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Providing Information on Climate Variability for the U.S.-Affiliated Pacific Islands

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## CURRENT CONDITIONS

**The year of 2008 both began and ended with La Niña conditions, with ENSO indices remaining neutral for most of the year. But while the prevailing state of the climate was ENSO-neutral, the weather patterns were far from normal.** Climatic effects more typical of La Niña were noted for much of 2008, and included well-known La Niña-related anomalies such as below normal tropical cyclone activity across most of Micronesia, a weak monsoon, higher than normal sea-level, and abnormally strong and widespread easterly surface winds in the low latitudes. Oceanic cooling observed along the equator in the central and eastern Pacific increased in magnitude in late 2008, nudging the climate back into La Niña by year's end.

**During the calendar year 2008, the weather throughout the U.S.-Affiliated Pacific Islands (USAPI) was generally tranquil, with no destructive wind events and few extremes of rainfall. However, the most dramatic climate extreme of the year occurred during the week of December 8-15, 2008, when an unusual pattern of gale-force winds located in the subtropics of the western North Pacific near the International Date Line generated oceanic swell that traveled to the south and caused phenomenal surf throughout eastern Micronesia and all the way south to the northern coast of Papua New Guinea** (see page 12 for press release). Massive inundation was experienced in many locations, with damage to infrastructure, personal property, and crops. Damages also occurred in the RMI, and a full investigation of the damages in all of the USAPI is now underway. The PEAC Center is committed to a thorough meteorological examination of this event, with a special report to follow.

The 2008 annual rainfall at most of the USAPI recording sites was below normal (see Figures 1a and 1b). Annual rainfall totals were less than 75% of normal at some of the atolls of the northern RMI, at Woleai in the southern part of Yap State, at Polowat in the western portion of Chuuk State, at Kahului Airport on Maui, and on parts of Guam. Annual rainfall totals with amounts below 70 inches occurred at Woleai, Saipan, Guam and in some of the northern atolls of the RMI. Annual rainfall totals exceeding 200 inches occurred on Pohnpei Island, Nukuoro, and Kosrae. The 223.67 inches recorded at the Kosrae Airport was the USAPI's highest reported annual rainfall total during 2008.

After a drier-than-normal October, the Hawaiian islands settled into a typical rainy season pattern, and most stations ended the year with near-normal rainfall. A series of storms throughout November and December brought much-needed rainfall and helped improve drought conditions to many areas of the state. However, the excessive rainfall in December caused significant flooding across portions of Kauai and Oahu, producing severe damage to homes, infrastructure, and farm lands. One particularly strong thunderstorm produced a rare tornado as it made landfall over the Pakala area of south Kauai on December 13.

No typhoons directly affected any island in the central or western North Pacific basin during 2008. In fact, until Typhoon Dolphin tracked past Guam in mid-December, the Guam Weather Forecast Office had issued no tropical cyclone watches or warnings in its area of responsibility. Guam and the CNMI were placed under a tropical storm watch and a tropical storm warning as Dolphin passed by (rather uneventfully).

Sea-level variation in the USAPI is sensitive to the ENSO-cycle, with low sea-level observed during El Niño years and high sea-level during La Niña years. Sea-levels have been above normal since early 2007. Current forecasts indicate that sea-levels will remain elevated at all USAPI stations through the next several months, as La Niña conditions continue to develop.

The following comments were taken from WFO Guam's MONTHLY PACIFIC ENSO DISCUSSION FOR MICRONESIA AND AMERICAN SAMOA, issued in January 2009:

"The return to La Niña conditions will keep trade winds stronger and more persistent than normal. This will reinforce the higher than normal sea-levels we have experienced in the western Pacific, exposing most of the Micronesian islands, especially the low islands, to periods of coastal flooding and inundation, particularly during full moon and new moon phases and during high surf episodes. This situation could last into early summer. Tropical cyclone activity will be pushed to the west, reducing the risk of hurricanes to American Samoa and likely delaying the Northern Hemisphere typhoon season for Micronesia. Rainfall in American Samoa will likely be below normal due to reduced monsoon activity. The Republic of the Marshall Islands, and Yap State and Chuuk State in the FSM will likely have below normal rainfall for the next few months. The Marianas will experience high month-to-month rainfall variability during its dry season. Pohnpei State will have near normal rainfall, while Kosrae State will have normal to above normal rainfall. Rainfall for Palau will also be normal to above normal."

## SEA SURFACE TEMPERATURES SOUTHERN OSCILLATION INDEX

### Sea Surface Temperatures (SST)

From September 2008 – January 2009, negative sea-surface temperature (SST) anomalies strengthened and became more widespread in the central and eastern equatorial Pacific as La Niña conditions redeveloped. During the last 4-weeks, SSTs were at least 0.5°C below-average throughout the central and eastern equatorial Pacific Ocean, and more than 1°C below-average between 170°W and 110°W. According to the U.S. Climate Prediction Center (CPC), the latest weekly SST departures are -0.8ºC in Niño 4, -1.1ºC in Niño 3.4, -0.9ºC in Niño 3, and -0.6ºC in Niño1+2. Positive SST anomalies covered much of the North Atlantic and west-central South Pacific Oceans, while negative anomalies were evident in a region extending from the west coast of North America to the Gulf of Alaska and Bering Sea.

### Southern Oscillation Index (SOI)

The 3-month average of the Southern Oscillation Index for the 4th Quarter of 2008 was +1.4, with monthly values of +1.3, +1.5, and +1.5 for the months of October, November and December 2008, respectively. With the exception of May 2008 (when the monthly SOI value dipped down to –0.3), the SOI has been positive since August 2007. 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. The SOI is an index representing the normalized sea level pressure difference between Darwin, Australia and Tahiti, respectively.

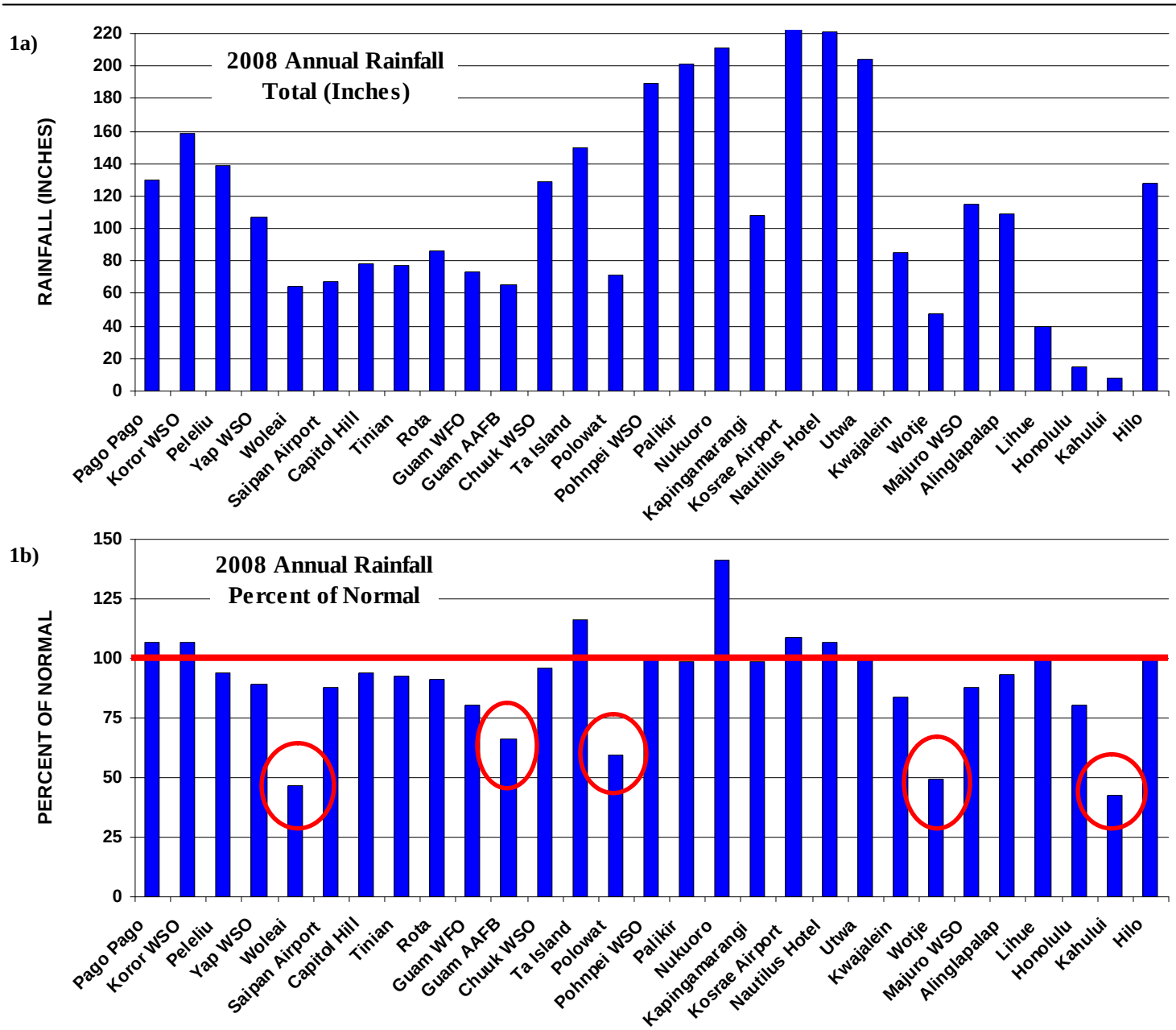



**Figure 1**, above. 2008 rainfall totals (a) in inches and (b) anomalies (expressed as % of normal). In 1b, solid line indicates normal rainfall (100%) and circles indicate rainfall less than 75% of normal.

## TROPICAL CYCLONE

The PEAC Center 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 United States Air Force and Navy, located at Pearl Harbor, Hawaii. Western North Pacific tropical cyclone names are obtained from warnings issued by the Japan Meteorology 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 pressure, and 10-minute average maximum sustained wind estimates from advisories issued by the Tropical Cyclone Warning Centers (TCWC) at Brisbane, the RSMC Nadi, and the New Zealand Meteorological Center at 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, but JTCW values are given precedence when available.

### Tropical Cyclone Summary

**For the second year in a row, the tropical cyclone season of the western North Pacific basin was below normal in almost every category of activity** (e.g., number of typhoons). The JTWC numbered 27 tropical cyclones in the western North Pacific basin during 2008. This was 4 below average. Of these 27 cyclones, 2 were tropical depressions, 14 were tropical storms, 11 were typhoons, and 2 of the typhoons were super typhoons. This corresponds to normal values of 3, 10, 18, and 4 for these statistics, respectively. (The JMA named 22 of the cyclones that JTWC numbered. The JMA named one cyclone, Phanfone, which the JTWC did not number.) Tropical cyclone activity in the western North Pacific basin was also shifted far westward and northward, which is typical during La Niña. Because of this major shift of basin cyclone activity, no area of Micronesia was severely impacted by a tropical cyclone during 2008. The Weather Forecast Office (WFO) Guam almost made it through the entire calendar year of 2008 without issuing a single tropical cyclone watch or warning for any of the islands of Micronesia. This unprecedented tranquility was interrupted by Typhoon Dolphin during December. This Typhoon, which had a very unusual origin (having developed from a sub-tropical disturbance), passed near enough to Guam and the CNMI in mid-December for the WFO Guam to issue a tropical storm watch and a tropical storm warning for these islands. Dolphin's passage by Guam and the CNMI was largely uneventful with some moderately gusty winds (30-35 mph) accompanied by some rain showers that contributed only about 1 inch of rainfall to December's rather dry monthly rainfall total.

The tropical cyclone activity in the eastern North Pacific (historically the world's 2nd most active basin) was near normal in total output of cyclones but below normal in the count of hurricanes and intense hurricanes for the year. During 2008, the National Hurricane Center, Miami, named 16 cyclones there, which is within normal limits. Of the 16 named cyclones, only 6 became hurricanes, and of the hurricanes, two of them (Hurricanes Hernan and Norbert) became major hurricanes (i.e., a hurricane with an intensity to place it at Category 3, 4 or 5 on the Saffir-Simpson hurricane damage potential scale). Normally there are 8 or 9 hurricanes in the eastern North Pacific, of which 4 typically reach major hurricane status. In the central North Pacific, only one tropical storm developed in all of 2008. On August 7, Tropical Storm Kika formed far southeast of the main Hawaiian islands. The storm moved westward over open water and weakened seven days later without incident. On average, 4-5 tropical cyclones are observed in the central North Pacific every year.

### PEAC Center Tropical Cyclone Outlook

**The PEAC tropical cyclone outlook for the upcoming typhoon season of 2009 is for more activity in the western North Pacific basin than occurred there in 2008, even though the typhoon season may once again start get off to a late start because of La Niña conditions in the basin. Also, the geographical distribution of western North Pacific tropical cyclones should return to a more normal pattern, elevating the risk of a typhoon in Micronesia (from Chuuk and westward) to near normal.** Islands from Pohnpei and eastward into the RMI experience tropical storms and typhoons primarily during El Niño. The risk of a damaging tropical cyclone in these locations is considered low during 2009 (but not quite so extraordinarily low as it was in 2007 and 2008).

The 2008-2009 South Pacific hurricane season is off to a relatively slow start. There has been only one cyclone (Charlotte) named by the responsible agencies in this basin from July 2008 through mid-January 2009. Although only one cyclone has been named in the South Pacific basin, an active monsoonal cloud band with embedded cyclonic disturbances contributed to severe flooding in Fiji in early January. **The focus of tropical cyclone and monsoonal activity in the South Pacific has been between northeastern Australia and Fiji, with one episode of northwest monsoonal winds reaching the islands of American Samoa.** This is typical of La Niña conditions. In ENSO-neutral years, the tropical cyclone activity of the South Pacific is more likely to extend eastward to the region of Samoa, or in the case of El Niño years, reach as far east as the Cook Islands and French Polynesia. The activity occurs further eastward in rough proportion to the strength of El Niño and further westward in rough proportion to the strength of La Niña.

The PEAC Center remains cautiously optimistic that the primary focus of South Pacific tropical cyclone activity will, for the next three months, remain in the Coral Sea from northeastern Australia eastward to Fiji, a view also supported by the TSR research group (see excerpt below). **Through April 2009, it is likely that 1 or 2 tropical cyclones will pass close enough to American Samoa to bring gusty northwesterly winds of near-gale strength to the islands and territorial waters.** The risk of a damaging impact by a hurricane or strong tropical storm in American Samoa is considered to be near normal (roughly a 5% - 10% chance) through April 2009. For comparison, the risk of a damaging impact by a typhoon on Guam is typically 15 - 20% during any given year, increasing to 30% - 40% during El Niño years.

The PEAC tropical forecast considers input from two seasonal outlooks for tropical cyclone activity in the western North Pacific basin: (1) The City University of Hong Kong Laboratory for Atmospheric Research, under the direction of Dr. J. C-L. Chan (http://aposf02.cityu.edu.hk/tc_forecast/2008_forecast_APR.htm), and, (2) The Benfield Hazard Research Centre, University College London, Tropical Storm Risk (TSR) research group, UK, led by Dr Adam Lea and Professor Mark Saunders (http://tsr.mssl.ucl.ac.uk/).

## LOCAL SUMMARY AND FORECAST

**American Samoa:** Month-to-month variability of rainfall was high during 2008. At Pago Pago, three months received over 15 inches of rainfall (January, May, and December), and four months received less than 5 inches of rain (February, July, August, and October). The 2008 annual total rainfall of 129.66 inches at Pago Pago was 109% of its normal value. No serious impacts were noted from tropical cyclones during 2008. In early January, the northwest monsoon extended across the islands of American Samoa for a few days. During this time, there were devastating floods in Fiji, but most of the monsoonal cloud band remained to the southwest of Samoa. This may be a herald of how the monsoon will behave for the rest of American Samoa's rainy season.

| American Samoa Rainfall Summary 4th Qtr 2008 | | | | | | |
|---|---|---|---|---|---|---|
| **Station** | | **Oct.** | **Nov.** | **Dec.** | **4th Qtr** | **Annual** |
| **Pago Pago WSO** | **Inches** | 3.28 | 11.86 | 18.46 | **33.60** | **129.66** |
| | **% Norm** | 33% | 106% | 138% | **97%** | **109%** |

**Climate Outlook:** American Samoa is now within the heart of its rainy season (December - April). **Nearly all climate models favor near normal to slightly below normal rainfall for at least the next three months.** Thereafter, American Samoa enters its typical dry season, and the rainfall should be near normal. Past rainfall in American Samoa during some similar La Niña years has been near normal. With La Niña conditions, tropical cyclone activity tends to remain in the Coral Sea and near Fiji. The northwest monsoon does not extend across American Samoa as frequently during La Niña; instead, heavy monsoonal rainfall remains southwest of Samoa, and its accompanying tropical cyclones and heavy rainfall affect Fiji and islands in the Coral Sea.

The PEAC Center remains cautiously optimistic that the focus of South Pacific tropical cyclone activity will remain in the Coral Sea from northeastern Australia eastward to Fiji (see Tropical Cyclone section). Through April 2009, it is likely that the monsoon will bring two or three prolonged (3- to 5-day) episodes of gusty northwest wind (20-25 kt), with or without the help of a tropical cyclone along the axis of the monsoon trough/ South Pacific Convergence Zone (SPCZ). **The risk of a damaging impact by a hurricane or strong tropical storm in American Samoa is considered to be slightly below normal (roughly a 5% to 10% chance) through April 2009.**

Predicted rainfall from January 2009 through December 2009 is as follows:

| Inclusive Period | % of long-term average / Forecast rainfall (inches) [2] |
|---|---|
| January - March 2009 (Heart of Rainy Season) | **95% (35.45 - Pago Pago)** |
| April - June 2009 (End of Rainy Season) | **100%** |
| July - September 2009 (Next Dry Season) | **100%** |
| October - December 2009 (Onset of Next Rainy Season) | **110%** |

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

## LOCAL SUMMARY AND FORECAST

**Guam/CNMI:** The 2008 annual rainfall was below normal throughout Guam and the CNMI, with very few extremes of rainfall noted. Annual rainfall totals on Guam during 2008 ranged from a low of 65.24 inches (66%) at Andersen AFB to a high of 81.30 inches (77%) at an experimental rain gage at a location in the Southern Mountains. The Rota Airport reported the highest 2008 total rainfall among all Guam and CNMI stations with its 2008 total of 88.26 inches (93% of its long-term average). At most locations, September was the wettest month of the year, after which the rainfall during the 4th quarter again fell below normal. The weather on Guam and the CNMI during all of 2007 and 2008 can best be described as tranquil and uneventful. Tropical cyclones remained to the west and north, the monsoon was weak or absent, and dry trade winds dominated for almost the entire time. The tranquility of the weather was in itself somewhat remarkable, in that almost no extremes of wind or rainfall have been observed now for over two years! The WFO Guam has not had over 4 inches of rain in 24 hours since

| Guam and CNMI Rainfall Summary 4th Qtr 2008 | | | | | | |
|---|---|---|---|---|---|---|
| **Station** | | **Oct.** | **Nov.** | **Dec.** | **4th Qtr** | **Annual** |
| **Guam** | | | | | | |
| **GIA (WFO)** | **Inches** | 7.21 | 4.79 | 3.30 | **15.30** | **73.24** |
| | **% Norm** | 60% | 58% | 61% | **60%** | **81%** |
| **AAFB** | **Inches** | 6.06 | 4.30 | 3.80 | **14.60** | **65.24** |
| | **% Norm** | 47% | 47% | 64% | **51%** | **66%** |
| **Dededo (Ypapao)*** | **Inches** | 10.59 | 3.54 | 3.14 | **17.27** | **77.44** |
| | **% AAFB** | 82% | 39% | 53% | **62%** | **79%** |
| **Ugum Watershed **** | **Inches** | 6.07 | 4.99 | 6.73 | **17.79** | **81.30** |
| | **% WSMO** | 47% | 55% | 113% | **64%** | **83%** |
| **Sinajaña ***** | **Inches** | 6.82 | 4.15 | 4.13 | **15.10** | **77.91** |
| | **% WFO** | 57% | 51% | 77% | **59%** | **86%** |
| **CNMI** | | | | | | |
| **Saipan Intl. Airport** | **Inches** | 9.03 | 6.58 | 2.28 | **17.89** | **67.46** |
| | **% Norm** | 80% | 107% | 57% | **84%** | **88%** |
| **Capitol Hill** | **Inches** | 10.24 | 4.94 | 2.13 | **17.31** | **78.39** |
| | **% Norm** | 85% | 67% | 44% | **72%** | **94%** |
| **Tinian Airport** | **Inches** | 8.08 | 4.62 | 2.54 | **15.24** | **77.40** |
| | **% Norm** | 67% | 63% | 53% | **63%** | **93%** |
| **Rota Airport** | **Inches** | 9.72 | 4.81 | 3.01 | **17.54** | **88.26** |
| | **% Norm** | 77% | 56% | 53% | **65%** | **93%** |

* % of normal with respect to Andersen AFB.
** % of normal with respect to WSMO Finigayan (now closed), on the northwest side of Guam.
*** % of normal for Sinajaña is with respect to WFO Guam.

## LOCAL SUMMARY AND FORECAST

August 2006. The year's only instance of extreme weather occurred on 11-12 December 2008 when Typhoon Dolphin passed near Guam while it was becoming a tropical storm. The WFO Guam issued tropical storm watches and warnings for Guam and portions of the CNMI, marking the only time during 2008 that tropical cyclone watches or warnings were issued for any Micronesia location. On Guam, about an inch of rain was experienced during the passage of Dolphin, and a peak wind gust of 48 kt (55 mph) was recorded in Apra Harbor.

**Climate Outlook:** The dry season on Guam and in the CNMI is underway. **The return to La Niña conditions will keep trade winds stronger and more persistent than normal; this in turn will reinforce the higher than normal sea-levels already present in the western Pacific, and continue to generate rough seas/surf high in the island waters and exposed shores.** Tropical cyclone activity will likely be delayed, and once again shifted to the west, reducing the risk of tropical cyclones on Guam and in the CNMI for at least the first half of 2009. **Computer models available to PEAC indicate that the rainfall will be near normal in Guam and in the CNMI through the dry season.** If La Niña persists into the spring, the ongoing tranquility of the past two years will likely continue for the foreseeable future.

Predicted rainfall for Guam and the Mariana Islands from January 2009 through December 2009 is as follows:

| Inclusive Period | % of long-term average / Forecast rainfall (inches) [2] | |
|---|---|---|
| | Guam/Rota | Saipan/Tinian |
| January – March 2009 (1st Half of Dry Season) | **100% (11.17 inches)** | **110% (8.51 inches)** |
| April – June 2009 (2nd Half of Dry Season) | **95%** | **100%** |
| July - September 2009 (Heart of Next Rainy Season) | **95%** | **100%** |
| October - December 2009 (End of Next Rainy Season) | **100%** | **110%** |

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

### Federated States of Micronesia

**Yap State:** Annual rainfall totals for 2008 at all Yap Island locations were generally in the range of 95 to 100 inches, which is approximately 20 to 25 inches below the typical value (120 inches) for a calendar year. The same weather patterns that resulted in tranquil conditions for Guam and other locations throughout Micronesia produced similar tranquil and uneventful weather on Yap during 2008. The 2008 annual rainfall total of 64.56 inches at Woleai was only 51% of normal, making this island one of the driest locations in Micronesia during 2008 (both in actual rainfall total, and with respect to normal). Rainfall amounts were close to normal in the 4th Quarter of 2008, with the 30.30 inches at the Yap WSO coming in at 101% of the long-term average. The 2008 annual total of 106.91 inches (89%) at the Yap WSO was the highest recorded value for all of Yap State for the calendar year of 2008. The 4th

LOCAL SUMMARY AND FORECAST

Quarter rainfall 2008 (month-for-month) and the 2008 annual rainfall was lower at every location on Yap Island than the rainfall recorded at each location for the 4th Quarter 2007 (month-for-month) and 2007 annual rainfall. Sea-levels have been higher than normal throughout Yap State for the past two years as a response to La Niña conditions in 2007 and its resurgence in late 2008. Astronomically higher tides in recent months have been compounded by high sea-level and strong trade winds to produce notably high water stands across Yap Island. High sea-level with some inundation of low-lying exposed areas has been noted throughout Micronesia in the past few months.

| Yap State Rainfall Summary 4th Qtr 2008 | | | | | | |
|---|---|---|---|---|---|---|
| Station | | Oct. | Nov. | Dec. | 4th Qtr | Annual |
| **Yap Island** | | | | | | |
| Yap WSO | Inches | 14.14 | 7.84 | 8.32 | **30.30** | **106.91** |
| | % Norm | 118% | 86% | 93% | **101%** | **89%** |
| Dugor* | Inches | 9.66 | 9.65 | 6.78 | **26.09** | **94.68** |
| | % WSO | 79% | 109% | 73% | **87%** | **79%** |
| Gilman* | Inches | 8.50 | 8.68 | 7.37 | **24.55** | **97.93** |
| | % WSO | 69% | 98% | 79% | **82%** | **82%** |
| Luweech* | Inches | 11.85 | 6.41 | 7.96 | **26.22** | **90.95** |
| | % WSO | 97% | 73% | 85% | **87%** | **76%** |
| Maap* | Inches | 12.07 | 10.46 | 6.98 | **29.51** | **98.01** |
| | % WSO | 99% | 116% | 75% | **98%** | **82%** |
| North Fanif* | Inches | 11.16 | 10.58 | 5.70 | **27.44** | **98.16** |
| | % WSO | 91% | 120% | 61% | **91%** | **82%** |
| Rumung* | Inches | 10.69 | 11.19 | 7.28 | **29.16** | **101.38** |
| | % WSO | 87% | 127% | 78% | **97%** | **84%** |
| Tamil* | Inches | 10.53 | 10.22 | 7.31 | **28.06** | **99.75** |
| | % WSO | 86% | 116% | 78% | **93%** | **83%** |
| **Outer Islands** | | | | | | |
| Ulithi | Inches | 12.02 | N/A | N/A | **N/A** | **N/A** |
| | % Norm | 118% | N/A | N/A | **N/A** | **N/A** |
| Woleai | Inches | 5.36 | 9.78 | 3.06 | **18.20** | **64.56** |
| | % Norm | 39% | 91% | 27% | **51%** | **46%** |

* Long term normal is not established for these sites.

**Climate Outlook:** All of the islands of Yap State should have near normal rainfall for the next three months. The recent resurgence of La Niña should guarantee that most months of 2009 should have normal or above normal rainfall throughout Yap State. **Stronger than normal trade winds and sub-surface ocean heating in the western North Pacific will keep sea levels above normal for at least the next three months.** Tropical cyclone activity in the western North Pacific is expected to be higher than it was during the quiet years of 2007 and 2008, although the activity should still be displaced farther west than normal. Being on the western side of Micronesia, **2 or 3 tropical cyclones should pass to the north of Yap Island and Ulithi producing gusty westerly winds and rough seas in the island waters, with one such cyclone sometime in the spring months of April to June, and the other two in the fall.**

## LOCAL SUMMARY AND FORECAST

Predicted rainfall for Yap State from January 2009 through December 2009 is as follows:

| Inclusive Period | % of long-term average / Forecast rainfall (inches) [2] | |
|---|---|---|
| | Yap and Ulithi | Woleai |
| January – March 2009 (Heart of Dry Season) | **110% (20.71 inches)** | **90% (23.99 inches)** |
| April – June 2009 (Onset of Rainy Season) | **120%** | **90%** |
| July – September 2009 (Heart of Next Rainy Season) | **100%** | **90%** |
| October – December 2009 (End of Next Rainy Season) | **120%** | **100%** |

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

**Chuuk State:** The 4th Quarter was relatively dry at most locations across Chuuk State; nearly all islands dropped below 10 inches of rain during December, with some locations receiving even less than 5 inches. Annual rainfall in Chuuk State during the calendar year 2008 was distributed in a north-south pattern, with the northern atolls receiving the least, and some of the atolls further south in the Mortlocks receiving the most. The annual total of 149.24 inches observed at Ta Atoll in the southern Mortlocks was the highest annual total throughout Chuuk State. The annual totals of 71.40 inches and 94.05 inches at Polowat and Fananu, respectively, were the lowest annual readings in the state. The 128.42 inches recorded at the Chuuk WSO was near normal (96%). The weather was tranquil throughout Chuuk State during 2008 with few unusually heavy rains or episodes of strong wind. As was the case a year earlier in 2007, persistent trade winds and high surf contributed to substantial and damaging sea inundation on some of the atolls of Chuuk State. Of note, the high surf event of the 2nd week of December 2008 was particularly destructive in some of the atolls of Chuuk State and elsewhere in Micronesia.

| Chuuk State Rainfall Summary 4th Qtr 2008 | | | | | | |
|---|---|---|---|---|---|---|
| **Station** | | **Oct.** | **Nov.** | **Dec.** | **4th Qtr** | **Annual** |
| **Chuuk Lagoon** | | | | | | |
| **Chuuk WSO** | **Inches** | 11.37 | 13.86 | 7.70 | **32.93** | **128.42** |
| | **% Norm** | 81% | 130% | 71% | **93%** | **97%** |
| **Piis Panew*** | **Inches** | 6.87 | 10.24 | 2.48 | **19.59** | **95.16** |
| | **% WSO** | 49% | 96% | 23% | **57%** | **71%** |
| **Southern Mortlocks** | | | | | | |
| **Lukunoch*** | **Inches** | 14.14 | 10.65 | 5.03 | **29.82** | **119.67** |
| | **% WSO** | 101% | 100% | 46% | **86%** | **89%** |
| **Ettal*** | **Inches** | 20.89 | 15.66 | 7.46 | **44.01** | **137.65** |
| | **% WSO** | 149% | 146% | 69% | **127%** | **102%** |
| **Ta*** | **Inches** | 11.57 | 18.10 | 6.64 | **36.31** | **149.24** |
| | **% WSO** | 83% | 169% | 61% | **105%** | **111%** |

* Long term normal is not established for these sites.

## LOCAL SUMMARY AND FORECAST

| Chuuk State Rainfall Summary 4th Qtr 2008 | | | | | | |
|---|---|---|---|---|---|---|
| **Station** | | **Oct.** | **Nov.** | **Dec.** | **4th Qtr** | **Annual** |
| **Northern Atolls** | | | | | | |
| **Fananu*** | **Inches** | 7.56 | 10.28 | 2.55 | **20.39** | **94.05** |
| | **% WSO** | 54% | 96% | 23% | **59%** | **70%** |
| **Onoun*** | **Inches** | 13.55 | 11.25 | 4.32 | **29.12** | **117.04** |
| | **% WSO** | 97% | 105% | 40% | **84%** | **87%** |
| **Northern Mortlocks** | | | | | | |
| **Losap*** | **Inches** | 11.68 | 14.74 | 6.61 | **33.03** | **140.62** |
| | **% WSO** | 83% | 138% | 61% | **93%** | **105%** |
| **Nama*** | **Inches** | 13.37 | 16.31 | 15.09 | **34.77** | **145.95** |
| | **% WSO** | 96% | 153% | 139% | **100%** | **109%** |
| **Namoluk*** | **Inches** | 16.48 | 16.45 | 11.29 | **44.22** | **123.99** |
| | **% WSO** | 118% | 154% | 104% | **128%** | **92%** |
| **Western Atolls** | | | | | | |
| **Polowat** | **Inches** | 4.70 | 9.26 | 5.90 | **19.86** | **71.40** |
| | **% WSO** | 34% | 87% | 54% | **57%** | **53%** |

**Climate Outlook:** Gusty easterly trade winds should continue to dominate the flow throughout Micronesia for the next three months. **Higher than normal sea-level coupled with high surf may cause more inundation events on the islands in Chuuk Lagoon and other atolls in Chuuk State. These conditions are possible through April 2009, after which the trade winds and swell from winter storms should become weaker.** For the next three months, rainfall will be distributed in a north-south pattern across Chuuk State, with atolls in the north (Fananu and Onoun) receiving less rain than atolls located further south (Ta and Namoluk). **From August through December, several of the tropical cyclones of the western North Pacific basin will begin their lives in Chuuk State as depressions. One or two occurrences of gale-force wind associated with a tropical cyclone may affect Chuuk Lagoon or atolls to the north, especially in the fall of 2009, representing a normal risk.**

Predictions for Chuuk State from January 2009 through December 2009 are as follows:

| Inclusive Period | % of long-term average / Forecast rainfall (inches) [2] | | | |
|---|---|---|---|---|
| | Chuuk Lagoon, Northern Mortlocks | Polowat | Northern Atolls and Islands | Southern Mortlocks |
| Jan – Mar 2009 | **100% (25.77 inches)** | **85% (21.90 in)** | **90% (23.19 in)** | **110% (28.35 in)** |
| Apr – Jun 2009 | **110%** | **90%** | **90%** | **120%** |
| Jul – Sep 2009 | **110%** | **95%** | **100%** | **100%** |
| Oct – Dec 2009 | **100%** | **95%** | **100%** | **100%** |

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

## LOCAL SUMMARY AND FORECAST

**Pohnpei State:** The majority of locations in Pohnpei State had near normal rainfall during 2008. The 189.34 inches recorded at the WSO in Kolonia was 100% of its normal annual value. Other Pohnpei Island locations such as the Airport and Palikir also had near-normal rainfall during 2008. Nukuoro was particularly wet during 2008; its annual total of 211.14 was the highest amount observed in Pohnpei State during 2008, although the amounts were most certainly higher in the interior of Pohnpei Island where rain gages installed by the UOG have measured over 300 inches of rain in each of the years 2004 through 2007. Other atolls of Pohnpei State were either slightly dry (Pingelap and Mwoakilloa) or near normal (Kapingamarangi) during 2008. High sea-levels and strong trade winds associated with the resurgent La Niña allowed some ocean inundation to occur on Pohnpei Island in recent months. The PEAC Center received reports that wind-whipped waves were splashing water over the causeway at the airport and eroding the rock and gravel fill on its east side. Brisk trades and high sea levels are typical during La Niña. Because of its protective fringing reef, the high surf event of December 2008 was not as destructive on Pohnpei Island as at other atolls and islands with more exposure.

**Pohnpei State Rainfall Summary 4th Qtr 2008**

| Station | | Oct. | Nov. | Dec. | 4th Qtr | Annual |
|---|---|---|---|---|---|---|
| **Pohnpei Island** | | | | | | |
| **Pohnpei WSO** | **Inches** | 20.41 | 16.61 | 9.58 | **46.63** | **189.34** |
| | **% Norm** | 122% | 106% | 63% | **98%** | **100%** |
| **Palikir** | **Inches** | 19.95 | 18.16 | 10.84 | **48.95** | **201.12** |
| | **% Norm** | 110% | 107% | 66% | **95%** | **99%** |
| **Kolonia Airport** | **Inches** | 18.73 | 12.12 | 7.42 | **38.27** | **161.74** |
| | **% Norm** | 137% | 94% | 59% | **98%** | **104%** |
| **Atolls of Pohnpei State** | | | | | | |
| **Nukuoro** | **Inches** | 18.04 | 17.02 | 9.38 | **44.44** | **211.14** |
| | **% Norm** | 168% | 142% | 78% | **128%** | **141%** |
| **Pingelap** | **Inches** | 11.38 | 12.57 | 7.51 | **31.46** | **157.36** |
| | **% Norm** | N/A | N/A | N/A | **74%** | **89%** |
| **Mwoakilloa** | **Inches** | 9.61 | 11.43 | 14.48 | **35.52** | **144.43** |
| | **% Norm** | N/A | N/A | N/A | **91%** | **93%** |
| **Kapingamarangi** | **Inches** | 6.38 | 3.27 | 10.88 | **20.53** | **108.39** |
| | **% Norm** | 132% | 40% | 124% | **94%** | **99%** |

**Climate Outlook:** In a climate of enhanced trade winds, such as during La Niña, the trade-wind trough and zonal band of cloudiness associated with it sharpens and increases the rainfall on Pohnpei Island and atolls that lie within the latitude bounds of 4º to 8º N. This is especially true for the months of April and May when Pohnpei Island usually experiences its highest monthly average rainfall. **Another month of 30 inches or more (such as May 2008), could be experienced again during any of the months between April and June 2009.** Nukuoro recorded particularly high rainfall in this pattern, and will likely see a repeat of high rainfall in the coming months. Easterly trade winds should continue to dominate the flow in eastern Micronesia for the next several months. **These gusty winds coupled with elevated sea-level could lead to a few episodes of minor coastal inundation and coastal erosion, especially at times of the month when the astronomical tidal range is greatest.** The airport causeway on Pohnpei Island may again have sea water splash across it. **No typhoons or tropical storms are anticipated to adversely affect Pohnpei State during 2009, although several of the basin's tropical cyclones may begin as depressions near Pohnpei. These will only contribute to the expected abundant rainfall.**

LOCAL SUMMARY AND FORECAST

Predicted rainfall for Pohnpei State from January 2009 through December 2009 is as follows:

| Inclusive Period | % of long-term average / Forecast rainfall (inches) [2] | |
|---|---|---|
| | **Pohnpei Island and atolls** | **Kapingamarangi** |
| Jan - Mar 2009 | **100% (36.26 inches)** | **95% (34.46 inches)** |
| Apr - Jun 2009 | **125%** | **100%** |
| Jul - Sep 2009 | **100%** | **100%** |
| Oct - Dec 2009 | **100%** | **95%** |

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

**Kosrae State:** Typically one of Micronesia's wettest locations, the 223.67 inches of rain recorded at the Kosrae Airport was the highest annual value seen throughout the region. Other locations in Kosrae saw slightly less rainfall than the total at the airport. Kosrae was hit hard by the phenomenal surf event of early December 2008. High surf sent white water surging across the beach and onto roadways and shoreline properties. At the time of this writing, U.S. government officials are assessing the damage caused by this event.

**Kosrae State Rainfall Summary 4th Qtr 2008**

| Station | | Oct. | Nov. | Dec. | 4th Qtr | Annual |
|---|---|---|---|---|---|---|
| **Airport (SAWRS)** | **Inches** | 12.60 | 17.41 | 20.24 | **50.25** | **223.67** |
| | **% Norm** | 78% | 109% | 140% | **108%** | **108%** |
| **Utwa*** | **Inches** | 13.08 | 16.64 | 19.99 | **49.71** | **204.10** |
| | **% WSO** | 81% | 105% | 138% | **107%** | **99%** |
| **Nautilus Hotel*** | **Inches** | 13.94 | 19.37 | 23.12 | **56.43** | **220.66** |
| | **% WSO** | 86% | 122% | N/A | **121%** | **107%** |
| **Tofol*** | **Inches** | NA | NA | NA | **NA** | **NA** |
| | **% WSO** | N/A | N/A | N/A | **N/A** | **N/A** |

* Long term normal is not established for these sites.

**Climate Outlook:** During La Niña, the trade-wind trough and its associated zonal band of cloudiness sharpens, bringing abundant rainfall to Kosrae. **The months of March through June (normally the wettest of the year) are anticipated to be especially wet this year.** Normal monthly rainfall values at Kosrae typically average between 17 and 20 inches for all months of the year. In the 1st Quarter of 2008, the PEAC Center predicted that five or six of the months during 2008 would see monthly rains in excess of 20 inches; this verified well, with 5 months receiving in excess of 20 inches. The calendar year 2009 should see a similar rainfall distribution. Enhanced easterly winds should continue to cause rough seas and elevated sea level on the east-

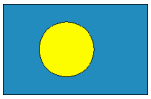
## LOCAL SUMMARY AND FORECAST

ern reefs and shoreline, at least through the first half of 2009. No adverse tropical cyclone activity is expected for Kosrae State during 2009.

Forecast rainfall for Kosrae State from January 2009 through December 2009 is as follows:

| Inclusive Period | % of long-term average / Forecast rainfall (inches) [2] |
|---|---|
| January – March 2009 | **110% (54.35 inches)** |
| April – June 2009 | **115%** |
| July - September 2009 | **100%** |
| October - December 2009 | **110%** |

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



**Republic of Palau:** Rainfall was abundant throughout the Republic of Palau during 2008. The 158.98 inches at the WSO was 107% of normal. Rainfall at most other Palau locations was higher than at the WSO, with the highest reading of 185.28 inches noted at the International Airport. Installed for several years now, the rain gage at the International Airport has consistently reported higher rainfall totals than at the WSO in Koror. Peleliu has a history of being drier than the WSO, and 2008 was no exception, with Peleliu's 2008 annual total of 146.71 inches.

| Republic of Palau Rainfall Summary 4th Qtr 2008 | | | | | | |
|---|---|---|---|---|---|---|
| **Station** | | **Oct.** | **Nov.** | **Dec.** | **4th Qtr** | **Annual** |
| **WSO Koror** | **Inches** | 18.25 | 17.36 | 11.50 | **47.11** | **158.98** |
| | **% Norm** | 132% | 153% | 96% | **127%** | **107%** |
| **Nekken** | **Inches** | 18.98 | 15.20 | 16.40 | **50.58** | **161.16** |
| | **% Norm** | N/A | N/A | N/A | **136%** | **109%** |
| **Intl. Airport** | **Inches** | 21.49 | 20.92 | 13.59 | **56.00** | **185.28** |
| | **% Norm** | N/A | N/A | N/A | **151%** | **125%** |
| **Peleliu** | **Inches** | 11.53 | 14.47 | 17.55 | **43.55** | **146.71** |
| | **% Norm** | N/A | N/A | N/A | **118%** | **100%** |

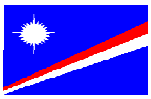
**Climate Outlook**: The rainfall distribution on Palau in 2009 should be similar to 2008. The normally drier months of February through May should see above average rainfall; then, the normally wetter months of June and July should see rainfall amounts near normal. Tropical cyclone influence should be slightly enhanced in both the early part of the season (April to June), and again at the end of the year (late October to December). Though the basin as a whole is anticipated to have a slow start in 2009, **Palau could experience one episode of near-gale (25 to 35 mph) westerly wind associated with a tropical storm or depression that passes to the north between April and June. Two or three such episodes of gusty winds and heavy showers are likely to occur from October to December.** Because of its southerly location, it is not anticipated that Palau will experience a direct strike by a strong tropical storm or a typhoon, even though the risk of such an occurrence is considered to be slightly higher than average during La Niña years.

## LOCAL SUMMARY AND FORECAST

Predicted rainfall for Palau from January 2009 through December 2009 is as follows:

| Inclusive Period | % of long-term average / Forecast rainfall (inches) [2] |
|---|---|
| January – March 2009 | **120% (35.57 inches)** |
| April – June 2009 | **100%** |
| July – September 2009 | **100%** |
| October – December 2009 | **110%** |

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



**Republic of the Marshall Islands (RMI):** During 2008, the rainfall in the central and southern atolls of the RMI was slightly lower than normal rainfall. The 115.17 inches at the WSO Majuro was 88% of its long-term average. The 2008 annual rainfall totals at some of the atolls in the northern RMI were among the lowest values at any of the USAPI. The less than 50 inches of annual rainfall at Wotje represented only half of the normal annual rainfall expected at this location. The RMI was hit hard by the phenomenal surf event of early December 2008. High surf sent white water surging across the beachfront and into homes and crops. The College of the Marshall Islands in Majuro was particularly hard hit, reporting

| RMI Rainfall Summary 4th Qtr 2008 | | | | | | |
|---|---|---|---|---|---|---|
| **Station** | | **Oct.** | **Nov.** | **Dec.** | **4th Qtr** | **Annual** |
| **RMI Central Atolls (6º N - 8º N)** | | | | | | |
| **Majuro WSO** | **Inches** | 12.18 | 14.27 | 11.80 | **38.25** | **115.17** |
| | **% Norm** | 88% | 111% | 100% | **99%** | **88%** |
| **Laura*** | **Inches** | 8.26 | 9.26 | N/A | **N/A** | **N/A** |
| | **% Norm** | N/A | N/A | N/A | **N/A** | **N/A** |
| **Arno*** | **Inches** | N/A | N/A | N/A | **N/A** | **34.50** |
| | **% Norm** | N/A | N/A | N/A | **N/A** | **95%** |
| **Aling-laplap*** | **Inches** | 11.86 | 11.26 | 15.56 | **38.68** | **108.97** |
| | **% Norm** | N/A | N/A | N/A | **112%** | **93%** |
| **RMI Southern Atolls (South of 6º N)** | | | | | | |
| **Jaluit*** | **Inches** | 7.56 | 10.28 | 2.55 | **20.39** | **94.05** |
| | **% Norm** | N/A | N/A | N/A | **53%** | **72%** |
| **RMI Northern Atolls (North of 8º N)** | | | | | | |
| **Kwajalein** | **Inches** | 11.89 | 5.85 | 7.45 | **25.19** | **85.22** |
| | **% Norm** | 100% | 55% | 92% | **82%** | **83%** |
| **Wotje*** | **Inches** | 6.17 | 4.31 | 2.71 | **13.19** | **47.93** |
| | **% Norm** | 55% | 43% | 35% | **45%** | **49%** |
| **Utirik*** | **Inches** | N/A | N/A | N/A | **N/A** | **N/A** |
| | **% Norm** | N/A | N/A | N/A | **N/A** | **N/A** |

* Normal values are estimated based on WSO Majuro, Kwajalein and satellite-derived precipitation distribution.

## LOCAL SUMMARY AND FORECAST

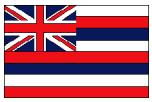
$760,000 in damage. The causeway connecting Ebeye with Gugeegue was washed out. Japanese structures built on Rui Namur during the WWII were undermined by run-up from waves that may have exceeded 20 feet in height. At the time of this writing, U.S. government officials from FEMA and USAID are assessing the damage caused by this event. The PEAC Center will author a meteorological summary of this unusual event.

**Climate Outlook**: With the resurgence of La Niña in the Pacific basin, the trade wind trough sharpens across Micronesia; this also sharpens the rainfall gradient across the RMI. In this pattern, rain bands just graze Majuro at its northern extent, keeping the more southerly atolls (Mili) in abundant rain. **Atolls to the north of Majuro (Kwajalein and Wotje) are now entering their normal dry season, and rainfall on some of these northern atolls may be meager for a few months. Low rainfall in the next two or three months might impact potable water supplies on some atolls in the northern RMI, such as Utirik and Wotje. Residents of the northern RMI are thus urged to participate in voluntary water conservation measures.** Near normal rain should return to all atolls by mid-year and continue for the rest of the calendar year.

Predicted rainfall for the RMI from January 2009 through December 2009 is as follows:

| Inclusive Period | % of long-term average / Forecast rainfall (inches) [2] | | |
|---|---|---|---|
| | South of 6ºN | 6ºN to 8ºN | North of 8ºN |
| Jan – March 2009 (Dry Season) | 110% (25.72 inches) | 95% (22.21 in) | 85% (10.77 in) |
| April – June 2009 (Onset of Rains) | 100% | 95% | 95% |
| July – Sept 2009 (Rainy Season) | 100% | 100% | 100% |
| Oct – Dec 2009 (Start of Dry Season) | 100% | 100% | 100% |

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



**Hawaii:** October marked the beginning of Hawaii's rainy season. Despite several moderate rain events throughout the month of October, more than 75 percent of the state was under moderate drought or worse conditions. In mid-November, the north Pacific weather pattern shifted to more winter-like conditions. Heavy rains over east Molokai on the morning of November 18 produced flash flooding that forced the brief closure of the Kamehameha V Highway. As the system shifted eastward, heavy rainfall moved over to Maui where minor flooding occurred along the slopes of the West Maui Mountains and windward Haleakala. On November 21, a kona low, or subtropical cyclone, developed northwest of the state and produced about 1 to 4 inches of widespread rainfall over Kauai, Oahu, and Molokai. Fortunately, most of the rainfall occurred at light to moderate intensities over prolonged periods, which was able to soak into the ground and help bring meaningful drought relief. Despite the wet conditions in the west half of the state, the Big Island remained drier than normal overall through November and the area under severe drought spread eastward.

## LOCAL SUMMARY AND FORECAST

Like November, the month of December began with relatively stable conditions and little rainfall across the state. However, a significant shift in the weather pattern over the north Pacific resulted in wet conditions across most of the Hawaiian Islands from December 10 through the remainder of 2008. A series of strong kona lows and short wave troughs brought episodes of heavy showers and thunderstorms to the state, resulting in several instances of flooding across Kauai and Oahu. The first in a series of heavy rain events occurred over Kauai and Oahu on December 10 - 11. An intense area of rain moved into central and northeast Oahu with peak rain rates in excess of 4 inches per hour. According to the U.S. Geological Survey (USGS), several streams in central and windward Oahu set new peak flow records during the storm. Flooding produced severe damage to homes, infrastructure, and farm lands with losses easily running into the range of millions of dollars. A second round of serious flooding occurred December 12 – 13 over southwest Kauai. The shortwave trough also helped generate a severe thunderstorm with a rare tornado which moved over the Pakala area of south Kauai on December 13. The band of heavy rainfall shifted eastward and reached Oahu during the mid-afternoon hours, where two boys had to be rescued after being swept downstream in a flash flood near Waianae.

For up-to-date information about hydrology in Hawaii, please visit: www.prh.noaa.gov/hnl/pages/hydrology.php.

| State of Hawaii Rainfall Summary 4th Qtr 2008 | | | | | | |
|---|---|---|---|---|---|---|
| Station | | Oct. | Nov. | Dec. | 4th Qtr | 2008 Total |
| Lihue Airport | Inches | 3.15 | 6.05 | 19.46 | **28.66** | **39.87** |
| | % Norm | 74% | 129% | 407% | **209%** | **101%** |
| Honolulu Airport | Inches | 0.57 | 2.90 | 7.58 | **11.05** | **14.66** |
| | % Norm | 26% | 128% | 266% | **151%** | **80%** |
| Kahului Airport | Inches | 0.13 | 0.65 | 4.54 | **5.32** | **7.99** |
| | % Norm | 12% | 30% | 147% | **84%** | **43%** |
| Hilo Airport | Inches | 5.40 | 6.73 | 30.38 | **42.51** | **127.37** |
| | % Norm | 56% | 43% | 289% | **119%** | **101%** |

**Climate Outlook:** The following comments are from the US Climate Prediction Center's Seasonal Outlook Discussion:

"NCEP models predict above normal temperatures for Honolulu and Lihue for February 2009. Above normal precipitation is expected for Hawaii for February 2009. NCEP models predict a tendency for above normal temperature from March-April-May to June-July-August 2009 at Hilo - and from February-March-April to June-July-August 2009 at Kahului, Honolulu and Lihue. Models also predict above normal precipitation for Hawaii from February-March-April to May-June-July 2009."

**For more information on weather and climate in Hawaii go to**
http://www.prh.noaa.gov/pr/hnl/
or
www.cpc.noaa.gov/products/predictions/long_range/fxhw40.html

## Seasonal Sea Level Outlook for the US-Affiliated Pacific Islands

The following sections describe: (i) the *Canonical Correlation Analysis* (*CCA*)-based forecasts of sea level deviations for forthcoming seasons JFM, FMA and MAM 2009; (ii) the observed monthly mean and maximum sea-level deviations for the season OND 2008, and (iii) forecast verifications (observed/forecast values) for the previous season OND 2008. All units are in inches. *Note that 'deviation' is defined here as 'the observed or forecast difference between the monthly mean [or maximum] and the climatological monthly mean values (from the period 1975- 1995) computed at each station'. Also, note that the forecasting technique adapted here does not account for sea level deviations created by other atmospheric or geological conditions such as tropical cyclones, storm surges or tsunamis.*

**(i) Seasonal Sea Level Forecast** *(deviations with respect to climatology*) **for JFM, FMA and MAM 2009** (**Table 1**). See Figure 2 for locations of tide stations.

**Table 1**: **Forecasts of sea level deviation (in inches) for Jan-Feb-Mar, Feb-Mar-Apr, and Mar-Apr-May 2009.**

| | Seasonal Mean Deviations [1] | | | | Seasonal Max Deviations [2] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tide Gauge Station** | **JFM** | **FMA** | **MAM** | **Forecast Quality [3]** | **JFM** | **FMA** | **MAM** | **Forecast Quality [3]** | ***Return Period [4] for JFM Season*** | |
| **Lead Time [5]** | *0* | *1M* | *2M* | | *0* | *1M* | *2M* | | *20 Year* | *100 Year* |
| **Marianas, Guam** | +5 | +5 | +7 | V. Good | +19 | +20 | +21 | Good | *5.6* | *6.7* |
| **Malakal, Palau** | +2 | +3 | +3 | V. Good | +39 | +39 | +39 | V. Good | *9.6* | *14.3* |
| **Yap, FSM** | +2 | +3 | +3 | V. Good | +30 | +32 | +33 | V. Good | *16.7* | *33.0* |
| **Chuuk, FSM**** | +3 | +2 | +2 | N/A | +30 | +32 | +33 | N/A | *N/A* | *N/A* |
| **Pohnpei, FSM** | +4 | +5 | +5 | V. Good | +30 | +34 | +34 | V. Good | *5.8* | *7.1* |
| **Kapingamarangi, FSM** | +4 | +4 | +3 | Good | +30 | +29 | +28 | Good | *7.4* | *9.4* |
| **Majuro, RMI** | +3 | +4 | +3 | Good | +44 | +44 | +44 | Good | *4.1* | *5.1* |
| **Kwajalein, RMI** | +3 | +4 | +5 | Good | +42 | +43 | +43 | Good | *4.5* | *5.9* |
| **Pago Pago, Am. Samoa** | +3 | +3 | +3 | V. Good | +27 | +28 | +27 | V. Good | *3.9* | *5.4* |
| **Honolulu, Hawaii [6]** | -1 | -1 | -1 | Fair | +18 | +17 | +17 | Fair | *4.1* | *5.9* |
| **Hilo, Hawaii [6]** | -1 | -1 | 0 | Good | +23 | +20 | +20 | Good | *7.9* | *11.4* |

***Remarks:*** The positive sea-level deviations forecast for the JFM, FMA, and MAM 2009 seasons (Table 1, above) indicate that sea-levels will remain slightly elevated at all USAPI stations for the next several months. However, the Hawaiian stations are expected to record a marginal fall during the same time period. **Consistent with on-going La Niña conditions, which are likely to continue for at least another three months, both mean and maximum sea-levels are expected to be about 2 to 6 inches higher than the normal.**

**Note:** (-) indicates negative deviations (fall of sea level from the mean), and (+) indicates positive deviations (rise of sea level from the mean); N/A: data not available. Deviations from -1 to +1 inch are considered negligible (***), and deviations 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.

**Seasonal Mean Deviations (1)** is defined as the difference between the mean sea level for the given month and the 1975-1995 mean sea level value at each station. Likewise, **Seasonal Maximum Deviations (2)** is defined as the difference between the maximum sea level (calculated from hourly data) for the given month and the 1975-1995 mean sea level value at each station.

**Forecast Quality (3)** is a measure of the expected CCA cross-validation correlation skill. Higher skills correspond to greater expected accuracy of the forecasts. In general terms, these kinds of forecasts are thought to be of useful (but poor) skill if the CCA cross-validation value lies between 0.3~0.4. Skill levels greater than 0.4 and 0.6 are thought to be fair and good skills. Skill level greater than 0.7 is thought to be very good. Refer to **www.soest.hawaii.edu/MET/Enso/peu/2009_1st/Sea_Level.htm** for cross-validation skills.

**Return period (RP) (4)** of extreme values are calculated from hourly sea-level data. For example, the predicted rise of 5.6 inches at 20-year RP at Marianas, Guam indicates that this station may experience an extreme tide event once every 20 years that could result in sea level rise of up to 5.6 inches **above the median of seasonal maxima** during the JFM season. Likewise, about once every 100 years we can expect the highest JFM tide at Marianas, Guam to be as high as 6.7 inches above the median of seasonal maxima. During some seasons some stations display alarmingly high values at the 20 and 100 year RP. *These high values are due to large and significant increases in the tidal range caused by the passage of past storm events during that season.*

**Lead time (5)** is the time interval between the end of the initial period and the beginning of the forecast period. For example, lead-0, lead-1M, and lead-2M means 'sea-level' of target season 0 (JFM), 1 (FMA), and 2 (MAM) month leads based on SSTs of OND 2008.

**Hawaii stations (6)** should be considered experimental. Any feedback regarding the usefulness of these forecasts will be appreciated.

## Seasonal Sea Level Outlook for the US-Affiliated Pacific Islands

**(ii) Observed Monthly Sea Level Deviation in October-November-December (OND) 2008 Season**

The monthly time series (October - December) for sea level deviations have been taken from the UH Sea Level Center. The full time series (in mm) is available at ftp://ilikai.soest.hawaii.edu/islp/slpp.deviations. See **Figure 2** (below) for location of these stations.

**Table 2 : Monthly observed max/mean sea level deviations in inches (year to year standard deviation in parentheses)**

| Tide Gauge Station | Monthly Mean Deviations[1] | | | | Monthly Max Deviations[2] | | | |
|---|---|---|---|---|---|---|---|---|
| | Oct. | Nov. | Dec. | Standard Deviations | Oct. | Nov. | Dec. | Standard Deviations |
| **Marianas, Guam** | +8.1 | +8.0 | +7.8 | (+4.2) | +28.4 | +24.8 | +24.5 | (+4.1) |
| **Malakal, Palau** | +7.1 | * | +7.0 | (+4.1) | +43.4 | +42.4 | +42.1 | (+4.8) |
| **Yap, FSM** | +5.3 | +4.7 | +4.6 | (+4.7) | +32.1 | +33.2 | +32.4 | (+3.8) |
| **Chuuk, FSM**** | * | * | * | (*) | * | * | * | (*) |
| **Pohnpei, FSM** | +3.0 | +4.6 | * | (+4.7) | +31.8 | +35.1 | * | (+3.9) |
| **Kapingamarangi, FSM** | +1.5 | +1.0 | +5.4 | (+3.0) | +29.7 | +30.8 | +34.2 | (+3.9) |
| **Majuro, RMI** | +5.1 | +3.5 | * | (+3.7) | +47.0 | +43.3 | * | (+2.7) |
| **Kwajalein, RMI** | +1.9 | +3.0 | +1.8 | (+3.2) | +40.2 | +41.9 | +40.5 | (+2.8) |
| **Pago Pago, American Samoa** | +1.8 | +2.4 | * | (+2.2) | +23.2 | +26.7 | +26.0 | (+2.7) |
| **Honolulu, Hawaii** | +1.8 | +1.4 | +1.0 | (+1.8) | +19.5 | +24.5 | +26.1 | (+2.4) |
| **Hilo, Hawaii** | +3.8 | +1.9 | +1.7 | (+2.1) | +23.5 | +23.5 | +28.4 | (+2.8) |

**Note**: - indicate negative deviations (fall from the mean), and + indicate positive deviations (rise from the mean); N/A: data not available; Data for Chuuk (**) is estimated subjectively based on information from WSO Chuuk and observations from neighboring stations. Standard deviations describe how widely spread the values are in the dataset. **See Table 1 for other notes.**

***Remarks:*** The observed values for seasonal mean/maxima display positive deviation at all the USAPI stations. As compared to November 2008, the mean/maxima of sea-level in December 2008 was slightly lower at most stations. However, some stations in FSM recorded a rise in sea-level (Pohnpei, Kapingamarangi). The rise is Pohnpei was quite considerable. The forecast values predict elevated sea-levels of 2 to 6 inches for the next three months. This trend is consistent with the recent resurgence of La Niña.

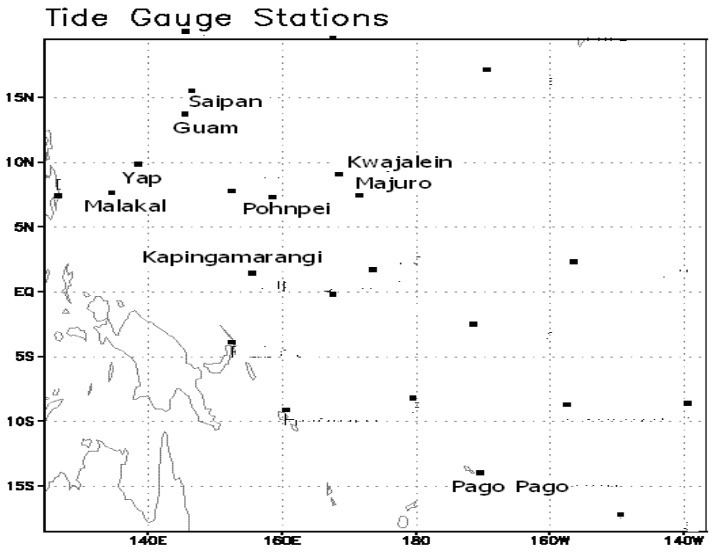



**Figure 2,** above: Locations of USAPI tide gauge stations.

**(iii) Forecast Verification (Seasonal Mean) for OND 2008**

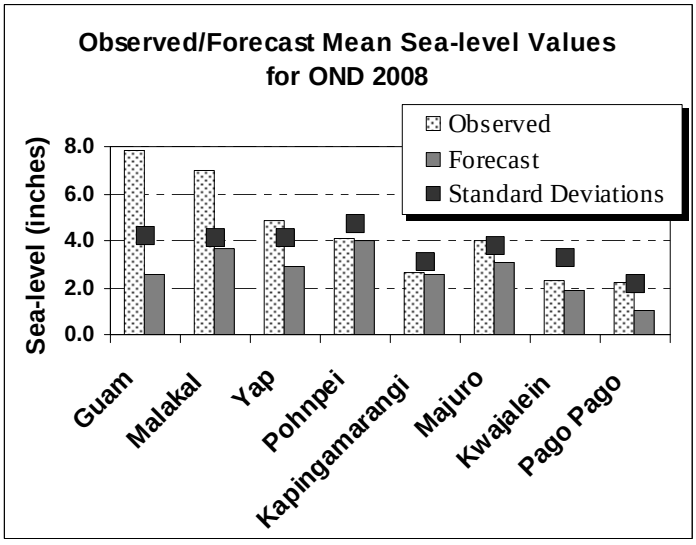



**Figure 3**: The observed and forecast values for the previous season OND is presented above. Forecasts were in general skillful; however, some locations (especially Guam and Malakal) were under-forecast by several inches.

# Pacific ENSO Update

**Press release #0109-05**

**FSM Information Services - Palikir, Pohnpei**

**January 16, 2009**

"As information continues to come in on the affects of the tidal surges from early December, reports from the Upper Mortlock Islands in Chuuk State and the Southern Islands of Pohnpei State are now available.

A Preliminary Damage Assessment Report was sent to the National Emergency Task Force detailing the damage of the Upper Mortlock Islands of Nema, Pis Emwar, and Losap. The report stated that all of the islands in the Upper Mortlocks were affected by salt water. On Losap, 95% of the taro, 90% of the breadfruit, and 90% of the bananas were sprayed. On Pis Emwar, 85% of the taro, 70% of the breadfruit, and 65% of banana were affected, and on Nama, 80% of the taro, 75% of the breadfruit and 65% of the banana and other crops were sprayed with sea water.

On January 5th, 2009, Caroline Voyager departed Pohnpei to the Southern Islands of Pohnpei to deliver emergency relief and to allow the Joint FSM/US/State Preliminary Damage Assessment (PDA) Team to these islands as the first part of the President Emergency Relief Plan.

On January 10, 2009 the Caroline Voyager returned from the islands of Ngatik, Nukuoro, Kapingamarangi, and Oroluk. The PDA Team reported that Nukuoro and Kepingamaragi were affected by the tidal surge and 75% of the taro, 77% of the breadfruit, 55% of the banana, 12% of the coconut and 10% of the other crops were sprayed with sea water. On Oroluk Island, 50% of the taro was damaged and Sapwafik had no damage to their crops…

Finally, the National Government has also received a pledge for additional funding for the relief efforts from the Australian Government that will provide US$50,000 in immediate emergency assistance to each of the Federated States of Micronesia and the Republic of the Marshall Islands, in response to tidal surges and storms that have inundated the low-lying islands."

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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 Sarah Duncan, at peac@noaa.gov or at the address listed below.

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

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