

Significant Weather & Climate Events

2023



WORLD
METEOROLOGICAL
ORGANIZATION

Contents

Tropical cyclones	3
Africa	4
Asia.....	6
North America, Central America and the Caribbean	10
South-West Pacific	12
Europe.....	14

This is a supplement to the [WMO State of the Climate 2023 report](#). It expands on the summary of significant high-impact events in the main report, with a broader range of events included, including some events which were climatically extreme but had limited immediate impacts.

Tropical cyclones

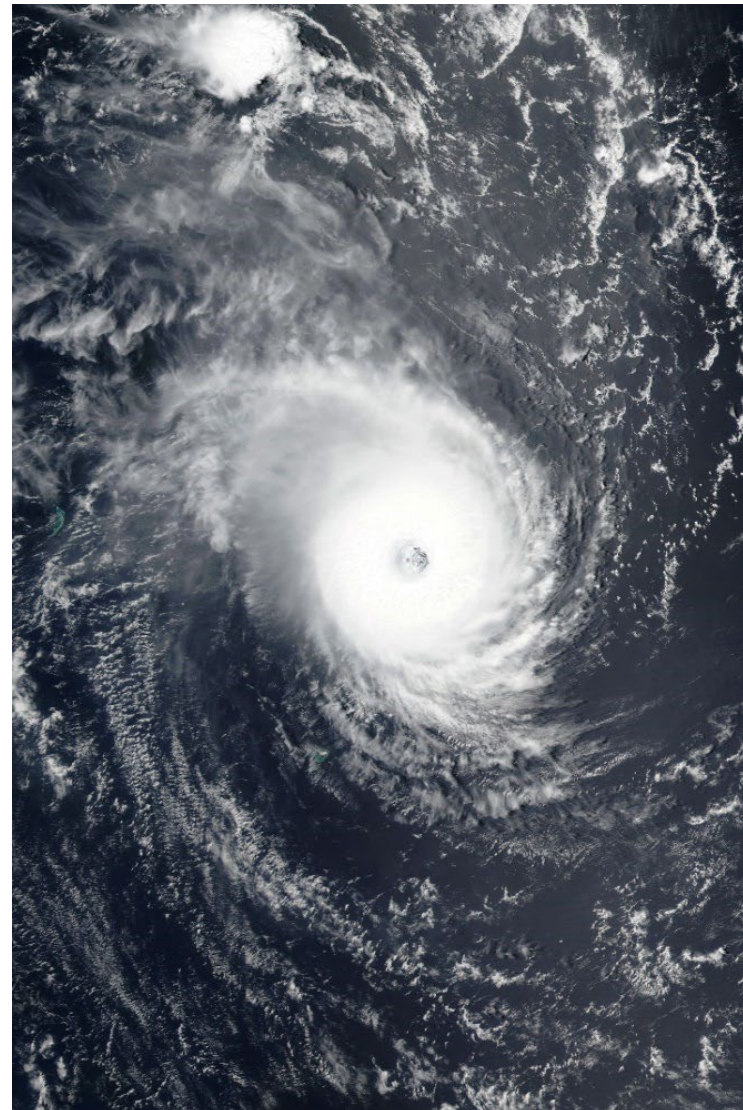
Overall assessment

2023 has seen a slightly below average total number of tropical cyclones globally, but an above average number of intense tropical cyclones, and a number of notably long-lived tropical cyclones, including Cyclone Freddy in the South Indian Ocean, which was one of the longest-lived tropical cyclones on record¹.

In total, there were 76 tropical cyclones in the season², somewhat below the long-term average. This largely reflects below-average tropical cyclone numbers in the 2022-23 Southern Hemisphere season, particularly in the South Pacific, which had its second-lowest number of cyclones this century. Northern Hemisphere numbers have been very close to average, with well above average numbers in the North Atlantic offset by well below average numbers in the western North Pacific, where the 17 cyclones observed in 2023 were the second lowest this century after 2010. The North Indian Ocean has had well above average activity, and the eastern North Pacific near average. The North Atlantic anomalies are opposite to those which would normally be experienced during an El Niño event.

The intensity and longevity of tropical cyclones in 2023 is reflected in the Accumulated Cyclone Energy (ACE) index, which merges cyclone intensity and duration. ACE has been above average in the majority of basins, and near average in the western North Pacific where cyclone numbers have been well below average, with only the South Pacific being significantly below average. In the South Indian Ocean, largely as a result of Cyclone Freddy, the ACE value was the second highest this century despite cyclone numbers being slightly below average.

Notable individual cyclones are discussed in the relevant regional sections (below).



Cyclone Freddy was one of the longest-lived tropical cyclones on record.

¹ A WMO committee is currently evaluating whether Cyclone Freddy surpassed existing records (held by Hurricane/Typhoon John in 1994) for the longest duration and longest track of a tropical cyclone.

² For these purposes, the 'season' is defined as the combination of the 2022-23 Southern Hemisphere season (1 July 2022 to 30 June 2023) and the 2023 Northern Hemisphere season (starting 1 January 2023).

Africa

In terms of currently known loss of life globally, the most significant event of 2023 was the Mediterranean cyclone, referred to locally as 'Storm Daniel', in September. After affecting Greece, Bulgaria and Türkiye (see Europe section), the storm was slow-moving in the eastern Mediterranean for several days before the main rainbands associated with it impacted north-eastern Libya on 10 and 11 September. Extreme rainfalls affected the coast and nearby mountains, with 414.1 mm falling in 24 hours at Al-Bayda on 10-11 September. The intense rainfalls resulted in extreme flooding in the region. The most extreme impacts were in the city of Derna (about 50 km east of Al-Bayda), where much of the central city was destroyed by flooding, exacerbated by the failure of two dams. At least 4 700 confirmed deaths in Libya have been attributed to the flooding with 8 000 still missing (as of 15 December).³

Tropical Cyclone Freddy in February and March was one of the world's longest-lived tropical cyclones. It formed on 6 February off the western coast of Australia and moved westwards across the Indian Ocean, intensifying to reach maximum wind gusts of 325 km hr⁻¹-intensified before a second landfall in Mozambique on 24 February. Although it

dropped below cyclone intensity, the system remained organised over land and re-emerged over the Mozambique Channel on 1 March, re-intensifying to become a cyclone again. It remained slow-moving over the Mozambique Channel before moving northwest and making its final landfall in Mozambique on 11 March, then moving inland as a remnant low. The major impacts of Freddy came as a result of flooding during the final landfall, both in Mozambique and Malawi, as extremely heavy rain fell (up to 672 mm during the storm in Mozambique). Malawi was especially hard hit with at least 679 deaths reported. A further 165 deaths were reported in Mozambique. Casualties were also reported in Madagascar and Zimbabwe.⁴ This catastrophic event submerged extensive agricultural areas and inflicted severe damage on crops.

A major episode of severe flooding with associated landslides affected central Africa in early May, focused on the Lake Kivu region on the border between Rwanda and the Democratic Republic of the Congo.

182.6 mm of rain fell on 2 May at Mushubati, a national daily record for Rwanda, with records also set at several other Rwandan stations. At least 574 deaths were associated with this event, 443 in the Democratic Republic



Flood damage in Derna, Libya, September 2023. Photo: Libyan Red Crescent Society

At least 4700 confirmed deaths in Libya have been attributed to the flooding following Storm Daniel, with 8000 still missing.

³ <https://reliefweb.int/report/libya/libya-flood-response-humanitarian-update-15-december-2023-enar>

⁴ EM-DAT

of the Congo⁵ and 131 in Rwanda⁶. High rainfalls in the early months of 2023 extended north to the Lake Victoria basin, further prolonging flooding downstream in South Sudan which has persisted for much of the period since 2020. The White Nile in White Nile State (South Sudan) reached record high levels in February. This prolonged flooding rendered basic needs such as food, clean water, and healthcare difficult to access and contributed to the near collapse of local livelihoods.

Extreme heat affected northern Africa on a number of occasions during July and August, a southward extension of the persistent heat which impacted southern Europe (see Europe section). In the July heatwave, all-time records included those at Tunis (Tunisia) (49.0 °C on 24 July) and Algiers (49.2 °C on 23 July), while a second heatwave brought a temperature of 50.4 °C to Agadir (Morocco) on 11 August, the first time that 50 °C has been reached in Morocco. Northwestern Africa was also affected by drought, with rainfall in Morocco for the 2022-23 rainy season 28% below average, the fourth successive year with rainfall at least 20% below average and the country's driest four-year period on record. Rainfall was also well below average in the early part of the 2023-24 rainy season.

The Greater Horn of Africa region, which had been experiencing long-term drought, suffered substantial flooding in 2023, particularly later in the year as heavy rains associated with El Niño and the positive Indian Ocean Dipole became established.

The most badly affected area was the region encompassing the southern half of Somalia, southeastern Ethiopia and northeastern Kenya. During the Deyr rainy season (October and November), monthly rainfall in this region was widely 100 to 200 mm and locally exceeded 200 mm, several times long-term averages. This followed widespread above-average rainfall in the Gu rainy season (April to June).

⁵ UNICEF (via ReliefWeb)

⁶ EM-DAT

There was widespread and severe flooding, with at least 352 deaths and 2.4 million displaced people reported across the three countries, although the wet conditions did lead to some recovery in pasture and crop conditions after the extended drought. Landslides and flooding in early December also resulted in at least 89 deaths in northern parts of the United Republic of Tanzania⁷.



Floods in Elwak, Mandera County, Kenya, November 2023. Photo: Hon. Abdul Haro (Kore) MP

The Greater Horn of Africa region, which had been experiencing long-term drought, suffered substantial flooding in 2023.

⁷ National contribution by Tanzania.

Asia

Tropical Cyclone Mocha, in May, was one of the most intense cyclones ever observed in the Bay of Bengal, reaching peak 10-minute sustained winds of 210 km hr⁻¹. It formed on 11 May and became more intense as it moved north, reaching a peak of intensity early on 14 May, then weakening somewhat before making landfall near the Bangladesh-Myanmar border a few hours later⁸. There were significant impacts, particularly in Rakhine State of Myanmar, with substantial wind damage and inundation, both from storm surge and freshwater flooding. There were also major impacts on settlements of refugees and internally displaced people, both in Myanmar and Bangladesh. In total at least 156 lives were lost in Myanmar and over 270 000 buildings damaged or destroyed⁹.

Typhoon Doksuri (Egay) crossed the northern Philippines in late July, passing across the Luzon Strait and the northeastern part of the South China Sea before making landfall in Fujian province of China. It caused substantial flooding both in the Philippines and China, with some of the most significant flooding occurring in the Beijing region from the remnants of the storm. A 24-hour total of 744.8 mm was observed at Wangjiayuan Reservoir, in the hills near Beijing. At least 56 deaths were attributed to Doksuri in China, and 45 in the Philippines¹⁰. In early September, Typhoons Saola and Haikui both had significant impacts in southern China. The remnants of Haikui contributed to record-breaking rainfall intensities in Hong Kong on 7-8 September, with Hong Kong Observatory receiving 158.1 mm of rain in an hour and 605.8 mm in 12 hours.

A major and prolonged heatwave affected much of south-eastern Asia in April and May, extending as far west as Bangladesh and eastern India and north to southern China.



Tropical Storm Mocha over the Bay of Bengal.
Image Source: JMA

Tropical Cyclone Mocha was one of the most intense cyclones ever observed in the Bay of Bengal.

The most exceptional temperatures occurred in Thailand, Lao People's Democratic Republic (PDR) and Viet Nam.

In Thailand, 44.6 °C at Tak on 15 April was the equal-highest temperature on record in the country's main observation network, while 41.0 °C at Bangkok Metropolis on 7 May was the highest on record in metropolitan Bangkok. Luang Prabang (Lao PDR) reached 43.5 °C on 6 and 7 May, and Thong Duong (Viet Nam) 44.2 °C on 7 May, a record for the main national observation network. Ang Mo Kio (37.0 °C on 13 May) equalled Singapore's national record. There was also significant drought in the first half of the year in southern China, with the drought intensity in Yunnan province the most significant of the post-1961 period.

Later in the year, persistent heat in Japan, particularly in Hokkaido and northern Honshu, resulted in the country having its hottest summer on record with national mean temperatures 1.76 °C above the long-term average. 106 of 915 reporting stations experienced their highest temperature on record. September was also the hottest on record. Northern China experienced a significant heatwave in June, with Beijing Observatory (41.1 °C on 22 June) reaching its

⁸ [India Meteorological Department](#)

⁹ <https://ahacentre.org/situation-update/situation-update-no-8-tropical-cyclone-mocha-myanmar-26-may-2023/>.

¹⁰ EM-DAT

second-highest temperature on record. It was also an exceptionally hot July in much of Kazakhstan, and Hong Kong Observatory had its hottest summer on record.

Extreme cold occurred in parts of northeast Asia in the second half of January. In the far northeast of China temperatures fell below -50 °C, with Mohe reaching -50.8 °C on 22 January, the lowest there since 1969, and automatic weather stations in the area as low as -53 °C, while Tonguloh (Russian Federation) reached -62.7 °C on 18 January, the country's lowest since 2002. Heavy snow fell during this period in Japan and the Republic of Korea. There was further significant cold in northern China in December, with the cold wave from 14 to 17 December assessed as the strongest nationwide in December since 1961. A record low of -33.2 °C occurred at Yunzhou and Shanxi province, and Beijing experienced 12 consecutive days with maximum temperatures below 0 °C.

The Indian southwest monsoon season was relatively dry, as is characteristic of El Niño years, with All-India rainfall for June to September 6% below the long-term average. There were still some significant flood and storm episodes, with at least 599 deaths reported from flooding, associated landslides and lightning in June and July across India, Pakistan and Nepal¹¹.

A glacial lake outburst flood in Sikkim, in the Indian Himalayas, on 4 October caused severe damage with over 100 deaths reported. Further west, near-average cool-season rainfall in eastern Turkey eased long-term drought in the Tigris and Euphrates, but rainfall for the 12 months ending in June 2023 was 40% to 60% below average in an area east of the Caspian Sea encompassing parts of Turkmenistan, Uzbekistan and Afghanistan.

Afghanistan experienced another poor crop season due to a substantial reduction in snowmelt and rainfall, despite significant and locally destructive flash floods in some areas during the summer. This led to widespread acute food insecurity, particularly in the north and northeastern regions.

¹¹ EM-DAT

South America

South America was badly affected by drought in 2023. Most parts of the continent, except for the far south, parts of southern Brazil, and parts of the west coast, were affected at some stage during the year.

Long-term drought continued in subtropical South America, focused on northern Argentina and Uruguay. Rainfall from January to August was 20 to 50% below average over much of northern and central Argentina, with some regions experiencing their fourth successive year of significantly below average rainfall. There were major crop losses in Argentina with wheat production in 2022-23 more than 30% below the five-year average. In Uruguay, water storages reached critically low levels, badly affecting the quality of supplies to major centres including Montevideo, although there was some improvement in the situation from August. Conditions in this region gradually moderated in the later part of the year.

Drought became increasingly widespread in the northern half of South America during the year. June-September rainfall was well below average in much of the Amazon basin and rivers fell to well below average levels, with the Rio Negro at Manaus falling to its lowest level on record on 26 October, 0.93 m below the previous record set in 2010¹². Eight Brazilian states had their driest July-September on record. Further south, after significant rainfall deficiencies in the southern eastern mountains of Peru, including the driest January since 1964, Lake Titicaca (Peru/Bolivia) also fell to its lowest level since 1996¹³. Significant agricultural losses are expected in many parts of the region.

Extreme heat occurred in South America on numerous occasions during the year. One of the most significant heatwaves occurred in late September and early October, with many locations experiencing record high temperatures in a broad region of the tropics east of the Andes. There were further major heatwaves through the remainder of the year.



Lake Titicaca
fell to its
lowest level
since 1996.

¹² <https://www.portodemanous.com.br/?pagina=niveis-maximo-minimo-do-rio-negro>

¹³ <https://www.gob.pe/institucion/senamhi/noticias/840699-puno-lago-titicaca-presenta-niveles-de-agua-mas-bajos-desde-hace-27-anos>

A territorial record high temperature was set in French Guiana (39.0 °C at Camopi on 17 October), while in Brazil locations where record high temperatures occurred included Belo Horizonte (38.6 °C on 25 September). In Peru, Tingo de Ponaza reached 41.4 °C on 27 September. Earlier in the year, March was exceptionally hot in Argentina and Uruguay, with temperatures 8-10 °C above average over much of northern Argentina from 1-19 March.

In contrast to the situation in many other parts of the continent, southern Brazil experienced major flooding at times during the year. The most widespread and significant floods occurred in Rio Grande do Sul state in the far south, peaking on 4-5 September, with rainfall exceeding 300 mm in some places and at least 46 deaths reported. These floods also affected northeast border areas of Argentina. There were further floods in the adjacent Santa Catarina state in October.

Earlier in the year, localised flash flooding and landslides on 18-19 February, following rainfall of up to 683 mm in 15 hours, resulted in at least 65 deaths in the São Sebastião area, near São Paulo. Severe thunderstorms impacted northern Argentina and Uruguay in December. In Argentina, there was widespread damage in Bahia Blanca and Buenos Aires on 16-17 December following wind gusts exceeding 150 km hr⁻¹, while a wind gust of 167 km hr⁻¹ was observed during the same event in Uruguay. Parts of central Chile, mostly near and to the south of Santiago, experienced significant flooding in August.



Floods in São Sebastião, Brazil, February 2023. Photo: Daniela

São Sebastião, Brazil had 683 mm of rainfall in just 15 hours, resulting in at least 65 deaths.

North America, Central America, and the Caribbean

One of the region's most significant single events of the year was Hurricane Otis, which hit the Pacific coast of Mexico in late October. Otis reached hurricane intensity at 1200 UTC on 24 October, and within 15 hours had intensified to a category 5 system, one of the most rapid rates of intensification observed in the satellite era. Shortly afterwards it made landfall just west of Acapulco at near peak intensity, with maximum sustained winds of 260 km hr⁻¹, the first known category 5 landfall on the Pacific coast of Mexico. The hurricane caused widespread destruction in Acapulco and surrounding areas, with estimated economic losses of at least US\$12 billion. At least 48 deaths were attributed to the hurricane with a further 32 missing, mostly at sea.

The Atlantic hurricane season, although with above-average activity overall, was less impactful than some recent seasons with most systems remaining out to sea.

The most significant landfall of the season was Hurricane Idalia, which made landfall in the relatively sparsely populated Big Bend region of the west coast of Florida as a category 3 system on 30 August with maximum sustained winds of 185 km hr⁻¹. Total losses were estimated at US\$3.6 billion and eight direct deaths were reported, all at sea¹⁴. A tropical low moving through the Caribbean in mid-November brought extreme rainfall and flooding to Jamaica, Haiti, and the Dominican Republic. In the Dominican Republic, 21 deaths were reported, and 431 mm of rain fell on 17 November at Arroyo Hondo Viejo, a national record¹⁵.

Canada's wildfire season was well beyond any previously recorded. Significant fire activity

began in late April, expanded during a very warm and dry May, and continued throughout the summer and into early autumn. The total area burned nationally was 14.9 million hectares, more than seven times the long-term average (1986-2022) and far above the previous record seasonal total of 6.7 million hectares in 1989¹⁶.

Many parts of the country were affected, with 4.3 million hectares burned in Quebec and at least 2 million in each of the Northwest Territories, British Columbia and Alberta, while Nova Scotia had the largest fires in its history in late May and early June. The city of Yellowknife, Northwest Territories, was evacuated for several weeks in August and September, and many remote communities were evacuated for significant periods. Many of the fires were in remote areas, but in Nova Scotia more than 200 structures were lost in the Halifax area on 1 June, and nearly the same number were destroyed around Kelowna, British Columbia, in August. The fires also resulted in significant and widespread smoke pollution, particularly in the heavily populated areas of eastern Canada and the north-eastern United States of America in the first half of June. Four deaths were directly attributed to fires, although the broader health impacts of the smoke are yet to be fully assessed.

Drought extended over many areas of Canada (including most of the significantly fire-affected areas), covering most areas within 500 km of the southern border from Lake Superior westwards, and also extending north into parts of the Northwest Territories and east into western Quebec, as well as southwards into northern parts of the midwestern United States. Despite the general drought, there was an extreme rainfall event in Nova Scotia on 21-22 July, including 100 mm in 1 hour and 173 mm in six hours at Bedford, a national record. There was major flash flooding in the area with four deaths reported.

¹⁴ https://www.nhc.noaa.gov/data/tcr/AL102023_Idalia.pdf

¹⁵ <https://floodlist.com/america/floods-november-2023-jamaica-dominicanrepublic-haiti>

¹⁶ Jain, P., et al., 2024: Canada Under Fire – Drivers and Impacts of the Record-Breaking 2023 Wildfire Season. Submitted.

A second major region of drought, which gradually worsened through the year, extended from the southern United States to cover much of Mexico and other parts of central America. By the end of August, parts of eastern Texas and Louisiana were classified as being in exceptional drought. Mexico had its driest year on record (21% below average), with almost all parts of the country affected at some stage during the year, although heavy rainfall associated with tropical cyclones moderated drought conditions later in the year in Baja California and on some parts of the Pacific coast. Rainfall for 2023 has been below average through most of Central America. Low water levels restricted traffic in the Panama Canal from August onwards. The return of El Niño in 2023 is expected to have adverse consequences in the entire crop cycle of maize in Central America and northern parts of South America, where water deficits could curtail both planting area and yields with compounding negative impacts on final production. The initial impacts of El Niño are becoming evident in Haiti, where irregular rainfall is disrupting the first season harvest.

In contrast, a very wet winter and spring eased or eliminated drought in much of the western United States, particularly in California, which experienced significant flooding. 345 mm of rain fell in San Francisco from 26 December 2022 to 10 January 2023, and state average precipitation for the period from December to May was 53% above the 1901-2000 average and the second highest of the 21st century. The normally dry Tulare Lake, in the southern San Joaquin Valley, filled for the first time since 1998, and snow depths reached levels amongst their highest of the last 50 years in many parts of the Sierra Nevada. There was further unseasonable rain in parts of the region in August as a result of Hurricane Hilary. In marked contrast to the situation further north, it was a relatively inactive wildfire season in the United States with the seasonal area burned among the lowest this century.

It was an exceptionally hot summer through most of the southern United States from Arizona eastwards. Phoenix had its hottest

month on record in July, with a monthly mean temperature of 39.3 °C and a record 31 consecutive days of 110 °F (43.3 °C) or above from 30 June to 30 July. In August the most relatively extreme heat was near the Gulf of Mexico, with many locations from Texas to Florida experiencing their hottest month on record. Numerous locations reached record high temperatures, including New Orleans (40.6 °C on 27 August) and Houston Hobby Airport (42.8 °C on 27 August).

A short-lived intense cold outbreak affected the northeastern United States and adjacent areas of eastern Canada in early February, accompanied by strong winds and very low wind-chill temperatures. Temperatures in Boston fell to -23.3 °C on 4 February, the lowest since 1957. On Mount Washington the temperature fell to -43.9 °C with wind chills of -78 °C, amongst the lowest ever observed in the United States outside Alaska. Despite this event, overall winter temperatures were well above average. Baltimore and Atlantic City had their least snowy winters on record, and New York did not receive its first snow until 1 February, the latest date on record.

Severe storm activity in the United States for 2023 to date was above average, particularly early in the year, with the January-March period having the largest number of tornadoes on record. The most significant outbreak was on 31 March, when over 160 tornadoes were observed across southern and central states, the largest single outbreak on record for March and the third largest on record. There were further major storm outbreaks earlier in March, and also later in the year. In total there were 19 separate severe storm outbreaks with US\$1 billion or more in losses each, by far the most observed in any single year.

South-West Pacific

The North Island of New Zealand suffered repeated extreme rainfall and flooding events in January and February. The most significant was on 13-14 February, when Cyclone Gabrielle passed just east of the North Island as a post-tropical system. Daily rainfalls exceeded 500 mm in parts of the eastern North Island and Auckland (971.5 hPa) had its lowest air pressure on record. Extreme flooding occurred in the Gisborne and Hawke's Bay regions, and Northland, Auckland and the Coromandel Peninsula were also badly affected. A more localised event in the Auckland area on 27-28 January brought record rainfalls at all durations from 1 to 48 hours, with the central Albert Park site receiving 211 mm in 6 hours and 280 mm in 24 hours. 11 deaths were reported as a result of Gabrielle and 4 from the Auckland floods, with total economic losses from the two events estimated at US\$5.3 to 8.6 billion¹⁷, by far the costliest non-earthquake-related disaster recorded in New Zealand.

In early March, Cyclones Judy and Kevin crossed Vanuatu within 48 hours of each other, with both impacting the islands as category 4 systems (on the Australian scale), Judy making landfall from the northeast on 1 March and Kevin from the northwest on 3 March. This is the first known instance of two such severe cyclones impacting the same location within such a short period of time. The two cyclones caused widespread damage in Vanuatu, with Judy also having impacts in the Solomon Island, but no deaths or serious injuries were reported. Later in the year, Vanuatu was also impacted by Cyclone Lola on 25 October. Lola was the first South Pacific cyclone of the satellite era to reach category 5 intensity in October, although it weakened substantially before landfall in Vanuatu.

The deadliest single wildfire of the year globally occurred in Hawaii, on the western side of the

island of Maui. Extreme fire weather conditions, with low humidity and strong, gusty winds driven by a pressure gradient between strong high pressure to the north and the circulation of Hurricane Dora well to the south, combined with pre-existing drought to favour the development and rapid spread of intense fires. The most badly affected region was around the town of Lahaina, which was largely destroyed with over 2,200 structures lost. At least 100 deaths were reported¹⁸, the most in a wildfire in the United States for more than 100 years, with estimated economic losses of US\$5.6 billion. Wildfires of such intensity and speed of movement are extremely rare in the tropics. Parts of northern Australia experienced major flooding during the early months of 2023. The remnants of Tropical Cyclone Ellie, which made landfall on 22 December 2022 in the western Northern Territory, brought major flooding to the Kimberley region of northern Western Australia and adjacent parts of the Northern Territory in late December and early January. Dimond Gorge received 355.6 mm on 2 January and 830.2 mm in the week from 28 December to 3 January. The Fitzroy River at Fitzroy Crossing exceeded its previous record level by more than a metre, and the main road bridge was destroyed, severing the only road links between the east Kimberley and areas further south and west for several months. A second major flood affected the far northwest of Queensland and eastern Northern Territory in early March. The Gregory River reached record levels and the town of Burketown was evacuated, although it ultimately escaped full inundation. Several Indigenous communities were also evacuated for extended periods.

Later in the 2022-23 season, Tropical Cyclone Ilsa became the first category 5 landfall in Australia since 2009 when it crossed the coast east of Port Hedland on 13 April, in a sparsely populated area with limited impacts on land apart from the destruction of a roadhouse. At the start of the 2023-24 season, Tropical

¹⁷ NZ Treasury, <https://www.treasury.govt.nz/sites/default/files/2023-04/impacts-from-the-north-island-weather-events.pdf>

¹⁸ Events | Billion-Dollar Weather and Climate Disasters | National Centers for Environmental Information (NCEI)

(noaa.gov) [https://www.ncei.noaa.gov/access/billions/events/US/2023?disasters\[\]=wildfire](https://www.ncei.noaa.gov/access/billions/events/US/2023?disasters[]=wildfire)

Cyclone Jasper made landfall on 13 December near Wujal Wujal, north of Cairns, as a category 2 system, the earliest landfall at cyclone intensity on the east coast in the satellite era, and then stalled for several days, resulting in exceptionally heavy rainfall and severe flooding in the region. Whyanbeel Valley received 2085.8 mm of rain over the six days from 14 to 19 December, including 699.8 mm on the 18th, while Mossman South received 714.0 mm the same day, an Australian record for December.

Abnormally high fuel loads, arising from heavy vegetation growth following the wet conditions early in 2023, contributed to very extensive wildfires in the Northern Territory during late winter and spring, focused on the Barkly and Tanami regions (to the east and west of Tennant Creek respectively). Over 13 million hectares were burned in these fires, which occurred in very sparsely populated areas.

Much of Australia outside the tropics had average to below average rainfall in 2023, after widespread wet conditions in 2021 and 2022, and winter crop production is forecast to be slightly below the 10-year average, with a forecast 33% fall from record high levels in 2022¹⁹. September was especially dry and was the country's driest on record averaged over the continent, while August to October was the driest three-month period on record. However, rainfall was above average through much of eastern Australia in November and December, which is uncharacteristic of an El Niño year. Significant wildfires occurred in some areas, particularly in southern inland Queensland, where fires in the Darling Downs region in late October destroyed at least 46 properties with two lives lost. The second half of the year was also relatively dry in much of Indonesia, with rice production significantly impacted in some areas, although long-term drought associated with the 2020-2023 La Niña episode eased in the equatorial western Pacific, including Kiribati and Tuvalu.



The deadliest single wildfire of the year globally occurred in Hawaii, on the western side of the island of Maui.

¹⁹ <https://www.agriculture.gov.au/abares/research-topics/agricultural-outlook/australian-crop-report/overview>

Europe

A major Mediterranean cyclone (known locally as storm 'Daniel') impacted the eastern Mediterranean in early September. In its first phase, the storm brought exceptional rainfalls, with the most extreme totals in the Thessaly region of Greece north of Athens. There were also extreme rainfalls and flooding in parts of southern Bulgaria and Türkiye, while at the same time a second system further west resulted in significant flash flooding in Spain. In Greece, Zagora Pelion received 759.6 mm on 5 September and a 5-day total of 1096.2 mm from 4 to 8 September, while in Bulgaria, 329 mm fell in 16 hours at Kosti on 4-5 September. Major flooding resulted, with 19 deaths reported in Greece and Bulgaria. In Greece, the main north-south road and rail routes were cut for extended periods, and there were also severe agricultural losses, with many areas of highly productive land covered with silt. The storm went on to produce extreme impacts in Libya (see [Africa](#) section).

There were numerous other flood events in southern Europe during 2023, which resulted in major economic losses and some loss of life. In May, two intense rain events two weeks apart, on 1-3 May and 16-18 May, affected the Emilia-Romagna region of northern Italy, with two-day totals exceeding 250 mm in the second event and a record total of 260.8 mm in 48 hours at Monte Albano. The second event also extended to Croatia with a record daily total of 256.4 mm on 15 May at Gračac. There was major flooding in both countries, particularly in Italy, with total losses estimated at US\$9.7 billion²⁰.

Further episodes of extreme rainfall, severe thunderstorms and giant hail affected northern Italy, Slovenia and adjacent countries on several occasions in July and August. In Slovenia, following a very wet July, falls of over 200 mm of rain in 10 hours on 3-4 August, resulted in record flooding on several rivers. It was the country's costliest weather-related disaster with total losses estimated at

US\$5 billion. In northeastern Italy, hail reached 19 cm in diameter at Azzano Decimo on 24 July, the largest known hailstone observed in Europe.

In much of central and northern Europe, there was a marked contrast between dry conditions in the late spring and early summer, and very wet conditions thereafter. Numerous areas in northern Europe had exceptional dryness and warmth in May and June: The United Kingdom and Ireland had their warmest June on record; Uccle (Brussels, Belgium) had a 31-day dry spell from 15 May to 15 June, its second-longest on record; and Latvia had its driest May-June on record. However, mid- and late summer were wet in many areas. A major storm (known locally as Hans) affected Scandinavia in early August, with major flooding in Sweden and eastern Norway; 3-day rainfall totals between 110 and 140 mm were the highest on record at a number of Norwegian sites with over 100 years of data. There was also significant flooding during this period in Slovakia and Hungary. The wet conditions continued through much of the remainder of the year with regular and widespread flooding. Parts of Scotland were impacted by severe flooding in October, while the Meuse and Loire rivers reached record high flows for the month in November, and the Rhine and Danube approached monthly records in December. At the end of the year there was major flooding, extending into early 2024, in the Ems, Weser and Elbe catchments in northern Germany. 2023 was ultimately the wettest year on record for Denmark, and for the northwestern German state of Niedersachsen.

Multiple major heatwaves affected southern Europe, especially in the second half of July where severe and exceptionally persistent heat occurred. Italy was particularly affected, with temperatures reaching 48.2 °C on 24 July at the Sardinian sites of Lotzorai and Jerzu, only 0.6 °C below the European record set in Sicily in 2021. Record high temperatures also occurred further east in locations including Izmir (Türkiye) (43.2 °C on 26 July). The extreme heat shifted to southeast Europe in late July. Further

²⁰ EM-DAT

heatwaves affected west-central Europe in late August and early September. Numerous locations in southern France, northern Spain and western Switzerland set records during the late August event, including Toulouse (42.4 °C on 23 August), Lyon (41.4 °C on 24 August) and Bilbao (44.0 °C on 23 August), while the September event brought seven consecutive days which reached 30 °C in the United Kingdom and six consecutive days above 25 °C in Ireland, both September records. It was the hottest September on record for Europe as a whole, more than 1 °C above the previous record set in 2020, and was also the hottest on record for many countries, including Czechia, Denmark, France, Luxembourg and Poland. The heatwaves also affected northern Africa (see Africa section).

There was also extensive wildfire activity during the summer, particularly in Greece (both on the mainland and on islands). A fire in north-eastern Greece in late August and early September burned 96 000 hectares, the largest fire ever observed in Europe since comprehensive records began in 2000.

While 2023 was a wet year for Europe as a whole, there was significant drought in some areas, particularly in the western Mediterranean. A number of locations in southern France had their driest year on record, including Perpignan (245 mm, 57% below normal) and Montpellier (261 mm, 59% below normal), while annual rainfall was also more than 50% below normal in Catalonia and the far south of Spain. The Ebro River was at near-record low levels between February and May.

The last three months of the year were significantly colder than normal in parts of northern Europe, particularly the Nordic countries. Mean monthly temperatures in Finland were more than 2 °C below normal in each of October, November and December. The cold extended southwards in late November and early December. Heavy snow on 1 and 2 December caused major disruptions in Munich, with a maximum snow depth of 44 cm, the highest on record for December and the most in any month since 2006. -15.0 °C at Roskilde on 29 November was the lowest November temperature in Denmark since 1993.



Wet conditions continued in Hungary through much of the latter half of the year with regular and widespread flooding.
