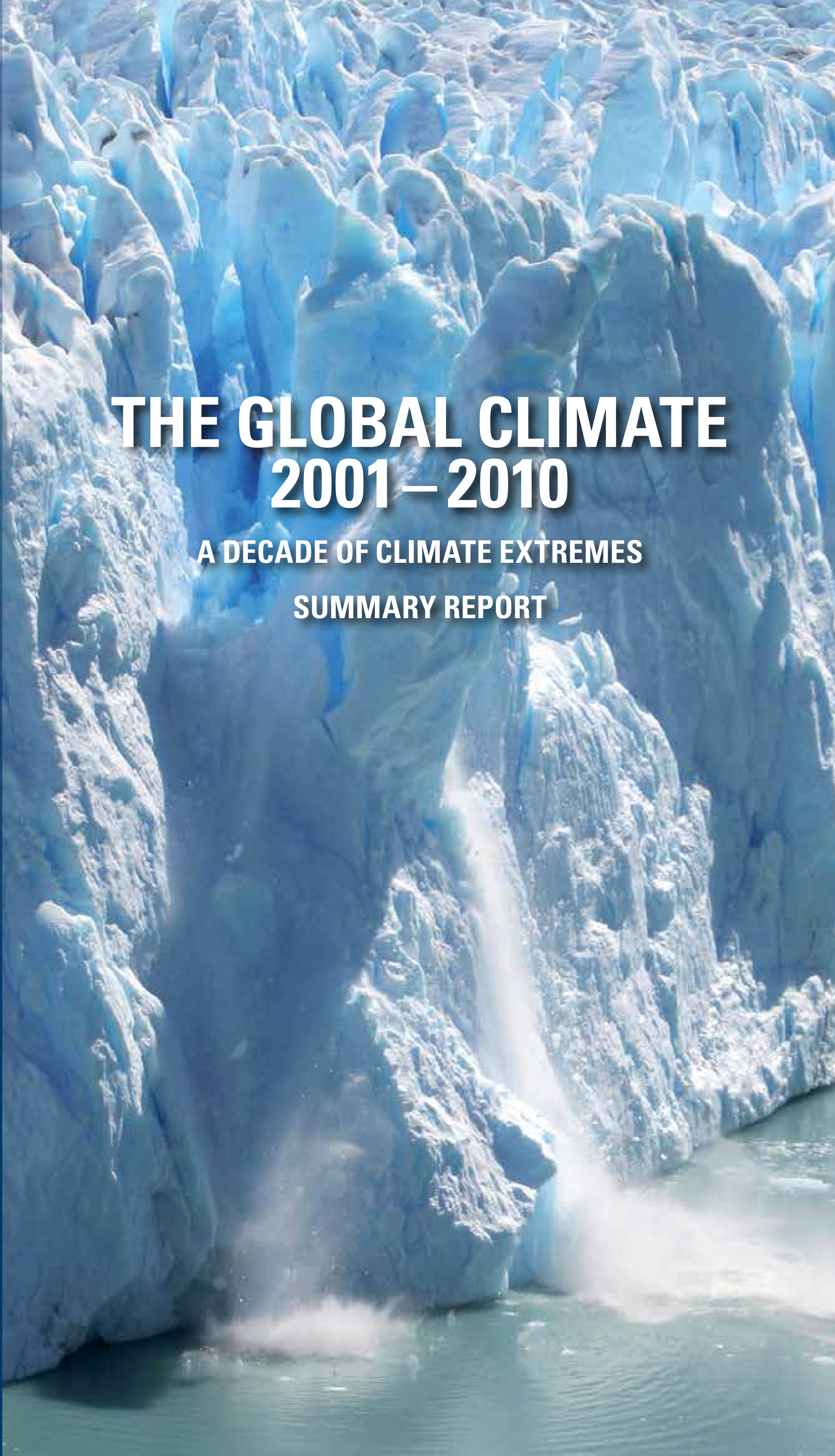


THE GLOBAL CLIMATE 2001 – 2010

A DECADE OF CLIMATE EXTREMES

SUMMARY REPORT

World Meteorological Organization
Weather • Climate • Water

WMO-No. 1119

WMO-No. 1119
© World Meteorological Organization, 2013

The right of publication in print, electronic and any other form and in any language is reserved by WMO. Short extracts from WMO publications may be reproduced without authorization, provided that the complete source is clearly indicated. Editorial correspondence and requests to publish, reproduce or translate this publication in part or in whole should be addressed to:

Chair, Publications Board
World Meteorological Organization (WMO)
7 bis, avenue de la Paix
P.O. Box 2300
CH-1211 Geneva 2, Switzerland

Tel.: +41 (0) 22 730 84 03
Fax: +41 (0) 22 730 80 40
E-mail: publications@wmo.int

ISBN 978-92-63-11119-7

NOTE

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

The mention of specific companies or products does not imply that they are endorsed or recommended by WMO in preference to others of a similar nature which are not mentioned or advertised.

The findings, interpretations and conclusions expressed in WMO publications with named authors are those of the authors alone and do not necessarily reflect those of WMO or its Members.

THE GLOBAL CLIMATE 2001–2010

A DECADE OF CLIMATE EXTREMES

SUMMARY REPORT

Foreword

The first decade of the 21st century was the warmest decade recorded since modern measurements began around 1850. It saw above-average precipitation, including one year – 2010 – that broke all previous records. It was also marked by dramatic climate and weather extremes such as the European heatwave of 2003, the 2010 floods in Pakistan, hurricane *Katrina* in the United States of America (USA), cyclone *Nargis* in Myanmar and long-term droughts in the Amazon Basin, Australia and East Africa.

Many of these events and trends can be explained by the natural variability of the climate system. Rising atmospheric concentrations of greenhouse gases, however, are also affecting the climate. Detecting the respective roles being played by climate variability and human-induced climate change is one of the key challenges facing researchers today.

The World Meteorological Organization (WMO) is proud to be a major contributor to international efforts to better understand our climate. We sponsor or co-sponsor leading research and observation programmes, notably the WMO Global Atmosphere Watch, the World Climate Research Programme, the Global Climate Observing System and the Intergovernmental Panel on Climate Change.

We also produce an annual statement – Status of the Global Climate – based on the WMO Climate System Monitoring network. This international collaboration facilitates the gathering of data from the world's leading climate data, monitoring and research centres. These data, together with climate information collected through a unique survey among the world's National Meteorological and Hydrological Services, were also used to produce the decadal report The Global Climate 2001–2010.

A decadal perspective makes it possible to assess trends and anticipate the future. It can also inform efforts to develop operational climate services that provide information and forecasts for decision-making in agriculture, health, disaster risk, water resources and other sectors. These efforts are being coordinated through the WMO-led Global Framework for Climate Services.

To learn more about the 2001–2010 decade of extremes, including the detailed results of the WMO survey of countries, you are strongly encouraged to read the complete technical report (WMO-No. 1103), which is available online on the WMO website.

(M. Jarraud)
Secretary-General

1. Climate variability and climate change

The Earth's climate fluctuates over seasons, decades and centuries in response to both natural and human variables. Natural climate variability on different timescales is caused by cycles and trends in the Earth's orbit, incoming solar radiation, the atmosphere's chemical composition, ocean circulation, the biosphere and much more.

Climate change refers to long-term changes in the average state of the climate and can also be due to natural factors. The rapid changes that have occurred since the middle of the past century, however, have been caused largely by humanity's emissions of greenhouse gases into the atmosphere. Other human activities also affect the climate system, including emissions of pollutants and other aerosols, and changes to the land surface, such as urbanization and deforestation.

Short-term natural climate variability can often be linked to recurring patterns of atmospheric pressure and ocean circulation. El Niño and La Niña episodes, for example, result from rapid changes in the sea-surface temperature in the equatorial Pacific Ocean. They influence weather patterns around the world through the subsequent large-scale interactions and transfers of heat in the coupled ocean-atmosphere system. Other patterns affect the climate by strengthening or weakening high-altitude air currents known as jet streams.

The decade 2001–2010 did not experience a major El Niño event, which is normally associated with a warming of the global climate (as occurred for example in the then-record warm year of 1998). La Niña and neutral conditions prevailed until mid-2006, followed by a brief El Niño. Cool La Niña conditions returned from late 2007, a brief El Niño appeared from June 2009 and then a strong La Niña episode started in mid-2010. This short-term natural variability may have masked some of the effects of long-term climate change.

The closely related Arctic Oscillation and North Atlantic Oscillation often affect the northern hemisphere winter. Since the 1990s, these two oscillations have remained mostly in a positive phase, which is associated with warmer and wetter winters in northern and central Europe and the eastern USA, drier winters in the Mediterranean and cold, dry conditions over northern Canada and Greenland. The winter of 2009/2010, however, saw extremely negative phases with low winter temperatures in northern and central Europe.

Unlike these natural back-and-forth oscillations, human-caused climate change is trending in just one direction. This is because atmospheric concentrations of carbon dioxide, methane, nitrous oxide and other greenhouse gases are increasing steadily, due to human activities. According to the WMO Greenhouse Gas Bulletin, global-average atmospheric concentrations of carbon dioxide rose to 389 ppm[1] in 2010 (an increase of 39 per cent compared to pre-industrial times), methane to 1 808.0 ppb[1] (158 per cent) and nitrous oxide to 323.2 ppb (20 per cent). This changing composition of the atmosphere is causing the global average temperature to rise, which, in turn, exerts a significant influence on the hydrological cycle and leads to other changes in climate and weather patterns.

Humanity's emissions of chlorofluorocarbons and other chemicals have also changed the

______

1 ppm = parts per million; ppb = parts per billion

Table 1. Mixing ratio of carbon dioxide, methane and nitrous oxide in 2010 and the decadal values for 1991–2000 and 2001–2010

	2010	Increase since pre-industrial times	1991–2000	2001–2010
Carbon dioxide	389 ppm	39%	361.5 ppm	380 ppm
Methane	1 808 ppb	158%	1 758 ppb	1 790 ppb
Nitrous oxide	323.2 ppb	20%	312.2 ppb	319.7 ppb

atmosphere by damaging the stratospheric ozone layer that filters out harmful ultraviolet radiation. Fortunately, the phase-out of ozone-depleting substances under the Montreal Protocol should allow the ozone layer to recover in a few decades. The Antarctic ozone hole is believed to influence the Southern Annular Mode oscillation and thus the regional climate. Meanwhile, emissions of reactive gases (such as nitrogen oxides and sulphur dioxide) and aerosols (such as dust and black carbon) also interact with the climate, for example by increasing the health impacts of heatwaves.

2. The warmest decade

The period 2001–2010 was the warmest decade on record since modern meteorological records began around the year 1850. The global average temperature of the air above the Earth's surface over the 10-year period is estimated to have been 14.47°C ± 0.1°C. This is 0.47°C ± 0.1°C above the 1961–1990 global average of +14.0°C and +0.21 ± 0.1°C above the 1991–2000 global average. It is 0.88°C higher than the average temperature of the first decade of the 20th century (1901–1910).

A pronounced increase in the global temperature occurred over the four decades 1971–2010. The global temperature increased at an average estimated rate of 0.17°C per decade during that period, while the trend over the whole period 1880–2010 was only 0.062°C per decade. Furthermore, the increase of 0.21°C in the average decadal temperature from 1991–2000 to 2001–2010 is larger than the increase from 1981–1990 to 1991–2000 (+0.14°C) and larger than for any other two successive decades since the beginning of instrumental records.

Nine of the decade's years were among the 10 warmest on record. The warmest year ever recorded was 2010, with a mean

Domain		Temperature anomaly (°C)		
		2001–2010 (A)	Warmest/least warm year during 2001–2010 (B)	Warmest/coldest decade on record (C)
Global	Land	+0.79°C	2007 (+0.95°C) 2001 and 2004 (+0.68°C)	2001–2010 (+0.79°C) 1881–1890 (–0.51°C)
	Ocean	+0.35°C	2003 (+0.40°C) 2008 (+0.26°C)	2001–2010 (+0.35°C) 1901–1910 (–0.45°C)
	Land-ocean	+0.47°C	2010 (+0.54°C) 2008 (+0.35°C)	2001–2010 (+0.47°C) 1901–1910 (–0.45°C)
Northern hemisphere	Land	+0.90°C	2007 (+1.13°C) 2004 (+0.76°C)	2001–2010 (+0.90°C) 1881–1890 (–0.52°C)
	Ocean	+0.41°C	2005 (+0.47°C) 2008 (+0.33°C)	2001–2010 (+0.41°C) 1901–1910 (-0.39°C)
	Land-ocean	+0.60°C	2010 (+0.69°C) 2008 (+0.53°C)	2001–2010 (+0.60°C) 1901–1910 (-0.38°C)
Southern hemisphere	Land	+0.48°C	2005 (+0.67°C) 2001 (+0.34°C)	2001–2010 (+0.48°C) 1901–1910 (–0.53°C)
	Ocean	+0.29°C	2002 (+0.34°C) 2008 (+0.20°C)	2001–2010 (+0.29°C) 1901–1910 (–0.51°C)
	Land-ocean	+0.33°C	2009 (+0.38°C) 2008 (+0.24°C)	2001–2010 (+0.33°C) 1901–1910 (–0.51°C)

Table 2. Surface temperature anomalies with respect to 1961–1990: over the globe, northern hemisphere and southern hemisphere for 2001–2010 (A), annual extreme values for 2001–2010 (B) and decadal extreme values for 1881-2010 (C) *(source: UK Met Office and US National Oceanic and Atmospheric Administration (NOAA) for global analyses combined; NOAA-National Climate Date Center (NCDC) for the northern and southern hemispheres)*

temperature anomaly estimated at 0.54°C above the 14.0°C baseline, followed closely by 2005. The least warm year was 2008, with an estimated anomaly of +0.38°C, but this was enough to make 2008 the warmest La Niña year on record.

The 2001–2010 decade was also the warmest on record for both land-only and ocean-only surface temperatures. The warmest worldwide land-only surface-air temperature was recorded in 2007, with a temperature anomaly of +0.95°C. The warmest worldwide ocean-only surface temperature was measured in 2003, with an anomaly of +0.4°C above the 1961–1990 average. This is consistent with climate-change science, which projects that the ocean surface will warm more slowly than the land because much of the additional heat will be transported down into the ocean depths or lost through evaporation.

When considered region by region, most areas of the world also experienced above-average temperatures during the decade, particularly in 2010, when records were broken by over +1°C in some areas. At the national level, a large majority of countries responding to the WMO survey reported that they experienced their warmest decade on record. Many geographically large countries and regions saw decadal temperature anomalies over 2001–2010 that exceeded +1°C relative to the long-term average of 1961–1990.

Europe experienced above-normal temperatures between 2001 and 2009, with 2007 the warmest year on record for large parts of the region. Europe, including Greenland, saw a median temperature anomaly of +1.0°C for the decade. Greenland recorded the world's largest decadal mean temperature anomaly of +1.71°C.

Much of Asia also saw anomalies exceeding +1°C over the course of the decade, including China, the Islamic Republic of Iran, Mongolia and the Russian Federation. For the whole continent the median temperature anomaly of the decade was +0.84°C.

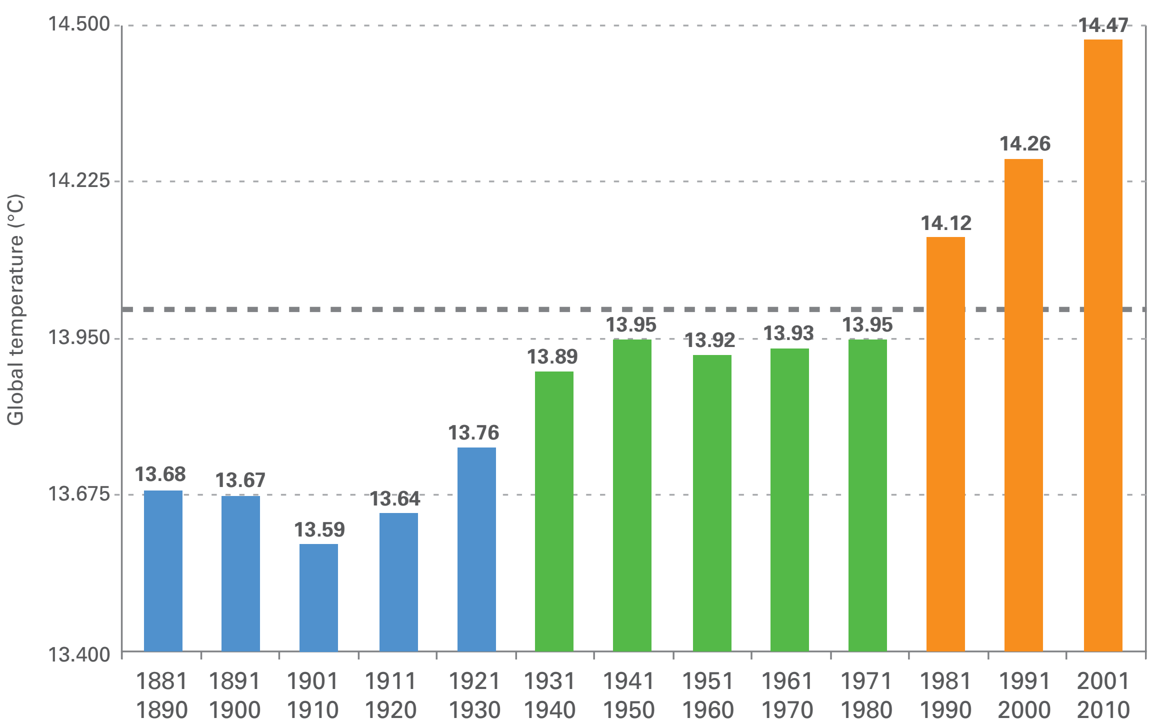


Figure 1. Decadal global combined surface-air temperature over land and sea-surface temperature (°C) obtained from the average over the three independent datasets maintained by the UK Met Office Hadley Centre and the Climatic Research Unit, University of East Anglia, in the United Kingdom (HadCRU), NOAA-National Climatic Data Center (NCDC) and the US National Aeronautics and Space Administration-Goddard Institute for Space Studies (NASA-GISS). The horizontal grey line indicates the long-term average value for 1961–1990 (14°C).

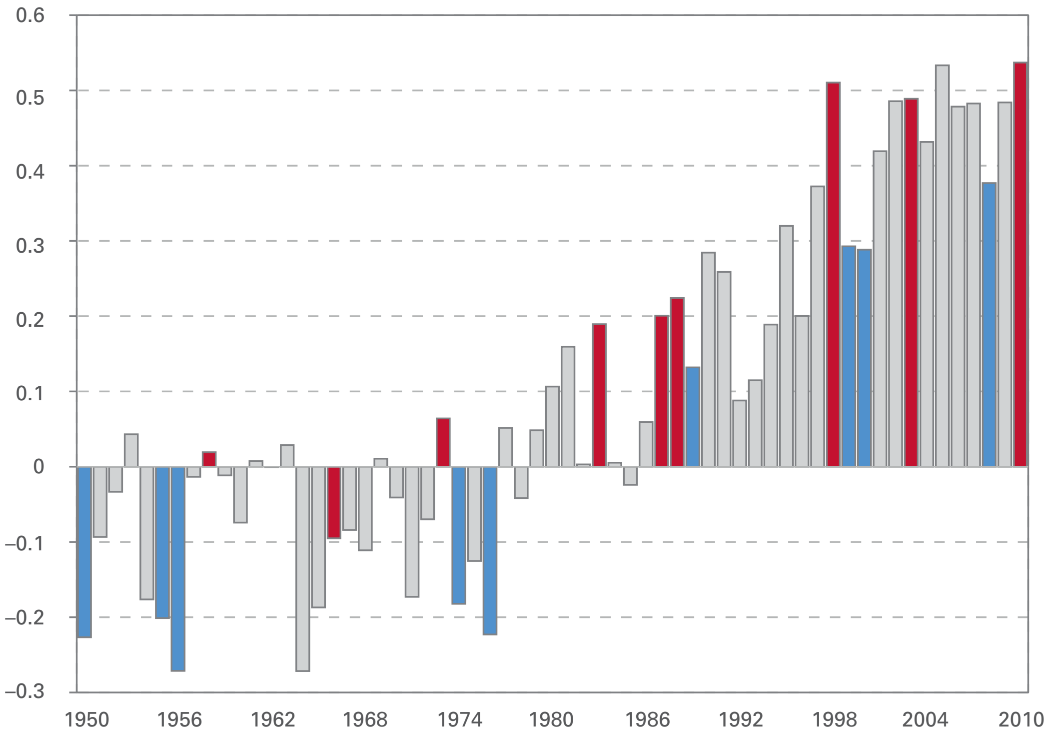


Figure 2. Annual global surface temperature anomaly for 1950–2010 with reference to the 1961–1990 base period, indicating the years with La Niña events (blue) and those with El Niño events (red) (*source: HadCRU, NOAA-NCDC and NASA-GISS*)

Africa experienced warmer-than-normal conditions in every year of the decade. The highest temperature anomalies occurred in countries north of the Equator. South of the Equator, Angola, Botswana, Madagascar, Namibia, South Africa and Zimbabwe confirmed temperature anomalies in the range of +0.5°C to +1°C. The median temperature anomaly of the decade in Africa was +0.7°C

The largest country in South America, Brazil, recorded the continent's highest temperature anomaly value of + 0.74 °C, making the decade the warmest on record there. The median value of the decadal temperature anomalies started to turn positive in 1981–1990 and reached +0.60°C in 2001–2010.

In North and Central America, Canada and the contiguous USA and Alaska, which together constitute by far the region's largest land area, recorded a combined average temperature anomaly greater than +0.5°C. On its own, Canada recorded the region's highest anomaly of +1.3°C, making 2001–2010 the country's warmest decade.

In Oceania, Australia, French Polynesia, New Caledonia, New Zealand and Tonga reported positive temperature anomalies in the last two decades, with a median value of +0.34°C for the 2001–2010 decade. In Australia, the largest country of the region, 2001–2010 was the warmest decade ever, with an anomaly value of +0.48°C.

As shown in Figures 1 and 2, the decade 2001–2010 continued the upward trend in global temperatures, despite the cooling effects of multiple La Niña episodes and other natural year-to-year variability.

3. Hot and cold extremes

While the average annual temperature is an important climate indicator, the temperatures that people experience can differ greatly from day to day and over the course of a year because of natural climate variability. At the

Extreme events, vulnerability, exposure and disasters

Monitoring and understanding extreme events is important because these events often destroy lives and property. Extreme events can, however, be prevented from becoming major disasters by reducing people's vulnerability and exposure.

While databases on disasters are useful for mapping the behaviour and impact of extremes in various regions, the data do not demonstrate that the increase in observed losses is caused by an increase in the frequency and intensity of extreme events. Other factors come into play, notably the increased exposure of people and property to climate extremes and the improved and increased reporting of disasters.

Nevertheless, it is worth noting the very large increase (more than 2 000 per cent) in the loss of life from heatwaves, particularly during the unprecedented extreme heat events that affected Europe in the summer of 2003 and the Russian Federation in the summer of 2010. On the other hand, there were fewer deaths due to storms and floods in 2001–2010 compared to 1991–2000, with decreases of 16 per cent and 43 per cent, respectively, thanks, in good part, to better early warning systems and increased preparedness.

There were fewer deaths, even while exposure to extreme events increased as populations grew and more people were living in disaster-prone areas. According to the 2011 Global Assessment Report, the average population exposed to flooding every year increased by 114 per cent globally between 1970 and 2010, a period in which the world's population increased by 87 per cent from 3.7 billion to 6.9 billion. The number of people exposed to severe storms almost tripled in cyclone-prone areas, increasing by 192 per cent, in the same period.

While the risk of death and injury from storms and floods declined, the vulnerability of property increased. This is because the expansion of socio-economic and infrastructural assets led to an increase in the amount and value of property exposed to weather and climate extremes.

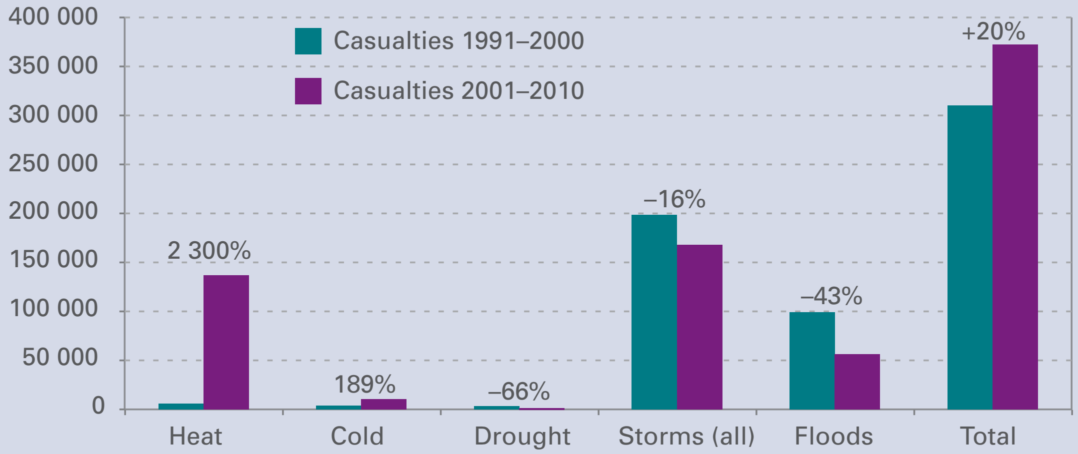


Figure 3. Impact of extreme events during 2001–2010 compared with 1991–2000: total number of lives lost. The change in per cent from 1991–2000 to 2001–2010 is shown above the bars.

same time, human influence has probably increased the maximum temperatures of the most extreme hot nights and days and the minimum temperatures of cold nights and cold days. It is also more likely than not that human-induced climate change has increased the risk of heatwaves.

According to the WMO survey, a total of 56 countries (44 per cent) reported their highest absolute daily maximum temperature record over the period 1961–2010 being observed in 2001–2010 compared to 24 per cent in 1991–2000, with the remaining 32 per cent spread over the earlier three decades. Conversely, 11 per cent (14 out of 127) of the countries reported their absolute daily minimum temperature record being observed in 2001–2010, compared to 32 per cent in 1961–1970 and around 20 per cent in each of the intermediate decades (Figure 4).

Over the course of the 2001–2010 decade, many countries and regions suffered heatwaves at one time or another (Figure 5). Some of the most dramatic included two severe heatwaves in India in 2002 and 2003, which each killed over 1 000 people; the 2003 summer heatwave over much of Europe, which caused more than 66 000 deaths; and the exceptionally

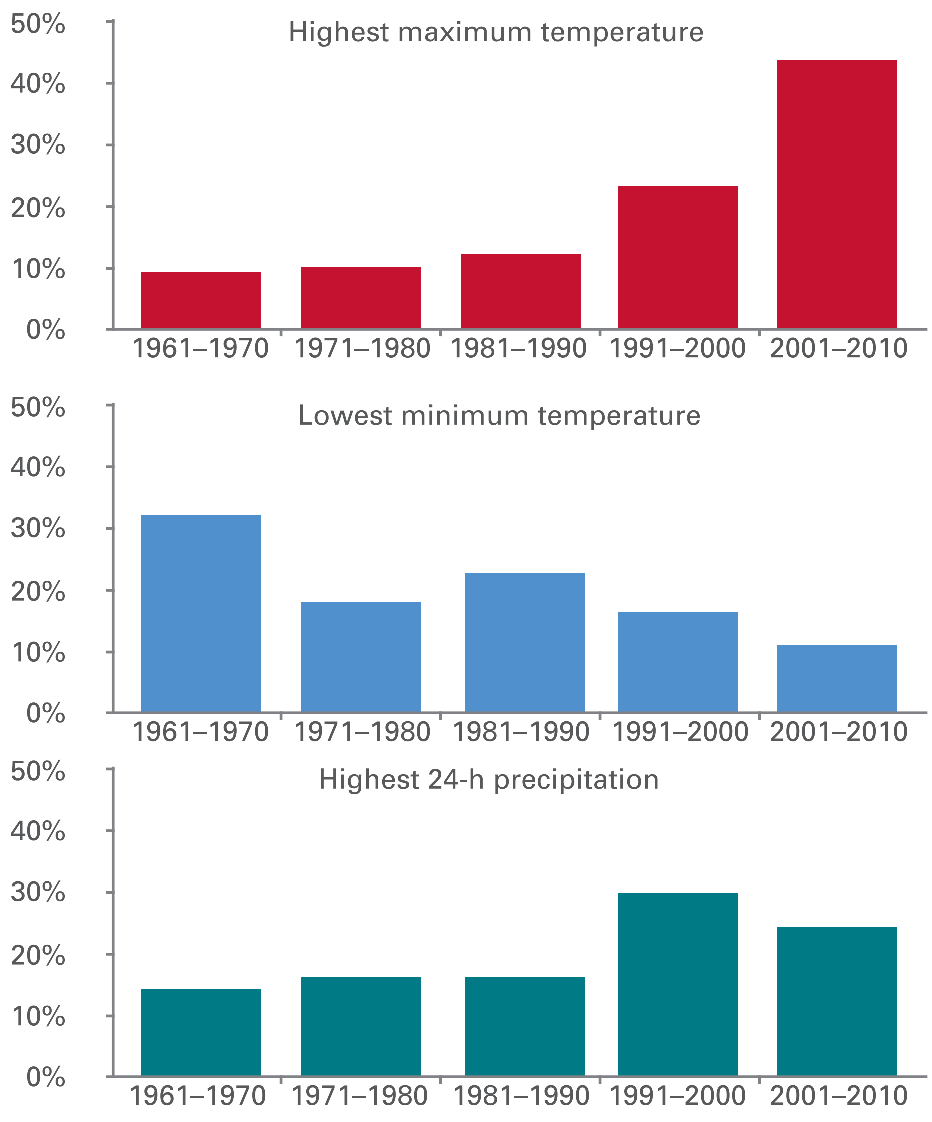
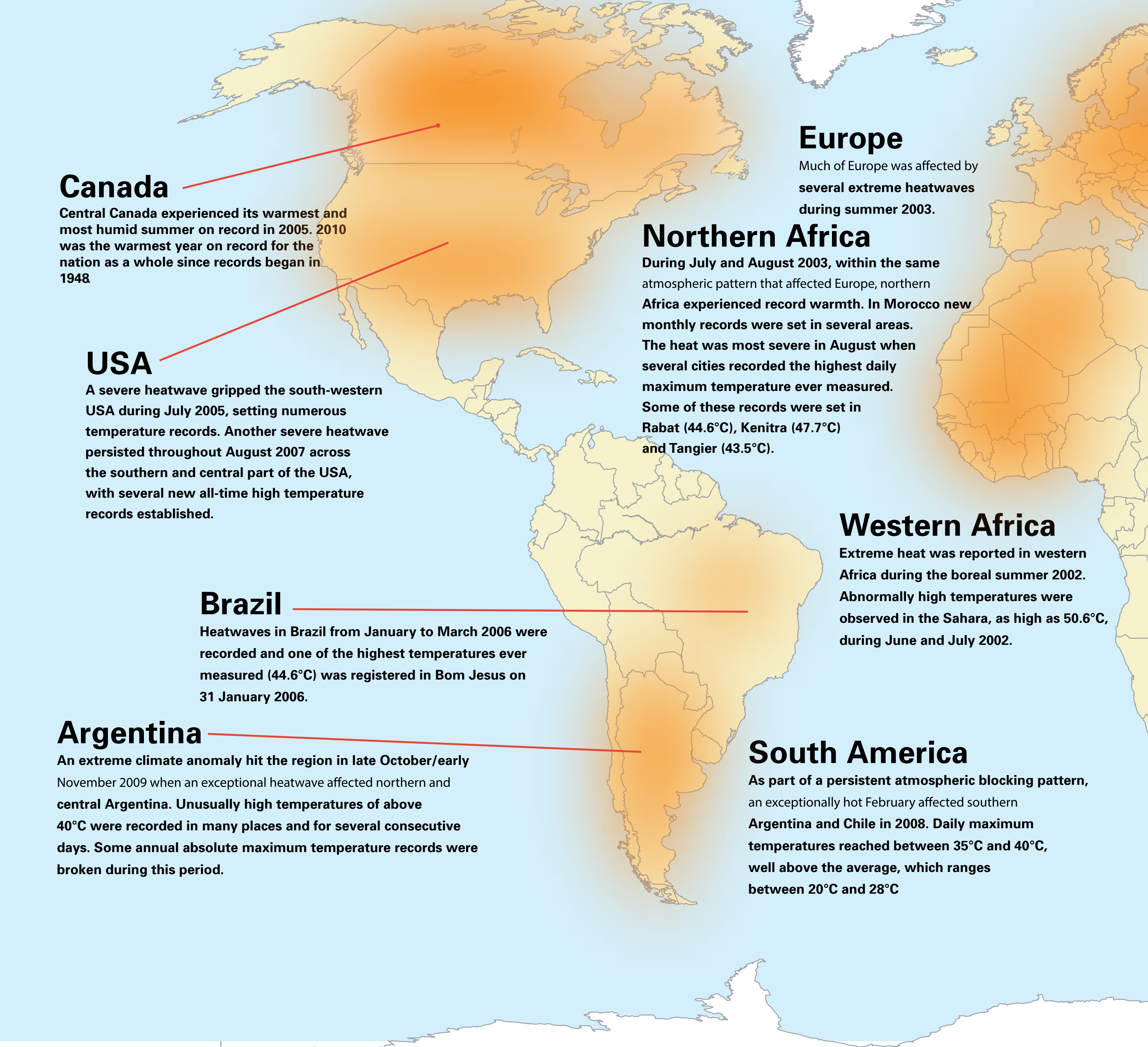


Figure 4. Absolute country records of the daily maximum and minimum temperature and 24-hour total precipitation in the last five decades (*source: WMO survey*)



intense and long-lasting heatwave that struck the Russian Federation in July/ August 2010, causing over 55 000 deaths. The WMO survey identifies many other abnormally high-temperature conditions, heatwaves and temperature records around the world.

Despite the record average warmth of the decade, cold waves continued to cause intense suffering in many countries. Coinciding with the extreme negative phase of the Arctic Oscillation and North Atlantic Oscillation, the northern hemisphere endured extreme winter conditions from December 2009 to February 2010. Prolonged cold and snow conditions across Europe resulted in over 450 deaths. The winter of 2009/2010 was also extremely cold in the Russian Federation, North America (particularly the USA) and parts of Asia. Other cold waves were experienced in the Plurinational State of Bolivia in 2002, southern Africa in 2002 and 2007, Peru in 2003, Morocco and Algeria in 2005, Australia in 2005, Asia in 2007/2008, and southern China in 2008.

4. Precipitation, floods and droughts

In all parts of the world, precipitation, floods and droughts vary naturally from year to year and from decade to decade. In addition,

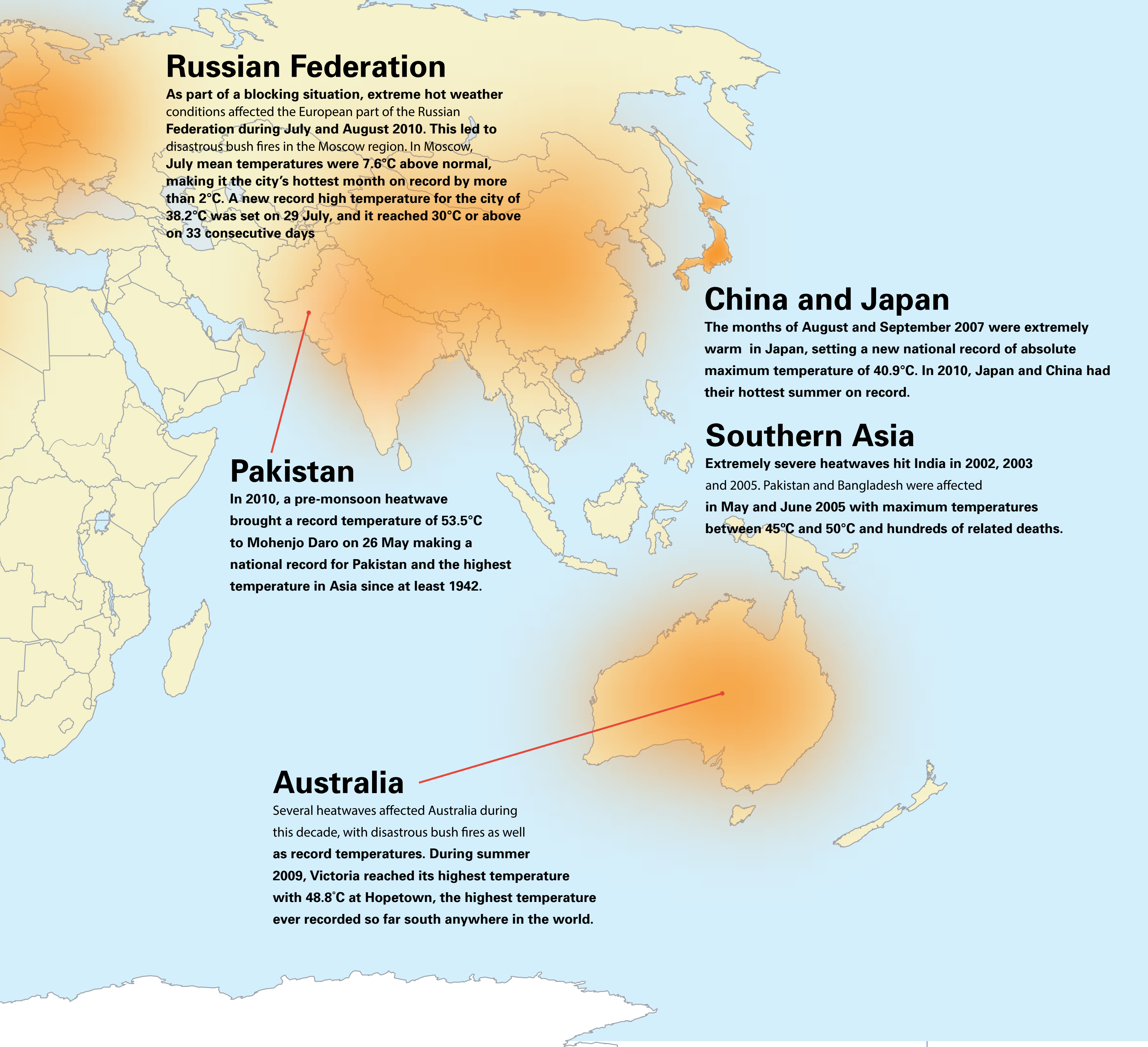


Figure 5. Most significant heatwaves and abnormally high temperature conditions reported during 2001–2010 (*source: NOAA-NCDC*)

because warm air can hold more moisture, it is likely that climate change has influenced the occurrence and intensity of extreme precipitation events. Greater warmth also speeds up the hydrological cycle, which should contribute to both heavier rainfall and increased evaporation. The largest number of national records for 24-hour extreme precipitation events, as reported in the WMO survey, occurred over the past two decades,1991–2010 (Figure 4).

Global land-surface precipitation averaged over 2001–2010 was above the 1961–1990 average. It was the wettest decade since 1901, except for the 1950s (Figure 6). In addition, 2010 was the wettest year ever recorded at global level. The previous wettest years were 1956 and 2000, which, like the second half of 2010, coincided with strong La Niña events.

Most parts of the globe had above-normal precipitation (Figure 7). The eastern USA, northern and eastern Canada, and many parts of Europe and central Asia were particularly wet. Other wetter-than-average regions were northern and southern Brazil, Uruguay and northern and eastern Argentina, southern Africa, Indonesia and northern Australia.

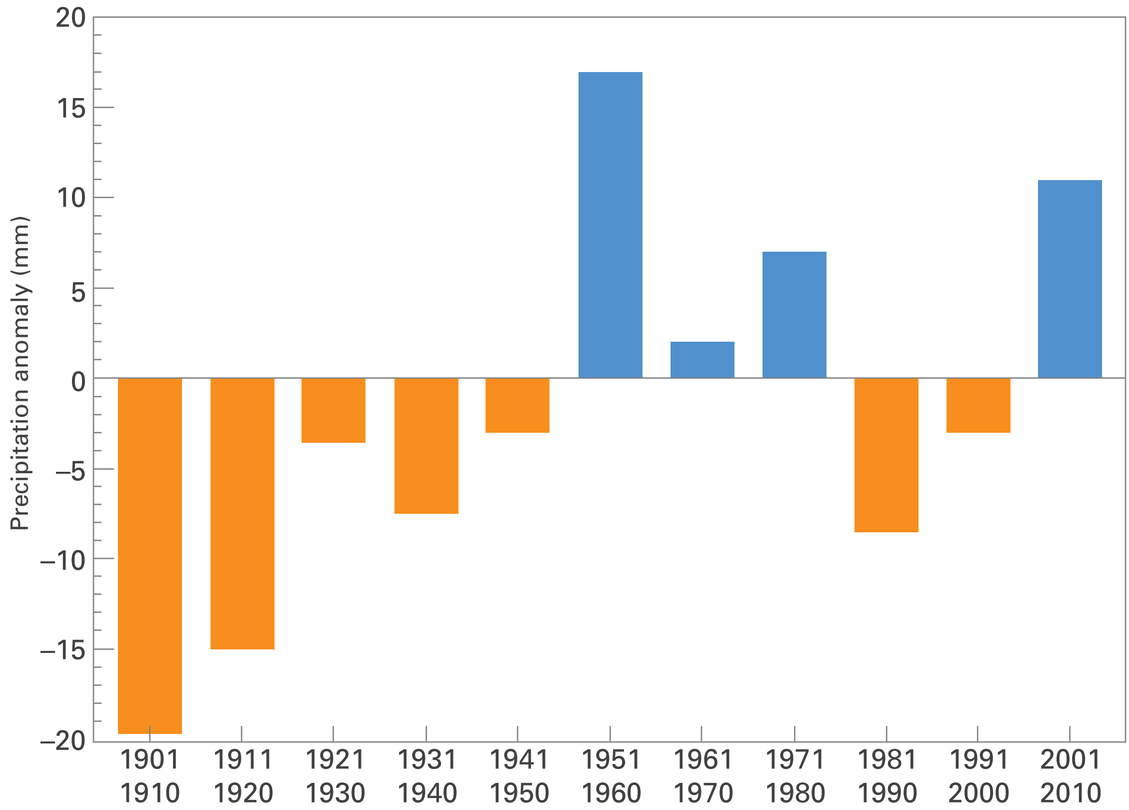


Figure 6. Decadal global precipitation anomaly (in mm) relative to the 1961–1990 WMO standard normal (*source: NOAA-NCDC*)

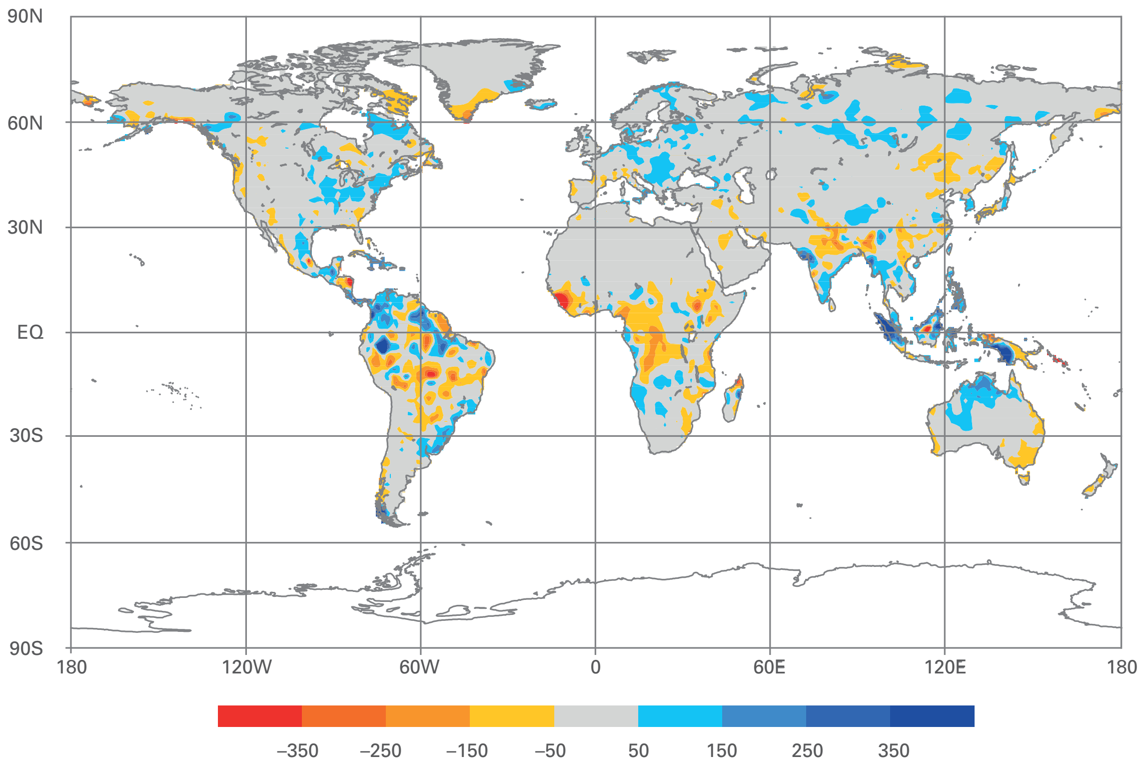


Figure 7. Decadal precipitation anomalies for global land areas for 2001–2010; gridded 1° raingauge-based analysis as normalized departures in mm/year focusing on 1951–2000 base period (*source: Global Precipitation Climatology Centre (GPCC), Deutscher Wetterdienst, Germany*)

Regions that experienced below-normal precipitation included the western USA and Alaska, south-western Canada, central South America, most parts of southern and western Europe, central Africa, most parts of southern Asia and eastern and south-eastern Australia.

According to the WMO survey, floods were the most frequently experienced extreme event over the course of the decade. Eastern Europe was particularly affected in 2001 and 2005, India in 2005, Africa in 2008, Asia (notably Pakistan, where 2 000 people died and 20 million were affected) in 2010, and Australia, also in 2010. In addition, many flash floods with landslides were reported by other countries.

Droughts affect more people than any other kind of natural disaster owing to their large scale and long-lasting nature. The decade 2001–2010 saw droughts occur in all parts of the world. Some of the highest-impact and long-term droughts struck Australia (in 2002 but also in other years), East Africa (2004 and 2005, resulting in widespread loss of life and food shortages) and the Amazon Basin (2010).

5. Severe storms

According to NOAA-NCDC, 2001–2010 was the most active decade since 1855 for tropical cyclones in the North Atlantic Basin. An average of 15 named storms per year was recorded, well above the 1981–2010 long-term average of 12 named storms per year.

The most active season ever recorded was 2005, with a total of 27 named storms, of which 15 reached hurricane intensity and seven were classified as major hurricanes (Category 3 or higher). *Katrina*, a Category-5 hurricane, was the most devastating hurricane of the decade, making landfall in the southern USA in August.

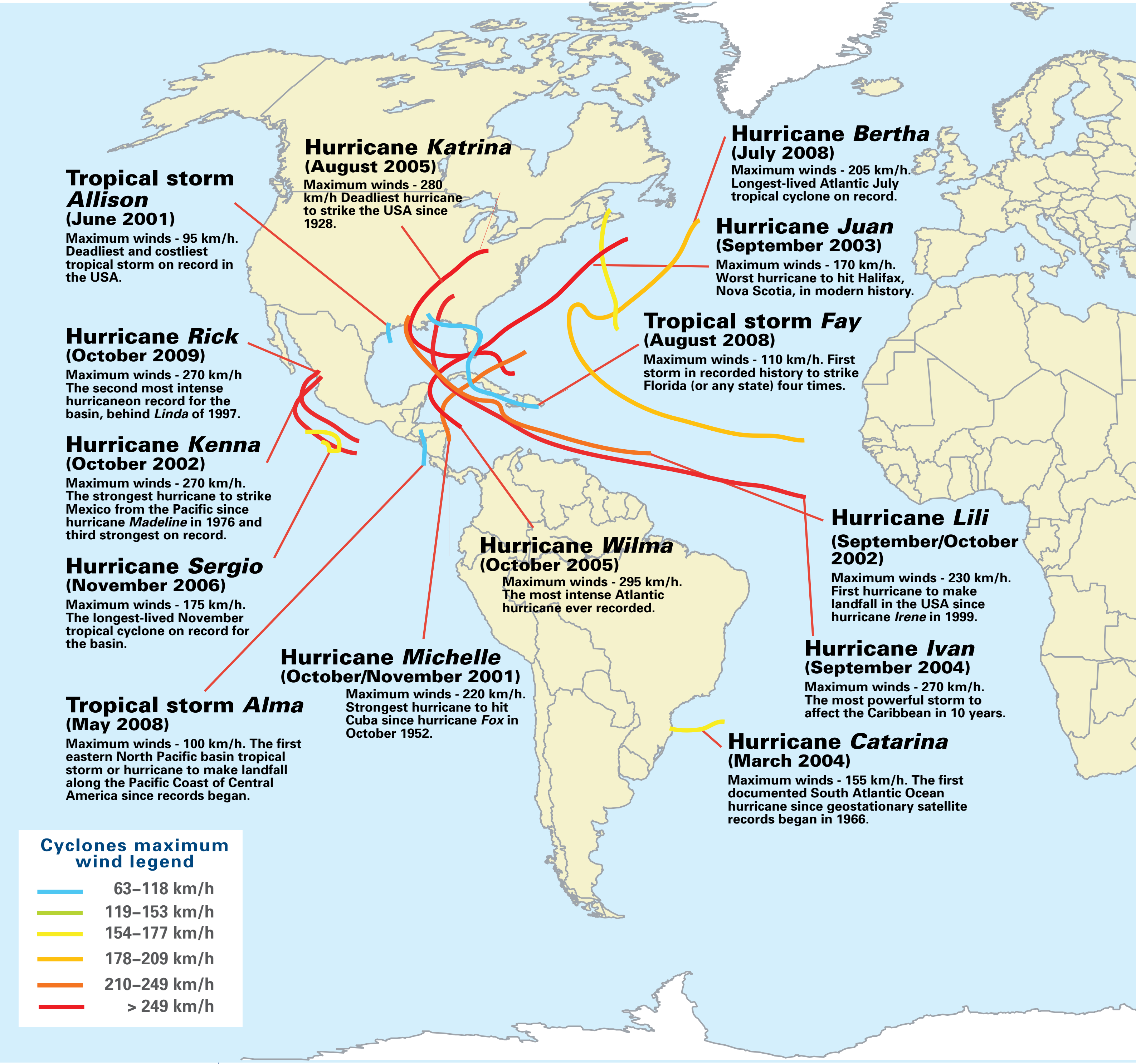
In other regions, cyclone activity was generally at average or below-average levels. The eastern North Pacific basin saw 139 named storms during the decade, of which 65 were classified as hurricanes, slightly below the average. The majority of these tropical cyclones did not make landfall and did not cause substantial damage. The 230 tropical cyclones in the North-West Pacific were also slightly below average. The most destructive of these storms was *Durian*, which struck the Philippines in 2006, killing more than 1 000 people and affecting 1.5 million.

The North Indian Ocean saw the deadliest tropical cyclone recorded during the decade, when *Nargis* struck Myanmar in early May 2008. More than 138 000 people were reported killed or missing, eight million people were affected and thousands of homes were destroyed.

Extra-tropical storms can also turn into devastating natural disasters, mainly in mid-latitude regions. Three major extra-tropical windstorms severely affected Europe: *Kyrill* struck several parts of central Europe in 2007; *Klaus* affected southern Europe in 2009 and *Xynthia* struck north-western Europe in 2010. These storms caused several billions of US dollars in damage and took nearly 100 lives. According to analyses by the insurance company Munich Re, winter storms in the USA and Canada in 2007 and 2008 rank among the 10 costliest storms since 1980 in terms of insured losses.

6. Shrinking ice and rising seas

The record warmth of the decade 2001–2010 was accompanied by the melting of ice caps, sea ice and glaciers and the thawing of permafrost. In addition to being a sign of a warming climate, melting ice and snow also affected water supplies, transport



routes, infrastructure, marine ecosystems and much more.

The state of Arctic sea-ice cover in the 20th century is relatively well documented. Until the 1960s, sea ice covered 14–16 million km^2 of the Arctic in late winter and 7–9 million km^2 at the end of the northern summer. Since then it has declined rapidly. The five years with the lowest ever recorded sea-ice extent in September were 2005, 2007, 2008, 2009 and 2010. The record minimum extent of 4.28 million km^2 – 39 per cent below the long-term average – occurred in 2007 (Figure 9). This record was broken in 2012. The estimated volume of Arctic sea ice has also been declining markedly since 2005, with a new record set in 2010. Meanwhile, Antarctic sea ice has expanded slightly overall, for reasons that continue to be investigated.

The world's two major ice sheets (long-lived ice accumulated over landmass) are in the Antarctic and Greenland. The loss of net

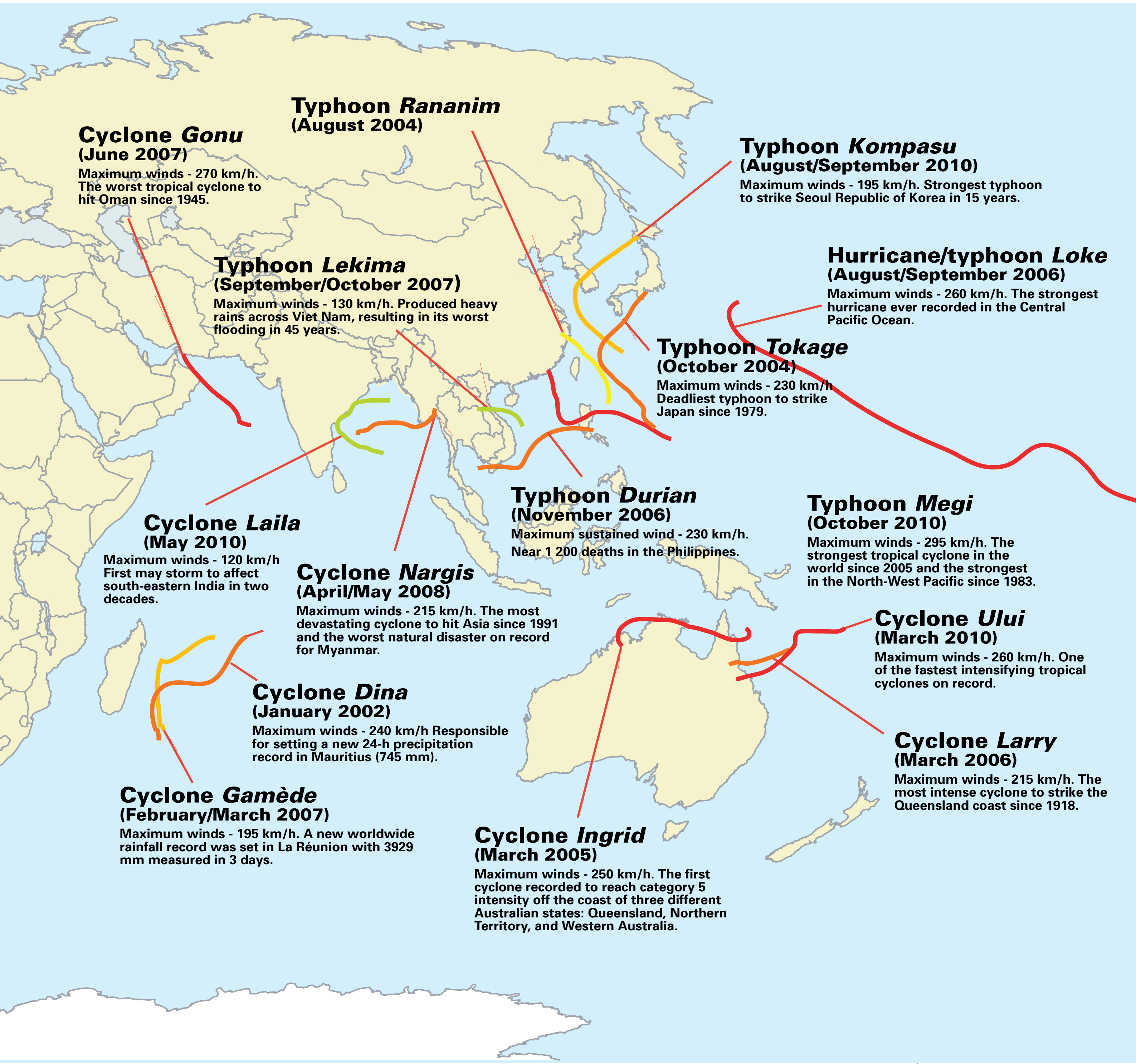


Figure 8. Most significant tropical cyclones recorded during 2001–2010 (*source: NOAA-NCDC*)

mass from both of these sheets has been accelerating, with the largest losses of the decade seen in 2007 and 2008. If this trend continues, ice sheets will contribute more to sea-level rise in the 21st century than any other factor.

The world's glaciers lost more mass in 2001–2010 than in any decade since records began. Snow cover declined significantly in the northern hemisphere (Figures 10 and 11). The temperatures of permafrost (frozen land) areas have been rising, with the 2001–2010 decade marked by an increase in the thickness of the seasonal thaw layer in many northern areas.

As a result of this widespread melting (and the thermal expansion of sea water), global mean sea levels continued to rise over the decade 2001–2010. The observed rate of increase was some 3 mm per year, about double the observed 20th century trend of 1.6 mm/yr. Global sea levels averaged over the decade were about 20 cm higher than those of 1880.

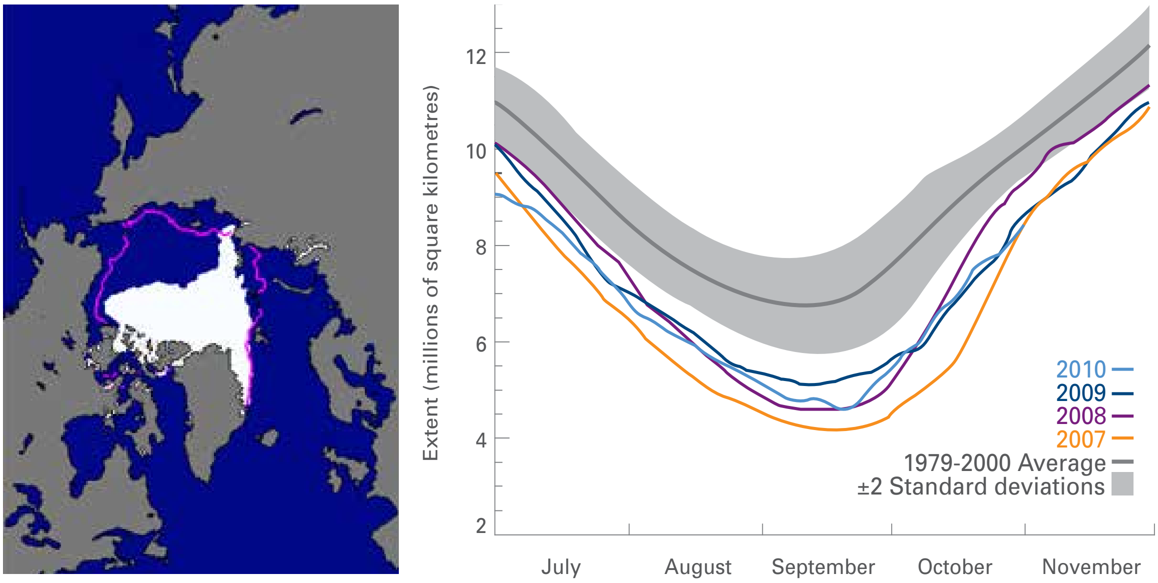


Figure 9. Sea-ice extent for September 2007; the magenta line indicates the long-term median from the 1979–2000 base period (left) and Arctic sea-ice extent at the end of the summer melt season from 2007 to 2010 (right) (*source: National Snow and Ice Data Center, USA*)

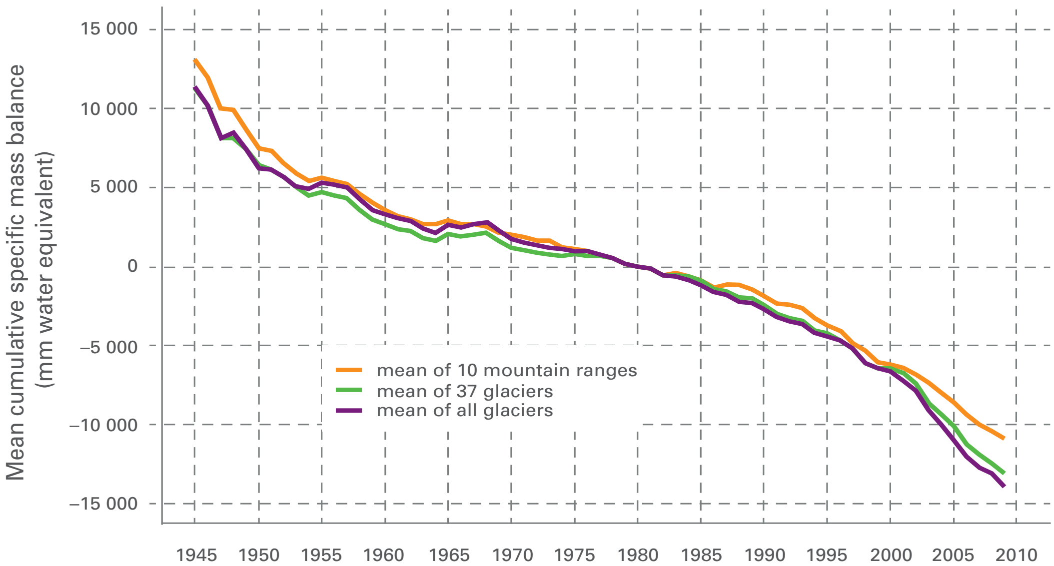


Figure 10. Mean cumulative specific glacier mass balance since 1945/1946 (*source: World Glacier Monitoring Service*)

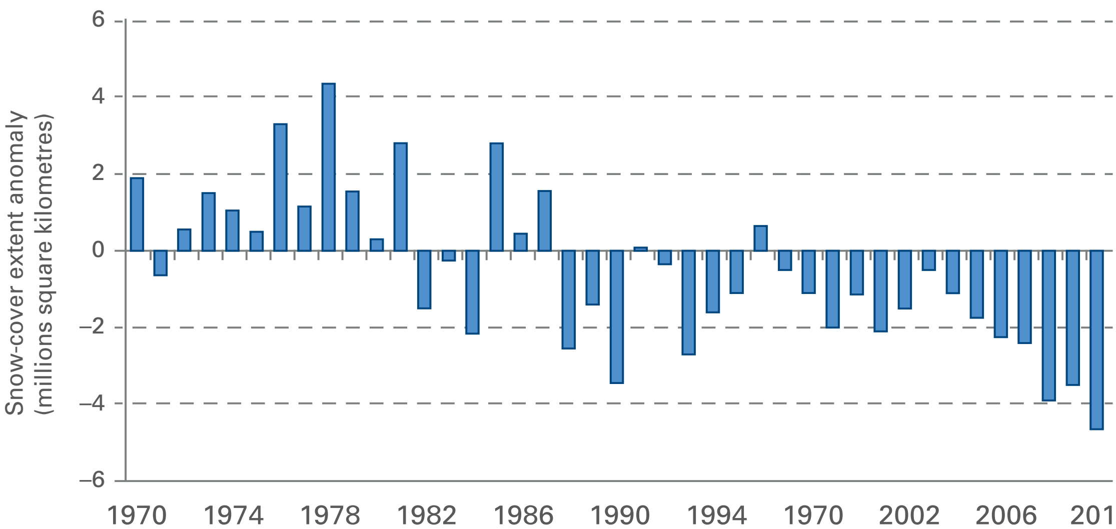


Figure 11. Northern hemisphere snow-cover anomaly for June (1970–2010) (*data source: Rutgers University Global Snow Laboratory, USA*).

Note: No similar data exist for the southern hemisphere as the land area subject to seasonal snow cover (outside the Antarctic) is very small.

7. Conclusion

Understanding the Earth's climate and trends in temperature, precipitation and extreme events is of vital importance to human well-being and sustainable development. As the report The Global Climate 2001–2010 confirms, climate scientists can now link some natural oscillations to seasonal climate trends. They also understand the mechanisms by which humanity's greenhouse-gas emissions are raising global average temperatures.

While there is evidence that the frequency and intensity of some types of extreme events are increasing, it is still difficult to assess the extent to which human-induced climate change has influenced individual events. Natural climate variability is clearly important, but there is also evidence that human influence has substantially increased the likelihood of some events occurring, such as the European heat wave of 2003. Science-based methodologies are emerging that seek to determine with more confidence how climate change is affecting extreme events.

No clear trend has been found in tropical cyclones and extra-tropical storms at the global level. More complete datasets will be needed in order to perform robust analyses of trends in the frequency and intensity of these hazards.

Distinguishing between natural climate variability and human-induced climate change will also require datasets that are more complete and long-term. A decade is the minimum possible timeframe for detecting temperature changes.

Assessing trends in extreme weather and climate events requires an even longer timeframe because, by definition, these events do not occur frequently. WMO's Commission for Climatology is currently addressing new approaches for the improved characterization, assessment and monitoring of these events. In addition, promising new research into the attribution of individual extreme events based on observational and model data is starting to emerge.

Long-term cryosphere monitoring has emerged as an urgent priority, both for climate research and for understanding the practical implications of the widespread melting. There are still uncertainties with respect to the future evolution of ice-sheet melting. Understanding cryosphere variability will also help to improve sea-level rise projections, which, in turn, will contribute to more effective coastal planning and management.

As observation, modelling and scientific understanding of the climate system advance, scientists will be able to provide increasingly useful information for decision-making. This will greatly benefit international cooperation through the United Nations Framework Convention on Climate Change and the Global Framework for Climate Services. WMO remains committed to supporting these efforts through its Members, its programmes and the regular reports made possible by the WMO Climate System Monitoring network.

For more information, please contact:

World Meteorological Organization

7 bis, avenue de la Paix – P.O. Box 2300 – CH 1211 Geneva 2 – Switzerland

Communications and Public Affairs Office

Tel.: +41 (0) 22 730 83 14 – Fax: +41 (0) 22 730 80 27

E-mail: cpa@wmo.int

www.wmo.int

JN 13658