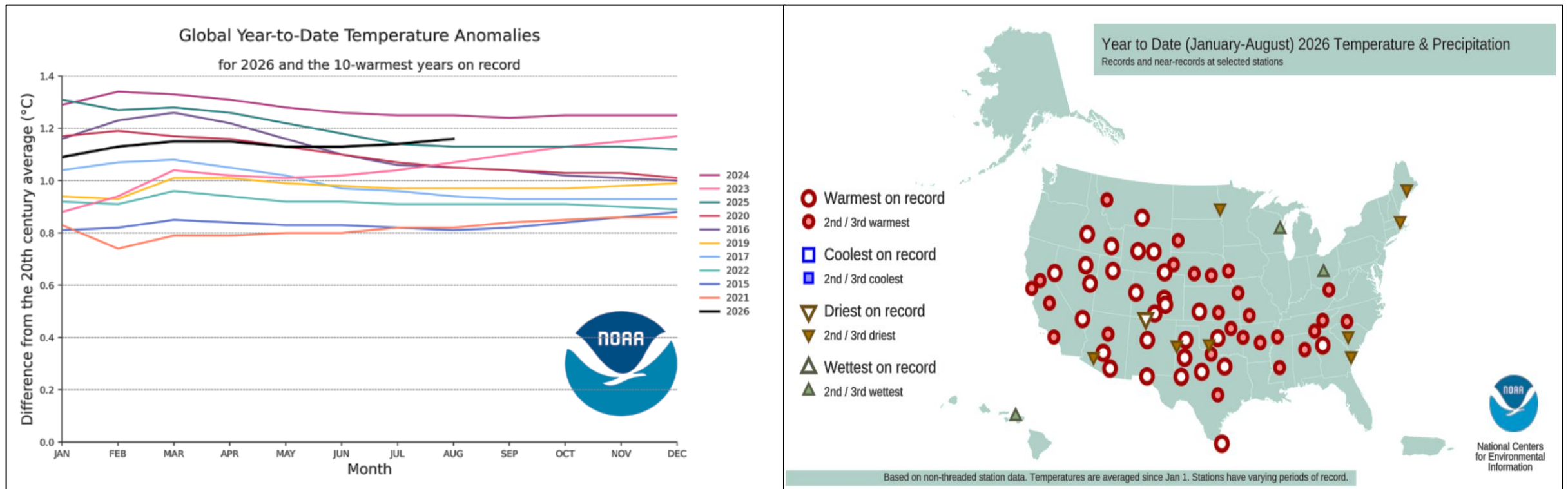


Low and Behold: Barometric Extremes and Weather Hazards

Impacts Sites, Staff, Security, and Supply Chain

*The 10 warmest years on record have all occurred **since 2015**. The January to December 2025 global surface temperature is ranked as the third warmest year in the NOAA 174-year record, which began in 1850.*



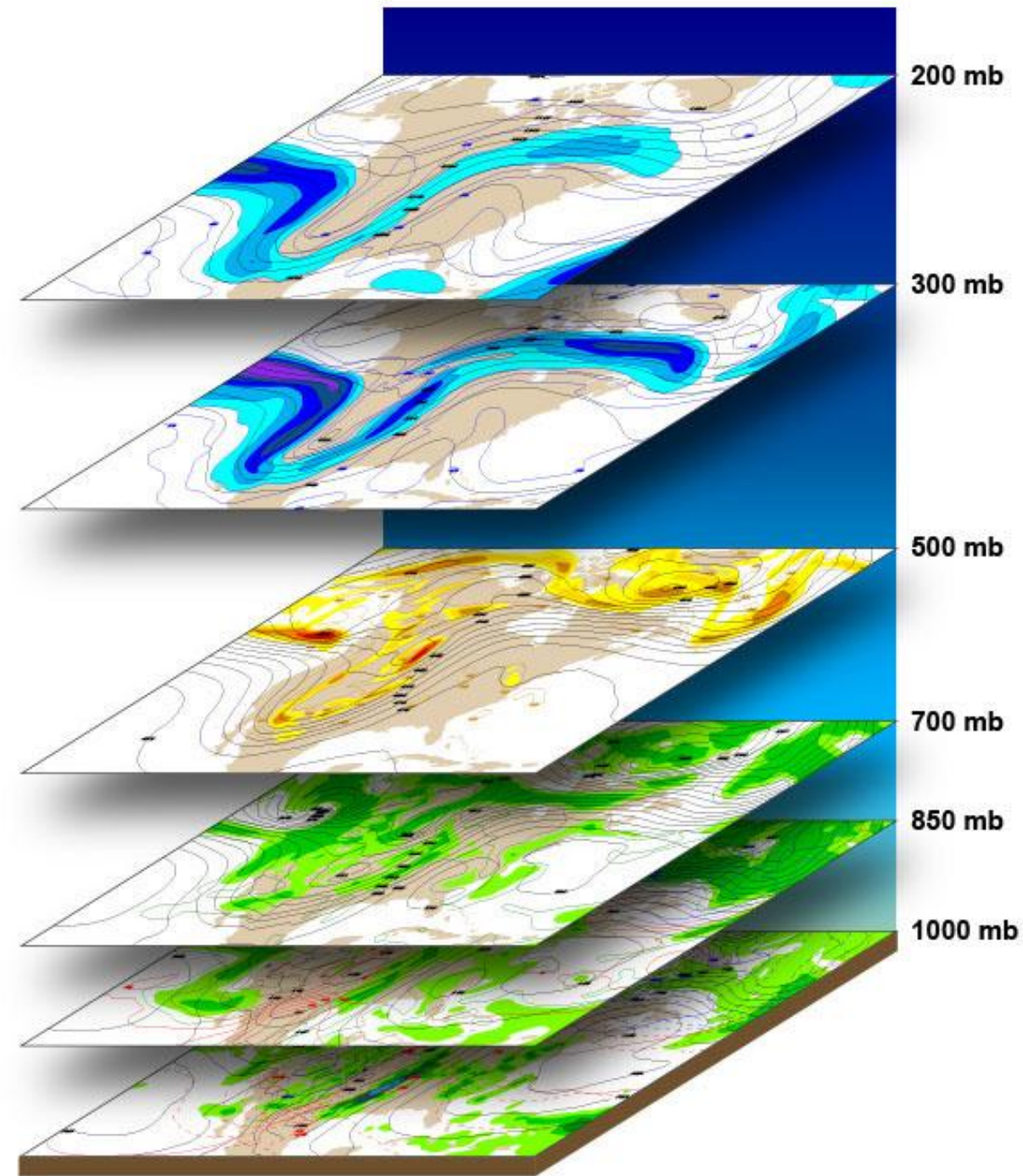
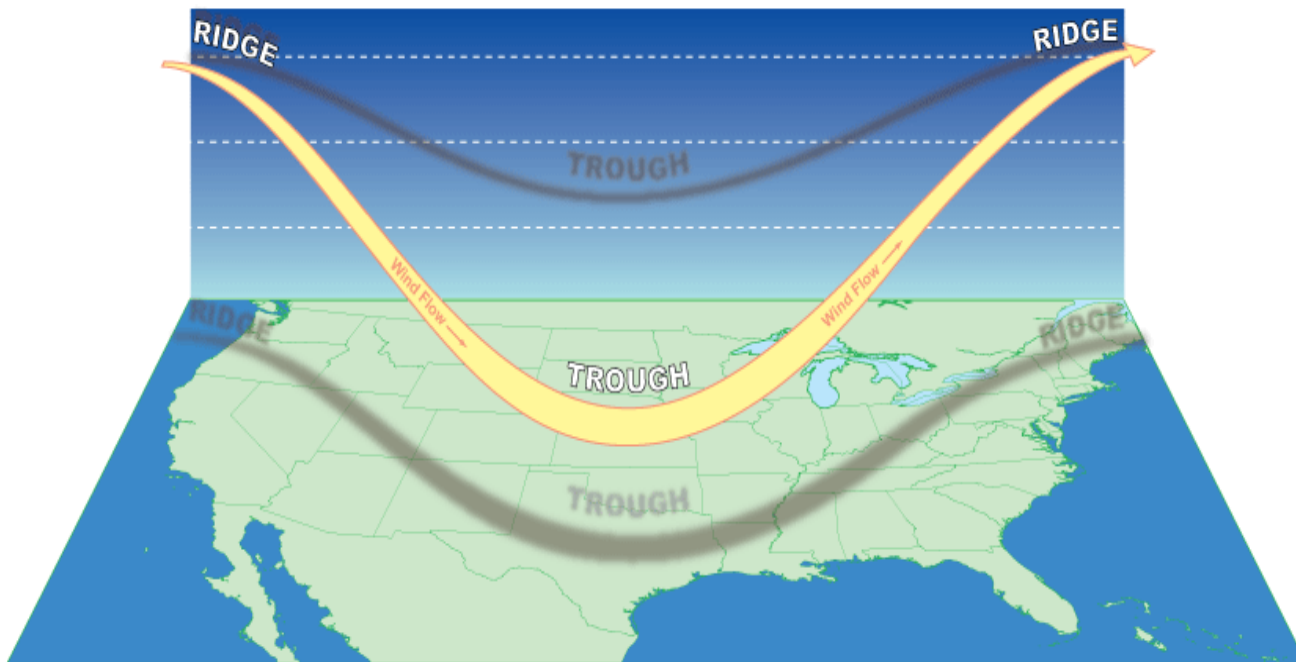
Chief Meteorologist Ms. Sunny Wescott
Critical Infrastructure and Emergency Response Operations

Atmospheric Pressure - Millibar 101

In essence, upper air charts show the atmosphere in three dimensions.

- Wind flowing from a ridge toward a trough is decreasing in height above the surface. Conversely, wind flowing from a trough into a ridge is increasing in height.
- Between the colder, more dense air and the warmer, less dense air is the location of the greatest change (gradient) in heights of any pressure level. (NWS Jet Stream)
- By looking at these contours, we observe patterns of higher heights (called ridges) and lower heights (called troughs). These ridges and troughs drive the weather we experience at the surface.

Atmospheric Pressure is measured with an instrument called a barometer, which is why it is also referred to as barometric pressure.



High and Low Pressures: the Carousel of Weather

A **low-pressure system** has lower pressure at its center than the areas around it. Winds blow towards the low pressure, and the air rises in the atmosphere where they meet.

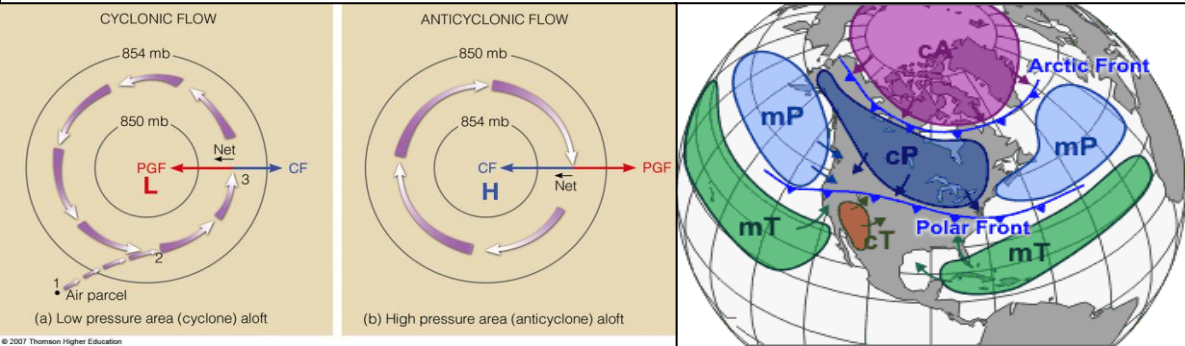
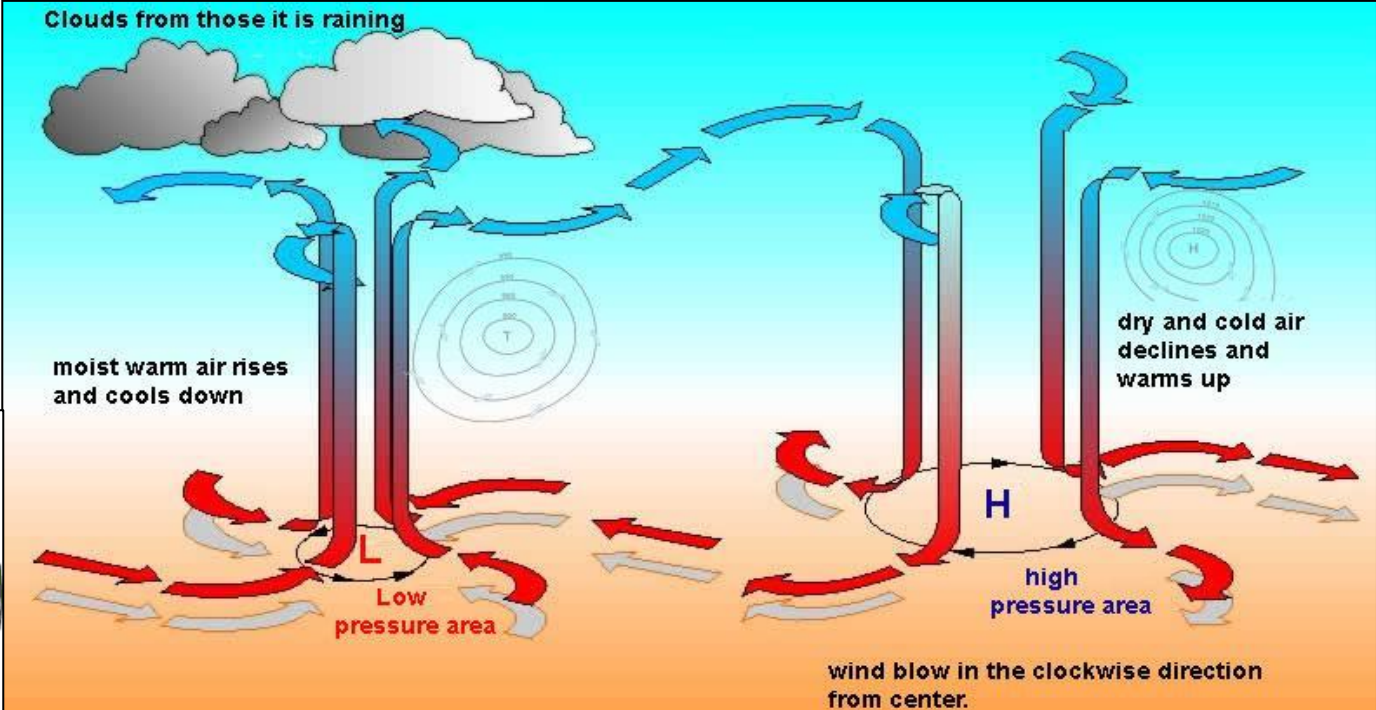
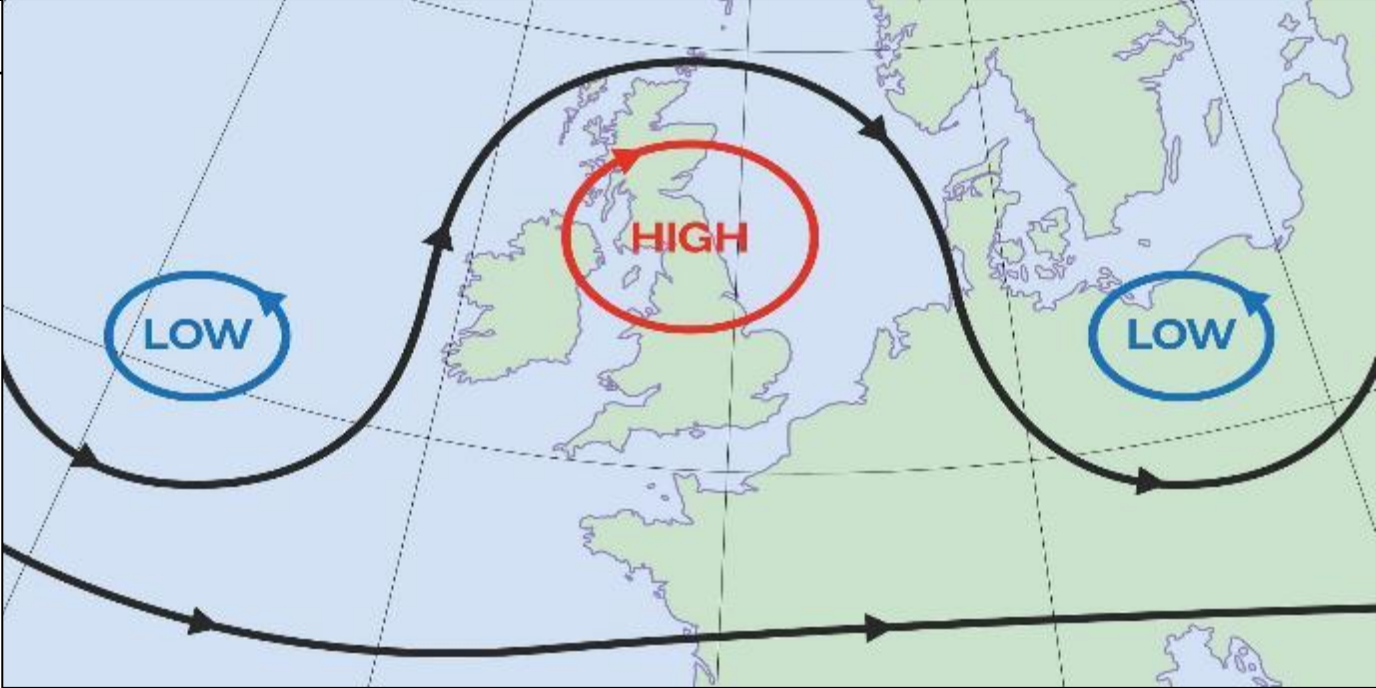
- Because of Earth's spin and the Coriolis effect, winds of a low-pressure system swirl counterclockwise north of the equator.
- As the air rises, the water vapor within it condenses, forming clouds and often precipitation.
- On weather maps, a low-pressure system is labeled with red L.

A **high-pressure system** has higher pressure at its center than the areas around it. Winds blow away from high pressure.

- Swirling in the opposite direction from a low-pressure system, the winds of a high-pressure system rotate clockwise north of the equator (anticyclonic flow).
- Air from higher in the atmosphere sinks down to fill the space left as air is blown outward. On a weather map, you may notice a blue H, denoting the location of a high-pressure system.

Air pressure depends on the temperature of the air and the density of the air molecules. Air masses differ based off their prevailing fields.

The tighter the gradient between the high and the incoming low, the stronger the winds will be as they mix down from the upper levels.



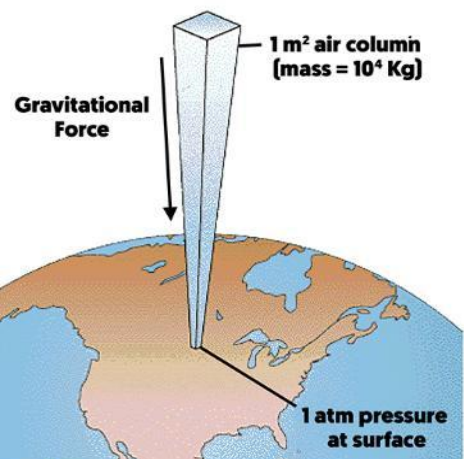
Major Pressure Swings Begin

As low pressures continue to change in depth and intensity, the high-pressure events are left to dominate for longer periods, increase coverage area, and promote significant levels of humidity and water vapor adding to trapped heat.

- The low-pressures drive global cooling winds, bring rainfall and storm events, and are responsible for all notable cloud coverage.
- High-pressures yield clear skies, heat domes, haze, stagnant air, and even the cold air damming periods.

This means a change in either pressure consistency or strength brings immediate consequences for the water cycle.

What is Atmospheric Pressure?

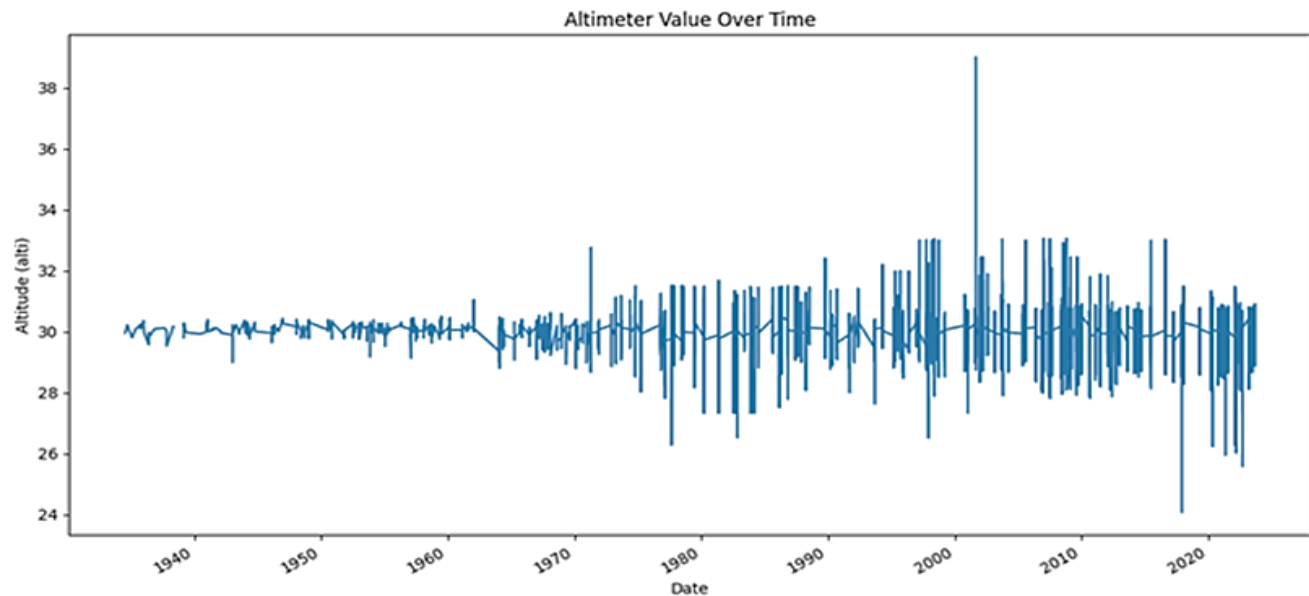


Atmospheric pressure, in physics, refers to the force exerted by the air molecules in Earth's atmosphere on surfaces within it.

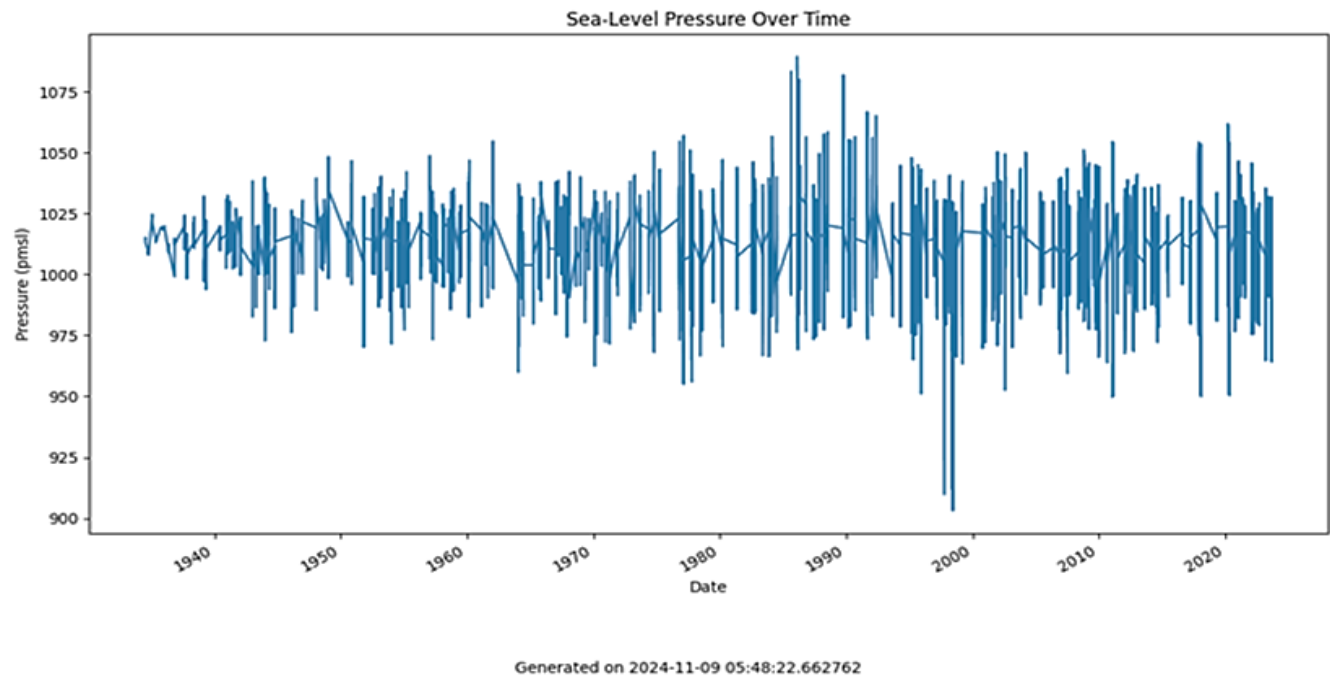
It decreases with altitude due to the decreasing density of air. Standard atmospheric pressure at sea level is around 101.3 kilopascals.

Variations in **atmospheric pressure** influence weather patterns and are measured using instruments like barometers.

Understanding atmospheric pressure is vital in meteorology, aviation, and various scientific applications. It plays a fundamental role in the behavior of gases, weather phenomena, and the dynamics of Earth's atmosphere.



ASOS Raw Data National Overview



Upper-Level Winds

A recent study, in *Nature*, suggests that **the fastest upper-level jet stream winds will accelerate by about 2% for every degree Celsius (1.8° Fahrenheit) that the world warms.**

- Furthermore, the fastest winds will speed up 2.5 times faster than the average wind.
- A 2019 study found that in the preceding nine years the global **average wind speed increased nearly 6%.**
- Over oceans evidence points more toward increasing average wind speeds in many areas, including widespread increases in extreme oceanic wind gusts in recent analyses.

Extreme regional wind events such as the Santa Ana, Diablo, and Chinook, have increased in general over the last 60 years.

- Shifts in winds carrying major seasonal precipitation like Atmospheric Rivers and Monsoons are forecast to amplify in variations of frequency and timeliness.

Studies over the past 45 years indicate changes to the tropopause, the top of the troposphere, and the width of the tropical belt may be shrinking, changing the overall storm pattern across the globe.

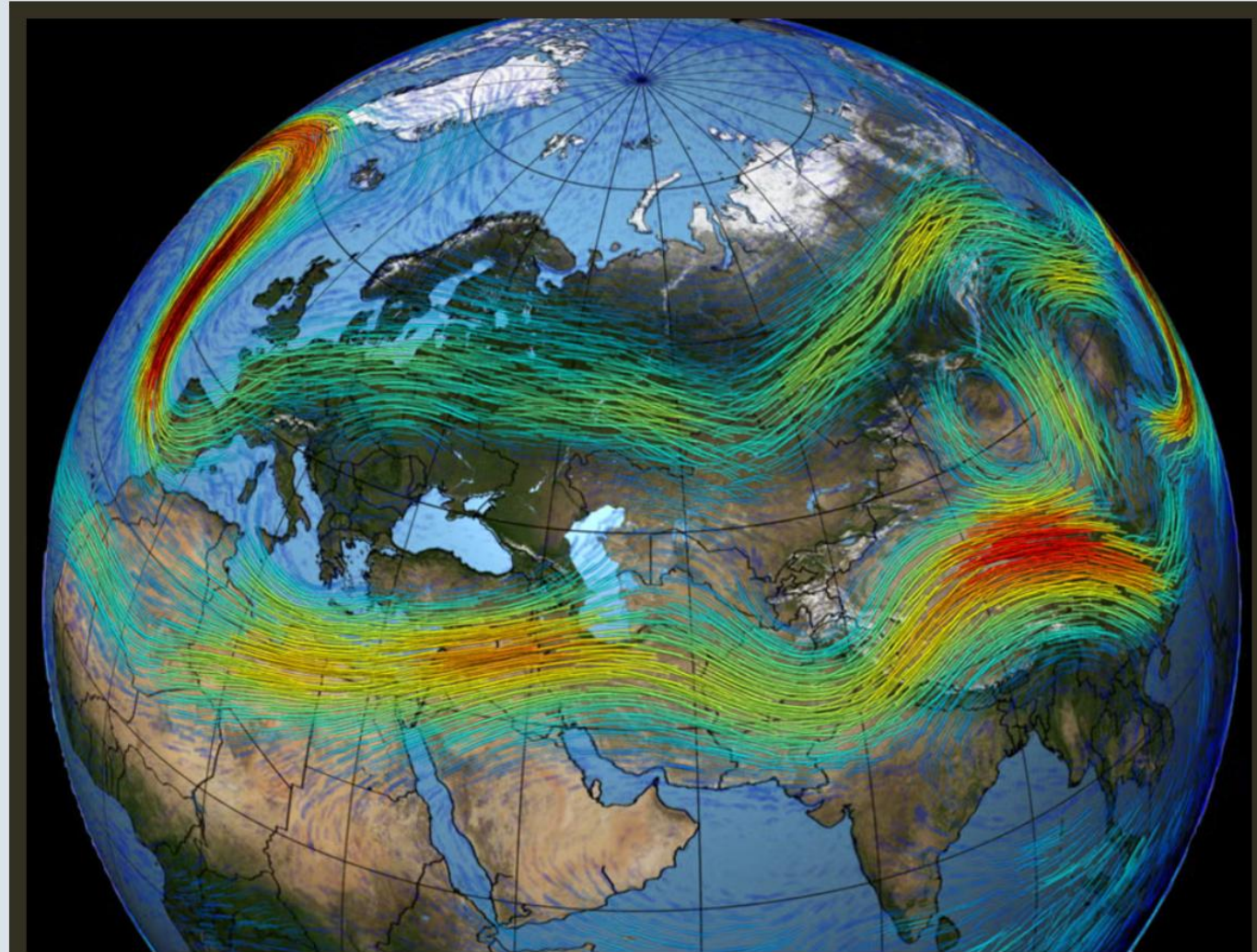
- The troposphere is the bottom layer of Earth's atmosphere and contains most of the atmosphere's mass, clouds and weather phenomena, and is where the global population and wildlife lives.

The tropopause has climbed about 50 to 60 meters per decade in the past 20 years.

JET STREAM WINDS WILL ACCELERATE WITH WARMING CLIMATE

Faster winds likely to cause bumpier flights, more severe weather

DEC 6, 2023 – BY STAFF



New research shows that the fastest jet stream winds will accelerate with climate change. (Image by NASA/Goddard Space Flight Center Scientific Visualization Studio.)

Atmosphere Height Changes

Reason to investigate: the tropopause, is pushing up the boundary with the stratosphere by about 50-60 meters (about 165-195 feet) per decade.

Temperature in the **stratosphere** rises with increasing altitude, because the ozone layer absorbs the greater part of the solar ultraviolet radiation. The ozone layer is an absorbing agent that protects life on Earth.

- A potential poleward shift of the subtropical jet streams, affecting storm tracks and hurricane formation, will be reflected in subtropical tropopause height trends.

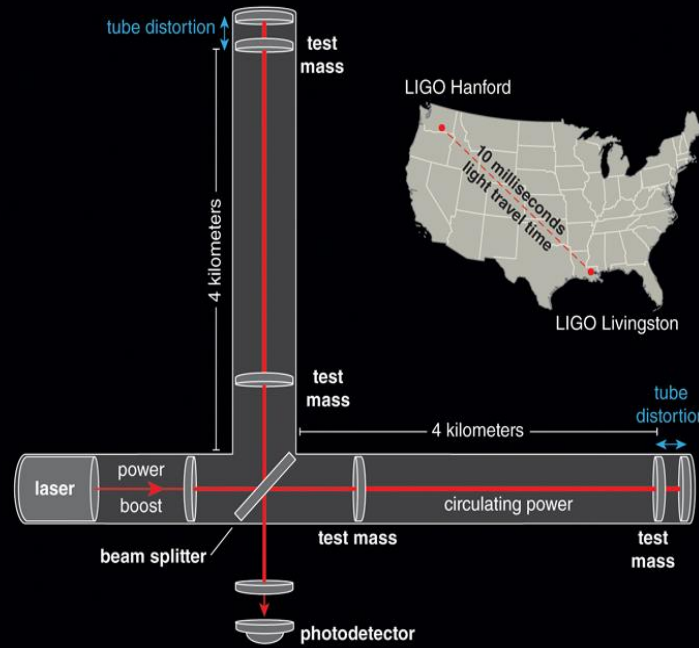
The **troposphere** is warming while the upper atmosphere layers are cooling at absolute values larger than in the troposphere. The stratosphere is contracting at a pace of more than 100 m/decade.

- Satellite observations indicate that the mesosphere has been cooling by up to -1.2 K/decade at low- to mid-latitudes during the last 20–30 years, in good agreement with model simulations.
- Simulations indicate that the temperature in the **thermosphere** at 400 km decreased by ~18 K due to the increasing concentration of CO₂ from the 1920s to the 2010s.
- **Ionospheric** peak heights show on average decreasing trends, with the F2 peak height getting lower by about 1 km/decade.
- This is consistent with the cooling trends in the neutral temperature, which cause the middle and upper atmosphere to contract, shifting ionospheric layers downward. A strong negative trend in ion temperature has been observed in the F2 peak region and above.

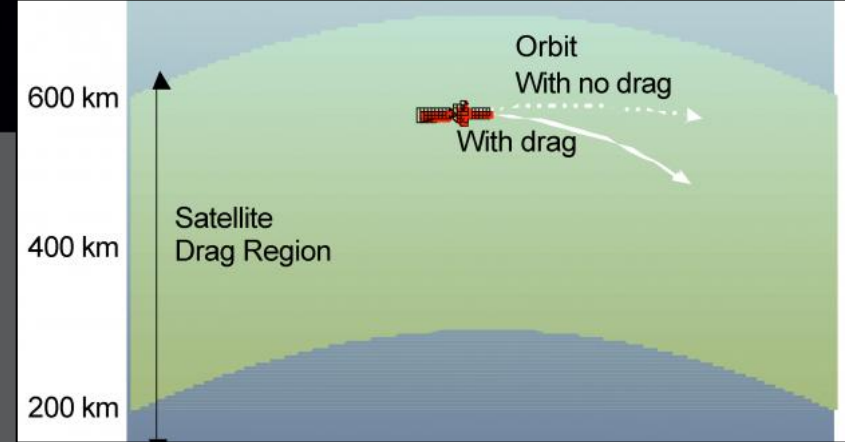
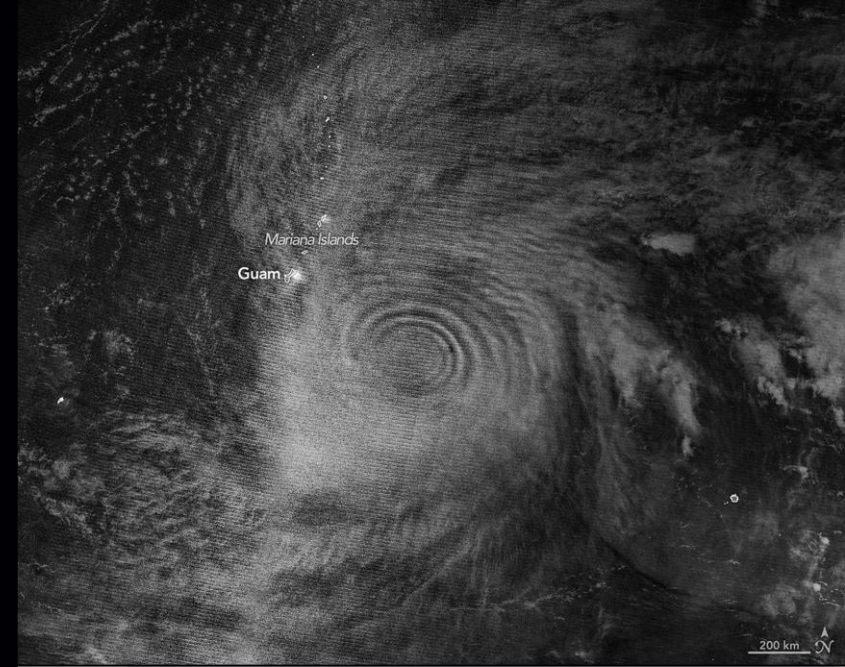
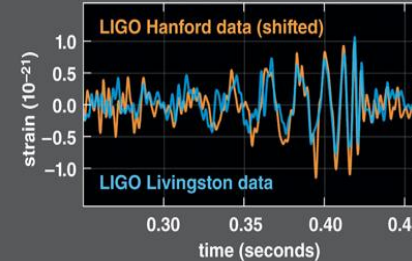
As a direct consequence of thermal shrinking, the neutral density is decreasing in the thermosphere at a rate of around -2%/decade.

Noctilucent clouds in the upper mesosphere at high latitudes display a positive trend in occurrence and brightness.

How LIGO Catches Gravitational Waves



LIGO Livingston



Atmospheric gravity waves (AGWs) directly impact low Earth orbit (LEO) satellites by transferring energy and momentum upward from Earth's weather systems into the upper atmosphere, causing fluctuations in neutral air density. These sudden density spikes alter atmospheric drag, which perturbs satellite orbits, shifts trajectories, and accelerates orbital decay.

- When density increases, the satellite cuts through more atmospheric particles, generating **a stronger drag force**. This causes the spacecraft to lose altitude and eventually de-orbit if its trajectory is not corrected.
- Gravity waves provide a pathway for severe terrestrial weather, to directly influence "space weather" and disturb spacecraft operations as well a surface support. Changing spheres can amplify space weather.

New Trend: Higher High Pressures

On July 6, 2026, the weather station in Ouse, Tasmania, logged an incredible 1044.5 hPa.

- This surpassed the previous 1967 national record of 1044.3 hPa, bringing widespread subzero temperatures, icy frosts, and sea levels 20-30 cm below normal across the country's southeast.
- The highland station at Liawenee in central Tasmania recorded the lowest minimum on Monday of -8.1 degrees Celsius, while Ouse dipped to -5.5C.
- Nearby inland stations of Bushy Park and Grove dropped to -3.0C and -2.3C.

An increase of 1hPa is responsible for a ~1 centimeter drop in water level.

A comparable event brought similarly high readings near 1044hPa just two years ago and data from the BOM since 1950 shows a clear upward trend in both the number and intensity of highs in the region. >>>

The lowest level of the atmosphere, called the troposphere, has been growing warmer and gaining thickness at a rate of 53 meters per decade since 2000

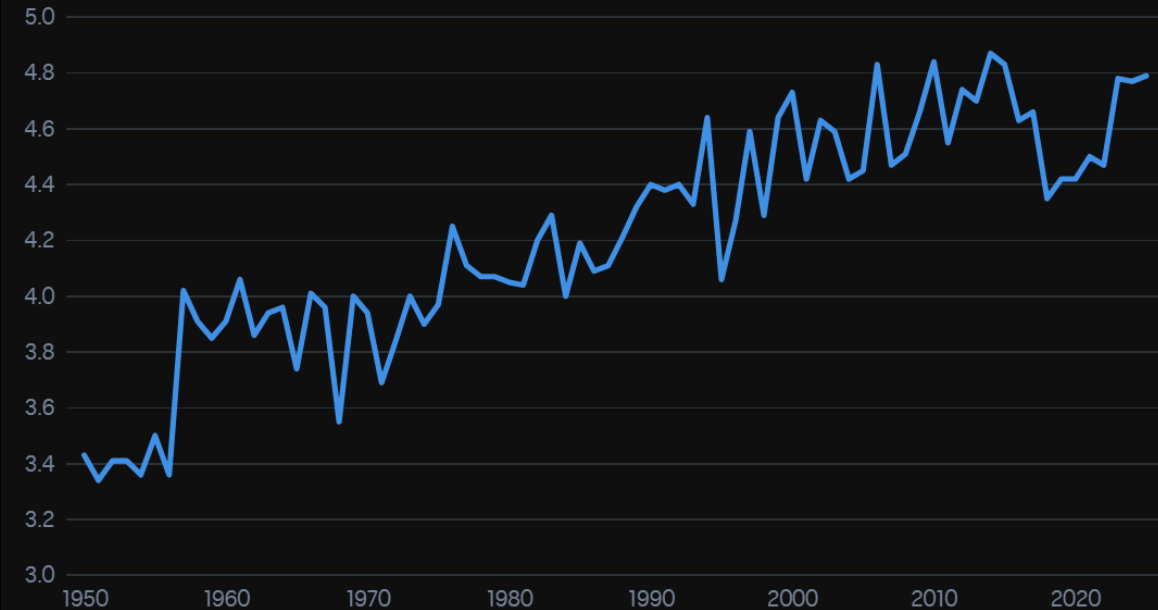
- Between 2001 and 2020, the altitude increased at a rate of around 53.3 meters per decade, which is a slightly higher rate of increase than between 1980 and 2000.

The lowest barometric pressure ever recorded on Earth was Typhoon Tip at 870 millibars (25.69 inHg), measured on October 12, 1979, in the eye of the storm.

2026 Hurricane Polo in the Eastern Pacific jumped from tropical storm to a Category 5 hurricane in 33 hours, the fastest development in the basin (+120mph increase) with an estimated record low barometric pressure of 892mb.

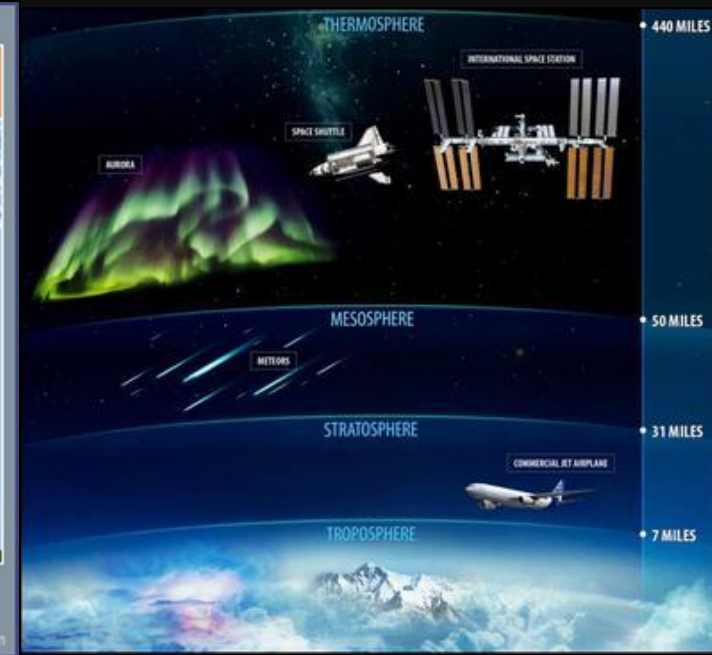
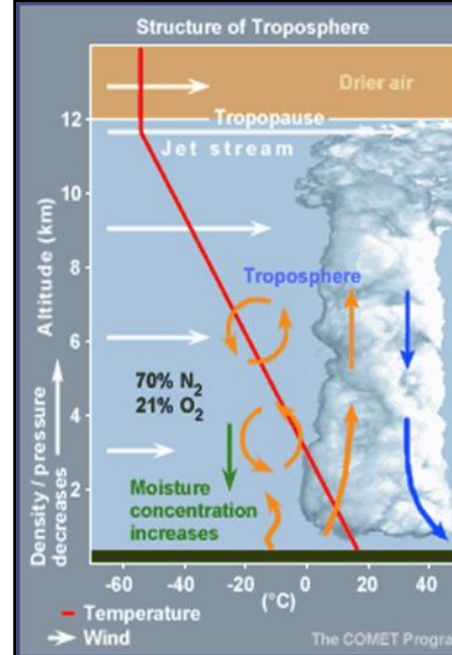
- The Hurricane Hunter aircraft reports came in as low as 889mb during its peak intensity Sept 22nd. The eye was 29F warmer than surround air and may set a record for the 'driest eye' on record.

Density of High Pressure Systems in Australian Region

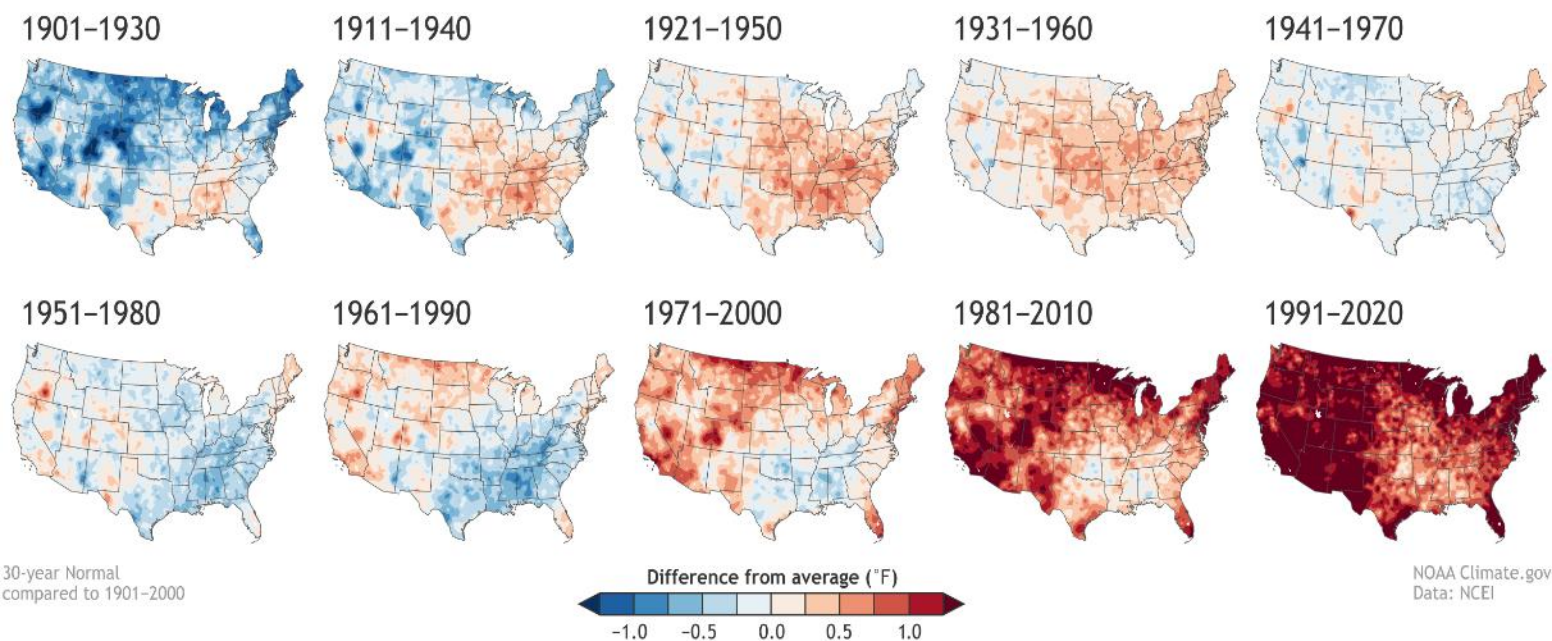


Average number of highs per season per degree of latitude squared

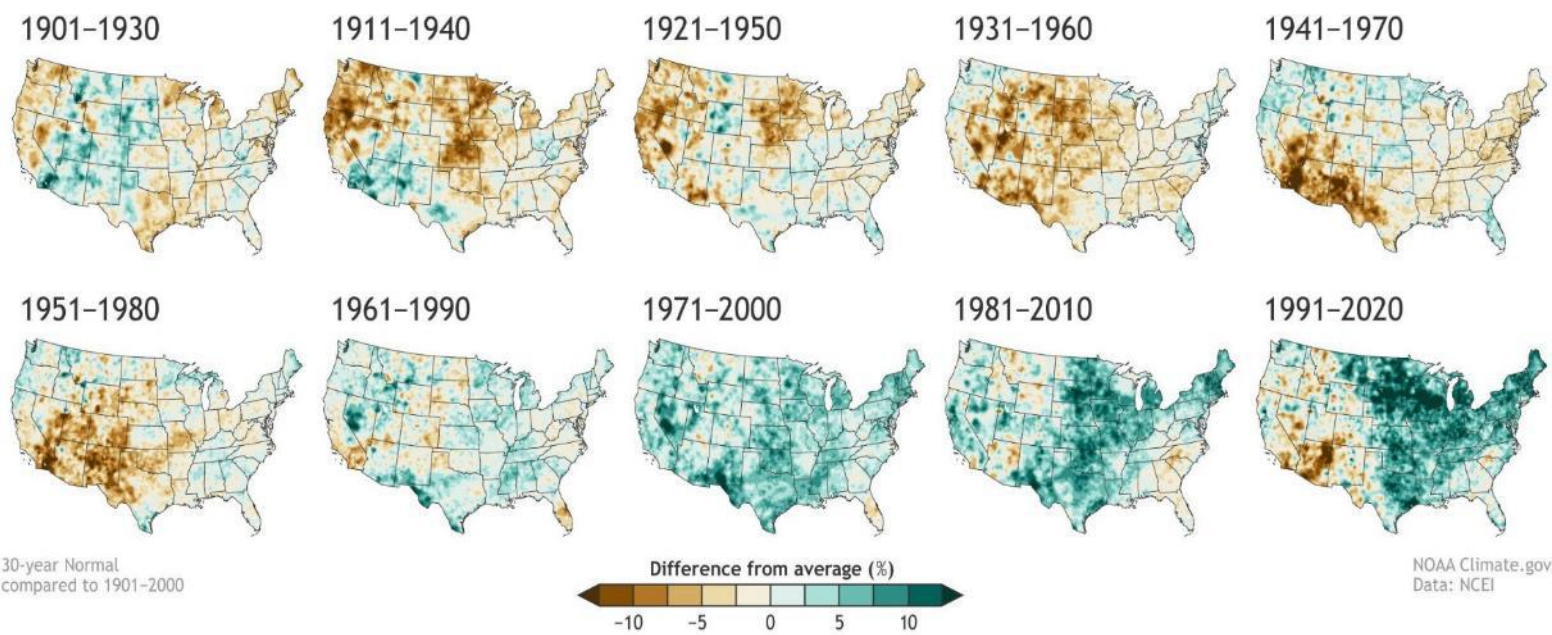
ABC News / Source: BOM / Get the data



U.S. ANNUAL TEMPERATURE COMPARED TO 20th-CENTURY AVERAGE



U.S. ANNUAL PRECIPITATION COMPARED TO 20th-CENTURY AVERAGE



By 2050, about 63% of the US may be forced to endure temperatures over 100°F. Areas where triple-digit temperatures are seasonal already, will see baseline temperatures and frequency of high heat events increase.

As average temperatures at the Earth's surface rise, **more evaporation occurs**, which increases overall precipitation. **For every 1.8°F of warming, the atmosphere can hold about 7% more moisture.**

- Warmer air holds more water because the water vapor molecules it contains move faster than those in colder air making them less likely to condense back to liquid.
- Sea surface temperatures have risen by 0.5–0.6°C since the 1950s, and over the oceans this has led to **4% more atmospheric water vapor since the 1970s.**
- As water vapor condenses to form rain it produces heat, brings warm air down and causing friction on impact, heating the surface.

As temperatures increase, short-burst heavy rainfall events will increase. The air is on average warmer and moister than it was prior to 1970, leading to **a 5-10% effect on precipitation and storms causing extreme downpours.**

Stronger Winter Storms

- Persisting Winds
- Temperature Swings
- Precipitation Deluges
- Larger Scale Systems
- Stronger Wind Gusts
- Thundersnow Events
- Nor'easters
- Polar Vortex Dips
- Atmospheric Rivers

Precipitation Shifts

- Heavy Snowfall
- Lake Effect Snow
- Freezing Spray
- Rain on Snow
- Rapid Runoff
- Avalanches
- River Floods
- Ice Dam Breaks
- Snowdrifts

Environmental Threats

- Frostbite
- Hypothermia
- Windchill
- Acclimation Loss
- Freezing/Dense Fog
- Blizzards/Whiteout
- Black Ice
- Freezing Rain
- Sleet and Ice Storms

Community Impacts

- Power Outages
- Supply Chain Delays
- Road Closures
- Repair Delays
- Strained EMS – Weather Whiplash
- Emergency Supplies Shortages
- Battery Drain
- Increasing Potholes

Personal Risk

- Resource Shortage (meds, food, water)
- Emergency Access Strain
- Unsafe Housing
- Temperatures
- Generator Risks
- House Fires
- Pipe Bursts
- Roof Leaks/Collapse

ICE ON TRANSMISSION LINES

920-foot span of 345kV transmission line. Normal height varies with temperature, which adds or reduces sag.

1/2 inch of ice: 4-foot drop

3/4 inch of ice: 6.2-foot drop

1 inch of ice: 8.6-foot drop

1 1/4 inch of ice: 11.6-foot drop

ICE ON DISTRIBUTION LINES

Distribution lines are lower to the ground and have shorter spans. Ice on these lines can lead to broken power poles or other pole equipment. Many outages on these lines are caused by tree branches that break and fall on the wires due to the weight of the ice.

Typical distribution lines in the metro area have a minimum clearance of 19 feet.

1/2 inch of ice: 1-foot drop

SUMMER SAG:

The sag on distribution lines is more severe during summer months than in winter, including when ice is on the lines.

WHAT ARE TRANSMISSION LINES?

These power lines carry electricity from generating stations to the substation.

WHAT ARE DISTRIBUTION LINES?

These lines carry electricity from substations to individual households, both overhead and underground.



Snow Load Can Cause Roof Damage or Failure

Weather Forecast Office
Medford, OR
Thursday, November 21



How much does this weigh?

Weight Of Snow Based On Depth And Water Content

Source: Cornell Univ, Curt Gooch

Roof Snow Depth	Fresh Dry Snow (lbs/sq ft.)	In-Between Snow (lbs/sq ft.)	Heavy Wet Snow (lbs/sq ft.)
6 inches	1.5	6	10.5
1 foot	3	12	21
2 feet	6.5	24	42
3 feet	9.5	36	62
4 feet	12.5	48	83
5 feet	15.5	60	104
6 feet	19	72	124

The accumulated weight of snow/ice on a roof can cause structural damage or even collapse if the building is not designed or built for extreme weather. As you can see, the weight of snow varies significantly depending on the snow's water content.

POWER GRID IMPACTS

STORMTRACK

WQAD
8



GALLOPING



ICE FORMS TEARDROP SHAPE
WIRES CAN SWAY AND COLLIDE

The weakening polar jet stream

The pressure difference between cold air in the Arctic and warm air in the mid-latitudes creates the powerful belt of wind we call the “polar jet stream.” This natural barrier keeps the freezing temperatures of the Arctic winter from intruding further south.



When the polar jet stream is strong, powered by large temperature differences between the Arctic and mid-latitudes, it moves relatively straight. This keeps the coldest winter temperatures in a predictable ring: the Arctic environments of Alaska, northern Canada, Greenland, Siberia and Scandinavia.



A warming Arctic produces a weaker jet, more likely to bend off course. This wavy pattern can shift the boundary between cold Arctic air and warm mid-latitude air to strange places. Southerly regions used to mild winters may be exposed to freezing temperatures at the same time that parts of the Arctic deal with unusual warm spells.

Strong El Niño events can send more planetary wave energy into the stratosphere, frequently disrupting or weakening the polar vortex.

- When the polar vortex weakens or splits, it loses its grip on tight Arctic air containment, allowing severe cold outbreaks and winter storms to push south into North America and Europe.
- Experts warn a strengthening Super El Niño could drive a volatile, storm-heavy 2026–2027 winter.

FROST QUAKES

THE SCIENCE BEHIND THE BOOMS

- ▶ Groundwater freezes and **expands** due to **rapidly** dropping temperatures
- ▶ Frozen water takes up more space than liquid water, creating internal pressure
- ▶ Pressure from the expanding ice forces the ground to crack
- ▶ The sudden cracking can produce **loud booms** or sustained rumbling



THIS WILL BE MOST LIKELY IN RAPIDLY DROPPING TEMPS

WATER TABLE

Warming Fall – Threats to Energy and Ecology

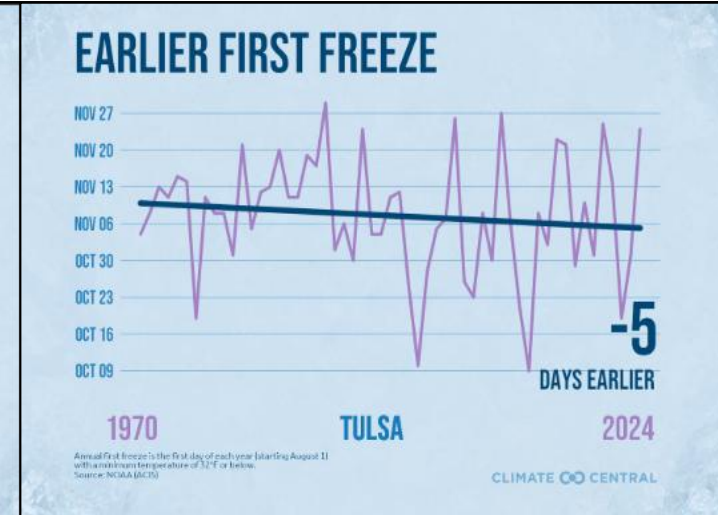
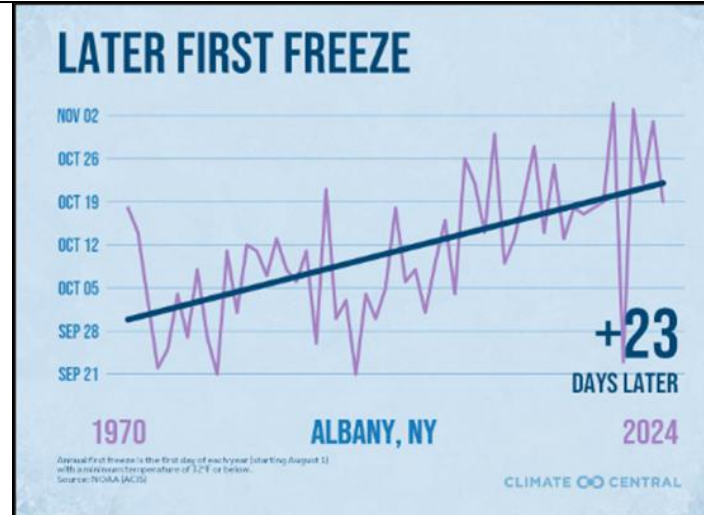
September 1st is the start of meteorological fall. The season has warmed in every county across the contiguous U.S. since 1970 and is warming fastest in the Southwest.

Fall has warmed in 237 US cities by 2.8°F on average from 1970 to 2024.

- Unusually warm fall days now happen more often in 238 cities, or 98% of the 243 cities analyzed.
- 103 (42%) of those locations have warmed by 3°F or more since 1970.

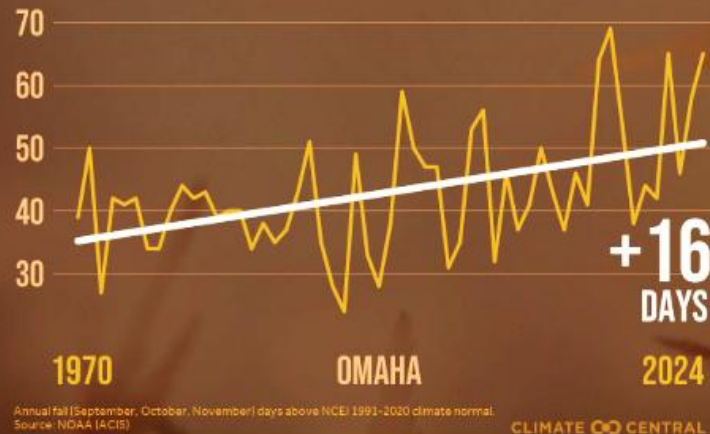
A warmer fall season means that the risky heat, high cooling demand, wildfires, and allergies of summer linger later into the year affecting health, ecosystems, and the economy.

- Top five fall warming locations: Reno, NV (7.7°F); El Paso, TX (6.5°F); Las Vegas, NV (6.2°F); Tyler, TX (5.8°F); and Tucson, AZ (5.8°F).
- Almost half of the cities analyzed (119, or 49%) now experience at least two more weeks' worth of above-normal fall days than in 1970. Over the last 10 years, back-to-school cooling demand increased by about 34%.



The first freeze now arrives later in 88% (179) of cities analyzed: 12 days later, on average, than in the early 1970s. A later freeze can worsen allergies, change migration, lengthen pest seasons, and reduce summer fruit yields and lead to more heat-driven drought and water stress. Ice cover on the Great Lakes has been consistently reducing, declining by ~25% from 1973 to 2023.

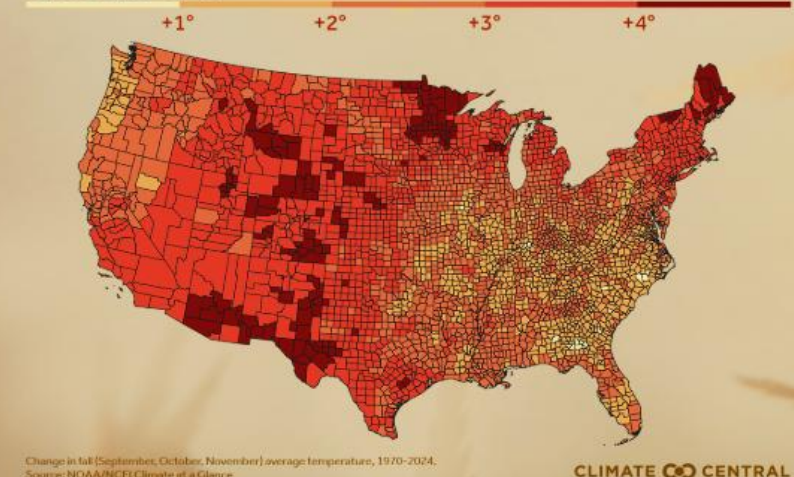
MORE WARM FALL DAYS DAYS ABOVE NORMAL



FALL WARMING AVERAGE TEMPERATURE



FALL WARMING SINCE 1970 (°F)



Changing Spring Conditions

The spring season has warmed in 234 (97%) of the 241 U.S. cities analyzed — by 2.4°F on average.

- Unusually warm spring days now happen more often. Four out of every five cities now experience at least one more week of warmer-than-normal spring days than in the 1970s.
- Spring has warmed the most across the southern tier of the country, particularly in the Southwest.
- Spring warming can prolong seasonal allergies, worsen wildfire risk, and limit snow-fed water supplies.

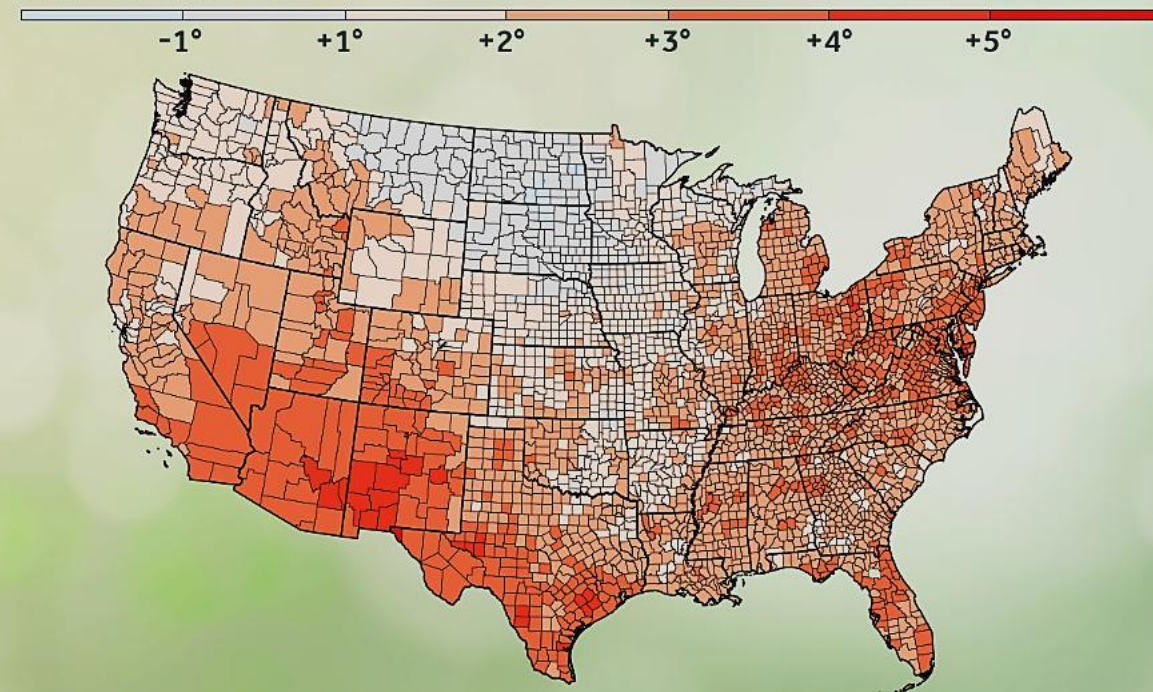
Spring warmed the most, on average, in locations across the southern tier of the country: Southwest (3.4°F), South (2.7°F), Southeast (2.5°F), and Ohio Valley (2.5°F).

- **Most locations (80%, or 194) now experience at least seven additional warmer-than-normal spring days than they did in the early 1970s.**

Warmer, shorter winters mean an [earlier spring thaw and later fall freeze](#).

SPRING WARMING

Since 1970 (°F)



Change in spring (March, April, May) average temperature, 1970–2025.
Source: NOAA (NCI). Accessed: 1/21/2026.

CLIMATE CENTRAL

MORE WARM SPRING DAYS

Days above normal



Average spring days (March, April, May) above NCEP 1981–2020 climate normal.
Source: NOAA (NCI)

CLIMATE CENTRAL

SPRING WARMING

AVERAGE TEMPERATURE



Average spring (March, April, May) temperatures in °F.
Source: NOAA (NCI)

CLIMATE CENTRAL

Warmer spring temperatures result in earlier thaws, heavier spring rainfall, longer growing seasons, double blooms, river system changes, marine and wildlife shifts, and changes to energy needs.

LONGER GROWING SEASON

Change in freeze-free season length from 1970–2023



Freeze-free season = number of days between the first and last average 32°F.
Source: FCD ACT.org

CLIMATE CENTRAL

Climate Central's Warming Seasons Graphics

Winters have warmed by 4°F on average across 235 US cities since 1970. Warmer, shorter winters have lingering effects on health, water supplies, and agriculture throughout the year.

Summers are heating up in 234 of major US cities by an average of 2.6°F since 1970.

Analysis also shows persisting warmer-than-normal summer nights since 1970 in 246 major US cities.

MORE HOT SUMMER DAYS

Days above normal



Average summer days (June, July, August) above NCEI 1991-2020 climate normal.
Source: NOAA (ACIS). Accessed: 04/21/2026.

CLIMATE CENTRAL

SUMMER WARMING

AVERAGE TEMPERATURE

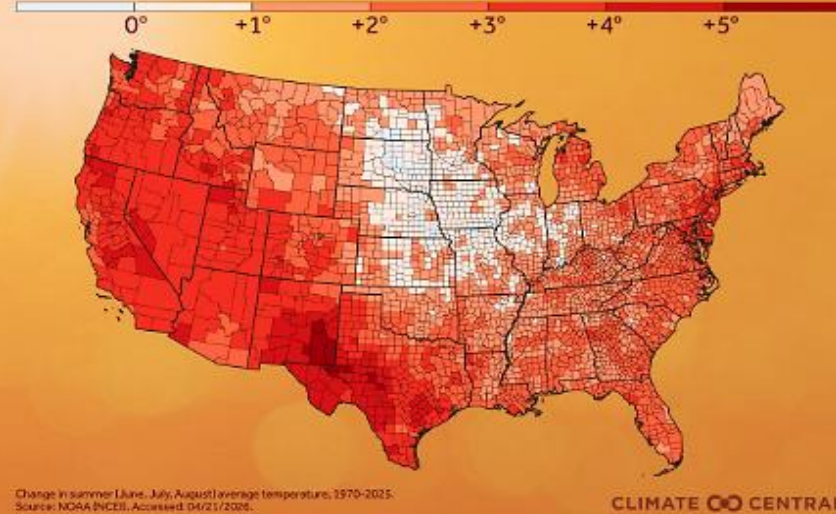


Average summer (June, July, August) temperatures in °F.
Source: NOAA (ACIS). Accessed: 04/21/2026.

CLIMATE CENTRAL

SUMMER WARMING

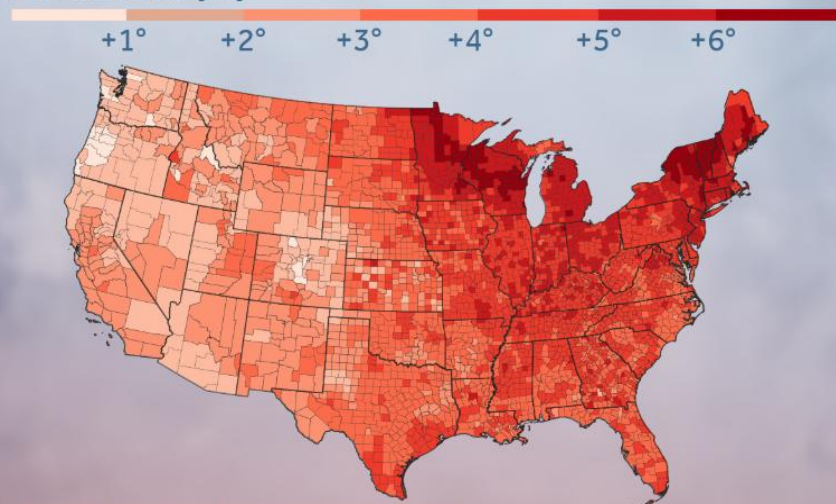
Since 1970 (°F)



Change in summer (June, July, August) average temperature, 1970-2025.
Source: NOAA (NCEI). Accessed: 04/21/2026.

WINTER WARMING

SINCE 1970 (°F)



Change in winter (December, January, February) average temperature, 1970-2025.
Source: NOAA/NCEI Climate at a Glance

MORE WARM WINTER DAYS

DAYS ABOVE NORMAL



Annual winter (December, January, February) days above NCEI 1991-2020 climate normal.
Source: NOAA (ACIS)

CLIMATE CENTRAL

WINTER WARMING

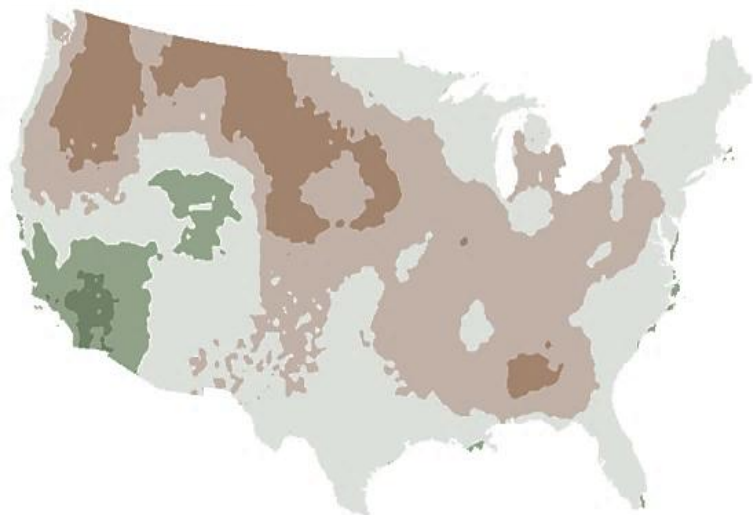
AVERAGE TEMPERATURE



Average winter (December, January, February) temperatures in °F.
Source: NOAA (ACIS)

CLIMATE CENTRAL

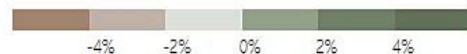
RISK FACTOR



Changing humidity

An increase in temperature also leads to an increase in the rate of water evaporation, causing changes to atmospheric humidity that affect the way heat impacts communities.

Change in relative humidity in 30 years



Climatology Lab MACAv2 downscaled GCM, based on historical period 1950-2005 and adjusted to future conditions using the RCP4.5 emissions scenario.

<https://riskfactor.com/>

WIND FACTOR

95 M

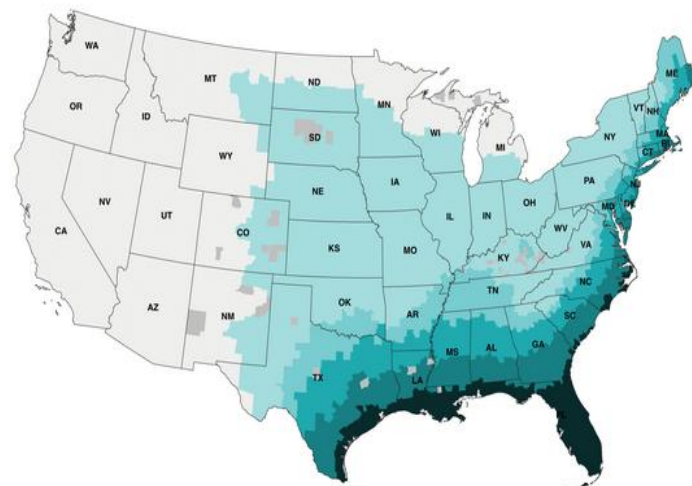
Properties at risk today

106 M

Properties at risk in 30 years

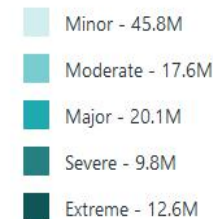
11.3 %

Change in risk



Map displayed at the county level

Distribution in properties at risk (145M analyzed)



FLOOD Risk across the United States

FLOOD FACTOR

FIRE FACTOR

HEAT FACTOR

24.7 M

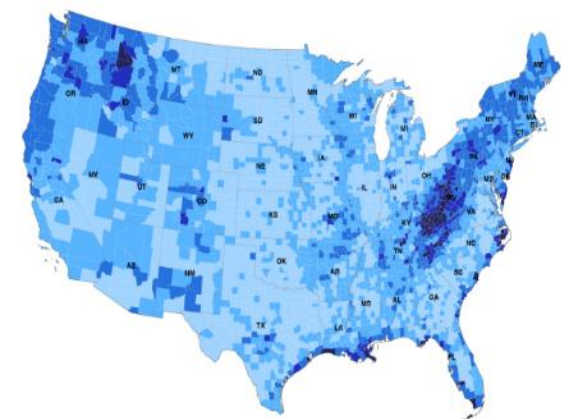
Properties at risk today

26 M

Properties at risk in 30 years

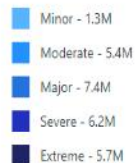
5.3 %

Change in risk



Property ☐ County

Distribution of properties at risk (145M analyzed)



FIRE Risk across the United States

FLOOD FACTOR

FIRE FACTOR

HEAT FACTOR

71.8 M

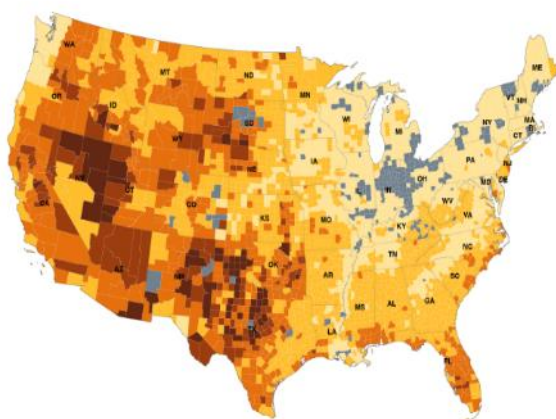
Properties at risk today

79.8 M

Properties at risk in 30 years

11.1 %

Change in risk



Property ☐ County

Distribution in properties at risk (145M analyzed)



HEAT Risk across the United States

FLOOD FACTOR

FIRE FACTOR

HEAT FACTOR

15.8 M

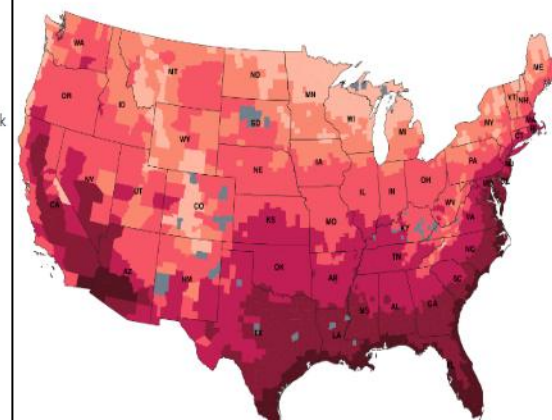
Properties with Extreme Risk

107 M

Population with yearly days above 125°F in 30 years

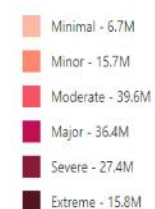
157 %

Avg. increase in local hot days



Property ☐ County

Distribution in properties at risk (145M analyzed)



Concrete: In high heat environments over 80°F, concrete should not be poured, or it will not set effectively. This can increase setting time from 2-3 days up to 7 days in hot weather.

- Thermal cracking is found particularly in thick slabs, or mass concrete, where the temperature differential between different areas of the concrete is too high. (Examples: airport aprons, bridge headsticks, and highways where repaving needs have been increasing).

Epoxy: Most heat-resistant epoxies need to be cured at temperatures at or beyond the temperature it will need to endure. If temperatures exceed these maximum service temperatures, the material could start to distort. At a temperature of 135°F or higher, epoxy may begin to exhibit heat damage.

- Epoxy faces the same concerns of needing a few days to cure but in persistent high heat/humidity levels it could take up to two weeks.
 - If Epoxy cures in too high of a temperature it can become too solid, resulting in less give during temperature swings and may crack.

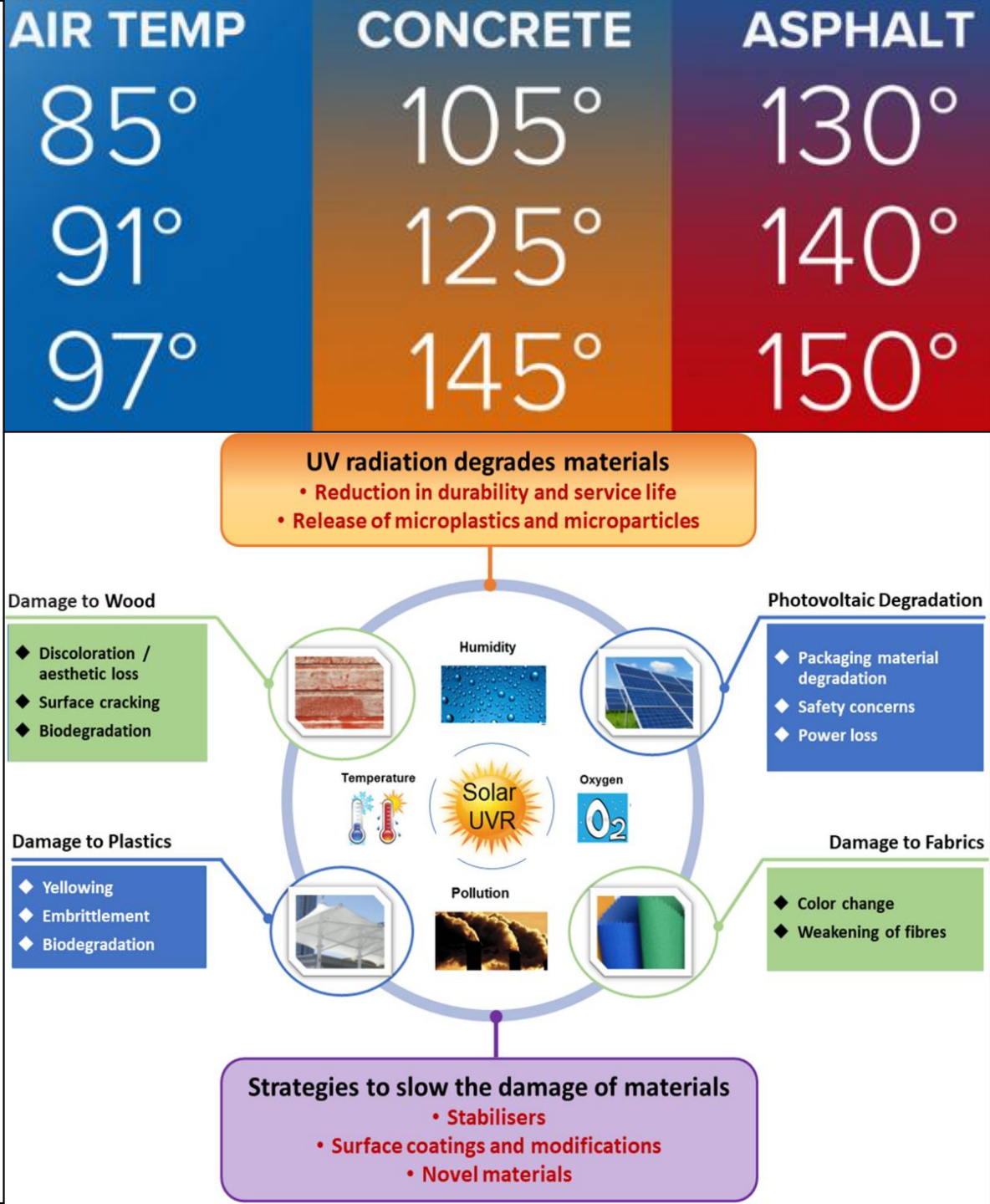
Metals: Extreme heat causes various metals to expand in addition to impacting the structure, electrical resistance, and magnetism. When metal heats, the bonds begin to break.

- Bridges in New York, Sacramento, and London have faced thermal expansion or cracking— 95°F in New York, 103°F in Sacramento, and 65°F in London.

Powerlines: Extreme heat can sag powerlines causing transmission lines to lose up to 5.8% of their capacity to carry electricity. Wind turbines can be 25% less efficient in high temperatures.

- The combined effects of extreme heat cost the US over \$162 billion in 2024 – equivalent to nearly 1% of the US GDP.

Cityscapes: Marble benches comparable can range up to 105°F while limestone can reach 116 degrees in sunlight. Shade often drops these temperature by 16-18°F. Water fountains can reach 95°F, bus stop signs/posts can reach 105°F, bicycles can range to 104°F, 102°F for handles, and crosswalk buttons near 98°F.



Radiative Heat Threats: Cities + Canals

In the 1980s, concurrent heat waves only occurred for 20-30 days each summer. Recent warming has driven a sixfold increase in the frequency of simultaneous heat waves over the last 40 years. The study also found that concurrent heat waves covered about 46% more space and reached maximum intensities that were 17% higher than 40 years ago.

Concrete is a great material for absorbing and storing heat from the sun, meaning it can warm to higher temperatures than most other materials and releases that heat more slowly as direct heating stops. On a hot summer day, concrete that's in the shade can easily average 70°F, however, concrete that's in direct sunlight can reach 135°F. Due to the higher temperature, these mixtures are at risk of expansion-triggered water incursion, weakening the structural integrity of various sites and foundations.

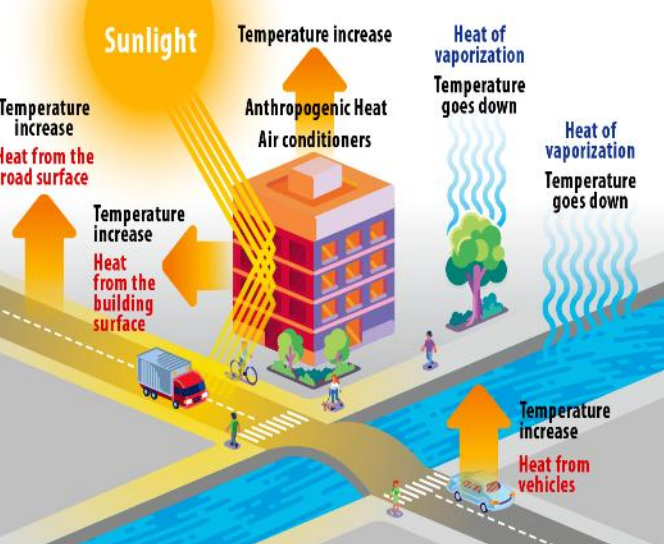
- Grass rarely exceeds 80°F, wood peaks around 90°F, composite decking about 100°F, but concrete can reach a hotter temperature and hold onto that heat longer. In cities, the developed areas of cityscapes may have cooler temperatures due to additions of vegetation and shading, creating significant heat disparities.
- Heat islands form because of reduced natural landscapes in urban areas and increases in heat-retentive materials. Trees, vegetation, and water bodies tend to cool the air by providing shade, transpiring water from plant leaves, and evaporating surface water, respectively.

Metal benches, grates, and shopping carts can exceed temperatures of 120°F resulting in burn potential for unhoused populations especially. Without cooling centers staying open overnight, at-risk populations are purged back into an abnormally warm city where pollution concentrations remain high due to the lingering heat. Coated benches exceed 108°F.

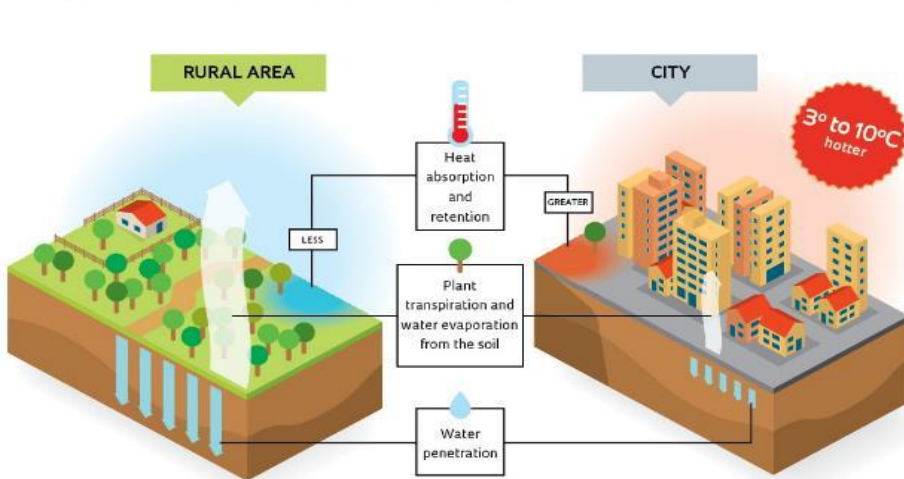
- The more densely packed a metro car is or a bus is, the greater the ambient temperature will become making it more difficult to cool down between stops.

When asphalt heats it becomes more malleable, making it soft and able to compress under weight and become disformed. High heat also rapidly ages the material, making infrastructure on or near it weaker.

At the current rate of heating, the expansion buffer will not stop the material from buckling more often. This will yield more potholes and lower income communities may not be able to repair at the heightened damage rate.



Why the urban heat island effect occurs



SURFACE TEMPERATURES			
AIR TEMPERATURE	3/4/22	6/21/22	
	10:30am	10:30am	3:30pm
1. Concrete (sidewalk)	58°- 61.5°	▲ 110°	◆ 142°
2. Asphalt (street)	62°- 64°	▲ 125°	◆ 155°
3. Plants	65°	▲ 89°- 91°	◆ 105- 115°
4. Turf (grass)	69°- 71°	▲ 93.5°	◆ 99.5°
5. Bare Dirt	78°	▲ 119°	◆ 159°
6. Mulch	81°	▲ 120°	◆ 154°
6a. Soil under mulch		▲ 96°	◆ 110°
7. Gravel (stones)	82° large 90° small	▲ 122° lg. ▲ 129° sm.	◆ 140° ◆ 149°
8. Artificial Turf	90.5°- 93°	▲ 143.5°	◆ 165°

Severe Weather on the Rise

Hail events throughout the US are forecasted to intensify regarding size of the hailstones as warmer seasons across multiple regions can enable stronger updrafts for supercell storms responsible for large hail especially across less hardened areas.

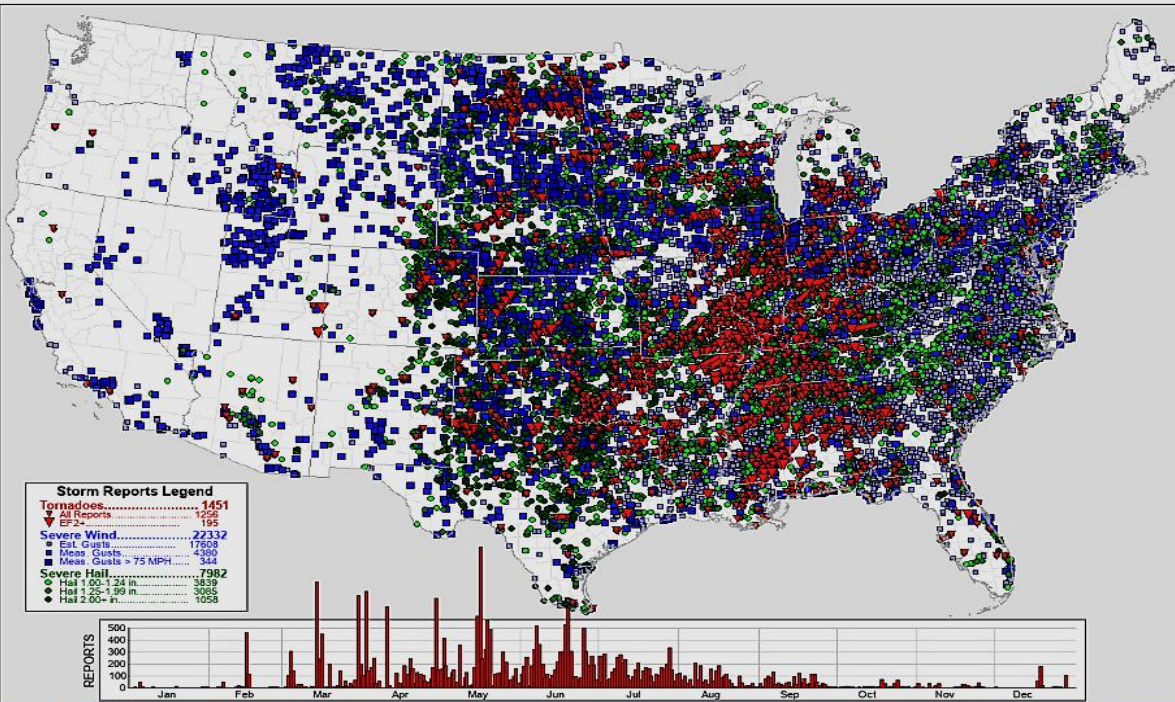
- Insured U.S. hail losses average \$8 billion - \$14 billion per year, or \$80-140 billion per decade.

A new [study](#) published by the National Center for Atmospheric Research finds there has been “a fivefold increase in the area affected by straight-line winds since the early 1980s” in the central U.S. Straight-line winds are often produced by thunderstorms and can impacts like that of a tornado. These winds have increased at a rate of 13% per degree of warming.

Tornado activity from 2008-2021 in comparison with 1991-2010 indicates the seasonal frequency has remained the same but the location and intensity of tornadic supercells has expanded from “Tornado Alley” to “Dixie Alley” producing larger, longer supercells. Dixie Alley includes Eastern TX, AR, LA, TN, KY, MS, AL, GA, South MO, Southeast OK, and the FL panhandle.

A recent study predicts a nationwide 6.6% increase in supercells and a 25.8% expansion in the area and time supercells remain over land by the year 2100. This may result in areas which do not often see tornadic activity reporting increases.

2025 Annual Final Report Summary



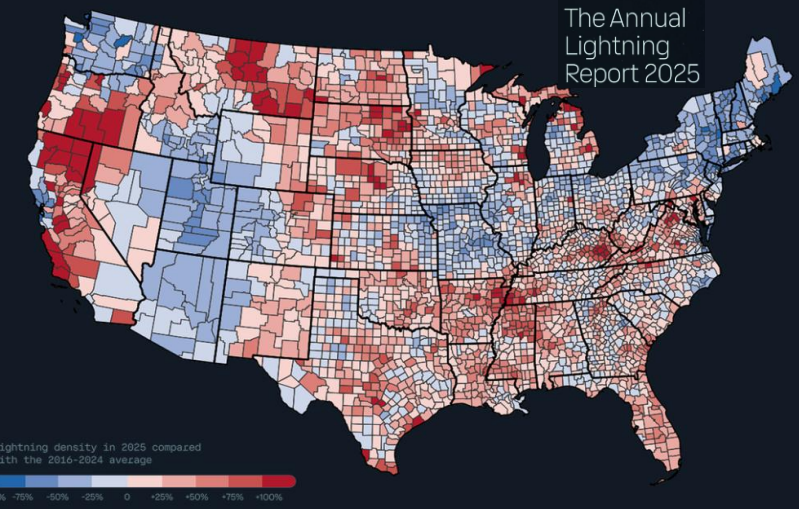
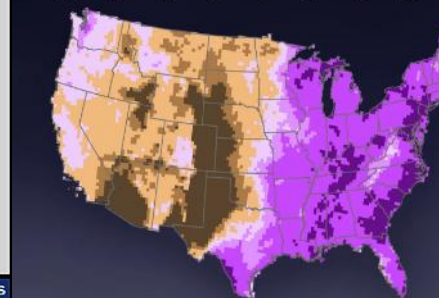
Recent storms following heatwaves in the Northeast and Midwest have resulted in multiple states hitting new record hailstone sizes ranging from melon size in over 9 states to even the record event the 4th of July of 2026 caused in Connecticut at a 3-inch diameter.

Severe weather events are now happening far more frequently across the US and internationally.

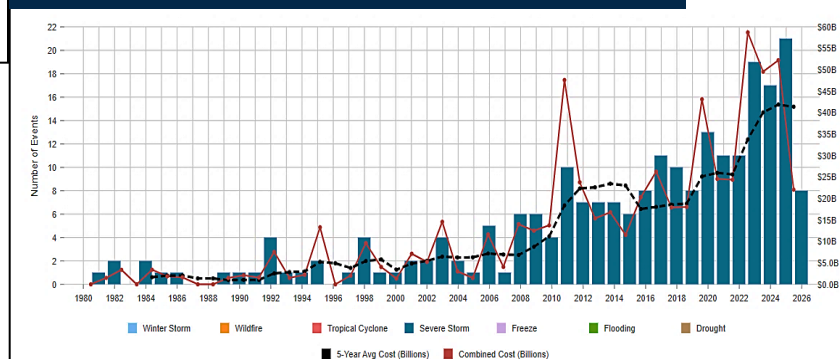
ANNUAL THUNDERSTORM POTENTIAL

Change in days with CAPE at or above 1000 J/kg since 1979

-40 -20 -10 -5 0 +5 +10 +20 +40



U.S. Billion-Dollar Weather and Climate Disasters



The history of billion-dollar disasters in the United States each year from 1980 to 2026, showing event type (colors), frequency (left-hand vertical axis), and cost (right-hand vertical axis) adjusted for inflation to 2026 dollars.

HAIL CLAIMS REPORT 2018-2020

TOP 5 STATES FOR HAIL CLAIMS:



1. Texas
605,866 Claims



2. Colorado
312,808 Claims



3. Illinois
150,970 Claims



4. Missouri
139,288 Claims



5. Minnesota
137,330 Claims

Hail Loss Claims



2,632,050
Total Hail Claims

The Role of Heat in Storm Growth

Severe thunderstorms are defined as having sustained winds above 93 kilometers (58 miles) per hour or unusually large hail, and there are two key factors that fuel their formation: convective available potential energy (CAPE) and strong wind shear.

- Research by Climate Central has shown an increase of 10 to 15 high-CAPE-value days annually between 1979 and 2021 across much of the eastern US.
- Cities such as Atlanta and New York City could see a doubling of the number of days that severe thunderstorms could occur.

Lightning: *Each 1 degree Celsius of warming could spur a 12% increase in lightning frequency, boosting the flash rate to about four times per second by 2090*, up from nearly three times per second in 2011. Many sites across the US reportedly do not invest in lightning protection systems.

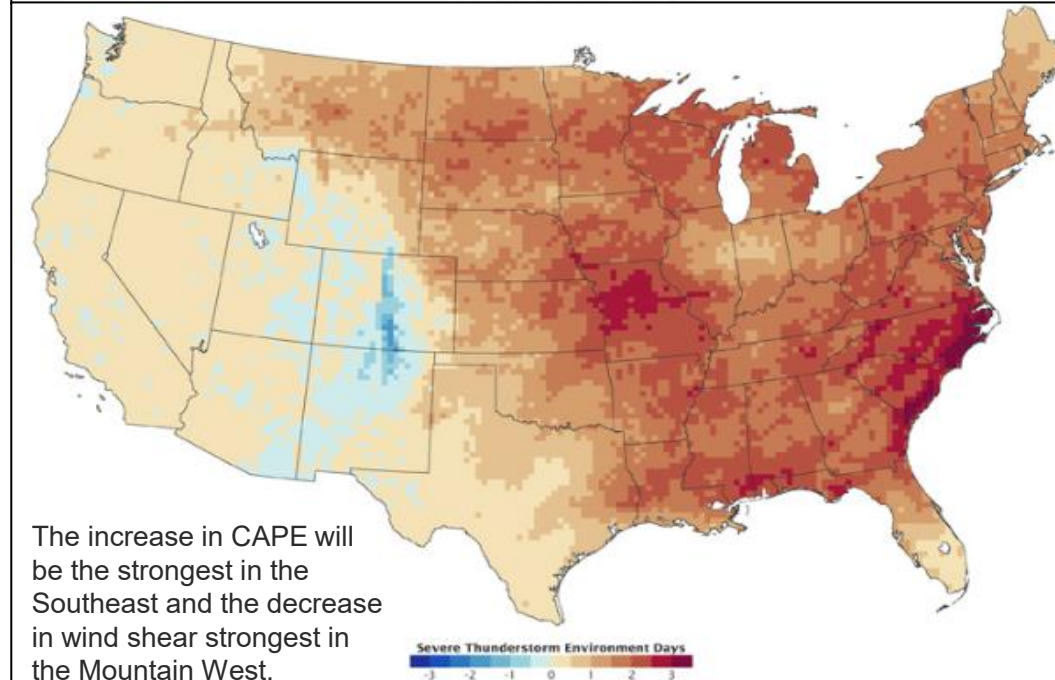
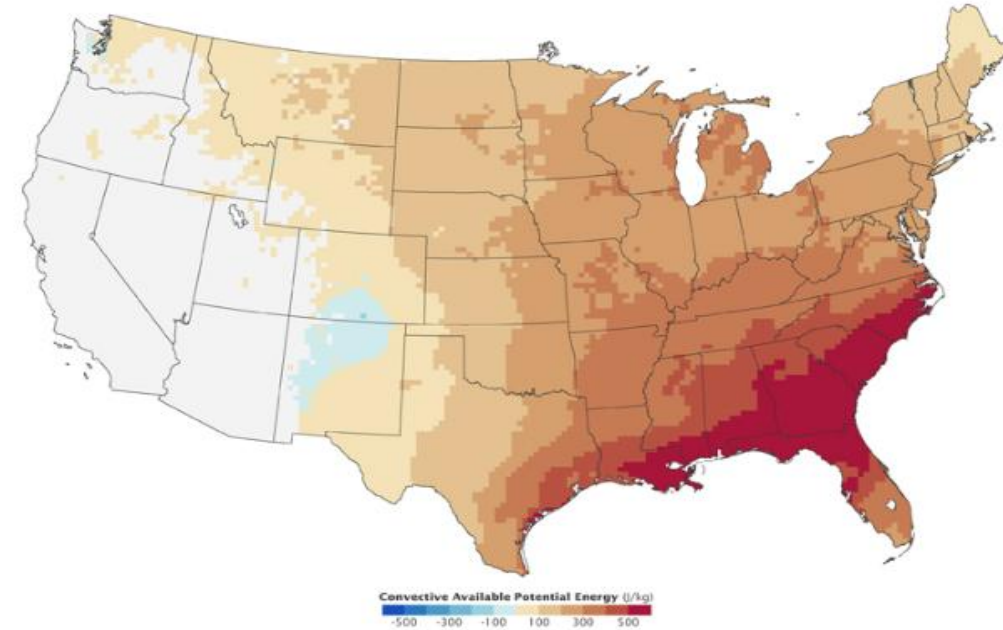
- Flashes that touch down amid minimal or no rainfall, known as dry lightning, are especially effective fire starters.
- Currently about 20 million lightning bolts touch down each year within the US.
- Hotter days may boost updraft within thunderstorms, causing lightning flashes to increase in frequency to about 4 strikes per second globally — about a 40% increase from 2011.
- *The rate of all cloud-to-ground strikes increasing to ~8 flashes per second (+28%).*

Hail: increasing temperatures and humidity could fuel larger hail and could mean smaller pellets are more likely to melt before hitting the ground.

- *Damage from severe thunderstorms has been inching up by about 7% annually for 30 years.*
- Worldwide, thunderstorm losses were almost 90% higher than the previous five-year average of \$32 billion and over double the previous 10-year average of \$27 billion.

Severe thunderstorms and climate change

Models compare the summer climate from 1962–1989 to future climate projections for CAPE indices in 2072–2099.



Lightning Impacts to Vegetation

The atmosphere is 78% nitrogen, one of the main ingredients in fertilizer, but in a gaseous state Plants cannot use nitrogen in this form, and it requires a lot of energy to break the dual-bond of.

- Lightning can heat surrounding air to about 50,000 degrees Fahrenheit. The free nitrogen atoms then combine with oxygen and mix with rainwater, forming nitrates.
- Globally, there are 44 to 100 lightning strikes per second, which is nearly 8 million strikes a day. That results in a substantial amount of thunderstorm nitrates and natural fertilizer.
 - These nitrates are immediately available to plants unlike organic fertilizers and manures as microbes must break them down into forms the roots can take up.

In the US, the National Science Foundation (NSF) has given [millions of dollars](#) to research the agricultural uses of cold plasma – essentially controlled lightning delivered at room temperature.

- In China, the government is backing agricultural projects that use giant rigs to draw electricity into the soil [to boost crop yields](#).
- In Canada, a commercial grower has been experimenting with [cold plasma to fertilize its lettuces](#).
- Treating seeds in plasma for less than a minute led to a 40% increase in potato harvests.
- Experiments in Germany showed that strawberries, beans, and barley grew larger and ripened faster when electrified

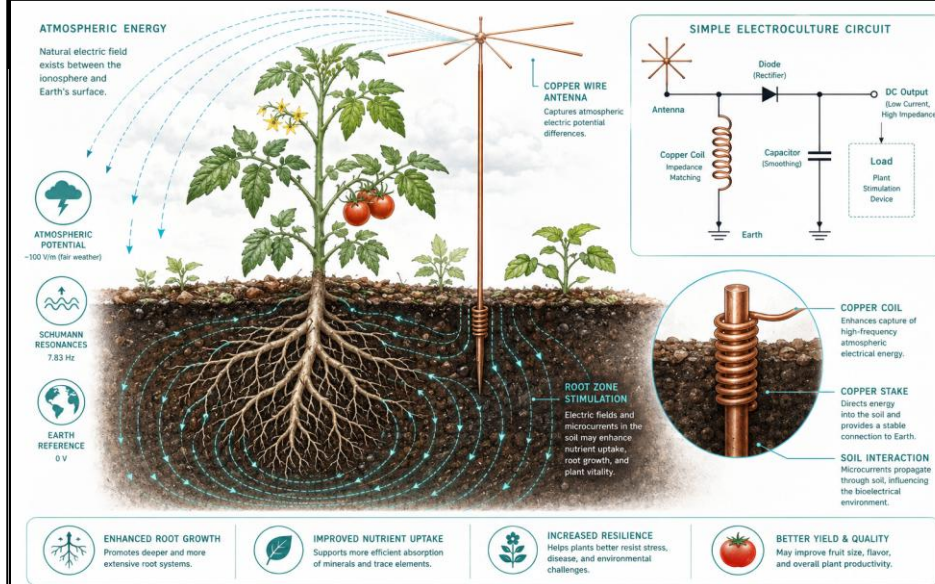
Plasma pens have been used by the NSF to boost growth in already-grown plants: The plasma stimulated more robust and healthy growth, bestowing a [20% increase in not just the height but the overall mass of the plant](#).

Finnish geophysicist Karl Lemström observed that plants appeared to grow rapidly near the aurora borealis on a trip near the Arctic in 1868.

In the 1920s, prolific French inventor Justin Christofleau published "Electroculture," a book on atmospheric electricity in gardening, which set a precedent for modern electroculture.



Researchers have discovered that living plants are literally 'green' power sources. This discovery reveals that certain leaf structures are capable of convert mechanical forces applied at the leaf surface into electrical energy by a process called **contact electrification**. These charges are then immediately transmitted into the inner plant tissue. The plant tissue acts similar to a "cable" and transports the generated electricity to other parts of the plant. Hence, by simply connecting a "plug" to the plant stem, the electricity generated can be harvested and used to power electronic devices.



Hail Records Continue to Rise

2010: A hailstone was discovered in South Dakota measuring 8.0 inches in diameter, 18.625 inches in circumference, and weighing 1.94 pounds.

2016/2022/2024 Colorado reported 2-feet of hail requiring plow trucks to move and triggering flooding as the ice melted quickly at the surface.

2023-2025: Multiple states reported melon-size hail (+6-inch diameter).

2025: Texas's new record hailstone reported at 7.25-inch diameter.

Pollution can influence hail formation and potentially lead to larger hailstones.

Pollutants provide cloud condensation nuclei, affecting the size and number of stones.

Hail severity will increase in most regions of the world while Australia and Europe are expected to experience more hailstorms.

Insured U.S. hail losses now average \$8 billion to \$14 billion per year, or \$80-140 billion per decade (as of 2022).

This outpaces the total of \$14.1 billion in insured US property loss from tornadoes over the decade from 2010 to 2020.



TEXAS Record MONSTER Hailstone!

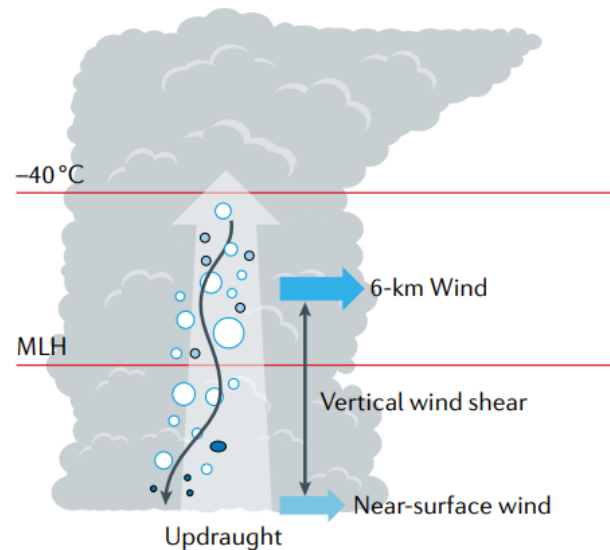
Documented 7.25" hailstone 3 miles WNW of Vigo Park, Texas at 7:37pm Sunday set a new state record (pending) shattering the previous record of 6.4" in Hondo, TX in 2021.

Permission: Val and Amy Castor

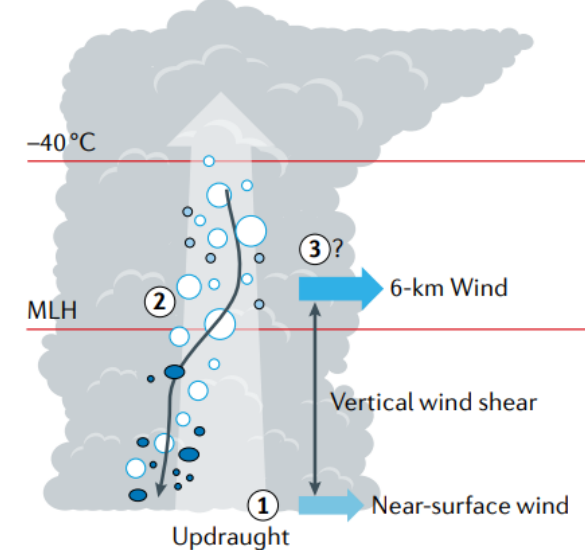
7:25 PM · Jun 4, 2024



a Current climate



b Future climate



○ Hailstones ● Supercooled liquid water ● Rain

Fig. 1 | Hail-relevant atmospheric phenomena in current and future climates. The expected changes in hail-relevant atmospheric phenomena between the current (panel a) and future (panel b) climates. The numbers in panel b correspond to the following changes: (1) increased low-level moisture leads to increased convective instability and updraft strength; (2) an increase in the melting level height (MLH) leads to enhanced melting of hailstones and a shift in the distribution of hailstone sizes towards larger hailstones; and (3) changes in vertical wind shear may affect storm structure and hailstone trajectories, but are generally overshadowed by instability changes.

Energy Sector Losses – Ex Wx

Between 2000 and 2023, 80% of reported major outages in the U.S. were due to weather-related events. Severe hailstorms can damage renewables like wind turbines and solar power.

- The average annual number of weather-related power outages increased by roughly 78% during 2011-2021, compared to 2000-2010.

The US experienced about two times more weather-related outages during the 10 years 2014-2023 versus the first 10 years analyzed of the 2000's (2000-2009).

- Future impacts: A two-week outage could cause a hit to the gross domestic product of the greater Chicago metropolitan area as high as \$17.1 billion.

Solar panels and turbines exposed to icing, freezes, or hail may see significant output loss, damage, or exponential deterioration rates.

- Wind turbines also face significant costs from lightning at +\$100 million a year and accounts for about 60% of the blade losses.

A new survey from the USC Center for Risk and Economic Analysis of Threats and Emergencies on power outages increasing nationally showed that 71% of large enterprises had some backup capacity, compared to only 22% of small businesses and 12% of residential customers.

- Researchers estimate that doubling the number of customers with generation capacity could reduce losses to gross domestic product by up to 14%.

Power outages cost the American economy between \$20 billion and \$55 billion annually from storm-related disruptions alone.

- The cost of a US data center outage has grown to \$8,851 per minute.

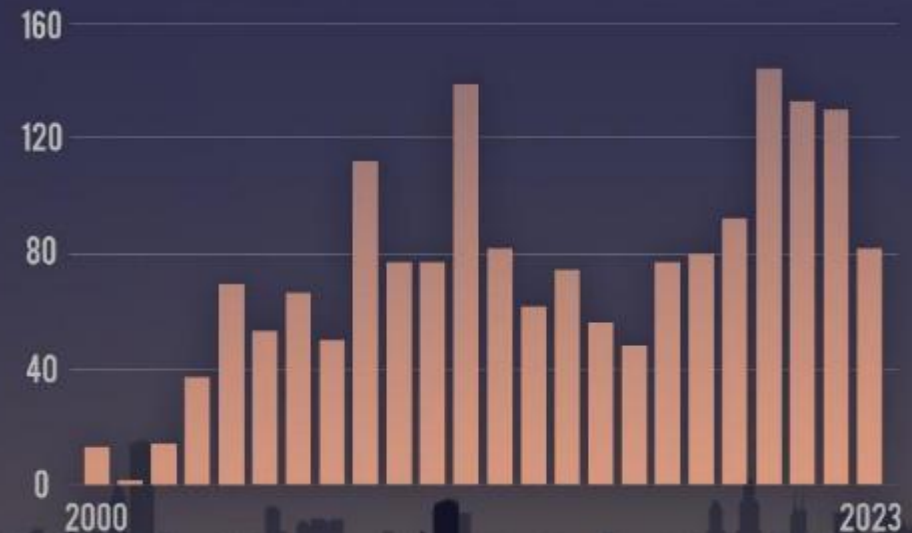
MAJOR U.S. POWER OUTAGES WEATHER-RELATED, 2000-2023



Weather-related major U.S. power outages (2000-2023) by weather type.
Number of outages affecting more than 50k customers or service of 300 megawatts.
Source: US Dept. of Energy from DOE-417

CLIMATE CENTRAL

WEATHER-RELATED MAJOR U.S. POWER OUTAGES



Annual number of weather-related major power outages.
Number of outages affecting more than 50k customers or service of 300 megawatts.
Source: US Department of Energy from DOE-417

CLIMATE CENTRAL

The Southeast (360), South (352), Northeast (350), and Ohio Valley (301) experienced the most weather-related outages from 2000 to 2023.

New Heat + Power Outage Graphics

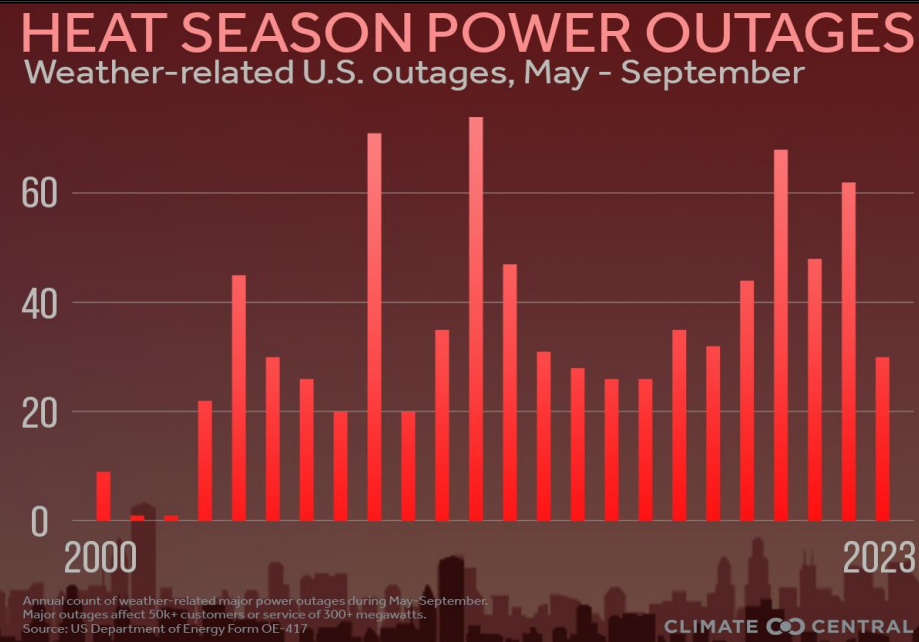
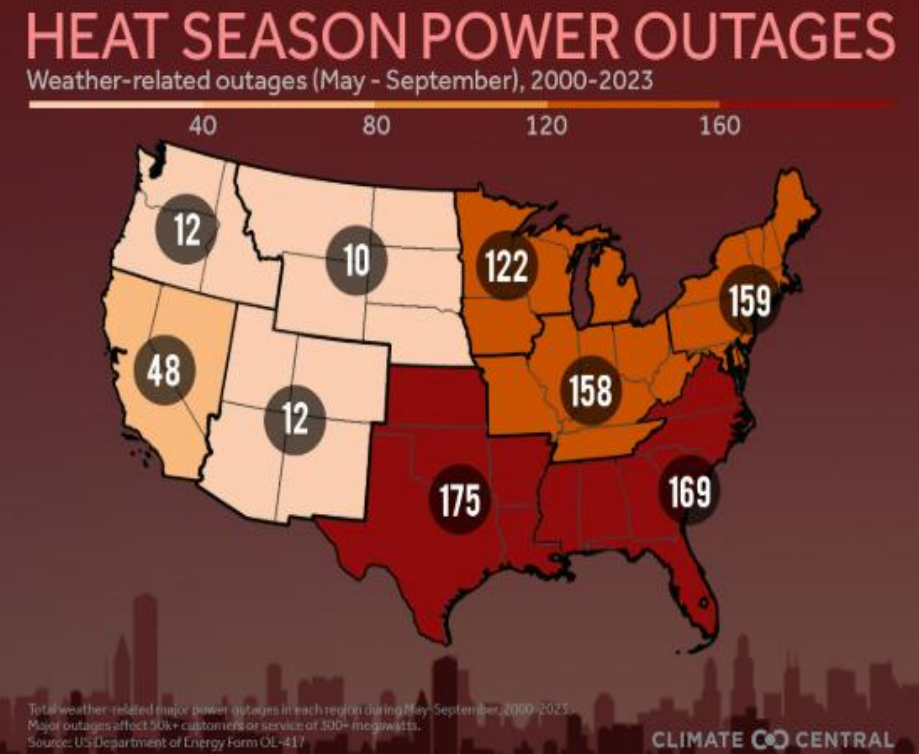
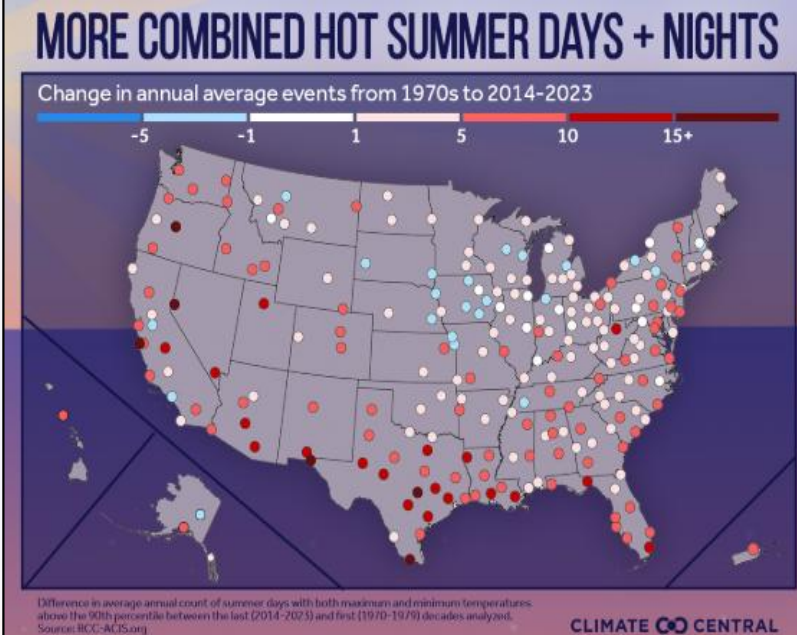
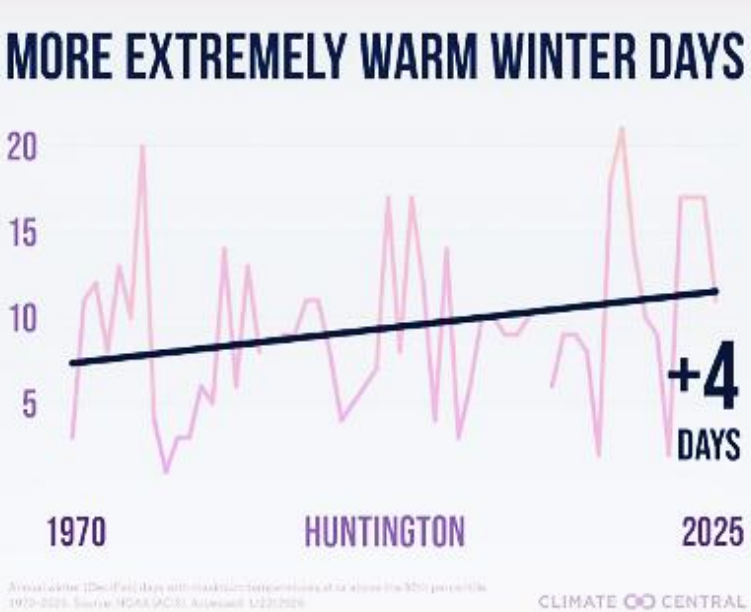
The U.S. experienced about **60% more heat season power outages** during the last 10 years (2014-2023) than during the first 10 years analyzed (2000-2009).

- The South faces more heat season power outages than any other region — followed closely by the Southeast, Northeast, and Ohio Valley.
 - Texas and Michigan led all other states in total heat season outages.

Multi-day heat streaks are dangerous. They worsen air quality and put people at risk from heat-related illness. They can also strain the grid and lead to power outages.

- Persisting heatwaves are becoming more common according to an analysis of the changing frequency of extreme heat streaks in 247 cities across the U.S. from 1970 to 2024.
- The annual number of extreme heat streaks increased in 198 (80%) of the cities analyzed.
- On average, these 198 cities now experience two more extreme heat streaks each year than in the early 1970s.

In Atlanta, Detroit, and Phoenix, between 68% and 100% of the population would face elevated risk of heat exhaustion or heat stroke during a combined blackout and heat wave. Such events could more than double rates of heat-related mortality in all three cities.



Fire Weather

Nationwide, the number of existing properties facing at least a 1% risk will almost quadruple, to 2.5 million by 2050; not accounting for subdivisions to be built in the intervening years.

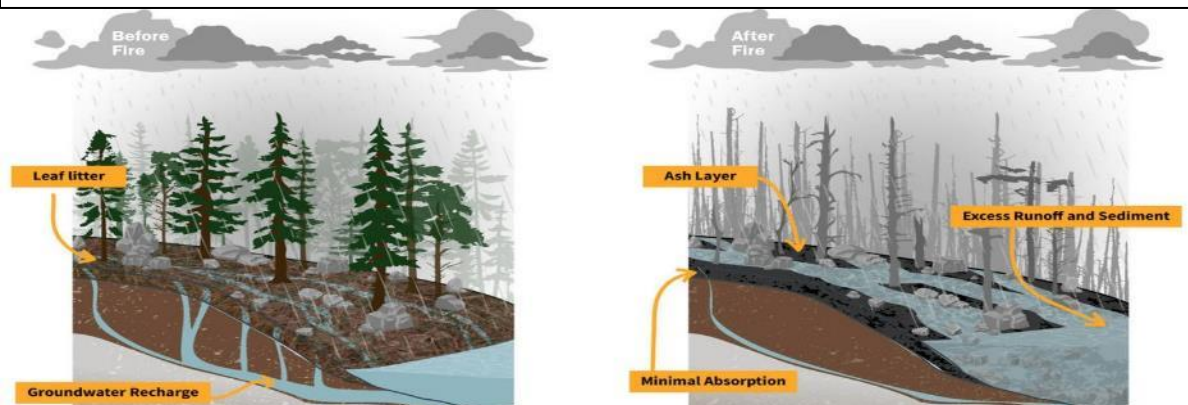
Over 7 million American homes currently have a “major” risk of wildfire damage, increasing to 13 million over the next 30 years, according to a national wildfire assessment by the First Street Foundation in May 2022.

A study from the University of Colorado states wildfires have become larger, more frequent, and more widespread since 2000.

- A new study from the University of Montana highlights burn scar impacts to tree regrowth across various regions, indicating new tree seedlings are unable to survive in hotter climates where parent trees remain. The study indicated that if large areas of the forested parts of the Rocky Mountains burned, only 50% would recover.

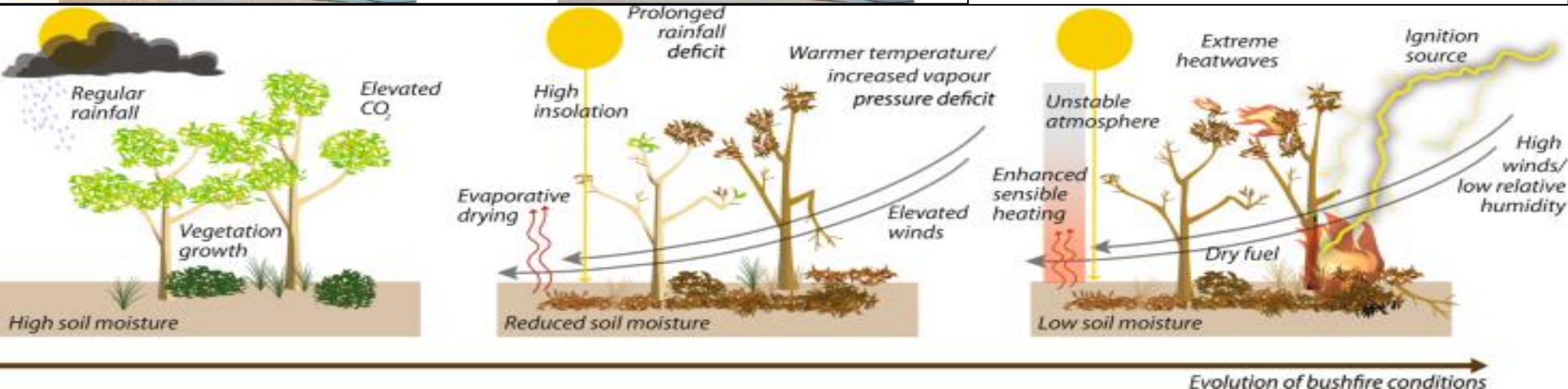
Satellite imagery and state/federal fire history records from 28,000 fires in 1984-2018 showed more fires occurred in the past 13 years than the previous 20 years. **On the West and East coasts, fire frequency doubled. In the Great Plains, fire frequency quadrupled.**

Burned vegetation and charred soil form a water repellent layer which blocks water absorption along with compacted soil from months to years of drought which also inhibits water absorption regionally.

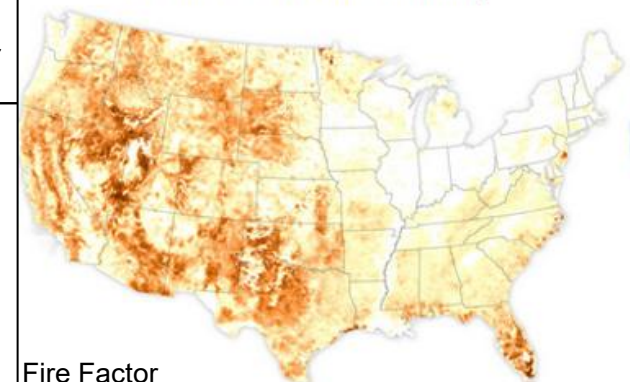


Disasters related to weather, climate, or water hazards happen five times more often now than they did in the 1970s. Droughts that may have occurred only once every decade or so now happen 70% more often.

- The IPCC states heavy rainfall that used to occur once every 10 years now occur 30% more often.
- 61% of western wildfires have occurred since 2000 with a steady increase in the number of wildfires the last 60 years.

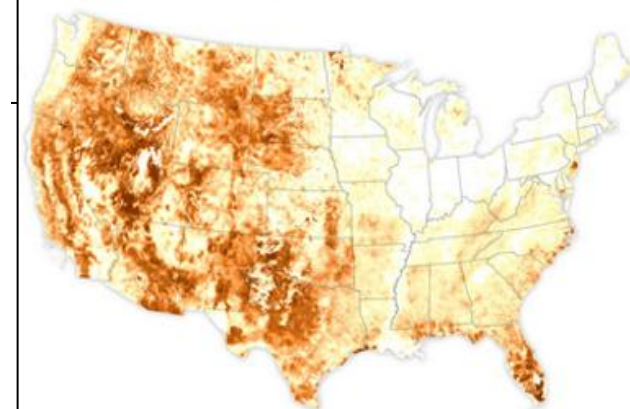


The estimated likelihood of wildfire **today**.

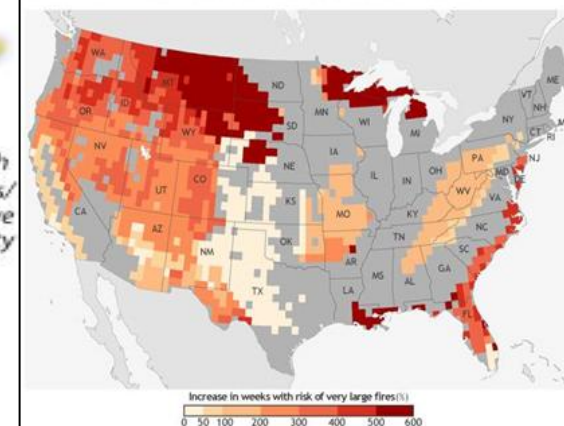


Fire Factor

And in 30 years, with warming.



The map below shows the projected increase in the number of “very large fire weeks”—periods where conditions will be conducive to very large fires—by mid-century (2041-2070) compared to the recent past (1971-2000). The projections are based on scenarios where carbon dioxide emissions continue to increase.



Source: NOAA Climate.gov map, based on data from Barbera et al, 2015.

Changes in Fire Weather - National

This analysis uses data from 476 weather stations to assess fire weather trends in 245 climate divisions spanning the contiguous U.S. from 1973 to 2024.

- On average, climate divisions in the western U.S. experience 31 fire weather days annually. That's almost four times more than in the eastern U.S. (8 days annually).
- Wildfire seasons are lengthening and intensifying, particularly in the western U.S. Parts of the eastern U.S. have seen smaller but impactful increases in fire weather days.
- Much of the country has seen fire weather increase the most during spring. The Southwest is also seeing more fire weather during summer.

On average, Nevada and New Mexico experience the most annual fire weather days (76 and 74, respectively). Washington and Oregon experience the fewest (both 11 days).

Some places, including parts of California, Nevada, New Mexico, and Texas now experience fire weather around twice as often as in the early 1970s.

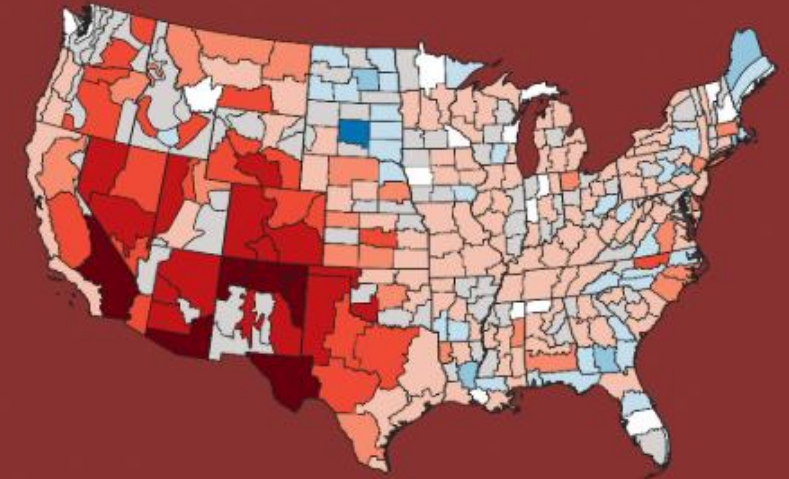
Parts of North Dakota and South Dakota have experienced a decline in the frequency of fire weather days.

On average, Rhode Island, Florida, and Connecticut experience the most annual fire weather days (24, 21, and 21, respectively). Michigan, Wisconsin, Kentucky, and Indiana experience the fewest (all 2 days).

- Every county in the contiguous U.S. now sees at least 16 wildfire smoke days each year. Wildfire smoke can spread hundreds or even thousands of miles away, harming health far from areas with active fires.

CHANGE IN FIRE WEATHER DAYS

Change in annual hot, dry, windy days, 1973-2024

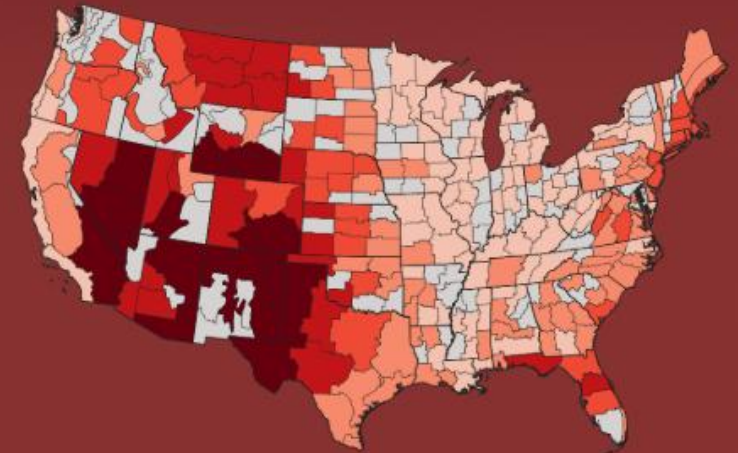


Change in average annual days (1973-2024) at/above fire weather thresholds in at least two hourly observations per day.
Source: NOAA/NCEI Local Climatological Data (LCD)

CLIMATE CENTRAL

ANNUAL FIRE WEATHER DAYS

Average annual hot, dry, windy days, 1973-2024



Average annual days (1973-2024) at/above fire weather thresholds in at least two hourly observations per day.
Source: NOAA/NCEI Local Climatological Data (LCD)

CLIMATE CENTRAL

FIRE WEATHER DAYS

Annual hot, dry, windy days

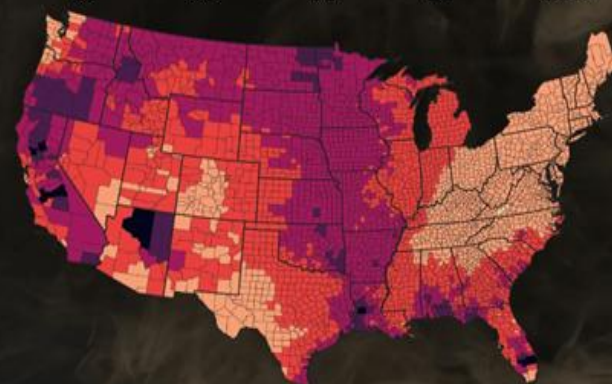


Annual days (1973-2024) at/above fire weather thresholds in at least two hourly observations per day.
Stations with data in climate divisions: 7. Source: NOAA/NCEI Local Climatological Data (LCD)

CLIMATE CENTRAL

WILDFIRE SMOKE DAYS

Annual average, 2006-2020



Average annual number of predicted wildfire-related smoke days by county, 2006-2020.
Source: Childs et al., 2022

CLIMATE CENTRAL

As fires burn wider areas and into higher elevations topography shifts from tree-creep, soil composition changes, soot deposits, debris flows, burn scars, vegetation/foliage decay, early blooms, flooding post-burn, less wildfire activity, and increased pollution from wildfire smoke, the cycle of heightened wildfire activity will worsen each year.

- Damaged soil from heat transfer result in less fire-resistant plant retention and more scraggly brush growing back between fire weather active periods.

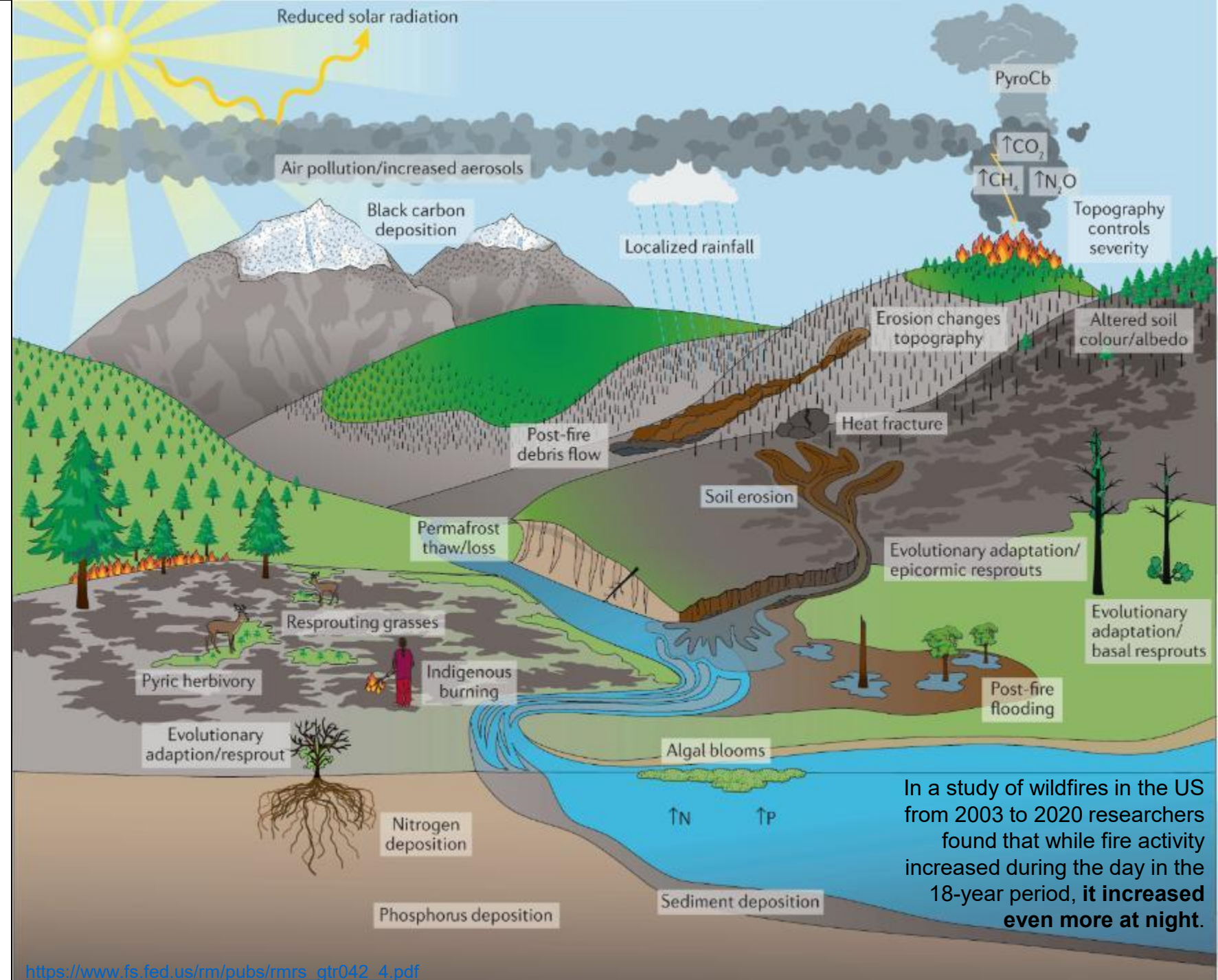
Large wildfires in the right atmospheric conditions can create Pyro-cumulus clouds which can amplify fire growth as they develop severe storm cell traits by causing erratic surface wind gusts, lightning ignitions, downbursts, and even tornadic activity.

Fires are getting larger and harder to extinguish.

The threats from fewer fires burning more acres can impact the immediate area of the fire by removing the groves/forests and amplifying wind threats and drying while reducing the water retention and force breakup capabilities naturally present historically.

- Without mature trees to hold soils back and slow runoff from storms, sedimentation rates are expected to increase across the rivers and reservoirs system.
- As bodies of water report greater rates of sedimentation there can be an increase in algal blooms or a decrease in retention capacity, causing water safety and ecology concerns.

Deposits of ash/soot into high elevations can provide a dark albedo, feeding snow algae and reducing the stability of snowpacks – yielding avalanche threats.



In a study of wildfires in the US from 2003 to 2020 researchers found that while fire activity increased during the day in the 18-year period, **it increased even more at night.**

Wildfire Emissions Studies

In a study in *Nature*, researchers estimate that continued global warming could lead to about **30,000 additional deaths each year nationwide by 2050**, as increases in fire activity generate more smoke pollution across North America.

- The researchers found no U.S. community is safe from smoke exposure.

When monetized, deaths related to wildfire smoke could reach \$608 billion in annual damages by 2050 under a business-as-usual emissions scenario where global temperatures rise about 2 degrees Celsius above pre-industrial levels.

Excess deaths from smoke PM2.5 exposure under a business-as-usual emissions scenario could increase more than 70% to 70,000 per year from roughly 40,000 annual deaths attributed to smoke from 2011 to 2020.

- The largest projected increases in annual smoke exposure deaths occur in California (5,060 additional deaths), New York (1,810), Washington (1,730), Texas (1,700), and Pennsylvania (1,600).

Researchers predicted that between the period 2010–2014 and 2095–2099, global fire carbon emissions could rise by 23% under mid-range emissions scenarios.

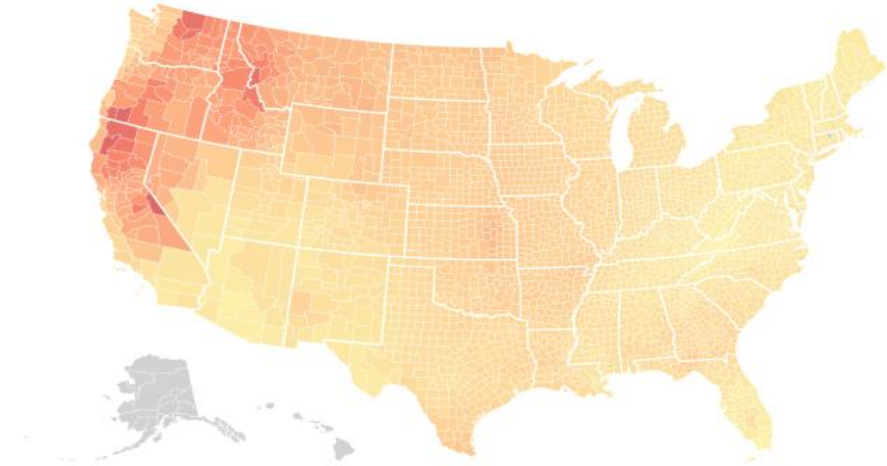
- The US regions with the [largest burned areas](#) — the West and Northwest, and parts of Arizona, generally experience the most [wildfire smoke days each year](#).
- Every county in the contiguous U.S. now sees at least 16 wildfire smoke days each year. large areas of the Northern Rockies and Plains as well as the central and southern U.S. experience at least two months' worth of wildfire smoke days each year.

New research shows that wildfire smoke caused 164,000 premature deaths in the U.S. from 2006 to 2020 — and that climate change accounted for about 15,000 of those smoke-related deaths.

- Per-person exposure to harmful wildfire smoke in the U.S. was four times higher during 2020-2024, on average each year, than during 2006-2019.

Smoke PM2.5, 2011-2020

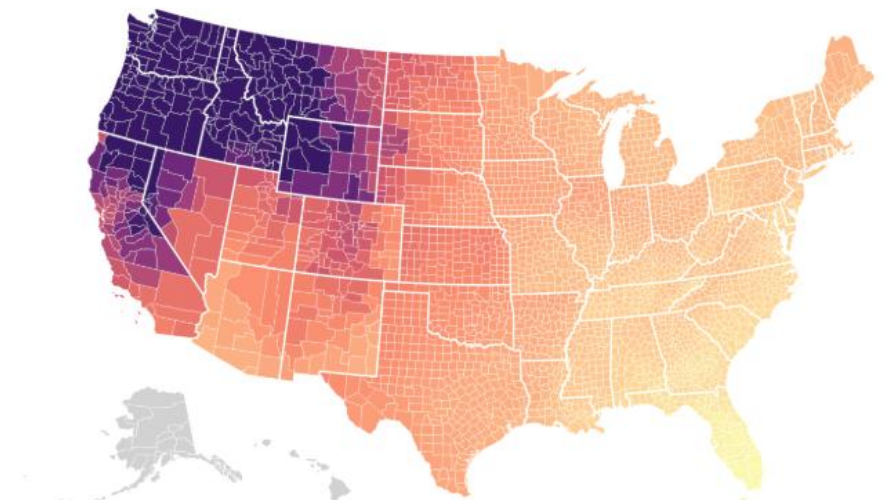
Annual average concentration of PM2.5 from wildfire smoke, in micrograms per cubic meter.



Created with Datawrapper

Smoke PM2.5, 2050

Annual average concentration of PM2.5 from wildfire smoke, in micrograms per cubic meter, in 2050 (RCP7.0).



Created with Datawrapper

Smoke and Severe Wx

Wildfire smoke can suppress supercells by blocking solar radiation and reducing surface heating, but when storms already exist, smoke particles act as cloud condensation nuclei that lower cloud bases and alter wind shear, which can paradoxically intensify rotation, increase tornado potential, **and produce more frequent positive lightning.**

In 1998 MIT Researchers found the same general correlation from forest fires in Mexico yielding **three times the normal number of positively charged lightning strikes to ground in the southern plains of the United States**

- “The smoke from these fires significantly altered the electrical characteristics of a wide variety of storm types during all phases of their life cycles.”
- Between April and June, nearly half a million flashes in the southern plains were positively charged.
- These thunderstorms also produced abnormally high numbers of mesospheric optical sprites.
- These fleeting red jellyfish-shaped glows are the signature of massive thunderstorms called mesoscale convective systems that occur in the wee hours of the morning in the Earth's upper atmosphere.

Following significant atmospheric smoke in 2011 studies at NOAA's NESDIS STAR began to identify interactions with existing storm conditions and smoke particles increasing the potential for formation of tornadoes and thunderstorm supercells.

- Researchers noted that the smoke lowered the base of the clouds and increased wind shear, defined as wind speed variations with respect to altitude.

A Harvard analysis done in 2023 for the American Meteorological Society proved a hypothesis, finding that the thunderstorms which ingested smoke from a wildfire did indeed have a higher rate of positive lightning flashes than those that did not interact with wildfire smoke.

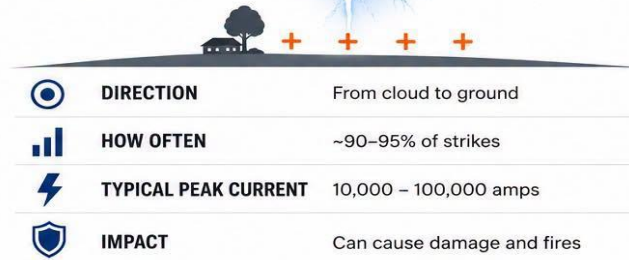
NEGATIVE vs. POSITIVE LIGHTNING

Both are lightning. The difference is in the charge.

NEGATIVE LIGHTNING

Negative charge

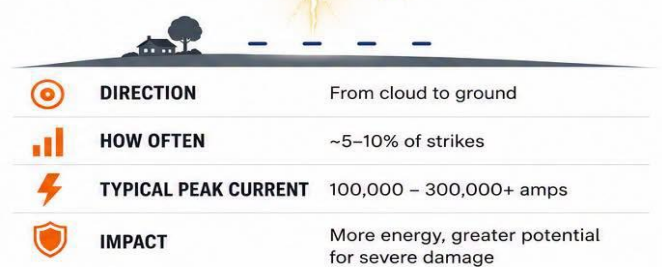
builds up in the bottom of the cloud and is attracted to positive charge on the ground.



POSITIVE LIGHTNING

Positive charge

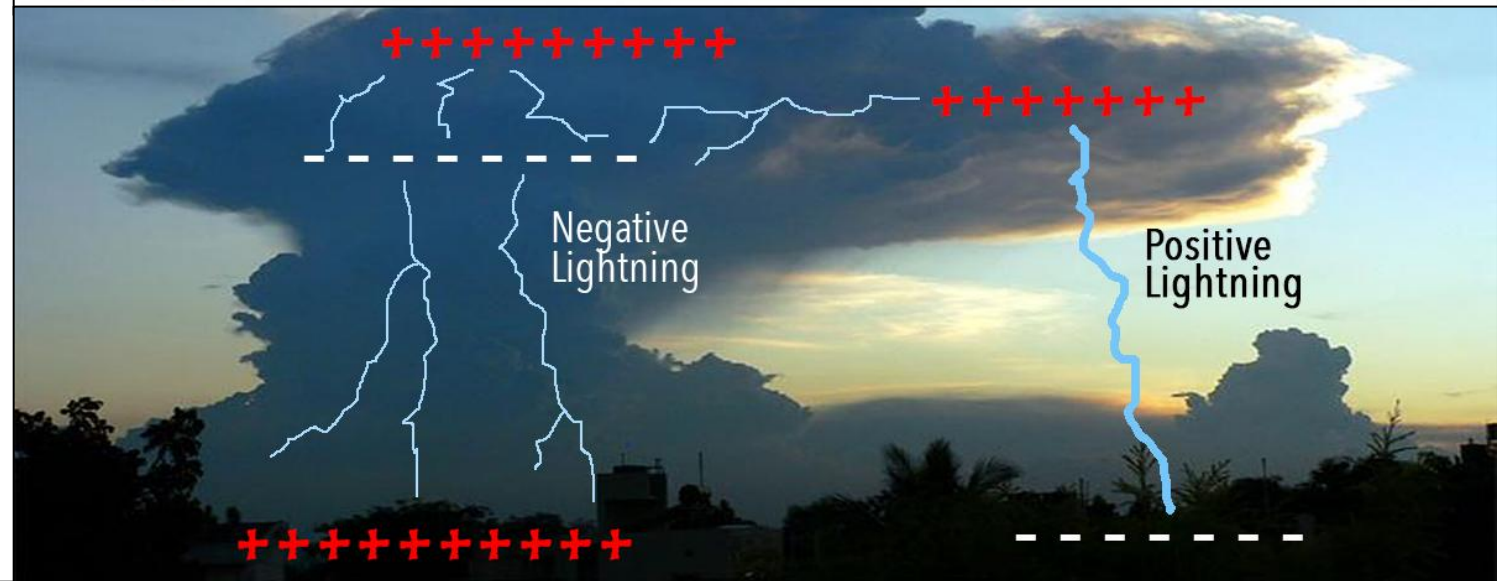
builds up in the top of the cloud and is attracted to negative charge on the ground.



KEY TAKEAWAY

Negative lightning is common and less powerful.

Positive lightning is rare but stronger and can be more dangerous.



Changing Rainfall Rates

Over the last decade, the length of impaired rivers and streams has increased from about 424,000 miles in 2010 to more than 588,000 miles in 2019, and in 2022, more than 703,000 miles.

- Nationally, the EPA estimated the 20-year need for large stormwater systems (Municipal Separate Storm Sewer Systems) had increased from \$23.8 billion in 2012 to \$115.3 billion a decade later.

Heavy rains after a drought caused nitrates to seep 33 feet under farm fields in as little as 10 days. The study was published in [Water Resources Research](#).

- Previous studies have shown about 40% of nitrogen fertilizer used for vegetables isn't absorbed by the plants but remains in the soil.

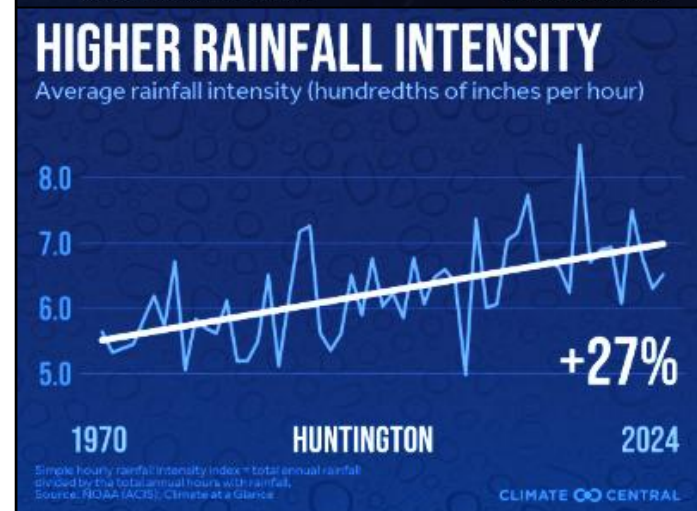
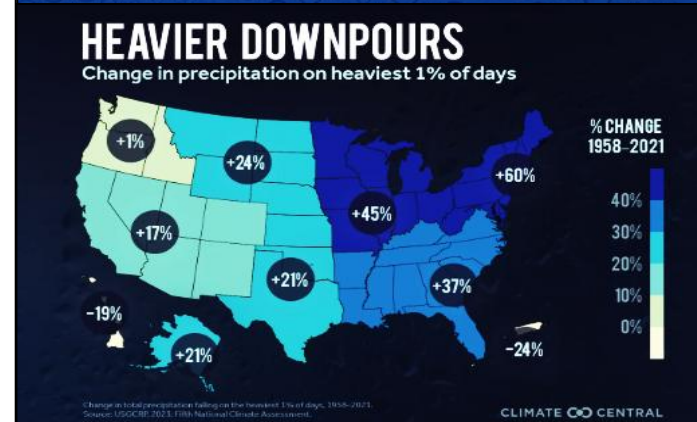
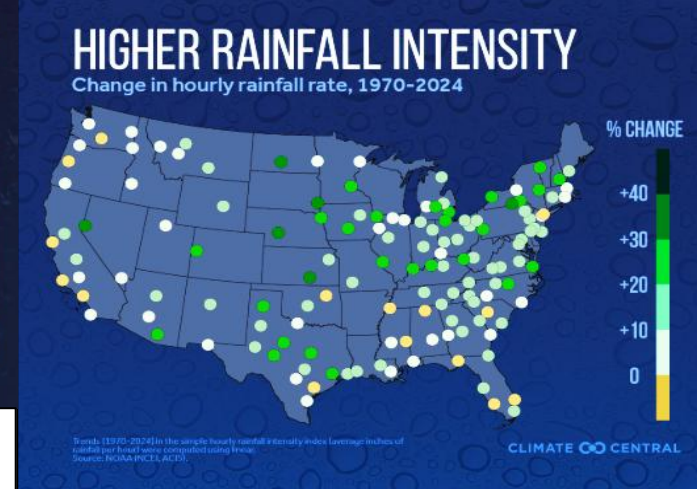
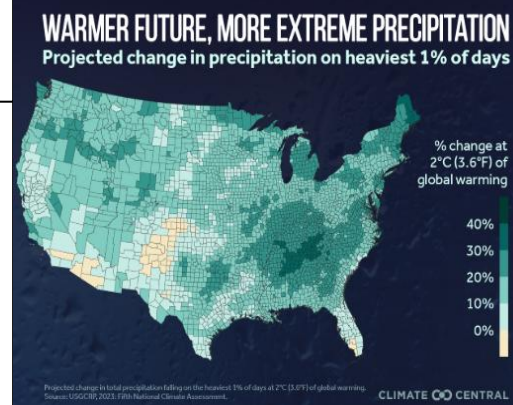
126 U.S. cities (88% of 144 analyzed) have experienced an increase in hourly rainfall intensity since 1970.

- Across the 126 locations, hourly rainfall rates are now 15% higher on average than in 1970.
- Heavy downpours bring more rain, faster — causing flash flooding and landslides that can displace families, drown crops, damage infrastructure, and expose people to hazardous debris, contaminants, and water-borne disease.
- On average, U.S. counties are likely to experience a 17% increase in precipitation falling on the heaviest 1% of days.
- In the Northeast and Midwest, the amount of precipitation falling on the heaviest 1% of days has [increased 60% and 45%](#), respectively, from 1958 to 2021a

New Research: the integration of multiple global geophysical datasets reveals a permanent decline in terrestrial water storage.

- The study provides robust evidence of an irreversible shift in terrestrial water sources under the present changes in climate. More [Here](#)

Another new study concluded that changes in the velocity of stormwater runoff into groundwater systems can change the flow deposits and further deteriorate soil systems and vegetation as extreme heat and drought rise.



BLUF: Extreme Weather Trends for Stormwater

Extreme rain can cause flooding in low-lying areas that have poor drainage and insufficient stormwater infrastructure systems.

This can cause flooding throughout the city, even for inland neighborhoods. Rain-driven flooding can occur suddenly and intensely, but flood conditions may subside more quickly compared to coastal surge flooding.

Extreme rainfall events will increase in number and severity in the future because of the change in baseline temperatures.

By the end of the century, cities could experience as much as 30% more annual rainfall than today, and 1.5 times as many days with over an inch of rain.

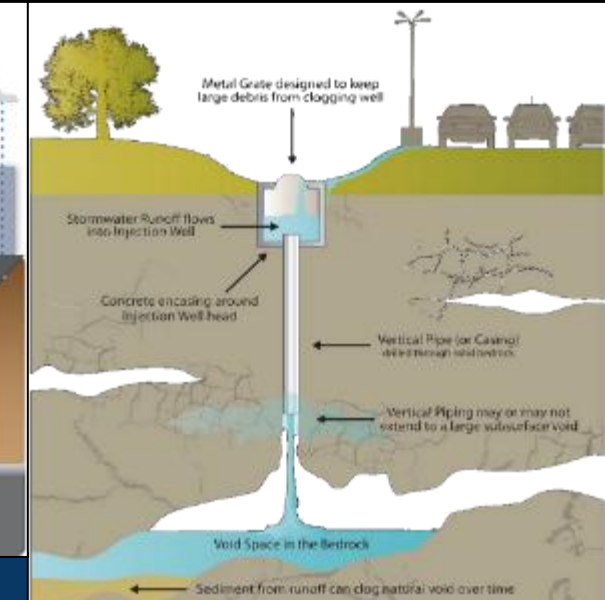
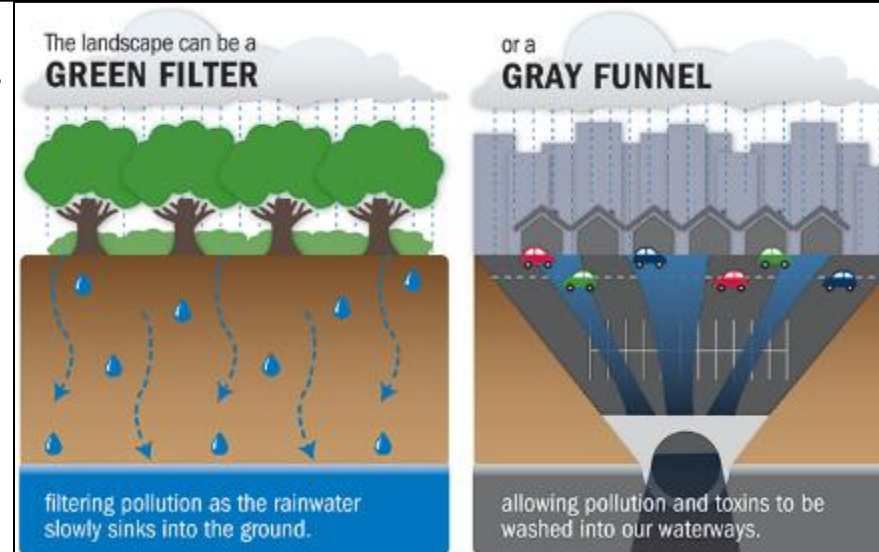
As sea level and groundwater tables rise, stormwater will drain more slowly and contribute to flooding.

- Record rainfall events in 2019 resulted in more than 100 Minnesota communities releasing partially treated wastewater into area rivers and streams.
- Untreated sewage carries pathogens and other contaminants that pose human health and ecological risks.

Extreme temperature swings can degrade the quality of materials in addition to the aging process already underway.

- Canals, reservoirs, earthen dams, roadways, sidewalks, and drainage ditches require water to hold the soils together.

Sinkholes are just one of many forms of ground collapse, or subsidence. Land subsidence is a gradual settling or sudden sinking of the Earth's surface owing to subsurface movement.



New Hurricane Studies

2025 was the second year to have produced three or more Category 5 storms, at least in recorded history.

- Storms exceeding 160 knots are appearing more frequently. Between 1982 and 2011, eight such storms were recorded. From 2013 to 2023, that number rose to 10.
- *In total, 18 Category ‘6’ storms have occurred over the past four decades, with more than half forming in just the most recent decade.*
- Hot spots for these exists in the Western Pacific, east of the Philippines and Borneo. Another major hot spot stretches across parts of the North Atlantic near and east of Cuba, Hispaniola, and Florida.
 - The study also found that these hot spots are expanding...

Five tropical cyclones that formed since 2013 would have been deemed Category 6 hurricanes if such a classification existed.

New summaries call for updates to the Saffir Simpson wind scale: Several well-known storms would fall into this proposed Category 6.

- Hurricane Wilma in 2005 remains the most intense hurricane ever measured in the Atlantic with a barometric pressure of 882 mb and winds over 200 mph, breaching the potential Category 6 threshold.
 - Typhoon Haiyan and Typhoon Hagibis both also breached a potential Category 6 threshold with landfalling winds causing catastrophic damages.
- 2015 Hurricane Patricia, in the Pacific Ocean off Mexico’s coast, produced winds at of 215 mph (185 knots), **powerful enough to qualify as a Category 7 storm, if such a category existed.**
- 2025 Hurricane Melissa, in the Atlantic Ocean, produced winds at 185 mph with gusts to 252 mph, globally the highest wind oceanic wind gust

Category 6 is the new hurricane normal, scientists warn

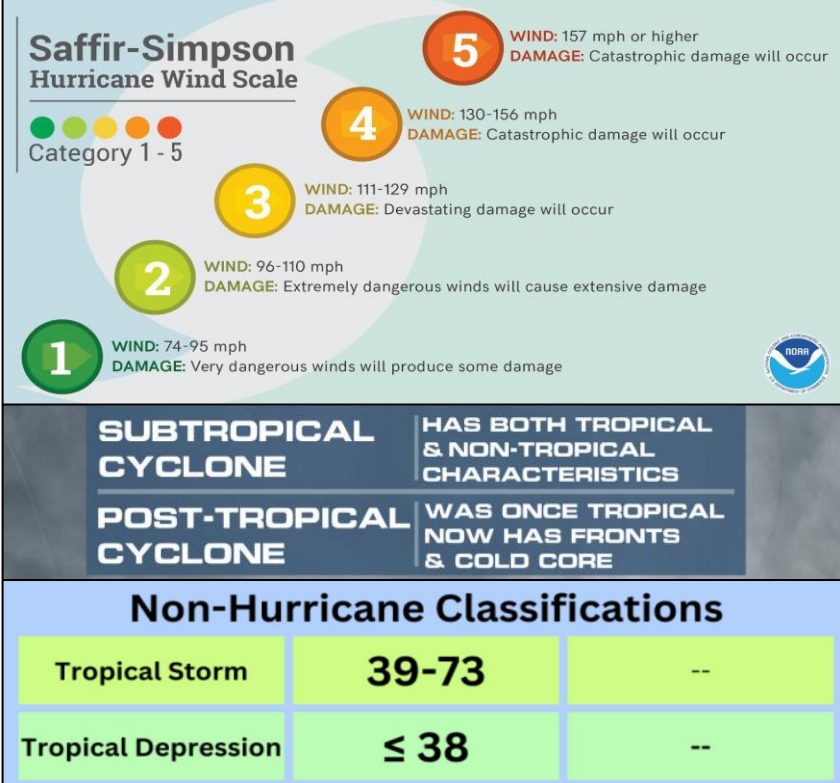
Human-caused climate change is making major hurricanes like Melissa much stronger, faster and ultimately more life-threatening

Julia Musto in New York
Monday 03 November 2025 12:12 EST

 Comments

Melissa was one of the fastest intensifying storms of all time and tied for the most powerful storm for wind speed and pressure in the North Atlantic.

A recent study from Imperial College London found that Melissa was made four times more likely by abnormal warming in recent decades, boosting its wind speed by 11 miles per hour.



In a February 2024 study published in the *Proceedings of the National Academy of Sciences* (PNAS), researchers Michael Wehner and James Kossin proposed adding a hypothetical Category 6 to the scale.

Proposed Category 6 Threshold: Sustained winds of 180 mph or greater. **A cat 7** could be sustained winds over 215 mph gusting to 260 mph

Changes to Tides: Higher Wave Heights

High tide flooding, also called *nuisance flooding* or *sunny day flooding*, is becoming more common in the U.S., where 29% of the population lives in coastal counties.

- The annual frequency of high tide flooding in the U.S. has more than doubled since 2000 — and is projected to more than triple again by 2050 as sea levels continue to rise.

High tide flooding happens when water levels exceed 1-2 feet above the daily average high tide (the threshold for minor high tide flooding).

- Maine's baseline sea level has risen 7 to 8 inches over the past century, allowing storm waves and high tides to reach further inland with higher energy.
- With more sediment deposit at the mouths of rivers from amplified flash flood runoff, this could result in greater rates of erosion and faster loss of sea floor critical for the coastal ecology.

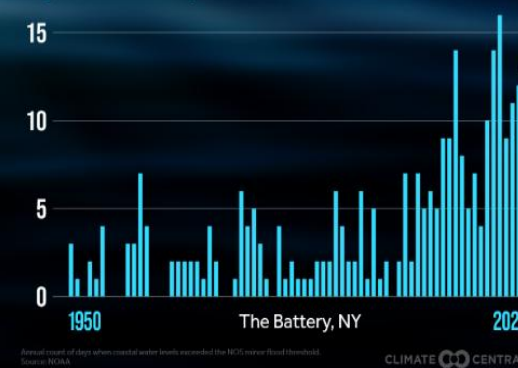
Ocean eddies are getting stronger and more energetic across major parts of the world's oceans. Satellite observations and ocean studies show that swirling eddy activity is intensifying

In California, average winter wave heights have increased by as much as a foot since 1970.

- Swells at least 13 feet tall (about 4 meters) are also happening a lot more often, occurring at least twice as often between 1996 to 2016 than from 1949 to 1969.

COASTAL FLOODING

High tide flood days



RISING SEAS

Sea level rise (inches)



RISING SEAS, MORE FLOODING

Sea level rise (inches)

High tide flood days



Subsidence Threats – Variable Impacts of Rise and Fall

The Mid-Atlantic Region will face separate threats than the New England states due to the Laurentide Ice Sheet, which has reported the increased temperatures is causing thawing of the sheet resulting in land uplifting as the weight of the ice reduces from melting runoff.

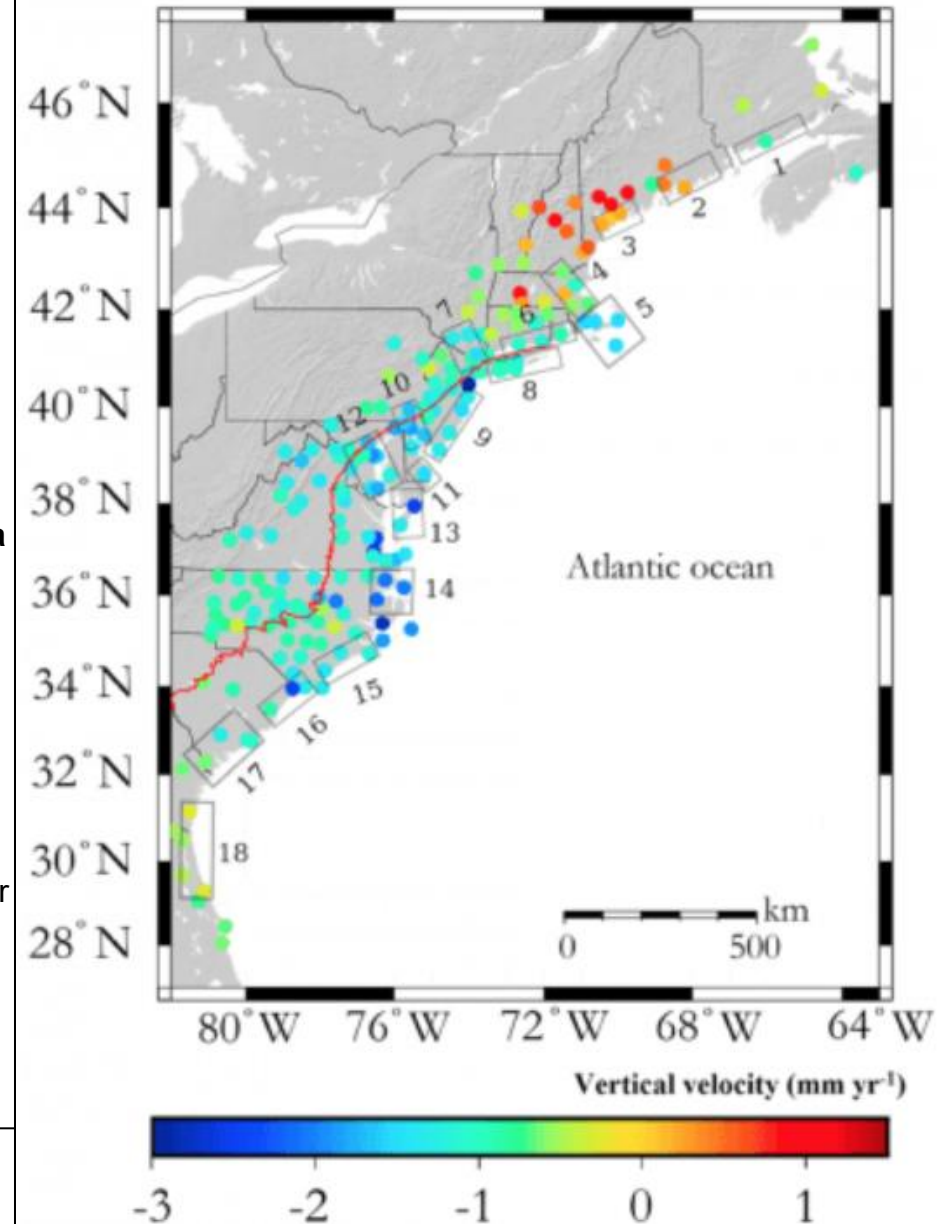
- As the uprising occurs in the Mid-Atlantic into the New England States, the other effects of coastal erosion and drought impacts to the aquifers in Region 1 will cause sinking.
 - Subsidence along parts of the Atlantic Coast constitutes the largest-amplitude proglacial forebulge collapse on Earth.
 - The GPS subsidence rates decrease with distance away from the coastal plain and toward the center of mass loading of the Laurentide Ice Sheet
- Comparably, infrastructure which runs between the two regions of uprising and sinking will face threats of separating more violently than other regions may experience as one portion of the landmass rises and the other portion sinks, increasing the vertical difference in some areas to exceed amount typically experienced from subsidence due to aquifer collapse or coastal erosion.
 - The present-day **subsidence rates** measured by GPS **between Virginia (38°N) and South Carolina (32.5°N) are approximately double** the long-term geologic rates, most likely reflecting recent **groundwater depletion**.
- Groundwater extraction in excess of recharge reduces pore fluid pressure, leading to aquifer-related compaction and surface subsidence. Conversely, net groundwater recharge increases pore fluid pressure and can lead to uplift.
 - Groundwater withdrawal and recharge induces spatially and temporally variable vertical motion in the Atlantic coastal plain.

Areas along the coastal plain (north of Cape Hatteras, North Carolina, 35.2°N) are susceptible to frequent minor to moderate storm-related flooding due to the combined effects of accelerated sea-level rise and land subsidence. Knowledge of present-day subsidence can help mitigate coastal land loss and predict future storm surge inundation. <https://www.whoi.edu/press-room/news-release/why-is-sea-level-rising-higher-in-some-places-along-u-s-east-coast-than-others/>

- Over the 20th century sea levels in Portland, Maine have risen about a half a foot in comparison to one foot around New York City, New York and a foot and a half near Cape Hatteras, North Carolina.

Map showing the location of GPS sites used in this study and 18 regions for which the late Holocene relative sea-level rise rate is known (region 1, Gehrels et al. [2004]; regions 2–17, Engelhart et al. [2009], Engelhart and Horton [2012], and Nikitina et al. [2015]; region 18, Kemp et al. [2014]). GPS and geologic rates for each region are detailed in supporting information Table S2. Red line shows the Fall Line, a boundary between compressible coastal plain sediments and incompressible bedrock of the Piedmont Province [Meng and Harsh, 1988]. Circle color indicates decadal average vertical land motion in IGB08 reference frame.

<https://agupubs.onlinelibrary.wiley.com/doi/10.1002/2016GL068015>



Global Data Centers: Extreme Weather Risks

China: At least 41% of China's national data center racks are in regions that are highly prone to drought and at least 28% are in areas that are highly prone to floods; at least a fifth are very prone to both. CWR estimates China's data center water consumption to be ~1.3 billion m3 today but could exceed 3bn m3 by 2030.

- 56% of China's data center racks are in coastal regions which are vulnerable to storm surge and sea level rise.
- The number of data center racks in China grew 27% from 4.3 million in 2020 to 5.4m in 2021 and expects racks to grow to 11.3m by 2030.

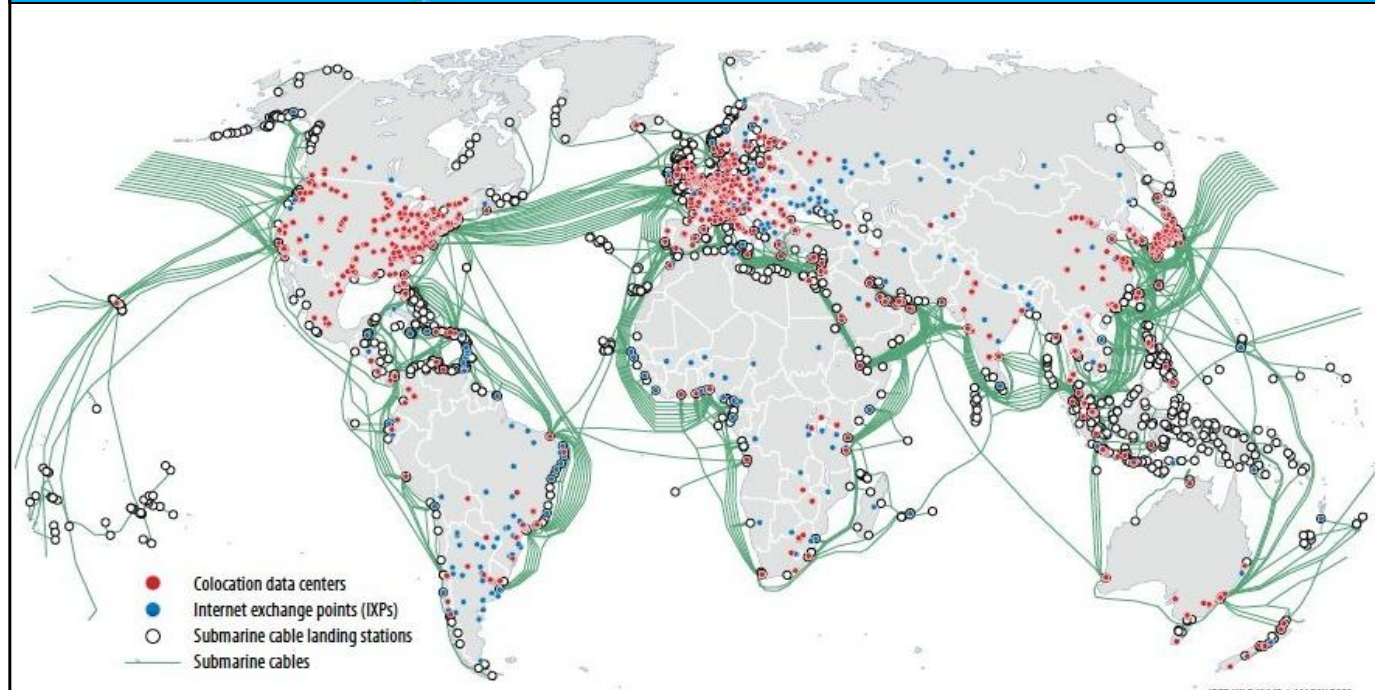
India: India's drought-prone regions have increased by 57% since 1997. Much of the country's data center infrastructure is in drought-prone or flood-risk areas like Mumbai, New Delhi, Bangalore, Pune, and Chennai. India's data center capacity is set to increase 4x to 2.01 thousand MW in 2024.

- Bengaluru, India's Silicon Valley, faces acute water shortage, with a daily deficit of 500 million liters impacting 16 data centers for banking, e-commerce, and cloud services.

Ireland: April 2024 drought, heat, and overall energy requirements resulted in Eirgrid, Ireland's power network, to limit supply to larger users such as data center operators. Amazon's cloud platform subsequently periodically limited access to its Ireland-based eu-west-1 region.

- Ireland is home to +80 data centers and is one of Europe's most active markets. Amazon has multiple campuses in Dublin, in Blanchardstown, and one further south in Tallaght. Last year it received planning permission for three new data centers at its existing site in Dublin.
- Figures published last year by Ireland's Central Statistics Office showed that data center power consumption in the country increased by 31% in 2022, accounting for 18% of all electricity used in Ireland.
- In 2021 data centers used near 17% of the country's power generation and use more metered electricity than all of Ireland's homes combined.
 - International Energy Agency stated data centers could use 32% of Ireland's power by 2026 due to the number of new builds planned.

Global Data Center Presence



Transportation Impacts

Extreme heat can degrade the structural integrity of roadways, railways, runways, and pipelines resulting in pivots of resource movement methods.

- When the Mississippi River runs low due to drought events and heat triggered evaporation of the surface waters, the **barges must reduce loads and speed causing notable delays in shipments and trucking needs to reduce increasing costs.**

Extreme heat for railways threatens railcars with prolonged exposure to solar radiation when stalled on the tracks and may see material combustion risks or degraded shipping conditions which may impact the supply chain.

- **Heat causing railways to warp can also cause reduced operations by requiring slower movement and reduced loads.**
 - Stalled materials in transport can overheat, damaging the products.

These events are occurring globally, resulting in loss of supply for key materials, minerals, metals, increased demand, rising costs, and subsequently delayed delivery.

As temperatures rise, the performance of the aircraft and their engines can deteriorate which can be amplified in major metropolitan areas due to the surrounding ambient temperatures.

- **Planes get 1% less lift with every 5.4°F (3°C) of temperature rise.**
- Refueling can be delayed due to heat while internal aircraft temperatures can rise rapidly during gate delays or takeoff delays.
- Thermal turbulence occurs due to uneven surface heating by the sun.
- **40-year study:** at an average point over the North Atlantic, the total annual duration of **light-or-greater CAT increased by 17%.** Increased Costs: Turbulence can lead to more fuel burn, delays, and even aircraft wear and tear rates increasing.
- Like railways and barges, the aircraft also cannot take on additional weight during the summer, resulting in higher cargo transportation costs and delays in shipping.

Individuals commuting are placed at a higher risk to include waiting on train platforms, bus stops, stalled in traffic, longer plane boarding times, overheating plane bridges, etc.



E-Scooters: Bomb Risks

Threats: A growing concern is the availability of materials already assembled being used for destruction during amplifying weather events such as heatwaves.

- Lithium-ion batteries in larger devices like e-bikes and scooters are volatile during major heatwaves as internal cooling systems are often missing and the equipment is recommended to be left in the external hazardous weather conditions.
- Many of these devices have been in operation for nearly a decade in the US and for over two decades in other countries resulting in wear-and-tear from general use and material fails.

From 2019 to 2022, there's been a more than 1,000% increase in injuries from fires that started with an e-bike or e-scooter, and there's been a more than 600% increase in the fires themselves.

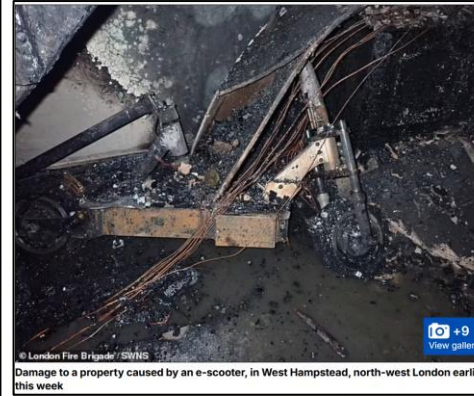
- In December 2022, the federal government's Consumer Product Safety Commission sent a letter to more than 2,000 manufacturers, imploring them to meet safety standards and urging them to review their product line immediately.
- Burn surgeons who treat these often life-changing injuries are calling for hazard labels to increase public awareness, while predicting cases will increase as the number of e-bikes and e-scooters in the UK – currently around 550,000 – continues to rise.
 - The London Fire Brigade, however, has said 143 fires were [caused by e-bikes and 36 by e-scooters in London in 2023](#), causing three deaths and 60 injuries.

Personal Mobility Devices (PMDs) use lithium-ion batteries, which are cheaper to make and more powerful than older types of rechargeable batteries but contain flammable chemicals.

- The other danger from PMD batteries is when the charger terminals are touched – particularly by children. In a fraction of a second, their temperature can rise above 400C, causing burns.

Dockless bikeshare and e-scooter systems expanded coverage, first appearing in the US in 2017 whereas areas like India have had them in use since the early 2000s.

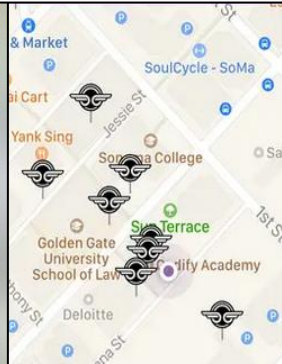
- As of June 30, 2024, there are 60 dockless bikeshare systems and 194 e-scooter systems (not counting systems limited to college / employer sites).
- There is an open-access interactive map showing all the major cities were e-scooters/bikes have been adopted and are in use today.



Urgent warning over 'an epidemic' of patients as young as THREE with horrific burns from exploding e-scooters

By [ANDY BEAVEN](#)

PUBLISHED: 20:34 EDT, 8 February 2025 | **UPDATED:** 20:57 EDT, 8 February 2025



Exploiting Weather and EV Flaws

In 2019 a 19-year-old security researcher gained access to the digital car keys of more than 25 Tesla EVs scattered across the globe.

- From a remote location, the hacker ran programs that disabled the vehicles' security mode, unlocked their doors and opened their windows.

The 2022 Brokenwire attack: hackers wirelessly send signals to targeted electric vehicles. This causes electromagnetic interference and interrupts the connection between a public EV charging station and the vehicle.

- The charging station won't provide the vehicle with a charge until the attack ends.
- There are ransomware attacks possible that could lock out the owner from operating the vehicle until the fee is paid.
- Extreme temperatures can cause electric vehicles (EVs) to charge slower and potentially for a longer duration resulting in a greater window of cyber risk.

These scams and infiltrations are critical to keep in mind for government fleets, emergency vehicles, and key staff which could result in vehicle shutdown or erroneous exposure of microphone access, personal data, routes, contacts, and more.

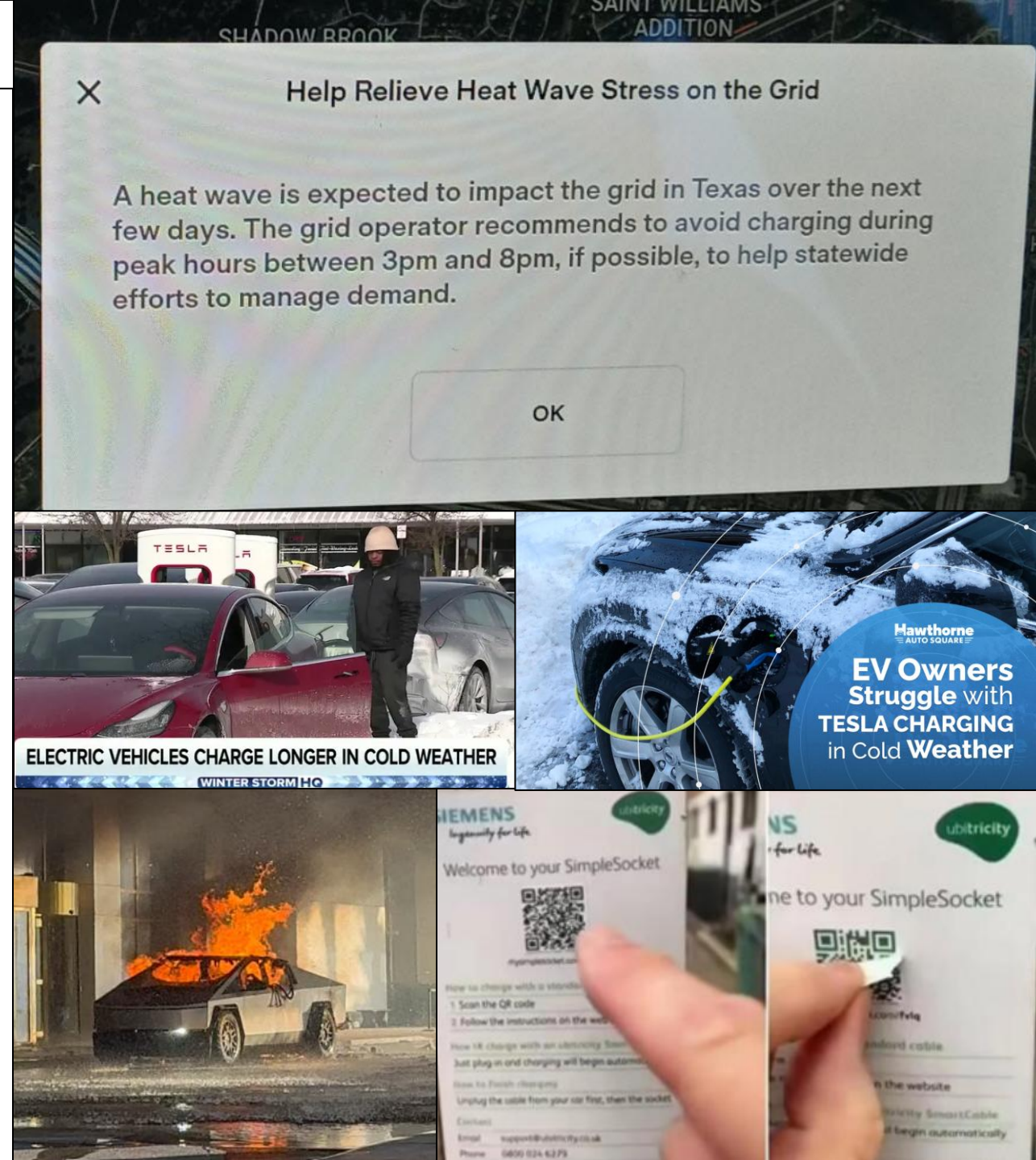
- Vehicles locking down for updates, forced or selected, can often be slower than anticipated during extreme temperatures.

Vehicles may also see their touch screens lifting due to extreme temperatures as heatwaves continue to intensify in longevity and intensity.

- Many electric vehicles do not have bypass physical systems installed where users can still access certain features or in some cases even turn on the vehicle without the main dashboard screen functioning.

Weatherproof QR codes can be used to share vital information like evacuation routes, emergency contacts, and safety guidelines, even when power and internet access are limited.

- QRLjacking**: involves a cybercriminal spreading malware to an individual's devices after a fraudulent QR code directs the user to a malicious URL.
- Device hacking**: Under certain circumstances, a malicious actor may be able to access a user's device if they scan a fraudulent QR code.



Physical Security, Site, and Staff Impacts

As severe weather increases the frequency of power outages, causes supply chain delays, amplifies impacts from personnel shortages, damages larger areas causing prolonged restoration times, *negative impacts will increase* for key security personnel and necessary physical security systems.

- Power outages can lead to badging and verification delays, record storing lapse, or loss of site access
- Extreme heat reduces the physical efficiency and mental capability of security staff (lethargy)
- Severe weather can halt drone monitoring operations and obscure video monitoring
- Flooding can result in sensor delays or destruction
- Evacuations being televised may result in exploitation of decreased security presence
- Damages to physical barriers (fences/) gates will likely be an evident security risk
- Extreme heat and frequent staff rotations may cause gaps in external physical security
- High heat periods may cause loss of sleep further reducing the capabilities of staff
- Extreme heat may cause burns or melt certain materials or cause foundations to crack/dimple
- Supply chain or resource hub damages from heat or storms may cause replacement part delays and heightened demand/cost
- Hail can damage or destroy backup generators
- Resource restrictions may result in targeted violence or theft of site resources (e.g. water)
- Theft of backup generators during recovery from storms
- Extreme heat can impede helicopter operations
- Amplified events may reduce emergency response availability (e.g. fire/EMS)
- Battery backups for security systems and control panels may deplete during prolonged outages
- Disaster scams, misinformation, and timed weather/cyber events may increase
- Increased rates of depression during low pressures and aggression during heat waves may lead to workplace violence events
- Theft of larger metal structures such as rural telecom towers or water systems in cages on external apartment or condo buildings have noted a rise in theft
- Attacks on restoration crews are increasing



ExWx and Critical Resource Theft

As extreme weather events continue to rise globally, attacks of opportunity have been on the rise to match the lack of resources following the disaster or during shortages.

Fake Restoration Crews: Roofing companies claiming to be repairing storm damages will gain access to homes and sites, do damage to “inspect” under areas of the roof and demand significant price hikes while threatening to leave the exposed roofing if left unpaid.

- These companies are permitted access to roofs, backyards, areas where generators are often present and even internal systems like HVAC units.

Thieves internationally have begun targeting larger energy systems either for the infrastructure or for the oil pulled to operate the equipment. This means the gangs have sufficient knowledge of systems to safely disconnect or access them during use.

Other theft is also prevalent in China, India, Mexico, and various other countries where rural residents illegally connect to long-distance transmission lines.

Recent similar events in Canada have been on the rise, mimicking events internationally.

- BC Hydro reported 24 maintenance hole theft and mischief cases since January 2024, up from 5 in the previous two years. They warned severed cables can spark fires and trigger outages. Repair costs were about \$1.2 million.
- May 2024: RCMP investigated multiple break-ins and copper wire thefts at substations in the Whitbourne area.
- In 2025 Four men were charged after 33 hydro poles were cut down for copper theft in northern Ontario.
- In 2023, A copper theft in Dartmouth caused an outage affecting about 10,000 residents.
- SaskPower said copper theft cost over \$41,000 in 2020.

In the US: In 2024 Hugo, Oklahoma thieves cut a 488-foot radio broadcast tower for copper.

In 2025 McClain County reported theft of 3,600 feet of copper coax cable from cell towers.

INFRASTRUCTURE NEWS

Unveiling the Impact: Transmission Line Collapse Stemming from Tower Parts Theft.

tamperfinder April 24, 2024 Add comment 2 min read

Several asset thefts have been reported in northern India. This type of theft is common in African countries also, where power lines are to be drawn through uninhabited places for a very long distance. The chances of close surveillance of the Distribution company officials are very remote and the perpetrators have enough time to topple a tower or steal a transformer itself. Several accidents have also been reported in such cases.

In Kanpur, police arrested a gang of antisocial elements who stole distribution transformers.



Radio tower copper theft suspect Candice Logan, seen photographed with a car containing what appears to be copper in the trunk. (Facebook/Terry Park)

Meteorological Intelligence

Power outages can significantly impact physical bank locations by disrupting essential services like ATMs, payment processing, and security systems, potentially leading to temporary closures and hindering customer access to funds

According to a recent study, hackers are leveraging these weather trends to target energy systems when they are at their most critical.

The study, titled “*Operational and economy-wide impact of compound cyber-attacks and extreme weather events on power networks*”, concluded that an attack carried out in the wake of a weather event increased the potential impact 3x more than a standalone cyberattack.

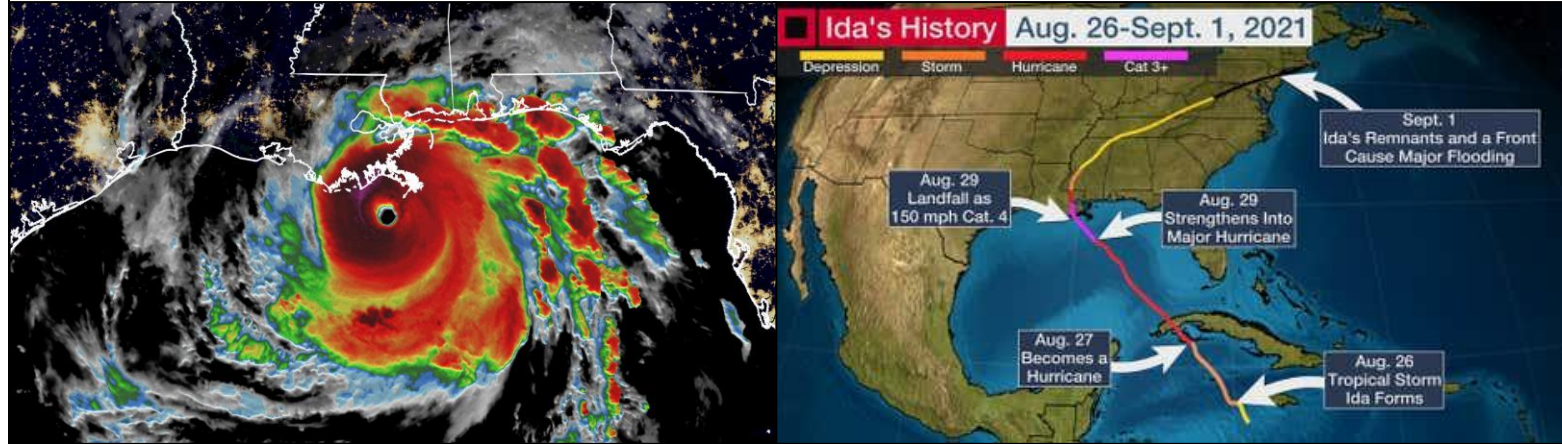
- **Local economies could experience a 37% drop-in economic activity if faced with a compound threat.**
- These events led to a 12% of energy demand going unmet and **a daily GDP reduction up to 3.1%.**

Example Event in Long Island:

- One conclusion listed a 9% increase in demand during a heatwave.
- A lone cyberattack could lead to 4% of demand going unmet.
 - Combined they could yield 12%, or nearly 200,000 customers.

HHS Office of Civil Rights states ransomware attacks on healthcare have surged by 264% over the last five years.

In 2021, [Hurricane Ida](#) in Louisiana left over one million people without power or internet. In the days following the storm, malicious actors launched a “malware attack” on the 24th Judicial District Court, disrupting its database and extending its storm-related closure.



A cyberattack on the grid/energy system components during an extreme weather event can cause ripples:

Restoration gets slower: Crews already face damaged lines, blocked roads, and safety limits. A cyber attack can disrupt outage management, switching, dispatch, and crew coordination at the same time.

Operators lose visibility: If Scada, sensors, or comms are degraded, utilities may not know what failed first, which assets are safe, or where to isolate faults.

Manual operations take longer: Systems can fall back to manual switching and field verification, which is much slower during flood, wind, or heat conditions.

Load stress gets worse: During heatwaves, demand is already high. A cyber event can block demand response, mismanage load shedding, or delay generator dispatch.

Cascading failures become more likely: Weather damage plus bad control signals can overload adjacent assets, spreading outages beyond the original footprint.

Equipment damage can increase: Delayed isolation can let transformers, substations, and feeders operate in unsafe conditions longer.

Public harm rises faster: Hospitals, water systems, telecom, and cooling access are hit longer, raising health and economic losses.

Recovery costs increase: Utilities face both physical repair and digital forensics, system rebuilds, and regulatory scrutiny.

Cybercriminals often intensify phishing and ransomware attacks in the aftermath of natural disasters, targeting affected regions and organizations that are already under stress.

Warm Summer Nights

Since 1970, average summer minimum (nighttime) temperatures have warmed in 231 US locations by 3.1°F on average.

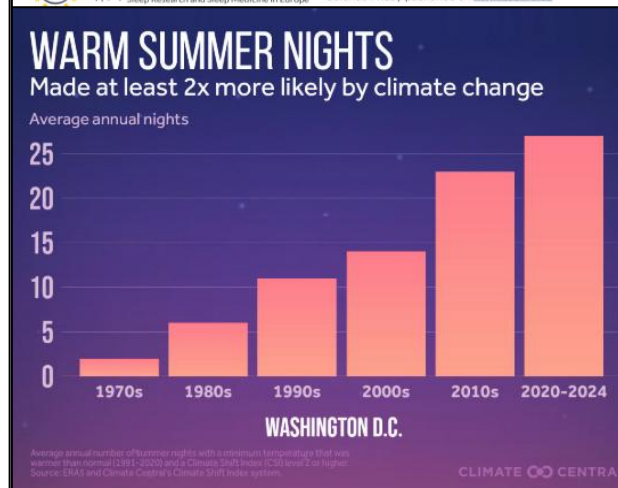
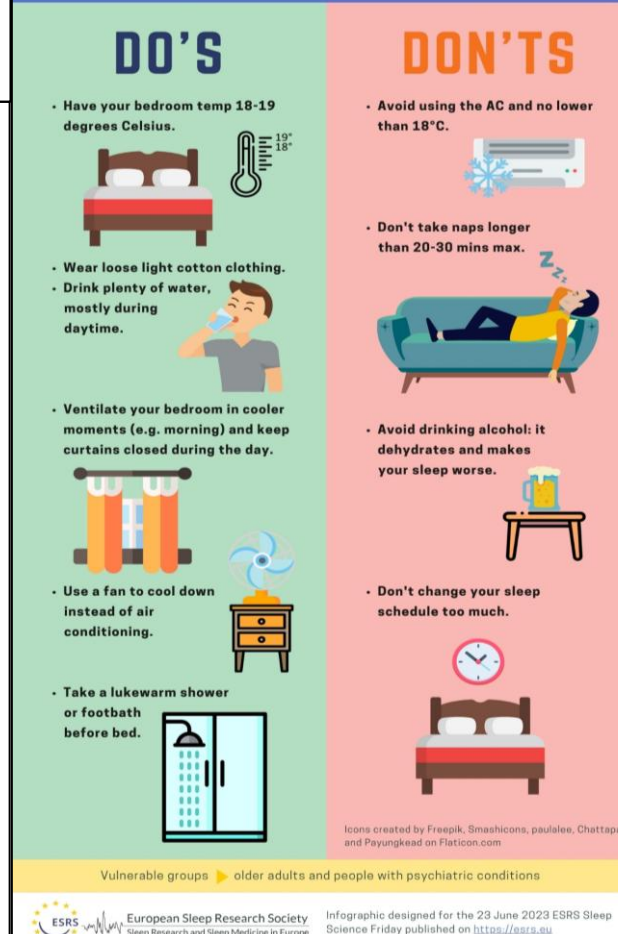
- New analysis shows that climate change is having a growing influence on the frequency of sweltering summer nights since 1970 in all but one of the 247 major U.S. cities analyzed.
- On average, these cities currently experience about 27 warmer-than-normal summer nights with a strong climate change fingerprint each year, compared to one such day annually during the 1970s..
- Hot summer nights limit our ability to cool off and recover from extremely hot summer days. This can lead to greater heat stress and related health risks.

When nights don't cool off enough relative to peak daytime temperatures, people have a harder time cooling off.

- Heat is the deadliest weather-related hazard in the U.S., and warm nights can worsen heat stress and related health risks during the hottest time of year.
- Summer nights have warmed the most since 1970 in the Southwest, where summer nights have warmed by 4.5°F on average across 11 locations.

Sleepless Nights, a 2024 report from Climate Central, quantifies the influence of human-caused climate change on the frequency of hot summer nights globally.

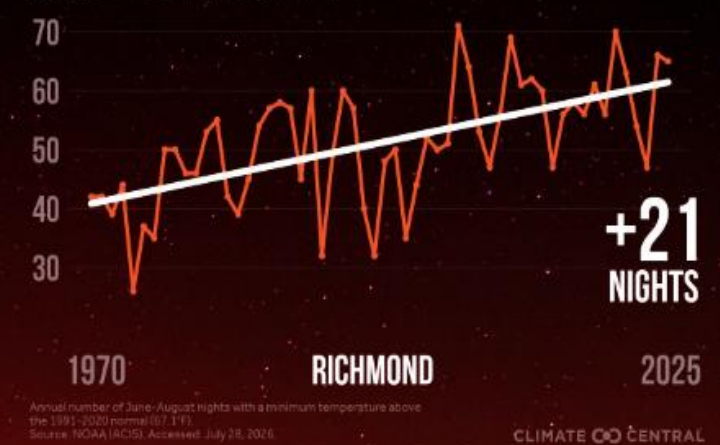
- **More warm nights also mean higher demand for air conditioning and greater evaporative demand from bodies of water and vegetation along with added stress to aquifer systems as groundwater continues to face depletion rates.**



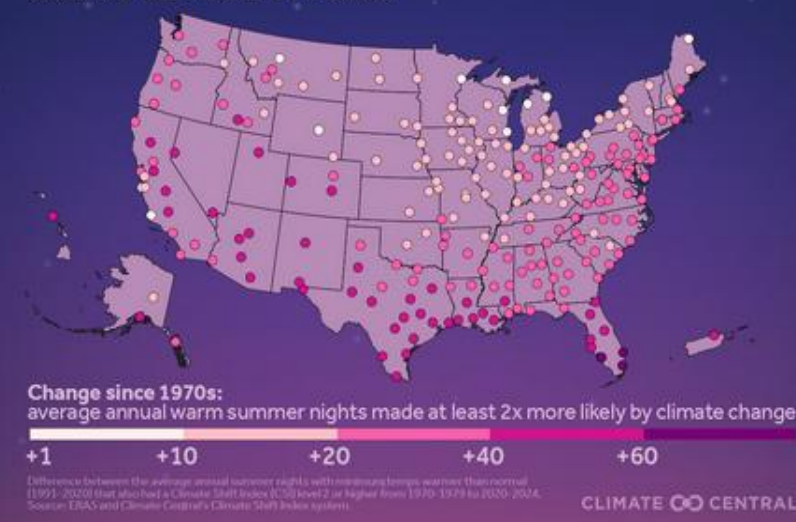
Abnormally high temperatures overnight present risks of wildfire threats, stressed vegetation, greater rates of evaporative demand, and increased aggression rates.

MORE WARM SUMMER NIGHTS

Nights above normal

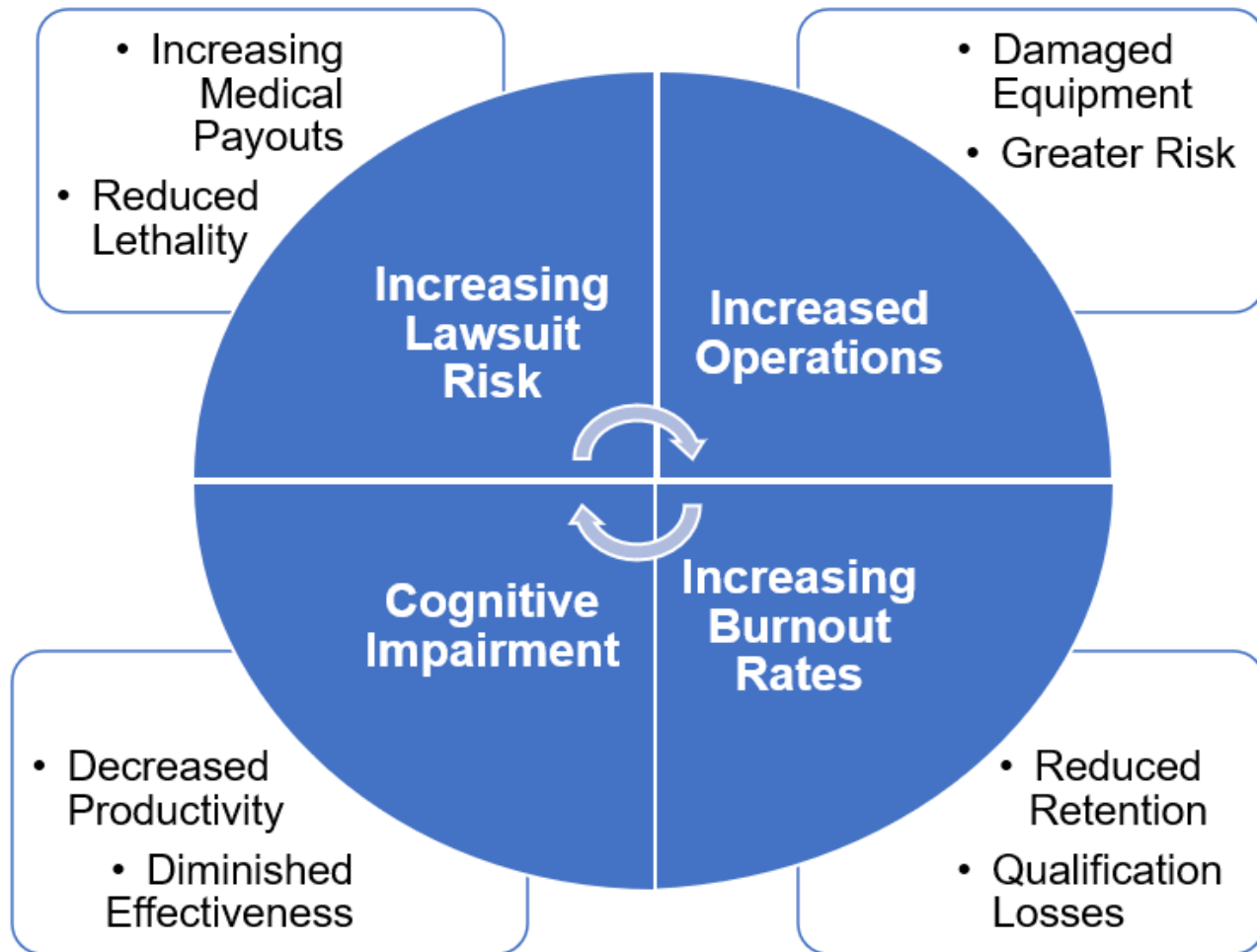


MORE WARM SUMMER NIGHTS DUE TO CLIMATE CHANGE

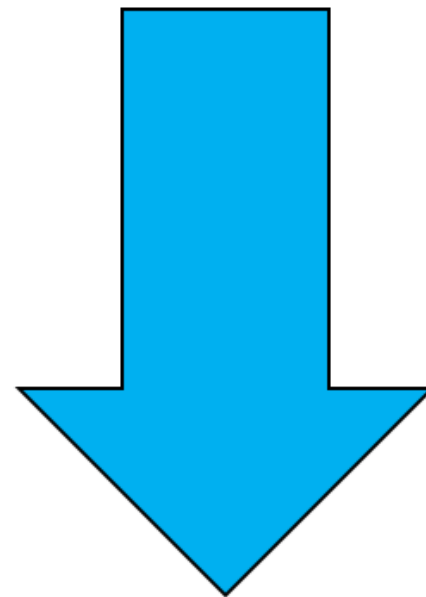


Higher Highs → Lower Lows

Variations outside of the normal for barometric centers present growing operational risks to emergency managers as many struggle to understand the impacts from this invisible threat and are thereby caught off-guard by the symptoms degrading their work performance and destabilizing societal norms.



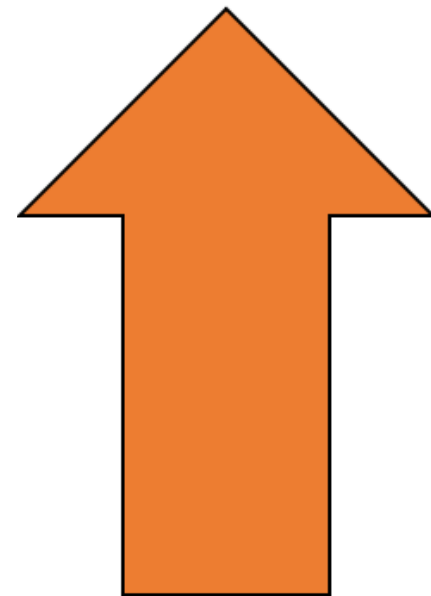
Low Pressure Impacts



- Suicidal Ideation
- Depression
- Lethargy
- Sinus Issues
- Muscular Pain
- Joint Aches
- Barometric Migraines
- Manic Events
- Digestive Issues

High Pressure Impacts

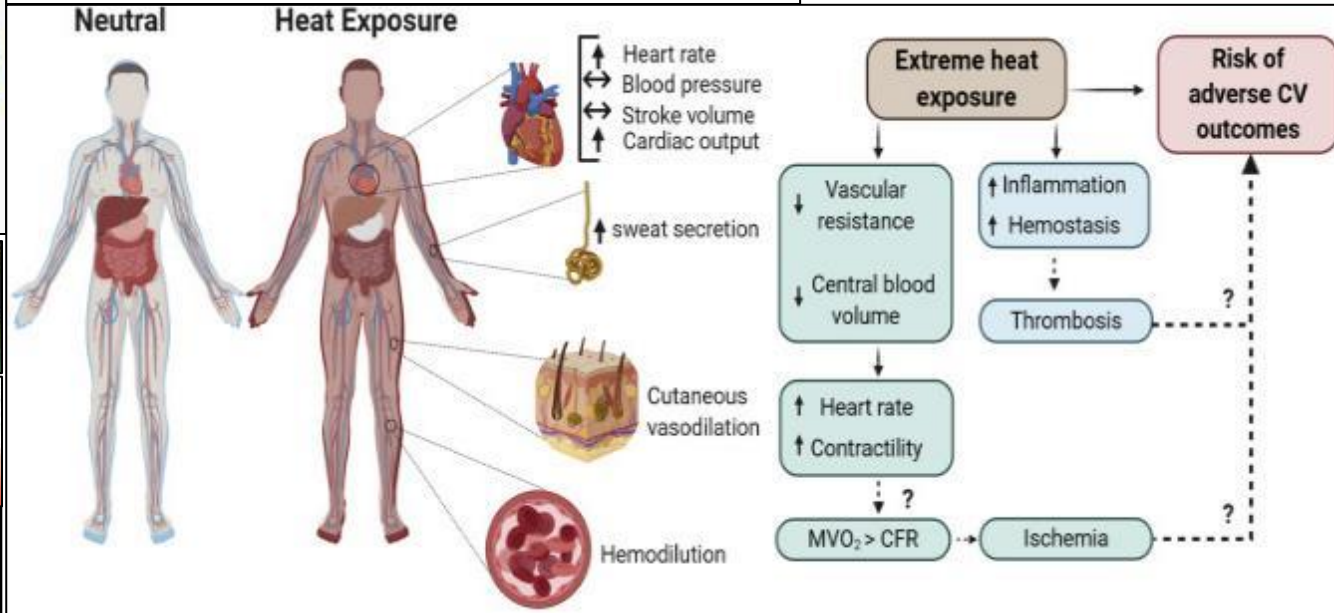
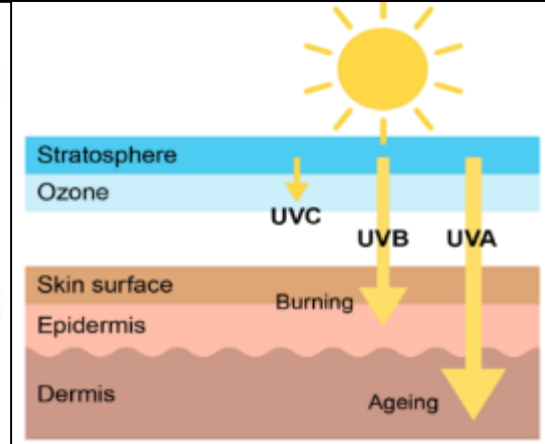
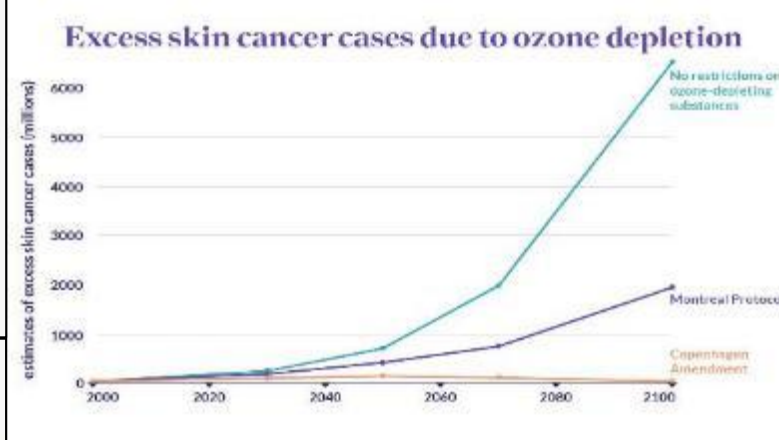
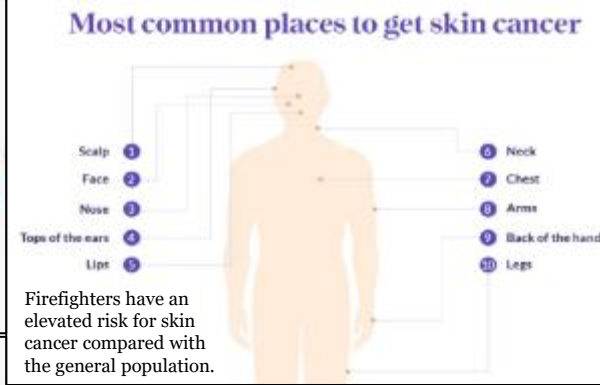
- Aggression
- Property Damage
- Workplace / Domestic Violence
- Membrane Rupture
- Rising Blood Pressure
- Poor Air Quality
- Heatwaves – Heatstroke
- Paranoia
- Poor Sleep



'Too Hot To Op'

First Responders/Operators Risks from Heat

- Higher Rates of Skin Cancer
- Inhalation of Greater Concentrations of Pollution
- Vision Impairment due to Reflectivity
- Overheating – Gear Amplification
- Equipment Degradation
- Dehydration and Mental/Physical Fatigue
- Heat Exhaustion/Stroke
- Sweat Induced Rashes
- Eczema Flareups – Heat
- Higher Heart Attack Risk
- Syncope (fainting)
- Cramps or Swollen Legs (reduced mobility)
- Increased Risk of Kidney Disease
- Extended Muscle Recovery Times
- Blisters from Burns/Heat Exposure
- Brittle Hair/Hair Loss from UV Light Exposure
- Increased Ingrown Nails or Bunions/Hammertoes
- Amplified PTSD Reactions – Heat-Induced Anxiety
- Sleep Disturbance – Persisting Body Temperature
- Development of Secondary Hyperhidrosis



Impacts to the Body

If the wet bulb temperature exceeds the human body's skin temperature of around 95°F sweating can no longer cool the body, which can result in death by overheating; causing more downtime for outside workers will be necessary to reduce mortality rates.

- At this temperature, even young, healthy people *die* in about six hours.
- **Air conditioning removes humidity from the air and is the best solution when wet-bulb temperatures get too high.**
- Fans can help sweat evaporate more efficiently but are less effective. People can die of heat stress at wet-bulb temperatures lower than 95°F.

"If there's enough moisture in the air, it's thermodynamically impossible to prevent the body from overheating, even if there is an endless supply of water available, shade, and light clothing."

A sustained wet-bulb temperature **exceeding 87°F** is likely to be fatal even to fit and healthy people, unclothed in the shade next to a fan; at this temperature human bodies switch from shedding heat to the environment, to gaining heat from it.

- At an internal temperature of **109.4°F** serious brain damage, continuous convulsions, shock, and death are possible results for humans. Cardio-respiratory collapse will likely occur.

During a heat stroke the body temperature increases to over 104°F. The acute overheating causes a brain edema, that evokes symptoms such as cramps, clouding of consciousness, headache, and sickness. In the worst cases heat stroke ends with lasting brain damages or with death.

The CDC states some medications can interfere with your body's ability to regulate temperature, making it harder to cool down and increase sun sensitivity to the skin, like:

- Heart medications (ex. water pills, Lasix, Microzide)
- Antidepressants (ex. Lexapro, Prozac, Zoloft)
- Antipsychotics (ex. Risperdal, Zyprexa)
- Central nervous system stimulants (ex. Adderall, Ritalin)
- Anticholinergics (ex. Cogentin, Detrol)
- Antihistamines (ex. Benadryl)
- Decongestants (ex. Sudafed, Afrin, Mucinex, and Zicam)
- Dopaminergics (ex. Sinemet)

The heat can also damage or degrade some medical devices such as insulin, inhalers, hearing aids, and EpiPens so make sure those are properly stored. Some drugs and substances that can act as diuretics, which rid the body of extra fluid and salt, include:

Antibiotics	Antidepressants	Corticosteroids
Alcohol	Antihistamines	Laxatives
Anticholinergic drugs	Beta-blockers	Lithium

LOW-INCOME FAMILIES ARE DISPROPORTIONATELY AFFECTED BY HIGH HOME ENERGY COSTS.

16.3%

OF A LOW-INCOME FAMILIES' GROSS ANNUAL INCOME IS SPENT ON HOME ENERGY COSTS

3.5%

OF OTHER HOUSEHOLDS' ANNUAL INCOME IS SPENT ON HOME ENERGY COSTS COMPARATIVELY

Heat Affects Health in Many Ways

Warmer temperatures increase the risk for a diverse range of health risks. For example:



An increased risk of **hospitalization for heart disease**.



Heat exhaustion, which can lead to **heat stroke** if not treated, can cause critical illness, brain injury, and even death.



Worsening **asthma** and **chronic obstructive pulmonary disease (COPD)** as heat increases the production of ground-level ozone.



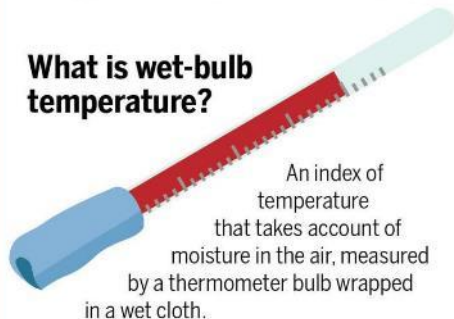
Dehydration, which can lead to **kidney injury** and blood pressure problems. Some kidney damage can become irreversible with repeated or untreated injury.



Violence, crime, and suicide may increase with temperature, adding to the rates of depression and anxiety already associated with climate change.

Wet-bulb temperature is a superior index of heat as perceived by the human body

What is wet-bulb temperature?



An index of temperature that takes account of moisture in the air, measured by a thermometer bulb wrapped in a wet cloth.

Wet-bulb temperature of 35 C is the survivability limit for humans



CORE TEMPERATURE: 37 C SKIN TEMPERATURE: 35 C

Above 35 C, the body cannot cool itself through sweat

Extreme Weather and Unrest: Response Risk

AED Equipment: Typically, the temperature range for normal AED operations is 32-122° F, since extreme temperatures can impact normal functions by draining the battery or altering the gel found in pads.

- High temperatures can negatively impact an AED's functionality and lifespan. Extreme heat can cause the internal circuitry to malfunction, potentially leading to device failure during a critical moment.
- Additionally, high temperatures can shorten the lifespan of the AED's battery and affect the gel on the electrode pads.

Emergency Vehicles: extreme heat or high humidity can impact safe temperatures of seatbelt buckles, steering wheels, laptop systems, windshield mounted radar, rifle racks, camera systems, leather accessories, radio console, prisoner cages, in-vehicle fire extinguishers, road flares, etc.

- High temperatures can impact the accuracy and performance of police car radar (speed guns).
- Higher temperatures are linked to increased rates of tire blowouts, diminished battery ranges, radiator cracks, and in smart vehicles may result in touchscreen lifting and loss of access to critical applications due to extremes.
- Over prolonged exposure, fire extinguishers can explode due to excessive heat and pressure buildup.
- Road flares degrade in high temperatures or humidity and should not be left in temperatures >120F for long.

Wounds: High moisture levels can make it harder for these chronic wounds to heal, increasing the risk of infection and complications. Dehydration can worsen ulcers and can reduce the ability to properly judge the level of discomfort.

- Whether you're recovering from a minor scrape, a surgical incision, or a more significant injury, the amount of moisture in the air can determine how quickly and effectively your body repairs itself.
- Too much humidity can increase the risk of infection, while too little can slow the healing process, causing unnecessary pain and discomfort.

Social Impact - Asthma: People may notice their asthma symptoms get worse on humid days when there is a lot of moisture in the air. This is especially true when exercising in humid conditions.

- Humidity can increase the levels of other substances in the air that irritate the bronchial tubes, such as pollen and pollution.
- After experiencing hot, humid air (49°C and 75–80% humidity) for 4 minutes, people with asthma had a 112% increase in airway resistance as opposed to the healthy group that only had a 22% increase in airway resistance.

Social Impact - Thunderstorm Induced Asthma: During the first 20-30 min of a thunderstorm, patients suffering from pollen allergies may inhale a high concentration of the allergenic material that is dispersed into the atmosphere, which in turn can induce asthmatic reactions, often severe.



Weather and Weapons

Guns: *humidity and heat impact manufacturing, firing, and successful shots.*

- Higher humidity causes less dense air and a faster bullet trajectory, delivering a high impact on the target when you don't account for it.
- Lower humidity results in thicker air, slowing down your bullet's trajectory and delivering low impact on target when you don't account for it.
- As temperature increases, the muzzle velocity increases as the air density reduces, causing less bullet drag. This action flattens the bullet path, resulting in high hits if there's no compensation.
- A temperature increase of 5°C can displace a bullet by as much as 8 inches between shots. Complete seasonal temperature changes, on the other hand, can result in far more drastic effects.
- Humidity has a significant influence on the preservation of ammunition and its components - ammunition bunkers must be kept dry and their relative humidity low.

Handcuffs: *metal handcuffs exposed to direct sunlight can cause thermal burns.*

- Most police handcuffs are made of stainless steel or similar metals that conduct heat well. Some agencies use polymer or coated handcuffs to reduce this risk.
- Arresting on hot asphalt/concrete may result in additional injury and liability risks.

Tasers: *humidity and heat can increase impact and degrade batteries.*

- High humidity or wet areas can damage sensitive electronics and batteries in stun guns and Tasers.
- Environmental conditions, such as humidity, can potentially change the chemical composition of the primer used to ignite the firing sequence in Taser cartridges, decreasing energetic output over time.
- Higher humidity means more moisture in the air, which can increase the electrical conductivity of both the air and skin.

Tear Gas: In a heatwave, you're likely to sweat more, which means more moisture for the tear gas to interact with, potentially increasing the discomfort and pain.

- Heat can help the tear gas spread more easily, increasing the risk of exposure.
- High temperatures can degrade the active chemical compounds in tear gas (e.g., CS gas), potentially reducing its effectiveness over time.

Humidity and Sirens: High humidity affects sound propagation by altering how sound waves travel through the air, specifically impacting higher frequencies. Increased humidity can lead to a decrease in sound absorption, allowing higher frequencies to travel further than they would in drier air. High humidity can reduce warning lights visibility.

Service Dogs and Emergency response dogs face amplified risks in heatwaves as the temperature and humidity are often higher closer to the ground. Areas with thinner fur, like the nose, ears, belly, and around the eyes, are susceptible to sunburn.

An increase in ticks, mosquitoes, and fleas are also noted during high heat and humidity days, bringing threats of disease.

HOT ASPHALT AWARENESS

Press the back of your hand firmly against the asphalt for 7 seconds to verify it will be comfortable for your dog.

K9 Heatwave Risks



Air Temp.	Asphalt Temp.
77°F	~125°F
86°F	~135°F
87°F	~143°F

Other factors could make a worst scenerio, such as direct sunlight, no wind, very low humdy, and high radiant energy.

At 125°F, skin destruction can occur in 60 seconds.

An egg can fry in 5 minutes at 131°F

PROTECT YOURSELF FROM HEAT & SUN



Drink plenty of **water** and avoid alcohol. Beverages with electrolytes can also help protect against heat stress.



Apply **sunscreen** (SPF 30 or higher) every two hours.



Wear lightweight, loose-fitting, and **light-colored clothing**.



Take regular breaks in the **shade**.



weather.gov



Avoid leaving your pepper spray or gel in a place where the temperature will drop below 32°F or above 120°F. Excessive heat or cold could cause the can to burst.

Extreme Weather and Site Security

Risks abound for attendees of any large events, indoors or outdoors and regardless of region or event type.

Panic and Stampedes

- **Risk:** Sudden storms, lightning, or tornado warnings can trigger panic, leading to stampedes or trampling. Example: At concerts or stadiums, people may rush toward exits, causing injuries or blocking egress.

Structural Failures

- **Risk:** Temporary structures (e.g., tents, stages, bleachers) may collapse under high winds, hail, or heavy rain. Example: The Indiana State Fair stage collapse (2011) during a storm killed seven people and injured dozens.

Communication Breakdowns

- **Risk:** Severe weather can damage communication infrastructure or overload networks, delaying emergency alerts and instructions causing slower emergency response and greater confusion in large crowds.

Power Outages

- **Risk:** Electrical failures in a crowded venue can result in complete darkness, elevator failures, security system malfunctions (CCTV, alarms, door locks) making it easier for crimes or looting to occur unnoticed.

Flooding or Blocked Exits

- **Risk:** Heavy rain or snow can flood pathways or exits, creating physical barriers and hazards prevents timely evacuation, especially for elderly, children, or disabled individuals.

Terrorism or Opportunistic Crime

- **Risk:** Confusion during severe weather may be exploited for theft, assault, or coordinated attacks. Reduced visibility and overwhelmed security personnel can create blind spots.

Medical Emergencies

- **Risk:** Hypothermia, heatstroke, injuries from debris or slips. Emergency medical services (EMS) may struggle to reach victims in crowded or weather-impacted zones.
- Aggression rates are also likely to surge during extreme heat posing an addition threat for violence throughout a venue or the surrounding areas such as tailgates.

Extreme weather

Changes in Atmospheric Stability Means More:



Winter storms



Freezing rain



Severe winds

What are the top risks from extreme weather?

Increased slips, falls and injuries



Extended power outages



Mental, physical and financial pressures



Risks aren't felt equally

Difficult to access essential services



More damaged roads and buildings



Learn more: engage.ottawa.ca/climate-resiliency



Traffic and Evacuation Chaos

- **Risk:** Severe weather + crowd evacuation = traffic gridlock and accidents. Emergency vehicles can't get in; civilians can't get out.

Misinformation and Rumors

- **Risk:** False social media posts or unofficial announcements can lead to misdirection and chaos. Example: People might flee toward danger zones based on incorrect assumptions.

Security Personnel Limitations

- **Risk:** Guards, law enforcement, or EMS may be spread too thin or unable to operate safely in the conditions. Reduced ability to protect or evacuate the crowd efficiently.

Unforeseen Risk

- Batteries face constraints during extreme heat or extreme cold resulting in reduced functionality, stranding attendees while thermal runaway can present an immediate risk to the sites if a battery catches fire (generator, electric vehicle/scooter/bike, cellphones, some metal detecting wands, and for portable LED displays).
- Parking garages are often not rated for electric vehicles additive weight and do not maintain continuous airflow presenting risks for evacuation, shelter, and operations.

High-Pressures and Humans

Hot weather increases body temperature, which in turn increases heart rate and blood pressure. Increased blood pressure and heart rate can lead to discomfort, which can be attributed to the correlation between high heat and increased anger and violence.

- A recent study in India found that a **1C increase in annual mean temperature was associated with a 4.5% increase in intimate partner violence**. Other studies noted the increase in sexual violence and heightened workplace violence during heat events.

When the barometric pressure is high, more pressure is pushed against our body, limiting tissue expansion, increasing blood pressure with an increased possibility of heart attacks.

- A 10-millibar decrease <1016 millibar and a 10-millibar increase >1016 mbar were associated with a 12% increase and an 11% [increase in myocardial infarction and coronary death events](#).

Studies have focused on temperatures more than the high-pressure centers enabling persisting heat events over regions for longer periods.

- [A 2019 study from Stanford University found weather instability contributed to between 3% to 20% of conflicts over the last century with the potential influence set to increase substantially due to warming temperatures.](#)
- [Research from Mexico took 16 years' worth of daily crime records and found an increase in temperature of 1C correlated with an increase across all types of crime by 1.3%.](#)
- [There were about a third more accusations of crime per population on days hotter than 32C than on days cooler than 10C.](#)

[A study of Los Angeles, CA](#): Overall crime increases by 2.2% and violent crime by 5.7% on days with maximum temperatures above 85F (29.4C).

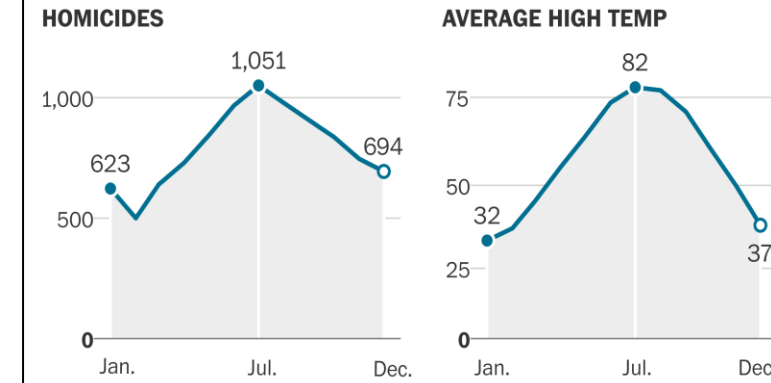
A 2019 study on terrorist attacks found that not only were terrorist attacks more common on hotter days, but also that the number of fatalities per attack were higher.

Even if the world's countries managed to keep "global temperature rise this century well below 2C above preindustrial levels," global terrorist attacks would increase by 14% solely due to hotter days.

Total terrorism fatalities would rise by 24% to include the increase in populations being outside more and larger events.

Temperature and violence

Total homicides in Chicago, by month, 2001 – 2018, with average daily high temperature by month

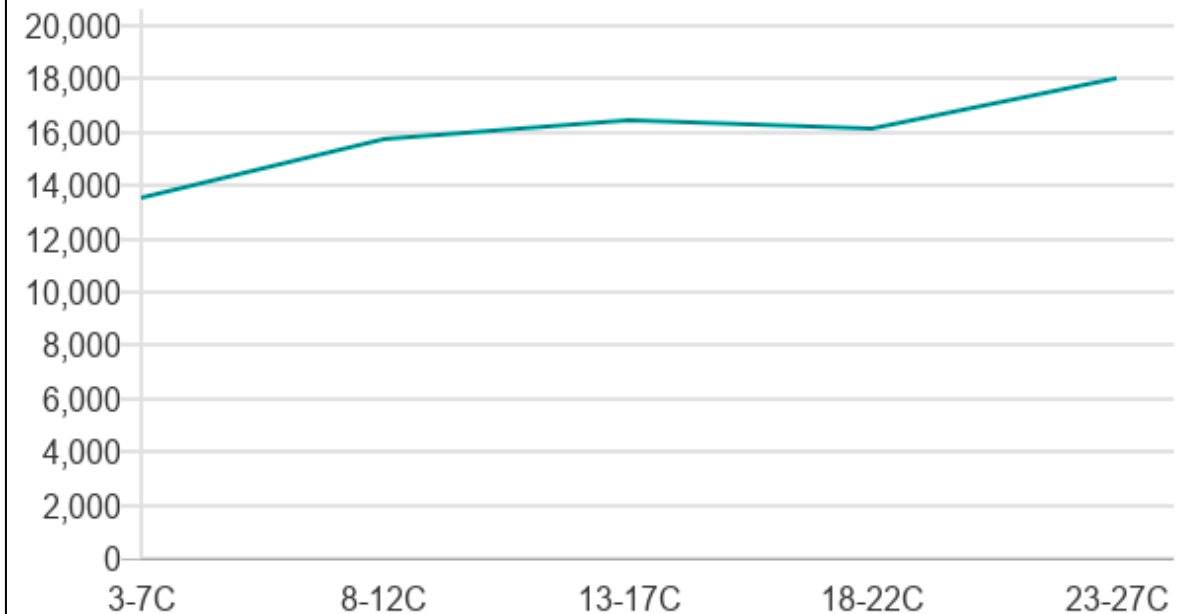


Sources: City of Chicago, NOAA

The Washington Post

As temperatures rise, so does violent crime

Average violent crime rates vs average temperature, London



Source: Metropolitan Police

BBC

According to a 2018 [study](#) published in *Nature Climate Change*, a 1.8°F (1°C) increase in average temperature in the U.S. and Mexico correlates to a 1% increase in suicides. Poor quality sleep may be one of the driving factors.

- Heat also plays a role in perceiving an aggressive tone or transgression when interacting with others. Violence in prisons also increases during extreme heat with days ranging over 27°C increasing the probability of violence by 18%.

Twitter sees hate tweets and online aggression [increase](#) during heatwaves, along with phrasing that researchers have linked to [anxiety and depression](#).

Analysis showed that productivity started dropping when average daily maximum temperatures rose above 20° C. The researchers' calculations suggest that [average annual output will decrease by 2.1% if average daily temperatures warm by 1 degree C](#) over current conditions; annual gross domestic product, or the value of goods and services produced in a single year, would drop by 3%.

- Impacts to venues and lodging for events include decreased productivity, more aggressive crowds, losses in supply chain, site damages, staff burnout, greater damage to operational capabilities, and delays/cancellations of performances/events.

Portland sees spike in gun violence as heat wave blankets metro area

Published: Jul. 8, 2024 at 1:21 AM EDT



As the temperature rose across Portland, so has violent crime, with six shootings since July 4. According to a local sociology professor, that is a predictable pattern.

According to the Mississippi Department of Public Safety, the violent crime rate in **Mississippi** increased by 2.4% in 2022 from the previous year.

- The most common violent crimes in Mississippi are aggravated assault, robbery and murder.

Research from Lancet Planetary Health states for every 5°C (9°F) increase in the average daily temperature, there was a 4.5% uptick in sex offenses in the following week across several major U.S. cities.

- On days when the temperature gauge exceeded 85°F (29.4°C), overall crime jumped by 2.2%, and violent offenses surged by 5.7%.

With each 5°C rise in temperature, **Chicago's** homicide rates shot up by 9.5%, and **New York City** wasn't far behind with an 8.8% increase.

In 1988, during the periods warmest summer on record, the US reported record-breaking violence (1.56 million cases).

[A study from Spain](#) found intimate partner femicide increases as much as 28% during heat waves.

[A laboratory experiment found](#) that participants demonstrated an increase in the joy of destruction when subject to increasing ambient temperatures.

Barometric Psychological Distress

A study of mental health-related emergency room visits in summer found an 8% increase in mental health visits on the hottest days compared to the coolest days.

- The increase ranged from 5% to 11% across different disorders: Specific mental health conditions exacerbated by heat included substance use disorders, anxiety and stress-related disorders, mood disorders, schizophrenia and related disorders, self-harm, and childhood behavioral disorders.
- A 2.2% increase in mental health-related mortality and 0.9% increase in mental health morbidity associated with every 1.8°F (1°C) rise in ambient temperature.

7% of American adults experience at least mild levels of climate change psychological distress.

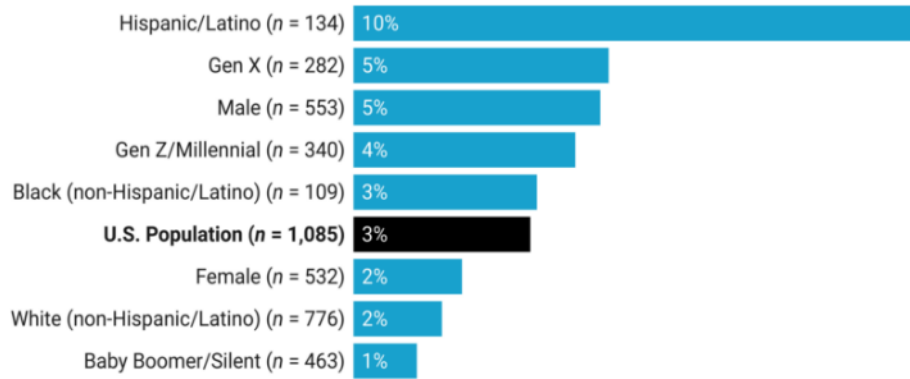
- Prolonged exposure to heat, including an increase of 1C, can activate many biochemical pathways associated with neurodegenerative diseases like Alzheimer’s and Parkinson’s.
- Air pollution can contribute in similar ways. In rats, such effects are seen after exposure to extreme heat for a mere 15 minutes a day for one week.
- Research suggesting that blue-green algae releases a potent neurotoxin that offers one of the most compelling causal explanations for the incidence of non-genetic ALS (downwind).

Cognitive neuroscientists identified that extreme heat and surging CO2 levels impair decision-making, diminish problem-solving abilities, and reduce the capacity to learn.

- Chinese economists noted that students who took mathematics tests on days above 32°C looked as if they had lost the equivalent of a quarter of a year of education, relative to test days in the range 22–24°C.
- Between 10% and 28% of heat stroke survivors experience persistent brain damage.

Climate Change Depression by Race/Ethnicity, Gender, and Generation

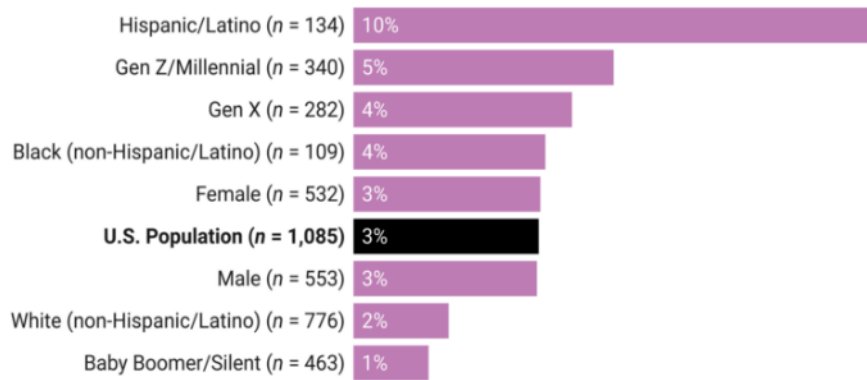
% who meet the cut-off to be considered clinically diagnosable on the PHQ-2 Climate



Over the last 2 weeks, how often have you been bothered by the following problems? [Little interest or pleasure in doing things because of global warming] [Feeling down, depressed, or hopeless because of global warming] 0 = "Not at all", 1 = "Several days", 2 = "More than half the days", and 3 = "Nearly every day"

Climate Change Anxiety by Race/Ethnicity, Gender, and Generation

% who meet the cut-off to be considered clinically diagnosable on the GAD-2 Climate



Over the last 2 weeks, how often have you been bothered by the following problems? [Feeling nervous, anxious, or on edge because of global warming] [Not being able to stop or control worrying about global warming] 0 = "Not at all", 1 = "Several days", 2 = "More than half the days", and 3 = "Nearly every day"

Responses to the questions were summed to create a score ranging from 0 to 6. People who scored 3 or higher were classified as having presumptive clinically significant levels of climate change anxiety.

December 2022. Base: 1,085 U.S. adults (n refers to the total number of respondents in the sample)
Source: Yale Program on Climate Change Communication;
George Mason Center for Climate Change Communication • Created with Datawrapper

Atmospheric Changes and Wildlife

Experts theorize air pressure changes affect a fish's swim bladder, which is used to help a fish maintain neutral buoyancy. The bladder is filled with air and is thereby sensitive to pressure changes that occur when moving between different depths, likely to be affected by changing air pressure.

Recent studies found that temperature indeed drives spatial and temporal changes in fish body size. Around 55% of species were smaller in warmer waters (especially among small-bodied species), while 45% were bigger.

[Dogs](#) are more likely to attack people on days with higher UV levels, according to Harvard Medical School [research](#).

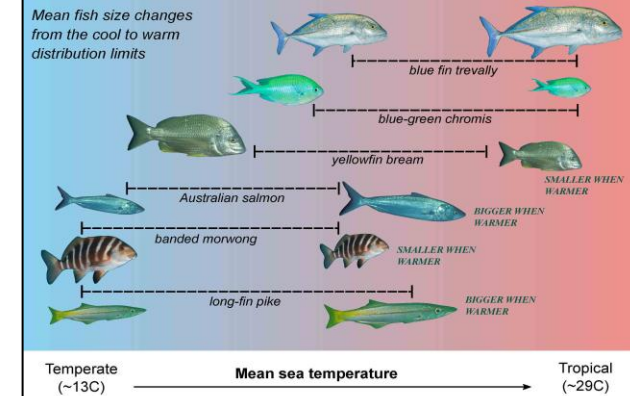
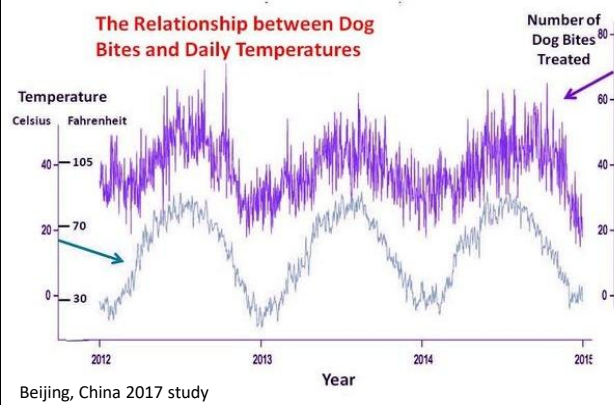
- Dog bites increased by 11% on days with higher UV levels, 4 percent on hotter days, and 3 percent on days with increased ozone levels.

Previous studies have linked high temperatures and air pollution to increased aggression in humans, [rats](#), monkeys and even ants.

As a warm weather loving animal, a hotter environment could allow North Carolina's alligators to expand their limited distribution to areas further inland and away from wet, boggy coastal areas.

- Warmer temperatures could also result in changes to reproductive rates, allowing for earlier sexual maturity and changes in body size for alligators. This could have implications for similar creatures globally.
- Florida has seen a significant rise in alligator attacks, with the [Florida Fish and Wildlife Conservation Commission](#) (FWC) reporting an upward trend in the number of alligator bites and fatalities.
- Almost half of the [453](#) alligator bites reported in Florida between 1948 and 2022, around 47%, occurred in the last 22 years, from (2000-2022).

An uptick in human-shark interactions has been occurring on the shores of Long Island, New York -- closing beaches as surfers, lifeguards and swimmers suffer bites from sharks in search of food.



While the onset of overall changes in heat can drive migration threats for animals, the amplification of intensity for storms (both continental and tropical) can trigger bursts of movement and subsequent threats to population centers which normally are not exposed to sudden influxes of insects, rodents, or predators.

- Sudden floods from a rare storm in Egypt flushed swarms of scorpions and tarantulas from their underground burrows into people's homes resulting in over 500 locals seeking medical attention due to stings.
- Torrential floods in Tanzania led to more lion attacks after their usual prey migrated away from floodplains.
- Higher air temperatures in Australia triggered more aggressive behavior in eastern brown snakes, leading to more incidents of snake bites.
- Wildfires in Sumatra, Indonesia drove Asian elephants and tigers out of reserves and into human-inhabited areas, leading to at least one death.
- Disruption of food webs in the Americas drove black bears in New Mexico and foxes in Chile into human settlements in search of food.
- Warmer air and ocean temperatures in a severe El Nino led to an increase in shark attacks in South Africa.

In India, unstable weather [reduced](#) vegetation for blue sheep (bharal), forcing them to feed on human crops, drawing snow leopards into town.

Weather Risks + Wildlife

Intrusion: As agricultural and urban spaces expand, natural forest covers diminish. Higher summer temperatures force moose to alter their natural movements, moving closer to agricultural lands, shaded city park networks, and backyard orchards to stay cool.

- Moose rest more during warm midday hours and move to shade instead of searching for food. Less time spent eating lowers fat reserves needed to survive harsh conditions.

Aggression: A 2025 study out of China showed that many animals, including snakes and cats, are more inclined to bite people when it gets hot.

Memory Loss: Researchers showed that when abnormally hot, mice have trouble finding their way around a maze and forget objects they've seen the day before. Bird also begin to fail cognitive tests in higher temperatures.

- Male guppies, popular aquarium fish, also have trouble getting through a maze after spending several days in heat-wave-like 90-degree water.

Aggression: Some fish become more aggressive, attacking others more often and becoming territorial, while die off rates typical surge in heatwaves.

Pests: Increasing temperatures raises the rates of bacterial exposure, e. coli, ticks, parasites, and algal blooms which can push wildlife into different responses.

Ecological Changes: Conflicts between dogs and wolves spike during summer bear training and hunting seasons.

Abnormal Events: A chance for encounters with polar bears are increasing as polar bears are being driven inland due to sea ice melting.

Bites: Research shows that for every 1°C rise in temperature, snakebite rates increase by about 6%. Venomous snakebite incidents rose by 5.6%, while non-venomous bites rose by 5.8%.

- Most bites occurred in summer, but the strongest link to warmer temperatures and more snake bites happened in the spring and fall.

Stings: bees and related stinging insects can become more irritable, stressed, and defensive during intense heatwaves. Bees change their foraging patterns, seeking out cooler times of day to gather nectar and pollen.



**Kerala issues guidelines
as snakebite incidents
rise amid heatwave**

**Snake bite claims 13 lives in
50 days in Uttarakhand amid
climate-change scare**

*Warmer winters prevent hibernation,
increasing activity of bears and snakes; 13
snakebite deaths reported in six weeks,
forest department warns of rising danger.*



El Niño – Helpful Trend Notes

The 1982-83 El Niño contributed to an estimated \$4.1 trillion in global income losses in the five years that followed, and the 1997-98 El Niño contributed to an estimated \$5.7 trillion in losses, according to [new research](#).

- The winter season of 1997-1998 with a very strong El Niño occurring was one of the wettest on record across California, with double the normal amount of rainfall and about \$850 million in flood and storm damage statewide.
- The winter El Niño season of 2002-2003 produced heavy rainfall across most of the Western US resulting in widespread power outages reaching over 1.1 million outages and torrents of floodwater causing damage. In coastal areas some sites saw 6 inches of rain in less than 24 hours while mountains saw heavy snowfall.

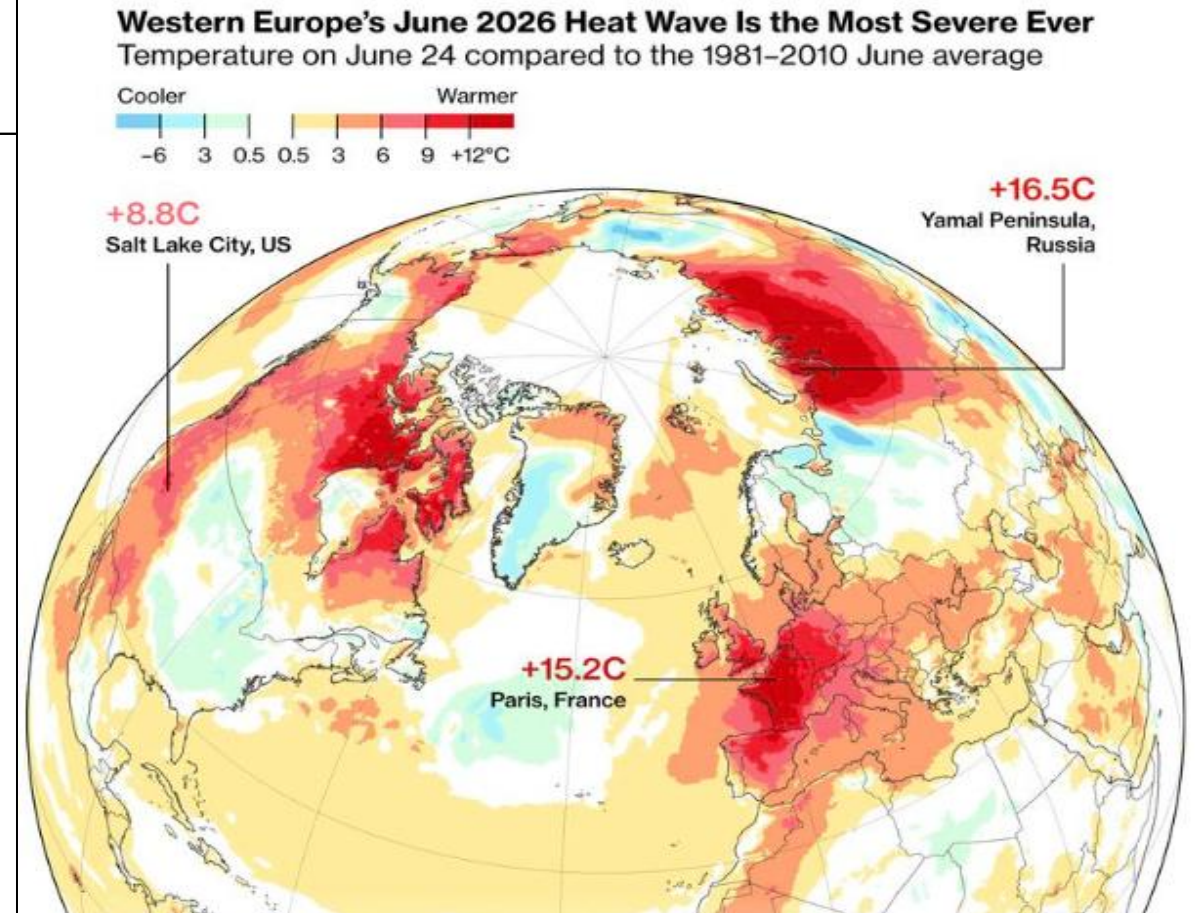
Median losses from incoming El Niño events could be at least \$3 trillion by 2029.

Major El Niño events can raise local sea level by around 6-10 inches in California during the winter rainy and stormy season through a combination of northward-propagating coastally-trapped Kelvin waves and thermal expansion of seawater.

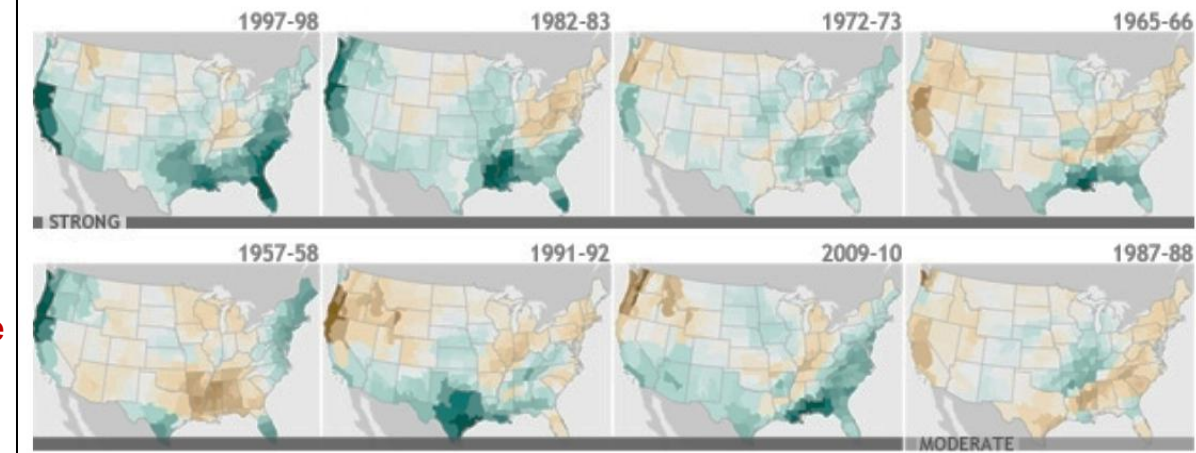
- While that might not seem like a lot, this (temporary) increase will occur atop an additional (permanent) 6-10 inches of sea level rise that has accumulated due to global warming over the past century.
- Levels could be as much as 2-3 feet higher than usual during major winter storms this year, and even higher than that should a storm coincide with the usual King Tides.

The odds of amplified or “blocking” high pressure systems in the Pacific Northwest is considerably higher during El Niño summers and autumns.

- That means that the odds of major heatwaves and fire weather events may be especially high in this region later this summer, and this could spell wildfire-related trouble given widespread drought.



Winter precipitation patterns during strong, moderate, and weak El Niño events since 1950



El Niño: Historic Comparisons

“Super El Niño” is simply a colloquial term used to refer to “very strong” El Niño events—i.e., those which are among the top 3 or 4 events in the reliable satellite record dating back to the late 1970s and characterized by an ONI/RONI value of +2°C or above.

In addition to boosting odds of a robust summer monsoon across the mountain and desert interior, there will likely also be an increased chance of abnormal convective activity across California.

Much like a snowflake, **no two El Niño, La Niña, or Neutral ENSO years are alike**. Some news outlets may attempt to draw correlations where there are none and may miss key connections to international impact.

Coinciding concerns: The 2026 Pac NW Wildfire Season saw Oregon alone scorch over 2.3 million acres and surpassing its previous high set in 2024 with Washington spending over \$200 million fighting fires in one month and thick smoke degrading air quality downstream for months.

El Niño - 28				La Niña - 25		
Weak - 12	Moderate - 7	Strong - 6	Very Strong - 3	Weak - 12	Moderate - 6	Strong - 7
1952-53	1951-52	1957-58	1982-83	1954-55	1955-56	1973-74
1953-54	1963-64	1965-66	1997-98	1964-65	1970-71	1975-76
1958-59	1968-69	1972-73	2015-16	1971-72	1995-96	1988-89
1969-70	1986-87	1987-88		1974-75	2011-12	1998-99
1976-77	1994-95	1991-92		1983-84	2020-21	1999-00
1977-78	2002-03	2023-24		1984-85	2021-22	2007-08
1979-80	2009-10			2000-01		2010-11
2004-05				2005-06		
2006-07				2008-09		
2014-15				2016-17		
2018-19				2017-18		
2019-20				2022-23		

Smoke particles can reduce the size of water droplets in cumulus clouds, increasing cloud reflectivity and potentially suppressing rainfall.

A recent study found that over the past 40 years, average yield losses due to ozone were 6.1% for soybean and 3.5% for maize, with soybean being more sensitive.

Wildfire smoke exposure lowers dairy cow milk production, reduces feed efficiency, and increases systemic inflammation.

Wildfire smoke significantly reduces egg production in chickens due to environmental stress, reduced lighting, and respiratory irritation.

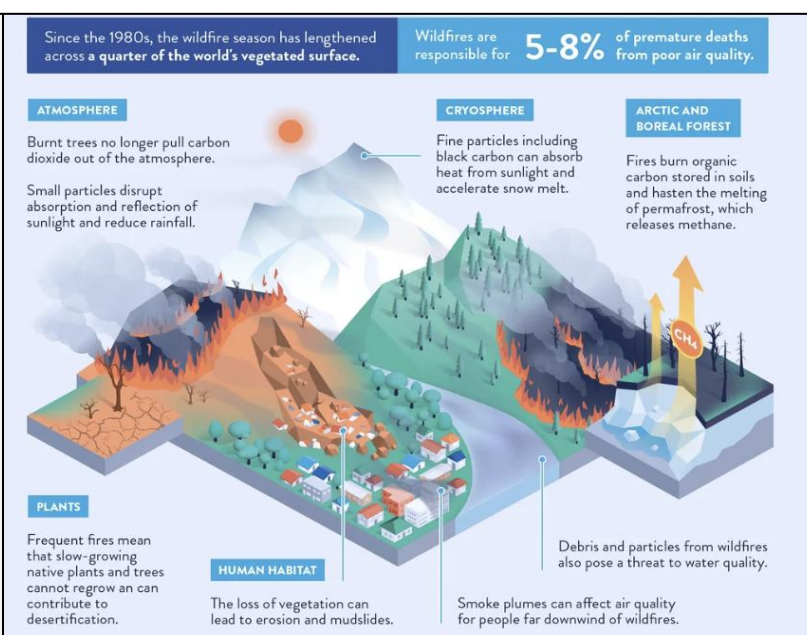
Smoke plumes actively scoop up, transport, and spread living fungal spores across long distances

Wildfire Smoke Crop Risks

A study across several agricultural areas in the U.S. found that wildfire smoke events have increased over time, affecting approximately 20% of growing season days, especially in July and August.

Dense wildfire smoke can reduce light intensity, limiting the energy available for photosynthesis and potentially slowing plant growth.

- Accumulation of particulate matter on leaves can interfere with normal plant function by promoting stomatal closure, reducing gas exchange, and limiting photosynthetic activity.
- Prolonged periods of haze may slow the accumulation of growing degree days (GDD), potentially delaying crop development and maturity.
- In northern production regions with shorter growing seasons, such delays could increase the risk of frost damage to crops before physiological maturity



Upwelling: Current Changes

During an El Niño, weakening or reversing trade winds allow warm tropical water to flow eastward, disrupting the California Current. This prevents deep, cold, nutrient-rich water from rising to the surface (upwelling).

- Consequently, the California Current warms significantly, bringing warmer, southern-dwelling marine species to the coast and triggering marine heatwaves.
- Cold-water species (like salmon) may migrate north to find favorable temperatures, while warm-water species (such as yellowtail or market squid) extend their range into California and Oregon.
- Low-level trade winds slow down, meaning surface waters are not pushed away from the Washington shore as efficiently.

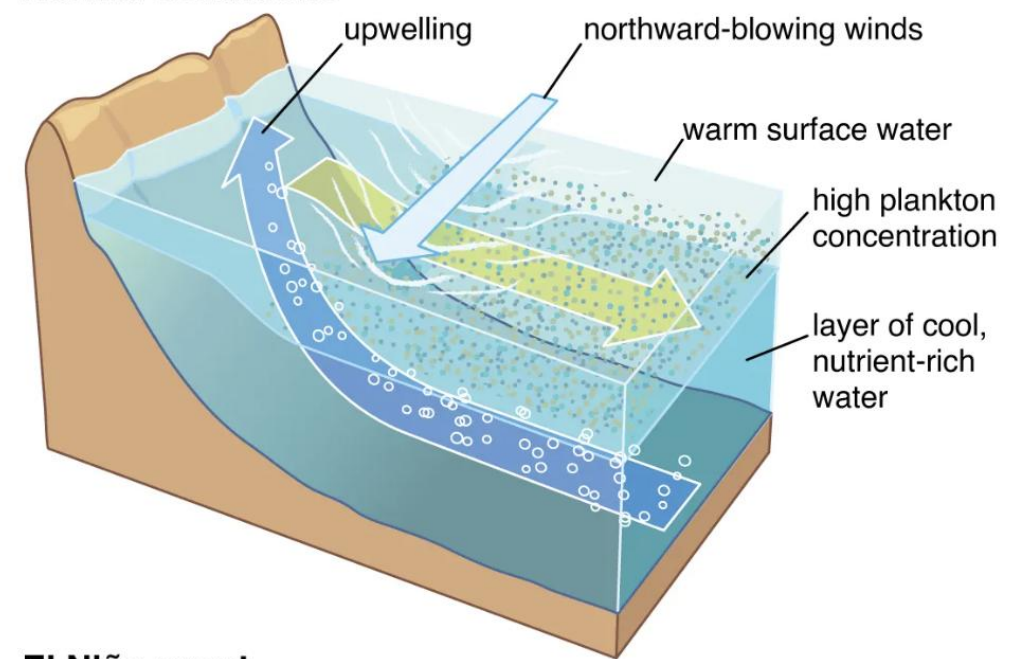
Major El Niño events can raise local sea level by around 6-10 inches along the West Coast during the winter rainy and stormy season through a combination of northward-propagating coastally-trapped Kelvin waves and thermal expansion of seawater.

- While that might not seem like a lot, this temporary increase will occur atop an additional (permanent) 6-10 inches of sea level rise that has accumulated due to warming waters and permafrost melts over the past century.
- **Levels could be as much as 2-3 feet higher than usual during major winter storms this year, and even higher than that should a storm coincide with the usual King Tides.**
- The highest predictable tides of the year arrive in **November, December, and January** along Washington's coast and Puget Sound.

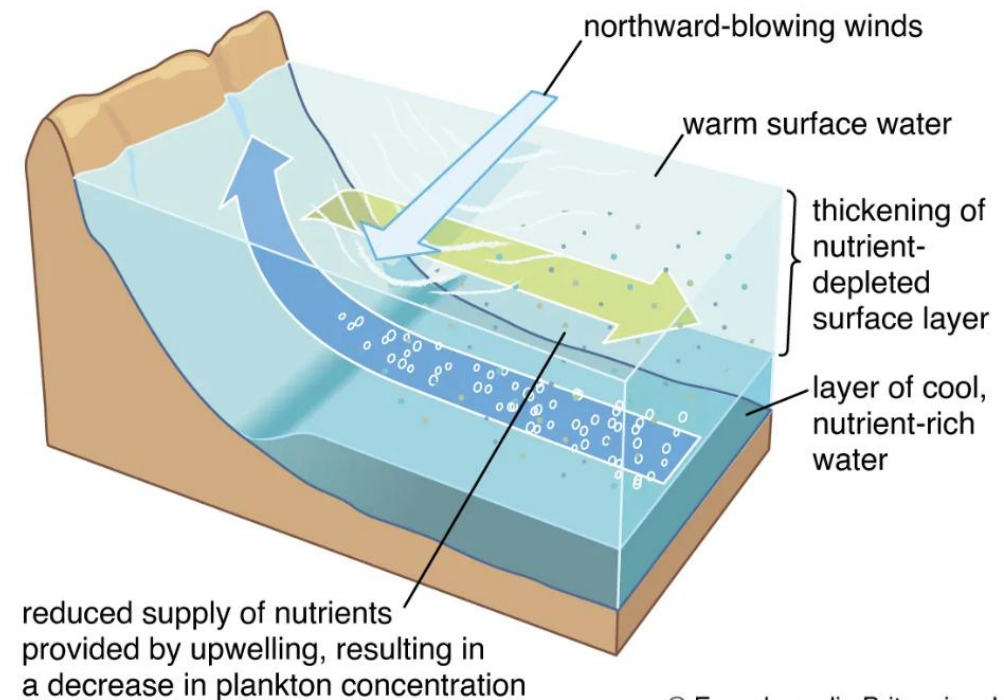
2015-2016 investigations of 29 beaches from Washington to southern California showed that winter beach erosion was 76% above normal, by far the highest ever recorded. Most beaches studied in California eroded beyond historical extremes.

A new study finds *the strongest nor'easters have intensified over the last 80 years, with a 6% increase in peak wind speeds resulting in a nearly 20% increase in destruction potential.* <https://www.pnas.org/doi/10.1073/pnas.2510029122>

Normal conditions



El Niño event



El Niño and Regional Winds

Research from the Scripps Institution of Oceanography indicates that average wind speeds during Santa Ana events can be about 10% stronger during El Niño years.

- While early-season winds can still occur, El Niño winters—particularly by March—tend to feature a significant decrease in the overall duration and frequency of these wind events due to changing pressure systems and increased stormy weather.

While El Niño often brings wetter winter conditions that dampen long-term fire danger, heavy prior rainfall can spur rapid vegetation (fuel) growth that becomes dangerous if an early dry spell or Santa Ana wind precedes the main winter storms.

- Extreme regional wind events, like the Santa Ana, Chinook, Diablo, and others, have increased in general over the last 60 years.

Chinook winds are warm, dry down sloping winds that form in the lee of major mountain ranges like the Rockies and can melt or sublimate deep snowpacks in a matter of hours, earning them the indigenous label "snow eaters"

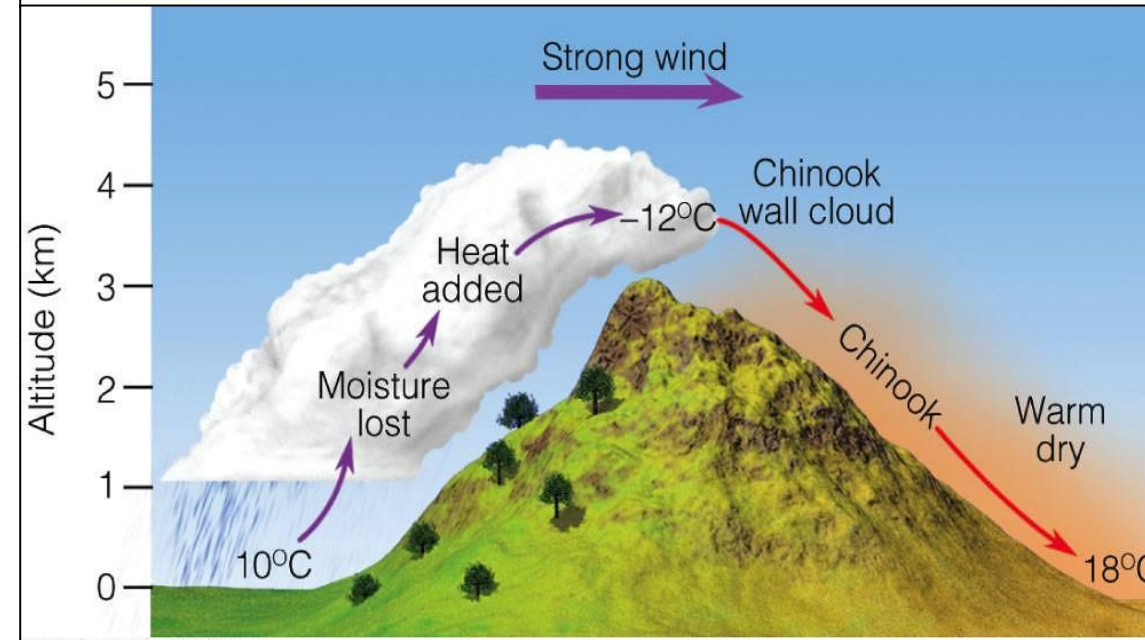
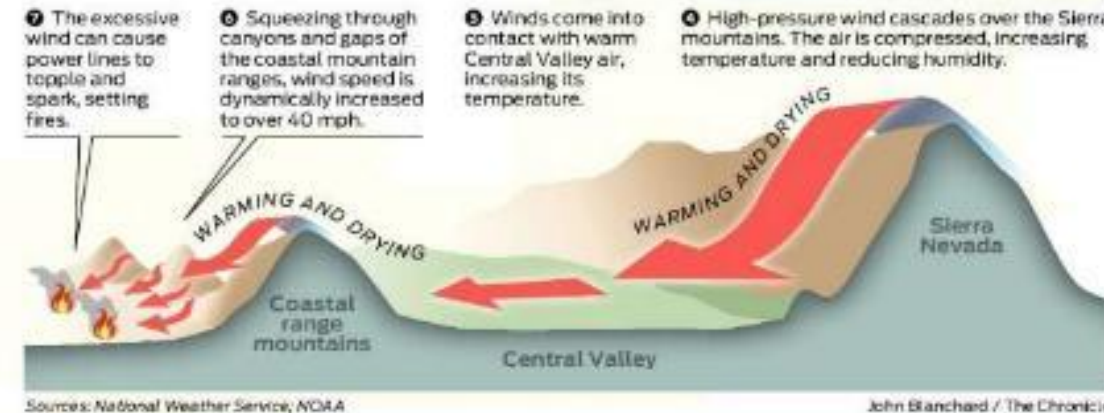
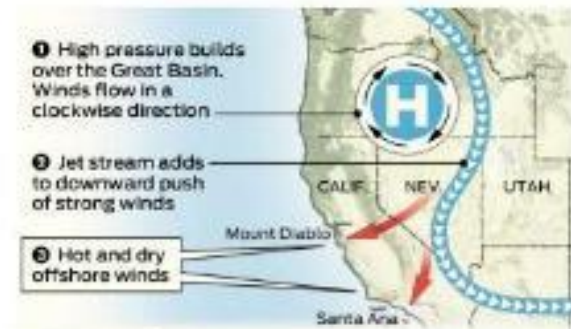
- In November 1958, strong pre-frontal Chinook winds—warm, dry downslope winds common in the Rocky Mountains—struck Boulder and the eastern foothills of Colorado, generating wind gusts up to 100 mph and causing structural damage in the northern metro Denver area.

A Nature Climate Change study suggests that the fastest upper-level jet stream winds will accelerate by about 2% for every 1°C (1.8°F) that the world warms. During El Niño, the air flowing over the coastal waters picks up higher baseline humidity and warmth.

- While diurnal winds dictate local hourly wind shifts, El Niño acts on a macro scale by shifting the broader Pacific jet stream and overwhelming local conditions and typical indicators for the various western microclimates which can influence swell patterns and pollution movements for the major cities.

What creates dangerous winds

The Diablo winds that were forecast for Northern California usually come in the fall, but their behavior is hard to predict because mountains, valleys and even cloud formations can alter their speed and direction.



Snow-Eater Events

Snow-eater heat-wave events are distinct from other drivers of snowmelt extremes, like rain-on-snow events and warm spells.

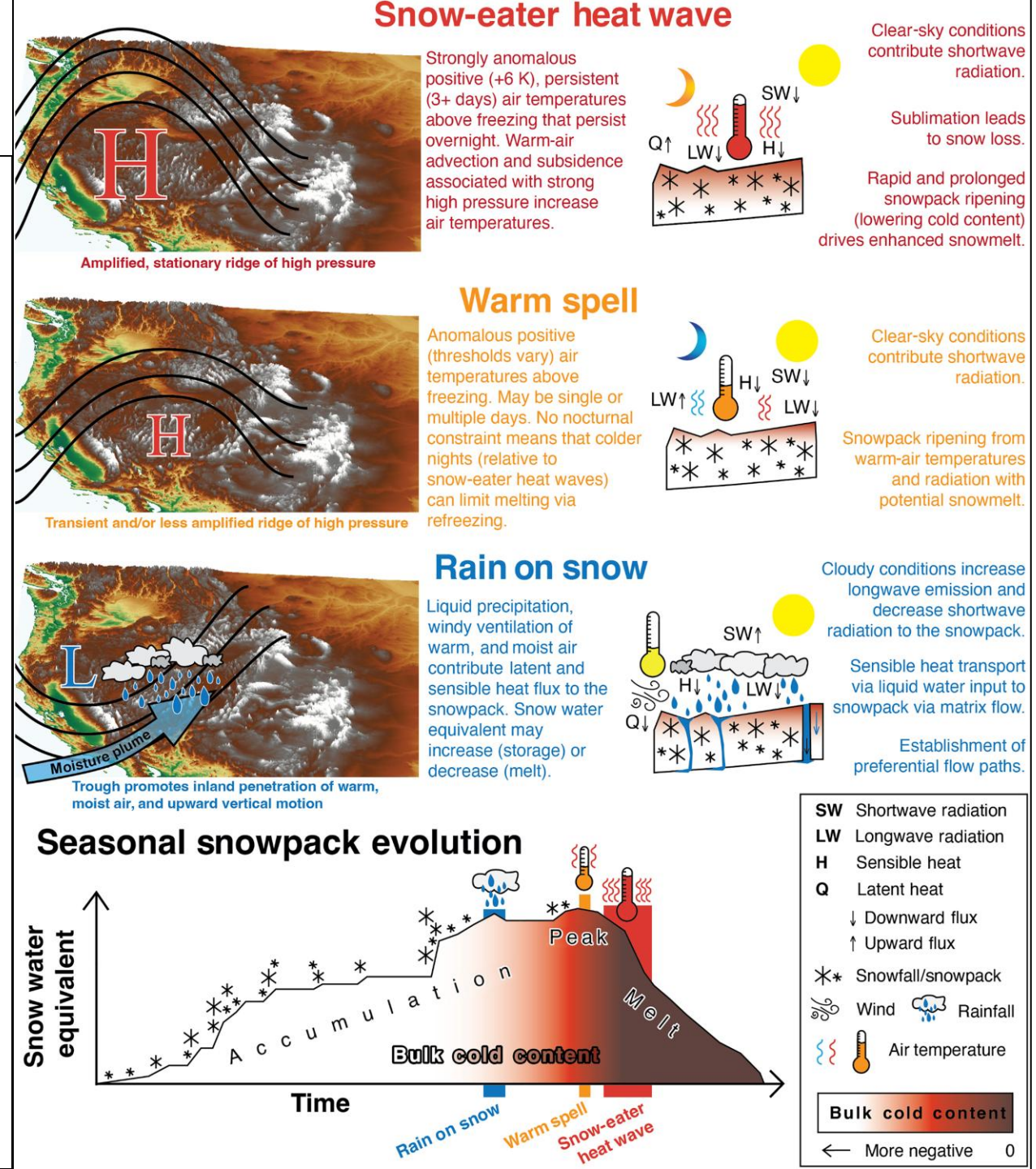
- Unlike rain-on-snow events, which are shaped by low-pressure troughs that promote the inland penetration of warm and moist air, snow-eater heat waves result from alternative synoptic-to-mesoscale mechanisms

A recent study, funded in part by NIDIS, examined "snow-eater heat waves"—short, intense warm spells that melt snow twice as fast as normal.

- Analyzing data from 1850-2015, these events usually lasted 3 to 5 days, occurred 3 to 5 times per season, doubled snowmelt rates, and coincided with 7 of 11 major spring super-floods in the period of analysis.
- By accounting for these heat waves, scientists can better predict extreme events.

Note that **melt potential is not actual snowmelt**. Rather, it is the maximum amount of melt that could occur if sufficient SWE existed.

The year with the highest mean seasonal total melt potential contributed by snow-eater heat waves during the period between 1980 and 2015. **occurred in 2015** at 152 km³ or 23% of the total melt potential of 652 km³ between 19 March and 1 July.



Stratospheric Warming

In recent years some extreme cold, winter snow events have all been connected to the surface effects of sudden stratospheric warmings.

- The stratospheric polar vortex and tropospheric vortex are two different things.
- The tropospheric polar vortex is a normal atmospheric feature that affects our weather every winter.
- The sudden stratospheric warming usually takes a few weeks to influence weather at the surface, or into the next month.

A sudden stratospheric warming is a significant disruption of the stratospheric polar vortex that begins with large-scale atmosphere waves (called Rossby waves) getting pushed higher into the atmosphere.

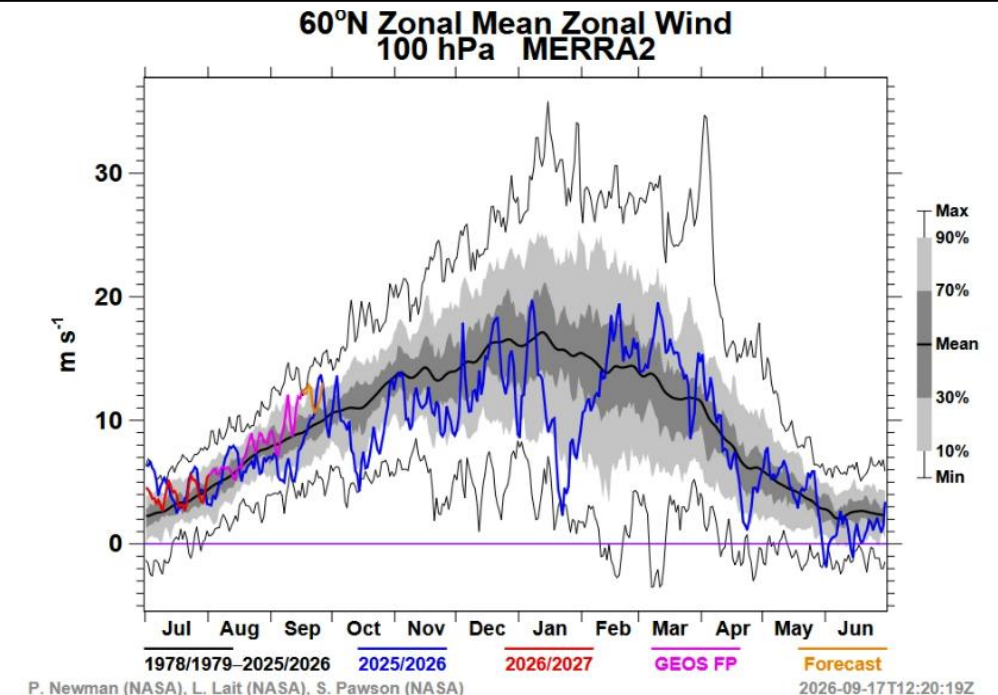
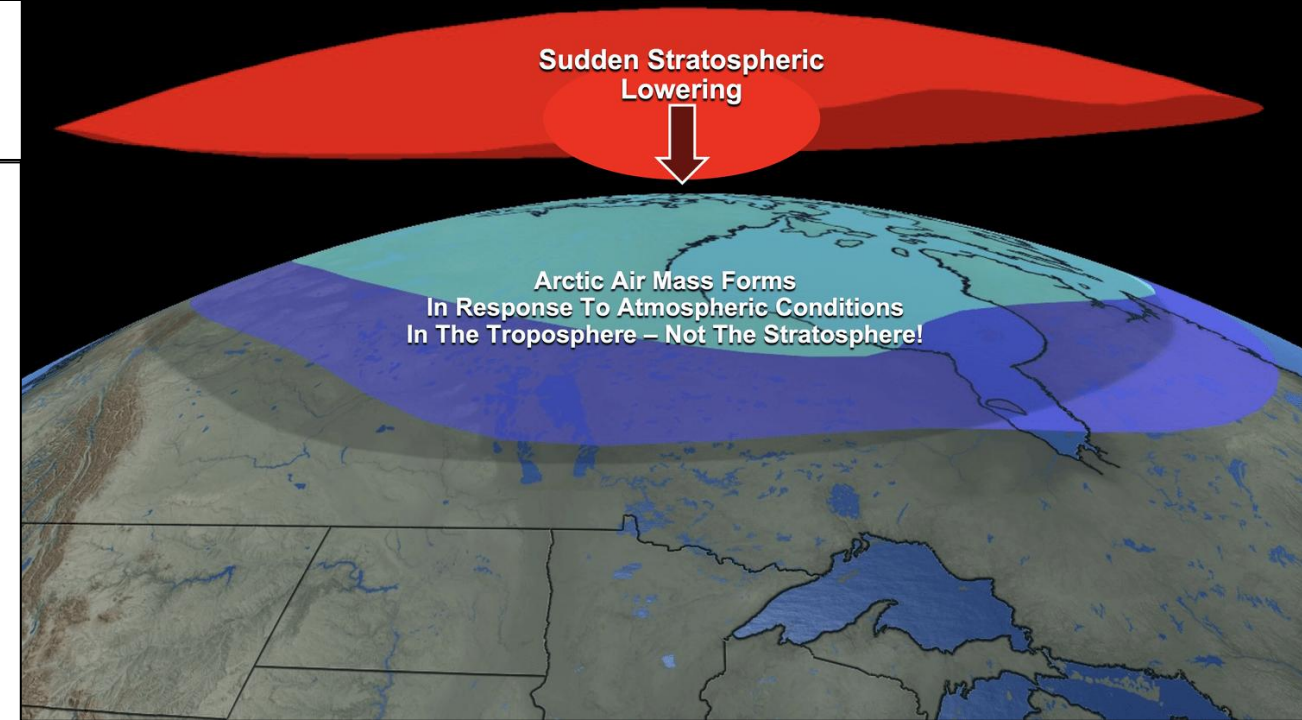
- These waves can “break” on top of the polar vortex and weaken it.
- This leads to cold air descending and warming rapidly, with the red line on the graph showing the sudden jump in temperature.

This can lead to a displacement or splitting of the polar vortex, so instead of cold air being locked above the polar region, it can push further south into the mid-latitudes.

- The stratospheric sudden warming can sometimes cause the jet stream to ‘snake’ more, and this tends to create a large area of blocking high pressure.

A strong El Niño event increases the likelihood of a disrupted stratospheric polar vortex and Sudden Stratospheric Warming (SSW) events.

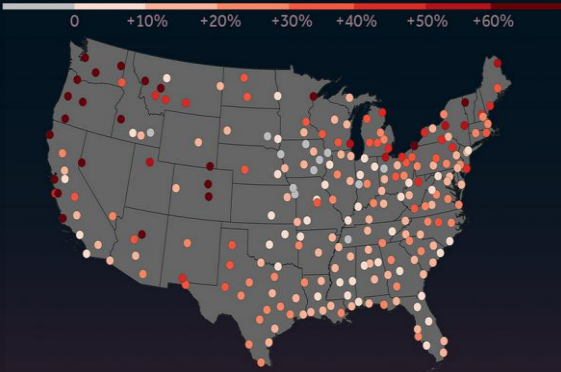
- An SSW event during El Niño can pave the way for sudden, intense late-winter cold snaps or major snowstorms if cold continental air meets southern moisture track.



Heat-Based Concerns Expand

BACK-TO-SCHOOL COOLING DEMAND

Change in cooling degree days (July 17 - September 8), 1970-2023



ARIZONA PREGNANCY HEAT-RISK DAYS

Average annual days above 97.4°F, 2020-2024



Pregnancy heat-risk days are days with maximum temperatures above the local 95th percentile. Analysis based on ERA5 reanalysis daily maximum temperature data for 2020-2024 and the Climate Shift Index system.

CLIMATE CENTRAL

SEASONS ARE SHIFTING



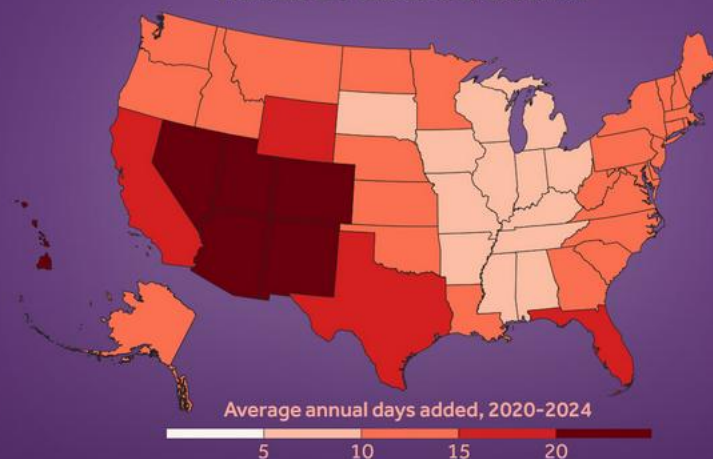
CLIMATE CENTRAL

HEAT RISKS DURING PREGNANCY

Climate change-fueled extreme heat increases risks of



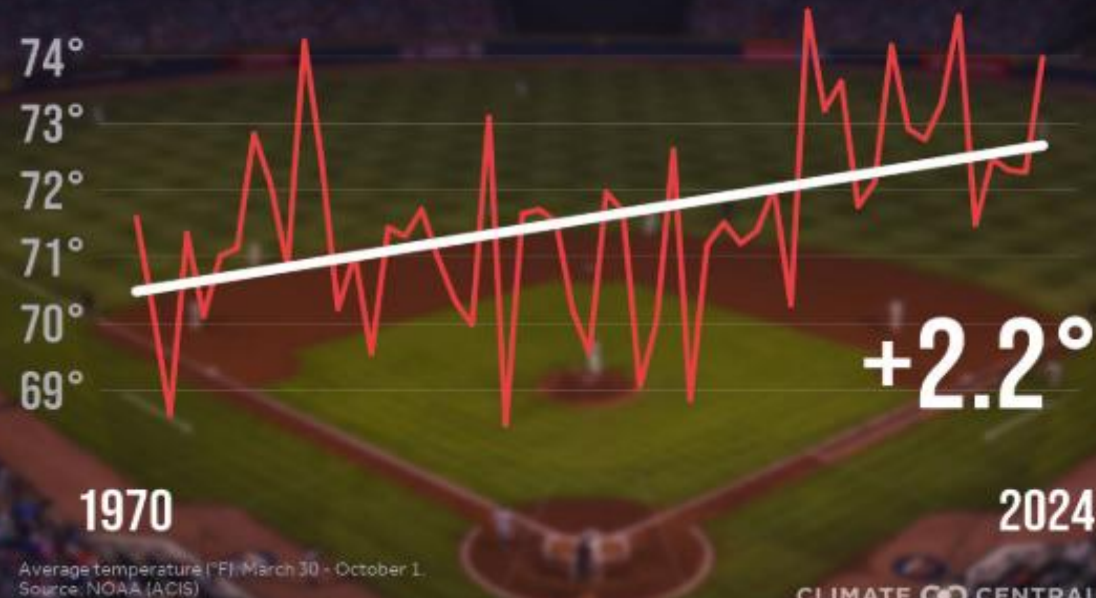
PREGNANCY HEAT-RISK DAYS ADDED BY CLIMATE CHANGE



Pregnancy heat-risk days are days with maximum temperatures above the local 95th percentile. Analysis based on ERA5 reanalysis daily maximum temperature data for 2020-2024 and the Climate Shift Index system.

CLIMATE CENTRAL

WASHINGTON NATIONALS BASEBALL SEASON IS HEATING UP

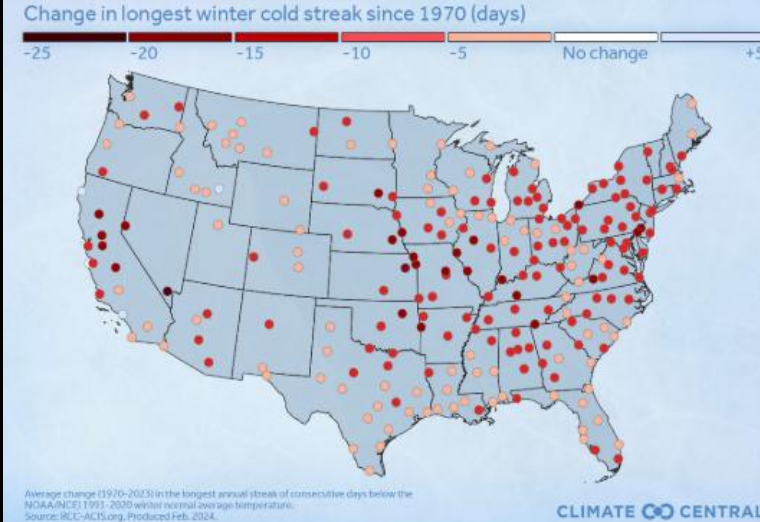


It takes ~2 weeks for a healthy person to acclimate to new temperature extremes.

Researchers found the maximum wet-bulb temperature a human can endure before the loss of regulation for internal temperature is about 31°C wet-bulb or 87°F at 100% humidity — even for young, healthy subjects.

SHORTER COLD STREAKS

Change in longest winter cold streak since 1970 (days)



Defined Threat: Condensed Period to Adjust

The change in heating is not just that it is baseline creeping upwards, it is that we built to norms from a window of time in stable conditions that we will not be returning to during the next few lifetimes. This means infrastructure was simply not built to withstand.

- The weather hazards defined in previous slides will amplify rapidly in coming decades as the temperature continues to rise.
- Acclimation periods will reduce rapidly as temperatures vary outside of human capacity, and materials will face comparable strain.

When comparing the historic warming period, it is critical to annotate which materials shift from rapid heating and may push against or pull away from partnered materials or stress the binding type for future concerns of structural stability.

Chief Meteorologist Sunny Wescott

Executive Director – Geospatial Intelligence

Information Sharing and Analysis Center

Emergency Response and Operations Support

LinkedIn:

<https://www.linkedin.com/in/sunnywescott/>

Email:

Sunny@unlimitedweather.com

