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International report confirms record-high global temperatures, greenhouse gases in 2023

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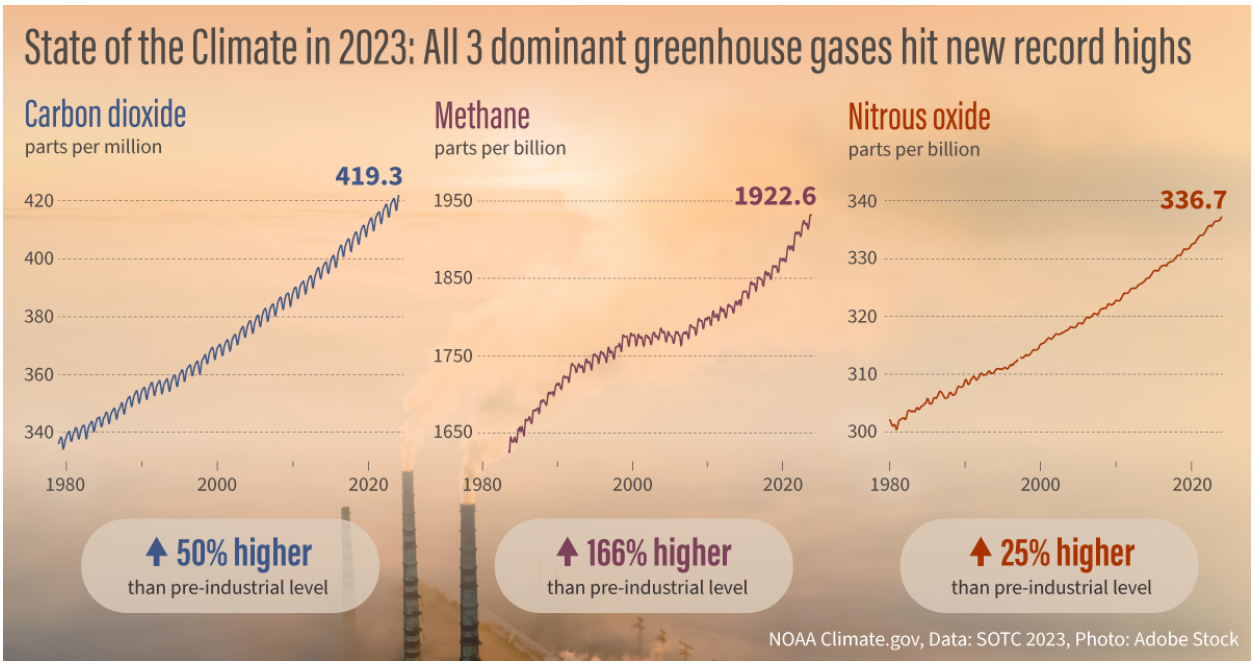
Water vapor and exhaust rise from the steel mill of Salzgitter AG, one of Europe's largest steel producers in Salzgitter, Germany. The company is investing heavily towards CO2-free steel production. (Image credit: Getty Images)

Greenhouse gas concentrations, the global temperature across land and the ocean, global sea level and ocean heat content all reached record highs in 2023, according to the 34th annual State of the Climate reportoffsite link.

The international annual review of the world's climate, led by scientists from NOAA's National Centers for Environmental Information (NCEI) and published by the Bulletin of the American Meteorological Societyoffsite link (BAMS), is based on contributions from nearly 600 scientists in 60 countries. It provides the most comprehensive update on Earth's climate indicators, notable weather events and other data collected by environmental monitoring stations and instruments located on land, water, ice and in space.

"The BAMS State of the Climate report is the product of an international effort to more fully understand global climate conditions in 2023," said NCEI Director Derek Arndt. "This report documents and shares a startling, but well established picture: We are experiencing a warming world as I speak, and the indicators and impacts are seen throughout the planet. The report is another signpost to current and future generations."



The three dominant greenhouse gases in Earth's atmosphere — carbon dioxide (left), methane (center), and nitrous oxide (right) — all reached new highs in 2023. (Image credit: NOAA Climate.gov image, adapted from Figure 2.59 in State of the Climate in 2023. Background photo from Adobe Stock.)
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Notable findings from the State of the Climate Report report include:

Record temperatures notable across the globe. A range of scientific analyses indicate that the annual global surface temperature was 0.99 to 1.08 of a degree F (0.55 to 0.60 of a degree C) above the 1991–2020 average. This makes 2023 the warmest year since records began in the mid-to-late 1800s, surpassing the previous record in 2016.

The transition in the Pacific Ocean from La Nina at the beginning of the year to a strong El Nino by the end of the year contributed to the record warmth. All seven major global temperature datasets used for analysis in the report agree that the last nine years (2015–2023) were the nine warmest on record.

Earth's greenhouse gas concentrations were the highest on record. Carbon dioxide, methane and nitrous oxide — Earth's major atmospheric greenhouse gases — once again reached record high concentrations in 2023. Annual growth in global mean CO2 has increased from 0.6 ± 0.1 parts per million (ppm) per year in the early 1960s to an average of 2.5 ppm per year during the last decade of 2014–2023.

El Nino conditions contributed to record-high sea surface temperatures. El Nino conditions in the equatorial Pacific Ocean emerged in boreal spring 2023 and strengthened throughout the year. The mean annual global sea-surface temperature in 2023 was record high, surpassing the

previous record of 2016 by 0.23 of a degree F (0.13 of a degree C). Each month from June to December was record warm.

On August 22, 2023, an all-time high globally averaged daily sea-surface temperature of 66.18 degrees F (18.99 degrees C) was recorded. Approximately 94% of the ocean surface experienced at least one marine heatwave in 2023, which is defined as sea-surface temperatures in the warmest 10% of all recorded data in a particular location on that day for at least five days.

Ocean heat and global sea level were the highest on record. Over the past half-century, the ocean has stored more than 90% of the excess energy trapped in Earth's system by greenhouse gases and other factors. The global ocean heat content, measured from the ocean's surface to a depth of 2000 meters (over 6,500 feet), continued to increase and reached new record highs in 2023. Global mean sea level was record high for the 12th-consecutive year, reaching about 4.0 inches (101.4 millimeters) above the 1993 average (when satellite altimetry measurements began).

Heatwaves and droughts contributed to massive wildfires around the world. During late spring and a record-warm summer, approximately 37 million acres burned across Canada, an area more than twice the size of Ireland and more than double the previous record from 1989. Nearly 232,000 people were evacuated due to the threat of wildfires, and smoke from the wildfires affected regions across Canada, the heavily populated cities of New York City and Chicago and even areas of western Europe.

Millions of acres of bushfires burned for weeks in the Northern Territory of Australia during September and October. In 2023, the European Union's largest wildfire since the start of the record in 2000 burned hundreds of thousands of acres in Greece from mid-August to early September.

The Arctic was warm and navigable. The Arctic had its fourth-warmest year in the 124-year record, with summer (July to September) being record warm. The seasonal Arctic minimum sea-ice extent, typically reached in September, was the fifth-smallest in the 45-year record. The amount of multiyear ice — ice that survives at least one summer melt season in the Arctic — continued to decline. Since 2012, the Arctic has been nearly devoid of ice that is more than four years old.

Antarctic sea ice set record lows throughout 2023. Eight months saw new monthly mean record lows in sea ice extent (coverage) and sea ice area, and 278 days in 2023 set new daily record-low sea ice extents. On February 21, 2023, Antarctic sea ice extent and sea ice area both reached all-time record lows, surpassing the previous record lows that were set just a year earlier in February 2022.

Tropical cyclone activity was below average, but storms still set records around the globe. There were 82 named tropical storms last year, which was below the 1991–2020 average of 87. Seven tropical cyclones reached Category 5 intensity on the Saffir–Simpson Hurricane Wind Scale. Globally, the accumulated cyclone energy — a combined measure of the strength,

frequency, and duration of tropical storms and hurricanes — rebounded from the lowest in the 43-year record in 2022 to above average in 2023.

The State of the Climate report is a peer-reviewed series published annually as a special supplement to the Bulletin of the American Meteorological Society. The full report is openly available onlineoffsite link. NCEI's high-level overview report is also available online.

Climate, weather, and water affect all life on our ocean planet. NOAA’s mission is to understand and predict our changing environment, from the deep sea to outer space, and to manage and conserve America’s coastal and marine resources.