PACIFIC ENSO UPDATE

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

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

http://www.weather.gov/peac

CURRENT CONDITIONS

Whereas the first half of 2018 was very wet at most locations across Micronesia, the first half (i.e., JFMAM, June not-yet tabulated) of 2019 was very dry at most locations across Micronesia (see Figures CC-1 and CC-2). A very wet first-half of a calendar year is typical during the onset of El Niño, and a very dry first-half of a calendar year is typical of the year following El Niño (also known as the post-Peak phase of El Niño, or the El Niño Year +1). In addition to heavy rainfall, the year 2018 was also noted for a very busy typhoon season for Micronesia (especially for Guam and the CNMI) and a very busy Hurricane season for Hawaii. So far during 2019, TC activity has been relatively subdued, with only one named tropical cyclone in the western North Pacific basin (Super Typhoon Wutip), which occurred in February. Based on the evolution of Wutip, we interpreted it to be an extension of the end of the 2018 tropical cyclone season rather than the beginning of the 2019 season.

Although the CPC did not declare the state of the climate to have entered El Niño until its February 9 El Niño Diagnostic Discussion, the atmosphere behaved in many ways as if El Niño had undergone its onset in 2018 (widespread heavy rainfall, lowering of the sea level, and abundant tropical cyclones). The atmosphere is now behaving as if it were the post-Peak phase of El Niño (widespread dryness, rising sea level and reduced tropical cyclone activity).

In summary, the main weather story of the first 5 months of 2019 is the persistent dryness at many of the islands of Micronesia, particularly at islands in the western half of the region (e.g., Palau, Yap, Guam and the CNMI), and at islands located in the northern portions of the region (e.g., Yap, Guam and the CNMI, the northern atolls of Chuuk State, and the northern atolls of the RMI). Drought has been particularly severe in the CNMI and in the northern RMI. At some islands, however, rainfall has been abundant — this includes: some of the atolls of central and southern Chuuk State; Pohnpei Island and most of the atolls of Pohnpei State; Kosrae; and some of the central and southern atolls of the RMI. Conditions at American Samoa were also wet through the first 5 months of 2019, even though it was a quiet period for tropical cyclones there.

The CPC has determined that the state of the climate is still El Niño (having crossed that threshold in February 2019), and that it will likely continue to be El Niño at least through the summer and possibly for the remainder of 2019. The emergence of El Niño-like weather patterns in 2018, and the establishment in the first 5 months of 2019 of weather patterns that are typical of the post-Peak Phase of El Niño, have complicated the long-range forecasts of the weather elements for the US-API. As for the recent dry conditions, the PEAC successfully anticipated them by assuming that the atmosphere would behave as if the climate system were in the post-Peak Phase of an El Niño that had its onset and maturity in 2018. Going forward into the remainder of 2019, the PEAC will consider the climate to be impacted by El Niño oceanic conditions or the warm side of ENSO-neutral conditions with warm ocean waters concentrated near the International Date Line. And, with such conditions being more dangerous (especially with respect to an enhanced risk of typhoons in Micronesia we will use the CPC outlook for a continuation of El Niño or warmish ENSO-neutral conditions as the basis for our long-range forecasts of rainfall and typhoons.

Please see the Local Variability Summaries for more details.

Drought

During some (or in some cases, all) of the first 5 months of 2019, many of the islands and atolls of Micronesia experienced (and still are experiencing) varying levels of unusual dryness. Despite the fact that Micronesia is now well into its 2019 dry season, particularly low levels of rainfall, leading to problems with adequate private and municipal water supplies, desiccation of forest vegetation and food crops, and exacerbation of wildfires, have occurred in the following regions/islands:

(1) The Republic of Palau;
(2) Yap Island and its outer atolls;
(3) The island of Guam;
(4) All of the major islands of the CNMI (Rota, Tinian and Saipan);
(5) Some of the islands in the northern part of Chuuk State; and,
(6) Many of the northern atolls of the RMI.

To date, WFO Guam has issued 10 Drought Information Statements (DIS), each covering 2-week periods, to address the ongoing shortfall of rain and its impacts. Excerpts from the latest DIS issued on June 13, 2019 are appended below:

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          DROUGHT INFORMATION STATEMENT
        NATIONAL WEATHER SERVICE TIYAN GU
          1010 AM CHST THU JUN 13 2019
...EXTREME TO EXCEPTIONAL DROUGHT PERSISTS OVER NORTH-
ERN MICRONESIA...

SYNOPSIS...
THE  POST  EL  NINO  DRY  WEATHER  PATTERN  PER-
SISTS...ESPECIALLY FOR AREAS NORTH OF 10N...BUT WIND
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CURRENT CONDITIONS

Drought

FLOW PATTERNS SHOULD SLOWLY CHANGE AND HELP SPREAD RAINFALL OVER THE REGION. THE NORTHERN MARSHALL ISLANDS NORTH OF KWAJALEIN AND NORTHERN YAP STATE ALONG WITH NORTHERN MARIANA ISLANDS AND GUAM REMAIN MUCH DRIER THAN NORMAL. THE WEATHER OVER THESE AREAS WILL BE RELATIVELY DRY FOR THE NEXT FEW WEEKS ALTHOUGH SOME WIDESPREAD SHOWERS HAVE ALREADY OCCURRED IN JUNE.

DROUGHT REMAINS EXCEPTIONAL FOR ATOLLS AND ISLANDS OF THE FAR NORTHERN MARSHALL ISLANDS ALONG AND NORTH OF 10N. RESIDENTS OF THESE ATOLLS SHOULD CONTINUE STRICT WATER CONSERVATION MEASURES. AREAS AROUND MAJURO AND KWAJALEIN/EBEYE HAVE RECEIVED A FEW SHOWERS. AREAS FROM ENEWETAK TO UTIRIK AND WOTJE REMAIN VERY DRY BUT PATCHY SHOWERS COULD START PASSING OVER THESE AREAS. THE SOUTHERN ISLANDS OF THE RMI HAVE RECEIVED HELPFUL SHOWERS BUT DRIER WEATHER MAY DEVELOP AND ALL PEOPLE OF THE RMI SHOULD SERIOUSLY CONSIDER WATER CONSERVATION MEASURES. SEE SUGGESTIONS BELOW AND CONTACT LOCAL WATER MANAGERS FOR WATER CONSERVATION GUIDELINES.

COMPUTER MODELS SUPPORT THE PREDICTION THAT DRIER THAN NORMAL WEATHER WILL CONTINUE OVER NORTHERN PARTS OF MICRONESIA INCLUDING THE MARSHALL ISLANDS AND THE MARIANA ISLANDS. MODELS ARE INDICATING SOME RELIEF AS WIND FLOW PATTERNS HAVE CHANGED AND PATCHY SHOWERS WILL DEVELOP NEAR AND OVER THESE MORE NORTHERN LOCATIONS...BUT RELIEF FROM DROUGHT WILL BE A LONG-TERM PROCESS. THE MAIN ISLANDS OF MICRONESIA APPEAR TO HAVE SUFFICIENT WATER RESOURCES AT THIS TIME.

THE OPERATIONAL U.S. DROUGHT MONITOR SHOWS UTIRIK AND WOTJE OF THE RMI REMAIN IN EXCEPTIONAL DROUGHT D4-SL (SHORT AND LONG-TERM DROUGHT LEVEL 4 OF 4). SAIPAN AND TINIAN OF THE CNMI REMAIN IN EXTREME DROUGHT D3-L (LONG-TERM DROUGHT LEVEL 3 OF 4) AND ROTA EXTREME DROUGHT D3-S (SHORT- TERM DROUGHT LEVEL 3 OF 4). GUAM HAS IMPROVED TO SEVERE DROUGHT D2-S (SHORT-TERM DROUGHT LEVEL 2 OF 4). CHUUK LAGOON AND FANANU ALONG WITH YAP ARE IN SEVERE DROUGHT LEVEL D2-S (SHORT-TERM DROUGHT LEVEL 2 OF 4). PALAU...KWAJALEIN/EBEYE AND WOLEAI ARE IN MODERATE DROUGHT D1-S (SHORT- TERM DROUGHT LEVEL 1 OF 4). OTHER ISLANDS REMAIN ABNORMALLY DRY D0-S (SHORT-TERM ABNORMALLY DRY).

Sea Level

The sea level across most of Micronesia was above average during the 1st Quarter of 2018, but underwent a substantial lowering during the course of 2018, with Palau and Guam exhibiting the most pronounced fall. In early 2019, the sea level began to rise, and now (June 2019) is slightly above average. Note the strong coherence of sea level across the stations of Micronesia, and also the close relationship of the sea level with the trade winds (see Figure CC-5). An abrupt lowering of sea level typically accompanies El Niño, with a rapid rise of sea level typically occurring in the year following El Niño (see the sea level section for more details).

Sea Level

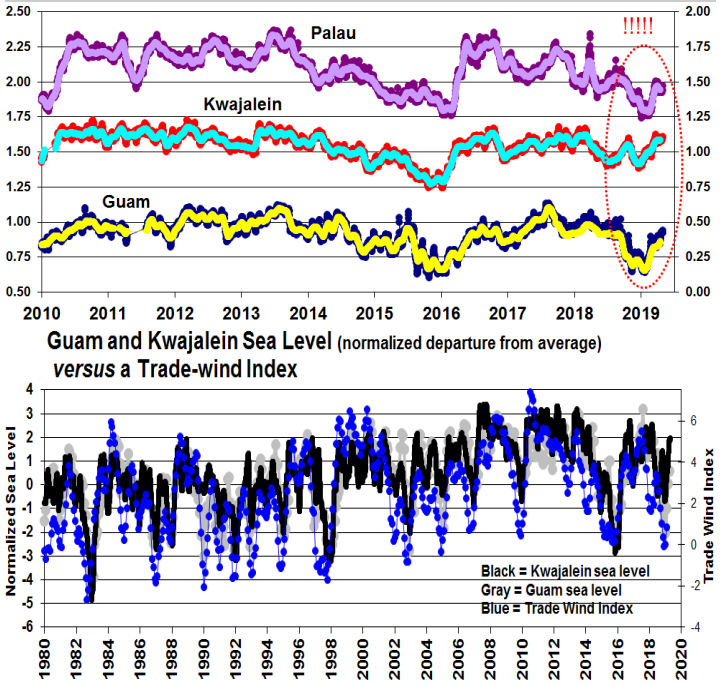


Figure CC-2. (Top) Sea level recorded at Palau, Guam and Kwajalein (as indicated). Daily data is overlain with a 30-day moving average. Over the past decade, only the stand of the sea at the end of the 2009 El Niño and at the end of the 2015 El Niño is lower than the late 2018 stand of the sea. (Bottom) The sea level at Guam and Kwajalein plotted with NOAA's Trade Wind Index (5N-5S ; 135E-180) (blue). A weakening of the trade winds in 2018 corresponds with a net fall of sea level of about 12 inches from early 2018 to late 2018. An uptick of the trade winds in the first few months of 2019 has accompanied a renewed sea level rise. (see the sea level discussion for more details).

ENSO Evolution

The evolution of ENSO during 2018 was hard to interpret. In many ways, the weather and climate across the US-API during 2018 evolved in a way typical of El Niño. The calendar year 2018 began with La Niña-like weather patterns, which had persisted through the 4th Quarter of 2017 into the 1st Quarter of 2018. During early 2018, the climate system remained within the SST bounds of La Niña (see Fig. CC-4). During March and April, the Oceanic Niño Index (ONI) warmed and crossed into the cold side of the zone of ENSO-neutral. By June 2018, the ONI became weakly positive, and the CPC's ENSO diagnostic discussion elevated its alert status to an El Niño Watch. By the fall of 2018, the SST warmed to the El Niño threshold, but the CPC's ENSO diagnostic discussion continued an El Niño Watch, waiting for the warmth to be sustained.

Some weather features typical of El Niño or impending El Niño occurred during 2018; these include:
(1) a very wet eastern Micronesia in the first half of the year;
(2) dryness in Palau for several months;
(3) several early season tropical disturbances in eastern Micronesia;
(4) the continual formation of typhoon pre-cursor disturbances in central and eastern Micronesia;

CURRENT STATE OF ENSO

(5) the endless battering of the Mariana island chain by typhoons;
(6) some unusual westerly winds in eastern Micronesia; and,
(7) a lowering of the sea level at many islands of Micronesia (and particularly a very sharp drop of sea level in the spring, and then in the final two months of the year).

Note: The raw monthly values of the CPC's Oceanic Niño Index did not reach El Niño thresholds until October 2018. Rather, the highest positive SST anomalies for much of the 2018 were found north of the equator between 5° and 10°N. The state of the climate was not officially declared to be El Niño until February 2019 since the official declaration of El Niño requires 5 months of raw monthly values of the ONI to be at-or-above the El Niño threshold.

Whether El Niño has recently begun, recently matured, or is undergoing an unusually prolonged period of El Niño-like conditions (e.g., 1986-87 and 2014-15), the forecast for rainfall throughout the US-API leans toward a gradual easing of the dry conditions at most locations. Thereafter, adequate rainfall is anticipated at least from late July through October 2019. Computer model forecasts now indicate Micronesia-wide below average rainfall through July, but with some easing of the recent very dry conditions. The uncertainty in the interpretation of the recent and near-term evolution of ENSO precludes a confident forecast of rainfall or typhoon distribution in Micronesia. Going forward into the remainder of 2019, the PEAC will consider the climate to still be impacted by El Niño oceanic conditions. And, with such a condition more dangerous than other possible scenarios (especially with respect to an enhanced risk of typhoons in Micronesia and hurricanes in Hawaii) we will use the CPC outlook for a continuation of El Niño as the basis for our long-range rainfall and tropical cyclone forecasts. See the Tropical Cyclone Section for more details.

El Niño Diagnostic Discussion[1]
CLIMATE PREDICTION CENTER/NCEP/NWS
and the International Research Institute for Climate and Society
9 May 2019

***ENSO Alert System Status**: El Niño Advisory*

Synopsis: A transition from El Niño to ENSO-neutral is expected in the next month or two, with ENSO-neutral most likely to continue through Northern Hemisphere fall and winter.

During June, El Niño was reflected in the continued presence of above average sea surface temperatures (SSTs) across the central equatorial Pacific Ocean. However, SST anomalies across most of the eastern Pacific decreased during the month. The latest weekly ENSO indices were +0.9°C in Niño-4 and +0.6°C in Niño-3.4, with smaller departures in the Niño-3 and Niño-1+2 regions. Upper-ocean subsurface temperatures (averaged across 180°-100°W) were above average at the beginning of June, but returned to near average by end of the month as anomalously cool waters expanded at depth. Weakly suppressed tropical convection continued over Indonesia, while weakly enhanced convection persisted near the Date Line. Low-level wind anomalies were near average over the tropical Pacific Ocean, and upper-level wind anomalies were westerly over the far eastern Pacific. The traditional and equatorial Southern Oscillation Indices were slightly negative. Overall, oceanic and atmospheric conditions were consistent with a weakening El Niño.

The latest plume of North American Multi-model Ensemble forecasts of the Niño-3.4 index shows a rapid transition toward ENSO-neutral by the late Northern Hemisphere summer, remaining neutral through fall and winter. Due to this model guidance and recent observations, the forecast consensus also favors a transition to ENSO-neutral during the next few months. In summary, a transition from El Niño to ENSO-neutral is expected in the next month or two, with ENSO-neutral most likely to continue through Northern Hemisphere fall and 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)."

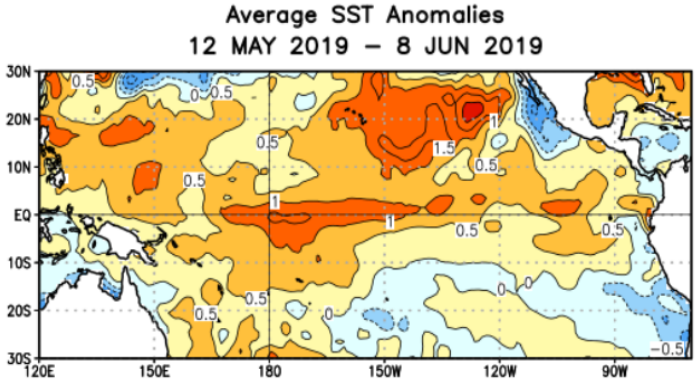


Figure CC-3. A plot of the tropical Pacific Oceanic SST anomalies for the 30-day period 12 May - 08 June 2019. The warm water in the equatorial central Pacific yields an ONI that is El Niño.

CURRENT STATE OF ENSO

ENSO Alert System Status: El Niño Advisory
(1) El Niño is present.
(2) Equatorial sea surface temperatures (SSTs) are above average across most of the Pacific Ocean.
(3) The pattern of anomalous convection and winds are consistent with El Niño. El Niño is likely to continue through the Northern Hemisphere summer 2019 (70% chance) and fall (55-60% chance).

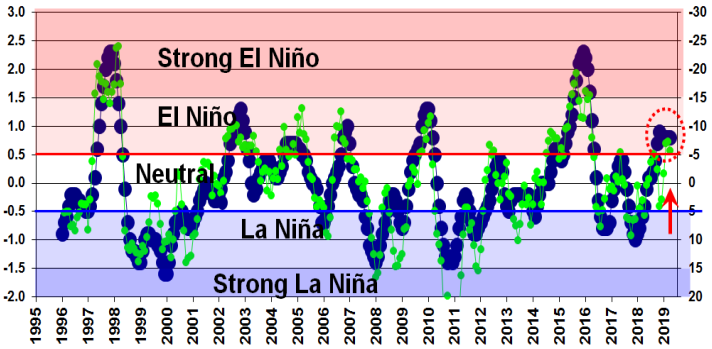


Figure CC-4. A plot of the CPC's Oceanic Niño Index (ONI) for the past two decades (blue dots). During the first half of 2018, the ONI began a move through ENSO-neutral and toward El Niño. Continued warming late in 2018 moved the ONI across the El Niño threshold, with the CPC declaring the onset of El Niño in February 2019. The green dots are the corresponding values of the Australia BoM SOI. Breaking News: the state of the Pacific climate system continues in El Niño as per the May 2019 CPC ENSO statement (see CPC ENSO discussion above).

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

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, and Wellington, and RSMC-Nadi (Fiji). 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.

Western North Pacific

It is still early in the 2019 typhoon season, and so far, the JTWC has numbered only 3 tropical cyclones (near average). Two of these —Tropical Storm Pabuk (January) and Super Typhoon Wutip (February) — were named by the JMA. If one considers Pabuk and Wutip to be residual storms from the busy 2018 season, then 2019 is indeed off to a slow start, with only one weak tropical depression (TD 03W) that occurred in May. The eastern North Pacific (EPac) has yet to see its first named storm.

Southern Hemisphere

The 2018-2019 Southern Hemisphere Cyclone season will end on June 30. While the number of named storms was overall near average (See Table CC-1), there was a high number intense cyclones, especially in the South Indian Ocean. Contrary to earlier expectations, the activity in the South Pacific was below average, especially east of the International Date Line. American Samoa was spared a strike by a major TC.

Basin	Named Storms	Named Storm Days	Hurricanes/ Typhoons	Hurricane Days	Major Hurricanes	Major Hurricane Days	ACE
S. IO < 135E	18 (16.8)	99.5 (81.9)	13 (8.9)	45.5 (30.0)	11 (4.6)	19.75 (9.2)	204.4 (138.3)
S. Pac >135 E	9 (10.1)	45.25 (42.6)	4 (5.2)	10.75 (15.3)	1 (2.5)	0.75 (4.4)	53.6 (72.1)
S. Hem	27 (26.9)	144.75 (124.5)	17 (14.1)	56.25 (45.3)	12 (7.1)	20.5 (13.6)	258.0 (210.4)

Table CC-1. 2018/2019 tropical cyclone activity of the Southern Hemisphere for 01 July 2018 through 13 June 2019 (see basin archives, http://tropical.atmos.colostate.edu/Realtime/). Numbers in parentheses are long-term averages.

TROPICAL CYCLONE ACTIVITY

PEAC tropical cyclone assessment

Western North Pacific and American Samoa

Two organizations routinely provide forecasts of western North Pacific 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, (2) Tropical Storm Risk (TSR), Dr Adam Lea and Professor Mark Saunders, Department of Space and Climate Physics, UCL (University College London). On 07 May 2019, the TSR issued its outlook for the western North Pacific typhoon season. Citing a change of TC climate in the western North Pacific, the Hong Kong team has not issued an outlook since 2014.

PEAC (Micronesia)

The WFO Guam (Chip Guard) in coordination with the UOG PEAC partner (Mark A. Lander) recently issued pre-typhoon season tropical cyclone activity outlooks for Guam and for the CNMI. Based on the assumption of continued El Niño-related warm SSTs in low latitudes near and east of the International Date Line, they foresee an active season for Micronesia, especially during late September through December. The activity is anticipated to be on-par with that of 2018 in terms of total numbers of tropical systems passing near the islands of Guam and the islands of the CNMI. We do not anticipate another catastrophic strike by a CAT 5 super typhoon, since that is such a rare event. However, we are urging the islands to be prepared for what is likely to be a better-than-even chance (50% chance) for at least minimal typhoon-force winds (65-kt sustained with gusts to 80 kt) to be experienced on any island, with a near certainty (90% chance) that some island will experience at least CAT 1 typhoon conditions. From Chuuk and eastward, the odds are less than those for Guam and the CNMI, but are still elevated above their respective long-term averages.

The Guard-Lander Guam and CNMI regional TC forecasts are consistent with the 07 May 2019 TSR basin-wide typhoon outlook predicting that the 2019 Northwest Pacific typhoon season will see activity of about 15 per cent above the 1965-2018 averages:

NW Pacific ACE Index and System Numbers in 2019

		ACE Index	Intense Typhoons	Typhoons	Tropical Storms
TSR Forecast (±FE)	2019	354 (±86)	10 (±3)	17 (±3)	27 (±4)
54yr Climate Norm (±SD)	1965-2018	295 (±101)	9 (±3)	16 (±4)	26 (±4)
Forecast Skill at this Lead	1965-2018	26%	25%	14%	6%

Key: ACE Index = Accumulated Cyclone Energy Index = Sum of the Squares of 6-hourly Maximum Sustained Wind Speeds (in units of knots) for all Systems while they are at least Tropical Storm Strength. ACE Unit = $x10^4$ $knots^2$.

Intense Typhoon = 1 Minute Sustained Wind > 95Kts = Hurricane Category 3 to 5.
Typhoon = 1 Minute Sustained Wind > 63Kts = Hurricane Category 1 to 5.
Tropical Storm = 1 Minute Sustained Winds > 33Kts.
SD = Standard Deviation.
FE (Forecast Error) = Standard Deviation of Errors in Cross-Validated Hindcasts 1965-2018.
Forecast Skill = Percentage Improvement in Mean Square Error Afforded by Cross-Validated Hindcasts 1965-2018 over Hindcasts Made with the 1965-2018 Climate Norm.
Northwest Pacific = Northern Hemisphere Region West of 180°W Including the South China Sea. Any Tropical Cyclone (Irrespective of Where it Forms) Which Reaches Tropical Storm Strength Within this Region Counts as an Event.

The PEAC concurs with the Guard-Lander and TSR outlooks that the 2019 typhoon season will feature an above average risk for a typhoon across Micronesia, especially for Guam and the CNMI, and that this elevated risk will be primarily concentrated in the latter months of the year (i.e., late September through December 2019).

American Samoa

The 2018/2019 TC season in American Samoa was below average, and certainly quieter than earlier forecast. The cyclone season there is now over, and it is too early at this time to offer a dependable outlook for the upcoming 2019/2020 TC season.

SEASONAL SEA LEVEL OUTLOOK FOR THE US-AFFILIATED PACFIC ISLANDS

Executive Summary: The recent variability of sea level may be explained by Warm Pool (WP) El Niño type, as the positive sea level anomaly (SLA) is located over/or near the central Pacific and maximum near 160^{0}E-180. Therefore, Pohnpei, Kwajalein, and Majuro are elevated. The negative SLA is located near 130^{0}E-150^{0}E along Koror, Yap, and Chuuk. As for impacts, there is no noticeable inundation in low-lying atolls and there is no report of major damage, so far. And for the next seasons (JJA to SON), we are anticipating near to slightly above-normal sea level in the north Pacific islands (Koror, Yap, and Chuuk) and near to above-normal sea level in Chuuk and Pohnpei. The RMI stations are likely to stay slightly above-normal too. In Hawaii, both Honolulu and Hilo are likely to be near to above-normal too.

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 June-July-August (JJA) of 2019 to September-October-November (SON) of 2019 (Table SL-1), (ii) the observed monthly mean and maximum sea-level anomalies for the previous season October to January (MAM) of 2018-19 (Table SL-2) (also see Fig. SL-2 at p.22), and (iii) a general perspective of sea level variability during the Cold Tongue (CT), Warm Pool (WP), and Mixed (M) El Niño events (Table SL-3/Fig. SL-1). *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 JJA, JAS, ASO, and SON 2019

Forecasts of the sea-level anomalies in the USAPI are presented using CCA statistical model (see Chowdhury M. R., Chu P-S, and Guard C. (2014): *An Improved Sea Level Forecasting Scheme for Hazards Management in the U.S.-Affiliated Pacific Islands.* ***Int. Journal of Climatology*** *6, 2320-2329*.). Based on the independent SST and zonal wind (U) (SST-U) values in MAM of 2019, the resulting CCA model has been used to forecast the sea level of four consecutive seasons (see Table SL-1: left panel shows values for seasonal mean while the right panel shows the seasonal maxima). All the tide gauge stations (at 0 to 3-months lead time) provided skillful forecasts for these three consecutive seasons.

Table SL-1: Forecasts of sea level anomalies in inches (JJA, JAS, ASO, and SON)

	Seasonal Mean Deviations [1]					Seasonal Max Deviations [2]			
Tide Gauge Station	**JJA**	**JAS**	**ASO**	**SON**	**Seasonal Outlook[3]**	**JJA**	**JAS**	**ASO**	**SON**
Lead Time [5]	**0-M**	**1M**	**2M**	**3M**	**Seasonal Outlook[3]**	**0-M**	**1M**	**2M**	**3M**
Marianas, Guam	+3	+3	+3	+3	Above	+18	+17	+17	+16
Malakal, Palau	-3	-3	0	0	Normal	+34	+34	+32	+32
Yap, FSM	+3	+3	+3	+3	Above	+26	+25	+25	+25
Chuuk, FSM**	+3	+3	+3	+3	Above	+26	+26	+25	+25
Pohnpei, FSM	+4	+4	+4	+3	Above	+30	+28	+28	+28
Majuro, RMI	+2	+4	+4	+3	Above	+40	+40	+38	+38
Kwajalein, RMI	+2	+4	+4	+3	Above	+38	+38	+37	+37
Pago Pago, Am. Samoa***	+8 (+14)	+7 (+13)	+7 (+12)	+7 (+12)	Above	+34 (+39)	+34 (+39)	+32 (+37)	+32 (+37)
Honolulu, Hawaii	+2	+3	+3	+2	Normal	+22	+22	+21	+21
Hilo, Hawaii	+3	+4	+4	+4	Above	+28	+26	+24	+24

Table SL-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.

Table SL-2: Monthly observed mean/maximum sea-level anomalies in inches for February to May of 2019

Tide Gauge Station	Monthly Mean Deviations[1]					Monthly Max Deviations[2]				
	Oct	**Nov**	**Dec**	**Jan**	**Standard Deviations**	**Oct**	**Nov**	**Dec**	**Jan**	**Sea level Trend**
Marianas, Guam	-1	+1	+2	+5	3.5	+20	+19	+26	+15	Above
Malakal, Palau	-6	-2	-3	-3	4.3	+31	+33	+33	+31	Below
Yap, FSM	-6	-7	-5	0	4.7	+27	+28	+26	+24	Below
Chuuk, FSM*	0	0	+1	+4	3.5					Above
Pohnpei, FSM	+4	0	+4	**	3.8	+35	+30	+27	+31	Above
Majuro, RMI	+3	+3	**	**	2.8	+43	+47	+46	+43	Above
Kwajalein, RMI	+2	+2	+4	+4	3.2	+29	+37	+38	+38	Above
Pago Pago, American Samoa***	+7 [+12]	+7 [+12]	+9 [+14]	+9 [+14]	3.2	+37	+38	+36	+33	Above
Honolulu, Hawaii	+2	0	+2	+3	1.8	+25	+24	+23	+19	Normal
Hilo, Hawaii	+2	+1	+4	+4	1.8	+30	+25	+28	+25	Above

SEASONAL SEA LEVEL OUTLOOK FOR THE US-AFFILIATED PACFIC ISLANDS

Table SL-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. *** 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, Black: Stable SL, and Blue: Rising trend. * In Pago Pago, there was a level shift (approximately 2-4 inches) at the time of September 2009 earthquake. *Data Source: University of Hawaii Sea Level Center (UHSLC). ftp://ilikai.soest.hawaii.edu/islp/slpp.anomalies.*

Sea level variability during the Cold Tongue (CT), Mixed (M), and Warm Pool (WP) El Niño events

The anomalous low-level wind generates a non-typical anomalous oceanic state in the tropical Pacific Ocean and, as a result, variations in sea level occur. Therefore, the need for more detailed physical interpretations of these different types of El Niño impacts increased significantly in order to support the island-specific short-to-mid-term planning and management in climate-sensitive sectors. Table SL-3 shows years and Figure SL-1 shows sea level anomalies during the CTE (top), ME (middle), and WPE (bottom) events.

Table SL-3: Years of CTE, ME, and WPE events

Cold Tongue El Niño (CTE) (Niño-3 region) 5°S–5°N, 90-150° W)	Mixed El Niño (ME) (Niño-3.4 region) (5°S–5°N, 170-120° W)	Warm Pool El Niño (WPE) (Niño-4 region) 5°S–5°N, 160°E–150°W)
1972-73	1986-87	1977-78
1976-77	1987-88	1990-91
1982-83	1991-92	1994-95
1997-98		2002-03
2015-16		2004-05
		2009-10
		2018-19

For the **CT El Niño** composite, with the deepening (shoaling) thermocline over the eastern (western) Pacific, the negative anomaly starts from early September (El Niño 0) along with the onset of El Niño (e.g., positive SST anomalies) and all (or most) north Pacific stations stay significantly below normal until the following March (El Niño +1) **(Fig. SL-1, top).** After March, there seems to be slight rise. After April some north Pacific stations like Palau, Pohnpei, Majuro, and Kwajalein start to show near normal or positive anomaly while Guam still stays marginally below normal. This is due to warm SST anomalies that are dominant in the eastern Pacific like any other conventional El Niño. Added to that, the steep zonal slope of sea level that leads to a strong discharge of equatorial heat content to off-equatorial regions by poleward geostrophic currents, leading to the transition from El Niño to La Niña.

The **ME (Fig. SL-1, middle)** events display a pattern similar to CTE (e.g., lower than normal sea level), but with some noticeable exceptions. For example, while the sea level during CTE events stay significantly below normal with a positive gradient (on average 200–50 mm below) from October to March (Fig. SL -1, top), the ME events display a negative gradient (on average 20-150 mm below) from October to April. In the case of ME, lower than normal (50–150 mm below) sea level during December to April is clearly noticeable in Fig. SL-1 (middle).

In case of the **WPE events**, both the RMI stations (e.g., Majuro and Kwajalein) in the north Pacific display positive anomalies from September El Niño 0) to following May (El Niño +1) **(Fig. SL-1, bottom).** One of the FSM station (e.g., Pohnpei) stays near normal from October to February then shows some marginally positive anomalies from March to June. The other three stations (Guam, Palau and Yap) show significant negative anomalies (25 to 100 mm below) until the following April. The positive sea level anomaly is located over the central Pacific (maximum near 150°W) but does not efficiently produce a warm SST anomaly. Furthermore, anomalous easterlies over the tropical eastern Pacific induce shoaling of the thermocline thereby cooling, rather than warming, over the tropical eastern Pacific. In addition, there are anomalous easterlies over the eastern Pacific; as a result, the sea level anomaly is small over the eastern Pacific, indicating that the thermocline there does not support SST warming (also see Kug, J.-S., F.-F. Jin, and S-I. An, 2009: *Two types of El Niño events: Cold tongue El Niño and warm pool El Niño.* ***J. Climate***, 22, 1499–1515) .

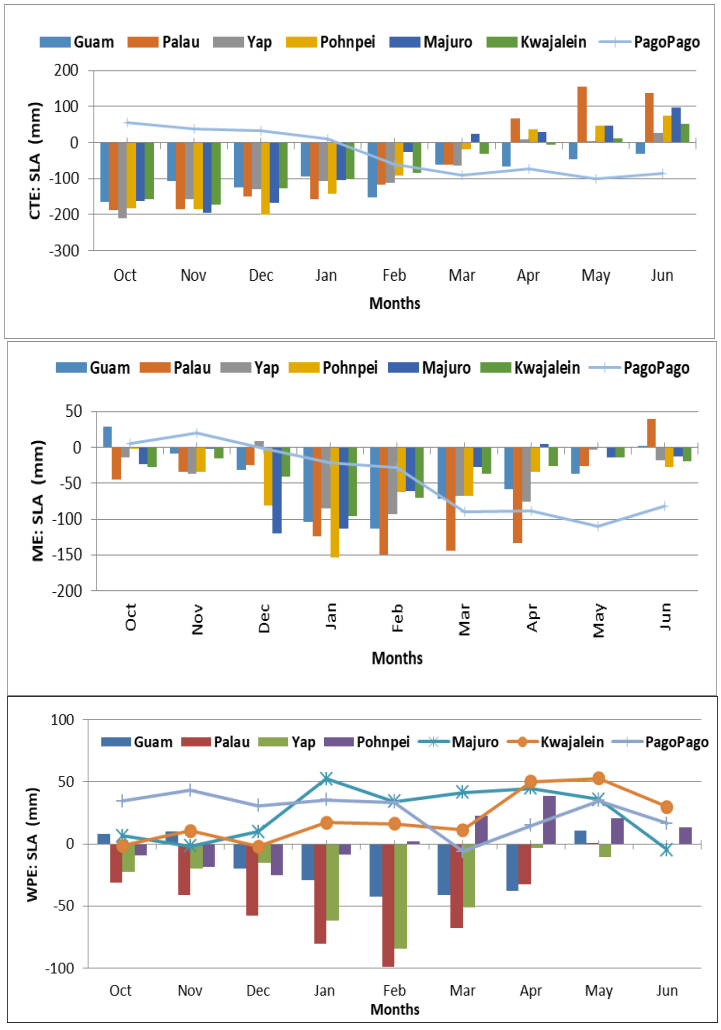


Figure SL-1: Monthly observed mean sea level anomalies in the USAPIs during **CTE (top), ME (middle**), and **WPE (bottom)** events during 1975–2019 (Y-axis: sea level anomaly in mm, X-axis: months). (Data Source: PEAC's monthly conference call note available at https://www.weather.gov/peac/PEAC_Monthly_Call, accessed on March 21, 2019.)

LOCAL SUMMARY AND FORECAST

American Samoa:

Over the past 12 months (June 2018 through May 2019) it has been very wet across American Samoa Figure AS-1). The total rainfall during this 12-month period at WSO Pago Pago was 150.29 inches (122%). This was the 10th highest such total in that station's 53-year climate record. It has been wet for several years at WSO Pago Pago. A plot of a 5-year moving sum of the rainfall at WSO Pago Pago (Figure AS-2), shows that the rainfall over the most recent 5 years (looking backward from May 2019) has been high, and has been equaled or exceeded only 4 other times in that station's 53-year history. During the first 5 months of 2019, there were several heavy rain events that required the WSO Pago Pago to issue flash flood warnings (see the WSO Pago Pago Facebook page for a listing). These events resulted in only nuisance effects (ponding on roadways), with no reported injuries. A relatively minor sea inundation from high surf occurred in early June.

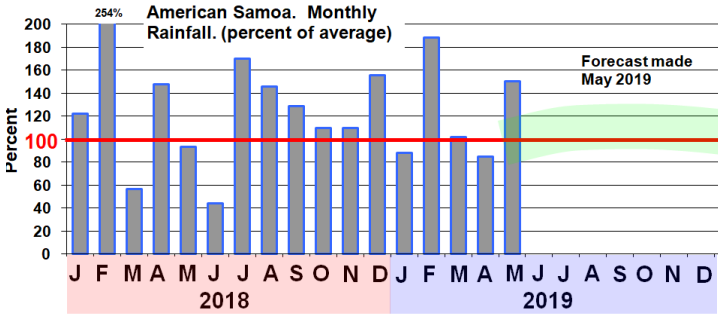


Figure AS-1. A time series of the monthly rainfall at Pago Pago during 2018 and 2019 to-date. Nine of the past 12 months have had above average rainfall. Note also the high month-to-month variability. The most recent rainfall forecast adopted during the May 2019 PEAC conference call is shown in light green. A continuation of above-average rainfall is anticipated.

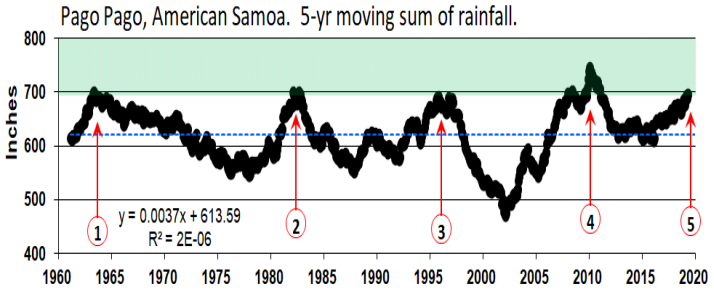


Figure AS-2. A 5-year moving sum (looking backward) of the monthly rainfall at WSO Pago Pago. Note that the current such sum looking backward from May 2019, is very high, and has been equaled or exceeded only 4 other times in the climate record (indicated by the red arrows and numbered circles). The numbers in the circles show only the sequence, not the ranking. The linear trend (dashed blue line) has been included along with the regression equation, which shows a very small positive value that is not statistically significant. Even at such long time periods, there is substantial variation, with the difference between the lowest and highest 5-year sums exceeding 200 inches!

LOCAL SUMMARY AND FORECAST

American Samoa Rainfall Summary: First 5 months of 2019

American Samoa							
Station		JAN	FEB	MAR	APR	MAY	5-Mo
Pago Pago	Rain (Inches)	11.10	24.04	11.47	10.17	14.91	71.69
	% of Average	88%	188%	102%	84%	150%	122%
Siufaga Ridge	Rain (Inches)	6.85	12.92	9.37	10.76	15.18	55.08
	% of Average	43%	86%	72%	83%	138%	81%
Toa Ridge	Rain (Inches)	8.89	16.10	4.92	7.23	13.05	50.19
	% of Average	56%	107%	38%	56%	119%	74%

(JFMAM), and 5-month total.

Pago Pago Sea Level

The sea level at Pago Pago remains elevated well-above its long-term average, even after accounting for the approximately 10-cm shift of the datum during the 2009 earthquake/tsunami event (Figure AS-4). See the sea level discussion for more details. A high surf event in early June resulted in some relatively minor

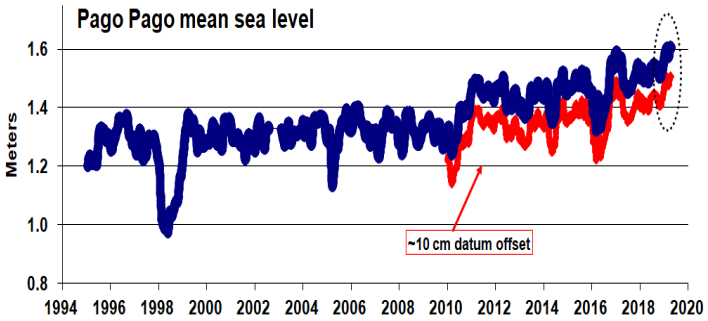


Figure AS-4. A 12-month moving average of the mean sea level at Pago Pago (dark blue time series). A sudden jump in the raw data in 2009 was the result of a datum change (a land subsidence) that occurred during the large earthquake/tsunami event of 29 September 2009. The red line shows the time series with the 10-cm land movement removed. With correction (red line), the lowered sea level during both the 2009 and 2015 El Niño events is more clearly depicted. The dotted oval shows the most recent stand (valid through April 2019). It is at a new historical high!

Figure AS-5. High surf during June 11-13 resulted in the coastal erosion seen here in photos taken by Salu Hans Malala (US National Weather Service Pago Pago American Samoa. Top Fan · June 13 at 1:33 PM).
https://www.facebook.com/NWSPagoPago/
Picture caption reads:
"Coastal erosion from the latest High Surf event. Usually have sand from the coconut line to the water but now the sand just eroded out to sea."

LOCAL SUMMARY AND FORECAST

coastal erosion as seen in photos posted on WSO Pago Pago's Facebook page (Figure AS-5).

WSO Pago Pago temperature time series

The temperature at WSO Pago Pago has a complex history that is not well explained as a simple trend of steady warming. After a period of stable MAX temperatures from 1966 through 1993, there was a decade of excessive warmth from 1994 through 2003, followed by cooler temperatures thereafter (Figure AS-4). The MIN temperature warmed substantially during the 1970s through the mid 1990s, then (as with the MAX temperature)

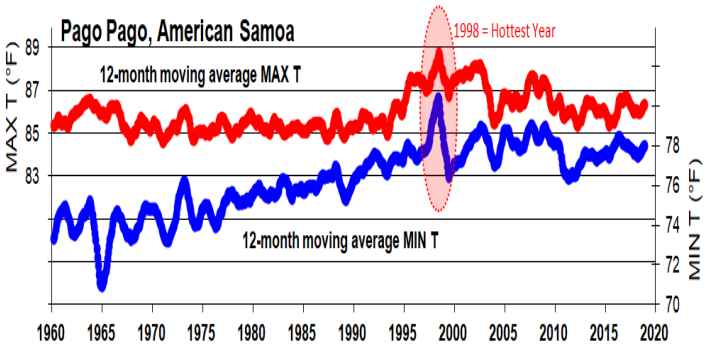


Figure AS-3. A time series of the MAX and MIN temperature at WSO Pago Pago. The values plotted are 12-month moving averages. The red-filled oval highlights the hottest year (1998) in the time series.

cooled slightly thereafter. Note that 1998 is the hottest year in the WSO Pago Pago climate record, a statistic that is shared by many of the US-API.

Climate Outlook:

After a long climb during 2018 from the cool side to the warm side of ENSO-Neutral, the state of the Pacific climate system finally entered El Niño as per the February 2019 CPC ENSO statement (see the Current Conditions Section). Important climatic elements such as rainfall, cyclone distribution and sea level are not as well correlated at American Samoa as they are in other ENSO core locations (e.g., Micronesia, Australia and even French Polynesia). Considering only rainfall, American Samoa lies along the zero-line separating strong effects of ENSO to the west, and strong (but opposite sign) ENSO effects to the east. Only during strong El Niño events are there useful correlations of ENSO with climatic rainfall conditions at American Samoa.

Whether El Niño has recently begun, recently matured, or is undergoing an unusually prolonged period of El Niño-like conditions (e.g., 1986-87 and 2014-15), it is (so far) undeniable weak, and the outlook for rainfall for American Samoa is somewhat uncertain. That being said, persistence of ongoing wet conditions and computer models indicating average to above-average rainfall over the period JJA 2019 suggest continued above average rainfall for at least the next 3 to 6 months.

The 2018-2019 South Pacific cyclone season ends June 30. The season was quieter than forecast near American Samoa, which was spared a direct strike by a major cyclone. American Samoa is now in its dry season, and tropical cyclones are not anticipated to affect this location until late in 2019. It is now too early to provide a reliable assessment of the anticipated character of the next (2019-2020) South Pacific cyclone season.

LOCAL SUMMARY AND FORECAST

Chip's rules of thumb are repeated from the last newsletter:

ENSO-neutral or La Nina—reduced TC activity in AS, most west of dateline;
Weak El Nino—Lots of monsoon activity and weak TCs vicinity AS;
Moderate El Nino—Most activity and strongest TCs;
Strong El Nino—most activity is north and east and affects French Polynesia and Cook Islands.

Predicted rainfall for American Samoa from July 2019 through June 2020:

Inclusive Period	% of long-term average
Jul - Sep 2019 (Heart of the Dry Season)	**115%**
Oct - Dec 2019 (Onset of Next Rainy Season)	**110%**
Jan– Mar 2020 (Heart of Rainy Season)	**115%**
Apr - Jun 2020 (Onset of next Dry Season)	**100%**

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

Guam/CNMI:

The first 5 months of 2019 (JFMAM) were mostly dry on Guam and in the CNMI (see Figure G1), with two notable exceptions: (1) heavy rainfall on Guam during the February nearby passage of Typhoon Wutip (Figure G-2, Right); and (2) a one-time extreme of daily rainfall on Saipan on the 21st of May when the island was affected by a slow moving line of thunderstorms. Despite the heavy February rainfall, dryness in all the other months (Jan, Mar, Apr and May) of the first 5 months of 2019 was exceptional on Guam. Not long after the heavy rainfall from Typhoon Wutip in late February, most of the island of Guam began to exhibit signs of dryness (brown lawns, desiccated roadside weeds, lowered stream flow, and extensive wildfires). Saipan and other islands of the CNMI did not receive abundant rainfall from Wutip, and these islands became profoundly affected by dryness (symptoms as above for Guam, but even further exacerbated on Tinian and Saipan in areas with near 100% tree-fall from the passage of Super Typhoon Yutu in October 2018). In a visit to Saipan in April by the UOG Guam PEAC partner, Dr. Mark Lander, many parts of Saipan -- and almost all of Tinian (as observed from the air) – were observed to be a wasteland of flattened forest all-the-more desiccated and brown from drought. Heavy rainfall from an isolated line of thunderstorms affected Saipan on the 21st of May, with an extreme daily rainfall of almost 4 inches observed at the Saipan International Airport (Figure G-3, Bottom). During the same week of May as the Saipan rainfall, Guam also experienced some isolated thunderstorms that formed over the island during the heat of the day (Figure G-2, Left; and Figure G-3, Top). In areas on Guam that experienced the May episodes of island convection, new green vegetation sprang quickly to life, while in other areas, the brown appearance of drought remained.

LOCAL SUMMARY AND FORECAST

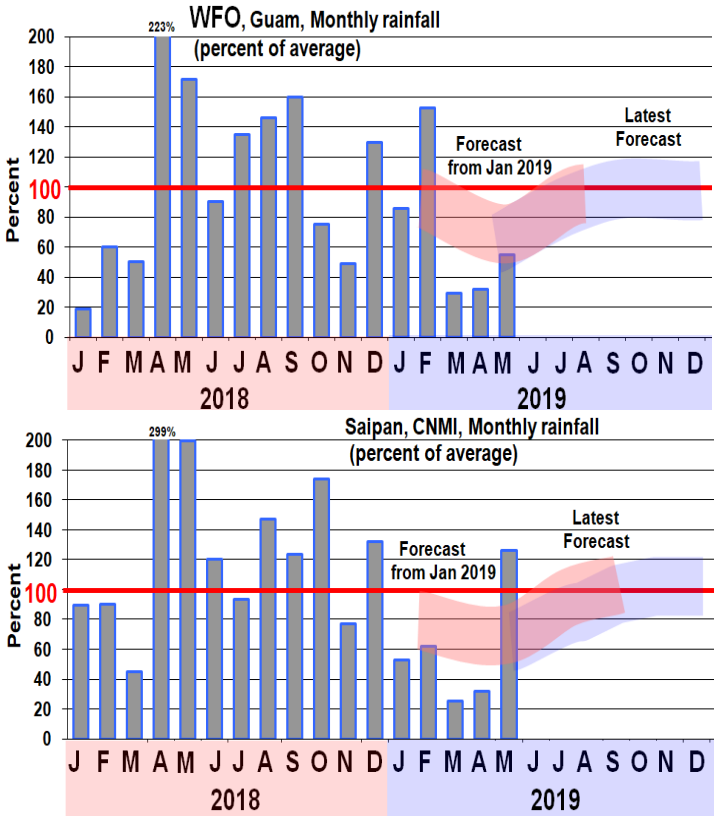
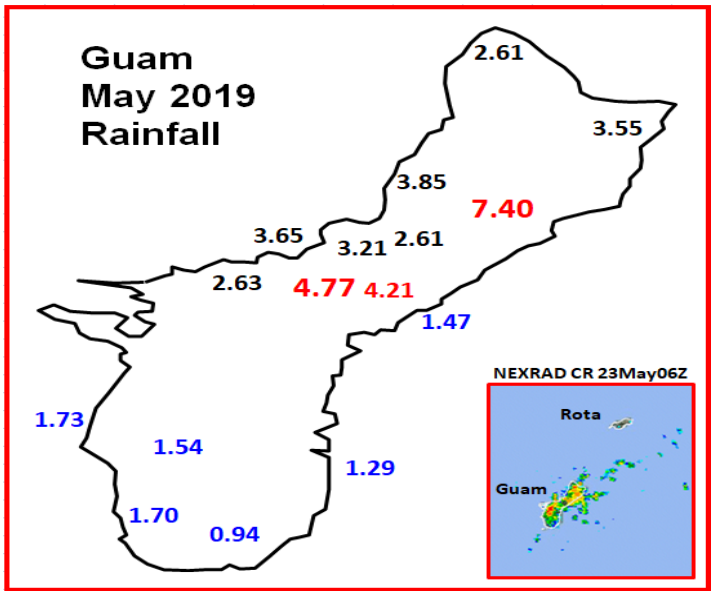


Figure G2. **Top**: A time series of monthly rainfall percentages at the Guam WFO during 2018 and the first 5 months of 2019. **Bottom**: Same as the top panel, but for monthly rainfall percentages at the Saipan International Airport. Prior forecasts of rainfall made in January 2019 by the PEAC (just for illustration) are indicated by light red bands. The forecast rainfall going forward from May 2019 is indicated by the light blue bands. Note that whereas the 2018 rainy season on Guam and in the CNMI was very wet (in large measure from many passing tropical cyclones), 4 of 5 of the first 5 months of 2019 were very dry on Guam and Saipan, with the exception of a wet February on Guam (Typhoon Wutip) and a wet May on Saipan (a one-off slow-moving line of thunderstorms).



LOCAL SUMMARY AND FORECAST

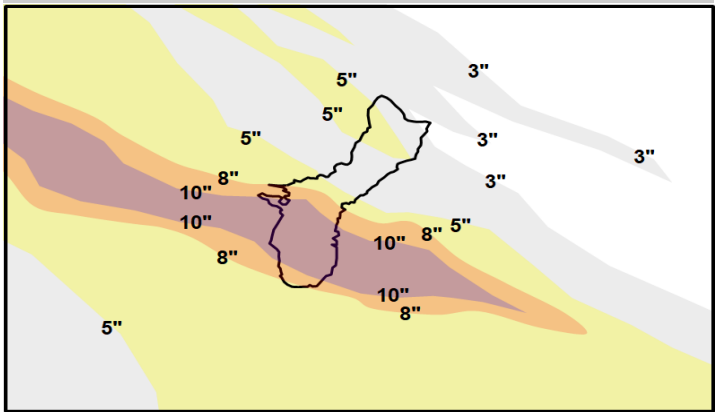


Figure G-2. (Bottom Left) Guam May 2019 rainfall (Inches). Blue = < 2" ; Red = > 4". Inset is the NEXRAD composite reflectivity at 4 PM local time on the 23rd of May showing the distribution of island convection. **(Top)** NEXRAD-observed storm-total precipitation (STP) on Guam during the 2-day (23 - 24 February) passage of Typhoon Wutip to the southwest of the island. Amounts indicated are in inches (as labeled).

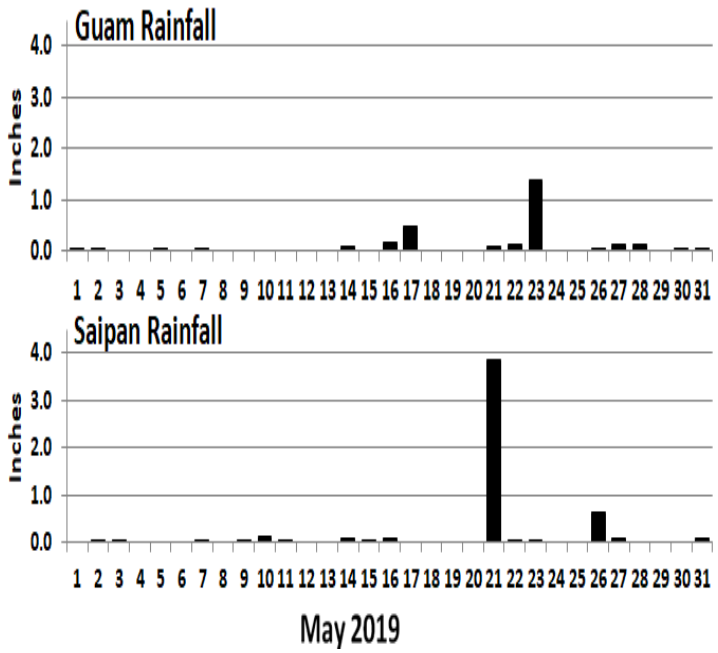


Figure G-3. (Top) Guam May 2019 rainfall (Inches). **(Bottom)** Saipan May 2019 rainfall (Inches). Note that the 3.84 inches of rainfall at the Saipan International Airport on the 21st comprised 66% of the May monthly total. Without that daily extreme, the SIA would have had only 1.94 inches in May.

LOCAL SUMMARY AND FORECAST

Guam and CNMI Rainfall Summary: Jan-May 2019 and JFMAM Total

Station		JAN	FEB	MAR	APR	MAY	5-Mo
GIA (WFO)	Rain (Inches)	4.24	6.90	0.81	1.15	2.61	15.71
	% of Average	95%	184%	27%	29%	43%	74%
AAFB	Rain (Inches)	3.32	11.99	1.79	0.93	3.55	21.58
	% of Average	95%	184%	27%	29%	43%	81%
Southern Mountain	Rain (Inches)	5.81	8.89	1.08	1.38	1.54	18.70
	% of Average	102%	170%	26%	28%	23%	71%
Saipan Int Airport	Rain (Inches)	1.76	1.54	0.53	0.93	5.78	10.54
	% of Average	55%	64%	27%	33%	131%	71%
Capitol Hill	Rain (Inches)	2.58	2.55	1.25	1.16	4.89	12.43
	% of Average	65%	85%	50%	33%	89%	67%
Tinian Airport	Rain (Inches)	2.88	4.00	0.98	1.78	3.93	13.57
	% of Average	72%	133%	39%	51%	71%	73%
Rota Airport	Rain (Inches)	4.94	2.83	1.99	1.41	1.99	13.16
	% of Average	94%	61%	54%	31%	31%	54%

Sea Level

The sea level at Guam fell during 2018, but had a very dramatic drop in the final 3 months (see Figs. G4 and G5). A survey of Guam surfers reveals awareness in that community of noticeable lowered sea level late in 2018. Lowered sea level on Guam is typically a feature of El Niño. By April 2019, the sea level on Guam had recovered over half of its 2018 loss, and was again above average. Once again, local surfers were aware of the sea condition, and reported much higher sea levels at popular local surfing spots. This is typical of the post-Peak Phase of El Niño.

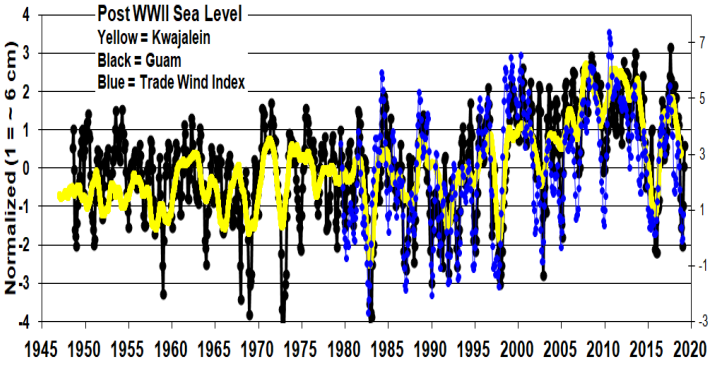


Figure G-4. A time series of Guam monthly sea level (black) and one of NOAA's trade wind indexes (blue). Note the very steep fall late in 2018 of both the sea level and the trade winds. The sea level at Kwajalein is also presented (yellow) to show the coherence of sea level fluctuations across Micronesia with the wind.

LOCAL SUMMARY AND FORECAST

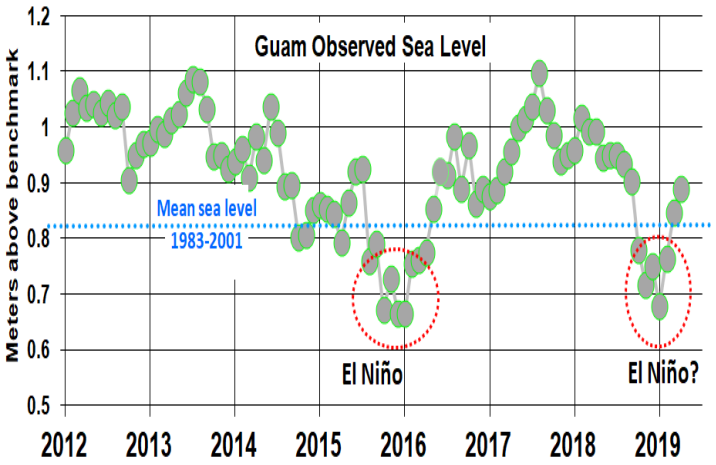


Figure G-5. A time series of Guam monthly sea level at a shorter time resolution (2012 through April 2019). Note the very steep fall late in 2018 followed by a quick rise thereafter. Also, note the behavior of the sea level during the 2015/2016 El Niño event and the similarities with the recent sea level behavior.

Breaking news:
(1) Drought Statement
WFO Guam releases Drought Information Statement (11 February 2019). Selected statements from the full document are quoted below:

DROUGHT INFORMATION STATEMENT...FIRST
NATIONAL WEATHER SERVICE TIYAN GU
200 PM CHST MON FEB 11 2019

"...VERY DRY WEATHER DEVELOPING ACROSS MANY PARTS OF MICRONESIA..."

SYNOPSIS

"POST EL NINO-LIKE DRY CONDITIONS MAY CONTINUE THROUGH THE SPRING OF 2019."

MARIANA ISLANDS

"THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS (CNMI)... RAINFALL HAS DIMINISHED OVER THE COMMONWEALTH SINCE JANUARY. SAIPAN...TINIAN...ROTA AND THE FAR NORTHERN MARIANA ISLANDS WILL EXPERIENCE DROUGHT IMPACTS DURING THE COMING WEEKS."

"IN PARTICULAR FOR SAIPAN... VEGETATION WILL DRY OUT AND A SEVERE WILDFIRE SEASON COULD DEVELOP...ESPECIALLY WHERE DEBRIS FROM TYPHOON YUTU REMAINS."

GUAM

"GUAM HAS RECEIVED A FEW SHOWERS AT TIMES RECENTLY AND SHOULD RECEIVE A LITTLE BETTER RAINFALL THAN OTHER MARIANA ISLANDS. GUAM RAINFALL IS EXPECTED TO BECOME DRY AND WILL CONTINUE TO BE MONITORED CAREFULLY."

LOCAL SUMMARY AND FORECAST

RAINFALL

"REPORTS AND COMPUTER MODELS INDICATE ABNORMALLY DRY WEATHER CONTINUING OVER MUCH OF MICRONESIA. THE CLIMATE PREDICTION CENTER INDICATES THE ENSO ALERT SYSTEM STATUS" HAS BEEN ELEVATED TO EL NINO ADVISORY. THIS IS WELCOMED SINCE THE "WEATHER PATTERNS OVER MICRONESIA DURING THE LAST SEVERAL MONTHS WOULD SUGGEST THAT WE HAVE EXPERIENCED EL NINO-LIKE WEATHER. REGARDLESS, IT LOOKS LIKE DRIER CONDITIONS ARE IN STORE FOR MICRONESIA."

Climate Outlook:

After a long climb during 2018 from the cool side to the warm side of ENSO-neutral, the state of the Pacific climate system finally entered El Niño as per the February 2019 CPC ENSO statement (see the Current Conditions Section). In several ways, the climatic elements (typhoon distribution, sea level and the pattern of rainfall) were, and still are, what one might expect at the maturity of a weak El Niño in late 2018/early 2019. Whether El Niño has recently begun, recently matured, or is undergoing an unusually prolonged period of El Niño-like conditions such as seen in 1986-88 and 2014-16, the forecast of rainfall for Guam and the CNMI will be for average to above-average rainfall July through December. Looking ahead to the upcoming rainy season, the uncertainty in the evolution of ENSO precludes a confident forecast of rainfall or typhoon distribution. Any strengthening of El Niño in the next few months would typically be associated with average to above average rainfall and an increase in the chances for an early-season typhoon. If El Niño fades over the next few months, a dry forecast is prudent, along with an associated reduction and delay of typhoon activity through the first half of 2019. We are opting for the drier scenario.

Predicted rainfall for the Mariana Islands from July through June 2020:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]	
	Guam/Rota	Saipan/Tinian
Jul-Sep 2019 (Onset of the Rainy Season)	110%	100%
Oct-Dec 2019 (End of the Rainy Season)	120%	120%
Jan-Mar 2020 (1st half of the Dry Season)	80%	80%
Apr-Jun 2020 (2nd half of the Dry Season)	70%	70%

Federated States of Micronesia

Yap State:

Rainfall at the WSO Yap was below average for 4 of the first 5 months of 2019 (Figure Y-1). After very high rainfall in January, persistent dry conditions became established. During May, large wildfires were reported in Maap and Tamil in the northern part of Yap Island. Some heavier rainfall in June suppressed any further wildfires. No problems with potable water supplies were reported.

The very high January 2019 rainfall at WSO Yap was largely the result of an extreme 24-hour rainfall of 9.10 inches that occurred there on the 18th during the passage through Yap State of an extensive band of heavy showers associated with the long-lasting, but continually disorganized cloud system of Tropical Depression 01W.

LOCAL SUMMARY AND FORECAST

The 5-month (JFMAM) grand total of rainfall across Yap Island was relatively uniform, with the driest values seen in the north at Maap and Tamil (where the big wildfires occurred), with the highest amounts across the center of the island (Figure Y-2).

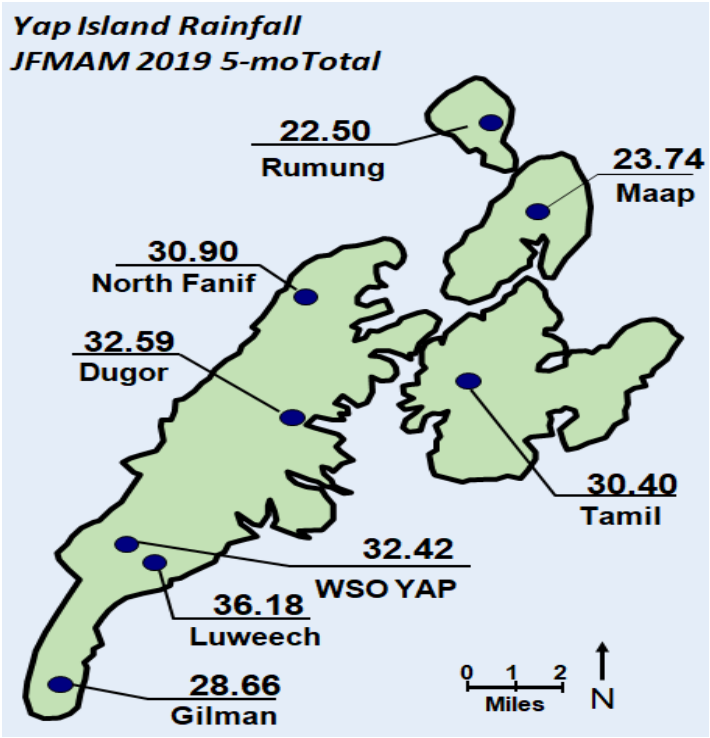


Figure Y2. Rainfall totals for the first 5 months of 2019 (JFMAM) at locations on Yap Island. The average rainfall at WSO Yap for this 5-month period is about 34 inches. The observed 5-month total of 32.42 inches at WSO Yap was 95% of average, but keep in mind that 9.10 inches—28% of the 5-month total—occurred in a single 24-hour extreme event on the 18th of January.

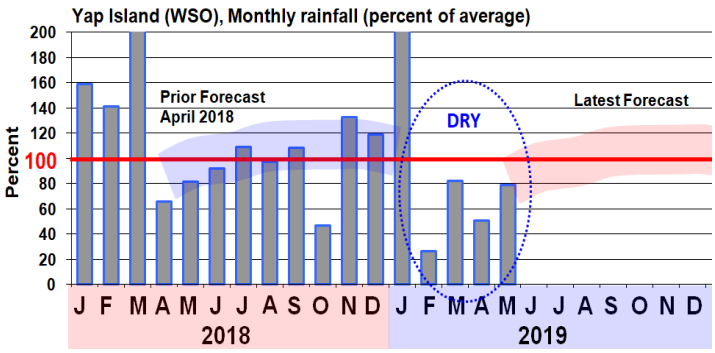


Figure Y1. Time series of monthly rainfall at the Yap Island WSO (gray bars) for January 2018 through May 2019. High month-to-month variability is evident. Overall, the rainfall total during the calendar year 2018 was above average. The dotted blue circle highlights a notable dry spell that occurred during February through May 2019. A long-term forecast of rainfall made by the PEAC in April 2018 (light-blue band) seems to have captured the overall picture. The latest PEAC long-term rainfall forecast (light-red band) for the remainder of 2019 is similar to the one made a year ago: a steady recovery from early dryness to near-average to above average later.

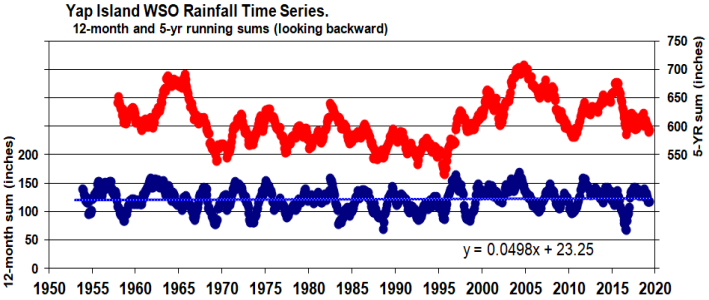
LOCAL SUMMARY AND FORECAST

Climatic Trends in Yap

(1) Rainfall

Long-term rainfall records at the Yap WSO, starting shortly after WWII, show high variability at all time scales: month-to-month (see Figure Y1 above); and at even longer periods, such as the 1- and 5-year running sums shown in Figure Y3 (below). A simple linear trend applied to the 1-year running sum indicates a modest increase of rainfall since the start of the time series in the early 1950s. The magnitude of the trend is roughly 0.50 inches per decade, for a net gain of about 3.2 inches of rain per year over the entire 67-year period of the historical record. Because of high variability, the variance explained by the trend is very low (a near-zero value of R^2).

High variability of the 12-month rainfall that is in large measure an effect of ENSO. The 5-year running sum brings out longer-period variability, with the dry decade of the late 1980s-to-early 1990s and the wet decade of the 2000s sharply apparent. The long-term trend of the 1-year time series (blue line) shows a modest rising trend of .05 inches per year.



(1) Temperature

Long-term trends of temperature at WSO Yap are complicated (Figure Y4). No clear picture emerges, with the daytime MAX temperature seeming to rise overall, and the nighttime MIN temperature clearly falling, at least until the relocation of the WSO in 2008. After April 2008, there was an abrupt increase of 5 °F in the MIN T. At the same time, the trace of the MAX T shows substantial warming with unusually large variability.

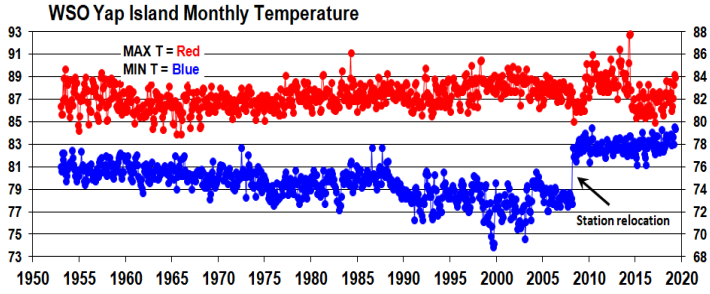


Figure Y4. The Post-WWII historical record of MAX and MIN temperature at WSO Yap Island. Plotted data are the observed individual monthly averages . The abrupt change in each of the time series (particularly in the MIN T) in 2008 (black arrow) is the consequence of a station relocation in April 2008.

Climate Outlook:

After a long climb during 2018 from the cool side to the warm side of ENSO-Neutral, the state of the Pacific climate system finally entered El Niño as per the February 2019 CPC ENSO statement (see the Current Conditions Section). The recent dryness in Yap State is typical during the post-Peak Phase of El Niño. Whether or not the current El Niño has already matured, or will continue through 2019 lends some extra uncertainty to the forecast of rainfall and TC activity for Yap State. For now, in keeping with an assumed maturity of El Niño, 3-month computer projections and persistence, the PEAC forecast of rainfall throughout Yap State will call for average to below-average rainfall over the next few months, rising to near average or even slightly above-average thereafter. Tropical cyclone activity across Yap State has been relatively quiet during the first half of 2019, a behavior also typical during the post-Peak Phase of El Niño). Despite the early quiescence of the TC activity, the risk of a damaging tropical storm or typhoon in Yap State may be slightly enhanced during late September through the end of the year, especially if warm SST remains in-place in equatorial waters near the International Date Line.

LOCAL SUMMARY AND FORECAST

Yap State Rainfall Summary: JFMAM Individual Monthly Totals and 5 Month Grand Total

Station		JAN	FEB	MAR	APR	MAY	5-Mo
Yap State							
Yap WSO	Inches	15.90	1.57	4.88	2.92	7.15	32.42
	% AVG	217%	26%	82%	51%	79%	95%
Ulithi*	Inches	.*	.	.	.	.	.
	% Norm	%	%	%	%	%	%
Woleai	Inches	6.37	2.83	6.07	4.22	2.96	22.45
	% AVG	60%	38%	73%	38%	24%	45%

* The rainfall at Ulithi has been missing for several months.

Predicted rainfall for Yap State from July through June 2020 is:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]	
	Woleai	Yap & Ulithi
Jul – Sep 2019 (Heart of Rainy Season)	90%	95%
Oct – Dec 2019 (End of the Rainy Season)	95%	100%
Jan– Mar 2020 (Onset of Dry Season)	90%	90%
Apr – Jun 2020 (End of Dry Season)	90%	95%

Chuuk State:

The pattern of rainfall during the first five months of 2019 across Chuuk State repeated the pattern of rainfall observed during the calendar year 2018: below-average rainfall throughout most of Chuuk State, with above-average at Weather Service Office (WSO) Chuuk (see figure CH-1, figure CH-2, and the rainfall table). The 5-month (JFMAM) totals varied substantially across the state, ranging from over 50 inches at WSO Chuuk and some of the atolls of the Mortlocks (e.g., Ettal and Ta), to 30 inches or less at some of the northern atolls (e.g., Fananu and at Polowat. Apart from the WSO, all the reported values were below average (Figure CH-2).

The passages of TD 01W and Typhoon Wutip through the state during January and February, respectively, were unforeseeable extreme events yielding well-above average rainfall at some locations during those two months.

LOCAL SUMMARY AND FORECAST

In the June PEAC conference call, it was noted that some problems with the supply of potable water had occurred at Polowat, and on some of the Mortlocks. It was thought that these water problems were due to limited storage capacity and or troubles with the storage infrastructure and not for lack of rainfall. In fact, none of the southern Mortlocks Islands experienced more than two consecutive months of dry weather. At the time of the PEAC call (13 June), these islands seemed to have enough water.

There were no reports of any recent significant sea inundation events. The sea level across most of Micronesia fell several inches during 2018, but increased again through the first five months of 2019 is now near average to slightly above average (see the sea level discussion for more details).

Climate Outlook:

After a long climb during 2018 from the cool side to the warm side of ENSO-Neutral, the state of the Pacific climate system was finally declared to be El Niño as per the February 2019 CPC ENSO statement (see the Current Conditions Section). In several ways, the regional and local climatic elements (typhoon distribution, sea level and the pattern of rainfall) were (and still are) what one might expect at the maturity of a weak El Niño in late 2018/early 2019. The uncertainty in the evolution of ENSO precludes a confident forecast of rainfall or typhoon distribution. The forecast of rainfall for all islands and atolls of Chuuk State will be for near-average values over the next few months. There are some indications that warm SST may linger at low latitudes near the International Date Line. This could act to enhance TC activity within Chuuk State, particularly from September through the end of the year.

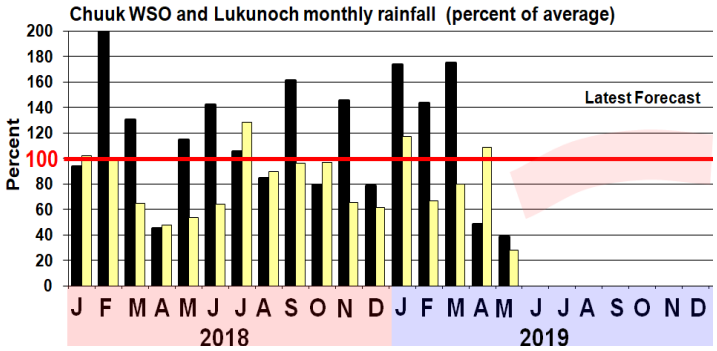
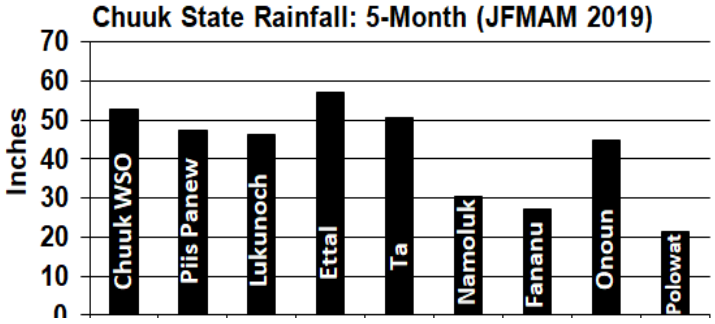


Figure CH-1. A time series of the monthly rainfall at WSO Chuuk (black bars) and at Lukunoch in the southern Mortlock Islands (yellow bars) during 2018 through May 2019. The light red band is a long-range rainfall prediction for the remainder of 2019: a steady rise to near average by July or August, thereafter followed by near-average rainfall.



LOCAL SUMMARY AND FORECAST

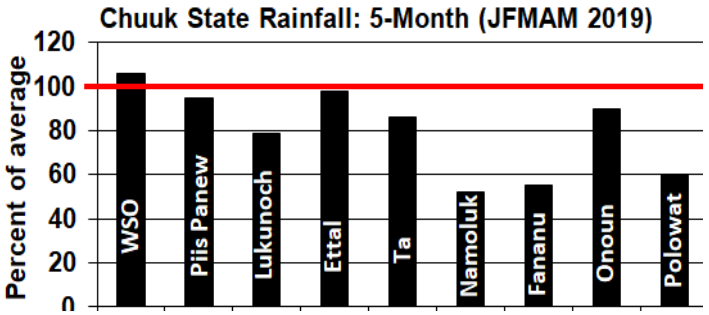


Figure CH-2. Two bar charts depicting the total rainfall across selected islands of Chuuk State during the first five months of 2019. The top panel shows the rainfall total in inches and the bottom panel shows the rainfall total as a percent of average. Note that at all locations except WSO Chuuk the rainfall was below average. Polowat is almost always much drier than the other locations; this might indicate an exposure problem with the rain gauge.

Chuuk State Rainfall Summary: JFMAM							
Station		JAN	FEB	MAR	APR	MAY	5-Mo
Chuuk Lagoon							
Chuuk WSO	Inches	18.49	8.87	14.56	6.00	4.74	52.66
	% Avg	173%	143%	174%	49%	39%	106%
Mortlocks							
Lukunoch	Inches	12.41	6.33	9.58	14.30	3.75	46.37
	% Avg	117%	66%	80%	109%	28%	79%
Ettal	Inches	14.21	4.98	18.33	17.17	2.50	57.19
	% Avg	134%	52%	152%	130 %	19%	98%
Northern & North Western Atolls							
Fananu	Inches	8.92	3.08	5.43	4.95	4.86	27.24
	% Avg	84%	50%	65%	40%	40%	55%
Ounoun	Inches	13.52	6.98	8.76	24.51	95.85	
	% Avg	127%	127%	94%	107%	20%	90%
Western Atolls							
Polowat	Inches	3.64*	7.20*	3.54*	4.74*	2.19*	21.31*
	% Avg	46%	115%	57%	79%	24%	60%

Predicted rainfall for Chuuk State from July 2019 through June 2020 is:

Inclusive Period	% of long-term average			
	Chuuk Lagoon, Losap, & Nama	Polowat	Northern Is.	Southern Mortlocks
Jul-Sep 2019	100%	90%	95%	100%
Oct-Dec 2019	100%	85%	100%	100%
Jan - Mar 2020	100%	80%	95%	100%
Apr– Jun 2020	110%	85%	95%	110%

Pohnpei State:

"May was a bit dry towards the end of the month … June OK!" Assessment of the recent climate at Pohnpei Island provided by WSO Pohnpei Island forecaster, Wallace Jacob.

The rainfall was overall below average on Pohnpei Island and some of the outer atolls during the first 5 months (JFMAM) of 2019 (Figure PN-1 and the tabular rainfall summaries). Despite the relatively low rainfall, there were no reported problems with potable water, except for a brief period (two days in the morning) of water rationing in late May on Pohnpei Island.

Rainfall at Kapingamarangi was very high during 2018, and continues to be high through the first 5 months of 2019. The 12-month running sum of rainfall reached its historical high of 199.82 inches in August 2018 (Figure PN-2). High rainfall in the first 5 months of 2019 has kept the long-term (6- and 12-month) accumulations well above average. On most of the atolls of the US-API, very heavy rainfall is generally welcome, and causes little trouble. On the high islands, such as Pohnpei Island and Kosrae, extremes of short-term rainfall can result in damaging stream flooding and landslides.

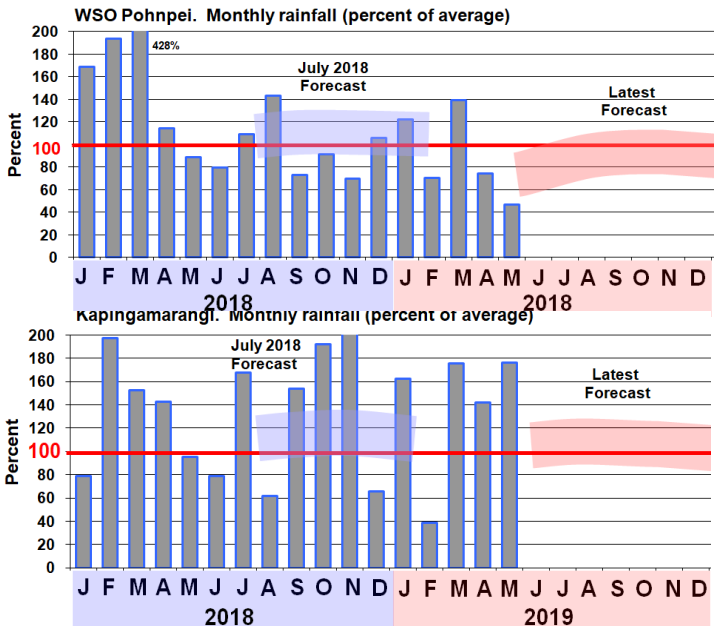
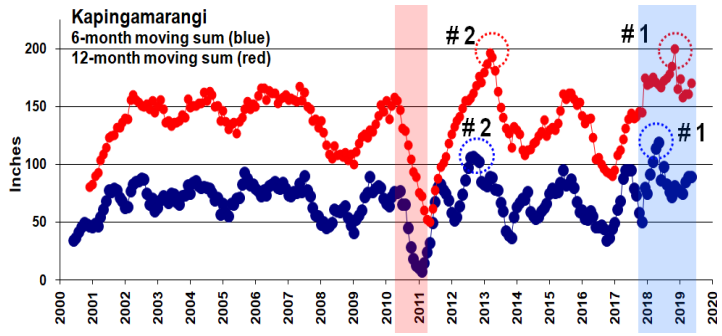


Figure PN-1. A bar chart of the monthly rainfall at the Pohnpei Island weather station (top) and at Kapingamarangi (bottom) during 2018 through the first 5 months of 2019. The PEAC's long-range rainfall forecast made one year ago in July (light blue band) was correct to indicate above average rainfall. The current long-range forecast (light red band) continues to indicate above average rainfall that may slowly decline toward the end of the year. High month-to-month variability is nearly always present.



LOCAL SUMMARY AND FORECAST

Figure PN-2. A time series of a 6-month moving sum (blue) and a 12-month moving sum (red) of monthly rainfall at Kapingamarangi. Numbers in the red and blue circles indicate relative rankings of the wet extremes (# 1 = highest). Red and blue shaded vertical bars highlight a severe drought and the current period of high rainfall, respectively. The severe drought of 2010/2011 led to insufficient potable water and damage to crops and island vegetation.

Pohnpei State Rainfall Summary: monthly totals for each of JFMAM and the 5-month grand total.

Pohnpei State Rainfall Summary 2nd QTR and 2019 Annual							
Station		**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**5-Mo**
Pohnpei WSO	**Rain (Inches)**	**16.0**	**7.57**	**18.84**	**12.23**	**8.94**	63.58
	% of Average	**122 %**	**70%**	**139%**	**74%**	**47%**	87%
PNI Airport	**Rain (Inches)**	**16.0**	**6.81**	**18.21**	**12.08**	**7.85**	60.95
	% of Average	**149 %**	**77%**	**164%**	**89%**	**50%**	102%
Atolls of Phonpei State							
Station		**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**5-MO**
Nukuoro	**Rain (Inches)**	**11.76**	**9.73**	**15.36**	**16.39**	**5.22**	58.46
	% of Average	**100 %**	**92%**	**113%**	**109 %**	**35%**	89%
Pingelap	**Rain (Inches)**	**5.70**	**10.20**	**11.06**	**8.92**	**11.06**	46.94
	% of Average	**46%**	**84%**	**76%**	**52%**	**65%**	64%
Kapinga	**Rain (Inches)**	**17.87**	**4.06**	**22.56**	**17.33**	**20.46**	82.28
	% of Average	**162 %**	**39%**	**176%**	**142 %**	**176%**	142%
Mwoakil	**Rain (Inches)**	**11.61**	**18.57**	**14.07**	**8.57**	**11.56**	64.08
	% of Average	**108 %**	**206 %**	**127%**	**63%**	**74%**	107%

Predicted rainfall for Pohnpei State from July 2019 through June 2020 is:

Inclusive Period	% of long-term average	
	Pohnpei Island/ atolls	Kapingamarangi
Jul - Sep 2019	**95%**	**120%**
Oct - Dec 2019	**100%**	**100%**
Jan - Mar 2020	**100%**	**100%**
Apr - Jun 2019	**90%**	**90%**

LOCAL SUMMARY AND FORECAST

Climate Outlook:

After a long climb during 2018 from the cool side to the warm side of ENSO-Neutral, the state of the Pacific climate system finally entered El Niño as per the February 2019 CPC ENSO statement (see the Current Conditions Section). Some aspects of the current weather patterns (e.g., dryness across some of the northern island of Micronesia, and a quiet typhoon season so far) are typical during the post-Peak Phase of El Niño. Whether or not the current El Niño has already matured, or will continue through 2019 lends some extra uncertainty to the forecast of rainfall and TC activity for the islands and atolls of Pohnpei State. The latest PEAC forecast of rainfall for Pohnpei State will be for near-average rainfall over the next few months. There are some indications that warm SST may linger at low latitudes near the International Date Line. This could act to enhance TC activity within Pohnpei State, particularly from September through the end of the year. Note that the previous PEAC forecast for rainfall and TC activity in Pohnpei State contained in the 1st Quarter Newsletter was accurate: *"If El Niño fades over the next few months, a dry forecast is prudent, along with an associated reduction and delay of typhoon activity through the first half of 2019."*

Kosrae State:

Over the course of the calendar year 2018 through the first 5 months of 2019, the rainfall at Kosrae underwent a large see-saw from wet, to dry, then wet again! (Figure KS-1). The dryness at the end of 2018 was extreme (while it lasted), with the 4-month (SOND 2018) total of 28.14 inches at Kosrae International Airport being the lowest such 4-month total (by far); the 41.12 inches of rainfall during SOND 1990 is the distant 2nd. Despite the drier conditions, the Official in Charge of the Pohnpei Weather Service Office (WSO), a native of Kosrae, indicated that there were no reports of water rationing or outages or grass fires, and that the island maintained its lush green appearance.

During the first 5 months of 2019, there was a renewal of heavy monthly rainfall amounts. *"Plenty Rain!"* – a signature phrase of the same Kosrae native mentioned above – was used to describe the recent climatic conditions at Kosrae. During a heavy rainfall event in May 2019, there was a landslide at a construction area in Tofol. The PEAC did not receive word of any serious damage or injuries from this landslide.

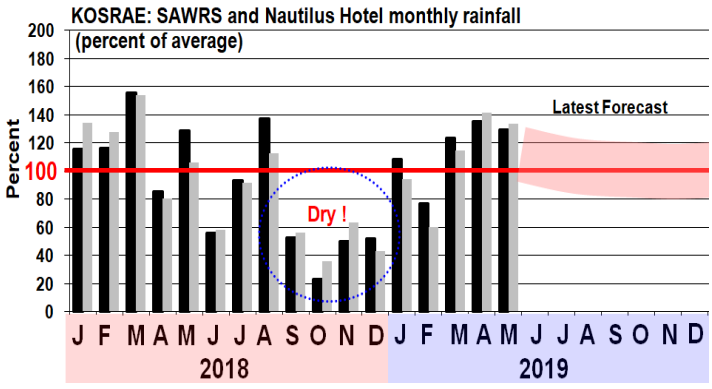


Figure KS-1. A time series of the monthly rainfall at Supplemental Aviation Weather Reporting Station (SAWRS) at the Kosrae International Airport (black bars) and the Nautilus Hotel (gray bars) for the period January 2018 through May 2019. The light red band shows the PEAC forecast for July 2019 through the end of the year. Dryness during SOND 2018 (dotted blue oval) set a record for the lowest value for that 4-month sum.

LOCAL SUMMARY AND FORECAST

There are four rainfall reporting stations on the island of Kosrae that routinely provide monthly rainfall data: the International Airport; the Nautilus Hotel; Utwa; and Tofol (see the map inset at the beginning of the LVS). The rainfall at the airport on the northwest side of the island tracks closely with the rainfall at the Nautilus Resort Hotel located on the east-northeast side of the island (Figure KS-2). These two stations have very similar rainfall amounts and inter-annual variability.

The May rainfall at the Nautilus Hotel and at Utwa exceeded 30 inches. Monthly rainfall over 30 inches has occurred 29 times out of 689 months of observation, or 4.2% of the time, at Kosrae SAWRS (See Table 1). Monthly rainfall over 25 inches has occurred 71 times (10.3%).

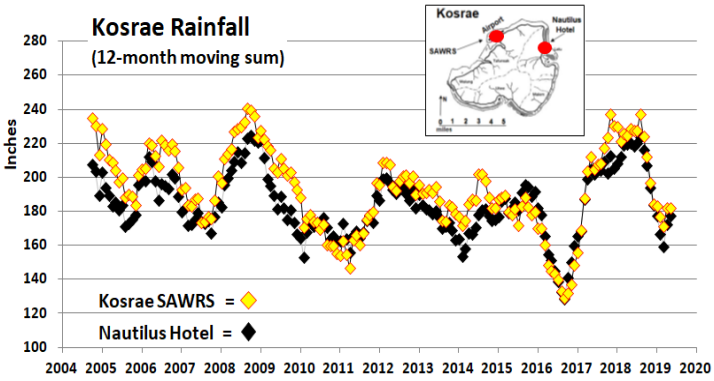


Figure KS-2. A plot of the 12-month moving sum of rainfall at the Supplemental Aviation Weather Reporting Station (SAWRS) at the Kosrae International Airport and at the Nautilus Hotel (locations indicated by the red dots in the inset). Rainfall across the relatively small island seems to be coherent. Note the big dip of rainfall amounts in response to the 2015-2016 El Niño, with the subsequent rapid recovery to very wet conditions during 2017 and early 2018. Very dry conditions during SOND 2018 are responsible for the sudden plunge in the values near the end of the time series, with an ongoing recent modest recovery.

Climate Outlook:

After a long climb during 2018 from the cool side to the warm side of ENSO-Neutral, the state of the Pacific climate system was finally declared to be El Niño as per the February 2019 CPC ENSO statement (see the Current Conditions Section). In several ways, the regional and local climatic elements (typhoon distribution, sea level and the pattern of rainfall) were (and still are) what one might expect at the maturity of a weak El Niño in late 2018/early 2019. The uncertainty in the evolution of ENSO precludes a confident forecast of rainfall or typhoon distribution. The forecast of rainfall for Kosrae State will be for near-average values over the next few months. There are some indications that warm SST may linger at low latitudes near the International Date Line. This could act to enhance TC activity within Kosrae State, particularly from September through the end of the year.

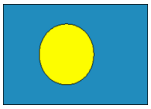
LOCAL SUMMARY AND FORECAST

Kosrae State Rainfall Summary: monthly totals for each of JFMAM

Kosrae						
Station	Rain	JAN	FEB	MAR	APR	MAY
Airport SAWRS	Inches	15.58	12.62	23.02	29.33	24.32
	%Avg	108%	77%	123%	135%	129%
Nautilus Hotel	Inches	13.58	9.87	21.35	30.65	25.18
	%Avg	94%	60%	114%	142%	134%
Tofol	Inches	18.28	13.88	-	27.19	32.88
	%Avg	127%	85%	%	126%	172%
Utwa	Inches	11.36	6.41	17.89	30.88	-
	%Avg	79%	39%	96%	143%	30%

Predicted rainfall for Kosrae State from July 2019 through June 2020 is:

Inclusive Period (Kosrae)	% of long-term average / Forecast rainfall (inches) [1]
Jul – Sep 2019	105%
Oct - Dec 2019	100%
Jan– Mar 2020	95%
Apr - Jun 2020	90%



Republic of Palau:

Dry conditions prevailed throughout the Republic of Palau during the first 5 months of 2019 (Figure PL-1), adding to deep losses of rainfall over the past several years (Figures PL-2 and PL-3). By August 2016, a record-breaking drought during the course of the epic 2015-2016 El Niño event led to the accumulated loss (with respect to average amounts) of 85.73 inches of rainfall at WSO Koror (Fig. PL-2). This is well over half a year's typical annual total of 148 inches! With the return of some above-average monthly totals during 2017, the long-term deficit recovered to -49.24 inches by the end of that year. However, dryness throughout most of 2018 and continuing through the first 5 months of 2019 led to a renewed increase in the long-term accumulated deficit of rainfall, which stood at -108.29 inches on the last day of May 2019. The 5-year sum of rainfall at WSO Koror reached its historical low-point at the end of 2016 (Figure PL-3) and still has a long climb to reach even the average value for this statistic.

Municipal water supplies were severely affected in 2016, and water rationing was once again implemented in early 2019, which was mitigated by improvements to water infrastructure. Ecological impacts of dryness have also occurred, such as the total loss of millions of Golden Medusae in Jellyfish Lake in 2016. After abundant rainfall in late 2018, Jellyfish Lake underwent a modest recovery, and is again open. The Jellyfish count, however, is not yet at pre-drought values, and hopefully very dry conditions to-date in 2019 do not hinder the recovery (see Sidebar below for some recent news on Jellyfish Lake).

LOCAL SUMMARY AND FORECAST

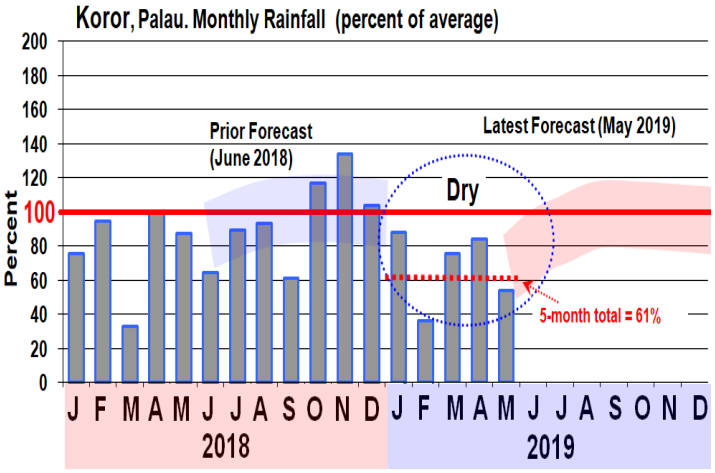


Figure PL-1 A bar chart of observed monthly rainfall (percent of average) at the WSO Koror during 2018 through May 2019. The forecast presented in the June 2018 Newsletter for the rest of 2018 is shown by the light-blue band. The forecast for the rest of 2019 is shown by the light-red band. Thirteen of the past 17 had below average rainfall, with the 5-month (JFMAM 2019) total only 61% of its average.

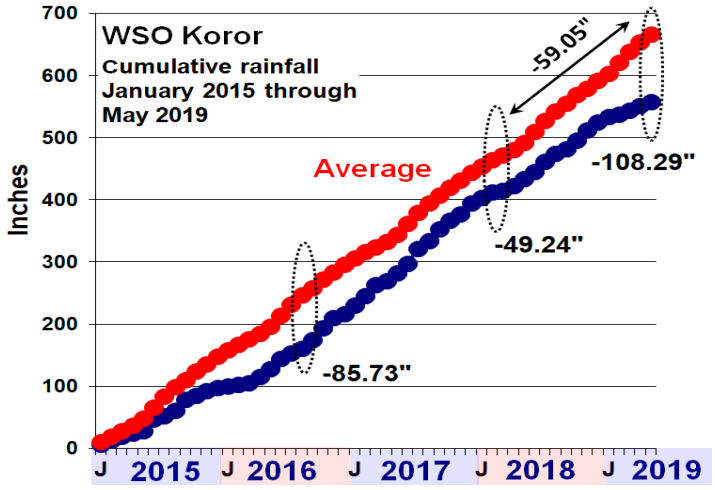


Figure PL-2. Cumulative rainfall at Koror since January 2015. The red line shows the normal accumulation of rainfall starting from JAN 2015, and the dark blue line shows the observed accumulated rainfall over the same time period. The accumulated deficit reached its extreme low of -85.73 inches in AUG 2016. Abundant rainfall in late 2016 and through 2017 erased 36 inches of the deficit which stood at -49.24" in DEC 2017. Renewed Dryness during 2018 through early 2019 increased the long-term deficit to -108.29" as of May 2019. The net loss of rainfall during 2015 into 2016 (-85.73") is, however, greater than the net loss during 2018 into 2019 of -59.05 inches.

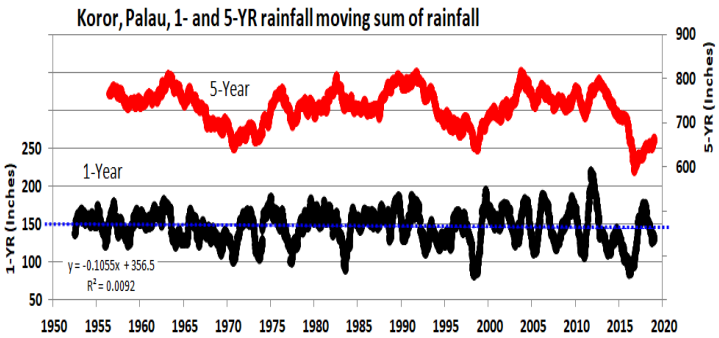


Figure PL-3. Time series of the 3-year and 5-year moving sums (looking backwards) of rainfall at the WSO Koror. Note the historical low-points of each time series during 2016. Note also that the two moving sums have yet to recover to their respective average value (dotted red and blue lines).

Sidebar: Jellyfish Lake

Jellyfish Lake is open to the public again!

An ecological impact of the 2015-16 El Niño was a severe die-off of jellyfish in Palau's famous Jellyfish Lake (see Figure PL-4). The lake remained closed to tourists as per official statement of the Palau Ministry of Natural Resources, Environment and Tourism (Ongeim'l Tketau, Jellyfish Lake, 18 May 2017). As recently as February 2018, a dive team sighted only one adult medusa in the lake. On December 13, 2018, the newsletter of the Palau Dive Adventures tour company announced the re-opening of Jellyfish Lake to tourists as an estimated 1 million adult golden jellyfish medusa have repopulated the lake. The following update appears in a March 18, 2019 travel report in the lifestyle portal of the Star Media Group:

Swimming with the famous golden jellyfish in Palau can be put back on the bucket list following a two-year ban…

The government ordered the famed Ongeim'l Tketau Jellyfish Lake closed to swimmers in 2016 because of dwindling numbers of the unique creature – blamed on warming waters although with some suspicion sunscreen on bathers may also have contributed.

…authorities in Koror State, which owns the resource, say stocks are now recovering and tourists are again being welcomed at Jellyfish Lake.

Swimming with the jellyfish on Mecherchar island, about a 45-minute boat ride from Koror, is "one of the most unique attractions" Palau has to offer, according to the Visitors Authority chairman Ngirai Tmetuchl.

The jellyfish population, which once swelled to around 20 million, slumped in 2016 because of El Nino, a climate pattern linked to warming waters in the central and eastern areas of the equatorial Pacific.

With the waters cooling over the past year the jellyfish have increased to numbers strong enough to invite tourists back but Sharon Patris, a research biologist at the Coral Reef Research Foundation said it would take some time to reach "normal numbers" of five to eight million.

LOCAL SUMMARY AND FORECAST

Patris added there was a similar fall in jellyfish numbers in 1998 linked to an El Nino event…

There are more than 50 marine lakes in Palau, five of them containing jellyfish but only the one Jellyfish Lake is open to visitors.

Read more at https://www.star2.com/travel/2019/03/18/palau-open-to-public-again/#JGoPLYEjPHeYwtsx.99

Figure PL-4. This photo (from https://blog.nationalgeographic.org/2014/09/10/palau-expedition-millions-of-jellyfish/) shows the typical abundance of jellyfish in Palau's world-famous Jellyfish Lake before they all disappeared during the 2015/16 El Niño). The undisturbed population of jellyfish in the lake is 5 to 8 million. This dropped to zero in 2016. Juvenile polyps lining portions of the lake bottom eventually detached to repopulate the lake to an estimated 1 million adults by the end of 2018.

Climate Outlook:

After a long climb during 2018 from the cool side to the warm side of ENSO-Neutral, the state of the Pacific climate system finally entered El Niño as per the February 2019 CPC ENSO statement (see the Current Conditions Section). In several ways, the climatic elements (typhoon distribution, sea level and the pattern of rainfall) were (and still are) what one might expect at the maturity of a weak El Niño in late 2018/early 2019. Whether El Niño has recently begun, recently matured, or is undergoing an unusually prolonged period of El Niño-like conditions (e.g., 1986-87 and 2014-15), the forecast of rainfall for the Republic of Palau will now be for a slow recovery of rainfall to near-average over the next few months. Computer model forecasts for Palau are not quite as aggressively dry as they were in the past few months, indicating the possible beginnings of a recovery of rainfall over the next 3 months. Therefore PEAC will adhere to an optimistic forecast of near-average rainfall throughout Palau at least through JAS 2019. Looking ahead for the remainder of 2019 and early 2020, the uncertainty in the evolution of ENSO precludes a confident forecast of rainfall or typhoon distribution. We have seen a reduction and delay of typhoon activity in the spring of 2019. Later in the year, the typhoon activity is expected to rise to average or above average in the

LOCAL SUMMARY AND FORECAST

western North Pacific basin, and as a precaution the PEAC anticipates at least a near-average risk of a typhoon in Palau, with the greatest risk in the final 3 months of the year.

Republic of Palau Rainfall Summary: JFMAM 2019 and 5-Month total

Station		JAN	FEB	MAR	APR	MAY	5-Mo
WSO** Palau	Rain (Inches)	9.79	3.45	6.24	6.89	6.78	33.15
	% of avg.	80%	33%	69%	76%	49%	61%
Mele-keok*	Rain (Inches)	12.23	3.40	5.60	6.43	5.50	33.16
	% of avg.	110 %	36%	68%	79%	44%	67%
Peleliu	Rain (Inches)	5.39	5.26	5.60	4.61	5.71	26.57
	% of avg.	51%	59%	75%	67%	47%	58%

* This is a new station; % of average uses (AVG Koror + AVG Intl. Airport)/2. The WSO moved from Koror to the International Airport and the climate data from Koror (as WSO) ended in February 2019. The WSO climate data is now from the new office at the International Airport.

Predicted rainfall for Palau from July 2019 through June 2020 is:

Palau Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]
Jul - Sep 2019	90%
Oct - Dec 2019	100%
Jan - Mar 2020	100%
Apr - Jun 2020	100%

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

Republic of the Marshall Islands (RMI)

Dry! Wet! Dry! Wet! And Dry again! Such has been the pattern of rainfall in the RMI over 2916, 2917, 2018 and through the first half of 2019 (Figure RMI-1). A major region-wide drought occurring in the first half of 2016 was the final major effect of the epic El Niño of 2015/16. In late 2016 and early 2017, conditions were wet, followed by yet another prolonged spell of relatively dry weather spanning the middle months of 2017. In the latter half of 2017 rainfall amounts steadily increased. This increase of rainfall continued into early 2018, so much so that during the first half 2018 both Majuro and Kwajalein experienced new historical records for high rainfall that crushed the old high marks by large margins! (see PEAC 3Q 2018 newsletter). In the latter half of 2018, and continuing into 2019, conditions again became drier, especially in some of the northern atolls.

Very dry conditions began in mid-January 2019 at some atolls of the northern RMI (e.g., Kwajalein, Wotje and Utirik), and was (and still is) of sufficient magnitude to warrant the inclusion of these atolls in each of a sequence of Drought Information Statements (DIS) issued by the WFO Guam. Relevant text from the latest DIS issued on 13 June 2019 is included below.

LOCAL SUMMARY AND FORECAST

```
DROUGHT INFORMATION STATEMENT
NATIONAL WEATHER SERVICE TIYAN GU
1010 AM CHST THU JUN 13 2019

...EXTREME TO EXCEPTIONAL DROUGHT PERSISTS OVER NORTH-
ERN MICRONESIA...

SYNOPSIS...
THE POST EL NINO DRY WEATHER PATTERN PER-
SISTS...ESPECIALLY FOR AREAS NORTH OF 10N...BUT WIND
FLOW PATTERNS SHOULD SLOWLY CHANGE AND HELP SPREAD
RAINFALL OVER THE REGION. THE NORTHERN MARSHALL IS-
LANDS NORTH OF KWAJALEIN AND NORTHERN YAP STATE ALONG
WITH NORTHERN MARIANA ISLANDS AND GUAM REMAIN MUCH
DRIER THAN NORMAL. THE WEATHER OVER THESE AREAS WILL
BE RELATIVELY DRY FOR THE NEXT FEW WEEKS ALTHOUGH SOME
WIDESPREAD SHOWERS HAVE ALREADY OCCURRED IN JUNE.

DROUGHT REMAINS EXCEPTIONAL FOR ATOLLS AND ISLANDS OF
THE FAR NORTHERN MARSHALL ISLANDS ALONG AND NORTH OF
10N. RESIDENTS OF THESE ATOLLS SHOULD CONTINUE STRICT
WATER CONSERVATION MEASURES. AREAS AROUND MAJURO
AND KWAJALEIN/EBEYE HAVE RECEIVED A FEW SHOWERS. AREAS
FROM ENEWETAK TO UTIRIK AND WOTJE REMAIN VERY DRY BUT
PATCHY SHOWERS COULD START PASSING OVER THESE AREAS.
THE SOUTHERN ISLANDS OF THE RMI HAVE RECEIVED HELPFUL
SHOWERS BUT DRIER WEATHER MAY DEVELOP AND ALL PEOPLE
OF THE RMI SHOULD SERIOUSLY CONSIDER WATER CONSERVA-
TION MEASURES. SEE SUGGESTIONS BELOW AND CONTACT LOCAL
WATER MANAGERS FOR WATER CONSERVATION GUIDELINES.

COMPUTER MODELS SUPPORT THE PREDICTION THAT DRIER THAN
NORMAL WEATHER WILL CONTINUE OVER NORTHERN PARTS OF
MICRONESIA INCLUDING THE MARSHALL ISLANDS AND THE MAR-
IANA ISLANDS. MODELS ARE INDICATING SOME RELIEF AS
WIND FLOW PATTERNS HAVE CHANGED AND PATCHY SHOWERS
WILL DEVELOP NEAR AND OVER THESE MORE NORTHERN LOCA-
TIONS...BUT RELIEF FROM DROUGHT WILL BE A LONG-TERM
PROCESS. THE MAIN ISLANDS OF MICRONESIA APPEAR TO HAVE
SUFFICIENT WATER RESOURCES AT THIS TIME.

THE OPERATIONAL U.S. DROUGHT MONITOR SHOWS UTIRIK AND
WOTJE OF THE RMI REMAIN IN EXCEPTIONAL DROUGHT D4-SL
(SHORT AND LONG-TERM DROUGHT LEVEL 4 OF 4).

SUMMARY OF IMPACTS...

FAR NORTHERN ISLANDS...
UTIRIK REPORTED 1.15 INCH AND WOTJE REPORTED 0.45 INCH
OF RAINFALL IN JUNE SO FAR. A FEW PASSING TRADE-WIND
SHOWERS SHOULD DEVELOP IN THE COMING WEEKS BUT THE FAR
NORTHERN ISLANDS ALONG AND NORTH OF 10N WILL REMAIN
VERY DRY. MORE SHOWERS WILL START DEVELOPING OVER ARE-
AS FROM ENEWETAK AND BIKINI TO UTIRIK AND WOTJE TO
KWAJALEIN/EBEYE...UJAE...RONGELAP...AILUK AND MEJIT
ISLAND BUT DROUGHT WILL PERSIST UNTIL MUCH MORE SUB-
STANTIAL RAINFALL ACCUMULATES. AT EBEYE...HEALTH IS-
SUES RELATED TO WATER PROBLEMS HAVE BEEN REPORTED.

MAJURO HAS RECEIVED SUBSTANTIAL JUNE RAINFALL BUT DUE
TO THEIR LARGE POPULATIONS...MAJURO AND EBEYE SHOULD
CAREFULLY MONITOR AND REGULATE FRESH WATER RESOURCES.

IT WAS REPORTED THAT DISCARDED CIGARETTES CAUSED SOME
FIRES ON MAJURO. THE MAJURO DUMP HAD A LARGE FIRE AND
IS HIGHLY VULNERABLE TO ANOTHER. GRASSLAND FIRES ARE
POSSIBLE ON ALL OF THE DRY ISLETS...AND THEY CAN
SPREAD RAPIDLY WITH BRISK TRADE WINDS.
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LOCAL SUMMARY AND FORECAST

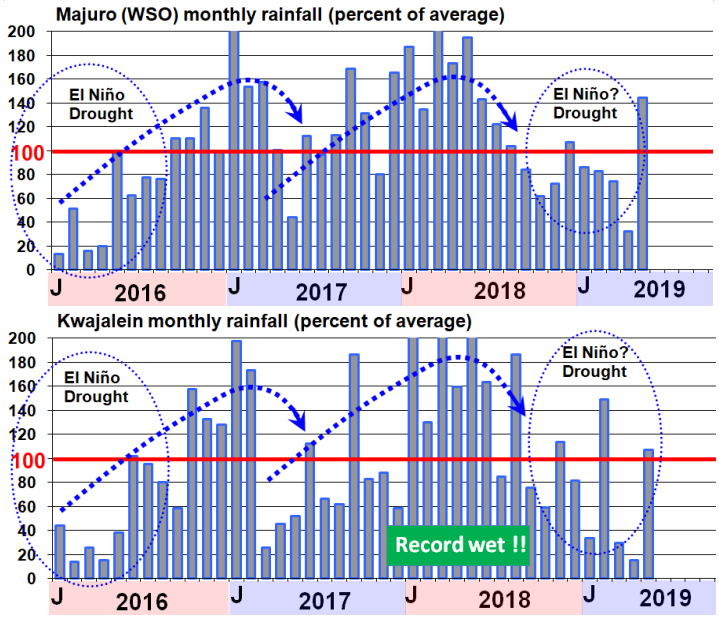
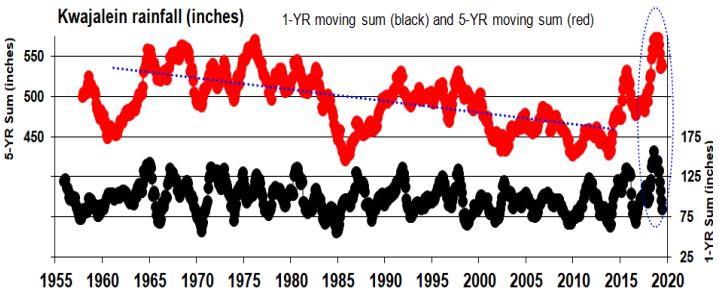


Figure RMI-1. (Top panel) A time series of rainfall at WSO Majuro (gray bars) during 2016 through May 2019. Note two repeated dramatic rises (dotted blue arrow-tipped lines) from dry conditions early in the year to the return of abundant rainfall in the both fall of 2016 and the fall of 2017. Rainfall in the first half of 2018 was at record high levels. (Bottom panel) A time series of rainfall at Kwajalein (gray bars) during 2016 though May 2019. Renewed dryness in 2019 severely affected potable water supplies in some northern atolls. Long-term fluctuations at Kwajalein are similar to those seen at Majuro in the top panel, except that the depth of dryness is greater at Kwajalein (an other atolls in the north). The El Niño drought of 2016 and the return of extreme dryness in the first half of 2019 are highlighted by the dotted blue ovals. Although El Niño officially began in February 2019, the extreme dryness of early 2019 is more typical of the post-Peak Phase of an El Niño.

RMI Long– Term Rainfall

Substantial rainfall occurring during the each of the first few months of 2014, 2015 and 2018 at many atolls of the RMI has had the effect of temporarily reversing a long-term drying trend that is apparent in the time series of the historical record of rainfall at both Kwajalein and Majuro (Figure RMI-2). The long-term drying that occurred from the 1960s through 2013 was substantial, resulting in the net loss of a typical rainy season month's worth (~10 inches) of rain from the annual average at these two stations. Big Wet conditions during 2014, 2015 and 2018 show most dramatically in the 5-year running sums, which at Kwajalein rose to a time-series high by the end of 2018. Figure RMI-3 shows the time series of the annual and the 5-month (JFMAM) rainfall at Wotje and Utirik. A highlight here is the near record annual rainfall during 2018, followed by record and very low rainfall at Utirik and Wotje, respectively, in the first 5 months of 2019.



LOCAL SUMMARY AND FORECAST

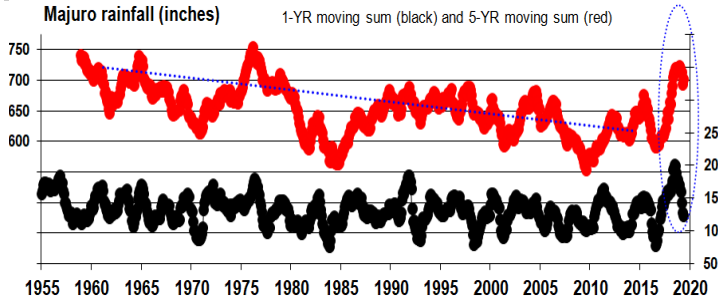


Figure RMI-2. 1- and 5-year moving sums of accumulated rainfall at (a) Kwajalein and (b) Majuro (looking backwards). Note two features of these time series: (1) the long-term downward trend and (2) the abrupt upswing at the end of each time series. Prior to the current "spike" of heavy rainfall, Majuro and Kwajalein had undergone a continual decline in rainfall over the span of their post-WWII historical record (blue dotted lines), but by the end of 2018 the Kwajalein 5-year sum had risen to its highest value in its historical record (blue dotted ovals).

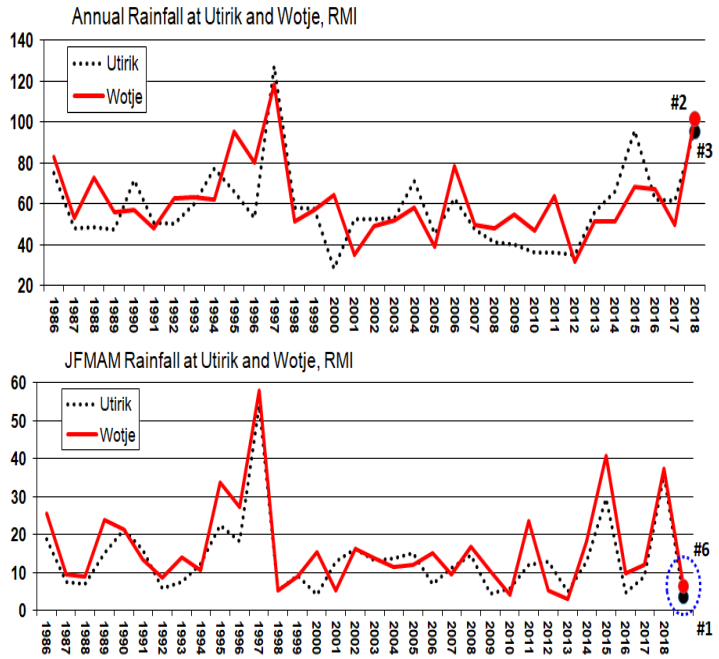


Figure RMI-3. Annual and 5-month (JFMAM) rainfall at Utirik and Wotje. Numbers on the endpoints highlight the ranking of near-record high annual values for 2018, and for the record and near-record low values for the first 5-months (JFMAM) of 2019.

RMI Sea Level

The sea level across the RMI has similar variations as seen across much of the rest of Micronesia (Figure RMI-4). Its ENSO response is also vey similar: high during prolonged La Niña with downward spikes of very low sea level that typically bottom-out in December of an El Niño year. Sea level recovery is rapid in the first few months of the post-Peak year of El Niño (e.g., 1983, 1998, 2010 and 2016). The plunge of sea level noted at Guam during 2018 was not as dramatic at Kwajalein. The sea level at both Guam and Kwajalein has commenced a rise in concert with an uptick in the trade-wind forcing.

LOCAL SUMMARY AND FORECAST

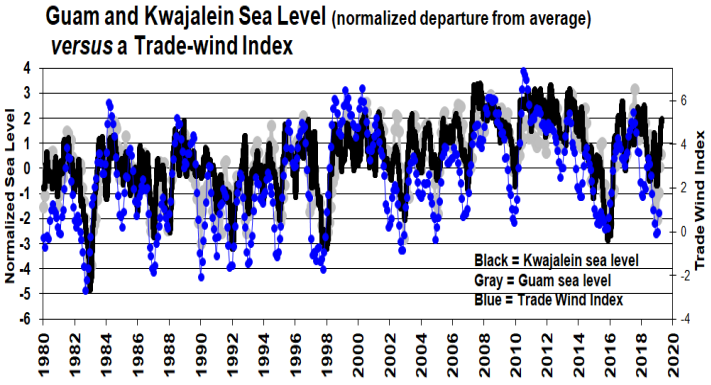


Figure RMI-4. A time series of the sea level at Guam and at Kwajalein for the period 1980 to present. Note the substantial fall of sea level during 2018, with a renewed up-tick in early 2019. Note also the close relationship of the sea level with the Pacific trade winds at these two locations. Plotted values are anomalies normalized to the respective standard deviations.

RMI Rainfall Summary: Monthly Totals for JFMAM and 5 Month Grand Total

RMI Rainfall Summary							
Station		**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**5– MO**
RMI Central and Southern Atolls							
Majuro WSO	**Inches**	**7.23**	**5.09**	**6.13**	**3.34**	**16.14**	37.93
	% Avg	**86%**	**83%**	**74%**	**32%**	**144%**	86%
Ailing	**Inches**	**3.19**	**10.30**	**6.90**	**0.72**	**3.19**	24.30
	% Avg	**49%**	**220%**	**111%**	**8%**	**30%**	66%
Jaluit	**Inches**	**2.93**	**7.04**	**8.73**	**6.84**	**6.67**	32.21
	% Avg	**35%**	**114%**	**105%**	**67%**	**60%**	73%
Mili	**Inches**	**8.50**	**8.79**	**15.92**	**2.93**	**11.54**	47.68
	% Avg	**101%**	**143%**	**192%**	**29%**	**103%**	108%
Station		**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**5– MO**
RMI Northern Atolls							
Kwajalein	**Inches**	**1.54**	**4.82**	**1.22**	**1.14**	**10.71**	19.43
	% Avg	**34%**	**149%**	**30%**	**15%**	**107%**	66%
Wotje	**Inches**	**1.93**	**1.18**	**0.30**	**0.40**	**2.66**	6.47
	% Avg	**88%**	**56%**	**11%**	**10%**	**58%**	41%
Utirik	**Inches**	**1.91**	**0.25**	**0.08**	**0.08**	**1.19**	3.51
	% Avg	**94%**	**13%**	**3%**	**2%**	**28%**	24%

Climate Outlook:

After a long climb during 2018 from the cool side to the warm side of ENSO-Neutral, the state of the Pacific climate system finally entered El Niño as per the February 2019 CPC ENSO statement (see the Current Conditions Section). The recent dryness in the northern atolls of the RMI is typical during the post Peak Phase of El Niño, even though El Niño has officially recently begun. Whether or not the current El Niño has already matured, or will continue through 2019 lends some extra uncertainty to the forecast of rainfall and TC activity for the RMI. For now, in keeping with an assumed maturity of El Niño, 3-month computer projections and persistence, the PEAC forecast of rainfall for the RMI will call for average to below-average rainfall over the next few months, rising to near average thereafter. The risk of a damaging tropical storm or typhoon in the RMI may be slightly enhanced during late September through the end of the year, especially if warm SST remains in-place in equatorial waters near the International Date Line.

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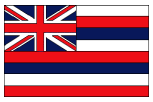
Predicted rainfall for the atolls of the RMI from July 2019 through June 2020:

Inclusive Period	% of long-term average		
	South of 6ºN	6ºN to 8ºN	North of 8ºN
Jul - Sep 2019	100%	**90%**	**95%**
Oct - Dec 2019	100%	**100%**	**100%**
Jan - Mar 2020	90%	**90%**	**85%**
Apr - Jun 2020	95%	**90%**	**90%**



Hawaii: Following the unusual heavy rain event in late June, most of the state experienced much drier conditions in July. Trade winds persisted through most of the month, but as was the case in June, these winds were mainly straight from the east, or even east-southeast, instead of from the east-northeast. Once again, this was due to lower than normal surface air pressure north of the state, resulting in a veering of the low level winds over the main Hawaiian Islands. The slight shift in the prevailing wind direction has shifted rainfall patterns on the islands as well, resulting in persistent dryness over central Oahu, windward West Maui, and the windward Kohala and Hamakua slopes of the Big Island.

There were no flash flood events that produced damage in July. The most notable heavy rain event during the month occurred on July 8 and 9 as the remnant circulation of Tropical Cyclone Barbara passed south of the state while moving generally westward. Periods of heavy rain along the southeast-facing slopes of the Big Island resulted in nuisance flooding on July 8. This was followed by briefly heavy rainfall over Lanai, leeward Maui, and the North Kona and South Kohala Districts of the Big Island on July 9. Lingering enhanced low level moisture helped boost afternoon rainfall over the west side of the Big Island on July 10 and 11.

According to the NOAA Climate Prediction Center (CPC), El Nino conditions remain present in the Pacific Ocean. The forecast from CPC favors a continuation of El Nino through at least the summer and possibly through the end of 2019. The El Nino is expected to remain a weak event based on a consensus of the main dynamical and statistical models. An update to the outlook will be issued by CPC on July 11.

Tropical Cyclone Barbara, which was a powerful Category 4 hurricane earlier in July, changed to a tropical cyclone. Cold sea surface temperatures and strong upper-level shearing winds caused Barbara to degenerate rapidly before entering the Central Pacific. Even though Barbara was not a tropical cyclone, it's forecast path was just south of the islands that brought locally heavy rainfall, especially for windward areas of the islands. A flash flood watch was posted for parts of the state.

LOCAL SUMMARY AND FORECAST

Seasonal rainfall Outlook for Hawaii:

	Station			
Inclusive Period	**Hilo**	**Honolulu**	**Kahului**	**Lihue**
Aug-Oct 2019	50% chance of Above Median rainfall	45% chance of Above Median rainfall	50% chance of Above Median rainfall	45% chance of Above Median rainfall
Oct-Dec 2019	40% chance of Above Median rainfall	40% chance of Above Median rainfall	40% chance of Above Median rainfall	40% chance of Above Median rainfall
Jan-Mar 2020	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
Apr-Jun 2020	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

Discussion: The precipitation outlook reflects the dynamical model output and a transition to ENSO neutral during early autumn. During transition to ENSO neutral, relationships from SSTs to precipitation weaken quickly, and intraseasonal variability is likely to dominate. Dynamical models (NMME) tilt toward above normal precipitation with some statistical tools on the drier side, compared to the dynamical models . The official outlook is between the two sets of tools. Trade winds are likely to return to normal levels as the calendar advances through 2019, which could lead to locally drier conditions on leeward sections of the islands, though the overall climate scale circulations still favor above normal precipitation as the most likely single category. The human With the predicted ENSO neutral state later in the year, a return to climatological conditions necessitates an equal chances forecast for later in 2019 (Source: https://www.cpc.ncep.noaa.gov/products/predictions/90day/fxhw40.html)

LOCAL SUMMARY AND FORECAST

Seasonal Drought Outlook for Hawaii: Severe drought is no longer present in Hawaii (http://w1.weather.gov/data/HFO/DGTHFO) :

SYNOPSIS...A low pressure system of the type normally seen during the October through April wet season brought significant rainfall to the west half of the main Hawaiian Islands in late June. As a result, drought conditions have eased from Kauai County to Molokai and Lanai in Maui County. Severe drought, or the D2 category on the U.S. Drought Monitor map, over the leeward slopes of Kauai, Oahu, and Molokai eased to moderate drought conditions, or the D1 category. The drought gradient on the southern slopes of the Big Island is very strong, with extreme drought, or the D3 category, remaining in place near South Point. On the island of Maui, severe drought remains in place along the lower leeward slopes of Haleakala from Kihei to Kaupo.

From the Global Satellite Picture: *Observations from the recent global satellite picture (Fig. SL-3, below) revealed that the sea levels have been near normal over the western part of the Pacific Basin.*

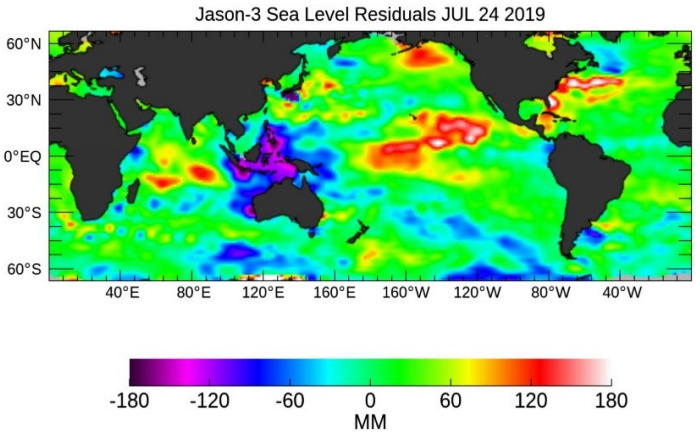


Figure SL-2. Jason-3 sea level residuals (July 24, 2019).

***Pacific ENSO Update* is Now Available Online:**
To receive notification when the newsletter is available online visit:
http://www.weather..gov/peac/update.php

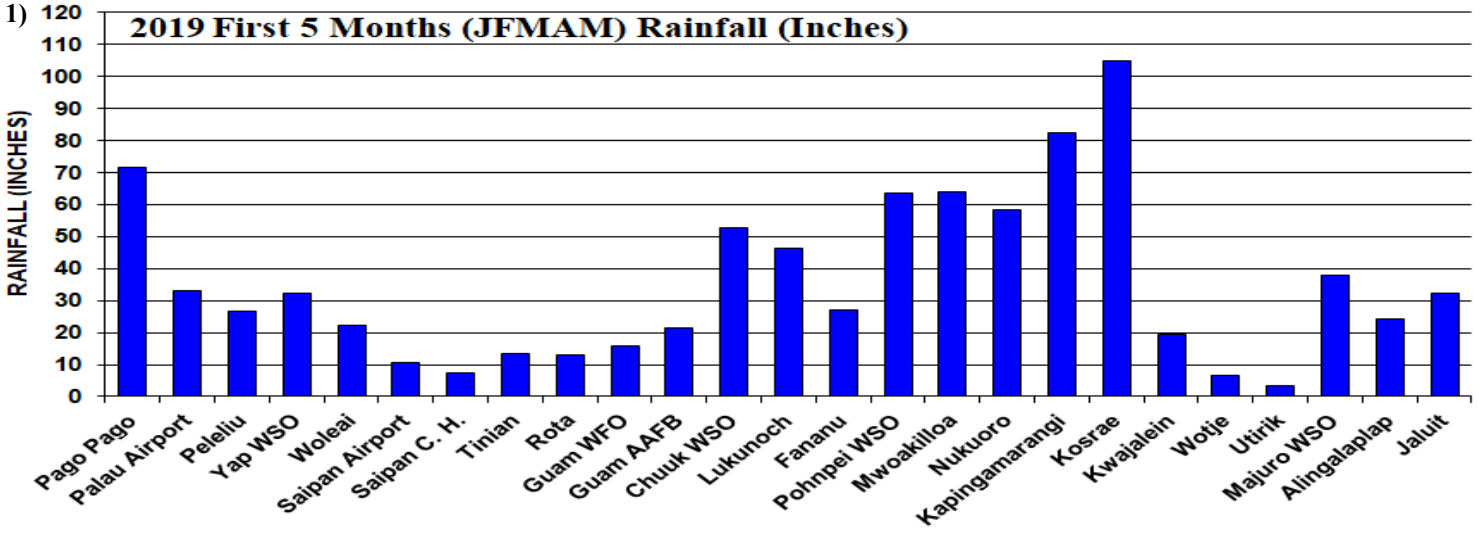
This will be the last newsletter edition of the PEAC Center's quarterly newsletter. The next issue will appear in a different format.

PACIFIC ENSO UPDATE

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

SEASONAL RAINFALL OUTLOOK FOR THE US-AFFILIATED PACFIC ISLANDS

1)



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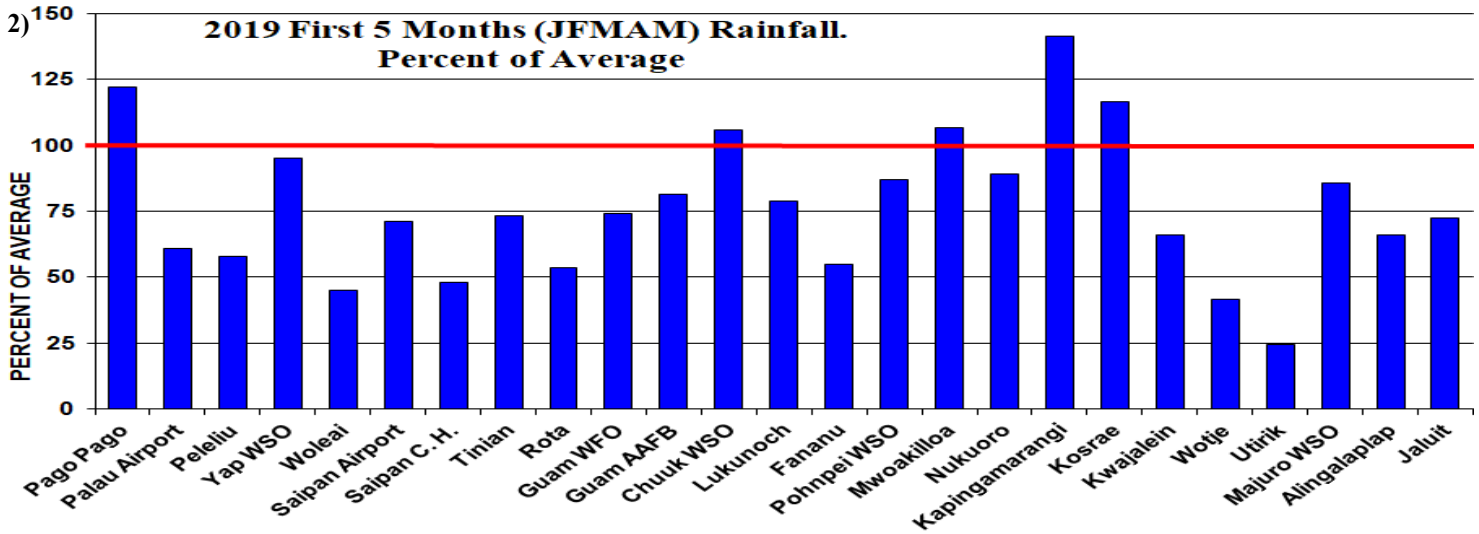

Figure 1 and 2, 2019 First 5 Months rainfall as a percent-of-average at the indicated locations. Note the widespread occurrence of below-average rainfall. This rainfall distribution is typical during the first half of a post-El Niño year.

ACKNOWLEDGEMENTS AND FURTHER INFORMATION

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

Dr. Rashed Chowdhury,
Principal Research Scientist, at 808-956-2324 (rashed@hawaii.edu): for information on ENSO and sea level variability in the USAPI.

University of Hawai'i - Joint Institute of Marine and Atmospheric Research (JIMAR), School of Ocean and Earth Science and Technology (SOEST),
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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:
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Christopher Brenchley, 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):
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Pacific ENSO Update Editors:
Sony Vang and Rashed Chowdhury

The Pacific ENSO Update is a bulletin of the Pacific El Niño-Southern Oscillation (ENSO) Applications Climate (PEAC) Services. 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 online and in hard copy (currently online ONLY), 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.

PEAC is part of the Weather Forecast Office (WFO) Honolulu's mission and roles/responsibilities. All oversight and direction for PEAC is provided by the Weather Forecast Office Honolulu in collaboration with the Joint Institute for Marine and Atmospheric Research (JIMAR) at the University of Hawaii. Publication of the Pacific ENSO Update is supported by the National Oceanic and Atmospheric Administration (NOAA), National Weather Service-Pacific Region Climate Services. The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA, any of its sub-agencies, or cooperating organizations.