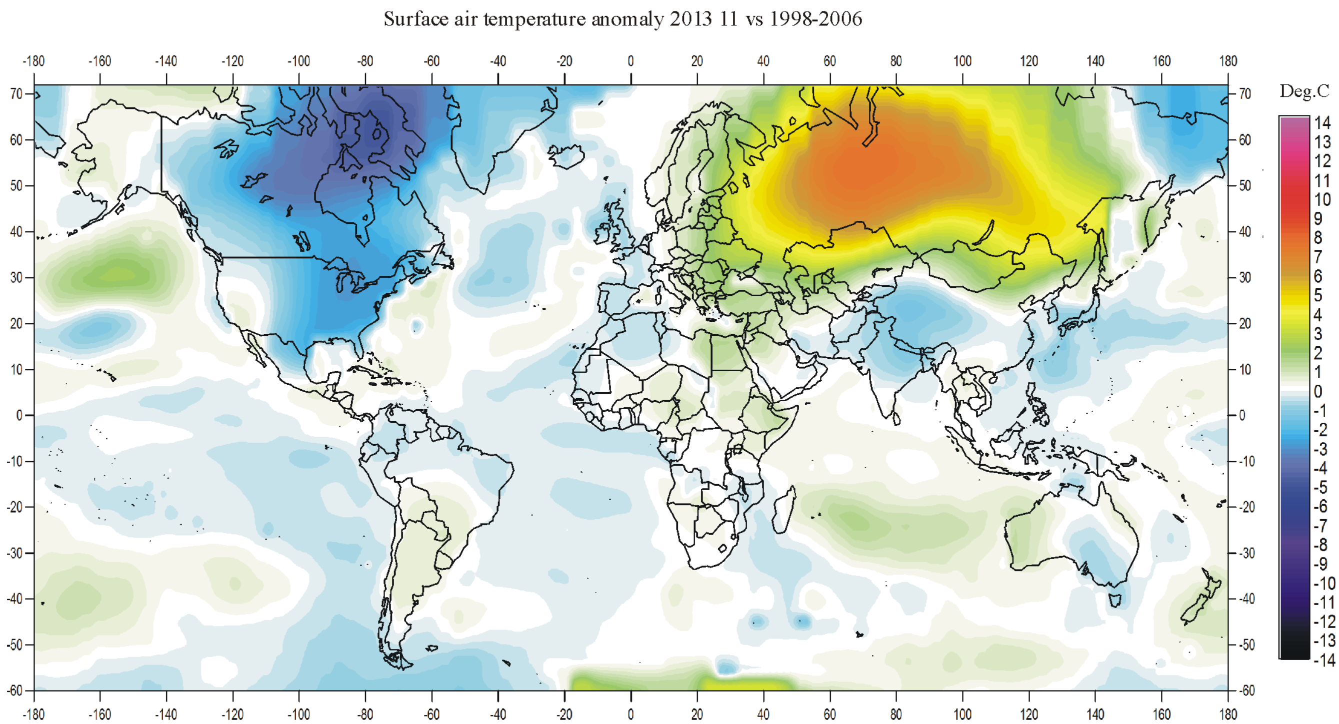
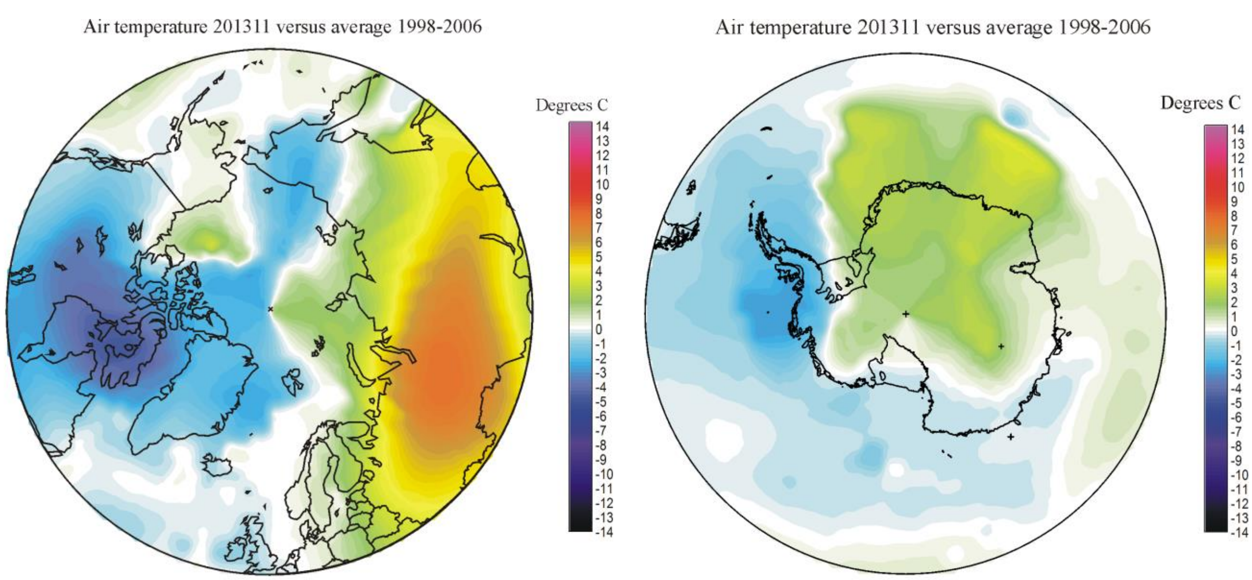
Climate4you update November 2013

Contents:

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

November 2013 global surface air temperature overview





November 2013 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 November 2013 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 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 and where modern surface air temperatures are increasing or decreasing at the moment. Comparing with a more recent period overcomes this problem.

In addition, the GISS temperature data used for preparing the above diagrams show a rather pronounced temporal instability for data before 2000 (see p. 6). Any comparison with the WMO 'normal' period 1961-1990 is therefore influenced by monthly changing values for the so-called 'normal' period, and therefore not suitable as reference using GISS data.

In addition to the above 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, 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.

November 2013 global surface air temperatures

General: In general, global air temperatures were a little above the 1998-2006 average, due to above average temperatures over central Russia. However, the surface air temperature records continue to show dominantly negative temperature trends for the last 5 and 10 years (page 8).

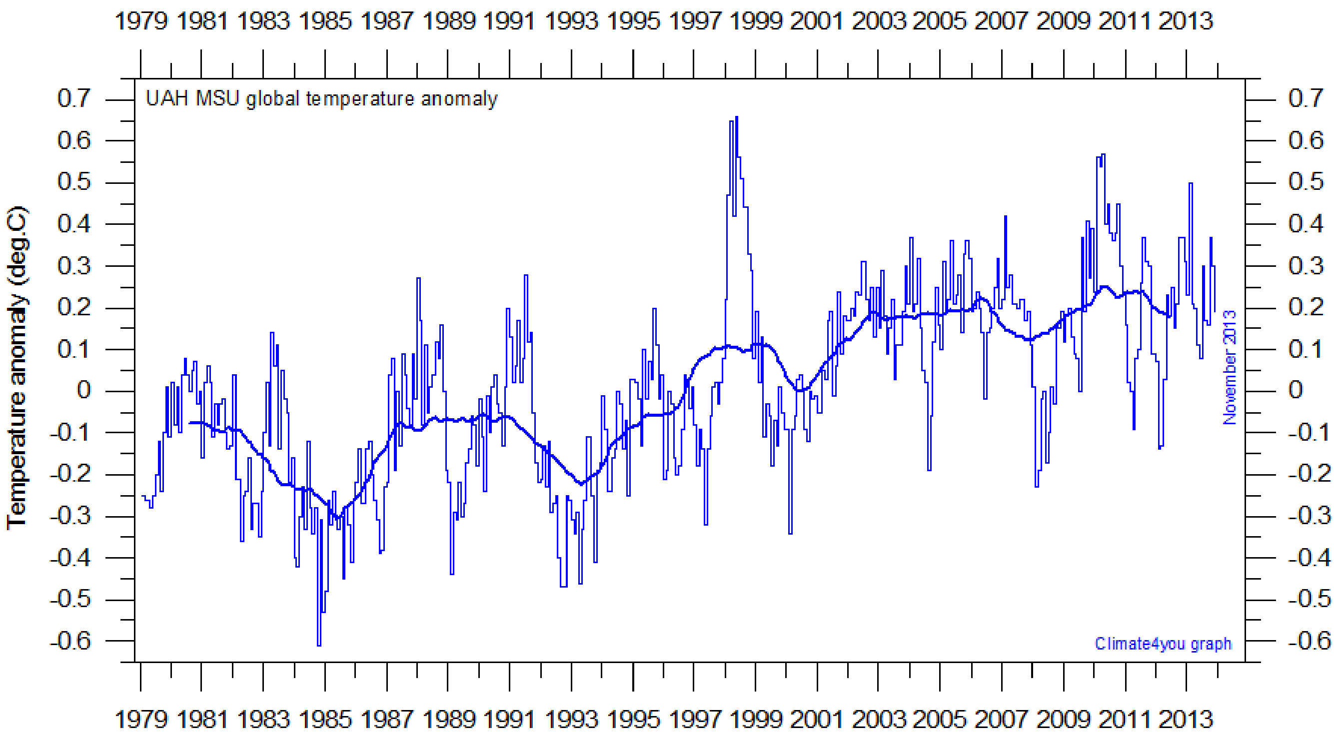
The Northern Hemisphere was characterised by pronounced regional contrasts. Most of North America and eastern Siberia had below average temperatures, while most of Russia had above average temperatures. The North Atlantic and Western Europe mainly had temperatures near or below average. Most of the Arctic has below average temperatures, with the exception of the Russian sector west of 150^{o}E, which had above average 1998-2006 temperatures.

Near Equator temperatures conditions were generally below or near the 1998-2006 average.

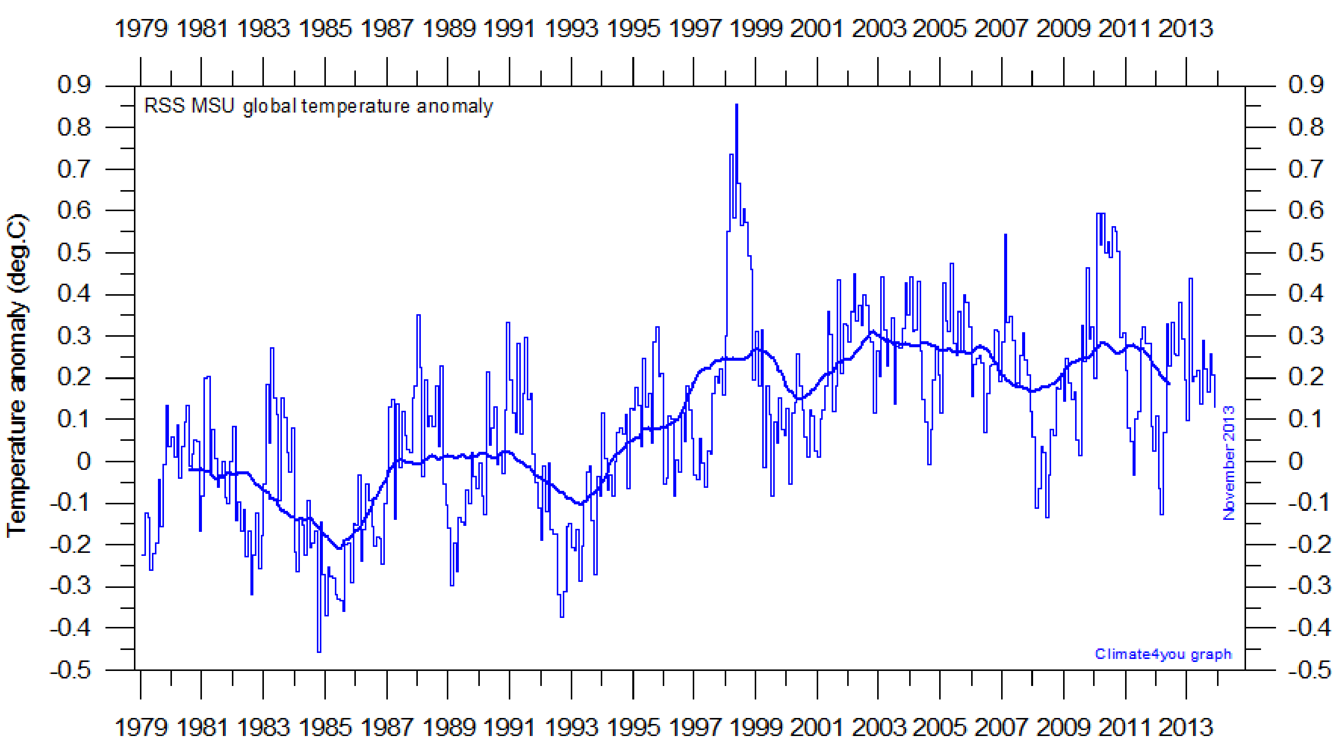
The Southern Hemisphere temperatures was mainly below or near average 1998-2006 conditions. The only major exception from this was extensive parts of East Antarctic and adjoining coastal regions.

The global oceanic heat content has been rather stable since 2003/2004, although with a small upward trend (page 13).

Lower troposphere temperature from satellites, updated to November 2013

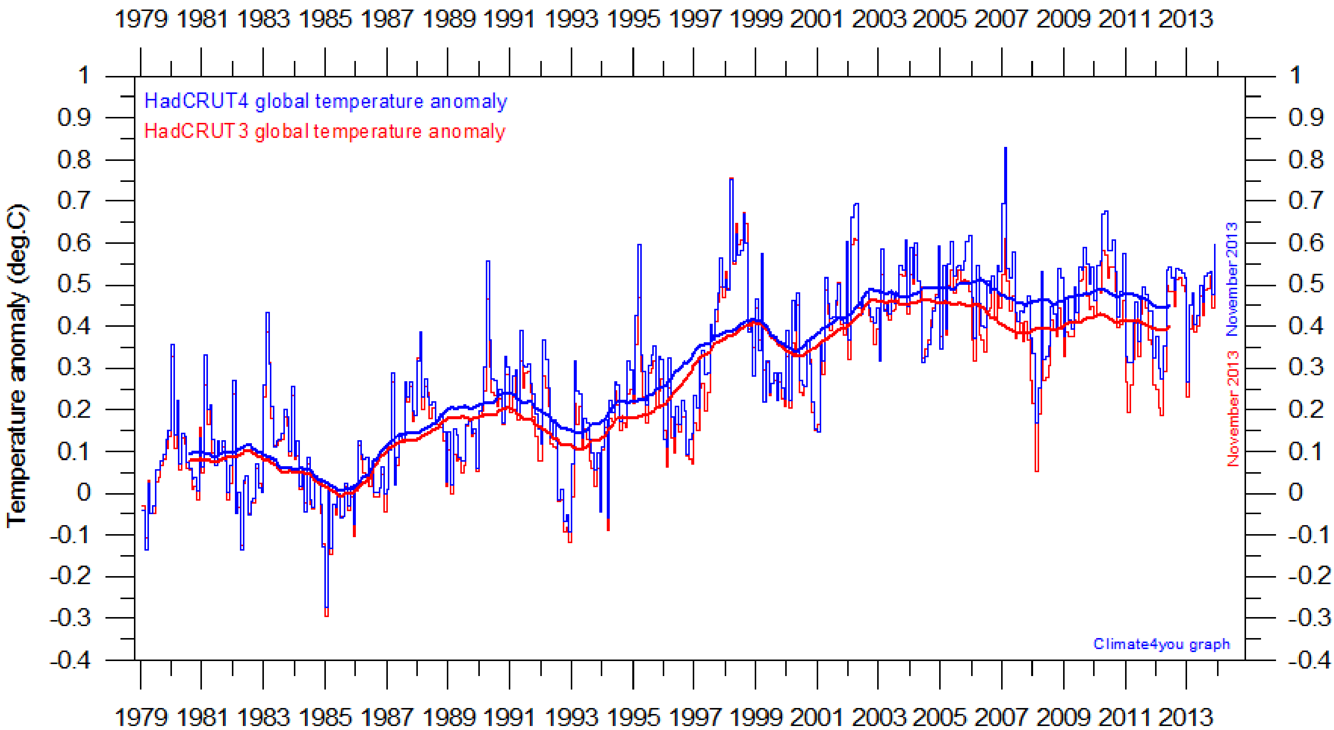


Global monthly average lower troposphere temperature (thin line) since 1979 according to University of Alabama at Huntsville, USA. The thick line is the simple running 37 month average.

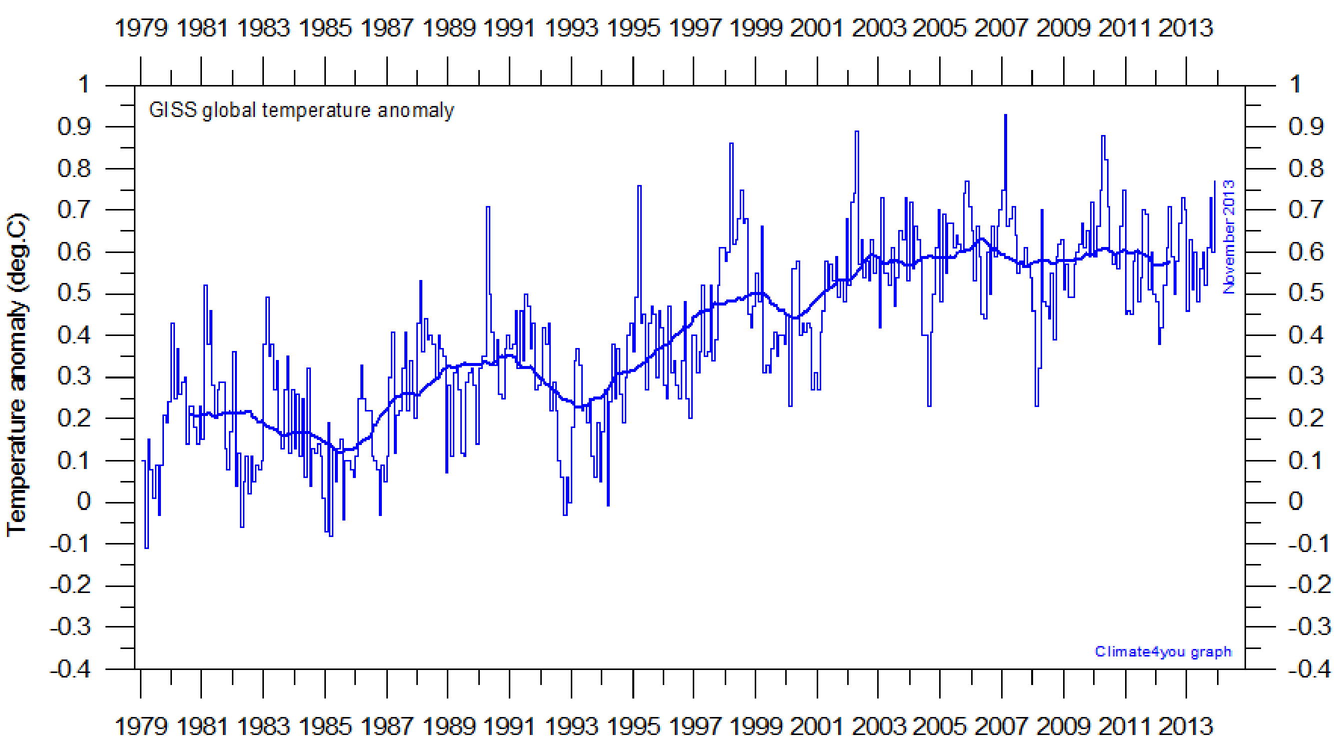


Global monthly average lower troposphere temperature (thin line) since 1979 according to according to Remote Sensing Systems (RSS), USA. The thick line is the simple running 37 month average.

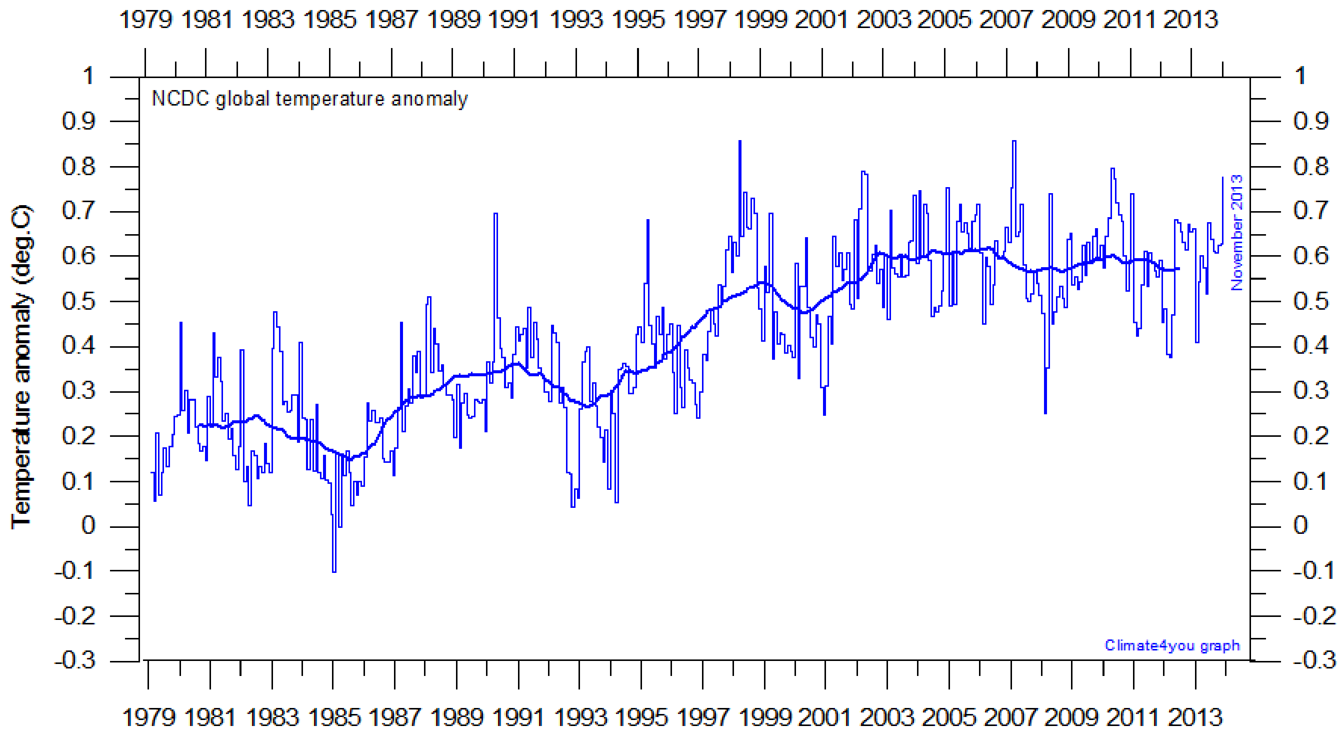
Global surface air temperature, updated to November 2013



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).



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. Presumably this reflects recognition of errors, changes in the averaging procedure, and the influence of other phenomena.

None of the temperature records are 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 means.

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

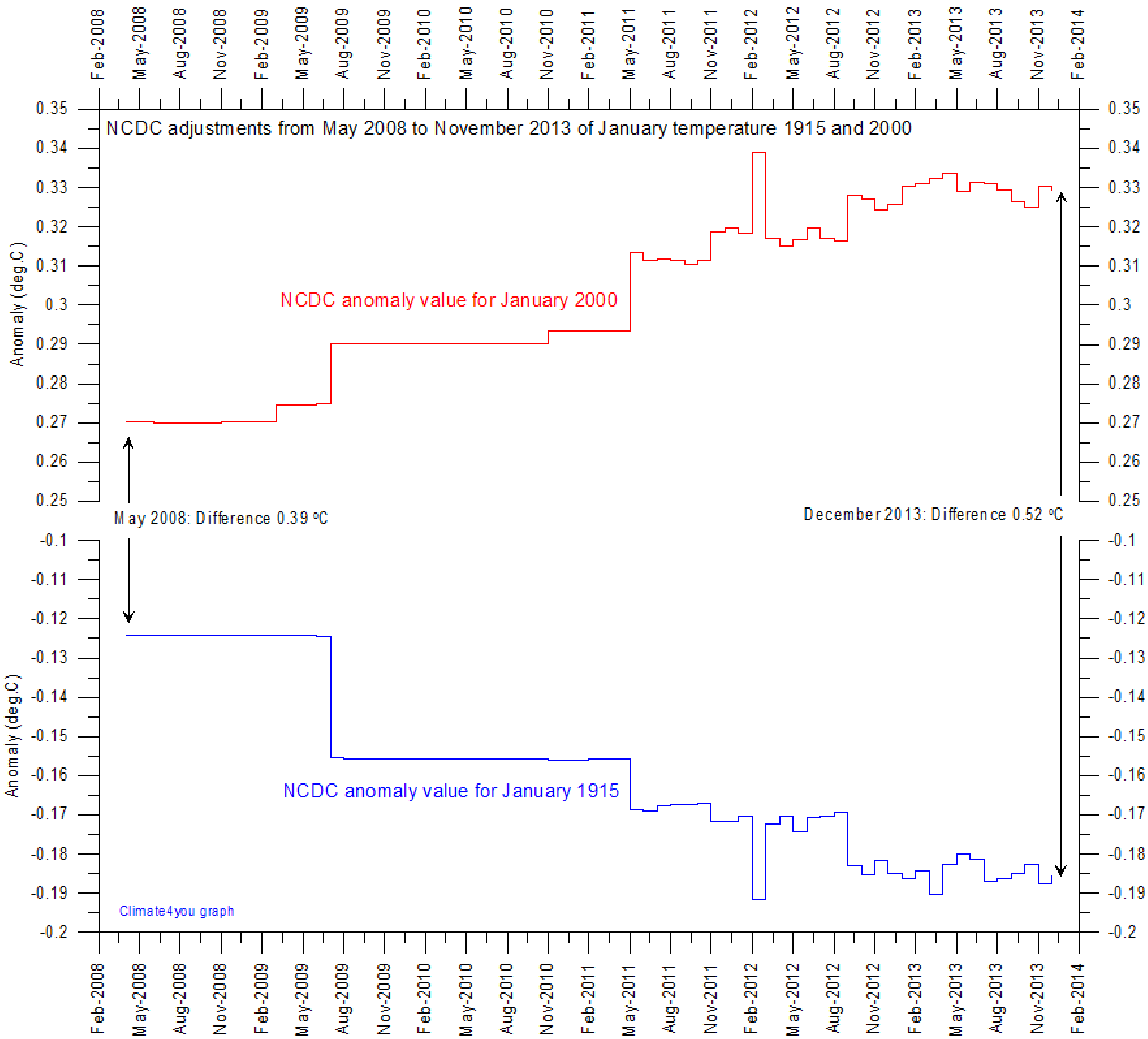


Diagram showing the adjustment made since May 2008 by the National Climatic Data Center (NCDC) in the anomaly values for the two months January 1915 and January 2000.

<u>September 2013:</u> By administrative means the July 2013 temperature increase from January 1915 to January 2000 has increased from 0.39 to 0.51 °C, representing an about 31% increase of the original temperature increase reported in May 2008.

Global surface air temperature linear trends

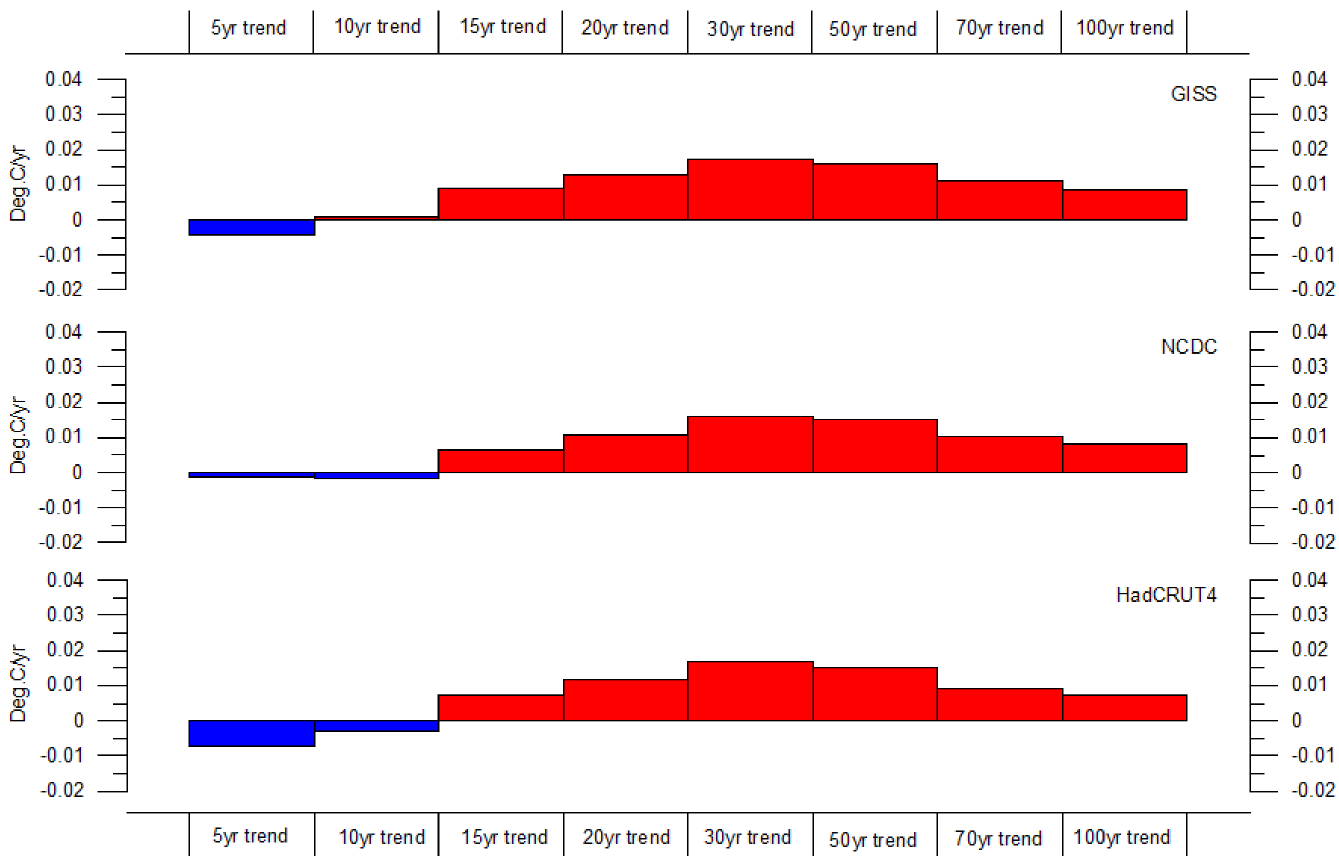
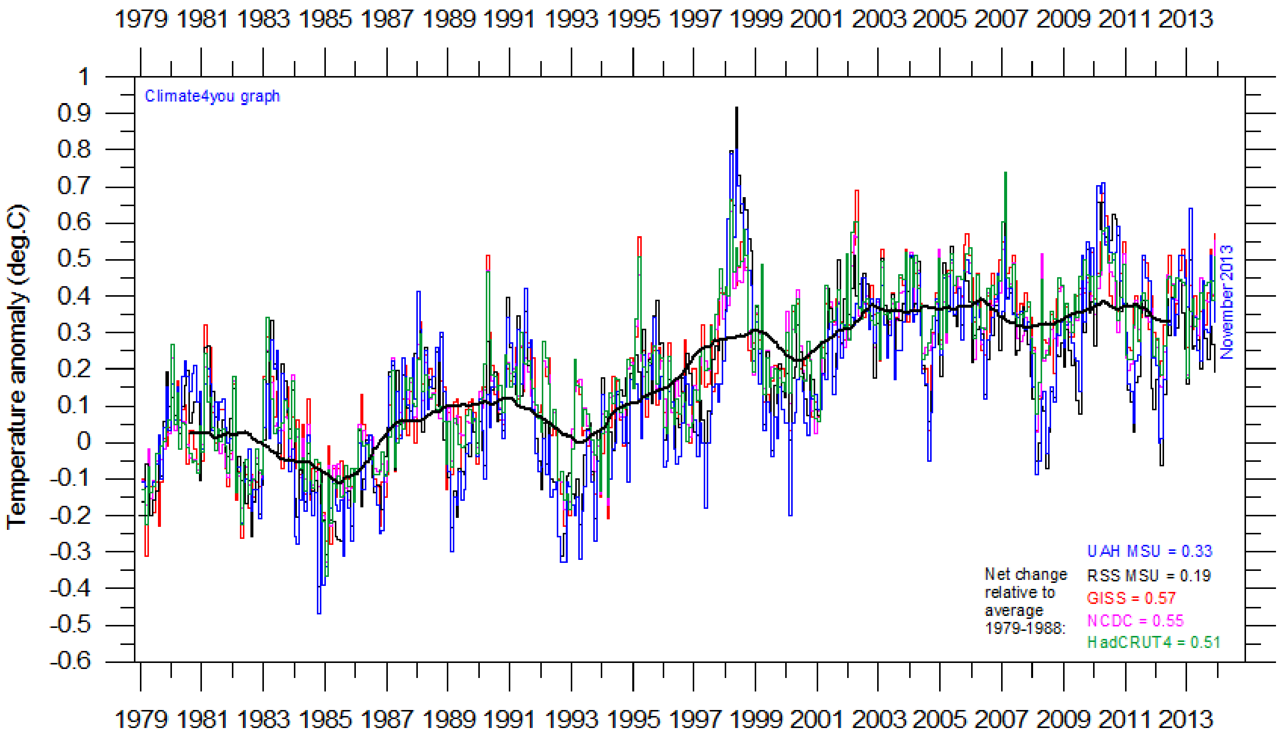


Diagram showing the latest 5, 10, 20, 30, 50, 70 and 100 year linear annual global temperature trend, calculated as the slope of the linear regression line through the data points, for three surface-based temperature estimates (GISS, NCDC and HadCRUT4). Last month included in all analyses: November 2013.

[All in one, updated to November 2013]

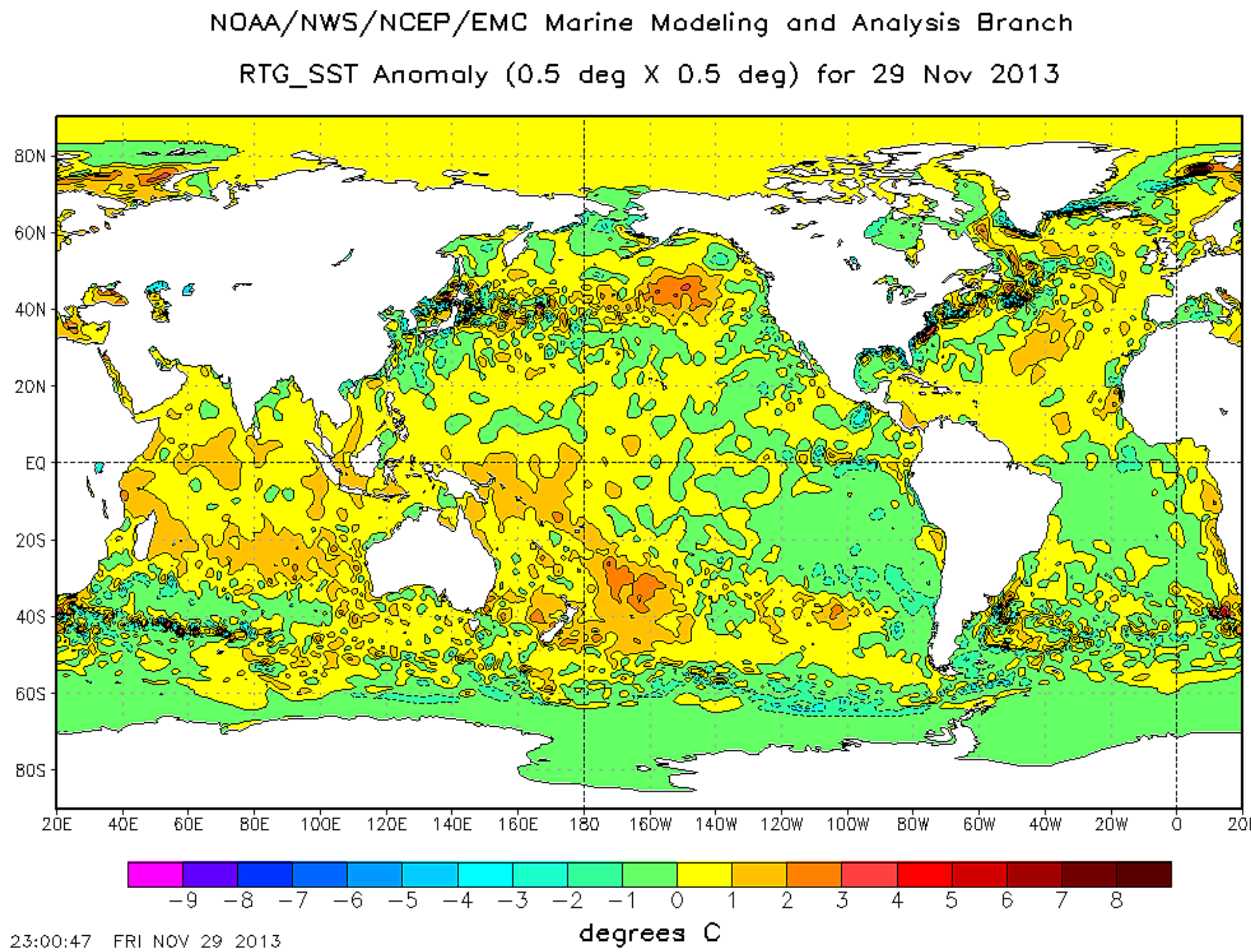


Superimposed plot of all five global monthly temperature estimates. As the base period differs for the individual temperature estimates, they have all been normalised by comparing with the average value of the initial 120 months (10 years) from January 1979 to December 1988. The heavy black line represents 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 in principle may be 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 within the coming years. Time will show which of these two possibilities is correct.

Global sea surface temperature, updated to November 2013



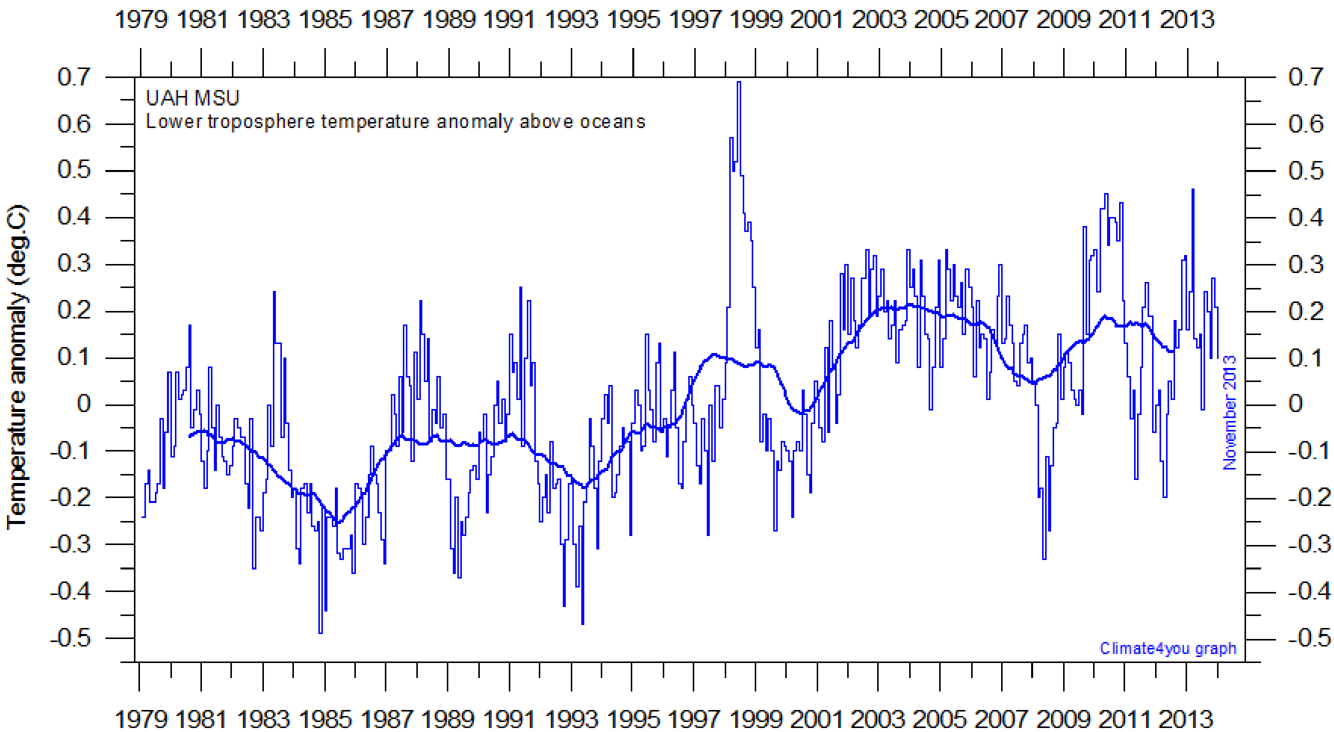
Sea surface temperature anomaly on 29 November 2013. Map source: National Centers for Environmental Prediction (NOAA).

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.3-5).

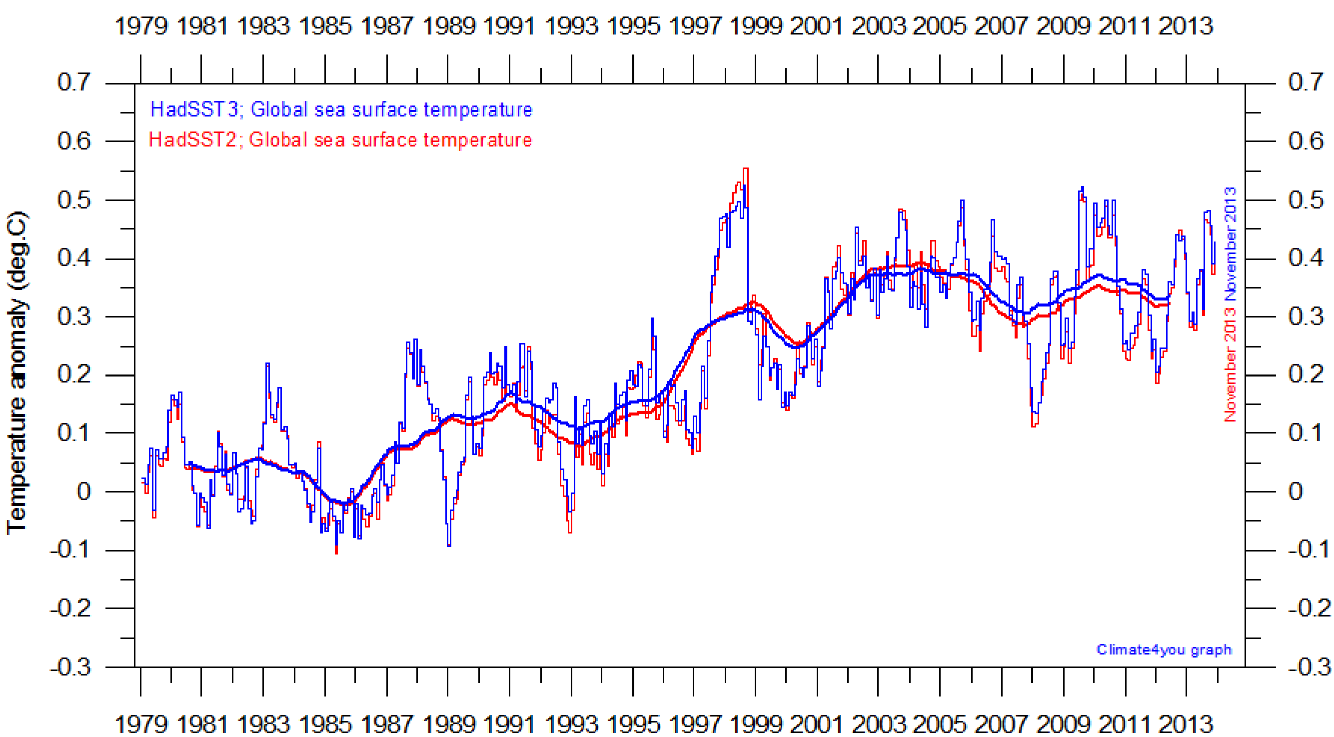
Relatively cold water is slowly spreading across the Pacific Ocean near the Equator, and may influence global air temperatures in the months to come.

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.

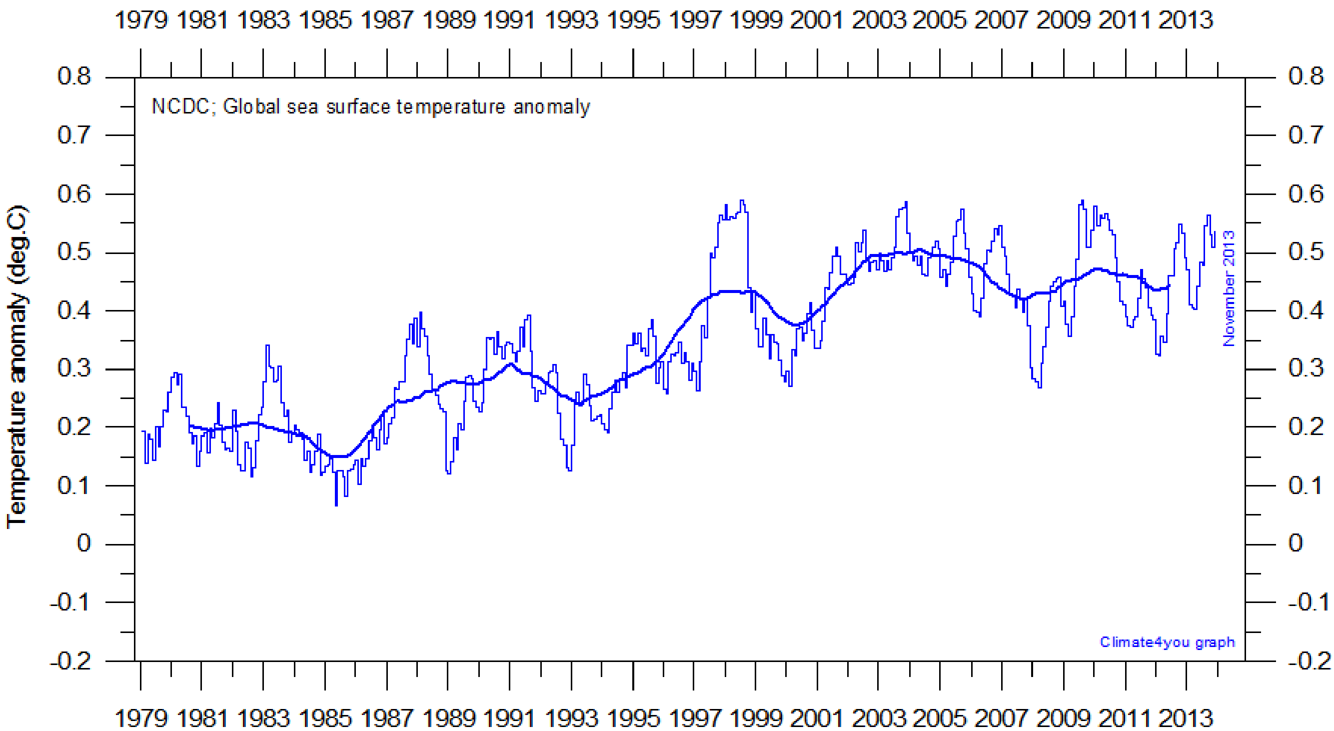
However, this does not reflect similar changes in the total heat content of the atmosphere-ocean system. In fact, global net changes can be small and such heat exchanges may mainly reflect redistribution of energy between ocean and atmosphere. What matters is the overall temperature development when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

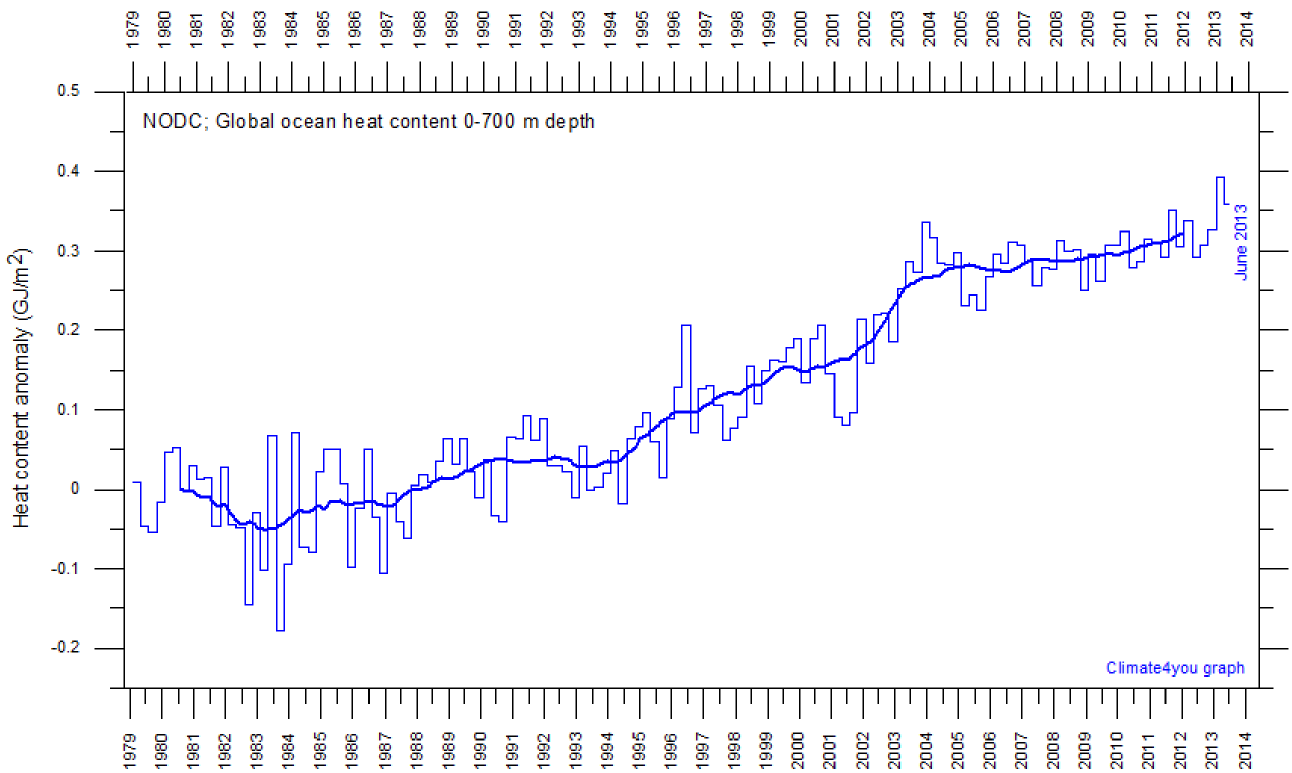


Global monthly average sea surface temperature since 1979 according to University of East Anglia's Climatic Research Unit (CRU), UK. Base period: 1961-1990. The thick line is the simple running 37 month average.

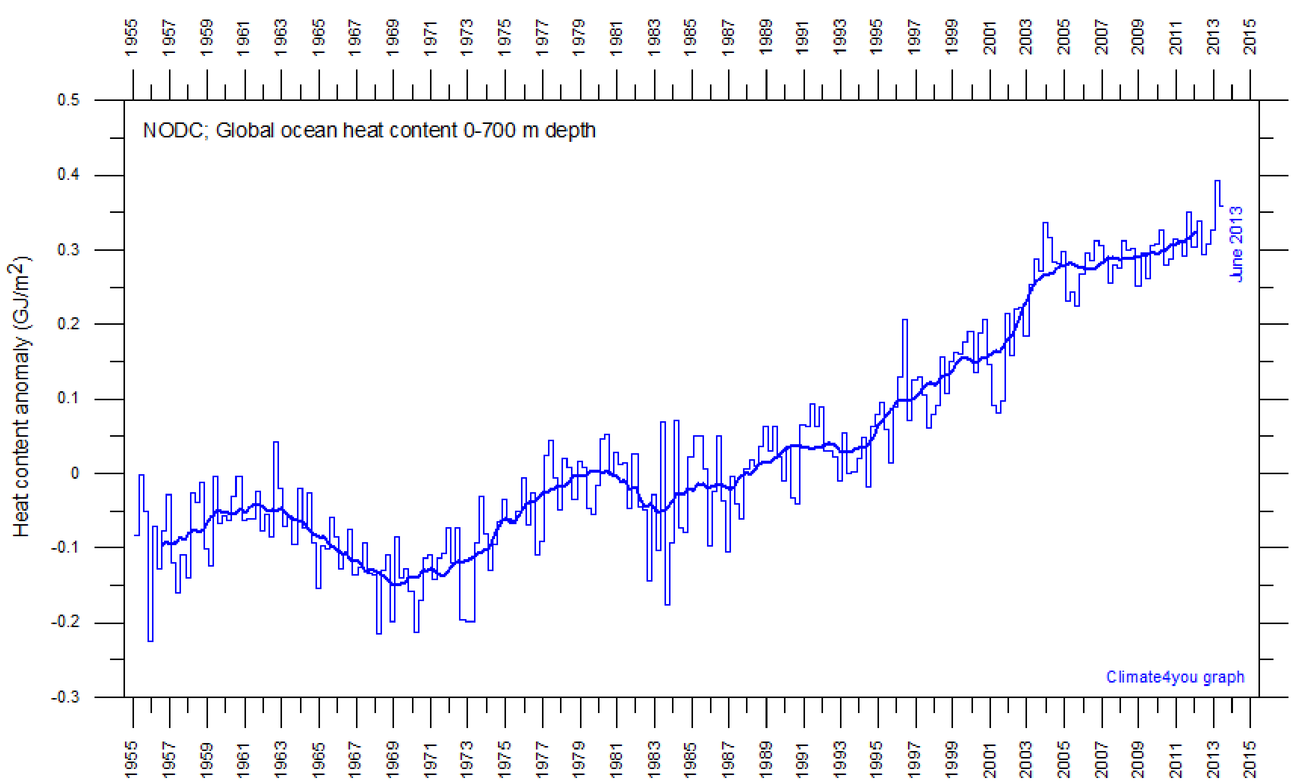


Global monthly average sea surface temperature since 1979 according to the [National Climatic Data Center](#) (NCDC), USA. Base period: 1901-2000. The thick line is the simple running 37 month average.

Global ocean heat content uppermost 700 m, updated to June 2013

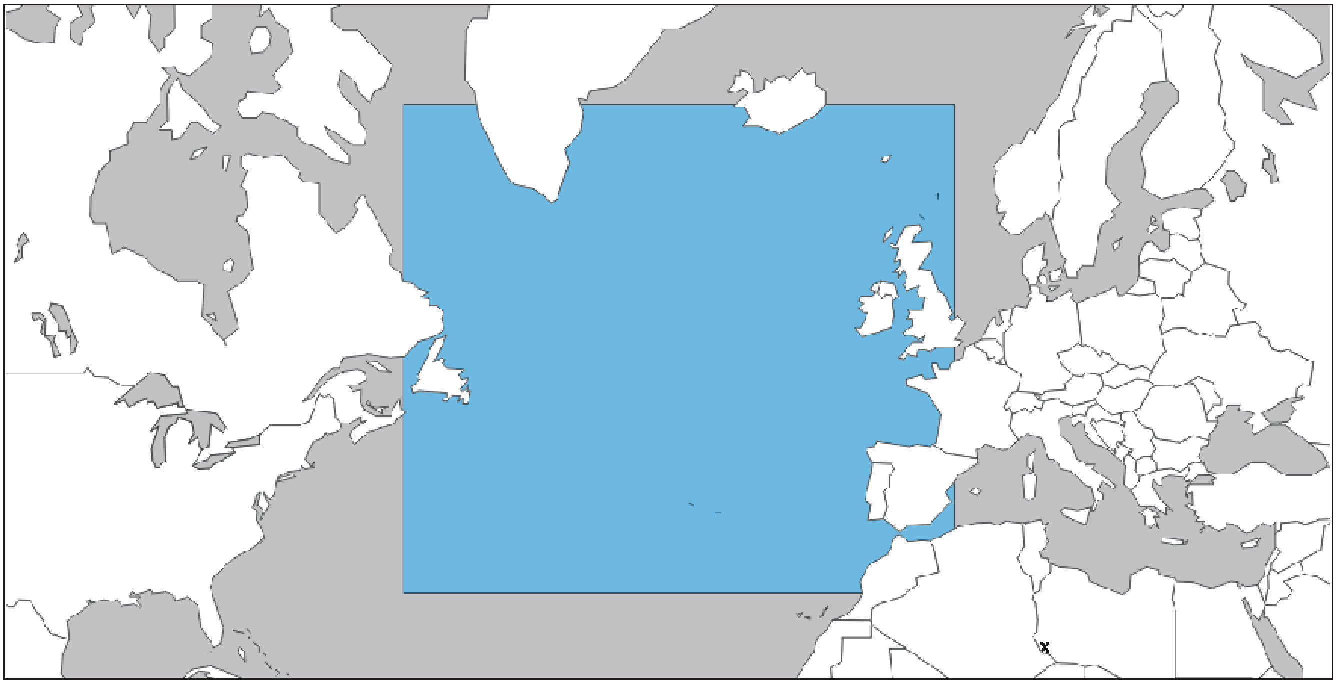


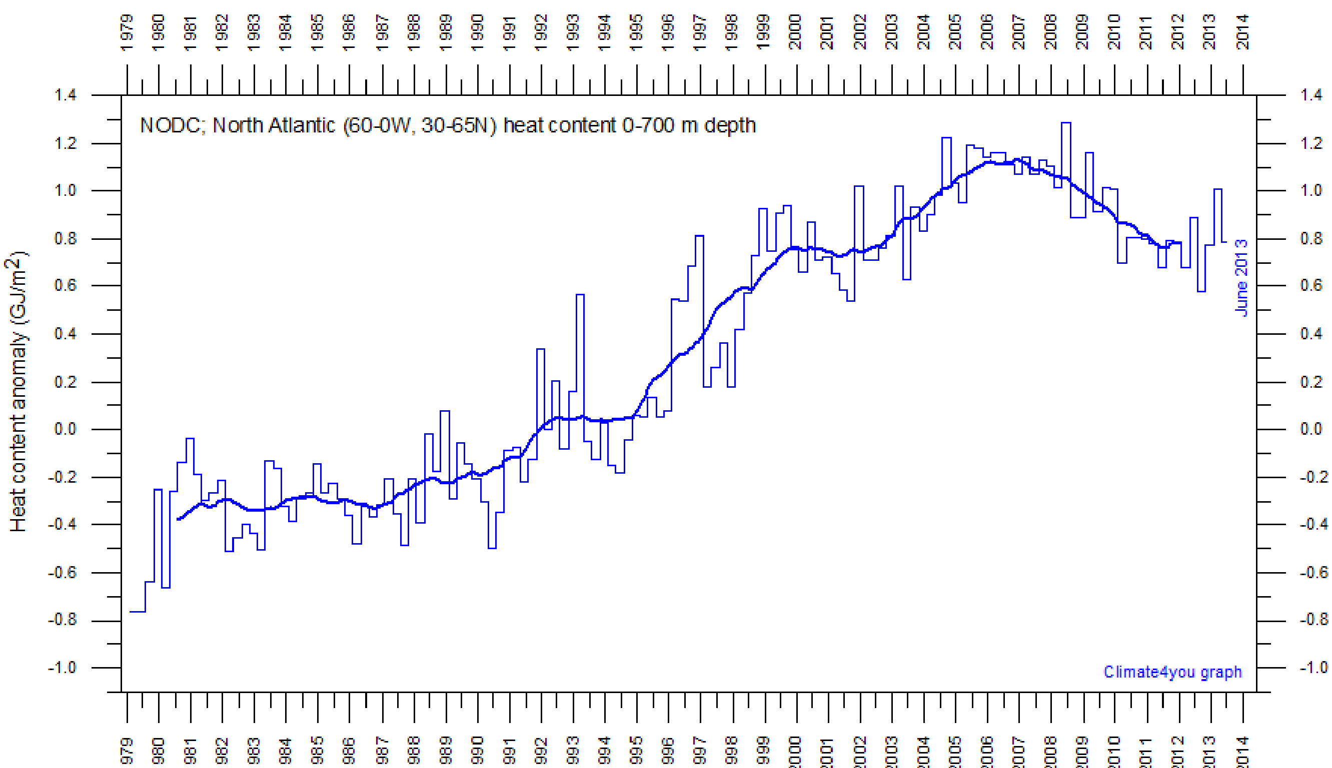
Global monthly heat content anomaly (GJ/m2) in the uppermost 700 m of the oceans since January 1979. Data source: National Oceanographic Data Center(NODC).



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).

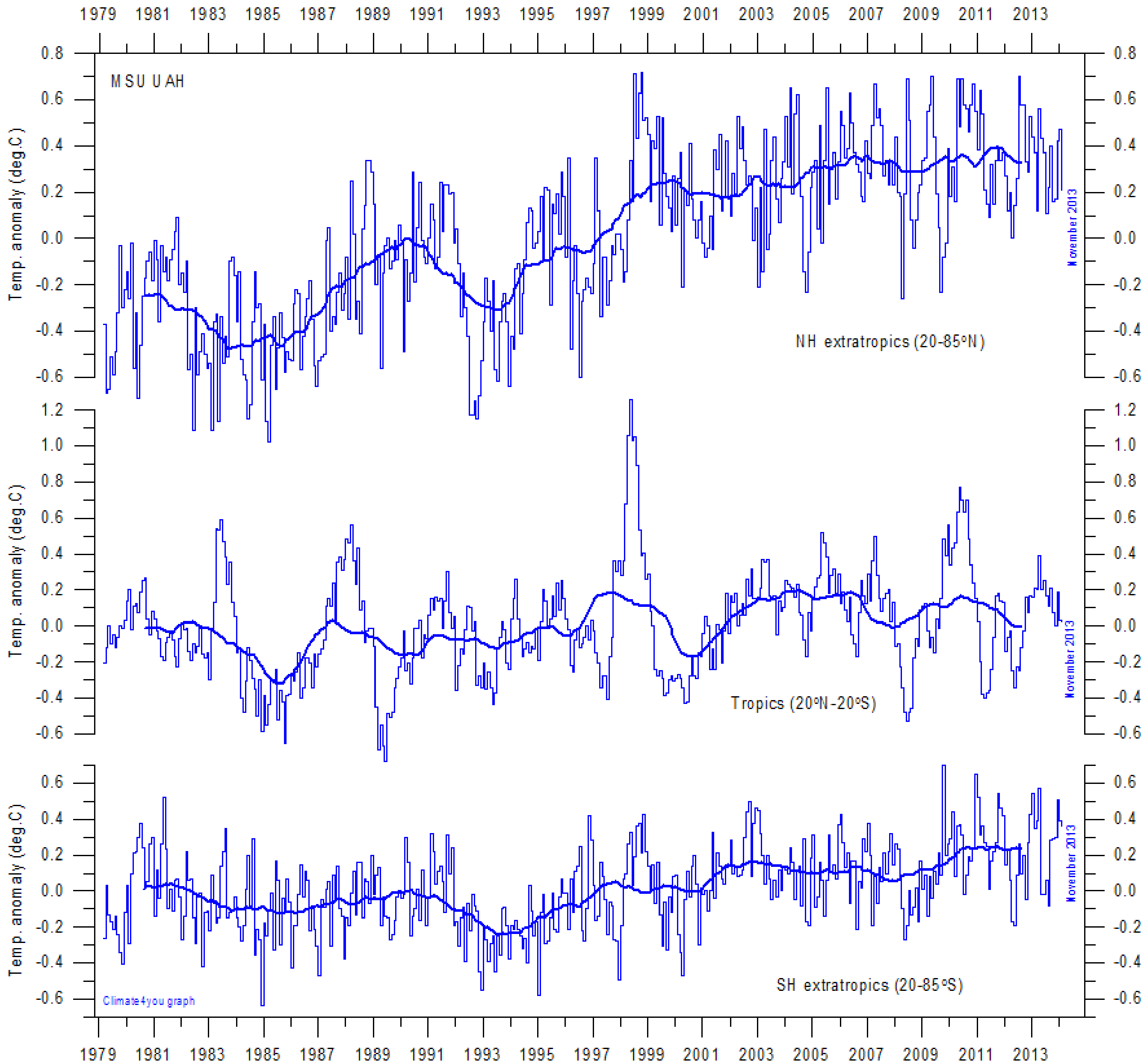
North Atlantic heat content uppermost 700 m, updated to June 2012





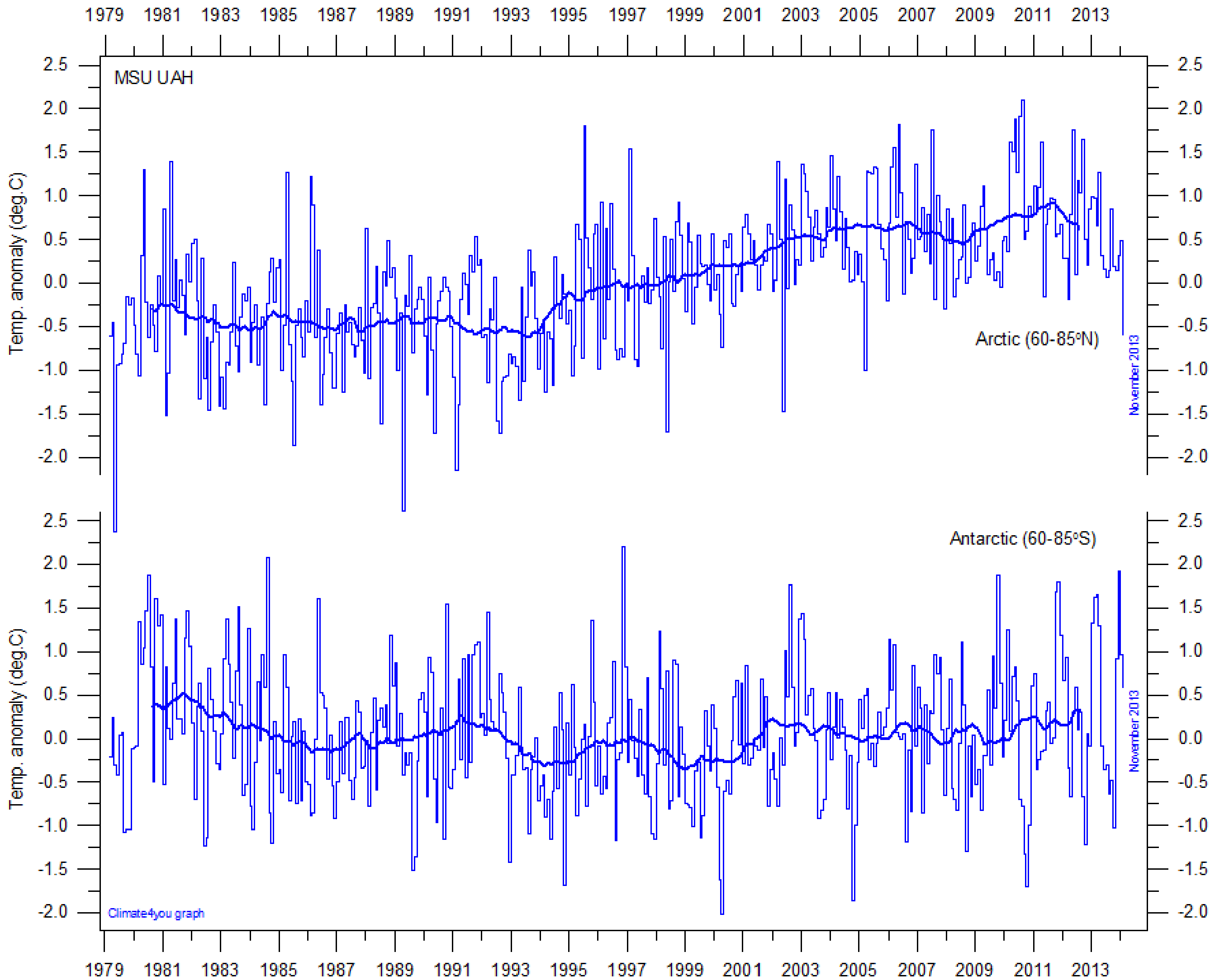
Global monthly heat content anomaly (GJ/m2) in the uppermost 700 m of the North Atlantic (60-0W, 30-65N; see map above) *ocean since January 1979. The thin line indicates monthly values, and the thick line represents the simple running 37 month (c. 3 year) average. Data source: [National Oceanographic Data Center](#) (NODC).*

Zonal lower troposphere temperatures from satellites, updated to November 2013



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 November 2013



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 October 2013

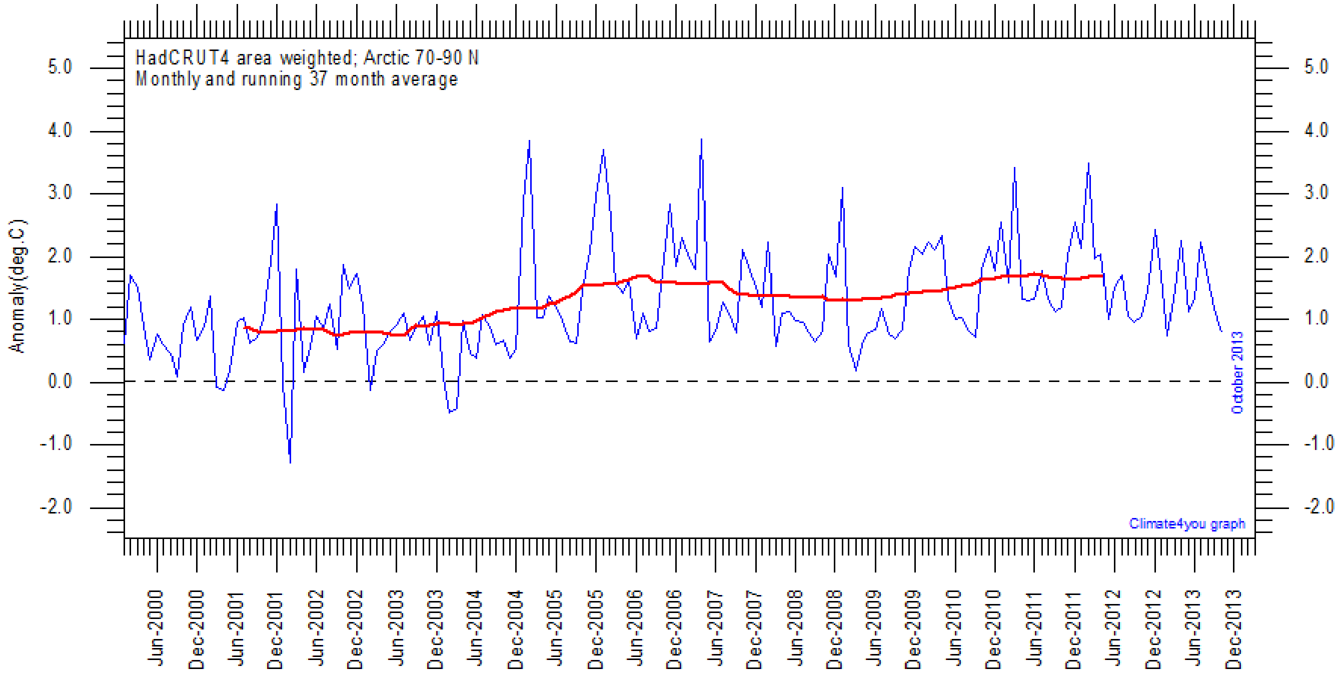


Diagram showing area weighted Arctic (70-90°N) monthly surface air temperature anomalies ([HadCRUT4]) since January 2000, in relation to the WMO [normal period] 1961-1990. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 37 month (c.3 yr) average.

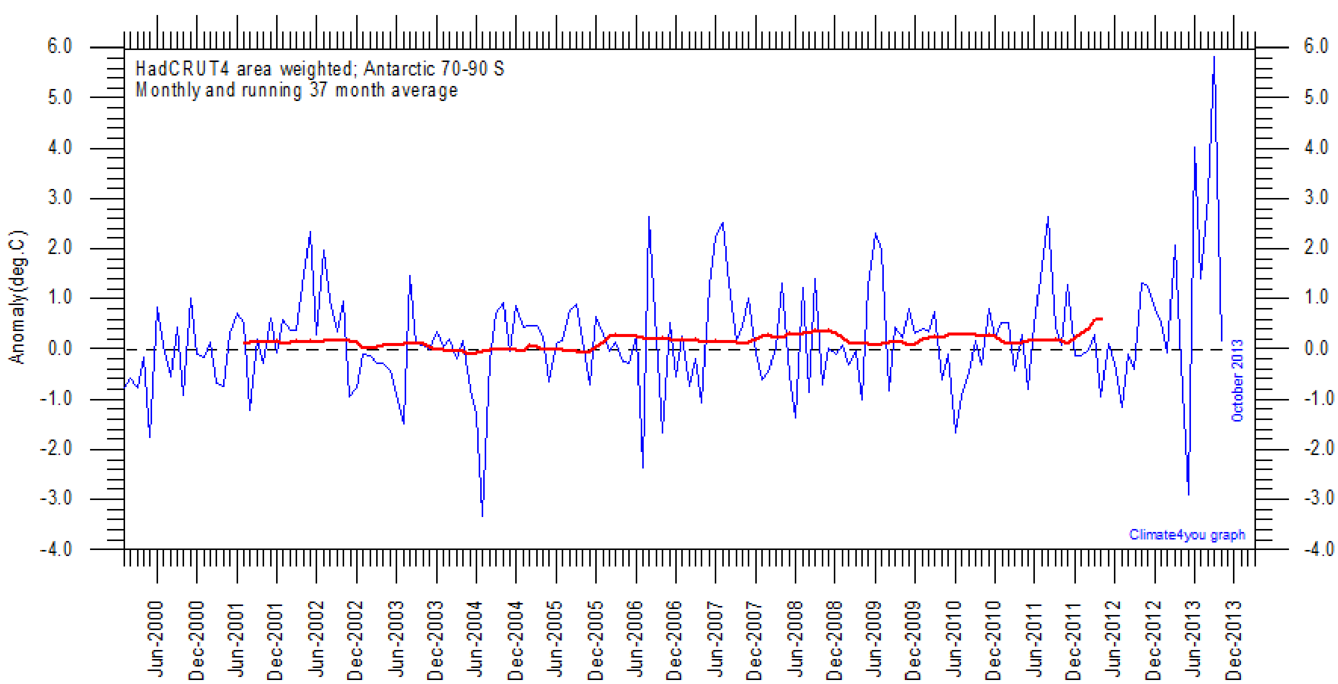


Diagram showing area weighted Antarctic (70-90°N) monthly surface air temperature anomalies ([HadCRUT4]) since January 2000, in relation to the WMO [normal period] 1961-1990. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 37 month (c.3 yr) average.

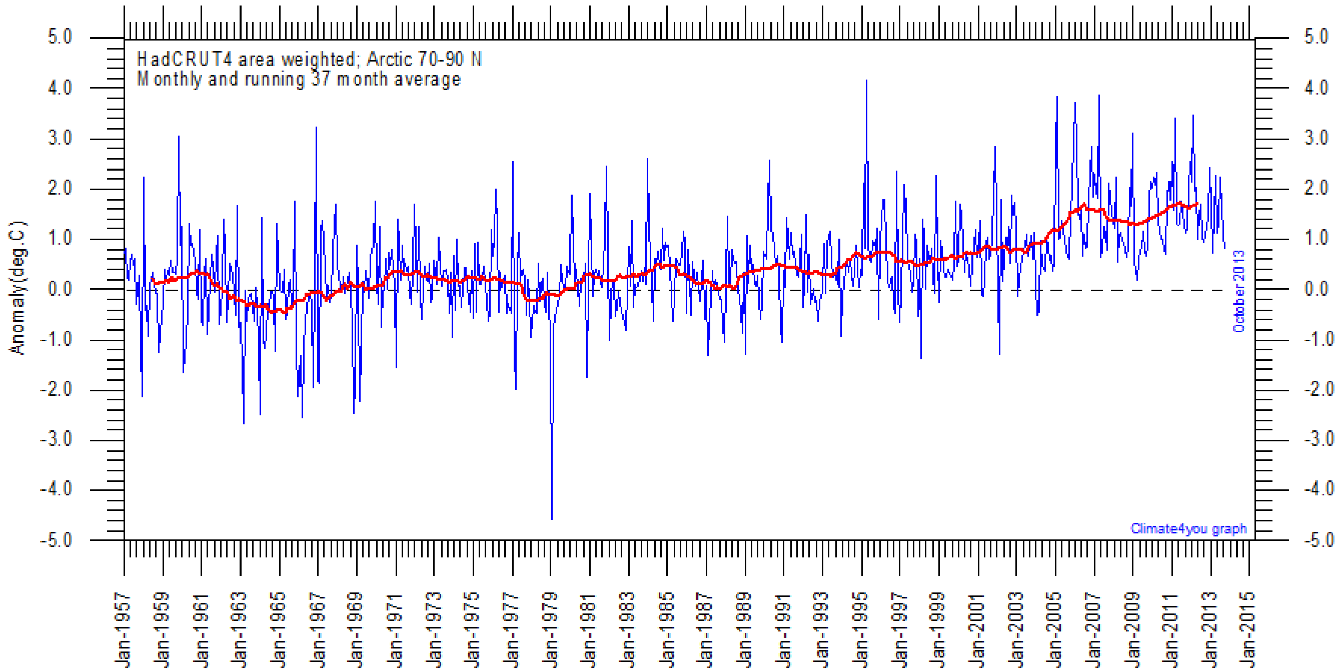


Diagram showing area weighted Arctic (70-90°N) monthly surface air temperature anomalies ([HadCRUT4]()) since January 1957, in relation to the WMO [normal period]() 1961-1990. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 37 month (c.3 yr) average.

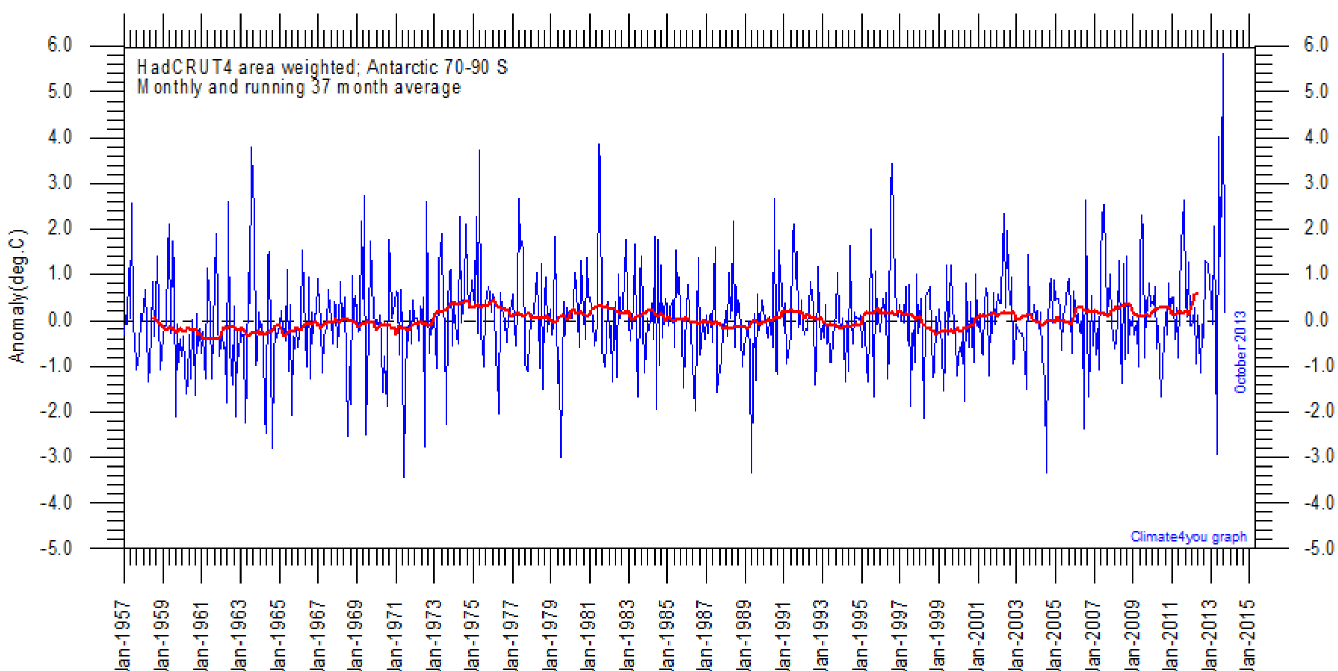


Diagram showing area weighted Antarctic (70-90°N) monthly surface air temperature anomalies ([HadCRUT4]()) since January 1957, in relation to the WMO [normal period]() 1961-1990. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 37 month (c.3 yr) average.

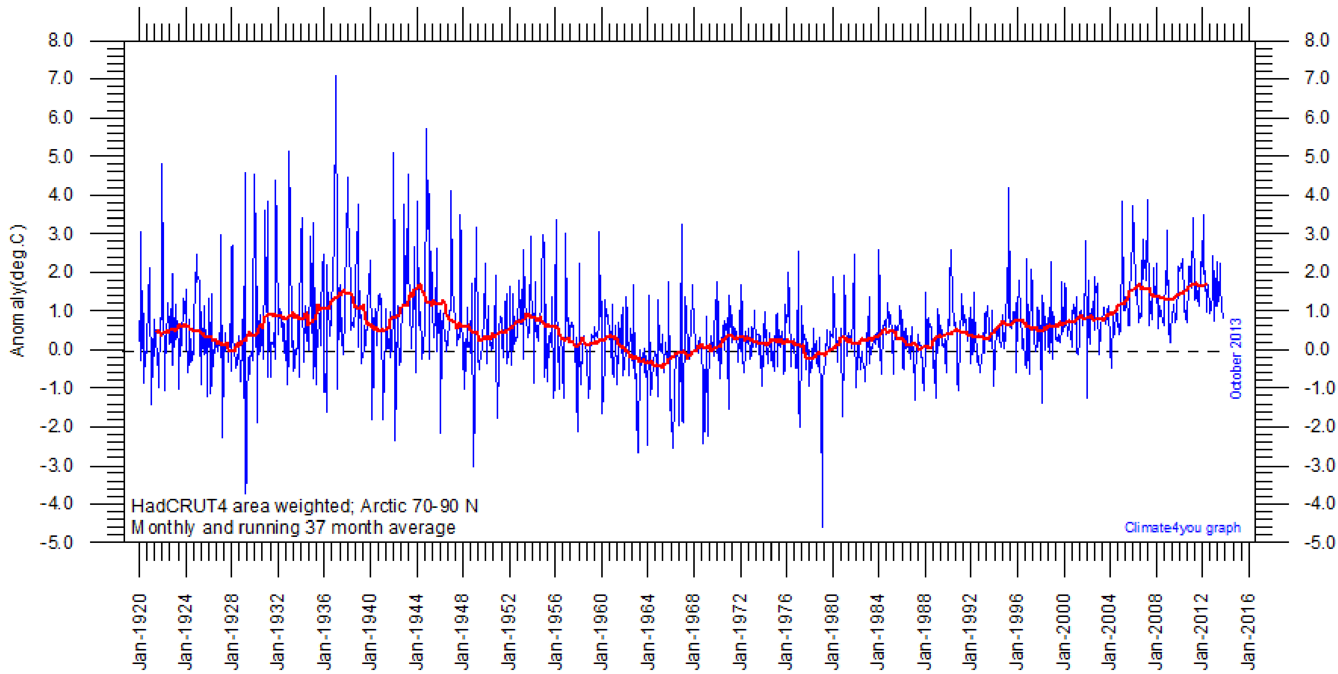


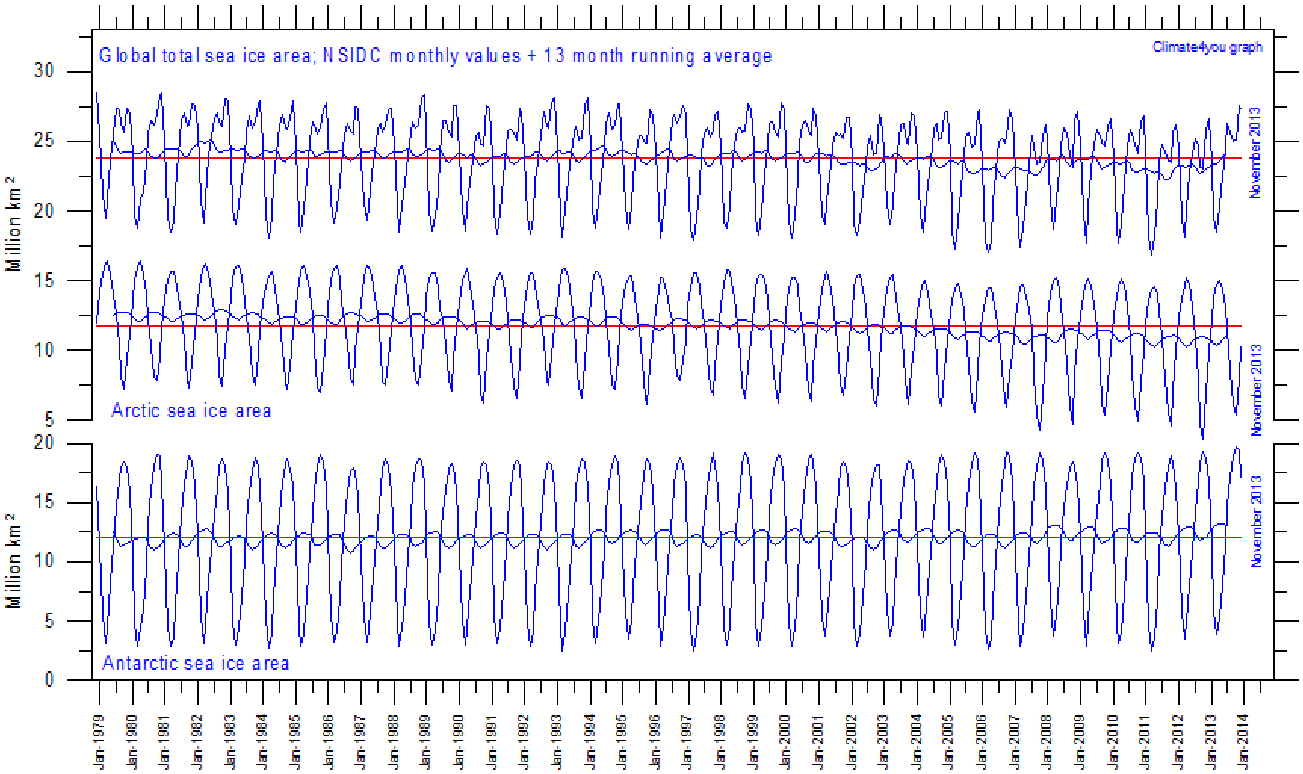
Diagram showing area weighted Arctic (70-90°N) monthly surface air temperature anomalies ([HadCRUT4]) since January 1920, in relation to the WMO [normal period] 1961-1990. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 37 month (c.3 yr) average. 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.

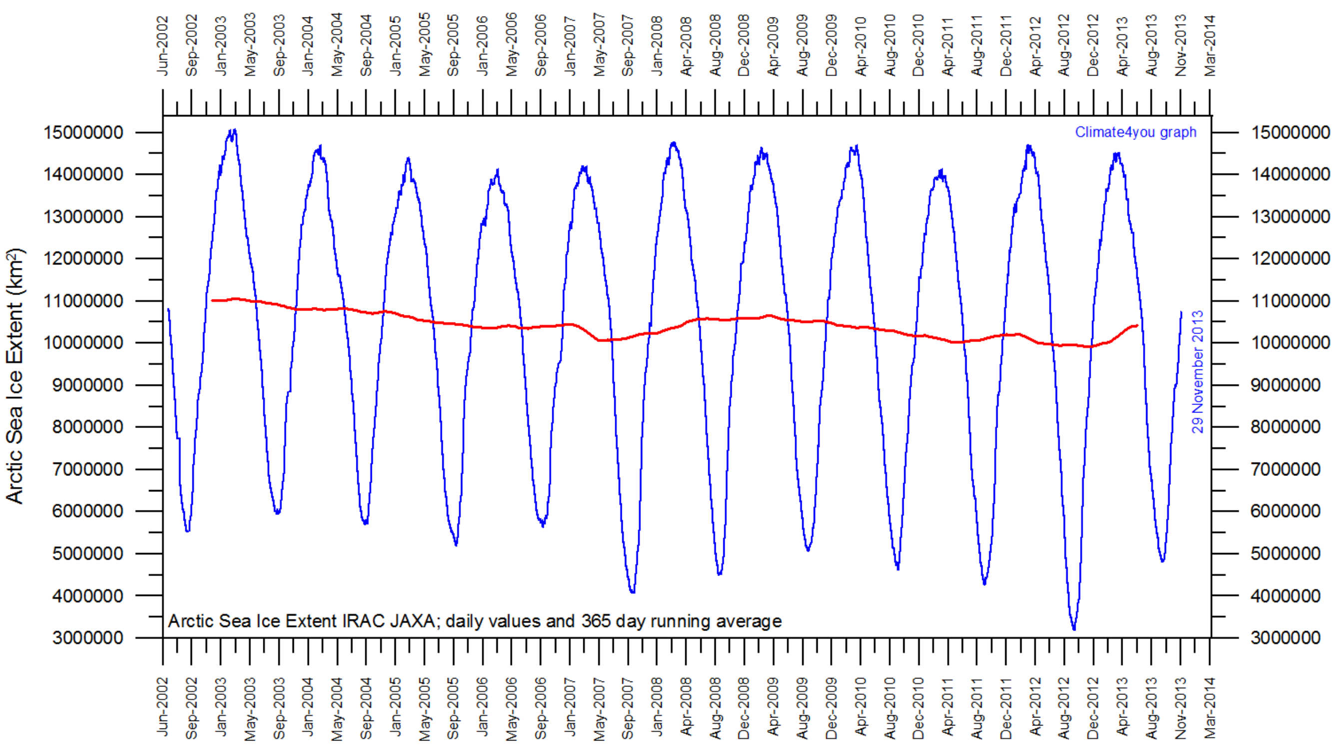
Literature:

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.

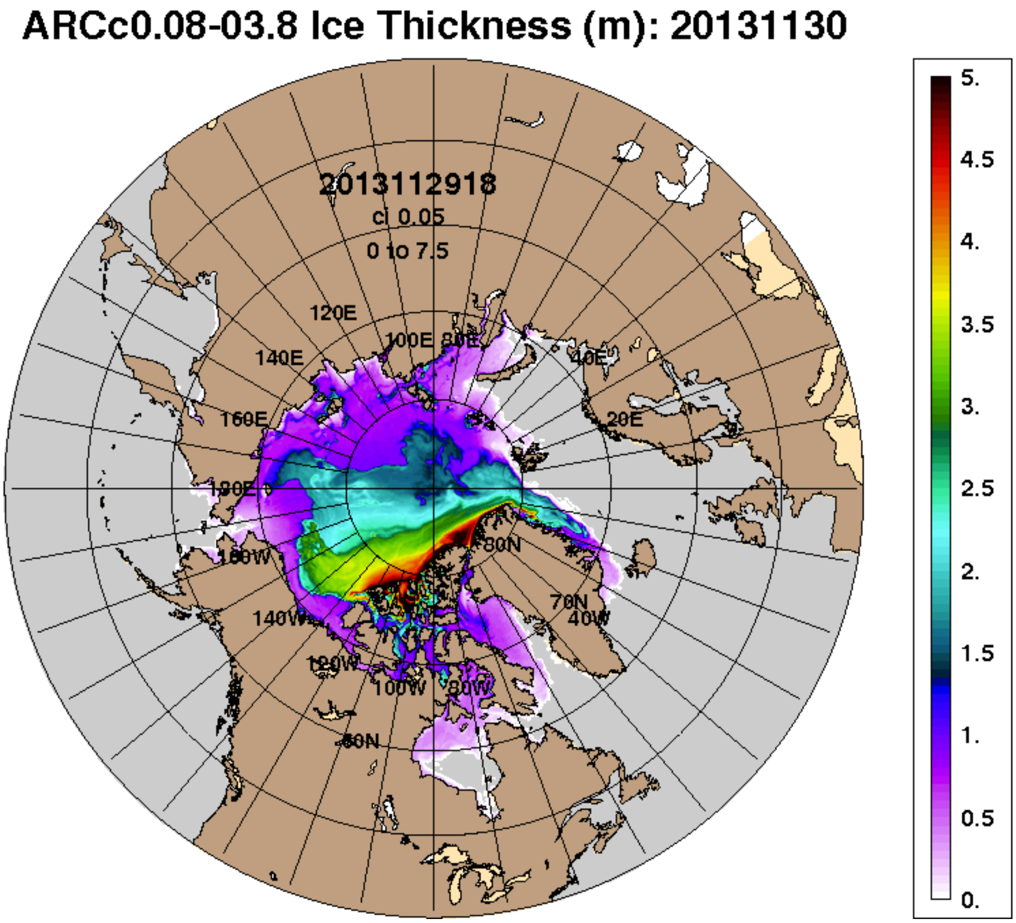
Arctic and Antarctic sea ice, updated to November 2013



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 29 November 2013, by courtesy of [Japan Aerospace Exploration Agency](#) (JAXA).



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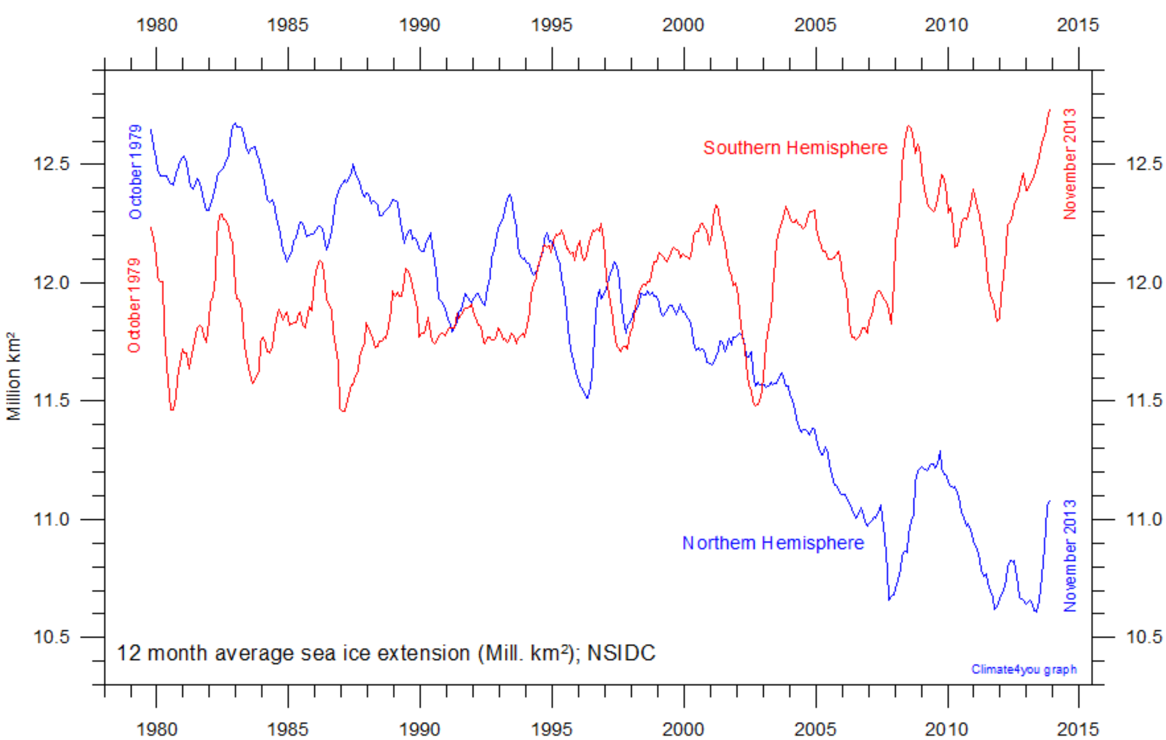
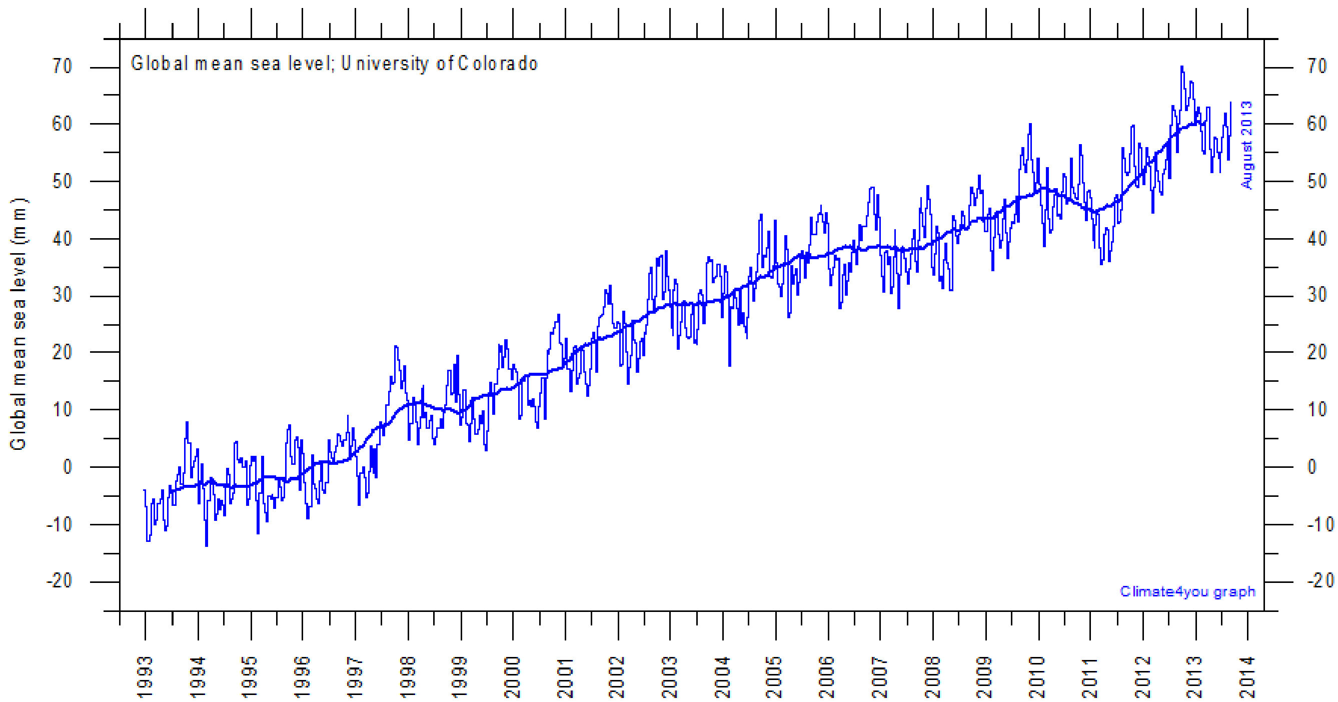
Northern hemisphere sea ice extension and thickness on 30 November 2013 according to the Arctic Cap Nowcast/Forecast System (ACNFS), US Naval Research Laboratory. Thickness scale (m) is shown to the right.

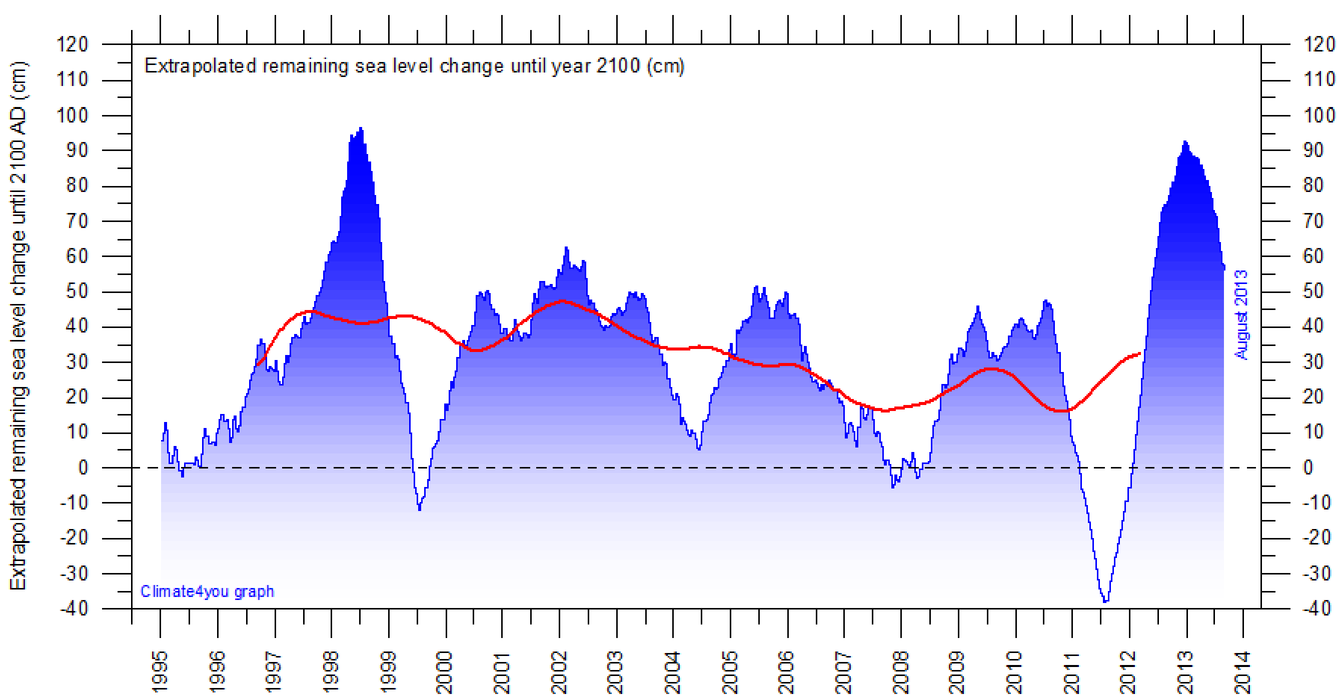


12 month running average sea ice extension in both hemispheres since 1979, the satellite-era. Data source: National Snow and Ice Data Center *(NSIDC).*

Global sea level, updated to August 2013

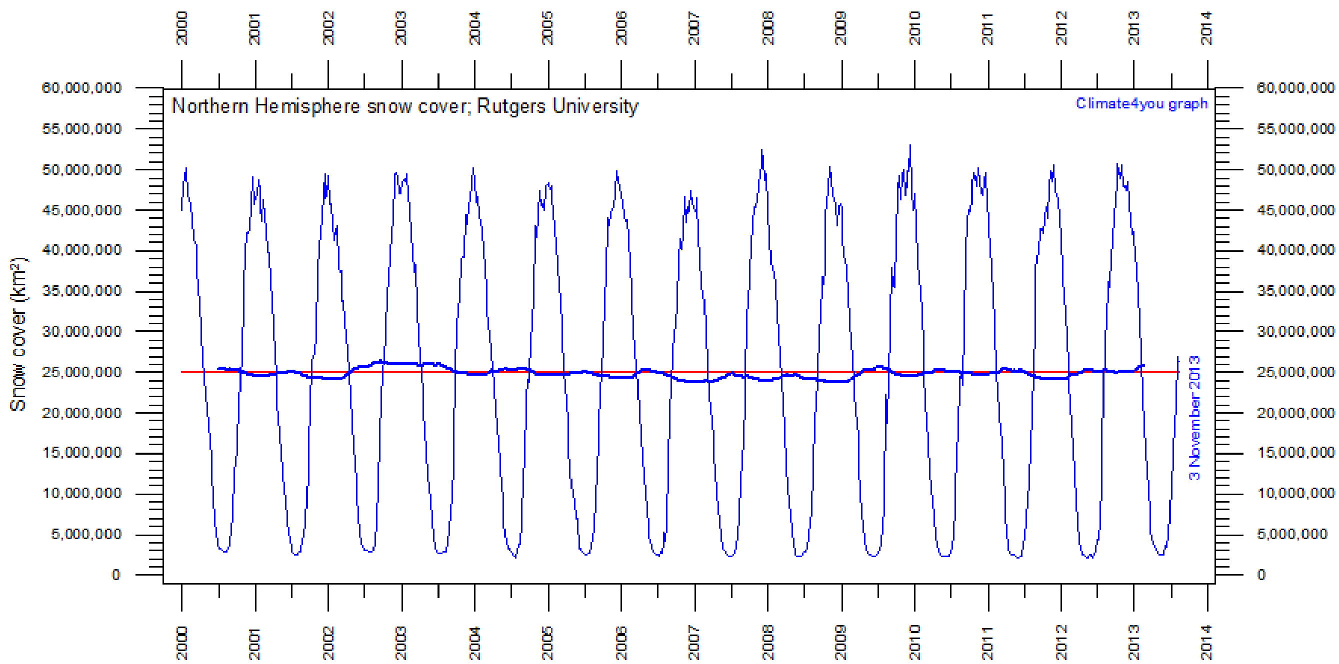


Globa lmonthly sea level since late 1992 according to the Colorado Center for Astrodynamics Research at [University of Colorado at Boulder](), USA. The thick line is the simple running 37 observation average, nearly corresponding to a running 3 yr average.

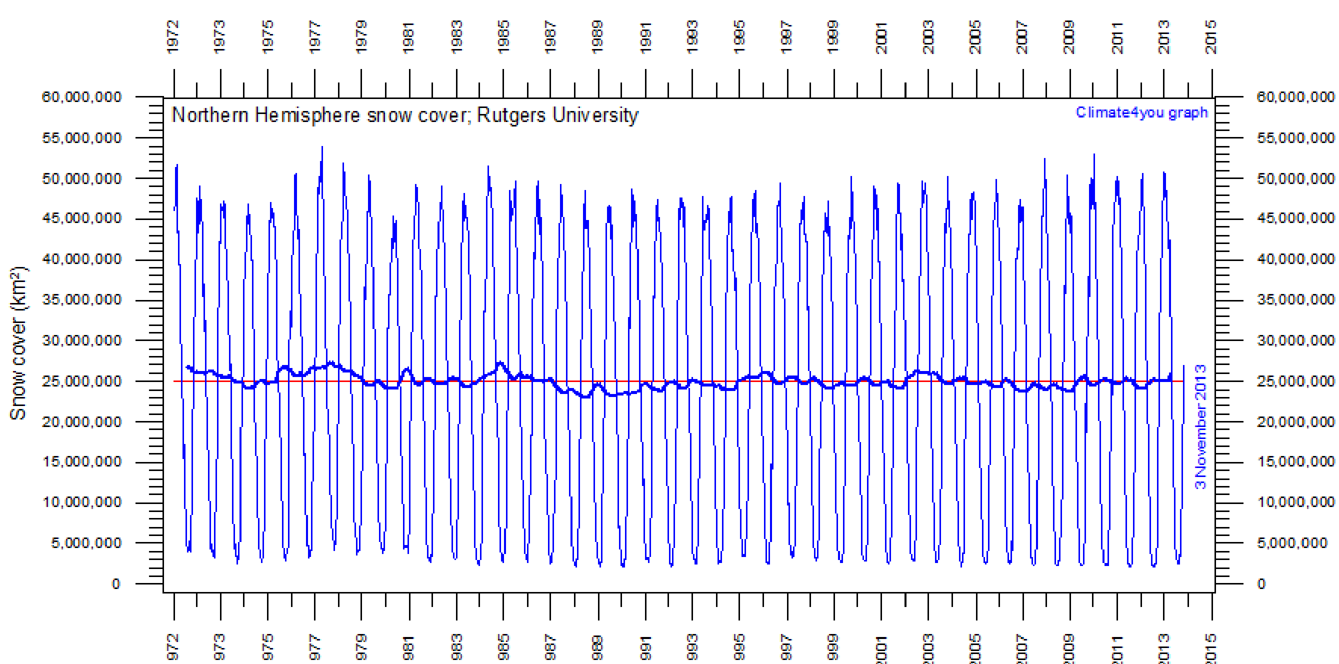


Forecasted change of global sea level until year 2100, based on simple extrapolation of measurements done by the Colorado Center for Astrodynamics Research at [University of Colorado at Boulder](), USA. The thick line is the simple running 3 yr average forecast for sea level change until year 2100. Based on this (thick line), the present simple empirical forecast of sea level change until 2100 is about +31 cm.

Northern Hemisphere weekly snow cover, updated to early November 2013

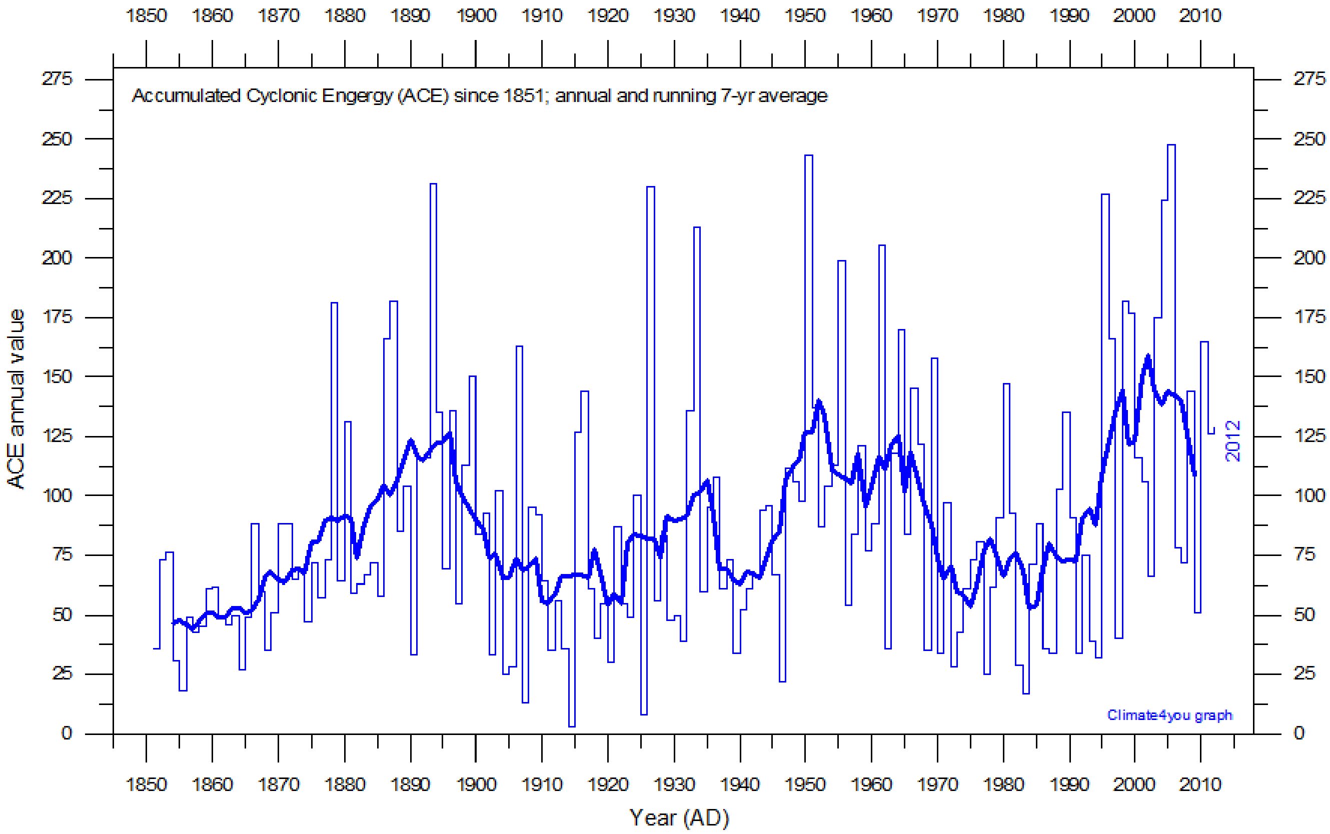


Northern hemisphere weekly snow cover since January 2000 according to Rutgers University Global Snow Laboratory. The thin blue line is the weekly data, and the thick blue line is the running 53 week average (approximately 1 year). The horizontal red line is the 1972-2012 average.



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 1972-2012 average.

Annual accumulated cyclone energy (ACE) Atlantic Basin



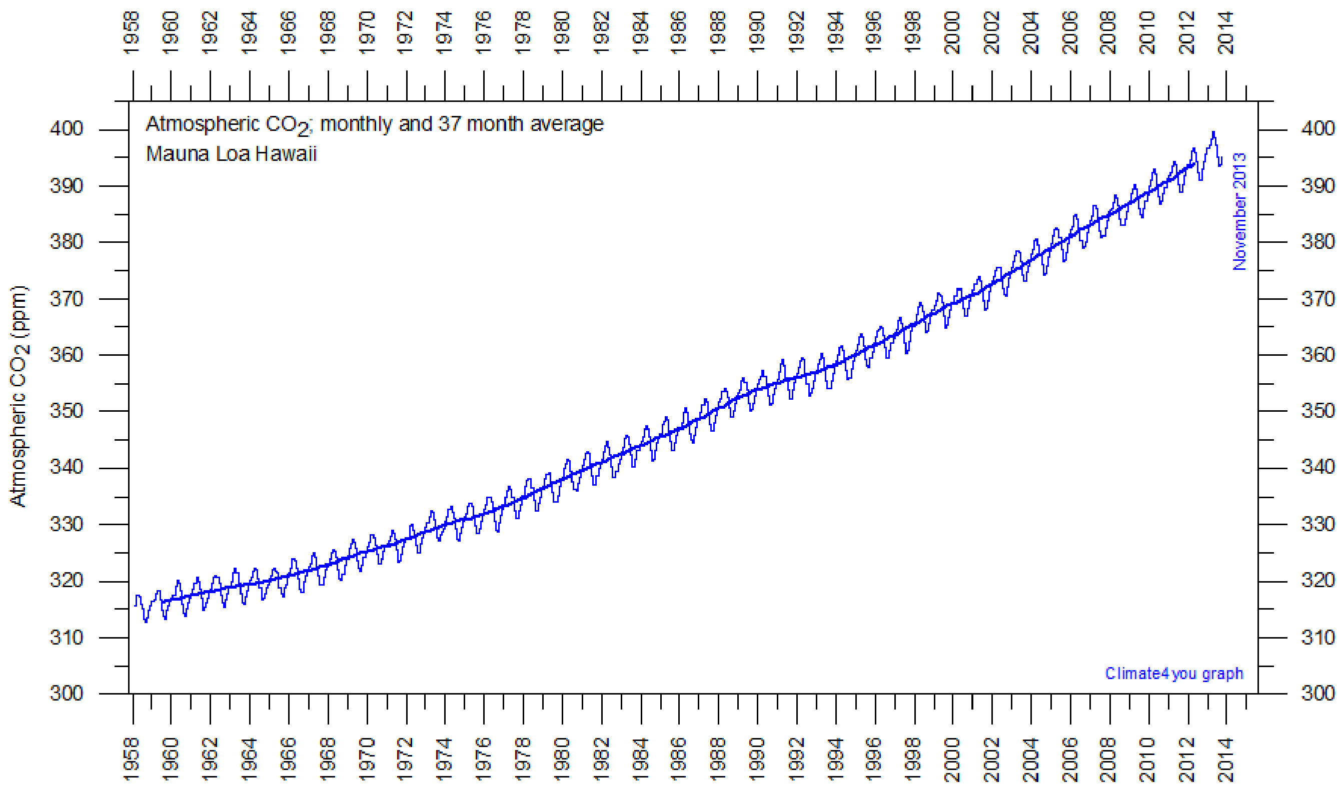
Accumulated cyclonic engergy (ACE; Atlantic basin) per year since 1850 AD, according to data from the Atlantic Oceanographic and Meteorological Laboratory, Hurricane research Division. Thin lines show annual ACE values, and the thick line shows the running 7-yr average. Last year shown: 2012.

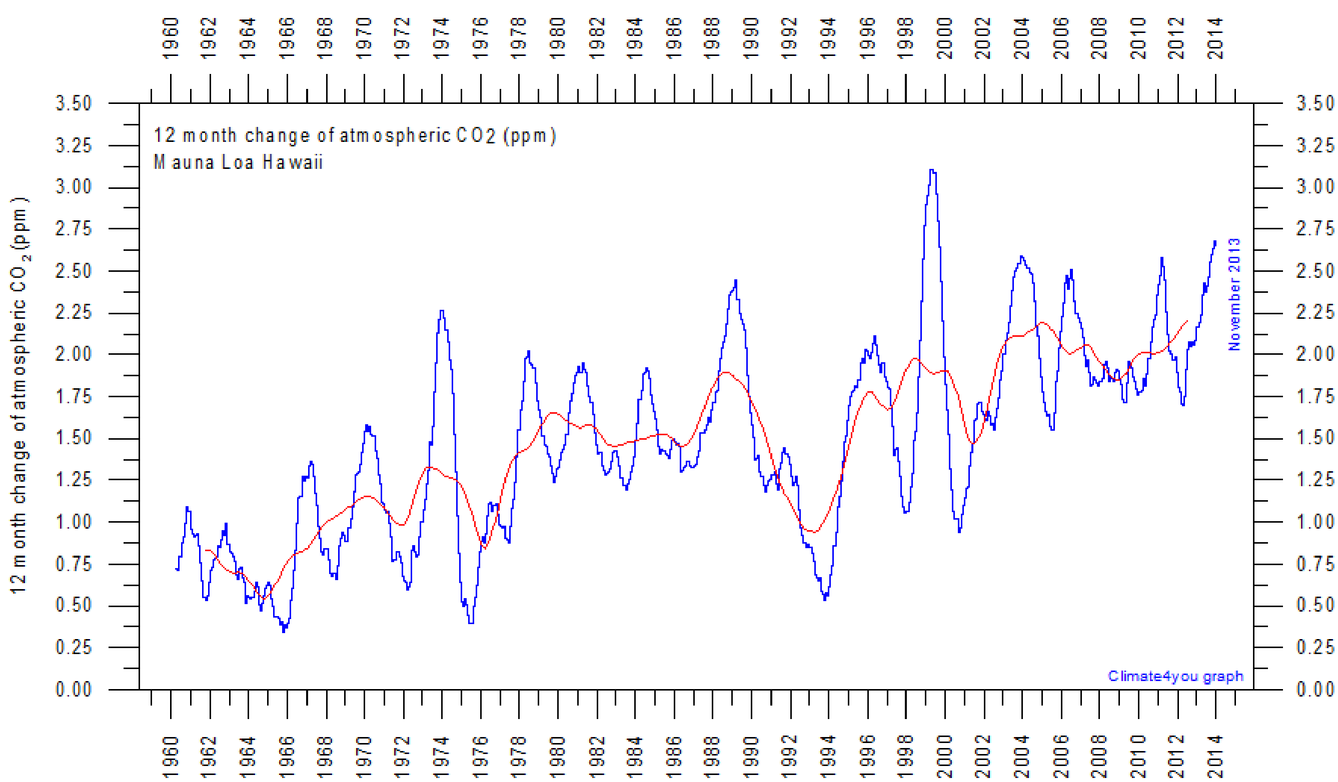
Accumulated cyclone energy (ACE) is a measure used by the National Oceanic and Atmospheric Administration (NOAA) to express the activity of individual tropical cyclones and entire tropical cyclone seasons.

ACE is calculated as the square of the wind speed every 6 hours, and is then scaled by a factor of 10,000 for usability, using a unit of 10^4 knots^2. The ACE of a season is the sum of the ACE for each storm and takes into account the number, strength, and duration of all the tropical storms in the season.

The damage potential of a hurricane is proportional to the square or cube of the maximum wind speed, and thus ACE is not only a measure of tropical cyclone activity, but also a measure of the damage potential of an individual cyclone or a season.

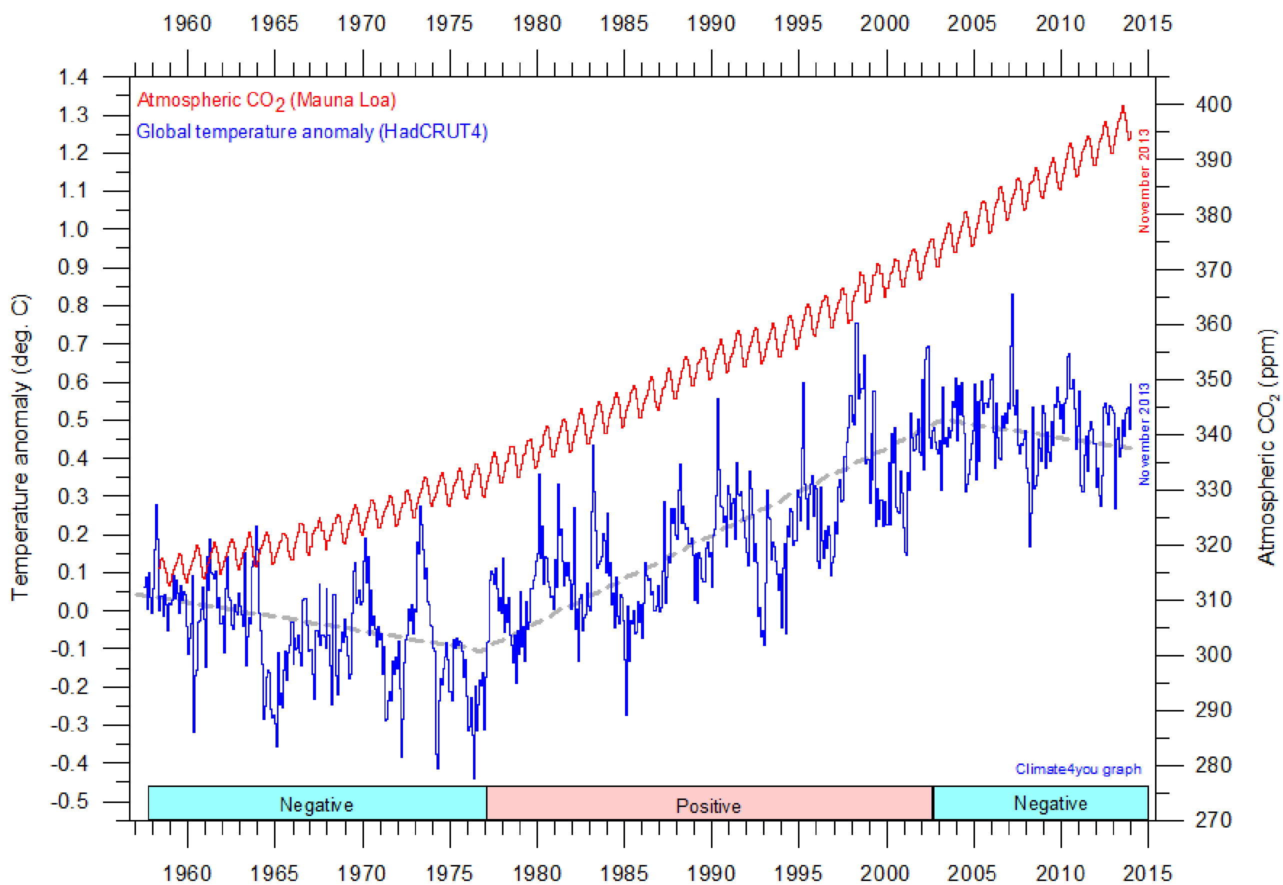
Atmospheric CO_2, updated to November 2013

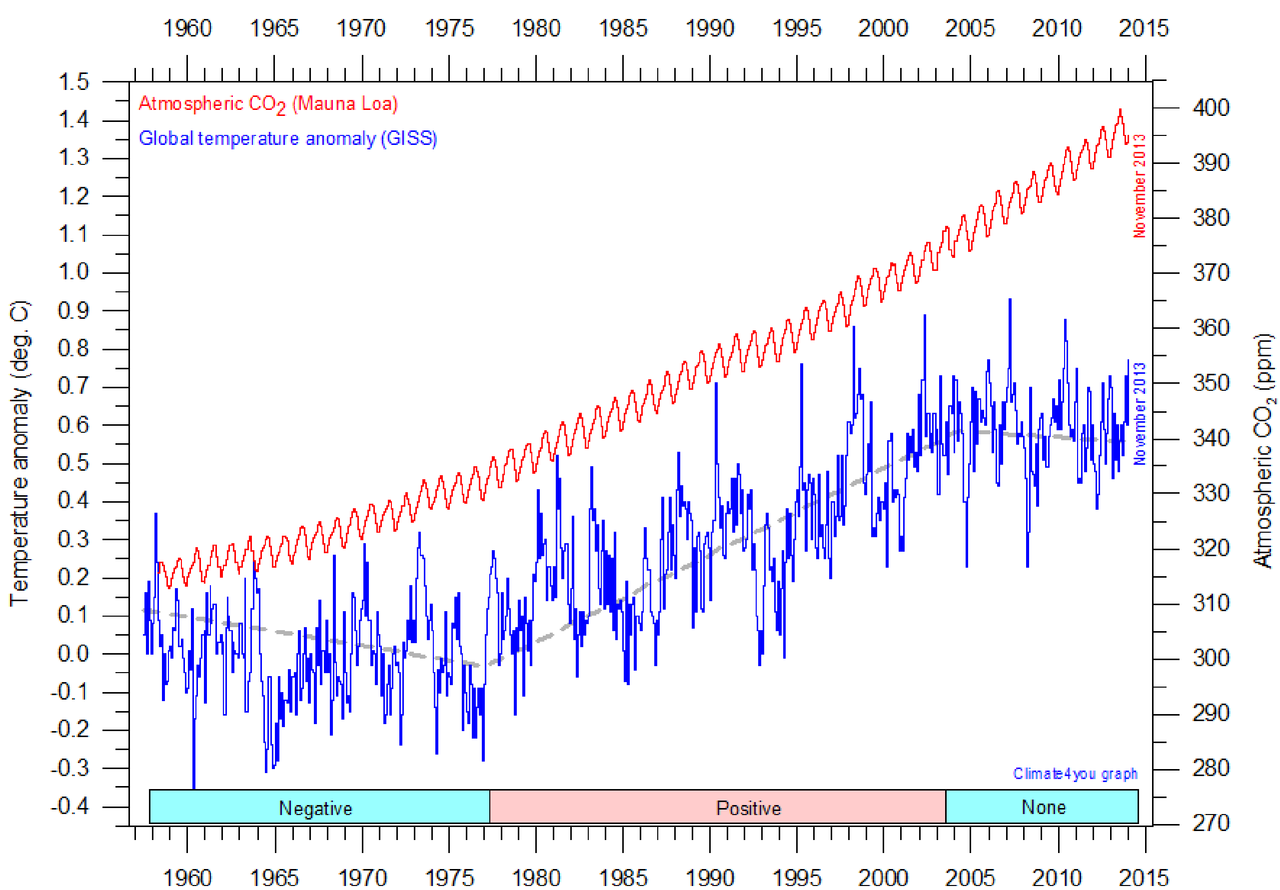


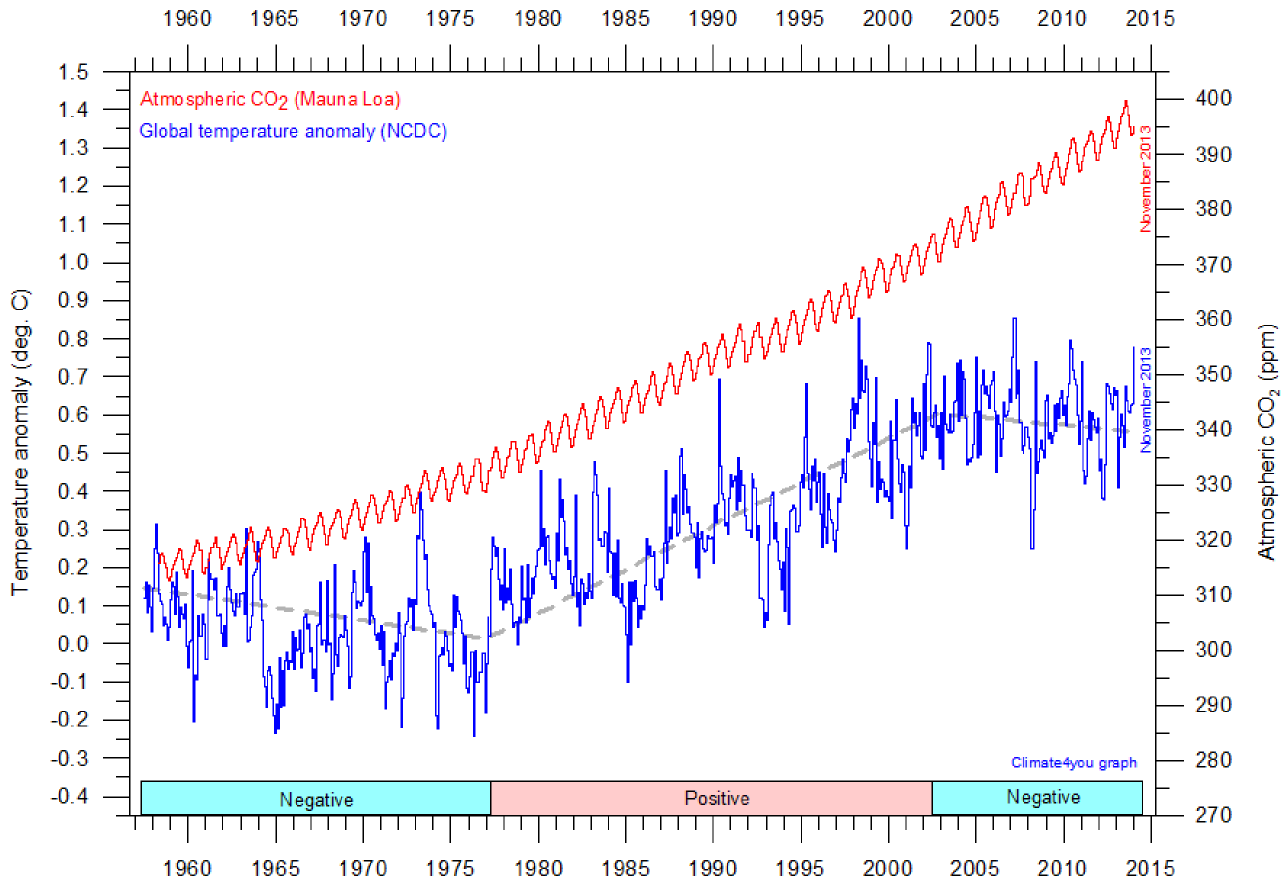


Monthly amount of atmospheric CO_2 (upper diagram) and annual growth rate (lower diagram); average last 12 months minus average preceding 12 months, blue line) of atmospheric CO_2 since 1959, according to data provided by the [Mauna Loa Observatory](), Hawaii, USA. The red line is the simple running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

Global surface air temperature and atmospheric CO_2, updated to November 2013







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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 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.

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.

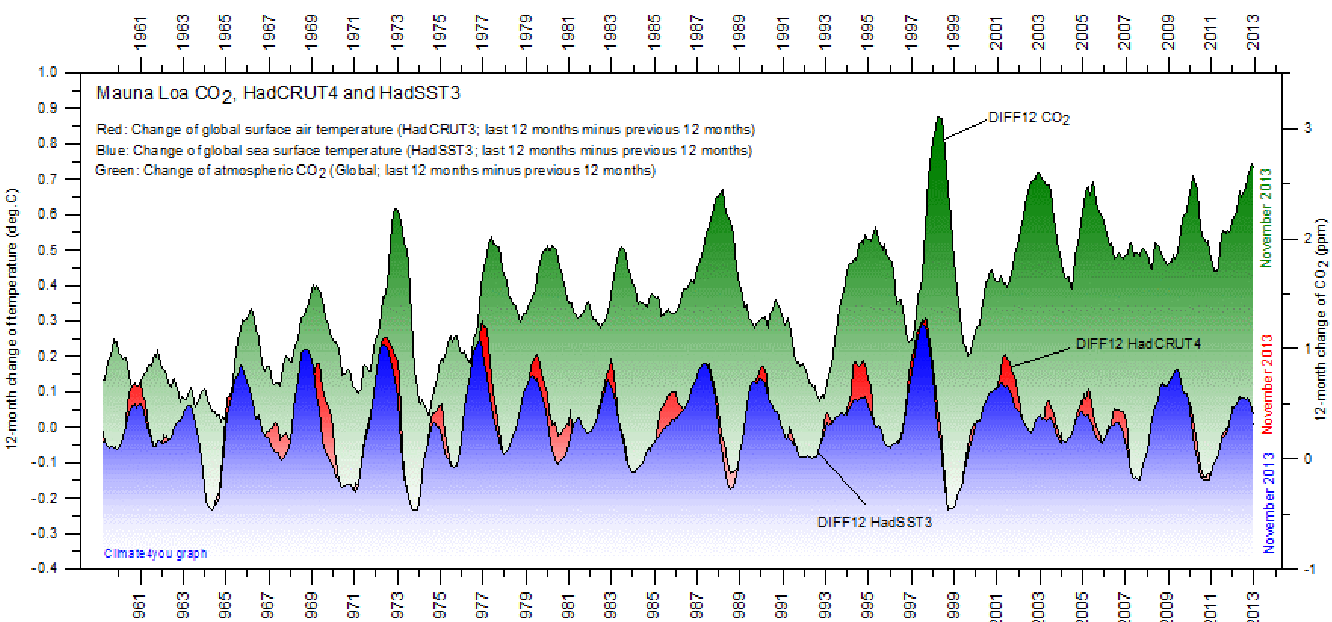
What exactly defines the critical length of a relevant time period to consider for evaluating the alleged importance of CO_2 remains elusive, and is still a topic for discussion. However, the critical period length must be inversely proportional to the temperature sensitivity of CO_2, including feedback 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.

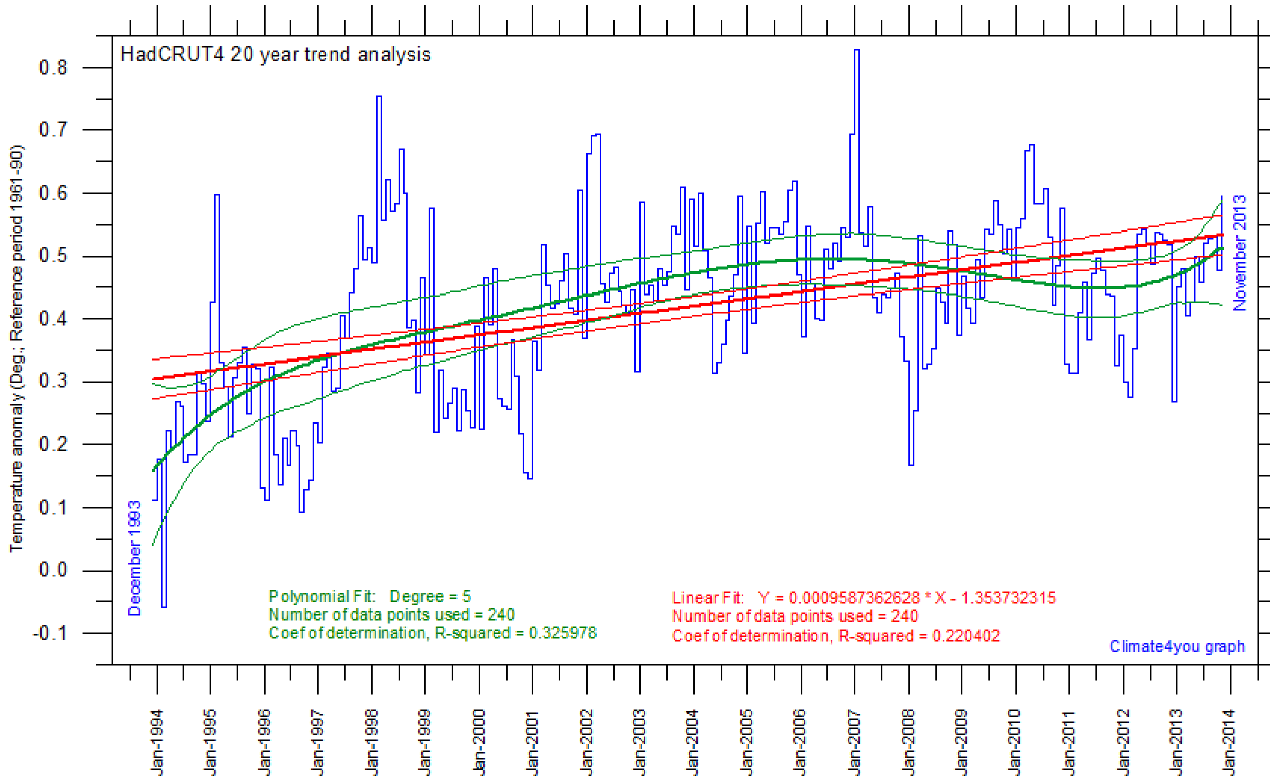
The phase relation between atmospheric CO_2 and global temperature, updated to November 2013



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. Changes in temperatures are seen to take place 9-12 months before corresponding changes in atmospheric CO_2. Last month included in analysis: November 2013.

References: Humlum, O., Stordahl, K. and Solheim, J-E. 2012. The phase relation between atmospheric carbon dioxide and global temperature. Global and Planetary Change, August 30, 2012. http://www.sciencedirect.com/science/article/pii/S0921818112001658?v=s5

Last 20 year monthly surface air temperature changes, updated to October 2012



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).

It is quite often debated if the global surface temperature still increases, or if the temperature has levelled out during the last 10-15 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.

Year 2005: Hurricane Katrina hits New Orleans on August 28

Figure 1. Hurricane Katrina at peak strength on August 28, 2005 (left). Flooded I-10/I-610/West End Blvd interchange and surrounding area of northwest New Orleans and Metairie, Louisiana (right). Picture sources: Wikipedia.

When the Atlantic hurricane Katrina struck New Orleans in late August 2005, this spurred many discussions on a possible connection between the increasing amount of atmospheric CO_2 and the frequency of tropical storms.

This must be understood on the sad background of Hurricane Katrina being the deadliest and most destructive Atlantic tropical cyclone of the 2005 Atlantic hurricane season. In addition, it was the costliest natural disaster, as well as one of the five deadliest hurricanes, in the history of the United States. Among recorded Atlantic hurricanes, it was the sixth strongest overall. At least 1,833 people died in the hurricane and subsequent floods, making it the deadliest U.S. hurricane since the 1928 Okeechobee hurricane; total property damage was estimated at $81 billion (2005 USD), nearly triple the damage brought by Hurricane Andrew in 1992 (c.f. Wikipedia).

However, an inspection of the accumulated cyclone energy (ACE; Fig.2) shows the often alleged connection between hurricanes and atmospheric

CO_2 to be elusive, and there is no relation between the Atlantic ACE data shown in figure 2 and the monotonously increasing amount of atmospheric CO_2 (p.25). However, at the same time the observed data series actually reveals some interesting and important clues as to the near future frequency of Atlantic hurricanes.

The accumulated cyclone energy (ACE) is a measure used by the National Oceanic and Atmospheric Administration (NOAA) to express the activity of individual tropical cyclones and entire tropical cyclone seasons. ACE is calculated as the square of the wind speed every 6 hours, and is then scaled by a factor of 10,000 for usability, using a unit of 10^4 knots^2. The ACE of a season is the sum of the ACE for each storm and takes into account the number, strength, and duration of all the tropical storms in the season.

The damage potential of a hurricane is proportional to the square or cube of the maximum wind speed, and thus ACE is not only a measure of tropical cyclone activity, but also a measure of the damage potential of an individual cyclone or a season. Below is shown (Fig.2) the ACE data series for the Atlantic basin since 1851, updated to year 2012.

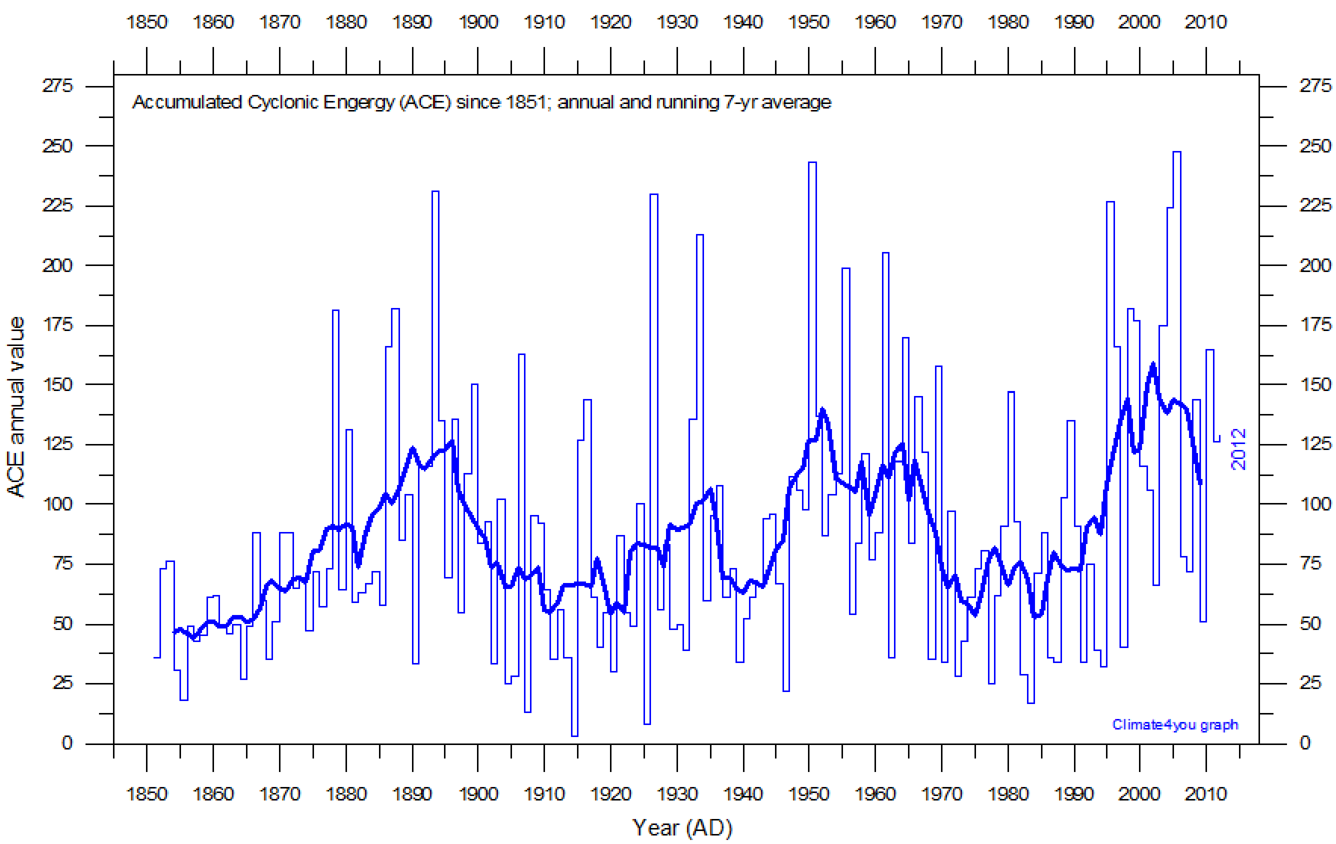


Figure 2. Accumulated cyclonic energy (ACE; Atlantic basin) per year since 1850 AD, according to data from the Atlantic Oceanographic and Meteorological Laboratory, Hurricane research Division. Thin lines show annual ACE values, and the thick line shows the running 7-yr average. Last year shown: 2012.

The ACE of a season is calculated by summing the squares of the estimated maximum sustained velocity of every active tropical storm (wind speed 35 knots (65 km/h) or higher), at six-hour intervals. If any storms of a season happen to cross years, the storm's ACE counts for the previous year. Kinetic energy is proportional to the square of velocity, and by adding together the energy per some interval of time, the accumulated energy is found. As the duration of a storm increases, more values are summed and the ACE also increases such that longer-duration storms may accumulate a larger ACE than more-powerful storms of lesser duration. Please note that although ACE is a value proportional to the energy of the system, it is not a direct calculation of energy.

It is clearly interesting to inspect the ACE series (Fig.2) for the presence of recurrent, natural variations. Such an inspection may be assisted by a frequency analysis, as shown in the diagram below (Fig.3).

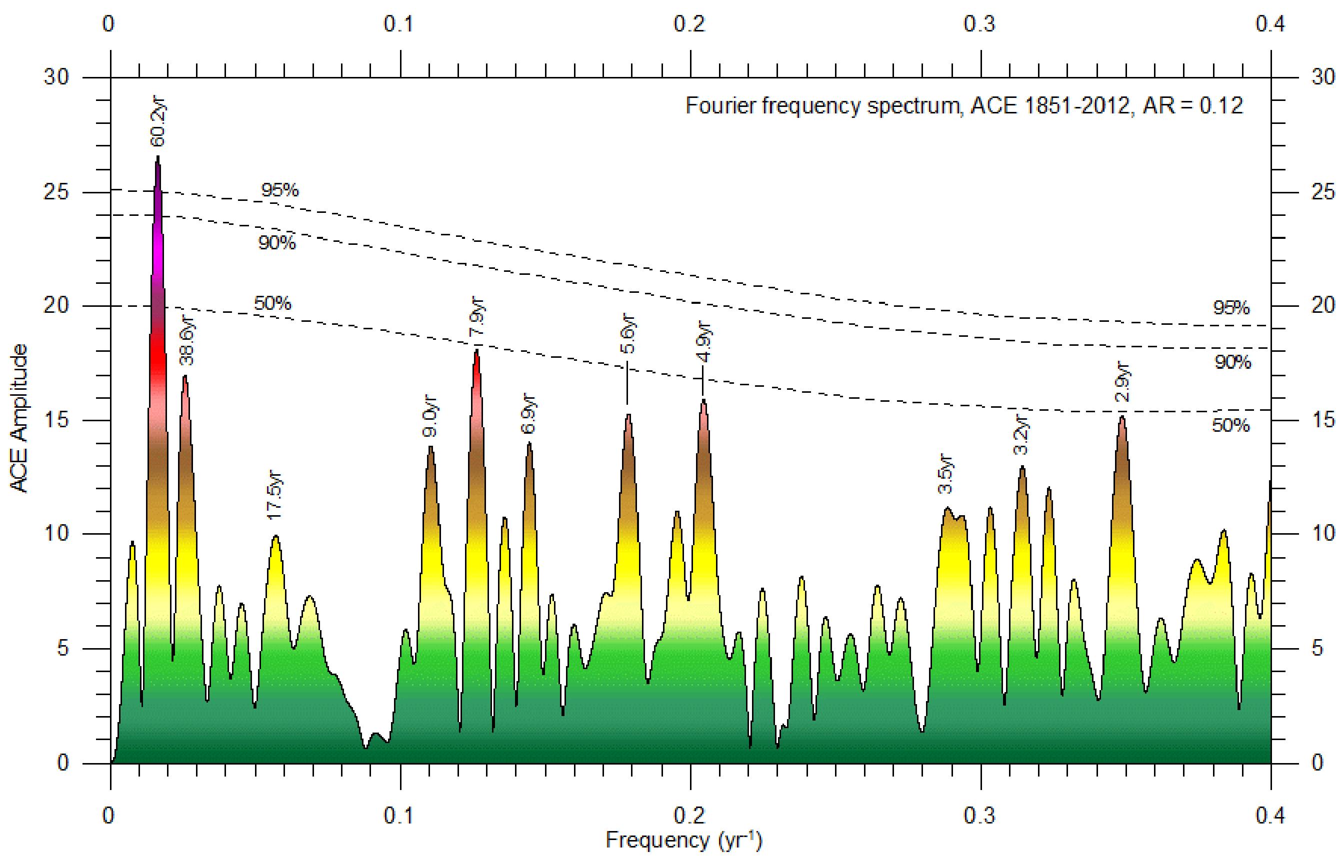


Figure 3. Fourier analysis (using Best Exact N composite algorithm) of the detrended ACE series, calculated for the Atlantic basin. The horizontal stippled lines indicate peak-based critical limit significance levels, while the colour scale indicates increasing amplitude. The ACE record is dominated by periods of about 60.2, 7.9, 5.6, 4.9 and 2.9 yr length, all with amplitude greater than 15. However, in a statistical sense, due to the still limited length of the ACE record, only the 60.2 yr peak is significant. Only frequencies lower than 0.4 yr^{-1} (periods longer than 2.5 yr) are shown. Last year incorporated in the analysis: 2012.

Visual inspection of climate data series like the Atlantic ACE series (Fig.2) often suggests the existence of recurrent variations (see, e.g. Humlum et al. 2011 and Humlum et al. 2012), and Fourier analysis represents a valuable tool for the identification of such natural variations, as shown by the diagram above (Fig.3). However, describing the character (persistence, period and amplitude) of such cyclic patterns might be difficult as they often come and go, lasting only for a limited period at each appearance. Especially the dynamics over time of the individual cycles can be complicated to analyse. For this reason, these natural oscillations may prove difficult to characterise fully from a normal Fourier power spectrum.

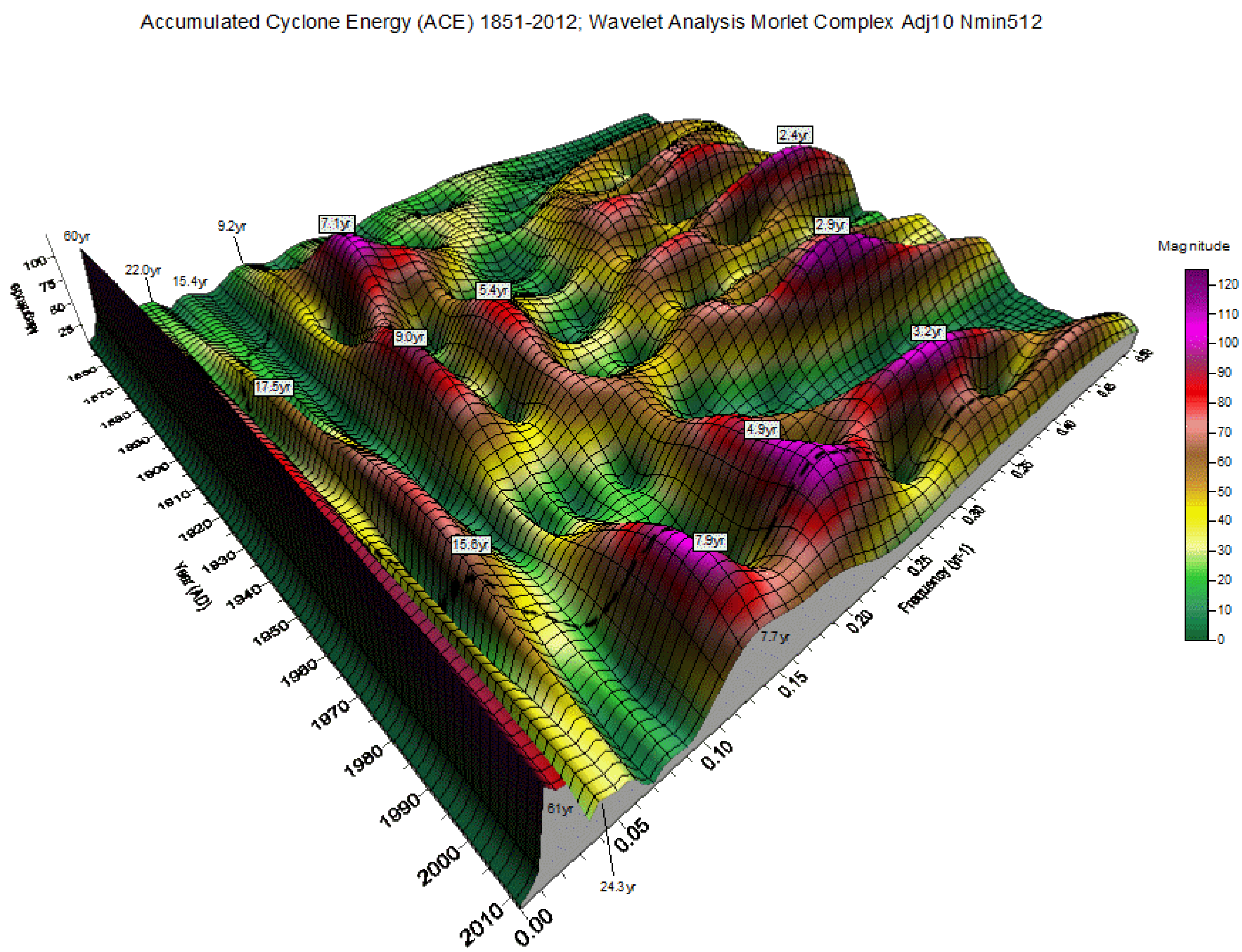


*Figure 4. Diagram showing the continuous wavelet time-frequency spectrum for the ACE series, calculated for the Atlantic basin. Time (AD) and frequency (yr-1) of cyclic variations embedded in the data are shown along the two horizontal axes. Frequencies higher than 0.5 yr-1 are not shown, corresponding to showing only periods longer than 2 yr. The vertical axis (and colour scale) shows the component (magnitude) of the Continuous Wavelet Spectrum at a given time and frequency. The magnitude is calculated as sqrt(Re*Re+Im*Im), where Re is the real component of a given segment's FFT at a given frequency and Im is the imaginary component. Usually the magnitude is 3-4 times the corresponding amplitude. The dotted line indicates the extent of the cone of influence, where the magnitude of oscillations may be diminished artificially due to zero padding, especially towards the ends of the time scale, see, e.g. the 7.9 and 4.9 yr periods. Last year incorporated in the analysis: 2012.*

To overcome the problem encountered when cyclic variations change their period and amplitude, a wavelet analysis (Morlet 1983) may be employed to identify and describe oscillating variations in the record as a supplement to the Fourier analysis. A more thorough description of the wavelet analysis is given by Torrence and Compo (1997) and by Humlum et al. (2011).

The result of a Morlet wavelet analysis of the Atlantic ACE data (Fig.2) is shown in the diagram above (Fig.4). The wavelet analysis reveals several cyclic variations in the ACE record (see diagram above). A dominant period of about 60 year length is seen to characterise the entire record. Other variations are more dynamic over time, and may come and go, although two periods of 8-9 year and about 5 year length appear to be rather persistent. At the moment, especially the period with about 8 year length appears to be important, and therefore not likely to disappear immediately.

Thus, there is reason to expect that the near future development of ACE within the Atlantic basin will predominantly be controlled by the above mentioned 60 and 8 year periods. As the 60 year period just now has entered its declining phase, it is likely that also the Atlantic ACE value will show an overall decline during the coming about 25-30 years.

References:

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Torrence, C. and Compo, G.P. 1997. A Practical Guide to Wavelet Analysis. *Bulletin of the American Meteorological Society* 79, No. 1, 61-78.

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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

Season's Greetings, yours sincerely,

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