UNIVERSITY OF ARIZONA

INSTITUTE OF ATMOSPHERIC PHYSICS

PROGRESS REPORT NO. 3

Roscoe R. Braham, Jr. - Director

June 15, 1956

INTRODUCTION

This, Progress Report No. 3, might better have been entitled, "Annual Report No. 2", since it is written very nearly on the second anniversary of the arrival at the University of Dr. J. E. McDonald, Associate Director of the Institute. His arrival marked the actual beginning of Institute activity and it was not long after that time that the balance of the present professional staff arrived and a program was launched.

Progress since that date has been heartening and the University can now point with some pride to a group that has emerged from the planning stage into a productive, recognized research organization which has taken its place with similar groups in the meteorological field. Probably the most notable feature of the second year of operation, of which this is a report, is the noticeable change from a planning, setting-up, and initial implementation type of operation to a properly productive operation.

As evidence that a productive level has been reached, this report is written as a brief outline of the aims of each phase of the operation and the real progress is reported in the Appendix where the abstracts and summaries of appropriately distributed Institute reports have been assembled.

It is intended that the "Progress Report" series of Institute publications will be distributed on the 15th of December and the 15th of June each year in the future.

REPORT OF PROGRESS

The various phases of the Institute operation, with no significance to be attached to the order of listing, are as follows:

1. Synoptic Climatology
2. Cloud Census
3. Freezing Nuclei Investigations
4. Solar Radiation Measurements

Certain other activities, both direct and supporting, have been started during the past year which do not necessarily fit in the above categories. These will be discussed separately in this section or under "Future Plans".

J. E. McDonald, R. B. DesJardins, and C. H. Reitan have undertaken the work of the Synoptic Climatology program. Under Dr. McDonald's direction the most significant phase of this part of the program was the setting up of the IBM punchcard facility. Now under the direction of Mr. DesJardins, this facility involves eight IBM punchcard machines of various types and a full-time additional operating staff of five people. On November 15, 1955 a "First Annual Progress Report" of the cooperative punchcard climatological program was distributed. The summary of this report is presented as Item 1 of the Appendix.

At present, almost exactly 50 per cent of the 3175 station years of data to be analyzed has been punched. When completed, the Institute library of historical Arizona climatological data will involve about one and one-half million cards, and will make this state's punchcard climatological resources among the most extensive in the country.

As a service, the IBM group made an analysis of the precipitation at nine stations in the Salt River Basin for the Arizona Watershed Program.

Another phase of the Synoptic Climatology program involves a study of the distribution and large-scale flux of water vapor, as well as the relation of surface and upper level winds to the distribution of moisture. Dr. McDonald summed up the Institute's position and work in this area in a paper presented at the Conference on the Scientific Basis of Weather Modification Studies, Tucson, April 11, 1956. The abstract of this paper is presented as Item 2 of the Appendix. The work in Synoptic Climatology has been supported entirely by state funds.

The Cloud Census phase of the Institute operation occupies the attention of almost the whole staff during the summer rainy period. All possible ground photographic, radar and visual observations are made to determine the locations, characteristics, and growth rates of precipitating and non-precipitating clouds. In addition, a flight program operated by the University of Chicago has been cooperating with the Institute in determining the in-cloud conditions at the same time. During the summer of 1955 approximately 40,000 feet of radar photographs were taken in addition to about 5000 feet of 16mm lapse-time movies and about 3500 stereo-pairs of cloud systems were taken with ground-based aerial cameras. This tremendous amount of data has only been superficially analyzed but many interesting facts are becoming apparent. R. R. Braham, Jr. devoted himself to radar data analysis, L. L. Sims to aerial photograph analysis and A. R. Kassander and L. L. Sims were largely concerned with the instrumentation.

In addition to the results reported in "Progress Report No. 2", November 30, 1955, Dr. Braham presented further results of this operation to the Conference on the Scientific Basis of Weather Modification Studies. The abstract of his paper is presented as Item 3 of the Appendix. Dr. Kassander outlined some of the Institute's field techniques in the cloud census area to this same conference and the abstract of his paper is

presented as Item 4 of the Appendix. In addition, since the use of ground-located aerial cameras in the field of cloud photogrammetry is new and since it is felt that the Institute's analysis techniques represent a contribution in the field, a complete discussion of the techniques is being prepared as "Scientific Report No. 2" to be distributed June 15, 1956. The abstract of this report is presented as Item 5 of the Appendix. This paper was prepared by A. R. Kassander and L. L. Sims. The work in the Cloud Census area was supported by Sloan Foundation Funds.

Less emphasis was placed on the field of Freezing Nuclei Measurements than had been in the previous year. Continuing the experiment with the Australian group, measurements were made at the laboratory during January of 1956. The ground measurements are inferior to airborne measurements, and, although a calculated risk was involved in making these measurements, it is felt that useful results were obtained even if the fluctuations characteristic of the "Bowen Peaks" were not detected.

A paper was prepared by Kassander, Sims and McDonald on the results of the 1955 measurements and on certain laboratory experiements that were performed subsequently. This paper was presented by McDonald at the Conference on the Physics of Cloud and Precipitation Particles at Woods Hole, September 7-10, 1955. The summary of a portion of this paper is presented as Item 6 of the Appendix.

In the area of Solar Radiation Measurements, progress has been made. A Total Incidence Pyrheliometer was installed at the Institute buildings. A new device was constructed to print out hourly totals of incoming radiation and this was reported to the World Symposium on Applied Solar Energy by Kassander on October 31, 1955. Subsequently, "Scientific Report No. 1.", dated March 1, 1956 was distributed. The

abstract to this report is submitted as Item 7 of the Appendix.

The Institute engaged the firm of Donovan and Bliss, local consultants in the field of solar energy, to make a study of the comparative solar energy receipts on the campus, at Sahuarita, and the top of Tumamoc Hill. It was felt that such information would be invaluable for any University or Institute effort in the direction of expansion of solar energy measurements or utilization experiments. Their report was submitted in March, 1956. It was a well-executed investigation and the general conclusion reached was that the total radiation on a horizontal surface may be diminished by a maximum of 10% due to the dust over the city and that the direct radiation may be diminished by twice that much under conditions of low solar altitude.

The Institute is now a regular cooperator with the Weather Bureau in supplying hourly totals of incoming solar radiation. A Normal Incidence Pyrheliometer has also been set up to measure the radiation in the direct solar beam. The Institute is therefore in the position to supply the most generally used basic solar radiation data to any persons on the campus or in the vicinity desiring to do solar energy utilization experiments. The solar radiation work is supported by state funds.

Another experiment has been started which does not quite fit into the categories listed although it would be most closely associated with the Synoptic Climatology. This is a study of the wind circulation on the ground in this general area and its relation to the topography and thermal structure. Six remote recording wind sets of a new design have been constructed and placed at sites at Casa Grande, Sonoita, Amado, Pearce, Fairbanks, and Cascabel. Coupled with the existing Weather Bureau observations the data to be obtained during the summer of 1956

should make an important contribution to the knowledge of valley winds and their relation to cloud formation. This work is also being supported by state funds.

During January and February of 1956 the Institute engaged in another activity directly concerned with the physics of clouds but separate from its four basic areas of activity. The Institute supported through its National Science Foundation grant a flight operation using the B-17 airplane supplied by the Air Force to the University of Chicago. Chicago personnel manned the airplane. The two Institute radar sets were an integral part of this operation. The regular 3-centimeter set was operated from the Engineering Building roof and the new 1.25 centimeter radar was operated from Ryan Field through the cooperation of the Tucson Airport Authority.

A total of ten flights were made, four of them in the hoped-for winter stratiform type clouds. Information was gathered on cloud droplet size distribution, liquid water content, temperature structure, condensation nuclei, and radar echo structure. This operation was considered highly successful, particularly in the light of the unfavorable probabilities associated with having the B-17 and the clouds in the sky at the same time during a relatively limited operational period. The data accumulated are still being processed. Much is hoped for from this experiment since very little is known about the stratiform clouds, in Arizona or anywhere else.

As a slightly different activity, the University entered into a contract with the Army Electronic Proving Ground at Ft. Huachuca whereby Institute personnel were to visit the Aviation and Meteorology Group at AEPG for the purpose of evaluating the forecasting program and the micrometeorological network being set up. Drs. McDonald and Kassander spent

three days with that group and then returned to Tucson to prepare a report in fulfillment of the contract. This report was submitted on May 10, 1956.

PERSONNEL

The Institute staff has remained relatively stable in number. Since "Progress Report No. 2" Ferdinand Baer, Assistant in Meteorology, resigned to return to the University of Chicago. Mrs. Delaney, IBM Supervisor and Mrs. McKaig, Key Punch Operator, resigned. Mrs. Emily Preskar, and Marion O'Brien joined the IBM group. Mrs. Jean Bruner was employed as Analyst to work on the radar data and John Ewing and Eileen Walsh joined the ranks of the student assistants. This makes for a staff of sixteen regularly employed persons and nine part-time employees. During June, 1956, Richard Neville and Richard Roth, undergraduates at California Institute of Technology and Harvard College, respectively, will join the staff.

SCIENTIFIC ACTIVITIES

The high point of the year as far as local meetings were concerned was the Conference on the Scientific Basis of Weather Modification Studies. This meeting was held on April 10-12, 1956 on the University campus. The meeting was organized and staged by the Institute with Dr. McDonald acting as program director. Funds were provided by the Rockefeller Foundation to bring foreign scientists to the campus. The meeting was considered to be an outstanding success. A draft of the report on the meeting which is to appear in the Bulletin of the American Meteorological Society is presented as Item 8 of the Appendix.

Institute personnel reported on Institute activities at the following group meetings:

Sept. 7-10	Cloud Physics Conference, Woods Hole, Mass. R. R. Braham, J. E. McDonald
Sept. 7	San Pimal Cattle Grower's Association, Tucson A. R. Kassander
Oct. 11	Agriculture Men's Club, Tucson J. E. McDonald
Oct. 20	Tucson High School Science Club J. E. McDonald
Oct. 22	Arizona State Science Teachers, Tucson J. E. McDonald
Oct. 27	Arizona Geological Society, Tucson A. R. Kassander
Oct. 31	World Symposium on Applied Solar Energy, Tucson A. R. Kassander
Nov. 3	Naval Research Unit, Tucson R. B. DesJardins
Nov. 30	Colorado River Water Users, Las Vegas J. E. McDonald
Dec. 13	PSIAC Hydrology sub-committee, Yuma J. E. McDonald
Jan. 4-5	Imperial College, London, England J. E. McDonald, R. R. Braham, Jr.
Jan. 8	Cross-section, U of A, TV, Tucson R. B. DesJardins
Jan. 10	Cross-section, U of A, TV, Phoenix R. B. DesJardins
Jan. 17	Sigma Pi Sigma, Tucson A. R. Kassander
Feb. 9	Amphitheatre H. S. Science Club, Tucson J. E. McDonald
Feb. 4	Air Pollution Symposium, Tempe J. E. McDonald, A. R. Kassander
Apr. 11	Weather Modification Conference, Tucson R. R. Braham, A. R. Kassander, J. E. McDonald

Apr. 13	Ivy College Group, Tucson A. R. Kassander
Apr. 19	American Meteorological Society, Bisbee J. E. McDonald, A. R. Kassander
May 2	Mountain States T & T Co., Tucson A. R. Kassander
May 4	National Association of Manufacturers, Tucson J. E. McDonald

FUTURE PLANS

All of the activities that have been described will be continued in the next year. Two new investigations are planned.

The first of these will start during the last two weeks of June, 1956. In this experiment it is intended to determine the trajectories of air-borne particles released from the ground in the vicinity of mountain ridges. Zinc sulphide pigment will be mixed with fog oil. This material will then be dispersed by Navy fog generators. Light airplanes will make traverses across the plume and the zinc sulphide particles will be captured as they impinge on gelatin-coated plastic strips mounted in impactors in the airplanes. The particles will then be detected and counted using a microscope and ultraviolet illumination. The zinc sulphide acts as a tracer material since it fluoresces brightly when illuminated by ultraviolet light.

The second new experiement involves setting up infra-red spectrometric equipment to observe the absorption of infra-red solar radiation by water vapor in the atmosphere. Previous experiments have indicated that the water vapor of the atmosphere may not be homogeneously distributed, and if this is the case, the actual distribution of atmospheric water vapor should be well understood by a group working on fundamental rainfall processes.

APPENDIX

Item 1. Cooperative Punchcard Climatological Program

"First Annual Progress Report"

James E. McDonald

November 15, 1955

IV. SUMMARY

The work done during the first twelve months of the punchcard climatological program of the Institute of Atmospheric Physics has been described in detail. In recognition of the pressing need for many types of planning information in the organization of a cooperative Weather Bureau-university punchcard program, this report has been written in such a way as to provide a reasonably complete summary of our own experience in setting up a punchcard program. It is thus hoped that the present report may prove useful to other university groups seeking information as to editing, punching, and processing rates and costs, machine types, and other details.

It is strongly recommended, upon the basis of our experience during the past year's punchcard work, that a very detailed manual for cooperative punchcard projects be drawn up by the Weather Bureau. Such a manual, if it contained in more comprehensive form the type of information we have attempted to incorporate into the present progress report, would be invaluable to other universities contemplating establishment of cooperative projects. We wish particularly to stress the need for a truly complete compilation of editing, punching, and processing rules that will enable cooperators to follow established Bureau procedure at every stage of their work.

An extended list of examples of problems proposed for analysis in the Institute's program has been presented here in order that the present report may not only inform Weather Bureau readers of the scope of our projected studies but also suggest to Arizona readers the types of problems which may be usefully explored by IBM punchcard methods. It is strongly hoped that the latter readers will communicate to the Institute of Atmospheric Physics additional problems for study based upon the suggestions inherent in the examples cited herein.

Item 2. Paper Presented at the Conference on the Scientific Basis of Weather Modification Studies, Tucson, April 11, 1956

CLIMATOLOGICAL STUDIES PREREQUISITE TO A RATIONAL WEATHER MODIFICATION PROGRAM

James E. McDonald
Institute of Atmospheric Physics
University of Arizona

Whereas cloud physics and physical meteorology in general have received vigorous impetus from the past decade's interest in cloud modification, climatology has remained relatively unaffected.

The underlying reason is the same in each case: the most pressing problem has been and still is that of proving or disproving the practical significance of modification efforts. However, excellent reasons do exist for institutions interested in the overall modification problem to pursue research on certain neglected problems of climatology. It is suggested that an embarrassingly large number of such climatological problems satisfy the following two criteria: (1) The problem must ultimately be solved if the efficacy of modification techniques is ever clearly proved and if modification programs are then to be conducted on a rational basis, (2) The problem is of such basic importance in the fields of meteorology and climatology that it warrants some measure of early attention regardless of the outcome of current weather modification studies.

The climatological research program of the Institute of Atmospheric Physics has been developed chiefly around problems satisfying the above two criteria, so it is possible to survey these gaps in climatological knowledge prerequisite to modification efforts with special reference to work now underway or investigations soon to be begun in the Institute program. Emphasis will be placed on four key areas of needed climatological investigation: Spatial and temporal distribution of precipitable water vapor, large-scale water vapor flux, cloud-census statistics, and spatial and temporal rainfall variability. It is to be noted that these problems of basic interest to modification efforts do also satisfy the second suggested criterion of needing early attention in this region, since there has been a surprising dearth of fundamental studies of the climatology of the arid southwestern United States and adjoining portions of the Sonoran Desert.

The present state of knowledge of the distribution of precipitable water vapor is summarized and concluded to be deficient. A special Institute study, just completed, has yielded mean monthly precipitable water vapor values from the surface to 325 mbs for the summer months from May to September for twenty-three radiosonde stations in the southwestern U.S., Mexico, and the Caribbean. Concurrently, mean 700- and 500-mb mixing ratios and coefficients of variation thereof have been computed for the same months for all U.S., Mexican, and Caribbean stations. Both of these studies have been based on the last ten year's of raob data and are the first portion of a continuing study of water vapor distribution which will be extended by IBM punchcard methods shortly. Some results of weather modification interest will be described.

Knowledge of the patterns of upper atmospheric water vapor flow is essential to any intelligent appraisal of what limitations will be inherent in any modification methods that may ultimately be realized. Here, as in the simpler problem of the vapor distribution, large gaps now exist. A study be Benton has revealed many interesting features of the flux of vapor over North America for a single year (1949). Much more work along these lines is desirable and preparations are now being made to study in detail the vapor flow over at least the entire Colorado River Basin, using the Institute IBM facilities. Closely related to this investigation is the study of the "efficiency" of release of water vapor as precipitation. A pilot study by Reitan has revealed that for Arizona summer conditions, amounts of rain varying between zero and a maximum of only about 13% of total precipitable water vapor are released per day. An interesting threshold effect and an unexpected rise of efficiency with rise of total precipitable water vapor has been noted by Reitan and will be described. Upper-level trajectory studies of summer vapor movements over Mexico and the southwestern United States will be summarized and the need for further investigations stressed.

An awkward lack of the type of cloud-climatology data needed for proper planning of weather modification research (let alone further modification applications) now exists. Institute studies to fill this gap in the case of the southwestern region are summarized, with special reference to a completed study by DesJardins in which 25,000 Weather Bureau cloud observations for Tucson were analyzed. Of particular importance is the finding that there appear to be fairly frequent discrepancies between variations in amounts of the rain-giving types of clouds and actual precipitation amounts received. These discrepancies seem to imply that a wetter-than-average month may be wet due to other factors then mere extent of condensation of available water vapor into rain-type clouds. Further study of these points is about to be undertaken by IBM methods, using all available first-order Weather Bureau stations in Arizona. Some shortcomings of existing cloud-reporting techniques that appear serious from the viewpoint of cloud physics research came to light in DesJardins' study and will be mentioned briefly.

The climatology of rainfall variability is one area in which one can actually point to real increases in understanding engendered by the past decade of interest in weather modification. Nevertheless, important shortcomings definitely exist even in this area. Examples of some remaining gaps are given, and a brief summary of Institute efforts to explore the variability problem in the arid Southwest will be presented.

Item 3. Paper Presented at the Conference on the Scientific Basis of Weather Modification Studies, Tucson, April 11, 1956

SYSTEMATIC CLOUD STUDIES AS A PREREQUISITE FOR CLOUD MODIFICATION EXPERIMENTS

Roscoe R. Braham, Jr.
Institute of Atmospheric Physics
University of Arizona

The course of evolution of a natural cloud depends upon physical, thermodynamical, hydrodynamical and chemical factors which are related and which interact in a complex and generally poorly understood fashion. As a consequence, it was quite natural that the first attempts at cloud modification were of an exploratory nature. Such experiments have illuminated many factors about cloud and precipitation development. Equally importantly, as a result of intense studies of clouds which have followed these experiments, we have come to realize, even better than before, the great variability in the way in which clouds develop. This variability is manifest between neighboring clouds; between clouds on various days, of various seasons and in various geographical localities; and in the way in which clouds respond to various treatment experiments.

Experience has shown that to go from the exploratory experiments to a series of testing experiments is a long and expensive task, largely because of this variability inherent in clouds. In order to design experiments which are capable of testing modification hypotheses with a minimum of effort, it is desirable first to undertake extensive systematic studies of clouds at many places and times. These studies are aimed at separating the influence of various parameters on the development of clouds and precipitation.

Several such studies of clouds have been carried out in recent years. Others are in progress. The research programs of the University of Arizona and the University of Chicago cloud physics group are concentrated along these lines.

From these studies it is possible to specify, at least for some regions and seasons, such parameters as 1) the types of clouds which are suitable for study (both from the standpoint of maximizing the power of the test experiments and from the standpoint of the suitability of maximum return from seeding), 2) the types of reagents which are suitable, 3) the probability of natural precipitation, 4) the size of the cloud region where seeding might be fruitful, 5) the natural precipitation mechanism, 6) the number of experiments required to test a hypothesis, 7) the average life of a cloud element (which determines the time available for a reagent to act), and many others.

Item 4. Paper Presented at the Conference on the Scientific Basis of Weather Modification Studies, Tucson, April 11, 1956

SOME FIELD STUDIES BASIC TO CLOUD PHYSICS RESEARCH

A. Richard Kassander, Jr.
Institute of Atmospheric Physics
University of Arizona

As of this date, the Institute of Atmospheric Physics has done no experiments in cloud seeding. However, the Institute has been engaged in a number of field experiments which are of basic importance to cloud physics and to future cloud seeding experiments.

In the past eighteen months, a number of the experiments done have been duplications of those done elsewhere, largely because they represent experiments fundamental to the science which may give different answers in this area. Thus, we have performed our own radar versus visual cloud census after the methods of the New Mexico Institute of Mining and Technology and the University of Chicago Cloud Physics Project. We have done air and surface freezing nuclei counts in cooperation with the Commonwealth Scientific and Industrial Research Organization of Sydney, Australia. We have made halide counts using millipore filters after the techniques of the Chicago Cloud Physics Project. We have operated a vertical pointing K-band radar in the manner of the Air Force Cambridge Research Center and McGill University. We have participated in in-cloud winter cloud flights with the University of Chicago group, and in June we will make air-flow studies over the local mountains using the fluorescent particle tracer technique of the New Mexico group.

In three of these studies, we have made some modifications or developed new techniques for making the measurements involved. We have now had an operating season's experience with each and feel that in their present form or with some modifications they represent an important contribution to the instrumentation of this field.

In the case of the cloud census we felt that to have Plan-Position-Indication type presentation of the radar data in addition to the Range-Height-Indication of our TPS-10 radar would be a big aid in analysis, both from the standpoint of finding the preferred location of precipitation echoes and their movements and also from the point of view of obtaining a simpler catalogue of the tremendous amount of data one obtains from RHI photographs. This has been obtained by the modification of a surplus TPS-3 PPI indicator fed directly from the RHI video input.

In addition it was felt that the basic techniques of visual cloud census were inadequate in that they either sacrificed field of view in order to gain accuracy or they sacrificed accuracy to gain field of view. We feel that we have reached a good compromise by the use of a pair of K-17 aerial cameras mounted on the ground, with their axes perpendicular to each other, roughly one mile and a quarter apart. Using simultaneous photographs and appropriate analysis equipment, ranges and heights to cloud points can be determined in a seventy-four degree field to about five percent accuracy out to about forty miles with the baseline used. Accuracy is, of course, better at shorter ranges and data is obtainable with less precision at ranges substantially greater than forty miles.

To get a regional picture of the wind structure in the June tracer experiment, we will use six recording wind speed and direction sets using modified 16 mm GSAP movie cameras. These units use contacting anemometers and vanes which record on a panel of electrical counters in such a way that each 1/60 mile contacting of the anemometer is directed to one of eight counters by means of the vane to indicate the passage of the wind in the particular one of the eight compass directions indicated by the vane. The panel is photographed every hour. Thus, the wind-speed weighted wind-direction rose is determined for each hour. The units are designed to operate unattended for one month on each magazine load of film.

The specific results of some of these studies will be reported in other papers of this conference. It can be readily seen that studies of this type are fundamental to any future weather modification experiment in that we will be better prepared to know the preferred areas of cloud formation, the percent of clouds in which precipitation processes initiate in a supercooled medium, the natural precipitation time scale, the number of natural freezing nuclei available, and, especially important, where a ground-generated plume goes under various wind conditions.

Item 5. Cloud Photogrammetry with Ground-located K-17 Aerial Cameras

"Scientific Report No. 2"

A. Richard Kassander, Jr. and Lee L. Sims

June 15, 1956

ABSTRACT

A technique is presented in which a pair of ground-located K-17 aerial cameras are used on a 1.30 mile baseline to determine cloud ranges to one mile accuracy at 40 miles and cloud height measurements to within 500 feet at this range. Details of the power supply, vacuum supply, and camera synchronization requirements are discussed as well as methods used in analysis. In particular, a detailed discussion is given of the theoretical and practical errors encountered in such a photogrammetric technique.

Item 6. Paper Presented at the Conference on the Physics of Cloud and Precipitation Particles, Woods Hole Oceanographic Institute, September 7-10, 1955

OBSERVATIONS OF FREEZING NUCLEI OVER THE SOUTHWESTERN U. S.

A. Richard Kassander, Lee L. Sims, and James E. McDonald

Summary and conclusions. The Arizona nuclei counts of January 1955 do not exhibit fluctuations that support in any clearly recognizable way the hypothesis that Bowen has formulated to account for certain irregularities in long-term rainfall records. Concurrent counts made in Sydney with the same apparatus and observing techniques do appear to support the meteoritic dust hypothesis, as do also concurrent counts taken in Hawaii and Panama. Whether some peculiarity in the high-level airflow over the southwestern Arizona could account for a failure to observe such peaks, or whether unrecognized differences in observing techniques are basically responsible, or whether some phenomenon not related to meteoritic dust is in control here is not clear.

It is of considerable interest to learn that the nucleating efficiency of freezing nuclei in Arizona during January 1955 was nearly identical, on the average, to that of nuclei over eastern Australia, for this poses the possibility that some sort of large-scale uniformity may exist in this regard. The Hawaii and Panama data tend to support this speculation, though those observations were less detailed than the Tucson and Sydney observations.

The work reported here must be regarded as making its principal contribution by virtue of providing free-air observations of the activation temperatures corresponding to a series of different crystal concentrations in air that may be regarded as representative of the southwestern U. S. in midwinter. In general, it would seem that air must rise to an altitude of between 20,000 to 25,000 ft. in winter in the southwestern U. S. in order to be cooled to such a low temperature as to yield crystal concentrations of the order of those currently felt to be necessary to initiate the Bergeron process in supercooled clouds.

Item 7. An Automatic Printing and Totalizing Device for Solar Radiation Measurements

"Scientific Report No. 1."

A. Richard Kassander and Lyle L. Knowles

ABSTRACT

A device is presented which performs the time integration operation when hourly totals of incoming solar radiation are desired. This device, which is coupled to a standard self-balancing potentiometer type of recorder, samples the record each minute and prints out the indicated value. After sixty such samples are taken the total is then printed as well as the time of day. The operation starts and stops automatically at pre-set dawn and dusk times.

Item 8. Report on scientific meeting for Bull. Am. Met. Soc.

CONFERENCE ON THE SCIENTIFIC BASIS OF WEATHER MODIFICATION STUDIES

James E. McDonald
Institute of Atmospheric Physics
University of Arizona

An international conference on the Scientific Basis of Weather Modification Studies was held April 10-12, 1956 at the Institute of Atmospheric Physics, University of Arizona. Scientists representing nearly all of the world's leading cloud modification and cloud physics research groups were present. A total of nine foreign scientists (whose travel travel was supported by the Rockefeller Foundation) and twenty-six U. S. scientists presented papers on a broad range of problems including cloud microphysics, cloud dynamics, nucleation phenomena, past and current cloud-modification experiments, and statistical evaluation methods.

By far the most vigorous Conference discussions developed around a recent evaluation study made by the President's Advisory Committee for Weather Control. Several of the statisticians present were unwilling to accept the implications, highly favorable to certain past seeding results in the western U. S., found in some of the communications accompanying the Advisory Committee's recent Interim Report to the President, and this chiefly on two accounts: 1) the basic data used were very limited, but, more particularly, were not derived from closely controlled randomized seeding trials (a situation which the staff of the Committee pointed out it clearly recognized from the start), and 2) the particular statistical methods employed were said to contain technical defects (of a nature which did not become quite clear to most non-statisticians present). The Committee emphasized that its results must not be extrapolated to any other regions than those (West Coast orographic) areas for which it felt it had evidence of increases, "granted that the Committee's procedures are valid", and reaffirmed its position with respect to its Interim Report. In all, the principal points of contention finally seemed to reduce to the two questions of whether the evaluation results should have been presented with more clear-cut reservations based on the limitations believed by most conferees to be inherent in the commercial cloud seeding data employed and hence whether these results should have been regarded as implying less of a break-through in this longstanding problem of the efficacy of seeding than the communications indicated.

Excellent summaries of nearly all of the past few years' scientific efforts to increase rain here and abroad were presented and formed a background to many discussions of physical, statistical, and technological matters. Emphasis was placed by several speakers on the great need for much more information on cloud dynamics. Recent tracer studies of the turbulent dispersion of ground-released particulates were cited and used to argue the need for many more such investigations, particularly under orographic conditions, now that there seems more than a little evidence that other level terrain diffusion is often incapable of elevating nuclei to effective altitudes before deactivation sets in. The plea for study of orographic effects on dispersion was related to a general agreement that it will be in mountain-upslope conditions above all that opportunity

may exist to obtain significant increases of rain by seeding. Current efforts to seed, from aircraft, the orographic clouds of the Snowy Mountains area of Australia were summarized and reported to be yielding substantial but not yet statistically significant positive effects. A now three-year-old randomized ground-generator seeding project in Israel was reported and described as giving indication that the detection of a 20% increase at the 5% significance level might require fifty years of operation under existing statistical design conditions. Efforts to redesign to reduce this time requirement were reported. No attempt will be made here to summarize many other Conference papers. The above points are likely to be the least familiar to most readers.

The gist of this conference seemed to this writer to be essentially this: The conferring investigators did not present findings which, viewed as a whole, provide much research evidence supporting the glowing claims that certain cloud seeders have issued in past years, but they reported many recent results that document the vigorous progress that cloud physics has been making towards understanding cloud and precipitation processes. Hence, one noted a prevailing point of view that might be briefly described as cautious optimism. So little is yet known of the intricacies of precipitation processes that it seems presumptious to assume either that we could yet expect to be exercising optimum control over cloud processes or that, alternatively, we could yet expect to have ruled out all possibility of useful control.

A limited number of copies of the mimeographed Conference Proceedings containing 500- to 1000-word abstracts of all papers, will be available to educational and research institutions on request. Such requests should be addressed to the Institute of Atmospheric Physics, University of Arizona, Tucson, Arizona.