WMO statement on

the status of the global climate in 2006

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This Statement is a summary of information provided by the Met Office Hadley Centre for Climate Change and the Climatic Research Unit, University of East Anglia, United Kingdom; the National Climatic Data Center and the Climate Prediction Center of the National Oceanic and Atmospheric Administration (NOAA) and the National Snow and Ice Data Center, United States. Other contributors are from WMO Member countries: Argentina, Australia, Brazil, Bulgaria, Canada, China, Fiji, France, Germany, Hungary, Iceland, India, Japan, Mauritius, Morocco, New Zealand, Norway, Romania and Sweden. The African Centre of Meteorological Applications for Development (ACMAD) in Niamey, Niger; the Alfred Wegener Institute, Bremerhaven, Germany; the Drought Monitoring Centre (DMC), Harare, Zimbabwe; the European Climate Support Network (ECSN) and the Intergovernmental Authority on Development Climate Prediction and Applications Centre (ICPAC) also contributed to the publication.

Foreword

The World Meteorological Organization (WMO), through its Commission for Climatology and in cooperation with its 188 Members, has issued annual statements on the status of the global climate since 1993. The statement for 2006 describes extreme weather and climate events and provides a historical perspective on the variability and trends of surface temperatures and other important parameters. The statements provide authoritative scientific information on climate and its variability, complementing the periodic assessments made by the Intergovernmental Panel on Climate Change (IPCC), which is co-sponsored by WMO and the United Nations Environment Programme (UNEP).

All the years since the beginning of the new century, including 2006, rank among the 10 warmest years of the observational period ranging from 1850 to the present. In the course of the year, Australia, the United States of America and parts of Europe experienced exceptional heat waves. The 2006 typhoon season, even if below average in terms of the number of events, caused disastrous impacts on some south-east Asian nations. Devastating floods and landslides due to heavy precipitation events were reported worldwide and especially affected the Greater Horn of Africa and the Philippines. Prolonged drought conditions persisted in Africa, Australia, China and the United States. The year 2006 continued the pattern of sharply decreasing Arctic sea ice, and the Antarctic ozone depletion reached new record values.

The role of WMO and the National Meteorological and Hydrological Services (NMHSs) of its Members is instrumental in addressing the challenges related to climate variability and change, since accurate and timely weather-, climate- and water-related products and services are prerequisites to the successful formulation and implementation of any adaptive response policies and measures, especially to climate extremes. WMO will intensify its efforts to assist all of its Members in modernizing their respective national networks and climate databases in order to help them reach the objectives of several agreed-upon regional and global strategies, including the United Nations Millennium Development Goals (MDGs).

WMO climate-related programmes contribute to capacity-building by promoting the development of comprehensive climate data management systems, thus ensuring that high-quality climate data are readily available to WMO Members, and by assisting these Members and the relevant international organizations in furthering applications to support public safety, health and welfare, alleviate poverty and foster sustainable development. In addition, major internationally coordinated multidisciplinary research efforts such as the International Polar Year (IPY) 2007–2008 will further help to improve our understanding of basic climate change processes.

According to the first published results of the 2007 IPCC Fourth Assessment Report (AR4), most of the observed increase in globally averaged temperatures since the middle of the twentieth century is very likely due to the observed rise in anthropogenic greenhouse gas concentrations. Discernible human influences now extend to other aspects of climate, including ocean warming, continental average temperatures, temperature extremes and wind patterns. In this context, the timely release of authoritative climate statements, assessments, reviews and historical perspectives provides crucial information on the state of the climate and facilitates the important role played by WMO in contributing to sustainable development in the twenty-first century.

(M. Jarraud)
Secretary-General

Global temperatures during 2006

The analyses made by leading climate centres indicate that the global mean surface temperature in 2006 was 0.42°C to 0.54°C above the 1961–1990 annual average. Accordingly, 2006 will most likely go down as the sixth warmest year on record. December 2006 was the warmest December since global surface records were instituted.

Based on the Hadley Centre analyses, 2006 surface temperatures averaged separately for both hemispheres were 0.59°C above the 30-year mean of 14.6°C/58.28°F for the northern hemisphere, which was the fourth warmest year on record, and 0.26°C above the 30-year mean of 13.4°C/56.12°F for the southern hemisphere respectively, for the eighth warmest year on record. The global average temperature anomaly for December was +0.54°C.

All temperature values have uncertainties, which arise mainly from gaps in data coverage. The size of the uncertainties is such that the global average temperature for 2006 is statistically indistinguishable from, and could be anywhere between, the first and the eighth warmest year on record.

Since the start of the twentieth century, the global average surface temperature has risen approximately 0.7°C. But this increase has not been steady. Since 1976, the global average temperature has risen sharply, at 0.18°C per decade.

Note: Following established practice, WMO's global temperature analyses are based on two different data sets. One is the combined data set maintained by the Met Office Hadley Centre, and the Climatic Research Unit, University of East Anglia, United Kingdom. The other is maintained by the US Department of Commerce's National Oceanic and Atmospheric Administration (NOAA). Both centres use improved temperature analyses, but different methodologies. Hadley Centre analyses showed that the global mean surface temperature in 2006 was 0.42°C above the 1961–1990 annual average (14°C/57.2°F) and hence marks the sixth warmest year on record. According to the National Climatic Data Center, the global mean surface temperature anomaly was +0.54°C, which ranks 2006 the fifth warmest year in their record.

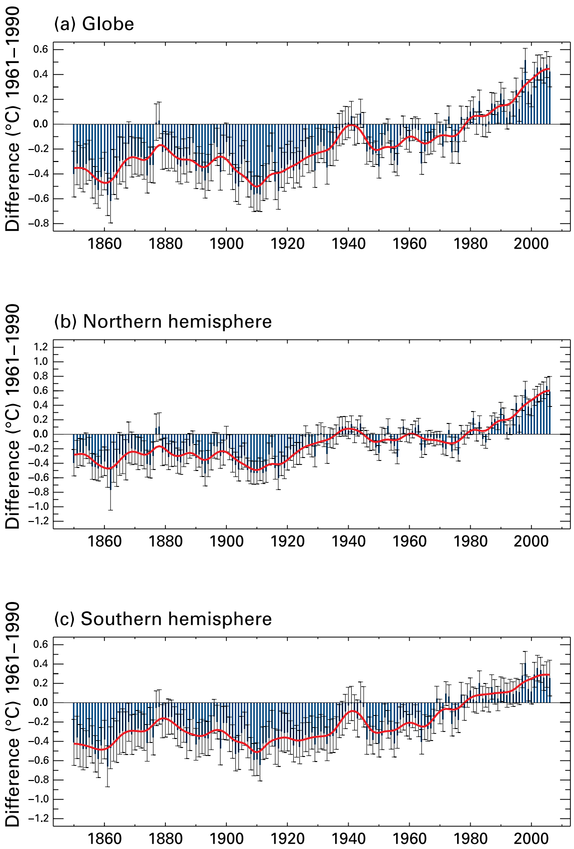


Figure 1 – This figure highlights annual global and hemispheric combined land surface air temperature and sea surface temperature (SST) anomalies, 1850–2006, with respect to the 1961–1990 mean. The source data are blended land surface air temperature and SST from the HadCRUT3 series (Brohan et al, 2006). Values are simple area-weighted averages. *[Source: The Met Office Hadley Centre, United Kingdom, and Climatic Research Unit, University of East Anglia, UK]*

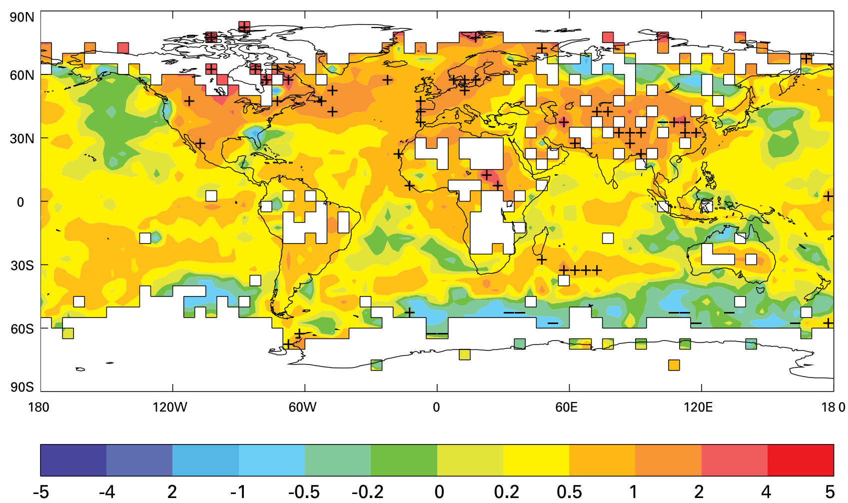


Figure 2 – Global field of surface temperature anomalies in degrees Celsius, relative to 1961–1990 for 2006 from the HadCRUT3 series; crosses indicate that the anomaly in a pixel is the warmest in the 157-year record *[Source: The Met Office Hadley Centre, UK, and Climatic Research Unit, University of East Anglia, UK]*

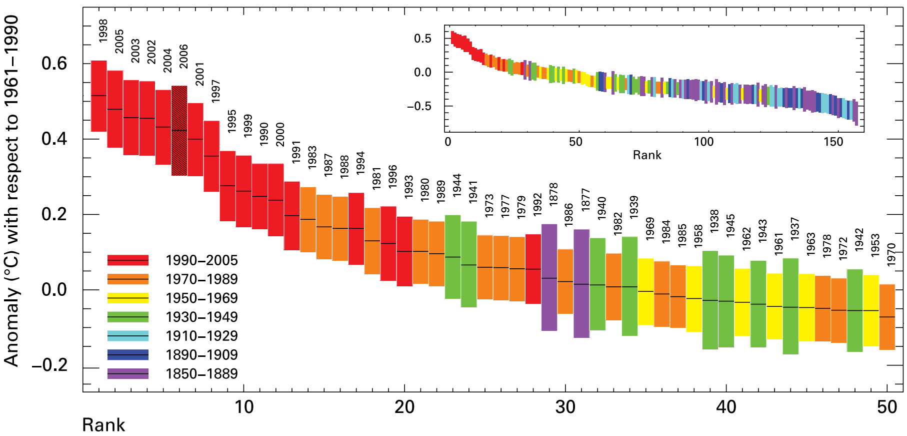


Figure 3 – Global ranked surface temperatures for the warmest 50 years; inset shows global ranked surface temperatures from 1850. The size of the bars indicates the 95-per cent confidence limits associated with each year. The source data are blended land surface air temperature and SST from the HadCRUT3 series (Brohan et al, 2006). Values are simple area-weighted averages for the whole year. *[Source: The Met Office Hadley Centre, UK, and Climatic Research Unit, University of East Anglia, UK]*

Regional temperature anomalies

Warmer than average conditions occurred throughout most land areas of the world. The largest anomalies were observed throughout the high-latitude regions of North America and Scandinavia, and in China and Africa. Temperatures in these regions were 2–4°C above the 30-year mean. The only widespread area of negative anomalies occurred in the central part of the Russian Federation.

Much of the North Atlantic was significantly warm, a pattern that reflects the current warm phase of the Atlantic multi-decadal oscillation, which began in the mid-1990s. The southern Indian Ocean was also significantly warm. For the North Atlantic north of 35°N, the monthly anomalies in May and August have been the warmest on record at +0.94°C and +1.26°C above the 1961–1990 average, respectively.

The year 2006 marked the warmest year in the 348 years of the Central England Temperature series, with also the warmest July and September ever. In the United States, the average annual temperature for 2006 was nearly identical to the record set in 1998. Australia's mean temperature for the year was 0.47°C above the 1961–1990 mean, making it the eleventh warmest year on record. In terms of area, 70 per cent of the continent experienced above-normal temperatures during 2006.

The beginning of 2006 was unusually mild in large parts of North America and the western European Arctic islands, although there were harsh winter conditions in Asia, the Russian Federation and parts of eastern Europe. Canada experienced its mildest winter and spring on record, and the monthly temperatures on the Arctic island of Spitsbergen (Svalbard Lufthavn) for January and April included new highs with anomalies of +12.6°C and +12.2°C, respectively.

Persistent extreme heat affected much of eastern Australia from late December 2005 until early March with many records being set, with, for example, the second hottest day on record in Sydney: 44.2°C/111.6°F on 1 January. Heat waves were also registered in Brazil from January until March: one of the highest temperatures ever recorded there was 44.6°C/112.3°F in Bom Jesus on 31 January.

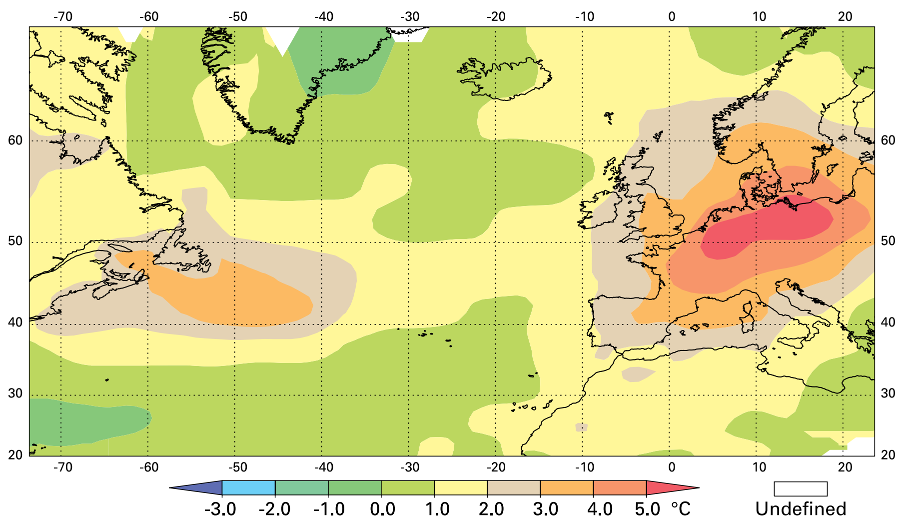
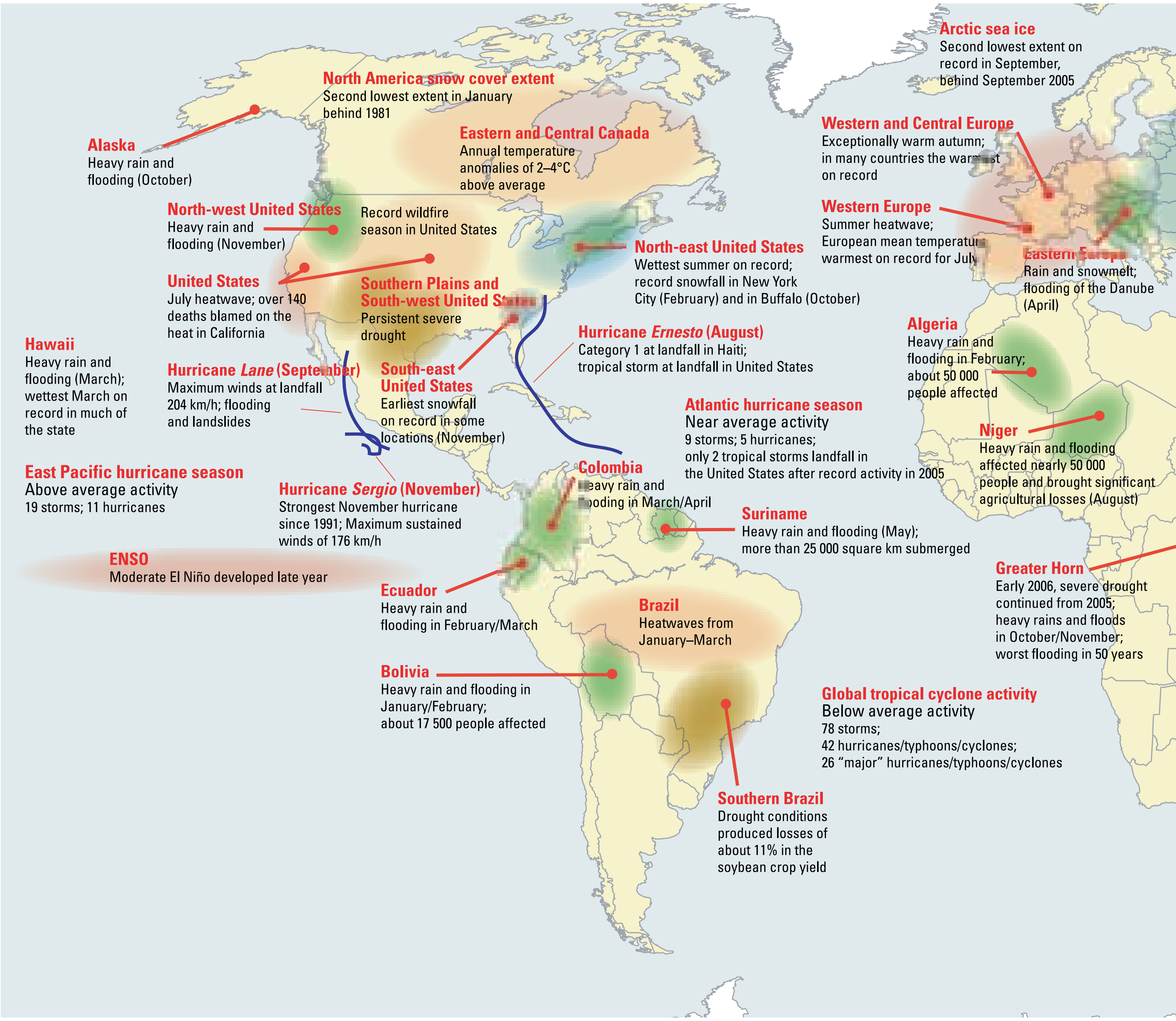


Figure 4 – Monthly air temperature anomalies showing departures in degrees Celsius, 1961–1990 base during the July 2006 summer heat wave over Central Europe *[Source: Deutscher Wetterdienst, Germany]*



Several parts of Europe and the United States experienced heat waves with record temperatures in July and August. Air temperatures in many parts of the country reached 40°C/104°F or more. The July European average land-surface air temperature was the warmest on record at 2.7°C above the climatological normal.

Spring 2006 (September–November) was Australia's warmest since seasonal records were first compiled in 1950.

Autumn 2006 (September–November) was exceptional in large parts of Europe at more than 3°C warmer than the climatological normal from the north side of the Alps to southern Norway. In many countries it was the warmest autumn since official measurements began: records in central England go back to 1659— and as far back as 1706 in the Netherlands and 1768 in Denmark. December also was extraordinarily mild in Europe; in Germany it was the third warmest December since measurements began in 1901, with an anomaly of +3.4 °C.

The Alpine region experienced a distinct delay of the snow season, receiving up to 60 per cent less snowfall in parts of the mountains until the end of November.

Prolonged drought in some regions

Long-term drought continued in parts of the Greater Horn of Africa including parts of Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Somalia and the United Republic of Tanzania. At least 11 million people were affected by

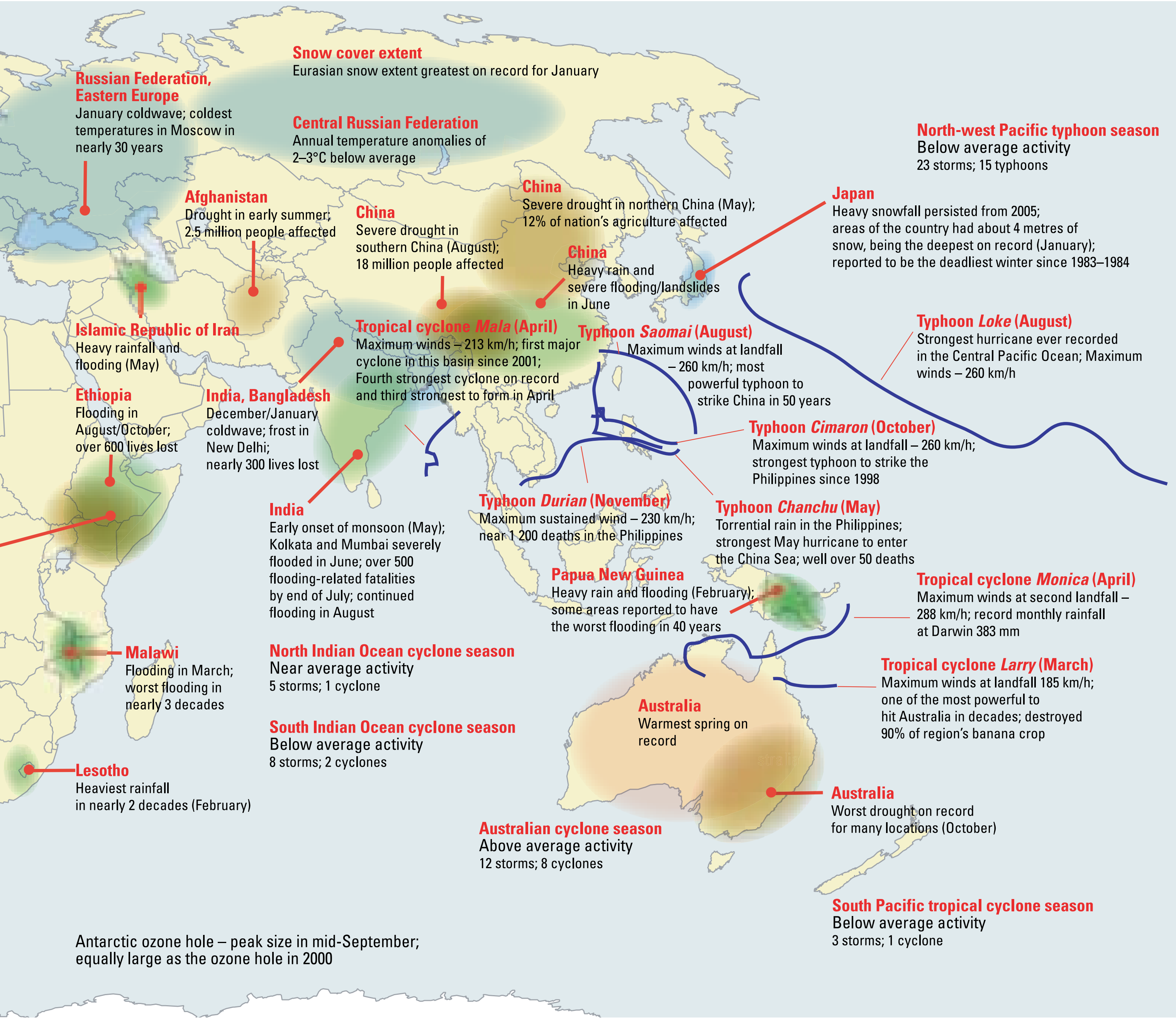


Figure 5 – Significant climate anomalies and events in 2006 *[Source: National Climatic Data Center, NOAA, USA]*

food shortages; Somalia was hit by the worst drought in a decade.

For many areas in Australia, the lack of adequate rainfall in 2006 added to significant longer-term dry conditions, with large regions having experienced little recovery from the droughts of 2002–2003 and 1997–1998. Dry conditions have now persisted for 5 to 10 years over large parts of eastern Australia and in south-west Western Australia for around 30 years.

Across the United States, moderate-to-exceptional drought persisted throughout parts of the south-west desert and eastward through the southern plains, also developing in areas west of the Great Lakes. Drought and anomalous warmth contributed to a record wildfire season in that country, with more than 3.9 million hectares burned in 2006. Drought in the south of Brazil caused significant damage to agriculture in the early part of the year with losses of about 11 per cent estimated for the soybean crop yield alone.

Severe drought conditions also affected China. Millions of hectares of crops were damaged in Sichuan province during the summer and in eastern China in autumn. Significant economic losses as well as severe shortages in drinking water were other consequences.

Rainfall and flooding

For land areas, global precipitation in 2006 was much above the 30-year mean, the largest value in five years. Drier than average conditions were widespread across the United

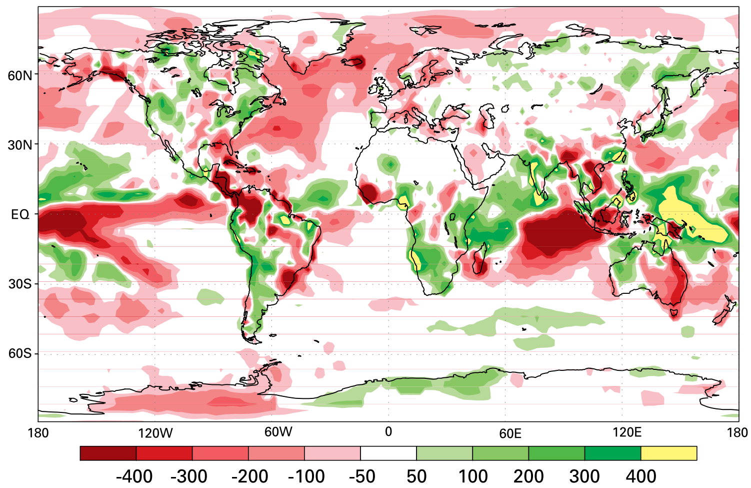


Figure 6 – Annual precipitation anomalies derived from the Climate Anomaly Monitoring System OLR Precipitation Index are shown as departures in millimetres from a 1979–2000 base period for 2006. Green and yellow indicate areas that received above-normal precipitation for the calendar year 2006 as a whole, whereas pink and red depict 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 rain-gauge observations and satellite-derived precipitation estimates. *[Source: Climate Prediction Center, NOAA, USA]*

States Great Plains and Gulf Coast regions, the western coast of Canada and large parts of Australia. Conversely, the north-east United States and India experienced wetter than average conditions.

In northern Africa, floods were recorded in Morocco and Algeria during 2006 causing infrastructure damage and some casualties. Rare heavy rainfall in the Algerian Sahara Desert produced severe flooding in February, affecting 50 000 people. In Bilma, Niger, the highest rainfall since 1923 affected nearly 50 000 people throughout August. In the same month, the most extensive precipitation in 50 years brought significant agricultural losses to the region of Zinder, Niger. Heavy rain also caused devastating floods in Ethiopia in August, claiming more than 600 lives. Some of the worst floods occurred in Dire Dawa and along the swollen Omo River. Again in October until early December, the Greater Horn of Africa countries experienced heavy rainfall associated with severe flooding. The worst hit areas were in Ethiopia, Kenya and Somalia. Somalia faced its worst flooding in recent history; some places have received more than six times their average monthly rainfall and hundreds of thousands of people have been affected. The 2006 floods are said to be the worst in 50 years in the Greater Horn of Africa region. The heavy rains followed a period of long-lasting drought and the dry ground was unable to soak up large amounts of rainfall. As the 2005–2006 rainy season was ending, most countries in southern Africa were experiencing satisfactory rainfall during the first quarter of 2006.

Heavy rainfall in Bolivia and Ecuador in the first months of the year caused severe floods and landslides with tens of thousands of people affected. Torrential rainfall in Suriname during early May produced the country's worst

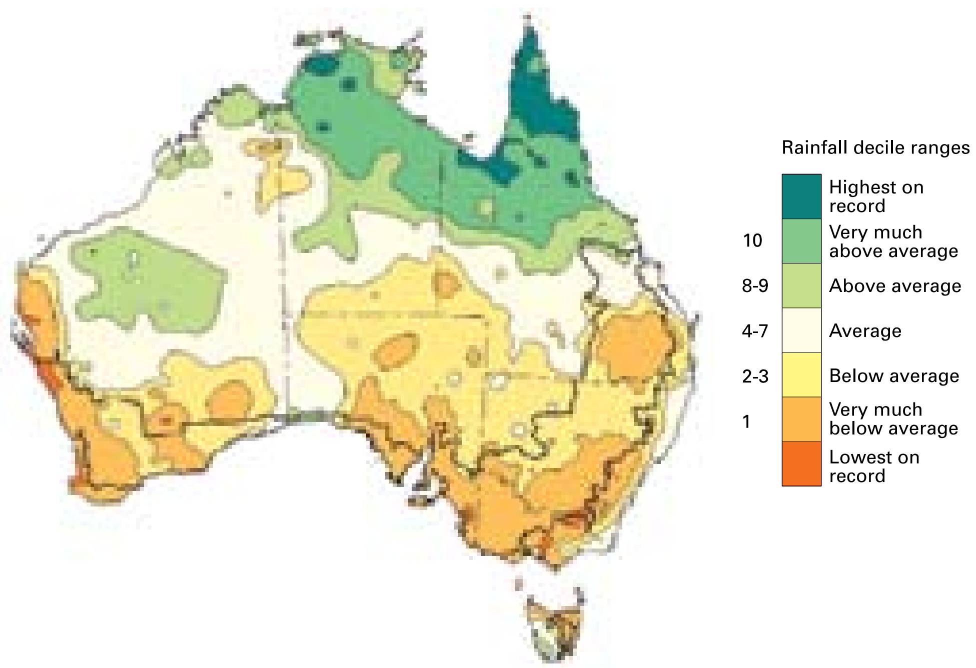


Figure 7 – Australian rainfall deciles for the cropping season, April to October, 2006; Australia's crop-growing regions are outlined in bold. Deciles are calculated relative to the period 1900–2006, with distribution based on gridded data from the National Climate Centre. Rainfall for Australia's main crop- and pasture-growing season over the cropping region was 163 mm, sixth driest on record after the El Niño-related droughts of 1994, 1982, 1902, 1940 and 2002. *[Source: Commonwealth of Australia 2006, Australian Bureau of Meteorology, Australia, www.bom.gov.au]*

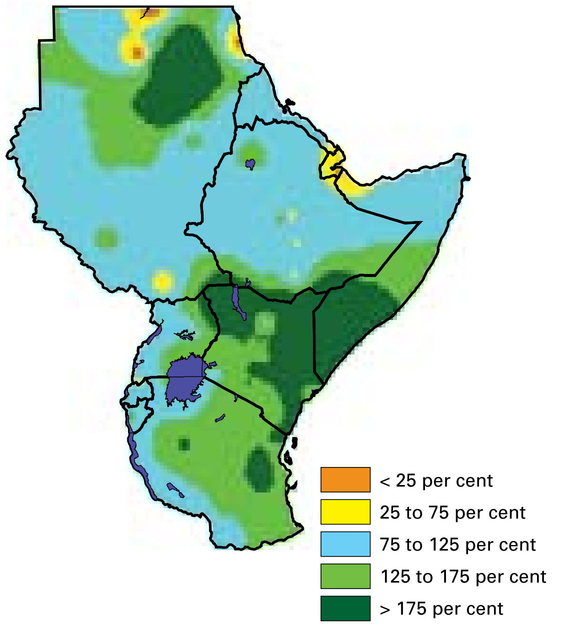


Figure 8 – Precipitation anomalies; departures in per cent, 1961–1990 base during the 2006 September-to-November season for the Greater Horn of Africa. Some locations of the eastern African coast received rainfall amounts exceeding 500 per cent of the long-term average. *[Source: IGAD Climate Prediction and Applications Centre (ICPAC), Kenya]*

disaster in recent times, destroying approximately 70 per cent of the crop.

After 500 mm of torrential rainfall during a five-day period in February, a large-scale landslide occurred in Leyte Island, the Philippines, with more than 1 000 casualties. Although close to average in total rainfall, the Indian monsoon season brought many heavy rainfall events with the highest rainfall in 24 hours ever recorded in several locations. During the last ten days of December, heavy rains in Indonesia's Aceh province produced severe flooding that displaced more than one hundred thousand people. Heavy rainfall in southern Malaysia forced the evacuation of tens of thousands of people in the same month.

Only months after the destructive summer flooding in eastern Europe in 2005, heavy rainfall and snowmelt produced extensive flooding along the Danube River in April and the river reached its highest level in more than a century. Areas of Bulgaria, Hungary, Romania and Serbia were the hardest hit with hundreds of thousands of hectares inundated and tens of thousands of people affected.

Persistent and heavy rainfall from 10 to 15 May brought historic flooding to New England in the United States, described as the worst in 70 years in some areas. Across the US mid-Atlantic and North-East, exceptionally heavy rainfall occurred in June. Numerous daily and monthly records were set and the rainfall caused widespread flooding which forced the evacuation of some 200 000 people. Vancouver, Canada, experienced its wettest month ever in November with 351 mm, nearly twice the average monthly accumulation. Seattle, United States, also experienced its wettest month in 115 years of record: 396 mm in November.

Tropical cyclones

In the North-west Pacific, 15 typhoons developed with wind speed higher than 118 kilometres per hour among 23 named

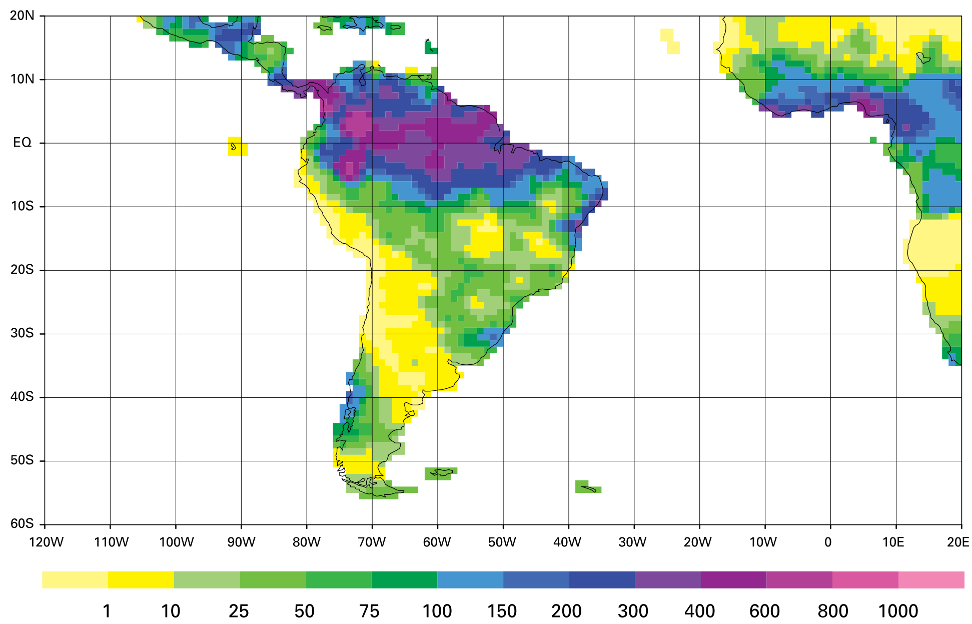


Figure 9 – Monthly precipitation totals for South America in May 2006; gridded 1.0 degree gauge-based analysis derived from GPCC's Monitoring Product *[Source: Global Precipitation Climatology Centre, Deutscher Wetterdienst, Germany]*

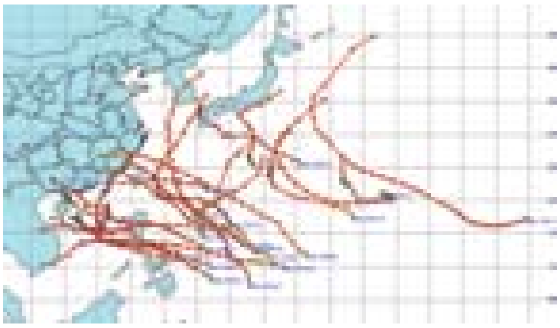


Figure 10 – Tracks of tropical cyclones in the North-west Pacific *[Source: China Meteorological Administration, China]*

tropical cyclones of an average 27. Typhoons *Chanchu, Prapiroon, Kaemi, Saomai, Xangsane, Cimaron* and tropical storm *Bilis* brought deaths, casualties and severe damage to the region. Landed tropical cyclones caused more than 1 000 fatalities and economic losses of US$ 10 billion in China, which made 2006 the severest year in a decade. Typhoon *Durian* affected some 1.5 million people in the Philippines in November/December 2006, claiming more than 500 lives with hundreds missing.

During the 2006 Atlantic hurricane season, 9 named tropical storms out of an average of 10 developed. Five of the named storms of an average of 6 were hurricanes and two of those were "major" hurricanes—category three or higher on the Saffir-Simpson scale. In the eastern North Pacific 19 named storms developed, which is well above the average of 16; 11 reached hurricane strength, of which 6 attained "major" status.

Twelve tropical cyclones developed in the Australian Basin, two more than the long-term average. Tropical cyclone *Larry* was the most intense cyclone to strike the Queensland coast since 1918, destroying 80 to 90 per cent of the Australian banana crop.

Development of moderate El Niño in late 2006

Conditions in the equatorial Pacific from December 2005 until the first quarter of 2006 showed some patterns typically associated with La Niña events. These however, did not lead to a basin-wide La Niña and, during April, even weak La Niña conditions dissipated. Over the second quarter of 2006, the majority of atmospheric and oceanic indicators reflected neutral conditions but, in August, conditions in the central and western equatorial Pacific started resembling typical early stages of an El Niño event. By the end of the year, positive sea-surface temperature anomalies were established across the tropical Pacific basin and a moderate El Niño episode had developed.

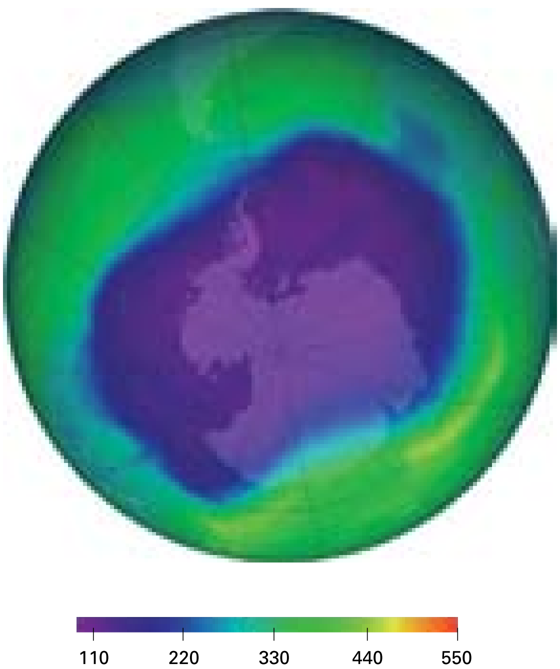


Figure 11 – Average total ozone map for November 2006 based on data derived from the Ozone-Monitoring Instrument on the Aura satellite; data processed and mapped at NASA *[Source: WMO Antarctic Ozone Bulletin No. 7/2006]*

Ozone in the Antarctic and Arctic

On 25 September, the maximum area of the 2006 ozone hole over the Antarctic was recorded at 29.5 million km², slightly larger than the previous record area of 29.4 million km² reached in September 2000. These values are so similar that the ozone holes of these two years could be judged of equal size. The size and persistence of the 2006 ozone hole area, with its ozone mass deficit of 40.8 megatonnes, also a record, can be explained by the continuing presence of near-peak levels of ozone-depleting substances in combination with a particularly cold stratospheric winter. Low temperatures in the first part of January prompted a 20-per-cent loss in the ozone layer over the Arctic in 2006. Milder temperatures from late January precluded the large ozone loss seen in 2005.

Feature article

Arctic sea ice and global climate change

Sea ice is frozen ocean water. It forms, grows and melts in seawater. In contrast, icebergs, glaciers and ice shelves originate on land before entering the ocean. For most of the year, Arctic sea ice is covered with snow.

In the Arctic, sea ice typically covers 14 to 16 million km² in late winter and 7 to 9 million km² at northern summer's end. Satellites have shown the fluctuation in sea ice from year to year since 1972. According to scientific measurements, both the thickness and sea ice extent in the Arctic have shown a marked decline over the past thirty-five years. Data indicate, however, an even more dramatic reduction in Arctic sea ice cover in recent years. The year 2006 continues the pattern of sharply decreasing Arctic sea ice: according to the National Snow and Ice Data Center, the average sea ice extent for the entire month of September was 5.9 million km², the second lowest on record, missing the 2005 record by 340 000 km². The small sea ice area was consistent with the very warm winter air temperatures in the Arctic, which severely limited ice growth. The year 2006 is the fifth consecutive year with the September sea ice extent well below the long-term 1979–2000 mean. The rate of September sea ice decline is now approximately -8.59 per cent per decade, or a loss of 60 421 km² per year.

Arctic sea ice is important because it keeps the polar region cool and helps moderate global climate. Impacts of its change are complex:

(a) Sea ice melts in response to rising air temperatures and creates a positive feedback loop: as sea ice has a bright surface, up to 80 per cent of the incoming solar radiation is reflected back into space—even more when sea ice is snow covered. Melting sea ice exposes the dark ocean surface. Instead of reflecting 80 per cent of the sunlight, the ocean absorbs 90 per cent of the sunlight. As a consequence, the ocean heats up and Arctic temperatures rise further, and hence more ice melts away.

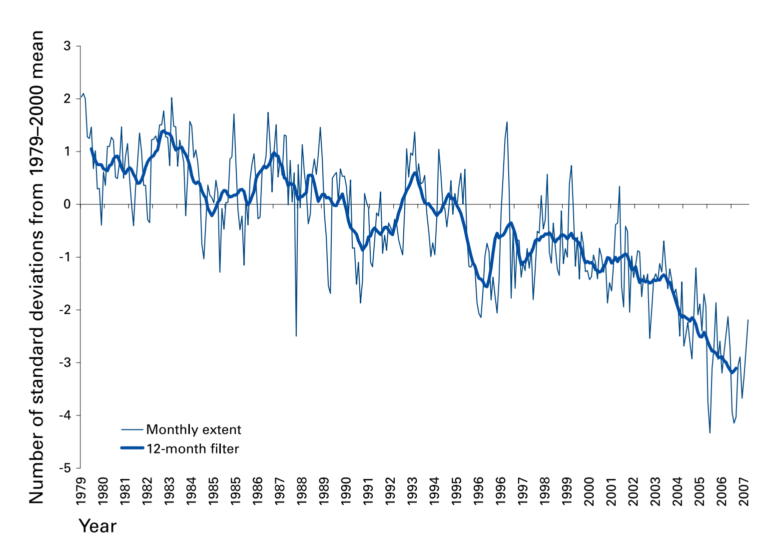
(b) Sea ice also affects ocean circulation. When sea ice forms, most of the water's salt is ejected. This addition of salt makes the water under forming sea ice dense. The cold, dense water sinks, stimulating a circulation. Thus, changes in the amount of sea ice can help disrupt the normal large-scale ocean circulation, thereby leading to changes in global climate.

(c) During winter, the Arctic's atmosphere is very cold and dry. In comparison, the ocean is much warmer. The sea ice separates the two, preventing the transfer of heat and moisture from the ocean into the overlying atmosphere. If sea ice cannot efficiently insulate the ocean from the atmosphere because it is very thin or has openings, the Arctic atmosphere warms, which in turn influences the global circulation of the atmosphere.

All in all, the loss of sea ice has the potential to change climate patterns and accelerate observed trends in global climate change.

The International Polar Year (IPY) 2007–2008 is a major international research programme which is expected to have a profound impact upon our understanding of the conditions in the polar regions and how they interact with and influence the atmosphere, oceans and land masses. Initiated by the International Council for Science and the World Meteorological Organization, IPY will also improve our knowledge about changes in sea ice and its global consequences.

Figure 12 – Passive microwave-derived sea ice extent departures from monthly means for the northern hemisphere; a clear signal of decline regionally, seasonally and extending beyond the satellite record *[Source: Image courtesy of W. Meier, J. Stroeve and F. Fetterer, National Snow and Ice Data Center, USA]*



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