# 2021 Climate and Weather: The Year in Review

The year 2021 saw significantly wetter-than-average[1] conditions and is Singapore's second wettest year since 1980. The annual total rainfall recorded at the Changi climate station was 33% higher than the long-term average of 2113.3 mm. The wetter conditions contributed to moderating Singapore's overall temperature in 2021. In addition, La Niña conditions prevailed during the first quarter of 2021, returning to neutral El Niño – Southern Oscillation (ENSO) conditions in the second quarter, with La Niña conditions re-emerging in the third quarter of the year.

## Temperature

The last 10 years from 2012 to 2021 is the warmest decade on record. The mean temperature from 2012 to 2021 was 27.97°C, 0.02°C higher than the previous record of 27.95°C for the decade from 2010 to 2019.

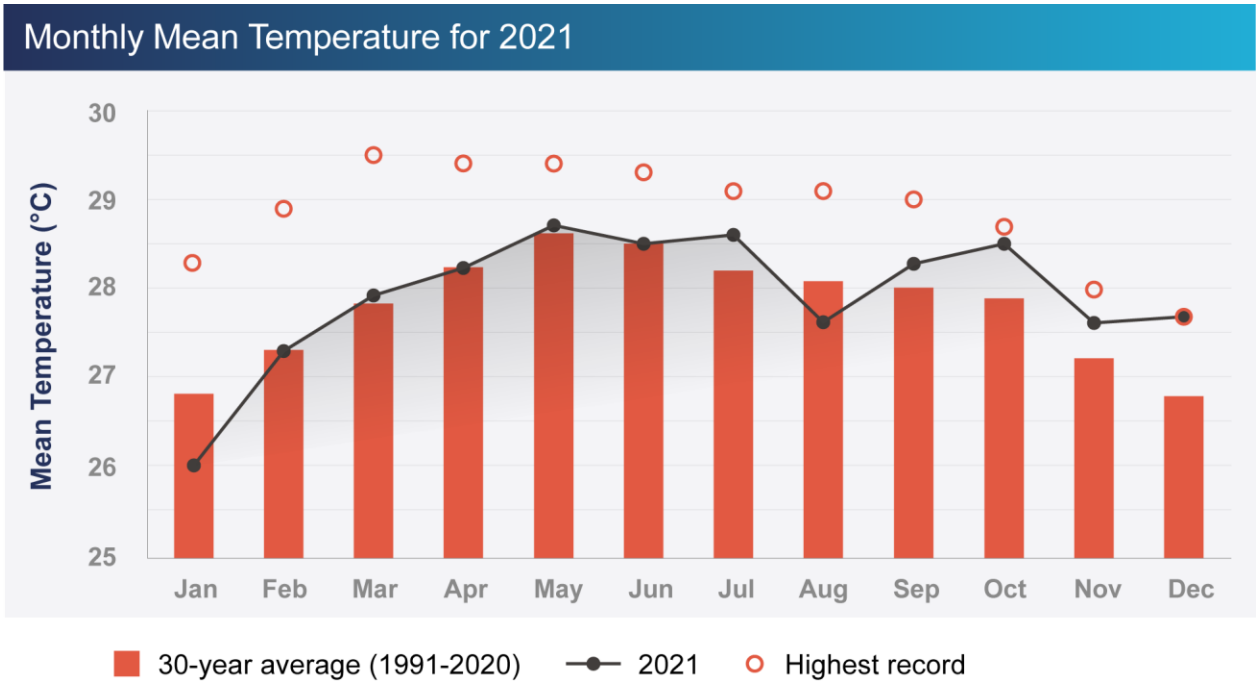


*Figure 1: Singapore monthly mean temperature for 30-year average from the Changi climate station (bars, 1991 – 2020) compared to 2021 (solid line). Also shown are the highest recorded monthly values for the historical period prior to 2021 as 'dots'.*

[1] According to World Meteorological Organization (WMO) guidelines, the standard climatological normal (derived from meteorological observations) calculated as the average over a 30-year period is updated every 10 years. As year 2021 marked the beginning of a new 30-year climatological period, a new set of climatological normals for Singapore was compiled based on the meteorological data from stations with continuous long-term records from 1991 to 2020.

In the first half of the year, mostly near-average temperatures were observed while warmer-than-average conditions were observed during the second half of the year. The warmer-than-average temperatures towards the end of the year were associated with relatively drier weather conditions. The annual mean temperature in 2021 was 27.9°C, which is 0.1°C above the long-term average of 27.8°C and the 10th warmest year on record (tied with 2018, 2014, 2009, and 2004).

In January and August, the cooler-than-average temperatures (Figure 1) were associated with significantly higher-than-average rainfall during these two months. The mean temperatures in January and August were 26.0°C and 27.6°C respectively, which are 0.8°C and 0.5°C cooler than their respective long-term monthly averages. Notably, January 2021 is the coolest January in the past 30 years, while August 2021 is the second coolest August in the past 20 years. While no long-term monthly temperature records were broken in 2021, the monthly mean temperature of 27.7°C in December is the joint warmest December (together with December 2015) since temperature records started in 1929.

## Rainfall

The annual total rainfall in 2021 was well above average, resulting in the second wettest year since 1980 both at the climate station[2] and for the islandwide average[3]. The annual total rainfall recorded was 2809.6 mm at the Changi climate station and 3167.7 mm when averaged across islandwide stations with long-term records, which was 33% and 25% above their respective long-term annual averages of 2113.3 mm and 2534.3 mm.

Most months in 2021 experienced above-average rainfall. Based on the islandwide average, almost all of these wetter months also rank within the top 10 wettest for the respective months over the past 40 years. In particular, total rainfall in January (480.5 mm) and August (426.2 mm) were at least twice their respective long term monthly averages (Figure 4), resulting in the wettest January and August in the past 40 years. At the climate station (Figure 5), similar significantly above-average rainfall was recorded in January with a total rainfall of 692.8 mm. This makes January 2021 the second wettest January on record after January 1893 (818.6 mm).

Among the few months that showed drier-than-average monthly rainfall in 2021, February had significantly drier conditions. Monthly total rainfall in February both for the islandwide average (35.8 mm) and the Changi climate station (1.0 mm) were about 73% and 99% below average respectively, resulting in the second driest February over the past 40 years, based on the islandwide average, and second driest for the climate station since rainfall records started in 1869.

[2] It is ranked at 21st wettest when compared to the entire climate station record since 1869.

[3] The islandwide average is based on the data from 32 stations across Singapore that have a continuous record from 1991 onwards.

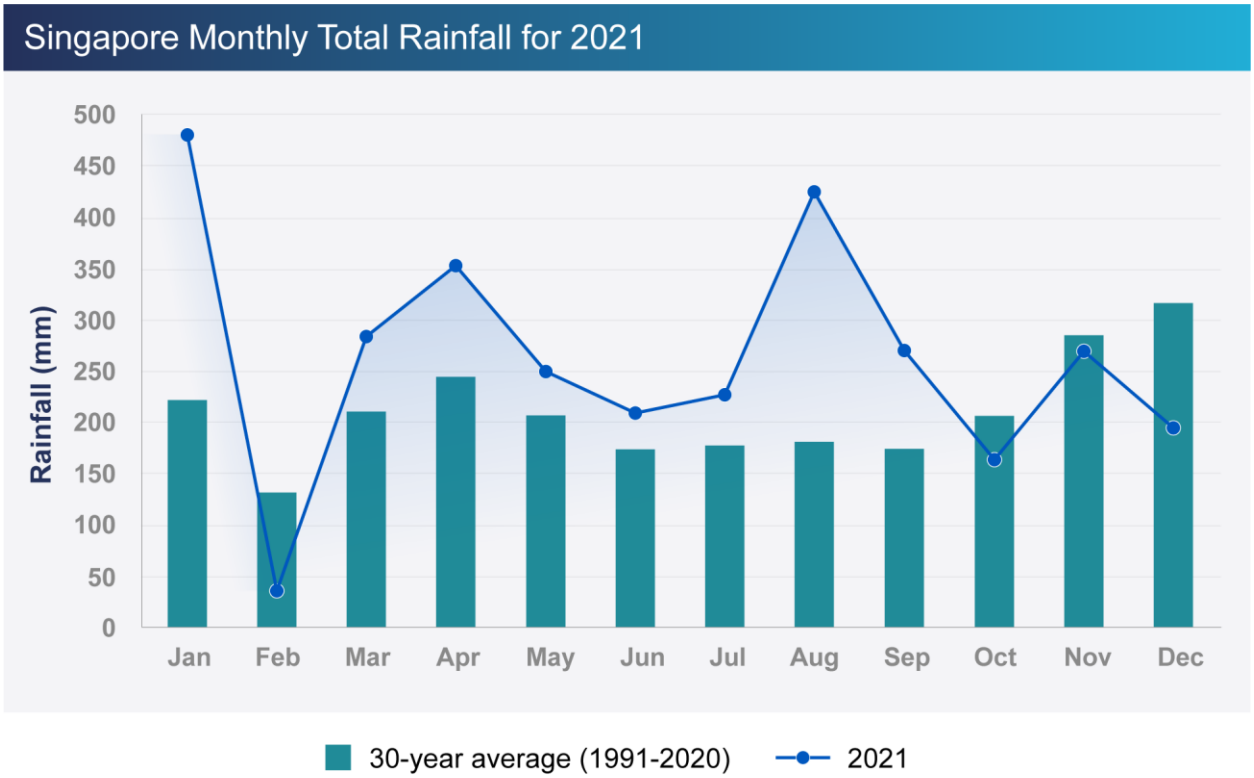


*Figure 2: Singapore monthly total rainfall for 30-year average over islandwide stations with long-term records (bars, 1991 – 2020) compared to 2021 (solid line). The annual total rainfall of 3167.7 mm for 2021 was 25% above the long-term annual average of 2534.3 mm.*

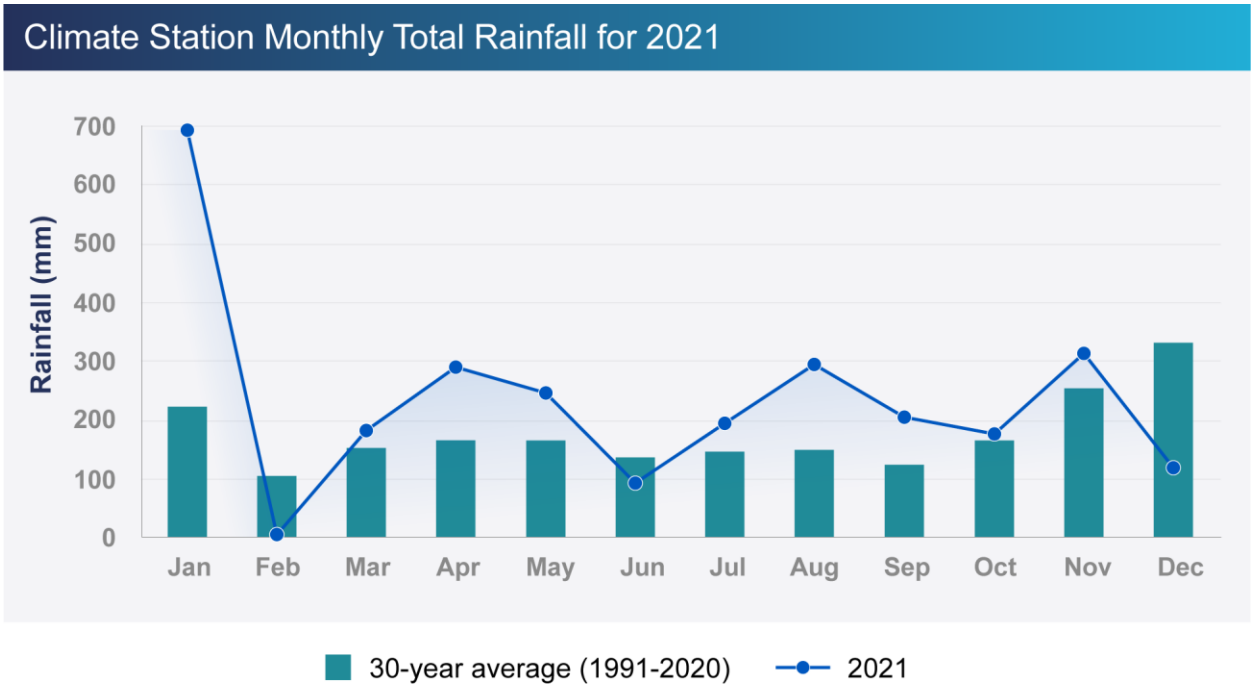


*Figure 3: Monthly total rainfall for 30-year average at the Changi climate station (bars, 1991 – 2020) compared to 2021 (solid line). The annual total rainfall of 2809.6 mm for 2021 was 33% above the long-term annual average of 2113.3 mm.*

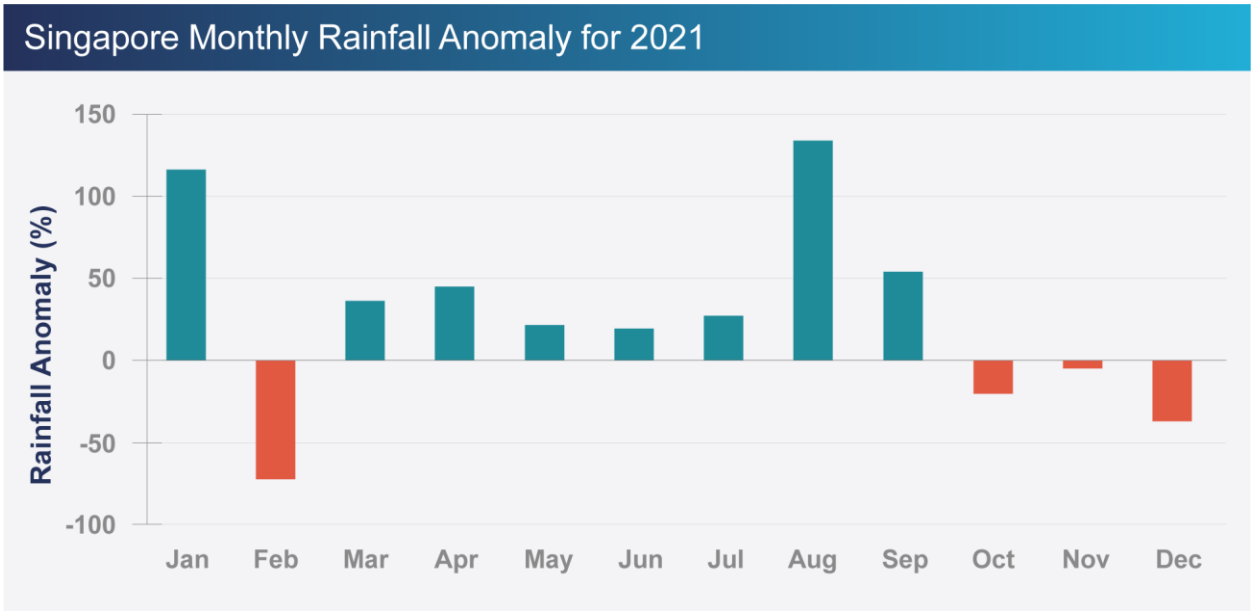


*Figure 4: Monthly rainfall anomaly for 2021 averaged over islandwide stations with long-term records. Rainfall was significantly above average in most months of the year especially January and August. Below average rainfall was observed in February and last quarter of the year.*

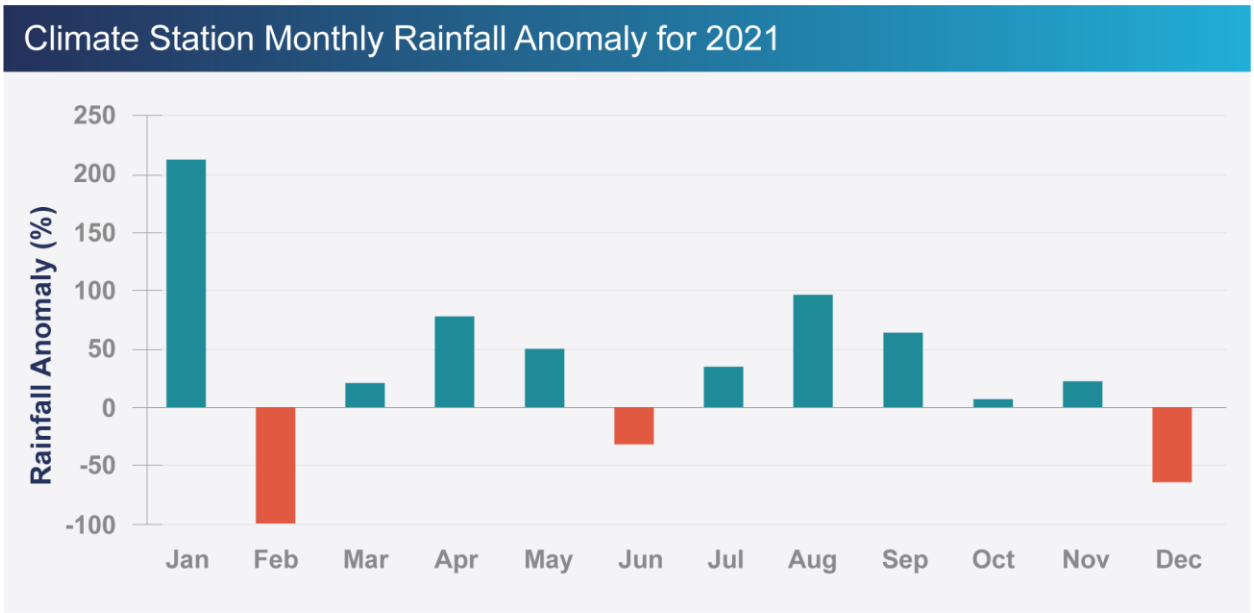


*Figure 5: Monthly rainfall anomaly for 2021 at the Changi climate station. Rainfall was significantly above average in most months of the year especially in January and August. Below average rainfall was observed at the climate station in February, June, and December 2021.*

La Niña conditions prevailed during the first quarter of 2021, returning to neutral El Niño – Southern Oscillation (ENSO) conditions in the second quarter. After approximately four months of neutral conditions, La Niña conditions re-emerged towards the end of the third quarter. While the La Niña conditions continued to strengthen in the fourth quarter of 2021, the magnitude of the La Niña event was slightly weaker at the end of 2021 compared to the start of 2021. Based on historical observations, La Niña events tend to have the strongest effect on Singapore's rainfall

during the Southwest Monsoon season and the weakest effect during the Northeast Monsoon season.

Along with La Niña conditions, a negative Indian Ocean Dipole (IOD[4]) was also present in 2021. In the second quarter of 2021, there were signs of a negative IOD developing with the negative IOD established by the third quarter. The strength of the negative IOD fluctuated considerably during the second half of the year and returned to neutral by the end of 2021. A negative IOD typically results in wetter-than-average conditions over Singapore and the nearby region during the Southwest Monsoon season.

## Weather Extremes in 2021

| | 2021 | | Since 1869 (rainfall), 1929 (temperature), 1984 (wind) |
|---|---|---|---|
| | **All Available Stations*** | **Climate Station** | **Climate Station Records** |
| **Hottest Day *(°C)*** | 36.3<br>2 Apr<br>*Ang Mo Kio* | 34.7<br>2 Apr | **36.0**<br>26 Mar 1998 |
| **Coldest Night *(°C)*** | 21.1<br>2 Jan<br>*Newton* | 21.7<br>2 Jan<br>3 Jan | **19.4**<br>30 - 31 Jan 1934 |
| **Warmest Month *(°C)*** | 29.6<br>Jun<br>*Marina Barrage* | 28.7<br>May | **29.5**<br>Mar 1998 |
| **Coolest Month *(°C)*** | 25.5<br>Jan<br>*Jurong (West)* | 26.0<br>Jan | **24.2**<br>Jan 1934 |
| **Wettest Day *(mm)*** | 247.2<br>24 Aug<br>*Mandai* | 210.6<br>2 Jan | **512.4**<br>2 Dec 1978 |
| **Wettest Month *(mm)*** | 692.8<br>Jan<br>*Changi* | 692.8<br>Jan | **818.6**<br>Jan 1893 |
| **Driest Month *(mm)*** | 1.0<br>Feb<br>*Changi* | 1.0<br>Feb | **0.2**<br>Feb 2014 |
| **Strongest Wind Gust *(km/h)*** | 87.4<br>5 Oct<br>*Pasir Panjang* | 57.4<br>15 Aug | **90.7**<br>29 Nov 2010 |

*Table 1: Temperature, rainfall and wind extremes recorded at climate station in 2021 compared to the historical record; additional information from all available stations provides further context.*

[4] The IOD refers to a sustained change in the difference between sea surface temperatures (SSTs) in the tropical western and eastern Indian Ocean. The IOD varies between three phases – positive, negative, and neutral.

## Notable Weather Events in 2021

### A Wet Start to the Year – Second Wettest January On Record

2021 began on a wet note, with the first half of January experiencing exceptionally wet and cool weather due to the occurrence of a Northeast Monsoon surge. This refers to a strengthening of northeasterly winds blowing from a strong high-pressure system toward the South China Sea, bringing periods of prolonged widespread rain and windy conditions to the surrounding region. The monsoon surge brought continuous widespread rain, at times heavy, over Singapore in the first weekend of the year. The highest daily total rainfall of 210.6 mm was recorded at the Changi climate station on 2 January 2021.

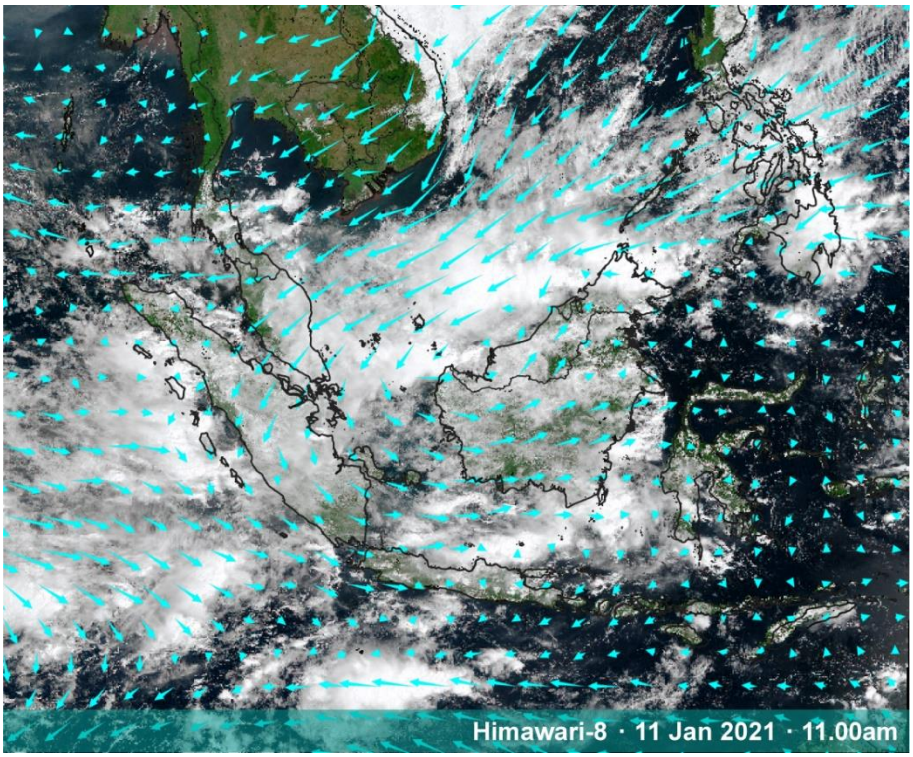


*Figure 6: Satellite image on 11 January 2021 showing extensive rainclouds and strong winds (depicted by arrows) from a Northeast monsoon surge that brought wet weather to Singapore and its surrounding region.*

Another monsoon surge developed about a week later. Strong northeasterly winds coupled with convergence of winds over Singapore and the surrounding region brought windy and rainy weather on 8 – 13 January 2021. Continuous moderate to heavy rain fell across the island on 10 January 2021, resulting in a total daily rainfall of 204.0 mm recorded at Changi, the highest recorded during this surge episode.

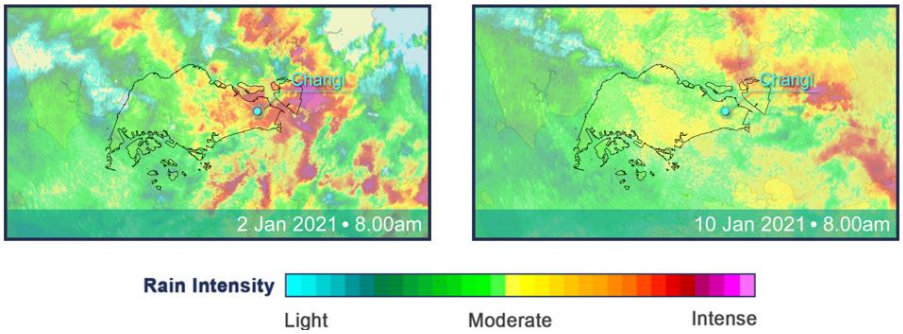


*Figure 7: Radar images showing widespread rain over Singapore and the vicinity during the monsoon surge episodes on 2 January 2021 (left) and 10 January 2021 (right).*

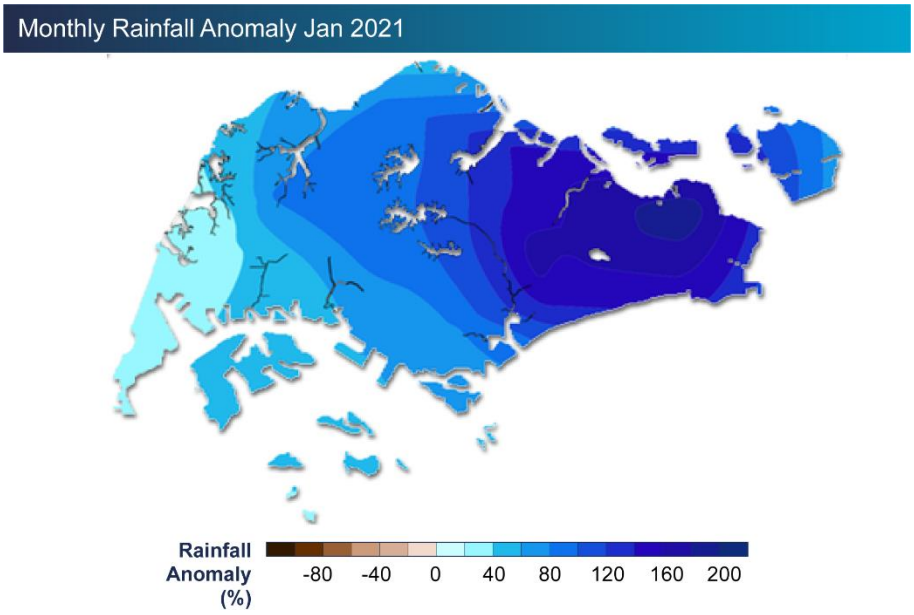


*Figure 8: Rainfall anomaly map for January 2021. Well above-average rainfall was recorded particularly in the eastern part of Singapore.*

The monthly rainfall recorded at the Changi climate station for January 2021 was 692.8 mm, with 648.4 mm recorded in the first fortnight alone. This makes January 2021 the second wettest January since rainfall records began in 1869, exceeding the previous second highest value of 634.5 mm recorded in 1918. The highest ever total rainfall for January recorded at the climate station was 818.6 mm in 1893. Figure 8 shows the monthly rainfall anomaly for January 2021, where well above-average rainfall was recorded particularly in the eastern parts of the island.

The exceptionally wet weather in January 2021 also brought relatively cool weather on most days. At the Changi climate station, the monthly mean temperature of 26.0°C for January 2021 was the lowest for January in the last 30 years.

## A Dry and Windy February – Second Driest February On Record

In contrast to a very wet January 2021, February 2021 was fair and windy on most days, as the dry phase of the Northeast Monsoon season set in over Singapore and the surrounding region. The monsoon rain band remained mostly south of the equator in the vicinity of the Java Sea during this period.

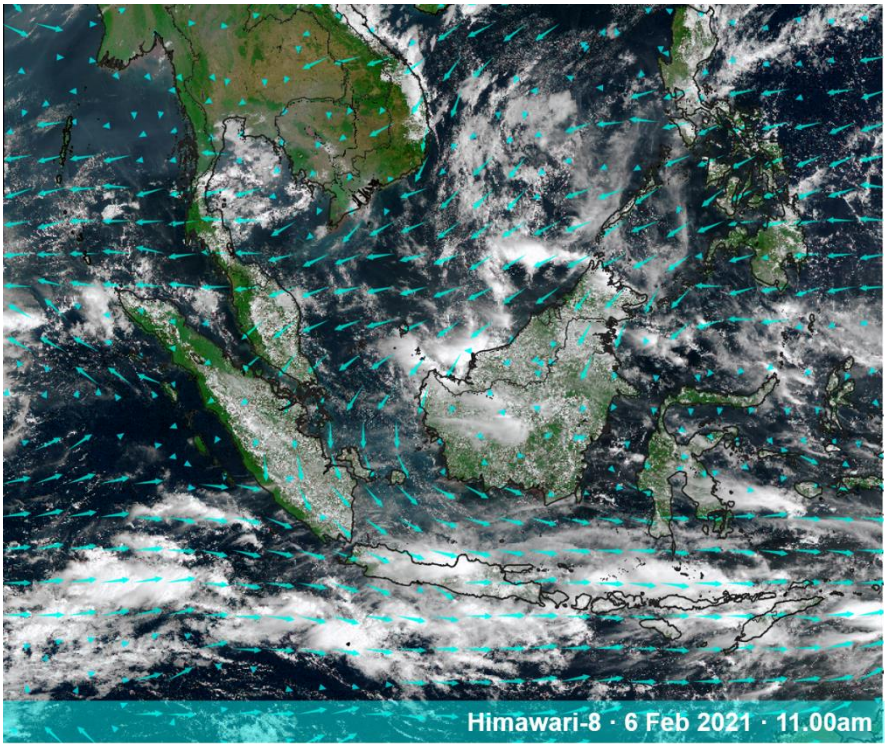


*Figure 9: Satellite image on 6 February 2021 showing that the monsoon rainband has now shifted south, so that dry weather prevails over Singapore and its surrounding region. Strong winds (depicted by arrows) are still observed over the South China Sea, bringing windy conditions to Singapore and its surrounding region.*

The highest daily total rainfall in February 2021 of only 46.9 mm was recorded at Jurong West on 11 February, while the Changi climate station recorded a mere 1.0 mm for the entire month. February 2021 was the second driest February on record after February 2014 which recorded 0.2 mm of total rainfall. Figure 10 shows the February total rainfall recorded at the climate station in the past 20 years.

February 2021 was also a very windy month, with the Changi climate station recording an average daily wind speed of 13.1 km/h. As a result, February 2021 was the second windiest February since continuous wind records commenced in 1984, behind the 13.7 km/h recorded in February 2014.

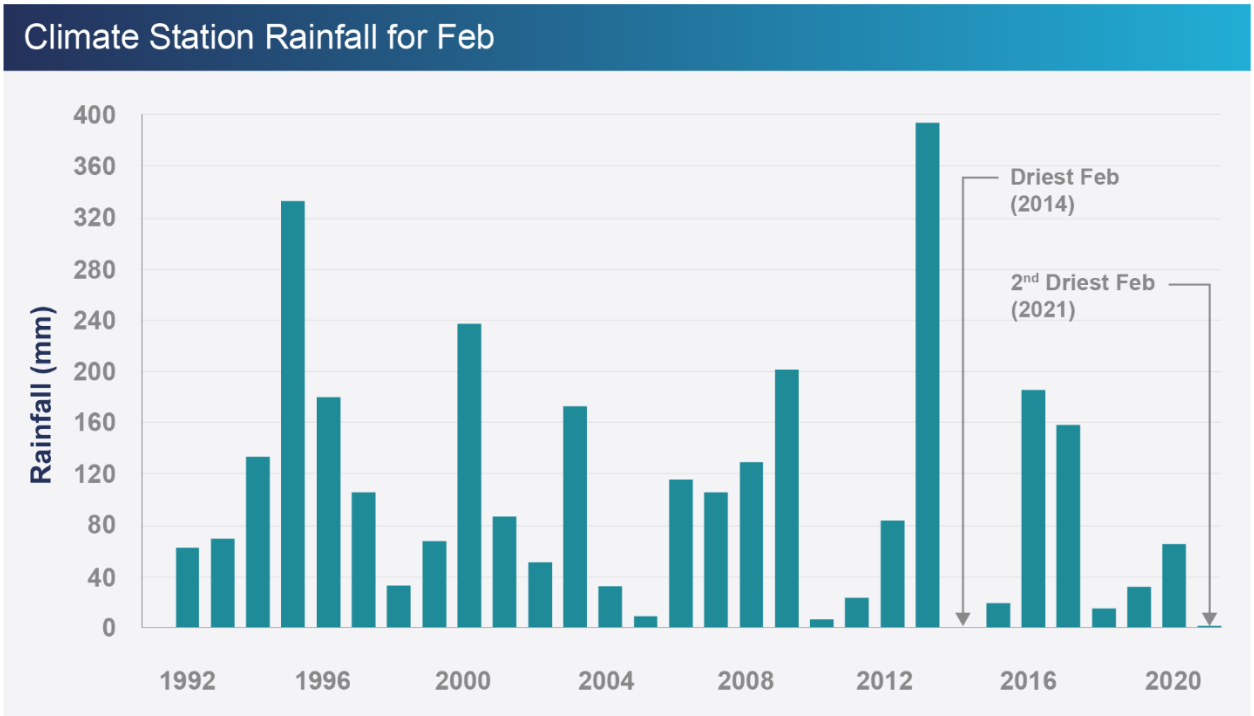


*Figure 10: February total rainfall recorded at the climate station between 1992 and 2021. February 2021 was the second driest February after February 2014 since rainfall records started in 1869.*

## A Sumatra Squall Triggers the Highest Daily Rainfall for April

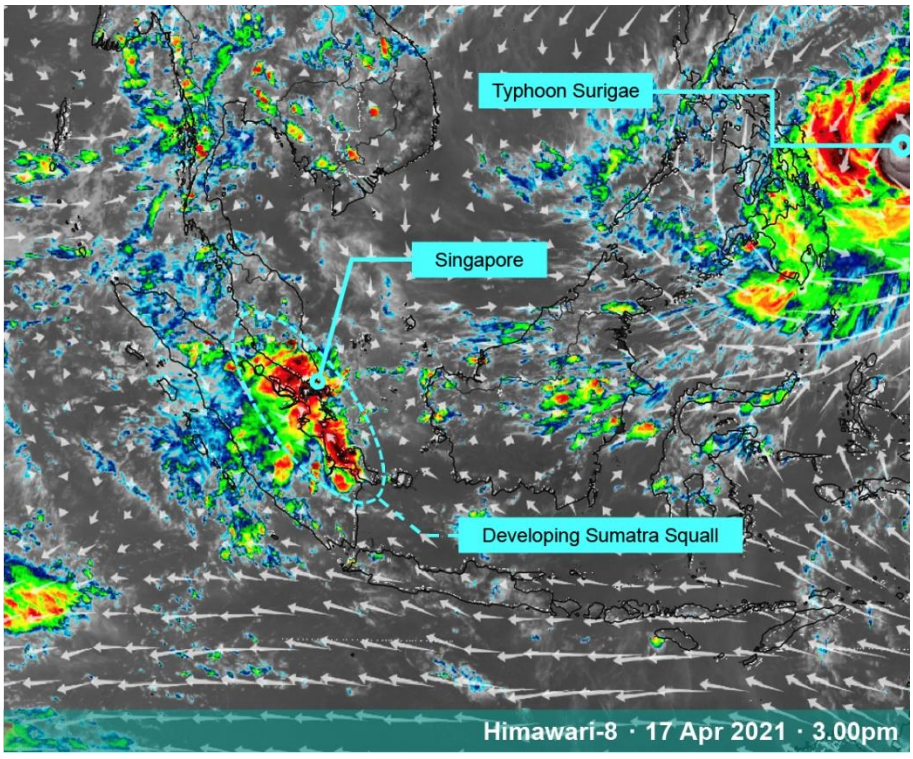


*Figure 11: Himawari-8 satellite image at 3pm on 17 April 2021, showing a Sumatra squall line affecting Singapore under the influence of Typhoon "Surigae" over the Western Pacific Ocean.*

Although tropical cyclones do not directly affect Singapore, they affect the wind flow and impact the weather in the surrounding region. On 17 April 2021, the convergence of prevailing winds under the influence of Typhoon Surigae in the western Pacific Ocean contributed to the development of a Sumatra squall over the Strait of Malacca in the morning. The Sumatra squall moved eastward to affect Singapore, bringing widespread thundery showers in the afternoon.

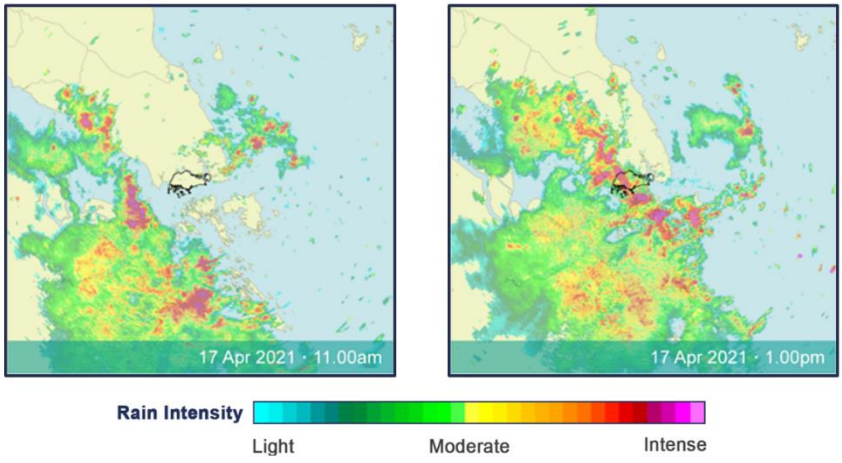


*Figure 12: Weather radar images showing an organised line of thunderstorms from a Sumatra squall approaching Singapore (left) and bringing widespread thundery showers in the afternoon (right) on 17 April 2021.*

Rainfall was heaviest over the western and southern parts of the island with a number of stations recording over 100 mm of rainfall. Of note was the daily total rainfall of 170.6 mm recorded at Ulu Pandan, the highest recorded for April 2021. It also set a record for the highest rainfall in a day for April, breaking the previous record of 159.9 mm set on 25 April 2007.

*Figure 13: Heavy rain from a Sumatra squall led to flash floods along Dunearn Rd on 17 April 2021 (Photo credit: Robin Low)*

## Unseasonably Wet August

Climatologically, August is among the drier months of the year. However, August 2021 was anomalously wet, with well-above average rainfall recorded across the entire island. There were two days with exceptionally heavy rain that led to flash floods in some areas.

On the morning of 20 August 2021, the convergence of two wind flows from the south and west-northwest of Singapore brought widespread thundery showers to the island and its surrounding vicinity. Rainfall was heaviest over the central, northern, and eastern parts of Singapore, and several areas including Hougang, Choa Chu Kang, Pasir Ris, and Ang Mo Kio recorded more than 100 mm of rainfall.

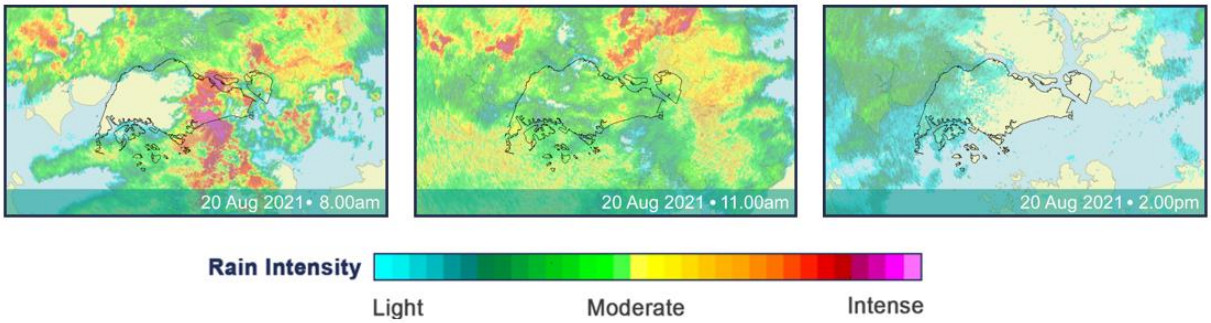


*Figure 14: Sequence of weather radar images between 8am and 2pm on 20 August 2021 showing widespread thundery showers affecting Singapore on 20 August 2021.*

On 24 August 2021, several spells of moderate to heavy thundery showers, induced by large-scale convergence of winds, fell over the entire island in the pre-dawn hours and morning. The rainfall station at Mandai recorded a remarkable daily total rainfall of 247.2 mm, setting a record for the highest daily total rainfall for August, and far surpassing the previous high of 181.8 mm at Changi on 22 August 1983. It was also the wettest day of 2021.

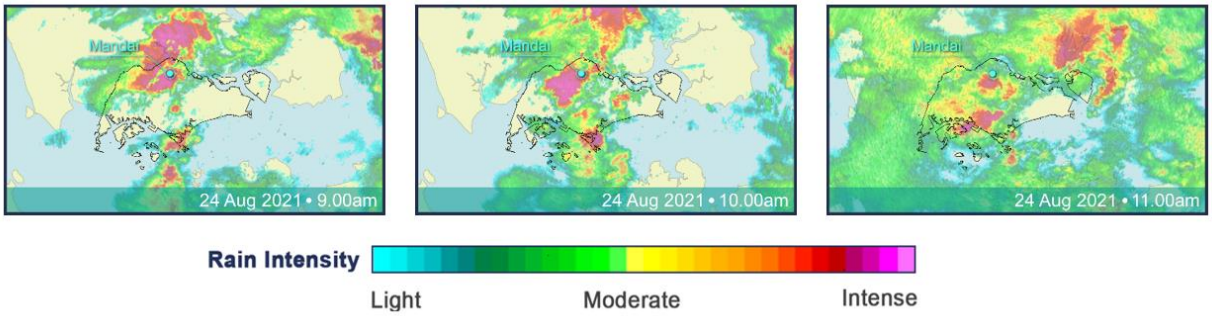


*Figure 15: Sequence of weather radar images between 9am and 11pm showing multiple spells of widespread moderate to heavy rain on 24 August 2021.*

A combination of factors contributed to the exceptionally wet weather in August 2021. These include the influence of the negative phase of the Indian Ocean Dipole (IOD), developing La Niña conditions, and the passage of the wet phase of the Madden-Julian Oscillation (MJO)[5] over the region. Based on the islandwide average, August 2021's total rainfall of 426.2 mm was the highest since 1980, exceeding the previous high of 346.6 mm in 1996.

[5] The MJO is characterised by a large-scale "pulse" of rain clouds that move eastwards around the equator with a typical cycle of 30-60 days.