CLIMATE SCIENCE FORUM

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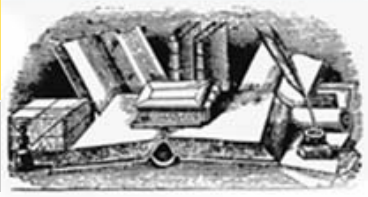
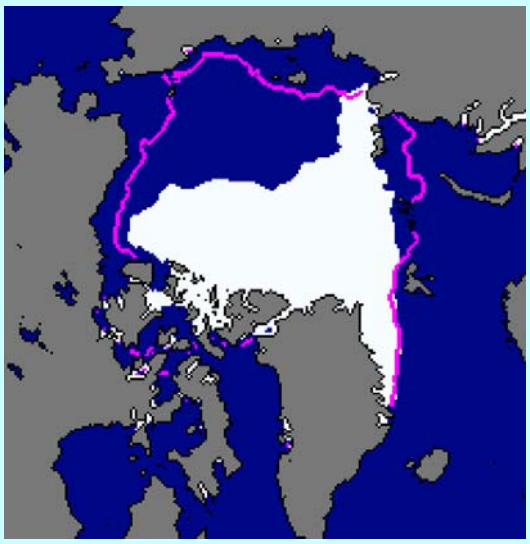


Arctic Ice at a Record Low Extent

The ice cover on the Arctic Ocean had diminished to the smallest area yet observed by August 20 of this year, with one month still left in the summer melting season, according to the National Snow and Ice Data Center, and the University of Illinois. By the week of September 16 the Arctic ice covered an area 23% less than it had in 2005, when the previous record was set, and now covers 39% less *(at right)* than the long term average extent of ice in September *(figure at right)*. The conditions that led to the shrinking ice cap this year deserve our attention.

Marc Serreze, senior scientist of the Snow and Ice Data Center, cited two responsible factors, which have added to the melting expected on a warming Earth. A high pressure cell was parked over the Ocean north of Alaska for most of June and July, causing clear skies and abundant sunshine shining on the ice in a season when skies are typically cloudy. The high pressure also favored offshore winds that blew from eastern Siberia into the Arctic Ocean.



Extent of sea ice (white) at the time of this year's annual minimum ice pack on September 16, 2007. This map may be compared with the previous record minimum extent in 2005 here. The magenta line is the average location of the ice edge in September, from 1979 to 2000.
Credit: National Snow and Ice Data Center

These winds, which were warmer than the ice, melted the ice and pushed it away from shore -- exposing more dark water to absorb the abundant sunlight of long summer days. The greatest reduction in summer ice cover has been in fact in the Siberian half of the Arctic Ocean.

The other factor has been recent wind patterns that sweep multi-year ice out of the Arctic into the Atlantic Ocean. Multi-year ice is thicker and resists complete melting in the summer. Large areas previously covered by multi-year ice now are covered only by 1-year or 2-year-old ice. This younger ice more often melts away by September.

These natural factors are compounded by a relentless increase in Arctic air temperature since 1979, according to scientist Serreze, who said, "While a number of natural factors have certainly contributed to the overall decline in sea ice, the effects of greenhouse warming are now coming through loud and clear."

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CLIMATE SCIENCE FORUM

Online @ http://climate-science.org

Chief Editor: Michael A. Fortune Ph.D.

Email: editor at climate-science.org

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Silver Spring, Maryland — USA
Telephone (301) 754-1766

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Hurricanes: *are they strengthening globally or locally?*

Climate trends can be difficult to determine, because methods of observing the Earth have changed radically from early to modern times, and the quality and reliability of measurements have changed as well. To establish a trend, we need to know what the early measurements were, as far back in time as possible. The trend in hurricane activity over the oceans is a great example of the difficulty. (All hurricanes form and strengthen over the oceans, often over remote expanses of water.)

Before airplanes, tropical storms far from land were discovered by chance, and many must have been unobserved. Knowledge about the existence and strength of hurricanes was spotty and inconsistent until quite recently. Until reconnaissance aircraft from the Weather Services began to target these storms around 1950, such storms were avoided, if they were detected at all. After "hurricane hunter" aircraft flew into the storms to fix their locations, and measure wind speeds and intensities, observations became more consistent and reliable than before. But it is a problem to compare the observations after 1950 with the less consistent observations before that time.

Then, when weather satellites began to observe the Earth and its clouds after 1970, hurricanes were observed in a consistent manner even in their early stages and in the most remote oceans. That change introduced another discontinuity in measurement of their strength.

Dr. James Kossin of the University of Wisconsin asks whether the observed trend in hurricane intensity is credible in all ocean basins of the world. In addition to the measurement problems through time, he points out that techniques for estimating the intensity have differed in the six ocean basins where hurricanes are monitored. He chooses to rely on satellite data since 1983 as a consistent data source, and ignore the trends before that time. Even after 1983, methods of calculating intensity differed around the world, so his team introduced a consistent technique for re-analyzing thousands of satellite images.

Kossin constructed a new measure of mean "storm energy," *focusing on those storms of hurricane intensity (64 mi/hr or greater).* His results agreed well in the Atlantic and the Eastern Pacific Oceans in comparison with the traditional intensity estimates. Hurricanes *have* become more intense in the Atlantic, and less intense in the eastern Pacific, over the last 25 years. But the agreement was "terrible" for the other four basins in the Pacific and Indian Oceans, where 85% of hurricanes were found. Kossin found *no trend* in these four basins. Previous analysis by the Joint Typhoon Warning Center showed increasing intensity in the other four basins, especially in the South Indian Ocean. Kossin's trend results differed the most from the Joint Typhoon trend in the two basins of the Indian Ocean, south and north of the equator.

Believing that the satellite-based technique is consistent around the globe, but the older technique is not, he asserts that the upward trend in the four Pacific and Indian Ocean basins, from the conventional record, is "spurious." That 4-basin trend also strongly affects the trend for the globe, which must also be spurious, he concludes.

As the data (especially before 1970) cannot be trusted, Kossin looks forward to a better understanding of the physics of hurricanes, rather than the historical record of intensities, to illuminate how hurricanes will respond in a warming world.

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High Points of 2007 Fourth Assessment Report of the IPCC

Warming *"very likely related"* to activities of mankind

After three years of study, an inter-governmental panel of the United Nations has summarized its Fourth assessment of climate change since 1990. The latest report exudes more confidence that recent climate changes are likely caused by human activities, especially by the release of greenhouse gases to the atmosphere.

Direct observation of climate warming

"Warming of the climate system is unequivocal," the report intones. Eleven of the 12 most recent years rank in the warmest 12 years in the century-and-a-half of instrumented observations. The upward trend of surface temperature is accelerating: the trend over 100 years ending in the year 2000 was +0.6°C, but the trend from 1905 to 2005 was +0.74° C, because the last six years have been abnormally warm.

Previously reported differences between warming at the surface of Earth and in the free atmosphere "have been largely reconciled." Errors in temperature measurements by both satellite and balloon borne sensors have been identified and corrected. The warming in the free atmosphere is now seen as comparable to the warming at the ground.

The ocean has been absorbing over 80% of the heat added by the warming atmosphere, and ocean temperatures down to a depth of 3000 meters have been rising since 1961. This was one cause of sea level rise, which was observed to be +17 cm in the 20th Century. The rate of sea level rise nearly doubled in the period from 1993 to 2003.

Greater losses of ice from the ice shelves of Greenland and Antarctica may have something to do with that recent surge. Not only has melting increased, but the flow speed of some outlet glaciers which drain ice from the interior of the two land masses has increased, and the ice sheet has also thinned in places.

Changes on a regional scale

Arctic temperatures have increased at twice the average global rate in the last 100 years; late-summer extent of sea ice in the Arctic has decreased by 7.4% per decade, since 1978.

Precipitation has increased in eastern North America, northern Europe, and central Asia. Less precipitation has been observed in the Mediterranean basin, southern Africa and the Sahel.

Storms with heavy precipitation have been observed more often in most land areas.

While there is more evidence of intense tropical cyclones (especially hurricanes) in the North Atlantic Ocean since 1970, "there is no clear trend in the annual numbers of tropical cyclones" around the world.

Modern climate in the context of ancient climates

The past 50 years are likely the warmest 50-year period in the past 1300 years, insofar as science can infer what the temperatures were before instruments were used. The last time that the polar regions were warmer than they are today, the sea level was 4 to 6 meters higher than it is now. That period was 125,000 years ago.

What drives climate change?

The IPCC assigns the main drivers of climate change to be ever-growing levels of carbon dioxide (CO_2), methane, and some other gases, plus changes in land-use. The concentration of CO_2 in the atmosphere in 2005 was *higher than it has been during the last 650,000 years,* as inferred from ice cores. The increasing

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presence of CO_2 results first from burning of fossil fuels, and secondly from changes in land use. Concentrations of methane have more than doubled in the industrial age, as a result of agricultural activity and use of fossil fuels. The third most important greenhouse gas, nitrous oxide, has also been increasing because of agriculture.

The effect of the greenhouse gases mentioned above has been to create an imbalance between energy coming into the Earth and atmosphere, and energy leaving the Earth and atmosphere. The imbalance now amounts to 2.3 Watts of excess incoming energy, per square meter of ground; the imbalance is called a *radiative forcing*.

The contribution of carbon dioxide to this imbalance has increased by +20% in the last ten years, the largest change for any decade in over 200 years.

Attributing causes for climate change

IPCC says that the widespread warming of the last 50 years, together with the loss of ice, is extremely unlikely to have resulted from purely natural variations within the atmosphere and ocean; and very likely not due to natural causes alone. They conclude then the cause is very likely the increasing greenhouse gas amounts which are introduced into the air by human activity. Human influences now can be detected in the patterns of ocean warming, of winds, and of extreme temperatures.

The lower atmosphere (the troposphere) which extends up to about 10 km, has warmed while the stratosphere above it has cooled. This pattern is "very likely due to greenhouse gas increases plus the depletion of ozone."

Temperatures on the hottest nights, the coldest nights, and the coldest days have increased, and that is likely due to greenhouse effects. Also, such effects are "more likely than not" to have increased the risk of heat waves.

The overall sensitivity of climate to changing levels of greenhouse gases has not been accurately known before this report. This new IPCC report appraises the global average warming to be between 2° to 4.5°C, and the most likely value to be 3°C, when the concentrations of CO_2 are doubled from natural levels that prevailed before the industrial age. Six years ago the IPCC gave a wider range, and did not give a best estimate.

Finally, the climatic variations of temperature in the seven centuries from 1250 to 1950 are now said to be caused by volcanoes and changes in the output of the sun, plus some human influence in the first half of the 20th Century.

Some climates have NOT changed.

There is no significant trend in sea ice around Antarctica (in contrast to the Arctic). Nor is there enough evidence for any trends in small phenomena like hail or tornadoes, or for any changes in the grand circulation of the Oceans (the "meridional overturning").

Projections of Future Changes

Though the IPCC considered a wide range of projections of future economic trends and emissions, little difference is expected in global temperatures in most projections until the year 2030. For the next 25 years, the global temperature trend is mainly affected by warmth already stored in the Ocean and by greenhouse gases already in the atmosphere. Until 2030, the Report projects a warming of 0.2°C per decade, close to the warming observed since 1990.

Even if greenhouse gases could somehow be kept at the year 2000 concentrations (this requires drastic cuts in emissions), the warming would still be +0.1°C per decade. Half the warming over the next 25 years will result from the climate lag from greenhouse gases already present in the air by 2000.

Current rates of emission cause further warming (after 2030) and other kinds of changes on Earth that will be larger than the changes seen in the 20th Century. The 2007 Report claims to provide more advanced projections than the previous (2001) report, as "it relies on a larger number of climate models of increasing complexity and realism, and new feedbacks from the carbon cycle."

It is often overlooked that further warming diminishes the ability of both the Land and the Ocean to absorb more carbon dioxide.

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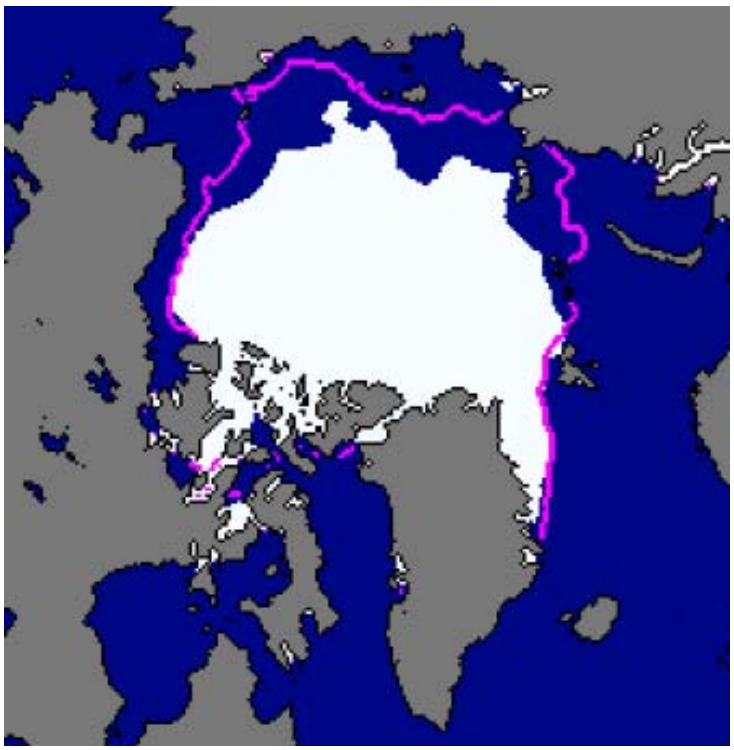
Arctic Ocean Has Record Low Summer Ice Cover

Maps for the months of September 2005 and 2007



2005

2007

The minimum area covered by sea ice **in September** (at the end of the summer melt season) fell by 23% in two years from 2005 to 2007. A purple line marks the long-term average location of the ice edge in September on both maps. In 2007, the extent of ice cover was **39% less** than the typical extent observed in September from 1979 to 2000.

Scientist Mark Serreze of the National Snow and Ice Data Center said, "The sea ice cover is in a downward spiral and may have passed the point of no return. As the years go by, we are losing more and more ice in summer, and growing back less and less ice in winter. We may well see an ice-free Arctic Ocean in summer within our lifetimes." He concluded, "The implications for global climate, as well as Arctic animals and people, are disturbing."

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The satellite image released by the Snow and Ice Data Center reveals another feature worth noting: an ice-free Northwest Passage from the Atlantic Ocean all the way to the Pacific. The passage winds through the Canadian Arctic islands to the Beaufort Sea off Alaska's North Slope. This news has been long awaited by international traders, who may well try to ship crude oil and gas from Arctic fields directly to Europe and the East Coast by this shorter route.

While the Northwest Passage did open up in the American Arctic, the sea route along the northern coast of Russia and Siberia remained firmly closed by ice this year (see story on this page). That route "over the top of Asia" was open in 2005 and is often passable in some summers – but not this year.

Comparisons of Arctic ice in 2005 and 2007 — see the images above.