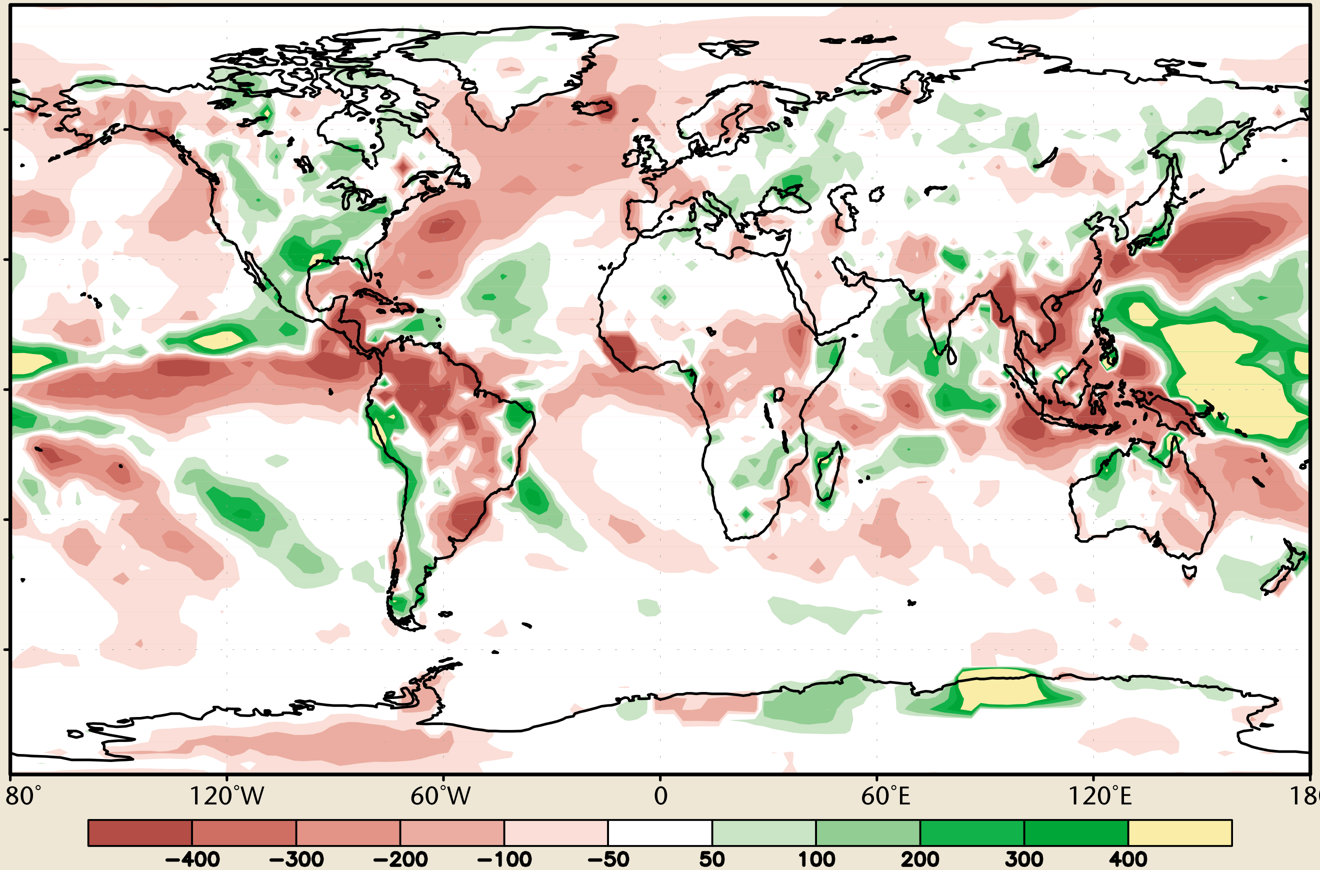
WMO STATEMENT ON THE STATUS OF THE GLOBAL CLIMATE IN 2004



World Meteorological Organization

Weather • Climate • Water

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Front cover: *Annual precipitation anomalies (departures in millimetres from a 1979–1995 base period) in 2004. Green and yellow indicate areas that received above normal precipitation for the calendar year 2004 as a whole. The different shades of burgundy depict those regions of the world that were drier than normal. Areas in white show regions where departures are within +/-50 mm of the average annual value. Precipitation values are obtained by merging raingauge observations and satellite-derived precipitation estimates (*Source: *Climate Prediction Centre, NOAA, United States).*

Back cover: *Right: Tracks of the typhoons which affected Japan during the 2004 cyclone season (*Source: *Japan Meteorological Agency).*

*Left: Maximum temperature anomalies (departures in degree Celsius from the 1961–1990 base period) over Australia for the fortnight ending 22 February 2004 (*Source: *Bureau of Meteorology, Australia).*

NOTE

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the World Meteorological Organization concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

This statement is a summary of the information provided by the Hadley Centre of the Met Office, United Kingdom; the Climatic Research Unit, University of East Anglia, United Kingdom; and the National Climatic Data Center and the Climate Prediction Center of the National Oceanic and Atmospheric Administration (NOAA), United States. Other contributors were from the following WMO Member countries: Argentina, Australia, Canada, China, France, Germany, Iceland, India, Japan, Mauritius, New Zealand, Norway, Russia, Sweden, Switzerland, as well as from the International Research Institute for Climate Prediction in New York, the IGAD Climate Prediction and Applications Centre in Nairobi, and the AGRHYMET Centre in Niamey.

World Meteorological Organization
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FOREWORD

Since 1993, the World Meteorological Organization (WMO), through the Commission for Climatology and in cooperation with its Members, has issued annual statements on the status of the global climate to provide credible scientific information on climate and its variability. This year's statement describes the climatic conditions, including extreme weather events, for the year 2004 and provides a historical perspective on some of the variability and trends that have occurred since the nineteenth century. The statements complement the periodic assessments of the WMO/United Nations Environment Programme (UNEP) Intergovernmental Panel on Climate Change (IPCC), which is now in the process of preparing its fourth Assessment Report.

The information contained in this statement enhances our scientific understanding of the climate variability and the associated impacts that have occurred in the past. Through continuing research and the collection of consistent and high quality observations by WMO and its Members, it is possible to progress towards better understanding of the Earth's climate system and to improve on our projections for the future.

The 2004 cyclone season saw some of the most destructive hurricanes and typhoons on record, which claimed more than 6 000 lives and caused heavy damages to property. Disastrous floods and landslides due to heavy precipitation events were also reported worldwide. Prolonged drought conditions continued to affect parts of Africa, Australia, South Asia and the western United States. Conversely, in 2004, the natural climate variability also produced benefits to society. An example is the significant boost in grain harvests in Europe due to favourable climate conditions and Middle East winter grain crops benefiting from early-season precipitation.

A significant threat to sustainable development is the increased impact of extreme weather and climate events such as tropical cyclones, floods, drought and heat waves. According to the IPCC Assessment Report the duration, location and frequency of extreme weather and climate events are likely to change, and would result in mostly adverse impacts on biophysical systems. In the longer term, sustainable development also therefore requires that the climate system be better understood with the possibility to project future climate changes and their potential impacts. A major challenge for the meteorological and hydrological communities is to work towards a major reduction of the fatality rate associated with natural disasters of hydrometeorological origin. For countries that are at high risk of extreme weather and climate events, increased awareness and preparedness of people and societies are required to face such events. Adequate preparation and response to these events require an improvement of existing weather- climate- and water-related monitoring services and applications, and the development of new ones.

WMO remains committed to assisting the National Meteorological and Hydrological Services (NMHSs) to achieve these goals through the development of a more integrated approach to global observing comprising its surface- and space-based networks. The timely provision of authoritative climate statements, climate assessments, and climate reviews and their historical perspective will also contribute to the important role of WMO in ensuring sustainable development in the twenty-first century.

(M. Jarraud)
Secretary-General

GLOBAL TEMPERATURES DURING 2004

The global mean surface temperature in 2004 was 0.44°C above the 1961–1990 annual average (14°C). This value places 2004 as the fourth warmest year in the temperature record since 1861 just behind 2003 (+0.49°C). However, 1998 remains the warmest year, when surface temperatures averaged +0.54°C above the same 30-year mean. The last 10 years (1995–2004), with the exception of 1996, are among the warmest on record. The five warmest years in decreasing order are: 1998, 2002, 2003, 2004 and 2001.

Over the twentieth century, the increase in global surface temperature has been between 0.6 and 0.7°C. The rate of change since 1976 is roughly three times that for the past 100 years as a whole. In the northern hemisphere, the 1990s was the warmest decade with an average of 0.38°C. The surface temperatures averaged over the recent five years (2000–2004) were, however, much higher (0.58°C). Surface air temperatures at a worldwide network of land stations have shown that trends of night-time minimum temperature on still nights have been the same as on windy nights.

Calculated separately for both hemispheres, surface temperatures in 2004 for the northern hemisphere (+0.62°C) were the fourth warmest and, for the southern hemisphere (+0.25°C), the sixth warmest in the instrumental record from 1861 to the present. Globally, the land-surface air temperature anomalies for October and November 2004 were the warmest on record for these months. The blended land and sea-surface temperature (SST) value for the Arctic (north of 70°N) in July and the

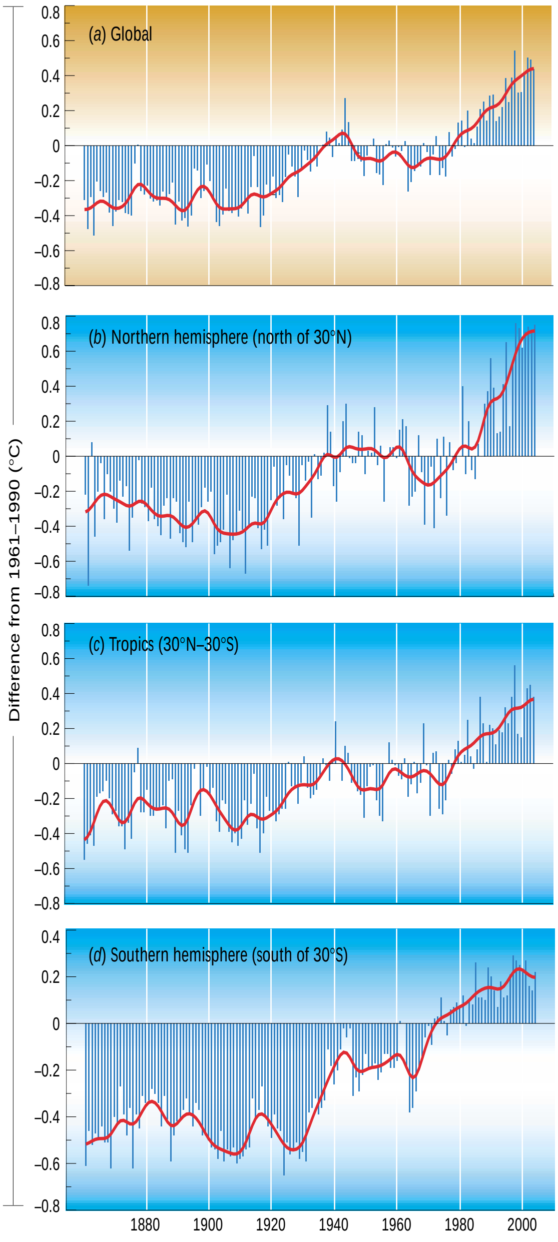


Figure 1 — Combined annual land (near surface) and sea-surface temperature anomalies from 1861–2004 (departures in degrees Celsius from the average in the 1961–1990 base period) for (a) *the globe;* (b) *the northern hemisphere north of 30°N;* (c) *the Tropics (30°N–30°S); and* (d) *the southern hemisphere south of 30°S. The solid red curves have had subdecadal timescale variations smoothed with a binomial filter. Anomalies (in degrees Celsius) for 2004 are: +0.44* (a)*; +0.75* (b)*; +0.38* (c)*; and +0.22* (d) (Sources: *Hadley Centre, The Met Office, and Climatic Research Unit, University of East Anglia, UK).*

NOTE: There are some differences in annual anomalies between this and the earlier WMO statements. In this new analysis, more quality-improved, land station data have been used.

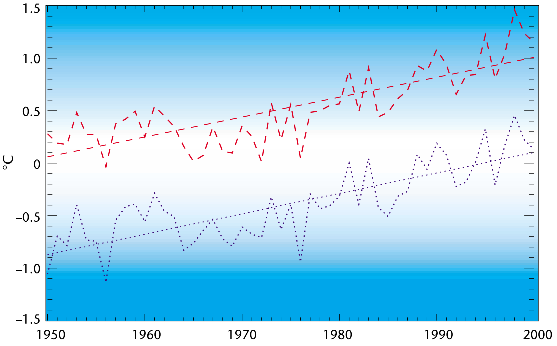


*Figure 2 — Trends of night-time minimum air temperature anomalies (departures in degrees Celsius relative to the 1961–1990 base period), averaged over a worldwide set of land stations for 1951–2000. The red line shows the observations recorded on windy nights and the blue line shows the observations recorded on still nights (*Source: *Hadley Centre, The Met Office, UK).*

land-surface air temperature values for Africa south of the Equator in July and November were the warmest on record for these months. Significant positive annual regional temperature anomalies, notably across much of the land masses of central Asia, China, Alaska and western parts of the United States, as well as across major portions of the North Atlantic Ocean contributed to the high global mean surface temperature ranking.

REGIONAL TEMPERATURE ANOMALIES

Large portions of the northern hemisphere had warm conditions in 2004 that exceeded 90 per cent of the annual temperatures recorded in the 1961–1990 period (the 90th percentile). Northern China, parts of central Asia and the eastern North Atlantic had warm temperatures exceeding the 98th percentile. Only a few small areas experienced temperatures below the 10th percentile.

During June and July, heatwaves with near-record temperatures affected southern Spain, Portugal and Romania, with maximum temperatures reaching 40°C. In the second week of August, an unusual heatwave affected parts of Iceland, making the month of August the second warmest on record.

An exceptional heatwave affected much of eastern Australia during February, as maximum temperatures soared to 45°C in many areas with temperature anomalies exceeding 8°C (see back cover). The spatial and temporal extent of the heatwave was greater than that of any other February heatwave on record and ranked among the top five Australian heatwaves in any month.

A prolonged severe heatwave across northern parts of India during the last week of March and the beginning of April caused more than 100 deaths. During this period, maximum temperatures generally exceeded the long-term averages by 5 to 7°C. In Japan, extreme hot conditions persisted during the summer with record-breaking maximum temperatures. Tokyo experienced a maximum temperature of 39.5°C on 20 July, which set a record since 1923.

During the northern hemisphere winter, very cold weather episodes were observed in parts of South Asia (northern parts of India and Bangladesh), which were blamed for as many as 600 deaths. Maximum and minimum

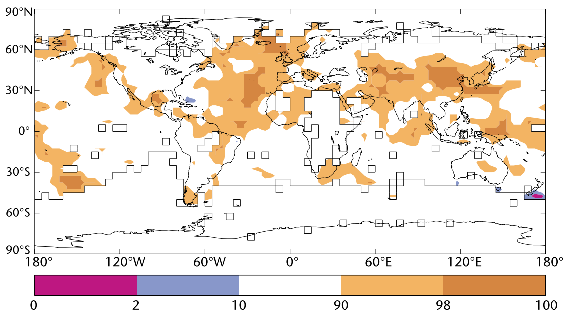
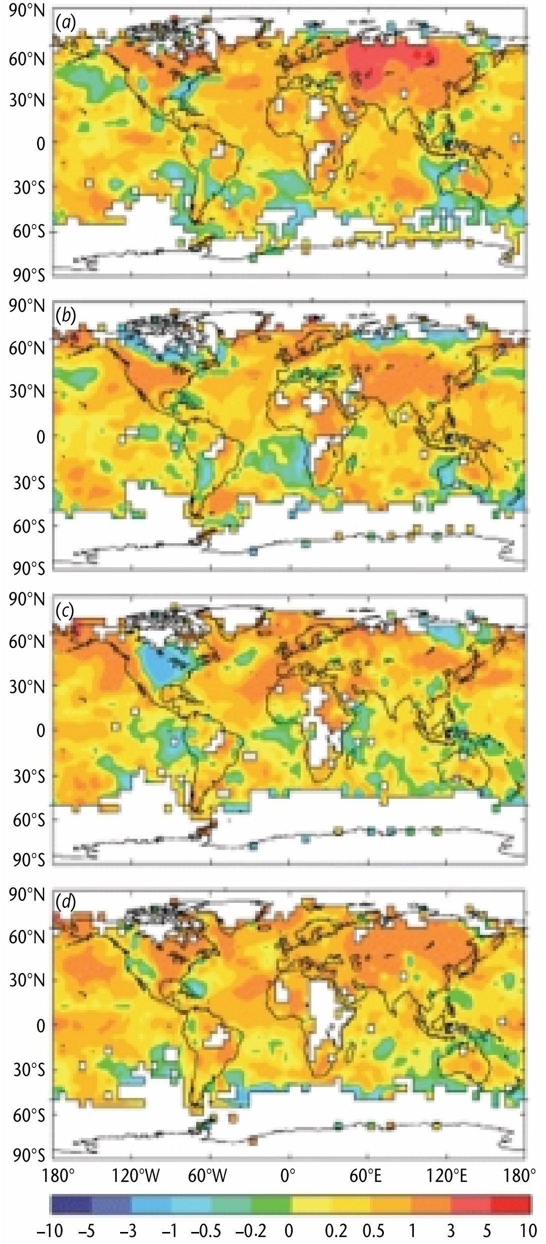


*Figure 3 — Global annual temperature anomaly percentiles for 2004 based on a gamma distribution for the 1961–1990 base period, calculated in five-degree grid boxes. Orange and brown indicate regions where the temperature anomalies were estimated to be within the highest (warm) 10 and 2 per cent, respectively, of the climatological occurrences. Blue and purple indicate the lowest (cold) 10 and 2 per cent of occurrences, respectively. Note that grid areas without sufficient data for analysis are left blank (*Source: *Hadley Centre, The Met Office, UK).*



temperatures were below normal by 6–10°C. During the austral winter, abnormally cold conditions in the high-altitude areas of the Andes in southern Peru reportedly killed 92 people and more than 100 000 farm animals.

PROLONGED DROUGHT IN SOME REGIONS

In early 2004, drought conditions continued to affect parts of eastern South Africa, Mozambique, Lesotho and Swaziland. However, enhanced precipitation in the last half of the rainy season (November to March) provided some benefit to crops in southern Africa. Rainfall during both the long (March to June) and short (October to November) rainy seasons of 2004 was well below normal across parts of the Greater Horn of Africa, resulting in a continuation of multi-season drought in this region. Isolated regions in the southern sector and portions of Uganda experienced driest conditions on record since 1961. In Kenya, a premature end to the 2004 long rains exacerbated the drought conditions resulting from several years of poor rainfall in many areas. Food production in Kenya was projected at approximately 40 per cent below normal. In spite of abundant rainfall in 2004, multi-year drought conditions also continued in Somalia, threatening agriculture and food security in the region. In Eritrea, which was struggling from nearly four years of drought, poor rains during the March–May rains exacerbated drinking-water shortages.

In India, the 2004 seasonal rainfall during the south-west monsoon season (June–September) over the country as a whole was 13 per cent below normal with 18 per cent of the

Figure 4 — Global surface temperature anomalies (departures in degrees Celsius from the average in the 1961–1990 base period) for the three-month periods (a) December 2003–February 2004; (b) March–May 2004; (c) June–August 2004; (d) September– November 2004 (Sources: Hadley Centre, The Met Office, and Climatic Research Unit, University of East Anglia, UK).

country experiencing moderate drought conditions. Rainfall deficiency was the highest over north-west India, where only 78 per cent of normal rainfall was received. In neighbouring Pakistan, poor rains in July and August aggravated the long-term drought conditions, which had prevailed since the boreal spring. The rainfall deficiency was the largest over the Balochistan and Sindh provinces, causing water crisis over these regions. In Sri Lanka, drought conditions prevailing since the end of 2003 aggravated due to deficient rainfall during the 2004 summer monsoon season. In Afghanistan, drought conditions that had plagued the country for the past four years continued in 2004 due to below normal precipitation in March–April. In the spring season, parts of north-east China experienced the worst drought conditions since 1951, due to deficient spring rainfall and above normal temperatures. Later during the fall season, the southern provinces of China received the lowest rainfall since 1951, resulting in the worst drought in the region, affecting agriculture and drinking water.

Long-term hydrological drought continued to affect much of southern and eastern Australia, as a result of rainfall deficits experienced since the major drought event of 2002/2003. The weak *El Niño* conditions in the Pacific, hindered any significant recovery from long-term rainfall deficiencies. This has resulted in significant crop losses in many areas of eastern Australia. Moderate to severe drought conditions continued in some areas of the western United States for the fifth year in a row. By the beginning of 2004, moderate to extreme drought conditions covered about one-third of the contiguous United States. Some relief was experienced during September and

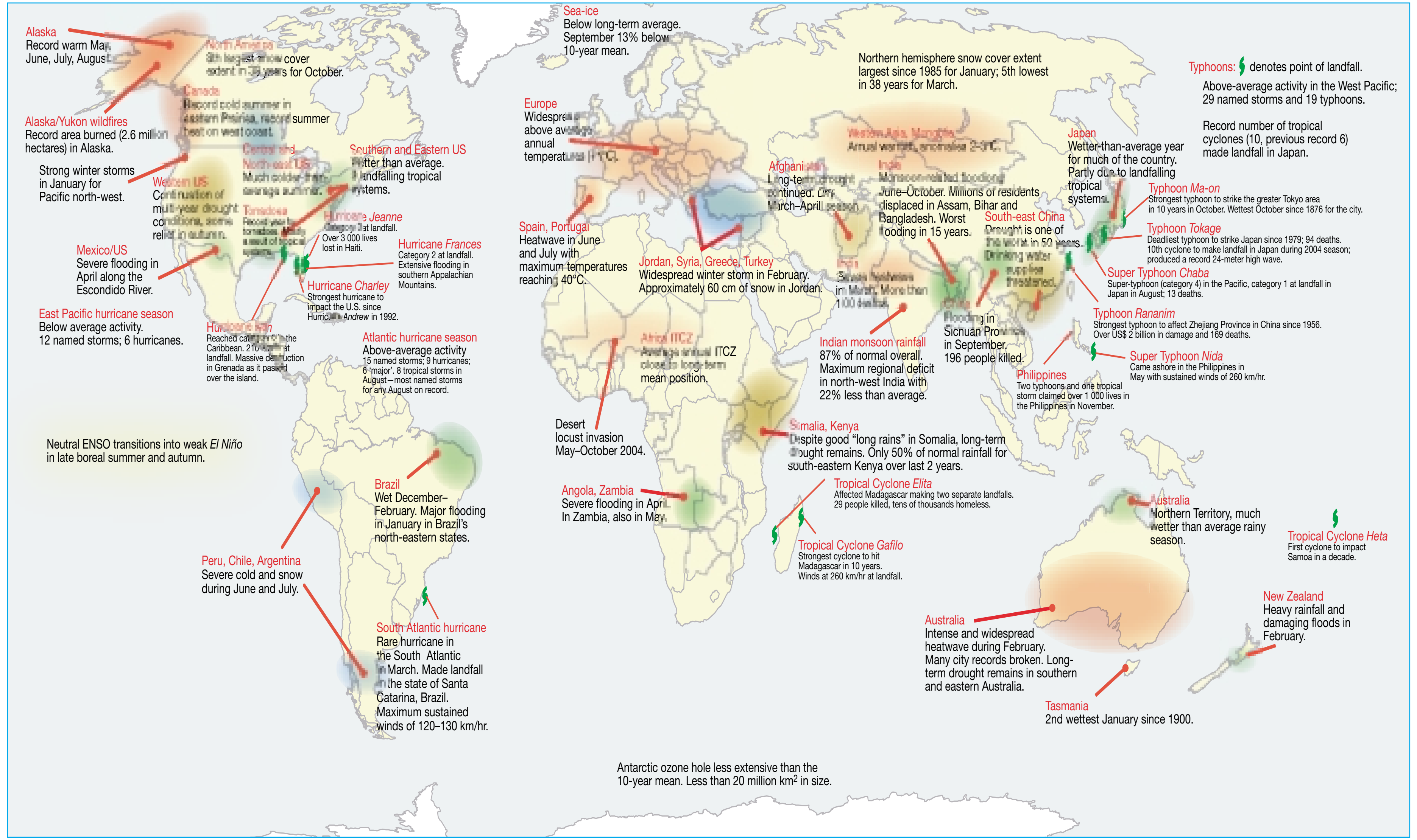


Figure 5 — Significant climatic anomalies and events in 2004. The average global temperature was the fourth warmest on record. There has been a rise in global temperature greater than 0.6°C since 1900 (Source: National Climatic Data Center, NOAA, United States).

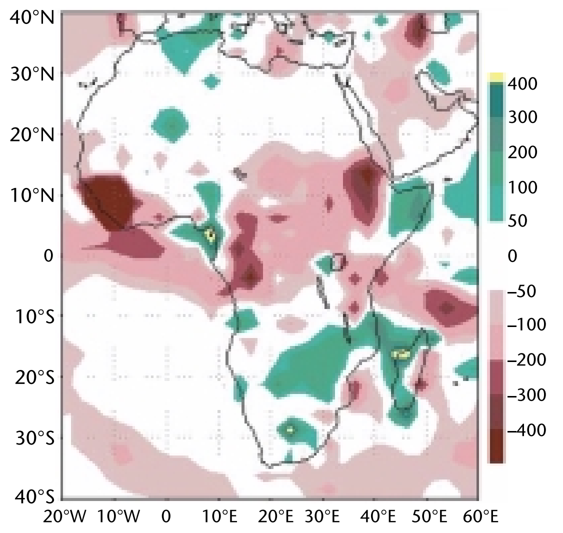


Figure 6 — Accumulated precipitation anomalies (departures in millimetres from a 1979–1995 base period) in 2004 for Africa. Green indicates areas that received above normal precipitation for the calendar year 2004 as a whole while purple depicts those regions that were drier than normal. Areas in white show regions where departures are within +/-50 mm of the average annual value. Precipitation values are obtained by merging raingauge observations and satellite-derived precipitation estimates (Source: *Climate Prediction Center, NOAA, United States).*

October causing a decrease in the national drought area to about 5 per cent by the end of October. In 2004, due to deficient annual rainfall, the eastern provinces of Cuba experienced the effects of the worst drought, eroding 40 per cent of farmlands. A prolonged drought also affected and severely threatened the food security and health in the south-eastern El Chaco region of Bolivia.

RAINFALL AND FLOODING

Precipitation in 2004 was above average for the globe and 2004 was the wettest year since 2000. Wetter-than-average conditions prevailed in the southern and eastern United States, Russia, parts of western Asia, Bangladesh, Japan, coastal Brazil, Argentina and north-west Australia.

The Asian summer monsoon during June-September brought heavy rain and flooding to parts of northern India, Nepal and Bangladesh, leaving millions stranded. Throughout India, Nepal and Bangladesh, some 1 800 deaths resulted from flooding brought by heavy monsoon rains. Flooding in north-east India (the states of Assam and Bihar, in particular) and Bangladesh was the worst in over a decade. In eastern and southern China, heavy rains during the summer produced severe flooding and landslides that affected more than 100 million people and caused more than 1 000 deaths nationwide. Heavy monsoon rainfall during July and August produced flooding along several rivers in north-eastern and central Thailand. A significant low-pressure system brought record-breaking snowfalls in the Republic of Korea on 5 March, resulting in damage to agriculture worth more than US$ 500 million. In October, two typhoons and active frontal systems brought record-breaking heavy rainfall to Japan. Tokyo received a total amount of 780 mm precipitation in October, which is the largest monthly amount on record since 1876. In the second half of November and the beginning of December, two typhoons and one tropical storm passed over southern and central parts of the Philippines, drenching the islands with several days of torrential rainfall and triggering catastrophic flash floods and landslides, which killed, according to reports, more than 1 800 people.

Mudslides and floods due to heavy rains across areas of Brazil during January and early February left tens of thousands of people homeless and resulted in 161 deaths. The rainy season in the Peruvian and Bolivian highlands brought heavy seasonal rainfall, hailstorms and landslides, which caused heavy damage to agricultural crops and lands and killed at least 50 people. In Haiti, torrential rainfall due to the passage of Hurricane *Jeanne* produced disastrous flooding that claimed some 3 000 lives. This disaster came in the wake of flooding and landslides that affected Haiti and the Dominican Republic in late May 2004, in which more than 2 000 people were killed and several thousand others were affected. A series of winter storms during late June and into early July 2004 brought heavy rains and produced mudslides over the Patagonia region of Chile and Argentina.

In April, a storm brought heavy rain to the south-western United States and adjoining Mexico, causing the worst flash floods in the region. In February, a winter storm brought record-breaking snowfalls and blizzard conditions in Canada. The city of Halifax recorded

Disastrous cyclone season

The 2004 tropical cyclone season over the North Atlantic and the north-west Pacific saw some of the most deadly hurricanes and typhoons responsible for more than 6 000 deaths and heavy damages to infrastructure. The 2004 cyclone season was the second costliest cyclone season after 1992 and the number of deaths due to tropical cyclones was the highest since 2000.

During the Atlantic hurricane season, 15 named tropical storms developed; the average is around 10. During August, eight tropical storms formed, which is a record for the most named storms for any month of August. Since 1995, there has been a marked increase in the annual number of tropical storms in the Atlantic Basin, which is coincident with the active phase of the Atlantic multi-decadal signal. Nine of the named storms were classified as hurricanes. Six of those were "major" hurricanes (category three or higher on the Saffir-Simpson scale). Hurricane *Ivan* was the most powerful storm to affect the Caribbean in 10 years. Hurricane *Charley* was the strongest and most destructive hurricane to strike the United States since *Andrew* in 1992. In all, nine named storms impacted the United States, causing extensive damage estimated at more than US$ 43 billion and making 2004 the costliest hurricane season in the United States on record. Atlantic tropical cyclones were directly responsible for more than 3 000 deaths in 2004; the vast majority were in Haiti due to floods from Hurricane *Jeanne*.

Conversely, in the eastern North Pacific, tropical cyclone activity was below average. Only 12 named storms developed during the year, compared to an average of 16. Out of those 12 storms, six reached hurricane strength and three reached "major" status. None of the cyclones made landfall as a tropical storm or hurricane.

In the South Atlantic Ocean, sea-surface and atmospheric conditions do not favour the formation of hurricanes. During March 2004, however, the first documented hurricane since geostationary satellite records began in 1966 developed. Unofficially named *Catarina*, it made landfall along the southern coast of Brazil (in the state of Santa Catarina) on 28 March 2004, causing great damage to property and some loss of life.

In the north-west Pacific, 29 named storms developed; the average is around 27. Nineteen of them reached typhoon intensity, which was slightly more than the long-term average. On an average, three tropical cyclones make landfall in Japan. However, in 2004, 10 tropical cyclones made landfall, breaking the previous record of six, established in 1990. Typhoon *Tokage* was the deadliest typhoon to affect Japan since 1979. Two hundred and nine people were killed in Japan by floods, landslides, strong wind and storm surge caused by the tropical cyclones. They also caused damages to infrastructures worth around US$ 10 billion. Typhoon *Rananim*, which was the most severe typhoon affecting Zhejiang, China since 1956, claimed 169 fatalities and caused damages worth over US$ 2 billion.

The South-west Indian Ocean cyclone season was also active with an above normal number of tropical storms. Tropical Cyclone *Gafilo*, which is responsible for 237 deaths, was the strongest to affect Madagascar in 10 years. The tropical storm *02B* made landfall on the coast of Myanmar on 19 May, which caused 200 fatalities. However, tropical cyclone activity over the South Pacific/Australian region was suppressed.

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record-breaking snowfalls and blizzard conditions in Canada. The city of Halifax recorded 88.5 cm of snow on 19 February, which doubled the previous record for a single day. In July, torrential rain and hail deluge due to a storm resulted in horrendous flash floods in Edmonton and Peterborough, which are estimated to be the worst in 200 years.

Severe winter weather also affected much of western and northern Europe during the last week of January with heavy accumulations of snow reported in parts of the United Kingdom, France, Germany and Denmark. In April, heavy long rains caused flooding in some parts of western Siberia. In northern Caucasus, hundreds of buildings, bridges and motorways were heavily damaged; crop production has also been affected. In November, an early season winter storm brought record-breaking heavy snowfall and strong winds across much of the Scandinavian region and central Europe causing heavy damages.

Heavy rains from mid-January to March in areas of Angola produced flooding along the river system, which flows into neighbouring Zambia, Botswana and Namibia. Extensive flooding along the Zambezi River, the worst flooding since 1958, threatened more than 20 000 people in north-eastern Namibia and caused extensive damage to crops.

Rainfall was above normal over most of the western and central Australian tropics during the 2003–2004 tropical wet season (October–April). In some parts of the Northern Territory, it was the wettest rainy season on record. A series of strong storms during February produced heavy rainfall and damaging floods in southern parts of New Zealand's North Island.

WEAK EL NIÑO CONDITIONS

Sea-surface temperature and sea-level atmospheric pressure patterns in the tropical Pacific at the beginning of 2004 reflected near-neutral *El Niño* conditions. However, the increase and eastward expansion of anomalous warmth in the central and east-central equatorial Pacific during July–December indicated weak *El Niño* conditions. Since the last week of July, SSTs over the equatorial central Pacific region were approximately 0.8°C above average. However, the pattern of above-average SST anomalies was focused only near the dateline. The eastern Pacific, which is usually instrumental in the development of an *El Niño* event, remained largely neutral throughout 2004. The Tahiti-Darwin Southern Oscillation Index was negative since June 2004, but fluctuated considerably. The large-scale atmospheric changes expected during an *El Niño* event were however conspicuously absent during this episode.

ANTARCTIC OZONE HOLE

Extensive ozone depletion was observed over Antarctica during the southern hemisphere winter/spring of 2004. This year, the Antarctic ozone hole area (defined as the area covered by extremely low ozone values of less than 220 Dobson Units) reached maximum size of 19.6 million km^2 in mid-September. Except for the year 2002, when the ozone hole split into two, the October ozone hole this year was the smallest observed in more than a decade. The ozone hole in 2004 dissipated earlier than usual, in mid-November.

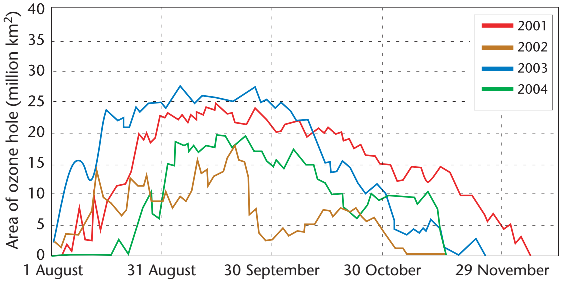


Figure 7 (Left) — Daily size of the Antarctic ozone hole (in million square km) from 1 August to 15 December for the period 2001–2004 using total ozone observations from NOAA's solar backscatter ultraviolet (SBUV/2) instrument on board NOAA's polar-orbiting satellites (Source: Climate Prediction Center/ NOAA, United States).

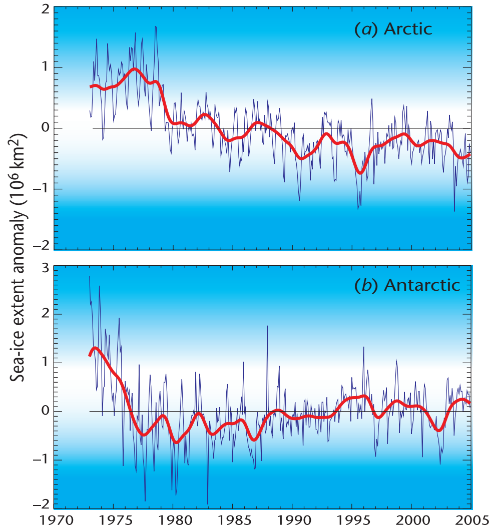


Figure 8 (Right) — Monthly sea-ice extent anomalies for 1973–2004 (departures in millions of km² from the average in the 1973–2004 base period) for (a) the Arctic and (b) the Antarctic. The values are derived from satellite passive microwave sounder data (Source: Hadley Centre, The Met Office, UK).

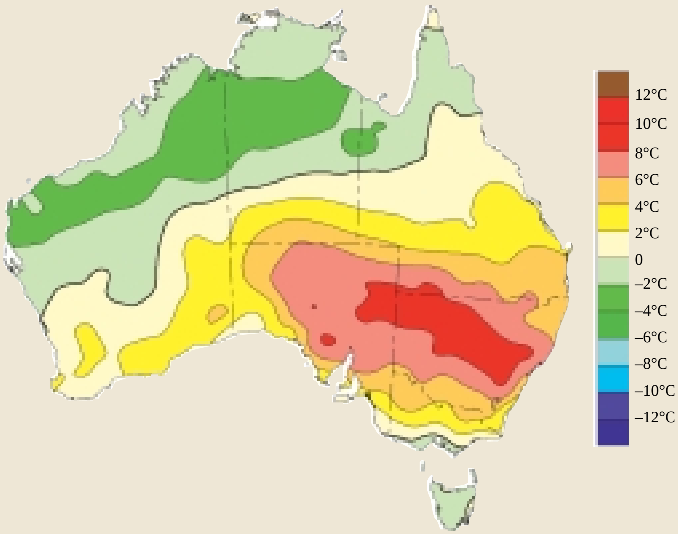
Variations in size, depth and persistence of the ozone hole are due to year-to-year changes in the meteorological conditions in the lower stratosphere, rather than to changes in the amount of ozone-depleting substances present in the ozone layer. Measurements show that most of these substances are decreasing in the lower atmosphere. However, chemicals already in the atmosphere are expected to continue to impact the ozone concentration for many decades to come. Continued monitoring and measurements are essential to achieve the understanding needed to identify ozone recovery.

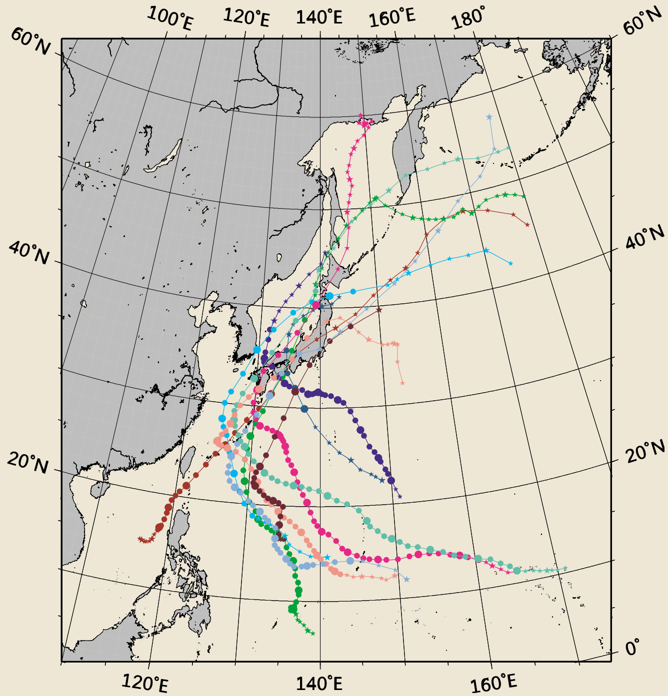
ARCTIC SEA-ICE

In 2004, sea-ice extent in the Arctic remained well below the long-term average. In September 2004, it was about 13 per cent less than the 1973–2003 average. Satellite information suggests a general decline in Arctic sea-ice extent of about 8 per cent over the last two-and-a-half a decades. This is the third year in a row with extreme sea-ice losses. The September sea-ice deficit was especially evident in extreme northern Alaska and eastern Siberia. Sea-ice extent responds to a variety of climatic factors. While natural variability is responsible for year-to-year variations in sea-ice extent, three extreme minimum extent years along with the evidence of thinning of the ice pack suggest that the sea-ice system is experiencing changes not solely related to natural variability.

CONCLUDING REMARKS

According to the third IPCC Assessment Report the duration, location and frequency of extreme weather and climate events are likely to change, and would result in mostly adverse impacts on biophysical systems. The IPCC also notes that for certain extreme phenomena there is currently insufficient information to assess recent trends, and climate models currently lack the spatial detail required to make confident projections. Therefore the linkages between climate variability and climate change and patterns of natural hazards remain a research topic that needs to be further investigated by the scientific community.





For information about WMO, please contact:

Communications and Public Affairs Office
World Meteorological Organization
7*bis*, avenue de la Paix
P.O. Box 2300
CH-1211 Geneva 2, SWITZERLAND
Tel: (+41-22) 730 83 14 / 730 83 15
Fax: (+41-22) 730 80 27
E-mail: cpa@wmo.int
Web: http://www.wmo.int

For more information about the contents of this brochure, please contact:

World Climate Programme Department
World Meteorological Organization
7*bis*, avenue de la Paix
P.O. Box 2300
CH-1211 Geneva 2, SWITZERLAND
Tel: (+41-22) 730 83 77
Fax: (+41-22) 730 80 42
E-mail: wcdmp@wmo.int
Web: http://www.wmo.ch/web/wcp/wcp_prog.htm