NWS-CDC Joint Webinar on Experimental NWS HeatRisk

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April 22, 2024

Webinar Logistics

- This webinar is being **recorded** and will be publicly posted along with the Presentation PDF after the webinar. *By attending this webinar, you consent to the recording of your likeness including voice and/or webcam images.*
  - https://www.weather.gov/wrn/calendar
- All lines will remain muted throughout the presentation.
- Please use the **Question Box** to ask questions, which will be answered at the end during the Q&A.

Opening Remarks

Michelli Mainelli

Deputy Director

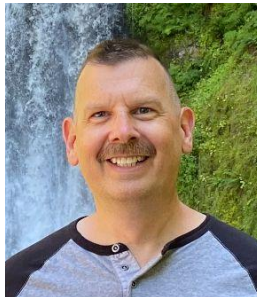
NWS, NOAA

Aaron Bernstein, MD, MPH

Director

NCEH/ATSDR, CDC

Today's Presenters



Mike Staudenmaier

Division Chief - WRH Science and Technology Infusion Division, NWS, NOAA

Kim McMahon

Public Weather Services Program Manager, HQ

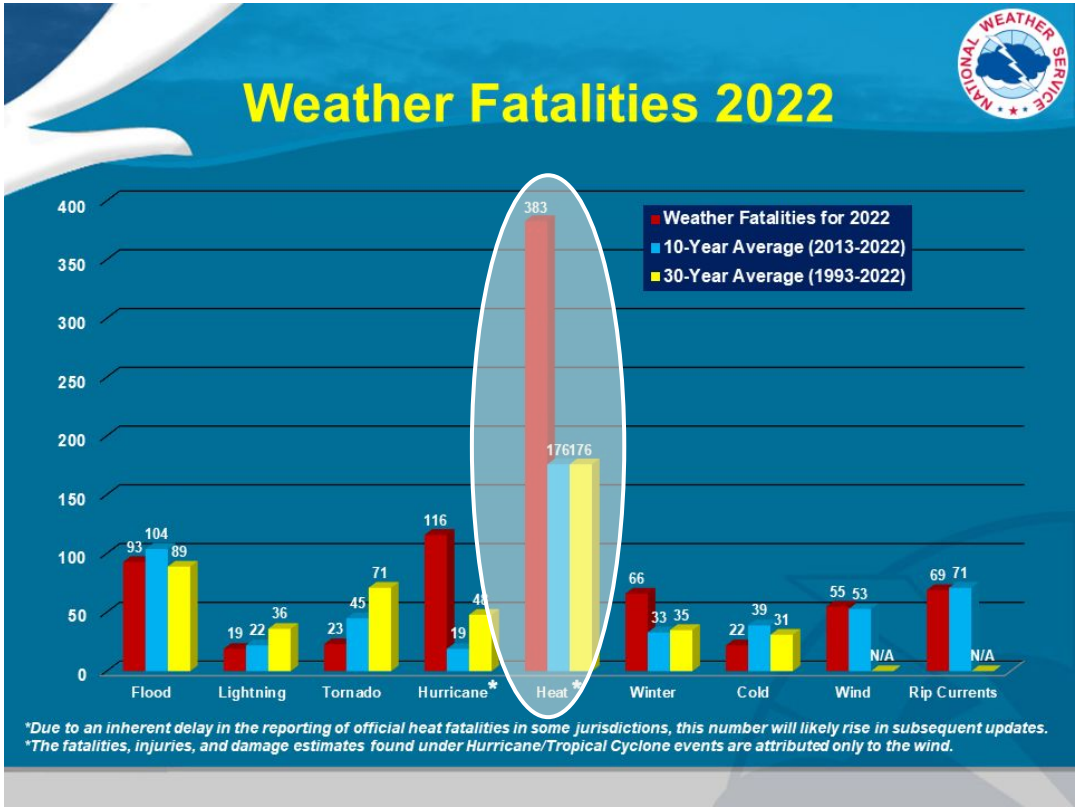
NWS, NOAA

Ambarish Vaidyanathan, Ph.D

Senior Health Scientist - Climate and Health Program, National Center for Environmental Health, CDC

Why Heat Matters

- Heat is the leading weather-related killer
- 2023 was the warmest year on record, with the top 10 warmest years on record occurring from 2014-2023
- Studies show heatwaves trending hotter, longer, and more frequent with less overnight relief



Agency Collaboration

CDC and NOAA National Weather Service worked together to develop a service that contextualizes heat forecasts with data relevant public health data.

Climatological
Temperature Data

+

Health-based
temperature thresholds

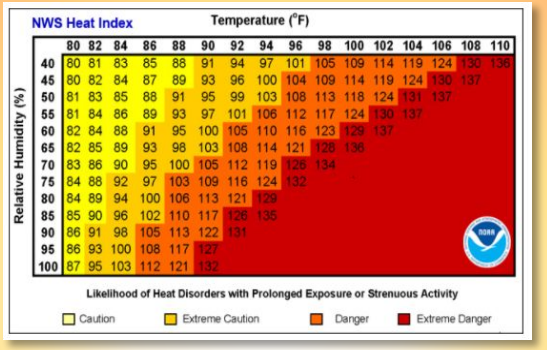
NWS integrated health-based temperature thresholds that were provided by CDC with local temperature parameters to devise HeatRisk — a numeric and a color-coded system.

Who is Most At Risk to Extreme Heat

- Children and Older Adults
- People who are Pregnant
- People with Disabilities
- People with Chronic Health Conditions
- First Responders
- Outdoor Workers
- People exercising or doing strenuous activities outdoors
- People who lack access to cooling
- People who lack housing and/or quality housing
- Pets and Service and Support Animals

NWS Forecast Tools to Assess Heat

Heat Index

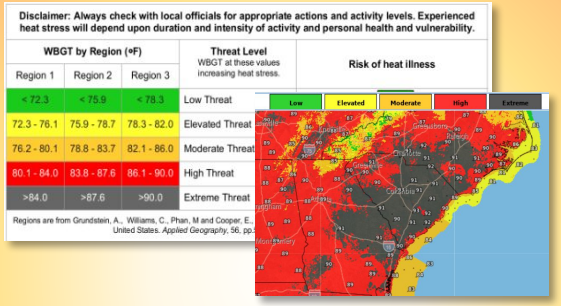


Heat stress in context for **general public.**

- Relatively simple: T + RH
- Light physical activity in shade

5'7" adult, 147.7 lbs, walking outside at 3.1 mph, wearing trousers and short sleeved shirt

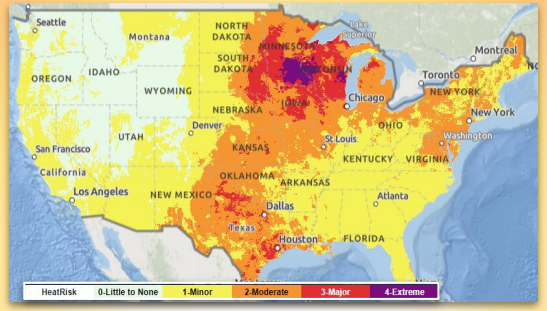
Wet Bulb Globe Temperature



Heat stress in context for **healthy, active outdoor** communities.

- More Complex: T + RH + wind + solar radiation
- High levels of outdoor physical activity

HeatRisk (experimental)



Risk of heat related impacts in **climatological context** with CDC heat-health information.

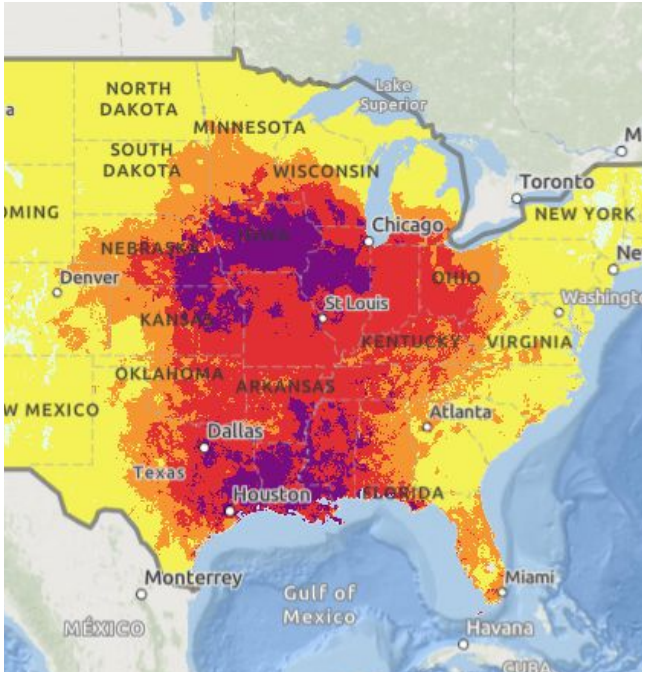
- Impacts-based: MaxT + MinT + CDC heat-health data
- Spectrum of heat-health impacts for *all* populations

What is HeatRisk?

A numeric/color-based heat service that serves as a ***framework*** for leveraging peer-reviewed heat-health science and data consistently across the CONUS

Category	Risk of Heat-Related Impacts
Green 0	Little to no risk from expected heat.
Yellow 1	Minor - This level of heat affects primarily those individuals extremely sensitive to heat, especially when outdoors without effective cooling and/or adequate hydration.
Orange 2	Moderate - This level of heat affects most individuals sensitive to heat, especially those without effective cooling and/or adequate hydration. Impacts possible in some health systems and in heat-sensitive industries.
Red 3	Major - This level of heat affects anyone without effective cooling and/or adequate hydration. Impacts likely in some health systems, heat-sensitive industries and infrastructure.
Magenta 4	Extreme - This level of rare and/or long-duration extreme heat with little to no overnight relief affects anyone without effective cooling and/or adequate hydration. Impacts likely in most health systems, heat-sensitive industries and infrastructure.

Simple Numeric/Color System



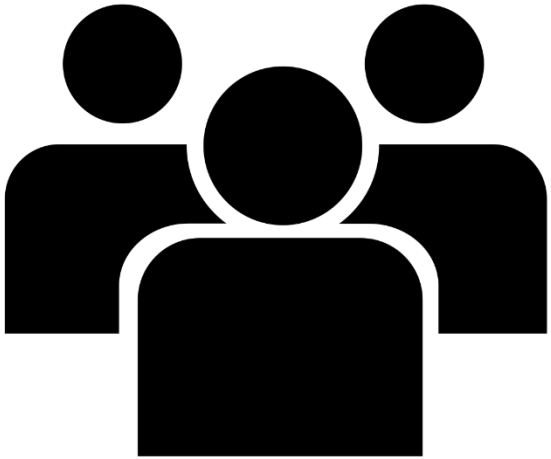
Excellent Geographical Coverage

Kind of like AQI…

But for Heat!

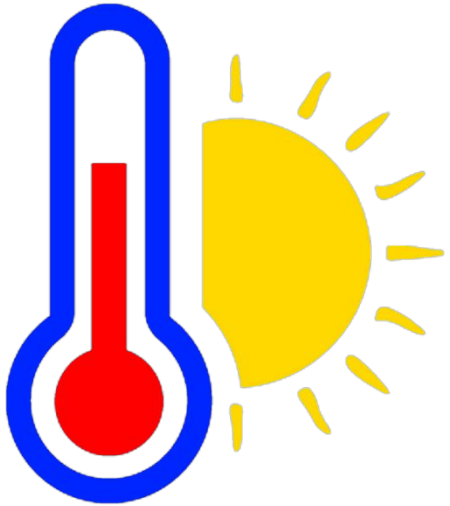
HeatRisk Basic Tenets

- Communities adapt to their **local climatology**
- **Acclimation** to heat is important
- There is some level where heat is dangerous, **no matter the time of year**
- Everyone has different heat tolerances – **no single threshold works**



HeatRisk Basic Tenets

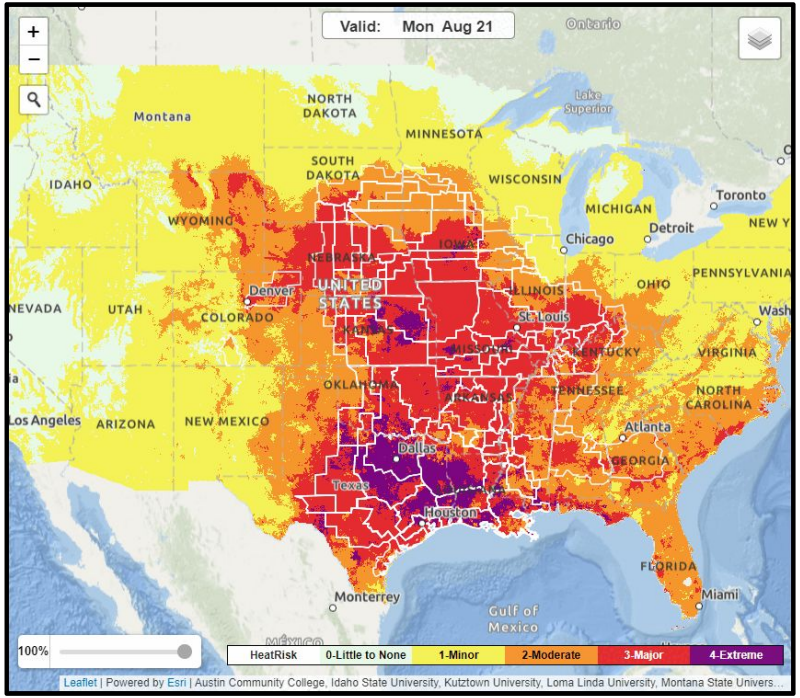
- The **95th percentile** approach is used to identify excessive heat
- Temperature is the **first order driver** for heat impacts
- **Humidity can be roughly estimated** by temperature ranges and min temps
- Framework rules are **applied nationally** to remain consistent



HeatRisk Considerations

What does it take into account?

- How significantly above normal high and low temps are for a location (24h period, 7 days out)
- Time of the year
- Duration of unusual heat
- Overnight relief
- If temperatures are at high enough levels to pose an elevated risk for heat complications (based on CDC heat-health thresholds)



CDC-NWS Collaboration

Climate Region	Hospitalization Outcome	Heat-Sensitive Zones with Heat Alert Criteria, by Heat Index Ranges				
		<= 80 °F	81 – 90 °F	91 – 100 °F	101 – 110 °F	> 110 °F
Northwest	All-Causes					
	All cardiovascular					
	All respiratory					
	Diabetes					
	Fluid and electrolyte					
	Renal failure					

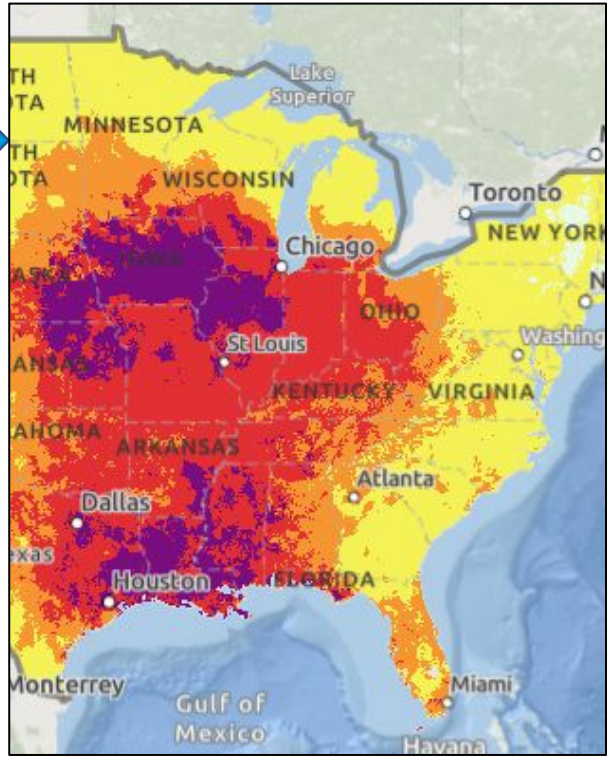
Heat-sensitive zone

Heat index ranges at which positively significant peak heat-attributable health risk / burden are observed

Heat index ranges used for issuing alerts

Median heat alert criteria

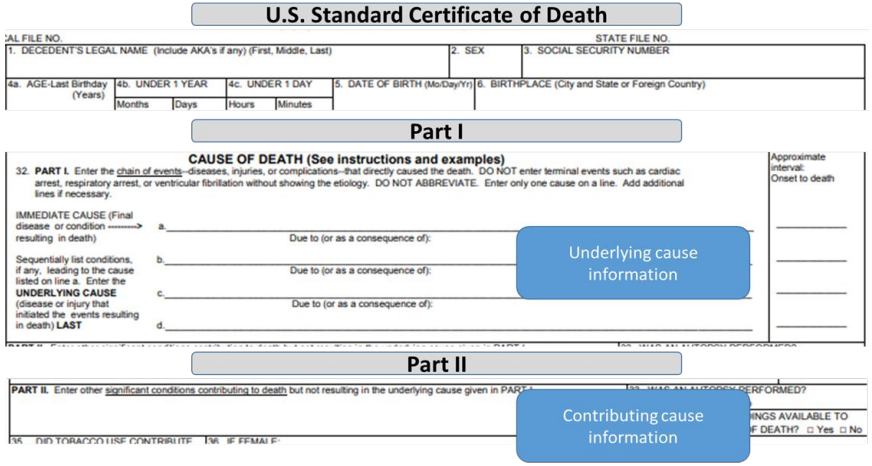
Vaidyanathan, A. et al.. Assessment of extreme heat and hospitalizations to inform early warning systems. *Proceedings of the National Academy of Sciences*, *116*(12), 5420-5427.



- HeatRisk v1.0 was based on local/long-term climatology and available at the start of this collaboration.
- CDC-NWS focused on incorporating health evidence and calibrating alert thresholds based on heat-health impact information.

Data Sources and Analytical Framework

Code-based (ICD-9 / ICD-10) assessment of heat-related burden



https://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf

- The primary or underlying reasons (and contributing factors) for adverse health outcomes.

Data Sources and Analytical Framework

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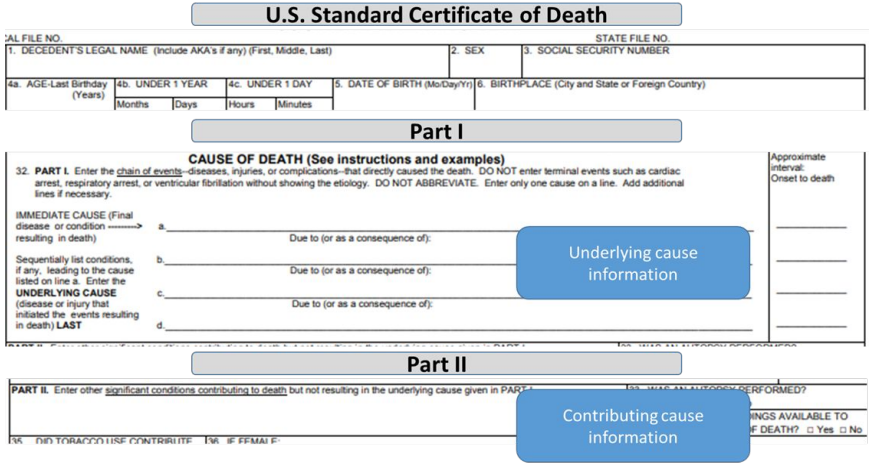

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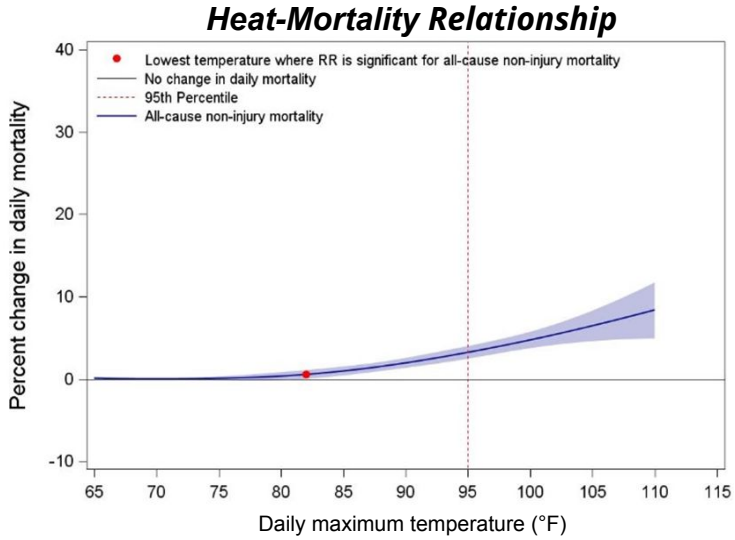
Statistical Attribution Approach



- Generate relationships between temperature and adverse health outcomes using a statistical framework.

Data Sources and Analytical Framework

Data Sources

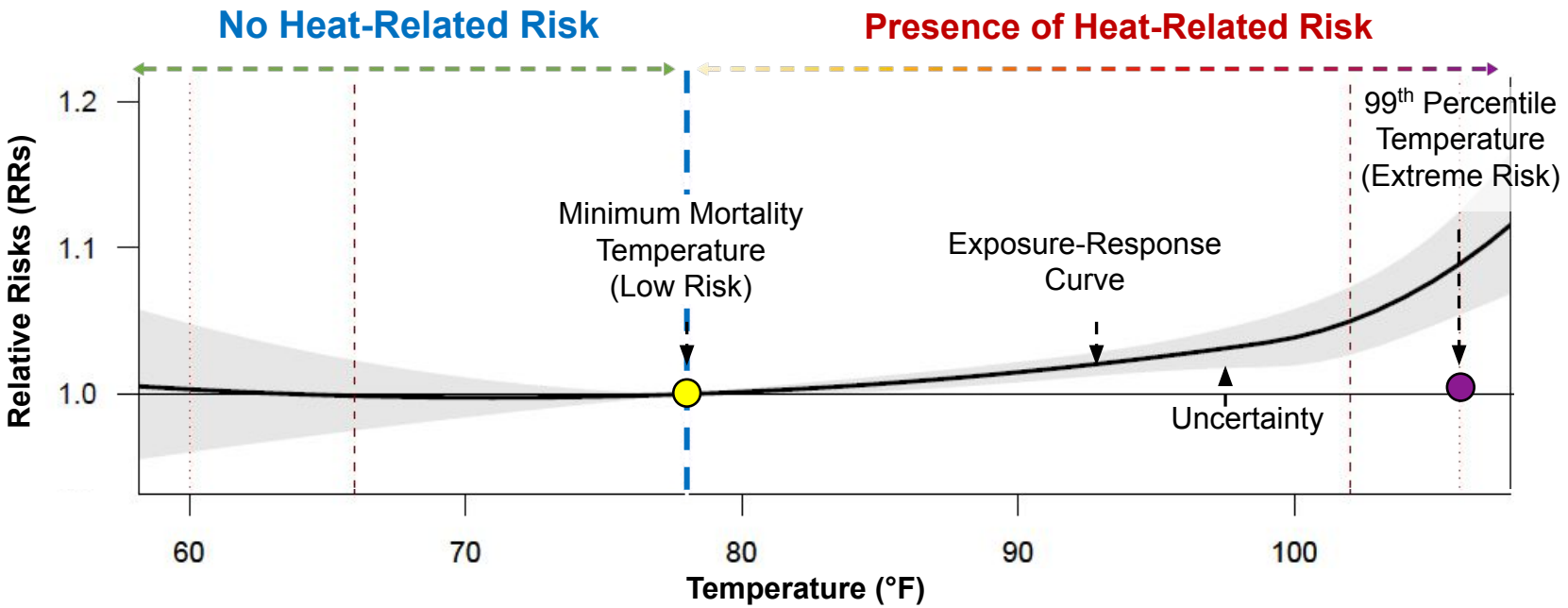
- **Health data: CDC's** National Vital Statistics System for mortality data
- **Meteorological data:** National Weather Service

Analytical Framework

- **Stage One:** county-level time series analysis using a Distributed Lag Non-Linear Model (DLNM) for the warmer months (April 1 through October 31)
  - Heat exposure measures: Daily maximum and minimum temperatures
    - Controls for air pollution, seasonality, long-term trends, day of the week, etc.
    - Health risks estimated for cumulative lag period of 0-3 days
- **Stage Two:** multivariate random-effects meta-analysis to derive overall cumulative heat-mortality relationships and estimate heat-attributable deaths over a range of temperature values.

Basis for Creating Heat-Related Health Impact Information

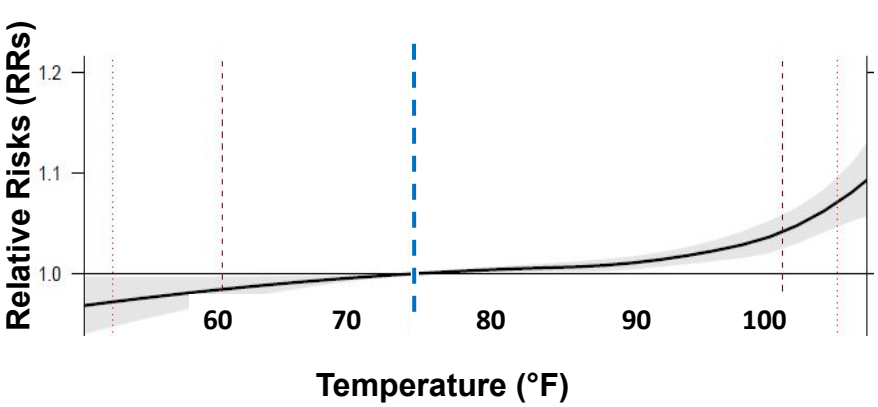
Heat-Mortality Relationship



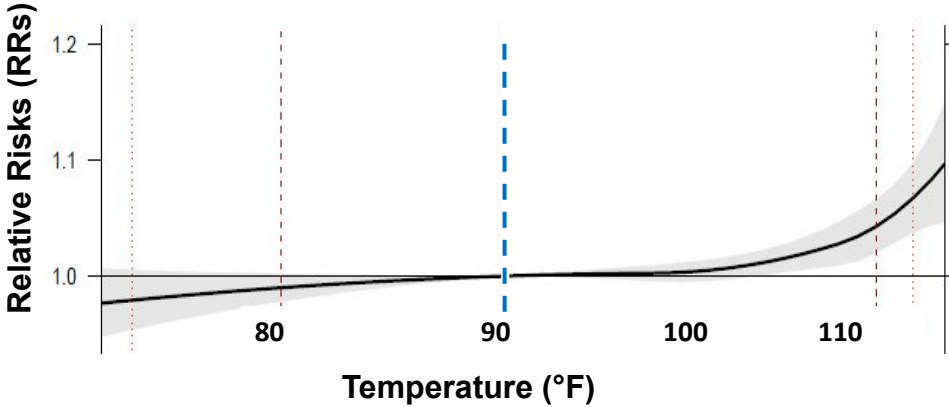
Understanding Health Impacts over a Range of Temperatures

Heat-Mortality Relationship

Cooler Climate

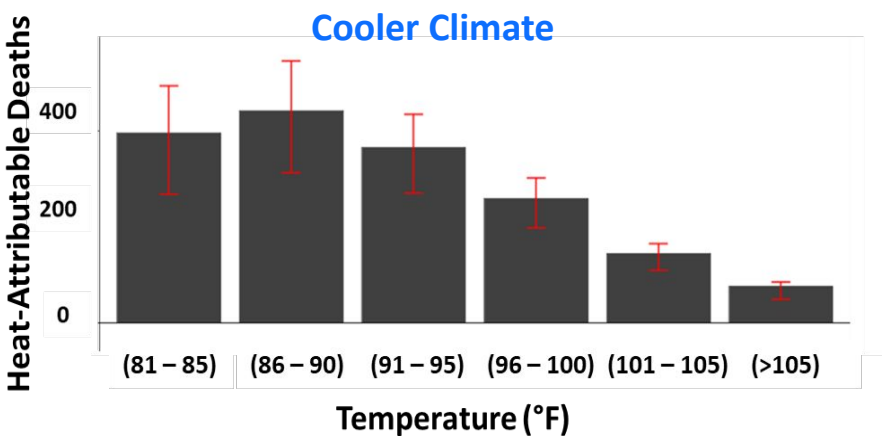


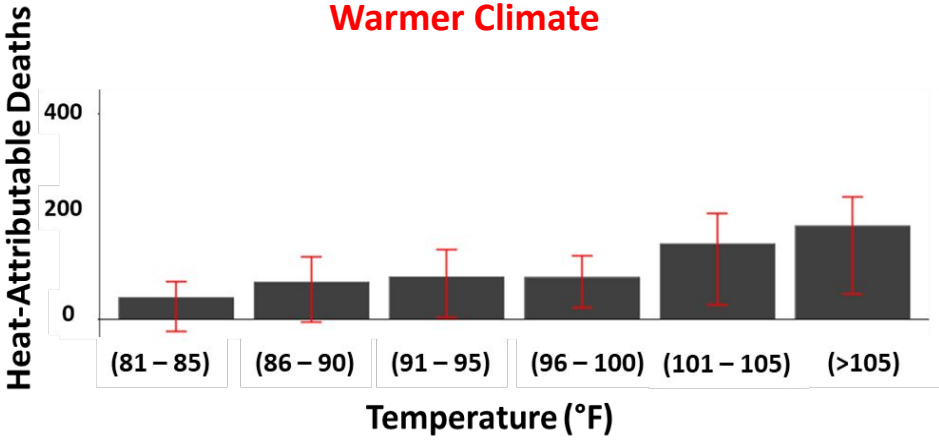
Warmer Climate



Understanding Health Impacts over a Range of Temperatures

Heat-Attributable Deaths (Health Impacts)





Generating Local Heat-Health Impacts

$$\textbf{Percent of Heat-Attributable Deaths (PHAD)} = \frac{\textit{Heat-Attributable Deaths at a Specific Temperature} * 100}{\textit{All Heat-Attributable Deaths}}$$

Location-Specific Heat-Attributable Health Impacts

Location	Percentile Range: 25 to 30		Percentile Range: 30 to 35		…	…	…	…	Percentile Range: 95 to 99		Percentile Range: > 99	
	Temp. Range	*PHAD (%)*	*Temp. Range*	*PHAD (%)*	…	…	…	…	*Temp. Range*	*PHAD (%)*	*Temp. Range*	*PHAD (%)*
Baldwin, (Alabama)	>83°F to 84°F	0	>84°F to 85°F	0	…	…	…	…	>95°F to 102°F	31	>102°F	2
Calhoun, (Alabama)	>79°F to 81°F	0	>81°F to 82°F	1	…	…	…	…	>95°F to 104°F	25	>104°F	2
Colbert, Alabama	>78°F to 80°F	0	>80°F to 82°F	1	…	…	…	…	>97°F to 107°F	25	>107°F	2
…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…
Natrona, (Wyoming)	>63°F to 66°F	0	>66°F to 69°F	1	…	…	…	…	>95°F to 104°F	26	>104°F	0.79
Sheridan, (Wyoming)	>62°F to 65°F	0	>65°F to 67°F	0	…	…	…	…	>96°F to 107°F	27	>107°F	0.91
Uinta, (Wyoming)	>58°F to 60°F	0	>60°F to 63°F	0	…	…	…	…	>87°F to 94°F	30	>94°F	0

- Created an algorithm to identify specific and cumulative mortality impacts
- Ascertained heat-health impact information for multiple locations across the United States

HeatRisk Categories

Extreme (4)

- ***Rare long duration and/or extreme event***
- Extreme risk of widespread heat-related impacts (including illness and mortality) for anyone without effective cooling and/or hydration.
- Temps above 95th percentile for 2+ days and/or near all-time records.

Major (3)

- Major risk of widespread heat-related impacts (including illness and mortality) for anyone without effective cooling and/or hydration.
- Excessively warm day and nights (generally above 95th percentile).

Primary difference between Extreme and Major is duration and/or maximum intensity of heat. Both are potentially VERY impactful!

HeatRisk Categories

Moderate (2)

- Moderate risk of heat-related impacts, mostly in “at higher risk” populations without effective cooling and/or hydration
- Primarily heat-related illness. Non-zero, but low, risk of heat-related mortality expected.

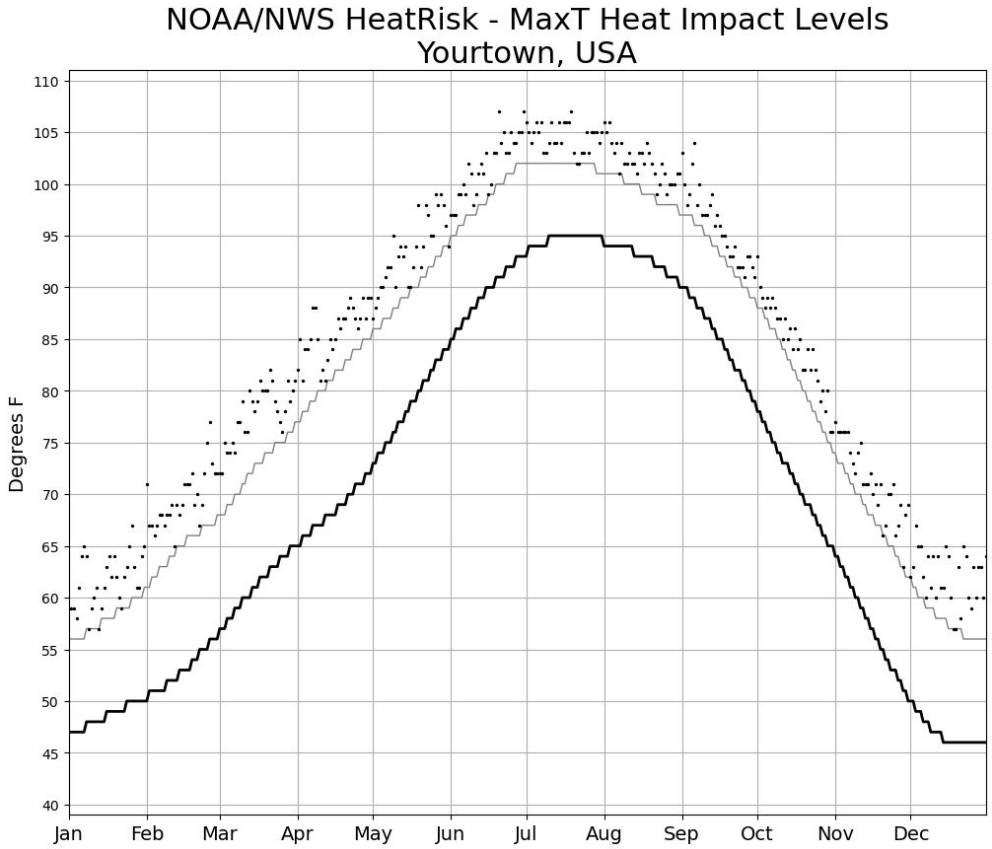
Minor (1)

- Minor risk for “at higher risk” populations. Minor spike in heat illness. Non-zero, but very low, risk of mortality expected.

None (0)

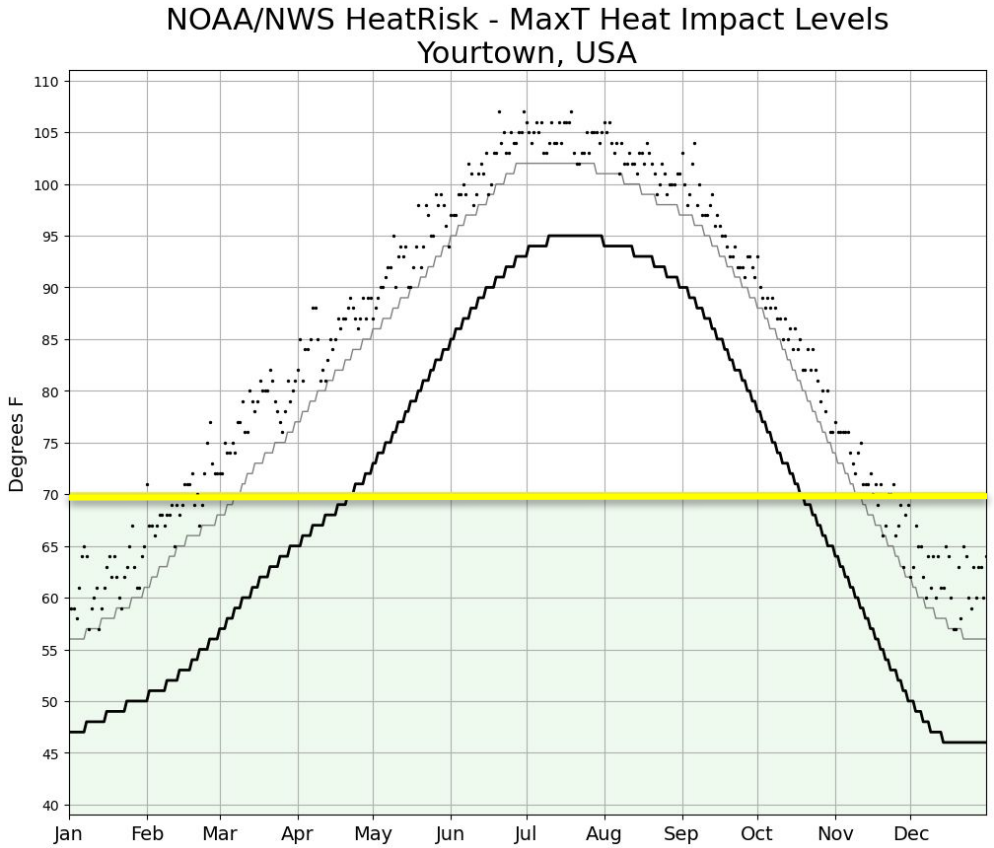
- Little to no risk from expected heat.

How HeatRisk Works



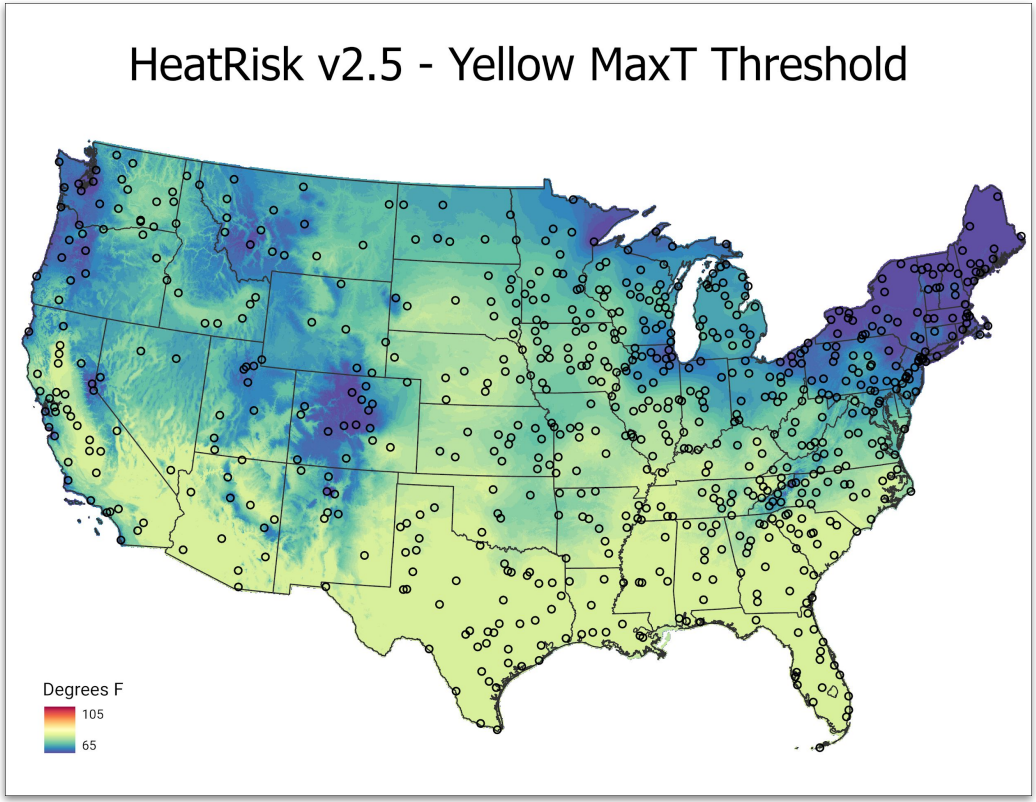
- HeatRisk leverages local climatology normals, including the 95th percentile of temperatures to identify excessive heat for ***that*** location
- Dark curve = 1991-2020 NCEI Normals
- Light grey curve = 95th percentile curve (30-day smooth applied)
- Dots = daily record highs in the period of record

How HeatRisk Works



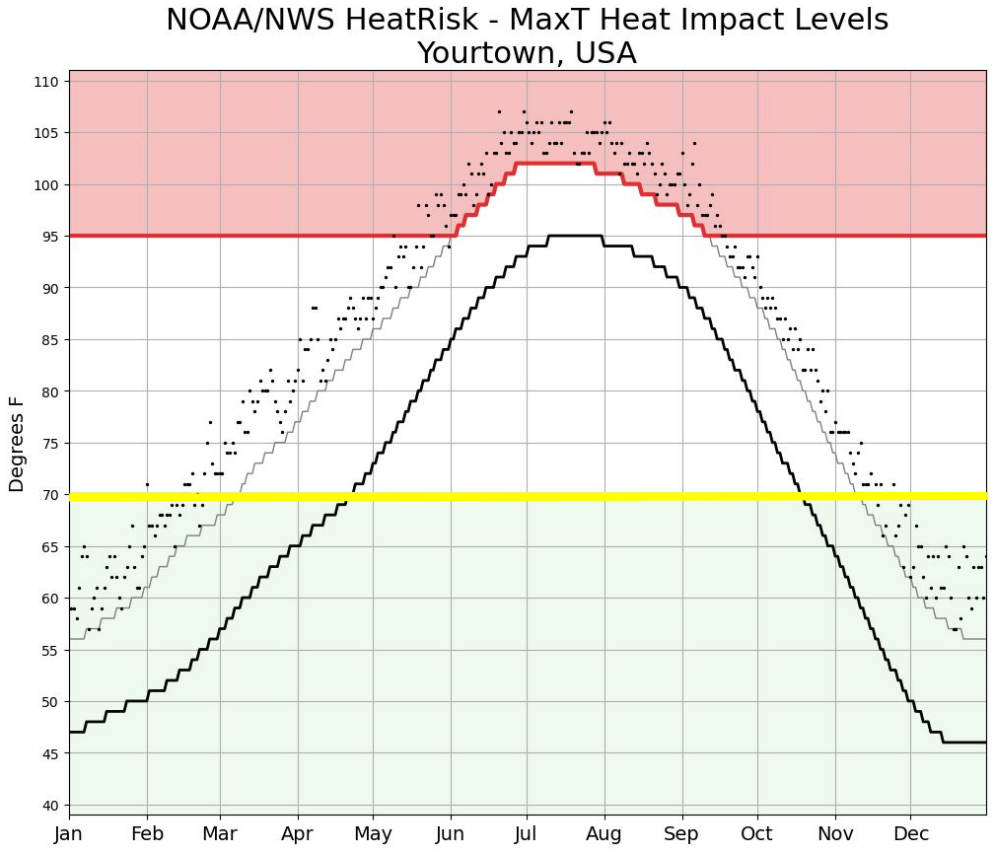
- The first threshold we define is the Yellow threshold
- We leverage the CDC Minimum Mortality Temperature (in urban areas) or 1st percentile (for rural areas)
- This means nearly all heat-attributable deaths were modeled to have occurred above this temperature
- Temperatures below this are in the Green category

How HeatRisk Works



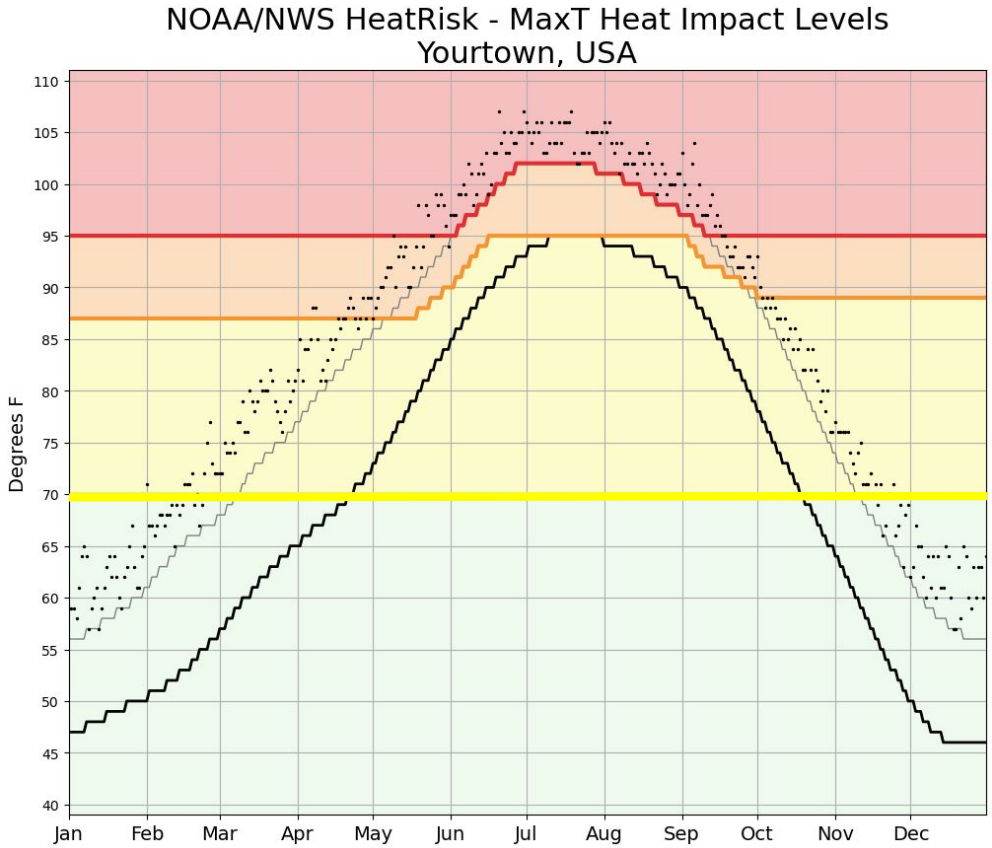
- Map of the Yellow maximum temperature threshold across the US based on CDC-derived data for ~700 stations.
- Modeled relationships (county/regional heat-health statistics modeled to single station location) were available from small rural locations up to large metropolitan areas.

How HeatRisk Works



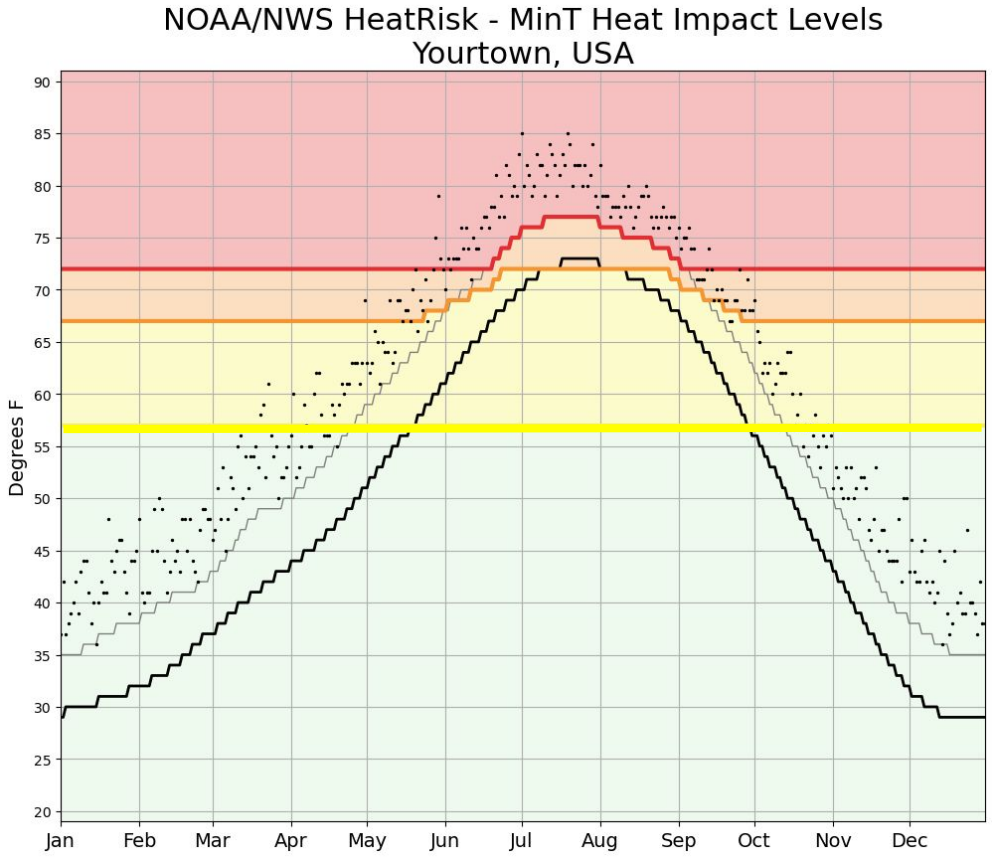
- The “base” Red threshold is based on the 50th percentile of heat- attributable deaths from the CDC data
- This means that half of those deaths were modeled to have occurred above/below this value
- In the warmer months, the Red threshold is then defined as the higher value between the base value or the 95th percentile curve (light gray curve)

How HeatRisk Works



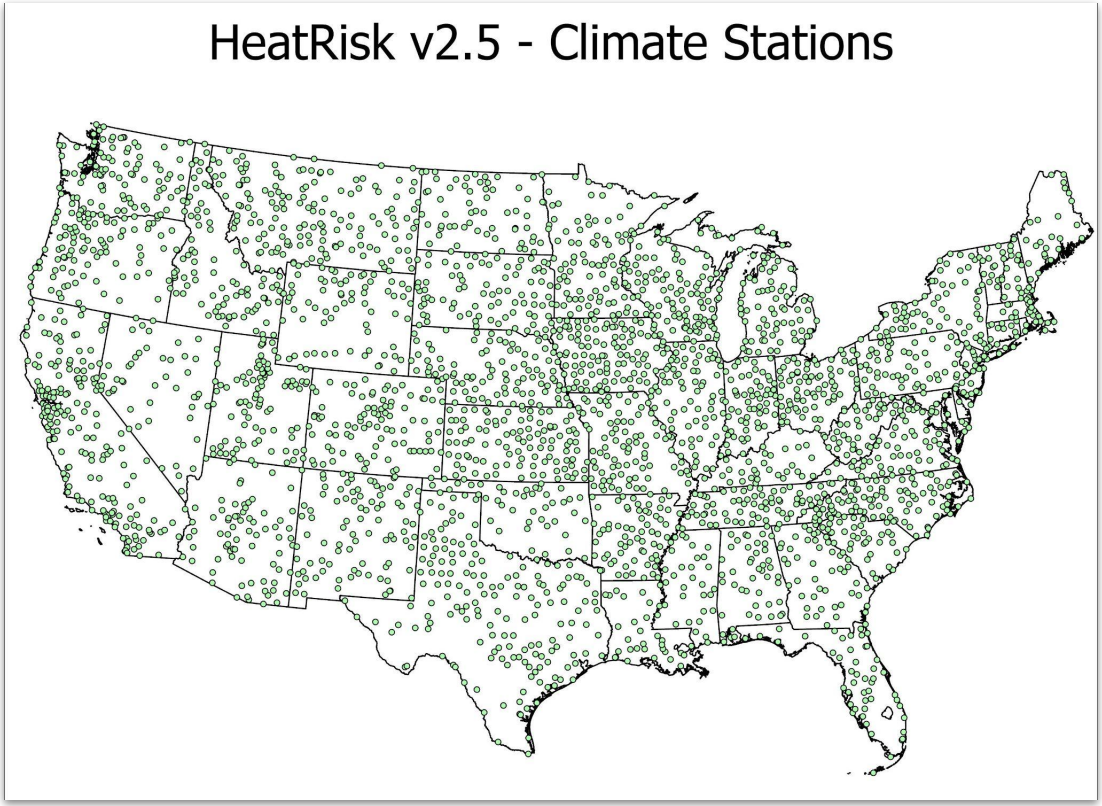
- Finally the **Orange** threshold is generated
- This involves:
  - Mathematically leveraging the Red and Yellow values
  - Taking into account the time of year (Spring vs Fall) and CDC data (25th percentile)
  - Capping at the Red base value (where applicable)
- Note differences in early and late season Orange thresholds, which account for acclimation aspects.

How HeatRisk Works



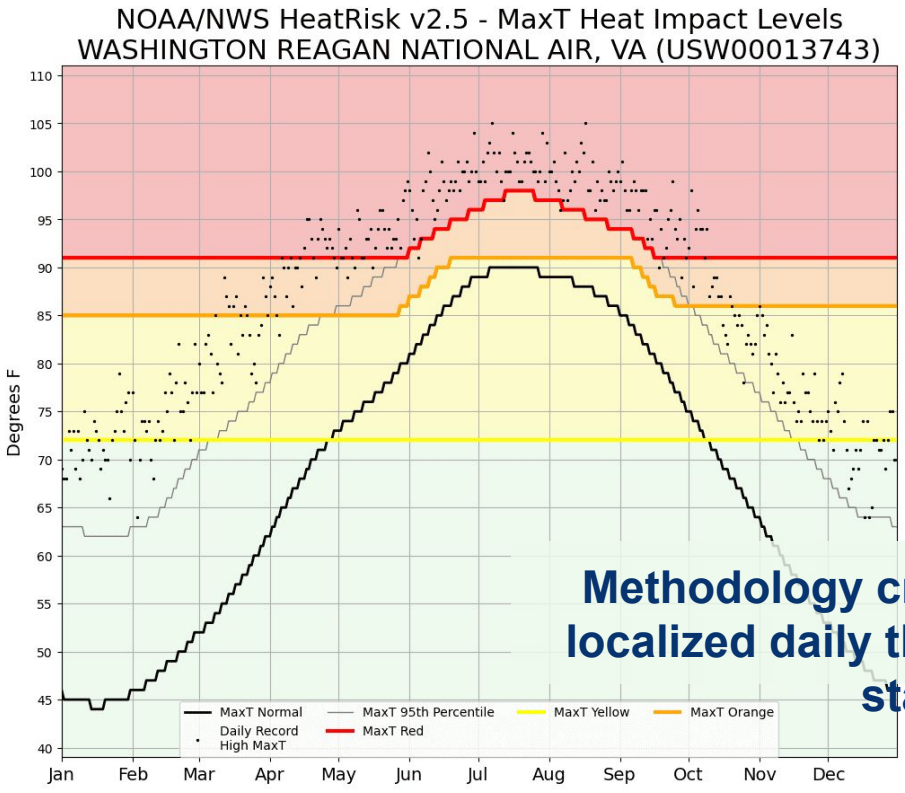
- For minimum temperature, Orange and Red thresholds are based primarily on climatology. Yellow levels are based on CDC thresholds and climatology.
- Minimum temperatures are used in the 24-hour HeatRisk approach to better account for:
  - Overnight relief potential
  - Humidity

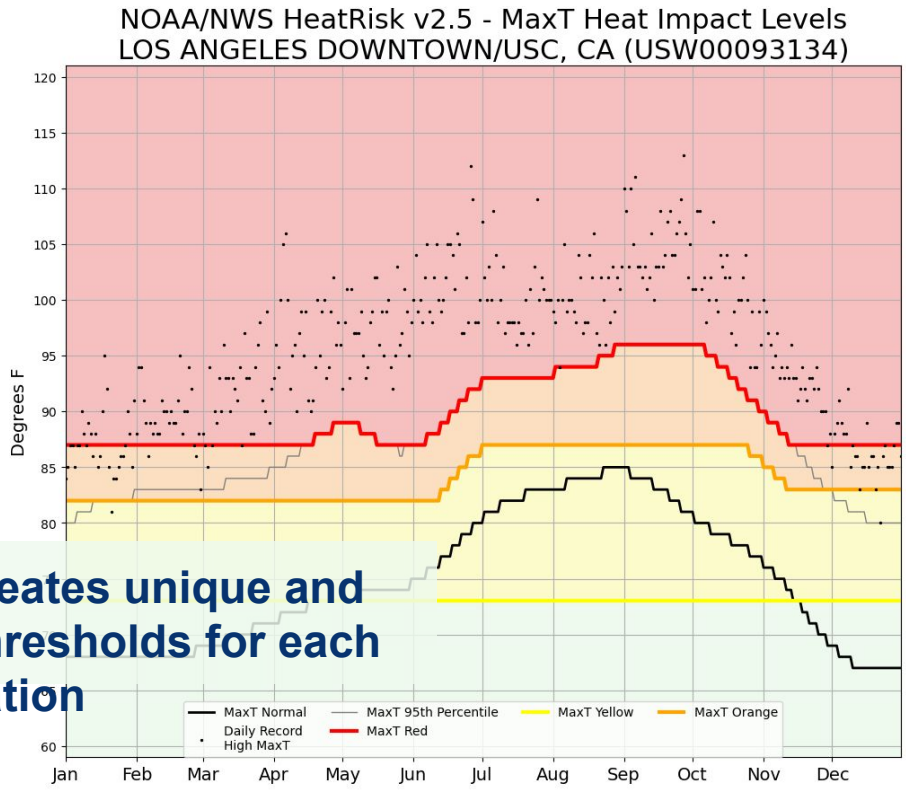
How HeatRisk Works



This process is applied to ~3100 stations across the Contiguous US

How HeatRisk Works





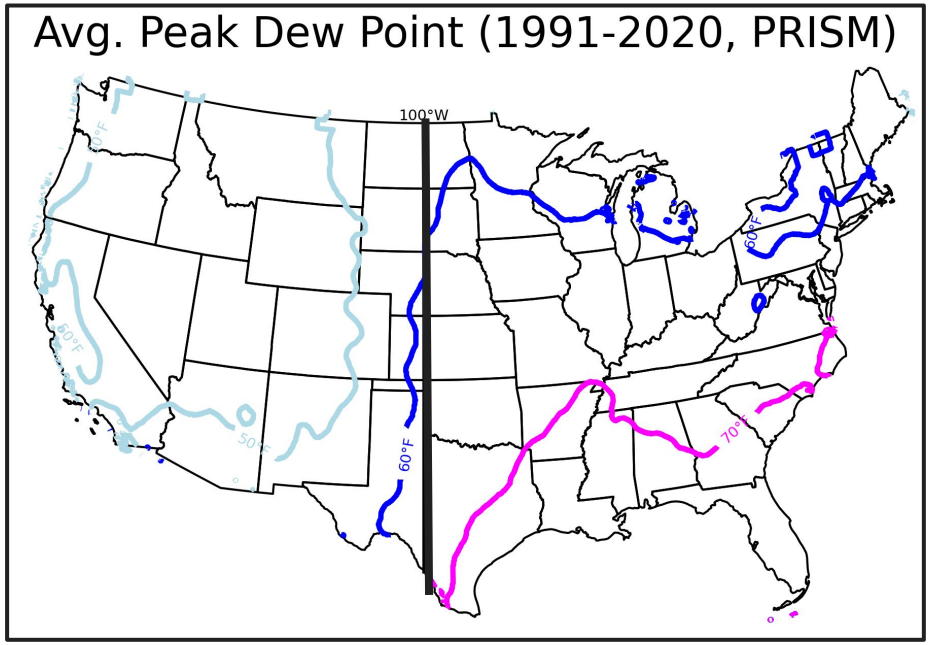
Methodology creates unique and localized daily thresholds for each station

How HeatRisk Works

How is humidity accounted for?

- Natural dividing line along 100°W, with higher average dew points (measure of moisture) to the east and lower to the west

“Along the hundredth meridian from Manitoba to Mexico there is a zone of semiarid land. … Passing from east to west across this belt a wonderful transformation is observed. On the east a luxuriant growth of grass is seen… Passing westward, species after species of luxuriant grass and brilliant flowering plants disappear; the ground gradually becomes naked, with “bunch” grasses here and there; now and then a thorny cactus is seen, and the yucca thrusts out its sharp bayonets. At the western margin of the zone the arid lands proper are reached.” (Powell 1890, Seager et al 2018)



HeatRisk Algorithm - Combining to 24 hour value

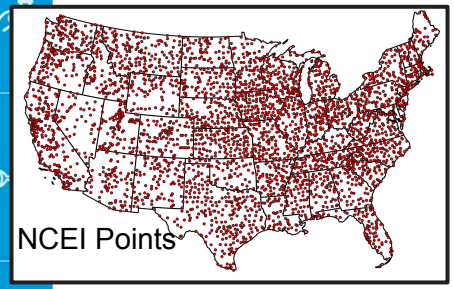
	MaxT (0,1,2,3)	MinT (0,1,2,3)
Humid	45%	55% 27.5% Day 1 | 27.5% Day 2
Dry	67%	33% 11.5% Day 1 | 21.5% Day 2

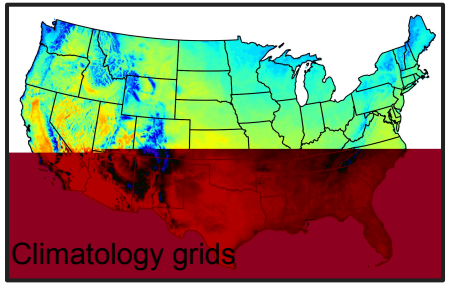
MaxT/MinTs are each assigned a 0, 1, 2, 3 based on where they fit within the daily threshold values.

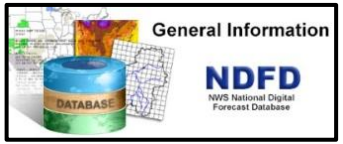
Different weighting schemes are used for the “humid” and “dry” climates.

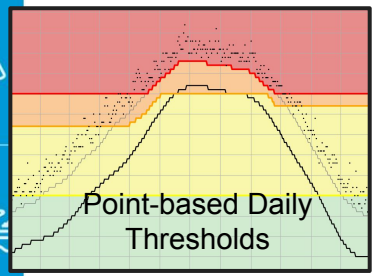
Final HeatRisk values consider the morning low, the afternoon high, and the following morning low to describe the 24 hour risk

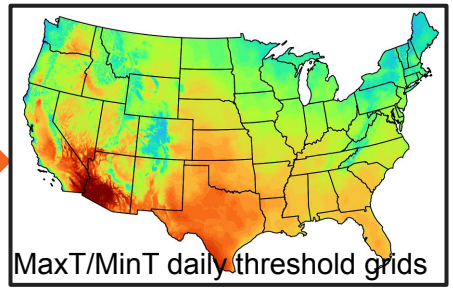
HeatRisk Process Review - Points to Grids to Forecast

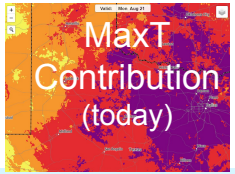






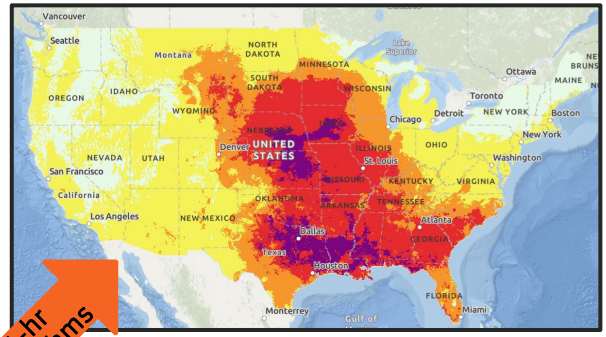






24-hr Algorithms

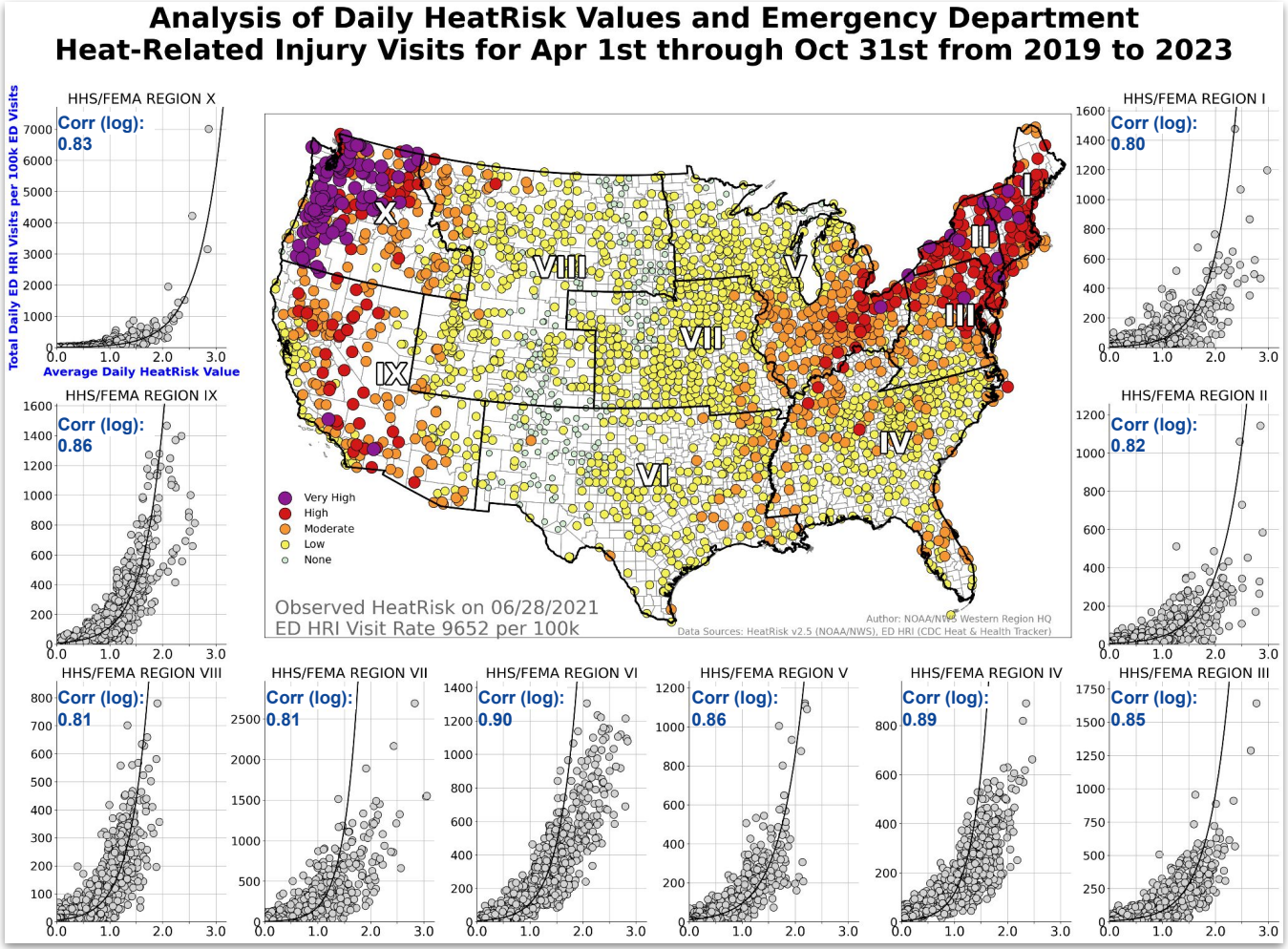
Magenta - Two or three consecutive 24-hr periods are >= 95th percentile, and/or highs are near or above all time records



Daily 24-hour HeatRisk

Impact-Based Verification

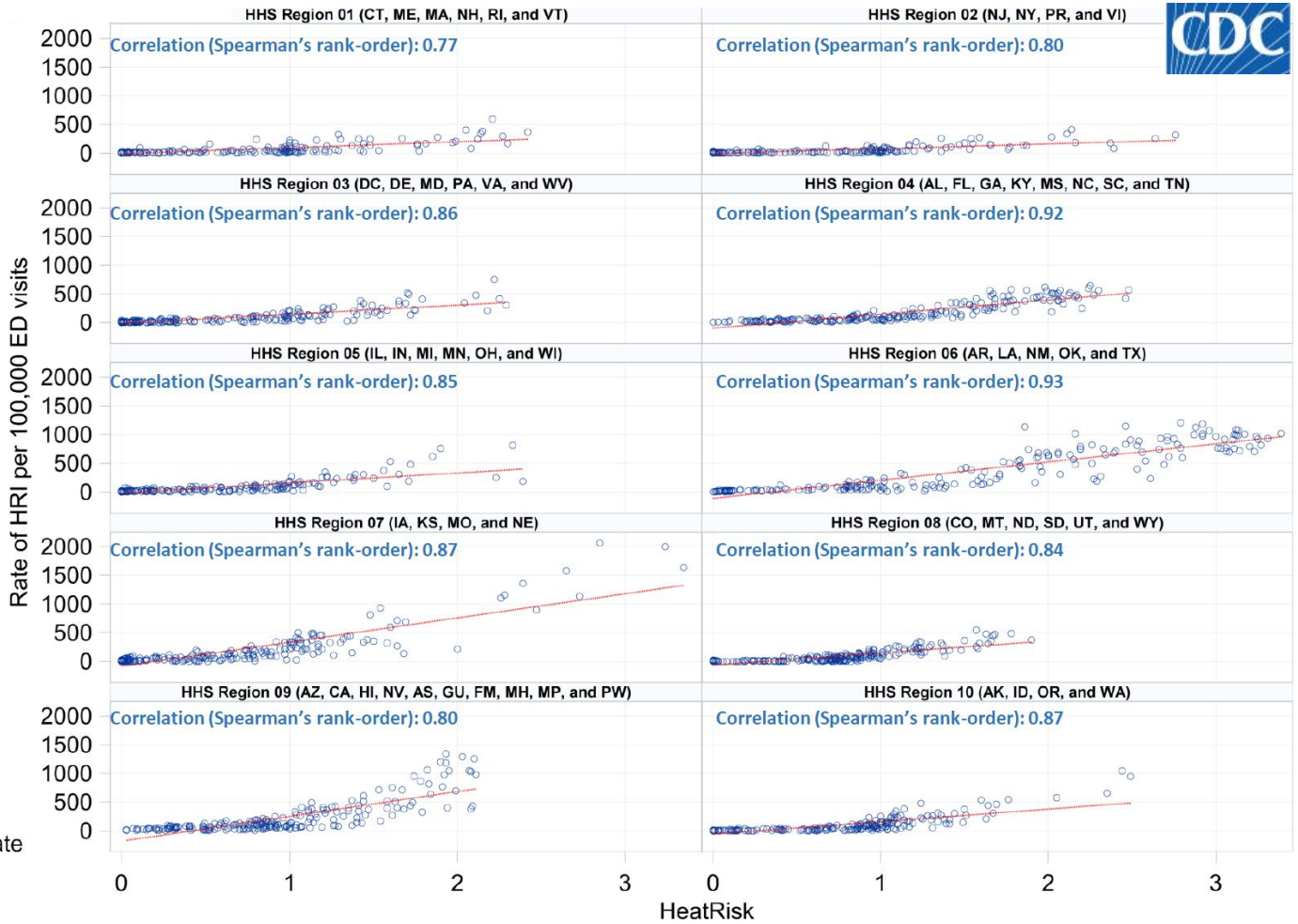
Comparing regional observed HeatRisk values (FEMA/HHS regions) against emergency dept. (ED) heat-related illness (HRI) for the combined 2019-2023 heat seasons found a **strong** correlation (0.80-0.90).



Impact-Based Verification

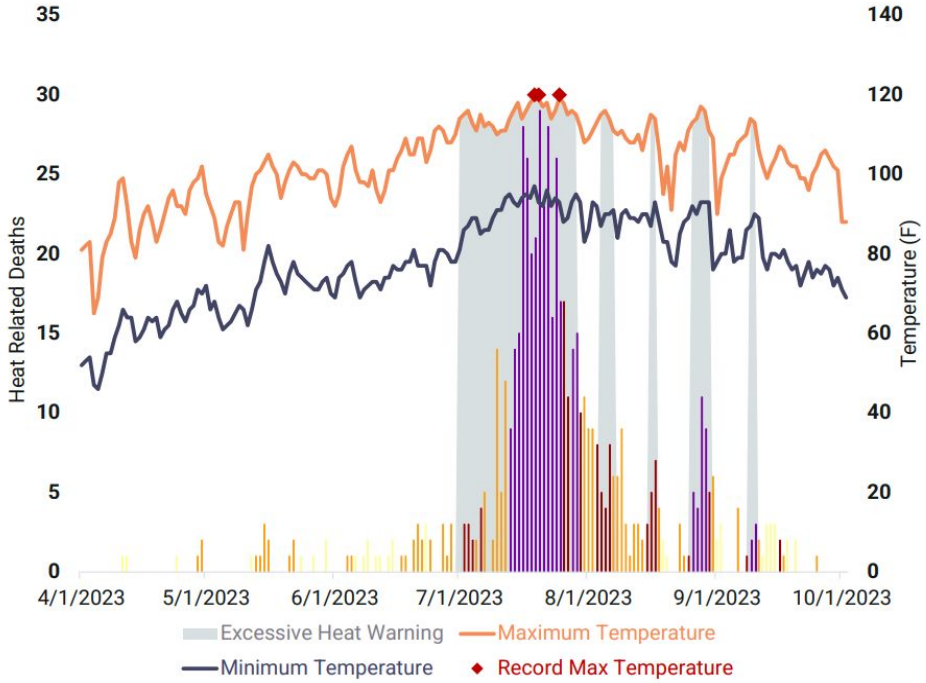
HeatRisk vs. HRI ED Visit Rate Correlation for Warm Season Months (Apr - Oct) of 2023

Population Weighted



Impact Based Verification

Daily temperatures were not below 91 degrees from July 10th – July 25th. **During these two weeks, 303 deaths occurred.** A new top 5 record-breaking hottest temperatures of 119 occurred on July 19th, 20th, and 25th in Maricopa County.



Over half of all heat related deaths in 2023 occurred on days where heat risk was calculated as extreme. There were 21 days in 2023 where the NWS calculated an extreme heat risk.

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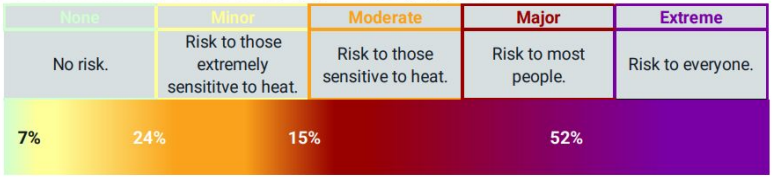
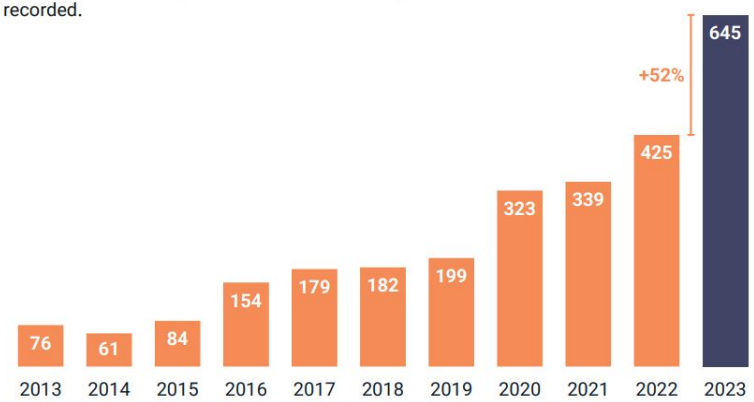
For more information: National Weather Service https://www.weather.gov/psr/heat



Heat Related Deaths Over Time

Deaths by Year

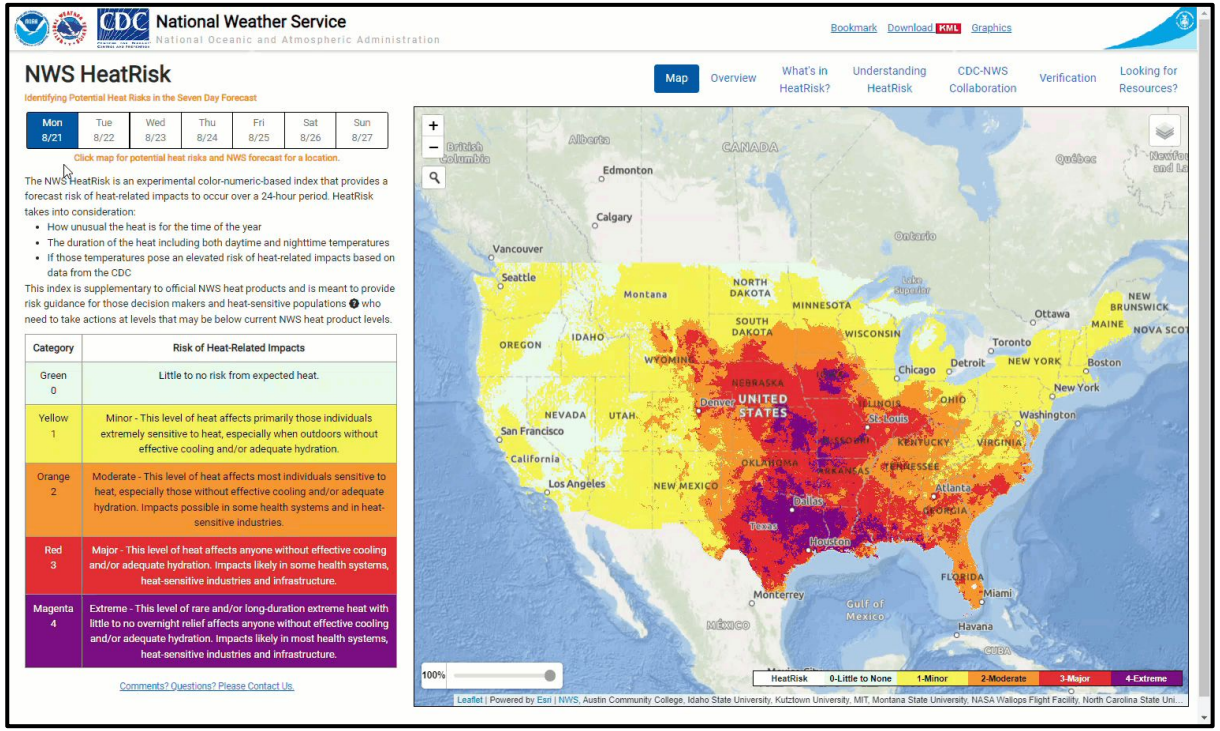
Maricopa County identified a total of 645 heat related deaths occurring in 2023. This represents a 52 percent increase from last year and the most heat related deaths ever recorded.



** 1 death that occurred in September of 2023 is pending a cause of death*

WPC HeatRisk CONUS Viewer

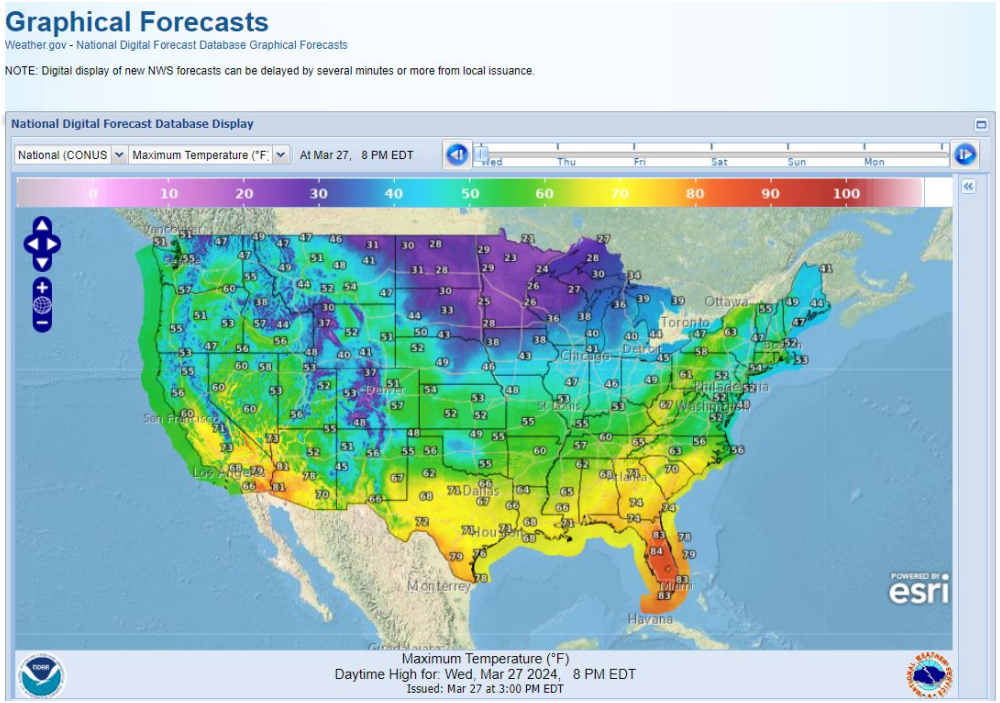
https://www.wpc.ncep.noaa.gov/heatrisk



- Access daily interactive maps with point-based forecasts
- Overview of HeatRisk, including a definition of each level
- Data Formats: static images, KML and GeoTIFF files

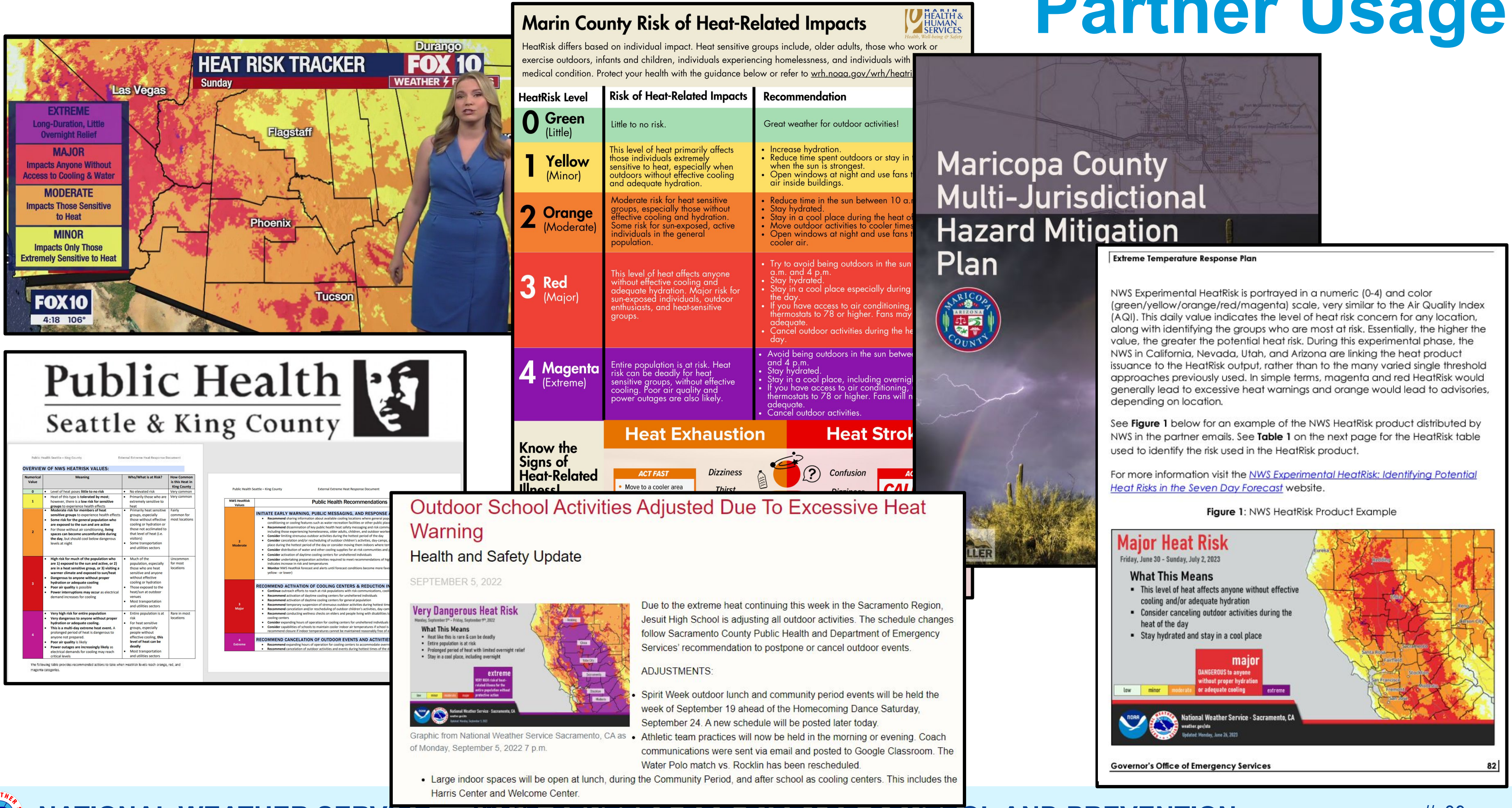
National Digital Forecast Database (NDFD)

https://digital.weather.gov



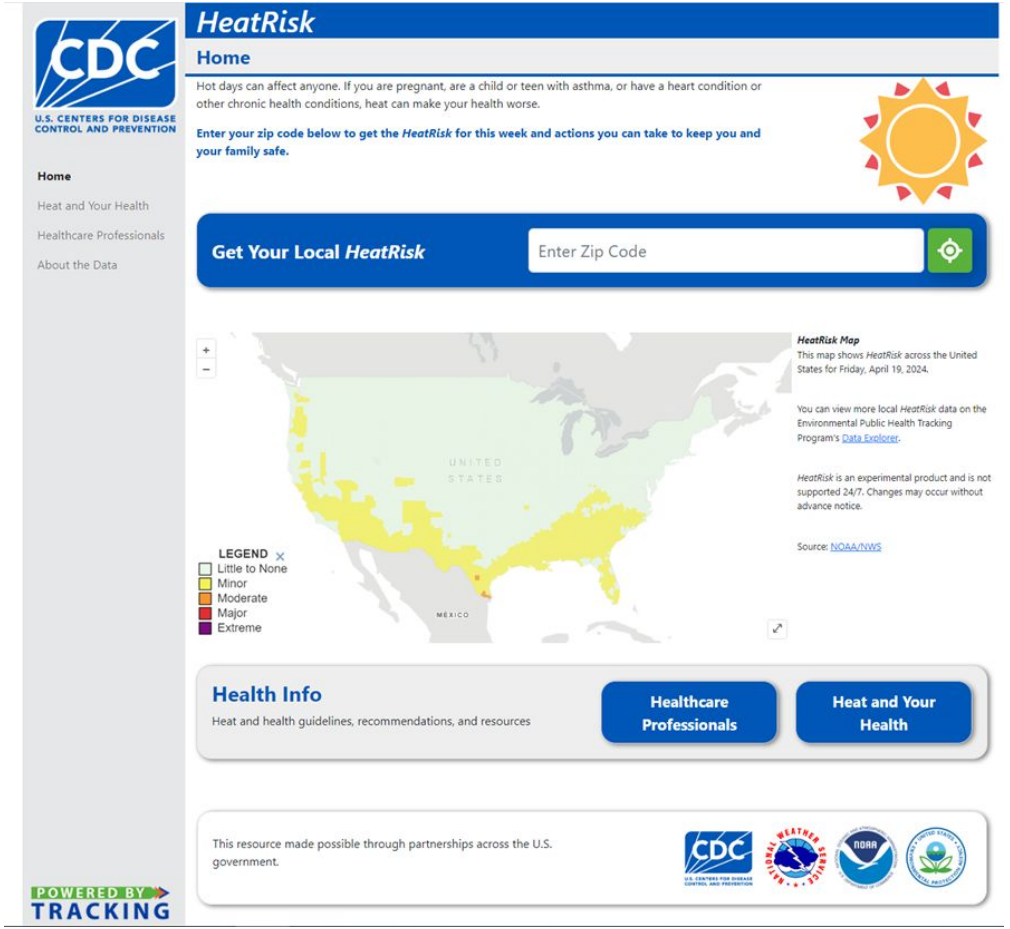
- HeatRisk will be available on NDFD for all CONUS locations by the end of May
- Data formats: GRIB2, XML, and WMS

Partner Usage



CDC HeatRisk Dashboard

www.cdc.gov/heatrisk



CDC HeatRisk Dashboard

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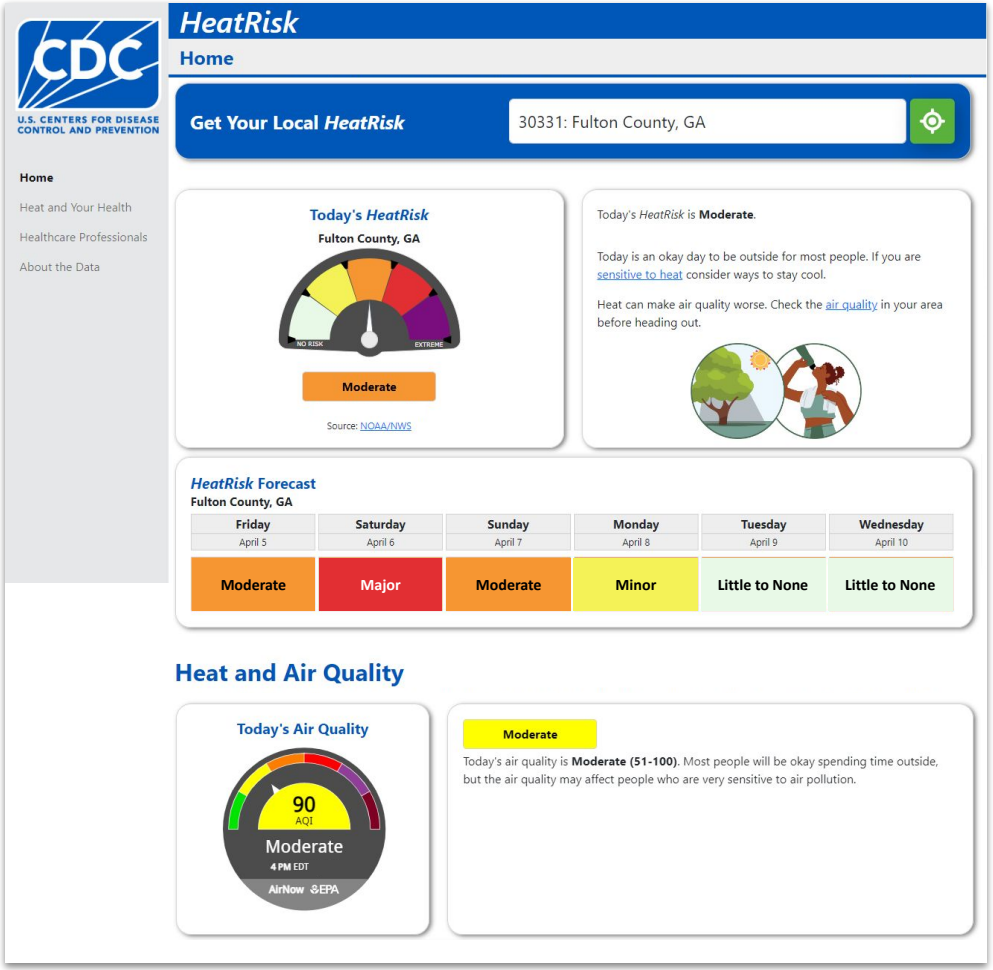


CDC HeatRisk Dashboard

www.cdc.gov/heatrisk

Today's *HeatRisk* is **Moderate.**

Today is an okay day to be outside for most people. If you are sensitive to heat consider ways to stay cool.

Heat can make air quality worse. Check the air quality in your area before heading out.

Actions you can take to protect your health

Stay hydrated, stay cool. People who are outside for a long time or who are sensitive to heat could have health impacts. Even a few hours in a cool location can lower your risk for health problems from heat.

If you are **outside**, especially for a long time, you can:

- Stay in the shade as much as possible.
- Take breaks when you can.
- Do outdoor activities during the coolest parts of the day or evening, if possible.

If you are **indoors**, you can:

- Use air conditioning or find a location that has one.
- Use a fan to cool your body off, only when indoor temperatures are less than 90°F.

Check on your family, friends, and neighbors, especially if they have chronic medical problems or live alone. Check on pets.

Work with your doctor to see if you need to take additional health actions.

Go to Heat and Your Health to learn more.

Today's *HeatRisk* is **Extreme.**

This level of heat affects everyone, as the heat is very intense and can last for a long time. Everyone can take steps to protect themselves from impacts of heat on your health.

Heat can make air quality worse. Check the air quality in your area before heading out.

Actions you can take to protect your health

Stay hydrated, stay cool. **Everyone** can have health impacts at this level of heat.

Staying cool on these days likely requires staying inside with air conditioning if possible. If you don't have air conditioning, consider finding a location that does. Fans may not cool you off when it is this hot outside. Even a few hours in a cool location can lower your risk for health impacts from heat.

If you are must be outside:

- Do outdoor activities during the coolest parts of the day or evening, or move to a cooler day, if possible,
- Stay in the shade as much as possible,
- Take breaks when you can.

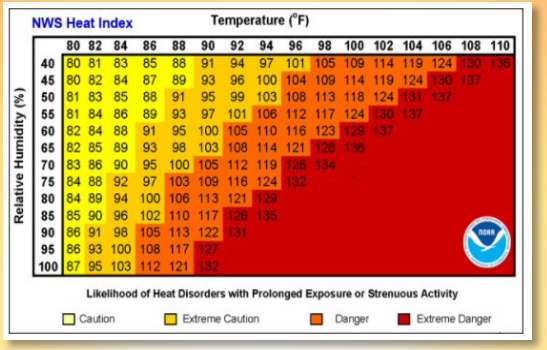
Check on your family, friends, and neighbors, especially if they have chronic medical problems or live alone. Check on pets.

Work with your doctor to see if you need to take additional health actions.

Go to Heat and Your Health to learn more.

NWS Forecast Tools to Assess Heat

Heat Index

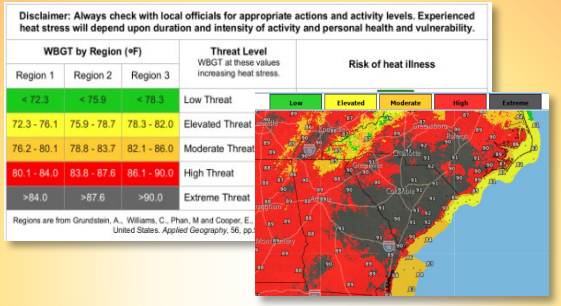


Heat stress in context for **general public.**

- Relatively simple: T + RH
- Light physical activity in shade

5'7" adult, 147.7 lbs, walking outside at 3.1 mph, wearing trousers and short sleeved shirt

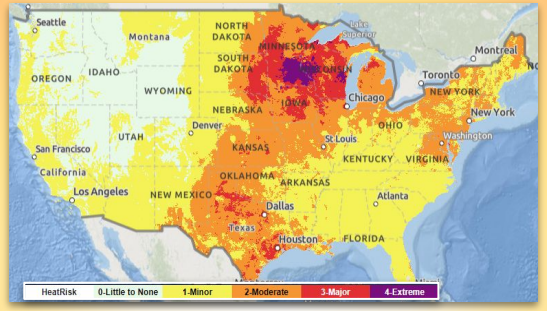
Wet Bulb Globe Temperature



Heat stress in context for **healthy, active outdoor** communities.

- More Complex: T + RH + wind + solar radiation
- High levels of outdoor physical activity

HeatRisk (experimental)



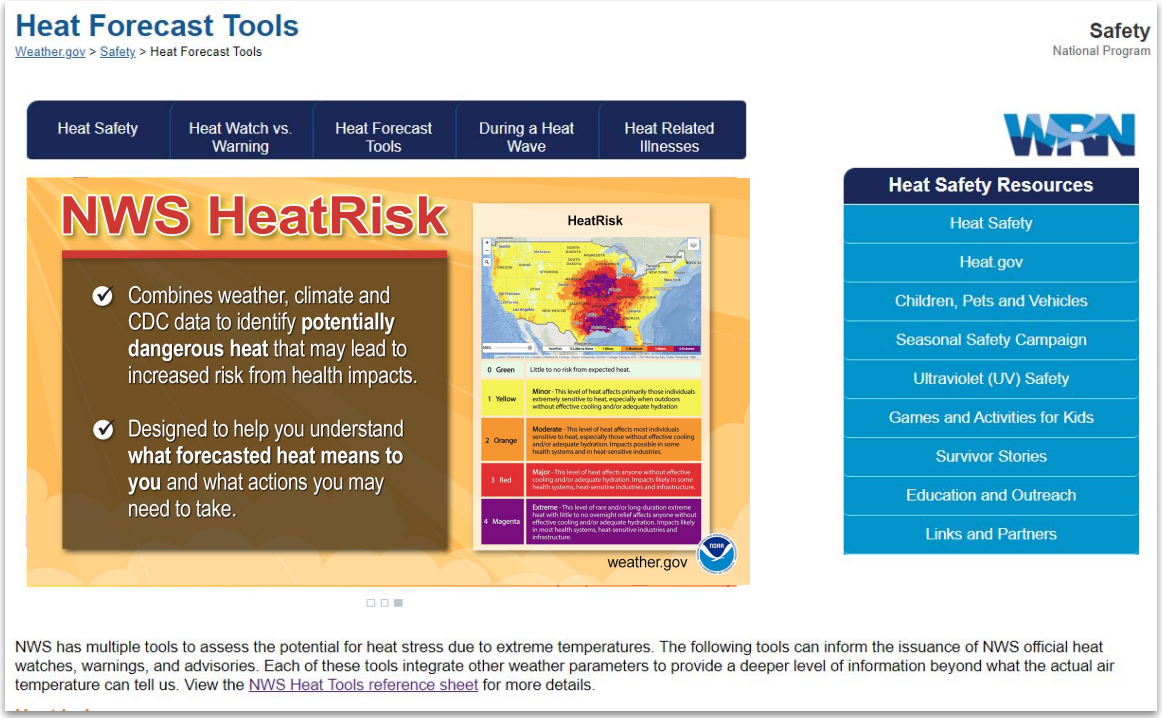
Risk of heat related impacts in **climatological context** with CDC heat-health information.

- Impacts-based: MaxT + MinT + CDC heat-health data
- Spectrum of heat-health impacts for *all* populations

Resources

https://www.weather.gov/safety/heat-index

- Overview of each of the three NWS heat tools
- Downloadable reference sheet
- Additional resources and outreach materials



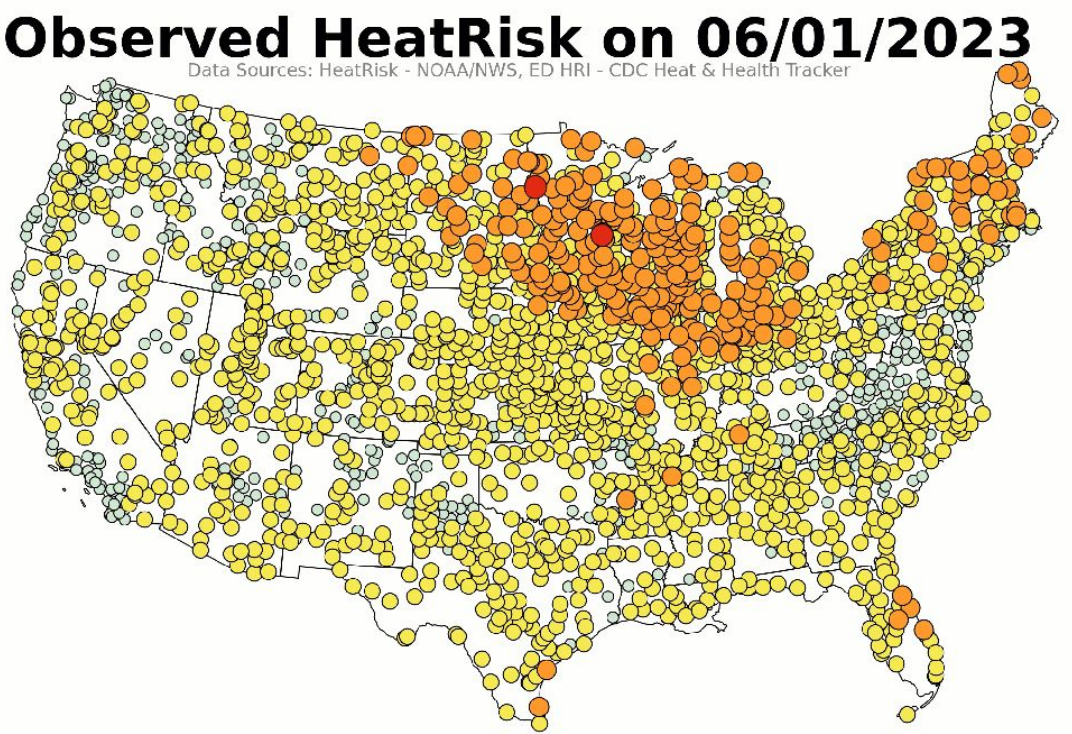
Thanks!

NWS

- Mike Staudenmaier, WRH/STID
- Chad Kahler, WRH/STID
- Mark Loeffelbein, WRH/STID
- Kimberly McMahon, Public Program
- Jessica Lee, Public Program
- Paul Iniguez, formerly of WFO Phoenix
- William Rasch, SOO WFO Sacramento
- Andrea Bair, WRH/ISD

CDC

- Ambarish Vaidyanathan, CDC



Feedback on HeatRisk can be made here: https://www.surveymonkey.com/r/ExpNWSHeatRisk_2024

Questions

To ask a question, open your toolbar

Go to the Questions header

Type in your question and hit enter.