**If you've been following the channel since the early days, you may remember me talking about a natural phenomenon called the latent heat of fusion.**

**Essentially it means in order to warm something up enough to change from one state to another, like changing these ice cubes from solid ice to liquid water, you have to shove in quite a lot of extra energy to convince the molecules to start jiggling around in a more liquidy kind of a way. So as these ice cubes take in energy from their surroundings, they warm up towards zero degrees Celsius, which is the freezing point. But they're still solid ice. To make them change from solid ice to liquid water, still at zero degrees Celsius, you have to put in an extra 334 joules of energy for every gram of ice. And that extra energy is what they call the latent heat of fusion. But here's the thing. Once you've done that, and you've got liquid water at zero degrees Celsius, if you put in another 334 joules of energy for every gram, you'll heat that water up from zero degrees Celsius to 79 degrees Celsius, which is basically scalding water. So if we say this glass of water represents the arctic ocean, and these ice cubes represent arctic sea ice, and this spotlight represents a source of heat, you know, like the sun, then you can start to see why the climate scientists are suggesting we might have a bit of a problem.**

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

**Now just for clarity, I don't think the scientists are suggesting that the arctic ocean is suddenly going to heat up to 79 degrees Celsius, but then again you don't need anything like that kind of warming in a body of water as large as Canada, Alaska and Greenland combined, to cause a pretty significant change to the entire global atmospheric temperature.**

**What the scientists are very sure about is that the metaphorical spark that lit the fire of global warming over the course of the last one hundred and fifty years or so, is a rapid increase in the concentration of carbon dioxide in the planet’s atmosphere. And that increase is down to us humans. Now our planet has warmed up and cooled down loads of times over the vast geological timescales going back millions of years. That's why we get ice ages and inter-glacial periods, which is what we're in right now. And it's absolutely true to say that carbon dioxide hasn't always been the initial cause of the warming. In many cases the graph shows us that warming started before CO2 concentrations began to increase. But in every case, when the CO2 levels did start going up, they amplified the heating by setting up a feedback loop, a bit like this microphone. Sound goes in here, passes through an amplifier and comes out of this speaker. But if I was to put this microphone next to that speaker then the sound going in here would come straight back out of there, effectively doubling the noise going in here, and then twice the noise is coming out of there and going in here so now you've got four times the noise and so on and so on. And very quickly you get that tell-tale feedback loop screech that the metal heads love so much.**

**Our planet's been in an interglacial period for about eleven thousand years now, during which time the overall global temperature has never varied by more than about half a degree Celsius above or below the long term average. And its that remarkable climate stability that's allowed human civilisation to flourish on almost every available land mass. Right now, the earth should be starting to cool down towards the next glacial period, and it would be too if wasn't for us pesky humans. The carbon dioxide we've pumped into the atmosphere since the start of the industrial revolution is now LEADING the warming of our atmosphere rather than following it like it has on so many occasions in the past.**

**And that means, just like the feedback loop this system produces with noise, we humans have now sparked off a heat feedback loop up in the arctic which is impacting all sorts of variables up there, causing what the scientists refer to as arctic amplification.**

**Here's what's going on...**

**The industrial revolution gets into full swing towards the end of the nineteenth century. Industrial societies burn oil, coal and gas for fuel, releasing hundreds of billions of tons of carbon dioxide into the atmosphere over the course of the 20 century. During that time we also clear country sized areas of forestry land to provide grazing pasture for industrial scale livestock farming and agricultural space for cereal crops, all of which removes trees and plants that suck up carbon dioxide and breathe out oxygen.**

**So towards the end of the twentieth century the global atmosphere starts to warm a little bit, and our oceans start to warm up too. Research published by the US National Academy of Sciences in 2019 found that the oceans have absorbed as much as 90% of the extra heat caused by CO2 emissions since 1870.**

**According to this Forbes article that's about a thousand times more energy than the global population uses each year.**

**The warming seas cause an increase in the amount of melting ice up in the arctic sea, and as we saw earlier with our glass of ice water, once the energy of the sun hits liquid water it heats it up pretty quickly. Not only that but when there's ice covering the water, it's bright white surface reflects much of the sun's energy back out into space. That's the albedo effect that climate scientists talk about. So now you've got less reflection and more absorption of energy.**

**And as the channels between the Arctic Ocean and the Pacific and Atlantic Oceans on either side start to lose their permanent plugs of ice, the warm waters of those two vast oceans start to infiltrate the Arctic Ocean and warm up the water even more.**

**Some of that extra warmth is picked up from the water by the prevailing arctic winds, which increases the local atmospheric temperature. Then things start getting a bit funky. The warmer air causes the huge ice sheet sitting on top of Greenland to start melting faster. That means more exposed land to absorb heat and less ice to reflect it. A similar thing starts to happen over in Siberia and on the East Siberian Arctic Shelf, which sits below a very shallow layer of arctic water, barely fifty metres or so deep. All these land masses are made up of large amounts of permafrost or permanently frozen earth containing organic material from plants and animals that got buried and compressed over geological time periods. As the permafrost thaws out, all the tiny micro-organisms in the soil start feeding on organic matter, and as they do that they release enormous quantities of methane, which is a greenhouse gas many times more powerful than carbon dioxide. So that adds another dollop of warming to the arctic atmosphere. On the 21st June this year, the town of Verkhoyansk in Siberia, which sits even further north than Fairbanks in Alaska, hit 38 degrees Celsius or just over a hundred degrees Fahrenheit.**

**That's not normal. And those freaky temperatures are causing wildfires that are not just burning trees and plants, but also huge swathes of peatland which is extremely rich in carbon. So more CO2 goes up in smoke and the mercury rises still further.**

**All that arctic warming starts doing strange things to the Jet Stream. We've looked at the Jet Stream in detail in a previous video and you can click up there to jump back to that one, but in basic terms, as the temperature difference between the middle of the planet and the top of the planet gets smaller, so the Jet Stream starts to get slower and more wavy. The upward waves drag even more warm air up from the middle of the planet and the downward waves drag cold air away from the arctic. All these feedbacks mean the arctic isn't just warming up. It's warming up as much as three times faster than anywhere else on earth.**

**And that impacts all of us. The polar regions act like gigantic thermal regulators for the entire planet, which is one of the reasons our atmospheric temperatures have remained so stable since the last ice age, and we humans have been able to build the civilisations and societies we live in today. And you can see from our feedback loop that arctic sea ice is a major factor in the climate stability of the northern latitudes. So, tracking the ebb and flow of sea ice from it's winter maximum in March to it's summer minimum in September has been a major feature of arctic research for nearly fifty years.**

**In 2012, arctic sea ice reached its lowest summertime minimum surface area on record at just 3.4 million square kilometres.**

**In 2019 we hit the second lowest extent on record. Those two years are the only recorded instances of sea ice dropping below 4 million square kilometres.**

**Statistically speaking a summertime sea ice extent of less than one million square kilometres is regarded as effectively an ice-free arctic ocean. That's never happened in modern human history but if it did, then so much solar heat energy would be absorbed into the water that it's highly likely the ocean would be ice-free again the following summer and every summer from then on. And as each subsequent year went by the length of time that the ocean stayed ice free would get longer and longer until eventually there'd be no significant level of ice in the water at any time during any season, including winter.**

**So, what's the state of play in 2020?**

**Well we're there again I'm afraid. At the time of filming this programme on the 10th September 2020, Arctic Sea Ice had dropped to 3.8 million square kilometres, very close to the 2012 record minimum. But there's a big difference between the ice of 2012 and the ice of 2020.**

**These are charts produced by the United States navy using upward looking sonar from their fleet of submarines. Those submarines have to surface from time to time so it's in their interest to know exactly how thick the ice is above them.**

**The key at the bottom of the screen indicates ice thickness from zero to 5 metres.**

**If we zoom in on the 2012 chart you can see that the coastal ice is all about 4 or 5 metres thick, and even out into the middle of the ocean there's still a good deal of multi-year ice more than 2 or 3 metres thick.**

**Contrast that with a zoom in on the 2020 chart. All that multi-year ice has almost completely disappeared leaving little more than 30 centimetres of slush. It's covering a similar area but it's nothing like the same kind of ice that was there only eight years earlier.**

**Latest estimates are that we may see an ice free arctic by about 2035, but some researchers think it could be sooner than that, arguing that a covering of ice as thin and vulnerable as the one we're witnessing this year could easily be smashed up and dissipated by a single violent arctic storm - something that's not unusual in that part of the world.**

**A raft of new research papers and articles were published during the summer of 2020 pointing to a worse than expected acceleration of all these feedback loops and tipping points, including the faster than expected melting of the Greenland ice sheet itself, which not only contributes to increasing arctic temperatures but also to global sea level rises.**

**The general consensus of scientific opinion is that it's very unlikely we can now reverse the process of climate change - we're about 30 years too late for that. But there's still plenty we can do to slow it down and mitigate some of the worst effects that it'll bring.**

**That action starts with our global leaders of course. At the COP 26 Climate Conference to be held in Glasgow in 2021, all participating countries are legally obliged to present their updated and vastly improved nationally determined contributions towards a rapid reduction in global greenhouse gas emissions. It remains to be seen whether those reworked numbers will achieve the target of limiting global atmospheric temperatures to a maximum of 2 degrees above pre industrial levels, but one thing is for sure, nature doesn't care about viruses or economic shutdowns or political point scoring, so while those global leaders are pre-occupied with their self-absorbed introspection, our atmosphere continues to get warmer and wetter and our planet continues to get less and less hospitable to the way our societies are organised today.**

**No doubt you've got strong opinions on this one so feel free to dive down to the comments section below and leave your thoughts there.**

**Now on a completely different tack before I go, I want to let you know about a couple of significant developments here at the Just Have a Think channel.**

**The first is the long-awaited website that many of you long term supporters will have heard me promising for over a year now. Well it's finally seen the light of day and you can visit it at**

[**www.justhaveathink.com**](http://www.justhaveathink.com/)

**It's a pretty straightforward site. No floating parallax backgrounds or 3D virtual reality experiences and it wont wake you up in the morning with a nice cup of tea or anything, but it serves as an online signpost to all of the channel's videos, and it'll also be where I post the transcripts of each video, which is something that a lot of you have asked for so that you can translate the programmes more easily into your own language. In time it'll also become a blog post for me to talk about more wide-ranging issues that don't always make it into the main videos.**

**The second exciting development is an exclusive Just Have a Think app that you can download to your phone or tablet. I've teamed up with a company called Bubblr, who already operate a news aggregator app called NewzMine. As many of you know, I don't do paid sponsorships or endorsements at this channel, so no money has changed hands in either direction on this project. What I really like about the app is that you don't have to register any of your information to use it so Bubblr don't exploit your data in any way. They also don't run ads on the app itself, which is entirely in keeping with my ad free approach to the channel videos. So what you'll get is a completely free to use platform from where you can jump directly to the Just Have a Think videos each week, plus news and articles from thousands of sources around the world on climate and sustainable technology categories that I've specifically chosen for the app. You can also add you own categories and you can turn notifications on and off for each category too, so you only get notified about the subjects that you're interested in. It's simply called Just Have a Think, and it's available from the App Store or Google Play. I'll also leave clickable links in the description section below.**

**I must also say a big thank you to our amazing supporters over at Patreon who allow me to keep the channel ad-free and maintain independent content. You can get involved in that too by visiting**

[**www.patreon.com/justhaveathink**](http://www.patreon.com/justhaveathink)

**and of course you can hugely support the channel absolutely for free by subscribing and hitting that like button. And make sure you hit the little bell icon too so you get notified when new videos come out.**

**Dead easy to subscribe, you just need to click down there 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**