Are We Successfully Adapting Science to Climate Change?

BY KRISTEN AVERYT

The planet is committed to a certain degree of warming as a consequence of past greenhouse gas emissions, meaning that society will be forced to adapt to the impacts of climate change. In 1989, scientists were challenged to address emerging environmental problems such as climate change by engaging in a new "social contract" and embracing problem-oriented science. But has the climate community stepped up to this challenge? As scientists, are we adequately helping prepare society to successfully adapt to climate impacts? Progress developing policies geared toward mitigation of greenhouse gas emissions suggests science has been successful at wholesaling climate science through vehicles such as the Intergovernmental Panel on Climate Change (IPCC). However, what is in fact an accumulated body of knowledge can appear transitory in the public arena, as illustrated by the decline since 2007 in the number of Americans who "believe" in global warming. Climate research is likely falling short in the retail end: scientists do not always know or understand societal needs, so the science is not necessarily usable. To rectify this situation, the climate-science community needs to rethink its training and promotion systems to better provide young scientists with opportunities to learn and engage in integrated climate research[1] that includes stakeholders in the scientific process. The new generation of climate scientists needs to be armed with the ability to break from the single hypothesis mode of research in order to engage in the problem-oriented frameworks necessary to address the multifaceted challenges posed by climate change. Otherwise, the scientific community will fall short of meeting society's climate information needs to manage risk and adapt.

The mismatch between what applied climate science provides and what society needs to successfully adapt is best illustrated by this metaphor: if climate scientists were medical doctors, most patients would be told when they are likely to die, but would be offered no help about how to avoid their imminent demise. When I have a fever, I do not go to articles published in the *Journal of the American Medical Association* to figure out why or to determine what I should do. I may search the Internet to gather more information, but ultimately I go to my physician, and we work together to determine the best treatment. There are scant few "doctors" in climate science that can diagnose the problem, and then work with "patients" to identify information that will inform the best course of action; this scenario reflects the pervasive incapacity or reluctance of scientists to communicate or understand the perspectives of those outside a specific academic realm. Climate scientists should not assume that those who need climate information for planning purposes are exposed to the relevant science. Simply, policy-relevant science can often be hidden from the decision-making domain in journals, lab notebooks, or obscure data formats. It is unreasonable to expect that those trained in public administration and policy will find useful information in the technical details included in scientific journal articles. Scientists need to recognize that even *Science* and *Nature* are obscure to many nonresearchers. Unfortunately, journal publication is the primary avenue scientists

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[1] Integrated science refers to efforts that involve research and researchers from different scientific fields (e.g., biology, engineering, psychology, etc.).

ECHOES

"Sea level change is a very big deal."
—Jeffrey Dorale, professor at the University of Iowa, on recent research he led that indicates sea levels were about 1–1.5 m higher than present-day levels about 81,000 years ago—right in the middle of the most recent ice age. The discovery challenges other research that suggests sea levels were significantly lower around that time than they are today. Dorale led a team that ventured into caves on the island of Majorca, off the coast of Spain in the Mediterranean Sea, and examined mineral deposits called speleothems. Left by ancient waters, these deposits reflect tidal changes and can be used to determine sea level measurements more accurately than other methods. While the researchers found a number of caves that indicated the brief period of higher sea levels, some have suggested that this could have been caused by tectonic uplift, in which the release of weight on the Earth caused by the melting of ice masses at the end of an ice age leads to a rising of the land. But the researchers also found caves that showed levels about 20 m lower than today that occurred just 4,000 years earlier (about 85,000 years ago) and about 15 m lower than current levels from 79,000 years ago—levels consistent with those discovered in other parts of the world and which not only refute the tectonic uplift theory, but also highlight the significance and uniqueness of the brief period of higher levels. Dorale noted that the unexplained spike 81,000 years ago likely would have followed a remarkably swift melting of ice equal to approximately 2 m of sea level change every 100 years—a puzzlingly rapid change. "It's tough to explain how to melt that much ice that fast," he says. The subsequent sea level drop (and ice formation) was equally accelerated. (Sources: University of Iowa; *U.S. News & World Report*)

use (and are told by their funders to use) to report their findings, so many of the missing pieces that decision-makers need in order to include climate information in adaptation planning have not been adequately communicated through traditional scientific approaches.

However, decision-makers' needs extend beyond improved packaging of climate information. Simply improving the delivery of climate science and assuming users will go forth and make informed decisions is insufficient. In order to enhance decision-making with the use of climate science, stakeholders need to be included in the scientific process and connections need to be made across disciplinary spheres. As an example, consider the role of climate change in water resource management. As water-planning strategies attempt to grow beyond stationarity to include many evolving factors (climate, population, ecological and environmental needs, etc.), water managers are demanding that scientists and engineers expand the set of parameters in the modeling and research that inform their planning strategies. Their adaptation planning requires that the science transcend the boundaries of physical scientific disciplines into the biological, geographical, and social sciences, as well as engineering and economics. Unfortunately, from what those water managers at the forefront of adaptive management say, the multidisciplinary capacity within the research community needed to address water resource issues is insufficient. In this case, developing research questions with the decision-makers and constructing multidisciplinary research teams would be the most efficient way for science to reduce the vulnerability of the water sector to the impacts of climate change by informing resource management and planning.

Unfortunately, there are two major hurdles preventing climate scientists from successfully building integrative research frameworks that include decision-makers in the scientific process. The culture of the academic climate-science community fails to teach the younger generation of postgraduate students how to work with decision-makers in order to develop successful applied science strategies, and it fails to reward junior faculty members for focusing on multidisciplinary, user-involved climate science.

From the beginnings of our careers as scientists on through the tenure process, the academic path does not encourage integrative research that also links users with research. Indeed, not every student wants or needs to bridge disciplinary boundaries or work with stakeholders, but there are too few opportunities for graduate students to engage in such research, much less to find a junior faculty position that will encourage such work. This has been true for a long time, and despite periodic attempts by academia to correct its narrow disciplinary focus, it remains a problem. Indeed, addressing these challenges will be difficult, but now is the time to revisit this issue.

As a first step, scientists must learn to hone their bedside manner. An imperative component of linking users with research is building stakeholder relationships, particularly with the regional and local entities that will likely make most of the decisions related to climate adaptation. Again, medicine can serve as a guide here for the climate sciences. During medical

school and nursing classes, professors teach students about the importance of constructing professional trust when working with patients, as studies reveal better outcomes for patients who trust their medical caregivers. Similarly, scientists must learn to value and use the information coming from "patients." This model needs to be applied to some aspects of climate science: the upcoming generation of climate researchers must have the opportunity to learn how to work with "patients" beginning in graduate school. Then, junior scientists should be encouraged to use integrated approaches to answer the novel research questions shaped by these relationships.

I am optimistic that those who have realized the benefits of integrated, problem-based research will drive the climate science community to value such science. Many of my research colleagues and I have spent the last few years scrambling to develop the communication skills necessary to collaborate with decision makers on real-world problems, and build connections with researchers outside our disciplines to answer them. My vision is that in the future, those coming up through the educational ranks will begin learning these skills in graduate school. Graduate students will be able to hit the ground running when pursuing postdoctoral opportunities or beginning faculty careers because they will have already cultivated the skills necessary to build relationships with stakeholders and decision makers, in addition to their scientific networks. I believe it is also imperative that incentives exist throughout our careers as climate scientists that foster multidisciplinarity and user-driven research.

There are many programs that offer training for young scientists in communicating with decision makers, including the American Association for the Advancement of Science Policy Fellowships, NOAA Knauss Sea Grant Fellowships, Aldo Leopold Fellowships, and the National Academy of Sciences Graduate Science and Policy Fellowships. In these programs, one learns to identify what scientific information is useful for decision making in different contexts. There are limited positions in these programs, and their popularity illustrates a growing desire by scientists to engage with decision-makers, make science more relevant, and see science in action. However, these programs are highly competitive, and there ought to be more opportunities for such training.

The change needed in the climate-science community cannot end with graduate education and training—it must continue along the academic career path. A few years ago, I was at a meeting with a small group of recent Ph.D. recipients interested in working on interdisciplinary climate issues (the National Science Foundation-funded Dissertations Initiative for the Advancement of Climate Change ReSearch). Surprisingly, the senior scientists at the workshop agreed that the young participants should wait until they had tenure before taking on interdisciplinary endeavors. Why? The reason is simple: the academic promotion process does not encourage or reward multidisciplinary research. Although we identified many reasons for this, I believe the "publish or perish" mantra emerged as the major issue contributing to the cross-disciplinary hurdle posed by the tenure track. The science that informs climate adaptation planning decisions is not necessarily published in traditional, peer-reviewed journals, but often in assessments and guidance documents categorized as "gray literature." Despite the importance of gray literature in decision support, these scientific efforts are not held in the same esteem as peer-reviewed publications, and often do not carry the same weight in hiring, tenure, and

DROUGHT LEADS TO MONKEY BUSINESS

El Niño caused a drought this spring in the Philippines, and the nation's normally friendly monkeys weren't happy about it. In the town of New Israel, persistent droughts devastated many crops, including the bananas that the monkeys subsist on. As a result, most of the approximately 1,000 monkeys in the town split to find food elsewhere. The town has become a local tourist destination after the government declared it a sanctuary for the primates, protecting them from harm and allowing them to roam freely and interact with humans. "These animals even play with us and our children and visitors," notes Darwin Paraiso, a town councilor. But the lack of food drove most of the monkeys out and led some of them to break into local homes and steal food. The abnormal warmth and drought brought on by El Niño has created a major agricultural crisis in the country. Through the end of March, the damage to crops in the Philippines was estimated at more than 8.4 billion Filipino pesos (about $190 million). The government cited corn and rice as the major crops affected, but the monkeys begged to differ.

job-promotion decisions. Yet such gray literature can at times undergo even more rigorous reviews than the journal process (e.g., IPCC; Climate Change Science Program assessments).

Then, too, multidisciplinary work takes longer (because of the importance of network building, mutual learning activities, etc.) and is more expensive to conduct, creating obvious burdens for a young scientist. This reinforces the need for improvements in postgraduate education; if a student can create or engage with a stakeholder network during graduate school, then one is better poised to meet the demands of the tenure timeline while pursuing multidisciplinary, use-inspired research as a faculty member.

However, perhaps universities and academic institutions are not the place to foster this kind of research. Many of my colleagues suggest that there is a misconception in academic departments that integrated, user-informed research equates with policy-prescriptive, activist science with the potential to compromises one's scientific credibility. The reality is that all scientists, regardless of what one chooses to do as a postgraduate, are trained in an academic environment where such misperceptions may exist. In an ideal world, academic departments would be intrepid about engaging stakeholders and other nontraditional fields in research, as it can lead to novel insights revealing exciting research pathways. Multidisciplinary endeavors can also result in more usable applied research, and as applied research is the public face of science, it can only improve the public perception of science. It is a win–win situation.

As a consequence of the lack of training and a lack of incentive in the traditional academic career track, as well as academic perceptions of multidisciplinary, stakeholder-driven research, my generation (I completed my Ph.D. in 2004) is indeed likely to see integrative research and the engagement of users in framing scientific questions as something one does after tenure. Today, there are too few scientists with the skills and the career incentives necessary to engage and contribute to strategic climate adaptation initiatives. Society would be well served by prioritizing the training and support of a generation of scientists eager to engage in boundary-spanning, multidisciplinary research. For those students who want it, we need to provide the educational opportunities and the academic incentives to address cross-cutting knowledge gaps, adequately communicate science to stakeholders, and collaborate with decision makers. Unless graduate training and postgraduate promotion systems in the climate sciences evolve so they provide young scientists with opportunities to engage in use-inspired, multidisciplinary, integrated climate research, the scientific community will fall short of meeting society's information needs. Changing the culture of climate science will be the way we can collectively step up to the "social contract" challenge.

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FOR FURTHER READING

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