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.prh.noaa.gov/peac

CURRENT CONDITIONS

By the early fall of 2015, the Pacific basin climate entered into a state classified as strong El Niño, where it still sits as of the end of January 2016. The ultimate strength of El Niño is usually pegged to the peak values of the oceanic SST indices. This typically occurs in December or January. The El Niño event of 2015/16 is now ranked among the top three of the past 40 years, in a league with the epic El Niño events of 1982/83 and 1997/98. Important regional weather and climatic anomalies, such as enhanced typhoon activity or drought, manifest at various times during an El Niño event, which progresses over a period of roughly 18 months from onset to peak and then to an important post-peak El Niño phase (Fig. 1 and Fig. 2). Some regional climatic extremes, such as greatly enhanced tropical cyclone activity in Micronesia, begin very early during the onset of El Niño, often before the oceanic indices reach the official El Niño threshold.

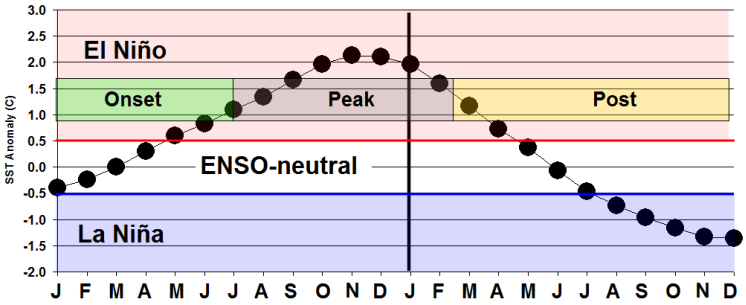


Figure 1. Typical evolution of the Niño 3.4 ENSO index over the entire span of a strong El Niño event, with timing of "Onset", "Peak" and "Post-peak" phases indicated.

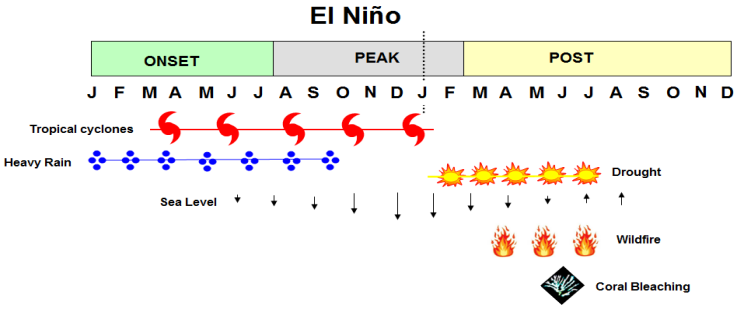


Figure 2. Timing of climatic hazards associated with El Niño. The depicted timing of hazards is a generic average for Micronesia, and individual island groups may vary somewhat, especially for American Samoa and islands near the equator (e.g., Kapingamarangi and Nukuoro).

During the progression of El Niño, the State of Hawaii and most islands of Micronesia typically transition from above average rainfall to below average rainfall during October or November as the El Niño nears its peak. In a strong El Niño event, substantial rainfall deficits thereafter persist during the extended post-peak period of January through May, leading to drought conditions that are often extreme. Abnormal dryness begins to abate by May or June, with a return to near- normal rainfall by July or August. The timing of drought and recovery varies somewhat across the region, with islands to the west, such as Palau and Yap entering drought sooner, and islands to the north remaining drier than normal for a longer period of time. On islands near the equator (e.g., Kapingamarangi and Nukuoro), rainfall remains high (or at least adequate) through the duration of an El Niño event. At American Samoa, the timing of high rainfall, an excess of tropical cyclone activity, and the occurrence of drought is shifted later by three to six months.

During 2015, a monthly rainfall pattern typical of strong El Niño unfolded, with many islands following a similar general temporal distribution of wet and dry months (Fig. 3). Wetter than average rainfall (and in some cases, much wetter than average rainfall) was observed at most islands, particularly during March, April and May. This was consistent with an anticipated onset of El Niño. June and July were relatively dry. August was wet, followed by a steady decline thereafter. Annual totals during 2015 were mostly higher than average, with early wetness outweighing dryness later in the year (Figures 9 and 10 on page 6). The 2015 4th quarter rainfall totals at Yap Island and at Palau were the lowest and second lowest in their ~65-year post-WWII historical record, respectively! By January 2016, persistent dry conditions became firmly established at most of the islands of Micronesia and across Hawaii. American Samoa, however, was very wet at the end of 2015, associated with a strong monsoon and the close passage of tropical cyclones.

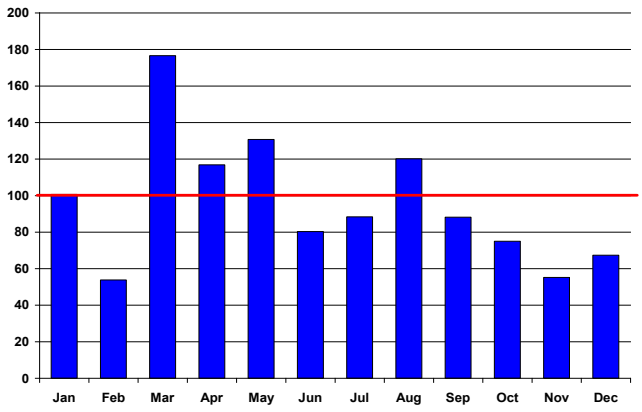


Figure 3. A composite index of the 2015 annual rainfall (% of average) for stations of Micronesia, but not including American Samoa or Hawaii.

CURRENT CONDITIONS

After nearly a decade of very high values, the sea level has dramatically fallen across Micronesia over the past two years (Fig. 4). Since the middle of 2013 to the end of 2015, the total drop in the sea level at both Guam and at Kwajalein was approximately 40 cm, or 1.3 feet! The magnitude of the fall was roughly the same in both 2014 and 2015. A sharp drop of mean sea level typically occurs during El Niño, with the lowest value of sea level occurring in December of the El Niño year. A sharp rise of sea level occurs in the first few months of the post-peak year of the El Niño event. The first half of 2016 is anticipated to feature this post-peak sharp rise of sea level, similar to the post-peak rises occurring in 1983 and 1998. The behavior of the sea level during El Niño is quite similar across all of Micronesia, as the figures below indicate. See the sea level discussion for more details and specific forecasts.

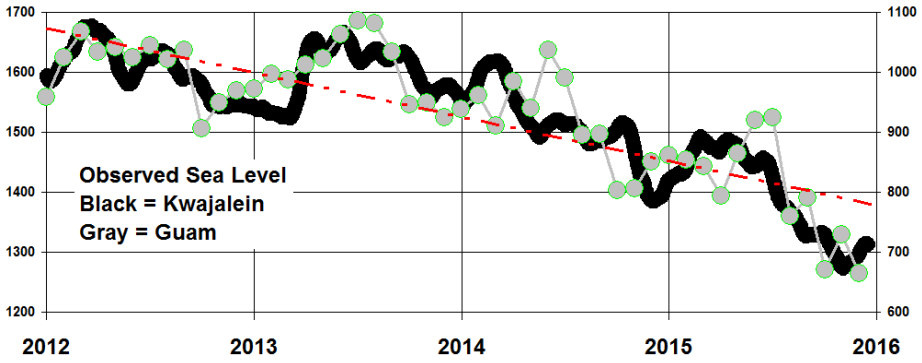


Figure 4. Time series of sea level at Guam and Kwajalein from 2012 through 2015. Note the steady decline through most of the period.

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

The distribution of tropical cyclones in the western North Pacific during 2015 (Fig. 5 and Fig. 6) was typical for a strong El Niño event, with a very high number of tropical cyclones forming within the geographical bounds of Micronesia. At least one named tropical cyclone passed through the regional waters of each island jurisdiction (Table 1). Many islands experienced damaging and life-threatening impacts of high wind, high waves and heavy rainfall.

During the calendar year 2015, the JTWC numbered 29 significant tropical cyclones. This is two short of the average number (31) of tropical cyclones given numbers by the JTWC that develop in the western North Pacific. However, two additional typhoons (Halola and Kilo) crossed into the western North Pacific from the Hawaii side of the date line, for a grand total 31 tropical cyclones for which the JTWC provided advisories during 2015. Of these 31, 19 were typhoons, 9 were tropical storms and 3 were tropical depressions. Of the 19 typhoons, 7 were super typhoons. The JTWC climatology indicates an average distribution of 18 typhoons, 10 tropical storms and 3 tropical depressions. Tropical cyclone 12W was not named by the JMA, but was considered to have reached tropical-storm intensity by the JMA. The number of very intense typhoons was higher than average during 2015, which is typical during El Niño. During the last very strong El Niño (1997-98), eleven typhoons reached super typhoon status.

Palau	4
Yap	6
Guam	12
Saipan	11
Chuuk	7
Pohnpei	7
Kosrae	3
Kwajalein	2
Majuro	2

Table 1. Number of named typhoons passing 300 n mi of the indicated location. Data obtained using typhoon tools on the Digital Typhoons web site: http://agora.ex.nii.ac.jp/digital-typhoon/year/wnp/2004.html.en

In summary, while 2015 was not a particularly active year for the whole basin, it was an extraordinary year of high tropical cyclone activity across Micronesia. 2015 will be long-remembered for its endless parade of tropical storms and typhoons throughout Micronesia, and for its very damaging typhoons, particularly: Typhoon Maysak (direct strike on Chuuk Lagoon and later a devastating strike on Ulithi Atoll); Typhoon Dolphin (glancing strike of northern Guam and a more direct hit on Rota), and Typhoon Soudelor (devastating strike of Saipan).

PEAC Center Tropical Cyclone Assessment

Western North Pacific and American Samoa

Three organizations typically produce seasonal outlooks for tropical cyclone activity in the western North Pacific that are routinely used by the PEAC Center for guidance on the upcoming typhoon season: (1) The Guam Weather Forecast Office (WFO), (2) The City University of Hong Kong Laboratory for Atmospheric Research, and (3) The Benfield Hazard Research Centre Tropical Storm Risk (TSR) research group.

There are no forecasts of 2016 typhoon activity available at this time. However, based on the anticipated demise of El Niño, the PEAC believes that it should be a quiet year across Micronesia. A sharp reduction of early season tropical cyclones and a pronounced shift of the activity to the north and west of Micronesia are typically observed during years that follow the peak of El Niño. The risk of a damaging tropical cyclone will be well below average at all Micronesia locations from March 2016 through August 2016. Late in the year (October through December), the risk of a tropical storm or typhoon increases across far western Micronesia (Yap State

TROPICAL CYCLONE ACTIVITY

and the Republic of Palau), but remains low at Guam and points eastward.

Three named tropical cyclones affected American Samoa during the period November 2015 through January 2016: Tuni (TC 04P), Ula (TC 06P) and Victor (TC 07P) with some adverse impacts (see the LVS for American Samoa). This was anticipated in the previous PEAC newsletter based on the association of strong El Niño with a slightly enhanced up-front (i.e., November through January) risk of a damaging tropical cyclone there. The risk of a damaging tropical cyclone in American Samoa will likely fall away to near average in the latter portion of the cyclone season (i.e., February through April) as some of the South Pacific TC activity should be drawn away from American Samoa farther to the east into the Cook Islands and French Polynesia.

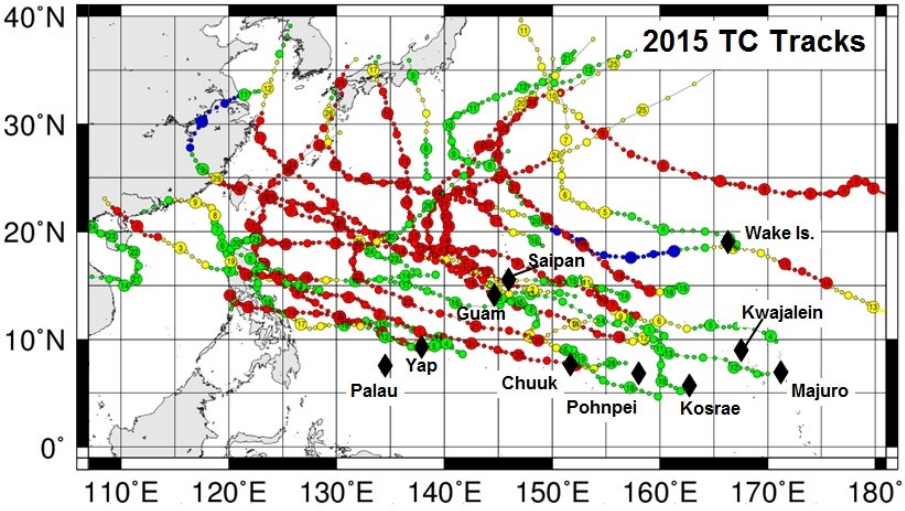


Figure 5. Western North Pacific tropical cyclone tracks during 2015. Note the nexus of typhoon tracks near Guam and the high number of tracks originating to the east of Guam's longitude. This distribution of tropical cyclones is typical for a strong El Niño event.

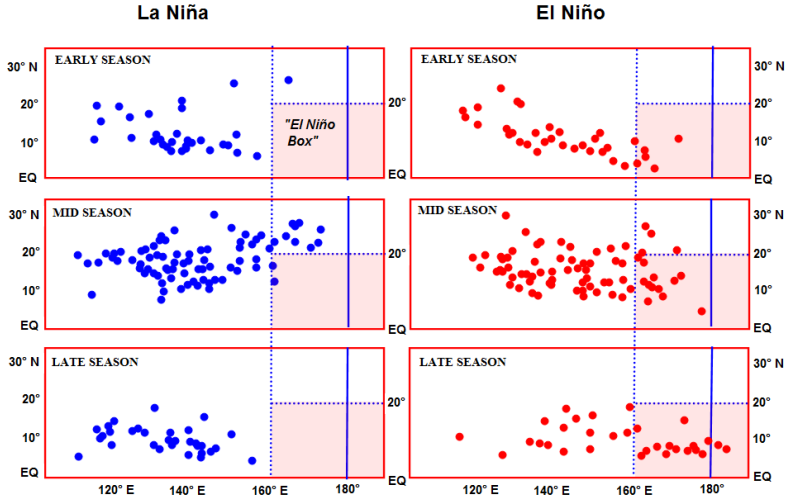


Figure 6. Origins of tropical cyclones by season during La Niña (high-magnitude SOI) (left) and El Niño (low-magnitude SOI) (right). EARLY SEASON = March through mid-July; MID SEASON = mid July through mid-October; and LATE SEASON = mid-October through January. The red-shaded box is defined as the "El Niño Box", a region where tropical cyclone formation occurs almost exclusively during El Niño. Figure adapted from Fig. 6 of Lander, M.A., 1994: An Exploratory Analysis of the Relationship between Tropical Storm Formation in the Western North Pacific and ENSO. Mon. Wea. Rev. 122, 636-651.

SEA SURFACE TEMPERATURES

For the past Quarter (November, December, and January), 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.

Well above-average SSTs remained across the equatorial Pacific with anomalies exceeding 1 degree Celsius. Subsurface temperatures while still above-average have shown signs of weakening. Consistent with ocean-atmosphere coupling low level westerly winds and upper level easterly winds persisted for the past three months. The combined atmospheric and oceanic state are consistent with the weakening strong El Niño.

SOUTHERN OSCILLATION INDEX

The 3-month average of the Southern Oscillation Index for the First Quarter of 2016 including November, December, and January remained negative at –1.1. The respective monthly values were –0.5, -0.6, and –2.2. 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 observed monthly mean and maximum sea-level anomalies for the previous season OND of 2015; 2 year seasonal sea level variability and forecasts; the Canonical Correlation Analysis (CCA) forecasts for seasonal (mean and maxima) sea level anomalies (seasonal cycle removed) for the forthcoming seasons January-February-March (JFM), February-March-April (FMA), and March-April-May (MAM) of 2016; JFM return values at 20 and 100-yr period and;

SEASONAL SEA LEVEL OUTLOOK FOR THE US-AFFILIATED PACFIC ISLANDS

and island-wise outlook. *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 OND 2015

The monthly time series (October to December) 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.

Observations from the recent global satellite pictures revealed that the 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 2015-16), and our observations and forecasts are very consistent to these satellite images. The monthly mean sea level of most of the stations (except Guam, Majuro, and Kwajalein) stayed stable and below normal in December/2015. Guam displayed a sharp fall in December (this station showed a sharp rise in November) while other stations like Majuro and Kwajalein displayed rise. This rise indicates a turning point towards normal sea level within the next couple of months. Pago Pago--the lone south Pacific island--is slightly above normal and it is currently stable. In Hawaii, both Honolulu and Hilo is stable. The monthly maxima also displayed considerable 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. 7). As compared to the sea level of JFM 2014, the sea level in most of the USAPI-islands recorded considerable fall (4 to 6 inches) in JFM 2015. This fall is even more significant when compared to last 10 years. Current synopsis for 2016 is "JFM 2016 is the beginning turning point where sea level transitions to normal stage from its year-long low".

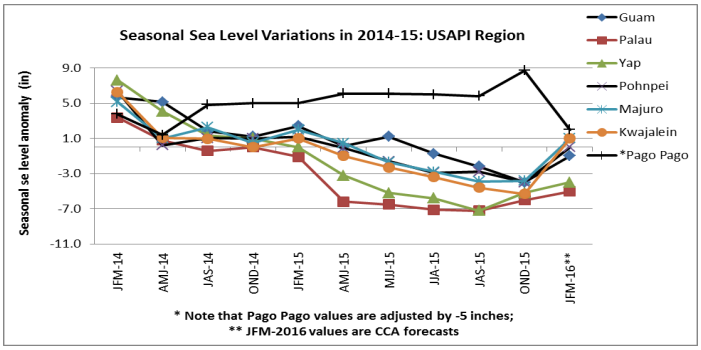


Figure 7. A comparative perspective of Island-wise seasonal sea level variations (JFM 2014 to JAS 2015; Forecasts for OND are denoted by **) (*Note that Pago Pago data was adjusted by subtracting 4 inches from the current values. This correction was done because of level shift (approximately 4 inches) after 2009 earthquake).

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]				
	Oct	Nov	Dec	Standard Deviations	Sea level Trend	Oct	Nov	Dec	Standard Deviations
Marianas, Guam	-6	-1.5	-4.5	4.1	Falling	-6.8	-1.4	-6.5	3.6
Malakal, Palau	-7	-7	-5	4.3	Below	-5.7	-6.8	-8.2	4.4
Yap, FSM	-8	-4	-4	4.6	Bellow	-7.6	-3.8	-4.8	5.1
Chuuk, FSM***				**	**				**
Pohnpei, FSM	-4	-4	-4.5	4.7	Below	-4.7	-6.8	-7.4	4.9
Kapingamarangi	+1	-1.5	-3		Falling	-3.1	-2.8	-5.3	
Majuro, RMI	-5	-5	-2	3.5	Below	-5.9	-4.3	-4.1	3.7
Kwajalein, RMI	-6.5	-6.3	-3.5	3.6	Below	-7.2	-6.8	-7.1	3.8
Pago Pago*	+9 (+3)	+9 (+3)	+8(+2)	3.1	Above	+2.0	+1.5	-1	3.3
Honolulu	+1.5	0	+1	1.7	Above	+0.7	-0.2	-1.5	2.5
Hilo	+4	+2	-0.5	1.8	Falling	+6.1	+1	-1	2.2

Seasonal sea level forecast (anomalies with respect to climatology) for JFM, FMA, and MAM 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

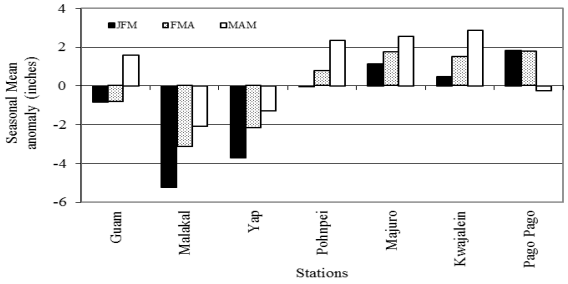
SEASONAL SEA LEVEL OUTLOOK FOR THE US-AFFILIATED PACFIC ISLANDS

lead time) provided skillful forecasts for these three consecutive seasons.

The current sea level forecasts indicate that most of north Pacific stations—except Yap, and Chuuk-- are likely to be slightly below normal in the forthcoming JFM, FMA, and MAM seasons ((normal and average are synonymously used throughout the sea level section). While the forecasts is below normal in JFM, it is very close to normal in FMA, and slightly elevated (above normal) in MAM. However, Palau, Yap, and Chuuk will still be well below normal in JFM while Pohnpei, Majuro, and Kwajalein are likely to be marginally above normal. Pago Pago is expected to be marginally below normal initially in JFM, but further fall is expected as the season advances (this station has been above normal for a long time). In Hawaii, both Honolulu and Hilo are likely to be slightly elevated.

From a historical perspective, the current fall of sea level is significant (i.e., 4-7 inches), but it has not experienced the minima, which was observed during the historically strongest El Niño year 1997-98. Any further fall in the north Pacific islands is most unlikely as the on-going El Niño has already started to be weakening and turning to be in neutral phase by early summer of 2016. Also note that, some of the stations located in Micronesia and Marshalls Islands have already started rising, which is expected in the current weakening phase of El Niño. This is a turning point when sea level transitions to normal (or above normal) stage from its year-long below normal stage. Despite rise in the north Pacific islands, some further fall is still expected in the lone south Pacific islands (i.e., Pago Pago), as the fall here maintains 4-6 months lag with respect to the north Pacific stations.

Observations revealed that, in terms of sea level, the Pacific basin has not experienced the strongest impacts like that of 1982-83 and 1997-98. We are therefore motivated to conclude that, in addition to ENSO, there are other factors (i.e., PDO, IOD etc.) might also equally important for causing seasonal sea level variability and change in the vicinity of the USAPI region. We will be investigating this matter further as part of our future research direction.



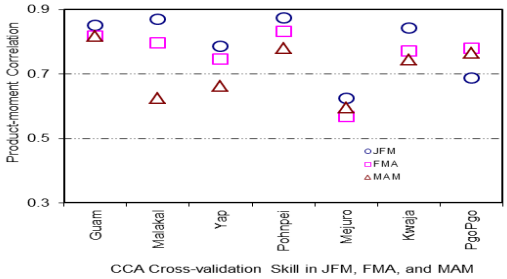


Figure 8. (Left) Monthly mean sea level anomaly forecasts (inch) for JFM, FMA, and MAM seasons (left for mean and right for maximum); (Rightl) Forecasts skill for all the tide gauge stations (at 0 to 2-months lead time).

Table 1: Forecasts of sea level anomalies in inches (JFM, FMA, and MAM)

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	**JFM**	**FMA**	**MAM**	**Seasonal Outlook[3]**	**JFM**	**FMA**	**MAM**	**Seasonal Outlook[3]**	**JFM: Return Period[4]**	
Lead Time [5]	**0M**	**1M**	**2M**	**Seasonal Outlook[3]**	**0**	**1M**	**2M**	**Seasonal Outlook[3]**	**20- YR**	**100-YR**
Marianas, Guam	-1	-1	+2	Average-Above	0	+1	+2	Average-Above	5.6	6.7
Malakal, Palau	-5	-3	-2	Below	-4	-1	-1	Below	9.6	14.3
Yap, FSM	-4	-2	-1	Below	-2	+2	+2	Average-Above	16.7	33.0
Chuuk, FSM**	-4	-3	-2	Below	-2	+2	+2	Average-Above	n/a	n/a
Pohnpei, FSM	0	+1	+2	Average-Above	0	0	+1	Average	5.8	7.1
Majuro, RMI	+1	+2	+3	Average-Above	+2	0	0	Average	4.1	5.1
Kwajalein, RMI	+1	+2	+3	Average-Above	+1	+1	+2	Average	4.5	5.9
Pago Pago, Am. Samoa***	+2 (-2)	+2 (-2)	0 (-4)	Marginal Below	+3 (-1)	+1 (-3)	-1 (-5)	Average-Below	3.9	5.4
Honolulu, Hawaii	+1	+1	+2	Average-Above	-2	+1	+1	Average-Above	4.1	5.9
Hilo, Hawaii	+3	+3	+2	Above	+2	+1	+1	Average-Above	7.9	11.4

[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).

RAINFALL SUMMARY FOR THE US-AFFILIATED PACFIC ISLANDS

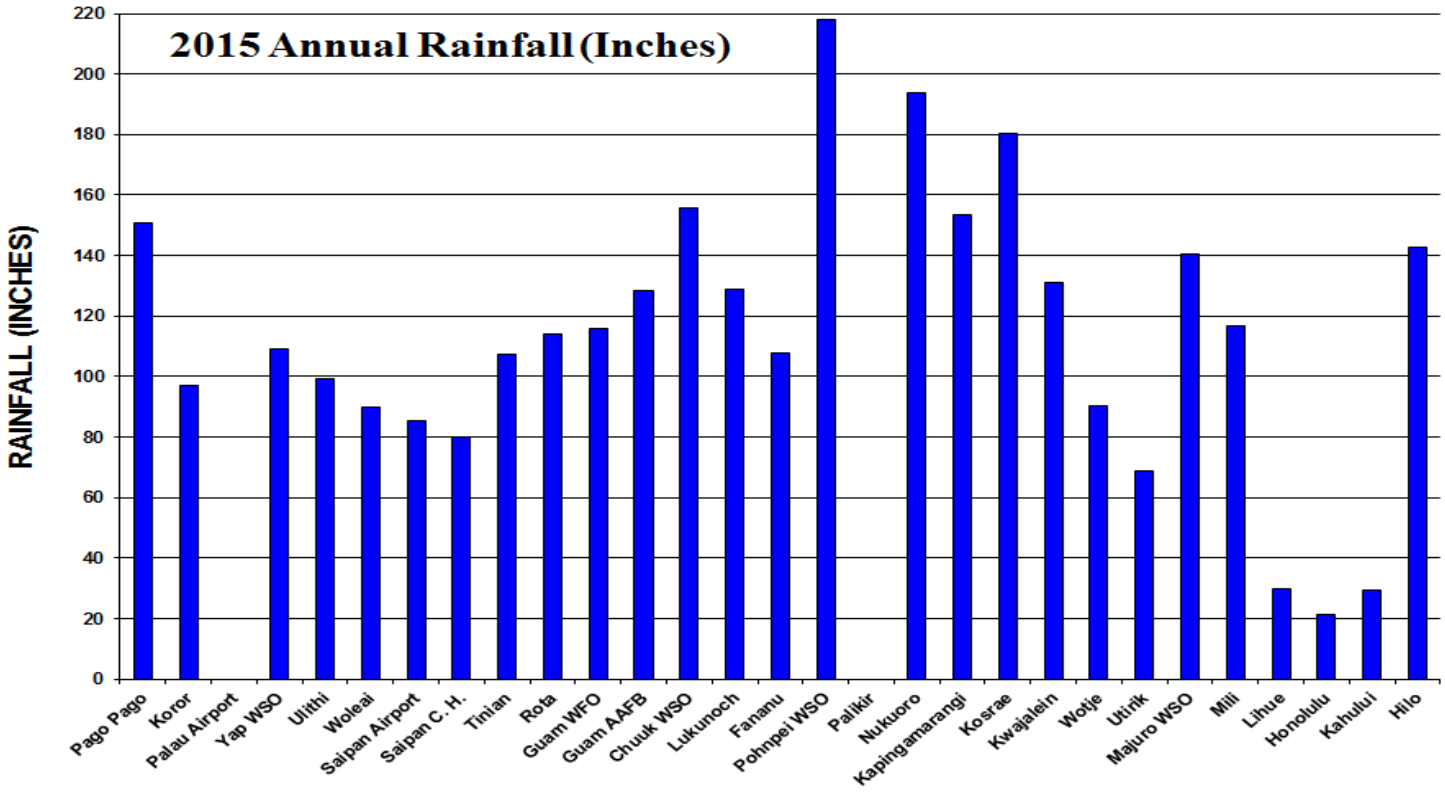


Figure 9. 2014 Annual rainfall amounts in inches at the indicated locations.

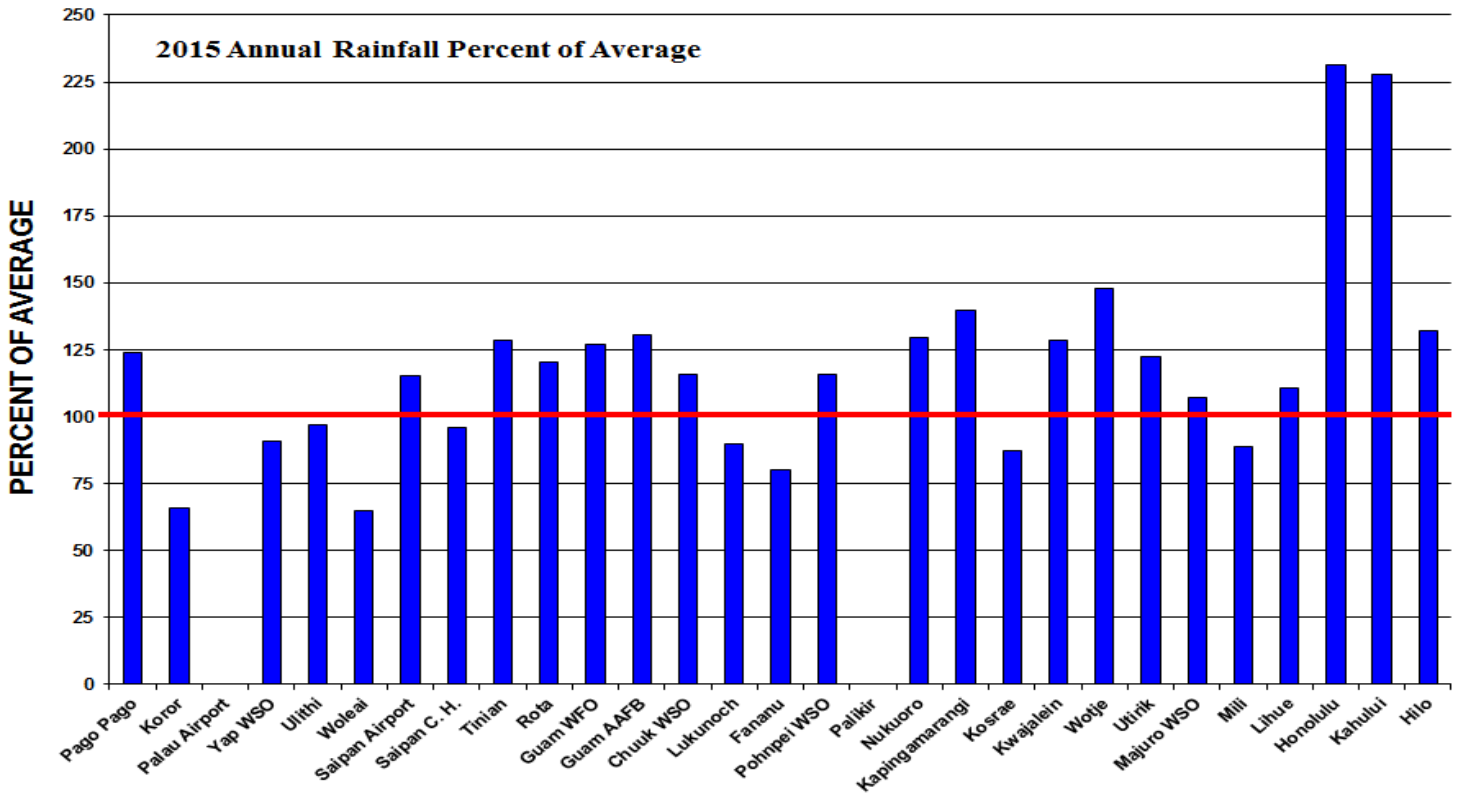


Figure 10. 2014 Annual rainfall departure from average (in percent) at the indicated locations.

LOCAL SUMMARY AND FORECAST

American Samoa: The rainfall at American Samoa was highly variable during 2015, with a see-saw pattern of high monthly totals adjacent to low monthly totals. The 2015 annual total of 150.92 inches recorded at the Pago Pago Weather Service Office was 124% of average. This was enough to make 2015 the 7th wettest year in the 62-year climate record at Pago Pago. The final two months of the year were very wet, as the northwest monsoon brought gusty winds and heavy showers to the region as well as some tropical cyclones passing south of American Samoa along the axis of a persistent trough of low pressure (i.e., monsoon trough/South Pacific Convergence Zone (SPCZ)). The SPCZ is a loosely anchored feature of the regional climate, and can become a conduit for the Australian northwest monsoon to reach American Samoa (and beyond) under certain circumstances, especially during El Niño. Three named tropical cyclones affected American Samoa during the period November 2015 through January 2016: Tuni (TC 04P), Ula (TC 06P) and Victor (TC 07P). Ula, passing south of American Samoa in late December, caused the most trouble, promoting a long period of heavy rainfall, high winds and hazardous surf. Heavy rainfall caused flooding and landslides that blocked roads and river crossings. High winds generated hazardous surf that claimed a life by drowning on the island of Manu'a. Since January 2014, the monthly mean sea level in Pago Pago remained above normal and, currently, it is +8 (or +3in adjusted) 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. The monthly maxima fell sharply—as of December 2015, the maximum is 1 inches (or -4 inches) below normal.

American Samoa Rainfall Summary: 2015 4th QTR/Annual						
Station		**Oct**	**Nov**	**Dec**	**4th Qtr**	**Annual**
Pago Pago	**Inches**	**8.15**	**21.33**	**23.53**	**53.01**	**150.92**
	% Avg	**76%**	**197%**	**162%**	**147%**	**124%**
Siufaga Ridge	**Inches**	**24.56**	**20.53**	**15.38**	**60.47**	**173.55**
	% Avg*	**N/A**	**N/A**	**N/A**	**N/A**	**N/A***

* Long-term averages unavailable for this station

Climate Outlook: At the end of January 2016, the Pacific basin climate remained in strong El Niño, with indications that it has already reached its peak and is beginning its inevitable fade towards ENSO-neutral by the late spring, or early summer months. Historically, strong El Niño events shift to La Niña conditions late in the year following its peak. Regardless of the time it takes for the climate system to fade to ENSO-neutral and/or transition all the way to La Niña, the major weather threat now for American Samoa is the same: drought!!

American Samoa lies in an area of the Pacific where the relationships between rainfall and ENSO are weak, with few consistent El Niño-related weather patterns that can be used to inform a reliable long-range forecast. During the very strong El Niño events of 1982-83 and 1997-98, American Samoa experienced continual dryness punctuated by a few wet months (Fig. 11 and Fig. 12). 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. The 2016 rainfall outlooks for American Samoa are made assuming that the behavior of the local climate during 2016 will be similar to that of 1983 and 1998.

As previously mentioned, some tropical cyclones have already affected American Samoa. This was anticipated in the previous PEAC newsletter based on the association of strong El Niño with a slightly enhanced up-front (i.e., November through January) risk of a damaging tropical cyclone there. The risk of a damaging tropical cyclone in American Samoa falls away to near average in the latter portion of the cyclone season (i.e., February through April) as some of the South Pacific TC activity should be drawn away from American Samoa farther to the east into the Cook Islands and French Polynesia.

Lastly, the sea level behavior at American Samoa lags that of Micronesia by 3 to 4 months. Whereas the mean sea level falls to its lowest level in Micronesia in December or January at the peak of El Niño, at American Samoa the mean sea level falls to its lowest level during March or April of the post-Peak phase of El Niño (See Figs 29 and 30 continued on page 16). Thereafter, the sea level rises for the rest of the post-Peak year (e.g., 2016), but is still typically slightly below average at the close of such a year. Forecasts for American Samoa are marginally below normal in JFM and FMA, and considerably below normal in in MAM.

Predicted rainfall for American Samoa from January through December 2016 is:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]
January - March 2016 (Heart of next Rainy Season)	**70% (26.12 inches - Pago Pago)**
April– June 2016 (Onset of Next Dry Season)	**50%**
July– September 2016 (Dry Season)	**60%**
October– December2016 (Onset of next Rainy Season)	**90%**

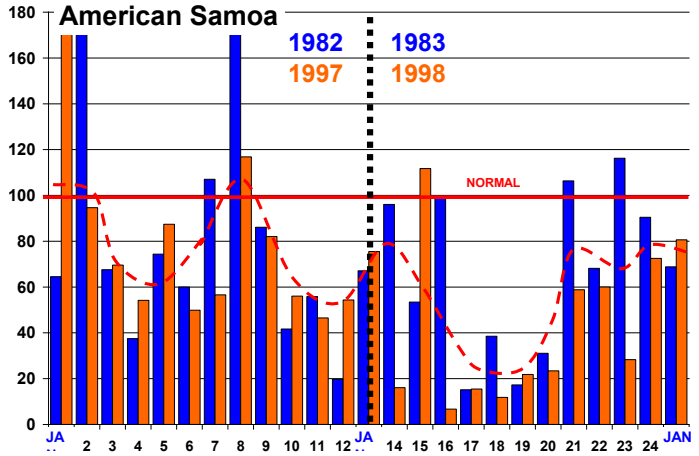


Figure 11. Monthly rainfall distribution (in percent) during two strong El Niño events: 1982-83 (blue) and 1997-98 (orange). Note the similar seasonal variability and the occurrence of the driest anomaly during the dry season months of the year that follows both these El Niño events. This behavior is how the PEAC long-range rainfall forecasts for American Samoa have been tailored. The red dashed line shows the smoothed rainfall trends for the two events .

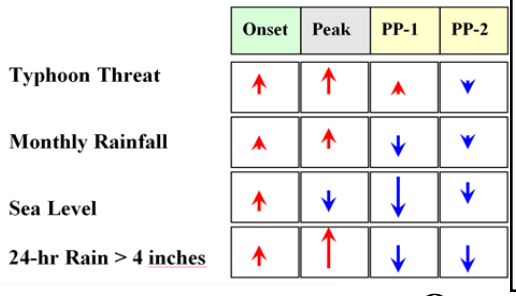


Figure 12. Evolution of climatic variables during the course of a strong El Niño on the islands of American Samoa. Onset = Jan – Jun 2015; Peak = Jul 2015 – Feb 2016; Post-Peak (PP) 1 = Mar – Jun 2016; PP2 = Jul – Dec 2016.

LOCAL SUMMARY AND FORECAST

Guam/CNMI: The calendar year 2015 featured some wild weather across Guam and the CNMI. It was a typical El Niño year, with an early start to typhoon activity (Tropical Storm Bavi in March and Typhoon Dolphin in May), and then a continuation of a series of close passages of tropical cyclones through November. The final list of tropical cyclones passing within 180 n mi of Guam, Rota, Tinian, or Saipan include:

(1) Tropical Storm Bavi (March) -- (gales and high waves, Guam, Rota, Tinian and Saipan);
(2) Typhoon Dolphin (May) -- (typhoon winds on northern Guam and Rota);
(3) Tropical Storm Chan-hom (July) -- (gales on Rota, Tinian and Saipan);
(4) Super Typhoon Nangka (July) -- (gales on Saipan, direct hit of Alamagan, CNMI);
(5) Typhoon Soudelor (August) -- (devastating strike of Saipan);
(6) Typhoon Goni (August) – (gales on Tinian and Saipan);
(7) Typhoon Champi (October) – (gales, extreme rainfall, Tinian and Saipan) and,
(8) Typhoon In-fa (November) – (brief gales and moderate waves on Guam).

During November and December 2015, and continuing into January 2016, the weather became quiet. A trade wind regime dominated, with typical gusty east-northeast winds and several episodes of hazardous surf (at or just above 8-10 ft) on north and east exposed locations on all islands. After the passage of In-fa safely to the south of Guam in mid-November, no further tropical cyclones affected the region. Rainfall began to lessen, and by late January 2016, wildfire activity on Guam began to increase. Annual rainfall amounts – boosted by several 24-hour extremes associated with passing tropical cyclones – were well above average at most locations on Guam and in the CNMI. For example, the annual total of 129.90 inches at AAFB was the 5th highest annual rainfall total in its 63-year modern climate record. The monthly mean sea level of Guam remained slightly elevated throughout the years of 2014 and part of 2015. It fell down to below normal (-2 in) in April 2015, but did not last long. In August 2015, it fell down abruptly (-5 in) again and stayed below since then. It recorded slight rise in November, but continued to stay below normal. Currently, it is below normal (-4.5 in). The monthly maxima also fell down sharply—as of December 2015; the maximum is 6.5 inches below normal.

Guam and CNMI Rainfall Summary: 2015 4th QTR/Annual

Station		Oct	Nov	Dec	4th Qtr	Annual
CNMI						
Capitol Hill	Inches	19.96	3.41	5.93	29.30	79.31
	% Avg	166%	47%	124%	115%	95%
Saipan Intl. Airport	Inches	21.00	3.61	5.94	30.55	85.32
	% Avg	194%	62%	154%	126%	115%
Tinian Airport	Inches	30.73	2.81	6.89	40.43	107.20
	% Avg	256%	38%	144%	168%	129%
Rota Airport	Inches	15.45	5.54	4.93	25.92	113.18
	% Avg	122%	64%	87%	100%	120%

LOCAL SUMMARY AND FORECAST

Guam and CNMI Rainfall Summary: 2015 4th QTR/Annual

Station		Oct	Nov	Dec	4th Qtr	Annual
GUAM						
GIA (WFO)	Inches	14.26	5.96	3.77	23.98	115.75
	% Avg	118%	73%	70%	94%	127%
AAFB	Inches	12.63	8.57	5.14	26.34	129.90
	% Avg	98%	94%	86%	94%	132%
Sinajaña	Inches	17.15	8.32	5.77	31.24	125.53
	% Avg	142%	101%			

Climate Outlook: As of January 2016, the Pacific basin climate remains in strong El Niño, with indications that it has already reached its peak and is beginning its inevitable fade towards ENSO-neutral by the late spring, or early summer months. Historically, strong El Niño shifts to La Niña conditions late in the year following its peak. Regardless of the time it takes for the climate system to fade to ENSO-neutral and/or cool all the way to La Niña, the major weather threat is the same: drought!! Very dry conditions are anticipated on Guam and all the islands of the CNMI through June 2016. Thereafter, through the remainder of 2016, it should remain relatively dry. Guam and the CNMI are some of the islands that do not fully recover in their rainy seasons from El Niño-related spring drought, primarily a result of Post-Peak year easterly surface wind anomalies and the reduction -- or near elimination—of the monsoon trough and tropical cyclone activity in the region (see Fig 12and the table of predicted rainfall below).

The tropical cyclone threat on Guam and in the CNMI is greatly reduced in the post-peak El Niño year. It is tempting to declare that no direct strikes of any tropical storm or typhoon are likely during 2016, but the odds do not fall to zero, as illustrated by the passage of tiny Tropical Storm Alex over Rota during October of 1998 (a post-peak year of a strong El Niño event). It is possible that in the latter quarter of 2016, two or three of the basin's tropical cyclones could develop near enough to the southwest of Guam to bring some much-needed rains to the region. Consistent to the current weakening El Niño state, forecasts for seal level are marginally below normal in JFM and FMA and slightly elevated (above normal) in MAM.

Predicted rainfall for the Mariana Islands from January 2016 through December 2016:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]	
	Guam/Rota	Saipan/Tinian
January – March 2016 (1st Half of Dry Season)	50% (5.58in)	60%* (4.65in)
April– June 2016 (2nd Half of Dry Season)	65%	70%*
July– September (Heart of next Rainy Season)	85%	85%
October– December 2016 (End of next Rainy Season)	80%	80%

* percentages are higher than at Guam only because it is normally very dry on Saipan during the indicated months.

LOCAL SUMMARY AND FORECAST

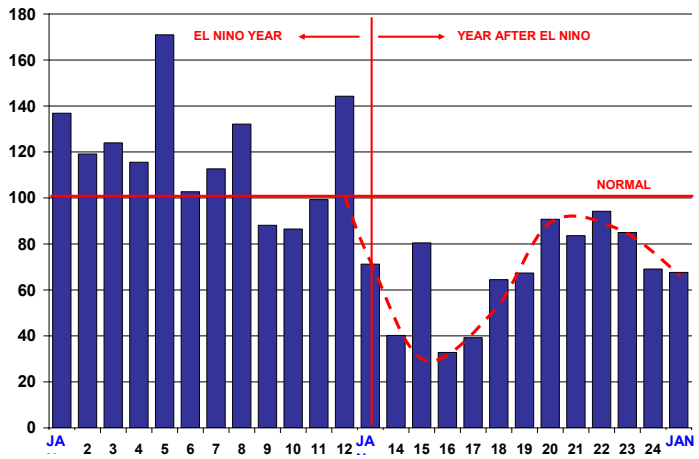


Figure 12. Rainfall at Guam for a composite of five El Nino events. Note the wet conditions in the first half of the El Nino year, with a gradual drying that begins in September. Drying is substantial in the first half of the year that follows El Nino, and does not recover for the whole year. Note the spike in December in what otherwise should be in a drying trend. This is an artifact of typhoon strikes late in the El Nino year.

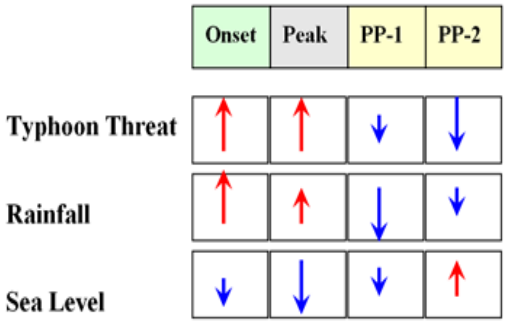


Figure 13. Evolution of climatic variables during the course of a strong El Niño on Guam and in the CNMI. Onset = Jan – Jun 2015; Peak = Jul 2015 – Feb 2016; Post-Peak (PP)1 = Mar – Jun 2016; PP2 = Jul – Dec 2016.

Federated States of Micronesia

Yap State: The year 2015 will long be remembered for the severe beating by typhoons that many islands of Micronesia experienced. Yap State was not spared during this busy typhoon season. In fact, the Yap State atolls of Ulithi and Fais were delivered by Super Typhoon Maysak perhaps the most devastating strike by a typhoon in the region during this wild El Niño year. Throughout much of the year, there was a continual passage through regional waters of additional tropical cyclones that were either weaker or more distant than Maysak, thereby reducing impacts.

Another notable behavior of the climate throughout Yap State during 2015 was a sharp decline of monthly rainfall after a wet August (Fig. 13). The 4th Quarter rainfall total of 13.53 inches at the Yap Island Weather Service Office (WSO) was the driest such 3-month total in the post-WWII historical climate record at that observing site! Woleai Atoll, some 300 miles southeast of Yap Island, was even drier, with only 10.35 inches of rain for the 3-month period. During El Niño, the islands of Yap State (and those of the Republic of Palau) are among the first locations within Micronesia to experience a substantial El Niño-related drying. The PEAC forecasts for Yap State began to congeal toward an outlook for drought by July of

Sea level in Yap has been considerably below normal since February 2015. As compared to OND of 2014, it fell about 6 inches in OND of 2015. After a record 8 inches fall in October, it started to rise again. Currently it is staying about 4 inches below normal. The monthly maxima also displayed similar trend.

LOCAL SUMMARY AND FORECAST

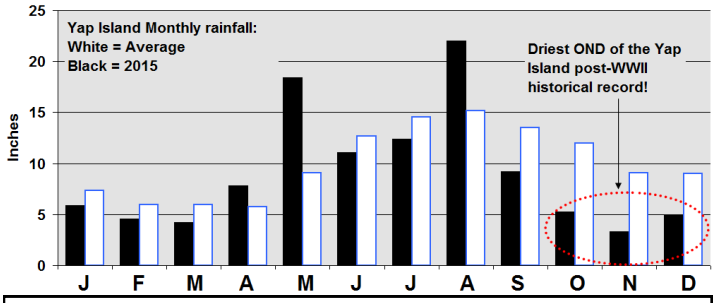


Fig. 13. Time series of monthly rainfall at the Yap Island WSO. The continuous dryness at the end of the year set a new historical record low.

Yap State Rainfall Summary: 2015 4th Quarter and Annual						
Station		**Oct**	**Nov**	**Dec**	**4th Qtr**	**Annual**
Yap State						
Yap WSO	**Inches**	**5.29**	**3.31**	**4.93**	**13.53**	**109.08**
	% Norm	**44%**	**36%**	**55%**	**45%**	**91%**
Ulithi	**Inches**	**6.28**	**3.26**	**7.42**	**16.96**	**99.07**
	% Norm	**62%**	**42%**	**97%**	**66%**	**97%**
Woleai	**Inches**	**2.22**	**2.58**	**5.55**	**10.35**	**90.01**
	% Norm	**16%**	**24%**	**48%**	**41%**	**65%**

Climate Outlook: As of January 2016, the Pacific basin climate remains in strong El Niño, with indications that it has already reached its peak and is beginning its inevitable fade towards ENSO-neutral by the late spring, or early summer months. Historically, strong El Niño shifts to La Niña conditions late in the year following its peak. Regardless of the time it takes for the climate system to fade to ENSO-neutral and/or transition all the way to La Niña, the major weather threat is the same: drought!! Very dry conditions are anticipated throughout Yap State through June 2016. Thereafter, monthly rainfall amounts should recover to near average.

For many months following the post-Peak phase of El Niño (e.g., March through December 2016), the typhoon threat is reduced across Yap State. In the first half of the year, the general reduction of Pacific basin typhoons reduces the local risk, and in the second half of the year, the westward and northward displacement of the basin's tropical cyclones helps to reduce the local typhoon threat in Yap State. Late in the year (OND), Yap State is among the first locations in Micronesia where the risk of impacts from tropical cyclones returns to near normal. Sea level forecasts are below normal in JFM and slightly elevated (above normal) in FMA and MAM.

Predicted rainfall for Yap State from January 2016 through December 2016 is:

Inclusive Period	**% of long-term average / Forecast rainfall (inches) [1]**	
	Woleai	**Yap & Ulithi**
January – March 2016 (Heart of Next Dry Season)	**40% (7.53in)**	**40% (10.59in)**
April– June 2016 (End of Next Dry Season)	**60%**	**60%**
July– September 2016 (Heart of Rainy Season)	**85%**	**95%**
October-December 2016	**85%**	**95%**

LOCAL SUMMARY AND FORECAST

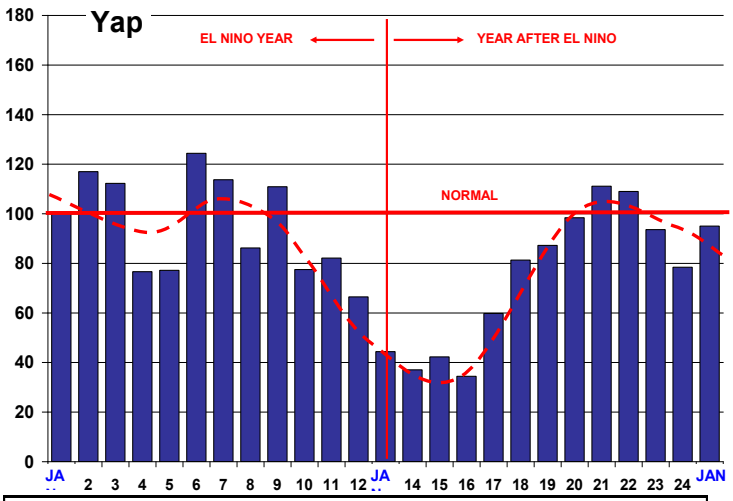


Figure 14. Percent of monthly average rainfall at the WSO Yap for a composite of five El Nino events. Note the near-average conditions in the first half of the El Nino year, with a gradual drying that begins by August or September. Significant drying occurs in the latter 3 months of the El Niño year and is severe in the first half of the year that follows El Nino. Full recovery occurs by about August of the year following El Niño.

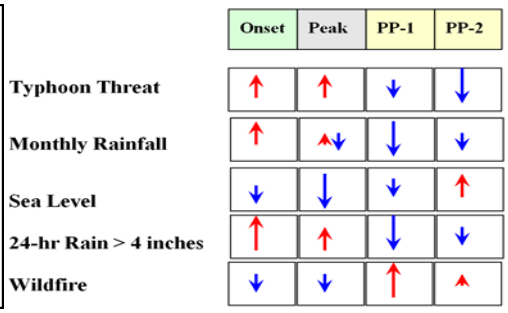


Figure 15. Evolution of climatic variables during the course of a strong El Niño throughout Yap State. Section. Onset = Jan – Jun 2015; Peak = Jul 2015 – Feb 2016; Post-Peak (PP)1 = Mar – Jun 2016; PP2 = Jul – Dec 2016.

Chuuk State: The rainfall distribution at most islands of Chuuk State during 2015 was typical for a strong El Niño event: very wet on most islands during the first six-to-nine months of the year, with a dry finish in the final three months of the year. The high rainfall included several "big days" (i.e., extreme 24-hour rainfall at-or-above 5 inches), many of which occurred in association with the passage of tropical cyclones through the state. Of the several named tropical cyclones that affected Chuuk State during 2015, Typhoon Maysak, occurring during May, was the most destructive as it made a direct hit on Chuuk Lagoon as a Category 2 typhoon. In addition to the heavy damages, four people lost their lives, three to falling tree limbs and one to a mudslide. In mid-November, Chuuk State had one final typhoon scare during this busy year. Typhoon In-fa passed through regional waters with the small core of the system passing through the 60 n mi gap between the Chuuk Lagoon to the south and Fananu to the north. Fortunately, In-fa temporarily weakened to a tropical storm while passing through Chuuk State, so damage was not severe. The Chuuk Weather Service Office on Weno Island in Chuuk Lagoon, reported 2.91 inches of rainfall and wind gusts over 40mph as In-fa passed to the north. By mid-January, the PEAC received reports that Fananu had asked for water assistance for itself and other drying northern atolls. Other late 2015 notable weather conditions included high surf on the northeast sides of the atolls and the barrier reef of Chuuk Lagoon. The high surf was generated by the return of brisk trade winds in December. On Weno Island, in the Chuuk Lagoon, local wind waves raised by trade winds, were responsible for nuisance-level splashing of sea water onto coastal roads on the northeast side. The mean sea level, manifested very low low-tides that were readily apparent to residents nearly every day on the west sides of islands.

LOCAL SUMMARY AND FORECAST

Chuuk State Rainfall Summary: 2015 4th QTR & Annual

Station		Oct	Nov	Dec	4 Qtr	Yrly.
Chuuk Lagoon						
Chuuk WSO	Inches	6.09	7.46	9.25	22.80	155.79
	% Avg	45%	72%	85%	66%	116%
Southern Mortlocks						
Namoluk	Inches	7.57	10.02	7.40	24.99	160.29
	% Avg	73%	92%	57%	73%	112%
Northern Mortlocks						
Losap	Inches	9.65	19.25	16.53	45.43	159.67
	% Avg	72%	186%	152%	131%	119%
Northern Atolls						
Onoun	Inches	8.39	7.24	7.06	22.69	128.50
	% Avg	63%	70%	65%	66%	96%
Western Atolls						
Polowat	Inches	4.21	3.15	5.10	12.46	79.03
	% Avg	35%	34%	55%	41%	65%

Climate Outlook: As of January 2016, the Pacific basin climate remains in strong El Niño, with indications that it has already reached its peak and is beginning its inevitable fade towards ENSO-neutral by the late spring, or early summer months. Historically, strong El Niño shifts to La Niña late in the year following its peak. Regardless of the time it takes for the climate system to fade to ENSO-neutral and/or transition all the way to La Niña, the major weather threat is the same: drought! Very dry conditions are anticipated throughout Chuuk State through June 2016. Thereafter, monthly rainfall amounts should recover to near average by July and continue near to above average for the remainder of the year (see Fig. 16, 17). At atolls to the north of Chuuk Lagoon, the dryness is likely to be more severe than at atolls to the south of Chuuk Lagoon, which is at 7.5° N. During 2015, Chuuk State experienced a great abundance of tropical cyclones that should not be repeated soon. For the remainder of 2016, the risk of a damaging tropical cyclone in Chuuk State should be lower than average, with the greatest risk during this quiet year occurring from late September through the end of the year. Lastly, the sea level, which is still very low throughout Chuuk State, should soon undergo a rapid rise returning mean sea level to near average by summer, and to above average by the end of the year .

Predictions for Chuuk State for January through December 2016:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]			
	Chuuk Lagoon, and Nama	Polowat	Nrn & NW Islands	Srn Mortlocks
Jan – Mar 2016	50% (12.89in)	50% (12.89in)	50% (12.88in)	50% (12.88in)
Apr – Jan 2016	75%	70%	70%	70%
Jul– Sep 2016	90%	80%	90%	95%
Oct– Dec 2016	105%	95%	100%	110%

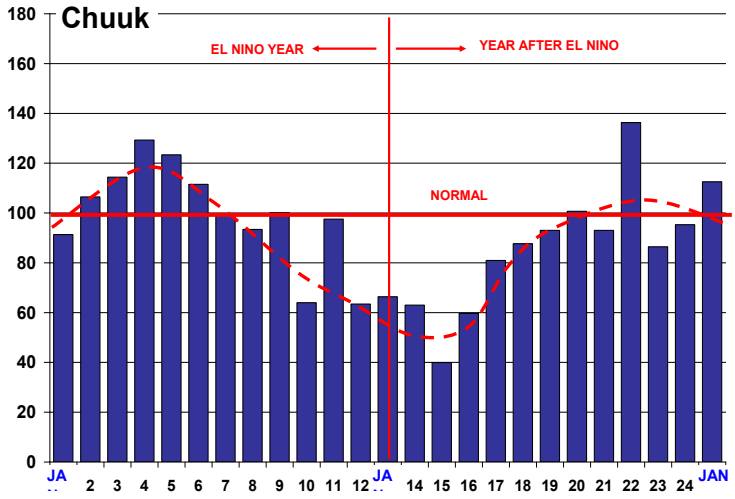


Figure 16. Rainfall at the WSO Chuuk for a composite of five El Nino events. Note the wet conditions in the first half of the El Nino year, with a gradual drying that begins by August or September. Drying is substantial in the first half of the year that follows the El Nino Peak, but recovers by July or August of that year. This bar chart is applicable only at islands at or near the latitude of the Chuuk Lagoon (7.5° N). Northern atolls may be drier and recover more slowly (delayed by about a month), while atolls to the south may recover more quickly (accelerated by about a month).

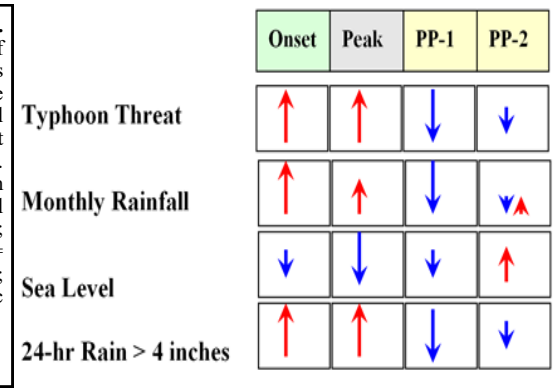


Figure 17. Evolution of climatic variables during the course of a strong El Niño throughout Chuuk State. Onset = Jan – Jun 2015; Peak = Jul 2015 – Feb 2016; post-Peak (PP)1 = Mar – Jun 2016; PP2 = Jul – Dec 2016.

Pohnpei State: The year 2015 will be remembered on Pohnpei Island for "Plenty! Plenty! Rain!" This was Eden Skilling's (the Pohnpei Weather Service Office (WSO) Official-in-Charge) memorable quote as a concise summary of the local Pohnpei Island weather during July, August, and continuing into September. The 2015 annual total of 216.87 inches at the WSO in Kolonia on Pohnpei Island was the 6th highest annual total in that station's 63-year post-WWII climate record. Some of the atolls of Pohnpei State, such as Nukuoro and Kapingamarangi, also were very wet during 2015. In addition to high rainfall, 2015 will also be remembered for relentless strong westerly winds, which were the result of an extended monsoon trough, a continual parade of monsoon depressions, and several named tropical cyclones passing close by to the north of the State. The persistent strong westerly wind and high surf hampered the efforts of residents to fish in their local waters. Early season heavy rains in Pohnpei accompanying unusual episodes of monsoonal westerly winds are a reliable predictor of El Niño (Fig. 18). Monthly rainfall was anticipated to begin to decline late in 2015. Indeed, the rainfall during the 4th Quarter of 2015 was below average at all Pohnpei Island recording sites and at Pingelap. At atolls near the equator (e.g., Nukuoro and Kapingamarangi), the 4th Quarter rainfall totals remained above average. Low sea levels were perceptible to local residents of Pohnpei Island.

Dry conditions were anticipated to continue during January 2016, but on the 5th of that month, an extreme 24-hour rainfall of 8.11 inches occurred at the WSO site on Pohnpei Island. This heavy rain was caused by localized deep convection within a relatively small, unorganized and innocuous looking tropical disturbance that was passing through Pohnpei State on that day. After this one big daily rain, conditions returned to dryness, and on the 31st of the month, news was relayed from the WSO Pohnpei Island that a brush fire had crawled up the eastern side of Sohkes Rock, the massive edifice of columnar basalt that is an iconic symbol of the State of Pohnpei (Figure 18).

LOCAL SUMMARY AND FORECAST

Sea level for Pohnpei started to fall as of April 2015. As compared to OND of 2014, it fell about 5 inches in OND of 2015. Since October 2015, it is staying about 4.5 inches below normal. The monthly maximum also stays at 5 inches below normal.

Pohnpei State Rainfall Summary: 2015 4th QTR & Annual						
Station		Oct	Nov	Dec	4th Qtr	Annual
Pohnpei Island						
Pohnpei WSO	Inches	11.86	9.95	11.41	33.22	216.88
	% Norm	71%	63%	75%	70%	115%
Atolls of Pohnpei State						
Nukuoro	Inches	10.49	13.37	16.31	40.17	204.58
	% Norm	98%	111%	136%	116%	137%
Pingelap	Inches	8.95	3.17	7.28	19.40	120.74
	% Norm	60%	22%	54%	46%	68%
Kapinga-marangi	Inches	5.13	8.28	13.20	26.61	153.49
	% Norm	76%	96%	132%	105%	123%

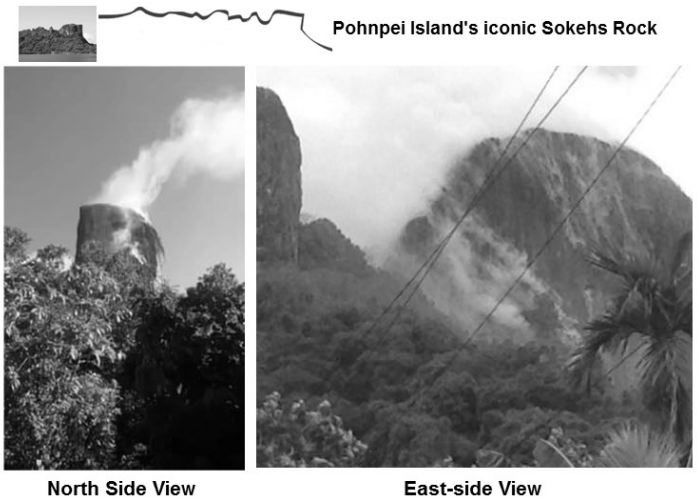


Figure 18. A wildfire crawls up the side of Sokehs Rock on 31 January 2016. This 190 m edifice comprised of columnar basalt pillars is an iconic symbol of Pohnpei State, and is clearly visible close by to the west of the International Airport on the north side of Pohnpei Island. The little inset image on top is the view from the airport, and the outline is part of the logo of the island's newspaper, the Kaselehlie Press. Wildfires seem unimaginable on an island that receives nearly 200 inches of annual rainfall, but during the dryness associated with strong El Niño, they actually do occur there. It also seems unimaginable that of all places on Pohnpei Island, Sokehs Rock would catch fire, but then again, it is El Niño, after all. Photos courtesy of Mr. Wallace Jacob, Weather Service Specialist, WSO Pohnpei.

LOCAL SUMMARY AND FORECAST

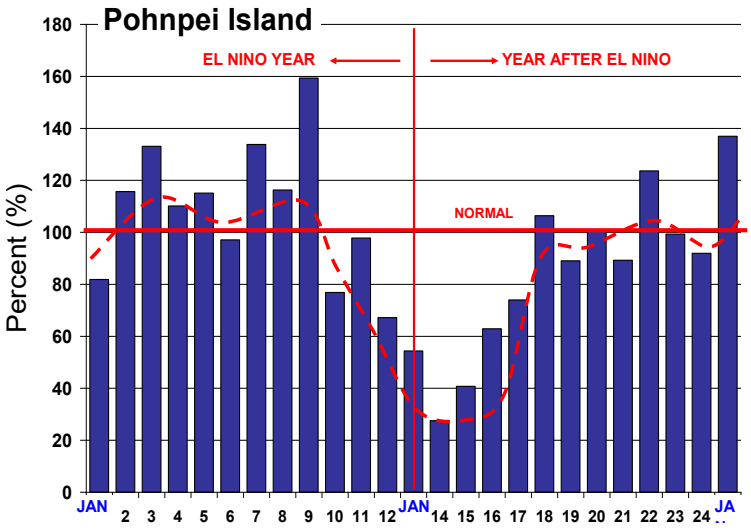
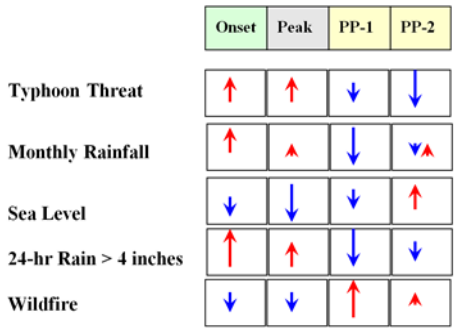


Figure 19. Percent of average rainfall at the WSO Pohnpei for a composite of five El Nino events. Note the wet conditions through September of a typical El Niño year, with a gradual drying that begins by October. Drying is substantial from December of the El Niño year through May of the year that follows El Niño. Rainfall recovers to near average by July of the year following El Niño. Note: the spike in September is not just an artifact of a single big month; all five September members of the composite were well above average.

Figure 20 Evolution of climatic variables during the course of a strong El Niño Pohnpei Island and atolls north of 5° N (not entirely applicable to locations south of 5° N, such as Nukuoro and Kapingarangi). Onset = Jan – Jun 2015; Peak = Jul 2015 – Feb 2016; Post-Peak (PP)1 = Mar – Jun 2016; PP2 = Jul – Dec 2016.



Climate Outlook: At the end of January 2016, the Pacific basin climate remained in strong El Niño, with indications that it has already reached its peak and is beginning its inevitable fade towards ENSO-neutral by the late spring, or early summer months. Historically, strong El Niño shifts to La Niña conditions late in the year following its peak. Regardless of the time it takes for the climate system to fade to ENSO-neutral or transition all the way to La Niña, the major weather threat now for Pohnpei State is the same: drought! Very dry conditions are anticipated on Pohnpei Island and all atolls north of 5° N. Atolls south of 5° N remain wet for the whole 18-month period of an El Niño event. Low stream flow, inadequate rain catchment and possible wildfires are anticipated at locations where the post-Peak El Niño drought takes hold. By June of 2016, rainfall at all islands of Pohnpei State should be near average. Late in 2016, if the climate system aggressively moves toward strong La Niña, Kapingamarangi could become dry.

In the upcoming El Niño post-Peak months, and indeed all the way through to the end of 2016, the threat of a damaging tropical cyclone anywhere within Pohnpei State is very low (less than a 1-in-10 chance).

Lastly, sea level forecasts for the next seasons (JFM to MAM) indicate a gradual rise and, by MAM, the sea level is likely to be marginally above normal.

Predicted rainfall for Pohnpei State from January 2016 through December 2016:

Quarter 1, 2016

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Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]	
	Pohnpei Is. And Atolls	Kapingamarangi
Jan - Mar 2016	50% (16.96in)	110%* (54.37in)
Apr—June 2016	65%	100%*
Jul– Sep 2016	90%	100)*
Oct– Dec 2016	110%	85%*

* 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: Monthly rainfall on Kosrae was generally near average to slightly wetter than average through the first 9 months of 2015. And then, rainfall amounts were well below average during both October and November, which was anticipated to occur in association with the ongoing strong El Niño. During December, however, monthly rainfall bounced back to near normal. Despite the bump in rainfall amounts during December, the sudden shift to dryness in October will still likely be regarded as the start of a prolonged period of dryness that will continue over the next few months as we enter the post-Peak phase of El Niño.

The big weather story of 2015 at Kosrae was the unusual prevalence of gusty westerly winds caused by two related phenomena: (1) an unusual eastward extension of the western North Pacific monsoon trough; and, (2) the passage near Kosrae of tropical cyclones, two of them already named when at their closest point of approach to Kosrae (Bavi in March and Dolphin in May), with several others passing near Kosrae at their beginning pre-named stages. The continual strong westerly winds caused some damage to banana crops by uprooting trees. Other effects of the westerly winds included high surf, nuisance inundation and coastal erosion in Walang.

Kosrae State Rainfall Summary: 2015 4th QTR & Annual						
Station		Oct	Nov	Dec	4 Qtr	Annual
Kosrae State						
Airport (SAWRS)	Inches	6.90	4.55	15.37	26.82	179.53
	% Avg	43%	29%	106%	58%	87%
Nautilus	Inches	8.74	3.86	14.77	27.37	191.45
	% Avg	54%	24%	102%	59%	93%

Climate Outlook: As of January 2016, the Pacific basin climate remains in strong El Niño, with indications that it has already reached its peak and is beginning its inevitable fade towards ENSO-neutral by the late spring, or early summer months. Historically, strong El Niño shifts to La Niña conditions late in the year following its peak. Regardless of the time it takes for the climate system to fade to ENSO-neutral and/or transition all the way to La Niña, the major weather threat is the same: drought! Very dry conditions are anticipated throughout the Republic of Palau through June 2016. Thereafter, monthly rainfall amounts should recover to near average (see Fig. 21, and 22). Tropical cyclones occur at Kosrae almost

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exclusively during the months of El Niño Onset through the El Niño Peak phase. During the El Niño post-Peak months, and indeed all the way through to the end of 2016, the threat of a damaging tropical cyclone at Kosrae is very low. Lastly, the sea level typically begins a rapid rise throughout all of Micronesia in the post-Peak months. Thus, the sea level at Kosrae should return to average by mid-summer.

Predicted rainfall for Kosrae State from January through December 2016 is:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]
January – March 2016	50% (24.71 inches)
April– June 2016	75%
July– September 2016	90%
October-December 2016	90%

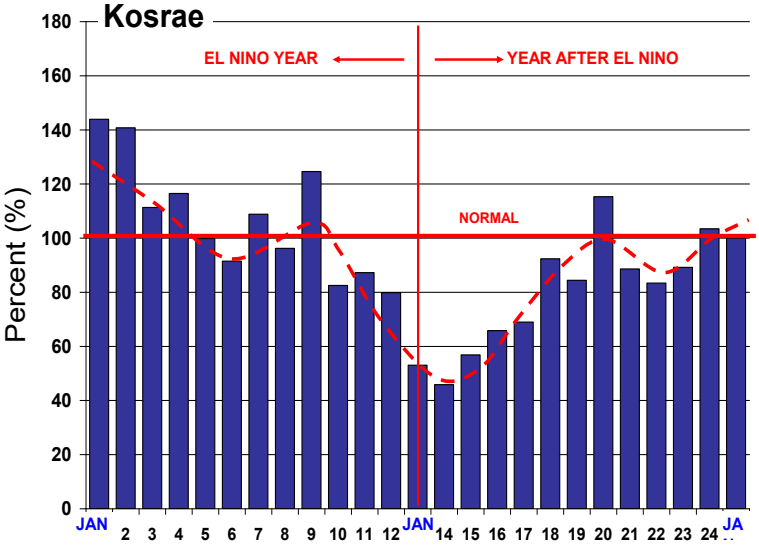


Figure 21. Percent of average rainfall on the island of Kosrae for a composite of five El Niño events. Note the relatively wet conditions through September of a typical El Niño year, with a gradual drying that begins by October. Drying is substantial from January through May of the year following the peak of El Niño. Rainfall then recovers to near average by June or July. The red dashed line shows a smoothed the rainfall behavior during the a 2-year period of a strong El Niño, beginning with the year of El Niño Onset and Peak (e.g., 2015) through the year following the peak of El Niño (e.g., 2016).

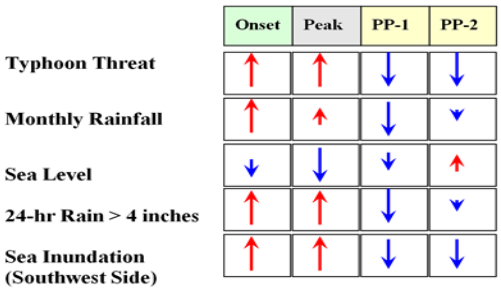
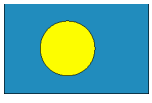


Figure 22. Evolution of climatic variables during the course of a strong El Niño at Kosrae. Onset = Jan – Jun 2015; Peak = Jul 2015 – Feb 2016; Post-Peak (PP)1 = Mar – Jun 2016; PP2 = Jul – Dec 2016.



Republic of Palau: The character of the climate and weather of 2015 throughout the Republic of Palau can be summarized as "Dry! Dry! Dry", which is the inverse of the situation further east at locations such as Pohnpei, where the phrase, "Plenty! Plenty! Rain" is applicable. In fact, the 2015 annual total rainfall of 97.06 inches (66%) recorded at the Weather Service Office in Koror made 2015 the driest year in that station's 63-year post-WWII climate record. Dryness was experienced early in the year, with the total rainfall of 28.04 inches (58%) during the 5-month period January through May 2015 ranking as the 4th driest such period in the climate record (see Figs. 23 and 24). Later in the year, it was very dry again at Koror, with a sum-total of 18.69 inches (50%) during October, November and December (OND). This was the 2nd driest OND in the climate record at Koror. There were only two months during 2015 — June and September — with above average rainfall. Other stations in the Republic of Palau were not quite as dry as at Koror, but still ended 2015 with substantial rainfall deficits. The record low rainfall at Koror is important since that station is the site of the longest and most complete climate record in the Republic of Palau, and even includes 16 years of climatic data compiled by the Japanese from 1924 to 1941 during their League of Nations mandate period at Palau. The driest year at Palau in the Japanese data is the 128.76 inches recorded during 1938. Thus, the 2015 total of 97.06 inches is the driest in all 79 years of available climate records from Koror. "Dry! Dry! Dry!" indeed.

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At its western location in the geographical bounds of Micronesia, Palau is one of the first places to begin experiencing dryness associated with El Niño, usually around June. The dryness in the 2nd half of 2015 is typical of El Niño, but the extreme dryness of early 2015 was not typical of El Niño, and has no ready explanation, except perhaps that is was a follow-on response to conditions in the prior year (2014), which was on the borderline of El Niño. Despite the unusual dryness, there were no reports of any serious impacts. There was, however, one large brush fire in Babeldaob reported, also it was reported that the vegetation was turning yellow on Palau's beautiful Rock Islands.

Palau sea level has been below normal since March 2015. Currently it is considerably below normal (-6 in). This fall is supportive to the on-going El Niño state, as Palau displayed similar fall in 1997 too. The monthly maxima fell down sharply—currently the monthly maximum is 8.2 inches below normal.

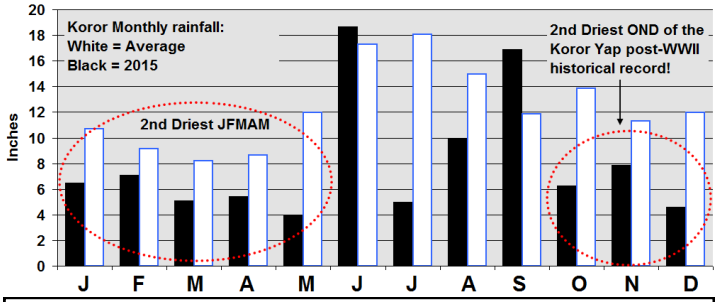

Figure 23. Time series of monthly rainfall at the Koror WSO. The rainfall total for all of 2015 was a record low, and other internal splits [multi-monthly periods] rainfall amounts (e.g., JFMAM and OND) were also near record lows.

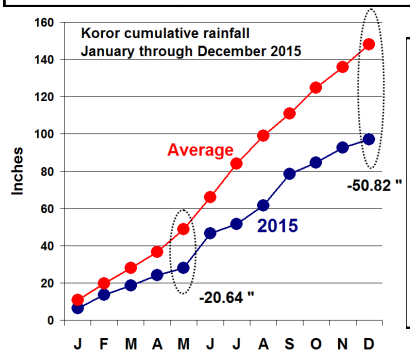

Figure 24. Cumulative rainfall at Koror. Red line shows the normal accumulated rainfall during 2015, and the dark blue line shows the measured accumulated rainfall. By the end of the year, the accumulated rainfall total was 97.06, or 66% of average to make 2015 the driest year in Koror's 63-year historical post-WWII record.

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Republic of Palau Rainfall Summary: 2015 4th Quarter and Annual						
Station		Oct	Nov	Dec	4th Qtr	Annual
Koror (WSO)	Inches	6.24	7.86	4.59	18.69	97.06
	% Norm	45%	69%	38%	50%	66%
Intl. Airport	Inches	4.61	11.38	6.45	22.44	118.92
	% Norm	30%	91%	49%	55%	73%

Climate Outlook: As of January 2016, the Pacific basin climate remains in strong El Niño, with indications that it has already reached its peak and is beginning its inevitable fade towards ENSO-neutral by the late spring, or early summer months. Historically, strong El Niño shifts to La Niña conditions late in the year following its peak. Regardless of the time it takes for the climate system to fade to ENSO-neutral or transition all the way to La Niña, the major weather threat is the same: drought!! Very dry conditions are anticipated throughout the Republic of Palau through June 2016. Thereafter, monthly rainfall amounts should recover to near average by August and perhaps even above average by the end of the year (see Fig. 25).

For many months following the post-Peak phase of El Niño, the typhoon threat is reduced in far western areas of Micronesia, including the Republic of Palau. In the first half of the year, the general reduction of Pacific basin typhoons reduces the local risk, and in the second half of the year, the westward and northward displacement of the basin's tropical cyclones helps to reduce the local typhoon threat. Late in the year, the Republic of Palau is among the first locations where the risk of impacts from tropical cyclones returns to near average.

Current forecasts indicate that sea level in Palau is likely to stay considerably below normal in JFM, and then gradually rise again, but will still stay below normal. By MAM, sea level may return close to normal.

Predicted rainfall for Palau from January 2016 through December 2016 is:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]
January – March 2016	40% (11.85in)
April - June 2016	65%
July– September 2016	90%
October– December 2016	110%

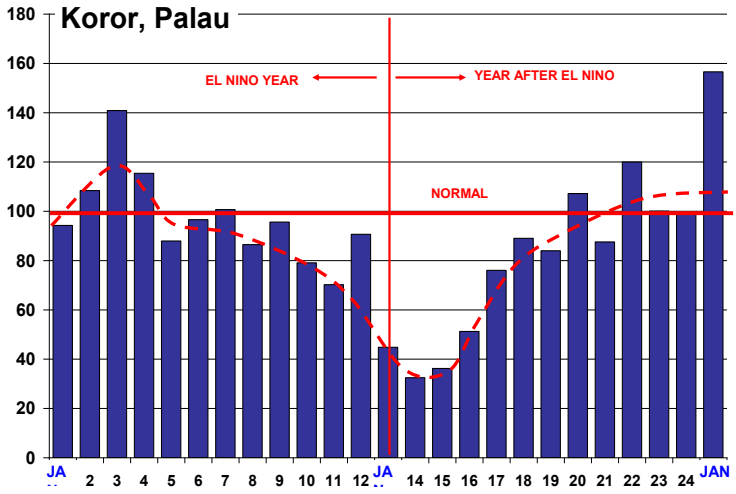

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Figure 25. Composite monthly rainfall for 5 strong El Niño events at Palau for the two-year period that covers the El Niño year and the year that follows El Niño. Values plotted are monthly percent of average rainfall. Red dashed line shows smoothed rainfall trend, and suggests that despite the drought, the rainfall deficit is erased by early fall.

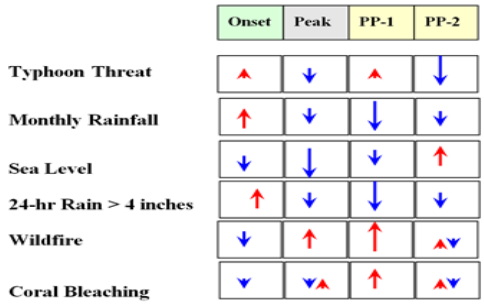

Figure 26. Evolution of climatic variables during the course of a strong El Niño event throughout Palau. Onset = Jan – Jun 2015; Peak = Jul 2015 – Feb 2016; post-Peak (PP)1 = Mar – Jun 2016; PP2 = Jul – Dec 2016.

Republic of the Marshall Islands: For most of 2015, a strong El Niño brought wild, wet and windy weather to many of the atolls of the Republic of the Marshall Islands (RMI). Some of the wild weather (e.g., monsoonal winds, tropical cyclones and very heavy rainfall) began several months before the Niño 3.4 Index officially reached the threshold of El Niño (Fig. 27). The spring of 2015 was particularly wet in association with unusual monsoonal westerly winds reaching the southern RMI and with equally unusual tropical cyclone activity. Through the year, several tropical cyclones continually affected the region, and there were three separate instances of damaging sea inundation. Each of the damaging sea inundations was associated with a nearby tropical cyclone or developing tropical cyclone: (Bavi, March 2015); Dolphin (May 2015); and, Nangka (July 2015).

During the 4th Quarter of 2015, rainfall amounts began to decline. This is a typical response to El Niño. By November and December, most atolls began experiencing monthly rainfall values below a critical 8-inch per month threshold, and some fell below a more serious threshold of less than 4 inches per month. The PEAC Center is participating in a study of drought in the tropical Pacific islands. Two key thresholds of monthly rainfall have been identified: 8 inches and 4 inches. 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. 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. The 37-million- gallon Majuro Airport Reservoir, requiring roughly 8 inches of rainfall per month to meet demand, was a key factor in the selection of the 8-inch impact-based drought threshold.

Although the 2015 annual rainfall was above average at many RMI recording locations, it was the result of high rainfall in the spring and summer that outweighed dryness which began in September and October and then accentuated further in November and December. The RMI is now entering its dry season on the heels of a deficient rainy season. This is an unwelcome set-up for anticipated El Niño post-Peak dryness over the next few months.

Breaking News (from Richard Heim, U.S. Climate Prediction Center, U.S. Drought Monitor co-author):

"A State of Emergency was declared by the Government of the Republic of the Marshall Islands on February 3, 2016. Thirteen atolls have formally requested assistance from the National Government starting January 14 to address water shortage

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challenges, household water catchments and other water storage facilities have run out of water, and drought effects are beginning to be seen on agriculture. The last four months have been the driest October-January in the last 62 years at Majuro and the driest in 12 or 13 years of data at Mili and Jaluit, respectively. So far in February (through the 8th), Majuro has received 0.19 inch of rain, Kwajalein 0.12 inch, and Utirik 0.04 inch. The remaining stations have had no rain this month. Wotje has had no measurable rain in the last 5 weeks. The USDM status at Ailinglapalap was changed from D1-S to D2-S. According to the State of Emergency declaration, RO machines have been deployed to affected communities in Aur, Mili, Likiep, Ujae, Lae, and Arno atolls. These atolls are in the southern and eastern portions of the Marshall Islands, so the USDM status at Mili and Wotje was changed from D2-SL to D3-SL (Extreme Drought). The status at Jaluit, Kwajalein, Majuro, and Utirik continued at D2-S or D2-SL, but these stations will be watched for possible deterioration to D3 if the dryness continues."

Starting from May 2015, the monthly mean sea level in Majuro started to fall. It recorded the highest fall (-5 inches) in October 2015 and then started to rise again in December. As compared to OND of 2014, it fell about 5 inches in OND of 2015. The monthly maximum also stays at 5 inches below normal. The monthly mean sea level in Kwajalein started falling from March 2015. It registered record 7 inches fall in October 2015. As compared to OND of 2014, it fell about 5 inches in OND of 2015. It started to rise again in December and, currently, the monthly mean is 3.5 inches below normal. The monthly maximum value, which is currently 7 inches below normal, indicates dominant low-tides in that region.

RMI Rainfall Summary: 2015 4th Quarter and Annual

Station		Oct	Nov	Dec	4th Qtr	Annual
RMI Central and Southern Atolls						
Majuro WSO	Inches	10.52	5.33	6.93	22.78	140.88
	% Avg	76%	42%	58%	59%	107%
Aling-laplap	Inches	9.85	4.25	3.80	17.90	82.27
	% Avg	76%	36%	38%	52%	70%
Jaluit	Inches	4.51	4.35	8.62	17.48	77.33
	% Avg	33%	34%	73%	45%	59%
Mili	Inches	8.80	5.99	4.36	19.15	116.73
	% Avg	64%	47%	37%	73%	89%
RMI Northern Atolls						
Kwajalein	Inches	11.71	9.98	3.90	25.59	131.13
	% Avg	98%	94%	48%	83%	128%
Wotje	Inches	8.60	8.12	1.84	18.56	95.75
	% Avg	104%	119%	42%	95%	157%
Utirik	Inches	12.63	1.80	6.79	21.22	68.42
	% Avg	164%	28%	167%	117%	121%

Climate Outlook: At the end of January 2016, the Pacific basin climate remained in strong El Niño, with indications that it has already reached its peak and is beginning its inevitable fade towards ENSO-neutral by the late spring, or early summer months. Historically, strong El Niño shifts to La Niña conditions late in the year following its peak. Regardless of the time it takes for the climate system to fade to ENSO-neutral and/or transition all the way to La Niña, the major weather threat now for the RMI is the same: drought! Very dry conditions are anticipated throughout all but perhaps the southern-most atolls of the RMI through June 2016. Beginning

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by July of 2016, and through the remainder of the year, rainfall should return to near average to slightly below average.

Tropical cyclones occur within the RMI almost exclusively during the months of El Niño Onset and during El Niño Peak. In the upcoming El Niño post-Peak months, and indeed all the way through to the end of 2016, the threat of a damaging tropical cyclone within the RMI is very low (less than 10%).

Currently sea level for Majuro is 2 inches below normal and the forecasts for the next seasons (JFM, FMA, and MAM) indicate slightly elevated sea level (+2 inches). Forecasts for the next seasons (JFM, FMA, and MAM) in Kwajalein indicate slightly elevated sea level (+2 inches).

Predicted rainfall for the RMI from January 2016 through December 2016 is:

Inclusive Period	% of long-term average / Forecast rainfall (inches) [1]		
	South of 6°N	6°N to 8°N	North of 8°N
Jan – Mar 2016	50% (11.69in)	40% (9.64in)	40% (5.07in)
April– June 2016	60%	60%	50%
Jul– Sep 2016	90%	90%	90%
Oct– Dec 2016	100%	90%	90%

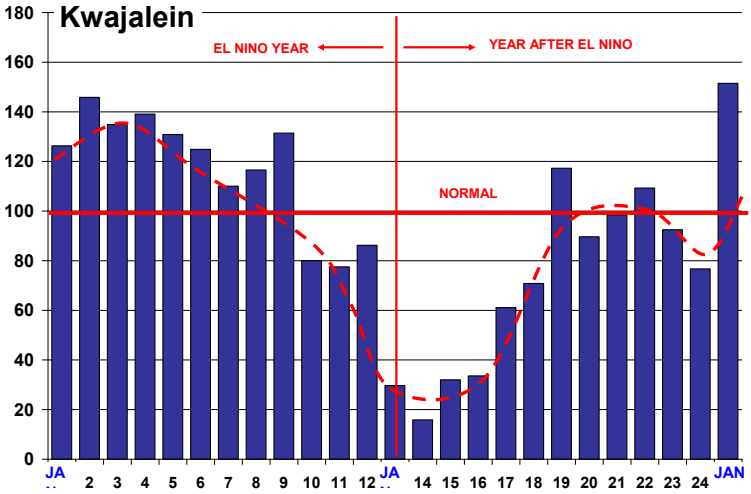

Figure 27. The typical response during El Niño of monthly rainfall (% of average in the RMI. The data plotted are for Kwajalein.

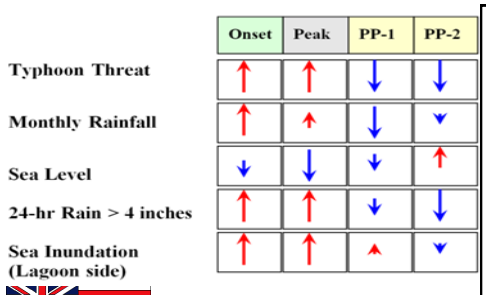

Figure 28. Evolution of climatic variables during the course of a strong El Niño on the central and northern atolls of the RMI. Onset = Jan – Jun 2015; Peak = Jul 2015 – Feb 2016; Post-Peak (PP)1 = Mar – Jun 2016; PP2 = Jul – Dec 2016.

Hawaii: 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.

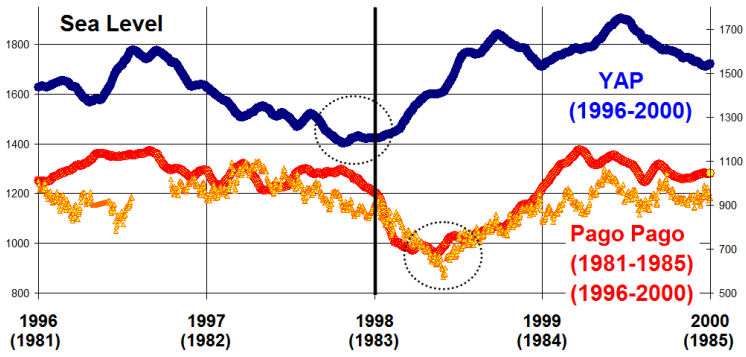

Figure 29. Sea level behavior at American Samoa during strong El Niño. Note that the lowest value of mean sea level in American Samoa occurs roughly three to four months later than the lowest value of sea level across Micronesia (Yap plotted as an example).

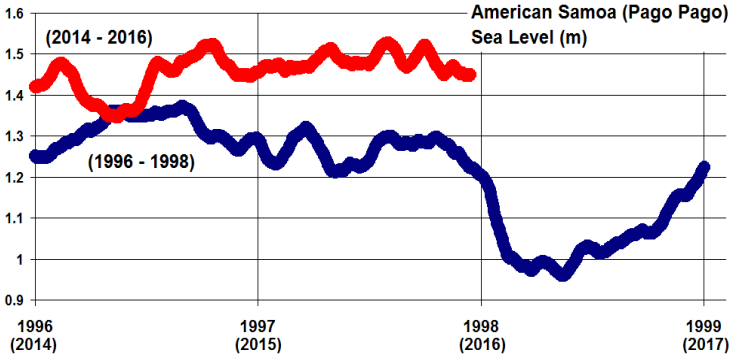

Figure 30. Sea level behavior at American Samoa From January 2014 through December 2015 (red) versus the sea level there during the strong El Niño event of 1997-98 (dark blue).

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.

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