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Climate Trends and Projections for Guam

The island of Guam experiences a tropical marine climate, which is warm and humid moderated by seasonal tradewinds and a wet and dry season. The dry season lasts from January to June, while the rainy months are from July to December. Annual rainfall totals 84–116 inches (2133–2946 mm), of which two-thirds falls during the rainy season (Fig. 1)[1]. Seasonal temperatures and precipitation are also affected by the El-Niño Southern Oscillation (ENSO) and tropical cyclones, which cause the largest deviations from average precipitation. An average of three tropical storms and one typhoon pass within 80 nautical miles of Guam each year[2], and both flooding and drought can impact freshwater supply management and associated infrastructure.

A large part of Guam's economy depends on Department of Defense (DoD) installations, and DoD and non-military populations share freshwater resources. Seasonal and long-term climate change may exacerbate existing stresses on water resources. A four-year, interdisciplinary, DoD Strategic Environmental Research and Development Program (SERDP) funded study is evaluating potential climate impacts on freshwater supplies in Guam, and will identify new and existing methods of increasing the system's resilience.

Air Temperature. Continuous surface air temperature records, recorded since 1952, show a generally increasing trend with interannual variability correlated to ENSO events (Fig. 2). In much of Micronesia, the rate of increase in temperature trends has been less since the 1998 El Niño, however the difference between the daytime high and nighttime low has increased since then [3,4].

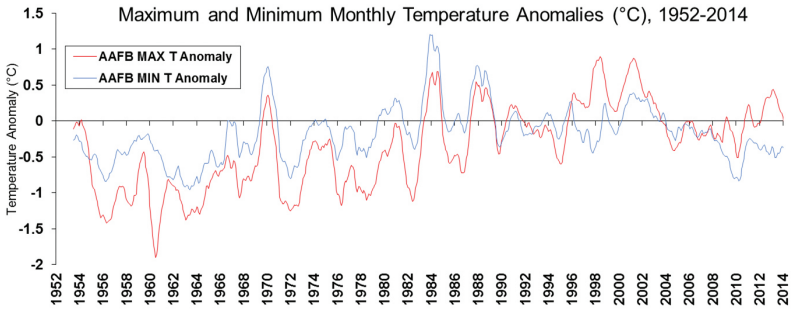

Figure 2. Maximum and minimum monthly temperature anomalies as a 12-month moving average at Andersen Air Force Base (AAFB). Values are expressed as departures from the 1981–2010 base period[3].

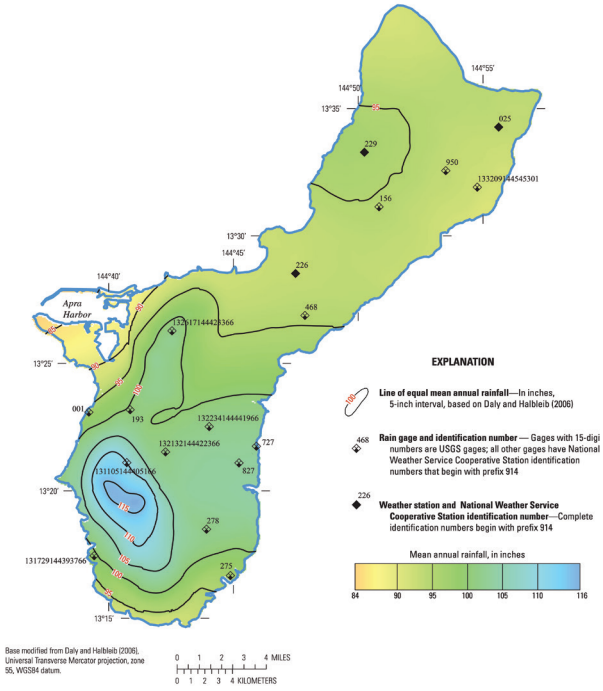

Figure 1. Mean annual rainfall and locations of selected rain gages and weather stations, Guam[1].

Sea Level. Regional sea-level trends differ from global averages on interannual and decadal time scales, and may be due to wind patterns, ENSO events and changes in the Pacific Decadal Oscillation (PDO). The highest rate of sea-level rise in the world from 1993–2010 occurred in the western tropical Pacific, attributable to an increase in tradewind strength and the PDO (Fig. 3)[4]. Increased sea levels can also be linked to La Niña events[4].

Rainfall and Streamflow. Guam receives abundant rainfall. Since 1953, data show a significant drying trend in the eastern Micronesian islands, while western islands like Guam show no significant trend (Fig. 4). In a 49-year record

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of streamflow data, no significant trend was found in total flow, baseflow, or high and low flows[4].

Extremes. Extremes such as drought are more likely in the winter and spring after an El Niño, while flooding is strongly correlated to tropical cyclones. Guam is located in a region vulnerable to storms (Fig. 5). Since 1962, ten of thirteen major disaster declarations resulted from tropical storms[2]. The last intense typhoon to pass over Guam was Super Typhoon Pongsona on December 8, 2002, with sustained winds of 125 miles per hour, leaving massive destruction as the oil tanks in Apra Harbor caught fire[2]. The region has been relatively calm since then, although storms tend to be more intense in El Niño years.

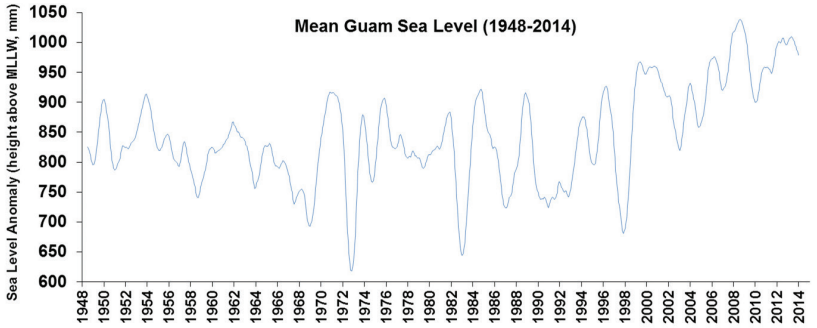

Figure 3. Sea level anomaly in mm (represented as height above mean lower low water, [MLLW]) as a 12-month moving average from Guam tide gage data. (*Figure from M. Lander, WERI, UoG, 2015*)

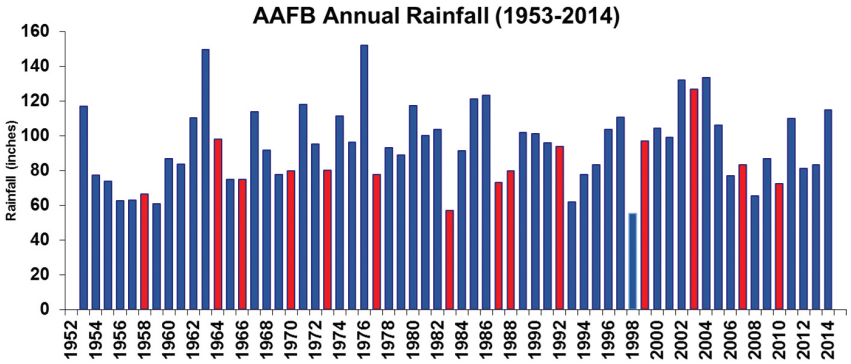

Figure 4. Annual average rainfall at Andersen Air Force Base. Years indicated by red bars show the year after El Niño events, which tend to be characterized by drought conditions[3]. (*Updated figure from M. Lander, WERI, UoG, 2015*)

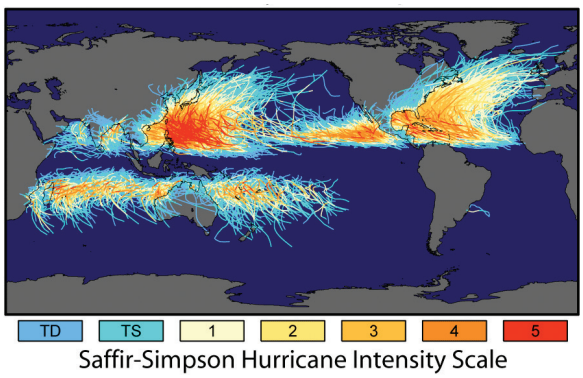

Figure 5. This map shows the tracks of all recorded tropical storms. Guam is in a vulnerable region. (Image by Robert A. Rodhe, Global Warming art. Courtesy of NASA Earth Observatory)

Climate Indicator	Year	Projection
Mean Annual Air Temperature	2050–2074 (compared to 1980–2004)	Increase of 1.99°C over the average
Mean Daily and Annual Precipitation	2050–2074 (compared to 1980–2004)	Moderate increase of 0.61 mm/day (.03 in/day) (222.2 mm/year; 8.7 in/year) over the average
Global Mean Sea Level	2046–2065 (compared to 1986–2005) 2081–2100	An increase of 0.30m (0.22–0.38m) An increase of 0.74m (0.52–0.98m)
Mean Annual Extreme Events	End of 21st century	Fewer, more intense storms with changing track location (potentially moving poleward)[6].

Table 1. Global and coarse end-of-century projections for select climate indicator variables using the IPCC's RCP8.5 scenario, the highest projected level of future greenhouse gas emissions[6].

Projections. At this time, projections for Guam's future climate are at a general and coarse scale. Table 1 summarizes available data about future climate in Guam. Through this DoD SERDP funded project, we hope to provide more detailed projections of future temperature, precipitation, and tropical storm frequency and intensity under future climate conditions, and the associated impacts on surface water and groundwater supply and crucial infrastructure. For more information, please contact investigators listed at the bottom of page 1.

References

[1] Gingerich, SB, 2013. The effects of withdrawals and drought on groundwater availability in the Northern Guam Lens Aquifer, Guam: U.S. Geological Survey Investigations Report 2013-5216, 76 p., http://dx.doi.org/10.3133/sir20135216.

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