Rainfall
The first half of 2019 was very dry at many locations across Micronesia (see Figures R-1 and R-2). Drought was particularly severe in the CNMI and in the northern RMI. A very dry first-half of a calendar year is typical of the year following El Niño; also known as the post-Peak phase of El Niño, or the El Niño Year (+1). Whereas 2018 was noted for a very busy typhoon season for Micronesia (especially for Guam and the CNMI) and a very busy Hurricane season for Hawaii; so far during 2019, TC activity has been relatively subdued in Micronesia and Hawaii. After widespread dryness at many locations through July of 2019, southwesterly monsoonal winds made their first surge into Micronesia during the first week of August (see the time series of Saipan sea-level pressure in Figure R-3 that nicely highlights the timing of the monsoon surge of early August, and another one in mid-September). Heavy rainfall occurred throughout the Mariana Islands during both of these monsoon episodes. In addition, gusty southwest winds with very high surf affected locations in Palau, Yap, Guam and the CNMI.

Figure 1 2019 First 5 Months (JFMAM) Rainfall (Inches)
Figure 2 2019 First 5 Months (JFMAM) Rainfall, Percent of Average
Rainfall totals for the three-month period June, July and August was mostly near-average across Micronesia (Figures R-4 and R-5). Much wetter than average 3-month totals were observed at Kapingamarangi and at American Samoa. Some lingering dryness was observed at some of the atolls of the RMI. Dryness at some locations in western Micronesia (e.g., Palau, Yap and Guam) was the result of early dryness followed by a sharp increase of rainfall in August (see August summary next).
Recent Conditions for August and September

Rainfall during August 2019 was mostly at-or-above average across all of Micronesia (see Figure R-6). Only a few August readings were below average (the red-highlighted amounts on Figure R-6), but even these were not especially dry. As of late September, nearly all locations across the region were drought free (Figure R-7).
Relatively dry weather was experienced on Guam and in the CNMI during the first half of 2019, with dry conditions extending into July (e.g., Figure R-8 left). With the season’s first arrival of the monsoon in early August, very heavy rainfall occurred on Guam (Figure R-8 right) and on Saipan and other islands of the CNMI. August rainfall totals at WFO Guam and at the Saipan International Airport were near 20 inches. Rainfall at some locations on Guam exceeded 20 inches during August. The WFO Guam has experienced 20 inches or more rainfall in August 14 times over its 70-year climate record — for a one-in-five, or 20% rate of occurrence. By contrast, the SIA has had 20 inches or more of rainfall during August only 3 times in 31 years, for a one-in-10, or 10% rate of occurrence. As of the time of this writing (25 September), the September total rainfall at WFO Guam was 16.01 inches, and 20.39 inches at SIA — wet indeed! Rainfall totals in excess of 20 inches have occurred 8 times at the WFO in its climatic record. The SIA has no occurrences of rainfall in excess of 20 inches (at least in the SIA record from 1989-2018), so the 2019 September rainfall to-date of 20.39 inches is already a record high.
Figures (6) July monthly rainfall across the island of Guam. Rainfall totals over 7 inches are highlighted red. The little inset is a picture of lightning taken by M. Lander on the 26th of July while hunkered down in a field just west of the University of Guam campus. (Figure 7) August monthly rainfall across the island of Guam. Rainfall totals in excess of 20 inches are highlighted red.
The behavior of the sea level across most of Micronesia during 2018 and through the first half of 2019 (see Figure 1) was typical for that seen during a canonical El Niño event (Figure 2) if one considers the onset, maturation and peak of the event to be within 2018, and the post-peak phase of the event set to 2019. As seen in Figure 2, the sea level was above average during the 1st Quarter of 2018, but underwent a substantial lowering during the course of 2018, with Guam and Palau (not shown) exhibiting the most pronounced fall, and islands father to the east (e.g., Kwajalein) not falling as much. In early 2019, the sea level began to rise throughout Micronesia, and by the summer months (JJA), the sea level was substantially above average.

Figure 8. A time series of the sea level at Guam (blue dots) and at Kwajalein (black line). A substantial lowering of sea level typically accompanies El Niño, with a rapid rise of sea level occurring in the year following El Niño. Notice the similarity of the behavior of the sea level during 2018/19 with respect to the behavior of the sea level during the El Niño event of 2015/16 (red-shaded bars).
The highest rates of regional sea level rise over the past two decades have occurred in the western tropical Pacific (WTP) (Figure 3), with values that are nearly three times the global average [Nerem et al., 2010]. Merrifield [2011] used tide gauge data to show that the regional sea-level rise rate increased abruptly in the early 1990s, and that the trend shift matched an enhancement in trade wind speeds averaged across the tropical Pacific. Numerical model simulations [Merrifield and Maltrud, 2011; McGregor et al., 2012] confirm that the steady intensification of the trade winds largely accounts for the amplitude and spatial pattern of WTP sea-level rise since the early 1990s (depicted in Figures 3 and 4). Linear trends applied to WTP sea level time series such as in Figure 3 can give the impression that sea level rise is a particular concern for this region relative to other ocean regions. On the contrary, unique sea level changes in this region rise and fall with low frequency trade wind fluctuations.

Figure 9. Daily sea level at selected Micronesian Locations (Guam, Yap or Palau) during the course of strong El Niño events, with respect to the sea level at the end of the event. Events included are 1972/73, 1982/83, 1997/98, 2009/10 and 2015/16. Note the typical timing of the minimum sea level at the end of Year (0). The outlying low values in the dark blue time series occurred on Guam during the 1972/73 event.

Figure 10. The sea level at Guam plotted with NOAA’s Trade Wind Index (5N-5S ; 135E-180) (blue).
Sea Level Cont.

**Figure 11.** The simple index of the trade winds is clearly related to the sea level, and is likely a dominant cause of the variations, with about a 2-month lead of trade wind changes to sea level response.

### References


### ACKNOWLEDGEMENTS AND FURTHER INFORMATION

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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.

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