NWS-CDC Joint Webinar on Experimental NWS HeatRisk

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Mike Staudenmaier - NWS HeatRisk Developer

Ambarish Vaidyanathan - CDC Senior Health Scientist

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

Weather Fatalities 2022
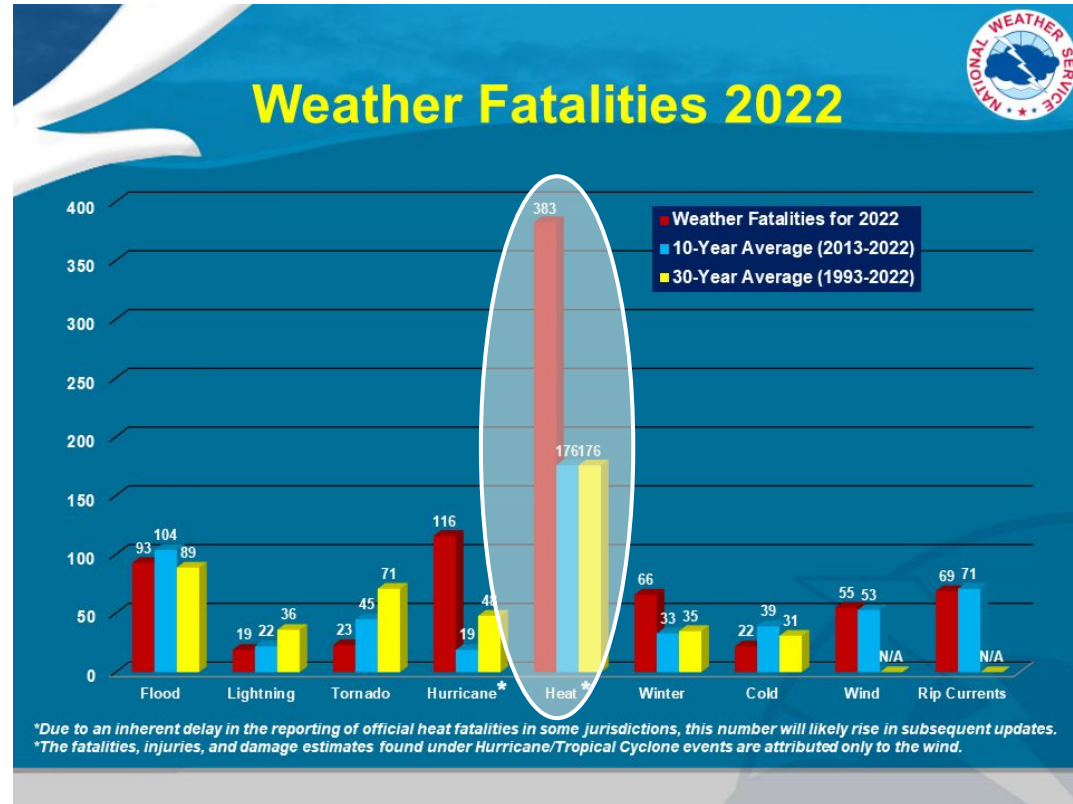
Agency Collaboration

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
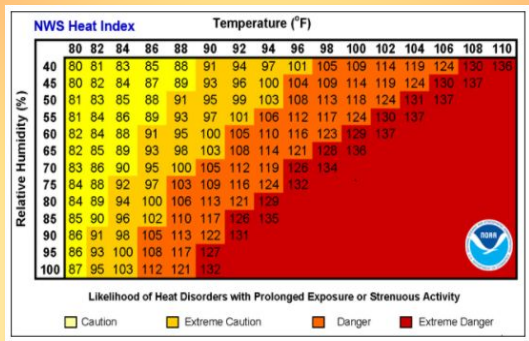- Pets and Service and Support Animals

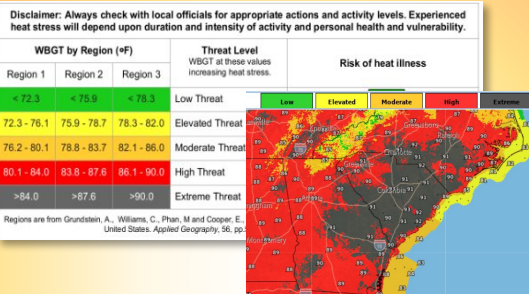# NWS Forecast Tools to Assess Heat

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.

Kind of like AQI…

	AQI AIR QUALITY INDEX	
Good	0-50	
Moderate	51-100	
Unhealthy for sensitive groups	101-150	
Unhealthy	151-200	
Very Unhealthy	201-300	
Hazardous	301-500	

Simple Numeric/Color System   **Excellent Geographical Coverage**   **But for Heat!**
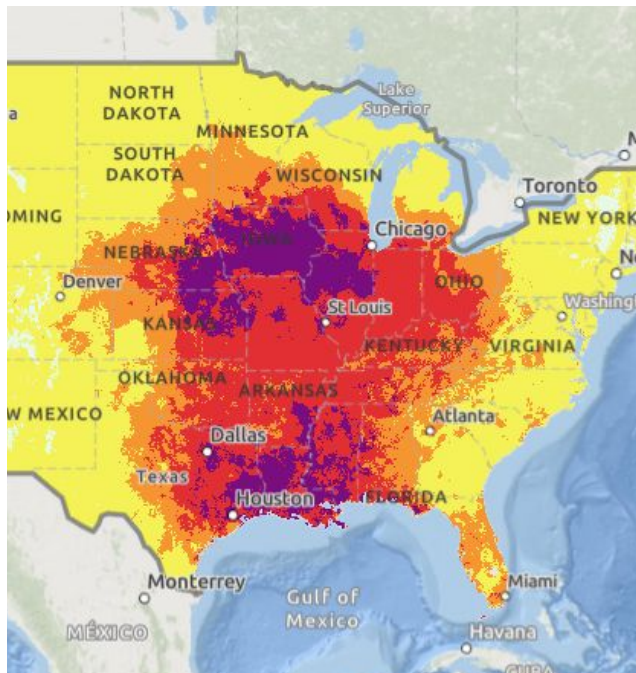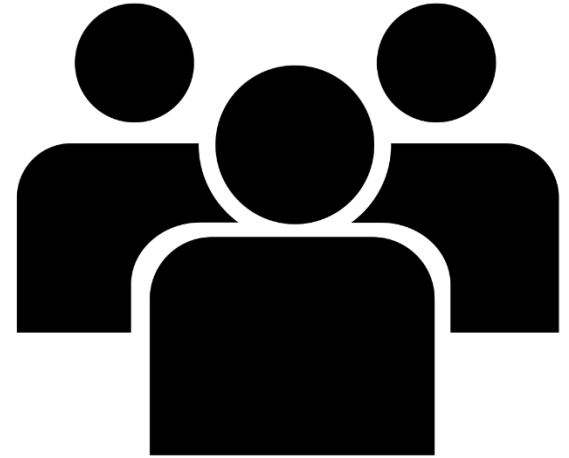
HeatRisk Basic Tenets

- 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
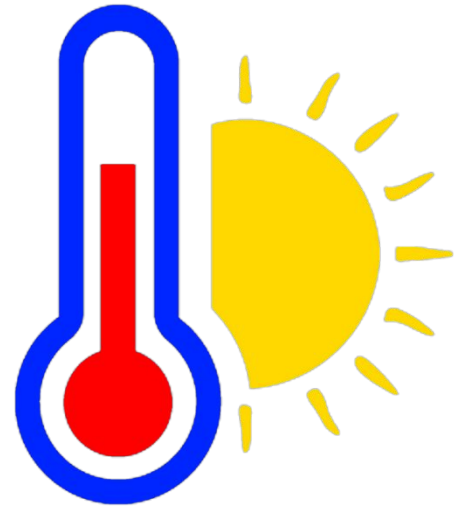
HeatRisk Considerations

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)
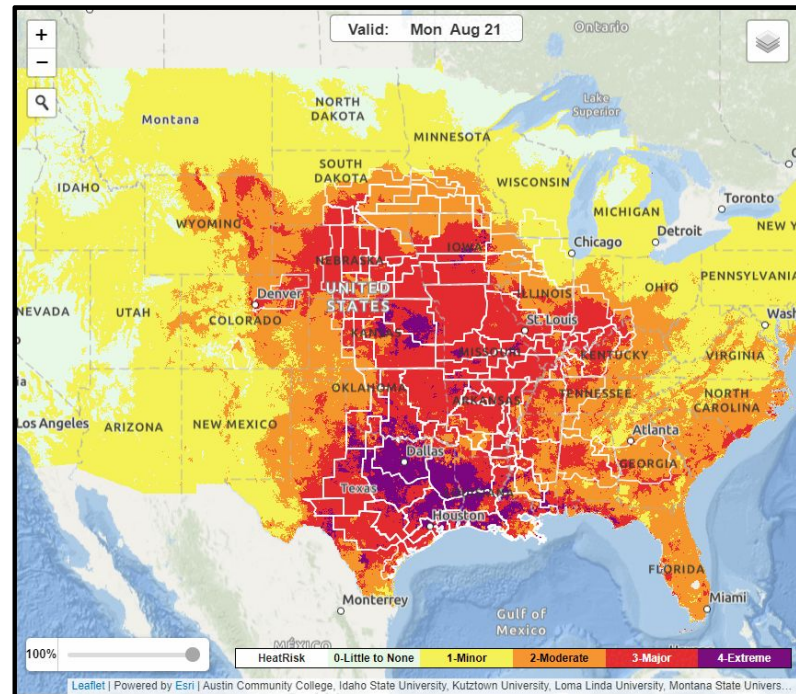
CDC-NWS Collaboration

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.
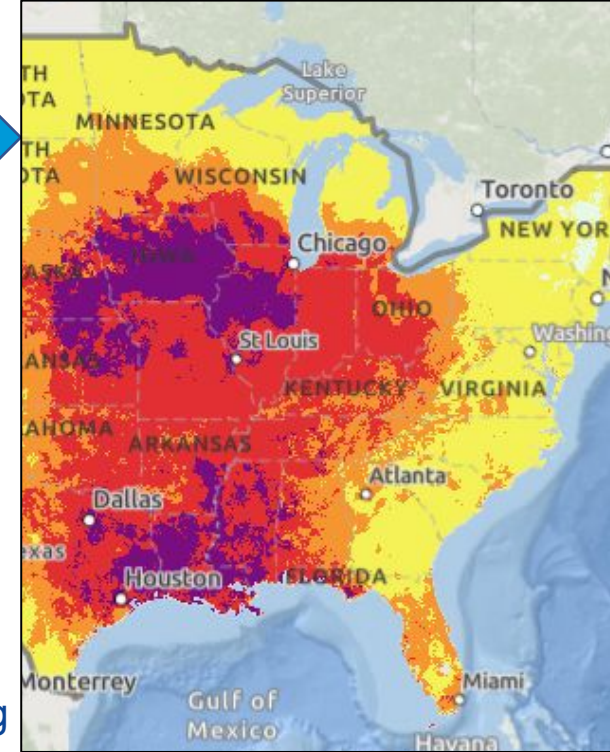
Data Sources and Analytical Framework

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

U.S. Standard Certificate of Death		
AL FILE NO.		STATE FILE NO.
1. DECEDENT'S LEGAL NAME (Include AKA's if any) (First, Middle, Last)	2. SEX	3. SOCIAL SECURITY NUMBER
4a. AGE-Last Birthday (Years) / 4b. UNDER 1 YEAR Months Days / 4c. UNDER 1 DAY Hours Minutes	5. DATE OF BIRTH (Mo/Day/Yr)	6. BIRTHPLACE (City and State or Foreign Country)

Part I

CAUSE OF DEATH (See instructions and examples)

32. **PART I.** Enter the chain of events--diseases, injuries, or complications--that directly caused the death. DO NOT enter terminal events such as cardiac arrest, respiratory arrest, or ventricular fibrillation without showing the etiology. DO NOT ABBREVIATE. Enter only one cause on a line. Add additional lines if necessary.

Approximate interval: Onset to death

IMMEDIATE CAUSE (Final disease or condition resulting in death) a. ___

Due to (or as a consequence of):

Sequentially list conditions, if any, leading to the cause listed on line a. Enter the **UNDERLYING CAUSE** (disease or injury that initiated the events resulting in death) **LAST**

b. ___

Due to (or as a consequence of):

c. ___

Due to (or as a consequence of):

d. ___

> Underlying cause information

Part II

PART II. Enter other significant conditions contributing to death but not resulting in the underlying cause given in PART I

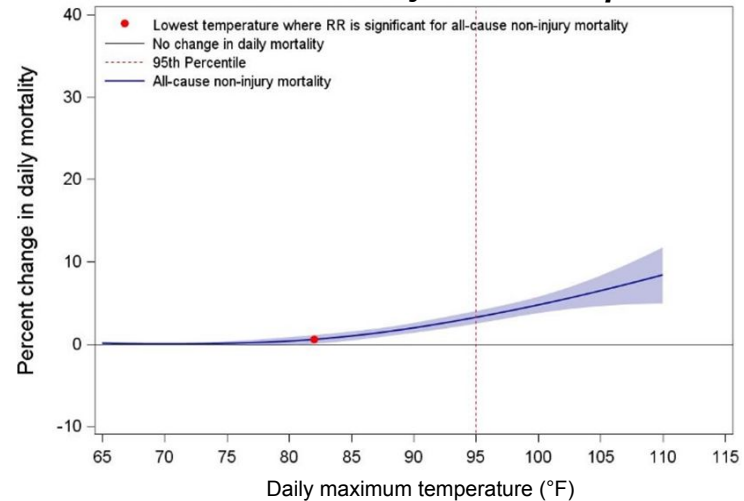WAS AN AUTOPSY PERFORMED?

NGS AVAILABLE TO F DEATH? ☐ Yes ☐ No

DID TOBACCO USE CONTRIBUTE | IF FEMALE:

> Contributing cause information

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

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

U.S. Standard Certificate of Death

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

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

Statistical Attribution Approach

Heat-Mortality Relationship

- 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)
  - <u>Heat exposure measures:</u> 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.

Heat-Mortality Relationship

Heat-Mortality Relationship

Cooler Climate

Warmer Climate

Heat-Attributable Deaths (Health Impacts)
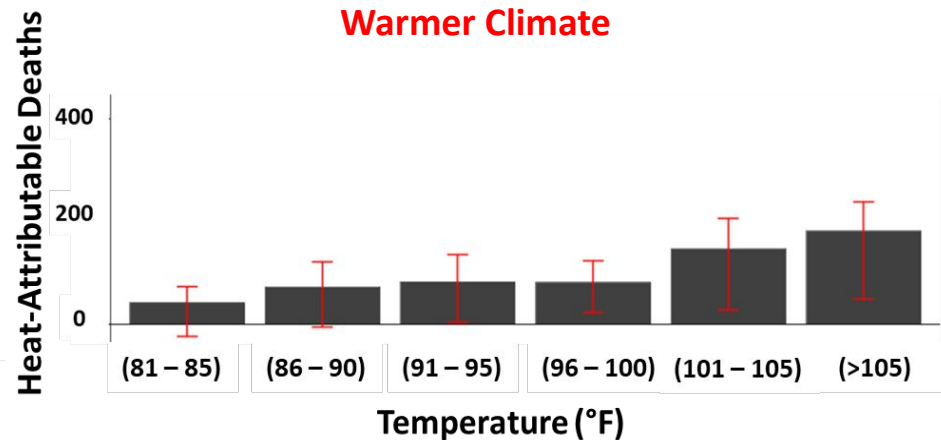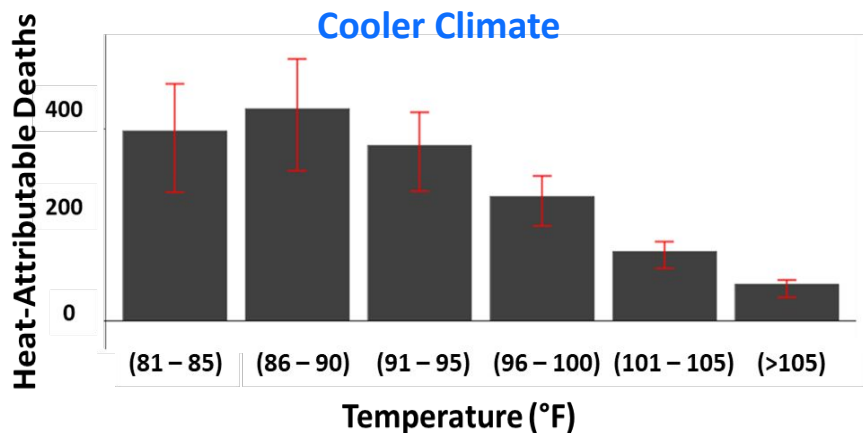
Generating Local Heat-Health Impacts

Percent of Heat-Attributable Deaths (PHAD) = $\dfrac{\text{Heat-Attributable Deaths at a Specific Temperature} \times 100}{\text{All Heat-Attributable Deaths}}$

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

NOAA/NWS HeatRisk - MaxT Heat Impact Levels
Yourtown, USA
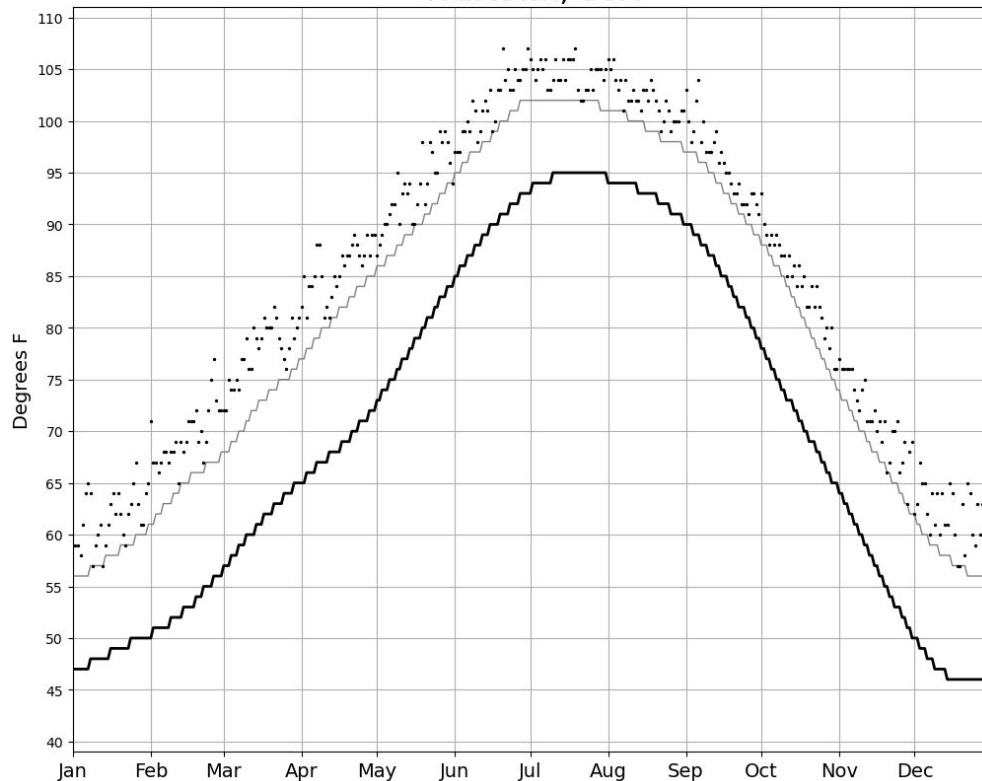
- HeatRisk leverages local climatology normals, including the 95th percentile of temperatures to identify excessive heat for *that* location

- 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

NOAA/NWS HeatRisk - MaxT Heat Impact Levels
Yourtown, USA
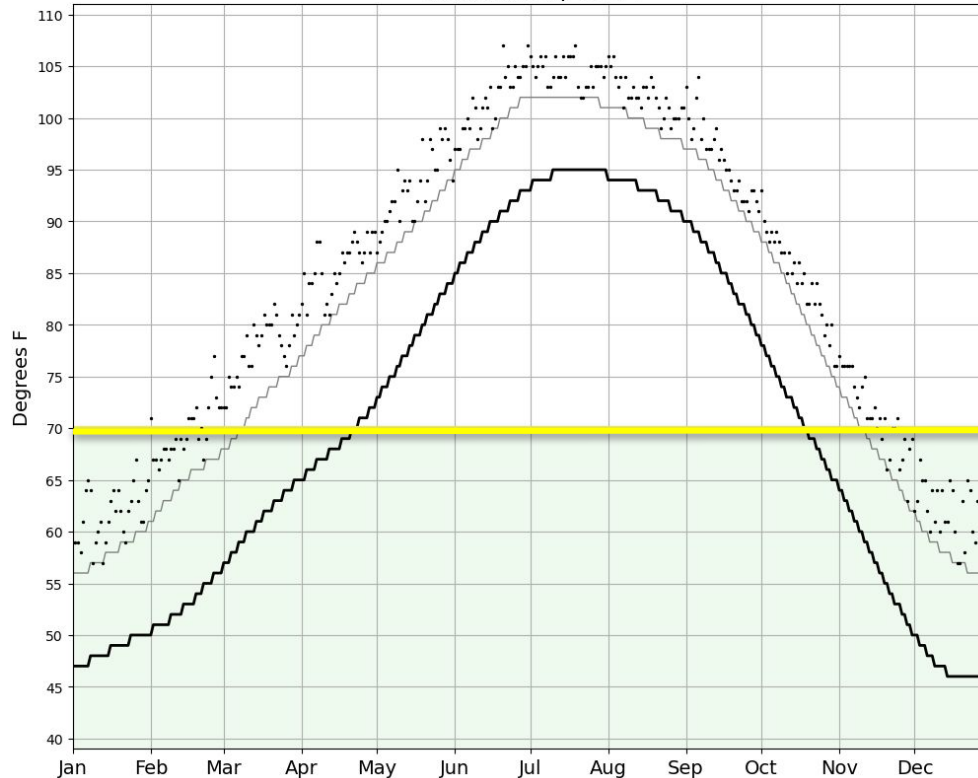
- The first threshold we define is the Yellow threshold

- 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

HeatRisk v2.5 - Yellow MaxT Threshold

Degrees F
105
65
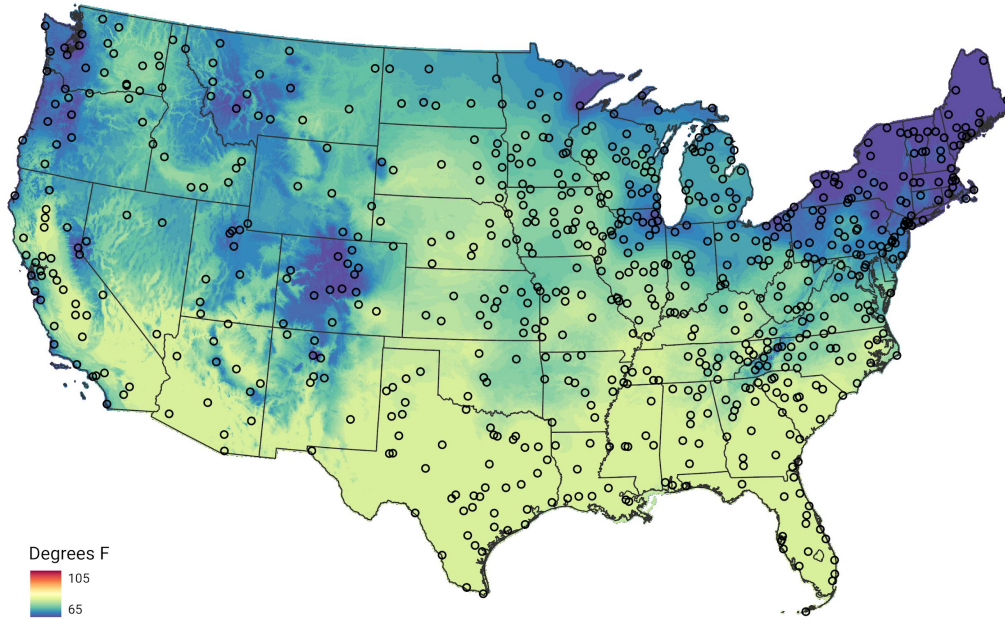
- Map of the Yellow maximum temperature threshold across the US based on CDC-derived data for ~700 stations.

- 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

NOAA/NWS HeatRisk - MaxT Heat Impact Levels
Yourtown, USA
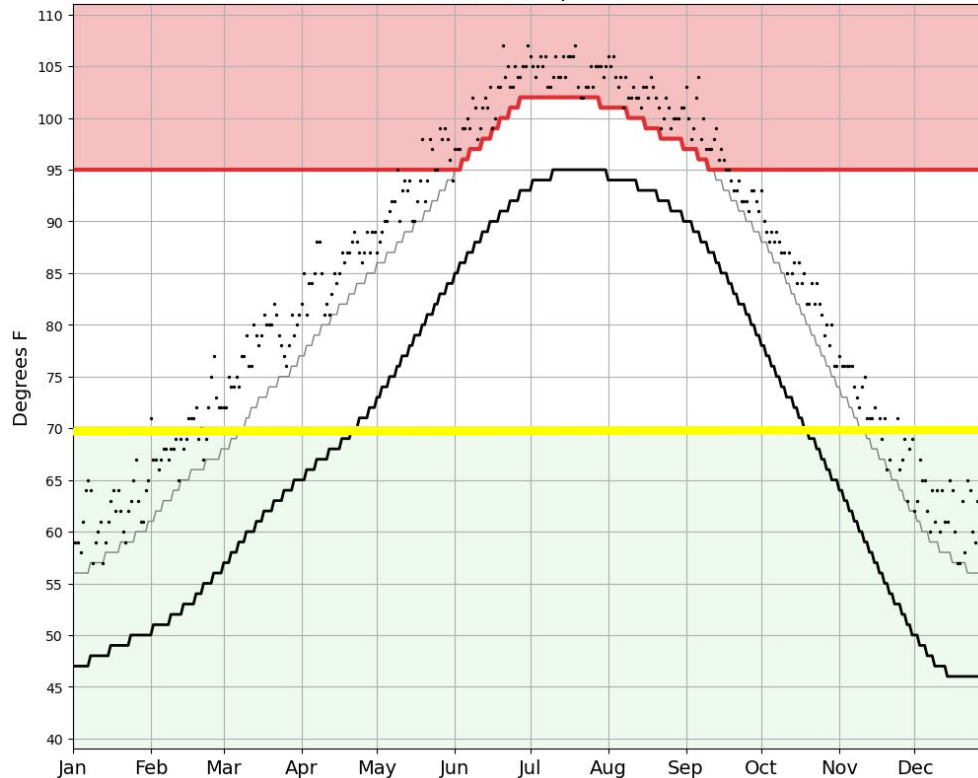
- The "base" Red threshold is based on the 50th percentile of heat- attributable deaths from the CDC data

- 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

NOAA/NWS HeatRisk - MaxT Heat Impact Levels
Yourtown, USA
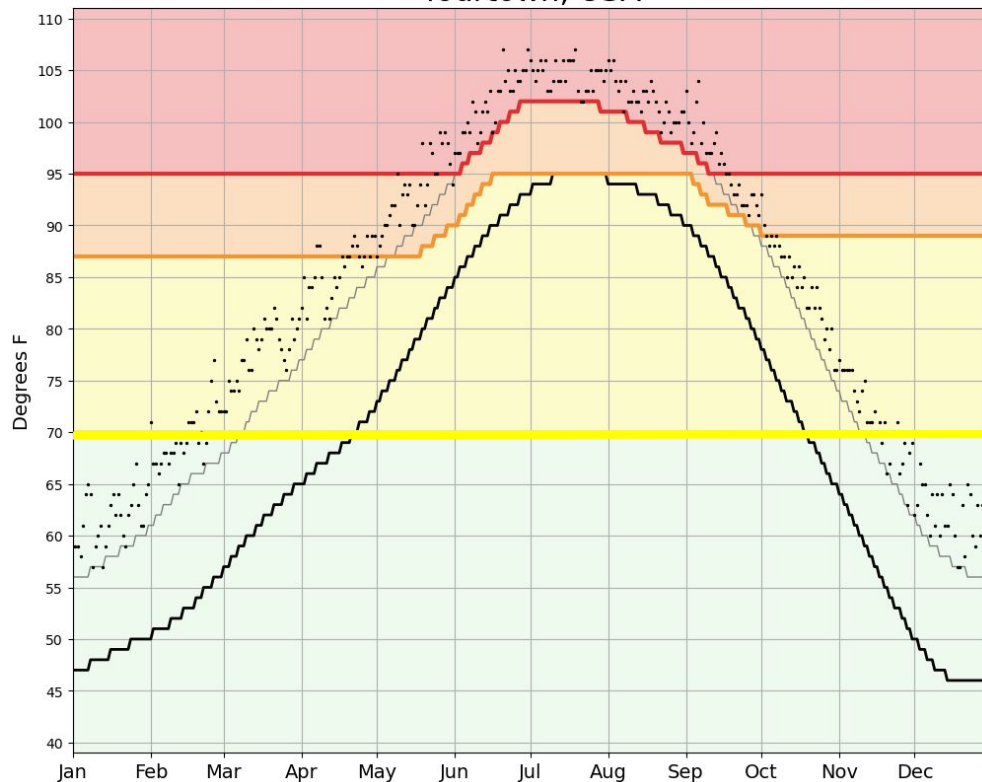
- Finally the **Orange** threshold is generated

- 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

NOAA/NWS HeatRisk - MinT Heat Impact Levels
Yourtown, USA
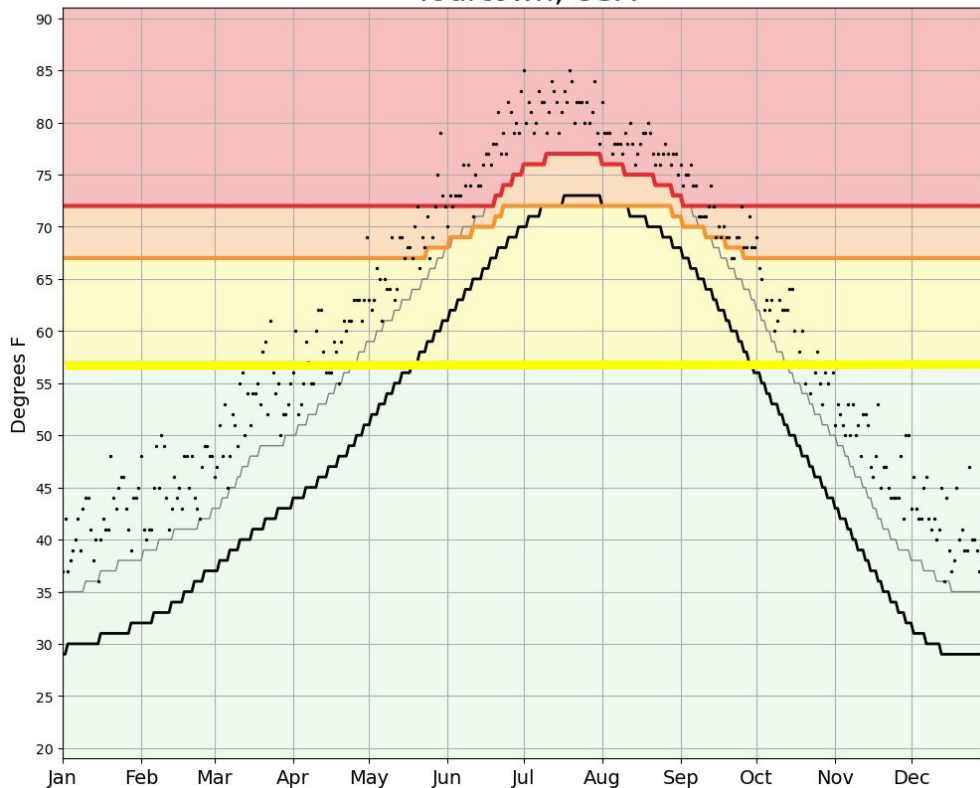
- For minimum temperature, Orange and Red thresholds are based primarily on climatology. Yellow levels are based on CDC thresholds and climatology.

- Minimum temperatures are used in the 24-hour HeatRisk approach to better account for:
  - Overnight relief potential
  - Humidity

How HeatRisk Works

HeatRisk v2.5 - Climate Stations
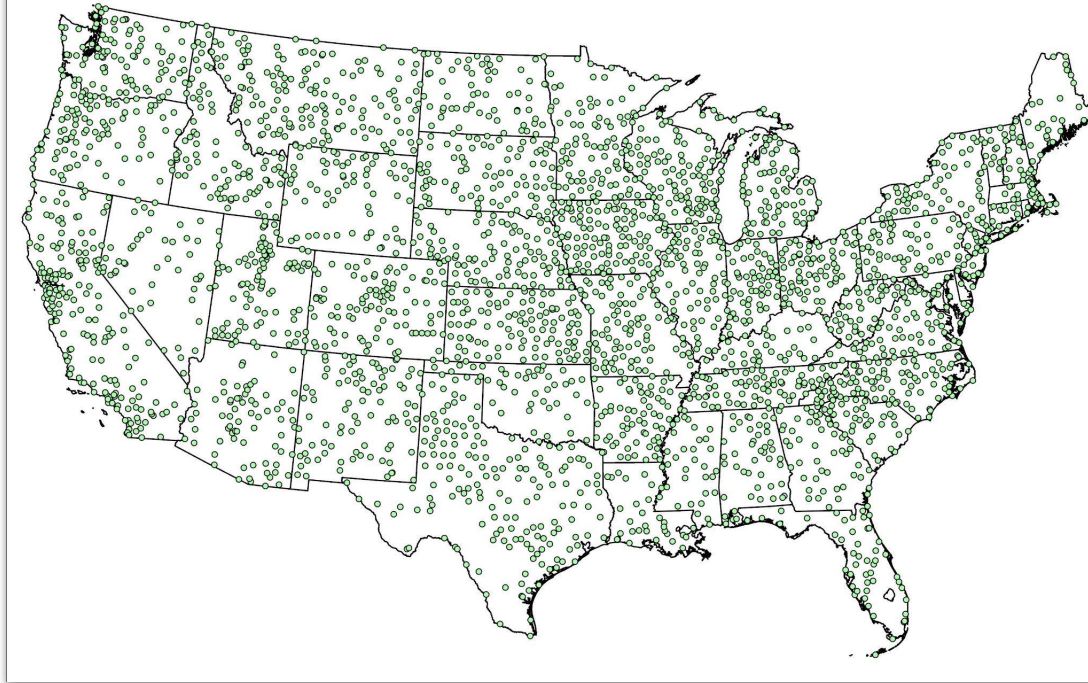
This process is applied to ~3100 stations across the Contiguous US

How HeatRisk Works

NOAA/NWS HeatRisk v2.5 - MaxT Heat Impact Levels
WASHINGTON REAGAN NATIONAL AIR, VA (USW00013743)
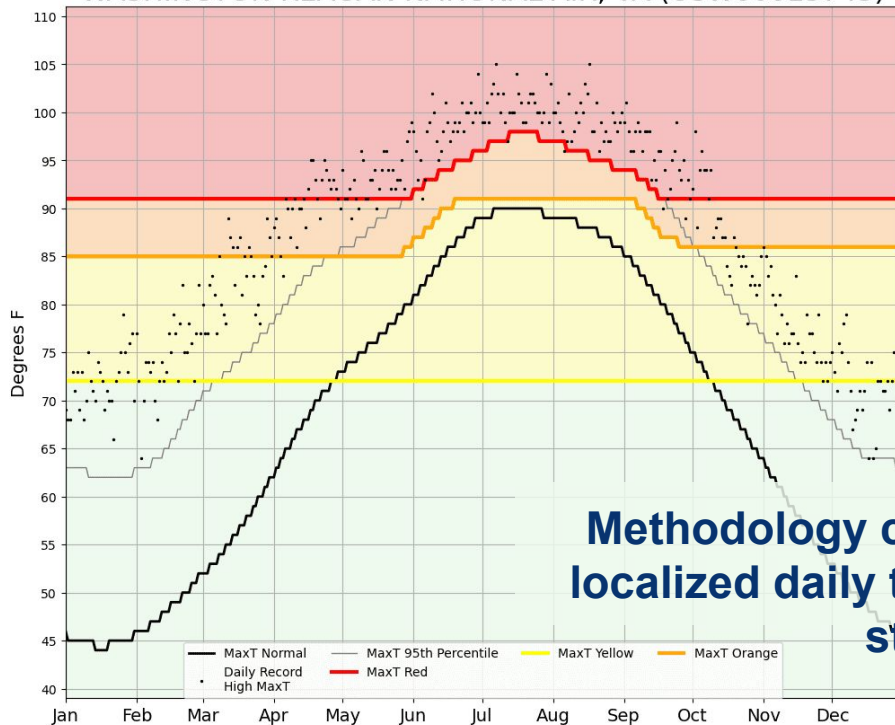
NOAA/NWS HeatRisk v2.5 - MaxT Heat Impact Levels
LOS ANGELES DOWNTOWN/USC, CA (USW00093134)
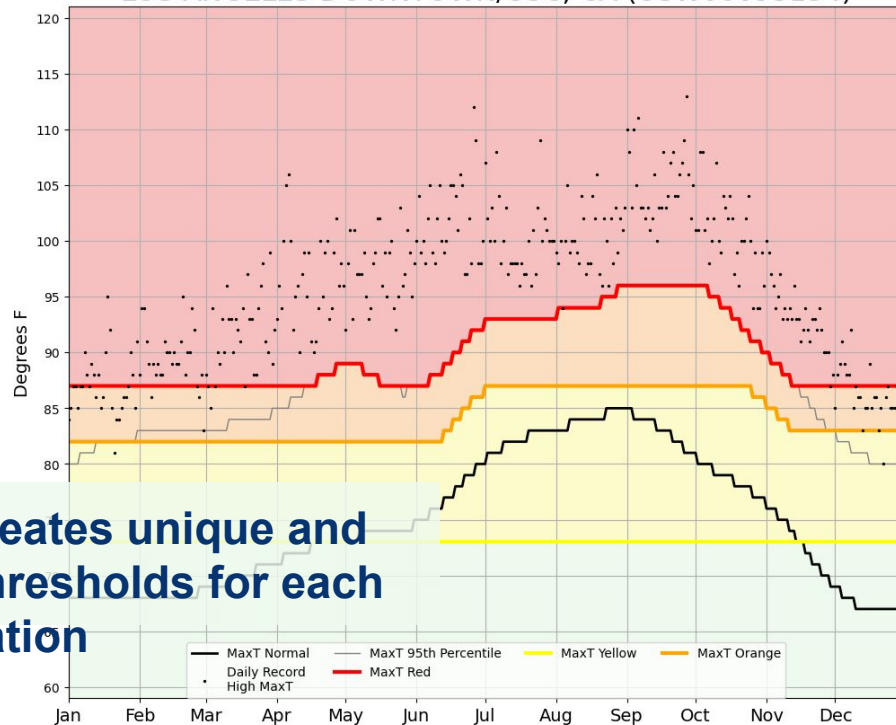
Methodology creates unique and localized daily thresholds for each station

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)

Avg. Peak Dew Point (1991-2020, PRISM)
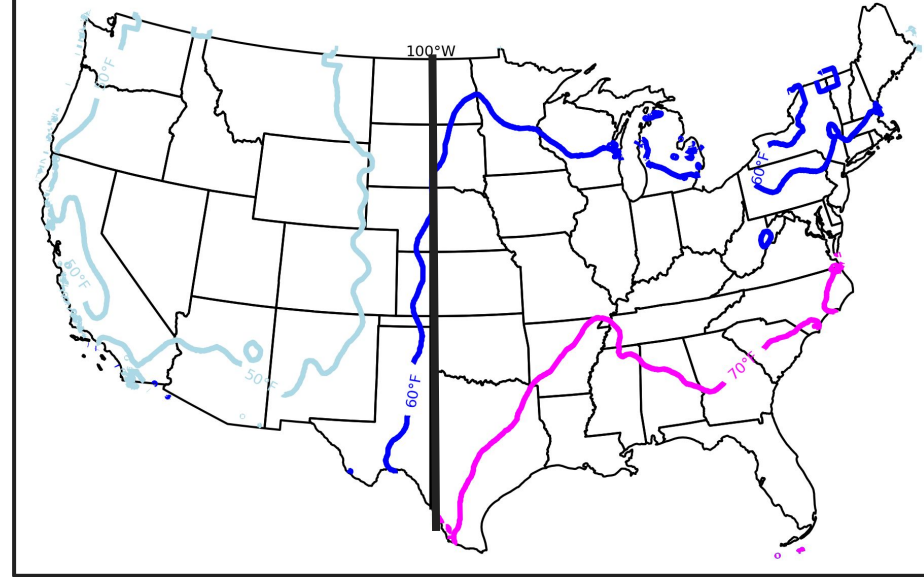
HeatRisk Algorithm - Combining to 24 hour value

	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

NCEI Points

Climatology grids
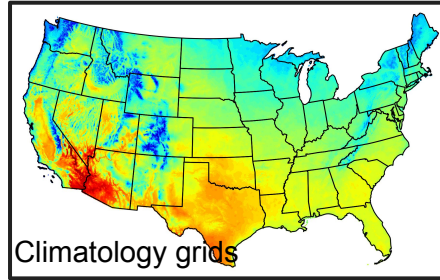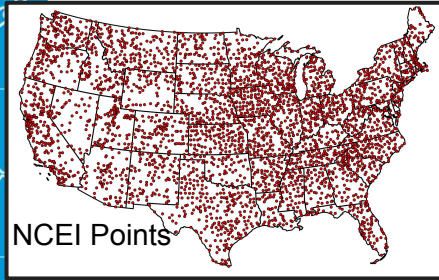
Magenta - Two or three consecutive 24-hr periods are >= 95th percentile, and/or highs are near or above all time records
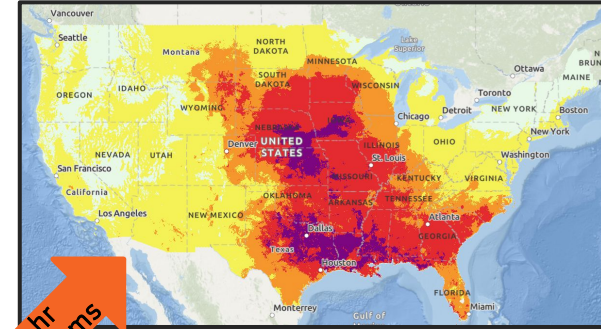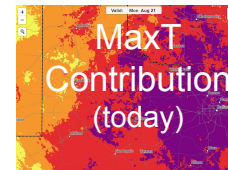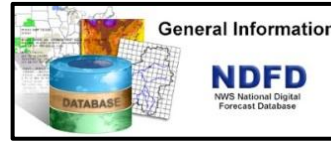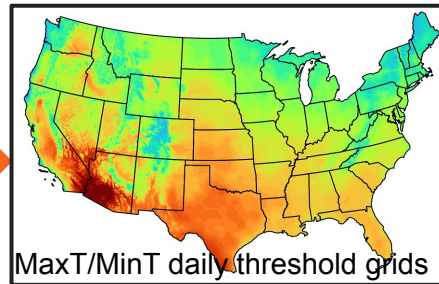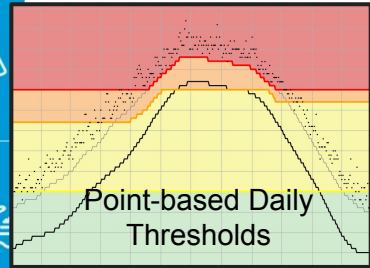
General Information
NDFD
NWS National Digital Forecast Database
DATABASE

Daily 24-hour HeatRisk

Point-based Daily Thresholds

MaxT/MinT daily threshold grids

MaxT Contribution (today)

MinT Contributions (today/tomorrow)

24-hr Algorithms

Point Thresholds

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).

Analysis of Daily HeatRisk Values and Emergency Department Heat-Related Injury Visits for Apr 1st through Oct 31st from 2019 to 2023

HHS/FEMA REGION X — Corr (log): 0.83
HHS/FEMA REGION I — Corr (log): 0.80
HHS/FEMA REGION IX — Corr (log): 0.86
HHS/FEMA REGION II — Corr (log): 0.82
HHS/FEMA REGION VIII — Corr (log): 0.81
HHS/FEMA REGION VII — Corr (log): 0.81
HHS/FEMA REGION VI — Corr (log): 0.90
HHS/FEMA REGION V — Corr (log): 0.86
HHS/FEMA REGION IV — Corr (log): 0.89
HHS/FEMA REGION III — Corr (log): 0.85

Total Daily ED HRI Visits per 100k ED Visits
Average Daily HeatRisk Value

Very High
High
Moderate
Low
None

Observed HeatRisk on 06/28/2021
ED HRI Visit Rate 9652 per 100k

Author: NOAA/NWS Western Region HQ
Data Sources: HeatRisk v2.5 (NOAA/NWS), ED HRI (CDC Heat & Health Tracker)

Impact-Based Verification

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

Population Weighted

HHS Region 01 (CT, ME, MA, NH, RI, and VT)
Correlation (Spearman's rank-order): 0.77

HHS Region 02 (NJ, NY, PR, and VI)
Correlation (Spearman's rank-order): 0.80

HHS Region 03 (DC, DE, MD, PA, VA, and WV)
Correlation (Spearman's rank-order): 0.86

HHS Region 04 (AL, FL, GA, KY, MS, NC, SC, and TN)
Correlation (Spearman's rank-order): 0.92

HHS Region 05 (IL, IN, MI, MN, OH, and WI)
Correlation (Spearman's rank-order): 0.85

HHS Region 06 (AR, LA, NM, OK, and TX)
Correlation (Spearman's rank-order): 0.93

HHS Region 07 (IA, KS, MO, and NE)
Correlation (Spearman's rank-order): 0.87

HHS Region 08 (CO, MT, ND, SD, UT, and WY)
Correlation (Spearman's rank-order): 0.84

HHS Region 09 (AZ, CA, HI, NV, AS, GU, FM, MH, MP, and PW)
Correlation (Spearman's rank-order): 0.80

HHS Region 10 (AK, ID, OR, and WA)
Correlation (Spearman's rank-order): 0.87

Rate of HRI per 100,000 ED visits

HeatRisk

Trend line: Daily HeatRisk vs. HRI rate

Daily HeatRisk vs. HRI rate
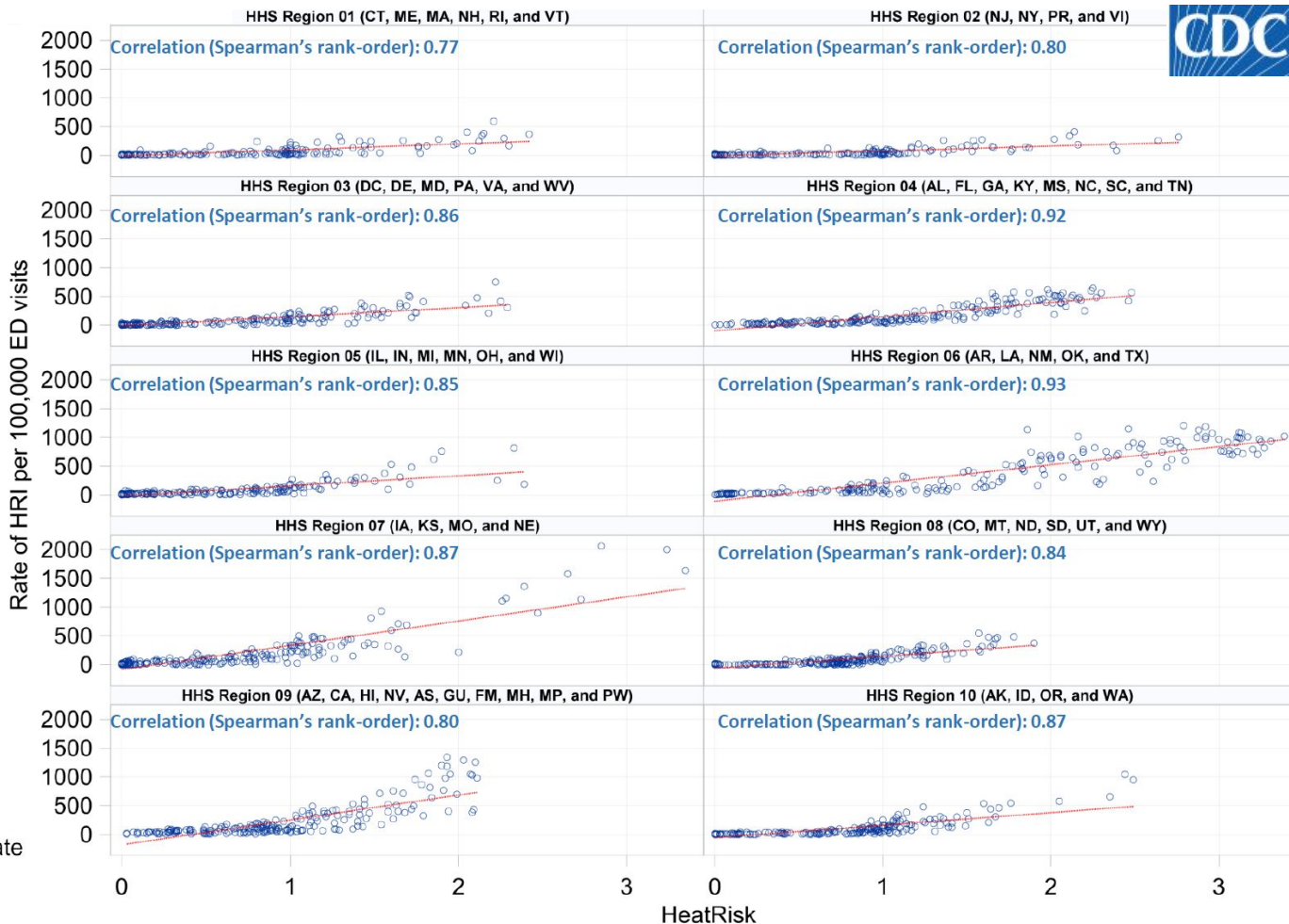
Impact Based Verification

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.
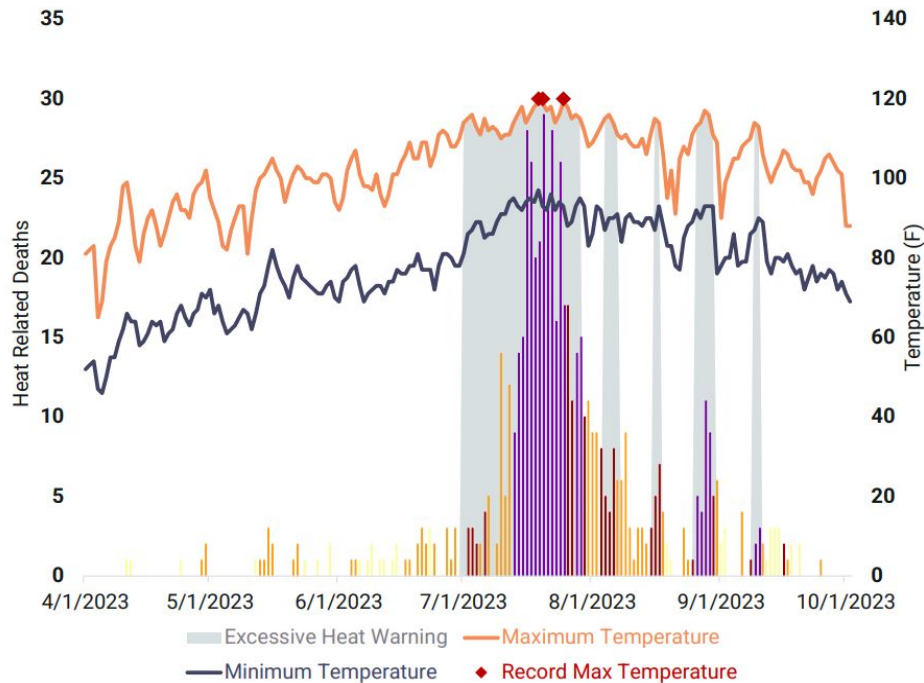
Legend: Excessive Heat Warning — Maximum Temperature — Minimum Temperature ◆ Record Max Temperature

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.

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.

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

None	Minor	Moderate	Major	Extreme
No risk.	Risk to those extremely sensitive to heat.	Risk to those sensitive to heat.	Risk to most people.	Risk to everyone.

7%	24%	15%	52%

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.

2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
76	61	84	154	179	182	199	323	339	425	645

+52%
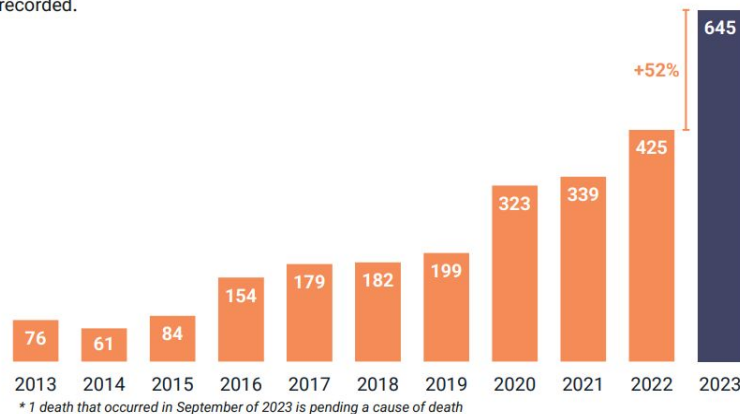
* 1 death that occurred in September of 2023 is pending a cause of death

WPC HeatRisk CONUS Viewer

https://www.wpc.ncep.noaa.gov/heatrisk
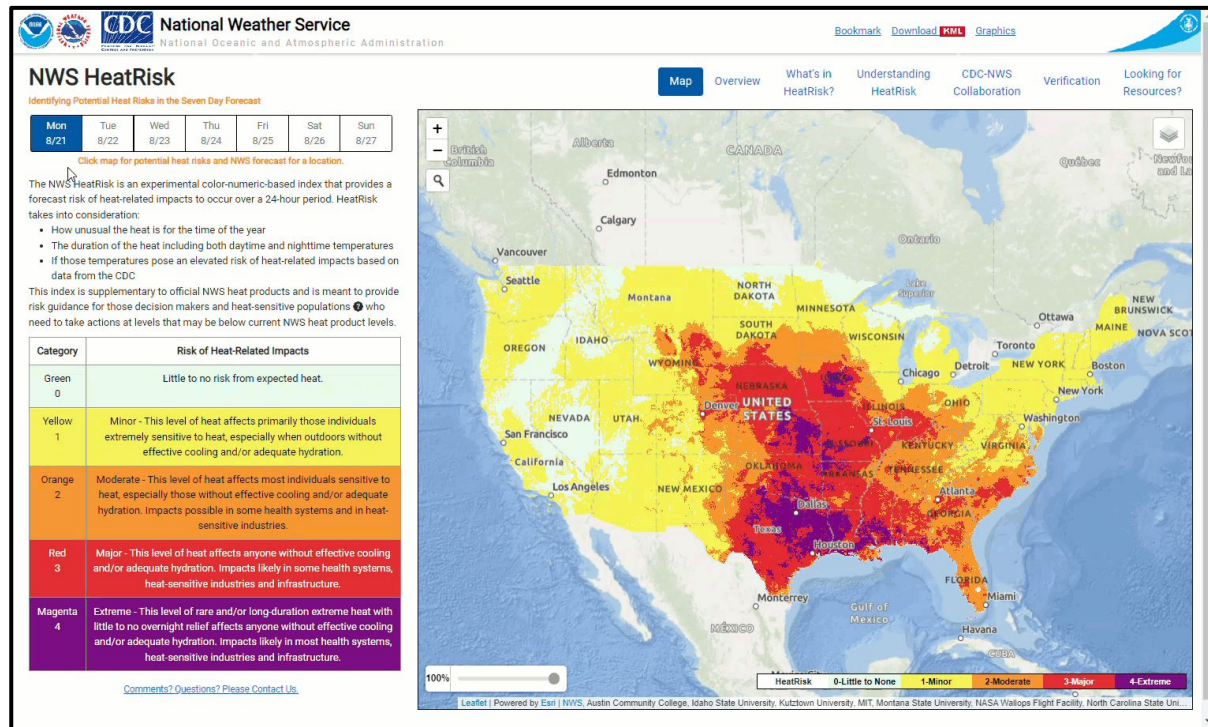
- Access daily interactive maps with point-based forecasts

- 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
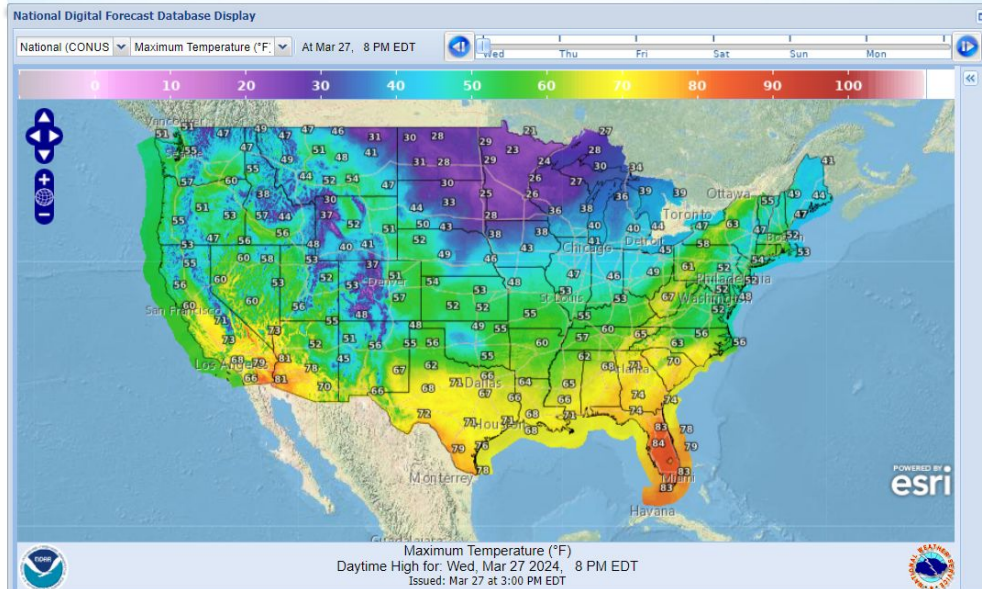
- HeatRisk will be available on NDFD for all CONUS locations by the end of May

- Data formats: GRIB2, XML, and WMS

Partner Usage

CDC HeatRisk Dashboard

www.cdc.gov/heatrisk

CDC HeatRisk Dashboard

www.cdc.gov/heatrisk

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.

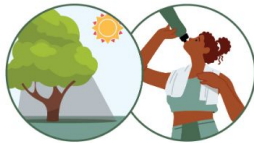Heat can make air quality worse. Check the air quality in your area before heading out.

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.
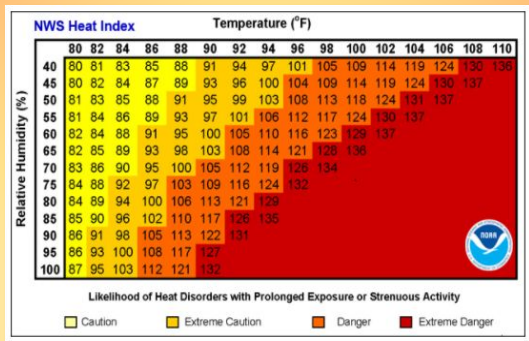
Go to Heat and Your Health to learn more.

NWS Forecast Tools to Assess Heat
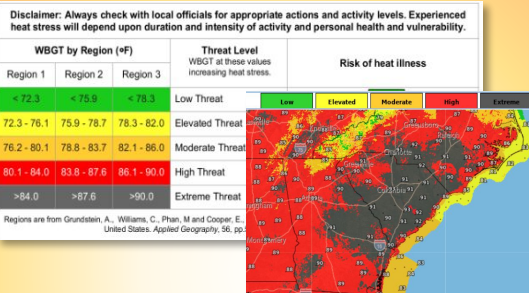
Heat Index

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

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

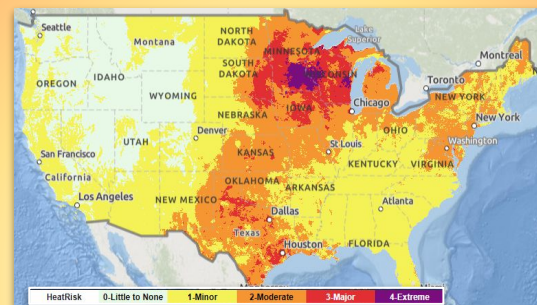5'7" adult, 147.7 lbs, walking outside at 3.1 mph, wearing trousers and short sleeved shirt

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

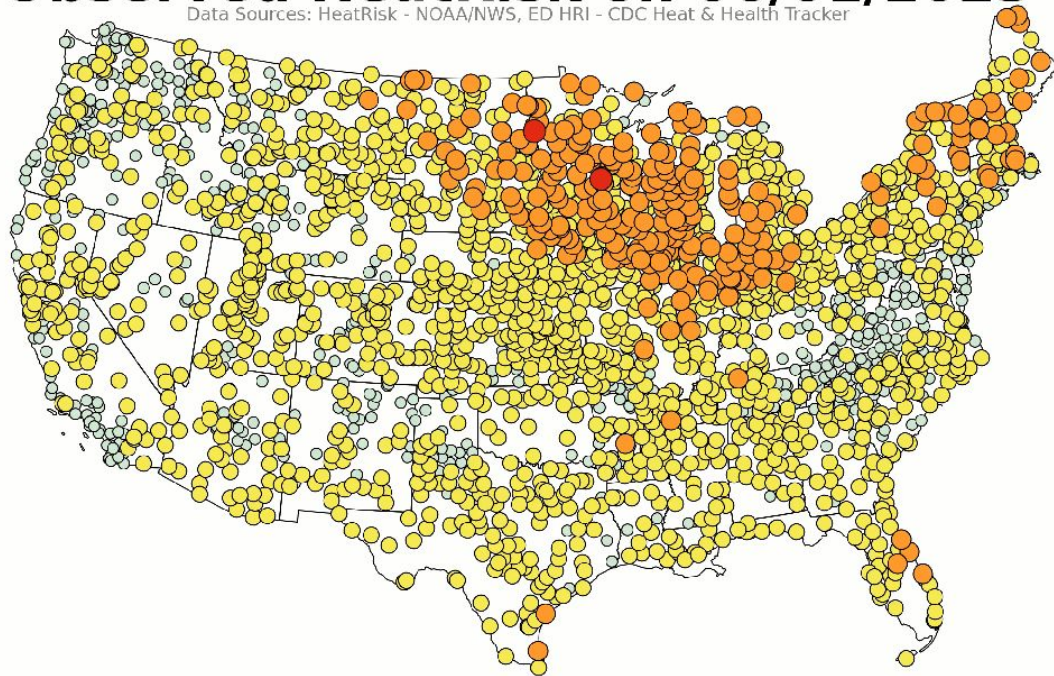- Additional resources and outreach materials

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

Observed HeatRisk on 06/01/2023
Data Sources: HeatRisk - NOAA/NWS, ED HRI - CDC Heat & Health Tracker

Questions

To ask a question, open your toolbar

Go to the Questions header

Type in your question and hit enter.