

# The National Weather Service

Urban Heat Island Workshop  
October 31, 2023



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NOAA - NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION  
NWS - Tucson, AZ

# Presentation Summary

## Heat Forecasting Tools

- Heat Index
- Wet Bulb Globe Temperature
- HeatRisk
- NOAA UHI Campaign

## National Blend of Models

- Calibration
- Probabilistic

# Heat Index



**NWS**

NATIONAL WEATHER SERVICE  
TUCSON, AZ

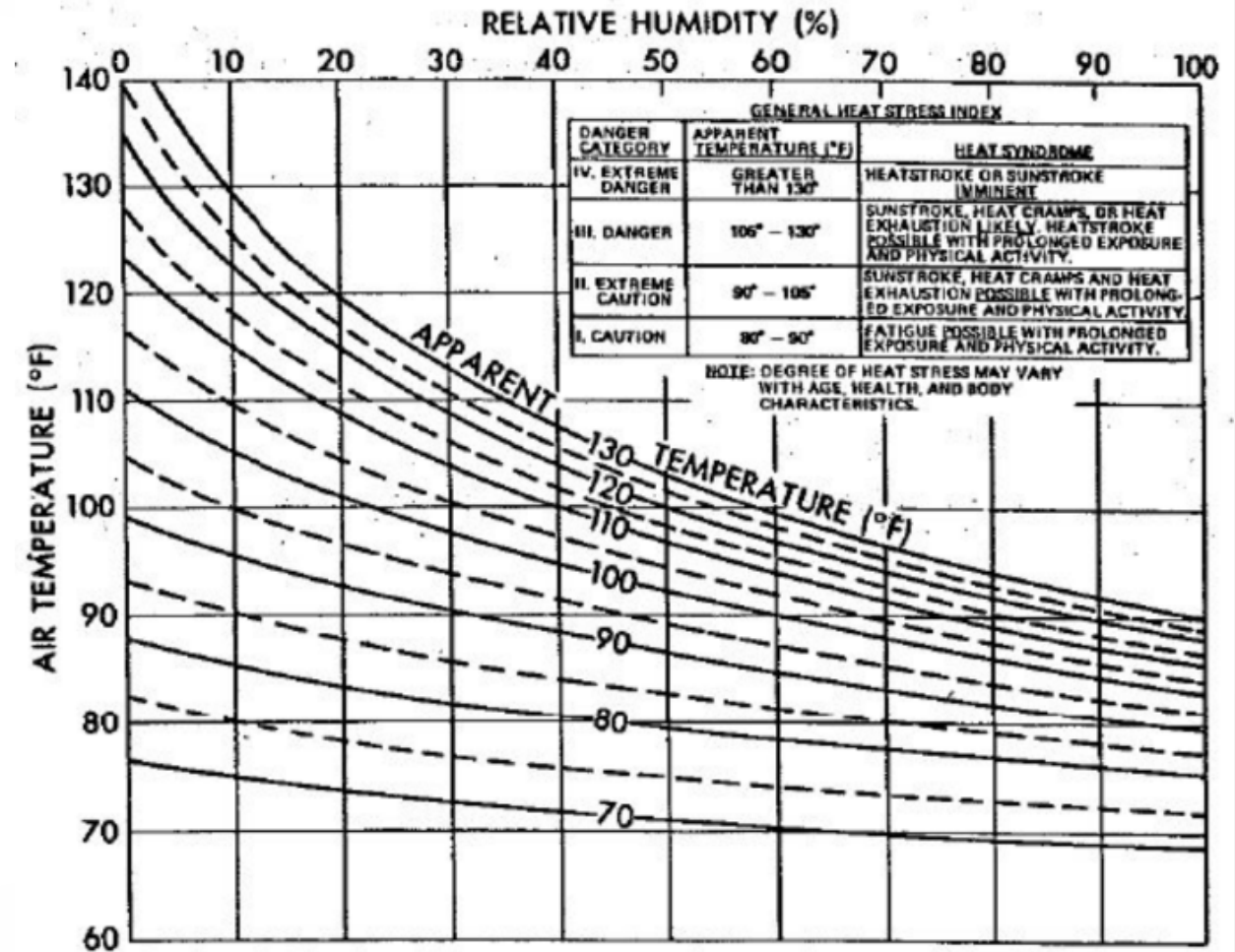
# Heat Index (Apparent Temperature)

Robert Steadman developed mathematical equations to measure the impacts of high temperatures and high humidity on the human body; and to quantify the effects of clothing, sunshine, wind, and other parameters.

• Includes several (21) parameters and assumptions:

- body mass & height
- Clothing
- physical activity
- heat tolerance
- sunlight and UV exposure
- wind speed

Figure 1. The relationship of air temperature and relative humidity to apparent temperature, (after Steadman, 1979). This graph can be used for various combinations of temperature and relative humidity. For areas with low relative humidities, the apparent temperature tends to be lower than the air temperature.



Quayle, R. and Doehring, F. 1981. Heat stress: A comparison of indices. *Weather-wise*, 34: 120-124.

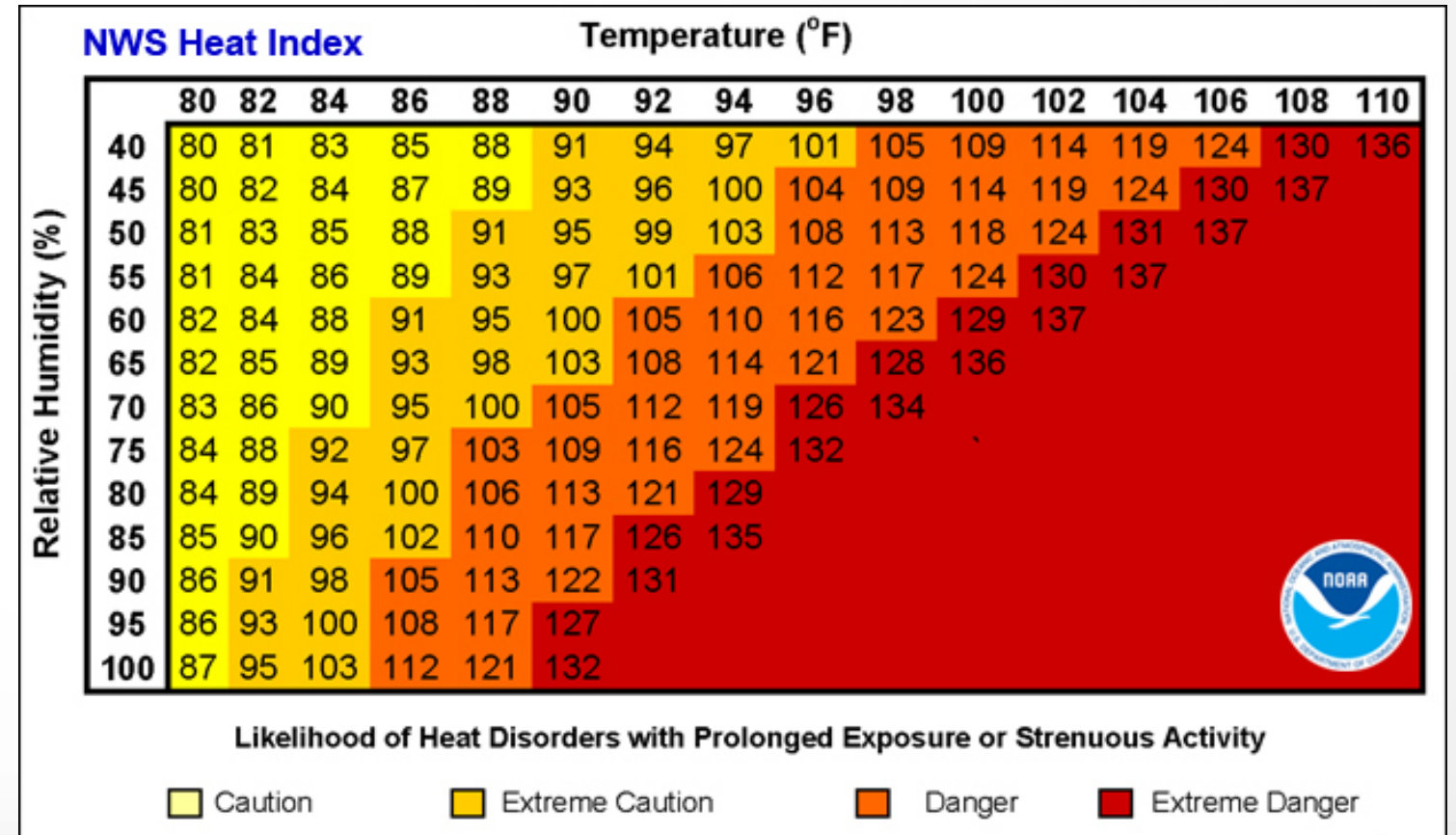
# Heat Index Equation

Derived from Steadman's work and simplified by Lans Rothfus

$$HI = -42.379 + 2.04901523T + 10.14333127R - 0.22475541TR - 6.83783 \times 10^{-3}T^2 - 5.481717 \times 10^{-2}R^2 + 1.22874 \times 10^{-3}T^2R + 8.5282 \times 10^{-4}TR^2 - 1.99 \times 10^{-6}T^2R^2$$

where T = ambient dry bulb temperature (°F)  
R = relative humidity (integer percentage).

- The NWS Peachtree Office color coded Steadman's chart



# Heat Index: Known Issues

- Discrepancies between the calculator and the chart
  - Rounding errors
- HI chart data does not go beyond 137°F
  - Max temperature parameter in original equations is 122°F
- HI is calculated for shady areas
  - Steadman notes that full sun can increase the apparent temperature.
  - Disclaimer on NWS website: “...exposure to full sunshine can increase heat index values by up to 15°F.”

# Heat Index: Known Issues

- Assumptions
  - 5'6" adult
  - 147.7 lbs
  - Walking outside at 3.1 mph
  - Wearing trousers and short sleeved shirt or blouse
- Not an accurate measure of heat impacts on active individuals who are outdoors
- May not be the best indicator of heat impacts in areas with low humidity



# Resources for Heat Index

- Tech Attachment:

- [https://www.weather.gov/media/ffc/ta\\_htindx.PDF](https://www.weather.gov/media/ffc/ta_htindx.PDF)

- NWS Heat Safety Page:

- [www.weather.gov/safety/heat](http://www.weather.gov/safety/heat)

## Heat Safety Tips and Resources

[Weather.gov](http://Weather.gov) > [Safety](#) > Heat Safety Tips and Resources

Safety  
National Program



Heat Safety	Heat Watch vs. Warning	Heat Forecast Tools	During a Heat Wave	Heat Related Illnesses
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**Practice HEAT SAFETY Wherever You Are**

Heat related deaths are preventable. Protect yourself and others from the impacts of heat waves.

**Job Sites**  
Stay hydrated and take breaks in the shade as often as possible.

**Indoors**  
Check up on the elderly, sick and those without AC.

**Vehicles**  
Never leave kids or pets unattended - LOOK before you LOCK

**Outdoors**  
Limit strenuous outdoor activities, find shade, and stay hydrated.

[weather.gov/heat](http://weather.gov/heat)

Heat Safety Resources
Heat Safety
Heat.gov
Children, Pets and Vehicles
Seasonal Safety Campaign
Ultraviolet (UV) Safety
Games and Activities for Kids
Survivor Stories
Education and Outreach
Links and Partners









# Wet Bulb Globe Temperature (WBGT)



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# Wet Bulb Globe Temperature (WBGT)

	WBGT
Measured in the sun	
Uses temperature	
Uses relative humidity	
Uses wind	
Uses cloud cover	
Uses sun angle*	

$$\text{WBGT} = 0.7T_w + 0.2T_g + 0.1T_d$$

where:

$T_w$  = Wet-Bulb Temperature (indicates humidity)

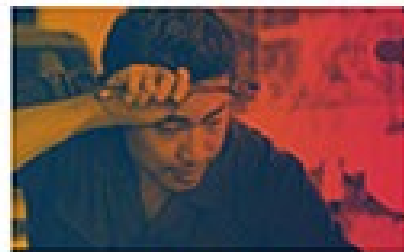
$T_g$  = Globe temperature (indicates radiant heat)

$T_d$  = ambient air (dry) temperature

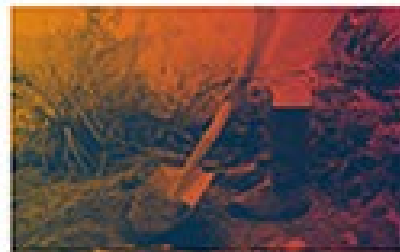
# Wet Bulb Globe Temperature (WBGT)

## WHO CAN BENEFIT FROM the USE of WET BULB GLOBE TEMPERATURE

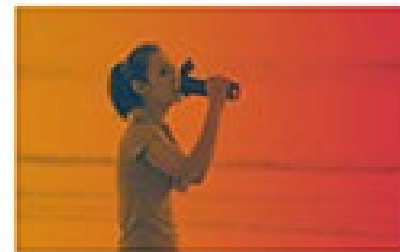
Heat is a major weather-related hazard. Although heat hazards are common in outdoor work environments or during physical activity, heat-related illness and fatalities are preventable.



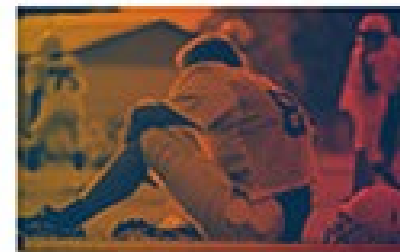
Outdoor  
Workers



People Doing Strenuous  
Outdoor Activities



Active  
People

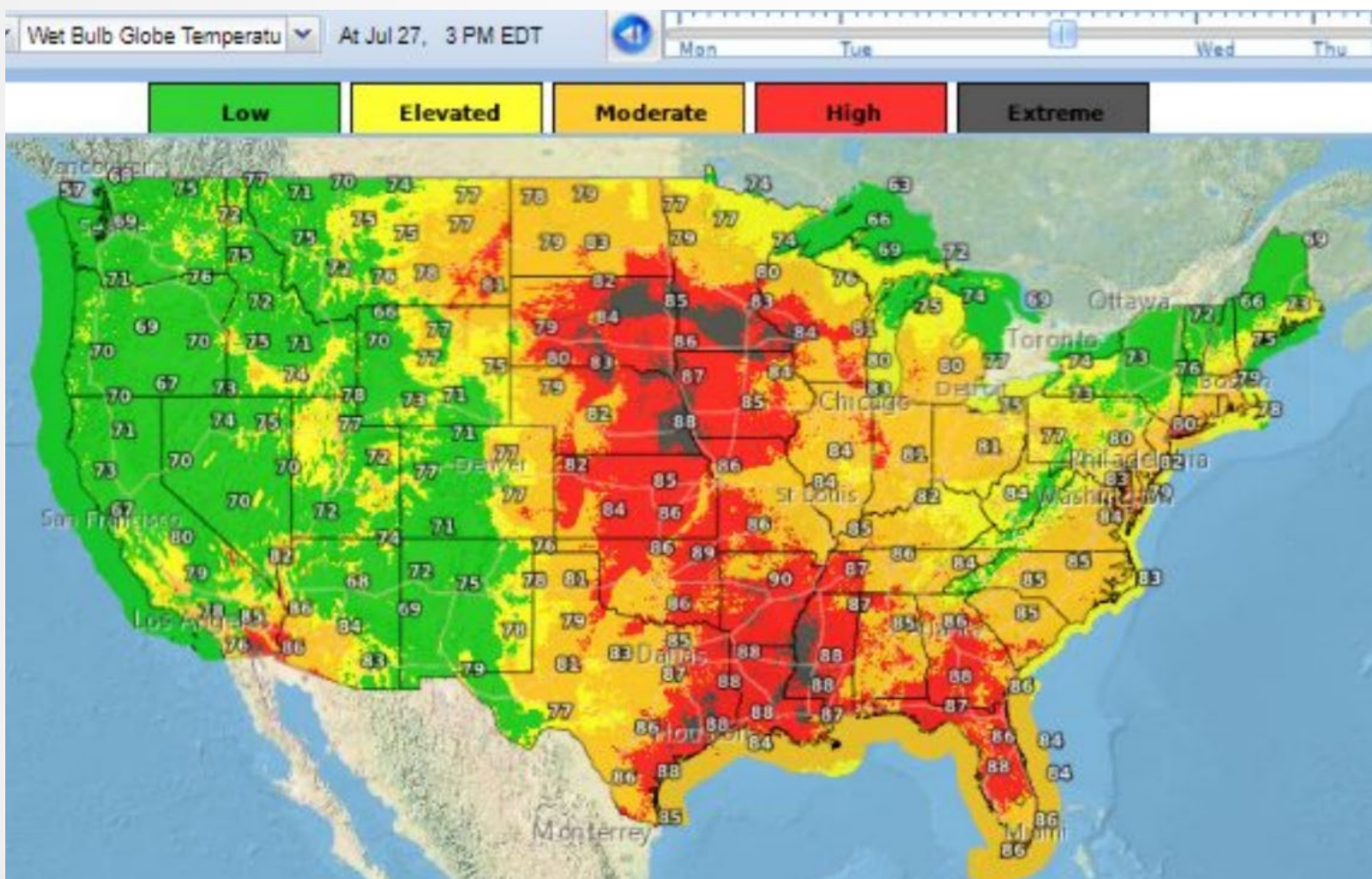


Athletes and  
Marching Band



# Wet Bulb Globe Temperature (WBGT)

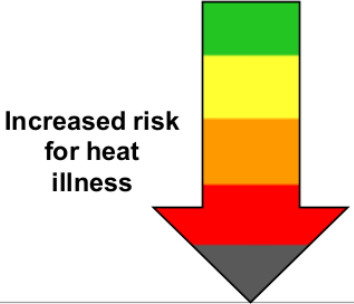
Public display available at  
<https://digital.mdl.nws.noaa.gov/>



- Uses NWS forecast
  - Temperature
  - Dewpoint
  - Wind
  - Sky Cover
- Surface Pressure & Solar Radiation (sun angle) are calculated
- WBGT centrally post-processed

# Wet Bulb Globe Temperature (WBGT)

**Disclaimer: Always check with local officials for appropriate actions and activity levels. Experienced heat stress will depend upon duration and intensity of activity and personal health and vulnerability.**

WBGT by Region (°F)			Threat Level WBGT at these values increasing heat stress.	Risk of heat illness
Region 1	Region 2	Region 3		
< 72.3	< 75.9	< 78.3	Low Threat	
72.3 - 76.1	75.9 - 78.7	78.3 - 82.0	Elevated Threat	
76.2 - 80.1	78.8 - 83.7	82.1 - 86.0	Moderate Threat	
80.1 - 84.0	83.8 - 87.6	86.1 - 90.0	High Threat	
>84.0	>87.6	>90.0	Extreme Threat	

Regions are from Grundstein, A., Williams, C., Phan, M and Cooper, E., 2015. Regional heat safety thresholds for athletics in the contiguous United States. *Applied Geography*, 56, pp.55-60. 10.1016/j.apgeog.2014.10.014.

- Color bin thresholds based on Grundstien's work on WBGT climatology and widely accepted across the nation.
- We do not provide recommendations for activity modifications and/or work-rest ratios
  - Activity modifications vary geographically and are activity-specific

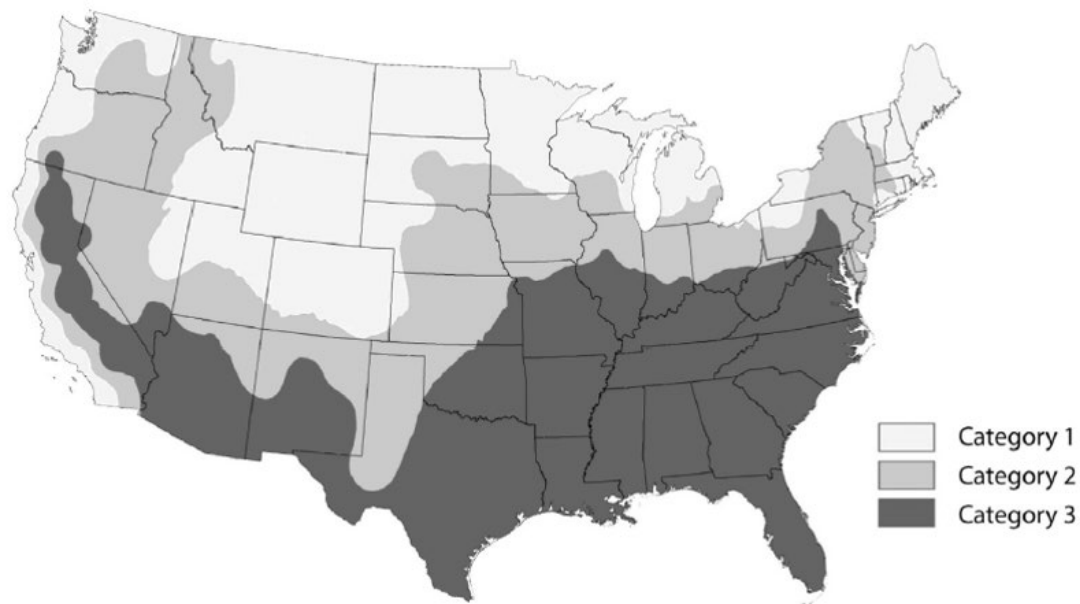
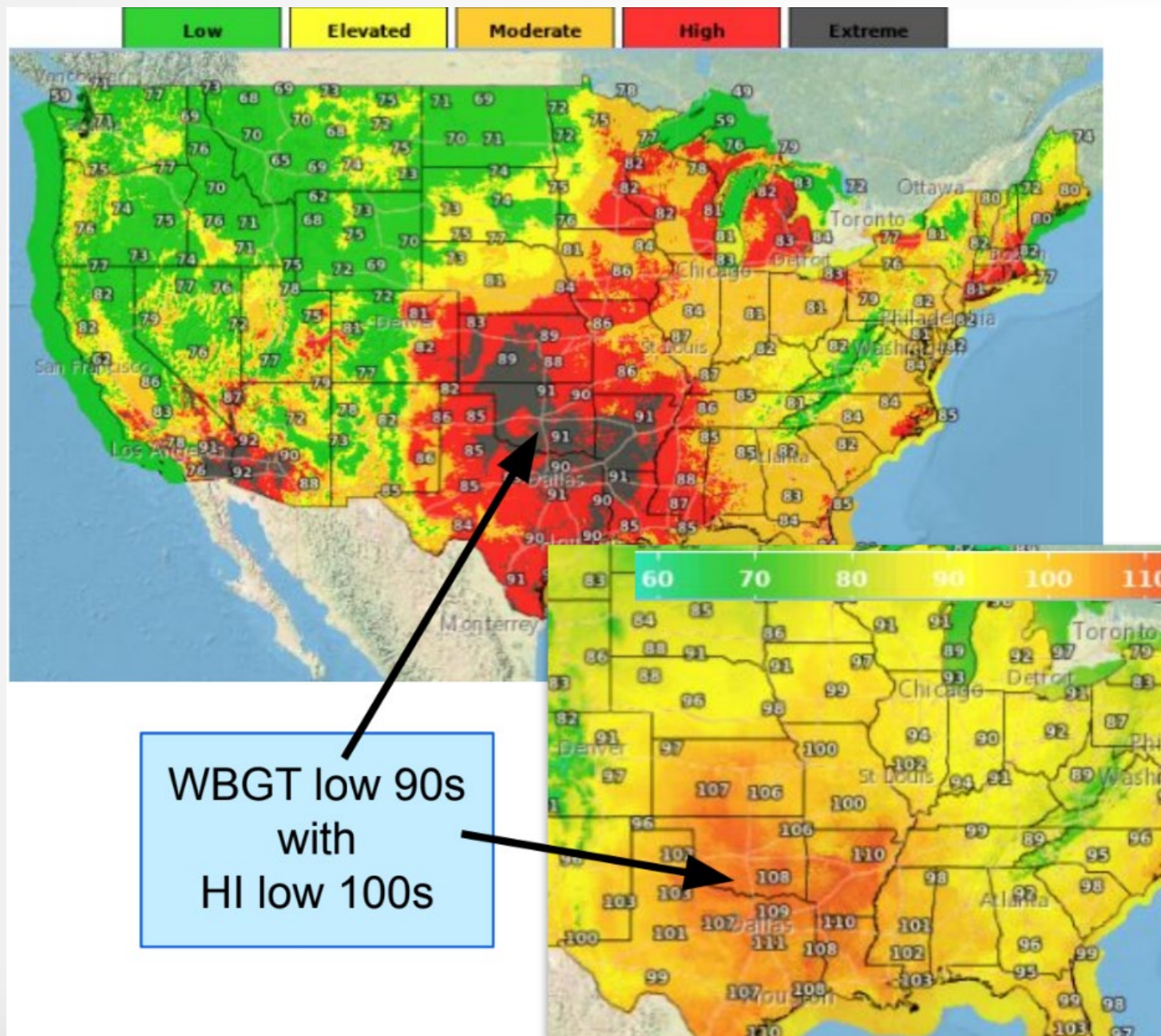


Fig. 2. Heat safety regions.

# Wet Bulb Globe: Considerations



- WBGT highly sensitive to:
  - surface conditions (e.g. grass vs asphalt)
  - wind speed and wind fetch (e.g. area sheltered by trees, wind coming from moisture source such as a lake)
- WBGT is not directly comparable to temperature or heat index scales
  - WBGT can be lower than Heat Index and air temperature, complicating messaging of heat stress

# Wet Bulb Globe Resources

Public display available at

<https://digital.mdl.nws.noaa.gov/>

NWS Heat Safety Page

[www.weather.gov/safety/heat](http://www.weather.gov/safety/heat)

# Heat Risk



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# HeatRisk

- A numeric/color-based index that serves as a framework for leveraging peer-reviewed heat-health science and data consistently across the CONUS
- Developed as a heat service, to include serving the heat-vulnerable populations
- Unique local thresholds are based on local climatology and CDC heat-health relationships

**NWS HeatRisk Prototype**  
Identifying Potential Heat Risks in the Seven Day Forecast

Mon 8/28	Tue 8/29	Wed 8/30	Thu 8/31	Fri 9/1	Sat 9/2	Sun 9/3
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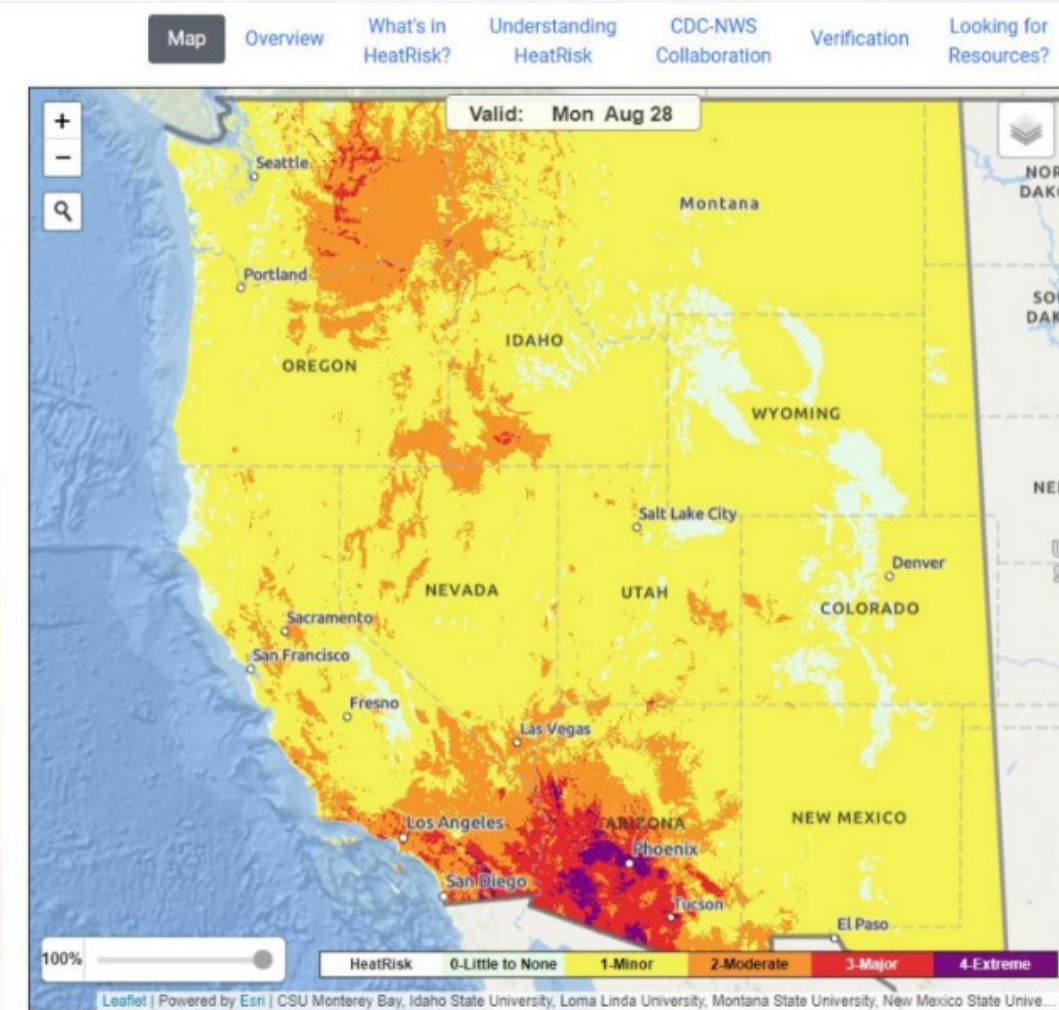
Click map for potential heat risks and NWS forecast for a location.

The NWS HeatRisk Prototype is a color-numeric-based index that provides a forecast risk of heat-related impacts to occur over a 24-hour period. HeatRisk takes into consideration:

- How unusual the heat is for the time of the year
- The duration of the heat including both daytime and nighttime temperatures
- If those temperatures pose an elevated risk of heat-related impacts based on data from the CDC

This index is supplementary to official NWS heat products and is meant to provide risk guidance for those decision makers and heat-sensitive populations who need to take actions at levels that may be below current NWS heat product levels.

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.



# HeatRisk

- Puts expected heat into a climatological context using NWS official forecast and CDC heat-health data

## What does it take into account?

- How above normal temps (high & low) are for a location
- Time of the year
- Duration of unusual heat
- Overnight relief
- Difference between lows and highs
- If temperatures are at high enough levels to pose an elevated risk for heat complications (based on CDC heat-health thresholds)

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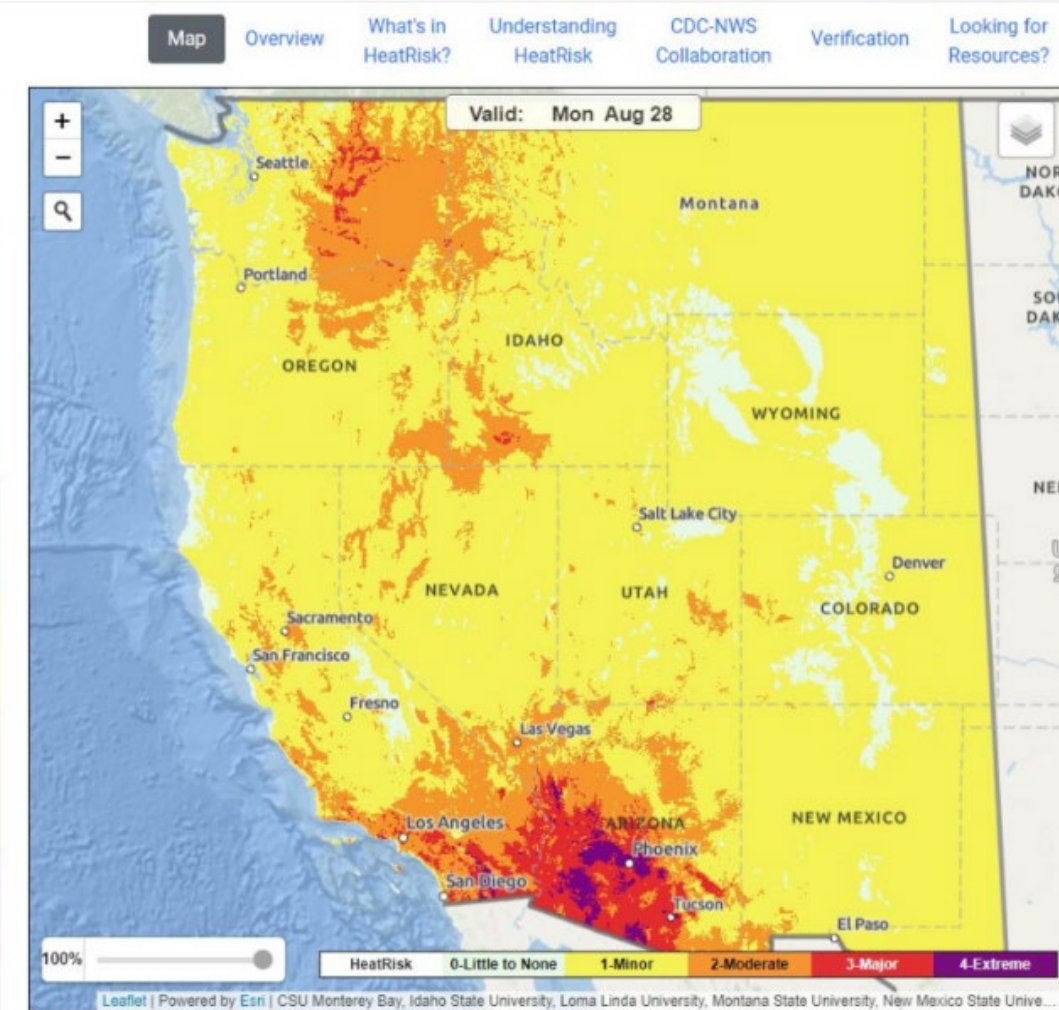
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# HeatRisk

- HeatRisk can provide awareness to more sensitive groups without overwarning the entire population.

## What are the benefits?

- Helps people understand what forecasted heat means to them
- Provides heat risk guidance for decision makers and heat sensitive populations who may need to take action below NWS heat product levels

## What are the limitations?

- Only tested in the western US
- Unknown how this will perform with humidity

**NWS HeatRisk Prototype**  
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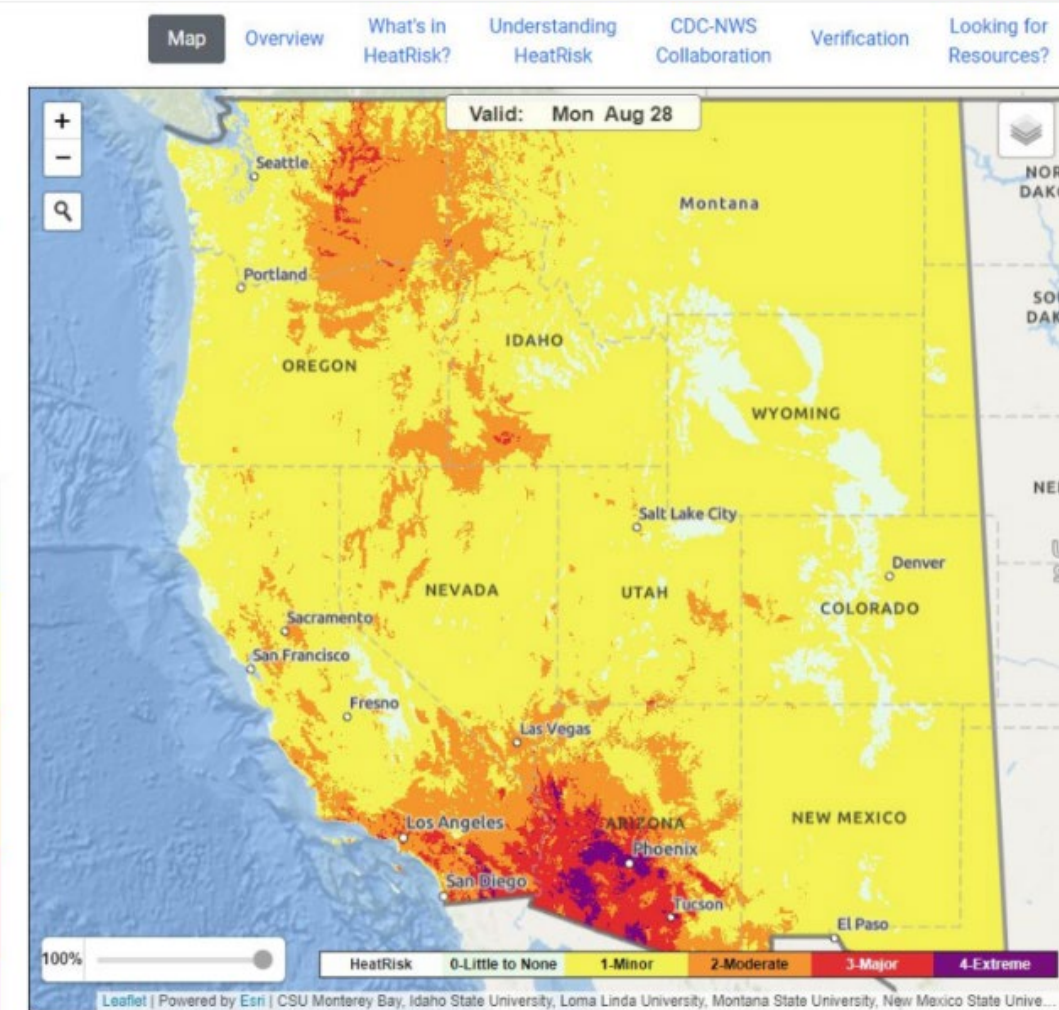
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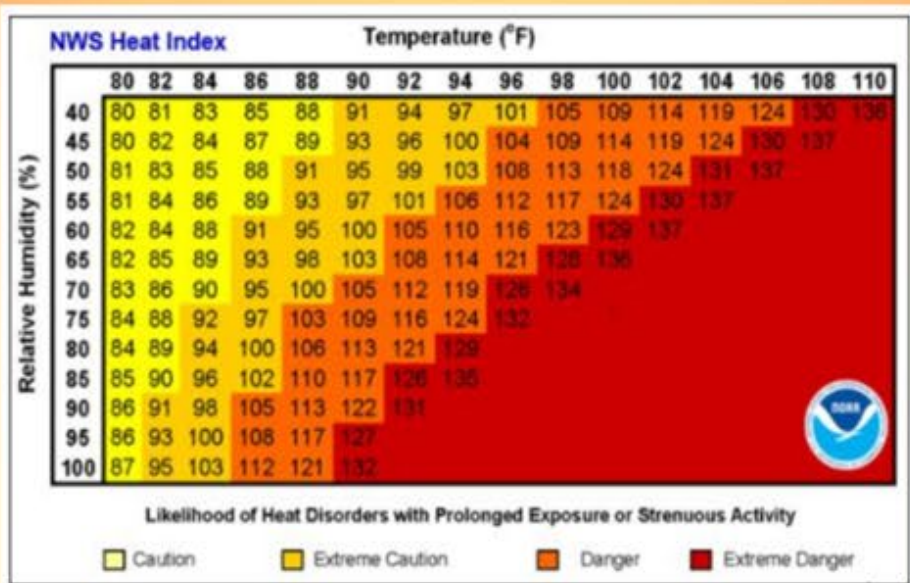
# HeatRisk Resources

Public display for Western US available at  
<https://www.wrh.noaa.gov/wrh/heatrisk/>

NWS Heat Safety Page  
[www.weather.gov/safety/heat](http://www.weather.gov/safety/heat)

# NWS Forecast Tools to Assess Heat

## Heat Index



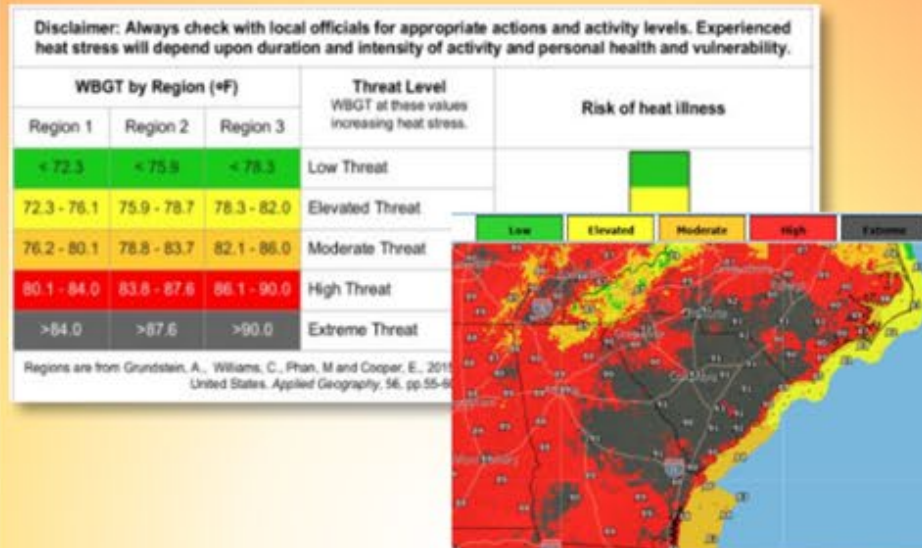
### Heat stress context for **general public.**

- Simple (T + RH); Light physical activity in shade

#### How/When to use?

- Messaging heat & humidity
- WWA decision making

## WBGT



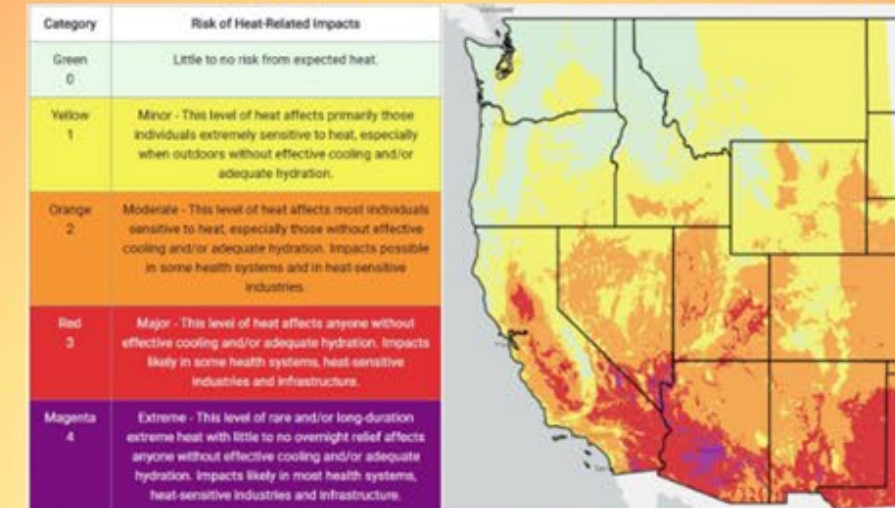
### Heat stress context for **healthy, active outdoor** communities.

- Complex (T+RH+wind+solar rad.); High physical activity

#### How/When to use?

- IDSS for those familiar
- Inform WWA decision making

## Exp. HeatRisk



### Climatological context, CDC-based health impact messaging.

- Complex (TX/TN climo, duration, etc)
- Messaging: more sensitive groups

#### How/When to use?

- IDSS & messaging highlight spectrum of heat impacts
- Inform WWA decision making

# Urban Heat Island Mapping

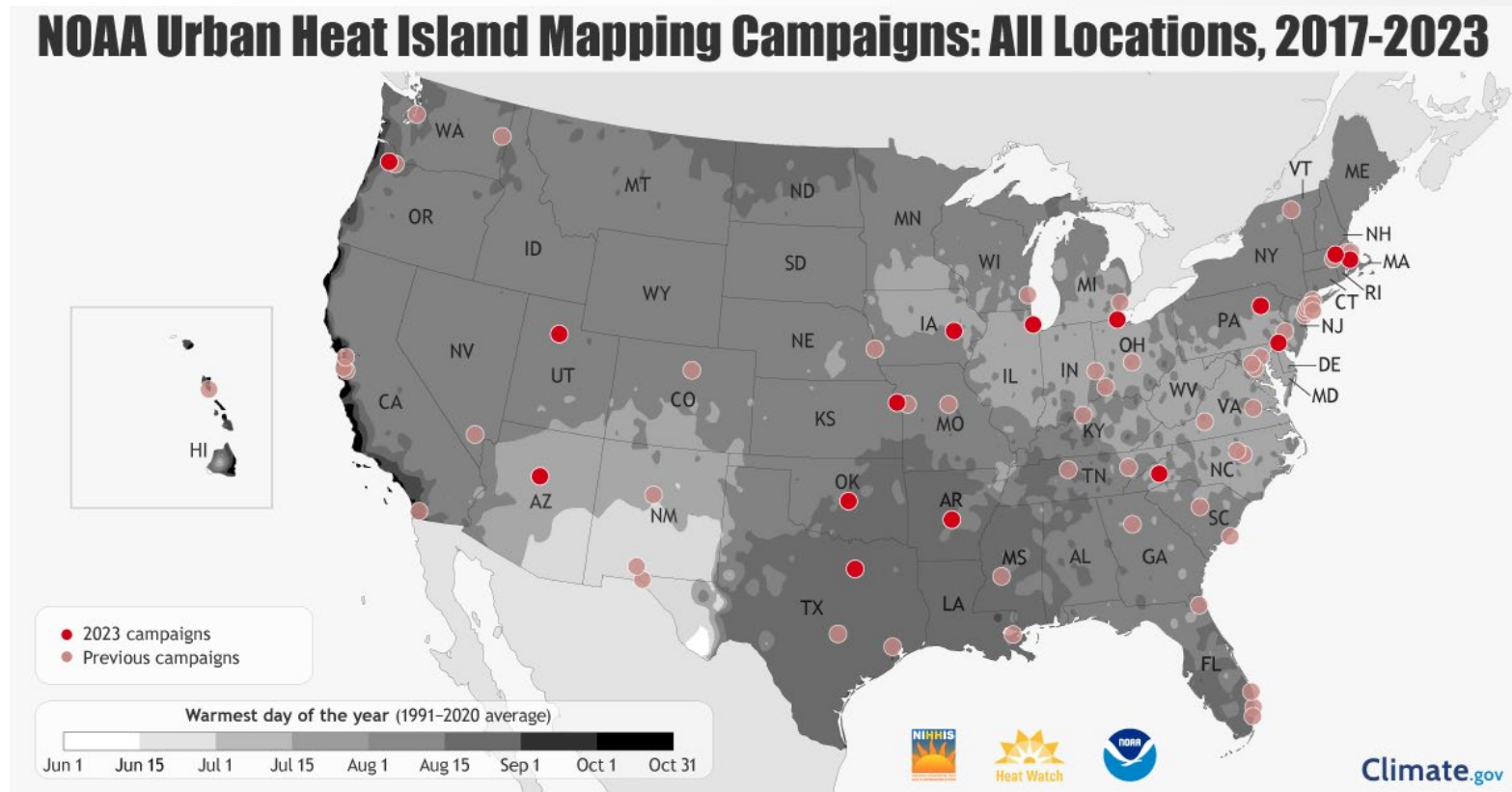


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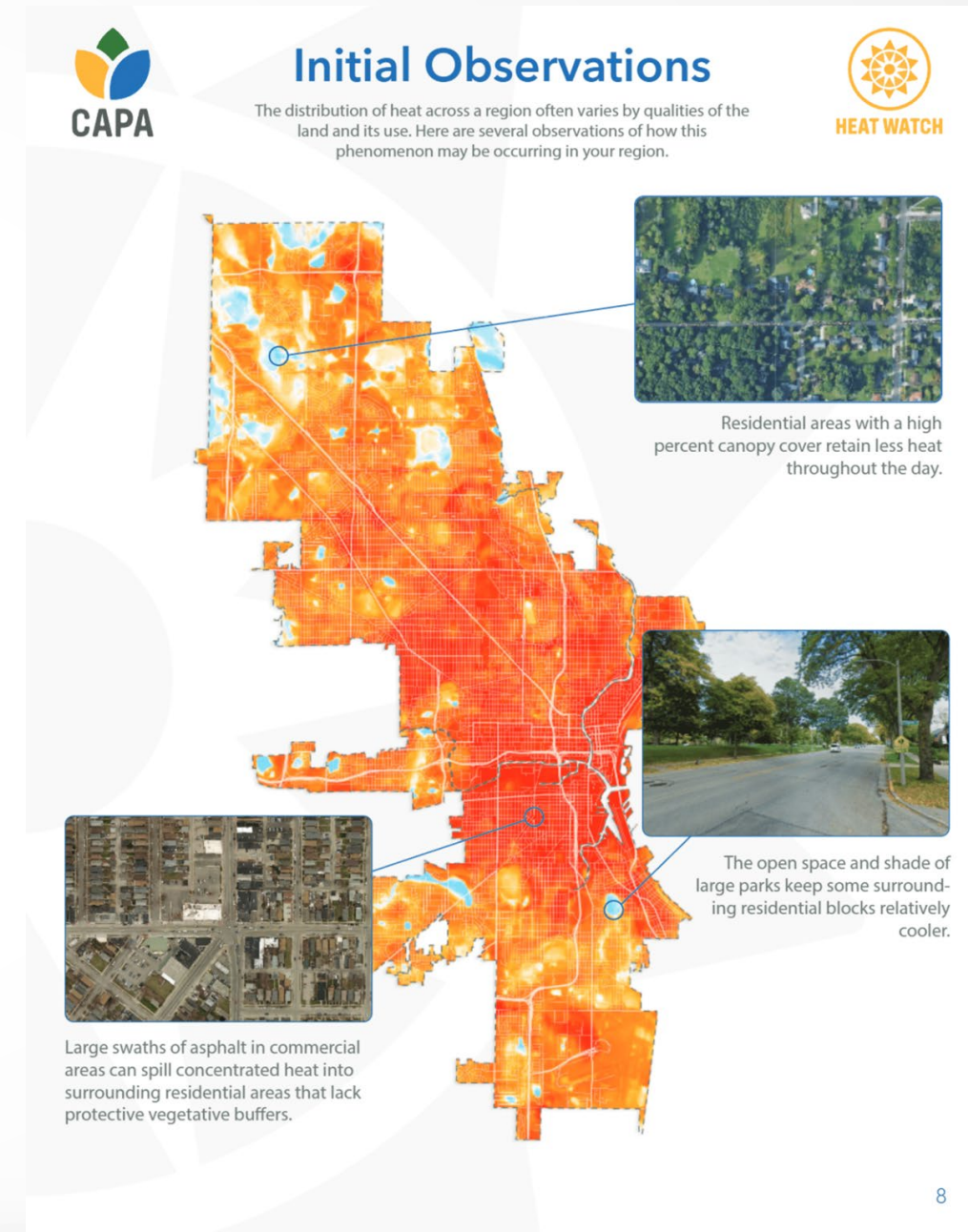
# Urban Heat Island Mapping

- NWS working with the Office of Oceanic and Atmospheric Research (OAR) to gain a better understanding of UHI across the country.
- NWS WFOs, WPC, and CPC support UHI Mapping Campaigns via outlooks and forecasts to help determine best days each city should conduct mapping.



# Urban Heat Island Mapping

- The detailed maps resulting from these campaigns can be used to inform emergency managers where to focus efforts in emergency response to extreme heat events, inform city planners where to focus green space efforts, and inform NWS forecasters where hottest areas will be for targeted outreach, decision support, and messaging





# Urban Heat Island Mapping

**CAPA** **FLIR** **HEAT WATCH**

Transit amenities at a bus stop outside the Clark County Government Center. (Temperature scale: 136.4 to 73.6)

Artificial turf and walkway near Lou Ruvo Center. (Temperature scale: 148.5 to 89.5)

Transit amenities at a bus stop outside the Clark County Government Center. (Temperature scale: 128.7 to 65.2)

19

**CAPA** **Initial Observations** **HEAT WATCH**

The distribution of heat across a region often varies by qualities of the land and its use. Here are several observations of how this phenomenon may be occurring in your region.

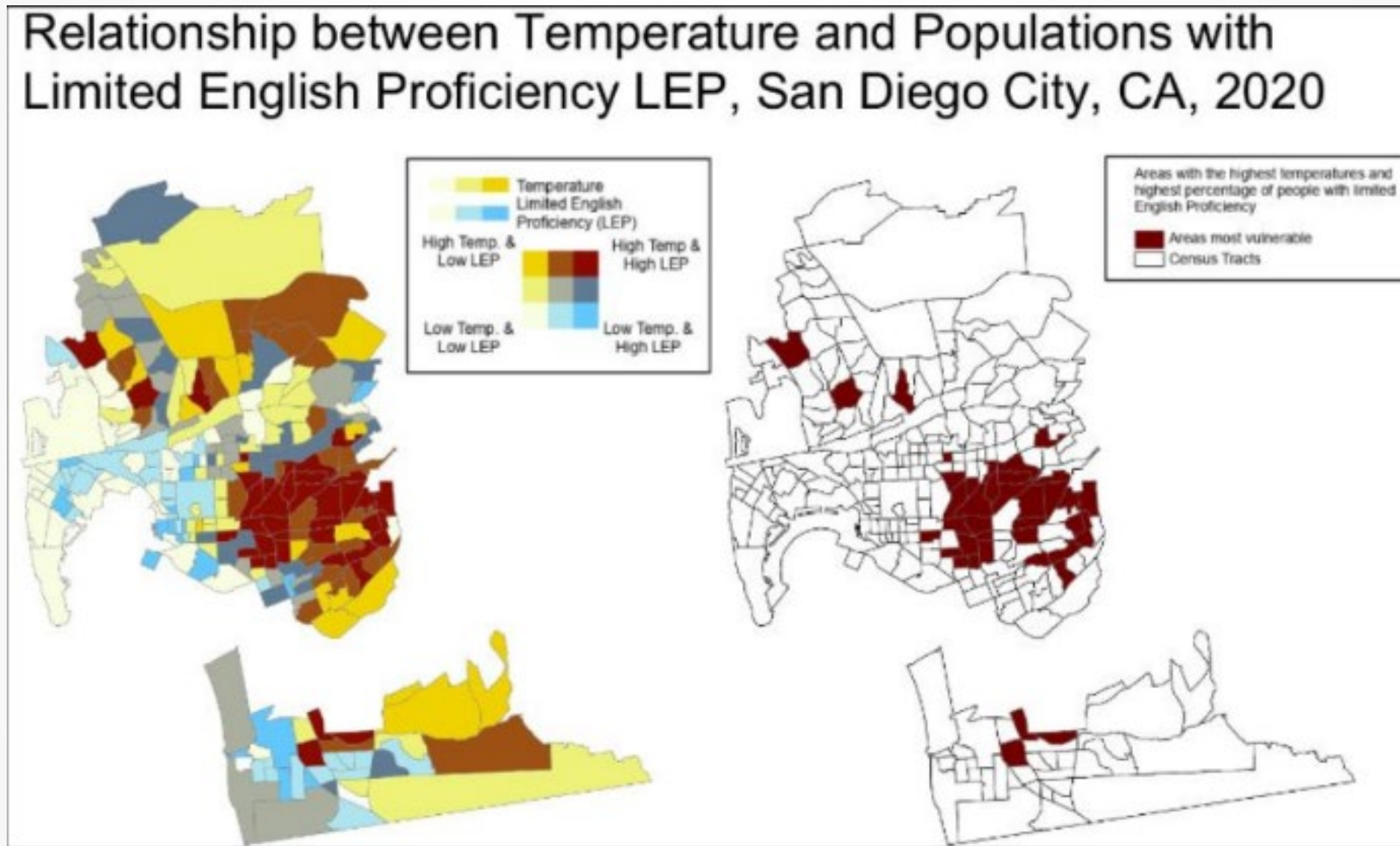
Areas with large amounts of dark, low reflectance surfaces (like asphalt roadways) seem to concentrate heat.

Residential neighborhoods with all-white rooftops appear to reflect away solar radiation and heat.

The GIS tool "Dynamic Range Adjustment" is helpful for more closely viewing differences in heat between areas.

8

# Urban Heat Island Mapping



# National Blend of Models (NBM)

# National Blend of Models

## National Blend of Models

A nationally consistent and skillful suite of calibrated forecast guidance based on a blend of both National Weather Service and external numerical weather prediction model data and post-processed model guidance.

A highly accurate, skillful and consistent starting point for the gridded forecast.

Probabilistic and bias-corrected weather elements across several service areas.

Providing forecasters with a suite of information to use for their forecasts.

An important part of the efforts to evolve NWS capabilities to achieve a Weather-Ready Nation.

## NBM Inputs

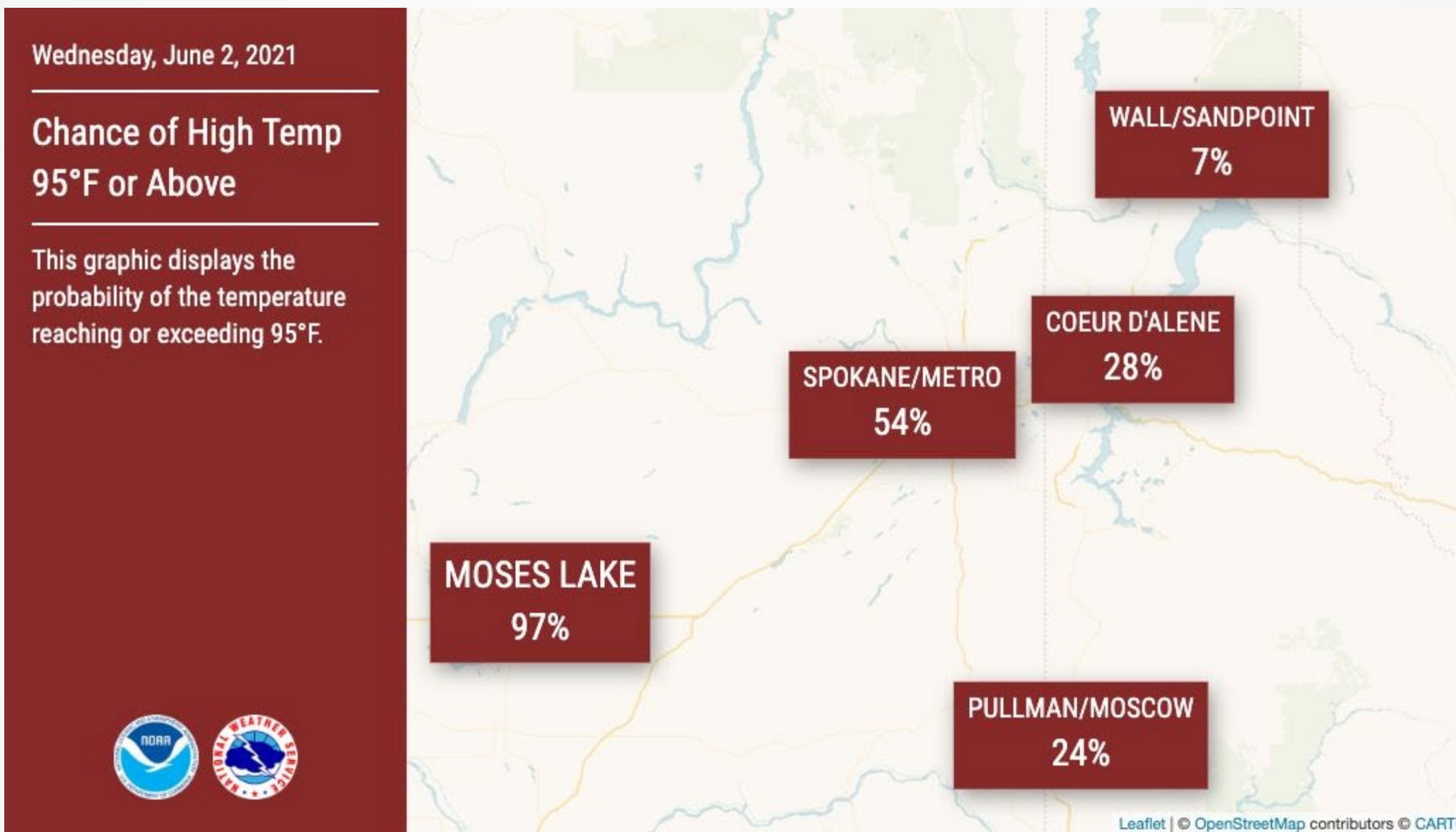
WRF MEM2  
WRF ARW  
RAP  
RAPX  
HRRR  
HRRRX  
GFS GMOS  
NAM GMOS  
EKDMOS/BMOS  
GLMP  
WW3D (0.5)  
WW3E (0.5)  
WW3D-Regional  
GLW  
HWRF  
HMON  
wTCM

GEFS  
GFS  
NAM-Parent  
SREF  
NAM-Nest  
NEMS NMMB  
WRF ARW  
CMC GDPS  
CMC RDPS  
CMC REPS  
CMC GEPS  
ECMWFD  
ECMWFE  
NAVGEMD  
NAVGEME  
FNMOC  
ACCESS-G

- ▶ NOAA
- ▶ Canadian Meteorological Centre
- ▶ European Centre for Medium-Range Weather Forecasts
- ▶ U.S. Navy Fleet Numerical Meteorology and Oceanography Center
- ▶ Australia Bureau of Meteorology



# National Blend of Models



# Thank You!



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