Heat Load Discomfort Index

and

its applications via Shelly H&T sensors

by

**Meir Rom**

**Introduction**

This project combines Calculations and Categorization of some well-known Heat-Load (or Heat-Stress) indices with continuous real-time measurements taken from Shelly H&T or Shelly Plus H&T devices.

Following Epstein and Moran (2006), and Vacellio (2022) Heat-Stress has an important impact on our lives. It can seriously affect the productivity and the health of the individual and diminish tolerance to other environmental hazards. Translation of Heat Load into meaningful measures e.g., indices is a well-documented scientific area and also widely used in various fields such as: industrial physiology, sport events, military trainings and many more.

Here, we focus on two known indices: *The Wet-Bulb Temperature (WT)*, Vacellio (2022), Żuławińska (2023) and the *Discomfort Index (DI)***,** discusseddeeply byEpstein and Moran (2006). Those Indices are accurately estimated using ordinary measures of temperature (or Dry Temperature, *DT*) and relative humidity (*RH*).

*The WT* Index is the temperature read by a special thermometer that is wrapped in water-soaked fabric and ventilated. It has many applications discussed by Vacellio (2022), but its main affect relates to evaporation limitations in most living organisms. Vecellio et al. (2023) deeply discuss the evaporative limitations and hazards on human bodies when the WT approaches to 35°C .

Here we accurately estimate the *WT*. The function *wetTempCalc*(*DT,RH*) [wetTempCalc.js] returns the *WT* value for each pair of argument measures (DT,RH) using the Stull approximating formula (Stull, 2011). This function is also invoked in the main script of the *DI* calculation.

*The DI*uses the average of *WT* and *DT* as an individual index of heat stress and also as an accurate estimate of the well-known *Wet-Bulb Globe Temperature (WBGT),*which takes into account additional outdoor conditions such as direct radiation; see Epstein and Moran (2006) for more details.

Following Epstein and Moran (2006), we categorize each *DI* result into 4+1 hierarchical categories: “No Heat Stress”, “Mild”, “Moderate” and “Severe Heat Discomfort”; and additional category, “Extreme Dangerous Heat Conditions” which unfortunately is being reached too often nowadays, due to the climate change.

**Main Script:** *Heat-Load-Discomfort-Index/src/app.js*

The main script *app.js* is run on Shelly Plus 1PM. It links thru the cloud and gets the time, *DT* and *RH* values from a pre-specified Shelly HT (or Plus HT) sensor. The *WT* and *DI* are then calculated, and *DI* is categorized. Timer is set by default to 5 minutes for cycle repetition.

Output in console contains two rows and looks like the following message:

[*Device Name*]: Time: 14:58, \*\*\* Extreme Dangerous Heat Conditions \*\*\* (DI: 33.1)

Dry Temperature: 38.38, Relative Humidity: 42, Wet-Bulb Temperature: 27.8

**API**

User must define the following properties in the CONSTANTS section of main script ***app.js***:

SERVER: User server’s url, - can be found in Shelly app,

AUTH\_KEY: User authentication key - can be found in Shelly app.

HT\_TYPE: "HT" for Gen 1 Shelly HT sensor ---OR --- "HTP" for Gen2 Shelly Plus HT sensor,

DEVICE\_ID: Can be found in Shelly app for the specific sensor,

HT\_NAME: pick any useful name to identify the sensor,

TEMP\_UNIT: choose between "C" (Default: Celsius) to “F” (Fahrenheit),

TIMER\_RECALL\_IN\_MINUTES: Repetition cycle for engaging the HT (or Plus HT) sensor.

**Notes and Suggestions for Future Developments**

1. Running and testing the script on *Shelly Plus 1PM* is the author self-limitation (*Shelly Plus 1PM* is the only Gen 2 device owned by the author). It is recommended to install the main script on *Shelly Plus Plug S* device. In that case it is advisable to add an “*alertColor(DI)”* function to enable a colored alert for each *DI* category, in addition to the message given in console. For example, when the *DI* category is set to “*Extreme Dangerous Heat Conditions”*, the plug may change its color to dark red. This kind of function has been discussed and published many times in the *Scripting Course but* is not given here since it cannot be tested.
2. Since the pair (*DT*, *RH)* is the only input data needed for constructing our indices, it is quite straightforward to engage forecasts of such data and construct forecasts of *WT and DI* in various locations*.*
3. Using our script, the historical data of (*DT*, *RH*) can be easily converted to (*WT*, *DI*) and be populated in the same way and same figures as shown in Shelly app for HT sensors. Using historical virtual data of (*WT*, *DI*) can lead to Statistical surveys and analyses on the environmental living conditions in specific locations.
4. All papers that were referenced here are saved in sub-folder \ scientific-papers \

**References**

Epstein, Y. and Moran, D., S., “Thermal Comfort and the Heat Stress Indices”, Industrial Health (2006).

Stull, R., “Wet-Bulb Temperature from Relative Humidity and Air Temperature”, Journal of Applied Meteorology and Climatology, 50,(2011)

Daniel J. Vecellio, S. Tony Wolf, Rachel M. Cottle, and W. Larry Kenney [“Evaluating the 35°C wet-bulb temperature adaptability threshold for young, healthy subjects (PSU HEAT Project**)**“](https://journals.physiology.org/doi/abs/10.1152/japplphysiol.00738.2021) Journal of Applied Physiology (2022)

Żuławińska Julia, “The Wet-Bulb Calculator”, <https://www.omnicalculator.com/physics/wet-bulb#how-to-calculate-the-wet-bulb-temperature>, OMNI Calculator (2023)