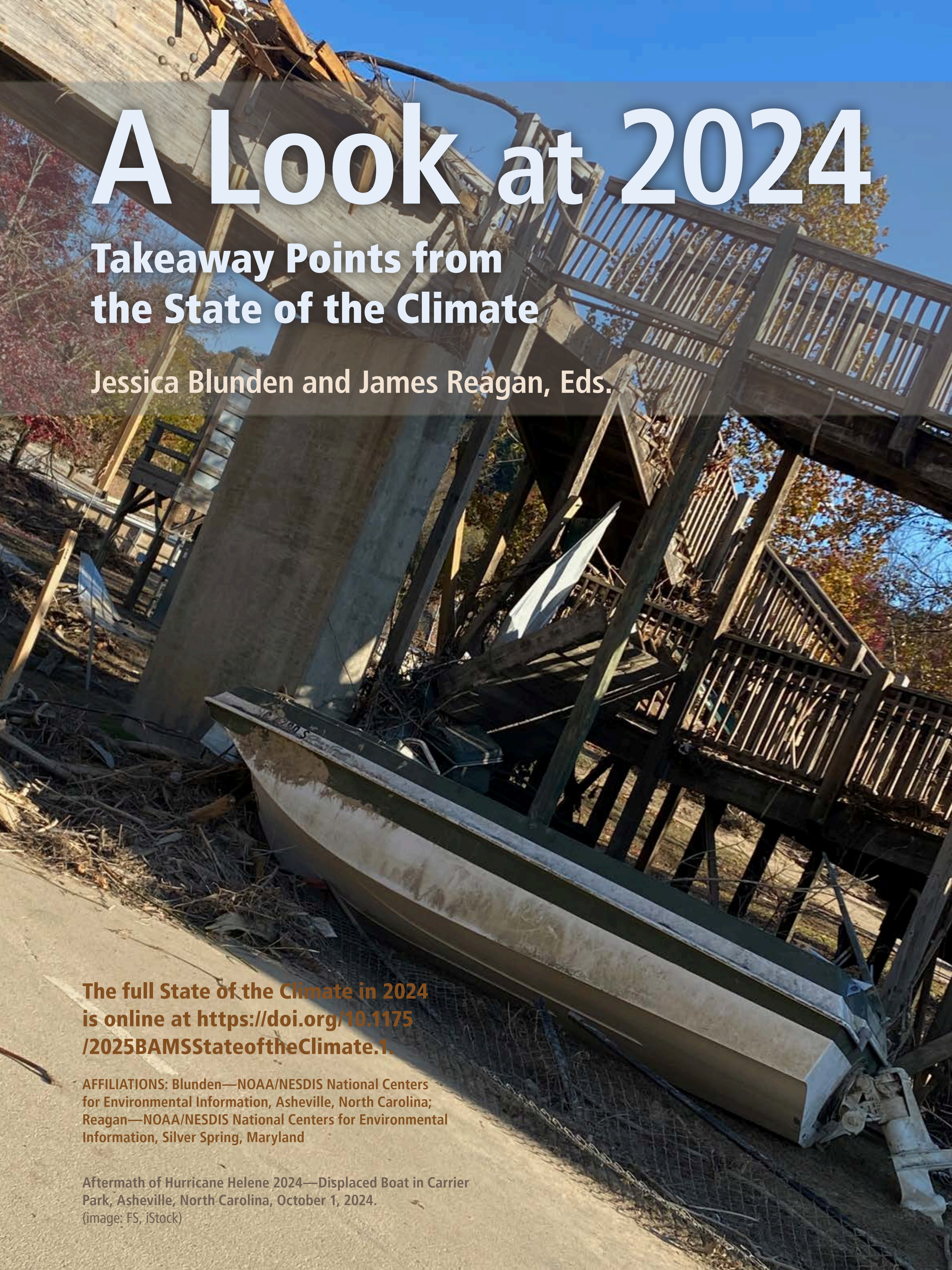


A Look at 2024

Takeaway Points from the State of the Climate

Jessica Blunden and James Reagan, Eds.

The full State of the Climate in 2024 is online at https://doi.org/10.1175/2025BAMSStateoftheClimate.1.

AFFILIATIONS: Blunden—NOAA/NESDIS National Centers for Environmental Information, Asheville, North Carolina; Reagan—NOAA/NESDIS National Centers for Environmental Information, Silver Spring, Maryland

Aftermath of Hurricane Helene 2024—Displaced Boat in Carrier Park, Asheville, North Carolina, October 1, 2024.
(image: FS, iStock)

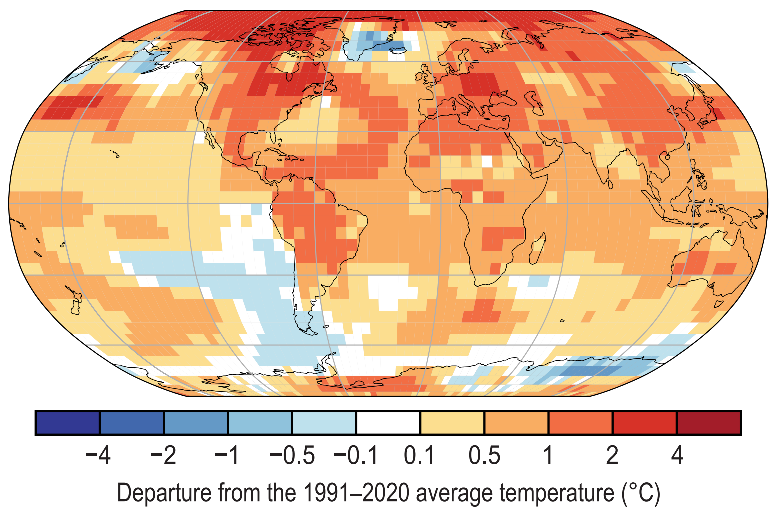
GLOBAL CLIMATE

With a strong warm-phase El Niño in place at the beginning of the year, the average temperature over Earth's land and ocean surfaces reached a new high in 2024, surpassing the previous record set in 2023. This was the first time since 2015 and 2016 that record-high annual global temperatures were set back-to-back. A strong El Niño also straddled those two years. As the 2024 record was set, the three main greenhouse gases that warm our atmosphere by trapping some of Earth's outgoing energy—carbon dioxide, methane, and nitrous oxide—all reached record-high levels in 2024.

Permafrost is defined as ground with temperatures that remain below freezing for at least two consecutive years; it is critical for ecosystem health and infrastructure stability. In 2024, there was widespread warming of permafrost. The active layer—the layer above the permafrost that melts and refreezes seasonally—thickened, and ground ice coverage decreased, continuing the pattern of recent years. Additionally, all 58 global reference glaciers around the world lost ice mass. The average loss was 1.30 meters of water equivalent, which broke the record set in 2023. The Conejeras Glacier in Colombia, South America, was declared extinct in 2024, following the Ice Worm Glacier extinction in 2023 in Washington state. In Venezuela, all glaciers have now officially disappeared. The continuing loss of these glaciers here and around the world affect people and surrounding ecosystems who depend on their meltwater during the warm season.

Precipitation is critical for many human activities, including drinking water and agriculture. The globally averaged precipitation total for 2024 was the third highest in the record that dates to 1983, with near-normal precipitation over land but much-higher-than-normal precipitation over the ocean when compared to the 1991–2020 average. The enhanced precipitation over the ocean in 2024 was likely a result of high sea surface temperatures that increased ocean evaporation and therefore available atmospheric moisture. Relatedly, the 2024 global average amount of water vapor in the air, which is measured in a vertical column that extends from Earth's surface to the top of the atmosphere, set a record for being the wettest in the observational record and was about 5% wetter than the 1991–2020 average.

Global surface temperatures were warmer than usual across most of the world



During 2024, above-normal temperatures, as indicated by the yellow, orange, and red shadings, were observed across the globe. Conversely, below-normal temperatures, as indicated by the blue shading, were isolated to portions of the southeast Pacific, southern Greenland, the Bering Sea, and Eastern Antarctica. Similar to 2023, the highest departures from average were largely seen in the Arctic. The Northern Hemisphere also experienced greater temperature departures than the Southern Hemisphere, partly due to the Northern Hemisphere containing much more land than the Southern Hemisphere. (Plate 2.1a in State of the Climate in 2024; see discussion in section 2b.)

Surface albedo is a measure of how much sunlight is reflected by Earth's surface; as albedo darkens, more sunlight is absorbed into the surface, and as it becomes lighter, more sunlight is reflected back to space. Albedo continued to darken in 2024, a trend that has been evident over the last few years. This darkening was primarily due to an increase in vegetation growth and a decrease in snow and ice coverage. Vegetation growth and meteorological conditions can contribute to the potential for wildfires. Even though global total estimated fire emissions in 2024 were below the 2003 to 2020 average, there were still notable regional wildfires. Canada, which experienced its worst drought in its 75-year observational record, saw extreme fire activity for the second straight year. South America and the Arctic also experienced devastating fires during the year.

The salient events and trends highlighted here are reported in greater depth in the State of the Climate in 2024, the supplement to the August issue of BAMS. Figures shown here are drawn from the supplement and are not cited in text.

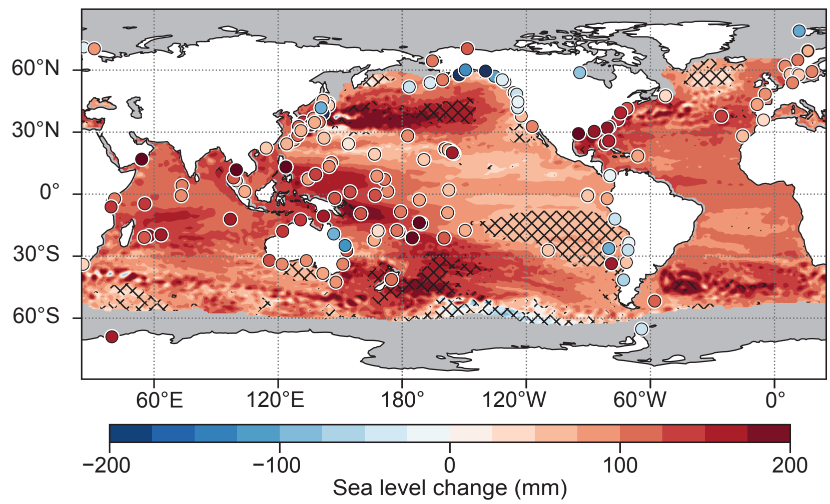
GLOBAL OCEANS

Similar to the overall global temperature, the global average sea surface temperature for 2024 was the highest in the 171-year record, surpassing the previous record set in 2023. There has also been an acceleration in the warming trend of sea surface temperature, increasing from 0.11±0.01°C per decade for the 75-year period that begins in 1950 to 0.18±0.06°C per decade for the more recent 25-year period that begins in 2000. Marine heatwaves, which occur when sea surface temperatures are within their highest 10% of all measurements at a particular location for five or more consecutive days, were observed over 91% of the global ocean during 2024. Conversely, marine cold spells, which occur when sea surface temperatures are within their lowest 10% of all measurements at a particular location for five or more consecutive days, were observed over 26% of the global ocean.

Almost 90% of the excess heat in Earth's climate system is absorbed by the world's oceans. The globally averaged ocean heat content from the surface to 2000 meters depth—the amount of heat stored in this portion of the oceans—reached a record high in 2024. The average global mean sea level for 2024 set a new record for the 13th year in a row, at 105.8 millimeters above the average for 1993, the year when satellite altimetry measurements began. The average sea level for 2024 was 4.6±1.4 millimeters higher compared to 2023; this increase was higher than the average increase of 3.8±0.4 millimeters per year since the start of the 32-year record. Water expansion due to warming temperatures and melting glaciers and ice caps contribute to the rise.

The ocean also plays a major role in removing carbon dioxide from the atmosphere. In 2024, the ocean absorbed an estimated 2.7 petagrams (or 2.7 trillion kilograms) of carbon, which was ~1 petagram less than the average of the past decade. 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.

Sea levels continued to rise throughout most of the global ocean



Since satellite altimetry measurements began in 1993, sea levels have risen in most areas of the major ocean basins, and by more than 200 millimeters in multiple regions including the North and South Pacific Ocean, as indicated by the red shadings. Sea level has fallen over time in only a few locales, as shown in blue. Tidal gauges, which are shown by the circles in the map and measure sea level compared to land, show similar increases. However, there are some notable exceptions in regions of active land and tectonic plate movements where the land is sinking faster than the ocean is rising, for example in parts of Japan and Alaska. The hatch marks indicate areas where local changes in sea level differ from the change in global mean sea level by more than one standard deviation. (Fig. 3.16b in State of the Climate in 2024; see discussion in section 3f.)

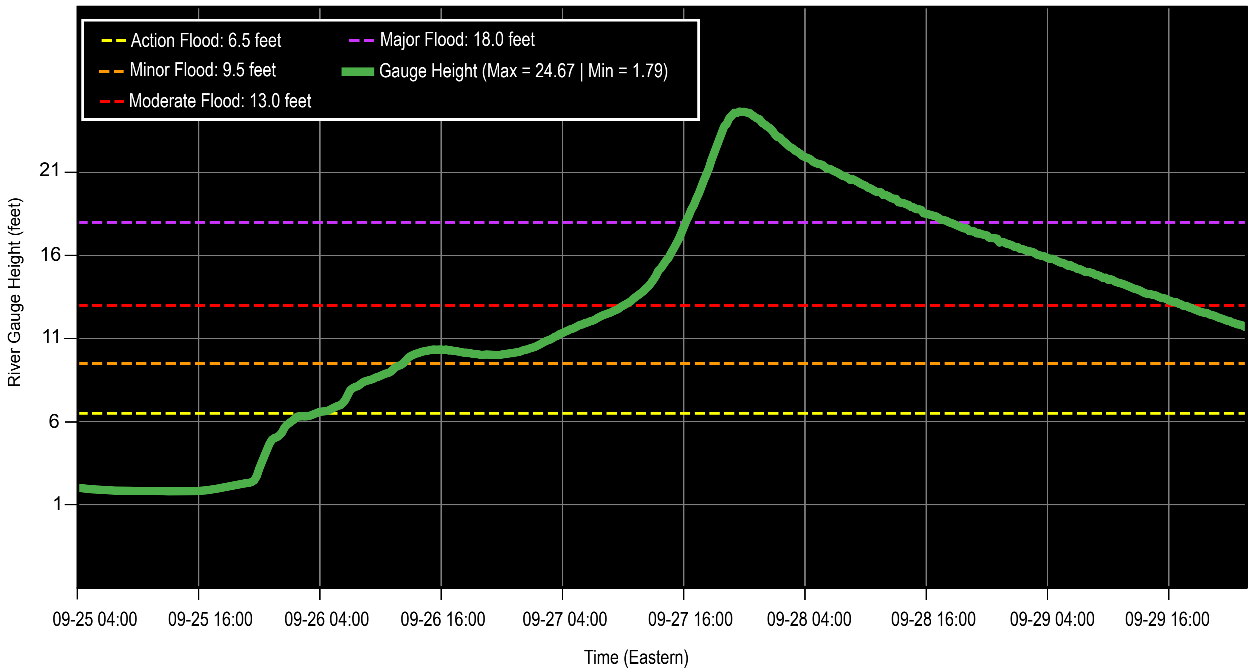
THE TROPICS

The El Niño–Southern Oscillation transitioned from a strong warm-phase El Niño during the early part of 2024 to a neutral phase during the Northern Hemisphere spring and cooled to La Niña–like conditions by the end of 2024. Tropical precipitation patterns changed as the El Niño–Southern Oscillation shifted throughout 2024, and the 2024 annual temperature across the tropics, from 20°S to 20°N, was the highest in the 175-year data record.

In total, there were 82 named tropical cyclones during the 2024 Northern Hemisphere season (January–December 2024) and the 2023/24 Southern Hemisphere season (July 2023–June 2024). This number was equal to the 82 tropical cyclones reported during the 2023 season but below the 1991–2020 global average of 87. Forty-three storms reached hurricane strength and 23 reached major hurricane strength, which is equivalent to Category 3 or higher on the Saffir–Simpson Hurricane Wind Scale. Both of these were below average. Four storms reached Category 5 intensity, which is more than in 2022 (three) but less than in 2023 (seven). Only the North Atlantic and South Indian basins had an above-normal number of named storms.

The accumulated cyclone energy—a combined measure of strength, frequency, and lifespan of tropical storms and hurricanes—was below normal, but greater

Hurricane Helene caused record flooding in the Southern Appalachians



The Southern Appalachians experienced a 1-in-1000-year rainfall event in late September 2024. The historic rainfall was a result of Hurricane Helene's direct passing and an associated predecessor rain event that arrived days earlier. The French Broad River in Asheville, North Carolina, exceeded major flood stage on 27 September and peaked at 24.67 feet shortly thereafter. This exceeded the height of the July 1916 record flood by 1.7 feet and caused devastating damage to the area. (Fig. SB4.2 in State of the Climate in 2024; see discussion in Sidebar 4.1)

than the record low in 2022. The Australian and North Atlantic basins were the only two basins that did not have below-normal accumulated cyclone energy. The 2024 North Atlantic hurricane season was classified as a hyperactive season, with the total amount of energy just above the threshold of the 165% 1951–2020 median value. There were 18 named storms in the North Atlantic, and 11 of those became hurricanes.

Two notable North Atlantic hurricanes impacted the eastern United States, both of which occurred during the typical core months of the season. Hurricane Helene made landfall as a Category 4 storm on 26 September along the Big Bend of Florida and caused destruction from Big Bend all the way up through the southern Appalachian Mountains, where historic flooding was recorded. Helene contributed to over 200 deaths. Hurricane Milton became the strongest October hurricane on record in the Gulf of America/Gulf of Mexico, with maximum winds of 155 kt and a minimum pressure of 895 hPa recorded on 7 October. Milton made landfall near Siesta Key, Florida, on 10 October as a Category 3 storm, just 12 days after Helene.

THE ARCTIC

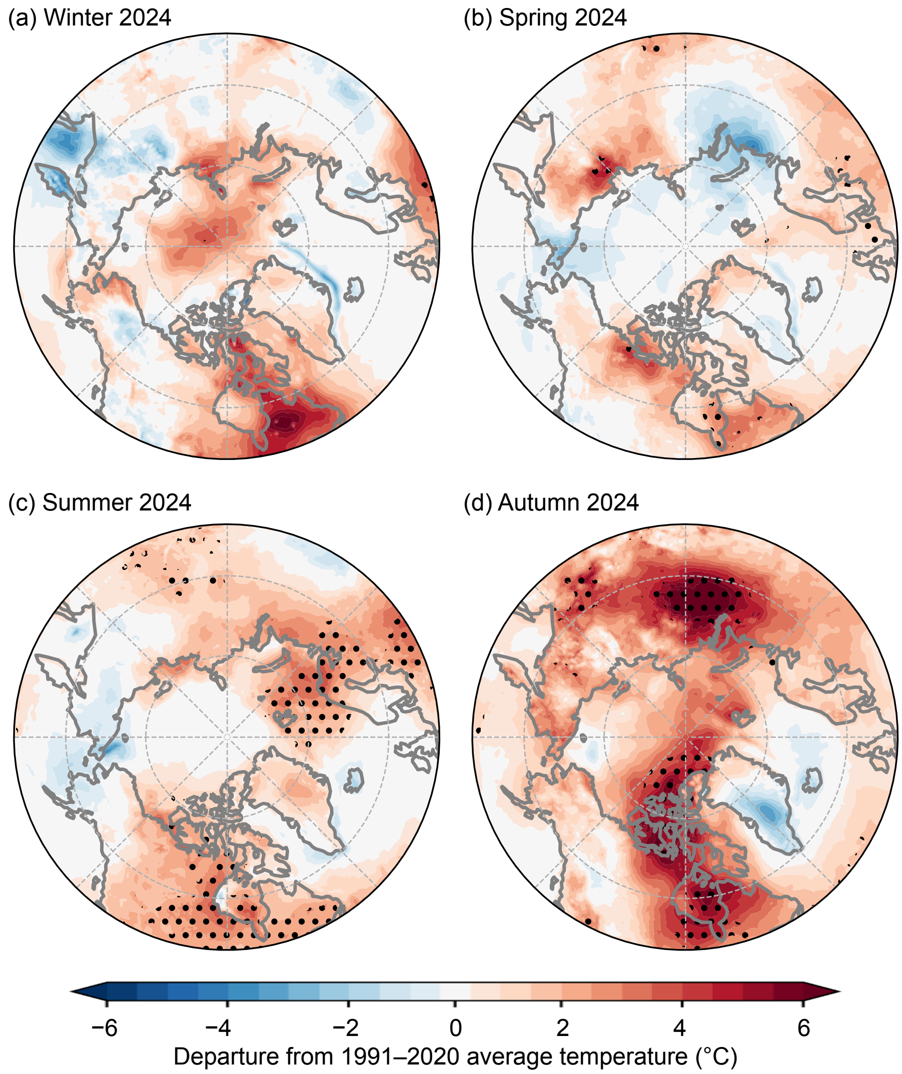
The 2024 average surface air temperature in the Arctic, which encompasses the area north of 60°N, was the second highest since the record began in 1900. For the 11th consecutive year, the Arctic annual temperature departure from average was greater than that of the global average departure. An intense heatwave in August in the northwest North American Arctic contributed to multiple new high temperature records, and autumn (October to December) 2024 was the warmest for the entire Arctic in the 125-year record. Tundra greenness, which is the amount of vegetation cover and productivity in Arctic ecosystems and is influenced by temperature and the length of growing seasons, was the fifth highest in the 43-year record. Still, in some Arctic locales, reduced vegetation productivity, or browning, was evident in 2024 due to wildfires and other disturbances. Beneath the surface, record-high permafrost temperatures were set in 2024 at 8 of 25 monitoring sites: 7 in North America and 1 in the Norwegian archipelago of Svalbard.

Precipitation for 2024 across the Arctic was the third highest in the record dating back to 1950 and was the highest on record for summer, specifically July to September. There were sharp regional contrasts in 2024 with respect to how long snow remained on the ground over the

Arctic. Snow cover in portions of Canada were the shortest in the twenty-first century, while it lasted the longest, or close to the longest, over the Nordic and Asian Arctic over the same period. On the Greenland Ice Sheet, the total amount of ice has decreased every year since the late 1990s; however, the decline in 2024 was 50% to 80% less than the average decline since 2002. This was due to a persistent weather pattern that kept warm air masses from developing for extended periods of time over Greenland during the summer.

Across the Arctic waters, sea ice coverage for March, which is the month of maximum sea ice extent during the year, was near the 1991–2020 average overall, but it was below average in some regions, including the Barents Sea and Gulf of St. Lawrence. Surface ocean temperatures in the Arctic typically peak in August. In 2024, the Arctic August sea surface temperatures varied by region, with the Chukchi Sea experiencing its lowest such temperatures in more than 40 years, while the sea surface temperatures to the east in the southern Beaufort Sea were significantly above the 1991–2020 average. The late summer sea surface temperatures in the Barents and Kara Seas were as much as 4°C higher than normal. The sea ice coverage for September, the month with minimum sea ice extent, was the sixth lowest in the 46-year satellite record.

Arctic autumn temperatures set new record in 2024



The seasonal temperatures compared to the 1991–2020 average in the Arctic were dominated by unusual warmth throughout the year, as indicated by the orange and red shading, and were particularly notable in the Northern Hemisphere summer and autumn. These high temperatures, which were more than 6°C above average during autumn in some locales, led to many records being broken in 2024, as shown by the black dots. Below-average temperatures, as indicated by blue shading, were mostly transient and occurred predominately in the winter and spring. (Fig. 5.6 in State of the Climate in 2024; see discussion in section 5c.)

ANTARCTICA AND THE SOUTHERN OCEAN

Significant atmospheric anomalies occurred over Antarctica in 2024. There was strong warming in the stratosphere above the continent in July followed by extreme warming at the surface in August. Estimates from reanalysis—a combination of observations with past short-range weather forecasts rerun with modern weather forecasting models—suggest that surface temperatures were 6°C to 10°C above average across much of the interior Antarctic during these two months. This is consistent with available but sparse weather station observations. The high pressure associated with these above-average temperatures also set multiple records.

During the melt season on the Antarctic Ice Sheet, which lasted from 1 October 2023 to 30 April 2024, the Antarctic Peninsula had above-average melt compared to the 1991–2020 average, with significant melting events in late February and early March that broke daily records for the area. In the surrounding ocean waters, following record lows in 2023, sea ice extent continued to be well below average in 2024. The daily minimum sea ice extent for the year, which is typically observed in February, was the third lowest on record in 2024, while the daily maximum extent, which is typically seen in September, was the second lowest in the 46-year record. The annually averaged sea surface temperatures across the Southern Ocean were predominately above average. The western Pacific region of the Southern Ocean had the highest departures, reaching 1.4°C above average in May. The ocean heat content from the surface to 2000-meter depth also reached a record in 2024, surpassing the previous record set in 2023.

Far above the surface, the Antarctic ozone hole appeared later than average in 2024 and became the seventh smallest in the 32-year record. The ozone hole reached its maximum area of 22.4 million square kilometers on 28 September and was about 25% less than the record maximum area that was reached on 9 September 2000.

REGIONAL CLIMATES

North America

North America as a whole observed its warmest year in the 115-year record that dates back to 1910. Canada, the continental United States, and Mexico were also each record warm. For Mexico, 2024 marked the 15th consecutive year with an above-average national temperature. Even with record warmth, freezing winter temperatures still had major impacts, including a severe mid-January cold snap in western Canada that led to dozens of fatalities among the area's homeless population. Conversely, during the summer, extreme heatwaves brought record-breaking temperatures to parts of the Canadian Arctic, the Maritime provinces, and to western Canada, which in turn fueled wildfires that consumed nearly 5.4 million hectares during the year and displaced thousands in Labrador and Alberta. On 5 August in Alberta, large hailstones pelted thousands of homes and vehicles across the northern suburbs of Calgary. The storm caused damage of more than 3.25 billion Canadian dollars, including the collapse of part of a terminal roof at Calgary International Airport, making this the second-costliest disaster in Canadian history. It was also Calgary's second billion-dollar hailstorm in less than five years.

In Mexico, the largest drought footprint during the year occurred in May, covering 76% of the country. Three heatwaves in April and May, with temperatures rising to as much as 18°F (10°C) above normal, contributed to the dry conditions. In June, a temperature of 125.6°F (52.0°C) was recorded in Tepache, Sonora, equaling the highest national temperature on record set during 27–28 July 1995 in Mexicali, Baja California. A record-large area was burned by fires across the country during the year.

In the United States, the drought footprint reached its smallest extent for the year (12%) in mid-June. This was also the smallest extent since early 2020. By early November, however, abnormal dryness and drought covered 87.8% of the contiguous United States—the greatest such coverage in the U.S. Drought Monitor record that began in 2000. As drought conditions grew, the fourth-largest wildfire in California history, known as the Park Fire, consumed nearly 174,000 hectares and destroyed over 600 structures in northern California during summer and autumn. Also during summer, record heat and heatwaves impacted several regions, including the Southwest. On 7 July, Las Vegas, Nevada, reported an all-time record high temperature of 120°F (49°C), while Palm Springs, California, measured a record high of 124°F (51°C) on 5 July. An extended heatwave in Phoenix, Arizona, produced 113 consecutive days of temperatures of 100°F (38°C) or higher during the summer, shattering the previous record of 76 days set in 1993. These persistent and extreme temperatures contributed to more than 600 fatalities in Maricopa County.

Central America and the Caribbean

The annually averaged temperature across the Caribbean was the highest in the 75-year record, with winter and spring also record warm and summer and autumn each second warmest on record. The record warmth of the tropical North Atlantic Ocean drove the record-high air temperatures. At the local level, 15 of the 38 stations measured across the Caribbean islands recorded their warmest year on record. Twenty-four stations had an annual mean temperature among their highest 10%, while only one station recorded an annual mean temperature among its lowest 10%. Record high daily minimum temperatures were also observed across several stations. Among nine stations in Central America, eight reported an above-average annual temperature, while only one, Liberia Airport in Costa Rica, reported a below-average temperature.

The annually averaged precipitation across the Caribbean was the eighth wettest on record. Cabrera, Dominican Republic, recorded its wettest year in its 54-year record, with 3383.3 millimeters of total rainfall, more than twice its normal amount. For the Central American stations, there was a mix of below- and above-normal precipitation totals. The three stations that reported below-normal annual totals were all located on the Pacific slope where tropical cyclone activity was relatively low. On the Atlantic side, Hurricane Helene brought flooding and storm surge to Artemisa, Cuba, and its surrounding coastal communities on 26–27 September, while Hurricane Oscar affected eastern Cuba on 21–22 October, leading to 10 fatalities. Both made landfall as Category 1 storms. Hurricane Rafael and Tropical Storm Sara both formed in the Caribbean Sea in November. Rafael caused two fatalities in Jamaica and affected four million people in Cuba with over $1 billion U.S. dollars in damage. Rafael also caused indirect effects over the southernmost part of Central America, leading to five deaths in Panama and two in Costa Rica. Tropical Cyclone Sara impacted the Dominican Republic and Haiti and also caused landslides and floods across most countries in Central America that contributed to 19 fatalities.

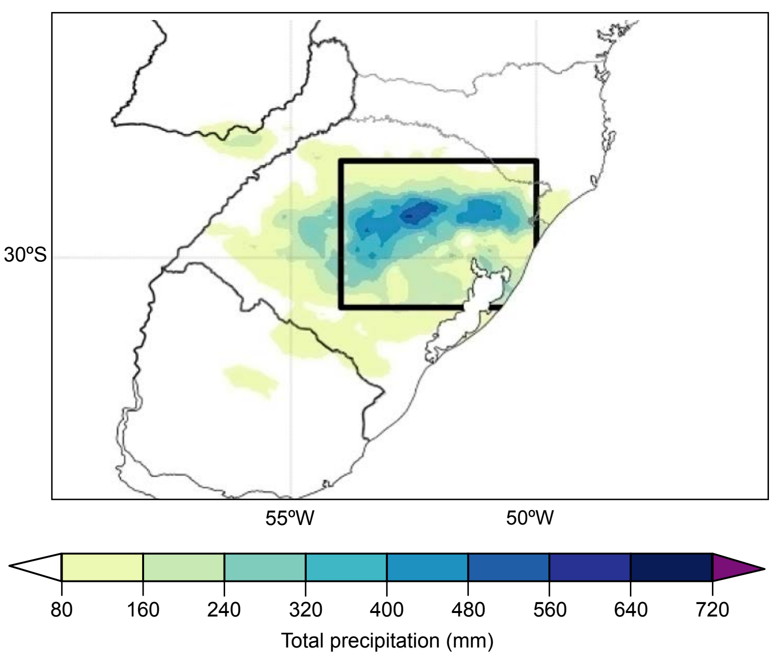
South America

Annual minimum, mean, and maximum temperatures in northern South America were mostly above normal, with maximum temperatures as much as 9°F (5°C) above average in Colombia early in the year and again in September and October. Venezuela became the first Andes country to register the loss of all glaciers; the general decline has been observed since 1970, but the rate of decline has increased since 2016. For central South America, 2024 was the warmest year since the start of the record in 1961, surpassing the previous record set in 2023. At the national level, both Brazil and Peru reported record warmth. In southern South America, Argentina recorded its second-warmest year on record, in part due to an unprecedented heatwave that affected almost all of the country between 21 January and 12 February. However, during the Southern Hemisphere autumn, several cities—including Esquel, Paso de Indios, and Perito Moreno in Argentina and Coyhaique in Chile—each saw their coldest autumn since the start of their records in 1961. During the first half of July, a coldwave impacted central and northeastern Argentina and Uruguay. The city of Florida, Uruguay, recorded 13 consecutive days with a minimum temperature below 0°C, surpassing its previous record of 8 consecutive days. Buenos Aires, Argentina, recorded four days with temperatures below 0°C, an event that had not occurred there since 1980. Some other locations in Argentina broke all-time minimum temperature records. This coldwave was Argentina's most significant since winter 1992.

Heat dominated central South America in spring. During 7–8 October, the southern city of Villamontes in the Chaco region recorded 116.6°F (47.0°C), the highest temperature ever recorded in Bolivia, surpassing the previous maximum of 116.1°F (46.7°C) at the same location.

Dry conditions across much of northern South America early in the year led to drought and wildfires, except in Ecuador, which experienced heavy precipitation due to the impacts of El Niño. Rainfall was about 30%–40% below normal across most of central South America and 40%–50% below normal in southern and western Amazonia and Pantanal in the austral winter, triggering drought in those regions. However, in some regions of Brazil and Bolivia, rainfall totals as much as twice the normal were reported. Rainfall in southern Brazil was about 30%–40% above normal, triggering floods in Rio Grande do Sul in May. The abundant rainfall in southern Brazil and the drought in the Amazon and Pantanal were associated with El Niño during the first half of 2024.

Floods in Rio Grande do Sul marked Brazil's worst climate disaster on record



Widespread and unprecedented rainfall totals of 400 mm or more occurred from late April to early May in the southern Brazil state of Rio Grande do Sul. The abundant and persistent rainfall caused an increase in soil moisture, which made water infiltration difficult. The Taquari, Cai, dos Sinos, and Antas River levels rose by several meters and triggered the worst flooding event on record for the country; the event is considered to be the worst climate disaster in Brazil's history in terms of damage and loss. Several cities were submerged and nearly 2.4 million people were impacted, with 184 fatalities reported and $630 million dollars in damage to agriculture alone (Fig. SB7.1 in State of the Climate in 2024; see discussion in Sidebar 7.1.)

Africa

Africa observed its warmest year on record, surpassing the record set in the previous year of 2023. Annual temperatures were mostly above normal across most of the continent, with some areas of northwestern Africa and the western part of southern

Africa seeing temperatures more than 4.3°F (2.4°C) above their average. In central Africa, the Democratic Republic of Congo, Cameroon, Gabon, Congo, Equatorial Guinea, southwestern Chad, and much of the Central African Republic all saw temperatures in the highest three percent of the record. South Africa reported its warmest year since the start of its record in 1951, with hot conditions mainly in the central and northern interior. Annual maximum temperatures were as high as 4.5°C above normal across southern and northeastern Angola, northeastern Namibia, and northwestern Botswana. In eastern South Africa, many weather stations reported their highest maximum temperature on record during November and December, with several heat warnings and heatwaves issued. In the western Indian Ocean, the island nation of Mayotte observed its warmest year in the 64-year record, while Seychelles International Airport had its second-warmest year and Réunion its third. It was also the third-wettest year on record for Seychelles.

Several storms impacted western Indian Ocean island countries and southern Africa in 2024. In mid-January, Tropical Cyclone Belal impacted Réunion and Mauritius, with rainfall exceeding 1000 millimeters locally in the former. In mid-March, heavy rain affected parts of South Africa after Storm Filipo made landfall in Mozambique. In mid-December, Tropical Cyclone Chido impacted Mozambique, Malawi, Mayotte, and Madagascar, affecting more than 864,000 people and causing at least 155 deaths in these regions. Unusually, in eastern Africa, Cyclone Hidaya—a Category 1 equivalent and the most intense tropical cyclone on record for this region—struck on 4 May, bringing heavy rainfall and strong winds to a region already impacted by extreme weather.

During early January, exceptionally heavy rainfall caused the Congo River in Central Africa to rise to a level of 6.26 meters in Kinshasa, marking its highest level since 1961 and prompting the government to declare a hydrological and ecological catastrophe, with 300 lives lost. The June to August period is not typically a wet season in northern Africa; however, unusually heavy rains were observed in August in the mountains along parts of the Red Sea coast. In September, Ouarzazate in southeast Morocco, which typically observes little rainfall, received 648% of its monthly normal rainfall.

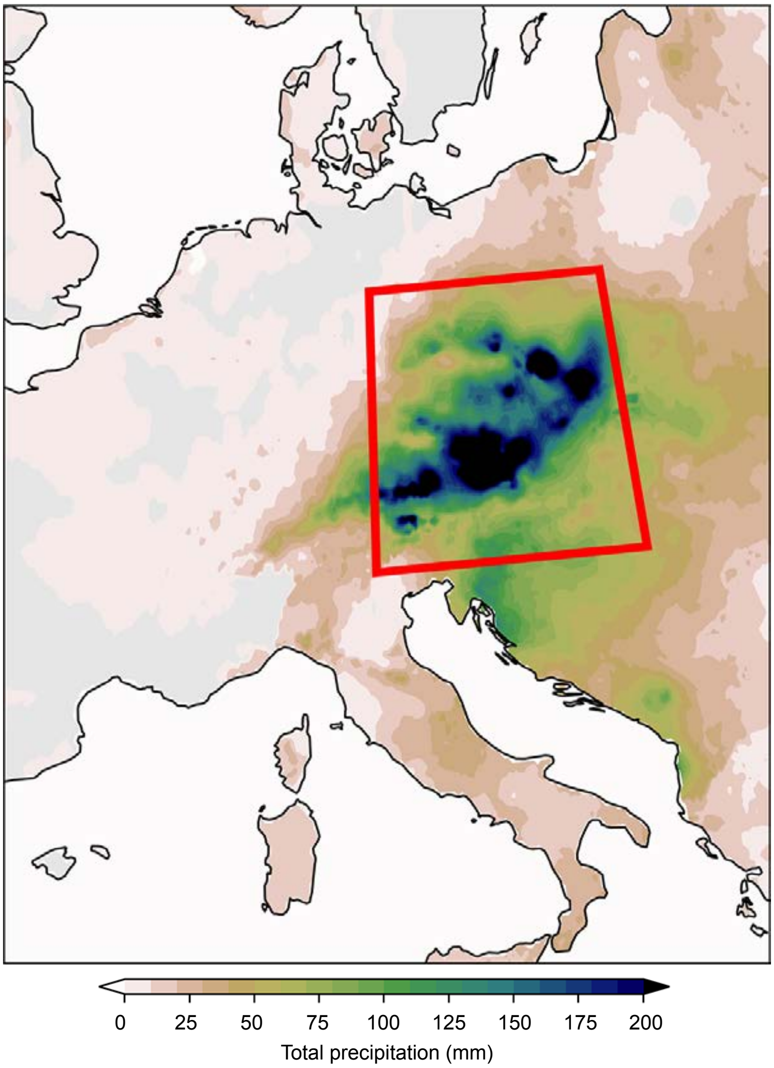
The El Niño event that began in 2023 and continued into the boreal spring of 2024 contributed to heavy rains and flooding across Eastern Africa, particularly during the long rainy season that occurs from March to May. The floods caused widespread devastation in Burundi, Kenya, Somalia, Rwanda, and Tanzania, affecting over 636,000 people and leading to significant infrastructure damage, crop destruction, and heightened disease risks like cholera. Conversely, the El Niño teleconnection patterns contributed to widespread drought across many countries in Southern Africa. The resulting food and water shortages affected more than 33 million people across Zimbabwe, Zambia, Malawi, Angola, and Namibia. Northern Ghana in western Africa suffered its worst drought in 40 years, which led to significant crop losses. In Mayotte and Réunion, the dry season, which lasts from May to October, was one of the driest recorded in the past few decades. The droughts also coincided with high temperatures. Water cuts started early in the dry season and lasted for months in areas where such conditions are highly unusual.

Europe and the Middle East

Europe as a whole observed its warmest year on record, according to six different datasets that date as far back as 1900. The warmth was widespread, with the highest departures from average over eastern parts of Central Europe, western parts of Eastern Europe, and over the Balkan Peninsula. Twenty-seven countries reported their warmest years on record with most others having been near-record warm. The year was colder than normal only over Iceland, but some areas also experienced extreme cold in the winter months. During a coldwave, Kvikkjokk in Sweden reported its lowest temperature on record of −43.6°C on 3 January, with records dating to 1888. On 6 January, −31.1°C became the lowest temperature on record in the Oslo region of Norway. But there was more record heat than record cold. In Cyprus, temperatures reached 40°C every day for a week in mid-June. The highest temperature was 45.3°C in Astromeritis, a village in the Nicosia district. Belgrade (Serbia) reported a record 67 days with temperatures at least 3°C above average; a minimum temperature of 30.6°C at Vrsac on 13 July set a national record for Serbia. In Iceland, the first 14 days of November were the warmest ever observed for this time of year at many stations. The highest recorded temperature was 23.8°C at Kvísker in Öræfi, which set a new November record for the country.

There was a mix of above- and below-normal precipitation across the region and throughout the year, with many extreme events occurring. Persistent and heavy rain occurred in parts of western Germany in mid-May. At some stations, new all-time records were observed. On 29 July, Kalnciems in Latvia recorded 198.3 mm of rain in a 24-hour period, setting a new national record for daily rainfall, surpassing the previous high of 160 millimeters that was recorded in Ventspils on 9 July 1973. Heavy rain fell in Baku, Azerbaijan, during 21 and 22 October. Over an 18-hour period, 86 millimeters fell, which is 306% of Baku's monthly normal for October. Locally, torrential and persistent rains affected eastern and southern Spain between 28 October and 4 November. Particularly intense rainfall occurred on 29 October in the Valencia region, setting new historical records with accumulated

Storm Boris brought heavy rain and flooding to a large area of eastern Central Europe



Extreme precipitation associated with Storm Boris fell in eastern parts of Central Europe. A large area saw at least half a month's worth of rainfall during the five-day period of 12–16 September, with the most-affected areas—including Austria, Czechia, Slovakia, southern Poland, and southeastern Germany—highlighted in the red box. Several locations recorded totals of 200 mm–500 mm. Boris produced severe river flooding in the upper and middle Danube, Oder, and Elbe basins. Total damage was estimated at several billion U.S. dollars and at least 27 people were killed; however, the death toll was significantly lower than in past major floods, highlighting the effectiveness of early warning systems and emergency measures. The severe weather was classified as a 100-year event, meaning a comparable event could be statistically expected once every 100 years. (Fig. SB7.3 in State of the Climate in 2024; see discussion in Sidebar 7.2.)

rainfall totals of 184.6 mm in 1 hour, 620.6 mm in 6 hours, and 720.4 mm in 12 hours. This event resulted in severe flooding across 78 municipalities, causing at least 224 fatalities and damage exceeding $14.8 billion U.S. dollars.

In Ukraine, for the first time since 1961, no precipitation was recorded in May in many areas of the Kharkiv, Poltava, Lviv, and Volyn regions. In Poland, a hydrological drought developed due to a very warm and dry summer. On 10 September, a record-low water level of 0.02 meters was recorded at the Warsaw–Bulwary station located at the Vistula River. In total, 26 stations in Poland recorded their absolute minimum water levels that day.

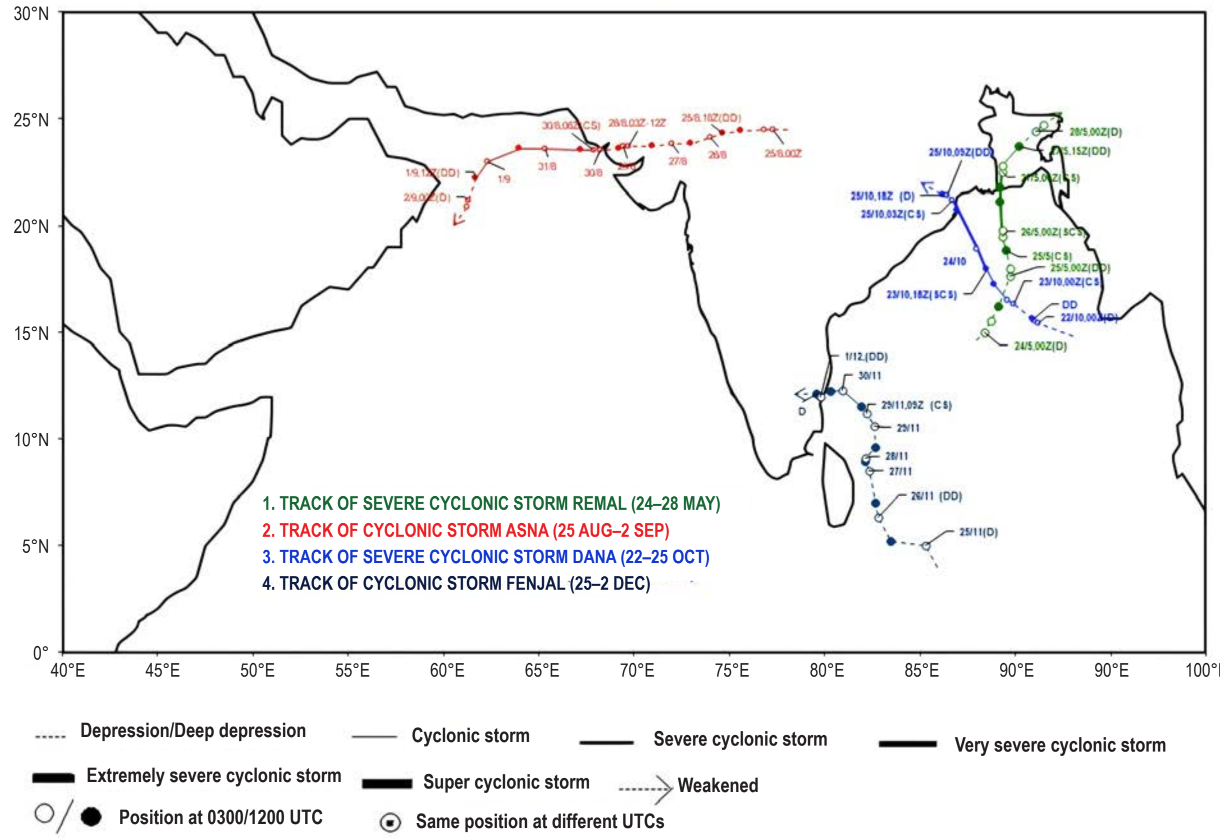
Asia

Annual mean temperatures were above normal across most of Asia. Only parts of eastern Siberia observed below-normal annual temperatures. It was a record-warm year for India, China, Japan, the Republic of Korea, Indonesia, and Singapore, the latter of which tied with 2019 and 2016. Mongolia reported its second-warmest year. Russia also observed its second-warmest year in a record that begins in 1936, despite experiencing its second-coldest winter of the past decade. In April, high minimum temperatures that were 4°C–7°C above average accelerated snowmelt across Kazakhstan, which—combined with heavy precipitation—triggered rapid river overflow and widespread flooding. This cascade of events caused severe impacts and led to seven fatalities. The Republic of Korea recorded over 30 days of heatwaves, the second-highest number of such days on record, and 24 tropical nights—during which temperatures remain at or above 25°C—the most on record. More than 30 heat-related fatalities were reported.

Annual precipitation totals were above normal across large parts of Asia. It was the third-wettest year on record for Indonesia and sixth wettest for Mongolia. For China, it was the fourth-wettest year on record; the average total precipitation during the Meiyu (rainy) season was 151% of its normal amount. In the Tokai region of Japan, the annual precipitation total was the highest since the start of the record in 1946, equal to that of 1998.

From the end of March to May, a series of slow-moving weather systems delivered repeated floods to coastal and inland areas of the Persian Gulf. Southern Iran received two to three times its typical April rainfall in just 72 hours. Flash floods submerged entire villages.

Several cyclones impacted South Asia



Four cyclones formed over the North Indian Ocean in 2024. Severe Cyclonic Storm Remal formed over the north and adjoining east-central Bay of Bengal, leading to 51 fatalities in Northeast India and 10 in Bangladesh. Cyclonic Storm Asna formed in late August and strengthened into a tropical storm over the Arabian Sea before dissipating without further impacting land. Severe Cyclonic Storm Dana formed during the post-monsoon season over the east-central Bay of Bengal, claiming four lives in West Bengal and affecting 3.5 million people in Odisha. Cyclonic Storm Fengal also formed in the post-monsoon season over the Bay of Bengal and caused 15 fatalities in southern India. (Fig. 7.52 in State of the Climate in 2024; see discussions in sections 4g5 and 7g4.)

Dubai recorded 250 mm of rain in 24 hours—nearly three times its annual average—resulting in floodwaters that halted operations at the Dubai International Airport for 48 hours. Also in April and May, heavy rainstorms swept across South China, resulting in devastating floods. The extreme rainfall caused 53 rivers in the region to exceed warning water levels. The disaster impacted 2.5 million people and caused direct economic losses of $19.4 billion U.S. dollars.

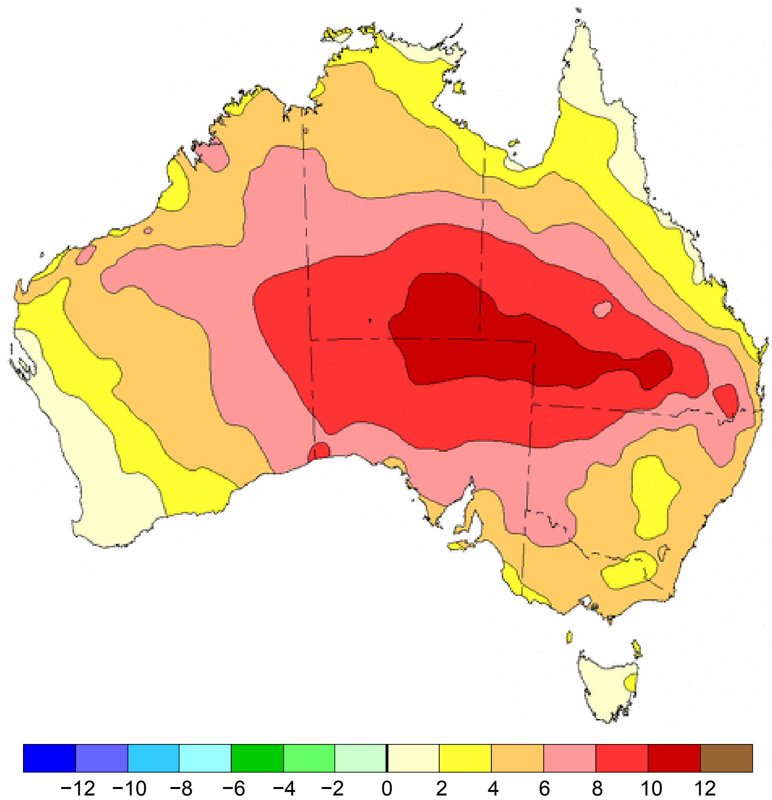
In India, the 2024 summer monsoon set in over Kerala two days earlier than the average onset date of 1 June, and covered the entire country on 2 July, six days ahead of normal. The total summer monsoon rainfall averaged over the country was 108% of its long-term average. In Pakistan, the summer monsoon onset was two days earlier than normal, and the total average rainfall was 131% of its long-term average. Both Bangladesh and Sri Lanka also received above-normal rainfall during their summer monsoon season. For Nepal, the 2024 summer monsoon began three days earlier than normal and withdrew 10 days later than normal. On 28 September, 25 stations, including Kathmandu Airport, recorded their wettest day on record.

In Indonesia, the eastern part of Bima Regency on the island of Sumbawa saw a dry spell of 214 days, resulting in a drought that triggered a clean water crisis for more than 21,000 people. Eastern and south-central parts of the Iranian Plateau received less than half the average total in places, compounding multiyear drought conditions. Similarly, Mesopotamia (Iraq) and the Syrian Desert recorded below-normal rainfall, which worsened food insecurity in regions already strained by conflict.

Oceania

Air temperatures were mostly near normal across Micronesia throughout 2024, although surrounding ocean surface waters were near-record to record warm. The stations on Pohnpei and Chuuk observed their highest annual mean temperatures on record. For Australia, it was the second-warmest year since national records began in 1910, while New Zealand reported its 10th warmest since 1909. Australia also reported its highest annual minimum temperature on record. Heatwave conditions impacted Western Australia during February. Record-high temperatures included 49.9°C at Carnarvon on 18 February, which equaled the eighth-highest temperature ever recorded in Australia. There were also some below-normal temperatures during austral winter, notably in July in northern and southern Australia: on 4 July, Liawenee reached −13.5°C, the second-lowest temperature ever recorded in Tasmania, and on 18 July, Palmerville in northern Queensland observed 0.5°C, the lowest temperature at that location since 1913. From 8 to 21 July, freezing fog and black ice were regularly reported for some inland parts of the South Island, New Zealand. The icy conditions were associated with an exceptionally strong high-pressure system. On 10 July, the town of Ranfurly recorded a mean sea level pressure of 1046.5 hPa—a record high for the nation.

August in Australia set records



August 2024 brought a very warm end to the austral winter in Australia. The mean temperature was 2.44°C above the 1991–2020 average, making this the warmest August on record since national observations began in 1910, and breaking the previous record by around 0.5°C. Maximum temperatures of at least 40.0°C were recorded on 20 occasions during the month, including a national August record of 41.6°C on the 26th at Yampi Sound in northern Western Australia. This is also the highest temperature ever recorded in winter across all of Australia. Prior to 2024, 40.0°C had only been reached four times in August. The previous record-high Australian area-average August daily maximum temperature of 29.9°C (on 31 August 2009) was exceeded on six days in 2024, peaking at 31.3°C on 29 August. (Fig. SB7.6 in State of the Climate in 2024; see discussion in section Sidebar 7.4.)

Precipitation was mostly below normal during the first half of the year across Micronesia, with the exceptions of Pohnpei and Kapingamarangi Atoll, and was mixed during the second half of the year. As is typical with El Niño events, the Intertropical Convergence Zone was shifted southward of its usual position at the start of the year. This shift contributed to enhanced rainfall for the northern Papua New Guinea islands, Nauru, and much of Kiribati through the first quarter of the year. Additionally, five stations in Fiji, two in Tonga, and one in Vanuatu recorded their wettest January–March periods on record. Australia reported its eighth-wettest year on record, although it was the driest year on record for parts of southern South Australia. Annual rainfall totals for 2024 varied across New Zealand. Two locations, both in Northland, observed their driest year on record.

An intense North Pacific cyclone developed north of Micronesia during mid-January. The storm inundated coastal areas exposed to large waves, and saltwater damaged taro fields in Chuuk and eastern Yap States. Waves also damaged homes in Kosrae and Arno Atoll in the Marshall Islands. Tropical Cyclone Megan made landfall as a Category 3 system across the southwestern Gulf of Carpentaria in Australia's Northern Territory in March, close to where Lincoln, another cyclone, had crossed several weeks earlier. Heavy rains from both Lincoln and Megan, combined with numerous other rain events earlier in the year, contributed to extensive and long-lasting flooding in many parts of the Northern Territory, which caused a number of remote communities to be inundated and brought substantial disruptions to road and rail transport. In New Zealand, a low-pressure system delivered persistent and heavy rain over southeastern parts of the South Island during 3–4 October. A state of emergency was declared in Dunedin and the Clutha District.