



2022 U.S. HEAT STRESS REPORT:

Where Heat-Related Hazards Are on the Rise and How to Protect Students, Workers, and Visitors from Extreme Heat



About this report

The 2022 Heat Stress Report was prepared by AEM using various weather station data. The report includes heat index data, an analysis of degree days over 90 degrees, precipitation rates, and more.

AEM Wet Bulb Globe Temperature

Wet bulb globe temperature is a comprehensive measure of temperature, cloud cover, sun angle, wind speed, and humidity that provides a better measurement on the impacts of heat on the body compared to just heat index or temperature. Through an on-site weather station, WBGT conditions are measured in real-time and forecasted. Alerts can be created to ensure that the essential people are aware of dangerous heat conditions and can make the correct decisions regarding outdoor athlete and worker safety.

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Terminology

To help you better understand the insights from this heat stress report, we've included definitions of our frequently used terminology.

WET BULB GLOBE TEMPERATURE:

The measurement used to estimate the most accurate level of heat stress in direct sunlight. Considers temperature, sun angle, wind speed, cloud cover, and humidity.

WET BULB TEMPERATURE:

A measurement taken by a thermometer that has a bulb covered by a water-soaked cloth. The evaporative cooling shows the wet bulb temperature on the thermometer. This measures dew point and humidity.

HEAT ACCLIMATIZATION:

The gradual adjustment of the body to high temperature conditions, lowering the possibility of heat illness or exertional heat stroke.

HEAT STRESS:

The net heat load to which a person is exposed. The combination of clothing, environmental factors, and physical exertion can be key contributors.

HEAT STRAIN:

The body's physiological response to heat stress (sweating and increased heart rate).

HEAT-RELATED ILLNESS:

An increase in core body temperature above healthy levels, inhibiting normal body function

HEAT WAVE:

Three or more consecutive days with high temperatures at or above 90 degrees

EXCESSIVE HEAT WARNING:

A weather service alert issued when the heat index value is expected to reach or exceed 110 degrees, with criteria as low as 100-105 degrees in cooler climates

HEAT ADVISORY:

A weather service alert issued when the heat index reaches 105 to 109 degrees for 3 or more hours or if the heat index is expected to reach 100 to 104 degrees each afternoon for several consecutive days





How heat stress impacts your organization

Have you ever considered how heat stress may impact your business operations, organization, or life in general?

Heat stress incidences are prevalent in the news, hence the need for heat stress regulations across organizations. Whether on the field or at the workplace, heat stress impacts the risk management process at your organization. Student athletes, workers, and business patrons alike all face the risk of heat stress. Understanding the significance of heat stress can help mitigate its adverse impact on your organization. In this report, you will take away the importance of effectively monitoring heat stress, as well as several steps for implementing heat stress safety at your organization.



Heat Stress and its Impact on Education

Protecting students is just one of the many jobs school administrators and faculty have.

Student athletes are at risk of heat stress during outdoor activity in extreme temperatures. The safety and health of students is a number one priority and measuring Wet Bulb Globe Temperature for school athletics is important for keeping students safe from exertional heat stroke and the risks associated with it.

Over 9,000 students suffer from heat illness every year, mostly due to a lack of required safety policies. Safety policies for prevention of sudden death and catastrophic injury vary by state, with Florida having the most comprehensive safety requirements for high school athletes and California having the least comprehensive safety requirements as of 2021.

9,000+
students

.....
Suffer from heat illnesses every year.

OSHA

In September of 2021, The Occupational Safety and Health Administration (OSHA) announced that measures are being initiated to better protect workers in hot conditions.

These measures include an enforcement initiative on heat hazards and creating workplace heat standards for heat inspections when heat index exceeds 80°F. The average number of heat deaths per 3 years has doubled from the early 1990s to today. Climate change has caused an increase in average temperatures across the United States, along with more intense and frequent heat events. Many extreme heat deaths are not documented as such because medical examiners may not know the exact cause of death. An estimated 1,300 deaths per year are a result of extreme heat, but only 600 are documented as heat-related deaths.

To address these increasing heat stress concerns, OSHA announced a **National Emphasis Program (NEP)** focused on heat hazards, effective April 8, 2022, to protect employees from heat-related hazards and resulting injuries and illnesses in outdoor and indoor workplaces. The program is intended to encourage early interventions by employers to prevent illnesses and deaths among workers during high heat conditions, such as working outdoors in a local area experiencing a heat wave, as announced by the National Weather Service (NWS). Early interventions include, but are not limited to, implementing water, rest, shade, training, and acclimatization procedures for new or returning employees.

1,300
deaths

.....
Estimated deaths per year are a result of extreme heat.

600
deaths

.....
Documented deaths per year due to extreme heat.

Korey Stringer Institute: State High School Sports Safety Policies



In August 2001, Korey Stringer, a Minnesota Vikings offensive lineman, passed away from exertional heat stroke.

Since the time of Korey's death, his wife, Kelci, worked tirelessly to develop an exertional heat stroke prevention institute to honor her husband's legacy, joining forces with exertional heat stroke expert Douglas Casa, Ph.D, ATC, at the University of Connecticut. The mission of the Korey Stringer Institute is to provide research, education, advocacy and consultation to maximize performance, optimize safety and prevent sudden death for the athlete, warfighter and laborer.

The [appendix](#) contains a chart sourced from the Korey Stringer Institute, and lists the 2022 state rankings of high school sports health and safety policies across the United States. The chart ranks states regarding the implementation of evidence-based best practices for preventing and managing the leading causes of sudden death in secondary school athletics, with exertional heat stroke listed as the #1 topic area. According to the KSI, Florida, New Jersey, Georgia, Kentucky, and Louisiana are doing the best at protecting student athletes from the perils of exertional heat stress.

Photo source: <https://ksi.uconn.edu/>



Regional Differences in Measuring Heat Stress

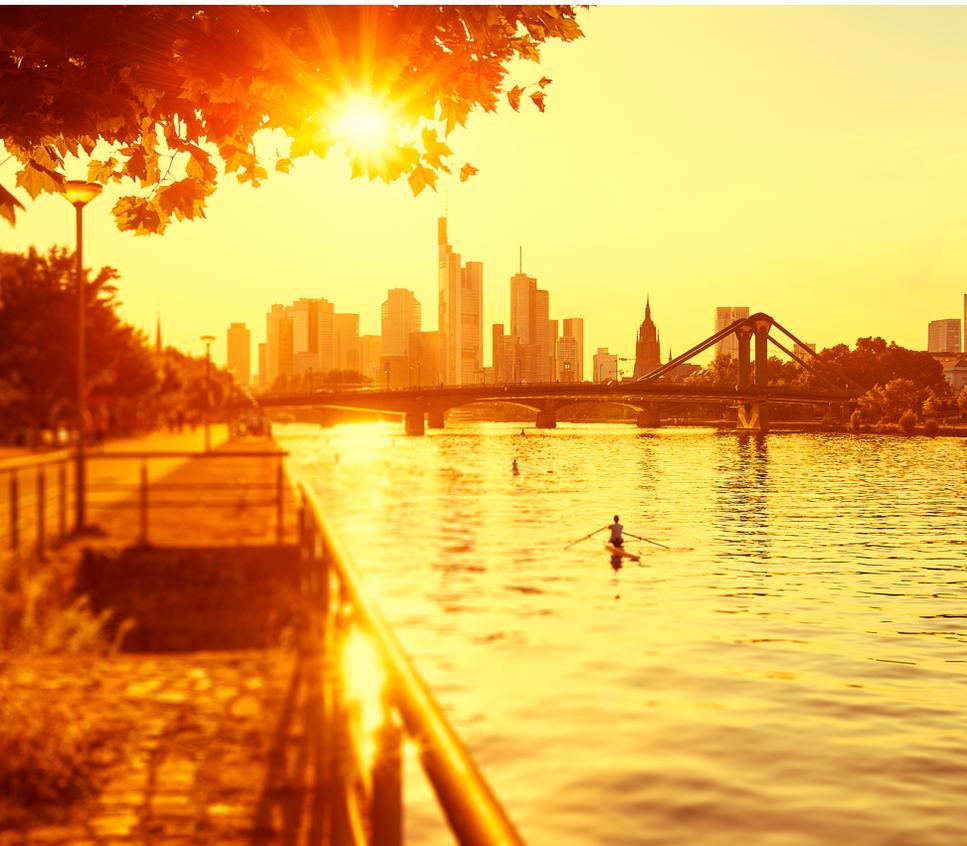
Heat waves or extreme heat events are a series of unusually hot days and can result in illness and death.

Heat waves are increasing in frequency and duration across the United States. In the 1960s, there were an average of 2 heat waves per year, and in the 2010s there were an average of 6 heat waves per year per a report by the United States Environmental Protection Agency. Average duration of these heat waves has increased from 3 days to 4 days since the 1960s. To keep athletes and workers safe in outdoor heat, it is recommended that a program is implemented to make sure that they gradually adapt to the heat (heat acclimation). Time spent outside should be regulated each day along with temperature, making sure that heat tolerance is slowly adapted so no one endures major heat stress. The cooler the conditions that workers or athletes are used to, the more time they need to adapt to humidity and hotter conditions.



The risk for heat illness is different depending on the region of the United States, given that some states experience higher temperatures than others. These are the ten hottest states in 2022, based on average annual temperatures:

RANK	STATE
1.	Florida
2.	Hawaii
3.	Louisiana
4.	Texas
5.	Georgia
6.	Mississippi
7.	Alabama
8.	South Carolina
9.	Arkansas
10.	Arizona

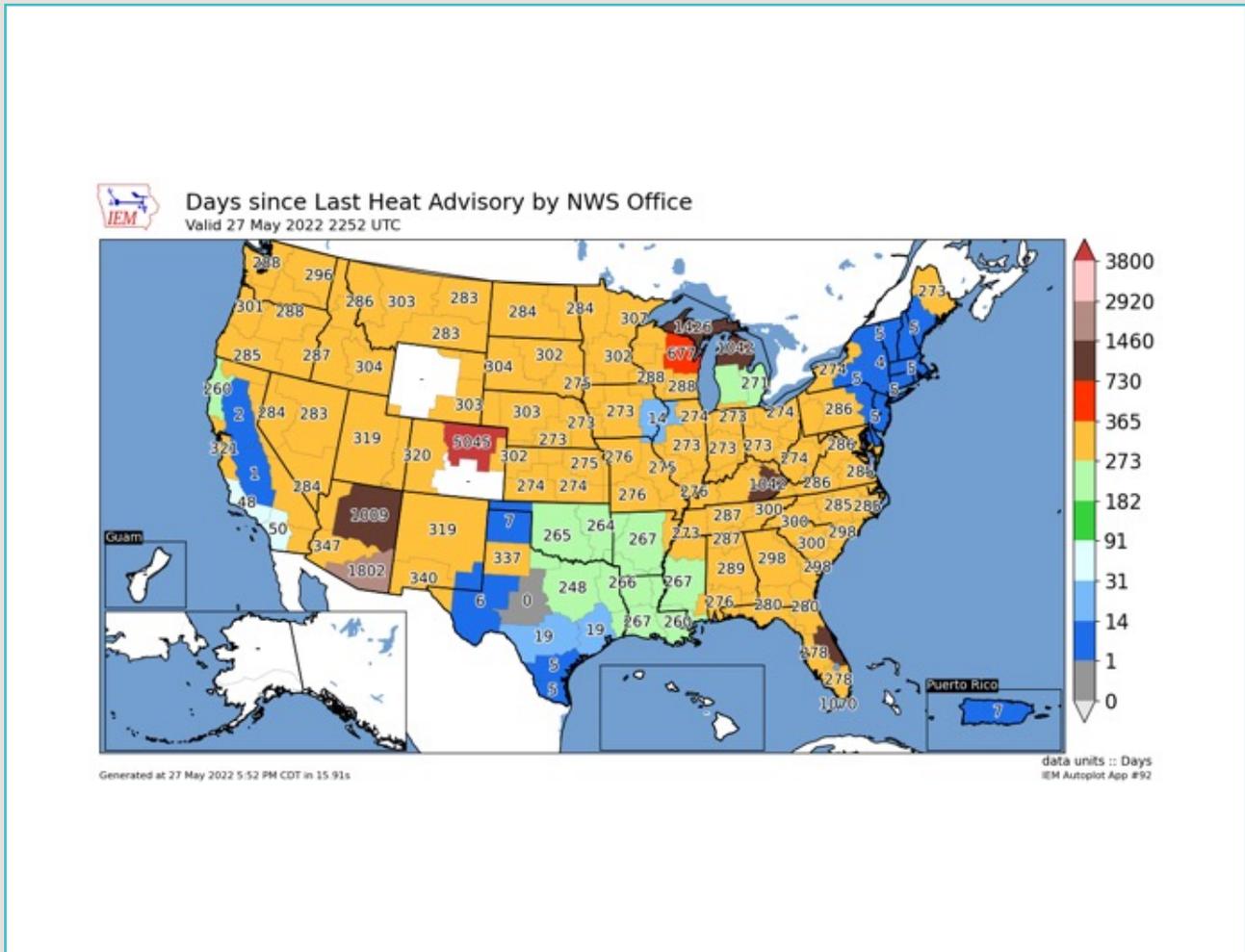


Heat Advisories and High Temperature Patterns Across the United States

The following maps were sourced from the Automated Data Plotter tool provided by the Iowa Environmental Mesonet. The maps and charts examine excessive heat trends across the United States.

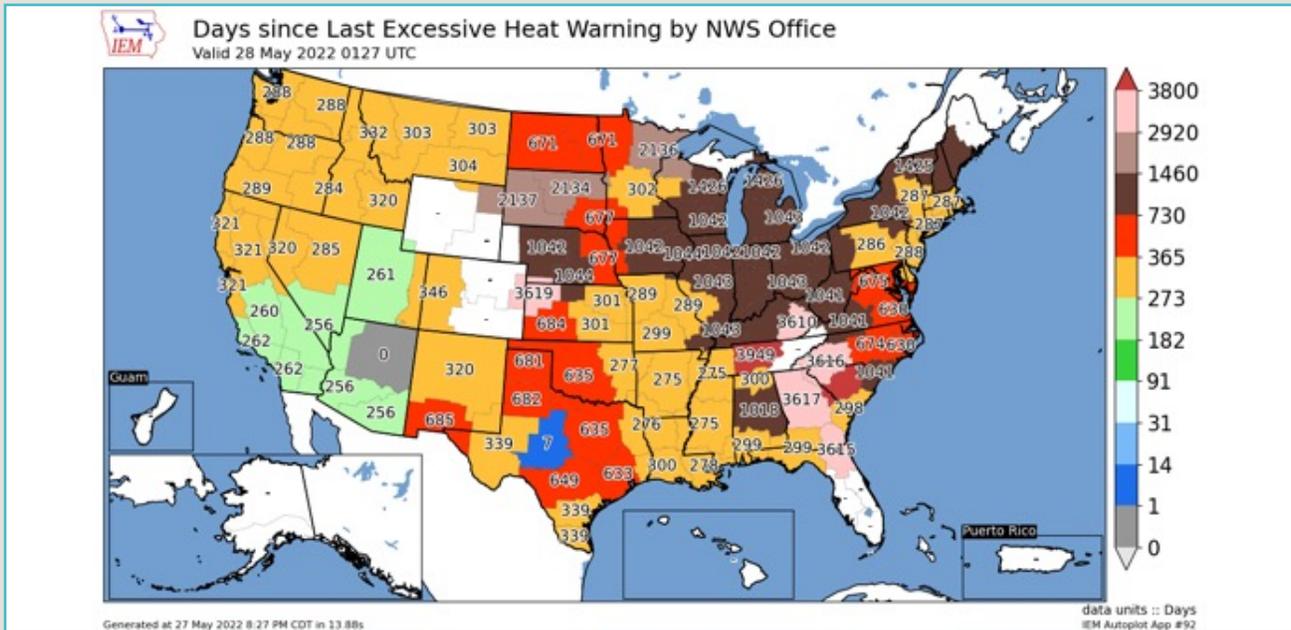
01

The map below shows that more than 90% of the U.S. has been under a heat advisory in the last year. Only the Upper Peninsula of Michigan and central Rocky Front Range has gone longer than a year without being under a heat advisory.



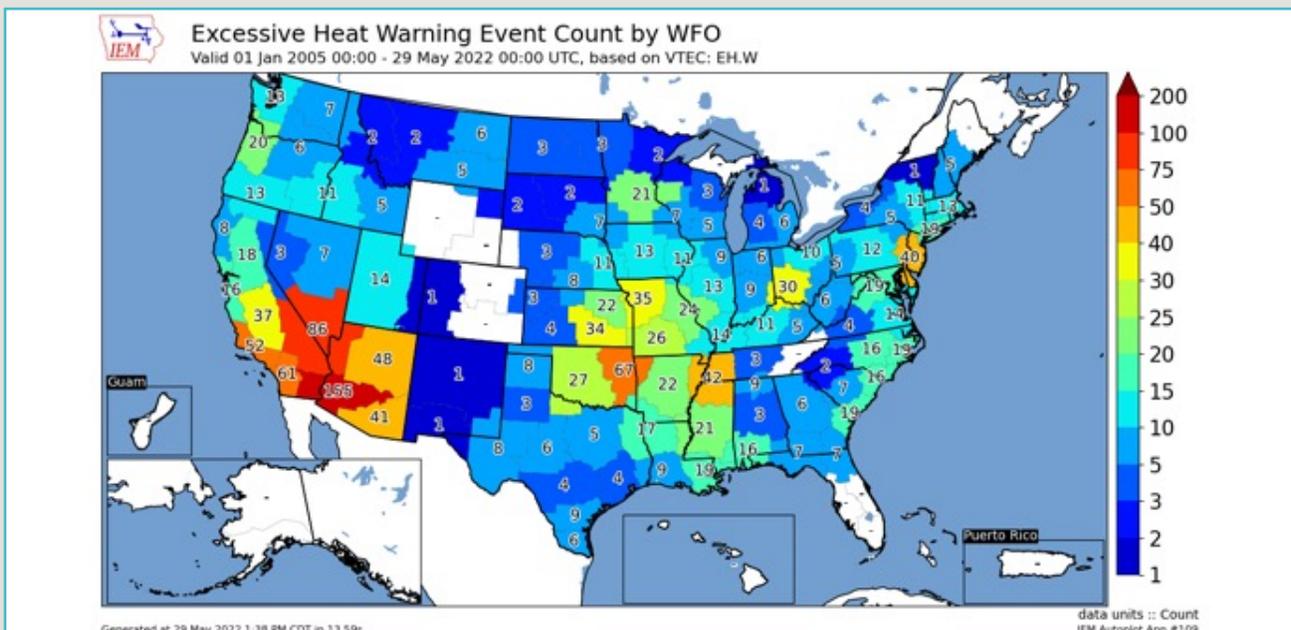
02

The map below shows the number of days since the highest-level heat warning, an **Excessive Heat Warning**, was issued in states across the U.S. These alerts are most common in the West, Lower Mississippi Valley and along the populated I-95 corridor. They have been least common as of late in the Upper Midwest, Great Lakes and Northeast.



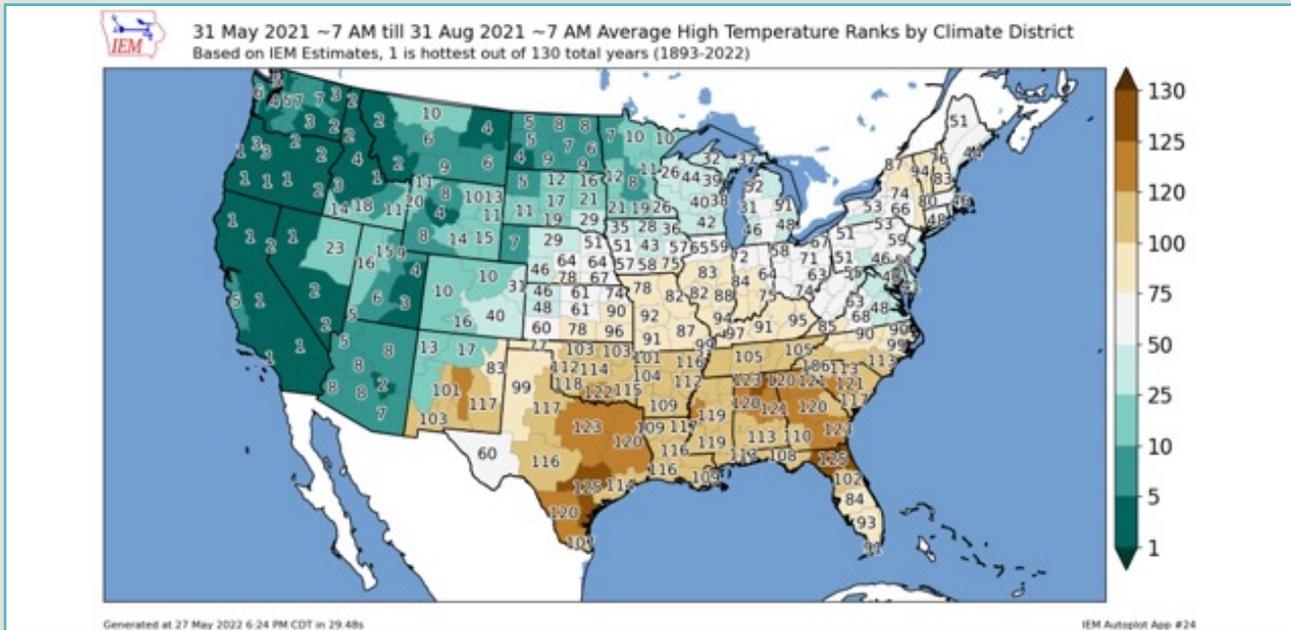
03

The following map shows the number of Excessive Heat Warnings issued since the start of 2005. The greatest concentration of these warnings is along the Mid-Atlantic's populated I-95 corridor, the Ohio Valley, eastern Plains to Mississippi Valley, Southwest and southern California.



04

As seen below, the average high temperature last summer ranked in the top 50 of the last 130 years from the Mid-Atlantic and Northeast to the Midwest, central and northern Plains into the West. For many locations from Southern California to the northern Rockies, high temperatures ranked first, second and third place out of the last 130 years.



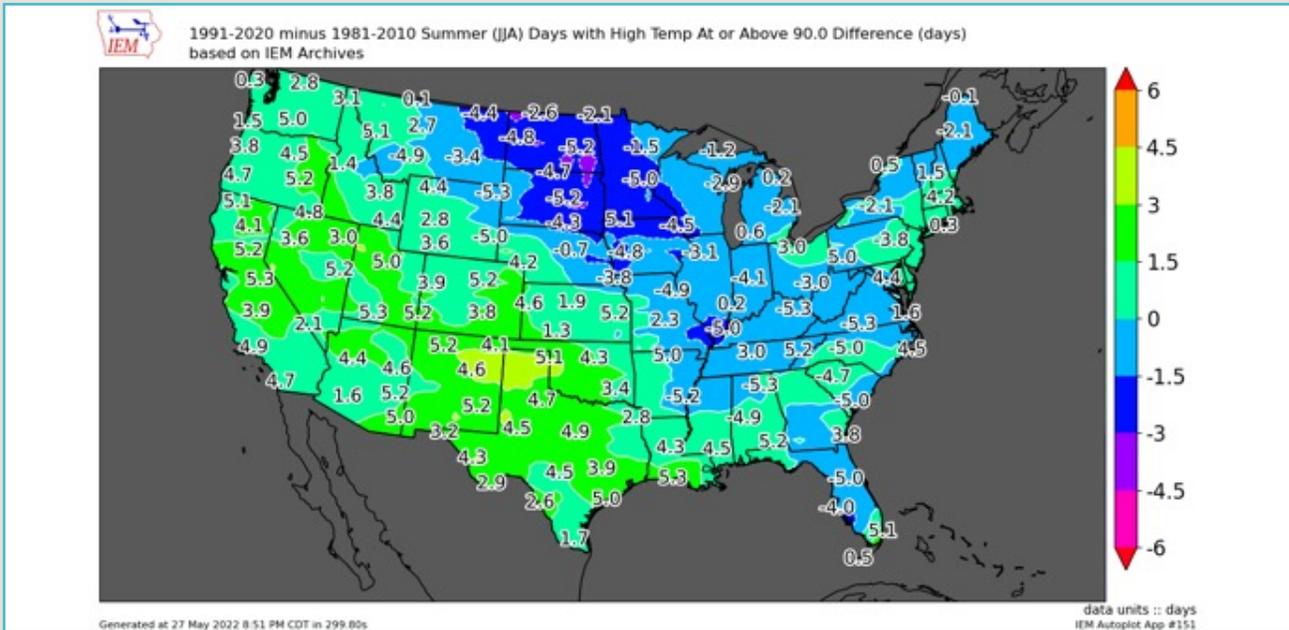
05

The chart below was prepared by the AEM meteorology team, indicating the number of days in 2021 that the temperature reached or exceeded 90 degrees across the United States.



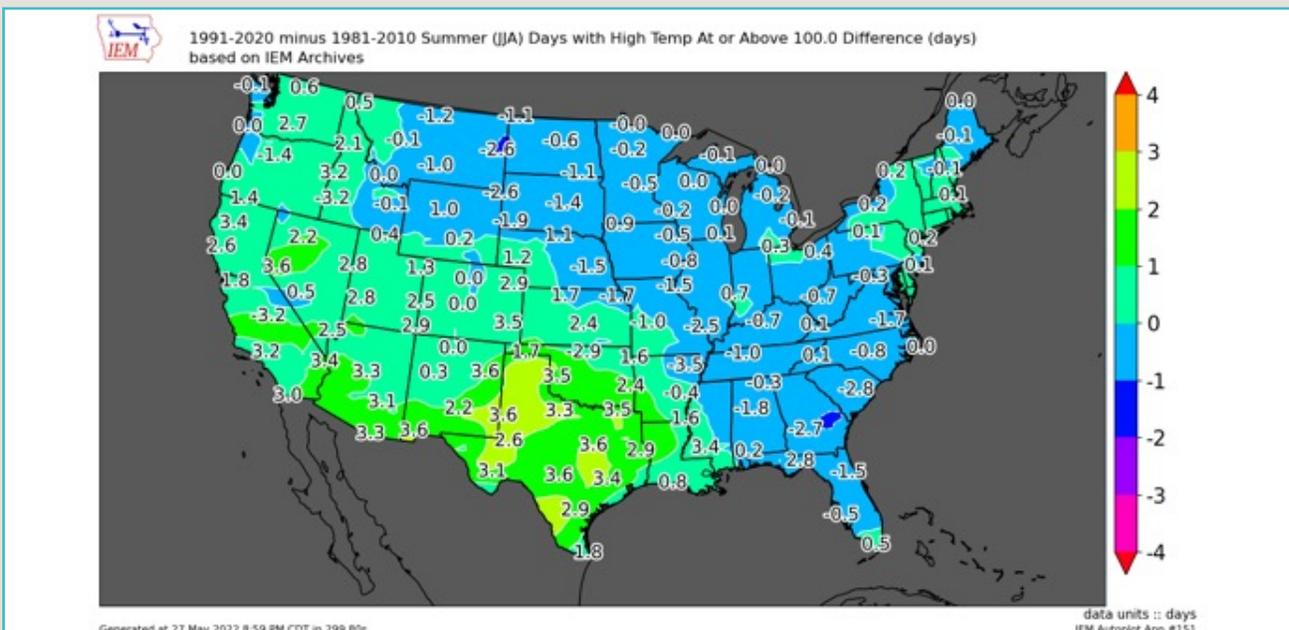
06

Comparing the number of days with the high temperature at or above 90 degrees between the last 30-year climate averages (1991-2020) and the previous 30-year averages (1981-2010) show a **clear trend towards more 90-degree days in the West, central and southern Rockies, southern Plains and Gulf Coast**. Fewer 90-degree days are noted in the last 30 years across the northern Plains to Mid-Miss. Valley with little change noted along the East Coast.



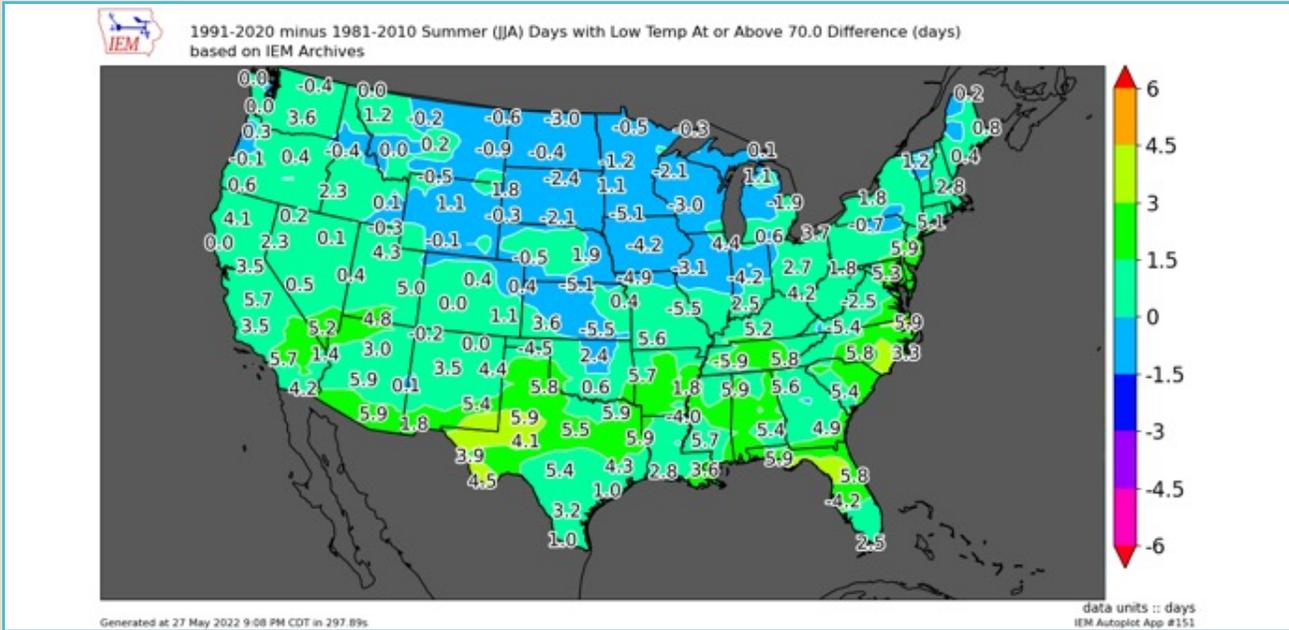
07

The number of 100-degree days across the U.S. with the latest climate averages shows a similar trend to the 90-degree days. There are more days when the high temperature reaches or exceeds 100-degrees in the Southwest and southern Plains and fewer 100-degree days from the northern Plains to the Southeast.



08

Morning low temperatures are trending warmer in much of the United States. The number of low temperatures at or above 70 degrees has increased by 1-5 days from the Southwest into the southern Plains, Southeast, Tennessee Valley, Carolinas and Mid-Atlantic. There are fewer 70-degree mornings though across the northern Rockies to Upper Great Lakes.



09

Our team of meteorologists at AEM are forecasting the continuation of rising heat trends in 2022. In the 2022 Summer, [Wildfire and Drought Outlook webinar](#), our expert meteorologists explored recent rainfall and temperature trends, assessed the risk of drought and wildfire, and examined ENSO (El Niño, La Niña) trends and forecasts.

AEM 2022 Summer Temperature Outlook

Summer Outlook - Temperature Forecast June - September 2022

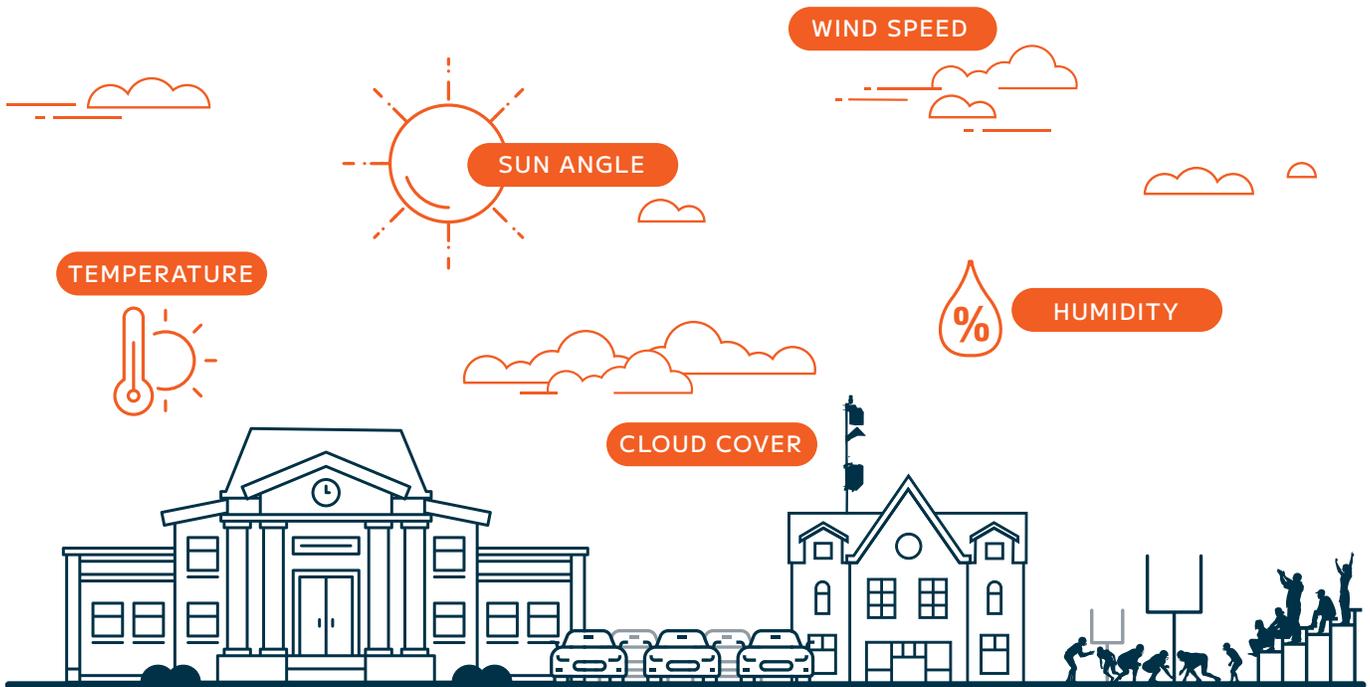
Near Average

Above Average

Near Average

HIGHLIGHTS

- Warmer than average temperatures expected for most of the U.S.
- No upside or downside risk to warmer than average temperatures in the Southeast and Northwest Coast.
- Much of southern Canada will see above average temperatures.



The Wet Bulb Globe Temperature (WBGT) is a measure of heat stress in direct sunlight, which is based on temperature, humidity, wind speed, sun angle, and cloud cover (solar radiation), per the National Weather Service. This differs from the heat index, which is based only on temperature and humidity and is calculated for shady areas

All About WBGT

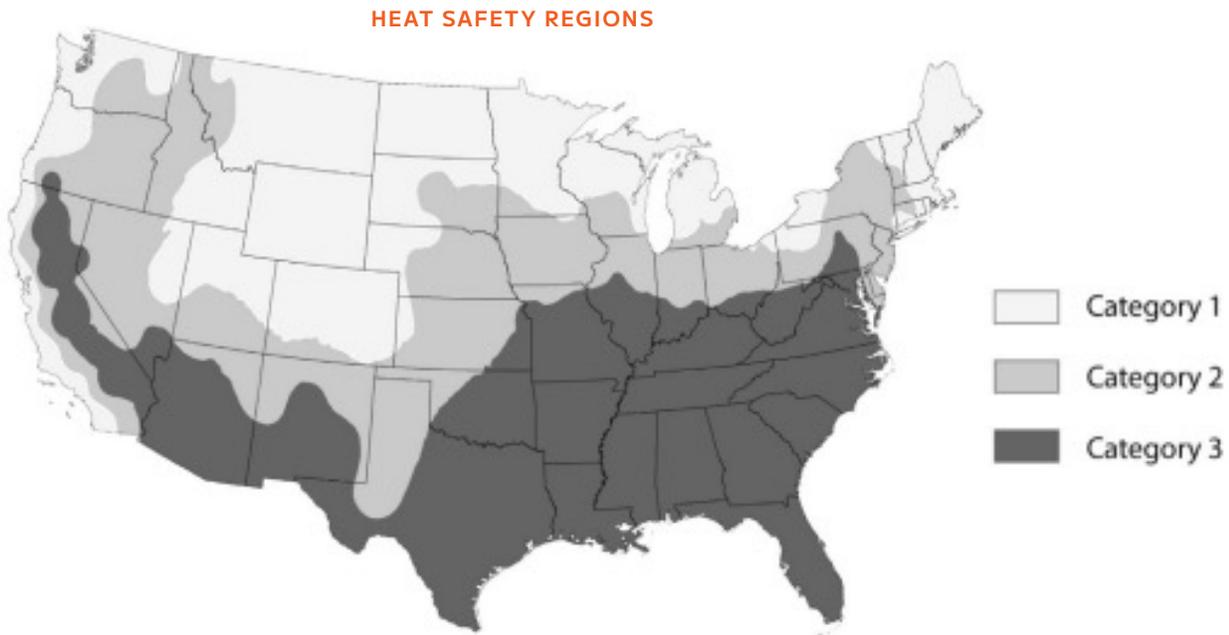
Wet Bulb Globe Temperature (WBGT) is a proactive heat safety management and measurement tool used to estimate the most accurate level of heat stress in direct sunlight.

WBGT is the most precise way to measure environmental heat stress and can be used to implement preventative measures against heat related illnesses or death. In this section, we will explore WBGT, its importance, and its implications as it relates to monitoring heat stress.

The following map and charts display the three categories of heat safety regions across the United States, and their respective WBGT threat levels. These values dictate which activity levels are safe dependent upon WBGT temperatures, and the corresponding risk of heat illness.

How does WBGT differ from Heat Index?

The following map and charts display the three categories of heat safety regions across the United States, and their respective WBGT threat levels. These values dictate which activity levels are safe dependent upon WBGT temperatures, and the corresponding risk of heat illness. The dark gray areas in the southern United States are considered Category 3, whereas the northern and mid-western states are primarily Category 1 and 2 in terms of heat safety.



WET BULB GLOBE TEMPERATURE

The Wet Bulb Globe Temperature (WBGT) is a parameter that estimates the effect of temperature, relative humidity, wind, and solar radiation on humans.

HEAT INDEX

The traditional measure of what the temperature feels like to the human body when relative humidity is combined with the air temperature, also known as apparent temperature.

	WBGT	HEAT INDEX
Measured in the sun	●	●
Measured in the shade	●	●
Uses temperature	●	●
Uses relative humidity	●	●
Uses wind	●	●
Uses cloud cover	●	●
Uses sun angle	●	●

Source: <https://www.weather.gov/ctp/WBGT>



WBGT Safety Thresholds Across the U.S.

People generally think of Heat Index when measuring heat stress. However, WBGT is a better parameter to keep people safe while performing strenuous outdoor activities at high temperatures. The following chart depicts the WBGT safety thresholds across the United States.

WBGT BY REGION (°F)			RISK OF HEAT ILLNESS
CAT 1	CAT 2	CAT 3	
< 72.3	< 75.9	< 78.3	Normal activities, monitor fluids
72.3 – 76.1	75.9–78.7	78.3–82.0	Normal activities, monitor fluids
76.2 – 80.1	78.8–83.7	82.1–86.0	Plan intense or prolonged exercise with discretion
80.1–84.0	83.8–87.6	86.1–90.0	Limit intense exercise and total daily exposure to heat and humidity
> 84.0	> 87.6	> 90.0	Cancel exercise

University of Georgia Guidelines, based on regions. Grundstein, Andrew & Williams, Castle & Phan, Minh & Cooper, Earl. 2015. Regional heat safety thresholds for athletics in the contiguous United States. Applied Geography. 56. 55–60. 10.1016/j.apgeog.2014.10.014.

Source: <https://www.weather.gov/ctp/WBGT>



Who should be monitoring WBGT?

WBGT is the gold standard for heat stress management.

WBGT monitoring and alerting should be used to plan outdoor activities and heat stress accommodations to avoid the hottest days or hours of the day.

01

SCHOOLS

Maintain compliance with heat safety regulations for student athletes when the WBGT forecast surpasses the maximum heat stress levels that are safe for outdoor practice and games

02

SPORTS COMPLEXES AND PARKS

Can be sure to keep organized athletic practices, games, players and spectators safe.

03

AIRPORTS

Can avoid heat illness for crew working outdoors in ground operations activities such as baggage handling, catering, marshaling, and maintenance.

04

COMPANIES

Can maintain compliance with OSHA's OSH Act, keeping outdoor workers in loading docks, logistics, transportation and maintenance out of danger.

05

MILITARY BASES AND INSTALLATIONS

Can keep those participating in training, operations and events safe.

06

ANY ORGANIZATION WITH OUTDOOR ACTIVITIES

Will know when conditions permit outdoor exertion, which is essential for worker safety and the operational regulations for organizations, businesses, and facilities.

What can you do with the WBGT forecast?

You don't have to wait until conditions are dangerous to act; use the WBGT Forecast to plan your outdoor activities.

- Reschedule athletic practice to a cooler time/date
- Move activities indoors
- Plan extra rest and hydration breaks
- Modify conditioning drills or exercises to be less strenuous
- Remove pads and other athletic clothing

OSHA provides simplified heat exposure recommendations to help determine whether an environment is too hot to safely work, based on the following WBGT temperatures:

EFFECTIVE WBGT (°C)	UNACCLIMATIZED WORKERS	ACCLIMATIZED WORKERS
Below 70°F (21°C)	Low risk of heat-related illness	Low risk of heat-related illness
70 to 77°F (21 to 25°C)	Strenuous work possibly unsafe	Low risk of heat-related illness
Above 77°F (25°C)	High risk of heat-related illness with strenuous work	Strenuous work possibly unsafe



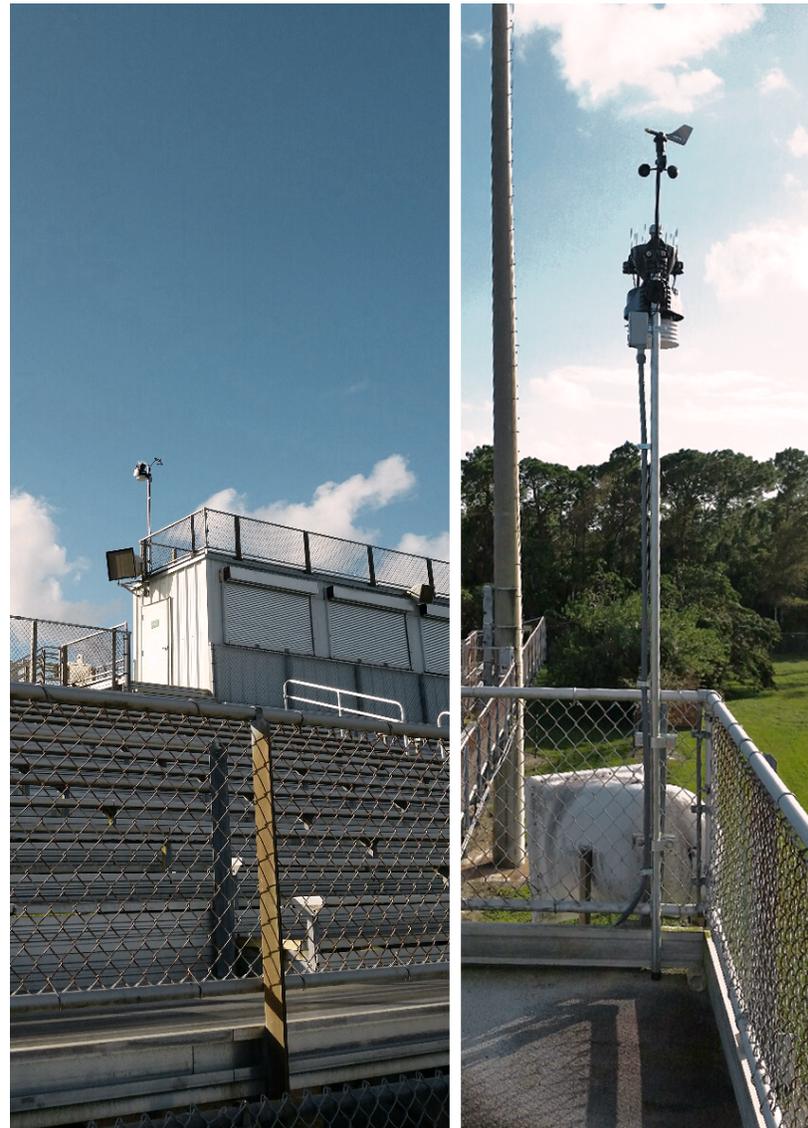
CASE STUDY: Palm Beach County

Palm Beach County School District is the 10th largest school district in the nation, consisting of 26 high schools that all participate in the Florida high school athletic association. When the **Zachary Martin Act** was passed in the summer of 2020, the school district only had two weeks to comply. This law enforces mandatory heat safety protocols to increase the safety of student athletes, including the following mandates:

1. Provide training on how to monitor heat stress
2. Guidelines in place for monitoring heat stress through measuring WBGT
3. Require schools to monitor heat stress and activities based on heat stress guidelines
4. Enforce hydration guidelines
5. Require cooling zones
6. Create an emergency action plan that includes on site cooling before a student is transported to a hospital for heat stroke

Fred Cahill, District Safety Specialist for Palm Beach County, was in charge of making sure all 26 schools were in compliance with this new law. The schools now had to monitor WBGT at the site of the game, practice, or event instead of just the general heat index. Prior to installing Earth Networks weather stations, WBGT was measured with handheld measuring tools, but these were not as accurate and regularly forgotten by coaches and staff. Cahill announced that the Palm Beach school district is now fully compliant with the Zach Martin Act of Florida, which regulates Heat Stress Monitoring, Hydration, and Cooling Zones for student athletes. The addition of the new WBGT forecast feature in Palm Beach County will allow increased monitoring of WBGT for heat stress precautions.

Installing Earth Networks weather stations allowed for more accurate and timely data collection that could be accessed on phones and computers, with customizable alerts for when WBGT reaches 92 degrees (the limit to stop all outdoor activities). The County leased the weather stations from Earth Networks so that maintenance would be included, avoiding the need for training in house staff and the added expenditure of parts and labor for the specialized weather station equipment. This also helped with budgeting as the cost is a known amount for the duration of the contract. Maintenance is provided quickly to ensure that the student athletes of Palm Beach County are staying safe and avoiding heat stress. Installing Earth Networks weather stations has provided a peace of mind to staff and coaches by ensuring accurate and timely data collection and delivery because safety is the number one priority.



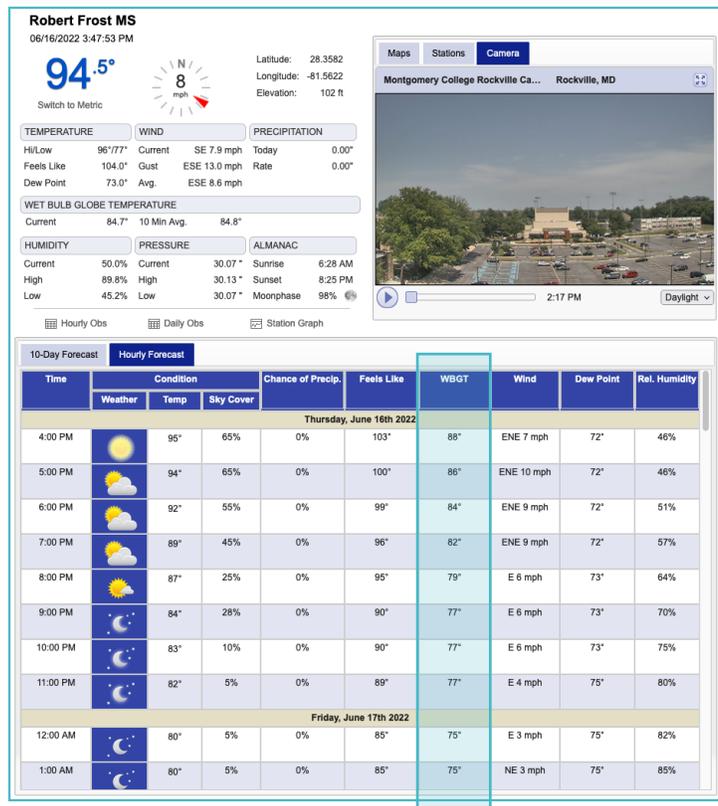
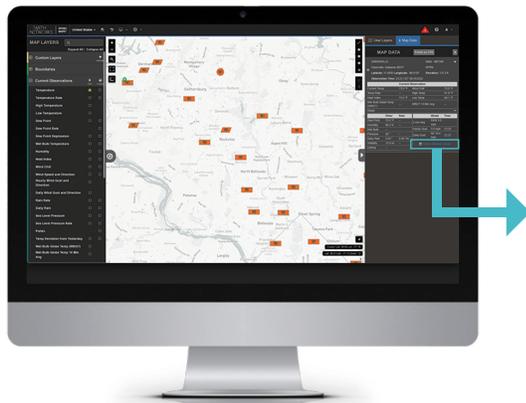
Safely make the call with AEM's Heat Safety Package

Heat stress safety is critical for protecting athletes, employees, and spectators from the heat. We can help keep any organization safe with our AEM heat safety packages, which include **WBGT Forecast**. We will show you how to implement a comprehensive heat stress safety plan with the most advanced wet bulb globe temperature technology and automated mass alerts. Protecting students from the dangers of heat stress is a great responsibility, and our solutions can help ease the burden for schools and athletic trainers on the field.

AEM's **heat stress safety solutions** can help take the burden off schools, and bring them into compliance with heat related policies, where they exist, or be proactive where there are no heat policies. The **Wet Bulb Globe Temperature (WBGT) Forecast displays** a daily and hourly forecast value for WBGT at your weather station's location, in the Online Weather Center (OWC).

When enabled, the WBGT Forecast is available in the Online Weather Center, and is accessible via **Sferic Maps**, which provides real-time weather alerts and storm tracking. Community members, employees, and visitors can **view the WBGT forecast high for the current day, and the following 5 days**. This forecasting capability is beneficial for planning outdoor activities safely. The WBGT Forecast is available to AEM customers subscribing to **heat safety packages**.

Contact us to learn about our comprehensive heat stress solutions.



SOURCES

Akrherz@iastate.edu, Daryl Herzmann. "Automated Data Plotter." *Iowa Environmental Mesonet*, https://mesonet.agron.iastate.edu/plotting/auto/?_wait=no&q=92&phenomena=EH&significance=W&e=all&edate=2022%2F05%2F27&_r=t&dpi=100&_fmt=png.

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Webdev. "Home." *Korey Stringer Institute*, 19 Feb. 2015, <https://ksi.uconn.edu/>.

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Appendix

RANK	STATE	SCORE (%)
1	<u>Florida</u>	86.04
2	<u>New Jersey</u>	85.00
3	<u>Georgia</u>	81.67
4	<u>Kentucky</u>	71.75
5	<u>Louisiana</u>	71.00
5	<u>District of Columbia</u>	71.00
7	<u>Massachusetts</u>	69.40
8	<u>North Carolina</u>	68.58
9	<u>Tennessee</u>	67.35
10	<u>Washington</u>	63.13
11	<u>Illinois</u>	63.00
12	<u>Arizona</u>	62.20
13	<u>Missouri</u>	62.00
14	<u>Hawaii</u>	61.33
15	<u>Arkansas</u>	61.20
16	<u>Delaware</u>	59.35
17	<u>Oregon</u>	58.60
18	<u>Wisconsin</u>	58.13
19	<u>New Mexico</u>	58.08
20	<u>South Dakota</u>	57.95
21	<u>Texas</u>	57.60
22	<u>Virginia</u>	57.40
23	<u>Utah</u>	54.00
24	<u>Mississippi</u>	52.00
25	<u>New York</u>	51.38



RANK	STATE	SCORE (%)
26	<u>Kansas</u>	50.60
27	<u>Vermont</u>	50.60
28	<u>Alabama</u>	49.70
29	<u>Indiana</u>	48.00
30	<u>Ohio</u>	47.93
31	<u>Alaska</u>	47.40
32	<u>Nevada</u>	47.00
33	<u>Nebraska</u>	46.50
34	<u>Idaho</u>	46.00
35	<u>South Carolina</u>	45.80
36	<u>Pennsylvania</u>	45.00
37	<u>Connecticut</u>	44.80
38	<u>Rhode Island</u>	44.73
39	<u>West Virginia</u>	44.40
40	<u>New Hampshire</u>	42.80
41	<u>Michigan</u>	42.73
42	<u>Maryland</u>	42.63
43	<u>North Dakota</u>	42.00
44	<u>Iowa</u>	41.00
45	<u>Wyoming</u>	41.00
46	<u>Colorado</u>	40.80
47	<u>Oklahoma</u>	38.90
48	<u>Montana</u>	38.25
49	<u>Maine</u>	37.60
50	<u>Minnesota</u>	37.55
51	<u>California</u>	30.8

