

The Limit of Heat Is Set by Temperature and Humidity Together

— At 35°C the wet-bulb temperature is **22.1440** at 30 per cent humidity and **33.5445** at 90, a span of **11.4005** degrees — 35°C at 90 per cent sits closer to the limit than 50°C at 25, which gives only **31.6032** —

[Paper 460]

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— *From thinking to syncing.* —

Abstract

Heat is measured by air temperature. This paper shows that at the same air temperature the wet-bulb moves by **11.4005** degrees with humidity—so 35°C can be more dangerous than 50. No new theorem or law is claimed. First, at 35°C and 30 per cent humidity the wet-bulb is **22.1440** $^{\circ}\text{C}$ (Section 2). Second, at the same temperature and 90 per cent it is **33.5445**, a span of **11.4005** (Section 2). Third, this is the core of the paper. 35°C at 90 per cent gives **33.5445**, above the **31.6032** of 50°C at 25 (Section 3). Fourth, reaching the 35 limit at an air temperature of 35 requires **99.2530** per cent humidity (Section 3). Fifth, at saturation the wet-bulb returns to the air temperature, **35.1163** in the fit, within 0.5 degrees (Section 2). Sixth, the separator is whether one quantity measures it, or a pair (Section 4). **Keywords:** wet-bulb temperature, humidity, heat stress, evaporative cooling, air temperature.

Scope of this paper (scope note): No new theorem or law is claimed—the wet-bulb temperature, evaporative cooling and physiological limits to heat are all standard. No medical advice is given—diagnosis, response and treatment are not the subject; in a hazardous situation follow professional guidance. No survival threshold is asserted—the 35°C wet-bulb figure is a representative value from the literature and varies with individual, duration and activity. One empirical fit is used—Stull’s single expression; near saturation it departs by about 0.5 degrees. No weather is forecast—where and how often such conditions occur is not the subject. Radiation and wind are excluded—sunlight, radiant load and wind speed all matter to a person, but only air temperature and humidity are treated. Relation to earlier papers: Paper 459 showed that a round trip multiplies the loss by 1.9—there too, one quoted number did not stand for the whole. Paper 300 showed that common root and distinct root can be decided—“heat measured by air temperature” and “by the wet-bulb” are distinct roots by that criterion. Paper 403 showed that the order of temperatures is not the order of hotness—there too, one word for temperature hid two quantities. What is added is giving the wet-bulb at four combinations, giving the span at fixed temperature as 11.4005 degrees, exhibiting a pair where 35°C exceeds 50, solving for the critical humidity as 99.2530 per cent by bisection, confirming that the fit returns to the air temperature at saturation, and placing the separator at one quantity versus a pair.

1. Notation and the Question

Setting: The wet-bulb temperature is what a thermometer wrapped in a wet cloth reads. Evaporation takes heat, so it lies below the air temperature and approaches it as the humidity rises. Stull’s empirical expression from air temperature T [°C] and relative humidity H [%] is

$$T_w = T \arctan(0.151977\sqrt{H + 8.313659}) + \arctan(T + H) - \arctan(H - 1.676331) \\ + 0.00391838 H^{1.5} \arctan(0.023101H) - 4.686035$$

A wet-bulb of 35°C is often taken as the point beyond which a person cannot shed heat.

Observation 1.1

Heat is measured by air temperature. Forecasts, records and warnings all speak in it—one number, easily ordered.

Observation 1.2

But a person cools because sweat evaporates. In damp air it does not—so the same air temperature can offer an escape or none.

Question: By how much do they differ.

2. An Eleven-Degree Span at One Air Temperature

Computation 2.1: Take the wet-bulb at four combinations.

Air temperature [°C]	Humidity [%]	Wet-bulb [°C]
35	30	22.1440
35	60	28.4883
35	90	33.5445
40	50	30.8939

Observation 2.2

At one air temperature the wet-bulb moves **11.4005** degrees.From 22.1440 to 33.5445—a single figure for air temperature does not carry that span.

Observation 2.3

The wet-bulb never exceeds the air temperature.Evaporation only cools—so air temperature is a ceiling, not the load.

Observation 2.4

At saturation it returns to the air temperature.35.1163 at 100 per cent—within 0.5 degrees even in the fit, an independent check that the expression is set up correctly.

Observation 2.5

40°C at 50 per cent gives 30.8939, below the 33.5445 of 35°C at 90.Five degrees hotter in air—and the order has already reversed.

3. Thirty-Five Can Beat Fifty

Computation 3.1: Trade air temperature against humidity and tabulate the wet-bulb.

Air [°C]	Humidity [%]	Wet-bulb [°C]	To the limit [°C]
35	90	33.5445	1.4555
40	60	32.9810	2.0190
45	40	32.6437	2.3563
50	25	31.6032	3.3968

Observation 3.2

The two orderings are exactly opposite. Air temperature climbs from 35 to 50 while the wet-bulb falls from 33.5445 to 31.6032—monotonically, in the other direction.

Observation 3.3

50°C sits 1.9413 degrees further from the limit than 35. Because dry air lets the sweat go—a dry desert at 50 and a humid 35 are different phenomena.

Computation 3.4: Solve by bisection for the humidity that reaches the 35 limit at an air temperature of 35.
99.2530 per cent (inverting gives a wet-bulb of 35.000000).

Observation 3.5

Practically saturation is required. At 35°C, even 90 per cent leaves 1.4555 degrees—the limit comes from neither quantity alone.

Observation 3.6

None of the four reaches the limit. The nearest, 35°C at 90 per cent, still has 1.4555 degrees—but the order of those margins is not the order of air temperature.

4. The Separator

The separator: does one quantity measure it, or a pair.

Observation 4.1

One quantity, and there is an order. 50 is hotter than 35—easy to compare and easy to build warnings on.

Observation 4.2

A pair, and there is no order. Neither air temperature alone nor humidity alone suffices—neither component carries an ordering by itself.

Observation 4.3

These are distinct roots by the criterion of Paper 300. Both are called “heat”—one a component of the state of the air, one the room left for evaporation.

Observation 4.4

This stands where Paper 403 stands. There, the order of temperatures was not the order of hotness—here the order of air temperatures is not the order of danger. In both, one word serves two quantities.

Observation 4.5

It overlaps Paper 459 as well. There, the quoted 0.90 did not stand for the whole path—here the quoted air temperature does not stand for the whole load.

Observation 4.6

So when records are compared, print the humidity. “The highest air temperature on record” is not necessarily the greatest heat—it counts a different quantity.

Observation 4.7

To be honest—the 35 wet-bulb figure is itself only representative. It moves with individual, activity, duration, wind and sunlight—this paper can say that the ordering reverses, not where the danger lies.

5. Roll Call and Closing

1. 35°C at 30 per cent gives **22.1440** (Computation 2.1): **ample margin**.
2. At 90 per cent it gives **33.5445** (Computation 2.1): **same air temperature**.
3. A span of **11.4005** (Observation 2.2): **not carried by air temperature**.
4. Saturation returns the air value (Observation 2.4): **35.1163, within 0.5**.
5. 50°C at 25 gives **31.6032** (Computation 3.1): **the core**.
6. The orderings are opposite (Observation 3.2): **monotone, reversed**.
7. 50 is **1.9413** degrees safer (Observation 3.3): **a different phenomenon**.
8. The limit needs **99.2530** per cent (Computation 3.4): **practically saturation**.
9. The separator is one or a pair (Observation 4.3): **distinct roots by Paper 300**.
10. Print the humidity with records (Observation 4.6): **a different quantity**.

Closing: Heat is measured by air temperature—forecasts, records and warnings all speak in it, one number and easily ordered. But a person cools because sweat evaporates, and in damp air it does not: the same air temperature can offer an escape or none. Within one air temperature there is an eleven-degree span—at 35°C the wet-bulb is **22.1440** at 30 per cent humidity, **28.4883** at 60 and **33.5445** at 90, a span of **11.4005** degrees. The wet-bulb never exceeds the air temperature, since evaporation only cools—so air temperature is a ceiling and not the load. At saturation it returns to 35.1163, within 0.5 degrees, which is an independent check on the expression. And the ordering reverses—35°C at 90 per cent gives **33.5445**, 40 at 60 gives **32.9810**, 45 at 40 gives **32.6437** and 50 at 25 gives **31.6032**: air temperature climbs from 35 to 50 while the wet-bulb falls monotonically. 50°C sits 1.9413 degrees further from the limit than 35, because dry air lets the sweat go. A dry desert at 50 and a humid 35 are different phenomena. Reaching the 35 limit at an air temperature of 35 requires **99.2530** per cent humidity, and

inverting returns a wet-bulb of 35.000000. So practically saturation is required: even 90 per cent leaves 1.4555 degrees, and the limit comes from neither quantity alone. One thing separates them—does one quantity measure it, or a pair. One quantity, and there is an order: 50 is hotter than 35, easy to compare and easy to build warnings on. A pair, and there is none: neither air temperature alone nor humidity alone suffices, because neither component carries an ordering by itself. They are distinct roots by the criterion of Paper 300, one a component of the state of the air and one the room left for evaporation. This stands where Paper 403 stands, where the order of temperatures was not the order of hotness: in both, one word serves two quantities. It overlaps Paper 459 too, where the quoted 0.90 did not stand for the whole path: here the quoted air temperature does not stand for the whole load. So when records are compared, print the humidity—“the highest air temperature on record” is not necessarily the greatest heat, because it counts a different quantity. To be honest—the 35 wet-bulb figure is itself only representative, moving with individual, activity, duration, wind and sunlight. This paper can say that the ordering reverses, not where the danger lies.

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