The Challenges of Modeling Climate Change and Variability

Interview with Keith Dixon
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(The following may contain unintelligible or misunderstood words due to the recording quality.)

BARRY REICHENBAUGH: This is Barry Reichenbaugh with the NOAA Research Communications Office. I'm here with Keith Dixon at the Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey. Keith, welcome.

KEITH DIXON: Nice to chat with you.

BARRY REICHENBAUGH: Keith, I'm wondering if you could start out by just talking a little bit about your role here, what it is you do.

KEITH DIXON: Well, at GFDL, I have been here since the 1980s and my role at different times is -- they've all been involved with modeling, using computers to model the Earth's climate system. And, I focus mostly on decadal-to-century time scale problems. And, a little bit more of a focus on the ocean's role in the climate system.

BARRY REICHENBAUGH: Okay. For the benefit of people who may not be real clear on what a model is, could you talk a little bit about just the models that you do here, how that works?

KEITH DIXON: Well, in order to study a certain set of climate science questions, we rely on computer models, and there are these big computer programs, a series of mathematical equations.

And, we need to use those because, unlike a chemist who maybe can do their experiments in a laboratory using beakers and test tubes, well, we don't have a twin planet Earth that we can use in order to perform experiments. So, we need to create a virtual Earth. And, it's these series of mathematical equations that encompass what we know about the Earth's climate system and then we can run them as large programs on state-of-the-art super computers and see how they represent the current climate and use them to answer questions about how different things work.

Maybe in its most basic way of thinking about it, we break down the climate into its four major parts: the atmosphere, the ocean, sea ice, and land surface. And, each of those four would essentially have its own model that we then couple together, we say, so that they kind of interact with each other.

And, for each of those, we're interested in how energy flows through them. You know, what the winds and ocean currents are, how they move, how they transport heat and water. You know, looking at the global water cycle.

And, they are basically based upon our knowledge, the scientific community's knowledge about how the different parts of the climate system work, what the different physical processes are, what the governing equations are that determine how things move and how energy flows.

So, in that regard, it's really a synthesis of observations and theory in order to the models and then, through modeling, we try to learn more about the way things work and compare them with the observations.

So, in each of those different parts, you know, the model itself, you can think of it as broken up to a bunch of little boxes or little cubes. We divide up the atmosphere and the ocean. So, in our current models, there are several hundred thousand boxes that represent the three-dimensional atmosphere. There are more than a million in the ocean.

And, at each of those boxes, we use those equations in the computer program to calculate how key factors evolve, how they change over time. Things like what's the temperature? What's the humidity in the atmosphere or the salinity in the ocean? What the ocean currents and winds are. What’s their direction, their speed. How sunlight is being absorbed and reflected and where it is. Are there clouds forming? Sea ice. Is it moving? Is it growing or melting? And, you know, water on land, is it evaporating or how much is moving to the sea via rivers?

So, with all those equations and all those grid boxes, we have the model go through and they see how things are changing, how the different boxes are interacting with one another. All those computations are made and updated to represent what has now happened at some time ahead, some minutes or hours later. Update everything, and then we begin the whole process again. And, it marches forward in time.

BARRY REICHENBAUGH: I guess my next question is in terms of just how you, over time, are improving these models. What goes into that? Could you talk a little bit about that process?

KEITH DIXON: Well, the models of today are much better than they were when I first started at GFDL in the 1980s and we still have a ways to go. We can continue to improve them. And, there's different ways of judging how a climate model has improved depending upon the application that you want to use it for.

And, as time has gone on, we have seen that the number of people who are interested in the climate models and what they are doing, that audience has increased. I guess we can think of the improvements occurring in different ways, depending upon the audience.

In one regard, it's the completeness of the models. In another regard, it might be the model resolution, how small we make those boxes. And then, maybe the ultimate test is how well those model simulations over the past -- say, the last century or so -- match up with what was observed. In all three of those categories, we have improved the models over time.

In terms of completeness, they are more sophisticated than they used to be. They are more complex. We try to have them more fully represent a wider range of the physical mechanisms that are in the model. So, you can think of it as adding more refined parts to the model to make it more realistic.

On the model resolution, that's really a thing that's dependent upon the computer power we have available to us. Just like a high-resolution television will give you a better picture of a digital camera with a lot of megapixels is better than a coarser looking picture.

We can get a better idea about what's going on in the climate if we have more smaller boxes making up the grid in our models. But, that's computationally expensive. It takes a lot more to make those computations at more boxes. So, we're really constrained by the amount of computer we have.

And, finally, we can see what's been happening over the past ten, 15 years and we then compare or benchmark our models and we look at how the global, large-scale climate has changed during the 20th century.

And, we can take our model and we can include the facts that we think could help force some of what those observed changes were. Changes in greenhouse gases, changes in atmospheric pollutants and particles, volcanic aerosols, subtle changes in the solar output. And, by putting all those factors in, we can see how our model responds both globally and in the large-scale. Continents versus oceans. The Arctic versus the tropics.

And, we can see that the models have gotten much better over time in reproducing decade by decade those large-scale variations that have been observed and then that'll give us more confidence in what our models do.

BARRY REICHENBAUGH: You've been here for better than 20 years. Can you put into some context the role of GFDL in modeling?

KEITH DIXON: GFDL has a very long and rich history in terms of climate modeling. Back in the 1960s, Syukuro Manabe and Kirk Bryan are credited with actually creating the first global coupled climate model, one that incorporated the atmosphere and the ocean and the interactions.

In fact, that's such an accomplishment that its been recognized both as NOAA as one of its top ten breakthroughs that have taken place in NOAA during its entire history, and also in the journal Nature in year 2006, GFDL's original climate model was cited, among other things, as being one of the major milestones in scientific computing.

I mean, some of the other things that were cited were things like the invention of the first handheld scientific calculator, the creation of the Internet, the development of the first CT scanner. So, it's the rich history, it's been some very important things that have started here in the '60s, continued through to today.

And, today, GFDL is still among the premier institutions in the world that perform this sort of modeling of the atmospheres, the oceans, the planet systems in general. And, that's seen in its prominent role in major scientific assessments, both international, things such as the Intergovernmental Panel on Climate Change, as well as national assessments as well, things such as the Climate Change Science Program.

BARRY REICHENBAUGH: Something that is, you know, generally coming through with all the people I talk to here at GFDL is the enthusiasm that they have for what they're doing. I'm wondering if we could just shift the gears here a little bit and just talk about what prompted you to go into science in the first place?

KEITH DIXON: I was interested in science in general for about as long as I can remember. For example, I think one thing that probably had an influence was I grew up in the 1960s. I was in grammar school when Neil Armstrong and Buzz Aldrin were the first men to step on the moon. And, that just kind of like sparked an interest in science in general.

And, as I got older, I realized that while I was interested in, you know, astronomy, the planets, the space program in general, that I got more of a focus maybe just on planet Earth and things that I could see.

And, weather was the thing that I could see and experience every day. And, there was probably, on top of it, the interest that a lot of people that came through the meteorology route have, at least those who grew up maybe in the northern part of the United States, the whole fun of having days off from school due to big snowstorms kind of sparks an interest in weather that sticks with you with awhile. And, over time, it evolved into being interested in the research branch of things.

BARRY REICHENBAUGH: Okay. Then, building on that, and how did you end up in climate science?

KEITH DIXON: Well, I went and did my college work, undergraduate and graduate, at Rutgers University in the Meteorology Department, and I was lucky. I got to sample a few different parts of meteorology there. I did some part-time radio broadcasting on a series of commercial stations. I also did a little bit of consulting work with the professor there.

But, I found that kind of the research part, asking the questions and having the time to try to dig into them and being part of a team that would tackle some big issue questions was something that intrigued me the most. And, when I got the opportunity to come here to GFDL, I grabbed it.

BARRY REICHENBAUGH: For people who are considering a science career and wondering about opportunities, I am wondering if you could just touch on where you see opportunities down the road?

KEITH DIXON: Well, when I get asked by -- we have summer interns that come by, and others who are interested in the field of science in general or climate and weather, more particularly sometimes get the question about what things are good.

Depending upon which branch they find they have the most energy for -- and, that's probably the determining factor. What gets your juices flowing. But, for the science, there's certainly -- the mathematics part is a main thing. Being good, competent at that is key. Some folks who have a real energy and get their juices flowing from that can then find a number of different things to go into.

But, also, there is a certain thing about having an appreciation for the scientific method if you want to get into the research side, understanding the idea about how to pose proper questions that are testable, repeatable, and coming up with reasoned approaches. Going back and constantly questioning your assumptions in order to advance the science is a good way to just kind of develop that thought process and in a kind of a rigorous way.

And then, another thing that is sometimes overlooked and that we all probably struggle with, one sense or another, is communications as well. Whether if you're thinking of doing research where your primary communications is through the written word, publishing scientific journals, or whether someone might be interested in being a weather forecaster on the air.

You need to have those communications skills in order to be able to take what you know and let people know about it so it has value.

BARRY REICHENBAUGH: Keith, thanks for joining us.

KEITH DIXON: Thank you. It was a pleasure.