**Early in September each year I sit down to start reading the latest scientific research on the state of play up in the Arctic, and every year I get reminded of what an immense and dynamic part of the world it really is.**

**I mean take the Arctic Ocean for example. You could fit all fifty American states in there and still have plenty of room left over for a country the size of India. And yet every winter temperatures drop low enough for its entire area, to completely freeze over into an ice sheet thick enough to effectively become a land mass. Then, as the northern hemisphere comes back around to face the sun during the summer months, the ocean absorbs enough solar radiation to melt the excess winter ice away. It’s a dance that mother nature has performed annually for more than ten thousand years, since the end of the last ice age, and it has a huge influence on global ocean circulation and northern hemisphere climate patterns.**

**And then there’s Greenland. An island the size of the 5 largest western European countries combined, eighty percent of which is covered with an ancient ice sheet that’s nearly two miles thick in its centre and a mile thick on average. That equates to about three million cubic kilometres of water, or put another way, enough water to raise global sea levels by more than seven metres or about twenty-four feet.**

**Now, unless you’ve been living under a rock for the past decade or so, you will, no doubt, already be aware of scientific research and modelling suggesting that global warming is reducing the amount of Arctic Sea ice that forms each year and melting some of the land-based ice from the Greenland ice sheet. And you’re probably aware that, for all sorts of reasons, that’s not an ideal state of affairs. But as researchers carry out more and more in-depth analysis of the region and ever more sophisticated computer modelling software provides greater levels of accuracy, our scientists are beginning to realise that previous studies have been seriously underestimating the magnitude of the changes taking place. And in the summer of twenty-twenty-two, three separate peer reviewed papers were published that provide us with the unvarnished and perhaps unwanted truth.**

**Hello and welcome to Just Have a Think,**

**A few years ago I heard a comedy parody of a famous old Rudyard Kipling poem, which went something like this…**

**“if you can keep your head while all those around you are losing there’s…then you probably haven’t understood the seriousness of the situation!”**

**And that’s a sentiment that came to mind several times as I was reading through these new research papers.**

**So, what’s going on then?**

**Well, let’s start with one of the most visible symptoms before we look at the causes. Around about this time in September, right at the end of a Summer season of warming, the extent of Arctic Sea ice reaches its annual minimum. Back in twenty-twelve there were some freak weather conditions, including unusually warm North Atlantic waters moving into the Arctic Ocean, an area of freakishly warm water just south of Greenland, extra warm air coming in from a record North American Heatwave, and the transport of warm water vapour across the surface of Greenland via what’s known as an atmospheric river delivered by the Atlantic. All of that resulted in an uncharacteristically low September Arctic Sea ice minimum. This year didn’t see such freakish conditions but nevertheless this September’s minimum is still noticeably lower than nineteen-eighty-one to twenty-ten median. While it's nowhere near the one million square kilometres that is scientifically defined as an ice -free Arctic, as some doom mongers predicted it would be this year, it does mark another step on an inexorable trajectory towards that eventuality. And it does look likely that we’ll see ice free summer Arctic conditions within the next decade, especially when we factor in ice thickness. Ten years ago, when we had that historic low surface area event, there was still a healthy amount of very thick multi-year ice stretching right out into the centre of the ocean. That thick ice has now all but disappeared and in many places the ice is now only centimetres thick. One violent storm event could break up that wafer thin ice and cause it to melt away into the water.**

**One of the causes of this unfortunate phenomenon is exceptional warming over the Barents Sea area, which this June twenty-twenty-two paper delves into. Researchers from all these academic institutions reanalysed warming in the Barents Sea area over the past forty years based on newly available observations and a quality controlled comprehensive dataset taken from the sea’s northern archipelagos. Their results suggest a much stronger rate of atmospheric warming compared to previous analysis. The team identified what they describe as “a statistically significant” record-high annual warming in the Barents Sea of up to two-point-seven degrees Celsius per decade, with a maximum in autumn of up to four degrees Celsius per decade. This Arctic hotspot phenomenon isn’t just about warming AIR though. The researchers point out that the Northern Barents Sea region also hosts a more pronounced LOSS of WINTER sea ice than anywhere else in the Arctic, and since the early two thousands the region has experienced a sharp increase in both temperature and salinity in the entire water column, caused by increased ocean heat transport entering the region from warming Atlantic waters in the west. Less freshwater in the ice means saltier water in the upper layers of the ocean. That reduces ocean stratification and increases upward heat flux. The projection is that if the rise in ocean temperature and salinity continues, the originally cold and stratified Arctic shelf region may be transformed into an Atlantic-dominated climate regime with a warmer and more well-mixed water column strongly preventing future sea ice formation.**

**That paper was followed on the eleventh of August by this one**, **published by researchers at the Finnish Meteorological Institute. Their objective was to apply the latest state-of-the-art climate modelling techniques to four major observational datasets of Arctic temperatures dating back to nineteen-seventy-nine, which is when the modern era of satellite monitoring began.**

**Previous climate simulations from something called the Coupled Model Intercomparison Project, or CMIP, run by the World Climate Research Programme suggested that Arctic warming over the last forty-three years had been twice or even three times higher than the global average. But by applying more sophisticated and holistic modelling to the data the Finnish researchers found that the old models were underestimating the differential between Arctic warming and overall global warming by as much as thirty four percent.**

**The new analysis showed that across the entire Arctic region, warming since nineteen-seventy-nine has, on average, actually been about four times higher than the rest of the planet, and in a very large area of the Eurasian Arctic, local warming has been more like seven times higher than the global average.**

**And that extreme warming is inevitably impacting the vast ice sheet sitting on top of Greenland, which brings us nicely to our third research paper, published at the end of August twenty-twenty-two. This one was the result of an academic collaboration between several universities and institutes, led by the Geological Survey of Denmark and Greenland.**

**Once again, the researchers identified shortcomings in previous process-based models including what they describe as “imprecise atmospheric and oceanic couplings.” Correcting for those inaccuracies showed that, based on the climate over the last twenty years or so, we’re already locked into surface mass loss from precipitation, ice flow discharge and meltwater run-off that will cause nearly sixty thousand square kilometres of the Greenland ice sheet to slip away into the surrounding ocean in the coming decades regardless of which climate mitigation pathway our global leaders eventually agree on. That’s about three-point-three percent of the total mass of the ice sheet and it will cause more than twenty-seven centimetres, or about 12 inches of sea level rise. And that’s just based on AVERAGE conditions over the last two decades. The researchers point out that there can be a great deal of variability in Arctic conditions from one year to the next. Twenty eighteen for example was dominated by unusually cold waters coming in from the Atlantic and cold polar air across Greenland’s western side. That suppressed surface melt and resulted in the lowest surface mass loss 9 recorded so far this century. The twenty-twelve anomaly that I mentioned earlier though was at the other end of the scale. As well as resulting in a record low September Arctic Sea ice area, it also caused increased and sustained surface melting and evaporation, and meltwater run-off from the Greenland ice sheet. Twenty-twelve is more likely to be a portent of the future though, and if that year was taken as the analogue for a projected late-twenty-first century sustained warmer climate, then the researchers calculated that ten percent of the ice sheet would disappear, causing almost eighty centimetres of global sea level rise. That’d impact hundreds of millions of people in coastal areas around the world who would lose their livelihoods as sea water encroached on agricultural land, and possibly even their lives as extreme storm surges devasted entire regions.**

**And if all that lot wasn’t enough to cheer you up, we got a bonus fourth research paper just last week from the Stockholm Resiliency Centre, outlining all the tipping points that could be triggered if we go beyond one point five degrees Celsius of average global surface temperature warming compared to pre industrial times, which by the way, we’re only zero point three degrees away from right now. Greenland ice sheet collapse sits right at the top of the list, kicking in with conviction as temperatures rise by less than two degrees Celsius. The papers projections also show that abrupt sea ice loss that we just looked at in the Barents Sea ice and a collapse of an important circulatory system in the North Atlantic. Two degrees also causes the die off of low latitude coral reefs and it accelerates the collapse of the West ANTARCTIC ice sheet.**

**If we stray towards four degrees of warming, the researchers say we’re looking at serious consequences in the Amazon and the loss of mountain glaciers all over the world.**

**Go beyond four degrees and the Arctic Sea is not only ice free in the Summertime but ice free all year round. The permafrost in the vast expanses of boreal forests thaws out allowing microbes to digest the organic matter and release huge quantities of methane into the atmosphere. The famous AMOC ocean circulation system grinds to a halt and the immense land-based EAST Antarctic ice sheet starts to give way. There’s enough water locked up in there to raise sea levels by fifty-two metres or a hundred and seventy feet, which is not something I think any of us would want to inflict on our grandchildren and their descendants.**

**These tipping points are like a massive, planetary scale game of dominos. The first few dominos to fall represent fairly abstract concepts that few of us directly feel the effects of. But as those dominos create more tipping points further along the line, the consequences become increasingly tangible for the majority of the human population until they eventually become existentially threatening to all of us.**

**That’s why the scientific community is imploring us to lose our apparent fixation with one point five degrees Celsius or two degrees Celsius of warming, which are the upper and lower targets set by the Paris Agreement in twenty fifteen. Those numbers are pretty much irrelevant now because even at one point two degrees of warming we’ve already set in motion the first few tipping points. What we’ve got, say our scientists, is an emergency, and what we need is for our global leaders to implement immediate emergency measures to deal with it.**

**And if you want to dig into the detail of the papers I’ve referenced in this video then, as always, I’ll leave links in the description section below to each one of them.**

**That’s it for this week** **though. Thanks as always, to our fantastic Patreon supporters who help me maintain the channel’s independence and allow me to make videos like this one without having to worry about ad revenue or whether the YouTube algorithm will like it or not. You can join them and have your say in future video content plus watch exclusive monthly updates from me, by visiting**

**Patreon dot com forward slash just have a think.**

**And if you WOULD like to see us getting noticed more by the dreaded algorithm then the best way to help with that is by subscribing and hitting the like button and that notification bell if you haven’t already done so. It’s just a simple click which you can do down here or on that icon there.**

**As always, thanks very much for watching, have a great week, and remember to Just Have a Think.
See you next week**