PACIFIC ENSO UPDATE

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

3rd Quarter, 2016 Vol. 22, No. 3 **ISSUED: August 23rd, 2016**

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

http://www.weather.gov/peac

CURRENT CONDITIONS

The epic El Niño of 2015/16 is now in its post-Peak phase (Fig. 1) with the CPC's Oceanic Niño Index poised to soon transform from El Niño to ENSO-neutral (Fig. 2). Indeed, taking a wide view of the recent behavior of the Pacific climate, the CPC, on its 14 July diagnostic discussion, officially announced the transition of the state of the Pacific climate system from El Niño to ENSO-neutral. During the first half of 2016, very dry conditions prevailed across Micronesia and into Hawaii, with all of the reporting locations within Micronesia receiving below average rainfall (Figs 3 and 4). Several records for low rainfall were set (repeated for emphasis from the 2Q Newsletter):

(1) Koror, Palau — driest Oct-Mar, driest Apr-Mar;
(2) Yap Island — driest Oct-Mar;
(3) Pohnpei Island — 3rd driest Oct-Mar, 4th driest Apr-Mar;
(4) Nukuoro (Pohnpei State) — driest Apr-Mar, 3rd driest Oct-Mar;
(5) Ulithi (Yap State) — 2nd driest Oct-Mar, driest March;
(6) Woleai (Yap State) — driest Oct-Mar, driest Apr-Mar;
(7) Alingalapalap (RMI) — 2nd driest Oct-Mar;
(8) Kwajalein (RMI) — 5th driest Oct-Mar;
(9) Majuro (RMI) — driest Oct-Mar;
(10) Jaluit (RMI) — driest Oct-Mar, driest Apr-Mar;
(11) Mili (RMI) — 2nd driest Oct-Mar, driest March.

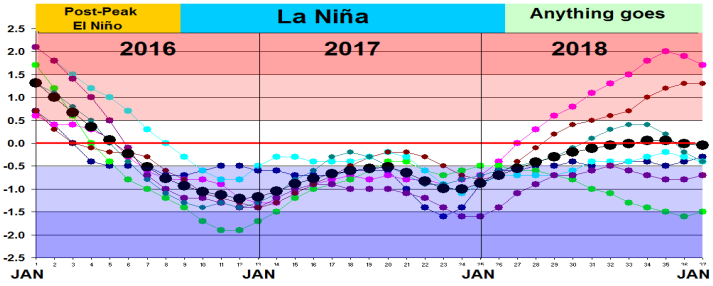

Figure 1. Typical evolution of the Niño 3.4 ENSO index following a strong El Niño event, with timing of "post-Peak" and subsequent phases indicated.

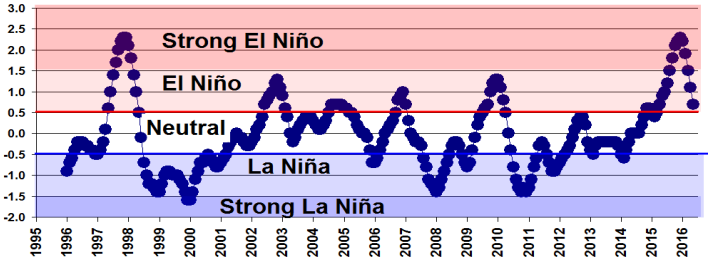

Figure 2. The NCEP Oceanic Niño Index (ONI) for the period 1996 through the value plotted for AMJ 2016.

In response to the impact of drought conditions on water supply, local governments issued proclamations concerning drought: the governments of Palau and of the FSM declared drought emergencies for portions of their jurisdictions, and the government of the Republic of the Marshall Islands went even further with a declaration of drought disaster. With very dry conditions now abating at most locations, all emergency water use directives and outdoor fire restrictions have been lifted. Information about the nature and extent of drought impacts is still being gathered and assessed. During June 2016, University of Guam (UOG) PEAC scientists completed drought assessment trips to Saipan and to Yap, and will soon travel to Chuuk, Pohnpei and Kosrae to assess the impact of the 2015 El Niño in these locations. The PEAC continues to be actively involved in cataloging and assigning drought impacts to the drought categories (D0, D1, D2, D3 and D4) used in the U.S. National Drought Monitor to portray the severity of drought. In an ongoing project to incorporate the US-API into the USDM, the PEAC is working closely with Mr. Richard Heim (co-author of the weekly USDM) and the Guam Weather Forecast Office and other regional Weather Service Offices.

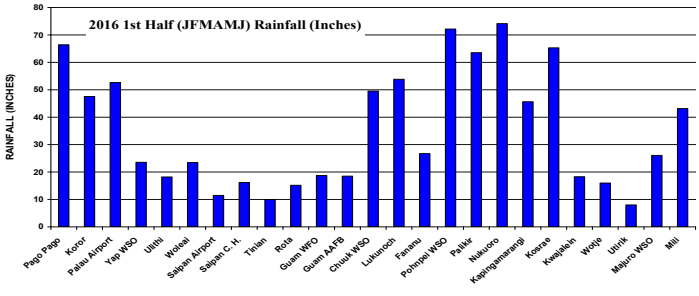

Figure 3. 2016 First Half rainfall amounts in inches.

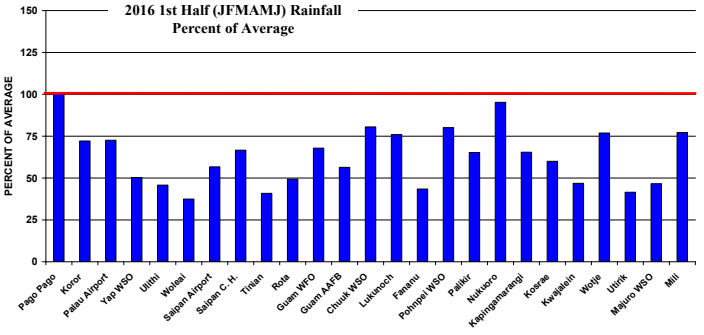

Figure 4. 2016 First Half rainfall as a percent of average .

CURRENT CONDITIONS

Sea Level : After nearly a decade of very high values, the sea level dramatically lowered across Micronesia during 2014 and 2015 (Fig. 5; *also see sea level section*). Since the middle of 2013 to the end of 2015, the total drop in the sea level at both Guam and at Kwajalein was approximately 40 cm, or 1.3 feet! A sharp drop of mean sea level typically occurs during El Niño, with the lowest value of sea level occurring in December of the El Niño year. A sharp rise of sea level typically occurs in the first few months of the post-Peak year of an El Niño event. By February 2016, the sea level across Micronesia saw a sharp reversal of its prior steep downward trend to begin the anticipated steady rise of sea level for the rest of 2016. See the sea level discussion for more details and specific forecasts.

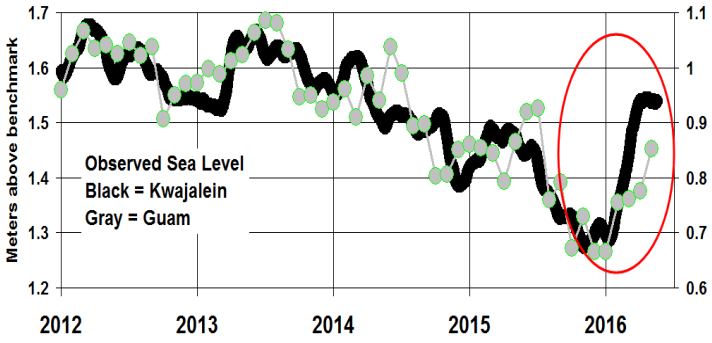

Figure 5. Time series of sea level at Guam and Kwajalein from January 2012 through May 2016. Note the steady decline that reaches a low point at the end of 2015. This is consistent with El Niño reaching its peak in late 2015. Note also the abrupt upturn in early 2016 (within the red oval). This is consistent with the decay of El Niño.

CURRENT STATE OF ENSO

Current Situation and Outlook Summary

- **ENSO-neutral conditions have persisted since the end of the strong El Niño in May.**
- **The majority of the models surveyed and expert opinion suggest La Niña development is possible in the third quarter of 2016, with about a 50-65% probability, lasting through the remainder of 2016.**
- **The most likely strength of a La Niña, should it develop, is weak.**
- **There is virtually no chance of El Niño re-development in 2016.**

***Pacific ENSO Update* is Now Available Online:**
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http://www.weather..gov/peac/update.php
.

Synopsis: La Niña is slightly favored to develop during August - October 2016, with about a 55-60% chance of La Niña during the fall and winter 2016-17.

"ENSO-neutral conditions were observed during the past month, featuring slightly below average sea surface temperatures (SSTs) close to the equator across the eastern tropical Pacific Ocean (Fig. 6). While the weekly Niño-1+2 and Niño-4 regions were near average, the Niño-3 and Niño-3.4 indices were slightly below average (approaching -0.5°C) during July. Although below-average subsurface temperatures continued, they weakened during the past month but remained near the surface in parts of the central and eastern equatorial Pacific. Atmospheric anomalies over the tropical Pacific Ocean also indicated ENSO-neutral conditions. Both the traditional Southern Oscillation index and the equatorial Southern Oscillation index were near average during July, while the upper and lower-level winds also were near average across most of the tropical Pacific. Convection was suppressed over portions of the western and central tropical Pacific and enhanced over part of Indonesia. Overall, the combined ocean and atmosphere system is reflective of ENSO-neutral."

"Many models favor La Niña (3-month average Niño-3.4 index less than or equal to -0.5°C) by the beginning of the Northern Hemisphere fall, continuing into winter. Statistical models predict a slightly later onset time (i.e., mid- to late fall) than dynamical models, and also predict a slightly weaker event. The forecaster consensus favors La Niña onset during the August-October season, and predicts a weak event (Niño-3.4 index between -0.5°C and -1.0°C) if La Niña forms. Overall, La Niña is slightly favored to develop during August - October 2016, with about a 55-60% chance of La Niña during the fall and winter 2016-17. ... ". Climate Prediction Center National Centers for Environmental Prediction. NOAA/National Weather Service. College Park, MD 20740

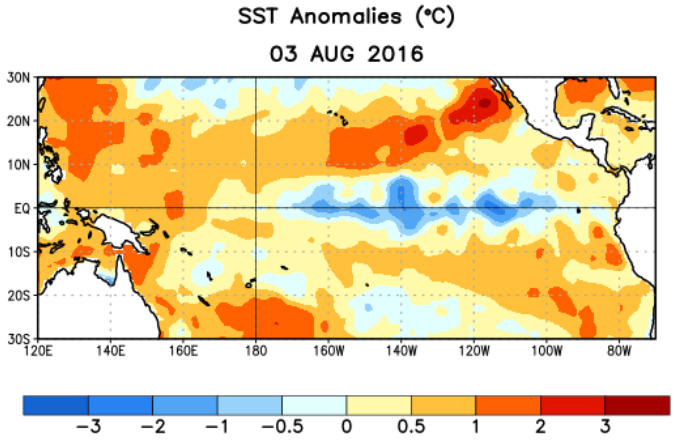

Figure 6. Average sea surface temperature (SST) anomalies (°C) for the week centered on 4 May 2016. Anomalies are computed with respect to the 1981-2010 base period weekly means.

Also see: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/ensodisc.pdf

TROPICAL CYCLONE ACTIVITY

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 significant differences in the statistics (e.g., storm maximum intensity) for a given cyclone among the agencies that are noted in this summary.

Tropical Cyclone Summary

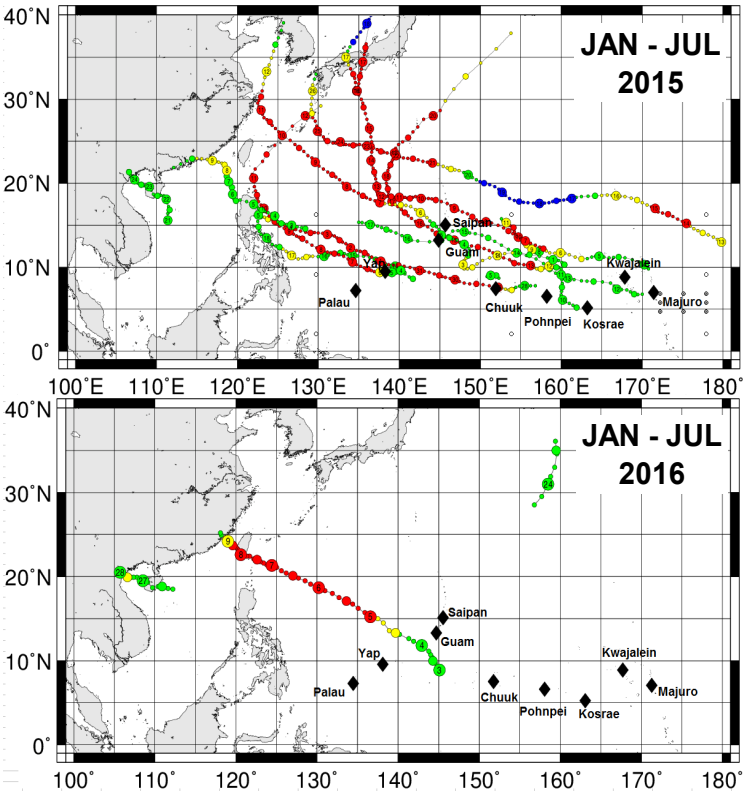

Figure 7. The stark contrast of Western North Pacific Tropical Cyclone activity during the first half of 2015 versus the first half of 2016.

As anticipated far in advance, TC activity in the western North Pacific was very low during the first half of 2016. The season had a very late start, with the first named storm (Super Typhoon Nepartak) reaching tropical storm intensity on the 3rd of July and then becoming an intense (150 kt) super typhoon on the 6th of July after a period of rapid intensification. Also as anticipated, the TC activity (what there was of it) during the first half of 2016 was displaced to the west and north of average, in stark contrast to the activity during the first half of 2015, which was unusually abundant and displaced eastward in to Micronesia (Fig. 6). The count of TCs occurring in the western North Pacific during the first half of 2016 is somewhat convoluted, with TC 01W upgraded post-facto by the JTWC to the season's first numbered . This relatively weak cyclone formed near, and tracked across, the Philippine archipelago to make landfall near Hong Kong on the 12th of June. Both JMA and PAGASA tracked TC 01W as a tropical depression in real time, with the JTWC posting its post facto upgrade to the community about two weeks later. On 17 July, another relatively weak TC was carried by the JTWC as TC03W for a short time while it was southeast of Okinawa. The JMA did not name it. Through the time of the preparation of Figure 6 (25 July 2016), the JTWC had numbered 5 TCs in the western North Pacific, with the JMA providing names for three of them.

In contrast to the western North Pacific, the eastern North Pacific had a wild and crazy start to its 2016 hurricane season. At first, the season was very slow-paced. Agatha (TC 02E) formed on 02 July, becoming the latest first named storm in the eastern North Pacific since reliable records began in 1971. Then, after this slow start, the eastern North Pacific had a record-setting month of July, with a total of 7 named storms, equaling the previous record set in 1985 and 2015. Five of the named cyclones during July became hurricanes, and this was a record.

The 2015-16 Southern Hemisphere (SH) TC season ended on 30 June 2016 with a well-below average annual count. The JTWC numbered only 20 systems, of which only 17 were named by any SH tropical cyclone warning center. In fact, the 2015-16 Australian region cyclone season was the least active season since reliable records started during 1969, with only three named cyclones. The Australia region was expected to fall short of TC count in the 2015-16 season, with the active region of TC formation shifting eastward toward Fiji and beyond into French Polynesia. Indeed, activity was high near Fiji, with the Fiji Islands severely impacted by cyclones during early 2016. The activity was also high near American Samoa, with several cyclones tracking nearby, bringing episodes of heavy rainfall and gusty winds. The final cyclone of the 2015-16 SH season (TC 20P, Amos) threatened American Samoa in late April. Amos weakened rapidly as it swept past American Samoa, largely sparing this jurisdiction from any major damage, but contributing yet additional rainfall to a very high April total.

PEAC Center Tropical Cyclone (TC) Assessment

Western North Pacific and American Samoa

The PEAC concurs that TC activity will be below average in the western North Pacific basin in most categories of activity (e.g., basin annual counts of tropical storms and typhoons, and basin Accumulated Cyclone Energy (ACE) (Fig. 7). The PEAC further believes that it will also be a relatively inactive year within the bounds of Micronesia, a result of both the low basin count and a westward and northward shift to the activity. Through July 2016, one named tropical cyclone (Nepartak) passed within the bounds of Micronesia. Nepatak became a tropical storm well south of Guam on 03 July, then passed between Guam and Yap before later intensifying to a typhoon on its way to Taiwan. The risk of a

Table 1: 2016 Accumulated Cyclone Energy (ACE) calculated for the first half of 2016

2016 Accumulated Cyclone Energy [ACE]

Basin	Current YTD	Normal YTD	% of Normal YTD	Yearly Climo*	2015 **
Northern Hemisphere	134.9575	137	98%	568	848
Western N Pacific	32.09	78	41%	302	478
Eastern + Cent N Pac	91.4325	43	212%	138	288
North Atlantic	7.485	7	106%	104	60
North Indian	3.95	7	56%	18	37
Southern Hemisphere +	211.715	209	101%	209	205
Global	333.6405	309	107%	771	1041

TROPICAL CYCLONE ACTIVITY

damaging TC will remain well below average at all Micronesia locations through August 2016. Later in the year (October through December), the risk of a tropical storm or typhoon should increase to near average across western Micronesia (Yap State and the Republic of Palau), but remain low (but not zero!) at locations eastward of Guam.

The cyclone season is now over for American Samoa. The new 2016-17 South Pacific cyclone season officially began 01 July 2016. No activity is anticipated near American Samoa in the new season until November or December of 2016. Estimates of the severity of the next cyclone season (i.e., 2016-17) in American Samoa will not be made at this time, but will be considered in subsequent newsletters.

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 August-September-October (ASO), Sep-Oct-Nov (SON), and Oct -Nov-Dec (OND) of 2016, (ii) JAS return values at 20 and 100-yr period, (iii) the observed monthly mean and maximum sea-level anomalies for the previous season May-Jun-Jul (MJJ) 2016, and (iv) Seasonal sea level variability: Island Summary. *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 such as tropical cyclones, storm surges or tsunamis.*

Seasonal Sea Level Forecast (anomalies with respect to climatology) for ASO, SON, and OND of 2016

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 2016, the resulting CCA model has been used to forecast the sea level of three consecutive seasons: ASO, SON, and OND (see Table 2: 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 2: 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	JAS: Return Period[4]	
Lead Time [5]	0-M	1M	2M	Seasonal Outlook[3]	0-M	1M	2M	20- YR	100-YR
Marianas, Guam	+2	+2	+2	Marginal Above	+19	+19	+19	6.3	10.9
Malakal, Palau	+3	+4	+4	Above	+38	+38	+38	8.1	10.2
Yap, FSM	+4	+4	+4	Above	+29	+30	+31	8.4	11.3
Chuuk, FSM**	+4	+4	+4	Above	+29	+30	+30	n/a	n/a
Pohnpei, FSM	+5	+5	+5	Above	+32	+32	+33	5.8	7.0
Majuro, RMI	+5	+5	+4	Above	+43	+42	+41	3.5	4.2
Kwajalein, RMI	+4	+4	+4	Above	+41	+40	+40	5.2	6.8
Pago Pago, Am. Samoa***	+2 (-3)	+2 (-3)	+2 (-3)	Normal	+29 (+24)	+29 (+25)	+29 (+25)	4.1	5.2
Honolulu, Hawaii	+2	+2	+2	Normal	+20	+21	+21	4.1	5.4
Hilo, Hawaii	+2	+2	+2	Normal	+23	+23	+23	3.4	5.7

Table 2 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.

The current sea level forecasts indicate that most of north Pacific stations are likely to be above-normal (normal and average are synonymously used throughout the sea level section) in the forthcoming ASO, SON, and OND seasons. The lone south Pacific Island (American Samoa) is expected to be normal to slightly above-normal during the same time-period. In Hawaii, both Honolulu and Hilo are likely to be slightly elevated but still close to normal. The tropical Pacific atmosphere and ocean are currently at ENSO neutral state. This rise is somewhat expected, and the stable condition also corresponds very well with the current developing phase of weak La Niña.

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 2016

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: The monthly mean sea level in most of the stations stayed above normal (Table 3). Except Majuro, most of the stations didn't record any significant rise in July 2016. Majuro recorded a considerable rise during this time. This rise indicates a turning point towards normal state within the next couple of months. Pago Pago--the lone south Pacific island--is currently normal and stable. This rise is somewhat expected and the stable condition also corresponds very well with the current developing phase of La Niña. Because the most likely strength of a La Niña is weak, should it develop, (according to WMO), we may not see any significant rise of sea level in the near future.

Table 3: Monthly observed mean/maximum sea-level anomalies in inches

Tide Gauge Station	Monthly Mean Deviations[1]				Monthly Max Deviations[2]			
	May	June	July	Standard Deviations	May	June	July	Sea level Trend
Marianas, Guam	0	+2	+1	3.5	+15	+16	+16	Below-Rising
Malakal, Palau	+9	+6	+5	4.4	+47	+43	+43	Below-Rising
Yap, FSM	+4	+4	0	3.0	+32	+32	+27	Below-Rising
Chuuk, FSM*	+5	+5	+5	4.0	**	**	**	**
Pohnpei, FSM	+6	+5	+6	3.0	+35	+35	+34	Below-Rising
Majuro, RMI	+4	+8	+7	4.0	+42	+46	+46	Normal-Rising
Kwajalein, RMI	+2	+4	+4	4.0	+40	+39	+39	Below-Rising
Pago Pago, American Samoa***	+4 (-1)	+6 (+1)	+6 (+1)	3.7	+29*	+30*	+29*	Normal-Falling
Honolulu, Hawaii	+4	+4	+4	1.6	+25	+27	+25	Above-Stable
Hilo, Hawaii	+6	+5	+2	2.0	+27	+31	+25	Normal-Stable

Notes in Table 3. +/- 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. *** Guesstimated values, ** 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. Red: Falling trend, * In Pago Pago, there was a level shift (approximately 5 inches) at the time of September 2009 earthquake.

Synopsis of 2-years Sea Level Variability and Forecasts

Starting from JAS of 2014, a comparative perspective of two years of seasonal sea level variations is given below (Fig. 8). The sea level in the western Pacific started to fall from JFM 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 AMJ of 2016. The abrupt rise was due to the flow of water from east to west Pacific after prolonged El Niño effect. So, the abrupt rise lasted for a while and again displayed fall in ASO. It is slightly elevated now and likely to stay elevated during the remainder of 2016.

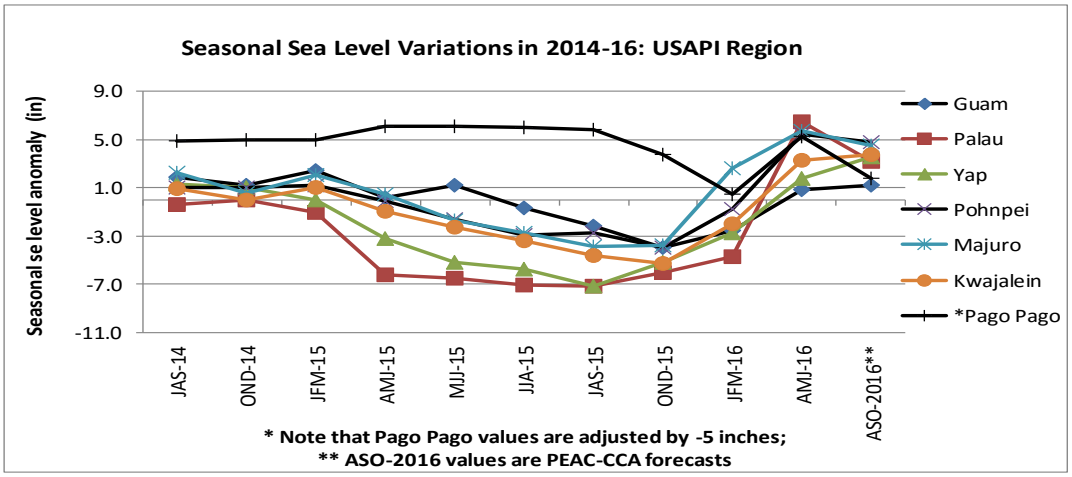

Figure 8. A comparative perspective of Island-wise seasonal sea level variations (JFM 2014 to JFM 2015) (*Note that Pago Pago data needs correction because of level shift after 2009 earthquake. ,There was a level shift (approximately 2-4 inches) at that time which has not been adjusted). Also see *See page 15 for sea level observations from Jason-2 satellite picture (Fig. 24).*

LOCAL SUMMARY AND FORECAST

American Samoa: Rainfall amounts at American Samoa are not strongly correlated with any ENSO index. During the few cases of strong El Niño in the historical record, there is a tendency for dry conditions to occur at American Samoa in the post-Peak phase, although with some high month-to-month variability. With low confidence, the PEAC nonetheless forecast dry conditions at American Samoa to begin in the 1st Quarter of 2016 and extend into the 2nd Quarter. This forecast was on track through the 2016 First Quarter, with the rainfall total of 21.74 inches at the Pago Pago WSO falling well short of average at 60%. The dry conditions were spectacularly interrupted during April, 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, with the 28.35 inches recorded during April 1992 the previous peak value. In fact, the April 2016 rainfall total at Pago Pago is the second highest rainfall total of any month in the historical record, exceeded only by the 32.66 inches recorded at Pago Pago during February 1968. A closer look at the monthly rainfall totals over 2015 and 2016 to-date (Fig. 9) reveals that all months of 2016, except for April, were below average. If April is assigned its average value (~12 inches), then the period January to July of 2016 would have been the 3rd driest such period in the 50-year climate record at Pago Pago. With the high April 2016 value included, the first half of 2016 had a near average amount of rainfall (101%). Also of note is the high annual rainfall at Pago Pago during 2015. The 150.41 inches was the 5th highest annual total in the 50-year climate record.

American Samoa Rainfall Summary: 2nd Qtr, & 1st Half 2016

Station		Apr	May	Jun	2nd Q	1st Half
Pago Pago WSO	Inches	30.87	9.89	3.88	44.64	66.38
	% Avg	256	100	53	152	101
Siufaga Ridge	Inches	23.89	11.0*	6.0*	40.89	67.26
	% Avg	184	100	67	124	87

*Estimated

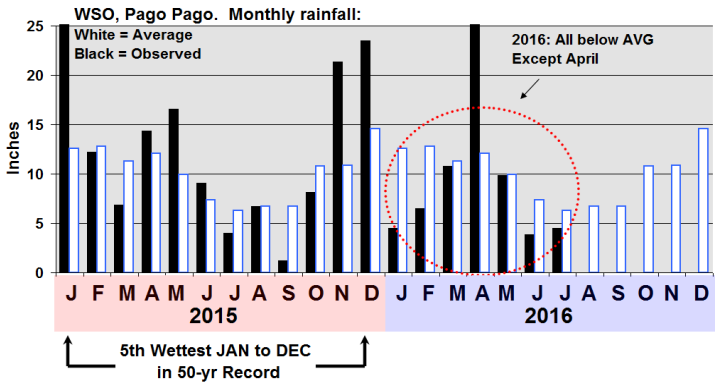

Figure 9. A time series of the monthly rainfall recorded at the Pago Pago WSO during 2015 through July 2016.

One of the big surprises of early 2016 was the failure of tropical cyclone activity to shift eastward toward the northern Cook Islands and French Polynesia. For the now-ended 2015/16 South Pacific cyclone season, the focus of tropical cyclone formation was continually near the Fiji Islands, with several

LOCAL SUMMARY AND FORECAST

cyclones passing near American Samoa. Two cyclones adversely affected American Samoa: Cyclone Ula, in late December 2015, and Cyclone Amos, in late April. These caused heavy rainfall, flooding and landslides, and hazardous surf. A life was lost in the hazardous surf generated by Cyclone Ula. Cyclone Amos, the final cyclone of the 2015-16 season to threaten American Samoa, weakened rapidly on approach and yielded only minor damage.

The mean sea level in American Samoa fell during the first half of 2016 to a low level that has not been recorded since the first half of 2010 (see Fig. 10). Lowered sea level is a typical response to El Niño in American Samoa. The seasonal cycle in American Samoa is very much flat; however, the lowest value tends to occur in March or April and rises thereafter (see sea level section).

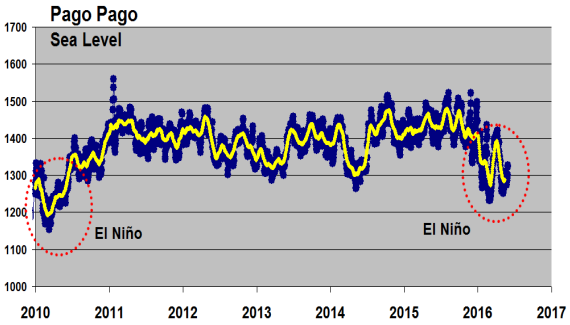

Figure 10. A time series of the monthly sea level recorded at the Pago Pago tide gauge from 2010 through May 2016.

Climate Outlook:

By July 2016, the CPC ended its El Niño advisory, declared the state of the climate to have entered ENSO-neutral, and continued its La Niña watch. Given that the rainfall at American Samoa is only loosely linked to the status of ENSO, the PEAC relies heavily on the seasonal computer forecasts, except in cases of strong El Niño, when analogs to other strong events are considered. The most recent suite of seasonal rainfall prediction models indicate above normal rainfall at American Samoa over the next three months. PEAC scientists, WFO Guam and local American Samoa forecasters manually intervened to temper the model wet forecasts to bring the forecast of rainfall over the next three months closer to average. Looking ahead into 2017, there are no compelling reasons at this time to bias the forecast to the wet or dry side of average

The South Pacific cyclone season of 2015-16 is now over. There is little risk of a tropical cyclone in American Samoa waters until the fall of 2016. No forecast of the upcoming 2016-17 cyclone season is offered at this time, but will be considered in the next quarterly newsletter.

Lastly, the sea level behavior at American Samoa lags that of Micronesia by 3 to 4 months. Whereas the mean sea level falls to its lowest level in Micronesia in December or January at the peak of El Niño, at American Samoa the mean sea level falls to its lowest level during March or April of the post-Peak phase of El Niño (see the sea level section for details). Predicted rainfall for American Samoa from April 2016 through March 2017 is:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]
July - September 2016 (Heart of Next Dry Season)	105%
October - December 2016 (Onset of Next Rainy Season)	105%
January - March 2017 (Heart of Rainy Season)	100%
April - June 2016 (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: The weather throughout Guam and the CNMI during 2015 and through the first half of 2016 progressed as expected during the course of a strong El Niño event. The calendar year 2015 featured some wild weather, with an early start to typhoon activity, and then a continual series of additional close passages of tropical cyclones through November. During the first quarter of 2016 the weather in Guam and the CNMI was dominated by comfortable cool trade winds. Temperatures and dew points were relatively low (see Fig. 11), giving the feel of a fine day in Hawaii! Then, rather abruptly in late March, the winds slackened and temperatures jumped. Day-after-day of bright sun with maximum temperatures over 90°F were tempered at first by relatively low dewpoints that made for comfortable evenings. But during June, the high temperatures crept upward by yet another degree or two, and coupled with light winds, residents began to feel uncomfortably warm. In the very first few days of August, a monsoon depression moved to the north of Guam and Saipan. The southwest monsoon swept in with the year's first widespread and prolonged episode of cool rainy weather (yes, the high of only 81 degrees on August 3rd is real!).

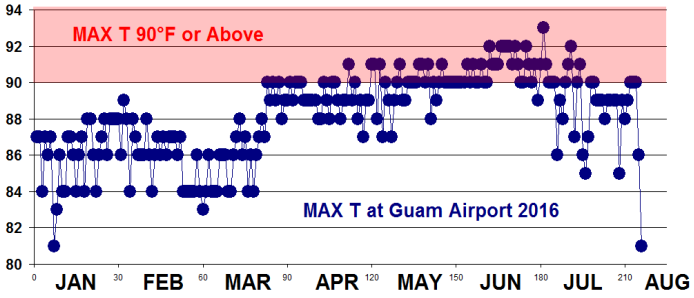

Figure 11. A time series of the daily maximum temperature at the Guam Weather Forecast Office for the first half of 2016. Note the cool temperatures during February through most of March that abruptly give-way to warmer days at the end of March.

Guam and CNMI Rainfall Summary: 2016 1st Qtr.						
Station		Apr	May	Jun	2nd Q	1st Half
GUAM						
GIA (WFO)	Inches	1.31	1.80	7.73	10.84	18.72
	% Avg	34%	30%	119%	66%	68%
AAFB	Inches	1.13	0.93	4.66	6.72	18.46
	% Avg	23%	14%	74%	38%	56%
Sinajaña	Inches	0.89	1.05	6.54	8.48	17.07
	% Avg	23%	17%	101%	52%	62%
CNMI						
Saipan Intl. Airport	Inches	1.78	2.07	2.05	5.90	14.14
	% Avg	64%	47%	44%	50%	73%
Capitol Hill	Inches	1.40	1.47	2.04	4.91	16.18
	% Avg	40%	27%	35%	33%	67%
Tinian Airport	Inches	0.97	0.57	1.63	3.17	9.92
	% Avg	28%	10%	28%	21%	41%
Rota Airport	Inches	0.91	1.97	2.54	5.42	14.16
	% Avg	20%	31%	41%	32%	49%

LOCAL SUMMARY AND FORECAST

Reduction of rainfall throughout the first half of 2016 led to an incremental manifestation of the outward signs of drought: yellowing of vegetation, complete browning of un-watered lawns, reduction of stream flow, cracks in the clay soil, and an increase of "boonie fires". Saipan, Rota and Tinian suffered the most from prolonged dry weather. Some beneficial rainfall occurred on Guam on the night of 21 June, when a cluster of thunderstorms moved across the center of the island dumping 3-4 inches of rain in a about a 3-hour period during the late evening hours. The CNMI did not receive appreciable rainfall during this event, and drought hung on there.

While July was a dry month, and the effects of drought lingered, the southwest monsoon swept into the region accompanying a passage of a monsoon depression. A huge amount of rainfall accumulated during the first 4 days of August, and ended all perception of drought. Six to eight inches of rainfall occurred across Guam over three days, and Saipan had a whopping 10 inches of rainfall in 24 hours on the 3rd.

Climate Outlook: By July 2016, the CPC ended its El Niño advisory, declared the state of the climate to have entered ENSO-neutral, and continued its La Niña watch. Whether or not the climate state progresses all the way to La Niña, or simply retreats solidly into ENSO-neutral, the seasonal rainfall and typhoon outlooks are the same. Computer model forecasts still indicate below normal rainfall over the next three months (July, August and September), but PEAC scientists and WFO Guam forecasters manually intervened in the forecast to temper the model dryness and bring the forecast of rainfall over the next three months closer to average. If La Niña develops over the next few months and continues into 2017, the rainfall amounts in such a scenario are generally near average, with average to slightly above average rainfall over the next dry season.

The TC threat on Guam and in the CNMI is usually greatly reduced during the year of the post-Peak of a strong El Niño event. It is tempting to declare that no direct strikes of any tropical storm or typhoon will occur during 2016, but the odds do not fall to zero. The basin TC activity should exhibit a westward and northward shift, with a lower than average annual count (see the TC section). Copious drought-ending rainfall has recently been brought to the region by a large monsoon depression moving by to the north. This may well set the tone for the heart of the 2016 rainy season, with some additional week-long episodes of monsoonal rainfall, augmented by two or three of the basin's TCs that could develop near enough to Guam and the CNMI to bring some gusty winds and high seas.

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]	
	Guam/Rota	Saipan/Tinian
Jul-Sep 2016 (Heart of rainy season)	90%	90%
Oct-Dec 2016 (End of rainy season)	90%	90%
Jan-Mar 2017 (1st half of next dry season)	95%	95%
Apr-Jun 2017 (Heart of next dry season)	95%	90%

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

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Federated States of Micronesia

Yap State: Drought slowly tightened its grip on Yap Island and the outer islands and atolls of Yap State at the close of 2015 into the beginning of 2016. The rainfall total of 21.70 inches at the Yap Island Weather Service Office (WSO) during the 6 months of OND (2015) + JFM (2016) was only 39% of average, and was the driest such 6-month total in that station's post-WWII historical climate record! (Fig. 12). By March 2016, the Yap Island reservoir was nearly depleted, and several wild fires had scorched portions of the island. In late June 2016, UOG PEAC scientists visited Yap Island to assess the impact of drought on that island and the Yap State outer islands and atolls. At the time of this visit, the roadside vegetation and forests across Yap Island had become lush and green, except in areas earlier scorched by wildfires. The total number of wildfires (23) during the 2015/16 El Niño drought was near the long-term average, but the total land area scorched (1090 acres, or 4.5% of the Yap Island land area) was more extensive than average. The largest fire (nearly a square mile – 567 acres) occurred near the airport (Fig. 13).

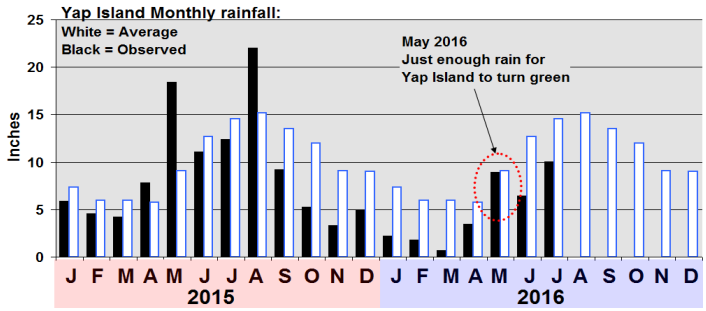

Figure 12. Time series of monthly rainfall at the Yap Island WSO for 2015 through July 2016. The continuous dryness at the end of 2015 into JFM of 2016 set a new historical record.

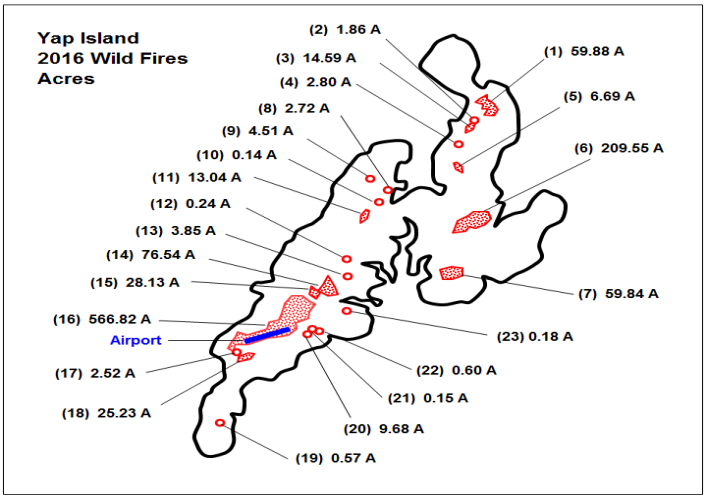

Figure 13. Location of wild fires on Yap Island during the El Niño drought of 2016. Adapted from a chart obtained from the Fire Section, Division of Agriculture and Forestry (DAF) and Division of Land, Yap State Government. Units are in acres (A).

Municipal water supplies on Yap Island were not as severely affected as in other major droughts (e.g., 1988 and 1998). The Yap Island reservoir was substantially depleted, but other sources of water (e.g., wells), and water in storage precluded both mandatory conservation measures and water rationing. Uninterrupted 24-hour water service was largely maintained across most of the island. Yap Island has three water tanks that

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when full provide 90 days of water under normal rates of consumption. High rainfall during May 2016 averted any further deterioration in water resources. Full water service was available when PEAC scientists visited Yap Island in late June; although the level of the reservoir was still very low.

The outer islands and atolls of Yap State did not fare as well as Yap Island. Emergency supplies of water had to be delivered by ship to several of the outer islands. Reverse osmosis units were used to provide water on-site at Ulithi, and to provide water to be transported by ship to more remote locations.

Yap State Rainfall Summary: 2016 2nd Quarter						
Station		Apr	May	Jun	2nd Q	1st Half
Yap State						
Yap WSO	Inches	3.47	8.90	6.46	18.83	23.53
	% Avg	60%	98%	51%	68%	50%
Ulithi	Inches	3.24	5.55	4.88	13.67	18.19
	% Avg	66%	72%	45%	58%	46%
Woleai	Inches	2.41	7.61	12.28	22.30	23.44
	% Avg	22%	62%	94%	62%	37%

Climate Outlook: By July 2016, the CPC ended its El Niño advisory, declared the state of the climate to have entered ENSO-neutral, and continued its La Niña watch. Whether or not the climate state progresses all the way to La Niña, or simply retreats solidly into ENSO-neutral, the seasonal rainfall and typhoon outlooks are similar. Computer model forecasts still indicate below normal rainfall over the next three months (July, August and September), but PEAC scientists and WFO Guam forecasters manually intervened to temper the model dryness and bring the forecast of rainfall over the next three months a bit closer to average. If La Niña develops over the next few months and continues into 2017, the rainfall amounts in such a scenario are generally near average, with average to slightly above average rainfall over the next dry season.

For many months following the post-Peak phase of El Niño (e.g., March through December 2016), the typhoon threat is reduced across Yap State. Indeed, during the first half of the year, there were no major threats or any actual damage from TCs across Yap State. Super Typhoon Nepartak (the first typhoon of 2016 in the western North Pacific) tracked between Yap and Guam in early July while it was still a tropical storm. The general reduction of Pacific basin typhoons during a post-Peak year of El Niño reduces the local risk, and in the second half of the post-Peak year, the westward and northward displacement of the

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]	
	Woleai	Yap & Ulithi
July-September 2016 (Start of Rainy Season)	85%	90%
October-December 2016 (End of Rainy Season)	90%	95%
January-March 2017 (Heart of next Dry Season)	110%	100%
April-June 2017 (End of Dry Season)	110%	100%

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basin's TCs helps to reduce the local typhoon threat in Yap State. Late in the year (OND 2016), Yap State is among the first locations in Micronesia where the risk of impacts from TCs returns to near normal (10-15% chance of some damaging effects: high waves, gales or very heavy rainfall).

Chuuk State: The weather and climate at most islands of Chuuk State evolved as expected during the course of the 2015/16 strong El Niño event: very wet during the first nine months of 2015 followed by a prolonged period of below average rainfall. The first 9 months of 2015 were indeed wet, with the 9-month total rainfall of 132.99 inches at the Chuuk WSO the 3rd wettest such period in the 60-year record at that station (Fig. 14). This was surpassed only by higher rainfall during JAN – SEP 2002 and JAN – SEP 2014. Monthly rainfall fell below normal in October 2015, and thereafter, every month through July 2016 was below average at the WSO Chuuk and at most other locations throughout the state. The period October 2015 through March 2016 was particularly dry, which caused some problems with potable water supplies. Then, during the months of April through July of 2016, higher (but still slightly below average) rainfall amounts returned to central and southern islands and atolls. By May 2016, the perceptible impacts of dry weather had ended at all but the atolls in the far north of Chuuk State (e.g., Fananu and Onoun) where dry conditions were more pronounced (Fig. 15). Overall, Chuuk State was not as hard-hit by drought during the 2015-16 El Niño event as it was during the 1997-98 event.

Climate Outlook: By July 2016, the CPC ended its El Niño advisory, declared the state of the climate to have entered ENSO-neutral, and issued a La Niña watch. Whether or not the climate state progresses all the way to La Niña, or simply retreats solidly into ENSO-neutral, the seasonal rainfall and typhoon outlooks are similar. Computer model forecasts still indicate below normal rainfall over the next three months (July, August and September), but PEAC scientists and WFO Guam and local forecasters manually intervened to temper the model dryness and bring the forecast of rainfall over the next three months a bit closer to average. If La Niña develops over the next few months and continues into 2017, the rainfall amounts in such a scenario are generally near average, with average to slightly above average rainfall through the next dry season with a good chance of above-average rainfall in the spring associated with an active trade-wind trough.

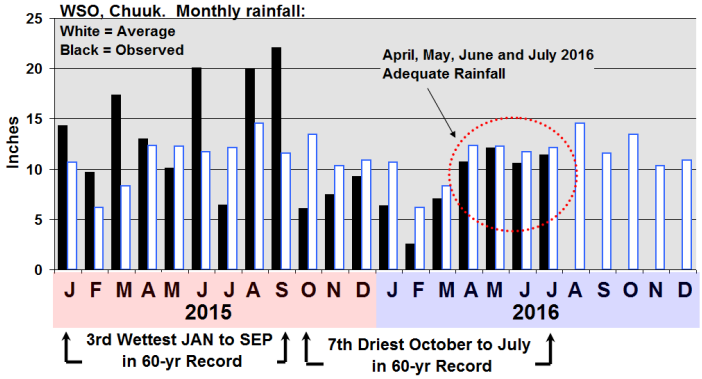

Figure 14. A time series of the monthly rainfall at the WSO Chuuk during the calendar year of 2015 and 2016 to-date. Note the wild weather during January through September of 2015, with several very wet months. It became abruptly dry in October 2016 and every month thereafter had below average rainfall.

LOCAL SUMMARY AND FORECAST

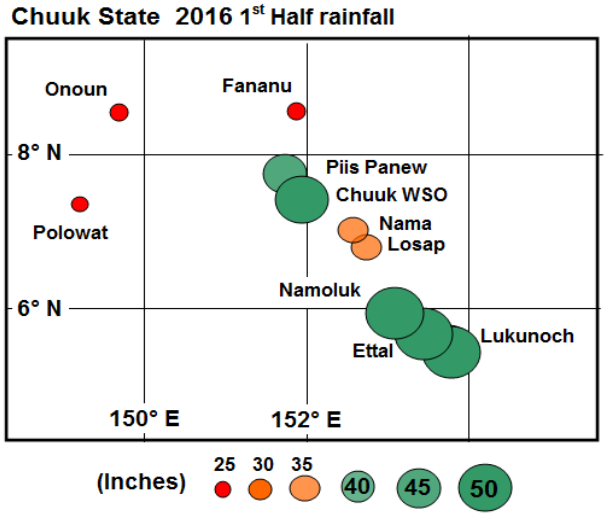

Figure 15. A pictorial representation of the 2016 1st Half rainfall total at recording sites across Chuuk State.

Chuuk State Rainfall Summary: 2016 2nd Qtr

Station		Apr	May	Jun	2nd Q
Chuuk Lagoon					
Chuuk WSO	Inches	10.73	12.11	10.61	33.45
	% Avg	87	99	91	92
Southern Mortlocks					
Namoluk	Inches	12.83	11.92	8.49	33.24
	% Avg	97	89	69	86
Northern Mortlocks					
Losap	Inches	6.71	7.29	10.63	24.63
	% Avg	54	60	91	68
Northern Atolls					
Fananu	Inches	4.26	8.84	8.65	21.75
	% Avg	34	72	74	60
Western Atolls					
Polowat	Inches	2.71	7.65	3.82	14.18
	% Avg	45	85	31	52

During 2015, Chuuk State experienced a great abundance of tropical cyclones that should not be repeated soon. For the remainder of 2016, the risk of a damaging tropical cyclone in Chuuk State should be lower than average at first (August and September) with the risk rising to near average late in the year (OND). The tropical cyclone activity in Chuuk State is most likely to be the passage through the state of the early disturbance or monsoon depression stages of a few developing systems, particularly during OND. The first half of 2017 should also be quiet, but not a complete shut-out as the first half of 2016. A damaging typhoon is not anticipated for the remainder of 2016, but the risk of one never goes to zero! The weaker the oncoming La Niña, the greater chance there will be for a tropical storm or typhoon in Chuuk State, so this will be monitored and forecasts updated as necessary. Chuuk State could also see a few monsoon surge episodes but they will likely be short-lived.

Lastly, the sea level should continue its steady rise, with the mean sea level reaching slightly above average already. It is

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likely to stay above average throughout of the year (see the sea level section for details). Predictions for Chuuk State for April 2015 through March 2017:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]			
	Chuuk Lagoon, and Nama	Polowat	Northern Atolls	Mortlocks
Jul-Sep 2016	90%	80%	85%	95%
Oct – Dec 2016	95%	85%	90%	100%
Jan – Mar 2017	100%	85%	95%	110%
Apr-Jun 2017	100%	85%	95%	110%

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

Pohnpei State: The calendar year 2015 was wet at the WSO Pohnpei, but mostly derived from high rainfall in the spring of that year (see Fig. 16). Beginning with June 2015, monthly rainfall values were mostly below average, with 11 of the 14 months from June 2015 through July 2016 having below average totals. The first half of 2016 was below average at the WSO, and also below average at other Pohnpei Island locations and outer atolls of Pohnpei State. After a wet 2015, a period of substantially decreased rainfall was predicted to occur on Pohnpei Island and the northern atolls of Pohnpei State through the first 4 or 5 months of 2016 as a response to the post-Peak phase of El Niño. Looking at the time series of monthly rainfall for the WSO Pohnpei (Fig. 17), one can see that persistent dryness began on Pohnpei Island in the 2nd half of 2015 and continued through May of 2016. February and March 2016 were particularly dry. These two months were perceived to be very dry by residents of Pohnpei Island with many uncomfortably hot dry days and dusty conditions thought to be responsible for an uptick in the number of cases of pink eye (conjunctivitis). Water hours were implemented by the public water utility. During April, however, an increase of rainfall brought a suspension of water restrictions on Pohnpei Island. Abundant rains returned during May and June, and no reports of significant impacts of the prior dry conditions were received by the PEAC. All things considered, Pohnpei Island and the atolls of Pohnpei State were spared the severity of dry conditions that were observed at many other locations across Micronesia in this event and also during the 1997-98 strong El Niño event.

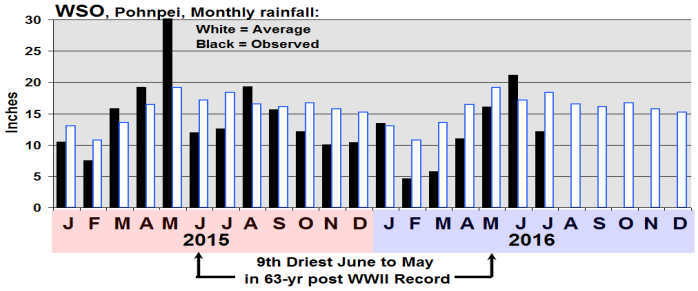

Figure 16. A time series of the monthly rainfall at WSO Pohnpei during the calendar year of 2015 and JAN – JUL of 2016. Note the domination of the time series by months with below average rainfall. The total rainfall in the period June 2015 through May 2016 was the 9th driest such period in the post-WWII record.

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Although dry conditions during 2015 and 2016 were not perceived to be severe by residents of Pohnpei Island, and there was no serious impact to municipal water quantity and quality, the 12-month period June 2015 through May 2016 was the 9th driest such period in the 63-year post-WWII historical record (Fig. 17).

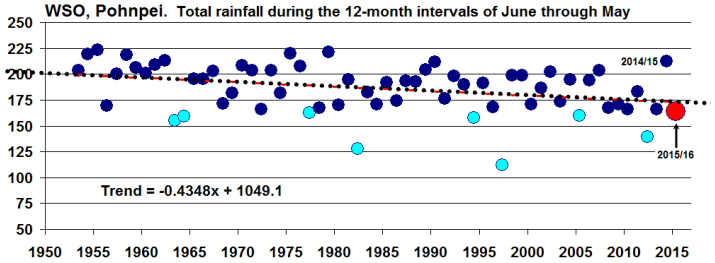

Figure 17. A time series of the historical record of rainfall in one-year intervals of June through May of the following year. The rainfall during JUN 2015 through MAY 2016 (large red dot) was the 9th lowest in the 63-year time series. Light blue dots show values that were lower than the 2015/16 value. The trend has been included to show the fairly substantial reduction of annual rainfall at Pohnpei island (nearly 25 inches over the 63-year period of record).

Pohnpei State Rainfall Summary AMJ : 2016 2nd Qtr and 1st Half						
Station		Apr	May	Jun	2nd Q	1st Half
Pohnpei WSO	Inches	11.01	16.06	21.18	48.25	72.14
	% Avg	67%	84%	124%	92%	80%
PNI Airport	Inches	7.99	15.47	18.83	42.29	61.57
	% Avg	59%	99%	134%	98%	83%
Atolls of Phonpei State						
Station		Apr	May	Jun	2nd Q	1st Half
Nukuoro	Inches	7.23	25.53	10.33	43.09	74.11
	% Avg	48%	173%	85%	103%	95%
Pingelap	Inches	5.39	8.52	5.02	18.93	35.06
	% Avg	31%	50%	31%	38%	39%
Kapinga ..	Inches	12.78	4.07	3.30	20.15	45.61
	% Avg	105%	35%	28%	57%	65%

Climate Outlook: In July 2016, the CPC ended its El Niño advisory, declared the state of the climate to have entered ENSO -neutral, and continued its La Niña watch. Whether or not the climate state progresses all the way to La Niña, **or** simply retreats solidly into ENSO-neutral, the seasonal rainfall and typhoon outlooks are similar. Computer model forecasts still indicate below normal rainfall over the next three months (July, August and September), but PEAC scientists and WFO Guam forecasters manually intervened to temper the model dryness and bring the forecast of rainfall over the next three months closer to average. If La Niña develops over the next few months and continues into 2017, the rainfall amounts in such a scenario rise to near average to slightly above average in the fall (OND 2016). Average to slightly above average rainfall is anticipated to continue in 2017. For the remainder of 2016, the threat of a damag-

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ing TC anywhere within Pohnpei State is very low (less than a 1-in-10 chance).

Lastly, the sea level typically begins a rapid rise in the post-Peak months, and sea level could be above average by mid-summer (see the sea level section for details). Predicted rainfall for Pohnpei State from July 2016 through June 2017 is given below:

Inclusive Period	% of long-term average	
	Pohnpei Island/ atolls	Kapingamarangi
Jul – Sep 2016	95%	95%
Oct – Dec 2016	100%	95%
Jan – Mar 2017	110%	90%*
Apr – Jun 2017	120%	80%**

** Located near the equator, the rainfall pattern at Kapingamarangi is much different than at islands and atolls farther to the north. It remains wet through the onset and peak of El Niño, and typically stays wet through all of the post-Peak period El Niño. Major drought at Kapingamarangi is often associated with strong La Niña events, and dryness could begin at Kapingamarangi in the second half of 2017 if the climate system makes a sharp push toward La Niña late in 2016.

Note: If the climate system moves into La Niña in 2017, the spring months of 2017 could be very wet at Pohnpei Island and Sapuawafik Atoll, followed by a drying at Kapingmarangi.

Kosrae State: The 10-month total rainfall at Kosrae from October 2015 through July 2016 was the 3rd-driest such period in the time series of rainfall at Kosrae (See Fig. 18). Despite the low rainfall totals, the PEAC received no reports of any serious problems related to dry conditions on Kosrae. This may be an artifact of the observed sequence of drier and wetter months and its small population. A very dry October and November was followed by a 3-month period of rainfall closer to average (Fig. 19). Another very dry back-to-back 2-month duo then occurred in March and April that was followed by more abundant rainfall in May, June and July.

With nearly 200 inches of annual rainfall, "dryness" is a relative term on Kosrae. Surprisingly, the dryness during October 2015 through July 2016 was of greater magnitude than the dryness there during October 1997 through July 1998. During the 1997-98 event, there was a longer run of very dry months (four versus two), which might explain the lack of perceived impacts in the 2015-16 event. Perhaps, as at Palau (where historically low rainfall had ecological impacts such as the death of the jellyfish in Jellyfish Lake), prolonged relatively low rainfall on Kosrae may induce subtle ecological damages.

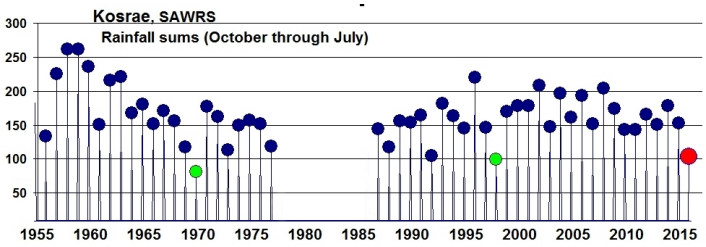

Figure 18. Time series of 10-month Oct-Jul rainfall totals at Kosrae SAWRS (Airport) observing site (1986-2016). The period Oct 2015 to July 2016 was the 3rd driest such period in the time series (red dot) behind only 1970 and 1998 (green dots).

LOCAL SUMMARY AND FORECAST

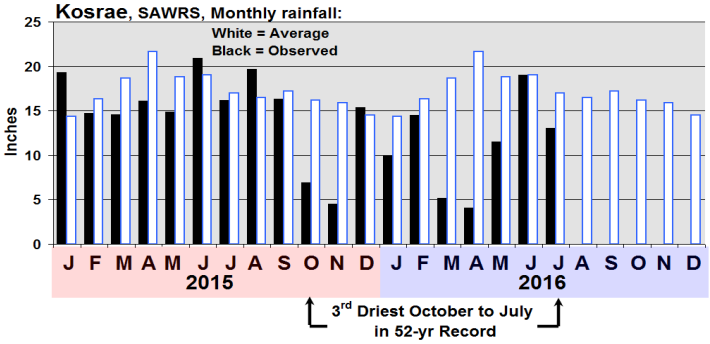

Figure 19. A time series of the monthly rainfall at Kosrae Supplemental Aviation Weather Reporting Station (SAWRS) for the calendar year of 2015 and January through July of 2016.

Kosrae State Rainfall Summary: 2016 2nd Qtr and 1st Half						
Station		Apr	May	Jun	2nd Q	1st Half
Pohnpei WSO	Inches	4.05	11.51	18.99	34.55	64.15
	% Avg	19	61	100	58	59%
Nautilus Hotel	Inches	2.78	13.39	16.35	34.78	62.39
	% Avg	23%	71%	86%	58%	57%

Climate Outlook: In July 2016, the CPC ended its El Niño advisory, declared the state of the climate to have entered ENSO-neutral, and continued its La Niña watch. Whether or not the climate state progresses all the way to La Niña, or simply retreats solidly into ENSO-neutral, the seasonal rainfall and typhoon outlooks are similar. Computer model forecasts still indicate below normal rainfall over the next 3 months (July, August and September), but PEAC scientists manually intervened to temper the model dryness and bring the forecast of rainfall over the next 3 months closer to average. If La Niña develops over the next few months and continues into 2017, the rainfall amounts in such a scenario rise to near average to slightly above average in the fall (OND 2016). During the spring of 2017, a strong trade wind trough could bring wetter than average conditions.

Tropical cyclones occur at Kosrae almost exclusively during the months of El Niño Onset through the El Niño Peak phase. During the El Niño post-Peak months, and indeed all the way through to the end of 2016, the threat of a damaging tropical cyclone at Kosrae is very low.

Lastly, the sea level typically begins a rapid rise throughout all of Micronesia in the post-Peak months of an El Niño event. Thus, the sea level at Kosrae should return to average by mid-summer, and likely rise to above average late in the year (see the sea level section for details). Predicted rainfall for Kosrae State from July 2016 through Jun 2017 is:

Inclusive Period (Kosrae)	% of long-term average / Forecast rainfall (inches) [1]
Jul-Sep 2016	85%
Oct – Dec 2016	90%
Jan – Mar 2017	100%
Apr – Jun 2017	110%

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

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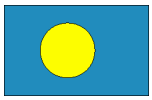

Republic of Palau:

It is hard to imagine that an annual sum of rainfall of approximately 100 inches could set an all-time record low. That is, however, the case for Koror, Palau, where the 2015 annual total rainfall of 97.06 inches (66%) recorded at the Koror Weather Service Office was the driest calendar year in that station's 63-year post-WWII climate record. Including rainfall readings taken by Japanese observers on Palau during the period 1924-1937, the recent dry conditions still set record lows for the entire 80 years of combined observation. The driest 12-month sum (not constrained by the calendar year boundary) found in the historical record (including Japanese data) is the 86.09 inches that occurred from August 1997 to July 1998. The second lowest unconstrained 12-month sum is the 86.25 inches recorded during April 2015 to March 2016, making this the driest APR to MAR 12-month sum when compared head-to-head with other post-WWII APR to MAR periods (Fig. 20).

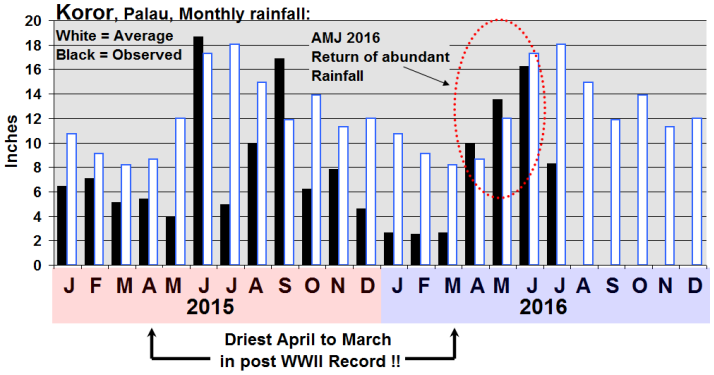

Figure 20. Observed rainfall (black bars) versus average rainfall (white bars) at Koror, Palau, for all of the calendar year 2015 through July 2016.

By March of 2016, Koror had accumulated a deficit of 71 inches in the 15-month period beginning in January 2015 and ending in March 2016. During April, May and June 2016, higher rainfall amounts returned yielding a 2nd Quarter total of 39.70 inches that was slightly above average (105%) (Fig.PL-1). The high 2nd Quarter rainfall totals provided a small easing of the long-term accumulated rainfall deficit (Fig. 22). But, a return of dry conditions in July 2016, gave a serious set-back to the accumulated rainfall deficit, so that it now stands at its lowest value in the past year-and-a-half (i.e., - 78.98 inches). Abundant rainfall in the 2nd Quarter is certainly a hopeful sign that the long dry spell at Palau may soon ease, but many months of above-average rainfall will be needed to fully erase the long-term rainfall accumulated deficit. April 2016 was the first month since September 2015 with above-average rainfall.

Palau is typically so very wet, that even a substantial reduction in terms of percent of average rainfall (e.g., cut-in-half to 50%) may still be adequate rainfall for municipal water supplies. The water supply held through 2015, but by early spring 2016, municipal water began to run low as the long dry period began to take its toll. Palau President, Tommy Remengesau declared a state of emergency for the drought effects of El Niño in March 2016. Access to tap water was rationed to three hours a day or less in Koror and schools were only open half days because they could not give students enough to drink. In early May, with the return of near normal rainfall, 24-hour water was restored to Koror, but some states still struggled. There were also reports of ecological impacts of dryness including brush fires, reduced stream flow, yellowing of vegetation, and the

LOCAL SUMMARY AND FORECAST

death of millions of jellyfish in Palau's world-famous Jellyfish Lake. It stands to reason that an ecosystem adapted to very high annual rainfall may suffer if the rains are reduced by a substantial amount with respect to its own typically high value, even if the actual value of that reduced amount would be a bounty year at other locations.

The loss of most or all of the jellyfish in Palau's freshwater-Jellyfish Lake during this substantial disruption to Palau's average climate is a good case in point. By April 2016, Jellyfish Lake was found to be devoid of all mature Golden Jellyfish that typically have populations in the lake of several million. By July 2016, it was still reported by tourists visiting there were still no jellyfish in the lake. Based on prior occurrences of jellyfish population decimations, it may take over a year before the population begins to recover. Thee last major die-off of jellyfish occurred during the strong 1997/98 El Niño event. In that event

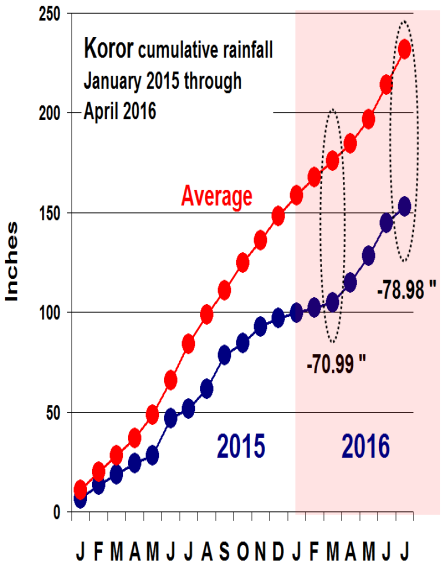

Figure 22. Cumulative rainfall at Koror. Red line shows the normal accumulated rainfall from JAN 2015 through JUL 2016, and the dark blue line shows the measured accumulated rainfall over the same time period. By MAR 2016, the accumulated rainfall deficit was -70.99 inches. With above average rainfall during AMJ, the deficit abated by a small amount, but then low rainfall during July sent it to its lowest value so far.

the jellyfish began a precipitous decline in number starting in the fall of 1998. By December 1998, the population had declined to nearly zero. The last mature golden jellyfish medusa was observed in the lake in April 1999. Not until January 2000 were golden jellyfish medusa observed in Jellyfish Lake for the first time since the total collapse. The population made a remarkable recovery thereafter, and by May, 2012, the population had returned to pre-decline levels of many millions of adult golden medusa.

Republic of Palau Rainfall summary
AMJ 2016 and 2nd Quarter total.

Station		Apr	May	Jun	2nd Q	1st Half
Koror WSO	Inches	9.90	13.55	16.25	39.70	47.55
	% Avg	114%	113%	94%	105%	72%
Intl. Airport	Inches	13.68	15.47	15.15	44.30	52.63
	% Avg	143%	117%	80%	106%	73%
Nekken	Inches	10.85	19.45	17.62	47.92	54.68
	% Avg	125%	162%	102%	126%	83%

LOCAL SUMMARY AND FORECAST

Climate Outlook: In July 2016, the CPC ended its El Niño advisory, declared the state of the climate to have entered ENSO -neutral, and continued its La Niña watch. Whether or not the climate state progresses all the way to La Niña, or simply retreats solidly into ENSO-neutral, the seasonal rainfall and typhoon outlooks are similar. Computer model forecasts still indicate below normal rainfall over the next 3 months (July, August and September), but PEAC scientists and WFO Guam forecasters manually intervened to temper the model dryness and bring the forecast of rainfall over the next three months a bit closer to average. If La Niña develops over the next few months and continues into 2017, the rainfall amounts in such a scenario are generally near average to slightly above average in the fall (OND 2016). Average to slightly above average rainfall is anticipated over the next dry season.

For many months during the post-Peak phase of El Niño (e.g., March through July), the typhoon threat is reduced in the Republic of Palau. In the first half of the year, the general reduction of Pacific basin typhoons reduces the local risk, and in the second half of the year, the westward and northward displacement of the basin's tropical cyclones helps to reduce the local typhoon threat, at least until late in the year (OND), when the Republic of Palau is among the first locations in Micronesia where the risk of impacts from TCs returns to near average (i.e., a 10-15% chance of one or more of the potentially damaging effects of TCs: gale force winds, hazardous high surf and heavy rainfall events).

Lastly, the sea level was very low in Palau during 2015, and is now undergoing a rapid rise (see the sea level section for details). Predicted rainfall for Palau from July 2016 through June 2017 is:

Palau Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]
Jul-Sep 2016	90%
Oct-Dec 2016	105%
Jan-Mar 2017	110%
Apr-Jun 2017	110%

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

Republic of the Marshall Islands (RMI)

The weather in the Republic of the Marshall Islands during 2015 and through July of 2016 progressed almost exactly as expected during the course of a strong El Niño event: very wet, then very dry! The spring of 2015 was particularly wet in association with unusual monsoonal westerly winds reaching the southern and central RMI and with enhanced tropical cyclone activity. The 105.54 inches of rainfall measured at Kwajalein during the 9-month period, January through September 2015 was the wettest such period in a 70-year historical record. At Majuro the same 9-month period was the 6th wettest in a 62-year historical record. The last of the suite of climate anomalies typically delivered to the RMI by a strong El Niño, severe drought, arrived in late 2015 (as forecasted by the PEAC more than 6 months earlier) and persisted through most of the first half of 2016. The total rainfall at the Majuro WSO from October 2015 through July 2016 was the lowest total in its 62-year historical record. (see Fig. 23 and the tabulation below of wet and dry rainfall extremes in the RMI during the 2015-16 El Niño event).

During the 4th Quarter of 2015, rainfall amounts throughout the RMI began to decline. Rainfall amounts were particularly low during January through April of 2016. This is a typical response to El Niño, and was well-forecast several months in advance. Impacts of drought became severe by the late winter of 2015, with a State of Emergency declared in February by the RMI President, and a State of Disaster declared by the RMI President in March. The northern-most atolls were hardest hit, with accumulated rainfall totals less than 25% of the rainfall at atolls farther to the south. Drought-relieving rains arrived in May at Majuro, and in June at Kwajalein.

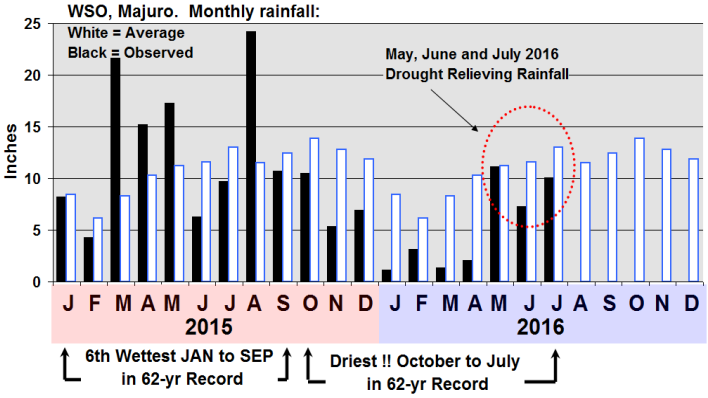

Figure 23. A plausible scenario for the slow recovery of rainfall at Majuro for the remainder of 2016. The average monthly values of rainfall at Majuro are shown in black, and the forecast values are shown in yellow white.

A list of record events, background and timelines of the drought response follows:

Record events

Ailingalapalap – **driest March**, 2nd driest Oct-Mar
Kwajalein – **wettest Jan – Sep (2015), driest Oct-Mar, driest Apr-Mar**, 5th driest Oct-Jul
Majuro – **driest Oct-Jul,** 2nd driest Oct-Mar, 6th Wettest Jan – Sep (2015),
Jaluit – 5th driest Oct-Mar
Mili – **driest Oct-Mar**
Utirik – **driest Oct-Mar, driest Apr-Mar**
Wotje – **driest March**, 2nd driest Oct-Mar,

The following is contained in a situation report issued on 05 May 2016 by the International Office for Migration (IOM), Marshall Islands Office:

Background

Below average rainfall throughout the equatorial Pacific Ocean in early 2016 created drought conditions in many Pacific nations. According to the National Oceanic and Atmospheric Administration (NOAA), 'all locations across the Marshall Islands entered a severe or extreme drought' caused by 'one of the strongest El Nino events in recorded history.'

Time Line of Drought

- February 03, 2016: RMI President H.E. Dr. Hilda Heine declares State of Emergency.
- March 08, 2016: RMI President H.E. Dr. Hilda Heine declares State of Disaster.
- April 27, 2016: U.S. President Barack Obama Declares Disaster in the Marshall Islands.
- 21,000 people in RMI are affected by severe drought conditions.

LOCAL SUMMARY AND FORECAST

● 1,257 households are affected on the outer islands and 5,195 households are affected in urban areas.
● Government of RMI identified 8.99 million USD in emergency response needs.

U.S. President Obama Declares Disaster

On April 27, 2016, United States President Barack Obama officially declared a disaster in RMI due to the ongoing drought. President Obama's declaration will make federal funding available for "emergency relief…assistance to the Republic of the Marshall Islands", according to the White House. IOM, in close coordination with the RMI Government and the donor community [including USAID/OFDA]*, continues to deploy RO units and distribute hygiene materials throughout the RMI. Additional funding could help address other needs, including supplemental food assistance.*

Sidebar[1]

On the afternoon of Tuesday, 05 July 2016 between 5:34PM and 5:55PM local time, portions of the Kwajalein Atoll received gusts of winds from the ENE (070deg) at 46kt (53mph) to 50kt (58mph) from an outflow boundary that was initiated from a thunderstorm complex on the order of 100km (62 miles) away. At the Kwajalein Airport, PKWA, (Buckholz Field), gale (34kt (39mph)) or near gale-force winds were maintained for almost one hour (with gusts in the 40s) and then into the mid to upper 20s (kt) with gusts to 30kt or more for the next 7 hours. By 1400Z (0200 L), sustained winds finally weakened to their pre-downburst values from the east (100deg) at 15kt (17 mph). Interestingly, there was only a very brief period of precipitation (2 1/2SM +DZ) at 0600Z with no accumulation during this entire episode. The Kwajalein Fire Department noted some rooftop damage. In addition the small commuter plane returned from Roi-Namur at the time of the strongest gusts, but landed safely (wind direction was a directly down the runway). A visiting C-130 delayed its departure during this period.

RMI Rainfall Summary: 2016 2nd Qtr & 1st Half						
Station		**Apr**	**May**	**Jun**	**2nd Q**	**1st Half**
RMI Central and Southern Atolls						
Majuro WSO	**Inches**	2.05	11.12	7.27	20.44	26.05
	% Avg	20%	99%	63%	62%	47%
Mili	**Inches**	2.70	8.71	22.40	33.81	43.12
	% Avg	26%	78%	193%	102%	77%
Ailing-laplap	**Inches**	2.54	5.97	7.29	15.80	24.37
	% Avg	28%	56%	69%	52%	51%
Jaluit	**Inches**	4.52	6.86	4.32	15.70	25.59
	% Avg	44%	61%	37%	48%	46%
RMI Northern Atolls						
Kwajalein	**Inches**	1.13	3.80	9.81	14.74	18.27
	% Avg	15%	38%	102%	54%	47%
Wotje	**Inches**	0.16	9.27	6.21	15.64	15.98
	% Avg	4%	202%	119%	114%	77%
Utirik	**Inches**	1.86	0.73	3.30	5.89	7.99
	% Avg	52%	17%	69%	46%	41%

[1] Excerpted from in-house event report authored by Guam WSO SOO, R. Edson.

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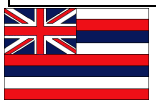
Climate Outlook: By July 2016, the CPC ended its El Niño advisory, declared the state of the climate to have entered ENSO -neutral, and continued its La Niña watch. Whether or not the climate state progresses all the way to La Niña, or simply retreats solidly into ENSO-neutral, the seasonal rainfall and typhoon outlooks are similar. Computer model forecasts still indicate below normal rainfall over the next three months (July, August and September), but PEAC scientists and WFO Guam and local forecasters manually intervened to temper the model dryness and bring the forecast of rainfall over the next three months closer to average. Rainfall in the RMI is now undergoing a recovery with near average rainfall anticipated over the next several months. Above-average rainfall could occur in the central and southern atolls in the spring associated with an active trade-wind trough.

Tropical cyclones occur within the RMI almost exclusively during the months of El Niño Onset and during El Niño Peak (e.g., 2015). Now that the climate state has moved out of El Niño, the threat of a damaging tropical cyclone within the RMI during the remainder of 2016 through the first half of 2017 is very low (less than 10%). Lastly, the sea level typically begins a rapid rise in the El Niño post-Peak months, and sea level should be at or above average by mid-summer, and above average by the end of the year (see the sea level section for details).

Inclusive Period	**% of long-term average / Forecast rainfall (inches)** [1]		
	South of 6ºN	**6ºN to 8ºN**	**North of 8ºN**
Jul – Sep 2016	**90%**	**90%**	**90%**
Oct—Dec 2016	**95%**	**95%**	**95%**
Jan—Mar 2017	**100%**	**100%**	**95%**
Apr –Jun 2017	**110%**	**100%**	**90%**



Hawaii

The following information was compiled from the NWS Honolulu Office Drought Information Statements for the first quarter or 2016 found at http://www.prh.noaa.gov/hnl/pages/hydrology.php.

The Hawaiian Islands appeared to be more like what one would expect during the early wet season with a middle and upper level low pressure system producing several days of afternoon heavy showers and two cold frontal passages. These two cold fronts brought enhanced rainfall to many of the north- and northeast-facing slopes across the island chain. Between the cold front passages the state was affected by a low pressure system which brought unstable conditions from May 24 through May 27. The unstable air mass enhanced the showers which became occasionally intense and caused minor flooding in localized spots in all 4 counties. The most notable rain event occurred from June 12 through June 17 as unstable conditions from an upper level low pressure system enhanced showers along the windward slopes of the Big Island. Rainfall totals ranged from 6 to over 14 inches during the 6-day period but produced just minor flooding problems.

July was the big month with an active period of TC development in the eastern Pacific Ocean. The initial effects occurred in the form of low level moisture from the remnant of Hurricane Blas,

LOCAL SUMMARY AND FORECAST

which produced enhanced trade wind showers across portions of the state on July 13 and 14. Several days later, the remnant circulation of former Hurricane Celia passed north of the Hawaiian Islands and disrupted the trade wind flow, allowing land and sea breezes to become fully established within humid conditions. The main event of the month was Tropical Storm Darby, which made a direct hit on the Big Island on July 23 then moved through the Kauai Channel on July 24. After decades without a direct impact, the Big Island has been hit twice in a three-year period. Heavy rainfall prior to landfall mostly affected the windward slopes with peak totals within the range of 5 to 8 inches. Flash flooding occurred in the South Kohala and Hamakua Districts which forced the closure of several local roads. Darby proceeded northwestward as it passed over the coastal and offshore waters south of Maui County in a weakened state. The center of Darby appeared to move through the Kauai Channel, thus avoiding a second landfall from the same system. Fortunately, and despite the numerous flooding impacts, there was no loss of life.

Hawaii Rainfall Summary: AMJ 2016 2nd Qtr & 1st Half						
Station		Apr	May	Jun	2nd Q	1st Half
Lihue Airport	Inches	0.84	1.81	1.08	3.73	7.52
	% Avg	43%	121%	84%	79%	28%
Honolulu Airport	Inches	0.22	3.17	0.19	3.58	4.23
	% Avg	42%	793%	106%	325%	46%
Kahului Airport	Inches	1.20	3.03	0.36	4.59	8.83
	% Avg	135%	618%	400%	312%	69%
Hilo Airport	Inches	9.57	5.83	11.19	26.59	35.31
	% Avg	107%	79%	177%	117%	33%

Climate outlook:

The El Niño event is now declared to have entered the ENSO-neutral conditions. Sea Surface Temperatures (SSTs) are near or below average in the East-Central and Eastern Pacific, and upper and lower-level winds are near average across most of the Tropical Pacific. La Niña is favored to develop during August to October season with a 55-60% chance of La Niña during the fall and winter months. According to the CPC long range seasonal forecast for Hawaii (found here http://www.cpc.ncep.noaa.gov/products/predictions/90day/fxhw40.html) During the September -November season, above normal temperatures are predicted due to the warm SSTs across the region. Above median precipitation is also favored across the state from September to November by Multi Model Ensemble predictions.

The CPC U.S. Seasonal Drought Outlook (found here http://www.cpc.ncep.noaa.gov/products/expert_assessment/sdo_summary.php) notes that during the past El Niño, drought coverage peaked at nearly 80 percent of the Hawaiian Islands in early April. Since that time, that coverage decreased and is currently less than 15 percent. The enhanced odds for above-median precipitation forecast during SON favors continued removal of drought.

Predicted rainfall for Hawaii State from September 2016 through May 2017 is:

	Station			
Inclusive Period	Hilo	Honolulu	Kahului	Lihue
Sep – Nov 2016	40% chance of Above Median rainfall	40% chance of Above Median rainfall	40% chance of Above Median rainfall	40% chance of Above Median rainfall
Dec – Feb 2017	50% chance of Above Median rainfall	40% chance of Above Median rainfall	40% chance of Above Median rainfall	50% chance of Above Median rainfall
Mar – May 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

SEASONAL SEA LEVEL OUTLOOK Cont.

Current sea level forecasts indicate that both the stations will stay marginally above normal during the next season.

Sea Level Observation from the Global Satellite Picture:

Observations from the recent global satellite picture (Fig. 24, below) revealed that the sea levels have been normal / (or slightly elevated) over the western part of the Pacific Basin and slightly high over eastern Pacific. ***The tropical Pacific atmosphere and ocean are currently at ENSO-neutral phase.*** *Any further sea level rise in the north Pacific islands is most unlikely as the on-going ENSO-neutral state is likely to continue for another 2-3months. According to CPC, if La Niña develops, it will be a weak one. This satellite data are supportive to tide-gauge observations, and revealed that some of the stations located in Micronesia and Marshalls Islands is slightly above normal.*

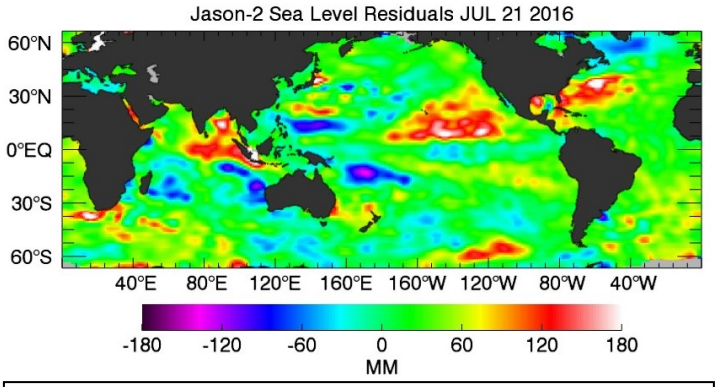


Figure 24. Jason-2 sea level residuals (July 21 2016). (Source: https://sealevel.jpl.nasa.gov/images/latestdata/jason/2016/20160721G.jpg)

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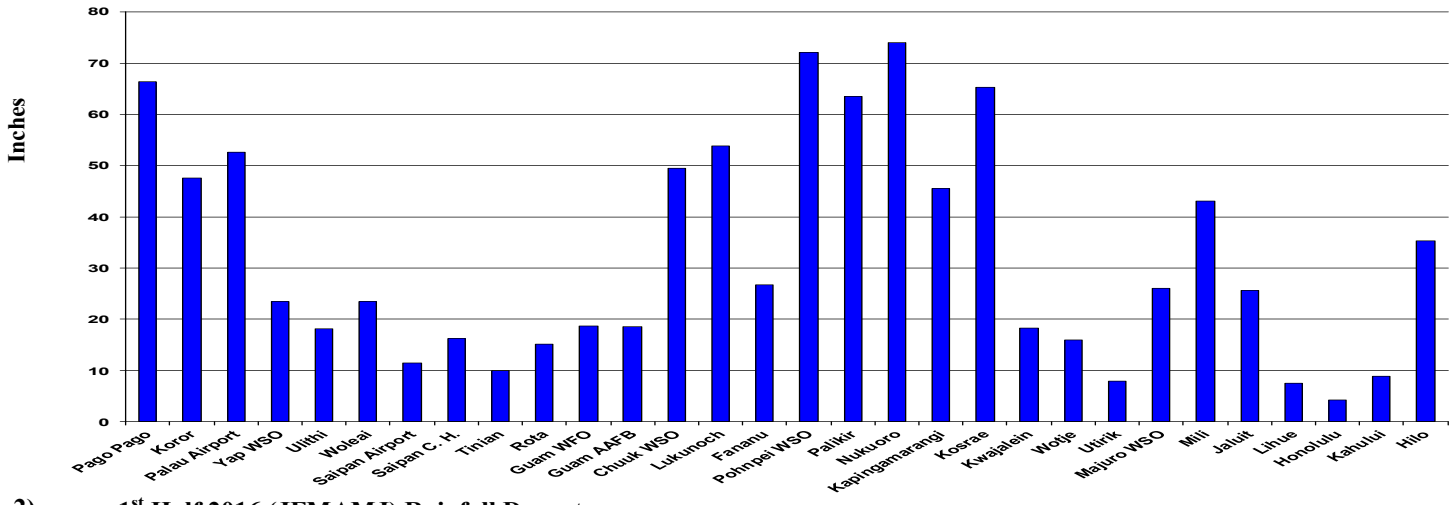
SEASONAL RAINFALL OUTLOOK FOR THE US-AFFILIATED PACFIC ISLANDS

1) 1st Half 2016 (JFMAMJ) Rainfall Amounts



2) 1st Half 2016 (JFMAMJ) Rainfall Departures

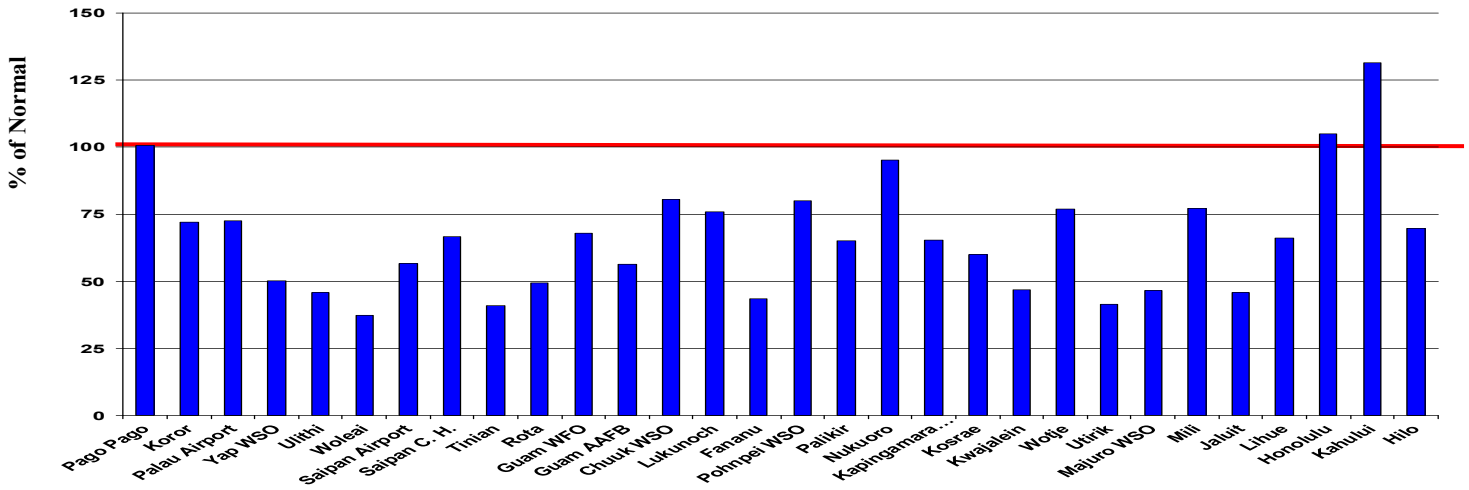


Figure 23 and 24, 2016 First Quarter Percent of Average rainfall amounts in inches at the indicated locations and rainfall departure from average (in percent) at the indicated locations.

ACKNOWLEDGEMENTS AND FURTHER INFORMATION

Pacific ENSO Applications Climate (PEAC) Center:
HIG #340, 2525 Correa Road, Honolulu, Hawai'i 96822
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Dr. Rashed Chowdhury, ***Editor—Pacific ENSO Update***
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:
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Dr. Mark Merrifield, PEAC Principal Investigator at 808-956-6161: for more information on sea level and climate in Hawai'i.

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Weather Forecast Office (WFO) Honolulu:
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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 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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