NATIONAL ACADEMY OF SCIENCES

HORACE ROBERT BYERS
1906–1998

A Biographical Memoir by

ROSCOE R. BRAHAM, JR., AND
THOMAS F. MALONE

Biographical Memoirs, VOLUME 79

PUBLISHED 2001 BY
THE NATIONAL ACADEMY PRESS
WASHINGTON, D.C.

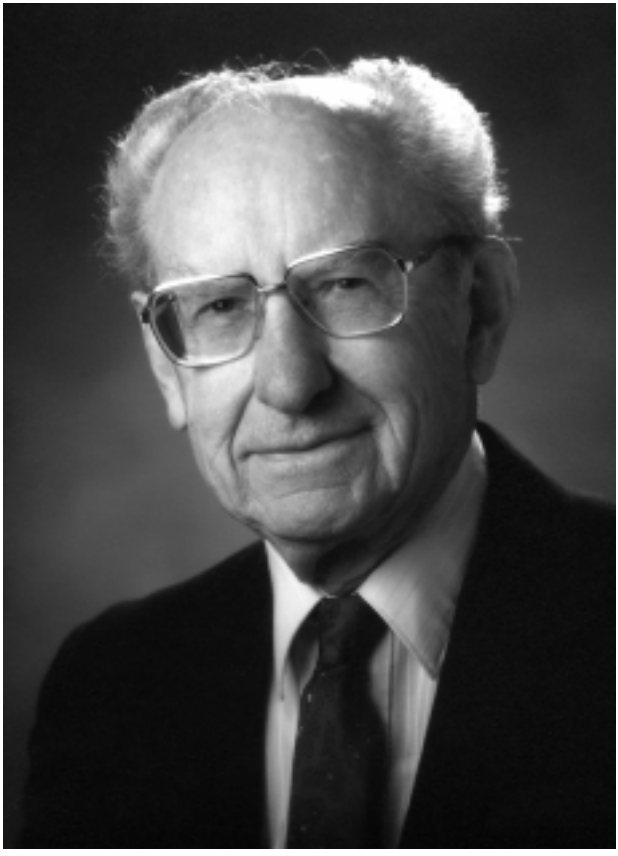

Photo by Alex Jauregd

Horace R. Byers

HORACE ROBERT BYERS

March 12, 1906–May 22, 1998

BY ROSCOE R. BRAHAM, JR., AND
THOMAS F. MALONE

HORACE ROBERT BYERS was a pioneer in aviation meteorology, synoptic weather analysis, severe storms, cloud physics, and weather modification—an educator, an organizer and communicator for meteorology, a scientist, author of one of the most widely used textbooks in meteorology, a university administrator, and a quietly effective scientific statesman. The hallmark of his scientific career was his ability to organize groups and activities for meteorological research and his ability to identify and provide opportunities for developing scientists with whom many of his papers were co-authored. During his long career at the University of Chicago, Professor Byers taught and helped to supervise the training of a large number of Ph.D. students, many of whom became distinguished leaders in meteorology. The pinnacle of his scientific career, and the thing for which he is most noted, came with the Thunderstorm Project, the first comprehensive investigation of the turbulence and vigorous vertical motions inside thunderstorms.

EARLY YEARS

Horace R. Byers was a son of Charles H. and Harriet (Ensminger) Byers with ancestral lines back to the early

colonial period in Pennsylvania. His parents met and married in Kansas City. His father was a civil engineer employed in constructing new lines as the railroad system advanced westward. As a consequence of this employment, the family migrated westward, ending up on the West Coast.

H orace R. Byers was in born in Seattle on March 12, 1906. He had an older brother, Fred, a younger sister, Louise, and a younger brother, Lyle. When he was nine years old, his father accepted a position in San Francisco as assistant chief engineer, western district, of the Interstate Commerce Commission's Bureau of Valuation, and the family moved to Berkeley, California. Here Horace grew up and went to college. He described this period in autobiographical statements on file at the National Academy of Sciences, from which we quote the following:

> My mother had an artistic bent, painted, and [was] also quite musical as an amateur pianist and singer, while my father was almost a caricature of the practical-minded engineer. . . Our home had a cultural atmosphere, with many books. . . My mother sponsored musical evenings in our home where accomplished Berkeley musicians performed for up to fifty guests. . . .
>
> In high school I developed a passionate interest in journalism, became editor of the school paper and had a summer job as a reporter [of] high school activities for the Berkeley Daily Gazette. . . Upon graduation I took a job as a newspaper reporter and worked full time for a year before entering the University of California, after which I worked part-time at this job, advancing to reportorial positions on various newspapers of the San Francisco Bay region.

In the geography department at the University of California, Berkeley, he became acquainted with the world of science and decided to make meteorology his life work. His mentors were Richard J. Russell, a physical geographer, and John B. Leighly, a climatologist. While an undergraduate,

Byers was appointed meteorological observer at the university. His twice-daily observations were published by the geography department in a monthly bulletin over his name. This bulletin was distributed to several places, including the Port of Oakland, which had jurisdiction over the Oakland airport.

BYERS MEETS ROSSBY

In the spring of 1928, his junior year, Byers received a call from the chief engineer of the Port of Oakland stating that a representative of the Daniel Guggenheim Fund for the Promotion of Aeronautics was looking for a meteorological assistant to help operate an experimental "airway weather service" to assist a fledgling airline operating between the Oakland airport and Vail Field, near Los Angeles. The airline would later become Transcontinental and Western Airways, Inc. (TWA). The Guggenheim representative was Carl-Gustaf Arvid Rossby.[1] This was the beginning of a long and fruitful association between these two men. It would be hard to overestimate the impact this association had on subsequent developments in meteorology. Later that summer, operation of the experimental airway weather service was turned over to the U.S. Weather Bureau. Byers returned to school and Rossby departed to head a new meteorology program in the Department of Aeronautical Engineering at the Massachusetts Institute of Technology.

After graduation from Berkeley in 1929 with an A.B. degree in geography, Byers received a fellowship from the Daniel Guggenheim Fund to attend MIT, where he studied meteorology under Rossby and Hurd C. Willett. When he completed his M.S. degree in 1932 the country was in a serious economic depression and jobs in meteorology were scarce. Byers returned to California as a research assistant at the Scripps Institution of Oceanography. This was followed by a period at TWA, where he instructed flight crews and other

company personnel in the new concepts of weather fronts and air masses. These classes were held in Kansas City, Newark, New Jersey, and Glendale, California. His lecture notes formed the basis for his first textbook, *Synoptic and Aeronautical Meteorology*, published in 1937.

In the meantime, General Motors had acquired TWA, and Byers became eligible for the Alfred P. Sloan Fellowship in meteorology at MIT. With this financial assistance he returned to MIT in 1934 and obtained his Sc.D. degree in 1935. His thesis was entitled "The Changes in Air Masses During Lifting." Upon completion of the Sc.D. degree, he was appointed to the U.S. Weather Bureau as an associate meteorologist and was placed in charge of the newly created Air Mass Analysis Section with responsibility for developing new methods of weather forecasting. This period has been described as one of great change and reorientation in the U.S. Weather Bureau. The polar front theory of weather disturbances, developed by Vilhelm Bjerknes and colleagues at the Bergen Geophysical Institute, Bergen, Norway, was just coming into use by the Weather Bureau in the analysis of weather observations and making of weather forecasts.

In 1935 the Weather Bureau instituted a program whereby employees were brought into the Washington, D.C., central office in small groups for two months of training and practice in air mass analysis and the use of frontal maps in forecasting. As head of the Air Mass Section, Byers was in the forefront of this activity. The Weather Bureau's in-house training program continued to expand, and by 1940 plans were underway for five such units (Chicago, Washington, New Orleans, Denver, and San Francisco). Byers volunteered to head up the unit in the Chicago District Forecast Office on the top floor of the old post office building in downtown Chicago.

BYERS AT THE UNIVERSITY OF CHICAGO

At the University of Chicago, Byers's career flowered. In the fall of 1940 he persuaded the university to set up an Institute of Meteorology in the physics department (with financial support from Sewell Avery, chief executive officer of Montgomery Ward Co.).[2] This event took advantage of the launching of programs at several universities to train meteorologists for the U.S. Navy and Army Air Corps. Rossby was designated head of the Chicago program, but responsibility for most of its operations fell to Byers. "He was the balance wheel in the administration of one of the greatest meteorology programs the world has ever known; a spirited, if at times unruly, department energized in its early days by the creative genius of Carl Rossby. The low profile he played in that milieu prevented widespread recognition…." (H. R. Simpson, e-mail message, August 8, 1998). The institute evolved into a separate Department of Meteorology. Byers was appointed associate professor (1940-45), professor (1945-65), and department chairman (1948-60). In 1944 he published his textbook *General Meteorology*, which subsequently went through several editions.

During World War II and the early postwar years, Byers served as a consultant to several government agencies, including the Department of Defense, Atomic Energy Commission Manhattan Project, National Science Foundation, and to the Illinois State Water Survey and University of Arizona.

In 1960 the Departments of Meteorology and Geology at Chicago joined to form the Department of Geophysical Sciences. Professor Sverre Petterssen (from meteorology) and Professor Julian R. Goldsmith (from geology) were designated co-chairmen. This opened the possibility for a new career for Byers, who by now was ready for a change. In 1965 he left the University of Chicago to assume duties

as dean of a newly formed College of Geosciences at Texas A&M University, with the added title of distinguished professor of meteorology. In 1968 he was appointed academic vice-president. In 1974 he retired and moved into a retirement center near Santa Barbara, California. In 1975 Byers was a visiting professor at the University of Clermont-Ferrand, where he taught cloud physics, lecturing in French.

BYERS THE ORGANIZER AND COMMUNICATOR FOR METEOROLOGY

The remarkable influence of Horace R. Byers in meteorology came in part from his unusual blend of skills. He was an excellent writer and communicator, possibly a result of his early training in journalism. He had great skill in recognizing promising young investigators and in assisting them to accomplish their goals. He was also skilled in marshaling support and galvanizing action in the meteorological community. As a member of the National Academy of Sciences rather early in his career, he was in a position of influence beyond the reach of many others.

Over a period of years, Byers served in leadership roles in several scientific organizations worldwide. He joined the American Meteorological Society in 1929, and was elected to its council (1938-50) and to its presidency (1951-53). He joined the American Geophysical Union, Section on Meteorology, in 1935, and served as section vice-president (1944-47) and president (1947-50). He was elected to the National Academy of Sciences in 1952, and served as chairman of the Section on Geophysics (1966-69). From 1954 to 1960 he served as vice-president of the International Association of Meteorology and Atmospheric Physics, where he contributed to the famed International Geophysical Year. He served as president of the IAMAP from 1960 through 1963. He was a member of the Subcommittee on Meteorological Problems, National Advisory Committee for Aeronautics (now NASA),

and the National Research Council's Committee on Meteorology (1956-59).

One of his important contributions was the role he played in the formation and guidance through its early years of the National Center for Atmospheric Research / University Corporation for Atmospheric Research.[3] In early 1956, Detlev W. Bronk, president of the National Academy of Sciences, appointed a committee of the National Research Council to "consider and recommend means by which to increase our understanding and control of the atmosphere . . . ." This Committee on Meteorology, organized in April 1956, consisted of Lloyd V. Berkner and Carl G. Rossby (co-chairmen), Horace R. Byers, Henry G. Booker, Hugh L. Dryden, Carl Eckhart, Paul E. Klopsteg, Thomas F. Malone, John von Neumann, and Edward Teller. Early in the work of the committee, Rossby died, and Jule Charney was appointed to membership. Byers was appointed vice-chairman. The committee was charged with viewing "in broad perspective the present position and future requirements of meteorological research." Byers chaired a working group on education; Charney and Malone co-chaired a working group on research.

A major recommendation from the education group was for the universities to form an inter-university committee to review the needs and problems of meteorological research. This recommendation matched with that of the research group that proposed the establishment of a national institute for atmospheric research organized by a group of universities under a prime contract with the National Science Foundation. In retrospect, the involvement of the NSF turned out to be crucial to the phenomenal progress in meteorology during the past several decades. Byers's distinctive contribution, after the release of the report, was to pick up the telephone and call Henry Houghton at MIT and urge him

to take the leadership in acting on the recommendation for a University Committee on Atmospheric Research (UCAR). Byers's telephone call was one of the most important telephone calls on a meteorological matter in the last 50 years. Throughout the early years of UCAR, Byers was involved in the governance of UCAR and the National Center for Atmospheric Research, serving on its Board of Trustees and as board chairman (1962-65).

Less well known, was his role in the initiation of the sequence of international programs in meteorology that ultimately led to the massive World Climate Research Program in the final years of the twentieth century. On an airplane journey to Australia for a conference to review E. G. Bowen's precipitation enhancement program in the Snowy Mountains of Australia, Malone (who had just come from a meeting at the White House to discuss the possibility that President Kennedy might include a proposal for a global initiative in an address to the United Nations) and Byers had a long conversation concerning the scientific merits of such an initiative. His strong endorsement of the initiative and his insistence that it have firm roots in the broad, non-governmental, scientific community carried great weight with Malone. A year after President Kennedy made that proposal, the United Nations invited the non-governmental International Council of Scientific Unions (ICSU) to participate in drawing up this program. Again in the summer of 1963, Byers and Malone traveled together by plane (in the Travelers corporate aircraft) to Toronto to urge Warren Godson (secretary general of the International Association of Meteorology and Atmospheric Physics) to involve all of ICSU in planning the proposed program. The mission was not successful, but at an international conference in Los Angeles in September, Byers's views became a highly successful, joint activity of the governmental and non-governmental sectors

and established a kind of partnership that has served the world well—thanks in no small part to the wisdom of Horace Byers.

Byers also played an important role in the formation of the Institute of Atmospheric Sciences (later a department) at the University of Arizona. This came about in an interesting way. In 1953 Lew Douglas, a prominent citizen of Arizona, proposed that the University of Arizona set up a cloud-seeding research group, using funds contributed by local ranchers. The head of an eminent private sector cloud-seeding company was identified to direct the effort. Douglas came to Byers for advice. Professor Byers thought that it would be tragic for the University of Arizona to set up the group under those conditions. Instead, he negotiated an arrangement whereby a research colleague, Roscoe R. Braham, Jr., became the founding director of the institute in Tucson, under a joint appointment between the two universities. Byers continued to serve as an advisor to the Arizona group after Braham returned full time to Chicago.

BYERS THE SCIENTIST

During his senior year at the University of California, Professor Leighly persuaded Byers to write a paper on the summer sea fogs of the California coast. This paper, published as a bulletin of the University of California, Berkeley, was his first published scientific paper. The scientific publications of Horace Robert Byers are mainly in three areas: general meteorology, thunderstorms and severe weather, and cloud physics. Using his skill as a communicator, he wrote many of his papers to acquaint non-meteorologists with some of the latest findings in the field of meteorology.

While at the University of Chicago, Byers organized and directed three pioneering research programs: the Thunderstorm Project, the Artificial Cloud Nucleation Project, and

the Cloud Physics Project. Arguably, the pinnacle of his career as a scientist came with the Thunderstorm Project. In later correspondence with one of the authors (R.R.B.), Byers stated that he first became interested in thunderstorms in 1929 as he rode a train from California to MIT. He crossed the Great Plains at night; a night of major thunderstorms along the route. The incessant lightning seemed to challenge understanding. While with the Weather Bureau he began a study of thunderstorm rainfall using data from a Soil Conversation Service network of rain gages in Ohio. This study then was published after he arrived at Chicago.

By the end World War II, thunderstorms were regarded as the most serious weather obstacle to the rapidly expanding aviation industry. In 1946, under pressure from the commercial air lines, the National Advisory Committee for Aeronautics (predecessor of NASA) and the U.S. military departments, Congress passed P.L. 647, which directed the chief of the U.S. Weather Bureau to conduct research on the internal structure of thunderstorms. Weather Bureau Chief Reichelderfer named Byers director of the Thunderstorm Project.[4] It operated in Florida and Ohio during the summers of 1946 and 1947. The final report of the Thunderstorm Project was widely acclaimed as the first definitive study of the interior structure and air motions inside thunderstorms. Well over half the citations to Byers's publications are to this report. This project demonstrated the value of weather-sensitive radar to the safety of airplanes flying through and around thunderstorm conditions and did much to prompt industry to develop radar suitable for routine use on airplanes. While analyzing data from this project, a graduate student (R. Braham) discovered that intense downdrafts develop adjacent to strong updrafts in thunderstorms to form a coupled pair that undergo a regular life cycle.[5] These he called thunderstorm cells. The important role played by

strong downdrafts in the structure of thunderstorms was a major new finding of the Thunderstorm Project. The thunderstorm cell model was the centerpiece of the project's final report, and has served as the foundation for much of subsequent research on thunderstorms.

Byers's concern for thunderstorms and severe weather continued beyond publication of the results of the Thunderstorm Project. About 1951 he arranged for the Japanese scientist Ted Fujita to come to Chicago, thus beginning a new chapter in severe storm research for which Professor Byers was justifiably very proud. His last publication was coauthored with Fujita in 1977: "Spearhead Echo and Downburst in the Crash of an Airliner." This paper provided a fitting closure to a career heavily concerned with aircraft safety.

While the Thunderstorm Project was in progress, Irving Langmuir and Vincent Schaefer, of General Electric Laboratories, discovered that silver-iodide smokes were effective in initiating ice crystals in all-liquid supercooled clouds. Experiments in thin supercooled stratus clearly demonstrated that such clouds could be turned to ice crystals if natural ice nuclei were insufficient. This offered a scientific possibility for useful anthropogenic influence on clouds and weather, a possibility that captured the imagination of many persons and led to unwarranted claims of what might be achieved through cloud seeding. Cloud seeding came on like a steamroller. Byers could not escape. The possibility that significant weather changes might be induced through cloud seeding made it imperative that the U.S. military agencies conduct research to assess the probable tactical value of cloud seeding. A high level governmental advisory group recommended that the military conduct research into the physics of precipitation and artificial weather control. About 1951 the U.S. Air Force Cambridge Research Laboratories contracted with the University of Chicago to study

the physics of cumulus clouds and their response to seeding. This was part of a multi-agency effort called the Artificial Cloud Nucleation Project. Professor Byers was designated director of the University of Chicago portion. Quickly he engaged several persons from the Thunderstorm Project. The final report, published as an American Meteorological Society Monograph,[6] contained many new findings about the physics of clouds and their response to seeding, but little encouragement for cloud seeding. There were follow-on contracts and grants that enabled the University of Chicago Cloud Physics Lab, under Byers's leadership, to achieve world-wide distinction in the study of the physics of clouds and their response to cloud seeding. Byers was deeply involved in two very carefully designed and executed scientific experiments to test the efficacy of cloud seeding: the Arizona Seeding Experiment and Project Whitetop. Both experiments went to great lengths to minimize experimenter biases and to cope with the well-known fact that no two clouds are alike nor are they completely independent of nearby clouds or those on nearby days. He firmly believed that statistics and statisticians were essential in the design and evaluation of these experiments. Although the results of these experiments were controversial, they offered little encouragement for cloud seeding.

It was in his views about cloud seeding that Byers came into conflict with the eminent academician Irving Langmuir. Byers was one of many meteorologists who thought that Langmiur's claims for substantial changes in convective clouds and large weather systems, as a result of weather modification, were extravagant and mainly a result of a lack of appreciation for the complexity and variability of natural weather phenomenon. Whereas laboratory experiments can be carefully controlled and replicated, in the atmosphere no two clouds are identical or are completely independent. In the

strictest sense, no weather modification experiment can be replicated, and careful statistical controls are required for interpretation of weather modification experiments.

Byers was a constructive critic of weather modification. He advocated basic research in cloud physics. His background in atmospheric thermodynamics and energetics of atmospheric systems made him cautious about the possibility of significant weather changes through seeding. His first scientific paper on this subject, in 1953, called for study of the physical processes of natural rain formation, the physics of artificial intervention (as it was perceived at that time), and the need for carefully designed experiments. In 1965 he published a textbook *Elements of Cloud Physics* based upon class lecture notes at the University of Chicago. His 1974 chapter in the book *Weather and Climate Modification*, edited by W. N. Hess, gives a definitive review of scientific research in weather modification up to about 1971.

BYERS THE INDIVIDUAL

In 1927 Horace R. Byers married Frances Isabel Clark in Berkeley. They had one daughter, Henrietta Byers, who married Thomas W. Bilhorn.

Some who knew him only casually found Professor Byers somewhat formal and reserved, but those who really knew him recognized him as a friend and supporter who worked hard to advance meteorology. He might be called a vigorous go-getter, one who did not like to come off second best. He was a statesman among meteorologists. He also had a lighter side. His humor as a banquet speaker is mentioned in several places. He loved to ride horses. He obtained a private pilot's license in 1941. He was a gourmet cook and connoisseur of fine wines. Over a period of many years he was given the task of selecting "just the right wine" whenever he gathered with colleagues for dining.

AWARDS

1941 Robert M. Losey Award, American Institute of Aeronautics and Astronautics
1952 Elected to the National Academy of Sciences
1959 Award of Merit, Chicago Technical Societies Council
1960 Charles F. Brooks Award, American Meteorological Society
1978 Cleveland Abbe Award, American Meteorological Society

SCIENTIFIC SOCIETIES

Fellow, American Meteorological Society (president, 1952-53; honorary member, 1975)
American Geophysical Union (section president, 1947-48)
International Association of Meteorology and Atmospheric Physics (president, 1960-63)
National Academy of Sciences (chair, Geophysics Section, 1966-69)
Royal Meteorological Society
American Geography Society
American Association for the Advancement of Science
Sigma Xi (president, Chicago chapter, 1958-60)
Phi Kappa Phi

NOTES

1. An account of Professor Carl-Gustaf Rossby's coming to the United States and his association with the Guggenheim Foundation can be found in Byers (1959,2 [pp. 56-59]).

2. H. R. Byers. The founding of the institute of Meteorology at the University of Chicago. *Bull. Am. Meteorol. Soc.* 57(1976):1343-45.

3. E. L. Hallgren. *The University Corporation for Atmospheric Research and the National Center for Atmospheric Research: An Institutional History*. Boulder, Colo.: 1974.

4. A brief history of the Thunderstorm Project can be found in R. R. Braham, Jr. The Thunderstorm Project. *Bull. Am. Meteorol. Soc.* 77(1966):1835-45.

5. See H. R. Byers. Probing the thunderstorm. *Weatherwise* 1(1948):47-50. Structure and dynamics of the thunderstorm. *Science* 110(1949):291-94.

6. R. Braham, Jr., L. J. Battan, and H. R. Byers. Artificial nucleation of cumulus clouds. *Am. Meteorol. Soc. Meteorol Monogr.* 2(1957):47-85.

SELECTED BIBLIOGRAPHY

1930

Summer sea fogs of the central California coast. *Univ. Calif. Publ. Geogr.* 3(5):291-338.

1931

Characteristic weather phenomena of California. *Mass. Inst. Tech. Meteorol. Pap.* 1(2):1-54.

1937

Synoptic and Aeronautical Meteorology. New York: McGraw-Hill.

1941

With V. Starr. The circulation of the atmosphere in high latitudes during winter. *Mon. Wea. Rev.* 47(suppl.).

1942

Non-frontal Thunderstorms. University of Chicago Institute of Meteorology Miscellaneous Report No. 3.

1944

General Meteorology. New York: McGraw-Hill.

1946

With B. G. Holzman and R. H. Maynard. A project on thunderstorm microstructure. *Bull. Am. Meteorol. Soc.* 27:143-46.

1948

With H. R. Rodebush. Causes of thunderstorms over the Florida peninsula. *J. Meteorol.* 5:275-80.

With R. R. Braham, Jr. Thunderstorm structure and circulation. *J. Meteorol.* 5:71-86.

1949

With R. R. Braham, Jr. *The Thunderstorm: Final Report of the Thunderstorm Project.* Washington, D.C.: U.S. Government Printing Office.

Thunderstorms. In *Compendium of Meteorology*, ed. T. F. Malone, pp. 681-93. Boston: American Meteorological Society.

1953

With R. R. Braham, Jr. Thunderstorm structure and dynamics. In *Thunderstorm Electricity*, ed. H. R. Byers, pp. 46-65. Chicago: University of Chicago Press.

1954

The atmosphere up to 30 kilometers. In *The Earth as a Planet*, vol. 2, ed. G. P. Kuiper, pp. 299-370. Chicago: University of Chicago Press.

1955

With R. K. Hall. A census of cumulus-cloud height versus precipitation in the vicinity of Puerto Rico during the winter and spring of 1953-1954. *J. Meteorol.* 12:176-78.

1957

With J. B. Sievers and B. J. Tufts. Distribution in the atmosphere of certain particles capable of serving as condensation nuclei. In *Artificial Stimulation of Rain*, eds. H. Weickmann and W. Smith, pp. 47-72. New York: Pergamon.

With R. R. Braham and L. J. Battan. Artificial nucleation of cumulus clouds. In *Cloud and Weather Modification. Am. Meteorol. Soc. Meteorol. Monogr.* 2:47-85

1959

Carl-Gustaf Arvid Rossby. In *Biographical Memoirs*, vol. 34, pp. 249-70. Washington, D.C.: National Academy of Sciences.

Carl-Gustaf Arvid Rossby, the Organizer. In *The Atmosphere and Sea in Motion* (Rossby Memorial), ed. B. Bolin, pp. 56-59. New York: Rockefeller Institute.

1962

With T. Fujita. Model of a hail storm as revealed by photogrammetric analysis. *Nubila* 5:85-105.

1965

Elements of Cloud Physics. Chicago: University of Chicago Press.

1974

History of weather modification. In *Weather and Climate Modification*, ed. W. N. Hess, pp. 3-44. New York: Wiley.

1976

The founding of the Institute of Meteorology at the University of Chicago. *Bull. Am. Meteorol. Soc.* 57:1343-45.

1977

With T. Fujita. Spearhead echo and downburst in the crash of an airliner. *Mon. Wea. Rev.* 105:129-46.