Annual Report for

THE CSU-CHILL RADAR FACILITY

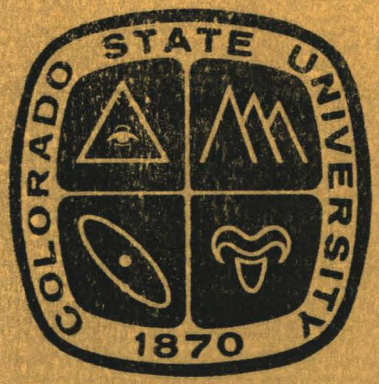
Cooperative Agreement No. ATM-8919080

Submitted to

The National Science Foundation

Division of Atmospheric Sciences

15 January 1991



DEPARTMENT OF ATMOSPHERIC SCIENCE
DEPARTMENT OF ELECTRICAL ENGINEERING
COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO

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1. Introduction

This report marks the first annual report for the CHILL National Facility since the award of the Cooperative Agreement, ATM-8919080 to Colorado State University (CSU) which became effective 15 April 1990. The highlights for this period included the relocation of the CHILL radar to Greeley, CO where it will be situated while in operation at CSU. At this time, the CHILL radar is fully operational in essentially the configuration it was in during operations in Illinois. The contents of this report, as outlined in the Table of Contents, follows the list of required items as given in the cooperative agreement.

2. Summary of Activities for Year 1

Most of the period of time occupied by the first year of this cooperative agreement was spent in relocating the CHILL radar to it's new home in Greeley, CO. Site preparations, including the installation of a concrete pad for the antenna and complete underground power system were completed in August 1991. At that time the radar system was delivered to the site, and the actual installation of the radar system commenced. The construction of the CHILL building (2500 sq. ft.) and erection of a site enclosing security fence were completed in the first week of December 1990. Major changes and improvements to the radar as well as site plan details are presented below. Basically all the refurbishment activities planned for this facility in our proposal to the NSF have been completed or are nearing completion. The only proposed item that has not been addressed during this funding period was the conduct of an X-band evaluation study to restore a dual-frequency capability. We plan to address this evaluation in the next funding year, first informally at the upcoming International Radar Conference and then formally at a workshop to be convened here by the CSU-CHILL Facility.

To insure higher quality measurements of Z_{dr}, the CHILL antenna was rotated 45° when it was reinstalled in Greeley to allow better sidelobe matches between horizontal and vertical polarizations. The antenna rotation places the feedhorn/waveguide support struts at 45° angles, hence their projections are theoretically identical between the orthogonal polarization planes of H and V. Additionally, following Mueller (1984; 22nd Conference on Radar Meteorology), a calculation procedure for differential propagation phase shift is presently being programmed into the SP20 signal processor to allow realtime computation of this parameter. The CHILL antenna system was also steam-cleaned and received a fresh coat of paint prior to reassembly in Greeley.

Far-field antenna pattern measurements were conducted on 11 December 1990. The test horn was located on a cherry picker about 2.6 km directly west of the radar. Prior to the measurements, absorber material was placed on the feed support struts. Pattern measurements were obtained with and without absorber material. The HH, VV and HV patterns were measured in a sector covering ±5° in azimuth and elevation about the boresight direction. Preliminary analysis revealed that the test horn site was not ideal for pattern measurements, the elevation angle for peak reception being only 0.2° rather than a more desirable value of 0.7°. There was evidence of interference from both fixed and moving objects in the vicinity of the transmission path. The absorber material reduced the peak gain of the antenna by several dB but the peak cross-polar lobe was improved by nearly 4 dB. We plan to repeat the antenna pattern measurements after locating a more desirable site for the test horn, e.g., a nearby tower. Drs. Bringi and Chandrasekar and two graduate students from the Department of Electrical Engineering collaborated in this effort with the CSU-CHILL staff.

Improvements have also been made to the data processing portion of CHILL (the Sunrise system), as well as the radome, antenna, and auxiliary power supply systems. An overview of the new CHILL data system was given in the semiannual report of 1 October 1990 submitted to the NSF. Most of the new data system equipment resides in the radar trailers. Analog quadrature video (I,Q) and analog log video are fed from the radar receiver into the new analog input card for the SP20 which has been installed. This input card generates the triggers for the radar and polarization switch and the instantaneous automatic gain control (IAGC) signal which controls the switchable attenuator in the linear receiver. The output of the SP20 will feed both the existing Microvax/Adage display system and the new Sunrise system. The existing Microvax/Adage display system will be retained to help verify the performance of the new system and to serve as a backup, in addition to offering expanded color display capabilities.

The Sunrise VME bus system will eventually control the antenna motion and set radar operating modes through control of the SP20. We expect this capability to exist within a few months. The VME bus houses a 68030 processor which will generate product files such as PPI's, CAPPI's, and randomly oriented vertical cross-sections. Also housed in the VME chassis is a Sun SPARC 1/E computer which provides a complete color workstation when connected to an external display and keyboard. This SPARC board will

run the standard Sunrise user software which allows the viewing of radar products and interactive control of the radar scanning and operating modes.

An Ethernet cable will connect the VME chassis to a Sun SPARCstation IPC in the User van which is located adjacent to the radar trailer in addition to a Sun SPARCstation II in the CHILL staff building. This Ethernet is extended using remote bridging hardware and a T1 telephone line (1.5 megabits/sec) back to the CSU Atmospheric Sciences weather lab to serve the Sun SPARCstation IPC located there. The network is further extended by way of the existing CSUNET back to the engineering campus and to more remote locations via Internet. Workstations running Sunrise in the User van, at the ATS weather lab, and in the Department of Electrical Engineering will be able to view radar products and control the radar if authorized. Products will be available for viewing at the weather lab within seconds of when they become available at the radar. The local radar Ethernet is also extended via fiber optic repeaters into the nearby CHILL office building. There it will connect to personal computers and to another radar display color workstation, a Sun SPARCstation II.

The initial installation of the Sunrise data system is behind schedule because of problems with the contractor (Lassen Research). Presently we are anticipating Sunrise providing data ingest and display capabilities by the end of January, 1991. Controlling the radar with Sunrise (including from the campus locations in ATS and EE) will be accomplished in early spring provided Lassen Research develops the antenna control software.

A new 73 foot diameter CHEMFAB radome has been installed. This radome was acquired from NCAR stock as it was intended for installation at CP-2. An identical replacement radome was ordered from CHEMFAB by CSU and has been shipped to NCAR. A new airlock entry way has also been installed at CHILL as part of this cooperative agreement.

The antenna drive system has been improved by the installation of the fourth, and final, motor and amplifier board. The new system is operating well and will be more reliable than the earlier motor-generator based system. Both azimuth drive high speed gearboxes have been refurbished with new oil and grease seals. The rate of oil leakage has been substantially reduced as a result of these actions. We have also ordered a new S band polarization switch from Raytheon to be delivered in three months. This switch will

replace the present switch on CHILL which is nine years old and should add better temperature stability and allow higher power levels to be used in the Z_{dr} mode. A state of the art microwave signal generator from Hewlett-Packard ($23K) has been acquired for CHILL.

Plans for the CHILL staff building were given in the semiannual report. This building has now been completed. A photographic reproduction of the site is shown in Fig. 1. This building provides office space for CHILL staff, two visiting scientist offices (with four desk positions), electronic lab space, and a machine shop.

3. Future Programs

A total of six different programs are currently in their planning stages or are under consideration for use of the CSU-CHILL radar facility. Importantly, these programs are equally divided between basic research programs and educational programs. A listing and brief description of each program (and current status) is given below. In addition to these planned programs, the radar will also be a key part of the upcoming WISP (Winter Icing and Storms Project) to be conducted from 15 January through 31 March 1991. The radar will participate in a multiple Doppler network along with the University of North Dakota 5 cm Doppler radar, the NCAR CP-3 5 cm Doppler radar, and the NCAR Mile High 10 cm Doppler radar. Multiple-Doppler data will be collected to study the kinematics of winter snowbands in the Front Range area. In addition, multi-parameter measurements will be made by the CSU-CHILL radar for intercomparison with in-situ aircraft measurements to reveal cloud microphysical processes. Prof. Rutledge from the Department of Atmospheric Science and Profs. Bringi and Chandrasekar from Electrical Engineering will all participate in WISP data collection and analysis in addition to at least six students.

Research programs:

1. Srivastava multi-parameter study. Prof. R. Srivastava of the University of Chicago plans to use the CSU-CHILL radar for a limited period of time in the spring/summer of 1991 to acquire multi-parameter data over a NOAA profiler to continue his work on the retrieval of drop size distributions. We plan to support this project in our "20 hour category", where limited expenses for such an operation are borne by the cooperative agreement. Prof. V. N. Bringi of CSU will be a collaborator on this project.

2. STORM Fest, 1992. We anticipate the STORM office requesting the CSU-CHILL radar for operation during the proposed STORM Fest (Fronts and Systems Test) for the February-March timeframe in 1992. The proposed operations of the CSU-CHILL radar will be at the Greeley, CO field site.

3. North Dakota Thunderstorm Project, 1992. We have received a letter of intent from the North Dakota Thunderstorm Project indicating a planned request for the CSU-CHILL radar during the summer of 1992 in North Dakota.

Educational Programs:

1. University of Nevada-Reno radar training and education. Prof. John Hallett of the University of Nevado-Reno has requested the CSU-CHILL radar system for a two-week period during April-May 1991 for an educational program. Prof. Hallett has proposed to bring 10-12 students to the CHILL site in Greeley to acquaint them with the acquisition of Doppler data and analysis of such data. We have provided a cost estimate for this project totalling about $10K. Prof. Hallett has submitted a proposal to the NSF for this project, and if supported, costs for operation of the CSU-CHILL radar are expected to come from the deployment pool fund. We can accommodate a group of this size and the project is feasible from the viewpoint of the CSU-CHILL staff.

2. Research Experiences for Undergraduates, submitted to the NSF. Prof. Chandrasekar of the Department of Electrical Engineering at CSU has submitted a proposal under the REU program at NSF for possible support of undergraduate research projects at CSU. The mode of this proposed project is to provide summer employment for a total of 10 students (including students from CSU and Ft. Lewis College in Durango, CO) at the CSU-CHILL site in Greeley, CO for the summer of 1991. These students would have completed their junior year at the time of this summer employment. Their summer experience at the CSU-CHILL radar would be followed by a senior project based on a CSU-CHILL radar project. The student projects would be written up in a formal report and results presented in a seminar series.

3. Radar Meteorology short course, 1992. Prof. Rutledge plans to conduct a short course on radar meteorology during the summer of 1992 using the CSU-CHILL radar facility. This six week long course will cover the basic operation and theory of Doppler radar, in addition to traditional areas of radar meteorology with emphasis on research applications. Emphasis on hands-on experience will be stressed. We plan to target several groups for this course. Besides our own students at CSU, we plan to attract students from other institutions who desire to learn more about Doppler radar but do not have formal courses in this area offered at their home institutions, or the advantage of working at a radar facility. Secondly, the COMET (Cooperative Program for Operational Meteorology, Education and Training) program has expressed considerable interest in this short course to the extent that they plan to support the attendance of 2-3 faculty from four-year institutions to attend this course. In this way, these faculty will be able to more effectively train undergraduates at their home institutions after having such a course. Support avenues for this effort are presently being explored with the NSF.

4. University of Northern Colorado radar course. The CSU-CHILL radar facility will also be used this spring to provide experience to a class of approximately 10 undergraduates from the University of Northern Colorado in Greeley, CO. Pat Kennedy, CSU-CHILL Facility Manager, will teach this course at UNC which meets for 4 hours per week. Mr. Kennedy plans class visits to the CSU-CHILL site to allow these students to experience operations at a Doppler radar site. Mr. Kennedy's participation in this effort will be paid for by the UNC.

4. Publication and Reports

Rutledge, S. A., V. N. Bringi, E.A. Mueller, D. A. Brunkow, P. C. Kennedy, and K. Pattison, 1990: New capabilities of the CSU-CHILL radar. Preprint volume, 25th International Conference on Radar Meteorology, June 24-28, 1991, Paris, France. (To be presented by S. A. Rutledge.)

5. Statement of Current and Pending Support for Key Personnel

CURRENT AND PENDING SUPPORT
Steven A. Rutledge
1/15/91

A. Current Support

Agency	Project Title	K$/ YR	Role	Period Covered	Commitment (months)
National Science Foundation	Dynamical and Electrical Studies of Mesoscale Precipitation Systems	163	PI	1/1/91 to 12/31/94	1 summer 1.5 academic
National Science Foundation	Studies of Winter Storms in Colorado with the CSU-CHILL Radar	33	PI	2/15/91 to 2/14/93	0.5 academic
National Science Foundation	The CSU-CHILL Radar Facility	375	Co-PI	4/1/90 to 3/31/91	1 summer 1 academic
National Science Foundation	The Climatological Effects of Convective Cloud Systems	101	CO-I	7/1/89 to 6/30/92	0.5 academic

B. Pending Support

Agency	Project Title	K$/ YR	Role	Period Covered	Commitment (months)
National Aeronautics and Space Administration	Cloud Modeling Studies in Support of Microwave Rainfall Retrievals	132	Co-PI	10/1/90 to 9/30/91	1 summer 0.5 academic
National Oceanic and Atmospheric Administration	Doppler Radar Studies in TOGA/COARE	54	PI	2/1/91 to 1/31/94	1 summer

CURRENT AND PENDING SUPPORT
V. N. Bringi
1/15/91

A. Current Support

Agency	Project Title	K$/ YR	Role	Period Covered	Commitment (months)
National Science Foundation	Continuation of Utilizing CP-2 Multiparameter Radar Data in the Study of Micro-burst and Non-Microburst Thunderstorms during MIST	66.7	PI	1/1/90 to 12/31/90	1 academic
ARO Center for Geosciences	Center for Geosciences, 5th year	158	Co-PI	10/1/90 to 9/30/91	2 summer
National Science Foundation	The CSU-CHILL Radar Facility	375	Co-PI	4/1/90 to 3/31/91	1 summer
National Science Foundation	Renewal of Microphysical Studies of Precipitation Using the Advanced Polarimetric DFVLR Radar	63	PI	3/1/90 to 2/28/91	0.5 academic

B. Pending Support

Agency	Project Title	K$/ YR	Role	Period Covered	Commitment (months)
National Science Foundation	Multiparameter Radar and Aircraft Based Studies During CAPE	86	Co-PI	10/1/90	1.3 summer
AFOSR	Multiparameter Radar and Aircraft Based Studies During CAPE	43	Co-PI	10/1/91	0.7 summer

A statement of current and pending support for S. K. Cox is not included since he receives no salary support under this cooperative agreement.

6. Second Year NSF Budget

Budget Explanation for specific items reported on the NSF form.

E. Travel

1. Domestic; attendance at NSF Advisory Panel Meetings.
2. Foreign; to partially support travel for senior personnel to attend International Radar Conference where a paper on the new capabilities of the CSU-CHILL radar will be presented.

G.6. Other Direct Costs

$10,000	telephone
$ 9,000	utilities
$ 5,500	software/hardware maintenance
$ 2,500	machine shop
$ 3,300	X-band workshop

7. Report on Cost Sharing Activities at CSU Including Projected Expenditures for Year 2

The following describes cost sharing expenditures at CSU for the first year of the cooperative agreement:

Building and site preparation	$188,275
Freight, transportation insurance, crane	11,835
Furniture for staff building	10,728
Materials, parts, supplies, paint	4,403
Expenditures through 12/31/90	215,241
Estimated 1/1/91 - 4/15/91	10,000
Total Planned Expenditures - First Year	$225,241

In addition the following items have been procured via the Colorado State University Research Foundation (CSURF) on a municipal lease program with the initial semi-annual payment due during the second year of the cooperative agreement.

Computers (Sunrise system, Sun workstations, personal computers)	$239,448
Radome and Airlock Entry	94,949
High speed communication line (Tl line)	17,162
Test equipment, new backup power generator, antenna drive motors	48,981
Polarization switch	29,997
Total Value	$430,537

These specific costs will be amortized over years two through five; however, having the equipment items available for current use will greatly enhance the CSU-CHILL radar capabilities.

Planned expenditures of CSU cost sharing for the second year are as follows:

Junior Technician	$ 18,000
Lease payments - CSURF	160,000
Other Direct Costs	72,000
Total Second Year	$250,000

8. Statement on Cost Recovery Funds for Year 1

There were no cost recovery projects supported, hence no cost recovery funds were received.

(SEE INSTRUCTIONS ON REVERSE BEFORE COMPLETING)

SUMMARY PROPOSAL BUDGET

APPENDIX IV

FOR NSF USE ONLY

PROPOSAL NO. | DURATION (MONTHS) Proposed | Granted

AWARD NO.

ORGANIZATION: Colorado State University

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: S. A. Rutledge and V. N. Bringi

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	NSF FUNDED PERSON-MOS. CAL.	ACAD	SUMR	FUNDS REQUESTED BY PROPOSER	FUNDS GRANTED BY NSF (IF DIFFERENT)
1. S. A. Rutledge, Co-PI, Scientific Director		1	1	$ 9,707	$
2. V. N. Bringi, Co-PI			1	7,712	
3. E. Mueller, Sr. Engineer	12			67,573	
4. P. Kennedy, Facility Manager	12			43,663	
5. (1) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE) Dave Brunkow, Sr. Software Engineer	12			54,058	
6. (5) TOTAL SENIOR PERSONNEL (1-5)				182,713	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.) Technician	12			30,000	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. (1) SECRETARIAL-CLERICAL				5,356	
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				218,069	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				42,087	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				260,156	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $1,000:)					
TOTAL PERMANENT EQUIPMENT				-0-	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				1,500	
2. FOREIGN				1,500	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $					
2. TRAVEL					
3. SUBSISTENCE					
4. OTHER					
TOTAL PARTICIPANT COSTS				-0-	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				6,992	
2. PUBLICATION COSTS/PAGE CHARGES				3,000	
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER				30,300	
TOTAL OTHER DIRECT COSTS				40,292	
H. TOTAL DIRECT COSTS (A THROUGH G)				303,448	
I. INDIRECT COSTS (SPECIFY) Indirect costs are 45.0% of total direct costs excluding equipment and tuition. MTDC = 303,448 TOTAL INDIRECT COSTS				136,552	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				440,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPM 252 AND 253)					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$440,000	$

PI/PD TYPED NAME & SIGNATURE: S. A. Rutledge — Stan A. Rutledge — DATE: 14 Jan 91

INST. REP. TYPED NAME & SIGNATURE*: D. W. Kelly — Donald W. Kelly — DATE: 1/16/91

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NSF Form 1030 (1-87) *Supersedes All Previous Editions*

*SIGNATURES REQUIRED ONLY FOR REVISED

Figure Caption

Fig. 1. CSU-CHILL site photograph.