PACIFIC ENSO UPDATE

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

4th Quarter, 2017 Vol. 23, No. 4 **ISSUED: December 01, 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

Rainfall throughout the United States-Affiliated Pacific Islands (US-API) was generally near average during the 3rd Quarter of 2017 (Fig. 1 and Fig. 2). A quiet weather pattern -- in many ways typical of La Niña – persisted, with a notable lack of tropical cyclones (TCs) and a displaced monsoon system. Monthly extremes of 24-hour rainfall and peak observed wind gusts were mostly unremarkable for the region (for example, WFO Guam's greatest 24-hour rainfall during 2017 to-date is 3.65 inches, and the highest wind gust is 42 mph). A heavy daily rainfall of 5.60 inches at Kwajalein on the 10th of September was one of the highest in Micronesia during 2017, and contributed to a record September rainfall of 22.06 inches at that station. Typical summer increases in rainfall helped ease dry conditions that occurred during the first half of 2017 in some isolated areas, including most of the atolls of the northern RMI and some of the northern atolls of Chuuk State.

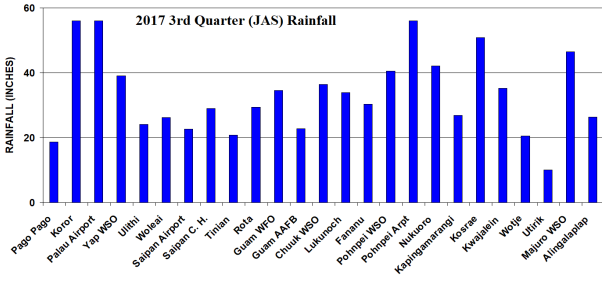

Figure 1. 2017 3rd Quarter (JAS) rainfall amounts in inches at the indicated locations.

Third-Quarter totals below 25 inches were experienced at Pago, Ulithi, Saipan International Airport, Tinian, Guam AAFB, Wotje and Utirik.

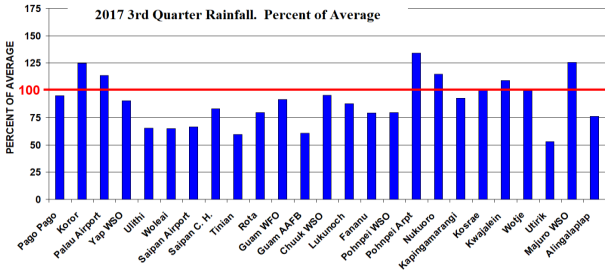

Figure 2. 2017 3rd Quater rainfall as a percent of average at the indicated locations.

Note that at most locations in Micronesia the 3rd Quarter totals were below average.

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 Half of 2017. Drought information statements were issued by the WFO Guam regarding dry conditions in the northern RMI and at some of the northern atolls of Chuuk State through 28 September 2017. With the summer increase of rainfall at these locations, drought statements were thereafter discontinued.

CURRENT STATE OF ENSO

ENSO Alert System Status: La Niña Advisory

During the first few months of 2017, there were indications 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 (Fig. 3). 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). The La Niña-like weather patterns persisted through the 3rd Quarter of 2017, as the climate system backed away from El Niño, with an onset of ocean cooling that has now reached the La Niña threshold (see again Fig. 3). The CPC's latest ENSO advisory (appended below) activates a La Niña Advisory.

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

Synopsis: La Niña conditions are predicted to continue (~65-75% chance) at least through the Northern Hemisphere winter 2017-18.

"During October, weak La Niña conditions emerged as reflected by below-average sea surface temperatures (SSTs) across most of the central and eastern equatorial Pacific Ocean. The weekly Niño indices were variable during the month, with values near -0.5° C during the past week in the Niño-3.4 and Niño-3 regions. Sub-surface temperatures remained below average during October, reflecting the anomalously shallow depth of the thermocline across the central and eastern Pacific. Also, convection was suppressed near the International Date Line and slightly enhanced over parts of the Maritime Continent and the Philippines. Over the equatorial Pacific Ocean, low-level trade winds were mainly near average, but the upper-level winds were strongly anomalously westerly and the Southern Oscillation Index was positive. Overall, the ocean and atmosphere system reflects the onset of La Niña conditions."

"For the remainder of the Northern Hemisphere fall and winter 2017-18, a weak La Niña is favored in the model averages of the IRI/CPC plume and also in the North American Multi-Model Ensemble (NMME). The consensus of forecasters is for the event to continue through approximately February-April 2018. In summary, La Niña conditions are predicted to continue (~65-

CURRENT CONDITIONS

75% chance) at least through the Northern Hemisphere winter (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)."

[1] Climate Prediction Center National Centers for Environmental Prediction, NOAA/National Weather Service, College Park, MD 20740.

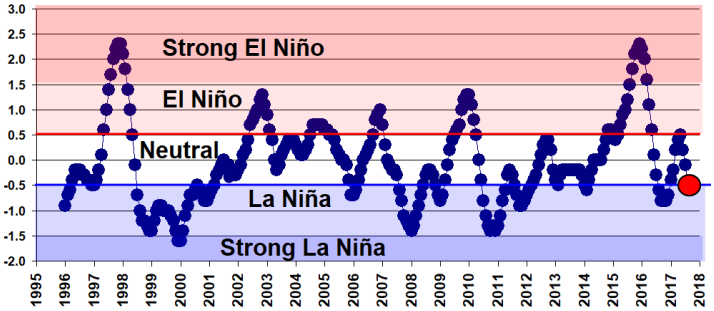

Figure 3. A plot of the CPC's Oceanic Niño Index (ONI) for the past two decades. The red dot indicates the latest three month average. Note that it made a run toward El Niño early in 2017, but now has reversed itself and is currently at the threshold of La Niña.

Sea Level

As long anticipated by the PEAC, the sea level across Micronesia continually increased during 2016 and during 2017 to-date. A temporary hiatus of the rise of sea level occurred in late 2016, but a sustained rise returned in early 2017. Sea levels are now about 5-9 inches above average across most of Micronesia and A. ENSO-related sea level changes are shifted by about 3 months at American Samoa (Sea Fig. 4).

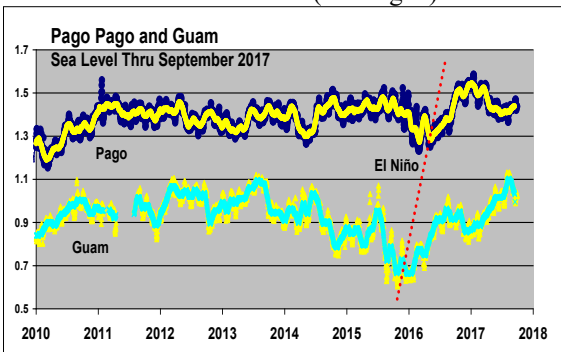

Figure 4. Sea level recorded at Guam and at American Samoa during 2010 to present. During El Niño, there is a sharp drop in sea level at most locations followed by a steep rise thereafter. The lowest sea level occurs at Guam a few months before the minimum is observed at American Samoa.

Note that the rise and fall of sea level closely tracks the strength of the low-latitude wind (Fig. 5), and hence the very strong connection of regional sea level with ENSO. Looking closely at Fig. 5, 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.

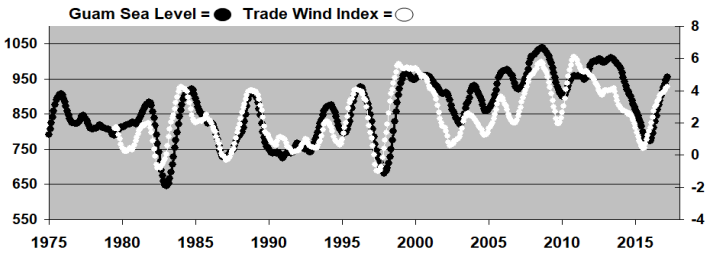

Figure 5. Time series of sea level at Guam (NOAA Sumay Cove tide gauge) from January 1975 through September 2017. Black line is a 12-month moving average of Guam's sea level, and the white line is a 5-month moving average of NOAA's trade wind index (5°S-5°N ; 135°E to 180°). The sea level at Guam and throughout the tropical western Pacific closely tracks the trade winds.

The PEAC archives western North Pacific tropical cyclone (TC) numbers, track coordinates, and 1-minute average maximum sustained wind taken from operational warnings issued by the Joint Typhoon Warning Center (JTWC) of the U. S. Air Force and Navy, located at Pearl Harbor, Hawaii. Western North Pacific tropical cyclone names are obtained from warnings issued by the Japan Meteorological Agency (JMA), which is the World Meteorological Organization's Regional Specialized Meteorological Center (RSMC) for the western North Pacific basin. The PEAC archives South Pacific TC names, track coordinates, central pressures, and 10-minute average maximum sustained wind estimates from advisories issued by the Tropical Cyclone Warning Centers at Brisbane, Nadi, and Wellington. The numbering scheme and the 1-minute average maximum sustained wind estimates are taken from warnings issued by the JTWC. There are sometimes differences in the statistics (e.g., storm maximum intensity) for a given cyclone among the agencies that are noted in this summary.

TROPICAL CYCLONE ACTIVITY

Western North Pacific

For all the wild and crazy hurricane activity in the Atlantic basin, the TC activity in the Pacific was well below average in many categories (Table 1). The inactivity of the Pacific was more than enough to cancel the influence of Atlantic high activity on the summation of TC activity for the whole Northern Hemisphere!

The first half of the 2017 typhoon season of the western North Pacific (WNP) was relatively inactive, with only seven systems developing, of which only two intensified into tropical storms. Activity picked-up in late July, but through October, most TC number statistics remained below normal, with the JMA naming 22 storms, including 9 typhoons and 2 super typhoons. Until mid-October, when the developing typhoons Lan and Saola formed west of Guam and north of Yap Island, the WFO had issued no tropical cyclone warning products (e.g. TS or TY watches/warnings) for Micronesia.

Throughout 2017, there was a westward and northward displacement of the TC activity. This was similar to the TC distribution during 2016, but starkly different than the TC distribution during the 2015 El Niño year (Figure 6). A particular characteristic of the 2017 typhoon season was a clustering of activity across the South China Sea. The westward and northward displacement of the 2017 TCs is consistent with the development of La Niña. (See the LVS for each island group for specific TC details).

EastPac

The eastern North Pacific (ENP) hurricane season was near average to below average in most number statistics (Table 1). There were no TCs having any serious impact to the state of Hawaii, and there were no TCs named by the CPHC.

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. The 2016–17 South Pacific cyclone season was one of the least ac-

Basin	Named Storms	Named Storm Days	Hurricanes/ Typhoons	Hurricane Days	Major Hurricanes	Major Hurricane Days	ACE
NAtl	16 (11.4)	88.75 (55.0)	10 (6.0)	51.25 (22.7)	6 (2.6)	19.25 (6.0)	224.1 (99.3)
ENP	18 (16.3)	66.00 (72.2)	9 (8.7)	19.75 (29.7)	4 (4.3)	4.75 (8.9)	98.2 (130.5)
WNP	**22 (23.1)**	**85.50 (119.5)**	**11 (14.8)**	**35.75 (58.7)**	**4 (7.6)**	**6.00 (19.9)**	**143.8 (259.4)**
NIO	2 (3.2)	4.00 (8.5)	1 (0.8)	0.25 (1.7)	0 (0.5)	0.00 (0.7)	3.5 (11.1)
N Hemi	58 (54.0)	244.25 (255.2)	31 (30.3)	107.00 (112.8)	14 (15.0)	30.00 (35.5)	469.6 (500.3)

Table 1. 2017 Northern Hemisphere Tropical Cyclone Activity (through October), by basin and with hemisphere totals (http://tropical.atmos.colostate.edu/Realtime/). Numbers in parentheses are long-term averages. A major hurricane/typhoon is any such storm at-or-above Category 3 intensity (115 mph) as per the Saffir-Simpson Hurricane Wind Scale. Accumulated Cyclone Energy (ACE) is a measure of the energy of a TC, and is proportional at any given time to the square of the wind speed.

tive South Pacific cyclone seasons on record, with only two tropical cyclones occurring within the South Pacific Ocean to the east of 160°E. The 2016–17 South-West Indian Ocean cyclone season was also below average with only 5 TCs, three of which acquired hurricane intensity.

The 2017-18 SH TC season (beginning on 01 July 2017) has seen no activity to-date. The average number of named TCs in the SH during the period July through October is only 1. The activity begins to pick-up in November and December. Local agency forecasts of SH TC activity for the upcoming season indicate a near-average distribution in the Australia region, falling to below average in the South Pacific eastward of 160° W (see forecast discussion below).

PEAC tropical cyclone assessment

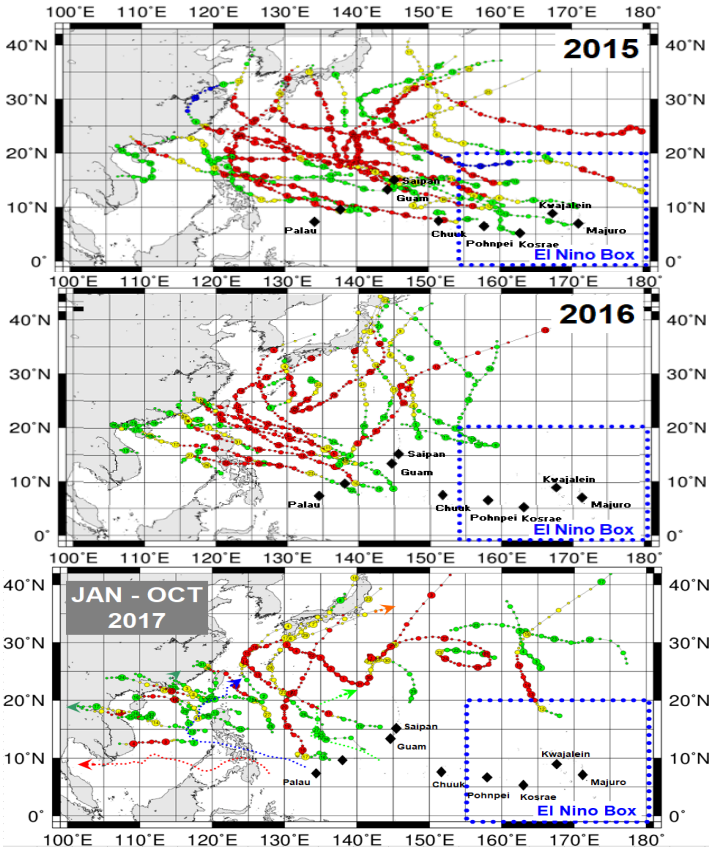

Figure 6. Tropical cyclone tracks during 2015, 2016 and JFMAMJJAS 2017 in the western North Pacific. TCs 01W and 02W of 2017 were not named by the JMA. The blue "El Niño Box" is a region in which tropical cyclones occur primarily during El Niño.

Western North Pacific and American Samoa

Earlier in the year, two entities provided forecasts of 2017 typhoon activity: (1) The Guy Carpenter Asia-Pacific Climate Impact Centre (GCACIC) at the School of Energy and Environment, City University of Hong Kong; and, Tropical Storm Risk (TSR), Dr Adam Lea and Professor Mark Saunders Dept. of Space and Climate Physics, University College London (UCL). Both entities called for reduced activity, with the TSR group dramatically decreasing the number forecast in its July update since the anticipated development of El Niño did not occur. The Hong Kong group called for a below-normal number of landfalling TCs in each of three East Asian regions: South China Sea/Philippines; east China/Taiwan; and, Japan/Korea. This forecast may have underestimated the number, particularly in the South China Sea, but we await the final verification.

In June, Mr. Charles "Chip" Guard (the warning coordination meteorologist for WFO Guam) provided predictions for the 2017 typhoon season to the Emergency Managers of the Governments of Guam and the CNMI. Until the year is done, the predictions are still relevant:

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

2. The Northern Islands 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."

Using all the above as guidance, the PEAC anticipates that TC activity numbers will be near average during the remainder of 2017 (i.e., three or four more numbered TCs), but still with a westward displacement (Philippine Sea and South China Sea to remain the focus). below average in the western North Pacific basin through the remainder of 2017. For the remainder of 2017, one or two 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.

The 2016-17 South Pacific cyclone season ended on June 30, 2017, with record low activity across several categories (cyclone numbers, major cyclone numbers and the quantity known as the Accumulated Cyclone Energy1 (ACE)). The end-of-season total of 101.4 ACE units was only 48% of the average (see: http://models.weatherbell.com/tropical.php).

1 ACE is an approximation of the wind energy produced by a tropical system over its lifetime and is calculated every six-hour period.

Two local agencies -- Australia's Bureau of Meteorology

TROPICAL CYCLONE ACTIVITY

(BoM) and the New Zealand National Institute of Water and Atmospheric research (NIWA) have issued seasonal outlooks for the upcoming 2017-18 Southern Hemisphere TC activity. The BoM is calling for near-average to slightly above average activity in each of the Australian TC regions. NIWA is calling for a slightly above average risk for a TC to move into New Zealand waters, some quotes follow:

"Analysis by forecasting centres across the Southwest Pacific shows tropical cyclone activity is expected to be higher around the Coral Sea and west of the International Date Line, and lower further east."

"Islands on the fringe of the north Coral Sea, including Papua New Guinea, the Solomon Islands, Vanuatu, New Caledonia and Tonga may experience slightly increased activity. Reduced activity is expected in some islands, especially those east of 160°W longitude, including the Cook Islands, the Marquesas and French Polynesia."

With due consideration of these local agency forecasts, the **PEAC foresees a near average to slightly below average TC season for American Samoa.**

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 Oct-Nov-Dec (OND), Nov-Dec-Jan (NDJ), and Dec-Jan-Feb (DJF) of 2017-18 , (ii) OND return values at 20 and 100-yr period, (iii) the observed monthly mean and maximum sea-level anomalies for the previous season Aug-Sep-Oct (ASO) 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 OND, NDJ, and DJF of 2017-18

Forecasts of the sea-level anomalies in the USAPI are presented using CCA statistical model [(see Chowdhury MR., Chu PS, and Guard C (2014), *Int. Journal of Climatology* 6, 2320-2329)] . Based on the independent SST and zonal wind (U) (SST-U) values in Jul-Aug-Sep (JAS) of 2017, the resulting CCA model has been used to forecast the sea level of three consecutive seasons: OND. NDJ, and DJF (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 (OND, NDJ, and DJF)

	Seasonal Mean Anomaly				Seasonal Max Anomaly				
Tide Gauge Station	**OND**	**NDJ**	**DJF**		**OND**	**NDJ**	**DJF**	**OND: Return Period[4]**	
Lead Time [5]	**0-M**	**1M**	**2M**	**Seasonal Outlook**	**0-M**	**1M**	**2M**	**20- YR**	**100-YR**
Marianas, Guam	+4	+4	+4	**Above**	+22	+22	+21	6.5	9.1
Malakal, Palau	+5	+4	+4	**Above**	+41	+41	+41	6.1	6.4
Yap, FSM	+5	+5	+5	**Above**	+34	+34	+34	8.2	11.0
Chuuk, FSM**	+5	+5	+5	**Above**	+34	+34	+34	n/a	n/a
Pohnpei, FSM	+6	+5	+5	**Above**	+37	+36	+36	9.1	11.8
Majuro, RMI	+5	+5	+4	**Above**	+45	+45	+45	5.7	6.4
Kwajalein, RMI	+4	+4	+4	**Above**	+44	+44	+44	6.6	8.4
Pago Pago, Am. Samoa***	+5 (0)	+5 (0)	+5 (0)	**Above**	+31 (+26)	+32 (+27)	+32 (+27)	4.9	6.1
Honolulu, Hawaii	+3	+2	+2	**Above**	+23	+23	+22	3.0	3.7
Hilo, Hawaii	+2	+2	+2	**Above**	+25	+26	+26	3.2	5.2

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 5 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.

It is ENSO-neutral, but atmospheric and oceanic signals are leaning towards La Niña. La Niña means higher-than-average sea level in the vicinity of USAPIs. PEAC-CCA1 statistical model forecasts indicate with high confidence that most of north and south Pacific stations will be elevated (4-6 inches) in the forthcoming OND, NDJ, and DJF seasons. Complementary to PEAC forecasts, some dynam-

SEASONAL SEA LEVEL OUTLOOK FOR THE US-AFFILIATED PACFIC ISLANDS

ical models are also predicted high sea levels (this is partly due to impact of a wind-forced equatorial Rossby wave that is not simulated by the statistical models). At two and four months lead (November–January), sea levels are likely to be above-normal (4-8 inches) for Majuro, Pohnpei, and Chuuk. At longer ranges (> 5 months), dynamical models suggest likelihood of rising sea levels in parts of the South Pacific (including American Samoa). This could potentially impact islands with minor coastal flooding or salt water intrusions and increase vulnerability to flooding from storms or large waves. The State of Hawaii will again be affected by "King Tides"—highest tides of the year ("king tides") will occur again in the early mornings over a few days either side of December 4, and January 2.

Observed Monthly Mean Sea Level Anomalies (with respect to climatology) for Aug-Sep-Oct (ASO) 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.

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

Tide Gauge Station	Monthly Mean Anomaly				Monthly Max Anomaly			
	Aug	Sep	Oct	Standard Deviations	Aug	Sep	Oct	Sea level Trend
Marianas, Guam	+9	+7	+7	3.6	+22(0)	+22(0)	+22(0)	Above-Stable
Malakal, Palau	+1	+5	+5	4.5	+37(1)	+39(3)	+41(5)	Above-Stable
Yap, FSM	+6	+7	+7	4.8	+33(6)	+33(6)	+35(8)	Above-Stable
Chuuk, FSM*	+5	+4	+6	*	**	**	**	Above-Stable
Pohnpei, FSM	**+6**	**+6**	**+9**	3.4	+34(4)	+30(0)	+33(3)	Above-Rise
Majuro, RMI	+3	+4	+4	**	+28(1)	+26(-1)	+26(-1)	Above-Stable
Kwajalein, RMI	**+4**	**+6**	**+9**	2.5	+41(1)	+44(4)	+45(5)	Above-Rise
Pago Pago, American Samoa* **	+5	+5	+6	3.0	+38(1)	+38(1)	+41(4)	Above-Stable
Honolulu, Hawaii	+9 [4]	+9 [4]	+10 [5]	3.4	+33(0) [28]	+32(-1) [27]	+320-3) [25]	Above-Stable
Hilo, Hawaii	+8	+5	+5	1.8	+28(8)	+21(1)	+21(1)	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 JAS of 2015, a comparative perspective of two years of seasonal sea level variations is given below (Fig. 7). The sea lever in the western Pacific started to rise from JAS of 2015. This rising trend continued up to JAS of 2016. Again it started to fall from OND of 2016 and, starting from AMJ of 2017, sea level receded and remained marginally low until JFM of 2017. It started to rise again from June 2017, and currently staying above normal. It is likely to stay elevated throughout the remainder of the year of 2017 and beginning of 2018.

See page 15 for sea level observations from Jason-2 satellite picture (Fig. 8).

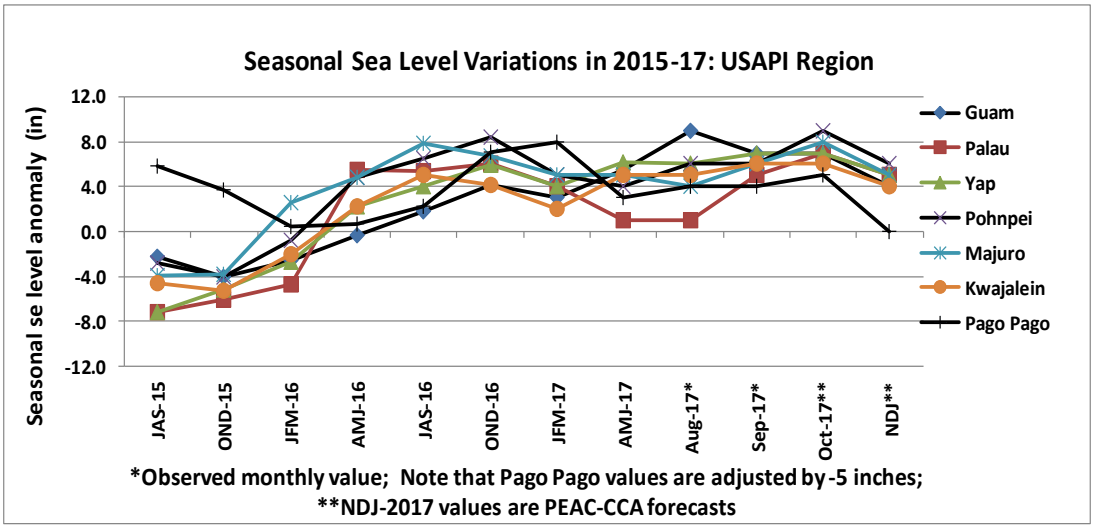

Figure 7. A comparative perspective of Island-wise seasonal sea level variations (JAS 2015 to NDJ 2017) (Note that Pago Pago data has been adjusted (approx. –5 inches) to 2009 level.

LOCAL SUMMARY AND FORECAST

American Samoa:

The monthly rainfall totals at American Samoa during 2017 (through October) have been mostly below average, with two major exceptions: extreme rainfall (off-the-chart in Fig. AS-1) fell in May 2017, with another very high monthly value occurring in October. 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 20.11 inches recorded there in October ranking as the 3rd highest in the historical record. The heavy daily rainfall event in May caused severe flooding across American Samoa and also in Samoa (formerly Western Samoa). During October 2017, there were two flash flood warnings issued by the WSO Pago Pago: one on the 12th of October, and another on the 19th of October. The event of 19 October was the more serious of the two, with at least 3 inches of island-wide rainfall reported across Tutuila. According to information found on the WSO Pago Pago Facebook page (https://www.facebook.com/NWSPagoPago), there appears to have been only some reports of flooded roads and debris washed onto roads. The satellite imagery shows the primary cloud band of the SPCZ overlying the region during the times of these heavy rainfall events, and indeed for many of the days during the wet month of October.

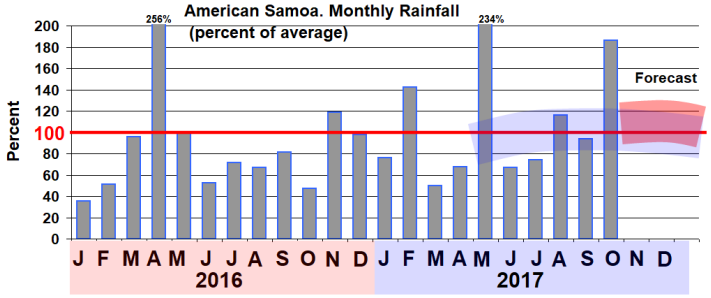

Figure AS-1. A time series of the monthly rainfall at Pago Pago from January 2016 through October of 2017. Note that most of the months plotted had below average rainfall with the spectacular exceptions of April 2016 and May 2017, with another high (but not off-the-chart) amount in October 2017. An earlier rainfall forecast made by the PEAC in May 2017 is shown in light blue, and a new forecast for the remaining months of 2017 is shown in light red. Note the slight increase of amounts in the current forecast over the previous one.

American Samoa Rainfall Summary: 2017, 3rd QTR (JAS), with Oct & 3Q Totals

Station		Jul	Aug	Sep	Oct	3rd QTR
Pago Pago WSO	Rain (in)	4.66	7.78	6.26	20.11	18.70
	% Avg.	74%	116%	94%	186%	95%
Siufaga Ridge*	Rain (in)	9.18	11.38	8.06	18.09	28.62
	% Avg.	75%	69%	47%	N/A	62%

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.

The very quiet 2016-17 Southern Hemisphere TC season ended on 30 June. American Samoa passed through its dry season without any unusual TC activity. At this time, the outlooks for the 2017-18 TC season are generally for a below average TC season. The current TC seasonal outlook issued by the WSO Pago Pago on October 31, 2017 is quoted, in-part, below:

4th Quarter, 2017

LOCAL SUMMARY AND FORECAST

NWS - WSO Pago Pago Office Predicts a below-normal Tropical Cyclone season for 2017-18.

The International Research Institute and the National Weather Service (NWS) Climate Prediction Center predicts1 a weak La Nina to start off the season before gradually rising to ENSO-Neutral in February through April. With this scenario, the South Pacific Convergence Zone (SPCZ) typically develops near and just to the southwest of the Samoan Islands before drifting southwest in February. Tropical Cyclones will have a higher chance of developing within 300 nautical miles of the Samoan Islands from late December through January this season.

American Samoa will likely see below normal activity (30% chance below tropical cyclone climatology) consistent with neutral to possibly weak La Niña conditions. With the outlook looking to be in La Niña conditions by austral summer (Dec-Jan-Feb), the outlook looks to be for 0 to 2 tropical cyclones affecting the Samoan Islands this season. Although La Nina conditions favors below normal tropical cyclone activity near American Samoa, we continue to urge residents and mariners to be fully prepared before the onset of our tropical cyclone season.

1 This TC seasonal outlook was issued before the CPC upgraded its ENSO alert status to La Niña Advisory. The PEAC believes that the particulars of this outlook are not substantially changed by this issuance.

Predicted rainfall for American Samoa from October 2017 - September 2018

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

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

Guam/CNMI:

Whereas rainfall throughout Guam and the CNMI was generally above average during the 1st half of 2017, rainfall during the 3rd Quarter of 2017 was below average, with Saipan particularly dry (see Fig. G1). Reasons for persistent regional dryness in the 3rd Quarter include a weak and largely absent monsoon and a lack of tropical cyclone activity. The statement quoted below from the last newsletter regarding dryness going into July 2017 is now a good summary for the entire 3rd Quarter:

"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. There has yet to be an episode on Guam and in the CNMI of southwesterly wind. …"

The monsoon was not just late going into July, but was totally absent through September 2017! Finally, in October 2017, two tropical cyclones formed in the region: Lan (TC 25W) and Saola (TC 27W). Lan was a very large TC that developed to the west of Guam and the CNMI, but was able to draw strong southwesterly winds into the region. Over the two-day period 17-18 October, Guam experienced a wind-driven island-wide heavy rainfall

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of 4-6 inches. Persistent southwesterly winds gusted to 35-40 mph for three days. On the night of the 17th into the morning of the 18th, an unusual small-scale surge in the monsoon (possibly the precursor disturbance to TC Saola a few days later) brought a brief period of gales to Saipan, accompanied by heavy rainfall. At the SIA, the winds reached a sustained value of 45 mph with a peak gust to 59 mph. That station had 1.97 inches of rainfall during this event. Power was knocked-out for a few hours across much of Saipan during this storm event. About a week later, a new TC – Lan Saola (27W) – formed to the east of Guam and the CNMI. It moved westward to pass to the south of Guam on the morning of October 24th. A brief period of gales was experienced on eastern exposed locations of Guam. AAFB had a peak wind of 40 mph with a gust to 53 mph. Saola produced little rain in the area, but did produce a thick haze of suspended sea salt, and generated large waves up to 15 feet on Guam's eastern shoreline (Fig. G2).

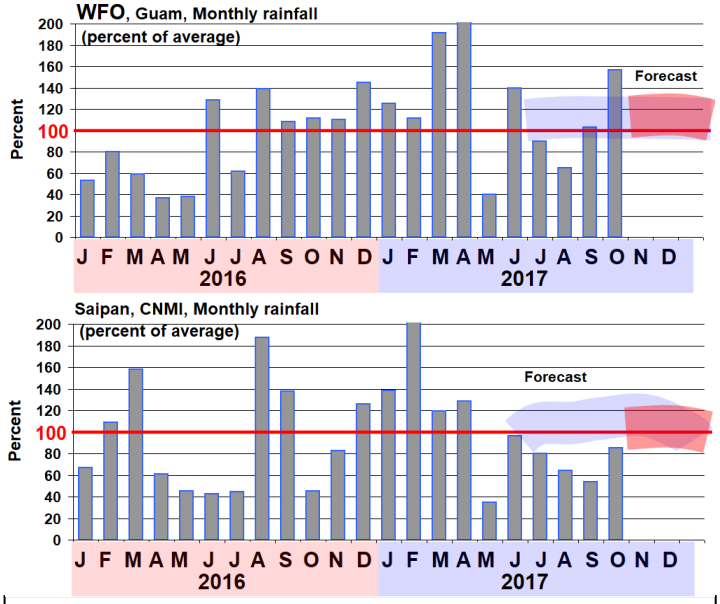

Figure G1. **Top**: A time series of monthly rainfall percentages at the Guam WFO. Bottom: Same as the top panel, but for Saipan International Airport. Prior forecasts of rainfall made by the PEAC are indicated by light blue bands. The forecast rainfall for the remainder of 2017 is indicated by the light red bands. Note that the rainfall on Saipan was much less than forecast, but that on Guam was greater and closer to the forecast amounts.

Figure G2. Large breaking waves at Anao Point (northeastern Guam) on the 24th of October as Tropical Storm Saola passed by to the south.

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Guam and CNMI Rainfall Summary: JASO 2017, 3rd QTR

Station		Jul	Aug	Sep	Oct	2nd QTR
GUAM						
GIA (WFO)	Inches	9.86	9.73	14.92	18.47	34.56
	% Avg	94%	71%	111%	153%	N/A
AAFB	Inches	5.78	7.48	9.54	14.74	22.80
	% Avg	53%	56%	72%	114%	61%
Southern Mountain	Inches	5.49*	16.40*	16.35	15.49	38.24
	% Avg	47%	122%	123%	120%	N/A
CNMI						
Saipan Intl. Airport	Inches	6.75	8.36	7.57	9.58	22.68
	% Avg	83%	67%	56%	89%	67%
Capitol Hill	Inches	6.15	11.24	11.62	10.67	29.01
	% Avg	68%	90%	86%	89%	83%
Tinian Airport	Inches	4.51	7.58	8.72	16.63	20.81
	% Avg	50%	61%	65%	139%	59%
Rota Airport	Inches	3.79	10.64	15.00	22.91	29.43
	% Avg	36%	81%	112%	181%	80%

* Problems with rain gauge: used nearby Umatac-Merizo Treatment Plant.

Climate Outlook:

La Niña is here! During La Niña, rainfall across Guam and in the CNMI follows the rules below:

(1) During the year directly following El Niño (e.g., 2016), it is dry, even if the onset of La Niña conditions occurs in that year (e.g., 1998);
(2) During La Niña conditions in a year that does not directly follow El Niño (e.g., 2017), whether making an onset or persisting from a prior year, the rainfall is typically near average, with few extremes of heavy rainfall;
(3) During a year in which La Niña (or cold side of ENSO-neutral) conditions are, early-on, giving way to El Niño conditions later in the year, it is very wet, and the chances for extremes of heavy rainfall are high.

With La Niña now in-place, computer model forecasts are aggressively indicating above average rainfall over the next three months across Guam, the CNMI and most of the rest of Micronesia. The PEAC concurs with these projections, but has manually tempered the model aggressiveness for above average rainfall in some locations. For Guam and the CNMI, the PEAC let stand the model projections of a 45% chance of above-average rainfall, with only a 25% chance of below average rainfall.

Regarding the threat of a tropical cyclone during the remainder of 2017 into January 2018, the PEAC still gives assent to points (3) and (4) of a forecast given five months ago to Saipan emergency managers by the Guam WFO Warning Coordination Meteorologist, Chip Guard:

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

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

For the remainder of 2017 into January 2018, the odds of a typhoon strike (winds 65 kt or greater) are probably less than 10% for Guam and throughout the CNMI (these odds are well-below average). However, a developing late-season (now through January 2018) could pass through the region as a tropical storm to bring high waves, and a brief period of gales. The odds of this occurrence are 20-30%.

Predicted rainfall for the Mariana Islands from October 2017 through September 2018:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]	
	Guam/Rota	Saipan/Tinian
Oct-Dec 2017 (End of rainy season)	115%	110%
Jan-Mar 2018 (1st half of next dry season)	100%	100%
Apr-Jun 2018 (2nd half of next dry season)	95%	95%
Jul-Sep 2018 (Onset of next rainy season)	100%	100%

Federated States of Micronesia

Yap State:

Over the past two years, rainfall has been highly variable across Yap State. New records of both wet and dry conditions were established. In Figure Y1 below, there are four major anomalies of rainfall identified that occurred over the past two years:

(1) The 6-month period OND (2015) – JFM (2016) was the driest such period in the 65 year historical climate record at the WSO on Yap Island;

(2) The 6-month period OND (2016) – JFM (2017) was the wettest such period;

(3) The 6-month period AMJJAS (2017) was the 11th driest; and,

(4) October 2017 was the 6th wettest at Yap Island.

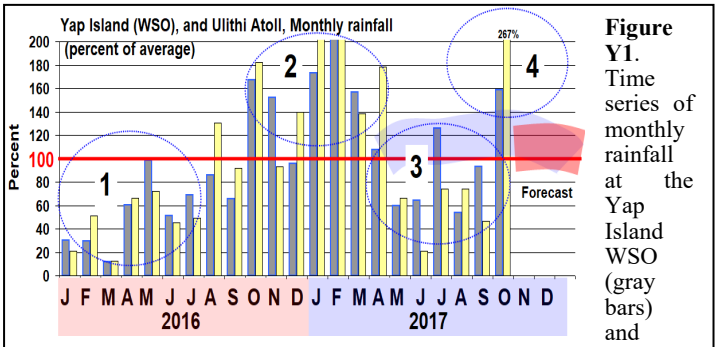

Figure Y1. Time series of monthly rainfall at the Yap Island WSO (gray bars) and Ulithi Atoll (yellow bars) for all of 2016 through October 2017. The continuous dryness at the end of 2015 through July of 2016 set a new historical record for low rainfall. Heavy rainfall in October 2016 began a 7-month run of persistent above-average rainfall that set some historical records for high rainfall. An unexpected dry spell commenced in May 2017 and persisted through September 2017. With an active monsoon and two nearby TCs, October was very wet. PEAC forecasts of rainfall made for Yap in the 2nd and 3rd quarters (light blue shading) were too optimistic. The current 3-month outlook is indicated by the light red shading.

The dryness of the 2nd and 3rd quarters was unforeseen, and the PEAC 3-month outlooks (made in early April and again in early July) for the 2nd and 3rd Quarter rainfall, respectively, had called for near-average to above-average rainfall. The rainfall was, instead, below average. 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 and 3rd Quarter, then a wet October. 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 until July, and thereafter the monsoon remained weak through September. The axis of the monsoon trough was continually south and west of its usual position with light easterly trade winds, a dominant weather pattern in the region. The delayed and weak monsoon and lack of tropical cyclones in the region likely contributed to the dryness of the 2nd and 3rd quarters.

Finally, in October 2017, the monsoon trough became active and two TCs affected Yap State: Lan (25W) and Saola (27W). Typhoon Lan had a large circulation with extensive outer rainbands that caused a prolonged period of gusty southwesterly winds and heavy rainfall across Yap State. During Lan's slow passage to the north of Yap State, over several days in mid-October, upwards of 10 inches, or more, of rainfall occurred across Yap Island and most of the outer atolls. PEAC scientist Dr. Mark Lander was on Yap Island during the passage of Lan, and on the night of 18 October witnessed a spectacular nighttime thunderstorm with frequent lightning, heavy rain and wind gusts to perhaps 50 mph. Power was knocked out for about an hour in Colonia. About a week after the passage of Lan, TC Saola moved on a similar track past Yap, bringing a second round (not quite as severe as the 1st) of heavy rainfall and southwest winds to Yap State. The monsoon and typhoon activity of October contributed to a very high rainfall. Note: Although the October rainfall at the WSO Yap was a very wet 18.99 inches, other locations on Yap Island were much wetter, with Maap (on the north side of Yap Island) reporting an October rainfall of 28.36 inches – even higher than Ulithi's extraordinary 27.12 inches!

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 dWith La Niña now in-place, computer model forecasts are aggressively indicating above average rainfall over the next three months throughout Yap State. The Computer model forecasts made in April (and again in July) over-estimated the AMJ and JAS monthly rainfall totals, respectively. However, despite this past observed dryness, the models are yet still indicating above average rainfall over the next three months (OND). The PEAC concurs with these projections, but has manually tempered the model aggressiveness for above average rainfall in some locations, especially beyond the first three months. Given that the dryness was likely a result of altered rainy season weather patterns (e.g., a delayed and weak western North Pacific monsoon, and reduced TC activity), rainfall over the upcoming dry season should not be similarly impacted, and rainfall is anticipated to be at least near average.

As anticipated by the PEAC in the last newsletter, the basin TC activity during July through September 2017 exhibited a westward and northward shift, with a near average basin count of tropical cyclones. During October 2017, two TCs brought gusty winds and heavy rainfall to Yap State (this was also anticipated in the last newsletter: "Later in the year (late September through December), 2 or 3 named cyclones should track somewhere through Yap State". For the remainder of 2017 into Janu-

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Yap State Rainfall Summary: JASO 2017, 3rd QTR						
Station		Jul	Aug	Sep	Oct	3rd QTR
Yap State						
Yap WSO	Inches	18.27	8.16	12.59	18.99	39.02
	% Norm	126%	54%	93%	159%	90%
Ulithi	Inches	9.13	9.54	5.37	27.12	24.04
	% Norm	74%	74%	47%	267%	65%
Woleai	Inches	16.74*	4.55*	6.19*	11.10	27.48
	% Norm	111%	31%	53%	82%	N/A

* Missing days

ary 2018, the PEAC assesses the risk of some damaging effects from the near passage of a TC, such as high waves, gales or very heavy rainfall at 10-15% (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 (this risk is about average for this time period). ryness 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 October 2017 through September 2018

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

* 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:

Over the past two years, there has been high variability of rainfall throughout Chuuk State at time scales from monthly to seasonal. Four major anomalies of rainfall occurring over the past two years include:
(1) Persistent dryness during 2016;
(2) A period of high rainfall during the 6-month period OND (2016) – JFM (2017);
(3) Another period of persistent dryness during the 6-month period AMJJAS (2017); and,
(4) A wet October 2017 (at about half the reporting sites).

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These same four anomalies were also noted in the 2016-17 rainfall distribution across Yap State. In Yap State, the anomalies were more accentuated and some record values were observed, but no rainfall records were tied or broken at the Chuuk WSO during 2016 or 2017.

During the first half of 2017, 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 Information Statements (DGTs) issued by the WFO Guam during the 1st Half of 2017. However, due to a small (but sufficient) increase of rainfall in June and early July, mention of the northern atolls of Chuuk State was dropped from the DGT issued on 20 July. The dryness at Polowat is thought to be, in part, an artifact of poor exposure of the rain gauge. No reports of impacts of low rainfall were received from this or nearby atolls.

The PEAC rainfall forecasts for the 2nd quarter were too wet, while the forecasts for the 3rd quarter were accurate at most atolls.

In summary, the weather across Chuuk State during the 1st half of 2017 and during the 3rd quarter 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.

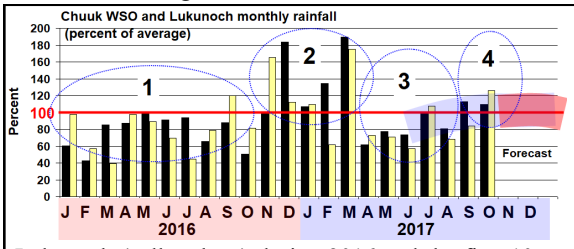

Fig. CH-1. A time series of the monthly rainfall at the WSO Chuuk (black bars) and at Lukunoch (yellow bars) during 2016 and the first 10 months of 2017. The 3rd Quarter forecast (light-blue band) was for slightly below-average rainfall from July into August, rising thereafter to near-average rainfall for the rest of 2017. The light red band is the 4th Quarter rainfall predictions for the remainder of 2017.

Chuuk State Rainfall Summary: JASO 2017, 3rd QTR						
Station		Jul	Aug	Sep	Oct	3rd QTR
Chuuk Lagoon						
Chuuk WSO	Inches	11.86	11.65	12.92	14.64	36.43
	% Avg	98%	80%	112%	109%	95%
Southern Mortlocks						
Lukunoch	Inches	16.47	8.88	8.51	13.10	33.86
	% Avg	108%	68%	84%	126%	88%
Northern Mortlocks						
Nama	Inches	11.75	10.15	10.58	8.99	32.48
	% Avg	97%	70%	92%	67%	85%
Northern Atolls						
Fananu	Inches	8.91	14.56	6.85	4.05	30.32
	% Avg	74%	100%	59%	30%	79%
Ounoun	Inches	N/A	N/A	N/A	10.70	N/A
	% Avg	%	%	%	80%	%
Western Atolls						
Polowat	Inches	3.86*	2.24*	1.96*	N/A	8.06*
	% Avg	28%	15%	15%	%	19%

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

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Climate Outlook:

The dryness of the 2nd and 3rd quarters of 2017 was unforeseen, and the forecasts in the last two newsletters indicating average to above-average rainfall for most of Chuuk State during AMJJAS were too high.

Recent computer model forecasts are nearly unanimous in a forecast for above average rainfall for at least the next three months for Chuuk State, and indeed, for almost all of Micronesia. The PEAC team considered tempering these forecasts downward slightly, but decided to go with the computer forecasts for the next three months. During the spring of 2018, the ITCZ could be accentuated across the central and southern islands of Chuuk State, bringing abundant rains there in April, May and June.

For the remainder of 2017, the threat of a damaging TC anywhere within Chuuk State is anticipated to be less than average: The precursor disturbances to 1 or 2 named storms could track through State waters, with possible impacts of rough seas, large swells and heavy rainfall for some atolls. The risk of a direct passage of a typhoon over any atoll of Chuuk State from now through January 2018 is thought to be below average (about a 1-in-10, 10% chance) at each island location in the Chuuk State area.

Lastly, because of the strengthening of the Pacific trade wind system during La Niña, the sea level in Chuuk State now is at a higher-than-average stand of approximately 6 inches above the long term average, and is forecast to remain at-or-above the magnitude of this elevated stand for at least the next three months (see the sea level section for details).

Predicted rainfall for Chuuk State from October 2017 through September 2018 is:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]			
	Chuuk Lagoon, Losap, & Nama	Polowat	Northern Is.	Southern Mortlocks
Oct - Dec 2017	115%	90%	100%	115%
Jan - Mar 2018	100%	85%	95%	100%
Apr - Jun 2018	110%	90%	100%	115%
Jul - Sep 2018	105%	90%	100%	100%

Pohnpei State:

For most of 2017, Pohnpei Island and the atolls of Pohnpei State have had a long period of uneventful tranquil weather. The rainfall has been near-average, although with high month-to-month variability. Apart from the month of February 2017, the rainfall at the WSO Pohnpei Island was at-or-above average through July 2017; then, for the most recent three consecutive months (ASO), the monthly rainfall was below average (Fig. PN-1). The low-latitude atolls (Nukuoro and Kapingamarangi) were particularly wet during the first half of 2017. Then, with a dry August and a dry October at Kapingamarangi, the temporal distribution of rainfall appears to be trending lower (Figs. PN-1 and PN-2). Lying along the equator, where fluctuations of SST in the equatorial cold tongue have a big influence on convection, Kapingamarangi Atoll is subject to enormous variations in rainfall. As is shown in Fig PN-2, the 6-month running sum of rainfall at Kapingamarangi has varied from 7.12 inches (in the 6-months ending February 2011) to 106.61 inches (in the 6 months ending September 2012). There were severe impacts of drought

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(depletion of all freshwater sources and death of vegetation) seen there during the former event, and moderate impacts of drought (a need for importation of drinking water) during the latter dry spell. Figure PN-2 suggests some thresholds for drought impact on Kapingamarangi: Severe, if the 6-month rainfall total drops below 20 inches; and moderate, if the 6-month rainfall drops below 40 inches. By October 2017, the 6-month rainfall total had fallen to 57.78 inches. This is in the lower tercile of all such values, but still remains above the moderate-drought impact threshold of 40 inches mentioned above.

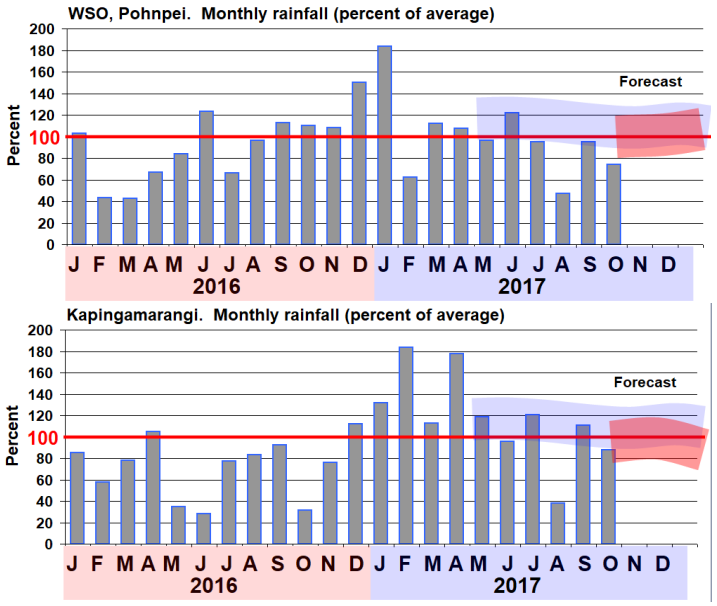

Figure PN-1. A bar chart of the monthly rainfall at WSO Pohnpei Island (top) and at Kapingamarangi (bottom) during the calendar-year 2016 through October 2017. The extended forecast for rainfall made by the PEAC in April of 2017 (light blue band in each chart) was reasonable for the first three months, then was too high for the latter three months. The latest forecast (light red band) now indicates an expectation for near average rainfall at Pohnpei Island, with below average rainfall at Kapingamarangi.

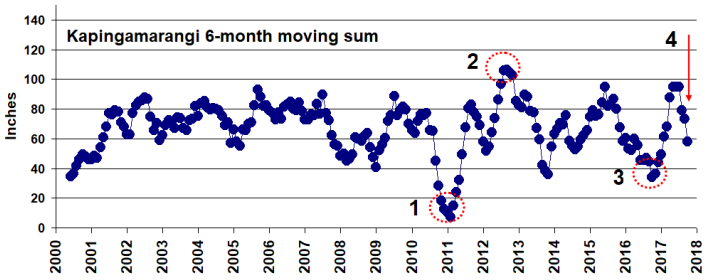

Figure PN-2. A time series of the 6-month first-half-of-the-year rainfall totals at Kapingamarangi for the years 2000 to present. The 94.76 inches of rainfall at Kapingamarangi during the first half of 2017 (red arrow) was the 2nd-highest in the time series.

While the weather across Pohnpei State has been tranquil, with no reported major impacts, it was the elevated sea level that brought about one climatic event of note: very high astronomical tides combined with La-Niña generated elevated sea level resulted in sea inundation of coastal homes in parts of Sohkes (Pohnpei Island) (**Fig. PN-3**) and also wave splash-over of the causeway that leads from Kolonia to the Pohnpei International Airport. The affected Sohkes homes have been flooded by very high tides in the past, and the causeway is also prone to flooding by seawater when the tides are exceptionally high. It may be that three factors contribute to high water in the Sohkes location and the causeway: (1) very high astronomical tides, (2) La Niña

associated elevated sea level; and (3) brisk easterly winds that develop a heavy chop across the extensive shallow-water reef flat zone (particularly to the east of the causeway).

Pohnpei State Rainfall Summary JASO 2017, 3rd QTR						
Station		Jul	Aug	Sep	Oct	3rd QTR
Pohnpei WSO	Rain (Inches)	17.45	7.82	15.27	12.36	40.54
	% of Average	95%	47%	95%	74%	80%
PNI Airport	Rain (Inches)	25.40	11.66	19.02	16.52	56.08
	% of Average	168%	86%	144%	120%	134%
Atolls of Phonpei State						
Station		Apr	May	Jun	2nd QTR	1st Half
Nukuoro	Rain (Inches)	15.41	8.43	18.32	27.07	42.16
	% of Average	107%	74%	167%	252%	115%
Pingelap	Rain (Inches)	11.99	6.54	12.06	15.25	30.59
	% of Average	75%	44%	81%	103%	67%
Kapinga	Rain (Inches)	14.47	3.35	9.13	5.93	26.95
	% of Average	120%	38%	111%	88%	93%

Figure PN-3: High-Tides and Inundation pictures of Sohkes coast on Nov 5-6) (PC: Wallace Jacob, WSO-Pohnpei)

Climate Outlook:

Recent computer model forecasts are nearly unanimous in a forecast for above-average rainfall for at least the next three months for Pohnpei State, and indeed, for almost all of Micronesia. For the remainder of 2017 into January 2018, the threat of a damaging TC anywhere within Pohnpei State is anticipated to be less than average: the precursors to 1 or 2 named storms could yet track through Pohnpei State waters, with impacts of rough seas, large swells and heavy rainfall. The risk of a direct passage of a typhoon over any location in Pohnpei State from now through January 2018 is thought to be very low (a 1-in-20, 5% chance).

Predicted rainfall for Pohnpei State from October 2017 through September 2018 is:

Inclusive Period	% of long-term average	
	Pohnpei Island/ atolls	Kapingamarangi
Oct – Sep 2017	105%	85%
Jan – Mar 2018	100%	85%
Apr – Jun 2018	110%	90%
Jul – Sep 2018	120%	95%

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Lastly, because of the strengthening of the Pacific trade wind system during La Niña, the sea level in Pohnpei State now is at a higher-than-average stand of approximately 6 inches above the long term average, and is forecast to remain at-or-above the magnitude of this elevated stand for at least the next three months (see the sea level section for details). Very high astronomical tides are anticipated at the time of the full-moon spring tides in early December. The astronomical highest high tide for December occurs Tuesday afternoon 05 December at 4.9 feet. The astronomical projections do not include the increase of the sea level by La Niña or other climatic factors.

Kosrae State:

The Kosrae Supplemental Aviation Weather Reporting Station (SAWRS) 3rd Quarter rainfall total of 50.82 inches was almost exactly 100% of average, thanks to a wet September that balanced dryness in July and August. The temporal pattern of rainfall during 2017 was the same at SAWRS as it was at the Nautilus Hotel: a wet beginning (JFM), trending to a dry middle (JJA), followed by an increase of rainfall in the 3rd Quarter. The PEAC long-term rainfall forecast made in June 2017 (shown in Figure KS-1) was good.

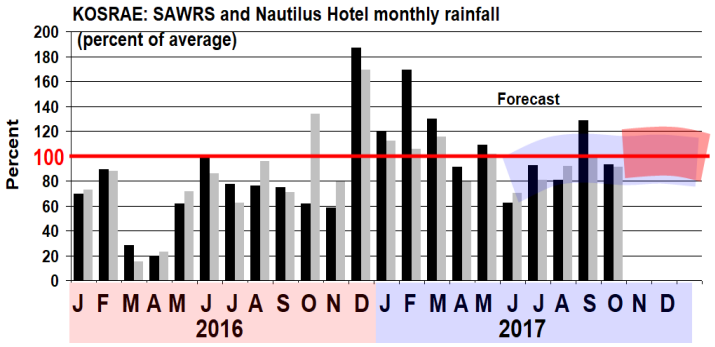


Figure KS-1. A time series of the monthly rainfall at Kosrae Supplemental Aviation Weather Reporting Station (SAWRS) (black bars) and the Nautilus Hotel (gray bars) for the period January 2016 through October 2017. The PEAC rainfall forecast made in June (light blue band) for the remainder of 2017 was good. The light red band shows the latest PEAC forecast for the remainder of 2017. The SAWRS is located on the northwest side of the island, while the Nautilus Hotel is located on the east-northeast.

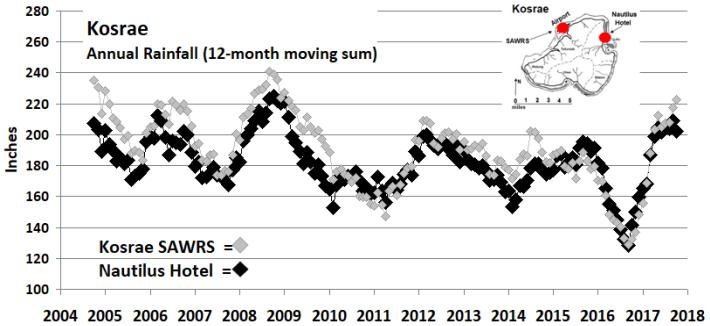


Figure KS-2. A plot of the 12-month moving sum of rainfall at the Kosrae Supplemental Aviation Weather Reporting Station (SAWRS) (gray diamonds) versus at the Nautilus Hotel (black diamonds). Note the tendency for the rainfall at SAWRS to be slightly higher than at the Nautilus Hotel). The small inset shows an outline of Kosrae with the locations of SAWRS and the Nautilus Hotel indicated.

Kosrae is a lone high island, without any outer islands within its State boundary. It is relatively small (about 7 miles across), encompassing a land area of 42 square miles, and with a central mountain peak reaching 2,080 ft. (by comparison, the land area

LOCAL SUMMARY AND FORECAST

of Saipan is 45 square miles with a high point of 1560 ft, while Pohnpei Island has a land area of 129 square miles and a central mountain reaching 2566 ft). The rainfall on the top of Pohnpei Island's central peak (Nahna Laud) has been measured1 at 330 inches per year. This was very close to the value predicted by the PRISM method (www.prism.oregonstate.edu). The rainfall on the top of Kosrae's central peak (Mt. Finkol) has not been measured, but is estimated by PRISM to be close to 260 inches per year. Whereas on Pohnpei Island, measurements (and PRISM) show that the rainfall on the east coast (e.g. Nan Madol) is about 50 inches less than that on the west coast2 (e.g., Palikir), it is not known to what extent the rainfall varies from coast to coast in Kosrae. The PEAC has assumed that the SAWRS averages are valid for the other Kosrae stations (e.g. Utwa, Tafunsak and Nautilus Hotel). Comparison of SAWRS with the Nautilus Hotel (Fig. KS-2) for a 15-year period (2003 to present), shows a remarkable coherence with a small (5%) rainfall advantage at SAWRS (annual rain average = 192 inches) versus the Nautilus Hotel (annual rain average = 183 inches).

Kosrae State Rainfall Summary: JASO 2017, 3rd QTR

Station		Jul	Aug	Sep	Oct	3rd QTR
Airport (SAWRS)	Rain (Inches)	15.57	13.23	22.02	14.95	50.82
	% of Average	92%	80%	128%	92%	100%
Nautilus Hotel	Rain (Inches)	13.69	15.11	17.13	14.75	45.93
	% of Average	81%	92%	100%	91%	91%

Climate Outlook:

Recent computer model forecasts are nearly unanimous in a forecast for above-average rainfall for at least the next three months at Kosrae, and indeed, across almost all of Micronesia. Since rainfall at Kosrae has been near-average over the past 3 months, it would be prudent to meld a persistence of this condition with the computer forecasts for above-average rainfall. In consultation with island partners, the PEAC has settled on a forecast favoring near-average to slightly above-average rainfall at Kosrae over the next few months. During the spring of 2018, the ITCZ could be accentuated across Kosrae bringing above-average rains there in April, May and June. During La Niña, colder water along the equator reduces cloudiness and rainfall there and helps to concentrate cloudiness and rainfall over the warmer water to the north under the ITCZ cloud band.

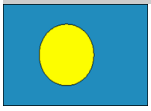
Damaging TCs are rare at Kosrae, and those rare storms that do occasionally strike Kosrae do so primarily during strong El Niño events. Thus, the risk of a damaging TC on Kosrae during the remainder of 2017 through January 2018 is considered to be typically low (less than 1-in-10 chance).

Lastly, because of the strengthening of the Pacific trade wind system during La Niña, the sea level in Kosrae is approximately 6 inches above the long term average, and is forecast to remain at-or-above the magnitude of this elevated stand for at least the next three months (see the sea level section for details).

Predicted rainfall for Kosrae State from Oct 2017 through Sep 2018:

Inclusive Period (Kosrae)	% of long-term average / Forecast rainfall (inches) [1]
Oct – Dec 2017	105%
Jan – Mar 2018	100%
Apr – Jun 2018	110%
Jul – Sep 2018	100%

LOCAL SUMMARY AND FORECAST



Republic of Palau:

During 2017 (through the 3rd quarter), 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. On balance, wet months outweighed dry months to yield accumulated totals that were above average (Fig. PL-1). By October 2017, a full 32 inches had been shaved from the -85.73 inch low-point of the long term rainfall deficit reached in August 2016 (Fig. PL-2).

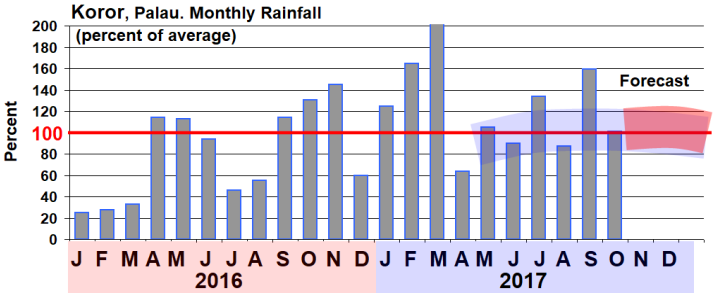


Figure PL1. A bar chart of observed rainfall (percent of average) at the Koror WSO for 2016 through October 2017. The forecast presented in the April Newsletter for the rest of 2017 is shown by the light-blue band. Current 3-month rainfall forecast is shown by the light red band.

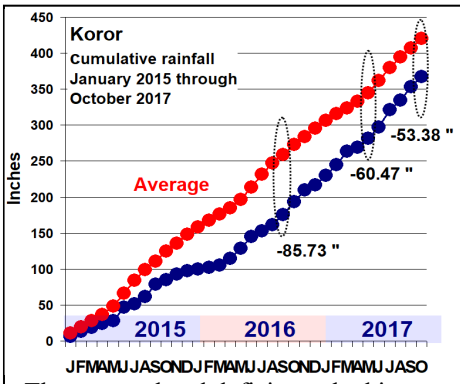


Figure PL-2. Cumulative rainfall at Koror. Red line shows the normal accumulated rainfall from JAN 2015 through OCT 2017, and the dark blue line shows the observed accumulated rainfall over the same time period. The accumulated deficit reached its extreme low of -85.73 inches in August 2016. Abundant rainfall in late 2016 and through 2017 to-date have allowed for a recovery of 32 inches against the long-term deficit.

Through 2017 to-date, the basin TC activity has exhibited a westward and northward shift, keeping TC activity away from Palau. During October, TCs Lan (25W) and Saola (27W) passed to the north of Palau at a distance that tempered the effects of these TCs. During the relatively distant passages of these two TCs, Palau experienced cool and breezy weather with scattered heavy showers (Fig. PL-3 (below).

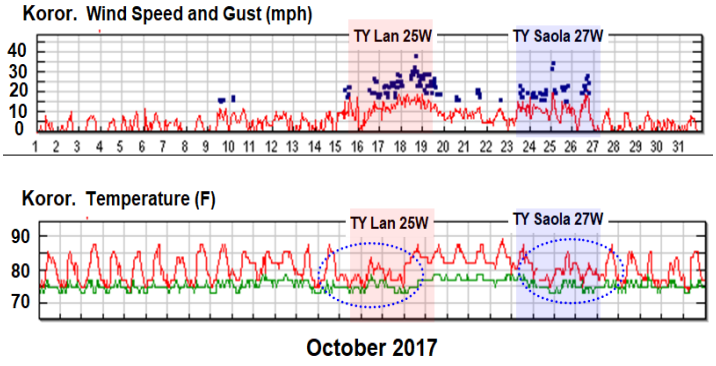


Figure PL-3 (see next page for caption). .

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Figure PL3. **(Top)** A time series of wind speed (red line) and gusts (blue dots) at the WSO, Koror during October 2017, and **(Bottom)** the temperature and dew point temperature at the WSO Koror (red line, green line is dewpoint). Note the enhanced wind and daytime cooling experienced as TCs Lan (25W) and Saola (27W) passed well to the north.

Regarding the severe die-off of Jellyfish in Palau's famous Jellyfish Lake (Ongeim'l Tketau in Palauan) during the 2015-2016 El Niño, the lake remains closed to tourists as per official statement of the Palau Ministry of Natural Resources, Environment and Tourism. The lake will remain closed until an assessment can be made of how to best "… ensure the health and improved condition of the unique biodiversity found in the Jellyfish Lake."(part of the Official Statement, 18 May 2017).

Republic of Palau Rainfall summary: JASO 2017, 3rd QTR

Station		Jul	Aug	Sep	Oct	3rd QTR
Koror WSO	Rain (Inches)	24.14	12.99	18.90	14.03	56.03
	% of avg.	134%	87%	159%	101%	125%
Intl. Airport	Rain (Inches)	25.40	11.66	19.02	16.52	56.08
	% of avg.	128%	71%	146%	108%	114%
Melekeok*	Rain (Inches)	18.38	9.24	16.43	17.69	44.05
	% of avg.	97%*	59%*	132%*	121%*	94%*
Nekken	Rain (Inches)	22.16	10.38	16.83	20.34	49.37
	% of avg.	123%	69%	142%	147%	110%
Peleliu	Rain (Inches)	20.52	5.27	10.44	7.95	36.23
	% of avg.	114%	35%	88%	57%	81%

Climate Outlook:

Recent computer model forecasts are nearly unanimous in a forecast for above-average rainfall across the Republic of Palau for at least the next three months. The PEAC concurs with this and will go with the computer forecasts for the next three months. Beyond the next three months, we anticipate continued above-average to near-average rainfall. Through June 2017, the basin TC activity should continue to exhibit a westward shift, with a near average basin count of 3 or 4 named cyclones during March through June 2017. One or two of these TCs may become a tropical storm or low-end typhoon while passing north of 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). 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 the island chain. 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

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(2012) and Haiyan (2013) affected Palau in November or December. Notably, one major typhoon (Sally) affected Palau in March (1967).

The PEAC assesses the risk of potentially damaging effects from a passing TC, such as high waves, gales or very heavy rainfall at 15% (a 1-in-7 chance), through the remainder of 2017 into January 2018. This level of risk is slightly below average. The passages 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). In addition, Typhoon Kate in October 1970 passed near Sonsorol on 16 October with 115-120 mph winds. We have no reports of damages in Palau from this typhoon, but 915 people were killed or missing and 5,000 homes were destroyed as the storm ravaged parts of Mindanao in the Philippines.

Lastly, with the recent onset of La Niña, the regional sea level now stands substantially above average across nearly all of Micronesia (see the sea level section for details).

Predicted rainfall for Palau from October 2017 through September 2018 is:

Palau Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]
Oct - Dec 2017	120%
Jan - Mar 2018	110%
Apr - Jun 2018	115%
Jul - Sep 2018	110%

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

Republic of the Marshall Islands (RMI): Over the past two years (2016 and 2017 to-date) the RMI has undergone substantial variations of rainfall. 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). Then, in early 2017, there was another period of dryness that was most pronounced in the northern atolls (i.e., at-or-north of the latitude of Kwajalein). Rainfall amounts that were at-or-above average commenced at Majuro in June, but dryness was more prolonged in the northern atolls. As reported in the last newsletter, dry conditions in early 2017 severely impacted potable water supplies in the northernmost atolls of the RMI, with household rain catchment tanks and shallow dug wells depleted. Emergency short-term assistance was provided by the RMI government to the drought-impacted northern islands. Food plants and other island vegetation were stressed, and are still recovering.

Back-to-back Drought: Severe drought in the RMI typically occurs in the first-half of the year that directly follows the peak of El Niño (e.g., 1983, 1998 and 2016). Dryness in early 2016 was anticipated well in advance as part of the evolution of the strong El Niño event of 2015-16. The severity of dry conditions

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in the northern RMI in early 2017 was not anticipated. The dryness of early 2017 was more localized than the dry conditions typically caused by El Niño. In fact, many locations in the RMI, and throughout Micronesia, had abundant rainfall in early 2017 (apart from a dry month or two). Localized areas of persistent and severe dryness have occurred with apparently random timing throughout Micronesia in the past. The very dry conditions on Guam in the first half of 1993 are a good example of what was then labeled a "personal" drought -- only on Guam, but not anywhere else. New research by a PEAC-sponsored doctoral student, Alex Ludert, suggests that while *widespread* severe drought across the RMI typically accompanies El Niño, *localized* severe drought in the northern RMI might also have a consistent link with the status of the large-scale Pacific climate. His dissertation reports that in addition to severe dryness over the latter stages of a strong El Niño event, drought conditions reliably occur in the northern RMI at another non-El Niño stage of the ENSO cycle. If such is the case, then it should be possible to forecast these dry conditions.

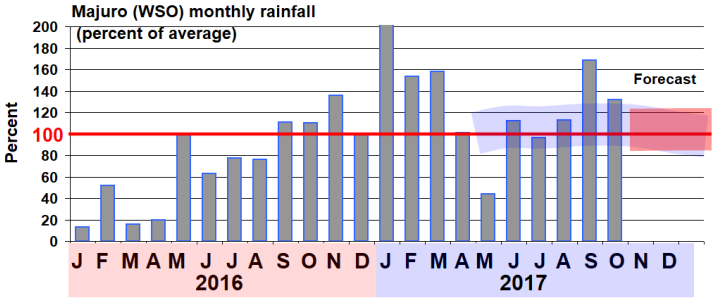

Figure RMI-1. A time series of rainfall at the WSO Majuro (gray bars) during 2016 through October 2017. Note the dramatic rising trend from extremely dry during early 2016 to the return of abundant rainfall in the fall of 2016 into early 2017. After a sharp drop of rainfall in the spring months, abundant rainfall returned in June and continued thereafter. The PEAC long-term forecast of rainfall made in April (light blue band) was reasonable. The latest forecast for rainfall for the remainder of 2017 is indicated by the light red band.

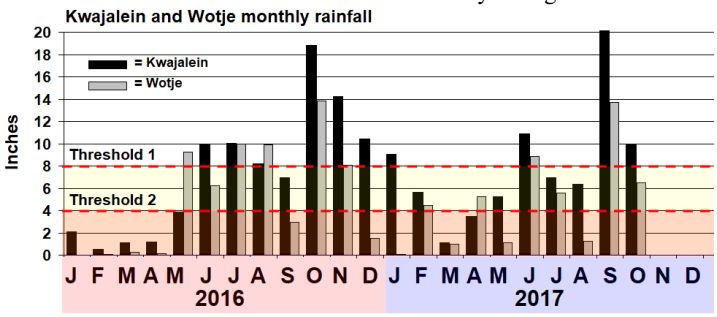

Figure RMI-2. A time series of rainfall at Kwajalein Atoll (black bars) and at Wotje (gray bars) during 2016 through October 2017. Note the evolution from extremely dry conditions during the first half of 2016 to wet at the end of 2016. There was a return to dry conditions in early 2017 that was more pronounced at Wotje (and other northern atolls). Amounts of rainfall at Wotje were well below critical water-needs thresholds in both the 2016 and 2017 dry spells. The two thresholds: Threshold 1 = 8 inches; Threshold 2 = 4 inches, are the monthly amounts needed to adequately replenish municipal water supplies, and the amount needed to avoid desiccation and death of island vegetation, respectively. These two thresholds are now used to inform the drought categories (D0, D1-4) assigned to the island sites in the U.S. National Drought Monitor[1] (USDM).

[1] The PEAC is collaborating with Mr. Richard Heim (contributing author, USDM, NOAA NCEI) to implement the inclusion of the US-API into the USDM.

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Breaking News, Lagoon-side inundation: On the last few days of October into the first few days of November, a slow moving tropical disturbance passed through the RMI, bringing heavy showers, thunderstorms and a gusty southwesterly wind. Southwest winds gusting to near 30 mph caused lagoon-side inundation in Majuro on Wednesday, 01 November. Reports were received of roadside splash-over and flooding of low-lying shorefront areas. Astronomical tides at the time were not extreme (Fig. RMI-3). Astronomical spring or King tides are not a necessary or even sufficient condition for sea inundation in the RMI. Wind and waves (local or remotely generated) are the primary cause of damaging inundation – both on lagoon-side shores and on the seaward side.

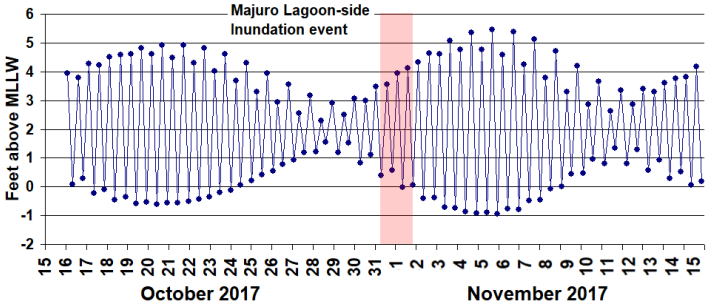

Figure RMI-3. Astronomical high and low tide projections for Majuro during October and November 2017 (tidesandcurrents.noaa.gov). Lagoon-side inundation was experienced at Majuro during a time of gusty southwesterly wind on 01 November (red shading). The tidal range at the time was close to the neap condition.

RMI Rainfall Summary: JASO 2017, 3rd QTR						
Station		**Jul**	**Aug**	**Sep**	**Oct**	**3rd QTR**
RMI Central and Southern Atolls						
Majuro WSO	**Inches**	12.52	13.00	20.93	18.21	46.45
	% Avg	101%	44%	112%	122%	126%
Ailing	**Inches**	7.91	6.20	12.31	7.86	26.42
	% Avg	67%	57%	101%	61%	76%
Jaluit	**Inches**	8.56	5.22	7.39	5.40	21.17
	% Avg	66%	45%	60%	39%	57%
Mili	**Inches**	27.79*	17.48	17.61	N/A	62.88
	% Avg	214%	152%	142%	%	170%
RMI Northern Atolls						
Kwajalein	**Inches**	6.91	6.28	22.06**	9.83	35.25
	% Avg	66%	62%	186%	83%	109%
Wotje	**Inches**	5.55	1.26	13.72	6.50	20.53
	% Avg	93%	19%	176%	78%	100%
Utirik	**Inches**	1.74	4.59	3.80	6.22	10.13
	% Avg	31%	73%	53%	81%	53%

* Possibly too high, pending verification.
** Verified record-high September rainfall. Extremes of daily rainfall include: 5.60 inches, 2.88 inches and 2.66 inches on September 10th, 15th and 16th, respectively.

Climate Outlook: Recent computer model forecasts are aggressively projecting above-average rainfall for at least the next three months at Majuro and Kwajalein, and indeed, across almost all of Micronesia. . In consultation with island partners, the PEAC has settled on a less aggressive forecast favoring near -average to slightly above-average rainfall at Majuro, Kwajalein

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and throughout the RMI over the next few months. During the spring of 2018, the ITCZ could be accentuated across the central RMI bringing above-average rains to that location in April, May and June. During La Niña, colder water along the equator reduces cloudiness and rainfall there and helps to concentrate cloudiness and rainfall over the warmer water to the north under the ITCZ cloud band.

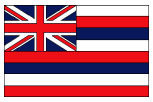
The extreme dryness in the northern atolls of the RMI during the first half 2016 and again during the first half of 2017 is considered to be an unusual combination of a major El Niño-related drought coupled with a follow-on localized drought. There are no factors at this time that would suggest yet another widespread or localized severe drought in the northern RMI, but confidence is only moderate that it will not occur for a third straight year.

Damaging TCs are rare in the RMI, and those rare storms that do occasionally pass through the RMI do so primarily during strong El Niño events. Thus, the risk of a damaging TC anywhere in the RMI during the remainder of 2017 through January 2018 is considered to be typically low (less than 1-in-10 chance).

Lastly, because of the strengthening of the Pacific trade wind system during La Niña, the sea level in the RMI is approximately 6 inches above the long term average, and is forecast to remain at-or-above the magnitude of this elevated stand for at least the next three months (see the sea level section for details).

Predicted rainfall for the atolls of the RMI from October 2017 through September 2018:

Inclusive Period	% of long-term average		
	South of 6ºN	6ºN to 8ºN	North of 8ºN*
Oct - Dec 2017	100%	110%	105%
Jan - Mar 2018	100%	100%	90%
Apr - Jun 2018	110%	110%	95%
Jul - Sep 2018	100%	100%	100%



Hawaii: Climate Outlook: Above average October rainfall across most of the main Hawaiian Islands has halted the spread and intensification of drought conditions in the state. In the leeward areas of the state, most of the above average rainfall occurred on just a few days whereas windward rainfall was more broadly distributed throughout the month. Most of the drought impacts have been in the agriculture sector so it is too soon to tell how much improvement occurred until an assessment of pasture and vegetation conditions is completed. Thus, the U.S. Drought Monitor map continues to show extreme drought, or the D3 category, over portions of the Big Island. This includes the South Kohala District from Waimea to Kawaihae and the Kau District from Punaluu to South Point. Severe drought, or the D2 category, also persists along the upper slopes of the Hamakua, North Hilo, and South Hilo Districts.

In Maui County, moderate drought, or the D1 category, was eliminated over the windward slopes of Haleakala and portions of Upcountry Maui. Areal coverage of moderate drought over Kauai was reduced slightly with D1 conditions pushed south of Wailua. The Oahu moderate drought area remains unchanged for now over the lower leeward slopes of the Waianae Range. See http://www.prh.noaa.gov/hnl/pages/hydrology.php for more details on drought and rainfall in Hawaii.

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

	Station			
Inclusive Period	Hilo	Honolulu	Kahului	Lihue
Dec-Feb 2017-18	(A50) 50% chance of Above Median rainfall	(A50) 50% chance of Above Median rainfall	(A50) 50% chance of Above Median rainfall	(A50) 50% chance of Above Median rainfall 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
Sep—Nov 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

Seasonal Sea Level Outlook (Cont.)

From the Global Satellite Picture: *Observations from the recent global satellite picture (Fig. 8, below) revealed that the sea levels have been high over the western part of the Pacific Basin. This satellite data are supportive to tide-gauge observations, and revealed that some of the stations located in Micronesia and Marshalls Islands are rising.*

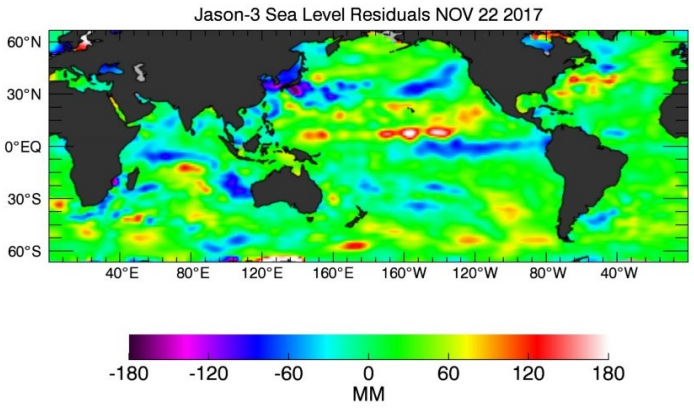

Figure 8. Jason-3 sea level residuals (Nov 22, 2017). (Source: https://sealevel.jpl.nasa.gov/images/latestdata/jason/2017/20171122G.jpg

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SEASONAL RAINFALL OUTLOOK FOR THE US-AFFILIATED PACFIC ISLANDS

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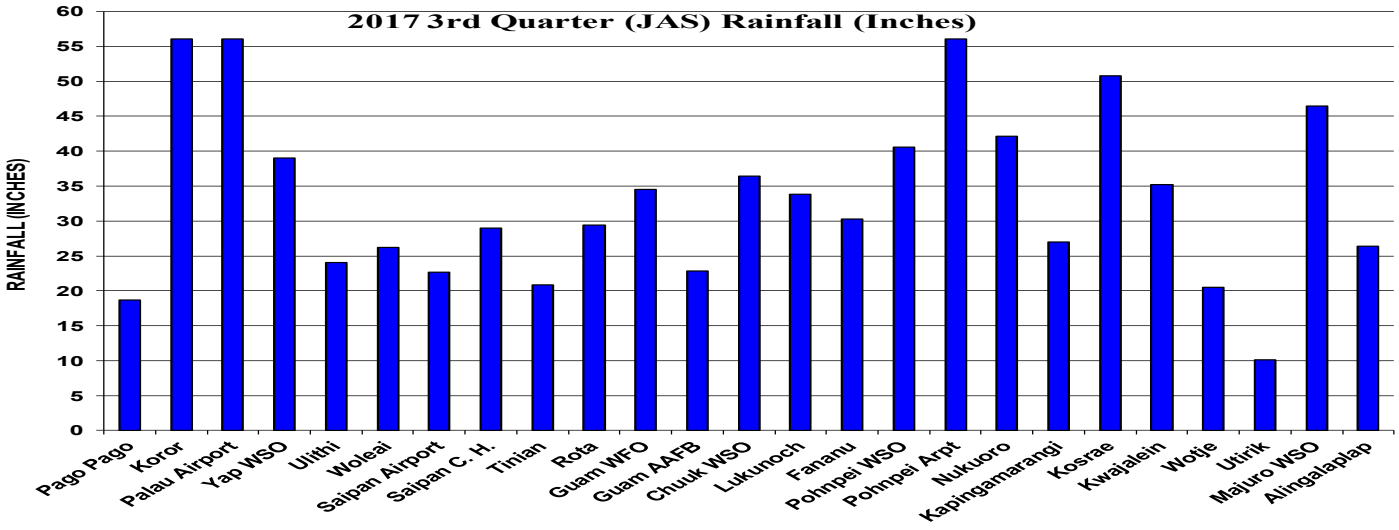

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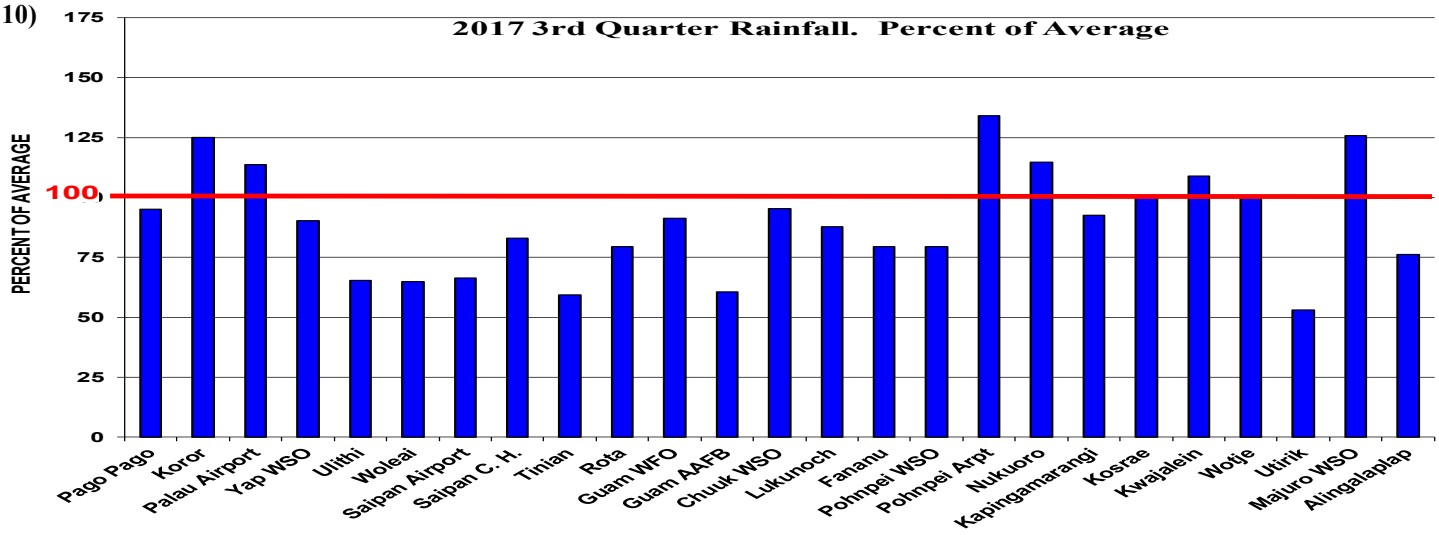

Figure 9 and 10, 2017 Third Quarter Percent of Average rainfall amounts in inches at the indicated locations (top) and rainfall departure from average (in percent) at the indicated locations (bottom).

ACKNOWLEDGEMENTS AND FURTHER INFORMATION

Pacific ENSO Applications Climate (PEAC) Center:
HIG #340, 2525 Correa Road, Honolulu, Hawai'i 96822
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Dr. Rashed Chowdhury,
Principal Research Scientist, at 808-956-2324 (rashed@hawaii.edu): 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),
MSB #317, 1000 Pope Road , Honolulu, Hawai'i 96822
Dr. Jim Potemra, PEAC Principal Investigator at jimp@hawaii.edu for more information on 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.

Pacific ENSO Update Editors:
Joseph Brinkley, Rashed Chowdhury, and Alejandro Ludert

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.

The Pacific ENSO Update is produced quarterly both online and in hard copy, with additional special reports on important changes in ENSO conditions as needed. For more information about this issue please contact the PEAC Center at peac@noaa.gov or at the address listed below.

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