Wet Bulb Temperatures and Human Habitability

The Intergovernmental Panel on Climate Change (IPCC), in its 2023 Synthesis Report CLIMATE CHANGE 2023 p32, pointed out that, at hotter temperatures (and the associated increased humidity levels), global warming could render increasing regions of the planet less and less habitable by humans.

The way I would look at this information is by using the scale provided. It depicts the number of days per year that the combination of humidity and temperatures could be lethal to humans.

More areas will become less habitable as the number of dangerous days in the year increase, posing a risk of mortality increase. Add to that related increasing diseases and malnourishment. The summary of these heat/humidity studies is presented in these graphics. [The timeframes, e.g., 2030±, are from CSSG-2.26 and from my recent Timing and Impacts Study, both of which can be accessed in our Materials Library CSSG-2 Materials Library .

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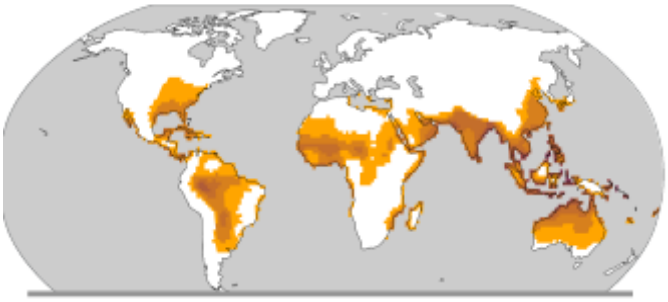
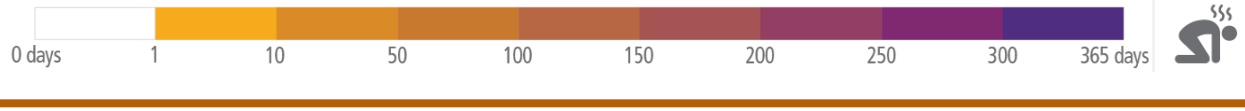
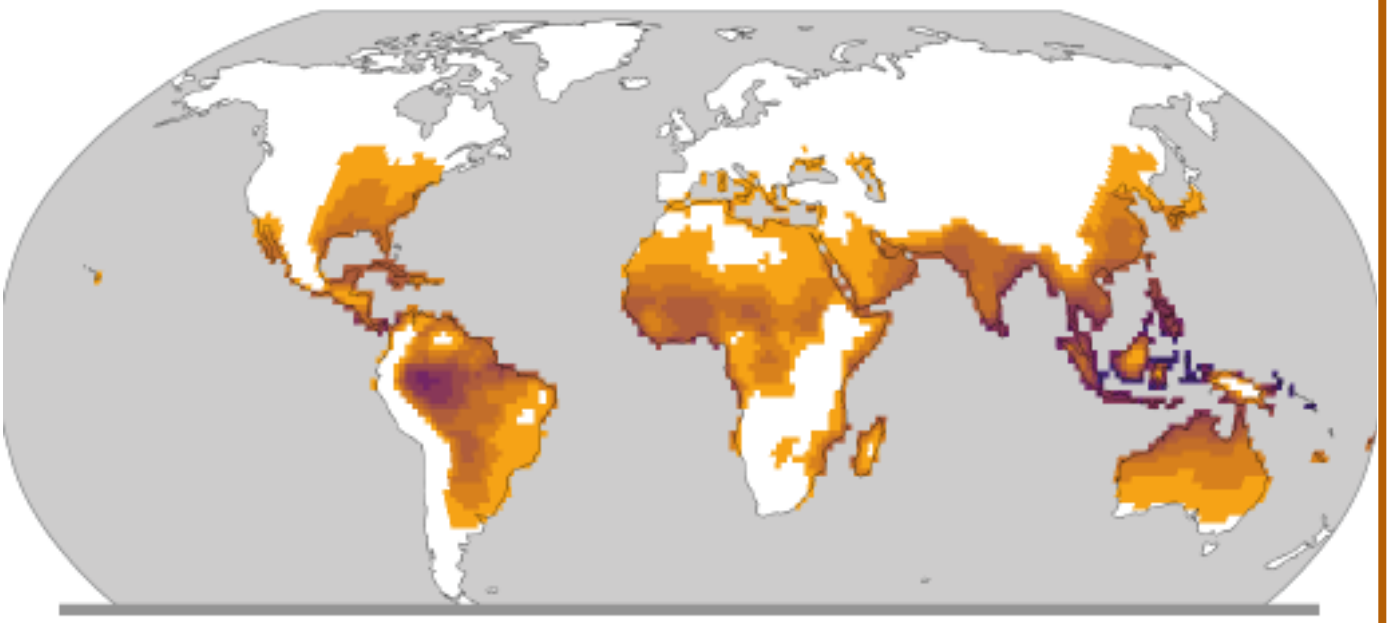
Heat-humidity risks to human health



Historical 1991–2005

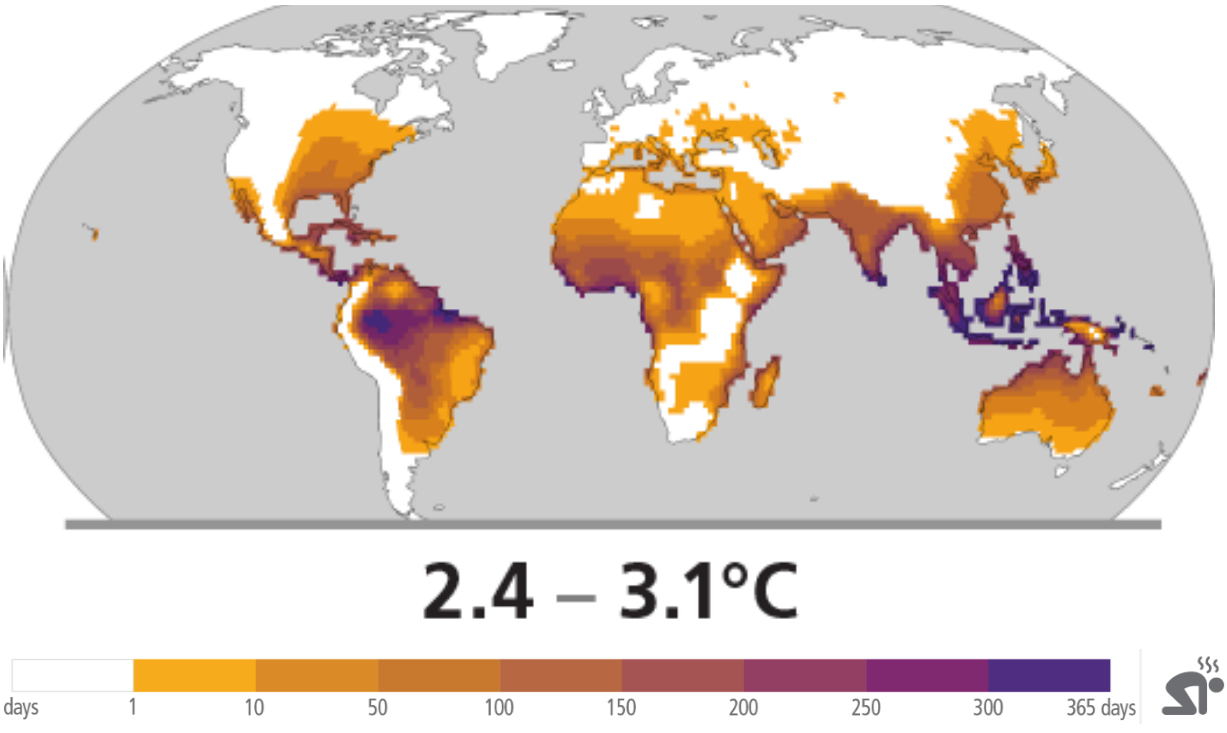




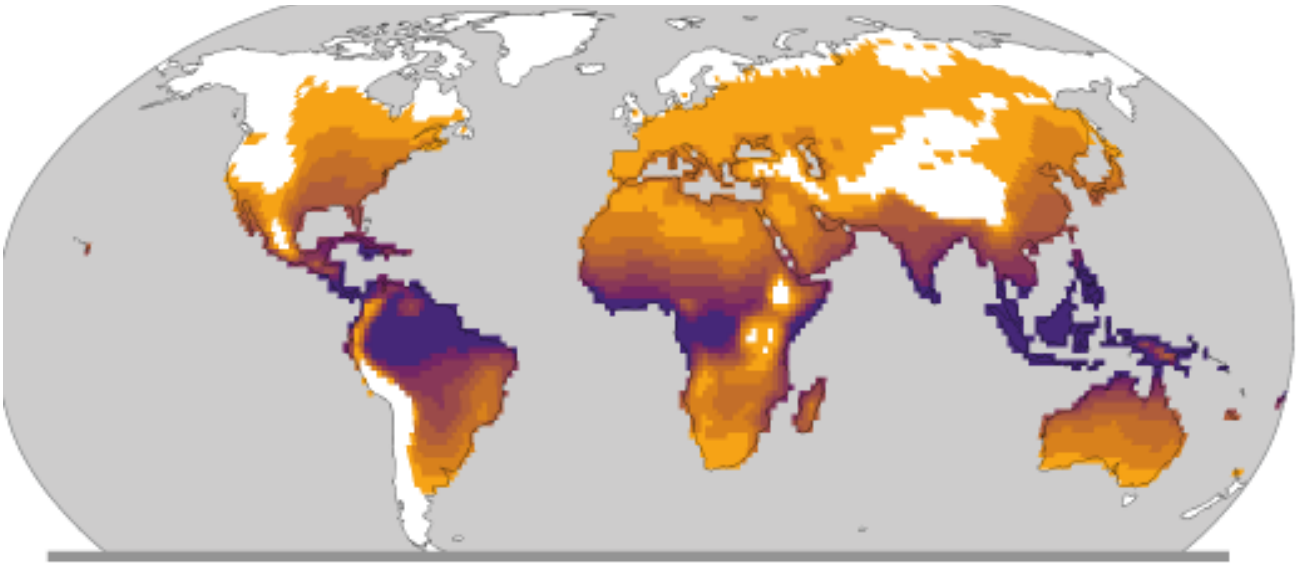
1.7 – 2.3°C

(2030±)

Wet Bulb Temperatures and Human Habitability



(2055-2070±)



4.2 – 5.4°C

(2100±)

The concern is obvious: more and more regions can be expected to become simply uninhabitable for humans, if we keep adding heat. How populations in these regions may respond is a separate, although critical, question. **How many un-livable days/year could you tolerate?**

The purpose of this Study is to bring some direct understanding of these conditions which would destroy the habitability of these regions, barring air conditioning (spatial or personal).

Temperature (in the shade) + **Humidity** (affecting ability to sweat) + **Direct Sun** (which hits the skin about 100 F higher than air temp) + **Wind** (to help take heat away) ⟶ the factors of keeping our core temperatures around 98.6 ^{0}F. This does not even take exertion, air quality, health, water intake, etc. into account .

If our core goes up to 104 ^{0}F, we can be within hours of dying. Symptoms on the way: Sweating: Heavy sweating, which can lead to cold, pale, and clammy skin. Muscle cramps: Painful, uncontrollable spasms in the arms, legs, or back. Headaches: Can be caused by dehydration, sun exposure, barometric pressure, or physical activity. Other symptoms: Dizziness, nausea or vomiting, weakness, fatigue, irritability, thirst, elevated body temperature, fast or weak pulse, poor coordination, anxiety, and fainting.

Constancy of Internal Body Temperature

•Effect of high and low atmospheric temperatures of several hours' duration on the internal body "core" temperature.

•In general, a nude person in dry air between 55° and 130°F is capable of maintaining a normal body core temperature somewhere between 97° and 100°F.

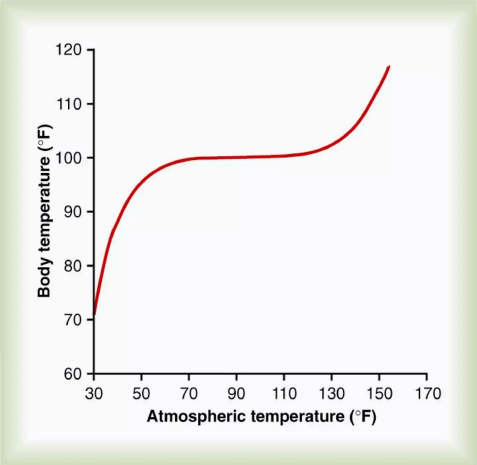
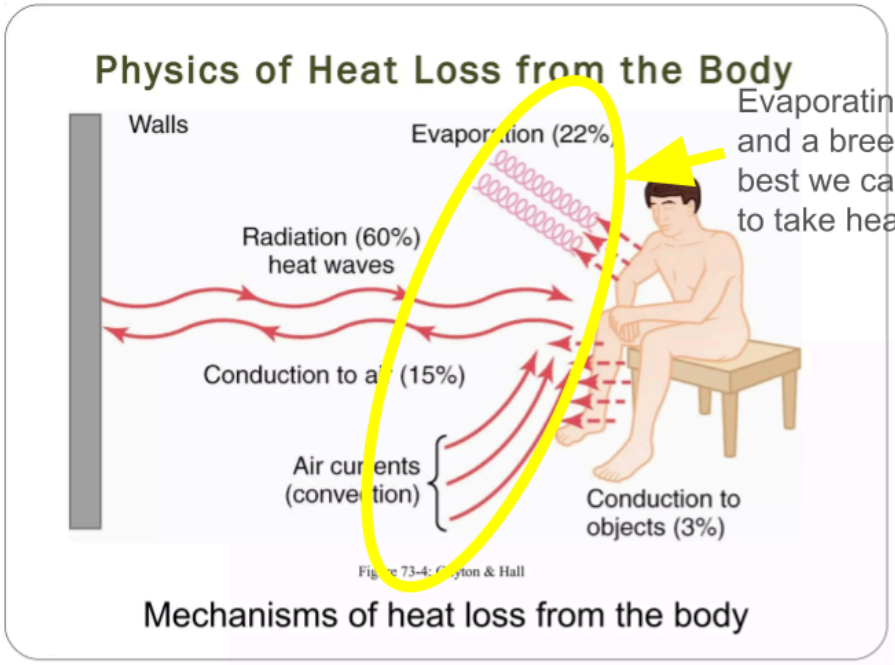


Figure 73-6; Guyton & Hall

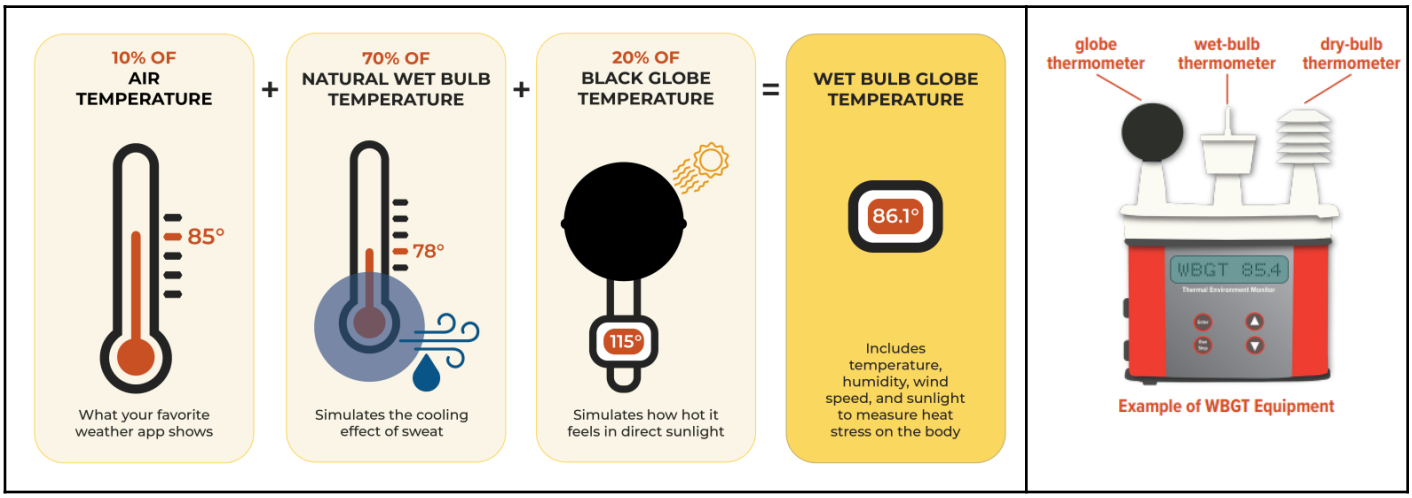
This chart obviously assumes low humidity, so the body can get rid of heat.

For relative simplicity, we can get most of the picture by just looking at **temperature, humidity, and the best breeze we could hope for**. Direct sun, exertion, particulate pollution, and weak personal health definitely also matter, but only make things worse.

Here's how it works:



Now, just for completeness, we could measure all of these factors, and they are all important to differing degrees (! amounts?).



But, the simplest way to figure HABITABILITY is to notice that the **"Wet Bulb Temperature" above has been shown to have the biggest impact (see the 70%) factor**.

And we're going to pretty much ignore how it gets uncomfortable as the temperature and humidity rise, and FOCUS ON WHERE THE CONDITIONS MAKE THE OUTDOORS UNINHABITABLE. It turns out that we can think of this in a simple way:

IF THE TEMPERATURE/HUMIDITY IS SO HIGH THAT YOU CAN'T GET RID OF BODY HEAT EVEN IN THE SHADE WITH A STIFF BREEZE, AND YOUR CORE TEMPERATURE RISES, THEN IT'S TIME TO GO INSIDE (OR MOVE!) !

And it turns out that it's pretty easy to measure this.

You take a regular thermometer, and put a soaked cloth over the bulb, and then give it a stiff breeze. If the relative humidity isn't 100%, and especially if you have wind, the moisture on the cloth will evaporate and cool the bulb. The cloth on the bulb also makes it so it's in the shade. THIS IS THE WET-BULB TEMPERATURE.

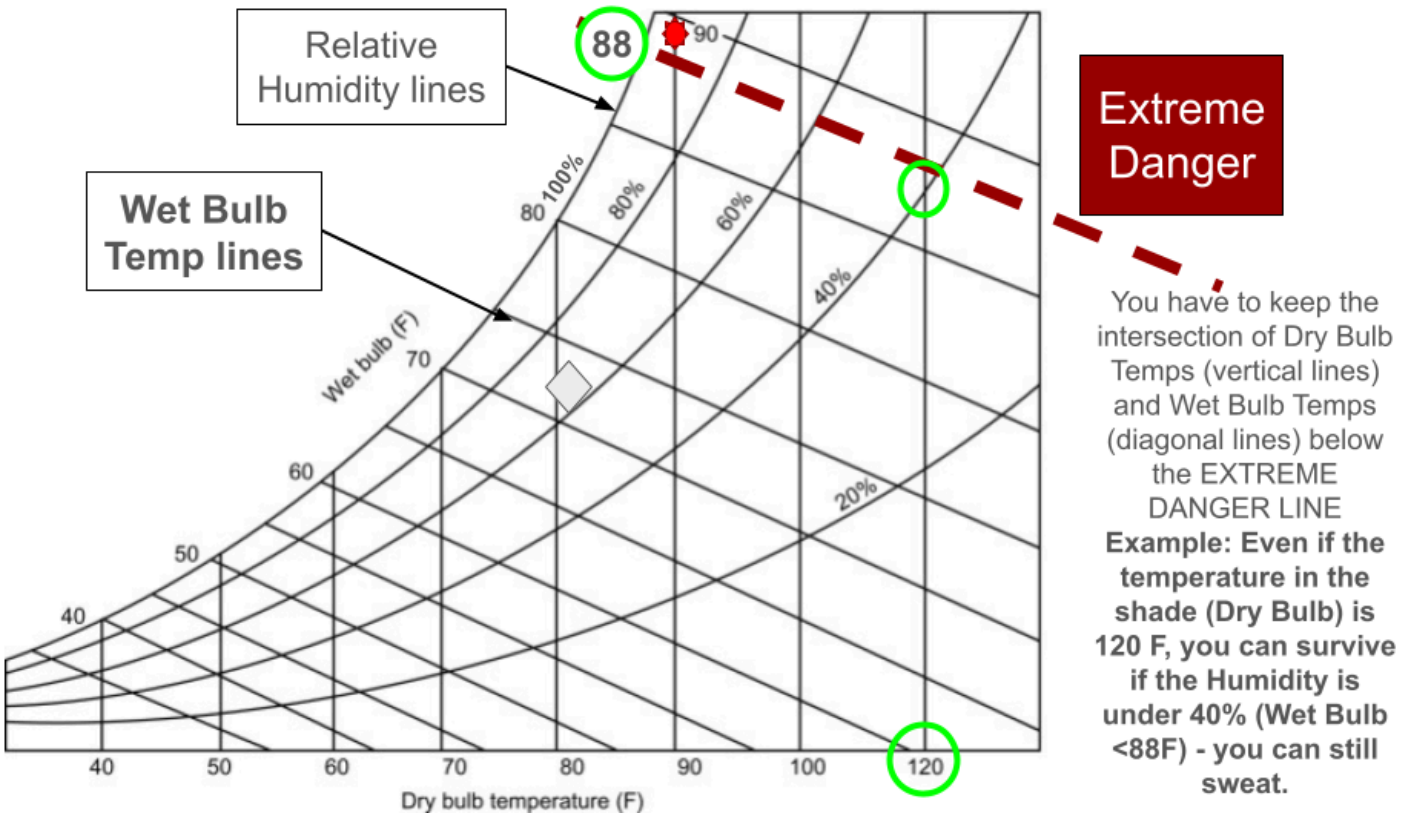
IF THE WET-BULB TEMPERATURE

First decide what temperature is dangerous, **if you can't sweat even in a stiff breeze**. Various studies (and athlete deaths on the afternoon practice fields) have settled around **88 ^{0}F.**

> A landmark study co-authored by Huber in 2010 found that a wet-bulb temperature of 35C (95F) persisting beyond six hours could induce hyperthermia in people and cause serious health consequences or death. While Huber's study assumed more of an ideal scenario —perhaps a person in the shade drinking water — real people might be out exercising in direct sunlight. Research published in the Journal of Applied Physiology in 2022 suggested that limit could be lower. Scientists placed young, healthy adults in chambers that mimicked high wet-bulb temperatures and had them perform tasks that mirrored those of daily life. **They found the limit could be much lower — between 30C (86F) and 31C (88F).**
>
> "That's kind of a game changer if that's right," said Huber.

That 88 F danger "Wet Bulb" temperature doesn't mean the shaded air temperature couldn't be higher - we often experience 100 F without too much discomfort IF THE HUMIDITY IS

LOW ENOUGH. If the humidity is low, we can sweat. This is all consistent with the chart below:



Wet-Bulb vs Dry-Bulb Temperature Measurements and Climate Change / ClimateCheck

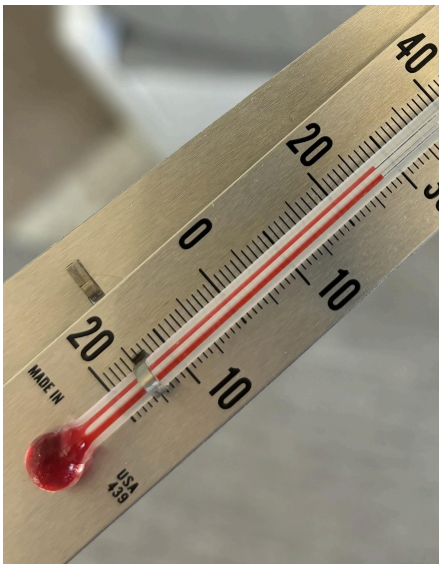
What this implies is: If we're not at 100% humidity, then the WET BULB TEMPERATURE < DRY BULB TEMPERATURE. We can sweat! The atmosphere, especially with a breeze, can evaporate our sweat, cooling our skin and preventing our core temperature from rising.

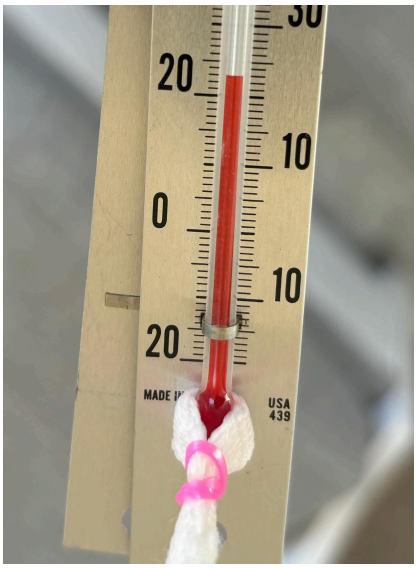
This is consistent with the findings that a wet-bulb temperature above 88 ^{0}F is dangerous.

If you add exertion and direct sunlight, or bad health or bad air quality to this, it's time to move. Here's an actual reading with a wet-bulb device. In this rig, the dry-bulb and the wet-bulb thermometers are back-to-back. I spin them around, inducing a strong breeze for about a minute.

This rig uses Celcius. The Dry-bulb reads 27.5 C (81.5 F) and the **Wet-bulb, because the humidity is low and cooling evaporation can occur, reads 23 C (73.4 F)**. This is well below the 88 F stipulated as Extremely Dangerous. **Find the diamond on the chart above**, where I've plotted this result. Using that diamond, one can estimate the relative humidity outside at around 65%. My Apple watch says it's 62%. All within the rough experiment I've done...

IF THE HUMIDITY HAD BEEN 100% AT THIS SHADED DRY-BULB TEMPERATURE (82F), WE WOULD STILL BE FINE; **BUT IF WE HAD A LITTLE HIGHER DRY-BULB TEMPERATURE (90 F in the shade) AND IT WERE 95% HUMIDITY, WE COULD DIE OUTSIDE**. (See the **orange star** on the chart.)

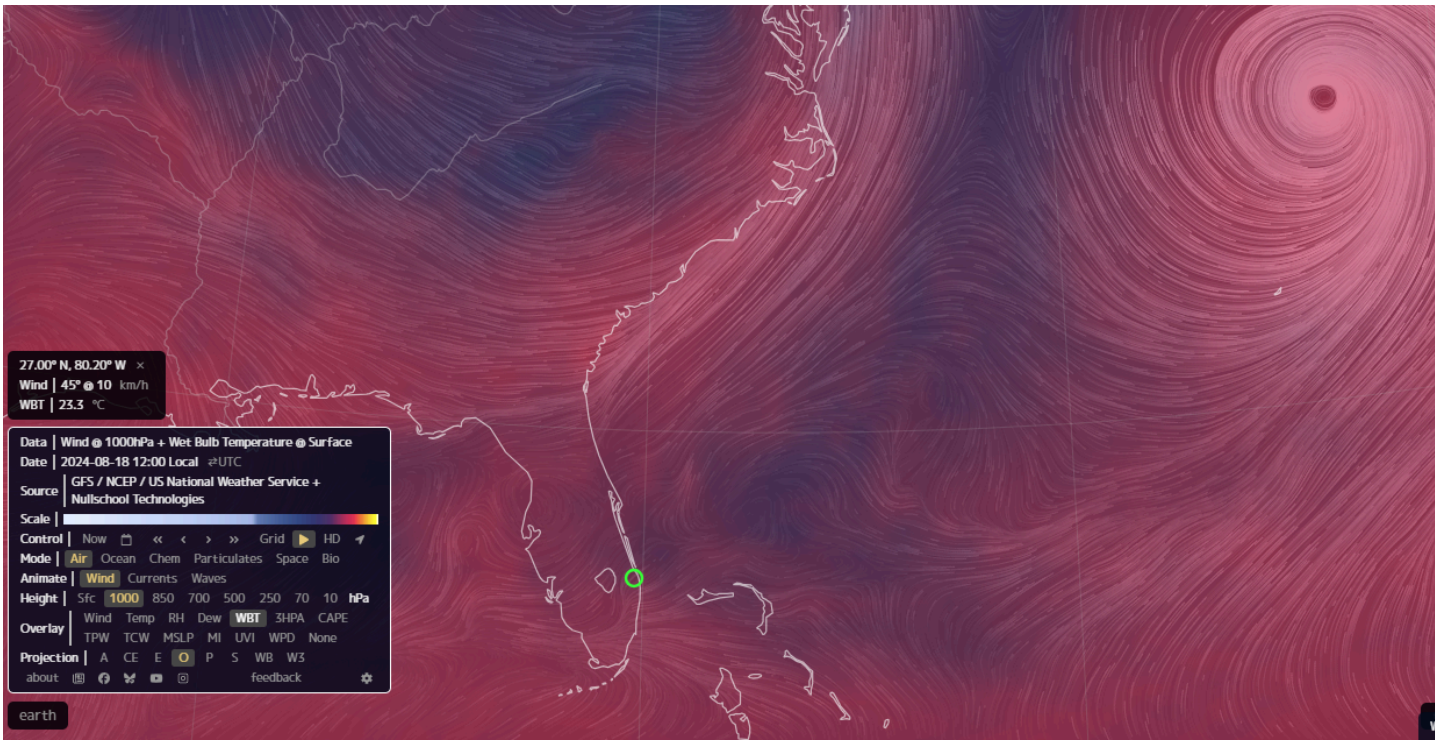




WBT = 23 C = 73.4 F

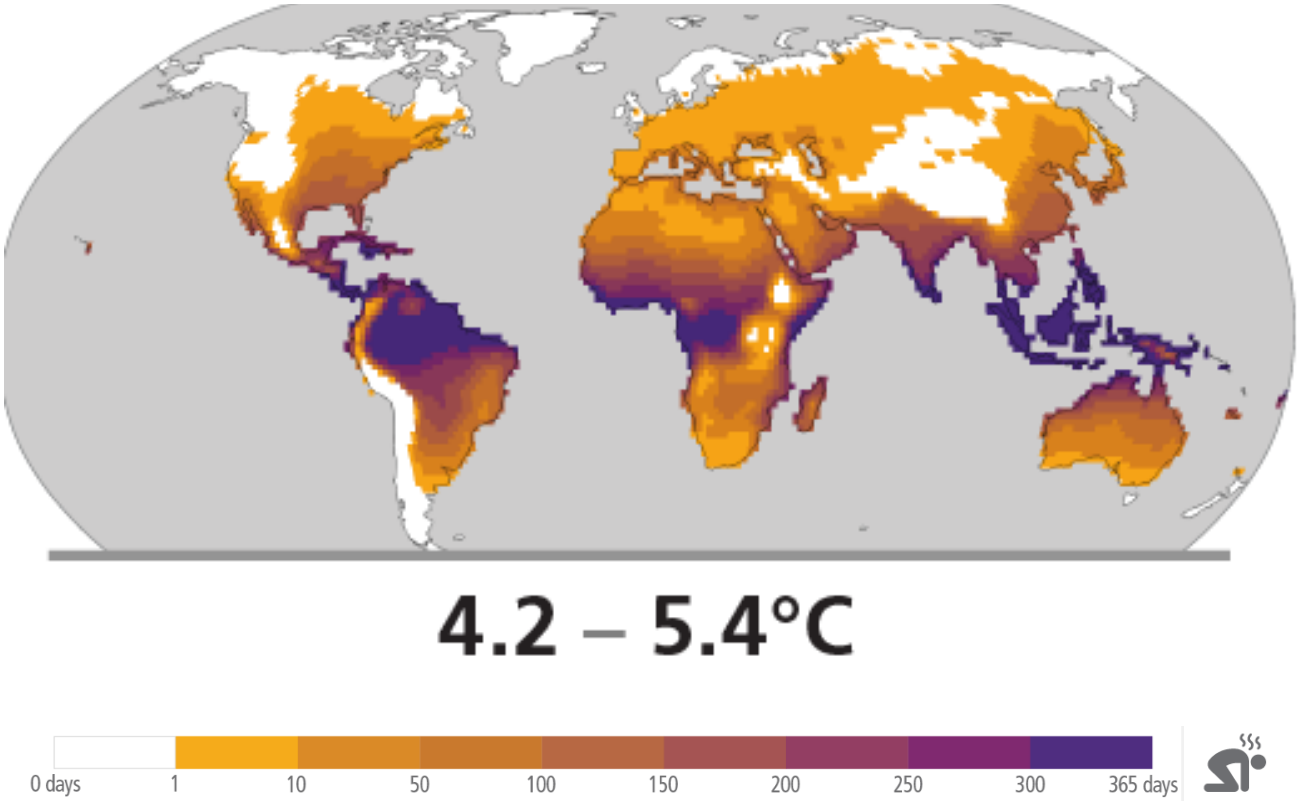
10	**Wet Bulb Temperatures and Human Habitability**	**CSSG-2.37**

This is Earth Nullschool for now (afternoon of Sunday 8/18/24), confirming the Wet Bulb Temperature in West Palm Beach. *Note Hurricane Ernesto!* **Shows WBT = 23.3C (same as above)**



Punchline:

As the planet warms, the combination of heat/humidity curtails the ability of humans to thrive. This will occur first where the heat/humidity is maximized - near the equator.



This addresses only one of the facets of human thriving. It is my assessment that there will be more and more pressure for societal migrations as the decades go by. Even in the next two decades, the heat/humidity factor is severe in certain regions of the planet.

Look carefully at the changes of shadings in South Florida. This projects 100 days with potentially lethal conditions per year by mid-century and perhaps 150 late in the century.

[Looks like our friends in Montana, Sweden, and Colorado may not be particularly impacted by this particular environmental factor. Perhaps those needing to move from equatorial regions may want to be welcomed here?]

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euronews. Latest Europe World EU Policy Business Euroviews Next Green Health Cult

Half a billion children suffer double the number of extreme heat days their grandparents did

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Why does South Florida feel so damn hot? It's not just the temperature that is rising

BY ASHLEY MIZNAZI
UPDATED AUGUST 14, 2024 11:17 AM | 3

Beads of sweat drips down the back of David Hicks, 46, a Miami Beach resident and DJ, after working out at the My Equilibra, a Miami Beach wellness park in August 2023. Especially if exercising outside, remember to drink plenty of water. CARL JUSTE *cjuste@miamiherald.com*

Approximate "Cheat Sheet":

1 meter → 3 feet **1 degree Celsius (°C)** → 2 degree Fahrenheit (°F)
ppm = parts per million **CO_2** = Carbon Dioxide
1 tonne = 1000 kilograms = 2205 pounds **1 gigatonne (1 Gt)** = 1 billion tonnes
1 trillion tonnes (1Tt) = 1000 gigatons

GOOD NEWS CORNER

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Palm Beach Zoo is helping save Florida's coral reef with a small team of divers and hope

Kimberly Miller, Palm Beach Post
Published 11:02 a.m. ET August 16, 2024
Updated 11:03 a.m. ET August 16, 2024

Coral Reefs Add +

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Finalist Wildlife category; In Papua New Guinea's Conflict Islands, conservation efforts have transformed former poachers into protectors. Amid this success swims the rare leucistic green sea turtle.

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