

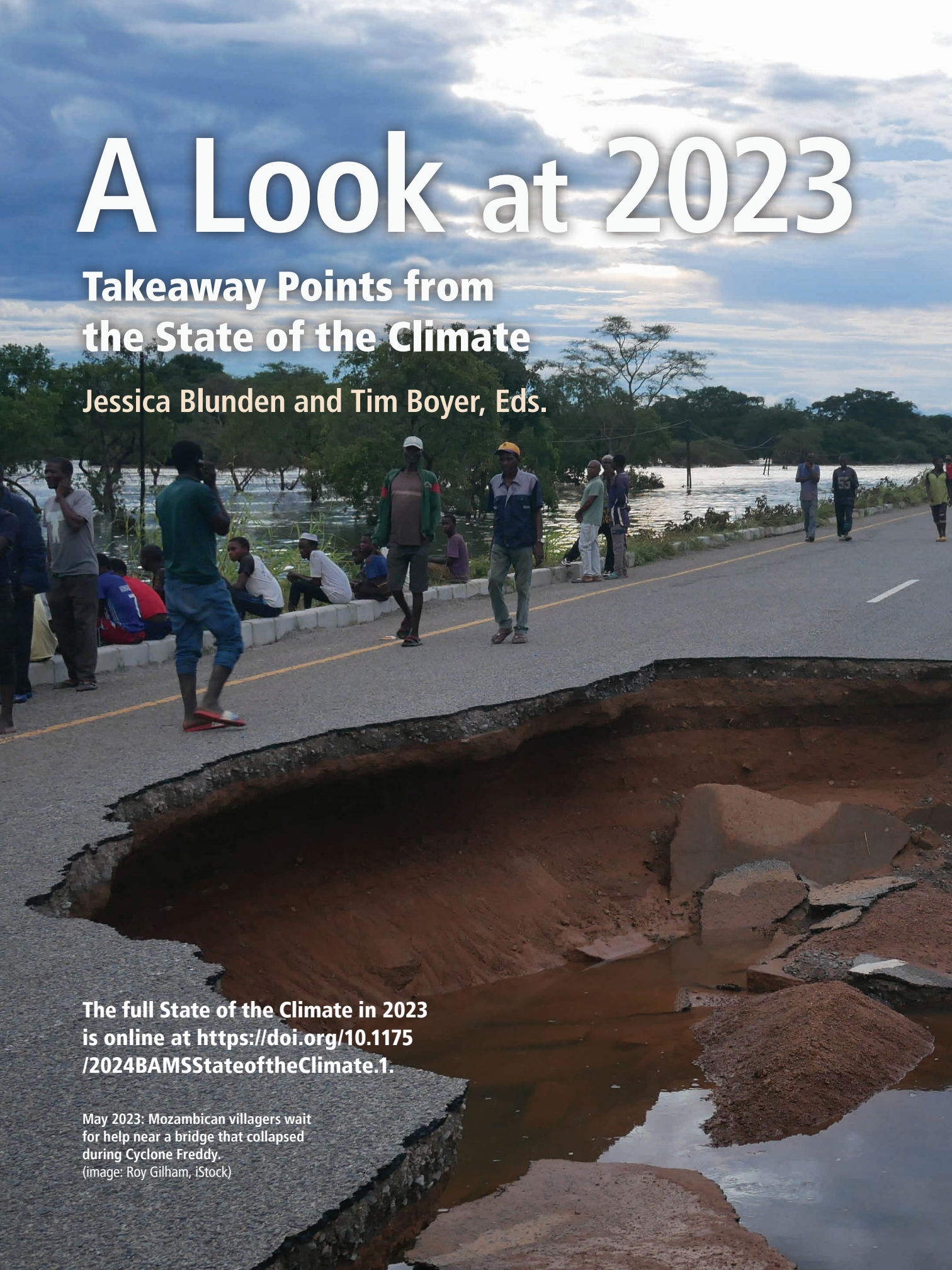
# A Look at 2023

## Takeaway Points from the State of the Climate

Jessica Blunden and Tim Boyer, Eds.

The full State of the Climate in 2023  
is online at <https://doi.org/10.1175/2024BAMSSStateoftheClimate.1>.

May 2023: Mozambican villagers wait  
for help near a bridge that collapsed  
during Cyclone Freddy.  
(image: Roy Gilham, iStock)







## GLOBAL CLIMATE

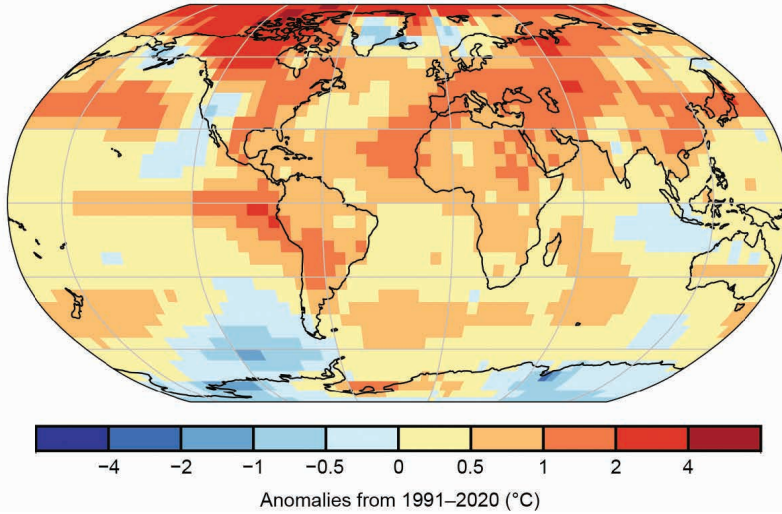
In 2023, cool-phase La Niña conditions that prevailed in the eastern tropical Pacific Ocean nearly continuously from mid-2020 into early 2023 gave way to the strongest warm-phase El Niño since 2015/16. At the same time, concentration levels in the atmosphere of Earth's major greenhouse gases—carbon dioxide, methane, and nitrous oxide—all increased to new record highs. The annual global average carbon dioxide concentration in the atmosphere rose to  $419.3 \pm 0.1$  parts per million, which is 50% greater than the pre-industrial level. Annual growth in global mean CO<sub>2</sub> has increased from  $0.6 \pm 0.1$  parts per million per year in the early 1960s to an average of 2.5 parts per million per year during the last decade of 2014–23. The growth from 2022 to 2023 was 2.8 parts per million, the fourth highest in the record since the 1960s.

The combination of the short-term warming due to El Niño and the long-term warming due to increasing greenhouse gases contributed to the highest annual global temperature across land and oceans in records dating as far back as 1850. The last seven months of the year—June through December—were each record warm. The globally averaged annual land temperature was also record high, with dozens of countries reporting record or near-record warmth for the year, including China (warmest on record) and India (second warmest), which, combined, are home to almost 30% of the world's population. The Earth's biota was affected by the record warmth. The full bloom for the cherry trees in the Arashiyama district of Kyoto, Japan, occurred on 25 March, the earliest date in the over-1200-year record, and there was an early start in the spring for red oak biological activity in North America. In the latter half of the year, leaf fall in boreal autumn was delayed in North America and Europe as above-average temperatures prevailed.

Above Earth's surface, 2023 was the least cloudy since records began in 1980, meaning that skies were clearer around the world on average. As a result, clouds reflected away to space a record small amount of incoming shortwave radiation, or energy produced by the sun, but also blocked a record small amount of outgoing longwave radiation, or heat energy, from leaving Earth. The net effect was the weakest cooling effect of clouds on record. Over land areas, the average global precipitation total for 2023 was one of the lowest among all years in the record dating to 1979; however, global 1-day maximum totals were above average, indicating an increase in rainfall intensity. In July, record high areas of land across the globe (7.9%) were experiencing extreme drought, breaking the previous record of 6.2% in July 2022. Overall, 29.7% of land experienced moderate or worse categories of drought during the year, also a new record.

## Global Surface Temperatures Were Above Average Across Most of the World

Surface Temperature



**During 2023, much-warmer-than-average conditions were observed across most of the world's surface, with the largest positive temperature anomalies across parts of the higher northern latitudes, shown here as areas shaded from orange to red. Limited areas, including parts of Greenland, western Alaska, the southwestern contiguous United States, and parts of the Southern Ocean and Antarctica, experienced near-average to cooler-than-average conditions (blue shading). (Plate 2.1a in State of the Climate in 2023; see discussion in section 2.b.)**

### GLOBAL OCEANS

The annual global sea surface temperature for 2023 shattered the previous record of 2016 by 0.13°C, marking the highest average annual temperature in the 170-year record. Daily and monthly records set from March until the end of the year contributed to this record. Among the most notable, an all-time high globally averaged daily sea surface temperature of 18.99°C was recorded on 22 August.

The melting of glaciers and ice caps contribute to rising seas, as do increasing ocean temperatures that cause water to expand. In 2023, global mean sea level reached a new record high for the 12th consecutive year, at 101.4 millimeters above the average from 1993, when satellite measurements began. This rise is an increase of  $8.1 \pm 1.5$  millimeters over 2022, marking the third highest year-over-year increase in the record. Since 1993, the oceans have been rising at an average rate of  $3.2 \pm 0.4$  millimeters per year, and the rate of rise is accelerating.

Globally averaged ocean heat content from the surface to 2000-meter depth—the amount of heat stored in this portion of the oceans—was also record high in 2023. In line with increasing carbon emissions from human activities, the oceans absorbed anthropogenic carbon at a rate of ~3.8 Petagrams, or  $3.8 \times 10^{15}$  grams, of carbon in 2023, nearly 10% above the 2013–22 average of ~3.5 Petagrams

of carbon per year. The amount of carbon absorbed by the oceans during the last decade of 2013–22 period equates to 26% of all the anthropogenic carbon released into the atmosphere during that time. The absorption of this carbon is the main cause of acidification in the oceans, which lowers the pH balance of the water and can alter and harm natural ecosystems.

### THE TROPICS

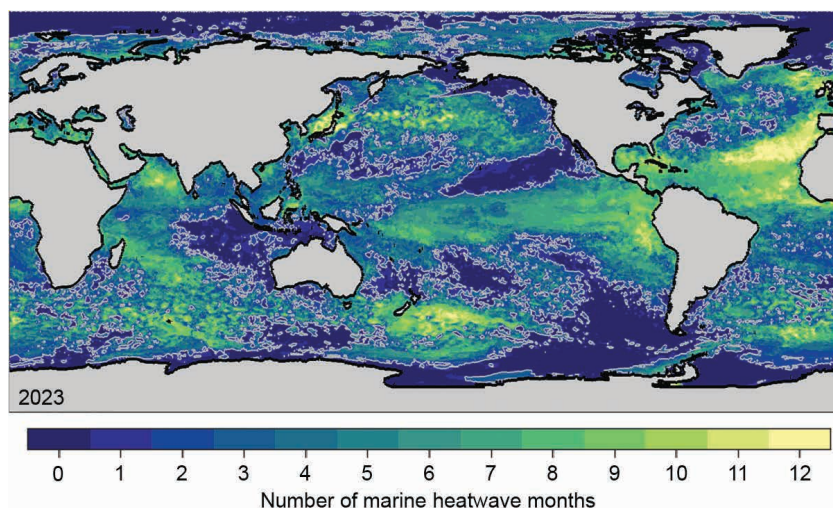
Cool-phase weak La Niña conditions—average sea surface temperatures 0.5°C to 1.0°C below the 1991–2020 average—were present in the central and eastern equatorial Pacific Ocean at the beginning of 2023 but quickly faded, and warm-phase El Niño conditions emerged in the Northern Hemisphere spring. The El Niño became strong by October, with average sea surface temperatures more than 1.5°C above average. In the Northern Hemisphere autumn, a positive Indian Ocean dipole event was established, with below-average temperatures in the east Indian Ocean and above-average temperatures

in the west. Positive events are linked to El Niño, and this was the fourth-strongest such event in the 42-year record. La Niña and El Niño impact climate patterns around the globe, while the phase of Indian Ocean dipole primarily affects the weather of the surrounding continents in the Southern Hemisphere.

A total of 82 named tropical cyclones were observed during the Northern and Southern Hemisphere storm seasons, below the 1991–2020 average of 87. There were seven Category 5 tropical cyclones across the globe; all of the basins, except for the Australian and southwest Pacific, had at least one Category 5 storm. Globally, the accumulated cyclone energy—a combined measure of the strength, frequency, and duration of tropical cyclones—rebounded from the lowest in the 43-year record in 2022 to above average in 2023. The North Indian Ocean had its second-highest accumulated cyclone energy on record behind 2019, and the North Atlantic had its seventh above-normal season in the last eight years. In the western North Pacific basin, impacts of Typhoon Doksuri (named Egay in the Philippines) caused \$18.4 billion U.S. dollars in economic losses in the northern Philippines and China. The remnants of the storm led to high rainfall rates; Beijing received 744.8 millimeters in a 40-hour period, which was the most for the city in the 140-year record. Floods associated with this rainfall killed 137 residents.



## Marine Heatwaves Dominated the Oceans in 2023



**Approximately 94% of the global ocean surface experienced at least one marine heatwave in 2023, while 27% experienced at least one cold spell. A heatwave is detected when five or more consecutive days of temperatures are higher than 90% of all temperatures recorded on that day, and a cold spell is detected when five or more consecutive days of temperatures are lower than 90% of all temperatures recorded on that day. The eastern tropical and North Atlantic Ocean, the Sea of Japan, the Arabian Sea, the Southern Ocean near New Zealand, and the eastern tropical Pacific were in a marine heatwave state for at least 10 months of 2023. The ocean experienced a new global average record of 116 marine heatwave days in 2023—which was far more than the previous 2016 record of 86 days in 2016—and a new record of 13 marine cold spell days, far below the previous record of 37 days in 1982. (Figure SB3.1c in State of the Climate in 2023; see discussions in Sidebar 3.1 and section 2.b.4.)**

Tropical Cyclone Freddy became the world’s longest-lived tropical cyclone on record, becoming a tropical cyclone on 6 February and finally dissipating on 12 March. Freddy crossed the full width of the Indian Ocean and made three landfalls in total: one in Madagascar and two in Mozambique.

### THE ARCTIC

In the high northern latitudes above 60°N, the annual surface air temperature across land areas was the fourth highest in the 124-year record, with the summer season of July to September record warm. At Svalbard Airport (78.2°N), the average July temperature exceeded 10°C for the first time on record. Snowpack in early spring 2023 was above normal

for North America and Eurasia, but then rapid snow loss in much of the Arctic resulted in record-low average snow water equivalent—the depth of water that would cover the ground if the snow cover was melted into liquid water—for the North American Arctic in May and near-record-low snow cover for the Eurasian Arctic in June. Below ground, permafrost temperatures were the highest on record at over 9 of 17 reporting sites across the Arctic. Permafrost thaw disrupts Arctic communities and infrastructure and can also affect the rate of greenhouse gas release to the atmosphere, potentially accelerating global warming. Across the Arctic Ocean and adjacent seas, the minimum Arctic sea ice extent for the year, which is typically reached in September, was the fifth-smallest in the 45-year record. The 17 lowest September extents in the satellite record have all occurred in the last 17 years (2007–23).

During the summer, both the Northern Sea Route and Northwest Passage became accessible to non-ice-hardened marine traffic. The Northern Sea Route, which connects the European Arctic to the Pacific Ocean via the north coast of Russia and the Bering Strait, saw 75 ship transits in the 2023 open

## Category 5 Major Hurricane Otis Devastates Acapulco, Mexico



**Off the west coast of Mexico, Hurricane Otis underwent an unprecedented rapid strengthening, intensifying from Category 1 to Category 5 in a record nine hours and became the strongest landfalling hurricane on record for that region. Based on records since 1950, Otis became the first Category 5 hurricane to make landfall in the state of Guerrero, Mexico, and is one of only two Category 5 hurricanes to make landfall from the eastern Pacific basin, along with Hurricane Patricia in 2015. The impacts on the city of Acapulco were devastating, with winds of up to 270 kilometers per hour and up to 266 millimeters of accumulated precipitation in just 24 hours, causing floods and severe damage to infrastructure. Otis caused at least 52 fatalities and damage estimated at \$12–\$16 billion U.S. dollars. (Figure SB4.2 in State of the Climate in 2023; see discussions in sections 4.g.3, 7.b.3, and Sidebar 4.1.)**

season. This is the second-highest number of ships, but the 2.1 million tons of transported cargo (including crude oil) was the highest on record. The Northwest Passage, which connects the Atlantic to the Pacific via northern Canada and Alaska waters, saw a record number of ship passages: 42 ships made the complete Northwest Passage transit, including 13 cargo ships. The previous high was 33 ships in 2017.

The tundra is sensitive to summer temperatures, as well as to sea ice, snow, and permafrost conditions; this means that the higher the temperatures of the ground and air and the lower the amount of ice and snow, the more vegetation will grow in the region. In 2023, average peak greenness of the tundra was the third highest in the 24-year satellite record. The greenness was much higher than normal across most of the North American Arctic

and especially in the eastern Beaufort Sea region, which experienced exceptionally warm summer temperatures.

## ANTARCTICA AND THE SOUTHERN OCEAN

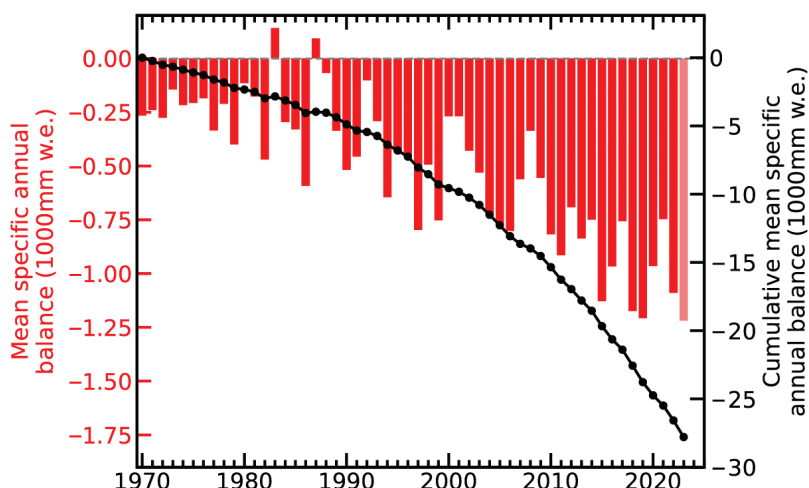
In Antarctica, temperatures for much of the year were 2°C to 6°C above the 1991–2020 average over the Weddell Sea and along coastal Dronning Maud Land. The Antarctic Peninsula also experienced well-above-average temperatures and observed its fourth consecutive summer of above-average surface melt on the Peninsula.

In the Southern Ocean, sea surface temperatures and ocean heat content from the surface to 2000-m depth were both well above average in 2023, marking a continuation of the warming trend observed in this region since 2005. On 21 February, Antarctic sea ice extent and sea ice area both reached all-time lows, surpassing the previ-

ous record lows that were set just a year earlier in February 2022. Eight months in 2023 had new monthly mean record lows in sea ice extent and sea ice area, and 278 days during the year set new daily record-low sea ice extents; for example, July 6 had a record-low daily sea ice extent that was 1.8 million square kilometers smaller than the previous record low for that day. Additionally, the absence of pack ice resulted in an unprecedented 154 days of record-high coastal exposure, during which there was a complete lack of a protective sea-ice “buffer.” Lack of this buffer exposes shoreline and ice shelves to erosion from strong winds and waves.

In the stratosphere, the 2023 ozone hole appeared earlier than normal and persisted for longer than normal, not breaking up until December 20. Its overall size was the 16th largest in 44 years of satellite observations.

## Glaciers Around the World are Shrinking and Thinning



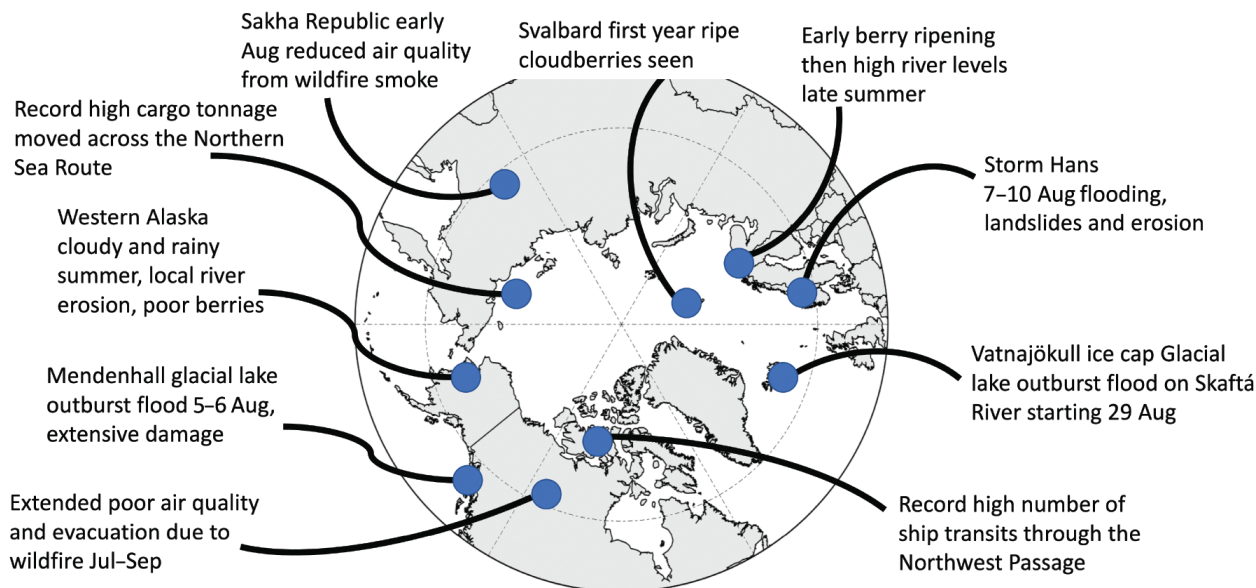
**Glaciers in mountainous regions have continued to lose mass, with 2023 marking the 36th consecutive year of global mass balance loss and the 15th with losses of more than 500 millimeters of water equivalent (w.e.), where a value of –500-millimeters w.e. per year represents a loss of 500 kilograms per square meter of ice cover or an annual glacier-wide ice thickness loss of about 0.55 meters per year, according to the World Glacier Monitoring Service. More frequent and intense heatwaves contributed to 2023 experiencing the greatest average mass balance loss for Alpine glaciers around the world since the start of the record in 1970. In August, a glacial lake on a tributary of the Mendenhall Glacier in Alaska burst through its ice dam and caused unprecedented flooding and severe property damage on Mendenhall River near Juneau, a direct result of dramatic glacial thinning over the past 20 years. Due to rapid volume loss beginning in 2021, St. Anna Glacier in Switzerland and Ice Worm Glacier in the United States disappeared completely. While these were considered small glaciers—less than 0.5 square kilometers in area—when the monitoring began, these glacier disappearances are reflective of the global pattern of glacial mass loss. In 2023, the Global Land Ice Measurements from Space initiative added an extinct glacier layer to its Glacier Viewer to indicate glaciers that have been lost. (Figure 2.17 in State of the Climate in 2023; see discussion in section 2.c.3.)**

## REGIONAL CLIMATES

### North America

North America observed its warmest year since the start of its continental surface record in 1910, with an average temperature that was 1.13°C higher than the 1991–2020 average. At the national level, Canada experienced its second warmest year in the country’s 76-year record, with summer and autumn both record warm. The contiguous United States reported its fifth warmest in the 129-year record. Mexico was both record warm and record dry (84-year

## A Record-Warm Summer in the Arctic Had Many Effects



Several societal and environmental impacts were documented during the record-warm Arctic summer of 2023. These impacts are consistent with expectations of environmental extremes that are likely to occur in a rapidly warming Arctic environment. Some of these impacts were directly related to the record-high temperatures. (Figure SB5.3 in *State of the Climate in 2023*; see discussion in Sidebar 5.2.)

record); a heatwave in June that was both the country’s most extensive and most intense on record contributed to the warmth, with nearly three dozen weather observatories or airports across Mexico reporting record-high temperatures. The highest recorded temperature was 48.0°C at the Ciudad Obregón Observatory in Sonora, Mexico, which was 9.0°C above the average June high temperature at that location. Following the June heat, July 2023 became the overall warmest month on record for Mexico. According to the Mexican Ministry of Health, 286 deaths associated with heat stroke and dehydration were reported through the end of July,

All three countries had widespread drought events during the year, with Canada experiencing a record-breaking wildfire season, particularly in terms of the area burned (see related figure for more details about the fires). Outside the contiguous United States, in Hawaii, the lower elevations of Maui saw an expansion of severe drought in early August. These dry conditions, combined with strong, dry winds instigated by Hurricane Dora, contributed to the deadliest wildfire in the United States in more than a century.

There were also extreme wet conditions. A series of atmospheric rivers in early 2023 delivered heavy rains to California and parts of adjacent states to start the year, resulting in floods and reservoirs being filled to capacity. The state of Alaska reported its fifth-wettest year on record. In Nova Scotia, Canada, heavy rain fell on 21–22 July due to a slow-moving trough of low pressure that interact-

ed with moist flow from the tropics. This event resulted in more than twice the monthly average total rainfall for July in just over two days in the hardest-hit areas. Totals of up to 260 millimeters fell in parts of Halifax. This was the most rain to affect the region in 50 years.

### Central America and the Caribbean

Most stations across Central America had well-above-normal annual temperatures in 2023. The Caribbean observed its warmest year since the start of the record in 1950 at 0.73°C higher than the 1991–2020 average. Seasonally, summer and autumn were also record warm. Additionally, the Caribbean heat season (May–October) was record warm at 18 of 36 reporting stations. Overall, the region has been warming at a rate of 0.18°C per decade over the past half century (since 1970).

Annually averaged rainfall for 2023 over the Caribbean was about 95% of the 1991–2020 average. Jimani in the Dominican Republic recorded its wettest year in 2023, Padre Las Casas, Azua, in the Dominican Republic its second wettest, and Lynden Pindling International Airport in the Bahamas, its fourth-wettest year. Conversely, El Valle, Hato Mayor, in the Dominican Republic, and Lajas, Puerto Rico, each observed their second-driest year on record and E.T. Joshua Airport in St. Vincent observed its third driest.

Tropical cyclone activity in the Caribbean and eastern tropical Pacific affecting Central America was below normal. Even so, during 2–6 June, heavy rains from



Tropical Storm Arlene caused flooding and landslides in Haiti. Seventy-eight deaths and damage in excess of \$420 million U.S. dollars were reported.

### South America

Overall, annual maximum temperatures across northern South America were higher than usual in 2023, while minimum and mean temperatures were variable. For central South America, the annual mean temperature was the highest for the region in the last 50 years, surpassing the previous record set in 2015. In southern South America, Argentina observed its warmest year on record, Uruguay its second warmest, and Chile its third warmest.

Both cold and warm extremes were observed during the year. Following a February heatwave, temperatures dropped significantly in parts of southern South America due to intruding polar air, and several minimum temperature records were broken across Argentina and Uruguay. On 17–18 February, typical winter conditions occurred in the middle of what would become the warmest austral summer on record for Argentina. Dry conditions and a persistent high-pressure system in the region then led to several heatwaves in Uruguay and central-east Argentina. The longest and most intense heatwave occurred during early March in both countries and set new daily records of highest minimum and maximum temperatures at several stations.

Three cold waves affected Brazil between May and July. In June, a cold air outbreak from the south impacted the Brazilian Amazon. On 13 June some cities in the Amazon experienced notably below-average temperatures, as low as 7.0°C at Santa Ana de Yacuma, which was 10°C below its average. Later in the year, six intense heatwaves impacted central tropical South America during August to December. At least 27 Bolivian cities recorded their highest—monthly or absolute—temperatures from July to November, with every Andean and lowland region affected. At several locations, maximum temperature records were broken two or more times. By 12 November, 1,120 cities in Brazil recorded their highest temperatures, including 40.4°C in Rio de Janeiro, which was 11.0°C above normal. On 20 November, the temperature reached 44.8°C in Araçuaí in Minas Gerais, potentially

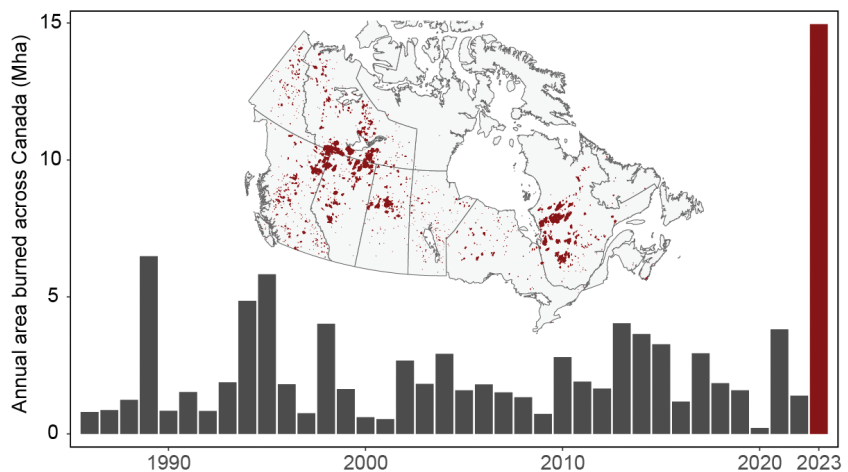
a new national high temperature for Brazil and 12.8°C above normal for that area.

Large wildfires raged across the heat-affected regions in Paraguay and Brazil, including Bahia, Pantanal, and the Amazon where at least 22,050 fires were recorded since October. Heavy smoke from the fires impacted the entire city of Manaus, Brazil, which has a population of more than two million people. More than 3.5 million hectares also burned in Bolivia during September to November, causing severe air pollution that affected many Bolivian cities. In southern Brazil, however, rainfall was 200 millimeters to 300 millimeters per month above normal from August to December. Both the abundant rainfall in southern Brazil and drought in Amazonia were associated with El Niño. The El Niño phenomenon also intensified drought conditions in Colombia in northern South America during the second half of 2023.

### Africa

Above-average annual temperatures were observed over most of Africa in 2023. The highest annual anomalies (compared to the 1991–2020 average) reached 1.8°C in places, notably across almost all of Morocco and the western half

## Canada Has its Worst Wildfire Season on Record



**Wildfire seasons in Canada typically begin with the loss of snow cover in the spring, and in 2023 the snowmelt was earlier than normal across much of the country. This early melt, along with already-existing drought conditions and record to near-record heat, contributed to the country’s worst wildfire season on record. Approximately 15 million hectares (Mha) burned, an area more than twice the size of Ireland and more than double the previous record from 1989. Much of the area burned in western Canada aligns with the regions that experienced their hottest year on record, as well as those that experienced prolonged drought conditions. Approximately 232,000 people were evacuated due to the threat of wildfires, including the entire city of Yellowknife, which has more than 20,000 residents. Smoke from the wildfires impacted regions across Canada and also affected parts of the United State, including the heavily populated cities of New York City and Chicago, and even areas of western Europe. (Figure SB7.1a in State of the Climate in 2023; see discussion in Sidebar 7.1.)**

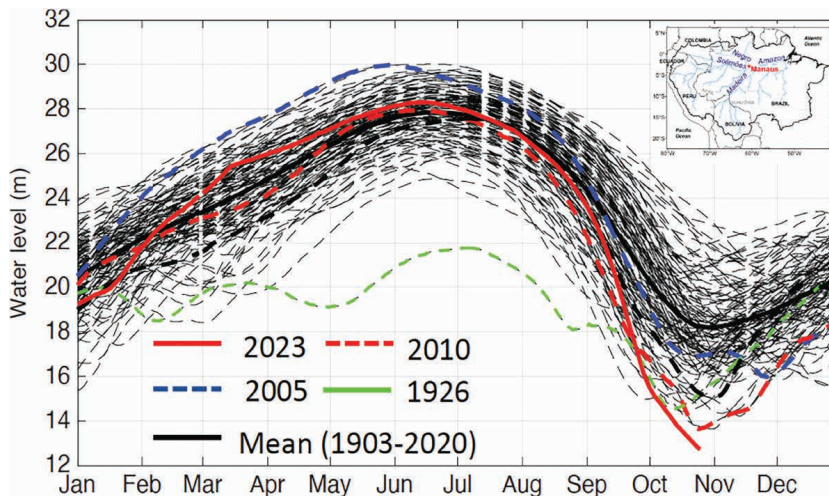
of Mauritania in northwestern Africa. Several Moroccan stations reported new local maximum temperature records during July and August, including 50.4°C at Agadir. Temperatures were as much as 5°C above normal in Algeria in July. Tunisia reported its hottest July since records began in 1950, with an average temperature 4°C above normal. In the southern part of the continent, South Africa had its eighth-warmest year on record since its record began in 1951. The Indian Ocean island countries were also warmer than normal. Mayotte observed its warmest year on record, Reunion its second warmest, and Seychelles its third warmest, based on their reporting stations. The start of the year was cold, however, in some parts of Africa. January to March was the coldest such period on record throughout both the Sahel and Gulf of Guinea regions, with February contributing the greatest below-average departures.

Most of the Sahel experienced below-normal rainfall. Cameroon observed one of its driest three-month periods (July–September) since the start of the record in 1991. Conversely, record-high rainfall was observed over Libya in September, which was associated with Storm Daniel, a tropical cyclone that formed in the Mediterranean Sea. The storm reached its peak in northeastern Libya on 10 September and brought extreme rainfall. The city of Al-Bayda, for example, received a total of 414.1 millimeters during 10–11 September. Entire neighborhoods disappeared after waters from burst dams flooded the city of Derna.

The transition from La Niña early in the year to a strong El Niño by autumn helped bring relief to the prolonged drought conditions in equatorial eastern Africa. However, El Niño, along with positive Indian Ocean dipole conditions, also led to excessive rainfall that resulted in devastating floods over southeastern Ethiopia, Somalia, and Kenya during October to December that displaced around 1.5 million people.

Tropical Cyclone Cheneso brought 200 millimeters to 500 millimeters of rain to Antalaha (Sava Region) and the Diana Region in northern Madagascar during 19–23 January, which resulted in flooding and landslides that caused 53 fatalities. During 24 February–11 March, Tropical Cyclone Freddy impacted several provinces in Mozambique, resulting in 165 fatalities. Rainfall totals ranged between 200 millimeters and 750 millimeters in

## Amazon River at the Port of Manaus Drops to its Lowest Level in Brazil.



**Due to the warm and dry conditions in austral spring, most of the main rivers in the Amazon, including the Solimões, Purus, Acre, and Branco, suffered extreme drops in their levels in some regions, or dried up completely. By the end of October, the Rio Negro at Manaus, a major tributary of the Amazon River, fell to its lowest water level since records began in 1902. (Figure SB7.3 in State of the Climate in 2023; see discussion in Sidebar 7.2.)**

central and southern Mozambique. In Malawi, Freddy triggered flooding and landslides, which caused 679 fatalities.

### Europe and the Middle East

The year 2023 was the warmest or second warmest on record for continental Europe, according to a range of analyses, with above-average temperatures across most of the region. Nationally, it was the warmest year on record for Ireland, Moldova, Kazakhstan, Romania, Malta, Slovenia, Serbia, Germany, Czechia, Bulgaria, Austria, Slovakia, Hungary, Croatia, Montenegro, and the Netherlands. Only the Scandinavian countries, Estonia, and Iceland reported annual temperatures that were not among their five highest. Unusually high temperatures of 1°C to 2°C above the 1991–2020 average were particularly notable across much of the region during the summer due to the influence of high pressure. The United Kingdom and the Netherlands each observed their warmest June on record. On 10 August, a new local all-time high temperature record of 46.8°C was recorded at Valencia airport in Spain, exceeding its typical August temperatures by almost 10°C. On 15 August, a new all-time national temperature record of 49.5°C was set in Eskisehir in northwestern Türkiye, and on 17 August, Lithuania set a new national maximum record of 34.6°C.

It was also wet overall in Europe in 2023, either record wettest or third wettest according to two different data analyses. Denmark reported its wettest year on record,



with 129% of its normal precipitation total. There were many extreme rainfall events across the continent. On 8 June southern and central Germany received heavy rains, with up to 119 millimeters of precipitation falling in two hours in the Hessen region. The return time for such an event is more than 100 years. In September, Greece received record rainfall from Storms Daniel and Elias that caused severe flooding in regions including Thessaly and central Greece. The town of Zagora received the highest daily rainfall ever recorded in Greece (754 millimeters in 21 hours, after which the station ceased reporting), resulting in significant damage to infrastructure and homes. This daily total corresponded to the typical annual total for Zagora.

On July 24, a supercell produced record-size hail in the Friuli Venezia Giulia region of northeastern Italy; in Azzano Decimo, a hailstone measuring 19 centimeters in diameter broke the European record for hail size. In Estonia, a storm on 7 August produced hailstones that measured 8 centimeters in diameter, a new national record for the country.

There were also dry spells. No measurable rain, meaning less than 1 mm, fell over France for 32 consecutive days, from 21 January to 21 February, the longest such occurrence since records began in 1959. In Syria, summer heatwaves contributed to declining water levels of the Euphrates River, which reached a historic low at Tabqa Dam in mid-August and affected nearly one million residents in the Hassakeh governorate. Beginning on 19 August, the largest wildfire since the start of the record in 2000 for the European Union destroyed many buildings in the Alexandroupolis municipality of Greece, forced residents in 13 towns to evacuate, and killed at least 21 people. The fire burned almost 94,000 hectares by 3 September. Overall, the total area burned in Greece in 2023 was more than four times its long-term average.

## **Asia**

Annually averaged temperatures were above the 1991–2020 normal across most of Asia in 2023, including more than 2°C above average across Central Asia and the Siberian plain. China, South Korea, and northern, eastern, and western (equal with 1998) Japan reported their warmest year on record, and Hong Kong (China), Singapore, and Vietnam each observed their second warmest. Russia experienced its third-warmest year on record and also equaled its third wettest year on record. A major and prolonged heatwave affected much of northern Vietnam in May; an all-time national maximum temperature record of 44.2°C was observed at Tuong Duong on 7 May, surpassing the previous record of 43.4°C at Huong Khe on 20 April 2019. A heatwave in June claimed more than 160 lives in various parts of India. While June is normally hot for the region, the heatwave drove tem-

peratures to as high as 43.3°C. During October, extreme high temperatures affected northeast Asia. Northern China observed its hottest October since the start of the record in 1961. The above-normal temperatures over this region lasted 26 days, with an average maximum anomaly of +8°C on 25 October.

There were some notable cold extremes as well. Afghanistan experienced one of its coldest Januarys on record due to a disrupted polar vortex. Temperatures during the month reached –28°C and resulted in 162 fatalities. At the end of the year, extreme minimum temperatures during 10–13 December were –25°C to –35°C across the Zhambyl region of Kazakhstan, reportedly damaging gas pipelines in the region and leaving at least 1,200 homes without fuel.

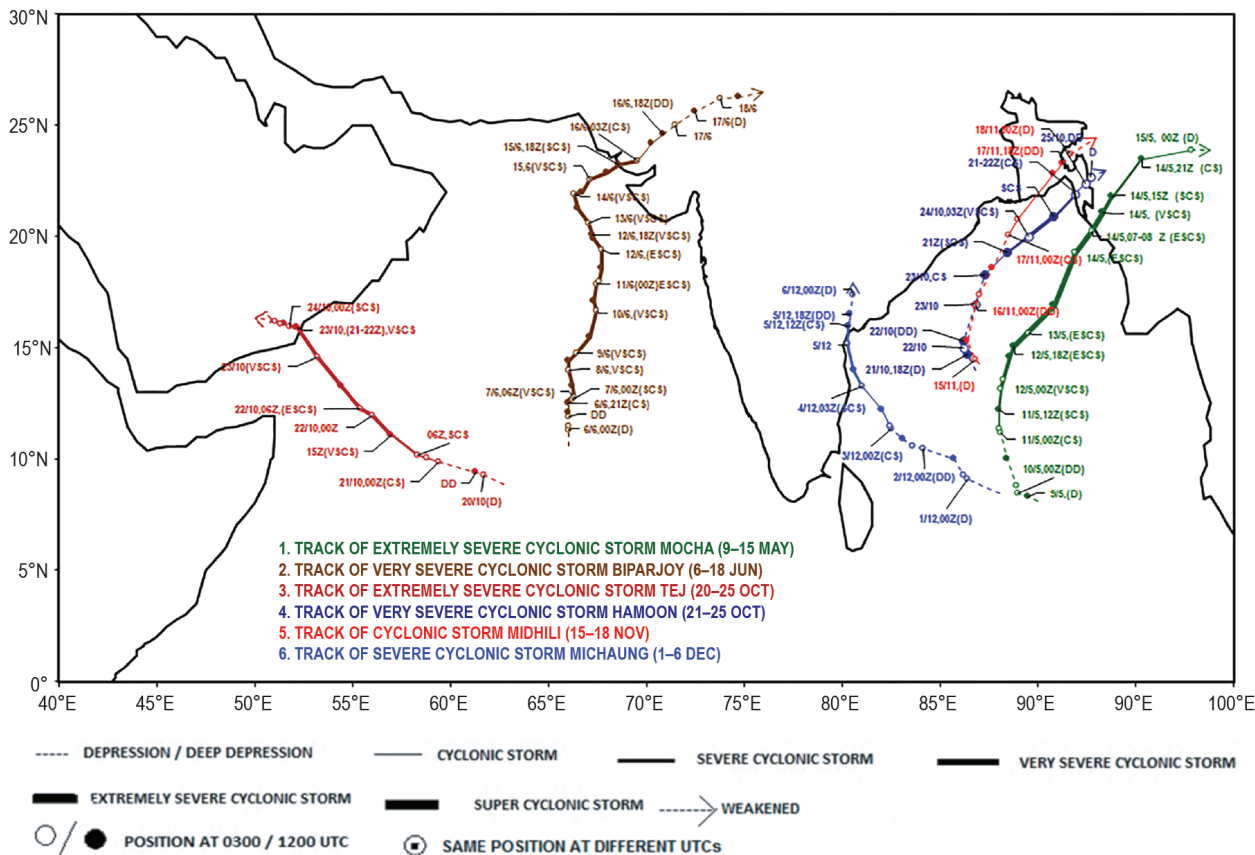
India's summer monsoon set in over Kerala—which is located in the southwestern state of Kerala—on 8 June, seven days later than the normal onset date of 1 June. The monsoon quickly covered the entire country on 2 July, which is six days ahead of its normal date of 8 July. In total, the summer monsoon seasonal rainfall averaged over the country from June through September was 95% of its long-term average, which is considered to be within the normal range. The rain was variable through the season, however; August rainfall averaged across the country was just 162.7 millimeters, the lowest since the start of the record in 1901. Monsoon rainfall over Pakistan was also normal at 104% of its average. There was also large seasonal variability, with July having significantly above-normal rainfall and August significantly below normal.

During the year, Iran was in persistent drought that resulted in substantial losses for the agricultural sector and produced severe hydrological challenges. Lake Urmia in northwestern Iran nearly completely dried up, while Lake Hamoon in the east has been completely dry since 2021 due to long-term drought conditions. The dried lake beds have become a significant source of rising dust during late spring and summer wind storms, leading to adverse health effects on the local population.

## **Oceania**

The El Niño–Southern Oscillation, a positive Indian Ocean dipole, and the long-term warming trend all impacted Oceania in 2023. Sea surface temperatures in the Niño-4 region, which covers a large area in the western and central tropical Pacific, reached record highs for the July–December period as El Niño strengthened. These warm surface waters impacted air temperatures in some places: Majuro, the capital of the Republic of the Marshall Islands, tied its all-time highest minimum temperature of 28.9°C on 8 September. New Zealand reported its second-warmest year overall since the start of its record in 1909. May and September were both the warmest on record for their respective months; August, however,

## The North Indian Ocean Tropical Cyclone Basin Had a Busier-Than-Normal Season in 2023.



Among the storms that formed in this basin, Extremely Severe Cyclonic Storm Mocha, which developed in May during the pre-monsoon season, was one of the most intense cyclones to ever form over the Bay of Bengal, with winds peaking at 260 kilometers per hour and a minimum central pressure of 918 millibars, equivalent to a Category 5 hurricane on the Saffir-Simpson Hurricane Wind Scale. The storm formed on 11 May and intensified as it moved north, reaching its peak intensity early on 14 May before making a catastrophic landfall in Myanmar, causing over \$1 billion U.S. dollars in damage and hundreds of fatalities between Myanmar and Bangladesh. (Figure 7.55 in State of the Climate in 2023; see discussions in sections 4.g.5 and 7.g.4.)

was the first month with a below-average national temperature since May 2017. For Australia, 2023 tied as the eighth-warmest year since the start of its record in 1910. January was the coldest January since 2002, but June–November was the warmest such period on record, contributing to the warm year overall. The high temperatures in the second half of the year aligned with the developing El Niño and positive Indian Ocean dipole, both of which are known to increase temperatures in the austral winter and spring. Additionally, August to October 2023 was the driest three-month period in Australia in the record dating to 1900, with an average of just 22.63 millimeters of total rainfall. Due to the warm and dry conditions, millions of hectares of bushfires burned for weeks in the Northern Territory during September and October.

Post-Tropical Cyclone Gabrielle affected New Zealand during 12–15 February, resulting in 11 fatalities, widespread flooding, and extensive damage. A national state

of emergency was declared for only the third time in the country's history. Floodwaters cut off entire communities in Hawke's Bay and Gisborne. Gabrielle was also one of the costliest natural disasters in New Zealand history, with over an estimated \$9.5 billion U.S. dollars of costs to the insurance industry. Severe Tropical Cyclones Kevin and Judy impacted Vanuatu within 48 hours of each other in early March. Approximately 80% of the population were affected by at least Category 2 strength winds from one or both of the storms. In May, Typhoon Mawar became the strongest tropical cyclone to impact Guam since Super Typhoon Pongsona in 2002, bringing over 600 millimeters of rain in less than 24 hours and maximum sustained winds up to 225 kilometers per hour across the far north. Damage estimates exceeded \$4 billion U.S. dollars. Guam International Airport reported its second-wettest year on record, behind 1976. Nearly 20% of the annual rainfall was from Mawar.