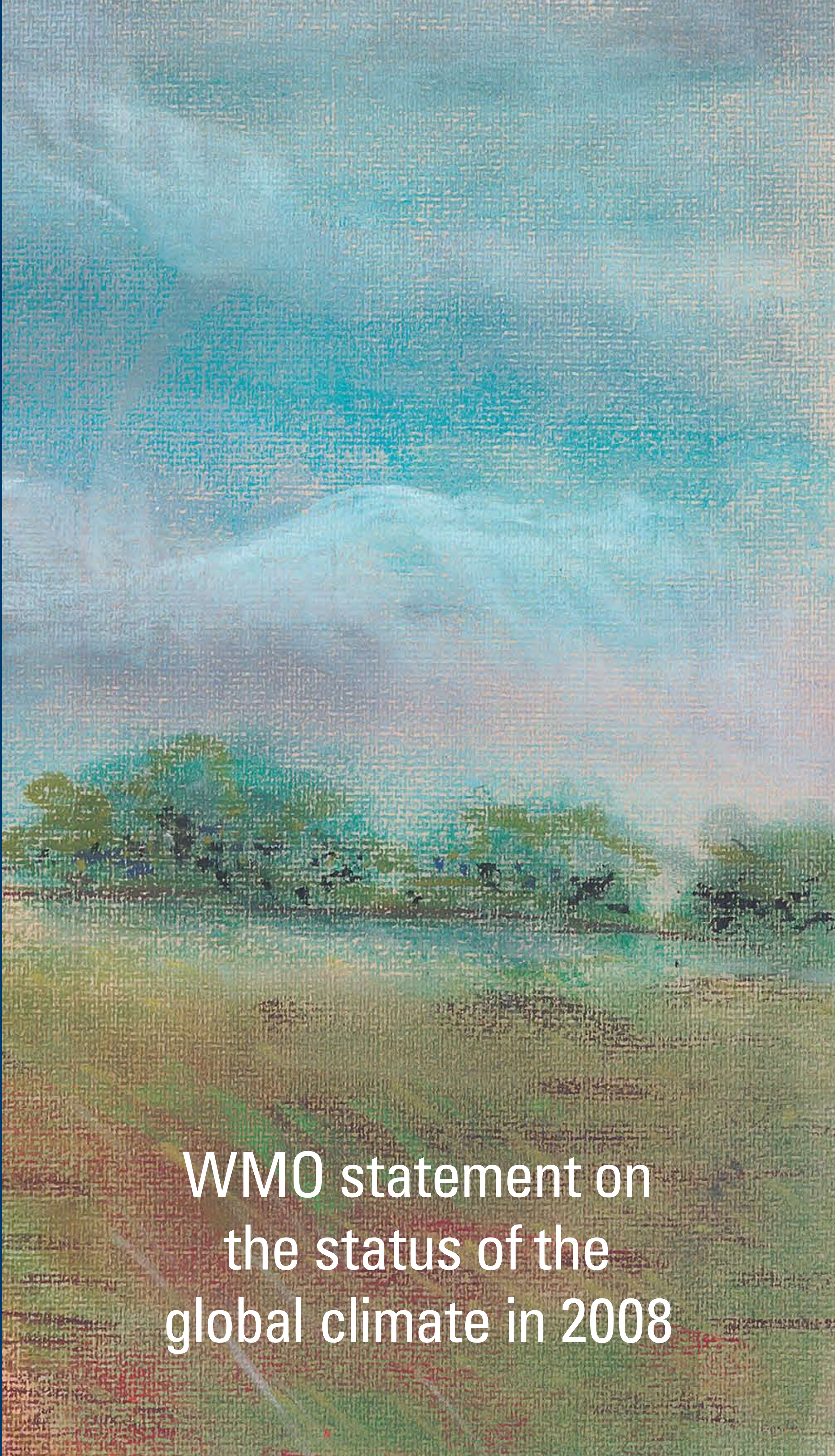

WMO statement on the status of the global climate in 2008

World Meteorological Organization
Weather • Climate • Water

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Foreword

In 1873 the First International Meteorological Congress assembled in Vienna to establish the International Meteorological Organization (IMO), which by 1929 had launched its Commission for Climatology. During August 1947, the ten IMO technical commissions and its six regional commissions held their respective sessions simultaneously in Toronto, Canada. These meetings immediately preceded the Washington (Eighth) Conference of Directors of Meteorological Services, which in October 1947 unanimously approved the Convention of a new organization: the World Meteorological Organization (WMO). Following the necessary ratifications, WMO took over the IMO responsibilities on 23 March 1950 and, one year later, WMO became a specialized agency of the United Nations system.

Fifty years after the founding of the IMO Commission for Climatology, in 1979 WMO organized the First World Climate Conference, in collaboration with the International Council for Science, the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization, the United Nations Environment Programme (UNEP) and the Food and Agriculture Organization of the United Nations. This historic conference led to the establishment of the WMO World Climate Programme and, in 1980, to the World Climate Research Programme, which WMO first co-sponsored with the International Council for Science and subsequently also with the Intergovernmental Oceanographic Commission. Furthermore, the conference paved the way for the 1988 establishment of the WMO/UNEP co-sponsored Intergovernmental Panel on Climate Change, which received the prestigious Nobel Peace Prize in 2007 for its efforts "to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change".

The Second World Climate Conference, which WMO organized with partners in 1990, provided decisive momentum to the international efforts that resulted in the development of the United Nations Framework Convention on Climate Change and the Global Climate Observing System. In the wake of these historic events, WMO began to issue in 1993 its annual report "WMO Statement on the Status of the Global Climate", which by now has become a well-established source of authoritative information, eagerly sought after every year by the scientific community and the media. The *WMO Statement on the Status of the Global Climate in 2008* is the latest in this successful series.

The year 2008 was notable, in particular, as it signalled positive global temperature anomalies, which positioned it among the ten warmest on record since the beginning of modern measurements in 1850. Several extreme weather and climate events were recorded in various parts of the world in 2008, of which perhaps the most dramatic was tropical cyclone *Nargis*, which made landfall in Myanmar in May, causing catastrophic destruction and more than 70 000 fatalities. Other parts of the world suffered severe flooding, extreme heatwaves and droughts in 2008, while Arctic sea ice was once more observed to decline markedly, reaching during September its second-lowest historic extent.

I would like to highlight that 2008 was the second year of the International Polar Year 2007–2008, a WMO co-sponsored scientific venture that has already made decisive contributions to our scientific understanding of climate in the polar regions.

I wish to express the appreciation of WMO to all the Centres and the National Meteorological and Hydrological Services of WMO Members that collaborated with WMO and contributed to the present publication. As with previous editions, I would like to underscore the importance of receiving your feedback. WMO looks forward to your comments on the *WMO Statement on the Status of the Global Climate in 2008* and to your welcome suggestions for its further improvement.

(M. Jarraud)
Secretary-General

Global temperature during 2008

The year 2008 ranked as one of the warmest years on record according to the analyses made by leading climate centres. The Met Office Hadley Centre analyses showed that the global combined sea surface and land surface air temperature for 2008 was 0.31°C (0.56°F) above the 1961–1990 annual average of 14.0°C (57.2°F), ranking 2008 as the tenth warmest year on record. According to the National Climatic Data Center of the National Oceanic and Atmospheric Administration, the global mean surface temperature anomaly was 0.49°C (0.88°F) above the twentieth century average (1901–2000), which ranks 2008 as the eighth warmest year on record.

Based on the joint Met Office Hadley Centre and Climate Research Unit, University of East Anglia analyses, in 2008 the northern and southern hemispheres, with a mean temperature anomaly of +0.51°C (+0.92°F) and +0.11°C (+0.20°F), ranked ninth and seventeenth, respectively.

The global average temperature in 2008 was slightly lower than for the previous years of the twenty-first century, owing in part to the moderate-to-strong La Niña that developed in the latter half of 2007. The global mean temperature anomaly in January 2008 (+0.05°C/+0.09°F) was the lowest recorded since February 1994 (–0.09°C /–0.16°F).

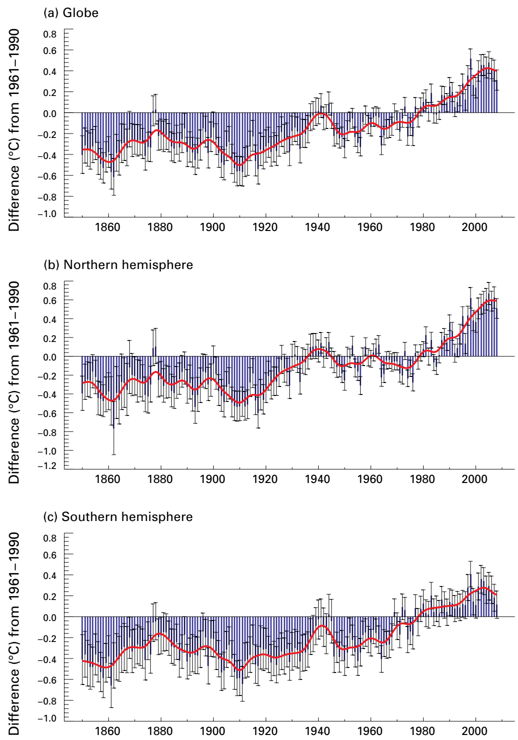


Figure 1. Annual global and hemispheric combined land surface air temperature and sea surface temperature (SST) anomalies (°C) for the period 1850–2008, relative to the average for 1961–1990. The source data are blended land surface air temperature and SST from the HadCRUT3 series (Brohan and others, 2006). Values are simple area-weighted averages.
(Source: Met Office Hadley Centre, UK, and Climatic Research Unit, University of East Anglia, UK)

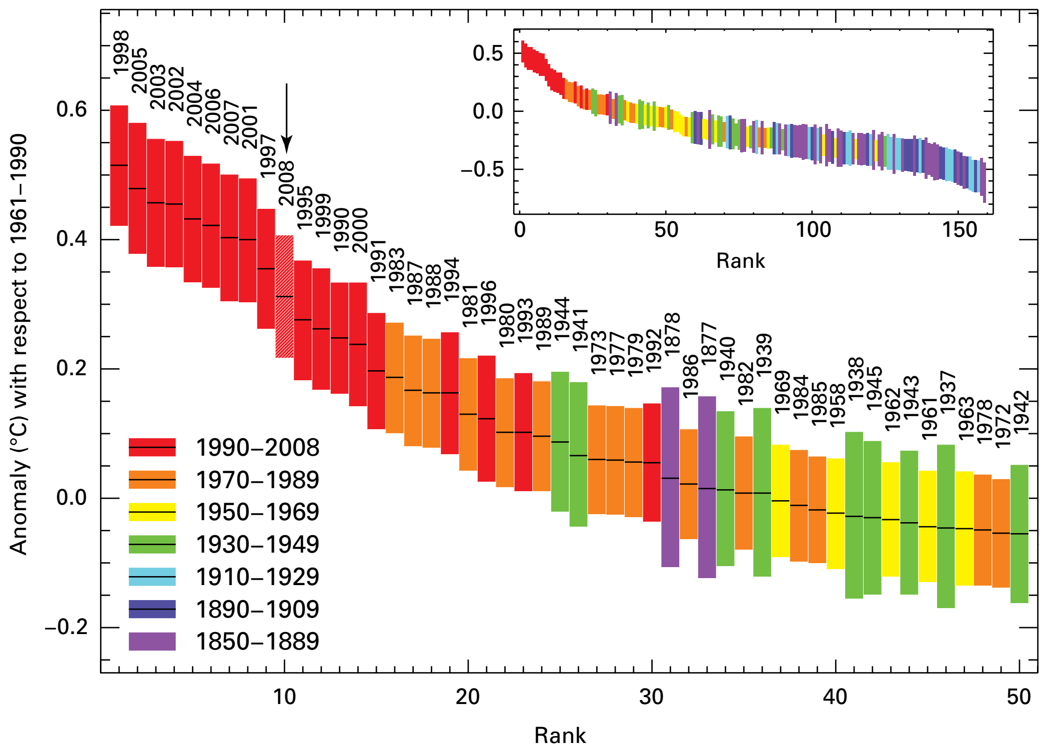


Figure 2. Global ranked surface temperatures for the warmest 50 years. Inset shows global ranked surface temperatures from 1850. The size of the bars indicates the 95 per cent confident limits associated with each year. The source data are blended land surface air temperature and SST from the HadCRUT3 series (Brohan and others, 2006). Values are simple area-weighted averages for the whole year.
(Source: Met Office Hadley Centre, UK, and Climatic Research Unit, University of East Anglia, UK)

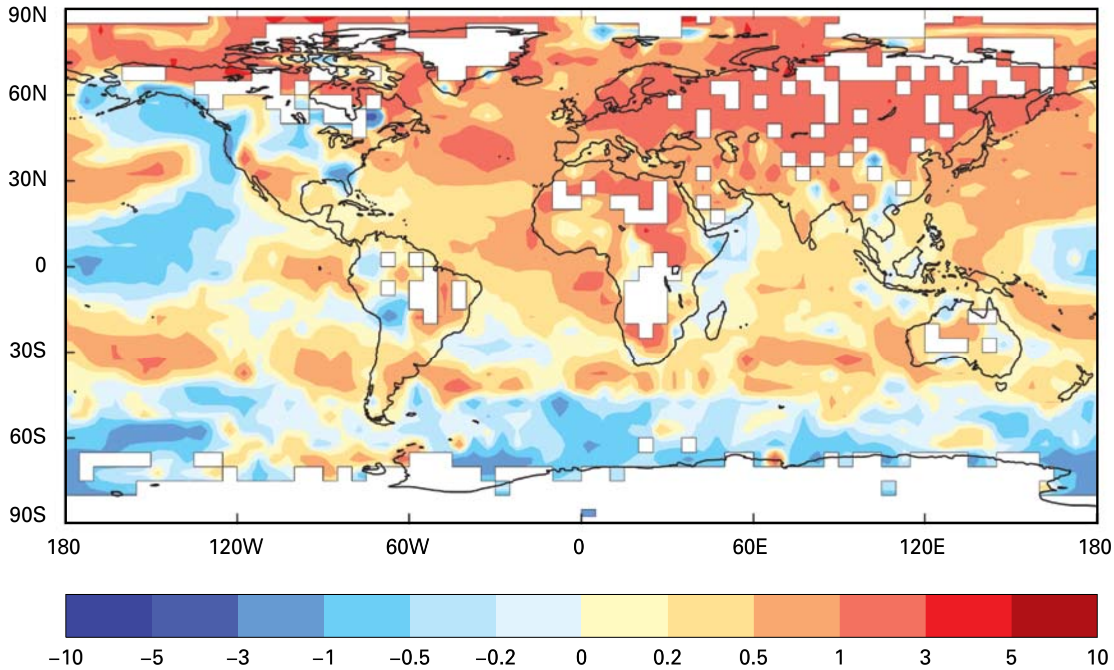


Figure 3. Global field of land surface and sea surface temperature anomalies (°C, relative to 1961–1990) for 2008 *(Source: Met Office Hadley Centre, UK, and Climatic Research Unit, University of East Anglia, UK)*

All temperature values have uncertainties, which arise mainly from gaps in data coverage. The size of the uncertainties is such that, for example, although 2008 is nominally the tenth warmest year on record, it could lie anywhere between the seventh and fourteenth warmest years.

Since the beginning of the twentieth century, the global average surface temperature has risen by 0.74°C, although this increase has not been continuous. The linear warming trend over the past 50 years (0.13°C per decade) is nearly twice that for the past 100 years.

Note: Following established practice, WMO global temperature analyses are based on two different datasets. One is the combined dataset maintained by the Met Office Hadley Centre, UK, and the Climatic Research Unit, University of East Anglia, UK. The other is maintained by the United States Department of Commerce's National Oceanic and Atmospheric Administration. Both centres use improved temperature analyses, but different methodologies. These differing methodologies may result in small differences in global ranking.

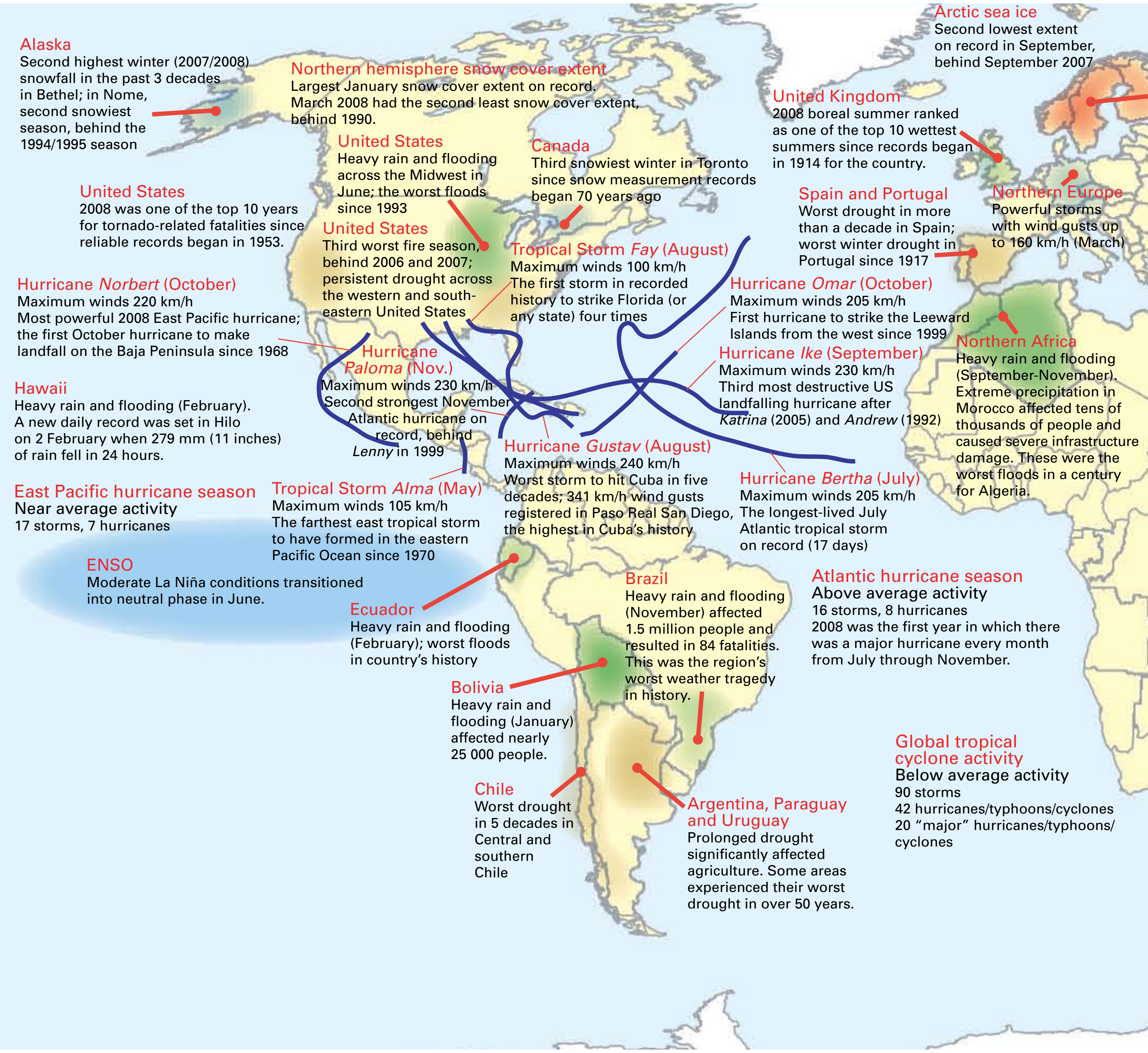
Regional temperature anomalies

In 2008 most parts of the world experienced yet again a year of above-average temperatures. The northern hemisphere, particularly Europe, Asia and the North Atlantic, had the largest anomalies (the anomalies reached between +1°C and +3°C); conversely, part of the United States and Canada experienced slightly cooler than average temperatures. In the southern hemisphere, over the ocean and south of 45° latitude, the temperatures were mostly below average.

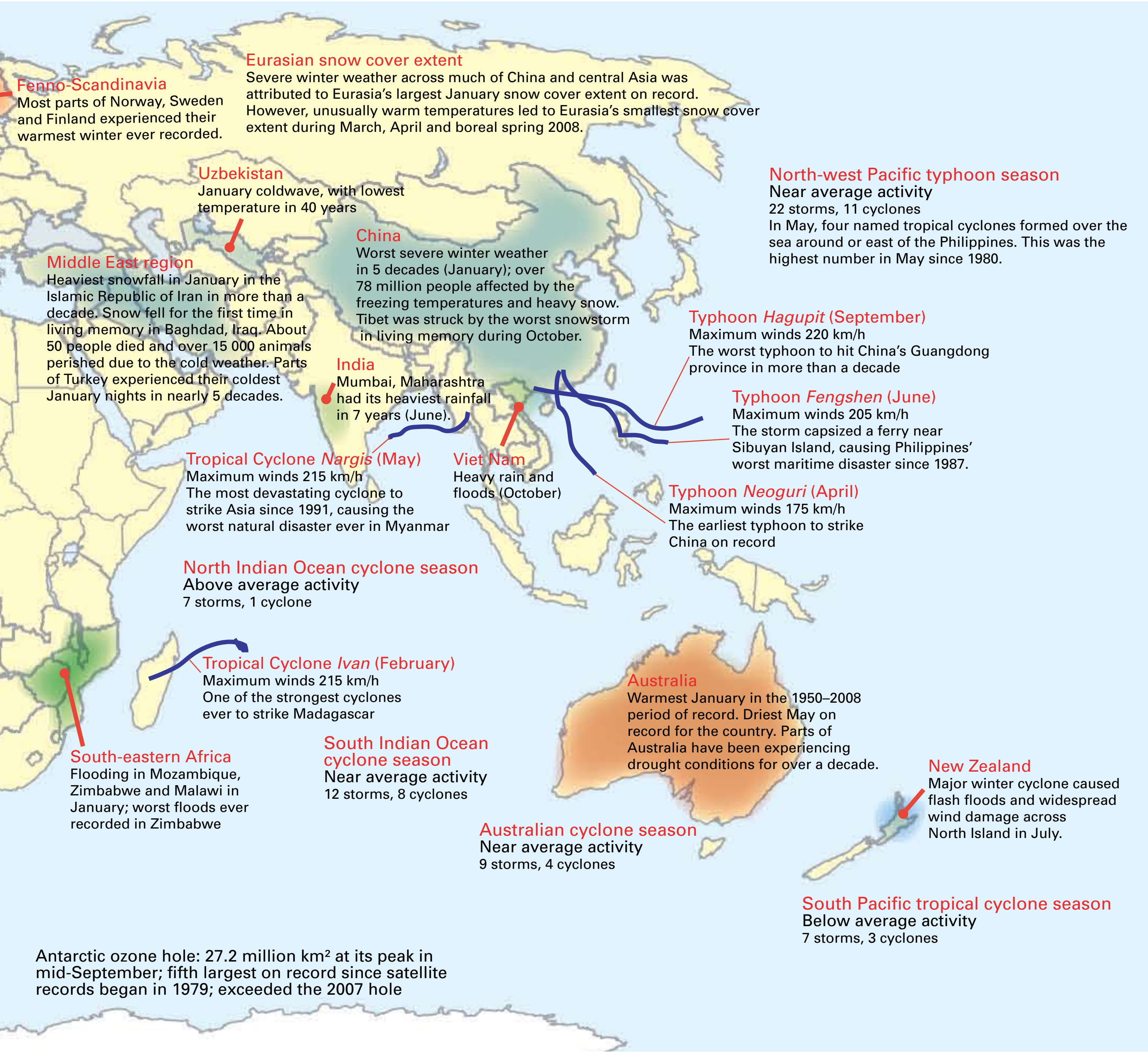
Europe and Asia

A large geographical area, including northwestern Siberia and part of the Scandinavian region, recorded a remarkably mild winter. January and February were very mild in most of Europe. Monthly mean temperature anomalies for these months exceeded +7°C in some places in Scandinavia. In most parts of Finland, Norway and Sweden, winter 2007/2008 was the warmest recorded since the beginning of measurements. The previous mildest winter in Finland was the 1924/1925 winter, more than 80 years ago. Large parts of Western Europe, including the United Kingdom, France, Germany, the Netherlands, Switzerland and Austria, had an exceptionally sunny February with some areas recording over double their monthly average sunshine duration. The United Kingdom experienced its sunniest winter since 1929.

The boreal winter was remarkably cold for a large part of Asia, extending eastward from



Turkey to China. Some places in Turkey experienced their coldest January nights in nearly 50 years. This extreme cold weather caused hundreds of casualties in Afghanistan and China. In January the mean temperatures reached anomalies between –4°C and –10°C around this region. Spring was very warm in large parts of Europe and Asia, especially in March when anomalies were above +5°C in central and north-west Asia. In addition, several heatwaves occurred in south-eastern Europe and the Middle East during April. In Crete, Greece, the temperature of 37.4°C recorded on 22 April was the highest ever measured on the island for that month. Summer was also warmer than average in most parts of Europe and Asia, as was autumn, particularly November, when significant temperature



anomalies ranging between +3°C and +5°C were recorded from eastern Europe to central Asia.

North America

The year started warmer than normal across Canada and the central-eastern United States, but cooler than average in the western United States. Two daily maximum temperatures records were set in Toronto on 7 and 8 January when temperatures soared to 14°C. February was much colder than average across Canada, Alaska and the northern United States, with average daily temperatures ranging from 4.0°C to 5.0°C below normal in some areas. In spring, temperatures were cooler than average in most parts of the United States and Canada, and warmer than average in

Figure 4. Significant climate anomalies and events in 2008
(Source: National Climatic Data Center, NOAA, United States)

Mexico. During the summer season, temperatures were near normal except in eastern Canada. November was also particularly mild over Canada and the western part of the United States.

South America

Between January and April, above-normal temperatures predominated over southern South America; conversely, below-normal temperatures were recorded in the central and north-western part of the region. During the same period, southern Argentina and Chile were affected by persistent atmospheric blocking situations that brought very hot weather to the area. February was particularly warm throughout this region. Many locations recorded the warmest February in 50 years, with daily maximum temperatures reaching between 35°C and 40°C, well above the average, which ranges between 20°C and 28°C.

May was colder than average especially because of an early Antarctic air mass outbreak that affected southern South America, particularly central and northern Argentina, where the minimum temperature dropped below –6°C in some locations, breaking annual absolute minimum temperature records. Conversely, mean July temperatures were more than +3°C above average in large parts of Argentina, Uruguay, Paraguay, south-east Bolivia and southern Brazil, making it the warmest July in the past 50 years for many locations. November also broke historical temperature records in part due to an unusual heatwave at the end of the month in central Argentina.

Australia

In Australia, the year started with the hottest January since 1950. An exceptionally prolonged heatwave affected much of southern Australia in March. For example, Adelaide had its longest running heatwave on record, with 15 consecutive days of maximum temperatures above 35°C, well in excess of the previous record of 8 consecutive days. Despite this, the rest of the austral autumn was characterized, in much of the country, by above-average daytime and below-average overnight temperatures. In Queensland, the first ever sub-zero March minimum (–0.2°C) was recorded at Stanthorpe, while Kalumburu (Western Australia) and Kowanyama (Queensland) had 60 or more consecutive below-normal nights, extending from early April to early June. September and October were very warm months ranking, with the two-month combined period, second behind 1988.

Global precipitation

In 2008, global precipitation over land was slightly above the 1961–1990 average. Precipitation throughout the year was variable in many areas. Less than average conditions were observed across the western and south-central contiguous United States; south-western Alaska and the Hawaiian Islands;

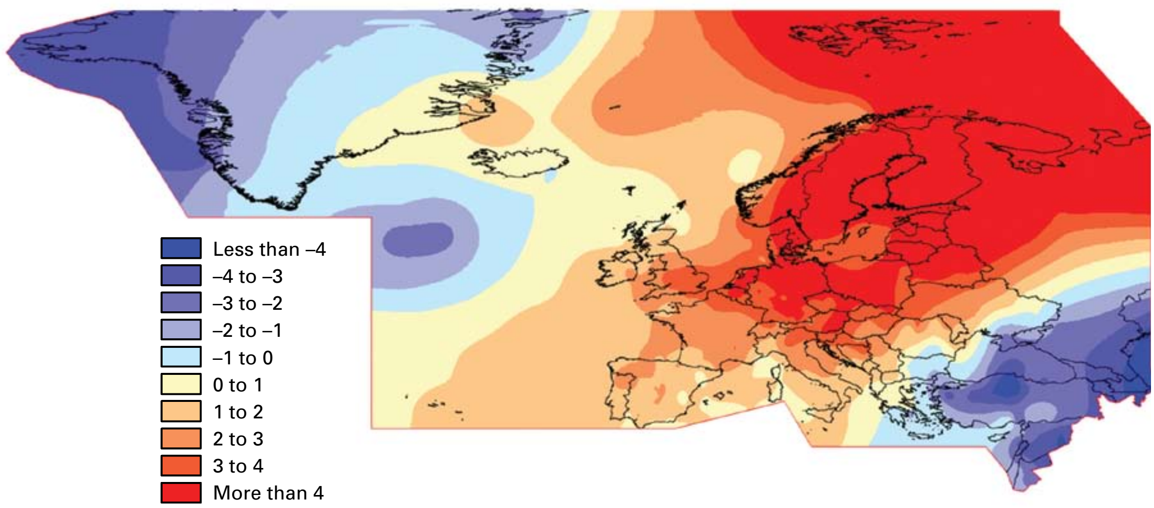


Figure 5. Monthly air surface temperature anomalies showing departures in degrees Celsius, 1961–1990 base for January 2008 over Europe *(Source: Deutscher Wetterdienst, Germany)*

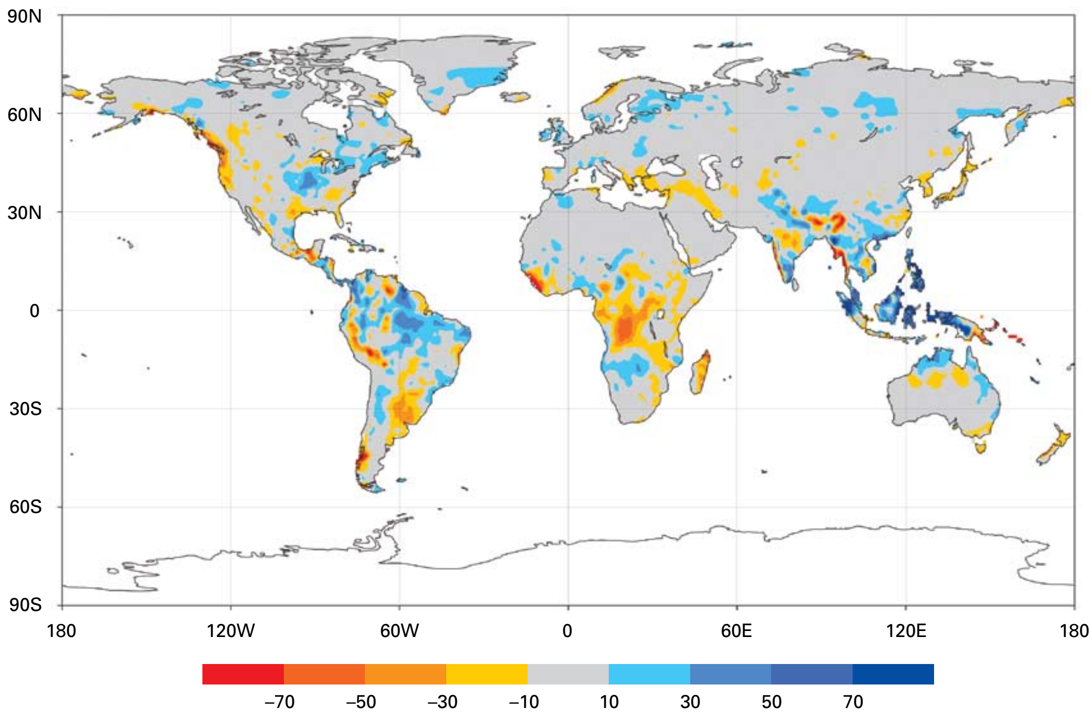


Figure 6. Annual precipitation anomalies for global land areas for 2008; gridded 1.0-degree raingauge-based analysis as normalized departures in mm/month from normal focusing on 1951–2000 base period *(Source: Global Precipitation Climatology Centre, Deutscher Wetterdienst, Germany).*

south-eastern Africa; southern Europe; northern India; and parts of Argentina, Uruguay, eastern Asia and southern Australia. Most of Europe, western Africa, the north-eastern and central contiguous United States, parts of northern South America, south-eastern Asia and northern Australia experienced wetter than average conditions.

Drought

At the end of July, most parts of the south-east of North America were classified as having moderate to exceptional drought conditions, based on the United States Drought Monitor. The continuous dry conditions across northern and central California resulted in numerous large wildfires.

In Canada, southern British Columbia experienced its fifth driest period in 61 years. In Europe, Portugal and Spain experienced their worst winter drought in decades.

South America, including the centre-east and north-east of Argentina, and a large part of Uruguay, Paraguay and southern Brazil, was particularly hit by a severe and prolonged drought, which started in the latter half of 2007. The precipitation index used in Argentina, as shown in Figure 7 for the north-east region, shows the severity and duration of this drought. This drought caused some damage to agriculture, livestock and water resources. During 2008, the total precipitation was between 40 and 60 per cent below normal and many locations recorded one of the driest years since 1900.

In south-eastern Australia dry conditions reinforced long-term drought over much of that region. This was the third consecutive year in which the September–October

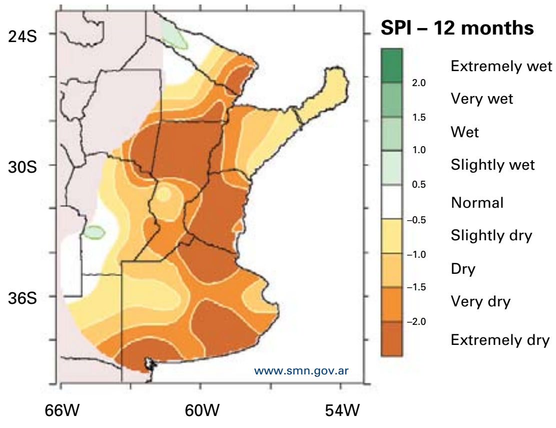


Figure 7. Standardized Precipitation Index for 2008 (SPI 12) for the centre-east and north-east regions of Argentina *(Source: National Meteorological Service, Argentina)*

period was exceptionally dry. These conditions exacerbated severe water shortages in the agriculturally important Murray–Darling Basin, resulting in widespread crop failures in the area.

Extreme storms and flooding

In January, 1.3 million square kilometres (km^2) in 15 provinces in southern China were covered by snow. Persistent low temperature and icing affected the daily lives of millions of people who suffered not only from damage to agriculture, but also from disruptions in transport, energy supply and power transmission.

In Canada, several all-time snowfall records were set during winter, reaching more than 550 centimetres (cm) in many locations, including Quebec City. In Toronto, it was the third snowiest winter on record for the past 70 years. At the end of January, Prince Edward Island was struck by one of the worst ice storms in decades.

In the United States, heavy April rainfall, combined with previously saturated ground and snowmelt, resulted in widespread major flooding that affected Missouri and southern Indiana. During June, 78 stations reported their wettest day of any June and 15 of these stations set a new all-time record for the wettest 24-hour period for any month. Also, 2008 was one of the top 10 years for tornado-related fatalities (123) since reliable records began in 1953. According to statistics, 2 192 tornadoes were recorded during the year, well above the 10-year average of 1 270.

In Germany, between May and September, a large number of strong thunderstorms with heavy rain, tornadoes and hailstorms were observed, causing some casualties and significant damage.

Sub-Saharan Africa, including West and East Africa, was affected by heavy rains, which caused the worst-ever recorded flooding in Zimbabwe and affected more than 300 000 people in West Africa during the monsoon season.

In northern Africa, heavy and extended rainfall during the September–November period affected Algeria and Morocco, causing important infrastructure damage and several casualties. Extreme rainfall intensities with up to 200 millimetres (mm) of rainfall

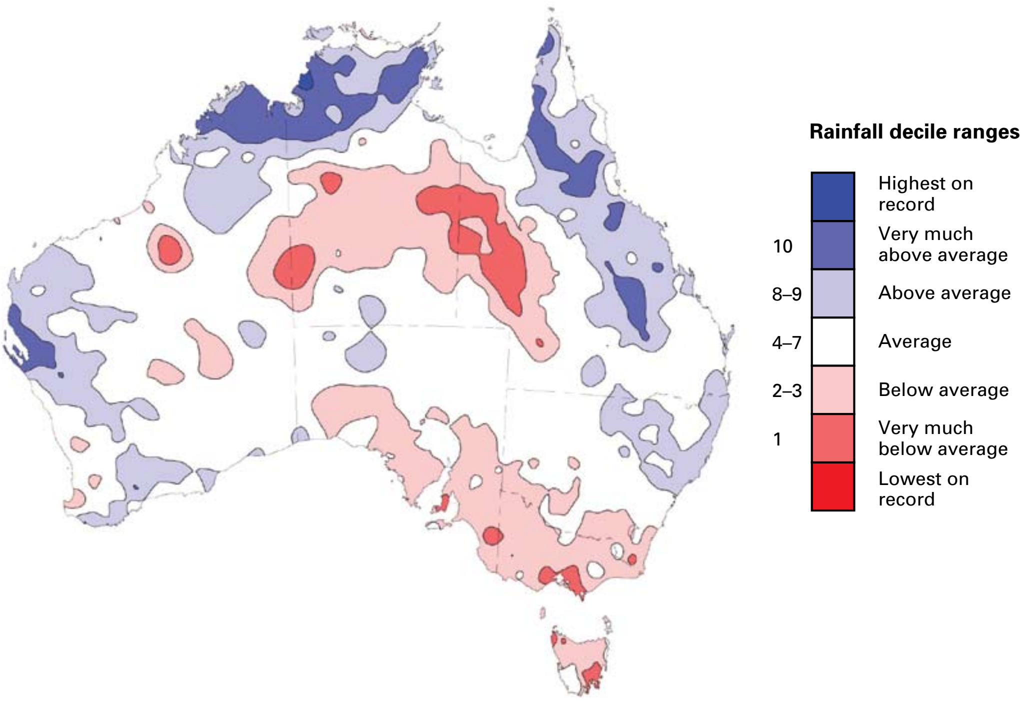


Figure 8. Australian rainfall deciles for the year 2008. Deciles are calculated relative to the period 1900–2008, with distribution based on gridded data from the National Climate Centre. *(Source: Commonwealth of Australia, Australian Bureau of Meteorology, Australia)*

in less than six hours were recorded in the northern provinces of Morocco. Within the same climate anomaly context and period, intense rainfall was also recorded in south-western Europe. In Valencia, Spain, a total rainfall of 390 mm was recorded in 24 hours, of which 144 mm was recorded in less than 1 hour. In France, heavy and intense rains affected several locations from 31 October to 2 November. In those three days, total rainfall reached 500 mm in some locations, which caused severe flooding and flash floods, particularly in the central and east-central parts of the country.

Several major rain events affected eastern Australia in January and February, causing significant flooding, particularly in Queensland. In November, widespread heavy rains occurred across most of the continent, ending an extremely dry period in central Australia. Associated severe thunderstorms caused damage from winds, hail and flash floods in many places.

In southern Asia, including India, Pakistan and Viet Nam, heavy monsoon rains and torrential downpours produced flash floods, killing more than 2 600 people, and displacing 10 million people in India.

In western Colombia, continuous above-normal rainfall resulted in severe flooding and landslides that affected at least half a million people and caused extensive damage during the second half of the year.

In Southern Brazil, intense rainfall affected Santa Catarina state from 21 to 24 November, causing severe flooding and deadly mudslides, which affected 1.5 million people and resulted in more than 80 casualties. During this period, more than 500 mm of rainfall was recorded, including more than 200 mm of rainfall in 24 hours (breaking historical records for 24-hour rainfall), for example, at Blumenau, Balneário Camboriú, São Francisco do Sul, Itapoá and Biguaçú.

Tropical cyclones

The most deadly tropical cyclone recorded in 2008 was *Nargis*, which developed in the North Indian Ocean and hit Myanmar in early May, killing more than 70 000 people and destroying thousands of homes. *Nargis* was the most devastating cyclone to hit Asia since 1991 and resulted in the worst natural disaster on record for Myanmar.

A total of 16 named tropical storms formed in the Atlantic, including 8 hurricanes, 5 of which were major Category 3 or higher, compared with the long-term average of 11 tropical storms, 6 hurricanes, 2 which were Category 3 or higher. The 2008 Atlantic hurricane season was devastating, with many casualties and widespread destruction in the Caribbean, Central America and the United States. For the first time on record, six consecutive tropical cyclones (*Dolly*, *Edouard*, *Fay*, *Gustav*, *Hanna* and *Ike*) made landfall on the United States, and a record of three major hurricanes (*Gustav*, *Ike* and *Paloma*) hit Cuba. *Hanna*, *Ike* and *Gustav* were the deadliest hurricanes of the season, causing several hundred casualties in the Caribbean, including 500 deaths in Haiti.

In the East Pacific, 17 named tropical storms were recorded, of which 7 evolved into hurricanes and 2 into major hurricanes, compared with averages of 16, 9 and 4, respectively.

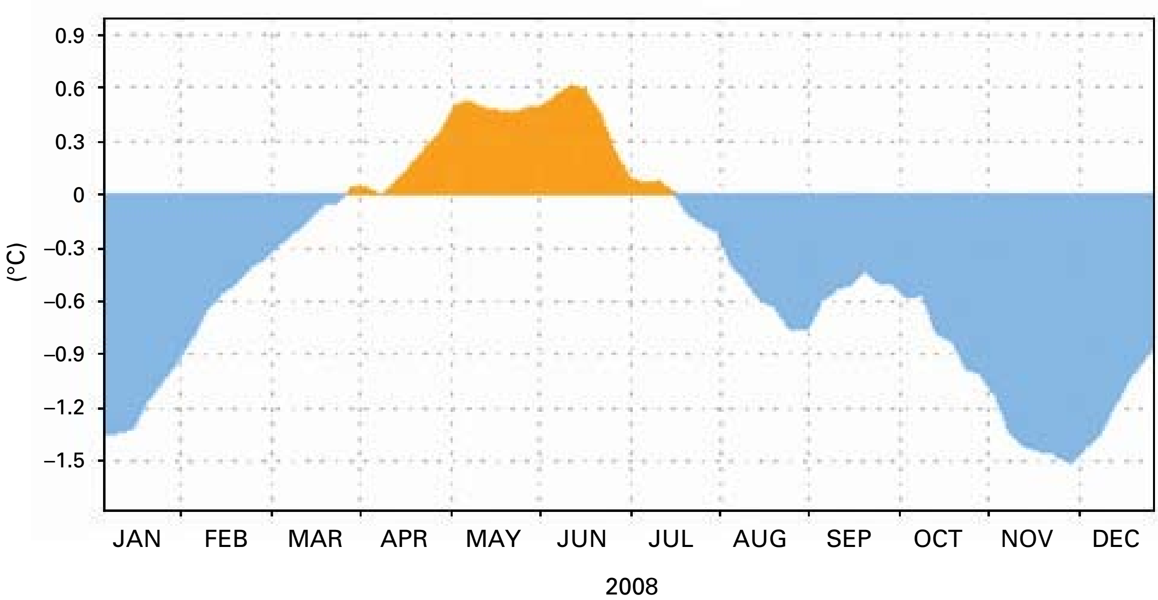
In the western North Pacific, 22 named tropical storms were recorded; of these, 11 were classified as typhoons compared with the long-term averages of 27 and 14, respectively. The Philippines, Cambodia, the Lao People's Democratic Republic, Thailand, Viet Nam and south-eastern China were severely affected by these events. For the first time since 2001, no named tropical cyclones made landfall in Japan during the year.

In the broader Australian region, tropical cyclone numbers during the 2007/2008 season were close to normal, with a total of 10 systems. However, it was a quiet season for landfalls and intense systems.

Weakening of La Niña

The first quarter of 2008 was characterized by a La Niña event of moderate to strong intensity, which began in the second half of 2007 and prevailed through May 2008. The large area of cool surface waters over the

Figure 9. Area-averaged upper-ocean heat content anomalies (°C) in the upper 300 m of the equatorial Pacific (5°N–5°S, 180°–100°W). Heat content anomalies are computed as departures from the 1982–2004 base period pentad means.
(Source: Climate Prediction Center, National Centers for Environmental Prediction, NOAA, United States)

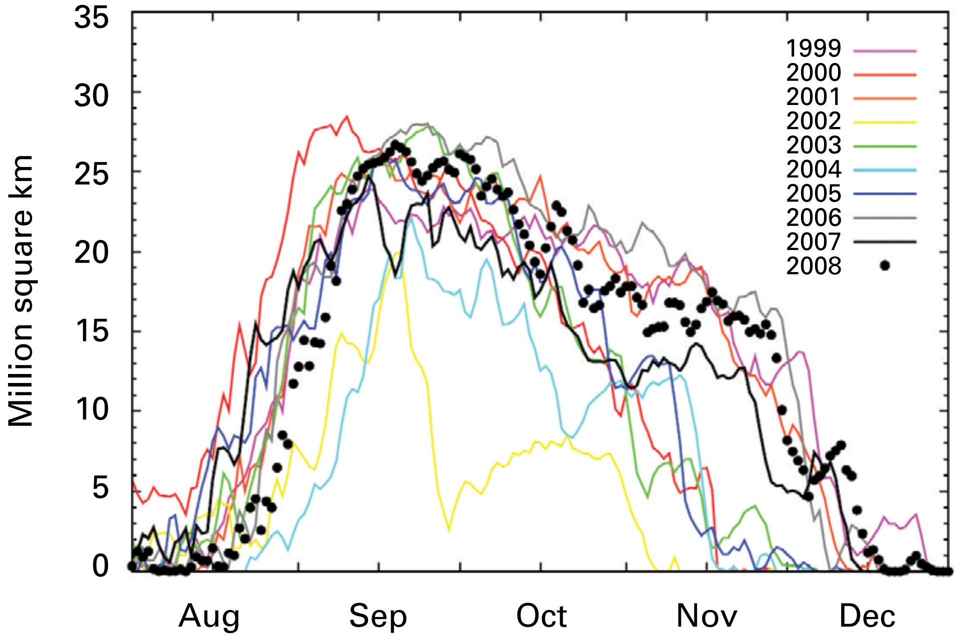


bulk of the central and eastern equatorial Pacific, combined with warmer than normal conditions in the equatorial western Pacific, represented typical La Niña forcing on the global atmosphere. La Niña conditions gradually weakened from their peak strength in February, and near-neutral conditions prevailed during most of the latter half of 2008. However, cold sea surface temperatures developed in December in the central and eastern equatorial Pacific. Atmospheric wind patterns coupled with the cooler than normal surface waters, generally indicating La Niña conditions, across the tropical Pacific towards the end of the year.

Antarctic ozone hole larger than in 2007

The ozone hole area reached a maximum of 27 million km^2 on 12 September. This is less than in the record years of 2000 and 2006

Figure 10. Ozone hole area with respect to 220 DU (Dobson Unit) in the southern hemisphere from August to December for the years 1999–2008; observations made by GOME and SCIAMACHY
(Source: Royal Netherlands Meteorological Institute)



(more than 29 million km^2), but larger than in 2007 (25 million km^2). The variation in the size of the ozone hole from one year to another can be explained, to a large extent, by the meteorological conditions in the stratosphere, as ozone depletion becomes more severe if the stratosphere is cold. Temperature conditions in the 2008 Antarctic stratospheric vortex were colder than in 2007 but warmer than in 2006. Over the next few years, the variation in the severity of ozone hole will be governed by inter-annual changes in meteorology rather than changes in ozone depleting substances, whose decline is quite slow.

Arctic sea ice down to second-lowest extent

Arctic sea-ice extent during the 2008 melt season dropped to its second-lowest level since satellite measurements began in 1979, reaching the lowest point in its annual cycle of melt and growth on 14 September 2008. Average sea-ice extent over the month of September, a standard measure in the scientific study of Arctic sea ice, was 4.67 million km^2. The record monthly low, set in 2007, was 4.3 million km^2. As the ice was thinner in 2008, its overall volume was less than that in any other year. A remarkable occurrence in 2008 was the dramatic disappearance of nearly one quarter of the massive ancient ice shelves on Ellesmere Island. The season strongly reinforces the 30-year downward trend in Arctic sea-ice extent.

For the first time in recorded history, the navigable deep-water routes of the fabled Northwest Passage over the top of North America, and the Northeast Passage over the top of the Russian Federation, were simultaneously free of ice. The year 2008 marked the third consecutive summer that ships could easily navigate the Northwest Passage without hitting or being blocked by sea ice.

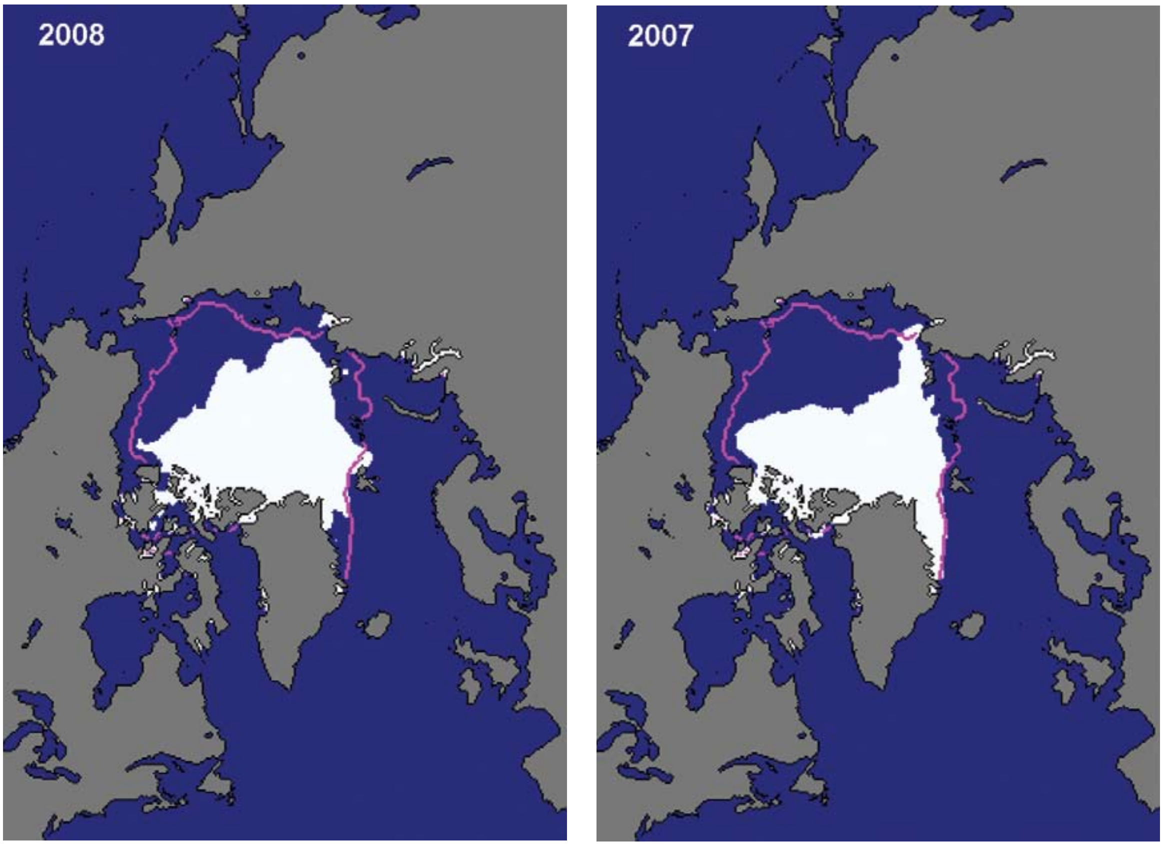


Figure 11. Sea-ice extent for September 2008 and September 2007; the magenta line indicates the long-term median from the 1979–2000 base period. The sea-ice extent in September 2008 was 4.67 million square kilometres, reaching the second lowest value after the record of 4.28 million square kilometres observed in 2007. *(Source: National Snow and Ice Data Center, United States)*

Benefits for climate monitoring and assessment of data rescue activities

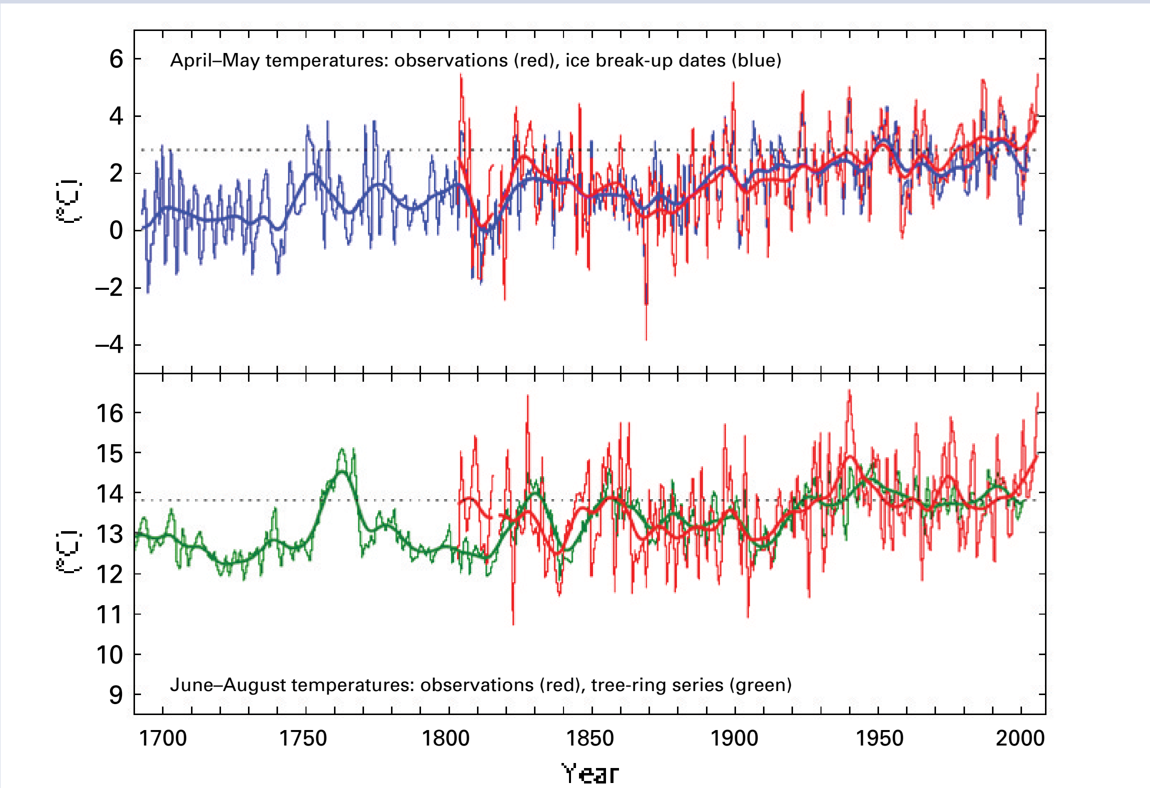
by Phil Jones, Climatic Research Unit, School of Environmental Sciences, University of East Anglia, UK

In most regions of the world there are longer instrumental records than apparent in a cursory search of the website or archives of a National Meteorological and Hydrological Service (NMHS). In most cases this results from the NMHS not yet having digitized all the meteorological data in its archives. In many cases the records pre-date the founding of the Service, whereas in others they pre-date the founding of the country. It is important that these early records, which were often taken with meticulous care by early scientists and medical doctors, be digitized and made available for climatological use. These early records are generally to be found in national or learned society archives, sometimes located in the archives of an earlier colonial power. Present-day scientists owe their forebears much gratitude for taking these early measurements with meticulous care and diligence. Given this effort, it would be a shame if they were left to collect more dust in an archive.

Extending climatic series brings a number of scientific benefits, both to the NMHS and to the climatological research community in the country and in the region. The primary benefit is that the longer records enable trends and other analyses to be more extensive, placing recent records and extremes in the longer context. Longer climatic series also provide instrumental data for more extensive calibration of natural and documentary proxies, both of which have the potential for extending the climatic history further back in time. Longer observational data provide better coverage (in both space and time) for extended reanalysis projects, planned to begin from the late nineteenth century. Lastly, longer records are useful for assessing impacts of climate change over more extensive time frames than just the recent past. The following two examples discuss the above for northern and western Europe. They illustrate what has been achieved through more extensive digital instrumental data.

Longer records for the assessment of proxy evidence

Longer climatic reconstructions require information from natural (for example, trees and ice cores) and documentary (written archives) proxy material. These proxy records must use instrumental records to calibrate the proxy



Comparison of instrumental and proxy records developed for northern Fennoscandia (using the instrumental temperature series for Haparanda, developed by Klingbjer and Moberg (2003), which extends back to 1800); top panel: April–May instrumental temperatures (red), estimated temperatures based on ice break-up dates (blue); bottom panel: June–August instrumental temperatures (red), calibrated temperatures based on tree-ring width and density data (green, from near Lake Torneträsk) source. In many regions, calibration is hampered by the lack of long instrumental records. In Europe, however, it is generally possible to assess the quality of possible reconstructions, especially the longer decadal-timescale details, for almost 200 years. The figure shows examples of such calibration exercises using a long instrumental record developed for northern Fennoscandia. Both proxy series show good replication of instrumental temperatures at the inter-annual and decadal timescales.

Extensions of the North Atlantic Oscillation

The longest record of the winter North Atlantic Oscillation (NAO), back to 1820, has been derived by Jones and others (1997) based on pressure data from Gibraltar and Reykjavik. As the NAO is essentially a measure of the westerly wind strength over western Europe, two long well-located pressure records would provide a good surrogate for the more distant locations in Iceland and southern Iberia or the Azores. The two locations with the greatest potential length anywhere in the world are Paris and London. At both sites, near-continuous daily pressure records have been taken since the late seventeenth century. For Paris, a complete record has been developed back to 1677, missing only most of the years in the 1720s and 1730s. For London, the record is complete from 1692, missing only the years between 1717 and 1722. Despite these short gaps, a very useful approximation to the winter NAO has been developed back to 1692.

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