

UCAR

UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH

Report for 1968 and 1969

UCAR

UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH

Report for 1968 and 1969



CONTENTS

UCAR — 1968 and 1969	4
The National Center for Atmospheric Research	9
NCAR Research Highlights in 1968 and 1969 .	12
UCAR and NCAR Educational Activities . .	46
UCAR Members' Representatives	50
UCAR Board of Trustees	54
NCAR Senior Management Staff	55
UCAR Financial Report	56

UCAR - 1968 and 1969

The central aim of the University Corporation for Atmospheric Research was set forth in the Certificate of Incorporation at UCAR's founding in 1959: "To engage in, assist, and contribute to the support of scientific activities and projects in the field of atmospheric research and related fields and to foster and encourage the advancement of knowledge concerning the atmosphere in all of its aspects." The Corporation now has twenty-seven member universities in the United States. With its strong relationships to the universities and the National Science Foundation, UCAR is favorably placed to stimulate cooperation among federal agencies, university research groups, and other laboratories dedicated to progress in atmospheric science, and to encourage research leading to major advances in this field.

The growth and development of UCAR, outlined in the UCAR Report for 1967, reflect a worldwide sense of urgent need for progress in understanding, interpreting, predicting, and perhaps controlling the earth's atmosphere. During the last decade, UCAR's energies have been used principally to create and develop the National Center for Atmospheric Research, which it operates under contract with the National Science Foundation. NCAR scientists and engineers seek to attack major unsolved problems of the atmospheres of the earth and sun with the scale of effort and interdisciplinary approach befitting the vastness and complexity of atmospheric processes.

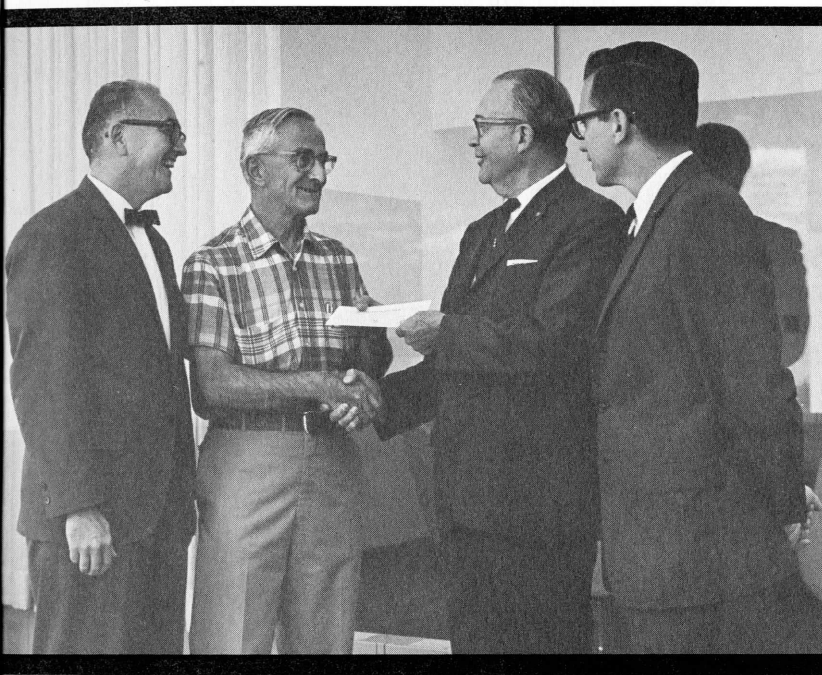
The key to progress in the atmospheric sciences is the application of modern technological resources to the interpretation of terrestrial and solar atmospheric behavior. Numerical modeling of the earth's atmosphere, using powerful computer techniques, makes it possible to treat it as the single complex physical system it is in nature, and thereby to develop methods of accurate long-range weather prediction, to assess schemes of large-scale weather and climate modification, and to evaluate the full effect of inadvertent weather modification brought about by various types of air pollution.

Success in developing and using numerical models, however, depends upon the marshaling of resources far beyond those of UCAR and NCAR. Accurate models demand a vastly improved world weather network and will eventually require cooperative

programs involving all the nations of the world. They also demand improved and enlarged computers capable of dealing rapidly with data from such an enlarged network. UCAR feels a deep responsibility to promote participation in enterprises related to these endeavors, not only at NCAR but also at universities and in private industry and government, both in the United States and abroad. The rewards of success in atmospheric modeling will extend to many walks of life, and justify high priority commitment of national and international effort.

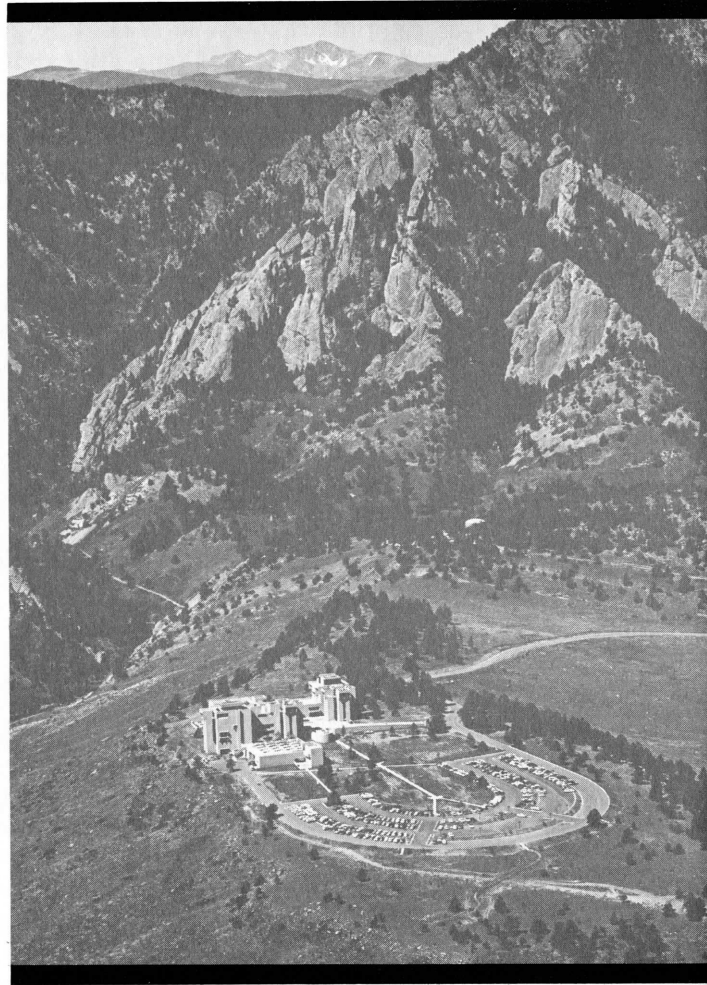
UCAR also feels a special responsibility to promote educational activities in the atmospheric sciences. The UCAR fellowship program, initiated in 1963, has the specific objective of attracting especially promising potential scientists to the study of the atmospheres of the earth and sun. The NCAR Advanced Study Program provides study and research opportunities for young postdoctoral scientists, many of them from other nations. Scientific communication with other countries has been expedited, in particular through support of visiting scientists, travel of NCAR scientists to meetings abroad, and support of international planning of global studies of the atmosphere.

Two recent changes in the structure of UCAR have strengthened the effectiveness of the Corporation. In 1967, the Board of Trustees was reduced from thirty-four to sixteen members, creating a tightly knit group capable of attacking UCAR problems vigorously, in depth, and on a continuing basis. In 1968, the offices of the President of UCAR and the Director of NCAR, previously both held by Walter Orr Roberts, were separated. In May, John W. Firor was appointed Director of NCAR, while Dr. Roberts continues as President and chief executive officer of UCAR. This change allows Dr. Roberts greater time and freedom for activities relating to the universities and their atmospheric science departments, while permitting him to work closely with the Director of NCAR in carrying out the policies of the Board of Trustees, which is responsible to the UCAR member universities. It is the Corporation's view that UCAR, based squarely in the academic community, can play a significant role in national and international atmospheric science efforts foreseen for the next decade, as well as in the debates expected to ensue concerning Federal sponsorship of environmental science efforts in coming years. UCAR will therefore strive to represent the best interests of its members, its realm of science, and the public.



Garrett W. Craig, Division Manager of the Public Service Company of Colorado, presents a check to Bernhard Haurwitz, Director of the Advanced Study Program, for the UCAR Fellowship Fund. Left, Walter Orr Roberts, President of UCAR; right, Fred W. Roecker, NCAR Assistant Director for Administration.

The NCAR Laboratory, near Boulder, Colorado, was completed in 1967. The 567-acre site at the foot of the Front Range of the Rockies was donated by the State of Colorado.



THE NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

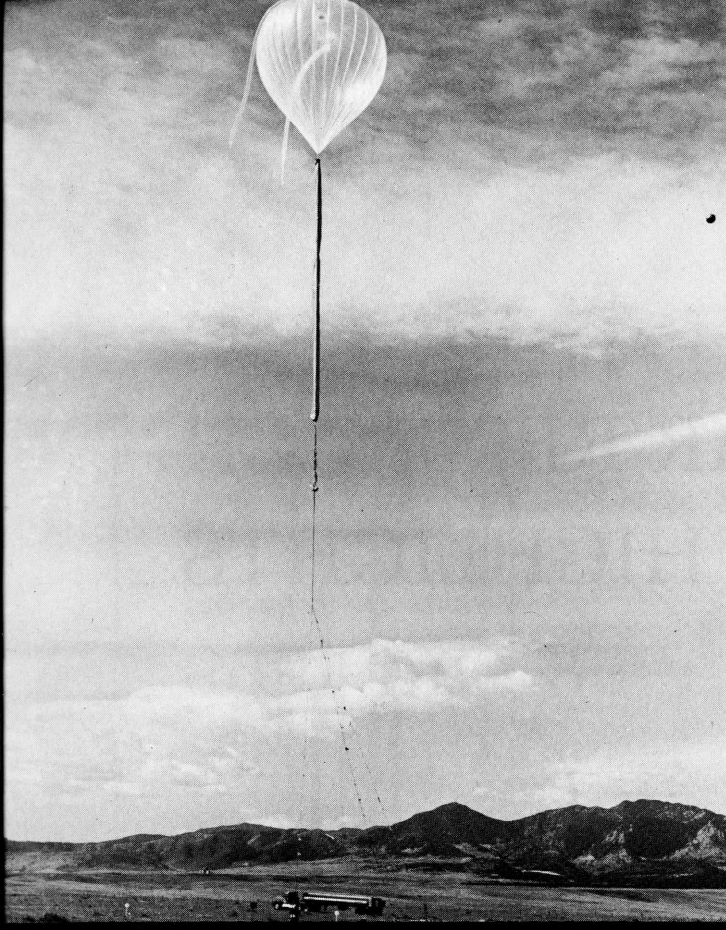
NCAR's principal laboratories, the focal points of its activities, are located in Boulder, Colorado. Field sites are established as needed for special studies. In 1968 and 1969 field activities included: balloon launches from a permanent site near Palestine, Texas, as well as from Christchurch, New Zealand, and Ascension Island in the Atlantic; analyses of tropical meteorology in Panama, Venezuela, and Barbados; research on ice nucleation in Yellowstone Park and the Colorado Rockies; snowfall seeding experiments in Colorado and Wyoming; studies of hail in north-eastern Colorado; and observations of the sun's corona from high altitude stations at Climax, Colorado, and near the summit of Mauna Loa, Hawaii.

NCAR's three research divisions and its Facilities Laboratory offer a unique opportunity for an integrated approach to atmospheric problems. The Laboratory of Atmospheric Science (LAS) embraces the fields of atmospheric chemistry and microphysics, and atmospheric dynamics. The High Altitude Observatory (HAO), recognizing that there is a large body of theory that overlaps the dynamics of terrestrial, planetary, and stellar atmospheres, devotes much of its effort to solar physics and planetary studies. Investigations of solar-terrestrial relationships analyze the influence of the so-called solar wind and of solar tidal forces on the earth's atmosphere, and detail the effects of such solar phenomena as prominences and flares. The Advanced Study Program (ASP) supports visiting postdoctoral and senior scientists and conducts seminars, summer studies, and other activities designed to illuminate fundamental problems common to many areas of the atmospheric sciences.

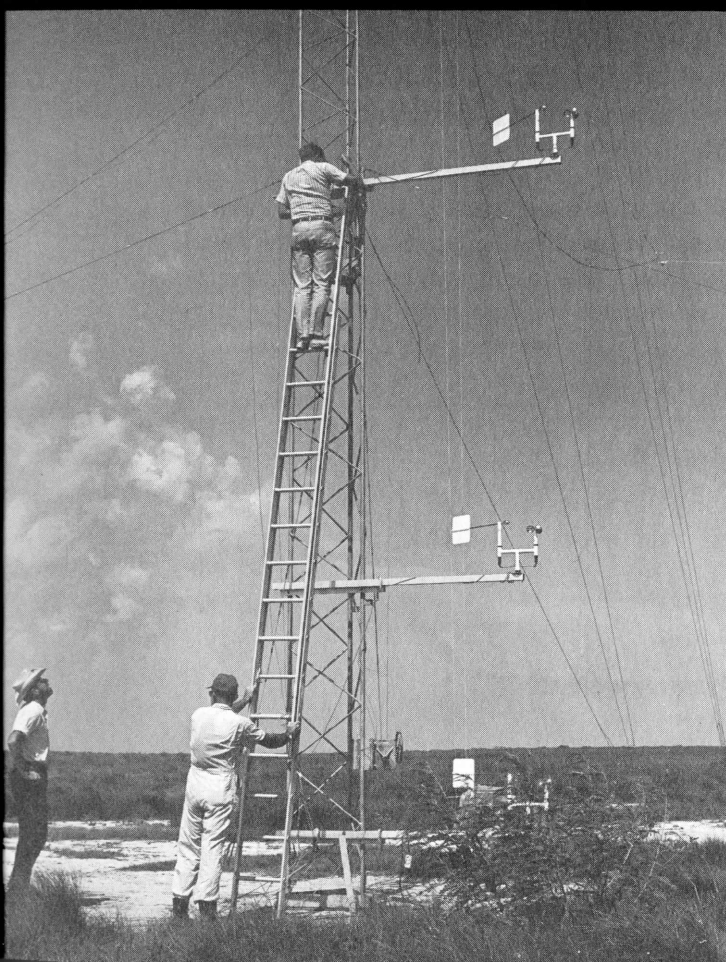
The Facilities Laboratory (FAL) provides research support and develops new observational and data-handling techniques for NCAR scientists and those of other scientific and educational institutions. FAL operates four joint-use facilities: the Computing

Facility, the Scientific Balloon Facility, the Research Aviation Facility, and the Field Observing Facility. It also includes the Global Atmospheric Measurements Program, developing new operational systems for global data collection. The Design and Prototype Development Facility provides engineering and systems design for NCAR programs and for joint efforts involving NCAR and university research groups.

The programs of these divisions embrace virtually the whole realm of atmospheric science. What is more, the association at NCAR of specialists in many fields, with strong support facilities, offers unusual opportunities for collaborative work in solving problems demanding a large-scale effort and a multidisciplinary approach.



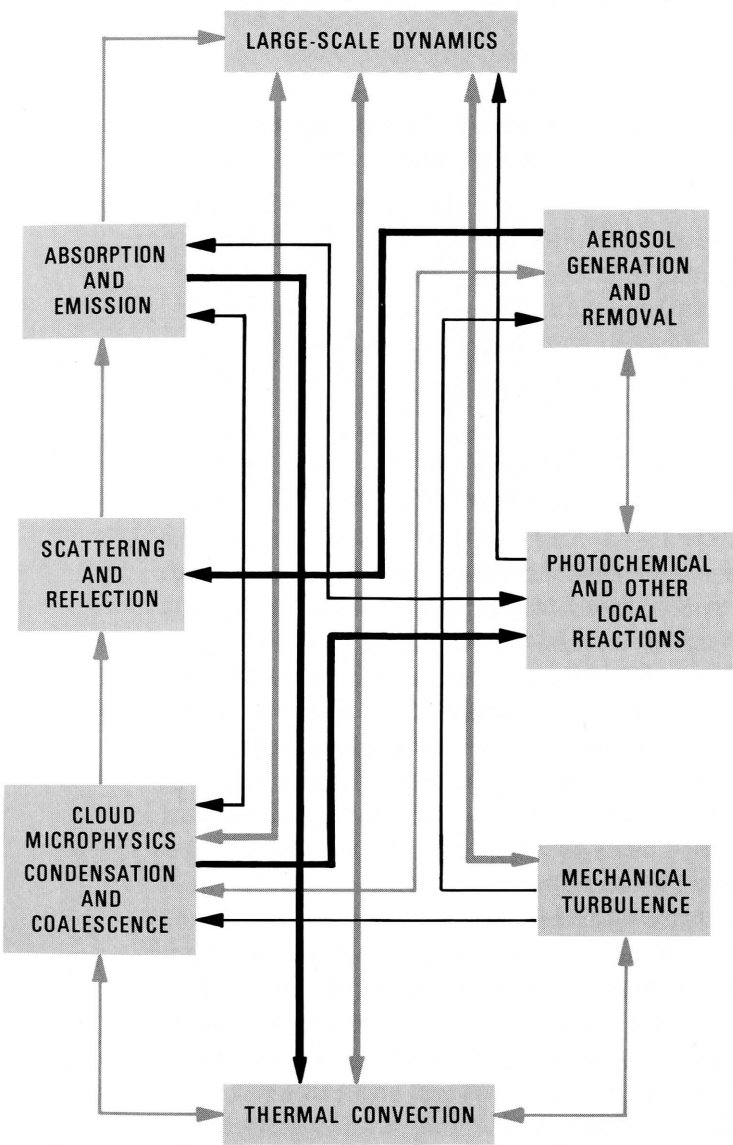
Balloon payloads, often heavy but delicate, are particularly vulnerable at launch. NCAR has developed a number of new and improved techniques for accomplishing safe launches. Here, a small balloon rises from a field site near Boulder in a modification of the Stonehenge launch system developed by the Scientific Ballooning Facility.



In 1968 and 1969 NCAR supported a number of university projects, among them a study of sea and land breeze cycles on the Texas Gulf Coast by University of Texas scientists. NCAR field and flight staff, instruments, power generating equipment, and a Queen Air 80 aircraft were made available for the project.

NCAR RESEARCH HIGHLIGHTS in 1968 and 1969

NCAR achieved major progress in many directions in the interpretation of terrestrial and solar atmospheric behavior during the last two years. This progress was not always spectacular, with well-defined achievements on a particular day or in a particular month, but the forward motion can be measured from year to year, as is characteristic of most scientific achievement in any field. NCAR's scientific activities are reported fully in the **Annual Report, NCAR Research and Facilities Programs**. Among the many projects undertaken, only a few particularly wide in scope or significant in effect are selected for discussion here as highlights for 1968 and 1969.



All atmospheric processes are interrelated — no process in the above diagram can be completely isolated or treated completely independently of the rest. Thus all atmospheric research, no matter what the processes being studied, ultimately relates to the large-scale dynamics of the atmosphere, and to the problem of modeling the atmosphere numerically.

THE GENERAL CIRCULATION MODEL

In 1904 the Norwegian meteorologist Vilhelm Bjerknes presented the scientific basis for numerical weather forecasting:

If it is true, as every scientist believes, that subsequent atmospheric states develop from the preceding ones according to physical law, then it is apparent that the necessary and sufficient conditions for the rational solution of forecasting problems are the following:

1. A sufficiently accurate knowledge of the state of the atmosphere.
2. A sufficiently accurate knowledge of the laws according to which one state of the atmosphere develops from another.

In the years since Bjerknes's definition of the problem, many of the complex physical laws of hydrodynamics and thermodynamics have become known, and mathematical equations have been derived for them. Within the last decade the advent of electronic computers, with their capability of solving these equations at speeds equal to many millions of mathematical steps per second, has opened the doors of science to the promise of numerical forecasting. Many research groups, in the United States and elsewhere, have demonstrated that numerical simulation of the atmosphere not only is possible, but promises the very solution to forecasting problems predicted by Bjerknes.

At NCAR, Akira Kasahara, Warren Washington, and their colleagues have been working since 1964 on a general circulation model of the entire global atmosphere. Their model is built upon four forecast equations representing changes in east-west wind, north-south wind, air pressure, and water vapor content. The model also considers such factors as atmospheric radiation, surface conditions of continents and oceans, evaporation and condensation, small-scale turbulence, and the effects of mountain

barriers. The model is structured on a grid with five-degree latitude and longitude spacing, and involves solving all these equations for about 2450 grid points at each of several levels, at intervals representing six minutes of real time. Two versions of the model are currently in operation: one with two layers each six kilometers deep, and one with six layers each three kilometers deep.

During 1968 and early 1969, Kasahara's group ran a number of experiments with the model on NCAR's Control Data 6600 computer. By varying the influence of various physical elements, numerically, the importance of each element upon atmospheric motions was determined. For example, the influence of clouds on solar and terrestrial radiation was shown to be important in simulating a realistic climate; and the effects of the earth's major mountain ranges, when taken into account, significantly improve the realism of the model. Through these controlled experiments with the model — such experiments cannot be conducted with the real weather — researchers are beginning to understand how the atmosphere works and to recognize what is still not known about weather and climate. The experiments thus indicate areas for further improvement in the physics of the model as well as in computational schemes.

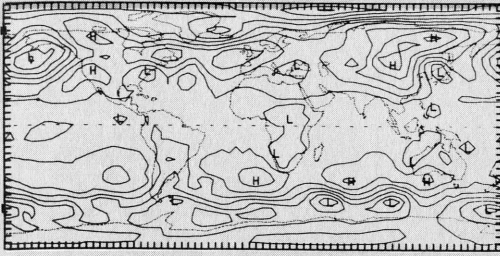
Besides being used for studying global climate, the NCAR model is being tested for prediction of day-to-day changes of weather, using real (though not yet real-time) weather data as the initial state of the atmosphere. Computer-developed forecasts based on weather data for 15 January 1958 were compared with the real weather that developed in ensuing days. The comparison shows that, given adequate initial data, the present model can predict large-scale global weather patterns several days in advance.

In preparing these forecasts, the computer must perform about 100 arithmetic operations for each grid point, at each level, for every six-minute time step. The accumulation of output data far exceeds the maximum storage capacity of the computer, but can be recorded graphically, as weather maps, by the computer's

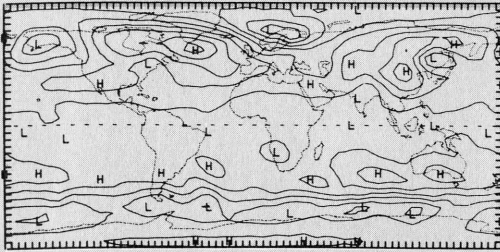
peripheral equipment. Grid point data resulting from the model's calculations are analyzed by the computer and plotted immediately by a Data Display 80 unit as contour lines overlying maps of the globe. Motion pictures assembled from plotted maps portray vividly the genesis, movement, and decay of weather patterns.

Solving the equations for the general circulation model requires millions of mathematical operations — a time-consuming process even for a computer. On NCAR's Control Data 6600 computer, the two-layer version of the model produces thirty days of simulated weather in one day of computer time; the six-layer version needs three days for the same task. These periods are lengthened by the necessity of sharing the computer with other projects. As the model is further refined, greater computer capacity will be needed.

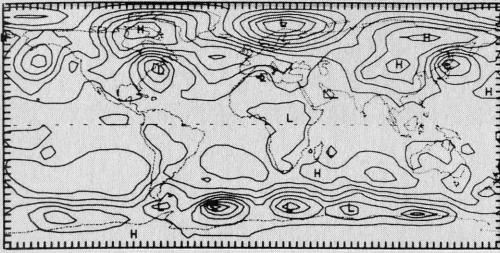
INITIAL



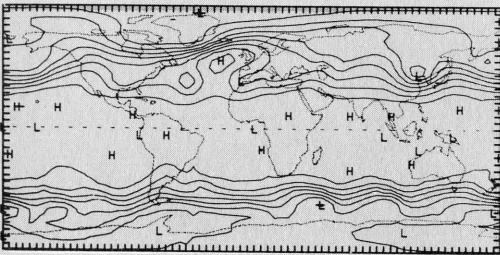
48 HR. FORECAST



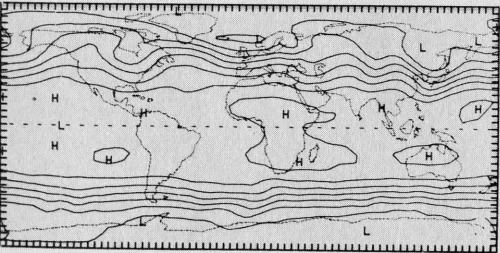
48 HR. VERIFICATION



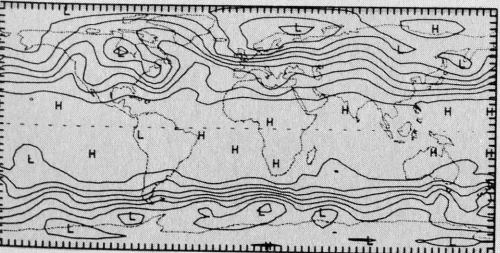
INITIAL



96 HR. FORECAST

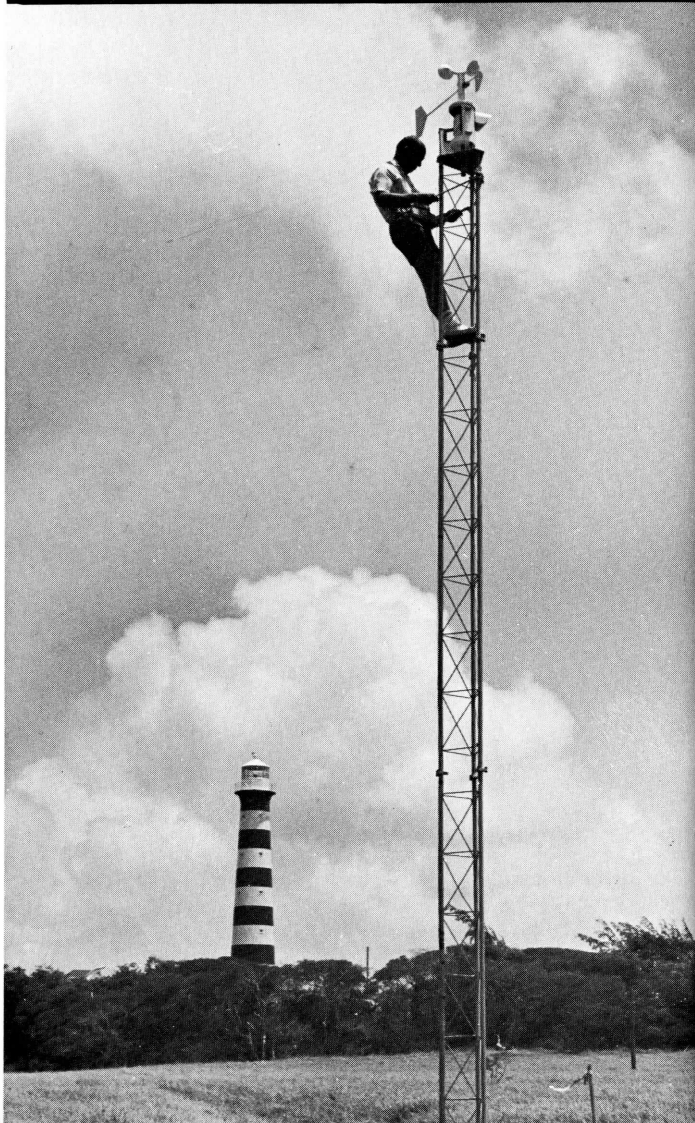


96 HR. VERIFICATION



To check the NCAR model's ability to forecast the real atmosphere, experiments are conducted with real data as a starting point. In these examples, the model predicted more or less correctly the movement of highs and lows, but underestimated their intensity. The 48 hour forecast is of sea level pressure; the 96 hour forecast is of pressure at 6 kilometers.

A number of NCAR scientists and technicians participated in the 1968 Barbados Experiment. This project was organized by Florida State University to study the influence of small-scale weather events on large-scale weather patterns in the tropics. NCAR's Field Observing Facility and Aviation Facility gave active support to the program.



THE GLOBAL ATMOSPHERIC RESEARCH PROGRAM

Successful forecasting depends on accurate knowledge of the atmospheric conditions at a given moment—the data from which the forecast is derived. Obtaining this knowledge is by no means a trivial problem. Weather data available today are abundant for most continental areas in north temperate latitudes, but data are scarce or nonexistent for wide oceanic, polar, and tropical areas, particularly in the southern hemisphere.

In a number of new international observational programs, chief among them the World Weather Watch sponsored by the World Meteorological Organization (WMO), long-range efforts are being made to gather meteorological observations over the entire globe. These data will be available, via telemetry links, in ever-increasing quantity and quality as new stations are established and brought into the world network and as new instrumentation, some of it balloon-borne or buoy-borne, is put into use.

At the same time, it is important that observational and scientific experiments be mounted to enlarge our understanding of many atmospheric processes. A research-oriented program, the Global Atmospheric Research Program (GARP), will gather additional data for research purposes, not only from existing networks but from temporary stations and networks operating for short periods of time to produce data on a more-than-usually intense basis. GARP is endorsed jointly by the International Council of Scientific Unions and the WMO. Target dates reach into the late 1970s.

A major focus for GARP-related programs is now on the tropics. NCAR scientists have joined others in the realization that the tropics play a crucial but as yet imperfectly understood role in processes contributing to weather patterns all over the globe. It was on this basis that NCAR became involved in and coordinated the Line Islands Experiment in 1967, participated in the Barbados Experiment of Florida State University in 1968, and became involved in the Barbados Oceanographic and Meteorological Experiment (BOMEX), a large interagency experiment carried out during the summer of 1969.

Leading American meteorologists have now proposed a still more ambitious tropical meteorological study for implementation at an early date — probably 1973. A concept for this experiment, originally called TROMEX, was published at NCAR in March 1968. William W. Kellogg, Henry M. E. van de Boogaard, Edward J. Zipser, Douglas K. Lilly, and other NCAR scientists contributed to the formulation of a proposal defining a laboratory area in the western tropical Pacific, with the area of chief emphasis including the Marshall, Caroline, and Mariana island groups. NCAR conducted a survey trip to the Marshall Islands region in early 1969, resulting in a working plan for the experiment.

This study is expected to involve the collaboration of several nations. Research will concentrate on field studies of the interactions of mesoscale and large-scale processes, the development of a variety of theoretical models that deal with these interactions, and the testing of instruments and systems for a full-scale global experiment.

NCAR is already taking an active part in many other phases of GARP. For example, the Global Atmospheric Measurements Program (GAMP), directed by Vincent E. Lally, is designing and testing new types of instrumentation suitable for use in oceanic or uninhabited land areas now poorly represented meteorologically. Notable among these is the GHOST superpressure balloon system, in which fleets of instrumented balloons, drifting at constant density levels, will relay weather data via satellite to ground stations for incorporation into computer-produced global weather descriptions and forecasts. One of the GHOST balloons, now being test flown from Christchurch, New Zealand, remained aloft for 441 days, completing more than twenty-five circumnavigations of the southern hemisphere.



A constant-level GHOST balloon is launched from Christchurch, New Zealand. Balloons such as these, drifting with the wind, will transmit temperature, pressure, and wind data to satellites for relay to ground stations.

One of a series of dropsondes is released from an NCAR Queen Air aircraft flying above a thunderstorm. Falling through the storm, the sondes report vertical wind speeds, enabling NCAR scientists to map wind structures within the storm.



THERMAL CONVECTION AND TURBULENCE

Studies of thermal convection, especially that involved in severe thunderstorms and hailstorms, have been prominent in NCAR research. In recent years they have included several field, laboratory, and theoretical programs, only a few of which are described below.

Douglas K. Lilly, M. H. Davis, Ronald R. Drake, and Douglas G. Fox have launched theoretical and laboratory studies of cumulus clouds, in which an unstable, heated body of air penetrates upward into a stable, stratified layer. Their ultimate objective is a numerical model of a developing cumulus cloud, including both air motions and microphysical processes such as condensation, droplet coalescence, and ice crystal growth. Current efforts are directed particularly toward bridging the gap between theoretical models of the microphysical processes and models of convective air circulation.

James Fankhauser, using data from the National Severe Storms Laboratory of the Environmental Science Services Administration (ESSA), analyzed selected thunderstorm situations to determine the importance of latent heat in natural convection. Also, he released radar-reflective chaff as an air motion tracer in an experimental study to determine flow characteristics in and around storms. The experiments revealed that most of the flow at mid-cloud levels near mature thunderstorms resembles flow around a cylindrical obstacle, with only a small proportion of the air entering the cloud circulation.

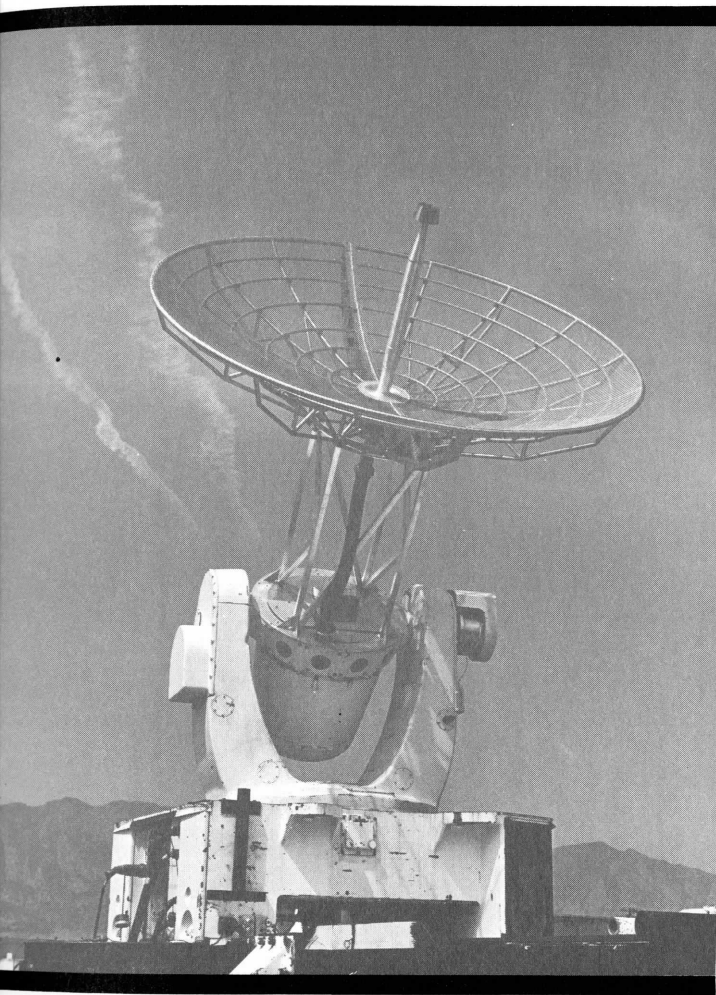
Advances in dropsonde instrumentation and techniques now make it possible to probe the centers of turbulent storms where aircraft cannot fly safely. NCAR's dropsondes, parachute-equipped sensor packages which may be dropped directly into storms from high-flying aircraft, measure vertical air motions within clouds during their fall. Attempts are being made to develop additional instrumentation to measure cloud drop sizes from dropsondes.

Lilly, James E. Deardorff, and their colleagues have studied various aspects of atmospheric turbulence from both theoretical

and observational points of view. Among the important scientific results of their studies are the successful numerical simulation of two-dimensional turbulence and three-dimensionally turbulent channel flow, such as occur in the earth-atmosphere boundary layer. The results of their studies relate directly to questions of atmospheric modeling and atmospheric predictability.

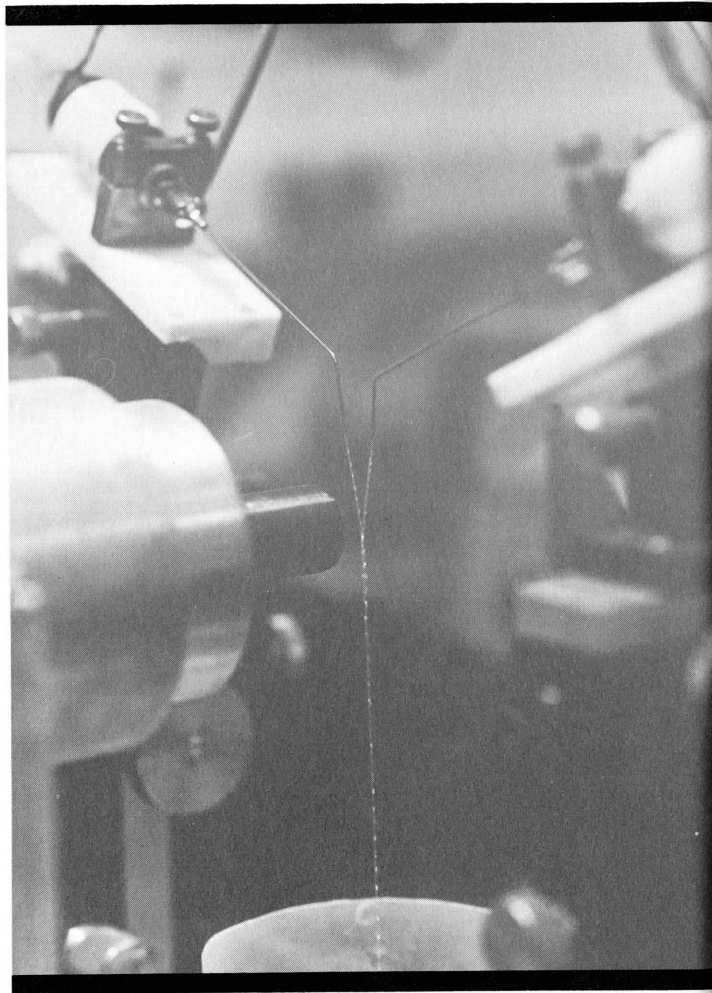
An airborne turbulence measuring system has been developed by Donald Lenschow and installed in one of the NCAR Queen Air aircraft. Vertical and horizontal velocity fluctuations, heat and momentum, and water vapor eddy fluxes can be calculated from the output of the aircraft sensors. The effectiveness of the system will be greatly enhanced by using it with the inertially stabilized platform recently installed in the NCAR de Havilland Buffalo aircraft.

In various parts of the world, where strong deep wind currents flow over high mountain ranges, downslope areas in the lee of the mountains often experience high-speed, damaging winds. The generic name for such winds is foehn, a name that originated in the European Alps. Mountain lee winds and related phenomena are frequent wintertime occurrences in Colorado, and at NCAR's mesa-top location winds coming down off the Rockies can exceed 100 miles per hour. During 1968 a cooperative observational program was mounted to study lee flow effects. ESSA, the Canadian National Aeronautical Establishment, the Explorer Research Corporation, the White Sands Missile Range, and the Air Force HICAT program joined NCAR in carrying out airborne reconnaissance during February, using ground-based instruments and six specially instrumented aircraft flying at altitudes up to 70,000 feet. Data collected revealed many features of the lee flow structure from near the surface to above the tropopause. Theoretical studies of these phenomena will add to development of a two-layer model, aimed at producing detailed predictions of lee flow structure which can be tested against past and future observations in the Boulder area.



An NCAR radar installation southeast of Boulder tracks aircraft and gliders in support of a program to define the speed and direction of the high winds that sometimes occur along the eastern slope of the Rocky Mountains.

To produce droplets for studies of raindrop coalescence, water is pumped through hypodermic needles in electronically controlled pulses.



ELECTRICITY AND RAINDROPS

Although the role played by electricity in rain formation is still far from clear, recent studies at NCAR have shown many details of the effect of electricity on colliding water drops. Some of the most vivid evidence is contained in a series of photographs made under the direction of J. Doyne Sartor. These pictures show drops colliding and either coalescing or bouncing apart, depending on their size, velocity, and charge, and on the nature of the surrounding electric field. The experimental arrangement used by Sartor's group allows precise control of the relevant parameters.

Laboratory observations have firmly established that freely falling drops become charged according to their size and the strength and direction of the electric field. Transfer of charge between drops occurs in two distinct modes. When the electric field is sufficiently strong the transfer is by airborne spark and is very rapid. Below the sparking threshold the charge transfer is accomplished more slowly, depending on the conductivity of the drops.

New laboratory techniques now make it possible to observe and measure charge transfer between drops remotely. Sartor and his colleagues will use these techniques in experiments to be conducted in a particle control chamber recently installed in the rainshaft in the NCAR Laboratory. In these experiments a drop production mechanism will operate in a completely controlled environment to test theoretical concepts of cloud drop and ice particle interaction.



On the prairies of Pawnee National Grassland,
north of Raymer, Colorado, an NCAR radar
detects developing hailstorms.

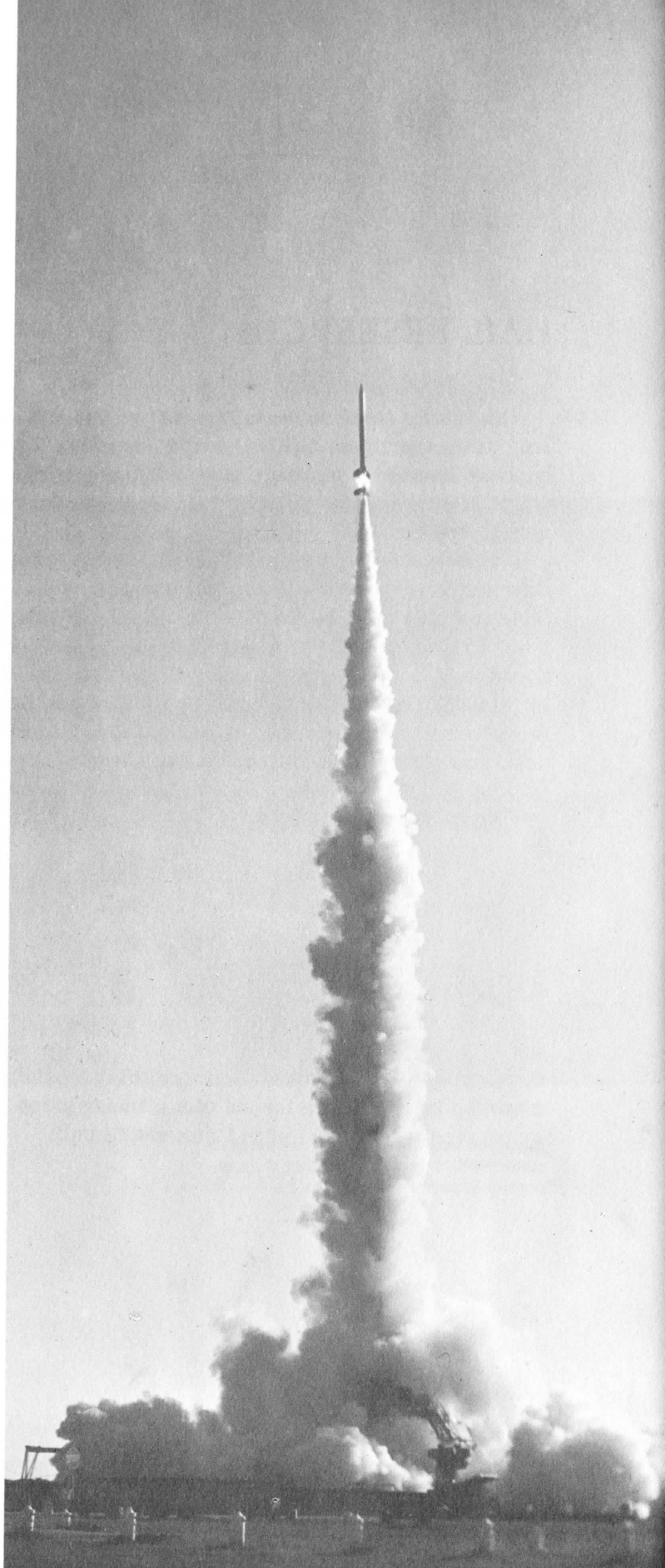
HAIL RESEARCH

Hailstorms cause between \$200 million and \$300 million in crop losses every year in the United States alone. To this must be added damage to buildings, machinery, automobiles, and aircraft. Total losses over the whole world due to hail cannot be accurately estimated.

In the summers of 1968 and 1969, NCAR joined with ESSA and Colorado State University in a cooperative field program to study hailstorm structure and patterns of hailfall. Scheduled to continue for several summers, this program is giving researchers an opportunity to explore the theoretical and practical questions upon which possible hail modification techniques will depend. In northeastern Colorado, studies were made of storms and their environment, and of techniques for cloud seeding, hail forecasting, and hailswath mapping. Research aircraft flew around and through storm clouds to record wind and temperature patterns, air and water vapor influx, and other features of hailstorms. Radar crews surveyed the hailstorms with ground-based equipment, and mobile crews measured hailfalls.

In December 1968, the Interdepartmental Committee on Atmospheric Sciences, a subgroup of the Federal Council on Science and Technology, asked the National Science Foundation to prepare a plan for an integrated hail research program built upon the joint NCAR-CSU-ESSA work. Plans for this program, to be conducted over a five-year period beginning in 1971, have been drawn up by NCAR with the aid of a planning group of hail research experts from the United States and Canada.

The ENCAR-1 rocket-borne sampler, built at NCAR with cooperation and support from NASA and private contractors, was flown from White Sands Missile Range, New Mexico, in September 1968. The sampler collected the equivalent of nearly 10,000 cubic feet of high-altitude air by condensing it on low-temperature coils.



ATMOSPHERIC CHEMISTRY

A number of research projects at NCAR have been devoted to determining the nature and distribution of minor constituents of the upper atmosphere. Foremost among these has been development of a rocket-borne cryogenic air sampler, ENCAR-1. This sampler, built at NCAR with cooperation and support from NASA and private contractors, was flown successfully in September 1968 from White Sands Missile Range, New Mexico, on a NASA Aero-bee rocket. Opening at 143,000 feet (43.6 kilometers), the sampler collected the equivalent of nearly 10,000 cubic feet of high-altitude air by freezing it on low-temperature coils. Edward A. Martell and his associates at NCAR are now analyzing this unique sample.

Interest at NCAR has also been directed toward understanding the origin of the sulfate layer in the lower stratosphere. Some years ago, Christian Junge proposed that this layer, 16 to 22 kilometers above the earth's surface, may be the result of oxidation of gaseous sulfur compounds into aerosols of predominantly sulfate composition. Recent investigations by Julian P. Shedlovsky and Allan L. Lazrus indicate that Junge's ideas may well be correct, and that such gases may result from bacterial reduction of organic matter, combustion of fossil fuel, and volcanic emissions.

This and other atmospheric aerosol layers are now being studied by lidar (laser radar), by directing powerful pulses of ruby laser light upward and measuring the backscatter from the aerosol layers. In recognition of the potential of lidar as a tool for atmospheric science, NCAR sponsored the First Conference on Laser Probing of the Atmosphere, in April 1968. More than forty scientists and engineers gathered for this meeting, at which research already in progress was described, and major problem areas were defined.

During the summer of 1968, electron microscope grids were flown on a NASA rocket from Churchill, Manitoba, to sample

noctilucent clouds, the feathery, high-elevation (about 90 kilometers) clouds occasionally seen at high latitudes in summer. The sample obtained is now being analyzed. Also in 1968, Richard D. Cadle collected samples from the eruptive plumes of several volcanoes — Kilauea in Hawaii, Arenal in Costa Rica, and Mayon in the Philippines — in his continuing program to determine the composition of particles erupted into the atmosphere. Such particles may become significant climatologically during periods of exceptionally active or widespread volcanism.



ENCAR-1 landed on a dune after its successful flight. A recovery party arrived at the scene within an hour. The sampler was essentially undamaged and will be reused.

NCAR's de Havilland DHC-5 Buffalo twin-engine turboprop can fly to altitudes of 35,000 feet and has a range of more than 2000 miles. The aircraft, with its large boxcar-like interior, will provide room for several simultaneous or coordinated atmospheric experiments.



TROPOPAUSE FOLDING

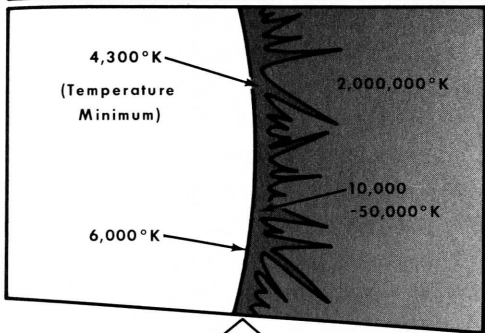
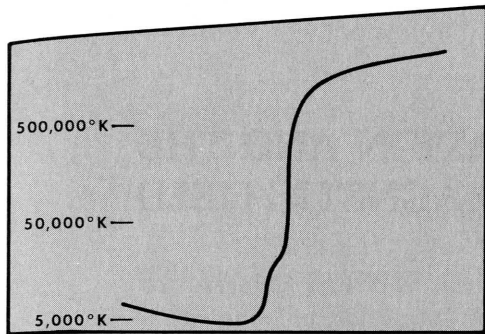
Much of the research concerned with aerosols furnishes information not only about the chemistry of the atmosphere but also, about large-scale atmospheric motions. Thus the aerosols within a given parcel of air travel with it, and act as tracers, revealing the movements of that air.

In recent years, studies of ozone and radioactivity concentrations have revealed that the tropopause, the boundary between the troposphere and the stratosphere, is not a flat and highly impermeable discontinuity as had long been supposed, but that it often "folds," particularly in the vicinity of the jet stream, so that tongues of stratospheric air extend down into the troposphere. This leads to an exchange of air between the troposphere and stratosphere.

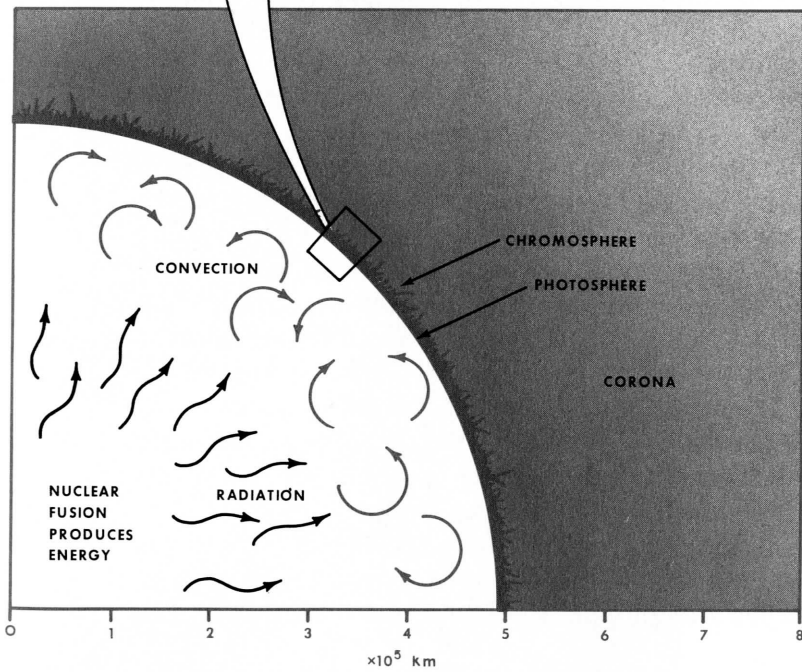
During 1968 and 1969, NCAR and the Air Weather Service of the United States Air Force joined to sample the stratosphere and troposphere during folding episodes to obtain answers to some of the many questions which remain concerning the mechanisms of this exchange. Guided by meteorological analyses to locations of probable folding, NCAR and Air Force aircraft sampled both above and below the tropopause in the region of the fold. Stratospheric air, recognizable by its high content of ozone, sulfate, and radioactive aerosol particles, was found at tropospheric levels on the northwest side of the jet stream; tropospheric air, high in silicon and other surface-derived minerals, was found to have entered the stratosphere on the opposite side of the jet stream. These findings supplement our meager knowledge concerning this interesting phenomenon and indicate the desirability of further studies of tropopause folding.

THE TEMPERATURE OF THE SUN

Studies of the sun's far infrared and far ultraviolet spectra have yielded new information on temperatures near the surface of the sun and in the solar corona. Using specially designed instruments flown in a NASA jet, John A. Eddy and Robert M. MacQueen of HAO and Pierre Léna of the Paris Observatory, Meudon, obtained far infrared spectra which indicate that the minimum solar temperature is about 4300° Kelvin. R. Grant Athay ascertained from studies of far ultraviolet solar radiation that above this minimum the temperature rises extremely sharply to about $1,000,000^{\circ}$ K at the chromosphere-corona interface (actually reaching a gradient of $10,000^{\circ}$ per kilometer) and then increases more slowly to about $2,000,000^{\circ}$ in the corona. The reason for the high temperature of the corona is unknown.



The sun's interior is thought to reach temperatures as high as 10,000,000° Kelvin. Temperatures at the sun's surface are about 6000°; just above the surface they decline to 4300°. They rise again dramatically in the chromosphere and lower corona to 1,000,000° and 2,000,000°, respectively.



SOLAR ROTATION AND THE SUN'S MAGNETIC FIELD

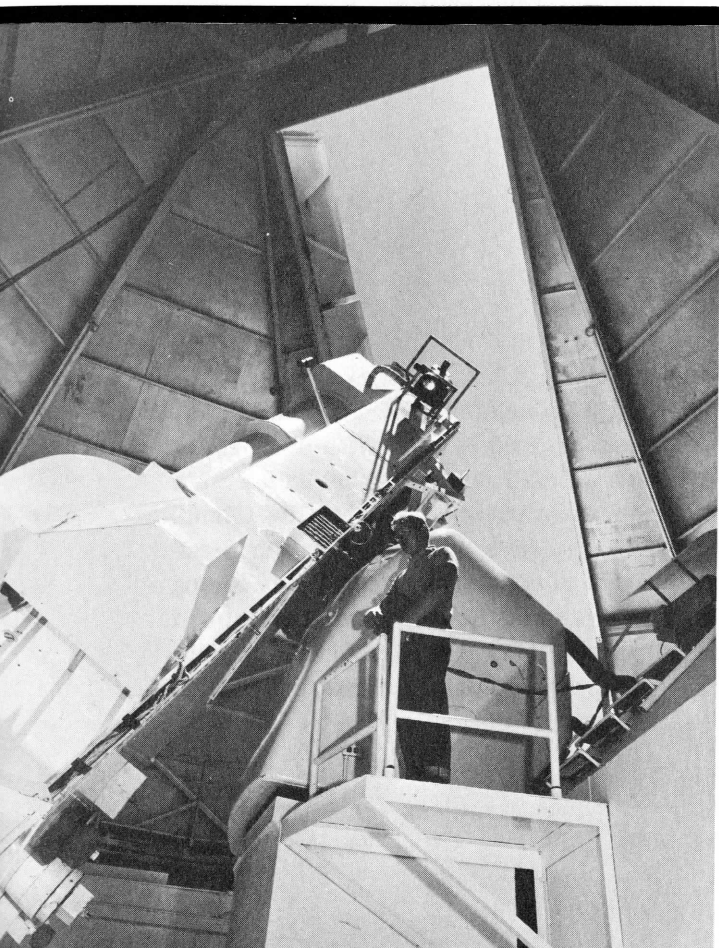
Although the rotation of the sun was first observed by Galileo in 1610 and has been studied ever since, no satisfactory explanation has ever been offered for the fact that the equatorial regions rotate faster than the polar regions. This phenomenon is apparent from the movement of sunspots across the face of the sun.

Yoshinari Nakagawa, Surindar Trehan, Paul Swarztrauber, and others are now working on theoretical aspects of this problem. They have found that the differential rotation appears to be closely linked to the sun's general magnetic field. By means of computer-aided numerical studies they have shown that the well-known eleven-year cycle of solar activity can be reproduced numerically by using a formula for differential rotation that is derived from the motions of sunspots, and that development and drift of polar prominences can be reproduced by using a different formula. Studying the possible causes of differential rotation, Shoji Kato and Nakagawa showed that the observed rotation of the solar surface could be maintained by energy from large-scale convective motions below the surface. Further refinements and improvements of the theories involved in studies such as these require more realistic models of the sun's interior, and a greater understanding of the complex interactions between rotation, convection, and the sun's magnetic field.

Bernard Durney and Andrew Skumanich have studied other aspects of the rotation of the sun (or, theoretically, of any rotating star), such as the effects of gyroscopic and gravity motions. In addition to studying these motions, they have investigated the influence of rotation on the onset of thermal convection — an important question since convective mechanical energy is thought to be the ultimate source of energy for the production of the chromosphere, the corona, and the solar wind.

Richard and Shirley Hansen, in collaboration with Harold Loomis of ESSA and the University of Hawaii, are using a sequence of day-to-day measurements obtained from 1964 to 1967

with the K-coronameter at HAO's Mauna Loa field station to determine the rotation of the corona. Their results indicate that at equatorial latitudes the corona rotates at about the same rate as the solar surface, but at higher latitudes the corona rotates faster than the underlying photosphere, thus in effect smoothing out the differential rotation.



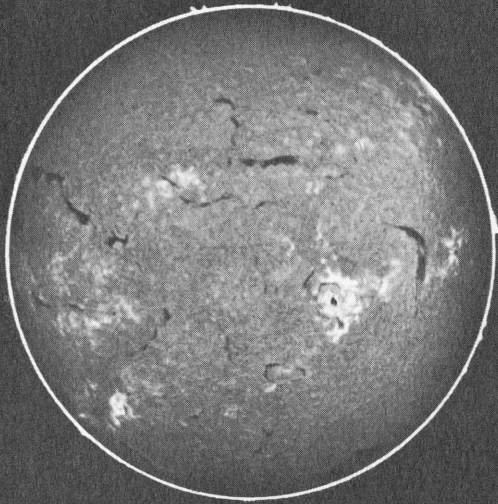
A coronagraph-spectrograph at NCAR's Climax observing station makes possible systematic studies of changing patterns of coronal activity on the sun. A magnetograph used in conjunction with this instrument detects details of the sun's magnetic fields.

MAGNETIC FIELDS IN PROMINENCES AND THE CORONA

It has become increasingly evident that the primary agent which shapes the corona is the main solar magnetic field. This premise is borne out by recent work at HAO. Martin D. Altschuler and Gordon A. Newkirk, Jr., have analyzed photographic and photometric records of the 12 November 1966 eclipse, and compared them with magnetic measurements made at the same time. Shapes of coronal rays and plumes, which are denser areas in the solar atmosphere, conform well with the shape of the solar magnetic fields, reflecting the loops and arches of the field lines. In the lower corona the field seems to be strong enough to completely control the coronal gases, while in the outer corona the solar wind, composed of escaping gases, seems to be capable of unraveling the magnetic field and carrying it out into interplanetary space.

In addition to the main magnetic field of the sun, there seem to be many small, very strong magnetic fields, often of opposite polarity from the main field. These cause or control various phenomena associated with solar activity, such as sunspots, plages, flares, and prominences. The origin of these fields is unknown; they may be created in the turbulent ionized gas below the visible surface of the sun. In complex sunspot groups, the large amounts of energy involved are often great enough to cause auroras and radio disturbances in the earth's atmosphere.

Magnetic fields of individual prominences have been examined by Einar Tandberg-Hanssen and John W. Harvey, using spectral lines of different elements in the magnetograph at HAO's field station at Climax, Colorado. Studies of the role of magnetic fields in prominences have focused on the accumulation of a unique body of measurements collected at Climax. The Climax magnetograph has now been modified to provide greater precision. Recent data suggest that in active prominences very strong local magnetic fields control both the flow of solar material and the temperature gradients, and limit such prominences to their characteristic shapes — loops, surges, caps, filaments, and coronal clouds.

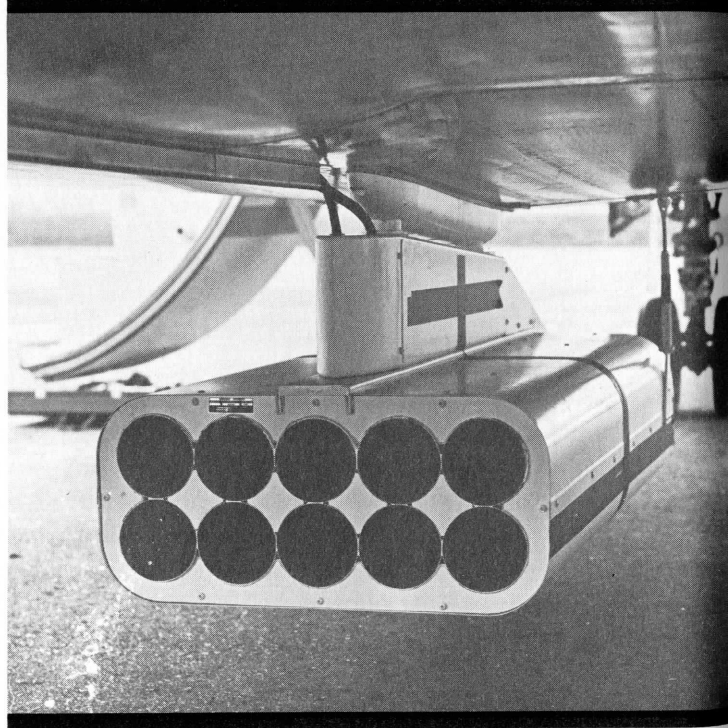


The observing station at Climax keeps continuous watch for the violent flares that erupt in active regions around sunspots. Such flares may cause magnetic disturbances or radio disruptions on earth, or endanger astronauts in space.

During 1968 NCAR acquired a Sabreliner twin-jet aircraft especially modified for research. The seventeen-foot boom will support scientific instruments well in front of aircraft-caused turbulence.



A pod mounted below the NCAR Sabreliner will carry dropsondes, which can be released individually.



FACILITIES OPERATIONS

The NCAR Facilities Laboratory continues to support a broad range of NCAR and university projects. The Research Aviation Facility provided research flight support for many programs and made significant strides in aircraft modification and instrumentation design. During 1968 the Facility acquired a de Havilland Buffalo twin-engine turboprop and a North American Rockwell twin-jet Sabreliner. Both of these aircraft have been modified for research use, and have joined the NCAR Queen Airs as research tools available to the atmospheric science community.

The Scientific Ballooning Facility continued to improve its launch site at Palestine, Texas, and to develop new techniques and carry out research in balloon design and electronic support systems. Staff members met with representatives of the balloon industry and the government to discuss issues of common concern; an outgrowth of these meetings was the formation of a Committee on Scientific Ballooning Standards, to promote use of uniform terminology and to prescribe safety and packaging standards.

The Computing Facility has developed methods to minimize turnaround time and is therefore able to fulfill many more requests, especially for short-run computing jobs. In addition to general-purpose computing for NCAR, university, and other groups, the Facility devotes an entire shift to large-scale dynamic problems associated with development of the NCAR global atmospheric model. The group has also been actively preparing software for the Control Data 7600 computer NCAR hopes to acquire. In addition, they are working closely with a University of Illinois group developing ILLIAC IV, a fast computer particularly suitable for atmospheric simulation.

Support activities of the Field Observing Facility were divided nearly equally between NCAR and university programs. The Facility assisted in field activities of Florida State University's Barbados Experiment in the summer of 1968, the Barbados Oceanographic and Meteorological Experiment in 1969, and a number of other programs. This Facility will play an increasingly prominent role in managing field phases of GARP-related experiments.

Most of the staff of the Global Atmospheric Measurements Program have now moved to the flight station at Christchurch, New Zealand. This group works toward improvement in all phases of the GHOST balloon operation: balloon development, packaging, shipping, launch techniques, electronics performance, tracking accuracy, and interpretation and use of data. In addition, they are developing instrumentation and techniques for automatic surface sensors for remote continental and oceanic areas.



At NCAR's scientific balloon launch station at Palestine, Texas, a balloon is readied for launch. The launch vehicle, known as "Tiny Tim," is able to support heavy, fragile payloads until they are safely airborne.

UCAR AND NCAR EDUCATIONAL ACTIVITIES

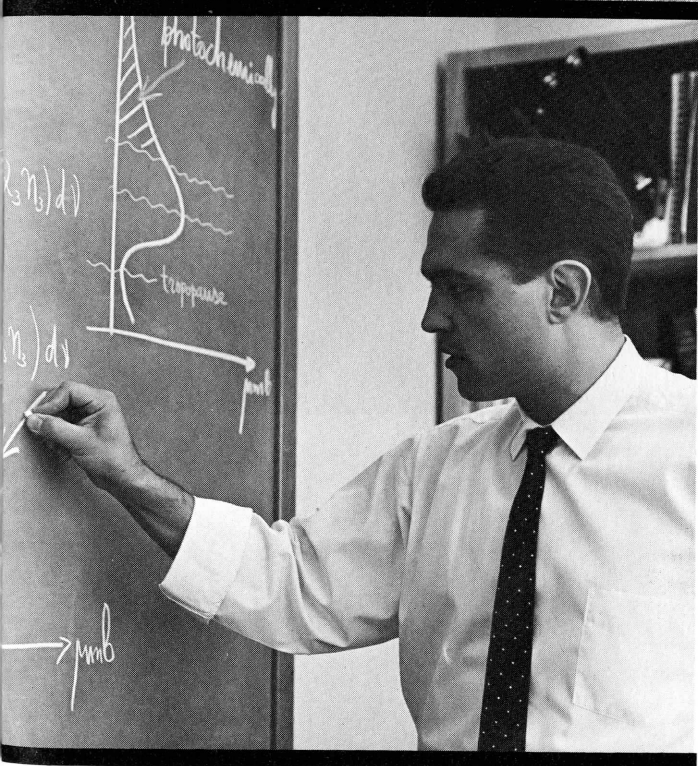
During the past decade, UCAR and NCAR have become increasingly involved in educational activities. These activities have attracted outstanding students into graduate study in atmospheric science and related fundamental disciplines, and have provided established scientists with opportunities to contact and become a part of research activities at NCAR.

Eight UCAR predoctoral fellowships were awarded in 1968 and 1969; recipients receive summer research appointments at NCAR, where they observe and assist in various programs before attending graduate schools of their own choosing with UCAR-sponsored grants-in-aid. Through the Advanced Study Program, NCAR also sponsors postdoctoral appointments for a year of study and research. These appointments are usually on an academic year basis. Fourteen recipients, many from countries other than the United States, were at NCAR during part or all of 1968, eleven during the first half of 1969.

Each summer the ASP also sponsors a colloquium on a topic of fundamental interest in atmospheric science. In 1968 the colloquium, cosponsored by the Department of Astro-Geophysics of the University of Colorado, was on internal gravity and acoustic waves in the atmosphere. Lectures, seminars, and informal discussions involved about twenty invited postdoctoral participants, fifteen graduate students, and other NCAR and University of Colorado scientists and students. The 1969 colloquium, on solar magnetohydrodynamics, is cosponsored by the High Altitude Observatory and the Astro-Geophysics Department of the University of Colorado.

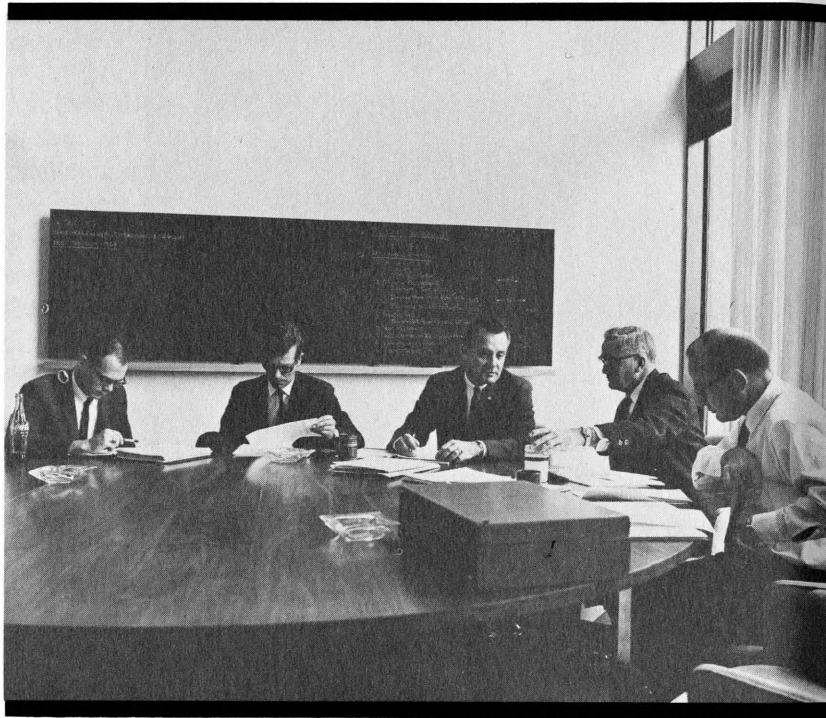


The Max C. Fleischmann Building, begun in 1968 and completed in 1969, will house many of the activities of the Advanced Study Program. Construction funds for the new building came from the Max C. Fleischmann Foundation of Nevada, the El Pomar Foundation of Colorado Springs, UCAR corporate funds, and other sources.



The Advanced Study Program brings to NCAR the talents of visiting scientists from many nations. Rumen Bojkov, from the University of Sofia, Bulgaria, explains a numerical method for computing vertical ozone distribution profiles.

At one of the many conferences held at NCAR, scientists and engineers from NCAR and Goddard Space Flight Center discuss a balloon-satellite system for investigating tropical winds. Left to right are James P. Brown (GSFC), Philip D. Thompson (NCAR), William R. Bandeen (GSFC), John E. Masterson (NCAR), and Charles R. Laughlin (GSFC).



Ten NCAR scientists now hold affiliate professorships at as many universities. During their three-year appointments, affiliate professors consult or lecture for short periods, assist graduate students, and spend at least one term in residence.

NCAR continues to sponsor and host university-based planning conferences, specialized seminars, and colloquia. Among conferences held at NCAR in 1968 and 1969 were the First Conference on Laser Probing of the Atmosphere in April 1968, the Conference on the Structure and Cause of Sporadic E, sponsored jointly by NCAR and ESSA in June 1968, a Hail Workshop in January 1969, the BOMEX Planning Committee meeting in March 1969, and the Conference on the Chromosphere-Corona Transition Region in August 1969.

Summer work-study programs have been conducted by the Computing Facility and the Research Aviation Facility at NCAR. The eight-week work-study program in scientific computing provides atmospheric science students with experience in programming research problems for NCAR's Control Data 6600 computer. The corresponding program in aircraft research observation and instrumentation acquaints students with the capabilities and limitations of aircraft as atmospheric research tools, and provides basic instruction and field experience in aeronautics, instrumentation, and data processing.

UCAR Members' Representatives

UNIVERSITY OF ALASKA
 Keith B. Mather
 Director, Geophysical Institute
 Kenneth M. Rae
 Vice President, Research and Advanced Study

UNIVERSITY OF ARIZONA
 A. Richard Kassander, Jr.
 Director, Institute of Atmospheric Physics
 David L. Patrick*
 Coordinator of Research

UNIVERSITY OF CALIFORNIA
 Orvin W. Campbell
 Vice Chancellor, Business and Finances
 Morton G. Wurtele
 Professor, Department of Meteorology
 University of California at Los Angeles

THE CATHOLIC UNIVERSITY OF AMERICA
 C. C. Chang
 Head, Department of Space Science and Applied Physics
 Donald E. Marlowe
 Dean, School of Engineering Architecture

UNIVERSITY OF CHICAGO
 Roscoe R. Braham, Jr.
 Professor, Department of Geophysical Sciences
 Gilbert L. Lee, Jr.
 Vice President, Business and Finance

COLORADO STATE UNIVERSITY
 A. Ray Chamberlain
 President
 Herbert Riehl
 Professor, Department of Atmospheric Science

UNIVERSITY OF COLORADO
 Charles A. Barth
 Scientific Director of LASP and
 Professor of Astro-Geophysics
 Thurston E. Manning
 Vice President and Dean of Faculties

CORNELL UNIVERSITY
 Ralph Bolgiano, Jr.
 Professor, Department of Electrical Engineering
 Thomas R. Rogers
 Director, Office of Sponsored Research

UNIVERSITY OF DENVER
 Robert L. Chasson
 Chairman, Department of Physics
 Shirley A. Johnson, Jr.
 Director, Denver Research Institute

*Deceased 14 March 1969;
 replaced by Bowen C. Dees,
 Provost for Academic Affairs.

FLORIDA STATE UNIVERSITY

E. Laurence Chalmers, Jr.
Vice President, Academic Affairs
Seymour L. Hess
Professor, Department of Meteorology

UNIVERSITY OF HAWAII

Wytze Gorter
Dean, Graduate Division and Director of Research
Colin Ramage
Associate Director, Hawaii Institute of Geophysics

JOHNS HOPKINS UNIVERSITY

Owen M. Phillips
Professor, Geophysical Mechanics
Benjamin G. Willis
Coordinator, Sponsored Research Administration

UNIVERSITY OF MARYLAND

Helmut Landsberg
Professor, Institute for Fluid Dynamics and Applied Mathematics
Michael J. Pelczar, Jr.
Vice President for Graduate Studies and Research

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Carl F. Floe
Vice President, Research Administration
Henry G. Houghton
Chairman, Department of Meteorology

UNIVERSITY OF MIAMI

Eugene E. Cohen
Vice President for Financial Affairs
Eric B. Kraus
Director, Institute of Atmospheric Science

UNIVERSITY OF MICHIGAN

A. G. Norman
Vice President, Research
A. C. Wiin-Nielsen*
Chairman, Department of Meteorology and Oceanography

UNIVERSITY OF MINNESOTA

Warren B. Cheston
Dean, Institute of Technology
Homer T. Mantis
Professor of Physics

UNIVERSITY OF MISSOURI

William D. Bryant
Coordinator, Research and University-wide Planning
Grant L. Darkow
Associate Professor of Atmospheric Science

*To be replaced temporarily June 1969 to July 1970 by
Edward S. Epstein,
Professor, Department of Engineering.

NEW YORK UNIVERSITY
 James E. Miller
 Chairman, Department of Meteorology and Oceanography
 David Z. Robinson
 Vice President for Academic Affairs

UNIVERSITY OF OKLAHOMA
 Amos Eddy
 Professor of Meteorology
 Gene M. Nordby
 Dean, College of Engineering

PENNSYLVANIA STATE UNIVERSITY
 Alfred K. Blackadar
 Head, Department of Meteorology
 E. F. Osborn
 Vice President, Research

SAINT LOUIS UNIVERSITY
 Edward J. Hellman*
 Business Manager
 Albert J. Pallmann
 Associate Professor, Geophysics and Geophysical Engineering

TEXAS A & M UNIVERSITY
 Horace R. Byers
 Academic Vice President
 John C. Calhoun, Jr.
 Vice President for Programs

UNIVERSITY OF TEXAS
 Norman Hackerman
 President
 University of Texas at Austin
 Archie W. Straiton
 Director, Electrical Engineering Research
 University of Texas at Austin

UNIVERSITY OF UTAH
 Shih-Kung Kao
 Professor, Department of Meteorology
 William S. Partridge
 Director, Research Administration

UNIVERSITY OF WASHINGTON
 Robert G. Fleagle
 Chairman, Department of Atmospheric Sciences
 Joseph L. McCarthy
 Dean, Graduate School

UNIVERSITY OF WISCONSIN
 Robert L. Clodius
 Vice President
 Eberhard Wahl
 Professor of Meteorology

*Replaced 1 July 1969 by
 Clifford J. Murino,
 Vice President for University Research.

UCAR Board of Trustees

- John C. Calhoun, Jr., Chairman
Vice President for Programs
Texas A & M University System
- Earl G. Droessler, Vice Chairman
Vice President for Research
State University of New York
- Seymour L. Hess, Secretary
Department of Meteorology
Florida State University
- Thomas R. Rogers, Treasurer
Director, Office of Sponsored Research
Cornell University
- Walter Orr Roberts
President, UCAR
Boulder, Colorado
- Horace R. Byers
Academic Vice President
Texas A & M University
- A. Ray Chamberlain
President
Colorado State University
- Carl F. Floe, Member of Executive Committee
Vice President, Research Administration
Massachusetts Institute of Technology
- William T. Golden
New York, New York
- Ross R. Heinrich
Acting Dean, School of Engineering and Earth Science
Saint Louis University
- A. Richard Kassander, Jr.
Director, Institute of Atmospheric Physics
University of Arizona
- Helmut Landsberg
Institute for Fluid Dynamics and Applied Mathematics
University of Maryland
- Gilbert L. Lee, Jr.
Vice President, Business and Finance
University of Chicago
- Thomas F. Malone
Senior Vice President and Director of Research
Travelers Insurance Company
Hartford, Connecticut
- Kenneth M. Rae
Vice President, Research and Advanced Study
University of Alaska
- Walter J. Saucier
Professor of Meteorology
University of Oklahoma
- William S. Jackson, Trustee Emeritus
Denver, Colorado

NCAR Senior Management Staff

John W. Firor
Director

Gordon A. Newkirk, Jr.
Associate Director and
Director, High Altitude Observatory

William W. Kellogg
Associate Director and
Director, Laboratory of Atmospheric Science

Philip D. Thompson
Associate Director and
Head, Atmospheric Dynamics Department, Laboratory
of Atmospheric Science

Daniel F. Rex
Associate Director and
Director, Facilities Laboratory

Bernhard Haurwitz
Director, Advanced Study Program

Fred W. Roecker
Assistant Director for Administration

UCAR Financial Report

Fiscal Years 1968 and 1969

Contracts, grants, and gifts administered by UCAR totaled approximately \$15.2 million in Fiscal Year 1968 and \$15.4 million in Fiscal Year 1969. The corporate management fee from the National Science Foundation for services rendered by UCAR in management of NCAR was \$140,000 for each year.

Funding from NSF through Contract NSF-G460 for maintenance and operation of NCAR totaled approximately \$11.6 million in FY 1968 and \$10,510,000 in FY 1969. These funds were apportioned among the operating divisions as follows:

	<u>1968</u>	<u>1969</u>
Laboratory of Atmospheric		
Science	\$2,090,000	\$2,370,000
High Attitude Observatory.....	1,360,000	1,340,000
Advanced Study Program.....	270,000	360,000
Facilities Laboratory	5,800,000	4,330,000
Research Support Group.....	613,000	630,000
Administration	1,467,000	1,480,000
	<u>\$11,600,000</u>	<u>\$10,510,000</u>

Included in the Facilities Laboratory funds in 1968 is approximately \$1.6 million used for the acquisition of a North American Sabreliner jet aircraft modified for research purposes.

An additional \$3.4 million was received in 1968 and \$3.8 million in 1969 from contracts with NASA, the Air Force, the Army, Colorado State University, and the National Institutes of Health. Included in these figures are \$620,000 in 1968 and \$733,000 in 1969 from the Air Force to support the work of High Altitude Observatory staff members at the Air Force's Sacramento Peak (New Mexico) Observatory. HAO also received approximately \$2,260,000 in 1968 and \$2,493,000 in 1969 from NASA to continue the design and construction of a white-light coronagraph to be flown in an Apollo spacecraft in 1972. The Facilities Laboratory received \$425,000 in 1968 and \$481,000 in 1969 from NASA to support NASA-sponsored balloon flights from NCAR's Balloon Flight Station at Palestine, Texas. Approximately \$95,000 in 1968

and \$119,000 in 1969 were received from NASA, NIH, CSU, and the Department of the Army for specific research projects, with definite termination dates, in the Laboratory of Atmospheric Science and the High Altitude Observatory. Under these contracts, a total of \$1,862,000 was actually spent or committed during 1968 and \$3,734,000 in 1969.

Property is recorded at cost except for property acquired from United States Government excess, donations, and grants, which is recorded at an appraised value of \$4,304,000 and \$4,845,000 at 30 June 1968 and 30 June 1969, respectively. Title to \$22,030,916 of UCAR property is vested in the National Science Foundation and other government agencies, with the balance owned outright by the Corporation. In accordance with practices generally followed by organizations similar to the Corporation, no provision has been made for depreciation of property.

On 30 June 1969, the University Corporation for Atmospheric Research had unfilled purchase order and contract commitments of approximately \$2,678,000 and a contingent liability of approximately \$546,000 for employee vacations which would be satisfied in event of termination of the NSF contract for the convenience of the government.

The number of regular staff members employed by UCAR in the operation of NCAR was 501 on 30 June 1969. Of this number, 222 were scientists, engineers, and professional staff; 167 technical and maintenance staff; and 112 administrative, secretarial, and clerical staff.

UCAR's balance sheet as of 30 June 1968 and as of 30 June 1969, and a statement of revenues and expenditures for fiscal 1968 and 1969, are included at the end of this section.

University Corporation for Atmospheric Research

Balance Sheet
30 June 1968 and 1969

		ASSETS	
		<u>1968</u>	<u>1969</u>
Current Fund			
Cash (includes \$105,000 in 1968 and \$75,000 in 1969 in interest-bearing deposits)	\$	200,078	\$ 183,620
U.S. Government securities		208,619	210,310
Receivables		2,729,935	2,263,651
Prepaid expenses		238,373	217,687
Total Current Fund....		<u>3,377,005</u>	<u>2,875,268</u>
 Plant Fund — Property, Plant, and Equipment			
Plant		8,338,832	8,454,660
Equipment		12,434,695	14,370,355
Construction in progress		295,680	345,382
Total Plant Fund.....		<u>21,069,207</u>	<u>23,170,397</u>
TOTAL	\$	<u>\$24,446,212</u>	<u>\$26,045,665</u>

LIABILITIES AND FUND BALANCES

Current Fund			
Accounts payable and accrued expenses	\$	564,117	\$ 602,282
Balance			
National Science Foundation & other government contracts and grants (restricted)		2,478,469	1,927,011
Corporate (unrestricted).....		334,419	345,975
Total balance		<u>2,812,888</u>	<u>2,272,986</u>
Total Current Fund		<u>3,377,005</u>	<u>2,875,268</u>
Plant Fund Balance		<u>21,069,207</u>	<u>23,170,397</u>
TOTAL	\$	<u>\$24,446,212</u>	<u>\$26,045,665</u>

University Corporation for Atmospheric Research

Revenues and Expenditures
and Changes in Current Fund Balance
for the Years Ended 30 June 1968 and 1969

	<u>1968</u>	<u>1969</u>
Revenues from Contracts,		
Grants and Gifts	\$15,245,041	\$15,400,465
Expenditures		
Operating		
Salaries and wages.....	5,350,182	6,187,715
Employee benefits	595,829	727,264
Materials and supplies.....	1,424,257	1,740,288
Services	4,222,535	4,417,149
Travel	420,463	400,772
Other	246,869	179,341
TOTAL	<u>12,260,135</u>	<u>13,652,529</u>
Property	1,956,785	2,287,838
TOTAL	<u>14,216,920</u>	<u>15,940,367</u>
Revenues over (under)		
expenditures	1,028,121	(539,902)
Current Fund Balance,		
Beginning of Year	<u>1,784,767</u>	<u>2,812,888</u>
Current Fund Balance, End of Year	<u>\$ 2,812,888</u>	<u>\$ 2,272,986</u>

Changes in Plant Fund Balance
for the Years Ended 30 June 1968 and 1969

	<u>1968</u>	<u>1969</u>
Fund Balance, Beginning of Year	\$19,186,231	\$21,069,207
Acquisitions	4,224,399	2,882,225
Disposals	<u>(2,341,423)</u>	<u>(781,035)</u>
Fund Balance, End of Year	<u>\$21,069,207</u>	<u>\$23,170,397</u>

HASKINS & SELLS

CERTIFIED PUBLIC ACCOUNTANTS

621 SEVENTEENTH STREET
DENVER 80202

ACCOUNTANTS' OPINION

Board of Trustees,
University Corporation for Atmospheric Research:

We have examined the balance sheets of the University Corporation for Atmospheric Research as of June 30, 1968 and June 30, 1969, the related statements of revenues, expenditures, and changes in current fund balance, and the related statements of changes in plant fund balance for the two years then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying financial statements present fairly the financial position of the University Corporation for Atmospheric Research at the above-mentioned dates and the results of its operations for the two years then ended, in conformity with generally accepted accounting principles applied on a consistent basis.

August 1, 1969

Yours truly,

