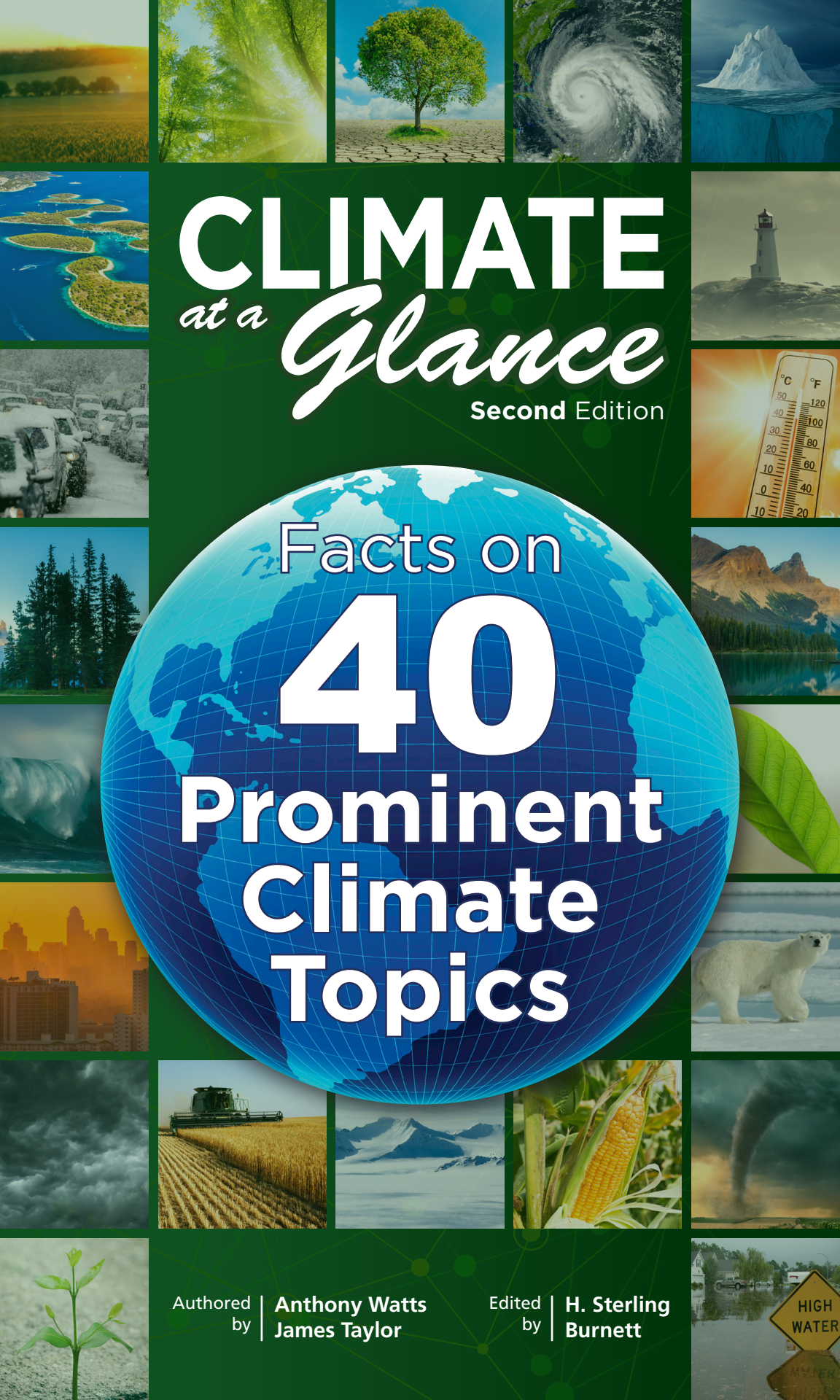

CLIMATE at a Glance

Second Edition

Facts on 40 Prominent Climate Topics

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INTRODUCTION

The Heartland Institute's second edition of *Climate at a Glance* covers 40 prominent topics related to the subject of climate change. Some topics are original to the second edition, while others are updates of chapters from the first edition.

Each topic is sourced from official data and publications provided by organizations like the National Oceanic and Atmospheric Administration (NOAA), the Intergovernmental Panel on Climate Change (IPCC), the National Aeronautics and Space Administration (NASA), the United States Geological Survey (USGS), and more. It also includes references to dozens of peer-reviewed research papers published in prominent journals.

By using these sources, we ensure that the 40 topics covered are analyzed with objective data and fact-based evidence. Each topic includes a list of all source references.

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COLD SPELLS

Global warming activists frequently respond to polar vortex events and other extreme cold weather events by claiming climate change is to blame.[1] Not only does blaming cold weather outbreaks on global warming defy common sense, it also defies well-established scientific evidence and the findings of the United Nations Intergovernmental Panel on Climate Change (IPCC).

The IPCC's 2018 SREX report says it is "very likely" there have been fewer very cold days and nights in recent decades, and the report's authors further claim it is "virtually certain" that there will be "decreases in cold extremes" due to global warming.[2]

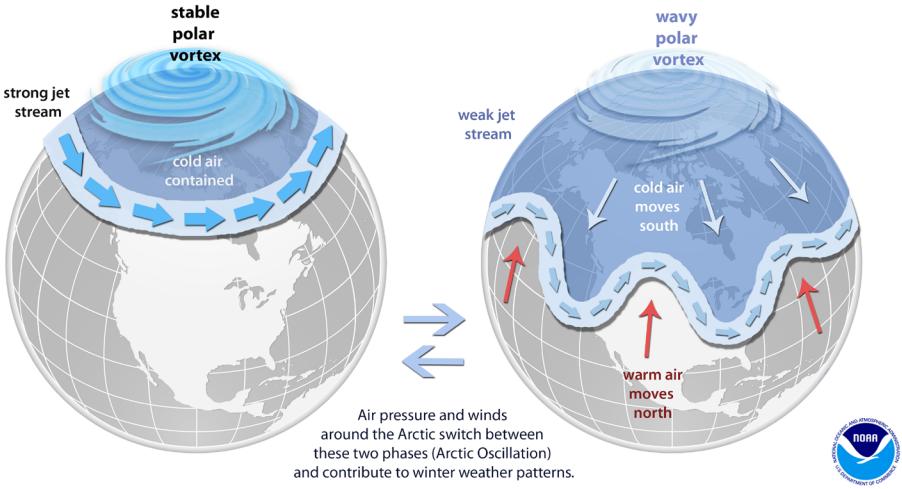
Extreme cold spells have always occurred and always will. Blaming a "polar vortex" or other extreme cold events on global warming ignores common sense, scientific observations, and the findings of the IPCC.[3]

KEY TAKEAWAYS

- Objective data show global warming has not caused an increase in the frequency or severity of cold weather events.
- The IPCC reported in 2018 it is "very likely" that there have been fewer cold days and nights in recent decades.
- The IPCC reports it is "virtually certain" that there will continue to be decreases in cold temperature extremes.

The Science Behind the Polar Vortex

The polar vortex is a large area of low pressure and cold air surrounding the Earth's North and South poles. The term vortex refers to the counterclockwise flow of air that helps keep the colder air close to the poles (left globe). Often during winter in the Northern Hemisphere, the polar vortex will become less stable and expand, sending cold Arctic air southward over the United States with the jet stream (right globe). The polar vortex is nothing new — in fact, it's thought that the term first appeared in an 1853 issue of E. Littell's *Living Age*.



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FLOODS

Occasional heavy precipitation events and floods have always occurred and always will. The United Nations Intergovernmental Panel on Climate Change (IPCC) reports it has "low confidence" climate change has had a measurable impact on flooding. Moreover, the IPCC acknowledges that climate change is as likely to have reduced flooding as it is to have made flooding events more common. When climate activists point to a particular flooding event and claim climate change is to blame, the assertion disregards objective data and the IPCC's own analyses.

Predictions of future flooding are merely that: speculative forecasts. Those who claim flooding events could increase in the future do so in contradiction to real-world data. Additionally, if any increase in flooding were to occur in the near future, that increase would need to be considered alongside real-world reductions in drought reported by the U.S. National Oceanic and Atmospheric Administration (NOAA).

As Figure 1 shows, NOAA has documented a significant reduction in the costs associated with flooding in the United States over the past century. NOAA's 2018 National Climate Assessment notes, "Human-induced warming has not been formally identified as a factor in increased riverine flooding and the timing of any emergence of a future detectable human caused change is unclear."

KEY TAKEAWAYS

- The IPCC reports it has "low confidence" climate change is impacting flooding.
- The IPCC admits having "low confidence" in even the "sign" of any changes—in other words, it is just as likely that climate change is making floods less frequent and less severe.[1]
- Studies of rivers and streams that have not been altered by human development show very little, if any, increase in flooding events.
- Floods always have and always will occur. With no increase in overall flooding activity, there is no justifiable reason to blame any recent, current, or near-future flooding event on climate change.

According to a study on the potential of climate-change-related impacts on flooding in the United States and Europe, published in the *Journal of Hydrology*, "The number of significant [flooding] trends was about the number expected due to chance alone. … The results of this study, for North America and Europe, provide a firmer foundation and support the conclusion of the IPCC that compelling evidence

for increased flooding at a global scale is lacking."[2]

Further, a 2014 study titled "Flood Risk and Climate Change: Global and Regional Perspectives,"[3] published in the *Hydrological Sciences Journal*, examined claims in the IPCC's Fifth Assessment Report and concluded that "presently we have only low confidence in numerical projections of changes in flood magnitude or frequency resulting from climate change."[4]

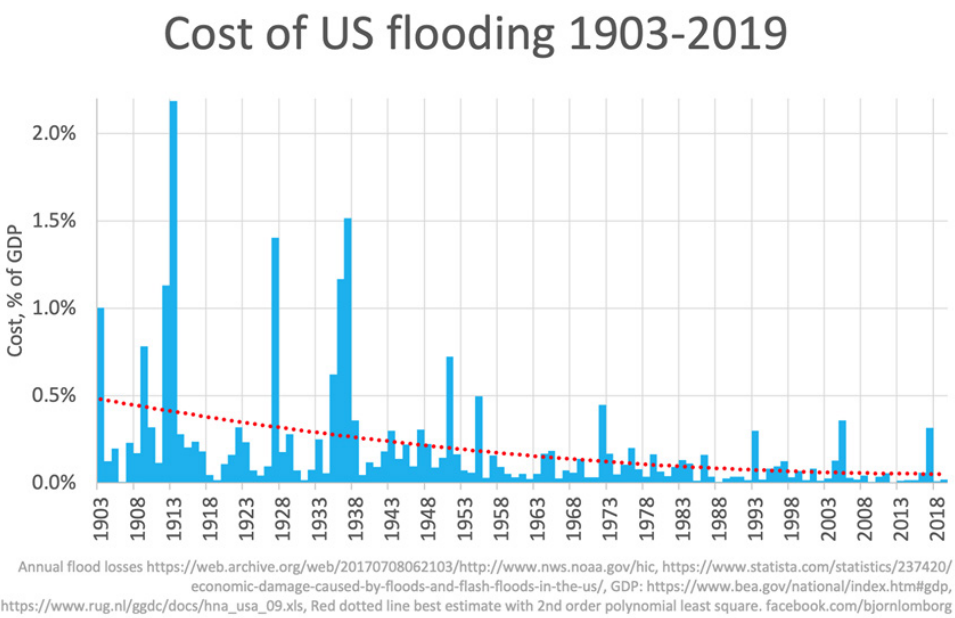

Figure 1. U.S. flood damage as a proportion of U.S. gross domestic product. Data plotted by Bjorn Lomborg. Data Source: National Oceanic and Atmospheric Administration.

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TORNADOES

Tornadoes typically form when very cold, dry air clashes with warm, humid air. Climate change warms the Arctic more than the tropics and subtropics, resulting in less clash between cold Arctic air masses and warm Gulf of America air masses. As a result, fewer and less-violent tornadoes occur today than in previous periods.[1,2]

The number of tornadoes in the United States and globally has been declining for decades. Also, the number of strong-to-violent tornadoes, EF3 or higher, has sharply declined over the past 70 years. (See Figure 1).[3,4,5] In fact, the United States set a record in 2017–2018 for the longest period in recorded history without a tornado death, and it set a record for the longest period in history (306 days) without an EF3 or stronger tornado.[6,7] The two record-low years for tornado strikes in the United States each occurred in the past 12 years, in 2014 and 2018.[8]

Even the United Nations Intergovernmental Panel on Climate Change has acknowledged, "There is low confidence in observed trends in small spatial-scale phenomena such as tornadoes."[9]

A recent peer-reviewed paper, "Time trends in losses from major tornadoes in the United States," confirms that U.S. tornado damage and strong tornado incidence are both sharply down.[10] (See Figure 2, below).

KEY TAKEAWAYS

- The number of tornadoes and strong and violent tornadoes, rated EF3 or higher, have been dramatically declining for decades.
- In 2017-2018, the United States set a record for the longest period in history without a tornado death.
- In 2017-2018, the United States set a record for the longest period in history without an EF3 or stronger tornado.
- The two record-low years for tornado strikes in the United States each occurred within the past 12 years, in 2014 and 2018.
- According to a report by the United Nations, "There is low confidence in observed trends in small spatial-scale phenomena such as tornadoes."

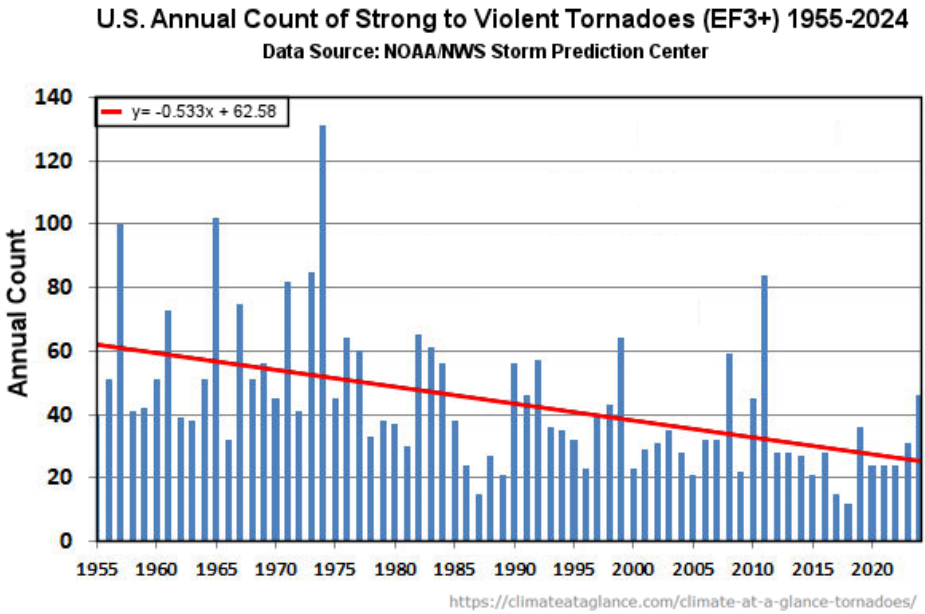

Figure 1. This figure shows the frequency of strong to violent tornadoes (tornadoes registering EF3 or stronger) has been declining since the early 1970s. Sources: Graph by Anthony Watts and David Burton using official NOAA/ Storm Prediction Center data.[7,8,9]

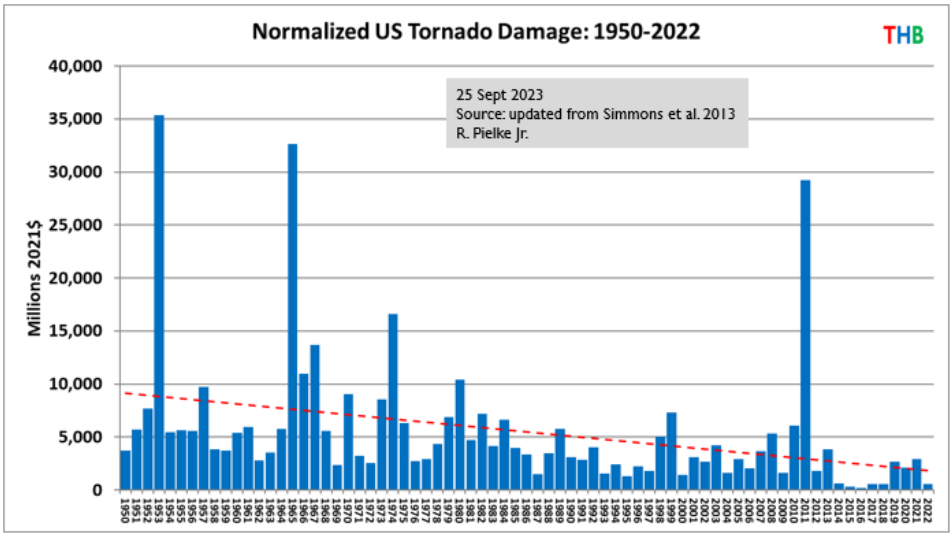

Figure 2: Normalized US Tornado Damage from 1950-2022. Graph by Roger Pielke, Ph.D, updated from data in Simmons et al. 2013. Red dashed line indicates the trend.

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DROUGHT

Real-world data show drought in the United States has become less frequent and severe as the climate has modestly warmed.

Moreover, the United Nations Intergovernmental Panel on Climate Change (IPCC) reports "low confidence" there are negative trends globally.[2] Droughts have always occurred, and they always will. The available evidence shows droughts in recent years were not caused or worsened by global warming. Instead, global and U.S. drought data show recent droughts were less frequent and severe than the droughts of the early and mid-twentieth century.

National Oceanic and Atmospheric Administration data displayed in Figure 1 show that the United States is in the midst of its longest period in recorded history without at least 40 percent of the country experiencing "very dry" conditions.[3] Further, the peak drought years displayed in Figure 1—occurring around 1900, 1930, 1954, and 1978—were much more extensive and severe than any experienced in the United States in the last two decades of the twentieth century or the first two-and-a-half decades of the twenty-first century.

KEY TAKEAWAYS

- The United States is benefiting from fewer and less extreme drought events as the climate modestly warms.
- The United States set records in 2017 and 2019 for having its smallest percentage of land area experiencing drought conditions.[1]
- The United States is undergoing its longest period in recorded history with less than 40 percent of the country experiencing "very dry" conditions.
- The IPCC reports with "high confidence" that precipitation has increased over mid-latitude land areas of the Northern Hemisphere (including the United States) during the past 70 years, while IPCC has "low confidence" about any negative trends globally.

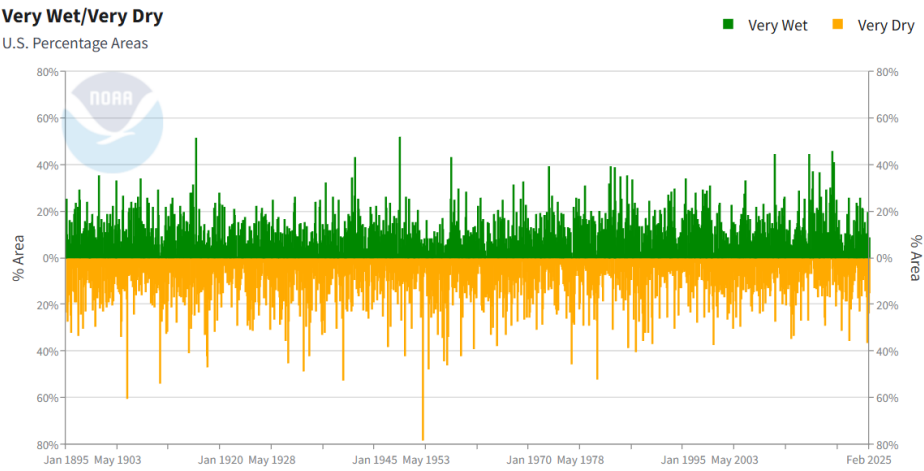

Figure 1: Standardized precipitation values based on the U.S. Climate Divisional Dataset. Climate divisions with a standardized anomaly in the top ten percent (> 90th percentile) of their historical distribution are considered "very wet" and those in the bottom ten percent (< 10th percentile) are classified as "very dry".

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HURRICANES

Devastating hurricanes occurred long before the invention of automobiles and coal-fired power plants, and real-world hurricane activity shows little, if any, impact from global warming.

The United Nations Intergovernmental Panel on Climate Change (IPCC) confirms this, stating in its 2018 interim report that "only low confidence for the attribution of any detectable changes in tropical cyclone activity to anthropogenic influences."[1] Similarly, the IPCC's 2021 Sixth Assessment Report (AR6) by Working Group 1 noted, "[i]dentifying past trends in TC [tropical cyclone] metrics remains a challenge," a statement that essentially admits scientists have yet to identify a solid measurable upward trend in the data.[2]

Objective hurricane and tropical storm data confirm the IPCC's conclusions.[3] In Figure 1 below, note that the blue line for hurricanes is trending slightly downward while major hurricanes in green show no trend.

A 2022 peer-reviewed paper published in *Nature Climate Change,* titled "Declining tropical cyclone frequency under global warming," confirms the recent hurricane decline.[4]

Currently, hurricane impacts in America have been at all-time lows. The United States recently went more than a decade (2005 through 2017) without a major hurricane—a hurricane measuring Category 3 or higher—making landfall. That is the longest such period in recorded history.[5]

The United States also recently experienced the fewest number of hurricane strikes in any eight-year period in recorded history, from 2009 through 2017.[6] Additionally, America's most vulnerable state for hurricanes, Florida, concluded an 11-year period without a landfalling hurricane of any size in 2016, the longest such period in recorded history.[7] The Gulf of Mexico also recently benefited from its longest hurricane-free period in recorded history (2013–2016).

KEY TAKEAWAYS

- There has been no increase in hurricanes as the planet has modestly warmed. In fact, data show hurricanes are trending slightly downward since 1971.
- Even the IPCC agrees, finding no increase in the frequency or severity of hurricanes.
- Recently, the United States went through its longest period in recorded history without a major hurricane strike, also experiencing its fewest total hurricanes in any eight-year period.
- Florida, America's most hurricane-prone state, recently underwent its longest period in recorded history without any hurricanes.

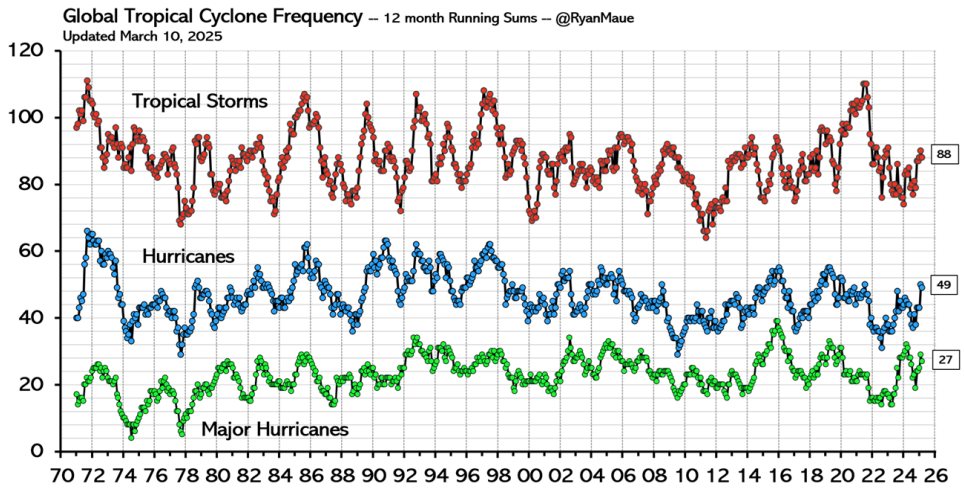

Figure 1. This figure shows that global hurricane and tropical cyclone activity is not increasing. Even with the slight uptick in the number of tropical storms in 2021, it is still below the peak recorded in 1971. Source: Ryan N. Maue, "Global Tropical Cyclone Activity," Climate Atlas, accessed May 25, 2025.

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U.S. HEATWAVES

Heatwaves have always been a natural part of the American climate. Global warming will not put an end to heatwaves. Nor is global warming making heatwaves more frequent or severe. That is because the lion's share of the Earth's modest warming occurs during winter, at night, and closer to the poles.

As Figure 1 shows, there has been no sustained increase in daily high temperatures since at least 2005, when the National Oceanic and Atmospheric Administration launched its most accurate temperature station network, the Climate Reference Network.[1,2]

Further, the data illustrated in Figure 2 show extended periods of very high temperatures were much more common in the 1930s than they have been in the present decade. Moreover, recent heat wave frequency and intensity remain in line with the historical norm.

Objective data show the all-time high temperature records set in most states occurred in the first half of the twentieth century, decades before anyone was talking about human-caused climate change.[3]

Further, there was a slightly higher percentage of very hot days annually during the early 1900s—specifically, days exceeding 95°F and 100°F. There is no trend in days greater than 105°F, as seen in Figure 3 below.[4]

The data indicate the frequency of 95° days over the period 1961-2020 was approximately 18 percent lower than it was during the 60-year period from 1901-1960. The conclusion from the data is that U.S. heat waves are not increasing in frequency or intensity.

KEY TAKEAWAYS

- In recent decades in the United States, data indicate heat waves have been far less frequent and severe than they were in the 1930s.
- The all-time high temperature records set in most states occurred in the first half of the twentieth century.
- The most accurate nationwide temperature station network, implemented in 2005, shows no sustained increase in daily high temperatures in the United States since at least 2005.

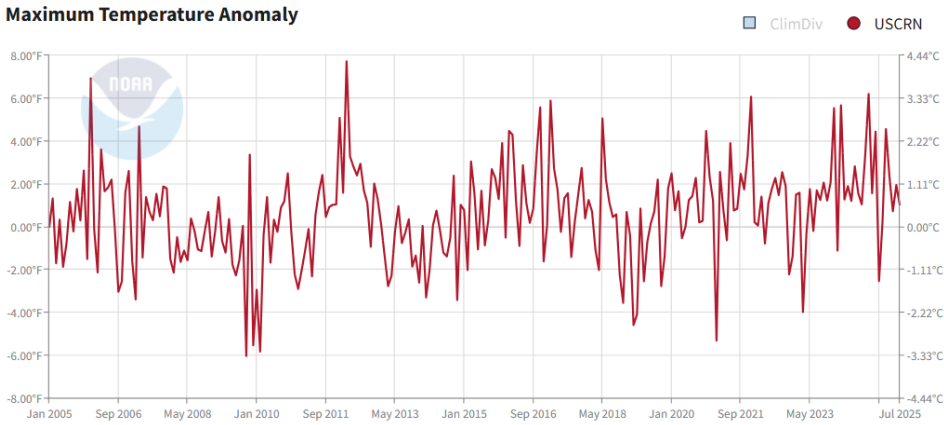

Figure 1: High surface temperature anomalies in the United States, January 2005 to July 2025. U.S. Climate Reference Network, "Average Surface Temperature, January 2005 to July 2025 ," ncie.noaa.gov, National Climatic Data Center, National Oceanic and Atmospheric Administration, accessed August 13, 2025. https://www.ncei.noaa.gov/access/monitoring/national-temperature-index/time-series/anom-tmax/1/0

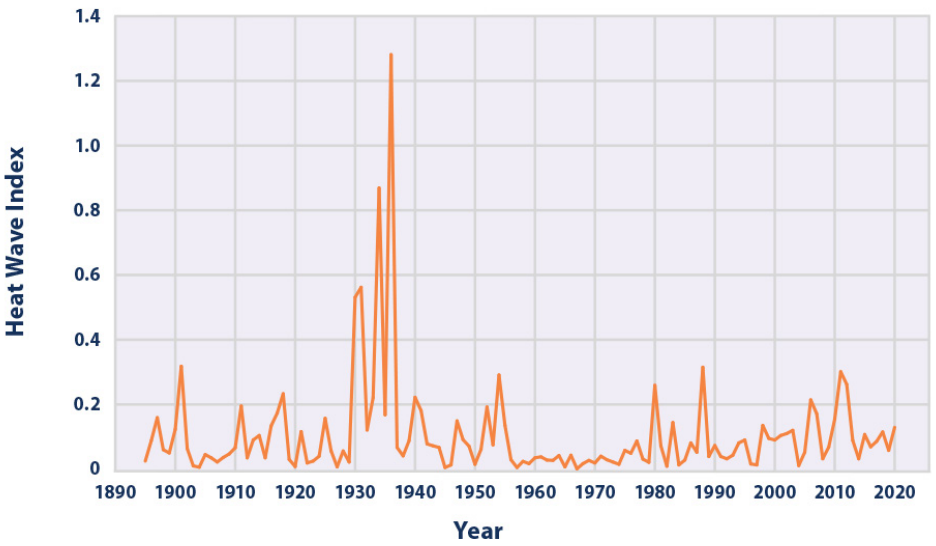

Figure 2. Annual values of the U.S. Heat Wave Index, from 1895 to 2020 for the contiguous 48 states. The index defines a heat wave as a period lasting at least four days with an average temperature that would only be expected to occur once every 10 years, based on the historical record. Source: Environmental Protection Agency, "Climate Change Indicators: Heat Waves," accessed August 14, 2021, https://www.epa.gov/climate-indicators/climate-change-indicators-heat-waves#%20. Data Source: K. Kunkel, Figure 2.3 in "Weather and Climate Extremes in a Changing Climate," U.S. Climate Change Science Program: Synthesis and Assessment Product 3.3, originally published in 2008, updated in 2021, accessed August 14, 2021, www.globalchange.gov/browse/reports/sap-33-weather-and-climate-extremes-changing-climate

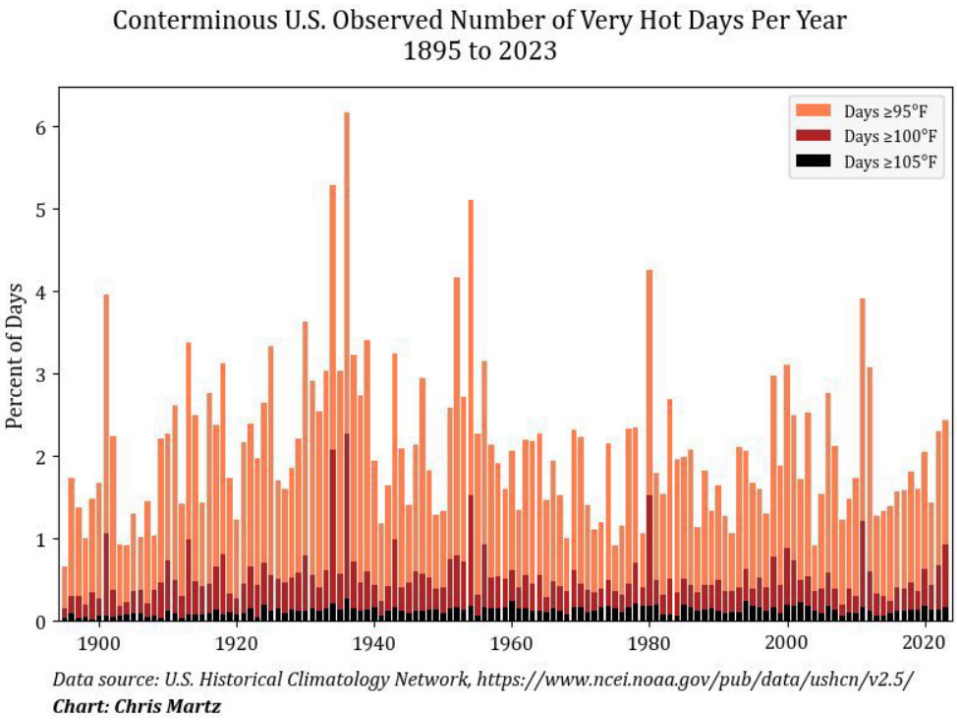

Figure 3: The annual mean number of days with a daily maximum temperature ≥95°, ≥100° and ≥105° each at 828 NOAA USHCN stations with at least 100 years of daily temperature readings between 1895 and 2023. Graph by Chris Martz from NOAA data at https://www.ncei.noaa.gov/pub/data/ushcn/v2.5/

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DEATHS FROM EXTREME WEATHER

Extreme weather events are just that: weather events. Conflating such events with climate change is a mistake. Weather and climate operate on vastly different timescales.[1]

The United Nations Intergovernmental Panel on Climate Change (IPCC) AR6 report concludes that changes in the frequency and intensity of most severe weather events have not been detected nor can they be attributed to human-caused climate change.[2]

Real world data show that there has been no increase in drought, heatwaves, flooding, tropical cyclones, hurricanes, winter storms, thunderstorms, tornadoes, or associated hail, lightning, and extreme winds from thunderstorms.

Regardless of weather trends and climate change, human mortality attributable to weather-related disasters, including floods, droughts, storms, wildfires, and extreme temperatures has declined by more than 99 percent over the past century. In the 1920s, death related to weather-related disasters averaged approximately 485,000 per year. By 2020, the average number of deaths attributable to extreme weather events fell to 7,790. (See Figure 1, below).[3]

Claims that climate change is killing more people are refuted by hard data showing a significant decline in weather-related deaths.

KEY TAKEAWAYS

- Extreme weather events are often attributed to climate change, but weather and climate are not the same thing.
- Real-world data show no significant increase in extreme weather over the past 100 years.
- Existing data show that deaths from extreme weather events have declined dramatically during the recent period of modest warming.

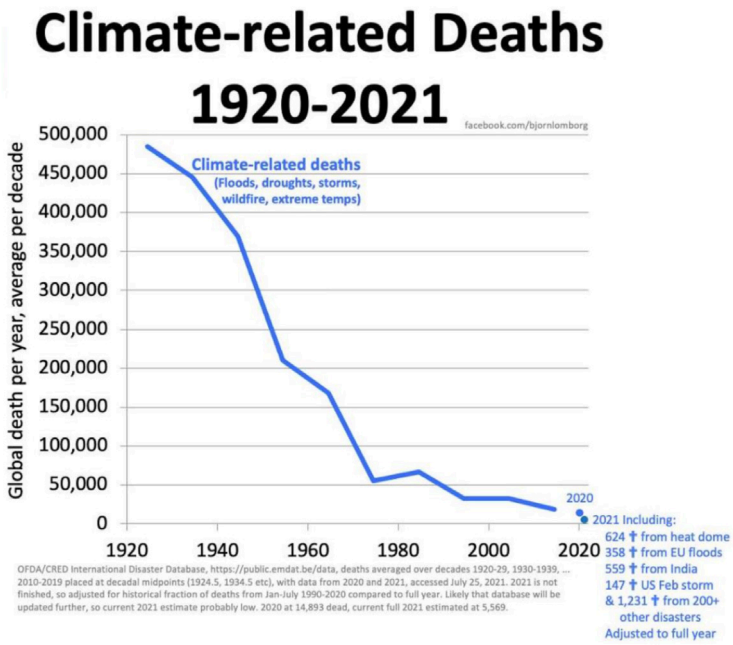

Figure 1. The graph demonstrates a vast improvement in human mortality related to all extreme weather events over a 100-year span from 1920 to 2021. Source: Bjorn Lomborg, data from International Disaster Database published in ScienceDirect.

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GLOBAL TROPICAL CYCLONES

Devastating tropical cyclones have been common in coastal regions and islands around the world long before the advent of fossil fuels.[1] Present-day real-world data suggest little or no effect of global warming, also known as "climate change," on tropical cyclone frequency or intensity.

The United Nations Intergovernmental Panel on Climate Change's (IPCC) 2018 interim report states there is "only low confidence for the attribution of any detectable changes in tropical cyclone activity to anthropogenic influences."[2] In its AR6 WG1 report, released in August 2021, the IPCC noted, "Identifying past trends in TC [tropical storm] metrics remains a challenge," a statement that essentially admits scientists have yet to identify a solid measurable upward trend in the data.[3]

The IPCC's findings are well supported by objective tropical storm data. (See Figures 1 and 2)[4, 5]

The total amount of energy contained in tropical cyclones, known as accumulated cyclone energy (ACE) has also been measured since 1972, and as shown in Figure 2, there is no obvious increase in ACE. In fact, the value of ACE is lower in 2022 than it was in 1972. These data suggest that tropical cyclones have not become more powerful since the globe began modestly warming in the late nineteenth century.

Multiple other studies suggest that over the past 100 years, the frequency and intensity of tropical cyclones have declined, with one report finding a 13 percent decrease in tropical cyclones from 1850 to 2012.[6, 7, 8]

Research published by the University of Miami indicates that increases in wind shear have hampered the formation and power of hurricanes, as well as their ability to maintain cohesion, explaining why tropical cyclone trends have declined.[9]

KEY TAKEAWAYS

- Tropical cyclones, also known as typhoons and hurricanes, have occurred for millennia.
- There has been no increase in the number or intensity of tropical cyclones since at least 1972 as the planet has modestly warmed, and some data suggest tropical cyclone frequency has actually declined over the past century.
- Even the IPCC agrees, finding it can detect no increase in the frequency or severity of tropical cyclones.

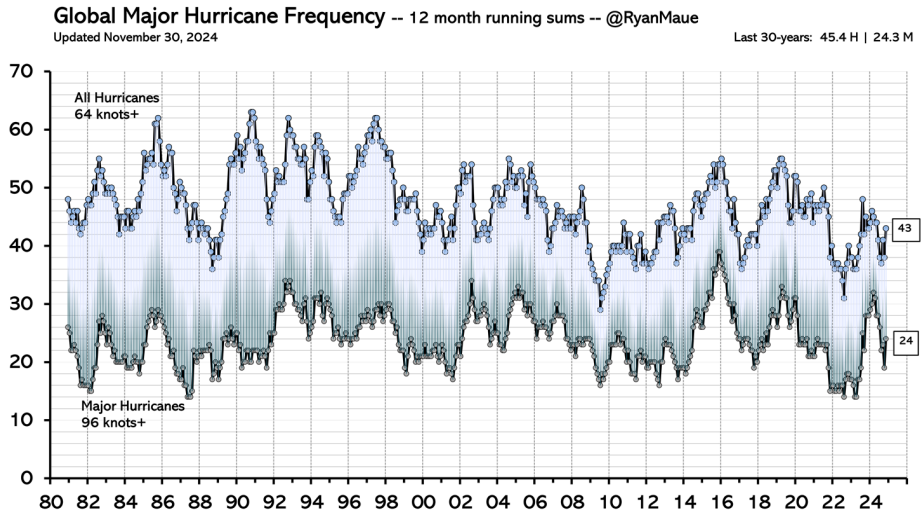

Figure 1. This figure shows that global hurricane and tropical cyclone activity is not increasing. In fact, it demonstrates a downward trend from the peak recorded in 1991. Source: Ryan N. Maue, "Global Tropical Cyclone Activity," Climate Atlas, accessed February 25, 2025, https://climatlas.com/tropical/global_major_freq.png

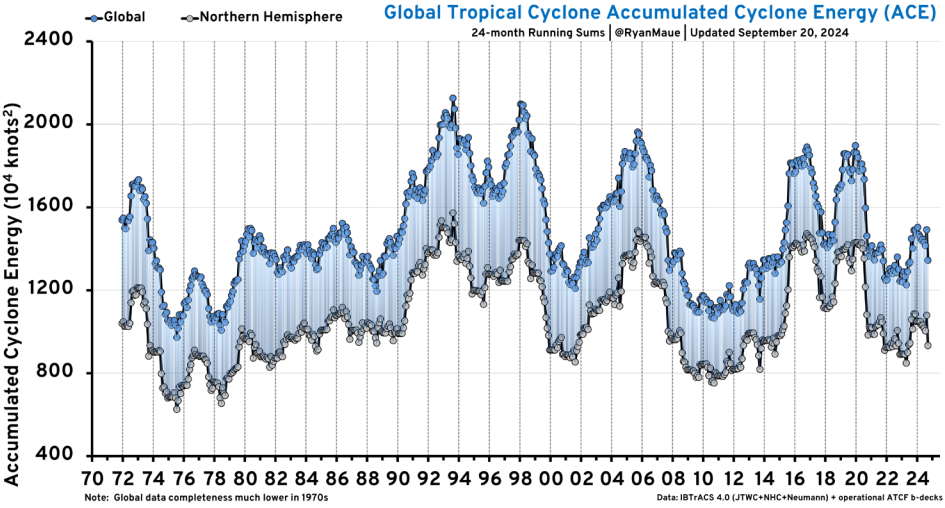

Figure 2. Last 52 years of Global and Northern Hemisphere Accumulated Cyclone Energy: 24 month running sums in different hemispheres. Source: Ryan N. Maue, "Global Tropical Cyclone Activity," Climate Atlas, accessed February 25, 2025, https://climatlas.com/tropical/global_running_ace.png

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TEMPERATURE-RELATED DEATHS

A 2021 study published in the prestigious medical journal *The Lancet* reported that cold temperatures contribute to far more deaths each year than warmer temperatures and that temperature-related deaths are declining globally.[1]

The study reports that the decrease in deaths associated with cold temperatures was more than twice the increase in deaths tied to hotter temperatures over the 20-year period of the study.

The study is arguably the largest of its kind analyzing the issue of temperature-related deaths. Sixty-eight scientists representing universities and research institutes in 33 countries spanning all regions of the world contributed to the study. Their research found that as the Earth has modestly warmed, deaths caused by "non-optimal" hot and cold temperatures have declined dramatically. Annually, nearly 600,000 people die globally from heat, compared to 4.5 million from cold.

Monash University's press release announcing the study stated, "[i]mportantly, cold-related death decreased 0.51 per cent from 2000 to 2019, while heat-related death increased 0.21 per cent, leading to a reduction in net mortality due to cold and hot temperatures."[2] (See Figure 1, below).[3]

KEY TAKEAWAYS

- Extreme heat is often identified as the most significant cause of premature death attributed to climate change.
- Peer-reviewed research, informed by real-world data, clearly shows deaths associated with cold temperatures significantly outnumber heat related deaths by almost 10 to one.
- The same research shows that deaths associated with extreme temperatures have declined significantly during the recent period of modest warming.

Another critical finding of *The Lancet* study is that cold-related deaths outnumber heat-related deaths 10 to one. (See the table below).

Partially as a result of the decline in cold temperatures, over the period of the study, temperature-related mortality has declined significantly, with a total of 166,000 fewer deaths tied to non-optimal temperatures.

This study confirms what research previously published in *The Lancet*, the *Southern Medical Journal*, and the U.S. Centers for Disease Control and

Prevention's *National Health Statistics Reports* has consistently shown: Cold is the biggest temperature-related killer, not heat.[4,5,6]

These studies also indicate the slight warming experienced over the past century has reduced overall mortality related to extreme temperatures. This positive trend should continue if the Earth continues to warm modestly.

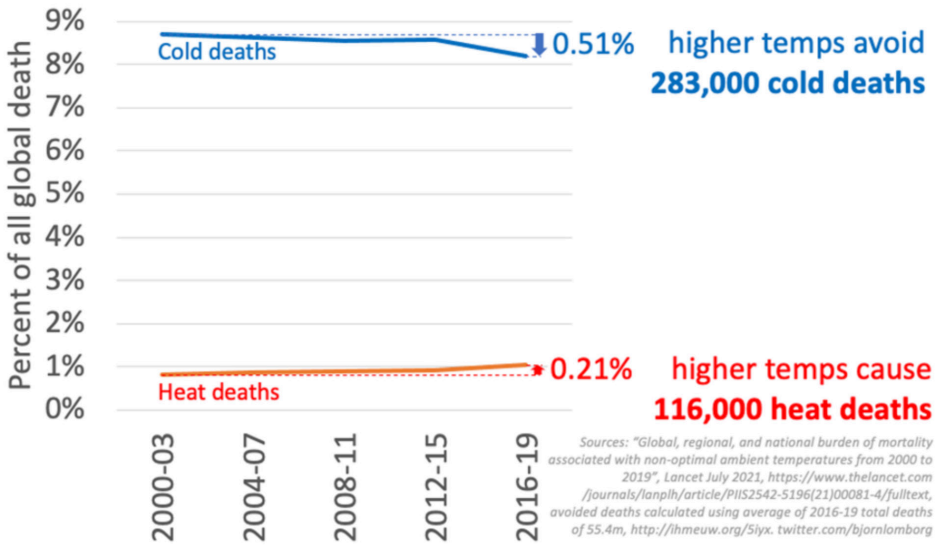

Figure 1. Global heat and cold related deaths by percentage of all global deaths, from 2000-2019. Graph created Dr. Bjorn Lomborg from Monash study data.

Cold Related Deaths by Region		Heat Related Deaths by Region	
Africa	1.18 million	Africa	25,550
Asia	2.4 million	Asia	224,000
Europe	657,000	Europe	178,700
South America	116,000	South America	25,250
UK	44,600	UK	8,000
US	154,800	US	18,750
China	967,000	China	71,300
India	655,400	India	83,700
Australia	14,200	Australia	2,300
Total	**6,189,000**	**Total**	**637,550**

Table 1. Total global cold related deaths vs. heat related deaths by region from 2000 to 2019. Data source: Monash University press release.

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NATIONAL SECURITY

Economic strength is the most important factor in determining a nation's ability to fund and deploy a powerful military over the long term. America's economic might is one of the primary reasons it has, by far, the world's most capable military, even though Russia and Canada are larger in size, geographically, and China and India have far more people.

Affordable energy is the lifeblood of America's economy. Forcing businesses, households, and government agencies to unnecessarily depend on expensive and unreliable energy sources would reduce economic output and limit the United States' ability to fund and deploy a robust military. Thus, climate activism puts U.S. national security at grave risk.

Although climate activists claim global warming is increasing national security "threat multipliers," the truth is, the opposite is happening. Even if one accepts climate activists' dubious claims that weather events like droughts and floods pose a serious threat to U.S. national security interests, or that climate change is causing or will soon cause waves of climate refugees to stream across America's borders, modest recent warming has actually had a net beneficial impact on extreme weather events and agriculture. For instance, the frequency and severity of droughts, crop failures, weather-related deaths, and wildfires have all declined in recent decades relative to the long-term historical record.[1]

One of the most important examples is global crop production, which has experienced consistent growth in the twenty-first century, in large part due

KEY TAKEAWAYS

- Climate activism rather than climate change poses a significant threat to U.S. national security.
- The economic strength of the United States is the single greatest factor for ensuring our military remains dominant.
- Earth's modest recent warming is reducing "threat multipliers" such as crop failures and weather-related catastrophes.
- The world runs on energy sources such as coal, oil, and natural gas, which the United States possesses and produces in abundance. Restricting U.S. production, use, and export of these energy sources leaves the United States and its allies at the mercy of potentially hostile foreign nations.

to the presence of higher-than-usual atmospheric carbon dioxide and modest warming trends. Global crop yields have set new records nearly every year, reducing climate-related pressures for people to flee their countries.[2]

Additionally, the United States is one of the world's leading producers of coal, oil, and natural gas that power the American and global economies.[3] This means America has direct access to reliable and affordable energy, which we can export to our allies and use as leverage against geopolitical energy threats.

By contrast, rare earth minerals are necessary for the construction of wind and solar power equipment. China produces and refines more rare earth minerals than the rest of the world combined.[4] Restricting U.S. conventional energy sources and switching to a wind- and/or solar-based energy grid is placing the United States and its allies at the mercy of the Chinese Communist Party.[5]

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LIVESTOCK AND METHANE

Climate activists often claim that ranchers, livestock, and meat production are a leading cause of rising greenhouse gas emissions and global warming. However, the U.S. Environmental Protection Agency (EPA) has compiled information on greenhouse gas emissions by source. According to EPA, beef production accounts for 2 percent of U.S. greenhouse gas emissions, while livestock production as a whole accounts for less than 4 percent of U.S. greenhouse gas emissions.[1]

By contrast, U.S. agricultural crop production emits more greenhouse gases than total livestock production.

This is the case even though the United States leads the world in beef production.[2] Livestock primarily impact greenhouse gas emissions through methane released when livestock burp or pass gas. Although this is often presented as a serious problem, data show U.S. methane emissions have fallen over the past three decades. According to EPA, methane emissions dropped from 1990 to 2018.[3]

KEY TAKEAWAYS

- Neither the agricultural practices of American ranchers nor consumers' meat consumption have any impact on overall greenhouse gas emissions or climate change.
- EPA reports cattle and beef account for just 2 percent of U.S. greenhouse gas emissions.
- EPA reports all livestock account for less than 4 percent of U.S. greenhouse gas emissions.

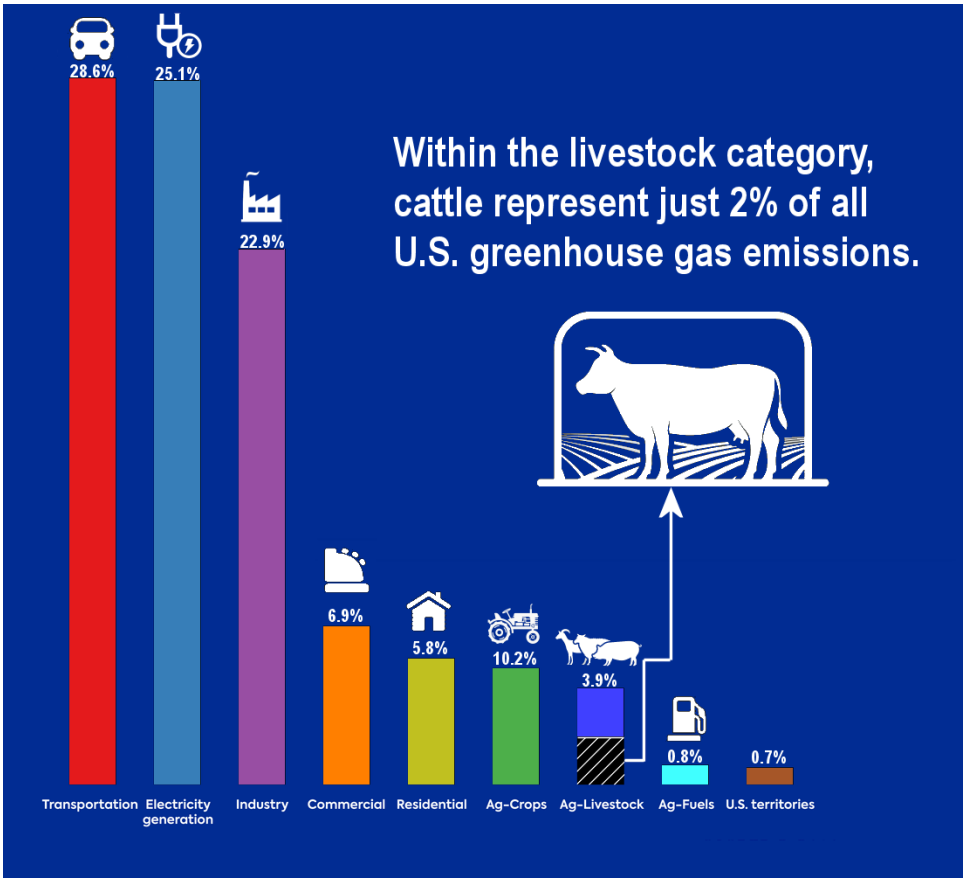

Figure 1. Greenhouse gas emissions by sector in the United States. Note that beef production is less than half of the entire livestock sector, at just 2 percent. Source: Data from U.S. Environmental Protection Agency. Graphic by Anthony Watts. Artwork icons in graphic licensed from 123rf.com.

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CORAL REEFS

Coral has existed continuously for at least the past 60 million years.[1]

The primary reasons for coral bleaching events, which vary significantly depending on the time and location, include sediment and fertilizer pollution from nearby coastal lands, chemicals found in sunscreen (oxybenzone), fertilizer and nitrogen loading from agriculture, and cold temperature events.[2,3,4,5] The argument that corals are being decimated by man-created carbon dioxide emissions is easily disproven by the available data. Coral survived, and even thrived, when global temperatures were significantly higher than they are today.[6]

Short-term strong heat waves or cold snaps can cause bleaching events, but such events have occurred many times in history, including long before humans started producing substantial amounts of carbon dioxide emissions. Moreover, studies show corals can and do adapt genetically, and that they are growing increasingly poleward as Earth experiences gradual long-term global warming.[7,8]

Further, history shows that cold snaps can harm corals much more than warm spells. In 2010, lower-than-usual ocean temperatures off the coast of Florida killed more corals than any warm-water event, destroying more than 40 percent of reef-building corals in the area.[9]

According to the National Oceanic and Atmospheric Administration, "The majority of reef building corals are found within tropical and subtropical waters. These typically occur between 300 north and 300 south latitudes. The red dots on this map show the location of major stony coral reefs of the world."[10]

Additionally, many of the stories concerning coral bleaching are not accurate and/or overestimate the problem. For example, the poster child for coral activism is the Great

KEY TAKEAWAYS

- Coral thrive in warm, not cold water.
- Recent warming has allowed coral to expand their range poleward, while still thriving near the equator.
- Coral has existed continuously for the past 60 million years, surviving temperatures and carbon dioxide levels significantly higher than what is occurring today.
- The primary causes of coral bleaching include oxybenzone (a chemical found in sunscreen), sediment runoff from nearby coastal lands, and cold temperatures like those recorded in 2010 off the Florida coast.

Barrier Reef in Australia. The Australian Institute of Marine Science documented that approximately 22 percent of the Great Barrier Reef experienced bleaching recently, not 93 percent, as reported in some erroneous media stories.[11,12]

Perhaps most importantly, recent evidence shows much of the bleached corals in the Great Barrier Reef are fully recovering. A study by Peter Ridd revealed that not only are the coral at the Great Barrier Reef recovering, the amount of healthy corals is now at an all-time high.[13]

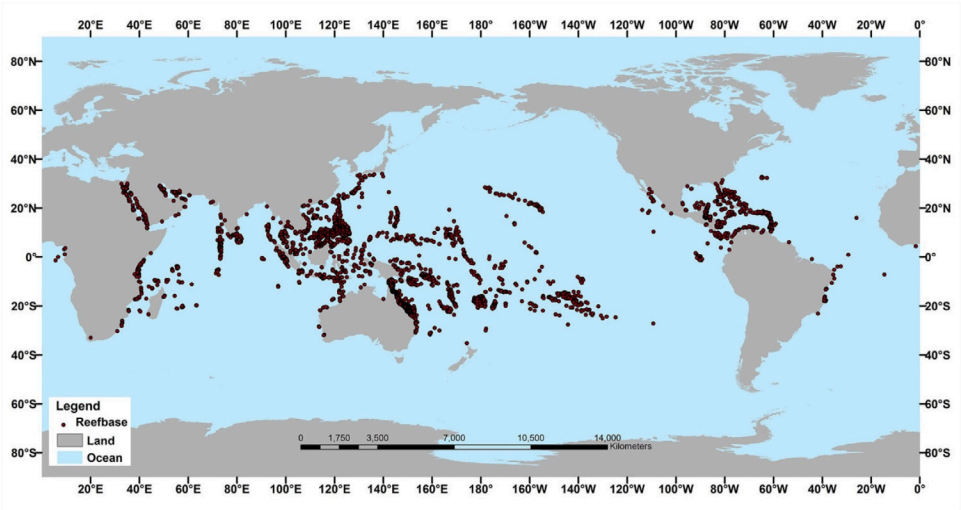

Figure 1. Corals thrive in the warmest of Earth's waters. Source: National Ocean Service, "Where Reef Building Corals Found," National Oceanic and Atmospheric Administration, accessed July 26, 2021, https://serc.carleton.edu/eslabs/corals/4a.html

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MALARIA AND MOSQUITO-BORNE DISEASES

Claims that warming temperatures will cause more malaria cases and deaths are contradicted by real-world evidence. As the Earth warms, malaria cases and deaths are declining in all areas of the world. If global warming causes more malaria cases, we certainly should have witnessed more malaria cases and deaths by now.

The World Health Organization (WHO) publishes global estimates of the number of people who die from malaria. According to the WHO, the global death toll from malaria has been cut nearly in half – from 839,000 deaths in 2000 to 438,000 in 2015.[1]

Africa is the world region that is most affected by malaria, with nine out of every 10 malaria victims living there. As shown in Figure 1, Africa is also the region that has achieved the most progress in preventing death from malaria. However, since 2015, progress has slowed. The number of deaths actually increased in 2020 as a result of disruptions due to the COVID-19 pandemic.

As detailed in Chapter Four of *Climate Change Reconsidered II: Fossil Fuels*, the vast body of scientific literature refutes climate activists' claim that climate change is likely to exacerbate the spread of mosquito-borne diseases.[2] Further, as seen in Figure 2, Australia, Europe, North America, South America, and the United Kingdom reported zero deaths from malaria from 1990 through 2017.[3]

KEY TAKEAWAYS

- The number of malaria deaths occurring globally has declined in recent decades, not increased, despite modest global warming.
- The global death toll for malaria has been cut in half since 2000.
- There have been no malaria deaths in North America or Europe since 1990, even though malaria deaths were frequent on both continents in the early 1900s.
- If global warming causes an uptick in mosquito-borne diseases, malaria being the most prevalent, the world should have already seen a substantial increase in illnesses and deaths from malaria and other mosquito-borne diseases, not a dramatic decline.

Even though media figures continue to raise a false alarm, peer-reviewed research demonstrates there is simply no link at all between mosquito-borne diseases and a modestly warming world.[4,5]

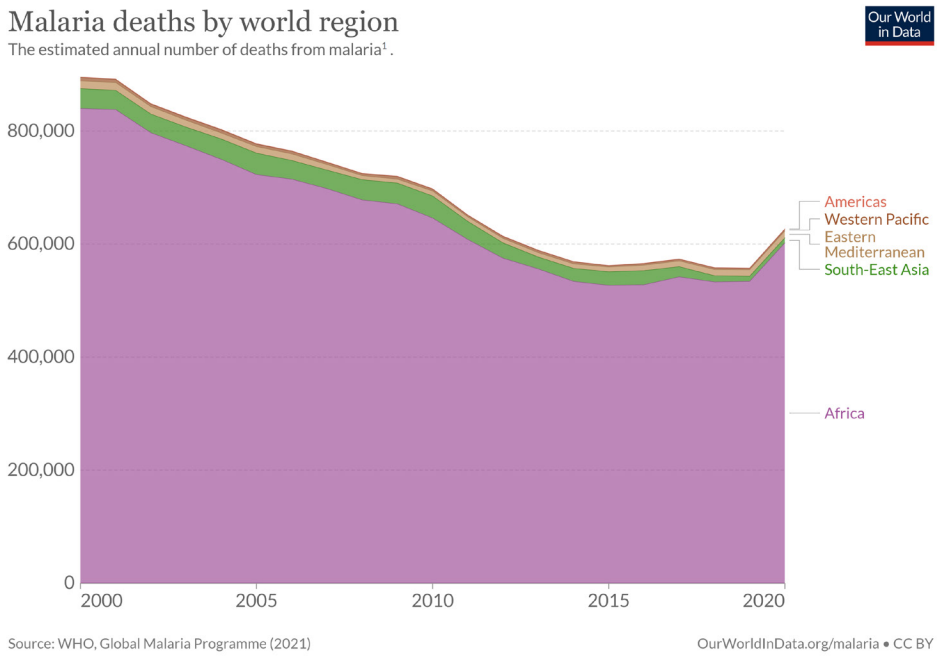

Figure 1. Global Malaria Deaths by Region, 2000–2020. Source: Max Roser and Hannah Ritchie, "Malaria," Our World in Data, Oxford Martin School, University of Oxford, last updated, September 27, 2023 https://ourworldindata.org/malaria#malaria-death-estimates-from-who

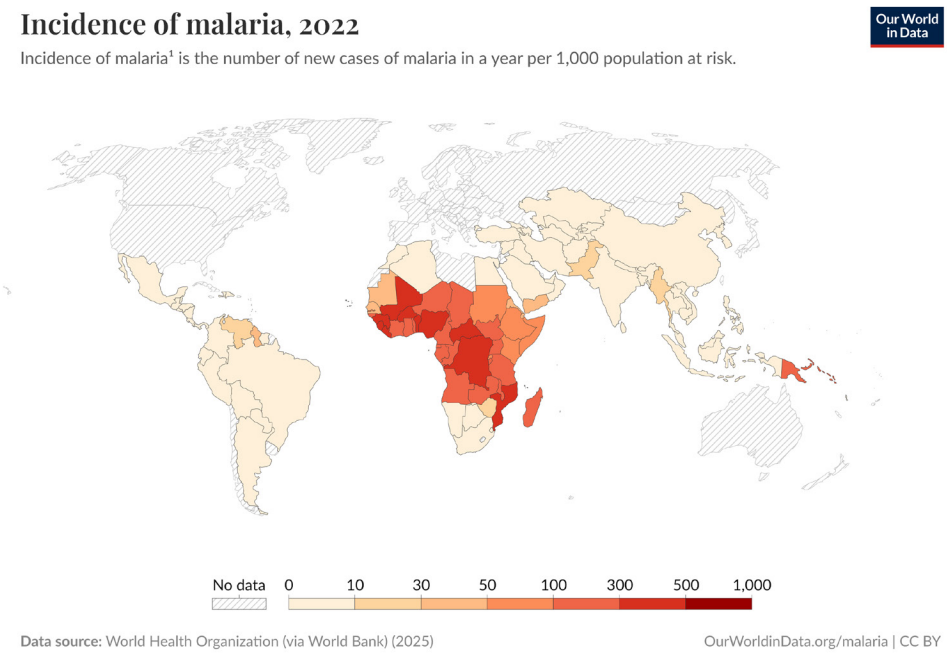

Figure 2. The map visualization shows the age-standardized death rate caused by malaria, measured as the number of deaths per 1,000 individuals. Note that Africa is where the vast majority of cases occur. Source: "Death Rates from Malaria, 2022," Our World in Data, Oxford Martin School, University of Oxford, accessed May 29, 2022, https://ourworldindata.org/grapher/malaria-deaths-ihme

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SNOWPACK

NASA satellites have measured snow coverage since 1966.[1] The lines graphed in Figure 1 represent 12-month snow-cover anomalies, which are a departure from a defined reference point. The blue dots represent North American snow totals. Note that they show almost no declining trend since 1966, and a rising trend since the late 1980s.[2] Further, the Eurasian snow data appearing in Figure 1 illustrate there has been a modest decline in Eurasian snow since the 1960s, but that there has also been an increase in snow coverage since the late 1980s.

On a seasonal basis, snowpack throughout the Northern Hemisphere has increased over the past several decades in the fall and winter, as shown in Figures 2 and 3. As these and other data reveal, the only long-term negative overall snow-cover trends occurring in recent decades have been limited to spring snow cover, primarily in Eurasia.

North American snow cover remains approximately the same today as when coverage was first precisely measured in the 1960s, and snow cover has been increasing since the late 1980s.

KEY TAKEAWAYS

- Average North American snowpack extent is virtually unchanged in recent years compared to the late 1960s, when satellite measurements began.
- Following a short-term decline in snowpack in the mid-1980s, average North American snowpack has increased.
- There has been only a modest decline in Eurasian snowpack in recent years.

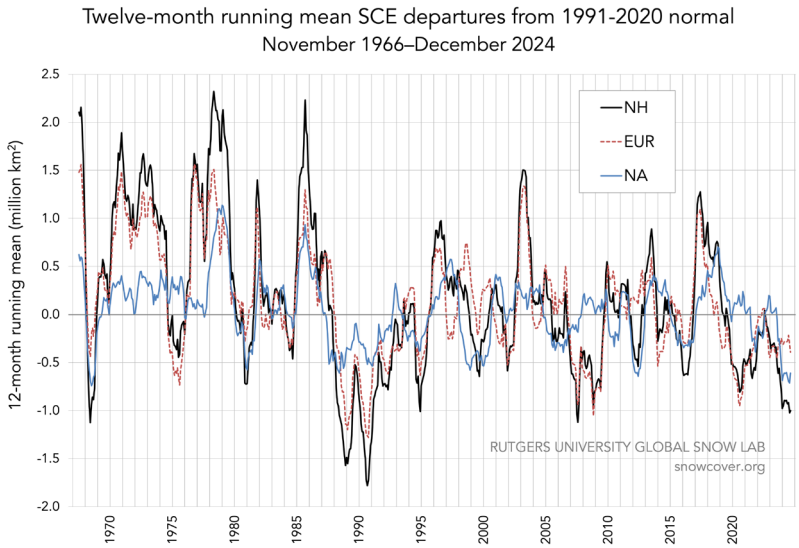

Figure 1: Twelve-month running anomalies of monthly snow extent, from November 1966 to October. Note that North America, represented by the blue dots, remains virtually unchanged in recent years compared to the late 1960s, when satellite measurements first began. Source: Global Snow Lab, "12-month Running Anomalies of Monthly Snow Extent from November 1966 to December 2024," Rutgers University Climate Lab, May 27, 2025, https://climate.rutgers.edu/snowcover/chart_anom.php?ui_set=0&ui_region=nhland&ui_month=2.

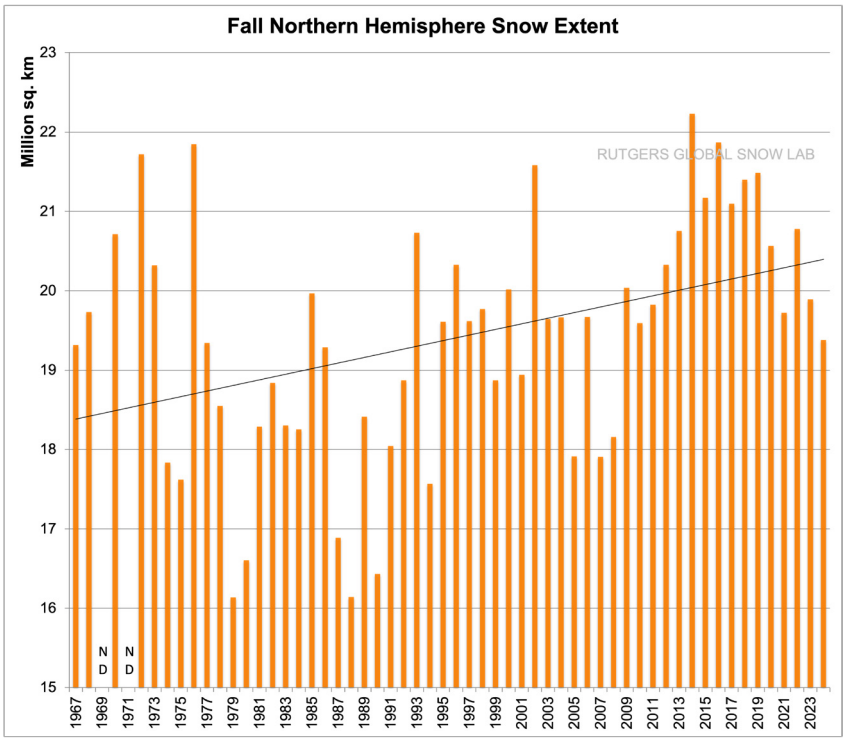

Figure 2: This figure displays fall Northern Hemisphere snow extent. Note that Figure 2 shows that snow cover throughout the Northern Hemisphere has increased during the fall months since the 1960s. (The "ND" in the chart indicates no data for a given year.) Source: Global Snow Lab, "Fall Northern Hemisphere Snow Extent," Rutgers University Climate Lab, accessed May 27, 2025, https://climate.rutgers.edu/snowcover/chart_seasonal.php?ui_set=nhland&ui_season=4.

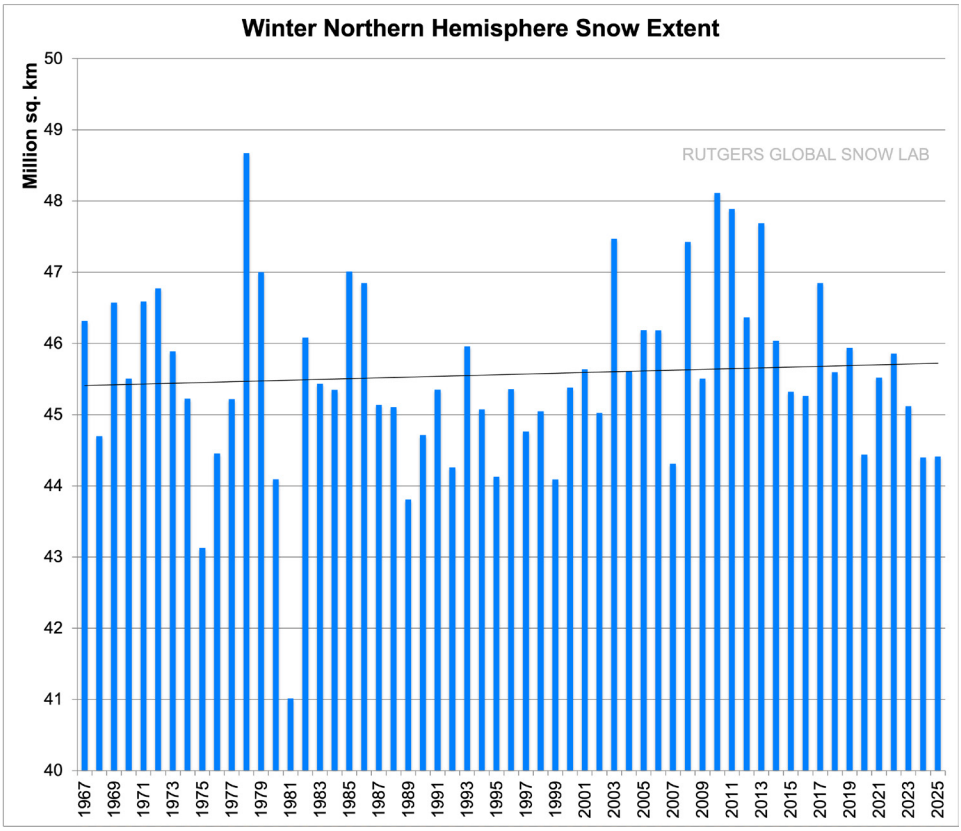

Figure 3: This chart shows winter Northern Hemisphere snow extent. Note that global snow cover throughout the Northern Hemisphere has increased during the winter months since the 1960s. Source: Global Snow Lab, "Winter Northern Hemisphere Snow Extent," Rutgers University Climate Lab, accessed May 27, 2025, https://climate.rutgers.edu/snowcover/chart_seasonal.php?ui_set=nhland&ui_season=1.

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U.S. WILDFIRES

Wildfires, especially in arid parts of the United States, have always been a natural part of the environment, and they likely always will. Global warming did not create wildfires. In fact, wildfires have become less frequent and less severe in recent decades. One of the key contributing factors has been that the United States has experienced fewer droughts in recent decades than in periods throughout the twentieth century.[1]

The U.S. National Interagency Fire Center (NIFC) provides data about U.S. wildfires dating back to 1926. NIFC data show the number of acres burned in recent years has been far less than it was during the early twentieth century. (See Figure 1.) The number of acres burned in recent wildfires is roughly one-fourth to one-fifth of the size of the record values that occurred in the 1930s. At that time, the peak wildfire burn was greater than 52 million acres. From 2010 to 2020, the peaks were typically 10 million acres or less.[2]

Some climate activists cite a relatively small upward trend, starting in the late 1980s, in the amount of acreage burned in wildfires as evidence that climate change has been making wildfires considerably worse. However, the data show that trend is minor compared to the much longer historical record. Wildfires burned many more acres, on average, prior to 1950.

KEY TAKEAWAYS

- Compared to the first half of the twentieth century, the number of wildfires that have occurred in the United States in recent decades has declined, and the fires have been less severe.
- Even the worst recent wildfire seasons burned typically one-fifth to half as much land as average wildfire seasons did during the early twentieth century.
- Drought is the key climate factor for wildfires, an important consideration because the United States has experienced relatively little drought recently.
- Data showing greater numbers of acres lost to wildfires in previous decades were removed from an important database by a government fire agency, likely because the data did not support the claim that wildfires are becoming more frequent and severe.

In a disturbing attempt to skew recent data to indicate climate change is causing increased wildfires, climate activists and some scientists deleted significant amounts of wildfire data from years prior to the start of the

very modest upward trend, making it appear as though the United States is in the midst of a much greater trend than the historical record shows.

In March 2021, NIFC removed wildfire data from years prior to 1983. The stated justification for the decision was that data are allegedly "unreliable." This assertion should be viewed with great skepticism considering that the supposedly unreliable data had been used in peer-reviewed scientific publications for many decades.

By ignoring all data prior to 1983, which happens to be the lowest point in the dataset for the number of fires, NIFC data now suggest wildfires are getting much worse and that the number of fires is aligned with global temperature.[3] Without a distorted dataset, these dire claims about wildfires would be impossible to make with any degree of credibility. (See Figure 2).

The U.S. Forest Service and academic studies consistently report that humans cause the majority of wildfires. According to a 2017 study published in *Proceedings of the National Academy of Sciences*, humans activities—such as arson, uncontrolled campfires, fireworks, negligently discarded cigarettes, and trash burning—were responsible for 84 percent of all wildfires from 1992 to 2012.[4] More recent estimates from NIFC suggest this number is even higher—up to 90 percent in some regions, especially in the eastern United States and California.[5]

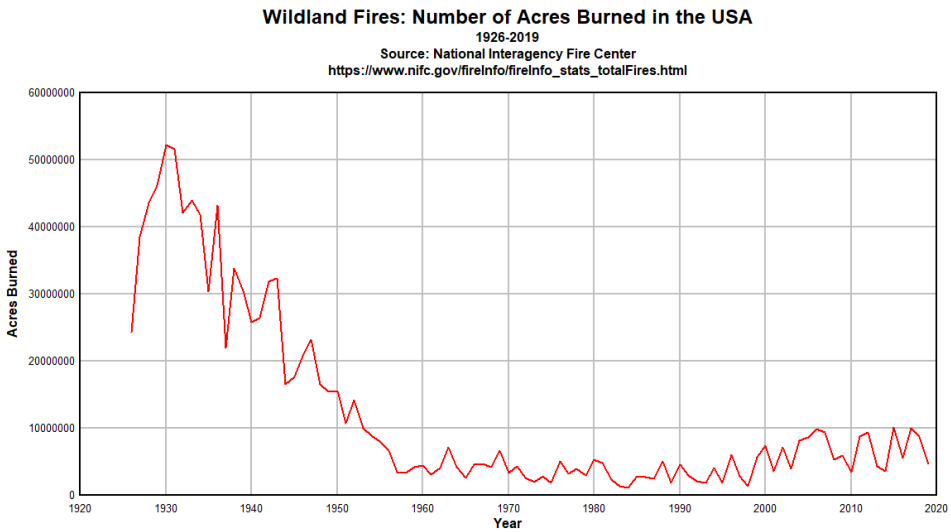

Figure 1. Available wildfire acreage burned, by year, in the United States, 1926 to 2019. This includes data from NIFC prior to the disappearance of data that occurred in 2021. Graph by Anthony Watts.

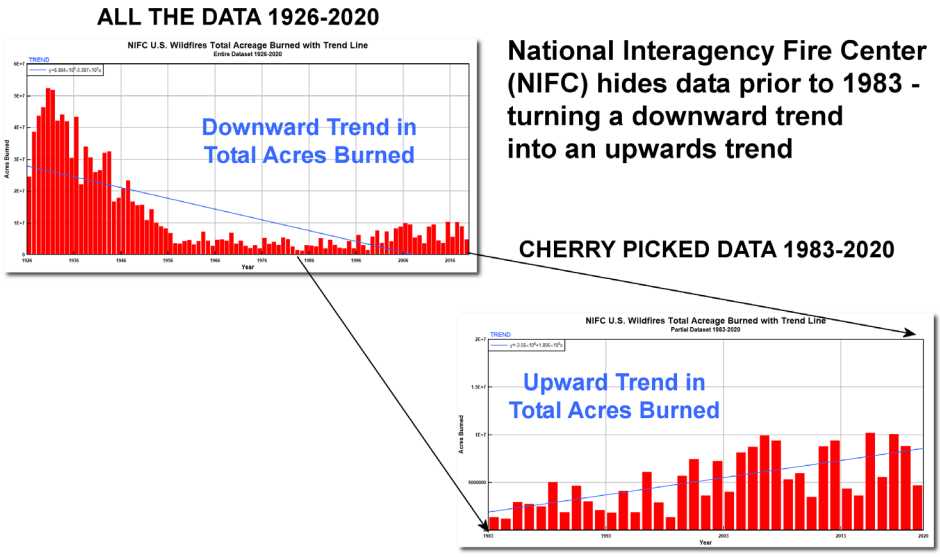

Figure 2. A comparison of NIFC wildfire datasets. It illustrates that when NIFC agreed to remove wildfire data for the years prior to 1983, it provided the public with a distorted view of wildfires. Graphs by Anthony Watts.

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CROP PRODUCTION

As global climate modestly warms, U.S. and global crop yields are setting new records almost every year. Thanks in large part to longer growing seasons, fewer frost events, more precipitation, and the fertilization effect of atmospheric carbon dioxide, farmers are producing more food on less land, allowing them to feed a growing global population.

The United Nations Food and Agriculture Organization (UNFAO) reports that the 2023 and 2024 global crop years – which were the two most recent years as this summary went to press in 2025 – registered the two highest years ever in yields per acre.[1] See Figure 1. This continues short-term, medium-term, and long-term trends of increasing crop yields and new crop records being consistently set during Earth's modest warming.

U.S. corn production set a new record in yield per acre in 2024, eclipsing the previous record set in 2023.[2] Global rice production is projected to set new records in 2025.[3] Global wheat production in the 2024-2025 growing season set a new record for the fifth year in a row.[4] Breakdown by crop is shown in Figures 2a, 2b, and 2c.

Global warming lengthens growing seasons, reduces frost events, and makes more land conducive to crop production. Global soil moisture has maintained pace or modestly improved as global temperatures have risen modestly, with greater oceanic evaporation leading to more global precipitation, especially during summer and fall crop seasons.[5,6]

Moreover, carbon dioxide greatly benefits crop production, as atmospheric carbon dioxide works as an aerial fertilizer.[7] Higher atmospheric carbon dioxide levels assist plant growth and resistance to drought and heat. It is for this reason that greenhouses often pump in elevated amounts of carbon dioxide.

KEY TAKEAWAYS

- As the planet has slightly warmed, global crop yields and production set new records almost every year.
- U.S. crop yields continue to grow, setting new records nearly every year.
- Longer growing seasons, more atmospheric carbon dioxide, and more rainfall are creating ideal crop conditions.

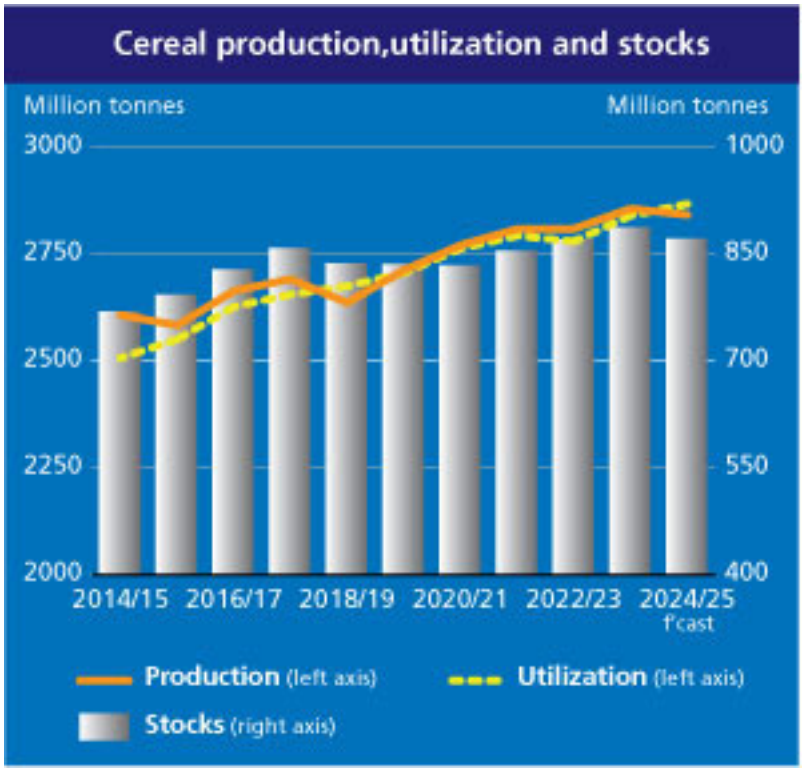

Figure 1. UN Food and Agriculture Organization, "World Food Situation," fao.org, April 7, 2025, http://www.fao.org/worldfoodsituation/csdb/en

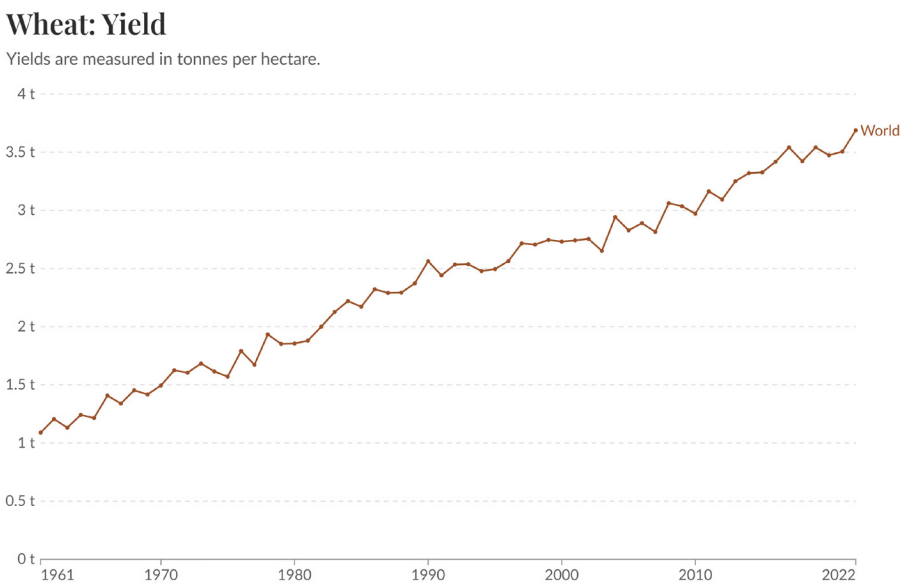

Figure 2a: UN Food and Agriculture Organization, "FAOSTAT: Compare Data," accessed July 22, 2025, fao.org/faostat/en/#compare

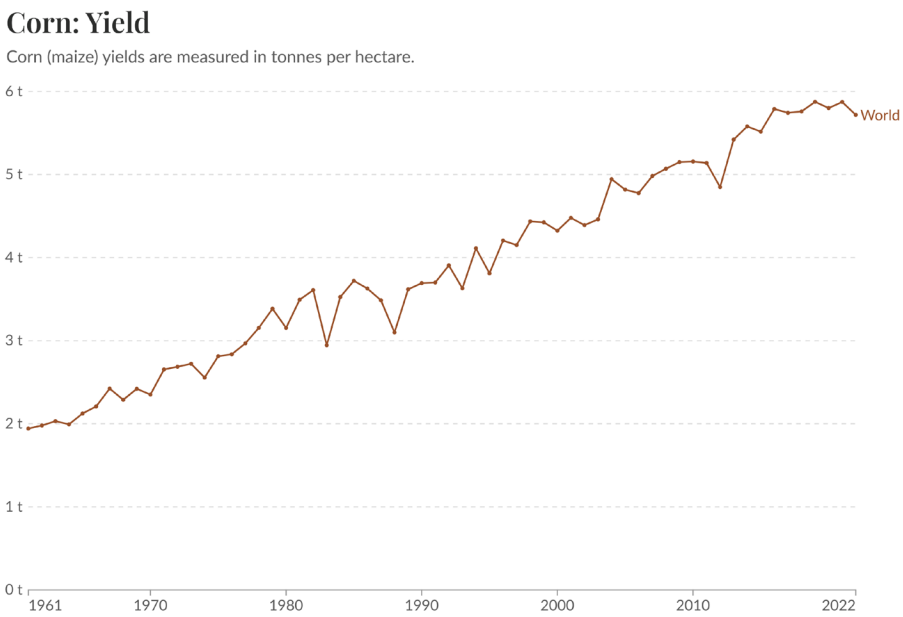

Figure 2b: UN Food and Agriculture Organization, "FAOSTAT: Compare Data," accessed July 22, 2025, fao.org/faostat/en/#compare

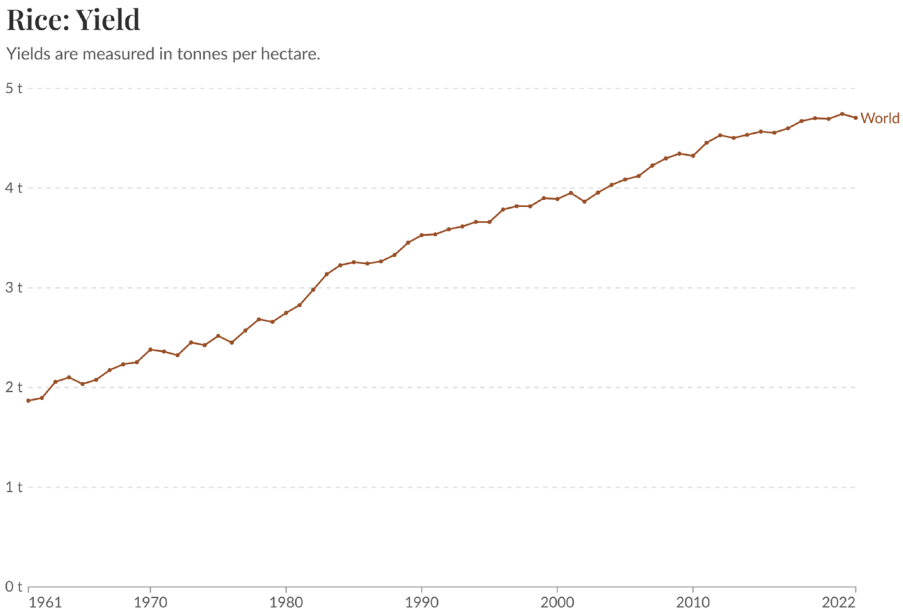

Figure 2c: UN Food and Agriculture Organization, "FAOSTAT: Compare Data," accessed July 22, 2025, fao.org/faostat/en/#compare

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GREENLAND ICE MELT

Sea level measurements contradict claims that the loss of ice in the Greenland ice sheet threatens to cause global coastal flooding. NASA satellite images, which include readings dating back to 1993, show sea levels rising at a pace of merely 1.2 inches per decade, which is not significantly different than the typical rate of sea level rise recorded since the mid-1800s.[1]

Over the past few decades, claims of ice melt in Greenland have been used to bolster fears of runaway sea level rise. For example, NASA scientists said the following about the Greenland and Antarctic ice sheets:

"The two regions have lost 6.4 trillion tons of ice in three decades; unabated, this rate of melting could cause flooding that affects hundreds of millions of people by 2100."[2,3]

Although several trillion tons of ice sounds like massive ice loss, it amounts to less than 1 percent of Greenland's total ice mass. As shown in Figure 1, the total ice loss each year is nearly undetectable, coming in at just 0.005 percent of the Greenland ice sheet.[4]

Similarly, on July 30, 2021, media outlets touted scary headlines such as, "Greenland: Enough Ice Melted on Single Day to Cover Florida in Two Inches of Water."[5] While that might sound scary, data show this amount of ice melt is not unheard of in Greenland, where temperatures are known to rise above freezing on particularly sunny days, which can melt a large amount of surface ice in a short span. It's an event that has happened many times before, including as recently as 2012.[6]

It is also important to note that pooled meltwater typically refreezes, resulting in virtually no net loss of ice in Greenland's ice sheet. Greenland experienced some melt events in the summer of 2021, driven by abnormally sunny weather, but the melt events were quickly followed by refreezing and a return to normal ice levels within a few days.

KEY TAKEAWAYS

- Climate activists, including government bureaucrats, claim the Greenland ice sheet is melting six times faster than it was 30 years ago. But 30 years ago, the Greenland ice sheet was barely melting at all. Six times almost no ice loss is hardly an example of a climate change crisis.
- When recent ice loss is compared to the full Greenland ice sheet, the loss is so small that it is almost undetectable.

Corroborating this, the National Snow and Ice Data Center wrote of the recent events: "The Greenland Ice Sheet had two extensive melt events in the second half of July. The second melt event had the sixth-largest melt area and fourth-highest runoff in the satellite record, which began in 1978. However, snow cover from earlier snowfall in early summer blunted the potential impact of the melting by limiting the exposure of bare ice and reducing runoff. The two events resulted in the 2021 season flipping from a net gain of ice to near-average net change."[7]

A full-context examination of the data shows only a tiny fraction of Greenland's ice sheet is melting, and with very little impact—the exact opposite of what many climate alarmists claim.

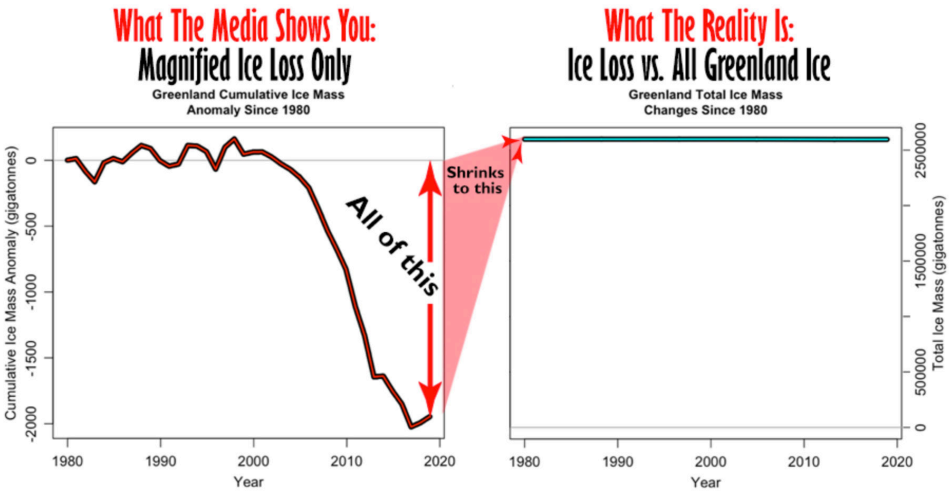

Figure 1. A comparison of presentations of satellite data capturing Greenland's ice mass loss. The image on the right shows changes in Greenland's ice mass relative to Greenland's total ice mass. Sources: The data plotted in these graphs are from the Ice Sheet Mass Balance Inter-Comparison Exercise, a joint exercise by NASA and the European Space Agency.4 Graphs originally by Willis Eschenbach. Adapted and annotated by Anthony Watts.

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OCEAN ACIDIFICATION

Scientists and media outlets claim ocean acidification is occurring due to increased carbon dioxide (CO2) levels in the atmosphere,[1] but objective data show the oceans are far from acidic.

A pH of 7 is considered neutral, with anything below 7 considered acidic and anything above 7 considered alkaline. Ocean pH averages 8.1, which is alkaline rather than acidic. Climate models suggest the ocean's surface pH may have dropped from a pH of 8.2 to 8.1 since 1750, though that change was never actually measured. In reality, the very small pH drop is merely a modeled conjecture.[2]

A study by scientists at the CO2 Coalition notes that the health of ocean life is enhanced by more carbon dioxide, not less.[3] CO2 is food for phytoplankton, which form the foundation of the marine food chain.

As Figure 1 shows, with an average pH of 8.1, the oceans are a long way from turning acidic. It is likely that media reports often use the word "acidic" because it sounds scarier than a more accurate description, such as "a modeled, modest decline in alkalinity."

KEY TAKEAWAYS

- Ocean water is not acidic.
- A pH of 7 is considered neutral. A pH below 7 is acidic, while anything above 7 is alkaline. The pH of the oceans averages 8.1, ranging between 7.8 to 8.5—well above the point of flipping from alkaline to acidic.
- Since 1850, the pH of surface ocean waters has fallen by merely 0.1 pH units.
- The health of ocean life is improved, not harmed, by more carbon dioxide. CO2 is food for phytoplankton that form the foundation of the marine food chain. Marine life thrives and improves growth rates in elevated CO2 conditions.

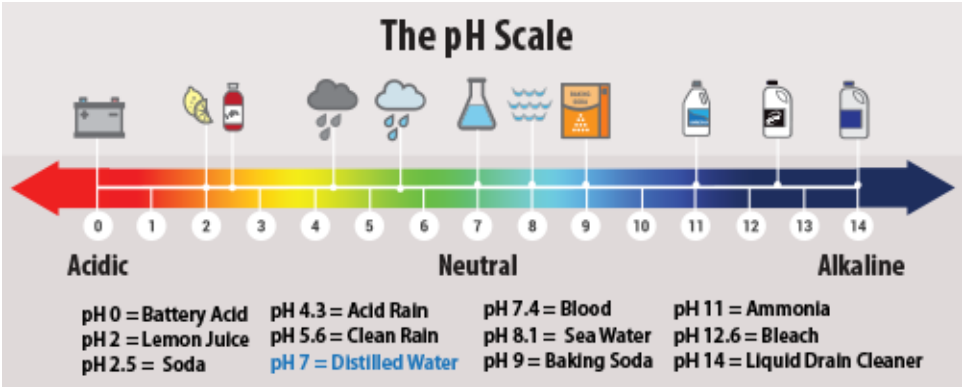

Figure 1: Comparison of the pH of common substances. Source: U.S. Environmental Protection Agency, "Measuring Acid Rain," epa.gov, last accessed August 12, 2021, https://www.epa.gov/acidrain/what-acid-rain

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POLAR BEARS

Climate activists often speculate that even a modest amount of warming would substantially reduce Arctic ice and polar bears' food availability to the point that it would push polar bears to extinction. The evidence suggests this is false, however. Polar bears evolved hundreds of thousands of years ago and have thrived under much warmer climatic conditions than those that exist today,[1] including during the Mid-Holocene Warm Period, which lasted for 2,000 years and occurred 5,000 to 7,000 years ago.[2]

After dropping to a low of 10,000 bears in 1950, during the middle of a global cooling period, polar bear numbers have quadrupled to about 39,000 today. Further, polar bear experts, such as Susan Crockford, have documented at length how polar bear populations have managed to increase despite a modestly warming world.[3] (See Figure 1.)

Contrary to the many dire claims made by climate activists about polar bears, proof of declining polar bear populations essentially vanishes when all of the available data are considered.[4]

In September 2023, Crockford published new data that show no trend in lower Artic sea ice levels between 2007 and 2023, suggesting polar bears are not in danger from declining Arctic sea ice at all.[5]

KEY TAKEAWAYS

- Polar bear populations have increased dramatically during recent decades, despite the modest global warming that has occurred over the same period.
- The estimated polar bear population has quadrupled since 1950, rising from 10,000 bears in 1950 to 39,000 bears today.
- Polar bears have evolved for hundreds of thousand of years, and they survived and even thrived in much warmer climates than what we're seeing today.

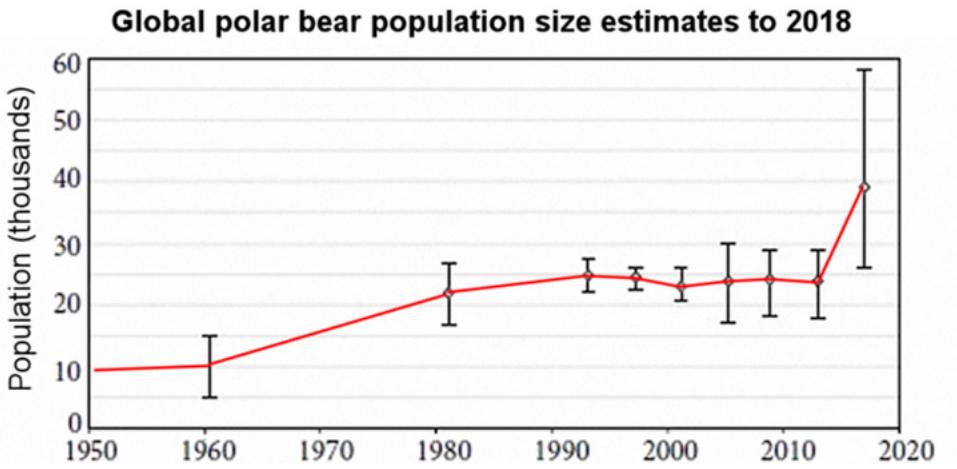

Figure 1. Global polar bear population. Source: Susan J. Crockford, The Polar Bear Catastrophe That Never Happened, Chapter 10 (London, U.K.: The Global Warming Policy Foundation, 2019).

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CLIMATE REFUGEES

For the past 30 years, climate activists have claimed that islands, cities, and even entire nations will spawn millions of refugees as climate change makes these places uninhabitable. In 1989, for example, a senior United Nations environmental official claimed, "entire nations could be wiped off the face of the Earth by rising sea levels if the global warming trend is not reversed by the year 2000."[1]

Similarly, in 2005, the United Nations claimed, "Rising sea levels…will create up to 50 million environmental refugees by the end of the decade."[2]

Those predictions proved to be false, along with hundreds of others made by climate change activists. To avoid embarrassment, the United Nations removed the prediction—which we reprint here as Figure 1—of "50 million environmental refugees" from its website.[3]

As documented in the *Climate at a Glance* chapter "Islands and Sea-Level Rise," most small islands—including the islands of Tuvalu—are growing in land mass rather than shrinking due to rising sea levels.[4] Further, nearly every nation is benefiting from steadily increasing crop yields, which have improved in part because of recent modest warming periods.[5] And the number of climate-related disasters, as well as the number of victims from those disasters, has been declining over the past 100 years, as seen in Figure 2.[6] The factors that climate activists claim will soon cause numerous climate refugee crises are not present and, in many cases, are actually becoming less common and/or severe.

KEY TAKEAWAYS

- The asserted causes of so-called "climate refugees"—increasing crop failures, catastrophic weather events, and islands lost to rising seas—have not materialized.
- Despite significant fearmongering, many of the islands that climate activists have predicted would produce climate refugees have actually increased in land mass in recent decades, not decreased.
- Nearly all of the nations that are expected to produce climate refugees due to crop failures have benefited in recent years from steadily increasing crop yields.
- The United Nations confirms casualties linked to climate-related natural disasters have declined this century.

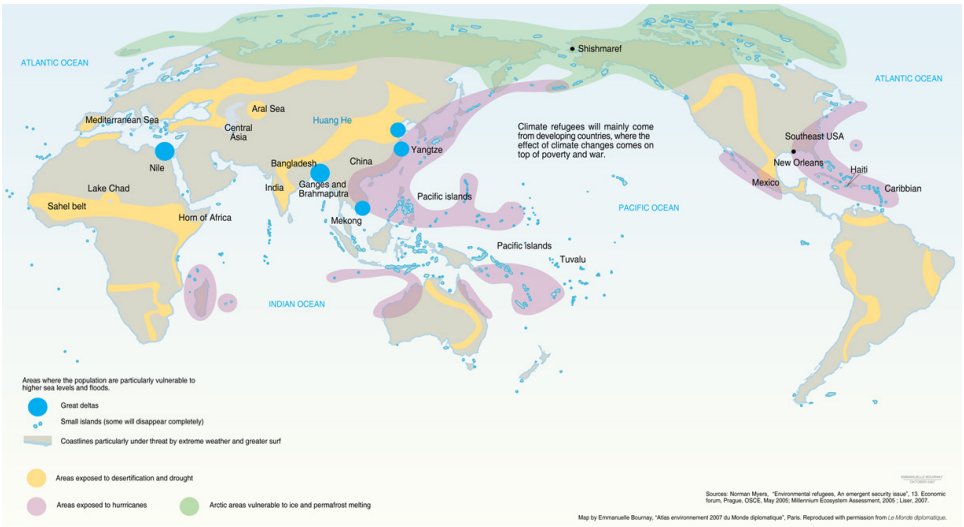

Figure 1. Original map created in 2005 by the United Nations to illustrate where "50 million climate refugees" would move. The map has since been removed from the internet by the United Nations. Source: Anthony Watts, "The UN 'Disappears' 50 Million Climate Refugees, then Botches the Disappearing Attempt," WattsUpWithThat, April 2011, https://wattsupwiththat.com/2011/04/15/the-undisappears-50-million-climate-refugees-then-botches-the-disappearing-attempt/

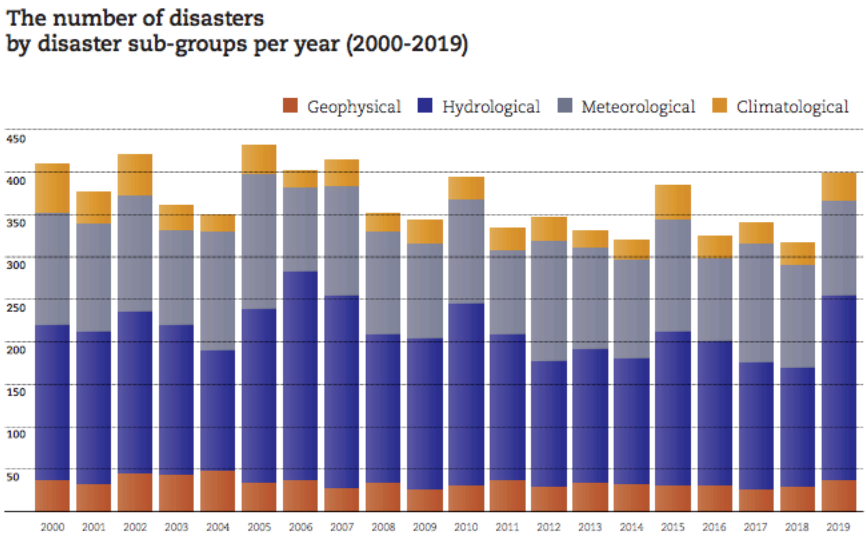

Figure 2. This chart published by the United Nations shows a downward trend in the number of climate-related disasters. Source: Nima Yaghmaei et al., The Human Cost of Disasters: An Overview of the Last 20 Years (2000-2019), U.N. Office for Disaster Risk Reduction and Centre for Research on the Epidemiology of Disasters, October 13, 2020, https://www.undrr.org/media/48008/download

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ISLANDS AND SEA LEVEL RISE

Objective scientific evidence refutes claims that climate change is causing small islands to disappear under rising seas. Rising seas bring sand and sediment, which build up coastal shorelines along with rising waters. Also, coral, as living organisms growing near sea level, build up their height along with the rising sea, as seen in Figure 1.

Climate change activists routinely argue that numerous Pacific Islands will soon be underwater due to rising sea levels caused by climate change. But recent population patterns suggest Pacific Islanders know they are not facing substantial threats from sea level rise. Some allegedly "endangered" islands have even built or made plans to build new airports or resorts.[1,2]

More importantly, objective scientific evidence debunks claims that climate change is causing small islands to disappear.

An important example is the island of Tuvalu. Climate activists often claim the island nation of Tuvalu is sinking because of rising seas. However, a recent peer-reviewed study found eight of Tuvalu's nine large coral atolls have grown in size during recent decades, and 75 percent of Tuvalu's 101 smaller reef islands have increased as well.[3]

Further evidence can be found in Tuvalu's population records. Many climate activists have warned that rising seas have started to cause or will soon cause waves of climate refugees seeking to flee islands like Tuvalu. However, Tuvalu's population, like the population of many other island nations, has consistently grown in recent years, not declined. At the time of this publication, the population of Tuvalu had increased by 20 percent over the past 30 years, and doubled compared to its population recorded in 1970.[4]

Additional peer-reviewed studies have confirmed other islands in the Pacific Ocean are keeping up with rising sea levels.[5,6] Their atolls have gained more

KEY TAKEAWAYS

- Most islands and atolls in the Pacific Ocean, including Tuvalu, are growing, not shrinking.
- As the sea gradually rises, the sea brings sand and sediment along with it, building up the height of islands.
- Despite many predictions that island nations in the Pacific would spawn waves of climate refugees, the populations of Tuvalu and other islands have steadily grown, not decreased.

than enough height and mass to offset modest sea level rise.[7]

Climate activist groups and some scientists have made false and dire warnings about sea level rise for many decades. For instance, more than 30 years ago, the AFP international news agency reported all 1,196 islands that comprise the Maldives could be completely underwater over the next few decades.[8] Not only are all 1,196 islands still above water, people from all over the world are flocking to the Maldives, not fleeing them. Like Tuvalu, the Maldives are benefiting from a lucrative tourist trade, not spawning climate refugees.

Figure 1. Coral atolls, Maldives. Note that the coral rings "float" with the sea level, and because they are living things, they rise with the sea level as new coral grows. Source: Pinterest

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OCEAN CURRENTS

Ocean currents distribute heat across the globe. The great ocean conveyor moves water in a well-known pattern, known as the Atlantic Meridional Overturning Circulation (AMOC), as seen in Figure 1.[1]

For many years, some scientists and climate activists have claimed the world's ocean currents are slowing down and that global warming is to blame. They have cited computer model simulations that predicted and replicated a slowdown due to a predicted increase of freshwater caused by Arctic melting.[2] Slower ocean currents, they claim, would alter African and Indian rainfall patterns and impact Atlantic hurricanes. Additionally, in 2019, op-eds and studies claimed ocean currents had declined to their slowest pace in 1,600 years.[3,4]

Other recent scientific research, however, relying on real-world measurements, suggests that ocean currents likely sped up in recent decades, during the time period in which climate activists were asserting global warming had been causing ocean currents to slow.[5] It seems that scientists cannot agree on whether ocean currents are speeding up or slowing down. Either way, the media asserts that human activity is causing the change, downplaying natural variations in Earth's climate system that have driven changes in ocean currents historically. Global warming activists cannot have it both ways. Ocean currents can't be both slowing down to record lows during the past 20 years and simultaneously speeding up.

Whether ocean currents are slowing down or speeding up, climate change activists blame human greenhouse gas emissions for the purported trend, and, citing computer model projections, claim the changes will result in disaster.[6]

A January 2025 peer-reviewed paper published in *Nature Communications*

KEY TAKEAWAYS

- For many years, global warming activists claimed climate change would soon cause ocean currents to slow to a pace that has not been experienced in 1,600 years.
- Climate activists claim computer models predicted the slowdown and that a slowdown would have disastrous consequences for marine life. They also suggested it could cause a new "mini" ice age.
- A new peer-reviewed study in January 2025 finds that the critical ocean current known as the Atlantic Meridional Overturning Circulation has not declined over the past 60 years.

complicates matters further. The authors of that paper found the AMOC has neither declined nor sped up over the past 60 years.[7] The results mean that the AMOC is currently more stable than expected.

Global warming activists constantly shift their claimed "climate crisis" to fit the evolving scientific evidence, rather than simply admitting the obvious: Earth's climate and ocean currents have regularly shifted over long time periods and always will, due to relatively poorly understood natural causes. At the moment, ocean currents are likely stable, with no indication that ongoing climate change is having any measurable effect.

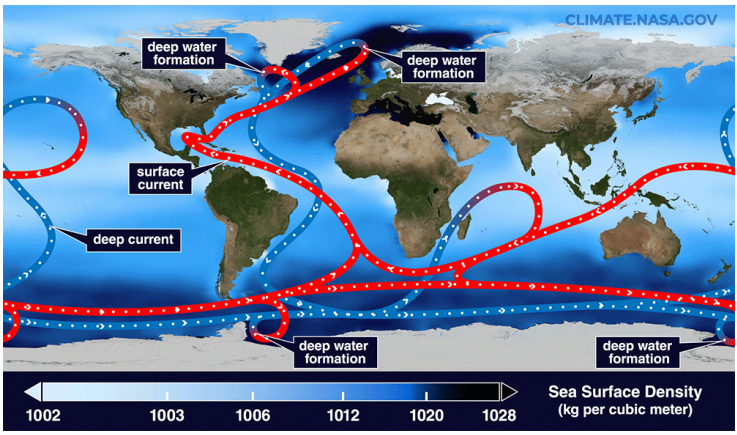

Figure 1. A simplified illustration of the global "conveyor belt" of ocean currents that transport heat around Earth. Red shows surface currents, and blue shows deep currents. Deep water forms where the sea surface is the densest. The background color shows sea-surface density. Source: NASA/ Goddard Space Flight Center Scientific Visualization Studio.

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SEA LEVEL RISE

Global sea level has risen more than 400 feet since the end of the last Ice Age glaciation period. Global sea levels have been rising at a relatively steady pace of approximately 1 foot per century since at least the mid-1800s.[1] One of the oldest tide-gauge records of sea level, New York City's "Battery," shows a linear trend of 2.88 mm per year (0.113 inches per year) since 1856, with very little, if any, recent acceleration.[2] (See Figure 1.)

Satellite data going back to 1993 also show little, if any, acceleration in the pace of sea-level rise.[3]

Perhaps most importantly, an independent analysis of tide-gauge data, which has a much longer record compared to satellite data, found humans have likely had only a very modest impact on long-term sea-level rise. Climatologist Roy Spencer performed the analysis, which is illustrated in Figure 2.

Spencer's analysis suggests humans' contribution to sea level rise could be as little as three-tenths of an inch per decade, or about three inches per century. Natural sea level rise accounts for half an inch of sea level rise per decade, or 5 inches per century.[4]

Combined, the rate of sea level rise is eight-tenths of an inch per decade, or 8 inches per century, which is even slower than what satellite instruments report.

KEY TAKEAWAYS

- Global sea level has been rising since at least the mid-1800s, and data show there has been only minor recent acceleration.
- NASA satellites, with readings dating back to 1993, show global sea level rising at a pace of merely 1.2 inches per decade.
- Isolated locations with more accelerated sea level rise reflect local conditions, such as tectonic plate movement and withdrawing underground freshwater reserves, rather than climate change.
- Human civilization successfully dealt with sea level rise utilizing nineteenth and twentieth century technologies, and it will be able to adapt to rising sea levels even more successfully in the coming decades by utilizing twenty-first century innovations.

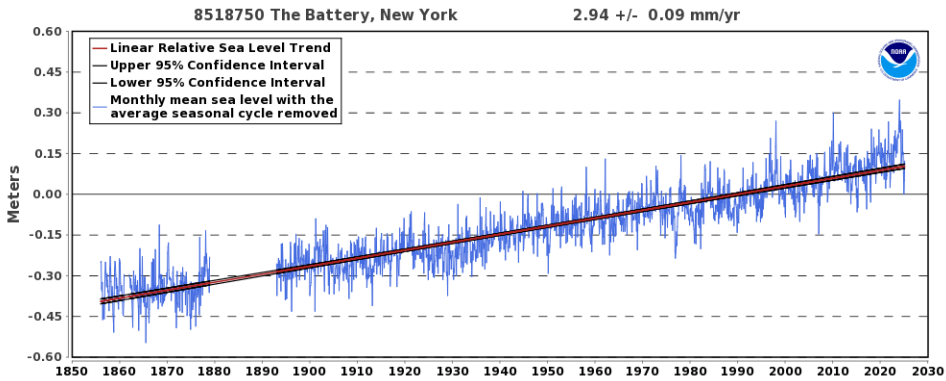

Figure 1: Tidal gauge measurements at the Battery in New York City illustrate there has been a steady, modest pace of sea level rise of just less than 1 inch per decade. This rate of sea level rise goes back more than a century. Source: National Oceanic and Atmospheric Administration: https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8518750.

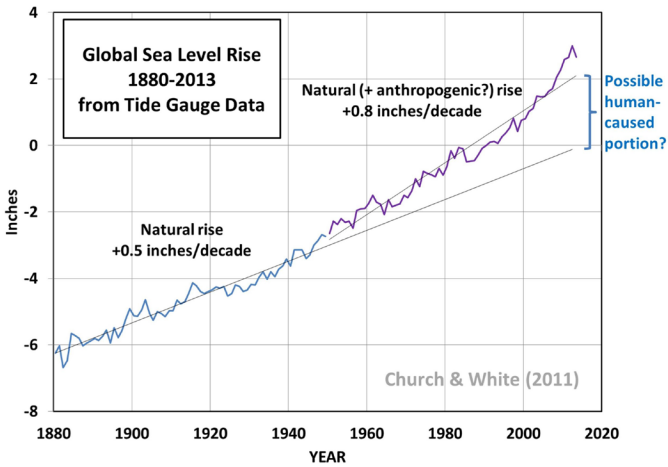

Figure 2. This figure shows sea level rise dating back to 1880. Graph by Roy Spencer, Ph.D. For a more detailed analysis, see Spencer's article, which can be found in Note 4 in the References section below.

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URBAN HEAT ISLANDS

The majority of U.S. temperature stations utilized for the National Oceanic and Atmospheric Administration and NASA temperature records have been compromised by the encroachment of artificial surfaces like concrete, asphalt, buildings, and air conditioner exhausts. The effects of these manmade structures are often referred to as urban heat islands. (Figures 1 and 2 provide examples of how temperature stations have been compromised by urbanization.)

Urban heat islands cause temperature data to display higher temperatures than what would have been recorded if the same stations were located away from urban areas. Some researchers have found urban heat islands are responsible for almost half of reported U.S. warming. When only non-urban temperature stations are used, warming trends are still present in the data, depending on the period examined, but they are minimal and not alarming.[1]

The data in Figure 3 show temperature stations that have not been corrupted by the urban heat island effect report significantly less warming than temperature stations corrupted by urban heat island impacts.[2] Still, despite this well-known problem, corrupted temperature stations comprise a majority of the stations used to report official U.S. temperature data.[3]

There is also strong evidence of similar siting problems in other parts of the world, including at many official weather stations. This suggests the same urban heat island corruptions that have occurred in U.S. data are also present in data compiled from other countries. Researchers at the Oak Ridge National Laboratory confirmed this theory in important work published in 2019.[4]

KEY TAKEAWAYS

- Urban heat islands, which grow along with the size of cities, create artificial warming at many long-term temperature stations.
- On average, urban heat islands increase the global surface temperature trend by almost 50 percent.
- Nearly 90 percent of U.S. temperature stations have been compromised by urbanization effects.
- Almost half of the reported U.S. warming disappears when reporting only stations uncorrupted by heat islands.

Figure 3, below, shows that temperature stations that have not been corrupted by urban heat island impacts report much less warming than temperature stations corrupted by urban heat island impacts.

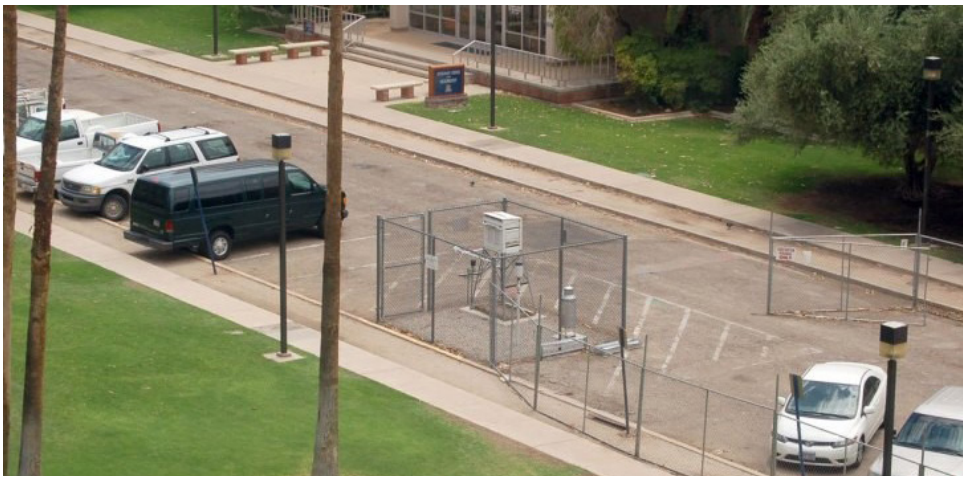

Figure 1. U.S. Historical Climatology Network weather station used to collect climate data. This station is located in a parking lot at the University of Arizona in Tucson. The station was previously located in a grassy area, but researchers moved the station as the campus grew. Photo by Anthony Watts.

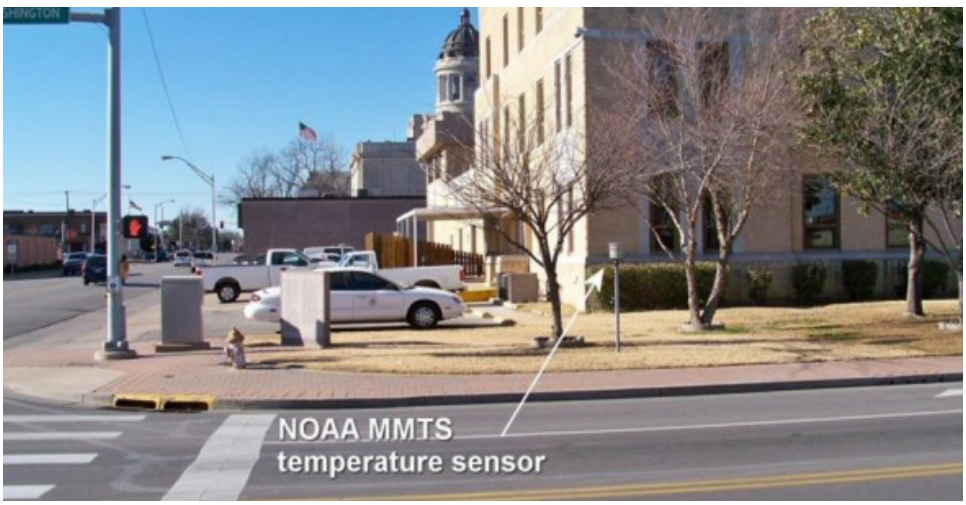

Figure 2. NOAA temperature sensor (used for climate data) located on street corner in Ardmore, Oklahoma. Note that the sensor's data is being corrupted by heating signatures of the nearby building, asphalt, and automobiles. Photo by Anthony Watts.

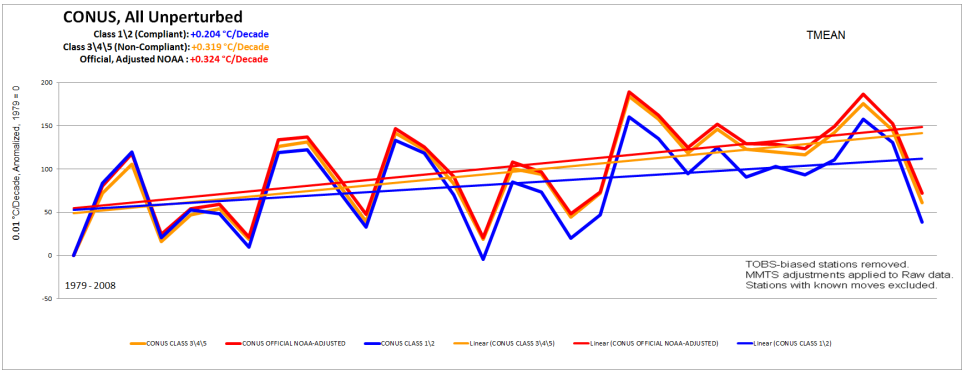

Figure 3. Uncorrupted stations (classes 1 and 2) report much less warming than stations corrupted by urban heat island factors (classes 3, 4, and 5). Source: Anthony Watts

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ANTARCTIC ICE MELT

NASA has said this about Greenland and Antarctic Ice: "The two regions have lost 6.4 trillion tons of ice in three decades; unabated, this rate of melting could cause flooding that affects hundreds of millions of people by 2100."[1] Citing NASA, media outlets began claiming in 2019 the Antarctic ice cap is melting six times faster than it was 30 years ago.

However, Antarctica and Greenland are barely losing ice mass. The 6.4 trillion tons of ice lost in the last three decades is short of even 1 percent of their total ice mass.[2] As shown in the graph in Figure 1, the total ice loss each year is a nearly undetectable three ten-thousandths of one percent (0.0003 percent) of Antarctic ice mass.[3] NASA satellites show global sea levels rising at a pace of 1.2 inches per decade.[4] This rate of sea level rise is not significantly different from that since the mid-1800s, and does not indicate any increased risk of coastal flooding.

In fact, a 2025 report found that four major glaciers in East Antarctica have experienced significant mass increases in recent years, reversing the previous trend.[5]

KEY TAKEAWAYS

- Media outlets in 2019 and 2020 began claiming the Antarctic ice cap is melting six times faster than it was 30 years ago.
- Antarctica and Greenland are barely losing ice mass.
- NASA satellite measurements of sea levels show no significant threat of flooding from ice loss.
- Recent scientific research shows Antarctic ice mass has been expanding recently.

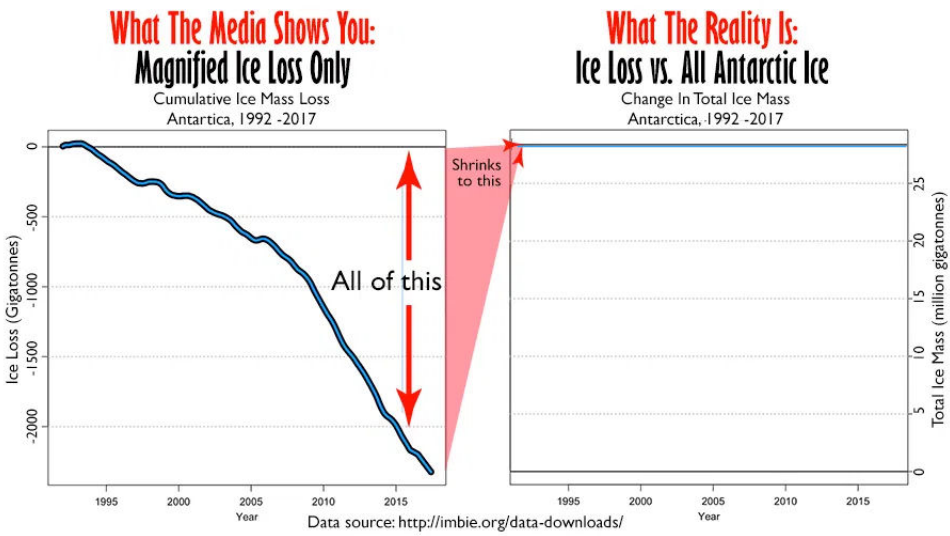

Figure 1: (click to enlarge) Comparison of satellite data for Antarctic ice mass loss. Cumulative ice mass loss on the left and that same data compared to the total mass of ice on the right. Data source: http://imbie.org. Graphs originally by Willis Eshenbach, adapted and annotated by Anthony Watts.

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ARCTIC SEA ICE

Consistent and comprehensive measurement of Arctic sea ice has only occurred since 1979 through the use of satellites. Proxy data and historical records indicate that Arctic sea ice waxes and wanes from year to year and decade to decade.[2] The National Snow and Ice Data Center (NSIDC) examined these lines of evidence and concluded, "Arctic sea ice may have melted completely in summertime about 125,000 years ago, during a warm period between glaciations. As recently as 5,500 years ago, summertime Arctic sea ice may have been much less extensive than it is today."[3]

Satellite data showing a decline in Arctic sea ice has been wrongly used by scientists, politicians, and media as an indicator of climate change. Because of an abrupt drop in 2007 in the summer minimum sea ice extent, claims of imminent "ice-free summers" in the Arctic were common. For example, in 2008, NSIDC scientist Mark Serreze told ABC News the Arctic could be "ice free" that summer.[4] In 2009, Al Gore predicted "the North Pole will be ice-free in the summer by 2013 because of man-made global warming."[5]

However, data in Figure 1 from the NSIDC show none of these predictions came true.[6]

The sea ice minimum in September 2023 was essentially the same as it was in 2007, when all the predictions of "ice-free summers" began. Moreover, data from 2007 to 2023 show a zero net-change over the past 17 years. The flat trend from 2007 to 2023 suggests a shift in the Arctic sea ice system to a new, stable level.[7, 8]

There is precedence for such a pattern of ice drop. The May 1, 1931 issue of *Monthly Weather Review* quoted a report from the Danish Meteorological Institute noting "extraordinarily little ice" in the Barents Sea, and "around Spitsbergen open water was more extensive than in any other year during this century."[9] This occurred well before modern claims of man-made climate change affecting Arctic sea ice.

KEY TAKEAWAYS

- Arctic sea ice melts and refreezes every year, typically peaking in March, while the summer minimum typically occurs in September.[1]
- Many scientists, politicians, and media sources wrongly predicted Arctic sea ice would disappear in the summer.
- Satellite data show the summer minimum sea ice has not decreased at all since 2007, and instead has remained stable after a temporary low in 2012.

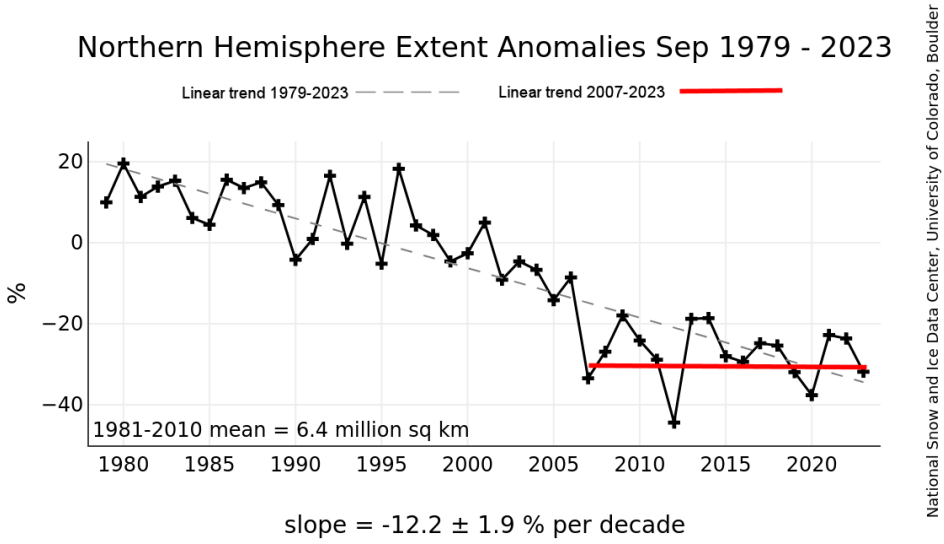

Figure 1. Shows satellite-derived summer-minimum Arctic Sea ice-extent values from 1979 to 2023, with dashed line showing the linear trend. The added trend line in red shows no change in summer minimum extent since 2007. Image source: NSIDC. Red trend line from 2007 and trend line examples under the title added by A. Watts

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GLOBAL WILDFIRES

One of the more common harms attributed to climate change is that it has caused an increase in wildfires due to warmer temperatures and more severe drought.[1] Multiple lines of data show that this claim is false.

Short-term satellite data from NASA's Earth Observatory confirms this. NASA found that the global area burned from 1998 to 2015 declined by 24 percent.[2] The data are seen in Figures 1 and 2.

Scientific data show a similar long-term reduction in wildfires. A peer-reviewed study on global wildfires found, "The average global burned area is $\sim 442 \times 10_4$ km_2 yr_{-1} during 1901–2007 and our results suggest a notable declining rate of burned area globally."[3]

The European Space Agency (ESA) corroborates this evidence. The ESA maintains a database of wildfire area burned, which is collected from Earth-observing satellite data beginning in 1982. This database also shows a steady drop in global acreage burned.[4]

A third source, combining recent data with a scientific reconstruction of global historical fire records, demonstrates a long-term reduction in global wildfires even as the planet warmed slightly over the past century.[5] Total area burned across the world has declined significantly since 1900. Over the past few decades, the area lost to wildfires has fallen by approximately 18 percent.[6] This is illustrated in Figure 3.

Contrary to commonly made claims that climate change is causing an increase in wildfires, the acreage lost to wildfires globally has decreased substantially during the last century even as the planet has slightly warmed.

KEY TAKEAWAYS

- Climate activists and the mainstream media often claim that wildfires have increased due to climate change.
- Data from satellites as well as reconstructed historical terrestrial fire records both show that global wildfire area burned has decreased substantially during recent decades, as well as over the last 120 years.

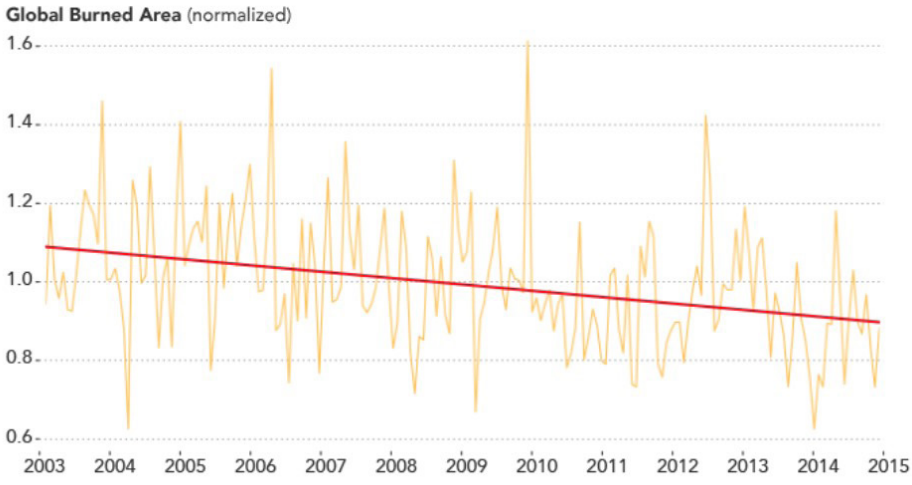

Figure 1: Total acreage burned by fires each year between 2003 and 2015. Trend line in red indicates a steady decline. Source: NASA Earth Observatory, "Researchers Detect a Global Drop in Fires," June 30, 2017, https://earthobservatory.nasa.gov/images/90493/researchers-detect-a-global-drop-in-fires

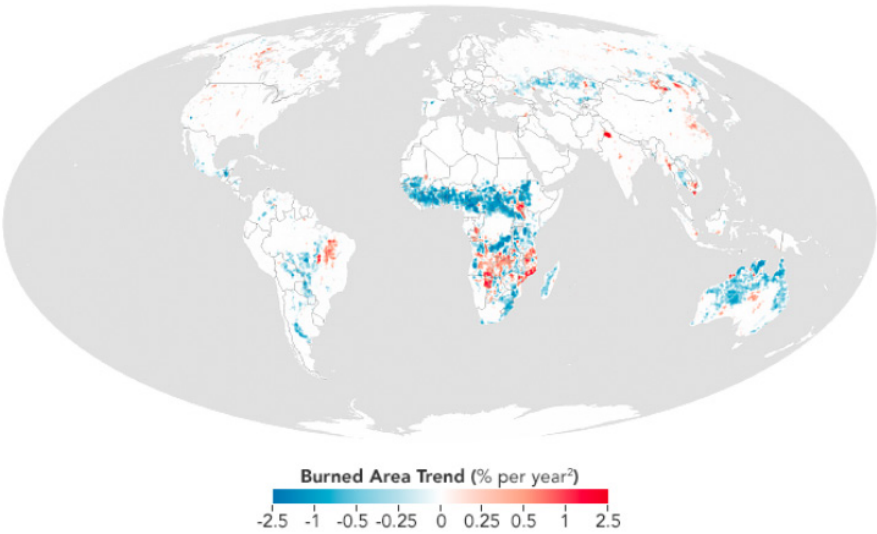

Figure 2: Global observations of burned areas and trends show a decline in wildfires from 1998-2015. Source: NASA Earth Observatory, "Researchers Detect a Global Drop in Fires," June 30, 2017, https://earthobservatory.nasa.gov/images/90493/researchers-detect-a-global-drop-in-fires

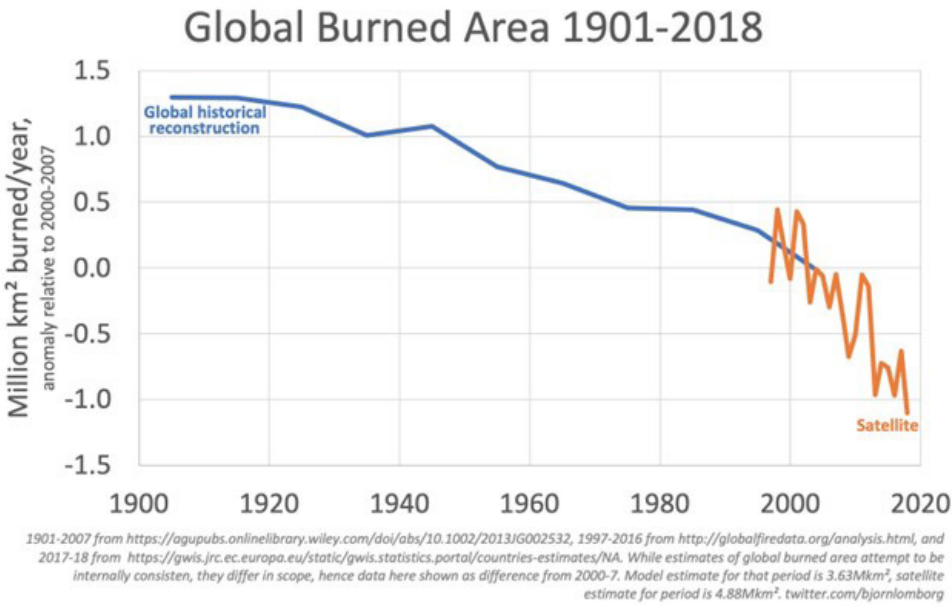

Figure 3: Combined reconstruction and satellite data. Blue curve, global wildfire area burned reconstruction. Orange curve, global wildfire area burned measured by satellites. Graph plotted by Bjorn Lomborg, Ph.D.

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OCEAN TEMPERATURES

The temperature of the oceans is the dominant factor for Earth's overall temperature, as they cover approximately 71 percent of the planet's surface and have a much higher heat capacity than the atmosphere. Effectively, the world's oceans act as a global thermostat that regulates temperature changes on Earth.[4]

Since 1880, the global ocean temperature has gradually increased, indicating a slow warming trend over the past century. During this period, the average ocean surface temperature has risen by roughly 0.7°C (1.26°F) compared to the late nineteenth century average from 1880 to 1900, as seen in Figure 1.

Figure 1 illustrates that the start of gradual ocean warming is correlated with the end of the Little Ice Age (LIA), which was a period of global cooling that occurred from approximately 1400 to 1900.[5] After the LIA ended, a natural rebound of ocean temperatures via slow warming was to be expected.

In addition to that gradual warming, naturally occurring El Niño events in the Pacific Ocean are known to cause ocean temperature increases. These have been anecdotally recorded as far back as 2,000 years ago.[6] For example, the 1997/1998 Super El Niño event caused temperatures to elevate worldwide.[7] Specifically, ocean temperatures in the equatorial Pacific rose by an average of 2-4°C (3.6-7.2°F) above normal, with some areas experiencing increases exceeding 2.5°C (4.5°F) compared to the long-term average. This

KEY TAKEAWAYS

- Climate activists and the mainstream media often claim global ocean temperatures have dramatically increased due to climate change, citing record temperatures in 2023 to support their claims.[1]
- Actual data from satellites show ocean temperatures are not uniform, but widely scattered in distribution. Ocean temperatures are driven by the El Niño Southern Oscillation, which can cause a flip from cold to warm in the space of a single year.[2,3]
- The gradual warming of the oceans is consistent with expected mild warming coming out of the "Little Ice Age" that ended around 1900.
- The 1997 and 2015 Super El Niño events caused a significant upward shift in global ocean temperature that lingers today.

warming significantly impacted global temperatures due to the redistribution of heat through atmospheric circulation.[8]

Figure 2 shows how the 1997/1998 Super El Niño event caused a steep elevation in ocean and air temperatures that remains today, because the heat created from that event has yet to fully dissipate from the planet.

A second Super El Niño event that occurred in 2015 added more heat to the oceans and atmosphere. According to National Oceanic and Atmospheric Administration data, the 2015 El Niño event caused sea surface temperature to rise more than 2°C (3.6°F) above average, ranking it among the strongest on record.[9] It contributed significantly to the overall heat content of the tropical Pacific Ocean. This contributed to 2015 being recorded as the warmest year on record at the time due to the substantial heat added by the El Niño event.

In 2023, global temperatures reached new peak levels, which contributed to one of the hottest years on record. A scientific analysis showed that once again, an El Niño event was the driver. The results indicate that the 2023 warming spike was primarily caused from the El Niño–Southern Oscillation, rather than human-induced global warming.[10]

Despite chronic claims that human-caused climate change is warming the oceans, the warming over the past century can be attributed to natural events, such as rebound from the LIA and two Super El Niño events adding heat to the oceans that is slowly dissipating. Moreover, because oceans constitute more than 70 percent of the Earth's surface, naturally warming oceans contribute to rising estimated global average temperatures.

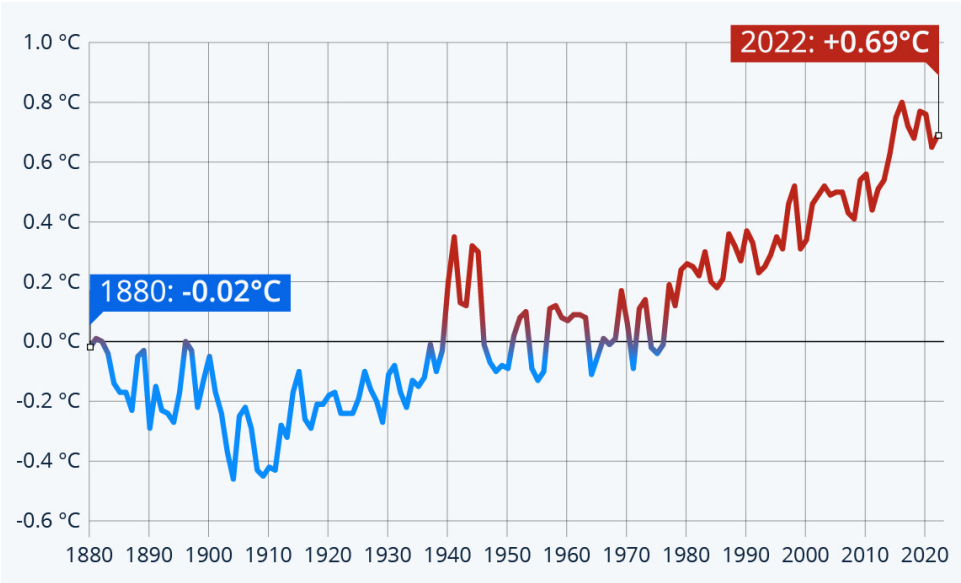

Figure 1: Global Ocean Surface Temperature Anomaly, 1880-2022. Data from the National Center for Environmental Information, (NCEI). Graph by Statista.

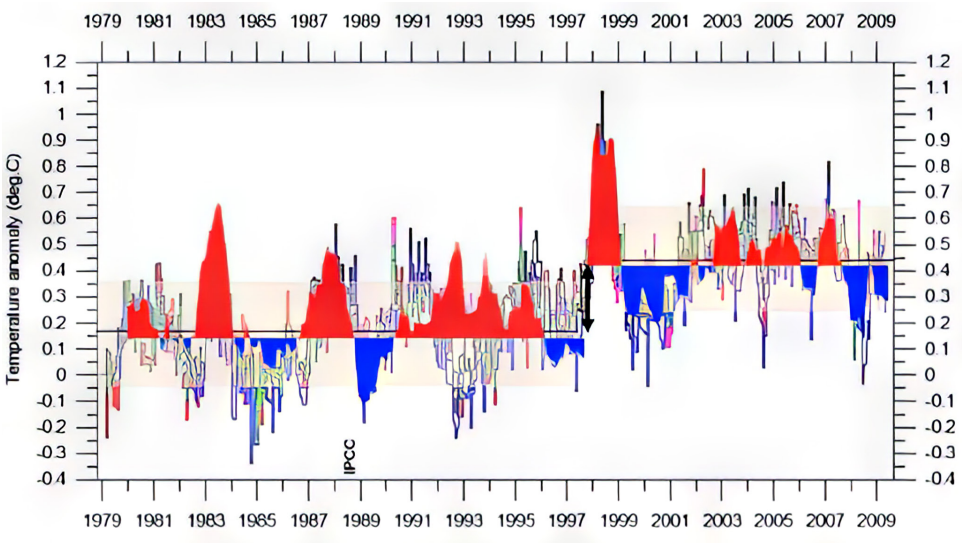

Figure 2: Comparison of ENSO events (red is El Niño, blue is La Niña) with global ocean and air temperatures from several sources. Note the steep change to a new baseline temperature in 1997/1998 from the Super El Niño event. Graphic by Robert Tisdale.

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BEES AND CLIMATE CHANGE

Many media outlets have repeatedly warned that climate change is decimating wild bee populations throughout North America. The most recent claims are based on a January 12, 2021 study highlighted by *Science News*.[1] The study, however, is flawed. This is partially because it fails to account for the primary cause of bee mortality: colony collapse disorder (CCD). In non-scientific jargon, CCD occurs when entire hives suddenly experience population crashes. CCD has been called the honeybee's biggest enemy by scientific researchers.

The U.S. Environmental Protection Agency (EPA) notes:[2]

> "There have been many theories about the cause of CCD, but the researchers who are leading the effort to find out why are now focused on these factors:
>
> - Increased losses due to the invasive varroa mite (a pest of honey bees).
> - New or emerging diseases such as Israeli Acute Paralysis virus and the gut parasite Nosema.
> - Pesticide poisoning through exposure to pesticides applied to crops or for in-hive insect or mite control.
> - Stress bees experience due to management practices such as transportation to multiple locations across the country for providing pollination services.
> - Changes to the habitat where bees forage.
> - Inadequate forage/poor nutrition.
> - Potential immune-suppressing stress on bees caused by one or a combination of factors identified above."

KEY TAKEAWAYS

- The biggest mortality issue facing beekeepers is colony collapse disorder, which is unrelated to climate change.
- Despite CCD, the U.S. Department of Agriculture reports U.S. honey production has remained steady.
- Market demand for honey in the United States has increased, and is being met by imported honey. With honey to spare from other countries, there is no evidence that global climate change is reducing bee populations or honey production.

Climate change is not among the myriad factors indentified by EPA researchers as contributing to CCD. Moreover, it is very likely that since wild and domestic bees share pollination zones, CCD's invasive varroa mite has been transmitted to wild honeybees as well.

The widely cited 2021 study claimed rising temperatures pose a threat to wild honey bees, saying: "[The] study found that the most critical factor influencing wild bee abundance and species diversity was weather, particularly temperature and precipitation."[3] The study then went on to cite "very hot summers" as a primary cause to bee loss.

There has been a modest increase in average temperature over the past century in North America; however, record-setting high summer temperatures have not been increasing at all. In fact, as the EPA notes, most record-high temperatures occurred during the Dust Bowl in the 1930s.[4]

Additionally, despite issues with CCD and modestly higher temperatures, the United States has managed to maintain steady honey production according to the U.S. Department of Agriculture (USDA), as seen in Figure 2.

However, demand for honey in America has increased and is being met by increased imports. According to the USDA:

"U.S. imports of honey have surged by 73 percent in the last 10 years, reaching a near-record 433 million pounds in 2020. While domestic honey production has remained stable at around 156 million pounds per year, American consumers' taste for honey and honey-sweetened products has grown."[5]

Data show there is honey to spare for the U.S. market and suggests any global bee crisis is unrelated to climate change.

Finally, *The New York Times* published a story on August 19, 2023 stating that, "conservationists are trying — and mostly failing — to combat the widespread belief that honey bees are in danger."[6]

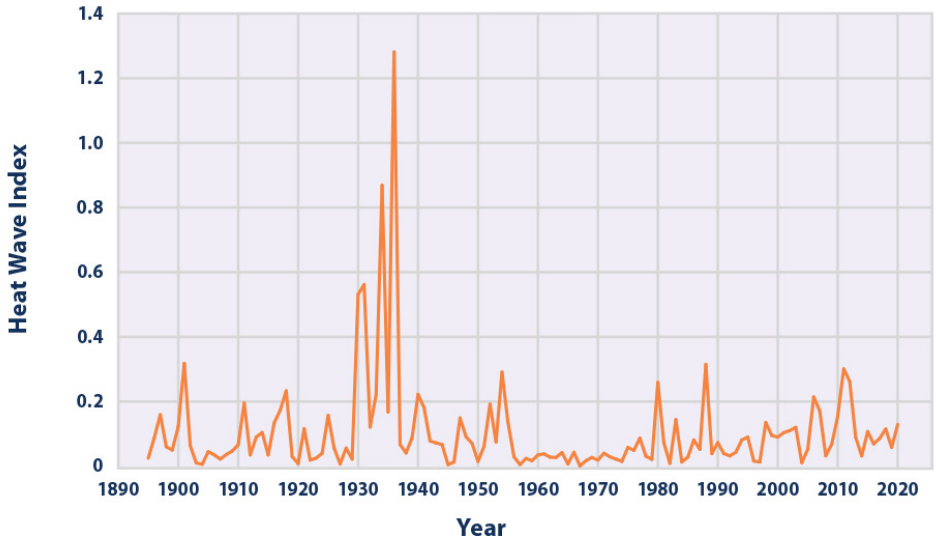

Figure 1. This figure shows the annual values of the U.S. Heat Wave Index, from 1895 to 2020. These data cover the contiguous 48 states. This index defines a heat wave as a period lasting at least four days with an average temperature that would only be expected to occur once every 10 years, based on the historical record. The index value for a given year depends on how often heat waves occur and how widespread they are. Source: Graph from Environmental Protection Agency, "Climate Change Indicators: Heat Waves," https://www.epa.gov/climate-indicators/climate-change-indicators-heat-waves

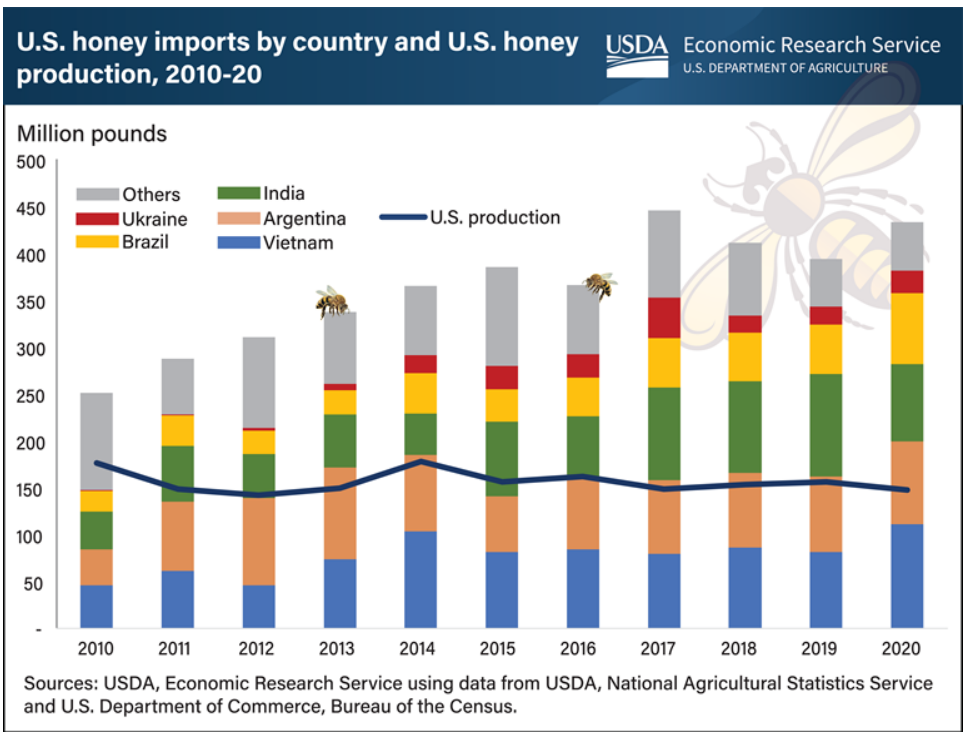

Figure 2. Demand for honey increasingly met through imports as U.S. production plateaus. Source USDA.

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THE GREAT BARRIER REEF

Coral has existed for 60 million years, surviving temperatures and carbon dioxide levels significantly higher than today.[1]

Objective scientific evidence refutes claims in recent decades that warming oceans and coral bleaching are resulting in a decline of the Great Barrier Reef (GBR). For more than a decade, scientists and the media have warned the GBR would be almost gone today due to climate change.[2] This claim was based on a single scientific study published in 2012 that analyzed GBR coral loss over a 27-year period.[3] The researchers primarily blamed coral bleaching in response to warmer waters and tropical cyclones, suggesting both are exacerbated by climate change and the GBR's decline.

A 2021 report from Australian Institute of Marine Science (AIMS) showed that the amount of coral impacted by recent bleaching events—which was claimed to be 93 percent—was actually much less than reported by researchers and media. In addition, as has occurred at coral reefs around the world that have suffered bleaching, most of the GBR's corals have recovered.

In 2021, AIMS reported 22 percent of the GBR had bleached. AIMS also discovered more than 75 percent of the bleached coral had recovered. AIMS wrote, "After a series of severe and widespread disturbances over the last decade, the Great Barrier Reef is currently in a recovery window with coral cover rising in all three regions."[4]

The AIMS 2022 report on the GBR contained more good news:[5]

"Continued coral recovery leads to 36-year highs across two-thirds of the Great Barrier Reef."

KEY TAKEAWAYS

- Coral coverage on the Great Barrier Reef set the record for the highest amount measured in 36 years of consistent record keeping by the Australian Institute of Marine Science in 2022, breaking the record set the previous year.
- AIMS' survey of the GBR found that between August 2021 and May 2022, average hard coral cover in the upper region and central areas of the reef increased by around one-third.
- Coral has existed continuously for the past 60 million years, surviving temperatures and carbon dioxide levels significantly higher than what is occurring today.

As seen in Figure 1, the 2022 data show the rise in coral coverage in the GBR since 2019 has been dramatic.

Over the past 36 years of monitoring, coral reefs in the GBR have shown an ability for recovery after disturbances such as tropical storms and coral bleaching events. In 2022, widespread recovery has led to the highest coral cover recorded in the Northern and Central GBR, largely due to increases in the fast-growing Acropora corals, which are the dominant group of corals on the GBR.[6]

Data show the GBR's corals are thriving and expanding, as is true for other coral reefs around the world, providing clear evidence climate change is not causing their decline.

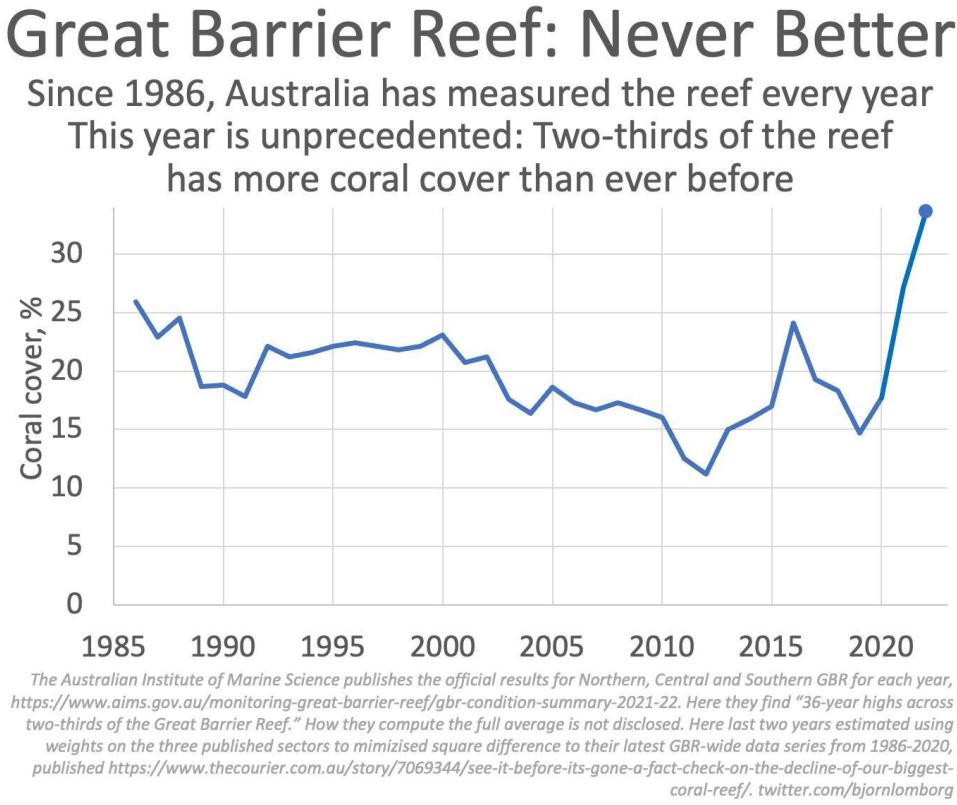

Figure 1: Australian Institute of Marine Science GBR coral coverage data plotted by Bjorn Lomborg.

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GLOBAL GREENING

Plant life is integral to the biosphere.[1] Plants take CO2 in, and via the process of photosynthesis, turn it into oxygen and water vapor that is released into the atmosphere. During photosynthesis, plants combine water, CO2, nutrients, and energy (light) to grow.[2]

Liebig's law of the minimum, which defines the most limiting resource in photosynthesis, says that if one of those elements increases—all other elements remaining equal—growth will occur.[3] Carbon dioxide concentration has increased in Earth's atmosphere over the past century, and plants have benefited from the extra CO2, producing a general greening of the planet.[4]

NASA satellite imagery has recorded this greening and quantified it in the normalized difference vegetation index (NDVI), created to measure the vegetative cover on the surface.[5] The NDVI also identifies water, deserts, and ice.

In 2016, NASA reported that up to half of Earth's vegetated lands have shown significant greening over the past 35 years, largely due to rising levels of atmospheric carbon dioxide. From 2000 to 2020, NASA measured a 10 percent greening of the globe. The greening represents a net increase in leaves on plants and trees equivalent in area to two times the size of the continental United States.[6] (See Figure 1 below.)

NASA's results confirm earlier research that found the 14 percent increase in atmospheric CO2 from 1982 to 2010 resulted in up to a 10 percent increase in green foliage cover in warm, arid environments.[7]

Plant life is not just expanding in temperate regions. A 2018 study found the Sahara Desert had shrunk in area by 8 percent over the previous three decades, due to a CO2-fertilization-induced expansion of plant coverage.[8]

A follow-up study in 2020 found that on a global scale: greening can be attributed to the increase of carbon dioxide in the atmosphere; it has produced a beneficial cooling effect; and the increased plant growth is acting as a significant carbon sink.

KEY TAKEAWAYS

- NASA satellite imagery analysis shows significant plant growth globally over the past 35 years.
- Studies from NASA and several other sources conclude that increased plant growth is a response to rising carbon dioxide in the planet's atmosphere, which creates better growing conditions.
- The increased plant coverage mitigates surface warming due to increased efficiency of heat and water vapor transfer to the atmosphere.

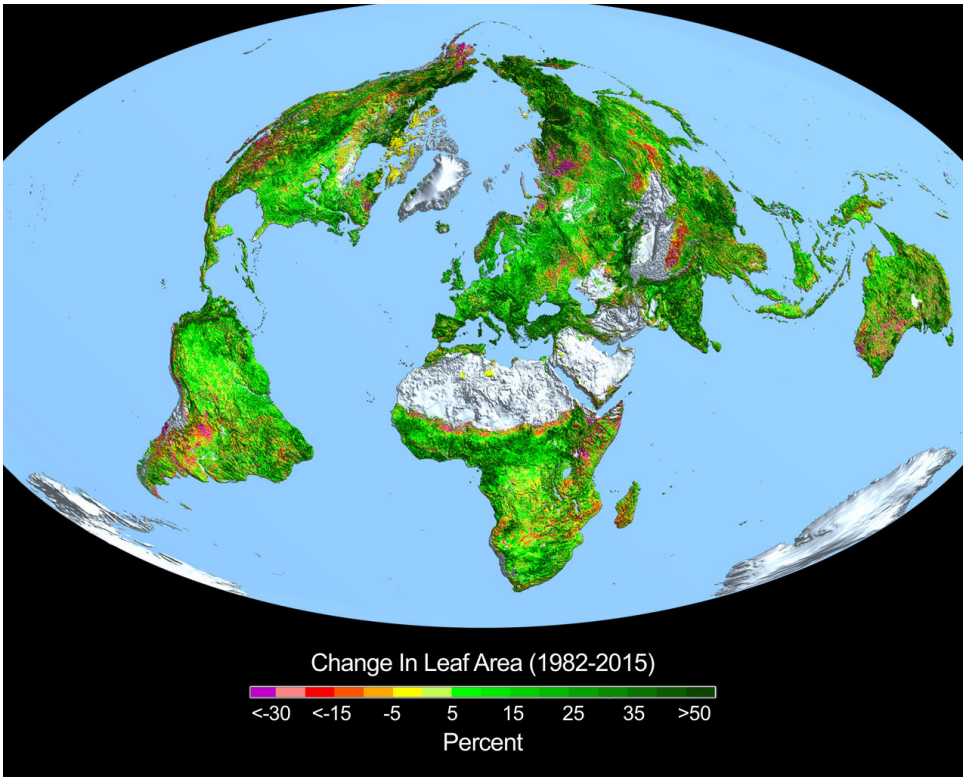

Figure 1. This image shows the change in leaf area across the globe from 1982-2015 detected by satellite. Credits: Boston University/R. Myneni. Image source: NASA

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CONSENSUS

Science entails an objective evaluation of evidence, not a vote or show of hands. Yet, even if one were to accept the erroneous premise that "scientific consensus" is important, there is significantly less consensus on climate change than the mainstream media and climate alarmists claim. In fact, multiple polls of climate experts in the scientific community indicate that while most scientists agree humans are responsible for some warming, there is significantly less agreement about the degree to which humans are responsible and whether that warming is cause for concern.

For example, one survey conducted by Fairleigh Dickenson University in 2022 found that just over half (59 percent) of the survey respondents expect climate change to cause "significant harm."[1] The survey polled only professionals and academics who held at least a bachelor's degree in the fields of meteorology, climatology, physics, geology, and hydrology. Among respondents with the most experience—those over the age of 50—less than half (44 percent) believe climate change will significantly reduce human living conditions. That is nowhere near a consensus.

Other surveys indicate similar disparities amongst scientists, with many rank-and-file members of organizations such as the American Meteorological Society (AMS) expressing a lack of consensus concerning the degree to which human activities cause global warming.[2] Yet, the AMS bureaucracy has issued statements asserting humans are creating a climate crisis. Position statements produced by science organizations such as the AMS are

KEY TAKEAWAYS

- Scientific truth is determined by facts and evidence, not a show of hands. "Consensus" is a political term, not a scientific one. Historically, consensus positions in science have commonly been wrong.
- Most scientists, including climate skeptics, believe the Earth is warming and humans are playing a role. However, polls show many scientists are not overly concerned about the level of warming and its purported impacts.
- The claim that 97 percent of climate scientists believe humans are causing catastrophic climate change is false.
- The key debate between alarmists and skeptics is the issue of impacts, not whether humans are causing some warming. And many scientists do not believe these effects will be catastrophic or even harmful.

often merely the opinions of the groups' politicized bureaucracies rather than the member scientists.[3]

Claims that 97 percent of scientists believe humans are causing catastrophic climate change have been refuted by multiple careful analyses.[4,5,6,7]

Finally, numerous prominent scientists and scientific organizations have openly and consistently rejected the view that humans are causing a climate change catastrophe. Clintel (the Climate Intelligence Group) is one such organization. Clintel produced a World Climate Declaration,[8] which among other points states that: natural as well as anthropogenic factors cause warming; warming is occurring at a far slower pace than predicted; climate policy relies on inadequate and overheated climate models; carbon dioxide is plant food, the basis of all life on Earth; and global warming has not increased deaths from natural disasters.[9,10,11]

As of July 2025, at least 2,000 scientists and experts have signed this declaration, including prominent researchers at MIT, Harvard, Columbia, Princeton, and the University of Pennsylvania, as well as researchers at other respected academic institutions and research organizations around the world.

Other climate realists have served as official state climatologists or have worked for important government agencies, such as NASA and NOAA. Among the many influential scientists who have questioned the causes and/or consequences of the alleged climate change "consensus" are several giants of the scientific world from the past half century, such as Nobel Prize laureates John F. Clauser and Ivar Giaever, as well as Freeman Dyson, S. Fred Singer, Richard Lindzen, Will Happer, and Steven Koonin.[12]

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U.S. TEMPERATURES

The United States has experienced no significant warming since at least 2005. The lack of warming is documented by the National Oceanic and Atmospheric Administration's U.S. Climate Reference Network (USCRN), an extremely accurate network of temperature stations located throughout the United States. Unlike other temperature data, USCRN data does not require corrective adjustments to account for factors that may compromise the accuracy of recorded temperatures.

Figure 1 illustrates there has been no significant increase in the number of temperature anomalies since the start of 2005.[1,2] Thus, when climate activists have claimed in recent years that warming has caused various U.S. environmental problems, their assessments cannot be accurate, unless they can show that USCRN data are wrong. To date, no credible scientific agency has claimed the USCRN data are inaccurate.

Further, long-term warming in the United States has been modest, at worst. Thermometer readings report current temperatures are no higher today than they were 80 years ago, a reality that has been masked in large part by government agencies that have chosen to adjust temperatures from past decades downward, making it appear as though recent temperatures are comparably much higher than the unadjusted data suggest. (See Figure 2.)

The poor placement of temperature stations that are not part of the Climate Reference Network is another factor biasing temperature data upward. Many stations are affected by urbanization, resulting in temperature inaccuracies.[3, 4, 5]

The raw, unadjusted data, shown in Figure 2, clearly illustrate recent temperatures are likely the same or nearly the same as they were in the 1930s, and perhaps even lower.[6]

KEY TAKEAWAYS

- There has been no significant warming in the United States since at least 2005.
- Any claimed recent warming at specific locations in the United States is isolated and indicative of natural variation and urbanization rather than a broad, long-term warming trend.
- Thermometer readings in the United States suggest current temperatures are similar to the temperatures recorded eight decades ago.

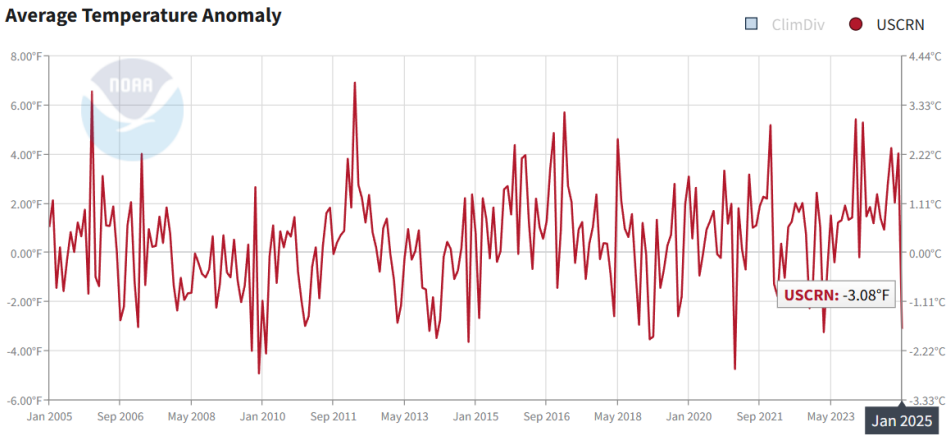

Figure 1. Average surface temperature anomalies in the United States, January 2005 to January 2025. Source: U.S. Climate Reference Network, ncei.noaa.gov, National Climatic Data Center, National Oceanic and Atmospheric Administration.

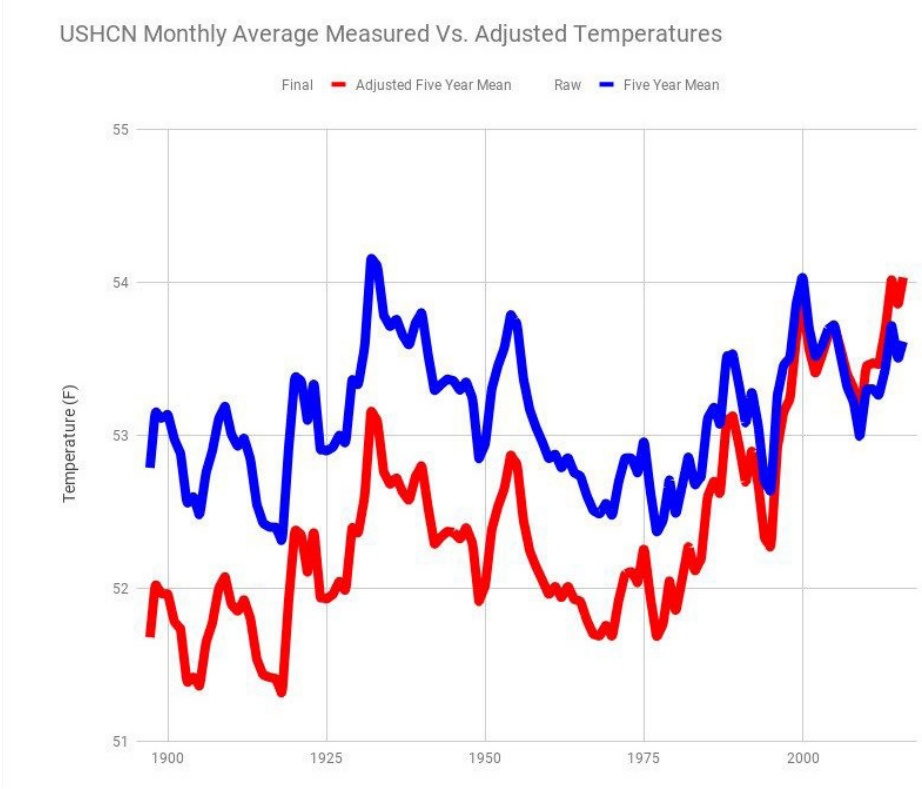

Figure 2: U.S. Historical Climatology Network (USHCN) data. The blue line represents unadjusted thermometer readings, which show temperatures are no higher now than they were 80 years ago. Source: Tony Heller, "61% Of NOAA USHCN Adjusted Temperature Data Is Now Fake," realclimatescience.com, February 11, 2019: https://realclimatescience.com/2019/02/61-of-noaa-ushcn-adjusted-temperature-data-is-now-fake

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CARBON DIOXIDE SATURATION IN THE ATMOSPHERE

There are many greenhouse gases in Earth's atmosphere, of which water vapor is by far the most prevalent and powerful. Carbon dioxide (CO2) is a trace gas comprising just four parts per 10,000 of Earth's atmosphere, up from three parts per 10,000 a century ago. The ability of CO2 to "trap" heat is limited and reaches 99 percent of its potential at four parts per 10,000. Recent research suggests that CO2 is already fully or nearly saturated, with additional CO2 having a minimal effect at present levels.[1] As a result, fretting over new coal or natural gas power plants or any other sources of new CO2 emissions is pointless from a climate perspective.

The chart in Figure 1 below is produced by Will Happer, professor emeritus at Princeton University, and Richard Lindzen, professor emeritus at the Massachusetts Institute of Technology. Happer and Lindzen are quite possibly the two most expert atmospheric physicists in the world. The chart illustrates how CO2 has already reached its near totality of heat-trapping potential.[2]

The smoothly curved blue line is the amount of heat that would radiate back into space if Earth's atmosphere had no greenhouse gases. The jagged black line shows how much heat is radiated into space under current greenhouse gas concentrations. The jagged green line shows how much and in which spectrums heat would radiate into space if there were no CO2 in the atmosphere. The jagged red line shows how much heat would radiate into space under a doubling of CO2 compared to present levels. The difference between the black line and the red line is how much additional

KEY TAKEAWAYS

- CO2 can absorb longwave radiation, which translates to retained warmth in only certain parts of the atmospheric spectrum and in finite amounts.
- Atmospheric CO2 has already reached 99 percent of its potential saturation level for absorbing warmth.
- More CO2 in the atmosphere will have virtually no impact on future temperatures, as near-saturation for absorbing warmth has already occurred.
- Restricting or phasing out conventional energy will do nothing for global temperatures and is scientifically pointless.

radiation would be trapped if CO2 concentrations double from present values. As shown by the chart, that difference is miniscule and would impact global temperatures by an imperceptibly small amount.

This concept is illustrated in a simpler way in Figure 2 below.[3]

In short, adding more CO2 to the atmosphere will have essentially no impact on global temperatures.

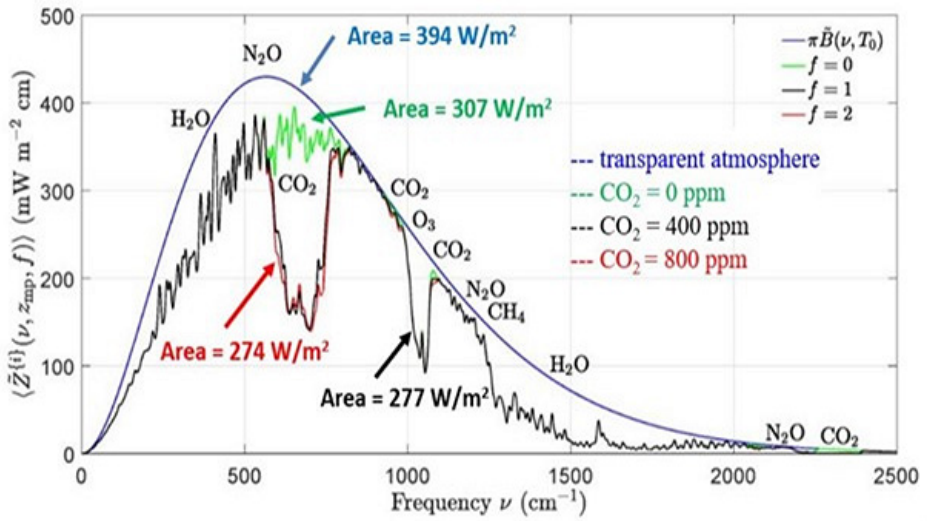

Figure 1: A graph of transparency of the atmosphere with three different concentrations of carbon dioxide. Source: W. Happer and R. Lindzen, "Comment and Declaration on the SEC's Proposed Rule "The Enhancement and Standardization of Climate-Related Disclosures for Investors," File No. S7-10-22, 87 Fed. Reg. 21334 (April 11,2022)

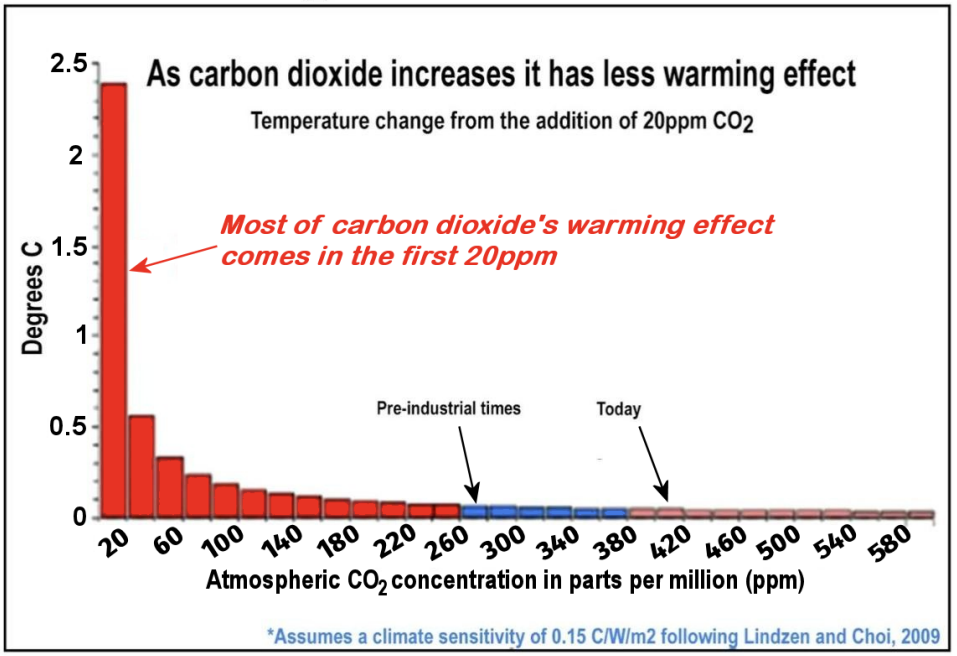

Figure 2: Atmospheric carbon dioxide saturation versus temperature increase, based on data from Lindzen and Choi, 20093. Note that CO2 becomes less and less effective (at a logarithmic rate) as its atmospheric concentration increases. Thus, there is limited opportunity for additional CO2 to cause heating.

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THE SUN'S IMPACT ON CLIMATE CHANGE

The Sun's heat and energy output varies over time rather than being constant or steady.[1] Scientists have been able to reconstruct the Sun's heat output going back hundreds of years. The data show changes in global temperatures have almost perfectly mirrored variations in the Sun's heat output throughout the past several hundred years, including during our current period of modest warming.

In Figure 1 below, scientists reconstructed changes in the Sun's energy output going back to AD 1600. The data, published in the peer-reviewed journal *Geophysical Research Letters*, show the Sun's energy output bottomed out in the 1600s, experienced a steep increase during the 1700s, plateaued in the 1800s, and then experienced another sharp increase during the 1900s.[2]

In the bottom image in Figure 2 below, the United Nations Intergovernmental Panel on Climate Change (IPCC) published Earth's temperature history during the same time period as the chart above. According to the IPCC, Earth's temperature changes since the 1600s almost perfectly match changes in the Sun's energy output throughout this time, including the present period of recent warming.[3]

In Figure 3 below, scientists have compared changes in the Sun's energy output, changes in atmospheric carbon dioxide levels, and changes in Northern Hemisphere temperatures (which are similar to changes in global temperatures). The top graph shows temperatures during the past 100-plus years, which almost perfectly mirror changes in the Sun's energy output. The bottom graph shows temperatures exhibiting little if any correlation with changes in Earth's atmospheric carbon dioxide levels.[4]

With global temperatures over many centuries mirroring changes in the Sun's energy output, it is not surprising that the same correlation continues recently, as well.

Not only does an increase in the Sun's energy output directly increase heating of the Earth, but scientists have

KEY TAKEAWAYS

- Scientific measurements show the Sun's heat and energy output varies over time.
- Changes in the Sun's heat and energy output have long been the most important factor driving climate change on Earth.
- A substantial increase in solar output during the 20th century likely explains much, and perhaps most, of recent warming.

presented evidence that more energy output from the Sun increases solar wind, which indirectly reduces the Earth's cloud cover. Less cloud cover results in more sunlight hitting the surface of the Earth, which amplifies the impact of the direct increase in the Earth's temperature from an increase in the Sun's energy output. Other scientists have presented experimental evidence that solar activity influences the volume of cosmic rays entering the atmosphere, which also impacts cloud formation.[5]

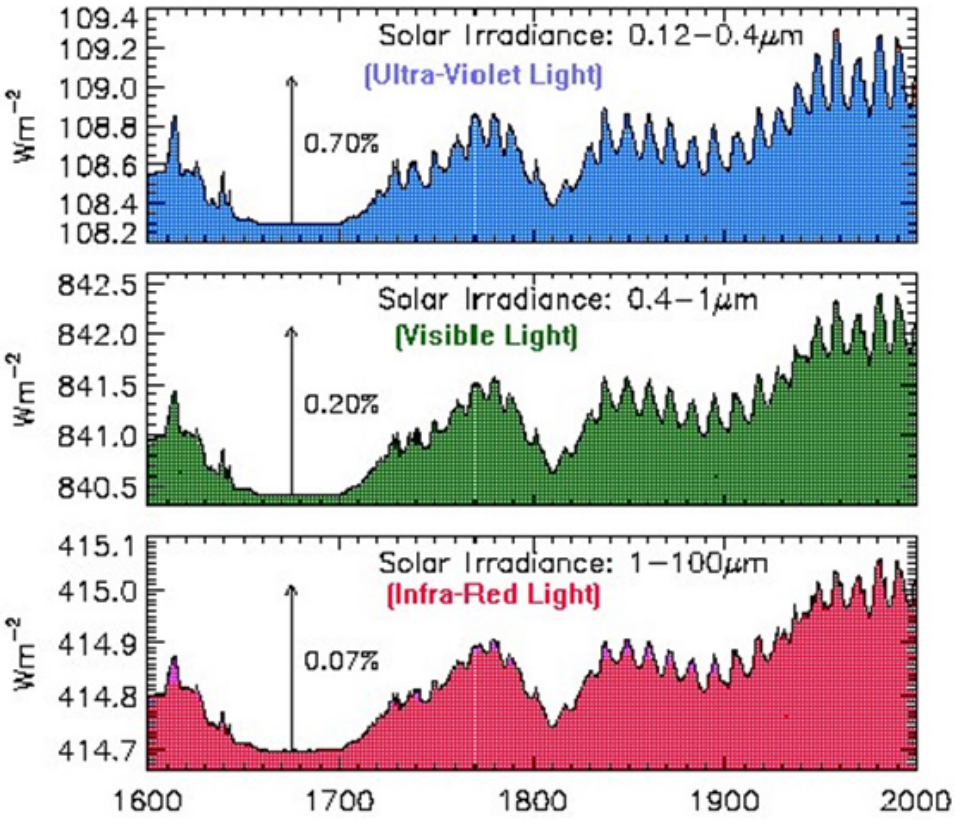

Figure 1. Changes in the Sun's energy output since 1900. The Sun's energy output has increased since the 1600s with its most recent increase occurring during the 20th century. Source: J. Lean, Geophysical Research Letters, Vol 27, No. 16 (2000); https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2000GL000043.

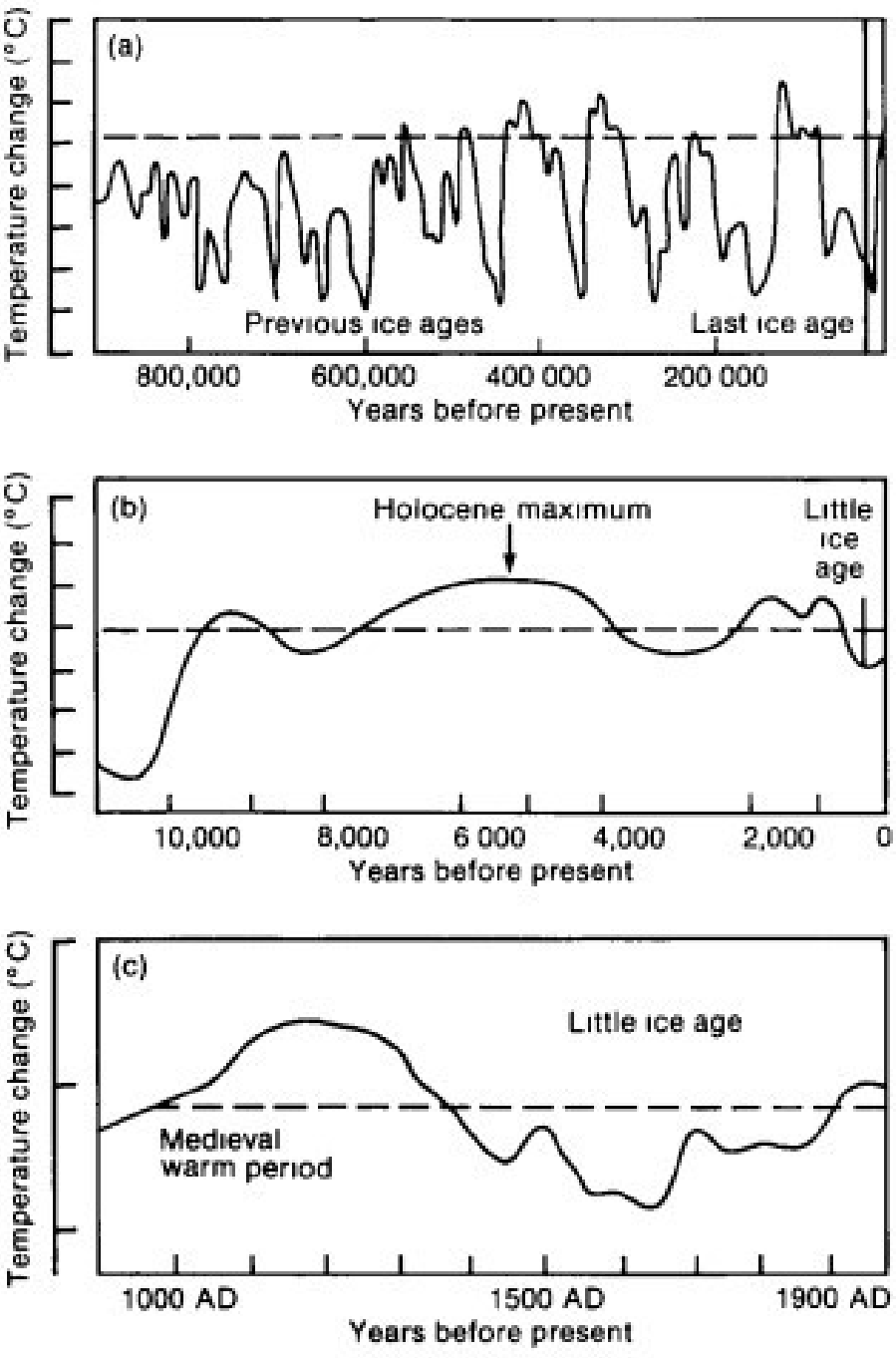

Figure 2: Temperature history according to the United Nations IPCC First Assessment Report. The top graph shows temperatures during the past 1 million years. The middle graph shows temperatures during the past 12,000 years. The bottom graph shows temperatures during the past 1,000 years. Present temperatures are at the far right. Temperatures in recent centuries closely mirror changes in the Sun's output, as shown in Figure 1. Source: IPCC First Assessment Report, United Nations, p. 202, https://archive.ipcc.ch/ipccreports/far/wg_I/ipcc_far_wg_I_chapter_07.pdf.

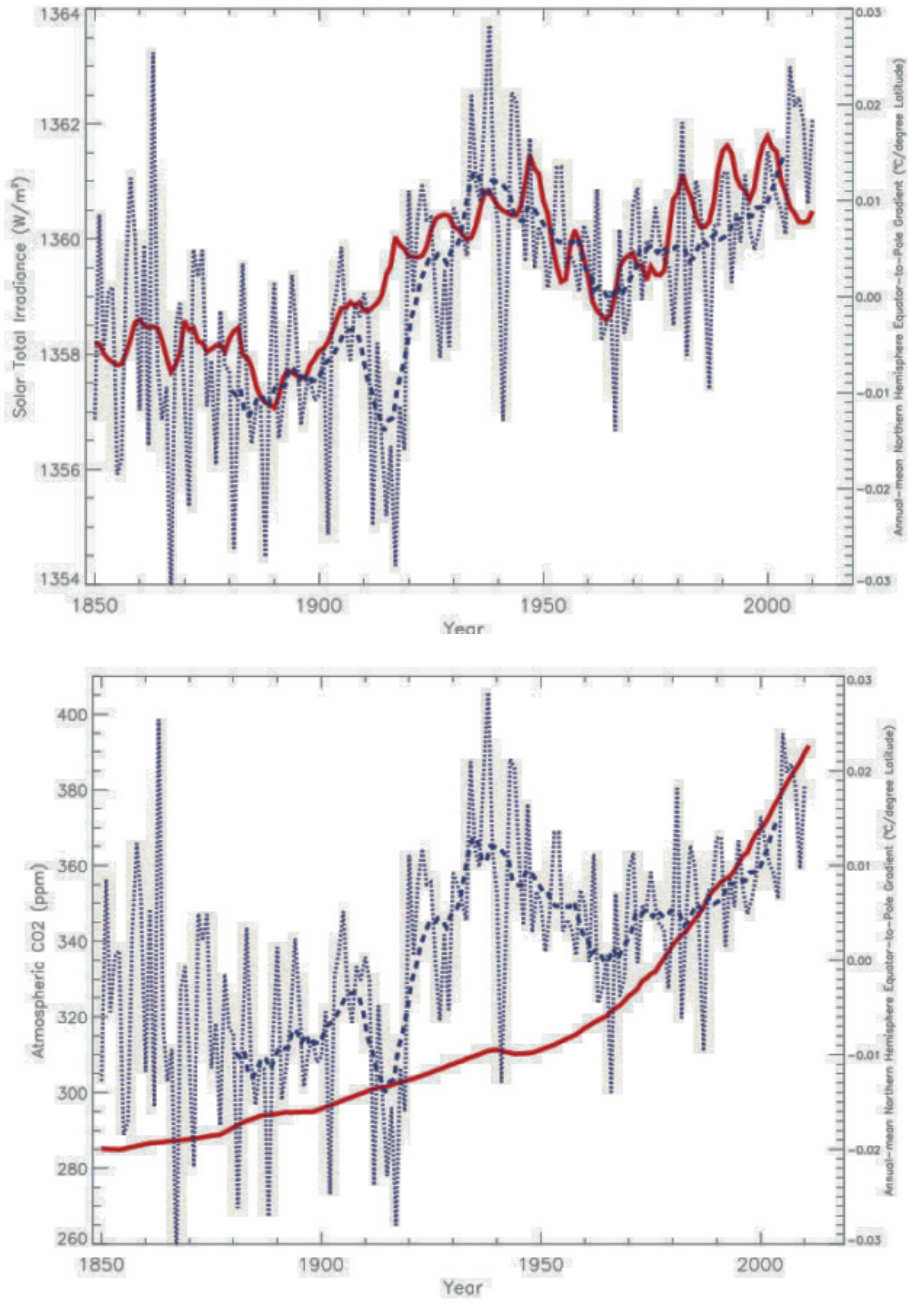

Figure 3: Temperature changes vs. changes in the Sun's energy output and changes in atmospheric carbon dioxide concentrations. The top graph shows 20th century temperature changes in blue vs. changes in the Sun's energy output in red. The bottom graph shows 20th century changes in blue vs. changes in atmospheric carbon dioxide emissions in red.

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ATMOSPHERIC RIVERS

Atmospheric rivers are long, concentrated regions in the atmosphere that transport moist air from the tropics to higher latitudes. In Figure 1, satellite imagery from October 2017 illustrates how the long train of moisture, originating in Asia, makes its way across the Pacific Ocean to reach the U.S. West Coast.[1]

As shown in Figure 2—produced by the National Oceanic and Atmospheric Administration—moisture-laden air and high wind speeds combine to produce heavy rain and snow upon landfall. This is especially true over mountainous terrain, such as in California, Oregon, and Washington.[2]

Extreme winter snowfall and rainfall are not uncommon, and not always the result of an atmospheric river (AR) event. The West Coast has always been prone to atmospheric-river-related severe weather episodes. From late 1861 into January 1862, the largest-ever atmospheric river event hit the West Coast.

Known as the Great Flood of 1862, it was the largest in California's recorded history. Weeks of continuous rains and snows in high elevations began November 1861 and continued into January 1862. This AR event dumped an equivalent of 10 feet of water on California, as rain and snow, over 43 days.[3]

That AR event flooded the Sacramento Valley, including Sacramento itself, causing the capitol to be moved temporarily to San Francisco.[4]

The U.S. Geological Survey (USGS) investigated historical AR events by drilling core samples in San Francisco

KEY TAKEAWAYS

- The phrase "atmospheric river" is often erroneously used by the media attempting to link climate change and excessive rainfall events on the U.S. West Coast.
- Atmospheric rivers are natural and normal parts of our global weather patterns, happening on the U.S. West coast every one to three years on average.
- Geological science has shown that extreme atmospheric river events have occurred on the U.S. West Coast as far back as AD 212, occurring on average every 200 years.
- Claims that climate change is making more severe atmospheric rivers are not supported by observational evidence, research on the phenomenon, or computer model projections.

Bay and in lake and marsh sediments throughout California.[5] The study positively identified the stream gravels deposited by the Great Flood of 1862. Core samples indicated that similar and even more devastating flooding occurred in AD 212, 440, 603, 1029, 1418, and 1605 — roughly every 200 years.

The USGS concluded that "[t]he geologic record shows 6 mega-storms more severe than 1861-1862 in California in the last 1800 years, and there is no reason to believe similar events won't occur again."[6]

Recent computer model simulations of the AR phenomena do not support claims that AR events are likely to become more severe or numerous in the future.[7]

Long-term observational and paleoclimatological records provide no support for claims that AR events have become more frequent or severe during the recent period of modest warming, nor do records support that such events are the result of climate change.

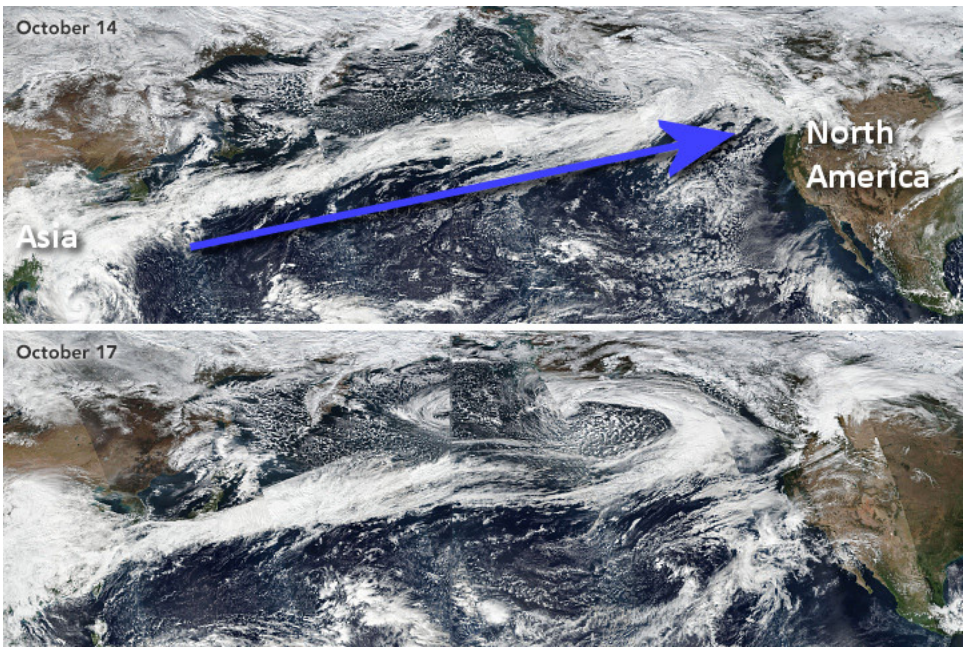
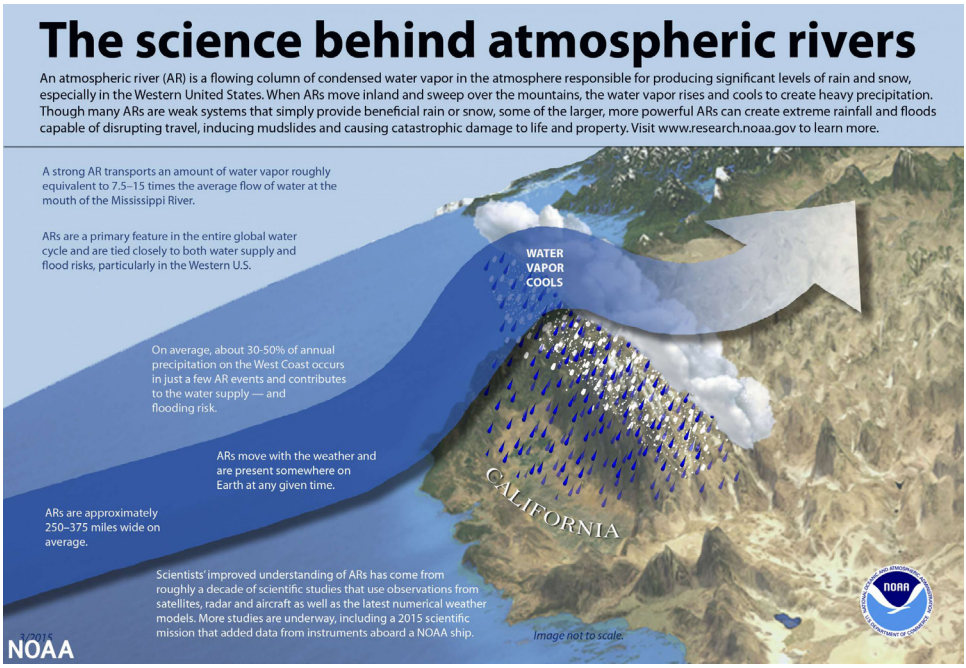


Figure 1. Composite satellite photos of an atmospheric river in the Pacific Ocean connecting Asia to North America in October 2017. The blue arrow shows the direction of travel. Original imagery from NASA Earth Observatory, annotation by Anthony Watts.



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CLIMATE MODELS VS. MEASURED TEMPERATURE DATA

Climate models projecting strong future global warming rates are often cited as demonstrating the need for immediate action to fight rapid climate change.[1,2] However, multiple lines of real-world data show the actual measured rate of warming is relatively mild and less than half the rates displayed by climate models.

A peer-reviewed scientific study by Alabama State Climatologist John Christy confirms this. Christy's research shows the climate model projections far outpace actual measurements, as seen in Figure 1.[3] Christy also presented his findings in congressional testimony.[4]

Figure 1 illustrates that actual measurements using satellites, weather balloons, and surface temperatures are in generally close agreement while climate models have strongly diverged from actual temperature measurements.

Figure 2 shows that every one of the climate models overstates measured warming. This suggests a fundamental failure with the scientific assumptions going into and the programming of the CMIP6 climate models.

A recent peer-reviewed study confirms what is shown in Figures 1 and 2, saying science recognizes a "hot model problem."[5]

Based on the observable, real-time data, the climate models run way too hot, producing implausibly high warming outputs.[6] Climate models that have run too hot in the past are highly likely to be predicting too much warming in the future, also.

KEY TAKEAWAYS

- Climate activists and the mainstream media often claim global temperatures have dramatically increased due to climate change, citing climate model temperature projections to support their claims.
- Actual data from satellites, radiosonde weather balloons, and surface temperature measurements show a warming rate of less than half that predicted by climate models.
- Not a single climate model's projections match real-world observations made today.

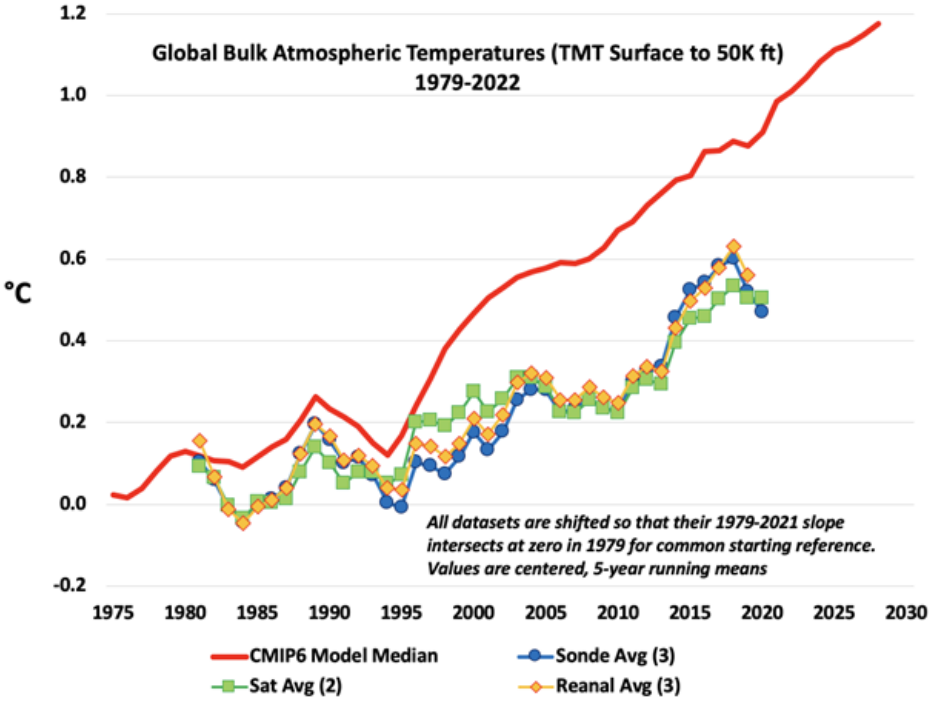

Figure 1: Comparison of global warming trends from 1979 to 2022 between CMIP6 climate models (median of all models in red) compared to average of satellite derived temperature measurements (green), average of weather radiosonde balloons (blue), and reanalysis of average surface temperature measurements (orange). Note the red line indicating climate model temperatures has rates of warming that are nearly double that of actual measurements in 2022. Graph by John Christy, PhD.

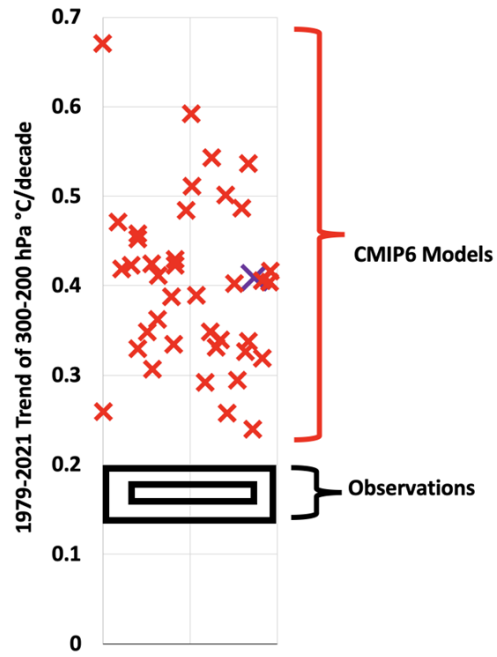

Figure 2: comparison of thirty-five CMIP6 climate model rates of warming from 1979-2021 (each indicated by a red X, with the mean value of all models indicated by a purple X) versus the average value of all real-world observations in the black box. Not a single CMIP6 climate model hits the target matching real-world observations made today. Chart by John Christy, PhD.

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NATURAL VS. HUMAN CONTRIBUTIONS TO GREENHOUSE GASES

Greenhouse gases make up no more than 2 percent of Earth's total atmosphere.[2] However, they are critical to making the planet habitable—keeping the planet from being a freezing rock in space like Mars.[3]

Carbon dioxide (CO2) has been directly measured in Earth's atmosphere since 1958.[4] CO2 concentrations are increasing in the atmosphere, in large part due to human activities, such as emissions from the burning of fossil fuels for energy.[5] Computer models project that rising CO2 concentrations will cause an increase in average global temperature through the greenhouse effect.[6]

The global atmospheric CO2 concentration trend is seen in Figure 1.[7, 8, 9]

Increases in CO2 began in 1850, coinciding with the end of the Little Ice Age and can be partly explained by outgassing of CO2 from the oceans as the planet modestly warms.[10,11] An analysis of the Earth's atmosphere shows:

- Greenhouse gases make up no more than 2 percent of the Earth's atmosphere.
- Humans contribute approximately 3.4 percent of annual CO2.[12] The remaining 96.6 percent come from natural sources, like volcanoes, decaying plants/biomass, and

KEY TAKEAWAYS

- Throughout Earth's history, atmospheric carbon dioxide (CO2) levels have ebbed and flowed, but over time, there has been a long slow drawdown of CO2.[1]
- Recent increases in atmospheric CO2 began around 1850, well before electric power generation and the internal combustion engine were common features of society.
- The 1850 start point coincided with the end of the cold period known as the Little Ice Age, suggesting a natural rise in temperature increased global CO2 concentrations from the oceans.
- Humans contribute approximately 3.4 percent of annual CO2 emissions today, but only 0.28 percent of the greenhouse warming effect on Earth.

animal activity, seen in Figure 2 below.

- CO2 and other trace gases comprise only 5 percent of the greenhouse gases in the atmosphere. Water vapor makes up the other 95 percent and is the main warming driver of the greenhouse effect, contributing 97 percent of the total warming effect on Earth, seen in Figure 3 below.

Looking at all sources for the greenhouse effect shows human emissions only contribute 0.28 percent of the warming on Earth. Water vapor provides 97 percent of the warming effect in Earth's atmosphere.

Put another way, humanity is responsible for about one-quarter of 1 percent of the greenhouse effect. The remainder is natural. (See Figure 3 below.)

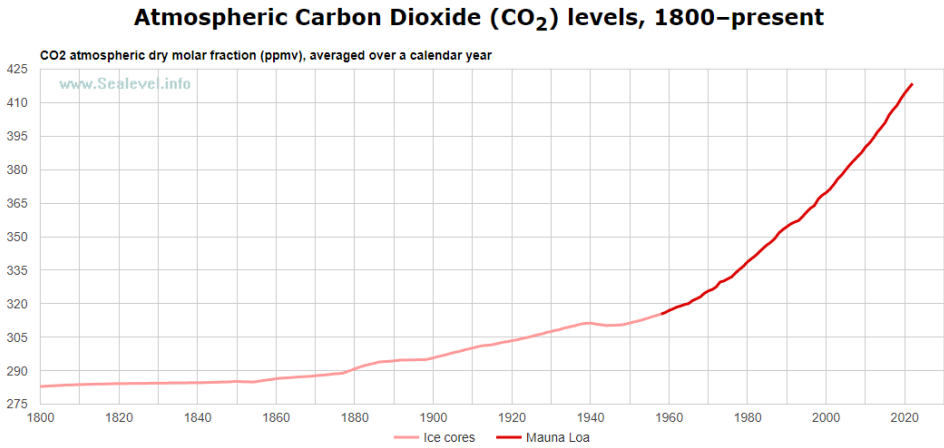

Figure 1: Global CO2 levels in parts per million since 1800, based on ice core samples and atmospheric measurements since 1958. Note that CO2 levels began an uptick in 1850 at the end of the Little Ice Age. Data Sources: sealevel.info, NOAA Mauna Loa Observatory, and NOAA ice core data. See references 7, 8, and 9.

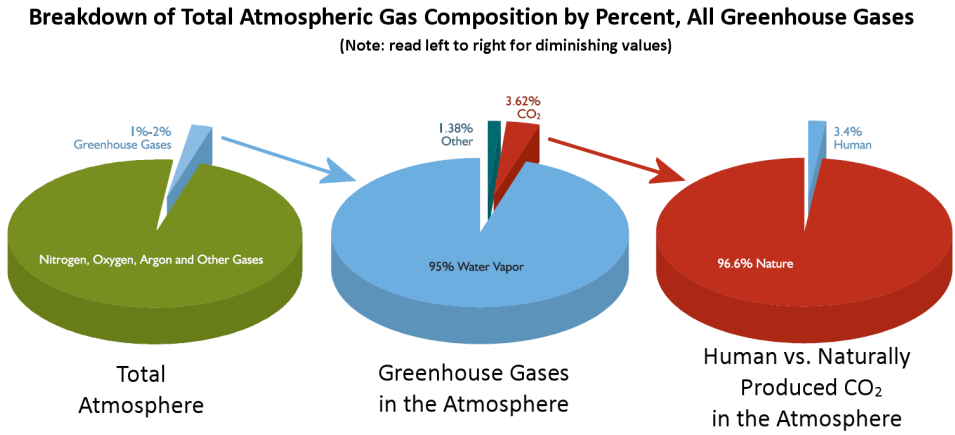

Figure 2: A breakdown of total atmospheric composition, all greenhouse gases, and human versus naturally produced carbon dioxide in Earth's atmosphere. Graphic by A. Watts adopted from NCPA Global Warming Primer. See Reference 13.

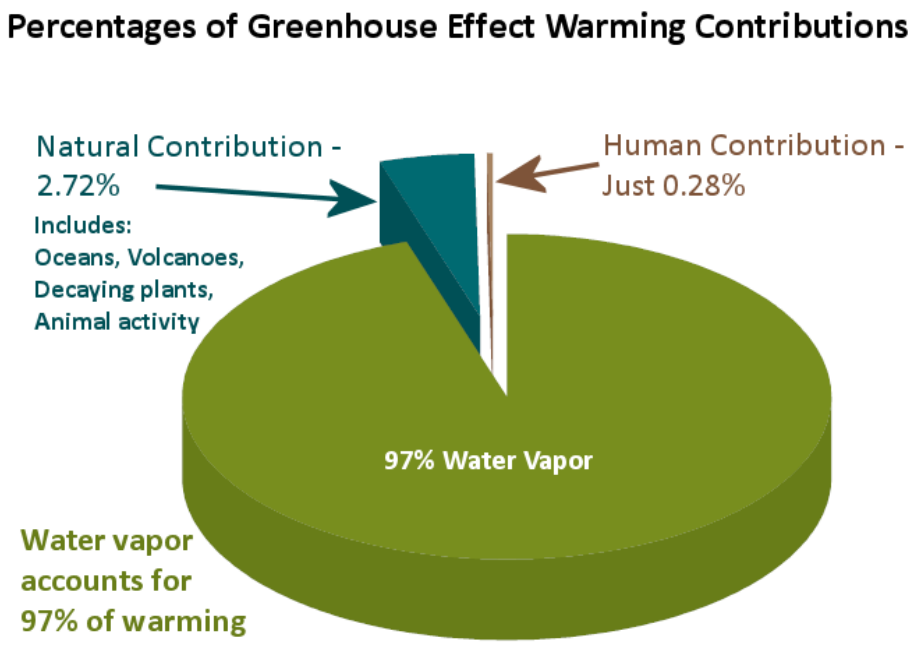

Figure 3: Breakdown of percentages of Earth's greenhouse warming by source. Water vapor source updated to use MIT value of 97 percent.13 Graphic by A. Watts adopted from original NCPA graphic. See Reference 13.

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EL NIÑO AND GLOBAL WARMING

According to the National Oceanic and Atmospheric Administration: "El Niño is a naturally occurring climate pattern associated with warming of the ocean surface temperatures in the central and eastern tropical Pacific Ocean, which can significantly influence weather patterns, ocean conditions, and marine fisheries worldwide."[1]

A major uncertainty in figuring out how much of the recent warming has been human-caused is not knowing how much nature has contributed. The the United Nations Intergovernmental Panel on Climate Change is quite sure that nature is responsible for less than half of the warming since the mid-1990s.[2] Predictably, many climate scientists, activists, politicians, and green energy pundits have claimed the modest warming is primarily human-caused. But real-world data show that natural El Niño events add to global warming, and it strongly impacts climate over time.

Examining the warming that occurred from 2000 to 2018, the record-setting El Nino event that took place between 2014-2016 caused increased sea surface temperature in the Pacific Ocean, which in turn increased global air temperature, as seen in Figure 1.[3]

That event created a "warm spike" in the global temperature record in 2015 and 2016, and caused increased global warming trends.[4]

KEY TAKEAWAYS

- El Niño events in the Pacific Ocean are natural patterns that have been going on for millions of years.
- El Niño events in the 21st century have had some very strong warming spikes.
- Since 2000, El Nino events account for almost half the warming of the twenty-first century.

Climate scientist Roy Spencer performed a calculation to remove the effect of the 2015/2016 El Niño event as seen in Figure 2 below.[5]

The result:

- The observed trend in HadCRUT4 surface temperatures is nearly cut in half compared to the CMIP5 climate model average warming over the same period, and the UAH tropospheric temperature trend is almost zero.
- The observed rate of warming—when we ignore the natural fluctuations in the climate system—is only about one-half of that projected by climate models at this point in the twenty-first century.

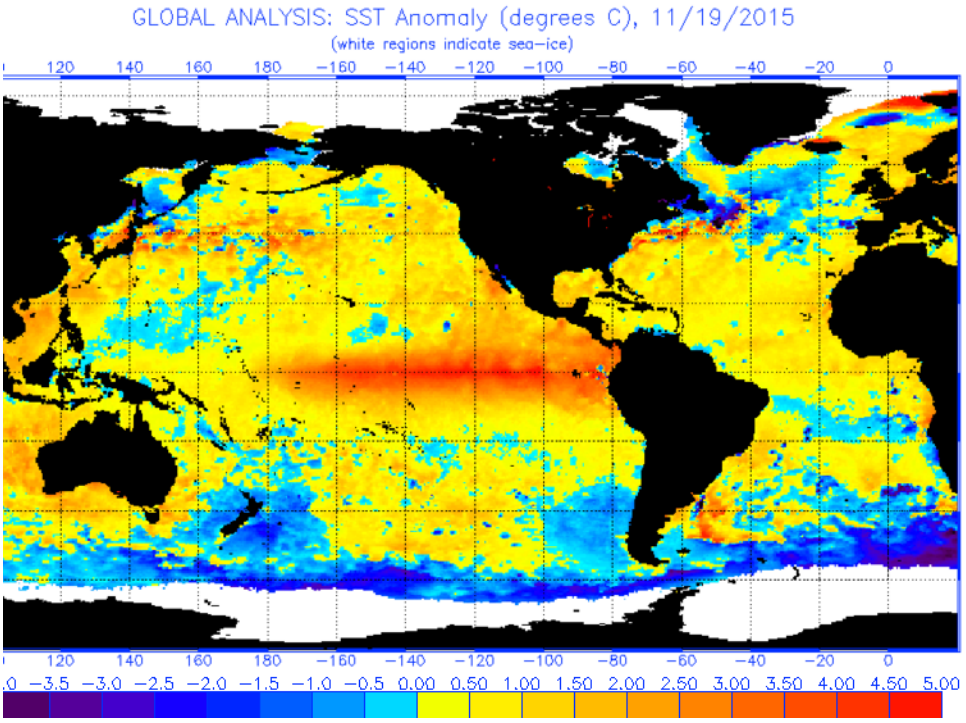
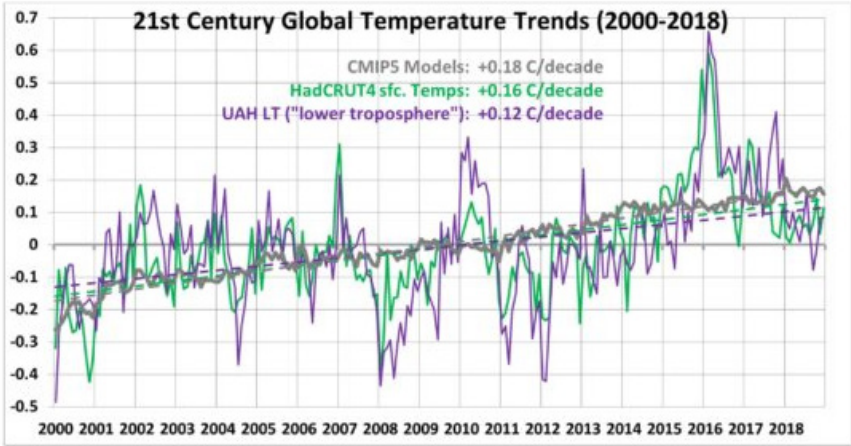


Figure 1: Satellite imagery showing a strong El Niño event in the Pacific Ocean in November 2015. Source: NOAA https://www.ospo.noaa.gov/Products/ocean/sst/anomaly/2015.html

With El Niño warming:

Even with the record warm 2015-16 El Nino, observed warming has not kept pace with climate model projections.



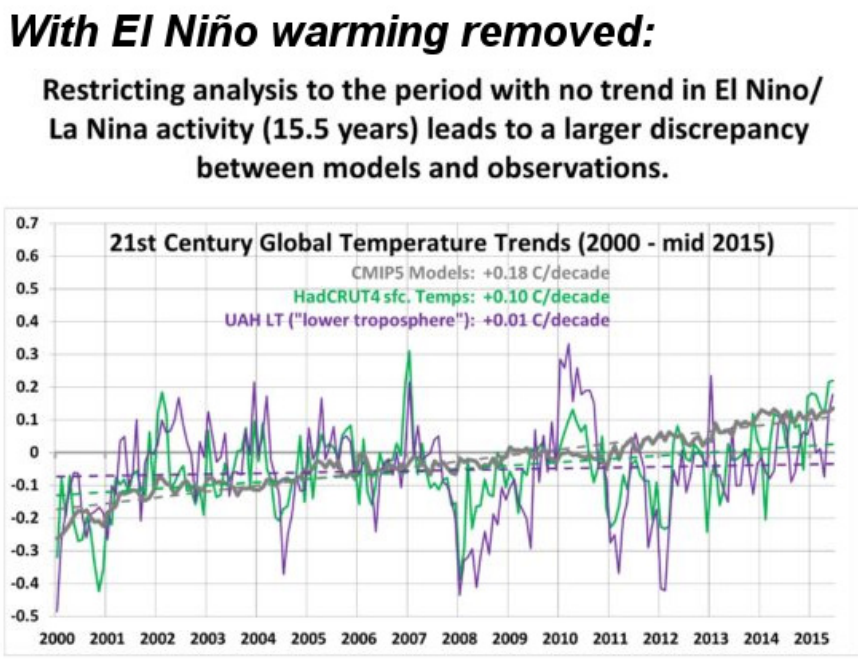


Figure 2: Comparison of warming trends for models, surface temperature, and satellite derived atmospheric temperature. Original data on the left, data with El Nino events removed on the right. Source: Roy Spencer with annotations by Anthony Watts.

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THE POLAR VORTEX

Extreme winter weather is often attributed to an atmospheric weather event known as a "polar vortex outbreak" or an "Arctic outbreak." The polar vortex is nothing new; the term first appeared in an 1853 issue of E. Littell's *Living Age*.[1]

According to the National Oceanic and Atmospheric Administration (NOAA):[2]

> The polar vortex is a large circulation of low pressure and cold air that forms every winter in the stratosphere above the North and South poles. The term vortex refers to the counter-clockwise flow of air that helps keep colder air close to the poles [represented by the left globe in Figure 1].
>
> Sometimes during winter in the Northern Hemisphere, the polar vortex will become less stable and disrupt the polar jet stream circulating in the same direction miles below the vortex — thus sending cold Arctic air southward over the United States [represented by the right globe in Figure 1].

Recently, some climate researchers have cited computer models to attribute specific polar vortex events to climate change.[3] However, there is no evidence contained in the long-term observational records that polar vortex events have become more frequent or severe during the recent period of modest warming. In its discussion of the polar vortex, NOAA says computer models fail to produce consistent projections linking climate change and the polar vortex. "Computer models don't agree on how global warming will affect the polar vortex," reports NOAA.[4,5]

Claims that climate change is creating new and more severe polar vortex events are not supported by either observational evidence or computer climate models.

Each polar vortex outbreak is an individual weather event spanning days to a week at any given location.

KEY TAKEAWAYS

- The phrase "polar vortex" is often erroneously used by the media to link climate change and severe winter weather events.
- The polar vortex was first identified as a cause for some instances of severe winter weather events in 1853.
- Claims that climate change is creating new and more severe polar vortex events are not supported by either observational evidence or computer climate models.

It is dubious to attribute these isolated events to climate change, which is a trend measured over 30 years at minimum.[6] Accordingly, the data show no increasing trend in polar vortex weather events.

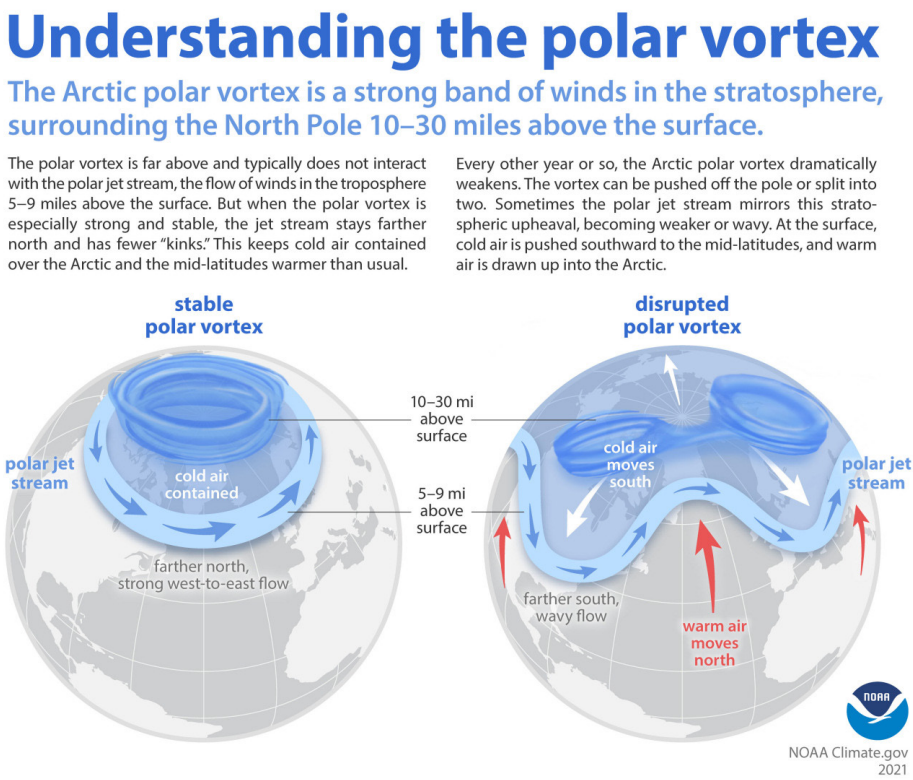

Figure 1: When the Arctic polar vortex is especially strong and stable (left globe), it helps keep the polar jet stream in a northward rotation. The coldest polar air stays in the Arctic. When the vortex weakens, shifts, or splits (right globe), the polar jet stream often becomes wavy, allowing warm air to flood into the Arctic and polar air to sink down into the mid-latitudes. Source: NOAA Climate.gov graphic.

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Climate at a Glance for Teachers and Students:
Facts on 40 Prominent Climate Topics

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