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PROJECT REPORT

DEVELOPMENTS IN NATIONAL WEATHER SERVICE METEOROLOGICAL DATA COLLECTION PROGRAMS AS RELATED TO EPA AIR POLLUTION MODELS

DEVELOPMENTS IN NATIONAL WEATHER SERVICE METEOROLOGICAL DATA COLLECTION PROGRAMS AS RELATED TO EPA AIR POLLUTION MODELS

by

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NOTICE

AFFILIATION

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ABSTRACT

During the next decade, the National Weather Service (NWS) will be upgrading its meteorological instrumentation and data dissemination procedures. Because these changes will affect the operation of the U.S. Environmental Protection Agency's (EPA) air pollution models, this project has been undertaken to report on proposed changes and to recommend how to make optimal use of the new NWS data products.

New instrumentation will include automated surface observation systems, next generation radar, and remote profilers. Data dissemination is being upgraded with an automated weather interactive processing system, the conversion of data tapes to an element format, and the introduction of data formats that are compatible with personal computers. Complete descriptions of existing and new formats that are applicable to EPA air pollution models are given in the Appendices.

To maximize the usefulness of NWS meteorological data, the following actions are recommended: (1) adapt the EPA meteorological processors to read the new data formats and upgrade them to incorporate advances in diffusion meteorology; (2) encourage the collection of meteorological data specific to diffusion modeling and investigate the feasibility of collecting some of these data at NWS sites; (3) improve the handling and formatting of NWS data for regional-scale models; and (4) maintain active communication with the National Climatic Data Center.

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SECTION 1

INTRODUCTION

One of the principal inputs to an air pollution model is meteorological data. Collecting and archiving the data poses a challenge to those involved in diffusion modeling. The Nuclear Regulatory Commission (NRC) and the Environmental Protection Agency (EPA) have addressed this problem of meteorological data quite differently. The NRC requires that nuclear installations collect comprehensive meteorological data, including temperature differences, hourly average winds, and turbulence fluctuations. These measurements are usually taken on masts at heights ranging from 30 to 100 m. In some localities, such as near a large body of water, multiple meteorological masts are required. In contrast, EPA regulates a greater number and many more types of sources than the NRC. Because it is impractical for every potential emitter of air pollution to operate a comprehensive on-site meteorological monitoring program, EPA has traditionally relied on meteorological data collected by the National Weather Service (NWS). EPA's models use simplistic characterizations of diffusion meteorology using only a few measured NWS meteorological variables. For example, the rate of dispersion is determined by a Pasquill stability class as estimated from routine observations of wind speed, cloud cover, and ceiling height. Hourly estimates of plume rise, dilution, and transport direction are based on a single 2-minute average wind value reported by an observer on the hour.

During the past few years, the NWS has started to modernize its meteorological instrumentation and data dissemination systems, and EPA has begun efforts to use additional meteorological information to characterize diffusion (EPA, 1987; Paumier et al., 1986). Upgrades in new instrumentation will include automated surface observation stations (ASOS), next generation radar (NEXRAD), and remote profilers. Data dissemination will be improved with the operation of an automated weather interactive processing system (AWIPS) and perhaps with a modern climatological data distribution system (NOAANET). The focus of this report is to assess how these changes in NWS meteorological data will affect EPA air pollution models. In particular, this report is intended to inform model users and developers on likely changes and to recommend upgrades in meteorological processors in order to effectively accomodate data from new instruments and in different formats.

In Section 2 of this report, current meteorological data requirements for EPA air pollution models will be reviewed. Proposed changes to NWS instrumentation and data dissemination will be discussed in Section 3, especially as related to EPA models. A summary and recommendations are given in Section 4.

SECTION 2

CURRENT REQUIREMENTS

Air pollution models in EPA can be broken down into two basic areas: UNAMAP models and regional models. In general, UNAMAP models are used by the public for regulatory modeling. It is estimated that several hundred organizations in the United States use UNAMAP models. Regional models tend to be larger and more complicated than UNAMAP models. They are either used for research and development or for planning emission reduction strategies across several states. Models such as the regional model for acid depostion (RADM) and the regional oxidant model (ROM) are being used in making important policy decisions. Like UNAMAP models, their successful operation depends on National Weather Service (NWS) meteorological data.

UNAMAP MODELS

UNAMAP stands for the User's Network for the Applied Modeling of Air Pollution. It began in 1973 to provide the EPA modeling community ready access to models for estimating air quality impact from proposed and existing sources of air pollution. The latest version of UNAMAP, version 6, was released in 1986 and contains over 24 models and meteorological processors. Version 6 contains both models that have regulatory status and models that are to be tested and evaluated. Two UNAMAP models, PLUVUE-2 and MESOPUFF-2, are regional-scale models. Attributes of each model are summarized in Table 1.

The models listed in Table 1 are either short-term or long-term models. Short-term models use hourly meteorological data to estimate air pollution concentrations for time periods ranging from 1 hour to 1 day. Long-term models use climatological frequency distributions of wind speed, wind direction, and stability class to estimate air pollutant concentrations for seasonal or yearly periods. Both types of models depend on National Weather Service data for meteorological information.

Table 1. Meteorological requirements for UNAMAP (Version 6) models.

Model	Averaging time	Meteorological processor	Format
BLP	Hourly	RAMMET	TD-1440/9689
RAM	Hourly	RAMMET	TD-1440/9689
ISCST	Hourly	RAMMET	TD-1440/9689
MPTER	Hourly	RAMMET	TD-1440/9689
CRSTER	Hourly	RAMMET	TD-1440/9689
MPTDS	Hourly	RAMMET	TD-1440/9689
COMPLEXI	Hourly	RAMMET*	TD-1440/9689
CALINE-3	Hourly	none	Unique
INPUFF	Hourly	none	Unique
PEM-2	Hourly	none	Unique
PLUVUE-2	Hourly	none	Unique
HIWAY-2	Hourly	none	Unique
PAL-2	Hourly	none	Unique
APRAC-3	Hourly	none	Unique
PBM	Hourly	PBMMET	TD-1440/9689
MESOPUFF-2	Hourly	READ56/MESOPAC	TD-1440/5600
TUPOS	Hourly	MPDA	TD-1440/5600/onsite
SHORTZ	Hourly	METZ	TD-1440/9689/onsite
PTPLU-2	Hourly	none	none-required
CDM-2	Long-term	none	STAR
ISCLT	Long-term	none	STAR
VALLEY**	Long-term	none	STAR
LONGZ	Long-term	none	STAR

*RAMMET is a generic name for EPA short-term meteorological processors.
**Can also predict 24-hour average concentrations.

As shown in Table 1, many of the UNAMAP models use meteorological data in special formats as available from the National Climatic Data Center (NCDC) in Asheville, North Carolina. The four currently-used data formats are summarized in Table 2. Descriptions of these data formats are contained in the Appendices.

Table 2. Meteorological data formats used with UNAMAP (Version 6) models.

NCDC format identifier	Description	Appendix
TD-1440	Hourly surface observations	A
TD-5600	Twice-daily rawinsonde observations	C
TD-9689	Twice-daily mixing height estimates	E
TD-9773	STAR data -- joint frequency distributions of wind speed, wind direction, stability class	F

Most short-term models require hourly surface and twice-daily mixing height data in the TD-1440 and TD-9689 data formats. Before these models can be operated, they depend on a meteorological program, called RAMMET, to process the data.

The TD-1440 format is generated from surface observations reported on WBAN forms. Variables included in the TD-1440 format are listed in Table 3. Only a few of these variables are currently used with the EPA meteorological processor as noted in Table 3. A complete description of the TD-1440 format is given in Appendix A.

Table 3. List of variables in the the TD-1440 format.

Variable name	Column	Description	
SFCID	1 - 5	WBAN 5 digit station number	
YR	6 - 7	Last two digits of year	
MONTH	8 - 9	01 = January, 12 = December	
DAY	10 - 11	Day of month	
HOUR	12 - 13	Local standard time (00 - 23)	
CEILHT	14 - 16	Ceiling ht. (hundreds of feet)	
SKY	17 - 20	Sky condition	(NOT USED)
VISB	21 - 23	Visibility	(NOT USED)
WX	24 - 31	Weather type	(NOT USED)
PRESS	32 - 35	Sea-level pressure	(NOT USED)
TDEW	36 - 38	Dew point temperature	(NOT USED)
WD	39 - 40	Wind direction (tens of degrees)	
WS	41 - 42	Wind speed (knots)	
STAPRE	43 - 46	Station pressure	(NOT USED)
TEMP	47 - 49	Dry bulb temperature (F)	
TWET	50 - 52	Wet bulb temperature	(NOT USED)
RH	53 - 55	Relative humidity	(NOT USED)
CLDS	56 - 78	Cloud information	(NOT USED)
OBSCUR	79	Total opaque sky cover (tenths)	

The TD-9689 format resulted from a study conducted by the EPA in collaboration with the National Climatic Center (now NCDC). In the study, reported by Holzworth (1972), twice-daily mixing heights and mean boundary layer wind speeds were computed for a five year period for 62 stations across the United States. The manner in which the twice-daily mixing heights have been calculated is shown in Figure 1. Both mixing heights are based on the 1200 GMT sounding. The morning mixing height, used only in urban short-term modeling, is computed as being the height at which the adiabat extending from the morning minimum temperature plus 5 C intersects the 1200 GMT temperature sounding. The afternoon mixing height is determined by taking the afternoon maximum surface temperature and finding the height at which its adiabat intersects the 1200 GMT sounding.

The UNAMAP models shown in Table 1 use these twice-daily values for determining hourly mixing heights. The manner in which hourly mixing heights are determined is shown in Figure 2. For rural applications, only the afternoon value is used as described in EPA (1977). For urban applications, both the morning and urban mixing heights are determined from both the morning and afternoon mixing heights as reported in TD-9689. The National Climatic Data Center makes no provision for missing data, precipitation, and cold advection. The user is therefore required to fill in these data gaps before running a preprocessor such as RAMMET.

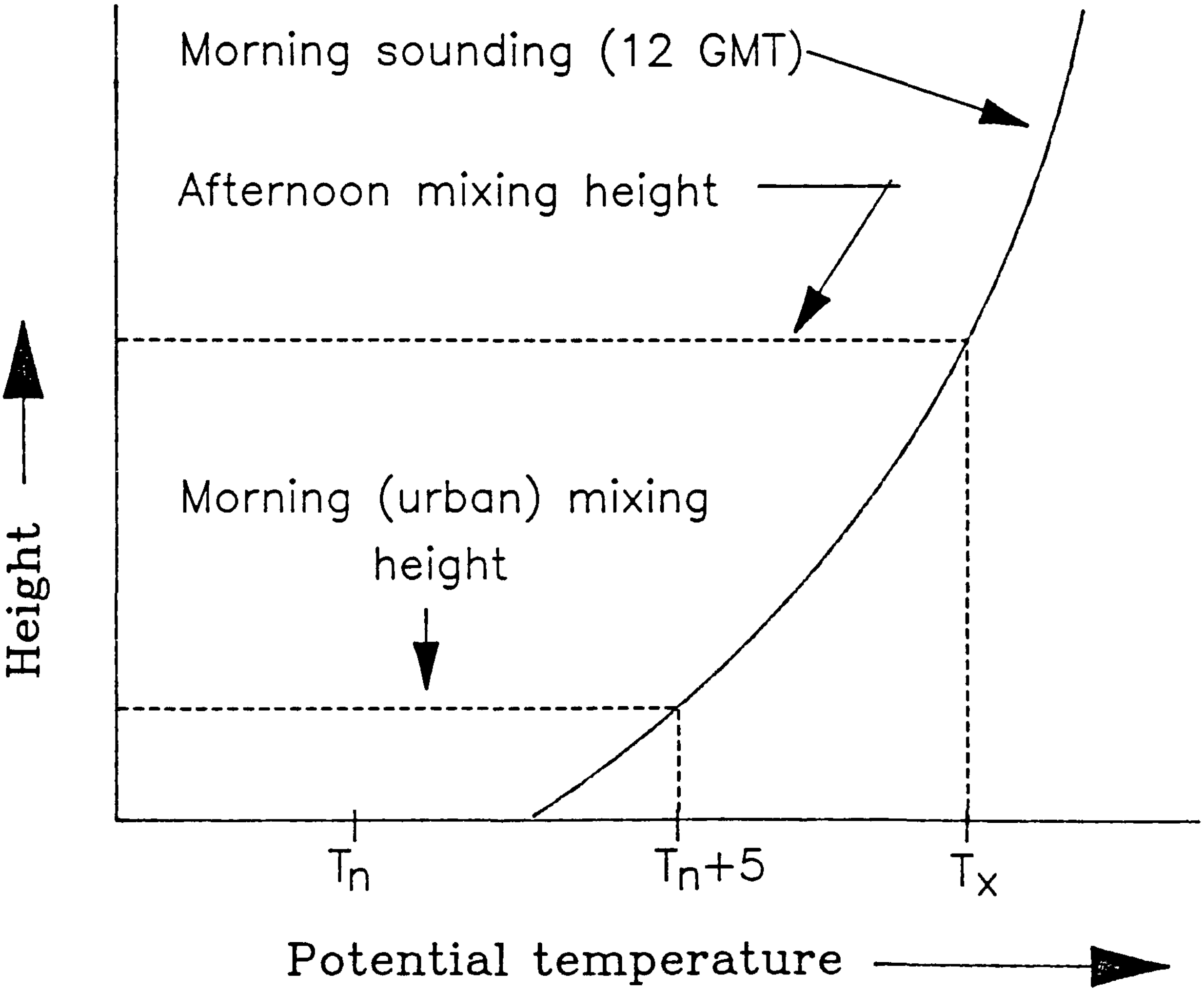

Figure 1. Determination of twice-daily mixing heights as used for TD-9689. T_n is the morning minimum temperature, T_n +5 is the morning minimum temperature plus 5 K, and T_x is the afternoon maximum temperature.

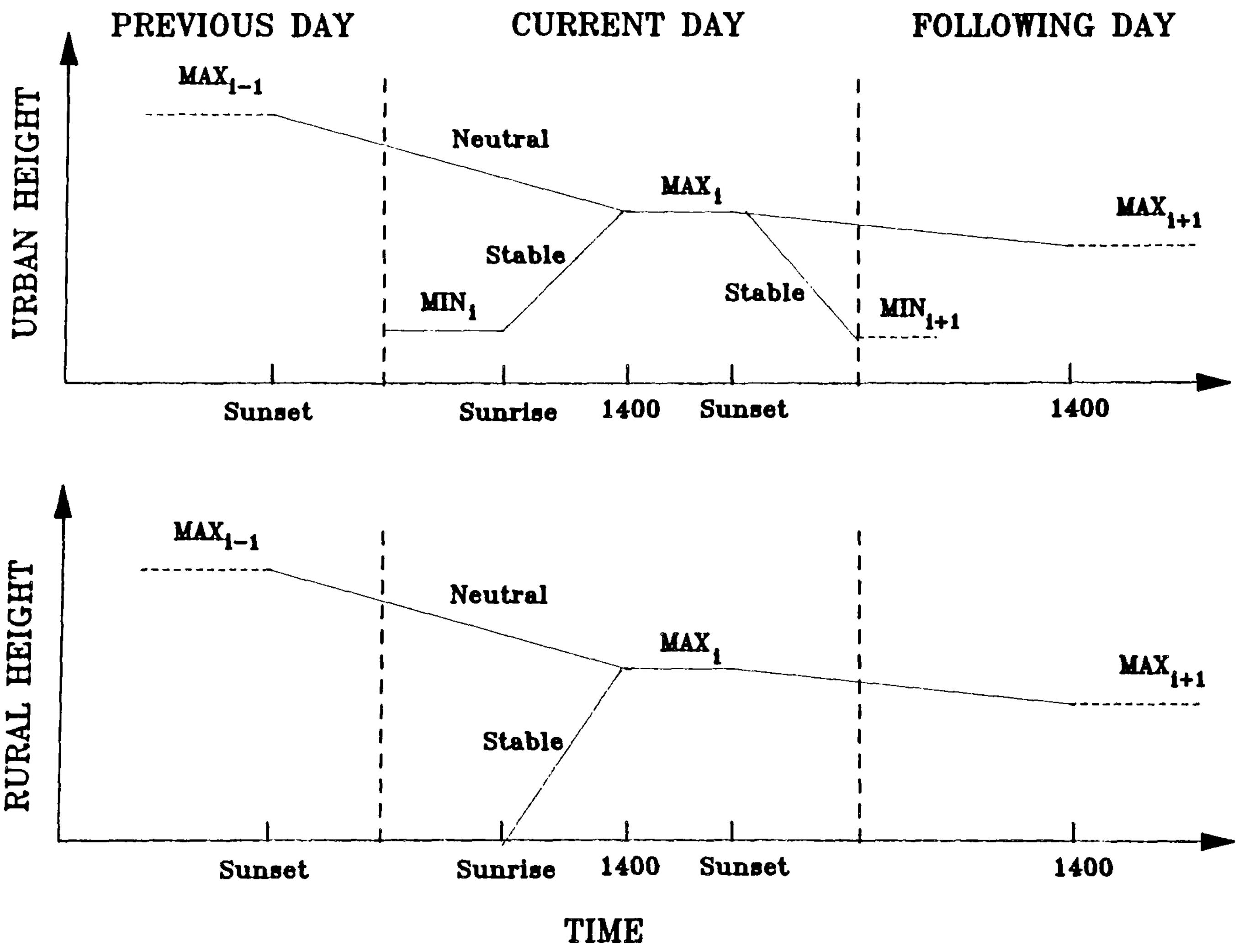

Figure 2. Determination of hourly mixing heights as used in UNAMAP short-term models.

In recent years, models have been added to UNAMAP that use additional information on the lower atmosphere in an attempt to simulate more accurately diffusion in the boundary layer. One example is the TUPOS dispersion model (Turner et al., 1986). TUPOS was especially designed to be compatible with the new EPA Meteorological Processor for Dispersion Analysis (MPDA) (Paumier et al., 1986). MPDA specifies diffusion in greater detail than the existing meteorological processor, RAMMET. It allows for on-site data, missing data, and uses upper air, wind, and temperature data from the twice-daily NWS radiosondes (as given in the TD-5600 format). The TD-5600 format consequently consists of more data than that available from the TD-9689 format which has been traditionally used. A description of the TD-5600 format is given in Appendix C. Other models that have special provisions for on-site data include INPUFF, HIWAY-2, and SHORTZ. The meteorological processor for SHORTZ handles on-site data but does not handle missing data periods. These more advanced meteorological preprocessors which handle missing data, on-site data, and available National Weather Service data apparently represent future trends in UNAMAP models and will be discussed in Sections 3 and 4.

Another sophisticated meteorological processor is included with MESOPUFF-2. It computes gridded values of meteorological information while using hourly surface and twice-daily radiosonde data. Meteorological data requirements for regional models such as MESOPUFF-2 will be discussed in the next subsection.

Long-term models such as CDM-2 and ISCLT are used for making seasonal and annual estimates of air quality. They rely on joint frequency distributions of wind speed, wind direction, and stability class. These data are usually obtained from NCDC in a format commonly known as STAR data. Recently, these data were made available on PC diskette (Heim, 1987) in format TD-9773. This format is described in Appendix F.

REGIONAL MODELS

As mentioned above, two of the UNAMAP models, MESOPUFF-2 and PLUVUE-2, are regional models. They require more data than the other UNAMAP models. MESOPUFF-2 requires surface and upper-air data from many locations within an area. Its meteorological preprocessor, MESOPAC, accepts data in the TD-1440 and TD-9689 formats. PLUVUE-2 has similar data requirements except it does not have a preprocessor for manipulating meteorological data into a specific format.

Other regional models used by EPA include RELMAP, ROM, and RADM. Most of these models are undergoing research and development, and their meteorological processors can be updated as new and improved meteorological data become available. Their data needs currently are similar to MESOPUFF except that RELMAP requires precipitation amounts for one degree latitude by one degree longitude areas. RADM estimates precipitaton amounts using its own dynamic prognostic meteorological model because adequate precipitation data do not exist for objective analysis (NCAR, 1986).

SECTION 3

PROPOSED NWS REVISIONS

The National Weather Service (NWS) is modernizing its observational systems and data dissemination procedures. Existing NWS instrumentation has not been significantly modified for 25 years and is rapidly approaching obsolescence. Furthermore, the current observational process is quite labor-intensive and requires a large expenditure of funds. Technology now exists for automated measurements of surface and upper-air weather variables. In addition, the advantages of Doppler radar have been clearly demonstrated, especially for severe weather application (Durham and Wilk, 1987). These new systems will generate additional data that will require enhanced data handling capabilities. The current AFOS system uses 1970s technology and is overburdened in its data handling and processing requirements. Also, the National Climatic Data Center is striving to meet the needs of new data formats and the increased amount of data that will be collected in the near future.

This section examines these changes from the perspective of air pollution modeling. First, instrument programs will be examined to see if they offer any potential for air pollution model application. Then, changes in data dissemination and data formats will be discussed.

INSTRUMENTATION

Advances are taking place in surface observations, upper-air observations, and radar. Current surface observation platforms will be replaced by an Automated Surface Observation System (ASOS). The upper-air rawinsonde system will be supplemented by remote profilers. Radars are being replaced by Doppler radar in the next generation radar (NEXRAD) project. This section examines the attributes of each of these systems.

Automated Surface Observation System (ASOS)

The National Weather Service (NWS) plans for ASOS to be in operation by the early 1990s. ASOS is the product of several years of research and is a cooperative venture among several federal agencies. Development of an automated surface observing systems was initiated by the Departments of Commerce (DOC), Defense (DOD). and Transportation (DOT) in the early 1970s. The promise of such a system became apparent in 1978 in a joint project by the Federal Aviation Administration (FAA) and the NWS. Since 1984, the ASOS project has been jointly funded by DOD, NWS, and FAA. Management and operation of ASOS is being assumed by the NWS.

ASOS will be implemented in one of two levels, basic or unmanned. In the unmanned level, ASOS systems will be installed at sites which currently do not have a meteorological observation system. This includes many of the general aviation facilities around the country. ASOS will therefore provide extensive surface meteorological measurements at locations where very little or no information has been available. In the basic level of service, ASOS will be installed at existing weather reporting stations. Initially, however, on-site observers will augment the system by reporting additional cloud information and special remarks. At some locations, where an observer is available less than 24 hours a day, ASOS will run in an unmanned mode when the observer is not available. In all, about 1500 ASOS sites are planned for the next 10 years.

To accomplish its objectives, ASOS uses recent advances in meteorological instrumentation. A laser ceilometer will replace the current 25 year old rotating beam ceilometer. The laser ceilometer can measure cloud bases through precipitation and can detect cloud layers up to 12,000 feet. Visibility measurements will be taken with a forward-looking visibility meter. Observers consequently will not be required to estimate visibility, which often varies from observer to observer and is difficult to estimate at night. With the eventual automation of ASOS, a laser weather identifier is being developed. The current design employs a light-emitting diode weather identifier (LEDWI). It projects a partially coherent light source over a 1 m baseline and measures the light's scintillation properties. The LEDWI can discriminate between rain, snow, and drizzle and can estimate their intensities. However, it can not discriminate between hail and ice pellets. Other instruments being updated include the hygrothermometer and the wind vane. The hygrothermometer, called HO-83, is based on a "cooled mirror" approach. The wind vane is a new prop-vane designed by R. M. Young. However, in preliminary tests, it has experienced problems associated with icing and stalling, and design changes are pending.

ASOS will have the capability of storing data on-site and will connect with the existing data dissemination network. Current plans are for hourly data summaries to be stored on-site for 30 days and 1 minute data to be stored up to 8 hours. ASOS will be integrated into the exisiting NWS network, currently called AFOS. Later in the 1990s, the data will be disseminated via the automated weather interactive processing system (AWIPS). Eventually, the data from ASOS will be archived at the National Climatic Data Center.

Despite its advantages, ASOS poses potential shortcomings for air pollution models. At unmanned sites, cloud information will be available only to 12,000 feet. Current EPA meteorological processors require opaque cloud cover for stability estimates. However, the ASOS program office intends to maintain observers at primary locations so that certain information such as the upper-level cloud cover can be reported. Unfortunately, current plans by the NWS state that hourly values of meteorological variables will be based on only 2 minute data averages collected on the hour. Since data will be sampled every minute, true hourly averages (especially of winds) could be obtained at little additional cost. However, this averaging and archival of hourly data requires a committment of funds that currently does not exist. In summary, ASOS represents a major change in surface observations. Its deployment and operation should be watched carefully by those concerned with using surface observations in air pollution models.

Rawinsondes

Since World War II, rawinsondes have been used to measure the vertical structure of wind, temperature, moisture, and pressure in the atmosphere. Although the system is well established, some minor improvements are being implemented. Microprocessors are being installed at each rawinsonde site which will automate data collection and perform many of the quality assurance checks. This should result in greater data capture and improved data quality. The microprocessors coupled with a redesign in the rawinsonde package will yield more frequent measurements. Instead of every 60 seconds, data will be archived every 30 seconds, thus providing improved resolution of vertical measurements. Also, data measured every six seconds will be archived at each site for up to six months. Special requests for six second data, say for a field study, can be made through the Upper Air Programs Office of the NWS.

Profiler

For years, rawinsondes have not provided upper-air data in a temporal and spatial resolution desired by numerical weather prediction and air pollution modelers. Currently, upper-air data are available every 12 hours and only at selected stations. The profiler system is designed to fill in these temporal and spatial data gaps for weather forecasting purposes.

The profiler is a ground-based remote sensing system designed to measure wind, temperature, and moisture profiles above a given site during all weather conditions. It consists of two subsystems: a wind profiler and a thermodynamic profiler. The wind profiler is a UHF (frequency currently established at 405 MHz) clear-air radar which is sensitive to backscatter from radio refractive-index irregularities caused by turbulence. Winds with the profiler are determined from Doppler shifts of the backscattered signal. The thermodynamic profiler used for measuring temperature and moisture consists of six channels of a radiometer which measures thermally emitted electromagnetic energy. More details on the profiler can be obtained from Chadwick and Hassel (1987) and Hogg et al. (1983).

The profilers are undergoing operational development. The first operational profiler network is expected to begin operation in 1989. Initially, 31 sites have been established in which it is hoped to demonstrate the feasiblity of the profiler. This demonstration network is expected to operate until 1994, when the NWS hopes to implement a national network of profilers. Currently, it is anticipated that the profilers will only augment the current rawinsonde network. Ultimately, as the technology is improved and field-tested, the profilers would be expected to replace the labor-intensive rawinsonde system.

Like the ASOS program, the profiler network does pose some potential problems for air pollution modelers. The lower limit of measurement for the 405 MHz wind profiler is 0.5 km. This limitation would be a detriment to boundary layer models which require lower-level tropospheric winds. The National Weather Service has indicated that it is considering to collocate acoustic Doppler sounders along with the wind profilers to provide lower level winds. However, these plans require further investigation. With the thermodynamic profiler, temperature and moisture data will be measured up from the surface, but the accuracy of these measurements will decrease with height. Satellite sensing data is expected to augment this data at upper levels. Preliminary tests of the radiometric data measurements indicate that while the temperature and moisture profiles are averaged quite accurately, the radiometer fails to detect rapid changes in these parameters. Research is continuing on how to integrate information from the wind profiler and other data sources to the temperature and moisture readings. Therefore, while it will be beneficial to have hourly vertical profiles of temperature and winds, much work remains to be accomplished with the profiler to obtain the data in sufficient vertical resolution for air pollution modeling.

NEXRAD

Another advanced system planned for deployment in the 1990s is the Next Generation of Weather Radars (NEXRAD). Like ASOS, it is the culmination of years of research in an effort by the DOC, DOD, and DOT to modernize instrument systems. The NEXRAD program will have Doppler radars which will provide increased range and resolution of reflectivity patterns. The radars also can estimate wind velocities within precipitating clouds. While their primary purpose is for severe storm detection and tracking, their output should assist in regional scale air pollution modeling.

Acquisition of the NEXRAD system was initiated by the NWS in 1980. In September 1987, the NWS was scheduled to have selected a final contractor to assume limited production of 10 units. These prototypes should be delivered during 1989 - 1991. Full-scale production and installation of NEXRAD at 165 sites is scheduled during 1990 - 1994.

Of the more than 25 meteorological products expected from NEXRAD, rainfall accumulation will probably most benefit air pollution modeling. NEXRAD will provide rainfall rates in 2 km x 2 km areas. NCDC anticipates that it will archive these gridded values for every 15 minutes. However, final archival requirements have not been established. Acid deposition models, such as RADM, would particularly benefit from the relatively high-resolution rainfall data.

DATA DISSEMINATION

Most users of EPA air pollution models rely on historical or climatic data. These data have traditionally been obtained through the National Climatic Data Center (NCDC) in Asheville, North Carolina. Near-real-time meteorological data and forecast products are available from the National Weather Service (NWS). Although NWS data are not usually accessed directly, it is possible that users may begin to use real-time data for emergency response applications.

This section primarily discusses changes in data dissemination related to NCDC, but will also briefly review a new data acquistion system under development by the NWS called AWIPS/NOAAPORT.

National Climatic Data Center

Most modelers of air pollution depend on the National Climatic Data Center (NCDC) for meteorological data. Because of this reliance on NCDC, it is important that renovations at NCDC be examined with respect to new data formats and changes in operation.

The center each day handles hundreds of requests for data. Six staff meteorologists interact with users to determine the data needs for each user. The number of data requests and the amount of data continue to grow at a staggering pace. The center handles over 20,000 requests for data per year. It also has to maintain a tape library of over 30,000 magnetic tapes which grows weekly. Because of this huge amount of data, NCDC has started to modernize its operation.

Modernization activites at NCDC include an increased use of Personal Computers (PCs) and the introduction of the element format. The use of PCs was recently discussed by Heim (1987). The primary motivation for going to floppy diskettes as a means of transferring data was because of the demand by the air pollution modeling community. Several data formats are available on floppy diskette. These include TD-1440 surface data, TD-3280 surface data, TD-9689 mixing height data, and TD-9773 STAR data. As PCs gain favor among the air pollution modeling community, the sale of floppy diskettes by NCDC will likely grow.

Thus far, the new element formats (TD-3280 and TD-6200) have not been used in EPA air pollution modeling. Although they have been available since 1984, changes in computer codes for EPA meteorological processors take time and money. However, discussions with NCDC have revealed that obtaining the same data in TD-3280 format instead of TD-1440 reduces costs by about 40 percent. NCDC is basically set up on a cost reimbursable basis -- they charge what it costs them to generate the data. Because data are stored in the element format, it is advantageous to obtain the data in the new format. Besides, the new format is fairly easy to run, and only the variables needed for modeling need be ordered. Descriptions of the new formats are given in Appendices B and D.

The advent of new observational systems in the NWS present additional challenges to NCDC. NCDC has made some effort on establishing formats for NEXRAD and profilers. Archiving data for NEXRAD will be a problem because of the amount of gridded data. The amount of data consists of gridded values (for 1 km by 2 km areas) every 5-15 minutes for up to 25 variables. Clearly, this is a large amount of data and needs to be maintained in a logical manner. Because profilers are still undergoing development, their data are being stored by NOAA's Environmental Research Laboratory in Boulder, Colorado. Eventually, the profiler data need to be added to the national archive, but no arrangements for archiving the data have yet been made.

As the size of the data bank continues to grow and if the center is restricted to a small staff, a greater reliance will be placed on computer technology to faciliate data transfer and processing orders. One idea which has been discussed is establishing a modern climatological data transfer system to be called NOAANET. The idea for such a system is that it would allow the user to order data via terminals (without interacting directly with people) and have the order filled either by electronic data transfer or by software which uses artificial intelligence to generate a magnetic tape or floppy diskette. Because the idea is preliminary, people requesting data for at least the next five years will probably continue to order data in the current manner.

AWIPS/NOAAPORT

A major component of the NWS's modernization is the development of an Automated Weather Interactive Processing System (AWIPS). It is intended as "an advanced data processing, display, and communications system" which will replace AFOS (Boezi et al., 1987). Although AWIPS will emphasize forecasting and improved severe-weather warning capability, some of its features may have a bearing on future air pollution modeling activities.

The design and installation of AWIPS is a five phase program. We are currently nearing the end of the first phase entitled Requirements. In March 1988, the NWS will select two contractors to participate in the second phase System Definition. The third phase will be for Development, and it is scheduled to begin in 1989. Deployment (Phase IV) is planned for 1991, and Full Operation (Phase V) is set to begin in early 1992.

Major components of AWIPS will include the following:

- o Acquire data and products from conventional and advanced observing systems.
- o Process and display data and guidance material for the forecaster.
- o Extract and assimilate information and help the forecaster in preparing warnings and forecasts.
- o Serve the needs of external users by interacting with NOAAPORT.

NOAAPORT is expected to be of interest to air pollution model users. When near-real-time meteorological data are needed, say for emergency response models, NOAAPORT would likely provide the necessary meteorological information. Also, NOAAPORT may be useful if information, for example from NEXRAD or profilers, are not being archived into the national data base. The specifications for NOAAPORT have not been defined, and interested parties should monitor development of the AWIPS/NOAAPORT system over the next few years.

SECTION 4

SUMMARY AND RECOMMENDATIONS

This project began as an attempt to understand how data formats from the National Climatic Data Center (NCDC) were changing and how these changes would impact EPA's meteorological processors. While investigating these changes, we learned of new advances in meteorological instrumentation and data dissemination which potentially can benefit EPA's air pollution models.

For EPA to best accomodate the planned changes to NWS observation and data dissemination programs and the planned changes to NCDC's data formats, we offer the following recommendations:

(1) Recognizing that EPA's meteorological processors will need to be modified to handle new NCDC data formats, they should also be upgraded to incorporate our more advanced knowledge of diffusion meteorology. This upgrade could also serve as a catalyst for incorporating more advanced modeling techniques into air pollution models. It should be noted that such efforts have begun with the development of the Meteorological Processor for Diffusion Analysis (MPDA) (Paumier et al., 1986) and the Turbulence Profile Sigmas (TUPOS) model (Turner et al., 1986).

(2) EPA should encourage the collection of meteorological data specific to diffusion modeling and should investigate the feasibility of collecting some of these data at NWS sites. As recommended by an expert panel (Hoffnagle et al., 1981), additional meteorological variables such as horizontal fluctuations of wind direction (σ_θ), harmonic mean wind speeds, low-level temperature gradients, and total solar radiation should be collected for air pollution modeling. It is promising to note that EPA (1987) recently provided guidance for collecting some of these variables at on-site measurement programs. Not all air pollution modeling applicants, however, will have access to an extensive meteorological monitoring program and will have

to depend on NWS data. Therefore, EPA should actively coordinate NWS meteorological data collection programs through the Office of the Federal Coordinator. In particular, it is advisable that EPA maintain vigorous participation in the Working Groups for Automated Surface Observations, Profiler Systems, and Radar Meteorological Observations. Perhaps with funding from appropriate organizations and cooperation with the NWS, additonal meteorological data for diffusion modeling can be collected at NWS sites.

(3) The formatting and handling of meteorological data for regional-scale models should be improved. Regional-scale models require vast amounts of surface, upper-air, and satellite data. Because these models operate sequentially, data must be sorted by hour. Unfortunately, NCDC data are sorted by station and not by hour. Consequently, much effort goes into generating a data set in the appropriate format. Two options which could be investigated include the development of a new NCDC data format and direct access and storage of NWS observations by EPA.

(4) The Environmental Operations Branch (EOB) should maintain active communication with NCDC. In performing this study, it became quite apparent that NCDC is willing to be responsive to the needs of the air pollution modeling community. By improving communication with NCDC, EOB can more effectively inform users about changes in data formats. One possibility is to develop a users' guide describing meteorological data requirements for UNAMAP models. The guide would also provide information on how to order meteorological data from NCDC, and it could serve as a valuable reference manual for NCDC meteorologists when dealing with air pollution modeling clients.

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APPENDIX A

DESCRIPTION OF THE TD-1440 FORMAT

This description is reproduced from documentation provided by the National Climatic Data Center (NCDC).

INTRODUCTION

SOURCE

Weather observations, in support of aircraft operations, have been taken at airports since the earliest days of aviation. The rapid growth of the industry during the 1940's made it evident that some mechanical means of summarizing the data must be developed. How was a site to be selected or an airport designed without adequate statistical information on which to base decisions? The first efforts toward this end caused the WBAN No. 1 card to come into being. For archiving purposes these observations, mostly from military stations, were designated as Card Deck-141. The period of record is generally 1941-1944. A change of format necessitated a new card deck designation (Card Deck-142) to be instituted in 1945. This deck remained in force into 1948. During 1948 additional major changes were made in observing and recording practises. These led to the development of Card Deck-144. Although the usual beginning data of digital information in this form is June 1948 the changeover was made station by station on varying dates. Then too, some stations have had observations back-punched in this format to much earlier dates.

In the early 1960's the FAA undertook a major airport study. To facilitate the handling of large masses of data necessary for this effort the Climatological Services of the Weather Bureau, Air Force and Navy along with the FAA devised the tape format described in this manual. This format was called Tape Data Family-14 (TDF-14) to retain some continuity with the card decks. Within this family of similar observations there are several Tape Decks each one uniquely identified at the beginning of each physical record on tape.

Beginning January 1, 1965, for most National Weather Service stations and March 1, 1972, for most Naval Weather Service stations the digitizing of the Airways Observations was reduced from 24 obs/day to 8 obs/day. These observations, at 3-hourly intervals, coincide with the normal GMT schedule of 00Z, 03Z, 06Z etc. This means, of course, that the observations, keyed in Local Standard Time (LST) differ according to time zone.

QUALITY CONTROL AND CONVERSIONS

All observations have been subjected to some form of quality control. During the earlier years this was almost entirely a manual effort. As more sophisticated techniques of processing were introduced the quality control procedures were also improved. Today, the quality control effort is a blend of several computer programs and manual review. Observations are checked for conformance to established observing and coding practises, for internal consistancy, for serial, or time oriented consistency, and against defined limits for various meteorological parameters.

The archiving of long term climatological information presents an almost constant dilemma to the archivist, systems analyst and programmer. Refinements of observational instruments, new techniques, changes in user needs and other factors combine to keep the incoming data in an almost perpetual state of change. In some instances the changes are of such significance that individual fields in the tape format must be redefined and the ultimate user must adapt this new information to his needs.

At other times the changes may be of such a nature that they can be incorporated into the existing format by converting units or other measurements. For example, wind speeds were recorded and punched in miles per hour through 1955 and in knots thereafter. All wind speeds on the tape file are in knots, the earlier period having been converted from mph.

USE OF THE MANUAL

This manual was designed so that recourse to additional reference material should be unnecessary. Occasionally, however, the researcher may wish to obtain a copy of the original Card Deck reference manual. This may be done by writing to the Director, National Climatic Center, Federal Building, Asheville, NC 28801.

Care should be taken to read carefully the general tape notations and coding practises.

MANUAL AND TAPE NOTATIONS

FORMAT

Each physical tape record contains six observations and is 495 bytes long.* These records consist of 15 bytes of identification followed by six logical records of 80 bytes each. Records always begin with the Local Standard Time hour of 00LST, 06LST, 12LST or 18LST. Thus, four physical records are needed to contain each day's observations.

Space is always retained on tape for 24 obs/day. When no observation is available the hour is indicated (2 bytes) and all other fields are coded blank. Care in programming should be taken to allow for this condition, particularly with most tapes from 1965 onward.

The manual presents a graphical representation of the standard format indicating Tape Fields, Tape Positions and Element Definition followed by detailed information for each field.

Also included as part of the manual is a simple FORTRAN program that may be used to overcome the problems of alphanumeric characters.

MANUAL AND TAPE

The following notations are used throughout the manual:

x = any numeric or alphanumeric character

i = same as x but used to show that the character is an indicator rather than part of the recorded element

= an "11" or zone punch

+ = a "12" punch

both the and the + may appear by themselves or in combination with a numeric digit to indicate an overpunch or signed field

Δ = blank

* = an 11,8,4 punch

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* Currently, archive tapes are 9 track, 1600 bpi, blocked four (495x4=1980 bytes) and can be furnished with this blocking factor if requested. The advantage is that the entire period of record for one station can be provided on one reel of tape.

SPECIAL NOTE

The observations described in this manual are those from Card Deck-144. The Tape Deck number is 1440. Elements for certain fields may differ in other Decks within this Tape Data Family. Requesters of data other than TD-1440 will be furnished appropriate reference material.

CHARACTER SET TDF-14

	HEXADECIMAL	OCTAL	EQUIVILANT CARD PUNCH COMBINATION
1	F1	01	1
2	F2	02	2
3	F3	03	3
4	F4	04	4
5	F5	05	5
6	F6	06	6
7	F7	07	7
8	F8	10	8
9	F9	11	9
0	F0	12	0
Δ(blank)	40	20	blank
	60	40	11
*	5C	54	11,8,4
&	50	60	12
A	C1	61	12,1
B	C2	62	12,2
C	C3	63	12,3
D	C4	64	12,4
E	C5	65	12,5
F	C6	66	12,6
G	C7	67	12,7
H	C8	70	12,8
I	C9	71	12,9
J	D1	41	11,1
K	D2	42	11,2
L	D3	43	11,3
M	D4	44	11,4
N	D5	45	11,5
O	D6	46	11,6
P	D7	47	11,7
Q	D8	50	11,8
R	D9	51	11,9
	C0	72	12,0
	D0	52	11,0
	E0	32	0,2,8 (record mark)

FORTRAN SUBROUTINE FOR SIGNED FIELDS

```
      SUBROUTINE SIGNCK (IFLD,ISGN)

C  THIS SUBROUTINE WILL TEST ANY WIND SPEED OR PSYCHROMETRIC WITH A SIGN OVER UNITS POSITION
C READ AS A1, AND THE HIGH ORDER POSITIONS READ AS AN I SPEC OF PROPER WIDTH.
C THE SIGN SHOULD ENTER THE PARAMETER LIST AS ISGN, THE REMAINING PORTION AS
C IFLD. UPON RETURN FROM THIS ROUTINE, THE VALUE OF THE FIELD WILL BE AN INTEGER
C WITH PROPER SIGN. IT WILL BE THE USER RESPONSIBILITY TO CONVERT THIS TO REAL
C FORM WITH PROPER DECIMAL ALIGNMENT. INVALID CONDITION CAUSES IFLD TO BE
C SET TO 9999.

      DIMENSION IP(10),MIN(10),NUM(10)
                                                   +
      DATA IP/'A','B','C','D','E','F','G','H','I','0'/
                                                    -
      DATA MIN/'J','K','L','M','N','O','P','Q','R','0'/
      DATA NUM/1,2,3,4,5,6,7,8,9,0/,IAST/'*'/

      IF (ISGN.EQ.IAST) GO TO 16
      DO 14 K=1,10
      IF (ISGN.EQ.IP(K)) GO TO 20
      IF (ISGN.EQ.MIN(K)) GO TO 22
 14   CONTINUE
 16   IFLD= 9999
      RETURN
 20   IFLD= IFLD*10 + NUM(K)
      RETURN
 22   IFLD= -(IFLD*10 + NUM(K))
      RETURN
      END
```

TAPE DECKS WITHIN TDF-14

TAPE DECK	NAME OF CARD DECK
1400	USWB Form 1130-Aero Hourly Surface Observations
1410	USAF Form 94-A Hourly Surface Observations
1411	Hourly Ceiling-Visibility Observations (Card 1)
1412	Canadian Hourly Surface Observations (Type 141)
1420	WBAN Hourly Surface Observations, 1945-1948
1422	Canadian Hourly Surface Observations (Type 142)
1440	WBAN Hourly Surface Observations, 1945-
1441	Hourly Ceiling-Visibility Observations (Card 2)
1442	Canadian Hourly Surface Observations (Type 144)
1443	Canadian Hourly Surface Observations, 1950-
1445	Metar Observations
1480	Turkish Hourly Observations
1481	British Hourly Observations
1482	Azores Hourly Observations
1483	Korean Hourly Observations (ROK)
1484	Taichung Hourly Observations
1485	German Hourly Observations (GZMO)
1486	Chinese & Formosan Hourly Observations

	TAPE DECK	STN NUMB	YR	MO	DY	HR	CEIL	VIS	WIND		DRY BLB	WET BLB	DEW PT	REL HUM	S.L. PRESS	STA PRES	SKY COND
									DR	SPD							
	14XX	XXXXX	XX	XX	XX	XX	iXXX	iXXX	XX	XXX	XXX	XXX	XXX	iXXX	XXXXX	XXXX	iXXXX
FIELD NUMBER	001	002	003	004	005	101	102	103	104	105	106	107	108	109	110	111	112

	TOT	OPQ	CLOUDS															WEATHER													WEATHER										
			LAYER 1			LAYER 2				LAYER 3				LAYER 4																										
			AMT	TYP	HGT	AMT	TYP	HGT	SUM	AMT	TYP	HGT	SUM	AMT	TYP	HGT	TDR	LP	QP	FP	RC	ZP	OV	BS	WD DR	BLK	RM	HR	CEIL	THD	LP	QP	FP	RC	ZP	OV	BS	WD DR	BLK	RM
	X	X	X	X	XXX	X	X	XXX	X	X	X	XXX	X	X	X	XXX	X	X	X	X	X	X	X	X	X X	ΔΔΔ	ǂ	XX	iXXX	X	X	X	X	X	X	X	X	XX	ΔΔΔ	ǂ
FIELD NUMBER	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	201	202	629	630	631	632	633	634	635	636	637	638	639

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT
001	001 004	TAPE DECK NUMBER
002	005 - 009	STATION NUMBER
003	010 011	YEAR
004	012 - 013	MONTH
005	014 - 015	DAY
101	016 - 017	HOUR
102	018 021	CEILING HEIGHT AND INDICATOR
103	022 - 025	HORIZONTAL VISIBILITY AND INDICATOR
104	026 - 027	WIND DIRECTION - 16 POINTS
105	028 030	WIND SPEED
106	031 - 033	DRY BULB (AIR) TEMPERATURE
107	034 - 036	WET BULB TEMPERATURE
108	037 - 039	DEW POINT TEMPERATURE
109	040 - 043	RELATIVE HUMIDITY AND INDICATOR
110	044 - 048	SEA LEVEL PRESSURE
111	049 - 052	STATION PRESSURE
112	053 - 057	SKY CONDITION AND INDICATOR
113	058	TOTAL SKY COVER
114	059	TOTAL OPAQUE SKY COVER
115	060	AMOUNT OF LOWEST CLOUD LAYER
116	061	TYPE OF LOWEST CLOUD OR OBSCURING PHENOMENA
117	062 - 064	HEIGHT OF BASE OF LOWEST CLOUD LAYER OR OBSCURING PHENOMENA
118	065	AMOUNT OF SECOND CLOUD LAYER
119	066	TYPE OF CLOUD - SECOND LAYER
120	067 069	HEIGHT OF BASE OF SECOND CLOUD LAYER
121	070	SUMMATION AMOUNT OF FIRST TWO CLOUD LAYERS
122	071	AMOUNT OF THIRD CLOUD LAYER
123	072	TYPE OF CLOUD THIRD LAYER
124	073 075	HEIGHT OF BASE OF THIRD CLOUD LAYER
125	076	SUMMATION AMOUNT OF FIRST THREE CLOUD LAYERS
126	077	AMOUNT OF FOURTH CLOUD LAYER
127	078	TYPE OF CLOUD - FOURTH LAYER
128	079 081	HEIGHT OF BASE OF FOURTH CLOUD LAYER
129	082	OCCURRENCE OF THUNDERSTORM, TORNADO OR SQUALL
130	083	OCCURRENCE OF RAIN, RAIN SHOWERS OR FREEZING RAIN
131	084	OCCURRENCE OF RAIN SQUALLS, DRIZZLE OR FREEZING DRIZZLE
132	085	OCCURRENCE OF SNOW, SNOW PELLETS OR ICE CRYSTALS
133	086	OCCURRENCE OF SNOW SHOWERS, SNOW SQUALLS OR SNOW GRAINS
134	087	OCCURRENCE OF SLEET, SLEET SHOWERS OR HAIL
135	088	OCCURRENCE OF FOG, BLOWING DUST, OR BLOWING SAND

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	
136	089	OCCURRENCE OF SMOKE, HAZE, SMOKE AND HAZE, DUST, BLOWING SNOW, BLOWING SPRAY	
137	090 - 091	WIND DIRECTION - 36 POINTS	
138	092 094	BLANK	
139	095	RECORD MARK	
201 - 239	096 175	SECOND OBSERVATION)	THESE OBSERVATIONS FOLLOW THE SAME FORMAT AS FIELDS 101-139 (TAPE POSITIONS 016-095).
301 339	176 - 255	THIRD OBSERVATION)	
401 439	256 - 335	FOURTH OBSERVATION)	
501 539	336 - 415	FIFTH OBSERVATION)	
601 639	416 - 495	SIXTH OBSERVATION)	

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
001	001 - 004	TAPE DECK NUMBER	1400 - 1499	Used to distinguish different data sources. See current list at beginning of manual.
002	005 009	STATION NUMBER	01001 - 98999	Unique number used to identify each station. Usually a WBAN number but occassionally a WMO number.
003	010 011	YEAR	00 - 99	Year of observation. 00-99 = 1900-1999
004	012 - 013	MONTH	01 - 12	Month of observation. 01-12 = Jan. - Dec.
005	014 - 015	DAY	01 31	Day of month.
101	016 017	HOUR	00 23	Hour of observation in local standard time. 00-23 = 0000-2300 LST
102i	018	CEILING HEIGHT INDICATOR	1,2,3,- &,Δ,A	These codes indicate various schemes used to convert ceiling heights to hundreds of feet or to indicate special conditions of little or no meaning to the general user.
102	019 - 021	CEILING HEIGHT	000 - 800 888, 999 ΔΔΔ, ΔΔ*	Ceiling in hundreds of feet. Ceiling is defined as sky cover of .6 or greater. 000-800 = 00000-80,000 feet 888 = Ceiling of cirroform clouds at unknown height. Used for the period Sep. 1956-March 1970. 999 = Unlimited ceiling ΔΔΔ = Unknown ΔΔ* = Original value invalid
103i	022	VISIBILITY INDICATOR	0 - 5 M, Δ	These codes indicate various schemes used to convert visibilities into statute miles and have little or no meaning to the general user.

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
103	023 025	HORIZONTAL VISIBILITY	000-990 999 (Not all values used) ΔΔΔ ΔΔ*	Prevailing horizontal visibility (usually at an elevation of 6 feet above the ground) in statute miles. 000 = Zero visibility 001 = 1/16 Statute miles 002 = 1/8 " 003 = 3/16 " 004 = 1/4 " 005 = 5/16 " 006 = 3/8 " 007 = 1/2 " 008 = 5/8 " 009 = 3/4-7/8 " 010 = 1 " 012 = 1 1/8 " 014 = 1 1/4 " 016 = 1 3/8 " 017 = 1 1/2 " 018 = 1 5/8 " 019 = 1 3/4 " 020 = 2 " 024 = 2 1/4 " 027 = 2 1/2 " 030-150 = 3-15 miles in increments of one mile 200-950 = 20-95 miles in increments of five miles 990 = 100 miles or greater 999 = Unlimited ΔΔΔ = Unknown ΔΔ* = Original value invalid
104	026 027	WIND DIRECTION 16 POINTS	00-88 ΔΔ, Δ*	Direction from which the wind is blowing in special 16 point WBAN code. 11 = North 349°-011° 12 = North-Northeast 012°-033° 22 = Northeast 034°-056° 32 = East-Northeast 057°-078° 33 = East 079°-101° 34 = East-Southeast 102°-123° 44 = Southeast 124°-146° 54 = South-Southeast 147°-168° 55 = South 169°-191° 56 = South-Southwest 192°-213° 66 = Southwest 214°-236° 76 = West-Southwest 237°-258° 77 = West 259°-281° 78 = West-Northwest 282°-303° 88 = Northwest 304°-326° 18 = North-Northwest 327°-348° 00 = Calm ΔΔ = Unknown Δ* = Original value invalid Note: Beginning Jan 1, 1964 wind directions were observed and coded to tens of degrees (see field 137). These values were converted to the 16 point code.

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
105	028 - 030	WIND SPEED	+ + 000 199 ΔΔΔ, ΔΔ*	Wind speed in whole knots. ΔΔΔ = Unknown ΔΔ* = Original value invalid Note: When this field is numeric it is <u>always</u> signed positive (12 over punch).
106 107 108	031 033 034 036 037 039	DRY BULB (AIR) TEMPERATURE WET BULB TEMPERATURE DEW POINT TEMPERATURE	$00\bar{1}$ $13\bar{0}$ $00\overset{+}{0}$ $14\overset{+}{0}$ ΔΔΔ ΔΔ*	Specified temperature in whole degrees fahrenheit. $00\bar{1}$ - $13\bar{0}$ = -1° -130°F $00\overset{+}{0}$ - $14\overset{+}{0}$ = 0° - +140°F ΔΔΔ = Unknown ΔΔ* = Original value invalid Note: When these fields are numeric they are always signed to indicate negative (11 overpunch) or positive (12 overpunch) temperatures
1091	040	RELATIVE HUMIDITY INDICATOR	&, Δ	& = Used to denote that dew point temperatures and relative humidities were originally coded with respect to ice when temperature was below 32°F but were recomputed with respect to water. Δ = No special conversions made.
109	041 043	RELATIVE HUMIDITY	001 100 ΔΔΔ, ΔΔ*	Relative humidity in whole percent. ΔΔΔ = Unknown ΔΔ* = Original value invalid.
110	044 - 048	SEA LEVEL PRESSURE	09000 - 10999 ΔΔΔΔΔ, ΔΔΔΔ*	Pressure, reduced to sea level, in millibars and tenths. 09000-10999 = 900.0 - 1099.9 mb ΔΔΔΔΔ = Unknown ΔΔΔΔ* = Original value invalid.
111	049 052	STATION PRESSURE	1900 3999 ΔΔΔΔ, ΔΔΔ*	Pressure at station level in inches and hundredths of Hg. 1900-3999 = 19.00 - 39.99 in Hg. ΔΔΔΔ = Unknown ΔΔΔ* = Original value invalid.

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
1121	053	SKY CONDITION INDICATOR	-, Δ	Indicator of method of recording sky condition or other phenomena. = Sky condition U.S. stations prior to June 1951. Δ = Sky conditions - U.S. stations June 1951 and later. Note: Some other decks have various configurations in this position denoting deviation from standard coding. Detailed information will be supplied when applicable.
112	054 057	SKY CONDITION		A descriptive symbolic coding of the state of the sky, referring in general to the amount of the celestial dome covered by clouds or obscuring phenomena. There was a major change in the method of recording this field in Jume 1951. When used to describe the amount of sky cover alphanumeric characters in this field have the following meaning: 0 = Clear or less than .1 cover 1 = Thin scattered clouds .1 .5 2 = Scattered clouds .1 .5 3 = Dark scattered clouds .1 .5 4 = Thin broken clouds .6 .9 5 = Broken clouds .6 .9 6 = Dark broken clouds .6 .9 7 = Thin overcast clouds 1.0 8 = Overcast clouds 1.0 9 = Dark overcast clouds 1.0 - = Obscuration Δ = Partial obscuration PRIOR TO JUNE 1951 During this period when scattered clouds were reported the two middle figures of the field represent the height, in hundreds of feet, of the lowest layer of scattered clouds. During this period only two layers were recorded in this field. The first digit always represents the higher layer and the last digit the lowest layer. The codes on page 7 describe the Sky Condition configurations that appear on tape prior to June 1951. Tape configurations for the period July 1951 onward are explained on page 8.

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TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
112	054 057	SKY CONDITION	0--- =	Obscuration occurring alone
			0--0 =	Clear or less than .1 cover
			0--Δ =	Thin obscuration reported alone
			0--4 to 0--9 =	One layer of broken or overcast clouds reported
			4--- to 9--- =	Obscuration with higher layer of broken or overcast clouds
			4--Δ to 9--Δ =	Thin obscuration with higher layer of broken or overcast clouds
			Δ--4 to Δ--9 =	Layer of broken or overcast clouds with thin obscuration above
			4--4 to 9--9 =	Two layers of broken or overcast clouds
			---- =	Two layers of obscuration phenomena
			---Δ =	Thin obscuration with obscuration above
			Δ--- =	Obscuration with thin obscuration above
			Δ--Δ =	Thin obscuration with thin obscuration above
			---4 to ---9 =	Layer of broken or overcast clouds with obscuration above
			0001 to 0993 =	Layer of scattered clouds
			1001 to 9993 =	Layer of scattered clouds with scattered, broken or overcast layer above
			-001 to -993 =	Layer of scattered clouds with obscuration above
			Δ001 to Δ993 =	Layer of scattered clouds with thin obscuration above
			**** =	Original value invalid
			ΔΔΔΔ =	Unknown
				For the two middle digits:
			00 - 98 =	Height of the lowest scattered layer in hundreds of feet
			99 =	10,000 feet or greater
			-- =	No low scattered clouds
			ΔΔ =	Unknown
			Δ, Δ, ** =	Original value invalid

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
112	054 057	SKY CONDITION	0000 - 9999 **** ΔΔΔΔ	Beginning June 1951 sky condition was reported and coded by layer in ascending order. This allows four layers to be described because heights of scattered clouds are no longer entered. Individual sky condition characters have the same meaning (0-9, Δ, -) as those described on page 6. If less than four layers are present the remaining positions are coded 0. Example: 2580 = Three layers of clouds lower scattered, broken layer and higher overcast ΔΔΔΔ = Unknown **** = Original value invalid
113	058	TOTAL SKY COVER	0 9 -, Δ	Amount of the celestial dome covered by clouds or obscuring phenomena. Opaque means clouds or obscuration through which the sky or higher cloud layers cannot be seen. 0 = Clear or less than .1 1-5 = .1 to .5 covered (scattered) 6-9 = .6 to .9 covered (broken) = > .9 covered (overcast) Δ = Unknown Note: When cloud amount for individual layers is less than one tenth, the height field may appear as the actual height of the fragment or as an invalid (ΔΔ*) configuration.
114	059	TOTAL OPAQUE SKY COVER		
115	060	AMOUNT OF LOWEST CLOUD LAYER		
118	065	AMOUNT OF SECOND CLOUD LAYER		
122	071	AMOUNT OF THIRD CLOUD LAYER		
126	077	AMOUNT OF FOURTH CLOUD LAYER		
116	061	TYPE OF LOWEST CLOUD OR OBSCURING PHENOMENA	0-9, - K,M,N,O P,R,Δ	Generic cloud type or obscuring phenomena. 0 = None 1 = Fog 2 = Stratus 3 = Stratocumulus 4 = Cumulus 5 = Cumulonimbus 6 = Altostratus 7 = Altocumulus 8 = Cirrus 9 = Cirrostratus K = Stratus Fractus M = Cumulus Fractus N = Cumulonimbus Mamma O = Nimbostratus P = Altocumulus Castellanus R = Cirrocumulus = Obscuring phenomena other than fog Δ = Unknown
119	066	TYPE OF CLOUD-SECOND LAYER		
123	072	TYPE OF CLOUD-THIRD LAYER		
127	078	TYPE OF CLOUD-FOURTH LAYER		

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
117	062 - 064	HEIGHT OF BASE OF LOWEST CLOUD LAYER OR OBSCURING PHENOMENA	000 - 800 --- ΔΔΔ ΔΔ* 888	Height of base of clouds or obscuring phenomena in hundreds of feet. 000-800 = 0 - 80,000 feet 888 = Cirroform clouds of unknown height --- = Partial obscuration when field 116 coded - or 1. Otherwise indicates none or no clouds for which height could be reported. ΔΔΔ = Unknown ΔΔ* Original value invalid
120	067 069	HEIGHT OF BASE OF SECOND CLOUD LAYER		
124	073 - 075	HEIGHT OF BASE OF THIRD CLOUD LAYER		
128	079 - 081	HEIGHT OF BASE OF FOURTH CLOUD LAYER		
121	070	SUMMATION AMOUNT OF FIRST TWO CLOUD LAYERS	0 9 -, Δ	Total amount of sky covered by the indicated layers. 0 = Clear or less than .1 1-9 = .1 to .9 covered = > .9 covered Δ = Unknown
125	076	SUMMATION AMOUNT OF FIRST THREE CLOUD LAYERS		
129	082	OCCURRENCE OF THUNDERSTORM, TORNADO OR SQUALL	0 - 6 Δ *	0 = None 1 = Thunderstorm - lightning and thunder. Wind gusts less than 50 knots, and hail, if any, less than 3/4 inch diameter. 2 = Heavy or severe thunderstorm - frequent intense lightning and thunder. Wind gusts 50 knots or greater and hail, if any, 3/4 inch or greater diameter. 3 = Report of tornado or waterspout. 4 = Light squall (through 5/51 only) 5 = Moderate squall 6 Heavy squall (through 5/51 only) Note: Beginning June 1951 only moderate squall is recorded Squall is sudden increase of wind speed by at least 16 knots, reaching 22 knots or more and lasting for at least one minute. Δ = Unknown * = Original value invalid
130	083	OCCURRENCE OF RAIN, RAIN SHOWERS OR FREEZING RAIN	0 9 Δ *	0 = None 1 = Light rain 2 = Moderate rain 3 = Heavy rain 4 = Light rain showers 5 = Moderate rain showers 6 = Heavy rain showers 7 = Light freezing rain 8 = Moderate freezing rain 9 = Heavy freezing rain Δ = Unknown * = original value invalid

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
130	083	OCCURRENCE OF RAIN, RAIN SHOWERS OR FREEZING RAIN		Light = Trace (< .005in.) to .10 inches per hour Moderate = .11 to .30 inches per hour Heavy = > .30 inches per hour
131	084	OCCURRENCE OF RAIN SQUALLS, DRIZZLE OR FREEZING DRIZZLE	0-9 Δ *	0 = None 1 = Light rain squalls 2 = Moderate rain squalls 3 = Heavy rain squalls See note under field 129. Beginning Jan 1949 squalls were reported separately and these figures should not appear thereafter. 4 = Light drizzle 5 = Moderate drizzle 6 = Heavy drizzle 7 = Light freezing drizzle 8 = Moderate freezing drizzle 9 = Heavy freezing drizzle Δ = Unknown * = Original value invalid When drizzle or freezing drizzle occurs with other weather phenomena: Light = Trace (< .005 in) to .01 inches per hour Moderate = > .01 to .02 inches per hour Heavy = > .02 inches per hour When drizzle or freezing drizzle occurs alone: Light = Visibility 5/8 mile or greater Moderate = Visibility 5/16 1/2 mile Heavy = Visibility 1/4 mile or less
132	085	OCCURRENCE OF SNOW, SNOW PELLETS OR ICE CRYSTALS	0-9 Δ *	0 = None 1 Light snow 2 = Moderate snow 3 = Heavy snow 4 = Light snow pellets 5 = Moderate snow pellets 6 = Heavy snow pellets 7 = Light ice crystals 8 = Moderate ice crystals 9 = Heavy ice crystals Δ = Unknown * = Original value invalid Beginning April 1963 any occurrence of ice crystals is recorded as an 8. Prior to this date intensities were reported.

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
133	086	OCCURRENCE OF SNOW SHOWERS, SNOW SQUALLS OR SNOW GRAINS	0-9 Δ *	0 = None 1 = Light snow showers 2 = Moderate snow showers 3 = Heavy snow showers 4 = Light snow squall 5 = Moderate snow squall 6 = Heavy snow squall Beginning Jan 1949 squalls were reported separately and these figures should not appear thereafter. 7 Light snow grains 8 Moderate snow grains 9 Heavy snow grains Δ = Unknown * = Original value invalid
134	087	OCCURRENCE OF SLEET, SLEET SHOWERS OR HAIL	0-9 Δ *	0 = None 1 = Light sleet or sleet showers (ice pellets) 2 = Moderate sleet or sleet showers (ice pellets) 3 = Heavy sleet or sleet showers (ice pellets) 4 = Light hail 5 = Moderate hail 6 = Heavy hail 7 = Light small hail 8 = Moderate small hail 9 = Heavy small hail Δ = Unknown * = Original value invalid Prior to April 1970 ice pellets were coded as sleet Beginning April 1970 sleet and small hail were redefined as ice pellets and are coded as a 1, 2 or 3 in this position. Beginning Sep 1956 intensities of hail were no longer reported and all occurrences were recorded as a 5.
135	088	OCCURRENCE OF FOG, BLOWING DUST OR BLOWING SAND	0-5 Δ *	0 = None 1 = Fog 2 = Ice fog 3 = Ground fog 4 = Blowing dust 5 = Blowing sand Δ = Unknown * = Original value invalid These values recorded only when visibility less than 7 miles.

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
136	089	OCCURRENCE OF SMOKE, HAZE SMOKE AND HAZE, DUST, BLOWING SNOW, BLOWING SPRAY	0 - 6 Δ *	0 = None 1 = Smoke 2 = Haze 3 = Smoke and haze 4 = Dust 5 = Blowing snow 6 = Blowing spray Δ = Unknown * = Original value invalid These values recorded only when visibility less than 7 miles.
137	090 091	WIND DIRECTION 36 POINTS	00 - 36 ΔΔ	Direction from which the wind is blowing, in tens of degrees. Stations began using this system on 01 Jan 1964. To achieve continuity with earlier records these values are converted to the 16 point scale and placed in field 104. 00 = Calm ΔΔ = Unknown CONVERSION CODE tens of degrees — 16 pt. 35-01 = 11 02-03 = 12 04-05 = 22 06-07 = 32 08-10 = 33 11-12 = 34 13-14 = 44 15-16 = 54 17-19 = 55 20-21 = 56 22-23 = 66 24-25 = 76 26-28 = 77 29-30 = 78 31-32 = 88 33-34 = 18
138	092 094	BLANK	ΔΔΔ	
139	095	RECORD MARK	‡, Δ	This position may contain a blank or record mark. Record mark = 0,2,8, card punch

APPENDIX B

DESCRIPTION OF THE TD-3280 FORMAT

This description is reproduced from documentation provided by the National Climatic Data Center (NCDC).

SURFACE AIRWAYS
HOURLY
TD-3280

Prepared by
National Climatic Data Center
Federal Building
Asheville, North Carolina

March 1986

This document was prepared by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite Data and Information Service, National Climatic Data Center, Asheville, North Carolina.

This document is designed to provide general information on the content, origin, format, integrity and the availability of this data file.

Errors found in this document should be brought to the attention of the Data Base Administrator, NCDC.

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INTRODUCTION

HISTORY AND DATA SOURCE

Weather observations, in support of aircraft operations, have been taken since the earliest days of aviation. Rapid growth of the industry during the 1940's made it evident that some mechanical means of summarizing the data must be developed. Adequate statistical information was needed in order to select appropriate airport sites. Military stations provided most of the early observations for archiving from 1941 through June 1948. Major changes in observing and recording practices during 1948 represent the primary basis of digital information for all the principle reporting stations residing in this data set.

A major airport study was conducted by the FAA in the early 1960's. To facilitate handling large masses of data necessary for this effort, the Weather Bureau, Air Force, Navy, and the FAA devised common tape formats called Tape Data Family-14 (TDF-14).

These principle reporting stations are usually fully instrumented and therefore record a complete range of meteorological parameters. Beginning January 1, 1965, for most National Weather Service stations and March 1, 1972, for most Naval Weather Service stations the digitizing of the Airways Observations was reduced from 24 obs/day to 8 obs/day. These observations, at 3-hourly intervals, coincide with the normal GMT schedule of 00Z, 03Z, 06Z etc. This means, of course, that the observations, keyed in Local Standard Time (LST) differ according to time zone. Beginning with August 1981 data, 24 obs/day were again digitized for most active stations.

Through the years approximately 1,380 principle stations have recorded observations in this program. In 1984 there were just under 300 active stations being processed for inclusion in the digital data base.

Surface Airways Hourly data were initially transferred to punched cards beginning in the late 1940's to facilitate summarizing climatological data. The late 1960's saw the transfer of punched cards to magnetic tape. These TDF-14 formats represented the digital file through 1983. During 1983 a new element file structure was developed and processing of airways hourly data was revised. This new processing system became operational Jan 1984. Data are currently processed utilizing the new element file structure. The conversion of historical data included gross data checks on the TD-1440 data file. No edited values were derived during the historical conversion but undecodable data were flagged.

Areal coverage includes the U.S., Caribbean Islands, Pacific Islands, and other overseas stations of the National Weather Service, U.S. Navy, and U.S. Air Force.

The digital file contains Record Type, Station Identification, Units of Measurement Indicators, Source Codes, Data Quality Flags, and Element Types:

CLOUD DATA: Amount, ceiling height, summation of cloud layer amounts, type of cloud, and cloud height.

VISIBILITY DATA: Horizontal.

WIND DATA: Speed and direction.

TEMPERATURE DATA: Dry Bulb, Wet Bulb and Dew Point.

SKY COVER DATA: Total Sky, total opaque, and the condition of the sky.

RELATIVE HUMIDITY DATA: Relative humidity.

PRESSURE DATA: Station pressure, sea level pressure, and altimeter.

PRESENT WEATHER DATA: The occurrences of thunderstorms, tornados, precipitation (Rain, squalls, snow, freezing rain/drizzle, etc.!), fog, blowing dust, smoke, hail, etc.

Air Force data are available only to the early 1970's. Navy data are available through current period of record. At the request of the Navy Office, DATSAV (Global Data Save from U.S. Air Force) telecommunicated data have been used as the primary source of Navy surface observations since the beginning of the 1981 data year. These data include 48 Airways stations and 11 Metar stations. See special notes on DATSAV Source Data.

Due to many special projects performed at NCDC and other Centers, 24 hourly observations may have been keyed for varying periods of time for selected stations. Inventories must be consulted to determine the exact period of record for each station.

Beginning with the data for January 1984 the Surface Airways Hourly observations were processed through a completely revised system. Relying heavily on new computer editing procedures, data are subjected to internal consistency checks, compared against climatological limits, checked serially, and evaluated against surrounding stations.

Quality control "flags" are appended to each element to show how they fared during the edit procedures and to indicate what, if any, action was taken. The files then, consist of observed values and, as necessary, an edited value. Flag 2 must be checked at all times to determine if an edited value is present.

Source codes were added to this file indicating (1) the primary source of the original record the element was taken from, and (2) the back-up source of the original record the element was taken from. The sources include: (1) Original manuscript; (2) SRRS - Service Record Retention System; (3) AFOS - Automated Field Operations and Services; (4) DATSAV - Global Data Save from U.S. Air Force; (5) NMC - National Meteorological Center; (6) Foreign Keyed; (7) MAPSO - Microcomputer Aided Paperless Surface Observations; (8) SRRS Manuscript; (9) Other/unknown. Source codes for pre-1984 data were reported as "original manuscript" only for all stations.

PURPOSE OF THE MANUAL

This manual was designed so that reference to other reference material should be unnecessary. However, additional information may be obtained by writing or calling:

National Climatic Data Center E/CC42
ATTN: USER Services Branch
Federal Building
Asheville, North Carolina 28801-2696

Telephone inquiries may be directed to:

Commercial 704 259-0682
FTS 672-0682

Read carefully "Manual and Tape Notations," and "Code Definitions and Remarks" sections.

SPECIAL NOTES

QUALITY

Quality of the Surface Airways Hourly data is considered quite good. All observations have been subjected to some form of quality control. During the earlier years this was almost entirely a manual effort. As more sophisticated techniques of processing were introduced the quality control procedures were also improved. Today, the quality control effort is a blend of several computer programs and manual review. Observations are checked for conformance to established observing and coding practices, for internal consistency, for serial, or time oriented consistency, and against defined limits for various meteorological parameters.

TIME

The time entered is that of the record observations, taken within 10 minutes prior to the hour (e.g. 1355 keyed 1400). Prior to Jun 57, observations were taken within 10 minutes prior to the half hour; minutes are disregarded in punching (e.g. 0222 punched 02; 1428, 14). All "War Times" and "Standard Meridian Times" were converted to Local Standard Time before punching. For Air Force stations in the United States, the times were punched in accordance with the established time zones. Time entries for Air Force stations outside the United States were edited prior to punching and where necessary converted to the Local Standard Time of the nearest meridian evenly divisible by 15 degrees.

CEILING HEIGHT

Ceiling was recorded in hundreds of feet above the ground to nearest 100 feet up to 5,000 feet, to nearest 500 feet from 5,000 to 10,000 feet, to nearest 1,000 feet above that. Before 1949, Air Force stations recorded ceilings up to and including 20,000 feet, above which point the ceiling was classified as unlimited; Weather Bureau and Navy stations recorded ceiling only up to and including 9,500 feet, above which point the ceiling was considered unlimited. Beginning in 1949, ceiling was redefined to include the vertical visibility into obscuring phenomena not classified as thin, that, in summation with all lower layers, cover 6/10 or more of the sky. Also at that time all limits to height of ceiling were removed, so that unlimited ceiling became simply less than 6/10 sky cover, not including thin obscuration. Then, beginning 1 Jun 51, ceiling heights were no longer established solely on the basis of coverage. The ascribing of ceilings to thin broken or overcast layers was eliminated. A layer became classified as "thin" if the ratio of transparency to total coverage at that level is 1/2 or more.

SKY CONDITIONS AND CLOUD LAYERS

Many different coding practices on sky conditions and cloud layers occurred throughout the years. The new element format conversion has taken all the different practices into account and has converted all the procedures into a common format. If you are interested in all the changes in coding please refer to WBAN Sfc. Observations Card Deck 144 documentation.

DATSAV SOURCE DATA

Because of differences in Airways and Metar codes and the limited information available on the telecommunicated source compared with manuscript forms, DATSAV derived data contains less complete information than otherwise available. Element conversions unique to Metar stations are as follows:

1. Visibility - Metar codes are converted to Airways codes for the NCDC data base. This conversion will cause 6 mile visibilities from Metar stations to be recorded as 7 mile visibilities. METAR code permits the transmission of a visibility of 9000 meters without obstruction while Airways requires a visibility of at least 7 miles without obstruction. The 9000 meters is converted to 6 miles in the program and flagged because it is less than the 7 mile requirement. These 6 mile visibilities are changed to 7 miles so that these data will conform with the rest of the data in the data base. When 'CAVOK' is found in the transmitted data 7 miles with no obstructions is entered in the data base.

2. Weather - Only the highest numbered weather code is transmitted. This causes all accompanying weather to be lost from the data base. For example, the manuscript form might indicate moderate or heavy rain and snow showers mixed (code 84) with fog (code 45). Only code 84 will be transmitted and fog will be eliminated.

3. Clouds - Total sky and sky condition are not reported on telecommunication data. Layer amounts are reported in eights and converted to tenths. This conversion results in the loss of any entries of 2 or 7 tenths.

4. Ceiling - When 'CAVOK' is found in the transmitted data an unlimited ceiling is entered in the data base.

5. Temperature and Dew Point Temperature - These temperatures are given in Celsius on the forms, Kelvin on DATSAV, Celsius on intermediate output, and are stored in Fahrenheit in whole degrees in the data base. Rounding during conversions can cause a loss of accuracy of one degree.

FILE STRUCTURE

The element file structure is designed to allow maximum flexibility in requesting data. Only those elements or groups of elements of particular interest need be ordered. End user input programs can be modified easily to operate on different sets of elements.

These variable length records contain data as originally reported through DEC 1983. After that the records contain both the original values and the edited values.

LOGICAL REFERENCE TO ELEMENT TYPES

(Note: Description of Elements begin on page 13 under 'Code Definition and Remarks')

Logically grouped Element types are as follows:

1. Clouds - CLCx, CLIx, and CLHT.
2. Present Weather - PWTH.
3. Pressure - - PRES, SLVP, and ALTP.
4. Relative Humidity - RHUM.
5. Sky Cover - CC51, C2C3, and TSKC.
6. Temperature - DPTP, TMPD, and TMPW.
7. Visibility - HZVS.
8. Wind - WD16, and WIND.

TAPE FORMAT

MANUAL AND TAPE NOTATIONS

1. FILE (NCDC Variable Length Storage Structure)

A. Physical Characteristics

Data in this file are retained in chronological order by station. Although library tapes are normally maintained as described below, different characteristics including fixed length records can be furnished on request. Additional charges may be accrued for special processing.

B. COBOL or FORTRAN Data Description

(1) Typical ANSI COBOL

```
FD   INDATA
     LABEL RECORDS ARE STANDARD
     RECORDING MODE D
     BLOCK CONTAINS 12000 CHARACTERS
     DATA RECORD IS DATA-RECORD.
01   DATA-RECORD.
     02 RECORD-TYPE        PIC X(3).
     02 STATION-ID         PIC X(8).
     02 ELEMENT-TYPE       PIC X(4).
     02 ELEMENT-UNITS      PIC XX.
     02 YEAR               PIC 9(4).
     02 MONTH              PIC 99.
     02 SOURCE-CODE-1      PIC X.
     02 SOURCE-CODE-2      PIC X.
     02 DAY                PIC 9(2).
     02 NUM-VALUES         PIC 9(3).
     02 DAILY-ENTRY
          OCCURS 1 to 100  TIMES DEPENDING ON NUM-VALUES.
        04 TIME-OF-VALUE   PIC 9(4).
        04 DATA-VALUE      PIC S9(5) SIGN LEADING SEPARATE.
        04 FLAG-1          PIC X.
        04 FLAG-2          PIC X.
```

(2) Typical FORTRAN 77

```
 DEFINE FILE 10 (ANSI, VB, 1230, 12000)
 CHARACTER*3 RECTYP
 CHARACTER*8 STNID
 CHARACTER*4 ELMTYP
 CHARACTER*2 EUNITS
 CHARACTER*4 IYEAR
 CHARACTER*2 IMON
 CHARACTER*3 NUM
 CHARACTER*2 IDAY
 CHARACTER*1 SCR1, SCR2, FLAG1, FLAG2
 DIMENSION ITIME(100), IVALUE(100), FLAG1(100), FLAG2(100)

 READ (10,20,END=999) RECTYP, STNID, ELMTYP, EUNITS, IYEAR,
+IMON, SRC1, SRC2, IDAY, NUM, (ITIME(J), IVALUE(J), FLAG1(J),
+FLAG2(J), J=1, NUM)

 20 FORMAT (A3, A8, A4, A2, I4, I2, A1, A1, I2, I3, 100 (I4, I6,
 2A1))
```

NOTE: If you do not have FORTRAN 77 you can read the character data described above into integer variables.

C. IBM JCL NOTES.

1. For ASCII Variable specify:

```
LRECL   = 1234
RECFM   = DB
OPTCODE = Q
```

2. For EBCDIC Variable specify:

```
LRECL = 1234
RECFM = VB
```

2. RECORD

A. Physical Characteristics

Each logical record contains one station's hourly data values for a specific meteorological element for a period of one day. The record consists of a control word, an identification portion, and a data portion. The control word is used by the computer operating system for record length determination. The identification portion identifies the record type, observing station, element type, element units, year/month, source codes, day and number of values. The data portion contains the meteorological observations for the hourly data values and flags. The data portion is repeated for as many hourly values as occur in a day.

NOTE: Present Weather Code (PWTH) is an exception. See Code Definitions and Remarks on 'PWTH'.

NCDC Library Tapes are structured as follows:

Record length : Variable with maximum of 1230 characters
Blocked : 12000 characters maximum
Media : ASCII 9 Track
Density : 6250 BPI
Parity : Odd
Label : ANSI Standard Labeled
File : 1 File per tape

B. FORMAT (VARIABLE RECORD)

1. The first ten tape fields, the ID PORTION of the record, describe the characteristics of the entire record. The DATA PORTION of the record contains information about each element value reported. This portion is repeated for as many hourly values as occur in a day.

Each logical record is of variable length with a maximum of 1230 characters. Each logical record contains a station's hourly data for a specific meteorological element over a one day interval. The form of a record is:

ID PORTION (30 characters) Fixed length

	REC TYP	STATION ID	ELEM TYPE	UNT	YEAR	MO	SRC 1	SRC 2	DAY	NO. VAL
	XXX	XXXXXXXX	XXXX	XX	XXXX	XX	X	X	XX	XXX
TAPE FIELD	001	002	003	004	005	006	007	008	009	010

DATA PORTION (12 Characters Number-Values Times)

	TIME HOUR	DATA ELEM		FL 1	FL 2	TIME HOUR	DATA ELEM	
		S	VALUE				S	VALUE
	XXXX	X	XXXXX	X	X	XXXX	X	XXXXX
TAPE FIELD	011	012	013	014	015	016	017	018

	DATA ELEM		FL 1	FL 2
	S	VALUE		
	X	XXXXX	X	X
TAPE FIELD	198	199	200	201

TAPE FIELD	TAPE RECORD POSITION	ELEMENT DESCRIPTION
001	001-003	RECORD TYPE
002	004-011	STATION I.D.
003	012-015	METEOROLOGICAL ELEMENT TYPE
004	016-017	MET. ELEMENT MEASUREMENT UNITS CODE
005	018-021	YEAR
006	022-023	MONTH
007	024	SOURCE CODE 1
008	025	SOURCE CODE 2
009	026-027	DAY OF MONTH
010	028-030	NUMBER OF DATA PORTION GROUPS THAT FOLLOW
011	031-034	TIME OF OBSERVATION (HOUR)
012	035	SIGN OF METEOROLOGICAL VALUE
013	036-040	VALUE OF METEOROLOGICAL ELEMENT
014	041	QUALITY CONTROL FLAG 1
015	042	QUALITY CONTROL FLAG 2
(016-020)	(043-054)	DATA GROUPS IN THE SAME FORM AS TAPE FIELDS
(021-025)	(055-066)	011-015. REPEATED AS MANY TIMES AS NEEDED
(026-030)	(067-078)	TO CONTAIN ONE DAY OF RECORD.
(196-201)	(1219-1230)	

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
001	1-3	Record-Type	The type of data stored in this record. Value is "HLY." Each record contains one day of hourly values.
002	4-11	Station-ID	Contains the WBAN Station Number. (Assigned by NCDC.) Range of values = 00000000-00099999. Five digit station numbers are always right justified zero filled.
003	12-15	Element-Type	The type of data element stored in this record. Range of values is listed below.

ALTP Altimeter setting. Range of values = 02700 to 03200. (Navy stations only beginning SEP 1984.)

CC51 The sky condition as recorded prior to June 1951. DATA-VALUE will appear as OXYYZ where:

X = Amount of higher layer
YY = Height of lowest scattered layer in 100rds of feet
Z = Amount of lowest layer

Note: This element is only recorded for data prior to June 1, 1951. Check Flags 1 and 2 for further definition of CC51. C-A-U-T-I-O-N must be taken when using this element.

Sky condition is a descriptive symbolic coding of the state of the sky, referring in general to the amount of the celestial dome covered by clouds or obscuring phenomena.

X and Z Code Amounts

0 = clear or less than .1 coverage
1 = thin scattered
2 = scattered
3 = dark scattered
4 = thin broken
5 = broken
6 = dark broken
7 = thin overcast
8 = overcast
9 = dark overcast
- = obscuration 10/10ths obscured
b̸ = (blank) partial obscuration

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
003			YY Code

00 to 95 = Height in hundreds of feet.
96 = Value unknown.
Manuscript entry was 'b̸b̸'.
97 = No low scattered clouds.
Manuscript entry was '__'.
98 = Invalid original value.
Manuscript entry was '**'.
99 = 10,000 feet or higher.

CLC"x" The sky condition and cloud coverage by layer where: The "x" in CLCx.

CLC1 = lowest cloud layer
CLC2 = 2nd cloud layer
CLC3 = 3rd cloud layer
CLC4 = 4th cloud layer
CLCN = N'th cloud layer if necessary

Cloud information pertaining to sky condition and cloud coverage are contained within one element per level. Check data Flags 1 and 2 for further definition.

The DATA-VALUE portion of the record will appear as: Example OXXYY constitutes the five character field where

XX = code for sky condition
YY = cloud coverage (tenths)

XX Code - Sky Condition

00 = clear or less than .1 coverage
01 = thin scattered .1 to .5 coverage
02 = scattered .1 to .5 coverage
03 = thin broken .6 to .9 coverage
04 = broken .6 to .9 coverage
05 = thin overcast 1.0 coverage
06 = overcast 1.0 coverage
07 = obscuration 1.0 coverage
08 = partial obscuration <1.0 coverage
09 = unknown

YY Code - Cloud Coverage

Cloud coverage is expressed in tenth's. Value of 9's indicate unknown values.

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
003			CLHT Ceiling height is defined as the height of the lowest sky cover layer that is more than 1/2 opaque. Heights are defined in hundreds of feet. The DATA-VALUE will appear as 00XXX. Range of value = 00000 to 00999. Unknown or missing value is 00999.
			CLT"x" The cloud type and height by layer where: The "x" in CLTx. CLT1 = lowest cloud layer or obscuring phenomena CLT2 = 2nd cloud layer CLT3 = 3rd cloud layer : CLTN = N'th cloud layer if necessary Cloud information pertaining to cloud type and cloud height are contained within one element per level. The DATA-VALUE portion of the record will appear as: example XXYYY constitutes the five character field where XX = Code for cloud type (or obstruction to vision code at lowest cloud layer) Code listed on following page. YYY = cloud height (hundreds of feet) 9's for any value = unknown Note: Cloud type/obscuring phenomena code on following page. Also check Flags 1 and 2 for further definition.

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
003			CLT"x" Generic cloud type or obscuring phenomena codes are:

CLOUD TYPE

00 = None
11 = Cumulus
12 = Towering Cumulus
13 = Stratus Fractus
14 = Stratus Cumulus Lenticular
15 = Stratus Cumulus
16 = Stratus
17 = Cumulus Fractus
18 = Cumulonimbus
19 = Cumulonimbus Mammatus
21 = Altostratus
22 = Nimbostratus
23 = Altocumulus
24 = Altocumulus Lenticular
28 = Altocumulus Castellanus
29 = Altocumulus Mammatus
32 = Cirrus
35 = Cirrocumulus Lenticular
37 = Cirrostratus
39 = Cirrocumulus

OBSCURING PHENOMENA
(Began Jan. 1984)

01 = Blowing spray
03 = Smoke and haze
04 = Smoke
05 = Haze
06 = Dust
07 = Blowing dust
30 = Blowing sand
36 = Blowing snow
44 = Ground fog
45 = Fog
48 = Ice fog
50 = Drizzle
60 = Rain
70 = Snow
76 = Ice crystals
98 = Obscuring phenomena other than fog (prior to 1984)

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
003			C2C3 The total amount of sky covered by the first two cloud layers and the first three cloud layers. DATA-VALUE will appear as 0XXYY where: XX = Summation of 1st two cloud layers (10ths) YY = Summation of 1st three cloud layers (10ths) Range = 00 to 99. 00 = Clear or < .1 01 = 0.1 02 = 0.2 03 = 0.3 04 = 0.4 05 = 0.5 06 = 0.6 07 = 0.7 08 = 0.8 09 = 0.9 10 = 1.0 99 = Unknown or missing NOTE: Check Flags 1 and 2 for further definition.
			DPTP Dew Point Temperature. The DATA-VALUE will appear as 00XXX. Range of value = 00000 to 00140. 00999 = unknown or missing. (Whole degrees F.)

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
003			HZVS The prevailing "Horizontal Visibility" (usually at an elevation of 6 feet above the ground). The DATA-VALUE will appear as XXXXX. Range of value = 00000 to 99999. 9's indicate unknown or missing values. (100th's of miles.) Code follows on next page.

HZVS CODE

00000 = Zero vsby
00006 = 1/16 mile
00012 = 1/8
00019 = 3/16
00025 = 1/4
00031 = 5/16
00038 = 3/8
00050 = 1/2
00062 = 5/8
00075 = 3/4
*00081 = 3/4 or 7/8
00087 = 7/8
00100 = 1 mile
00112 = 1 1/8
00125 = 1 1/4

00138 = 1 3/8
00150 = 1 1/2
00162 = 1 5/8
00175 = 1 3/4
00200 = 2 miles
00225 = 2 1/4
00250 = 2 1/2
00275 = 2 3/4
00300 = 3
00400 = 4
etc!
01000 = 10
10000 = 100
99999 = Missing Unknown or Unlimited (See Flag 1)

Note: Historical archived data prior to Jan. 1984 did not differentiate between 3/4 and 7/8 visibilities. This ambiguous TD-1440 Historic Data was converted to TD-3280 as '00081'.

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
			PRES The station pressure at station level in inches and thousandths of mercury generally. The DATA-VALUE will appear as XXXXX. Range of value = 19000 to 39990. 99999 = unknown or missing.

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
003	---		PWTH The present (or prevailing) weather occurring at the time of the observation. DATA-VALUE will appear as follows:

PRESENT WEATHER CODES

Present weather codes are two characters in length. The leftmost character indicates the general class of present weather while the rightmost character is a qualifier.

The two digit codes are stored into the five digits of the DATA-VALUE portion. ***If there is no occurrence of present weather the valid DATA-VALUE will always be 00000. Within the five digits used, the leftmost digit is always set to zero. The two-digit weather codes are entered left justified for the remaining four digits. Thus, if one type of weather occurs during an hour the code would appear as 0XX00, where XX is the appropriate code. If two types of weather occur for the same hour, the value field would appear as 0XXYY.

If more than two types occur for the same hour they will be stored into additional PWTH records as necessary.

Consider the following examples:

On day 11 Feb 1981 at 12 noon and 1300 hours no present weather occurred.

```
0054HLY00005264PWTHNA19810211100212000b̸
00000b̸11300b00000b̸1
```

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
003			On day 11 Feb 1981 at 12 noon light snow, light freezing rain, ice fog, and blowing snow all occur. The records will appear as:

```
0042HLY000005264PWTHNA19810211110011200
04026b̸1
0042HLY000052664PWTHNA19810211110011200
07184b̸1
```

Note: PWTH DATA-VALUE codes are described on pages 20 thru 25.

CODE FOR PWTH RANGE 00.

00 ********** No Occurrence
where:

00 = No present weather occurred

CODE FOR PWTH RANGE 10 TO 19.

1X ********** Thunderstorm, Tornado, Squall
where:

X = 0 thunderstorm - lightning and thunder. Wind gust < 50 knots - hail < .75 in.
= 1 heavy or severe thunderstorm - frequent intense lightning and thunder. Wind gust > 50 knots - hail > .75 in.
= 2 report of tornado or water spout
= 3 light squall (through May 1951 only)
= 4 moderate squall
Moderate squall is recorded. Squall is sudden increase of wind speed by at least 16 knots, reaching 22 knots or more and lasting for at least one minute.
= 5 heavy squall (through May 1951 only)
= 6 water spout (began Jan 1984)
= 7 funnel cloud (began Jan 1984)
= 8 tornado (began Jan 1984)
= 9 unknown

CODE FOR PWTH RANGE 20 TO 29

2X ********* Rain, Rain Showers, Freezing Rain

where:

X = 0 light Rain
= 1 moderate Rain
= 2 heavy Rain
= 3 light Rain showers
= 4 moderate Rain showers
= 5 heavy Rain showers
= 6 light freezing Rain
= 7 moderate freezing Rain
= 8 heavy freezing Rain
= 9 Unknown

Light = Trace (< .005 in.) to .10 inches per hour
Moderate = .11 to .30 inches per hour
Heavy = > .30 inches per hour

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
003			CODE FOR PWTH RANGE 30 TO 39 3X ********* Rain Squalls, Drizzle, Freezing Drizzle where: X = 0 light rain squalls = 1 moderate rain squalls = 2 heavy rain squalls (through 1948 only) = 3 light drizzle = 4 moderate drizzle = 5 heavy drizzle = 6 light freezing drizzle = 7 moderate freezing drizzle = 8 heavy freezing drizzle = 9 unknown When drizzle or freezing drizzle occurs with other weather phenomena: Light = Trace (< .005 in.) to .01 inches per hour Moderate = > .01 to .02 inches per hour Heavy = > .02 inches per hour When drizzle or freezing drizzle occurs alone: Light = Visibility 5/8 mile or greater Moderate = Visibility 5/16 - 1/2 mile Heavy = Visibility 1/4 mile or less

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
003			CODE FOR PWTH RANGE 40 TO 49

4X *********   Snow, Snow Pellets, Ice Crystals

where:

X = 0 light snow
= 1 moderate snow
= 2 heavy snow
= 3 light snow pellets
= 4 moderate snow pellets
= 5 heavy snow pellets
= 6 light ice crystals
= 7 moderate ice crystals
= 8 heavy ice crystals
= 9 unknown

Beginning April 1963 any occurrence of ice crystals is recorded as a 47. Prior to this date intensities were reported.

CODE FOR PWTH RANGE 50 TO 59

5X *********   Snow Showers, Snow Squalls, Snow Grains

where:

X = 0 light snow showers
= 1 moderate snow showers
= 2 heavy snow showers
= 3 light snow squall
= 4 moderate snow squall
= 5 heavy snow squall

Beginning Jan 1949 squalls were reported separately and these figures below should not appear thereafter.

= 6 light snow grains
= 7 moderate snow grains
= 8 heavy snow grains
= 9 unknown

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
003			CODE FOR PWTH RANGE 60 TO 69

6X ********* Sleet, Sleet Showers, Hail

where:

X = 0 light ice pellet showers
= 1 moderate ice pellet showers
= 2 heavy ice pellet showers
= 3 light hail
= 4 moderate hail
= 5 heavy hail
= 6 light small hail
= 7 moderate small hail
= 8 heavy small hail
= 9 unknown

Prior to April 1970 ice pellets were coded as sleet. Beginning April 1970 sleet and small hail were redefined as ice pellets and are coded as 60, 61, or 62. Beginning Sep 1956 intensities of hail were no longer reported and all occurrences were recorded as a 64.

CODE FOR PWTH RANGE 70 to 79

7X ********* Fog, Blowing Dust, Blowing Sand

where:

X = 0 fog
= 1 ice fog
= 2 ground fog
= 3 blowing dust
= 4 blowing sand
= 5 heavy fog
= 6 glaze (begin 1984)
= 7 heavy ice fog (begin 1984)
= 8 heavy ground fog (begin 1984)
= 9 unknown

These values recorded only when visibility less than 7 miles.

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
003			CODE FOR PWTH RANGE 80 TO 89 8X ********* Smoke, Haze, Smoke and Haze, Blowing Snow, Blowing Spray, Dust where: X = 0 smoke = 1 haze = 2 smoke and haze = 3 dust = 4 blowing snow = 5 blowing spray = 6 dust storm (begin 1984) = 9 unknown These values recorded only when visibility less than 7 miles.
			CODE FOR PWTH RANGE 90 TO 92 AND 99 9X ********* Ice Pellets where: X = 0 light ice pellets = 1 moderate ice pellets = 2 heavy ice pellets = 9 Unknown
			RHUM Relative Humidity expressed in whole percent. The DATA-VALUE will appear as 00XXX. Range of value = 00000 to 00100. 00999 indicates unknown or missing values.
			SLVP Pressure, reduced to sea level, expressed in millibars and tenths. The DATA-VALUE will appear as XXXXX. Range of value = 09000 to 10999. 99999 indicates unknown or missing values.

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS	
003			TMPD	Dry Bulb (Air) Temperature. The specified temperature in whole degrees Fahrenheit. The DATA-VALUE will appear as 00XXX. Range of value = 00000-00140. 00999 = unknown or missing.
			TMPW	Wet Bulb Temperature expressed in degrees Fahrenheit to tenths. The DATA-VALUE will appear as 0XXXX. Range of value 00000 to 01400. 00999 = unknown or missing.
			TSKC	Total sky cover and total opaque sky cover. Range of value 00 to 10 (tenths) and 99. The amount of the celestial dome covered by clouds or obscuring phenomena. Opaque means clouds or obscuration through which the sky or higher cloud layers cannot be seen. The DATA-VALUE will appear as 0XXYY where XX is the total sky cover and YY is the total opaque sky cover. 00 = clear or less than .1 coverage 01 = scattered clouds .1 coverage 02 = scattered clouds .2 coverage 03 = scattered clouds .3 coverage 04 = scattered clouds .4 coverage 05 = scattered clouds .5 coverage 06 = broken clouds .6 coverage 07 = broken clouds .7 coverage 08 = broken clouds .8 coverage 09 = broken clouds .9 coverage 10 = overcast 1.0 coverage 99 = unknown

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
003			WD16 Wind direction and speed to 16 point WBAN code. Direction is the direction from which the wind is blowing. Speed in knots.

WIND DIRECTION CODES
(through Dec. 1963 only)

16 Pt WBAN Code	Degrees
00 = Calm	Calm
11 = N	349-011
12 = NNE	012-033
22 = NE	034-056
32 = ENE	057-078
33 = E	079-101
34 = ESE	102-123
44 = SE	124-146
54 = SSE	147-168
55 = S	169-191
56 = SSW	192-213
66 = SW	214-236
76 = WSW	237-258
77 = W	259-281
78 = WNW	282-303
88 = NW	304-326
18 = NNW	327-348

Example of DATA-VALUE XXYYY for wind direction and speeds: 12037 Wind is from the NNE at 37 knots. 12 = Wind from NNE. 037 = Wind speed is 37 knots.

NOTE: Beginning 1 Jan 1964 wind directions were observed and coded to tens of degrees. WD16 code no longer reported.

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
003		WIND	Wind Direction and Speed. Direction is the direction from which the wind is blowing. Speed in knots. Range of value (direction) = 00 to 36 and 99. Range of value (speed) = 000 to 250. Example of DATA-VALUE XXYYY for wind direction and speeds: 02037 Wind is from 020 degrees at 37 knots. 02 = Wind 020 degrees. 037 = Wind speed is 37 knots. NOTE: WIND (10's of Degrees Code) element begins January 1964. Prior to 1964 winds observed in the WD16 (16 point code). WIND DIRECTION CODES (begin 1964) 10s of Degrees Code — Degrees 00 = Calm 01 = 010 02 = 020 " " " through " 36 = 360 99 = Unknown

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
004	16-17	ELEMENT-UNITS	The units and decimal position of the DATA-VALUE for this record. ELEMENT-UNITS TABLE DT Wind direction in tens of degrees F Whole degrees Fahrenheit HF Hundreds of feet HM Miles and hundredths IH Inches and hundredths of mercury IT Inches and thousandths of mercury KD Knots and direction in tens of degrees KS Knots and direction in 16 point WBAN Code MT Millibars and tenths NA No units applicable (non-dimensional) N1 No units applicable - element to tenths N2 No units applicable - element to hundredths P Whole percent TF Degrees Fahrenheit in tenths NOTE: Single digits are left justified blank filled.
005	18-21	YEAR	This is the year of the record. Range of value is 1900-current year processed.
006	22-23	MONTH	This is the month of the record. Range of value is 01-12.

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
007	24	SOURCE CODE-1	Contains a code indicating the primary source of the original record this element was taken from. Range is 1-9. SOURCE CODE TABLE 1 Original manuscript 2 SRRS 3 AFOS 4 DATSAV 5 NMC 6 Foreign keyed 7 MAPSO 8 SRRS plus 9 Other/unknown Source codes reflect normally expected data sources and do not necessarily indicate the actual source of a specific item. Pre-1984 data will only contain a 1.
008	25	SOURCE CODE-2	Contains a code indicating the back-up source of the original record this element was taken from. Range is 1-9. SOURCE CODE TABLE 1 Original manuscript 2 SRRS 3 AFOS 4 DATSAV 5 NMC 6 Foreign keyed 7 MAPSO 8 SRRS plus 9 Other/unknown Pre-1984 data will only contain a 1.
009	26-27	DAY	Contains the day of the record. Range is 01-31.

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
010	28-30	NUM-VALUES	This notates the actual number of values reported. Range of values is 001-048. NOTE: A record may contain fewer or more data values than you might expect. A daily record of hourly values may contain as few as 1 data value or as many as 48. This is primarily due to missing or edited data. If a particular data value was not taken or is unavailable there is no entry for it. Also, when erroneous data are encountered during quality control the original values are flagged and are followed by replacement values (see FLAG-2 TABLE for details).
011	31-34	TIME-OF-VALUE	Contains the hour and minute of the hourly element value. Range is 0000-2300. The hour is in the leftmost two digits and the minute is in the rightmost two digits. Hour is reported using the 24 hour clock. (Minutes are always 00.) See 'Special Notes' on time of record observations.
012	35	SIGN OF METEOR-OLOGICAL VALUE	This is the 'SIGN' of the meteorological data value (Tape Field 013). This field contains either a blank or a minus sign (never a plus sign).
013	36-40	DATA-VALUE	Actual data value. This field is a five digit integer. Units and decimal position are indicated in the ELEMENT-UNITS field described in Tape Field 004.

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
014	41	FLAG-1	The data measurement FLAG. FLAG-1 TABLE (Measurement Value) C Ceiling of cirroform clouds at unknown height (Sept 56 - Mar 70) D Derived value R Dew Point and/or Relative Humidity, originally calculated with respect to ice have been recomputed with respect to water. (DPTP,RHUM) U Unlimited ceiling height (DATA-VALUE = 99999). (CLHT) ƀ (blank) Flag not needed. (All elements except CC51) The following 4 flags apply only to the 'CC51' element type produced for cloud coverage prior to July 1951.. B The 0 found in byte 2 should be a 'ƀ' = Thin obscuration * The 0 found in byte 2 should be a '*' = Original value invalid - The 0 found in byte 2 should be a '-' = Total obscuration. 9 The digit found in byte 2 (high cloud amount) is a valid code. See Pre-6/51 Cloud Cover Table.

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
015	42	FLAG-2	The data quality FLAG.

FLAG-2 (Quality Flag)
(Valid for all elements except CC51)

0	Observed data has passed all internal consistency checks
1	Validity indeterminable (primarily for pre-1984 data)
2	Observed data has failed an internal consistency check - subsequent edited value follows observed value
3	Data beginning 1 JAN 84 - Observed data has failed a consistency check - No edited value follows. Data prior to 1 JAN 84 - Observed data exceeded preselected climatological limits during conversion from historic TD-1440 files. No edited value follows.
4	Observed data value invalid - no edited value follows
5	Data converted from historic TD-1440 exceeded known climatological extremes - no edited value follows
E	Edited data value passes all system checks - no observed value present
M	Manually edited data value added to data set after original archival. Automated edit not performed on this item.
S	Manually edited data passes all systems checks

The following 4 flags apply only to the 'CC51' element type produced for cloud coverage prior to June 1951.

B	The 0 found in byte 5 should be a 'b' = Thin obscuration
-	The 0 found in byte 5 should be a '-' = Total obscuration
*	The 0 found in byte 5 should be a '*' = Original value invalid
9	The digit found in byte 5 (low cloud amount) is a valid code. See Pre-6/51 Cloud Cover Table for Element 'CC51'.

SAMPLE VARIABLE RECORD
(As seen from tape dump)

NOTE: ƀ = Blank Space

```
(column           1         2         3         4         5         6
scale)   123456789012345678901234567890123456789012345678901234567890

(data)   0058HLY00034564TMPDFƀ19840241100021200ƀ00012ƀ11800-00005ƀ1
```

DUMP POSITION	RECORD POSITION	CONTENTS	MEANING	
1-4		0058	Record control word used by the operating system. (Contains the total number of characters in the record - not available to user programs)	
5-7	1-3	HLY	RECORD-TYPE	
8-15	4-11	00034564	STATION-ID (WBAN station number)	
16-19	12-15	TMPD	ELEMENT-TYPE	
20-21	16-17	Fƀ	ELEMENT-UNITS (Left justified blank filled)	
22-25	18-21	1984	YEAR	
26-27	22-23	02	MONTH	
28	24	4	SOURCE-CODE-1 (Primary source = DATSAV)	
29	25	1	SOURCE-CODE-2 (Back-up source = Manuscript)	
30-31	26-27	10	DAY OF THE MONTH	
32-34	28-30	002	NUM-VALUES; Two data entries follow	
35-38	31-34	1200	TIME-OF-VALUE (HOUR 12, MINUTE 00)	FIRST DATA ENTRY
39	35	ƀ	SIGN OF METEOROLOGICAL VALUE	
40-44	36-40	00012	DATA-VALUE	
45	41	ƀ	FLAG-1	
46	42	1	FLAG-2	
47-50	43-46	1800	TIME-OF-VALUE (HOUR 18, MINUTE 00)	SECOND DATA ENTRY
51	47	-	SIGN OF METEOROLOGICAL VALUE	
52-56	48-52	00005	DATA-VALUE	
57	53	ƀ	FLAG-1	
58	54	1	FLAG-2	

In this case, values for hours 00-11, 13-17, and 19-23 are missing.

APPENDIX A
FIXED DATA STRUCTURE (TD-3280) .

Definitions and general information about the Surface Airways Hourly observations are contained in the basic documentation used to describe the format of variable length records.

MANUAL AND TAPE NOTATIONS

1. FILE (NCDC Fixed Length (User Services))

A. Physical Characteristics

Data in this file are retained in chronological order by station. The fixed length records described below can be furnished upon request. Additional charges may be accrued for this special processing.

B. COBOL or FORTRAN Data Description

(1) Typical ANSI COBOL

```
FD  INDATA
    LABEL RECORDS ARE STANDARD (FOR STD LABEL TAPES)
    RECORDING MODE F
    BLOCK CONTAINS 12000 CHARACTERS
    DATA RECORD IS DATA-RECORD.
01  DATA-RECORD.
    02 RECORD-TYPE          PIC X(3).
    02 STATION-ID           PIC X(8).
    02 ELEMENT-TYPE         PIC X(4).
    02 ELEMENT-UNITS        PIC XX.
    02 YEAR                 PIC 9(4).
    02 MONTH                PIC 99.
    02 SOURCE-CODE-1        PIC X.
    02 SOURCE-CODE-2        PIC X.
    02 DAY                  PIC 9(2).
    02 NUM-VALUES           PIC 9(3).
    02 DAILY-ENTRY
         OCCURS 24 TIMES.
       04 TIME-OF-VALUE     PIC 9(4).
       04 DATA-VALUE        PIC S9(5) SIGN LEADING SEPARATE.

       04 FLAG-1            PIC X.
       04 FLAG-2            PIC X.
```

(2) Typical FORTRAN 77

```
DEFINE FILE 10 (ANSI, VB, 318, 6360)
CHARACTER*3 RECTYP
CHARACTER*8 STNID
CHARACTER*4 ELMTYP
CHARACTER*2 EUNITS
CHARACTER*1 SCR1, SCR2, FLAG1, FLAG2
DIMENSION ITIME(24), IVALUE(24), FLAG1(24), FLAG2(24)

READ (10,20,END=999) RECTYP, STNID, ELMTYP, EUNITS, IYEAR,
+IMON, SRC1, SCR2, IDAY, NUM, (ITIME(J), IVALUE(J), FLAG1(J),
+FLAG2(J), J=1, 24)

20 FORMAT (A3, A8, A4, A2, I4, I2, A1, A1, I2, I3, 100 (I4,
I6, 2A1))
```

NOTE: If you do not have FORTRAN 77 you can read the character data described above into integer variables.

1. RECORD

A. Physical Characteristics

Each logical record contains one station's hourly data values for a specific meteorological element for a period of one day. The record consists of an identification portion, and a data portion. The identification portion identifies the record type, observing station, element type, element units, year/month, source codes, day, and number of values. The data portion contains the meteorological observations for the hourly data values and quality flags. The data portion is repeated 24 times.

NOTE: Present Weather Code (PWTH) is an exception. See Code Definitions and Remarks on 'PWTH' in documentation on variable format.

NCDC Library Tapes are structured as follows:

Record length : FIXED 318 characters
Blocked : 6360 characters
Media : ASCII or EBCDIC Modes - 9 Track
Density : 800, 1600, or 6250 BPI
Parity : Odd
Label : ANSI standard labeled (ASCII only) or unlabeled
File : 1 File per tape

These fixed length records may be selected in either of the following two forms:

1. The data values as originally reported.
2. The data values as originally reported with edited replacement values substituted for the values which did not pass the quality checks.

If no choice is made by the User, NCDC will supply form #2.

B. FORMAT (FIXED RECORD)

1. The first ten tape fields, the ID PORTION of the record, describe the characteristics of the entire record. The DATA PORTION of the record contains information about each element value reported. This portion is repeated for 24 hourly values representing 1 full day of observations.

Each logical record is of fixed length with 318 characters. Each logical record contains a station's data for a specific meteorological element over a one day interval. The form of a record is:

ID PORTION (30 characters) Fixed length

	REC TYP	STATION ID	ELEM TYPE	UNT	YEAR	MO	SRC 1	SRC 2	DAY	NO. VAL
	XXX	XXXXXXXX	XXXX	XX	XXXX	XX	X	X	XX	XXX
TAPE FIELD	001	002	003	004	005	006	007	008	009	010

DATA PORTION (12 Character Data Portion repeats the number of times indicated by the data value stored in Tape Field 010, Fixed are 12 characters repeated 24 times.)

	TIME HOUR	DATA ELEM		FL 1	FL 2	TIME HOUR	DATA ELEM	
		S	VALUE				S	VALUE
	XXXX	X	XXXXX	X	X	XXXX	X	XXXXX
TAPE FIELD	011	012	013	014	015	016	017	018

	DATA ELEM		FL 1	FL 2
	S	VALUE		
	X	XXXXX	X	X
TAPE FIELD	127	128	129	130

SAMPLE FIXED RECORD
(As seen from tape dump)

NOTE: ƀ = Blank Space

```
(column             1         2         3         4         5         6
scale)     123456789012345678901234567890123456789012345678901234567890

(data)     HLY00001102TMPDFƀ1981010111010240100ƀ00012ƀƀ0200-99999Mƀ
```

RECORD POSITION	CONTENTS	MEANING	
1-3	HLY	RECORD-TYPE.	
4-11	00001102	STATION-ID 01102 (WBAN Station Number).	
12-15	TMPD	ELEMENT-TYPE.	
16-17	Fƀ	ELEMENT-UNITS. (Left justified blank filled)	
18-21	1981	YEAR.	
22-23	01	MONTH.	
24	1	SOURCE CODE 1. (Manuscript)	
25	1	SOURCE CODE 2. (Manuscript)	
26-27	01	DAY OF MONTH.	
28-30	024	NUM-VALUES: 24 data entries follow.	
31-34	0100	TIME-OF-VALUE (0100 Hour)	FIRST DATA ENTRY
35	(BLANK)	SIGN OF METEOROLOGICAL VALUE	
36-40	00012	DATA-VALUE	
41	(BLANK)	FLAG-1	
42	(BLANK)	FLAG-2	
43-46	0200	TIME-OF-VALUE (0200 Hour)	SECOND DATA ENTRY
47	-	SIGN OF METEOROLOGICAL VALUE	
48-52	99999	DATA-VALUE	
53	M	FLAG-1	
54	(BLANK)	FLAG-2	

(55-318 contains repeats for hourly values 3 thru 24.)

TAPE FIELD	TAPE RECORD POSITION	ELEMENT DESCRIPTION
001	001-003	RECORD TYPE
002	004-011	STATION I.D.
003	012-015	METEOROLOGICAL ELEMENT TYPE
004	016-017	MET. ELEMENT MEASUREMENT UNITS
005	018-021	YEAR
006	022-023	MONTH
007	024	SOURCE CODE 1
008	025	SOURCE CODE 2
009	026-027	DAY OF MONTH
010	028-030	NUMBER OF DATA PORTION GROUPS THAT FOLLOW (24)
011	031-034	TIME OF OBSERVATION (HOUR - LEFT JUSTIFIED)
012	035	SIGN OF METEOROLOGICAL VALUE
013	036-040	VALUE OF METEOROLOGICAL ELEMENT
014	041	QUALITY CONTROL FLAG 1
015	042	QUALITY CONTROL FLAG 2
(016-020)	(043-054)	DATA GROUPS IN THE SAME FORM AS TAPE FIELDS
(021-025)	(055-066)	011-015.
(026-030)	(067-078)	REPEATED 24 TIMES.
(126-130)	(307-318)	

APPENDIX C

DESCRIPTION OF THE TD-5600 FORMAT

This description is reproduced from documentation provided by the National Climatic Data Center (NCDC).

NAME: UPPER AIR (RAWINSONDE) OBSERVATIONS (TD-5600).

TIME PERIOD: 1952 (some as early as November 1945) through present (updated monthly).

GEOGRAPHIC COVERAGE: United States stations and U. S. controlled stations, Global.

FORMAT: IBM EBCDIC variable length records with no more than 6000 characters per block are on NCDC's library reels of magnetic tape which can be copied. NCDC cannot copy variable length to ASCII mode. A standard record length format is available, however, in either ASCII or EBCDIC modes. In the fixed format, blanks are filled in following the last reporting level making each observation (record) 2000 characters in length.

FILE SIZE: 232 magnetic tapes; 9-track, odd parity, 1600 bpi, EBCDIC mode.

FILE STRUCTURE: This file was produced from rawinsonde observations recorded on WBAN 31's and digital computer output for Automatic Raob stations. The file record allows for up to 89 levels, including the surface level. The surface level is always first and follows 25 positions of identification. Standard and significant levels follow the surface level in descending pressure (ascending height) order. The data are sorted on tape by station (WBAN number) in sets; beginning of record-June 1970, July 1970-December 1976, January 1977-December 1980, 1981, and 1982, and monthly thereafter. The data are also sorted by time for the beginning of record through June 1970 and 1977, 1978, and 1979. These magnetic tapes are available for purchase from the NCDC.

CONTENTS: The major parameters that make up this file are observation time (year, month, day, hour), number of levels, pressure of level (MB to 10ths), height of level (geopotential meters), temperature of level (Deg C to 10ths), relative humidity of level (%), and wind direction (whole degrees) and wind speed (meters per second) of level.

VARIABLE TAPE POSITIONS	STANDARD	ELEMENT	
39-43	31-35	HEIGHT	Height of the level, above sea level, in geopotential meters. Signed plus = HGT above sea level *Signed minus = HGT below sea level In later years the positive HGT may or may not be signed.
44-46	36-38	TEMPERATURE	Temperature of the level in degrees celsius and tenths. Signed plus = Positive temp *Signed minus = Negative temp In Later years the positive Temp may or may not be signed.
47-49	39-41	RELATIVE HUMIDITY	Relative humidity of the level in whole percent. Signed plus = Actual RH *Signed minus = Estimated RH In later years the actual RH may or may not be signed.
50-52	42-44	WIND DIRECTION	Wind direction of the level in whole degrees.
53-55	45-47	WIND SPEED	Wind speed of the level in meters per second.
56	48	BLANK	
57	49	BLANK	
58	50	LEVEL TYPE INDICATOR	BLANK = Blank 1 = SFC Level 2 = First Tropopause Level 4 = Mandatory or Sig. Level 8 = Generated Level 0 = All Others

Each data level is 25 bytes. Missing data fields are coded as all 9's (with signed fields being signed minus in recent years). The first level is always the surface level. All other levels then follow in decreasing pressure or ascending height order.

Variable - Observations are packed as many as possible into variable length blocks that do not exceed 6000 bytes.

Standard - Format allows for up to 79 levels, including the surface level of 25 positions each. Blanks are filled in following the last reported level making each observations 2000 character positions in length.

If observations contain more than 79 levels, the observations would continue in the next record and the number of levels (tape position 18-19) would be coded 90-99, i.e., 90 and 91 = level 80 and 81, etc.

*Right most position of these fields may contain the characters A-I = Positive 1 through 9 and J-R = Negative 1 through 9. A positive or negative 0 in this position may appear as a special character or a non-printable character.

TAPE FORMAT DOCUMENTATION

TAPE DECK	RAWINSONDE OBSERVATIONS	PAGE NO.
TDF-56 VAR AND STN		

* * *

				OBS. TIME						SURFACE (1st LEVEL)								
BLC LGTH	OBS LGTH	DECK NO.	STN NO.	YR	MO	DY	HR	NO. LVL	BLANK OR SHIP POS.	PRESS	HGT	TMP	RH	WND DIR	WND SPD	BLK	BLK	TYP
XXXX	XXXX	56XX	XXXXX	XX	XX	XX	XX	XX	XXXXXX	XXXXX	XXXXX	XXX	XXX	XXX	XXX	X	X	X

* * *

HIGHEST (LAST LEVEL)												OBS. TIME			
PRESS	HGT	TMP	RH	WND DIR	WND SPD	HTI	TI	BLK	OBS LGTH	DECK NO.	STN NO. OR LAT.	YR	MO	DY	HR
XXXXX	XXXXX	XXX	XXX	XXX	XXX	X	X	X	XXXX	56XX	XXXXX	XX	XX	XX	XX

VARIABLE TAPE POSITIONS	STANDARD	ELEMENT	
01-04		BLOCK LENGTH	Number of bytes in this physical record - in binary. This occurs once each block.
05-08		OBSERVATION LENGTH	Number of bytes in this logical record - in binary. This field occurs at the beginning of each observation.
09-12	01-04	DECK NUMBER	Unique for each type or source of data.
13-17	05-09	STATION NUMBER	WBAN number or ship number
18-19	10-11	YEAR	78 = 1978 etc.
20-21	12-13	MONTH	01 - 12 = Jan.-Dec.
22-23	14-15	DAY	01 - 31 = Day of month
24-25	16-17	HOUR	00 - 23 = GMT
26-27	18-19	NUMBER OF LEVELS	Number of 25 character levels contained in this observation.
28-33	20-25	BLANK OR SHIP POSITION	Blank for land stations $9oL_aL_aL_oL_o$ 9 = Indicator o = Octant of the globe L_aL_a = Whole degrees of latitutde L_oL_o = Units and tens digits of longitude If octant = 1, 2, 6 or 7, add one hundred to L_oL_o
34-38	26-30	PRESSURE	Pressure of the level in millibars and tenths.

APPENDIX D

DESCRIPTION OF THE TD-6200 FORMAT

This description is reproduced from documentation provided by the National Climatic Data Center (NCDC).

NCDC UPPER AIR
DIGITAL FILES
TD-6200 SERIES

Prepared by
National Climatic Data Center
Federal Building
Asheville, North Carolina

May 1986

This document was prepared by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite Data and Information Service, National Climatic Data Center, Asheville, North Carolina.

This document is designed to provide general information on the content, origin, format, integrity and the availability of this data file.

Errors found in this document should be brought to the attention of the Data Base Administrator, NCDC.

INTRODUCTION

SOURCE

The Upper Air Observations in this digital data file include stations operated by the National Weather Service, U.S. Navy, and certain South American stations whose data receive quality control at the National Climatic Data Center (NCDC). Additional Upper Air Observations from the Global Tele-Communications System (GTS), and the U.S. Air Force are also included in this digital file but are not quality controlled by NCDC.

A list of these files are:

TD-6201	U.S. Rawinsonde observations 1946-Present. (Includes U.S. Navy observations, U.S. Air Force, National Meteorological Center (NMC), and South American cooperative observations. Derived from TD-5600.)
TD-6202	Northern Hemisphere GTS observations 1963-1970, and Southern Hemisphere 1966-1970. (These data were extracted from NMC Operations Archive and processed into TD-5683.)
TD-6203	Global GTS observations 1971-1979. (These data are a composite of NOAA's National Meteorological Center (NMC) and U.S. Air Force Global Weather Center (GWC). Derived from TD-5681.

Background Information TD-6201

TD-6201:	PERIOD:
National Weather Service	Jan. 1946 - Current
U.S. Air Force	Jan. 1946 - Dec. 1970
U.S. Navy	July 1949 - Current

The information contained in TD-6201 includes pressure surface, height of the pressure surface, temperature, relative humidity, wind direction and speed. Beginning with Jan 1981, the elapsed time since release of the sonde is included. The pressure levels included fall into three categories:

1. Mandatory levels — Levels required by the WMO for transmission in parts A and C of a coded RAWIND report.

2. Standard levels — Levels used for internal processing by the NCDC, but not generally reported in a coded message.

3. Significant levels — Levels required to adequately describe a sounding, as transmitted in parts B and D of a coded message.

The number of mandatory and standard levels has increased over time. Table 1 lists the levels that are expected for a given period of record. Significant levels were not generally included in the earlier periods. Significant levels are included for most stations only after July 1952.

Levels below the surface were generated for the period January 1, 1981 through February 28, 1986. However, these levels only contain unknown values ('9999') for all data elements. Beginning March 1, 1986 this practice was stopped.

The actual time of releases from Jan. 1946 through May 1957 were usually 03, 09, 15, 21 GMT, 16, 17 = 15Z and 20, 21, 22, 23 = 21Z. Beginning June 1957 the scheduled time of release is used instead of the actual hour. The time of observations were changed from 03, 09, 15, 21 GMT to 00, 06, 12, and 18 GMT. Observations outside the plus or minus one-hour tolerance were reported as actual time, GMT. Stations scheduled to record only one observation daily are allowed a six-hour tolerance.

Relative humidities were computed with respect to ice from Jan. 1946 through Sept. 1948 and to water after that. Beginning Oct. 1948 relative humidity was computed over a water surface whenever the dry bulb was below freezing.

Observing practice for wind measurements varied from current practice. from Jan. 1946 to June 1949, wind directions were observed on a 16-point compass. These directions were converted to degrees before inclusion in TD-6201.

TABLE 1

Mandatory and Standard Levels TD-6201

Surface	1/46-6/49	7/49-12/55	1/56-6/57	7/57-12/60	1/61-Present
1000	*	*	*	*	*
950	*	*	*	*	*
900	*	*	*	*	*
850	*	*	*	*	*
800	*	*	*	*	*
750	*	*	*	*	*
700	*	*	*	*	*
650	*	*	*	*	*
600	*	*	*	*	*
550	*	*	*	*	*
500	*	*	*	*	*
450	*	*	*	*	*
400	*	*	*	*	*
350	*	*	*	*	*
300	*	*	*	*	*
250	*	*	*	*	*
200	*	*	*	*	*
175	*	*	*	*	*
150	*	*	*	*	*
125	*	*	*	*	*
100	*	*	*	*	*
80	*	*	*	*	*
70					*
60	*	*	*	*	*
50	*	*	*	*	*
40	*	*	*	*	*
30	*	*	*	*	*
25				*	*
20	*	*	*	*	*
15		*	*	*	*
10	*	*	*	*	*
7		*	*	*	*
5		*	*	*	*
4		*	*	*	*
3		*	*	*	*
2		*	*	*	*
1.5					*
1					*

Background Information TD-6202

TD-6202:	PERIOD:
National Meteorological Center (NMC)	
Northern Hemisphere	Sept. 1963 - Dec. 1970
Southern Hemisphere	June 1966 - Dec. 1970.

These data were assimilated from normal International communication channels and no detailed quality control measures were employed when converting to TD-5683. The observations, therefore, were subject to the usual errors inherent in such a collection.

The U/A observations contain all available mandatory and significant levels transmitted under International agreement. The period of record may vary from station to station, the general collection began Sept. 1963 and continued through Dec. 1970 (Northern Hemisphere). Stations in the Southern Hemisphere are usually not available until mid 1966 or later through Dec. 1970.

Relative humidities are derived statistically for RH's not reported originally.

Background Information TD-6203

TD-6203:	PERIOD:
National Meteorological Center (NMC)	July 1971 - Dec. 1978
Air Force Global Weather Center (AFGWC)	July 1971 - Dec. 1978

These U/A observations are a collection of data built by the National Climatic Data Center (NCDC). These data were received from NMC and AFGWC. NCDC converted these two data sources separately into TD-5681. Then these data sources were combined giving priority to the NMC source.

Areal coverage is worldwide.

The digital file contains: Station Identification (land and ships), Latitude and Longitude of location, date/time, and elements:

LEVEL QUALITY INDICATOR - results by level.

TIME - elapsed time since release.

PRESSURE - by level in kilopascals.

HEIGHT - by level in geopotential meters.

TEMPERATURE - by level in degrees Celsius.

RELATIVE HUMIDITY - by level in degrees Celsius.

WIND - Direction and speed by level.

QUALITY CONTROL FLAGS - by level for time, pressure, height, temperature, relative humidity, wind, and type of level.

SPECIAL NOTES

QUALITY

U.S. data processed by the NCDC are subjected to extensive quality control procedures. Suspect data are returned to a verifier for manual correction. GTS data are subjected to various degrees of automated quality control by the receiving agency. NCDC accepts the data as correct during the reformatting procedure. Therefore, the user must be prepared to perform his own quality checks on GTS data. (The primary function of NMC and AFGWC is to produce forecasts, not to provide an archive data base.)

When corrections are made to a level, that level will appear in the record twice. The first occurrence of the level will be the original observed values, with a level quality indicator of "2" or "4". The corrected data will appear in the second occurrence of the level, with quality indicator of "6".

USE OF THE MANUAL

This manual was designed so that reference to other reference material should be unnecessary. However, additional information may be obtained by writing or calling:

National Climatic Data Center E/CC42
ATTN: USER Services Branch
Federal Building
Asheville, North Carolina 28801-2696

Telephone inquiries may be directed to:

Commercial 704 259-0682
FTS 672-0682

Read carefully, the general tape notations, and coding practices.

TAPE FORMAT

MANUAL AND TAPE NOTATIONS

1. FILE (NCDC Variable Length Storage Structure)

A. Physical Characteristics

Data in this file are retained in chronological order by station. Although library tapes are normally maintained as described below, different characteristics including fixed length records can be furnished on request. Additional charges may be accrued for special processing.

2. RECORD

A. Physical Characteristics

Each logical record contains one station's Upper Air (U/A) Observation (Rawinsonde, Radiosonde, or Pibal) for each specific Upper Air Sounding (normally 2 each day). The record consists of a control word, an identification portion, and a data portion. The control word is used by the computer operating system for record length determination. For many systems this control word is transparent to the "users" program. The identification portion identifies the observing station, latitude, longitude, day and time (of release), and the number of repeating groups to follow. The data portion contains the U/A meteorological values and the quality control flag fields for each level. The data portion repeats for each level in the observation. The maximum number of levels is 200. This number was chosen so that observations containing one-minute wind data may be recorded in this format.

Record length : Variable with maximum of 7232 characters
Blocked : 12000 characters maximum
Media : ASCII 9 Track
Density : 6250 BPI
Parity : Odd
Label : ANSI Standard Labeled
File : 1 File per tape

B. FORMAT (VARIABLE RECORD)

1. The first five fields constitute the ID PORTION, and occur at the beginning of each record. The next ten fields of the record contain the DATA PORTION. The DATA PORTION is repeated for each level in the observation. The maximum number of levels is 200.

Each logical record is of variable length with a maximum of 7232 characters. Each logical record contains a station's complete Upper Air Observation for a specific release time. The form of a record is:

ID PORTION (32 characters) Fixed length

	STATION ID	LAT	LAT CODE	LONG	LONG CODE	DATE/TIME	NUMBER VALUES
	XXXXXXXX	XXXX	X	XXXXX	X	XXXXXXXXXX	XXX
TAPE FIELD	001	002	003	004	005	006	007

DATA PORTION (36 Characters) repeated Number-Values Times

	LVL-QLTY INDCTR	TIME	PRESSURE	HEIGHT	TEMP	RH	WIND DIR	WIND SPD	QUALITY FLAGS	TYPE OF LEVEL
	X	XXXX	XXXXX	XXXXXX	XXXX	XXX	XXX	XXX	XXXXXX	X
TAPE FIELD	008	009	010	011	012	013	014	015	016	017

	RH	WIND DIR	WIND SPD	QUALITY FLAGS	TYPE OF LEVEL
	XXX	XXX	XXX	XXXXXX	X
TAPE FIELD	1998	1999	2000	2001	2002

TAPE FIELD	TAPE RECORD POSITION	ELEMENT DESCRIPTION
001	001-008	STATION IDENTIFICATION
002	009-012	LATITUDE
003	013	LATITUDE CODE N/S
004	014-018	LONGITUDE
005	019	LONGITUDE CODE E/W
006	020-029	DATE AND TIME (YR/MO/DY/HR)
007	030-032	NUMBER OF DATA PORTION GROUPS THAT FOLLOW
008	033	LEVEL QUALITY INDICATOR
009	034-037	TIME (ELAPSED TIME SINCE RELEASE)
010	038-042	PRESSURE
011	043-048	HEIGHT
012	049-052	TEMPERATURE
013	053-055	RELATIVE HUMIDITY
014	056-058	WIND DIRECTION
015	059-061	WIND SPEED
016	062-067	FLAG FIELD (QUALITY FLAGS)
017	068	TYPE OF LEVEL
(1958-1972) (1973-1987) (1988-2002)	(7125-7160) (7161-7196) (7197-7232)	DATA GROUPS IN THE SAME FORM AS TAPE FIELDS 008-017. REPEATED AS MANY TIMES AS NEEDED TO COMPLETE ONE UPPER AIR OBSERVATION. A MAXIMUM OF 200 LEVELS ARE POSSIBLE.

The following COBOL and FORTRAN statements are to be used as guidelines only. NCDC recognizes the fact that many different types of equipment are used in processing these data. It is impossible to cover all the idiosyncrasies of every system.

Typical ANSI COBOL Data Description.

This ANSI Standard COBOL Data Description is expected to work on most systems.

```
FD   UA-DATA
     LABEL RECORDS ARE STANDARD
     RECORDING MODE D
     BLOCK CONTAINS 12000 CHARACTERS.
01   UA-RECORD.
     02   STATION-NUMBER              PICTURE X(8).
     02   LATITUDE.
          03   LATITUDE-NUM           PICTURE 9999.
          03   LATITUDE-ALPH          PICTURE X.
     02   LONGITUDE.
          03   LONGITUDE-NUM          PICTURE 99999.
          03   LONGITUDE-ALPH         PICTURE X.
     02   DATE-TIME.
          03   YEAR                   PICTURE 9(4).
          03   MONTH                  PICTURE 99.
          03   DAYS                   PICTURE 99.
          03   HOUR                   PICTURE 99.
     02   NUMBER-OF-LEVELS            PICTURE 999.
     02   LEVEL-RECORD
               OCCURS 1 to 200 TIMES DEPENDING ON NUMBER-OF-LEVELS.
          03   QUALITY-INDICATOR      PICTURE X.
          03   ELAPSED-TIME           PICTURE 999V9.
          03   PRESSURE               PICTURE 999V99.
          03   HEIGHT                 PICTURE S99999
                                      SIGN LEADING SEPARATE.
          03   TEMPERATURE            PICTURE S99V9
                                      SIGN LEADING SEPARATE.
          03   RELATIVE-HUMIDITY      PICTURE 999.
          03   WIND-DIRECTION         PICTURE 999.
          03   WIND-SPEED             PICTURE 999.
          03   FLAGS.
               04   TIME-FLAG         PICTURE X.
               04   PRESSURE-FLAG     PICTURE X.
               04   HEIGHT-FLAG       PICTURE X.
               04   TEMPERATURE-FLAG  PICTURE X.
               04   R-H-FLAG          PICTURE X.
               04   WIND-FLAG         PICTURE X.
               04   TYPE-OF-LEVEL     PICTURE X.
```

FORTRAN 77 Example 1.

This description is for those systems that can handle variable blocked records normally.

```
      IMPLICIT INTEGER (A-Z)

      OPEN (10,FILE = 'FILENAME',ACCESS = 'SEQUENTIAL', STATUS = 'OLD',
     +   RFORM = 'VB',MREL = '1230',TYPE = 'ANSI',BLOCK = '12000')
C        LAST line of OPEN statement is SPERRY UNIQUE

      CHARACTER*8 STNID
      CHARACTER*1 LATA,LONA,QIND(200),TIMEF(200),PRESSF(200),
     +            HGTF(200),TEMPF(200),RHF(200),WINDF(200),TYPLEV(200)

      REAL*4 LAT,LON,ETIME(200),PRESS(200),HGT(200),TEMP(200)

      DIMENSION ETIME(200),PRESS(200),HGT(200),
     +          TEMP(200),RH(200),WD(200),WS(200)

      READ (10,20,END=999) STNID,LAT,LATA,LON,LONA,YEAR,
     +           MONTH,DAY,HOUR,NUMLEV,(QIND(J),ETIME(J),
     +           PRESS(J),HGT(J),TEMP(J),RH(J),WD(J),WS(J),
     +           TIMEF(J),PRESSF(J),HGTF(J),TEMPF(J),RHF(J),
     +           WINDF(J),TYPLEV(J),J=1,NUMLEV)

 20   FORMAT (A8,F4.0,A1,F5.0,A1,I4,3(I2),I3,200(A1,F4.1,F5.2,
     +        F6.0,F4.1,3(I3),7A1))
```

IBM JCL NOTES.

(1) For ASCII Variable specify:
LREC = 7236
RECFM = DB
OPTCODE = Q

(2) For EBCDIC Variable specify:
LRECL = 7236
RECFM = VB

FORTRAN 77 Example 2.

This description is for those systems that can't handle variable blocked records normally.

```
$ MOUNT/FOREIGN/BLOCKSIZE=12000 MT:  tapename TAPE:  ! THIS IS VAX
.....                                                ! UNIQUE

     PROGRAM TAPEREAD
     IMPLICIT INTEGER (A-Z)
     .....
     OPEN(1,FILE=TAPE:',ACCESS='SEQUENTIAL',FORM=FORMATTED',
    +       STATUS='OLD',READONLY)

     CHARACTER BUFFER*12000            ! YOUR MACHINE MUST SUPPORT
     CHARACTER *8 STNID                ! CHARACTER VARIABLES THIS LARGE
     CHARACTER*1 LATA,LONA,QIND(200),TIMEF(200),PRESSF(200),
    +           HGTF(200),TEMPF(200),RHF(200),WINDF(200),TYPLEV(200)

     REAL*4 LAT,LON,ETIME(200),PRESS(200),HGT(200),TEMP(200)

     DIMENSION ETIME(200),PRESS(200),HGT(200),TEMP(200),RH(200),
    +          WD(200),WS(200)
     .....
     NBYTES=0
 5   NBEG=1
     READ(1,101,END=99)BUFFER           !READ IN PHYSICAL RECORD (BLOCK)
10   NBEG=NBEG+NBYTES
     READ(BUFFER(NBEG:NBEG+3,102)NBYTES  !READ THE CONTROL WORD
     IF( NBYTES.EQ.0 )GO TO 5
     READ(BUFFER(NBEG+4:NBEG+NBYTES-1),103)STNID,LAT,LATA,LON,LONA,YEAR,
    +    MONTH,DAY,HOUR,NUMLEV,(QIND(J),ETIME(J),PRESS(J),HGT(J),TEMP(J),
    +    RH(J),WD(J),WS(J),TIMEF(J),PRESSF(J),HGTF(J),TEMPF(J),RHF(J),
    +    WINDF(J),TYPLEV(J),J=1,NUMLEV)

     .....
     .....
     GO TO 10
99   CONTINUE
     .....
     .....
     STOP 'FINISHED'
101  FORMAT(A)
102  FORMAT(I4)
103  FORMAT(A8,F4.0,A1,F5.0,A1,I4,3(I2),I3,200(A1,F4.1,F5.2,
    +F6.0,F4.1,3(I3),7A1))
     END
```

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
001	1-8	STATION-ID	STATION IDENTIFICATION—For U.S. controlled and cooperative stations, the WBAN number (TD-6201). For stations received through GTS, the WMO number (TD-6202). TD-6203 has general WMO numbers but some are WBAN numbers. This field may contain alphabetic characters for ships and remote sensed observations. Numeric station numbers are right justified and zero filled, while alphanumeric station indentifiers are left justified and blank filled. If unknown, this field contains "99999999". If the station identification is unknown, both latitude and longitude must be present.
002	9-12	LATITUDE	LATITUDE—The station latitude in degrees and minutes. When unknown, this field contains "9999". Latitude will not normally appear for land stations.
003	13	LATITUDE CODE	LATITUDE CODE— CODE used to indicate the Northern (N) or Southern (S) latitudes.
004	14-18	LONGITUDE	LONGITUDE—The station longitude in degrees and minutes. When unknown, this field contains "99999". Longitude will not normally appear for land stations.
005	19	LONGITUDE CODE	LONGITUDE CODE—CODE used to indicate Longitudes East (E) or West (W).
006	20-29	DATE-TIME	DATE/TIME—The scheduled time of the observation, as defined by WMO. The format of date/time is YYYYMMDDHH, i.e., year, month, day, hour. This field may never be unknown.
	20-23	YEAR	YEAR-This is the Year of record. Range of values are 1946-current year processed.
	24-25	MONTH	MONTH-This is the Month of record. Range of value are 01 to 12.

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
	26-27	DAY	DAY-This is the Day of record. Range of values are 01 to 31.
	28-29	HOUR	HOUR-This is the Hour of record. Range of value are 00 to 23. Hour is GMT. Normal scheduled observation times are 00 and 12 GMT. For selected periods and areas observations may have been taken at other times, especially 06 and 18 GMT.
007	30-32	NUMBER-REPEAT-GROUPS	NUMBER-OF-REPEATING-GROUPS--This number represents the number of data levels found in the current observation, including edited levels. Range of values are 001-200. Two hundred is the maximum number of levels.
008	33	LEVEL-QUALITY-INDCTR	LEVEL-QUALITY-INDICATOR--Denotes the results of any quality controls applied to this level. Range is as follows: 0 Original values are correct. 1 Original values missing. 2 Original values doubtful, a corrected level follows. 3 Original values doubtful, uncorrected. 4 Original values in error, a corrected level follows. 5 Original values in error, uncorrected. 6 Corrected level. 9 Level not checked. A-Z Indicators supplied by NMC. NMC Indicators have changed many times over the years. If you wish to use their indicators you will have to contact NMC.
009	34-37	TIME-SINCE-RELEASE	TIME--The elapsed time since the release of the sounding in minutes and tenths. If the elapsed time is not known, this field contains "9999". Range is 0001 through 9999. Available only for U.S. quality controlled stations beginning Jan 1981.

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
010	38-42	PRESSURE-AT-LEVEL	PRESSURE—Atmospheric pressure at the current level in kilopascals and hundredths. If unknown, this field contains "99999". (TD6201 only - Subsurface levels were generated from Jan. 1, 1981 through Feb. 28, 1986. The values were always unknown. This practice was stopped Mar. 1, 1986.
011	43-48	HEIGHT-AT-LEVEL	HEIGHT--Geopotential height of the current level in whole meters. If unknown, this field contains "-99999". Range of values are -99999 through 99999.
012	49-52	TEMPERATURE AT-LEVEL	TEMPERATURE—The free air temperature at the current level in degrees and tenths Celsius. If unknown, this field contains "-999". Range of values -999 through ~~6~~999.
013	53-55	RELATIVE-HUMIDITY AT LEVEL	RELATIVE-HUMIDITY—The relative humidity at the current level in whole percent. If unknown, this field contains "999". In TD-6202, relative humidities are derived statistically for RH's not reported originally.
014	56-58	WIND-DIRECTION AT-LEVEL	WIND-DIRECTION—Direction of the wind at the current level in whole degrees (nearest five degrees for observations received through GTS). If unknown, this field contains "999".
015	59-61	WIND-SPEED AT-LEVEL	WIND-SPEED—Speed of the wind in whole meters per second. If unknown, this field contains "999".

TAPE FIELD	TAPE RECORD POSITION	ELEMENT NAME	CODE DEFINITIONS AND REMARKS
016	62-67	QUALITY-FLAGS	QUALITY-FLAG-FIELD—This field contains the results of any quality control procedures, identifying each individual element found in error (see table below). QUALITY CONTROL FLAG 0 Element is correct 1 Element is doubtful 2 Element is in error 3 Replacement value 4 Assumed or estimated value 9 Element not checked A-Z Indicators supplied by NMC. NMC flag indicators have changed many times over the years. If you wish to use their indicators you will have to contact NMC.
	62	TIME-QF	Time Quality Flag
	63	PRESSURE-QF	Pressure Quality Flag
	64	HEIGHT-QF	Height Quality Flag
	65	TEMPERATURE-QF	Temperature Quality Flag
	66	RELATIVE-HUMIDITY-QF	Relative Humidity Quality Flag
	67	WIND-QF	Wind Quality Flag
017	68	TYPE-OF LEVEL	TYPE OF LEVEL FLAG—See Table below. 0 Surface 1 Mandatory 2 Significant 3 Generated 4 Tropopause 5 Maximum wind 9 Other/unspecified NOTE: TD-6201 through December 1975 will contain Type of Level Flags 0, 1, and 9 only. The significant flag is not present.

APPENDIX E

DESCRIPTION OF THE TD-9689 FORMAT

This description is reproduced from documentation provided by the National Climatic Data Center (NCDC).

FILE NAME: MIXING HEIGHT STUDIES (TD-9689).

TIME PERIOD: January 1, 1960 through December 31, 1964 and various later years.

GEOGRAPHIC COVERAGE: Selected upper air stations in the United States.

FILE SIZE: One magnetic tape; 9-track, odd parity, 1600bpi, ASCII mode, labeled and two magnetic tapes; 9-track, odd parity, 6250bpi, ASCII mode labeled. Copies of these data are available on magnetic tape (EBCDIC or ASCII mode) and other computer media.

FORMAT: 34 characters per record, 10 records per block.

FILE STRUCTURE: Morning and afternoon mixing heights for the years 1960-1964 were calculated for 62 stations by NCDC for the Environmental Protection Agency. These data are on one reel of 1600bpi magnetic tape. Mixing heights for later years can be computed on demand. A great many of these studies for later years have been generated and are stored on two reels of 6250bpi magnetic tape.

CONTENTS: The major parameters that make up this file are date, morning type indicator, morning (near minimum) mixing depth (meters), morning average wind speed (meters per second to 10ths) through the mixing depth, morning average surface wind speed, afternoon type indicator, afternoon (near maximum) mixing depth, afternoon average wind speed through the mixing depth, and afternoon average surface wind speed.

ABSTRACT: The data utilized in generating this file are hourly surface weather observations (TD-3280), and upper air observations (TD-6201) taken at 0000 GMT and 1200 GMT. Since it takes two data files to generate a mixing height, two different stations (upper air and surface) may be used. Usually this involves a surface station close to the user's area of interest and an appropriate nearby upper air station.

For a mixing height study, it is assumed that a well mixed unsaturated atmosphere will have a lapse rate that is dry adiabatic (9.8 degrees C per kilometer). The morning mixing height is then defined as the height above ground level where the dry adiabatic extension of the morning minimum surface temperature plus 5 degrees C intersects the vertical temperature profile (RAOB) observed for the 1200Z sounding. The plus 5 degrees C is an overstatement of average effects of the urban heat island and therefore includes some surface solar heating. The estimated mixing height applies at the time and place where the surface temperature has increased 5 degrees C above the minimum. The afternoon mixing height is calculated in the same manner, using the 1200Z RAOB, but this time only the maximum surface temperature is used. In addition, the average wind speed through the mixing depth is calculated. Thus, for each day, a morning and afternoon (maximum) mixing depth is given along with the average wind speed through the mixing depth and precipitation if it occurred (considered to be a cleaning agent of the atmosphere). An inventory of this file is available to users from the NCDC. There are no known related files.

This file is also available for purchase from the NCDC.

MIXING HEIGHT STUDY

(34 Characters, Blocked 10)

TAPE POSITION	ITEM
1-5	Station number
6 9	Year, month
10	Season
	1 = Dec, Jan, Feb
	2 = Mar, Apr, May
	3 = Jun, Jul, Aug
	4 = Sep, Oct, Nov
11-12	Day
13-23	Morning
* 13	Type
	1 = No Precip
	2 = Precip
	3 = Cold Advection
	4 = Missing
14-17	Mixing depth (Meters)
18-20	Average wind speed thru mixing depth
21-23	Average surface wind speed
24-34	Afternoon
* 24	Type - 1, 2, 3, or 4
25-28	Mixing Depth
29-31	Average wind speed thru mixing depth
32-34	Average surface wind speed

* Period 1960 - 1964
Type (Blank,C or P)
Blank = Missing or no Precipitation
C = Cold Advection
P = Precipitation

APPENDIX F

DESCRIPTION OF THE TD-9773 FORMAT

This description is reproduced from documentation provided by the National Climatic Data Center (NCDC).

FILE NAME: STABILITY ARRAY-STAR (TD-9773).

TIME PERIOD: Not time dependent.

GEOGRAPHIC COVERAGE: 300 United States and Select World-Wide Stations.

FILE SIZE: 8 magnetic tapes; 9-track, odd parity, 1600bpi, ASCII mode, labeled. Copies of these data are available on magnetic tape (EBCDIC or ASCII mode) and other computer media.

FORMAT: 84 characters per record, 10 records per block.

FILE STRUCTURE: Data are sorted on each magnetic tape by header number or station number (WBAN or WMO).

CONTENTS: The major parameters that make up this file are wind direction (16 points and calm), stability class (A-G), wind speed (kts) frequencies, station ID, and beginning and ending year. The STAR output consists of monthly, seasonal, or annual frequency and percent frequency tables of wind direction versus wind speed groups for each stability category.

ABSTRACT: STAR was born from the work of Pasquill (1951), Turner (1964), and Martin and Tidvart (1968). It provides, at least roughly, the diffusion characteristics for the lowest part of the atmosphere and biosphere. It is an objective method of determining stability from readily available surface meteorological observations utilizing only the variables of ceiling height, total sky cover, and wind direction and speed as input. The methodology employed recognizes that stability near the ground is dependent primarily upon net radiation and wind speed. Wind direction is not a factor in objective determination of stability categories. Without the influence of clouds, insolation (incoming radiation) during the day is dependent mainly upon the solar elevation, which is a function of time of year, time of day, and station location. When clouds exist, their cover and thickness decrease incoming and outgoing radiation. In this system, insolation is estimated by solar elevation and modified for existing conditions of total sky cover and ceiling height. At night, estimates of outgoing radiation are again based on total sky cover and ceiling height. The STAR output consists of frequency and percent frequency tables of wind direction versus wind speed groups for each stability category. This system produces seven categories ranging from extremely unstable (A) to neutral (D) to extremely stable (G) and can be summarized on a monthly, seasonal, or annual basis.

NCDC can produce a STAR for any year or number of years for any station (world-wide) whose hourly or 3-hourly surface meteorological observations are stored in TD-3280 or TD-9999 AFDATSAV files. An optional output of the STAR that NCDC can generate is formatted, 100 characters per record/10 records per block, individual surface meteorological observations and associated stability categories on magnetic tape or other computer media.

A STAR TABULATIONS MASTER LIST (Index) is available to users from the NCDC. There are no known related files.

This file is available for purchase from the NCDC.