

TRANSCRIPT FROM NOAA/GFDL EDUCATIONAL INTERVIEW:

NOAA GFDL CLIMATE RESEARCH CONVERSATIONS

[ABRUPT CLIMATE CHANGE SCIENCE: A CONVERSATION WITH THOMAS DELWORTH](#)

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**QUESTION [KD]:** For today's climate research conversation, we'll be talking about the science of abrupt climate change with Tom Delworth. Tom is a climate researcher at NOAA's Geophysical Fluid Dynamics Laboratory, a research center more commonly referred to as GFDL. Tom is the head of GFDL's Climate Change, Variability, and Prediction Group, and he also participated in the writing of a report recently published by the United States Climate Change Science Program – a report that is simply titled, *Abrupt Climate Change*. Tom, maybe we should start by asking you to explain what is meant by the phrase "abrupt climate change." I mean people have probably heard, said one time or another, "if you don't like the weather, just wait a few minutes." But when scientists talk about abrupt climate change, you're talking about changes that take place over time periods longer than a few minutes or even a few months, right?

**ANSWER [TD]:** That's right. That was really one of the biggest and first challenges of this committee, to really define what abrupt climate change is. So we came up with the following: Abrupt climate change is a large scale change in the climate system that occurs over time scales of a few decades or less, and which we anticipate to persist for a few decades or more, and causes large scale disruptions in human or natural ecosystems. So they are changes that are major changes that we will feel in society, and they are changes that come on over a time scale that humans will see, over a time scale of a human generation or so, and that society will have a major challenge adapting to. Very large scale changes that will require adaptation in terms of infrastructure or other agricultural practices.

**Q [KD]:** When it comes to abrupt climate change, did the CCSP report you helped author consider changes in the kinds of things we hear about in daily weather forecasts? Things like surface temperatures, precipitation amounts, wind speeds, things like that?

**A [TD]:** We looked for changes, or the potential for large and abrupt changes in very large-scale aspects of the climate system. We were motivated in part by the kinds of large-scale abrupt changes that we've seen in ancient climates from the geologic record. So we looked at very large changes in the climate system. These would

have large impacts on the local scale in terms of what people would experience, but they are not strictly local. They are parts of large-scale changes in the climate system.

**Q [KD]:** So for this report, you were the lead author for the section that focuses on the possibility of fairly abrupt changes of the Atlantic ocean's three-dimensional ocean circulation. Is that ocean circulation pattern something that is of interest just for scientists, or does it impact the weather and climate that people experience where they live?

**A [TD]:** We think that the Atlantic Ocean plays a major role in the global climate system. In the tropical Atlantic, the ocean takes up a lot of heat because there is a lot of energy coming from the Sun. This warm and actually very salty water then moves northward in the upper layers of the Atlantic Ocean to higher latitudes. At higher latitudes, the cold dry air coming off the continents, takes up a lot of the heat out of the ocean. That makes the water denser. That dense water sinks to great depths in the Atlantic Ocean, and then moves back towards the equator. So this circulation, which we call the Atlantic meridional overturning circulation, plays a powerful role in the climate system by transporting heat from the tropics, where it gains energy from the Sun and moving it to higher latitudes, where it is released to the atmosphere. We see both using modeling studies and observational data, that changes in the intensity of this circulation have a major impact on global climate. It influences the intensity of Asian and monsoonal rainfalls as well as changes over the Caribbean. It influences the likelihood of drought over North America as well as summer conditions over North America and Europe. It also influences conditions in the tropical Atlantic, making it more or less favorable for hurricane activity. So these changes in the Atlantic Ocean, how much heat is transported from the tropics to the poles, have a very large impact on climate over a good deal of the northern hemisphere.

**Q [KD]:** Okay. So it sounds like there are reasons why people should care about the possibility of abrupt climate changes, though from what you've said, it sounds like the severity and abruptness that was shown in the movie like in *The Day After Tomorrow*, that's not necessarily realistic, is it?

**A [TD]:** The movie, *The Day After Tomorrow*, was really good entertainment, I liked it a lot. But it doesn't really represent our best understanding of how the climate system will work. When we look to the future, we want to see how will the Atlantic overturning circulation change. And our best estimates, based on a variety of modeling studies and evidence from the geologic record, suggests that as we go forward into the future, we don't think it's likely that the Atlantic overturning circulation will abruptly change or collapse. We actually say it's very unlikely, meaning

less than a 10% chance of this occurring. Now that's not zero. There's still some chance that it will occur. We just think that it is very unlikely. We think that there will be a gradual slow weakening of the circulation and our best estimate is over the course of the next century that circulation will weaken by about 25 to 30 percent or so. But we think the change will be slow and gradual. Not the abrupt kind of collapse that we see sometimes in science-fiction movies.

**Q [KD]:** Tom there was another report, one that came from the U.S. National Academy of Sciences back in 2002 that said, "available evidence suggests that abrupt climate changes are not only possible but likely in the future, potentially with large impacts on ecosystems and societies." In the years that past between the writing of that 2002 report and the more recent CCSP report that you helped author, has the research led to any refinements or changes in opinion as to exactly how likely it is that we might witness abrupt climate changes in the next fifty, one-hundred, or two-hundred years?

**A [TD]:** In developing this new report, we certainly try to build upon that previous report as well as a wealth of new studies that have occurred over the last five to eight years. In particular, many of these studies have used a new generation of climate models that have come into existence over that time frame. These models are in general more comprehensive, and represent the Earth's climate system with greater fidelity. So we are very comfortable with our statement that we think it's very unlikely that the Atlantic overturning circulation will change abruptly or collapse in the 21<sup>st</sup> century. A large part of this confidence comes from the modeling results, because when we survey the state of the art, comprehensive climate models, now in use around the world, we find that none of them, not a single one of those state of the art models, projects an abrupt change or collapse of the overturning circulation in the 21<sup>st</sup> century.

**Q [KD]:** You've described how the three-dimensional Atlantic Ocean circulation is something that researchers like yourself are studying. What other parts of the global climate system are scientists looking at as being potentially linked to future abrupt climate changes?

**A [TD]:** We looked at three other phenomenon in the Earth's climate system that we thought, especially based on geologic records, had the potential for abrupt climate change. The first of these is land based ice sheets over Greenland and Antarctica. A lot of the world's fresh water is tied up in those ice sheets, and if they were to rapidly melt under global warming scenarios, that has the potential to lead to rapid changes in sea level. So that is a very major concern. In the study we find that there is clearly evidence for an acceleration in the melting of the Greenland ice sheet.

However, our understanding of how ice sheets work, and in particular how they melt, is really quite limited. Think of these ice sheets that are a thousand or two thousand meters thick. How do you really understand what is going on at the base of those ice sheets under all of that ice? It is a very major challenge for us. And so our ability to really confidently model and predict how these ice sheets will evolve over the coming century is limited. We are very concerned about the possibility of abrupt climate change in ice sheets. We see an acceleration of the melting, but we are unable yet to confidently predict how rapidly these ice sheets will melt.

Another area we looked at was the possibility for a rapid release of methane into the climate system. We are concerned about this because methane is a very powerful green house gas, and if this was to be released rapidly into atmosphere, it could have very large climate consequences. There are a couple of sources of a potential rapid release of methane. One is from sediments on the sea floor. Another is from land-based sources. So we looked at whether or not there is a likelihood of rapid release in the future from those sources. We find that there is some increase in methane release from those sources, but we don't think it's likely that there will be a rapid or catastrophic release in the 21<sup>st</sup> century. We do think there will be a gradual increase in emissions from those sources, which will contribute to amplifying or accelerating global warming.

The final area we looked at was the likelihood of an abrupt increase of drought around the world. Of course water resources and drought is a major climate issue – particularly in the southwestern United States where the climate is already arid. When we look at this we see that the southwestern United States is already in a drought, and has been in a drought for a number of years now, and we are unable to say confidently whether that drought is due to increasing greenhouse gases and human activity, or part of the natural variability of the climate system. However, we do know that most climate models used for projection of future change do show a tendency for increasing drought in the southwestern part of the United States in response to increasing greenhouse gasses. So we are concerned that the drought we seen now, there is possibility that that may be a harbinger of increased droughts in the future that may result from global warming.

**Q [KD]:** A final question: What are the prospects for researchers at GFDL and elsewhere to increase your confidence in assessing the likelihood of future abrupt climate change? How do you go about tackling that issue?

**A [TD]:** That's a really important question. There are several avenues that we are pursuing to try and increase our knowledge of how the climate will change in the future. One of the most important is trying to improve the models we use to project future climate

change. Our models are continuously evolving as we increase our understanding of the climate system. So we are really trying to push the envelope on that. We do that in several ways. First of all, with faster supercomputers we are able to resolve more and more of the small-scale processes in the climate system. Also, we are trying to improve our understanding of how the physics and chemistry of the atmosphere work. This is always a major challenge to us because things like clouds are very important parts of the climate system and yet they have very small-scale structures involving ice particles and aerosol particles all interacting with clouds – so we are really trying to focus on improving models by incorporating additional processes that we understand better, as well as being able to simulate smaller scale processes in the climate system. We are also trying to combine that with the best possible use of observation of the climate system. It's really by comparing observations and models that we increase our understanding of how the system works. And that allows us to more confidently predict the future evolution of the system. We make use of observations both in the modern record, what we see out there today, as well as in the geologic record that tells us how climate has changed in the past. So by focusing on improving our models, improving our understanding through observations, and by bringing the two together, that's how we are really trying to improve our ability to predict more confidently the future evolution of the climate system, and whether that climate change will be abrupt or gradual.

**Q [KD]:** Thanks Tom. We've been talking with Tom Delworth, a climate scientist at the National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamics Laboratory located in Princeton, New Jersey. To read the CCSP's Abrupt Climate Change Report that was published in December 2008, you can go to [climatescience.gov](http://climatescience.gov). That's CLIMATESCIENCE (one word) dot G-O-V and look for *Synthesis and Assessment Product 3.4*. And for more information about the research done by Tom and his colleagues at GFDL you can go to W-W-W dot G-F-D-L dot N-O-A-A dot "gov" (<http://www.gfdl.noaa.gov>).

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