CREDIT: KOOS VAN DER LENDE/NEWSCOM

ADAPTATION TO CLIMATE CHANGE

Time to Adapt to a Warming World, But Where's the Science?

With dangerous global warming seemingly inevitable, users of climate information—from water utilities to international aid workers—are turning to climate scientists for guidance. But usable knowledge is in short supply

DENVER, COLORADO—The people who brought us the bad news about climate change are making an effort to help us figure out what to do about it. As climate scientists have shown, continuing to spew greenhouse gases into the atmosphere will surely bring sweeping changes to the world—changes that humans will find it difficult or impossible to adapt to. But beyond general warnings, there is another sort of vital climate research to be done, speakers told 1800 attendees at a meeting here last month. And so far, they warned, researchers have delivered precious little of the essential new science.

At the meeting, subtitled "Climate Research in Service to Society,"* the new buzzword was "actionable": actionable science, actionable information, actionable knowledge. "There's an urgent need for actionable climate information based on sound science," said Ghassem Asrar, director of the World Climate Research Programme, the meeting's organizer based in Geneva, Switzerland. What's needed is not simply data but processed information that an engineer sizing a storm-water pipe to serve for the next 50 years or a farmer in Uganda considering irrigating his fields can use to make better decisions in a warming world.

Researchers preparing for the next international climate assessment, due in 2013, delivered some discouraging news for those striving to generate actionable science of use at the regional and local scale. But the challenges to the climate science community also include creating so-called climate services that can deliver actionable information effectively to users, speakers said. "We have a very long way to go," Asrar noted.

ISO actionable information

"How can we make decisions in changing times with uncertainty hanging over us?" asked David Behar, the San Francisco Public Utilities Commission's climate program director. "We need actionable science." He defined that as "data, analysis, and forecasts that are sufficiently predictive, accepted and understandable to support decision-making." More concisely, climatologist Bruce Hewitson of the University of Cape Town in South Africa said that a result is actionable science if you would spend your own money on it.

Behar said he finds the uncertainties surrounding actionable climate information "fairly overwhelming" these days. And he's having trouble coming up with intermediaries between users and scientists who can at least put the uncertainties into perspective without killing any motivation to act, he said. "It's a wild, wild West in the assessment world," Behar said. "It's every man for himself." "We're drowning in data," Hewitson added, and "we're not very good at turning it into information."

Too often the provider of climate information takes the attitude that "I've got the knowledge and you'll use it," Hewitson said. Such take-it-or-leave-it approaches are part of the reason that only 30% or less of climate information offered is ever used, he said. And, he added, there is no example of an operation in Africa, at least, that is succeeding in the preferred approach of building effective communication between the climate research community and climate information users.

The situation is not much better in the United States, Behar said. In its fiscal year 2012 budget request, the National Oceanic and Atmospheric Administration (NOAA) asked for funds to support a reorganization that would create a National Climate Service (*Science*, 2 April 2010, p. 29). Such a service would more effectively deliver "eas-

*Open Science Conference of the World Climate Research Programme, 24–28 October, Denver, Colorado.

Published by AAAS

Adapt to that. Climate will change, but decision-makers want to know how, where, and when.

ily accessible and timely scientific data and information about climate that helps people make informed decisions in their lives, businesses, and communities," according to a NOAA web page.

While that proposal heads for the buzz saw that is money and politics in Washington, U.S. climate services reside in NOAA's Regional Integrated Sciences and Assessments (RISA) program. Through 10 regional operations variously called consortia, centers, programs, or partnerships, the RISAs support research addressing climate issues of concern to decision-makers. But the RISA centers "continue to struggle to meet demand," Behar says. "It's still a struggle for users to know where to go."

Shaky science

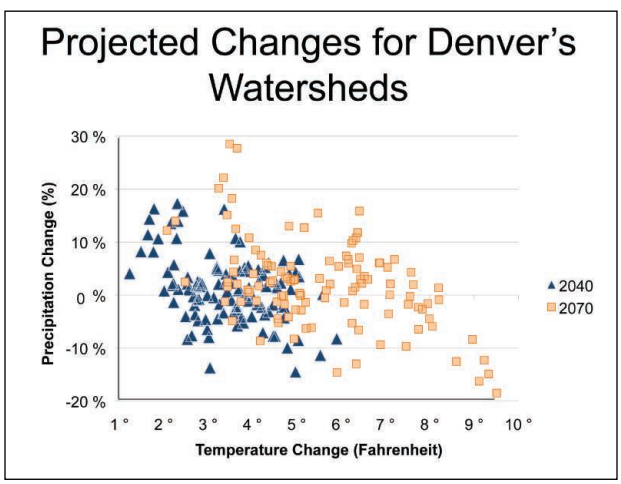
Nascent climate services may be struggling to create the conduit between scientists and users, but they could use more quality product to fill that conduit. The great hope as a source for actionable information is regional climate modeling, but the meeting pointed up its many inadequacies. In a well-received plenary talk, Behar related a couple of discouraging anecdotes. The U.S. Environmental Protection Agency now requires water utilities to prepare for climate change before it will issue permits, he explained. So the utility Denver Water was interested in how much water might be flowing down to Denver from the mountains to the west as the world warms through this century.

To determine what a warmer world might hold for Denver, a group of organizations led by Denver Water took an economical approach. Embedding a detailed, regional climate model in a global model is expensive. Instead, the organization "statistically downscaled" climate projections for north central Colorado from 16 different global models previously run by others. Modelers assumed that local changes would be proportional to changes on the larger scales of a global model, and they adjusted local projections in accordance with how well model simulations of past climate had matched reality.

The statistical downscaling results for Colorado were mixed (see figure). All the models are showing warming, says Denver Water's climate scientist, Laurna Kaatz. "Precipitation, on the other hand, is all over the place," she says. The region could get wetter or drier. And given the complexity of Colorado weather and climate, she adds, the more expensive model-within-model, dynamical approach might not have done any better. Besides, results from dynamical regional modeling have yet to show critics where, when, and how the approach is reliable (*Science*, 14 October, p. 173). And at the meeting, early results from the run-up to the next international assessment suggested there are no great improvements in the offing. Climate modeler Karl Taylor of Lawrence Livermore National Laboratory in California reported no progress over the past 5 years in narrowing the wide range in the sensitivity of climate models to added greenhouse gases.

In the meantime

While they wait for stronger support, users are going with what they've got, uncertain as it is. David Nagel, executive vice president of BP America in Washington, D.C., told how BP is thickening the gravel patch under Alaska oil drilling rigs as retreating Arctic sea ice allows storm waves to grow higher. BP is also beefing up its infrastructure in Azerbaijan in the wake of long-term forecasts of increasing storminess. And slowly rising sea level has prompted BP to raise the height of drilling platforms in the North Sea.



A fuzzy future. Sixteen climate models run under three greenhouse gas emission scenarios consistently showed warmings (horizontal spread), but some projected more precipitation and others less (vertical spread).

CREDIT: COURTESY OF DENVER WATER, 2011

Denver Water is developing scenarios: If this happens in climate, they posit, then here's the risk to your water supply, and here's how much the change will cost you if you don't prepare for it. Seattle Public Utilities asked Peter Gleick of the Pacific Institute in Oakland, California, about a quarter-billion dollars' worth of new storm drain pipes that would serve the city for up to 75 years. Gleick didn't know any more than anyone else how intense rain storms would become, but he was able to show the utility that increasing the size of storm drain pipes now would cost far less than being wrong about future rains.

To help get beyond the scenario mode of climate services, public organizations in and out of government are stepping forward. At the meeting, Craig Robinson of the National Science Foundation described how informed decision-making is one of four goals in the U.S. Global Change Research Program's draft 10-year strategic plan. Behar described the Societal Dimensions Working Group, which has invited him to become a member. It will strike up two-way communication between users and researchers developing one of the world's leading global climate models at the National Center for Atmospheric Research in Boulder, Colorado.

Behar also described Piloting Utility Modeling Applications (PUMA), a coalition of the five utilities of the Water Utility Climate Alliance and four RISAs. Within PUMA, state-of-the-art climate modeling would be identified for downscaling, uncertainties refined, and the need for climate services spelled out.

Universities are getting into the act as well. To develop and launch better ways to provide actionable environmental change information, said Antonio Busalacchi of the University of Maryland, College Park, UMD created a program called Climate Information: Responding to User Needs. The approach is in the style of the translational or "bench-to-bedside" approach used in medical research.

Most tenuously, speakers from the business community discussed the desirability of private climate services. Such businesses would develop and distribute climate information from data provided by a national climate service. That's how AccuWeather works: It takes data and forecasts from the National Weather Service to sell a presumably more useful product to the public and to business. Questions did arise about who could be trusted to project climate change—government or private enterprise—when, in contrast to forecasts in the weather business, no one can be proven right or wrong for decades.

"Can science save us?" asked one speaker. The answer running through the meeting was a guarded maybe—but only if someone can get usable science into the hands of decision-makers. And soon. **–RICHARD A. KERR**

Published by AAAS