Climate4you update February 2012

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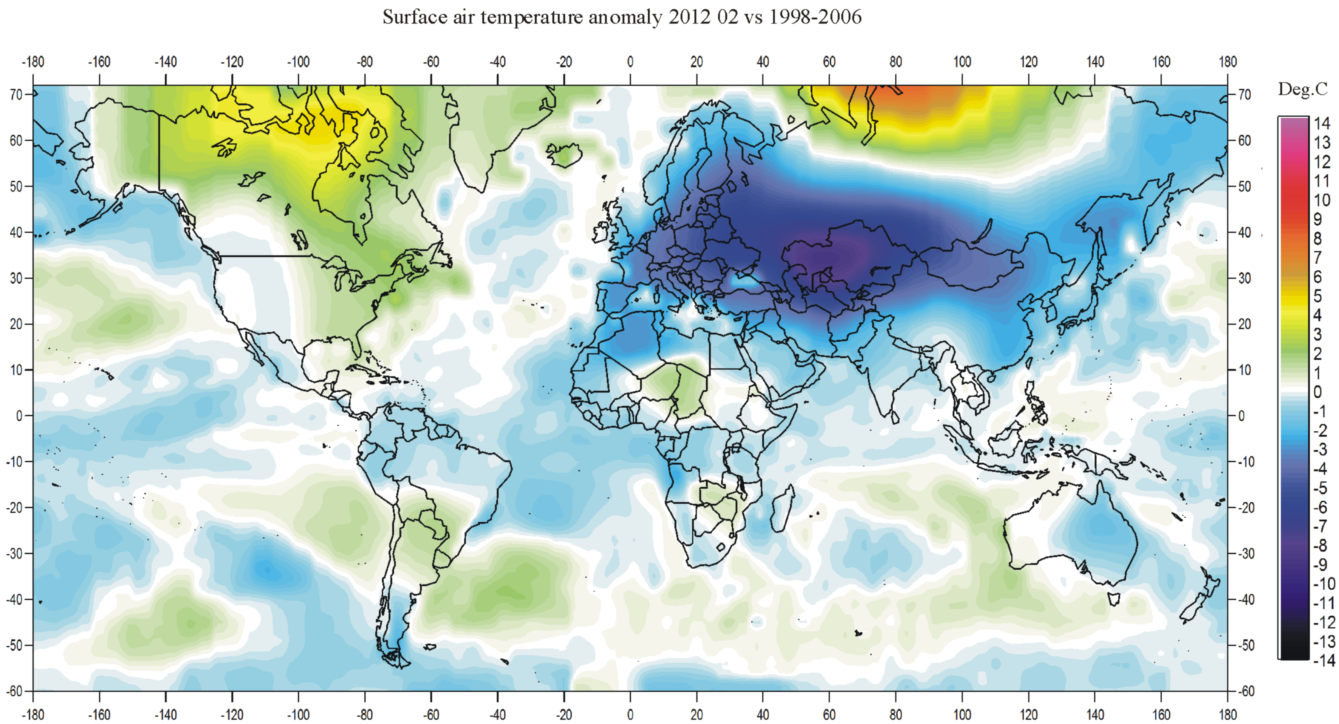
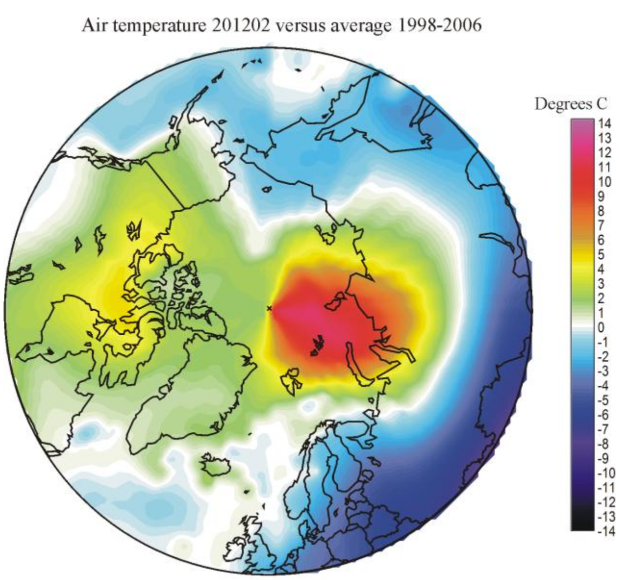
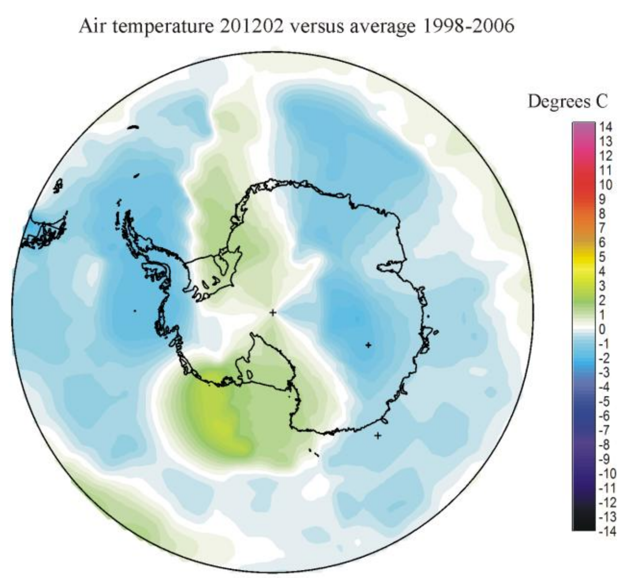
[February 2012 global surface air temperature overview]()







February 2012 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 2012 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 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, 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 grater detail on www.Climate4you.com.

The average global surface air temperatures February 2012:

General: Global air temperatures were relatively low.

The Northern Hemisphere was again characterised by high regional variability. All of Asia and Europe experienced below average temperatures, with the exception of northern Siberia, Scotland and Ireland. This was caused by an extensive Siberian high pressure, especially during first half of February. Eastern USA, northern Canada and eastern Alaska were relatively warm. The North Atlantic was below or near average 1998-2006 conditions. In the Arctic Greenland was relatively warm, as was European Arctic and northern Siberia. A marked Arctic hotspot was centred over the Kara Sea area, a feature caused by interpolation based on data from a number of stations influenced by local sea ice conditions, thereby reflecting the displacement of the Arctic temperature pole towards the Pacific during the present winter 2011-12. Presumably, the extension of the warm region towards the pole is mainly an interpolation artefact only.

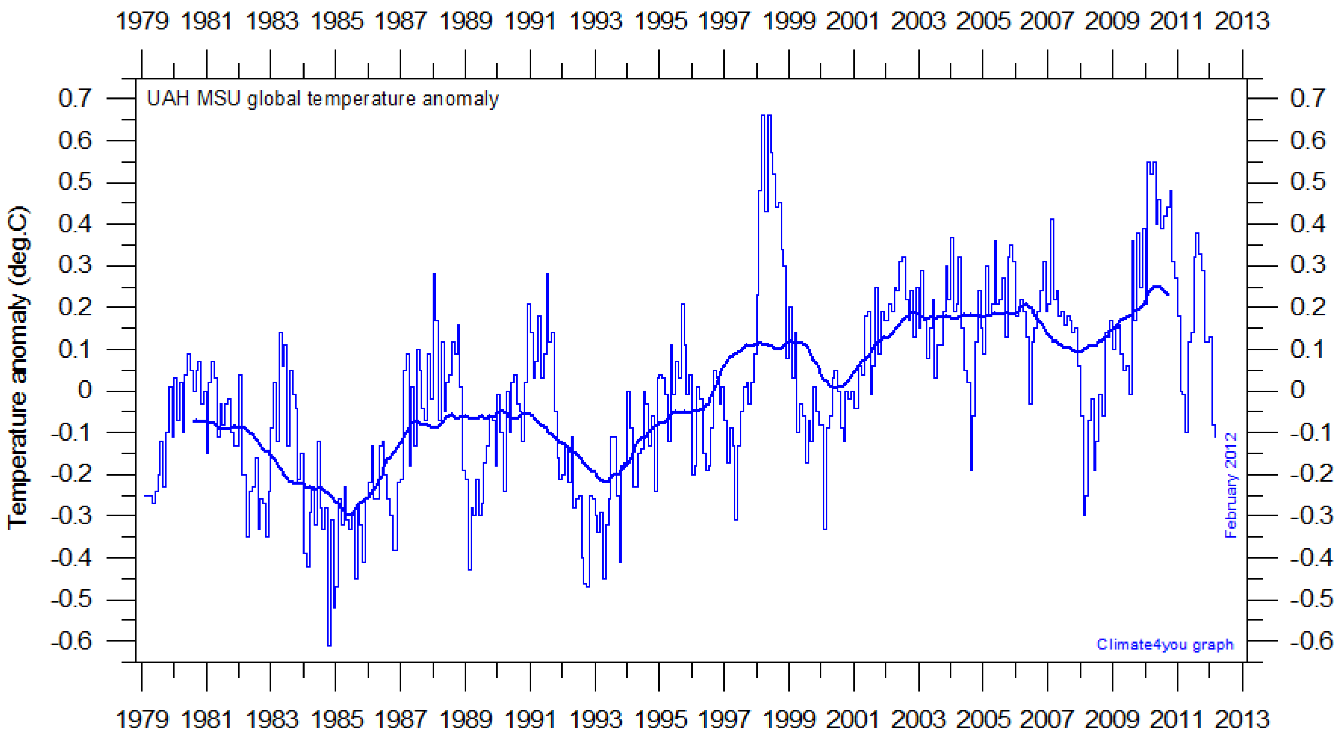
Near Equator temperatures conditions in general were below average 1998-2006 temperature conditions, both land and ocean.

The Southern Hemisphere was below or near average 1998-2006 conditions. Only central South America experienced temperatures somewhat above the 1998-2006 average. Africa had in general below average temperatures. Australia experienced above average conditions in the eastern part, while the west was close to average conditions. Most of the oceans in the Southern Hemisphere were near or below average temperature. The Antarctic continent in general experienced below average 1998-2006 temperatures, although some areas experienced above average temperatures.

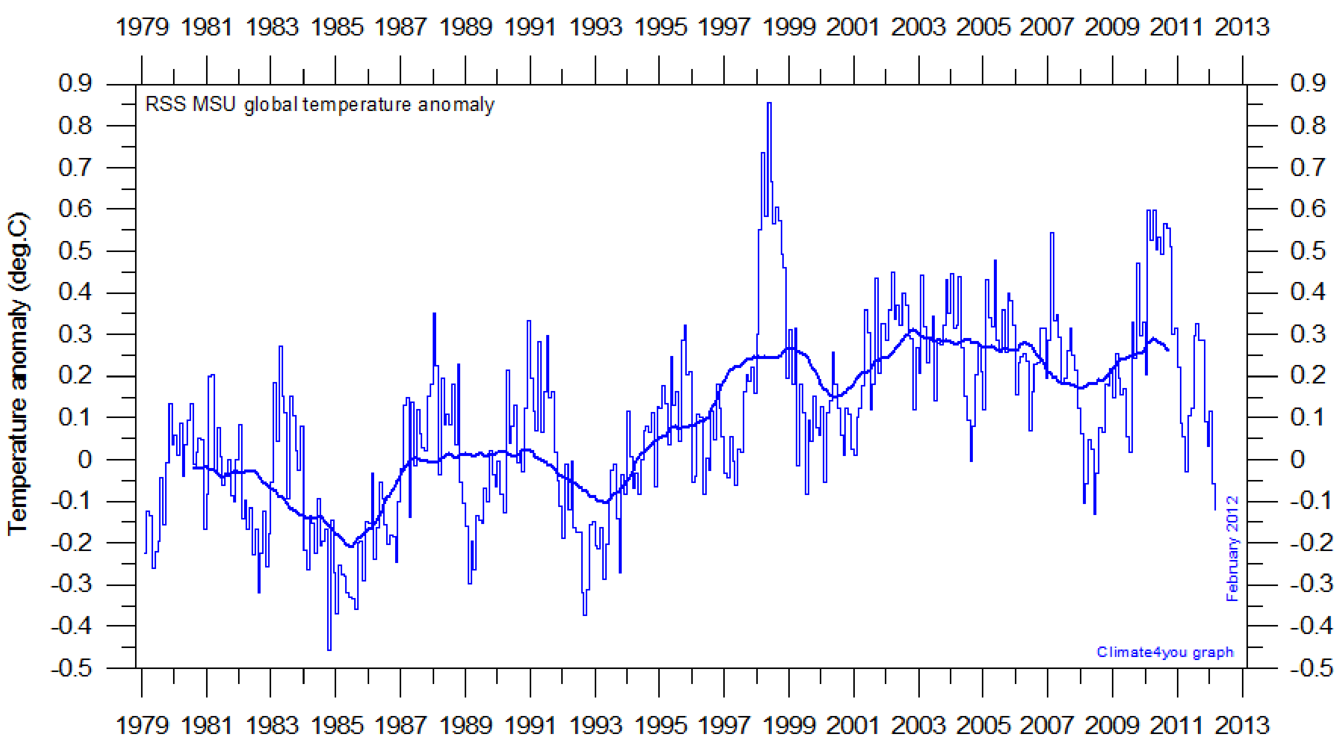
The global oceanic heat content has been almost stable since 2003/2004 (page 10).

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

Lower troposphere temperature from satellites, updated to February 2012

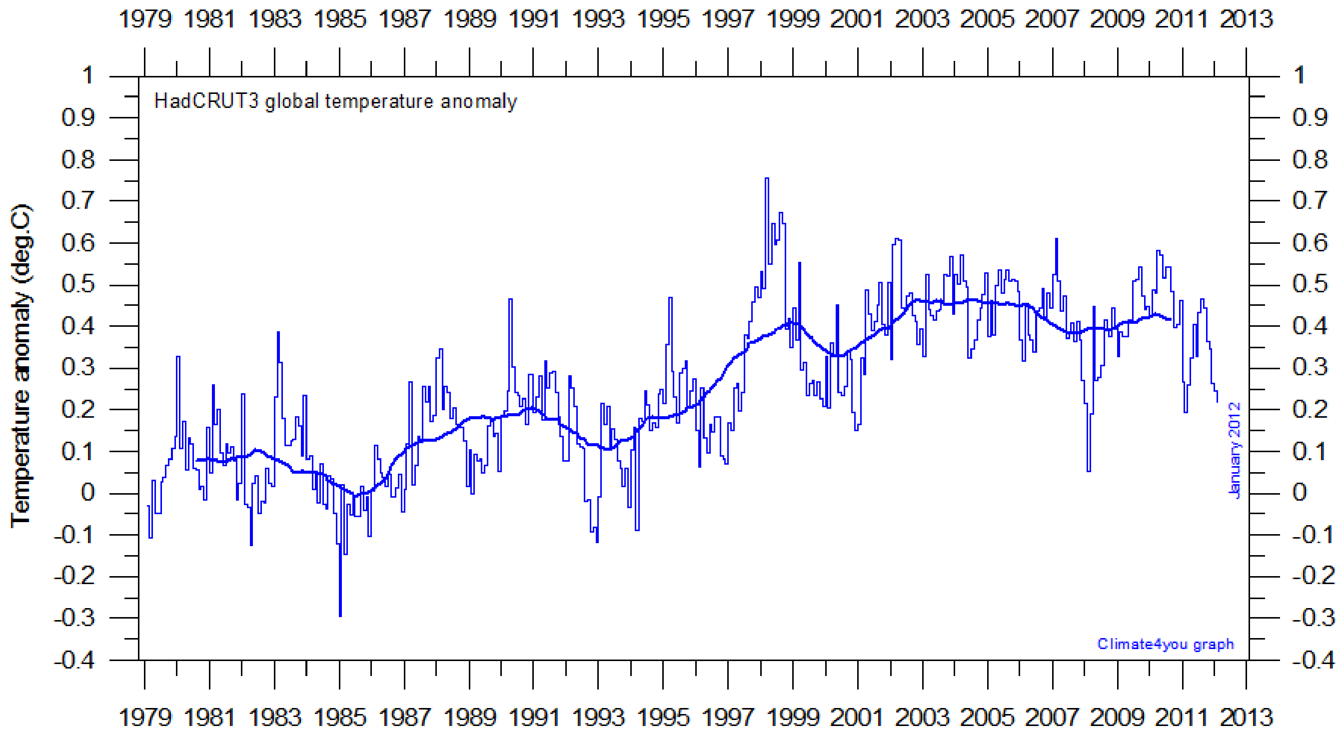


Global monthly average lower troposphere temperature (thin line) since 1979 according to [University of Alabama]() at Huntsville, USA. The thick line is the simple running 37 month average.

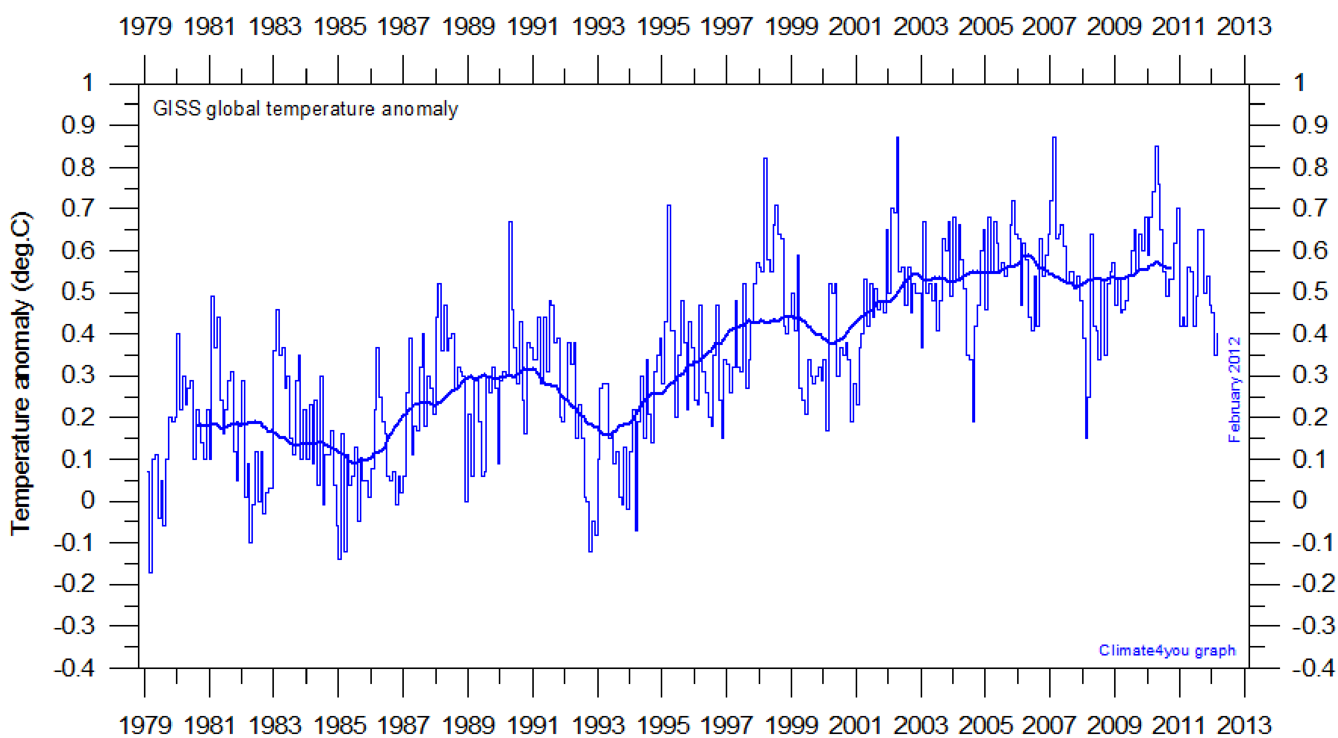


Global monthly average lower troposphere temperature (thin line) since 1979 according to according to [Remote Sensing Systems]() (RSS), USA. The thick line is the simple running 37 month average.

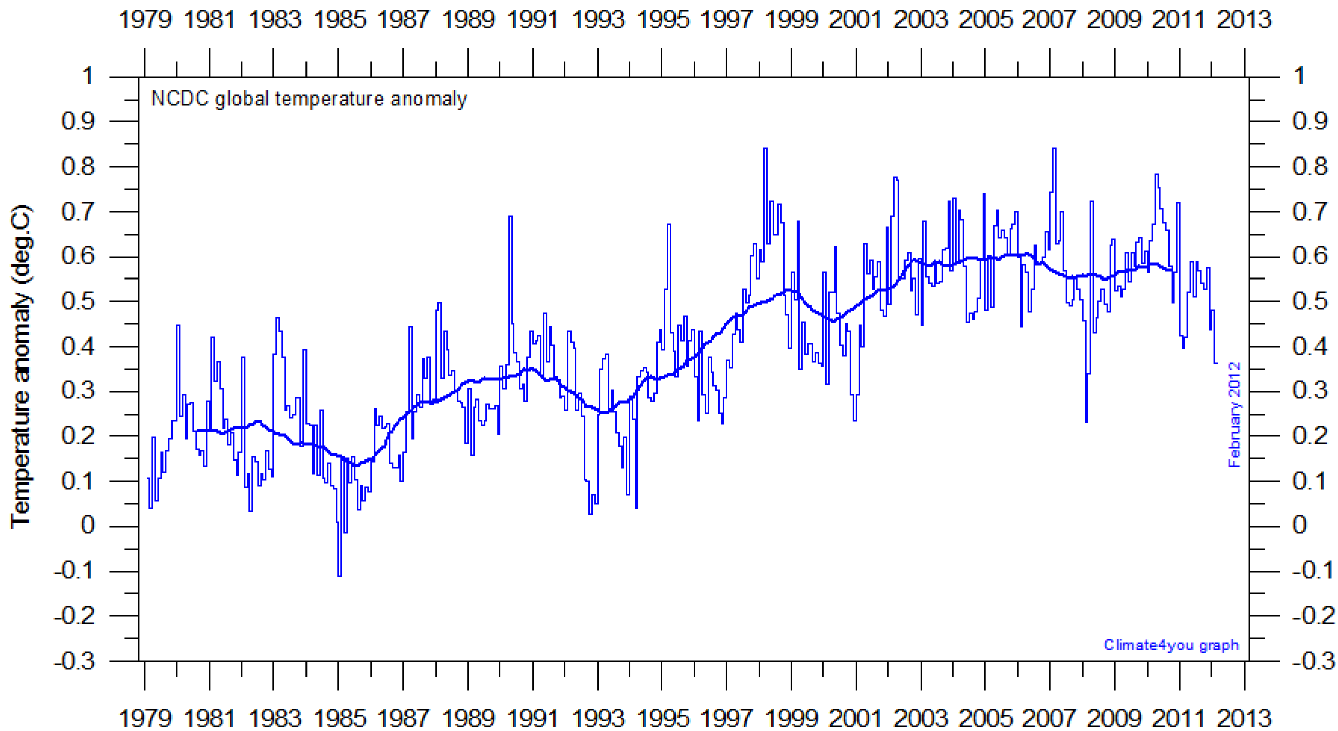
Global surface air temperature, updated to February 2012



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. Please note that this diagram has not been updated beyond January 2012.



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.

5

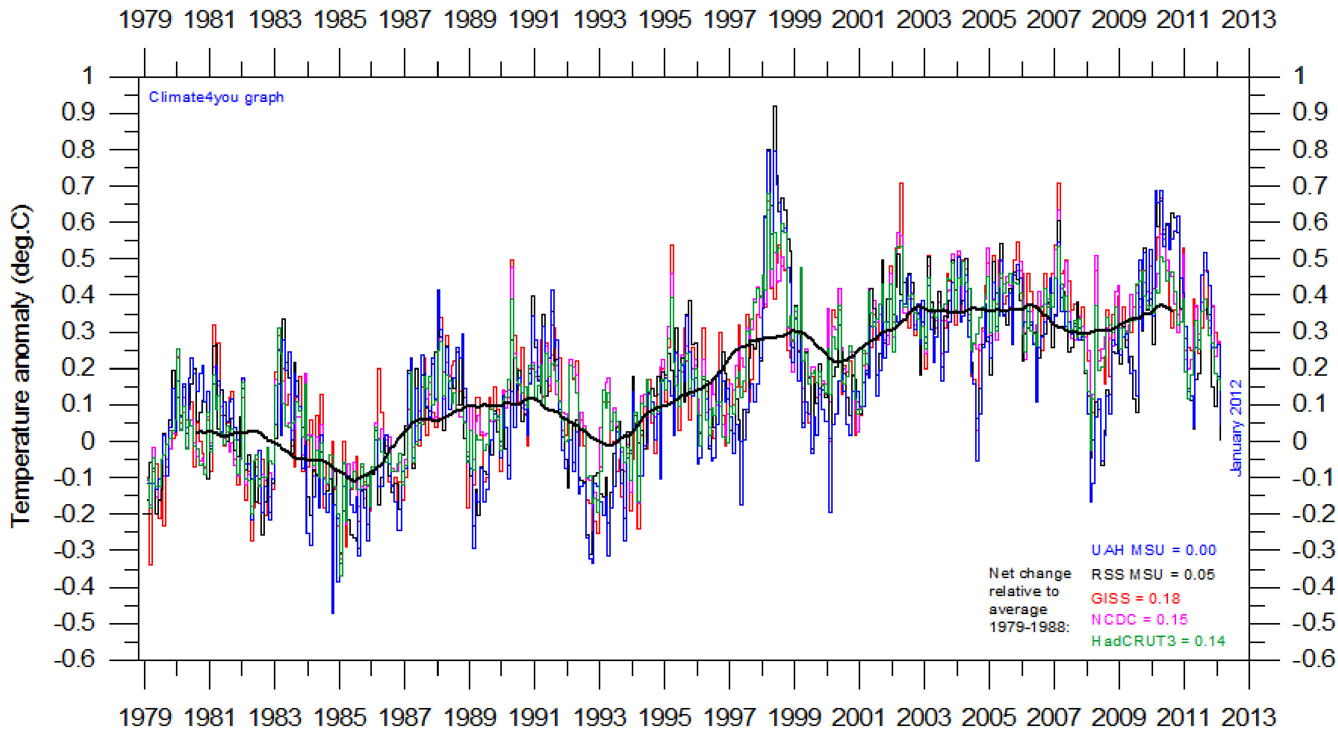
A note on data record stability:

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 additional 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 followed, and influence of other phenomena.

The most stable temperature record over time of the five global records shown above is by far the HadCRUT3 series.

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

All in one, updated to January 2012

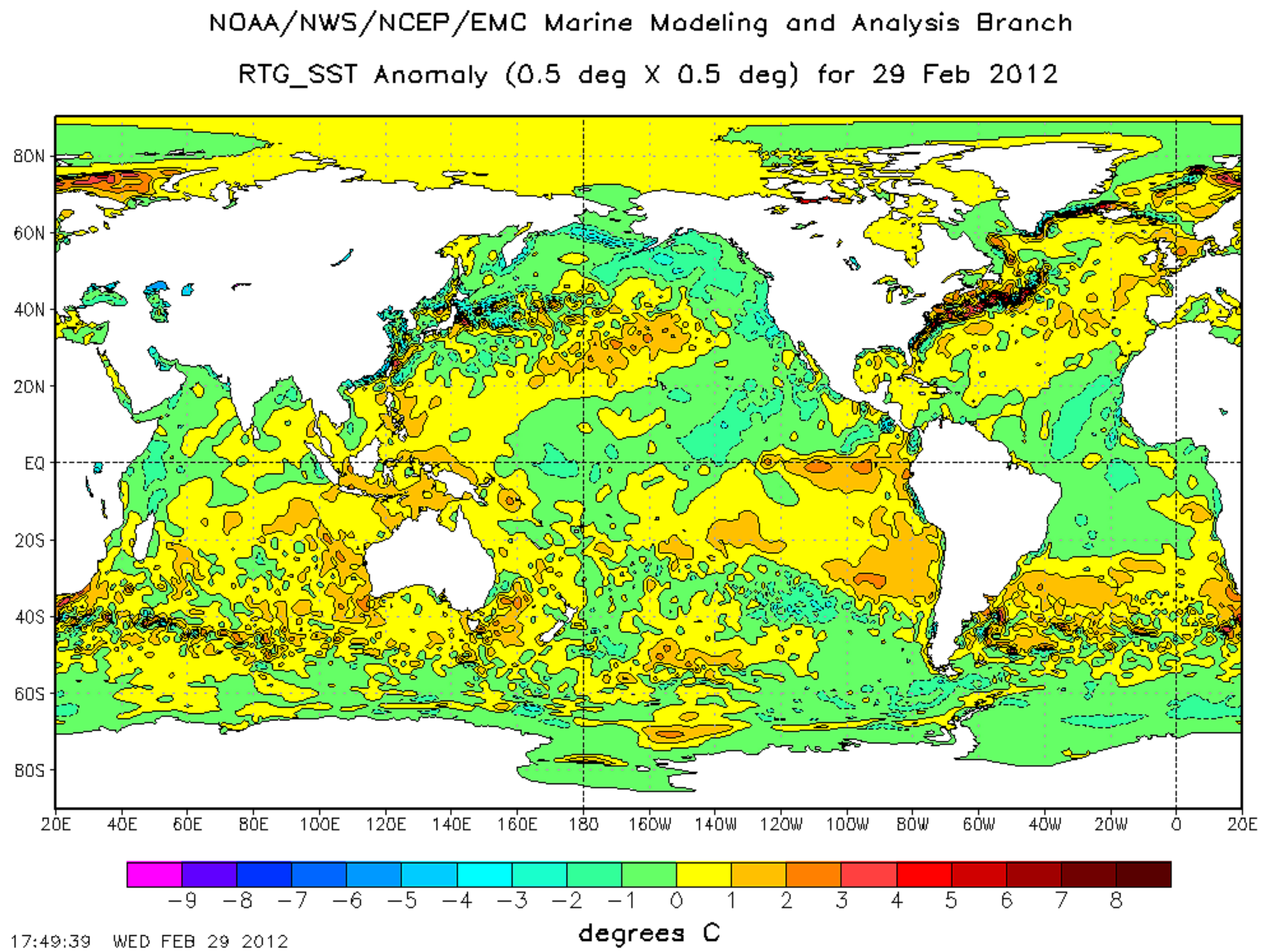


Superimposed plot of all five global monthly temperature estimates shown above. As the base period differs for the different temperature estimates, they have all been normalised by comparing to the average value of their initial 120 months (10 years) from January 1979 to December 1988. The heavy black 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 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 may be considerable differences between the individual records.

All five global temperature estimates presently show 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 late February 2012

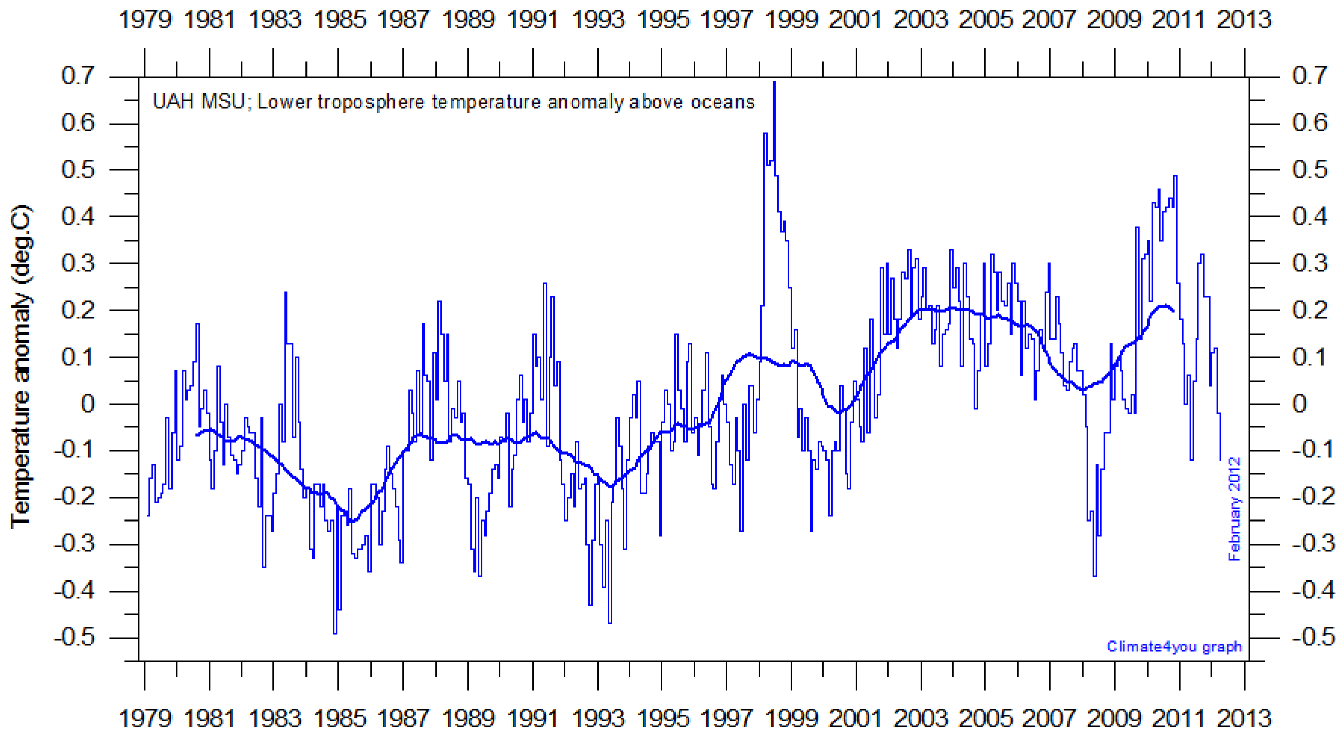


Sea surface temperature anomaly at 29 February 2012. Map source: National Centers for Environmental Prediction (NOAA).

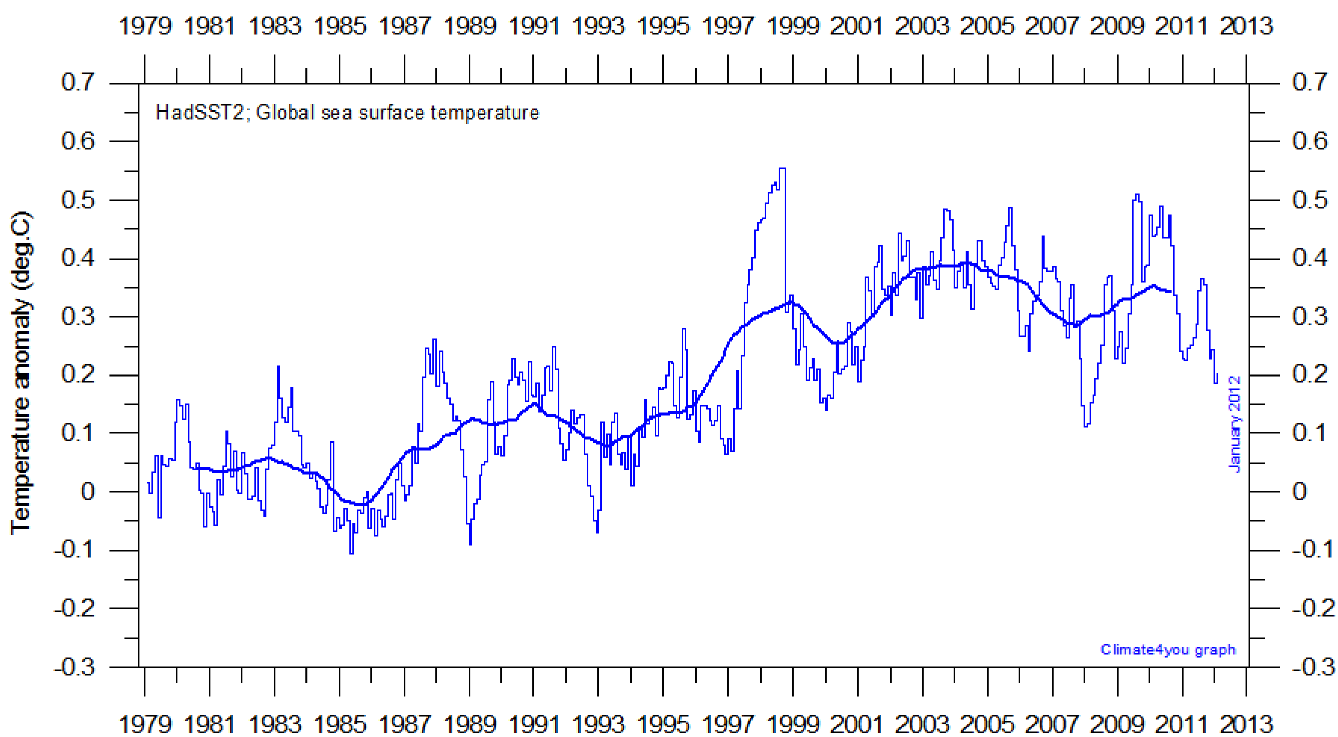
Relative cold sea surface water dominates the southern hemisphere and the regions near Equator. Because of the large surface areas involved especially near Equator, the temperature of the surface water in these regions significantly affects the global atmospheric temperature.

Not very surprisingly, it looks now as if the initial stage of a coming El Niño episode is beginning to materialise along the west coast of South America.

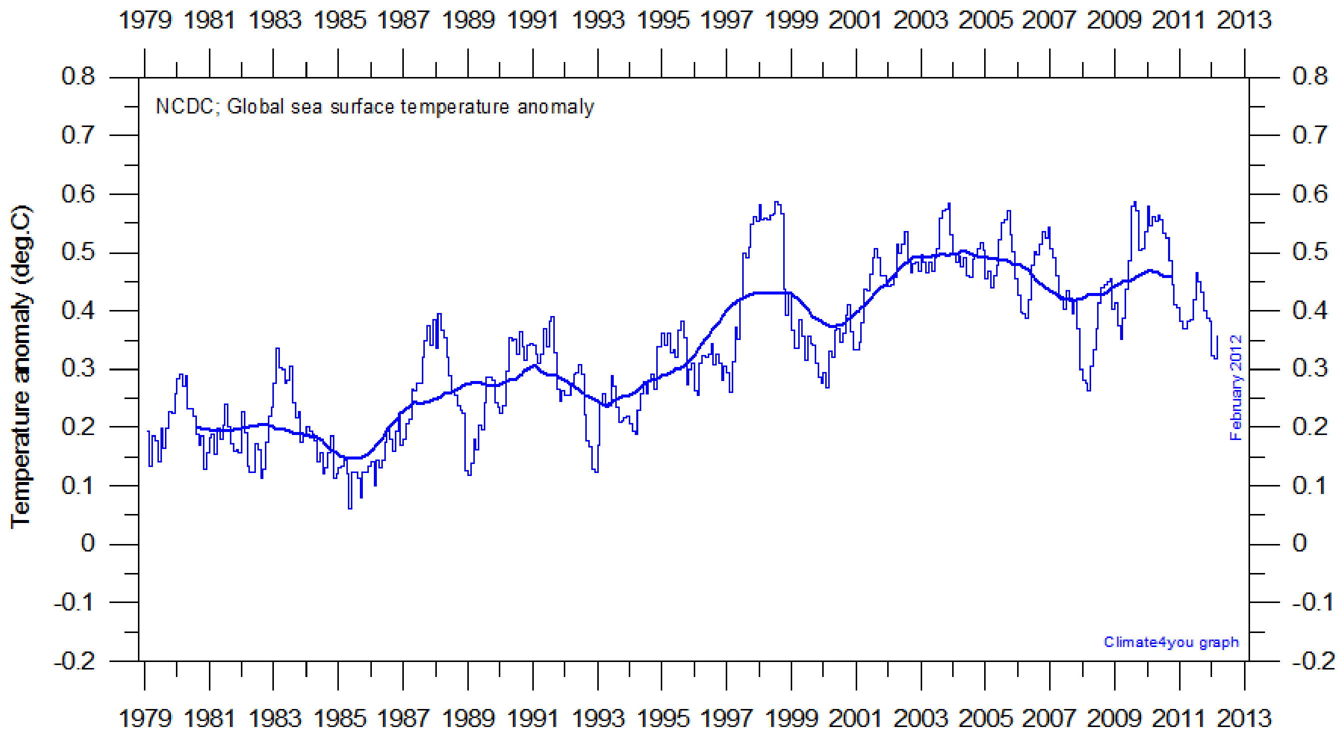
The significance of any short-term warming or cooling seen in surface air temperatures should not be over stated. Whenever Earth experiences cold La Niña or warm El Niño episodes (Pacific Ocean) major heat exchanges takes place between the Pacific Ocean and the atmosphere above, eventually showing up 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, net changes may be small, as heat exchanges as the above 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.

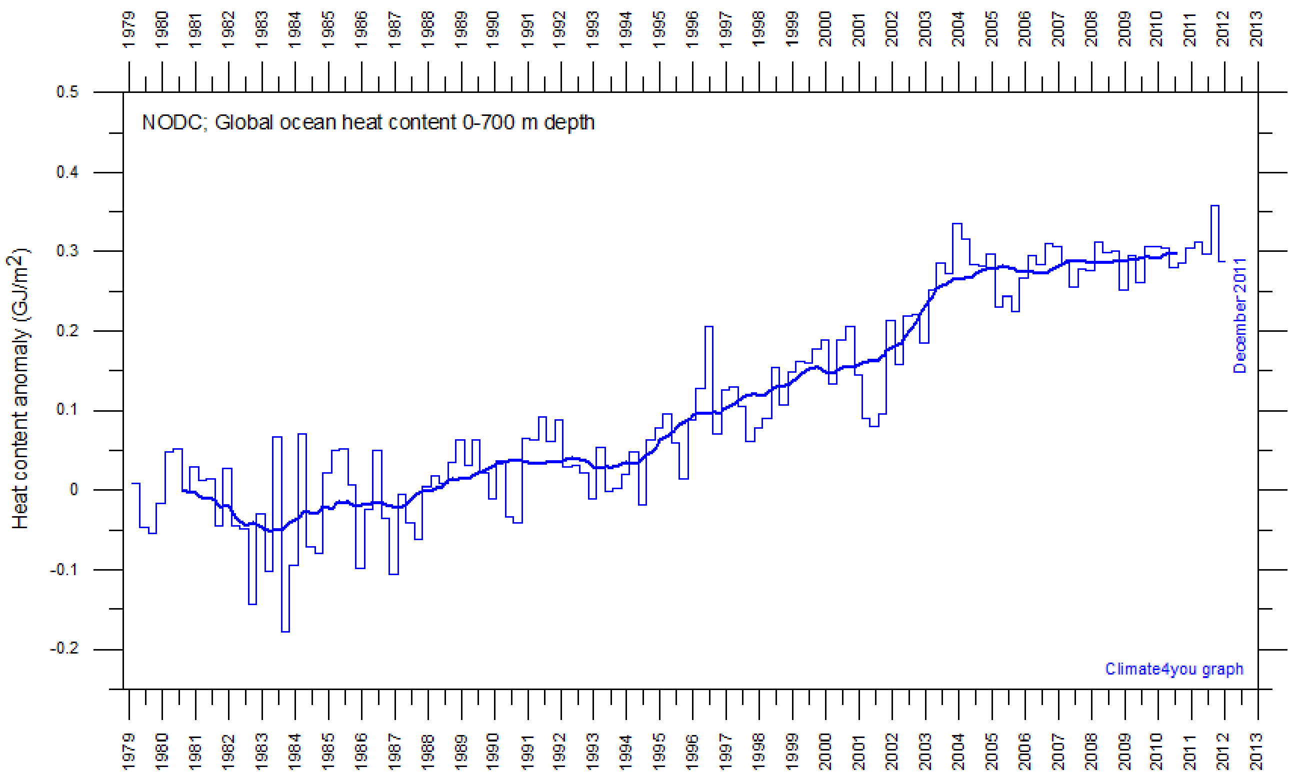


Global monthly average sea surface temperature since 1979 according to University of East Anglia's [Climatic Research Unit](#) ([CRU](#)), UK. Base period: 1961-1990. The thick line is the simple running 37 month average.

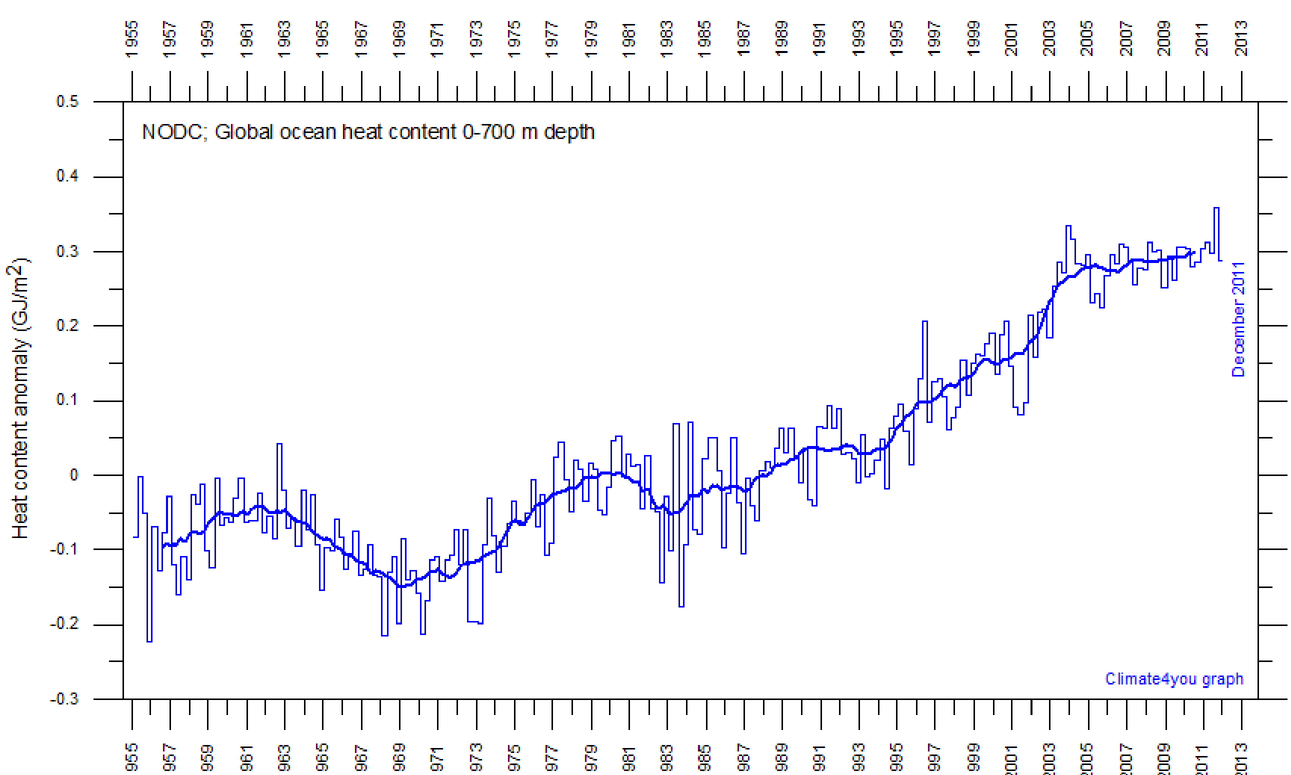


Global monthly average sea surface temperature since 1979 according to the National Climatic Data Center (NCDC), USA. Base period: 1901-2000. The thick line is the simple running 37 month average.

Global ocean heat content, updated to December 2011

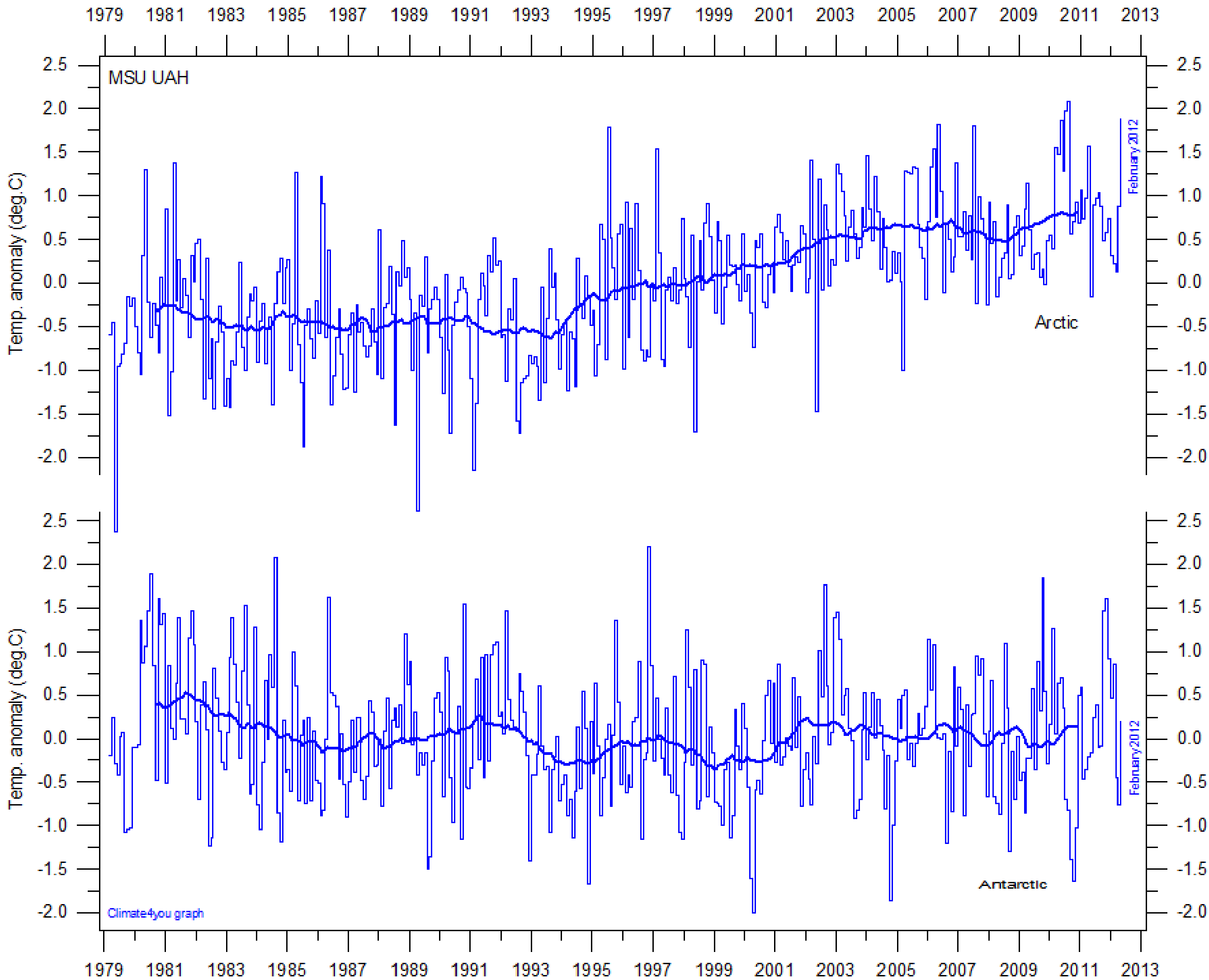


Global monthly heat content anomaly (GJ/m2) in the uppermost 700 m of the oceans since January 1979. Data source: National Oceanographic Data Center(NODC).



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 2012



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 December 2011]()

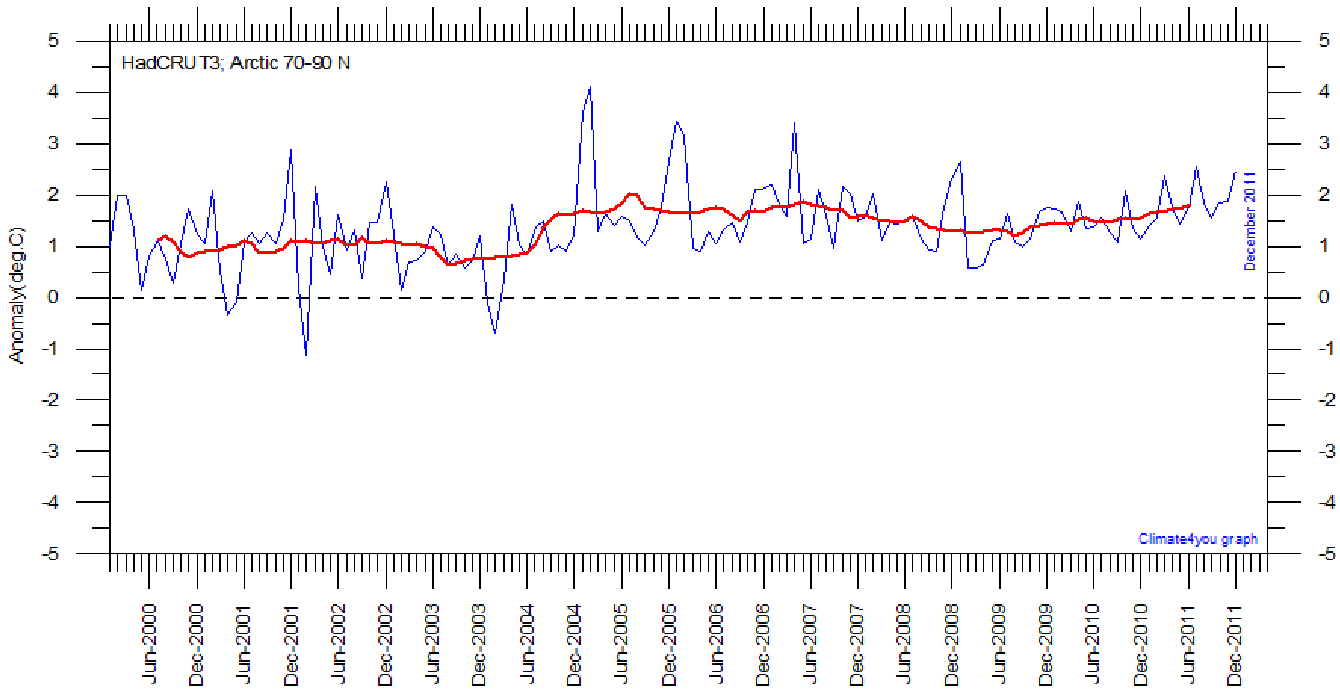


Diagram showing Arctic monthly surface air temperature anomaly 70-90^{o}N since January 2000, in relation to the WMO reference "normal" period 1961-1990. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 13 month average. Data provided by the Hadley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

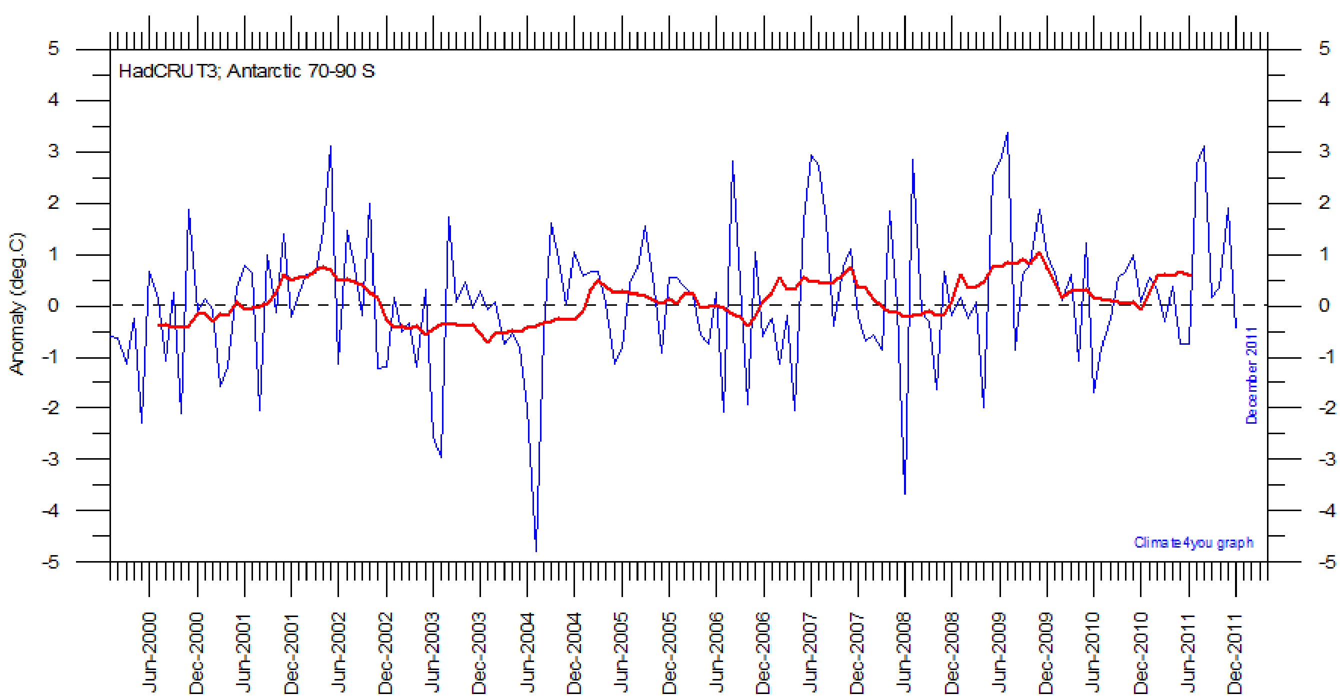


Diagram showing Antarctic monthly surface air temperature anomaly 70-90^{o}S since January 2000, in relation to the WMO reference "normal" period 1961-1990. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 13 month average. Data provided by the Hadley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

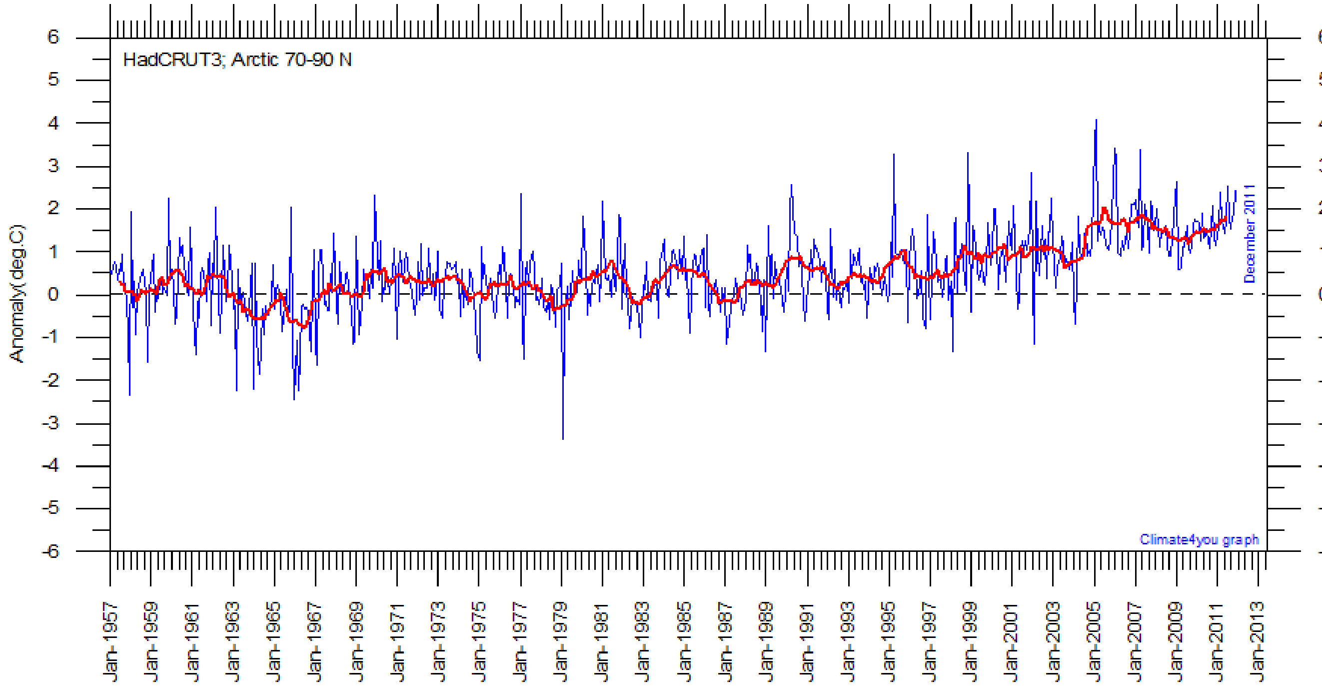


Diagram showing Arctic monthly surface air temperature anomaly 70-90°N since January 1957, in relation to the WMO reference "normal" period 1961-1990. The year 1957 has been chosen as starting year, to ensure easy comparison with the maximum length of the realistic Antarctic temperature record shown 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.

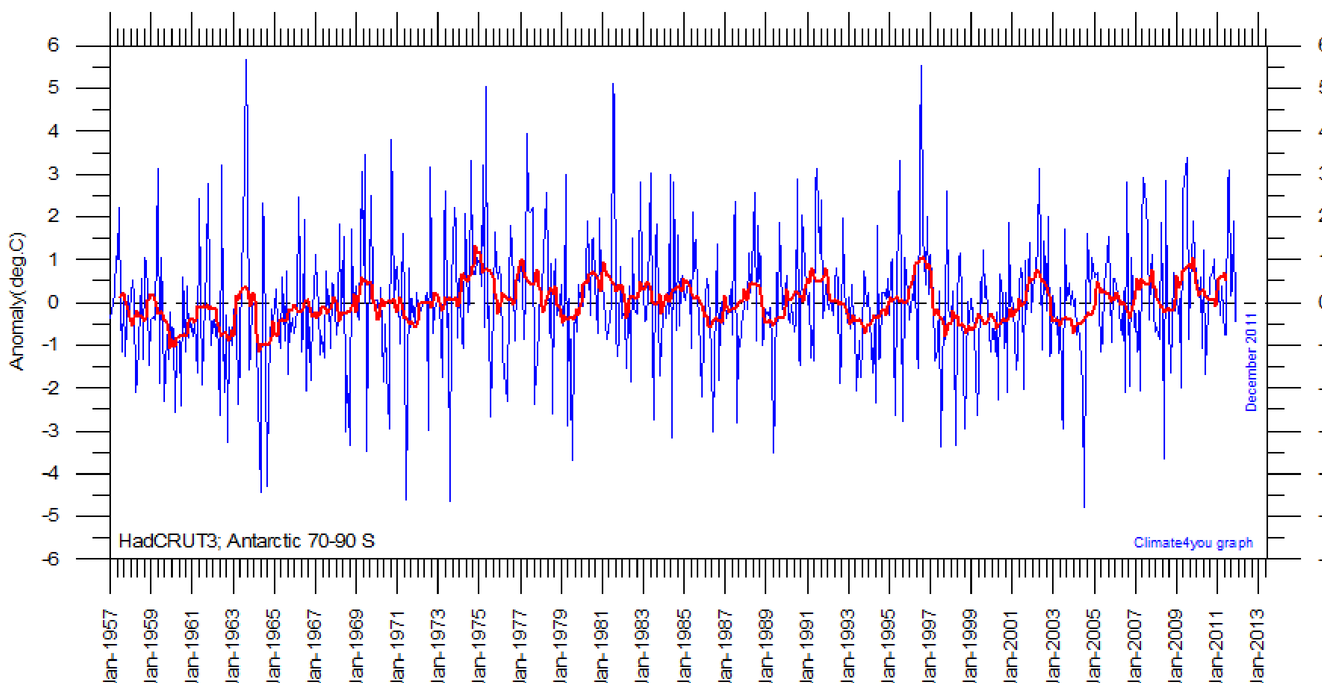


Diagram showing Antarctic monthly surface air temperature anomaly 70-90°S since January 1957, in relation to the WMO reference "normal" period 1961-1990. The year 1957 was an international geophysical year, and several meteorological stations were established in the Antarctic because of this. Before 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.

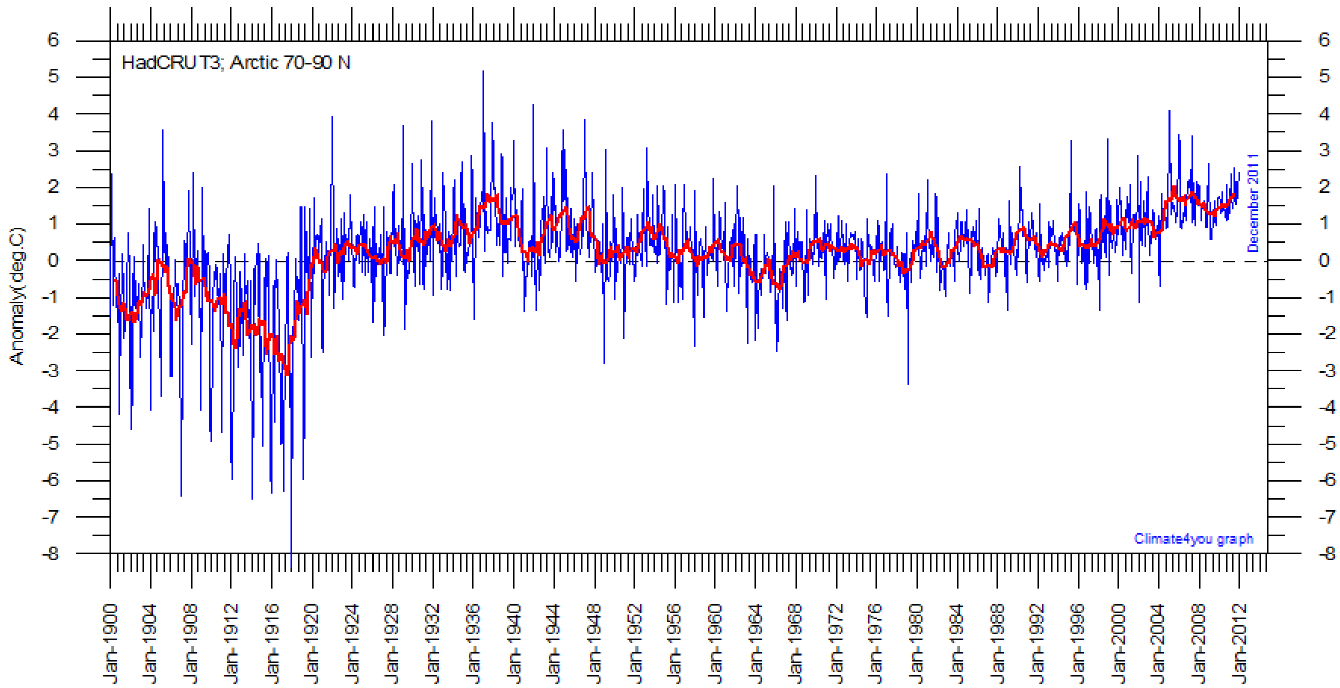


Diagram showing Arctic monthly surface air temperature anomaly 70-90°N since January 1900, in relation to the WMO reference "normal" period 1961-1990. The thin blue line shows the monthly temperature anomaly, while the thicker red line shows the running 13 month average. In general, the range of monthly temperature variations decreases throughout the first 30-50 years of the record, reflecting the increasing number of meteorological stations north of 70°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

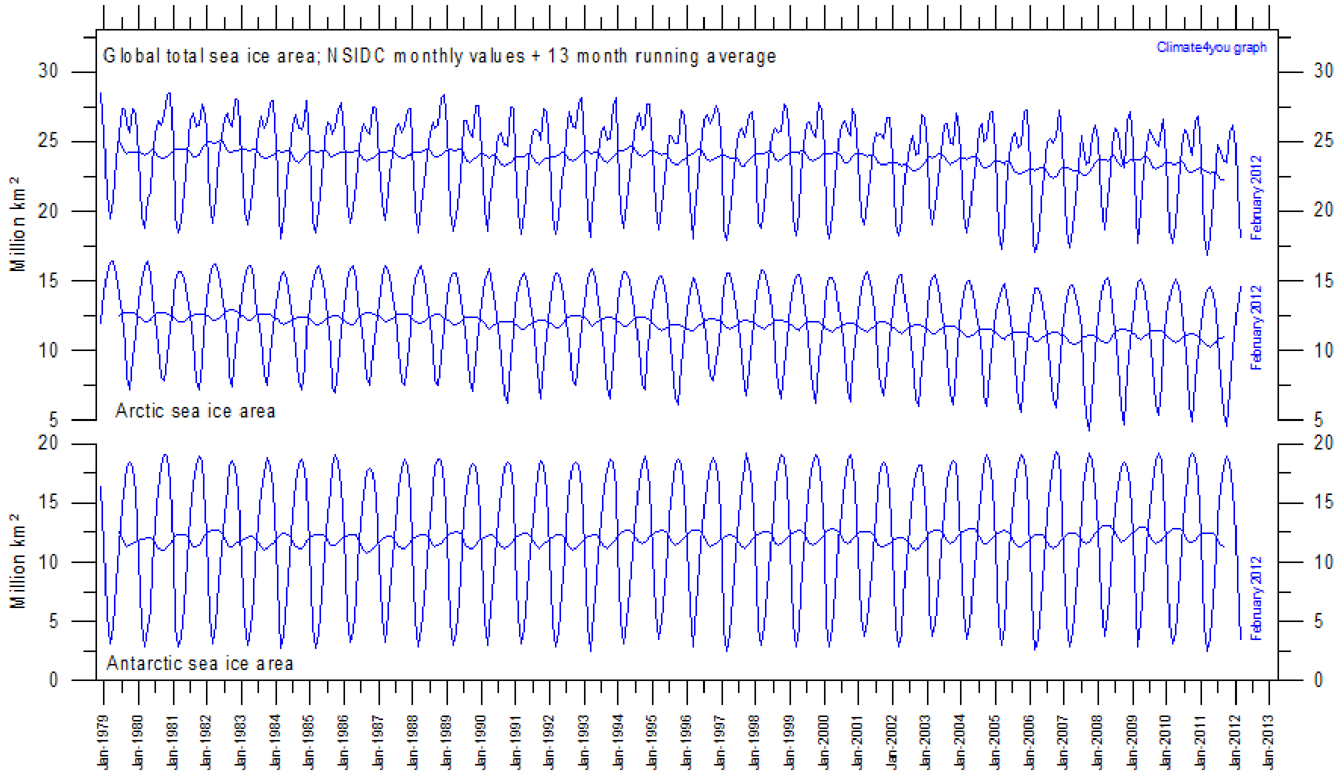
In general, the Arctic temperature record appears to be less variable than the Antarctic record, presumably at least partly due to the higher number of meteorological stations north of 70°N, compared to the number of stations south of 70°S.

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°x5° grid cell when calculating means, with no weighting by the surface areas of the individual grid dells.

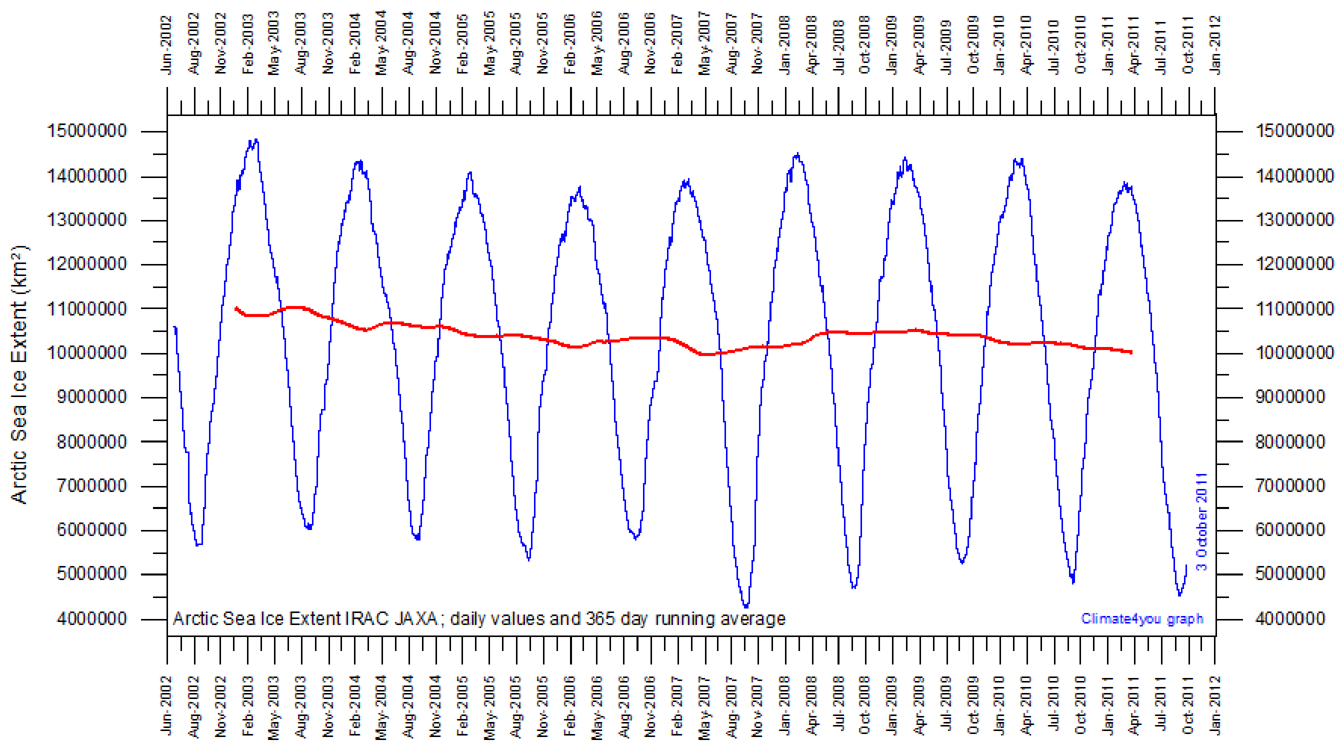
Literature:

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.

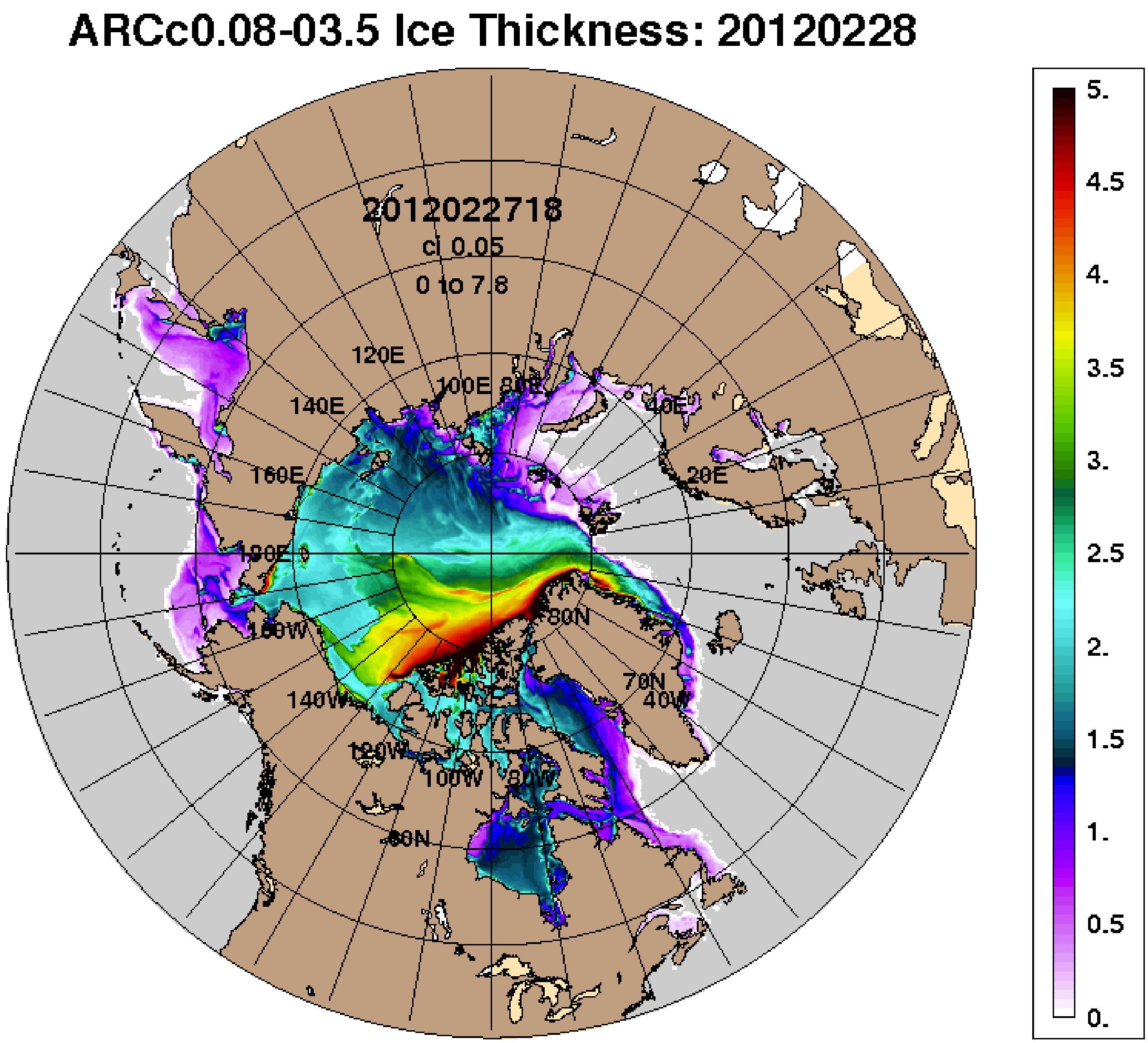
Arctic and Antarctic sea ice, updated to February 2012



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

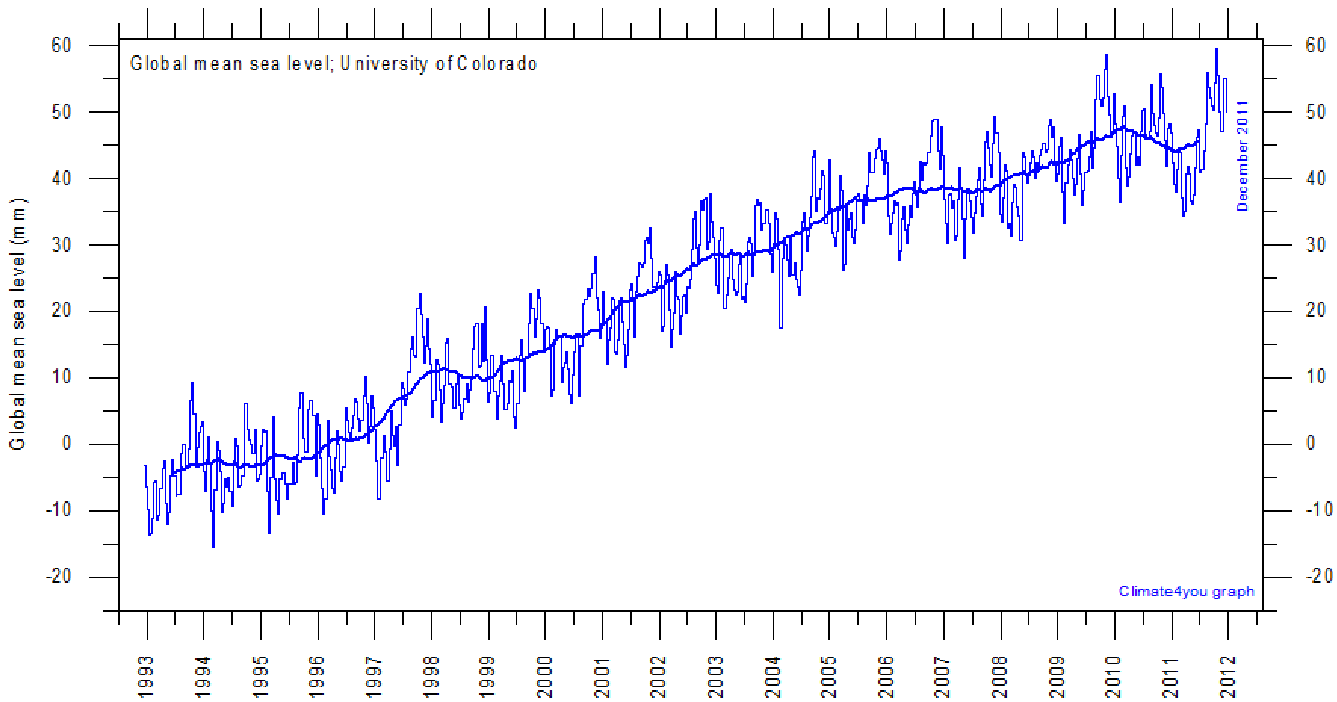


Graph showing daily Arctic sea ice extent since June 2002, to October 3, 2011, by courtesy of [Japan Aerospace Exploration Agency](#) (JAXA). Please note that this diagram is not updated beyond 3 October 2011 due to the present suspension of AMSR-E observation.

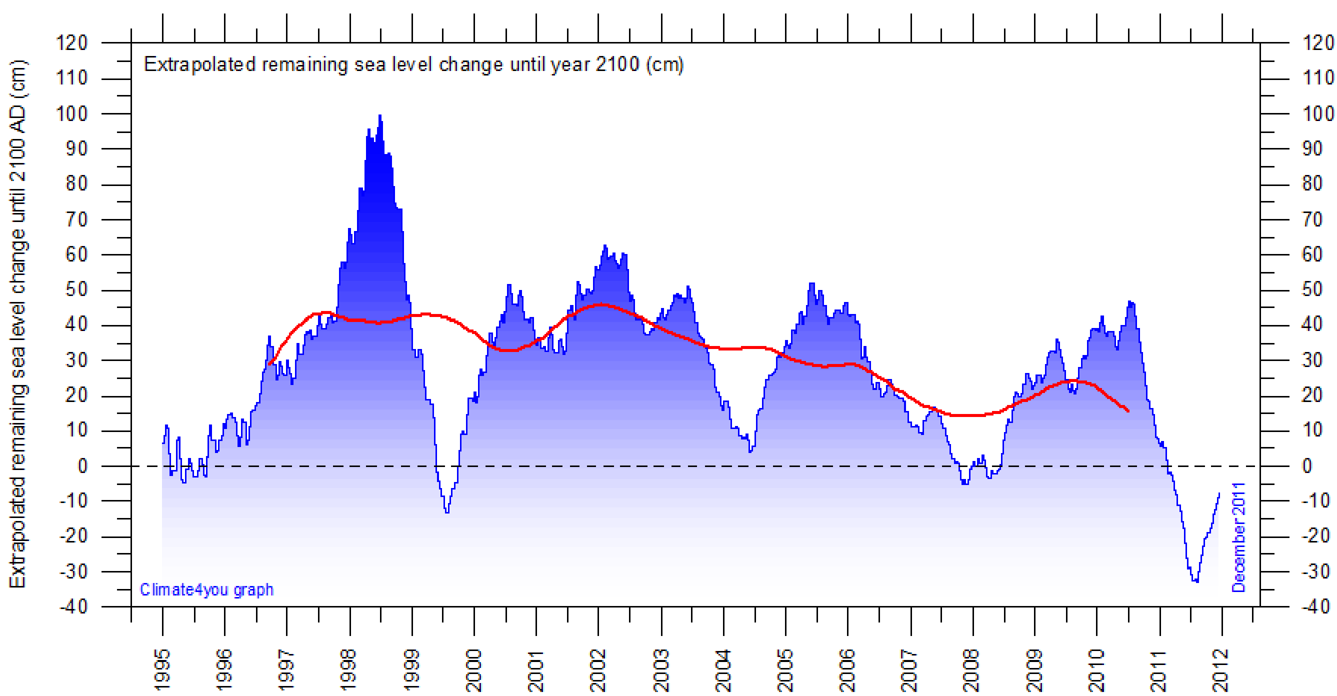


Northern hemisphere sea ice extension and thickness on 28 February 2012 according to the [Arctic Cap Nowcast/Forecast System]() (ACNFS), US Naval Research Laboratory. Thickness scale (m) is shown to the right.

Global sea level, updated to December 2011

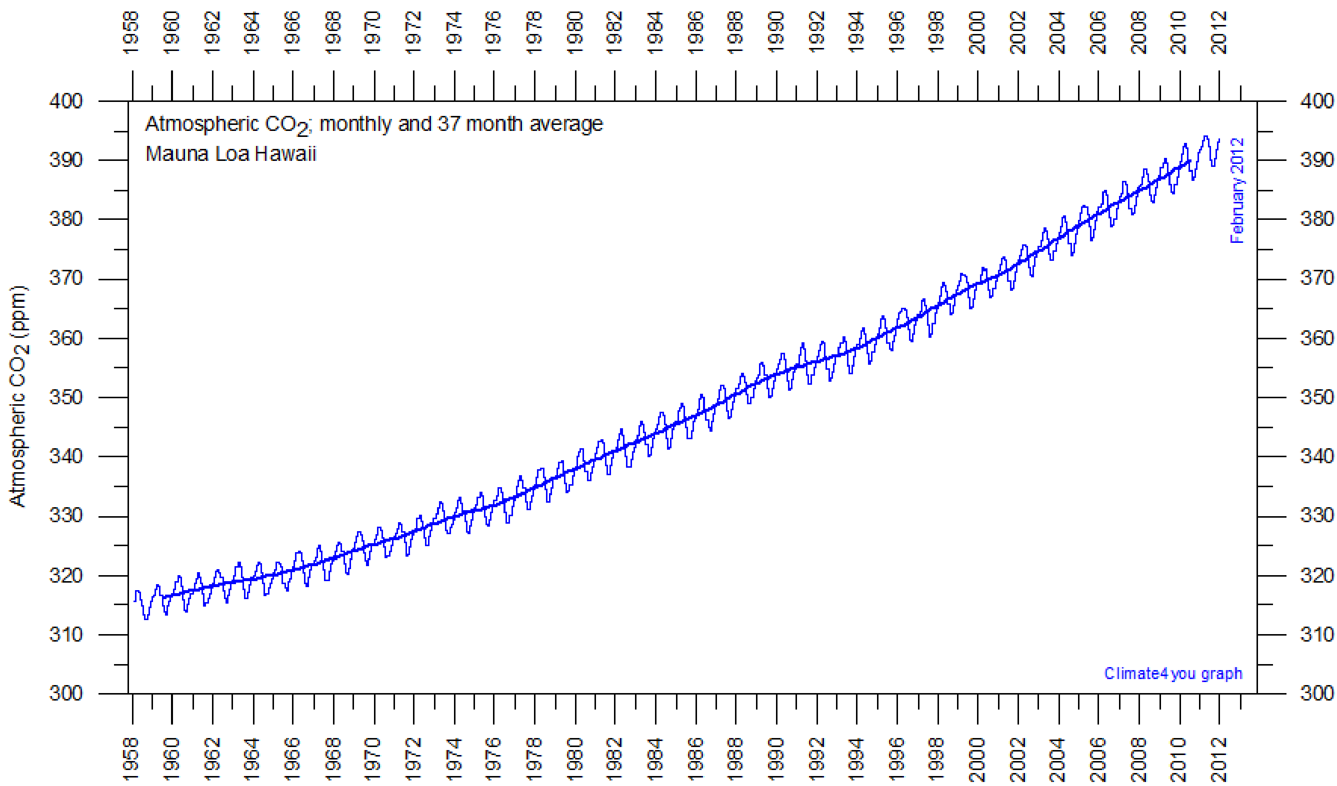


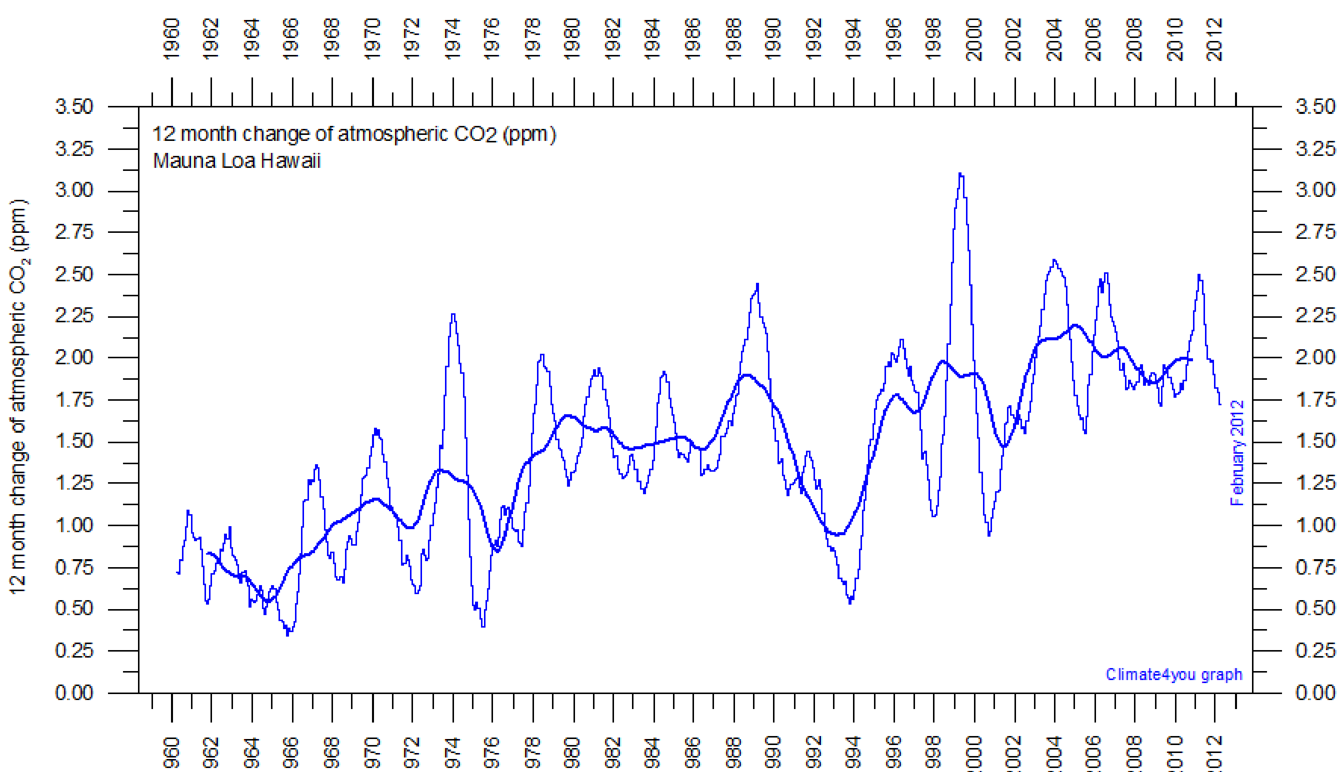
Globa lmonthly sea level since late 1992 according to the Colorado Center for Astrodynamics Research at [University of Colorado at Boulder](), USA. The thick line is the simple running 37 observation average, nearly corresponding to a running 3 yr average.



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 +18 cm.

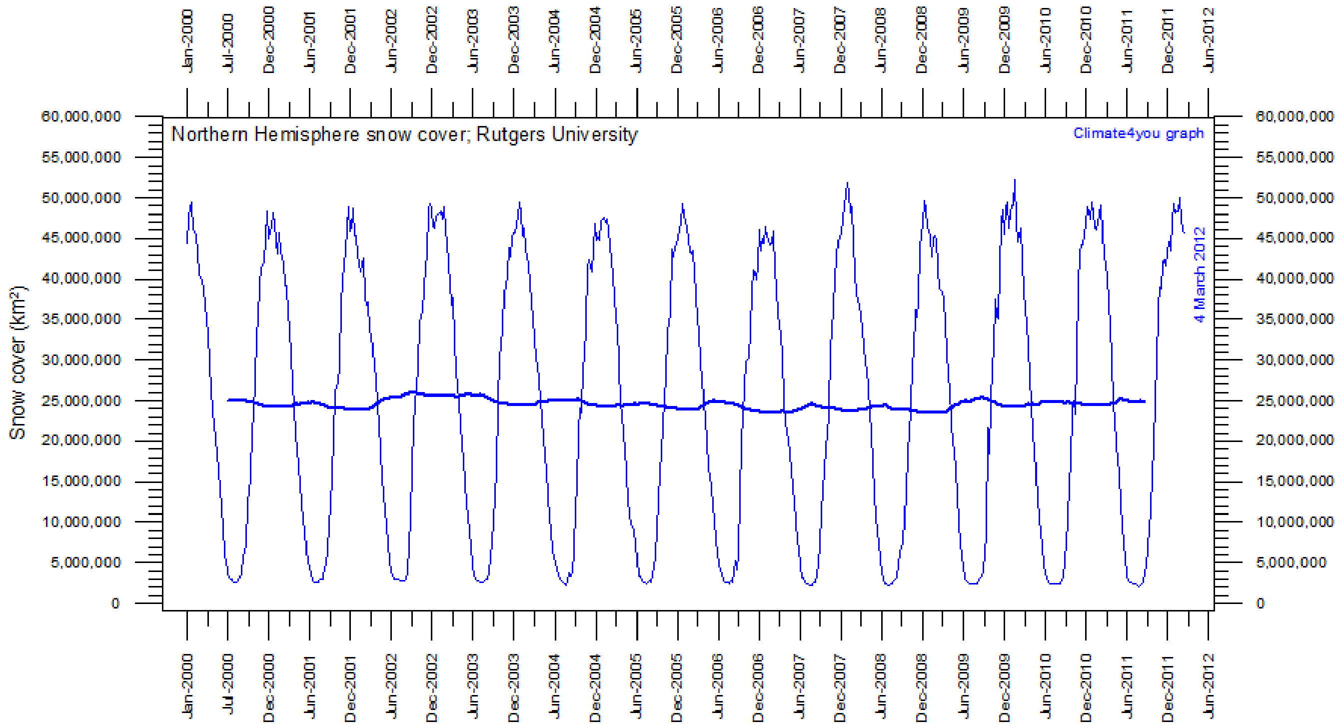
Atmospheric CO_2, updated to February 2012



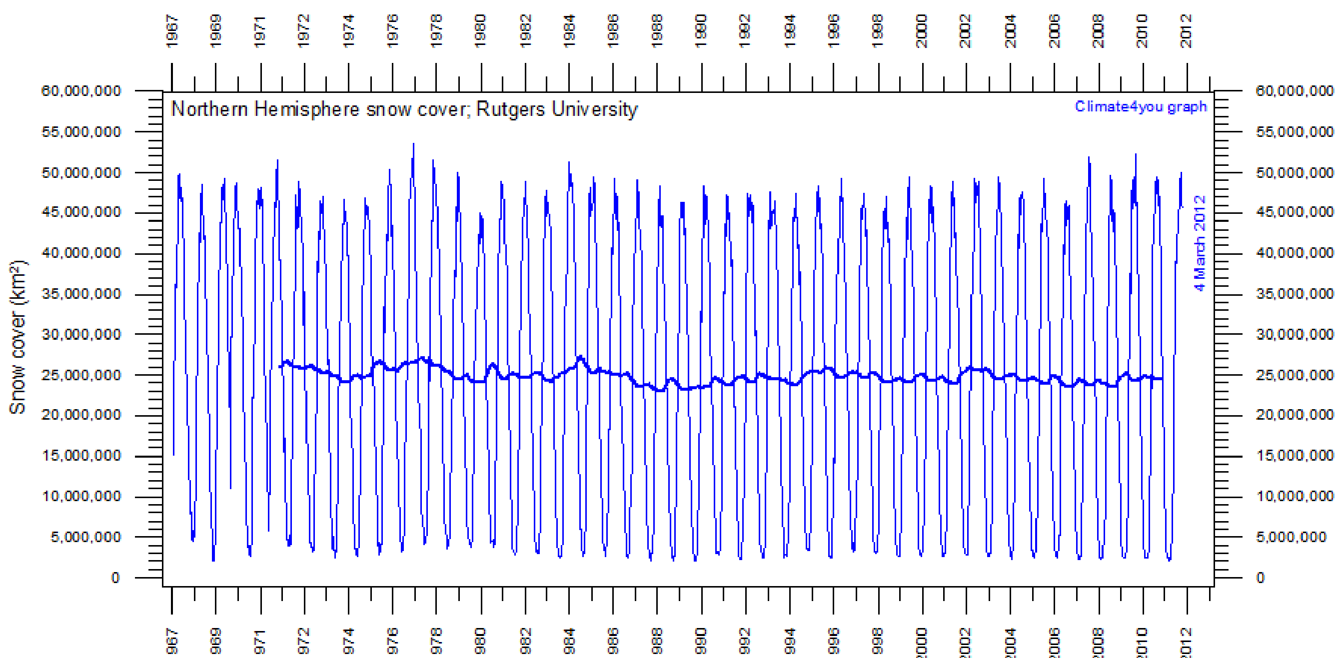


Monthly amount of atmospheric CO_2 (above) and annual growth rate (below; average last 12 months minus average preceding 12 months) of atmospheric CO_2 since 1959, according to data provided by the Mauna Loa Observatory, Hawaii, USA. The thick line is the simple running 37 observation average, nearly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

Northern Hemisphere weekly snow cover, updated to early March 2012

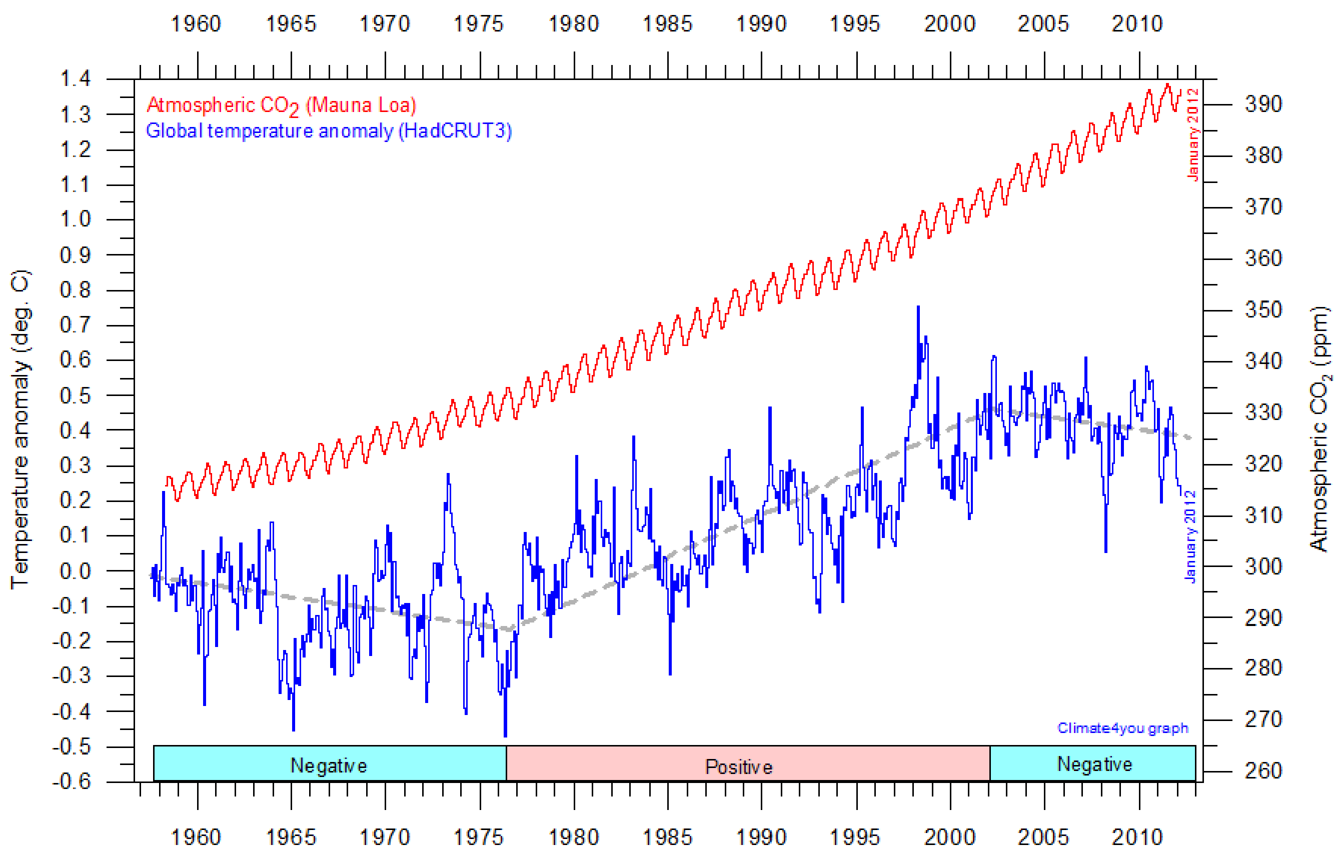


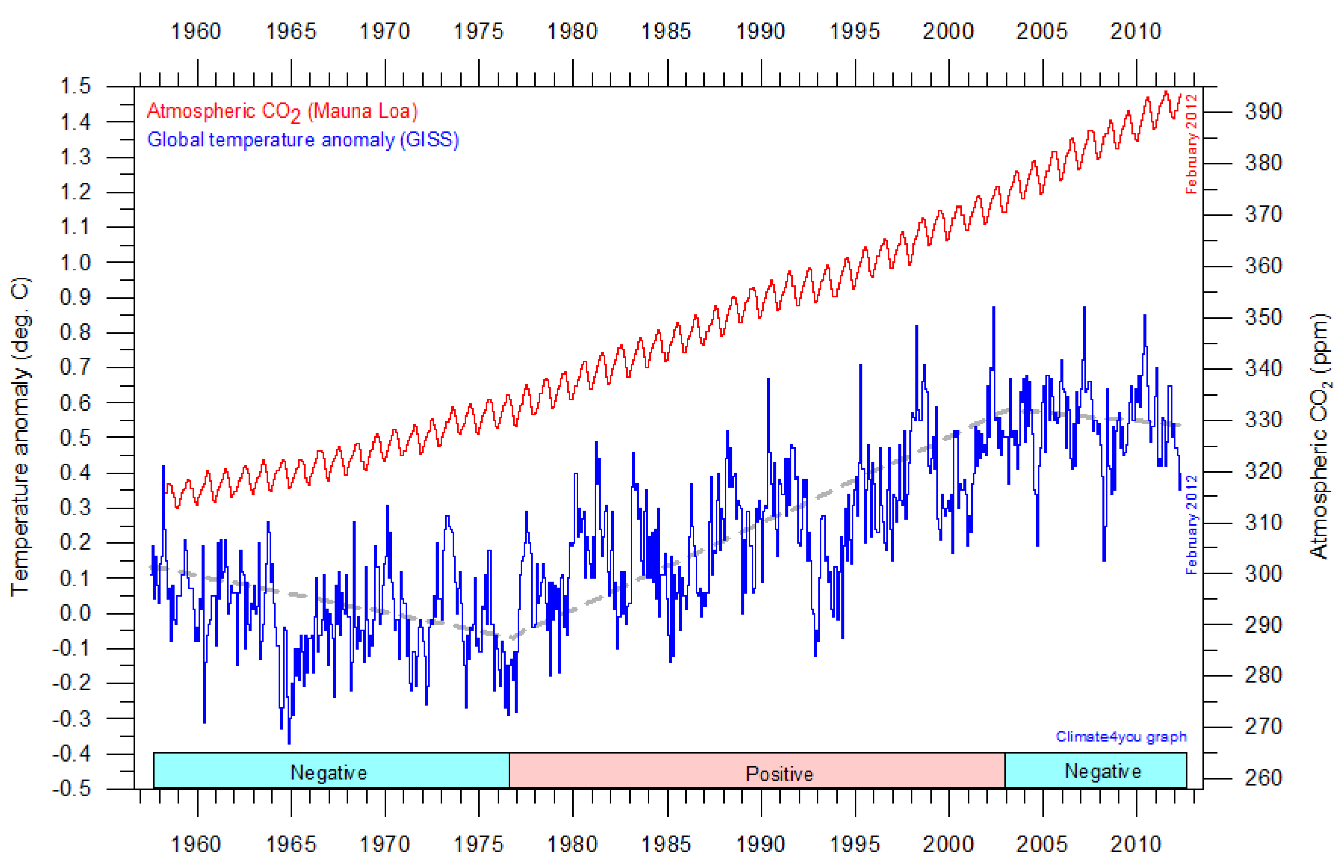
Northern hemisphere weekly snow cover since January 2000 according to Rutgers University Global Snow Laboratory. The thin line represents the weekly data, and the thick line is the running 53 week average (approximately 1 year).

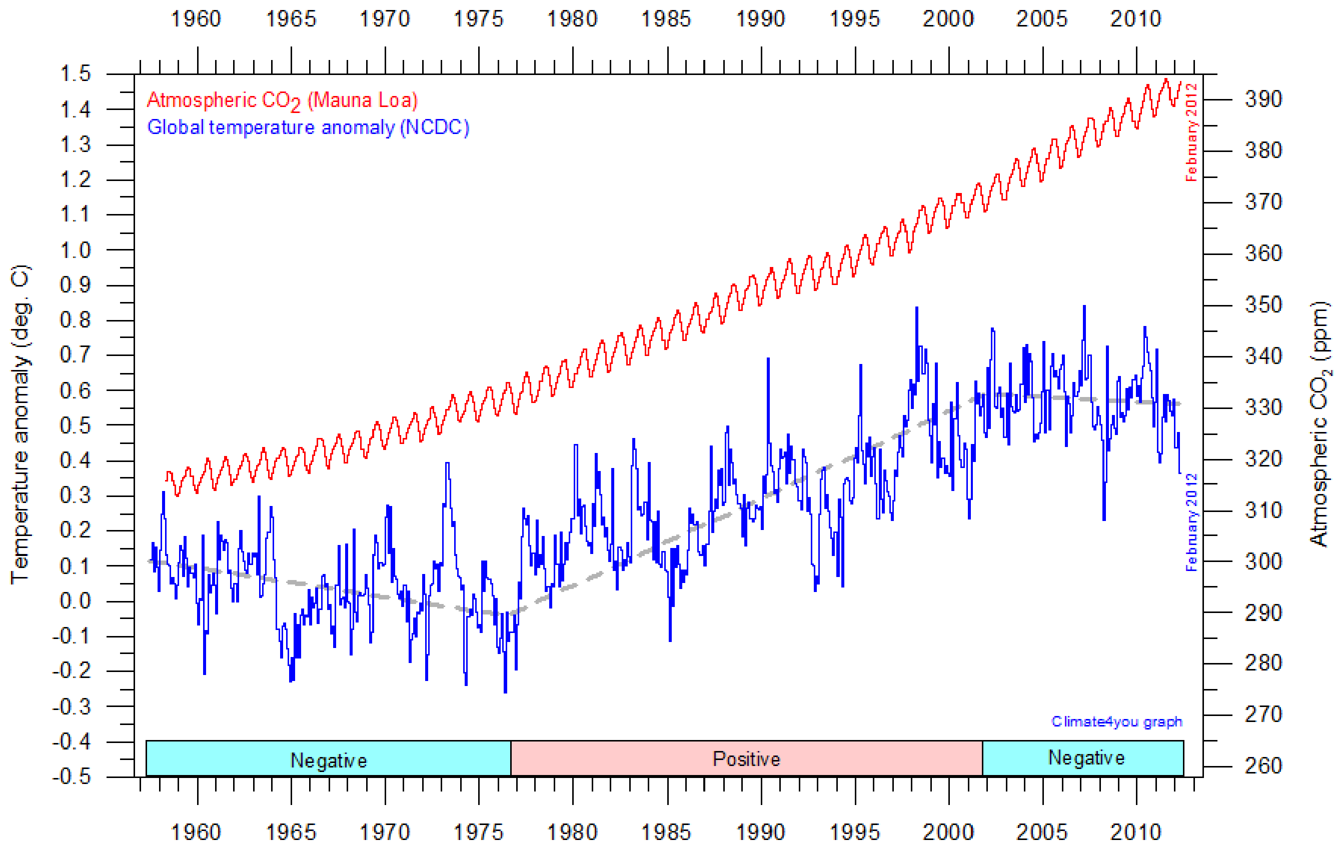


Northern hemisphere weekly snow cover since October 1966 according to Rutgers University Global Snow Laboratory. The thin line represents the weekly data, and the thick line is the running 53 week average (approximately 1 year). The running average is not calculated before 1971 because of data gaps in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

Global surface air temperature and atmospheric CO_2, updated to February 2012







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. Please note that the HadCRUT3 diagram has not been updated beyond January 2012.

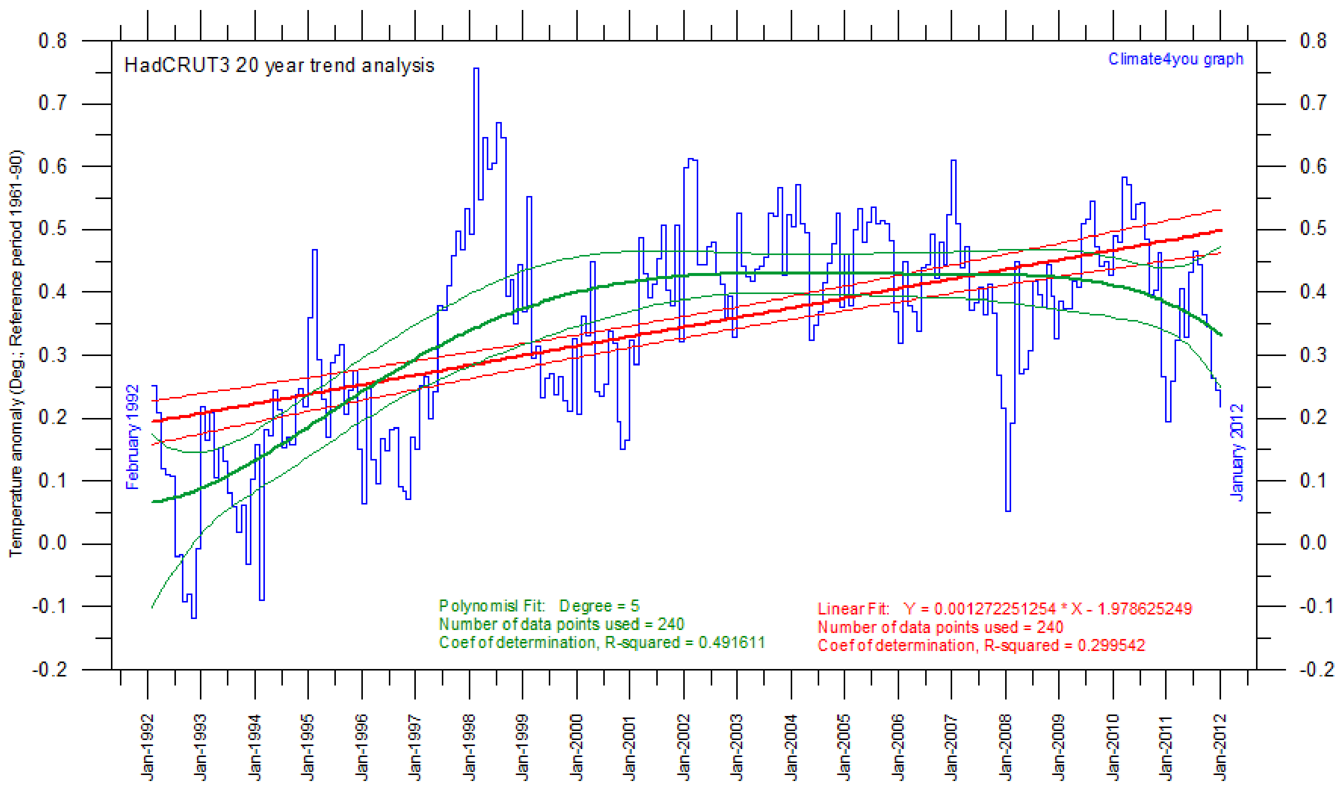
Most climate models assume the greenhouse gas carbon dioxide CO_2 to influence significantly upon global temperature. Thus, it is relevant to compare the different global temperature records with measurements of atmospheric CO_2, as shown in the diagrams above. Any comparison, however, should not be made on a monthly or annual basis, but for a longer time period, as other effects (oceanographic, clouds, volcanic, 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. However, the length of the critical period must be inversely proportional to the importance of CO_2 on the global temperature, including possible feedback effects. So if the net effect of CO_2 is strong, the length of the critical period is short, and vice versa.

After about 10 years of global temperature increase following global cooling 1940-1978, IPCC was established in 1988. Presumably, several scientists interested in climate felt intuitively that their empirical and theoretical understanding of climate dynamics in 1988 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 very important. Had the global temperature instead been decreasing, political and public support for the CO_2-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.

Last 20 year surface temperature changes, updated to January 2011



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). Last month included in analysis: November 2011.

From time to time it is debated if the global surface temperature is increasing, or if the temperature has levelled out during the last 10-15 years. The above diagram may be useful in this context. If nothing else, it at least demonstrates the differences between two different statistical approaches to determine recent temperature trends.

9 AD: Battle of the Teutoburg Forest

Topography of Germany (left) with insert showing location of map section to the right. Detailed map showing the location of the Battle at Teutoburg Forest (right).

The name of the Teutoburg Forest (German: Teutoburger Wald) in northwestern Germany is connected to one of the most famous battles from ancient history, the *clades Variana*, the defeat of the Roman general Varus. In September 9 AD, a coalition of Germanic tribes, led by a nobleman named Arminius, defeated a big Roman army consisting of three legions and other units, and forced their commander Publius Quintilius Varus to commit suicide.

The result of the battle in Teutoburg Forest was that Germania remained independent and was never included in the Roman Empire. Presumably the Roman defeat was indeed one of the most decisive and influential battles in world history. Weather played no small role in the outcome of this battle.

In the last decade of the second century BC, the expanding Romans first encountered Germanic tribes. The Cimbri and Teutones were considered dangerous enemies, but ultimately defeated by the Roman commander Marius in two battles in BC 102 and 101. For two generations, all was then quiet on the northern front, but in BC 58, when Julius Caesar was waging war in eastern Gaul, he got involved in a conflict with the Germanic leader Ariovistus. At Colmar, Caesar defeated his enemy, and Caesar subsequently bridged the Rhine and invaded the country east of the river, which he called Germania.

Following his successful campaign, Caesar declared the river Rhine as a natural boundary between the Gallic barbarians ("Celts") and the Germanic tribes, which in his official opinion were even more barbarous. In reality, Caesar needed a well-defined theatre of operations and the Rhine was, from a military point of view, a fine frontier. But from a cultural or ethnic point of view, it was not a natural frontier at all. The Celtic culture also existed on the east bank of the Rhine, and people speaking a Germanic language had already settled on the west bank.

In BC 39-38, Marcus Vipsanius Agrippa was governor of Gaul, and fought a war on the east bank of the Rhine on behalf of the Ubians against the Suebians, a Germanic tribe that was notorious for its aggressiveness. After this campaign, Agrippa resettled the Ubians on the west bank of the Rhine, and founded Cologne. The Rhine was now changing into being a frontier between an increasingly Roman Gaul and an increasingly Germanic Germania.

During this dynamic age, the tribes of the east bank sometimes raided the Roman empire west of the Rhine. This happened in the winter of BC 17-16, where the governor of Gallia Belgica, Marcus Lollius, was defeated by the Sugambri. At this occasion the Fifth legion Alaudae lost its eagle standard: the ultimate disgrace to a Roman army unit. The emperor Augustus then understood that the Rhine frontier was still highly unstable and therefore sent his adoptive son Drusus to the north, to pacify the region and create a more stable frontier.

In the years BC 16-13, the Romans reorganized the strip of land along the Rhine. The region now became a military zone, where the army of Germania Inferior defended the Roman Empire against invaders from Germania. A second army group was called the army of Germania Superior was stationed further south along the Middle Rhine. In the summer of BC 11, Drusus managed to reach the river Elbe with his army. However, on his way back home, he fell from his horse and died. The Roman conqueror of Germania was only 29 years old.

Drusus was succeeded by his brother Tiberius, a capable general who held the opinion that Germania was too cold and poor to ever represent a valuable part of the Roman Empire. On the other hand, the armies could not be recalled immediately after the death of Drusus, as this would look as if the Romans had been defeated. In the years BC 9 and 8, Tiberius therefore attacked the Sugambri and deported thousands of them to the west bank of the Rhine.

After this operation all now seemed quiet for a while along the upper reaches of the Rhine, and in AD 4, Augustus ordered Tiberius to advance northeast again, to finish the conquest of Germania. The whole of Germania was to become a normal, tax-paying province, cold climate or not. The army of Germania Inferior therefore was ordered to march from the Rhine to the sources of the river Lippe, where a camp was built at Anreppen. Next year, the legions had a rendez-vous with the Roman navy at the mouth of the Elbe, and Tiberius marched with his army along the Elbe, which was to become the new northeastern frontier of the Roman Empire.

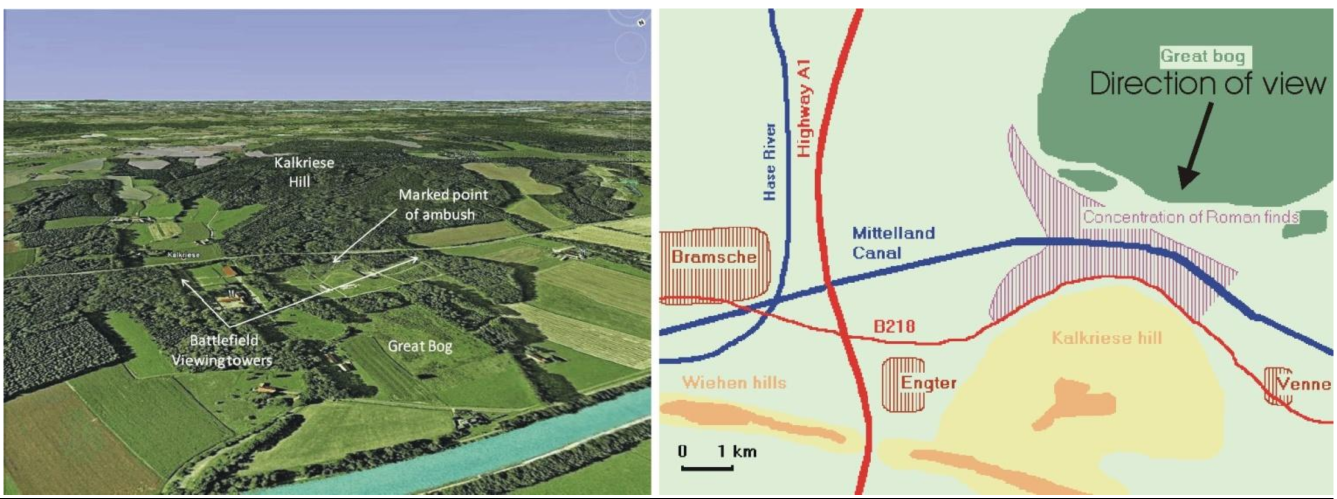
Meanwhile, the army of Germania Inferior was commanded by Publius Quinctilius Varus, one of the most important senators of his age and a personal friend of Augustus. Varus was ordered to make a normal province of the country between the Lower Rhine and Lower Elbe, and indeed had some initial success in doing this. Then, everything suddenly went wrong, probably because Varus decided to impose tribute in the new Roman Province.

The taxes imposed by Varus provoked resistance among a population that had at first been willing to accept Roman rule, but was not prepared to pay this amount of tribute. Presumably Varus did not take the gathering storm seriously, and as usual sent smaller groups of Roman troops to various places in Germania, which asked for them for the alleged purpose of guarding various positions, arresting robbers, or escorting provision trains. Thereby Varus did not keep his legions together, as would have been the proper procedure in a hostile country.

Next there came an uprising, first on the part of those who lived at large distances away from the Roman headquarter, deliberately so arranged, in order that Varus should march against them and so be more easily overpowered while proceeding through what was supposed to be friendly country. Varus, on hearing the first news about the revolt of a far-away tribe, sensibly decided to regroup his army before taking any action.

All sources agree that the Germanic leader of the uprising was Arminius, a member of the Cheruscan tribe and until then a loyal supporter of Rome. The rebels (or freedom fighters) must have made their preparation during the late summer of 9 AD. However, not all Germanic leaders agreed with Arminius' policy, and his plan was apparently betrayed to Varus. What happened next is not entirely clear. Presumably Varus refused to listen, and instead rebuked the person(s) that could have saved him.

The battle in Teutoburg Forest took place in the year 9 AD, most likely in September. The battles final stage took part at the northern foot of the Kalkriese hill, a site remarkably well-suited for an ambush. Although only 157 meters high, the Kalkriese is difficult to pass on its northern slope, because a traveller then has to cross many deep brooks and rivulets, and in the level terrain north of the Kalkriese extends a difficult wetland for large distances. However, in between this great bog and the hill exists a more accessible zone up to several hundred meters wide, consisting of stable, Quaternary sandy deposits. The most accessible part of this corridor has a width of only 220 meters. It therefore comes as no big surprise that much later, in the 19th century, German engineers choose this natural east-west corridor along the northern slope of Kalkriese for the construction of both the main road B218 and the Mittelland Canal further to the north.



Overview illustration of the Kalkriese Battlefield from Mike Anderson's Ancient History Blog (left). The Mittelland Canal is seen in the foreground (direction of view towards SW). Overview map showing the main features of the battlefield (right).

In September 9 AD, Varus' forces included three legions (Legio XVII, Legio XVIII, and Legio XIX), six cohorts of auxiliary troops (non-citizens or allied troops) and three squadrons of cavalry. The Roman forces were not marching in combat formation, and were interspersed with large numbers of camp-followers.

As they entered the forest shortly northeast of the modern town Osnabrück, they found the forest track narrow and muddy, and at the same time a violent rainstorm began. Apparently Varus neglected to send out advance reconnaissance parties, but instead advanced with all his forces along the narrow track in one long formation.

On this narrow track the Roman line soldiers rapidly became stretched out perilously long; estimates are somewhere between 15 and 20 km in total. The Roman forces were then suddenly attacked by Arminius's Germanic warriors armed with light swords, large lances and narrow-bladed short spears. The Germanic warriors quickly managed to surround the entire Roman army and rained down javelins on the intruders from the surrounding forest.

The German leader, Arminius, had grown up in Rome as a citizen and became a Roman soldier, understood Roman tactics very well and could thus direct his troops to counter them effectively, using locally superior numbers against the dispersed Roman legions. Indeed, the German warriors presumably used a very efficient tactic of isolating individual, manageable parts of the extended Roman column, to defeat them one by one. 1930 years later similar efficient 'motti' tactics were successfully employed by the Finnish army against the much bigger Red Army during the Finnish-USSR winter war 1939-40, again assisted by the prevailing weather.

The Roman main force however managed to set up a fortified night camp near Engter, and the next morning the remaining Roman soldiers managed to break out into the open country north of the Wiehen Hills, near the modern town of Ostercappeln. The break-out cost heavy losses, as did a further attempt to escape by marching through another forested area, with the torrential rains continuing.

According to Cassius Dio, Roman History (*Historia Romana*, in 80 books):

"They were still advancing when the fourth day dawned, and again a heavy downpour and violent wind assailed them, preventing them from going forward and even from standing securely, and moreover depriving them of the use of their weapons. For they could not handle their bows or their javelins with any success, nor, for that matter, their shields, which were thoroughly soaked. Their opponents, on the other hand, being for the most part lightly equipped, and able to approach and retire freely, suffered less from the storm."

The continuing rain prevented the Roman forces from using their otherwise efficient bows, because their sinew strings become slack when wet. This rendered the Roman soldiers virtually defenceless as their shields also became waterlogged and soft.

The Romans then undertook a night march to escape, but marched into another trap that Arminius had set, at the foot of Kalkriese Hill north of Osnabrück. There, the sandy, open strip on which the Romans could march easily was constricted by the hill to the south, so that there was a gap of only about 2-300 m between the woods and swampland with high vegetation at the edge of the Great Bog to the north. The Roman soldiers probably expected nothing at this stage, but were suddenly attacked on their left flank by part of the Germanic forces hiding in the swamp. Moreover, the Roman forces found the road ahead blocked by a fortified trench, and, towards the forest, an earthen wall had been built along the roadside, permitting the Germanic tribesmen to attack the Romans from cover. The Roman forces was surrounded on three sides.

The Romans made a desperate attempt to storm the wall to break one part of the Germanic pincer, but failed. The highest-ranking officer next to Varus, Legatus Numonius Vala, abandoned the troops by riding off with the cavalry; however, he too was overtaken by the Germanic cavalry and killed. The Germanic warriors then stormed the field and slaughtered the now disintegrating Roman forces.

Varus did what the Romans considered the honorable thing: he committed suicide. One commander, Praefectus Ceionius, shamefully surrendered and later took his own life, while his colleague Praefectus Eggius heroically died leading his doomed troops to the bitter end. The Roman defeat was a major one, and at that time it rarely happened that legionary soldiers lost a battle, and the loss of no less than three legions was one of the worst defeats in Roman history.

Archeological excavations in the area north of Kalkriese have shown that the staff of at least one legion was present, and the presence of cavalry and auxiliary infantry is also attested. There were also noncombatants and perhaps women at Kalkriese mountain battlefield. In total, around 15,000–20,000 Roman soldiers must have died; not only Varus, but also many of his officers are said to have taken their own lives by falling on their swords in the approved manner.

Other Roman soldiers from Germania had already reached the Rhine, and the news that something terrible had happened spread upstream along the river. Even in Rome, the populace was afraid, and the emperor Augustus ordered that watch be kept by night throughout the city.

According to Suetonius, Augustus, 23.4:

“He (Augustus) was so greatly affected that for several months in succession he cut neither his beard nor his hair, and sometimes he could dash his head against a door, crying "Quintilius Varus, give me back my legions!"

The battle in the Teutoburg Forest had a profound effect on 19th century German nationalism; the Germans, at that time still divided into many individual German states, identified with the Germanic tribes as shared ancestors of one "German people" and came to associate the imperialistic Napoleonic French and Austro-Hungarian forces with the invading Romans who were destined for defeat. This was part of the background on which the German statesman Bismarck could unify the numerous German states into one powerful German Empire under Prussian leadership, and thereby create a "*balance of power*" that preserved peace in Europe from 1871 until 1914.

Today, the place where the final battle at Kalkriese took place has been transformed into a museum and an archaeological park, Varusschlacht (Varus Battle).

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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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