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An Unsettled Forecast for Global Warming

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MALCOLM G. SCULLY

Climate science, Doug Macdougall writes, "is notoriously difficult, because there are so many interconnected variables at work that cause and effect are often impossible to discern with confidence."

Those variables, which Macdougall discusses in *Frozen Earth: The Once and Future Story of Ice Ages*, published recently by the University of California Press, have bedeviled the debate over global warming from the beginning.

Complexity breeds uncertainty, and uncertainty can lead to confusion in the general public and to deliberate obfuscation on the part of those who fear that any action to stem global warming would upset the economic status quo or their narrow self-interest. So while environmental activists and many climate scientists warn that the status won't be quo much longer without bold steps to curb the emission of greenhouse gases, skeptics try to sow doubts about the need to respond at all.

In that charged political climate, Macdougall, a professor of earth sciences at the Scripps Institution of Oceanography at the University of California at San Diego, offers a sober look at what we have learned about climate change and what we still need to learn. His book comes as more and more scientific studies and journalistic accounts document changes that already seem to be taking place. The focus of those reports has shifted from the global phenomenon to the impacts that warming may have on particular places, habitats, and lifestyles.

In November a panel of 300 scientists from eight countries released the results of a comprehensive, four-year study of the impact of warming on the Arctic region. The Arctic Climate Impact Assessment concluded that the region was undergoing "some of the most rapid and severe climate change on earth." The assessment showed that 386,100 square miles of sea ice -- about 8 percent of the total in the Arctic -- had been lost in the last 30 years and that winter temperatures in Alaska and western Canada had risen by from 5 to 7 degrees Fahrenheit since the middle of the last century.

"These changes in the Arctic provide an early indication of the environmental and societal significance of global warming," the assessment said.

While the changes may be most extensive in the Arctic, they appear to be worldwide. Glaciers are shrinking in the Himalayas, the Rockies, and, as Mark Lynas, a writer and activist, describes -- in *High Tide: The Truth About Our Climate Crisis*, published last summer by Picador -- in the Peruvian Andes.

He reports that glaciers in Peru's Cordillera Central lost a third of their volume from 1970 to 1997 and "will disappear altogether in just a few decades unless global temperatures stop rising." That could have disastrous consequences for the people of Lima, Peru's capital, who depend on the Rimac River for their drinking water. Once the glaciers are gone, he says, the Rimac, "which through the late twentieth century has been temporarily charged with additional meltwater from the rapidly retreating ice fields, will suddenly -- and disastrously -- dry up for half the year."

"It's difficult to imagine quite how a massive Third World city might cope with a crisis on this scale," Lynas writes. "With no water supply for six months every year, life will quickly become impossible. Where will the residents go? There is no spare land in the mountains, and few could survive in the jungle. Whilst the rich could pay for fresh water to be trucked in, the poor -- the massive majority of Lima's population, who already have difficulty accessing reliable water supplies -- will be forced to move or die."

Last summer the BBC reported on the findings of Scottish scientists who found that on the Shetland and Orkney Islands hundreds of thousands of seabirds had failed to breed this year. The most likely cause, they said, was rising seawater temperatures that had led to the disappearance from waters around the islands of the sand eel, a small fish that has been a key part of the food chain for the seabirds. The scientists speculated that the plankton on which the sand-eel larvae feed are moving northward to avoid the warmer seawater temperatures.

In October two environmental groups Results for America and **Clean Air-Cool Planet** -- held a briefing for reporters in which they warned, "Global warming already is starting to change New England's climate, endangering fall colors from hardwood forest maples and other trees. Over the next 100 years, the emerging climate-change trend could wipe out all or most of the autumnal foliage for which the region is best known and upon which its tourism economy is heavily dependent."

At the briefing, Barrett N. Rock, a professor of natural resources at the University of New Hampshire, reported, "Just 40 or 50 years ago, New England and New York produced about 80 percent of the world's maple syrup, compared to 20 percent in Canada. Now the ratio has been reversed as the optimal maple-sugar growing and tapping conditions have shifted north."

At another briefing in October, held at the Center for Health and the Global Environment at the Harvard Medical School, James J. McCarthy, a biological oceanographer at Harvard University, said that "global warming may well be causing bigger and more powerful hurricanes. Warmer seas fuel the large storms forming over the Atlantic and Pacific, and greater evaporation generates heavy downpours." McCarthy, the lead author of one section of the Intergovernmental Panel on Climate Change's Third Assessment Report, issued in 2001, added, "With warmer, saltier tropical seas, the IPCC has projected larger storms, heavier rainfalls, and higher peak winds."

And a study conducted by 19 scientists of the effects of climate change on California found that warming could, among other things, have a devastating impact on the state's wineries because it would lead to poorer-quality grapes. The study, which was published in the online version of the Proceedings of the National Academy of Sciences in August, also indicated that the snow pack in the Sierra Nevada could be reduced by 70 to 90 percent.

Complicating the debate further, some computer models show that there will be winners and losers as global warming continues, and that -- at least in the short term -- the winners will be in the developed world.

A study of the impacts of warming on agriculture by two scientists at Yale University's School of Forestry and Environmental Studies suggests that climate change will economically benefit countries in temperate areas but damage crops in countries closer to the Equator. "The 'winners,' ironically, are the developed countries that have done the most to produce these warming trends," says Robert Mendelsohn, a professor of forest policy who led the study.

For many scientists and environmentalists, such evidence amounts to a compelling case that human-induced warming is producing or will produce significant disruptions in our way of life. Even so, as Macdougall points out in *Frozen Earth*, we still don't understand exactly what is going on. "There is no such thing as average weather," he notes. "Weather is what we experience daily, and it can be misleading, because we are impressed most by the extremes."

To try to understand how the climate, as opposed to the weather, is changing, he looks at large changes on a longer time scale than the last few decades, pointing out that we are still in an ice age that reached its peak 20,000 years ago. At the moment, he says, we "are in the midst of the maximum warmth of an interglacial period." More important, he notes, "A hallmark of Ice Age climate change, at least when viewed from the perspective of its impact on human societies, is abruptness. With little or no warning, there have been drastic shifts in temperature, storminess, and precipitation, both regionally and globally."

Rapid climate shifts seem to take place when a threshold has been crossed, he adds, and some external process has to trigger that crossing. Recently, computer simulations have suggested that a change in ocean circulation may be one such trigger.

"In particular," Macdougall writes, "changes in the way ocean circulation occurs in the North Atlantic Ocean have been implicated in some of the large and abrupt temperature changes observed in the Greenland ice-core data over the past few tens of thousands of years."

He points to evidence from the distant past that large infusions of fresh water into the North Atlantic have affected ocean circulation and brought on prolonged cold periods in the Northern Hemisphere. If today's warming continues, melting glaciers in the Arctic could provide such an infusion. That prospect has caused some scientists to predict that global warming could lead to something akin to the "Little Ice Age," the period from the 14th to the 19th centuries when Europe and North America experienced extended periods of unusual cold.

While the mechanisms that lead to abrupt climate change remain mysterious, he

says, we have "several good examples of past civilizations collapsing as a result" of it -- from the Akkadians 4,200 years ago in Mesopotamia to the Maya 1,100 years ago in Central America.

"Modern societies," he adds, "for the most part are better equipped to deal with such surprises than were those of even a hundred years ago, but are not entirely immune. Just-in-time logistics systems and highly concentrated and specialized agriculture are as likely to be disrupted by abrupt climate change as some earlier technologies." Even now, he says, energy grids have trouble dealing with heat waves and cold snaps.

So, while Macdougall warns against reading too much into short-term changes in the weather, his analysis of the long term remains unsettling. We cannot predict, "even in a general way," he says, "what may happen to the climate system as a result of human influences. A great, unintended experiment in 'climate forcing' is under way as we add more and more greenhouse gases to the atmosphere. Whether or not we shall reach one of those thresholds that seem to separate different climate modes, and what will happen if we do, is still unknown."

Malcolm G. Scully is The Chronicle's editor at large.

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