Book Reviews

The National Hail Research Experiment

Hailstorms of the Central High Plains. CHARLES A. KNIGHT and PATRICK SQUIRES, Eds. Colorado Associated University Press, Boulder, 1982. In two volumes. Vol. 1, The National Hail Research Experiment. x, 282 pp., illus. $23.50. Vol. 2, Case Studies of the National Hail Research Experiment. xii, 246 pp., illus. $22.50.

This is an impressive book written mainly by participants in a major research program on hailstorms in northeastern Colorado. The objectives of the program, the National Hail Research Experiment, were (i) to investigate whether hail could be suppressed by methods inspired by (but not identical to) those practiced in the Soviet Union, for which great successes were claimed in the '60's and (ii) to provide improved understanding of the severe hailstorm by observation and analysis. This was not the intended order of the objectives, but the suppression tests, which were excessively tightly scheduled, prevailed over the more scientific aspects in the initial years 1972, '73, and '74. Although originally planned to last for a further two years, the tests were discontinued, since it had become clear that a demonstration of a significant success would not be possible; in plainer language, the conviction had emerged that the method tested did not work in Colorado, and indeed that it might in some cases augment rather than diminish hail. In fact, as storm types and structure had become better appreciated the original rationale of the method—identifying and then seeding the "accumulation zone" (of supercooled water) with silver iodide—had become untenable. In 1976, therefore, a major field program to seek basic information on the storms was conducted and the formulation of more promising suppression techniques was relegated to a lower priority.

NHRE (often nicknamed Henry) confirmed what most scientists had appreciated all along, namely how enormously complex large convective systems are when the interactions of all their aspects—such as inflow, updraft, and outflow, ambient winds and stability, cloud, precipitation, freezing, and evaporation—are considered. In the theory of hail suppression (and, in different contexts, of rain enhancement), most, and relatively too much, emphasis had been placed on the occasional shortage of freezing nuclei, without which water in the atmosphere cannot freeze. Such a shortage would lead to concentrations of supercooled drops among which hailstones can grow efficiently. Hence the provision of suitable artificial nuclei appeared to be a simple means of spoiling the natural growth process. As a result of the NHRE experience (and of comparable experience elsewhere), the crucial roles played by the interactions of the storm with the ambient atmosphere, the structure of the drafts, and the control of the condensed water by the drafts began to be more fully appreciated. This important return to a better balance and greater humility in the face of the complexity of the storm resulted in a complete redesign of NHRE and in its integration into the newly established Convective Storms Division of the National Center for Atmospheric Research. Incidentally, in 1981 CSD and the Bureau of Reclamation engaged in a major cooperative study of storms in Montana.

These preliminary remarks are necessary because the context of this work is an important clue to its value. They also allow me to celebrate an old pearl, namely that disciplined plans based on unrealistic expectation (here hail suppression by rockets à la Russe) can lead to important progress if the work is responsibly done and critically examined, and if the flexibility exists to change direction when appropriate. The scientists involved here, their directors, the late W. Swinbank, David Atlas, and Donald L. Veal, and fund administrators inside and outside NCAR had such flexibility. Though they could not achieve what they had set out to do, they produced results, challenges for further work, and a basis for future developments easily worth the considerable cost of the program, as these volumes demonstrate.

In particular, they buried the idea that our Soviet colleagues have an exportable technique for stopping hail. They enormously advanced our knowledge of storm structure, notably through the work of K. A. Browning and B. Foote, beyond the state to which the great studies of the Thunderstorm Project (in the '40's), the Canadian work in Alberta, and other major programs in Massachusetts, Illinois, South Dakota, Florida, and Oklahoma (to speak only of North America) had carried it.

They commissioned and helped develop and initiate the use of tools and techniques of unparalleled quality that may provide all the data we will eventually need. A short (and subjective) list of major accomplishments would include multiple Doppler radar (to obtain three-dimensional wind fields in echo regions), an armored aircraft suitable for local measurements inside the storm, a portable automated meso network (PAM) to provide half a dozen parameters at many surface locations, and techniques for the control of many aircraft engaged in the exploration of one storm. And they contributed in a major way to procedures for smooth cooperation in the field and subsequently in analysis by a dozen or so teams from separate institutions. All but the last two items on this list are described in the book.

Volume 1 covers the scientific aspects of the project and includes a chapter on the statistics of evaluating randomized suppression tests. (A much more complete analysis of the randomized hail suppression experiment mostly by the same writers appeared in nine articles in the *Journal of Applied Meteorology* in December 1979.) Volume 2 describes in considerable detail the storms that occurred on three days in June and July 1976, case studies that show the complexity of the material that must be dealt with.

The work is a very readable and carefully edited source book. The documentation is excellent, and references to more detailed partial studies in journals are quite complete. Though the product of 27 authors, the work has stylistic unity and is reasonably well cross-referenced. But it remains a collection of 23 chapters, each the equivalent of a major journal article. There is no index and no overall scientific summary. We thus do not have a definitive text on hailstorms, only careful and considered statements on their many aspects—surroundings, drafts, microphysics, thermodynamics, clouds, precipitation, and glaciation—and on techniques for measurement and numerical models.

Readers will regret this lack of integration, but I do not see how much more

could have been done with the information available to 1976. The storms are still too complex for us. The data, though they are sometimes spotty, are too plentiful to be fully assimilated, and the instrumental constraints are too severe. It would be foolhardy to say that these difficulties will soon be overcome (that's what some believed in the '50's), and yet it may not be too much to hope that the means of measuring all the parameters have become available, in no small part thanks to this experiment. Then, the tough imagination may emerge to go after the important data and with them to construct a quantitative taxonomy and mechanism of the major storm types.

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Geophysical Fluid Dynamics

Atmosphere-Ocean Dynamics. ADRIAN E. GILL. Academic Press, New York, 1982. xviii, 664 pp., illus. Cloth, $60; paper, $30. International Geophysics Series, vol. 30.

The economic and social impacts of the floods, droughts, and severe winters of the past decade have generated unprecedented demands for the development of useful weather and climate forecasts on monthly and seasonal time scales. Unfortunately, rapid mixing by transient weather systems appears to cause the atmosphere to lose all memory of its initial state after only a few weeks, suggesting that prospects for seasonal forecasting may be bleak.

Recently, however, meteorologists and oceanographers have found evidence suggesting that a small portion of the observed interannual climate variability in the Northern Hemisphere is associated with surface temperature anomalies in the equatorial Pacific, which are themselves excited by atmospheric motions. Apparently the oceans, with their huge thermal inertia, provide a means by which the climate system can retain some memory on seasonal and interannual time scales. Developing an understanding of the complex coupling between the atmosphere and oceans suggested by such observations will require the close collaboration of dynamic meteorologists and oceanographers. Such efforts appear to represent the only reasonable hope for climate forecasting.

Despite the scientific importance of treating the atmosphere and oceans as a coupled system, until recently no books presenting a unified treatment of atmosphere-ocean dynamics have been available. This is perhaps surprising since, contrary to superficial appearances, the dynamical processes governing the motions in the two fluids are virtually identical. The atmosphere and oceans are merely special cases of so-called "geophysical" fluids in which density stratification and rotation control the dominant motions.

The first attempt at a unified treatment of this subject was Joseph Pedlosky's *Geophysical Fluid Dynamics* (Springer-Verlag, 1979). Pedlosky's book provides an excellent systematic introduction to the theory of geophysical fluid dynamics, but with only minimal reference to observations. Gill's *Atmosphere-Ocean Dynamics*, by contrast, offers a wealth of information on observed phenomena in the atmosphere and the oceans, while still providing a carefully developed introduction to the fundamental dynamical theory, albeit with less rigor than Pedlosky's book.

The first several chapters of Gill's book cover the basic thermodynamics and fluid dynamics needed for analysis of atmospheric and oceanic motions. In subsequent chapters these concepts are further developed and applied to the study of forced motions, motions influenced by lateral boundaries, equatorial motions, midlatitude motions, and instabilities. Throughout the book Gill emphasizes the ubiquitous nature of waves in the atmosphere and oceans. Many novel linear wave solutions are presented to elucidate observed phenomena. Special emphasis is given to the equatorial regions, where, as indicated above, the large-scale interactions between the atmosphere and oceans may play a special role in climate variability.

The treatment is at a level suitable for introductory graduate courses in dynamic meteorology and dynamic oceanography. But the book will probably find its widest use as a reference work for professional meteorologists and oceanographers. The breadth of coverage, the strong emphasis on observational aspects, the comprehensive bibliography of recent literature, and the catalogue of data sources provided all make this book a treasure for the active researcher. The author's efforts to highlight critical historical developments in the subject are also to be applauded.

Atmosphere-Ocean Dynamics, with its clear focus on the application of dynamical principles to observed motion systems in the atmosphere and the oceans, should become the standard reference for oceanographers who wish to learn about the atmosphere and meteorologists who wish to learn about the oceans. The dynamics of these two geophysical fluids can no longer be treated in isolation. In providing a unified treatment, Gill has performed a vital service for the community.

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Social Medicine: Early Efforts

Death Is a Social Disease. Public Health and Political Economy in Early Industrial France. WILLIAM COLEMAN. University of Wisconsin Press, Madison, 1982. xxii, 324 pp., illus. $35. Wisconsin Publications in the History of Science and Medicine, no. 1.

"I have adopted throughout this work a subdued tone, one that is best suited, I believe, to portraying the central drama of this story, namely, the persistence of the discord between what one science, sociomedical investigation, presumed to teach and the action that another science, political economy, refused to countenance." In his introduction the author thus describes his approach and his organizing idea. His subject in the broadest sense is the relation between the empirical studies a society undertook of itself and its dominant values or ideology. At issue is research on health and human welfare undertaken in France during the years 1820 to 1850, years in which France experienced the first unsettling effects of the industrial revolution. Although Louis René Villermé, the leading sociomedical investigator in France in these decades, provides its focus, this book is not a biography; it is, rather, a case study of the emergence of the empirical study of the well-being of people in industrial society.

Coleman ably discusses both the nature of Villermé's research and the social and scientific notions he brought to it. The first third of the text considers the circumstances surrounding the work of this ardent investigator. Both the process and the economic and social consequences of early French industrialization are considered, as is the intellectual heritage of contemporaries who sought to investigate the human cost of such change. In the realm of ideas we are introduced to the skeptical and empirical tradition of Paris clinical medicine and to the legacy of French sensationalist psy-