de Broglie, and Claude Bloch, as well as those mentioned above); and comments on big and little science, fundamental research, and the relation between experimental and theoretical physics. (Some of these last topics are treated more succinctly in Abragam's *Reflections of a Physicist* [Oxford University Press, 1986].)

The importance of the book would have been enhanced by a fuller and more thoughtful description of Abragam's management of the CEA physics. One also would have welcomed more about what it meant seemingly always to be an outsider: first as a Jew in Russia, then as a Russian and a Jew in France, then as a graduate of Supelec and as an Oxonian Ph.D. in enterprises dominated by Normaliens and Polytechniciens (the CEA and the Collège). Abragam is much more revealing and introspective when he writes about his Russian upbringing and its legacy and when he discusses the influence of Pushkin and other Russian poets on his aesthetic life. The book has a different tone when he talks of his visits to Russia and Russian culture.

The most interesting part of *Time Reversal* is Abragam's description of his life before going to England and his seeming lack of accomplishment until he was well into his 30s. The fortuitous way he got to work with Pryce and into magnetism is astonishing. The story of late blooming is most refreshing. But the autobiography suffers from the fact that Abragam does not succeed in linking its various parts into a coherent whole. The last part of the biography is cluttered with irrelevant anecdotes about famous scientists.

Abragam admits that his various chapters are not "overflowing with the milk of human kindness" (p. 290). In places the book leaves one somewhat uncomfortable and reveals an apparent obsession with Nobel prizes, status, and hierarchies that is not unusual with eminent scientists but is not often expressed so openly in autobiographies. More important, one is left frustrated because important questions that Abragam could help answer are not addressed: What was the relationship between Abragam's work and what came before and after? What accounts for the success and impressive productivity of the postwar French scientific establishment, given its fragmented and impoverished prewar condition?

ALFRED REDFIELD
*Department of Biochemistry and Physics, Brandeis University, Waltham, MA 02154*
SILVAN SCHWEBER
*Department of Physics, Brandeis University, Waltham, MA 02154*

## Water and Global Warming

**Climate Change and U.S. Water Resources.** PAUL E. WAGGONER, Ed. Wiley-Interscience, New York, 1990. xvi, 496 pp., illus. $69. Wiley Series in Climate and the Biosphere.

Uncertainty makes all planners, managers, and engineers uneasy. To their credit, water resource professionals have, more than some, faced up to uncertainty. They have devised rules of thumb and statistical criteria that make it possible for them to deal with it systematically as they go about planning and building water supply systems, flood control projects, navigational waterway improvements, and so on. By using historical records in conjunction with such concepts as maximum probable flood, drought return period, safe yield, mass curves, and extreme event, the uncertainty inherent in natural phenomena like the hydrologic cycle can be quantified and handled in a consistent fashion. The uncertainty is not reduced, but neither is it ignored.

*Climate Change and U.S. Water Resources* is intended to capture the attention of the water resource community by calling into question not the concepts of uncertainty assessment but the reliance in their application on the assumption that the past is prologue. Its theme is that the future is not what it used to be and that climate change must be anticipated if water resource systems are to be managed effectively and planned wisely.

The book, the product of a panel of the Committee on Climate of the AAAS, takes as its starting point the consensus that warming will follow the continuing increase in the concentration of carbon dioxide and other heat-trapping gases. Specifically, the panel begins with the assumption that a doubling of carbon dioxide is likely to lead to an increase in the average global temperature of 2° to 5°C, an increase of 7 to 15 percent in precipitation, and a rise of 10 to 100 centimeters in sea level.

The first three papers set the stage. The initial paper reviews current and projected water use, assuming no climate change. The second reminds us of the limits of climate change predictions, and the third discusses problems of decision-making with imperfect information. For those concerned with policy, the most important observations are that previous water demand forecasts have been notoriously poor, even when not blurred by the prospect of climate change (Waggoner and Schefter); that a schism exists between atmospheric scientists who prefer to avoid making detailed forecasts and policy analysts who insist on high levels of resolution on a regional scale (Schneider *et al.*); and that the uncertainty associated with

the impact of global warming on the hydrologic cycle, combined with the nature of the water resources development process, requires more than "conventional expected value calculus" (Fiering and Matalas).

On the question of the climate-water resources relationship, Mearns *et al.* summarize both empirically based and simulation-based (general circulation model, or GCM) techniques for predicting climate change and include a critique of the latter. Other features of the climate-water resources relationship that are dealt with are precipitation, direct evaporation and evapotranspiration, including their relationship to surface water hydrology, water demand, soil moisture, regulation of flows, and, to a lesser extent, groundwater systems. The results are for the most part equivocal, which is not surprising given the warning by Mearns *et al.* that GCMs are unreliable at the regional scale (and for short time increments). The global models are simply not able to supply information that can be translated with ease and accuracy into rainfall and runoff forecasts at the river basin level. It is this section of the book that most clearly reveals the panel's predicament—how to present a compelling case for inclusion of global warming in water resources planning given these modeling limitations. The authors are cautious, and their caution serves them well.

The effects of changes in the hydrologic cycle on water resources are illustrated by examples involving floods and droughts, irrigation, water quality, recreation and wildlife, and urban water use. Some of the analyses suggest that impacts could be severe—extreme events becoming more likely, water supplies (particularly in the West) strained, and natural systems severely stressed. There are hints at other effects as well, some of which may be more important than direct ones. Cooper, for example, mentions wildfires, especially pertinent in view of the number of recent large fires in the West, all of which have affected watersheds, runoff, and water quality.

The final portion of the book moves from impacts to responses, offering a case study on hydroelectric power and institutional innovation, a discussion of the potential for markets to reallocate what may become a scarcer resource, and an assessment of where climate change fits, if at all, on the national political agenda.

All of the papers serve as the coda to a series of recommendations presented in the book's first section. The panel urges that GCMs be improved, that atmospheric scientists and water resource managers meet regularly, and that hydrologic data collection systems be expanded. It goes on to suggest that legal, technical, and economic procedures for evaluating, planning, and managing water resource systems be reevaluated in light of climate change, that government institutions become more flexible, and that water resource systems be managed over "problemsheds." There are also recommendations on interdisciplinary research, system design and vulnerability, water use efficiency, and public relations.

The appeal of their recommendations stems, in my opinion, more from common sense than from the panel's evidence and arguments. More important, the panel's audience—water resource professionals—may not eagerly embrace their recommendations. This seems especially likely in view of the profession's response to change in another arena. A large segment, if not all, of the water resource professionals resisted recommendations made roughly 20 years ago regarding the improvement of water quality. They lobbied against the passage of the Safe Water Drinking Act and the Federal Water Pollution Act (later called the Clean Water Act) and resisted their mandate after enactment. Their reaction to the current recommendations may be no different, particularly given Schwarz and Dillard's finding of a "wait and see" attitude toward climate change among urban water supply planners.

Though I support the panel's efforts, I do have some complaints. The first concerns an apparent bias toward physical solutions like water-supply and flood-control dams that supposedly increase system "resilience." Notwithstanding the inclusion of a paper on water markets (Frederick and Kneese), I think that the panel gave insufficient attention to other sorts of measures like flood plain planning and integrated system management. In the West, the area identified by Gleick as most vulnerable should warming lead to less runoff, most systems are already overbuilt.

My second complaint is one of form and organization—although the individual papers are clear, well crafted, and extensively cross-referenced by the editors, they do not, when taken as a whole, present an entirely coherent picture.

In all, I think Waggoner and his colleagues have contributed a worthwhile perspective. The issue of global climate change has produced its share of alarmist literature. This book is not of that genre. Rather, the papers in it are low-key, evenhanded, and thoughtful.

DANIEL F. LUECKE
*Environmental Defense Fund, Boulder, CO 80302*