Annual Report for

THE CSU-CHILL RADAR FACILITY

Cooperative Agreement No. ATM-8919080

Submitted to

The National Science Foundation

Division of Atmospheric Sciences

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1. Introduction

The past year has been a busy one for the CSU-CHILL radar facility and staff. The radar was used in two projects funded from the NSF deployment pool (one research and one education program) and also several "20 hour" programs. The radar was also used in a formal graduate course in radar meteorology in the Department of Atmospheric Science. In addition, technical improvements, modifications and testing continued, as described below. A CSU-CHILL newsletter was also produced in September 1991 and distributed to over 200 members of the atmospheric science community.

2. Summary of Activities for the Past Year

a. Projects funded by NSF

The CSU-CHILL was one of five Doppler radars that participated in the 1991 Winter Icing and Storms Project (WISP91). A major goal of this project was the study of the production and depletion of the regions of concentrated supercooled water that are conducive to the formation of aircraft icing. Real time operations of both the radars and research aircraft were coordinated from NCAR's Research Applications Program (RAP) field control center. In general, the combined data from the WISP91 radar network will be used to determine the three dimensional wind field associated with mesoscale snow events. In addition, on several occasions during WISP the CSU-CHILL collected dual polarization data in close proximity to the research aircraft flight paths. These aircraft data will provide useful in-situ measurements for comparison with the remotely sensed radar data. The use of the CSU-CHILL radar in WISP was supported by funds from the NSF deployment pool. Two M.S. theses, using WISP data, are presently being supervised by Prof. Rutledge in the Department of Atmospheric Science.

A formal project using the CSU-CHILL radar for education purposes was also conducted. In May of 1991 Profs. J. Hallett and M. Wetzel of the University of Nevada-Reno and a group of 12 graduate students came to the CSU-CHILL facility for a two week period for a short course in radar meteorology. The format of the course consisted of selected lectures on radar meteorology by Profs. Rutledge and Bringi, as well as real time operations. A number of excellent data collection sessions were conducted where the students studied a wide range of meteorological events including multi-cell hailstorms, a mesocyclone, and a squall line. Each student was given time on the SUN workstations at the radar and were exposed to various data analysis techniques. Funds for operating the CSU-CHILL radar for this program were provided by the NSF deployment pool.

b. In-house education projects

The CSU-CHILL radar played a key role in a graduate level radar meteorology class taught by Prof. Rutledge during the fall semester of 1991 in the Department of Atmospheric Sciences (with an enrollment of 14). In addition to providing "hands on" experience for the students (which emphasized the operation and technical aspects of the radar operation), data collected by the radar in "target of opportunity" events provided a unique opportunity for the students to gain experience is various types of radar data analysis techniques. During the last month of the course the students were assigned case studies from six different weather situations, ranging from a tornadic supercell storm, to the study of mesoscale snowbands in a winter cyclonic storm. Each student group was given access to several volumes of radar data on color workstations for each case. The student groups then edited and unfolded the velocity data, and performed studies relating fields such as radial velocity, reflectivity, differential reflectivity, and spectral width to the meteorological situation. One group was even able to conduct a dual-Doppler synthesis by combining CSU-CHILL and Mile High radar data. Each group presented their findings during a two hour "mini-conference" on radar meteorology. Faculty, staff and all graduate students were invited to the presentations. We are currently working on a manuscript describing this classroom activity which we plan to submit to the *Bulletin of the American Meteorological Society* .

Undergraduate education is also being addressed. Prof. V. Chandresekar of the CSU electrical engineering department was recently awarded a grant to support several undergraduate research projects through the NSF Research Experience for Undergraduates (REU) program. This grant will focus on the use of the CSU-CHILL radar facility and provide summer projects during the summer of 1992 for approximately 10 engineering students who will have completed their junior year. These summer projects will form the basis for subsequent senior year projects.

c. Description of 20 hour projects supported

A series of 20 hour projects supported by the CSU-CHILL were designed to allow their investigators to identify specific days of interest for data collection. These 20 hour projects are important in that they provide investigators opportunities to use a state of the art research radar to conduct highly focussed studies, without the burden of writing a full proposal and securing formal funding. The following 20 hour projects were supported in 1991. Professor R. Srivastava of the University of Chicago was interested in collecting dual polarization data with the CSU-CHILL at various heights above the NOAA profiler located near Platteville, Colorado. An evening during which stratiform remnants from a dissipating thunderstorm passed over the profiler provided the bright band echo structure that Prof. Srivastava desired. The echo requirements in Dr. Kostinski's (Michigan Technical University) 20 hour project were less stringent as he was interested in some of the statistical properties of time series data from precipitation targets. He returned to Michigan Technological University with data recorded in rain and snow shower activity that occurred during his late April visit to the radar. In a project designed to collect radar data for the initialization of a hydrological runoff model, Prof. Pierre Julien of the CSU civil engineering department was interested in observing a variety of precipitation regimes. Convective echo systems with several degrees of spatial organization were observed during this project. Some of these data are currently being used for model initializations in the Ph.D. thesis of Fred Ogden, a CSU student under the supervision of Prof. Julien. Another project centered around rainfall runoff implications was conducted under the guidance of Prof. Tom McKee of the CSU atmospheric science department. His focus was on convective precipitation events which generated rainfalls in excess of one inch in the foothills region lying immediately west of the Denver - Boulder metropolitan areas. Several drainages in this area have been instrumented to provide both streamflow and rainfall data in realtime. Many of the Denver area storms observed by the CSU-CHILL reached their most intense stages after they had moved east of the instrumented drainages. Nevertheless, Dave Speltz, an Atmospheric Science department Masters Degree candidate, has started analysis of the radar and surface data collected in this program, which will form the bulk of his thesis research. He is especially interested in relating multi-parameter measurements to hail and rainfall. The final 20 hour project supported by the CSU-CHILL radar during the past year was a radar - raingauge comparative study organized by Dr. David Hartley of the USDA Agricultural Research Service (ARS). The ARS operates a network of raingauges clustered near Nunn, Colorado, located approximately 40 km north of the CSU-CHILL site. Polarimetric data in both conventional and time series modes were recorded when precipitation echoes were observed over the raingauge network. The heaviest storm that crossed the network contained hail as well as rain. Initial results show improvements in the radar-raingauge comparisons when differential reflectivity data are used to identify the presence of hail.

In addition to the 20 hour projects summarized above, the CSU-CHILL radar was also operated for several "target of opportunity" events. The goal here was to collect data that could be used as classroom case studies at CSU and could also be made available for similar applications at other institutions. The Colorado convective season of 1991 succeeded in providing several such opportunities. For example, several thunderstorms bearing mesocyclone circulations were observed. Explosive thunderstorm development following fine line interactions was observed over a two hour period early in the evening of 8/19/91. Also, severe convection featuring a series of bow-echoes was observed on 23 May 1991. The bow echoes are presently being studied through dual-Doppler analysis in conjunction with multi-parameter data.

d. Engineering and technical accomplishments

A number of engineering improvements in the system were accomplished during the past year:

1. In order to improve the match between the antenna sidelobe patterns at both horizontal and vertical polarizations, the feedhorn/waveguide support struts were rotated 45 degrees when the antenna was assembled at Greeley. After the implementation of this rotation, it was deemed necessary to check the focusing of the antenna and to conduct beam pattern measurements. It was found that better patterns resulted when the horn position was moved toward the dish by one inch. Patterns were obtained for both copolar and cross polar antenna operations. An experiment to determine the improvement of the patterns by enclosing the struts with radio wave absorbent material was conducted. This resulted in unmeasurable differences in the copolar patterns both on the main lobe pattern and on the strengths of the side lobes. However, there was some effect on the cross polar patterns that will be verified by a repetition of pattern measurements.

2. Sphere calibrations were also conducted to check the overall calibrations of the radar. These tests confirmed the calibration accuracy of the radar system. In addition there were simultaneous measurements of weather echoes from the CSU-CHILL and the Mile High Radars. These two radars showed agreement within 2 db on the average with a reasonable scatter of points around this mean. Sphere

calibrations were also conducted during Prof. Hallett's visit to provide experience to the students in calibrating a radar.

3. There were a number of additions to the system during the year that enhance the operational capability of the radar or provide additional reliability of operation and equipment integrity. The more important of these were:

   a) A new radome monitor which monitors conditions at the site and provides control of standby devices to increase the chances of survivability during severe weather or power loss. This device alerts maintenance personnel by phone when unusual conditions are in existence.

   b) A third blower was added to the radome inflation system. This blower is powered by a gasoline engine and thus does not require either commercial or backup diesel power. Control of this blower is redundant and it will start either from control of the radome monitor or from its own radome-pressure switch.

   c) A new Diesel power plant was purchased and now provides backup power for the radar system. This plant is sufficiently large that it can run the radar and data system in the event of commercial power failure, thus permitting uninterrupted data collection.

   d) The fast polarization switch was updated with a new control electronics printed circuit board and a more accurate temperature control system. In addition, a completely new polarization switch has been purchased. This switch will be used as a spare and/or eventually in a three switch configuration to improve the isolation.

Part of the upgrade of the CSU-CHILL data system was the replacement of the video digitizer. The new digitizer was purchased from Lassen Research. It consists of one signal processor (SP20) card which contains all of the circuitry for digitizing the I, Q and Log Power video channels. In addition, this card controls the switchable attenuators used in the Instantaneous Automatic Gain Control (IAGC) and combines the linear and log channels to develop the floating point I and Q values used in the SP20 signal processor. The card is controlled through a micro-coded control program which allows flexible selection of sampling rates and averaging options. This same card generates the four triggers which drive the radar and polarization switch. The new card has centralized many of the radar control functions, and provides an improved solution to the problem of removing DC offsets and balancing the gains of the I-Q channels.

The switchable attenuators became operational during the summer of 1991. As a part of this installation, it was discovered that the existing attenuator arrangement was limited to about 36 db of attenuation. This was traced to leakage inside the attenuator box, which was corrected with additional shielding. The attenuator can now be switched from 0 to 60 db in 12 db steps. The static performance of the IAGC is good, but work is continuing on improving the switching characteristics. Part of this work has included the installation of a new low distortion quadrature detector, which will produce significantly higher video voltages than were previously available.

Another activity which was pursued in 1991 was the verification of the SP20 signal processing software used in the alternating VH polarization mode. To perform this test, a time series simulating an alternating VH polarization radar was produced at the CSU electrical engineering department. This time series was placed in a program and downloaded to a spare SP20 card. This program disabled the normal SP20 input card, and caused the simulated data to be placed on one of the SP20 busses in place of the normal input data. The remaining SP20 cards processed the data as usual. The results were recorded on tape for later comparisons. The correct values for the reflectivity, velocity, and VH and HV correlations and HH lag 2 correlations were calculated independently on one of the CSU-CHILL workstations, and then compared with the SP20 results. All fields produced by the SP20 agreed with the expected values. This experiment will be repeated with other known time series and other SP20 processing modes.

The SUNrise radar data/display system is an ongoing development by Lassen Research. The SUNrise system currently allows users to view CSU-CHILL product files from the laboratories on the CSU campus. The product files include conventional PPI scans as well as constant altitude PPI's (CAPPI), VAD's, and arbitrarily-oriented vertical cross sections. These images are transmitted back to Fort Collins via a T1 data line, which extends the campus network to the CSU-CHILL site. Lassen Research plans to complete the SUNrise installation in the near future.

e. Contributions from the Department of Electrical Enginering

Professors Bringi and Chandrasekar directed CHILL related research and educational activities during 1991. Two senior projects related to antenna pattern measurements were completed this year, and one senior project on Doppler spectra processing is on-going. One M.S. thesis entirely related to the CSU-CHILL radar system characterization is nearly completed. One sophomore EE student spent last summer on development of color image display of CSU- CHILL antenna patterns. She was supported by the Engineering and Applied Science Scholars program at CSU.

Professor Chandrasekar is evaluating and analyzing WISP'91 data. The case of 26 March 1991 was looked at in some detail. Positive Z_{DR} signatures were identified in a very thin layer at mid-levels, the hypothesis being that these are pristine dendritic crystals. One Ph.D. student is analyzing 2D PMS images taken by the University of Wyoming King Air as it flew near this layer. Substantial effort was spent on software development to display the PMS images on a UNIX SUN workstation. Previously developed particle classification software will be used on this dataset.

Convective storm data from several days were analyzed for evaluation of the differential propagation phase and copolar correlation coefficient data. Time series data were analyzed and, in fact, substantial software was developed to analyze the time series data. One paper was presented at a propagation workshop in Graz, Austria last summer, and it will appear in a Proceedings shortly.

Substantial effort was spent on radar system characterization including comprehensive copolar and cross-polar antenna pattern measurements and determining the effects of absorbing material placed on the feed support struts. A numerical technique for accurately predicting the far-field patterns based on geometrical theory of diffraction was obtained from Ohio State University and this software was installed at CSU. The primary feedhorn copolar and cross-polar patterns were accurately modelled at Ohio State. The reflector geometry including 3 support struts and feed blockage were also modelled. There was general agreement between the predicted and measured copolar patterns, e.g., maximum directivity, beam width and sidelobe levels. The agreement was less satisfactory for the cross-polar patterns, the measured values differing substantially (up to 10-15 dB) from the predicted ones. The cross-polar measurements appear to be contaminated by polarization mismatch at boresight between the transmit antenna and the CSU-CHILL antenna, i.e., we could not attain a sharp "null" in the cross-polar at boresight. The peak cross-polar with absorbers was around -28 dB and occurred in the 45 degree plane. It appears that this value is consistent with the peak cross-polar of the primary feed horn which was modelled to be around -24 dB. Without absorbers the peak cross-polar was around -25 dB; thus, the absorbers did reduce the peak cross-polar levels by about 3 dB. A feed horn with much better cross-polar performance may likely improve the secondary antenna cross-polar patterns. Scalar feed horns with -35 dB cross-polar levels are commercially available. We are taking up an offer with DLR, Germany who have indicated that they can design and manufacture a scalar feed horn as a courtesy repayment for scattering software supplied to them by CSU.

Other system tests included a detailed analysis of the sphere calibration data. The measured copolar patterns were integrated to compute the illumination function rather than using the Gaussian approximation. This resulted in a correction the the radar constant of 1.71 dB. The system gain referred to the receiver input is 41 dB in the bypass mode. The insertion loss through the switch was 2.5 dB. We also evaluated the system accuracy for measuring differential propagation phase (ϕ_{DP}). In particular, we were concerned that the polarization switch may introduce unwanted fluctuations in ϕ_{DP}. By analyzing the sphere calibration it was determined that the rms system error in ϕ_{DP} is around 0.38 degrees. This value is significantly less than statistical fluctuations introduced by the precipitation media, typically measured to be in the range 2°-5°. We also established that the polarization switch did not introduce any additional rms error in ϕ_{DP}. Measured values of specific differential phase (K_{DP}) in rain was found to be in the range 0-6° km^{-1}. A good power law relationship between K_{DP} and reflectivity was found which is in agreement with theory. The measured standard deviation in K_{DP} was determined to be around 0.5° km^{-1}, which is consistent with data from other S-band radars, e.g., the NCAR CP-2 and NSSL Cimarron radars.

The system bias in Z_{DR} was also evaluated. The contribution by the antenna alone, obtained by integrating the HH and VV patterns, is around -0.6 dB. The polarization switch also introduces a differential insertion loss that varies with temperature, but is believed to be around ±0.3 dB. From experimental data in very light rain, we have established a system Z_{DR} bias of -0.7 dB.

The copolar correlation coefficient data was also evaluated in a variety of precipitation conditions. In the ice phase of convective storms, i.e., well above the freezing level, the average ρ_{HV} is around 0.985. In one case where large hail was reported at the ground, the average ρ_{HV} was around 0.9, with individual values as low as 0.75 in hail regions. These values are consistent with those reported in the literature. The system limit for ρ_{HV} appears to be around 0.985 based on the sphere calibration data. We are also evaluating the effect on ρ_{HV} of ϕ_{DP} mismatch introduced by the antenna itself.

3. Publications and Reports

In this section we list all publications for the period 1990-1991 which used data collected by the CHILL radar. Studies by both CSU and non-CSU researchers are listed.

Achtemeier, G .A. 1991: The Use of Insects as Tracers for "Clear Air" Boundary Layer Studies by Doppler Radar. *J. Atmos. Oceanic Tech.*, **8**, 746-765.

Bringi, V. N., E. A. Mueller, V. Chandrasekar, and A. Mudukutore, 1991: Polarimetric Measurements and Interpretation Using the S-Band CSU-CHILL Radar. Proceedings, *International Workshop on Multiparameter Radar Applied to Microwave Progation*, September 3-6, Graz, Austria,.

Changnon, S. A., R. C. Czys, R. W. Scott, and N. E. Wescott, 1991: Illinois Precipitation Research: A Focus on Cloud and Precipitation Modification. *Bull. Amer. Meteor. Soc.*, **72**, 587-604.

Huston, W. M., A. G. Detwiler, F. J. Kopp and J. L. Smith, 1991: Observation and Model Simulations of Transport and Precipitation Development in a Seeded Cumulus Congestus Cloud. *J. Appl. Meteor.*, **30**, 1389-1406.

Kennedy, P. C., N. E. Wescott, and R. W. Scott, 1990: Single Doppler Radar Observations of a Mini-Tornado. Preprint Volume, *16th Conference on Severe Local Storms*, American Meteorological Society, Oct 22-26, Kananaskis Provisional Park, Alberta, Canada, 209-212.

Mueller, E. A. and V. Chandrasekar, 1992: Meteorologic Radar Polimetry in North America 1950-1991. Direct and Inverse Methods in Radar Polarimetry, D. Reidel Company.

Musil, D. J., P L. Smith, and N. E. Westcott, 1990: Armored Aircraft Observations of a Severe Hailstorm in Illinois. Preprint Volume, *16th Conference on Severe Local Storms*, American Meteorological Society, Oct 22-26, Kananaskis Provisional Park, Alberta, Canada, 485-488.

Ramamurthy, M. K., B. P. Collins, R. M. Rauber, and P. C. Kennedy, 1990: Dramatic Evidence of Atmospheric Solitary Waves. *Nature*, **348**, 314-317.

Ramamurthy, M. K., R. M. Rauber, B. P. Collins, P. C. Kennedy, and W. L. Clark, 1991: UNIWIPP: A University of Illinois Field Experiment to Investigate the Structure of Mesoscale Precipitation in Winter Storms. *Bull. Amer. Meteor. Soc.*, **72**, 764-776.

Rutledge, S. A., V. N. Bringi, E. A. Mueller, D. A. Brunkow, P. C. Kennedy and K. Parrison, 1991: New Capabilities of the CSU-CHILL Radar. Preprint Volume, *25th International Conference on Radar Meteorology*, June 24-28, Paris, France, 852-854.

Shields, M. T., R. M. Rauber, and M. K. Ramamurthy, 1991: Dynamical Forcing and Mesoscale Organization of Precipitation Bands in a Midwest Winter Cyclonic Storm. *Mon. Wea. Rev.*, **119**, 936-964.

Westcott, N. E., 1991: The Bridging and Growing of Aggregating Echo Cores. Preprint Volume, *25th International Conference on Radar Meteorology*, American Meteorological Society, June 24-28, Paris, France, 424-427.

Manuscripts in preparation

Rutledge, S. A., and P. C. Kennedy, 1992: Use of the CSU-CHILL Radar in Radar Meteorology Education at Colorado State University. (To be submitted to the *Bull. Amer. Meteor. Soc.*)

4. Statement of Current and Pending Support for Key Personnel

CURRENT AND PENDING SUPPORT
Steven A. Rutledge
1/15/92

A. Current Support

Agency	Project Title	K$/ YR	Role	Period Covered	Commitment (months)
National Science Foundation	Dynamical and Electrical Studies of Mesoscale Precipitation Systems	160	PI	2/1/91 to 1/31/94	1.5 academic
National Science Foundation	Studies of Winter Storms in Colorado with the CSU-CHILL Radar	33	PI	3/1/91 to 2/28/93	0.5 academic
National Oceanic and Atmospheric Administration (USTPO)	Doppler Radar Studies in TOGA/COARE	100	PI	4/15/91 to 4/14/94	1 summer 1 academic
National Science Foundation	The CSU-CHILL Radar Facility	450	CO-PI	4/1/90 to 3/31/92	1 summer 1 academic
National Aeronautics and Space Administration	Research in Support of Micro-wave Precipitation Retrieval Algoritm for TRMM	100K	CO-PI	4/15/91 to 4/14/94	1 summer
National Oceanic and Atmospheric Administration	Evolution of Mesoscale Convective Systems	14	PI	10/1/91 to 6/30/92	0
National Oceanic and Atmospheric Administration	Electrical Studies of Meso-scale Convective Systems	20	PI	8/15/91 to 6/30/94	0
National Oceanic and Atmospheric Administration	Refurbishment of the MIT C-Band Doppler Radar for Use in TOGA/COARE	500	PI	12/1/91 to 1/31/93	0
Colorado State University	Resident Instruction Support				6 academic

B. Pending Support

There is no pending support at this time.

CURRENT AND PENDING SUPPORT
V. N. Bringi
1/15/92

A. Current Support

Agency	Project Title	K$/ YR	Role	Period Covered	Commitment (months)
National Science Foundation	CAPE Radar Analysis	76	PI	4/1/91 to 3/31/94	2 months
Army Research Office	Center for Geosciences	150	CO-PI	3/31/91 to 4/15/92	2 months
National Aeronautics and Space Administration	Microwave Radiative Transfer	89	PI	9/1/91 to 8/30/92	0.5 months
National Science Foundation	The CSU-CHILL Radar Facility	450	CO-PI	4/1/90 to 3/31/92	1 month
AFOSR	CAPE Radar Analysis	43K	CO-PI	2/1/91 to 1/31/94	1 month
National Science Foundation	Renewal of DLR Radar	75	PI	4/15/91 to 3/31/92	1 month

B. Pending Support

There is no pending support at this time.

CURRENT AND PENDING SUPPORT
Stephen K .Cox
1/16/92

A. Current Support

Agency	Project Title	K$/ YR	Role	Period Covered	Commitment (months)
U.S. Department of Energy	Monitoring the Response of the Upper Troposphere/Lower Stratosphere to a Greenhouse Gas Scenario	150	PI	5/1/91 to 4/30/92	0.5 months
National Aeronautics and Space Administration	Observations of Upper and Middle Tropospheric Clouds	175	PI	5/1/91 to 4/30/92	2.5 months
National Oceanic and Atmospheric Administration	Surface Radiation Pilot Study for TOGA COARE	107	CO-PI	7/1/90 to 6/30/91	0.75 months
National Science Foundation	The CSU-CHILL Radar Facility	450	CO-I	4/1/90 to 3/31/92	1 month
National Science Foundation	Joint CSU-USSR Cloud-Radiation Climate Studies	30	CO-PI	10/1/91 to 9/30/92	0
Office of Naval Research	Observational and Modeling Studies in Support of the Atlantic Stratocumulus Transition Experiment	181	CO-PI	1/1/91 to 12/31/91	2 months

B. Pending Support

Agency	Project Title	K$/ YR	Role	Period Covered	Commitment (months)
National Aeronautics and Space Administration	Extended Rawinsonde Operations for the Study of Cirrus Cloud Systems	120	CO-PI	9/15/91 to 12/31/91	0

5. NSF Budget

Budget Explanation for specific items reported on the NSF form.

E. Travel

1. Domestic; attendance at NSF Advisory Panel Meetings and technical meetings.

G.6. Other Direct Costs

$10,000	telephone
$11,000	utilities
$ 5,500	software/hardware maintenance
$ 3,500	machine shop

4/14/92 - 4/15/93

APPENDIX V

(SEE INSTRUCTIONS ON REVERSE BEFORE COMPLETING

SUMMARY PROPOSAL BUDGET

ORGANIZATION Colorado State University	FOR NSF USE ONLY		
	PROPOSAL NO.	DURATION (MONTHS) Proposed	Granted
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR S. A. Rutledge and V. N. Bringi	AWARD NO.		

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	$ 10,336	$
2. V. N. Bringi, Co-PI			1	8,245	
3. E. Mueller, Sr. Engineer	12			70,952	
4. P. Kennedy, Facility Manager	12			45,846	
5. (1) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE) D. Brunkow	12			56,761	
6. (5) TOTAL SENIOR PERSONNEL (1-5) Sr. Software				192,140	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS) Engineer					
1. ( ) POST DOCTORAL ASSOCIATES					
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12			31,500	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. (1) SECRETARIAL CLERICAL				5,624	
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				229,264	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				44,248	
TOTAL SALARAIES, WAGES AND FRINGE BENEFITS (A+B+C)				273,512	
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)				4,400	
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ ____ 2. TRAVEL ____ 3. SUBSISTENCE ____ 4. OTHER ____					
( ) TOTAL PARTICIPANT COSTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				6,778	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				6,000	
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER				30,000	
TOTAL OTHER DIRECT COSTS				42,778	
H. TOTAL DIRECT COSTS (A THROUGH G)				320,690	
I. INDIRECT COSTS (SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS				144,310	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				465,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPM 252 AND 253)				-0-	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$465,000	$

PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY		
Steven A. Rutledge *Steven A. Rutledge*	13 Jan 92	INDIRECT COST RATE VERIFICATION		
INST. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date of Rate Sheet	Initials-DGC
Donald W. Kelly				

NSF Form 1030 (8/90) *Supersedes All Previous Editions*

*SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPM 233)

6. Report on Cost Sharing Activities at CSU Including Projected Expenditures for Year 3

The following describes cost sharing expenditures at CSU for the first two years of the cooperative agreements and a projection for year 3:

	YEAR 1 4/15/90- 4/14/91	YEAR 2 4/15/91- 4/14/92	Cumulative through 4/14/92	YEAR 3 4/15/92- 4/14/93
Building and site prep.	$188,275	$0	$188,275	$0
Freight, Transport, ins., crane	11,975	0	11,975	0
Furniture and grounds	13,258	3,252	16,510	3,000
Materials, parts, supplies, paint	13,189	8,161	21,350	12,000
Salaries and services	3,849	64,258[a]	68,107	40,000
Telephone and postage	151	5,538	5,689	5,000
Vehicles and fuel	1,257	644	1,901	1,000
Equipment	0	12,749	12,749	3,000
CSURF lease (equipment)[c]	0	224,000	224,000	80,000
Indirect cost @ 45%[b]	$13,689	$35,370	$49,059	$26,100
TOTAL	$245,643	$353,972	$599,615	$170,100
Estimate 1/1/92 - 4/14/92	0	10,000	10,000	0
TOTAL	$245,643	$363,972	$609,615	$170,100

(a) Includes one month each for Steven Rutledge, V. Bringi, and Stephen Cox for year one and one month each for year two.

(b) Indirect cost base excludes building, furniture, equipment and CSURF lease.

(c) 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.

7. Statement on Cost Recovery Funds for Year 2

There were no cost recovery projects supported during the past year.

8. Statement on Residual Funds from 1991

No significant funds are anticipated from the 1991 NSF budget.

9. Plans for the Coming Year

We expect to support several "20 hour" projects during the coming year. In addition to these projects, we will also support the REU project during the summer of 1992 (see Sec. 2b). A proposal to develop a fast FFT chip has been submitted to the Engineering Directorate at NSF by Profs. Chen and Chandra in the Department of Electrical Engineering at CSU. If funded, the CSU-CHILL radar will be used as a test bed for the FFT chip. We will also continue our data collection in "target of opportunity" events.

APPENDIX

Letters from CSU-CHILL users
Letters regarding 20 hour projects
CSU-CHILL Newsletter

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
RESEARCH APPLICATIONS PROGRAM
P.O. Box 3000 • Boulder, Colorado 80307-3000
Telephone: (303) 497-8488 • FAX: (303) 497-8401

18 December 1991

Dr. Steven A. Rutledge
Scientific Director, CSU-CHILL Radar Facility
Dept. of Atmospheric Sciences
Colorado State University
Fort Collins, CO 80523

Dear Steve,

On behalf of the WISP participants, we would like to thank you and your CHILL crew for the outstanding job you did supporting WISP91. The radar collected useful data on nearly all WISP cases, and the operators were always available when needed. The data examined during the project was of high quality, and will be a valuable part of the WISP dataset. We are particulary impressed with this performance considering that this was first major research project after CHILL was moved from Illinois, and that there were considerable upgrades performed on the system just prior to the project.

There were only two problems areas worth mentioning:

1) Reliability of the ZDR switch. The ZDR switch did not provide reliable data during the field season, especially during the beginning. While this in no way compromised field operations, some ZDR data on winter storms was lost.

2) Funding. We understand that the level of funding for CHILL's WISP support may not have been sufficient. It's always hard to estimate ahead of time the resources needed to run a field project. Add to that the uncertainty of winter weather, the long (12 weeks!) field season and the complication that WISP studied every type of storm from beginning to end, and it is no surprise that CHILL exhausted its funding. Again, the field project was not compromised, but it seems that some agreement needs to be made with NSF to ensure that sufficient funds are available to cover CHILL operating costs throughout the field season, even if the original estimate is overrun. CSU should not be forced to foot the bill for this.

It was a pleasure working with your crew during WISP. It was no doubt a valuable learning experience for the students serving as radar operators; there is little enough opportunity for direct participation for students in field programs. We look forward to working with you in the future.

Sincerely,

Roy Rasmussen

Roy Rasmussen
WISP Scientific Steering Committee Chairman

Marcia K Politovich

Marcia Politovich
WISP Field Operations Coordinator

11 July 1991

Professor Ramesh Srivastava
The University of Chicago
Department of the Geophysical Sciences
5734 S. Ellis Avenue
Chicago, Illinois 60637

Dear Ramesh:

Enclosed please find two 9 track Universal Format tapes containing the data collected by the CSU-CHILL radar for your 20 hr project. The first tape has the data collected during the 4/8/91 and the 5/16/91 operations; the second covers the activities on 5/22/91 and 6/2/91. A brief summary of the various cases is as follows:

Date	Remarks
4/8/91	Mostly virga; profiler in RASS mode; RHI scans; UTC time
5/16/91	Dissipating stratiform rain; PPI scans
5/22/91	Thunderstorm passing Platteville; RHI scans + 1 PPI
6/2/91	Stratiform remnants of a tstm, bright band, RHI scans

The data format follows the UF conventions outlined in the BAMS November, 1980 article, except that the recording density is 6250 BPI instead of 1600 BPI. Also, the Platteville profiler is located approximately on the 196 degree true azimuth from the CSU-CHILL at a range of 31 km.

Please advise me if there is additional information from us that you would find helpful.

Sincerely,

Pat Kennedy

Pat Kennedy
CSU-CHILL Facility Manager
(303) 491-6248

29 August 1991

Professor Pierre Julian
Department of Civil Engineering
Colorado State University
Ft. Collins CO 80523

Dear Pierre:

The purpose of this note is to summarize the data collected by the CSU-CHILL radar during the course of your recently completed 20 hr project. Our records indicate that radar data for your project were recorded on the following occasions:

Date	Time (local)	Field Tape #'s	Remarks
5/24/91	1400-1730	115-116	Scattered TSTMS in Fred Ogden's grid
5/31/91	1400-1730	120-121	Small TSTM NW grid corner
6/2/91	1830-2100	123-124	Stratiform TSTM remnants
6/3/91	1200-1530	126-128	TSTM line developing within grid

Gridded data from the primary cases of interest have been provided to Fred Ogden for use in his PhD thesis work. It should be noted that the gridding of the field format radar data was done with the aid of software previously developed by Dave Brunkow of the CSU-CHILL staff.

It is our belief that decisions regarding the analysis of 20 hr project data are best made by the project investigators themselves. However, the CSU-CHILL staff are quite willing to provide technical consultation to users of our data.

Thank you for your interest in using the CSU-CHILL radar facility. We look forward to future opportunities to support your research activities.

Sincerely,

Pat Kennedy

Pat Kennedy
(303) 491-6248
CSU-CHILL Facility Manager

29 August 1991

Dr. David Hartley
USDA Agricultural Research Service
Federal Building
P.O. Box E
Ft. Collins CO 80522

Dear David:

The purpose of this note is to summarize the data collected by the CSU-CHILL radar during the course of your recently completed 20 hr project. Our records indicate that radar data for your project were recorded on the following occasions:

Date	Time (local)	Field Tape #'s	Remarks
5/22/91	1430-1500	110	Small TSTM passing Nunn Gages
5/30/91	1630-1703	120	TSTM over gages; radar receiver saturation
6/21/91	1630-1915	138-143	Several TSTM passages over Nunn gages
8/14/91	1635-1715	148	TSTM just missing gages to the NE
8/15/91	1500-1600	150	Developing TSTM passing gages; (no time series data recorded)

You have been provided gridded PPI data from the primary cases of interest. Copies of field format data can be generated to allow Bringi's group to process the time series portion of the data set.

It is our belief that decisions regarding the analysis of 20 hr project data are best made by the project investigators themselves. However, the CSU-CHILL staff are quite willing to provide technical consultation to users of our data.

Thank you for your interest in using the CSU-CHILL radar facility. We look forward to future opportunities to support your research activities.

Sincerely,

Pat Kennedy

Pat Kennedy
(303) 491-6248
CSU-CHILL Facility Manager

2 September 1991

Dr. Tom McKee
Department of Atmospheric Science
Colorado State University
Ft. Collins CO 80523

Dear Tom:

The purpose of this note is to summarize the data collected by the CSU-CHILL radar during the course of your recently completed 20 hr project. Our records indicate that radar operations for your project were conducted on the following occasions:

Date	Time (local)	Field Tape #'s	Remarks
6/6/91	1600-1915	134-135	slow moving TSTM near Aurora
7/19/91	1500-1630	none	surveillance; no DEN area storms
8/5/91	1600-1745	145	small TSTM crossing DEN area
8/6/91	1630-1815	146-147	Boulder foothills TSTM; power failure at CHILL
8/15/91	1615-1710	151	small TSTM crossing S DEN area
8/28/91	1500-1600	156	moderate TSTM crossing DEN from SW to NE; meso-anticyclone

Some of the 6/6 case data has been translated into Universal Doppler Exchange Format and delivered to Dave Speltz. We will continue this process as additional times of interest are identified.

It is our belief that decisions regarding the analysis of 20 hr project data are best made by the project investigators themselves. However, the CSU-CHILL staff are quite willing to provide technical consultation to users of our data.

Thank you for your interest in using the CSU-CHILL radar facility. We look forward to future opportunities to support your research activities.

Sincerely,

Pat Kennedy

Pat Kennedy
(303) 491-6248
CSU-CHILL Facility Manager

CHILL RADAR NEWS

from

Colorado State University

Overview

(Steven Rutledge, Scientific Director)

This is the first edition of the Colorado State University (CSU)-CHILL newsletter which we plan to distribute on an annual basis, near the start of the academic year. The newsletter is intended to provide information to the community regarding activities of the CSU-CHILL facility, including research, education, and refurbishment activities. In April 1990 Colorado State University was awarded a five-year cooperative agreement from the National Science Foundation for operation and maintenance of the CSU-CHILL, a 10 cm, dual polarized Doppler radar. The radar is presently operational near Greeley, CO (located approximately one mile north of the Greeley-Weld County Municipal Airport), situated on an eighty acre agricultural site owned by Colorado State University. Co-Principal Investigators for the cooperative agreement are Profs. Steven Rutledge and Stephen Cox in the Department of Atmospheric Science and Prof. V. N. Bringi in the Department of Electrical Engineering.

Several improvements to the radar have been carried out since its relocation to Colorado including the installation of a new inflatable radome and airlock entryway system, the purchase of a new ferrite fast polarization switch, and a new diesel generator for back up power. In addition, the radar control and data display system of the radar are presently being replaced with a new SUNrise system developed by Lassen Research. Presently, five SUN workstations are available to users on this system for data display and analysis. A permanent, 2500 sq. ft. staff building has been constructed at the radar site. This building provides offices for the radar staff and visiting scientists in addition to conference, shop and laboratory space. Details of several improvements to the radar are provided in the following sections.

Besides the refurbishment activities, it has been a busy period for both research and education projects. The radar played an integral role in the 1991 Winter Icing and Storms Project (WISP), operating in support of this experiment from 15 January to 31 March. The CSU-CHILL was used in combination with the NCAR CP-2 , CP-3, and Mile High radars, as well as the University of North Dakota portable Doppler radar. The CSU-CHILL also collected dual-polarization data during the project. Several students in the Departments of Atmospheric Science and Electrical Engineering are developing theses around this data.

Normally the use of the CSU-CHILL radar is granted by the National Science Foundation after review by the NSF Facilities Advisory Committee and Observing Facilities Advisory Panel. However, for projects not needing more than 20 hours of radar operational time, the Scientific Director of the CSU-CHILL facility can award the use of the radar for such projects. In these projects, radar operational costs are provided by the cooperative agreement. We have recently supported five such projects including a multi-parameter study by Prof. R. Srivastava of the University of Chicago, time series studies of polarimetric data by Prof. A. Kostinski of Michigan Technological University, a radar-based hydrology study by Prof. P. Julien of the Civil Engineering department at Colorado State University, an urban stream flood program by Prof. T. McKee of the Department of Atmospheric Science at Colorado State in association with the U.S. Geological Survey, and a radar-raingage intercomparison study by Dr. David Hartley of the U.S. Department of Agriculture. More details of these 20 hour projects will be given in the following section. These small projects allow investigators to conduct highly focussed research with the CSU-CHILL radar.

Educational projects involving the CSU-CHILL radar are also ongoing. In May of 1991 Profs. J. Hallett and M. Wetzel of the University of Nevada-Reno and a group of 12 graduate students came to the CSU-CHILL facility for a two week period for a short course in radar meteorology. The format of the course consisted of lectures by Profs. Rutledge and Bringi, as well as real time operations. A number of excellent data collection sessions were conducted where the students studied a wide range of meteorological events including multi-cell hailstorms, a mesocyclone, and a squall line. Each student was given time on the SUN workstations at the radar and were trained in various data analysis techniques.

Undergraduate education is also being addressed. Prof. V. Chandresekar of the Colorado State electrical engineering department was recently awarded a grant to support several undergraduate research projects through the NSF Research Experience for Undergraduates (REU) program. This grant will provide summer employment during 1992 for approximately 10 engineering students who have completed their junior year. These summer activities will be the basis for subsequent senior year projects.

Operational Highlights
(Pat Kennedy, Facility Manager)

During 1991 the CSU-CHILL radar has collected data in support of a wide variety of interests. The context in which these data were collected has varied from comprehensive, multi-sensor observational programs to locally directed "target of opportunity" operations. The following is a brief overview of some of the highlights of these data collection efforts.

The CSU-CHILL was one of five Doppler radars that participated in the 1991 version of the Winter Icing and Storms Project (WISP91). A major goal of this project was the study of the production and depletion of the regions of concentrated supercooled water that are conducive to the formation of aircraft icing. Real time operations of both the radars and research aircraft were coordinated from NCAR's Research Applications Program (RAP) field control center. In general, the combined data from the WISP91 radar network will be used to determine the three dimensional wind field within echoing regions. In addition, on several occasions the CSU-CHILL collected dual polarization data in close proximity to the research aircraft flight paths. These aircraft data will provide useful in-situ measurements for comparison with the remotely sensed radar data.

On a smaller organizational scale, the series of 20 hour projects supported by the CSU-CHILL were designed to allow their investigators to identify specific days of interest for data collection. As always, the actual scientific yield from days that initially showed interesting prospects varied, but data of some value were obtained in each of the projects:

Professor Ramesh Srivastava of the University of Chicago was interested in collecting dual polarization data with the CSU-CHILL at various heights above the NOAA profiler located near Platteville, Colorado. An evening during which stratiform remnants from a dissipating thunderstorm passed over the profiler provided the bright band echo structure that Prof. Srivastava desired. The echo requirements in Dr. Kostinski's 20 hour project were less stringent; he was interested in some of the statistical properties of time series data from precipitation targets in general. He returned to Michigan Technological University with data recorded in rain and snow shower activity that occurred during his late April visit to the radar. In a project designed to collect radar data for the initialization of a hydrological runoff model, Prof. Pierre Julien of the Colorado State civil engineering department was interested in observing a variety of precipitation regimes. Convective echo systems with several degrees of spatial organization were observed during this project. Some of these data are currently being used for model initializations in the Ph.D. thesis of Fred Ogden, a student under the supervision of Prof. Julien. Another project centered around rainfall runoff implications was conducted under the guidance of Prof. Tom McKee of the Colorado State atmospheric science department. His focus was on convective precipitation events which generated rainfalls in excess of one inch in the foothills region lying immediately west of the Denver - Boulder metropolitan areas. Several drainages in this area have been instrumented to provide both streamflow and rainfall data in realtime. Many of the Denver area storms observed by the CSU-CHILL reached their most intense stages after they had moved east of the instrumented drainages. Nevertheless, Dave Speltz, an Atmospheric Science department Masters Degree candidate, has started a preliminary analysis of the radar and surface data. The final 20 hour project supported by the CSU-CHILL radar during this period was a radar - raingage comparative study organized by Dr. David Hartley of the USDA Agricultural Research Service (ARS). The ARS operates a network of raingages clustered near Nunn, Colorado, located approximately 40 km north of the CSU-CHILL site. Polarimetric data in both conventional and time series modes were recorded when precipitation echoes were observed over the raingage network. The heaviest storm that crossed the network contained hail as well as rain. Initial results show improvements in the radar-raingage comparisons when differential reflectivity data are used to identify the presence of hail.

In addition to the 20 hour projects summarized above, the CSU-CHILL radar was also operated for several "target of opportunity" cases. The goal here was to collect data that could be used as classroom case studies at Colorado State and could also be made available for similar applications at other institutions. The Colorado convective season of 1991 succeeded in providing several such opportunities. Several series of volume scans of thunderstorms bearing mesocyclone circulations were recorded. Explosive thunderstorm development following fine line interactions was observed over a two hour period early in the evening of 8/19/91. We hope to record additional "target of opportunity" cases during the upcoming winter season.

The final category of CSU-CHILL data collection has been to support in-house research investigations. Time series data, some of which were collected with 30 m range resolution, have been recorded briefly on several occasions for examination by Prof. Bringi's group in the Colorado State electrical engineering department. Also, a significant portion in the lifetime of a hailstorm that occurred on the plains east of Denver was observed. The evolution of the reflectivity core structure in this storm appeared to involve the cyclic growth and decay of series of bow echoes. Dual-Doppler analyses of this storm using data from the CSU-CHILL and Mile High radars are now in progress.

Engineering Highlights
(Eugene Mueller, Senior Engineer)

A number of engineering improvements in the system were accomplished during the past year:

1. In order to improve the match between the antenna sidelobe patterns at both horizontal and vertical polarizations, the feedhorn/waveguide support struts were rotated 45 degrees when the antenna was assembled at Greeley. After the implementation of this rotation, it was deemed necessary to check the focusing of the antenna and to map the beam patterns. It was found that better patterns resulted when the horn position was moved toward the dish by one inch. Patterns were obtained for both copolar and cross polar antenna operations. An experiment to determine the improvement of the patterns by enclosing the struts with radio wave absorbent material was conducted. This resulted in unmeasurable differences in the copolar patterns both on the main lobe pattern and on the strengths of the side lobes. However, there was some effect on the cross polar patterns that will be verified by a repetition of pattern measurements.

2. Sphere calibrations were also conducted to check the overall calibrations of the radar. These tests confirmed the calibration accuracy of the system. In addition there were simultaneous measurements of weather echoes from the CSU-CHILL and the Mile High Radars. These two radars showed agreement within 2 db on the average with a reasonable scatter of points around this mean.

3. There were a number of additions to the system during the year that enhance either the operational capability or provide additional reliability of operation and equipment integrity. The more important of these were:

a) A new radome monitor which monitors conditions at the site and provides control of standby devices to increase the chances of survivability during severe weather or power loss. This device will also alert maintenance personnel by phone when unusual conditions are in existence.

b) A third blower was added to the radome inflation system. This blower is powered by a gasoline engine and thus does not require either commercial or backup diesel power. Control of this blower is redundant and it will start either from control of the radome monitor or from its own radome-pressure switch.

c) A new Diesel power plant was purchased for the radar system. This plant is sufficiently large that it can run the radar and data system in the event of commercial power failure, thus permitting uninterrupted data collection.

d) The fast polarization switch was updated with a new electronics printed circuit board and a more accurate temperature control system. In addition, a completely new polarization switch has been purchased. This switch will be used as a spare and/or eventually in a three switch configuration to improve the isolation.

Many of the engineering improvements have been installed by Mr. Kenneth Pattison, who serves as a full-time technician for the CSU-CHILL radar.

Computer Systems
(David Brunkow, Software Engineer)

Part of the upgrade of the CSU-CHILL system was the replacement of the video digitizer. The new digitizer was purchased from Lassen Research. It consists of one signal processor (SP20) card which contains all of the circuitry for digitizing the I, Q and Log Power video channels. In addition, this card controls the switchable attenuators used in the Instaneous Automatic Gain Control (IAGC) and combines the linear and log channels to develop the floating point I and Q values used in the SP20 signal processor. The card is controlled through a micro-coded control program which allows flexible selection of sampling rates and averaging options. This same card generates the four triggers which drive the radar and polarization switch. The new card has centralized many of the radar control functions, and provides an improved solution to the problem of removing DC offsets and balancing the gains of the I-Q channels. Both the offset and gain of each channel are now controlled by the host computer. This card was installed in the fall of 1990, and it has made visible improvements in the area of DC offset removal, and spectral width estimates which previously exhibited artifacts which were attributed to imbalances in the I and Q channels.

The switchable attenuators became operational during the summer of 1991. As a part of this installation, it was discovered that the existing attenuator arrangement was limited to about 36 db of attenuation. This was traced to leakage inside the attenuator box, and was corrected with additional shielding. The attenuator can now be switched from 0 to 60 db in 12 db steps. The static performance of the IAGC is good, but work is continuing on improving the switching characteristics. Part of this work has included the installation of a new low distortion quadrature detector, which will produce significantly higher video voltages than were previously available.

Another activity which was pursued was the verification of the SP20 signal processing software used in the alternating VH polarization mode. To perform this test, a time series simulating an alternating VH polarization radar was produced at the Colorado State electrical engineering department. This time series was placed in a program and downloaded to a spare SP20 card. This program disabled the normal SP20 input card, and caused the simulated data to be placed on one of the SP20 busses in place of the normal input data. The remaining SP20 cards processed the data as usual. The results were recorded on tape for later comparisons. The correct values for the reflectivity, velocity, and VH and HV correlations and HH lag 2 correlations were calculated independently on one of the CSU-CHILL workstations, and then compared with the SP20 results. All fields produced by the SP20 agreed with the expected values. This experiment will be repeated with other known time series and other SP20 processing modes.

The SUNrise radar data/display system is an ongoing development by Lassen Research. When installation is complete, it will allow users to view CSU-CHILL product files and control scans from the laboratories on the Colorado State University campus. The product files will include conventional PPI scans as well as constant altitude PPI's (CAPPI), VAD's, and arbitrarily oriented vertical cross sections. These images are transmitted back to Fort Collins via a T1 data line, which extends the campus network to the CSU-CHILL site. Lassen Research plans to complete the SUNrise installation during the Fall of 1991. Part of the SUNrise system is operational now. It produces a remote real-time PPI display of reflectivity or velocity. In this mode CSU-CHILL data via SUNrise has been used in class demonstrations by the Atmospheric Science department.

Contact information: Potential users of the radar or anyone else desiring more information about this facility should contact Pat Kennedy at 303-491-6248 (E-mail; pat@lab.chill.colostate.edu). Other CSU-CHILL contacts are:

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