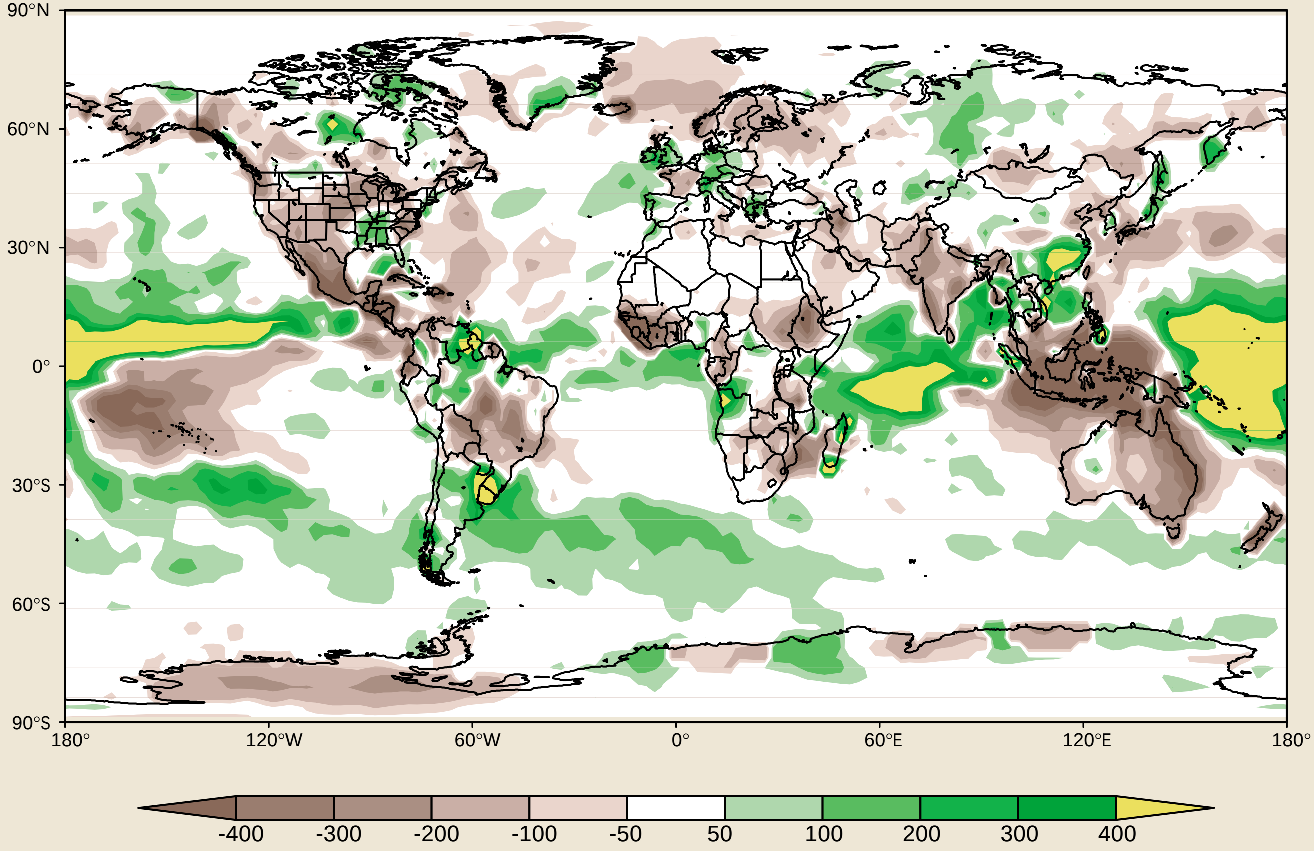
WMO STATEMENT ON THE STATUS OF THE GLOBAL CLIMATE IN 2002



World Meteorological Organization

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Front cover: Accumulated precipitation anomalies (departures in millimetres from a 1979-1995 base period) in 2002. Green indicates areas that received above normal precipitation for the calendar year 2002 as a whole while brown depicts 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 Center/NOAA)

Back cover: Ozone hole split:Southern hemisphere total column ozone on 25 September 2002 colour-coded in Dobson Units (DU). The two "holes" (ozone less than 220 DU) are shown separated by normal values of ozone.
(Source: Global Ozone Monitoring Experiment and European Space Agency - Data User Programme at the Royal Netherlands Meteorological Institute)

Australian rainfall deciles for the period March to December 2002
(Source: Australian Bureau of Meteorology)

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 Climatic Research Unit, University of East Anglia, United Kingdom and the Hadley Centre for Climate Prediction and Research of the Met Office, UK; and, in the United States, the Climate Prediction Center and the National Climatic Data Center of the National Oceanic and Atmospheric Administration (NOAA). Other contributors include the International Research Institute for Climate Prediction in New York and the WMO Member countries Algeria, Argentina, Australia, Brazil, Bulgaria, Canada, Chile, China, France, Germany, Iceland, India, Japan, Mauritius, New Zealand, Norway, the Russian Federation, Spain, Sweden and Switzerland, as well as the Drought Monitoring Centre-Kenya and the Drought Monitoring Centre-Harare.

World Meteorological Organization

Geneva - Switzerland

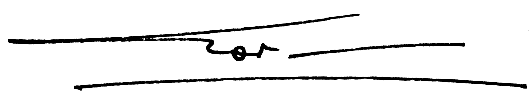
FOREWORD

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. This year's statement describes the climatic conditions, including extreme weather events, for the year 2002 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 Intergovernmental Panel on Climate Change (IPCC), which provide valuable input to national and international dialogues, such as the World Summit on Sustainable Development (WSSD), which was held in Johannesburg, South Africa from 26 August to 4 September 2002.

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 2002 bore witness to a transition from neutral to El Niño conditions in the equatorial Pacific Ocean. Though the magnitude of the episode that developed in 2002 is significantly smaller than the 1997/1998 event, many characteristic climate patterns nevertheless became evident as the 2002 El Niño matured. The warming in the equatorial Pacific contributed to making the 2002 global mean surface temperature the second highest on record. In fact, 2002 replaces the former second warmest year - 2001. In the northern hemisphere extratropics, it was the warmest year in the 1861-to-present record, supplanting 2001 as warmest. The rise in global mean surface temperature since 1900 now exceeds 0.6°C.

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. The provision of authoritative climate statements, climate assessments, climate reviews and descriptions of climate variations and their historical perspective are part of WMO's contribution to sustainable development. Furthermore, WMO support to developing countries in rescuing climate data and managing these data enables them to use climate information as a national resource for socio-economic development and poverty alleviation.



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

GLOBAL TEMPERATURES DURING 2002

The global mean surface temperature in 2002 was 0.48°C above the 1961-1990 annual average. This value places 2002 as the second warmest year in the temperature record since 1861. The warmest year remains 1998 when surface temperatures averaged 0.55°C above the same 30-year mean. The five warmest years in this period of record now include, in decreasing order: 1998, 2002, 2001, 1995 and 1997. Average annual temperature anomalies for the globe are shown in Figure 1(a), and by latitude belt in (b)-(d). For land and ocean regions poleward of 30°N, the mean temperature departure was 0.76°C, ranking as the highest on record. Across regions of the northern hemisphere mid- and high-latitudes, average surface temperatures in the last five years are the highest on record. In low latitudes (30°N–30°S), surface temperatures in 2002 rank as second highest, the highest since 1998, while for those regions poleward of 30°S, the average departure in 2002 was 0.22°C or eighth highest on record. Calculated for the entire northern and southern hemispheres separately, surface temperatures in 2002 rank as second highest in both hemispheres, with anomalies of 0.59°C and 0.36°C, respectively (not shown).

Widespread positive annual temperature anomalies, notably across much of the land masses of Africa, Asia and Europe, as well as across portions of the Indian Ocean and the central equatorial Pacific, contributed to the high global mean surface temperature ranking. In many of these regions, the mean annual temperature in 2002 for many locations met or exceeded 90 per cent of the annual

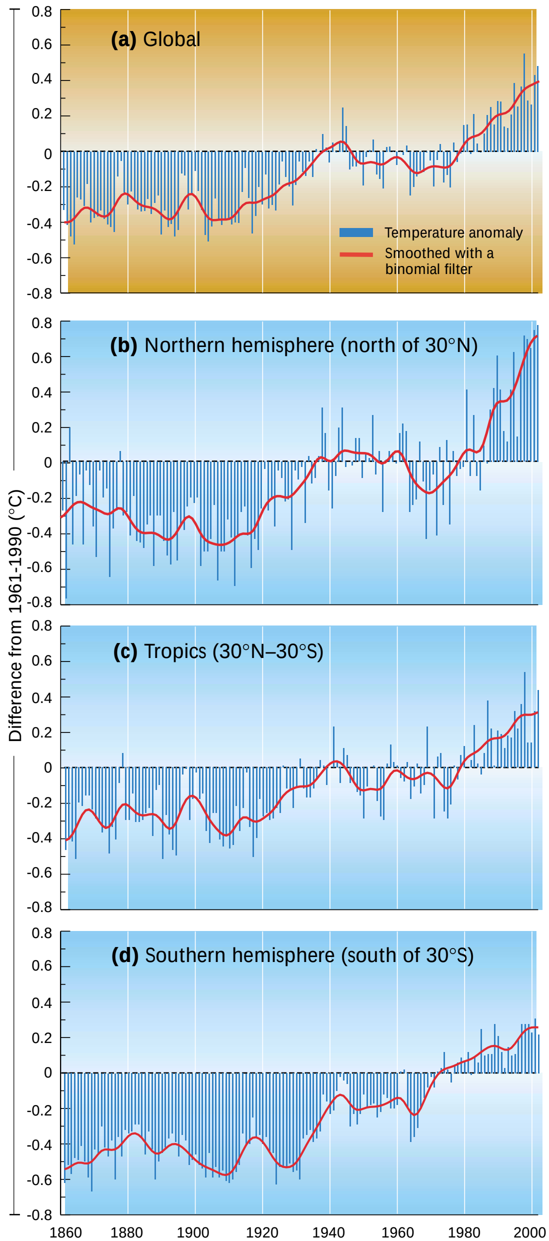


Figure 1. Combined annual land-surface and sea surface temperatures from 1861-2002, relative to 1961-1990: (a) for the globe; (b) for the northern hemisphere north of 30°N; (c) for the Tropics (30°N to 30°S); and (d) for the southern hemisphere south of 30°S. The solid curves have had subdecadal timescale variations smoothed with a binomial filter. Anomalies (in °C) for 2002 are: +0.48 (a); +0.76 (b); +0.44 (c); and +0.22 (d). (Sources: IPCC, 2001 and Climatic Research Unit, University of East Anglia and Hadley Centre, Met Office, UK)

NOTE: Some differences in annual anomalies exist between this and WMO statements prior to 2001. The analysis techniques now used in the creation of these time series include increased quality control of observational data as well as variance corrections and optimal averaging.

temperatures recorded in the1961-1990 period, as shown in Figure 2.

REGIONAL TEMPERATURE ANOMALIES

Widespread warmer than normal conditions for the year as a whole occurred across much of Europe and Asia. However, persistent cold temperatures were widely observed across eastern Europe and northern Asia in December. Across Norway, Sweden and Finland, the period January through September was warmer than average, especially in summer when record warmth was experienced in both Norway and Sweden. The period following September, however, was cold. The three-month period from October to December was the coldest since 1981 in Norway (see Figure 3). The onset of the 2002/2003 winter was reported to be the coldest in two decades in Moscow, and temperatures as low as minus 30°C were observed in Poland. Persistent high temperatures were observed during June in Switzerland.

Abnormally high temperatures were observed during April across India and a prolonged heatwave over northern regions from mid-April through the third week of May caused

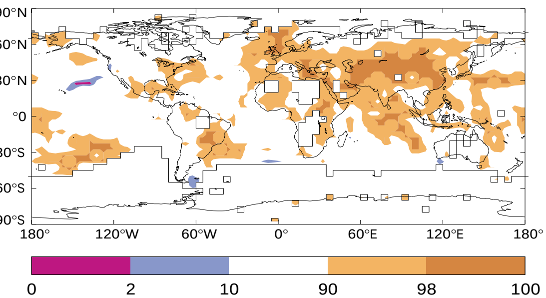


Figure 2. Global annual temperature anomaly percentiles for 2002 based on a gamma distribution for the 1961-1990 normal period, calculated in five-degree grid boxes. Shading in orange and red indicates regions where the temperature anomalies were estimated to be within the highest (warm) 10 and 2 per cent, respectively, of the climatological occurrences. Shading in blue and violet indicates 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, Met Office, UK)

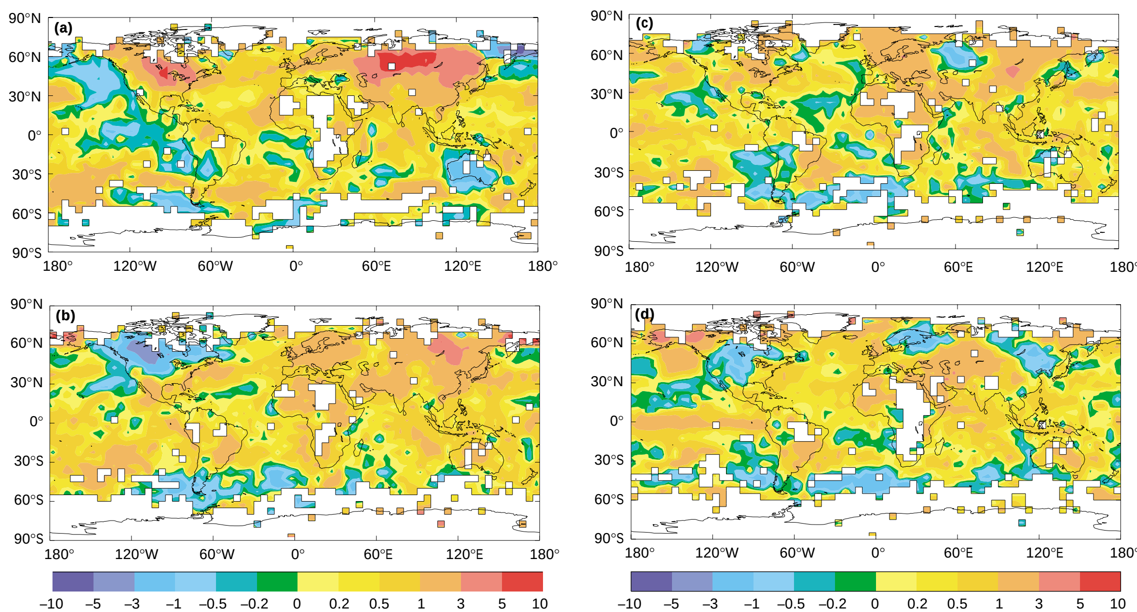


Figure 3 (far right). Global surface temperature anomalies (in °C) for three-month periods: (a) December 2001-February 2002; (b) March-May 2002; (c) June-August 2002; (d) September-November 2002. (Source: Climatic Research Unit, University of East Anglia and Hadley Centre, Met Office, UK)

Return of El Niño conditions

In the equatorial Pacific, sea surface temperature and sea level atmospheric pressure patterns at the beginning of 2002 reflected near neutral El Niño/Southern Oscillation (ENSO) conditions, though indications of a developing warm episode were evident. By March 2002, sea surface temperatures across much of the eastern equatorial Pacific were increasing and the Tahiti-Darwin Southern Oscillation Index (SOI) was negative. The magnitude of sea surface temperature anomalies increased after May in the central and eastern tropical Pacific and the atmosphere began to display circulation characteristics typical of warm episodes (El Niño), including a reduction in the strength of the easterly trade winds and a more negative SOI. The SOI remained negative for the rest of the year and sea surface temperatures remained higher than average across much of the central and eastern equatorial Pacific.

The El Niño episode that developed during 2002 was significantly smaller than the 1997/1998 event. Nevertheless, the transition from neutral to El Niño conditions was accompanied by a coincident transition in climate anomalies in many regions. Between January and May, the South Pacific Convergence Zone (SPCZ) was active and south of its climatological position, and nations in the northern southwest Pacific experienced normal to below normal rainfall. With the warming of sea surface temperatures in the central equatorial Pacific in May, and the weakening of the near-equatorial trade winds in June, a rapid shift toward wetter than normal conditions occurred in the northern Southwest Pacific. The SPCZ shifted northwards, becoming north of its climatological position by September when some stations in Kiribati received rainfall in excess of 10 times the average monthly rainfall. In contrast, Indonesia, Papua New Guinea, New Caledonia, Tonga, Niue and the southern Cook Islands recorded well below average precipitation in some or all of the months following May. In Australia, near normal rainfall and cooler than normal temperatures in January and February gave way to drier and warmer than normal conditions thereafter. On the eastern side of the Pacific, the impact of the return to El Niño conditions was also evident. Rainfall was above average along the southwest coast of South America during the (austral) winter and spring and one of the world's driest places, Arica, Chile, recorded 8.3 mm of rain on 3 July, the greatest amount in records that date to 1908. Wetter than normal conditions coincident with the maturing El Niño occurred across parts of Ecuador and northern Peru as well as the southeastern United States, while drier than normal conditions became more prevalent across much of central and northeastern Brazil (see Figure 4).

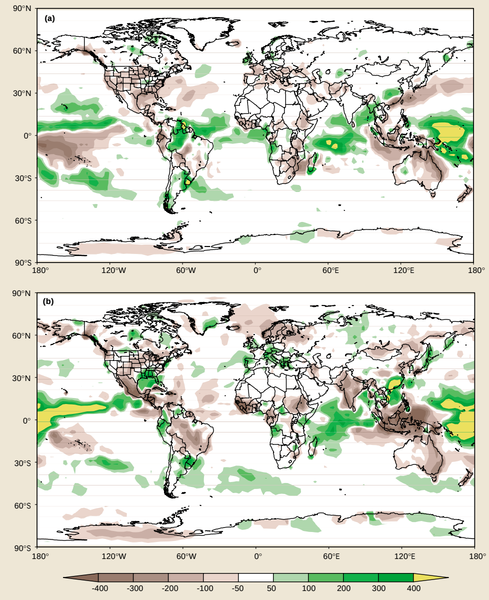


Figure 4. Accumulated precipitation anomalies (departures in millimetres from a 1979-1995 base period). Green indicates areas that received above normal precipitation for the calendar year 2002 as a whole while brown depicts those regions of the world that were drier than normal. Areas in white show 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.(a) January through May; and (b) June through December. (Source: Climate Prediction Center/NOAA)

more than 1 000 fatalities. On 10 May, the maximum temperature at Gannavaram reached 49°C. In Algeria, temperatures were above average for much of the year. A heatwave in June was reported in central regions, and abnormally high temperatures – as high as 50.6°C – were observed in the central Sahara during June and July. Monthly mean temperatures in the East Africa region were generally higher than average for much of the year.

Higher than average temperatures were observed in 2002 across much of central and southeastern Brazil, especially during austral winter. Warm and dry conditions in central and northeastern areas promoted the occurrence of wildfires in the region.

After a mild 2001/2002 winter in many areas, especially in the Great Lakes region, Canada recorded its fifth coldest spring overall. In parts of western Canada, spring 2002 was the coldest on record. Temperatures in Alaska, USA during all seasons in 2002 were above average leading to a record warm calendar year. Australian mean maximum temperatures in 2002 were the warmest on record, while minimum temperatures were close to average. The resulting mean temperature was the fifth warmest in a period of record that dates back to 1910.

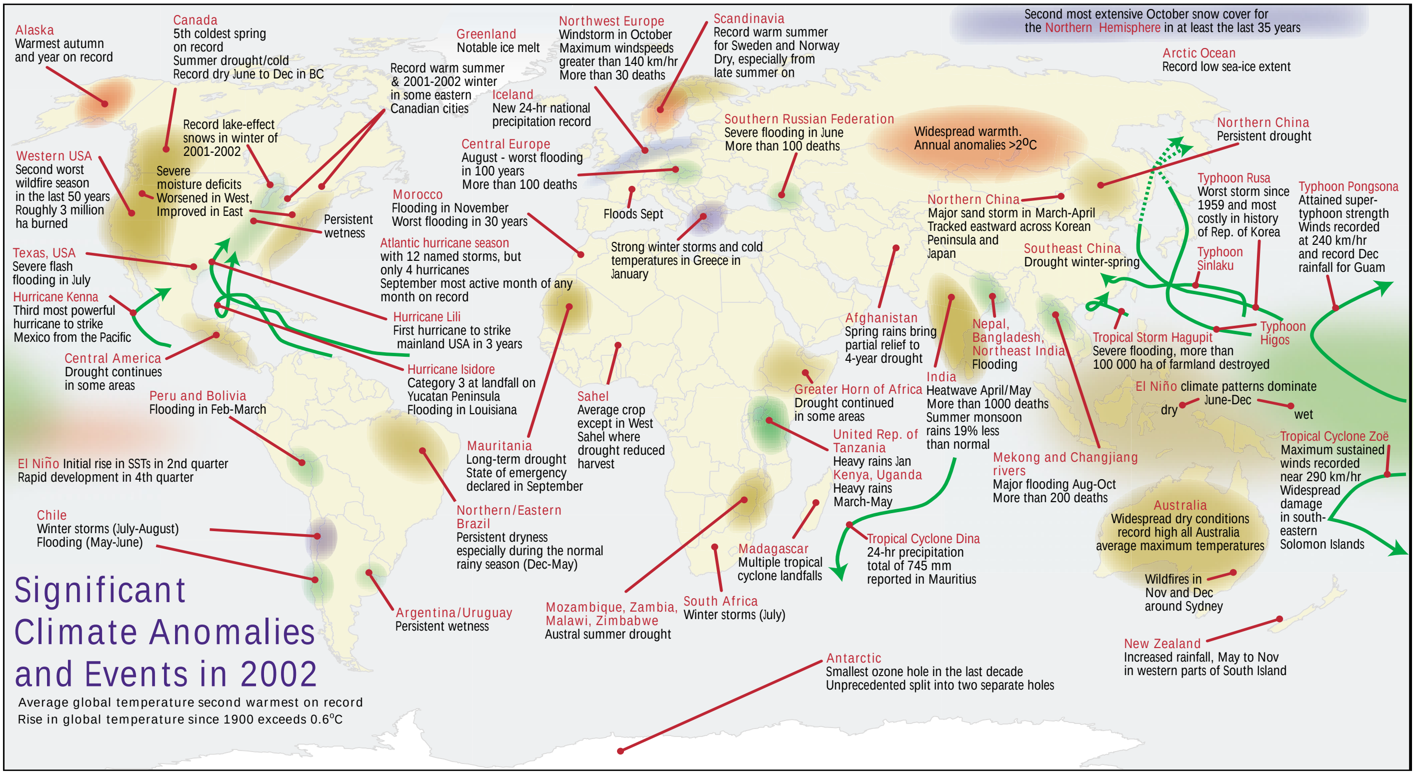


Figure 5. Significant climatic anomalies and events during 2002. (Source: National Climatic Data Center, NOAA)

DROUGHT PRESENT IN MANY REGIONS

The seasonal rainfall during the summer (southwest) monsoon (June to September) in India as a whole was 19 per cent below normal, qualifying 2002 as the first all-India drought since 1987 (Figure 5 on previous page). Rainfall deficits during July were most noteworthy, at a historical low of 49 per cent below normal. Remarkable recovery in rainfall occurred in August, which prevented the situation from becoming worse. In Afghanistan, spring rains brought some relief to the four-year drought. In parts of north and northeast China, persistent and extensive drought conditions during summer and autumn led to numerous water supply problems. Across West Africa, precipitation was below normal in the Sahel and the Guinea Coast region throughout much of their wet season. Countries in the far western Sahel, especially Mauritania, Senegal and Gambia, accumulated the greatest rainfall deficits, with some locations receiving only 25 per cent to 50 per cent of their normal rainfall by the end of September, and long-term drought conditions were present in some areas. In eastern Africa, drought conditions that date to mid-1998 continued unabated in parts of the region, especially in central and southern Ethiopia. Below to much below normal rainfall was observed from the start of the rainfall season (September to November) in parts of southern Africa including Swaziland, Lesotho, most of South Africa, southeastern Botswana, southwestern Zimbabwe, central United Republic of Tanzania and southern Malawi. Annual precipitation departures from average for the sub-Saharan region are shown in Figure 6.

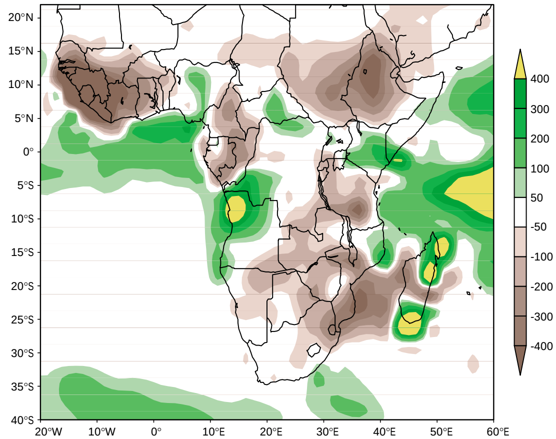


Figure 6. Accumulated precipitation anomalies (departures in millimetres from a 1979-1995 base period) in 2002 for sub-Saharan Africa. Green indicates areas that received above normal precipitation for the calendar year 2002 as a whole while brown depicts those regions that were drier than normal. Areas 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)

A period of severe drought was experienced in central European Russia from April through August, when the five-month precipitation total was one-third the 1961-1990 average, the lowest value in the period of record that begins in the late 19th century. Dry conditions beginning in the latter half of 2002 led to water shortage problems for hydropower generation in Norway, Sweden and Finland. For the second consecutive boreal summer, dry conditions were experienced across much of Central America and Mexico. As in the case of the severe drought during summer 2001, the countries most affected in 2002 were Honduras, Nicaragua, El Salvador and Guatemala where significant agricultural impacts were reported. Moisture deficits present at the end of 2001 across much of western Canada and the United States were exacerbated by less than normal precipitation during winter and spring 2002. In Canada, drought particularly affected central and northern areas of the Prairie Provinces, somewhat north of the region most affected in 2001. In the United States, while drought conditions worsened in the west, significant improvement was seen in the east. The persistent dry conditions in the western United States contributed to the second most severe wildfire season in history and severe to extreme drought conditions remained throughout the year across much of the Intermountain West. Dry conditions were experienced in Australia throughout the period March to December. During that time, 97.3 per cent of the Australian continent experienced below median rainfall, with 61 per cent of the country registering rainfall in the lowest 10 per cent (i.e. the lowest decile) of recorded totals. This was the second largest extent on record of rainfall totals in the lowest decile, only slightly smaller in area than during the drought of 1901/1902.

HURRICANES, TYPHOONS AND TROPICAL CYCLONES

During the Atlantic hurricane season (June–November), 12 named tropical storms were observed, somewhat higher than the average of around 10, though only four developed to hurricane strength – fewer than the average of 5 to 6. Twice the average number of four tropical storm systems affected the United States, including Hurricane *Lili*, which strengthened briefly to category 4 and was the first land-falling hurricane to strike the country since the 1999 hurricane season. Hurricanes *Lili* and *Isadore* crossed western Cuba less than two weeks apart. September 2002 was the most active tropical storm month on record in the North Atlantic Basin.

In the eastern North Pacific, 12 named hurricanes formed compared with an average of 16. Hurricane *Kenna* was the third strongest hurricane to strike Mexico from the Pacific and resulted in three deaths and thousands of persons left homeless. In the western North Pacific, 26 named storms were observed, near the 1971 to 2000 average of 26.7. Typhoon *Rusa* made landfall on the Korean Peninsula at the end of August resulting in flooding and more than 240 dead or missing. The one-day rainfall at Gangneung of approximately 870 mm was the greatest in national records, which date back to 1911.

The cyclone season in the South-West Indian Ocean was characterized by a slightly higher than average number of cyclones (13 formations versus 10 for a normal year). An intense tropical cyclone named *Dina* brought a record 24-hour precipitation amount of 745 mm over Mauritius in 24 hours. Winds reaching 228 km/hr were reported. In December, the southern hemisphere's strongest tropical cyclone of the year, *Zoe*, formed in the South Pacific. That category 5 cyclone passed through the islands of Tikopia, Fataka and Anuta of the Solomon Islands. At its peak, winds were estimated to average 290 km/hr.

FLOODING AND OTHER PRECIPITATION ANOMALIES

In January, rapid snow melt caused flooding in the western North Caucasus region of the Russian Federation, leading to damage in several communities in the Kuban River valley. Heavy rains and amplified mountain glacier melt water caused flooding in the whole North Caucasus region in June. The flood on the Terek and nearby rivers exceeded all levels recorded since 1900. The flooding led to the destruction of dams and considerable damage and loss of life. During the first two weeks of August, exceptionally heavy rains in parts of central Europe (including Germany, the Czech Republic, Austria, Romania and Slovakia) caused serious flooding, notably on the Elbe and Danube rivers. More than 100 deaths were reported with more than 450 000 people forced to evacuate. A number of rainfall records were set and the flood exceeded all previously recorded levels in some places. In southern France, severe flooding in September led to 24 deaths and induced severe damage; the greatest precipitation total in the region was nearly 690 mm, which fell in approximately 24 hours. In Bulgaria, frequent and intense rain and thunderstorms resulted in flooding with significant damage to property and agriculture during much of the summer and early autumn. Monthly rainfall totals were up to several times the average value in the months of July through October. In Iceland, a new national 24-hour precipitation record was established when 293.3 mm was measured on 10 January at Kvisker, and some stations in the eastern portion of the country reported the largest precipitation totals on record. Heavy precipitation occurred in parts of the northeast region of Spain during summer and autumn.

In East Africa, flooding was observed in southern United Republic of Tanzania in January and in Kenya and Uganda from March to May when some locations recorded the wettest conditions since 1961. Flooding was reported also in Uganda during October and November. The flooding episodes produced a number of impacts including landslides and loss of life. In southern United Republic of Tanzania, heavy rains were reported in January and widespread near-normal to wet conditions were experienced across much of the country

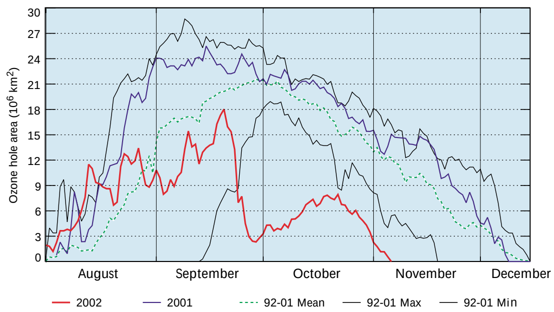


Figure 7. Daily size of the Antarctic ozone hole from 1 August through 15 December using total ozone observations from NOAA's solar backscatter ultraviolet (SUVB/2) instrument onboard NOAA's polar-orbiting satellites. (Source: Climate Prediction Center/NOAA)

through February and March. The regions of central and southern Ethiopia, however, experienced a general failure of the rains in the period from June to September. After a dry beginning to 2002, the Asian summer monsoon and several typhoons brought heavy rains to the region from southern China to the Indochina peninsula. Flooding along the Changjiang and Mekong rivers resulted in several hundred deaths. The southwest monsoon in eastern India, Nepal and Bangladesh was also active, leading to severe flooding in parts of the region and about 1 000 fatalities. Rainfall along the southwestern coast of Chile was in the highest 20 per cent of recorded totals during the austral summer and spring, and severe flooding in southern-central Chile during spring was produced by rainfall amounts that exceeded the historical records for the region. The north of the South Island of New Zealand was drier than normal, while the west and south were wetter than normal. In February, heavy rains in Jakarta, Indonesia flooded thousands of homes twice during the month, leaving at least 67 dead and more than 330 000 homeless. The last week of December brought heavy rains to the mountainous regions of Java and Sumatra, Indonesia, resulting in flash flooding, at least three deaths and the displacement of an estimated 365 000 inhabitants.

STRATOSPHERIC OZONE

In the Arctic, exceptionally low temperatures at the end of 2001 in the polar vortex allowed for the formation of polar stratospheric clouds (PSCs). Very low temperatures activate chemical processes which, in the presence of sunlight, result in rapid ozone depletion. Temperatures must be sufficiently low to form PSCs and initiate these chemical conditions. Since the low temperatures in the Arctic occurred during a period of diminished sunlight and were followed by early warmings in late December 2001 and January 2002, little ozone loss was observed. By mid-March 2002, column ozone values at northern hemisphere high latitudes were up to 10 per cent below the corresponding pre-1980 column values, but near-normal high-latitude column ozone values were apparent in the area average.

During 2002, the Antarctic ozone hole was the smallest since 1988. In early September, the hole was about half the size found in 2001 and 2000, as shown in Figure 7. In late September an unprecedented event occurred when the ozone hole split into two. The two holes were relatively small and each contained a core depleted of more than 50 per cent of its ozone. In the following week, one of the holes, located near South America, dissipated into surrounding areas. The remaining ozone hole intensified briefly until mid-October, but then disappeared in early November. Not only was the 2002 ozone hole the smallest since 1988, it was also the shallowest and the shortest lived. The size, depth and persistence of the ozone hole vary from year to year due to natural changes in the meteorological conditions in the stratosphere.

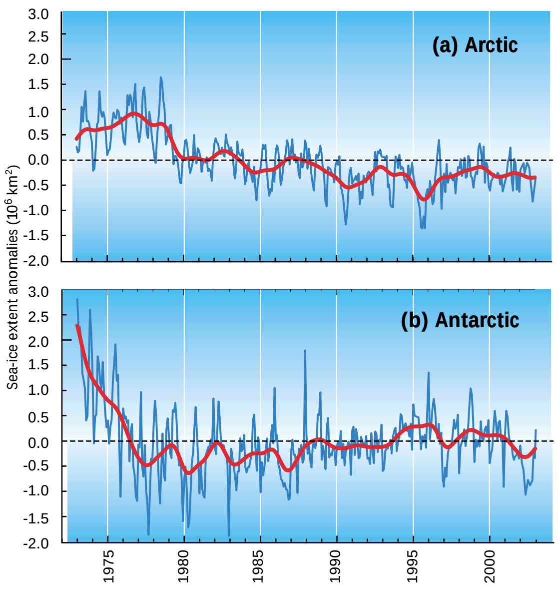
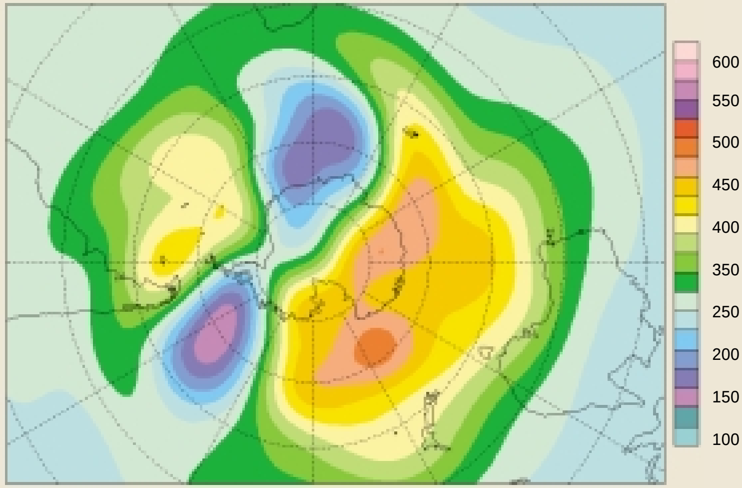
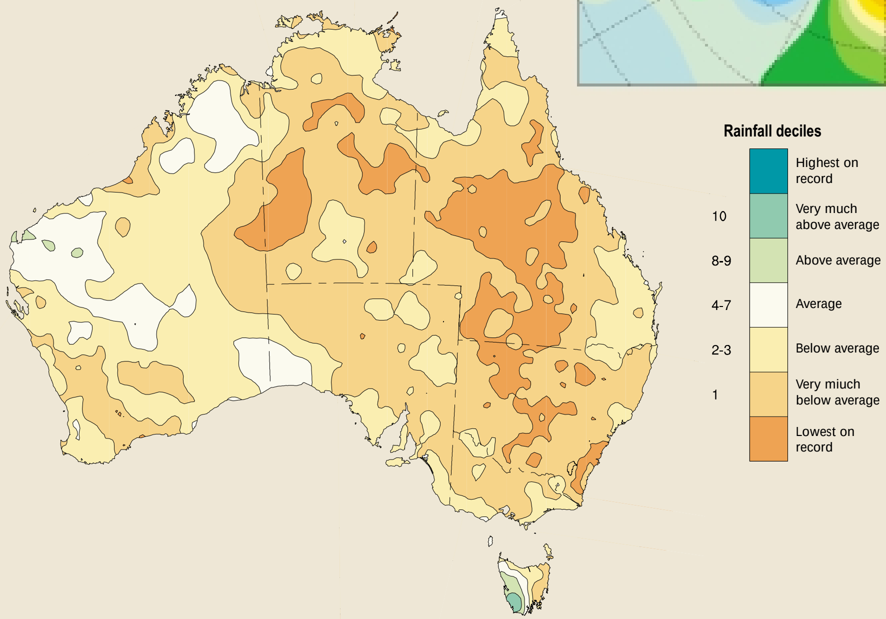


Figure 8. Monthly anomalies (millions of km^2) of (a) Arctic and (b) Antarctic sea-ice extent for the period 1973-2002, derived from satellite passive microwave sounder data. The anomalies were calculated with respect to the 1973-2002 period. (Source: Hadley Centre, Met Office, UK, updated with assistance from the National Centers for Environmental Prediction/NOAA)

ARCTIC SEA ICE

The use of satellites has greatly aided the monitoring of Arctic and Antarctic sea-ice extent during the past three decades. After a period of rapid decline in the mid-1970s, the extent of Antarctic sea ice has exhibited little trend. Throughout this period of record in the Arctic, however, there has been a general downward trend in arctic sea-ice extent, as shown in Figure 8, but there is also considerable variability from year to year. The extent of the sea-cover in the Arctic Ocean in September was lower than in any previous September in the satellite-observation period, which dates to 1978.





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