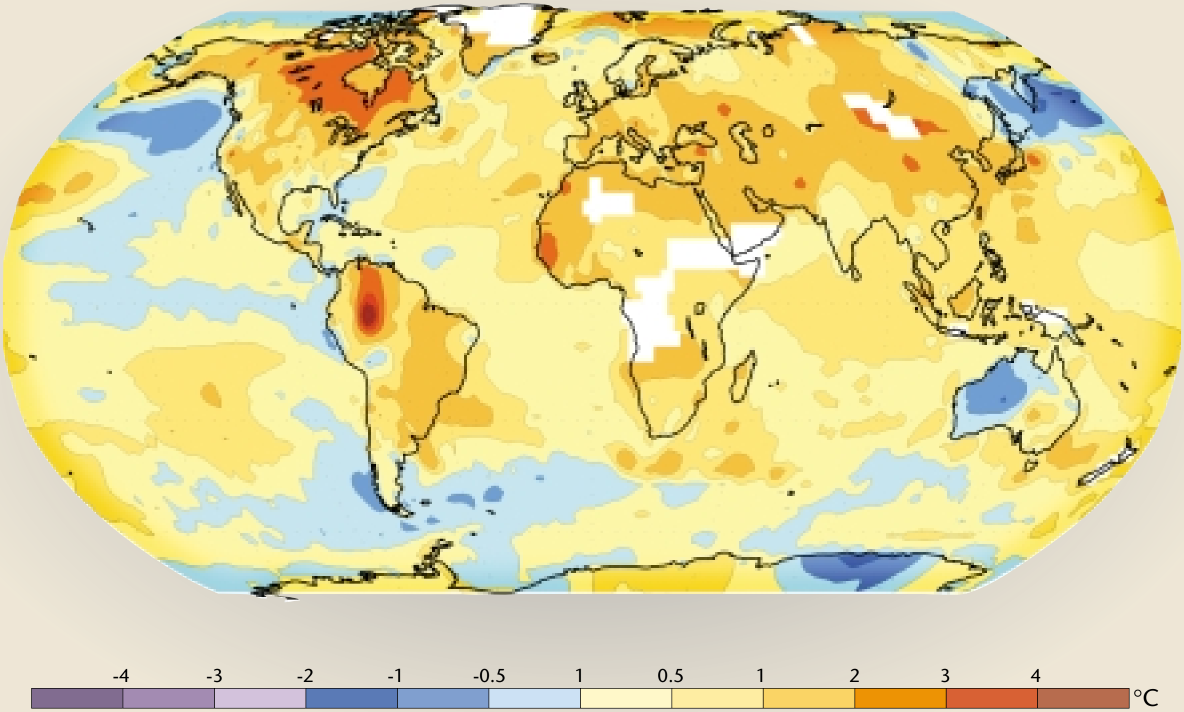
WMO STATEMENT ON THE STATUS OF THE GLOBAL CLIMATE IN 2001



World Meteorological Organization

WMO-No. 940

WMO-No. 940

ISBN 92-63-10940-0

Front cover: *Mean annual surface temperature anomalies* (°C) *for* 2001. *Anomalies are based on station data over land and sea-surface temperature data over water and are departures from a* 1961–1990 *base period. Yellow to red indicate areas of the world that were warmer than the* 30*-year average in* 2001 *while blue indicates the regions that were cooler than average. White areas on the map indicate an insufficient amount of data necessary for determining an anomaly.* (Source: Climate Prediction Center/NOAA)

Back cover:
(a) *Monthly values of the Southern Oscillation Index (the normalized difference in surface air pressure between Darwin and Tahiti) and smoothed values using a five-point binomial filter.* (Source: National Climate Centre, Bureau of Meteorology, Australia);
(b) *January–May* 2001 *accumulated precipitation anomalies (departures in millimetres from a* 1979–1995 *base period). Green indicates areas that received above-average precipitation during the January–May* 2001 *period and brown areas indicate those areas of the world that were drier than average. White areas indicate those regions of the world with near-average precipitation totals for the five-month period. Precipitation amounts are obtained by merging raingauge observations and satellite-derived precipitation estimates.* (Source: Climate Prediction Center/NOAA)

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 information provided by the Climate Prediction Center (CPC), the National Climatic Data Center (NCDC), and the International Research Institute for Climate Prediction in the United States, the Climatic Research Unit, University of East Anglia, United Kingdom and the Hadley Centre for Climate Prediction and Research of the United Kingdom Meteorological Office. Additional material was received from climate centres in a number of WMO Member countries including Australia, Brazil, Bulgaria, Canada, France, Germany, Iceland, India, the Islamic Republic of Iran, Jamaica, Japan, Mauritius, New Zealand, Norway, the Russian Federation and Sweden as well as the Drought Monitoring Centre in Kenya. Contributions were based on observational data collected and disseminated on a continuing basis by the National Meteorological and Hydrological Services (NMHSs) of World Meteorological Organization (WMO) Member countries.

World Meteorological Organization

Geneva - Switzerland

FOREWORD

Since 1993, the World Meteorological Organization (WMO), in cooperation with its Members, has issued annual statements on the status of the global climate. This year's statement describes the climatic conditions, including extreme weather events, for the year 2001 and provides a historical perspective on the variability and trends that have occurred since the nineteenth century. The statements complement the periodic assessments of the Intergovernmental Panel on Climate Change (IPCC) which provide valuable input to discussions leading up to, and during, the World Summit on Sustainable Development, to be held in Johannesburg, South Africa from 26 August to 4 September 2002. The Summit will review the implementation of the agreements of the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in 1992, in particular of Agenda 21. It will also identify new issues that have emerged since UNCED and determine where we need to refocus further efforts.

The information contained in this statement enhances the scientific understanding of the changes in the Earth's climate and the associated impacts that have occurred in the past, making it possible to improve on our projections of what may occur in the future. Through continuing research and the collection of consistent and complete observations by WMO and its Members, progress towards an even better understanding of the Earth's climate system is possible.

The year 2001 marked the end of the long-running *La Niña* episode that began in mid-1998. Prolonged drought, at least partly attributable to this cold episode, occurred in southern central Asia, parts of Africa and the Gulf Coast of the United States, affecting millions of people over the past three to four years. As indications of the next *El Niño* episode develop, the analyses of past warm episodes will provide a strong basis for an improved awareness of the type of climate extremes and impacts that may lie ahead. WMO is committed to lead, therefore, not only in providing the basis for early warnings of extreme weather and climate events, but also in assessing their effects and consequences as they occur.

The warming in the equatorial Pacific due to the dissipating *La Niña* contributed to making the 2001 global mean temperature the second warmest on record. In the northern hemisphere extratropics it was the warmest year since global observations began in 1861, and the temperature in the southern hemisphere extratropics was as warm as any previously measured. The global mean temperature has increased at a rate of 0.6°C per century since 1900; since 1976, temperatures have risen approximately three times faster.

The variability attributable to natural climate processes and phenomena such as the *El Niño*/Southern Oscillation, as well as to the effects of a warming climate that has a significant anthropogenic component, results in numerous weather- and climate-related disasters each year. Adequate preparation and response to these events require improved observing systems and active climate monitoring and research programmes to support Governments and world decision makers in industry and commerce in determining the right responses to enormously challenging problems. WMO remains committed to providing the lead in ensuring that this essential support is available, including the basic infrastructure on which it depends.

(G. O. P. Obasi)
Secretary-General

GLOBAL TEMPERATURES DURING 2001

The global mean surface temperature was 0.42°C above the 1961–1990 climatological normal in 2001 (Figure 1), the second warmest year since global surface records began in 1861. Without the persistent cooling influence of a strong *La Niña* in the central and eastern equatorial Pacific, temperatures in the tropics (20°N–20°S) were the warmest since the 1997–1998 *El Niño* episode, 0.28°C above average. Although 1998 was the warmest year on record for the globe, the 2001 surface temperature in the northern extratropics (north of 20°N) was the highest on record, 0.67°C above average. Temperatures in the southern extratropics (south of 20°S) equalled the record warmth of 1998 (0.30°C above average). The widespread nature of the anomalous warmth is evident in Figure 2. Temperatures estimated to be within the warmest 10 per cent of climatological occurrence covered a large part of the northern hemisphere with the most widespread area of anomalous warmth stretching from the eastern North Atlantic across southern Europe into central Asia and the western Pacific.

REGIONAL TEMPERATURE ANOMALIES

A notable departure from the pattern of above-average temperatures occurred during the boreal winter (December–February). Temperatures were more than 1°C below average across a large part of the United States and were more than 3°C below average over much of the Russian Federation. During a two-week period in January, minimum temperatures near –60°C occurred

La Niña comes to an end

The long-running cold episode (*La Niña*) that began in mid-1998, immediately following the end of the very strong 1997–1998 warm episode, ended during the 2001 northern hemisphere summer. During this three-year period, there was considerable seasonal variability in the strength and extent of the accompanying oceanic and atmospheric anomalies. Cold episode conditions were strongest during the northern hemisphere winter, followed by a weakening of the cold episode during the northern hemisphere spring. The cold episode conditions were weakest during June–September 1999 and 2000 before finally ending by the northern hemisphere summer of 2001. Indicators of a transition to *El Niño*, including positive sea-surface temperature anomalies in the central equatorial Pacific and the eastward expansion of warmer-than-normal subsurface waters beyond the Date Line, were becoming evident by year's end.

During the period January–May 2001, precipitation anomalies consistent with past cold episodes were confined to regions in the tropics and subtropics extending from the eastern Indian Ocean eastward to the central Pacific and along the Gulf Coast of the United States. Positive precipitation anomalies were observed over Indonesia, the eastern half of the tropical Indian Ocean, southeastern Asia, northern Australia, and the western and central subtropical South Pacific. This enhanced rainfall occurred during the rainy season in each of these areas, in association with a *La Niña*-related enhancement of the regional monsoon system.

In contrast, significantly below-average rainfall was recorded over the central and western-central tropical Pacific in response to the *La Niña*-related suppression of tropical convection in that region. In the extratropics, the Gulf Coast of the United States also experienced below-average rainfall during the January–May period. Long-term dryness affected this region from late 1998 to early 2001 in association with the persistent *La Niña* episode. Rainfall was above-normal during the June–October 2001 period (see related figures on back cover).

across central and southern Siberia (Figure 3). More than 100 deaths resulted from hypothermia in the Moscow region alone during the long winter season. Northern India also endured extreme cold in January contributing to more than 130 deaths. In Bolivia, anomalously cold temperatures and snowfall affected a large part of the Andean nation in late June and were associated with several deaths in the cities of La Paz, El Alto and Tarija.

Extremes in Sweden included record lows for the month of February in the province of Dalarna (–44°C) and for the month of April in Kvikjokk in Lapland (–26°C). However, the winter season was warmer than average for the country as a whole; the annual average temperature was 0.7°C above normal. The average temperature in Norway was 0.3°C above normal, temperatures were the warmest since 1991 across most of

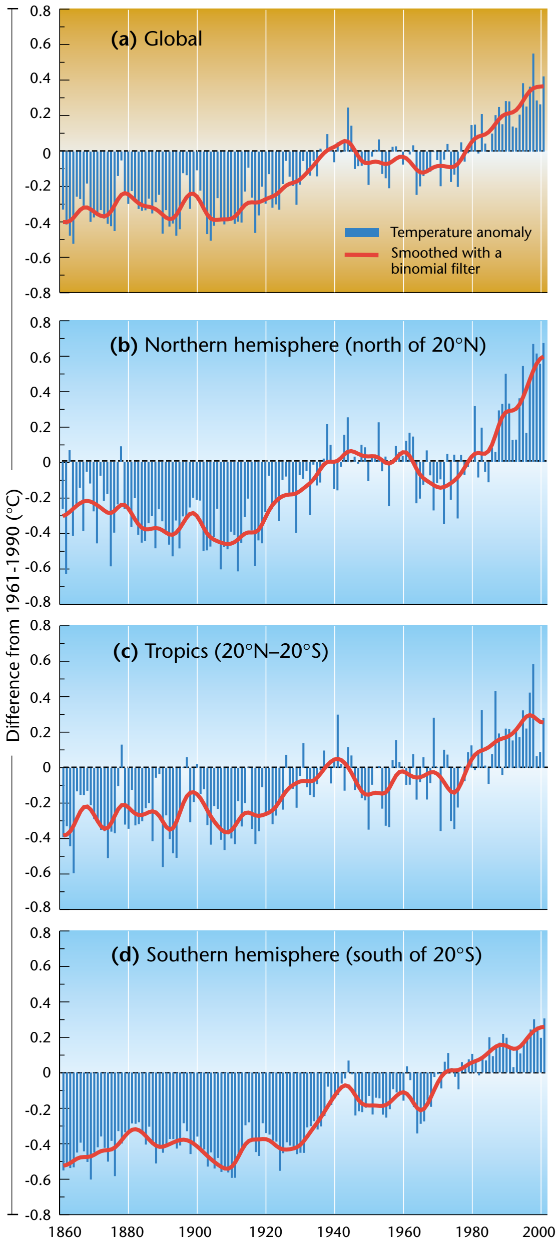


Figure 1: Combined annual land-surface air and sea-surface temperatures from 1861–2001, relative to 1961–1990 for the globe (1a); for the northern hemisphere north of 20°N (1b); for the Tropics (20°N–20°S) (1c); and for the southern hemisphere south of 20°S (1d). The solid curves have had subdecadal timescale variations smoothed with a binomial filter. Anomalies (in °C) for 2001 are +0.42 (1a); +0.67 (1b); +0.28 (1c); and +0.30 (1d). (Sources: IPCC, 2001 and Climatic Research Unit, University of East Anglia and Hadley Centre, The Met Office) NOTE: Some differences in annual anomalies exist between this and previous WMO statements. The analysis techniques used in the creation of these time series include increased quality control of observational data as well as variance corrections and optimal averaging.

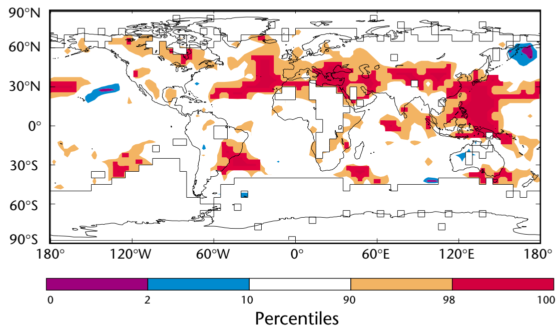
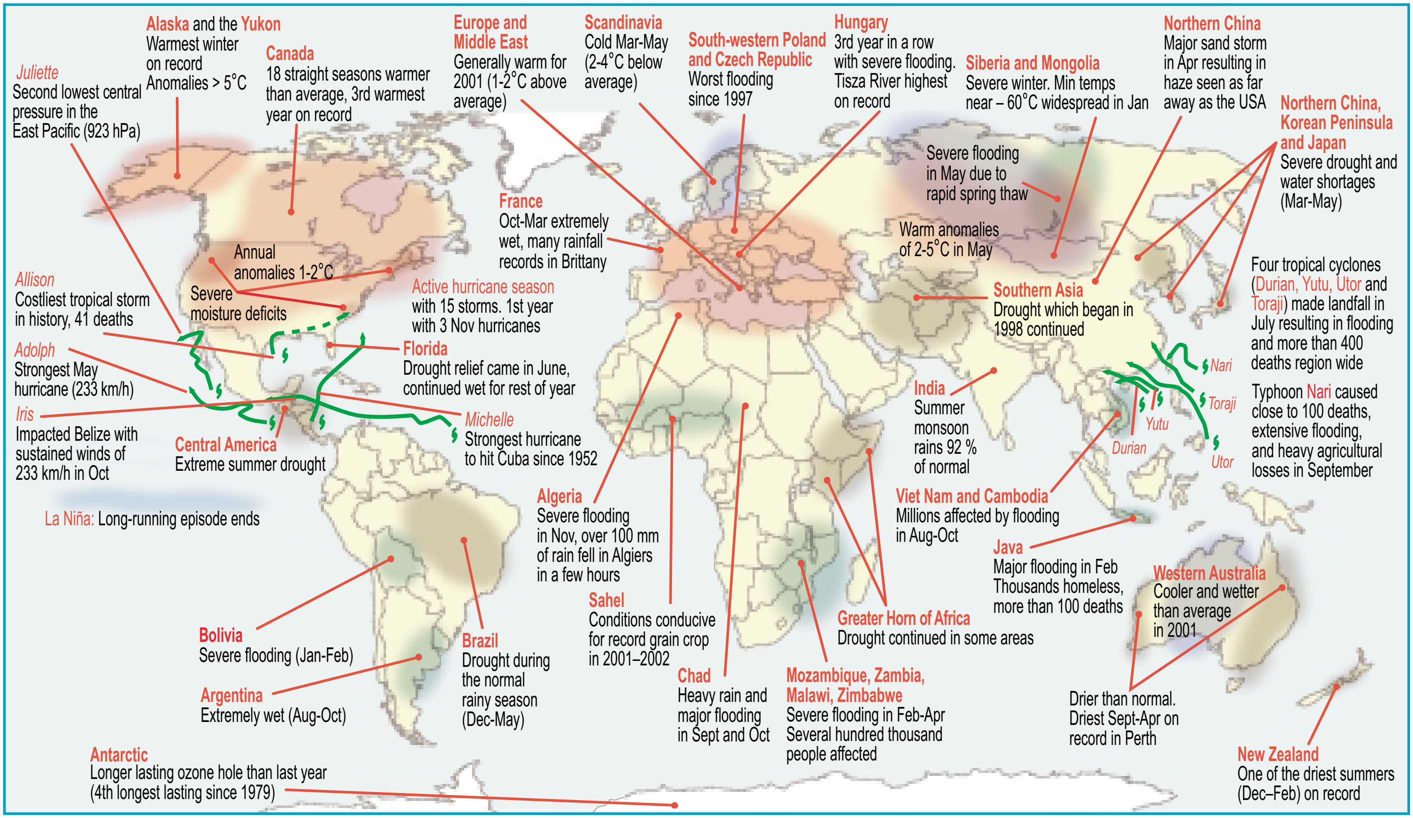


Figure 2: Global annual temperature anomaly percentiles for 2001 based on gamma distribution for the 1961–1990 normal period, in five-degree grid boxes. Shading in orange and red indicate regions where the temperature anomalies were estimated to be within the warmest 10 and 2 per cent, respectively, of climatological occurrences. Shading in blue and purple indicate the coldest 10 and 2 per cent, respectively. Grid areas without sufficient data for analysis are shown as empty boxes. (Source: Hadley Centre, The Met Office)

Iceland, and France recorded its sixth warmest year since 1949. A new record high December temperature for Iceland was established on 13 December when the temperature reached 18.4°C along the northern coastal region of the country. In the 343-year central England temperature series, October 2001 was the warmest October. The warmest October in more than 100 years of national records was also observed in Denmark and Germany, with temperatures in Germany as much as 4°C above average.

Anomalously warm Canadian temperatures continued throughout 2001 (Figure 4), extending a string of warmer than average seasons to 18 dating back to June–August 1997. Although an unusually cold and snowy winter occurred in much of eastern Canada, the average annual temperature for the country as a whole was 1.7°C above normal, tying with 1999 as the third warmest year since national records began in 1948. In the United States, the year ended with near-record warmth and was the sixth warmest in the 107-year record. The November–December 2001 temperature was only slightly less than the record warm November–December that occurred in 1999. This same two-month

Figure 3: Significant climatic anomalies and episodic events during 2001. Average global temperature was second warmest on record. There has been a rise in global temperature of 0.6°C since 1900. (Source: National Climatic Data Center, NOAA)



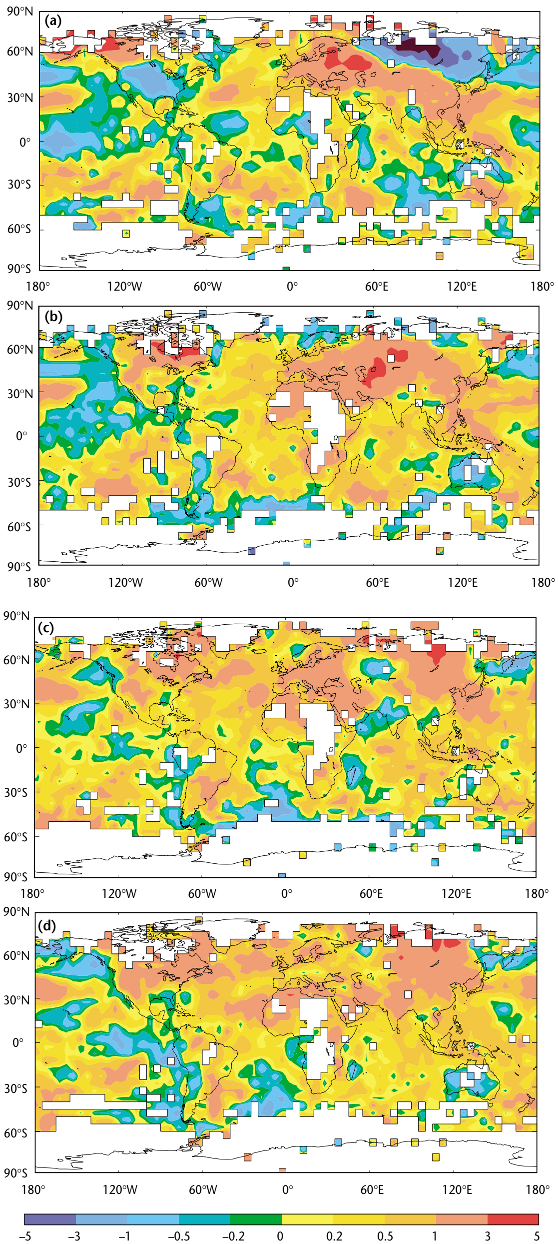


Figure 4: Global surface temperature anomalies (°C) for three-month periods December 2000–February 2001 (4a); March–May 2001 (4b); June–August 2001 (4c); and September–November 2001 (4d). Areas with insufficient data for the calculation of anomalies are shown as empty grid boxes. Anomalies are departures from the 1961–1990 reference period means. (Sources: Climatic Research Unit, University of East Anglia and Hadley Centre, The Met Office)

period was the coldest on record in 2000. In Japan, the average temperature was 0.18°C above normal, the twelfth warmest year since 1898. For the third consecutive year, the annual mean temperature was near normal in Australia.

FLOODING AND OTHER PRECIPITATION ANOMALIES

La Niña was a dominant influence in northern and central Australia in early 2001, with much above-average rainfall across the region, but its end brought a return of generally near normal rainfall to much of the country. Brief periods of heavy rainfall led to flash flooding in some areas. Alice Springs received 240 mm of precipitation in a four-day period in January, only 40 mm less than the annual average. Above-average rainfall continued in much of England and Wales during the first three months of the year making the 24-month period ending in March 2001 the wettest in the 236-year England and Wales precipitation time series. In Brittany, France, October 2000 to March 2001 precipitation totals were exceptional. The normal annual rainfall was exceeded by 20 to 40 per cent in parts of that region during the six-month period and new winter (October–March) rainfall records were established in many locations including Rennes (721 mm) and Brest (1 260 mm).

A third consecutive year of severe flooding occurred in parts of eastern Europe. In March, the rain-swollen Tisza River rose to 7.6 m in Zahony, Hungary, reaching its highest level since 1888. In July, the worst flooding to affect Poland since 1997 occurred as two weeks of heavy rains caused flooding along the Vistula River, displacing 140 000 people from towns and villages in southern and south-western Poland. Flood waters killed at least 52 people in Poland and 39 in the Czech Republic. Areas of northern Iran also experienced devastating flooding from a single August storm that resulted in at least 183 deaths in the provinces of Golestan and Khorassan.

In Siberia, rainfall and a rapid spring thaw following an anomalously cold winter resulted in widespread flooding. Temperatures of 2–5°C above average in May accelerated snowmelt causing ice-jammed rivers to overflow their banks. The homes of more than 300 000 people were lost or damaged in the Siberian republic of Yakutia, including 14 000 in the city of Lensk. Spring flooding also occurred in the upper Midwest region of the United States as a result of rapidly melting snow combined with heavy rain from a series of storms. Boat and barge traffic was closed along a 640-km stretch of the Mississippi River, and a state of emergency was declared in many areas. Three consecutive months of above-average precipitation in Argentina and adjacent areas of Uruguay from August to October led to flooding in the Pampas region, inundating more than 3.2 million hectares of agricultural land. Buenos Aires reported almost 250 mm of rainfall in October, more than twice the normal amount. Parts of Bolivia also received heavy rainfall that caused flooding in early 2001. More than 40 lives were lost and thousands were left homeless.

Heavy rainfall and flooding in the southern African countries of Mozambique, Zimbabwe, Malawi and Zambia during February–April caused at least 200 deaths, destroyed crops and left hundreds of thousands homeless. In western Africa, heavy rains fell in September bringing the worst flooding in 10 years along the Niger River in Guinea. Nearly 70 000 people were affected with 17 000 hectares of agricultural land submerged. Thousands of homes were also damaged or destroyed and at least 100 people killed in Chad as the Logone, Chari and Batha Rivers overflowed their banks. Algeria's worst flooding in almost 40 years killed hundreds of people in Algiers in November. More than 100 mm of rain fell in the span of a few hours, exceeding the normal monthly total for the city.

Torrential rains occurred in Java, western Indonesia, in February producing flooding and devastating landslides in at least 19 districts leading to great loss of life and reports of more than 20 000 homes and thousands of hectares of rice fields destroyed. In Vinh, Viet Nam, 685 mm of rain fell in one-week in late October, contributing to flooding in the Mekong Delta region that caused at least several hundred deaths between August and October. This followed some of Viet Nam's worst flooding on record in 2000.

Annual precipitation anomalies across the land areas of the world are shown in Figure 5.

HURRICANES AND TYPHOONS

Numerous tropical systems also contributed to widespread flooding and loss of life and property in 2001. There were 15 named storms in the north Atlantic Basin, five more than the long-term average. Nine storms reached hurricane strength with four becoming major hurricanes (category 3 or higher, winds stronger than 179 km h^{-1}), continuing a period of greater hurricane activity that began in 1995. A total of 26 tropical cyclones formed in the western tropical Pacific in 2001, slightly less than the 1971–2000 average of 27, and five storms reached tropical

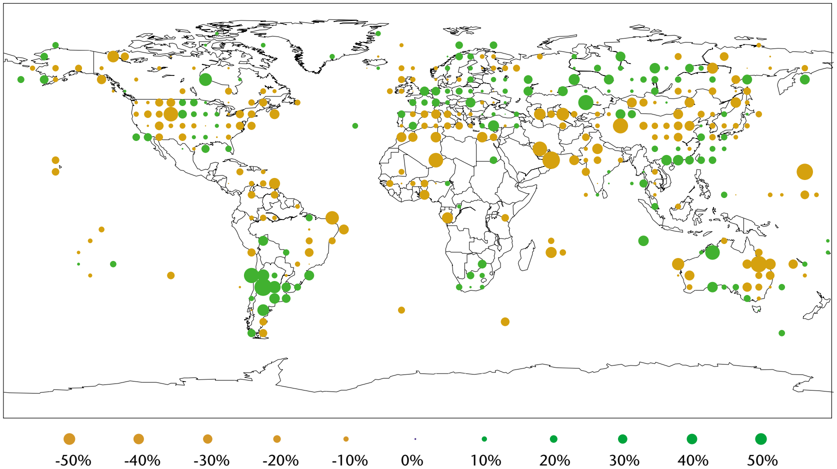


Figure 5: Global annual precipitation anomalies for five-degree grid squares, based on the 1961–1990 normal period. Anomalies are expressed as per cent departures from normal. The data source is the surface baseline climate dataset of the Global Historical Climatology Network (GHCN). The magnitudes of the anomalies are depicted by the areas of the circles. Green indicates above-normal, while brown indicates below-normal precipitation. Areas without circles reflect insufficient data for the calculation of anomalies. (Source: National Climatic Data Center, NOAA)

storm intensity in the south-west Indian Ocean, half the normal number. The 2000–2001 south-west Pacific tropical cyclone season was the least active since 1994–1995, partly as a result of enhanced trade winds and higher than normal mean sea-level pressures in a band centred on 40°S. Only five named storms developed with none resulting in severe property damage or deaths.

In June, slow-moving Tropical Storm *Allison* brought more than 750 mm of rain to several locations in south-eastern Texas. The slow movement and eventual track of *Allison* across the southern and eastern United States resulted in extensive flooding and caused at least 41 deaths and more than US$ 5 billion of property damage, making it the costliest tropical storm on record in the United States. The tropical depression that later became Hurricane *Michelle*, produced heavy rains, flooding and 10 deaths in Nicaragua and Honduras. After gaining strength in the Caribbean, Hurricane *Michelle* severely affected the coffee crop in Jamaica before moving over Cuba in early November. It was the strongest hurricane to make landfall in Cuba since 1952, hitting the coastal islands of the country as a category 4 storm and causing at least five deaths nationwide.

The most devastating storms of the year in the western tropical Pacific included Typhoon *Chebi*, which struck the Fujian Province of China in June with maximum sustained winds near 120 km h^{-1}, causing more than 150 deaths. Although the winds of Tropical Storm *Utor* were no greater than 111 km h^{-1}, more than 100 people lost their lives when it made landfall in the Philippines in July. Another destructive July tropical cyclone, Typhoon *Toraji*, left more than 200 people dead.

WIDESPREAD AND SEVERE DROUGHT

In contrast to the widespread episodes of flooding that occurred throughout the globe, heat and a lack of adequate rainfall continued to plague many regions in 2001. Devastating drought in central and southern Asia that began in 1998 continued in 2001 over a broad region centred on Iran, Afghanistan and Pakistan. Wet season (November–April) precipitation from 1998–1999 through 2000–2001 was less than 55 per cent of average. The lack of adequate rainfall during this period (Figure 6) greatly stressed water supplies as well as agriculture and directly affected more than 60 million people. Periods of extreme heat also occurred in parts of the same region. Many heat-related deaths were associated with temperatures near 50°C in parts of Pakistan in early May. There is some evidence of a relationship between the long-term drought and the combined effects of the prolonged *La Niña* and unusually warm sea-surface temperatures in the western Pacific and eastern Indian Oceans.

Drought in parts of Kenya and neighbouring countries in the Greater Horn of Africa also continued despite one of the wettest months of January in 40 years in parts of the region. The long-season rains (March–May) were well below normal with some parts of north-eastern Kenya experiencing their driest May since 1961. The short-season rains, which usually begin in October, did not fall until November and were primarily short-lived events with very poor distribution, aggravating drought conditions that have persisted in some areas since late 1998.

Very dry conditions were also prevalent during the austral summer and autumn (December–May) over much of Brazil. Although conditions began to improve in November, hydroelectric power stations that supply energy to some of the most heavily populated regions of the country continued to be adversely affected by low water levels. Severe drought and water shortages were also reported in parts of Central America, northern China, the Korean Peninsula and Japan during the first half of the year. April precipitation was less than 40 per cent of the 1971–2000 average in much of Japan.

Precipitation totals for the period November 2000 through February 2001 were the second lowest on record in the Pacific northwest region of the United States, worsening already dry conditions in many areas and contributing to water and energy shortages in parts of the region. Conditions began to improve in late November and early December 2001 as a series of early season storms produced snow pack approaching 25 per cent of the average late season maximum in some areas. Drought conditions also affected Canada from coast to coast. A record 35 straight days with no more than 1 mm of precipitation occurred in Montreal, many regions across the south experienced their driest growing season in 34 years, and Saskatoon endured its driest year in over 100 years of record.

STRATOSPHERIC OZONE

Temperatures observed in the lower stratosphere over the Arctic region were above their long-term average for most of the winter and spring of 2000–2001. Temperatures cold enough for the formation of polar stratospheric clouds, which promote the chemical destruction of ozone, occurred only in January and the beginning of February. A sharp rise in temperature followed later in February and March. These conditions were associated with intermittently low total ozone values over the Arctic region

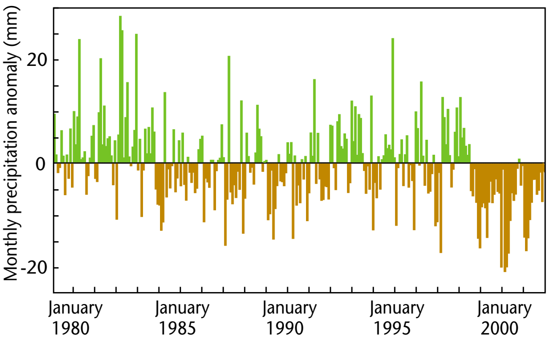


Figure 6: Monthly precipitation anomalies (mm) averaged over the region approximately 25°N–42°N, 42°E–70°E (the region that includes most of Iran, Afghanistan and Pakistan) for January 1979–December 2001. Data are from the Climate Prediction Center, NOAA. (Source: International Research Institute for Climate Prediction)

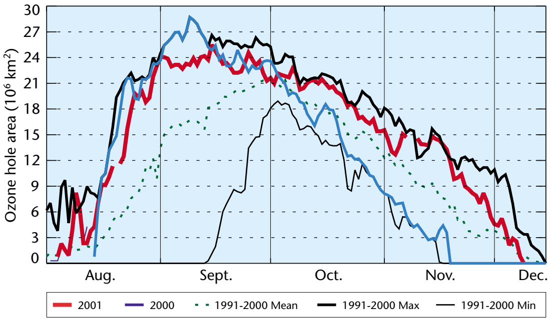


Figure 7: Daily size of the Antarctic ozone hole from August 1 through December 15 using total ozone observations from NOAA's solar backscatter ultraviolet (SBUV/2) instrument onboard NOAA's polar orbiting satellites. The red line indicates the size of the ozone hole in 2001. The size of the ozone hole in 2000 is shown in blue and the green line shows the average size during the period 1991 through 2000. The maximum and minimum sizes of the ozone hole during the same 10-year period are shown in black. (Source: Climate Prediction Center, NOAA)

during January and the first part of February and generally higher than average total ozone values throughout much of the northern hemisphere winter and spring of 2000–2001. Total ozone values in February were more than 20 per cent higher over portions of the Arctic region than comparable values during the early 1980s; December, January and March values over some Arctic areas averaged 10 to 15 per cent higher.

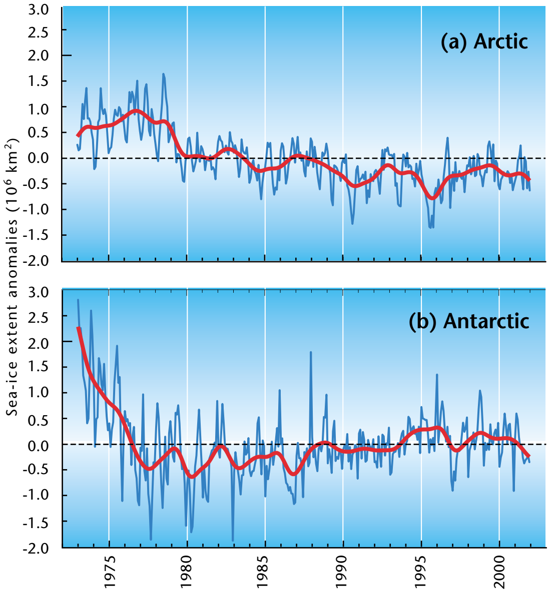
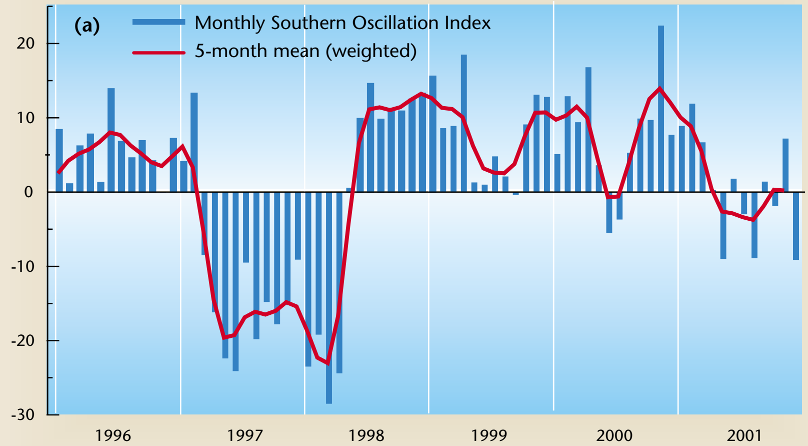


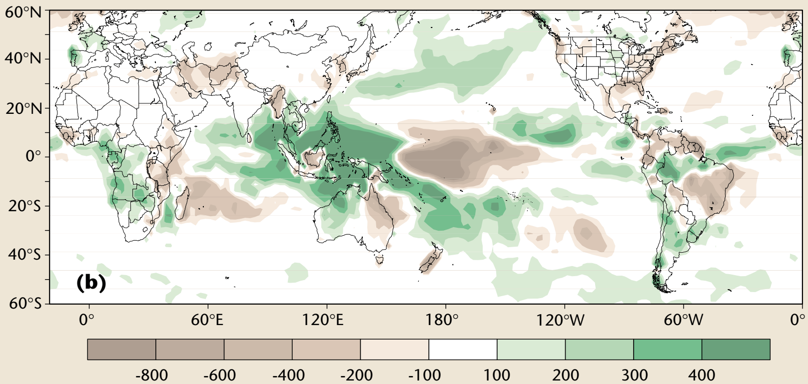
Figure 8: Monthly anomalies (millions of km²) of Arctic (8a) and Antarctic (8b) sea-ice extent for the period 1973–2001, derived from satellite passive microwave sounder data. The data source is the HadlSST1 dataset. Anomalies are with respect to the 1973–2001 period. (Source: Hadley Centre, The Met Office)

The Antarctic ozone hole covered an area of 25 million km² in 2001, slightly less than the record size of 28 million km² observed in 2000 (Figure 7). Unlike 2000, when the ozone hole was generally oblong and short lived, the ozone hole in 2001 was generally circular, centred on the South Pole, and more stable and persistent, with a period of very low ozone approximately one month longer. Total column ozone over the South Pole reached a minimum reading of 100 Dobson units, compared to a minimum of 98 Dobson units in 2000. The record low of 88 Dobson units was observed in 1993.

SEA ICE

The use of satellites has greatly aided the monitoring of Arctic and Antarctic sea-ice extent during the past three decades. Considerable year-to-year variability in sea-ice extent is evident in Figure 8. After a rapid decline in the mid-1970s, the extent of Antarctic sea-ice has shown little trend since, while an overall decline of nearly 3 per cent per decade occurred in the Arctic. Sea-ice extent remained below the long-term mean for much of 2001 in both the Arctic and Antarctic.





For information about WMO, *please contact*:

Information 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: ipa@gateway.wmo.ch
Web: http://www.wmo.ch

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@gateway.wmo.ch
Web: http://www.wmo.ch/web/wcp/wcp_prog.htm