Semiannual Report for

THE CSU-CHILL RADAR FACILITY

Cooperative Agreement No. ATM-8919080

Submitted to

The National Science Foundation

Division of Atmospheric Sciences

26 July 1993

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

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1. Introduction

The first seven months of 1993 have proven to be a very busy and productive period for the CSU-CHILL radar facility. A total of eight 20 hour projects have been supported during this period, which are discussed in Sec. 2. The acquisition of our new antenna is on schedule. We expect acceptance testing to begin in mid-September, followed by delivery of the antenna in late October (Sec. 4). Many research projects and student theses using CSU-CHILL data are in progress, which are listed in Sec. 3. A total of eight papers using CSU-CHILL data were presented at the recent AMS Radar Conference held in Norman, OK.

We also held a meeting of the CSU-CHILL Radar Advisory Committee during the recent Radar Conference. Attending were three members of the RAC (Drs. J. Keeler, R. Wakimoto and D. Zrnic), CSU-CHILL staff, Profs. Bringi (CSU-CHILL Co-PI) and Chandra from CSU/EE, and Prof. Rutledge (CSU-CHILL Scientific Director). Jon Lutz of NCAR was a guest attendee at this meeting. Presentations made at the meeting are summarized in the Appendix. We provided the RAC with a theoretical and experimental justification for our new antenna. The RAC gave their strong approval for this acquisition. We also provided a description of a polarization switch monitor, and updated pulse compression activities. We reviewed the use of the NCAR/RAP TITAN Remote Display System presently used on the CSU-CHILL radar. This system has generally been well received (as a replacement for the data display portion of SUNRISE, which was to be provided under a past contract to Lassen Research). A point about data formats in TITAN was raised and is being addressed. The RAC felt that if other users desired to display CSU-CHILL data at their facilities it might best be done using the NCAR Zeb software (since users have wider access to Zeb compared to TITAN). This point is now being addressed by CSU-CHILL staff by experimenting with a "real-time data ingest version" of Zeb, which was installed on one of the CSU-CHILL workstations just last week. We were informed that this version of Zeb should be capable of ingesting TITAN-format data. Tests are currently underway to explore this compatibility. If this is so, we can provide users with data archived by TITAN, who can then display these data using Zeb (along with other field data). The next formal meeting of the RAC will be held in early winter 1994, following installation of the new antenna.

Additional recent activities include the development of a new Facility Users Guide (scheduled for release in September 1993) and preparations for CSU-CHILL radar operations in WISP94 (with NSF Deployment Pool support). A description of our case study archive database with remote login procedures was recently released to the community.

2. Operational Summary: 1 January 1993 - 1 August 1993

A considerable amount of data collection activity has taken place at the radar facility during the January through August 1993 period. While no NSF-sponsored activities took place during this time, eight different 20 hour projects were supported. The following table summarizes the highlights of these projects:

Month(s)	Investigator(s)	Data Summary
Feb.	P. Kennedy (CSU-CHILL)	Coordinated multiparameter radar and dedicated surface precipitation observations during snow events.
March	R. Roberts (NCAR / CSU)	Multiparameter and dual Doppler (with NCAR Mile High Radar) observations during precipitation events in the WISPIT project.
March	V. Chandrasekar (CSU)	Joint research aircraft -multiparameter radar observations during the WISPIT project.
May-June	L. Carey (CSU)	Observations of the evolution of multiparameter radar and cloud electrification properties in thunderstorms.
May-June	T. Holtzer (CSU)	Radar support of an insect migration study. (Insects captured in flight via a research helicopter.)
June	K. Aydin (PSU)	Multiparameter radar observations during RAPS93 project hail events.
July	V. Bringi (CSU)	Multiparameter radar observations during RAPS93 project hail events.
July-August	W. Cotton (CSU)	Dual Doppler (with NCAR Mile High Radar) studies of the initial development of MCS's.

The first seven projects in the above list are completed, and were judged to be highly successful, from both weather and radar operational perspectives. The Roberts and Carey projects provided data for M.S. theses in the Department of Atmospheric Science at Colorado State University. The Cotton project already has yielded two excellent case studies, and will be completed in mid-August. It is anticipated that the radar will be unavailable for data collection during the October through December 1993 period while the installation of the new antenna is in progress.

3. List of Publications and Theses Using CSU-CHILL Data

CHILL Publications

1992-1993 CHILL Publications

In this section, all publications for the period 1992-1993 which used data collected by the CSU-CHILL radar are listed. Studies by both CSU and non-CSU researchers are included.

Reviewed publications:

Changnon, S. A. 1992: Temporal and spatial relationships between hail and lightning, *J. Appl. Meteor.*, **31**, 587-604.

Czys, R. R. and R. W. Scott, 1993: A simple objective method used to forecast convective activity during the 1989 PACE cloudseeding experiment. *J. Appl. Meteor.*, **32**, 996-1005.

Hallett, J., M. Wetzel and S. A. Rutledge, 1993: Field training in radar meteorology. *Bull. Amer. Meteor. Soc.*, **74**, 17-22.

Kennedy, P. C., N. E. Westcott, and R. W. Scott, 1992: Single Doppler radar observations of a tornadic mini-super cell thunderstorm. *Mon. Wea. Rev.*, **121**, 1860-1870.

Liu, L., V.N. Bringi, V. Chandrasekar, E.A. Mueller and A. Mudukutore, 1993: Analysis of the copolar correlation coefficient between horizontal and vertical polarizations. Submitted to J. *Atmos. Oceanic Tech.* (under review).

Rasmussen, R., M. Politovich, J. Marwitz, W. Sand, J. McGinley, J. Smart, R. Pielke, S. Rutledge, D. Wesley, G. Stossmeister, B. Bernstein, K. Elmore, N. Powell, E. Westwater, B. Stankov, and D. Burrows, 1992: Winter Icing and Storms Project. *Bull. Amer. Meteor. Soc.*, **73**, 951-974.

Rutledge, S. A., P. C. Kennedy, and D. A. Brunkow, 1993: Use of the CSU-CHILL Radar in radar meteorology education at Colorado State University. *Bull. Amer. Meteor. Soc.*, **74**, 25-31.

Papers presented at the 26th International Conference on Radar Meteorology (Norman, OK 24-28 May, 1993):

Achtemeier, G. A., R.W. Scott, and P. C. Kennedy: The Champaign macroburst: a rare radar event?

Benjamin, A., and V. Chandrasekar: Polarimetric radar and aircraft observations of winter storms.

Bringi, V. N., D. Brunkow, V. Chandrasekar, S. Rutledge, P. Kennedy, and A. Mudukutore: Polarimetric measurements in Colorado convective storms using the CSU-CHILL radar.

Hubbert, J., J. Caylor, and V. Chandrasekar: A practical algorithm for the estimation of Doppler velocity and differential phases from dual polarized radar measurements.

Kennedy, P. C. and S. A. Rutledge: Combined dual-Doppler and multiparameter radar observations of a Colorado bow echo hailstorm.

Liu, L., V. N. Bringi, V. Chandrasekar, E. A. Mueller, and A. Mudukutore: Statistical characteristics of the copolar correlation coefficient between horizontal and vertical polarizations.

McAnelly, R. L., J. E. Nachamkin, W.R. Cotton: Upscale growth processes in a mesoscale convective system.

Xiao, R., V. N. Bringi, D. Garbrick, E. A. Mueller, and S. A. Rutledge: Copolar and cross polar pattern measurements of the CSU-CHILL antenna.

Other publications:

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

Rutledge, S.A. and collaborators, 1992: The CSU-CHILL annual newsletter.

Turk, J., 1992: Ka-band propagation measurements using the ACTS propagation Terminal and the CSU-CHILL radar, NASA Earth-Space Propagation Newsletter, No. 18, Dec. 1992, University of Colorado.

1990-1991 CHILL Publications

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

Reviewed publications:

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.

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. Pattison, 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.

Rutledge, S.A. and collaborators, 1991: The CSU-CHILL annual newsletter.

Student Theses Using CSU-CHILL Data (CSU students)

Completed:

L. Liu, Electrical Engineering, Ph.D. - 1993
Ashok Mudukutore, Electrical Engineering, M.S. - 1992
Fred Ogden, Civil Engineering, Ph.D. - 1992
Nick Powell, Atmospheric Science, M.S. - 1992
Dave Speltz, Atmospheric Science, M.S. - 1992

In Progress:

Andrew Benjamin, Electrical Engineering, Ph.D.
Larry Carey, Atmospheric Science, M.S.
Mike Dixon, Civil Engineering, U.C. - Denver, Ph.D.
Rita Roberts, Atmospheric Science, M.S.

Undergraduate Projects:

Graphical Rendering of Radar Data, Electrical Engineering, 1993

4. Update on Antenna Acquisition

In the last Annual report, it was reported that invitations to bid on a replacement antenna were sent out to various manufacturers. The bids were returned and the lowest responsive bid was for $126,000 from Radiation Systems Inc. (RSI). An award was made at the end of March to RSI. The antenna is scheduled for delivery on October 29, 1993.

According to RSI, the antenna delivery is still on schedule as of July 15, 1993. Acceptance tests are to begin on September 20, 1993. RSI's expectation is that if a decision on the adapter can be made by at least mid-August, it will not effect delivery.

One area of immediate concern relates to the development of a new adapter plate which is needed to mate the new antenna with the existing side arms of the pedestal. The original intent was to have the mechanical design engineer at NCAR provide a design for the adapter plate. After examining the details of this design, particularly that of the antenna mounting procedure, the NCAR engineer anticipated considerable difficulty in the design and he recommended that the work be done either by RSI or some other engineering firm. The new structure would require finite element analysis and the facilities for accomplishing this were not available at NCAR.

Therefore, the first choice was to have RSI design and build this adapter. RSI could not find in their files the drawings of the existing adapter and side arms, both of which they built in 1969-1970. They asked to have an engineer come to the radar and make measurements before they would submit an estimate on cost. The cost of this trip was to be $2500. On receipt of this quote, a copy of the manual for the radar antenna and pedestal was sent to RSI. Using information in the manual (drawing numbers) instead of the project number allowed RSI to "find" the earlier drawings.

After examining the drawings RSI was still hesitant to quote or design the structure because they suspected that the sidearms may not have been built to exact specifications. This indeed appears to be true. The best measurements that could be made with the antenna in place indicated that the distance between mounting holes on the two side arms were not in exact conformity to the drawings. The decision was then made to have the adapter designed and built without drilling the holes for bolting the plate to the side arms. This would be done after the plate arrived in Colorado and would require marking the locations and taking it in to a machine shop.

On July 19, a proposal was received from RSI for $28,914 to design and manufacture the adapter. This seems quite high to the staff of the radar. Estimates made by the NCAR designer was that the construction cost would be of the order of $10K. The construction cost as per quote from RSI is $17,244. The non-recurring engineering cost of $11,670.

At this point no decision has been made as to whether to proceed with an award to RSI for this work. Other options are being actively considered, one being identifying an independent structural engineering firm to design and build the adapter plate. We are also consulting with RSI on a possible modification to the present adapter plate to support the new antenna. We expect to have a firm plan in place by mid-August.

5. Letters from RAC Panel Members and Various Users

This section contains letters received from the RAC panel members who attended the RAC meeting held at the recent AMS Radar Conference in Norman, OK (May, 1993). This section also contains letters from various 20 hour users, received at the completion of their projects.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES

National Severe Storms Laboratory
1313 Halley Circle
Norman, OK 73069

June 4, 1993 R/E/NS

Dr. Cliff Jacobs
National Science Foundation
Atmospheric Sciences Division
1800 G. Street
Washington, DC 20550

Dear Dr. Jacobs,

This is in reference to a recent advisory panel meeting concerning the CSU-CHILL radar facility. The meeting highlighted recent progress at the facility which I have also followed through informal contacts with Dr. Rutledge, Bringi, Chandrasekar and Mueller as well as through my visit with Mr. Kennedy and Brunkow. Furthermore I had ample exposure to the many papers at the 26 Radar Meteorology Conference which were produced by the PIs, their students, and post doctoral fellows.

The new home at CSU has instilled a breadth of fresh air in the personnel and I believe has truly lived up to the NSF expectations. First I support the present research and development direction. In the near future the radar will have a new antenna with which we should be able to asses the scientific and practical utility of depolarization measurements. The radar is currently providing valuable data that will allow us to map and gauge hydrometeor evolution within precipitating systems.

I am also impressed with the educational component. To my knowledge CSU is the only university where atmospheric science has blended well with electrical engineering. Thus both disciplines can benefit from each other. Also I am enthusiastic about the 20 hour projects for small field experiments. This is an extremely cost effective way to train students to do research as well as to obtain valuable data for scientific inquiries.

Overall the program has been a great success and I believe will continue to prosper in both research and in offering training opportunities to future radar meteorologists.

Sincerely yours,

Dusan S. Zrnic, Chief,
Doppler Radar & Remote Sensing
Research Group

cc: S. Rutledge
V.N. Bringi
G. Mueller
P. Kennedy
D. Bronkow

UNIVERSITY OF CALIFORNIA, LOS ANGELES UCLA

BERKELEY · DAVIS · IRVINE · LOS ANGELES · RIVERSIDE · SAN DIEGO · SAN FRANCISCO · SANTA BARBARA · SANTA CRUZ

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June 1, 1993

Professor Steve Rutledge
Dept. of Atmospheric Sciences
Colorado State University
Fort Collins, CO 80523

Dear Steve,

This letter summarizes my impressions of the recent (unofficial) RAC meeting at Norman regarding the CHILL radar. You are to be commended for your hard work and dedication on behalf of the meteorological community in making the CHILL radar a first class facility. Below I have listed several items (not in any particular order) that I wish to pass on to you:

1. I had a chat with Cindy Mueller and was informed that if the CHILL format was NetCDF then it would be relatively easy for a user to peruse the data set using the ZEB software. As I mentioned at the meeting, your choice of the TITAN software so users can have a quick look at the data set is a good one, however, you have assumed that they will accomplish this at CSU. There will be times when the users may wish to look at the data set at their home institution. I know of several universities (including UCLA) that already have the ZEB software up and running and would probably prefer to examine the CHILL data using this software rather than TITAN.

2. Although I enjoy reading the CHILL updates that you mail to the RAC, the meeting in Norman was only the second time I have attended a formal gathering (technically, even the Norman meeting was not a true RAC gathering since a couple of people were absent). I, personally would find my contributions more effective if regularly scheduled meetings were planned. Reports are nice but they do not substitute for active discussions.

3. Your recent accomplishments have been outstanding and I hope you follow my advice by documenting the reviews by the PIs on the major and 20-hr projects. I (along with NSF) would enjoy reading the statements from satisfied customers. I also would find it very useful to see a listing of the publications and student theses that have resulted from the CHILL data set.

Steve, you are doing a great job and my comments are to be considered minor. Good luck and it was great seeing you at the Radar Conference. Please feel free to contact me if you have any questions.

Sincerely,

Roger

Roger M. Wakimoto
Associate Professor of Meteorology

Copy to:
J.Keeler
C.Mueller
D.Zrnic

Atmospheric Technology Division -- Remote Sensing Facility
Memorandum

14 July 1993

Memo to: Steve Rutledge, CHILL Scientific Director
From : Jeff Keeler, NCAR/ATD/Remote Sensing Facility
Subject: **CHILL Radar Advisory Committee comments**

This memo addresses several points we discussed at the recent Radar Advisory Committee meeting in Norman, OK on 25 May 93.

I was pleased to hear of your recent activities regarding the new antenna acquisition, the planned pulse compression test, and the "ftp" CHILL radar data archive. All these activities play an important role in your educational mission as well as developing new research capabilities for CHILL. I was especially impressed with your success of several very interesting 20 hour projects. Roger Wakimoto suggested that you document and publicize these research accomplishments as you would a full blown field project and I support his suggestion.

You stated that your first 5 year contract with NSF is nearing completion and that NSF will be considering extending CSU's contract to operate the CHILL radar as an educational and national facility. I would urge NSF to exercise its option for a 6th year of operation under the current contract and definitely support an additional 5 year contract. The performance of the entire CHILL staff has shown its enthusiasm and professionalism in developing the radar and applying it to the education of the next generation of radar meteorologists and engineers.

You also described that you were integrating the Thunderstorm Initiation Tracking and Analysis Network (TITAN) display, courtesy of Mike Dixon at NCAR/RAP. Although this is a fine display, my impression is that it was developed as a specific research tool, not as a general purpose radar data display which seems to be your intent. I would recommend that you investigate NCAR/ATD's "zeb" display for a Cartesian-space data integration display. I'm not at all up on "zeb"'s capabilities, but it can combine various data sets from the radar and other sensors (including aircraft tracks). Cindy Mueller or Jon Corbet can give you all the details you'd like. "zeb" has been ported to many other universities and some CHILL visitors would already be familiar with "zeb" and perform extended analyses once they return to their own facilities.

My only other comment is that I think the entire CHILL RAC should be convened on a regular basis (say once or twice a year) to allow a better and more frequent exchange of information and advice.

Overall, I'm very impressed with the contribution you all have made and encourage you and NSF to continue this fine work.

cc: Wakimoto, Zrnic, Hildebrand

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at Urbana-Champaign

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217 333-2046
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June 3, 1993

Dr, Steve Rutledge
Scientific Director, CSU-CHILL radar facility
Department of Atmospheric Science
Colorado State University
Fort Collins, CO 80523

Dear Steve,

Ron Smith of Yale, Harry Ochs of the Illinois State Water Survey, and I want to thank you for CSU-CHILL support of our pilot project to use the stable isotope method to study water vapor transport into the upper atmosphere by cloud systems. We appreciated your rapid response to our late request for 20 hours of support. The CHILL staff was very accommodating during the project. We were provided with a UF tape shortly after the project ended. We look forward to working with you again in future projects.

Best regards,

Bob Rauber
Associate Professor

Pat. K

Pierre Y. Julien
Fred L. Ogden
Rm. A215 ERC
Colorado State University
Fort Collins, CO 80523
February 8, 1992

Prof. Steve Rutledge
Scientific Director, CSU-CHILL National Weather Radar Facility
Department of Atmospheric Science
Colorado State University
Fort Collins, CO 80523

Dear Steve,

Fred and I would like to express our sincere appreciation for your assistance with Fred's dissertation research. The access to the CSU-CHILL radar which you provided helped tremendously. The multi-parameter capabilities of the radar proved quite adequate for rainfall rate estimation, even in hail contaminated regions. The staff of the CSU-CHILL radar; Pat Kennedy, Dave Brunkow, Gene Mueller, and Ken Pattison, all provided Fred with a great deal of assistance. Their commendable efforts are also appreciated.

Sincerely,

Pierre Y. Julien

Pierre Y. Julien
Associate Professor of Civil Engineering

Fred L. Ogden
Rm. A215 ERC
Colorado State University
Fort Collins, CO 80523
February 8, 1992

Pat Kennedy, Dave Brunkow, Gene Mueller, Ken Pattison
Scientific Staff, CSU-CHILL National Weather Radar Facility
Department of Atmospheric Science
Colorado State University
Fort Collins, CO 80523

Gentlemen,

I would like to express my sincere appreciation for your assistance with my dissertation research. All of you made notable contributions to my research goals, and I enjoyed the time I spent working with you (except when the polarization switch was on the fritz). The data which we recorded on June 3, 1991 became a cornerstone of my dissertation. The multi-parameter capabilities of the radar proved quite adequate for rainfall rate estimation, even in hail contaminated regions.

I would like to come to the radar this Spring and give you a presentation of my research results. I also look foreward to possibly working with you again, as a researcher at the University of Iowa.

Sincerely,

Fred L. Ogden

cc:
Pierre Julien, Assoc. Prof. Civil Engineering

University of Colorado at Denver

Department of Civil Engineering

Campus Box 113
P.O. Box 173364
Denver, Colorado 80217-3364
Location: 1200 Larimer Street, Room 3027
(303) 556-2871 Fax: (303) 556-2368

26 September 1992

Patrick Kennedy
CSU-CHILL Facility Manager
Department of Atmospheric Science
Fort Collins, CO 80523

Dear Dr. Kennedy,

This letter is in reference to your letter of 11 September noting the summary of radar operations conducted in support of Mike Dixon's research project. I understand that Mike is making good progress on the analysis of the data and would expect some good results to be obtained.

Let me thank you and your group there at the CHILL radar site for providing a means for collection of the radar data, for working cooperatively with Mike, and for conducting all of these activities in a very efficient manner. Availability of the radar to operate in specialized modes for such purposes is a valuable resource to the research community and provides a basis for new insights into the science of rainfall estimation.

I look forward to future opportunities for our students to conduct research with your radar facility.

Sincerely,

Lynn E. Johnson
Associate Professor

cc/ Mike Dixon, NCAR,RAP

THE UNIVERSITY OF CHICAGO
DEPARTMENT OF THE GEOPHYSICAL SCIENCES
5734 S. ELLIS AVENUE
CHICAGO • ILLINOIS 60637

14 July 1993

Prof. S. A. Rutledge, Scientific Director
CSU-CHILL Radar
Department of Atmospheric Sciences
Colorado State University
Fort Collins, CO 80523

Dear Steve

I am writing this letter in response to a telephone call from Pat Kennedy.

We made use of the CHILL radar to perform so-called "20-hour" experiments during the springs of 1991 and 1992. At my request CHILL staff collected radar data (in particular, differential reflectivity data) each year on a number of days in conjunction with the NOAA profiler located at Plateville, Colorado; the data were subsequently provided to me by the CHILL staff on magnetic tape. The purpose of this experiment was to compare the ZDR measured by the CHILL radar with the ZDR computed from drop size distribution estimated from the profiler observations. The data provided by the CHILL radar (and the profiler) were of uniformly high quality. We look forward to further experiments with the CHILL radar.

Sincerely
Ramesh
R. C. Srivastava
Professor of Meteorology
copies to: P. Kennedy, CSU and D. Carter, NOAA , Aeronomy

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
RESEARCH APPLICATIONS PROGRAM
Mailing Address: P.O. Box 3000 • Boulder, CO 80307-3000
3450 Mitchell Lane • Boulder, Colorado 80301
Telephone: (303) 497-8422 • FAX: 497-8401

19 July 1993

Dr. Steven Rutledge
Department of Atmospheric Science
Colorado State University
Fort Collins, CO 80523

Dear Steve:

I would like to express my appreciation to you and to the CHILL staff for providing me with the opportunity to collect some additional radar data on Colorado winter storms through the 20-hr proposal program. I found the CHILL staff, specifically Pat Kennedy and Dave Brunkow, responsive to my operational needs. They were ready and willing to operate the radar late into the evening, during early morning hours, or on the weekend, if necessary. Changes in radar scanning were implemented quickly and often had already been anticipated by the CHILL staff before I could reach them by phone. I was promptly informed of radar processor problems and any hardware failures during operation, including the failure in a transmitter tube. Gene Mueller was quick to locate the latter problem and soon had the radar back on line.

I have received all my data requests in a timely fashion and in the format desired. Preliminary examination of the 11 March 1993 data indicates the data quality is good and will likely provide me with a nice case for winter storm analysis.

I look forward to working with you and your staff again in the future.

Sincerely,

Rita Roberts
Associate Scientist
NCAR/RAP

cc: Pat Kennedy, ATS Department

Colorado State University

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Fort Collins, Colorado 80523
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23 July 1993

Dr. Pat Kennedy
CSU-CHILL Facility Manager
Department of Atmospheric Sciences
Colorado State University

CHILL Evaluation

The Russian wheat aphid (RWA) (*Diuraphis noxia*) has become one of the most important insect pests of small grain crops in the United States. During the period when primary hosts (e.g., small grain crops, primarily wheat and barley) are unsuitable for development and reproduction, the RWA utilizes alternate hosts (e.g., range grasses, Conservation Reserve Program grasses, volunteer grain). Dispersal between alternate hosts and small grain crops is a key component of the life history of the RWA and has a significant bearing on development of economically damaging RWA infestations. However, the dynamics of RWA dispersal are poorly understood and programs to monitor dispersal are not well developed. Without this information, management systems for RWA will remain severely limited. We are developing a comprehensive understanding of the dynamics of RWA dispersal. This research involves aerial sampling of the atmosphere to collect RWA using helicopter mounted traps and quantifying the meteorological events that are strongly associated with RWA movement.

We used the CHILL radar facility to assist our efforts to collect RWA by identifying layers in the atmosphere that may contain insects. In addition, the data collected by the CHILL radar during the helicopter flights will provide valuable meteorological data to supplement that collected using the helicopter and radiosondes.

Preparation: The CHILL staff fully explained the operation and capabilities of the system and had prepared several programs to control the CHILL radar system. These programs greatly facilitated collection of data. The staff were also extremely flexible and altered the programs as necessary to allow us to collect data and direct the helicopter during flights.

Operation: During the duration of the project the staff were available and prepared to alter their schedule to ensure the radar was available during the helicopter flights. As our schedule was highly dependent on weather conditions this required that the staff be available at all times during the two week helicopter flight period. The staff were required to work weekends and Memorial Day to facilitate our schedule. At the outset of the project, a minor problem prevented the CHILL radar from working properly. To solve this problem a member of the staff returned early from a scientific meeting to

correct the problem. We experienced no appreciable loss of information due to the problem.

Data Analysis: We have not had an opportunity to analyze the data, however, preliminary discussions have been extremely positive and the staff have outlined several options to accomplish the analysis.

Sincerely,

Mark Carter
Research Associate
Entomology
491 - 7820s

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June 21, 1993

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

Dear Dr. Rutledge:

This letter is in response to Pat Kennedy's e-mail message concerning the radar advisory panel's interest in "feedback" letters from the 20-h project users. Accordingly, the following is our assessment of the radar performance, staff, data quality, etc., as they relate to our 20-h project in late July and early August of 1992.

First of all, we feel that the 20-h minigrant program is very important, and that our opportunity to conduct last year's project has contributed to our research program. Our biggest disappointment was with an overall below normal amount of MCS activity in northeastern Colorado during the project. Weather summaries in Climatological Data characterize July and August as unusually cool and moist, with unusual patterns of thunderstorm activity. Persistant strong northwesterlies aloft worked against the usual patterns of orogenic convection/MCSs developing in relatively weak flow aloft. Instead, MCS activity was shifted (1) to the northeast, where systems repeatedly developed in western Nebraska and moved rapidly to the southeast toward Kansas with the strong flow aloft, and (2) well to the south, along the frontal zones that were unusually far south and where the flow aloft was weaker. Only one episode of "monsoon" moisture transport from the south and west across the mountains occurred (25–26 July), but northeastern Colorado was too cool for significant MCS activity.

Thus, climatological expectations had us hoping for about three MCSs developing toward α-scale organization within dual-Doppler range, but we only documented one, which happened to be the final day of our project on 11 August. We missed no opportunities as they pertain to that primary objective. For the secondary objectives (β-scale convective processes), we consider only one case (3 August; a β-scale band weakening as it came off the mountains and then reintensifying) to be a lost

opportunity, which was due to our under-forecast of the reintensification and our desire to not squander radar hours for a marginal case.

The radar staff was 100% cooperative in answering all our questions before, during and after the project, in our daily conversations during the project which led to operational decisions, and in helping us collect data for the potentially worthy cases. No cases were missed due to staffing problems, the radar or other equipment being down, or conflicts with other radar users. The staff was completely supportive of operations on weekends if "ideal" conditions were expected, but fortunately no such weekend weather occurred. During our single good case, there were two brief periods of down time due to recording equipment failures, and another 30-min down period due to radar hardware failure, but these periods of missing data were not detrimental to the case study.

Two problems with the radar data became evident only after the field project, when we began analysis of the 11 August case. The most severe of these was bad "ringing" effects due to a clutter filter that worked improperly with the fast scan rate (20°/sec) that we used. The result was a clockwise smear or "tail" of reflectivity from the cores of cells into weaker or no echo on their down-azimuth (generally southwestern) flanks, and corresponding "tails" of near-zero velocites and usually high values of normalized coherent power. These effects are in the field-format data and are thus uncorrectable in last year's data. We eliminated the bad-data tails via subjectively drawn boundaries in RDSS. For most of the cells the tailing is across sharp reflectivity gradients generally into no-echo regions and only small areas of data in the gradient region are lost. We don't feel that the problem is too detrimental to the analysis, but it is possible that important wind features (strong inflow/outflow in low/high levels, for instance) are consistently missed or under-represented on those generally southwestern flanks of cells. In some instances, however, primarily as merging between storms occurs, the tails are into areas of stratiform echo, which thus also become areas of missing winds. Although it is unfortunate that neither we nor the radar staff recognized this "ringing" problem soon enough to correct it last year, Pat Kennedy has assured us that it can be eliminated this year.

The other data problem was that the velocity scaling factor derived by RDSS (from the UF data that were input into the editor) was too large, such that absolute magnitudes were limited to ± 32.767 m/s. This problem affected only a few velocities aloft (always positive in our case, with maximum observed values of about 40 m/s) that were folded beyond a certain value and which could not be properly unfolded. The result from our editting procedure is that velocity magnitudes up to 32.767 m/s are correct, but beyond that are 12.656 m/s too small (but still looking reasonably large in the RDSS display). Although this problem is correctable by restarting the analysis

with new UF data (with a smaller scale factor that RDSS could handle properly), we weren't fully aware of the problem until after having synthesized many volumes, and don't feel that the few affected velocities warrant the correction effort. The effect in our dual-Doppler analysis is primarily a slight under-estimation of upper-level divergence (and top-down integrated vertical velocity) when storm outflow aloft was strongest.

After fully realizing the effects of this velocity scaling problem on our analysis and belatedly asking the radar staff for clarification and possible remedies, they said they were aware of it and had corrected the problem from now on. We suggest for this and similar cases of such known data bugs, that an effort be made to determine all users who might be affected, and to notify them of the problem, rather than leaving it to the investigators to notice and deal with on their own. Perhaps an e-mail notification system such as NCAR/FOF uses to notify radar data users of such issues would be appropriate.

However, the primary lesson learned from these data problems is that data quality control should be performed by the invesigator (i.e., get the data into RDSS and make sure it looks good) very early in the project, or better yet, prior to the project's starting date with some sample data. We will try to do so this year.

In closing, we are grateful for the opportunity to participate in the 20-h minigrant program. In spite of last year's below normal MCS activity and the data problems, we have been very pleased with the support from the facility and with the analysis of the 11 August case. The results of this case study indicate a rapid upscale evolution (e.g., a sudden deepening of low-level, horizontally-averaged convergence by several km into mid levels) that occurs about 1-h after the maximum in a β-scale convective precipitation cycle. This evolution sequence is consistent with our hypothesis concerning a deep gravity wave that is first generated by latent heating associated with the precipitation maximum, and which then helps force the upscale evolution. We are considering expanding our recent radar conference paper and poster describing these results into a Note for Monthly Weather Review.

We look forward to another successful 20-h project this year.

Sincerely,

Ray L. McAnelly

Ray L. McAnelly
Research Associate

Colorado State University

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30 June 1993

Mr. Ray McAnelly
Research Associate
Colorado State University
Dept. of Atmospheric Science
Fort Collins, CO 80523

Dear Ray:

Thank you for taking the time to respond to my request for feedback from individuals who have used the CSU-CHILL radar in the 20 hour project mode.

The first issue that you raised, the data artifacts generated by ground clutter filter "ringing" effects, is a point well taken. The presence of high correlation, zero radial velocity "down-sweep echo tails" is a significant handicap to radar data analyses. Following your identification of this data artifact, we have learned that this problem is the result of the combined use of a rapid antenna scan speed with a ground clutter filter having a narrow stop band. Based upon both consultation with Frank Pratte, chief engineer of the NCAR Mile High Radar (which routinely scans at rates in excess of 20 degrees per second), and upon our own experimentation at CSU-CHILL, we now know how to prevent the filter ringing problem.

Your second issue, related to deficiencies in the RDSS system's handling of CSU-CHILL radial velocities, has also been noted by other users within the last few months. Our investigation has revealed that RDSS chooses its own internal velocity scaling factor. Dave Brunkow, CSU-CHILL Software Engineer, has determined that if the velocity field scaling factor used in the creation of the original Universal Format (UF) data is made sufficiently small, the "internal" scaling factor generated by RDSS will not become too large. As of March, 1993, the CSU-CHILL facility has adopted the use of this smaller UF radial velocity scaling factor to prevent subsequent RDSS data handling problems. We have been in telephone contact with the CSU-CHILL data users who are most likely to have been affected by the two issues that you have raised. We are considering means by which such information could be more generally disseminated.

Finally, I fully endorse the idea of collecting and examining test data sets before intensive field activities are started. We plan to collect such test data for your evaluation before the start of your upcoming 20 hour project.

Sincerely,

Pat Kennedy

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M E M O R A N D U M

TO: CSU-CHILL Radar Advisory Committee Members Attending Int. Radar Conference

FROM: Pat Kennedy and Steve Rutledge

DATE: 17 May 1993

Introduction

Attached are materials for the upcoming RAC meeting in Norman to be held on 25 May. This material updates selected developments that have occurred at the CSU-CHILL National Radar Facility since the issuance of the February 1993 Annual Report to the National Science Foundation (copies distributed to RAC). The selected items reflect enhancements that have been in progress at the facility; they also serve to guide future facility upgrades. A summary of research projects supported / anticipated between October 1992 and October 1993 will also be presented.

Outline

1. Overview, goals of meeting (S.A. Rutledge)
2. New Antenna for CSU-CHILL Radar (V. N. Bringi)
3. Polarization Switch Monitor (D. A. Brunkow)
4. Status of Pulse Compression Capabilities (E. A. Mueller)
5. CSU-CHILL Implementation of the RAP TITAN Remote Display System (D. A. Brunkow)
6. Electronic CSU-CHILL Case Archives (P.C. Kennedy and D.A. Brunkow)
7. Operations Summary: 10/92 - 10/93 (P.C. Kennedy)

cc: B. Cotton, CSU
P. Julien, CSU
J. Aunon, CSU

2. New Antenna for CSU-CHILL Radar

Extensive measurements made on our current antenna over the past several years clearly showed that the antenna was the principal limiting factor in achieving high quality polarimetric measurements. Significant improvements in antenna performance will be made with the acquisition of the new antenna principally in the areas of copolar sidelobe reduction (reduction in peak levels of close in sidelobes by 5 dB or better), reduction in peak cross-polarized lobes by 6-8 dB or better, and improved mainlobe matching in amplitude and phase in the different ϕ-planes that will reduce errors in the differential reflectivity and copolar correlation measurements (Xiao, et al., 26th Radar Met. Preprints).

Based on our experience with measuring and analyzing antenna patterns from both CSU-CHILL and CP-2 radars together with the Geometrical theory of Diffraction Reflector Analysis code obtained form the Ohio State University, and error simulation (convolution) results using three-dimensional input reflectivity profiles, we have developed a comprehensive set of specifications for the new antenna to be manufactured by RSI, Inc.

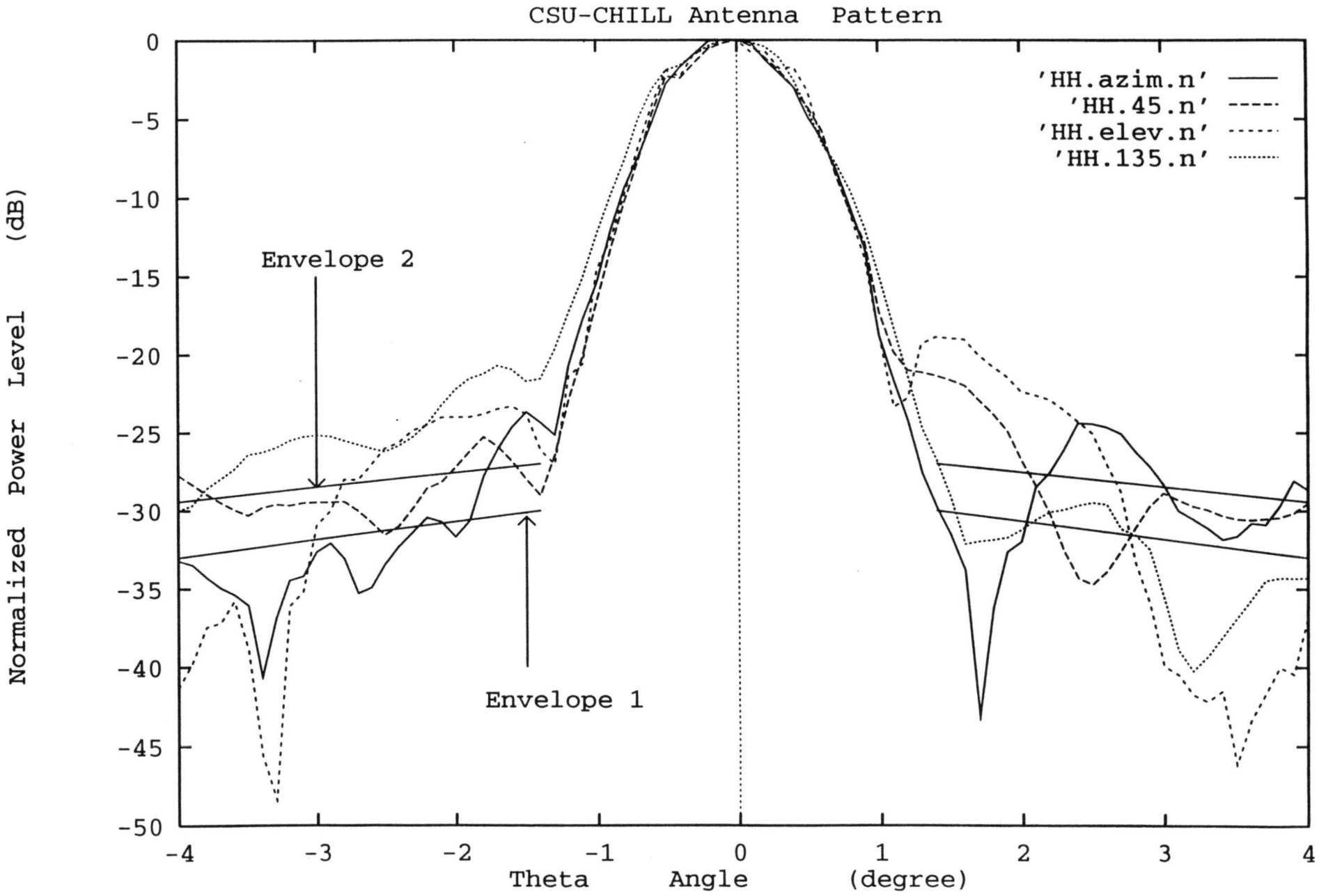
The principal areas of significant improvement will be, (a) reflector precision (0.02" rms) with ability to tear down and reassemble with high accuracy (as demonstrated by RSI for the TDWR contract and to be demonstrated for the CSU contract), and (b) high performance feedhorn/OMT with high isolation (<-35 dB) between H and V ports, very low cross-polar levels and rotationally symmetric primary horn patterns.

The attached figure shows the measured CSU-CHILL copolar patterns in the various ϕ-planes together with the sidelobe envelope specifications for the new antenna in the ϕ=0 and ϕ=45° planes (this being the plane containing the feed support struts and waveguide runs).

The figure-of-merit of interest for the cross-polar performance is the two-way cross-polar ratio in the $\pm$ 45 ϕ-planes defined as,

$$\mathrm{CPR} = 10\log\frac{\int f_{copol}(\theta) f_{cross-pol}(\theta)\sin\theta d\theta}{\int f_{copol}^2 \sin\theta d\theta} \leq -35\mathrm{dB}\ \text{(CSU specification)}$$

The chosen ϕ-planes are the ones where theoretically the maximum cross-polarized lobes occur.


CSU-CHILL Antenna Pattern
'HH.azim.n'
'HH.45.n'
'HH.elev.n'
'HH.135.n'
Envelope 2
Envelope 1
Normalized Power Level (dB)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-4
-3
-2
-1
0
1
2
3
4
Theta Angle (degree)

3. Polarization Monitor

The Raytheon polarization switch has been fairly stable in recent months, although it has in the past required considerable attention. This experience led to the development of a monitoring system designed to provide a quick and accurate assessments of the polarization switch performance. A block diagram is provided on the next page.

The monitor is located just above the sliprings on the rotating part of the antenna pedestal. It is connected to two directional couplers located in the Horizontal and Vertical waveguide runs just beyond the Raytheon switch. A Z8 microprocessor controls the apparatus and communicates with the antenna control computer. The monitor can measure average transmit power at each polarization by using the HP 4737 Power Meter. A 0-121 dB switchable HP attenuator was used in front of the power sensor since the power meter has no remote scale change capability. A high power noise source can optionally be directed to inject a signal into one of the directional couplers.

A polarization check scan (polcal) type was added to the antenna control program. This new scan can be scheduled into the overall scan strategy just like any other scan type. In general, a polcal is performed before and after each data collection episode. The operator is required to enter the average power reading taken from another directional coupler located at the transmitter.

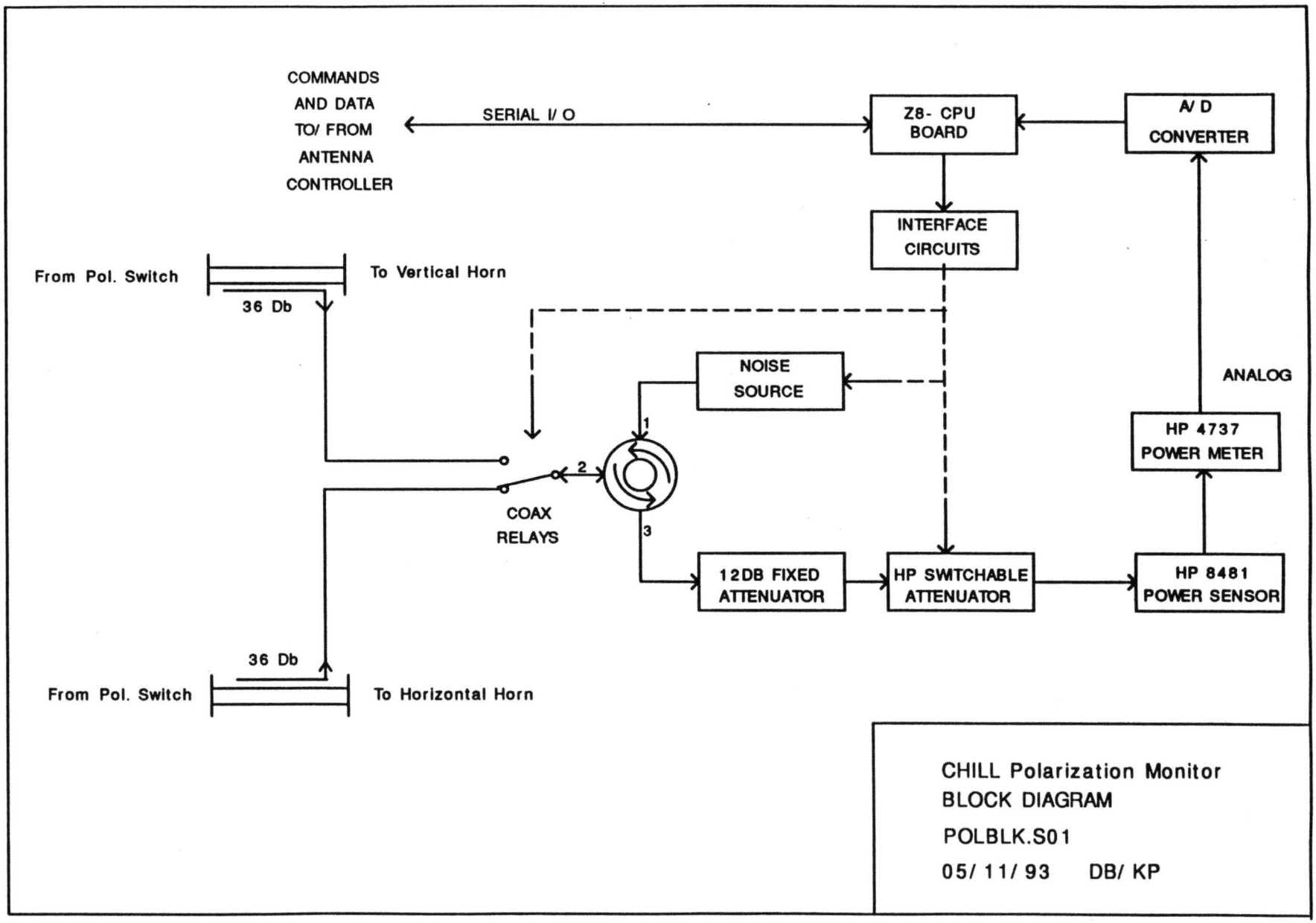
Transmit Test Sequence:
1) Measure Horizontal (H) power with Raytheon switch bypassed.
2) Put Raytheon switch in the circuit, wait 45 seconds for stabilization.
3) Measure power at H and V ports with switch in the H only mode.
4) Measure power at H and V ports with switch in the V only mode.

From 1) and power measured at transmitter, calculate loss in waveguide run. From 1), 3) and 4) calculate switch insertion loss (H), differential loss, and isolations for the transmit direction.

Receive Test Sequence:
1) Noise source on, connected to V port, measure V and H received power.
2) Noise source on, connected to H port, measure V and H received power.
3) Noise source on, connected to H port, switch bypassed, measure H received power.
4) Noise source off, attenuator to 121 dB, print summary.

From 1) and 2) calculate receive isolations and differential loss.
From 2) and 3) calculate receive insertion loss (H). Summarize by printing the net switch insertion loss for Horizontal Z measurements, net differential loss, and receive isolations.

A sample report generated by the antenna control program during a polarization check scan follows the block diagram.


COMMANDS
AND DATA
TO/ FROM
ANTENNA
CONTROLLER
SERIAL I/ O
Z8- CPU
BOARD
A/ D
CONVERTER
INTERFACE
CIRCUITS
From Pol. Switch
To Vertical Horn
36 Db
NOISE
SOURCE
ANALOG
HP 4737
POWER METER
1
2
3
COAX
RELAYS
12DB FIXED
ATTENUATOR
HP SWITCHABLE
ATTENUATOR
HP 8481
POWER SENSOR
36 Db
From Pol. Switch
To Horizontal Horn
CHILL Polarization Monitor
BLOCK DIAGRAM
POLBLK.S01
05/ 11/ 93 DB/ KP

Start polarization check at 1993/02/09 1025:42

TRANSMIT TESTS:

Peak transmit power=87.36 dBm, Transmit duty cycle= -30.37 dB

Horiz power (bypass) = 84.22 dBm

Horiz off power (thru switch) = 51.44 dBm

Horiz power (thru switch) = 82.29 dBm

Vertical power (thru switch) = 82.23 dBm

Vertical off power (thru switch) = 46.74 dBm

Waveguide loss = 3.14 dB

Txmit Insertion loss: Horizontal= 1.93 dB, Vertical= 1.99 dB

Txmit Isolations: Horizontal= 35.55 dB Vert= 30.79 dB

RECEIVE TESTS: (IP units are 3/8 dB per count)

Driving H port, Horiz IP avg= 65.38, Vert IP avg=15.00 (H-V= 50.38)

Driving V port, Horiz IP avg= 13.88, Vert IP avg=76.50 (H-V=-62.63)

Driving H port, switch bypassed, Horiz IP avg= 66.69

Horiz: Rcv insertion loss= 0.49 dB, Rcv Isolation= 23.59 dB

Vert: Rcv insertion loss= 1.02 dB, Rcv Isolation= 18.78 dB

TRANSMIT + RECEIVE SUMMARY:

Total Insertion loss (r0H correction) = 2.42 dB

Indicated zdr correction=-0.59

Setting attn to 121 dB, Noise source off

Terminating POL_CAL scan

4. Status of Pulse Compression 4/26/1993

The pulse compression system will consist of a coded pulse of 5 taking place in a 1 microsecond. The required bandwidth of this modulation is on the order of 6 MHz. We found initially that there were two components in the transmitter chain which would not pass this wide a band. They were the band pass filter that we used after the coho-stalo mixer and the SAS 60 klystron that was serving as the intermediate power amplifier (IPA). A new filter with a wider band pass has been obtained and a new solid state amplifier is on order to replace the present IPA.

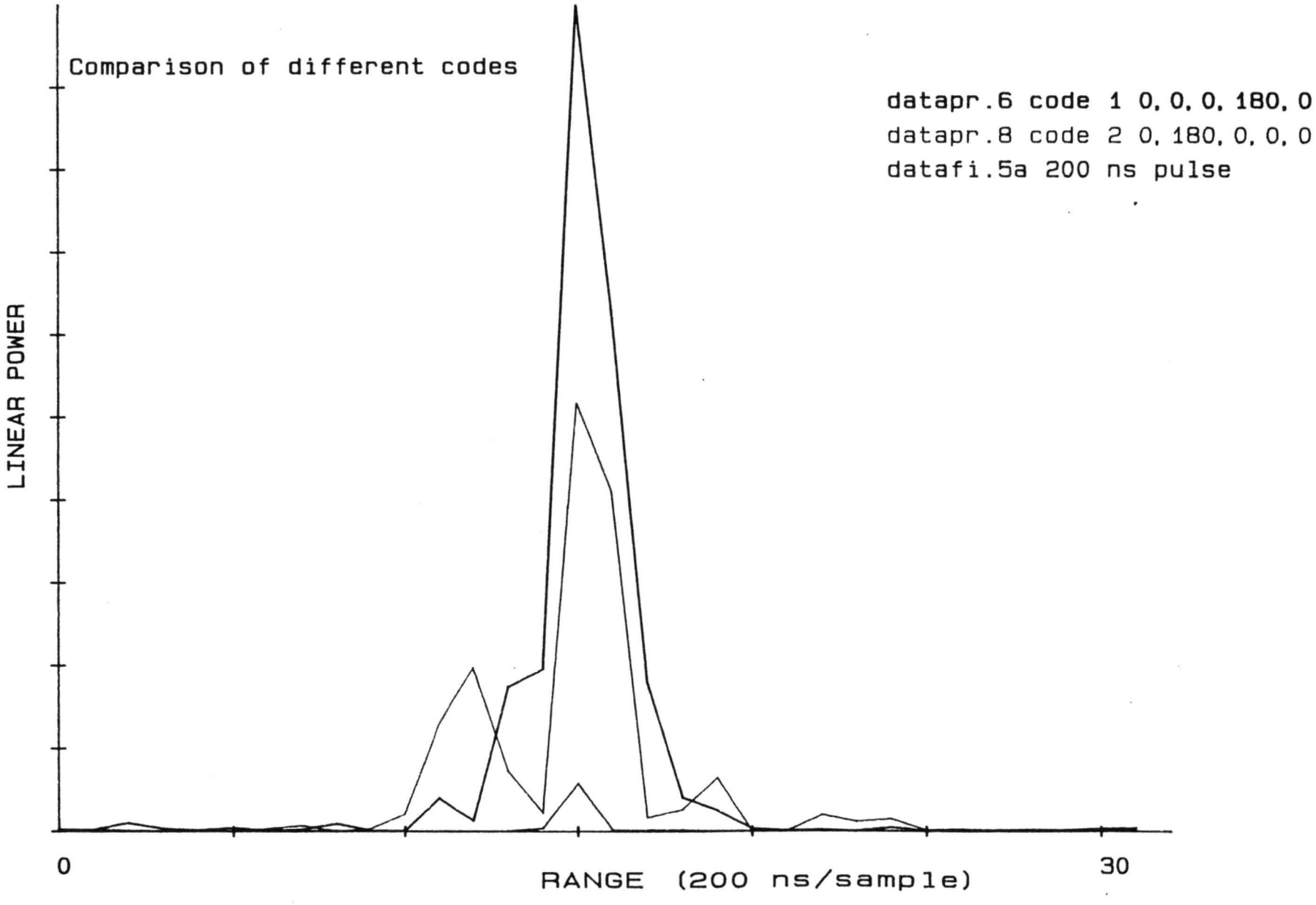
The receiver chain also had a band pass filter whose main purpose was to reduce the image frequency noise input. This filter along with the narrow I-F filter are simply removed when the pulse compression is used. Data have been taken on two occasions of an essentially point target. The results of several different codes have been tried and the results compared with a shortened transmitter pulse of 200 ns. The structure of the main targets agreed well with the short pulse regardless of the code used. However there is an interference target at approximately 30 meters greater range, and the sidelobe effects of this target are greatly different as a function of the particular code involved.

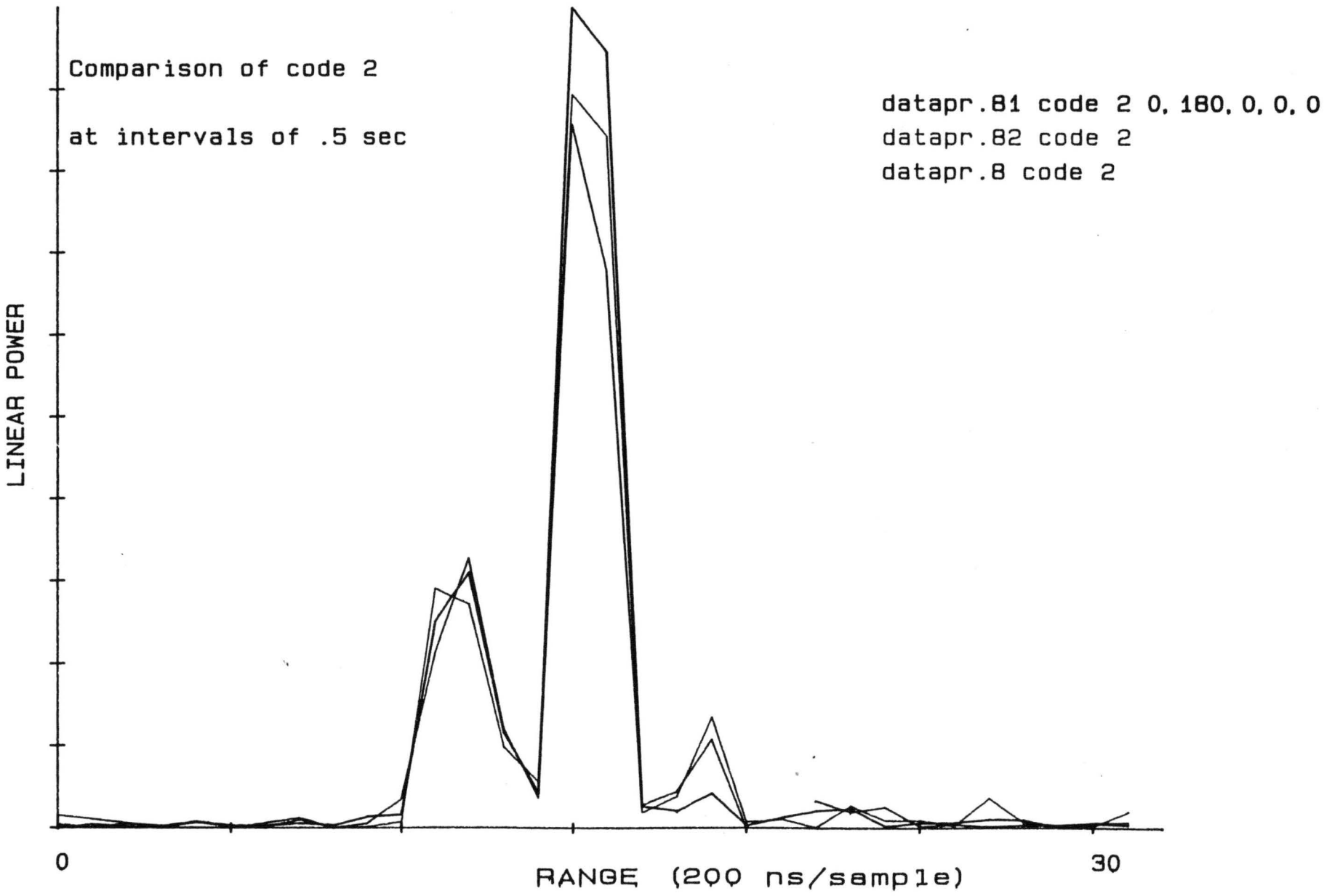
In the future, it is expected that the new IPA amplifier will further improve the system. The signal to noise of the compressed coded signal is about 12 dB above the signal to noise of the 200 ns transmitter signal to noise. In theory, one expects a gain of about 14 dB with a code length of 5. After the new IPA is installed and checked out, data will be taken in weather echo with pulse compression and with the 200 ns pulse. We will then try to do some complementary code operation and see if the side lobes can be reduced with the weather echo and Doppler effects included.

The following two figures illustrate several aspects of the current pulse compression capabilities. The data for these figures were taken without the new intermediate power amplifier, and thus still suffer from poor bandwidth in the transmitted signal. The target is a tower some 19 miles to the north. The antenna was elevated slightly (1.0 degree to provide a signal on the "A" scope that appeared to be a point target.

In the first of the two figures, two different codes are compared. These data were taken within a few minutes of each other and thus it is not expected that the targets should have changed materially. The red curve is plotted on the same vertical scale as the others. The red data was taken with a transmitted pulse that was just 200 ns long therefore the amplitude shows to be much smaller and the effect of the signal processing of the data compression algorithm is easily noted. In this case one would expect an improvement of 25 times if everything was correct. The actual improvement for code 1 is 18 times. Code 1 is a transmission of the phase sequence of 0, 0, 0, 180, 0. Code 2 is a sequence of phases of 0, 180, 0, 0, 0,. Besides the loss in sensitivity with the code 2, there is a surprising increase in what appears to be the near side lobe or perhaps an actual echo, in which case it is not seen nearly so strong with code 1 nor in an expanded version of the short pulse operation. This side lobe was a consistent result when using code 2. A second run on the same target on a different day exhibited the same strange effect in the side lobe characteristics. At this point the reasons for this are not understood, and will be under investigation in the future. In theory the side lobes of the two codes used are the same for a point target. It may be that there is more than one low level targets outside of the main tower target by a few tens of meters and the natural distance phase of these targets are such that they combine strongly in one code and not in the other and of course the single pulse does not cause any combining. If this is the explanation, it probably will not materially effect the use of compression in distributed targets (rain) since the phasing of signals outside of the point of interest are always changing and thus would not continually be of the additive type.

The second figure shows the repeatability of the pulse compression results. The three curves show three applications of coding sequence number two taken at time intervals of one-half second.


Comparison of different codes
datapr.6 code 1 0, 0, 0, 180, 0
datapr.8 code 2 0, 180, 0, 0, 0
datafi.5a 200 ns pulse
LINEAR POWER
0
RANGE (200 ns/sample)
30


Comparison of code 2
at intervals of .5 sec
datapr.81 code 2 0, 180, 0, 0, 0
datapr.82 code 2
datapr.8 code 2
LINEAR POWER
0
30
RANGE (200 ns/sample)

5. CSU-CHILL Implementation of the RAP TITAN Remote Display System

Interactive displays of real-time and archived CSU-CHILL radar data are now available at Colorado State's Atmospheric Sciences and Engineering campuses.

The software in use is the TITAN package developed by Mike Dixon of NCAR-RAP. It consists of a Cartesianizer and cell tracker, and data server which run at the radar, and a viewing program which can run anywhere on the network.

The conversion to Cartesian grids is table driven and does not involve interpolation. The grid currently in use is 260x260x15 with 1 km grid spacing. Currently reflectivity and velocity fields are available, though polarization fields will be added soon.

The display program is divided into two parts; One presents horizontal and vertical cross-sections through the grid. The second (optional) part provides three windows that present statistics on individual cell tracks, and a time-bar data selection window. There is a help window available, which provides information on the use of the numerous menu buttons available.

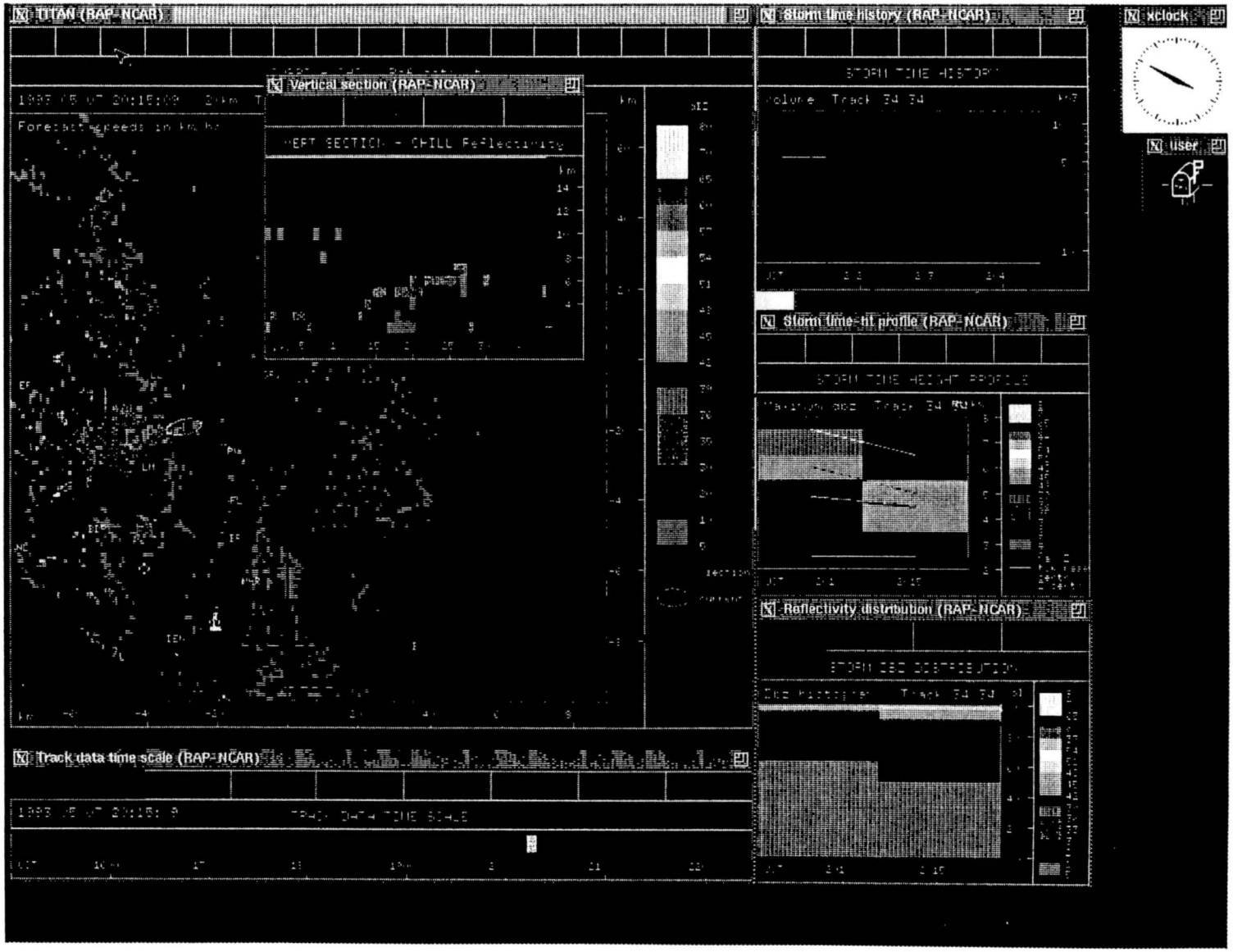
A few key operational features:

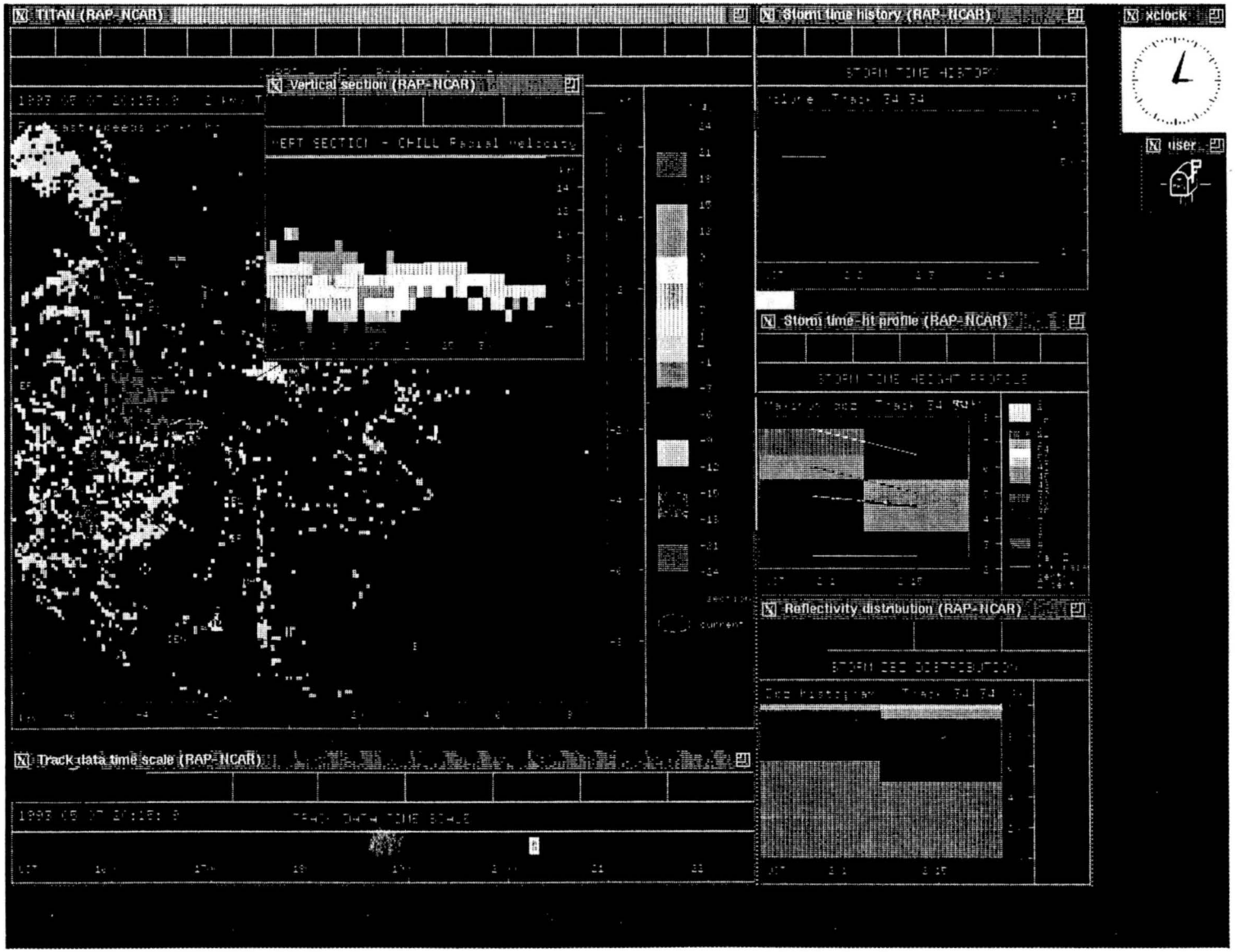
1) In the CAPPI display area, one can click and drag left button to define a area which will be zoomed to fill the window. On advantage of viewing zoomed areas is that only the data required is obtained from the server. This speeds up image updates by reducing network traffic. Dragging the middle button pans a zoomed area around. Two zoom levels are remembered, and can be restored or canceled by using the zoom menu button in the TITAN window

2) In the CAPPI display area, one can click and drag the right button to define an arbitrarily oriented plane. Another window will pop up with a vertical cross-section along the plane. This window can be left up on the display, in which case, it will update as the CAPPI image is updated.

3) Selecting a time: If the cell tracking option is in use, the "Track data time scale" window appears under the CAPPI window. It has a blue mark which shows the time of the current display. In real-time mode, the display comes up with the most recent data displayed. This display will automatically update every 30 seconds. Earlier data can be brought up by double clicking on the time bar at the desired time.

In summary, the TITAN package allows remote users to get a 1 km resolution view of what the CHILL radar is currently observing. Furthermore, since the TITAN data sets are compact, two to four weeks of data can remain on-line at one time. This will very useful as a perusal mechanism to allow researchers to select cases for further study. Color printer examples of TITAN-generated reflectivity and radial velocity CAPPI's are provided on the following two pages.


TITAN (RAP-NCAR)
Vertical section (RAP-NCAR)
Storm time history (RAP-NCAR)
xclock
user
Storm time-ht profile (RAP-NCAR)
Reflectivity distribution (RAP-NCAR)
Track data time scale (RAP-NCAR)


TITAN (RAP-NCAR)
Vertical section (RAP-NCAR)
Storm time history (RAP-NCAR)
Storm time-ht profile (RAP-NCAR)
Reflectivity distribution (RAP-NCAR)
Track data time scale (RAP-NCAR)
xclock
user

6. Electronic CSU-CHILL Case Archive

During the early months of 1993, the records of all operations that have been conducted at the Greeley, CO site since the radar was transferred from Illinois to Colorado were reviewed. Operations for radar system testing, i.e. antenna pattern measurements, sphere calibration experiments, and meteorological cases where no significant echoes developed were disregarded. Narrative summaries of the remaining cases of potential meteorological interest were entered into a data base file using a standardized format. For the most interesting of these cases (22 out of 84), distillations of the housekeeping inventories of the associated field format data tapes have been included in the data base entries. These tape inventory summaries should be a standard feature of all data base entries made after January, 1993.

This data base archive is designed to allow users a convenient means of initially identifying existing, potentially useful, CSU-CHILL data sets. Each case in the data base has had meteorological key words assigned to it that characterize the associated weather and echo patterns. A search of the these key words provides a path from a set of desired meteorological case characteristics to a list of field tape numbers that may contain data of interest. These candidate field tapes may then be replayed on the CSU-CHILL data system, or samples of the data may be distributed via computer network to users at distant institutions.

The case summary data base is accessible through anonymous ftp login to a Sun workstation located at the radar site. The specific keyboard entries that are required for data base access are provided below:

1) Login to the CHILL host with telnet:

   telnet lab.chill.colostate.edu
   If your nameserver cannot translate lab.chill.colostate.edu,
   try telnet 129.82.147.7

2) At the login prompt, login as info

3) The password is info

4) You will be prompted for your first and last name, which will be logged, and used to file any reports you want to transfer back to your home machine via ftp.

5) From here on, the system is (hopefully) self-explanatory. Most questions have a help option for further explanations.

Examples of the informational screens that are presented to the user during an interaction with the data base program are provided on the attached pages.

******** Welcome the CHILL Radar case summary system **********
Please enter your first and last names to identify any files saved:
First name= steve
Last name= rutledge

The purpose of this system is to allow the user to find CHILL cases which might be of interest. This is done by scanning a data base which summarizes all significant CHILL operations since 1991. We have tried to maintain an accurate data base, but there are undoubtedly some inaccuracies - if you have questions on specific cases, we will be glad to verify what is available.

If you are unfamiliar with the system, you will find that most menus have a help option which will offer an explanation of what is expected.

If you are using an xterm (X windows terminal emulator), make your window as large as you can for best operation. If you are not using an xterm or vt100 type terminal, the pager will beep when your screen is full, you press the spacebar to see the next screen, or <return> to see the next line.

f) find, d) details, k) keywords, m) matches, s) save, h) help, q) quit: ? help

The suggested procedure to follow is:

1) use the find option to produce a short-summary list (match list) of possibly interesting days.
2) use the d) detail option to see the details on cases selected from the match list, or use the m) match option to see the details on all the cases in the match list.
3) optionally use the s) save option to generate a case summary file you can take back to your host machine for future reference.

Information you save for anonymous ftp back to you host machine can be reached at lab.chill.colostate.edu (129.82.147.7) under the pub/info directory, filed by your name:(steve_rutledge).

Call CHILL staff: Dave or Pat at 303-491-6248 for more help, or to make suggestions.
e-mail: dave@lab.chill.colostate.edu

Menu Options with descriptions:

f) find: searches data base for user specified pattern
d) details: shows full data base entry for user specified case
s) save: allows user to append case details to a file which can be accessed via anonymous ftp. User is prompted for case numbers of interest.
k) keywords: display a list of keywords in the database.
m) show matches: re-display the results of the last search.
q) quit: terminate session
h) help: see help menu

f) find, d) details, k) keywords, m) matches, s) save, h) help, q) quit: ? k

Keyword List:

30M_RESOLUTION	ANTICYCLONIC_SHEAR	ARCTIC_FRONTAL_SNOWBAND
BARRIER_JET	BLIZZARD	BOW_ECHO
BRIGHT_BAND	CHAFF	CLASS_CASE
COLD_FRONT	COLD_SURGE	
	DEVELOPING_THUNDERSTORM_LINE	
DISTANT_THUNDERSTORM	ECHO_BAND	ECHO_TOP_ZDR
FINE_LINE	FLARE_ECHO	FLOODING_RAIN
FLOODING_THUNDERSTORM	FUNNEL_CLOUD	GRAUPEL
GUST_FRONT	GUST_FRONT_COLLISION	HAIL
HEAVY_RAIN	INSECTS	ISOLATED_THUNDERSTORMS
LIGHT_GRAUPEL	LIGHT_RAIN	LIGHT_RAINSHOWER
LIGHT_SNOW	LOW_LEVEL_JET	MERGING_THUNDERSTORMS
MESOCYCLONE	MICROBURST	MODERATE_SNOW
MULTICELL_MESOCYCLONE	NARROWING_BAND	NULL_HAIL
RAIN	RAINSHOWERS	RAIN_SHOWER
RAIN_SHOWERS	SCATTERED_SNOW	SCATTERED_THUNDERSTORMS
SEVERE_THUNDERSTORM	SIGNIFICANT_UPSLOPE_RAIN	SKIN_PAINTS
SMALL_HAIL	SNOW	SNOW_BAND
SNOW_BANDS	SNOW_SHOWER	SNOW_SHOWERS
SQUALL_LINE	STRATIFORM_RAIN	SUPERCOOLED_UPSLOPE
THINNING_CIRRUS	THUNDERSTORM	
TORNADO	THUNDERSTORM_PHOTOGRAMMETRY	
UPSLOPE	UPSLOPE_RAIN	UPSLOPE_SNOW
VIRGA	WAVE_CLOUDS	WEAK_THUNDERSTORM

f) find, d) details, k) keywords, m) matches, s) save, h) help, q) quit: ?

SAMPLE CASE SUMMARY:

Showing entry 26
DATE: 5/23/91 1545-1800 MDT
KEYS: BOW_ECHO HAIL CLASS_CASE
PROJ: KENNEDY BRINGI
NOTE: Weather: Several hail - producing thunderstorms developed in the DEN area and moved eastward onto the plains. The storm observed by CSU-CHILL propagated discretely, and periodically displayed a bow shaped core with 70 dBZ reflectivities. Surveillance at 1800 MDT showed the bow echo storm to be the strongest member of a widely scattered northwest - southeast line over eastern Wyoming and Colorado
Scans: Initially RHI's, then narrow sector PPI volumes. SP20 mode alternated between Doppler and VH.

Problems: Receiver attenuators fixed at 24 dB for most of the afternoon.

TAPE:
91CO112 has 21 vols (89 to 116) Date(05/23/1991) Times(1545 to 1649 MD) Fields-> NC=21 IP=21 VE=15 W2=9 DR=13 HV=13 VH=13 H2=13 LG=5 Scan Types->PPI=20 RHI=5
Scan Names->ZDRHI=4 EEPPI=12 DOPSCN=8
91CO113 has 36 vols (118 to 156) Date(05/23/1991) Times(1650 to 1754 MD)
Fields-> NC=36 IP=36 VE=36 W2=16 LG=6
Scan Types->PPI=36
Scan Names->DOPSCN=16 LONG=19 LRPPI=1

7. October 1992 through October 1993 CSU-CHILL Research Project Operational Summary

During the twelve months starting 1 October 1992, the CSU-CHILL facility has supported a number of small, specialized (i.e. "20 hour") projects at the Greeley site. No NSF Deployment Pool - funded programs were conducted during this period. Four of the 20 hour projects had been completed by 1 May 1993; operations in support of the remaining five projects will be done during the May through August 1993 period. The following table summarizes the four recently completed 20 hour projects. In this table, boldface text indicates each project's chief result.

Investigator	Months	Description
1. Bob Rauber (U. of Illinois)	Oct. 92	Echo surveillance during Sabreliner water sampler test flights: **REU (Research Experience for Undergraduates) RATS (Research Aircraft Tracking System) testing.**
2. Rita Roberts (CSU-NCAR)	Nov. 92- Mar. 93 (WISPIT)	Combined multiparameter and dual Doppler (CSU-CHILL and MHR) observations of winter storms: **Observation of snowband evolution.**
3. Chandrasekar (CSU EE)	Feb. 93- Mar. 93 (WISPIT)	Multiparameter data collection in Conjunction with NCAR King Air echo penetrations: **RATS - directed aircraft skin paints.**
4. Pat Kennedy (CSU ATS)	Feb. 93- Apr. 93	Coordinated multiparameter and surface precipitation observations at Ft. Collins - Loveland Airport: **Time history of snow Z_{DR}.**

Four additional 20 hour projects are scheduled for the 1993 Colorado convective season:

Larry Carey, a graduate student in the CSU Atmospheric Science Department, has devised a project to collect both radar and thunderstorm electrification data during the May through June time period. The radar data collection procedures will support dual Doppler analyses using data from the CSU-CHILL and NCAR Mile High radars. To gain insights into cloud microphysical characteristics, the CSU-CHILL data recordings will contain multiparameter observations. Larry will also be recording measurements of cloud to ground lightning discharge locations, local (at the radar site) atmospheric electrical field strength, and corona current intensity.

Dr. Tom Holtzer, Professor and Head of the CSU Entomology Department, is overseeing a project to study the migration of Russian Wheat Aphids into Colorado. The focal point of this project (24 May - 14 June) is the collection of insects in flight by means of a specially equipped helicopter. The CSU-CHILL radar will collect boundary layer reflectivity, radial velocity, and differential reflectivity measurements during the helicopter flights. The Research Aircraft Tracking System (RATS) will be used to record the helicopter location.

Two sequential 20 hour projects will be conducted in conjunction with the NCAR RAPS93 hail project. The first (15 - 30 June) will be under the direction of Dr. K. Aydin, of Pennsylvania State University. The second (1 - 15 July) will headed by Prof. V. Bringi of the CSU Electrical

Engineering Department. Both projects are designed to collect multiparameter radar data during hail events. The ground truth observations made by the RAPS93 hail chase teams will be a very valuable adjunct to these two 20 hour projects.

During the late summer "Colorado monsoon" season (19 July - 13 August), Prof. Bill Cotton and Research Associate Ray McAnelly of the CSU Atmospheric Science Department are interested in documenting situations in which the convective organization changes for independent cells into a larger, mesoscale complex. They plan to collect CSU-CHILL data in synchronization with the NCAR Mile High Radar to support dual Doppler analyses of these events.