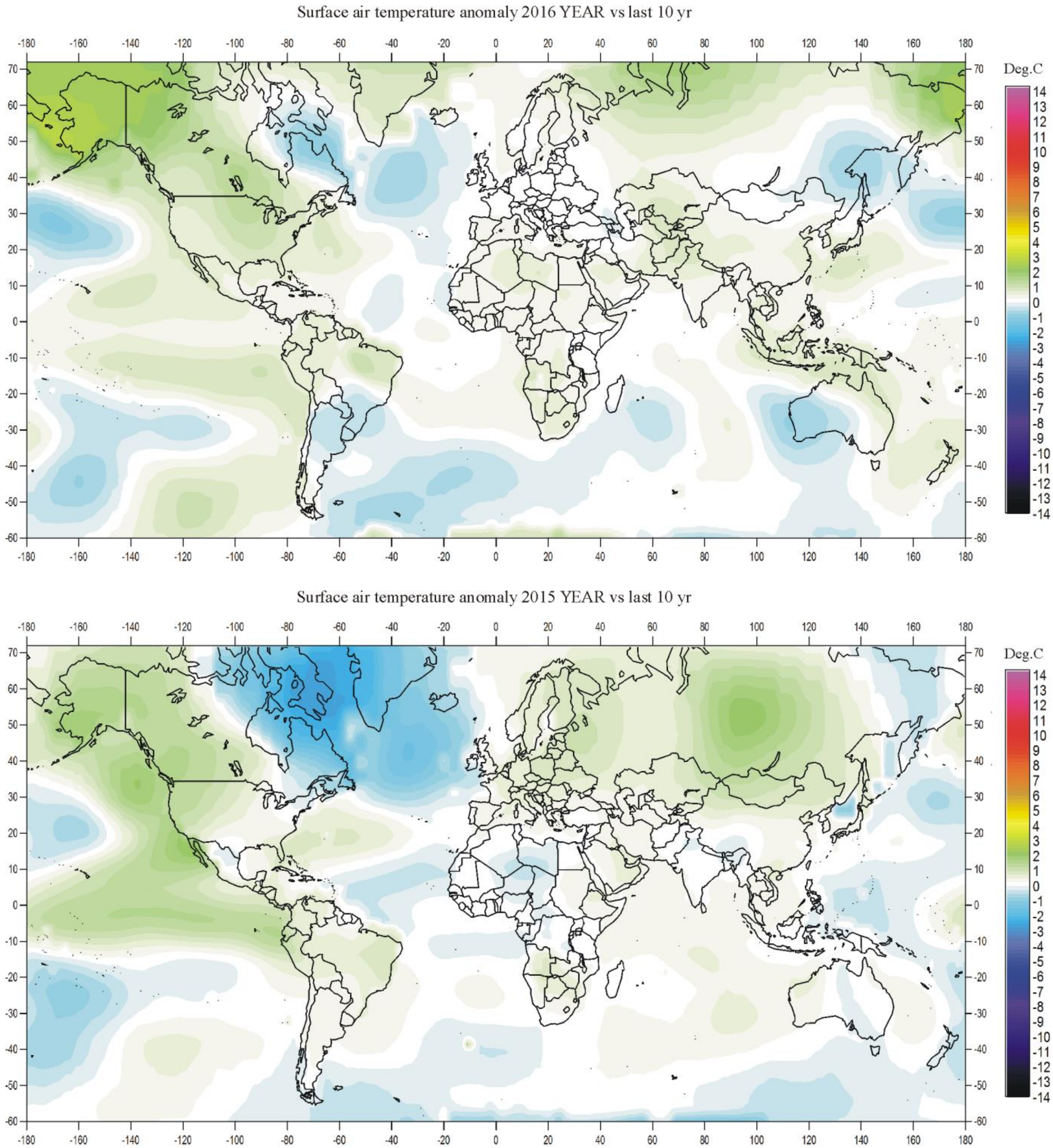
Climate4you update YEAR 2016

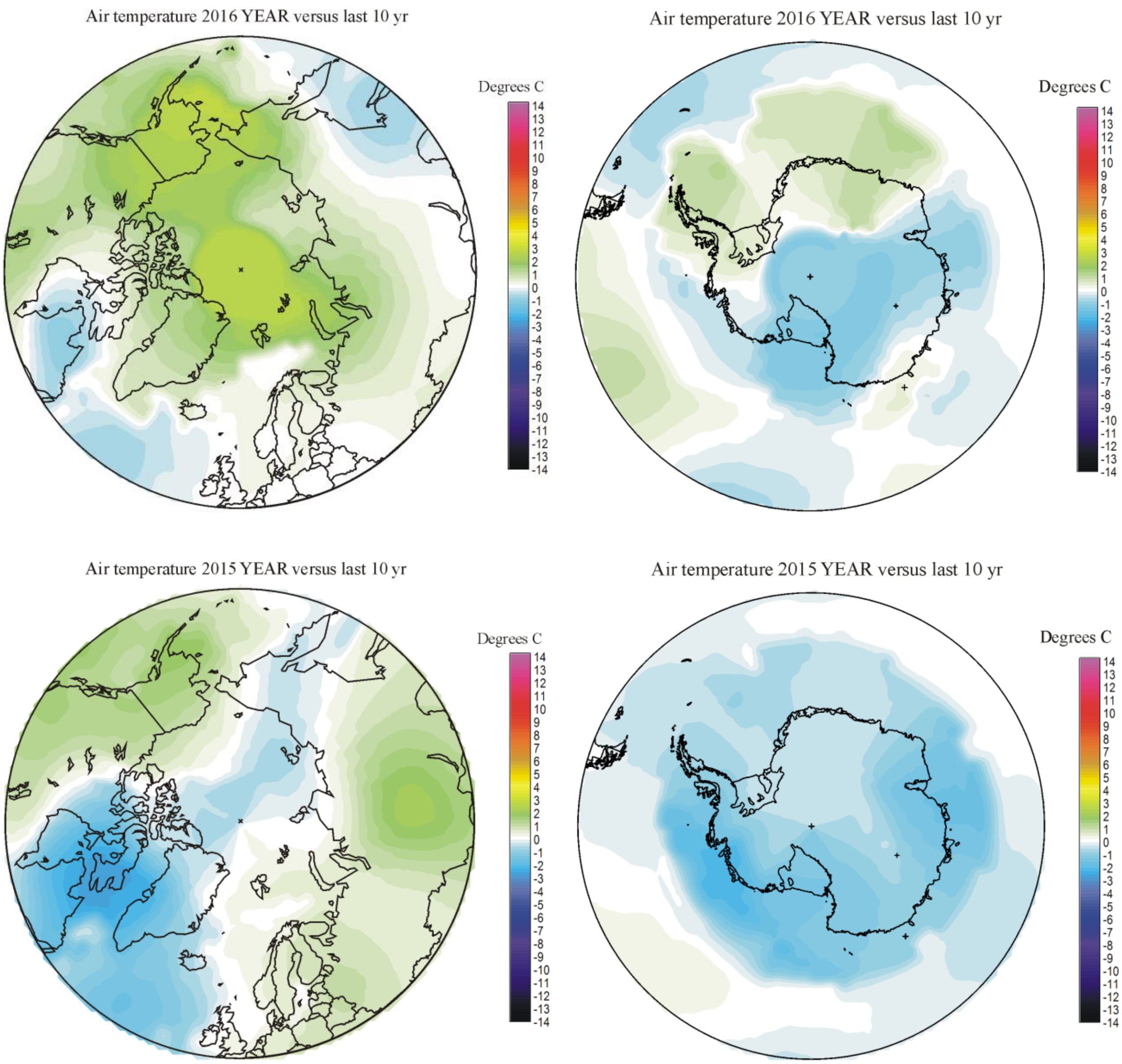
Contents:

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

Year 2016 and 2015 global surface air temperature overview



Year 2016 (upper panel) and 2015 (lower panel) surface air temperature compared to the average for the previous 10 years. Green-yellow-red colours indicate areas with higher temperature than the average, while blue colours indicate lower than average temperatures. Data source: Goddard Institute for Space Studies (GISS)



Year 2016 (upper panel) and 2015 (lower panel) Polar region surface air temperature compared to the average for the previous 10 years. Green-yellow-red colours indicate areas with higher temperature than the average, while blue colours indicate lower than average temperatures. Data source: Goddard Institute for Space Studies (GISS)

Comments to the Year 2016 global surface air temperature overview

This newsletter contains graphs showing a selection of key meteorological variables for the year 2016. All temperatures are given in degrees Celsius.

In the above maps showing the geographical pattern of surface air temperatures, *the last previous 10 years (2006-2015) are 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 profoundly affected by the cold period 1945-1980. Most comparisons with this time period will automatically appear as warm, and it will be difficult to decide if modern surface air temperatures are increasing or decreasing?

Comparing instead with the last previous 10 years overcomes this problem and displays the dynamics of ongoing modern change.

The average global surface air temperature for 2016.

On average, the global surface air temperature for year 2016 was higher than in 2015, see global temperature diagrams on pages 7-9. The corresponding sea surface temperature changes 2015-2016 is shown by the diagrams on pages 10-11.

The Northern Hemisphere was characterised by regional temperature contrasts, but was generally warm compared to 2015 north of 60^{o}N. Especially the Arctic Ocean and Alaska were warm. Compared to the average of the last 10 years, Greenland was warmer than in 2015. Relatively cold regions were only found in parts of the North Atlantic and in the Pacific Ocean. Most of North America had above average temperatures, Europe was close to the average, and most of Russia, Siberia, and Asia, were somewhat above average.

Near the Equator temperature conditions were generally lower than in 2015 when compared to the average of the last 10 years. In the Pacific, temperatures were still relatively high, reflecting the El Niño characterising the first part of 2016.

In the Southern Hemisphere surface air temperatures were near or below the average for the previous 10 years, just like in 2015. Especially western Australia and central South America had annual temperatures somewhat below the average.

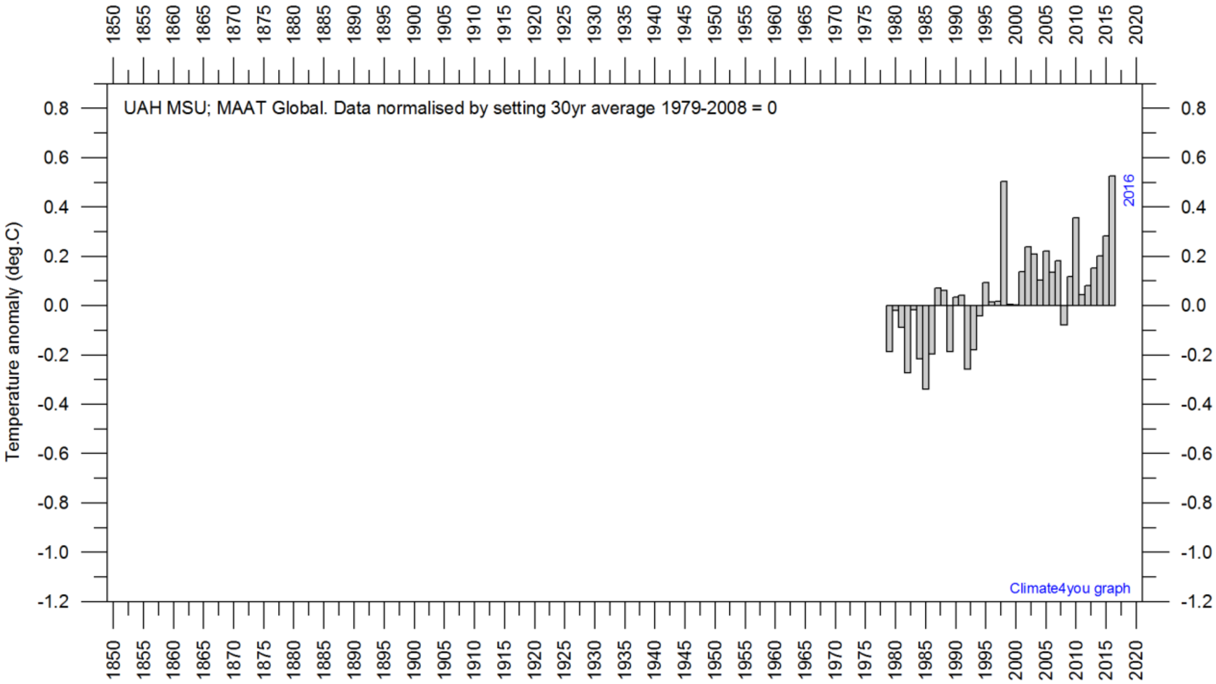
In the Arctic, most regions in 2016 had above average temperatures, especially within the Alaska and Greenland arctic sectors. The temperature pattern for 2016 is, however, influenced by a likely GISS-interpolation error, which results in a unreal temperature plateau north of 80^{o}N.

The Antarctic continent was divided between regions with above and below average temperatures in 2016, in contrast to 2015, where the entire continent was characterised by below average temperatures.

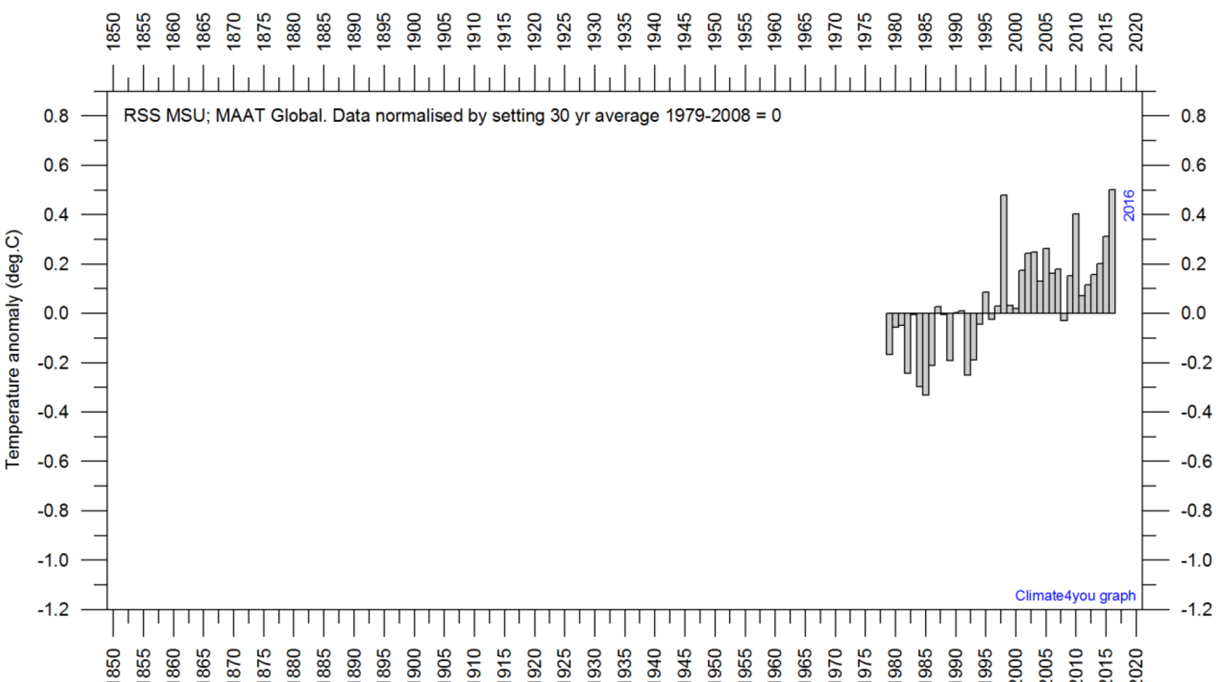
Globally speaking, at the end of 2016, air temperatures are essentially back at the level characterising the years leading up to the recent 2015-16 El Niño (p.13). Thus, the global air temperature peak 2015-16 appears mainly to be caused by this oceanographic phenomenon.

At the onset of the year 2017, atmospheric CO_2 are increasing (p.17), solar activity decreasing (p.18), and the global air temperature doing little beyond responding normally to oceanographic variations.

Lower troposphere temperature from satellites, updated to year 2016

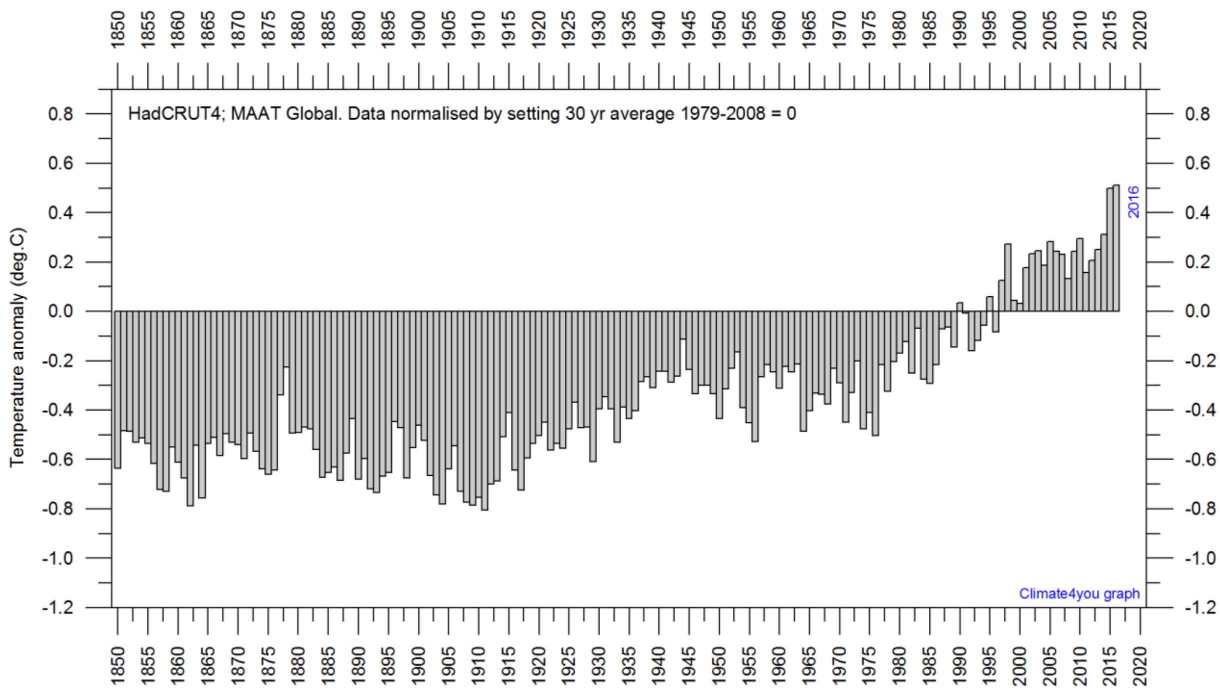


Mean annually lower troposphere temperature anomaly (thin line) since 1979 according to [University of Alabama](#) at Huntsville, USA. The average for 1979-2008 (30 years) has been set to zero, to make comparison with other temperature data series easy.

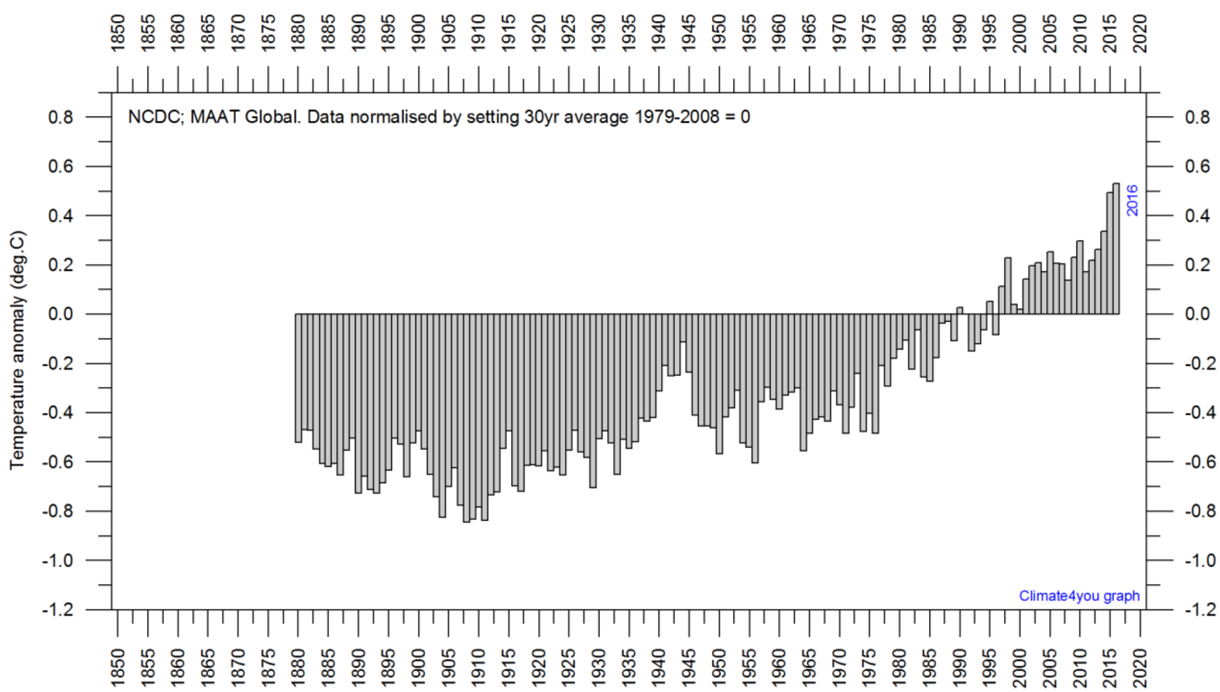


Mean annual lower troposphere temperature anomaly (thin line) since 1979 according to according to [Remote Sensing Systems](#) (RSS), USA. The average for 1979-2008 (30 years) has been set to zero, to make comparison with other temperature data series easy.

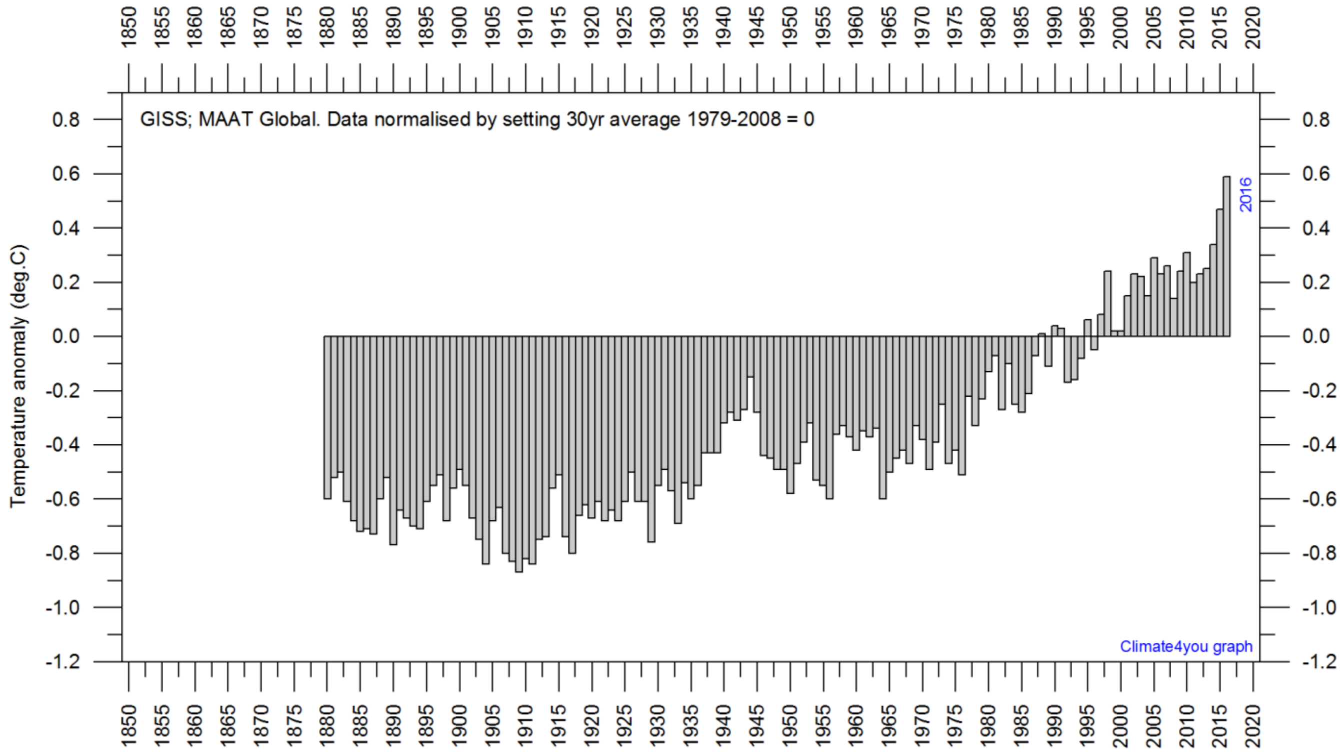
Global surface air temperature, updated to year 2016



Mean annual global surface air temperature (thin line) since 1850 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 average for 1979-2008 (30 years) has been set to zero.



Mean annual global surface air temperature since 1880 according to according to the National Climatic Data Center (NCDC), USA. The average for 1979-2008 (30 years) has been set to zero, to make comparison with other temperature data series easy.



Mean annual global surface air temperature (thin line) since 1880 according to according to the [Goddard Institute for Space Studies](#) (GISS), at Columbia University, New York City, USA. The average for 1979-2008 (30 years) has been set to zero, to make comparison with other temperature data series easy.

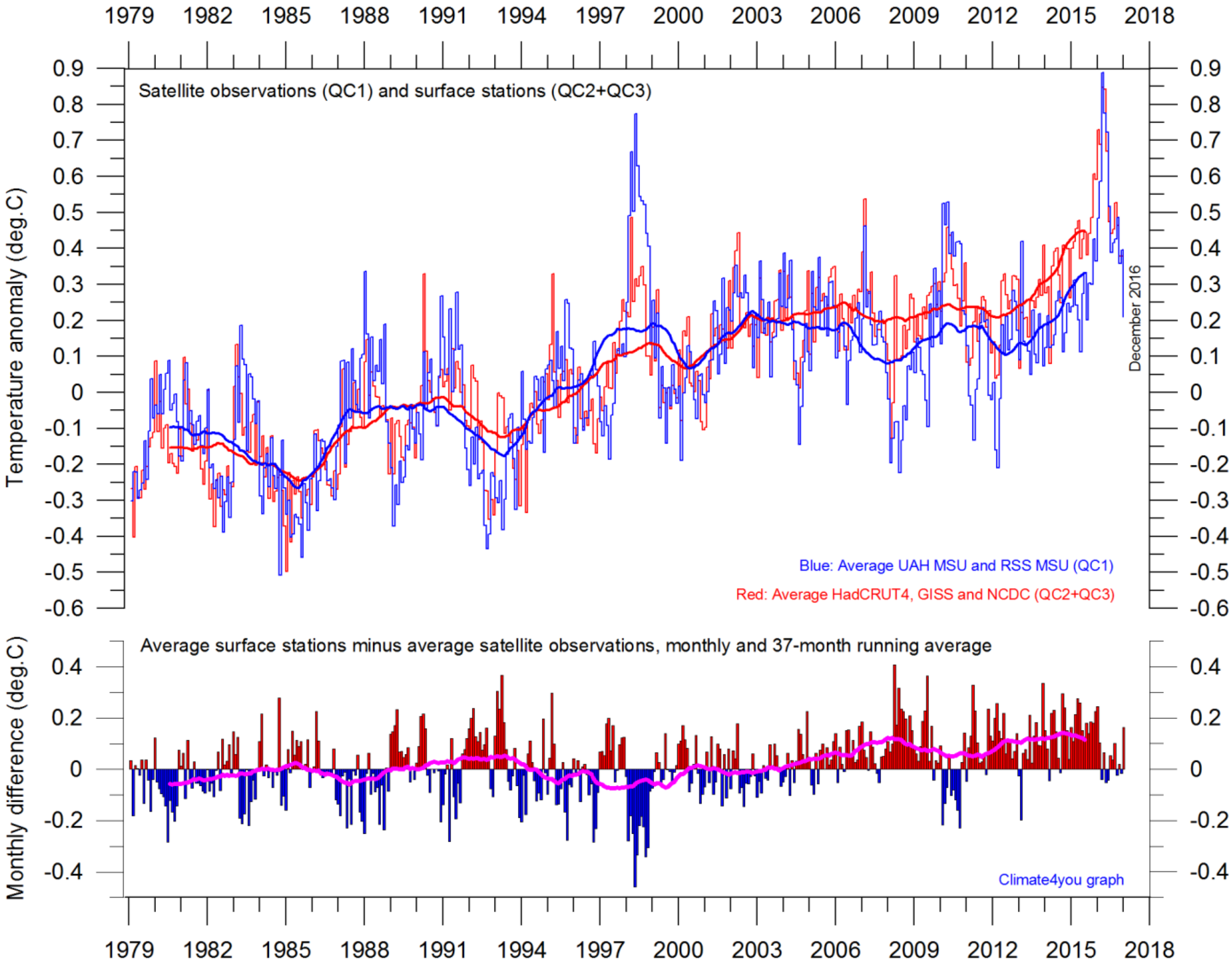
Reflections on the significance of the 2016 global annual temperature

According to the surface stations 2016 ranks as the warmest year since 1880 and 1850, depending on which data series is considered. According to the satellite records 2016 was warm, but not setting a clear new record.

The geographical fingerprint (p.2) of relative warm regions in 2016 demonstrate the importance of the natural oceanographic phenomena El Niño (p.5) in the Pacific Ocean for making both 2015 and 2016 warm years, thereby affecting the calculation of especially short-period linear trends (p.11).

The recent El Niño ended in 2016, and global temperatures are by the end of 2016 essentially back to the general level characterising the situation before 2015. Quite often -but not always- a warm El Niño episode is followed by a cool oceanographic reversal, known as La Niña, which may influence 2017. Just like El Niño, also La Niña represents a natural phenomenon.

Comparing surface air temperatures with data from satellites at the end of 2016



Plot showing the average of monthly global surface air temperature estimates (HadCRUT4, GISS and NCDC) and satellite-based temperature estimates (RSS MSU and UAH MSU). The thin lines indicate the monthly value, while the thick lines represent the simple running 37-month average, nearly corresponding to a running 3-yr average. The lower panel shows the monthly difference between surface air temperature and satellite temperatures. As the base period differs for the different temperature estimates, they have all been normalised by comparing to the average value of 30 years from January 1979 to December 2008.

Global satellite temperature trends calculated for different periods until December 2016

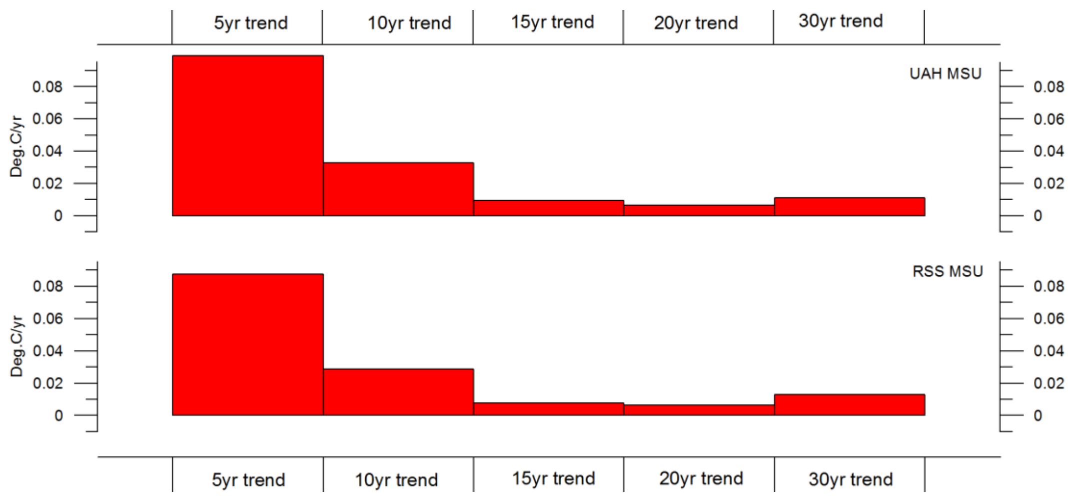


Diagram showing the latest 5, 10, 20 and 30 yr linear annual global temperature trend, calculated as the slope of the linear regression line through the data points, for two satellite-based temperature estimates (UAH MSU and RSS MSU).

Global surface air temperature trends calculated for different periods until December 2016

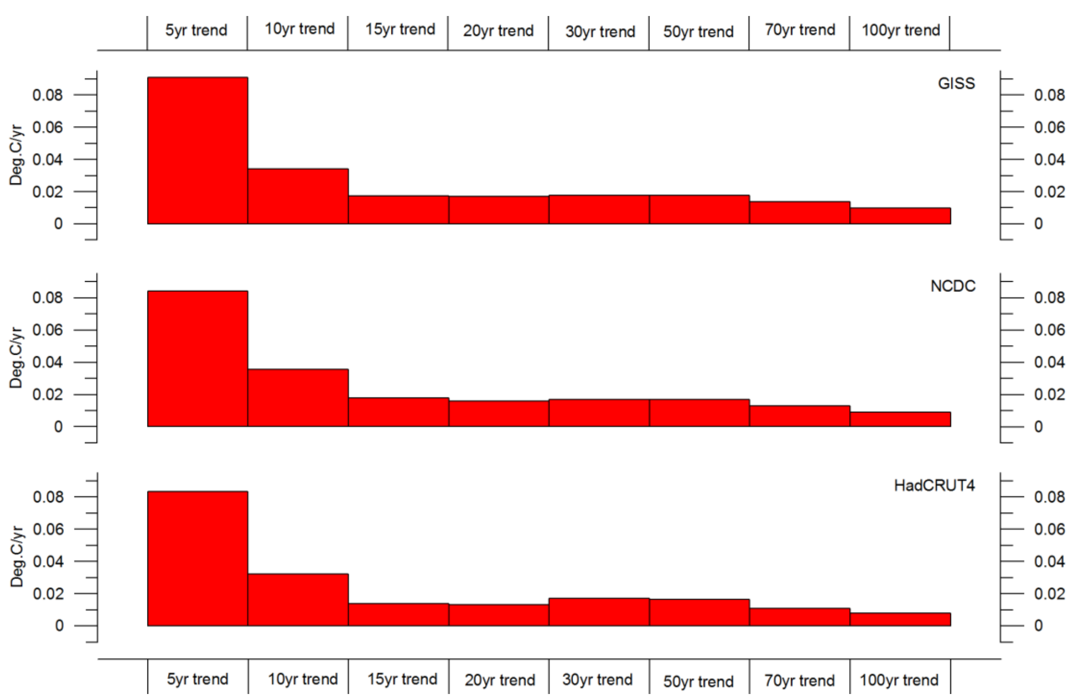
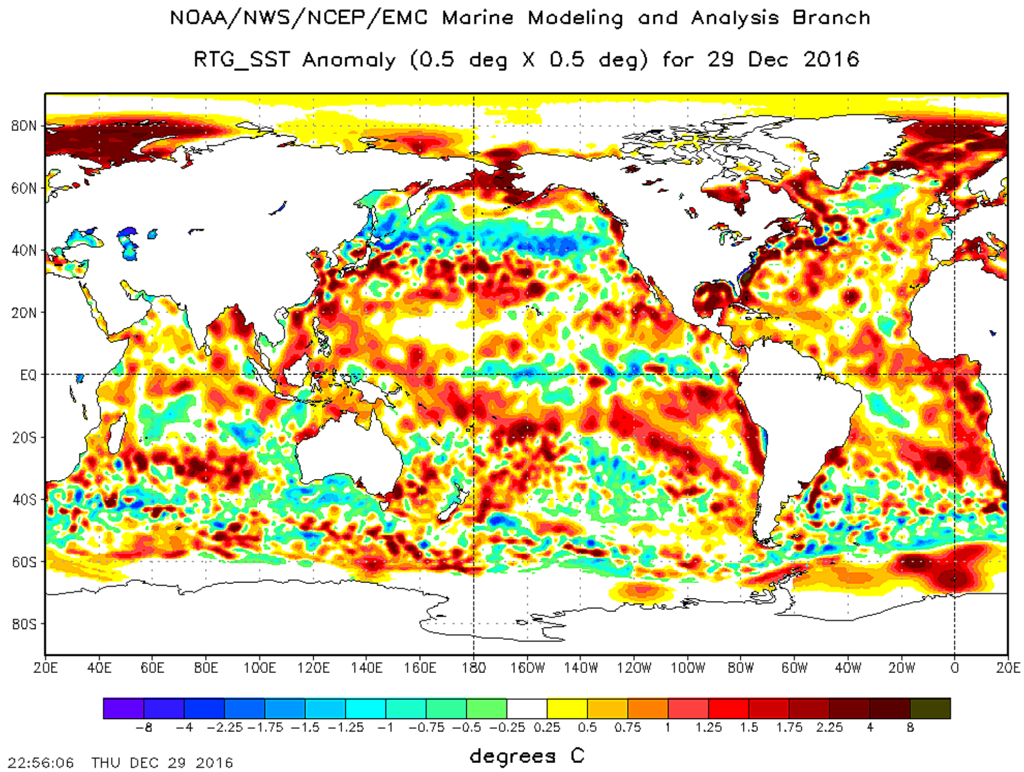
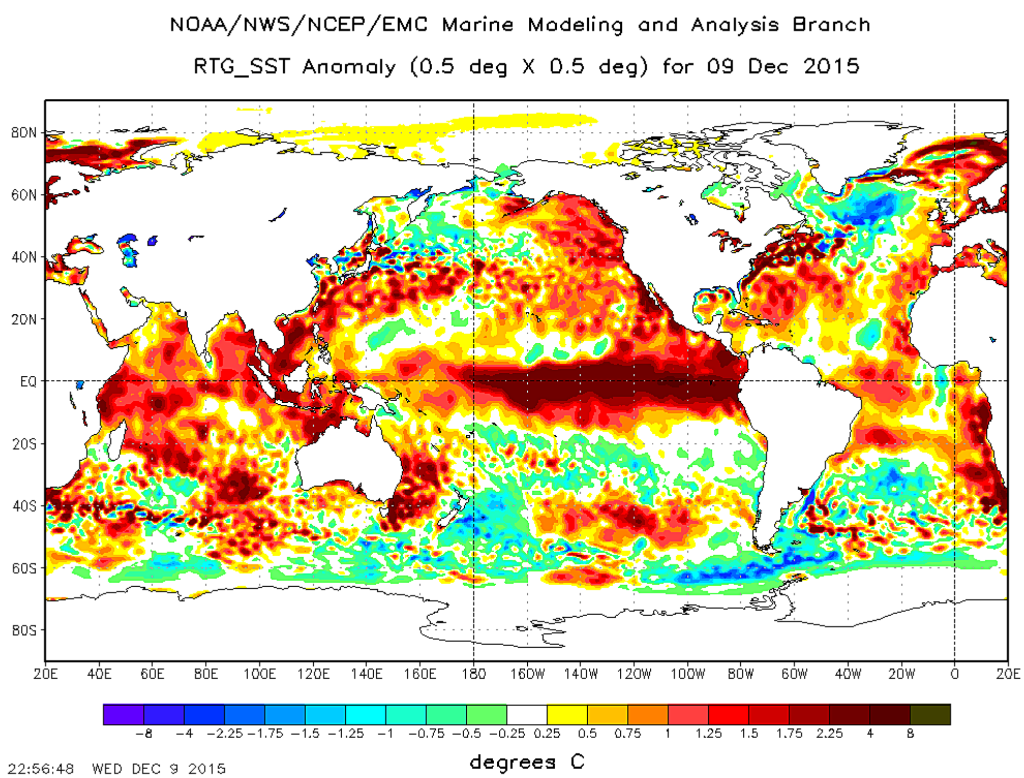


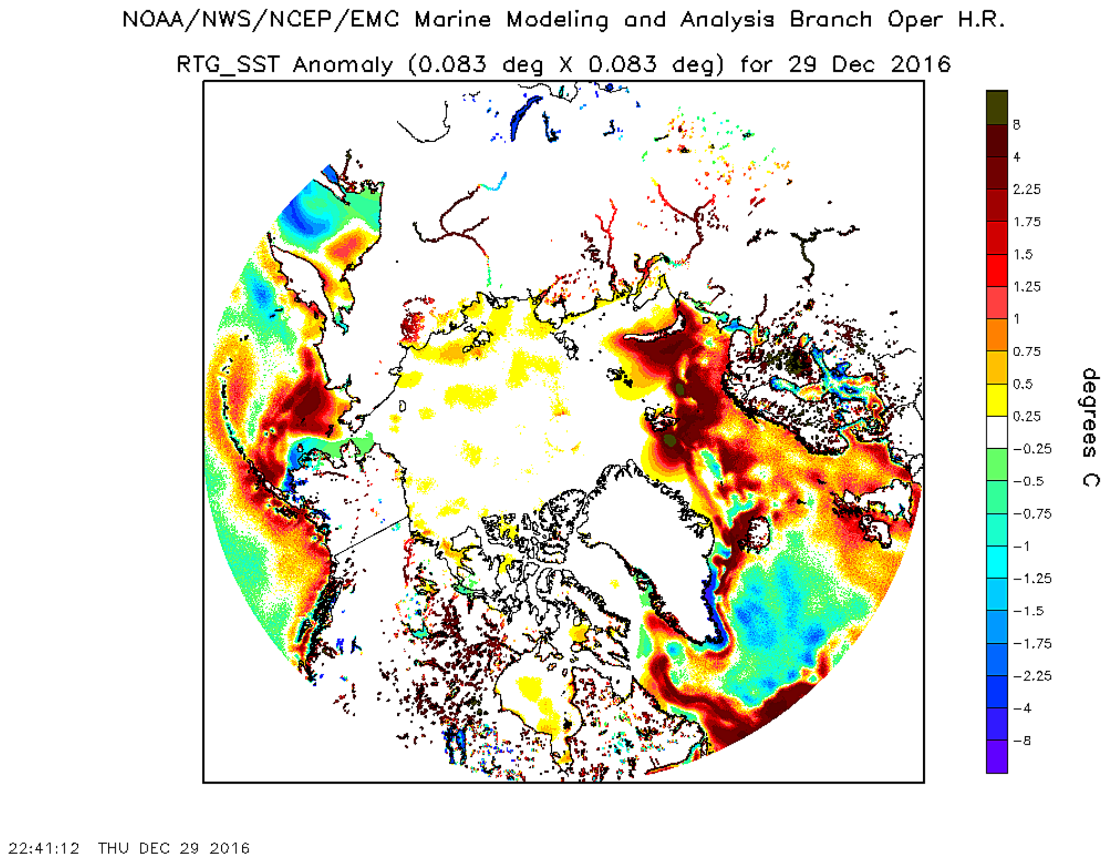
Diagram showing the latest 5, 10, 15, 20, 30, 50, 70 and 100-year linear annual global temperature trend, calculated as the slope of the linear regression line through the data points, for three surface-based temperature estimates (GISS, NCDC and HadCRUT3).

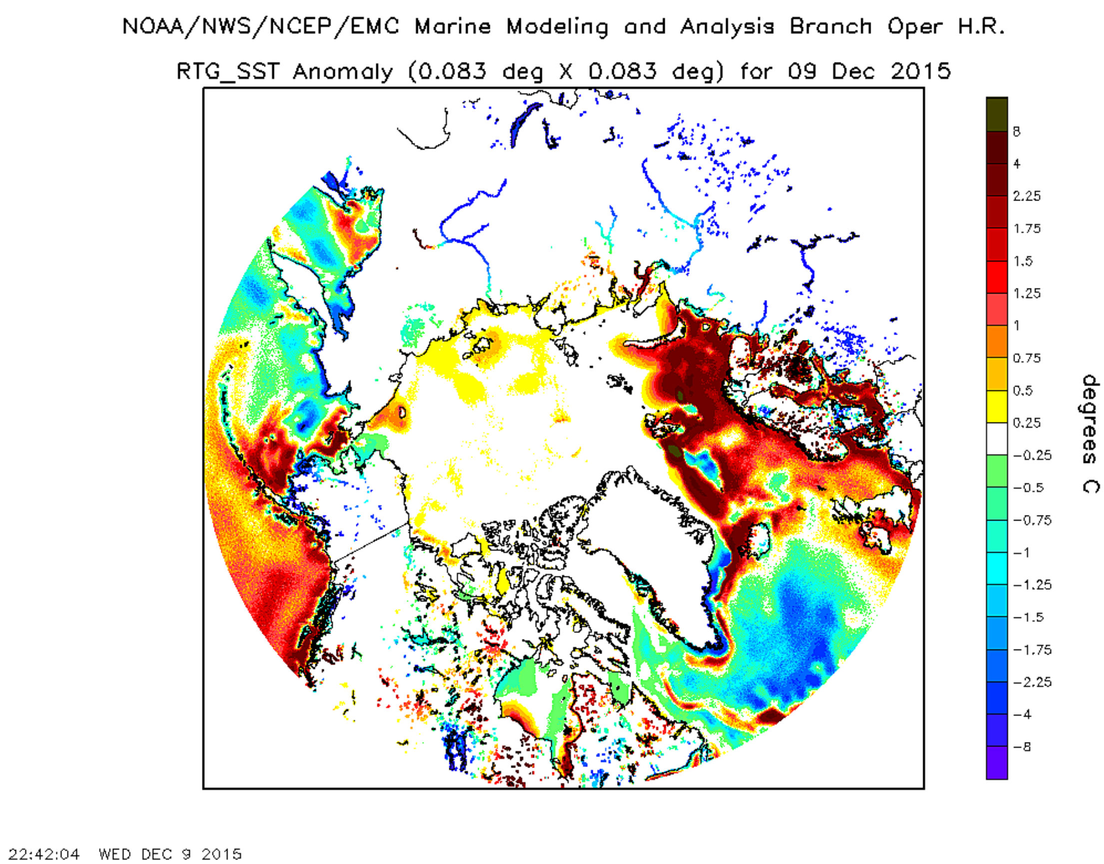
Sea surface temperature anomaly at the end of the years 2016 and 2015





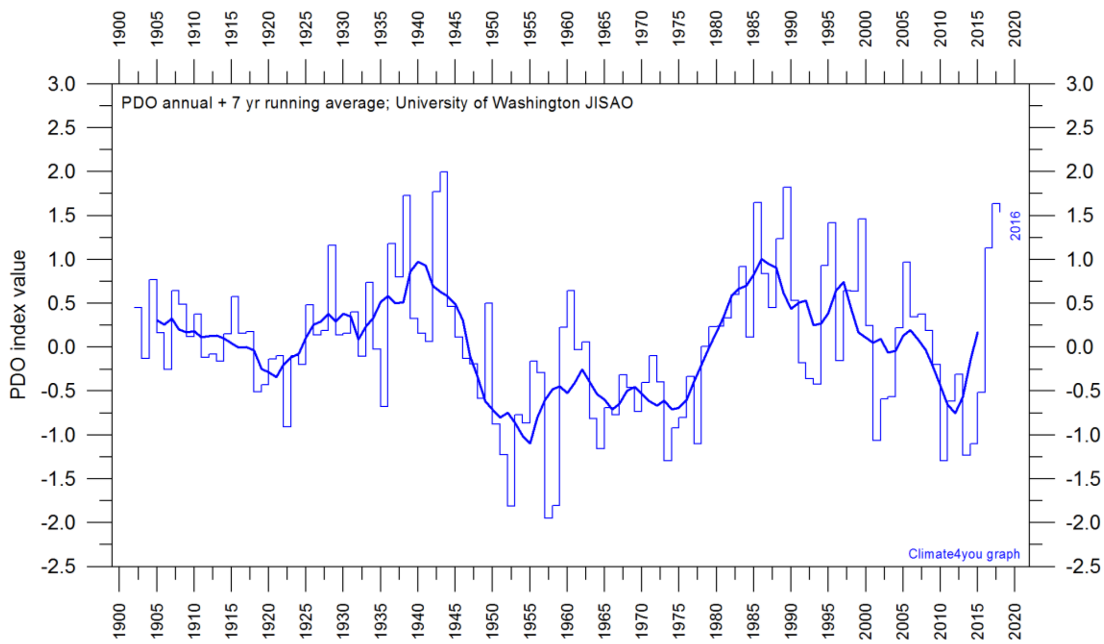
Sea surface temperature anomaly in December 2016 and 2015, upper and lower panel, respectively.





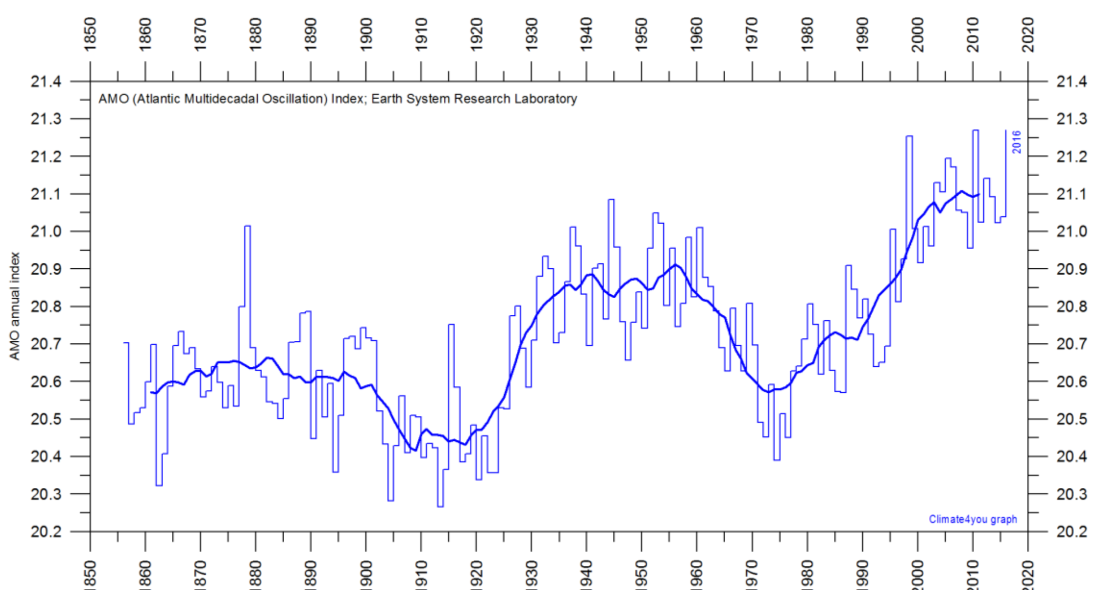
Arctic sea surface temperature anomaly in December 2016 and 2015, upper and lower panel, respectively.

PDO - Pacific Decadal Oscillation, updated to 2016



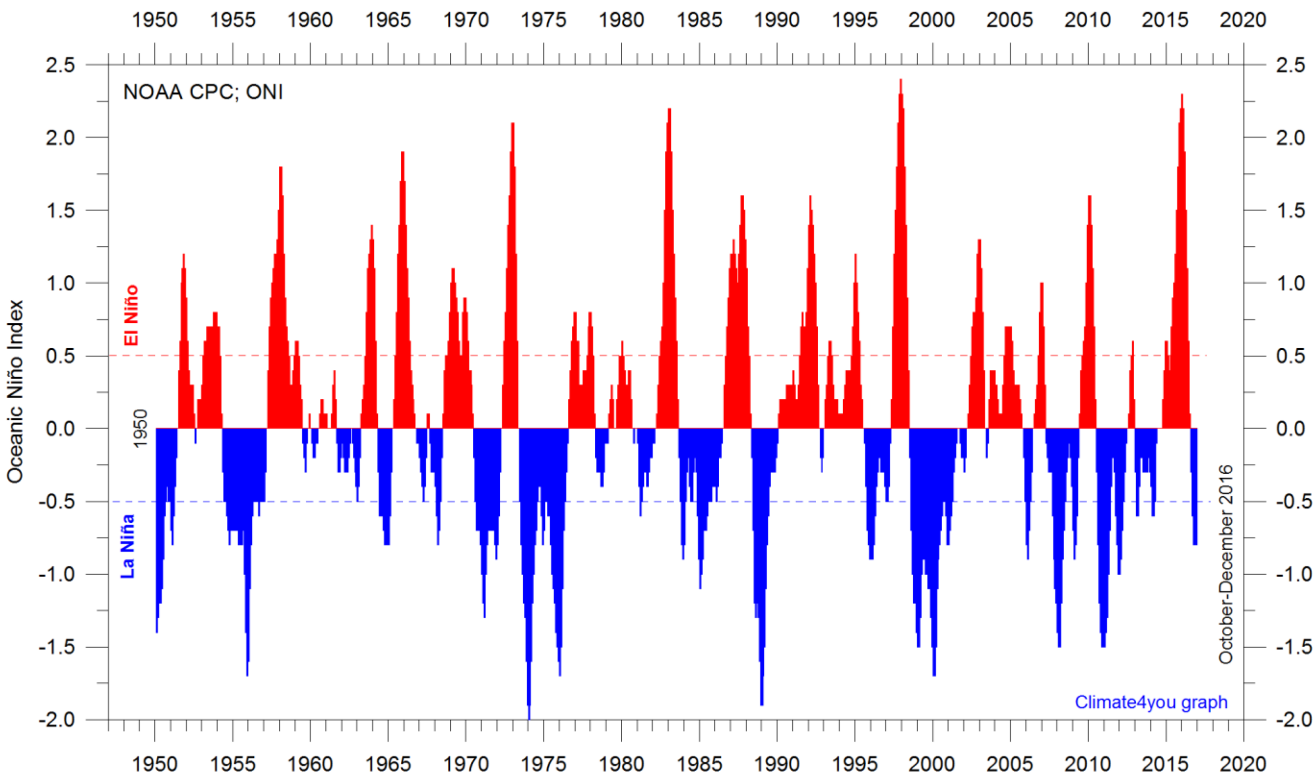
Annual values of the Pacific Decadal Oscillation (PDO) according to the Joint Institute for the Study of the Atmosphere and Ocean (JISAO), a Cooperative Institute between the National Oceanic and Atmospheric Administration and the University of Washington. The PDO is a long-lived El Niño-like pattern of Pacific climate variability, and the data series goes back to January 1900. The thin line indicates annual PDO values, and the thick line is the simple running 7-year average.

AMO (Atlantic Multidecadal Oscillation) Index, updated to 2016



Annual Atlantic Multidecadal Oscillation (AMO) index values since 1856. The thin line indicates 3 month average values, and the thick line is the simple running 11-year average. Further explanation in text above. Data source: Earth System Research Laboratory at NOAA.

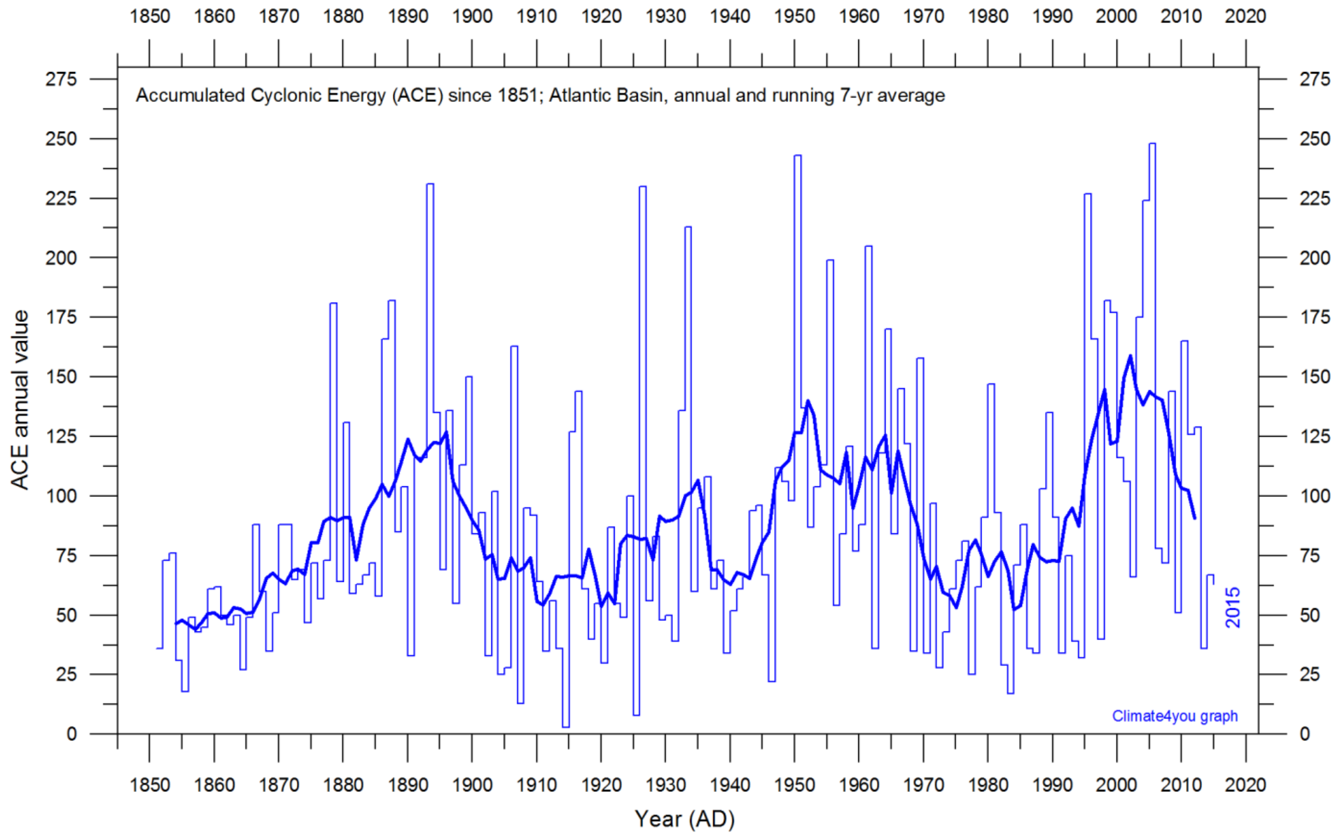
La Niña and El Niño episodes, updated to October-December 2016



Warm (>+0.5°C) and cold (<0.5°C) episodes for the Oceanic Niño Index (ONI), defined as 3 month running mean of ERSST.v3b SST anomalies in the Niño 3.4 region (5°N-5°S, 120°-170°W)]. Base period: 1971-2000. For historical purposes cold and warm episodes are defined when the threshold is met for a minimum of 5 consecutive over-lapping seasons.

The recent El Niño episode has now come to an end, and the index is moving towards the opposite cold situation, La Niña, as is shown by the diagram above. It is also clear from the diagram that the recent 2015-16 El Niño is among the strongest El Niño episodes since the beginning of the record in 1950. Considering the entire record, however, recent variations between El Niño and La Niña episodes do not appear abnormal in any way.

Annual accumulated cyclone energy (ACE) Atlantic Basin, updated to 2015



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. Please note that this data series is not yet updated beyond 2015.

Ocean temperatures, uppermost 1900m, updated to December 2016

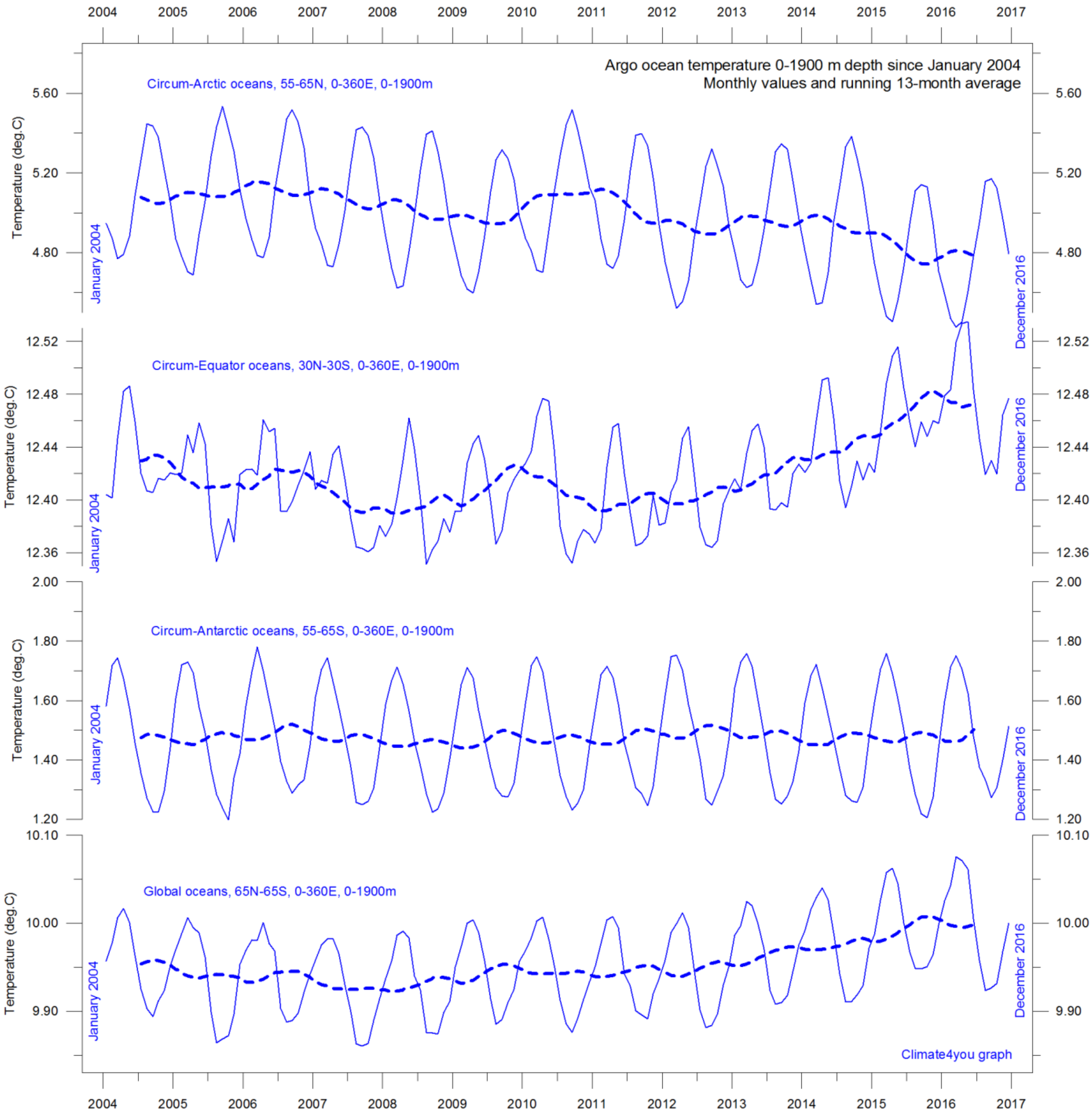
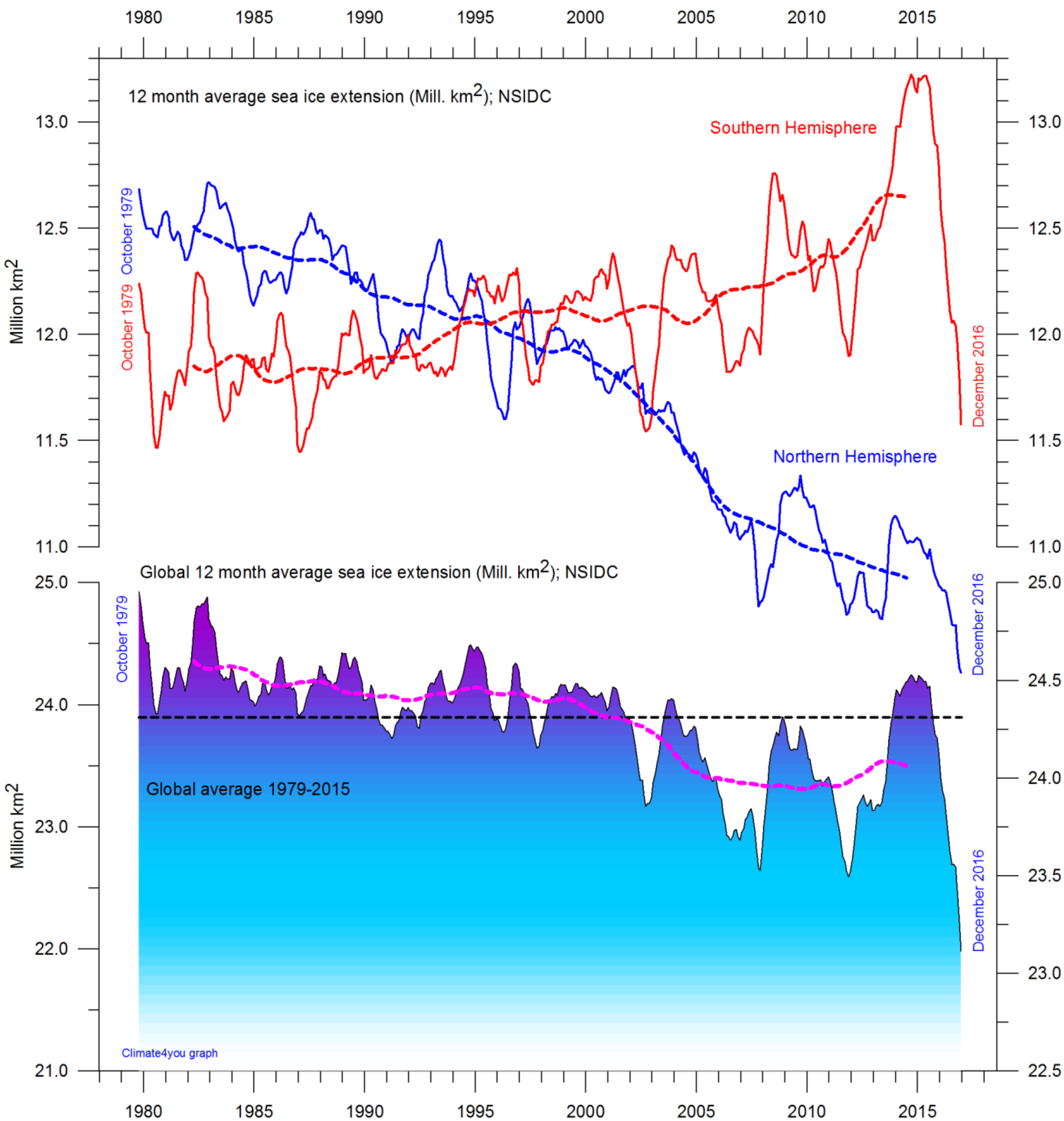


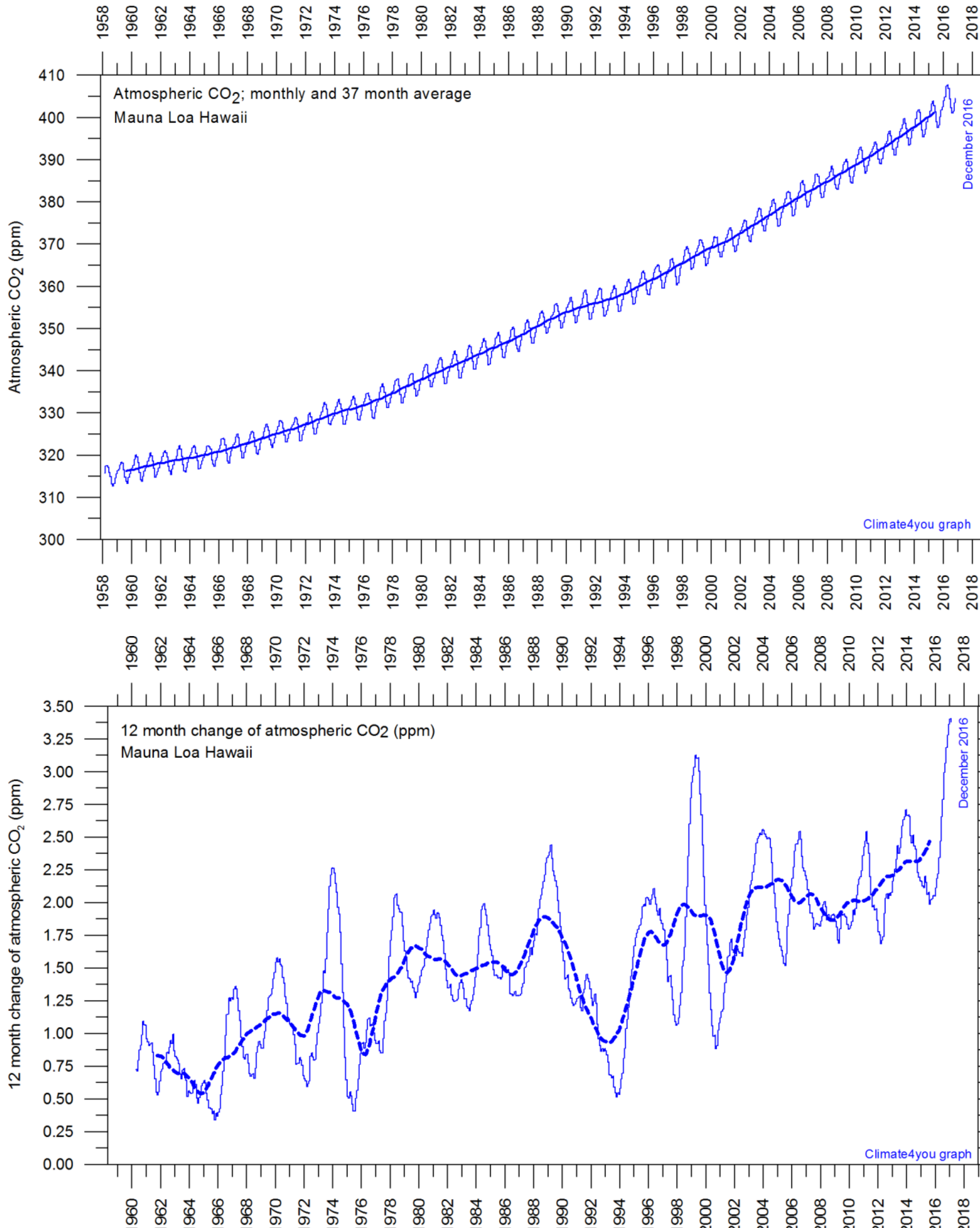
Diagram showing average 0-2000m depth ocean temperatures in selected latitudinal bands, using Argo-data. The thin line shows monthly values and the thick line shows the running 13-month average. Source: Global Marine Argo Atlas.

Arctic and Antarctic sea ice extension, updated to December 2016



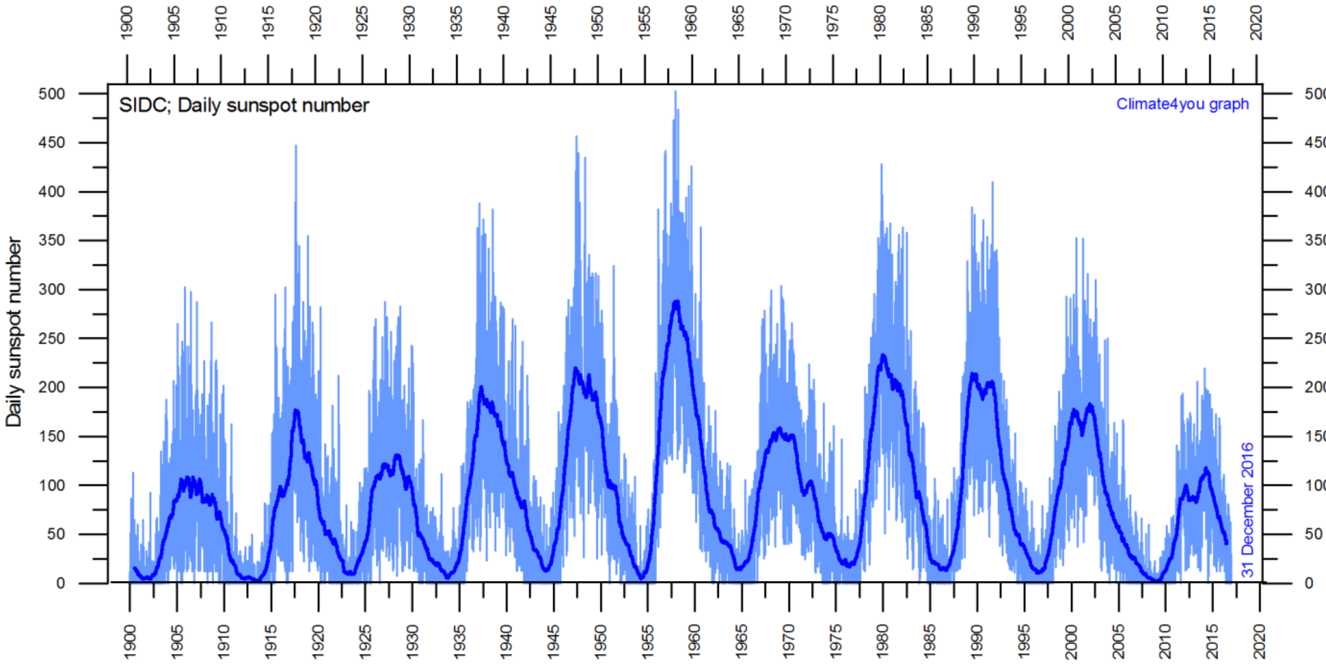
Global and hemispheric 12 month running average sea ice extension since 1979, the satellite-era. The October 1979 value represents the monthly average of November 1978 - October 1979, the November 1979 value represents the average of December 1978 - November 1979, etc. The stippled lines represent a 61-month (ca.5 years) average. Last month included in the 12-month calculations is shown to the right in the diagram. Data source: National Snow and Ice Data Center (NSIDC).

Atmospheric CO2, updated to December 2016



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-year average.

Number of daily sunspots since 1900, updated to December 31, 2016



Daily observations of the number of sunspots since 1 January 1900 according to [Solar Influences Data Analysis Center](#) (SIDC). The thin blue line indicates the daily sunspot number, while the dark blue line indicates the running annual average.

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

Yours sincerely, Ole Humlum (Ole.Humlum@unis.no)

January 23, 2017.