INVENTING ATMOSPHERIC SCIENCE: BJERKNES, ROSSBY, WEXLER, AND THE FOUNDATIONS OF MODERN METEOROLOGY

Is science “invented,” or “discovered”? When it comes to today’s very wide field of atmospheric science—including, at least in part, disciplines as diverse as space weather and ocean chemistry—there is at least some justification in the former term. In this engaging volume, James Fleming sets out his case, starting with a 19-year-old Vilhelm Bjerknes (1862–1951) visiting the International Electrical Exposition in Paris in July 1881 with his father, Professor Carl Anton Bjerknes. The story progresses briskly through Vilhelm Bjerknes’s early work on hydrodynamics, his progression from ideal fluids to real fluids including the atmosphere and ocean, to his setting out in Meteorologische Zeitschrift in 1902 a method of calculating the future state of the weather based upon sound hydrodynamic and thermodynamic principles. It was not all theory, of course, and Fleming describes the establishment of the “Bergen forecasting school” in 1917, founded initially to ensure Norway was able to feed its people during the long years of World War I by providing improved short-term forecasts for the country’s vital agricultural and fishing sectors. The relatively dense observing network it established led remarkably quickly to development of the “polar front model,” set out in Vilhelm’s son Jacob Bjerknes’s classic 1919 paper “On the Structure of Moving Cyclones.” Of course, we largely take such conceptual models for granted today, but Fleming’s research describes contemporary rival theories and their progenitors in some detail; it took two decades of sometimes heated resistance and conservatism for the Bergen methods of airmass and frontal analysis to become accepted practice in both the United Kingdom and the United States.

Carl-Gustav Rossby (1898–1957) was a student of Vilhelm Bjerknes, and Harry Wexler (1911–1962) was a student of Rossby’s: these personal links form the basis for the structure of the book, which then examines the careers and many achievements of Rossby and Wexler in turn. These are told through both published and anecdotal accounts: a major strength of the book is its reference throughout to original material, including archival and family sources, many of which appear in print for the first time. Fleming’s judicious use of letters and other close personal sources add a human dimension to the story of the principal characters in this book: memorable examples include the references to Rossby as “the centre of a moving seminar” (p. 93); the Bjerknes’s setting up of a small weather station on the deck of the RMS Caronia on a transatlantic voyage in July 1924, and their “entertaining the passengers with daily forecasts” (p. 59); and the recollections of Wexler’s daughter Susan on her father’s fitting in family life around a very full international career at the forefront of the science for three decades until his untimely death from overwork in 1962 (pp. 188–192). Although verging on the hagiographic at times, and with some repetition in places, Fleming maintains a good balance between facts and readability—both text and structure are vibrant, while the excellent index and almost 60 pages of bibliography and references offer ample scope for following up on any points of detail.

I have only two minor criticisms of the book. The first concerns the dismissive treatment of Richardson’s early attempts at numerical weather prediction in 1922 (pp. 64–65 and p. 116); of course, such criticisms of pioneers are always easy with the benefit of hindsight. My second comment relates to the small size at which some of the artwork has been reproduced, making it difficult to pick out detail on some figures.

Fleming’s narrative makes clear that, since the basic science problem was formulated a little over a century ago, rapid progress has been achieved not
only by the application of advances in theory and technology—including radio, then radiosondes and radar, and eventually computers and satellites—but by inspiration, leadership, and people skills. Enduring structures of learning and operational practice were established that integrated those advances into practical and workable systems and methods, and in doing so applied the “invention of atmospheric science” for the enormous benefit of humanity. This book offers a very readable account of those advances in the first half of the twentieth century through the lives of three leading scientists who were perhaps fortunate to be “in the right place at the right time.” It should appeal to a wide audience, particularly to young early-career scientists and historians of science, and I recommend it without hesitation.

—Stephen Burt

Stephen Burt is with the Department of Meteorology at the University of Reading, United Kingdom.


American Atmospheric Science circa 1950s

Detlev Bronk, president of the prestigious National Academy of Sciences National Research Council (NRC), created the Academy’s Committee on Meteorology (COM) in 1956. He did this after Louis S. Rothschild, Undersecretary of Commerce for Transportation, asked him for assistance in helping the U.S. Weather Bureau (USWB) “vitalize” the science. Although created prior to Sputnik, COM found itself energized by IGY and the events following the launch of the first artificial satellite. This committee also had an important effect on Boulder’s development as a city of atmospheric science knowledge and Roberts’s career as a scientific administrator. Why did Undersecretary Rothschild feel the need to make this request of Bronk?

Atmospheric science, maturing a great deal as a scientific discipline in WWII, still had significant issues facing it in the early and mid-1950s. Some historians note that meteorology had established itself as a serious academic discipline by 1950, especially by its use in WWII. Harper correctly points out that meteorology established itself as a true scientific discipline by the demands of WWII. But the strong operational and forecasting focus of the war years left significant gaps in its development as a serious, cutting-edge scientific discipline. Concerns about filling these gaps drove much atmospheric science development in the 1950s.

As a result of these perceived gaps, there still existed in the early and mid-1950s a widespread feeling among atmospheric scientists that the discipline needed to develop further. They had concerns that their field was not yet a fully developed modern scientific discipline on par with other physics-based sciences, such as nuclear research or astrophysics. Among problems often cited by those concerned were the development of significant theoretically sophisticated research problems and methods. Atmospheric modeling using advanced mathematical techniques was still only in its infancy in the early 1950s. Another, but related, concern expressed frequently centered on the lack of adequately trained personnel going into the science—many thought the best students went into more traditional physics precisely because of the perceived theoretical backwardness of the discipline. Much of this angst focused on, and resided in, the U.S. Weather Bureau. This resulted in Rothschild’s plea to Bronk for help.

Although not formally a part of the U.S. IGY effort, COM shared with USNC an institutional home at the National Academy of Sciences. A number of its original members had played important roles either directly or indirectly in IGY. Not the least of this group was the ubiquitous and influential U.S. entrepreneur of science, Lloyd Berkner. Bronk, somewhat tongue-in-cheek, wrote on his friend...
atmospheric science pioneer Vilhelm Bjerknes, served as atmospheric science and a gifted student of Norwegian Carl Rossby, one of the creators of modern American meteorologist, his freedom of action was “uninhibited.” He stated upon acceptance that, as he was not a “surprise,” the chairmanship of the committee. He only dealt with the lower atmosphere indirectly via radio propagation. He therefore had little scientific overlap with the bulk of atmospheric scientists. All shared in the widespread opinion that in many ways American meteorology was theoretically lacking. As a result, these scientific heavies were willing to participate in the committee’s deliberations and help provide this “cross-fertilization.”

This desire for an interdisciplinary approach to invigorate the atmospheric sciences dovetailed nicely with solar astronomer Roberts’s views on the best way to tackle the questions of the sun—earth connection. This confluence of Roberts’s growing interests in the atmospheric aspect of sun—earth science and the strong desires of those in meteorology to reach beyond the discipline helps explain how non-meteorologist Roberts became a major voice in the development of U.S. atmospheric science.

Berkner was an outsider to the world of atmospheric science and meteorology, for his research focused on the extreme upper reaches of the earth’s atmosphere. He only dealt with the lower atmosphere indirectly via his interest in radio propagation. He therefore had little scientific overlap with the bulk of atmospheric scientists. These researchers mostly thought about much lower regions of earth’s atmosphere (and how to forecast weather). But, as was the case with Roberts, his strong interdisciplinary interests and entrepreneurial skills enabled him to play a major role in the development of atmospheric science.

Berkner accepted not only membership but also, “with surprise,” the chairmanship of the committee. He stated upon acceptance that, as he was not a meteorologist, his freedom of action was “uninhibited.” Carl Rossby, one of the creators of modern American atmospheric science and a gifted student of Norwegian atmospheric science pioneer Vilhelm Bjerknes, served as co-chair. Rossby’s presence ensured there was a strong meteorological presence on the diverse committee from the beginning. The group took a broad view of their charter to advise USWB. They plunged into issues well beyond immediate concerns of their weather bureau sponsors. Rather than simply focus on the limited USWB concerns on how to forecast weather better and improve their staff’s scientific abilities, COM wanted to investigate the entire state of the discipline, including the widespread perceived woes of the field discussed previously. As the NAS committee set about its deliberations, there was another important element of U.S. science policy entering into the world of U.S. atmospheric science occurring across town in Washington.

The NSF and the Control of Weather

The National Science Foundation was the other D.C.-based organization that affected Boulder’s development. This occurred in the late 1950s when the agency decided to fund not just atmospheric research, but the study of weather control itself. This interest led to NSF funding HAO with small amounts of support in the earlier 1950s, including cosponsoring (with the American Meteorological Society) the summer seminar in sun–weather research at Roberts’s Institute for Solar Terrestrial Research in 1956. The true significance of NSF funding for Roberts did not come via support of HAO directly. Rather, it came from the NSF’s decision to get into the atmospheric science world in a major way via weather control research.

The impetus for this action came as a result of the “Orville report,” generated late 1957 by a congressionally directed study of the possibility of weather control and climate modification beginning in 1953. This led to the increased NSF effort in atmospheric sciences. The move was part of the foundation’s overall attempt to transition from the funding of small-scale efforts in the early 1950s to expanding into bigger science later in the decade.

This important turn of NSF toward the development of U.S. atmospheric science is not featured in some of the standard histories of the foundation, despite the importance of this move for both U.S. atmospheric science and the foundation itself. Perhaps NSF’s other work in the late 1950s, for example, its efforts on the large national astronomical observatories, overshadowed its support of the development of U.S. meteorology.

Weather modification ranked as an important national concern in the postwar era because of its perceived implications for the nation’s security and
commerce. Some argued that weather, if controllable, could serve as a weapon during hostilities. Those with interests in agriculture thought weather modification was a possible solution to the age-old problem of inconsistent rains and occasional droughts. Given this broad interest, there were many in the postwar years that thought weather modification a desirable thing to achieve. There were also a few scientists who claimed to know how to achieve it (at least to some degree).

In the late 1940s and early 1950s, a number of researchers engaged in radically different scientific approaches to the problem of weather modification. Among them included Nobel Laureate physicist Irving Langmuir of General Electric and high-profile private weather consultant Irving Krick.

Both these men began making extravagant claims relating to the efficacy of their methods on forecasting and rainmaking. These claims and counter-claims pitted many involved against one another. All of the proponents pitted themselves against a dubious and seemingly hapless U.S. Weather Bureau that could not confirm (or disprove) these claims to the American public. Irrespective of the weather control controversy, personnel at the USWB mainly wanted to concentrate on forecasting the weather more accurately.

The weather modification controversy reached a fever pitch in the nation. Richard D. Searles, Under Secretary of the Interior, even accused the U.S. Weather Bureau of “ineptitude” in addressing this whole “rainmaking” issue produced in the nation by these claims and counterclaims of weather modification proponents in 1952. Strong contention over methods, advocates versus skeptics, and legal issues arising from perceived damages resulting from the weather modification attempts served to create turmoil in U.S. meteorology. The USWB bore the brunt of the outcry. Spurred on by this highly visible controversy, and interested in the potential applications of weather modification both for agriculture and as a weapon, Senator Francis Case of South Dakota decided to do something about the situation. Case, apparently a weather buff himself, created and worked to pass a bill in 1953 that established a high-level committee to study issues of weather control and the general state of U.S. meteorology. Called the Advisory Committee on Weather Control (ACWC), officials selected meteorologist Howard T. Orville as its chairmanship. ACWC submitted its summary document, “the Orville report,” to Congress in December 1957 and concluded its work.

Among the conclusions rendered in the report, ACWC suggested that the nation needed to do much more fundamental atmospheric research in order to better understand the possibilities, if any, of weather control. Another key recommendation related to the need for the production of more research.
meteorologists and atmospheric scientists. Both these conclusions resonated with the COM report, then not yet finalized. Perhaps the most consequential of the recommendations for all involved related to NSF. The report suggested NSF assume leadership in providing resources to accomplish these recommendations. This recommendation in essence put NSF in charge of coordinating U.S. weather control efforts, including broad areas of basic atmospheric science research.

The Move toward a National Institute for Atmospheric Research
The exact manner through which NSF entered atmospheric science originated at the National Academy of Sciences. The NAS Committee on Meteorology, just about the same time as the release of the Orville report, produced its own summary of the state of U.S. meteorology. Released by the NAS in February 1958, the “Interim Report of the National Academy of Sciences Committee on Meteorology” made specific recommendations on increased funding and manpower requirements. The report also outlined the urgent need for a National Institute of Atmospheric Research (NIAR) to assist in the vitalization of atmospheric science. The NIAR’s primary purpose was to augment the research done by university atmospheric science departments.

COM acted to advance the recommendations of its own report. Committee members, motivated by internal disciplinary concerns, focused on the need to encourage more (and better) research scientists into meteorology. Other motivations included external factors such as a fear that the USSR had developed a much better weather forecasting ability than the United States, creating a “forecast gap.” This “gap” was the meteorological equivalent of the other perceived gaps in the American consciousness engendered by Sputnik in the United States—missile, space, education, etc. The real issue driving this gap phobia was the widespread idea that America had to be the world’s leader in everything scientific. In yet another scientific area, it appeared the U.S. lagged behind the Soviet Union—ominously so, as better weather forecasting might lead to better crop yields, military operations, and the like. As with other gaps, many in the nation expressed the opinion that the situation needed immediate high-level national attention. Atmospheric scientists and others involved with the COM eagerly gave it this attention.

COM met on January 31, 1958, in Berkner’s offices in New York City with members of the wider community of atmospheric science, including universities and USWB. Brookhaven’s lab director, Leland Hayworth, gave a presentation on the management structure of AUI and Brookhaven to the group. Most likely Berkner, president of AUI, which ran the lab, arranged for him to speak to the atmospheric scientists.
CLIMATE

The Thinking Person’s Guide to Climate Change

ROBERT HENSON

This fully updated and expanded revision of The Rough Guide to Climate Change combines years of data with recent research. It is the most comprehensive overview of climate science, acknowledging controversies but standing strong in its stance that the climate is changing—and something needs to be done.


Climate Conundrums: What the Climate Debate Reveals about Us

WILLIAM B. GAIL

This is a journey through how we think, individually and collectively, about humanity’s relationship with nature, and more. Can we make nature better? Could science and religion reconcile? Gail’s insights on such issues help us better understand who we are and find a way forward.


Living on the Real World: How Thinking and Acting Like Meteorologists Will Help Save the Planet

WILLIAM H. HOOKE

Meteorologists focus on small bits of information while using frequent collaboration to make decisions. With climate change a reality, William H. Hooke suggests we look to the way meteorologists operate as a model for how we can solve the 21st century’s most urgent environmental problems.


GUIDES


TOBY CARLSON, PAUL KNIGHT, AND CELIA WYCKOFF

With help from Penn State experts, start at the beginning and go deep. This primer, intended for both serious enthusiasts and new meteorology students, will leave you with both refined observation skills and an understanding of the complex science behind the weather: the ingredients for making reliable predictions of your own. It connects fundamental meteorological concepts with the processes that shape weather patterns, and will make an expert of any dedicated reader.


Eloquent Science: A Practical Guide to Becoming a Better Writer, Speaker, and Atmospheric Scientist

DAVID M. SCHULTZ

The ultimate communications manual for undergraduate and graduate students as well as researchers in the atmospheric sciences and their intersecting disciplines.


TEXTBOOK

Midlatitude Synoptic Meteorology: Dynamics, Analysis, and Forecasting

GARY LACKMANN

This textbook links theoretical concepts to modern technology, facilitating meaningful application of concepts, theories, and techniques using real data.

©2011, PAPERBACK, 360 PAGES, ISBN 978-1-878220-10-3 LIST $100 MEMBER $75 STUDENT MEMB. $65

Midlatitude Synoptic Meteorology Teaching CD

More than 1,000 PowerPoint Slides.

© 2013, CD, ISBN 978-1-878220-27-1 LIST $100 MEMBER $75

To order: bookstore.ametsoc.org, 617-226-3998, or use the order form in this magazine
Eyewitness: Evolution of the Atmospheric Sciences describes how the atmospheric sciences were transformed in the span of the author’s professional career from its origins in primitive weather forecasting to its current focus on numerical modeling of environmental change. It describes the author’s observations of persons, events, and institutions beginning with graduate study during the Second World War and moving on to continuing expansion of the atmospheric sciences and technologies, through development of a major university department, development of new scientific and professional institutions, and to the role that the science of the atmosphere now plays in climate change and other issues of social and political policy.

**Eyewitness: Evolution of the Atmospheric Sciences**
Order online: www.ametsoc.org/amsbookstore or see the order form at the back of this issue.

**About the Author**
Robert G. Fleagle earned degrees in physics and meteorology at The Johns Hopkins University and New York University and began his professional career in 1948 at the University of Washington (UW). His research has focused on the structure of midlatitude cyclones, the physics and structure of the surface boundary layer, and processes of air–sea interaction. He is the author of about 100 papers published in scientific journals and of books on atmospheric physics and global environmental change. Applications of science to social and political policy have been important motivations for his career and have occupied his attention increasingly as the decades passed.

Fleagle participated at close range in the beginnings and growth of a major university department and of the University Corporation for Atmospheric Research (UCAR). In 1963 and 1964 he served as a staff specialist in the Office of Science and Technology, Executive Office of the President, and in 1977–78 he served as consultant to the National Oceanic and Atmospheric Administration. He has held many administrative posts including chairman of the UW Department of Atmospheric Sciences (1967–77), chairman of the National Academy of Sciences Committee on Atmospheric Sciences (1969–73),