A Novel 75-year Database and Climatology of Heat Index Values in Miami

UNIVERSITY OF MIAMI
ROSENSTIEL SCHOOL of MARINE & ATMOSPHERIC SCIENCE

Brian McNoldy[1] and Robert Molleda[2]

[1] University of Miami, Rosenstiel School of Marine & Atmospheric Science
[2] National Weather Service, Miami Weather Forecast Office

Overview

The Heat Index is an apparent temperature experienced by the human body when humidity is taken into account, and is the basis for heat advisories issued by the National Weather Service.

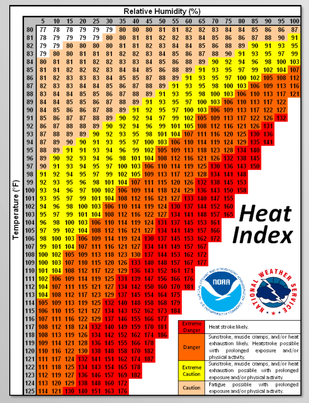
Using weather observations taken at Miami International Airport dating back to 1948, a database of heat index values was created. The heat index calculation requires only two inputs: air temperature and relative humidity.

Over the seven-plus decades of observations, increasing trends of temperature, dew point, and heat index are evident and point to a loss of relatively cool mornings and to more extreme and prolonged heat in the afternoons.

What is the Heat Index?

The Heat Index used in this work is an "assessment of sultriness" or apparent temperature developed by Steadman (1979) to describe the effect of heat and humidity on a person's perception of temperature.

- The same air temperature feels more comfortable when accompanied by low humidity than when accompanied by high humidity.
  - For example, 90°F and 70% RH = 106°F heat index
    90°F and 20% RH = 86°F heat index
- All other things being equal, as the humidity increases, the body's natural cooling mechanism (the evaporation of sweat) becomes less efficient and the core temperature rises.
- As pointed out by Rothfusz (1990), "no true equation for the Heat Index exists"… it is an empirical approximation derived from "extensive biometeorological studies" that includes more than a dozen assumptions about the person (height, weight, core temperature, clothing, etc) and the environment (wind speed, sunshine, vapor pressure, etc.).
- The Heat Index is simple to calculate from standard observations (temperature and humidity), making it well-suited for routine use. The exact equations used in this work are described in WPC (2022).



- There are many other possible metrics, but a few others include the wet bulb globe temperature (Budd 2008), equivalent potential temperature, and moist enthalpy or effective temperature (Pielke et al. 2007).
- While those certainly have their advantages and would be worth exploring, they are either more difficult (or impossible) to calculate from routine weather observations or are less intuitive to the public.

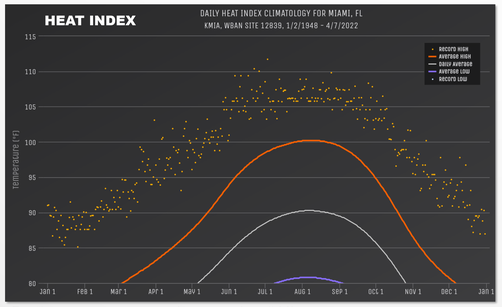
Data

- Weather observations collected by the Automated Surface Observing System (ASOS) station at Miami International Airport (MIA), from 1948 to present
- Data access: Environmental Mesonet at Iowa State University website
- For consistency through the period of record, temperature (T) and dew point (T_d) values are retrieved in degrees Fahrenheit (°F) then converted to degrees Celsius (°C)
- Relative humidity (RH) is calculated from the T and T_d values using the Magnus approximation (Alduchov and Eskridge 1996)
- The heat index (HI) is calculated using the regression equation and adjustments according to WPC (2022)
- T, T_d, and HI values quality-controlled using visual inspection and investigation of outliers, and by omitting days and times known to have faulty/questionable data. Days with >4 hrs of missing data are omitted
- *A useful side benefit of developing a heat index database is a new dew point database and climatology!*
- *The HI database is not an official NWS product; errors could still exist*

Climatology & Records

Daily updates posted to ***https://bmcnoldy.rsmas.miami.edu/mia/*** which features an interactive chart with daily average and record values, and an expandable sortable table below it with many additional details (best viewed on larger screens)

- Chart & table combination available for HI, T_d, and T
- Monthly averages and records have similar charts and tables
- Daily averages calculated over the 1991-2020 "climate normal" period
  - Values smoothed using appropriate Loess filter to remove noise but maintain meaningful/physical peaks and values
- Daily records calculated over the 1948-present period



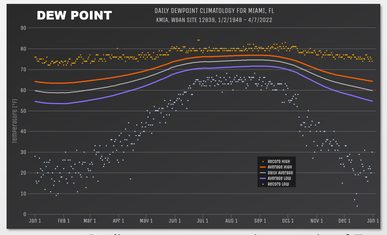
Daily averages and records of HI.

- Record HI is ≥ 85°F (29.4°C) every day of the year
- All-time record high HI is 111.7°F (44.3°C)
- Average highest HI peaks ~ 7Aug (100.2°F (37.9°C))

Heat Index Threshold	Consecutive Days (1st)	Ending Date	Consecutive Days (2nd)	Ending Date	Consecutive Days (3rd)	Ending Date
100	31	20200905	26	20170730	21	20110811
101	20	20200711	17	20170730	16	20050824
102	20	20200711	13	20050822	11	20110811
103	20	20200711	13	20050822	10	20200905
104	7	20170902	6	19810720	5	20200831
105	5	20170908	4	20170816	3	20210802
106	3	20210802	2	20210722	2	20190625
107	2	20210802	2	20170905	2	20090718
108	1	20210703	1	20150825	1	20100606
109	1	20210703	1	20150825	1	20100606
110	1	20210703	1	20090622	1	19950626

Record-longest spans (and 2nd and 3rd places) of peak HI exceeding various thresholds.

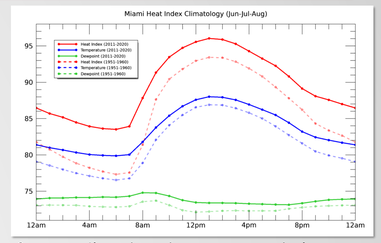
- Record T_d is ≥ 72°F (22.2°C) every day of the year
- All-time record high T_d is 84.0°F (28.9°C)
- Average highest T_d peaks ~ 26Aug (76.8°F (29.9°C))



Daily averages and records of T_d.

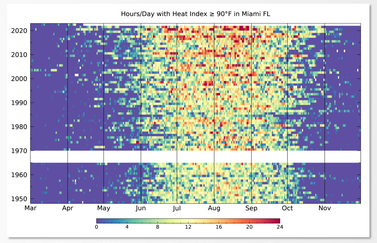
Trends & Applications

- Relatively cooler mornings are vanishing
- Dangerously hot afternoon temperatures are becoming hotter and lasting longer
- Result is increasing A/C demand throughout the day, AND increasing danger to population without A/C

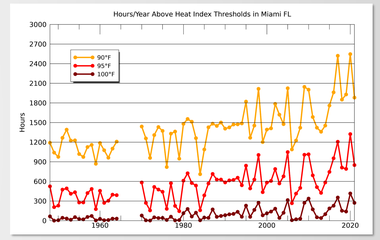


Summertime hourly averages during 1951-1960 and 2011-2020

- Miami is spending more time at high Heat Index values
  - "Summer weather" is expanding into Spring and Fall



Number of hours the HI was above 90°F per day of each year



Number of hours the HI was above 90°F, 95°F, 100°F per year

- A fraction of this warming trend is caused by the "urban heat island" (UHI) effect. UHI intensity is increasing year-round, but is least pronounced in summer months in south Florida (Kedzuf et al., 2018).
- A fraction of this warming trend is caused by increasing average ocean temperatures – temperatures in a coastal city like Miami are influenced by the surrounding water.

- For the NWS, a modern climatology of heat index values specific to an area can more accurately:
  - Inform Heat Advisory & Excessive Heat Warning thresholds when combined with health records
  - Define Heat Wave criteria based on the duration and frequency of extremes

References

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