Audio Interview Transcript: Climate Modeling

Erin: Hello and welcome to this audio interview from SESYNC, aptly called: SESYNC Audio Interviews. I'm your host, Erin Duffy.

Erin: The issue of climate change is both existential and urgent. Climate activists around the world continue to call for systemic changes from governments, green technology investments from industries, and sometimes even scientific acceptance from individuals. But that begs some questions, what if we did change our behaviors? What if we as individuals, conglomerates, and perhaps most importantly, political governing bodies, headed our own advice—how much would that change the projected increases in global temperatures?

Today we are talking with experts in the rather new field of integrating human behavior into climate change models, Dr.s Brian Beckage…

Brian: As you start to try to develop a model through a process—it's like thinking about the process and you begin to see links and interactions that you maybe didn't realize at first.

Erin: …and Katie Lacasse.

Katie: I have to say until I joined this first working group, I was like, what do you mean? I thought of course, climate modelers are including humans in the climate models.

Erin: So welcome Katie and Brian. Thank you so much for being here. We're excited to talk with you.

Brian: Thank you.

Katie: Thank you. Thank you. We're looking forward to it.

Erin: So let's start with you, Brian. Brian is a professor of both plant biology and computer science at the University of Vermont. He earned a bachelor's degree in engineering from Cornell University, a master's in biology, from the University of Central Florida. A master's degree in Bayesian statistics and a PhD in ecology from Duke University. (Does he have a lot of degrees? Yes, yes he does.) Brian is broadly interested in complexity and computation. But what I really loved about researching Brian and checking out his website is that I felt like I got to know him as a person. It had poetry, family photos, interesting quotes. And I even learned a little bit about Brian's family lineage and ancestry, which I believe has contributed in his interest in environmental stewardship. So, Brian, could you tell us a little bit about that?

Brian: Well, first I just want to say, this is a really interesting question and it is like self-reflective and, you know, I do think that having a mixed ancestry that includes Celtic and Nordic and Native American components and I also grew up a military dependent so I moved around a lot, but I'll come back to the Northeast very often to visit my extended family, and it was a very an interesting group of relatives and a landscape where the natural world was part of everything and you were, you're a part of that.

And then you have these social dynamics that were sometimes good, sometimes not. You know, there's definitely this intergenerational trauma component. And then you saw the landscape and the coal mining and the gypsy moth's defoliation. And, you know, it's just, it, it led you to think about and wonder about the connections—the connections between experiences, human behavior, and then our relationship with the landscape and how it was all, all interacting.

Brian: And so, you know, it was a rich and complex and answers were not always clear what was going on or why things were happening. So I do think it contributed to my interest in ecology because ecology really is the study of interactions between different components of a system. And then I think it also naturally kind of led to my interest in kind of systems thinking and integrating things like human behavior with climate change models because of this emphasis on connections between things. And sometimes the connections are good, sometimes they're bad, but everything is connected. And so yeah, really interesting question. And, so thank you for asking that, because that's something I'm going to think about for a while, actually.

Erin: Awesome. Thanks so much. And Katie, Katie is an associate professor in the department of psychology at Rhode Island College. She got her bachelor's in psychology from Providence College and her master's and PhD degrees in social psychology from Clark University. What I really loved about researching Katie was her chosen field. Turns out a lot of newspapers, magazines, et cetera, publish research by social psychologists and perhaps this is because we're social creatures and we want to learn more about the nature of our relationships and interactions. So I was curious what got you interested in the field, and I know that you incorporate environmental issues into your work as well. So how does that all come together?

Katie: Yeah. I agree with you. Sometimes in class I'll say we all are social psychologists, because we're always trying to figure out what other people are thinking, what are their motivations? Why did people do the things they do or say the things they say? So that's really why I was drawn to the field. And what I like about social psychology is that it's really focused on how we are influenced by the people around us, by our built environment, by our culture and those kind of external things that we don't always think about as having a big impact on the way we think and what we do. We like to think we have a lot of control, but there's a fair amount of social influence. And so I really got interested in applying this to environmental issues and climate change because as I was learning about different environmental problems, you know, human behavior is often a key factor in driving those environmental problems.

Katie: And there aren't actually a ton of psychologists in particular who study environmental psychology. We have a core group and we work together and we do a lot of good things together. But I think a lot of times environmental issues are thought of as more, you know, we need to understand what's going on with the atmosphere. We need to understand what's going on with the ocean. Or maybe we need to design some policies, but really understanding human thinking, what leads to behavior change and what leads to risk perception and decision making I think can help a lot of different environmental issues. So I decided to, you know, make that the focus of my work.

Erin: Thank you. Your first project is called integrating human risk perception of global climate change into dynamic earth system models. So Brian, maybe I'll start with you. Could you give us a little bit of background on this project?

Brian: Sure. This first project came from the realization, the understanding that we respond to our environment and we respond to our perception of change in the environment. And so it's a dynamic process where we not only influence the environment, but the environment influences us as well. And so at that point most climate models have these static emission trajectories where there was assumption about some set of technological change and where our energy sources were coming from, how fossil intensive versus the extent to which we adapted alternative green carbon free technologies. And then they just drove the models out to the end of this century or even further, and there was not this potential for humans to respond to the change they were seeing, for these other social processes to interact with the environment and possibly result in rapid change in our behavior, our emissions behavior.

Brian: And so we wanted to explore how important those interactions might be. And so what we did was submit a proposal to bring together interdisciplinary group with folks with different sets of expertise that we thought we would need to try to model this process. And that was our first working group. One of our major papers from that group was a, *Nature Climate Change,* paper that explored those processes. And yeah, that paper was, "Linking models of human behavior and climate alters projected climate change." Came out in January, 2018.

Erin: So when we're talking about these emissions behaviors, which areas of behaviors are you focusing on? Is that greenhouse gasses? Migration? What are you guys measuring?

Katie: So in this project, and in most of the other modeling projects we've been looking at, we've really just focused on overall, like how much are humans changing their emissions? We haven't looked at things like migration and factors like that. One thing we hope to do in the future is regionalize the globe. So you could look at like people moving from one place to another, or climate impacts being more severe in one region and leading to behavior change. But we haven't done that yet. So far, we've been treating the whole planet as just one population. And we've been looking at emissions behaviors. One way we tried to break them up, was looking at the types of behaviors that you have to do them over and over again for them to keep having emissions reductions.

Katie: So something like unplugging your appliances or deciding to ride your bicycle to work, you'd have to make that decision over and over again, to keep your emissions down. There's other types of behaviors people can take that they only have to do the behavior once and it leads to emissions reductions for a long period of time. So adding new insulation to your home or buying an electric vehicle. Those kinds of behaviors, you only…it's a big choice, you make it once, but once you do it has the emissions reductions for a long period of time. And we did find differences there. Those one-time behaviors seem to matter a whole lot more than the behaviors you have to choose over and over again to keep doing.

Erin: Oh, wow. Well, that's good to know.

Brian: Yeah, I think that the key thing was, in that first paper, is that infrastructure matters. So you build into your infrastructure where the power is coming from. So replacing a coal plant with some alternative source of energy is in totality more significant than all these individual actions, both because individual actions operate within an infrastructure. And then also because they're easily reversible and you might forget to do it, or you might change your mind. So buying a vehicle that's less carbon intensive or where

we get our power from, these decisions last a long time. And they also influence the importance of turning off that light and the individual decisions. That's why they can be more significant.

Here's an example, in terms of exercise: So I've noticed that when I go to a meeting and a meeting's in a town or a city someplace, and you're walking everywhere, then you walk your five or eight miles a day without even thinking about it. Whereas if you're back in my house here, which is in the outskirts of suburban area—You have to force yourself to walk three miles a day. And so the infrastructure and how you design the lived environment just seems to matter so much that it becomes easy to do things that are good. If you designed your lived environment so that fuels are less carbon intensive, your energy sources are less carbon intensive, then it just becomes much easier to be less carbon intensive than if it's a bunch of individual decisions of turning off lights, unplugging devices when you're not using them.

Erin: In your work you talk about extreme climate events. Can you define what that means broadly and the role that they played in your models?

Brian: In our model extreme climate events is one of the ways people perceive climate change and perceive how risky it is. So that's kind of one of the feedbacks between the natural and environmental system and the human system occurs is through extreme climate events. And so, it's an important component of some of our models, because that's how the linkage occurs. Now, how you define an extreme climate event is not trivial. And it's not like widely accepted across all kinds of events. So for instance, often here in the Northeastern US—days above 90 degrees, like three days in a row above 90 degrees, is a heat wave.

Brian: Well, if you go to Austin, Texas in the summer, it's probably a different set of extremes because almost every day it's going to be above 90 degrees. And so what we tend to use is like, if you have a probability distribution, you use some tail probability, like 5% in either tail is extreme. But five percent's not a magic number. You can use 1% or 10%. So there's a bit of individual agency in how we, how we define extremes.

Erin: I just want to circle back really quickly and focus a little bit on why you decided to do this project. So in other words, why do you think the status quo, or trying to solve environmental problems without including, or really thinking deeply, about, human behavior, is actually kind of problematic?

Brian: I don't want to sound pretentious at all. But if you think about all the…all the problems, or many of the problems, that we as humans are dealing with: climate change, eutrophication of water bodies, loss of biodiversity—these planet-wide limits to growth. Humans stressing the earth system in these ways—they're not technologically particularly complex problems. Like we know climate change can be addressed by putting less greenhouse gasses into the atmosphere. Eutrophication—use less fertilizers in your yards and farming and maybe have buffer strips. And same with biodiversity—save more land. So technologically they're not hard to figure out how to deal with them, but what is really difficult is getting people and shaping society so that we actually implement these solutions.

Brian: And I think what we tended to do as a human society is have scientists or the folks with the technological expertise, address these problems and learn more about climate change or learn more about eutrophication. And then the end result is some kind of understanding of phosphorous flow and some kind of statement like, oh, we need to reduce phosphorous flow by X percentage. And then their expertise stops there. Then the expectation is some policy maker is either going to listen to them and implement that, or people are going to suddenly stop fertilizing the yards. And there's a big disconnect.

And I think it's because we don't consider it all part of an integrated human-environmental system and the human part—the behavior part is just as important, or I think actually probably more important than the technical part because the human behavior or what motivates human behavior and perception of risk and group decision making is much harder, I think, to motivate and understand and change than the simple result: reduce phosphorus by X percentage and your problems will go away.

Katie: To add to that, I would just say, you know, I think that's what we tried to do with the model when we were saying, you know, we want to link not just how humans affect the environmental system, but then allowing things like extreme events or other things from the environment to come back and impact the human system, allowing humans to respond and react to those things they're experiencing. I think really kind of ties the loop together. And really, the only way to do this is to bring people with different expertise together. Like there are a lot of social scientists who are interested in environmental things, but for example, we aren't trained in how to create models in the same way that a lot of the more ecological researchers are. So sometimes it's just bringing people together to make those connections that maybe everyone can think of in their head, that seem rather obvious maybe, but people have different expertise. So I think part of it is also just bringing people together to work together who are, open-minded, willing to learn more from the other side so that you can create a product where you've got everyone's expertise together.

Brian: And I think that's key being open minded because the languages and the terminology we use. I mean, I remember when we first got together, it was not easy because we had very different vocabularies ways of thinking and first of all you need to sort of like each other and get along and then you need to be a certain kind of person that's open-minded and has a broad perspective on things and is willing to embrace other viewpoints and other you know, ways of looking at the world. I think it's really important.

Erin: Yeah, definitely what people consider soft skills I think are actually a lot harder some times. But I'm curious if you could talk a little bit about how did you integrate those very disparate fields to create like a cohesive model, how do you model human behavior and human decision making? I think that was probably something that like from a technical aspect, was a challenge, and now, you know, as technology develops, I think we're getting better at that. So how did you guys do that?

Katie: I'd say the first thing we did, especially with each of the models we've been working on is generally to take some well supported theory from the social sciences and then bring it back to the modeling group and say, okay, we know there's a lot of evidence for this theory. Like on one paper, it was used theory of planned behavior. That is a very common theory that explains why people change their behavior. And we had to sit down and say, okay, mathematically, how can we represent attitudes changing? And how can we link that to experiencing more extreme events? Is that going to make them feel like things are more risky and they'll get more positive attitudes towards reducing their emissions and how do we represent social influence and mathematically, can we make it so that we've got different groups and one group is…as more extreme events happen, do people move into one opinion group and become more concerned about climate change and supportive of emissions reductions? So I think with each model we created, we tried to say, okay, what are like key theories from the social sciences? How can we mathematically create the formulas to make the model work and function? And can we tie them together so that we're bringing in the social and tying it in with the natural system?

Brian: I don't think it's an easy thing to do, is to model human behavior and so a lot of the models we were dealing with for conceptual models. And so, so there's a lot of different ways of trying to instantiate in terms of an algorithm or a computational model, some of these models of human behavior and there's many different models that we could have tried to develop algorithms for. And so it, it's a very, it's very rich and complex and many different ways of doing it and different scales matter. So like, many people argue can't model human behavior, and I think they have in mind the fact that you can't model what an individual, any individual's going to do with a high degree of specificity, but then you can kind of coarse grain at population levels, you can start to do a pretty good job at how trying to model how populations are going to going to behave.

Brian: I think it's a really interesting question. And we had one way of trying to model human behavior, but there's many different ways and many different models we could have chosen and many different ways of trying to develop an algorithm for a particular human behavioral model. And so there's still a lot to do a lot to be done. And I just feel like, you know, we have just started doing some of this and…

Katie: So more people should do it, other people too, please join us. I think we made a call for like more people work on these social environmental models so we can compare and contrast. We really, you know, we don't think we've done it perfectly the first time, please. Yeah.

Erin: Yeah.

Brian: I'm pretty sure we haven't, we haven't done it perfectly.

Katie: No.

Erin: Yeah. And so you mentioned conceptual model, and I was just wondering if you wouldn't mind just defining that? What is a conceptual model and is that model predictive?

Katie: I think in general I would say our models are rather conceptual. Like we're really trying to understand how the factors interact with each other, but one of the downsides on the social science side and this came up with a few of our models is that we don't actually have the same level of like global data about like how much over the last 30 years have people all around the world, how concerned are they about climate change? Like we don't have those kinds of global surveys like we do for things like some of the natural systems where we have measurements. We can't feed in that measurement to then build off of that and predict the future.

Brian: Can I add to that? So like, what I think of as like conceptual model is you might think, well people would be more concerned about climate change if they see more extreme events in their local area, that's outside of their range of experience. So that's a conceptual model. And then you might say, well, they might habituate to changes and then maybe what their friends think might influence. So if their friends are really worried, they might be more worried. So this is like a conceptual model where you're identifying factors that you think might be important, but then you have to decide—what scale do you use to measure, say risk, or perceived risk of climate change. And then you have to decide how many extreme events over what period of time is going to increase their perception of risk by how much? And then how extensive is their network? And how much does the belief systems or the beliefs of people in their social network matter?

Brian: And so you quickly see you go from a very simple conceptual model to lots of decisions you have to make on the details. Of first of all, what's the mathematical form or the computational form? And then what are the parameters that relate those? And so there are so many different ways of implementing a simple conceptual model and they can make a difference. They can make a difference in how your model operates and what it shows. That going from a conceptual model to a computational model is not always easy or straightforward.

Erin: Thanks, Brian. And Katie, I just wanted to circle back to what you had said. It sounded like you were talking about some of the limitations of the model as far as the availability of some of the social science data. I'm glad you brought that up because I had been curious myself about how long, as you mentioned, these type of global, over-time data have been available. And it makes sense that it is somewhat limited, but I'm sure it will continue to expand in the future. And another question that kept coming up for me that is sort of related is about issues related to scales more broadly, maybe. So for instance, how quickly large scale behavior changes occur and how does that relate to how fast the climate is changing? Brian, maybe do you want to talk a little bit about these issues of scale?

Brian: There's this idea at the timescale at which humans operate versus at which the climate change operates. Humans tend to operate on much shorter timescales, and that's evident like in the democratic cycle where people are elected and are in office for a few years where the climate system operates at, you know, decadal or, longer time scales.

And so that is at the core of many of these problems—at the scale at which we try to model human behavior from an individual up to a population. And then groups within these populations, different cultural, ethnic groups, and then that interacts with their different experiences of climate change at different regions of the globe. So there's a spatial component to that. All of those different spatial and temporal scales do come together and make this a complex problem.

Brian: But an interesting one also.

Erin: So I want to jump now to kind of a communications question. One of your papers is called: "The earth has humans. So why don't our climate models?" Which I think is really great because anyone can understand that, right? Like so many academic papers are like, what are they even saying in the title? And this one is like, Nope, it's very straight to the point. So, so how'd you guys come up with that?

Katie: I believe Jonathan one of our co-authors, Jonathan Winter came up with that. And yeah, we, we felt the same way you did. We were like, this is a science communication beauty.

Brian: It was like, once we heard it, we were like, yep, that is the title we need to use.

Katie: And I want to add a little to that because I want to say again, as someone who…I was in grad school, I was taking some climate to change classes, but mostly I was focused in psychology. I was reading all this stuff about climate change, and I have to say until I joined this first working group, I thought, of course, climate modelers are including humans in the climate models. Like when I joined the group, I was like, what do you mean? Like, it wasn't obvious to me, as you explained before that climate models were just based on, well, let's make an assumption of, you know, the humans are going to start using more oil or let's make an assumption that humans are going do X, Y, and Z. I really thought that, of course, you know, if there's more events, of course, people are going reduce their emissions and that's

going to be in the model, but it wasn't. So, you know, as someone who wasn't trained in that area, I was surprised. And so I imagine a lot of other people don't…it's not necessarily clear to them too.

Erin: Yeah, absolutely. And I'm glad you said that too, because it reminded me when you guys first started this project, did you have a hypothesis about you know, once people understand the risks associated with climate change, were you optimistic and thinking that this knowledge would then produce a better result for emissions behaviors? Or did you think it wouldn't matter? How did you conceptualize that?

Brian: Well, I'll say the thought was that as people perceive the climate changing, both the risks of that, and then also sort of the loss of sense of place as things change for cultural reasons. And the thought was that we would change our behaviors. We would change our emissions behaviors to avoid dangerous climate change, to preserve the natural world as we experienced it as we were growing up. And so that was a thought, but as soon as you have that kind of hypothesis, that idea in your mind, then you begin to think of reasons why that won't be. And, and so like, think about in our own society, people move around all the time. And so they don't have a real strong sense of place. So maybe that weakens that cultural component, although it's different for, you know, native people, peoples who have lived in an area for a very long time, and they have a deep not just individual understanding of a region, but a cultural understanding of the natural world in a region.

Brian: And so that can be very important to that group. So then you begin to see how some of these relationships are going to vary across ethnic and cultural groups. And then also how we structure our modern society in terms of everyone moves around so much can weaken some of these links. And so you begin to explore all the different feedbacks and how things interact and it's kind of how the hypotheses and the ideas kind of initially began to develop.

Erin: And what did you guys find in terms of how people's behaviors did change these models?

Katie: I mean, I'd say one takeaway from a few of the different models we've done is that the changing climate, through extreme events or through a warming planet, does seem to lead people to change their behaviors. At least somewhat. In one of our models where we were focused on the theory of planned behavior that we were talking about earlier, we found that if people felt like other people around them, like the social norm is what we call it, but the people around them thought that reducing emissions was a good idea—that seemed to be an important factor. And also what the theory calls perceived behavioral control, which essentially just means how easy or difficult is it to change the behavior? Like, is it really expensive or is it cheap? Is it for whatever reason, if it's easier…

Katie: And if the people around me are doing it, then it's more likely that I'll reduce behavior. And again, this is still like at the global population level, but anything that makes it easier, you can think about policies that would make it easier to change. Or you could think about policies that would emphasize that, you know, the social norm is now changing and we should all be helping the environment. One of the more recent models that we were working on, led by Fran Moore at UC Davis, the article's recently been published in *Nature,* was actually comparing lots of different social factors at different levels. And we found, for example, on the one hand people, how much people perceive the climate is changing from extreme events and things like that, that seemed to matter. But also things like how quickly politicians or the political system responds to public opinion. So like if you're in a society where you know, maybe there's a lot of democratic process, the politicians are changing out.

Katie: So when the public opinion changes that forces politicians to react rather quickly, that seemed to reduce emissions. Whereas if you have a political system where the political system itself is very slow to respond to the public, then you didn't see emissions being reduced as much or other parts of the social system. One of the parts that was…that I thought was really interesting, that seemed to matter a lot was what we called, the expressive force of law, but it's like, when you change the law—you change the policy—that actually feeds back and changes people's minds. So, you know, if you start making policies that are more environmentally friendly, more eco-friendly, then people's opinions start to change. It starts to seem like, oh, okay. Like as a society, this is more important than I thought it was before.

Katie: Like now I'm maybe more concerned about climate change than I was before. Now that these policies are laws are being changed. So when we were able to design a model that looked at things like policy and individual behavior, and, you know, the type of political system and all of those things all together, you can see that factors at each of those levels interact to matter a lot. And that's the tough thing is it's not like one thing by itself is going be what changes everything in this massive system that you know, is planet earth, is going be them all interacting together.

Erin: And that's interesting too, because I think so often we think of ourselves as agents that influence policy. But it sounds like you're saying in a way, when you're able to manipulate it in a model type atmosphere, then the policies actually change the beliefs.

Katie: They can go both ways. Yeah. And then you get more public opinion, you get more support. And that leads to like a feedback loop where it's like, okay, now we can more quickly lead to emissions reductions, because now we've got a loop going. Now the loop could go in the other direction too. It's really expensive to change our behaviors. And so we don't do it and therefore no one makes new technology. And so the loop can just kind of be reducing.

Brian: So like before we're talking about interactions between the natural system and the human system, but then within the human system, you have all these different interactions as well that are contingent on what's going on the natural system, but then also are operating on their own scales and they can be reinforcing or they can be balancing. And so it's like habituation—habituation and bias to simulation. So we tend to be more receptive to beliefs that are consistent with our worldviews. And then at the same time we are habituating to change in climate. So that can be a reinforcing or balancing loop depending on the belief system. And so it's a complex interaction within just the social system.

Erin: Yeah. It sounds like you guys maybe even learned a little bit, how people's behaviors are changed and what influences them.

Brian: So that's a great observation. So one thing I wanna say is the process of modeling—as you start to try to develop a model through a process, you do… it's like thinking about the process and you begin to see links and interactions that you maybe didn't realize at first. So that the fact that you're building this model with this collaborative group of interdisciplinary people and you're opening up new spaces and new ideas, new intellectual spaces and new understanding of what matters, and maybe what might matter, and maybe what matters less. And so it's a very creative process that it kind of makes me think of this idea for Stu Kaufman. It's called the adjacent possible and new ideas kind of percolate as you kind of push forward. And you don't realize what's possible until you, until you've thought through things. And then you see other things that are possible and it's this expanding front of the adjacent possible. And so I think thinking through all these ideas, it's a very exciting and creative process and it's expansive.

Brian: But again this was one implementation about these different process. So like I think about the political system and how Katie was talking about the responsiveness of the political system and how being a democratic system with frequent elections allows the system to be responsive. On the other hand, there are also case studies from past societies that show that if there's a political system where the people in power expect to be in power for a very long time, then they take a longer range of view on protecting the environment because they think they're going to be in power. The elites are going to be in power for 20 years to pass on to their children, as opposed to if you think I'm here for a few years and I just need to worry about short term consequences versus long term consequences. So there are other models where you might actually get a different kind of behavior. And so you know, I think that's important to keep in mind as Katie's call earlier was to invite other people and the need for a diverse set of models and ways of examining this problem.

Erin: Maybe now we can move a little bit into the future, so to speak, I know you have a paper that's under review and it's led by one of our postdocs, Yoon Ah Shin, and it's called, "How coupled is coupled human natural systems research." What did you guys find?

Katie: One of the things we wanted to find was that it does seem difficult. Like if you're thinking about team science to actually get the right people together, to create a model where you have the environmental system influencing the human system, and then the human system coming back and influencing the environmental system, as we said before, it's often unidirectional, but actually getting, you know, a complete coupled loop is rather difficult. And we really wanted to see how much teams that are really focused on trying to create those coupled human natural systems—when you look at the papers and the different projects that they report on how much of their research is actually doing that? And we wanted to know what aspects of teams seem to lead to greater likelihood that they're going to create that fully coupled model, as opposed to just kind of coupling in one direction.

So what we found when we were looking at it, I'm sure there's more attributes you could look at of what makes an effective team. But what we found was that on the one hand teams that were using either very conceptual methods or more computational like modeling methods, they were much more likely to get those fully coupled models. Which shows to some extent, having some expertise, especially in that computational modeling seems to be important, like someone on the team needs to know how to do that.

Katie: And the other factor we found that was really important was having people on the team who are actually housed in interdisciplinary departments. So like where they work at the university, isn't just a psych department, so I'm bad. But would be someone who's in more of like an environmental science department or environmental ecology, like a department where there's automatically that interdisciplinary stuff happening. Having people from those departments on the teams really seem to increase the likelihood that those teams were making those fully coupled models. And it could be, we don't know exactly why, it could be because those folks, because they're housed in an interdisciplinary department are actively thinking about connections across disciplines, more than folks who aren't, or it could be also maybe on the kind of motivation side, like their departments are going to be very happy if they're publishing these interdisciplinary things and doing these big projects. Whereas if you're, at least for me in a psychology department, they often tend to be more excited about you publishing in a psych journal than maybe an environmental journal. So we're not exactly sure why, but those interdisciplinary individuals who are from interdisciplinary departments seem to be really important.

Brian: One thing I'll add is that the overall result we found was that the prevalence of models that had linkages going in both directions was much lower than we expected given that we sampled from a program, an NSF program, that was explicitly trying to fund projects to develop these two way linkages, coupled human-natural systems or natural-human systems.

Erin: So is that where the title comes in? Like how coupled are these really? That's what they're saying they're doing, but…

Brian: Exactly. Yes.

Erin: One final question. I was just curious personally, since you guys study emissions behaviors and of course with COVID a lot of people haven't been driving in their cars and, you know, all these kinds of things—is there data available on how COVID has impacted greenhouse gas behavior and even is it possible, do you think that these kind of behavior changes could have both positive and negative effects?

Brian: Great question. And I think a lot of people have thinking about this. So my understanding is that the lockdowns associated with COVID decreased overall emissions on the order of five to six percent. So it's not insubstantial, so it is a large change in emissions. But again, my understanding is that somewhat paradoxically, the actual change in atmospheric concentration of greenhouse gasses did not change as much because there were some compensating effects of emission reductions and pollution reductions. So that for instance methane lasts longer or was not being removed from the atmosphere as quickly with these reduced anthropogenic emissions. And so there were other components that sort of responded in an opposite way. So that overall composition of the environment in terms of greenhouse gasses did not—the trajectory did not change as much even though the emissions did.

Brian: And of course the emissions are bouncing back as things go back to normal. But, and so while that might seem, pessimistic depending on how you look at it. I think what struck me the most about this whole experience, we have all gone through over the last two years, and I guess are still going through is how rapid change can occur when we want it to. And so we completely changed how we, as a society, speaking from a US perspective, how things worked in our society and how we lived our lives. And we did it very quickly in a very dramatic fashion and it wasn't all bad. I mean, there's so many things that I think…changes that I was forced to make that I think are really good. And I don't want to go back to how things were before, some of them. And so I think the optimistic takeaway is that when we, as a society, as human beings want to change things, we can change them very rapidly.

Erin: Thank you. Thanks for helping us end on a positive note.

Brian: Okay, great. Thanks so much, Erin, I appreciate it.

Katie: Yeah. Thank you for the opportunity.

Erin: Still curious what the group found in terms of degrees of global temperature increases over the next century? Based on their model that they ran 100,000 times to simulate possible future policy and emissions trajectories, they estimate that in the year 2100 warming could vary between 1.8 to 3.6 degrees Celsius under different scenarios, with a strong probability of warming between 2 and 3 degrees

Celsius. This is less than the 3.9 degrees Celsius (or about 7 degrees Fahrenheit) increase that is estimated without the inclusion of climate policy. So can we make a change for the better? They think: yes, yes we can.

Be sure to stay tuned for future episodes by following us wherever you get your podcasts. Also, if you have any comments, questions, or suggestions for episodes, etc. feel free to write to me, Erin Duffy, at eduffy@umd.edu.

Thanks for listening.