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RESEARCH PROPOSAL

PHYSICAL AND STATISTICAL STUDY OF ROCKY MOUNTAIN OROGRAPHIC CLOUDS AND PRECIPITATION AND THEIR MODIFICATION

Principal Investigator: Lewis O. Grant

Continuing Research

Duration: Three years, beginning 1 July 1963

Estimated Cost:

First year $97,631.25

Second year $65,693.75

Third year $64,068.75

Department of Atmospheric Science
Colorado State University
Fort Collins, Colorado

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PHYSICAL AND STATISTICAL STUDY OF ROCKY MOUNTAIN OROGRAPHIC CLOUDS AND PRECIPITATION AND THEIR MODIFICATION

ABSTRACT

The apparent carry-over and redistribution of artificial ice nuclei from one day to another is one of the more interesting possibilities developing from current studies related to mountain snowfall and its modification at Colorado State University. Ground released silver iodide particles in concentrations from 10 to over 500/liter are being detected consistently at mountain top levels, when released at windward ground stations at distances greater than ten miles. The Colorado State University investigations are concerned with a step-by-step investigation of the seeding process, starting with the numbers and nucleating characteristic of Ag I crystals, considering their subsequent transport and actions, and continuing to their final deposition and detection in snowfall.

This is a proposal to progress the investigation of the step-by-step orographic cloud processes with emphasis on investigations of actions taking place within the clouds themselves, several thousands of feet above the mountain peaks. Continuous recording instrumentation will be carried aloft by large box kites.

Supporting studies of vertical transport of the ground released materials, ice nuclei numbers and activation characteristics, and snowfall velocity, mass and snow and ice crystal concentrations will be continued from the mountain observatory utilizing equipment and procedures developed under the current project. Parallel studies to detect difference in snowfall by statistical means will be continued.

I. INTRODUCTION

This is a proposal for the study of orographic clouds and snowfall, and changes resulting from the addition of artificial ice nuclei, over the higher elevations of the Rocky Mountains. The final objective of the proposed research, which is a thorough understanding of orographic cloud and precipitation process and their modification, is essentially the same as research currently in progress under a National Science Foundation Grant (10). The proposed continuation forms a natural progression of work underway, utilizing equipment, and procedures thus far developed.

This proposal is being prepared prior to the completion of the current study and final analysis of data in an effort to maintain continuity in the basic aspects of the studies in progress.

The Climax area for which these continued studies are proposed is located in central Colorado in a pass area where the Continental Divide is oriented east-west for a short distance. Elevations across the pass vary from around 8,000 feet at the base to near 12,000 m. s. l. The mountains in this area form a natural observation platform at an elevation well up into the atmosphere. The pass is kept open throughout the winter so that the area is readily accessible for observations at various elevations despite snow

accumulations to at least 6-8 feet by late winter. Housing facilities are available at the Climax Molybenum Company.

The area has a large number of days with precipitation and a comparatively low variability in precipitation amounts. Between November and April, the average number of days with precipitation (snow) at Climax was 85 per season for the period 1953-54 through 1959-60. The median was 88 per season. The precipitation for over 80 per cent of all precipitation days ranged between .04 and .51 inch and the greatest 24-hour amount was .81 inch. The large number of days with range of precipitation one order of magnitude is very desirable for statistical analyses.

II. OBJECTIVES

The objective of the research proposed is to advance research currently underway to obtain an increasingly complete understanding of orographic clouds and precipitation and the changes in their characteristics and processes when artificial ice nuclei are supplied.

This objective includes the obtaining of an increasingly detailed understanding of the transport, action and final deposition of ground and aerial released artificial nuclei.

III. BACKGROUND

Bergeron, 1949 (3) and Ludlam, 1955 (16) have considered the formation of precipitation over mountain ranges and have pointed out the possibilities for its modification by supplying artificial ice nuclei. Bergeron has considered the systematic lifting of an air-mass to condensation by a maintain barrier and has pointed out the importance of the extent and duration of the lifting to the occurrence of precipitation. Ludlam has considered the rate of growth of the ice crystals formed, their rate of deposition, the concentration of ice nuclei for the greatest precipitation efficiency, and the feasibility of supplying the required concentrations. A large number of other investigators have considered the individual phases or precipitation processes considered by Bergeron and Ludlam.

Bergeron and Ludlam both suggest that the potential for weather modification holds promise in such orographic clouds. While not extensive, experimentation using statistical means for testing for precipitation changes have and are being carried out in the United States, Europe, Australia and Japan. These studies have given from negative to inconclusive to positive indications of seeding effects (1), (2), (6), (13), (18), and (20). Certain of the experiments are still in progress. In most of the projects only

limited physical data has been collected in connection with the statistical experiment.

IV. RELATION TO PREVIOUS WORK AT COLORADO STATE UNIVERSITY

Investigations of orographic cloud and precipitation processes, along with a step-by-step investigation of the artificial seeding process, are underway at Colorado State University. In addition efforts are being made by statistical means to detect any associated change in precipitation.

The physical investigation of the seeding effort is directed at understanding each phase of action taking place in the seeding process. Consideration is being given to the numbers and nucleating characteristics of Ag I crystals, their transport and entry into the cloud system, the nucleation characteristics of artificial ice nuclei in relation to that of natural nuclei, the efficiencey of natural and artificial ice nuclei in utilizing available cloud water under different micro and macro scale weather situations, and the deposition pattern from natural and from seeded clouds.

Comparisons of snowfall are then being made between seeded and unseeded cases which are presently being selected on a random basis.

V. SUMMARY OF CURRENT STATUS OF COLORADO STATE UNIVERSITY STUDIES

1. Ground generators being utilized are producing around 5×10^{12} ice nuclei/sec. effective at -20° C.

2. These ice nuclei are being detected consistently in concentrations of 10 to 500/liter at the mountain observatory when generated on windward mountain slopes at distances varying from 10 to 40 miles from the observing site.

3. Increasing evidence, in support of theoretical consideration, shows that "wash out" of Ag I crystals between the seeding sites and the mountain observatory is not substantial even under conditions of intervening snowfall.

4. Investigations to date have not undertaken to verify the actual presence of artificially ice nuclei in the clouds themselves. Evidence that the vertical transport of the ground observed ice nuclei is taking place is available from associated "no lift" balloon data, vertical motions as measured from sequenced stereo cloud photographs, and periodic fluctuations in ground observed ice nuclei counts associated with cloud passage.

5. Investigation of cloud processes have been limited to date to analyses of precipitated ice crystals and snowflakes including

studies of their shape, mass, fall velocity, and numbers. In several cases the rate of cloud ice crystal production as determined from observed rate of fall and concentration has been in general agreement with corresponding ground observations of ice nuclei. Computations from considerations of observed fall velocities, number density, and mass tend to support the contention that ice crystal numbers in excess of 10/liter are needed for optimum utilization of available cloud moisture. No clear evidence has yet been obtained to determine whether a multiplying process for ice crystal production is working in the clouds being studied.

6. Perfection of techniques for identifying the Ag I in resulting snowfall is still in progress. Preliminary analysis of a limited portion of stored snow water samples from each seeded and unseeded storm using the Isono technique (13) indicates the presence of Ag I in certain snow samples. Since, as is pointed out above, there is no evidence of substantial scavanging of Ag I, the presence of Ag I in the snowfall should indicate it was instrumental in the formation of the collected snow. This would still not in itself clarify the question of the efficiency of the precipitation process had the Ag I crystal not been available. The answer to this question is one of the primary goals of the currently proposed research.

7. One of the most interesting developments in the investigations to date is the increasing evidence to suggest that carry-over effects are associated with continued seeding. Earlier work (11) had hinted at this possibility and its investigation was set down as one of the goals of the current research. Evidence suggesting such a carry-over effect include:

a. A persistent build-up in observed ice nuclei concentrations on "no seed" days as the random seeding progresses during the season.

b. The apparent detection of Ag I in snow water and local reservoir water in the vicinity of the target area.

c. A marked change in the statistical indications of the seeding effect on snowfall associated with the change in observed ice nuclei concentrations on non-seeded control days.

Further studies of this suggested carry-over effect and the processes by which it might be taking place are of primary importance not only from the standpoint of weather modification but also in experimental design.

8. The randomized seeding is currently still underway. As a result of the extreme snow deficiency in the Colorado Rockies this past winter, local ski operators have carried out commercial seeding that has interfered with the experimental statistical design

during this second year of the current program. Drawing conclusions as to snowfall changes from the present statistical sample is complicated and delayed by the probability that carry-over effects from the seeded days are affecting the unseeded control days. Ice nuclei concentrations on control days are now consistently of the order of 5 to over 10/liter, which is an order of magnitude higher than when the project was initiated or during the unseeded period from 1955 until 1960.

9. Peripheral studies of mountain snowfall includes:

a. The distribution of mountain snowfall relative to the mountain range.

b. The diurnal variation of snowfall which has a substantial peak in the early morning hours.

c. The techniques for observing snowfall.

d. The effect of drainage winds in the transport of ground released seeding agents.

V. PROCEDURES FOR PROPOSED RESEARCH

The proposed research will be directed at improving the presently increasing understanding of mountain cloud and precipitation processes using the Colorado Rockies as an observation

platform. This includes field and laboratory investigations of various phases of the seeding process and the initiation of a program of "in cloud" studies.

1. Further studies of silver iodide crystals and their generation will be considered but specific investigations will be carried out primarily under other joint projects between Colorado State University and the Chemistry Department of Arizona University.

2. The studies of horizontal and vertical transport of seeding agents will receive continued attention utilizing "no-lift" balloons and stereo photographs from stations activated during the course of the current research. One mountain top wind recording station will be established.

3. Ice nuclei observations will be continued at Climax using the continuous diffusion type counter which has been built and activated by the present project but which has been completed and in use only a short period. This is designed to obtain spectrum ice nuclei counts routinely at various temperatures, including those at which Ag I but not natural nuclei are effective. The expansion and portable ice nuclei counters available to the project will also be utilized. A nuclei counter will monitor the ice nuclei upwind of the study area, and Ag I generation sites, to assist in the

investigation of carry-over ice nuclei effects.

4. The program for detection of Ag I in snow will receive increasing attention. Analysis of samples from all snowfall for the past three years are now underway. The Isono technique and one being developed by Dr. James Lodge (unpublished) should supply valuable information of the action, distribution, and possibly the redistributions of Ag I crystals.

5. Considerable valuable additional information can be obtained from the observational and analysis program of atmospheric ice crystals and snowfall now underway. Crystals replications have been obtained from many snowfalls of the past two years. Equipment for obtaining ice crystal and snowflake fall velocity, concentration and mass has recently been put in use and is still being refined. Systematic observations with this equipment are expected to provide information from which significant conclusions can be reached regarding the rate of production and growth of ice crystals under a variety of cloud conditions. The observation site for collecting these crystal replicas is in many cases only a few hundred feet below the portion of the clouds in which ice and snow crystals are forming.

6. Statistical investigations of the snowfall on seeded days will be continued. Coordination is being established with the ski areas from which seeding interference resulted this past winter. Commercial seeding for this area has occurred only in extremely snow deficient years. The physical investigation, to which this proposal is primarily directed, could be continued essentially unaltered in a year when commercial seeding interference did occur. Some, to considerable, modification to the present random design will probably be made in consideration of the possible to probable carry-over effects of seeding nuclei into the control days. This will be formulated after further analysis of this winter's data and consulation with statistical advisors.

7. The need for information from within orographic clouds where precipitation is forming and growing has become increasingly apparent in the current studies. A major effort of the proposed research will be directed at obtaining this type of information and considering it with respect to a number of phases of the seeding process.

Most observations from within cloud systems have been made from aircraft traveling at relatively high speeds with resulting brief "in cloud" observation time. Observations are further

complicated by effects of the airplane itself. Some observations have been made with balloons but the data collected have been limited in scope. Neither aircraft or balloons would be suitable for "in cloud" observations in the Colorado Rockies due to the roughness of the terrain in the case of aircraft and the wind velocities experienced in the case of balloons.

It is believed that large kites flown from mountain peaks can provide an unusual opportunity for obtaining continuous "in cloud" data. In addition to being continuous over a period of time of a few hours to a few days such data can be obtained at a low cost relative to expenses involved in using aircraft.

Considerable work has already been done with respects to the development of kites and the equipment that could be used on them. Charles F. Marvin of the United States Weather Bureau began using kites in 1895. By 1898 a kite meteorograph had been developed and simultaneous kite observations to from 10 to 20,000 feet were being made at 17 stations. The program of kite observations started on a regular basis in 1907 and continued until 1933. The occurrence of winds at the surface of less than 10 to 15 m. p. h. was the primary handicap of the program. This is of no basic problem from the mountain platform being proposed for kite use.

During cloudy weather wind velocities are almost always above this level.

The Weather Bureau publication 740, "Instructions for Aerological Observers" (12) published in 1921 has surprisingly complete details on kite wires, reels and reel houses, kite instrumentation and kite flying procedures in addition to detailed information of kite construction and characteristics for use under different conditions, including winds to at least 80 m. p. h. This material is being used as a starting point in designing a kite program. In addition several commercial aeronautical groups have been contacted and are available for building special purpose kites.

It is expected, based on contacts with the Federal Aviation Agency, that authorization for kite flights to at least 4,000 feet above mountain top levels will not afford special problems. This will permit flights to around 16,000 feet m. s. l. which is an elevation well within the winter time orographic type clouds being studied.

It is anticipated that transmitting equipment as used in standard radiosonde units can be utilized to obtain and transmit basic weather data such as height, temperature, humidity, and wind on a continuous basis during kite flights. This data can be used in

investigation of rate of air and moisture flow past the mountain range, cloud environmental data for cloud droplet and crystal growth, and for investigations of embedded convection zones buried in the overall cloud system as pointed out by Elliott, et al. (7, 8, 9).

It is expected that instrumentation can be developed to obtain vertical motion data. The form this vertical motion instrumentation might take has not yet been resolved. The considerations of Telford and Warner (19) and the wind element of the Marvin Meteorograph (12) will form the basis for starting this instrumental development work.

Ice crystal and cloud particle observations will be made utilizing a modified form of a continuous particle sampler using a formvar coated film (17). Observations were taken with this type equipment during the past summer in connection with the Colorado State University hail studies. The use of varnish coated rotating rings as described by Yang (21) and millipore filters as described by Lodge (15) and discussed by Bigg (4) will be considered for ice nuclei detection for at least particles with activation characteristics of Ag I.

Certain of the data collected might be placed into the transmitting circuit of the radiosonde and transmitted to the base station while other types such as the formvar film would be collected and recovered at the time of the kite descent. In either case a more or less continuous "in cloud" record of the variables being measured could be obtained.

The kites in certain cases will also serve as a supporting vehicle for controlled seeding experiments under given cloud and temperature conditions. Dry ice as well as silver iodide can be used. Related cloud and precipitation characteristics as observed from the mountain peaks would be carried out in conjunction with this controlled modification.

The research herein is proposed for a three-year period in appreciation of the problems of bringing the kites and associated instrumentation to an operational status and to allow time for the collection and utilization of a reasonable sample of data. The mobile mountain laboratory being developed by Colorado State University, Atmospheric Science Department could serve as a base for these kite operations. Climax Molybdenum Company has in the past provided assistance with operational problems in the isolated high mountain country. This has included lodging, equipment, utilities, transportation and general assistance. It is expected that continued assistance and support of this nature can be obtained.

VI. PERSONNEL

Principal Investigator: Lewis O. Grant, Associate Research Meteorologist, holds a B. S. in Physics from the University of Tulsa and an M. S. in Meteorology from the California Institute of Technology. He served as a weather officer during World War II, and has had more than ten years of experience in a wide variety of problems in cloud physics and weather modification with the American Institute for Aerological Research. Since coming to Colorado State University in 1959, he has worked in problems involving hail characteristics and formation, ice nuclei, high-elevation snowfall, and other related problems. He is a professional member of the American Meteorological Society, the American Geophysical Union, Sigma Xi and Sigma Pi Sigma.

Associate Investigator: Several research people are under consideration for this position.

Assistant Investigator: John D. Marwitz, Junior Civil Engineer, Department of Civil Engineering, Colorado State University, received a B. S. in Civil Engineering from Colorado State University. He attended University of Washington for one

year as an Air Force Institute of Technology student studying basic meteorology. He has two years' experience as a weather officer in the Air Force which included interpretation of weather radar data, making terminal forecasts; six months as Wing Weather Officer; and eighteen months' experience with cloud physics problems at Colorado State University. He is a professional member of the American Meteorological Society and Sigma Xi.

Instrument Design Engineer: E. J. Plate, Assistant Professor of Civil Engineering, has an M. S. degree from Colorado State University and Dipl. Eng. in Civil Engineering from Technical University, Stuttgart, West Germany. He was a Fulbright Exchange student to the United States in 1954-57. His experience includes one year in Structural Engineering, two years in Hydraulic Research; and one year as Assistant to the Professor of Hydraulic Structures in Technical University, Stuttgart. He has been working in aerodynamic research at Colorado State University since 1959. He has been engaged extensively in the design of instruments and equipment for Colorado State University's Fluid Dynamics and Diffusion Laboratory. His primary research interest is in micrometeorological and turbulence research. He is a member of the American Meteorological Society and of Sigma Xi.

Advisors and Consultants: The following scientists are available as advisors and consultants for the project:

Dr. Herbert Riehl, Program Director for Meteorology at Colorado State University.

Dr. Vincent J. Schaefer, Consultant, Schenectady, New York.

Dr. Pat Squires, National Center for Atmospheric Research, and visiting professor in the Atmospheric Science Department, Colorado State University.

VII. PAPERS AND PUBLICATIONS RELATED TO PROPOSED RESEARCH

1. Grant, Lewis O. and Victor F. Tarbutton: Ice Nuclei in the Free Atmosphere in the V estern United States. Paper presented at the 151 National Meeting of the American Meteorological Society, Chicago, Illinois, March 1957.
2. Grant, Lewis O. and Richard A. Schleusener: The Occurrence and Variability of Ice Forming Nuclei During the Hail Season in Northeastern Colorado as Measured at 11,300 ft. m.s.l. at an Upwind Mountain Station. Nubila, anno IV-N. 2, 1961.

3. Grant, Lewis O. and Richard A. Schleusener: Snowfall and Snowfall Accumulation near Climax, Colorado. Proceedings of 29th Western Snow Conference, April 1961.

4. Schleusener, R. A. and L. O. Grant: Characteristics of Hailstorms in the Colorado State University Network 1960-61. Proceedings of the 9th Weather Radar Conference, 1961.

5. Grant, Lewis O.: Reactivation and Redistribution of Silver Iodide Following Atmospheric Deposition. Presented to the 31st Annual Meeting of the Western Snow Conference. Yosemite, Calif., 17-19 April 1963. To be published in the conference proceedings.

6. Schleusener, R. A., L. O. Grant and R. Steele: Preliminary Tests on a Non-combustion Type Silver Iodide Generator. Presented to the 31st Annual Meeting of the Western Snow Conference. Yosemite, Calif., 17-19 April 1963. To be published in the conference proceedings.

The following papers concerning the current research are in the process of preparation by the principal investigator.

Nine Years of Ice Nuclei Observations in the Colorado Rockies. To be submitted to J. of Atmos. Sci. or J. of Appl. Meteor.

The Colorado State University Automatic Continuous Ice Nuclei Counter and an Interpretation of Data Collected. With Erick Plate. To be submitted to an Instrumentation Journal.

The Colorado Rockies Orographic Cloud Seeding Experiment. To be submitted to J. of Appl. Meteor.

VIII. REFERENCES

1. Battan, Louis J. and A. Richard Kassander, Jr.: Artificial Nucleation of Orographic Cumulus Clouds. Monograph No. 5, American Geophysical Union, Physics of Precipitation, 1960.

2. Battan, Louis J. and A. Richard Kassander, Jr.: Evaluation of Effects of Airborne Silver Iodide Seeding of Convective Clouds. Univ. of Ariz., Inst. of Atmos. Phys., Scientific Rept. No. 18, 1962.

3. Bergeron, T.: The Problem of Artificial Control of Rainfall on the Globe. Tellus, 1, 1949.

4. Bigg, E. K., J. C. Mossop, N. S. C. Thorndike and R. T. Meade: About the article of J. P. Lodge and H. Bravo. Bull. de L'Observatoire du Puy de Dome, No. 3, 1962.

5. Brown, Edward N. and Roscoe R. Braham: Precipitation Particle Measurements in Cumulus Congestus. J. of Atmos. Sci., Vol. 20, No. 1, Jan. 1963.

6. Brownlee, K. A.: Statistical Evaluation of Cloud Seeding Operations. J. of Amer. Statistical Assn., Vol. 55, No. 291, Sept. 1960.

7. Elliott, Robert D., et al.: Investigation of Cloud-water Budget of Pacific Storms. Interim Rept. to National Science Foundation by Aerometric Research Inc., 1960.

8. Elliott, Robert D., Einar L. Hovind and John W. Flavin, Jr.: Investigation of Cloud-water Budget of Pacific Storms. Interim Rept. to National Science Foundation by Aerometric Research Inc., 1961.

9. Elliott, Robert D., Einar L. Hovind and John W. Flavin, Jr.: Investigation of Cloud-water Budget of Pacific Storms. Final Rept. (Contr. C-104) to National Science Foundation by Aerometric Research Inc., 1962.

10. Grant, Lewis O. and Richard A. Schleusener: Snowfall and Snowfall Accumulation near Climax, Colorado. Proceedings, 29th Annual Western Snow Conference, April 1961.

11. Grant, Lewis O. and Victor Tarbutton: Ice Nuclei on the Free Atmosphere in the Western United States. Paper presented at 151 st National Meeting of American Meteorological Society, Chicago, Illinois, March 1957.

12. Gregg, W. R., et al.: Instruction for Aerological Observers. Weather Bureau 740, Government Printing Office, 1921.

13. Isono, Kenji: Some Results of Cloud Seeding Experiments by the Use of Silver Iodide Ground Generators. Paper presented at the International Cloud Physics Conference held in Australia, Sept. 1961.

14. Koenig, L. Randall: The Glaciating Behavior of Small Cumulus Clouds. J. of Atmos. Sci., Vol. 20, No. 1, 1963.

15. Lodge, James P. and H. Bravo: An Improved Technique for the Determination of Freezing Nuclei Concentrations. Bull. de L'Observatoire du Puy de Dome, 1962, pp. 81-86.

16. Ludlam, F. H.: Artificial Snowfall from Mountain Clouds. Tellus, Vol. 7, No. 3, August 1955.

17. MacCready, Paul B.: The Continuous Particle Sampler at the Puy de Dome Comparison Conference. Bull. de L'Observatoire du Puy de Dome, 1962.

18. Neyman, Jerzy, Elizabeth L. Scott and Marija Vasilevskis: Randomized Cloud Seeding in Santa Barbara. Science, Vol. 131, Vo. 3407.

19. Telford, J. W. and J. Warner: On the Measurement from an Aircraft of Buoyancy and Vertical Velocity in Clouds. J. of Atmos. Sci., Vol. 19, No. 5, Sept. 1962.

20. Thom, H. C. S.: An Evaluation of a Series of Orographic Cloud Seeding Operations. Technical Rept. #2, Final Rept. of the Advisory Committee on Weather Control, Dec. 1957.

21. Yang, I. K.: An Impaction Ice Nucleus Counter. Bull. de L'Observatoire du Puy de Dome, No. 3, 1962.

IX. ESTIMATED COSTS OF RESEARCH

A. Salaries	First year	Second year	Third year	TOTAL
Personnel				
Principal investigator @$1100/mo. (6 mos.)	6,600	6,600	6,600	19,800
Associate investigator @$ 900/mo. (6 mos.)	5,400	5,400	5,400	16,200
Assistant investigator @$700/mo. (3 mos.)	2,100	2,100	2,100	6,300
Instrument design engineer @$ 900/mo.	5,400	3,600	1,800	10,800
Instrument technician @$600/mo. (9 mos.)	5,400	5,400	5,400	16,200
Radar technician @$550/mo. (3 mos.)	1,650	1,650	1,650	4,950
Graduate Students (2) @$250/mo. (9 mos. ea.)	4,500	4,500	4,500	13,500
	$31,050	$29,250	$27,450	$87,750
Labor				
Seeding generator operators	1,500	1,500	1,500	4,500
Field snow observers @$2/hr.	1,500	1,500	1,500	4,500
Mt. observatory assistants (2) @$400/mo. (6 mo. ea.)	4,800	4,800	4,800	14,400
Clerical and tabulation	1,200	1,200	1,200	3,600
	$9,000	$9,000	$9,000	$27,000
B. Equipment				
Kite development materials	2,500			2,500
Kite reels and houses	5,000			5,000
Radiosonde receptor	6,000			6,000
Recording wind equipment	2,500			2,500
Vertical velocity instrumentation	3,000			3,000
Water & ice particle samples	3,000			3,000
Light weight portable ice nuclei counter	1,000			1,000
Electric potential equipment	1,500			1,500
	$24,500			$24,500

	First year	Second year	Third year	TOTAL
C. Services and Supplies				
Kites and supplies	5,000	5,000	5,000	15,000
Kite reel system maintenance	1,000	1,000	1,000	3,000
Seeding chemicals & supplies	1,200	1,200	1,200	3,600
Film & processing	750	750	750	2,250
Machine computer, programming & processing	1,500	2,000	2,500	6,000
Misc. equipment & supplies	500	500	500	1,500
Weather facsimile (2 mo. equiv.)	1,000	1,000	1,000	3,000
	$10,950	$11,450	$11,950	$34,350
D. Travel and Transportation				
Transportation @ 10¢/mile				
Ft. Collins to project area	400	400	400	1,200
Daily observations in project area	1,050	1,050	1,050	3,150
Travel expenses in project area (@ $9/day)	655	655	655	1,965
Conference transportation and travel (@$15/day)	500	750	750	2,000
	$2,605	$2,855	$2,855	$8,315
E. Summary				
Salaries				
Personnel	31,050	29,250	27,450	87,750
Labor	9,000	9,000	9,000	27,000
Equipment (first year)	24,500			24,500
Services and Supplies	10,950	11,450	11,950	34,350
Travel & transportation	2,605	2,855	2,855	8,315
Totals	78,105	52,555	51,255	181,915
Overhead @ 25%	19,526.25	13,138.75	12,813.75	45,478.75
GRAND TOTAL	$97,631.25	$65,693.75	$64,068.75	$227,393.75

X. INFORMATION CONCERNING PROSPECTIVE CONTRACTOR

1. The contracting grantee agency is the Colorado State University.
2. Colorado State University is an agency of the STATE OF COLORADO and enjoys exemption from tort liability.
3. The address of the business office is FORT COLLINS, COLORADO.
4. The official authorized to sign and submit proposals and to negotiate a contract is the DIRECTOR, COLORADO STATE UNIVERSITY RESEARCH FOUNDATION, FORT COLLINS, COLORADO. Telephone Area Code 303 491-6355.
5. THE PRESIDENT OF COLORADO STATE UNIVERSITY OR HIS AUTHORIZED REPRESENTATIVE IS AUTHORIZED TO SIGN CONTRACTS OR ACKNOWLEDGE GRANTS.

XI. STATEMENT ON SOLICITING

We hereby certify that we have not employed or retained a company or person (other than a full-time employee) to solicit or secure this contract and agree to furnish information relating thereto as requested by the sponsor's cognizant officer.

Date _____

Lewis O. Grant, Associate Meteorologist, Atmospheric Science

Date 25 April 63

Herbert Riehl

Herbert Riehl, Head Department of Atmospheric Science

Date _____

Richard A. Schleusener
Assistant Director for Engineering
Colorado State University Research Foundation