2021 Climate Review for Puerto Rico and the U.S. Virgin Islands.

Synopsis: *Overall below normal rainfall was observed across Puerto Rico and the U.S. Virgin Islands during 2021; with the exception of portions of the western interior of Puerto Rico and other isolated areas over north central and coastal areas of northeastern Puerto Rico, which observed above normal rainfall. Due to the overall below normal rainfall, the U.S. Drought Monitor considered parts of Puerto Rico as having a "Moderate Drought" (D1), while Saint Thomas and Saint John islands had at times a "Severe Drought" (D2). Saint Croix fared the worst, reaching the classification of "Extreme Drought" (D3) by December. Tropical Storms Fred and Grace got close to the local islands this year, but stayed far enough south to not have a significant impact over the local islands. We closed the year with above normal mean temperatures across all the main climate sites, with this year being in the top-10 warmest years on record for all of the climate sites, and also the driest year on record for Saint Croix.*

Summary: The typical daily and seasonal weather patterns were observed this year, whether it was the brief onshore showers, hot summer temperatures and strong thunderstorms, Saharan dust events or tropical cyclones. However, with the exception of the below normal rainfall, the drought conditions and the occasional daily or monthly records; this year did not have particular events that caused a very significant impact. The overall rainfall patterns favored the western sections of Puerto Rico, a portion of north central and a few areas of the eastern coastal municipalities of Puerto Rico, causing near to above normal rainfall. Elsewhere in Puerto Rico, below normal rainfall was observed with estimates indicating about 50% to 90% of normal. The U.S. Virgin Islands also observed below normal rainfall, especially Saint Croix where the airport observed 58% or normal rainfall and the driest year on record, while Saint Thomas observed 70% of normal rainfall. The spring months were generally dry when compared to normal, with the main climate sites observing about 45% to 50% or normal rainfall. However, the biggest drought impact was observed through the fall months, which had about 45% to 70% of normal rainfall across the main climate sites. This is particularly true for the U.S. Virgin Islands, because the fall months are generally rainy, so the total rainfall deficit was around 8 to 9 inches in the fall, compared to around 4 inches below normal during the spring months.

The drought conditions degraded significantly across the local islands after the fall months. The U.S. Drought Monitor expanded the area under any drought classification over Puerto Rico from 35% at the beginning of the fall to 82% by the end. However, the spring was not far behind, with an increase in overall drought area from 40% at the beginning to almost 70% at the end of May, though peaking at 79% in early May. As far as the U.S. Virgin Islands at the beginning of the fall, Saint Thomas had no drought classification, Saint John was "Abnormally Dry" (D0), and Saint Croix was under a D2 classification. But by the end of the fall months, Saint Thomas was given a D2 classification, Saint John a D1, and Saint Croix a D3. There was a minor change after the spring across the U.S. Virgin Islands, with all 3 islands under D1 at the beginning of spring, and all 3 islands under D2 by the end of spring.

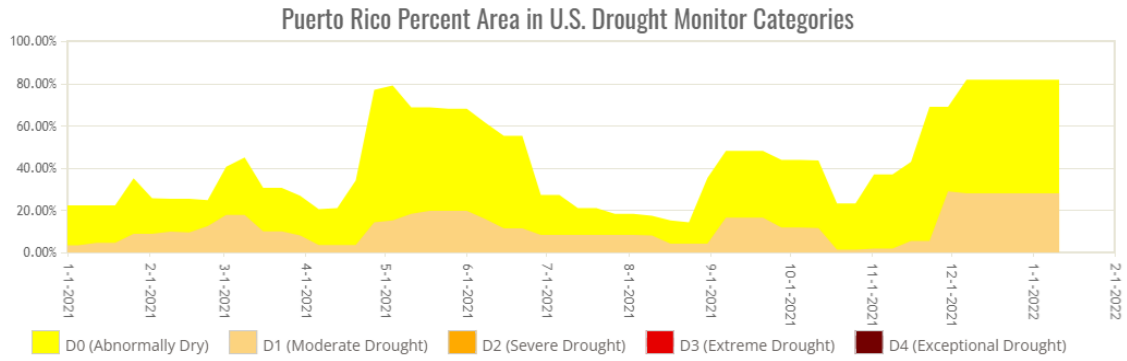


Figure 1. Percent Area of PR under U.S. Drought Monitor - Drought Categories 2021.

The year 2021 was no stranger to above normal temperatures, and the main climate sites had 2021 mean temperatures in the top-10 according to their respective records. It was a particularly warm fall at the San Juan Airport, recording the warmest fall on record. Only one minimum temperature record was set across the main climate sites. This one was in Saint Thomas, when a strong rain shower lowered the temperature temporarily, tying the previous record of 73 degrees on the 12th of September. In contrast, several daily maximum temperature records were either tied or broken across the local sites. The San Juan Airport recorded 11 daily maximum temperature records, Saint Croix had 18 records, while Saint Thomas did not have any maximum temperature records. However, the main contributing factor for Saint Thomas to have above normal mean temperatures was the overnight low temperatures. The overnight minimum temperatures were warmer than normal, and Saint Thomas had 30 nights where they either tied or broke the record for warmest low temperatures; Saint Croix had 6 of such records and San Juan 17.

As far as Saharan dust, it was a fairly normal year, with a few events more significant than others, but there was no highly memorable event. Therefore we did have several hazy days and some of that may have contributed to the drier than normal summer and early fall days as well as overnight low temperatures that were warmer than normal. That said, one thing to note is that there were fewer than normal Saharan dust events in the month of June, allowing for a much wetter than normal June. In fact, June was the rainiest month of the year at the San Juan Airport.

Weather patterns observed by month and season:

During January and February, the weather pattern was fairly typical, but even drier than normal conditions were observed across much of Puerto Rico and the U.S. Virgin Islands. In February, a surface trough caused significant rainfall across the eastern interior of Puerto Rico, totaling an estimated 3 to 5 inches of rain. However, that was the only significant rainfall event in the early months of the year. These months were also warmer than normal, February 2021 being the 4th warmest February on record for Saint Thomas and Saint Croix. In contrast, March was wetter

than normal, at least for some sections of the local area. Two main events contributed to periods of heavy and continuous rainfall, mainly over the San Juan metro area, the interior, western and northern sections of Puerto Rico. At the end of the month, some areas around Puerto Rico received 3 to 6 inches above the climatological value. As a positive note, the drought monitor shrunk the area of Abnormally Dry and Moderate Drought conditions, but still, around 27% percent of the territory remained under some drought category. April transitioned into more favorable conditions for widespread shower and thunderstorm activity over the area. However, as is usual with these events, mainly the interior and western Puerto Rico benefited with the rain. Doppler radar estimates only showed amounts 1 to 3 inches for the U.S. Virgin Islands, Vieques, Culebra and southeastern Puerto Rico. This is below normal, and therefore, drought conditions extended once again for most of the eastern and southern half of Puerto Rico with nearly 80% of Puerto Rico under any drought classification. For the U.S. Virgin Islands, Severe Drought (D2) conditions were introduced for St. Croix, and these conditions also continued for St. Thomas and St. John. In contrast, the interior and the east of Puerto Rico reached 3 to 8 inches, and it was 10 to almost 20 inches for sections of the northwest, which is 5 to 10 inches above the climatological value.

There were two main warm spells during the Spring months as well, with temperatures approaching or surpassing the 90 degree mark. The first one was centered around April 20th, and the second was around May 20th. These prolonged periods of above normal temperatures play an important role in the hydrological cycle. Specifically, warm temperatures act to increase the evaporation rates across the streams and reservoirs, which aggravate the water deficit and drought across the region.

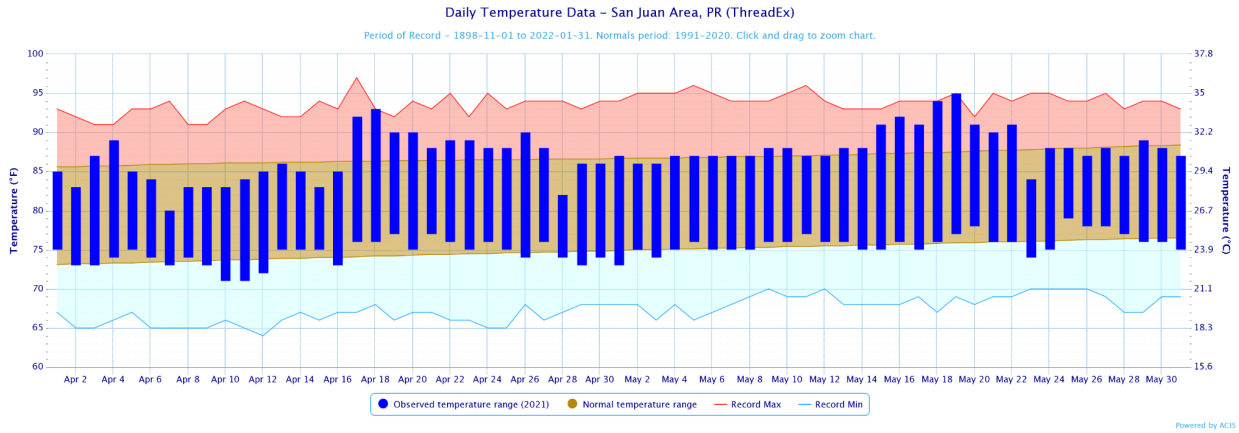


Figure 2. Temperatures in the San Juan Area from April 1st-May 31st, 2021

In the first month of the meteorological summer, June, most of the territory experienced above normal rainfall, which is the opposite of what is usually observed. Doppler radar estimates were as high as 20 inches for the Luquillo Mountain range, and 5 to 15 inches for the rest of the area, except the southern slopes of Puerto Rico and ISX, where below normal conditions prevailed.

IST received 3 to 6 inches and ISX, 1 to 2 inches. In fact, JSJ ended as the 6th wettest June on record, while IST reached the 10th respective place. A daily record was also established for JSJ on June 10th, with 3.50" collected. As a result of these rains, the drought conditions significantly improved for most of Puerto Rico and the northern U.S. Virgin Islands. By July, the drier than normal pattern resumed, and all the climatological sites ended drier than normal. The Doppler radar estimates were in the range of 5 to 20 inches, and less than 2 inches for the southern slopes of Puerto Rico. The U.S. Virgin Islands ranged from 1 to 5 inches. Even with values below normal, the rains were enough to reduce the drought to only the southern slopes of Puerto Rico and a section in the northwest coast. No improvement was registered for the U.S. Virgin Islands.

August is the first month of the active part of the Hurricane Season for the eastern Caribbean, and the second most dangerous for the islands. The islands were under two tropical storm warnings only one week apart from each other, Tropical Storm Fred and Tropical Storm Grace. Fred were generally uneventful, but Grace left heavy rainfall across the U.S. Virgin Islands, Vieques, and sections of southeastern and southwestern Puerto Rico. Regardless of the storms, the rest of the month was drier than normal, and Puerto Rico only received 69% of the normal rainfall amounts. Most of the area received 3 to 10 inches, with higher amounts for western Puerto Rico and the Luquillo Mountain Range. For the western coasts of St. Croix, St. Thomas and Vieques, 5 to 9 inches were observed, while the rest of the U.S. Virgin Islands and Culebra observed 2 to 5 inches. Drought conditions improved for the USVI, and all the islands went down one category of the U.S. Drought Monitor. For Puerto Rico, although D1 conditions shrinked to only a few sections of the southern slopes, D0 conditions stretched to the eastern interior municipalities. Temperatures were above normal for JSJ and IST, making it to the 8th and 10th warmest August on record, respectively.

The meteorological fall begins in September. No tropical cyclones approached the area during this month, which is the peak month of the Atlantic Hurricane Season. However, the most significant rainfall event on this month was associated with Tropical Depression Peter passing north of the area in combination with an upper level trough that increased moisture and instability across the islands. This resulted in accumulations of 2 to 5 inches across many areas of Puerto Rico. In general, rainfall distributions were above normal only for the interior and western sections of Puerto Rico, areas which benefited from local effects, while the rest of the area ended drier than normal. In fact, all the climatological sites ended drier than normal, and ISX made it to the 3rd driest September on record. It was a hot month as well, and the Ponce 4 E station reached 100 ºF on the 7th. Additionally, JSJ ended as the warmest September on record, and ISX made it to the 9th warmest.

The main climatological sites ended again drier than normal in October. There were a few areas, however, with above normal values, mostly confined to the east, extreme northwest and Vieques over Puerto Rico. For Saint Croix, even with the International Airport reporting below normal rainfall, the northwest corner of the islands did receive more than 10 inches of rain. The main

events were associated with significant thunderstorms that resulted in flooding across many sectors. Drought conditions improved for the Virgin Islands, but near 37% of Puerto Rico remained mainly under D0 conditions. Once again, above normal temperatures prevailed, and JSJ ended as the 4th warmest October on record.

Several days with temperatures above 90 degrees were reported from mid August to the end of October. Even though these months benefit from receiving the higher amounts of rainfall during the year, these continuous warm spells work to increase the water deficit across the soils, streams and reservoirs.

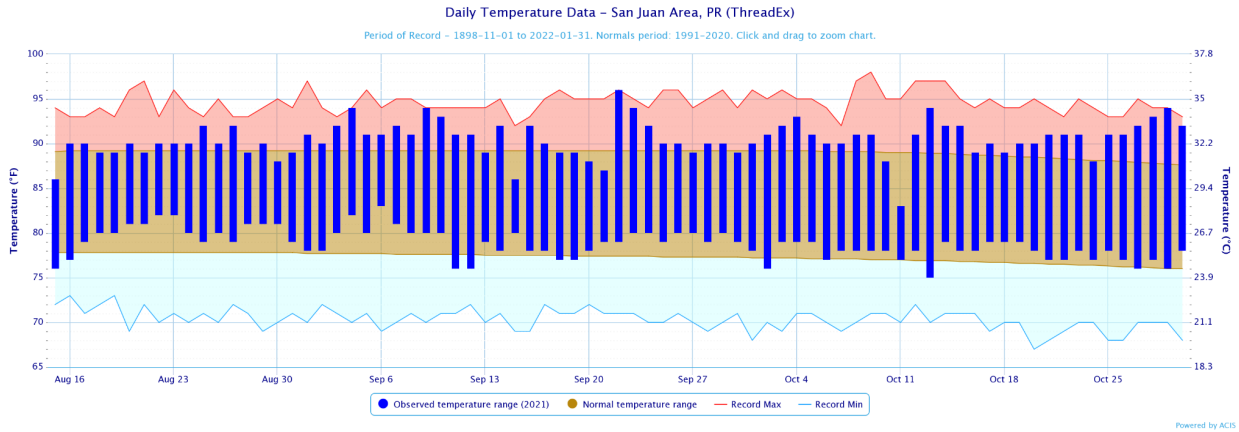


Figure 3. Temperatures in the San Juan Area from August 15th-October 31st, 2021

The dry spell stretched into November as well. Only a small area over western Puerto Rico received higher than normal precipitation. Places such as southeastern Puerto Rico barely observed 10 to 25% of the expected amounts. St. Croix ended as the driest November on record, with only one inch collected, while IST ended as the 9th driest. The deficit in San Juan was between 4 to 5 inches. Under this prolonged drier than normal conditions, drought conditions deteriorated significantly. St. Croix reached the Extreme Drought (D3) classification, while St. Thomas was upgraded to D2, and St. John to D1. For Puerto Rico, nearly 82% of the territory was at least under D0, but the Moderate drought extended to most of the southern plains, eastern interior, and sections across the north-central. By the end of the year, in December, once again drier than normal conditions plagued most of the area. Places such as the south coast from Guanica to Ponce, northern Salinas and eastern Vieques barely observed 10% to 25% of normal rainfall. Like a broken record, the three main climatological sites ended drier than normal, with ISX and IST ending as the 3rd and 9th driest December on record, respectively. The satellite and Doppler radar rainfall estimates were 1 to 3 inches for most of the southern slopes west of Salinas, the western interior and most of the western coast of Puerto Rico, as well as for Vieques and Culebra. For the San Juan metro area and the eastern half of Puerto Rico, amounts were around 3 to 5 inches, and up to 15 inches for the Luquillo Mountain Range. For the U.S. Virgin Islands, radar and satellite rainfall estimates were mostly less than two inches, except for central

to western St. Croix, where independent rain gauges recorded over 2 inches. No improvements nor deterioration was reported by the U.S. Drought Monitor. The last month of the year also ended warmer than normal. ISX and JSJ ended as the 3rd and 10th warmest December on record.

The local islands ended the year with mean temperatures warmer than the 30-year average based on the new normals released this year by the National Centers for Environmental Information (NCEI). This pattern of above normal temperatures was observed across most of the Caribbean region (Fig 4). The mean annual temperature at JSJ was 81.6ºF, which is approximately 0.7ºF warmer than normal. Saint Thomas observed an annual mean temperature of 82.0ºF and Saint Croix of 81.6ºF, which is 0.1ºF and 0.9ºF above normal respectively.

Across our COOP sites, the highest daily temperature was 100ºF, observed at the Ponce 4 E station on September 7th, and the lowest temperature was 50ºF at the Adjuntas Substation on February 8th. The highest temperatures across the main climate sites were 96ºF on September 22nd; 93ºF was the highest temperature at IST, observed three times with the latest day of occurrence being August 23rd; ISX observed 94ºF on September 6th. The lowest temperatures observed across the main climate sites were 68ºF on January 6th at JSJ; 71ºF three times on IST with the latest day of occurrence being December 21st; 66ºF at ISX on April 11th.

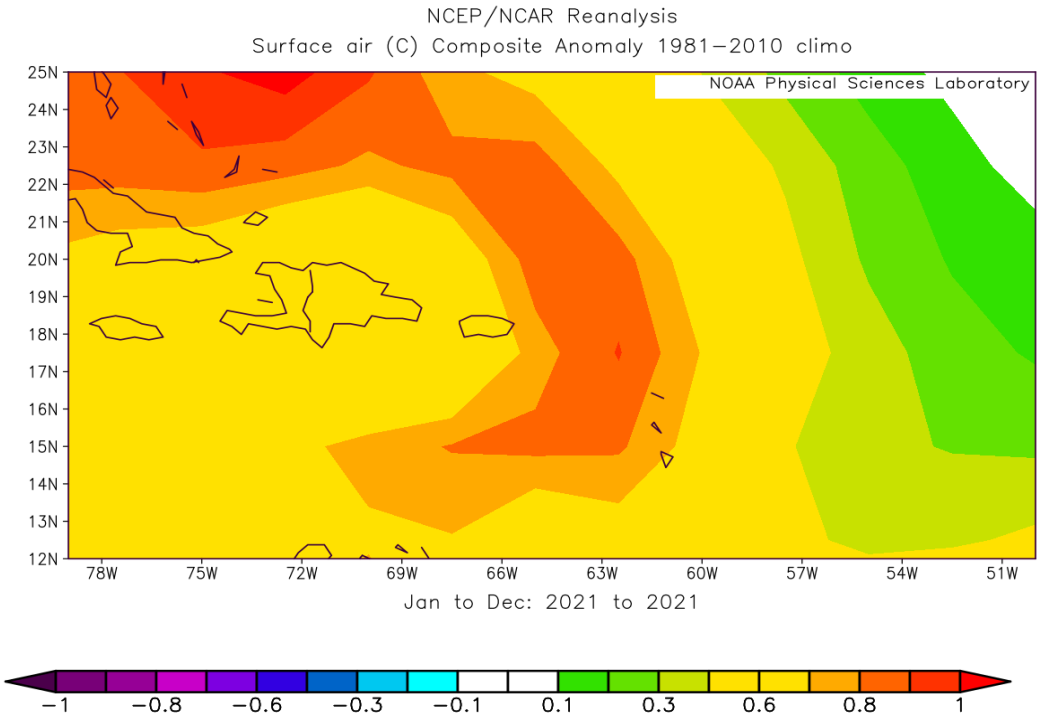
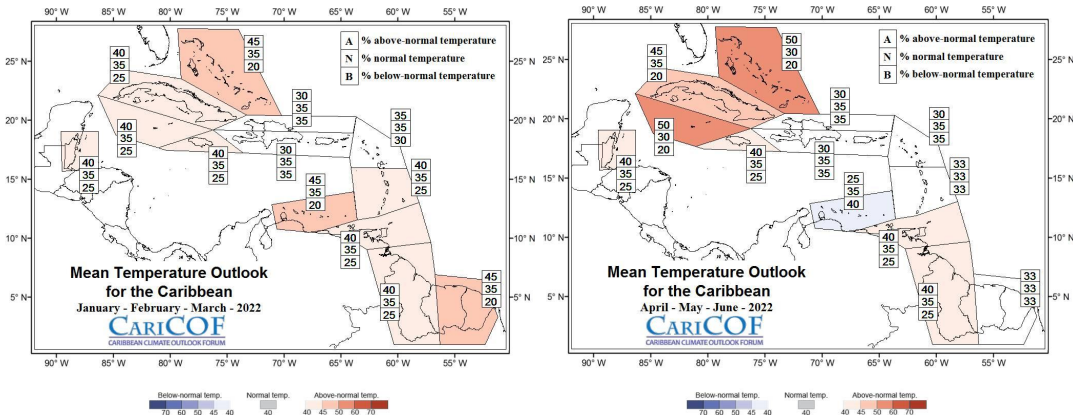


Figure 4. Surface Air Temperature Anomaly for the Caribbean from Jan 1st 2021 through Dec 31st 2021.

With respect to rainfall at the main climate sites; 85, 70, 58 percent of the normal rainfall was observed at Luis Muñoz Marin Airport **(JSJ)** in San Juan, Cyril E. King Airport **(IST)** in Saint Thomas, and Henry E Rohlsen Airport **(ISX)** in Saint Croix respectively. A preliminary rainfall total of 50.92 inches was measured at TJSJ, which is 8.95 inches below normal; Saint Thomas observed 28.98 inches of rain, which is 12.47 inches below normal; and Saint Croix observed 21.46 inches of rain, which is 15.55 inches below normal, making it the driest year on record. That said, the Saint Thomas Airport reported missing data in the month of February, and about 1.39 inches of rain was estimated by radar in that time period that is not reported, so the actual rainfall total at the Saint Thomas Airport may be closer to 30.37 inches of rain.

Looking Ahead



Images 1 and 2. CariCOF precipitation forecast for Jan-Feb-Mar and Apr-May-Jun

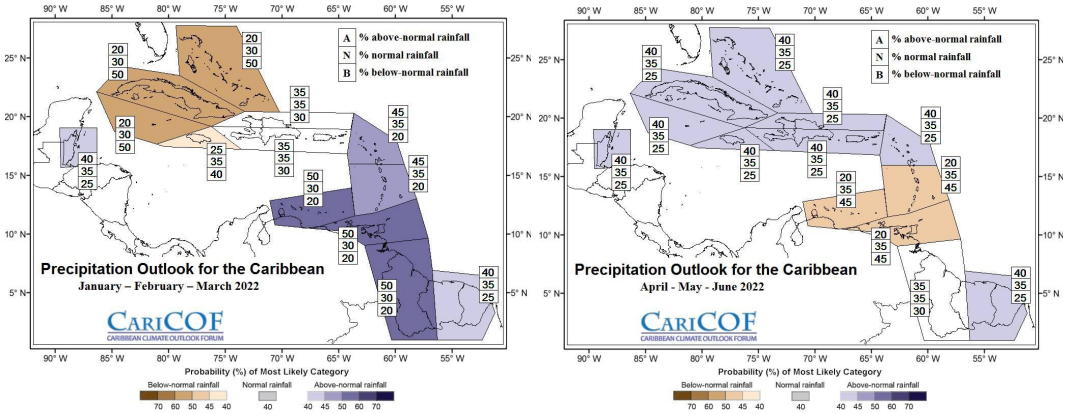


Image 3 and 4. CariCOF mean temperature forecast for Jan-Feb-Mar and Apr-May-Jun

Below average Sea Surface Temperatures (SSTs) were recently observed across the El Niño region of the Pacific, exhibiting La Niña conditions. Most models suggest temperature anomalies to transition into ENSO-neutral through the spring and early summer of 2021. When there are ENSO-neutral conditions, there is no significant impact or contribution to the forecast, but it does add uncertainty. Persistent higher than average SSTs across the Caribbean is what is driving the higher than average temperatures and the “Equal Chances" from January to March, and above normal precipitation from April through June across the local islands. SSTs across the Caribbean are expected to remain abnormally warm. Usually, warm SSTs in the Caribbean lead to above-average temperature and humidity, as well as enhanced atmospheric instability.

More Info: http://rcc.cimh.edu.bb/long-range-forecasts/caricof-climate-outlooks/

Highlights for Primary Climatological Data Sites

There were a total of **34** days (nights) with a minimum temperature of 80ºF or above at the San Juan **Luis Muñoz Marin Airport (TJSJ)** in 2021. This ranks as the 7th highest number of “80ºF or above” minimum temperature days on record**.**

Rank	Year	Number of days
1st	2009	59
2nd	2017	54
3rd	2020	48

Table 1. Total daily low temperatures of 80ºF or higher at TJSJ.

There were a total of **73** days (nights) with a minimum temperature of 80ºF or above at the Saint Thomas **Cyril E. King Airport (TIST)** in 2021. This ranks as the 7th highest number of “80ºF or above” minimum temperature days on record.

Rank	Year	Number of days
1st	2016	116
2nd	2020	115
3rd	2010	106
4th	2015	94

Table 2. Total daily low temperatures of 80ºF or higher at TIST.

There were a total of **21** days (nights) with a minimum temperature of 80ºF or above at the Saint Croix **Henry E. Rohlsen Airport (TISX)** in 2021. This ranks as the 37th highest number of "80ºF or above" minimum temperature days on record.

Rank	Year	Number of days
1st	1987	144
2nd	1986	104
3rd	1980	75
4th	2020	68

Table 3. Total daily low temperatures of 80ºF or higher at TISX.

2021 Monthly & Seasonal Highlights for Primary Climatological Data Sites

	Dec (2020)	Jan	Feb	Season
JSJ	---	---	---	---
IST	7th driest 1.42"	7th warmest 79.4ºF 2nd driest 0.75"	4th warmest 80.4ºF	6th warmest 80.0ºF
ISX	---	---	4th warmest 79.8ºF	---

Table 4. Winter 2020-21

	Mar	Apr	May	Season
JSJ	---	---	---	---
IST	7th warmest 80.7ºF	---	---	7th warmest 81.4ºF
ISX	9th driest 0.55"	---	---	6th driest 3.37"

Table 5. Spring 2021

	Jun	Jul	Aug	Season
JSJ	6th wettest 10.49”	---	8th warmest 84.2ºF 7th driest 2.68”	---
IST	10th wettest 4.42”	8th warmest 85.2ºF	10th warmest 85.0ºF	9th warmest 84.5ºF
ISX	---	---	---	---

Table 6. Summer 2021

	Sep	Oct	Nov	Season
JSJ	1st warmest 85.0ºF	4th warmest 84.2ºF	2nd warmest 82.2ºF 9th driest 2.79”	1st warmest 83.8ºF
IST	4th warmest 85.1ºF	---	9th driest 2.08”	5th driest 8.43”
ISX	8th warmest 83.9º 3rd driest 1.53”	---	1st driest 1.00” 10th warmest 81.6ºF	6th warmest 82.7ºF 1st driest 6.96”

Table 7. Fall 2021

	Dec (2021)	2020 Year-End
JSJ	10th warmest 79.8ºF	9th warmest 81.6ºF
IST	10th warmest 80.4ºF 7th driest 1.41”	5th warmest 82.0ºF
ISX	3rd warmest 81.0ºF 6th driest 1.18”	3rd warmest 81.6ºF 1st driest 21.46”

Table 8. December 2021 and Year-End 2021 Highlights

Additional Highlights Based on COOP Data

Wettest Days

Station	Rainfall	Date
Toa Baja Levittown	6.63”	March 21st
Maricao 2 SSW	6.00”	September 29th
Paraiso	5.21”	June 9th
Trujillo Alto 2 SSW	5.10”	May 9th
Arecibo Observatory	4.99”	September 18th

Stations With The Highest Daytime Temperatures

Station	Station’s Highest Temperature (ºF)	Date
Ponce 4 E	100	September 7th
Lajas Substation	99	August 11th
Aguirre	99	September 7th
Magueyes Island	96	August 17th
Dos Bocas	96	August 27th

Stations With The Lowest Nighttime Temperatures

Station	Station’s Lowest Temperature (ºF)	Date
Adjuntas Substation	50	February 8th
Dos Bocas	57	February 24th
Maricao 2 SSW	58	December 17th
Aguirre	58	January 22nd
Arecibo Observatory	60	December 31st

Data are preliminary and have not undergone final quality control by the National Centers for Environmental Information / NCEI/. Therefore, these data are subject to revision.

Maps with radar estimated rainfall and rainfall deficits

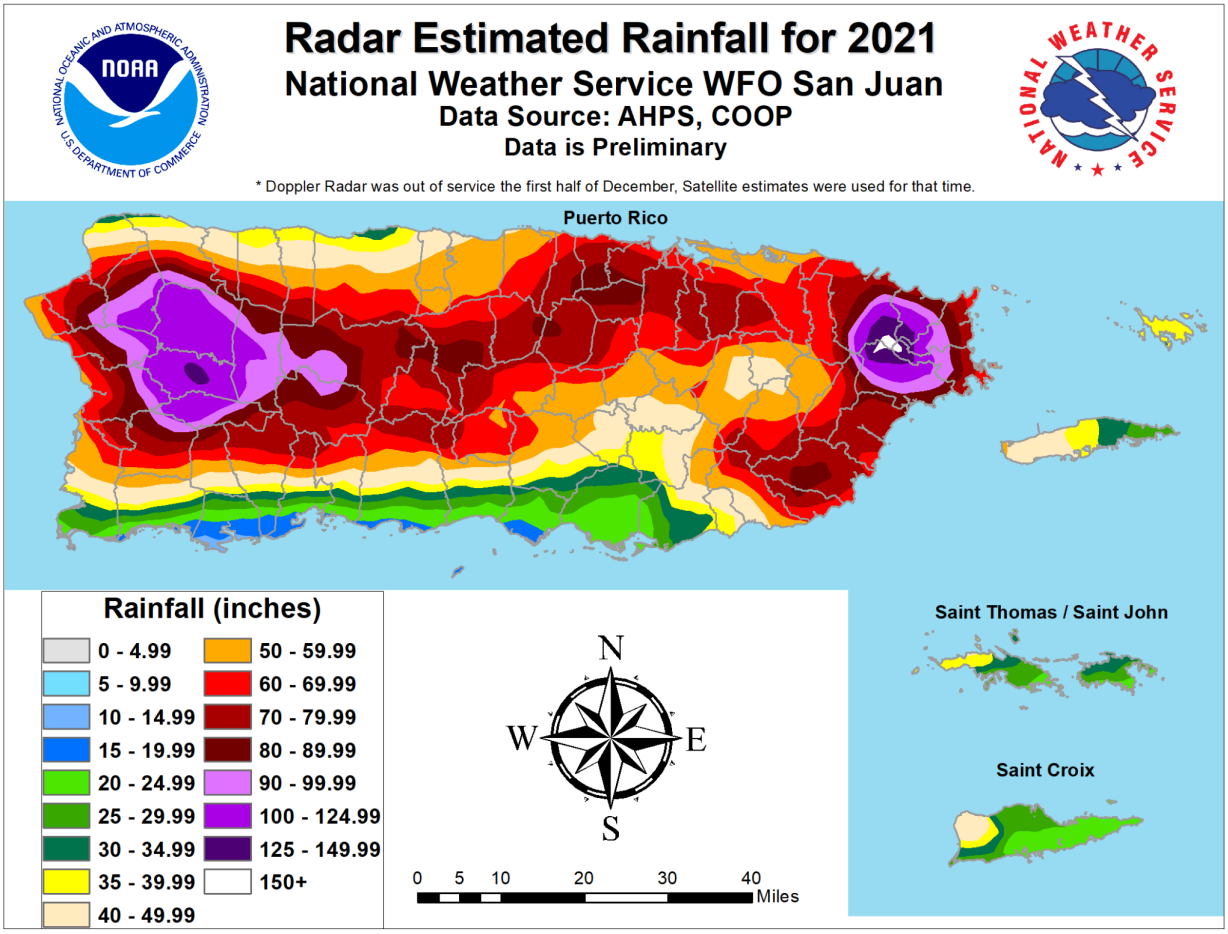


Image 5. Radar estimated Rainfall for Puerto Rico and the U.S. Virgin Islands for 2021

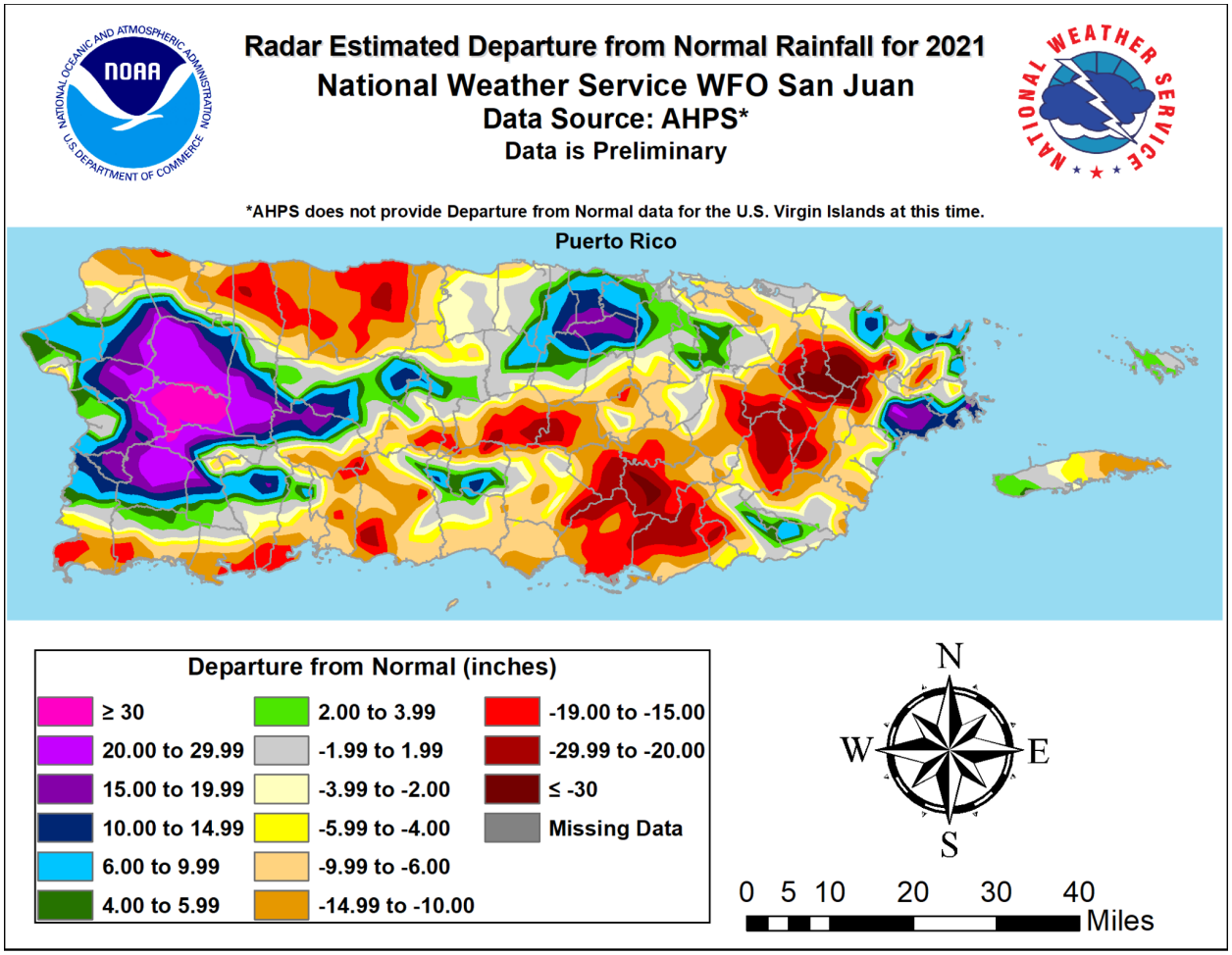


Image 6. Radar Estimated Departure from Normal Rainfall for 2021

New Normals Released on 2021

The National Center for Environmental Information (NCEI) released the temperature and rainfall normals for the 1991 to 2020 period. These values are released every 10 years as a requirement of the World Meteorological Organization (WMO) and the National Weather Service. The new normals are not meant to be used as indicators for climate change in the region (access the State Climate Summary for 2022 if you wish to learn more about the effects of climate change in Puerto Rico and the U.S. Virgin Islands).

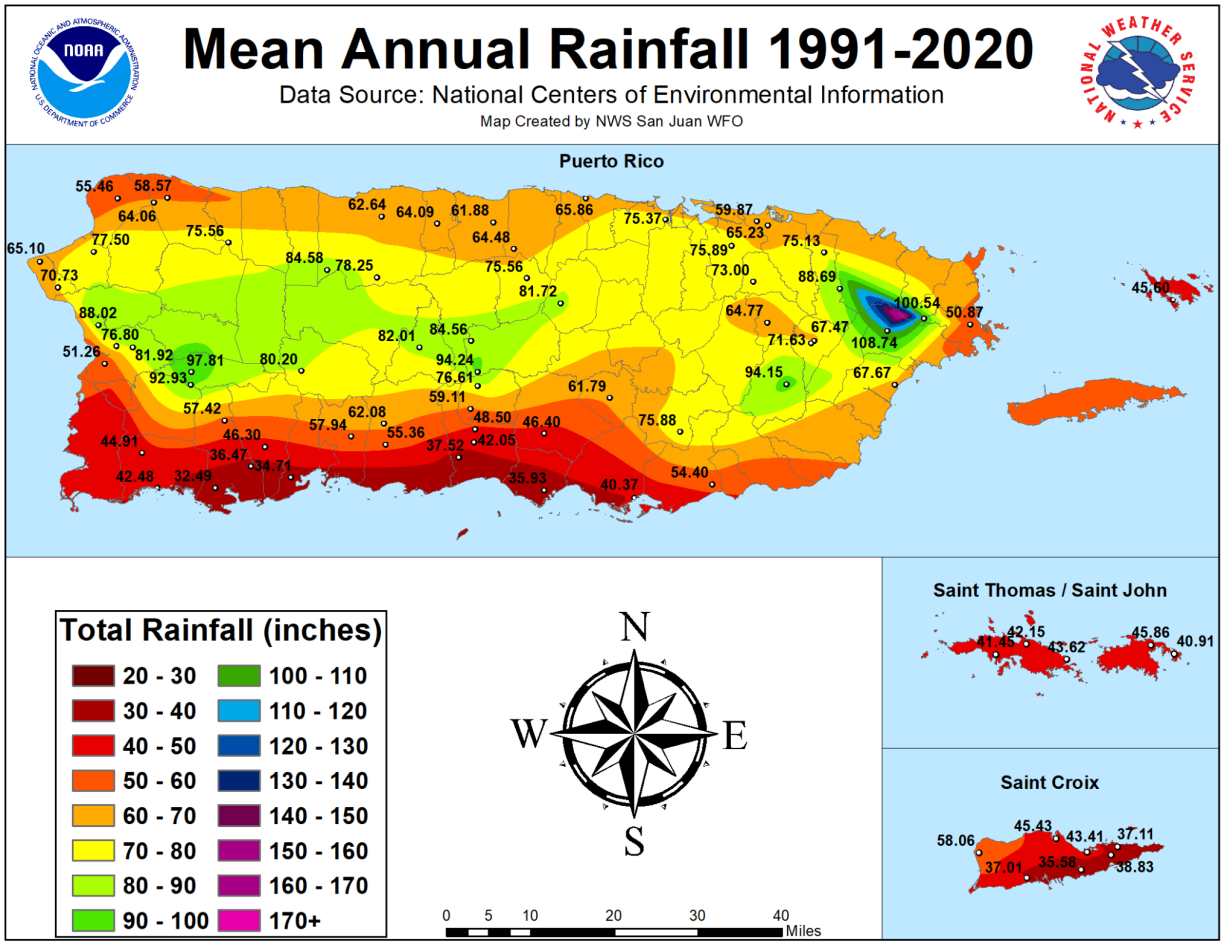


Image 7. Mean Annual Rainfall for Puerto Rico and the U.S. Virgin Islands for the 1991-2020 period.

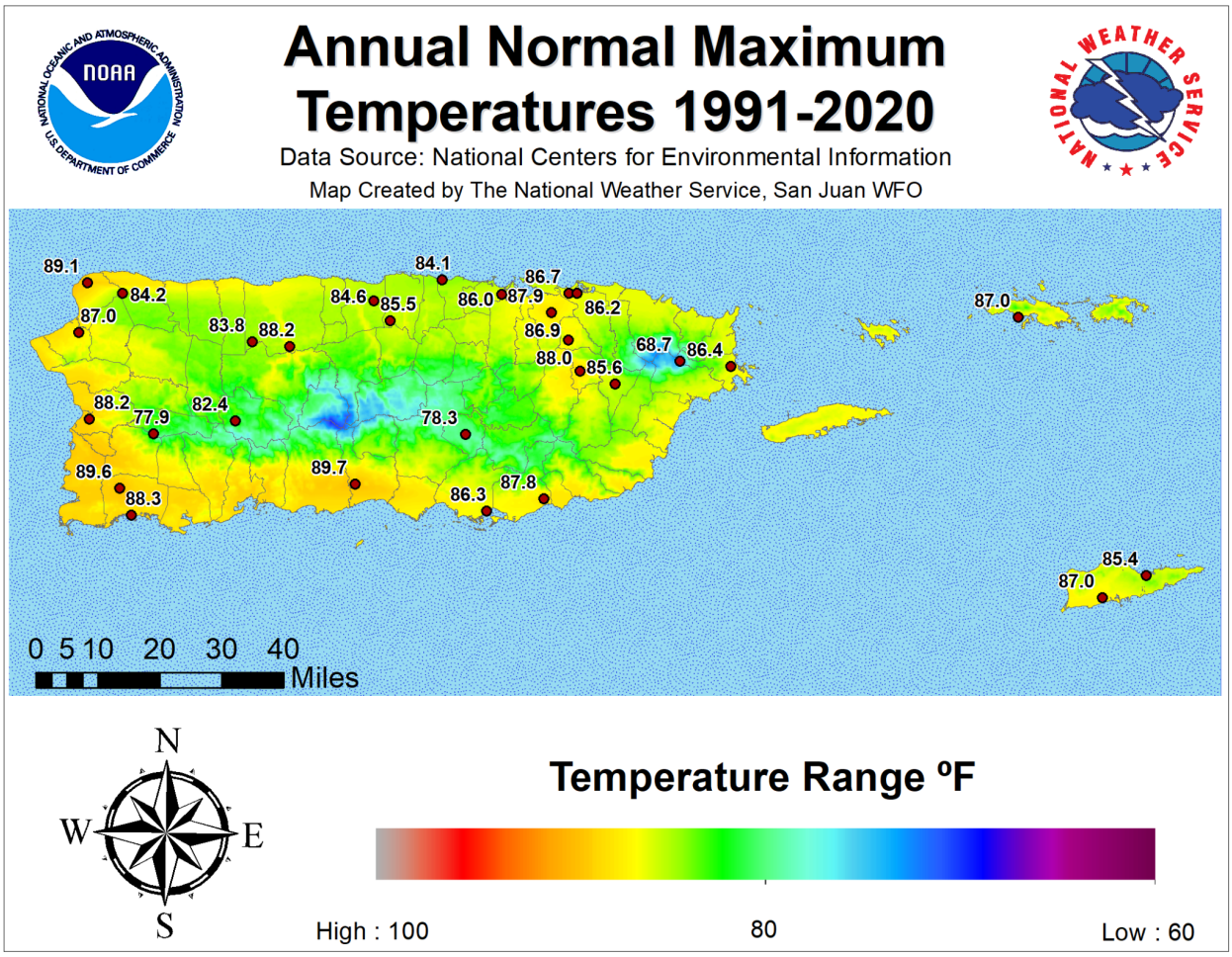


Image 8. Annual Normal Maximum Temperatures for Puerto Rico and the U.S. Virgin Islands for the 1991-2020 period.

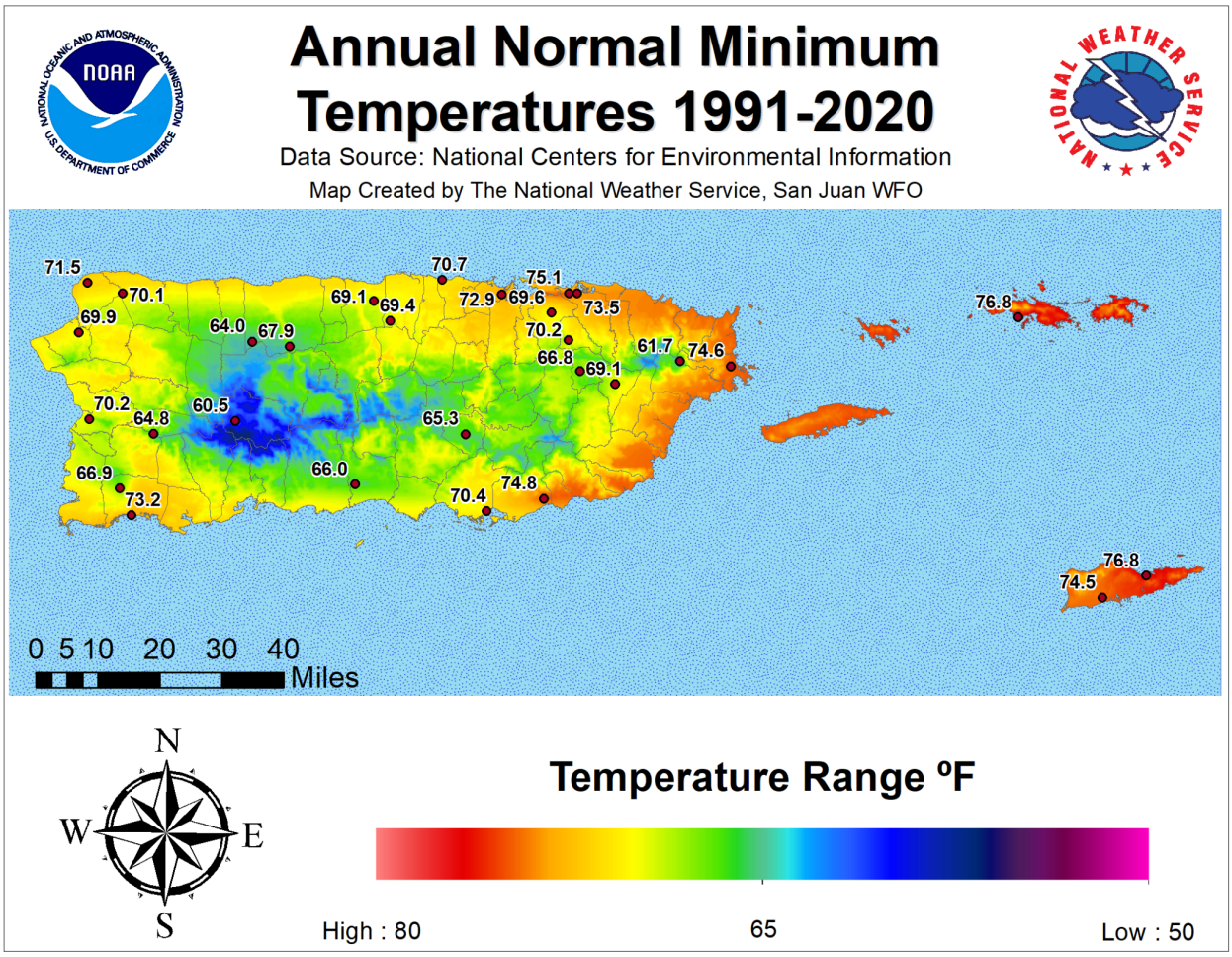


Image 9. Annual Normal Minimum Temperatures for Puerto Rico and the U.S. Virgin Islands for the 1991-2020 period.