**Hello and welcome to Just Have Another Think, our twice monthly look at some of the environmental, ecological and social consequences of the 21st century climate emergency.**

**Here’s a nice sciency phrase for you, courtesy of the Intergovernmental Panel on Climate Change.**

**They tell us that our climate is a non-linear chaotic system. It’s a phrase that’s often abused by folks who are, shall we say, less keen to accept the realities of climate change. Those folks argue that by definition a chaotic system can’t be predicted and so it’s impossible to produce a model that can accurately tell us what the future may hold. They sometimes go all the way back to 1963, when chaos theory was first expounded in a landmark paper by Edward Lorenz. He’s the guy that brought us the famous butterfly effect, you know the one that says if a butterfly flaps it’s wings in one part of the world, then a few weeks later it could result in a tornado somewhere else on the planet. Lorenz argued that the inherent chaotic nature of weather meant it was impossible to make accurate long-term forecasts by any method.**

**But that was 1963. We’ve got super computers now with processing capabilities that would have been pretty much inconceivable back then. Plus, two other very important points - climate is not the same as weather, and climate modelling is not the same as weather forecasting.**

**There’s a good analogy for climate and weather. It’s a bit cliched now, so forgive me if you’ve heard it before, but it still does a very good job of explaining the difference, so I’m gonna use it anyway.**

**Think of the climate as being like your personality and the weather as being like your mood.**

**Your mood can change from day to day and even from minute to minute depending on a very complex and often unpredictable set of variables that you’re confronted with in your daily life. Others around you can see your mood change but they accept that you are still fundamentally you. You might be having a good day or a bad day but your personality, the thing that makes you you, remains the same.**

**In climate terms, human activity, particularly since the start of the industrial revolution, has increased the level of greenhouse gases in our atmosphere. The result has been well over one degree Celsius of warming as an average across the entire planet. And for every one degree Celsius of warming, the atmosphere is able to retain seven percent more water. That means our climate is developing what you might call a personality disorder. The climate personality that our species has come to know and love, and depend on, over the twelve thousand years since the last ice age, is now changing in ways that are making it less recognisable, with much more energy and moisture now available to drive the weather. And just like a doctor providing a patient with a prognosis of how a personality disorder is likely to progress within upper and lower boundaries of probability, so our climate modellers can predict a range of very likely long-term outcomes for our climate. And of course, just as a doctor might warn family and friends to look out for extreme and sometimes violent mood swings in the personality disorder patient, so our changing climate is increasing the likelihood of more and more extreme weather events occurring all over the world. They can be anything from sub-zero arctic temperatures in Texas to record heatwaves in the Arctic circle or several months-worth of rain falling in forty-eight hours in Europe. Those weather events would, of course, all have been perfectly possible within the planet’s climate system at any point in the last twelve thousand years, but the changing personality of our climate makes those weather mood swings much more likely to happen once a decade or even once a year, instead of perhaps once a century or so. And if, for example, you live in a part of the world that was already pretty hot and humid for large parts of the year, the one thing you do not want is extra energy and moisture in the atmosphere.**

**That exact predicament has been assessed in some detail in a new research paper, published this month in Nature Geoscience.**

**The paper focusses on the tropical zone from twenty degrees north of the equator to twenty degrees south, and it looks specifically at a phenomenon known as ‘extreme wet bulb temperature’.**

**The bulb in question is not a plant bulb or a light bulb, it’s actually the little bit of glass at the bottom of a thermometer.**

**So, what does a wet thermometer have to do with climate change?**

**Well, one of the most effective mechanisms we humans have for cooling down when we’re overheating is to sweat, unless of course you are Prince Andrew, who appears to be on a one-man mission to definitively prove the lizard people conspiracy theory.**

**But for the rest of us, the water that we excrete from our sweat glands evaporates into the surrounding atmosphere, and as it does so it draws heat away from our bodies, and that cools us down. It’s all to do with something called latent heat of vaporization, which I looked at in earlier video that you can watch by clicking up there somewhere.**

**If the surrounding atmosphere already contains a lot of moisture, in other words if it’s very humid, then the water on your skin has less chance of evaporating. And that’s where the wet bulb comes in.**

**You can work out how humid the atmosphere is by purchasing two ridiculously oversized thermometers from your local hardware store. Stick them side by side somewhere out of the sun and away from the wind and then wrap a piece of damp material like muslin at ambient temperature around the glass bulb on one of them. If the surrounding air is very dry, then the moisture in the material can easily evaporate and the temperature in that thermometer will go down. If the air is humid, then the moisture won’t evaporate so easily, and the temperature won’t go down so much. And if the air is already saturated with moisture, in other words if it’s at one hundred percent humidity, there’ll be no evaporation at all and the temperature in both thermometers will be exactly the same.**

**So, the closer the temperatures in the two thermometers are, the more humid the ambient air must be.**

**Obviously, there are more sophisticated versions of that DIY apparatus that are very accurately calibrated to calculate humidity precisely, but you get the idea.**

**All of that matters because at a wet bulb temperature of just thirty-five degrees Celsius or ninety-five degrees Fahrenheit the human body is unable to lose enough heat through sweating to survive, and if that human body happened to be yours, then you’d be dead within about eight hours or so.**

**The authors of the new paper looked at climate modelling in four tropical locations ; the Amazon rain forest, the African Sahel, the Indian Peninsula and the South East Asian maritime continent, which is Indonesia and the Philippines and a few others.**

**What they wanted to know was how the extremes of basic air temperature and the extremes of wet bulb temperature are projected to change as a result of overall average warming across the entire tropical zone.**

**That analysis produced four charts which in their fully finished state are a wonderful cacophony of confusing lines and shaded areas, so I decided to dismantle them all and build them back up step by step so that I could more easily understand them.**

**First of all, you’ve got the horizontal axes which show a range of possible future increases in mean tropical warming, measured in degrees Celsius.**

**The vertical axes show a range of the potential extreme temperatures, relative to the tropical mean.**

**And these dotted black lines represent a one-to-one ratio between those two measurements.**

**So, let’s start with the basic air temperature, which is the one our weather forecasters use on TV. The red shaded areas show the range of projected extreme air temperature changes as the tropical mean temperature increases, taken from various different climate models. And you can see that there’s quite a lot of variability between the models, with the red line representing the average of all of them.**

**This blue shaded area is the range of modelling variability for extreme wet bulb temperatures, and the blue line is the average of all of THEM. You can quite clearly see that there’s much closer agreement between the models for extreme wet bulb temperatures than there is for extreme air temperature. In fact, the paper tells us that the modelling variation for extreme air temperature is three point seven times greater than the modelling variation for extreme wet bulb temperature. You can also see that extreme wet bulb temperatures increase in an almost exactly one-to-one relationship with rising average regional temperature.**

**So, what can we conclude from all of that?**

**Well, the research paper points out that the annual maximum of average daily extreme wet bulb temperatures across ninety-nine point nine-eight percent of the land area in the tropical region over the past forty years was thirty three degrees Celsius. So, if by some miracle the world does actually manage to keep average global atmospheric warming to below two degrees Celsius, then that potentially fatal thirty-five degree wet bulb temperature might just be averted. But if we sail past the two-degree threshold, which is most certainly what we’re on course to do at the moment, then temperature and humidity will become a real existential threat for about three billion people living in the middle part of the globe.**

**And let’s not forget that all the temperatures we’ve looked at so far in this video were taken in the shade. Meteorologists apply a different term for heat stress in direct sunlight. It’s something they call Wet Bulb GLOBE Temperature, and unsurprisingly the effect on the human body of direct exposure to sunlight is far more severe than heat stress in the shade.**

**Now you could argue that people will simply need to use a bit of common sense and stay inside an air-conditioned building during those extreme temperature events. That’s fine if you’ve got one of those buildings available to you and if you’ve got nothing else to do.**

**But if you’re one of the hundreds of millions of people in the tropical zone who rely on outdoor work for a living, then your options are either to stop working and lose a day’s pay, a week’s pay or maybe even a month’s pay, or carry on working regardless and risk your own life in the process. I don’t know about you but that’s a kind of horrific Hobson’s Choice that I wouldn’t wish on anyone.**

**Whether we reach that shocking milestone or not depends on the actions of every corporation, every government, and every individual like you and me, literally from today onwards.**

**So that’s your mid-week food for thought.**

**As always, thanks very much for watching, and I’ll see you for our regular Just Have Think program on Sunday.**

**Bye for now.**