

# STATE OF THE CLIMATE IN 2017

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FRONT: ©Ron\_ Thomas/Spring desert wildflowers in Anza Borrego Desert State Park, CA/Getty Images.

BACK: Smoke and Fire in Southern California: Thick smoke was streaming from several fires in Southern California when the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's *Terra* satellite acquired a natural-color image in the afternoon on December 5, 2017. On the same day, the Multi Spectral Imager (MSI) on the European Space Agency's Sentinel-2 satellite captured the data for a false-color image of the burn scar. Active fires appear orange; the burn scar is brown. Unburned vegetation is green; developed areas are gray. The Sentinel-2 image is based on observations of visible, shortwave infrared, and near infrared light.

NASA Earth Observatory images by Joshua Stevens, using MODIS data from LANCE/EOSDIS Rapid Response and modified Copernicus Sentinel data (2017) processed by the European Space Agency. Story by Adam Voiland.

Instrument(s):

*Terra* - MODIS

Sentinel-2

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In 2017, the dominant greenhouse gases released into Earth's atmosphere—carbon dioxide, methane, and nitrous oxide—reached new record highs. The annual global average carbon dioxide concentration at Earth's surface for 2017 was  $405.0 \pm 0.1$  ppm, 2.2 ppm greater than for 2016 and the highest in the modern atmospheric measurement record and in ice core records dating back as far as 800 000 years. The global growth rate of CO<sub>2</sub> has nearly quadrupled since the early 1960s.

With ENSO-neutral conditions present in the central and eastern equatorial Pacific Ocean during most of the year and weak La Niña conditions notable at the start and end, the global temperature across land and ocean surfaces ranked as the second or third highest, depending on the dataset, since records began in the mid-to-late 1800s. Notably, it was the warmest non-El Niño year in the instrumental record. Above Earth's surface, the annual lower tropospheric temperature was also either second or third highest according to all datasets analyzed. The lower stratospheric temperature was about 0.2°C higher than the record cold temperature of 2016 according to most of the in situ and satellite datasets.

Several countries, including Argentina, Uruguay, Spain, and Bulgaria, reported record high annual temperatures. Mexico broke its annual record for the fourth consecutive year. On 27 January, the temperature reached 43.4°C at Puerto Madryn, Argentina—the highest temperature recorded so far south (43°S) anywhere in the world. On 28 May in Turbat, western Pakistan, the high of 53.5°C tied Pakistan's all-time highest temperature and became the world-record highest temperature for May.

In the Arctic, the 2017 land surface temperature was 1.6°C above the 1981–2010 average, the second highest since the record began in 1900, behind only 2016. The five highest annual Arctic temperatures have all occurred since 2007. Exceptionally high temperatures were observed in the permafrost across the Arctic, with record values reported in much of Alaska and northwestern Canada. In August, high sea surface temperature (SST) records were broken for the Chukchi Sea, with some regions as warm as +11°C, or 3° to 4°C warmer than the long-term mean (1982–present). According to paleoclimate studies, today's abnormally warm Arctic air and SSTs have not been observed in the last 2000 years. The increasing temperatures have led to decreasing Arctic sea ice extent and thickness. On 7 March, sea ice extent at the end of the growth season saw its lowest maximum in the 37-year satellite record, covering 8% less area than the 1981–2010 average. The Arctic sea ice minimum on 13 September was the eighth lowest on record and covered 25% less area than the long-term mean.

Preliminary data indicate that glaciers across the world lost mass for the 38th consecutive year on record; the declines are remarkably consistent from region to region. Cumulatively since 1980, this loss is equivalent to slicing 22 meters off the top of the average glacier.

Antarctic sea ice extent remained below average for all of 2017, with record lows during the first four months. Over the continent, the austral summer seasonal melt extent and

melt index were the second highest since 2005, mostly due to strong positive anomalies of air temperature over most of the West Antarctic coast. In contrast, the East Antarctic Plateau saw record low mean temperatures in March. The year was also distinguished by the second smallest Antarctic ozone hole observed since 1988.

Across the global oceans, the overall long-term SST warming trend remained strong. Although SST cooled slightly from 2016 to 2017, the last three years produced the three highest annual values observed; these high anomalies have been associated with widespread coral bleaching. The most recent global coral bleaching lasted three full years, June 2014 to May 2017, and was the longest, most widespread, and almost certainly most destructive such event on record. Global integrals of 0–700-m and 0–2000-m ocean heat content reached record highs in 2017, and global mean sea level during the year became the highest annual average in the 25-year satellite altimetry record, rising to 77 mm above the 1993 average.

In the tropics, 2017 saw 85 named tropical storms, slightly above the 1981–2010 average of 82. The North Atlantic basin was the only basin that featured an above-normal season, its seventh most active in the 164-year record. Three hurricanes in the basin were especially notable. Harvey produced record rainfall totals in areas of Texas and Louisiana, including a storm total of 1538.7 mm near Beaumont, Texas, which far exceeds the previous known U.S. tropical cyclone record of 1320.8 mm. Irma was the strongest tropical cyclone globally in 2017 and the strongest Atlantic hurricane outside of the Gulf of Mexico and Caribbean on record with maximum winds of 295 km h<sup>-1</sup>. Maria caused catastrophic destruction across the Caribbean Islands, including devastating wind damage and flooding across Puerto Rico. Elsewhere, the western North Pacific, South Indian, and Australian basins were all particularly quiet.

Precipitation over global land areas in 2017 was clearly above the long-term average. Among noteworthy regional precipitation records in 2017, Russia reported its second wettest year on record (after 2013) and Norway experienced its sixth wettest year since records began in 1900. Across India, heavy rain and flood-related incidents during the monsoon season claimed around 800 lives. In August and September, above-normal precipitation triggered the most devastating floods in more than a decade in the Venezuelan states of Bolívar and Delta Amacuro. In Nigeria, heavy rain during August and September caused the Niger and Benue Rivers to overflow, bringing floods that displaced more than 100 000 people.

Global fire activity was the lowest since at least 2003; however, high activity occurred in parts of North America, South America, and Europe, with an unusually long season in Spain and Portugal, which had their second and third driest years on record, respectively. Devastating fires impacted British Columbia, destroying 1.2 million hectares of timber, bush, and grassland, due in part to the region's driest summer on record. In the United States, an extreme western wildfire season burned over 4 million hectares; the total costs of \$18 billion tripled the previous U.S. annual wildfire cost record set in 1991.