Performance Evaluation of NWS Heat Metrics in Central North Carolina

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Introduction

- According to the National Weather Service (NWS), heat is the #1 cause of weather-related fatalities in the US[1]. At one point over summer 2023, over ⅓ of the US was under a heat alert.
- Heat is projected to become worse (in severity/frequency) with climate change[2].
- NWS is updating its heat services[3]: additional tools being operationalized
  - **Heat Index (HI)**: 'apparent temperature', heat and humidity, used currently by NWS for Advisories and Warnings, documented limitations[4]
  - **Wet bulb globe temperature (WBGT)**: also accounts for solar radiation and wind speed, used by military/athletic/outdoor labor settings[5], but is not the primary metric used by NWS for Heat Advisories and Warnings
  - **HeatRisk (HR)**: prototype developed and used on West Coast of US but not operationalized coast to coast yet, utilizes minimum and maximum thresholds and climatology to build seasonal thresholds[6]
- This project investigates the performance of these 3 heat tools for Central North Carolina, seeking to inform best practices in the use of all three tools for heat alerts.

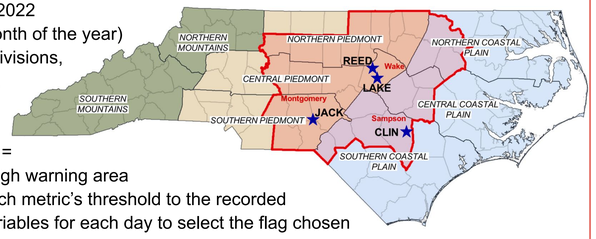
Objectives:

A. Investigate the three heat metrics to compare and contrast their effectiveness and capabilities

B. Provide insight for how these tools fit in the NWS Unified Heat Strategy locally (Raleigh, NC)

Methodology

- QUALITATIVE COMPARISON: First, literature review and SWOT (Strength Weaknesses Opportunities & Threats) analysis is completed for the 3 heat metrics [not detailed on this poster]
- QUANTITATIVE COMPARISON: A **4 station case study analysis** is utilized to explore how each of heat metrics performs on a set of case study days. Data from the NC State Climate Office ECONet Stations[7] (WBGT, HI) and from NWS Western Region HeatRisk[6] (utilizing COOP sites) (HR) is used.
  - July 2019-2022 (hottest month of the year)
  - 3 climate divisions, 3 counties, blue star = sites red outline = NWS Raleigh warning area
  - Applied each metric's threshold to the recorded climatic variables for each day to select the flag chosen



- All 3 metrics have different variables, thresholds, labels, color schemes, etc. For the purposes of analysis: I created 1 unified system of levels to compare how each metrics performs against one another

Unified Levels	Heat Index (HI)[8]	WBGT[9]	HeatRisk (HR)[10]
0	*	Low Threat < 78.3 °F	Little to No Risk
1	Caution 80 - 90 °F	Elevated Threat 78.3 - 82.0 °F	Minor Risk
2	Extreme Caution 90 - 105 °F	Moderate Threat 82.1 - 86.0 °F	Moderate Risk ***
3	Danger 105 - 110** °F	High Threat 86.1 - 90.0 °F	Major Risk
4	Extreme Danger > 110 °F	Extreme Threat > 90.0 °F	Extreme Risk

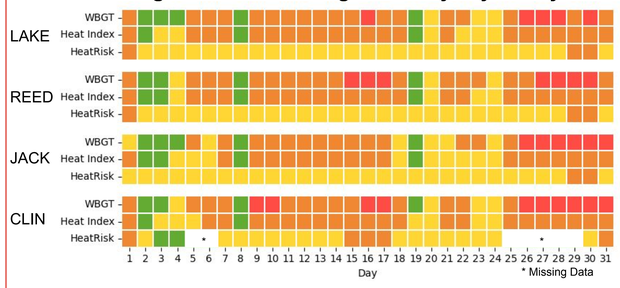
* HI has no level for below 80 °F. I labeled anything below 80 °F 'Low' or 0.

** HI levels are derived from the heat alert levels for Raleigh. Levels from the NWS HI chart are higher.

*** HR training presentation recommends considering heat alerts between Level 2 - 2.35, and urges heat alerts for Level 2.35+

Results

Fig 1. Heat Threat Flags for every day in July 2021



Example of 2021 case study month with risk level flag selections by day/site/index using the Unified Levels (see Fig.2). Reading vertically, on July 30 for CLIN site, WBGT = 3, HI = 2, HR =1. (LAKE and REED were in similar areas and used the same HR).

Fig 2. Frequency of threat levels by metric
Total *sum* of July 2019 - 2022, *averaged* across all stations

Summary of the frequency of all flags for each metric across entire date range (avg. across sites). Key takeaways:
- WBGT flags ~84% of days as higher threat, levels 2 and 3
- HI labels ~78% of all days as mid-threat, (2)
- HR selects ~60% of days as low-threat (levels 0-1)

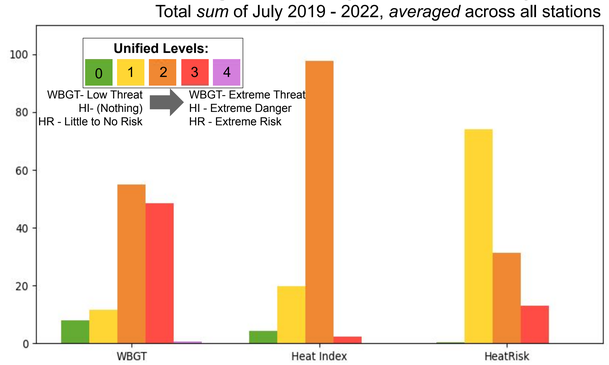
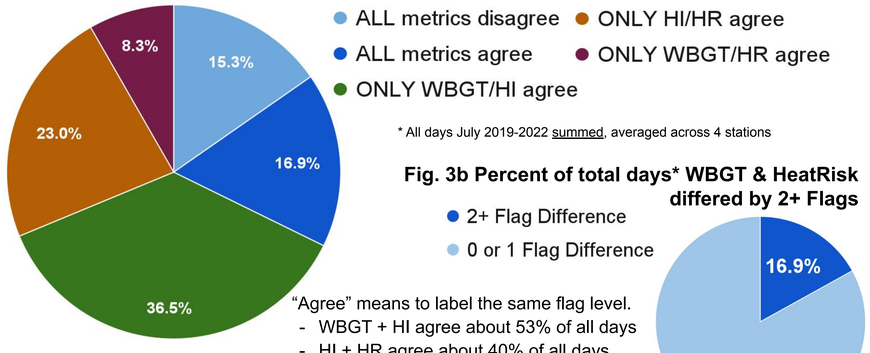


Fig. 3a Percent of total days* showing agreement between metrics



* All days July 2019-2022 summed, averaged across 4 stations

Fig. 3b Percent of total days* WBGT & HeatRisk differed by 2+ Flags

"Agree" means to label the same flag level.
- WBGT + HI agree about 53% of all days
- HI + HR agree about 40% of all days
- WBGT + HR agree about 25% of all days

About 17% of the time, WBGT and HR completely disagree by 2 or more threat levels

References

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Results

Fig. 5a Hourly WBGT and Heat Index Values for July 30, 2021 at CLIN

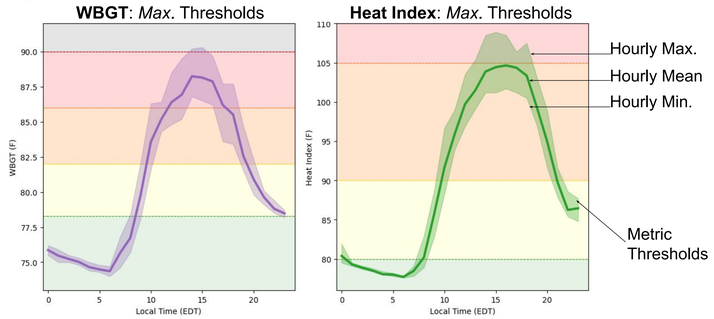
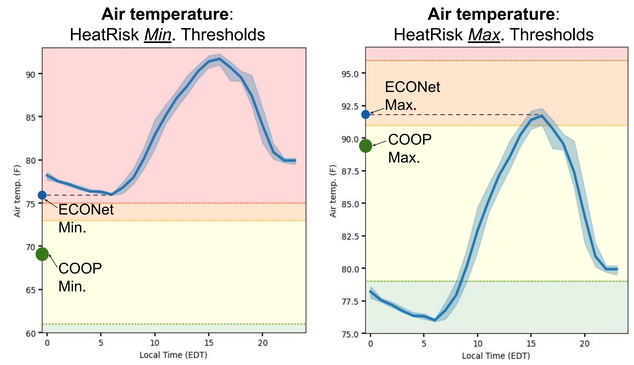


Fig. 5b Hourly Air Temp. for July 30, 2021 at CLIN for HeatRisk Thresholds



Each plot shows the hourly min., average, and max. values for each heat metric, as well as the threshold limits for each flag threat level. The rigidity of current thresholds limits the usability of heat alerts. A heat alert was issued for this day. (NOTE: HeatRisk uses different data and double thresholds, thus the difference in style and content of the figures.)

Conclusions

- Opportunities to utilize the strengths of each heat metric
  - Need a unified procedure: use-case documentation
  - Opportunity to adjust metric thresholds: Relative thresholds preferred over absolute
- Localized studies may be useful
  - In Raleigh: WBGT tends to show higher risk, HeatRisk tends more moderate
  - Agreeance across the metrics is not strong
- Partner engagement will be essential to operationalization
  - Messaging across metrics needs to be consistent and clear

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