Pacific ENSO Update

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

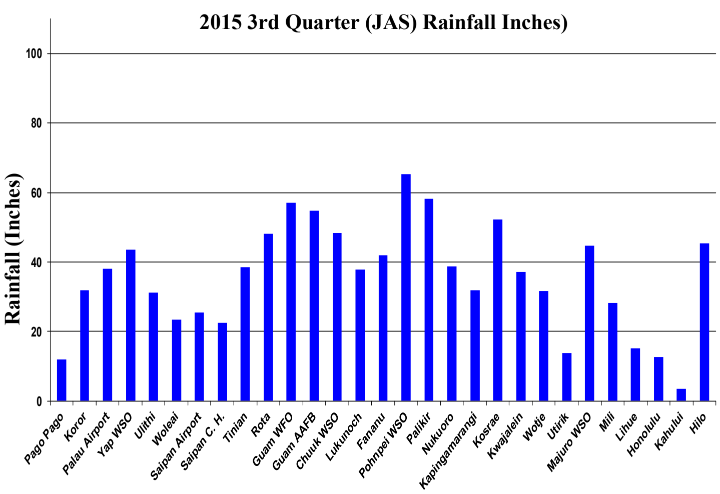
http://www.prh.noaa.gov/peac

CURRENT CONDITIONS

The 2015 El Niño event has become strong, rivaling the strong El Niño events of 1982-83 and 1997-98. During the first half of 2015, many of the atmospheric effects of the current El Niño event were already exhibiting substantial deviations from average conditions. These included noteworthy extremes of rainfall and an abundance of early-season tropical cyclones. Early oceanic responses portending strong El Niño included a rapid oceanic surface and sub-surface warming and a dramatic lowering of the sea level across much of Micronesia. Oceanic indices used to diagnose El Niño, such as the SST anomaly in the Nino 3.4 region, reach their peak long after the atmosphere begins to exhibit wild weather patterns typical of El Niño onset. Whereas wild weather patterns (e.g., extreme rains and early season typhoons) arrive in the first half of the El Niño year, the oceanic response to El Niño peaks late in the El Niño year (around December). Through mid-October, the whole North Pacific Basin has seen a very high number of tropical cyclones (see the tropical cyclone discussion), with Hawaii and most of the islands of Micronesia experiencing multiple threats and various effects from the passages of these cyclones. During the 3rd Quarter, the island of Saipan in the CNMI was impacted by two tropical cyclones: (1) very intense Typhoon Soudelor in early August; and (2) a lesser storm (Tropical Storm Champi) in mid-October (see the Saipan LVS for more details). Persistent gusty westerly surface winds had mostly nuisance effects at many Micronesian islands, such as disruption of local fisheries and minor inundation on west-facing shores. However, many atolls, especially those in the Marshall Islands, saw more substantial damages that amounted to more than $10 million. With the exit of Typhoon Champi from the western North Pacific during the last week of October, a dry spell ensued across most of the region that may mark the early stages of an anticipated post-El Niño widespread severe drought.

Rainfall totals during the first half and 3rd Quarter of 2015 were above average at most locations, with a hint of regional dryness just now beginning to show in the far west of Micronesia (i.e., at Palau and across the islands of Yap State) (Fig. 1 and Fig. 2). At locations in central and eastern Micronesia, rainfall was abundant at most locations. Wetter than average rainfall (and in some cases, much wetter than average rainfall) was observed at many islands. A tropical cyclone was observed within the bounds of Micronesia in every month of 2015 through October (see the tropical cyclone discussion).

The sea level throughout Micronesia has been very high over the past decade, with some small dips during times of weak to moderate El Niño events. As a sure sign of El Niño, sea level fell continually across most of Micronesia during late 2014 and through October of 2015. The lowest anomaly of sea level tends to occur in December of a typical El Niño year. See the discussion of sea level for more details.



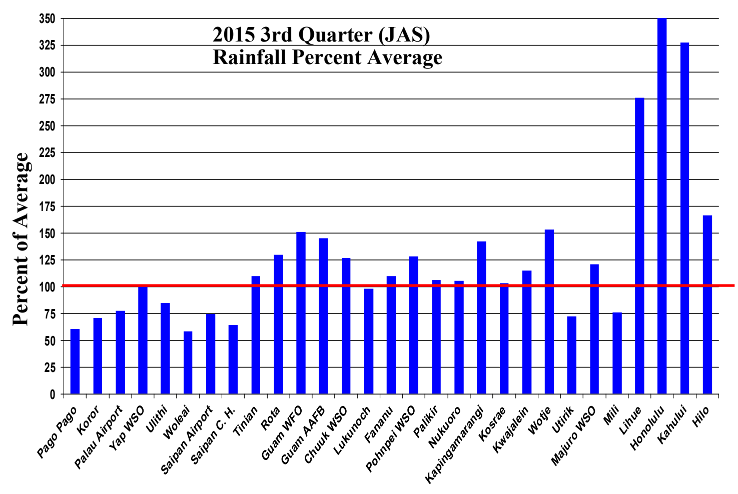


Figure 1 and 2, **(1)** 2015 3rd Quarter (JAS) rainfall amounts in inches at the indicated locations. **(2)** 2015 3rd Quarter (JAS) rainfall percent of average at the indicated locations.

TROPICAL CYCLONE ACTIVITY

The PEAC archives western North Pacific tropical cyclone 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 tropical cyclone names, track coordinates, central pressures, and 10-minute average maximum sustained wind estimates from advisories issued by the Tropical Cyclone Warning Centers at Brisbane, Nadi, and Wellington. The numbering scheme and the 1-minute average maximum sustained wind estimates are taken from warnings issued by the JTWC. There are sometimes differences in the statistics (e.g., storm maximum intensity) for a given tropical cyclone among the agencies that are noted in this summary.

Tropical Cyclone Summary

Since January 2015, there have been 27 numbered tropical cyclones in the western Pacific and 27 in the combined central and eastern Pacific. Typhoons Halola and Kilo, are counted in both basins as they developed in the central Pacific and crossed into the western Pacific. Many of the U.S.-Affiliated Pacific Islands have been under continual threat, with occasional adverse effects from close passages or direct hits of the basin's many cyclones.

Since the last PEAC Center regional summary, tropical cyclone activity was once again abundant across the tropical Pacific, with some large month-to-month variation and some see-saw of activity between the western and central North Pacific. Many of the US-Affiliated Pacific Islands were impacted by heavy rain, large surf and gale-force winds associated with the many tropical cyclones and the extended monsoon system. During strong El Nino years, storm genesis over the western Pacific Basin tends to shift eastward, as far as the Marshall Islands, making for increased greatly increasing the tropical cyclone threat for most of the U.S. Affiliated Pacific Islands. During September and October 2015, the U.S. Affiliated Pacific Islands were once again battered by tropical cyclones. Forming north of Pohnpei, the monsoon depressions that became typhoons Koppu and Champi produced high winds, heavy rainfall, and high surf from Kosrae westward through Guam and the CNMI. On October 16, Typhoon Champi, while still a tropical storm, passed very close to Saipan where wind gusted to 81 mph at the International Airport and nearly 20 inches of rain fell in 24 hours. Damage was relatively minor: a few trees felled, 8 utility poles toppled, and island power intentionally shut off for the day of the storm. A week earlier, Pohnpei Island experienced unusually strong monsoon squalls with repeated wind gusts to 40 mph. Local fishing on Kosrae and Pohnpei has been severely disrupted by the ceaseless gusty westerly winds and high surf. Except for islands in the far western portion of Micronesia (e.g., Palau and Yap) where the typical El Niño quiescence and dryness may have already begun, episodes of heavy rainfall, high wind, and high surf are stressing the residents of the battered region that still reels from the impacts of damaging storms like Maysak, Dolphin and Soudelor.

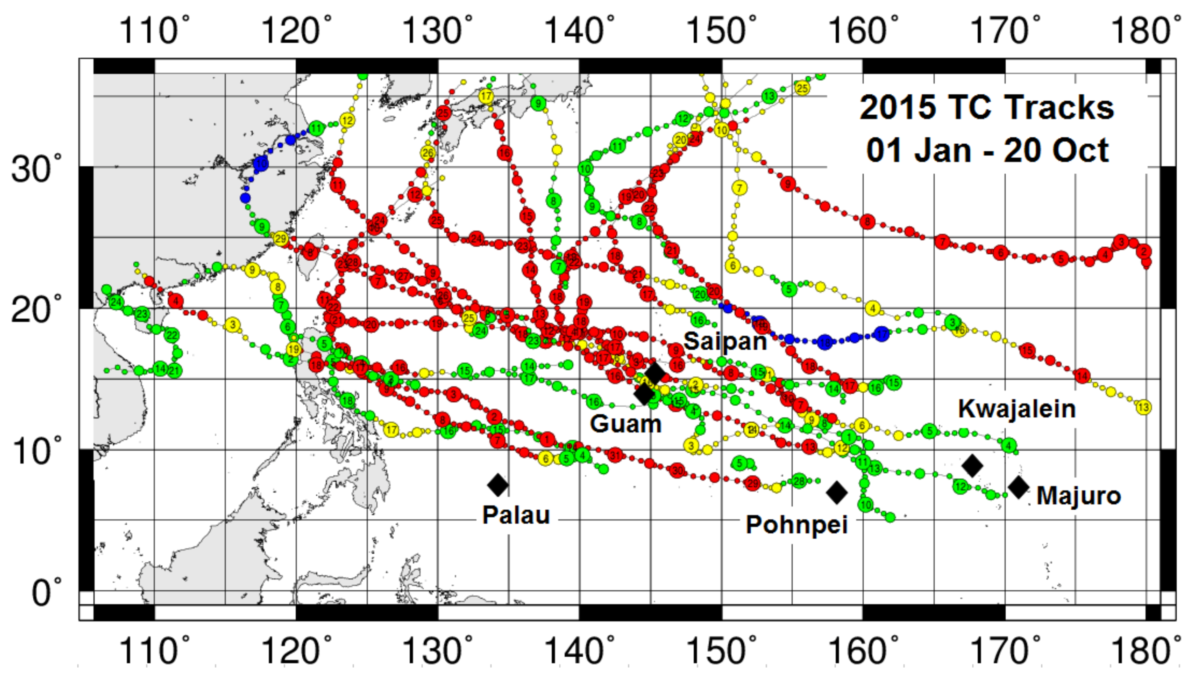


Figure 3. WestPAC tropical cyclones during Jan-Oct 2015. Note that nearly all pass somewhere within the boundaries of Micronesia, with two of them (Bavi and Nangka) becoming tropical storms while passing Kwajalein, and two others (Halola and Kilo) moving into the western North Pacific from the central Pacific. This distribution of tropical cyclones only happens during El Niño.

PEAC Center Tropical Cyclone Assessment
Western North Pacific and American Samoa

A very similar suite of climate indicators that had predicted El Niño in the first few months of 2014 was once again present in even greater force in early 2015. This includes heavy rainfall in the RMI, abundant early season typhoons, major westerly wind bursts (WWBs) along the equator, and falling sea level. During early March, early May, and early July, major WWBs occurred, with each leading to the formation of tropical cyclones. Two cases of named twins occurred in association with the March and July bursts: Bavi and Pam; then Chan-hom and Raquel (Fig. 3). Chan-hom and Raquel represented the first historical case of named twin cyclones during July. Continual low-latitude westerly winds and the WWBs forced an oceanic response to the east: a deepening of the thermocline that yielded a major surface and subsurface warm anomaly that tipped the climate system into relatively strong El Niño for this time of year, with a high likelihood of a continuation of moderate or strong El Niño for the rest of the year.

TROPICAL CYCLONE ACTIVITY

PEAC Tropical Cyclone Assessment

Western North Pacific and American Samoa

As time progresses during an El Niño year, typhoon activity shifts ever more exclusively to the east. This progression, however, is not enough to move the cyclones safely away from the eastern half of Micronesia. The risk of a damaging tropical cyclone in Micronesia is greatly enhanced by El Niño, even weak or moderate ones. Indeed, the US-Affiliated Pacific Islands (US-API) of the western Pacific have already this year suffered great damage from tropical cyclones associated with El Niño. This damage has been widespread (though not everywhere severe) from the Marshall Islands and westward across Chuuk State, Guam, the CNMI and Yap State. This is likely to continue through 2015 and into January 2016. The risk of a damaging tropical cyclone will be especially high for the remainder of 2015 through January 2016 across Micronesia from Guam all the way eastward to the RMI. Most Micronesia islands will have about a 1-in-3 chance of serious effects from some combination of high winds, large waves, and/or extreme rainfall associated with a late-season typhoon over the next three months, with a near better than 50% chance of additional severe effects from a typhoon somewhere generically within Micronesia during the remainder of 2015 through January 2016.

American Samoa passed its 2014-2015 cyclone season without major problems, and now is poised to enter its rainy season of 2015-2016. American Samoa may face a busy 2015-2016 cyclone season. During strong El Niño, there is a slightly enhanced up-front (i.e., November through January) risk of a damaging tropical cyclone. The risk falls away to near or below average in the latter portion of the cyclone season (i.e., February through April) as TC activity pushes far to the east into French Polynesia and beyond.

SEA SURFACE TEMPERATURES

For the past Quarter (July, August, and September), ENSO conditions remained in an El Niño Advisory.

Overall, across the Pacific representative conditions of El Niño were present with consistent enhanced convection over the central and eastern equatorial Pacific and suppressed convection over Indonesia.

Above-average SSTs continued to increase across the equatorial Pacific with anomalies exceeding 1 degree Celsius. Consistent with ocean-atmosphere coupling significant low level westerly winds and upper level easterly winds persisted for the past three months. The combined atmospheric and oceanic state are indicative of a strong El Niño.

SOUTHERN OSCILLATION INDEX

The 3-month average of the Southern Oscillation Index for the Fourth Quarter of 2015 including July, August, and September remained negative at –1.6. The respective monthly values were –1.4, -1.6, and –1.7. Consecutive periods of negative SOI values and warm ocean waters across the eastern tropical Pacific are indicative of El Niño.

Normally, positive SOI values in excess of +1.0 are associated with La Niña conditions, and negative SOI values below -1.0 are associated with El Niño conditions. Low SOI values suggest a weak coupling between the ocean and the atmosphere. The SOI is an index representing the normalized sea level pressure difference between Darwin, Australia and Tahiti.

SEASONAL SEA LEVEL OUTLOOK FOR THE US-AFFILIATED PACFIC ISLANDS

The following sections describe: the Canonical Correlation Analysis (CCA) forecasts for seasonal (mean and maxima) sea level anomalies (seasonal cycle removed) for the forthcoming seasons October-November-December (OND), November-December-January (NDJ), and December-January-February (DJF) of 2015 and 2016; OND return values at 20 and 100-yr period; the observed monthly mean and maximum sea-level anomalies for the previous season JAS of 2015, and; Seasonal sea level variability: Island Summary. *Note that, seasonal cycles have been removed for the data anomalies that are defined as 'deviations or departures from the normal' using the 1983 through 2001 mean sea level value computed at each station. Also note that CCA-forecasting technique adopted here does not account for sea level deviations created by other atmospheric or geological factors such as tropical cyclones, storm surges or tsunamis.*

Observed monthly sea level anomalies in JAS 2015

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

Current Conditions As compared to previous months, the monthly mean sea level in September 2015 recorded further fall in Yap, Pohnpei, and Majuro. However, stations like Guam, Palau, Honolulu, and Hilo recorded slight rise. Currently, all the north Pacific stations are below normal. Among others, Palau is about 8 inches below normal, Yap is 8 inches below, Majuro is 4 inches below, and Kwajalein is 5 inches below normal. Pago Pago is stable which is expected. The monthly maximum values also displayed some fall in most of the stations. Starting from JFM 2014, a comparative perspective of two years of seasonal sea level variations is given below (Fig. 4). In JFM 2015, most of the island recorded considerable fall (4 to 6 inches), as compared to the sea level of JFM 2014. This fall is even more significant when compared to last 10 years.

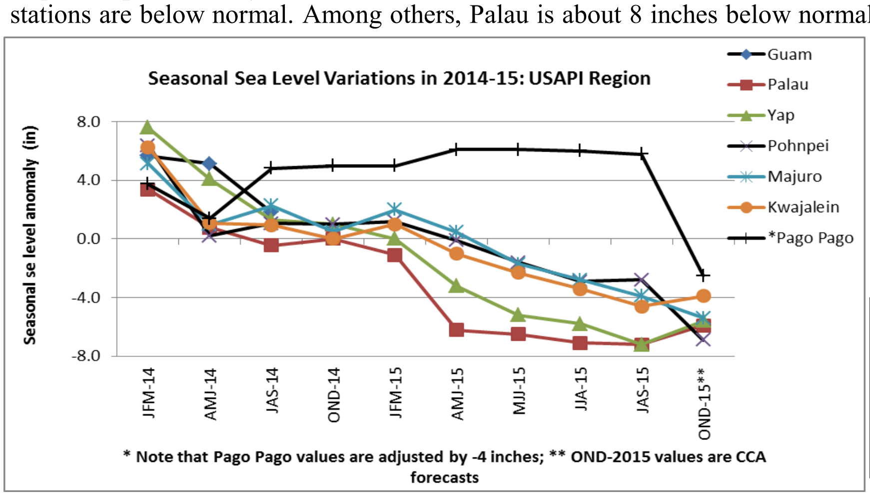


Figure 4. A comparative perspective of Island-wise seasonal sea level variations (JFM 2014 to JAS 2015; Forecasts for OND are denoted by **) (*Note that Pago Pago data was adjusted by subtracting 4 inches from the current values. This correction was done because of level shift (approximately 4 inches) after 2009 earthquake).

SEASONAL SEA LEVEL OUTLOOK FOR THE US-AFFILIATED PACFIC ISLANDS

Table 1: Monthly observed mean/maximum sea-level anomalies in inches

Table 1. +/- 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. * In Pago Pago, there was a level shift (approximately 2-4 inches) at the time of September 2009 earthquake.

Tide Gauge Station	Monthly Mean Deviations[1]				Monthly Max Deviations[2]				
	Jul	Aug	Sep	Standard Deviations	Sea level Trend	Jul	Aug	Sep	Standard Deviations
Marianas, Guam	+1	-5	-3	3.6	Falling	+4	-2	-1	3.4
Malakal, Palau	-7	-8.5	-7	4.5	Falling	-6	-4	-4	4.6
Yap, FSM	-7.2	-6.4	-8	4.8	Falling	-8	-2	-4	4.2
Chuuk, FSM***				*	**	**			
Pohnpei, FSM	-3.5	-2.8	-2.8	3.4	Falling	-6	-2	-5	3.3
Kapingamarangi	+2	0	0	**	Stable	+8	+2	+2	**
Majuro, RMI	-3.4	-3.9	-4.2	2.5	Falling	-4	-4	-2	3.2
Kwajalein, RMI	-4	-5	-5	3.0	Falling	-6	-3	-3	3.5
Pago Pago*	+10	+10	+9	3.4	Stable	-10	-10	-10	3.6
Honolulu	-0.5	0	+1	1.8	Stable	+2	+2	0	2.3
Hilo	-1	0	+3	1.8	Rising	+2	+2	+2	2.4

Seasonal sea level forecast (anomalies with respect to climatology) for OND, NDJ, and DJF of 2015-2016

Forecasts of the sea-level anomalies in the USAPI (see http://www.prn.noaa.gov/peac/map.php) are presented using CCA statistical model. Based on the independent SST and zonal wind (U) (SST-U) values in JAS of 2015, the resulting CCA model has been used to forecast the sea level of three consecutive seasons: OND (0-month lead), NDJ (1-m lead), and DJF (2-m lead) (see Table 1: panel shows values for seasonal mean while the right panel shows the seasonal maxima). All the tide gauge stations (at 0 to 2-months lead time) provided skillful forecasts for these three consecutive seasons.

The current sea level forecasts indicate that most of north Pacific stations are likely to be considerably below normal (normal and average are synonymously used throughout the sea level section) in the forthcoming OND, NDJ, and DJF seasons of 2015-16. Palau, Yap, Pohnpei, Chuuk, and Majuro are expected to be well below normal. Guam and Kwajalein are expected to be below normal during the same time period. The lone south Pacific Island Pago Pago is expected to be marginally above normal (this station has been above normal for a long time). In Hawaii, both Honolulu and Hilo are likely to be slightly elevated, but still close to normal. This current trend is very supportive to the on-going moderate-to-strong strength El Niño state; several features across the tropical Pacific are characteristic of moderate-to-strong El Niño conditions. The current forecasts show further falling trend when compared to the previous quarter. This fall is very significant fall (i.e., 4-7 inches) when compared to the forecasts of OND, NDJ, and DJF seasons of 2013-14. Note that the current seal level still remains higher than the sea level minima observed during the historically strongest El Niño year 1997-98. This suggests that, in terms of sea level, the Pacific basin may not yet experienced the full impact of a strong El Niño event, and we may therefore see another drop in sea level in the coming weeks.

Observations from the recent global satellite picture (Fig. 5) revealed that sea levels have been low over the western part of the Pacific Basin and high over the central and eastern Pacific. This is very typical in any moderate-to-strong El Niño year (i.e., 1982-83, 1997-98), and our observations and forecasts are very consistent to this satellite image.

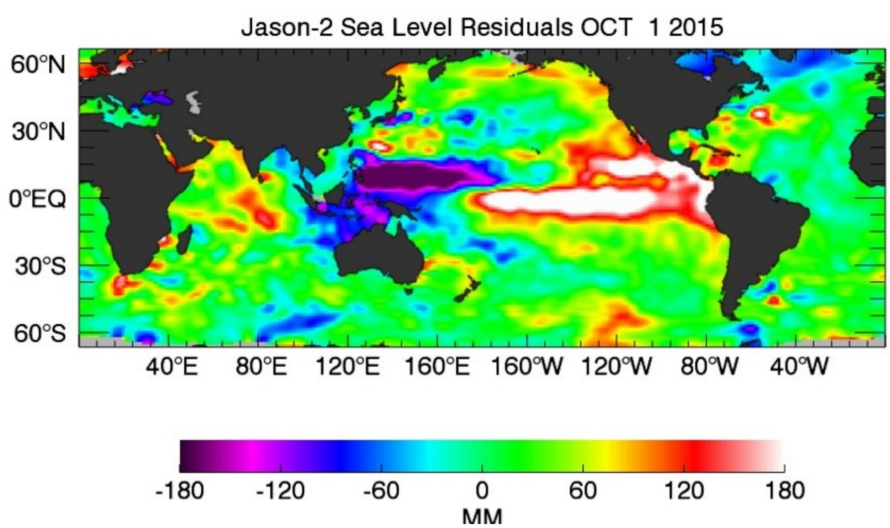


Figure 5. Jason-2 Sea Level Residuals October 1 2015.

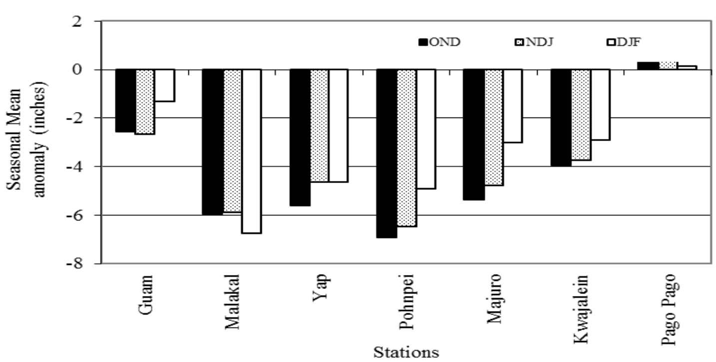
SEASONAL SEA LEVEL OUTLOOK FOR THE US-AFFILIATED PACFIC ISLANDS

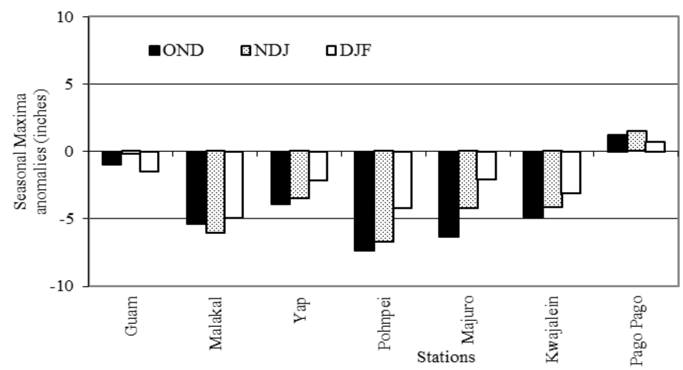
Table 1: Forecasts of sea level anomalies in inches (OND, NDJ, and DJF)

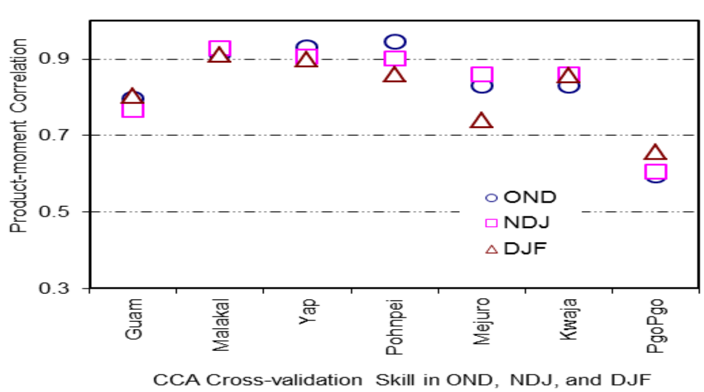
Table 2 Note: (-) indicate negative anomalies (fall of sea level from the mean), and (+) indicate positive anomalies (rise of sea level from the mean), n/a: data not available. Anomalies from -1 to +1 inches are considered negligible and anomalies from -2 to +2 inches are unlikely to cause any adverse climatic impact. Forecasts for Chuuk (**) are estimated subjectively based on information from WSO Chuuk and observations from neighboring stations of Pohnpei and Yap. All information is based on 1983-2001 epoch. *** There was a level shift (approximately 2-4 inches) in American Samoa at the time of September 2009 earthquake. So, -3 inches needs to be adjusted to the current tide-gauge values of Pago Pago. 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.

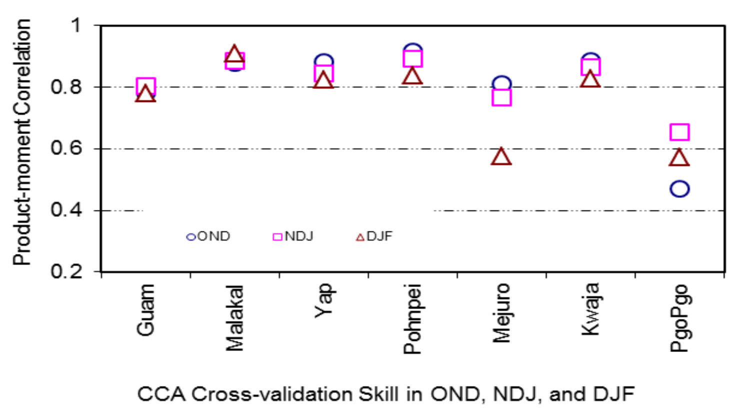
	Seasonal Mean Deviations [1]				Seasonal Max Deviations [2]					
Tide Gauge Station	**OND**	**NDJ**	**DJF**	**Seasonal Outlook[3]**	**OND**	**NDJ**	**DJF**	**Seasonal Outlook[3]**	**JAS: Return Period[4]**	
Lead Time [5]	**0M**	**1M**	**2M**	**Seasonal Outlook[3]**	**0**	**1M**	**2M**	**Seasonal Outlook[3]**	**20- YR**	**100-YR**
Marianas, Guam	-3	-3	-2	Below	-1	-1	-1	Marginal Below	6.5	9.1
Malakal, Palau	-6	-6	-7	Well Below	-6	-6	-5	Well Below	6.1	6.4
Yap, FSM	-6	-5	-5	Well Below	-4	-4	-2	Below	8.2	11.0
Chuuk, FSM**	-6	-5	-5	Well Below	-4	-4	-2	Below	n/a	n/a
Pohnpei, FSM	-7	-7	-5	Well Below	-7	-7	-4	Well Below	9.1	11.8
Majuro, RMI	-5	-5	-3	Well Below	-6	-4	-2	Well Below	5.7	6.4
Kwajalein, RMI	-4	-4	-3	Below	-5	-4	-3	Below	6.6	8.4
Pago Pago, Am. Samoa***	+1	+1	0	Normal	+1	+1	0	Normal	4.9	6.1
Honolulu, Hawaii	+2	+2	+2	Marginal Above	+1	+1	+2	Marginal Above	3.0	3.7
Hilo, Hawaii	+2	+2	+3	Marginal Above	+2	+1	+1	Marginal Above	3.2	5.2

[1] **See for reference,** Chowdhury M. R., Chu P-S., Guard C (2014): An improved Sea Level Forecasting Scheme for Hazards Management in the U.S.-Affiliated Pacific Islands, *Int. Journal of Climatology* 34: 2320-2329 (also see references therein).









SEASONAL SEA LEVEL OUTLOOK FOR THE US-AFFILIATED PACFIC ISLANDS

ENSO and Sea Level Variability: Understanding Low Sea Levels in 2015-2016

The sea level in the U.S-Affiliated Pacific Islands (USAPI) is very sensitive to the phase of the El Niño-Southern Oscillation (ENSO) climate cycle—indicating El Ninõ to low sea level and La Ninã to high sea level. Therefore, starting from January 2015, the sea level in the USAPI region is continuously falling. In the following section we discuss the falling trend during this year's El Niño, and compare the trend with respect to other historically strong El Niño events (i.e., 1997-98, 1982-83). These two strong El Niño event of 1997-98, 1982-83 consisted of El Niño-La Niña pairs containing consecutive years having an El Niño followed by a La Niña. Therefore, in investigating this, the sea-level variability of 1997-99 and 1982-84 ENSO reversals consisting of an El Niño immediately followed by a La Niña has been examined. While our comparison is primarily focused on the El Niño event, the analyses related to of El Niño-La Niña pairs also came to our analysis. The comparison therefore raises question about a probable La Niña in 2016 (see http://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/). However, at this exploratory stage, comprehensive analyses to isolate the role of atmospheric and oceanic dynamical factors are beyond the scope of this article; rather, our approach is mainly empirical.

ENSO and Sea-level Variability

Although ENSO events differ substantially from one another in various respects, there are defining patterns used for identifying specific ENSO events. The ranking method that we adopt here uses both the SOI and ONI, and is as follows. If the values of SOI are (i) less than -1.0 then it is a moderate-to-strong El Niño, and (ii) if the values are more than +1.0 then it is a moderate-to-strong La Niña event. The values of -0.5 to -1.0, or 0.5 to 1.0, correspond to a weak-to-moderate El Niño or La Niña event, respectively. Similarly, values of ONI of (i) more than +1.0 define moderate-to-strong El Niño, and (ii) less than -1.0 define a moderate-to-strong La Niña event. The values of 0.5 to 1.0, or -0.5 to -1.0, correspond to a weak-to-moderate El Niño or La Niña event, respectively. Based on these thresholds of SOI and ONI, the intensity of 2-year (8 consecutive seasons) having a reversal of warm-to-cold ENSO episodes may be categorized, as shown in Table 3 (also see Chowdhury el al., 2010)[1].

Table 3. Intensity of El Niño/La Niña events for 3-month periods during three two-year episodes with El Niño during the first year, followed by La Niña during the second year.

Note. JAS, OND, JFM, and AMJ stand for July-August-September, October-November-December, January-February-March, and April-May-June. * 2016-17 Intensity of El Niño/ La Niña are prepared from model based forecasts (see http://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/).

Season	2015-17	1997-99	1982-84
JAS	Moderate El Niño	Strong El Niño	Strong El Niño
OND	Strong El Niño	Strong El Niño	Strong El Niño
JFM	Strong El Niño*	Strong El Niño	Strong El Niño
AMJ	Moderate El Niño*	Transition	Moderate El Niño
JAS	Neutral*	Moderate La Niña	Transition
OND	Transition*	Moderate La Niña	Moderate La Niña
JFM	Weak La Niña*	Moderate La Niña	Weak La Niña
AMJ	Weak La Niña*	Moderate La Niña	Weak La Niña

Sea level of most of the stations in the USAPI region started to fall from late 2014; some stations went below average in April of 2015, and since then a gradual falling trend among all of the stations are observed—this trend is still prevailing. From July to September of 2015, a weak-to-moderate El Niño conditions influenced the ocean and atmosphere. In October, the event gained strength and became a strong one; it is currently (i.e., OND season) in the state of strong event and, according to statistical/dynamical model forecasts, the strong event is likely to last for another 3 to 6 months. Then after a brief transition through ENSO-neutral conditions, a weak-to-moderate La Niña conditions may develop and persist in the latter half of 2016. Likewise, the 1997-98 and 1982-83 El Niño events are classified as strong and moderate, and 1998-99 and 1983-84 La Niña events are classified as moderately strong. When the fall of sea level during the two other moderate-to-strong El Niño events (1997-98 and 1982-83) is compared to the fall of sea level in the 2015-16 event, the latter was found to be considerably higher in JAS to SON seasons. For example, Guam was 6.8 and 7.5-inches below in SON of 1997 and 1982; currently it is 3 inches below normal. There are several other stations that displayed similar pattern. On the other hand, Palau's recent fall was comparable to the values of 1997 and 1982.

Based on the above findings, we make the following conclusions. At this stage these are our hypothesis for further research:

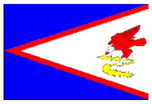
(1) The current seal level still remains higher than the sea level minima observed during the historically strongest El Niño year 1997-98 and 1982-83. This suggests that, in terms of sea level, the Pacific basin may not yet experienced the full impact of a strong El Niño event, and we may therefore see another drop in sea level in the coming weeks/months;

(2) As compared to previous two strong El Niño event, most of the USAPI tide stations recorded elevated sea levels from January to October of 2015, which from a historical perspective is quite significant, since no other El Niño event on record has resulted in an elevated sea level in the USAPI. Therefore, the elevated sea level during the El Niño period in JAS and SON of 2015 was an anomaly. We hypothesize that other factors in addition to ENSO contributed to this elevated sea level;

(3) Our observations at this stage support the anecdotal assertions of sea level rise in general in recent decades; we are therefore led to believe that the globally pervasive rise in sea level very much applies to the general vicinity of the USAPI, and is particularly accentuated in particular USAPI sub-regions.

[1]Also see Chowdhury M. R., Barnston A. G., Guard C., Duncan S., Schroeder T, and Chu P-S (2010): Sea-level variability and change in the U.S-Affiliated Pacific Islands—Understanding the high sea levels during 2006-08, Weather, 65(10):263-268, Wiley.

LOCAL SUMMARY AND FORECAST



American Samoa: The 3rd Quarter months of July, August and September are the heart of the typical Dry Season at American Samoa. The rainfall total of 11.94 inches during the 3rd Quarter 2015 was well below average (61%). Impacts of unusually dry weather included brown grass and deterioration of well water quality. The local Weather Service Office (WSO) issued a Drought Information Statement for the islands, and the local water and utility company issued a drought statement of its own. In view of the continuing and intensifying dryness, the drought status for Pago Pago was deteriorated to D2-S (Severe Drought-Short Term) as reflected in an experimental drought assessment conducted by the U.S. Drought Monitor. Rainfall amounts recovered during October with over 8 inches recorded at Pago Pago, but this was still below average (76%). Amounts at other locations on Tutuila Islands were wetter, with Suifaga Ridge reporting 23.36 inches in October or 115% of the Pago Pago average.

Since January 2014, the monthly mean sea level in Pago Pago remained above normal and in May it was reading +0.5 inch above normal. Currently, it is +5 in inches above normal. This rise is expected, as the sea level fall in American Samoa displays a couple of months delay with respect to north Pacific Islands.

American Samoa Rainfall Summary: 2015 3rd Quarter and October

Station		July	Aug	Sep	Oct	3rd Qtr
Pago Pago	Inches	3.99	6.75	1.20	8.15	11.94
	% Avg	64%	101%	18%	76%	61%
Siufaga Ridge	Inches	18.13	13.80	3.48	23.36	35.41
	% Avg*	149%	83%	20%	115%	77%

* Based on Pago Pago averages.

Climate Outlook: The Pacific basin climate is currently in a state classified as strong El Niño. Indices of El Niño typically peak late in the El Niño year, and the ultimate strength of El Niño is usually pegged to its condition in December or January. Regardless of the ultimate peak of the ENSO indices, the El Niño event of 2015-16 will take its place among the top three of the past 40 years, in a league with the epic El Niño events of 1982-83 and 1997-98. The PEAC will issue forecasts based on the occurrence of a strong El Niño.

American Samoa lies in an area of the Pacific where the relationships between rainfall and ENSO are weak, with few consistent anomalies that can be used to make a reliable long-range forecast. During the very strong El Niño's of 1982-83 and 1997-98, American Samoa experienced continual dryness punctuated by a few wet months (Fig. 3). The rainfall in the dry season of the year following both these El Niño events (e.g., May through August 1983, and May through August 1998) was especially low. For all lesser El Niño events, there is no consistent pattern to the rainfall behavior. The rainfall outlooks for American Samoa will assume that the behavior of the local climate during late 2015 into the first half of 2016 will be comparable to 1982-83 and 1997-98.

American Samoa may face a busier than normal 2015-2016 cyclone season. During strong El Niño, there is a slightly enhanced early season (i.e., November through January) risk of a damaging tropical cyclone. The risk falls away to near or below average in the latter portion of the cyclone season (i.e., February through April) as TC activity pushes far to the east into French Polynesia and beyond.

Sea levels should begin to fall now and likely to stay negative until June 2016. The highest fall is expected during March-May of 2016. The annual cycle of American Samoa (Pago-Pago) is nearly flat, with slightly higher sea level in March and lower sea-level in May-June. This is typical cycle of the tropical Southern Hemisphere, due to the seasonal steric effect and the expansion (contraction) of the water column at the end of the southern summer (winter).

Predicted rainfall for American Samoa from October 2015 through September 2016 is:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]
October - December 2015 (Onset of next Rainy Season)	75% (25.94 inches - Pago Pago)
January - March 2016 (Heart of next Rainy Season)	80%
April– June 2016 (Onset of Next Dry Season)	40%
July– September 2016 (Dry Season)	50%

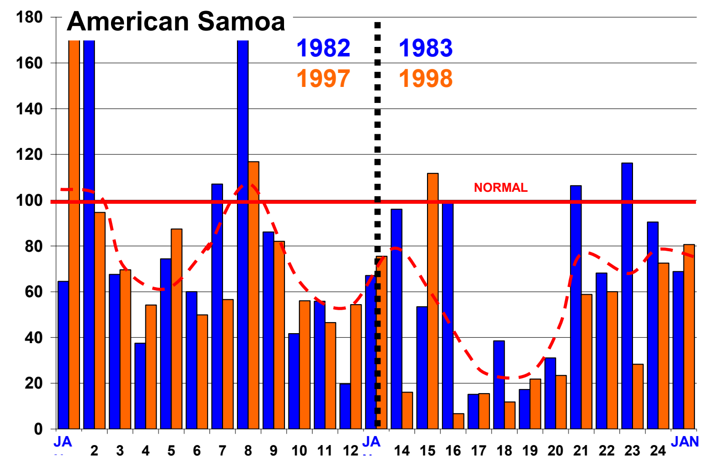
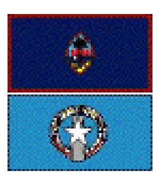


Figure 6. Monthly rainfall distribution (in percent) during two strong El Niño events: 1982-83(blue) and 1997-98(orange). Note a similar seasonal variability and the occurrence of the driest anomaly during the dry season months of the year that follows both these El Niño events. This behavior is how the PEAC long-range rainfall forecasts for American Samoa have been tailored. The red dashed line shows the smoothed rainfall trend for the average of the two events.



Guam/CNMI: Through October 2015, Guam and the CNMI were located at a nexus for tropical cyclone tracks (see earlier Fig. 3). All of these named cyclones (as well as the pre-named developing stages of many others) impacted the islands and regional waters with high winds, large surf and heavy rainfall. One of the typhoons – Soudelor – caused severe damage on Saipan during its passage at Category 4 intensity directly over that island on the night of 02 August. Named tropical cyclones that adversely affected Guam and/or the CNMI through October 2015 include:

(1) Tropical Storm Bavi (March); (2) Typhoon Dolphin (May); (3) Tropical Storm Chan-hom (July); (4) Super Typhoon Nangka (July); (5) Typhoon Soudelor (August); (6) Typhoon Goni (August); and, (7) Typhoon Champi (October)

The Pacific regional headquarters of NOAA in Pearl Harbor, Hawaii requested a meteorological assessment of Typhoon Soudelor on Saipan after that storm severely affected the island

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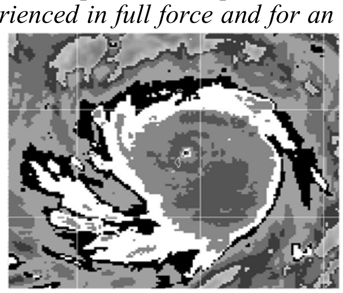
with winds substantially higher than anticipated. Fortunately there were no deaths or serious injury attributed to this typhoon. A portion of the final assessment written by Charles Guard (Guam Weather Forecast Office) and Mark Lander (University of Guam) follows:

In the earlier assessment, Soudelor was ranked as a high Category 3 typhoon, with peak over-water wind speed of 110 knots with gusts to 130 knots (127 mph with gusts to 150 mph). As noted in the first press release, some of the damage on Saipan was consistent with even stronger gusts to at-or-above the Category 4 threshold of 115 knots with gusts to 140 knots (130 mph with gusts to 160 mph). After reanalyzing more than a hundred original damage pictures obtained on-site by the assessment team, assessing some new damage information from subsequent visits, and conducting a careful analysis of other factors relating to typhoon intensity, such as the measurements of the minimum central pressure and the characteristics of Soudelor's eye on satellite imagery, the team has now raised its estimate of Soudelor's equivalent over-water intensity to the 115-knot (130 mph) sustained wind threshold of a Category 4 typhoon. The typical peak gust associated with a tropical cyclone of this intensity is 140 knots (160 mph).

Gusts of this magnitude are capable of causing the type of extensive damage seen on portions of central Saipan. Not every part of the island experienced these peak winds. The north and south ends of the island were spared the worst because those locations were not located under the inner portion of the eyewall. The central west coast of the island had some of the most impressive wind damage, with numerous healthy mature ironwood trees uprooted or snapped at the trunk. Patches and swaths of heavier wind damage are readily explained by turbulent wind flow across complex terrain. The treefall pattern was surprisingly coherent, and nicely delimits the path of the small typhoon across the mid-section of the island. The "First Wind" was dominant at most locations, with the "Second Wind" having a lesser signal in most areas. This was likely the result of the great extent of treefalls in the "First Wind". The presence of some trees in close proximity felled in opposite directions was thought by some to be evidence of tornadoes, but most, if not all, of the treefall pattern is consistent with the large-scale swirling cyclonic flow of the typhoon itself.

The reason for this supplemental release is to refine the assessed intensity and to provide a single reference value. In the original press release, the typhoon over-water intensity was assessed a bit lower. Patches of damage that seemed to be outliers slightly in excess of the assigned typhoon wind speed range were attributed to gusts enhanced by terrain or perhaps even small-scale features within the typhoon eyewall itself. Particularly after carefully studying the treefall pattern and damages, the assessment team felt that the large-scale swirling wind of the typhoon with a sustained wind and peak gust of a single magnitude would be an appropriate metric from which one could account for all the observed effects of the typhoon. The patches of heavier damage are now viewed as areas where, for reasons of complex terrain and exposure, the peak over water gust of 140 knots was experienced in full force and for an extended period."

Figure 7. Enhanced infrared satellite image (at 1301 UTC 02 August 2015, 0101 AM 03 August Local) using a false gray-shade enhancement known as the "BD Curve" indicates that the intensity of Soudelor has reached a sustained magnitude of 115 kt.



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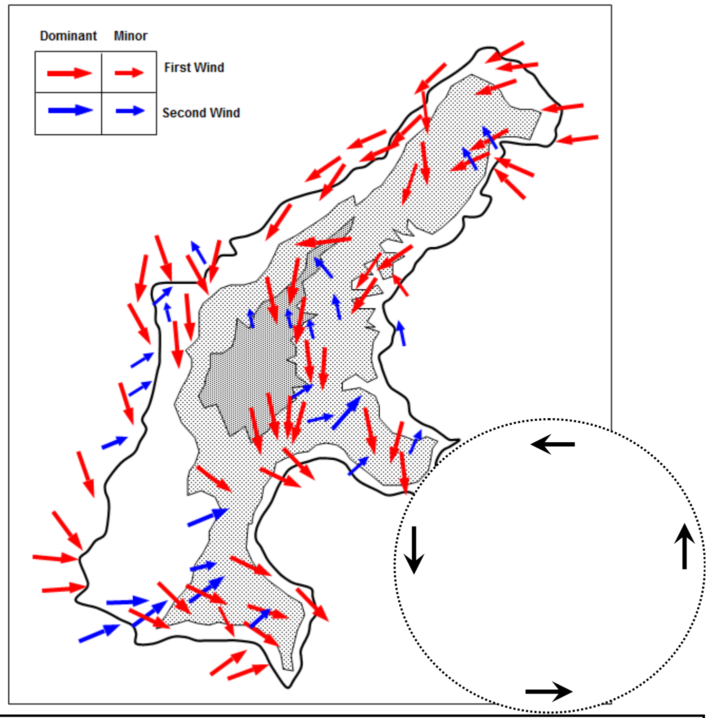

Figure 8. A map of the treefall pattern on Saipan caused by Typhoon Soudelor. The typhoon spins counterclockwise (circular inset), so as the eye passes across the island, the winds are first from a northerly direction (red arrows), then after the eye passes, the winds switch direction and have a southerly component (blue arrows). Most of the observed treefall was from the "First Wind". There were fewer trees blown over by the "Second Wind", primarily because there were so many trees blown over by the "First Wind" (almost 100% in some places) that there was little left for the "Second Wind". Many eyewitnesses perceived that the First Wind was stronger than the "Second Wind". Stippled areas show high ground: outer stippled area > 50 meters (164 feet), inner stippled area > 200 meters (656 feet).

Guam and CNMI Rainfall Summary: 2015 3rd Quarter

Station		July	Aug	Sep	3rd Qtr
GUAM					
GIA (WFO)	Inches	21.80	21.54	13.71	57.05
	% Avg	207%	157%	102%	151%
AAFB	Inches	20.19	24.24	10.32	54.75
	% Avg	185%	181%	77%	145%
Southern Mountains	Inches	16.54	26.98	15.82	59.34
	% Avg	151%	201%	119%	158%
CNMI					
Saipan Int'l Airport	Inches	8.47	7.69	9.26	25.42
	% Avg	105%	62%	69%	75%
Tinian Airport	Inches	8.43	20.86	9.24	38.53
	% Avg	134%	4%	217%	110%
Rota Airport	Inches	10.28	22.92	14.89	48.09
	% Avg	98%	174%	111%	130%

Guam sea level remained slightly elevated throughout the years 2014 and part of 2015. It fell down to below normal (-2 in) in April 2015, but did not last long. In the following May and June, it recorded slight rise again. In August it fell down

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abruptly (-5 in). Currently, it is below normal (-3 in). The monthly maxima also fell down sharply—currently the maximum is also below normal.

Climate Outlook: The Pacific basin climate is currently in a state classified as strong El Niño. Indices of El Niño typically peak late in the El Niño year, and the ultimate strength of El Niño is usually pegged to its condition at its peak. Regardless of the ultimate peak of the ENSO indices, the El Niño event of 2015-16 will take its place among the top three of the past 40 years, in league with the epic El Niño events of 1982-83 and 1997-98. The PEAC will issue forecasts based on the occurrence of a strong El Niño. This includes the continued high risk (1-in-3 odds) of a typhoon on Guam and on all southern islands of the CNMI. The typhoon threat will persist through January of 2016. Notorious El Niño-related typhoons tend to occur late in the year; examples include: Typhoon Karen (November 1962), Typhoon Roy (January 1988); Typhoon Yuri (November 1991); Typhoon Paka (December 1997), and Typhoon Pongsona (December 2002). The other threat posed by El Niño is major drought. Drought related to El Niño becomes severe early in the year that follows El Niño (e.g., 1983 and 1998). In a typical moderate or strong El Niño, rainfall begins to fall below normal as early as September, and then is drastically reduced in the period of January through May of the following year. November and/or December may be wet if a typhoon is experienced, otherwise abnormal dryness will take hold. Also note that the whole year following El Niño tends to be dry – Guam and the CNMI do not return to normal rainfall for over a full year following a strong El Niño. Consistent to the current El Niño state, sea level forecasts are below normal for the next seasons (OND, NDJ, and DJF) (-2 to -3 in).

Predicted rainfall for the Mariana Islands from October 2015 through September 2016:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]	
	Guam/Rota	Saipan/Tinian
October – December 2015 (Transition to Dry Season)	90%* (23.07 inches)	85%* (18.75 inches)
January – March 2016 (1st Half of Dry Season)	50%	50%*
April– June 2016 (2nd Half of Dry Seson)	65%	65%
July– September (Heart of next Rainy Season)	90%**	85%

* could be higher if a typhoon strikes!

** Higher than Saipan due to thunderstorm activity on Guam

Federated States of Micronesia

Yap State: After a spate of wild weather during the first half of 2015 associated with the passage of several tropical cyclones, the weather throughout Yap State during the 3rd Quarter of 2015 mellowed to a more tolerable typical summer pattern of moderate monsoonal westerly wind and occasional heavy showers. August was a very wet month on Yap Island, with rainfall surpassing 20 inches at the Yap WSO. September's rainfall total was generally a few inches less than during August, with the October rainfall total falling dramatically lower at every recording site in Yap State. The sharp lowering of rainfall throughout Yap State during October may be a harbinger of many months to come of below average rainfall. Ulithi and Fais are still recovering from the severe impacts of Super Typhoon Maysak that severely impacted these islands in May 2015. Yap sea level has been considerably below normal since February 2015. As compared to JAS of 2014, it fell about 9 inches in JAS of 2015. Currently it is about 8 inches below.

Yap State Rainfall Summary: 2015 3rd Quarter						
Station		Jul	Aug	Sep	Oct	3rd Qtr
Yap State						
Yap WSO	Inches	12.39	21.99	9.21	5.29	43.59
	% of avg	85%	145%	68%	44%	101%
Ulithi	Inches	14.84*	8.98*	7.42*	6.28*	31.18*
	% of avg	120%	69%*	65%	62%	85%
Woleai	Inches	11.60*	5.15*	6.72*	2.22*	23.47*
	% of avg	83%	35%	57%	16%	58%

*July: Ulithi 9 days missing; Woleai 2 days missing; Aug: Ulithi 3 days missing; Woleai: 3 days missing; Sep: Ulithi: 1-16 and 19 missing; Woleai: 7 days missing; Oct: Ulithi: 3 days missing; 2 days missing

Climate Outlook: The Pacific basin climate is currently in a state classified as strong El Niño. Indices of El Niño typically peak late in the El Niño year, and the ultimate strength of El Niño is usually pegged to its peak condition, usually in December or January. Regardless of the ultimate peak of the ENSO indices, the El Niño event of 2015-16 will take its place among the top three of the past 40 years, in a league with the epic El Niño events of 1982-83 and 1997-98. The PEAC will issue forecasts based on the occurrence of a strong El Niño. The threat of a damaging typhoon within Yap State is very high in the first half of an El Niño year – as was the case during the first half of 2015. As time progresses, typhoon activity shifts ever more exclusively to the east, and typhoons tend to lift north and/or east of Yap State. In the late fall of an El Niño year when Guam and the CNMI are under enhanced threat by typhoons, Yap State is often just out of range of the damaging effects of these storms. Good examples include typhoons Yuri (NOV 1991), Paka (DEC 1997), Roy (JAN 1988), Nida (NOV 2009) and Pongsona (DEC 2002). During the progression of El Niño, Yap State and other locations in the western half of Micronesia are among the first locations to experience a sustained drop in monthly rainfall. Drought related to El Niño becomes severe early in the year that follows El Niño (e.g., 1983, 1998 and likely now also 2016). In a typical moderate or strong El Niño, rainfall begins to fall substantially below normal by October, and then is drastically reduced in the period of December through May (Fig. 9). Monthly rainfall starts to return by May and returns to near normal by August of the year following El Niño. Forecasts for the next seasons (OND, NDJ, and DJF) sea level indicate below normal sea level (-6 inches).

Predicted rainfall for Yap State from October 2015 through September 2016 is:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]	
	Woleai	Yap & Ulithi
October – December 2015 (End of Rainy Season)	70% (25.45 inches)	75% (22.8 inches)
January – March 2016 (Heart of Next Dry Season)	40%	50%
April– June 2016 (End of Next Dry Season)	75%	70%
July– September 2016 (Heart of Rainy Season)	85%	95%

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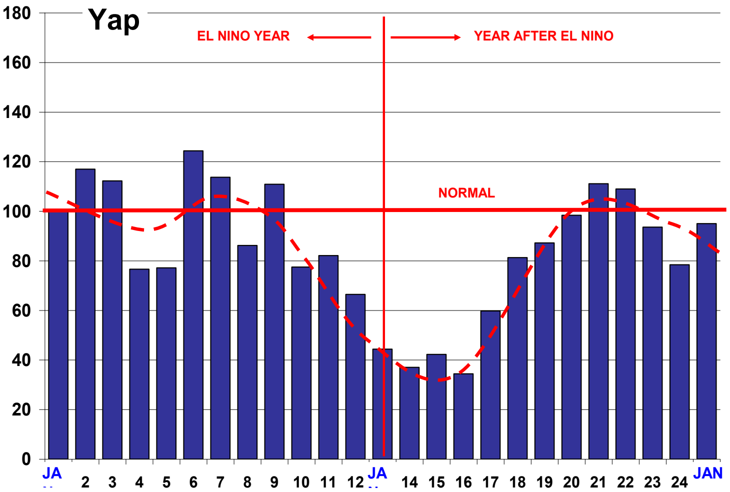

Figure 9. Rainfall at the WSO Yap for a composite of five El Nino events. Note the near-average conditions in the first half of the El Nino year, with a gradual drying that begins by August or September. Significant drying occurs in the latter 3 months of the El Niño year and is severe in the first half of the year that follows El Nino. Rains begin to return by May and full recovery occurs by about August of the year following El Niño.

Chuuk State: During 2015 to-date, most of the islands of Chuuk State have been drenched with above average rainfall. The high rainfall included several "big days" (i.e., extreme 24-hour rainfall at-or-above 5 inches). Month-to-month variation was high, and variation of rainfall among the islands and atolls of Chuuk State was also very high. This high spatial and temporal variability of rainfall observed over the first half and during the 3rd Quarter of 2015 was derived in large measure by a continual parade of tropical disturbances and named tropical cyclones passing close-by to the northern boundary of the State. Persistent and sometimes strong monsoonal westerly winds noted across Chuuk State throughout the first half of 2015 continued during August and September, bringing above average rainfall. Landslides where reported on August 12 and on September 8 as a result of heavy rains. Gusty westerly winds and rough sea conditions in the Chuuk Lagoon contributed to a boating accident with one fatality.

Islands in the Chuuk Lagoon that were heavily damaged by Typhoon Maysak during May 2015 have mostly recovered, but damage to vegetation and several structures is still apparent.

Chuuk State Rainfall Summary: 2015 3rd Quarter and October

Station		July	Aug	Sep	Oct	3rd Qtr
Chuuk Lagoon						
Chuuk WSO	Inches	6.45	19.91	22.07	6.09	48.43
	% Avg	53%	137%	191%	45%	127%
Southern Mortlocks						
Ettal	Inches	17.21	15.93	25.53	10.26	58.67
	% Avg	112%	122%	251%	99%	152%
Northern Mortlocks						
Losap	Inches	7.24	12.99	23.22	9.65	43.45
	% Avg	60%	89%	201%	72%	114%

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Chuuk State Rainfall Summary: 2015 3rd Quarter and October

Station		July	Aug	Sep	Oct	3rd Qtr
Northern Atolls						
Fananu	Inches	11.69	15.68	14.85	3.90	42.22
	% Avg	97%	108%	129%	29%	111%
Western Atolls						
Polowat	Inches	6.08	4.28	7.07	4.21	17.43
	% Avg	43%	29%	53%	35%	41%

Climate Outlook: The Pacific basin climate is currently in a state classified as strong El Niño. Indices of El Niño typically peak late in the El Niño year, and the ultimate strength of El Niño is usually pegged to its peak condition, usually in December or January. Regardless of the ultimate peak of the ENSO indices, the El Niño event of 2015-16 will take its place among the top three of the past 40 years, in a league with the epic El Niño events of 1982-83 and 1997-98. The PEAC will issue forecasts based on the occurrence of a strong El Niño.

The threat of a damaging typhoon within Chuuk State is high throughout an El Niño year, but highest earlier in the year, as the activity in the first half of 2015 has already shown. As time progresses during an El Niño year, typhoon activity shifts ever more exclusively to the east. This progression, however, is not quite enough to move the cyclones safely away from the islands and atolls of Chuuk State, except maybe at Polowat and nearby islands in the far west of the State. We anticipate two or three tropical cyclones to form in eastern Micronesia from November 2015 through January 2016. These late-season tropical cyclones may become typhoons that pose a serious threat to Guam and the CNMI, but could also pass close enough to the northern islands of Chuuk State to bring a risk of damaging wind, heavy rainfall and high surf.

El Niño also poses the threat of serious drought. Drought related to El Niño becomes severe early in the year that follows El Niño (e.g., 1983 and 1998). In a typical moderate or strong El Niño, rainfall begins to fall substantially below normal by October, and then is drastically reduced in the period of December through May (Fig. 9). Monthly rainfall begins to increase by May and returns to near normal by August of the year following El Niño.

Predictions for Chuuk State for October 2015 through September 2016:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]			
	Chuuk Lagoon, and Nama	Polowat	Nrn & NW Islands	Srn Mortlocks
Oct – Dec 2015	75% (26.67 in)	70% (24.89 in)	75% (26.66 in)	75% (38.40 in)
Jan – Mar 2016	50%	50%	50%	50%
Apr – Jan 2016	75%	70%	70%	75%
Jul– Sep 2016	90%	80%	90%	95%

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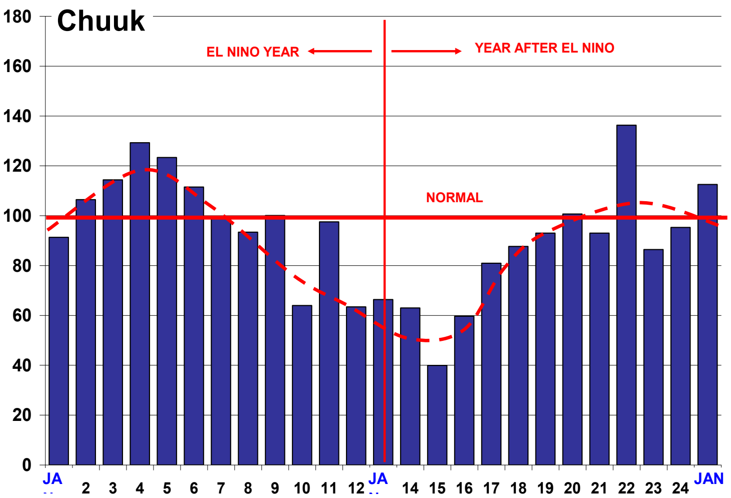

Figure 10. Rainfall at the WSO Chuuk for a composite of five El Nino events. Note the wet conditions in the first half of the El Nino year, with a gradual drying that begins by August or September. Drying is substantial in the first half of the year that follows El Nino, but recovers by July or August of the year following El Niño. Note the spike in November in what otherwise should be in a drying trend. This is an artifact of typhoon passages late in the El Niño year.

Pohnpei State: Plenty! Plenty! Rain! This was Eden Skilling's (the Pohnpei weather service Official-in-Charge) concise summary of the local Pohnpei Island weather during July, August and continuing into September. Both July and August had over 20 inches of rain at the WSO site on Pohnpei Island. Other sites on Pohnpei Island were not quite as wet as at the WSO, but were still generally above average. Nukuoro rainfall was well above average for the 3rd Quarter, while Pingelap was relatively dry. Pinglelap was the only recording location in Pohnpei State during 2015 with more dry months than wet. Near the equator at Kapingamarangi, 3rd Quarter rainfall was well above average at a time which is normally the heart of its local Dry Season. Rainfall during October was below average everywhere except at Kapingamarangi, which is consistent with the typical spatial and temporal pattern of rainfall associated with El Niño.

The big weather story of the 3rd Quarter, in addition to all the rainfall, was the relentless strong westerly wind. On September 17, a day with a total 24-hour rainfall of 3.38 inches at the WSO on Pohnpei Island, the wind gusted to 40 mph. The strong wind and copious rainfall on that day prompted many calls from the public into the Pohnpei WSO office asking if their cause was a nearby typhoon. On October 9, there was another occurrence of similar strong winds and rainfall, with wind gusts again reaching 40 mph. The public was again fearful of an unannounced nearby typhoon, and many callers were reassured by the WSO that their cause was only an active monsoon. These high winds produced only minor damage such as the felling of some banana trees. However, the persistent strong westerly wind and high surf did severely impact the ability of residents to fish their local waters. High surf advisories where issued from the Pohnpei WSO for the outer islands during these events. No reports of inundations were received from the outer islands. These heavy rain squalls driven by strong westerly winds are typical of El Niño in this region.

PEAC scientist Dr. Mark Lander visited Pohnpei Island in early October. In addition to experiencing the roaring monsoon squalls on the 9th of October, Dr. Lander noted that the damage to vegetation that occurred during the passage near the island of Tropical Storm Dolphin on the night of May 10 was still visible at some places along the high ground of ridges and mountain slopes.

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Pohnpei State Rainfall Summary: 2015 3rd Quarter and October

Station		Jul	Aug	Sep	Oct	3rd Qtr
Pohnpei Island						
Pohnpei WSO	Inches	21.31	28.33	15.59	11.86	65.23
	% Norm	116%	171%	97%	71%	128%
Atolls of Pohnpei State						
Nukuoro	Inches	15.38	26.71	11.27	10.49	53.36
	% Avg	107%	235%	102%	98%	145%
Pingelap	Inches	3.50	12.65	8.19	8.95	24.34
	% Avg	22%	85%	55%	60%	53%
Kapinga.	Inches	7.71	13.14	11.08	5.13	31.93
	% Avg	74%	213%	188%	106%	142%

*30 and 31 Aug missing for Pingelap, but that was maybe only 0.2".

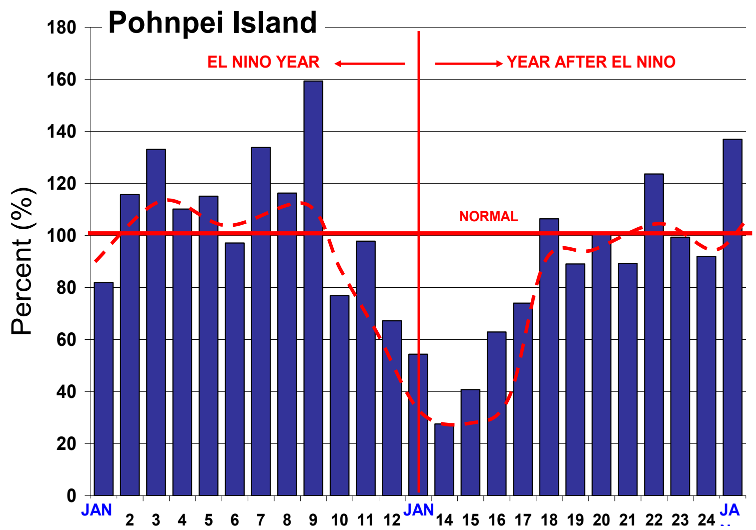

Figure 11. Percent of average rainfall at the WSO Pohnpei for a composite of five El Nino events. Note the wet conditions through September of a typical El Niño year, with a gradual drying that begins by October. Drying is substantial from December of the El Niño year through May of the year that follows El Niño. Rainfall recovers to near average by June or July of the year following El Niño. Note: the spike in September 2015 is not just an artifact of a single big month; all five September members of the composite were well above average.

Climate Outlook: The Pacific basin climate is currently in a state classified as strong El Niño. Indices of El Niño typically peak late in the El Niño year, and the ultimate strength of El Niño is usually pegged to its peak condition, usually in December or January. Regardless of the ultimate peak of the ENSO indices, the El Niño event of 2015-16 will take its place among the top three of the past 40 years, in a league with the epic El Niño events of 1982-83 and 1997-98. The PEAC will issue forecasts based on the occurrence of a strong El Niño.

El Niño poses the threat of serious drought. Drought related to El Niño becomes severe early in the year that follows El Niño (e.g., 1983 and 1998). In a typical moderate or strong El Niño, rainfall is heavy through August or September of the El Niño year, and then begins to fall below normal by October. Rainfall is substantially reduced in the period of December through May. Monthly rainfall begins to increase by April and returns to near average by July or August of the year following

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El Niño. PEAC forecasts mimic this behavior, with rainfall forecast to transition from above normal to below normal during the October-November-December season. A period of well-below normal rainfall is anticipated during January-February-March of 2016.

The threat of a damaging tropical cyclone within Pohnpei State is high throughout an El Niño year – as the passage of Dolphin and other cyclones near Pohnpei Island in the first 9 months of 2015 has already shown. As time progresses during an El Niño year, typhoon activity shifts ever more exclusively to the east. It is anticipated that two or three more tropical cyclones will form in eastern Micronesia or farther east from November 2015 through January 2016. These late-season storms will pose serious threats to Guam and the CNMI, but could also pass close enough to Pohnpei Island and the atolls of Mwokilloa and Pingelap to bring them a the risk of damaging wind, heavy rainfall and high surf.

Predicted rainfall for Pohnpei State from October 2015 through September 2016:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]	
	Pohnpei Is. And Atolls	Kapingamarangi
Oct - Dec 2015	75% (35.76 inches)	120% (26.12 inches)
Jan - Mar 2016	50%	100%*
Apr—June 2016	75%	100%*
Jul– Sep 2016	90%	100)*

* Located near the equator, the rainfall pattern at Kapingamarangi is much different than at islands and atolls farther to the north. It remains wet through the El Niño year, and may stay wet into the year following El Niño. Major drought at Kapingamarani is often associated with strong La Niña events.

Kosrae State: As at Pohnpei Island during the 3rd Quarter of 2015, there was also on Kosrae (as Eden Skilling put it succinctly) Plenty! Plenty rain! While there were no extraordinary monthly rainfall totals during the first 9 months of 2015 at the four recording sites on Kosrae, it was generally near average to slightly wetter than average, with relatively modest month-to-month variability. This was true until October 2015, when there was an abrupt decline in rainfall, and all sites were very dry. Before the rain shut off, however, there was a heavy rainfall event on October 3 that prompted the Pohnpei WSO to issue a flood statement for Kosrae (which has an airport weather observer, but does not have a local WSO). Despite this heavy rainfall, the rest of October was dry. The sudden shift to dryness in October could signal the start of a more prolonged period of dryness anticipated over the next few months as El Niño reaches its maturity and then gradually fades in the first half of 2016.

The big weather story through the first 9 months of 2015 was not particularly excessive rainfall, but the very unusual prevalence of gusty westerly wind, and the passage near Kosrae of two named tropical cyclones (Bavi in March and Dolphinin May) and the beginning pre-named stages of several other tropical cyclones. In March, during the developing phase of Typhoon Maysak, persistent westerly winds blew down a few trees, damaged or destroyed some light structures, and caused significant coastal erosion. Strong westerly winds and high surf dominated the month of September and continued into October. These strong westerly winds caused some damage to banana crops by uprooting trees. The very beginning of October was wet, before persistent dry conditions became established The persistent strong westerly winds and high surf severely impacted local fishing activities, and caused nuisance inundation and coastal erosion in Walang on the southwest side of the island. Unusually strong and persistent westerly winds are a sure sign of El Niño!

A near fatal accident occurred in the village of Lelu. A small landslide trapped a girl, and a 6-hour rescue effort was needed to extract her and get her to safety. All ended well.

Kosrae State Rainfall Summary: 3rd Quarter 2015 and October

Station		Jul	Aug	Sep	Oct	3rd Qtr
Kosrae State						
Airport (SAWRS)	Inches	16.17	19.69	16.36	6.90	52.22
	% Avg	95%	119%	95%	43%	103%
Nautilus	Inches	16.73	21.91	16.35	8.74	54.99
	% Avg	98%	133%	95%	54%	108%

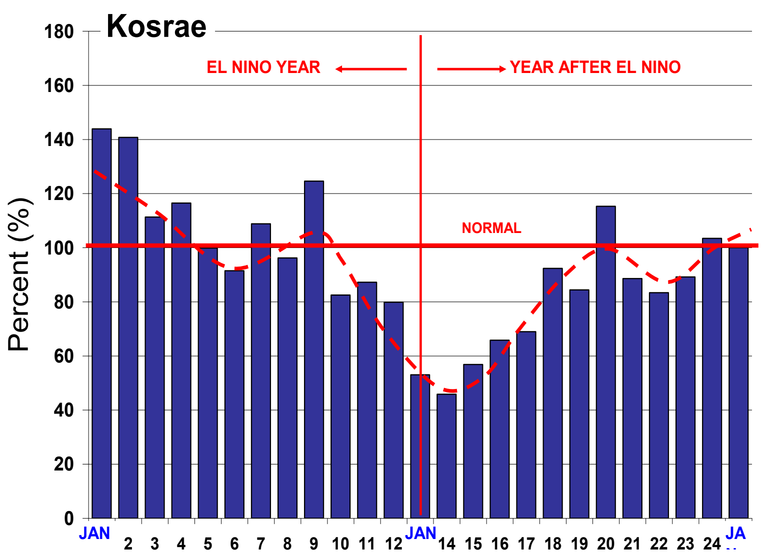

Figure 12. Percent of average rainfall on the island of Kosrae for a composite of five El Niño events. Note the relatively wet conditions through September of a typical El Niño year, with a gradual drying that begins by October. Drying is substantial from January of through May of the year that follows El Niño. Rainfall recovers to near average by June or July of the year following El Niño. The red dashed line shows the short-term rainfall trends during the El Niño and El Niño + 1 years. The red dashed line shows the short-term rainfall trends during the El Niño and El Niño + 1 year.

Climate Outlook: The Pacific basin climate is currently in a state classified as strong El Niño. Indices of El Niño typically peak late in the El Niño year, and the ultimate strength of El Niño is usually pegged to its peak condition, usually in December or January. Regardless of the ultimate peak of the ENSO indices, the El Niño event of 2015-16 will take its place among the top three of the past 40 years, in a league with the epic El Niño events of 1982-83 and 1997-98. The PEAC will issue forecasts based on the occurrence of a strong El Niño.

El Niño poses the threat of serious drought across all of the FSM. On Kosrae, drought related to El Niño becomes severe early in the year that follows El Niño, especially a strong event (e.g., 1983 and 1998). In a typical moderate or strong El Niño, rainfall is at-or-above average through September of the El Niño year, and then begins to fall below normal by October. Rainfall is substantially reduced (<70% of average) during the period of January through May. Monthly rainfall returns to near

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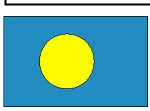
average by June of the year following El Niño. Our forecasts show a transition to below-normal during the October-November-December season, with the driest values of rainfall anticipated during January-February-March of 2016. Rainfall is expected to slowly recover to near average during April-May-Jun 2016.

The threat of adverse effects from a tropical cyclone on the island of Kosrae is high throughout an El Niño year – as the passages of Bavi (March) and Dolphin (May) and other cyclones (e.g., pre-named (Maysak, March; Chan-hom, July, Koppu and Champi, October) near or to the northeast of Kosrae have already shown. As time progresses during an El Niño year, typhoon activity shifts ever more exclusively to the east. We anticipate two or three tropical cyclones to form within or pass through eastern Micronesia from November 2015 through January 2016. These late-season storms will be serious threats to Guam and the CNMI, but could also pass close enough to the north of the island of Kosrae with the primary risks being damaging wind, heavy rainfall and high surf. Lastly, the sea level falls in an El Niño year (see the sea level section for details).

Predicted rainfall for Kosrae State from October 2015 through September 2016 is:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]
October - December 2015	80% (37.28 inches)
January – March 2016	50%
April– June 2016	75%
July– September 2016	90



Republic of Palau: The Republic of Palau was one of the few island groups of the western North Pacific where most (7 of 9) of the months of 2015 through October were drier than average. The cumulative total rainfall fell behind average in January and never caught-up. By the end of October, the cumulative rainfall at Koror for the first 9 months of the year was 84.70 inches, which was 39.97 inches short (or only 68%) of the 124.67 inches of rainfall that typically falls during that period (Fig. 14). The PEAC Center is participating in a study of drought in the tropical Pacific islands. Two key threshold amounts for drought impact have been identified: (1) at least 8 inches of rain per month is needed to sustain and/or replenish municipal and home rain catchment systems, sustain and/or replenish municipal surface and groundwater supplies, provide for adequate stream flow on high islands, and greatly reduce the risk of wildfire; and, (2) less than 4 inches of rainfall in a month exacerbates threats to agriculture (unless adequate irrigation water is available), greatly increases the number and extent of wildfires and leads to unacceptable draw-down of rain catchments and shallow dug wells. March, April and May were very dry at Koror and the Palau International Airport with each station recording about 5 inches of rainfall in each of these three months. In May, Koror fell below 4 inches. This prompted the Weather Forecast Office (WFO), Guam to issue a drought advisory (Drought Information Statement) for the Republic of Palau, citing ongoing dryness and likely impacts to agriculture and water supplies. Abundant rainfall arrived at Palau in June when the monsoon trough lifted across the island nation and brought a 2-week period of heavy showers. Koror received 18.66 (108%) inches of rainfall during June 2015. At the end of June, the drought advisory was lifted. July and August were relatively dry. Wet conditions returned in September, but rainfall amounts were not enough to offset the dryness of July and August; hence, the 3rd Quarter rainfall totals across Palau were below average. October was very dry, and raised fears that it could be the start of the anticipated post-El Niño Micronesia-wide drought. Sea level in Palau has been below normal since March 2015. Currently it is considerably below normal (-7 in). This fall is supportive to the on-going El Niño state, as Palau displayed similar fall in 1997 too.

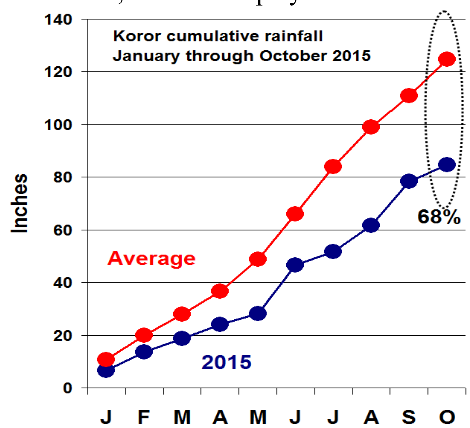


Figure 13. Cumulative rainfall at Koror. Red line shows the normal accumulated rainfall over the first 9 months of the year, and the dark blue line shows the measured accumulated rainfall over the first 9 months of 2015. By October 2015, the accumulated rainfall total stood at 68% of average.

Republic of Palau Rainfall Summary: 2015 3rd Quarter and October						
Station		Jul	Aug	Sep	Oct	3rd Qtr
Palau						
Koror WSO	Inches	4.98	9.90	16.88	6.24	31.76
	% Avg	28%	66%	142%	45%	71%
Intl. Airport	Inches	9.84	11.40	16.85	4.61	38.09
	% Avg	50%	69%	129%	30%	77%

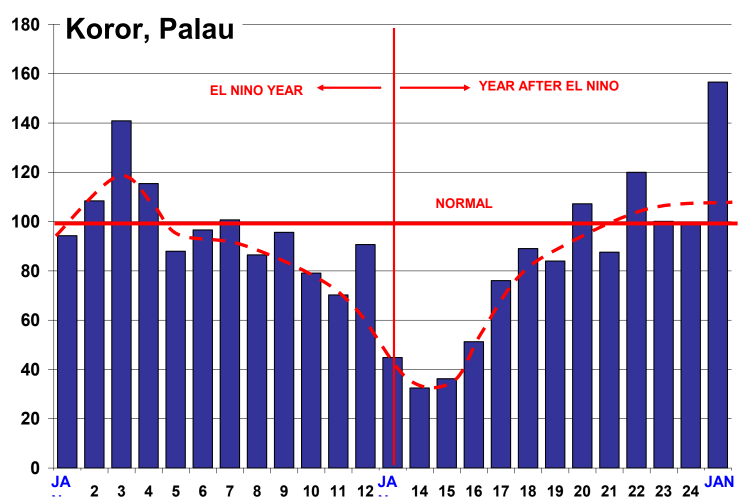


Figure 14. Composite monthly rainfall for 5 strong El Niño events at Palau for the two-year period that covers the El Niño year and the year that follows El Niño. Values plotted are monthly percent of average rainfall. Red dashed line shows smoothed rainfall trend.

Climate Outlook: The Pacific basin climate is currently in a state classified as strong El Niño. Indices of El Niño typically peak late in the El Niño year, and the ultimate strength of El Niño is usually pegged to its peak condition, usually in

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December or January. Regardless of the ultimate peak of the ENSO indices, the El Niño event of 2015-16 will take its place among the top three of the past 40 years, in a league with the epic El Niño events of 1982-83 and 1997-98. The PEAC will issue forecasts based on the occurrence of a strong El Niño.

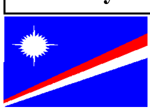
History has shown that El Niño does play some role in damaging typhoons at Palau. Three major historical typhoons have occurred with a plausible association with El Niño; these include: Typhoon Marie (April 1976), Typhoon Owen (December 1990), and Typhoon Mike (November 1991). Four major historical typhoons affected Palau outside of El Niño; these include: Sally (March 1967), Kate (October 1970); Bopha (2012); and Haiyan (2013). Although three of seven major typhoons affecting Palau have an association with El Niño: only one typhoon (Mike – Nov 1991) severely affected Palau in the fall of an El Niño year. Thus, for the rest of 2015 and early 2016, it is thought that the threat of a damaging typhoon at Palau is near average (~5-10%). It is not zero, and nervousness certainly remains after the recent back-to-back late season strikes of typhoons Bopha and Haiyan!

A looming threat posed by El Niño is major drought. Drought related to El Niño becomes severe early in the year that follows a strong El Niño (e.g., 1983 and 1998). Rainfall on Palau is typically greater than average early in an El Niño year (although this did not happen in early 2015), and then starts to drop farther below normal as the year progresses (Fig. PL2). Rainfall typically sinks to well below average during the first few months (January through May) of the year following El Niño (i.e., 2016). Recovery to near-average rainfall is delayed until July or August.

Forecasts for the next seasons (OND, NDJ, and DJF) sea level indicate about 6-8 inches below normal and, when compared to the forecasts of the previous quarter (JAS) of 2015, this is still considered to be a further fall.

Predicted rainfall for Palau from October 2015 through September 2016 is:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]
October – December 2015	70% (26.15 in)
January – March 2016	40%
April - June 2016	65%
July– September 2016	90%



Republic of the Marshall Islands: The During El Niño, the Republic of the Marshall Islands (RMI) experiences its most wildest and most extreme weather. Full-fledged tropical storms and typhoons occur in the RMI almost exclusively during El Niño. The monsoon of the western North Pacific extends far to the east to bring unusually strong and persistent westerly winds. Through the first 9 months of a typical strong El Niño (as 2015 is now considered to be), total rainfall in the RMI is high, extremes of daily rainfall occur, and there is large month-to-month variation.

The first 9 months of 2015 were indeed wild with extremes of wind, rain, and sea inundations at many atolls. Three separate instances of damaging sea inundation occurred on some of the atolls of the RMI. Each of the damaging sea inundations was associated with a tropical cyclone in the region: (Bavi, March 2015); Dolphin (May 2015); and, Nangka (July 2015). Strong westerly winds on the night of August 13 at Majuro required a special weather statement for lagoon-side rough seas with possible nuisance inundation. The new weather Chief (Joel Martin) at the Kwajalein missile test range posted the following excerpted comments on the Reagan Test Site Weather web page (http://rts-wx.com/) concerning the wild weather on Kwajalein Atoll during 2015:

"2015 - WILD, WET, WINDY, AND WONDEROUS WEATHER"

"While this year's weather seems unique, the weather of 2015 is much like 1997 in several respects. Both were significant El Niño years; both had increased Monsoon Trough activity spreading well east of Kwajalein Atoll, past the Date-line; and research by former Chief Meteorologist Mark Brad-ford revealed that this is the first time Kwajalein has experienced west winds like this since 1997. In 1997 there were 45 consecutive days of nearly 20-knot winds."

"When El Niño happens, the wind patterns are altered. The altered wind patterns tend to make the Monsoon Trough stronger and extend further East of Kwajalein Atoll than non-El Niño years. Then there is more convection, which means more rain. There are more storm threats. And, if the Monsoon Trough is pushed a little North of Kwajalein, there are extended periods of west winds."

"2015 truly is wild, wet, and windy. The complex meteorology producing it is wondrous science. Kwajalein Atoll is at ground zero for climate change and part of the factory floor for manufacturing the strongest storms on the planet!"

The RMI enters the heart of its typical Rainy Season in the fall (SON) – a bit later than at other locations in Micronesia. While August of this year was very wet, especially at central and northern atolls, September and October rainfall amounts were slightly below normal. The recent dryness, though not intense or unusual, heightens a sense of unease as a major drought is anticipated to begin soon. Dryness in this rainy season is un-welcome.

The monthly mean sea level in Majuro recorded a fall in the last couple of months. It levelled the mark of below normal in May 2015. Currently, it is considerably below normal (-4 in). The monthly mean sea level in Kwajalein recorded a fall in the recent months. It started to fall since March 2015 and, currently, it is below normal (-3 in). As compared to JAS of 2014, it fell about 6 inches in JAS of 2015.

RMI Rainfall Summary: 2015 3rd Quarter and October

Station		July	Aug	Sep	Oct	3rd Qtr
RMI Central and Southern Atolls						
Majuro WSO	Inches	9.72	24.24	10.72	10.54	44.68
	% Avg	75%	210%	86%	76%	121%
Aling...	Inches	3.06*	2.85*	7.53	9.85	13.44*
	% Avg	26%	26%	62%	76%	39%
Jaluit...	Inches	6.86	6.33	7.02	4.51*	20.21
	% Avg	53%	55%	57%	33%	55%
Mili	Inches	7.49	12.89	7.83	8.80*	28.21
	% Avg	58%	112%	63%	64%	76%
RMI Northern Atolls						
Kwajalein	Inches	10.28	16.63	10.24	11.71	37.15
	% Avg	98%	164%	87%	98%	115%
Wotje	Inches	15.48	9.34	6.83	8.60	31.65
	% Avg	258%	137%	88%	104%	154%
Utirik	Inches	5.17*	6.92*	N/A	7.82*	N/A
	% Avg	93%	110%	%	102%	%

* Several to many missing days.

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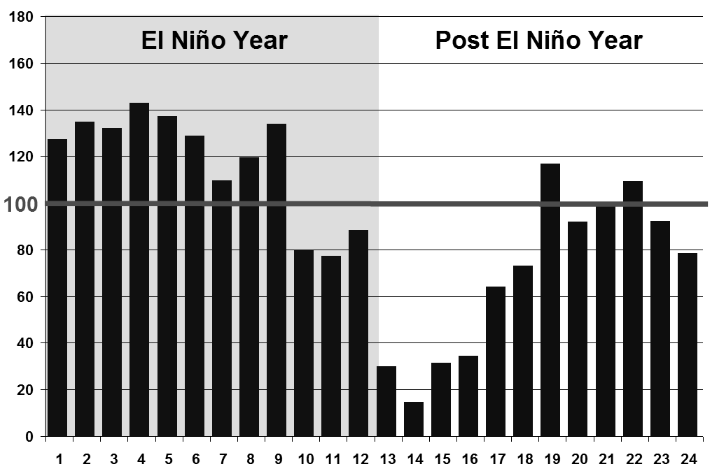
Climate Outlook: The Pacific basin climate is currently in a state classified as strong El Niño. Indices of El Niño typically peak late in the El Niño year, and the ultimate strength of El Niño is usually pegged to its peak condition, usually in December or January. Regardless of the ultimate peak of the ENSO indices, the El Niño event of 2015-16 will take its place among the top three of the past 40 years, in a league with the epic El Niño events of 1982-83 and 1997-98. The PEAC will issue forecasts based on the occurrence of a strong El Niño. El Niño has large effects on the climate of the RMI. Rainfall, sea level and the typhoon distribution are substantially altered.

The threat of a damaging tropical cyclone within the RMI is high throughout an El Niño year – as the passages of Bavi, Dolphin, Nangka and other developing cyclones through the region during the first 9 months of 2015 have already shown. As time progresses during an El Niño year, typhoon activity shifts ever more exclusively to the east. We anticipate two or three tropical cyclones to form in eastern Micronesia or farther east from October 2015 through January 2016. These late-season storms could be serious threats to some of the atolls of the RMI. The chances are estimated at least 50-50 for another tropical cyclone to bring damaging wind, heavy rainfall and/or high surf to one or more of the atolls of the RMI through January 2016.



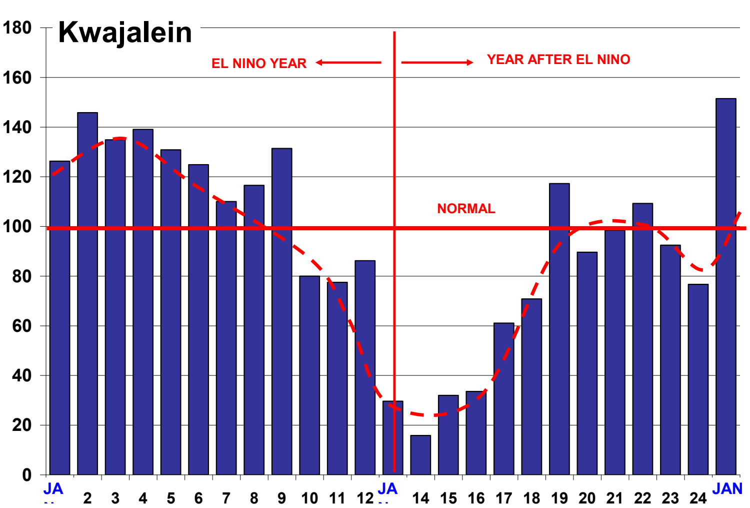


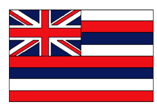
Figure 15. The typical response during El Niño of monthly rainfall (% of average in the RMI. The data plotted are for Kwajalein.

Another upcoming threat posed by El Niño is major drought. Drought related to El Niño becomes severe early in the year that follows a strong El Niño (e.g., 1983 and 1998). Rainfall during El Niño is greater than average during the first half of the year. After September, the monthly rainfall begins a steady decline, sinking to well below average during the first few months (January through May) of the year following El Niño (see Fig. RMI1). Recovery to average rainfall is delayed until June for the southern atolls and until July for the northern atolls.

Majuro forecasts for the next seasons (OND, NDJ, and DJF) sea level indicate considerably below normal sea level (-4 in) and, when compared to the forecasts of last quarter 2015, this is a significant decline. Kwajalein forecasts for the next seasons (OND, NDJ, and DJF) indicate below normal sea level (-3 to -4 inches) and, when compared to the last quarter's forecasts, this is about 3-4 inches fall.

Predicted rainfall for the RMI from October 2015 through September 2016 is:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]		
	South of 6ºN	6ºN to 8ºN	North of 8ºN
Oct - Dec 2015	85% (32.34 in)	85% (32.34 in)	85% (25.62 in)
Jan – Mar 2016	50%	40%	40%
April– June 2016	60%	60%	50%
Jul– Sep 2016	90%	90%	90%



Hawaii: October 2015 Precipitation summary for the State of Hawaii prepared on November 5, 2015 can be found at http://www.prh.noaa.gov/hnl/hydro/pages/oct15sum.php.

Since January 2015, the monthly mean sea level in Honolulu remained close to normal. Currently, it is staying close to normal (+1 in). Since January 2015, the monthly mean sea level in Hilo also remained close to normal. Currently, it is staying 3 inches above normal.

Hawaii Rainfall Summary: 2015 3rd Qtr and October						
Station		Jul	Aug	Sep	Oct	3rd Qtr
Lihue Airport	Inches	0.76	9.86	4.50	0.36	15.12
	%Avg	45	536	232	11	276%
Honolulu Airport	Inches	0.43	7.63	4.48	0.69	12.54
	%Avg	119	4016	747	55	1090%
Kahului Airport	Inches	0.86	2.34	0.24	0.89	3.44
	%Avg	226	488	126	162	328%
Hilo Airport	Inches	8.06	17.20	20.14	15.84	45.40
	%Avg	85	205	216	184	167%

Climate Outlook: The U.S. Climate Prediction Center's Hawaiian Seasonal Outlook Discussion, posted on October 15, 2015, can be obtained from the following website: http:www.cpc.ncep.noaa.gov/products/predictions/90day/fxhw40.html.

Forecasts for the next seasons (OND, NDJ, and DJF) indicate slightly elevated sea level (+2 in) for both Honolulu and Hilo.

DISCLAIMER STATEMENT

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

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

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CONTRIBUTORS

NOAA National Weather Service
Pacific ENSO Applications Climate (PEAC) Center:
HIG #340, 2525 Correa Road, Honolulu, Hawai'i 96822
LTJG G. Carl Noblitt IV, NOAA Corps, Pacific Region Climate Officer, at
808-956-2324: for information on PEAC, the Pacific ENSO Update and ENSO-related climate data for the Pacific Islands.

University of Hawai'i - Joint Institute of Marine and Atmospheric Research (JIMAR),
Pacific ENSO Applications Climate (PEAC) Center:
HIG #340, 2525 Correa Road, Honolulu, Hawai'i 96822
Dr. Rashed Chowdhury, Principal Research Scientist, at
808-956-2324: for information on ENSO and sea level variability in the USAPI.

University of Hawai'i - Joint Institute of Marine and Atmospheric Research (JIMAR),
Pacific ENSO Applications Climate (PEAC) Center:
HIG #340, 2525 Correa Road, Honolulu, Hawai'i 96822
Alejandro Ludert, Graduate Research Assistant and Webmaster.

University of Guam - Water and Environmental Research Institute (WERI):
UOG Station, Mangilao, Guam 96913
Dr. Mark Lander, PEAC Meteorologist, at
671-735-2685 for: information on tropical cyclones and climate in the USAPI.
808-956-2324 for: information related to the PEAC website.

CONTRIBUTORS

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.

NOAA National Weather Service
Weather Forecast Office (WFO) Guam:
Clint Simpson, Meteorologist, at
671-472-0950 for: information on tropical cyclones and climate in the USAPI.

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

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

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