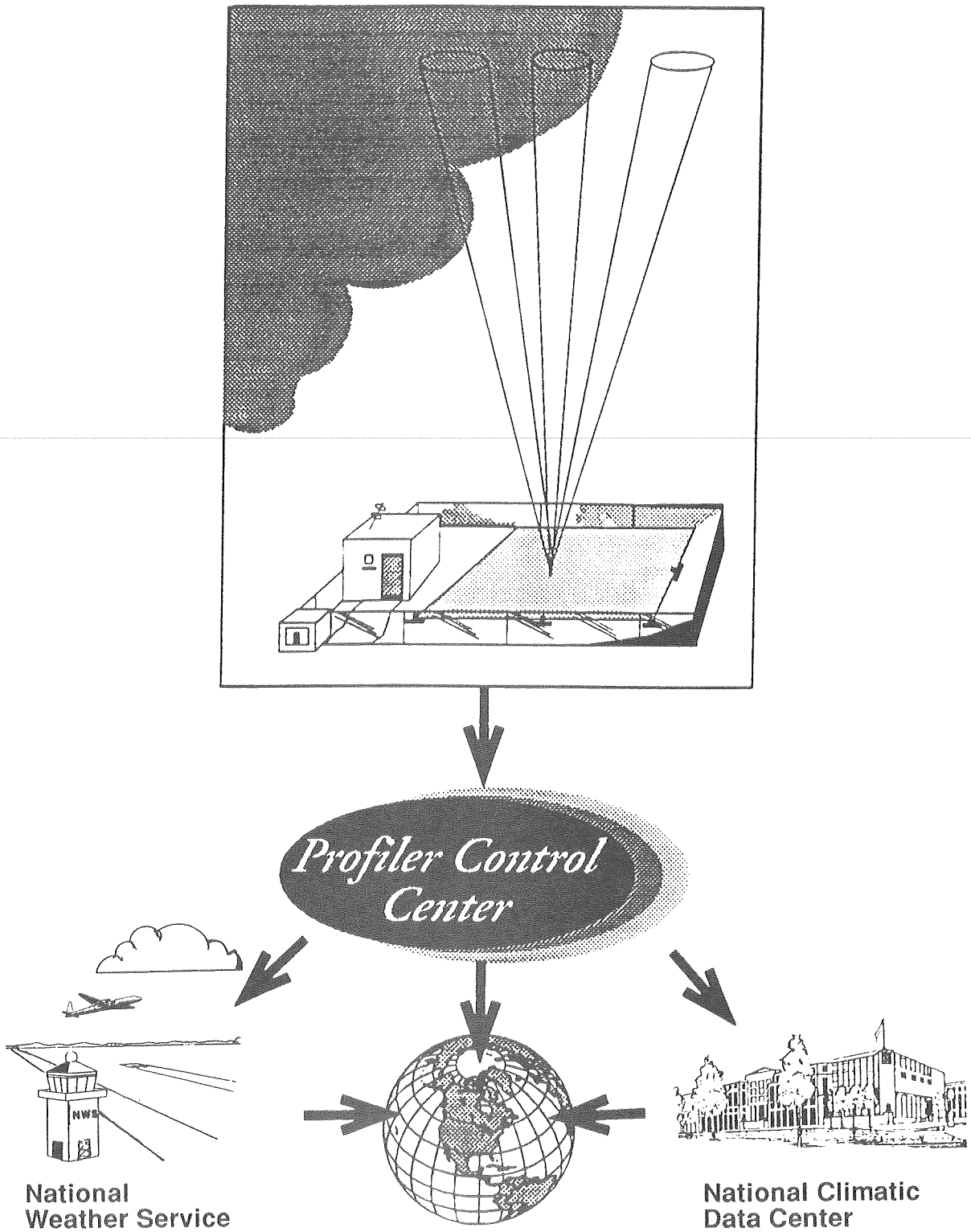
NOAA WIND PROFILER DEMONSTRATION NETWORK



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1. Scope

This summary describes the Wind Profiler Demonstration Network (WPDN), developed and operated by NOAA's Environmental Research Laboratories (ERL) - Forecast Systems Laboratory (FSL) - Demonstration Division, in conjunction with the research, development, and operational support of other ERL and National Weather Service (NWS) groups and staff. It provides the history, background, and concept of a remote wind measurement system, then explains what a wind profiler is, how it operates, what the demonstration network is, and what data are generated and available to customers of the National Climatic Data Center (NCDC).

2. Definition, History, and Background

2.1 Definition

A wind profiler is a Doppler radar used to measure the atmospheric winds above the profiler site. Typical operation of a wind profiler produces a vertical profile of the winds every hour from near the earth's surface to above the tropopause.

2.2 WPDN Historical Overview

Radar systems developed during the 1920s - 1930s were used primarily for upper atmospheric research concerning the ionosphere. World War II sped the development and use of short wavelength radars. It was not until the late 1960s and early 1970s that the potential for using sensitive clear-air radars to study the lower atmosphere became apparent. Chadwick and Gossard (1983) give an excellent account of developments in clear-air radars.

In the late 1970s, the Aeronomy Laboratory (AL) of ERL in Boulder, Colorado built and tested a very high frequency (VHF) 50 megahertz radar near Platteville, Colorado. This radar was a scaled-down prototype of a Mesosphere-Stratosphere-Troposphere (MST) research radar built and operated near Poker Flat, Alaska.

In 1980, the Wave Propagation Laboratory (WPL) of ERL began operating the Platteville radar jointly with the AL to measure tropospheric winds. The system operated for several years and produced coarse vertical resolution wind profiles. During the mid 1980s, a small network of five wind profilers operated in Colorado (Strauch et al., 1984). These profilers routinely produced hourly wind profiles of high vertical resolution.

In 1985, ERL formed the Profiler Technology Transfer Group within WPL to develop, deploy, and operate the WPDN, a demonstration network of 30 wind profilers across the central United States, plus the one at Platteville, Colorado. From this point, the Profiler Program Office set out as its own entity in 1986. Deployment of the WPDN began in 1988 and finished in the spring of 1992. The administrative office for this program was shifted to FSL's Demonstration Division in 1990.

The WPDN is a demonstration of wind profiler technology over a large region. An assessment of the utility of wind profilers and the WPDN in operational settings is being conducted by the NWS.

2.3 Network Background

The WPDN contributes to NOAA's national and global objectives for developing and deploying surface-based profilers, as described in the Strategic Plan for Upper-Air Observations (1992).

Requirements and specifications for a nationwide operational network of profilers come, in large measure, directly from the experience gained with the demonstration network. WPDN data also contribute to NOAA's efforts in refining and operationally implementing data integration and assimilation techniques.

NOAA global objectives are supported by the WPDN in several ways. WPDN data regularly contribute to global atmospheric studies. As an example, the network figures prominently in the Department of Energy's Atmospheric Radiation Measurement (ARM) program. Wind profiler technologies and operational experience are being transferred to the private sector, thereby enhancing the nation's position as a leader in the development, manufacture, and export of advanced sensor systems. The WPDN serves to encourage other countries to deploy similar systems and promotes the international exchange of data.

Field maintenance for the WPDN is conducted by electronics technicians from the central and southern NWS regions. Logistics support for the network is provided by the NWS's National Reconditioning Center (NRC) and by NOAA's National Logistics and Supply Center (NLSC), Kansas City, Missouri.

3. What is a Wind Profiler?

As defined in Subsection 2.1, a wind profiler is a Doppler radar used to measure winds above the profiler site. They are relatively low-power, highly sensitive clear-air radars, operating with wavelengths from 33 cm to 6 meters (van de Kamp, 1988).

Typical operation of a wind profiler produces a vertical profile of winds every hour from near the earth's surface to above the tropopause. An illustration of a typical wind profiler site is presented in Figure 1.

Gate spacing, defined in Figure 1, gives the atmospheric heights at which the resolution volume is centered. Winds measured by the profiler are an average within this volume.

There are two different modes of operation illustrated in Figure 1.

- Low mode measures wind from 0.5 km to 9.25 km. These lower heights require less power for wind measurements. Less power comes from a shorter pulse length, which results in higher resolution.

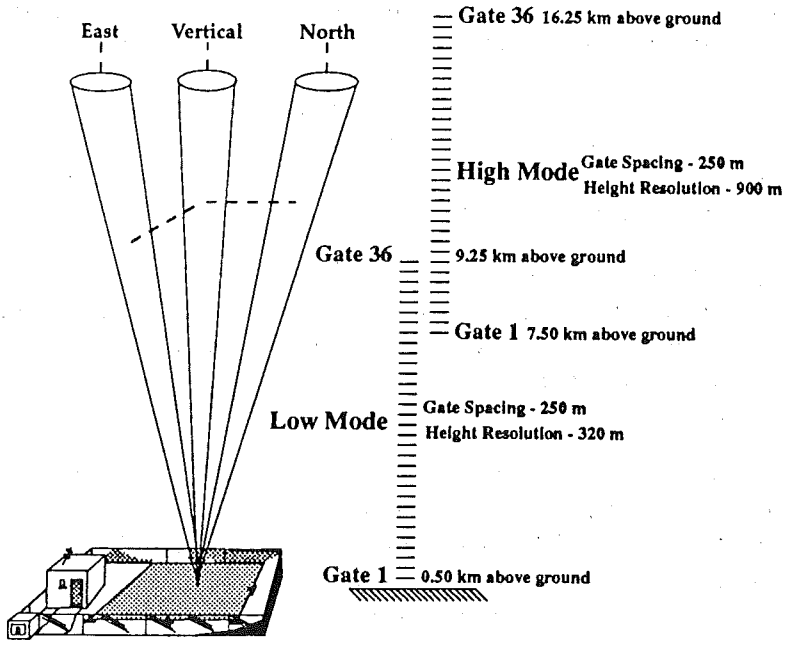

Figure 1. Wind Profiler Demonstration Network Site With Mode Data.

- High mode measures winds from 7.5 km to 16.25 km. These higher regions require more power for wind measurements. More power comes from longer pulse length, which results in lower resolution.

Wind profilers detect fluctuations in atmospheric density caused by turbulent mixing of volumes of air with slightly different temperature and moisture content. The resulting fluctuations of the index of refraction are used as a tracer of the mean wind in clear air. Although referred to as clear-air radars, wind profilers are capable of operating in the presence of clouds and precipitation. Obtaining wind profiles consistently to the tropopause in these varying weather conditions requires a relatively long wavelength radar. Typical NWS weather radars operate with wavelengths of 10 cm or less.

4. How Wind Profilers Operate

WPDN wind profilers are designed to operate reliably and unattended in nearly all weather conditions. To achieve this reliability, they have a minimum of moving parts. Therefore, the profilers use fixed beam antennas. For the most part, profilers have standard site and system configurations, plus standard logistics support requirements, to simplify repairs and minimize down time.

The major components of a WPDN wind profiler include the radar and satellite communications system, plus an optional Profiler Surface Observing System (PSOS) package.

WPDN wind profilers operate on standard 110/220 V, 60 Hz commercial power. The radar transmitter, generating approximately 20 kW of peak power, sends this energy to the radar antenna, which directs it in three known confined directions, north, east, and vertical. The antenna has a coaxial collinear (COCO) configuration made up of orthogonal radiating elements. Since there are no moving parts in the antenna, the direction of the three beams is determined by beam steering.

Radiated power is reflected from variations in the radio refractive index caused by turbulence in the atmosphere. Fluctuations in the radio refractive index are carried along by the mean wind flow and produce a slight Doppler shift in the returned signal. The timing of the transmission and reception of the radar beam is carefully controlled to permit vertical resolutions of 320 m for low mode and 900 m for high mode (refer to Figure 1 and Section 3 text for more information).

The returned signal is received by the antenna, processed by a signal processor, and sent to a data processor for determining wind velocity and direction. This information and the raw data used in their calculation are sent, via the satellite communications system, to a centralized data collection, processing, and distribution component called the Profiler Control Center (PCC), located in Boulder, Colorado. The raw data consists of signal power, radial velocity, and velocity variance.

5. The Wind Profiler Demonstration Network

The WPDN is an integrated system for data collecting, processing, distributing, and archiving, plus management functions. There are three primary goals of the WPDN Program:

- provide vertical profiles of winds to the NWS in near-real time so they can assess the impact of using profiler winds in operational products and models;
- assist major meteorological field studies, plus basic atmospheric research;
- operate as a platform for advanced developments in surface-based remote sensing of the atmosphere.

Three major components comprise the WPDN:

- Remote Profiler Site Subsystems;
- PCC for network operation, data collection, processing, and distribution, plus maintenance and logistics coordination;
- Archive Component.

5.1 Remote Profiler Site Subsystem

Each of the WPDN's Remote Profiler Site Subsystems consist of a Doppler radar system, optional surface meteorological package, local processing capability, and communications links to the PCC. A list of profiler sites is presented in Table 1. Figure 2 shows the locations of the sites and PCC.

State	Profiler Name	NWS Name	Latitude (Deg.)	Longitude (Deg.)
AK	Homer	HMRA2	59.76	151.17
AR	DeQueen	DQUA4	34.11	94.29
CA	Vandenberg	VBGC1	34.77	120.53
CO	Granada	GDAC2	37.77	102.17
CO	Platteville	PLTC2	40.18	104.71
CT	Bloomfield	BFMC3	41.88	72.70
IA	Slater	SLAI4	41.90	93.69
IL	Winchester	WNCI4	39.65	90.48
KS	Haviland	HVLK1	37.65	99.09
KS	Hillsboro	HBRK1	38.30	97.29
KS	Neodesha	NDSK1	37.37	95.63
LA	Winnfield	WNFL1	31.89	92.78
MA	Maynard	SBYM3	42.41	71.48
MN	Wood Lake	WDLM5	44.67	95.44
MO	Bloomfield	BLMM7	36.88	89.97
MO	Conway	CNWM7	37.52	92.70
MO	Lathrop	LTHM7	39.58	94.17
MS	Okolona	OKOM6	34.08	88.86
NE	Fairbury	FBYN1	40.09	97.34
NE	Merriman	MRRN1	42.90	101.69
NE	McCook	RWDN1	40.08	100.65
NE	Neligh	NLGN1	42.20	97.79
NM	Aztec	AZCN5	36.84	107.90
NM	Tucumcari	TCUN5	35.08	103.61
NM	White Sands	WSMN5	32.40	106.34
OK	Haskell	HKLO2	35.80	95.78
OK	Lamont	LMNO2	36.69	97.48
OK	Purcell	PRCO2	34.97	97.51
OK	Vici	VCIO2	36.07	99.21
TX	Jayton	JTNT2	33.01	100.98
TX	Palestine	PATT2	31.77	95.71
WI	Blue River	BLRW3	43.22	90.53
WY	Medicine Bow	MBWW4	41.90	106.18

Table 1. Wind Profiler Demonstration Network Site Information.

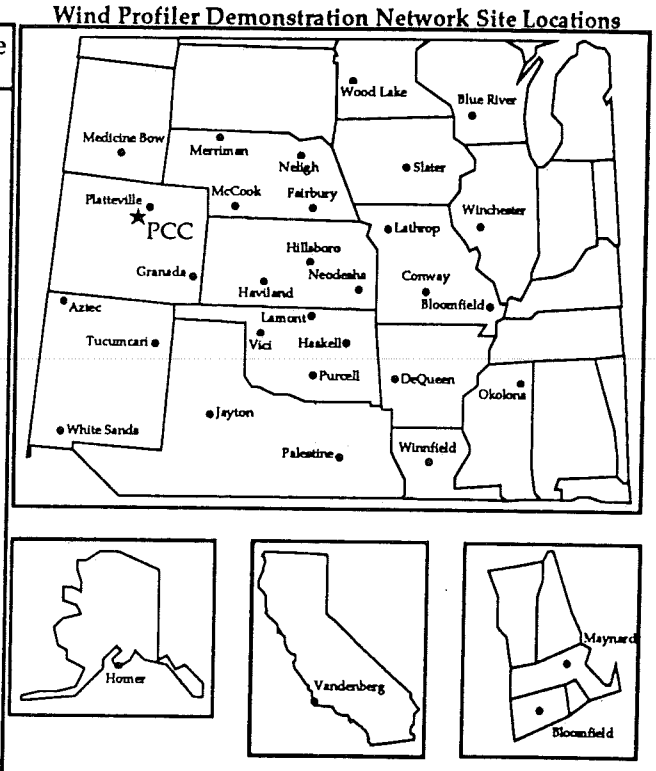

Figure 2. Wind Profiler Demonstration Network Site Map.

The system at each site is designed to continuously and automatically measure the upper atmospheric wind fields using the Doppler radar, plus a hardware/software system for local signal and data processing. Data transmission from a site to the central collection component is performed in two modes:

- high temporal resolution data transmitted by commercial satellite and land line links every six minutes;
- summary data transmitted via the Geostationary Operational Earth Satellite/Data Collection Subsystem (GOES DCS) every 60 minutes.

5.2 Profiler Control Center

The WPDN's Centralized Data Collection, Processing, and Distribution Subsystem is located in Boulder, Colorado (refer to Figure 2). This component, called the Profiler Control Center (PCC), is responsible for the following tasks:

- generating 60 minute resolution data from six minute data;
- using 60 minute data to generate specific meteorological products, including vertical wind profiles of horizontal wind speed and direction;
- performing quality control processing of the 60 minute resolution data acquired from each profiler site;
- distributing data and products to the community of users.

The PCC supports real-time monitoring of network operations, plus program assessment and evaluation activities by providing near-real-time data and status information.

Other operational tasks performed by the PCC include:

- directing and monitoring operations and maintenance of the WPDN;
- coordinating repairs of the radar units;
- updating station history information for the WPDN's Archive Component (refer to Subsection 5.3);
- displaying data and status information in support of the network's operations and maintenance activities;
- providing assistance in support of WPDN assessments conducted by ERL research scientists and NWS meteorological staff.

5.3 Archive Component

The WPDN's Archive Component is located at NCDC in Asheville, North Carolina. NCDC is responsible for the operation of the official archive, which includes assisting research customers by providing:

- retrospective data in response to their needs;
- on-line access to recent data;
- metadata on the WPDN.

6. What Data are Generated? How are Data Available to NCDC Customers?

6.1 Data and Data Flow

The PCC distributes data in a number of different ways. Figure 3 illustrates the major system components involved in distributing and archiving WPDN data.

The most complete and detailed data available are transmitted directly between the PCC and the NCDC archive. This primary WPDN data stream arrives at NCDC via an on-line system called Management of Atmospheric Data for Evaluation and Research (MADER) (McGuirk and Crowe, 1991). Refer to Subsection 6.2 for more information on MADER. This data stream consists of both 60 minute and six minute data in Enhanced-BUFR (E-BUFR) format (Brazille, 1991).

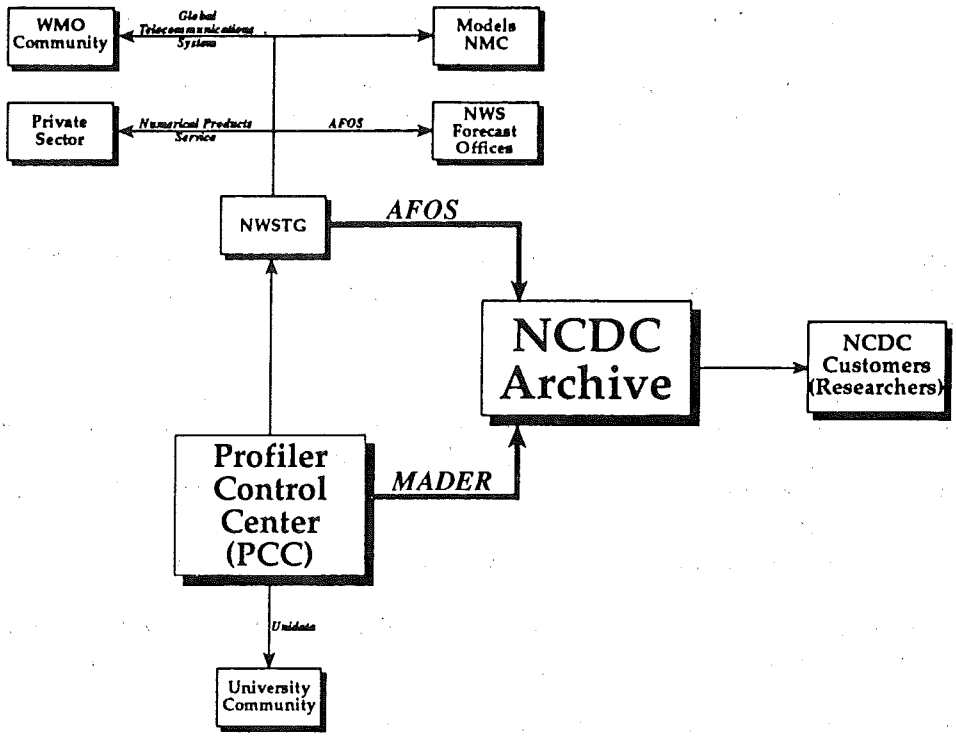

Figure 3. Wind Profiler Demonstration Network Data Distributing and Archiving Components.

The WPDN data stream is organized into eight data sets.

60 Minute Resolution

Winds_60 This data set contains winds averaged over an hour time period for the components in the u, v, and w directions, plus relevant quality control indicators for all levels of the wind profile. **On-Line for 30 Days.**

Moments_60 This data set contains hourly averaged zeroth, first, and second moment information for the three beams (north, east, vertical), the two modes (high/low), and the gates, as well as data availability indicators. **On-Line for Seven Days.**

Surface_60 This data set contains surface data averaged over the previous hour at a wind profiler site. Data include surface pressure, temperature, dew point, wind speed and direction, and precipitation. **On-Line for 30 Days.**

Control_60 This data set contains engineering status bytes, communications status, and other hourly information not directly related to individual data elements. **Not On-Line.**

Six Minute Resolution

Moments_6 This data set contains all six-minute zeroth, first, and second moment information for the three beams (north, east, vertical), the modes (high/low), and gates, as well as data availability indicators. **On-Line for Seven Days.**

Spectrum_6 This data set contains a diagnostic spectrum which can rotate any six-minute period to any beam, gate, or mode. **Not On-Line.**

Surface_6 This data set contains surface data averaged over the previous six-minute time interval at a wind profiler site. Data include surface pressure, temperature, dew point, wind speed and direction, and precipitation. **Not On-Line.**

Control_6 This data set contains engineering status bytes, communications status, and other six-minute information not directly related to individual data elements. **Not On-Line.**

Metadata sent in this stream includes station history, inventories, and instrument morphology. A complete data dictionary defining all the parameters in each of the eight data sets is also available in the stream. Refer to Subsection 6.2 for information on using MADER to access all WPDN data.

In addition to the MADER data stream, the PCC sends real-time profiler 60 minute winds in BUFR format to the NWS Telecommunications Gateway (NWSTG). From this gateway, profiler data is redistributed to the following organizations and groups:

- NWS, via the Automation of Field Operations and Services (AFOS), for its field offices, plus the National Severe Storms Forecast Center (NSSFC), Kansas City, Missouri;
- National Meteorological Center (NMC) for their model work;
- World Meteorological Organization (WMO) via the Global Telecommunications System (GTS);
- private sector via the Numerical Products Service.

Finally, the PCC uses Unidata to send a near-real-time data stream of profiler 60 minute winds in NetCDF format to the university community.

6.2 Accessing Profiler Data

WPDN data are available for both on-line (Snodgrass and Faas, 1992) and off-line delivery.

Data are available on-line via an advanced data management system setup developed as a cooperative effort between FSL, the Stormscale Operational and Research Meteorology (STORM) Project Office, and NCDC. It provides Internet users the means of retrieving on-line profiler wind data, engineering parameters, and metadata in a quick and easy fashion.

These and other profiler data files are available off-line as well. The on-line MADER System allows ordering profiler data for off-line delivery. Other off-line requests for profiler data are handled through the NCDC Research Customers Service Group.

- **Phone 704-259-0994**
- **Fax 704-259-0876**
- **E-Mail TROSS@NCDC.NOAA.GOV**

To access the on-line data via Internet, enter the Internet dot address

192.67.134.72

and follow the steps presented in Table 2.

1. From your prompt, type,

   telnet 192.67.134.72

2. Use the following as your login name,

   storm

   and the following as the password,

   researcher

3. Answer the prompts appropriately for X-Window information and terminal type emulation.

4. Login to the STORM Data Catalog by registering and assigning yourself your own password.

5. From the menu options displayed, select,

   On-Line Tutorial

   to teach yourself how to use the system.

6. A terse method of accessing profiler data would have you follow these menu choices in order:

   - Select

     Find, View, or Order Data

   - Select

     Network/Platform

   - Select

     NOAA Wind Profiler Demo Net

   - Begin Search

   This should bring up the eight wind profiler data sets discussed in Subsection 6.1.

   - Mark the desired data sets

     Select
     Actions

   - Select

     Order Off-line or On-line Data

   - Enter dates of data you want to acquire. Enter dates only, you will have an opportunity to select a subset of the data in a later step.

   - Download until the following appears,

     Processing Menu

   - Select

     Subset

     (i.e., enter time, latitude, and longitude at this point)

   - Enter FTP information for data transfer, including the following:

     - *Destination Dot Address*
     - *User Name*
     - *Account Number (Optional)*
     - *Password*
     - *Destination File*
     - *User E-Mail Address*

   - Download

   - Exit Storm Data Catalog

Table 2. Instructions for Accessing On-Line WPDN Data Using the MADER System.

If you have any questions about accessing wind profiler data, please contact the Research Customer Service Branch at 704-259-0994.

7. References

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