47.65	84.14
	% of Average	101 %	101%	128%	110%	114%
Atolls of Phonpei State						
Station		Apr	May	Jun	2nd QTR	1st Half
Nukuoro	Rain (Inches)	13.79	27.77	13.53	55.09	122.68
	% of Average	92%	188%	111%	131%	158%
Pingelap	Rain (Inches)	15.77	7.10	5.52	28.39	61.04
	% of Average	92%	42%	34%	56%	68%
Kapinga	Rain (Inches)	21.70	13.75	11.15	46.60	94.76
	% of Average	178 %	119%	96%	131%	136%

At the latitudes and longitudes of the islands of Pohnepei State, the chance for a damaging tropical cyclone is usually low (less than 10%), but the odds are increased during El Niño. For the remainder of 2017, the threat of a damaging TC anywhere within Pohnpei State is considered by the PEAC to be about average (a 1-in-10 chance) for the occurrence of any serious impact from the heavy rain, high seas or damaging wind of a nearby TC. Any stronger-than-anticipated advance of the climate system toward El Niño carries with it a higher risk for a tropical storm or typhoon to track across portions of Pohnpei State, most likely during mid-October through December.

Lastly, the sea level began 2017 at a moderately higher-than-average stand, but has remained stable —not rising or falling much— thereafter (see the sea level section for details).

Predicted rainfall for Pohnpei State from July 2017 through June 2018:

Inclusive Period	% of long-term average	
	Pohnpei Island/ atolls	Kapingamarangi
Jul – Sep 2017	110%	110%
Oct – Sep 2017	110%	110%
Jan – Mar 2018	100%	100%*
Apr – Jun 2018	120%	110%*

* A sooner-than-expected onset of El Niño could have a big impact on the rainfall amounts, so uncertainty at the long range is considered higher than average.

Kosrae State:

The year 2017 began with greater-than-average rainfall at locations on Kosrae (Fig. KS-1). While the Kosrae Supplemental Aviation Weather Reporting Station (SAWRS) 1st Quarter rainfall total of 68.88 inches was the highest 1st Quarter total in a 31-year climate record, the 2nd Quarter was much drier, and came in at a rank of only 16th wettest in the 31-year time series (about in the middle of the pack). June 2017 was very dry, and ranked as the 6th driest June in the 31-year record.

LOCAL SUMMARY AND FORECAST

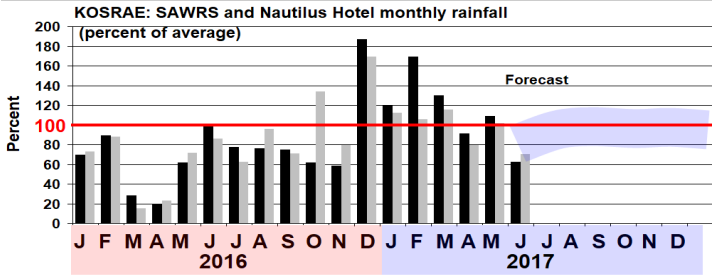


Figure KS-1. A time series of the monthly rainfall at Kosrae Supplemental Aviation Weather Reporting Station (SAWRS) (black bars) and the Nautilus Hotel (gray bars) for the period January 2016 through June 2017. The forecast for the remainder of 2017 is for the recent dryness to give-way to near average rainfall for the remainder of the year (light blue band).

Kosrae is one of the wettest locations in the US-API. The rainfall at the Kosrae SAWRS is the highest among all the first-order reporting sites (Fig. KS-2). There are some second-order sites and other unusual locations where the annual rainfall is near-or-above that of Kosrae SAWRS; for example: the annual rainfall at Palikir on Pohnpei Island is about 204 inches; at the high-elevation site, Aasufou, on American Samoa, it is about 193 inches; and, on the top of Nahna Laud (the highest elevation on Pohnpei Island), the annual rainfall is 330 inches. Compared to all cities in the U.S. mainland (and Alaska) (also plotted on Fig. KS-2), Kosrae receives an enormous amount of rain. Even soggy, rain-gray town, London, England, receives only 23.66 inches of annual rainfall – a whole order of magnitude less rainfall than at Kosrae! But aside from the occasional deafening roar of rain on the roof from a passing heavy shower (sometimes it does rain very hard), one would likely remember Kosrae for its spectacular night stars, beautiful sunsets, and bright cumulus clouds in a deep blue sky.

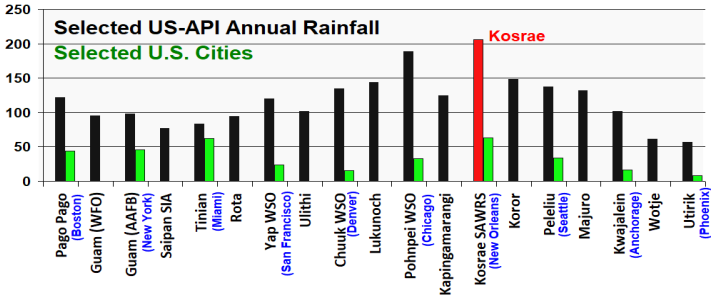


Figure KS-2. Annual rainfall at selected observing sites in the US-API. Note that rainfall at the Kosrae Supplemental Aviation Weather Reporting Station (SAWRS) (red bar) is the highest among all the sites. Rainfall at some selected U.S. mainland cities is plotted. The annual rainfall at the wettest of the U.S. cities (Miami and New Orleans) is comparable to the driest of the locations in the US-API (e.g., Wotje and Utirik)!

Kosrae State Rainfall Summary: AMJ 2017, 2nd QTR & 1st Half						
Station		Apr	May	Jun	2nd QTR	1st Half
Airport (SAWRS)	Rain (Inches)	19.62	20.34	11.73	51.69	120.57
	% of Average	91%	108%	62%	87%	111%
Nautilus Hotel	Rain (Inches)	17.18	19.12	13.33	49.63	104.43
	% of Average	79%	102%	70%	96%	83%

LOCAL SUMMARY AND FORECAST

Climate Outlook:

Since rainfall at Kosrae has been trending to drier conditions over the past 3 months, it would be prudent to meld a persistence of this dryness with the computer forecasts for near average rainfall. In consultation with island partners, the PEAC has settled on a forecast favoring near average rainfall at Kosrae over the next few months: slightly drier than average (90%) for the first three months, thereafter rising to at least 100% (this is a slightly lowered rainfall outlook than was called-for in the last Newsletter). For the extended outlook into the early months of 2018, the current state of ENSO and its anticipated evolution would continue to favor at least average rainfall.

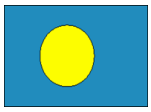
Damaging TCs are rare at Kosrae, and those rare storms that do occasionally strike Kosrae do so primarily during strong El Niño events. Thus, the risk of a damaging TC on Kosrae during the remainder of 2017 is considered to be typically low (less than 1-in-10 chance). Note: any stronger-than-anticipated advance of the climate system toward El Niño carries with it a higher risk for a tropical storm or typhoon to track near but north of Kosrae, most likely during mid-October 2017 through January 2018.

Lastly, the sea level began 2017 at a moderately higher-than-average stand, but has remained stable – not rising or falling much – thereafter (see the sea level section for details).

Predicted rainfall for Kosrae State from July 2017 through June 2018 is:

Inclusive Period (Kosrae)	% of long-term average / Forecast rainfall (inches) [1]
Jul – Sep 2017	90%
Oct – Sep 2017	100%
Jan – Mar 2018	100% *
Apr – Jun 2018	100% *

*Any early season move toward an El Niño would likely lead to a higher amount of rainfall than predicted.



Republic of Palau:

During the 1st half of 2017, the Republic of Palau continued its slow recovery from the record dry conditions that persisted continually over the course of the 2015-2016 El Niño event. Whereas the 2016 4th Quarter total rainfall and the 2017 1st Quarter total rainfall at the WSO Koror were both above average (Fig. PL1), the 2017 2nd Quarter rainfall was below average (Fig. PL-1). As a result, there was a small set-back in the ongoing recovery made against the very large accrued deficit of rainfall at the Koror observing site (Fig. PL2). After the very large amount of rainfall during March 2017, a full 25 inches had been shaved from the -85.73 inch low-point of the long term rainfall deficit reached in August 2016. With the 2nd Quarter running a small deficit, the long-term accumulation lost some of its recent gain

The rainfall at Palau tracks ENSO so well that it makes a good ENSO index in its own right! (see Fig. PL-3). During El Niño, the ONI is warm and Palau's rainfall is low; during La Niña, The ONI is cold and Palau's rainfall is high. Note that the substantial cooling of the ONI after the extreme warmth of the 2015-2016 El Niño did not make it all the way back into La Niña territory (-0.5°C, or cooler), and the rainfall at Palau (while making a good come-back), has similarly tracked the ENSO Index to only a near-average value.

LOCAL SUMMARY AND FORECAST

Regarding the severe die-off of Jellyfish in Palau's famous Jellyfish Lake during the 2015-2016 El Niño, there are recent reports that the juvenile polyps are in the process of releasing the next generation of adult medusas. Tourists are still restricted from the lake as island resource managers and property owners are in discussion of how best to protect the resource.

Lastly, we are happy to announce the start-up of a new rainfall station at Palau's Capitol in Melekeok, on the northern side of Babeldaub

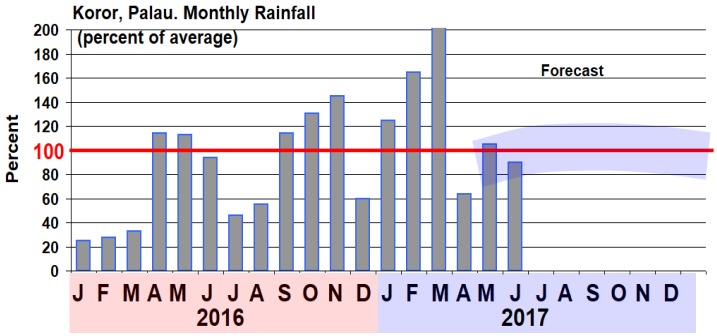


Figure PL-1. A bar chart of observed rainfall (percent of average) at the Koror WSO for 2016 and the 1st half of 2017. The forecast presented in the April Newsletter for the rest of 2017 is still applicable (light-blue band). .

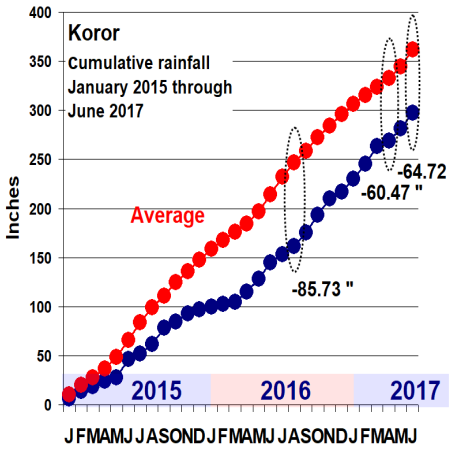


Figure PL-2. Cumulative rainfall at Koror. Red line shows the normal accumulated rainfall from JAN 2015 through JUN 2017, and the dark blue line shows the observed accumulated rainfall over the same time period. The accumulated deficit reached its extreme low of -85.73 inches in August 2016. Abundant rainfall in late 2016 and early 2017 allowed for a recovery of 25 inches against the long-term deficit, but has seen a slight set-back in the 2nd Quarter.

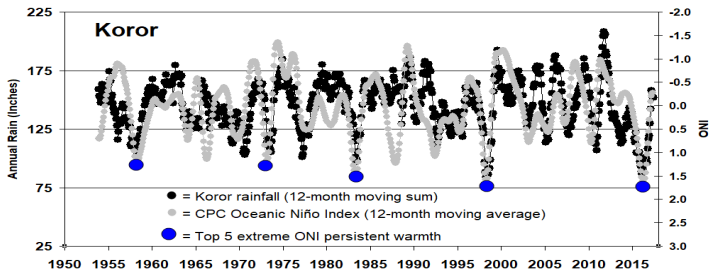


Figure PL3. A time series of a 12-month moving sum of the rainfall at the Koror WSO compared to a 12-month moving average of the CPC's Oceanic Niño Index (ONI). Values plotted look backwards 12 -months from the plotted location. That is, the plotted value at January 1980 is the rainfall total for the 12-month period ending in January 1980. Note how well the rainfall at Palau tracks the ONI. The correspondence is so good that the Palau rainfall is itself a good ENSO Index. The cooling of the ONI in recent months did not go all the way back into La Niña, and similarly, the recent rainfall has only recovered to near average.

LOCAL SUMMARY AND FORECAST

Republic of Palau Rainfall summary: AMJ 2017, 2nd QTR & 1st Half						
Station		Apr	May	Jun	2nd QTR	1st Half
Koror WSO	Rain (Inches)	5.54	12.61	15.53	33.68	80.23
	% of avg.	64%	105%	90%	89%	122%
Intl. Airport	Rain (Inches)	9.49	15.97	11.74	37.20	81.93
	% of avg.	100%	121%	62%	89%	113%
Mele-keok	Rain (Inches)	4.51	12.26	19.51	36.28	85.07
	% of avg.	*	*	*	*	*
Nekken	Rain (Inches)	6.63	14.21	8.99	29.83	76.98
	% of avg.	76%	119%	52%	79%	117%
Peleliu	Rain (Inches)	4.91	9.56	8.54	23.01	56.37
	% of avg.	57%	80%	49%	61%	85%

Climate Outlook:

Computer model forecasts still indicate above average rainfall at Palau, but some recent months have dropped below average. Using a blend of a declining influence of persistence with the computer projections, the PEAC believes that the rainfall at Palau should be at least near average for the remainder of 2017. The forecast for the state of ENSO is somewhat uncertain at this time, with odds (50-55%) now favoring a continuation of ENSO -neutral for the remainder of the year, but with the probability of the onset of El Niño (35-45%) running not too far behind. The timing and strength of the next El Niño are crucial for the Palau forecasts. So, for now, we will keep the rainfall forecast at near average through the end of 2017.

Through June 2017, the basin TC activity exhibited a westward and northward shift, keeping TC activity away from Palau. A slightly below average basin count of TCs is anticipated for the rest of the year. However, later in the year (October through December) the TC tracks should shift southward with possible impacts to Palau. The PEAC assesses the risk of some damaging effects, such as high waves, gales or very heavy rainfall at 10 -15% (a 1-in-10 to 1-in-7 chance), particularly after September. The passage of destructive typhoons Bopha and Haiyan across Palau late in 2012 and 2013, respectively, shows that the status of ENSO is not a strong predictor of typhoon activity in Palau. Perhaps the biggest factor to yield a destructive typhoon in Palau is the need to have the typhoon stay far enough south to affect Palau. This does at least narrow down the timing of greatest risk to the period mid-October to mid-January when low-latitude typhoon tracks are more common. Low-latitude typhoons Mike (1990), Bopha (2012) and Haiyan (2013) affected Palau in November or December. Notably, one major typhoon —Sally— affected Palau in March (1967).

Lastly, the sea level began 2017 at a moderately higher-than-average stand, but has remained stable – not rising or falling much – thereafter (see the sea level section for details).

Predicted rainfall for Palau from July 2017 through June 2018 is:

LOCAL SUMMARY AND FORECAST

Palau Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]
Jul-Sep 2017	100%
Oct-Dec 2017	110%
Jan-Mar 2018	100%
Apr-Jun 2018	100%

[1] Forecast rainfall quantities represent BEST ESTIMATES given the probabilistic forecast for each particular season and station.

* The uncertainty of the long-range forecasts will remain very high until the timing of the onset and the anticipated strength of El Niño is known with more certainty.

Republic of the Marshall Islands (RMI):

Beginning in the summer of 2016, most atolls of the RMI began a long and steady climb out of dry conditions to end 2016 and begin 2017 with a string of wet months (Fig. RMI-1 and RMI-2). Some of the atolls from Majuro and southward experienced very wet conditions during the first four months of 2017. The 1st Quarter rainfall totals ranked the 2nd and 9th wettest at Mili and Majuro, respectively. However, many of the atolls (e.g., Wotje, Utirik, Mejit, and Ailuk) north of the latitude of Kwajalein (8.7° N) began 2017 with a sharp decline of rainfall. Potable water supplies were quickly impacted, with household rain catchment tanks depleted. Emergency short-term assistance was provided by the RMI government to the drought-impacted northern islands.

Drought Update: Persistent dryness continued in many of the northernmost atolls through July 2017. In early May, a message was received from the WSO Majuro that on the 24th of April, the President of the RMI declared a "State of Emergency" for the northern atolls and islands affected by dry conditions. This was later extended to the end of June. During June 2017, some heavy rain showers provided relief to some of the northern atolls. On 25 June, heavy showers (with thunder reported) dumped 2.90 inches of rain on Kwajalein Atoll. This brought the June total on Kwajalein to 10.80 inches. A similar one-day extreme helped to alleviate drought conditions on Wotje, where the June total was a healthy 8.86 inches (170%). Over the course of the 1st Half of 2017, the WFO Guam issued a series of Drought Information Statements (DGT). Excerpts from the 20 July DGT include:

"...THE EXTREME DROUGHT CONTINUES IN THE NORTHERN AND NORTHWESTERN
MARSHALL ISLANDS BUT SHOWERS HAVE INCREASED..."
"VERY DRY WEATHER REMAINS ALONG AND NORTH OF 10N FROM THE DATE LINE
WESTWARD OVER THE MARSHALL ISLANDS. FAIRLY NORMAL RAINFALL HAS BEEN
REPORTED OVER THE SOUTHERN AND CENTRAL MARSHALL ISLANDS."
"[Heavier showers from upper level disturbances] HAVE BEGUN...BUT THE PROCESS WAS ABOUT A MONTH LATER THAN NORMAL. THESE ...DISTURBANCES ARE NEEDED TO HELP BRING EARLY TO MID SUMMER RAINS TO THE NORTHERN PARTS OF MICRONESIA. KWAJALEIN AND WOTJE HAVE RECENTLY BENEFITED FROM THOSE RAINS."
"THE EXPERIMENTAL DROUGHT ASSESSMENT OF THE U.S. DROUGHT MONITOR INDICATES THAT UTIRIK OF

LOCAL SUMMARY AND FORECAST

THE NORTHERN MARSHALL ISLANDS IS IN SHORT-TERM AND LONG-TERM EXTREME DROUGHT (DROUGHT LEVEL 3 OF 4). WOTJE ATOLL AND NEARBY ATOLLS ARE IN LONG-TERM SEVERE DROUGHT (DROUGHT LEVEL 2 OF 4). KWAJALEIN AND NEARBY ATOLLS HAVE IMPROVED TO A RATING OF D-NOTHING [D0].”

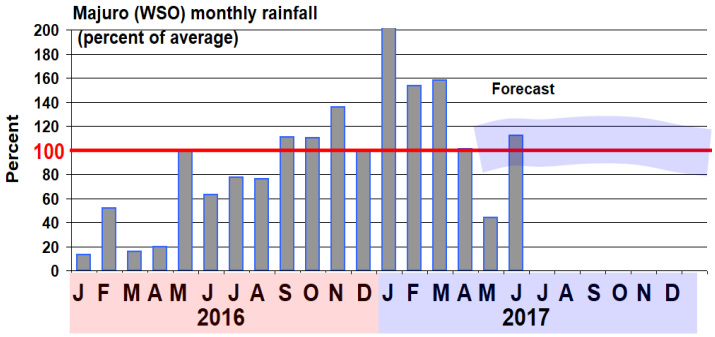


Figure RMI-1. A time series of rainfall at the WSO Majuro (gray bars) during 2016 through the 1st half (JFMAMJ) of 2017. Note the dramatic rising trend from extremely dry during early 2016 to the return of abundant rainfall in the summer and fall of 2016 and early 2017. May was anomalously dry, but adequate rainfall returned in June. Near-average rainfall is forecast for the remainder of 2017 (light blue band).

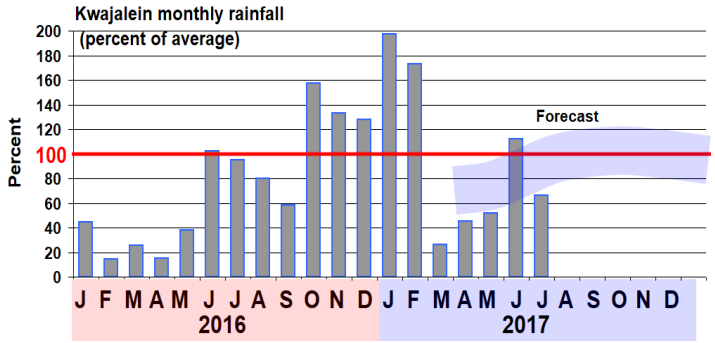


Figure RMI-2. A time series of rainfall at Kwajalein Atoll (gray bars) during 2016 and the 1st half (JFMAMJ) of 2017. Note the evolution from extremely dry conditions during the first half of 2016 to very wet at the end of 2016, and during January and February of 2017. There was a sudden onset of dryness during March 2017 that lasted through May. All RMI atolls northward of Kwajalein experienced some version of this return to dry conditions during the first few months of 2017. The July rainfall was just made available on the Kwajalein RTS web site, and it is plotted. The forecast made in the previous newsletter is retained here (light blue band), which shows below-average rainfall for AMJ that recovers to near average after July. This forecast is still applicable, although it was too optimistic for the 2nd Quarter).

Climate Outlook:

Recent computer model forecasts have trended slightly drier, and now indicate average to below average rainfall over the next 3 months (specifically for Majuro and Kwajalein). In consultation with RMI partners, the PEAC settled on a forecast favoring near-average rainfall throughout the RMI over the next three months and beyond.

The climate is now in a state of ENSO-neutral, where it is anticipated to remain through the remainder of 2017. The odds for El Niño to develop during the latter half of 2017 have fallen to 2nd place (behind ENSO-neutral) after being in the lead in earlier projections. In general, any movement of the state of the climate system toward El Niño (whether from La Niña to ENSO-neutral, ENSO-neutral to El Niño, or La Niña to El Niño) correlates well

LOCAL SUMMARY AND FORECAST

RMI Rainfall Summary: AMJ 2017, 2nd QTR & 1st Half						
Station		Apr	May	Jun	2nd QTR	1st Half
RMI Central and Southern Atolls						
Majuro WSO	Inches	10.36	4.93	13.03	28.32	68.47
	% Avg	101%	44%	112%	122%	86%
Ailing	Inches	9.82	2.82	9.45	22.09	49.99
	% Avg	110%	27%	89%	73%	105%
Jaluit	Inches	9.58	2.33	5.41	17.32	51.99
	% Avg	93%	21%	47%	52%	93%
Mili	Inches	14.01	2.05	8.18	51.93	24.24
	% Avg	136%	18%	71%	93%	73%
RMI Northern Atolls						
Kwajalein	Inches	3.44	5.20	10.80	19.44	35.11
	% Avg	46%	52%	112%	72%	90%
Wotje	Inches	5.23	1.14	8.86	15.23	20.78
	% Avg	134%	25%	170%	111%	100%
Utirik	Inches	T*	1.38	1.60	2.98	6.61
	% Avg	<1%	32%	33%	23%	34%

with average to above-average rainfall across most of the RMI at least through the first half of the year. The extreme dryness during early 2017 in the northernmost atolls of the RMI is considered to be a regional anomaly lacking a clear connection to ENSO.

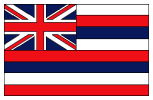
For the remainder of 2017, the threat of a damaging TC anywhere within the RMI is low (a 1-in-15 chance), but certainly there is a higher risk than during 2016. Note: any stronger-than-anticipated advance of the climate system toward El Niño carries with it a higher risk for a tropical storm or typhoon to track near or through the RMI. Two scenarios arise: a TC from the Central Pacific tracks westward at relatively higher latitude (~ 15° N) with minimal effects at most atolls, or the disturbance or tropical depression stage of one or two western Pacific TCs occurs within the bounds of the RMI, with intensification to tropical storm or typhoon taking place farther to the west. Central Pacific TCs could drift across the date line to the north of the region as early as August, and the risk for in-situ development of TCs begins in August, but reaches a peak later in the year.

Predicted rainfall for the atolls of the RMI from July 2017 through June 2018:

Inclusive Period	% of long-term average		
	South of 6°N	6°N to 8°N	North of 8°N*
Jul –Sep 2017	100%	95%	85%
Oct—Dec 2017	100%	100%	95%
Jan—Mar 2018	100%	100%	100%
Apr—Jun 2018	100%	100%	100%

* A residual persistence of dry conditions is possible at these atolls in this time period

** If there is an onset of El Niño in early 2018, the rainfall amounts could be higher.



Hawaii:

The following information was taken from the NWS Honolulu Office August 2017 (http://

LOCAL SUMMARY AND FORECAST

www.prh.noaa.gov/hnl/pages/hydrology.php): Rainfall picked up a bit during the second half of the month due to the presence of an upper level low pressure trough over or near the island chain and an increase in moisture in the lower levels of the atmosphere. Some of this moisture arrived as part of the remnant circulation of former Hurricane Fernanda which dissipated as a tropical cyclone east of the state. The remnant circulation of post -tropical cyclone Greg passed south of the main Hawaiian Islands during the final days of July but it was too far south to have any significant impacts on local rainfall conditions.

The NCEP climate forecast system (CFS) (available at: http://www.cpc.ncep.noaa.gov/products/predictions/90day/fxhw40.html) and other climate models run as a part of the North American multi-model ensemble (NMME) observes that there is high uncertainty with the precipitation forecast for Hawaii from ASO to NDJ of 2017. Equal Chances (EC) for above, near, or below median precipitation are indicated by most dynamical model forecasts and NMME Hawaii from ASO to NDJ of 2017. CPC Constructed Analog (CA) tool favors below median precipitation for Lihue, Honolulu, and Kahului for the incoming winter seasons from DJF to JFM 2018. Equal Chances (EC) for above, near, or below median precipitation are forecast for Hawaii in FMA 2018 and longer leads.

Predicted rainfall for Hawaii State from August 2017 through August 2018 is as follows:

	Station			
Inclusive Period	**Hilo**	**Honolulu**	**Kahului**	**Lihue**
Aug-Oct 2017	Equal probabilities of below, average or above average rainfall	Equal probabilities of below, average or above average rainfall	Equal probabilities of below, average or above average rainfall	Equal probabilities of below, average or above average rainfall
Dec-Feb 2018	Equal probabilities of below, average or above average rainfall	40% chance of Below Median rainfall	40% chance of Below Median rainfall	40% chance of Below Median rainfall
Mar—May 2018	Equal probabilities of below, average or above average rainfall	Equal probabilities of below, average or above average rainfall	Equal probabilities of below, average or above average rainfall	Equal probabilities of below, average or above average rainfall
Jun—Aug 2018	Equal probabilities of below, average or above average rainfall	Equal probabilities of below, average or above average rainfall	Equal probabilities of below, average or above average rainfall	Equal probabilities of below, average or above average rainfall

LOCAL SUMMARY AND FORECAST

Seasonal Drought Outlook for Hawaii:

An anomalously stable atmosphere has limited rainfall over many areas of the Big Island. As a result, severe drought, or the D2 category on the U.S. Drought Monitor map, has returned quickly to the leeward areas of the South Kohala District. Moderate drought, or D1 category conditions, have spread eastward to cover all of the windward slopes and the Kau District. Only portions of the Kona slopes and the windward slopes of the Kohala Mountains remain drought-free on the Big Island. No significant drought impacts reported in Kauai, Oahu, and Maui County. However, according to CPC's Seasonal Drought Outlook (July 20, 2017) (http://www.cpc.ncep.noaa.gov/products/expert_assessment/sdo_summary.php), in Hawaii, rainfall normally increases during the fall along windward sites, and with an active Pacific hurricane season and a wild card for enhanced rainfall on eastern sides, improvement was forecast for windward areas with persistence in leeward locations.

SEASONAL SEA LEVEL OUTLOOK Cont.

Sea Level Observation from the Global Satellite Picture:

Observations from the recent global satellite picture (Fig. 10, below) revealed that the sea levels have been slightly elevated over the western part of the Pacific Basin. ***The tropical Pacific atmosphere and ocean are currently at ENSO-neutral state.*** *This satellite data are supportive to tide-gauge observations, and revealed that some of the stations located in Micronesia and Marshalls Islands is slightly elevated. There remains likelihood of high sea levels affecting the tropical northwestern Pacific islands during late summer and fall.*

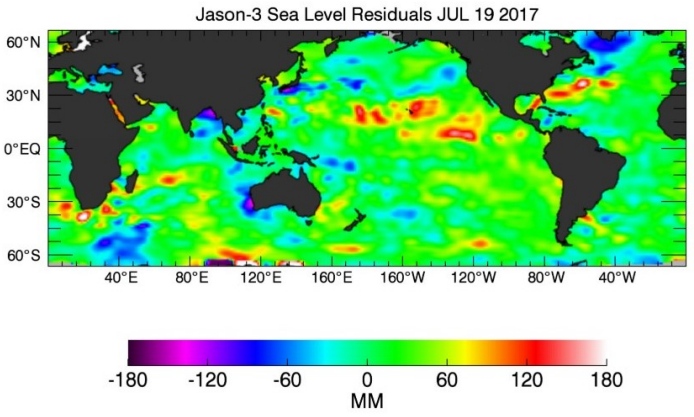


Figure 10. Jason-3 sea level residuals (July 8, 2017). (Source: https://sealevel.jpl.nasa.gov/images/latestdata/jason/2017/20170719G.jpg

***Pacific ENSO Update* is Now Available Online:**
To receive notification when the newsletter is available online visit:
http://www.weather..gov/peac/update.php
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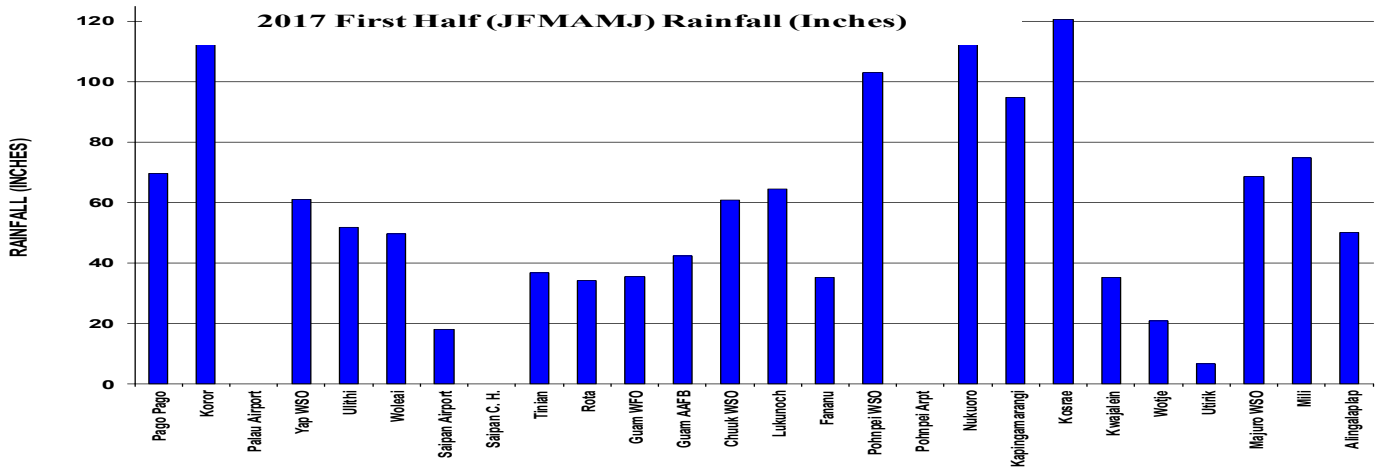
SEASONAL RAINFALL OUTLOOK FOR THE US-AFFILIATED PACFIC ISLANDS

11)



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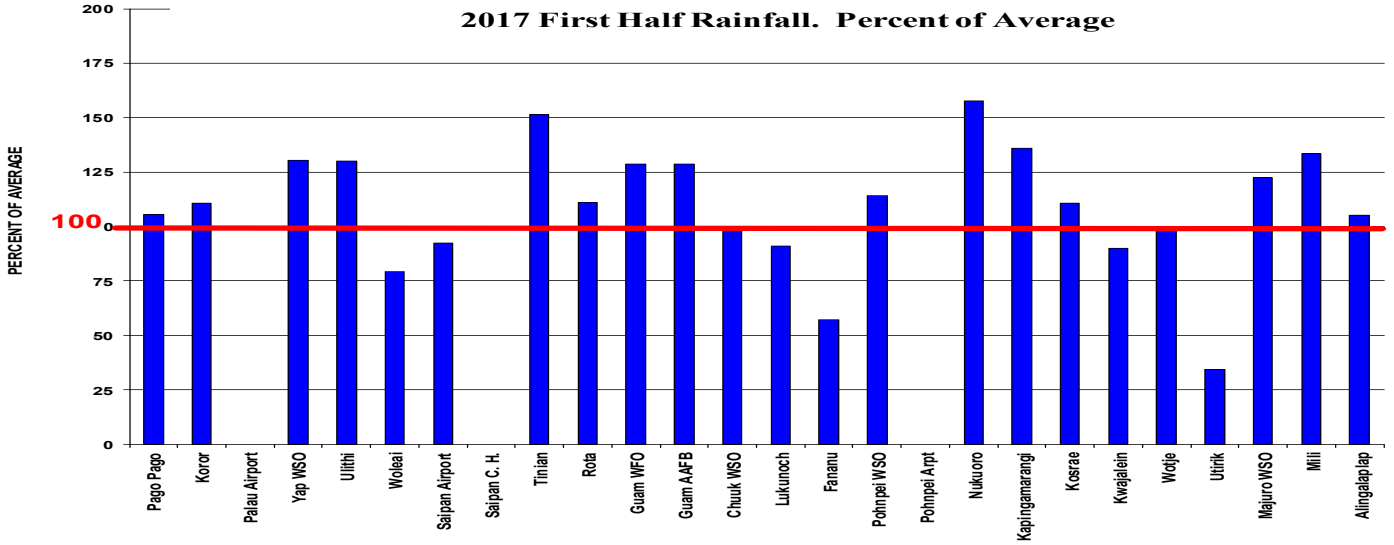

Figure 11 and 12, 2017 First Half rainfall (Fig. 11) and percent of average rainfall (Fig. 12) amounts in inches at the indicated locations and rainfall departure from average (in percent) at the indicated locations.

ACKNOWLEDGEMENTS AND FURTHER INFORMATION

Pacific ENSO Applications Climate (PEAC) Center:
HIG #340, 2525 Correa Road, Honolulu, Hawai'i 96822
Contact at 808-956-2324: for information on PEAC, the Pacific ENSO Update and ENSO-related climate data for the Pacific Islands.

Dr. Rashed Chowdhury,
Principal Research Scientist, at 808-956-2324: for information on ENSO and sea level variability in the USAPI.
Alejandro Ludert, Graduate Research Assistant and Webmaster, at 808-956-2324 for: information related to the PEAC website.

University of Hawai'i - Joint Institute of Marine and Atmospheric Research (JIMAR), School of Ocean and Earth Science and Technology (SOEST), Department of Oceanography:
MSB #317, 1000 Pope Road, Honolulu, Hawai'i 96822
Dr. Mark Merrifield, PEAC Principal Investigator at 808-956-6161: for more information on sea level and climate in Hawai'i.

NOAA National Weather Service
Weather Forecast Office (WFO) Honolulu:
HIG #250, 2525 Correa Rd., Honolulu, HI, 96822
Tom Evans, PEAC Director, at 808-973-5270: for information related to NWS.

NOAA National Weather Service—Weather Forecast Office (WFO) Guam:
3232 Hueneme Road, Barrigada, Guam, 96913
Chip Guard, Warning Coordination Meteorologist, at 671-472-0900: for information on tropical cyclones and climate in the USAPI.

University of Guam - Water and Environmental Research Institute (WERI):
UOG Station, Mangilao, Guam 96913
Dr. Mark Lander, PEAC Meteorologist, at 671-735-2685 for: information on tropical cyclones and climate in the USAPI.

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The Pacific ENSO Update is a bulletin of the Pacific El Niño-Southern Oscillation (ENSO) Applications Climate (PEAC) Center. PEAC conducts research & produces information products on climate variability related to the ENSO climate cycle in the U.S. Affiliated Pacific Islands (USAPI). This bulletin is intended to supply information for the benefit of those involved in such climate-sensitive sectors as civil defense, resource management, and developmental planning in the various jurisdictions of the USAPI.

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