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# State of the Climate Global Analysis Annual 2009

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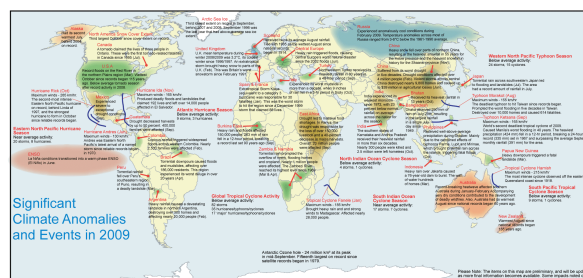
**Report:** Global Analysis

**Year:** 2009 **Month:** Annual

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2009 Global Significant Weather and Climate Events

### Global Highlights

- Global land and ocean annual surface temperatures through December tied with 2006 as the fifth warmest on record, at 0.56°C (1.01°F) above the 20<sup>th</sup> century average.
- The 2000-2009 decade is the warmest on record, with an average global surface temperature of 0.54°C (0.96°F) above the 20<sup>th</sup> century average. This shattered the

1990s value of 0.36°C (0.65°F).

- Ocean surface temperatures (through December) tied with 2002 and 2004 as the fourth warmest on record, at 0.48°C (0.86°F) above the 20<sup>th</sup> century average.
- Land surface temperatures through December tied with 2003 as the seventh warmest on record, at 0.77°C (1.39°F) above the 20<sup>th</sup> century average.

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**Please Note:** The data presented in this report are preliminary. Ranks and anomalies may change as more complete data are received and processed. Effective with the **July 2009** State of the Climate Report, NCDC transitioned to the new version (version 3b) of the extended reconstructed sea surface temperature (ERSST) dataset. ERSST.v3b is an improved extended SST reconstruction over version 2. This report uses the ERSST.v3b dataset to assess the entire year. Therefore, values for individual months of January-June presented in this report may differ slightly from those reported when ERSST.v2 was the operational dataset. For more information about the differences between ERSST.v3b and ERSST.v2 and to access the most current data, please visit NCDC's [Global Surface Temperature Anomalies page](#).

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## Global Temperatures

The years 2001 through 2008 each rank among the ten warmest years of the 130-year (1880-2009) record and 2009 was no exception. The global combined land and ocean surface temperature was 0.56°C (1.01°F) above the 20<sup>th</sup> century average, tying with 2006 as the fifth warmest since records began in 1880. Globally averaged land temperature was 0.77°C (1.39°F) above average, resulting in a tie with 2003 as the seventh warmest on record. The ocean temperature was 0.48°C (0.86°F) above average—tying with 2002 and 2004 as the fourth warmest since records began in 1880. The [2000s decade \(2000-2009\)](#) is the warmest on record for the globe, with a surface global temperature of 0.54°C (0.96°F) above the long-term (20<sup>th</sup> century) average. This shattered the 1990s value of 0.36°C (0.65°F). See the [global time series](#).

Global Top 10 Warm Years (Jan-Dec)	Anomaly °C	Anomaly °F
<b>2005</b>	0.62	1.11
<b>1998</b>	0.60	1.08
<b>2003</b>	0.58	1.04
<b>2002</b>	0.57	1.03
<b>2009</b>	0.56	1.01
<b>2006</b>	0.56	1.01
<b>2007</b>	0.55	0.99
<b>2004</b>	0.54	0.97
<b>2001</b>	0.52	0.94
<b>2008</b>	0.48	0.86
<b>1997</b>	0.48	0.86

*The 1901-2000 average combined land and ocean annual temperature is 13.9°C (56.9°F), the annually averaged land temperature for the same period is 8.5°C (47.3°F), and the long-term annually averaged sea surface temperature is 16.1°C (60.9°F).*

El Niño-Southern Oscillation (ENSO) began 2009 in a cold (La Niña) phase, but by April some anomalous warming took place in the sea surface temperature (SST) of all Niño regions across the equatorial Pacific Ocean. Such conditions are indicative of a transition from cold phase ENSO (La Niña) to ENSO-neutral conditions. By June 2009, warm phase (El Niño) conditions had entrenched across the equatorial Pacific basin, and persisted through the end of the year. In conjunction with the developing ENSO warm phase, the worldwide ocean temperatures increased relative to the long-term average during late spring. The presence of an El Niño in the tropical Pacific Ocean contributed to the warmest global ocean temperatures for the June-August season. Above average SST remained present in all Niño regions at the end of November and by December El Niño strengthened, and Oceanic Niño Index values exceeded the El Niño threshold for the year's last five months, ensuring that 2009 was recorded as an El Niño year. According to the end-of-year outlook from NOAA's Climate Prediction Center, El Niño was expected to continue through the Northern Hemisphere spring 2010. For more information on the state of ENSO during 2009, please visit [NOAA's Climate Prediction Center \(CPC\)](#).

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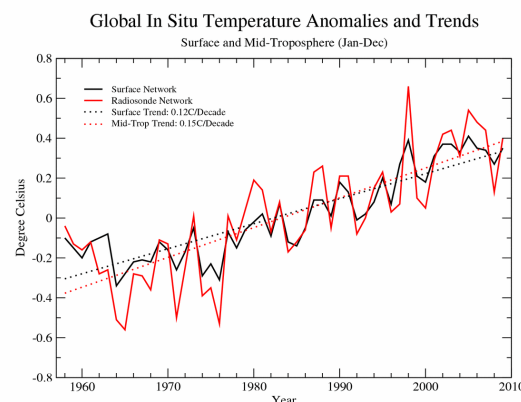
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## Temperature Trends

During the past century, global surface temperatures have increased at a rate near 0.06° C/decade (0.11°F/decade), but this trend has increased to a rate of approximately 0.16° C/decade (0.29°F/decade) during the past 30 years. There have been two sustained periods of warming, one beginning around 1910 and ending around 1945, and the most recent beginning about 1976. Temperatures during the latter period of warming have increased at a rate comparable to the rates of warming projected to occur during the next century with continued increases of anthropogenic greenhouse gases.

Temperature measurements have also been made above the Earth's surface over the past 52 years using balloon-borne instruments (radiosondes) and for the past 30 years using satellites. These measurements support the analyses of trends and variability in the troposphere (surface to 10-16 km) and stratosphere (10-50 km above the earth's surface).

The best source of upper air in-situ measurements for studying global temperature trends



RATPAC and Surface plot

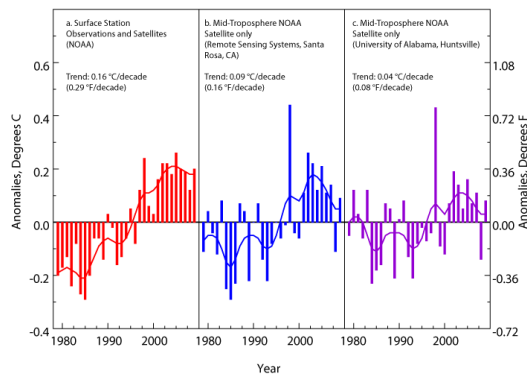
above the surface is the [Radiosonde Atmospheric Temperature Products for Assessing Climate \(RATPAC\)](#) dataset.

Data collected and averaged between the 850-300 mb levels (approximately 5,000 to 30,000 feet above the surface) indicate that 1958-2009 global temperature trends in the middle troposphere are similar to trends in surface temperature;  $0.12^{\circ}\text{C}/\text{decade}$  ( $0.22^{\circ}\text{F}/\text{decade}$ ) for surface and  $0.15^{\circ}\text{C}/\text{decade}$  ( $0.26^{\circ}\text{F}/\text{decade}$ ) for mid-troposphere. Since 1976, mid-troposphere temperatures have increased at a rate of  $0.17^{\circ}\text{C}/\text{decade}$  ( $0.31^{\circ}\text{F}/\text{decade}$ ). For 2009, global mid-troposphere temperatures were  $0.40^{\circ}\text{C}$  ( $0.72^{\circ}\text{F}$ ) above the 1971-2000 mean and the seventh warmest.

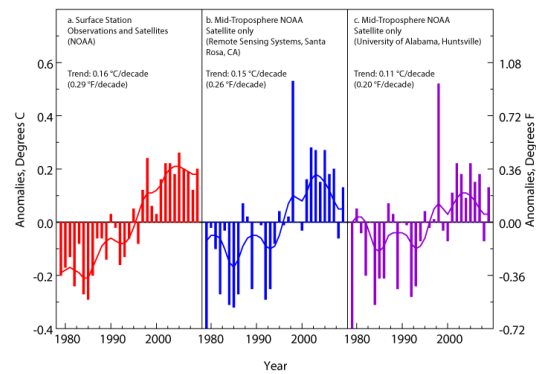
Since 1979, NOAA's polar orbiting satellite measurements have also been used to measure temperatures in the troposphere and stratosphere. [Microwave Sounding Unit \(MSU\)](#) data are analyzed for NOAA by the University of Alabama in Huntsville (UAH), Remote Sensing Systems (RSS, Santa Rosa, California) and the University of Washington (UW). These observations show that the global average temperature in the middle troposphere (the layer which is centered at an altitude of 2 to 6 miles, but which includes the lower stratosphere) has increased, though differing analysis techniques have yielded similar but different trends (see below).

In all cases these trends are positive. The analysis performed by RSS reveals a trend of  $0.09^{\circ}\text{C}/\text{decade}$  ( $0.16^{\circ}\text{F}/\text{decade}$ ) while the UAH analysis reveals a lower trend of  $0.04^{\circ}\text{C}/\text{decade}$  ( $0.08^{\circ}\text{F}/\text{decade}$ ). When adjusted by University of Washington scientists to remove the stratospheric influences from the RSS and UAH mid-troposphere average, the trends increase to  $0.15^{\circ}\text{C}/\text{decade}$  ( $0.26^{\circ}\text{F}/\text{decade}$ ) and  $0.11^{\circ}\text{C}/\text{decade}$  ( $0.20^{\circ}\text{F}/\text{decade}$ ), respectively. ([A journal article is available](#) that describes the University of Washington adjustments to remove the stratospheric influence from mid-troposphere averages.) Trends

Annual Temperature Anomalies: Middle Troposphere and Surface

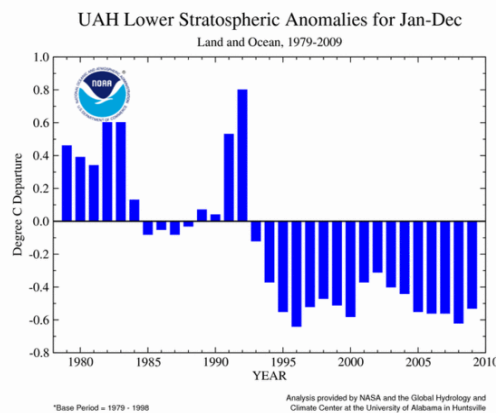


MSU and Surface Temperature Anomaly Time Series

Annual Temperature Anomalies: Middle Troposphere and Surface  
RSS and UAH data adjusted by U. Washington

UW adjusted MSU and Surface Temperature Anomaly Time Series

these MSU time series are similar to the trend in global surface temperatures, which increased at a rate near  $0.16^{\circ}\text{C}/\text{decade}$  ( $0.29^{\circ}\text{F}/\text{decade}$ ) during the same 30-year period.



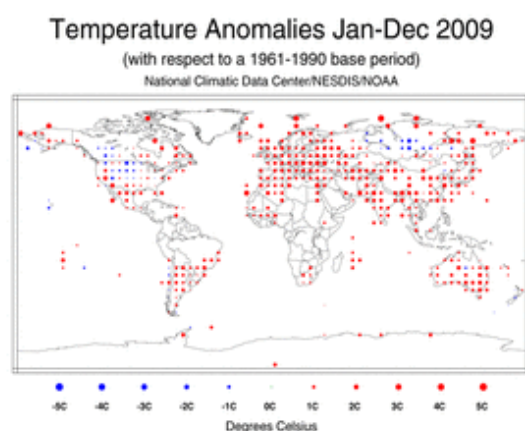
Time series of Global Stratospheric Temperatures

While middle tropospheric temperatures reveal an increasing trend over the last three decades, stratospheric temperatures (14 to 22 km / 9 to 14 miles above the surface) have been below average since the warming effects from the 1991 Mt. Pinatubo eruption dissipated in 1993. January-December 2009 was the 17<sup>th</sup> consecutive year with below-average temperatures (an anomaly of  $-0.53^{\circ}\text{C}/-0.95^{\circ}\text{F}$ ), the eighth coolest year on record. The below-average stratospheric temperatures are consistent with the depletion of ozone in the lower stratosphere and the effects of increasing greenhouse gas concentrations. The large temperature increase in 1982 is attributed to the volcanic eruption of El Chichon, and the increase in 1991 was associated with the eruption of Mt. Pinatubo in the Philippines.

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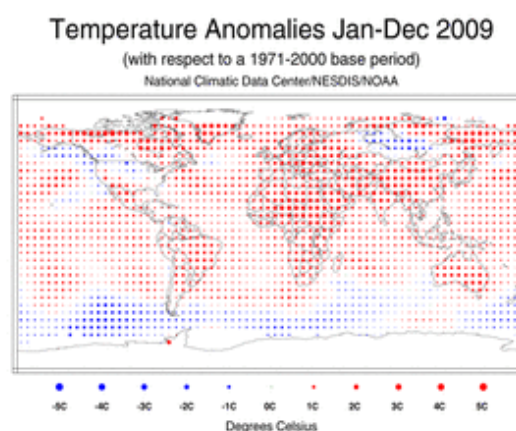
## Regional Temperatures

Warmer-than-average temperatures occurred during the year (January-December) for most of the world's surface. The warmest above-average temperatures occurred throughout high latitude regions of the Northern Hemisphere including much of Europe and Asia, also across Mexico, Africa, and Australia. Cooler-than-average conditions occurred across the southern oceans, parts of the northeastern Pacific Ocean, central Russia, and a region spanning southern Canada and the north central contiguous United States.



January-December 2009 Land Surface Temperature

Anomalies in degrees Celsius



January-December 2009 Blended Land and Sea  
Surface Temperature Anomalies in degrees Celsius

The map, above left, is created using data from the [Global Historical Climatology Network \(GHCN\)](#), a network of more than 7,000 land surface observing stations. Temperature anomalies are with respect to the 1961-1990 average. The map, above right, is a product of a merged land surface and sea surface temperature anomaly analysis developed by [Smith et. al \(2008\)](#). For the merged land surface and SST analysis, temperature anomalies with respect to the 1971-2000 average for land and ocean are analyzed separately and then merged to form the global analysis. For more information, please visit NCDC's [Global Surface Temperature Anomalies](#) page.

Notable temperature extremes in 2009 include southern Australia's record-breaking heatwave during their summer months of January-February. January's heatwave brought numerous new temperature records across the region. Southern South Australia and most of Victoria experienced their highest maximum temperatures since 1939. However, unlike the southern states, Queensland and Northern Territory had their coolest January since 1984. A second heatwave impacted the area during early February. The second time around, extreme heat was accompanied by very dry conditions that contributed to the development of deadly wildfires. The wildfires claimed over 200 lives. Please see [February 2009 U.S. Wildfire](#) page for a Special Summary of Bushfire Activity in Southeastern



## Australia.

In Europe, bitter cold temperatures gripped the northern and eastern region at the beginning of January. Temperatures plummeted to  $-9.9^{\circ}\text{C}$  ( $14.2^{\circ}\text{F}$ ) in Farnborough, Hampshire, U.K., the lowest temperature since January 1991. The United Kingdom experienced its coolest winter since the winter of 1996-1997. The United Kingdom's mean temperature during winter 2008-2009 was  $3.2^{\circ}\text{C}$  ( $37.8^{\circ}\text{F}$ ).

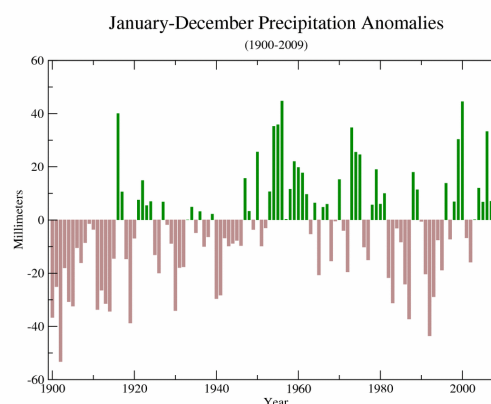
Temperatures across Ontario, Canada, were well below average during the month of July, with an overall anomaly of  $2.2^{\circ}\text{C}$  ( $4.0^{\circ}\text{F}$ ) below average. Several locations experienced their lowest temperatures since 1992. Several locations set new monthly low mean temperatures for the month of July. This was part of a larger pattern that brought much-cooler-than-normal temperatures to the U.S. Midwest.

Australia and New Zealand had their warmest August since national temperature records began 60 and 155 years ago, respectively. The August 2009 average temperature for Australia was  $2.47^{\circ}\text{C}$  ( $4.45^{\circ}\text{F}$ ) above the 1961-1990 average, shattering the previous record by  $0.98^{\circ}\text{C}$  ( $1.76^{\circ}\text{F}$ ). The national August 2009 average temperature for New Zealand of  $10.2^{\circ}\text{C}$  ( $50.4^{\circ}\text{F}$ ) was  $1.7^{\circ}\text{C}$  ( $3.1^{\circ}\text{F}$ ) above the August average. However, in October 2009 New Zealand experienced its coolest October since 1945.

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## Global Precipitation



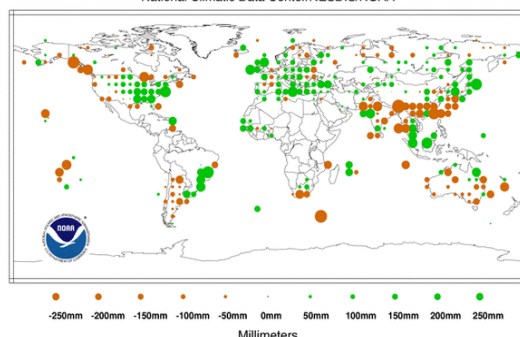
[January-December Global Precipitation Anomalies](#)

Global precipitation in 2009 was near the 1961-1990 average. Precipitation throughout the year (January-December) was variable in many areas. [Regionally, drier than average conditions](#) were widespread across the Hawaiian Islands, Alaska's panhandle, Australia, southern South America, and parts of western Europe and southern Asia. Southeastern

Brazil, parts of eastern and southeastern Asia, and most of Europe and the eastern half of the contiguous United States experienced wetter than average conditions.

### Precipitation Anomalies Jan-Dec 2009

(with respect to a 1961-1990 base period)  
National Climatic Data Center/NESDIS/NOAA



### January-December 2009 Precipitation Anomalies

Notable precipitation extremes in 2009 include the notably weak Indian Monsoon. The country as a whole reported just 77 percent of normal monsoon season rainfall, according to the India Meteorological Department, the lowest such total of the decade. The Philippine Islands had well-above-average precipitation, mainly due to the combined effects of typhoons that impacted the islands during 2009. During the month of June, central Europe had heavy rains that triggered floods and mudslides. The floods were reported to be central Europe's worst natural disaster since 2002.

Australia had its twelfth wettest January since records began in 1900; however, the southern states experienced very dry conditions during January 2009. Victoria had its driest January since 1956 and sixth driest January on record with 82 percent below-normal precipitation. South Australia and New South Wales had 80 percent and 67 percent below normal precipitation, respectively. In contrast, Queensland had its sixth wettest January (80 percent above normal) and January 2009 was the wettest since 1991.

Ottawa's International Airport set an all-time monthly record when 243.4 mm (9.6 in) of rain fell in July 2009, surpassing the previous all-time record of 224.8 mm (8.8 in) in June 2002. This value also shattered the previous July rainfall record of 186.4 mm (7.3 in) set in 1972. Earlton, Ontario, Canada experienced its wettest July since 1969.

Across the United Kingdom, precipitation was 133 percent of average in August 2009. Western Scotland received over twice its average August rainfall. It tied with 1985 as the wettest August since national records began in 1914. Dumfries and Galloway had their wettest August on record.

Typhoon Ketsana claimed nearly 500 lives across the Philippines, Cambodia, Laos and



Vietnam. The storm struck the Philippines on September 26<sup>th</sup>, lashing the islands with strong winds and torrential rains. Approximately 80 percent of Manila was submerged during its worst flooding in 40 years. The heaviest precipitation fell in a short time: 424 mm (16.7 inches) in a 12-hour period, with 340 mm (13.4 inches) in a six-hour period. Each value exceeded the existing 24-hour record (335 mm or 13.2 inches) set in 1967, as well as the average September monthly rainfall (391 mm or 15.4 inches).

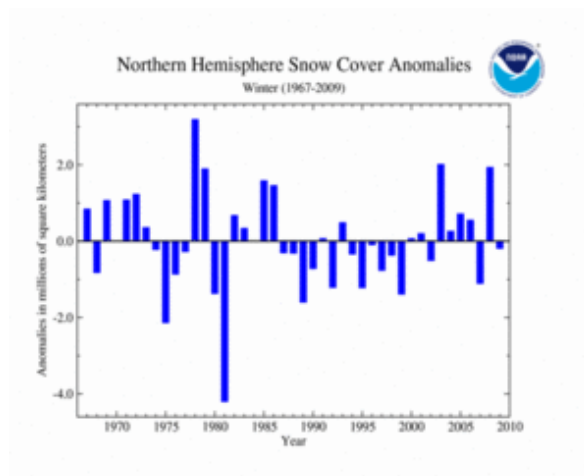
Over 200 mm (8 inches) of rain fell in a three-hour period on October 2<sup>nd</sup> in Sicily, Italy. The heavy downpours triggered mudslides that claimed the lives of 20 people with 40 others missing. These were Italy's worst mudslides in over a decade. India's southern states—Karnataka and Andhra Pradesh—had their heaviest rainfall in over six decades in October 2009. The effects of the copious rainfall were responsible for the deaths of 286 people and for leaving 2.5 million people homeless.

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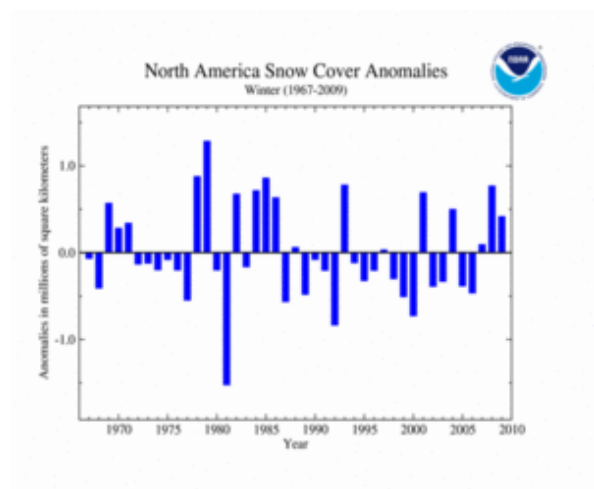
## NH Snow Cover Extent

Analyses of NOAA data were provided by the [Global Snow Laboratory](#), Rutgers University. Period of record is 1967-2009 (43-years).



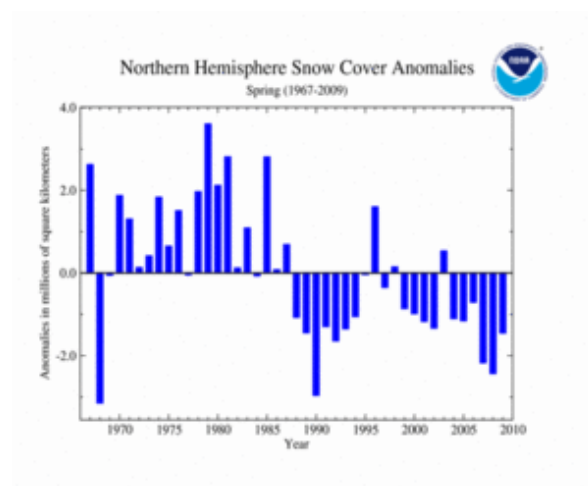
Northern Hemisphere Winter 1967-2009  
Snow Cover Extent plot

As shown in the time series to the right, the mean Northern Hemisphere snow cover extent during winter 2008-2009 was slightly below average. The Northern Hemisphere had the 20<sup>th</sup> lowest snow cover extent on record. The 43-year mean Northern Hemisphere winter snow cover extent for the 1967-2009 period of record is 45.5 million square kilometers.



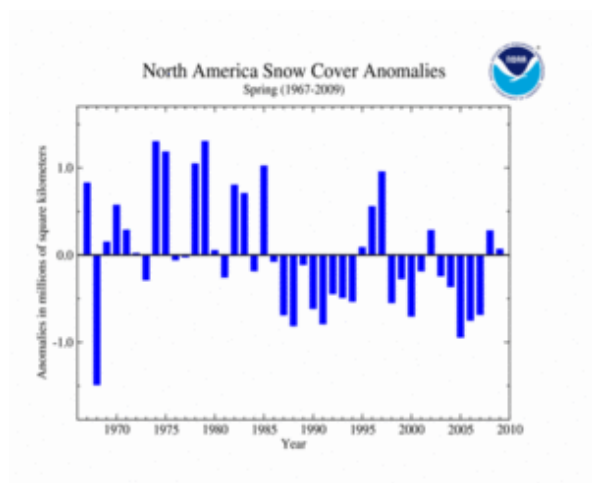
North America Winter 1967-2009  
Snow Cover Extent plot

Across North America, snow cover for winter 2008-2009 was above average; the 12<sup>th</sup> largest extent since satellite records began in 1967. The 43-year mean North America winter snow cover extent is 17.1 million square kilometers for the 1967-2009 period of record.



Northern Hemisphere Spring 1967-2009  
Snow Cover Extent plot

Snow cover extent during spring 2009 was the sixth-lowest spring snow cover extent on record. The 43-year average Northern Hemisphere spring snow cover extent for the 1967-2009 period of record is 30.8 million square kilometers.



North America Spring 1967-2009  
Snow Cover Extent plot

Across North America, snow cover for spring 2009 was the 17<sup>th</sup> largest extent since satellite records began in 1967. The average North America spring snow cover extent is 12.9 million square kilometers for the 43-year period of record.

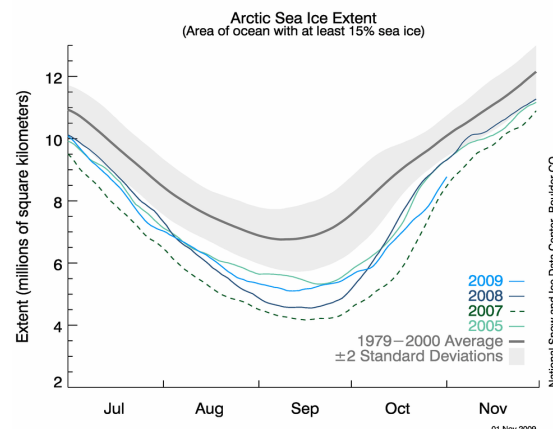
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## Sea Ice Extent

Arctic sea ice extent, which is measured from passive microwave instruments onboard NOAA satellites, usually expands during the cold season to a March maximum, then contracts during the warm season to a September minimum. According to NOAA's [National Snow and Ice Data Center](#), the September Northern Hemisphere average sea ice extent was 5.4 million square kilometers (23.8 percent or 1.7 million square kilometers below the 1979-2000 average)—the third lowest since satellite records began in 1979, behind 2007 and 2008. The past five years have had the five smallest minimum sea ice extent on record. The September 2009 Arctic sea ice extent was 1.1 million square kilometers greater than 2007's record low and 690,000 square kilometers greater than September 2008, the second-lowest extent. This was the 13<sup>th</sup> consecutive September with sea ice extent below average. September 1996 was the last year with above-average sea ice extent.

The image to the right depicts Northern Hemisphere sea ice extent from July-October, the five-month period centered on the regular annual minimum of Arctic Sea Ice. It shows that, over the course of the months spanning the late melt season, the annual minimum and the



Northern Hemisphere Sea Ice Extent plot

early recovery season, 2009 had either the second or third least ice extent (smallest "footprint" of ice), behind 2007 and, occasionally, 2005 or 2008. The annual minimum extent in September 2009 was the third smallest of the 31-year record. The average September rate of sea ice decline is 11.2 percent per decade. A [complete summary](#) of the 2009 Northern Hemisphere sea ice extent is available, courtesy of the National Snow and Ice Data Center.

Arctic sea ice conditions are inherently variable from year to year in response to wind, temperature and oceanic forcings. Quite often a "low" ice year is followed by recovery the next year. But increasing surface temperatures in high latitudes have contributed to progressively more summer melt and less ice growth in the fall and winter. While natural variability is responsible for year-to-year variations in sea ice extent, three extreme minimum extent years along with evidence of thinning of the ice pack suggest that the sea ice system is experiencing changes that may not be solely related to natural variability.

In contrast, the 2009 Southern Hemisphere sea ice extent had its second largest sea ice extent for April and August 2009, behind 2008 and 2000, respectively. It was also the third largest sea ice extent for September, behind 2006 and 2007.

For further information on the Northern and Southern Hemisphere snow and ice conditions, please visit the [NSIDC News page](#), provided by [NOAA's National Snow and Ice Data Center \(NSIDC\)](#).

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## Questions?

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