Climate4you update YEAR 2019

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

Year 2019 and 2018 global surface air temperature overview

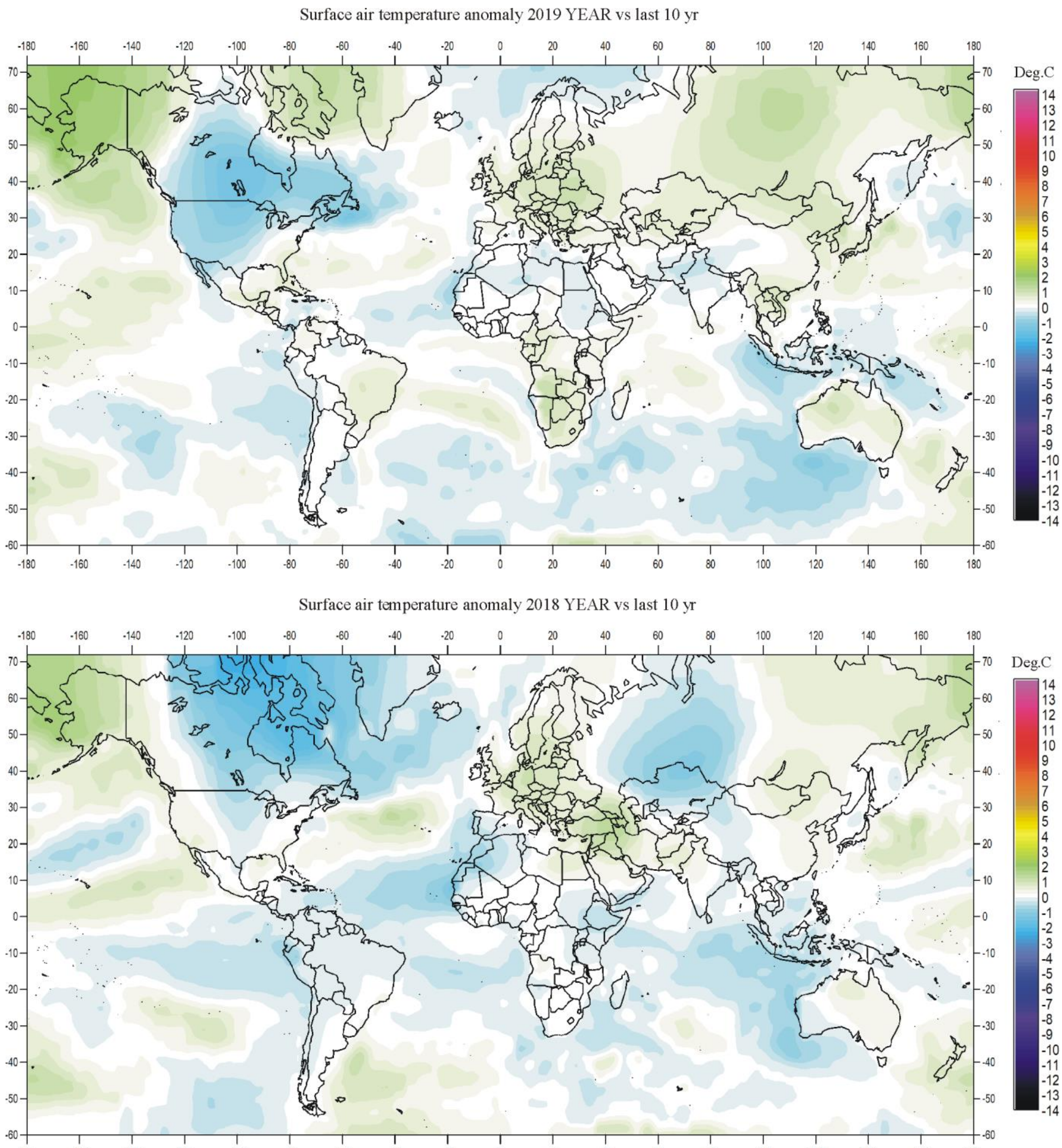


FIGURE 1. Year 2019 (upper panel) and 2018 (lower panel) surface air temperature compared to the average for the previous 10 years. Green-yellow-red colours indicate areas with higher temperature than the average, while blue colours indicate lower than average temperatures. Data source: Goddard Institute for Space Studies (GISS) using Hadl_Reyn_v2 ocean surface temperatures, and GHCNv4 land surface temperatures.

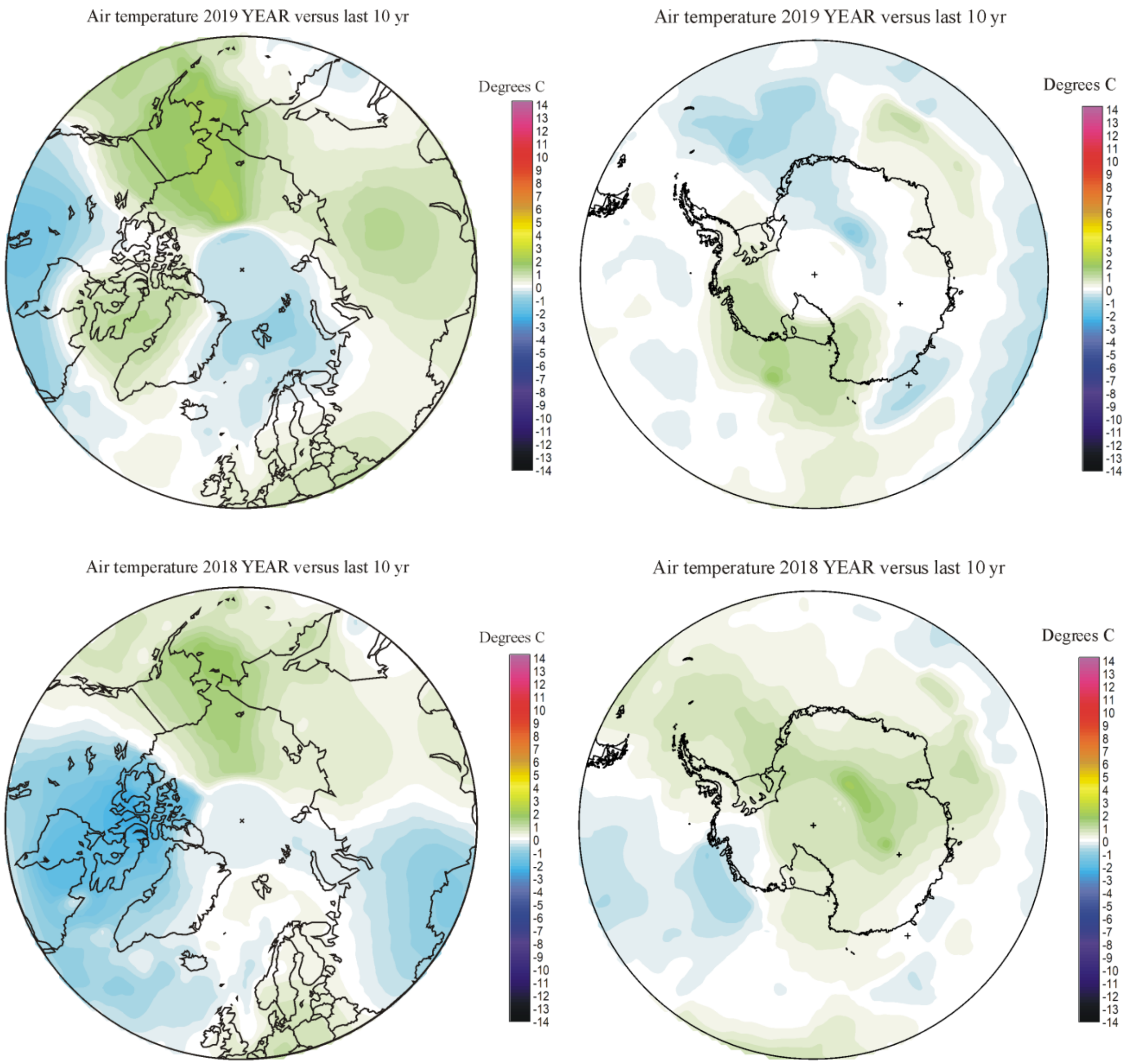


FIGURE 2. Year 2019 (upper panel) and 2018 (lower panel) Polar region surface air temperature compared to the average for the previous 10 years. Green-yellow-red colours indicate areas with higher temperature than the average, while blue colours indicate lower than average temperatures. Data source: Goddard Institute for Space Studies (GISS) using Hadl_Reyn_v2 ocean surface temperatures, and GHCNv4 land surface temperatures.

Comments to the Year 2019 global surface air temperature overview

The present newsletter contains graphs showing a selection of key meteorological variables for the year 2019. All temperatures are given in degrees Celsius.

In the above maps showing the geographical pattern of surface air temperatures, the last previous 10 years (2009-2018) are used as reference period.

The rationale for comparing with this recent period instead of the official WMO 'normal' period 1961-1990, is that the latter period is affected by the cold period 1945-1980. Most comparisons with this time period will inevitably appear as warm, and it will be difficult to decide if modern temperatures are increasing or decreasing.

Comparing instead with the last previous 10 years overcomes this problem and clearer displays the modern dynamics of ongoing change. This decadal approach also corresponds well to the typical memory horizon for many people and is now also adopted as reference period by other institutions, e.g. the Danish Meteorological Institute (DMI).

The average global surface air temperature for 2019.

Global average surface air temperature for year 2019 was high, higher than 2018, but cooler than 2016. The warm year 2016 were affected by the recent large El Niño episode playing out in the Pacific Ocean and culminating in early 2016. Also 2019 turned out to be affected by a new, but moderate, El Niño episode, bringing the gradual temperature decrease since 2016 to an end in 2019, at least for the time being.

The Northern Hemisphere was characterised by regional temperature contrasts, especially north of 30°N. Quite often this phenomenon is reflecting dominant patterns of jet streams in the Northern Hemisphere. One of the most pronounced temperature events in 2019 was the continuation of relatively cold conditions in much of North America. Additionally, the relatively warm conditions in Europe, Siberia and Alaska also prevailed from 2018.

Near the Equator surface air temperatures were generally near the average for the previous 10 years, much like the situation in 2018.

In the Southern Hemisphere surface air temperatures were near the average for the previous 10 years. Much of the oceans were relatively cold, while most of the land areas were relatively warm.

In the Arctic, the European sector was relatively cold, while most other regions of the Arctic in 2019 was relatively warm.

The Antarctic continent was mainly characterised by near average temperatures in 2019, in contrast to 2018, where most Antarctic regions were relatively warm.

Summing up for 2019, global average air temperatures were relatively high, reflecting the recent moderate 2018-19 El Niño episode playing out in the Pacific Ocean. Thus, the global surface air temperature record in 2019 continues to be highly influenced by this oceanographic phenomenon.

Lower troposphere temperature from satellites, updated to year 2019

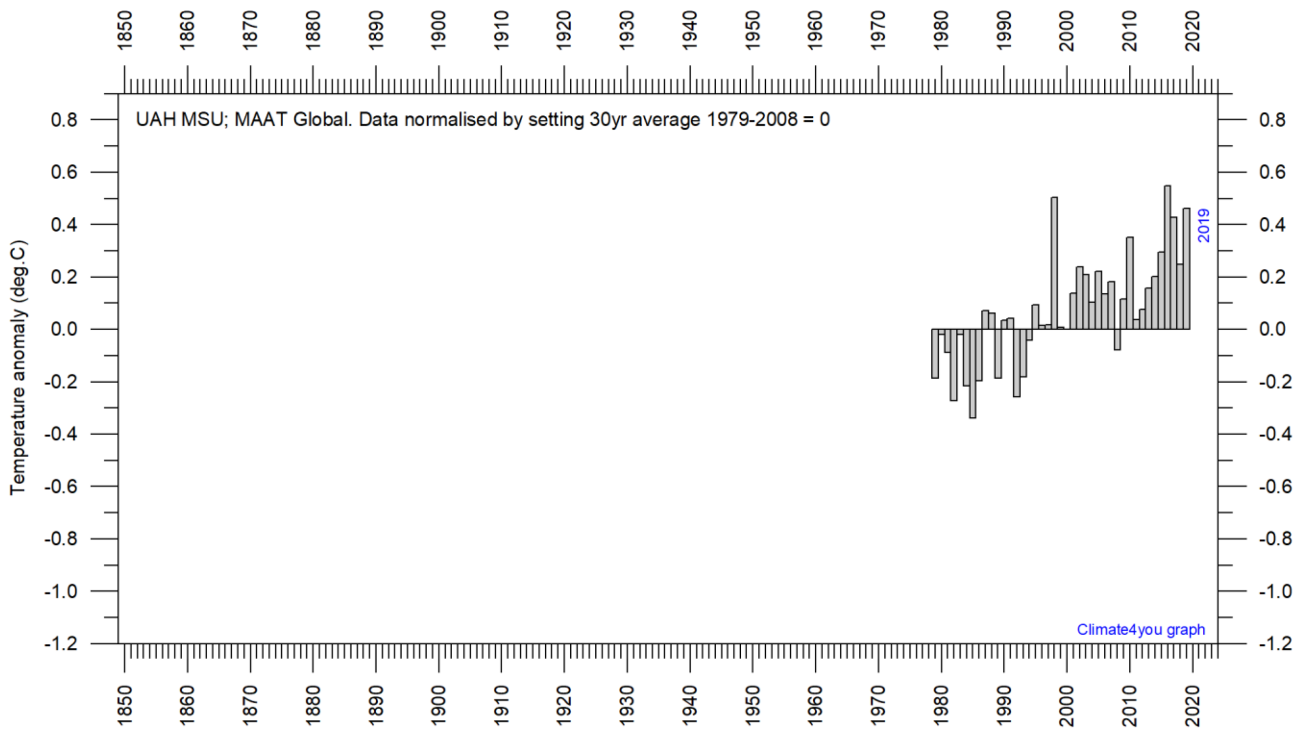


FIGURE 3. Mean annually lower troposphere temperature anomaly (thin line) since 1979 according to [University of Alabama](#) at Huntsville, USA. The average for 1979-2008 (30 years) has been set to zero, to make comparison with other temperature data series easy.

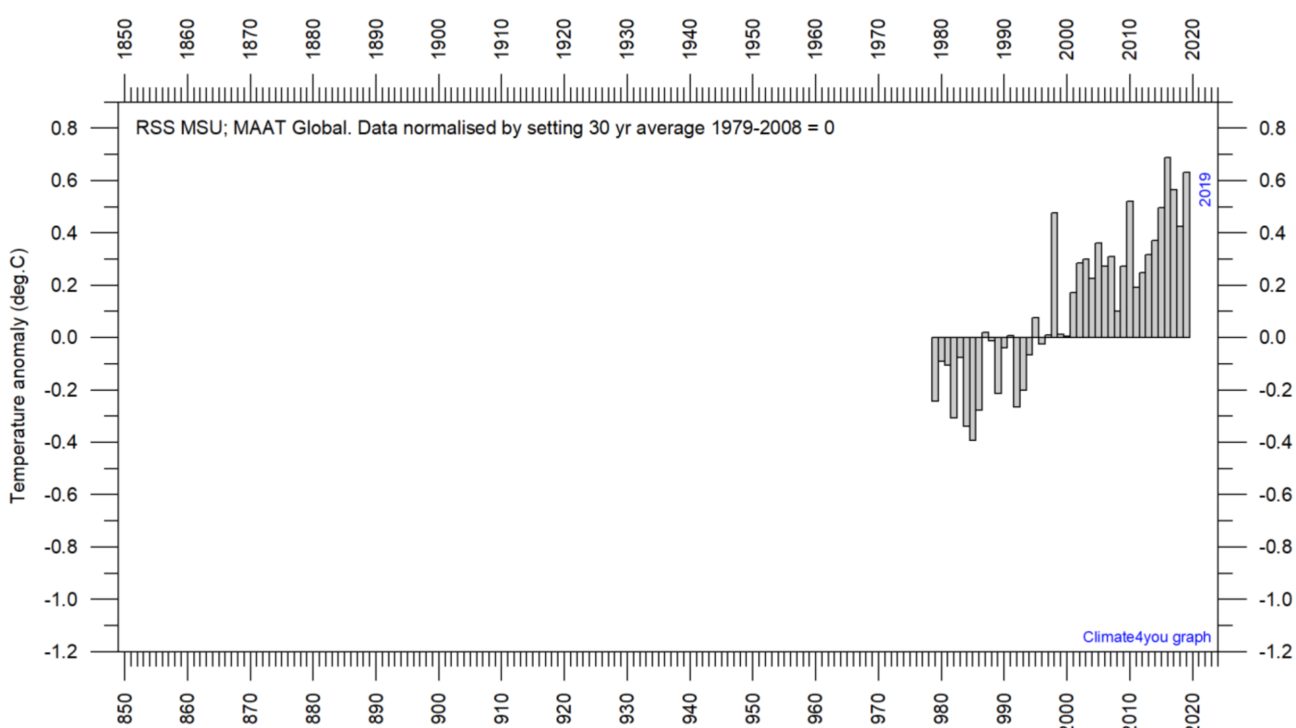


FIGURE 4. Mean annual lower troposphere temperature anomaly (thin line) since 1979 according to according to Remote Sensing Systems (RSS), USA. The average for 1979-2008 (30 years) has been set to zero, to make comparison with other temperature data series easy.

Global surface air temperature, updated to year 2019

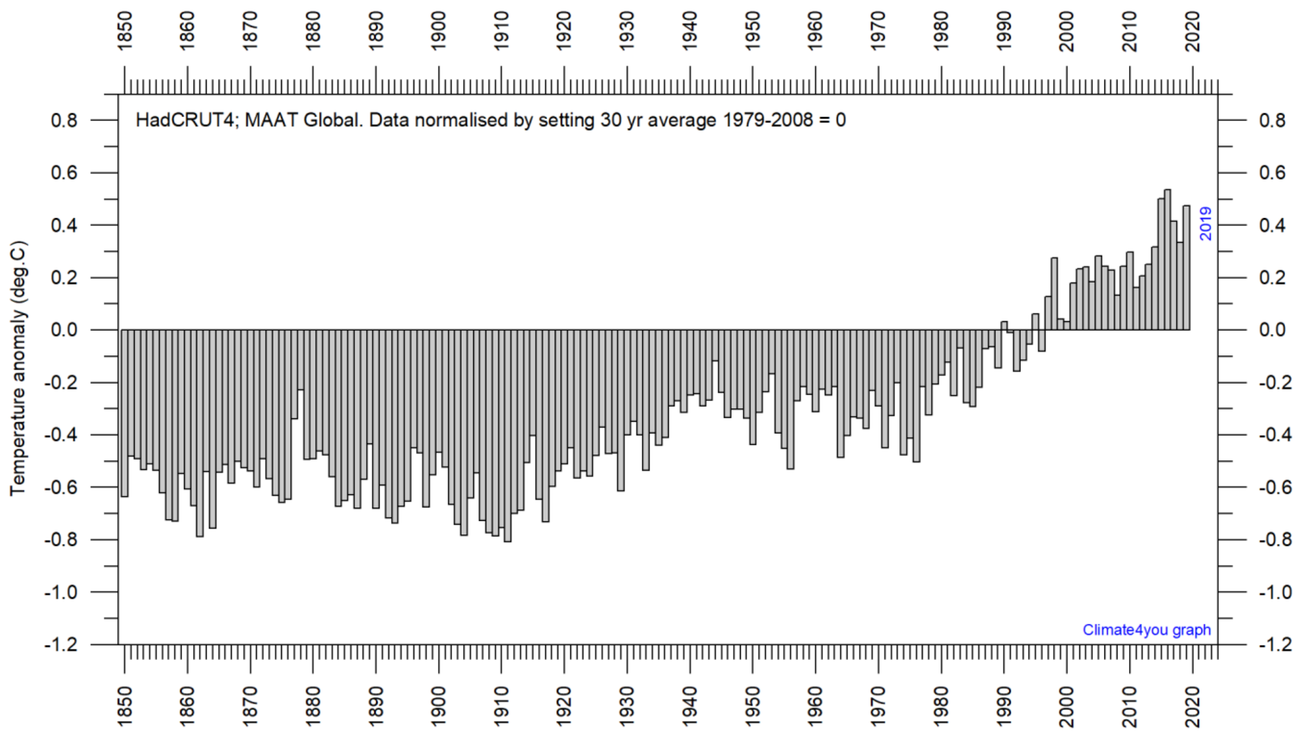


FIGURE 5. Mean annual global surface air temperature (thin line) since 1850 according to according to the Hadley Centre for Climate Prediction and Research and the University of East Anglia's [Climatic Research Unit](#) ([CRU](#)), UK. The average for 1979-2008 (30 years) has been set to zero.

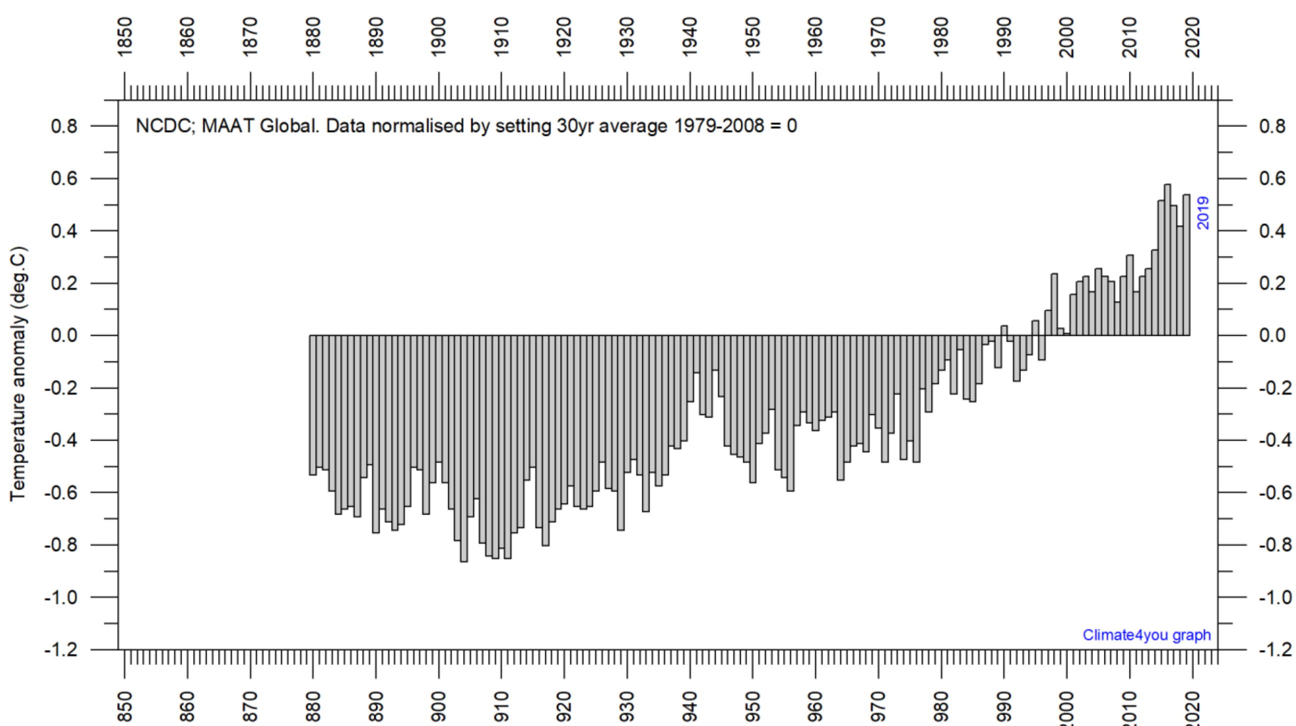


FIGURE 6. Mean annual global surface air temperature since 1880 according to according to the [National Climatic Data Center](#) (NCDC), USA. The average for 1979-2008 (30 years) has been set to zero, to make comparison with other temperature data series easy.

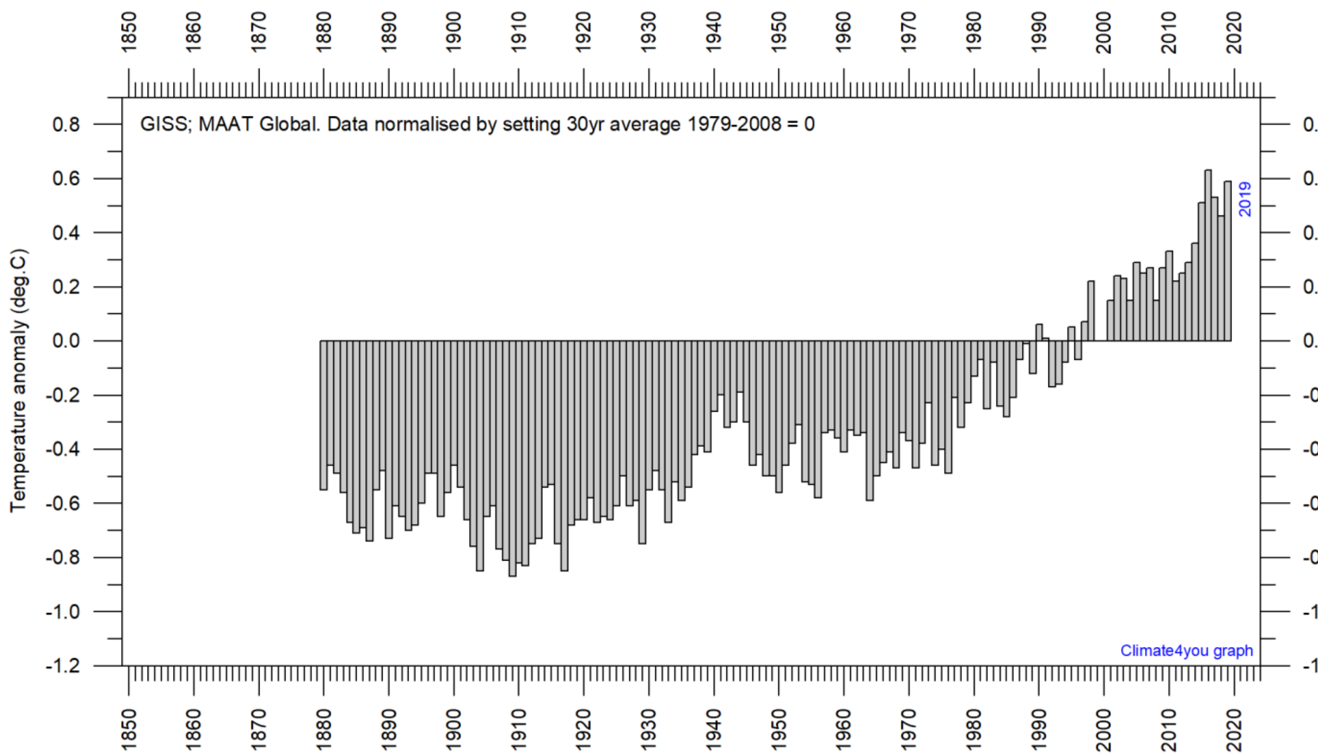


FIGURE 7. Mean annual global surface air temperature (thin line) since 1880 according to according to the [Goddard Institute for Space Studies](#) (GISS), at Columbia University, New York City, USA. The average for 1979-2008 (30 years) has been set to zero, to make comparison with other temperature data series easy.

Reflections on the significance of the 2019 global annual surface air temperature

According to the surface stations 2019 ranks as one of the warmest years since 1880 and 1850, although cooler than 2016. Also, according to the satellite records 2019 was warm, but not the warmest.

The recent very strong El Niño terminated during 2017. Quite often -but not always- a warm El Niño episode is followed by a cool oceanographic reversal, known as La Niña, which also will influence global air temperatures, but now towards lower values. In fact, a moderate La Niña episode established itself in late 2017, lasting until early 2018 (Fig. 14). Towards the end of 2018, however a new, moderate El Niño initiated and affected global air temperatures toward their high average values in 2019.

Air temperature changes do not only play out at the surface, but also at higher levels in the atmosphere (see Fig. 11). The current CO2 hypothesis projects that the initial and largest temperature increase should affect the upper Troposphere, at 6-8 km altitude. However, since 1979 the earth's surface has warmed faster than the upper Troposphere, implying that the surface heating observed is not predominantly due to added atmospheric CO2, but is largely caused by one or several other factors (oceans, cloud cover, etc.).

Comparing surface air temperatures with data from satellites at the end of 2019

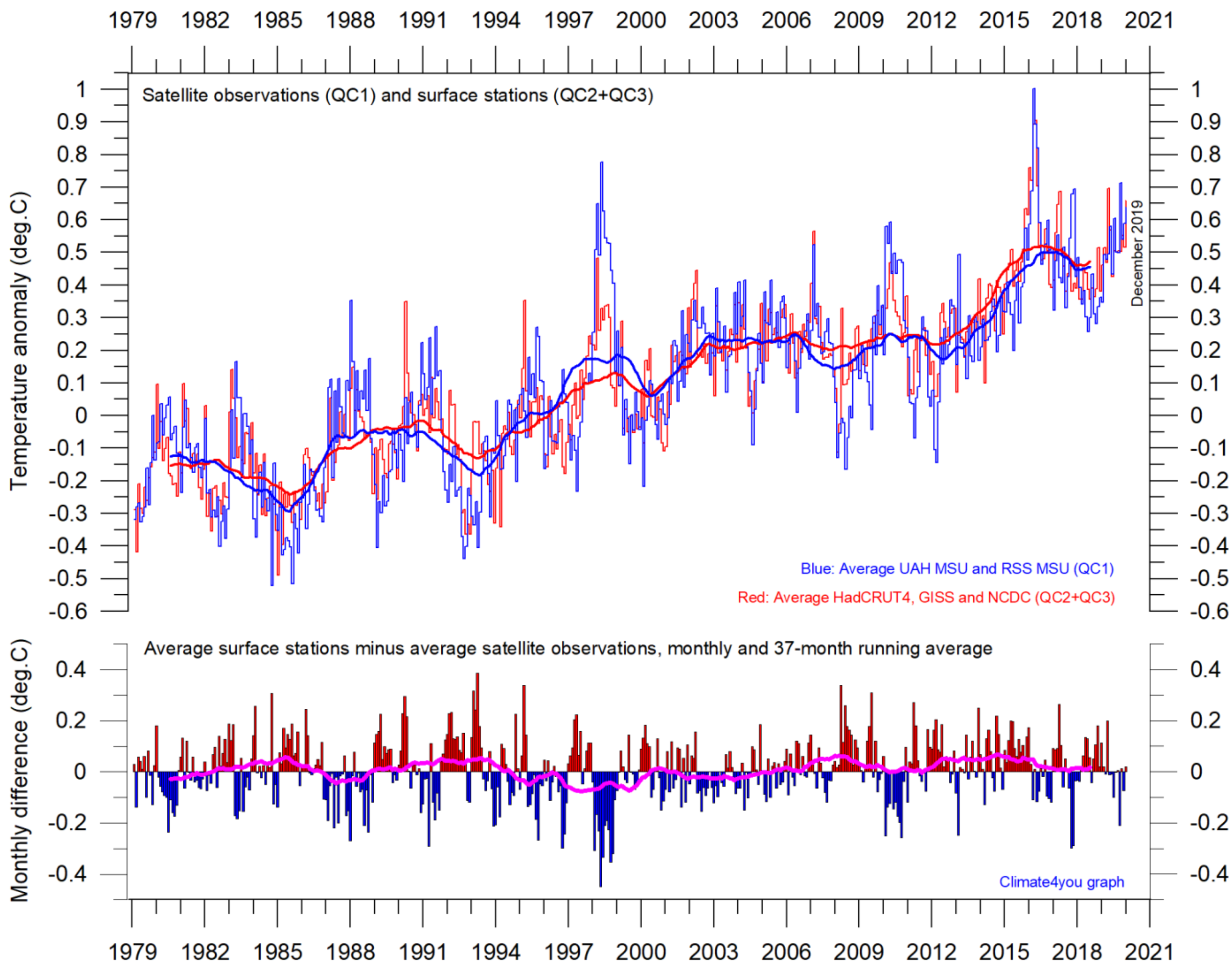


FIGURE 8. Plot showing the average of monthly global surface air temperature estimates (HadCRUT4, GISS and NCDC) and satellite-based temperature estimates (RSS MSU and UAH MSU). The thin lines indicate the monthly value, while the thick lines represent the simple running 37-month average, nearly corresponding 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 2019

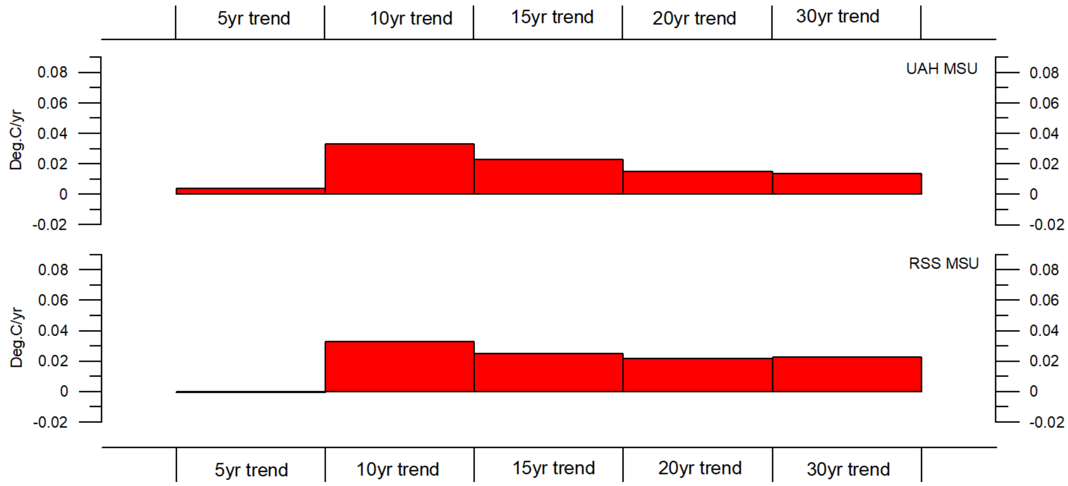


FIGURE 9. Diagram showing the latest 5, 10, 20 and 30 yr linear annual global temperature trend, calculated as the slope of the linear regression line through the data points, for two satellite-based temperature estimates (UAH MSU and RSS MSU).

Global surface air temperature trends calculated for different periods until December 2019

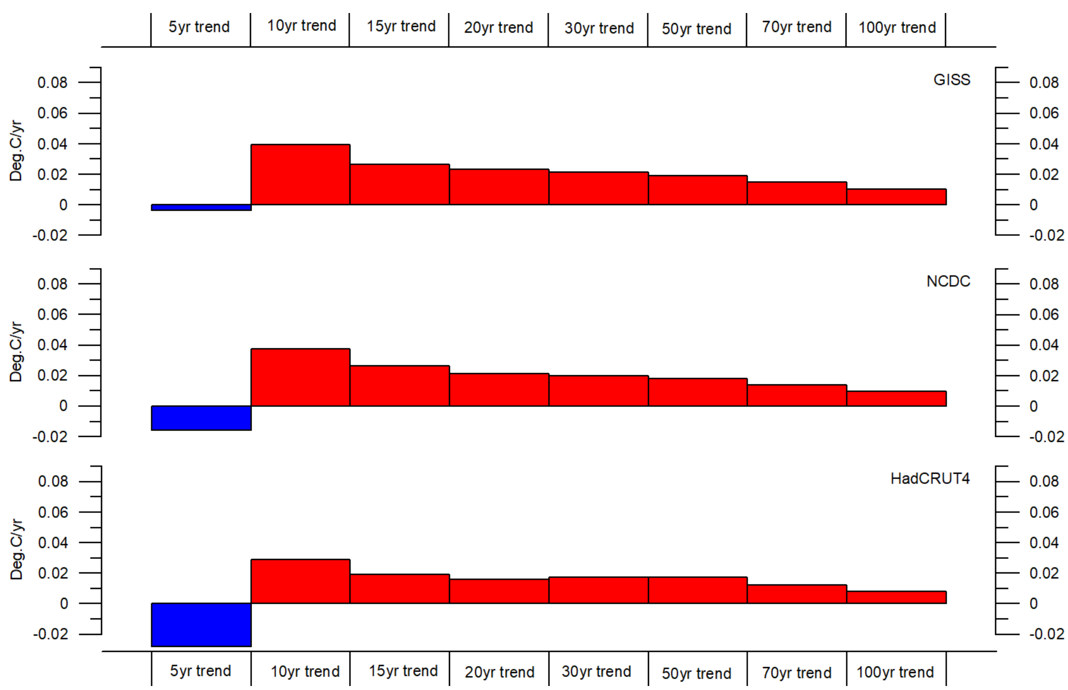


FIGURE 10. Diagram showing the latest 5, 10, 15, 20, 30, 50, 70 and 100-year linear annual global temperature trend, calculated as the slope of the linear regression line through the data points, for three surface-based temperature estimates (GISS, NCDC and HadCRUT3).

Troposphere and stratosphere temperatures from satellites at the end of 2019

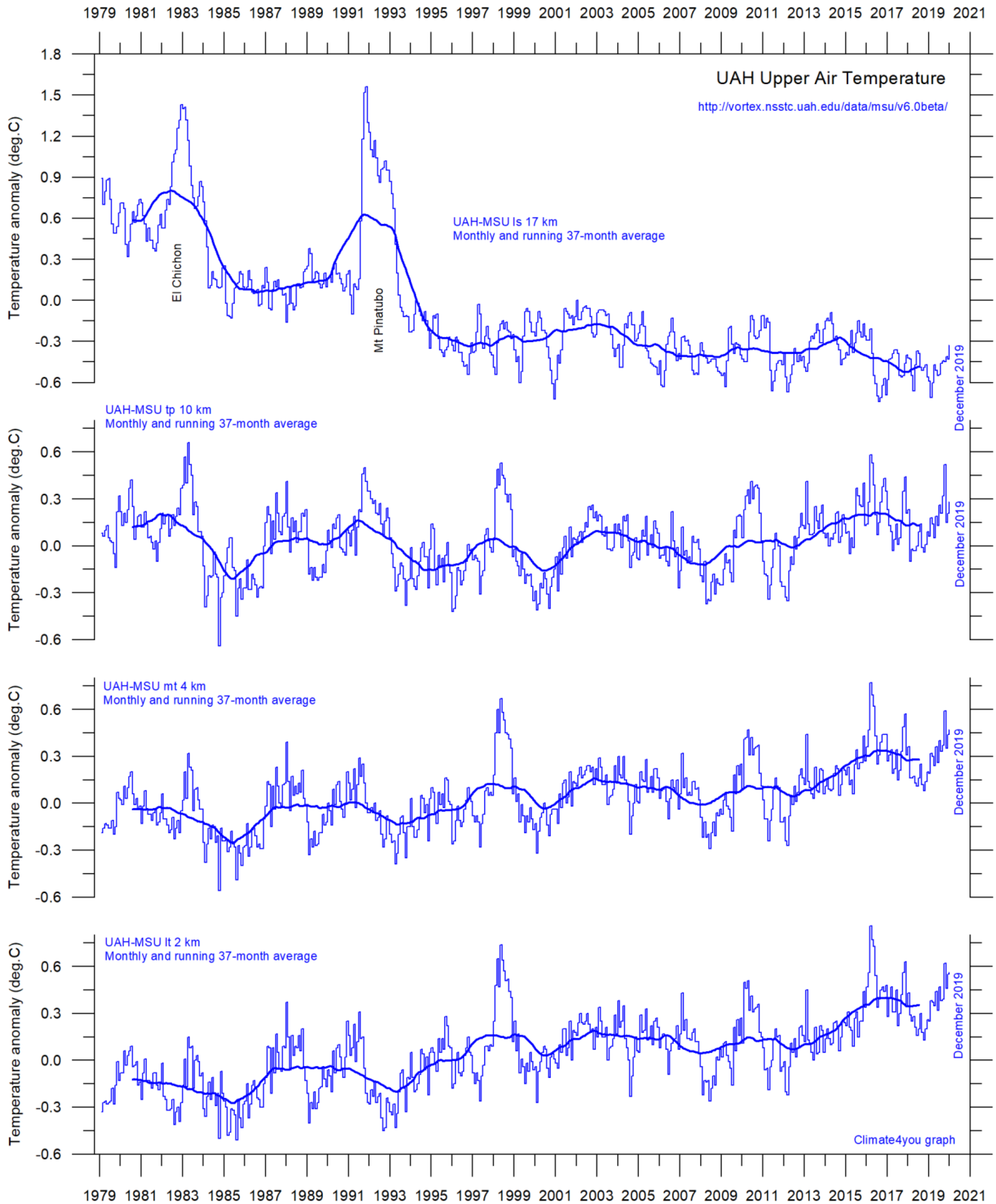
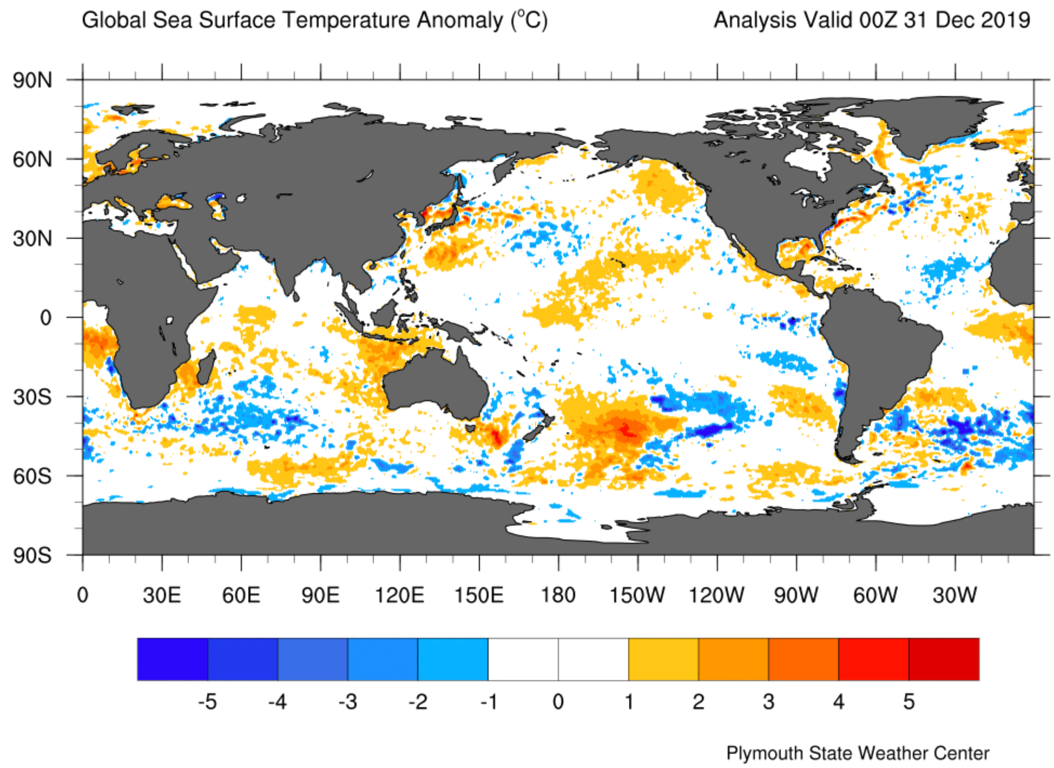


FIGURE 11. Global monthly average temperature in different according to University of Alabama at Huntsville, USA. The thin lines represent the monthly average, and the thick line the simple running 37-month average, nearly corresponding to a running 3-year average.

Sea surface temperature anomaly at the end of the years 2019 and 2018



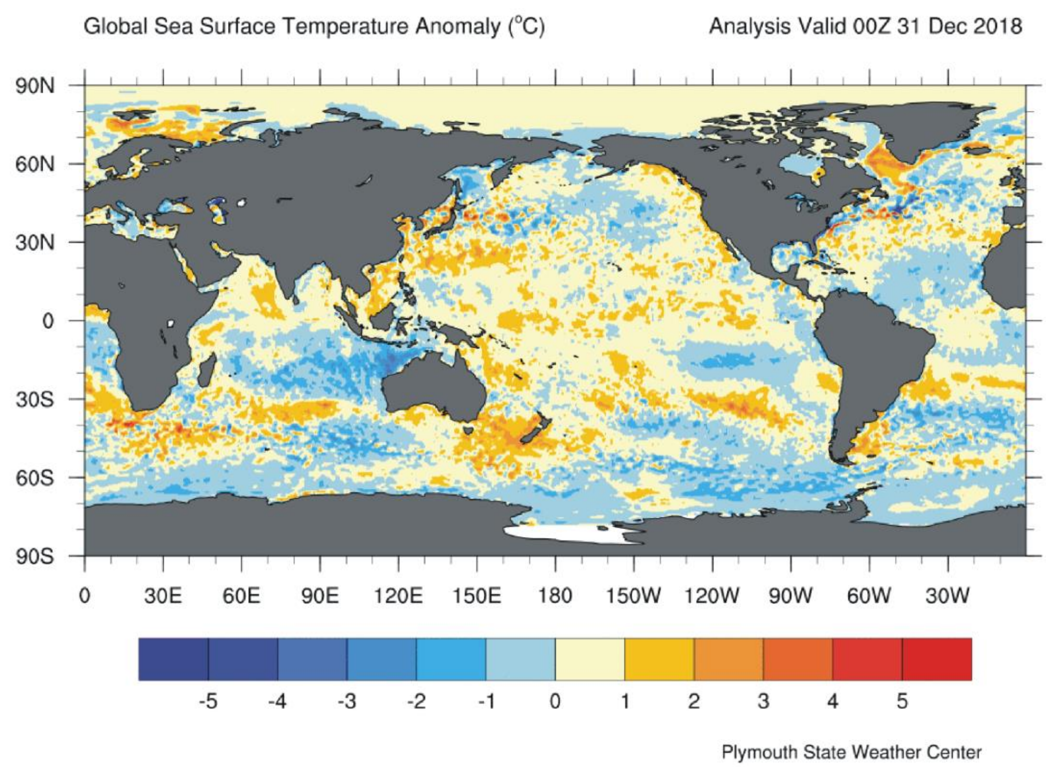


FIGURE 12. Sea surface temperature anomaly in late December 2019 and 2018, upper and lower panel, respectively. Reference period: 1977-1991. Map source: Plymouth State Weather Center. Please note the change of colour scale between the two years.

Ocean temperatures, uppermost 1900m, updated to July 2019

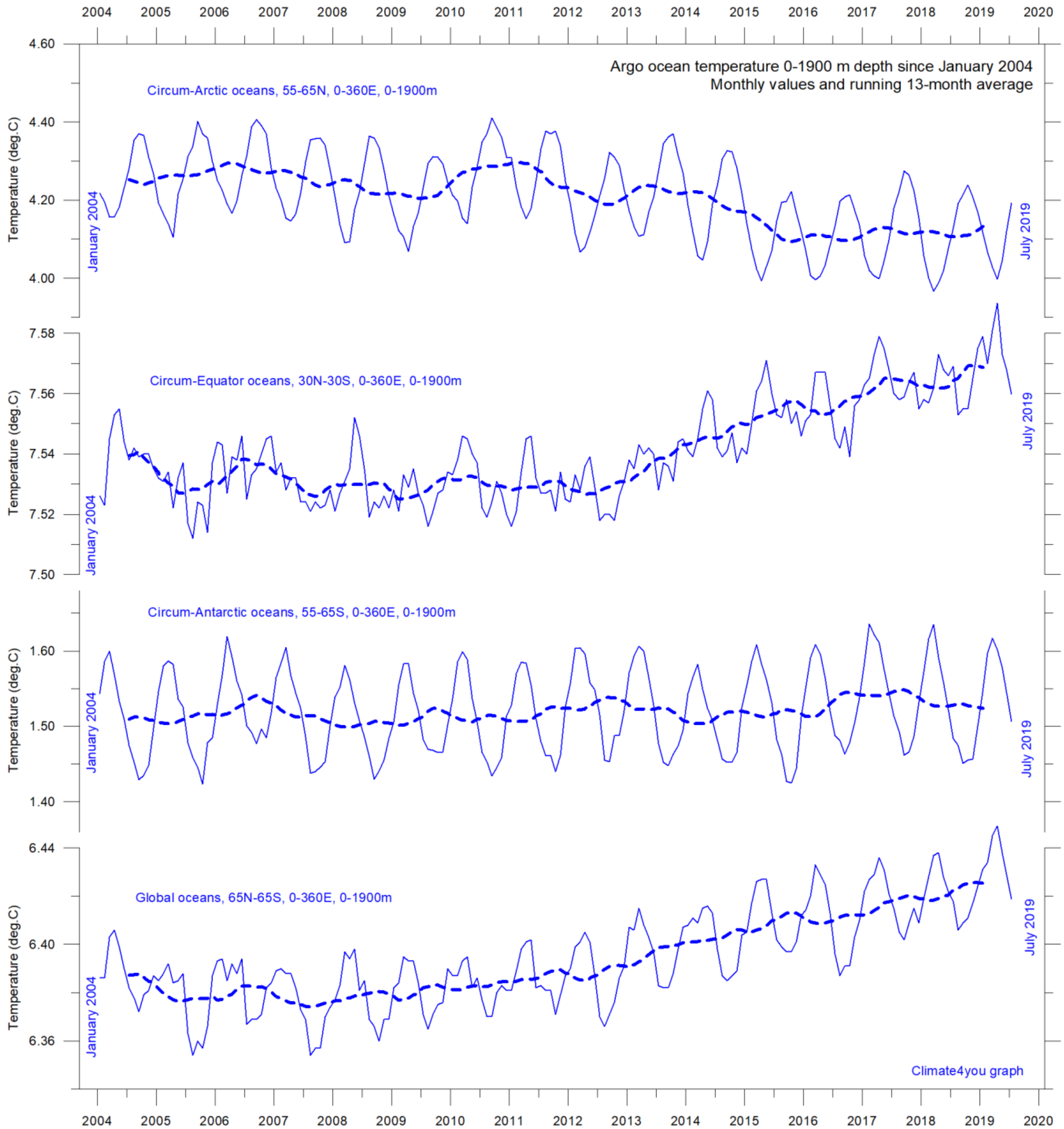


FIGURE 13. Diagram showing average 0-1900m depth ocean temperatures in selected latitudinal bands, using Argo-data. The thin line shows monthly values and the stippled line shows the running 13-month average. Source: Global Marine Argo Atlas. Please note that the Argo data series is not yet updated beyond July 2019.

La Niña and El Niño episodes, updated to October-December 2019

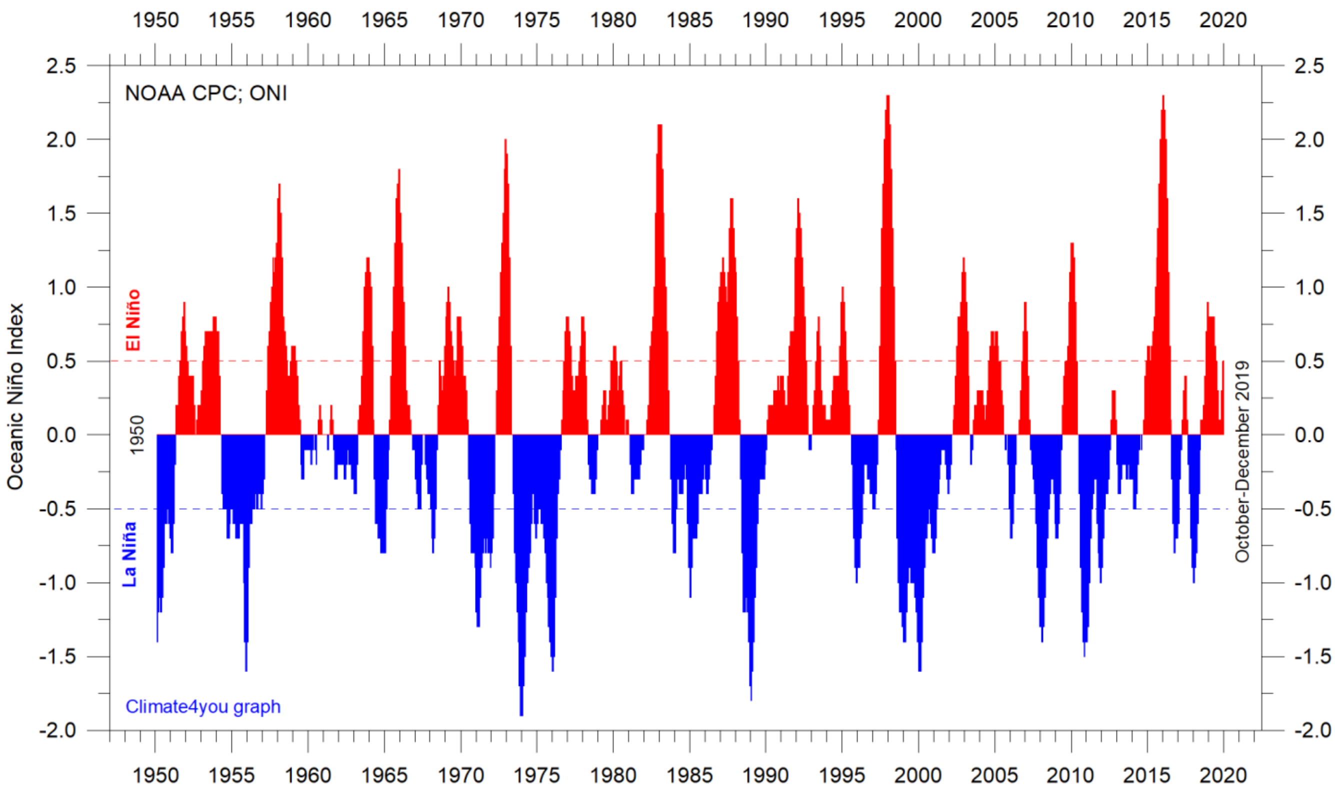


FIGURE 14. Warm (>+0.5°C) and cold (<0.5°C) episodes for the Oceanic Niño Index (ONI), defined as 3 month running mean of ERSST.v3b SST anomalies in the Niño 3.4 region (5°N-5°S, 120°-170°W)]. Base period: 1971-2000. For historical purposes cold and warm episodes are defined when the threshold is met for a minimum of 5 consecutive over-lapping seasons.

Year 2019 was characterized by a moderate El Niño episode in the Pacific Ocean. At the end of the year, the index is moving towards a more neutral situation, as is shown by Figure 14 above. The diagram also shows 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 are not abnormal.

PDO - Pacific Decadal Oscillation, updated to 2017

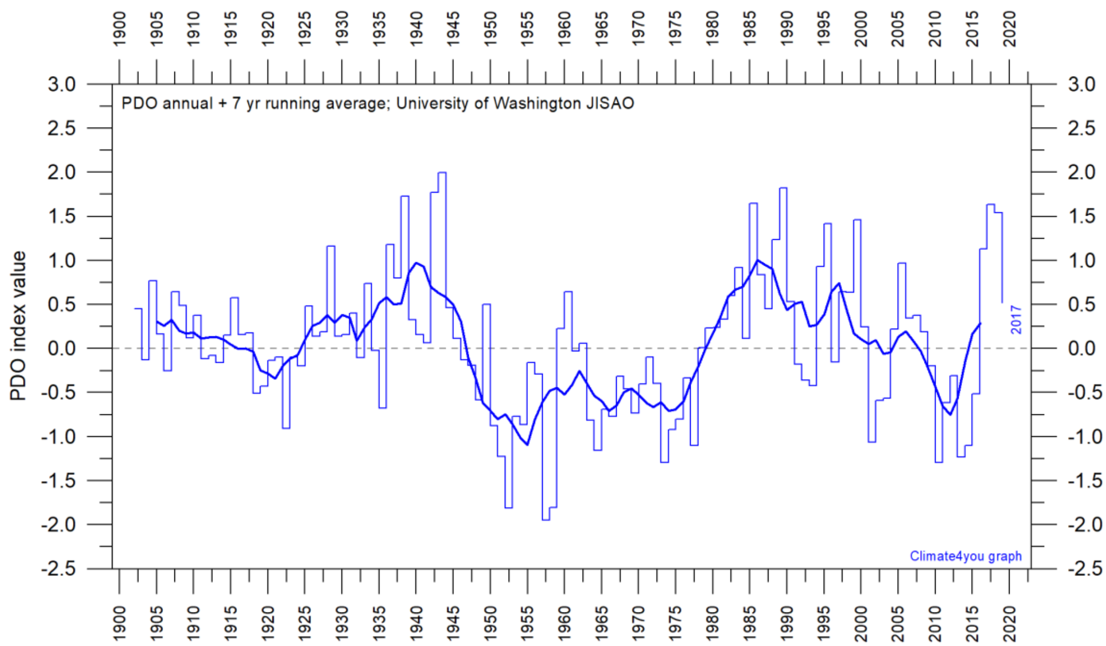


FIGURE 15. Annual values of the Pacific Decadal Oscillation (PDO) according to the Joint Institute for the Study of the Atmosphere and Ocean (JISAO), a Cooperative Institute between the National Oceanic and Atmospheric Administration and the University of Washington. The PDO is a long-lived El Niño-like 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. Please note that the annual PDO is not yet updated beyond 2017.

AMO (Atlantic Multidecadal Oscillation) Index, updated to 2019

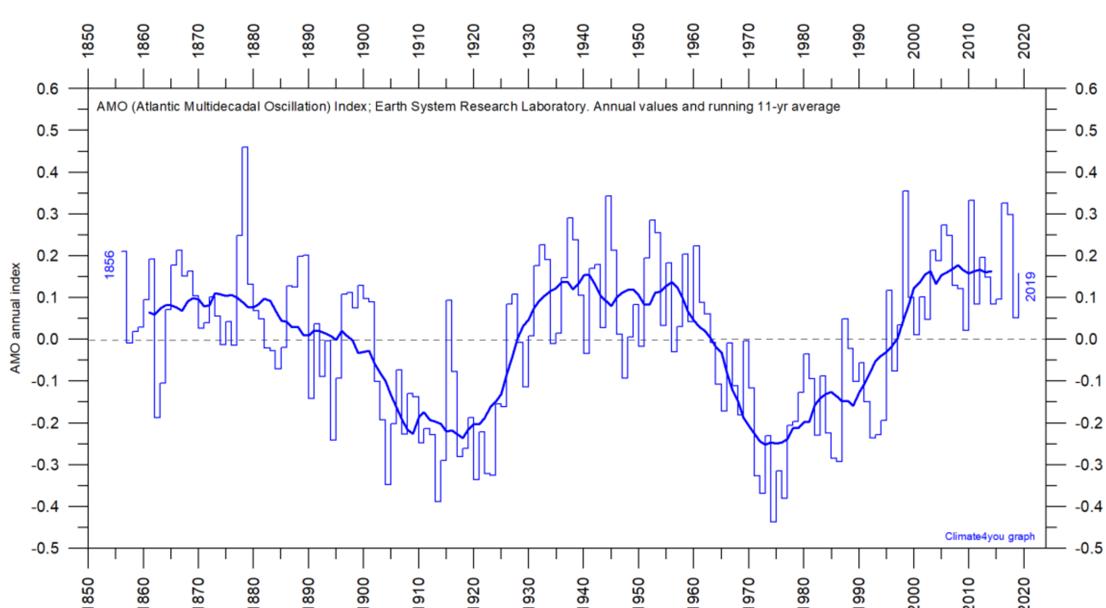


FIGURE 16. Annual Atlantic Multidecadal Oscillation (AMO) detrended index values since 1856. The thin line indicates the annual values, and the thick line is the simple running 11-year average. Data source: Earth System Research Laboratory at NOAA.

Annual accumulated cyclone energy (ACE) Atlantic Basin, updated to 2018

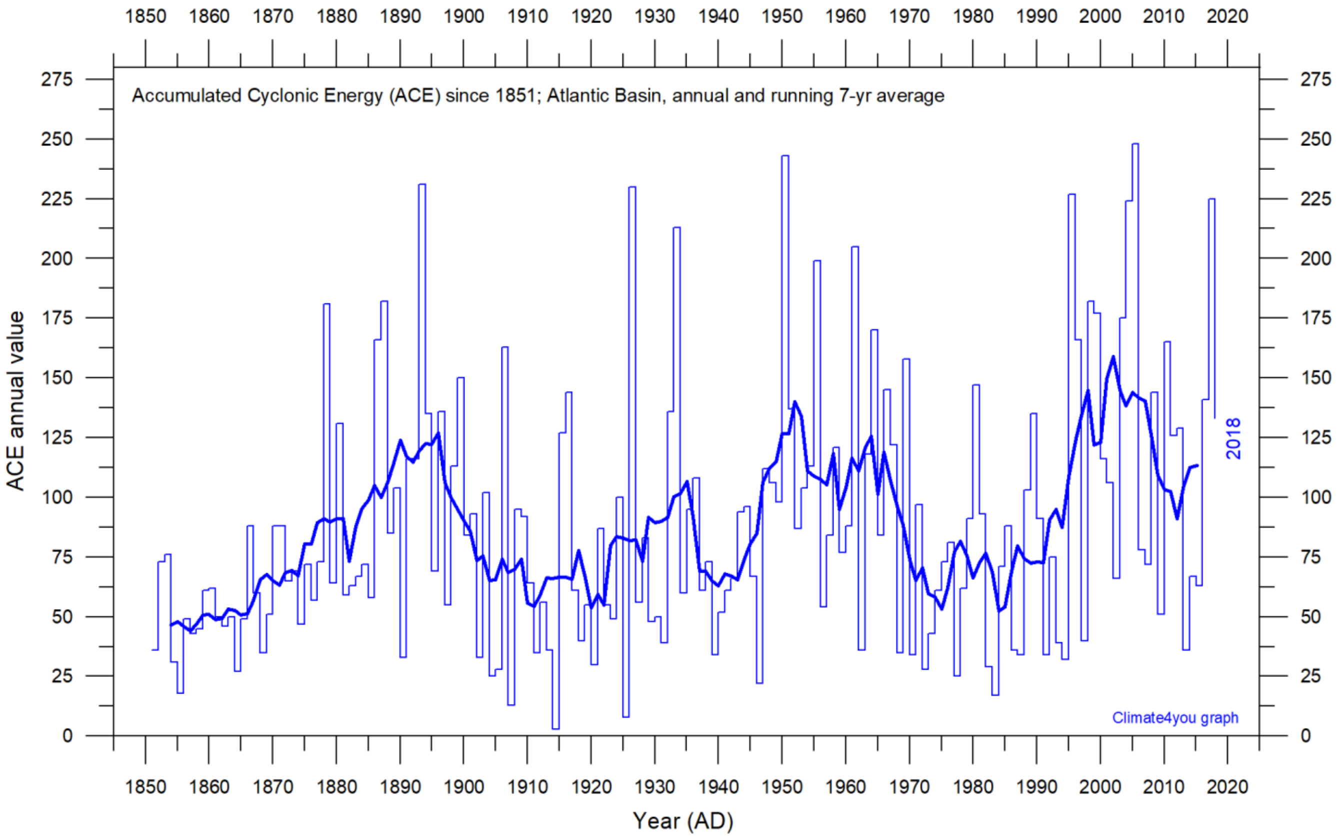


FIGURE 17. Accumulated cyclonic engergy (ACE; Atlantic basin) per year since 1850 AD, according to data from the [Atlantic Oceanographic and Meteorological Laboratory, Hurricane research Division](). Thin lines show annual ACE values, and the thick line shows the running 7-yr average. Please note that this data series is not yet updated beyond 2018.

The Atlantic Oceanographic and Meteorological Laboratory ACE data series goes back to 1850. A Fourier analysis for the Atlantic Basin (figure above) show the ACE series to be strongly influenced by a periodic variation of about 60 years' duration. At present, since 2002, the Atlantic ACE series is displaying an overall declining trend, but with large interannual variations. The North Atlantic hurricane season often shows above average activity when La Nina conditions are present in Pacific during late summer (August-October), as was the case in 2017.

Arctic and Antarctic sea ice extension, updated to December 2019

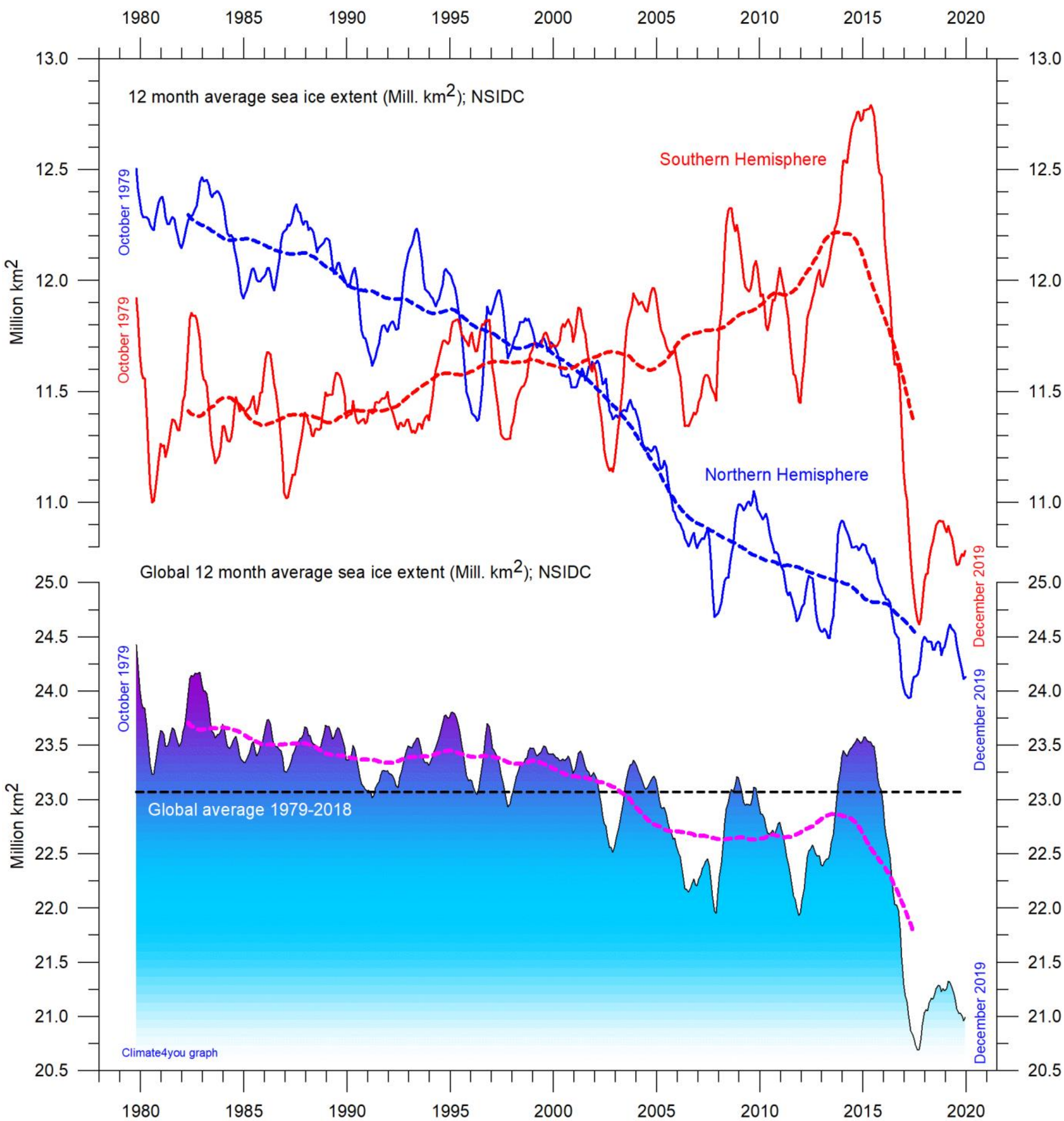


FIGURE 18. Global and hemispheric 12 month running average sea ice extension since 1979, the satellite-era. The October 1979 value represents the monthly average of November 1978 - October 1979, the November 1979 value represents the average of December 1978 - November 1979, etc. The stippled lines represent 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).

Northern Hemisphere snow cover, updated to December 2019

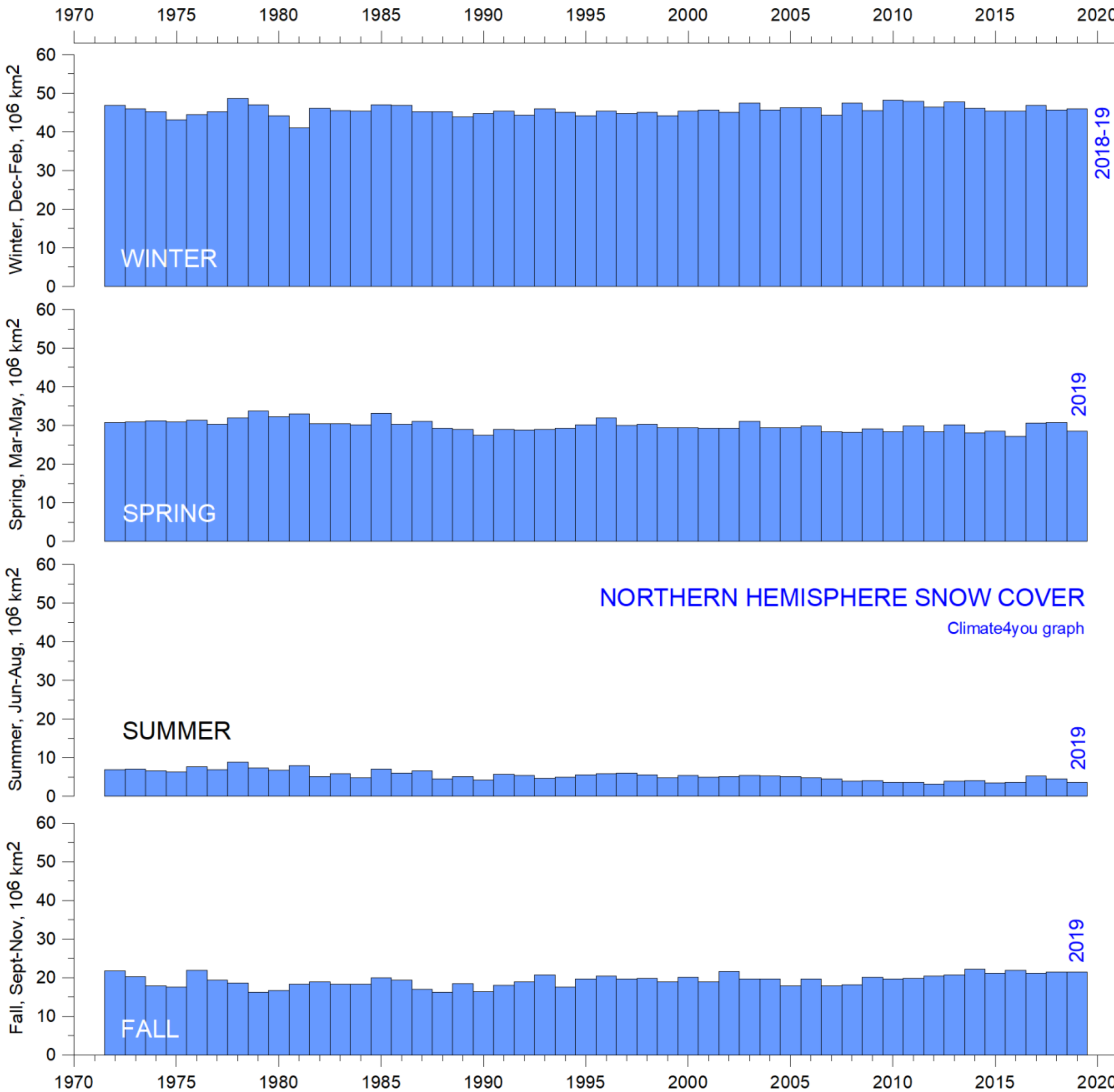


FIGURE 19. Northern Hemisphere seasonal snow cover since 1972 according to [Rutgers University Global Snow Laboratory](#).

Atmospheric specific humidity, updated to December 2019

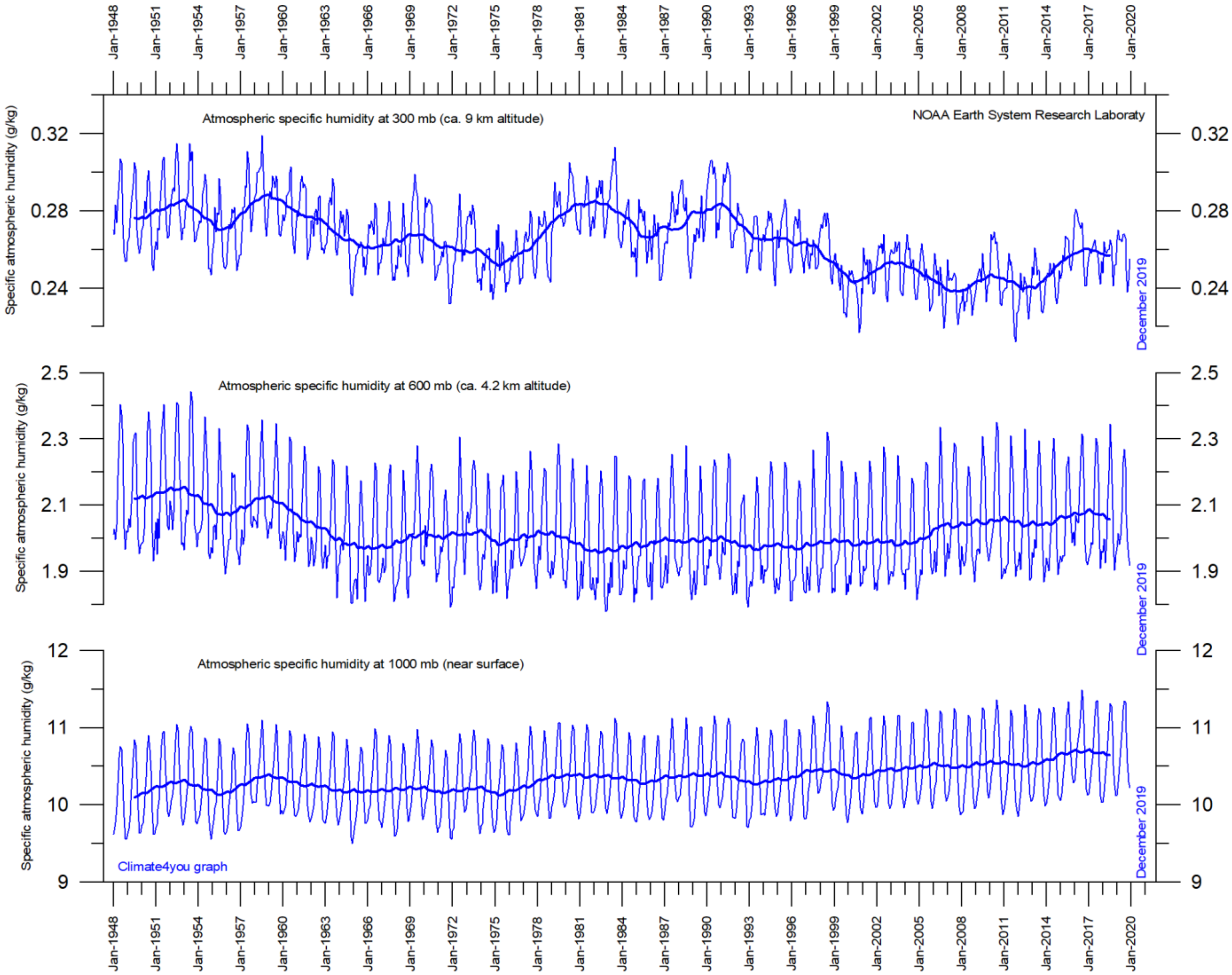
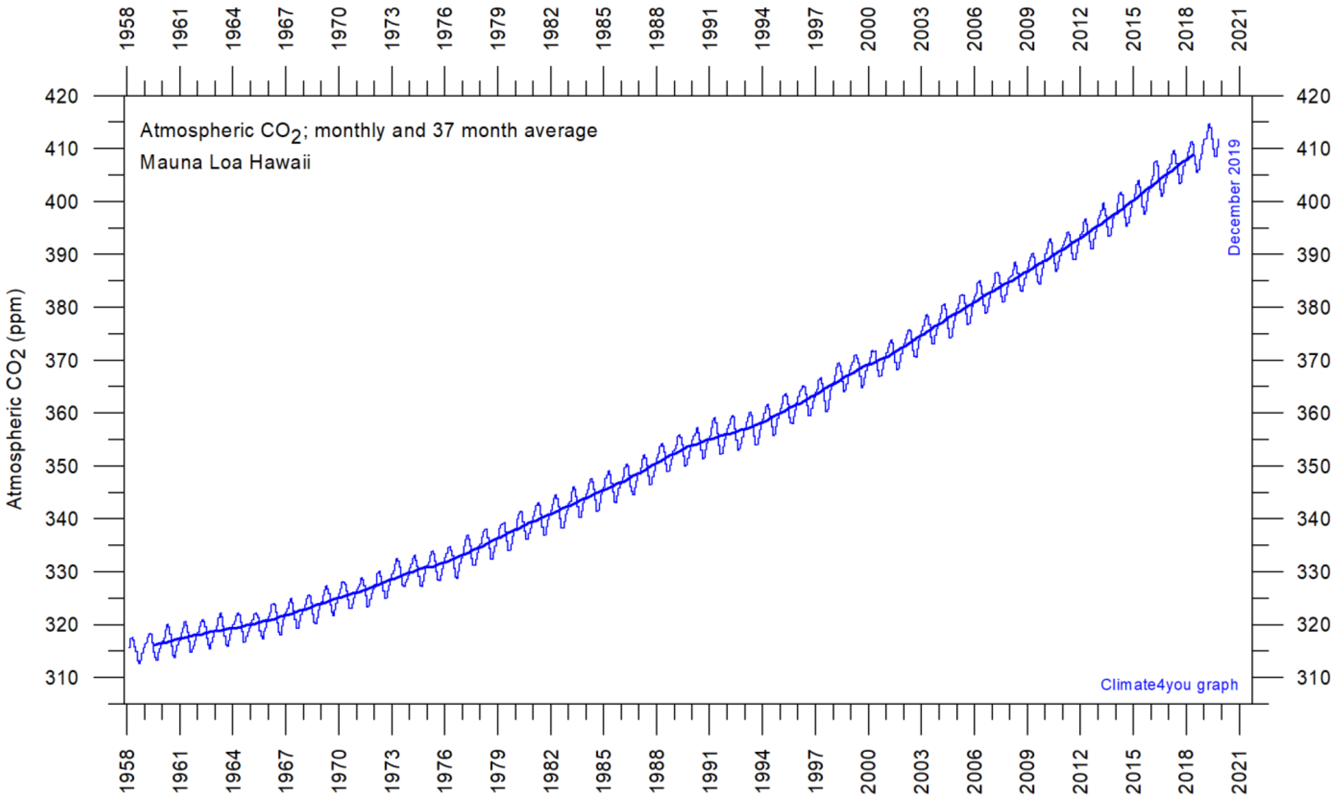


FIGURE 20. Specific atmospheric humidity (g/kg) at three different altitudes in the lower part of the atmosphere (the Troposphere) since January 1948 (Kalnay et al. 1996). The thin blue lines show monthly values, while the thick blue lines show the running 37-month average (about 3 years). Data source: Earth System Research Laboratory (NOAA).

Water vapour is the most important greenhouse gas in Earth's atmosphere, considerably more important than CO_2.

Atmospheric CO2, updated to December 2019



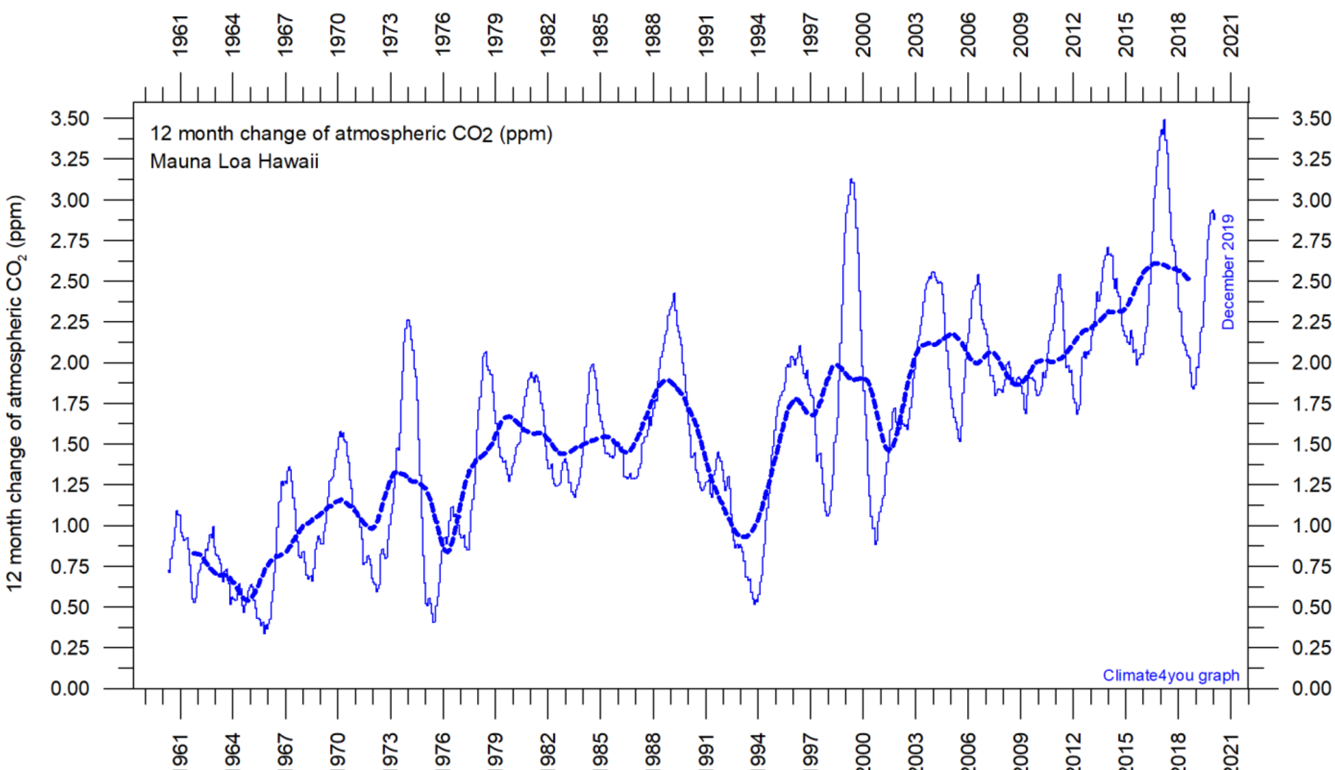


FIGURE 21. Monthly amount of atmospheric CO_2 (upper diagram) and annual growth rate (lower diagram); average last 12 months minus average preceding 12 months, thin line) of atmospheric CO_2 since 1959, according to data provided by the [Mauna Loa Observatory](), Hawaii, USA. The thick, stippled line is the simple running 37-month average, nearly corresponding to a running 3-year average.

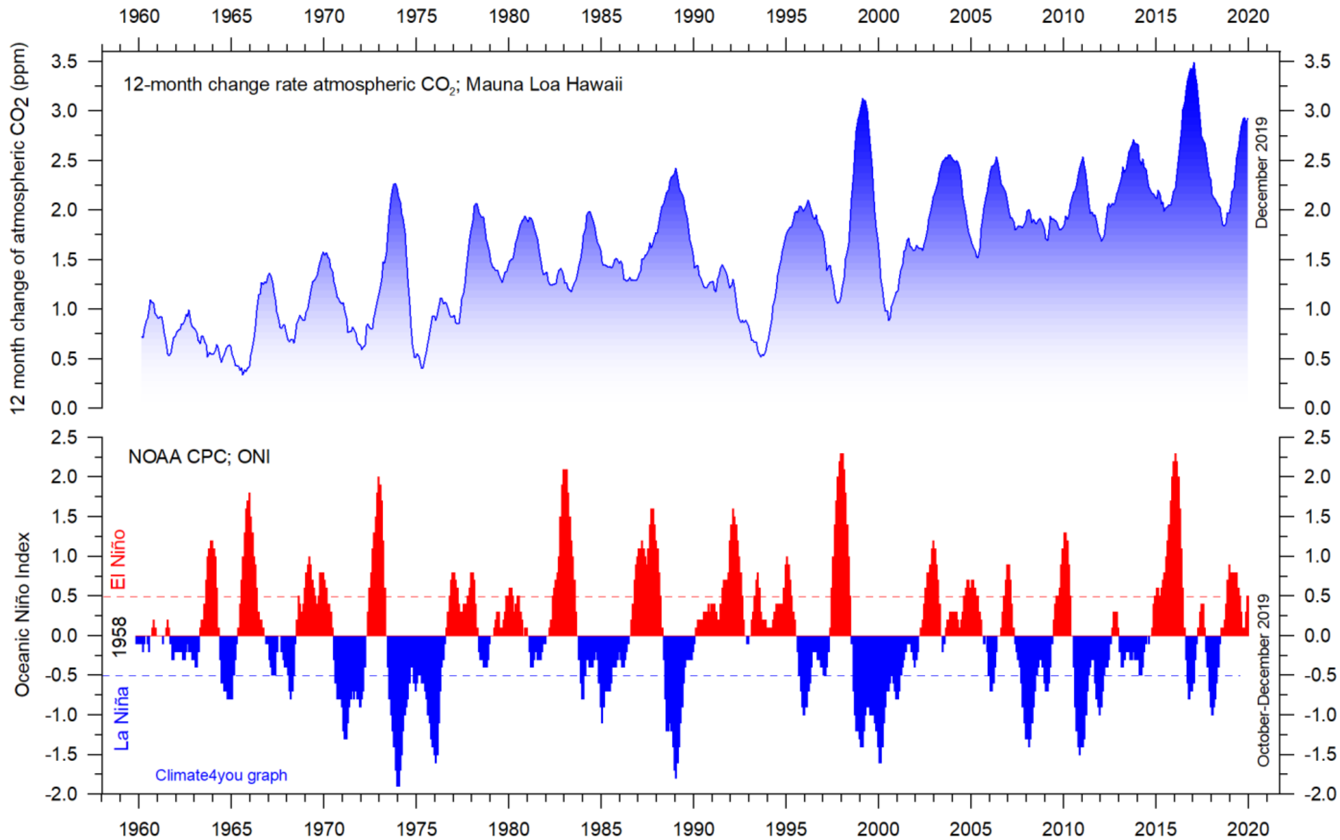


FIGURE 22. Visual association between annual growth rate of atmospheric CO_2 (upper panel) and Oceanic Niño Index (lower panel). See also Figure 14 and 21, respectively.

Number of daily sunspots since 1900, updated to December 31, 2019

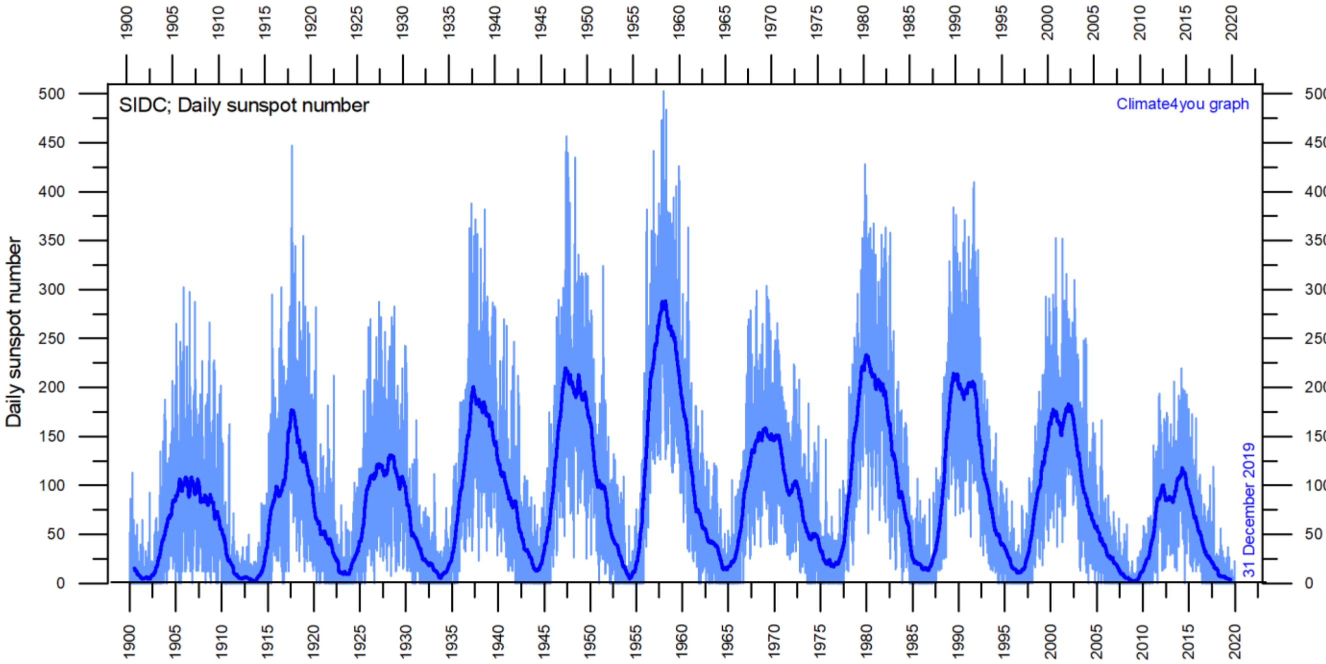


FIGURE 23. Daily observations of the number of sunspots since 1 January 1900 according to Solar Influences Data Analysis Center (SIDC). The thin blue line indicates the daily sunspot number, while the dark blue line indicates the running annual average.

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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,

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