**Evolution of Dangerous Humid Heat and Incarcerated People in the United States**

Cascade Tuholske1\* and Robbie M Parks2

1 Department of Earth Sciences, Montana State university, Bozeman, Montana, 59717, USA.

2 Department of Environmental Health Sciences, Mailman School of Public Health, Columbia University, New York, New York, USA.

\* Correspondence to: cascade.tuholske1@montana.edu

**Comments of Figures (Oct 1 - CPT)**

**Prison Datasets**

* Marshal Project: <https://www.themarshallproject.org> (media mainly)
* Prison Policy Initiative: <https://www.prisonpolicy.org/data/>
* Sentencing Project: <https://www.sentencingproject.org/research/us-criminal-justice-data/>
* Bureau of Justice Statistics:

https://bjs.ojp.gov/library/publications/correctional-populations-united-states-2020-statistical-tables

**Figure 1 (old Figure 2)**

* Try setting background map color to white, light blue or very dark gray … really hard to see the top plots and blue may not work well with the bottom plots

**Figure 2 (old Figure 3)**

* Make clear it’s the fitted value on x-axis and fitted slope on y-axis
* Try dropping the alpha (transparency) value of the points
* We need to make sense of the many prisons with decreases in hot-humid days
* Highlight 28°C and focus on most interesting regions (south, southeast, southwest)

**Figure 3 (old Figure 4)**

* Not really sure what this is without a title (forget old figure and update to below)
* Plot mean and percentile (10th and 90th) over time for all data and by region

**Figure 4**

* Comparison of prison trends to rest of state
* To do:
  + Population weighted values for state
  + X-axis is the average delta between population-weighted number of hot days in prisons and population-weighted number of hot days in the state
  + Y-axis is ranked by x-axis values (negative to positive delta)

**Supplementary Figure 1 (old Figure 1)**

* I don’t think showing how many people are incarcerated is sufficient for our first figure but it could be a good one for the supplement
* It’d be good to also plot rates of incarceration … so two panel

What year is this data from

**Abstract:** XX

**One sentence summary:** XX

**Main:**

Intro:

* Overview of prison population
  + Rank of USA (more than rest of the world combined or something like that?)
  + Change in Rates of Incarceration
  + heat waves + climate change + built environment
  + prisons and heat potential for harm
  + Yet, despite the potential increasing harm from extreme humid-heat to incarcerated populations in the United States, we lack a fine-grained assessment of how extreme humid-heat [exposure?] is changing for American prisons and jails.
* Overview of how hot-humid heat impacts health and well-being
  + Not one definition of heat wave
  + Health impacts at the individual level
    - We do acclimate
    - Importance of humidity
  + Potential to harm health of prisoners specifically
    - Can we find studies on the number of elderly or prisoners with co-morbidities?
    - Lack of HVAC + lack of $
    - Example of prisoner dying from paper I found
* Here we map how the frequency of extreme humid-heat changed from 1981 - 2021 for the XXXX prisons and jails in the United State that house XXXX people today. We define extreme humid-heat frequency as the number of days per year where the maximum wet bulb globe temperature (WBGTmax) exceeded three thresholds – 25 °C, 28 °C, and 30°C – set by the International Standards Organization as hazardous to occupational health [refs]. To accomplish this, we combine the PRISM high-resolution (5 km) daily maximum temperature and maximum vapor pressure gridded meteorological data [refs] to approximate WBGTmax for each prison and jail in the United States from 1981 - 2021. PRISM data has been shown to be robust in heat-epidemiological research [(*1*)](https://paperpile.com/c/0Y4jsM/XYgd). [Robbie rate of change…]
* Figure 1/2
  + [We need a one sentence main finding … something like]: On average, for all American prisons, the number of days per year that WBGTmax > 25 °C and 28°C increased by XYZ, respectively].
    - While few prisons have had WBGTmax > 30 °C, we map hot spots of concern in XYZ, where WBGTmax above 30 °C is increasing precipitously.
    - Dive into **Figure 2**
    - Compare to national average
      * Incarcerated populations live in locations that contend with xyz more heat days today than in 1981 than the American average …
* Figure 3
  + Dive into which prisons are increasing and why
  + Give examples of prisons of greatest concern [we should make figure 3 for the supplement but drop prisons with decrease for our examples ]
  + Dive into Florida, California, Texas
    - Mississippi + Louisiana + other states with highest incarceration rates
    - Rates of incarceration by race (age if we can get it)
* Figure 4
* Discussion
  + Demographics of prisons
  + Condition of prisons
  + Concern for prison staff too?
  + Prisons being black boxes for health information + private prisons
  + Prisons with decreasing hot-humid days explored
* Limitations
  + WBGT lacks radiated heat parameter leading to hotter conditions on sunny days, especially outside

**Acknowledgements:** XX

**Funding:** XX

**Author Contributions:** XX

**Competing interests:** Both authors declare no competing interests.

**Data and materials availability:**

* Prison Data
  + Source
  + What year is population estimate from
* Temperature Data

The Parameter-elevation Relationships on Independent Slopes Model (PRISM) dataset from Oregon State University provides high-resolution (4 km) daily Tmax and maximum vapor pressure deficit (VPDmax) from 1981 - to near present [ref]. As described in [(Daly et al. 2015; Daly et al. 2008; Daly et al. 1997)](https://paperpile.com/c/0Y4jsM/N0Yt+Hsft+qHSe), mean fields are produced by interpolating data from a dense network of weather stations with a spatial-weight regression model that uses landscape features like elevation and aspect to predict daily meteorological conditions across the CONUS. PRISM data has been well-validated and shown to be useful in lieu of station data in heat-related epidemiological research [(Spangler et al. 2019)](https://paperpile.com/c/0Y4jsM/XYgd). The 4-km dataset is freely available.

* Method

Daily Tmax and VPDmax mean fields were converted to approximated WBGTmax following the procedure described in [(Tuholske et al. 2021)](https://paperpile.com/c/0Y4jsM/73On). First, VPDmax are converted to daily minimum relative humidity fields shown in eq. X [(Spangler et al. 2019)](https://paperpile.com/c/0Y4jsM/XYgd):

(eq. x)

Next, we combine Tmax and RHmin to create daily maximum heat index (HImax) mean fields following the U.S. National Weather Service’s procedure [(NOAA 2014)](https://paperpile.com/c/0Y4jsM/2Gxq). Outdoor wet bulb globe temperature (WBGTout) is a linear combination of wet bulb temperature (Tw), black globe temperature (Tg) and dry bulb temperature (Td) (eq x), whereas indoor wet bulb globe temperature (WBGTin) combines only Tw and Tg (eq x) [(Bernard and Iheanacho 2015)](https://paperpile.com/c/0Y4jsM/LRhc). Both require

require in-situ field instruments to correctly measure [(Kong and Huber 2022; Bernard and Iheanacho 2015; Yaglou and Minard 1957)](https://paperpile.com/c/0Y4jsM/rMBA+LRhc+MpeV), though several methods exist to approximate WBGTout from meteorological data [(Kong and Huber 2022)](https://paperpile.com/c/0Y4jsM/rMBA).

WBGTout = 0.7Tw + 0.2Tg + 0.1Ta (eq. x)

WBGTin = 0.7Tw + 0.3Tg (eq. x)

Here we use the relationship identified by [(Bernard and Iheanacho 2015)](https://paperpile.com/c/0Y4jsM/LRhc) between HImax and WBGTin (eq x) to convert HImax values to an approximated WBGTmax. This power function is accurate ±0.5°C-WBGT above a Heat Index of 100°F. We recognize that our WBGTmax approximation assumes fixed wind speeds and neglects radiated heat of WBGTout. But given that incarcerated Americans spend the preponderance of their time indoors [ref] and that most incarceration facilities lack HVAC systems [ref], WBGTin is appropriate to measure how hot-humid heat has changed across all CONUS prisons and jails, yet can be applied to ISO standards and compared to international regions outside the CONUS where heat index is less commonly used.

(eq x)

* + Map to prisons
    - Area average?
    - Reproject data to align spatially
  + Rate of change

**List of Supplementary Materials:**

Materials and Methods

Figures S1

Tables S1

References (1-XX)

**Fig. 1**

1. [K. R. Spangler, K. R. Weinberger, G. A. Wellenius, Suitability of gridded climate datasets for use in environmental epidemiology. *J. Expo. Sci. Environ. Epidemiol.* **29**, 777–789 (2019).](http://paperpile.com/b/0Y4jsM/XYgd)