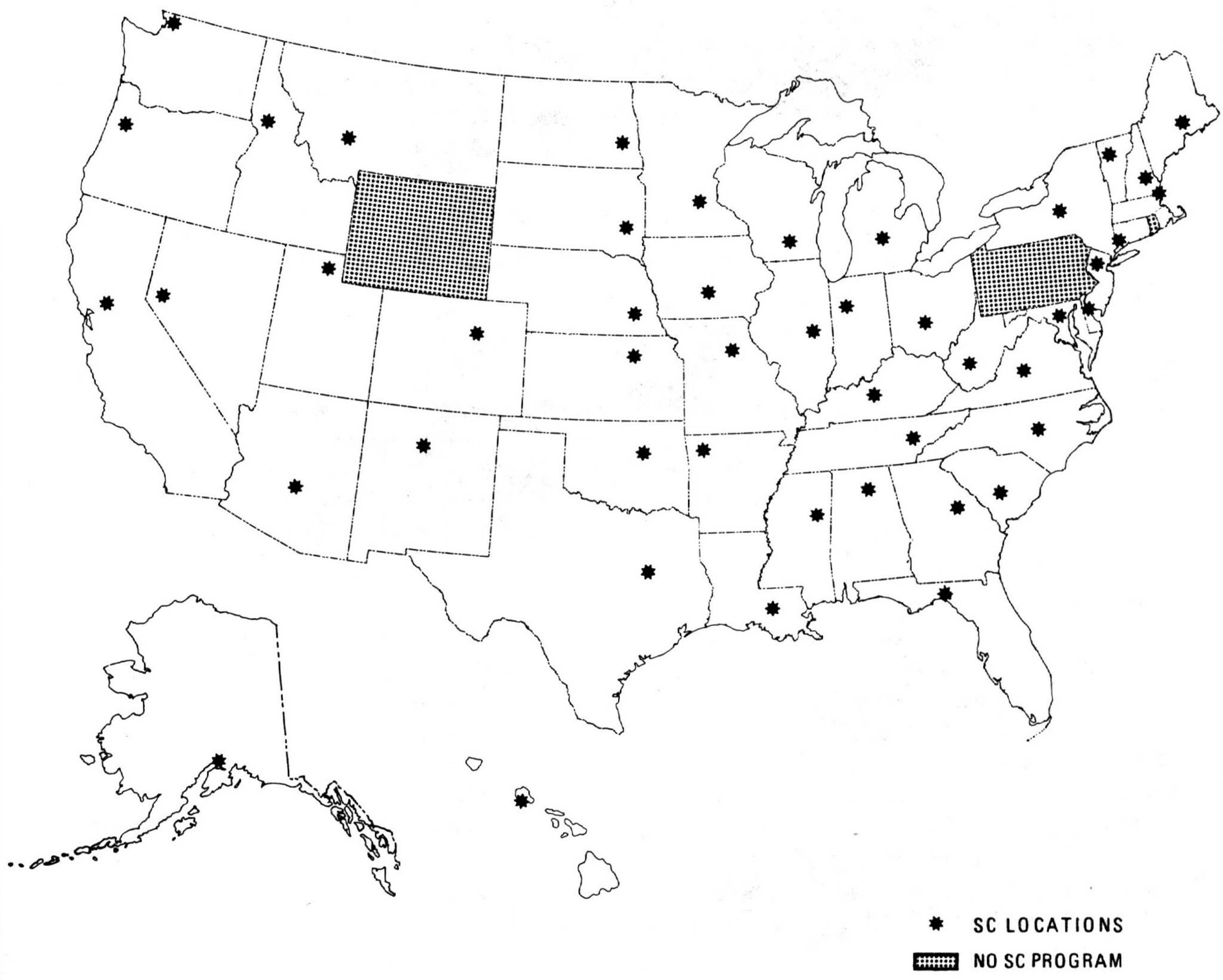
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE
NATIONAL CLIMATIC DATA CENTER

THE STATE CLIMATOLOGIST

IN COOPERATION WITH THE
AMERICAN ASSOCIATION OF STATE CLIMATOLOGISTS



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NCDC'S BILL BARTLETT ANNOUNCES RETIREMENT

William D. Bartlett, Meteorologist and Special Projects Officer for the National Climatic Data Center, has announced he will retire from the Federal civil service this August. Mr. Bartlett, known as "Bill" to his many friends and associates in the State Climatologist (SC) Program, has served concurrently as liaison officer, expert consultant, and advisor to the SC program since its inception in 1973. As many of you know, Bill has been the focal point at the NCDC for all matters of great or small degree that affected the program.

Bill was separated from the U.S. Marine Corps in October 1952 and was appointed to a meteorological position with the NCDC. He served in a variety of jobs at the Center; many of them involving designing, organizing, and operating the archival function to make it more responsive to user needs. Demise of the NOAA State Climatologist Program caused Bill to be assigned the task of gathering the climatological records archived in the NOAA State Climatologists' offices. He served with distinction as the "contact man" for the NCDC in performing this task. His success in this endeavor led to Bill being designated Special Projects Officer for the new SC Program. As SCs were appointed, he had the responsibility of encouraging and supporting them in the establishment of their programs.

Bill helped to found the American Association of State Climatologists (AASC) and arranged for the NCDC to sponsor the AASC's first annual meeting in Asheville, NC, in 1976. In the same year, he established, edited and published this quarterly newsletter devoted to the ongoing technical activities of the SCs.

Bill and his wife, Maxine, plan to do some traveling during retirement. Their itinerary has not yet been disclosed. Bill and Maxine reside at 427 Old Haw Creek Road, Asheville, North Carolina 28805.

NATIONAL CLIMATIC DATA CENTER BRIEFS

New State Climatologist in West Virginia. The NCDC and the American Association of State Climatologists are pleased to announce the appointment of Dr. Stanley J. Tajchman as West Virginia's State Climatologist. Dr. Tajchman is a native of Poland and has been in the United States six years. He is with the Division of Forestry at West Virginia University. His mailing address is Division of Forestry, 337 Perceival Hall, West Virginia University, Morgantown, WV 26505. Telephone: 304-293-3411. We look forward to meeting him personally at our August meeting.

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NRC Publication. The Nuclear Regulatory Commission has published "A Dust Climatology of the Western United States" by Michael Changery of the Applied Climatology Branch, NCDC. Data for 180 stations and a 30-year period of record were utilized in analyses including the annual number of hours with dust-induced visibility below specified values, annual number of dust episodes of various intensities, and dust episode durations. Results will be used in standards development for nuclear plant siting. A limited supply is available at the NCDC, Federal Building, Asheville, NC 28801.

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Cooling Degree Day Publication. The NCDC has revised and updated the monthly and seasonal cooling degree day publication of its Historical Climatology Series (No. 5-2). The publication now includes data through December 1982 and the year rank (i.e., relative standing) of the annual cooling degree day value. The ranks are given for the individual states, geographical regions, and the entire country. The cooling degree day statistic serves as an index of air-conditioning requirements during the year's warm months, and the publication State, Regional and National Monthly and Seasonal Cooling Degree Days Weighted by Population (1980 Census) (January 1931-December 1982) summarizes the monthly values for the past 52-year cooling seasons.

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CLIMPAX. A plan for national experiment to assess the impact, perceptions, and adjustments to climate change was presented to the National Academy of Sciences (NAS) on June 16, 1983. The National Climate Program Office was represented at the meeting and indicated that they are willing to take a lead role bringing about the experiment. NCDC has been developing the methodology to identify the temporal and spatial characteristics of persistent climate anomalies to be used in the experiment.

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Buoy Inventory. NCDC has produced a 13-page brochure listing the availability of buoy data at the Center. Maps display the locations of 85 buoy stations from which over one million observations have been received since the early 1970's. The inventory lists the station ID, location, years of record, and number of observations for each station by element for wind, pressure, air temperature, sea temperature, wave height, and a grand total.

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ANNUAL AASC MEETING

The 1983 Annual Meeting of the American Association of State Climatologists has been scheduled for August 9, 10, 11, 1983 at the National Climatic Data Center, Asheville, North Carolina. The agenda will include items vital to the future of the AASC and state climate programs.

Our business meetings will be held in the Main Conference Room of the NCDC. Plans are, at present, to work a morning and afternoon with NCDC personnel, devote another half day or less to other federal agencies, and a half day to resolve our internal AASC business. August 9 will probably be the day we devote to working with NCDC personnel. August 10 will be devoted to our internal business meeting and a special program organized around the interactions of the NCPO, NESDIS and the State Climatologist programs. We plan to have Ms. Margaret Courain talking with us that day.

On the evening of August 10 we plan to travel down the Blue Ridge Parkway to the Pisgah Inn for dinner. Our dinner speaker will be Dr. Robert Palmer, Science Consultant to the House Subcommittee on Natural Resources, Agriculture, Research and Environment, who will speak to us concerning the congressional point of view on federal and state climate needs and services.

Plan to join us.

Fred V. Nurnberger

Fred V. Nurnberger
President, AASC

CLIMATE DATA AND INFORMATION PROVIDED BY THE NATIONAL CLIMATIC DATA CENTER

BY

STEPHEN R. DOTY

THE MISSION OF THE NATIONAL CLIMATIC DATA CENTER

The mission of the National Climatic Data Center (NCDC) is, simply put, the archiving and publishing of the data and information sufficient to describe the climate of these United States. Housed in the heart of downtown Asheville, North Carolina, the NCDC now has some 425 people accomplishing this bold mission.

Why Asheville, NC for the worlds largest Climate Center? To answer this one must go back to the early 1950's when the New Orleans Tabulation Unit was evicted from the U. S. Army embarkation center. At this same time the U. S. Post Office's Postal Accounts Division was decentralizing from the major center housed in the Grove Arcade Building in Asheville. So, as if by magic, the homeless weather records center was matched with the now empty building in the mountains of Western North Carolina. A few years later additional regional weather record processing centers (San Francisco, Kansas City, Chattanooga) were combined to form the National Weather Records Center (NWRC). Several other reorganizations brought about the National Climatic Center and finally last November the National Climatic Data Center.

The NCDC receives many different data sets and formats, for many different parameters, on many different scales (time and space), and for many stations. This paper will concern itself with two basic data sets that have the most significance to the energy community. The first data set to be discussed will be the hourly data as received from many "airports" across the land. The second data set will be the daily and monthly data as received from various sources but mainly the "cooperative network" of National Weather Service (NWS) run climate stations.

AVAILABILITY OF HOURLY SURFACE DATA AND INFORMATION

Manuscript

As with most data sets the hourly surface data (sometimes known as airways data) arrive at the NCDC via a handwritten original manuscript form sent through the U. S. Postal Service. At the present time five different forms are used by the various observing agencies in the United States. Table 1 gives the form name, the primary user of the form and the number of stations for which NCDC presently receives forms.

Table 1. Hourly data forms, primary users and number of observing stations.

Form Name	Primary User	Number of Stations
MF1-10A/B	First Order NWS	247
MF1-10C	FAA and Non-First Order NWS	900
MF1-10	Navy and Air Force	270
NOAA Form 72	U. S. Coast Guard	200

The primary stations send their completed forms to NCDC in three shipments per month (days 1-15, 16-25 and 26 - end of month). These forms are first logged in and then placed in special folders for their long journey to the permanent archive. These folders hold one month's data for a given station and printed on the folder are the station name, station number, data month and keying instructions. The stations that receive no further attention such as keying or copying are sent straight to archiving.

Digital

For the 280 or so "lucky" stations a quick manual review is given the forms before delivery to the Data Entry Section (DES). The manual review includes a cursory scan to make sure all entries are filled in and that data seem reasonable. Keying instructions are then noted on the folder.

In DES the individual hourly observations are keyed via an Inforex system directly to disk. The key entry person must translate "weather" symbols and abbreviations into NCDC codes. Still a good person can key twelve to fifteen hundred observations per day with an error rate of less than one half percent. After each day's keying the disk is dumped onto magnetic tape so that these data may be transferred to the mainframe computer. From here a computerized quality control program is applied against these data, the resulting errors flagged for human review and updates or corrections made.

At this point a comment needs to be made concerning the number of observations keyed per day. Historically all 24 observations per day were punched onto cards. For the most part this was done on-station. Then in 1965 it was decided that this procedure was too expensive, so the number of keyed observations per day was dropped from 24 to 8. The keying effort was transferred from the field station to NCDC. For the period January 1965 through July 1981 only eight observations per day were keyed. This procedure was for National Weather Service stations only as the Air Force and Navy followed various other schemes.

Beginning in August 1981 the NCDC again returned to keying all 24 observations per day. This was possible due to some support outside the NCDC budget. However, many stations have had select periods (usually five years) of hourly data "back-punched" on as a-customer-was-willing-to-pay basis.

These digital data are then added to the NCDC data base on a monthly basis approximately 45 days after the end of the data month. There is one magnetic tape per month containing data for all available stations. After a year's data are compiled these monthly tapes are merged into a yearly set of tapes.

These data are in a card image format, referred to as Card Deck 144, in sort by station number. During late spring yearly updates are then made to the master data base file known as Tape Data Family 14 (TDF-14). In the TDF-14 format six observations are grouped together to form one record on the tape. Each station is thus contained on one 9 track, 6250 bpi, ASCII tape in sort by time. Inventories are available on microfiche.

Microfiche

Once these data have been keyed and quality controlled the original manuscript forms are prepared for archiving on microfiche. Also being microfiched are those station's data that were not digitized. This archiving includes sorting the forms into day order, insuring that they are photogenic (some light or pale copies have to be enhanced by use of a special dry copying machine) and, finally, filming by use of a high speed TDC camera. The final product is one microfiche per station per month. The title is prepared so that the microfiche become self-indexing without the aid of a reading device. A master copy is made (and stored off-site) as well as several working copies. After rigid quality control measures are passed the original forms may be disposed.

Publications

These hourly data along with daily and monthly values are printed in the Local Climatological Data (LCD) publication. The LCD is produced via a COM unit from the digital files. At the present time there are 282 stations for which LCD's are published. These are available by subscription on a monthly and annual basis.

Each LCD contains a summary of each day in the month including maximum and minimum temperature, precipitation, cloud cover, degree days, wind, etc. Each third hour observation is presented along with the hourly precipitation amounts.

LCD's are available for some stations as far back as 1949. All LCD's are available on microfiche as old issues have been manually filmed and newer issues are placed on microfiche via COM.

AVAILABILITY OF DAILY AND MONTHLY SURFACE DATA AND INFORMATION

For the purposes of this article the inclusion of daily and monthly data into a subtopic will facilitate the discussion of these akin data and information. Even though the "hourly stations" also record daily and monthly values and these values are included in the following data set, the primary emphasis will be on the cooperative station network.

Manuscript

Each month the NCDC receives forms for archiving and publication from some 7800 stations commonly known as cooperative (COOP) stations. According to NWS statistics there are some 11500 stations in the network with 4100 receiving some compensation for their efforts with the remaining 7400 giving of their time freely. The NWS provides and maintains the instruments for these observers and supplies them with forms on which to record their daily observations. At the present time there are only two basic forms received.

Notice that a month's worth of daily data are now recorded on one form. The elements available are daily maximum and minimum temperatures, temperature at time of observation, total daily precipitation, occurrence of weather and, for a few hundred stations, evaporation and soil temperature.

These forms are mailed monthly directly to NCDC or through a regional NWS Cooperative Program Manager (CPM). After receipt and indexing at NCDC, the forms eventually find their way to individual station storage boxes where they will reside until permanent archival procedures (filming) take place.

Digital

A large portion of the forms (some 7600 stations) are sent to DES for keying. By the twentieth work day after the end of the data month most of these data will have been keyed and processed through the edit routines. This QC effort was upgraded beginning with the January 1982 data. New computer software using sophisticated qualitative decisions now replaces many subjective decisions once made by manual validation.

After about six weeks the final digital file is produced. A monthly tape containing all stations for the data month is then added to the data base. These data are in the new element structure format, assigned to Tape Deck 3200 (daily) and 3220 (monthly). This element format groups like elements together in a record (i.e., maximum temperature, daily precipitation, or monthly total precipitation) breaking with NCDC's historical format of having an observation a record.

After a year's data are compiled a merge is accomplished grouping the data into a sort by station, then time. After five years a period of record merge takes place. The general period of record for these data is 1948 through to present. Each state is on a separate set of tapes. For example, Rhode Island data are on one 9 track 6250 bpi, ASCII tape while Texas data are contained on 7 tapes. Several states have had data "back-punched" through cooperative efforts with state universities. These data begin as early as 1876. Detailed inventories of these files are maintained on tape and microfiche at the NCDC.

Microfiche

The original forms are archived in storage boxes until 5 years worth of data become available. These forms are filmed in standard 5-year time groups, such as 1950-54 and 1955-59. As with the hourly forms, a large effort is made to insure the integrity of these filmed records. All COOP forms are filmed when data for the 5-year standard period become available. All stations have been filmed back to 1950. Earlier files are now being completed by state as long as money holds out.

Publications

These daily and summarized monthly values are printed in the Climatological Data (CD) publication. This CD is printed by state on a monthly and annual basis available by subscription. Specifically, the CD contains monthly temperature data, maximum, minimum, average, departure from normal, and extremes; degree days; precipitation totals, departure, greatest daily, snow and snow depth. Also included are tables of daily precipitation, and daily temperatures.

CD's (or equivalent) are available back into the 1890's. These are maintained on microfiche at the NCDC.

SERVICES AVAILABLE AT NCDC

How to Obtain

The reason for the very being of the NCDC is to collect, process and publish climate data sufficient to describe the climate of the United States. At the heart of this mission is the dissemination process. Publications are available on a subscription basis (there are now some 48,000 subscribers to LCD's and CD's). Publications are maintained as stock items since 1979 issues with prior publications available as paper copies from microfiche.

Digital data are available on magnetic tape either as copies of library reels or through a selection or reformatting routine.

A staff of eleven data resource consultants is available to provide assistance via telephone or by letter. The address is:

National Climatic Data Center
Climatological Services Section
Federal Building
Asheville, NC 28801

704-258-2850 X682
FTS 672-0682

*** Effective September 5, 1983 ***
704-257-6682
FTS 672-6682

Normal delivery is 10 working days.

Price

Price is a function of the cost to reproduce the item. It is NOAA policy to recover actual costs incurred in the production or reproduction process. Table 2 gives a simple approach to NCDC prices. Always contact us to determine specific prices for the items of interest.

Table 2. Selected NCDC Prices

PUBLICATION		SUBSCRIPTION	INDIVIDUAL	FICHE
LCD		$ 8.45/Stn Year	$0.65/Stn Mo	$0.70/Stn Yr
CD		$19.50/State Year	$1.50/State Mo	Variable
MANUSCRIPT	$0.35	per page or	$0.70 per microfiche	
		(Minimum charge is $5.00)		

TAPE	Input 1600 bpi	Input 6250 bpi
Copy	$ 99	$154
Selection	$120 ($65 each additional)	$185 ($120 each additional)

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THE FUTURE OF CLIMATE DATA INFORMATION

The NCDC is now making a concerted effort to increase the quantity, quality, and timeliness of its data and information. Probably the most exciting new product is the availability of an on-line system. Now undergoing a live test with the state climatologists, the new on-line data base includes current complete month preliminary summary of the day, final summary of the day, summary of the month, and hourly data. It is hoped that in the next several years this service will be available to any paying customer who has a computer and communication hardware/software.

Also in the future of digital data availability is the floppy disk. It is hoped that in the next several years NCDC will be able to produce floppy disks that meet the customer's specifications.

A new processing scheme for handling the hourly observations is to be implemented beginning with the January 1984 data. Combining new computer resources and more sophisticated software a higher quality data set should be forthcoming. These hourly data will also be converted to new element structure to take advantage of modern day processing systems.


TRANE COMFORT
WE SERVICE ALL MAKES
851-8310

A North Carolina Kind of Climate

When a contractor in Edenton is preparing to pour cement, or a farmer in Old Fort is about to plant corn—he might want to dial (919) 737-3056. The phone will be answered, "State Climatology Office, North Carolina State University."

The office, headed by Dr. Jerry M. Davis, State Climatologist and associate professor in the Department of Marine, Earth and Atmospheric Sciences at NCSU, provides information and advice which can help people make better decisions on operations that depend on climate.

Whether a caller needs rainfall data for June 1979, or information on average spring frosts for the past decade, Davis and his assistant, Brian Eder, have the answers.

The office, located in the School of Physical and Mathematical Sciences, offers general climatic information, climatic data management and climatic research.

"We don't attempt to provide long-range climate forecasts or give out current weather forecasts. That would be infringing on the responsibilities of the National Weather Service," Davis said.

The climatological information comes from the U.S. Weather Service stations at North Carolina airports and from more than 100 volunteer observers across the state who record and call in precipitation and temperatures on a daily basis.

The U.S. National Climatic Data Center (NCDC) in Asheville exchanges data with the NCSU office as well. The data is compiled and stored on computers at NCSU for easy access.

The North Carolina Climate Program cooperates with NCDC in Asheville in the preparation of publications such as *Climatic Data for North Carolina, Storm Data,* and *Local Climatological Data.*

The Climatologist's Office is funded by both NCSU and UNC-Chapel Hill. Dr. Peter Robinson of the Department of Geography at UNC, the program's coordinator, works closely with the State Climatology Office.

The uses of climatological information are limitless, Davis said.

"We provide maximum and minimum temperature data and rainfall information for industries interested in locating in a particular area of the state; advise scientists of the best time for conducting atmospheric or ocean studies; advise potential solar home builders of good locations; and compile important hurricane information," Davis said.

If North Carolinians have pressing questions about any aspect of their state's climate, they can relax—the answer is at N.C. State and as close as their nearest phone.

"In the heating and air conditioning business, we like to plan rather than react to the weather. Information provided by the State Climatologist's Office at N.C. State enables us to do this more effectively. Having a history of the climate makes it easier to plan preventive maintenance, adjust inventories, and service the needs of our heating and air conditioning customers." *Ron Schindel, Piedmont Trane Air Conditioning Company, Raleigh, North Carolina.*

THE NORTH CAROLINA CLIMATE PROGRAM
ANNUAL REPORT 1982

SUBMITTED BY

Peter J. Robinson
Coordinator, North Carolina
Climate Program

Jerry M. Davis
State Climatologist

The North Carolina Climate Program was initiated in November 1981. The first Annual Report covers the period from the start of the program until the end of December 1982.

The aim of the North Carolina Climate Program is to provide climate services to the people of the state. This is to be achieved by improving the availability and accessibility of climate data and information and by increasing public awareness of the range and scope of practical problems where such information can be beneficial.

Prior to 1981 climate services were not readily available, but requests for information from the public to individual climatologists were increasing in frequency. Consequently, after considerable discussions among climatologists, representatives of state government, and the University of North Carolina, it was decided to initiate the program as a joint venture between North Carolina State University and the University of North Carolina at Chapel Hill.

The Program, organized under a formal Memorandum of Understanding between the two Universities, is operated by the Department of Marine, Earth, and Atmospheric Sciences at NCSU and the Department of Geography at UNC-CH. The Office of the State Climatologist, at NCSU, is responsible for day-to-day program operation, and provides the focal point for requests for data and information from the citizens of the state. The Coordinator of the Program, at UNC-CH, has responsibility for long-range planning and development of the Program.

Personnel directly connected with the Program at present are:

Dr. J. Davis - State Climatologist Dr. P. J. Robinson - Program Coordinator
Mr. B. Eder - Assistant State Climatologist

Many people from the two participating campuses, notably those in the operating departments and in the Agricultural Weather Program of the Agricultural Extension Service at NCSU, have provided advice and assistance. Personnel associated with the National Oceanic and Atmospheric Administration, mainly from the National Weather Service (NWS) Forecast Office at Raleigh-Durham Airport and from the National Climatic Data Center (NCDC) in Asheville, have provided numerous services for the Program.

FIRST YEAR ACTIVITIES

The strategy adopted for this first year of operation was to launch the program as a public service in such a way that there would be a substantial, but not overwhelming, demand for services. This approach allowed the Program to begin service immediately while allowing personnel time to refine the mechanisms necessary to provide the service. It also provided time to become familiar with the potential range of requests that might be received and thus to plan for future operations. The initial announcement of the availability of services was issued in November 1981 and was carried by many newspapers and radio stations across the state. It indicated the type of service offered and gave the address and telephone number of the State Climatologist. This single announcement generated sufficient demand for services and no further direct publicity was given to the Program.

Services Offered

The main service offered has been responses to requests for specific data and information. A plateau of around 30 requests per month has now been reached (Table 1). The time needed to answer a specific request is highly variable. Some can be answered directly over the telephone, requiring only minutes, while others can involve several hours of research. During an average week about 15 hours are devoted to answering requests - an appropriate amount for the first year's operational strategy.

TABLE 1

MONTHLY TOTAL REQUESTS FOR INFORMATION, 1982

Nov 1981	Dec 1981	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
11	16	19	34	35	26	26	40	25	29	37	24	27	37	386

Requests have come from a variety of sources (Table 2). The preponderence of university-based requests was expected, because of the Program's location and the small amount of publicity given to it. Nevertheless, the wide range of other users is gratifying, and clearly indicates the demand for services and the benefits to be gained from them. Most of the requests came from the Triangle area, where Program personnel contacts in other areas of the state will lead to increased requests for services.

TABLE 2

SOURCES OF REQUESTS FOR INFORMATION

Percentage of Requests	User Affiliation
37	UNIVERSITY RESEARCH --including educational needs (70% of these requests originated at NCSU).
22	PRIVATE CITIZENS --members of the public interested in the general climate of the state, out-of-state residents considering moving in, gardeners interested in frost dates, weather buffs.

15	PRIVATE INDUSTRY --construction firm architects, developers, lawyers, insurance companies, utilities.
12	COMMUNICATIONS MEDIA --newspapers, radio/TV stations, and magazines interested in data for weather related stories.
8	GOVERNMENT AGENCIES --N.C. Department of Transportation, Utilities Commission, Office of State Budget and Management, various Chambers of Commerce needing local climatological summaries.
6	AGRICULTURALISTS --farmers interested in temperature and precipitation averages and freeze dates, Agricultural Extension Agents needing county climatological summaries.
100	

The second service activity of the Program has been the initiation of a publication program. The first publication "Variation in Monthly Precipitation over North Carolina" was ready for dissemination in January 1983. Several other publications, concerning drought, precipitation probability, and solar energy availability, were developed during the year. All are designed to meet existing, well defined and clearly articulated needs and provide essential information of great importance to the economy of the state.

The Program also produces a monthly column "On Weather" for Coastal Plains Farmer magazine, providing data and a narrative description of the climate as it affects agriculture on the coastal plain of North Carolina.

The North Carolina Climate Program is cooperating with the Federal Government by compiling and writing monthly summaries of extreme weather events, using information provided by NWS. These are transmitted to the NCDC for inclusion in the national publication "Storm Data."

Regionally the Program is working closely with the Committee on Agricultural Weather (Committee S-173) of the southern region of Agricultural Experiment Stations as they upgrade the quality of climatic information available to the agricultural community. The Program is undertaking the first task of this Committee by developing an inventory of climate data sources in the region.

Data Base Development

The Program has available a data base containing the major climatological observations for the state. The major thrust during the year has been to organize the base to allow ready response to information requests. This has been facilitated by acquisition of a micro-computer and a microfiche reader-printer.

Numerous requests have been received for data for the immediate past. Since National Climatic Data Center data are not available until 3 months after the observation date, the Program has initiated a system of collecting preliminary data from NWS first order stations on the first of each month. These are placed in the Program's computer and used until the official data arrive from NCDC.

Requests are also frequently received for average of "normal" conditions. Published normals are available only for the 1941-1970 period. A preliminary investigation by the Program indicated that there was a considerable difference between these values and those for 1951-1980. Consequently new climate summaries, using the more recent data, were developed by the Program for 35 stations in the state.

PROPOSED 1983 ACTIVITIES

Continuation and expansion of the services currently offered will have the highest priority in 1983. A modest effort will be made to increase public awareness of the Program, since the Office of the State Climatologist is in a position to respond to a small increase in demand. It is planned to issue two or three new publications now in preparation and to assess the need for others. Efforts will continue to be made to upgrade the data base to ensure that it is responsive to user needs. Linkage with national and regional efforts will be fostered.

Two major new initiatives are planned. The first is the establishment of a Climate Advisory Council comprised of representatives of major climate information user and producer groups. The Council will oversee program development, provide advice and guidance on Program needs and priorities, and assess Program performance. The second initiative is development of links between the Program and State Government agencies. Preliminary discussions indicate that the Program can be of assistance to several agencies. However, further exploration of the type of information required by individual agencies must be undertaken before useful products can be generated.

The extent of the expansion and the speed with which initiatives can be developed depends on the resources available to the Program.

FUNDING

The Program is primarily financed from the regular budgets of the two operating departments. Consequently it is not possible to determine exactly the funding levels, but a general indication of 1982 resources can be given.

The basic program operation funds provide the resources needed to maintain the Program at its current level. These funds provide office space and equipment, a small travel budget, support for a graduate student as the Assistant State Climatologist, and a limited amount of release time for the State Climatologist and the Program Coordinator. This is approximately equivalent to support in the order of $25,000 per year.

Program enhancement funds allow upgrading of the basic operation to provide better and more diversified services to a wider range of users. The North Carolina Agricultural Extension Service provided $6,000 for purchase of the micro-computer and the microfiche reader-printer. NCDC provides an annual line of credit (currently $500) for data purchase to expand the Program's data base.

Specific projects, such as publications on particular topics, or extensive research efforts, must be financed by the parties concerned with the topic. The precipitation variability publication was financed with a $2,500 grant from the Water Resources Institute of the University of North Carolina.

It is anticipated that resources in 1983 will be similar to those available in 1982.

The support of the two participating departments has been indispensable for program initiation. However, the demonstrated potential for program expansion indicates that there is a need for long-term funding outside the regular operating budgets of these departments. Hence, a high priority in 1983 will be exploration and development of a mechanism to ensure long-term operational funding. With a secure base, program development can continue.

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A CLIMATOLOGICAL ANALYSIS OF UTAH'S 1983 FLOODS

BY

E. ARLO RICHARDSON
UTAH STATE CLIMATOLOGIST

The catastrophic floods and landslides during the late spring of 1983 have received national attention. These events were the result of an interesting compounding of weather factors, which individually would have created only minor problems. In combination, however, they have produced some of the worst conditions in the recorded history of the state. The most extensive damage has been in the major population centers along the Wasatch Front.

In building the climatological background which led to the current situation, we must look back as far as the extreme drought conditions which reached their peak over a large area of the western United States during the latter part of 1976 and the first portion of 1977. This drought left the soils in much of Utah in a desiccated condition with little plant growth on the ranges and lower elevations of the mountains.

While more people are familiar with moisture accumulations for the calendar year as a climatological variable, in this report we will use water year accumulations which begin October 1 and continue through the 30th of September. By October 1 in most of Utah most of the plant growth on range and forest lands has been reduced to little or none and irrigated croplands are being harvested. Most of the moisture that falls during the late fall and winter season is deposited as snow in the mountains and builds the snowpack which normally reaches a maximum in early April, about the time that growth of most range plants begins. At lower elevations the moisture during this season is used to recharge the soil which has been desiccated by summer heat and plant growth.

When the surface of desert soils is desiccated, the first rains that fall fail to penetrate very deeply into the soil and most of the moisture is lost as runoff instead of recharging the soil. Thus, following the drought years, several years of above normal precipitation were required for the soils to regain their normal moisture reserves. The water years of 77-78, 79-80, and 81-82 produced above normal precipitation in most areas of the state. The year 81-82 was an extremely wet year, the wettest since division records were begun in the North Central Division and the 2nd wettest in the South Central Division. This much above normal moisture combined with a relatively cool summer to reduce moisture demands on the soil moisture in most areas of the state.

The next step in preparation for the catastrophe was the wettest or near wettest September of record in may areas of the state. This record precipitation at the end of the growing season allowed most of the state to begin the new water year and the period of normally heaviest precipitation with soils already saturated or near saturation.

The months of October through December of 1982 were all wetter than normal and cooler than normal. The snow pack in the mountains developed much earlier than usual. By contrast, January, February and March temperatures were all much above normal and the precipitation in most areas of the state was also above normal.

The maximum snowpack in the mountains usually occurs about the first week in April, but this year April temperatures dropped to much below normal and little or no melting occurred during that month. In fact, temperatures during the first three weeks in May were also below normal and above normal precipitation occurred in the mountains. The maximum snowpack did not occur until late in May.

This combination of events set the stage for severe flooding conditions if temperatures climbed rapidly. That is exactly what happened. Average temperatures during the third week in May averaged about 10 degrees below normal; but during the last week of the month, temperatures averaged 3 to 5 degrees above normal. This sudden rise in temperatures produced rapid melting of the above normal snowpack. Since the soil was saturated, there was no place for the melted snow to go except overland. The streams were unable to handle so much water in such a short time and the flooding occurred.

To further compound the situation, the several years of above normal moisture had also recharged the underground water aquifers and the snowmelt which did infiltrate the saturated soil caused springs at higher elevations in the mountains which had not produced water for years to begin to flow. The spring water flowed down draws and small canyons under the saturated soil providing a lubricant which the soil, with the additional weight of the saturating water, could not resist and down the slopes it moved, demolishing homes, streets and highways, blocking streams and producing additional flood problems. A new lake over 170 feet deep and several miles long has been formed by one slide.

Due to the topography around the Great Salt Lake, the only place the excess moisture could flow was into the lake. The end result has been the levels of both Great Salt Lake and Utah Lake are the highest of the century. Further, desert lake beds which have been dry for years are now supporting lakes larger than Utah Lake.

* * * * * * * * * * *

HOW WET IS WET ?

BY

ARLO RICHARDSON
UTAH STATE CLIMATOLOGIST

"For the Lord God had not caused it to rain upon the earth—but there went up a mist from the earth and watered the whole face of the ground." Thus, Moses recorded the first rain to fall on the newly created earth. Water is one of the most vital substances for all living organisms. A human can survive several weeks without food, but three days without water to replace that which has been lost from the body tissues finds a man in very serious distress.

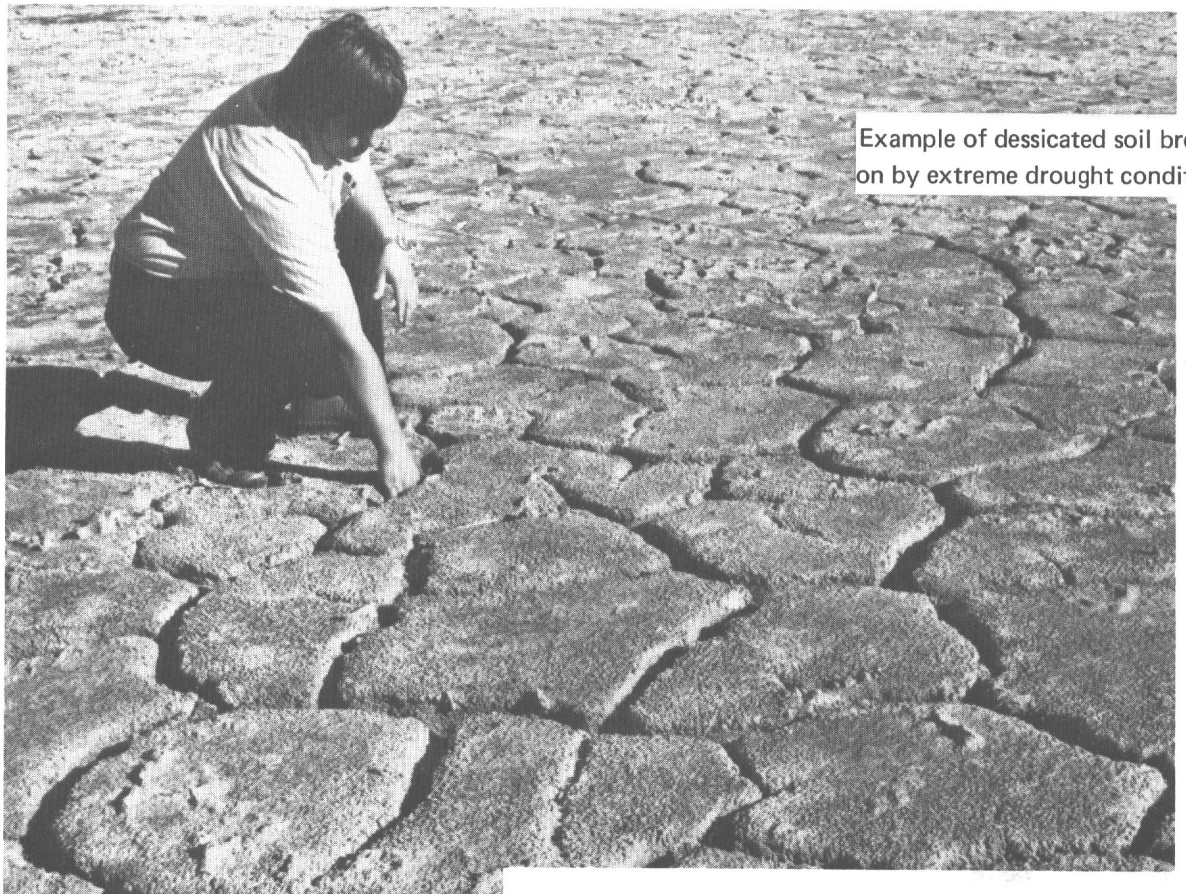
As every grade school student is aware, energy from the sun evaporates water from the surface of lakes, reservoirs, streams and from the ocean and causes plants to transpire moisture extracted by the roots from moist soil. In turn, this water vapor rises into the cooler air, condenses to form a cloud and finally returns to the surface of the earth in the form of rain, snow, hail, dew, frost, etc.

The rate at which this moisture returns to the earth and the form in which it falls is of great importance to all living organisms. At extreme rates of fall, the water erodes the soil and causes floods which destroy entire cities with tremendous loss of life and property. On the other extreme, lack of rainfall results in death of plants, animals and man and final desiccation of soil to the point that few, if any, living organisms can survive. Carried to an extreme, the earth would become a dead planet with no life at all.

During the last six or seven years in Utah we have moved from one extreme to the other. During the winter of 1976-77 a rapidly developing drought situation imposed serious stress on all water resources in the state. Since that time, above normal precipitation has been quite common. The combination of the wettest water year of record with an accumulation of 26.34 inches followed by the 2nd largest accumulation for the water year 1982-83 to date along the Wasatch Front has produced very serious potential for flooding. Other areas of the state have generally accumulated much above normal moisture during the past two years, but the totals have not been record breaking. The real causes of the current situation are not known but appear to be related to the accumulated effects of several years with much above normal precipitation.

By way of comparison, lets take a look at some of the extreme rainfall conditions that have been reported about the earth. A publication by the U.S. Army in 1970 reports that the driest place on earth is Arica, Chile. During the past 59 years, only .03 inches of moisture has been recorded. By contrast, the wettest place on earth is probably Cherrapunji, India. During the 12 month period, August 1860 to July 1861, the weather observer at Cherrapunji recorded 1042 inches of rainfall. A few other world records of interest—on July 4, 1956 Unionville, Maryland recorded 1.23 inches in a 1 minute period. A record 20 minute rainfall of 8.10 inches occurred at Curtea-de-Arges, Romania on July 7, 1889. A 42 minute accumulation of 12 inches occurred at Holt, Missouri on the 22nd of June, 1947 and a 24 hour record of 74 inches fell at Cilaos, La Reunion Island on the 15 and 16 of March, 1952.

While such extremes do occur, they are not representative of average conditions about the earth. A more representative figure of average conditions is that of average annual rainfall. In terms of annual extreme precipitation, Mt. Waialeale, Kauai, Hawaii takes top honors for the entire world as well as for the nation. Based on records for a 30 year period, Waialeale recorded an amazing 460 inches during one year. If this were to occur all at one time, there would be water over 38 feet deep spread across the landscape.



Example of dessicated soil brought on by extreme drought conditions

Flooding brought on by extreme rainfall

TORNADO OR "MICROBURST"[1] ?

BY

GRANT W. GOODGE

NATIONAL CLIMATIC DATA CENTER

On Sunday afternoon, May 22, 1983, a strong localized wind storm struck several locations east of Asheville, North Carolina. Following is a brief summary of the meteorological conditions that existed prior to and during the event, as well as a description of the resulting damage.

Before proceeding with the meteorological aspects of the storm, it would be helpful to briefly discuss the major geographic features of the area involved. The city of Asheville is located in the middle of the French Broad River Valley, which is about 10 miles wide and oriented SSE-NNW. About 20 miles NNW of the city the valley turns to the WNW and cuts through the relatively lower Bald Mountains, where it then opens into the broad SW-NE oriented Great Valley of east Tennessee.

In contrast to the SSE-NNW orientation of the French Broad River Valley, the more narrow Swannanoa River Valley is oriented WSW-ENE and empties into the French Broad River in south Asheville. The Swannanoa Valley is flanked on the north by the Black Mountains (maximum elevation 6684') and on the south by the Swannanoa Mountain Range (maximum elevation 4400'). It was in the western end of the Swannanoa Valley and on the north flank of the Swannanoa Mountain Range that the wind damage occurred (see Figure 1).

Sunday, May 22, 1983, started out as an overcast, windy day in Western North Carolina. There had been some showers and even a couple of thundershowers during the early morning hours; however, none of the thundershowers approached the intensity of the storms that occurred later in the day.

Synoptically, the southern Appalachians were in a moist unstable air mass that preceded a NE-SW oriented cold front that was approaching the area from the WNW. Thunderstorms had developed ahead of the front as it moved through east Tennessee, east Kentucky, and the upper Ohio Valley. Some of the storms had reached severe levels and had produced hail and several tornadoes.

Wind speeds ahead of the front were quite strong from the south through southwest from the surface to the 200mb level. The surface winds in the Asheville area were stronger than usual for a late spring cold frontal episode with the Asheville WSO (Elevation 2165') reporting gusts to 26 knots three hours prior to the storm, and the Flat Top Mountain cooperative station (Elevation 4370') reporting gusts to 40 knots during the same period. Winds aloft increased with height over the area. The 850mb winds were 200° at 35 knots and increased to 70 knots from 230° at 200mbs. The axis of the 500mb trough at 0700 EST on May 22nd was oriented NW-SE from northwest Minnesota to north central Georgia.

[1]Term described by Fujita as a "Microscale downburst with its path length less than 3.16 miles." Fujita, T. T., (1978): Manual of downburst identification for project NIMROD.

Both the 0700 and 1900 EST soundings for Athens, Georgia showed the atmosphere to be conditionally unstable with a Lifted Index of -1 and -3, respectively. However, during the intervening 12-hour period a major change had occurred in the moisture profiles, with the lower levels (900-600mbs) becoming more moist and the upper levels (above 600 mbs) drying out dramatically. Such a moisture profile is often synonymous with the outbreak of severe thunderstorms.

Not unlike other thunderstorm lines that move into the southern Appalachians from the west, this one also became less organized. The only exception was in the area where the French Broad Valley provided a significant break in the Appalachian Mountain barrier, and as a result allowed a portion of the thunderstorm line to move into the north end of the French Broad Valley.

The sky was dark to the NW of Asheville during the early afernoon with thunder beginning distant northwest at 1452 EST[2]. With the strong southwest winds aloft, however, the individual thunderstorm cells moved northeast along the remains of the line. Thunder ended distant north-northwest at 1525 EST, with the line having shown little or no movement to the southeast. At 1545 EST thunder began again to the north-northwest of Asheville, only this time it was closer and more frequent as a new series of cells developed to the southeast of the old line and the new line began to move east-southeast across Asheville. The individual cells were still moving rapidly northeast, but the line continued moving to the southeast. As the line crossed the low ridges east-southeast of the city at 1600 EST the cloud bases were ragged but mostly rain-free. At 1602 EST frequent intense lightning began in the rain-free area to the southeast through east of the existing line of cells, and at 1606 EST, in a matter of seconds, a narrow (1-2 mile wide) obscuring rain shaft dropped from the cloud base over the area that experienced the wind damage. In twenty-five years of observing thunderstorms in the East Tennessee and Western North Carolina area the author has never seen a rain shaft drop more rapidly from a cloud base than in this case. Even though the recording rain gauges in downtown Asheville and on Flat Top Mountain (9 miles to the ESE) were not in the center of the storm, both sites still recorded peak rainfall intensities of about 6 inches per hour.

The 1600 EST GOES-1 satellite photo showed at least one small overshooting top breaking through the cirrus tops from older cells (see Figure 2). Unfortunately there were no radar tops reported on this cell until 1630 EST when the Bristol, Tennessee, radar reported a height of 37,000 feet. The Athens, Georgia, and Greensboro, North Carolina, 0700 EST soundings showed the height of the tropopause to be between 43,700 and 44,000 feet. Radar photos from Bristol and Athens did show a characteristic "Bow" shaped echo that is commonly observed with intense thunderstorm episodes (see Figure 3). Despite the fact that the Bristol radar was located 50 nautical miles closer to the cell than the Athens radar, it only showed a convective VIP level 3 (1.1-2.2 inches of rain per hour) while at the same time Athens showed a convective VIP level 5 (4.5-7.1 inches of rain per hour). The Athens data more closely agree with the rainfall intensities reported by the downtown Asheville and Flat Top Mountain rain gauges. The most likely explanation for the difference in the reported VIP levels is that the Bristol radar beam was set on a 0^{o} elevation angle and was being attenuated by higher terrain between the radar site and the thunderstorm cell. It might be noted that similar differences in the VIP levels have been observed while studying several previous thunderstorm events that occurred in the same area.

As the storm approached the author's vantage point on Flat Top Mountain, the strong southerly winds subsided long enough to allow the author to hear a loud roar as the gust front came across High Hickory Knob one-half mile to the west. At 1620 EST a peak gust of 60 knots from a direction of 270° was recorded at Flat Top Mountain (see Figure 4). The peak gust was preceded a minute earlier by two gusts of 54 knots and the beginning of very heavy rain. All five individuals interviewed by the author who were in the wind damage areas agreed that the peak wind gusts occurred coincident with the onset of very heavy rain.

It was only after making an aerial survey the following day that the author and a National Climatic Data Center meteorologist discovered that the most severe wind damage had occurred in a remote uninhabited valley about one mile to the east of any damage areas that had previously been reported by the public. A careful study of the photos from five separate aerial surveys and four on-ground inspections showed that there were evidently three separate major wind damage areas, with the direction of most of the damage tracks being controlled by the orientation of the terrain.

The first damage area was centered on the Georgia Pacific Plant which is located in a shallow flood plain of the Swannanoa River (see Figure 5). Dimensions of the plant are approximately 125 feet by 250 feet with the narrow side facing a direction of about 250°. The plant is of a modular type construction of heavy corrugated steel with a large access door on the WSW side and two pull-down type doors at a loading dock on the NNW side of the building. Treefall direction on either side of the building was parallel from the southwest, indicating the direction of the winds. As a result, the large access door on the WSW side of the building was blown in, allowing the wind to move some of the wood products located inside the building. With no openings on the downwind side of the building, dynamic pressures increased enough to bulge the loading dock doors to such an extent that they could not be opened. Even portions of the plant walls were forced outward from the concrete foundation. The trailer portion of two tractor-trailers parked on the downwind side of the plant were also flipped over. One of the trailers came to rest against a large unfallen tree.

Aerial photos showed that the second damage area was centered on Potato Knob, a relatively small NW-SE oriented ridge that separates Buckeye Cove and Wilson Cove (see Figure 5). Contrary to what would normally be expected, the maximum wind damage was confined to the flanks of the ridge and the valleys either side as opposed to the more exposed ridgetop itself. There was one narrow area of treefall from SSE to NNW and parallel to the elevation contours about one third of the way down the west side of Potato Knob; otherwise, the predominant direction of treefall was downhill either side of the ridge. It was also on the southwest side of Potato Knob that a mobile home was broken free from its tie downs and moved several feet. On the east side of Potato Knob there were four damage tracks that occurred in separate narrow valleys that empty into Wilson Cove. Again the direction of treefall was downhill and concentrated in the deepest part of the valleys. Residents living in Buckeye and Wilson Coves also reported a "loud roar" prior to and with the onset of, the storm. One resident said that when the rain began it was "as if someone had thrown a large bucket of water at him."

[2]Beginning and ending times of thunder are as reported by the author from Flat Top Mountain, North Carolina.

As was previously mentioned, the most intense wind damage occurred in the third damage area in an uninhabited portion of Patton Cove. The upper part of the cove is bowl shaped with steep slopes dropping off rapidly from High Hickory Knob. There were several scattered areas of tree damage about 700 feet below the top of High Hickory Knob. The maximum damage occurred, however, about 300 feet farther below and at the focal point of four narrow valleys where the winds were concentrated (see Figure 6). A ground search of the area showed that scattered trees had fallen downhill in each of the valleys leading to the focal point. Even the tender vegetation beneath the deciduous canopy was laid downhill with the winds. Flash flooding was ruled out as the cause of the plant damage since the precipitation was not of sufficient duration to produce any overland flow and no signs of erosion were found.

The dimensions of the damaged area shown in Figure 6 are about 100 feet wide by 350 feet long. Figure 6 also shows the direction of treefall to be the same from one side of the damage area to the other, the only exception being where the steepest valley of the four empties into the damage area from the lower right as viewed in Figure 6. The result was a small area of trees that were fallen at about a 50^{o} angle to the left of the predominant treefall in this damage area.

Over 95% of the trees in the damaged areas were uprooted as opposed to being broken off above ground. This was true for various tree types and locations. The author believes that the reason for the uprooting was winds striking the trees downslope from the southeast which is opposite of their rooted strength against the predominant strong northwest winds that frequent this area. Many of the trees were also growing in rocky, shallow soil. A close examination of the root structure of the uprooted trees did confirm a minimal amount of large roots on the uphill or southeast side of the trees.

It is the conclusion of the author that the wind damage was most probably the result of a microburst as opposed to a tornado. This conclusion was reached after considering the following facts:

1. No one in the area, including the author, reported having seen a funnel cloud.

2. The strongest winds occurred with the onset of heavy rain and on the right front side of the reflectivity center of the bow echo as it moved eastward. This is the position, relative to the cell, where microbursts are likely to occur, while tornadoes are more likely to occur at the trailing ends or hook portion of the cell.

3. The vast majority of trees in the damage paths were fallen in a parallel manner and in the bottom of the valleys. Similar damage was documented by Fujita in the mountains of West Virginia after the major outbreak of storms on April 3, 1974. These narrow areas of tree damage were described by Fujita as "downburst fingers" or the "spreading ends of a downburst descending over rugged terrain."

References

Fujita, T. T., (1978): Manual of downburst identification for project NIMROD.

National Climatic Data Center
Athens, Georgia, radar film for May 22, 1983.
Bristol, Tennessee, radar film for May 22, 1983.
GOES-1 satellite photographs for May 22, 1983.
Athens, Georgia, radiosonde observations for 12Z May 22, 1983 and 00Z May 23, 1983.

Weighing rain gauge charts for National Climatic Data Center and Flat Top Mountain co-op stations for May 22, 1983.
Wind gust record for Flat Top Mountain, North Carolina, for May 22, 1983.

National Meteorological Center
Surface, 850, 700, 500, 300, and 200mb charts for 12Z May 22, 1983 and 00Z May 23, 1983.
The vorticity and LFM charts were unavailable at this time.

U. S. Department of Commerce
Federal Meteorological Handbook No. 7, "Weather Radar Observations" Part A; Effective January 1, 1980.

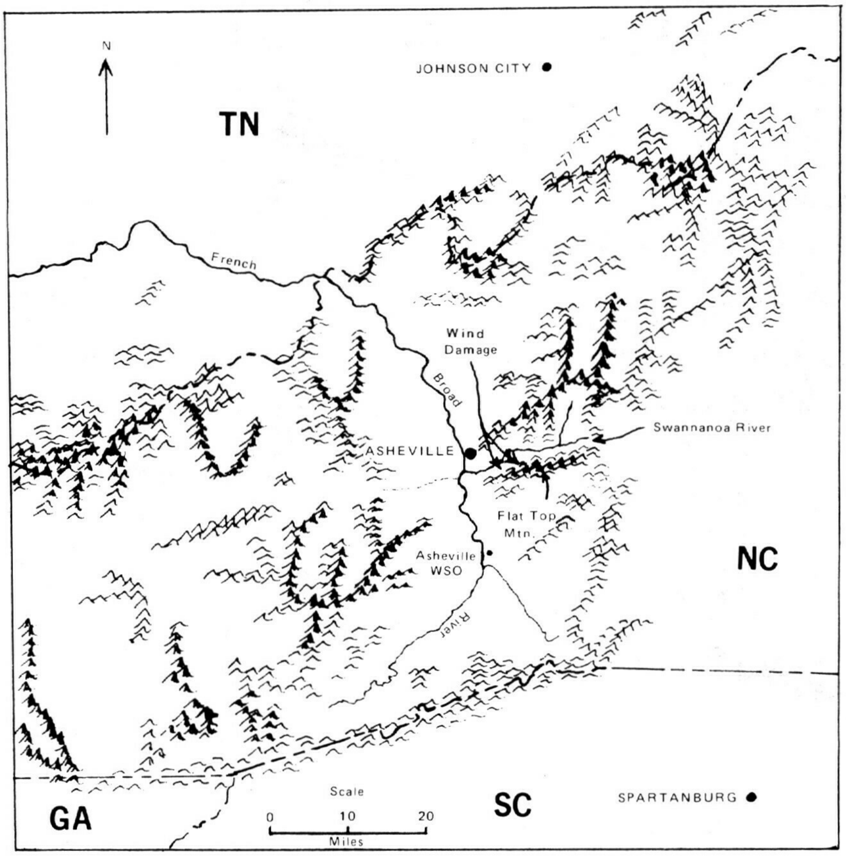


Figure 1. Locations and topographical features of Western North Carolina.

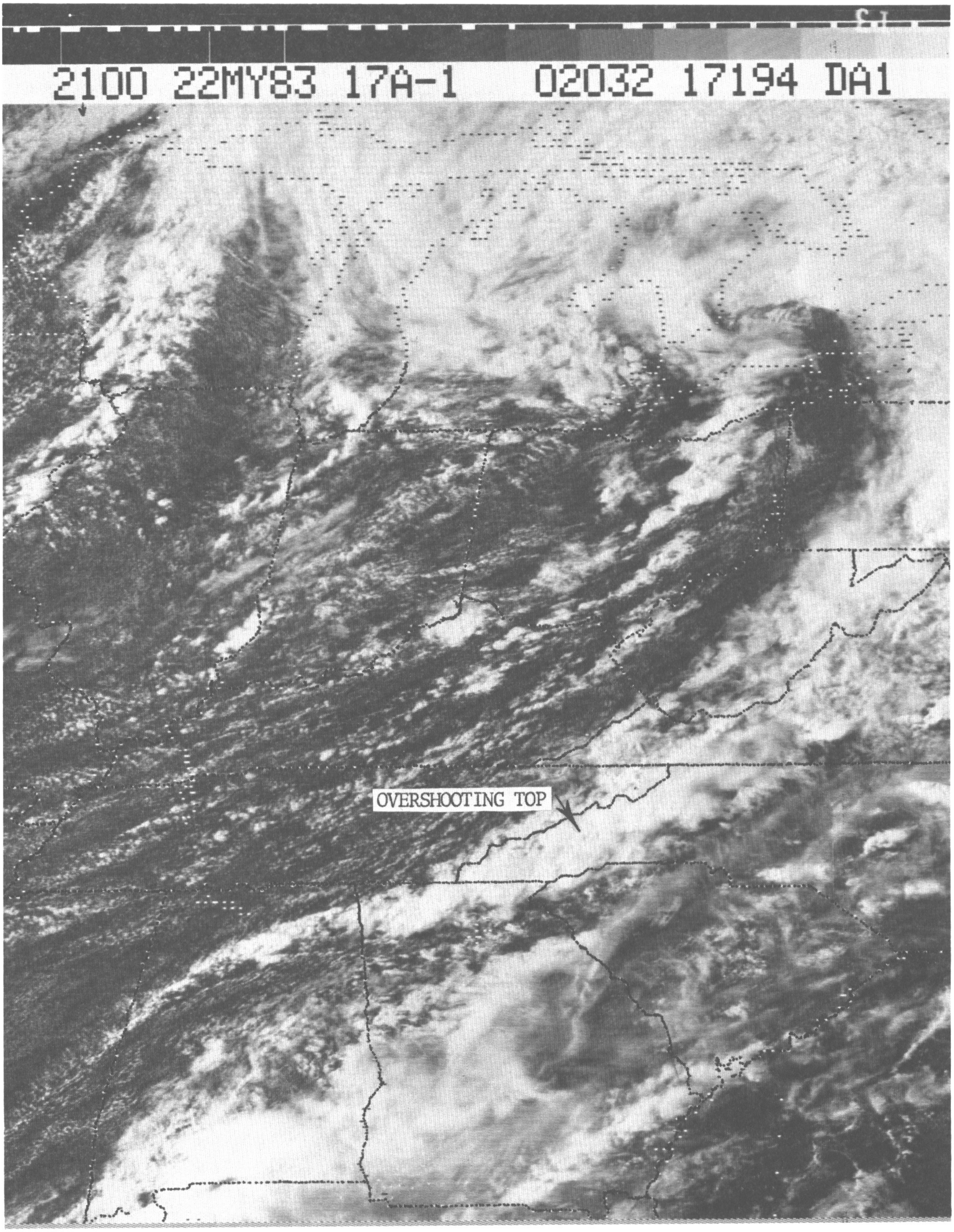


Figure 2. Goes-1 photograph for 1600 EST, May 22, 1983.

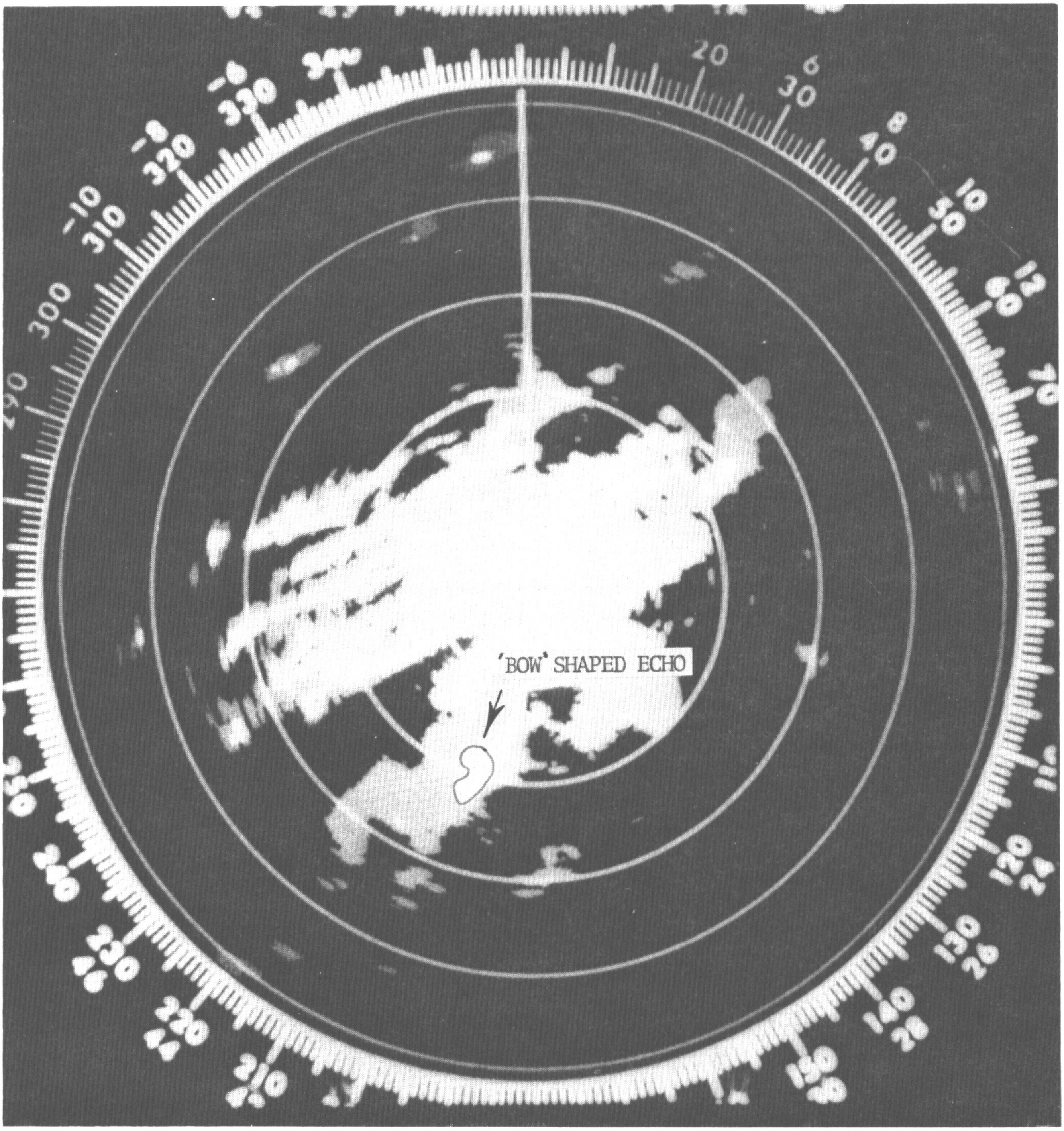


Figure 3. Bristol, TN radar photograph for 16:12 EST, May 22, 1983. "Bow" shaped cell outlined for clarity.

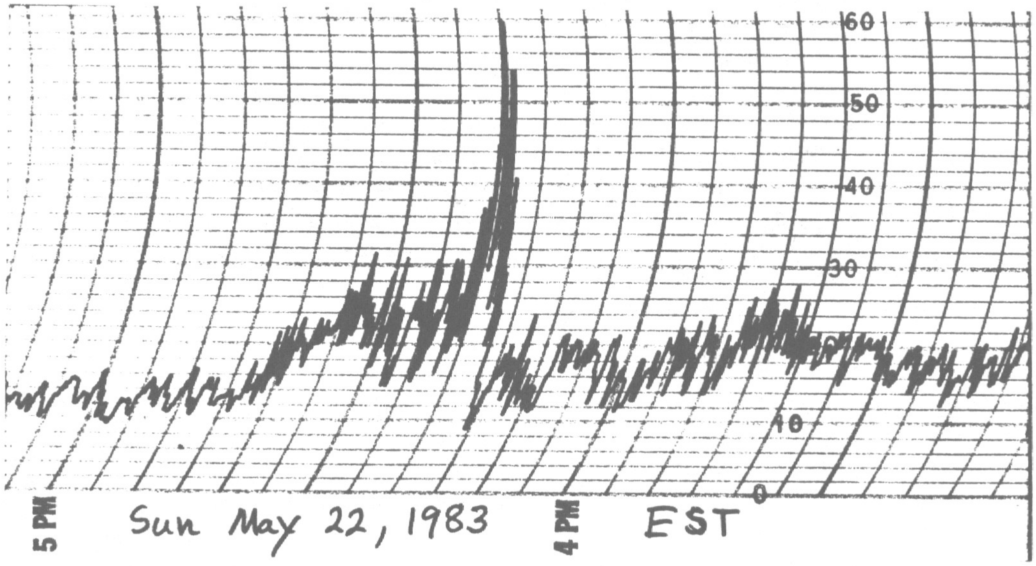


Figure 4. Wind gust record for Flat Top Mountain, N.C. May 22, 1983. Chart is calibrated in knots.

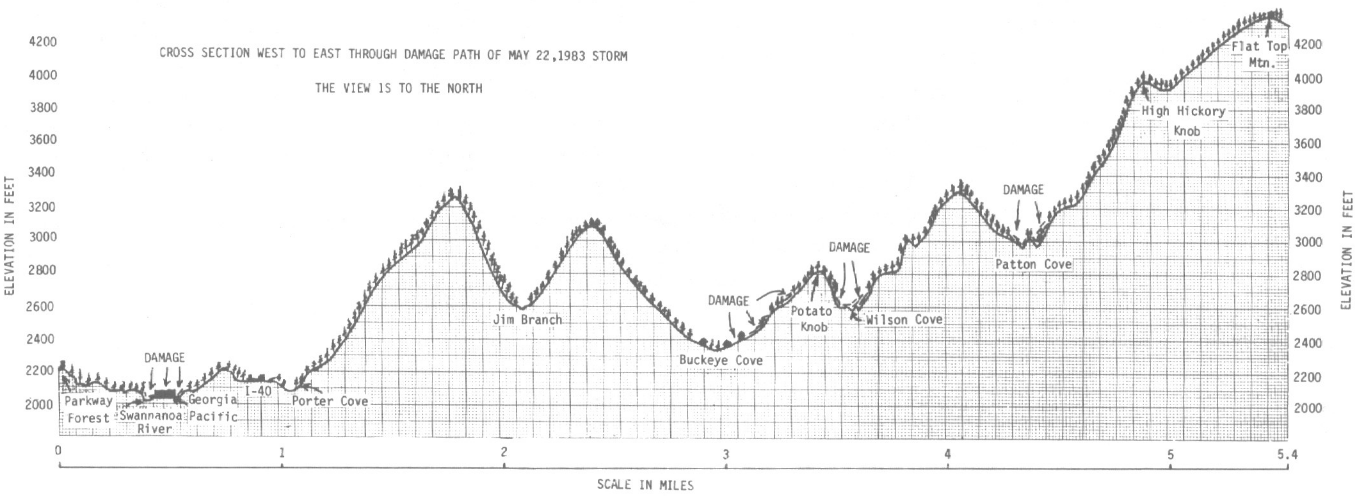


Figure 5. Cross section of terrain through the damaged areas. The view is to the north.

Figure 6. Aerial photograph of third "damage" area. The view is to the northwest. Photograph was taken from 300 feet above ground level.

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