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NOAA Mission Goal: Weather-Ready Nation

Not Just a Number: Intra-Hour Heat Metric Variability

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Heat kills



- Extreme heat is the #1 cause of weather-related deaths in the US.
- It will get worse with climate change



Source: 7-14-2023 Heat.gov, NOAA National Weather Service; US Census Bureau



IMAGE: Weather Related Fatality and Injury Statistics, NWS, https://www.weather.gov/hazstat/

NWS is updating heat services



- Current NWS heat alerts are based on Heat Index
- Other tools available that will be operationalized: wet bulb globe temperature (WBGT), HeatRisk
- What do we know about WBGT and how is it used?





IMAGES: NWS Unified Heat Strategy slideshow, NWS Public Program,

https://sites.google.com/noaa.gov/publicweatherservices /hazards/extreme-heat

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WBGT = 0.1(DB) + 0.20(GT) + 0.70(WB)



IMAGES: Duke Nicholas Institute for Energy, Environment, & Sustainability, https://nicholasinstitute.duke.edu/project/heat-policy-innovation-hub/what-is-wet-bulb-globe-temperature-wbgt

Wet Bulb Globe Temperature



WBGT Guidelines for the General Population:

Basics:

- Developed by the military around 1950
- Used in military, athletic, and labor settings

Strengths:

- Accounts for solar radiation and wind speed
- Has been shown in studies to be correlated with heat-related illnesses (HRI)

Weaknesses:

- Standardization concerns
- High spatial variability
- Confusing for general public
- Designed for a "fit" and acclimated individual

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	Dick of boot illnoop				
Region 1	Region 2	Region 3	increasing heat stress.	RISK OF heat liness			
< 72.3	< 75.9	< 78.3	Low Threat				
72.3 - 76.1	75.9 - 78.7	78.3 - 82.0	Elevated Threat	In concerned with the			
76.2 - 80.1	78.8 - 83.7	82.1 - 86.0	Moderate Threat	for heat			
80.1 - 84.0	83.8 - 87.6	86.1 - 90.0	High Threat	lliness			
>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.



IMAGE: Wet Bulb Globe Temperature, NWS Raleigh, NC, https://www.weather.gov/rah/WBGT



WBGT has dispersed literature and thresholds



Disclaime heat stres	r: Always ch s will depend	eck with loca d upon durat	I officials for appropriate on and intensity of activi	e actions and activity levels. Experience ity and personal health and vulnerability			
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Work/Rest Times and Fluid Replacement Guide

Heat Category	WBGT Index (°F)	Easy Work Walking on hard surface, 2.5 mph, <30 lb. load; weapon maintenance, marksmanship training.		Moderate Work Patrolling, walking in sand, 2.5 mph, no load; calisthenics.		Hard Work Walking in sand, 2.5 mph, with load; field assaults.	
		Work/Rest (minutes)	Fluid Intake (quarts/hour)	Work/Res (minutes)	t Fluid Intake (quarts/hour)	Work/Rest (minutes)	Fluid Intake (quarts/hour)
1	78° - 81.9°	NL	1/2	NL	3/4	40/20 (70)*	¾ (1)*
2 (GREEN)	82° - 84.9°	NL	1/2	50/10 (150)*	¾ (1)*	30/30 (65)*	1 (1¼)*
3 YELLOW)	85° - 87.9°	NL	3/4	40/20 (100)*	¾ (1)*	30/30 (55)*	1 (1¼)*
4 (RED)	88° - 89.9°	NL	3⁄4	30/30 (80)*	3⁄4 (11⁄4)*	20/40 (50)*	1 (1¼)*
5 (black)	> 90°	50/10 (180)*	1	20/40 (70)*	1 (1¼)*	10/50 (45)*	1 (1½)*
		NL = No limit to	NL = No limit to work time per hour. "Use the amounts in pa when rest breaks are n ensure several hours o continuous work.			rentheses for continuous work ot possible. Leaders should f rest and rehydration time after	

nce will rformance tion for at urs of work ified heat luid needs ased on lifforoncos and to full sun or (± 1/4 qt/hr). ns minimal ctivity (sitting a) in the esihle or - Add GT index in ates. PP 4) - Add Work) or erate or) to WBGT

Hourly should not ats. Daily should not ats

IL High School Athletics



WBGT Index and Athletic Activity Chart				
WBGT Index (F)	Athletic Activity Guidelines			
Less than 80	Unlimited activity with primary cautions for new or unconditioned athletes or extreme exertion; schedule mandatory rest/water breaks (5 min water/rest break every 30 min)			
80 - 84.9	Normal practice for athletes; closely monitor new or unconditioned athletes and all ath- letes during extreme exertion. Schedule mandatory rest /water breaks. (5 min water/ rest break every 25 min)			
85 - 87.9	New or unconditioned athletes should have reduced intensity practice and modifications in clothing. Well-conditioned athletes should have more frequent rest breaks and hy- dration as well as cautious monitoring for symptoms of heat illness. Schedule frequent mandatory rest/water breaks. (5 min water/rest break every 20 min) Have cold or ice immersion pool on site for practice.			
88 - 89.9	All athletes must be under constant observation and supervision. Remove pads and equipment. Schedule frequent mandatory rest/water breaks (5 min water/rest break every 15 min) Have cold or ice immersion pool on site for practice.			
90 or Above	SUSPEND PRACTICE/MUST INCLUDE MANDATORY BREAKS AS DIRECTED BY GAMEDAY ADMINISTRATOR DURING CONTEST.			

(WBGT guidelines courtesy of the North Carolina High School Athletic Association)



GA, SC, and FL High School Athletics AR Activities Association MA Interscholastic Athletic Association MS and MO High School Activities - Middle School MS and MO High School Activities - High School MN High School League- North MN High School League- South NJ Interscholastic Athletic Association VT Principals' Association KSI Region 1: Northern U.S. KSI Region 2: Central U.S. KSI Region 3: Southern U.S. Military American Academy of Pediatrics Running Races and Marathons





NOAA Mission Goal: Weather-Ready Nation

- A. How is the *intra-hour variability* of wet bulb globe temperature characterized?
- B. How does this impact its *utility as a heat metric* for use by NWS?



Case Study Methodology





JACK - Sandhills Research Station

Average Temporal Variance is greatest at the hottest time of day



WBGT avg. hourly range across all hours in July 2019-2022



Rapid change may not be reflective of ambient conditions... does it matter?



REED Station 1 min. WBGT, SR, & WS



Rapid change may not be reflective of ambient conditions... does it matter?





13

Same county will have different WBGT





IMPORTANCE OF STANDARDIZATION: 15-min roll decreases the extremes by 0.5 - 1°F, and introduces delays by almost 10 min)

Summary



Questions:

- A. How is the intra-hour variability of wet bulb globe temperature characterized?
- B. How does this impact its utility as a heat metric for use by NWS?
- Mid-day hours can have an average WBGT range > 4°F
 - Max. ranges were **> 10°F**, but influenced by convection and sunrise/sunset
 - SR and WS vary rapidly minute to minute could distract from general conditions but highlight importance of simple actions for reducing heat stress
- Intra-County differences show need for finer-grain heat communication
 - Who should be utilizing WBGT? And do they understand the variability associated?
- With cross-country operationalization: **standardization is key**
 - Partner engagement will be essential to operationalization
 - Messaging across metrics needs to be consistent and clear

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Questions?

Contact

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Interested in other work related to this? Curious about the comparison of other NWS heat metrics?

Check out this QR code for other work that I did this summer:



And check out my poster: Wed. 3pm

Summary & Key Takeaways

- WBGT is highly variable
 - Within an hour can have range greater than 5°F
 - Within a county can have different flag thresholds
- Standardization and proper messaging will be key
 - The type of instrumentation and post-processing of data is important
 - Considering your audience is also important
 - Operational forecasting using all 3 NWS metrics may improve performance