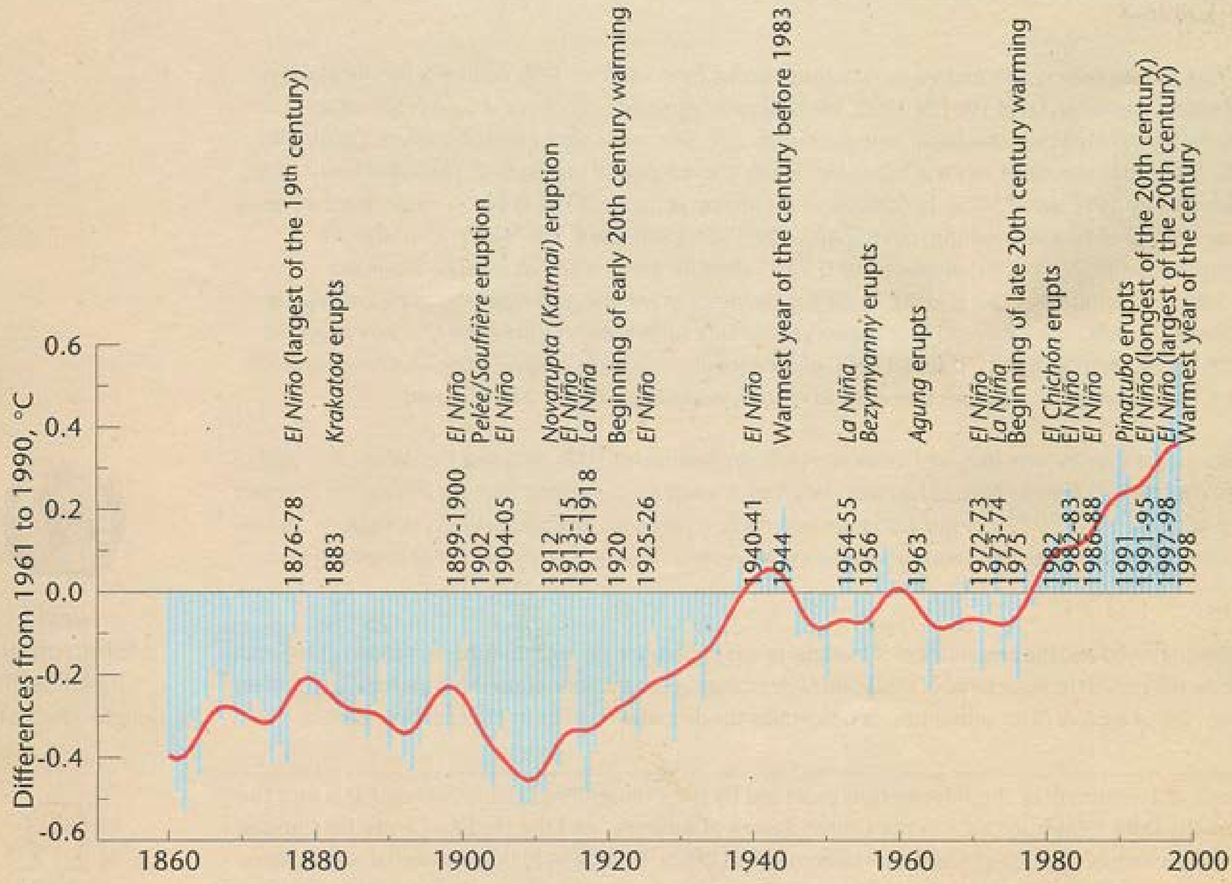
WMO STATEMENT ON THE STATUS OF THE GLOBAL CLIMATE IN 1998



World Meteorological Organization

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Front Cover: *Combined land-surface air and sea-surface temperatures from 1860 to 1998, relative to the climatological standard normal period of 1961 to 1990. The solid curve represents smoothing of the annual values shown by the bars to suppress sub-decadal time-scale variations. Selected strong El Niño/Southern Oscillation (ENSO) and other major events affecting the climate are indicated on the timeline. The global land and sea anomaly for 1998 was 0.57°C. In addition, in the tropical latitudes (30°N to 30°S) a new record anomaly was established by a wide margin, 0.61°C above the 1961-1990 mean. The Northern Hemisphere extratropics (30°N to 90°N) anomaly was 0.75°C above the mean, a new record. The Southern Hemisphere extratropics (30°S to 90°S) did not experience record heat, although temperature anomalies averaged 0.26°C above normal. Both the sea and the land surface temperature anomalies were above the 1961-1990 normal at 0.47°C and 0.88°C above normal, respectively.* (Sources: P.D. Jones, Climatic Research Unit, University of East Anglia; Hadley Centre, United Kingdom Meteorological Office; WMO secretariat)

Back Cover: *Sea surface temperatures (top) and anomalies (bottom) for January 1998 (left) and December 1998 (right), showing the shift from El Niño to La Niña conditions respectively. Departures from the average are computed based on the 1950-1979 adjusted Optimum Interpolation (Reynolds and Smith, 1995) climatology.* (Source: Climate Prediction Center (CPC), National Oceanic and Atmospheric Administration (NOAA), United States of America)

NOTE

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World Meteorological Organization
Geneva - Switzerland

This statement is a summary of the information provided by the Climate Prediction Center (CPC) and the National Climatic Data Center (NCDC) in the United States of America, and the Hadley Centre for Climate Prediction and Research of the United Kingdom Meteorological Office (UKMO). Additional material was received from climate centres in Australia, Canada, China, Germany, India, Japan, New Zealand, Norway and others. Contributions were based on observational data collected and disseminated on a continuing basis by the national Meteorological and Hydrological Services (NMHSs) of World Meteorological (WMO) Member countries.

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FOREWORD

Nineteen ninety-eight was by far the warmest year since worldwide instrument records began 139 years ago. No single year can indicate a change in climate, but a perspective of global data spread over a long period of time shows that the world is in a period of warming. Even if 1999 should prove to be cooler than 1998, the trend towards warmer temperatures is indisputable. What portion of the warming is due to natural variability and anthropogenic causes is a topic of continuing research.

Both *El Niño* and *La Niña* occurred in 1998. These episodes were accompanied by tremendous variations in the normal patterns of precipitation, and extreme events such as Hurricane Mitch and flooding in China. Such variabilities have been associated with total economic losses attributed to windstorms and flooding approaching US$ 76 billion in 1998. Throughout the world there is a need to reassess risks of weather events based on recent climatological data. These risks should be reflected in policies and planning with regard to land management, agriculture, water management, health services and housing.

The severity of extreme events in 1998 highlighted the need for continued vigilance in monitoring the global climate system. At the Fourth Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), held in Buenos Aires in November 1998, WMO, along with other bodies, urged the Conference to provide stronger support for climate monitoring and research, and to ensure the integrity of global observing systems. As a result, the Conference urged Governments to provide active support to national meteorological, atmospheric, oceanographic and terrestrial observing systems and networks, as an integral part of the implementation of the Global Climate Observing System (GCOS).

WMO is responsible for the publication of information on projects of the World Climate Data and Monitoring Programme (WCDMP). Beginning in 1993, WMO, in its role as a provider of credible scientific information on climate and its variability, began issuing annual statements on the status of the global climate. This booklet, the sixth in the series, focuses on the status of the global climate during 1998 and is provided through the Climate Change Detection Project (CCDP), which is a joint project of the WCDMP and the Climate Variability and Predictability (CLIVAR) Study of the World Climate Research Programme (WCRP).

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

SUMMARY

The Earth's global surface temperature in 1998 was the highest since reliable world-wide instrument records began in 1860, 0.57°C above the recent long-term average based on the period 1961 to 1990. As we approach the end of the century, the global temperature is almost 0.7°C warmer than at the end of the 19th century. It was the 20th consecutive year with an above-normal global surface temperature. The regional temperature patterns show all of the continents with above-average temperatures.

Over the oceans, a slowly fading *El Niño* and the unprecedented warmth of the Indian Ocean contributed to this record warm year. The *El Niño* event, which started in 1997, continued to influence the climate in 1998, including extremely dry conditions and fires in Indonesia, drought in Papua New Guinea, and extensive flooding in Ecuador, Peru and Kenya early in 1998. Lingering *El Niño* conditions in the eastern Pacific were associated with extremely dry conditions in Mexico and the southern United States of America.

The central equatorial Pacific warm *El Niño* waters gave way to colder-than-normal sea surface temperatures (*La Niña* conditions) by mid-year. The switch to *La Niña* conditions was associated with extremely heavy rains in the West Pacific, triggering landslides and floods in Indonesia. *El Niño* contributed to the late start of the 1998 Atlantic hurricane season, which, under the influence of *La Niña*, ended as one of the deadliest in history. Hurricane Mitch triggered massive flooding and landslides in late October that killed more than 11 000 people in Central America.

In China, severe flooding affected an area covering 25 million hectares. The death toll was more than 3 000, with a record number of rivers and lakes flooded. Floods in India and Bangladesh took more than 2 800 lives. In Bangladesh, three major floods occurred during July and August, leaving large parts of the country under water for an extensive period. In January, eastern Canada suffered from the longest-duration ice storm on record.

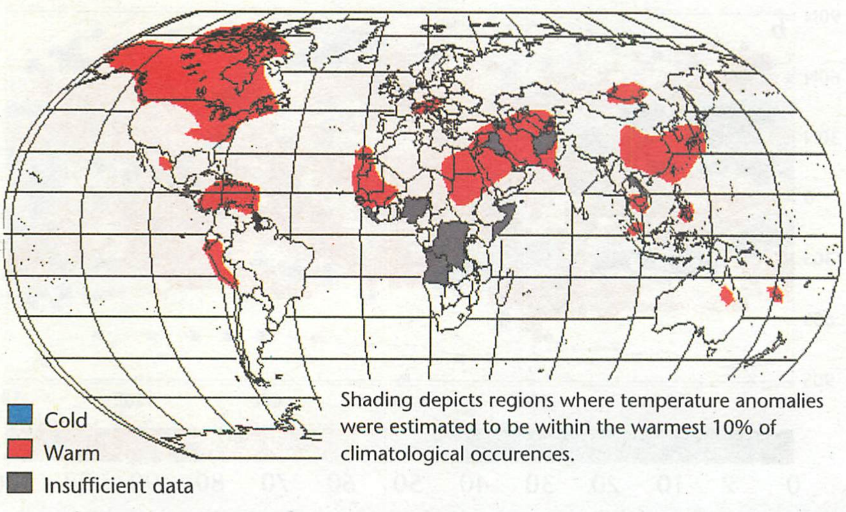
Extreme weather events in 1998 caused significant outbreaks of disease throughout the world, including large increases in the incidence of malaria, Rift Valley fever and cholera in eastern Africa. Central America, in the wake of Hurricane Mitch, experienced an increased incidence of cholera, dengue fever and malaria. Improved understanding of the changing patterns of climate and extreme weather events should lead to implementation of proactive programs to prevent or minimize some weather-related health problems.

RECORD WARM GLOBAL TEMPERATURE

The global temperature in 1998 was the warmest since reliable instrument records began 139 years ago. A persistent *El Niño* in the first half of the year and the unprecedented warmth of the western and central Indian Ocean contributed to this record warm year. Compared to climatological standard normals from the years 1961 to 1990, which was itself a warm era, the average temperature near the surface of the Earth in 1998 was 0.57°C above normal.

Parts of every continent experienced mean annual surface temperatures within the 10 per cent warmest on record, particularly in North America (Figure 1). Record mean annual temperatures were mainly due to exceptionally high minimum temperatures as reported in Australia, Ireland, Qatar and elsewhere. A record warm year was also reported in Cyprus, Canada, Japan, New Zealand and the United States of America. Annual temperatures near average were reported in only a few countries, including Germany, Iceland and Norway. It is remarkable that no significant areas reported temperatures within the 10 per cent coolest on record.

Figure 1. Global temperature anomalies based on the 1961-1990 normal period. Shading in red indicates regions where temperature anomalies were estimated to be within the warmest 10 per cent of climatological occurrences. Blue indicates the coldest 10 per cent.
(Source: CPC, NOAA)



20-Year Warming Trend

Examining global surface temperature anomalies for every year from 1860 to 1998 (see cover) shows:

(a) The global temperature in 1998 was higher, by a substantial margin, than ever before on record;
(b) The second warmest year was 1997, and seven of the 10 warmest years have occurred in the 1990s;
(c) It was the 20th consecutive year with an annual global mean surface temperature that exceeded the 1961-1990 average;
(d) The global mean surface temperature has increased by approximately 0.7°C since the late 19th century;
(e) The global temperature has risen in the past 20 years faster than in any other 20-year period; and
(f) There have been relatively frequent and strong *El Niño*/Southern Oscillation (ENSO) warm phase episodes, with only rare cool phase events in the latter part of the 20th century.

WARM TROPOSPHERE, COLD STRATOSPHERE

In the lower troposphere (up to about six kilometres), 1998 was the warmest year on record in each hemisphere. In the lower

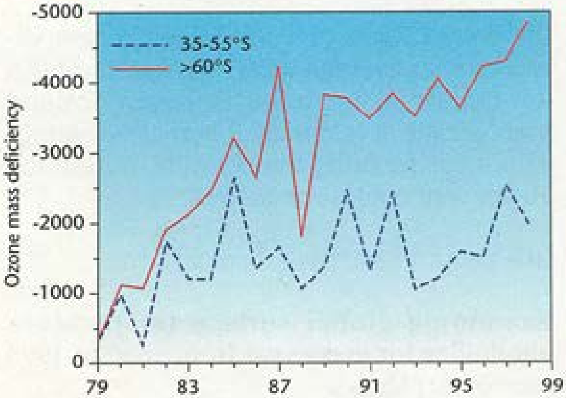


Figure 2. The integrated September-October 1998 ozone-mass-deficiency from pre-1976 values in units of Megatons. South of 60°, the integration is over sunlit areas. The ozone-mass-deficiency in 1998 over southern polar regions was 25 per cent greater than the average over the previous seven years.

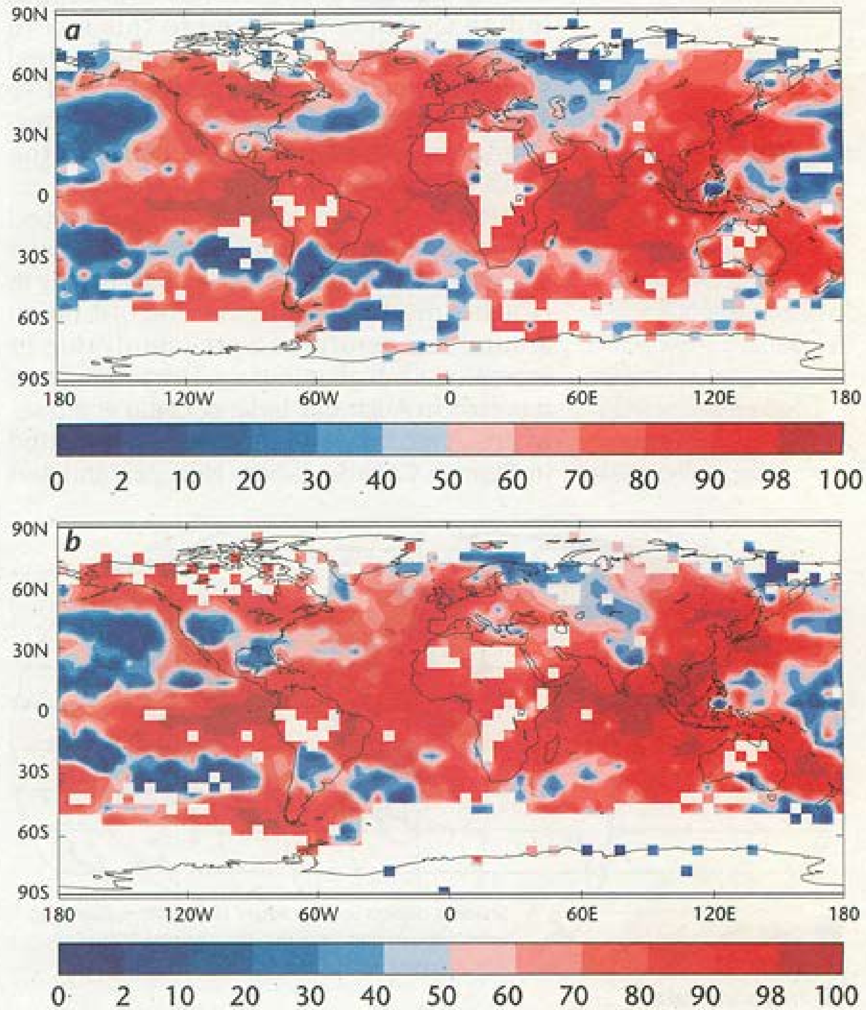
(Source: Bojkov, WMO Bulletin, 1999)

stratosphere, radiosonde measurements from about 400 land-based stations worldwide indicated another very cold year globally in 1998, although near-normal temperatures were recorded in the northern high latitudes. Computer models of the atmosphere show that increased carbon dioxide in the atmosphere and depleted stratospheric ozone can both be associated with cooling in the lower stratosphere.

RECORD OZONE LOSS

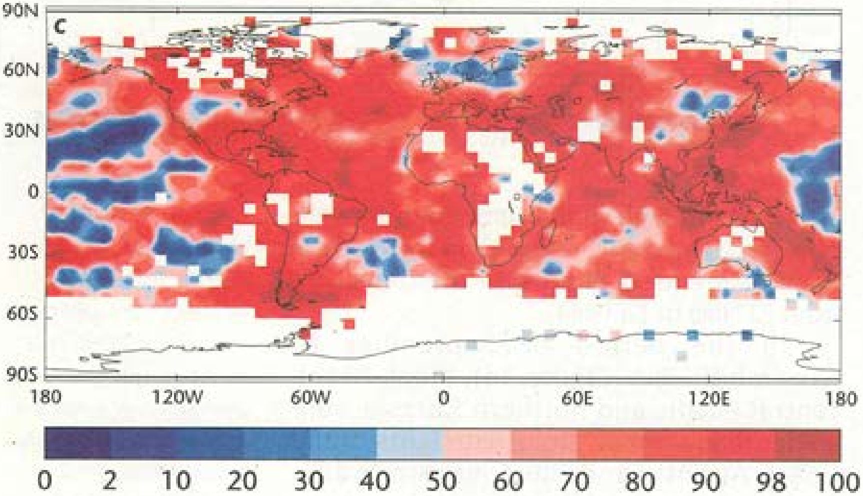
The ozone decline over Antarctica during the austral spring of 1998 set new records (Figure 2). The sunlit area with ozone hole values (less than 220 milliatmosphere centimetres) was greater than10 million square kilometres for more than 100 days. During the period of maximum ozone depletion at the end of September and early October, the area of the ozone hole exceeded 25 million square kilometres for an unprecedented 20 consecutive days. In the northern latitudes, the average ozone

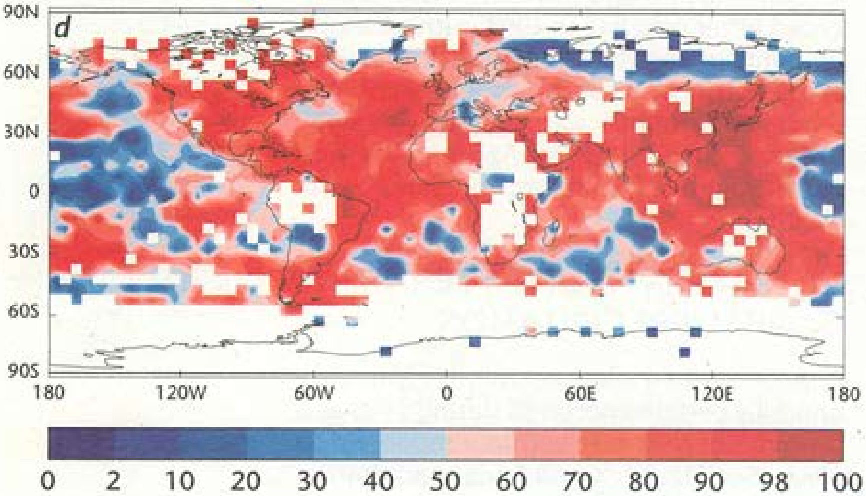
Figure 3. Global annual surface temperature anomalies expressed as percentiles plotted in five-degree grid boxes. Anomalies are with respect to the 1961-1990 normal period.



The anomalies are fitted to a gamma distribution. Areas without sufficient data for analysis are white. (Source: Climatic Research Unit, University of East Anglia; Hadley Centre, United Kingdom Meteorological)ffice)

amount in 1998 was about 4 to 6 per cent below the pre-1976 levels, which was a smaller deficiency than some of the previous years, possibly related to near-normal temperatures in the lower stratosphere.





CARBON DIOXIDE AND METHANE INCREASE

Atmospheric concentrations of both carbon dioxide and methane, two principal greenhouse gases, continued to increase in 1998. Globally, carbon dioxide concentrations increased at a rate of 1.5 parts per million per year. Recent measurements indicate that the rate of increase of methane has slowed.

SEA LEVEL RISE

The rate of global mean sea level rise, based on 100 to 150 years of sea level records, has been 2.1 millimetres per year. During 1998, global mean sea level rose above normal during the *El Niño* event, principally due to thermal expansion, then returned to normal.

EL NIÑO ENDS, LA NIÑA BEGINS

The global climate during 1998 was affected by both extremes of the ENSO cycle. One of the strongest *El Niño* episodes in the historical record prevailed into early May, then gave way to *La Niña* conditions for the rest of the year. The shift in sea surface temperatures from the beginning to the end of the year can be seen in the figure on the back cover. Temporal variations in surface temperature are discussed in the following section.

TEMPERATURE ANOMALIES DURING THREE-MONTH PERIODS

December 1997 to February 1998 (Figure 3a) was dominated by anomalous warmth throughout most of the tropics, North America, Europe and eastern Asia. The tropical Indian and Atlantic oceans, as well as the eastern tropical Pacific, and part of Canada, were extremely warm. North America experienced is warmest February in 100 years. Many places in Central Europe experienced their warmest January and February this century. Only north-west Russian Federation, the central North Pacific, the subtropical South Pacific and the midlatitude South Atlantic were colder than normal.

Similar conditions prevailed from March to May 1998 (Figure 3b), with cold anomalies continuing in the Pacific, and very high warm anomalies in the eastern tropical Pacific, the tropical Indian Ocean, the Tasman Sea and south-east Asia. In April, an extreme hot spell in the Middle East sent temperatures up to 41°C. In May, a severe heat wave prevailed over many parts of India, resulting in 1 300 deaths. During the same period, temperatures routinely exceeded 35°C in the south-eastern United States of America.

June to August (Figure 3c) was warmer than normal over almost the entire land area of the Earth. Only parts of the tropical and subtropical Pacific, the midlatitude South Atlantic and the Southern Ocean south of Australia were colder than normal. Parts of south-west Asia, the tropical Indian Ocean, the western Pacific and the western tropical Atlantic and Caribbean were exceptionally warm. In June, a record-breaking heat wave in central Russia resulted in extensive fires and more than 100 deaths. In New Zealand, where winter virtually failed to arrive, record high winter temperatures were observed. The cold anomalies in the tropical Pacific were associated with the transition from *El Niño* to *La Niña*.

In the period of September to November 1998 (Figure 3d), much of the central Pacific and northern Eurasia were colder than normal, along with parts of the South Atlantic and the southern Indian Ocean. Europe and northern Asia experienced bitter cold late in 1998, with excessive amounts of snowfall. By contrast, the western Pacific and parts of eastern Asia remained extremely warm, along with small areas of Brazil and the Azores. Much of North America had record-breaking warm weather.

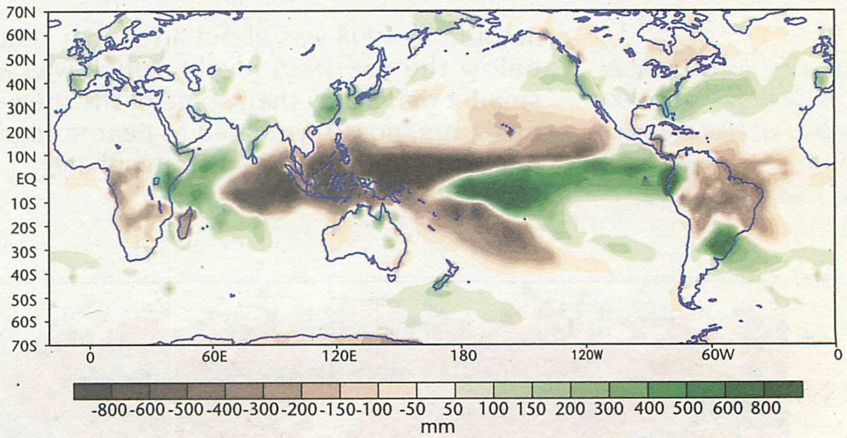


Figure 4. Precipitation anomalies for November 1997 to April 1998. Anomalies are departures from the 1979-95 base-period means. Data were obtained from a merge of rain gauge observations and satellite derived precipitation estimates. The satellite estimates were generated by the outgoing long-wave radiation precipitation index (OPI) technique (Xie and Arkin, 1997) which were merged with rain gauge data via the method adopted from Xie and Arkin (1996). (Source: CPC, NOAA)

EL NIÑO/LA NIÑA PATTERNS IN GLOBAL PRECIPITATION

A pronounced change in precipitation anomaly patterns occurred during 1998 as a powerful *El Niño* gave way to a moderate *La Niña*. (See Figures 4 and 5 for precipitation

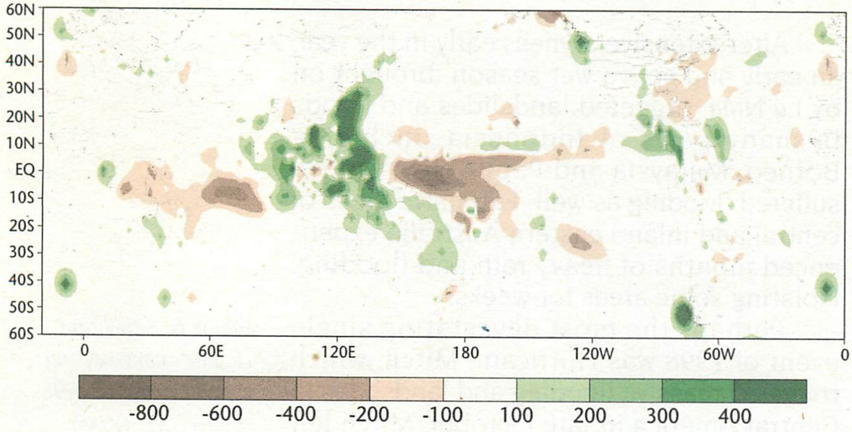


Figure 5. Precipitation anomalies for October 1998 to December 1998. Anomalies are departures from the 1979-95 base-period means. Data were obtained from a merge of rain gauge observations and satellite derived precipitation estimates. The satellite estimates were generated by the outgoing long-wave radiation precipitation index (OPI) technique (Xie and Arkin, 1997) which were merged with rain gauge data via the method adopted from Xie and Arkin (1996). (Source: CPC, NOAA)

anomalies in the first and last parts of the year.) The areas with a strong ENSO signal that experienced the greatest environmental stress due to the ENSO fluctuations were Indonesia, eastern Africa and Argentina. Indonesia experienced dry conditions in the beginning of the year followed by heavy rainfall at the end of the year. Eastern Africa and Argentina both began the year with heavy rainfall and ended the year with lower-than-normal precipitation. The late start to what ended as a strong Atlantic hurricane season was connected to the ENSO signal. The places and times of occurrence of these precipitation events, and other events not associated with ENSO, can be seen in Figure 6.

EXTREMELY DRY CONDITIONS

Very dry conditions in south-east Asia prevailed in early 1998. Devastating fires resulted in serious pollution and respiratory illnesses in Indonesia and Fiji. In one province of Borneo in Indonesia, it was estimated that losses in timber revenue due to fire were in excess of US$ 1 billion. Drought in New Zealand, estimated as having a one in 50-year return period, resulted in significant agricultural loss estimated at US$ 227 million. Papua New Guinea suffered a 100-year return period drought. In Fiji, the lowest-ever rainfall totals were recorded for February through October 1998. The drought left 240 000 people on food rations and emergency water supplies were required for some 480 000 households.

Other dry areas included Brazil, which experienced rare tropical rainforest fires in the first part of the year, and Central America. April to June was the driest period on record in the south-eastern United States of America, where dry conditions, combined with excess ground cover resulting from abundant January to March rainfall, contributed to numerous uncontrolled wildfires during June and early July. Canada reported one of the 10 driest years since records began. Summer heat and dryness plagued Ukraine and Kazakstan, and led to extensive fires in the eastern Russian Federation.

EXTREME PRECIPITATION EVENTS

Extensive flooding in parts of northern Argentina, Peru and coastal Ecuador occurred after *El Niño*-enhanced torrential rains in the early part of the year, leaving 50 000 people homeless. There were also significant floods in the Republic of Korea, Viet Nam, the Philippines, the Russian Federation and Sudan.

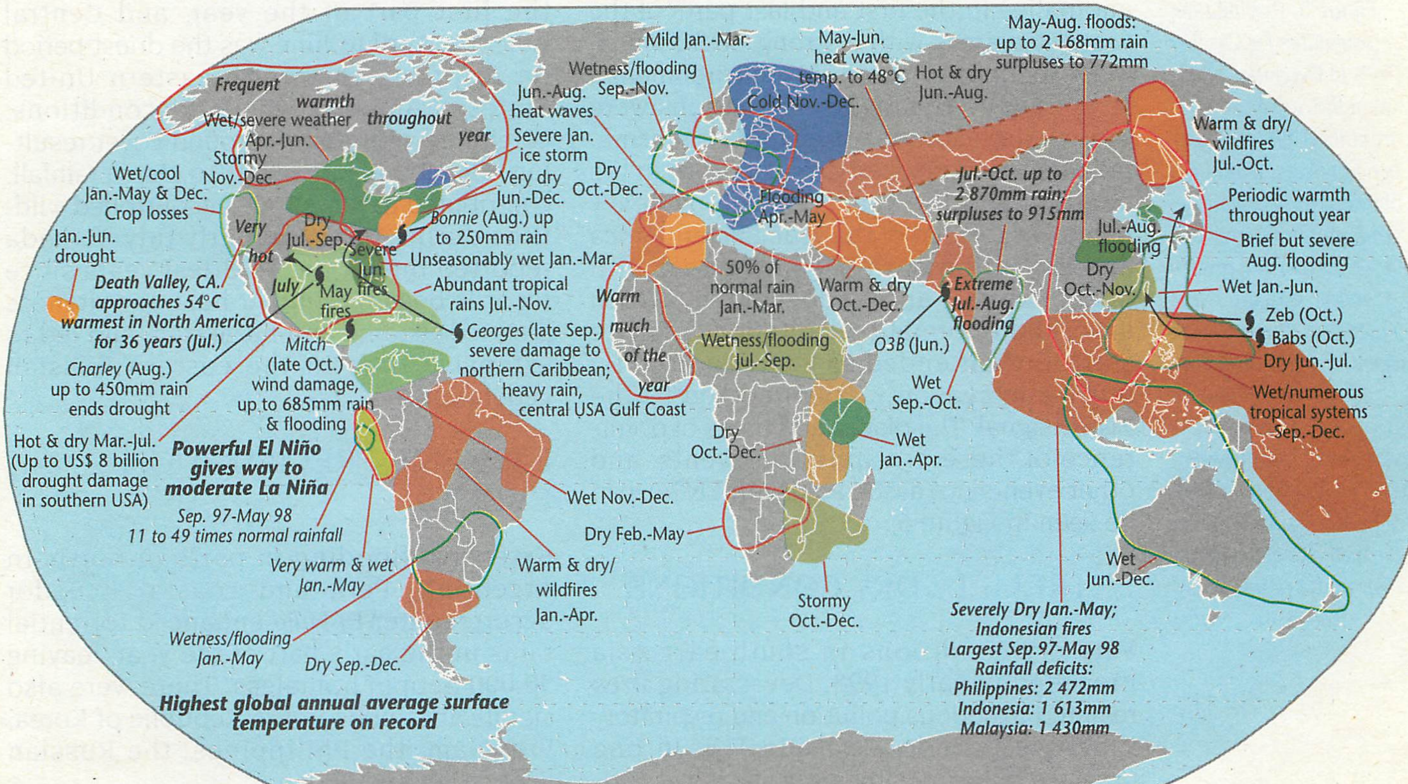
The Indian monsoon season brought massive flooding along the Ganges River valley in July and August. Flooding in India, Nepal, China and Bangladesh took more than 2 800 lives. In Bangladesh, about two-thirds of the country was left under water for an extensive period at depths up to three metres.

The rainy season in the African Sahel began late, but ended with higher-than-normal rainfall across much of the region. In tropical eastern Africa, the worst floods in 40 years occurred in January and February.

After extensive dryness early in the year, an early and active wet season, brought on by *La Niña*, triggered landslides and floods in many parts of Indonesia, including Borneo. Malaysia and Papua New Guinea suffered flooding as well. Extensive areas of central and inland eastern Australia experienced months of heavy rain and flooding, isolating some areas for weeks.

Perhaps the most devastating single event of 1998 was Hurricane Mitch, which triggered massive flooding and landslides in Central America in late October. Mitch left

Figure 6. Significant climate anomalies and episodic events of 1998. (Source: CPC, NOAA)



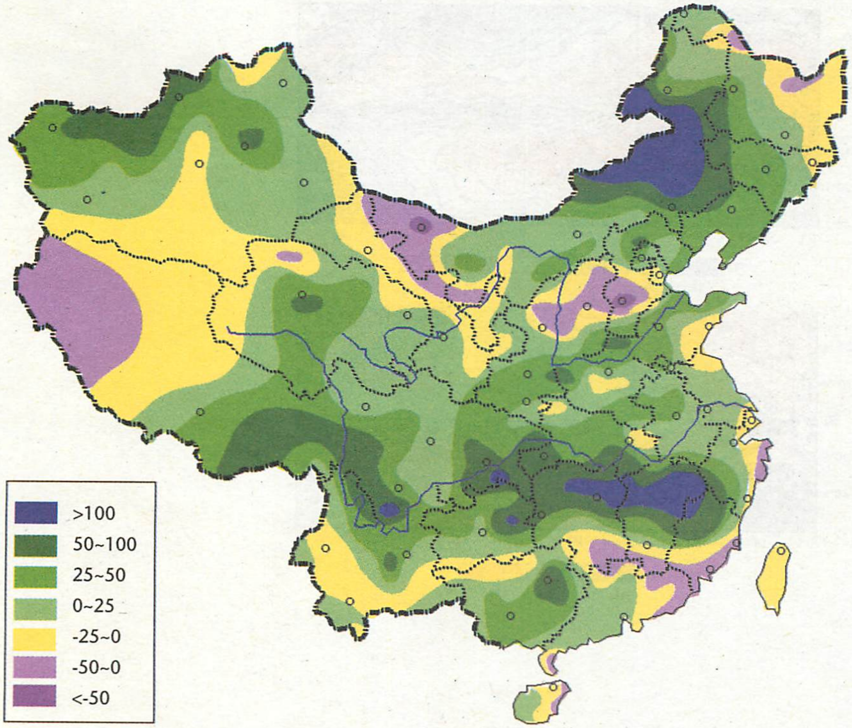


Figure 7. Rainfall in China from June to August 1998 shown as percent anomaly from the 1961-1990 base period.*
(Source: China Meteorological Administration)

* $\frac{P - \bar{P}}{\bar{P}} \times 100\%$

P= total precipitation for the period
$\bar{P}$= normal (1961-1990) precipitation for the period

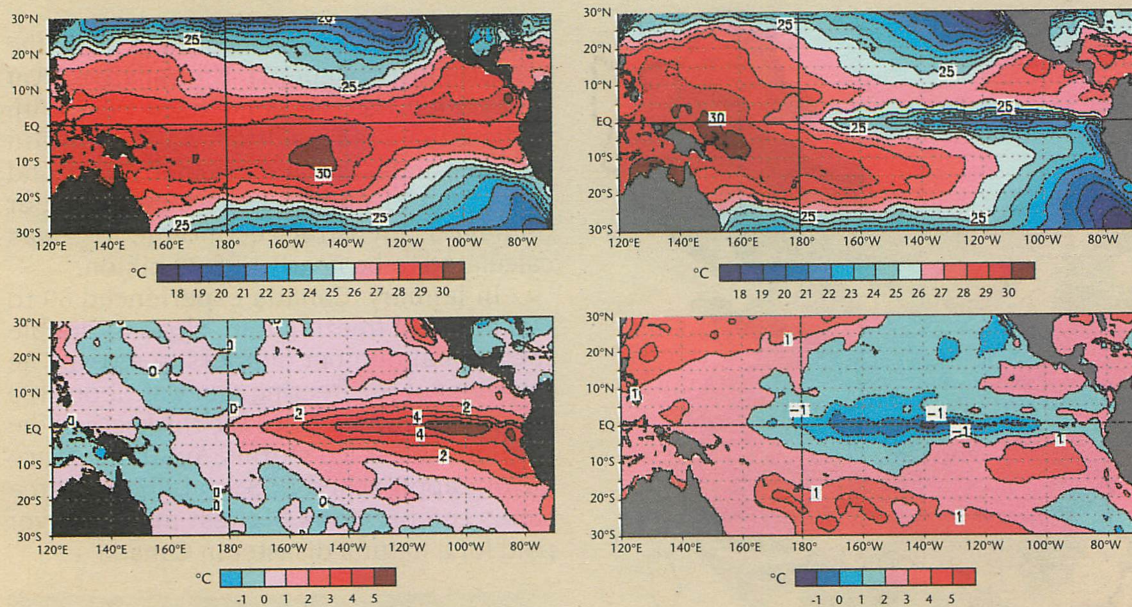
an estimated 18 000 people missing, caused more than 11 000 deaths, and displaced three million people. The hurricane will be remembered as the deadliest to strike the Western Hemisphere in the last two centuries, since the Great Hurricane of October 1780, which killed approximately 22 000 people in the eastern Caribbean. Mitch remained a Category 5 hurricane for 33 continuous hours, with winds exceeding 285 km/h for 15 hours, and was one of the strongest hurricanes ever recorded in the Atlantic basin. Damage estimates exceed US$ 5 billion.

China suffered from severe flooding brought on by heavy rains from June to August 1998 in the north-east and along the Yangstze River (Figure 7). The Yangstze River valley flood was the worst since 1954. With a disaster area as high as 25 million hectares, a death toll more than 3 500, and more than 21 million houses destroyed or damaged, the direct economic loss was calculated to be nearly US$ 32 billion.

In January, Canada experienced 80 to 100 hours of freezing rain, close to double the normal number of hours in a year. The thickness of the freezing rain was about 100 millimetres, about twice the thickness of the previous worst ice storms. Total insurance payout approached US$ 1.5 billion – three times the previous highest amount ever paid for a natural disaster in Canada.

Climate and Health

Extreme weather events in 1998 caused significant outbreaks of disease throughout the world. Extensive flooding in eastern Africa resulted in large increases in incidence of malaria, Rift Valley fever and cholera. In south-east Asia, delayed monsoons, compounded by local farming practices, led to prolonged fires, which caused widespread respiratory illnesses and extensive wildlife losses. Central America, in the wake of Hurricane Mitch, experienced an increased incidence of cholera, dengue fever and malaria. Improved understanding of the changing patterns of climate and extreme weather events should lead to implementation of proactive programs to prevent or minimize some of the weather-related health problems.



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