
Can We Control the Weather?

- The atmosphere is a complex fluid system.
- Complex interactions between many physical processes at different locations result in phenomena we call weather.

Image: Studio23 (Adobe Stock)

Humans have long sought to influence or control the weather, driven by needs like agriculture, navigation, and warfare. These efforts span mythology, religious rituals, folk practices, and scientific experiments, reflecting cultural beliefs and technological advancements across civilizations.

Mythological and Religious References

Many ancient cultures invoked supernatural forces or deities to manipulate weather, often through rituals or prayers:

In Greek mythology, Aeolus, the keeper of the winds, provided Odysseus with a bag containing winds that, when released, could create gales.

Ancient Romans used the sacred stone called lapis manalis, dragging it into the city during droughts to summon rain.

Scandinavian folklore featured witches who sold wind trapped in bags or staves to sailors for use during calm seas.

In ancient India, Vedic rituals known as yajna involved mantras and offerings by sages to induce rainfall in dry areas.

Indigenous American tribes performed rain dances and other ceremonies believed to bring precipitation.

Historical Folk Practices

Before modern science, communities relied on rudimentary or superstitious methods to avert destructive weather:

In Northern Europe during the 18th and 19th centuries, people fired cannons (without ammunition) into the sky to prevent hail, a practice adopted by agricultural towns.

In the 1890s, Austrian mayor Albert Stiger invented hail cannons—vertical, megaphone-like devices that shot smoke rings into clouds to disrupt hail formation and protect vineyards. The idea spread across Europe, with thousands in use by the early 1900s, though government tests in Italy deemed them ineffective.

Observations from wars like the Napoleonic and American Civil Wars noted rain following battles, inspiring attempts like U.S. general Edward Powers' 1871 proposal to use explosions for rainfall. This led to Robert Dyrenforth's 1891 government-funded experiment in Texas, where dynamite was exploded via kites and balloons, yielding minimal results.

Early Scientific and Pseudoscientific Attempts

The 19th and early 20th centuries saw more structured experiments blending science and speculation:

In 1832, American meteorologist James Pollard Espy proposed igniting massive forest fires along a 600-mile line to create convection and induce storms.

The 1881 "rain follows the plow" theory encouraged settlement in the U.S. Great Plains, claiming that tilling soil would naturally increase rainfall (it didn't, contributing to the Dust Bowl).

In 1891, "Ohio Rain Wizard" Frank Melbourne used chemical mixtures to attempt rainmaking in Kansas, selling his designs after mixed results.

Charles Hatfield, hired by San Diego in 1916, released 23 chemicals from a tower, causing heavy rains and floods that killed around 20 people; the city refused payment, blaming nature.

Modern Scientific Efforts

Advancements in the 20th century shifted toward techniques like cloud seeding, with mixed success and ethical debates:

In 1946, General Electric researchers Vincent Schaefer and Irving Langmuir discovered that dry ice dropped into supercooled clouds could create snow; Bernard Vonnegut found silver iodide worked similarly.

Project Cirrus (1947-1952), a U.S. military collaboration, seeded hurricanes and clouds with silver iodide, with controversial claims of success.

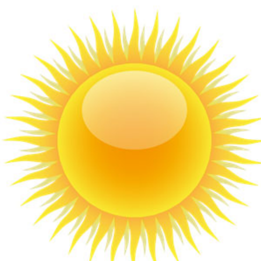
Operation Popeye (1967-1972) involved U.S. forces seeding clouds over Laos during the Vietnam War to extend monsoons and hinder enemies, increasing rainfall by 30-45 days before being halted by Congress.

Project Stormfury (1962-1983) attempted to weaken hurricanes by seeding eyewalls with silver iodide from aircraft, but was deemed ineffective and discontinued.

For the 2008 Beijing Olympics, China used over 1,000 rockets with silver iodide to disperse rain clouds, ensuring clear skies for the opening ceremony.

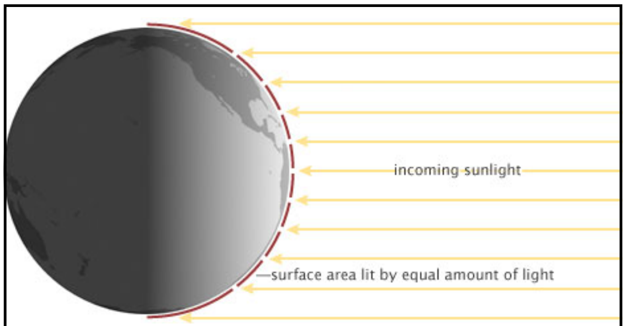
The Sun

- All energy on Earth comes from the Sun.
  - The sun heats the atmosphere and the surface of the Earth.



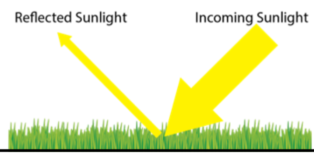
Latitude

- Latitude affects sunlight intensity.
  - Areas near the equator receive sunlight at a more direct angle, concentrating energy over a smaller surface area, which results in warmer temperatures.
  - Higher latitudes experience sunlight at a shallower angle, spreading the energy over a larger area and leading to cooler temperatures.



Landscape

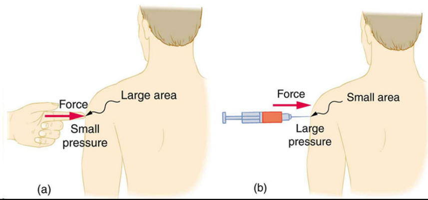
- When sunlight hits a surface, some of the energy is absorbed, and some is reflected.
- The Earth's surface heats up when it absorbs energy from the sun.
- The more energy that is reflected, the less the surface heats up.



- Some surfaces reflect more of the sun's energy than others.
- Albedo is a measure of the percentage of sunlight that a surface reflects away.
  - Fresh snow can have an albedo of up to 0.85, meaning that it reflects 85% of the sunlight that hits it.
  - Open ocean can have an albedo lower than 0.1, reflecting less than 10%.
  - Clouds have a very high albedo, reflecting most of the Sun's energy back into space.

Pressure

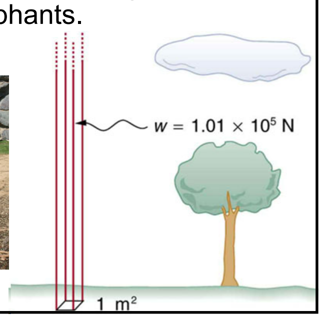
- Pressure is defined as the force divided by the area perpendicular to the force over which the force is applied.
  - A given force can have a significantly different effect depending on the area over which the force is exerted.



Air Pressure

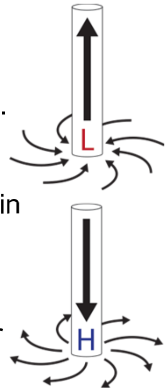
- At the Earth's surface, the air pressure exerted on you is a result of the weight of air above you.
- This pressure is reduced as you climb up in altitude and the weight of air above you decreases.
- The average pressure at sea level is 101.3 kPa.

- On average, at sea level, a column of air above $1\ \text{m}^2$ of the Earth's surface has a weight of 1.01×10^5 N.
  - The weight of around 2 large full grown male elephants.



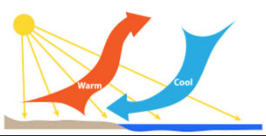
Hot and Cold Air

- Hot air is less dense than cold air.
  - Hot air rises and cold air falls.
- Rising air results in lower air pressure.
  - Clouds form due to moisture in the rising air.
- Falling air results in higher air pressure.
  - High pressure results in clear skies.

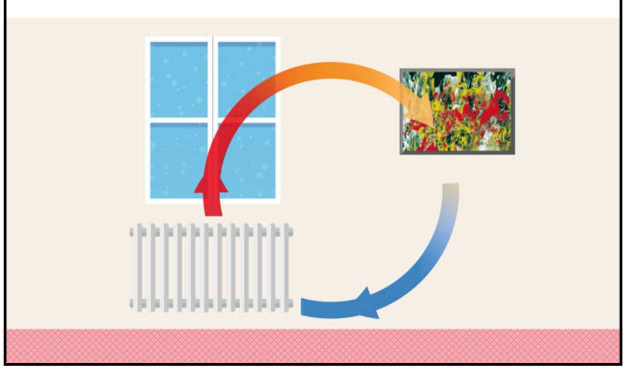


Wind

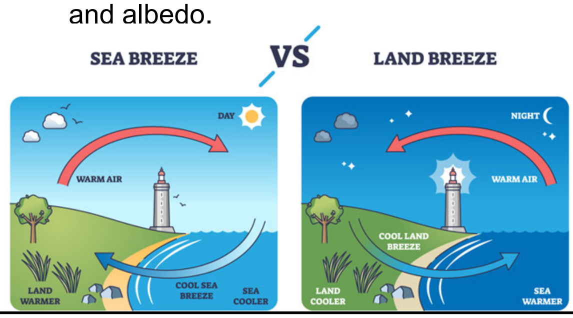
- The Sun heats up the air near the surface of the Earth.
- The warm air rises, leaving an "empty space" (low-pressure area).
- Cooler air from nearby moves into the low-pressure area left by the rising air.
- The moving air is what we feel as wind.



- This cycling of warm and cooler air is called a convection current.

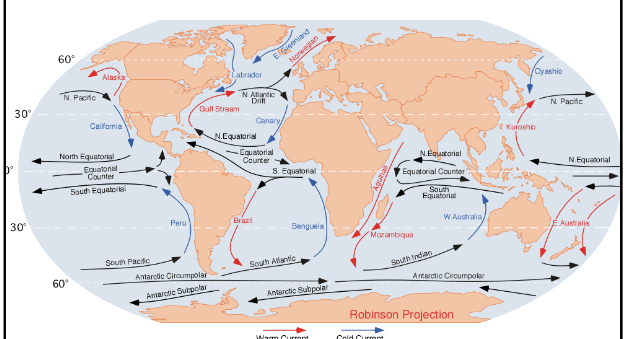


- Convection currents occur because the sun unevenly warms the surface of the Earth.
  - The uneven warming is due to latitude and albedo.



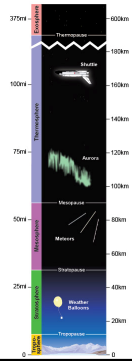
Ocean Currents

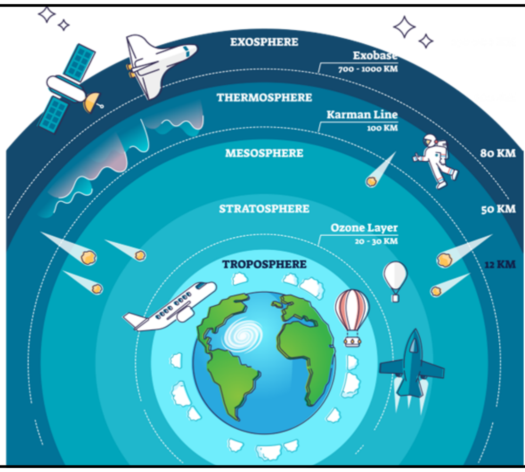
- Warm ocean water from the equator circulates to polar regions to regulate the temperature.
- Water from the poles travels to the equator to cool off tropical climates.
- For example, the Gulf Stream in the Atlantic brings warm water from Florida to western Europe. This keeps the weather and climate in the area moderate.



The Atmosphere

- The atmosphere is divided into layers.
- Almost all clouds and weather occur in the troposphere.
- We live in the atmospheric boundary layer (ABL), the bottom 3 km of the troposphere.
- The “ozone layer” is near the bottom of the stratosphere.

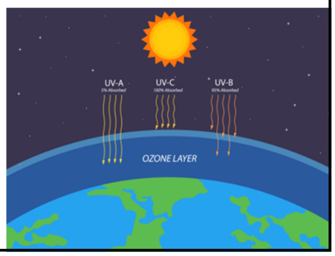




Ozone

- Ozone (O_3) is a highly reactive gas composed of three oxygen atoms.
- It is both a natural and a man-made product that occurs in the Earth's upper atmosphere (the stratosphere) and lower atmosphere (the troposphere).
- Depending on where it is in the atmosphere, ozone affects life on Earth in either good or bad ways.

- **Stratospheric ozone** is formed naturally through the interaction of solar ultraviolet (UV) radiation with molecular oxygen (O_2).
  - The "ozone layer" reduces the amount of harmful UV radiation reaching the Earth's surface.



- **Tropospheric or ground-level ozone** is a key component in smog.
- Breathing excessive amounts of ground-level ozone can result in a number of health effects.
  - coughing
  - irritation of the eyes, nose or throat
  - chest discomfort
  - shortness of breath
  - decreased lung function

Ozone "Hole"

- The ozone "hole" is really an area over the Antarctic where the amount of stratospheric ozone is lower than elsewhere on the planet.
- This thinning occurs from September to October, just after the Antarctic winter.
- Stratoshperic ozone depletion was immediately attributed to the use of CFCs.

In 1974, Dr. Mario Molina and Dr. Sherwood Roland of the University of California published a paper asserting that chlorofluorocarbon (CFC) pollution from industry was destroying the ozone layer in Earth's stratosphere.

The Antarctic ozone hole was first discovered in the late 1970s by the first satellite mission that could measure ozone, a spacecraft called POES and run by the National Oceanic and Atmospheric Administration (NOAA). The hole has continued to grow steadily during the 1980s and 90s, though since early 2000 the growth reportedly leveled off. Even so scientists have seen large variability in its size from year to year.

The significant thinning of the ozone layer over Antarctica—now known as the Antarctic ozone hole—was first documented in a scientific paper published on May 16, 1985, in the journal Nature by British Antarctic Survey scientists Joseph Farman, Brian Gardiner, and Jonathan Shanklin. Their research, based on ground-based measurements from Halley Bay station dating back to the 1950s, revealed unexpectedly large springtime (September–November) declines in total ozone column values, with levels dropping steadily since the mid-1970s and reaching reductions of over 30–40% by the early 1980s compared to earlier decades.

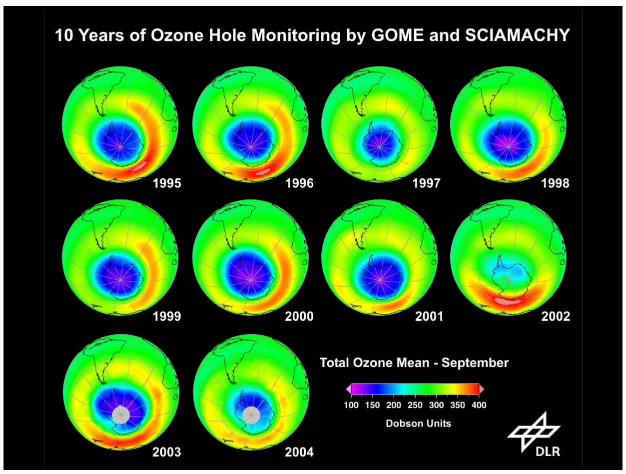
The Montreal Protocol

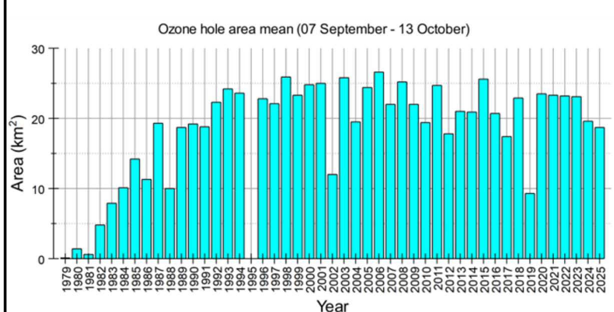
- 29 nations and the European Community signed the Montreal Protocol on Substances that Deplete the Ozone Layer in September of 1987.
- Over the next decade, the Protocol was universally signed by 197 nations, agreeing to ban the use of CFCs.
- Since 1986, world consumption of Ozone Depleting Substances (ODS) is down more than 99 percent, effectively reaching zero by 2010.

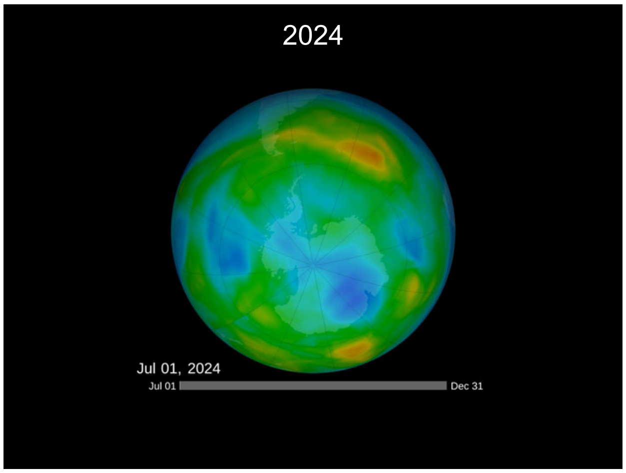
The Montreal Protocol (1987)

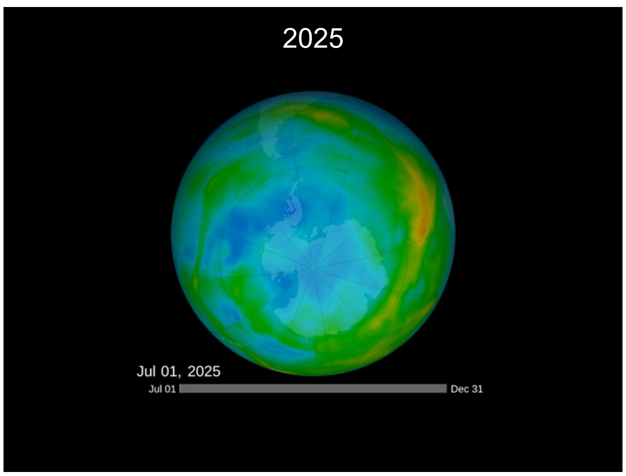
DuPont's patent for R22 expired in 1979. Currently a more expensive, less efficient, more dangerous (flammable) refrigerant is used.

- Despite the elimination of CFCs, the Ozone Hole remains as large as ever.
- In 2015 NASA announced that the hole would be half-closed by 2020.
  - Largest area (2016) = 26 km^2
  - Area in 2020 = 23.5 km^2
- The longer the hole persists, the greater the likelihood that the ozone layer is dominated by natural factors, not human CFC emissions.





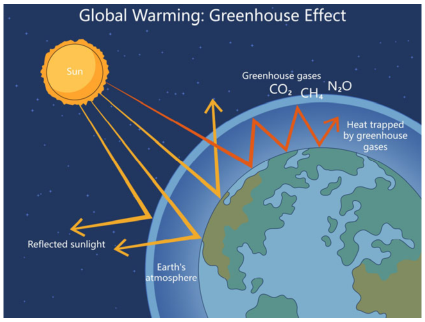




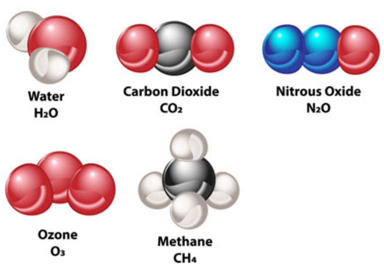
“Greenhouse Effect”

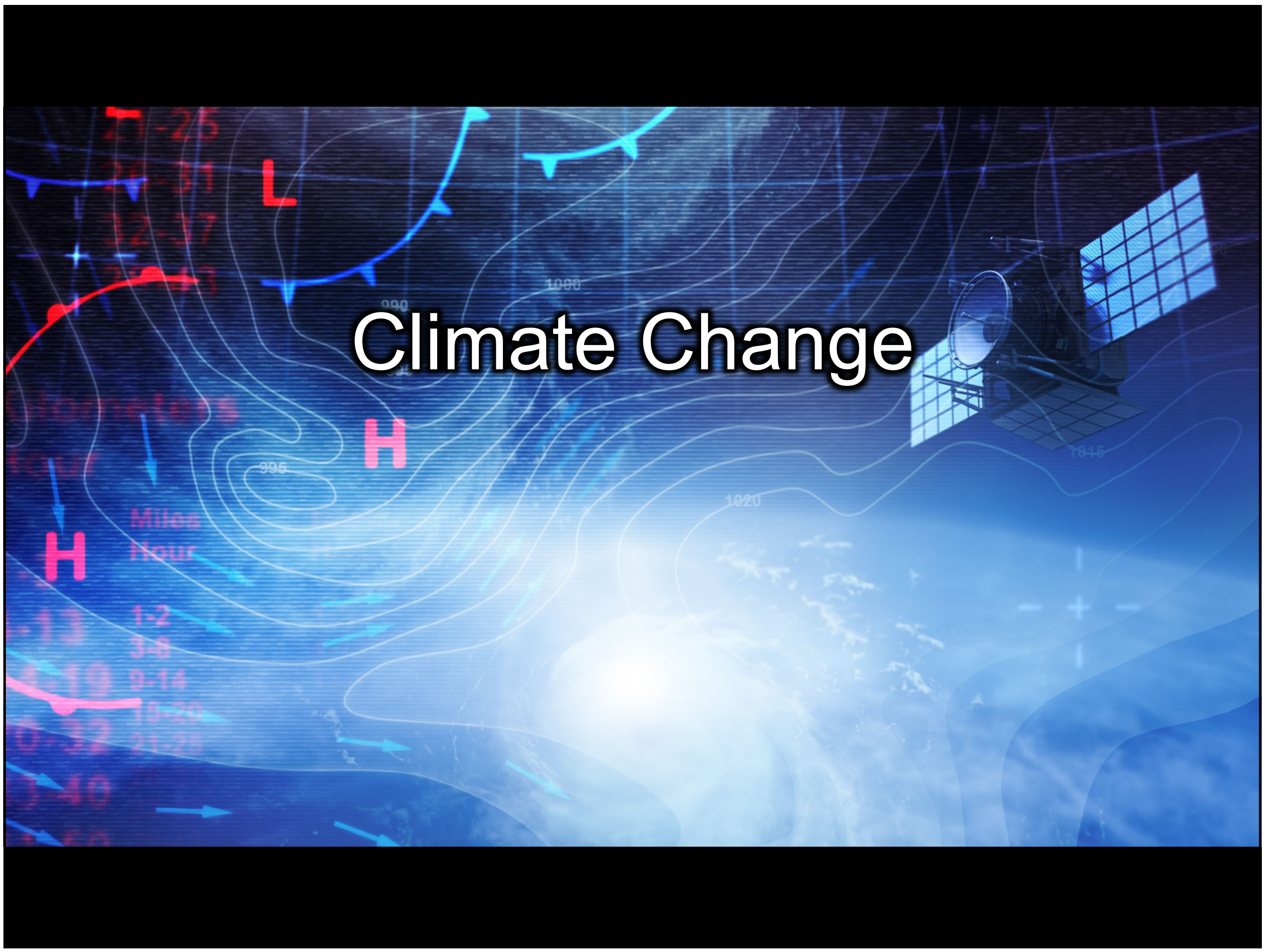
- Earth’s atmosphere contains gases that act as a blanket for our planet.
  - During the daytime, the gases absorb some of the heat from the sun.
  - At night, the gases release the heat back into the atmosphere.
- “Greenhouse” gases slow the rate of heat loss from the planet.

- Without “greenhouse” gases, temperatures on Earth would drop to extreme lows that are too cold to sustain life.



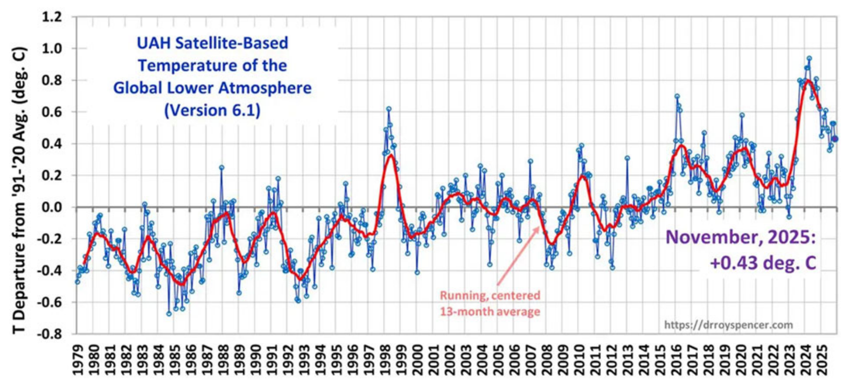
- The most important “greenhouse” gas in the atmosphere is water.
- Some other “greenhouse” gases are carbon dioxide, methane, nitrous oxide, and ozone.




Climate Change

Temperature

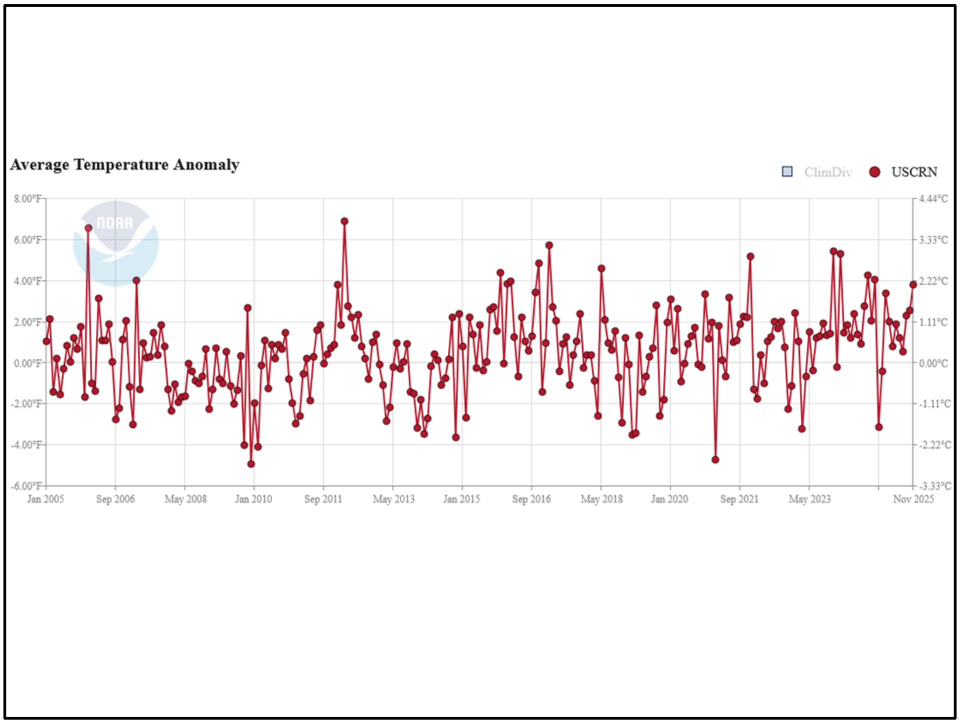
- Claim: The global average temperature is rising dramatically.
- Data:



Credit: UAH

This global temperature record from 1979 shows a modest and unalarming 0.16° Celsius rise per decade (0.28º Fahrenheit rise per decade) that is not accelerating as of 7/1/25.

The UAH satellite temperature dataset, developed at the University of Alabama in Huntsville, measures the temperature of various atmospheric layers from satellite measurements of the oxygen radiance in the microwave band, using the Advanced Microwave Sounding Unit (AMSU) temperature measurements on the AQUA satellite. This graph displays the Lower Troposphere aka TLT data. The reason for using the lower troposphere instead of the surface as viewed from space is that the temperature data seen by satellites at the surface is inherently too noisy to provide stable data. The altitude of TLT data used is at approximately 14,000 feet (4267.2 meters) which is representative of surface temperature, without the noise associated with weather and human activity, such as Urban Heat Islands (UHI), which skew the near-surface temperature record.



Credit: NOAA

The graph shows the Average Surface Temperature Anomaly for the contiguous United States since 2005. The data comes from the U.S. Climate Reference Network (USCRN) which is a properly sited (away from human influences and infrastructure) and state-of-the-art weather network consisting of 114 stations in the USA.

These station locations were chosen to avoid warm biases from Urban Heat Islands (UHI) effects as well as microsite effects as documented in the 2022 report *Corrupted Climate Stations: The Official U.S. Surface Temperature Record Remains Fatally Flawed*. Unfortunately, NOAA never reports this data in their monthly or yearly “state of the climate report.” Mainstream media either is entirely unaware of the existence of this data set or has chosen not to report on this U.S. temperature record.

The national USCRN data, updated monthly as shown in the above graph can be viewed here: https://www.ncei.noaa.gov/access/monitoring/national-temperature-index/time-series/anom-tavg/1/0

Wildfires

Claim: Wildfires are increasing

Data:

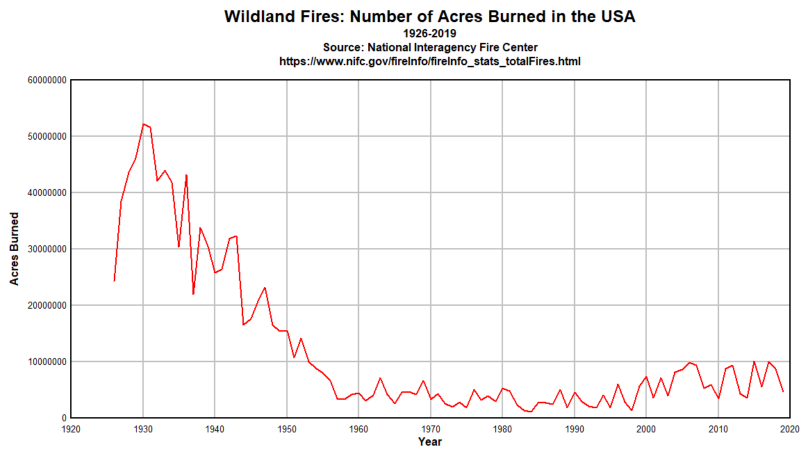
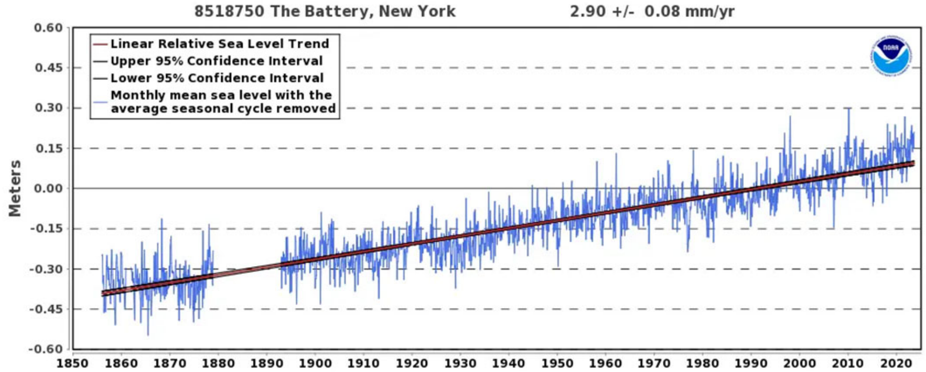


Image: All available wildfire acreage burned by year in the United States, 1926 to 2019. Data from NIFC prior to disappearance in 2021. Graph by Anthony Watts

Sea Level

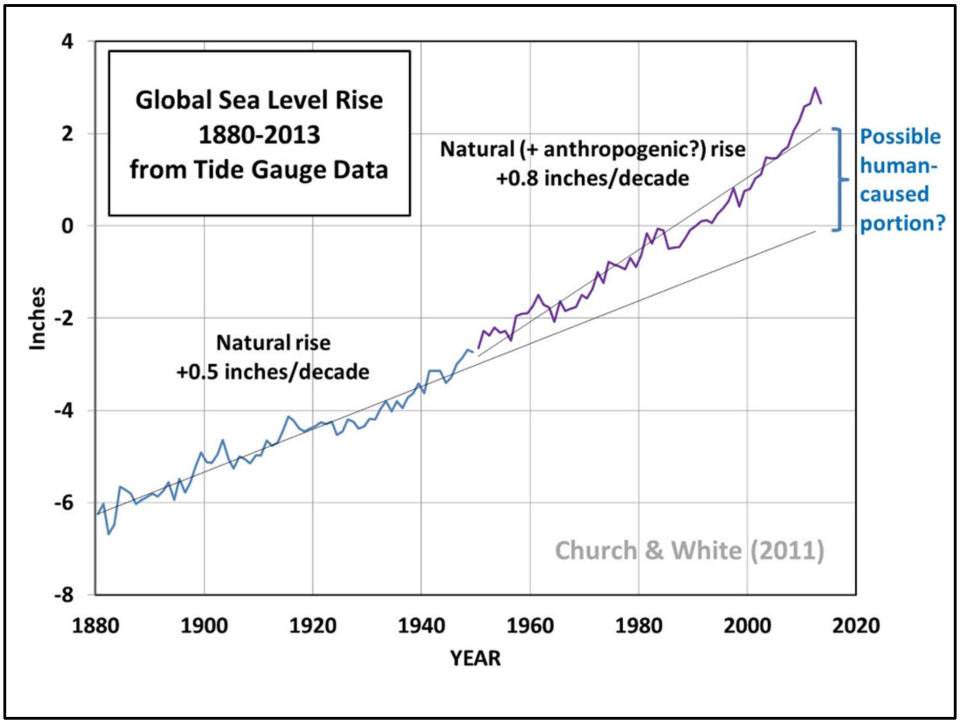
- Claim: Sea level is increasing at an accelerating rate.
- Data:



Credit: Data from NOAA.

The Battery in New York City. The relative sea level trend is 2.9 millimeters/year with a 95% confidence interval of +/- 0.08 mm/yr based on monthly mean sea level data from 1856 to 2022 which is equivalent to a change of 0.95 feet in 100 years. https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8518750

Ocean tide gauge data shows that the sea level trend has not changed in over 100 years, and show no signs of drastic acceleration. In New York City, sea level has risen only 0.94 feet in 100 years, and started well before human carbon dioxide emissions were significant. The trend is unchanged since 1856. All of the perceived acceleration comes from satellite measurements and could be within the range of measurement error.



Credit: Data from Church and White, 2011[1], updated in 2013[2]. Graph by Dr. Roy Spencer.

1. Church, J.A. & White, N.J. Surv Geophys (2011) 32: 585. https://doi.org/10.1007/s10712-011-9119-1
2. Church and White data update, 2013. CSIRO http://www.cmar.csiro.au/sealevel/GMSL_SG_2011_up.html

According to tide gauge data, global sea levels are rising at a rate of about 7-8 inches *per century*, a rate that has remained steady despite our escalating carbon dioxide emissions, i.e. the cause is probably predominantly natural. We could globally cease all carbon dioxide emissions overnight and sea levels would continue to rise, an inevitability to which we must adapt. There's simply no drastic acceleration of sea level rise. There is some recent sea level rise that could be called acceleration, but it is small, and short term, and may be due to natural variance.

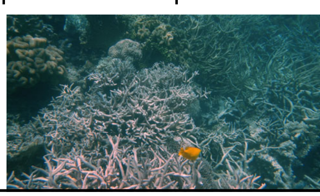
If we assume that the trend prior to 1950 was natural (humans really did not emit much CO_2 into the atmosphere before then), and that the following increase in the trend since 1950 was 100% due to humans, we get a human influence of only about 0.3 inches per decade, or 1 inch every 30 years.

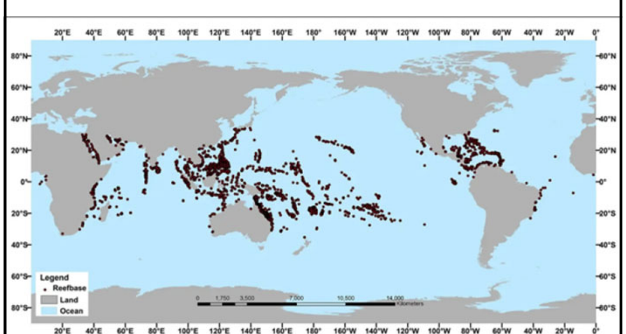
Ocean Acidification

- Claim: The ocean is becoming more acidic.
- Data:
  - Seawater is naturally alkaline, with a pH ranging from 7.8 to 8.5 with an average of 8.1 (7 is neutral.)
  - Since 1850, the pH of surface ocean waters has fallen by 0.1 pH units.
    - If anything, the ocean is becoming more "neutral."

Coral Reefs

- Claim: Coral reefs are dying because of rising temperatures.
- Data:
  - Coral requires warm water, not cold water, to live. Coral cannot live outside of tropical or subtropical waters.



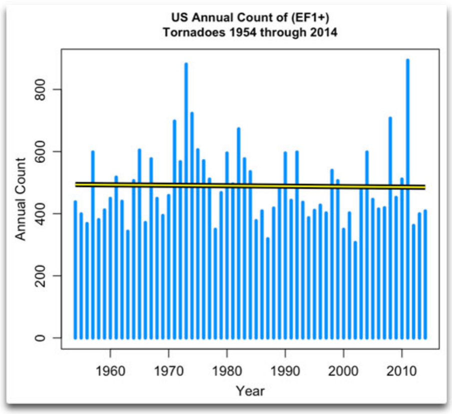


- Coral reefs thrive in locations throughout the globe where temperatures range from site to site by as much as 11°C.
- The temperature at coral reef sites ranges over 11°C from Summer to Winter at some locations around the world.
- Thus, coral reefs have proven to thrive in a substantial range of temperature environments, including temperatures that exceed those where coral bleaching has occurred.

- History shows that cold snaps can harm coral much worse than warm spells.
  - In 2010, colder ocean temperatures off the coast of Florida killed more coral than any warm-water event. And, despite these events, coral reefs recover over the course of several years or sometimes, even quicker.

Tornadoes

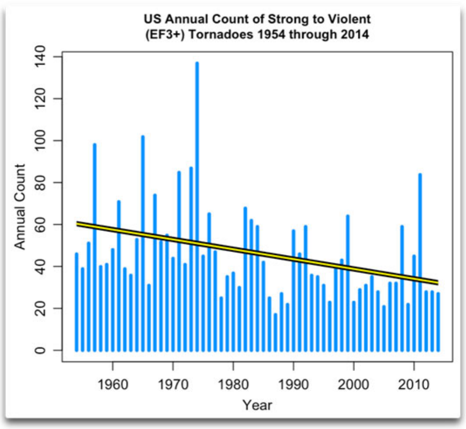
- Claim: Tornadoes are becoming more frequent and more dangerous.
- Data:

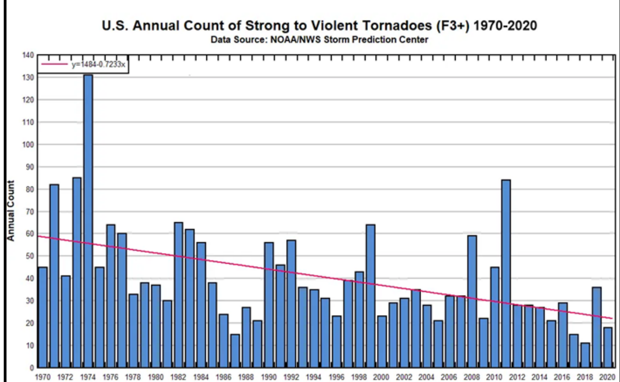


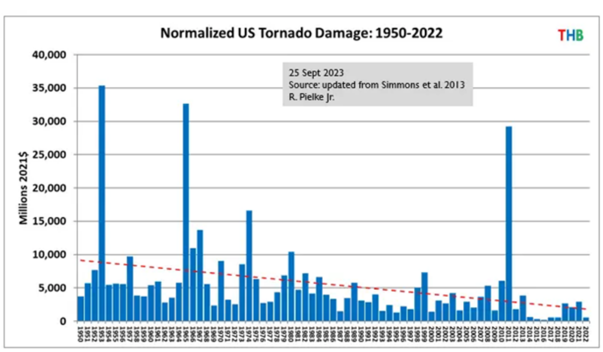
Data Source: National Oceanic and Atmospheric Administration, U.S. Tornado Climatology, Historical Records and Trends, https://www.ncdc.noaa.gov/climate-information/extreme-events/us-tornado-climatology/trends.

It would require several hundred years of detailed tornado data both before and after 1850 to accurately determine whether the natural trends and fluctuations of tornado activity have been altered by the 1.3 parts per ten thousand increase in atmospheric carbon dioxide since 1850. This is the period during which human activity contributed a portion of the increase of CO_2 in the atmosphere, most of which occurred since 1940. Without such sufficient data, no scientific comparisons and conclusions concerning the impact of the tiny increase in carbon dioxide in the atmosphere would be statistically meaningful.

Despite this lack of sufficient long-term tornado data, there is a very short period of historical data from 1950 to the present that can be analyzed. This historical tornado data, show that the number of all categories of tornadoes has been declining for the past 45 years and the number of strong tornadoes, F3 or higher, has been dramatically declining for the past 45 years.

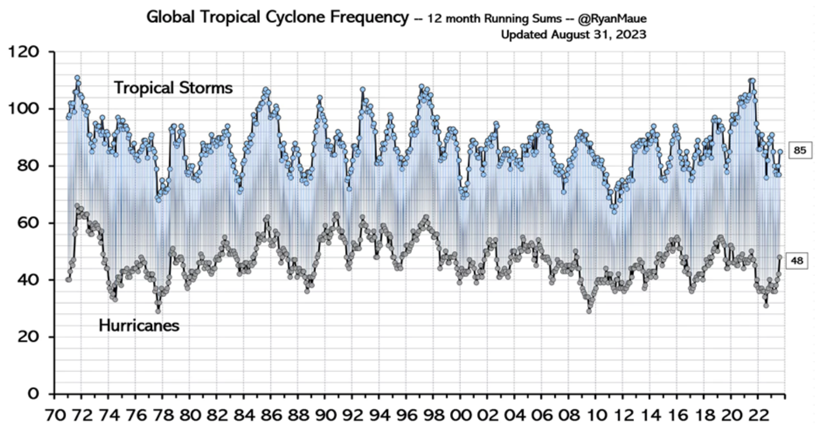

US Annual Count of Strong to Violent
(EF3+) Tornadoes 1954 through 2014
Annual Count
Year
0
20
40
60
80
100
120
140
1960
1970
1980
1990
2000
2010


U.S. Annual Count of Strong to Violent Tornadoes (F3+) 1970-2020
Data Source: NOAA/NWS Storm Prediction Center
y=1484-0.7233x
Annual Count


Normalized US Tornado Damage: 1950-2022
THB
25 Sept 2023
Source: updated from Simmons et al. 2013
R. Pielke Jr.
Millions 2021$
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0

Hurricanes

- Claim: Hurricanes are increasing in frequency and strength.
- Data:

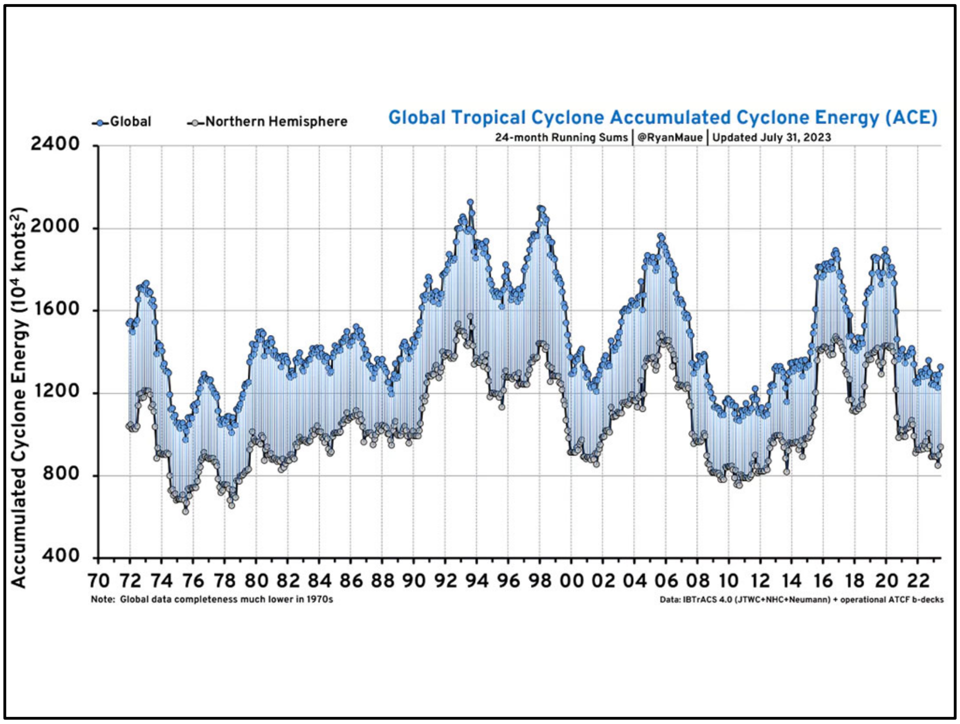


Source: Global Tropical Cyclone Activity, Dr. Ryan N. Maue, http://climatlas.com/tropical/frequency_12months.png.

There has been no increase in hurricanes as the planet has modestly warmed. since the end of the Little Ice Age, around 1850.

Even the U.N. IPCC agrees, finding no increase in the frequency or severity of hurricanes.

Devastating hurricanes occurred long before the invention of SUVs and coal-fired power plants. And hurricane activity shows little or no impact from global warming. Even the U.N. Intergovernmental Panel on Climate Change 2018 “Interim Report” observes there is “only low confidence for the attribution of any detectable changes in tropical cyclone activity to anthropogenic influences.”



Last 50-years+ of Global and Northern Hemisphere Accumulated Cyclone Energy: 24 month running sums. Note that the year indicated represents the value of ACE through the previous 24-months for the Northern Hemisphere (bottom line/gray boxes) and the entire global (top line/blue boxes). The area in between represents the Southern Hemisphere total ACE.