Speaker 1:

Research is really important because by definition, it's the only way to get new knowledge. There's so much that isn't yet known, that it's just a cool time to be in science.

Ben S.:

Well, I think at the end of the day, what really gets us out of bed in the morning is just a curiosity, trying to understand things we didn't understand the day before.

Beth Bamford:

Welcome to REACH, the podcast about why research matters. I'm Beth Bamford.

Cole Cullen:

And I'm Cole Cullen. Today, we're going to tell you about climate change, more specifically, the research being done at Penn State about climate change.

Remember all that rain we had last year?

Beth Bamford:

How could I forget?

Cole Cullen:

It seemed like last summer we had a lot of rain. In fact, here in central Pennsylvania, at least half of the days in 2018 had measurable precipitation.

Beth Bamford:

That's like saying it rained every other day. Every other day.

Cole Cullen:

Climatologist Michael Mann joined us to discuss climate change and the summer of 2018.

Michael Mann:

Hi, I'm Michael Mann. I am a professor here at Penn State in the Department of Meteorology and Atmospheric Science, and I direct the Penn State Earth System Science Center, which is a center for the study of climate research.

It's almost become a mantra of mine that the impacts of climate change are no longer subtle. We're seeing them now play out in real time on our television screens, in our newspaper headlines, in our social media feeds. And summer 2018 was to me, when climate change sort of really showed its hand, and where it became clear to I think about any reasonable person that something is happening here, that there is this impact. It turns out that my own research in recent years has been very much into precisely that issue, how is climate change influencing these extreme summer weather events. And in particular, extreme summer weather events like the floods and superstorms and droughts and heat waves and wildfires that we saw play out across the entire planet over the past year, in the northern hemisphere during our summer and now in the southern hemisphere during their summer that just finished up, where Australia saw the same sort of onslaught of unprecedented floods and heat.

Some of the underlying science is pretty basic. A warmer atmosphere holds more moisture, so you have the potential for larger precipitation events, bigger floods, short-lived, but very intense rainfall events. The heating of the surface dries out the land, so you get worse drought and you combine heat and drought and you've got a recipe for unprecedented wildfires, like we saw play out in California. California doesn't have a wildfire season anymore. It's a perpetual wildfire season. Their worst fire on record happened last winter. It's a perpetual fire season and then drought and heat is punctuated by short periods of time where you do get these intense winter storms and they pack a bigger punch because there's more moisture in the atmosphere. So you get the sort of flooding that California saw this winter as well. You see extremes on both sides becoming more extreme.

It has to do with this emerging behavior of the jet stream, the northern hemisphere jet stream, where it's slowing down and it's exhibiting larger sort of north south wiggles, meanders. You know, when you look at the weather map and you see the jet stream, they showed curving northward and southward, those meanders in the jet stream. Well, what climate change is doing is slowing down the jet stream and making those meanders larger, and the larger those meanders, the more extreme the weather systems underneath. Extreme heat and drought day after day after day or rainfall day after day after day. Our research demonstrates that that particular behavior of the jet stream is being favored by climate change in a subtle way really. It has to do with the fact that the characteristics of the jet stream depend on the variation in temperature in the atmosphere as you travel from the warm subtropics towards the cold polar regions.

That contrast in temperature, we call it temperature gradient, is actually what is responsible for the existence of the jet stream in the first place. The Arctic is warming faster than the rest of the planet because we're melting away that ice that allows more of the sunlight to be absorbed. So you get more warming over the Arctic, then you get down here in middle latitudes. So you're decreasing that contrast in temperature from the warm subtropics to the cold polar region, you're slowing down the jet stream. And it turns out that same change in temperature is also causing the jet stream to wiggle more dramatically, so you get those larger meanders and they stay locked in place. And that's what's behind these extreme weather events we've seen in recent summers.

The phenomenon that we're talking about has a fancy name called quasi-resonant amplification, and it turns out that this behavior in the jet stream mathematically is very similar to a problem in quantum mechanics. And of course, I came from theoretical physics and it turns out the same mathematics that was developed in the early 1900s to solve problems in quantum mechanics, the behavior of matter at the smallest scales also applies to this problem of how the jet stream behaves, the behavior of our atmosphere at the largest, at the planetary scale. And it corresponds to a phenomenon, a physics phenomenon that's known as resonance, and when you have resonance, you tend to get very large amplitude waves.

Whether you get or not depends on some subtle characteristics about that north-south difference in temperature that I was talking about. And so in any given summer, the condition may or may not be right to get this phenomenon. In summer 2018, the conditions were ideal for that. In 2010, when we saw those unprecedented wildfires breakout across Russia and at the same time Pakistan was experiencing record flooding, it was another example of that.

Whether or not it will happen in any given summer is hard to predict because it really depends on the specifics of the weather patterns and the temperature differences. But what we can show and have shown in a couple of different published research articles now is that this amplified warming of the Arctic makes those conditions more likely. It projects onto the pattern that gives you this resonant amplification, so we expect it to become more and more common as the Arctic continues to warm faster than the rest of the planet, and indeed we are seeing that happen. And 2018 was sort of the the poster child for that because the scale at which we saw unprecedented weather events was really what was unprecedented because it was North America, it was Europe, it was Japan, it was the entire northern hemisphere. And that sort of pan-hemispheric outbreak of extreme weather events to me was very worrying because it's what we've been predicting.

Hopefully, our predictions will lead to the behavior that prevents the realization of those predictions. Nonetheless, the fact is that we haven't acted yet to the extent necessary. We've already committed ourselves to far more warming and far more climate change than we should have and all of the things that we were predicting two decades ago are coming true.

Let's hope that we don't have to look back 50 years from now and say, and they were further validated by an additional 50 years of inaction. Let's hope that our message now and the remarkable success that our predictions, the track record, the remarkable track record that our predictions have had, let's hope that that is enough for us to act now to prevent the worsening of this problem by reducing carbon emissions, by acting on climate.

Cole Cullen:

There seems to be a lot of stories on the news about glaciers melting due to climate change, but what does that really mean?

Beth Bamford:

We sat down with Sridhar Anandakrishnan to talk about glaciers, sea levels rising, and what it means to us.

Sridhar A.:

Geoscience is a very broad field and my piece of it is something called geophysics, which is the use of things like light and sound and gravity and so on to study the Earth. And to narrow it down even more, I study glaciers.

Beth Bamford:

What motivated you to study glaciers?

Sridhar A.:

That's the one interesting thing about me, the only interesting thing about me is that I changed from electrical engineering to geophysics after I was in graduate school. I was actually doing a PhD in electrical engineering when I got a summer job at the University of Wisconsin with the folks in the Department of Geosciences to build some electronic instrumentation for them. So it was just a one-off summer job, they needed some help, I had the expertise and they said, “Well, why don't you come with us to Antarctica to install these instruments, make sure it works?” And I went down and here I am, 30 years later, still going to Antarctica.

When I first went down there, there were rumbles of concern about climate change, CO2 impacts on glaciers and sea level. But the sort of dynamism of this system had not been recognized that time. And now we understand the glaciers can change far more rapidly than perhaps I thought when I started my career.

So the urgency wasn't there even though it was known to be intellectually interesting and possibly societally important problem. Right now, it's in the forefront of one of the most critical issues that society faces. And I don't think I'd have said that back then.

There is an intimate connection between glaciers and sea level. Over the course of hundreds of thousands, millions of years, glaciers, wax and wane, they get smaller and they get bigger, and there is a one to one sort of dance between the glacier size and the sea level because there's a limited amount of water on this planet and for all practical purposes that water either lives in the ocean or it lives on glaciers.

Glaciers come in all different sizes and shapes and Thwaites is one of the largest in the world. Thwaites glacier is in Antarctica. It's 200 to 300 miles across, 300 to 400 miles long, a mile thick, so it's enormous. And the computer models, the theoretical studies all give us a great sense of dread that this is a glacier that has a potential to lose mass very rapidly and contribute to sea level rise very rapidly over the next decades to sort of 100 years.

When I, again, as a glaciologist, 35 years ago, when somebody said at a glacial pace, we all understood what it meant. That glaciers had timescales that were thousands of years to 5,000 years to 50,000 years, that things didn't change very fast. That glaciers changed their, what we call mass balance, which is basically how big they are, slowly. That's no longer the case. As observations have gotten more detailed and worldwide, what we're seeing is that Thwaites glacier is shrinking at meters per year. And so you know, meters per year, you sort of think, well, gosh, what does that even mean?

The oceans around the planet in some models, in some sort of the worst case scenario, those oceans could rise by up to three feet over the next century to 500 years. And again, these numbers are all very broad because we don't know the answer. But to even consider the possibility that sea level around the entire planet could rise by three feet in a length of time, that is 100 years to 500 years, is a simply breathtaking and frankly terrifying prospect. We don't really know how realistic that is or how possible that is, but we do know that it is within the range of possibilities.

And so places like New Orleans and that whole area, the Mississippi Delta needs to worry about sea level rise. Right now, today, the City of Miami has regular days where at high tide, there's standing water in the streets of Miami. Looking forward 50 years, what does Miami look like? New York city, hurricane Sandy came roaring through New Jersey in New York a few years ago and it had an enormous impact. Well, if you add three feet of sea level to that, then hurricane Sandy is now going to do more than just flood subways. It's going to do even worse damage.

And so when sea level rises around the world, coastlines are affected around the world and people are affected around the world. And some people live on islands and estuaries and river deltas. People in Bangladesh, they all live effectively at sea level. And so when sea level rises, this floods their houses.

Quite frankly, society cares about sea level over the next 100 years. They don't care as urgently about what sea level might look like in 500 years or 1,000 years, but over the next 10, 50, 100 years, that's absolutely critical because if you have confidence that something is going to happen over the next 50, 100 years, you can start to prepare for it. You can start to plan for it. You can start to be sort of strategic about how you spend your money, and you get better return on your money if you spend it over 50 years rather than 50 years from now, you'll have to spend fastly more money to protect against the same thing that you could have been more proactive about and been preparing for for decades. I don't think that, that's set in stone. We can change our behavior. If we think that this is a problem, then we ought to change our behavior.

The reality though is that to get the right answer to the level that the policy makers want and that public wants, which is, is it going to be one foot of sea level rise over the next 100 years? Is it going to be inches of sea level rise or is it going to be three feet of sea level rise? To get that range down to a number that people are willing to spend billions of dollars to build seawalls against, you need very specific pieces of information about different glaciers. You can't just use a broad brush and say all glaciers are the same and so we can build models. Once we know something about one glacier, we can apply it to all the glaciers. And so even though my piece of it is kind of connecting sea level rise to temperature and CO2, if we as a society decide, this CO2 emissions pathway, this temperature rise in the oceans, this temperature rise in the air is not a good thing because it leads to this catastrophic sea level rise. Well, then maybe as a society we can try and change that CO2 pathway, those CO2 emissions and slow the temperature rise.

And so what this project that we're, this Thwaites glacier project is to try and understand how much we would have to worry about it. Is that just an outlier situation? Do we not have to worry about three feet of sea level rise over the next century? Or do we have to worry about three feet of sea level rise over the next century? And that's what we're trying to do. And I don't have any answers for you today, but over the next sort of couple of years, three years, four years, maybe we'll be able to be a little more definitive about this.

Cole Cullen:

What's the point of the research if you can't answer the questions?

Beth Bamford:

That's what happens when researchers do research, they don't have all the answers. Research doesn't answer questions, it causes more questions.

Cole Cullen:

Well, that's kind of frustrating.

Beth Bamford:

But that's the point. We have to ask more questions to get more answers and get more answers, get more questions.

Cole Cullen:

Our final interview of this episode is with Ben Shaby, who is a statistician who uses math to study climate change.

Beth Bamford:

Math to the study climate change? Tell me more.

Cole Cullen:

Well, keep listening and Ben will do just that.

Ben S.:

I'm a statistician, so broadly my research role is to find new methods and new mathematical models for describing data and for learning about the world from data.

As a statistician, as a statistical researcher, my primary role is to do new statistics. And then in doing new statistics ... Hopefully, these are sort of inspired by some sort of need, but they're also is just sort of inspired by curiosity, and if I develop some new way of thinking about spatial models for extreme events, I'm going to go out looking for some way to apply it. In particular, I'm interested in rare events, the most extreme kind of events that that live in space. I think the easiest thing to think about is a rainstorm or something like that.

What I do is I come up with mathematical rules to describe the characteristics of these processes. As I said, I'm particularly interested in the very rare ones, and it turns out those behave pretty differently than the not so rare ones. So what I try to do is come up with realistic descriptions of the very rare events. So think of the worst rainstorms or the worst heat waves or something like that.

It's just sort of interesting and unknown, which is sort of weird. I mean you think about like, oh, we've been studying things like weather patterns for a long time. You think that we sort of understand how to describe them very well mathematically, but it turns out we don't.

It's exciting time to be in this area because it's changing really fast. But also from an impacts perspective, if you think about climate change or something like that, adaptation, mitigation, or whatever, a lot of times the things you care about are the extreme events, the worst storm surges or the biggest rain events. We really are not very good at describing them and understanding them. The mathematics are rare events, which is sort of interesting, but also from an impact perspective, they're probably the most important.

Cole Cullen:

Are you in the business of predicting rare events?

Ben S.:

Yeah, I guess I'm in the business of predicting rare events, but not in the way you're probably talking about. A meteorologist would predict a particular event. They'd say, “Oh, two days from now, you're going to get a huge rainstorm in your area.” And that's not what I do. My role would be more from a distributional standpoint. So say, given what we know about the current state of the climate, how large is the rain event that we'd see on average once every 100 years. And by large, I mean both in magnitude and in spatial extent. So that's the interesting spatial part of it. The amount of rain that falls at one particular rain gauge isn't that important from a flood perspective, you might care about how much rain falls on an entire watershed.

So I might answer questions like for the upper Susquehanna river drainage basin in the next 100 years, how likely are we to get an event that makes the river overflow its banks? That's a prediction in a way, but it's not a prediction of a particular sort of event. It's a prediction of the probability of certain kinds of events that you'd care about.

Cole Cullen:

Okay. So you're not in the business of, next Thursday expect a big storm? You're in the business of over the next 100 years, we need to be prepared for one, two, three big events to happen in said areas. Is that fair to say?

Ben S.:

Yeah, that's fair to say. And that's where the collaborations come into. I could look at the precipitation from gauges and do aerial, water, total probability assessments, but then I need to go to my hydrologist collaborators and try to understand what that means from a hydrology standpoint and what it means about the river banks. And maybe I talk to some urban planners or something to discuss, well what does that mean for infrastructure and stuff like that?

Cole Cullen:

So why is what you do important to the average Joe?

Ben S.:

I mean it depends on Joe as I suppose. I mean, if Joe is interested in purchasing land on a coastline or something like that, he's going to care what's the probability of a storm surge that's going to inundate my house. And you can get this really wrong, like people got this really wrong for hurricane Harvey, for example, the wildfires in California. There was much more area at risk than I think people probably understood.

Recently, I've been involved with a project in California with CAL FIRE, the California Department of Forestry and Fire Prevention. They wanted to understand where the extreme risk of fire was or at least the extreme conditions that are conducive to fire ignition and spread.

The reason this happened was in 2009, there was a really bad fire season, at least what we thought back then, was a really a bad fire season. Things have changed. So there's a really bad fire season and it turned out a lot of the wildfires were ignited by utility infrastructure. Like power poles blowing over and igniting some debris or something like that. And so California decided that maybe it was time to revisit the regulations regarding the strength of power poles and frequency of clearing tree branches and stuff away from power poles. And so they wanted to understand where this needed to be done. This is sort of like a spatial problems, so we want to know where the fire risk is the highest and they're particularly interested in the very, very bad fire risk regimes. And so that's why they contacted me. On this basis, they're writing regulations now. I don't know, maybe this is more a question for infrastructure planners, disaster response people, things like that, more than the average Joe. But certainly from a policy standpoint, these sorts of things are really important.

Cole Cullen:

Why are there people like you and an institution like Penn State doing the work you do?

Ben S.:

I ask myself that question all the time. I don't know. I mean, I think there are lots of reasons for research. I mean, one is that I think as people, as humanity, we just want to understand more all the time.

I think at the end of the day, it's what's driving a lot of us. We just want to know. We want to understand how things work. There's also a much more practical level to it where we're looking for solutions to actual problems.

It's very clear in biomedical research or energy research, the meteorologists I work with, trying to make better weather predictions. So there's real practical needs for these things. But I think at the end of the day, what really gets us out of bed in the morning is just the curiosity, trying to understand things we didn't understand the day before.

Beth Bamford:

Thank you for listening to REACH and a special thank you to doctors, Michael Mann, Sridhar Anandakrishnan, and Ben Shaby.

Cole Cullen:

And don't forget all the episodes of REACH can be found on our website. Please consider making a contribution to WPSU so that we can bring you content like this. Visit wpsu.org/donate. Thanks.