**VIEW to the U transcribed**
**Special edition**
**newly appointed Vice-Principal, Research**
**Professor Kent Moore, Department of Chemical & Physical Sciences –**
**U of T Mississauga**

[theme music fades in and then out]

Kent Moore (KM): And I was going to go into Applied Math, because that was something which actually I found quite interesting. And then, one day, I was reading a *Scientific American* or something, and I heard about this laboratory at Princeton University that did, actually, climate modeling. They were the first people to do climate modeling; this was back in the late '70s. And that sounded really cool to me, because they had a model of the climates and they could take the mountains off the earth and see what happens to the climate, and that sounded really, really cool. Almost a gut-wrenchingly cool thing. And so I applied to the program and I got accepted and I never actually did any of that stuff. I never took mountains out of a climate model, but that's how I got involved in this area. It was just serendipity.

When I talk to students, they say, "Oh, you know, I'm concerned about what I should do." And I think most things are really interesting, and as long as you kind of think that it actually has some interest to you, and something you want to do 24/7, then you should probably go do it, and not really worry about where you end up; door one or door two.

I was lucky to find that. I can't imagine doing something that doesn't just grab me. When I get up in the morning, I just want to get to work and do my science. Even today, I'm just so excited about what I do, and the things that are still to be found.

That's really what makes my job fascinating.

[theme music fades in]

Carla DeMarco (CD): Flights of Fancy and a researchers' fascination.

We interrupt our regularly scheduled programming, Women in Academia, to bring you this special addition of VIEW to the U that features Professor Kent Moore, who, as of July 2018, is U of T Mississauga's Vice-Principal, Research.

Hello, and welcome to VIEW to the U: an eye on UTM research.

I'm Carla DeMarco at U of T Mississauga. VIEW to the U is a monthly podcast that will feature UTM faculty members from a range of disciplines, who will illuminate some of the inner workings of the science labs and enlighten the social sciences and humanities hubs at UTM.

On today's show, Kent talks about his investigations in the dynamics of the climate system, as well as the meteorology of mountainous regions, which as you can tell from the opening excerpt of the podcast, still holds a deep fascination for him, and has done so ever since he was a graduate student.

[theme music fades out]

Kent Moore is a Professor from the Department of Chemical and Physical Sciences, and as of July 1, 2018, is UTM's Vice-Principle Research, appointed for a three-year term.

Kent has held a number of administrative roles including Chair, Interim Chair, and Associate Chair of the Department of Chemical and Physical Sciences at U of T Mississauga. Prior to these positions, he also served as Associate Dean Sciences and the Faculty of Arts and Science, from 1997 to 2000. In 2017, he spent half a year as the visiting Fulbright Chair in Arctic Science in the Department of Atmospheric Science at the University of Washington.

His research focuses on investigating climate change using theoretical, computational, and observational techniques to understand the dynamics of the climate system. And he also studies the impact that weather has on human physiology and performance.

Kent has managed major academic research grants with numerous international collaborators.

CD: I understand that your research examines the dynamics of the climate system and the meteorology of mountainous regions of the earth, and the possible impact on people. I'm thinking these are things like high altitude effects on people, but I was wondering if you could give me a bit more detail about this work, and a few examples of some of your current projects.

KM: Sure. I do kind of two different types of things. One of these things I do is work in high altitude regions. The other thing I do at sea level. I'll talk about the high altitude region first.

About a decade ago, I got an email one day from a surgeon at Women's College Hospital, and he said he had been talking to someone, and he talked to a former student of mine and the student said, "Oh, you should talk Kent, because he actually does some work on the mountain."

John Semple emailed me out of the blue, and he said he was a climber, as I am. And he said, "I'm interested in understanding the effect that weather has on people at altitude." I'd never thought of that as an actual subject. In fact, it wasn't an actual subject, because no one had ever looked at that until we started to.

The basic understanding of this is that as you go up in the atmosphere, the pressure drops, and as the pressure drops, the amount of oxygen which is available to you drops as well. Physiologists who study high altitude processes know this quite well. But John's wrinkle on this was, what happens when a storm comes by? What a storm is, it's essentially a time the pressure drops, so the pressure becomes lower.

At sea level, when we have a low-pressure system coming by, there will be a drop on pressure, but it's of no physiological importance, because there's so much oxygen at sea level that we don't actually feel that. But if you're at the top of a mountain, a very high mountain, then it turns out to be a physiological in the importance, so no one had actually tried to quantify this until we came along, so it's actually pretty cool.

The rule of thumb is that when you're climbing, going up to any altitude, you should probably go up only about 500 meters every day. This is maybe about 3,000 meters. If you go up more than that, then your body doesn't have the chance to adjust.

What we found, by looking at storms on Mount Everest, is that quite often in a bad storm, essentially you could be at the same height on the mountain, but effectively overnight, you may be 500 meters higher because the pressure's dropped. And so you may wake up on the morning with acute mountain sickness and wonder why it happened, and not really know why. And the reason is, is because you're suddenly actually higher up on the mountain. You've gone through, essentially, an effective increase in height without that acclimatization process.

CD: That effects of mountain-

KM: Sickness.

CD: ... sickness. What are the symptoms? Headaches…?

KM: Generally, you get headaches, you feel lethargic. All those sorts of things. There's a more intense disease state called high altitude pulmonary edema, where your lungs start to fill with water. That's quite dangerous. But mountain sickness, you just feel kind of lousy.

If you've ever gone skiing, especially go skiing in places like Colorado, you can go up quite high really, really quickly. And then you can get this kind of mountain sickness. You feel kind of ill and you have a headache.

What we were able to do was quantify that in some of these severe storms, you could actually trigger this acute mountain sickness. And also, at the top of Mount Everest ... If Everest was about, maybe, 2 or 300 meters higher, it wouldn't be possible for us to climb it without oxygen. If you're really, really high up on one of these 8,000 meter peaks, it could potentially put you into a hypoxic state, which is where there's not enough oxygen available for you, actually, to just run your basic metabolic functions. That could be quite severe.

We were able to introduce, actually, a whole new field of study because no one had ever looked at the effect that the storms have on people at altitude, so it was pretty cool.

CD: And have you done the bulk of the work on Mount Everest?

KM: We do most of the work on Mount Everest, just because there's lots of historical data for storms. Any mountain, when you get above about 6,000 meters, you tend to start getting into problems. 7,000 meters is what's called the death zone. Above 7,000 meters you're slowly dying, just because there's just not enough oxygen for you to survive.

I've been to 6500 meters, and that's really hard. That's brutal. In fact, I took my son, actually, my older son, about a decade ago we went climbing with John and his family; his kids and another colleague of ours. We were climbing and we would get into camp and it would take us maybe about two hours to catch our breath, that's how bad it was. And I had a satphone [satellite phone] with me, and I was calling my wife, and my wife was quite upset because we'd be sitting there and just like ... And we were just trying to catch our breath. And that was only about 6,000 meters. I haven't gone higher on Mount Everest. I don't really have an interest in doing that, but it's really, really hard without oxygen.

CD: I know that there's some people, they do go up the mountain. They're helping other people who are climbing and they're native to the region. Is it just that they are more acclimatized to that?

KM: The Sherpa who live at high altitudes in Nepal, there actually are physiological differences. Their physiology has evolved over time to be able to handle those higher altitudes. They just live up there.

Some people are just by nature, a genetic variation, that are able to handle high altitudes than others. It turns out not to be a function of fitness, which is kind of interesting. It's just the way you're put together. Although I run; I'm quite fit, I don't do really well with altitude. It actually causes me some problems, and it's just the way I am.

CD: I've heard that. That there's some people that are very fit, and they are always training for things, but I've heard they've also had a hard time with high altitude.

KM: It just depends. It's funny, when you go up to ... I've been up to the base camp at Everest a couple of times, and it's just a pack of people going up. It's a bit of a mob scene. But it's always usually young males that are going up and they zoom ahead, and you see them a few days later, they've gone too high, too fast, and they're coming down because they just can't handle it. If you take it slow and easy, then you can get to base camp. It just takes pretty much 10 days to do it, just going up a little bit every day and resting, and not trying to push yourself. Because it's when you push yourself that you run into problems. You either get mountain sickness or you're not feeling well. Then you just rapidly collapse and you lose your appetite and you have no energy. And then you really have to come down, or you're really going to cause yourself lots of problems.

CD: I'm guessing, though, that when you started out on this work, though, your background is more in, not so much the physiology part, right?

KM: Yeah, so the reason that John originally got involved with me, is I had ... About 15 years ago, I was involved in a project looking at an ice core from the top of Mount Logan, which is Canada's highest mountain. We had put some weather stations up on Mount Logan, and we had done some work, trying to reconstruct past climate from the ice core. That was actually the work that John found out from a student of mine about. And we got involved in this work, and I say it's been really fascinating.

We do other stuff, as well, now. We've also done some work ... There've been a couple of bad avalanches in Mount Everest the last, going back, 2014 and 2015. We've written papers on those avalanches and the impact they have on the people at base camp.

It's a really an interesting line of study, because not many people do it. And it's a bit of a challenge to publish the work, because there's no journals that are ... John has published work in geophysical journals, and I've published work in the New England Journal of Medicine and the British Medical Journal, which are pretty cool journals for a physicist, because not normally we would publish there.

One of the things I do is interdisciplinary work, and this is ultimate interdisciplinary because it really is two disciplines that normally don't have any interaction. We've been able to inform people who are climbing that they need to be aware of these pressure changes, which has never occurred to them, that they were enough to be important. We've been able to go back and look at, for instance, in 1924, Mallory and Irvine made the first attempt to climb Mount Everest, and they both died on the ascent. Or the descent – we're not really sure yet. We were actually able to uncover some weather data that they collected at the time, and actually pretty much demonstratively showed that they probably didn't make it to the top because they were climbing into a really, really bad storm.

And that's really fascinating, because you can go back and look at events. Everest is great that way, because we have 60-70 years of records of people climbing it, so we've been able to reconstruct some of these events in the past. The Into Thin Air storm 1996, we did a ... Again, we looked at that storm, and we were able to understand what went on in that storm. It's really fascinating work to do.

CD: Did you know Tuzo Wilson?

KM: You know, I met him a couple of times.

CD: Okay. I'm just curious, because I know I read some background work about him, and he was also a real dedicated climber, and as I understand, his mother was too, so [crosstalk 00:12:02].

KM: I didn't know his mother was.

CD: Yeah.

KM: I actually met him late in his life. He came into the physics building downtown one day, and I was able to chat with him. It was a real honor, because he is such a giant in Canadian science. And a nice person too.

CD: Now, you talked about some of your mountain work. Did you want to mention some of your sea level?

KM: Sure. I enjoy it, but it's not really my bread and butter. What I do mostly is, I'm interested in how the ocean and the atmosphere transfer heat and energy back and forth. Because it turns out that the way the climate system moves heat around and energy around is really what drives all of our weather. I'm interested in understanding how that transfer occurs. It's hard to observe, because it usually happens in the wintertime, and it usually happens in remote places where people don't normally go.

What we do, is we use research aircraft. For instance, in March I was flying over the Greenland Sea. These fluxes, the technical term is fluxes, but this transfer is most intense right at the surface, so to observe it you have to essentially observe the turbulence, or if you think of a pot of water, those bubbles. That's actually what's happening in the atmosphere. There's all these bubbles coming up, and those bubbles of air are the things that are moving heat between the ocean and the atmosphere. To sample those things, we want to fly really low, 50 feet above the ocean in stormy conditions.

We all know what wind chill is, so on a winter's day you can feel quite warm if there's no wind. But as soon as there's a wind, then that is just much more efficient taking heat away from your body. Same thing for the ocean. When it's windy, that's when these transfers are most intense, so we have to go out in stormy conditions and fly these aircraft.

I don't fly the aircraft myself. I just, essentially, as a mission scientist, direct the pilots where to fly the aircraft. We do that every, maybe, once a decade, because it's quite expensive to collect all the resources to do that. Actually, I've done it, maybe, four or five times in my career, but the most recent one was just in March when we were flying out of northern Iceland, and flying over the Greenland Sea in these stormy conditions, measuring-

CD: Were you scared?

KM: No, it's funny. First of all, I don't mind flying, which is important. But also, I think people get into trouble when they don't know what they're getting into. We know what we're getting into. We're flying with people who have spent their careers doing that kind of thing, and we have lots of instrumentation on the aircraft that tells us what's actually going on. I've never felt really fearful for myself. Safety is the first priority. Even if I wanted to fly somewhere, if the plane wasn't in a safe condition, they just wouldn't fly it. Even though I'm paying all the funds for it, the pilot won't do anything which isn't safe.

I never feel that way. I've had students who have been a bit nervous when they fly, but I just find it exhilarating because most scientists study things that are either really, really small, or really, really big. And they can never actually experience it. But I'm in the sweet spot, where I study the weather, and so when I'm sitting on that plane and it's really bumpy, I know it's bumpy because there's an energy being transferred between the ocean and the atmosphere, so my body is actually also sensing that, and I find that really incredibly satisfying to be able to actually sample what I've studied. I'm in that sweet spot where the length scales and the time scales that I'm studying, I can experience myself. There's not very many scientists who can do that.

When I started out, that wasn't what appealed to me, but over time, I realized that I'm a very unique scientist, that I can actually do that, and that's quite satisfying to me now.

CD: And I know you mentioned John already, but I understand that you do have some notable international collaborations.

KM: Yeah. The climate game is pretty international, because I think we all ... First of all, climate is everywhere, so we need to study that. But more importantly, I've been able to find collaborators around the world who are interested in the similar kinds of problems that I'm interested in.

For instance, I work quite closely with oceanographers, and oceanography and meteorology are two distinct disciplines. Clearly, they interact because the atmosphere and the ocean talk. But most oceanographers don't really care much about the atmosphere, and most meteorologists don't care much about the ocean. I've been able to, just by luck, find people who are oceanographers who have very, very similar interests to mine. They're primarily interested in the ocean, but they understand they need to study the atmosphere, as well. That's been really fortunate for me.

I have a really close collaborator who I've collaborated with for about 25 years now, from Woods Hole Oceanographic Institution in Falmouth, Cape Cod, Bob Pickart. He and I go back many, many years studying that, and I have collaborators in the UK, and also in Norway now, who I work with quite closely.

Again, I think it's important to work, especially my kind of work, because again, I don't have the resources to fund these big projects all by myself, so by having Americans and English and now Norwegians and Canadians, we can usually cobble together all the funds to actually get an aircraft out there. Usually, we have a ship out there, as well. And the ship probably costs more than the aircraft does out there. By all those collaborations, we've been able to mount these projects throughout the north Atlantic, from the Labrador Sea over to the Greenland Sea. I find those really quite satisfying collaborations.

CD: What do you feel is the impact of your work?

KM: Well, technically speaking, we've been able to improve our understanding of how the ocean and the atmosphere communicate and transfer energy back and forth, and that's important, for instance ... What the climate system is made up of is all these processes. Okay? Every process has some complexity to it, so what climate modelers do is they try to take all these processes and make mathematical models of them. And those mathematical models then are put into the climate model. The collection of all those processes are what generates future climate predictions.

But unless you understand those processes, then you probably don't represent them very well. We've been able to, for instance, show that most climate models, most weather models, over project the amount of energy that's being transferred between the ocean and the atmosphere. They have too much heat being transferred. By documenting that, by comparing the observations we have, with the predictions of the model, we can say, "Look it. Your understanding of this process isn't actually correct, and you need to change it in some way." By doing that, we're removing some of the uncertainty in the climate models, and that contributes to improving the forecast down the road.

I guess, from a public engagement perspective, I do work on Mount Everest and do work, basically, in the climate system, so I think it's really important, as scientists, that we engage in information or in education of society, because there's lots of cross-messaging going on. And some people say the climate system isn't changing, it's always been changing, and what we're seeing is just natural. And then other people say that, no, in fact, what we're seeing is fundamentally different.

I think, as a scientist, I don't have a vested interest in any policy. I just want to essentially understand what's actually going on. I didn't always feel this way, but I think as I've become older, I've felt it's really quite important that I engage in that debate. I do lots of interviews on the TV and media, and various ... And also give talks to people, just so that I can provide a context for people to understand that there is a misinformation out there, and I think 99.9% of the scientists who actually work in the field are quite concerned at what's happening.

You have to be a careful consumer of science. I think that's one thing we don't teach or let people know, for instance, if I have a dentist, I'm happy to let that dentist work on my teeth, but I don't want him to do heart surgery on me. When you hear someone who has an expertise in, let's say, chemistry, talking about the climate system, sure, that person has a PhD and maybe a professor, but they don't have any direct expertise. Unless, we as scientists who are engaged and are willing to step up, then the vacuum is filled by people who may have a vested interest in a particular outcome. I think that's quite important to do that. I think that's the outcome, that's the impact of my work in the larger society.

A few years ago, John Semple, my colleague, was a base camp doctor for one of the expeditions going onto Everest. I was giving weather forecasts, actually, from here in Mississauga, via satphone. We had this code. Every day I would text him on his satphone and tell him what was happening.

Again, climbing Everest is a really complicated process. One gets to a point where everyone has acclimatized and wants to make a push to the summit. I saw a storm coming, which looked quite severe, so I texted John, and said, "You know, there's a bad storm coming. You should probably bring your people down off the mountain." They were quite reticent because this was their one chance to go to the top. They did come down, and afterwards they actually were quite happy, because it was a really, really bad storm. We potentially saved their lives.

That's actually really quite satisfying, because it does have a direct impact on people. Because I think we have been able to sensitize the climbing community, that you need to worry about some of these storms. It's not just that the wind gets ... There's clearly wind effects and wind chill, but it actually can cause physiological harm to people. That's actually really, really satisfying, as well.

CD: And I know that you did touch on this already, how you got into the work with John, and the Mount Everest work, but how did you get into this field to begin with?

KM: That's a very good question. I did an undergraduate degree in at the University of Guelph in Theoretical Physics, which was mathematics and physics, and when I got farther into my undergraduate career, although physics was exciting ... Most physicists do what's called modern physics; quantum mechanics or condensed matter physics, or high energy physics. All these things that have been evolved during the 20th century. And that didn't really appeal to me, at all. It just didn't. It was fun as kind of a theoretical exercise, but it didn't really grab at me. I was going to go into Applied Math, because that was something which, actually, I found quite interesting.

And then one day, I was reading a *Scientific American* or something, not really sure. And I heard about this laboratory at Princeton University that did, actually, climate modeling. They were the first people to do climate modeling. This was back in the late '70s. And that sounded really cool to me, because they had a model of the climates and they could take the mountains off the earth and see what happens to the climate, and that sounded really, really cool. Almost gut-wrenchingly cool thing. And so I applied to the program and I got accepted and I never actually did any of that stuff. I never took mountains out of a climate model, but that's how I got involved in this area. It was just serendipity.

When I talk to students, they say, "Oh, you know, I'm concerned about what I should do." And I think most things are really interesting, and as long as you kind of think that it actually has some interest to you, and something you want to do 24/7, then you should probably go to it, and not really worry about where you end up, because you'll probably end up somewhere in not kind of fuss about whether you should do door one or door two.

I was lucky to find that, but I'm sure if I had gone into Applied Mathematics, I would have found something else that interests me, but it just really fascinated me. That's how I ended up in this field.

The University of Toronto is the only university in Canada that actually has people like myself, who are geophysicists in a physics department. No other university has that. Most meteorologists or oceanographers are in usually a separate department. And that means that physics students don't get exposed to that. Most physics students, like I was an undergraduate, had no idea that there was a huge area of physics called geophysics. That's one thing which is unique about the University of Toronto, both here in Mississauga and on St. George, that we have people in the physics department who actually do geophysics, and so our students are actually exposed to that, not just finding it by chance like I did.

And frankly, the training that I think is best, actually, for the discipline that I'm in, is actually just a pure physics undergraduate degree, because our work is very mathematical and very physical, so we can teach a physics student the meteorology or the fluid dynamics quite easily, because they have a really good foundation. But if they come from some other discipline, it's actually more of a challenge. I personally prefer physics undergraduate students as graduate students, because they just have that strong skill base that I can build on.

CD: What I great story. Because I can't imagine. It is total serendipity, and as you say, you just coming across this article. And there's a few times where I've heard other faculty members mention that, but I think that what you've also mentioned is just that something that's going to fascinate you. Because you know you're going to be spending all this time really picking it apart, or looking at it for years and years over your academic career, that it's got to hold you, right?

KM: It really does. Of course, I work a lot too, because it's frankly the best job in the world. Being an academic really is the best job in the world. When I was finishing up my PhD, I didn't know if I wanted go into academics or not. I was recruited by the Department of National Defense here in Canada, to work, because they have a research arm. One of the persons there told me, he says, "We're like a university. You can come here and you can sit at one desk for your whole career." Whereas, almost any other profession, think about it, right? You become a manager, and start managing people, and you kind of get away from what you really loved.

That's what the university professors do, You can sit at one desk, and literally your whole career, work on whatever you're interested in, and not have to ever do anything else, if you don't want to. And I think that's just the best job, you interact with really bright students and bright colleagues, and you can work on problems which you define. But if it's not something that you like, I can't imagine doing something that doesn't just grab you. When I get up in the morning, I just want to get to work and do my science. Even today, I'm just so excited about what I do, and the things that are still to be found. That's really what makes my job fascinating.

It doesn't have to be that. Everyone has some passion and so if you can find that passion, then it's not really work, right? Someone said that. If you like what you do, it's not really work. I feel, honestly, really privileged to be in this position, but it does allow me to really do what I'm passionate about.

CD: And that's so great, because you can see the enthusiasm, even if you've been studying it for as long as you've been studying it. You can see it coming through.

KM: Every day is something new. Every day something happens, or you do something. We're getting more and more data. One of the problems with the ocean is, the ocean's really poorly sampled. It's really hard to sample the ocean, which for reasons that are kind of cool, is that we use electromagnetic radiation, right? We can send a balloon up and it can radio stuff back to us. In the ocean, the ocean is opaque to electromagnetic radiation, so you can't send a probe out and have it radio stuff back, because the radio waves will be absorbed by the water. They have to go out and actually measure things locally. They have to go out and actually collect stuff.

Over the years, there have been more and more an emphasis on actually collecting field data. My friend, just the other day, he not only got some really cool results from these moorings that we put into the North Atlantic a couple years ago, there's a meteorological component, so…and so that was really,

really cool, because we can explain stuff that's going on. It was just so fascinating.

[theme music fades in]

CD: Coming up: Research on the Horizon.
Kent talks about his ambitions in his newly appointed role of the Vice-Principal (Research) at UTM, and what he envisions for the campus in the years to come.

[theme music fades out]

CD: I think my job is great, because I get to talk to people who are so passionate about their work all the time, but this sort of leads to my next and last question. As the new Vice-Principal, Research, you are overseeing our research environment here at UTM, so I just wanted to ask you, what are some of the things that you hope to accomplish, maybe, or some of your aims over the next little while?

KM: I'm really passionate about UTM. I think it's a really unique institution, and a unique division within the University of Toronto. And I think what makes us unique ... Well, there's many things, but one, I think, is just the fact that there's a potential for collaboration here, which doesn't exist on the other campuses of the University of Toronto. One thing that I really want to do, is try to build these links between people in different departments, who may not work together now, because there's no formal mechanism for them to work together, and allow them to leverage their expertise and do the kind of work that I do with John Semple, or with Bob Pickart, and bridge disciplines and actually have that research done here. I think that's really, really quite exciting, and it's something that we can do here at UTM.

I think I also want to just get the word out that this really is a fascinating and a really special place, so just, again, promoting the work that's done by other colleagues here, I think, is really important. I think I want to help get that word out.

Also, I think, because I've been involved in businesses and on boards of directors of companies and things, throughout my career, so I think I have a different perspective than others may have. And I think we all bring our perspectives to the table. I think I have a perspective which is maybe unique amongst academics, so I'm hoping that I can apply that to further the mission of this division, which is to showcase the excellence at UTM.

[theme music fades in]

CD: I would like to thank everyone for listening to today's show. I would like to thank my guest, Kent Moore, for speaking about his work and projects in the

Department of Chemical and Physical Sciences at UTM, and his vision for the office of the Vice-Principal, Research, and as my new boss in this portfolio.

Thank you to the Office of the Vice-Principal, Research, for their support.

Please feel free to get in touch with me. My contact information is on our SoundCloud page. If you have feedback, or if there is someone from UTM that you'd like to see featured on VIEW to the U, please get in touch with me.

Lastly, and as always, thank you to Tim Lane for his tunes and support.

Thank you!

[theme music fades out]