Climate4you update October 2014

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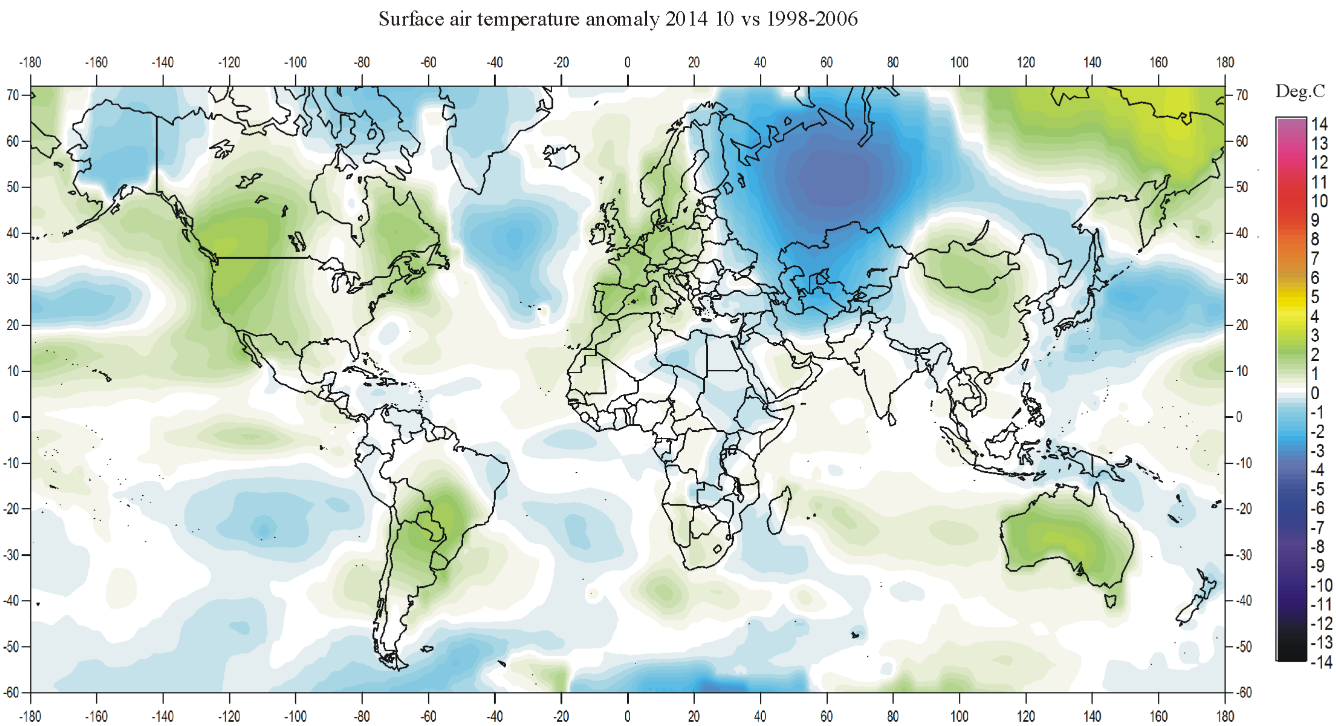
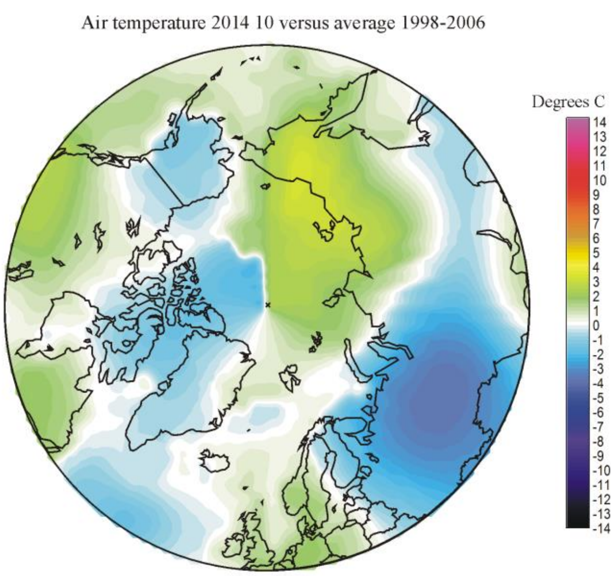
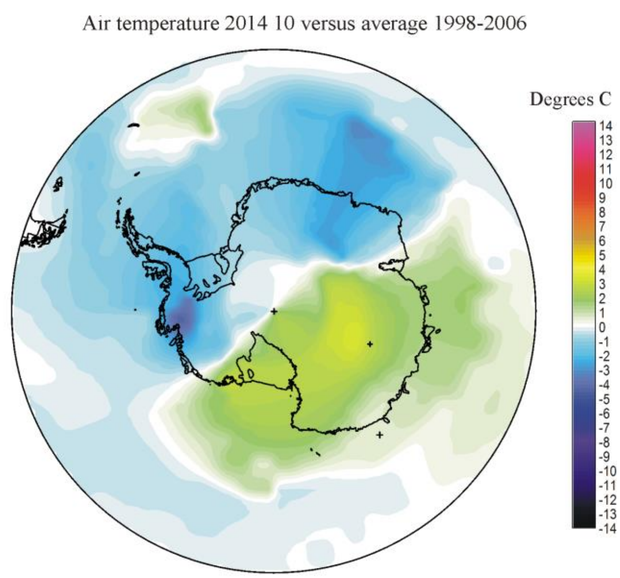
All diagrams in this newsletter as well as links to the original data are available on www.climate4you.com

[October 2014 global surface air temperature overview]







October 2014 surface air temperature compared to the 1998-2006 average. 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 October 2014 global surface air temperature overview

General: This newsletter contains graphs showing a selection of key meteorological variables for the past month. *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 cold period 1945-1980. Most comparisons with such a low average value will therefore appear as 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 the above consideration, the recent temperature development suggests that the time window 1998-2006 may roughly represent a global temperature peak (see, e.g., p. 4-6). However, it might be argued that the time interval 1999-2006 or 2000-2006 would better represent a possible temperature peak period. However, by starting in 1999 (or 2000) the cold La Niña period 1999-2000 would result in a unrealistic low reference temperature by excluding the previous warm El Niño in 1998. These two opposite phenomena must be considered together to obtain a representative reference average, and this why the year 1998 is included in the adopted reference period.

Finally, the GISS temperature data used for preparing the above diagrams show a pronounced temporal instability for data before 1998 (see p. 7). Any comparison with the WMO 'normal' period 1961-1990 is therefore influenced by monthly changing values for the so-called 'normal' period, which is therefore not suited as reference.

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, nearly corresponding to a three-year average. 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 many diagrams, as this roughly corresponds to both the beginning of satellite observations and the onset of the late 20th century warming period. However, several of the records have a much longer record length, which may be inspected in greater detail on www.Climate4you.com.

October 2014 global surface air temperatures

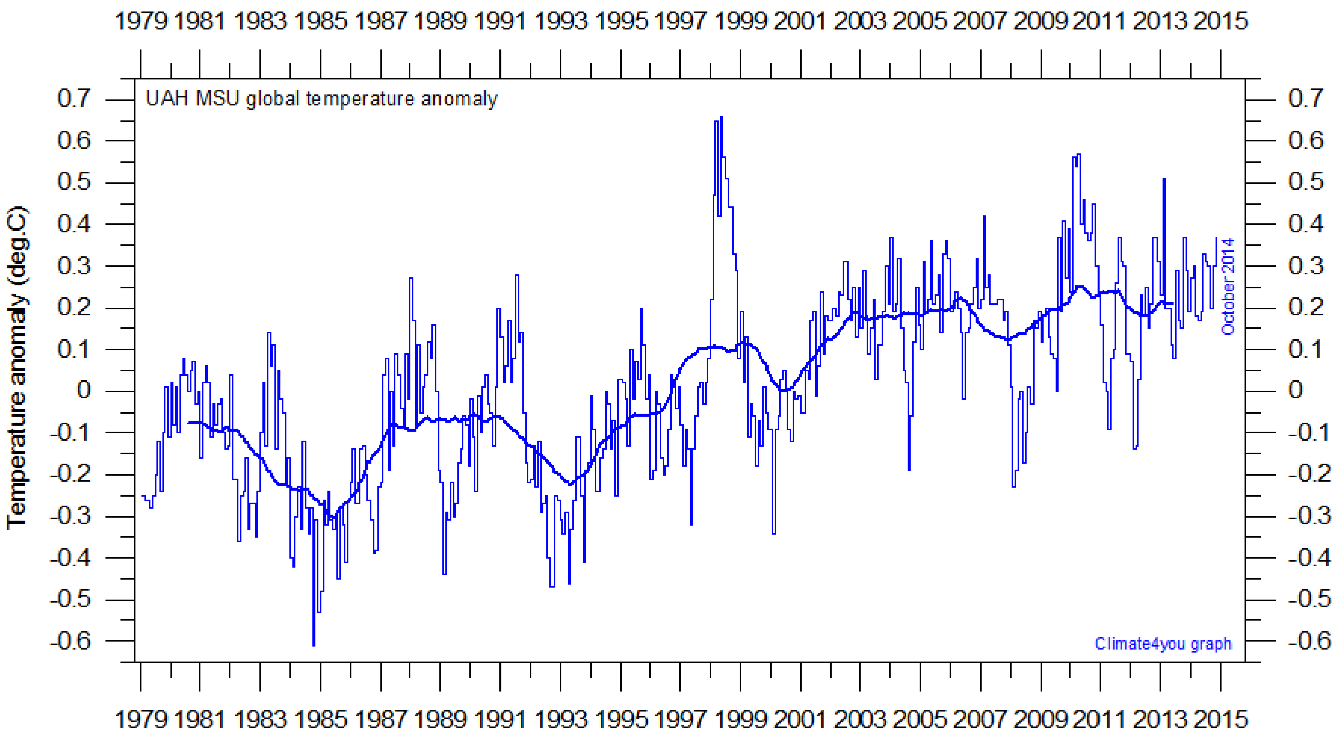
General: In general, the global air temperature was a little above the 1998-2006 average, mainly due to relatively high temperatures over parts of the Pacific Ocean and NE Siberia.

The Northern Hemisphere was characterised by marked regional air temperature contrasts. Russia, Alaska, NE Canada and Greenland had relatively low temperatures. Most of North America, Europe and NE Siberia had above average temperatures. The Arctic was relatively cold in the Greenland-North America and Russia sector, while especially the Siberian sector was relatively warm.

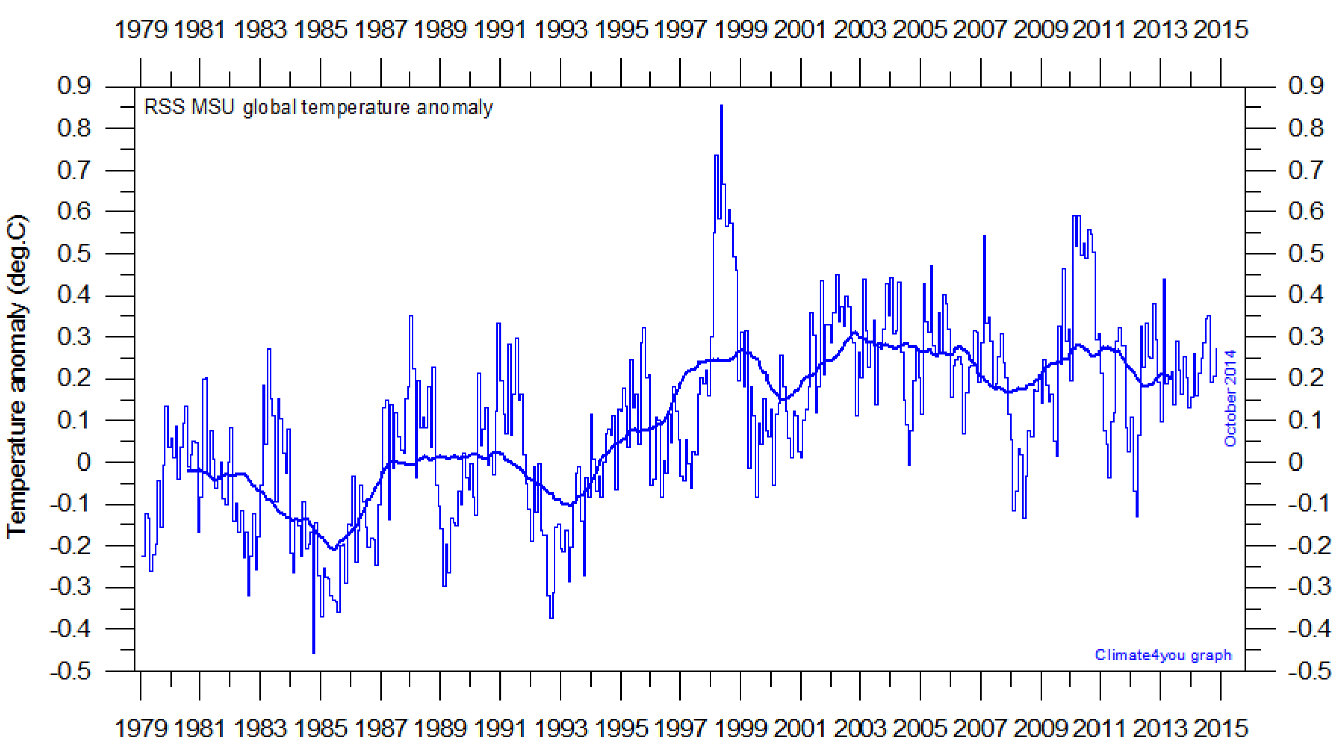
Near the Equator temperatures conditions were generally above the 1998-2006 average in the Pacific sector, but a little below average in the smaller Atlantic-Africa sector.

The Southern Hemisphere temperatures were mainly near or a little below average 1998-2006 conditions. Australia and central South America, however, had higher than average temperatures. The Antarctic was split in two about equally large regions characterised by above and below average temperatures, respectively.

Lower troposphere temperature from satellites, updated to October 2014

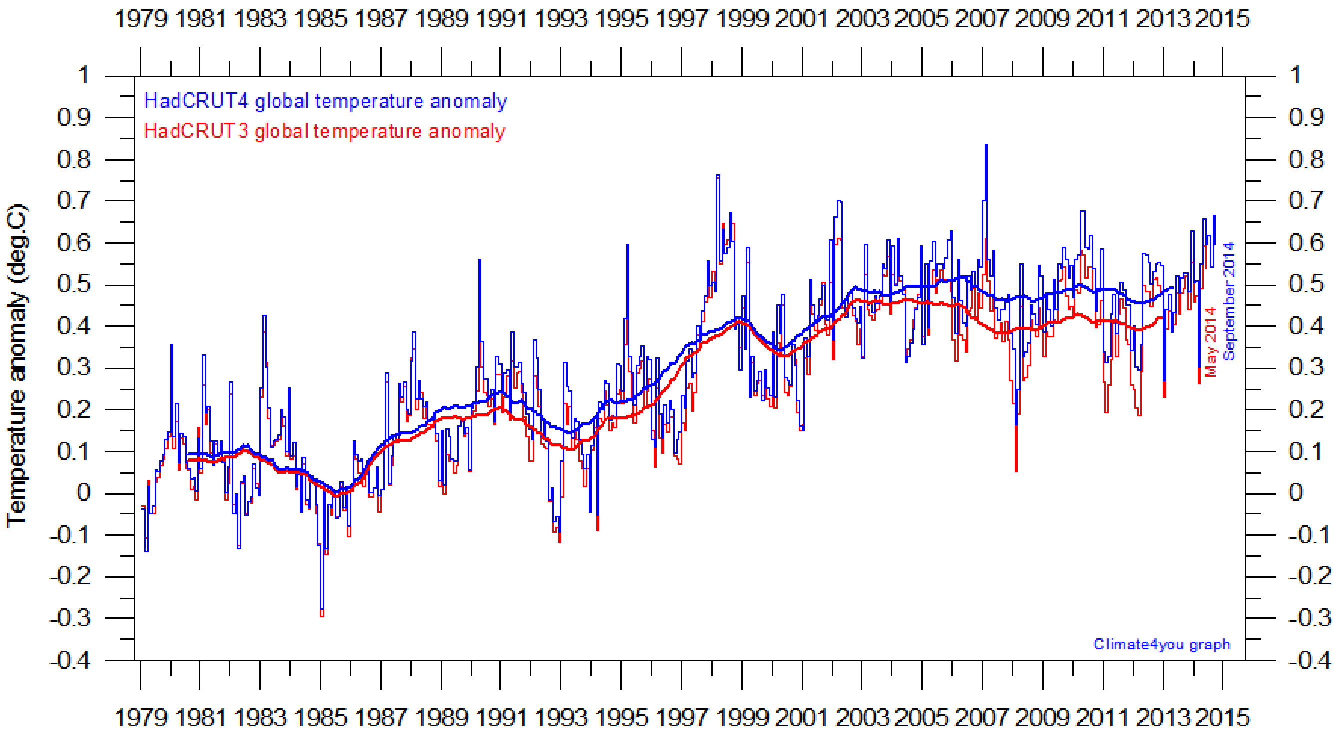


Global monthly average lower troposphere temperature (thin line) since 1979 according to University of Alabama at Huntsville, USA. The thick line is the simple running 37-month average.

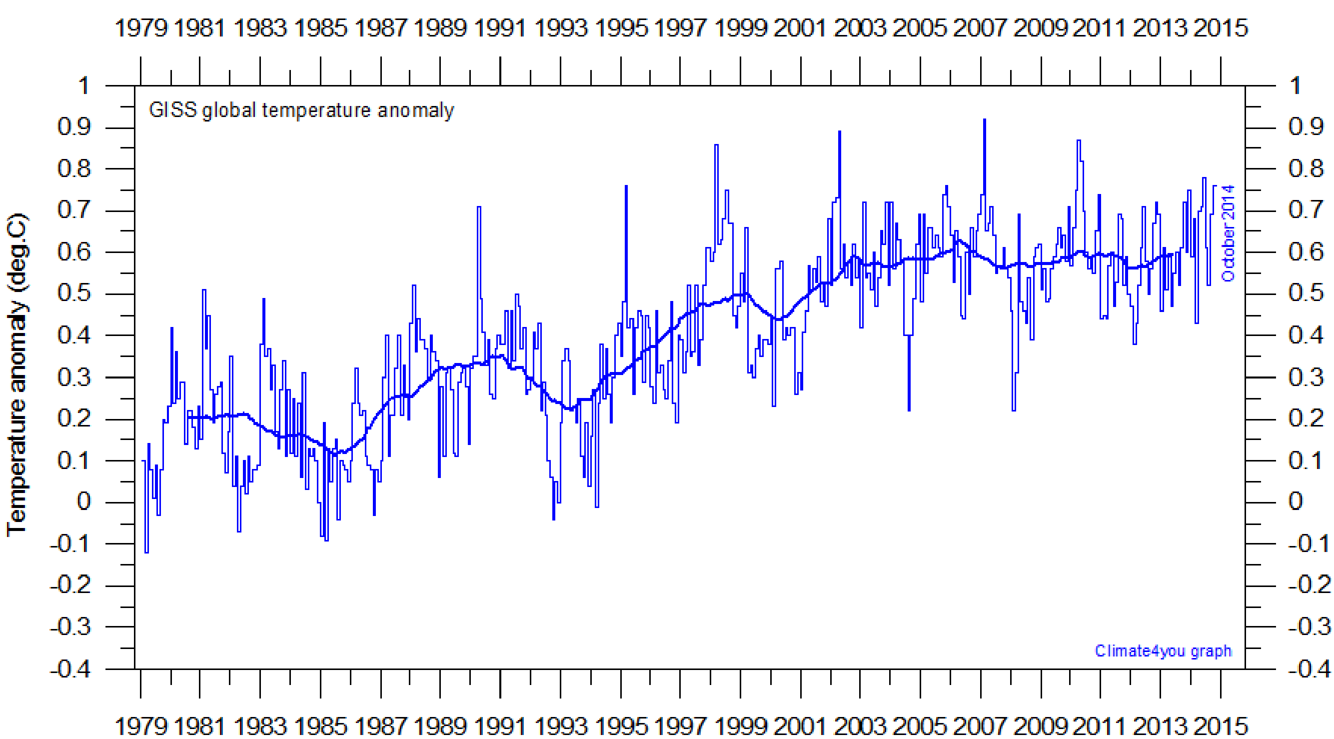


Global monthly average lower troposphere temperature (thin line) since 1979 according to according to Remote Sensing Systems (RSS), USA. The thick line is the simple running 37-month average.

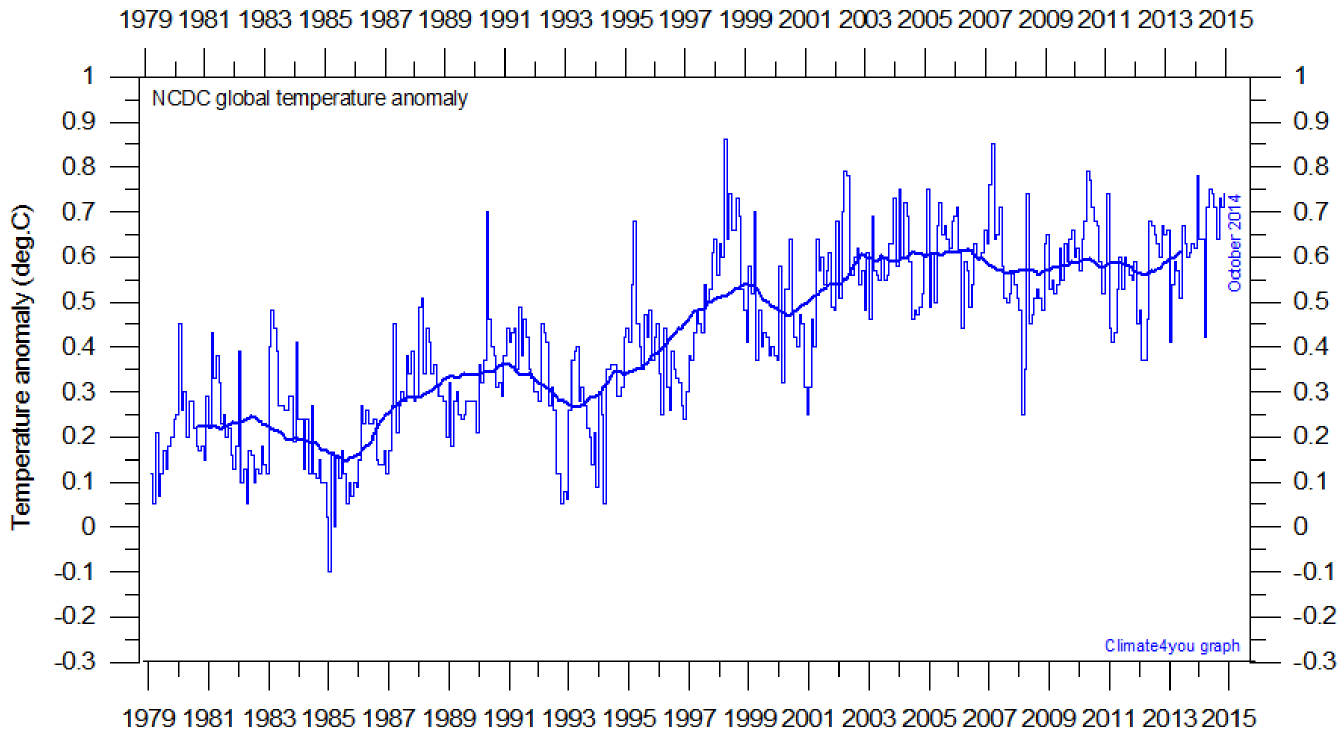
Global surface air temperature, updated to October 2014



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), UK. The thick line is the simple running 37-month average. Version HadCRUT4 (blue) is now replacing HadCRUT3 (red). Please note that this diagram is not yet updated beyond September 2014.



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.

A note on data record stability:

All the above temperature estimates display changes when one compare with previous monthly data sets, not only for the most recent months as a result of supplementary data being added, but actually for all months back to the very beginning of the records, more than 100 years ago. Presumably this reflects recognition of errors, changes in the averaging procedure, and the influence of other unknown phenomena.

None of the temperature records are entirely stable over time (since 2008). The two surface air temperature records, NCDC and GISS, show apparent systematic changes over time. This is exemplified the diagram on the following page showing the changes since May 2008 in the NCDC global surface temperature record for January 1915 and January 2000, illustrating how the difference between the early and late part of the temperature records gradually is growing by administrative adjustments.

You can find more on the issue of lack of temporal stability on www.climate4you (go to: *Global Temperature*, followed by *Temporal Stability*).

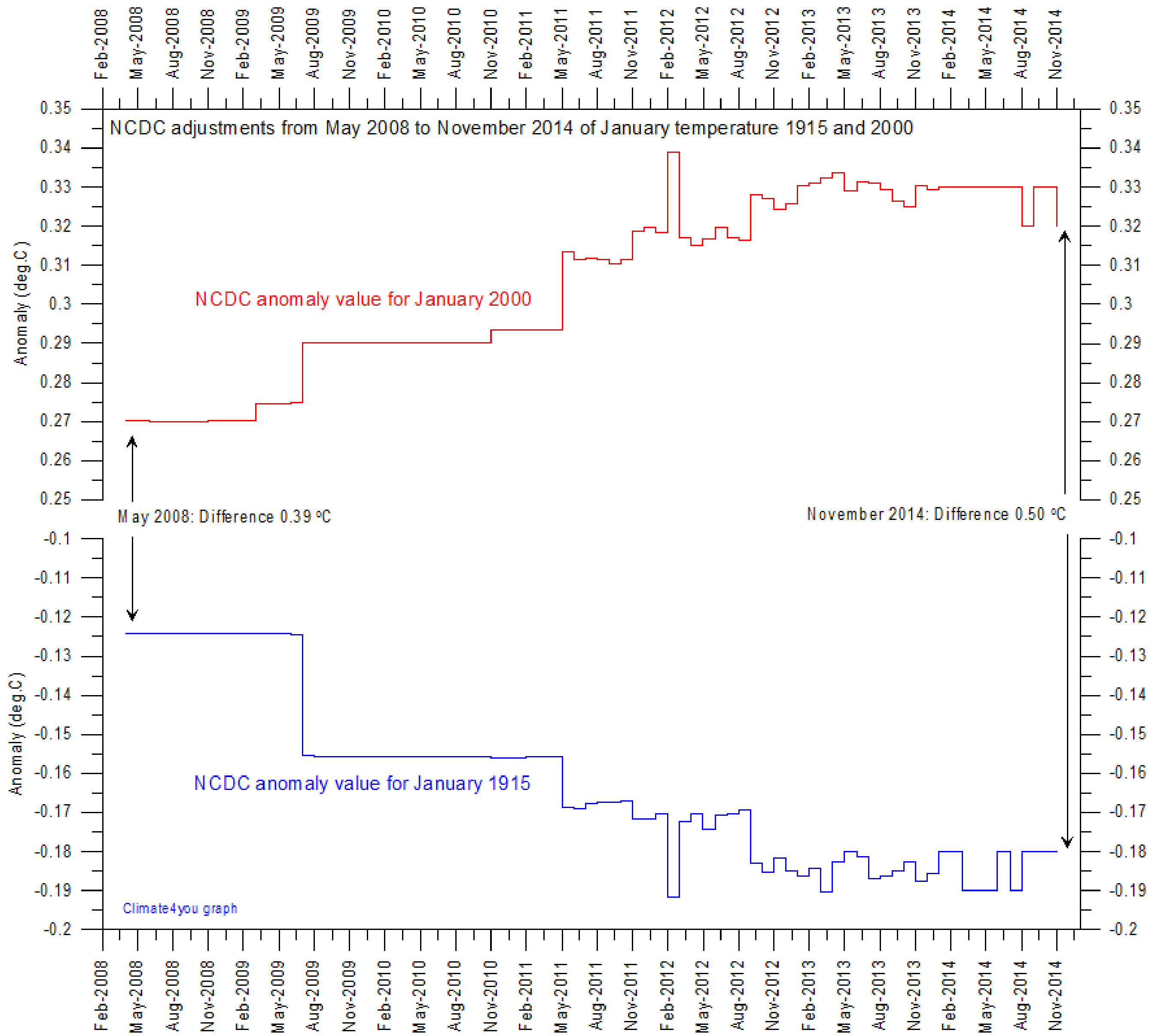


Diagram showing the adjustment made since May 2008 by the [National Climatic Data Center](#) (NCDC) in the anomaly values for the two months January 1915 and January 2000.

Note: The administrative upsurge of the temperature increase between January 1915 and January 2000 has grown from 0.39 (May 2008) to 0.50 ^{o}C (September 2014), representing an about 28% administrative temperature increase over this period.

Global air temperature linear trends updated to September 2014

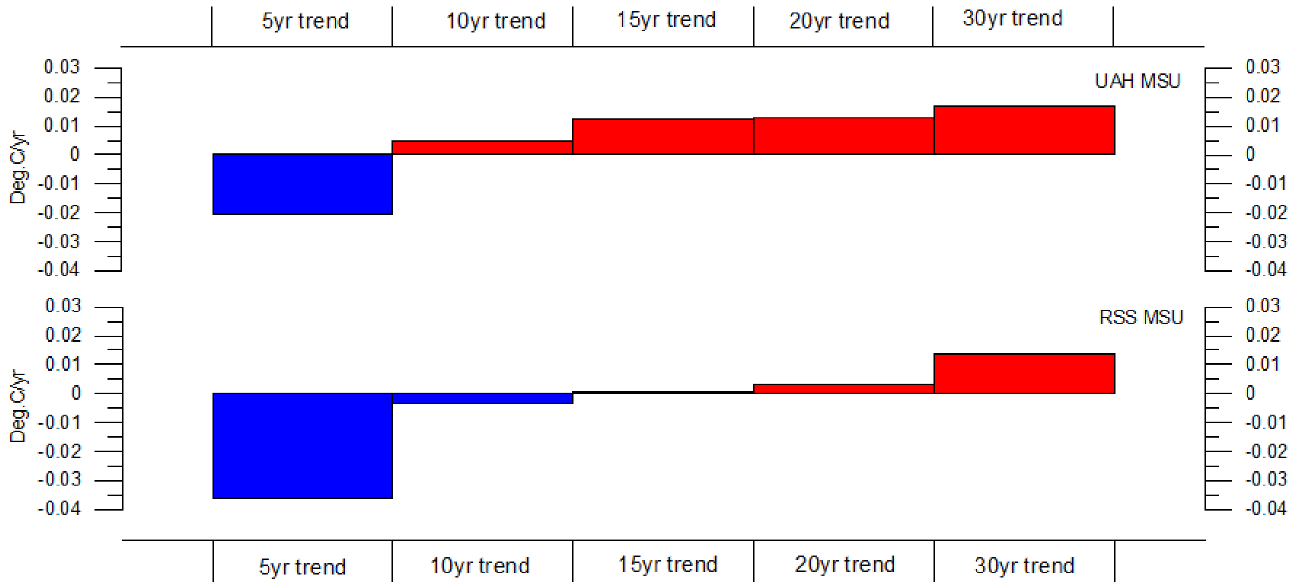


Diagram showing the latest 5, 10, 20 and 30 yr linear annual global temperature trend, calculated as the slope of the linear regression line through the data points, for two satellite-based temperature estimates (UAH MSU and RSS MSU). Last month included in analysis: September 2014.

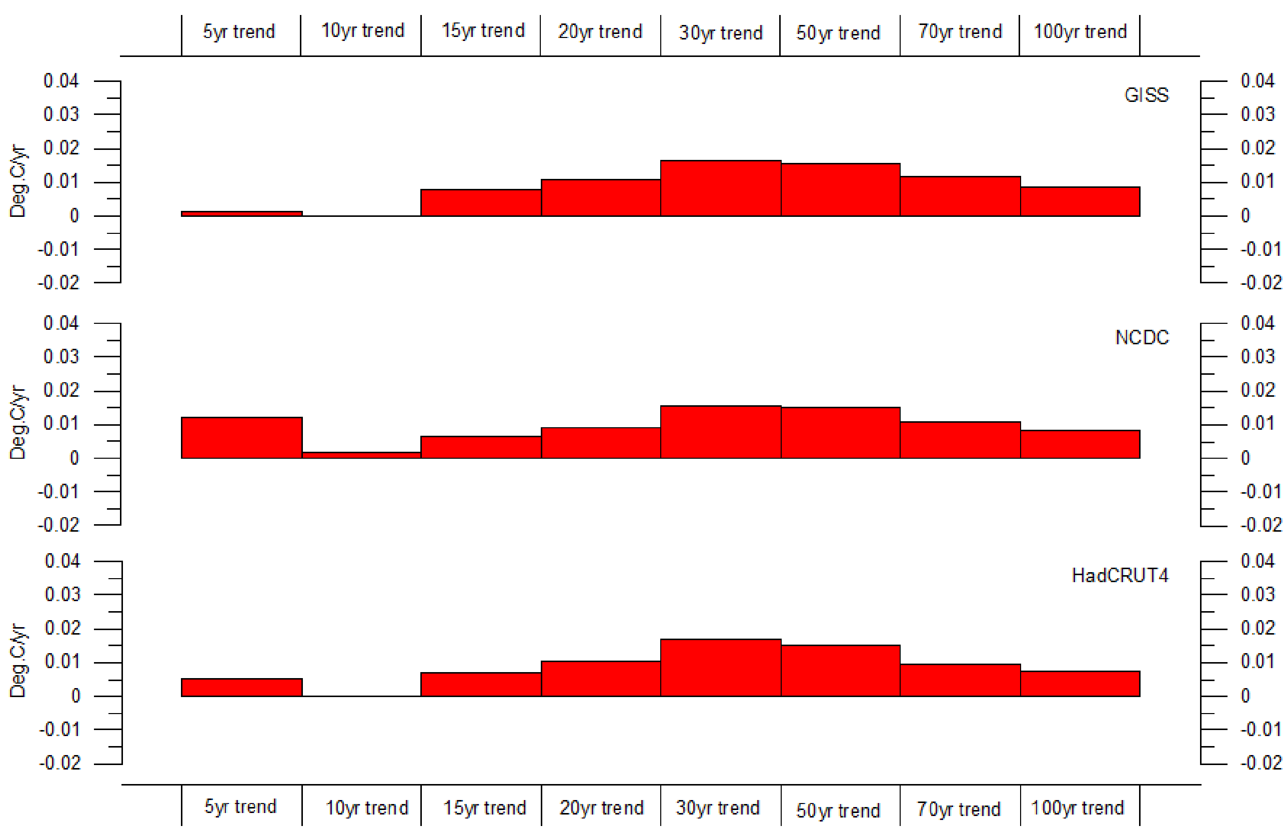
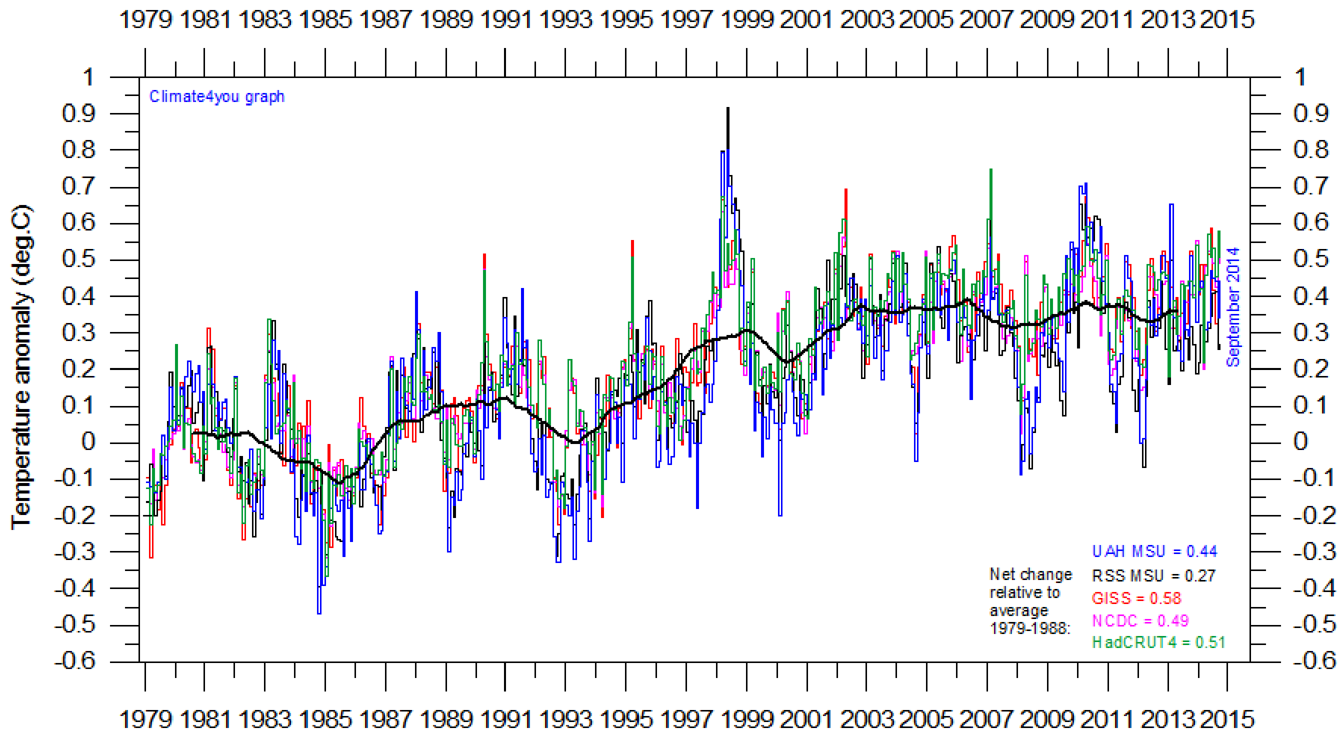


Diagram showing the latest 5, 10, 20, 30, 50, 70 and 100 year linear annual global temperature trend, calculated as the slope of the linear regression line through the data points, for three surface-based temperature estimates (GISS, NCDC and HadCRUT4). Last month included in all analyses: September 2014.

[All in one, updated to September 2014]()

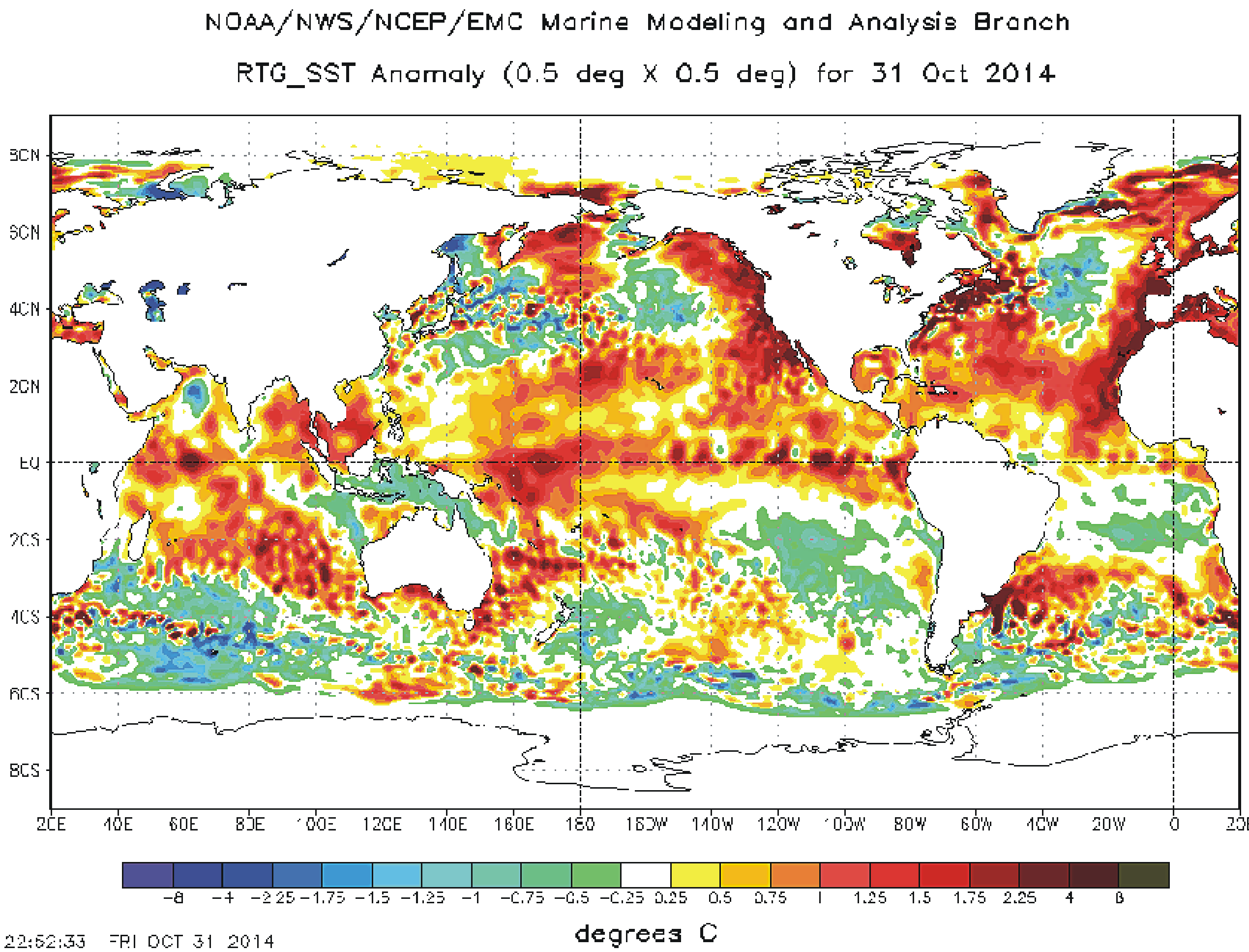


Superimposed plot of all five global monthly temperature estimates. As the base period differs for the individual temperature estimates, they have all been normalised by comparing with the average value of the initial 120 months (10 years) from January 1979 to December 1988. The heavy black line represents 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 individual 1979-1988 averages.

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 may be somewhat problematical. However, as both types of estimate often are discussed together, the above diagram may nevertheless be of some 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 shorter time scale there are often considerable differences between the individual records.

All five global temperature estimates presently show an overall stagnation, at least since 2002. There has been no increase in global air temperature since 1998, which however was affected by the oceanographic El Niño event. This stagnation 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 during the coming years. Time will show which of these two possibilities is correct.

Global sea surface temperature, updated to late October 2014



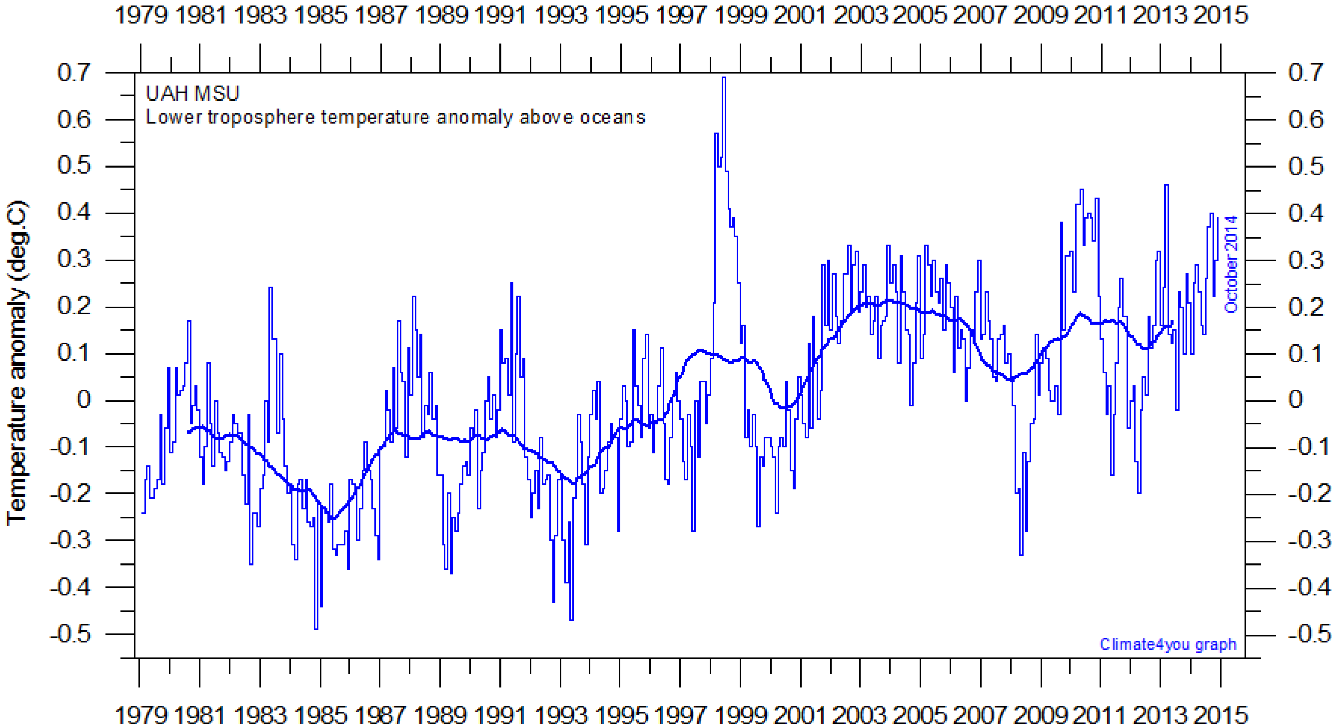
Sea surface temperature anomaly on 31 October 2014. Map source: National Centers for Environmental Prediction (NOAA).

Because of the large surface areas near Equator, the temperature of the surface water in these regions is especially important for the global atmospheric temperature (p.4-6).

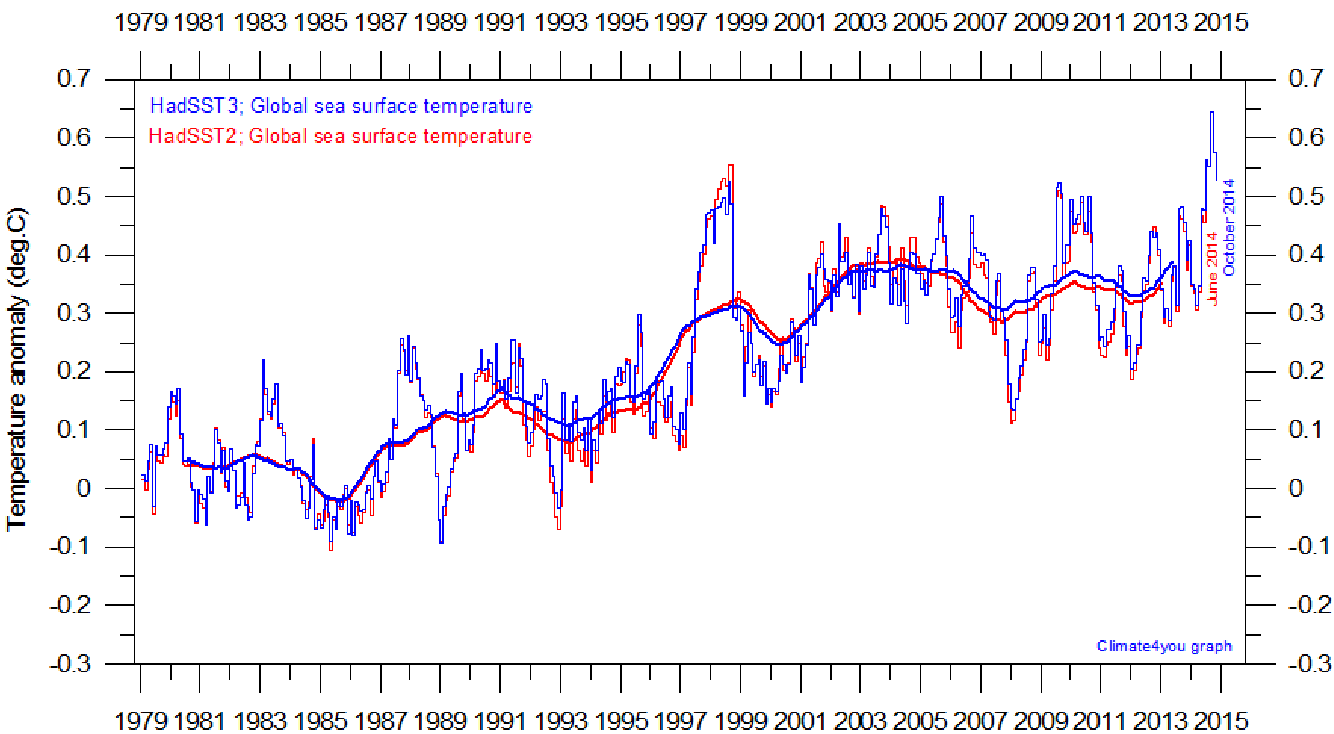
Relatively warm water is dominating the Pacific Ocean and Indian Ocean near the Equator, and is influencing global air temperatures now and in the months to come.

The significance of any such short-term cooling or warming reflected in air temperatures should not be over stated. Whenever Earth experiences cold La Niña or warm El Niño episodes (Pacific Ocean) major heat exchanges takes place between the Pacific Ocean and the atmosphere above, eventually showing up in estimates of the global air temperature.

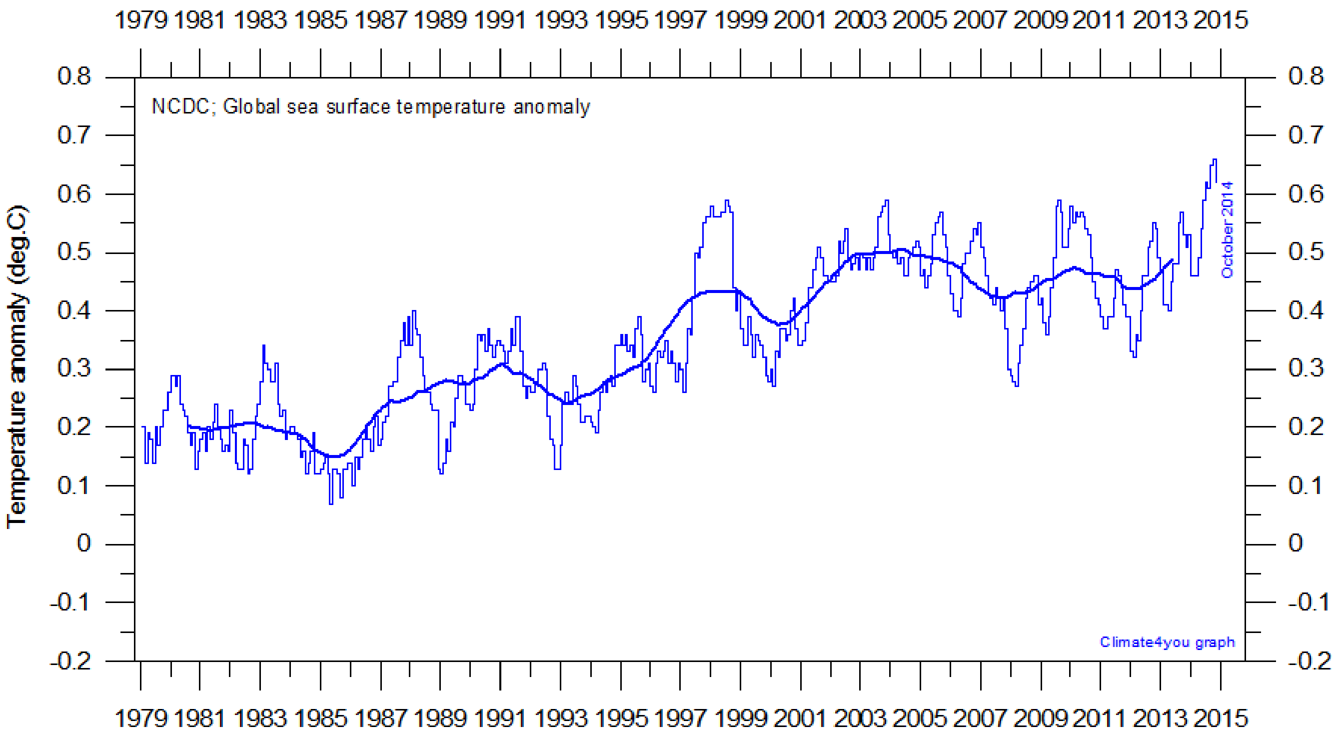
However, this does not reflect similar changes in the total heat content of the atmosphere-ocean system. In fact, global net changes can be small and such heat exchanges may mainly reflect redistribution of energy between ocean and atmosphere. What matters is the overall temperature development when seen over a number of years.



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.

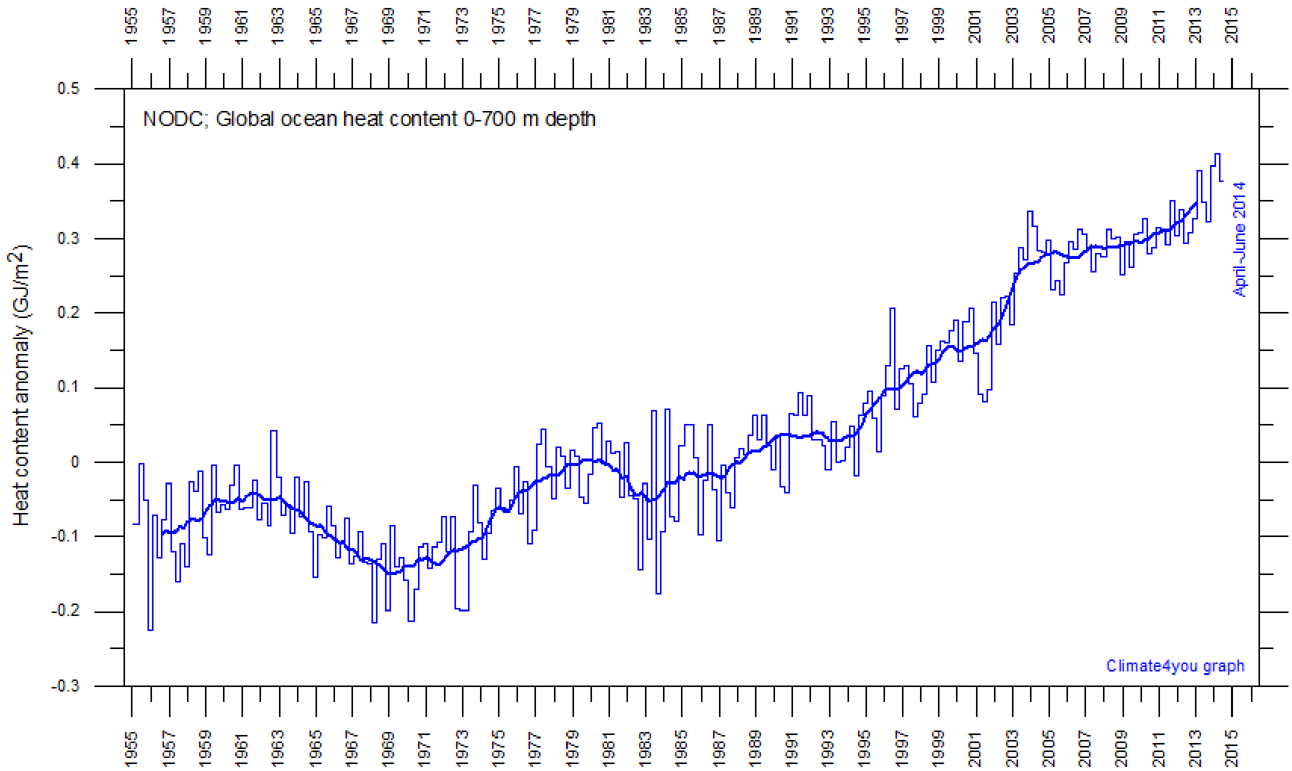


Global monthly average sea surface temperature since 1979 according to University of East Anglia's Climatic Research Unit (CRU), UK. Base period: 1961-1990. The thick line is the simple running 37-month average.

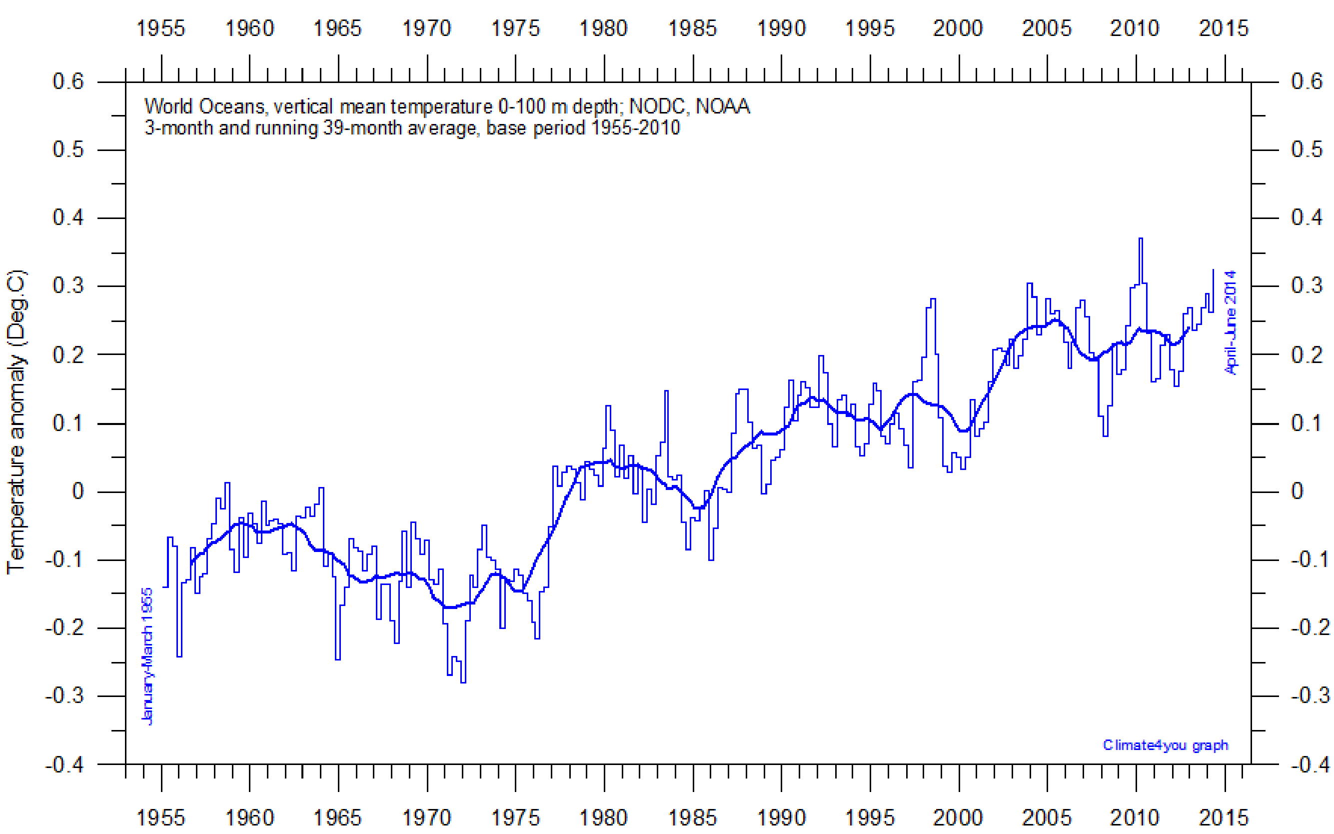


Global monthly average sea surface temperature since 1979 according to the National Climatic Data Center (NCDC), USA. Base period: 1901-2000. The thick line is the simple running 37-month average.

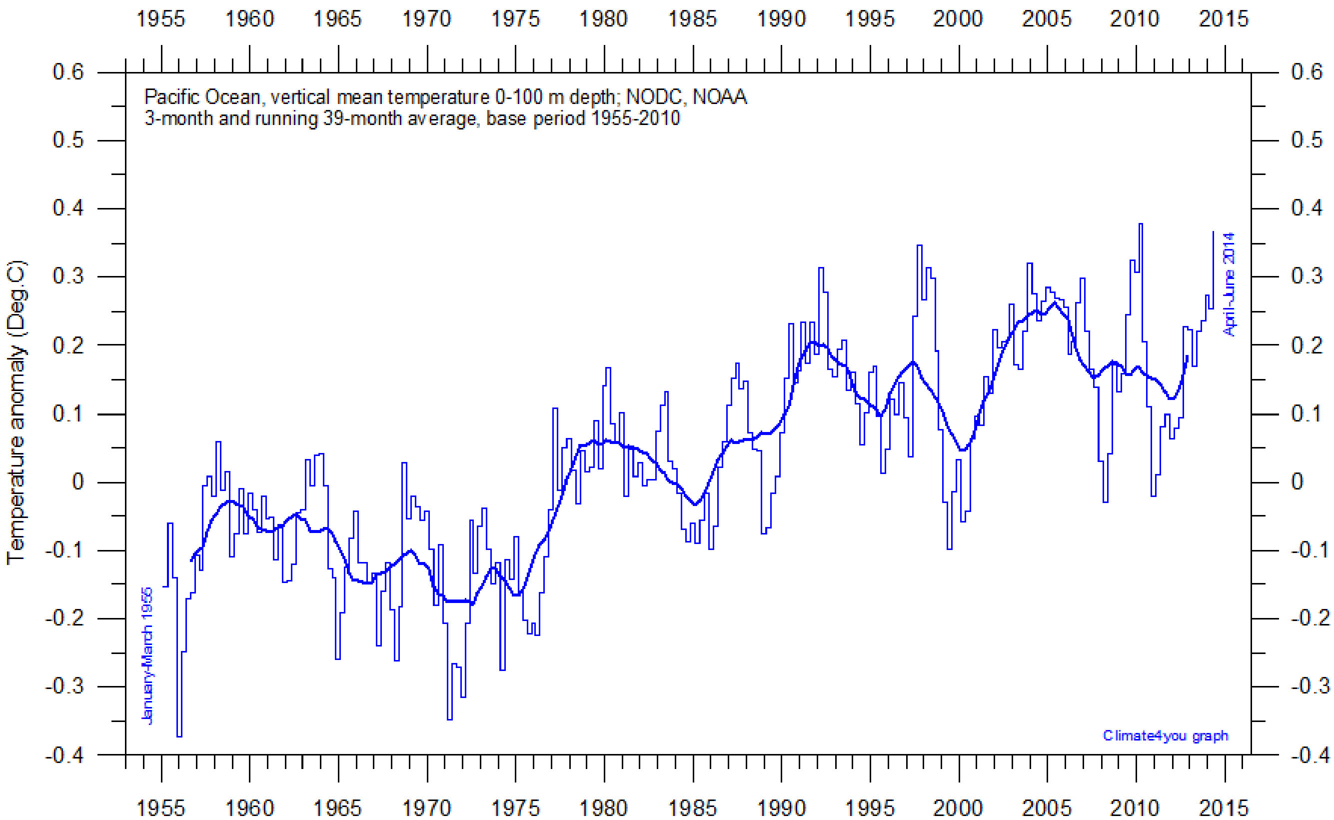
Ocean heat content uppermost 100 and 700 m, updated to June 2014



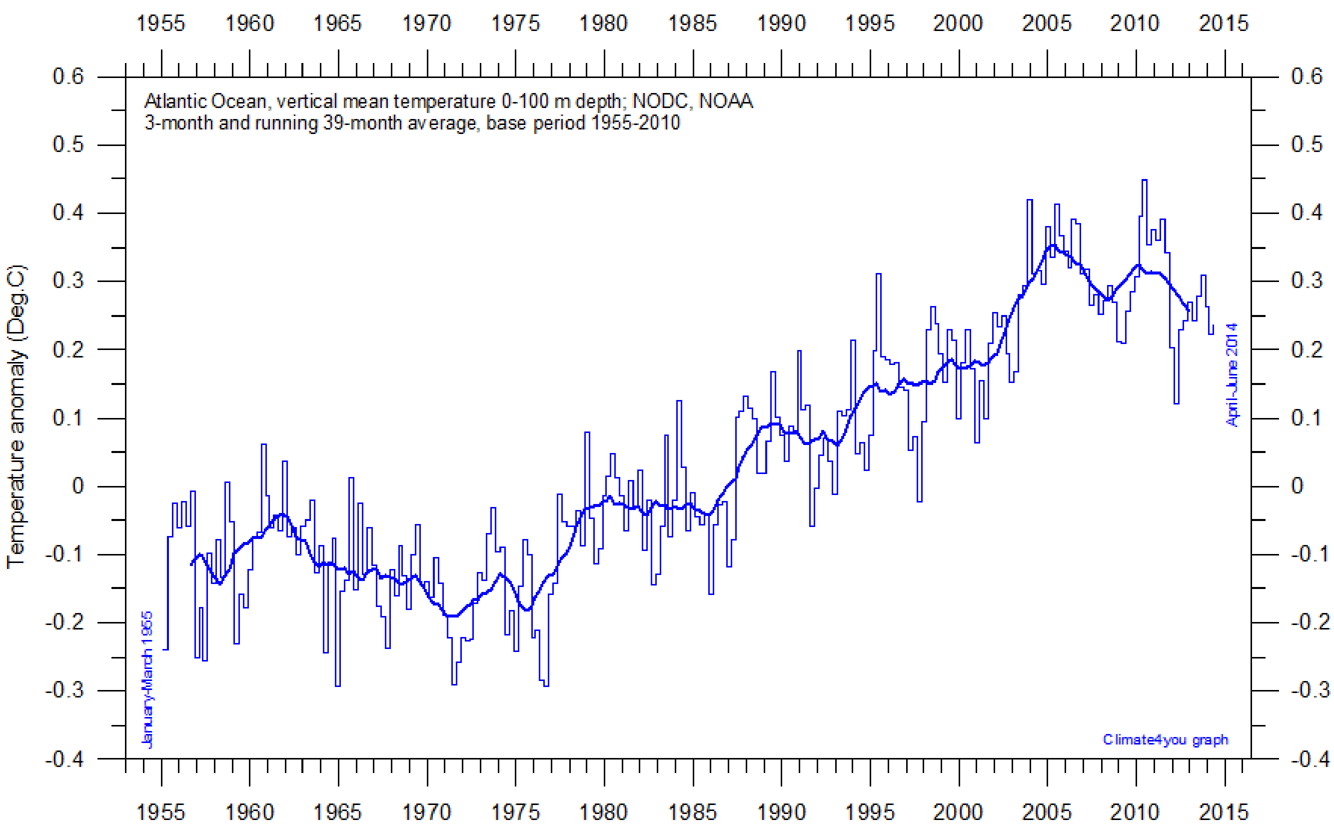
Global monthly heat content anomaly (GJ/m2) in the uppermost 700 m of the oceans since January 1955. Data source: National Oceanographic Data Center(NODC).



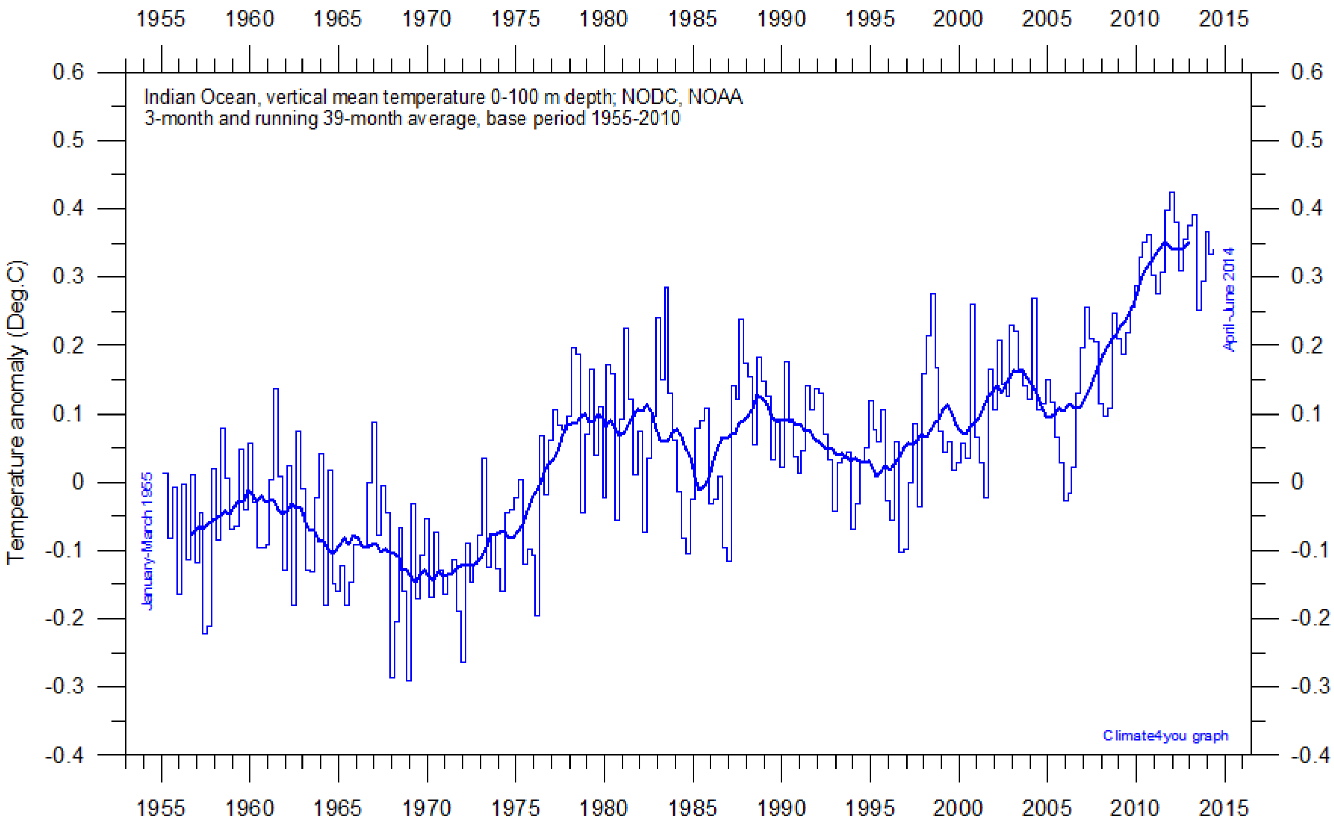
World Oceans vertical average temperature 0-100 m depth since 1955. The thin line indicate 3-month values, and the thick line represents the simple running 39-month (c. 3 year) average. Data source: NOAA National Oceanographic Data Center (NODC). Base period 1955-2010.



Pacific Ocean vertical average temperature 0-100 m depth since 1955. The thin line indicate 3-month values, and the thick line represents the simple running 39-month (c. 3 year) average. Data source: NOAA National Oceanographic Data Center (NODC). Base period 1955-2010.

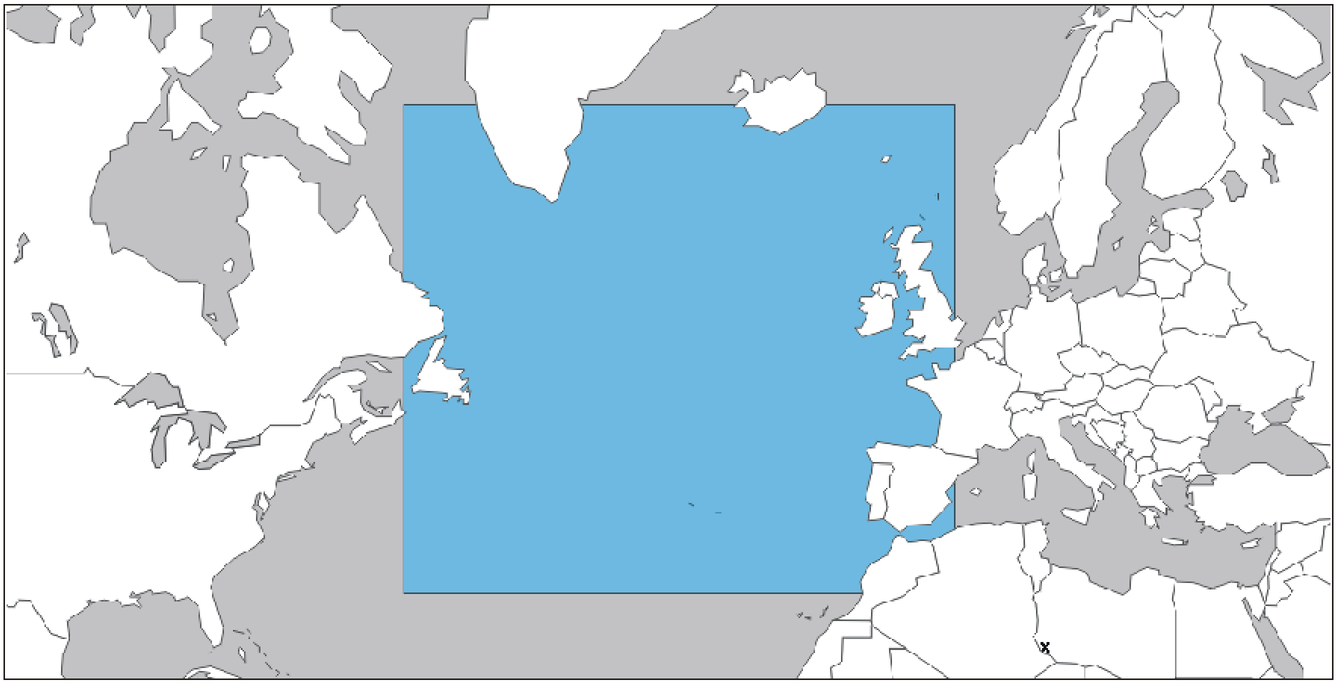


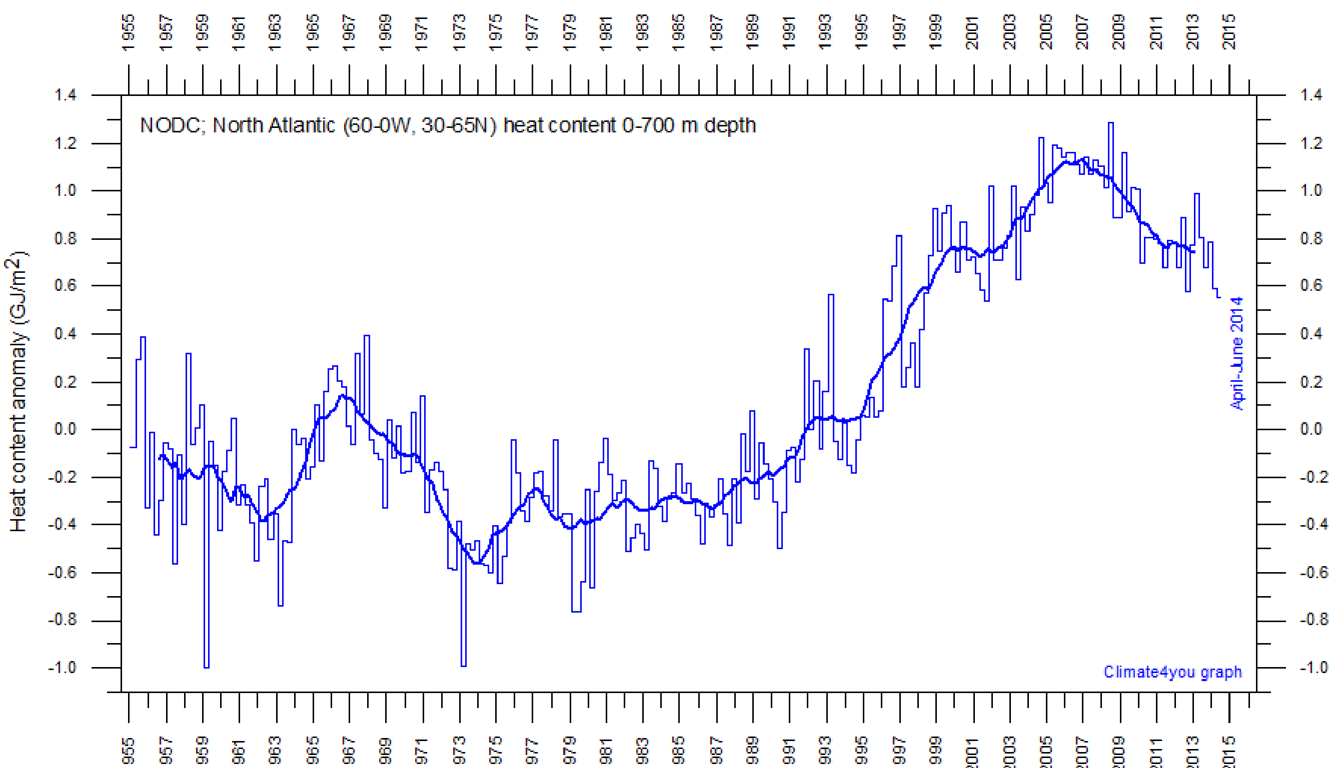
Atlantic Ocean vertical average temperature 0-100 m depth since 1955. The thin line indicate 3-month values, and the thick line represents the simple running 39-month (c. 3 year) average. Data source: NOAA National Oceanographic Data Center (NODC). Base period 1955-2010.



Indian Ocean vertical average temperature 0-100 m depth since 1955. The thin line indicate 3-month values, and the thick line represents the simple running 39-month (c. 3 year) average. Data source: NOAA National Oceanographic Data Center (NODC). Base period 1955-2010.

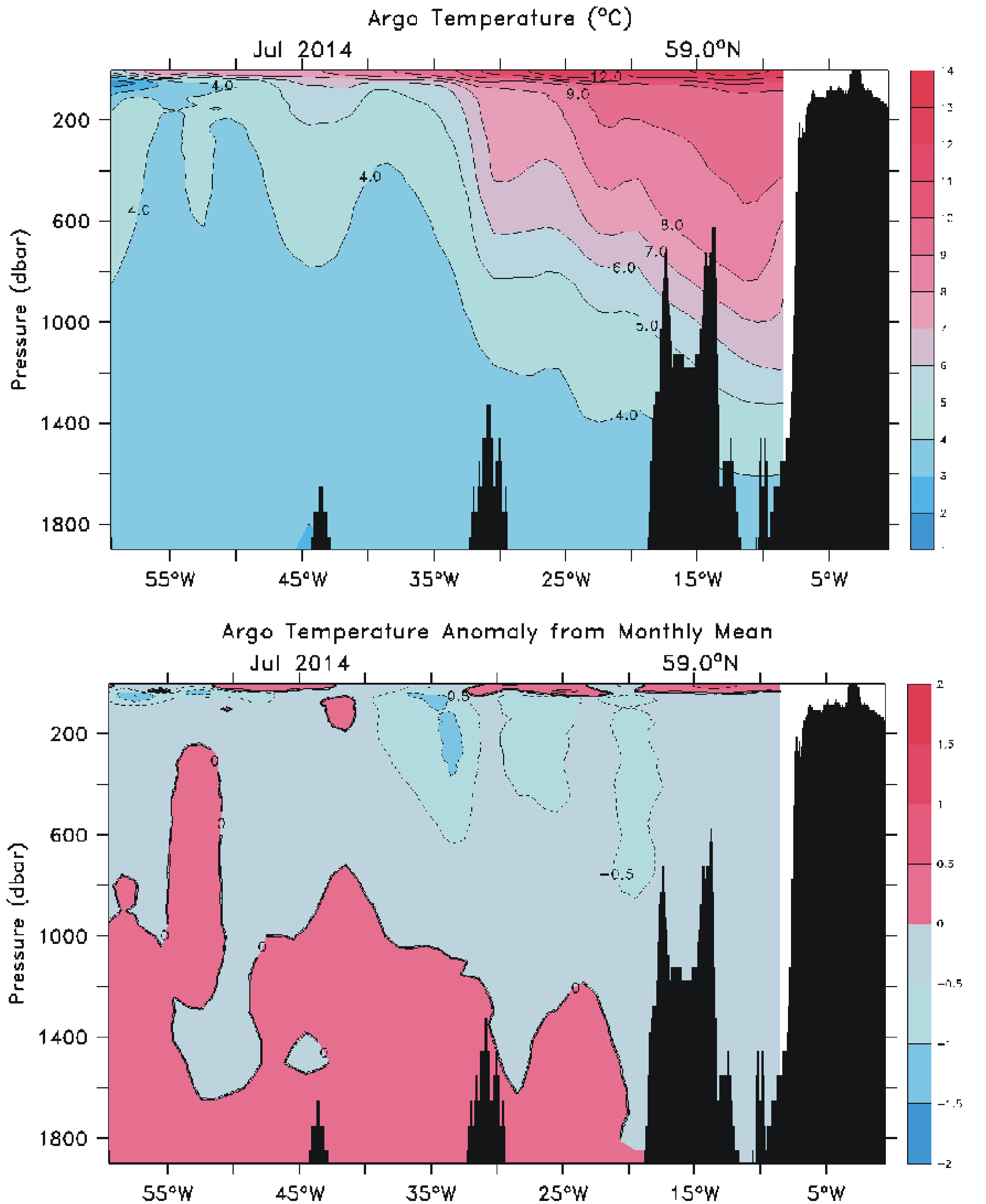
North Atlantic heat content uppermost 700 m, updated to June 2014





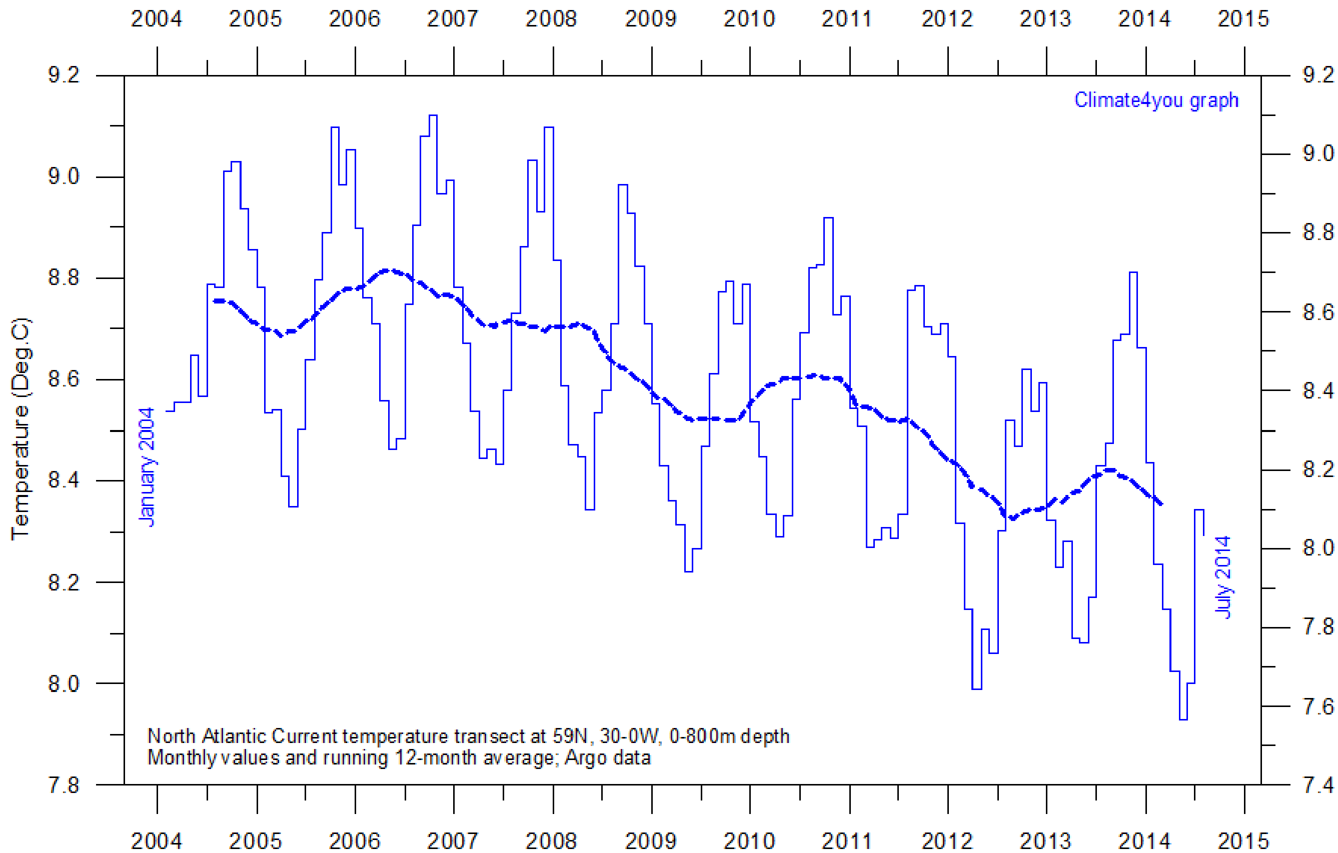
Global monthly heat content anomaly (GJ/m2) in the uppermost 700 m of the North Atlantic (60-0W, 30-65N; see map above) *ocean since January 1955. The thin line indicates monthly values, and the thick line represents the simple running 37 month (c. 3 year) average. Data source: National Oceanographic Data Center (NODC).*

[North Atlantic sea temperatures along 59N, updated to July 2014]



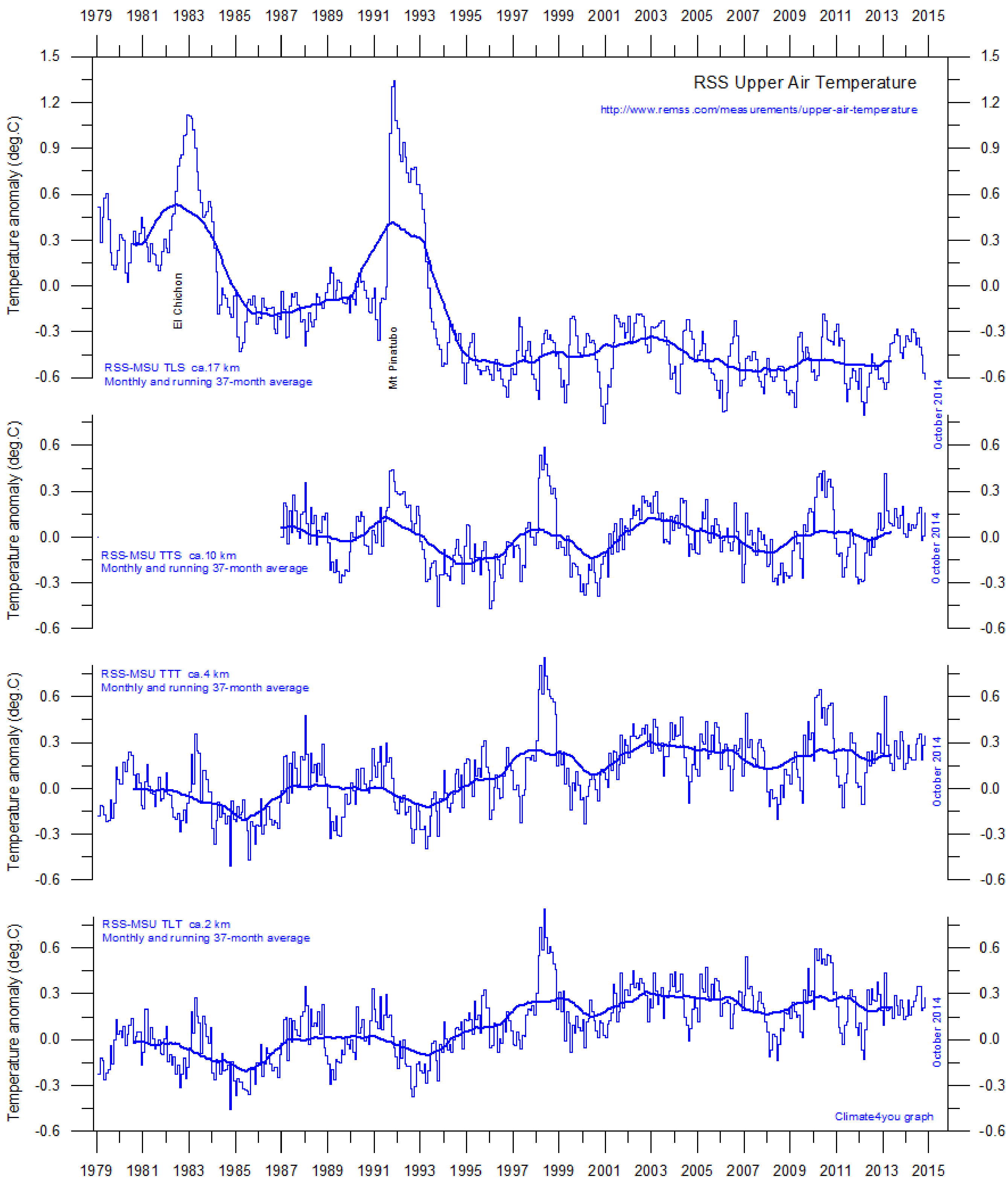
Depth-temperature diagram along 59 N across the North Atlantic, extending from northern Labrador in the west to northern Scotland in the east, using Argo-data. The uppermost panel shows the temperature, and the lower diagram shows the temperature anomaly, using the monthly average temperature 2004-2013 as reference. Source: Global Marine Argo Atlas.

North Atlantic sea temperatures 30-0W at 59N, updated to July 2014



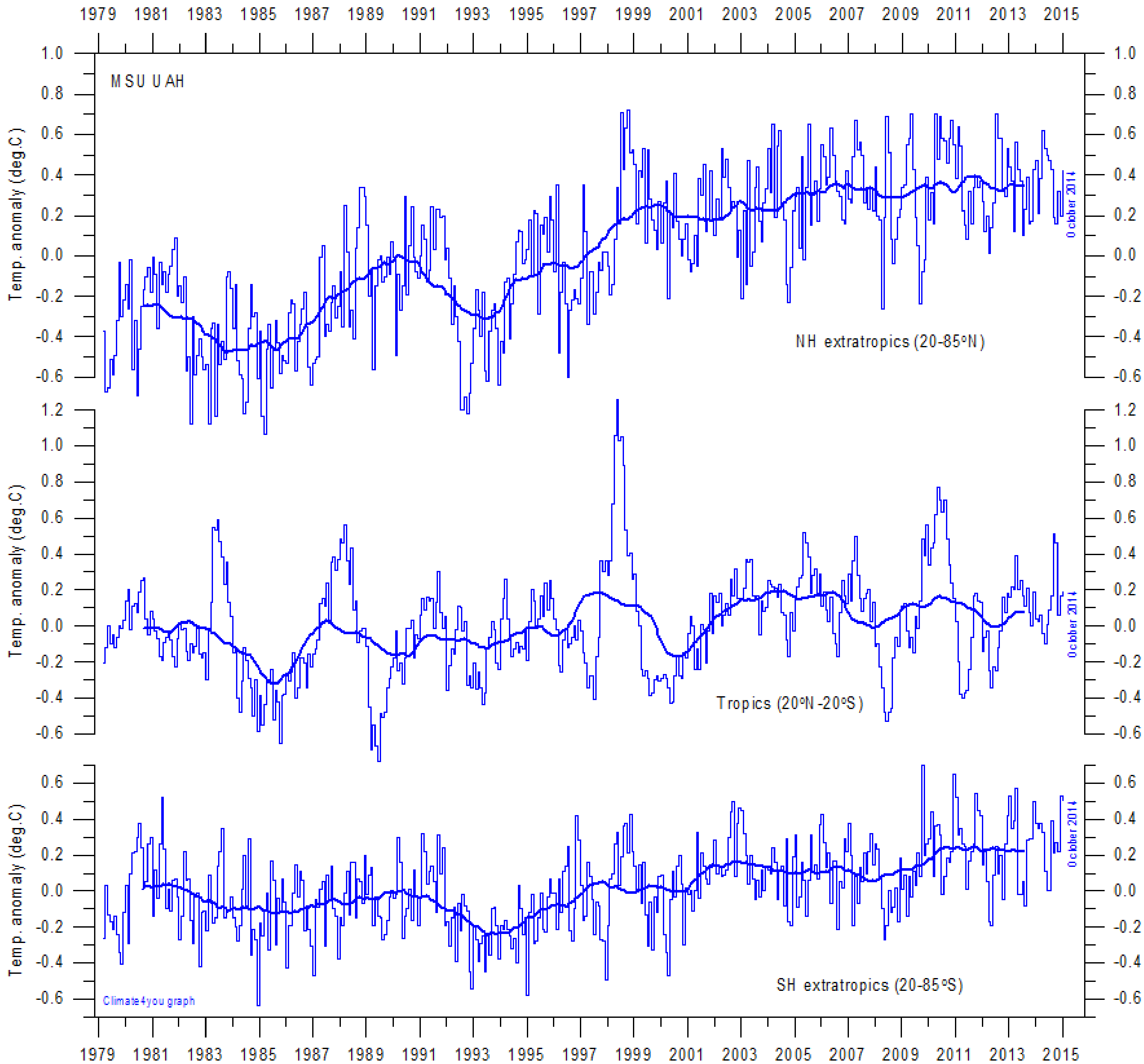
Average temperature along 59 N, 30-0W, 0-800m depth, corresponding to the main part of the North Atlantic Current, using Argo-data. Source: Global Marine Argo Atlas. Additional information can be found in: Roemmich, D. and J. Gilson, 2009. The 2004-2008 mean and annual cycle of temperature, salinity, and steric height in the global ocean from the Argo Program. Progress in Oceanography, 82, 81-100.

Troposphere and stratosphere temperatures from satellites, updated to October 2014



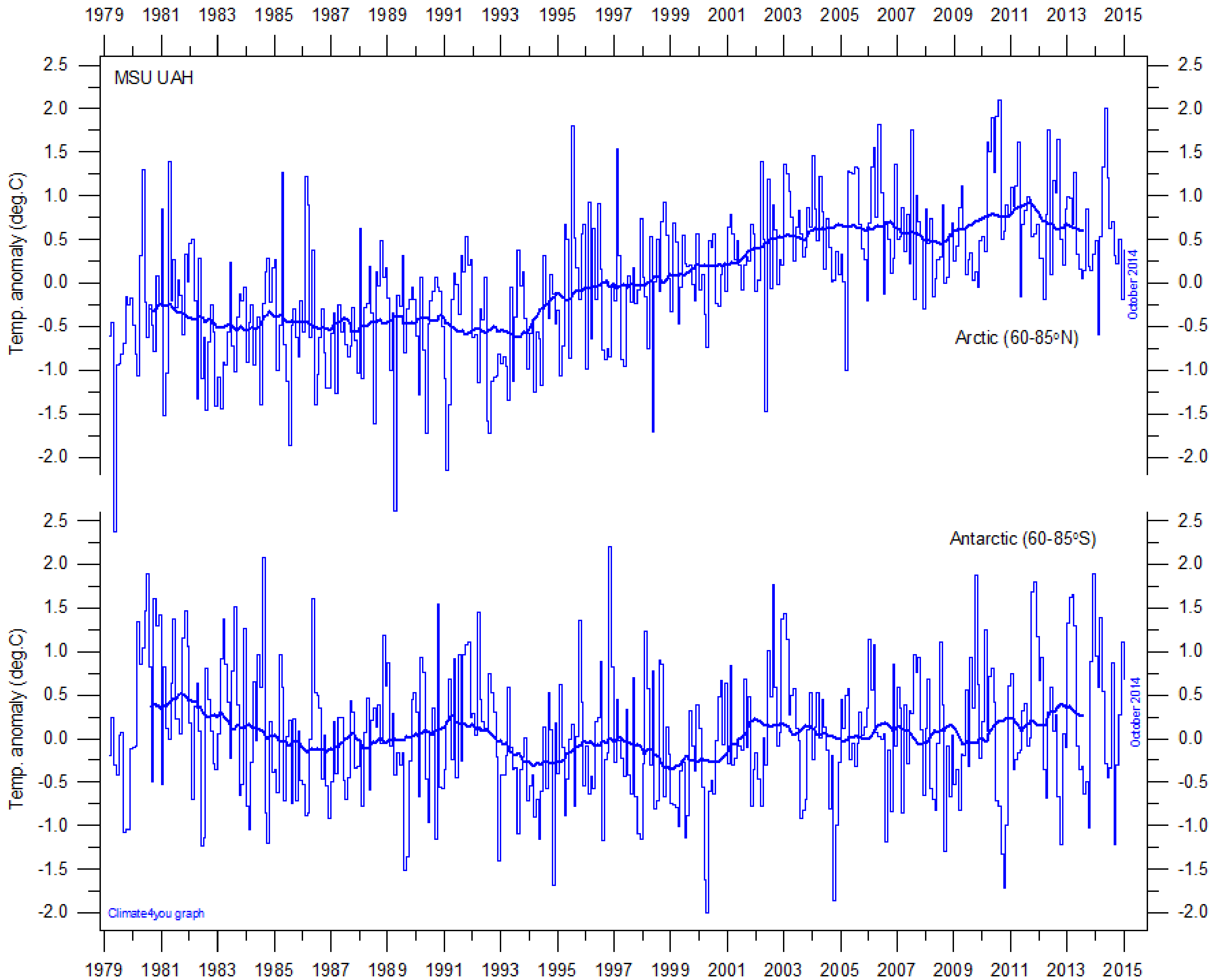
Global monthly average temperature in different altitudes according to Remote Sensing Systems (RSS). The thin lines represent the monthly average, and the thick line the simple running 37 month average, nearly corresponding to a running 3 yr average.

Zonal lower troposphere temperatures from satellites, updated to October 2014



Global monthly average lower troposphere temperature since 1979 for the tropics and the northern and southern extratropics, according to [University of Alabama] at Huntsville, USA. Thin lines show the monthly temperature. Thick lines represent the simple running 37-month average, nearly corresponding to a running 3 yr average. Reference period 1981-2010.

Arctic and Antarctic lower troposphere temperature, updated to October 2014



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). Thin lines show the monthly temperature. 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 September 2014

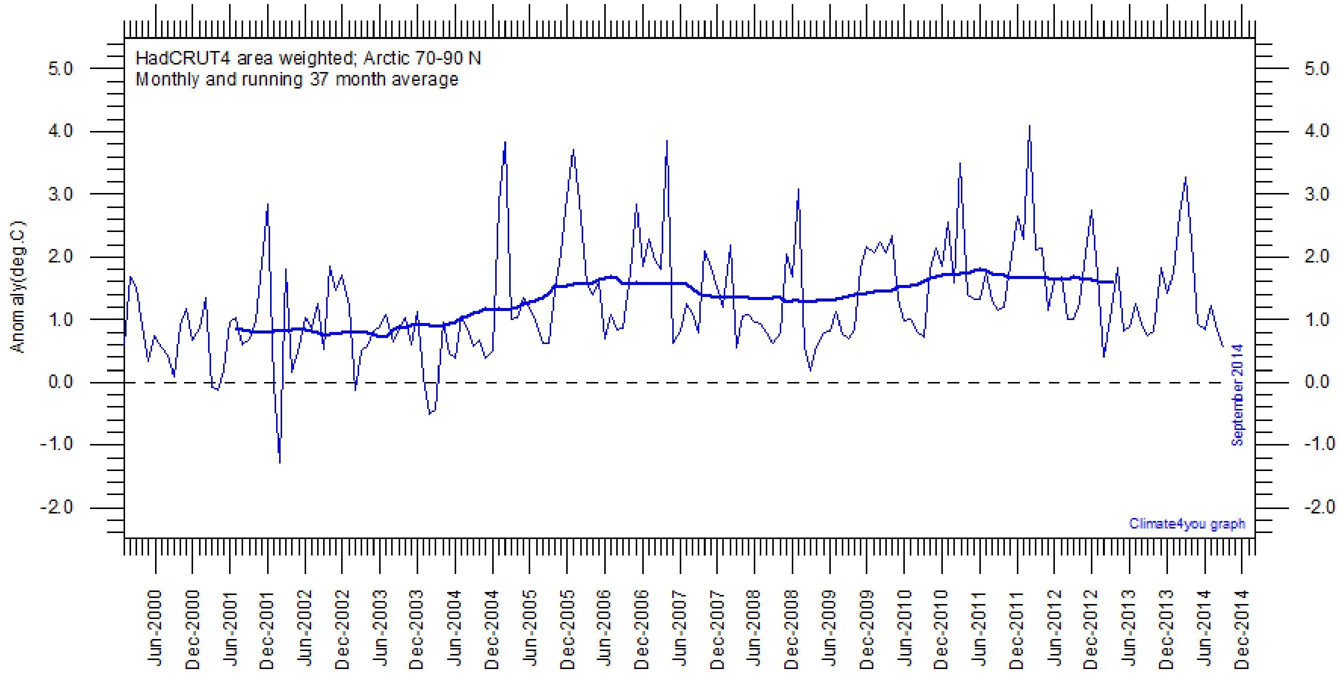


Diagram showing area weighted Arctic (70-90°N) monthly surface air temperature anomalies (HadCRUT4) since January 2000, in relation to the WMO normal period 1961-1990. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 37 month (c.3 yr) average.

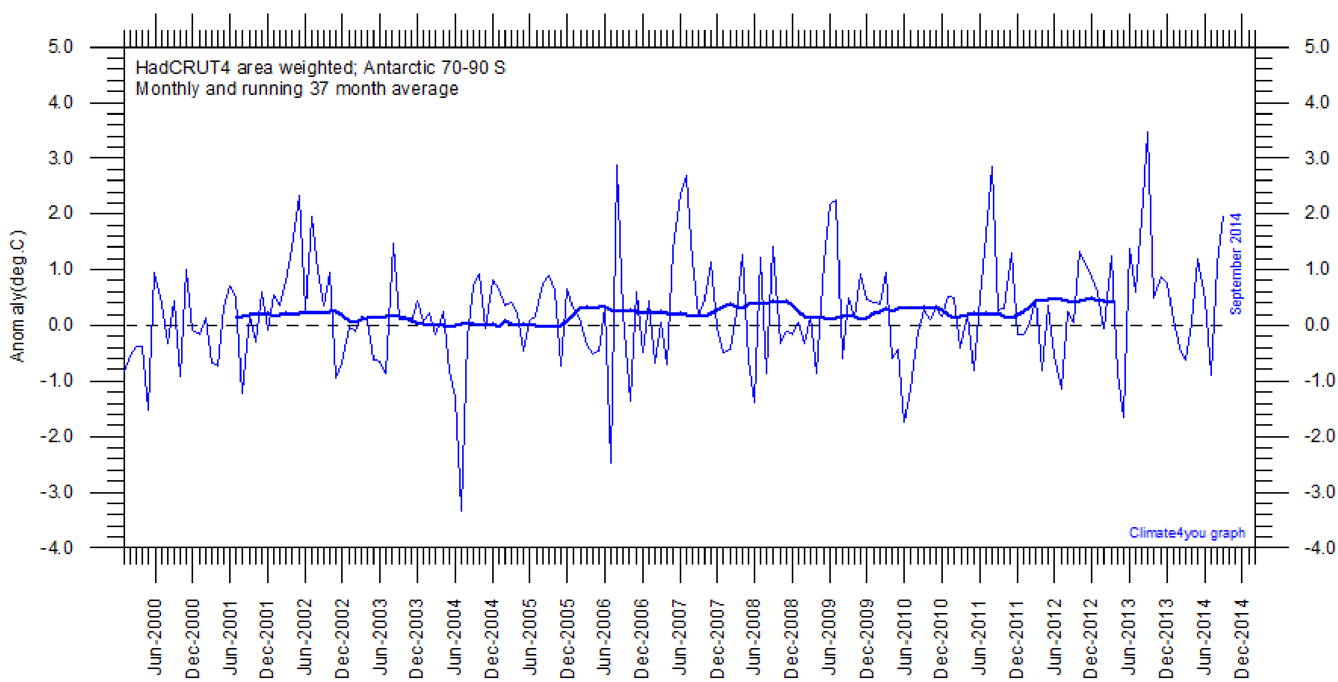


Diagram showing area weighted Antarctic (70-90°N) monthly surface air temperature anomalies (HadCRUT4) since January 2000, in relation to the WMO normal period 1961-1990. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 37 month (c.3 yr) average.

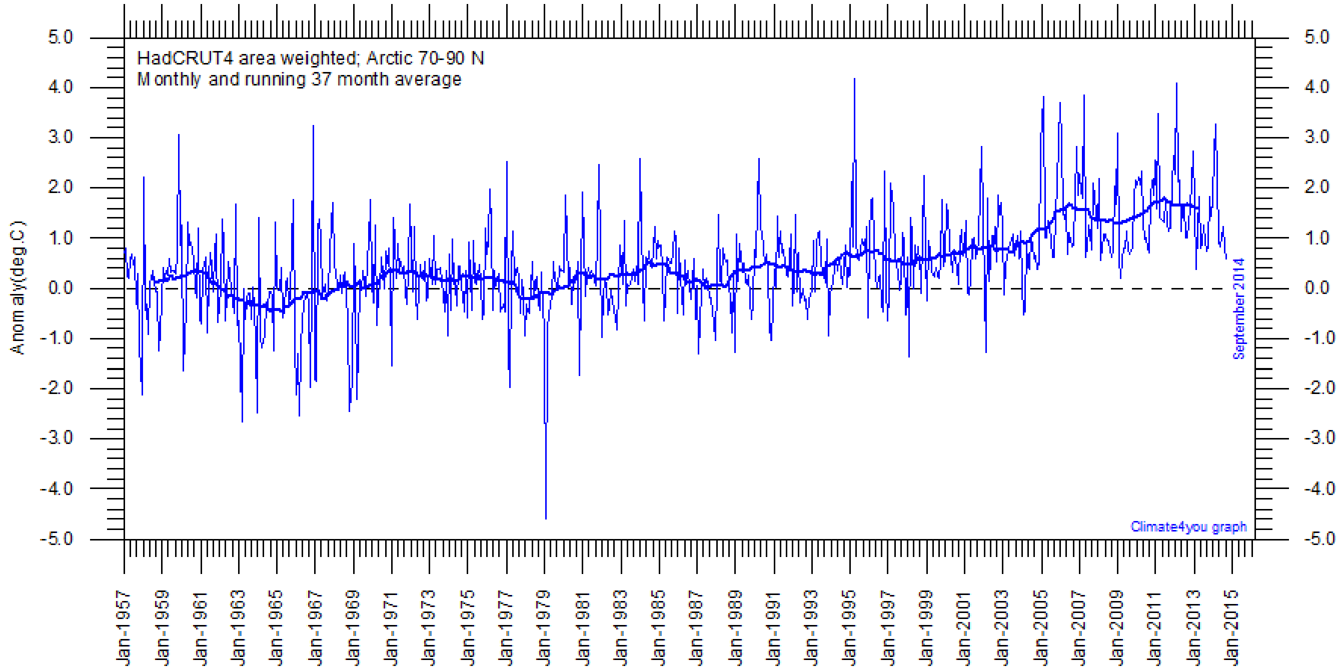


Diagram showing area weighted Arctic (70-90°N) monthly surface air temperature anomalies ([HadCRUT4]) since January 1957, in relation to the WMO [normal period] 1961-1990. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 37 month (c.3 yr) average.

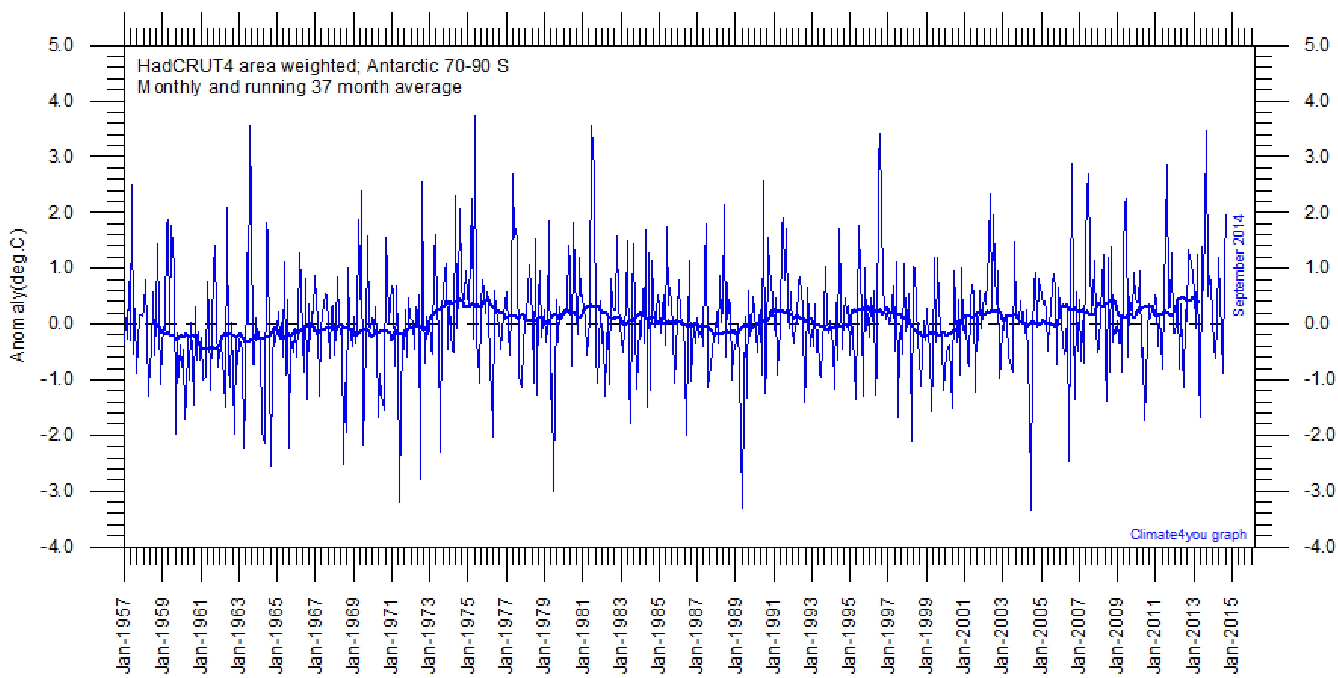


Diagram showing area weighted Antarctic (70-90°N) monthly surface air temperature anomalies ([HadCRUT4]) since January 1957, in relation to the WMO [normal period] 1961-1990. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 37 month (c.3 yr) average.

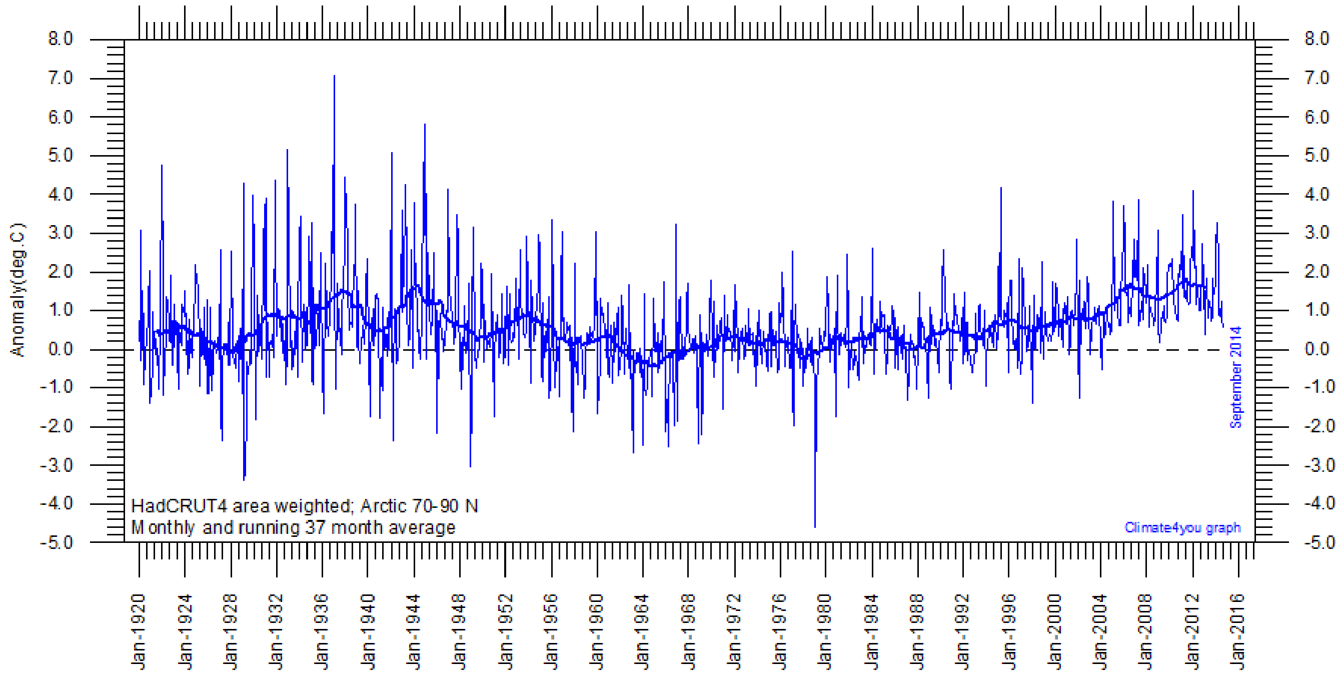


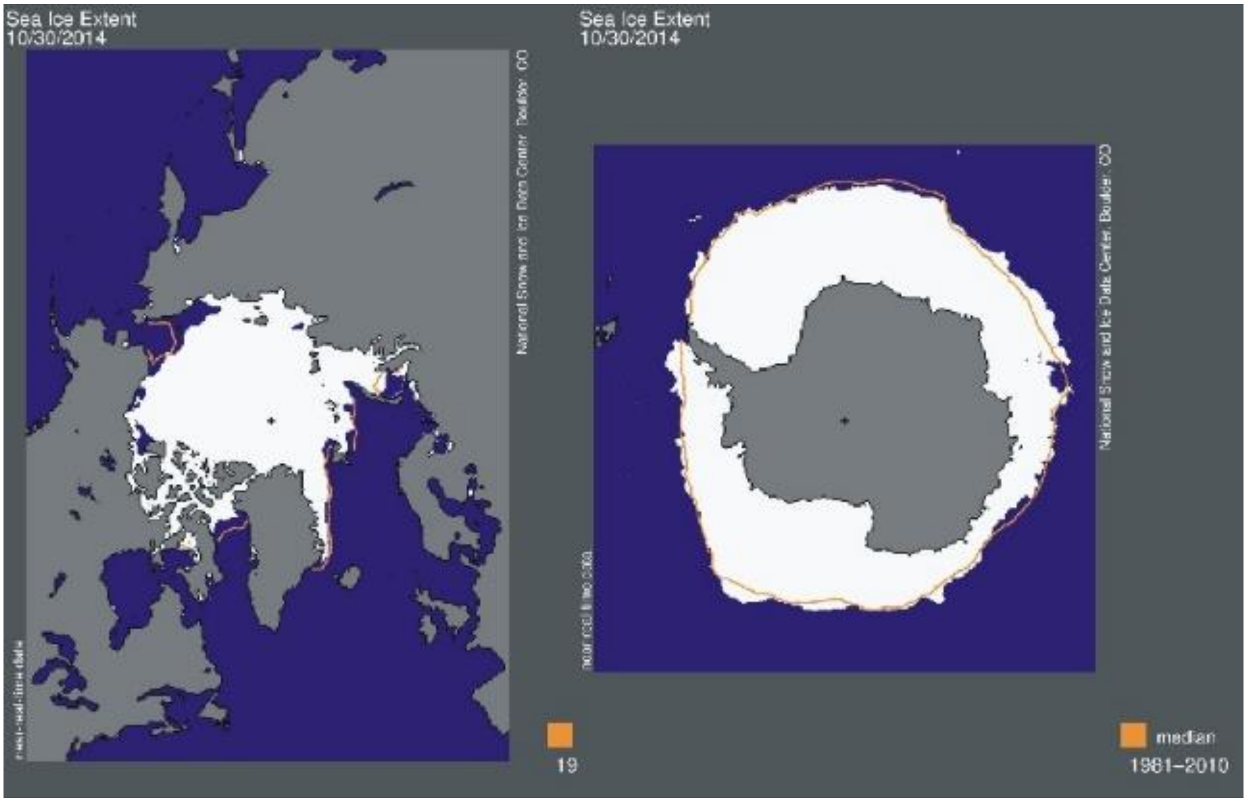
Diagram showing area-weighted Arctic (70-90°N) monthly surface air temperature anomalies ([HadCRUT4]) since January 1920, in relation to the WMO [normal period] 1961-1990. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 37 month (c.3 yr) average. Because of the relatively small number of Arctic stations before 1930, month-to-month variations in the early part of the temperature record are larger than later. 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. The period since 2000 is warm, about as warm as the period 1930-1940.

As the HadCRUT4 data series has improved high latitude coverage data coverage (compared to the HadCRUT3 series) the individual 5°x5° grid cells has been weighted according to their surface area. This is in contrast to Gillet et al. 2008 which calculated a simple average, with no consideration to the surface area represented by the individual 5°x5° grid cells.

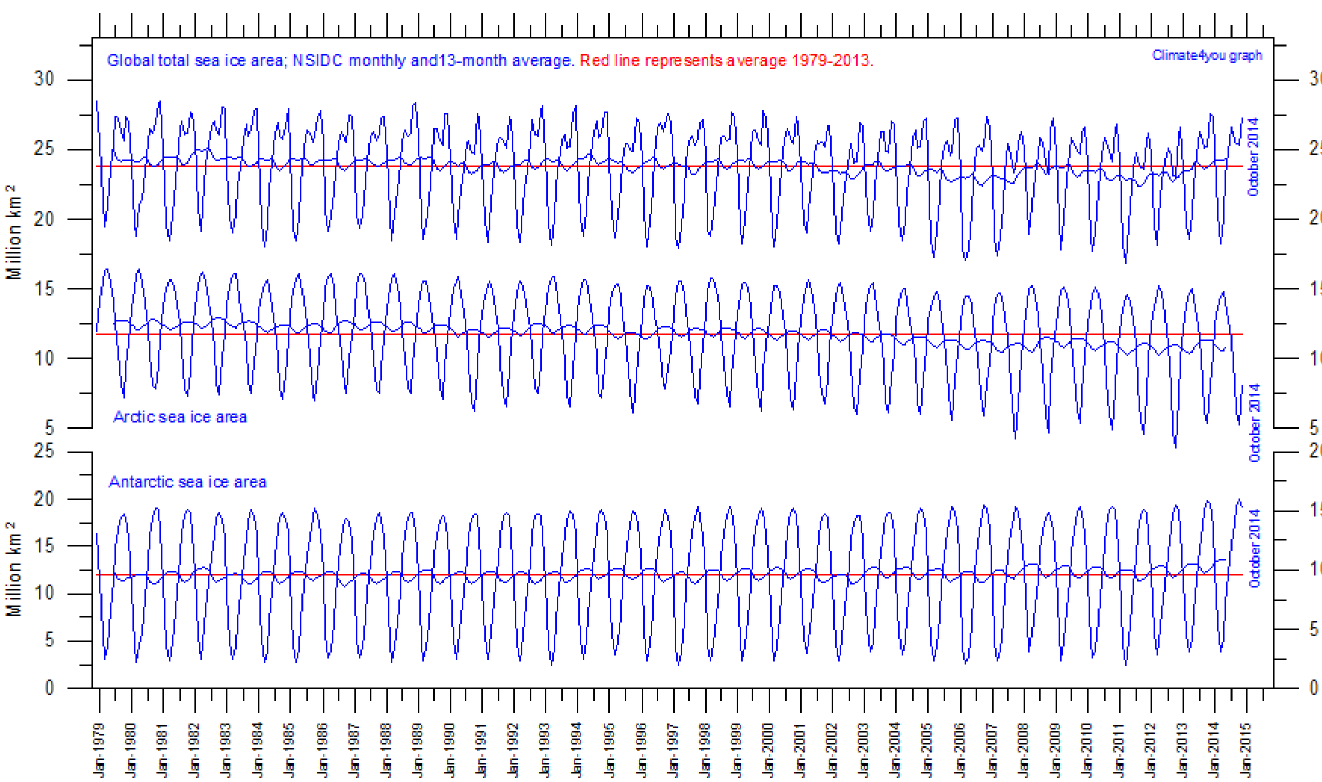
Literature:

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.

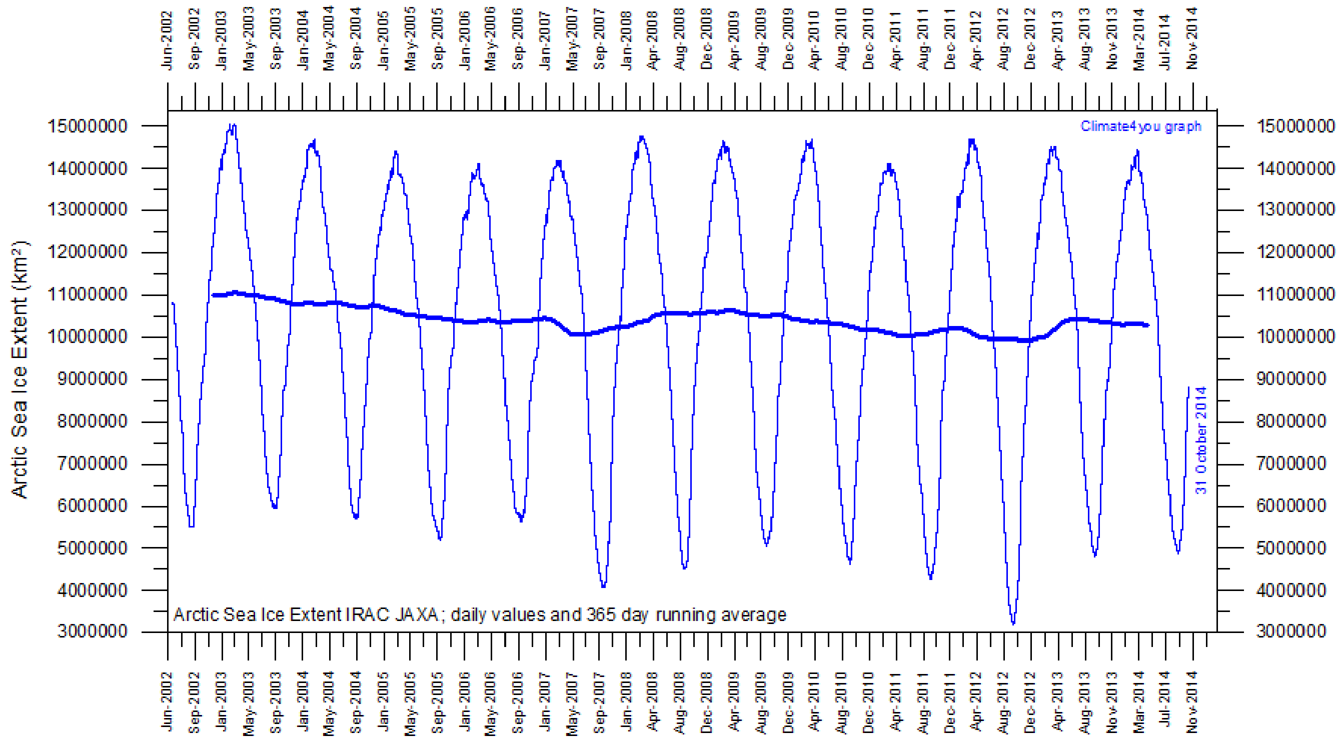
Arctic and Antarctic sea ice, updated to October 2014



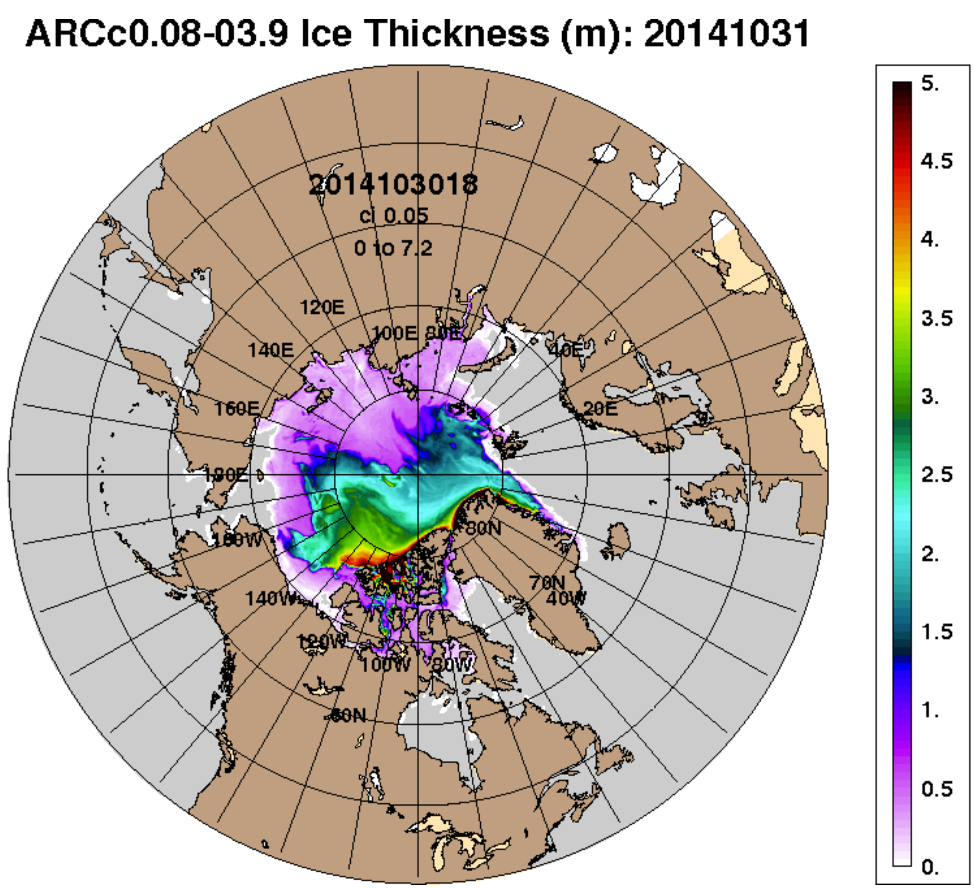
Sea ice extent 30 October 2014. The 'normal' or average limit of sea ice (orange line) is defined as 15% sea ice cover, according to the average of satellite observations 1981-2010 (both years inclusive). Sea ice may therefore well be encountered outside and open water areas inside the limit shown in the diagrams above. Map source: National Snow and Ice Data Center *(NSIDC).*



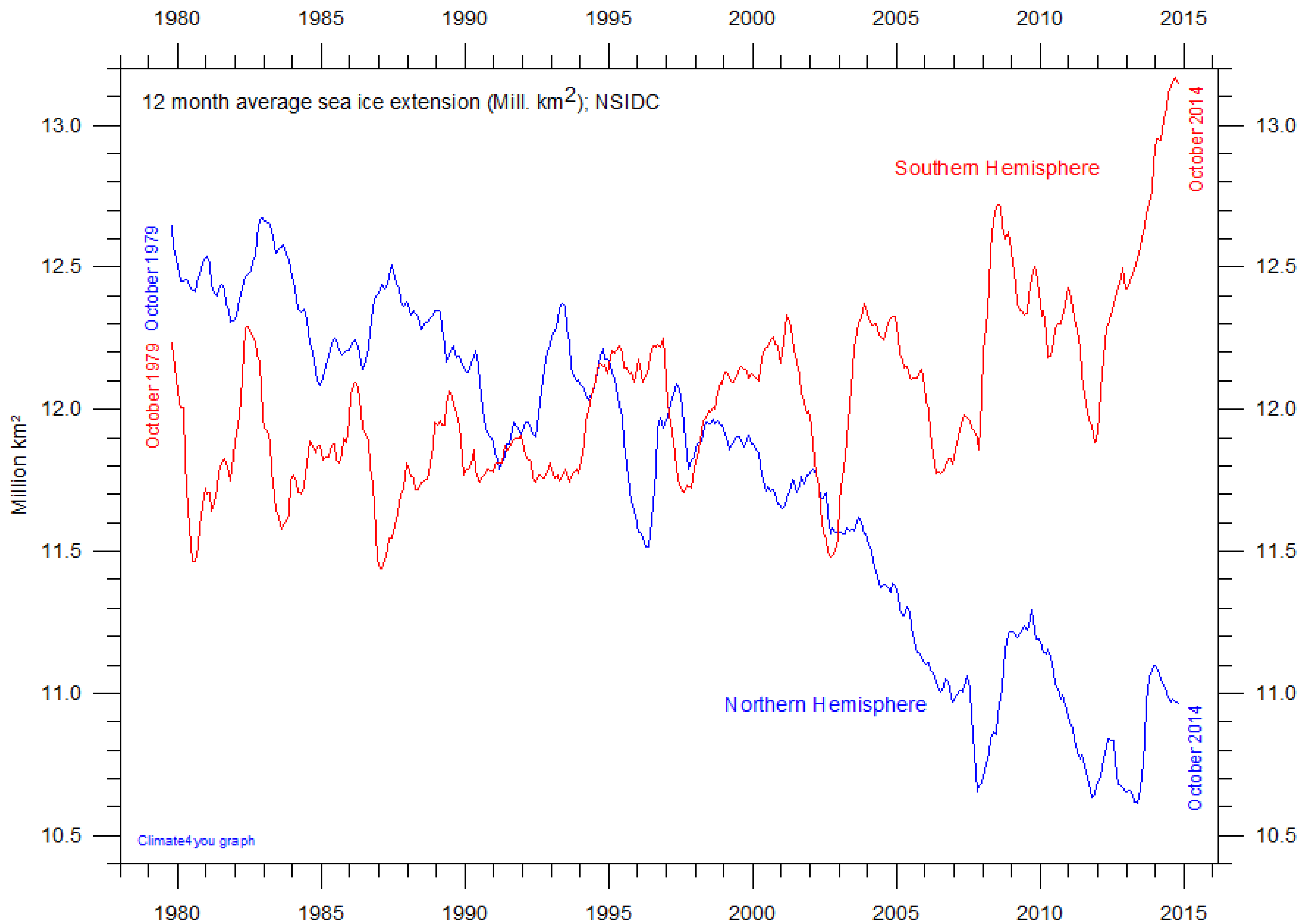
Graphs showing monthly Antarctic, Arctic and global sea ice extent since November 1978, according to the [National Snow and Ice data Center](#) (NSIDC).



Graph showing daily Arctic sea ice extent since June 2002, to 31 October 2014, by courtesy of [Japan Aerospace Exploration Agency](#) (JAXA).

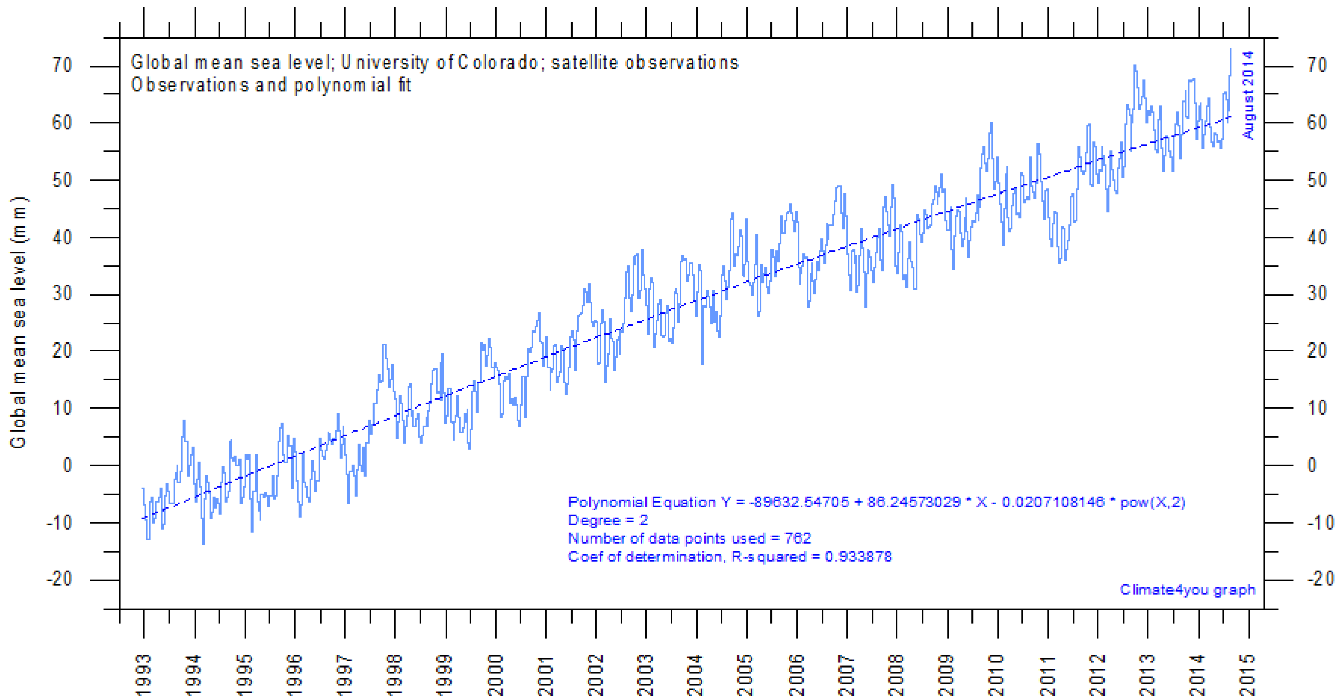


Northern hemisphere sea ice extension and thickness on 31 October 2014 according to the [Arctic Cap Nowcast/Forecast System](#) (ACNFS), US Naval Research Laboratory. Thickness scale (m) to the right.

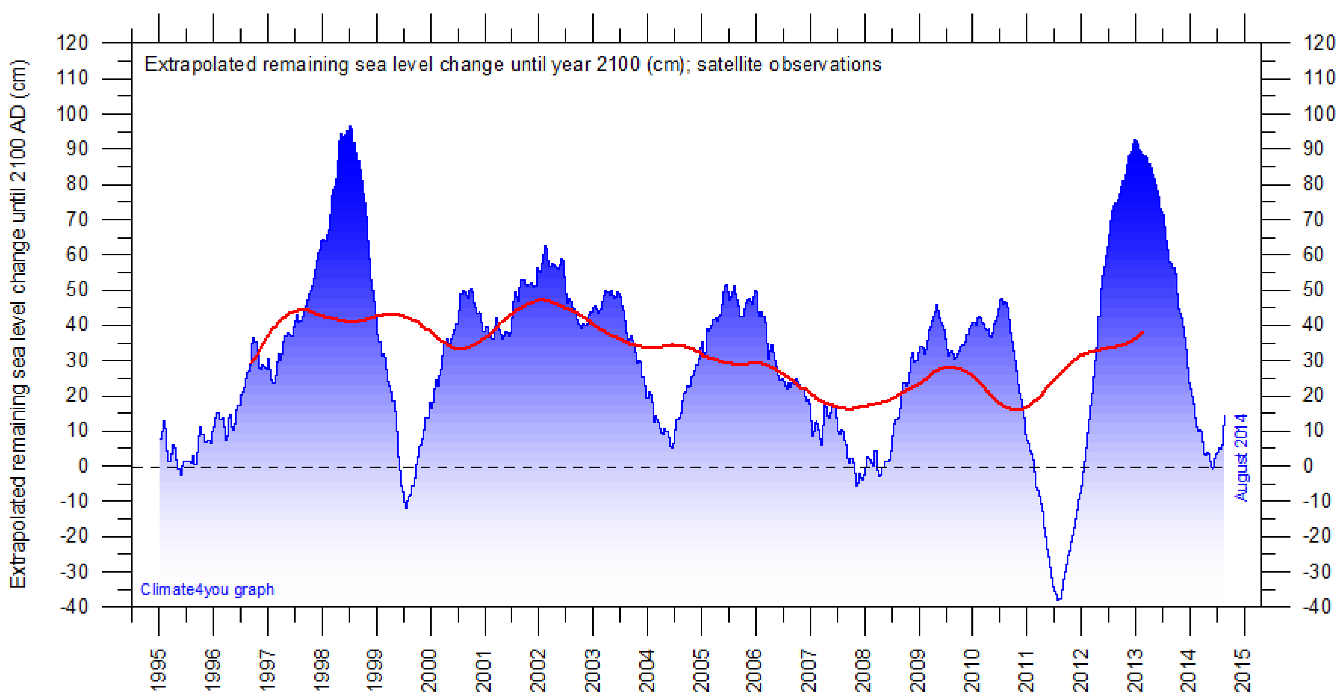


12 month running average sea ice extension in both hemispheres since 1979, the satellite-era. The October 1979 value represents the monthly average of November 1978 - October 1979, the November 1979 value represents the average of December 1978 - November 1979, etc. Last month included in the 12-month calculations: September 2014. Data source: National Snow and Ice Data Center (NSIDC).

Global sea level, updated to August 2014

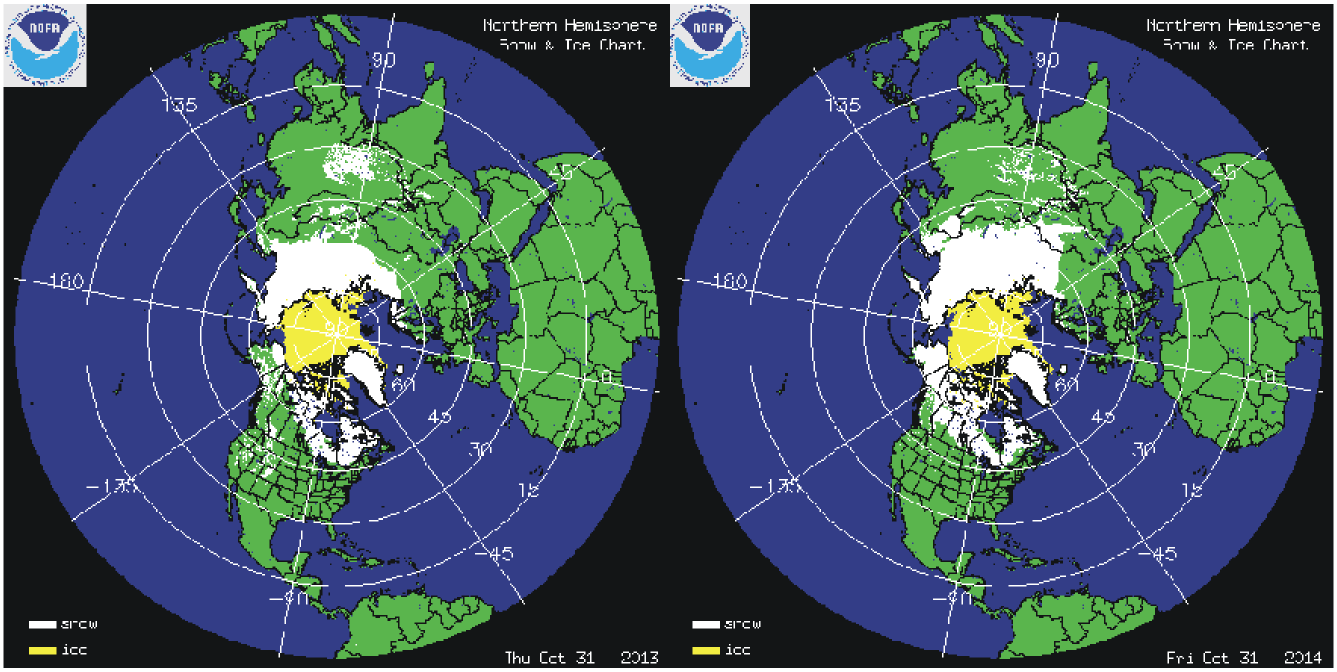


Global sea level (thin line) since late 1992 according to the Colorado Center for Astrodynamics Research at University of Colorado at Boulder. The thick stippled line represents a two-degree polynomium. The polynomium suggests the rate of the ongoing global sea level rise to be slowly decreasing. Time is shown along the x-axis as fractions of calendar years.

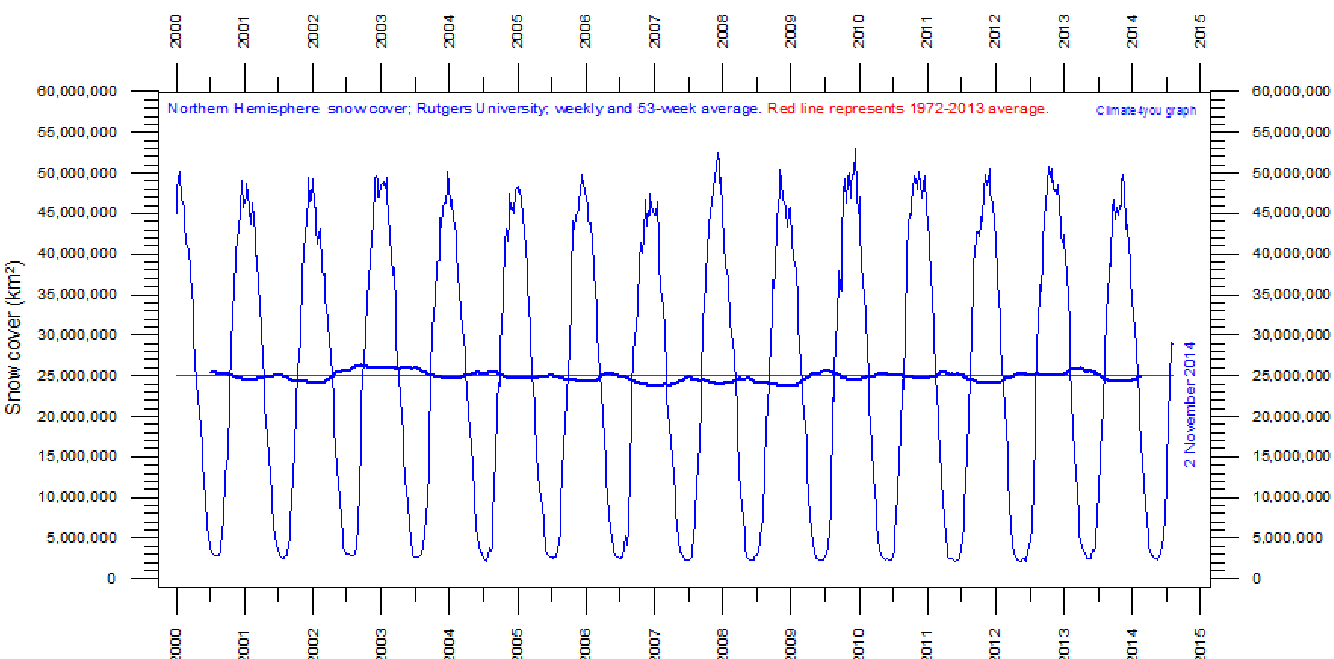


Forecasted change of global sea level until year 2100, based on simple extrapolation of measurements done by the Colorado Center for Astrodynamics Research at University of Colorado at Boulder, USA. The thick line is the simple running 3 yr average forecast for sea level change until year 2100. Based on this (thick line), the present simple empirical forecast of sea level change until 2100 is about +38 cm.

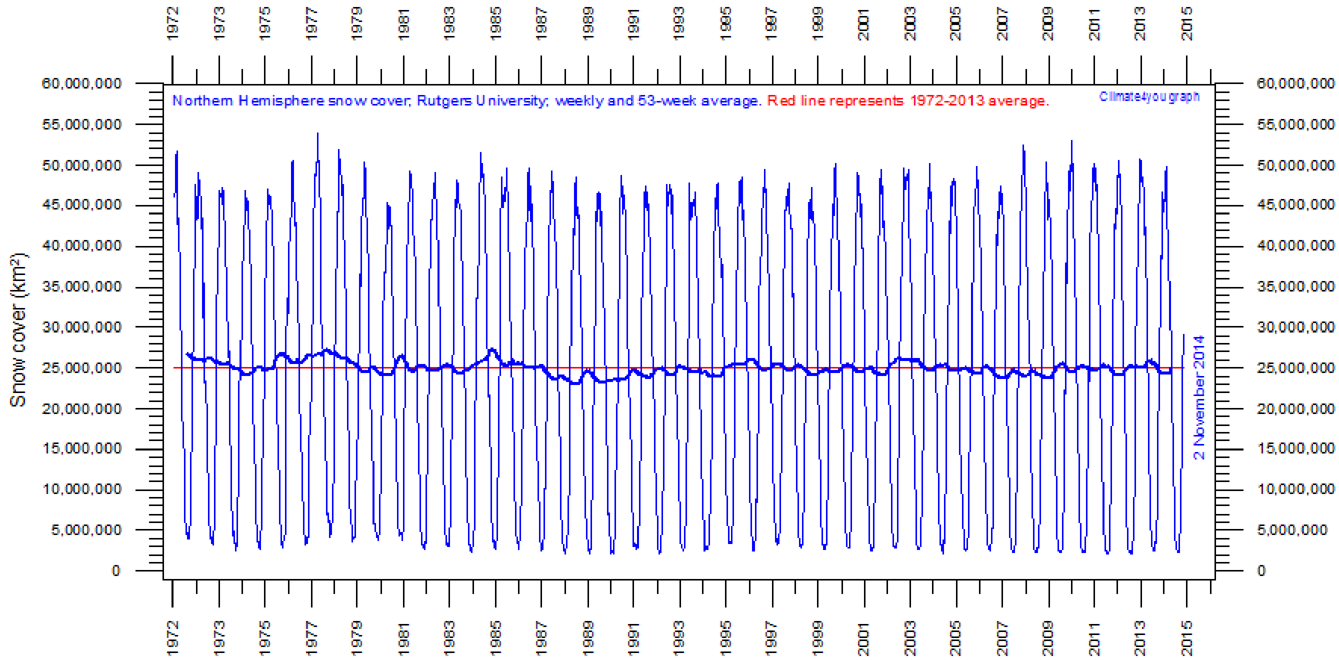
Northern Hemisphere weekly snow cover, updated to late October 2014



Northern hemisphere snow cover (white) and sea ice (yellow) 31 October 2013 (left) and 2014 (right). Map source: [National Ice Center](#) (NIC).

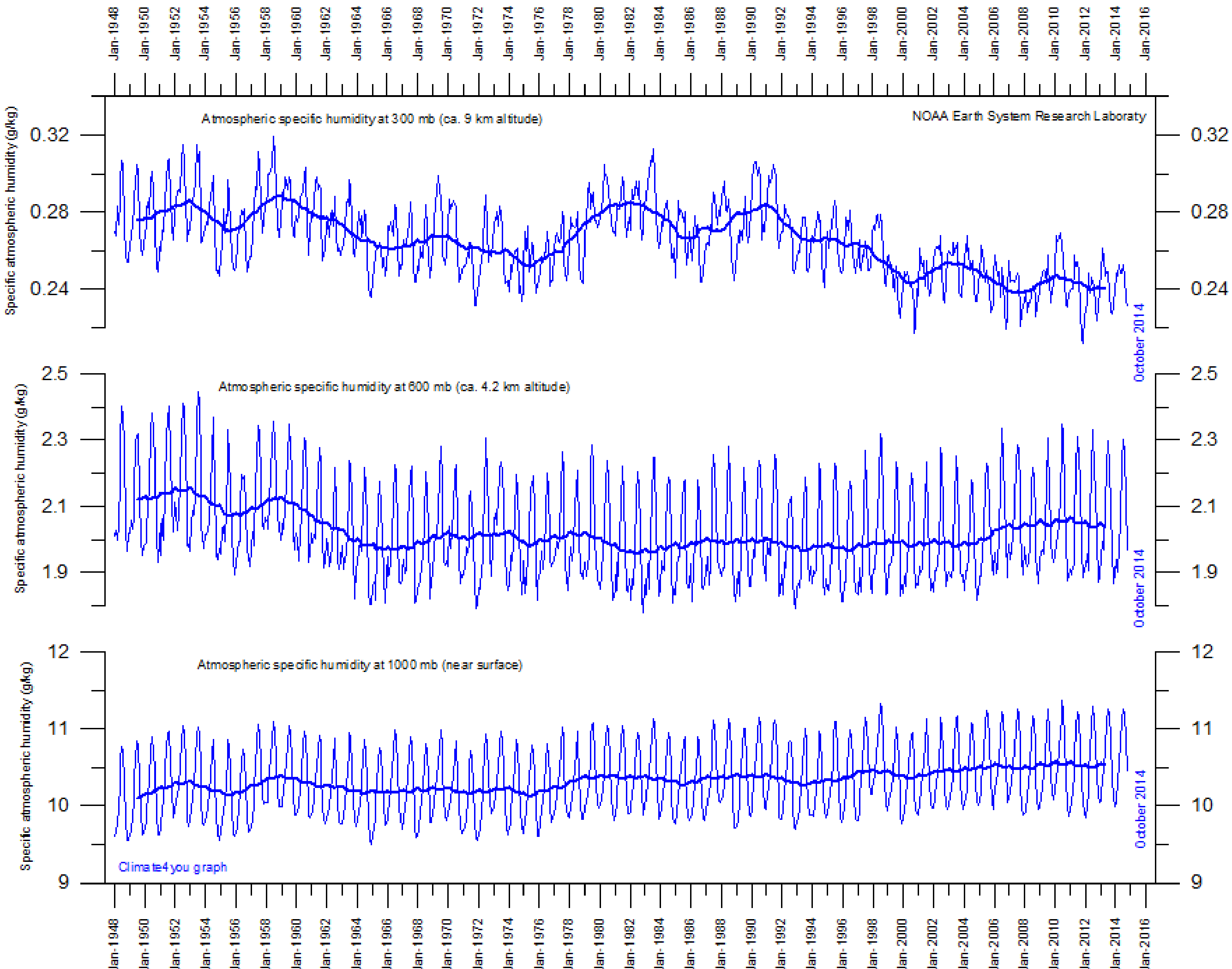


Northern hemisphere weekly snow cover since January 2000 according to Rutgers University Global Snow Laboratory. The thin blue line is the weekly data, and the thick blue line is the running 53-week average (approximately 1 year). The horizontal red line is the 1972-2013 average.



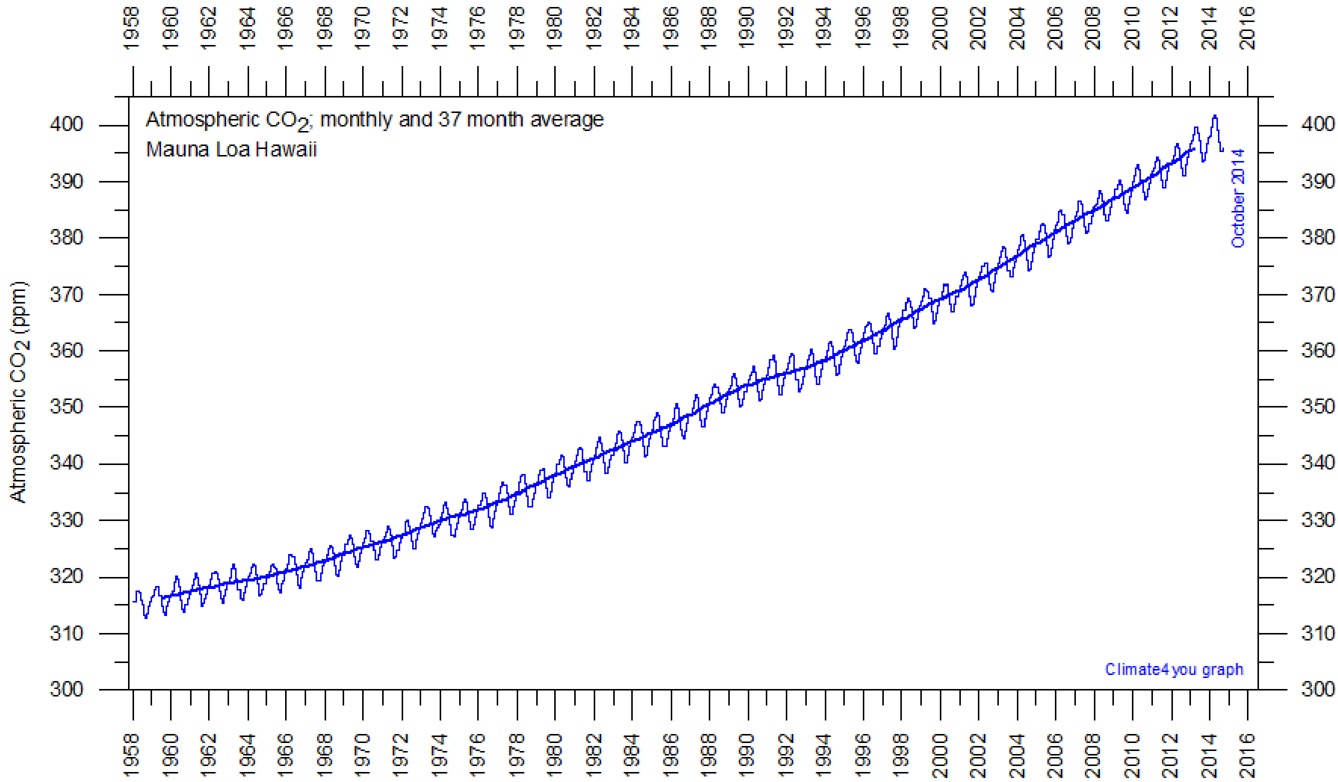
Northern hemisphere weekly snow cover since January 1972 according to Rutgers University Global Snow Laboratory. The thin blue line is the weekly data, and the thick blue line is the running 53-week average (approximately 1 year). The horizontal red line is the 1972-2013 average.

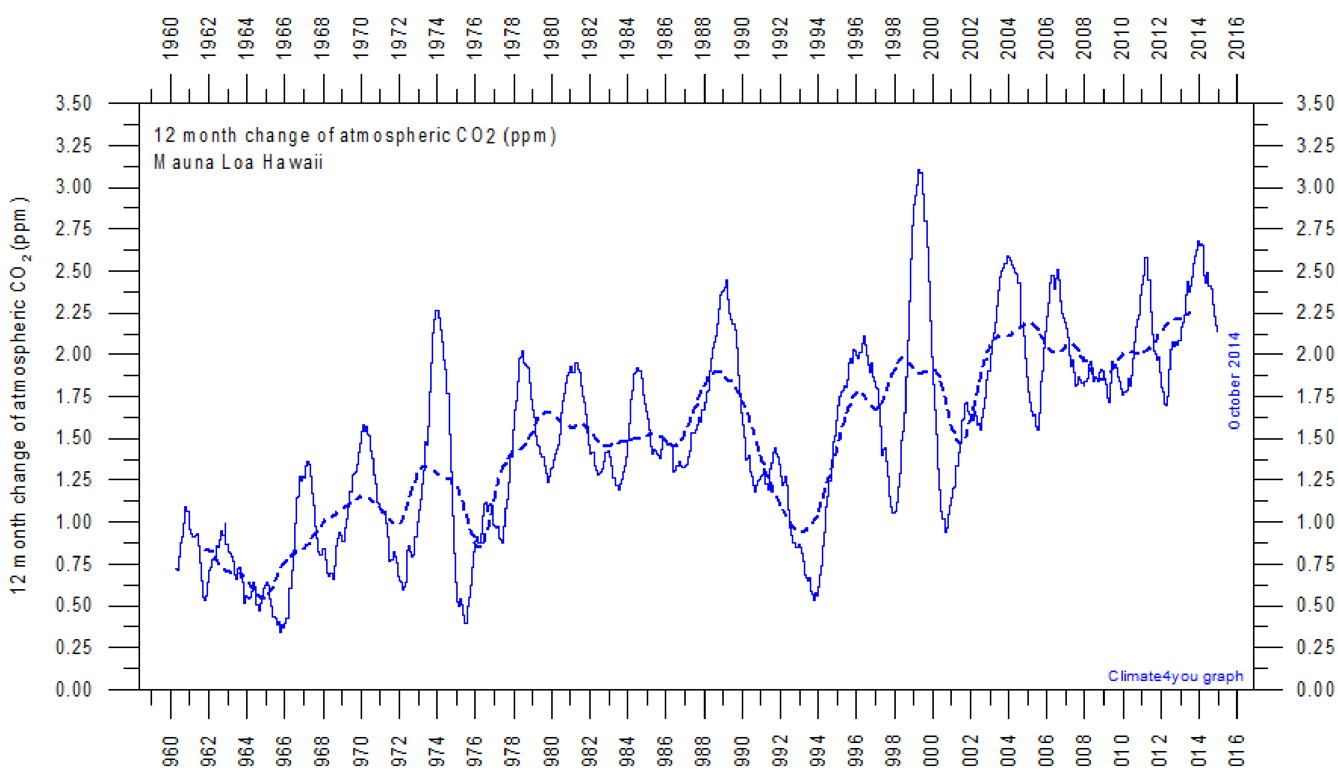
Atmospheric specific humidity, updated to October 2014



Specific atmospheric humidity (g/kg) at three different altitudes in the lower part of the atmosphere (the Troposphere) since January 1948 (Kalnay et al. 1996). The thin blue lines shows monthly values, while the thick blue lines show the running 37-month average (about 3 years). Data source: Earth System Research Laboratory (NOAA).

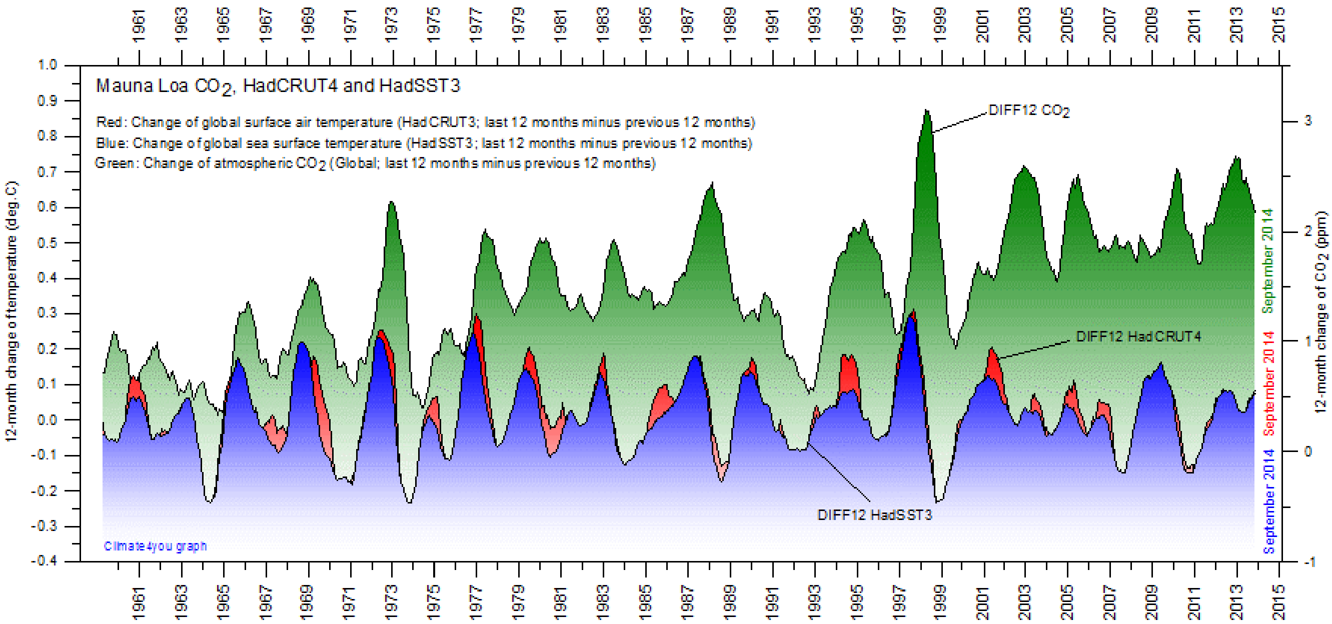
Atmospheric CO_2, updated to October 2014





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

The phase relation between atmospheric CO_2 and global temperature, updated to September 2014



12-month change of global atmospheric CO_2 concentration (Mauna Loa; green), global sea surface temperature (HadSST3; blue) and global surface air temperature (HadCRUT4; red dotted). All graphs are showing monthly values of DIFF12, the difference between the average of the last 12 month and the average for the previous 12 months for each data series.

References:

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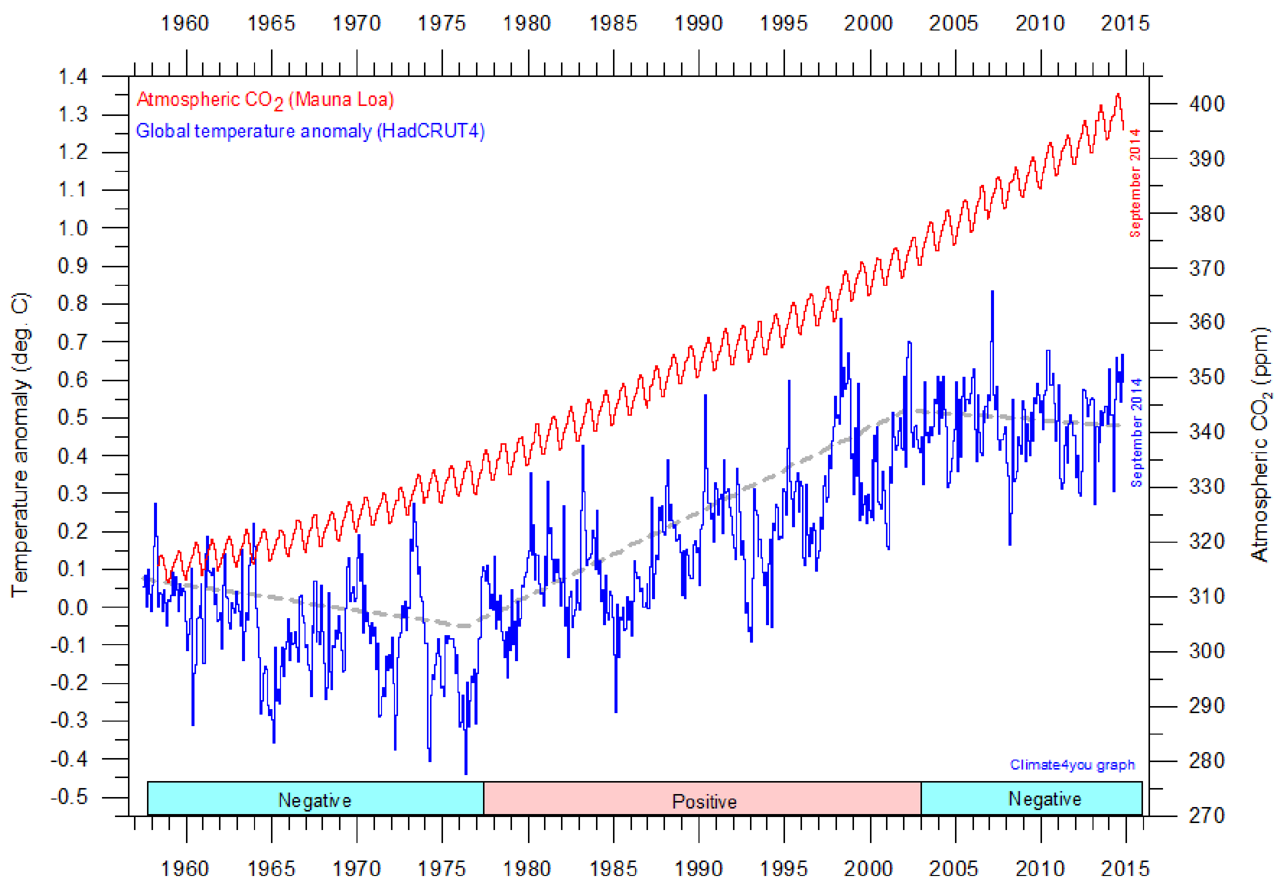
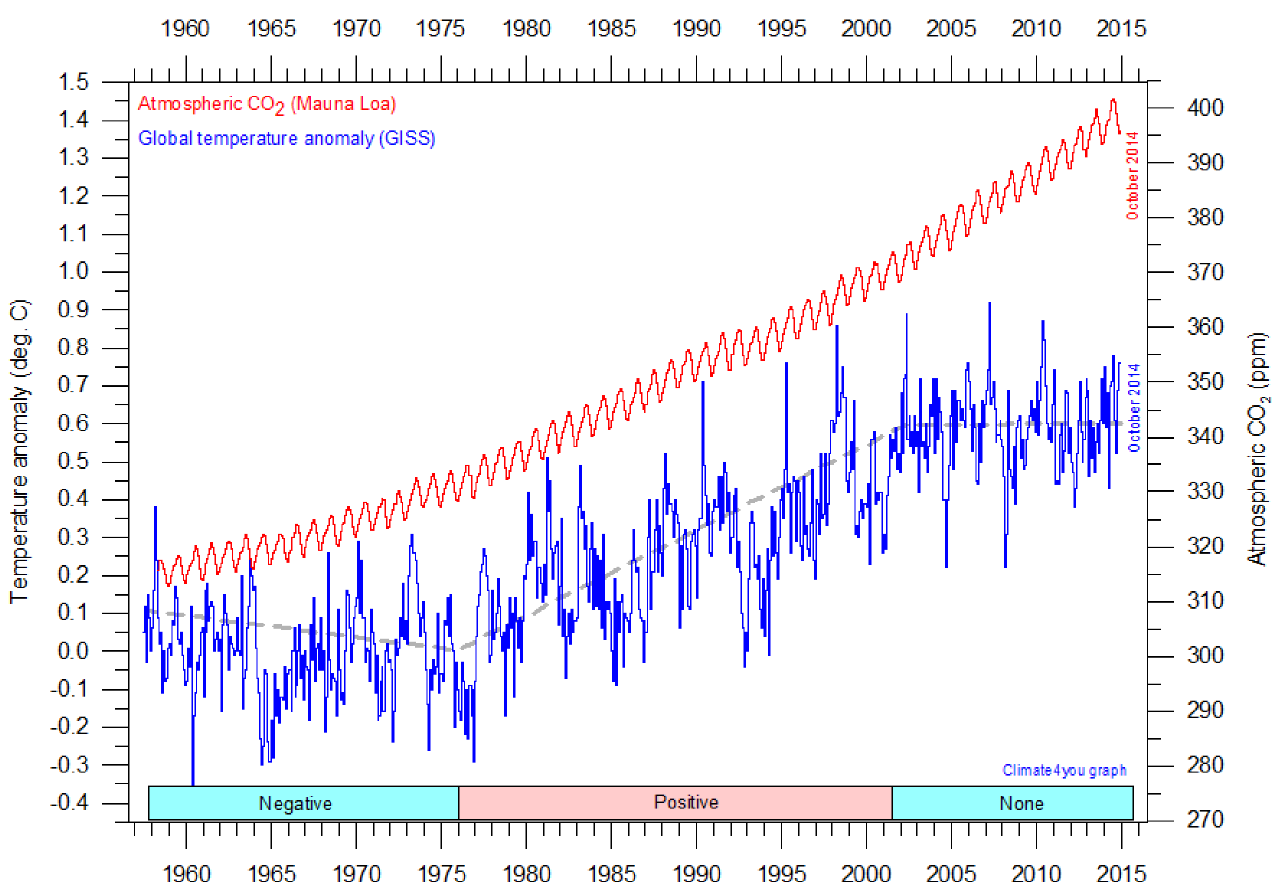
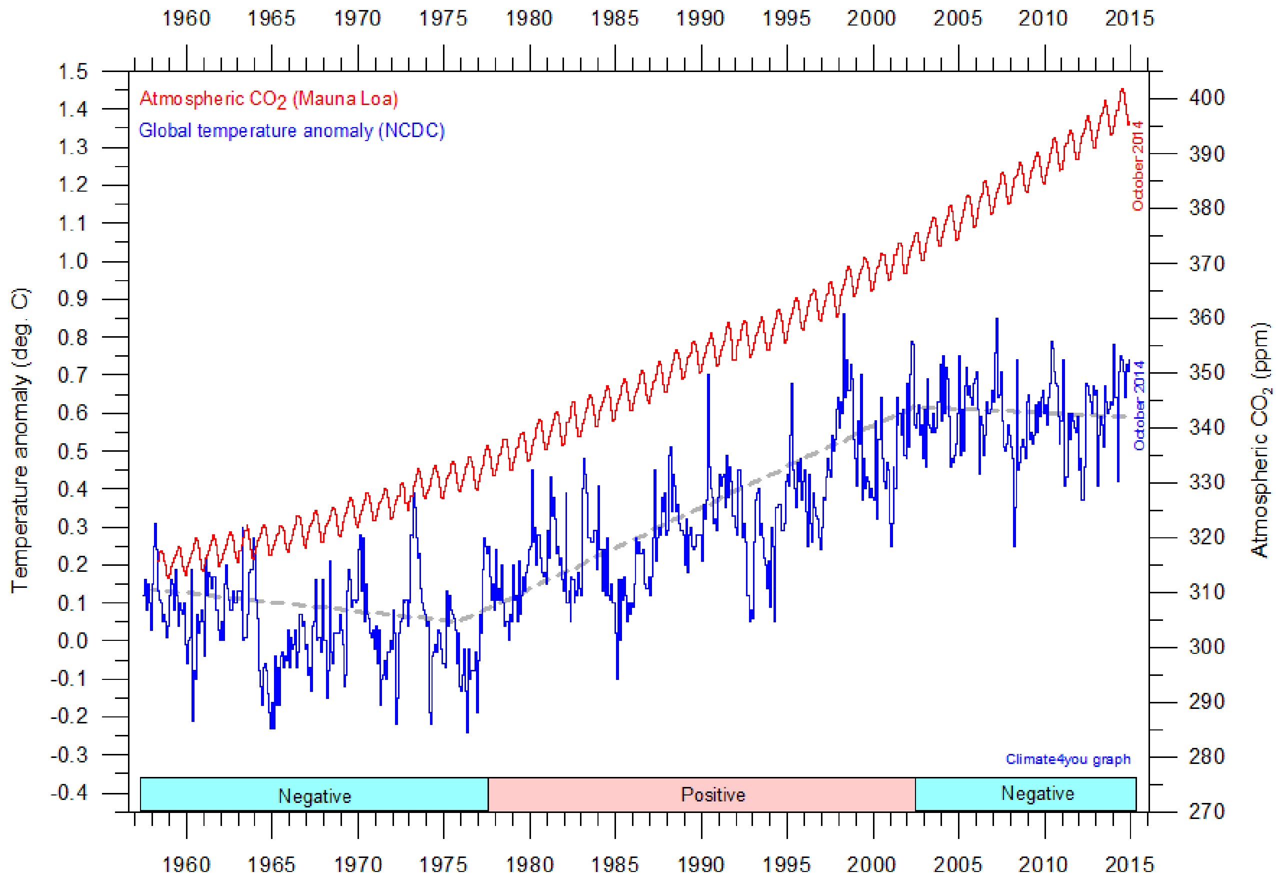
http://www.sciencedirect.com/science/article/pii/S0921818112001658?v=s5

Global surface air temperature and atmospheric CO_2, updated to October 2014







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 was therefore 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 direct 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. Please note that the HadCRUT4 diagram is not yet updated beyond September 2014.

Most climate models assume the greenhouse gas carbon dioxide CO_2 to influence significantly upon global temperature. It is therefore relevant to compare different 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, 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 meteorological record value may well be the result of other phenomena.

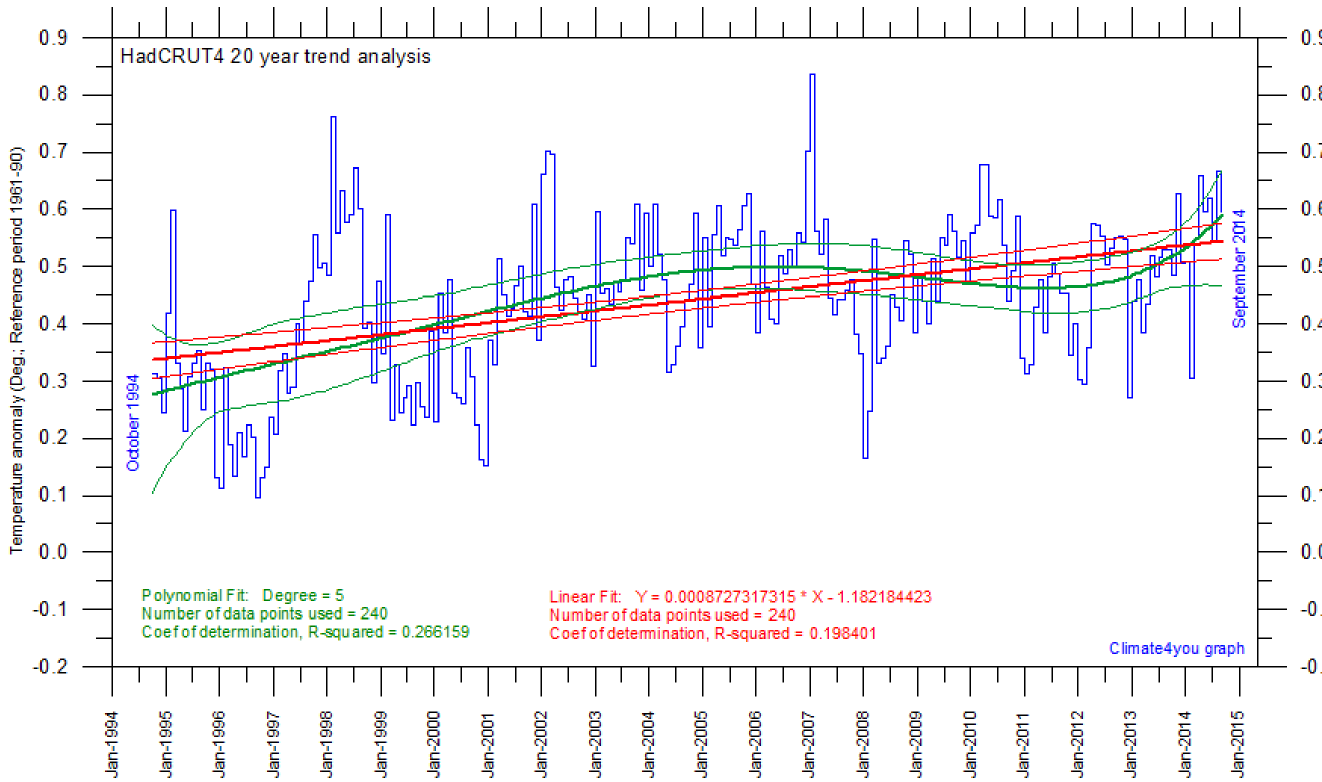
What exactly defines the critical length of a relevant time period to consider for evaluating the alleged importance of CO_2 remains elusive, and is still a topic for discussion. However, the critical period length must be inversely proportional to the temperature sensitivity of CO_2, including feedback effects. If the net temperature effect of atmospheric CO_2 is strong, the critical time period will be short, and vice versa.

However, past climate research history provides some clues as to what has traditionally been considered the relevant length of period over which to compare temperature and atmospheric CO_2. After about 10 years of concurrent global temperature- and CO_2-increase, IPCC was established in 1988. 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, politic support for the hypothesis would have been difficult to obtain.

Based on the previous 10 years of concurrent temperature- and CO_2-increase, many climate scientists in 1988 presumably felt that their understanding of climate dynamics was sufficient to conclude about the importance of CO_2 for global temperature changes. From this it may safely be concluded that 10 years was considered a period long enough to demonstrate the effect of increasing atmospheric CO_2 on global temperatures.

Adopting this approach as to critical time length (at least 10 years), the varying relation (positive or negative) between global temperature and atmospheric CO_2 has been indicated in the lower panels of the diagrams above.

Last 20 year monthly surface air temperature changes, updated to September 2014



Last 20 years global monthly average surface air temperature 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 thin blue line represents the monthly values. The thick red line is the linear fit, with 95% confidence intervals indicated by the two thin red lines. The thick green line represents a 5-degree polynomial fit, with 95% confidence intervals indicated by the two thin green lines. A few key statistics is given in the lower part of the diagram (note that the linear trend is the monthly trend). Please note that the linear regression is done by month, not year.

It is quite often debated if the global surface air temperature still increases, or if the temperature has levelled out during the last 15-18 years. The above diagram may be useful in this context, and demonstrates the differences between two often used statistical approaches to determine recent temperature trends. Please also note that such fits only attempt to describe the past, and usually have limited predictive power. In addition, before using any linear trend (or other) analysis of time series a proper statistical model should be chosen, based on statistical justification.

For temperature time series there is no *a priori* physical reason why the long-term trend should be linear in time. In fact, climatic time series often have trends for which a straight line is not a good approximation, as can clearly be seen from several of the diagrams in the present report.

For an excellent description of problems often encountered by analyses of temperature time series analyses please see Keenan, D.J. 2014: Statistical Analyses of Surface Temperatures in the IPCC Fifth Assessment Report.

Climate and history; one example among many

Kilimanjaro glaciers

The stratovolcano Kilimanjaro (5895 m asl.) in northeastern Tanzania (left). The Furtwängler Glacier on the summit plateau of Kilimanjaro (right). The vertical ice cliffs are about 40 m high.

Mount Kilimanjaro (5895 m asl.) is an inactive stratovolcano in northeastern Tanzania, near the border to Kenya. Kilimanjaro is also the tallest free-standing mountain in the world, rising 4,600 m from the surrounding plains. The first official climb of the highest summit was on October 6, 1889 by the German Hans Meyer, the Austrian Ludwig Purtscheller, guided by the Marangu army scout Yohanas Kinyala.

The glaciers on Mount Kilimanjaro have attracted much recent interest, especially in relation to global temperature changes. The Furtwängler Glacier (see illustration above) is located near the summit, and is a remnant of a bigger icecap which once crowned the summit of Mount Kilimanjaro . This glacier is named after Walter Furtwängler, who along with Ziegfried Koenig, were the fourth to ascend to the summit of Kilimanjaro in 1912. Furtwängler Glacier has lost much of its previous volume since first visited by Meyer and Purtscheller in 1889. Between 1912 and 2000, about 80 percent of the glacier ice on the mountain has disappeared.

A detailed analysis of six ice cores retrieved from the ice fields on the summit of Kilimanjaro shows that those glaciers began forming about 11,700 years ago (Thompson et al. 2002). The ice core records from the Furtwängler Glacier suggests conditions at the Summit of Kilimanjaro today are returning to those characteristic for the site 11,000 years ago.

For decades it has been known that solar radiation and sublimation, not air temperature, are the primary factors for loss of ice from tropical glaciers. In the tropics glaciers exist only at the highest elevations, and their size is controlled more by seasonal changes in precipitation than by air temperatures. Observations of the volume change of glaciers on Kilimanjaro suggest their total volume had already decreased by 66 percent from 1889 to 1953.

The balance between energy inputs and energy outputs are important to understand 20th century glacier reduction at Kilimanjaro. The primary input of energy is short-wave solar radiation, while ice loss is primarily by way of sublimation, the transition of ice directly to water vapor. Because neither solar radiation nor sublimation depends primarily on air temperatures, air temperature change does not have a big role in the loss of ice from tropical glaciers. That this also applies to glaciers on Kilimanjaro can be seen from the fact that the ice on Kilimanjaro forms high vertical walls (see illustration above) and finger-like features called penitents (see illustration below), the result of sublimation driven by direct radiation from the sun, rather than ablation caused by warm air.

Examples of ice and snow penitentes from tropical areas. The individual blades are between 1.5 and 2m in height, but may be as high as several meters. Because penitentes are formed by sublimation driven by direct solar radiation, their axis indicate the approximate position of the sun at noon at this latitude and time of the year. Snow penitentes was first described by Darwin (1839). *The term penitente date back at least to the beginning of the Little Ice Age, referring to Los Penitentes, the flagellant orders in Spain and Italy.*

A prolonged dry period is presumably responsible for the shrinking glaciers on Kilimanjaro. Kaser et al (2004) found that a marked drop in atmospheric moisture at the end of the 19th century and the ensuing drier climatic conditions are likely to represent the main driver for 20th century glacier retreat on Kilimanjaro.

Independent surface observations of water levels from nearby Lake Victoria suggest that water levels have been declining since the end of the 19th century (Thompson et al. 2002), lending support to the notion that the present glacier retreat is caused by more dry conditions, and that the large extent of the glaciers observed by Meyer and Purtscheller in 1889 was the result of a more humid period in eastern Africa at that time, rather than to lower air temperatures.

The ice core from from the Furtwängler Glacier (Thompson et al. 2002) yield evidence of three catastrophic droughts in the tropics 8,300, 5,200 and 4,000 years ago. The ice core also suggest a much wetter environment near Kilimanjaro 9,500 years ago, contemporary with the existence of the large Megalake Chad (see Climate4you update September 2014). The ice core also showed a 500-year period beginning around 8,300 years ago when methane levels in the ice dropped rapidly, suggesting that several lakes of Africa were beginning to dry up. Usually, atmospheric methane levels are assumed to reflect, among other things, the extent of the tropical wetlands.

In addition, the ice core from the Furtwängler Glacier showed an abrupt depletion in oxygen-18 isotopes that may signal a second drought event occurring around 5,200 years ago (Thompson et al.

2002). This coincides with the period when anthropologists believe people in the region began to come together to form cities and social structures. Prior to this, the population of mainly hunters and gatherers had been more scattered. A third marker type in the ice cores is a visible dust layer dating back to about 4,000 years ago (Thompson et al. 2002). This is interpreted as marking a severe 300-year drought which struck the region. Historical records show that a massive drought hit the Egyptian empire at the time and threatened the rule of the Pharaohs. Until this time, people in Africa had been able to exist and thrive in areas that are now just barren Sahara Desert.

The latest scientific development about Mount Kilimanjaro apparently suggests stabilization or perhaps even renewed growth of the glaciers on the famous mountain. Recently, the ETN Global Travel Industry News released the following statement (detailed on Kalte Sonne 2014):

Mount Kilimanjaro Glaciers nowhere near extinction. *The legendary glaciers, one of key tourists ecstasy, on Tanzania's majestic Kilimanjaro mountain, will not melt anytime soon after all, as it was earlier predicted.*

America's renowned climatologist, professor Lonnie Thompson in 2002 projected that the snow on the summit of Africa's highest mountain would completely disappear between 2015 and 2020, thanks to global warming.

But 12 years down the lane now, local ecologists who have been monitoring the trend say the ice, in fact, remains steady and it is nowhere near extinction.

"There are ongoing several studies, but preliminary findings show that the ice is nowhere near melting," said Mount Kilimanjaro National Park (KINAPA)'s Ecologist, Imani Kikoti.

Mr Kikoti hints that sustainable rainfalls supply on Mount Kilimanjaro in recent years could be a factor behind the snow resilient.

"Much as we agree that the snow has declined over centuries, but we are comfortable that its total melt will not happen in the near future," he stressed.

"With the current rate of glaciers melting, if any, I don't see the ice vanishing say in twenty or thirty years to come. For naked eyes you can't tell if there's any changes on the ice quantity from what we've seen ten years ago" Mr Manyanga noted.

He believes that the massive tree planting around the mount Kilimanjaro could have been mitigated the ripple effects of the global warming.

Alarmed by the Prof. Thompson study, way back in 2006, Tanzania President Jakaya Kikwete imposed a total ban on tree harvesting in Kilimanjaro region in a move aimed to halt catastrophic environmental degradation, including melting of ice on Mount Kilimanjaro.

So apparently chances are that the Mount Kilimanjaro glaciers will not disappear in the immediate future, but instead survive. As always, time will show.

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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

Yours sincerely,

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November 21, 2014.