Climate4you update February 2011

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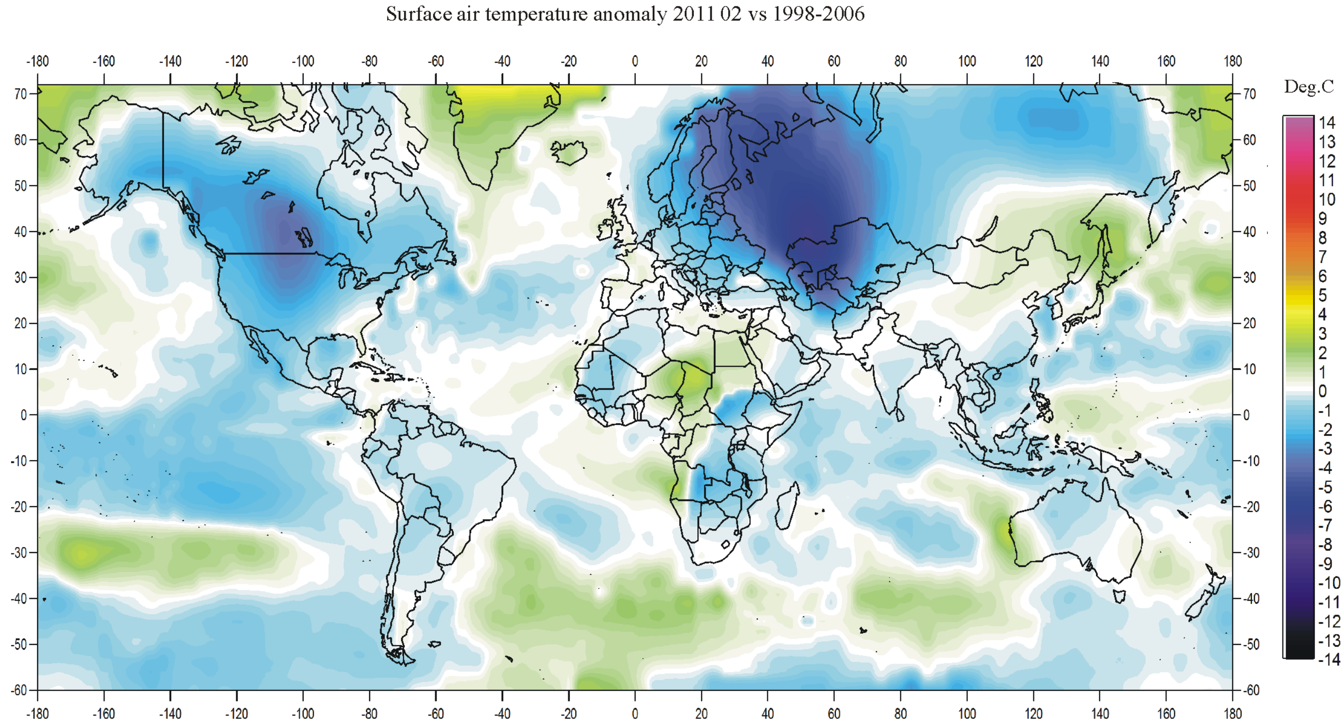
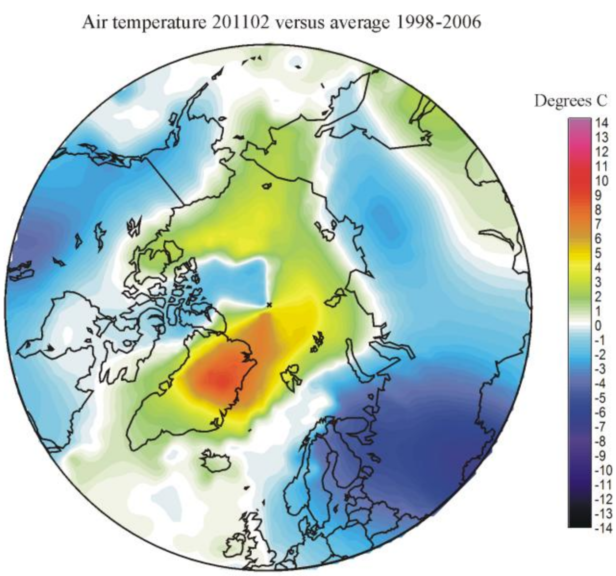
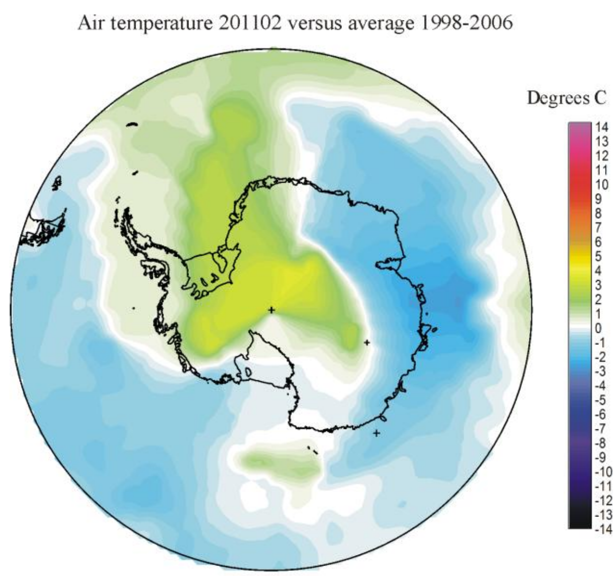
February 2011 global surface air temperature overview







February 2011 surface air temperature compared to the average 1998-2006. Green.yellow-red colours indicate areas with higher temperature than the 1998-2006 average, while blue colours indicate lower than average temperatures. Data source: [Goddard Institute for Space Studies](#) (GISS)

Comments to the February 2011 global surface air temperature overview

General: This newsletter contains graphs showing a selection of key meteorological variables for February 2011. All temperatures are given in degrees Celsius.

In the above maps showing the geographical pattern of surface air temperatures, the period 1998-2006 is used as reference period. The reason for comparing with this recent period instead of the official WMO 'normal' period 1961-1990, is that the latter period is affected by the relatively cold period 1945-1980. Almost any comparison with such a low average value will therefore appear as high or warm, and it will be difficult to decide if modern surface air temperatures are increasing or decreasing. Comparing with a more recent period overcomes this problem. In addition to this consideration, the recent temperature development suggests that the time window 1998-2006 may roughly represent a global temperature peak. If so, negative temperature anomalies will gradually become more and more widespread as time goes on. However, if positive anomalies instead gradually become more widespread, this reference period only represented a temperature plateau.

In the other diagrams in this newsletter the thin line represents the monthly global average value, and the thick line indicate a simple running average, in most cases a simple moving 37-month average, almost corresponding to three years. The 37-month average is calculated from values covering a range from 18 month before to 18 months after, with equal weight for every month.

The year 1979 has been chosen as starting point in several of the diagrams, as this roughly corresponds to both the beginning of satellite observations and the onset of the late 20th century warming period. Several of the records, however, have a much longer history, which may be inspected on www.Climate4you.com.

Global surface air temperatures February 2011 generally was below the 1998-2006 average, as detailed in several of the diagrams below.

The Northern Hemisphere was characterised by be low average temperatures with few exceptions, such as Greenland and easternmost Siberia.

The Southern Hemisphere also was characterised by generally below average temperatures, with the exception of a band around 30-40^{o}S over the oceans, which had above average temperatures.

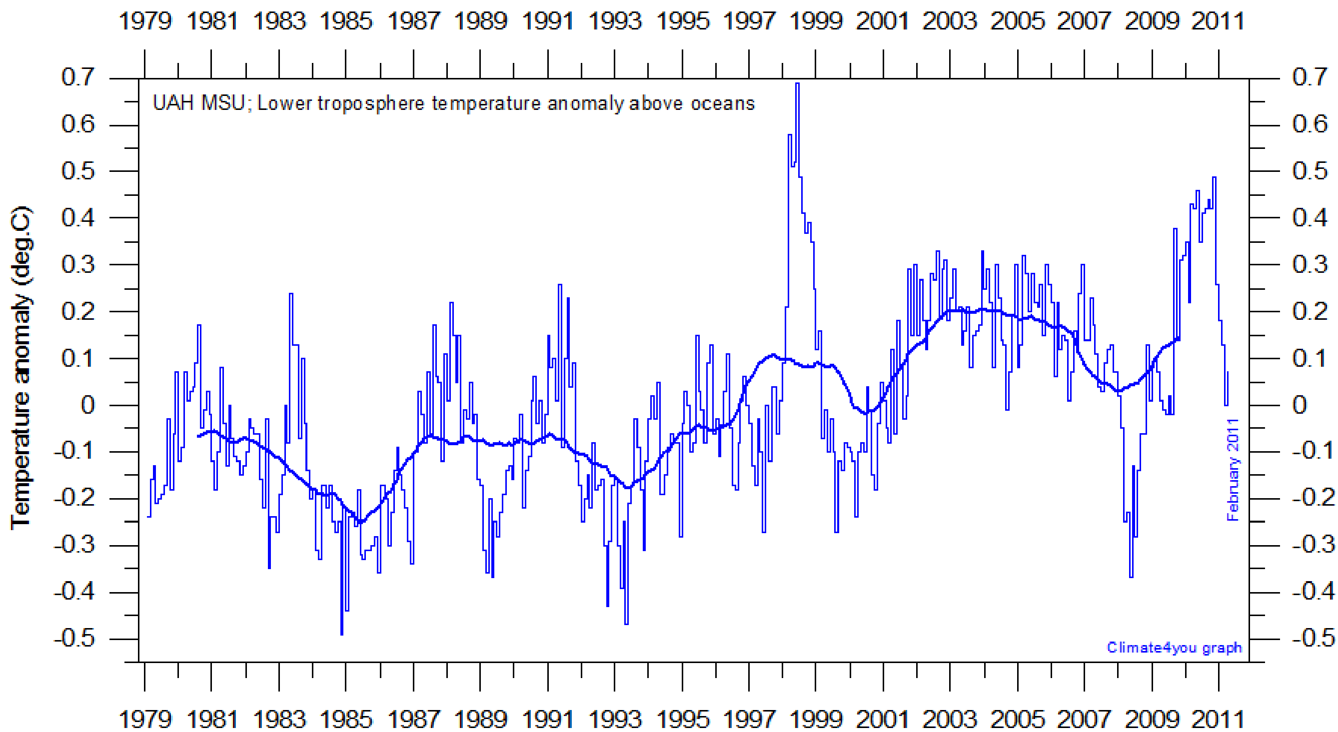
Near Equator temperatures conditions were influenced by the La Nina situation. Relatively low temperatures characterised most of the Equatorial regions in the Pacific and Indian Ocean. The Equatorial Atlantic was close to average conditions.

The Arctic was characterized by huge contrasts as to surface air temperatures. NE Greenland was especially warm, while northern Russia and Finland were especially cold.

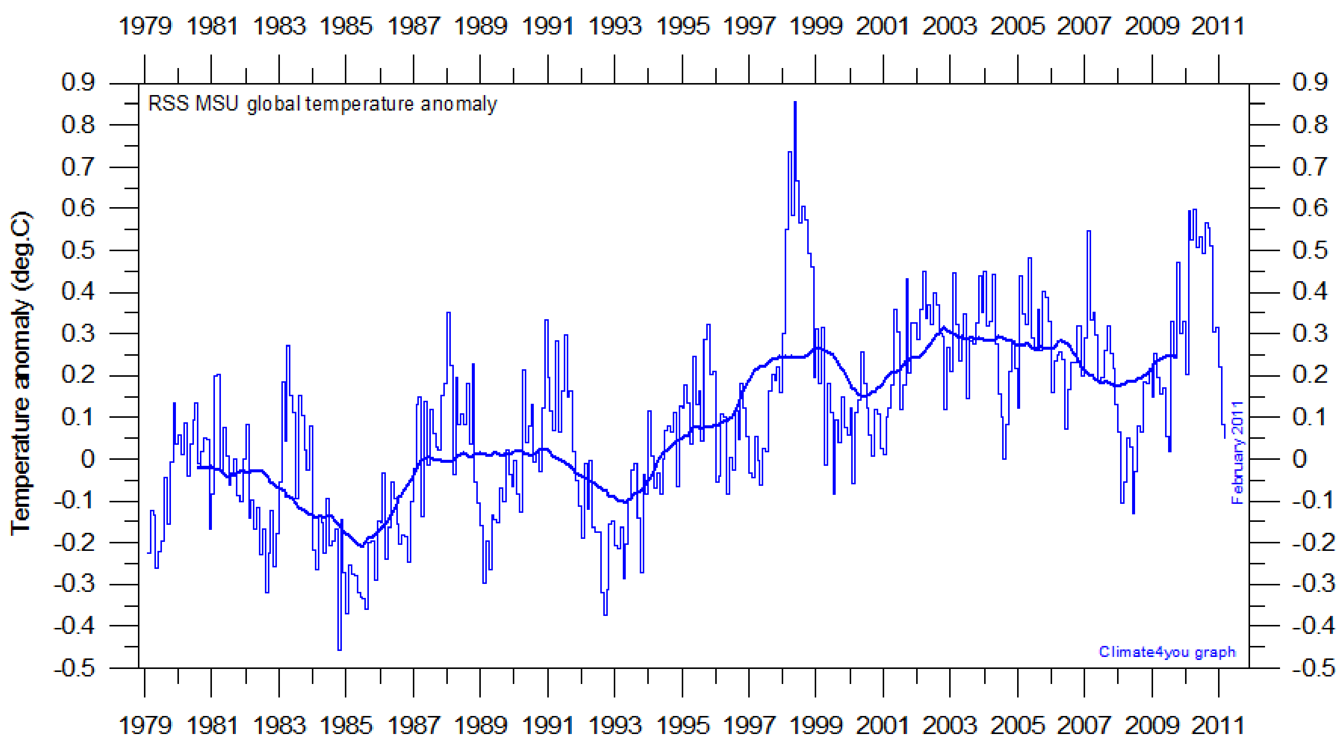
In the Antarctic temperature conditions were above the average for 1998-2006 in parts of West Antarctic, while parts of East Antarctic experienced below average temperatures

All diagrams shown in this newsletter are available for download on www.climate4you.com

Lower troposphere temperature from satellites, updated to February 2011

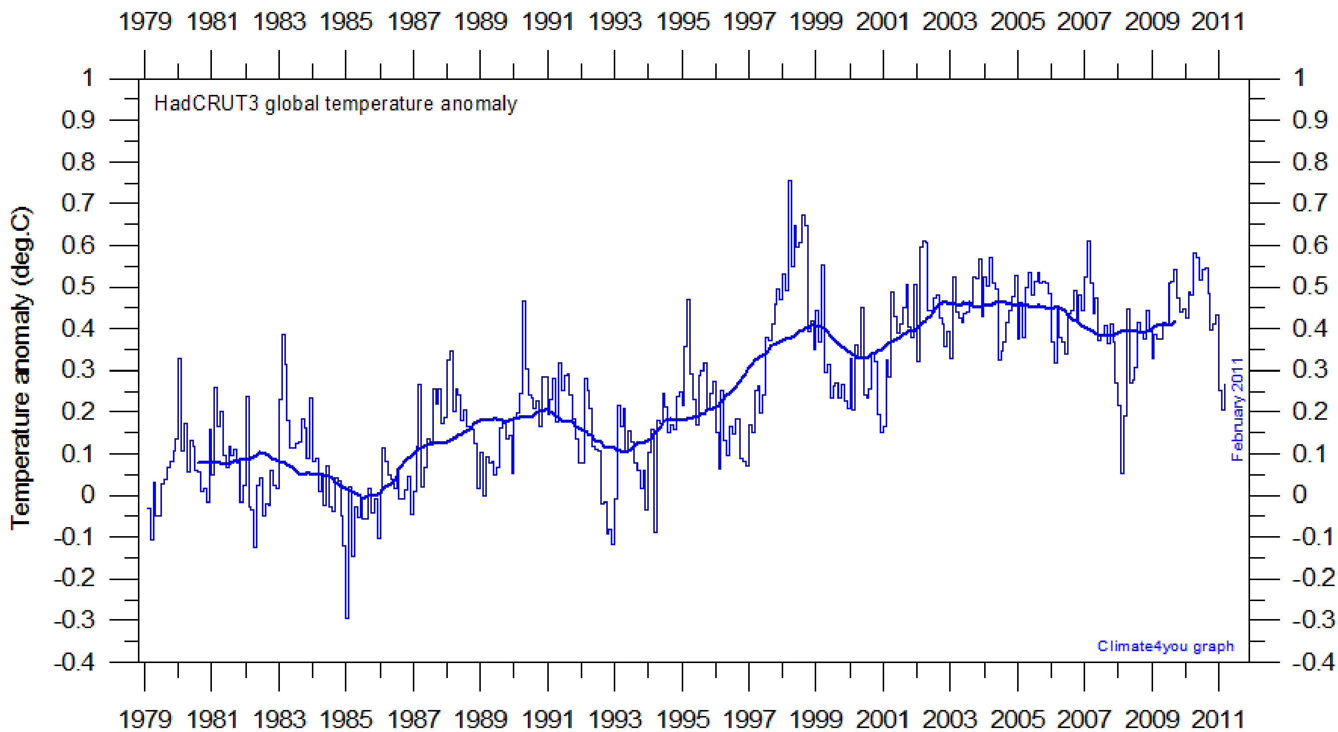


Global monthly average lower troposphere temperature (thin line) since 1979 according to [University of Alabama]() at Huntsville, USA. The thick line is the simple running 37 month average.

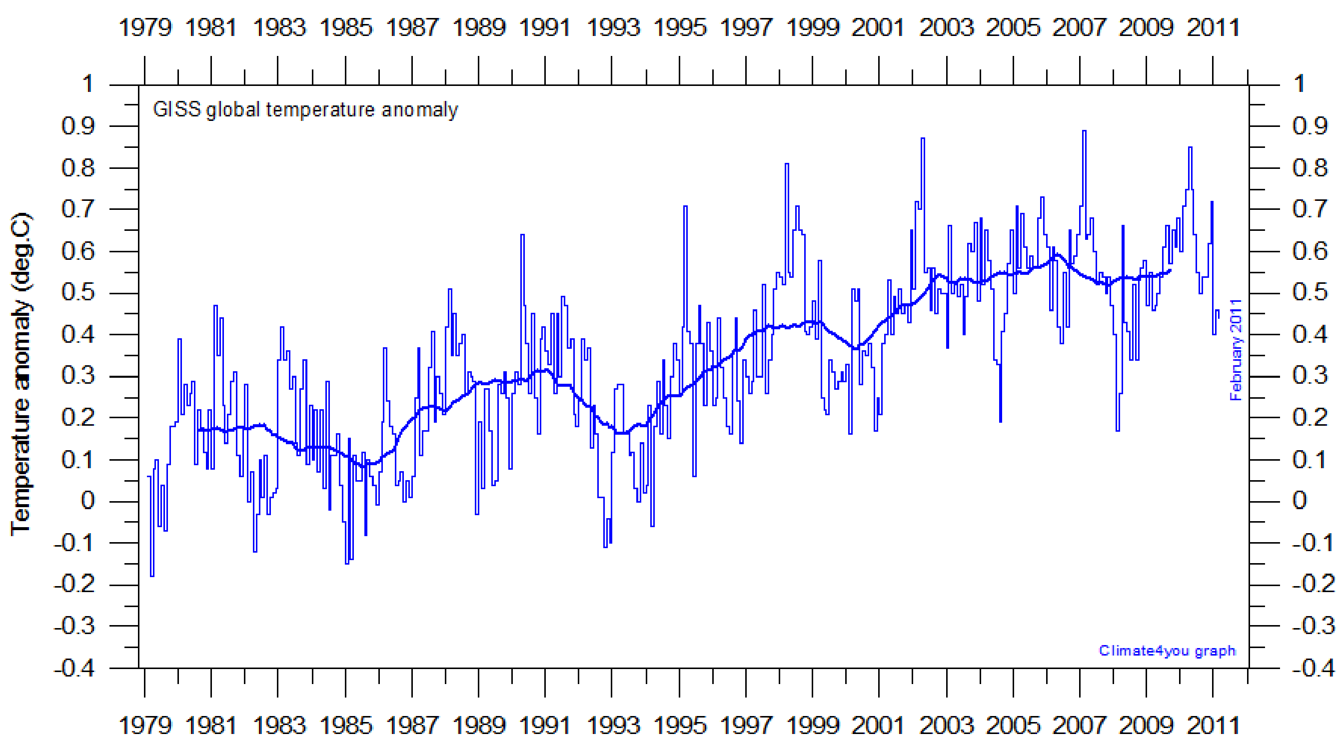


Global monthly average lower troposphere temperature (thin line) since 1979 according to according to [Remote Sensing Systems]() (RSS), USA. The thick line is the simple running 37 month average.

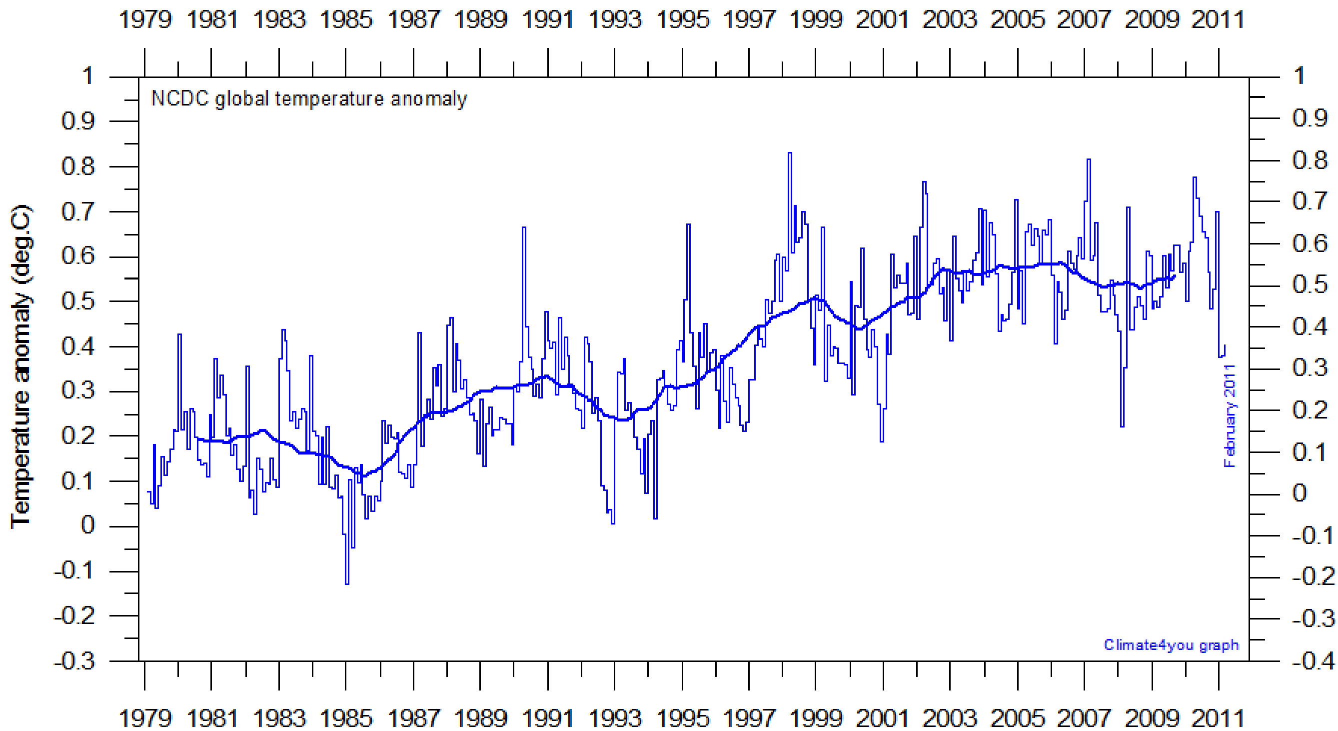
Global surface air temperature, updated to February 2011



Global monthly average surface air temperature (thin line) since 1979 according to according to the Hadley Centre for Climate Prediction and Research and the University of East Anglia's [Climatic Research Unit](CRU) ([CRU]), UK. The thick line is the simple running 37 month average.

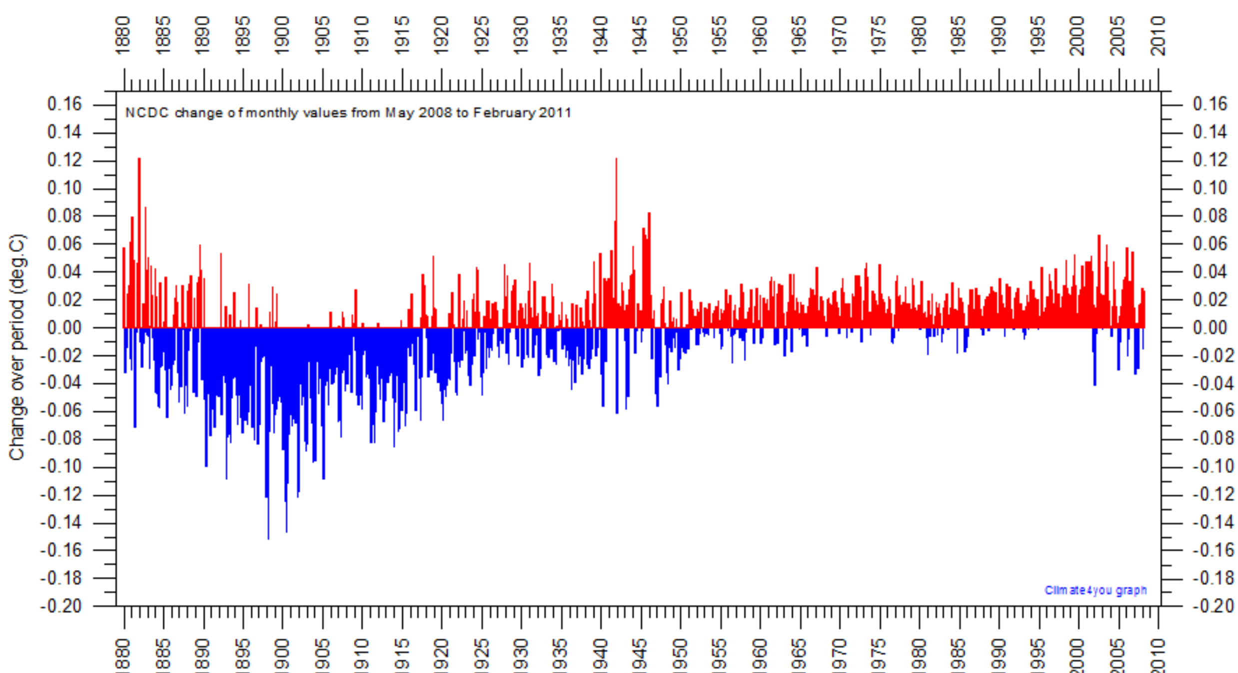


Global monthly average surface air temperature (thin line) since 1979 according to according to the Goddard Institute for Space Studies (GISS), at Columbia University, New York City, USA. The thick line is the simple running 37 month average.

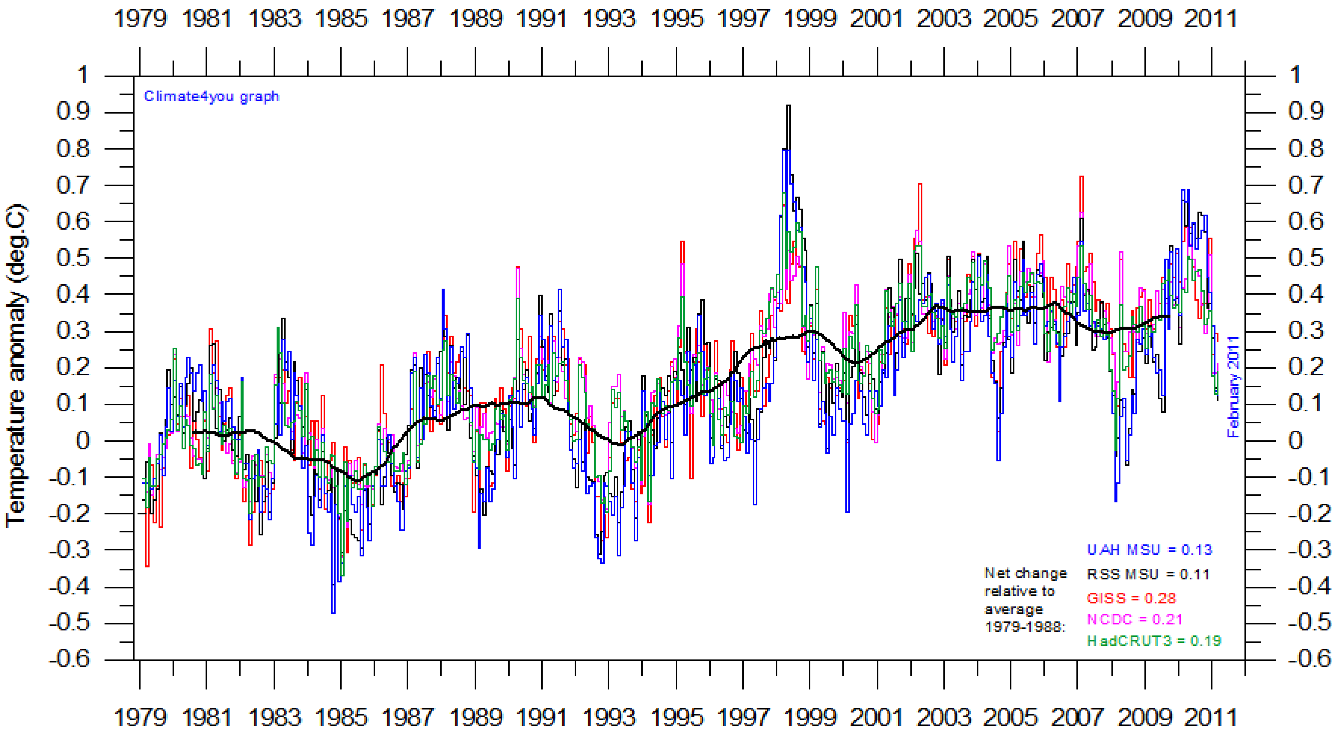


Global monthly average surface air temperature since 1979 according to according to the [National Climatic Data Center](#) (NCDC), USA. The thick line is the simple running 37 month average.

Some readers have noted that the above temperature estimates display changes when one compare with previous issues of this newsletter, not only for the most recent months, but actually for all months back to the beginning of the record. As an example, the net change of the NCDC record since 17 May 2008 is shown below. By this administrative effort the apparent global temperature increase since 1900 has been enhanced about 0.1°C, or about 14% of the total increase recorded since 1900 by NCDC. The interested reader may find more on this lack of temporal stability on [www.climate4you](#) (go to: Global Temperature and then Temporal Stability).



[All in one, updated to February 2011]

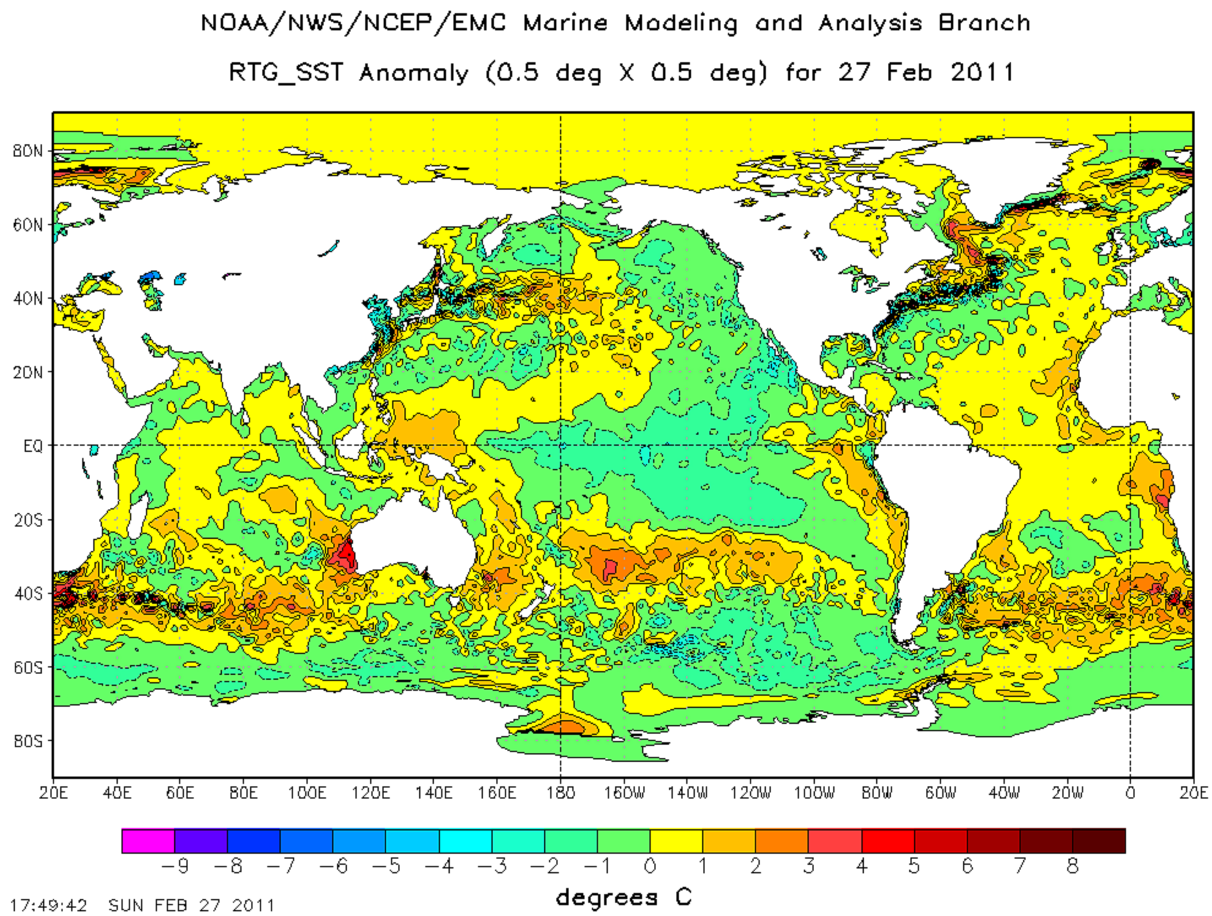


Superimposed plot of all five global monthly temperature estimates shown above. As the base period differs for the different temperature estimates, they have all been normalised by comparing to the average value of their initial 120 months (10 years) from January 1979 to December 1988. The heavy black line represents the simple running 37 month (c. 3 year) mean of the average of all five temperature records. The numbers shown in the lower right corner represent the temperature anomaly relative to the above average.

It should be kept in mind that satellite- and surface-based temperature estimates are derived from different types of measurements, and that comparing them directly as done in the diagram above therefore in principle is problematical. However, as both types of estimate often are discussed together, the above diagram may nevertheless be of interest. In fact, the different types of temperature estimates appear to agree quite well as to the overall temperature variations on a 2-3 year scale, although on a short term scale there may be considerable differences.

All five global temperature estimates presently show stagnation, at least since 2002. There has been no increase in global air temperature since 1998, which was affected by the oceanographic El Niño event. This does not exclude the possibility that global temperatures will begin to increase again later. On the other hand, it also remain a possibility that Earth just now is passing a temperature peak, and that global temperatures will begin to decrease within the coming 5-10 years. Only time will show which of these possibilities is correct.

Global sea surface temperature, updated to end of February 2011

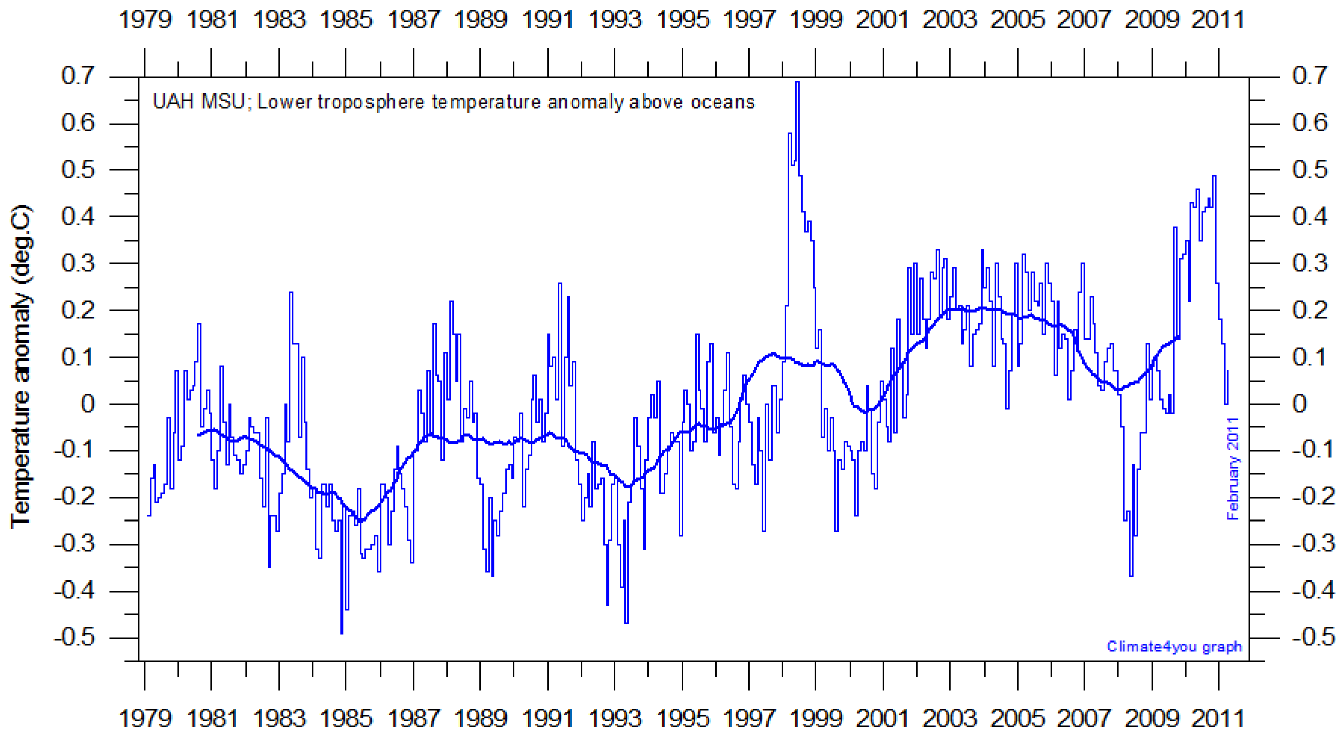


Sea surface temperature anomaly at 27 February 2011. Map source: National Centers for Environmental Prediction (NOAA).

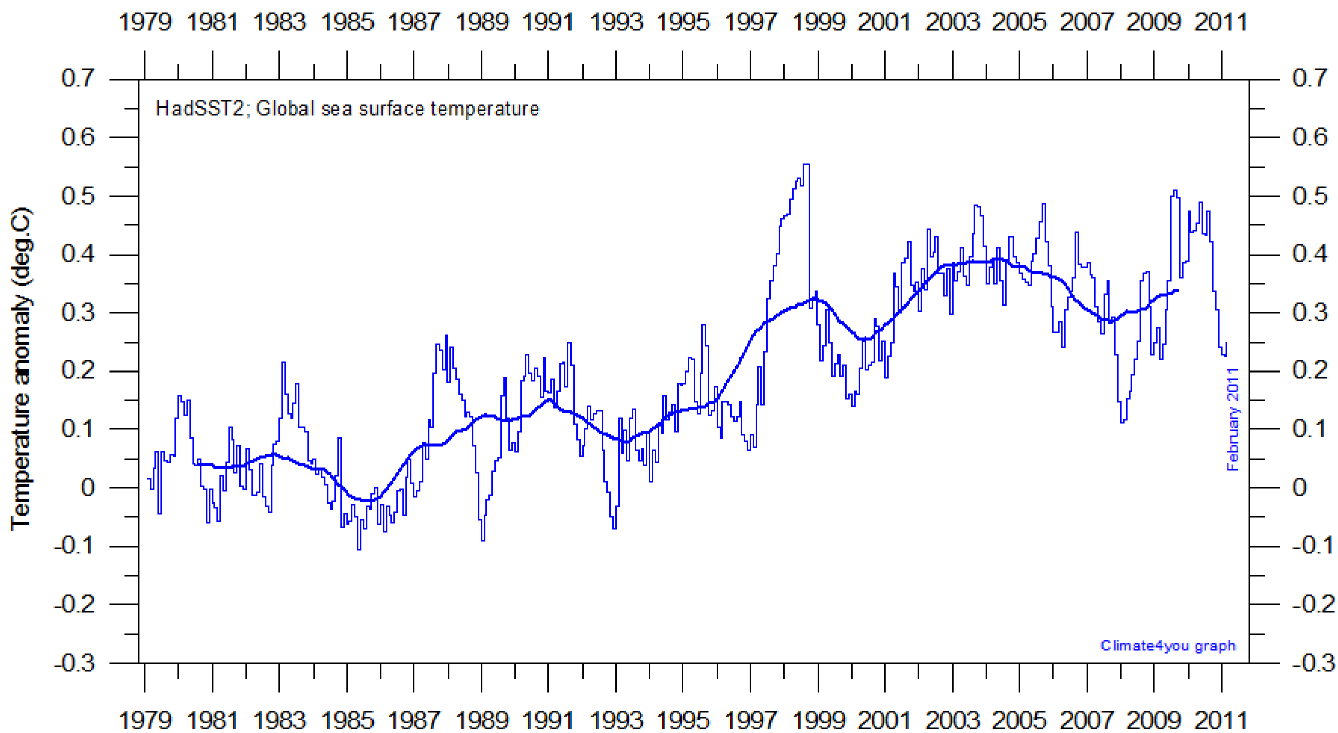
The relative cold surface water now dominating the Equator in the Pacific Ocean represents a La Niña situation and affects the temperature of the atmosphere above. Because of the large surface areas involved (near Equator) this natural cyclic development is at the moment affecting the global atmospheric temperature towards lower temperatures.

However, the significance of any such global cooling should not be over interpreted. Whenever Earth experiences cold La Niña or warm El Niño episodes major heat exchanges takes place between the Pacific Ocean and the atmosphere above, eventually showing up in estimates of the global air temperature. This does not, however, reflect similar changes in the total heat content of the atmosphere-ocean system. In fact, net changes may be small, as it mainly reflects a redistribution of energy. What matters is the overall development when seen over some years.

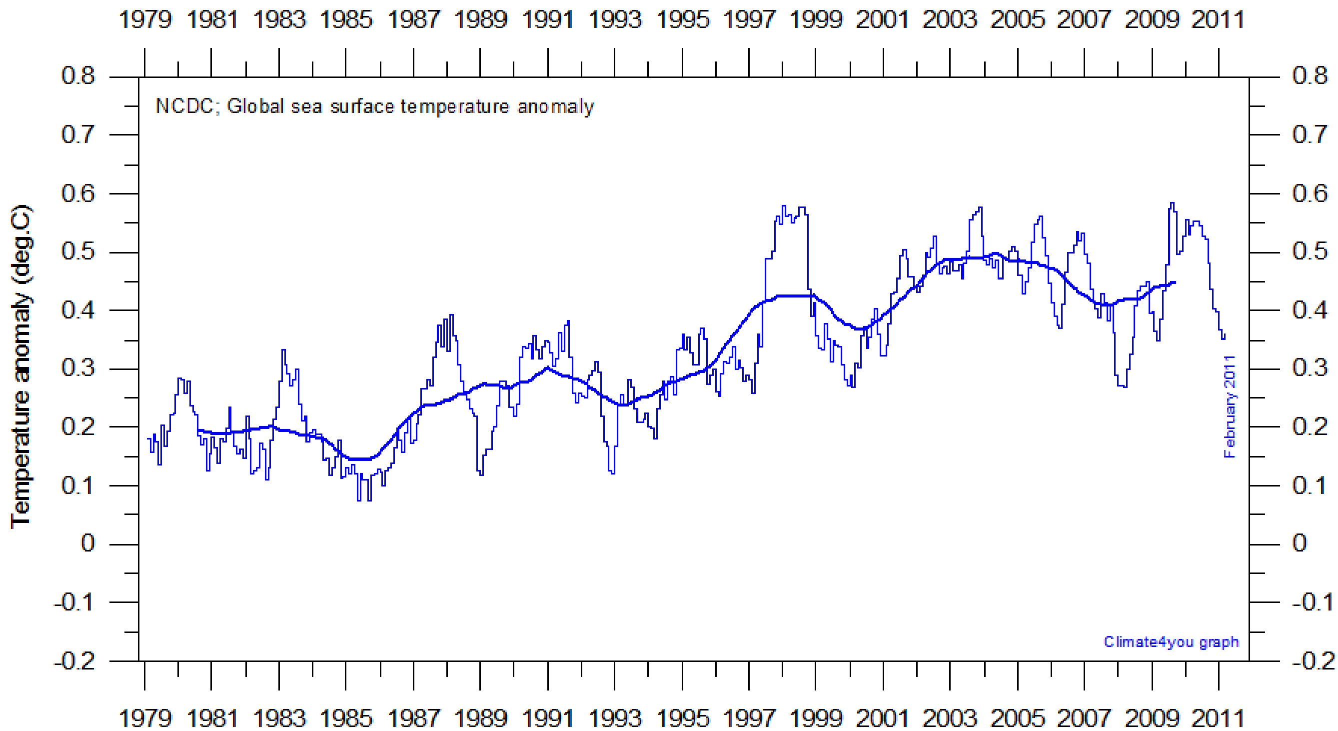
Along the east coast of South America relatively warm water now begins to appear at the surface; the first indication of the next warm phase to come.



Global monthly average lower troposphere temperature over oceans (thin line) since 1979 according to [University of Alabama]() at Huntsville, USA. The thick line is the simple running 37 month average.

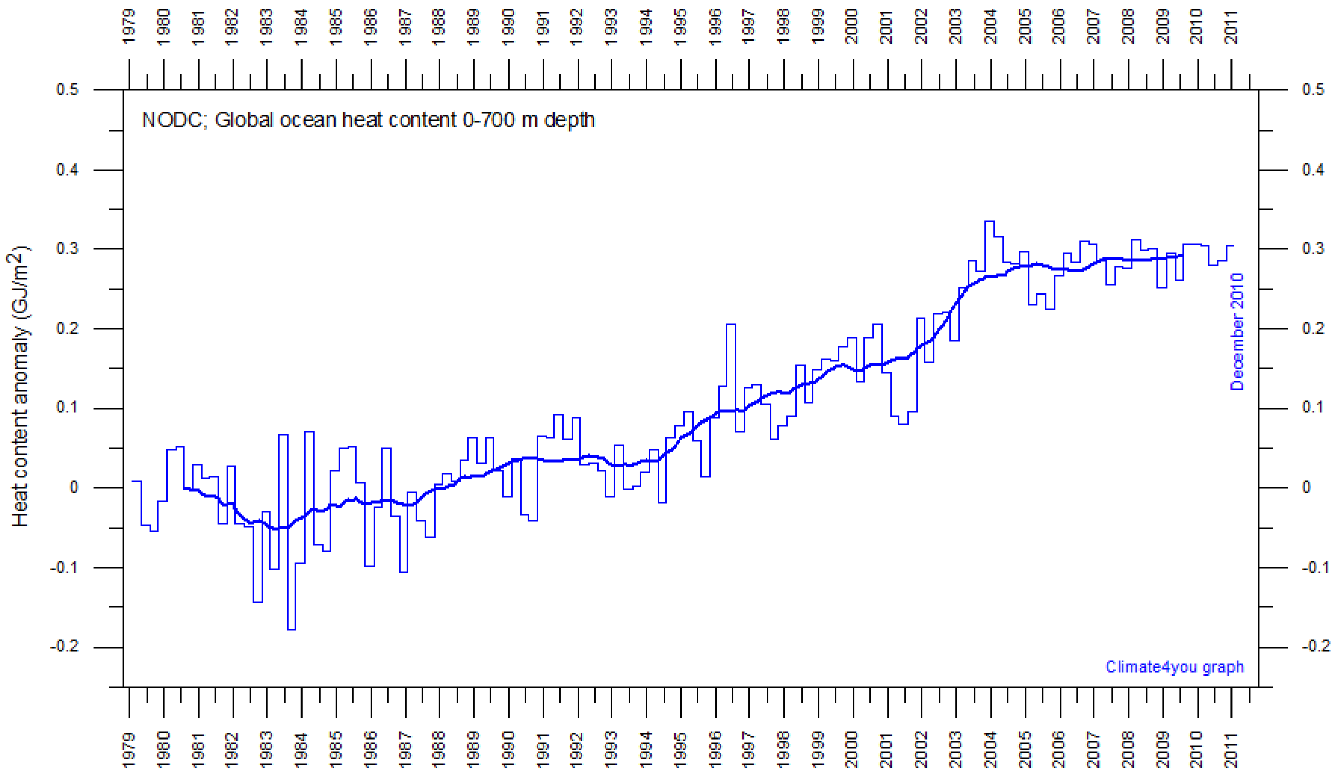


Global monthly average sea surface temperature since 1979 according to University of East Anglia's [Climatic Research Unit]() ([CRU]()), UK. Base period: 1961-1990. The thick line is the simple running 37 month average.

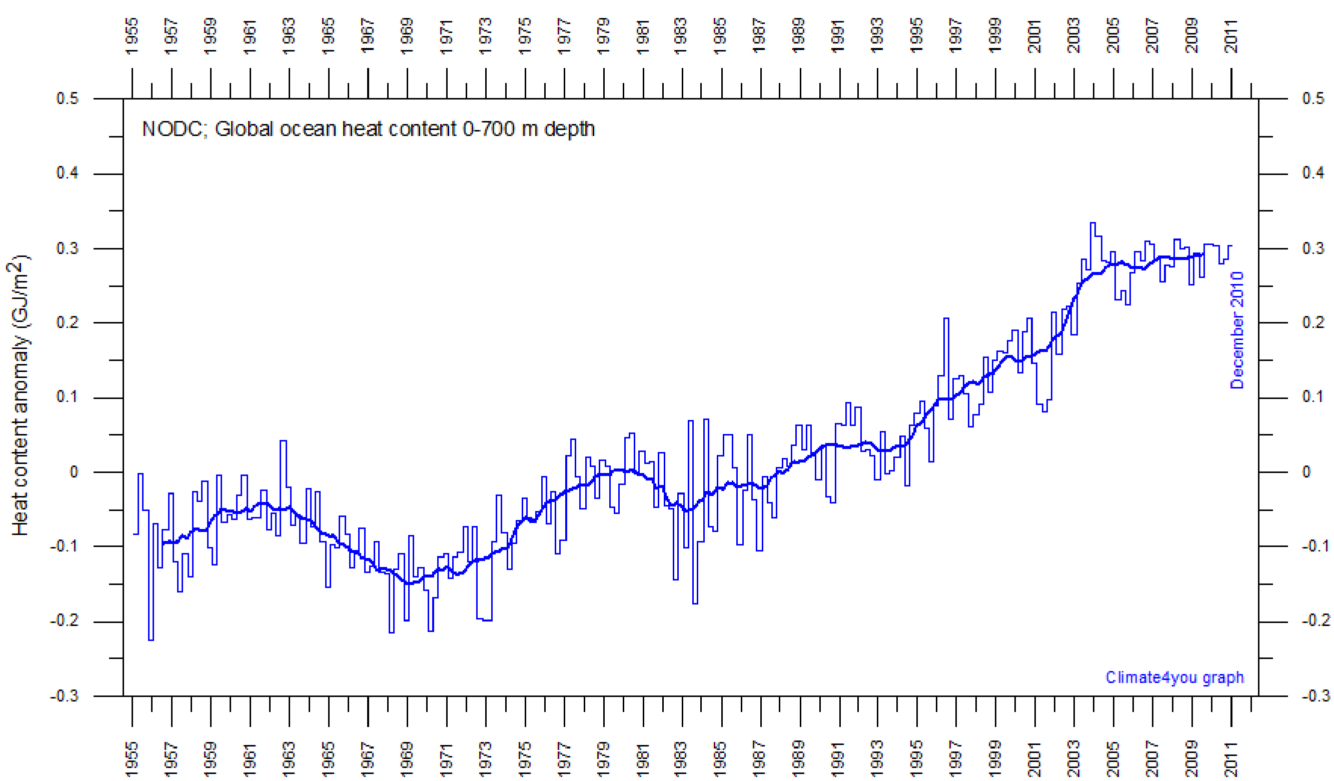


Global monthly average sea surface temperature since 1979 according to the [National Climatic Data Center](#) (NCDC), USA. Base period: 1901-2000. The thick line is the simple running 37 month average.

Global ocean heat content, updated to December 2010

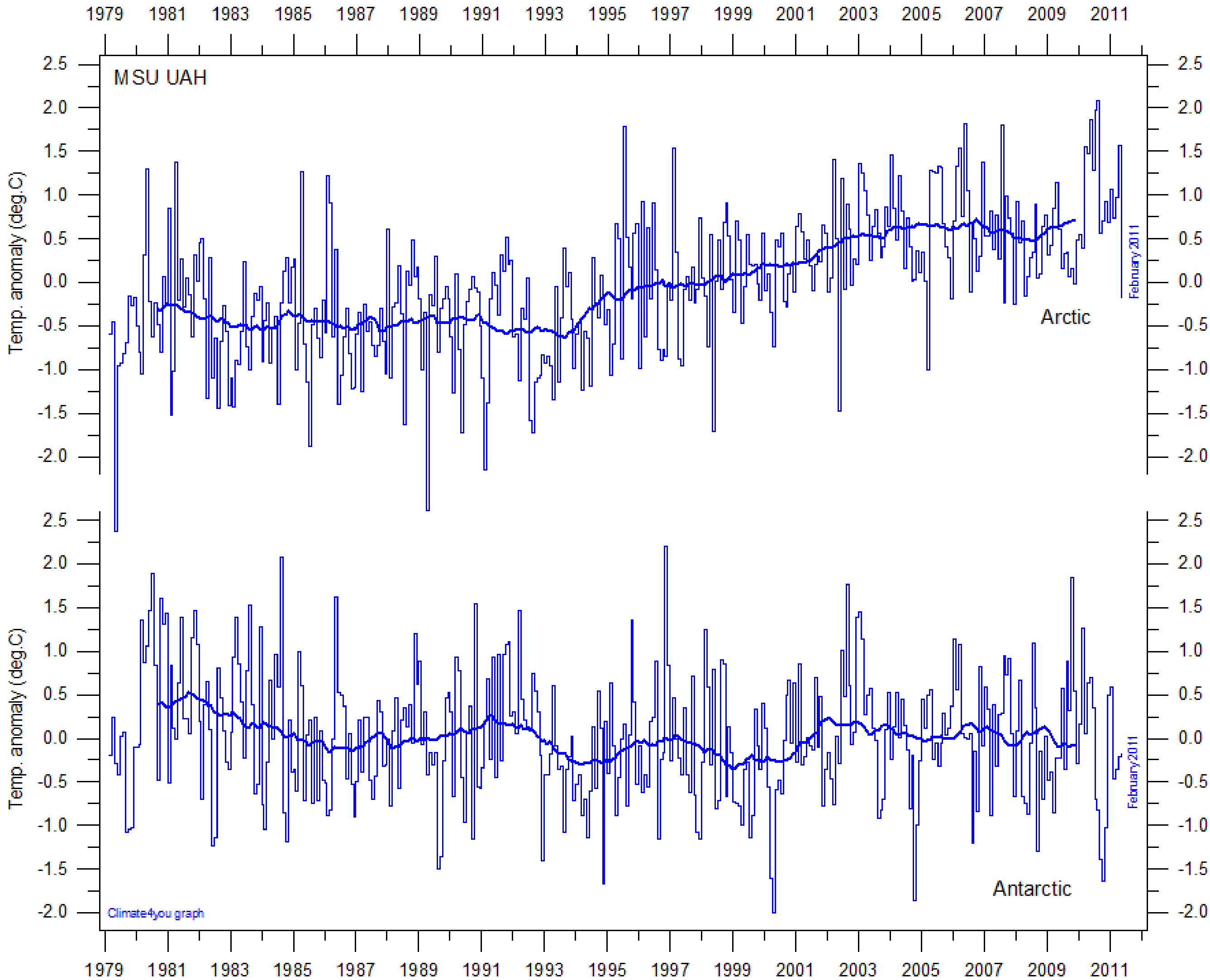


Global monthly heat content anomaly (GJ/m2) in the uppermost 700 m of the oceans since January 1979. Data source: National Oceanographic Data Center(NODC).



Global monthly heat content anomaly (GJ/m2) in the uppermost 700 m of the oceans since January 1955. Data source: National Oceanographic Data Center(NODC).

[Arctic and Antarctic lower troposphere temperature, updated to February 2011]()



Global monthly average lower troposphere temperature since 1979 for the North Pole and South Pole regions, based on satellite observations ([University of Alabama]() at Huntsville, USA). The thick line is the simple running 37 month average, nearly corresponding to a running 3 yr average.

Arctic and Antarctic surface air temperature, updated to January 2011

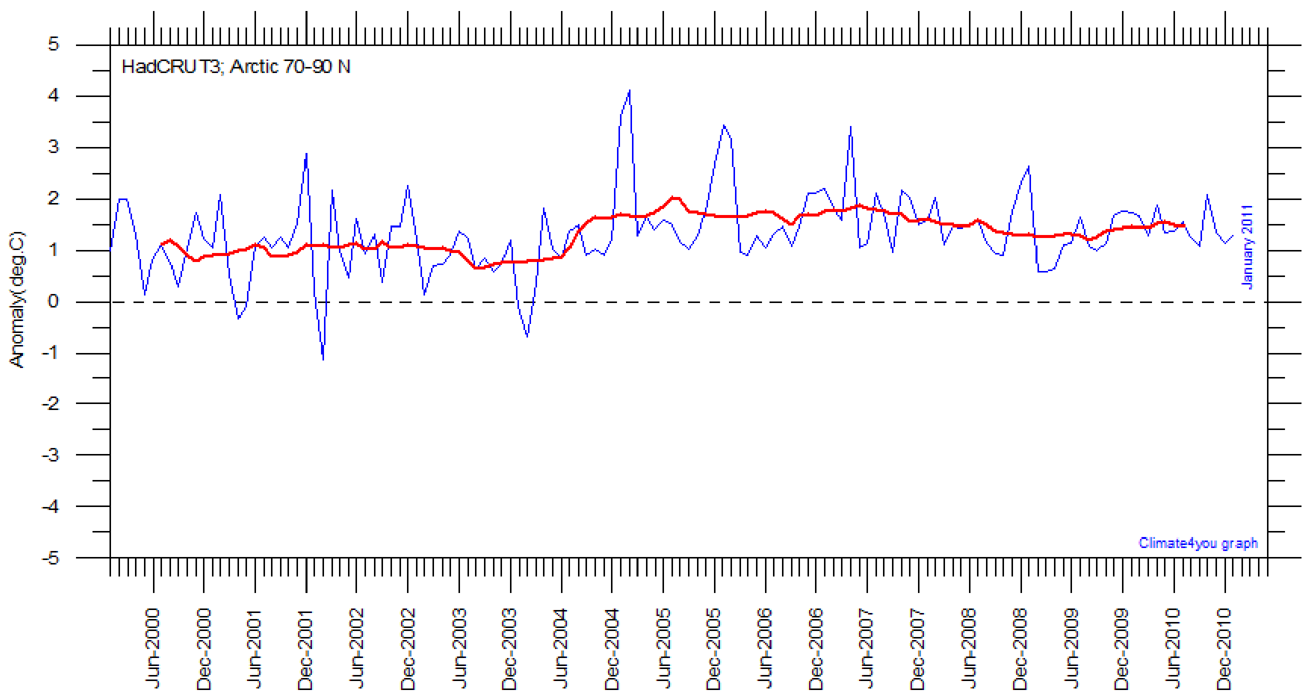


Diagram showing Arctic monthly surface air temperature anomaly 70-90°N since January 2000, in relation to the WMO reference "normal" period 1961-1990. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 13 month average. Data provided by the Hadley Centre for Climate Prediction and Research and the University of East Anglia's Climatic Research Unit (CRU), UK.

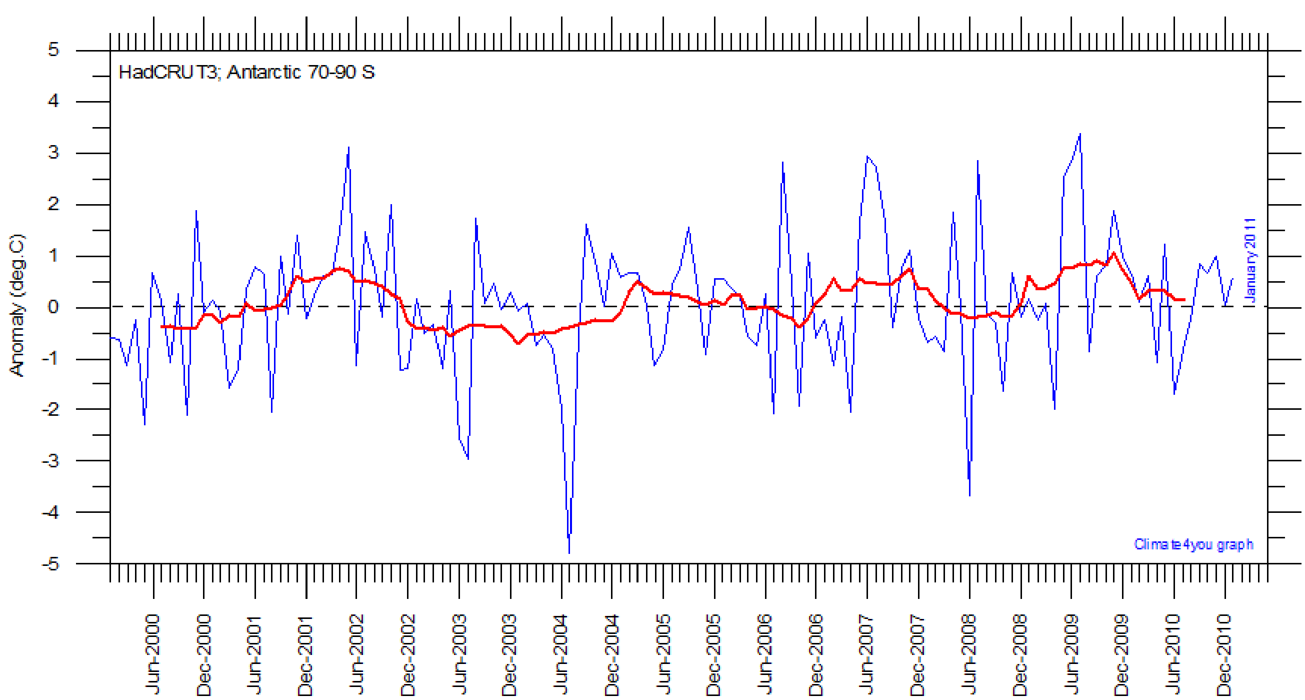


Diagram showing Antarctic monthly surface air temperature anomaly 70-90°S since January 2000, in relation to the WMO reference "normal" period 1961-1990. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 13 month average. Data provided by the Hadley Centre for Climate Prediction and Research and the University of East Anglia's Climatic Research Unit (CRU), UK.

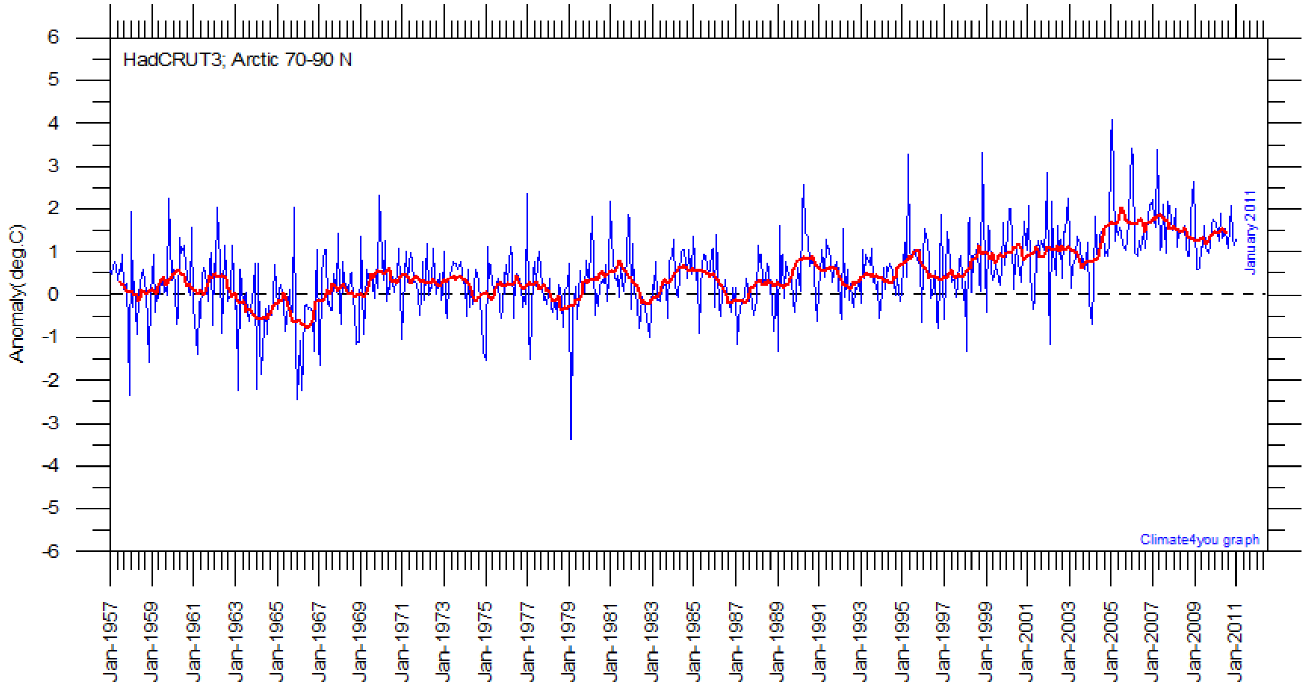


Diagram showing Arctic monthly surface air temperature anomaly 70-90°N since January 1957, in relation to the WMO reference "normal" period 1961-1990. The year 1957 has been chosen as starting year, to ensure easy comparison with the maximum length of the realistic Antarctic temperature record shown below. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 13 month average. Data provided by the Hadley Centre for Climate Prediction and Research and the University of East Anglia's [Climatic Research Unit](CRU) (CRU), UK.

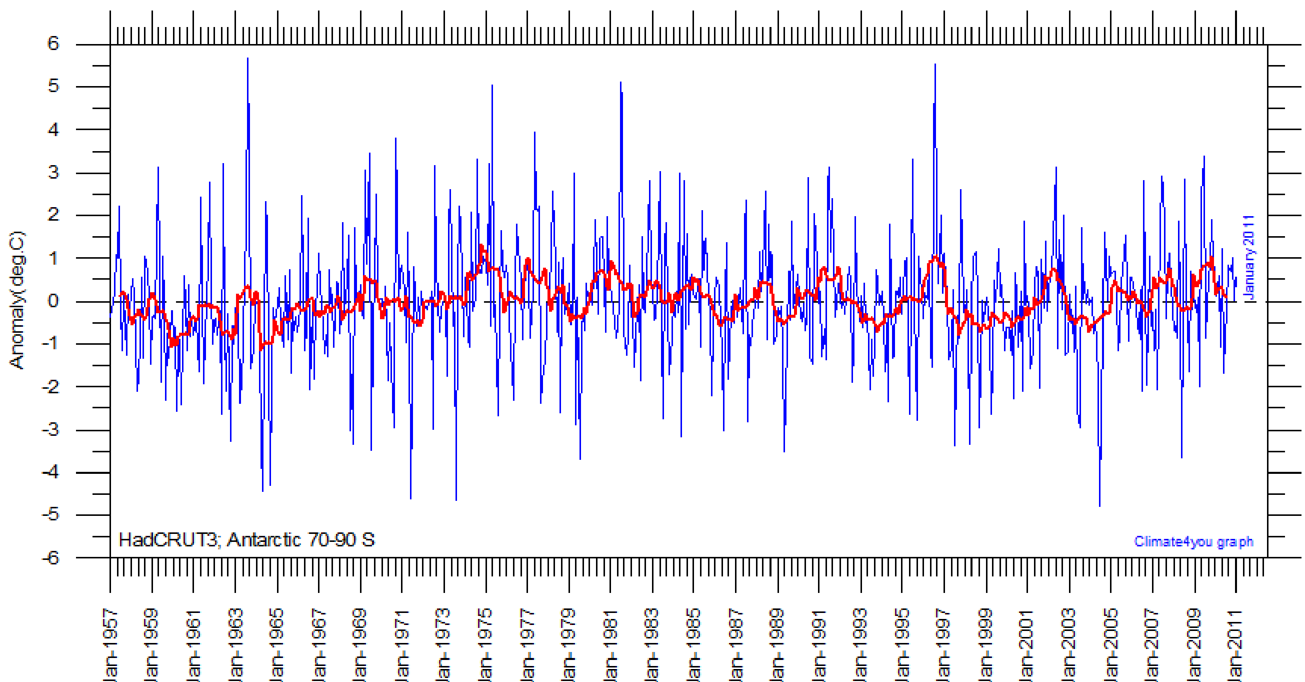


Diagram showing Antarctic monthly surface air temperature anomaly 70-90°S since January 1957, in relation to the WMO reference "normal" period 1961-1990. The year 1957 was an international geophysical year, and several meteorological stations were established in the Antarctic because of this. Before 1957, the meteorological coverage of the Antarctic continent is poor. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 13 month average. Data provided by the Hadley Centre for Climate Prediction and Research and the University of East Anglia's Climatic Research Unit (CRU), UK.

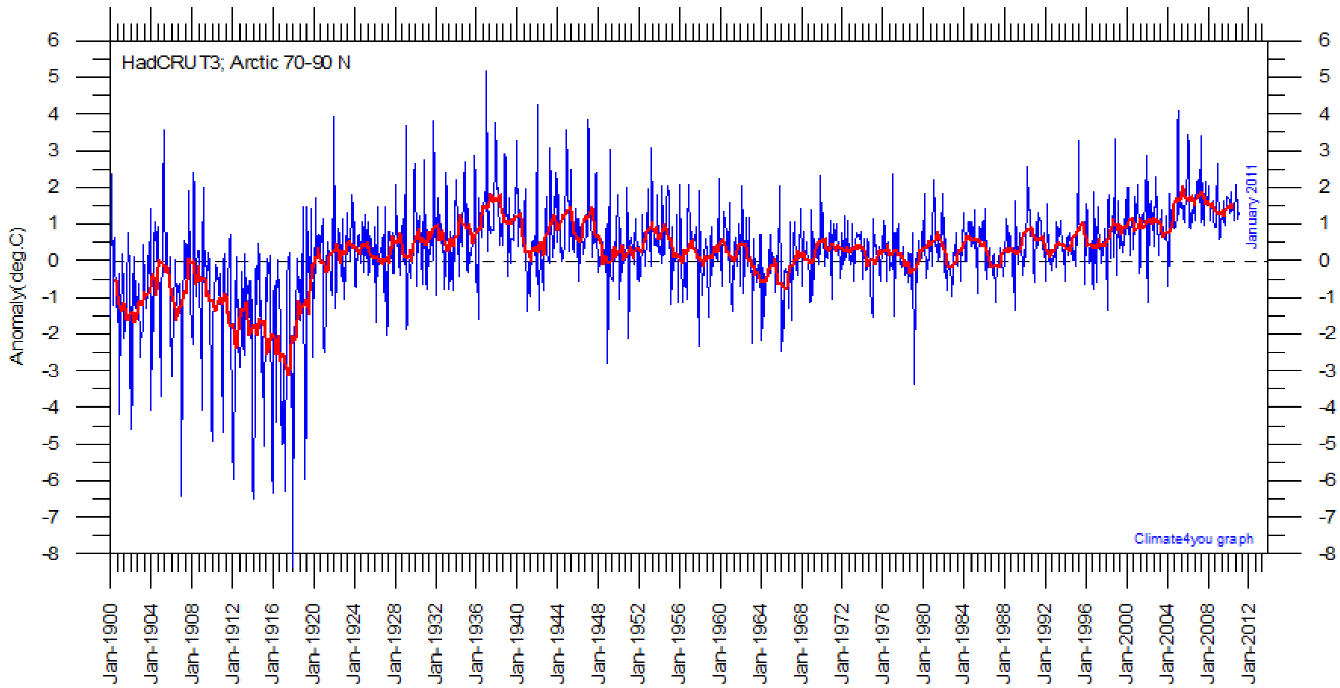


Diagram showing Arctic monthly surface air temperature anomaly 70-90^{o}N since January 1900, in relation to the WMO reference "normal" period 1961-1990. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 13 month average. In general, the range of monthly temperature variations decreases throughout the first 30-50 years of the record, reflecting the increasing number of meteorological stations north of 70^{o}N over time. Especially the period from about 1930 saw the establishment of many new Arctic meteorological stations, first in Russia and Siberia, and following the 2nd World War, also in North America. Because of the relatively small number of stations before 1930, details in the early part of the Arctic temperature record should not be over interpreted. The rapid Arctic warming around 1920 is, however, clearly visible, and is also documented by other sources of information. The period since 2000 is warm, about as warm as the period 1930-1940. Data provided by the Hadley Centre for Climate Prediction and Research and the University of East Anglia's Climatic Research Unit (CRU), UK

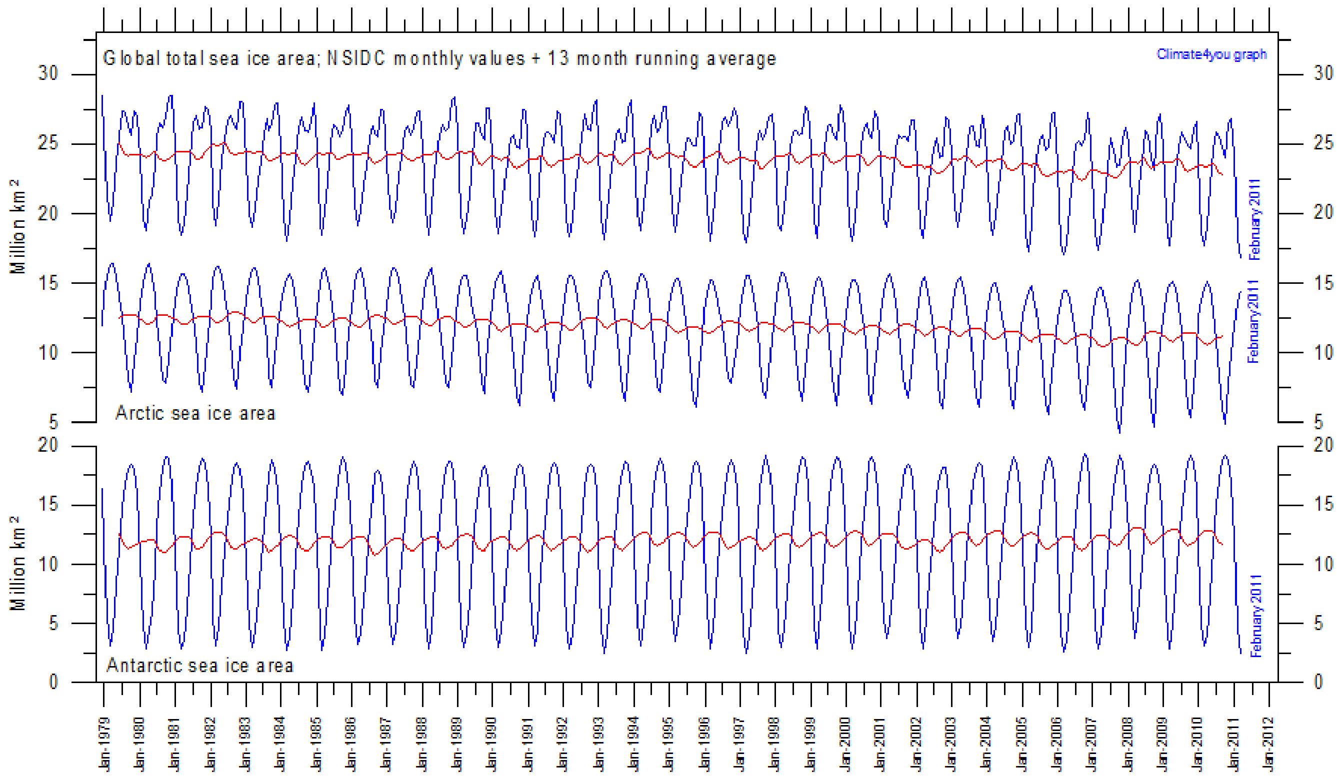
In general, the Arctic temperature record appears to be less variable than the contemporary Antarctic record, presumably at least partly due to the higher number of meteorological stations north of 70^{o}N, compared to the number of stations south of 70^{o}S.

As data coverage is sparse in the Polar Regions, the procedure of Gillet et al. 2008 has been followed, giving equal weight to data in each 5^{o}x5^{o} grid cell when calculating means, with no weighting by the areas of the grid dells.

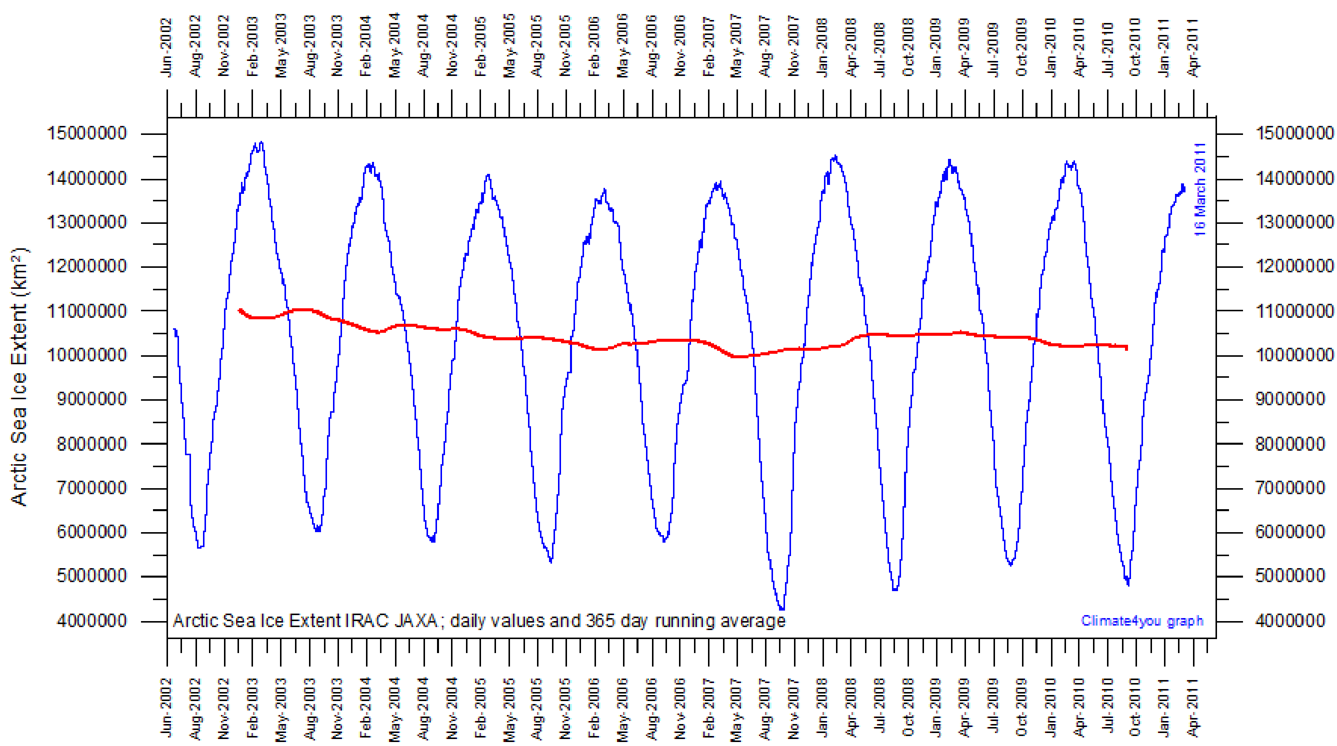
Literature:

Gillett, N.P., Stone, D.A., Stott, P.A., Nozawa, T., Karpechko, A.Y.U., Hegerl, G.C., Wehner, M.F. and Jones, P.D. 2008. Attribution of polar warming to human influence. *Nature Geoscience* 1, 750-754.

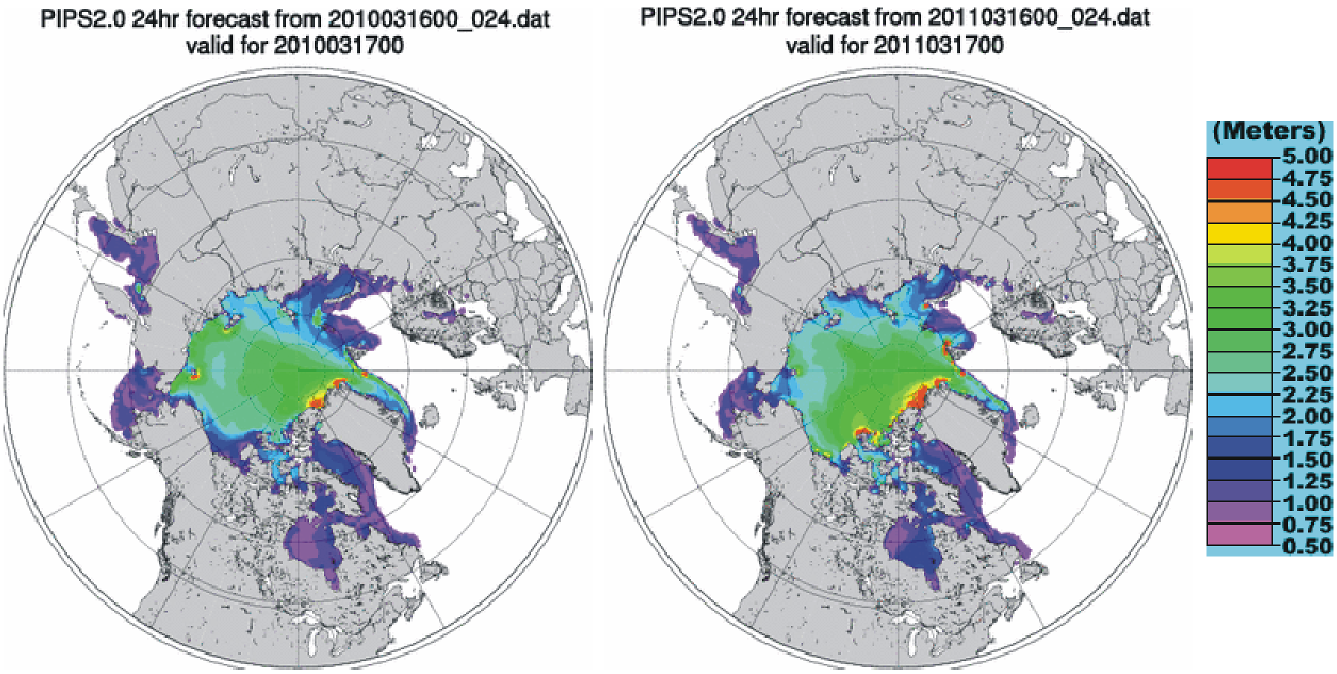
Arctic and Antarctic sea ice, updated to February 2011



Graphs showing monthly Antarctic, Arctic and global sea ice extent since November 1978, according to the [National Snow and Ice data Center](#) (NSIDC).

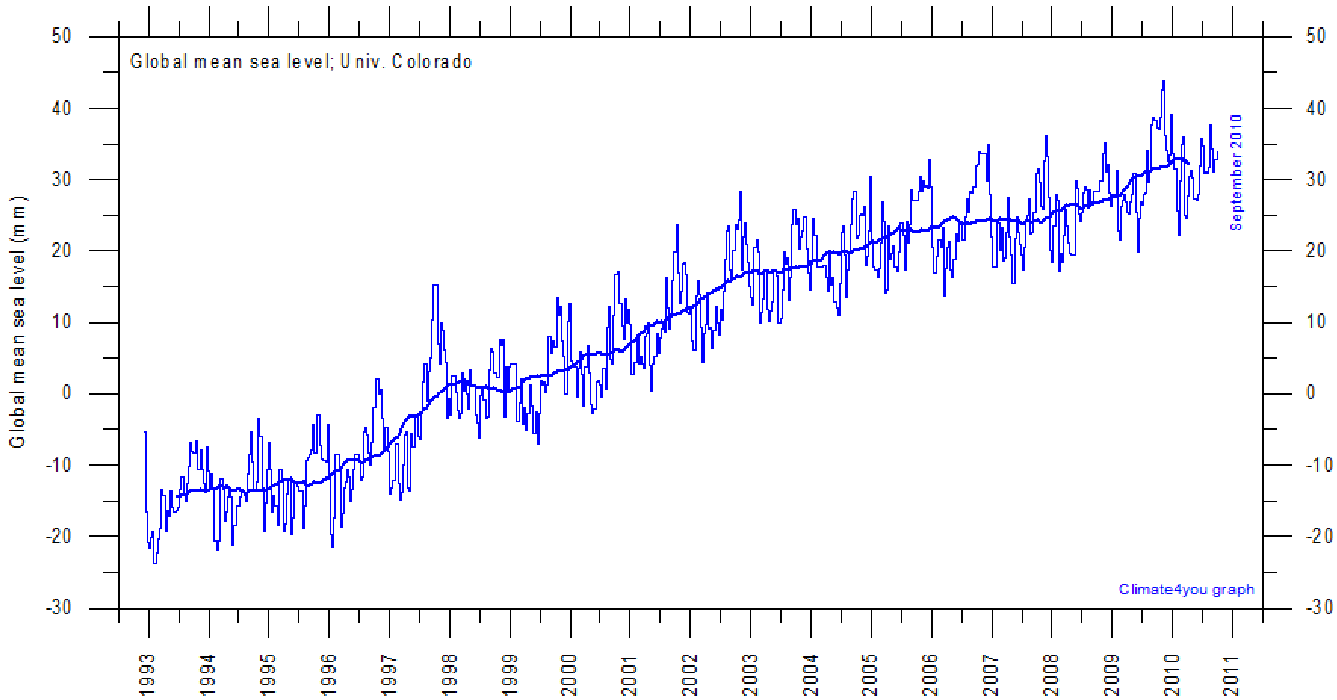


Graph showing daily Arctic sea ice extent since June 2002, to 16/03 2011, by courtesy of [Japan Aerospace Exploration Agency](#) (JAXA).

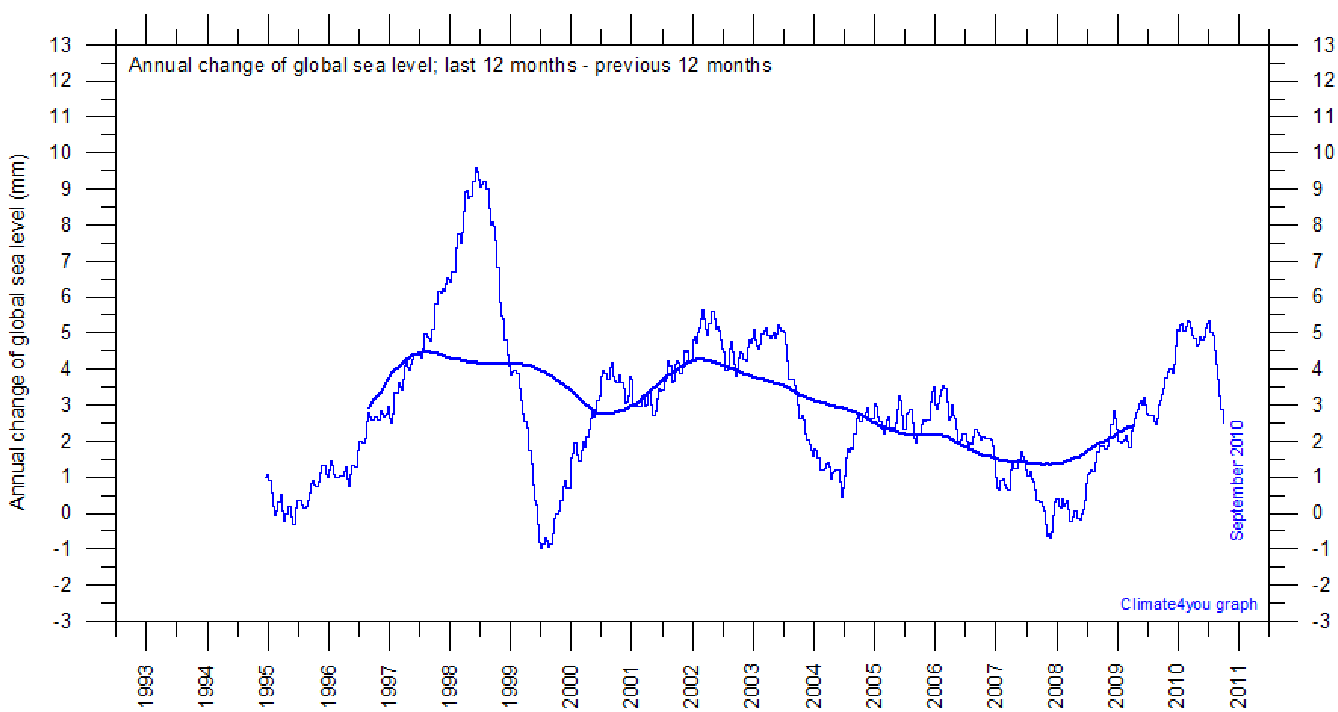


Northern hemisphere sea ice thickness on 17 March 2010 (left) and 2011 (right), according to the Naval Oceanographic Office *(NAVO). Thickness values are calculated by the Polar Ice Prediction System (PIPS 2.0), based on the Special Sensor Microwave Image (SSM/I) to initialize the calculation. Thickness scale (m) is shown to the right.*

Global sea level, updated to September 2010

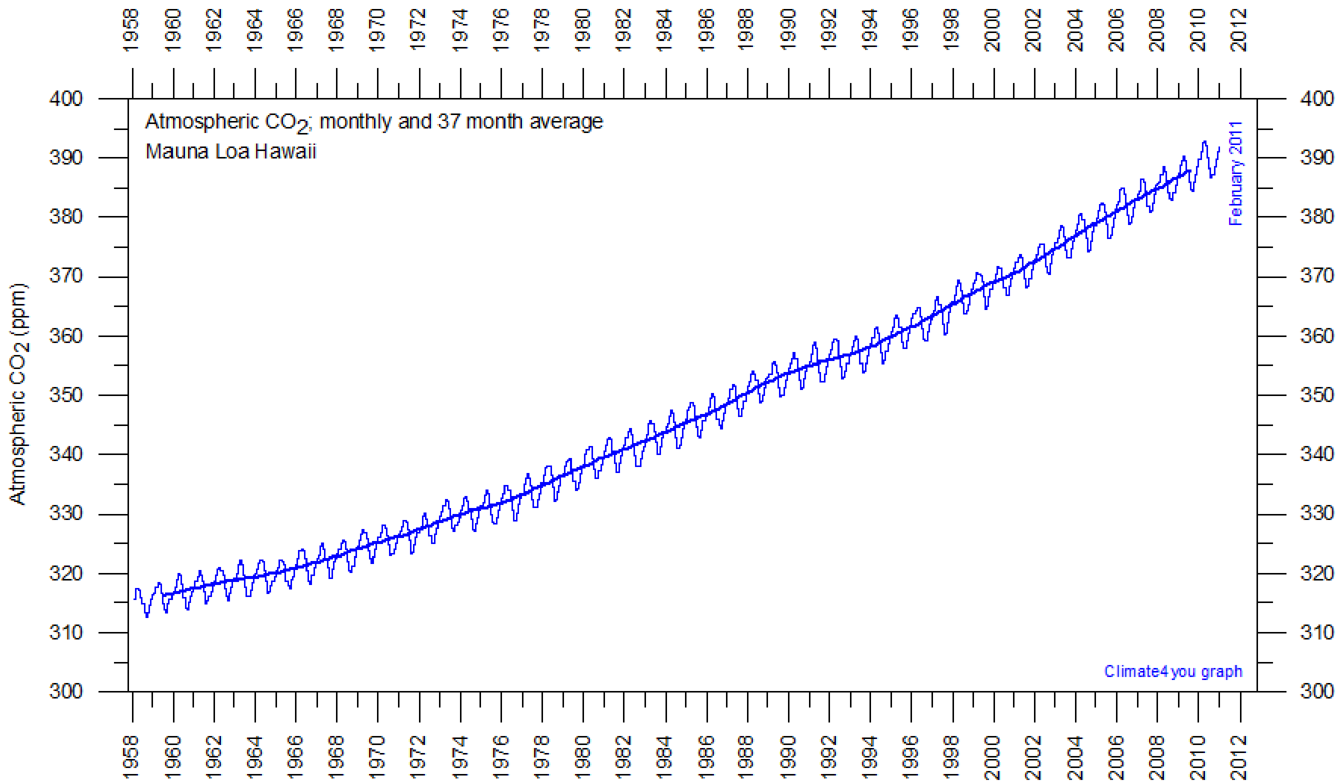


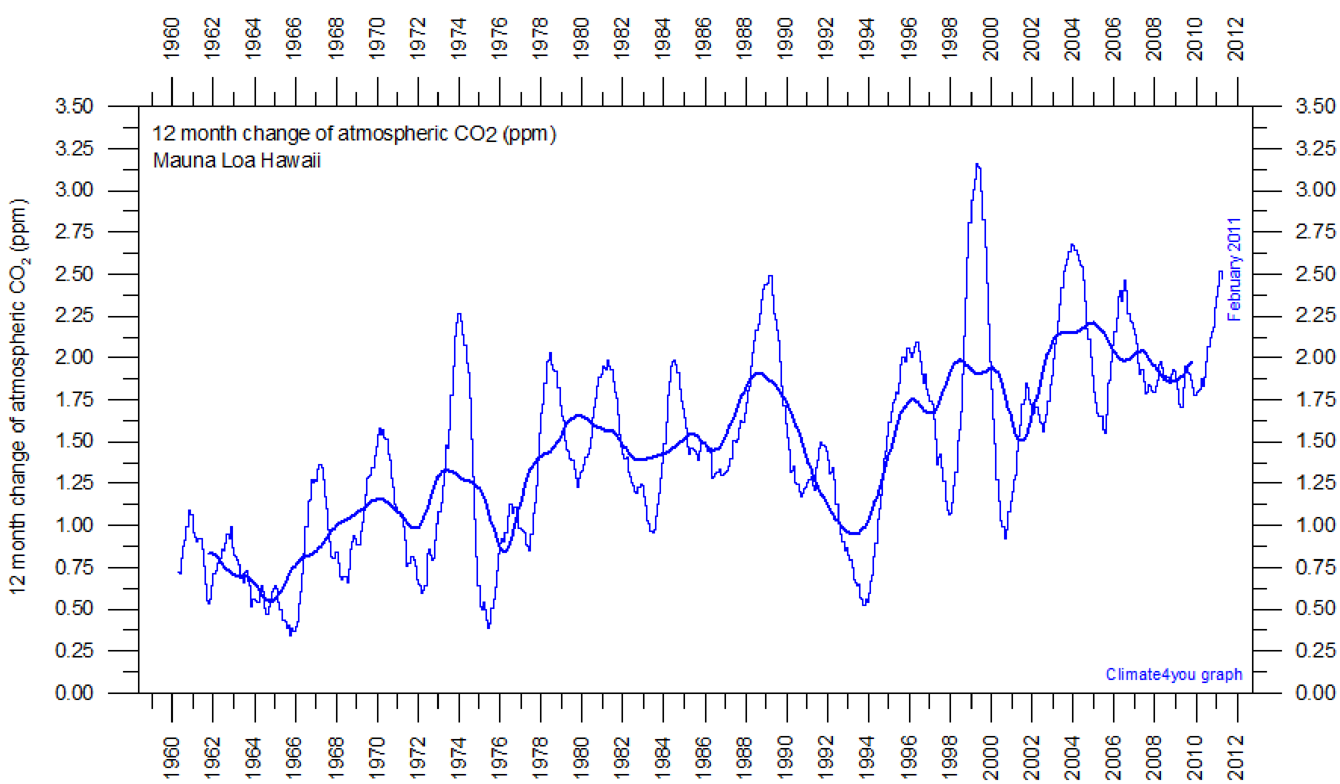
Globa lmonthly sea level since late 1992 according to the Colorado Center for Astrodynamics Research at [University of Colorado at Boulder](), USA. The thick line is the simple running 37 observation average, nearly corresponding to a running 3 yr average.



Annual change of global sea level since late 1992 according to the Colorado Center for Astrodynamics Research at [University of Colorado at Boulder](), USA. The thick line is the simple running 3 yr average.

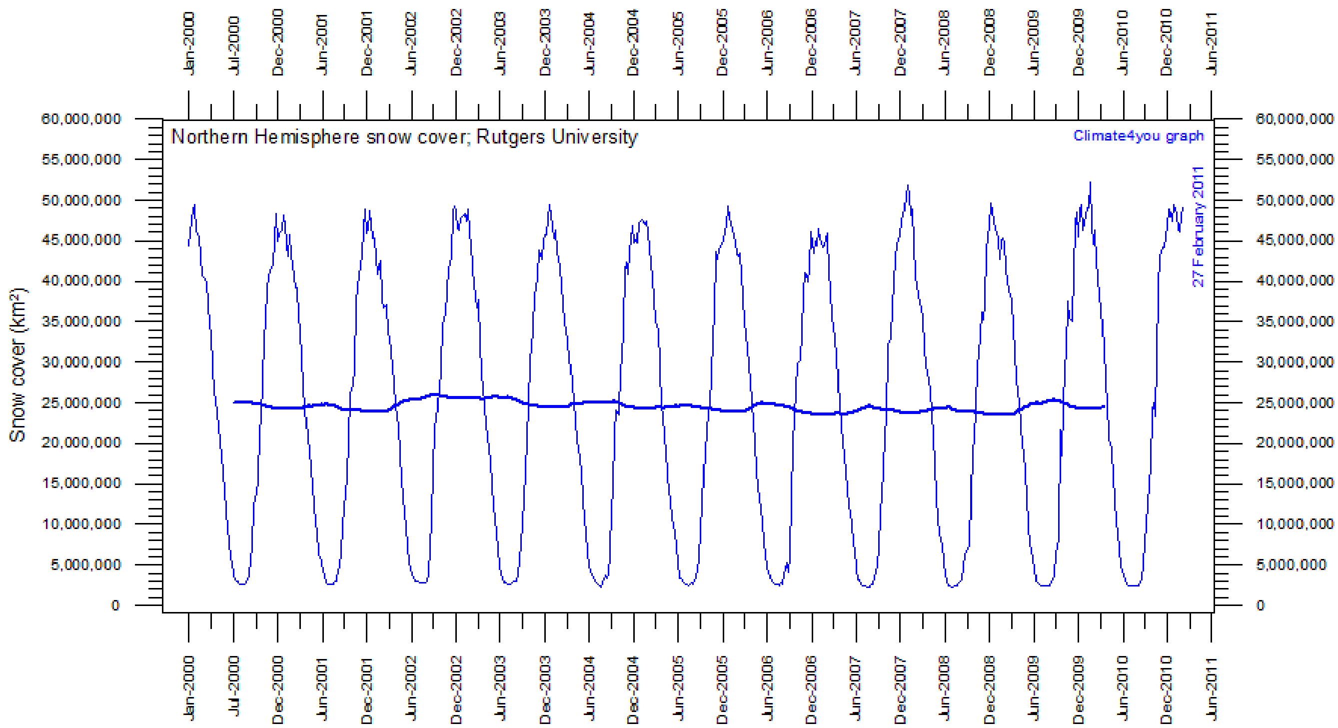
Atmospheric CO_2, updated to February 2011



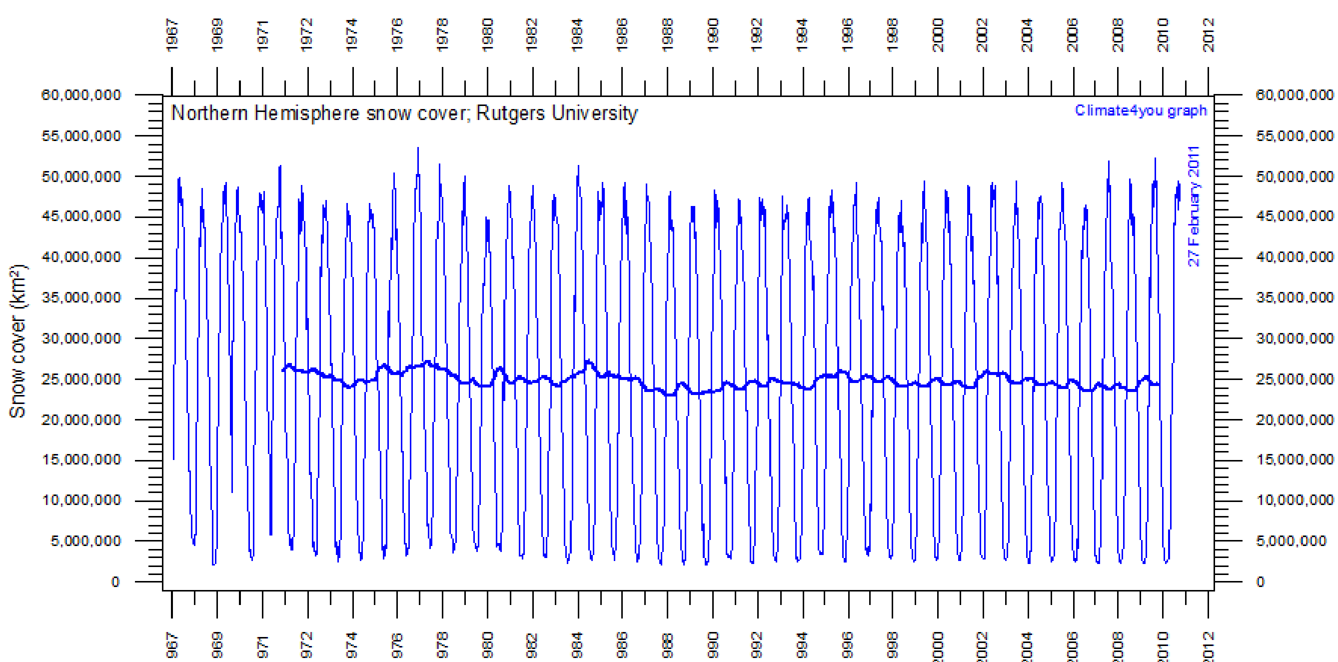


Monthly amount of atmospheric CO_2 (above) and annual growth rate (below; average last 12 months minus average preceding 12 months) of atmospheric CO_2 since 1959, according to data provided by the [Mauna Loa Observatory](), Hawaii, USA. The thick line is the simple running 37 observation average, nearly corresponding to a running 3 yr average.

Northern Hemisphere weekly snow cover, updated to late February 2011

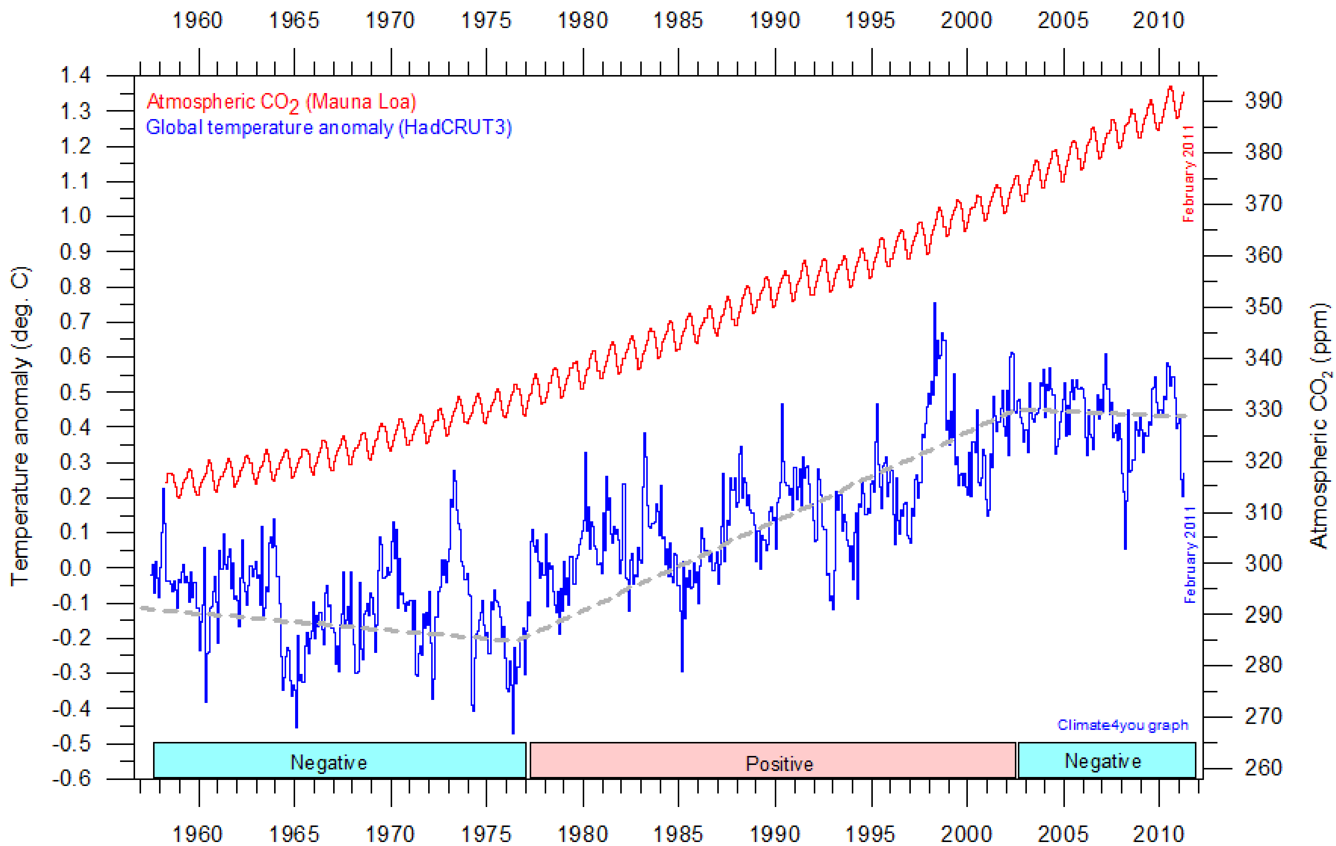


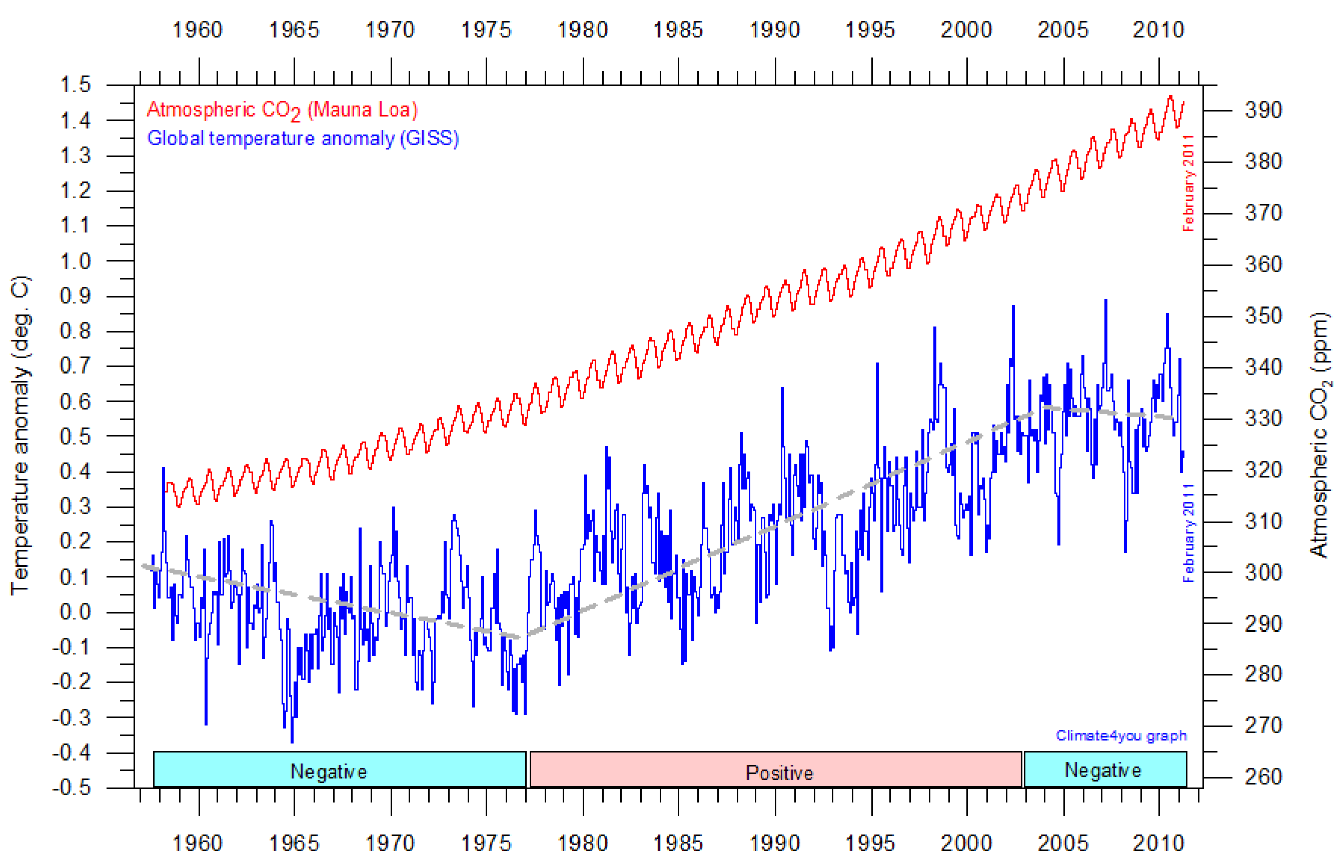
Northern hemisphere weekly snow cover since January 2000 according to Rutgers University Global Snow Laboratory. The thin line is the weekly data, and the thick line is the running 53 week average (approximately 1 year).

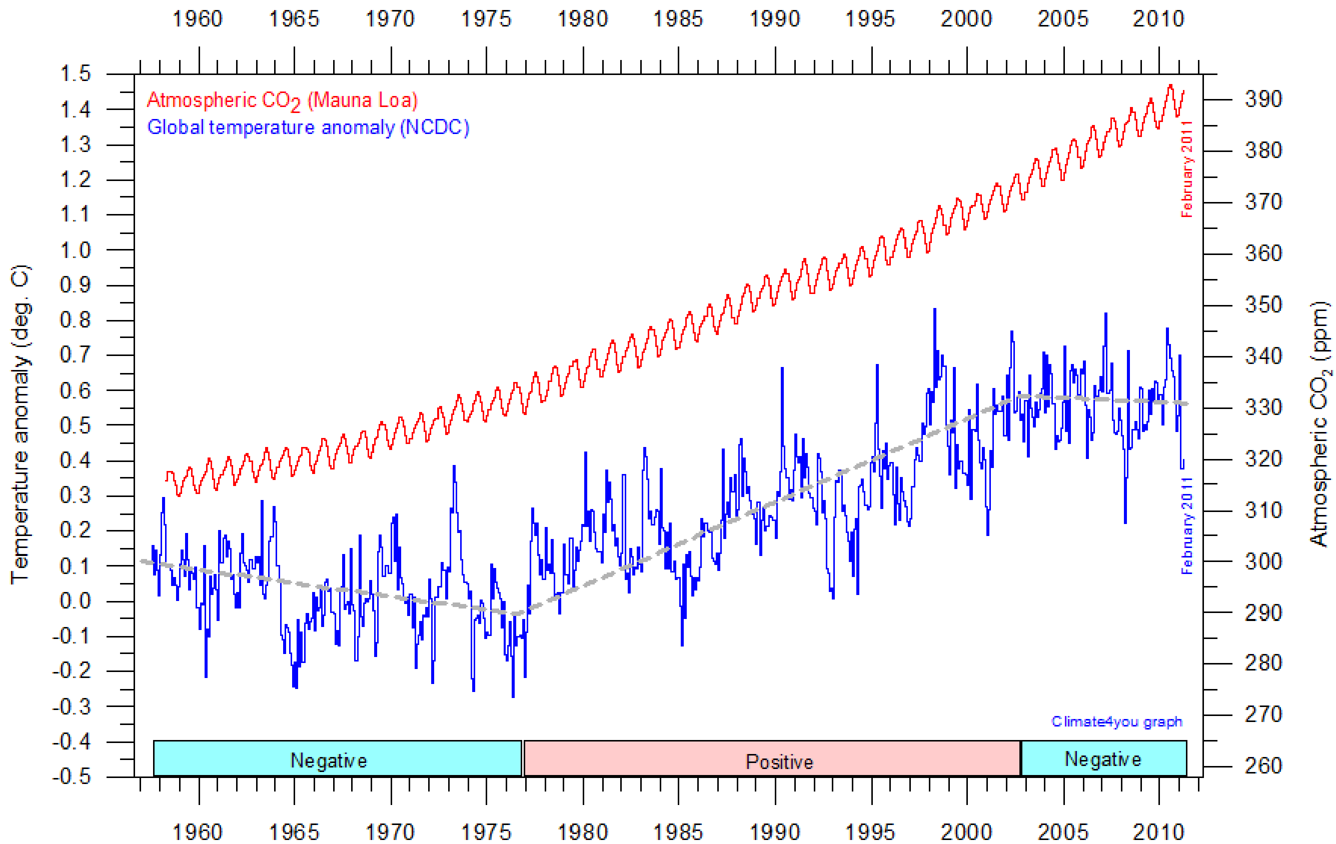


Northern hemisphere weekly snow cover since October 1966 according to Rutgers University Global Snow Laboratory. The thin line is the weekly data, and the thick line is the running 53 week average (approximately 1 year). The running average is not calculated before 1971 because of some data irregularities in this early period.

Global surface air temperature and atmospheric CO_2, updated to February 2011







Diagrams showing HadCRUT3, GISS, and NCDC monthly global surface air temperature estimates (blue) and the monthly atmospheric CO_2 content (red) according to the [Mauna Loa Observatory](), Hawaii. The Mauna Loa data series begins in March 1958, and 1958 has therefore been chosen as starting year for the diagrams. Reconstructions of past atmospheric CO_2 concentrations (before 1958) are not incorporated in this diagram, as such past CO_2 values are derived by other means (ice cores, stomata, or older measurements using different methodology, and therefore are not directly comparable with modern atmospheric measurements. The dotted grey line indicates the approximate linear temperature trend, and the boxes in the lower part of the diagram indicate the relation between atmospheric CO_2 and global surface air temperature, negative or positive.

Most climate models assume the greenhouse gas carbon dioxide CO_2 to influence significantly upon global temperature. Thus, it is relevant to compare the different global temperature records with measurements of atmospheric CO_2, as shown in the diagrams above. Any comparison, however, should not be made on a monthly or annual basis, but for a longer time period, as other effects (oceanographic, clouds, etc.) may well override the potential influence of CO_2 on short time scales such as just a few years.

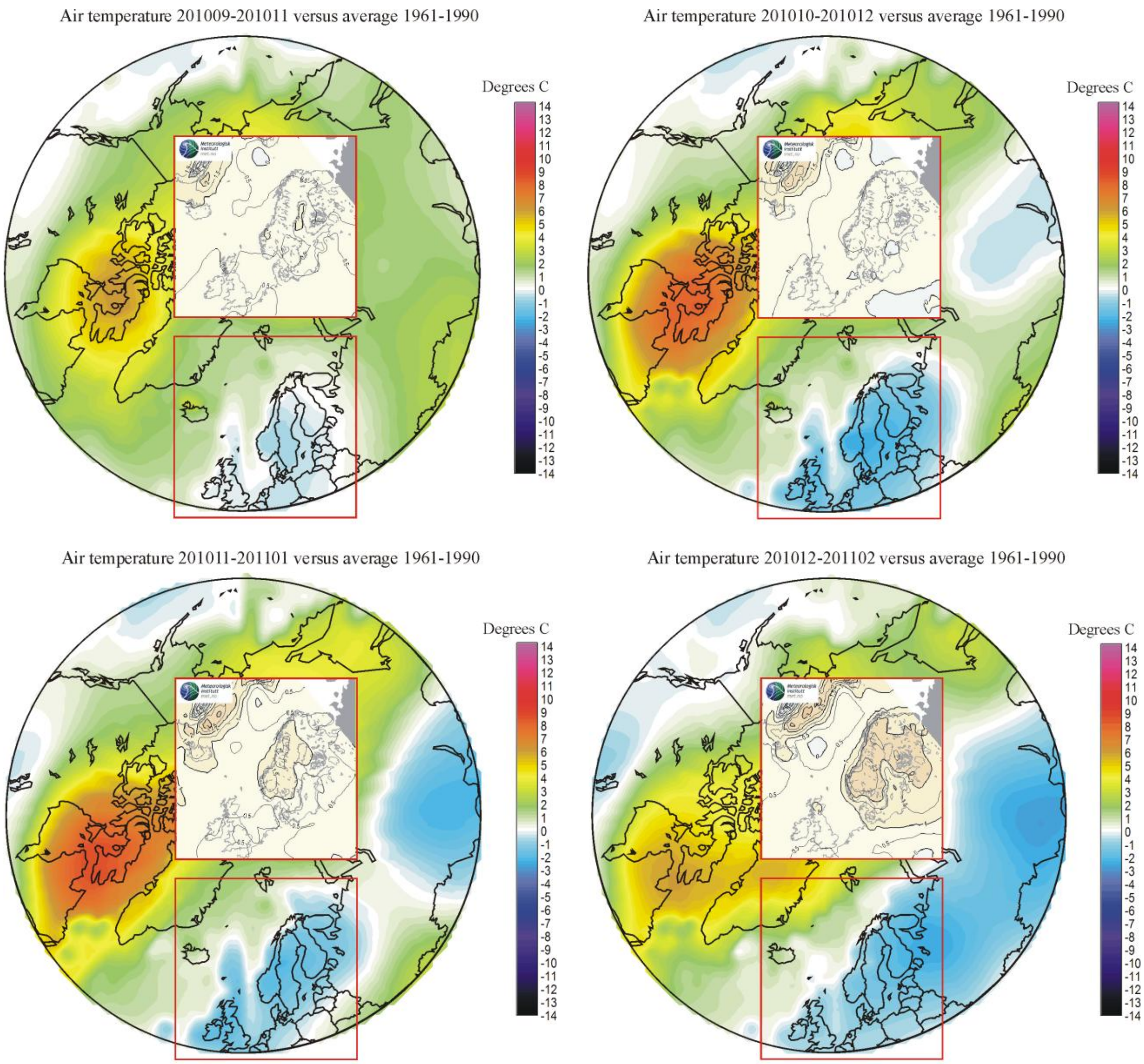
It is of cause equally inappropriate to present new meteorological record values, whether daily, monthly or annual, as support for the hypothesis ascribing high importance of atmospheric CO_2 for global temperatures. Any such short-period meteorological record value may well be the result of other phenomena than atmospheric CO_2.

What exactly defines the critical length of a relevant time period to consider for evaluating the alleged high importance of CO_2 remains elusive, and is still a topic for debate. The critical period length must, however, be inversely proportional to the importance of CO_2 on the global temperature, including feedback effects, such as assumed by most climate models. So if the effect of CO_2 is strong, the length of the critical period is short.

After about 10 years of global temperature increase following global cooling 1940-1978, IPCC was established in 1988. Presumably, several scientists interested in climate then felt intuitively that their empirical and theoretical understanding of climate dynamics was sufficient to conclude about the high importance of CO_2 for global temperature. However, for obtaining public and political support for the CO_2-hyphotesis the 10 year warming period leading up to 1988 in all likelihood was important. Had the global temperature instead been decreasing, public support for the hypothesis would have been difficult to obtain. Adopting this approach as to critical time length, the varying relation (positive or negative) between global temperature and atmospheric CO_2 has been indicated in the lower panels of the three diagrams above.

The winter 2010/11 in northern Europe; forecasts versus the real world

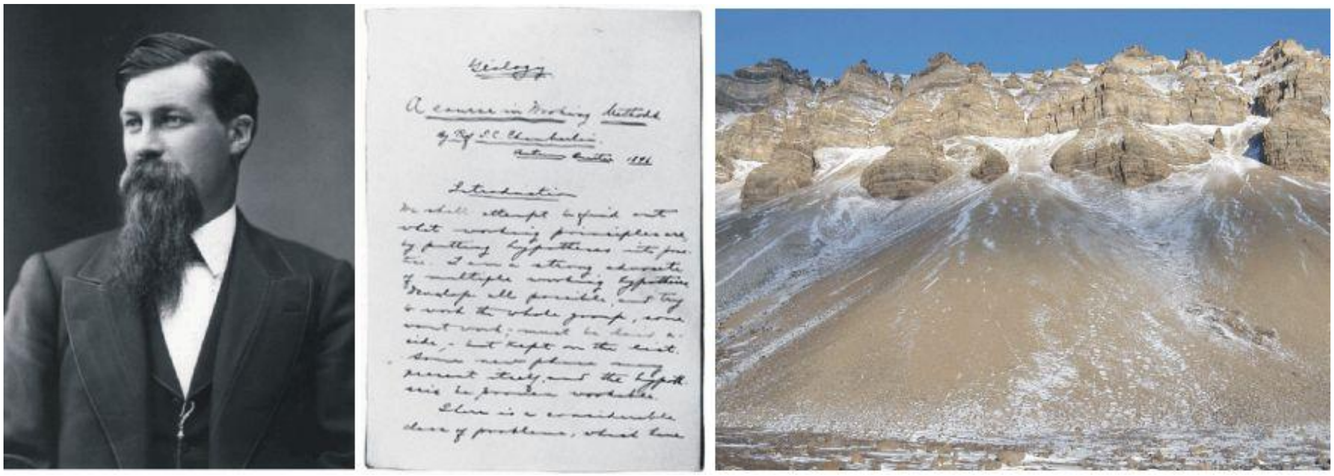
The Northern Hemisphere winter 2010/11 is now slowly drawing to a close in many regions, and it might be interesting to compare the performance of seasonal forecasts with observed data. The diagrams below show how modelled forecasts (small insert map) compare with observed data (GISS) for the overlapping periods September-November 2010, October-December 2010, November-January 2010/11, and December-February 2010/11. The forecasts are based on 40 different model runs, using slightly different initial values. For northern Europe above 1961-1990 average temperatures were forecasted for all periods. In reality the temperature turned out to be well below average for all periods.



The original larger diagrams and supplementary details are available on www.climate4you.com/Forecasting.htm.

Climate and history; one example among many

1897: Chamberlin, geology, oceans and the carbon cycle



Thomas Chamberlin (left). One of Chamberlin's notes from his graduate geology seminar "A Course in Working Methods in Geology" at the University of Chicago (centre). Huge slopes (talus slopes) consisting of angular rock fragments derived from weathering line the foot of the mountain Templet (515 m asl.) on eastern Spitsbergen, Svalbard (right).

Thomas Chrowder Chamberlin (1843-1928) was born in a pioneer settlement near Mattoon, Illinois, USA. His father was a farmer and Methodist minister, and Thomas received a strongly religious upbringing. With time, however, Chamberlin would acquire equally strong geological interests, and eventually developed into one of the most outstanding American geologists ever. Chamberlin also made his mark in history by being the first of many geologists seeing the atmosphere as a fundamental geological agent.

In 1862, Chamberlin entered Beloit College. It was here he received his introduction to geology and scientific research from professor Henry Bradford Nason, an authority on chemical methods in geology (Fleming 1998). Because of Chamberlin's religious upbringing, he initially defended the geological doctrine of catastrophic deluges - the so-called Neptunist or diluvial theory. This hypothesis held that the record of geological rocks could be read in conformity with the biblical stories of creation and universal deluge. After studying the subject intensely and working with professor Nason, Chamberlin rejected this position as unscientific, and he decided to pursue a career as educator and geologist (Fleming 1998).

In 1869 Chamberlin obtained his first teaching position at the State Normal School at Whitewater, Wisconsin. In 1873 he joined the Wisconsin Geological Survey as assistant geologist, and serving as chief geologist from 1882. In 1881, Chamberlin also was appointed chief geologist of the Pleistocene division of the United States Geological Survey, a position he held for the next 23 years. By this, Chamberlin became an authority on glaciers, and was among the first geologists to identify a series of multiple glaciations in North America, in contrast to the previous belief in only one single glaciation. In 1887, Chamberlin became president of the University of Wisconsin, until he in 1892 moved to the new

University of Chicago, where he was offered a position as professor of geology and chair of the geology department (Fleming 1998).

Each year at the University of Chicago, Chamberlin taught a graduate seminar in forefront geology research problems, entitled "*A Course in Working Methods in Geology*". One of the primary themes of the course was the geological significance of the atmosphere and its relationship to the great unsolved problems of the earth sciences, among them climatic variations leading to the recurrent glaciations, periods with extensive desert environments, as evidenced by salt and gypsum, periods with large accumulation of organic matter (coal deposits), and periods with decreases or increases in the number of species (Fleming 1998).

Inspired by the work of Tyndall and Arrhenius, Chamberlin in 1896 had the geological effect of atmospheric CO_2 as overall course theme, and based on this, he in 1897 published a CO_2 hypothesis of glaciation, entitled "*A Group of Hypotheses Bearing on Climate Changes*". Chamberlin proposed that variations of atmospheric CO_2 combined with water vapour feedbacks could account for the advance and retreat of the past ice sheets. In this publication, although strongly inspired by the work of Arrhenius, he was critical of the idea proposed by Arrhenius and Högbom, that volcanism controlled the amount of atmospheric CO_2. Instead, Chamberlin suggested that it was weathering of exposed bedrock which represented a main control on atmospheric CO_2. In addition, he was the first to introduce the question of how much carbon was contained in various reservoirs, including the oceans, atmosphere, solid earth, and biosphere (Fleming 1998).

Chamberlin taught that over geologic time, the Earth had sequestered fantastic amounts of CO2 in various geological deposits. He estimated that the sedimentary rocks contained 16,000 times the amount of atmospheric CO_2, coal beds 4,000, and oceans 18-22,000 times the amount of atmospheric CO_2. In 1896 geologists knew that weathering of rocks dominantly consumes huge amounts of atmospheric CO_2 and converts it to aqueous bicarbonates (e.g., $Ca(HCO_3)_2$), whereas the precipitation of calcium carbonates liberates CO_2. From the work of William Henry it was also known that the amount of CO_2 dissolved in the oceans would be inversely proportional to water temperature and salinity.

The North Sea east of Scotland on 29 September 2007. Oceans were pointed out as a large carbon reservoir by Thomas Chamberlin.

Based on this, Chamberlin formulated his carbon cycle dominated by geological processes. He saw chemical weathering of exposed rock as being a major factor for reducing the amount of CO_2 in the atmosphere. Following periods with uplift of large land areas, or mountain building, the overall rate of weathering would be greater, and the atmospheric amount of CO_2 smaller, than at times when low relief topography were dominating (Fleming 1998). The result of mountain building would then be global cooling, increased uptake of CO_2 by the oceans, and possibly a glaciation. In case of glaciation, the extensive ice cover on land would hinder weathering and allow CO_2 to increase in the atmosphere. Global warming would then be initiated with additional CO_2 being released from the oceans, and additional warming assisted by water vapour feedbacks. After the glaciers had disappeared, large areas of eroded bedrock would be exposed for weathering (see photo above), whereby a new period of diminishing atmospheric CO_2 and global cooling might be initiated. By proposing this hypothesis and also outline a global carbon cycle, Chamberlin was the first to argue in detail how geological processes might represent a dominant control on global climatic variations.

Chamberlin was convinced that variations in atmospheric CO_2 and water vapour were significant for the global climate. Initially, he considered positive feedback mechanisms associated atmospheric water vapour to dominate. Later (1923), Chamberlin speculated on negative climate feedbacks, which he called "*the adverse effect of* H_2O" (Fleming 1998).

In 1913, almost two decades after Chamberlin's initial work on the subject, however, the CO_2 climate hypothesis had fallen out of favour. In a long letter to Charles Schuchert of Yale's Peabody Museum he wrote: "*I have no doubt that you may be correct in thinking that the number who accepts the* CO_2 *theory is less now than a few years ago... I greatly regret that I was among the early victims of Arrhenius error*." The problem was that in 1900 Knut Ångström concluded that atmospheric CO_2 and water vapour absorb infrared radiation in the same spectral regions, and that any additional CO_2, it was argued, therefore would have little or no effect on the global temperature. In another letter written to Ellsworth Huntington in 1922, Chamberlin again expressed his deep regrets that he had overeagerly accepted Arrhenius's numerical results and that his "personal demon" had not kept Arrhenius's essay out of his way until after his 1897 paper had gone to press (Fleming 1998).

In 1922, towards the end of his commendable scientific career, Chamberlin thought that the role of CO_2 in the atmosphere had been overemphasized and that not enough attention had been given to the role of the ocean, which he considered "*my distinct contribution to the subject*" (Fleming 1998).

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Bringing the modern climate debate into a longer time perspective

Several of the temperature diagrams displayed above in this newsletter begin in the year 1979, where the fine satellite record begins. This is chosen as a general start date to make comparison between different data sources (satellite, surface, etc.) easy. On the other hand, this approach may conceal the fact that Earth's climate record is much longer. It is the purpose of the present short paragraph to introduce modern climate change to this longer time perspective.

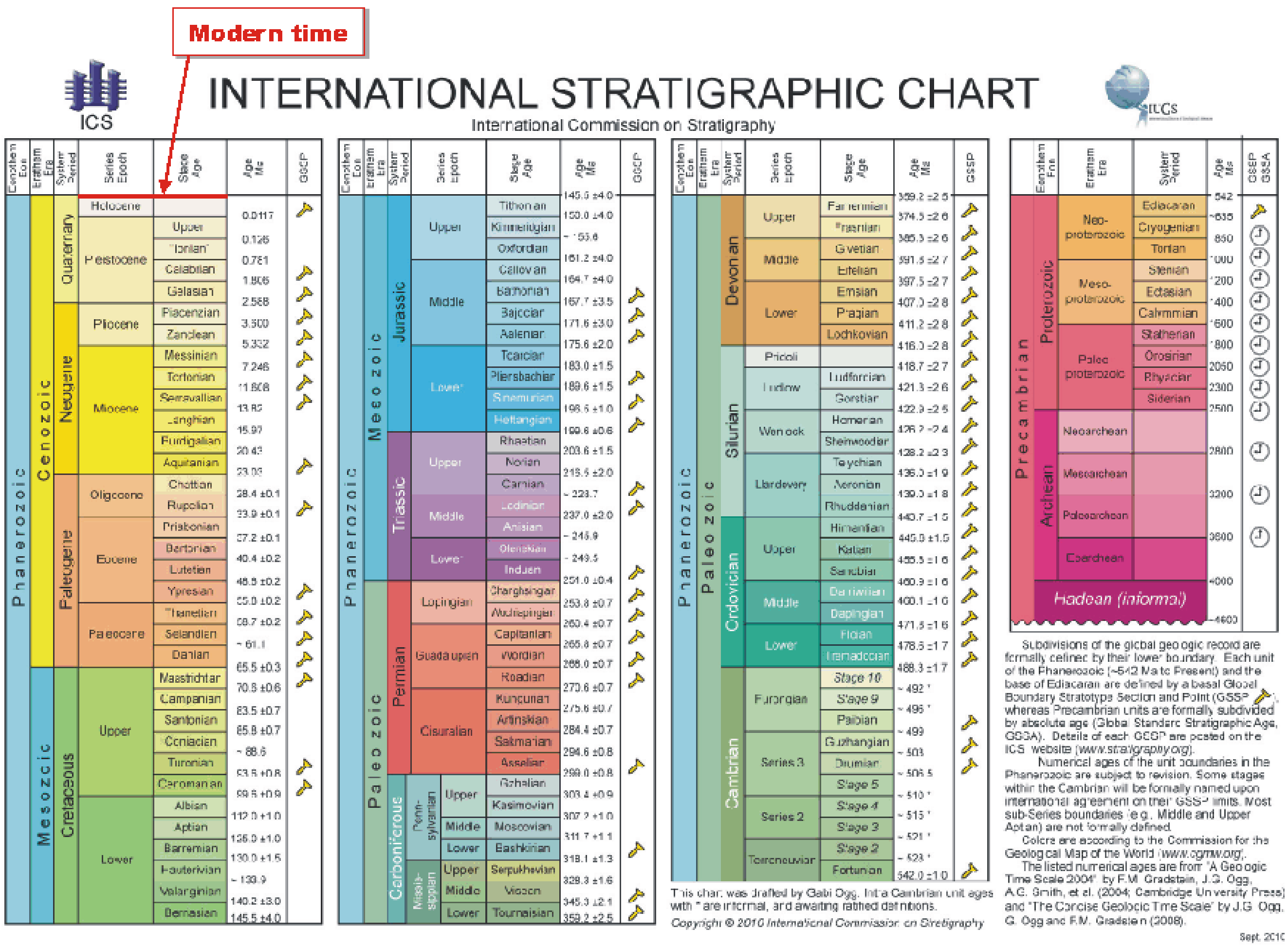

Fig.1. Geological stratigraphic chart for the entire geological history of planet Earth. Modern time is indicated by the thin red line at the top of the left column. Please note that the time scale is highly compressed, and increasing so towards higher ages. The left hand column fits on top of the next column to the right, column no 2 on top of no 3, and the right hand column should be at the bottom.

Planet Earth has an age of about 4600 million years. The diagram shown as figure 1 (*Subcommission for Stratigraphic Information*) shows a geological stratigraphic chart for the entire geological history, subdivided into a vast number of epochs, each consisting of a number of stages. Most (if not all) of these geological divisions are based on the recognition of environmental changes affecting the entire planet; that is, past global climate changes. In other words, global climate change has been the rule for the entire history of Earth, not the exception.

If each year in the time scale shown in figure 1 was represented by one millimetre, the entire stratigraphic chart would be about 4600 km (2858 miles) long. In Europe, this corresponds roughly to the distance between Madrid (Spain) to Sverdlovsk in the Ural Mountains (Russia). In North America 4600 km roughly corresponds to the distance between San Francisco (USA) and Quebec (Canada). On this scale modern humans would appear within the last 200 m, the Polar Bear within the last 150 m, and the entire global meteorological record since about 1850 would take up the last 16 cm. The period with satellite observations would fit into the final 3 cm.

From time to time the planet has been affected by millions of years with relatively cold climate, each such period leading to a long succession of glacial and interglacial periods. During the last couple of millions of years, planet Earth has been in such a cold stage. The last (until now) ice age ended around 11,600 years ago, and we are for the time living in a so-called interglacial period, until the next ice age will begin some time into the future.

The last four glacial periods and interglacial periods are shown in the diagram figure 2, covering the last 420,000 years in Earth's climatic history. This diagram shows a reconstruction of global temperature based on ice core analysis from the Antarctica. The present interglacial period (the Holocene) is seen to the right (red square). The preceding four interglacials are seen at about 125,000, 280,000, 325,000 and 415,000 years before now, with much longer glacial periods in between. All four previous interglacials are seen to be warmer (1-3^{o}C) than the present. The typical length of a glacial period is about 100,000 years, while an interglacial period typical lasts for about 10-15,000 years. The present interglacial period has now lasted about 11,600 years.

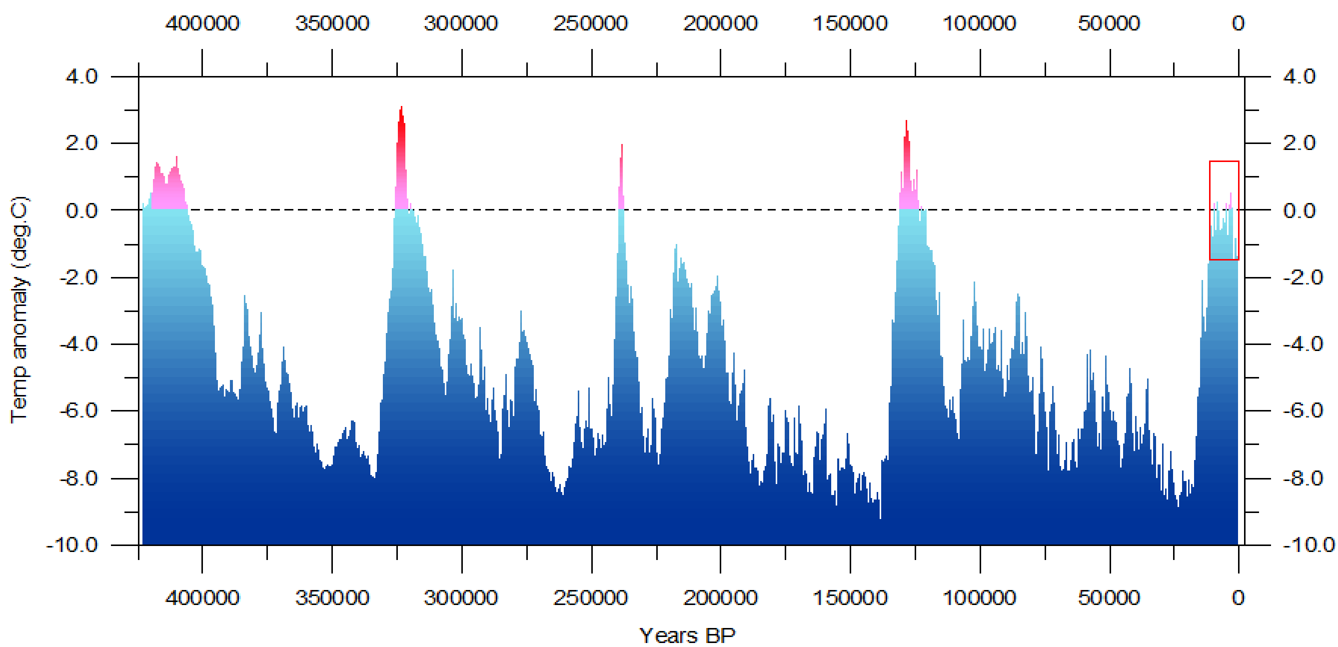

Fig.2. Reconstructed global temperature over the past 420,000 years based on the Vostok ice core from the Antarctica (Petit et al. 2001). The record spans over four glacial periods and five interglacials, including the present. The horizontal line indicates the modern temperature. The red square to the right indicates the time interval shown in greater detail in the following figure.

According to ice core analysis, the atmospheric CO_2 concentrations during all four prior interglacials never rose above approximately 290 ppm; whereas the atmospheric CO_2 concentration today stands at nearly 390 ppm. The present interglacial is about 2°C colder than the previous interglacial, even though the atmospheric CO_2 concentration now is about 100 ppm higher.

The last 11,000 years (red square in diagram above) of this climatic development is shown in greater detail in the diagram below (Fig.3), representing the main part of the present interglacial period.

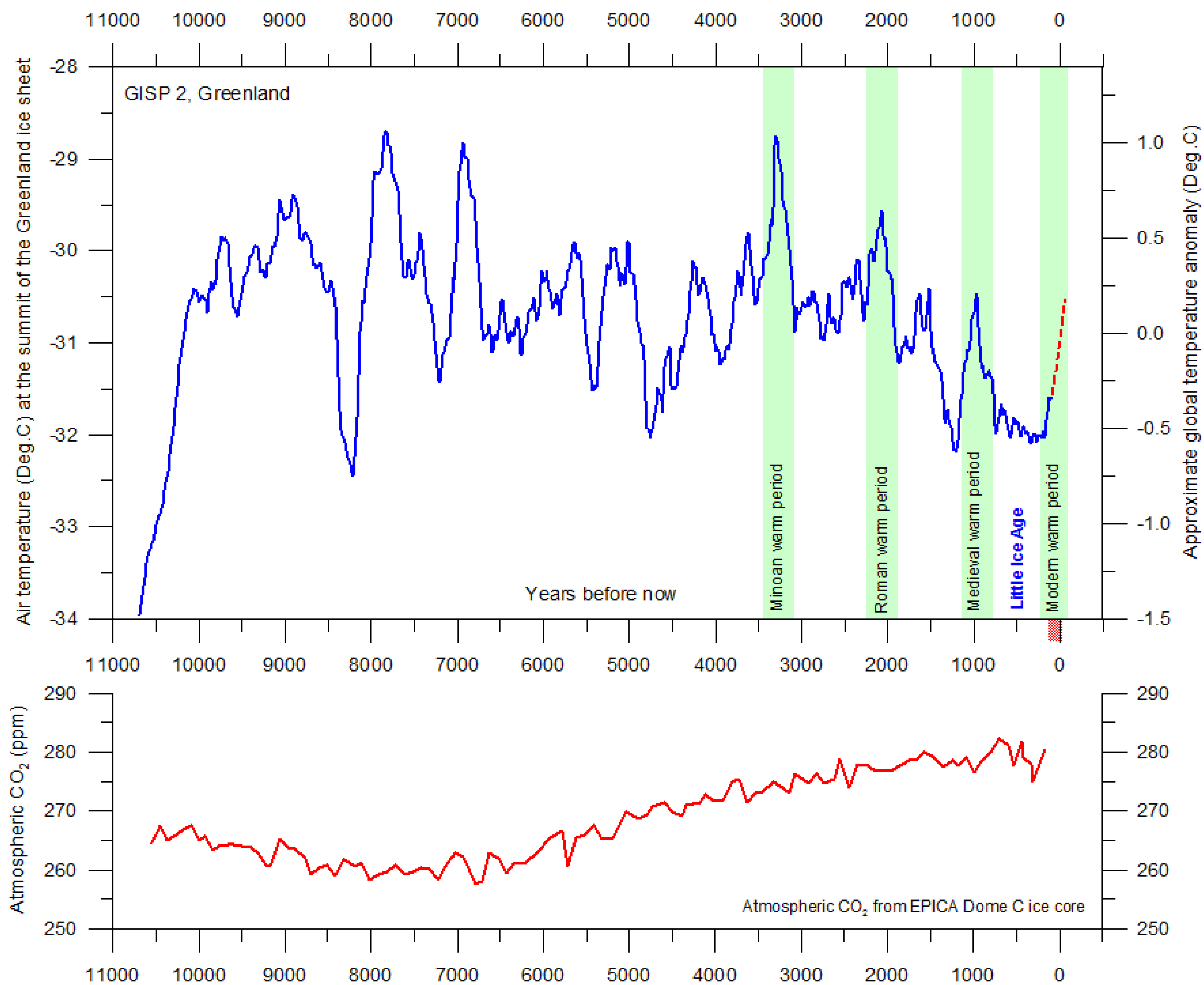

Fig.3. The upper panel shows the air temperature at the summit of the Greenland Ice Sheet, reconstructed by Alley (2000) from GISP2 ice core data. The time scale shows years before modern time, which is shown at the right hand side of the diagram. The rapid temperature rise to the left indicate the final part of the even more pronounced temperature increase following the last ice age. The temperature scale at the right hand side of the upper panel suggests a very approximate comparison with the global average temperature (see comment below). The GISP2 record ends around 1855, and the red dotted line indicate the approximate temperature increase since then. The small reddish bar in the lower right indicate the extension of the longest global temperature record (since 1850), based on meteorological observations (HadCRUT3). The lower panel shows the past atmospheric CO_2 content, as found from the EPICA Dome C Ice Core in the Antarctic (Monnin et al. 2004). The Dome C atmospheric CO_2 record ends in the year 1777.

The diagram above (Fig.3) shows the major part of the present interglacial period, the Holocene, as seen from the summit of the Greenland Ice cap. The approximate positions of some warm historical periods are shown by the green bars, with intervening cold periods.

Clearly Central Greenland temperature changes are not identical to global temperature changes. However, they do tend to reflect global temperature changes with a decadal-scale delay (Brox et al. 2009), with the notable exception of the Antarctic region, which is more or less in opposite phase (Chylek et al. 2010) for variations shorter than ice-age cycles (Alley 2003). This is the background for the approximate global temperature scale at the right hand side of the upper panel.

During especially the last 4000 years the Greenland record is dominated by a trend towards gradually lower temperatures, presumably indicating the early stages of the coming ice age (Fig.3). In addition to this overall temperature decline, the development has also been characterised by a number of temperature peaks, with about 950-1000 year intervals. It may even be speculated if the present warm period fits into this overall scheme of natural variations?

The past temperature changes show little (if any) relation to the past atmospheric CO_2 content as shown in the lower panel of figure 3. Initially, until around 7000 yr before now, temperatures generally increase, even though the amount of atmospheric CO_2 decreases. For the last 7000 years the temperature generally has been decreasing, even though the CO_2 record now display an increasing trend. Neither is any of the marked 950-1000 year periodic temperature peaks associated with a corresponding CO_2 increase. The general concentration of CO_2 is low, wherefore the theoretical temperature response to changes in CO_2 should be more pronounced than at higher concentrations, as the CO_2 forcing on temperature is decreasing logarithmic with concentration. Nevertheless, no net effect of CO_2 on temperature can be identified from the above diagram, and it is therefore obvious that significant climatic changes can occur without being controlled by atmospheric CO_2. Other phenomena than atmospheric CO_2 must have had the main control on global temperature for the last 11,000 years.

Figure 4 shows the period since 1850 (indicated by the reddish bar in the diagram above), where it is possible to estimate global temperature changes from meteorological observations.

From figure 3 it is obvious that the global meteorological record (Fig.4) begins in the final part of the Little Ice Age, and thereby documents the following temperature increase, especially clear since about 1915. In other words, the temperature increase documented by meteorological records represents the temperature recovery following the cold Little Ice Age.

The ongoing climate debate is essentially about this recent temperature increase being mainly a natural temperature recovery following the Little Ice Age, or caused by atmospheric CO_2, especially for the time after 1975? It can, however, from figures 2, 3 and 4 be concluded that the temperature increase 1975-2000 is not unique when compared with past records, and that the net temperature effect of atmospheric CO_2 has been small or even absent (Fig.3).

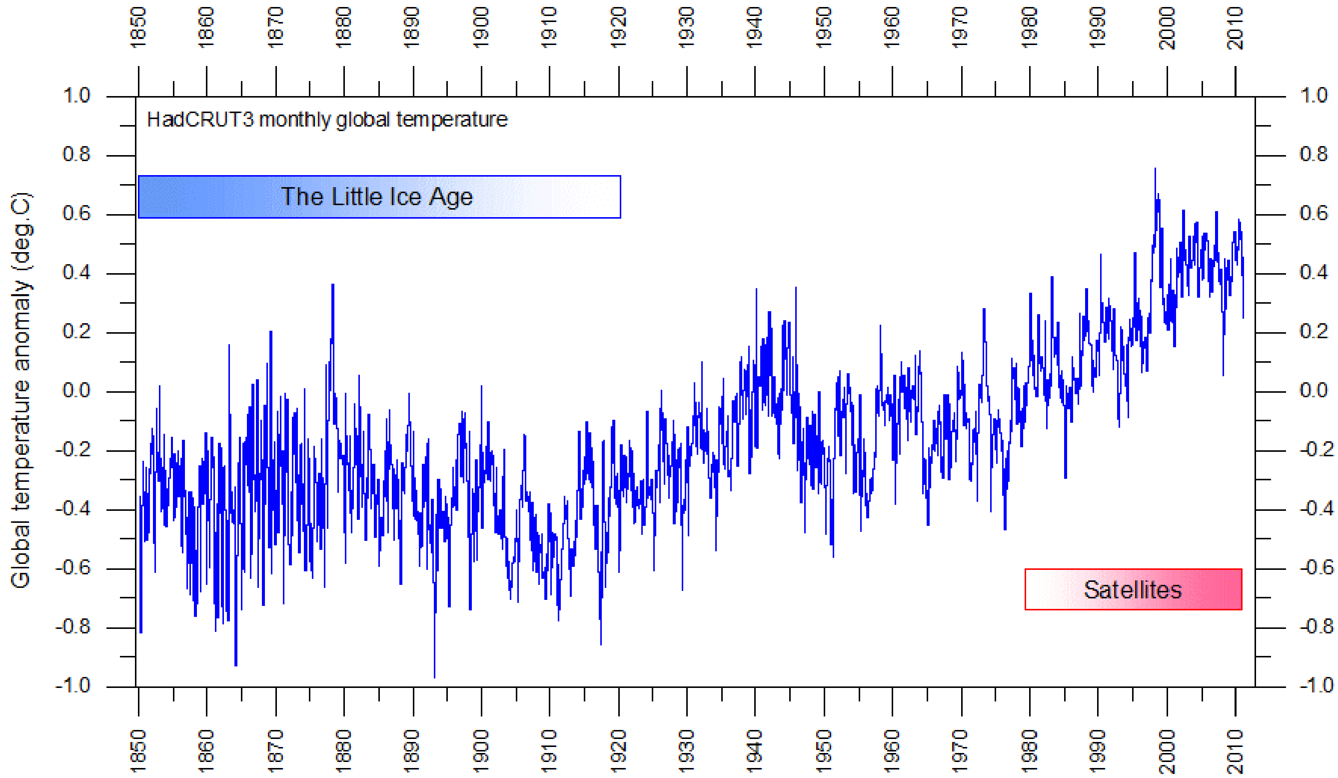

Fig.4. Global monthly average surface air temperature since 1979 according to Hadley CRUT, a cooperative effort between the Hadley Centre for Climate Prediction and Research and the University of East Anglia's Climatic Research Unit (CRU), UK. The blue line represents the monthly values. An introduction to the dataset has been published by Brohan et al. (2005). Base period: 1961-1990. Last month shown: December 2010.

From all diagrams shown above the still very short time period covered by the fine satellite observations is obvious. The period since 1979 only covers the most recent example of global warming (ca.1977-2001), but no examples of the many previous periods of warming or cooling.

This should prudently be borne in mind when interpreting the temperature record since 1979 only, such as shown in several of the diagrams found in this newsletter. As mentioned above the time since 1979 would only take up the final 3 cm of the entire 4600 km long geological climatic record, if each year is represented by one millimetre.

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All the above diagrams with supplementary information, including links to data sources and previous issues of this newsletter, are available on www.climate4you.com

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20 March 2011.