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A DIGITIZED METADATA SET OF GLOBAL UPPER-AIR STATION HISTORIES

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ABSTRACT

This report provides documentation for an initial version of a digitized metadata set containing historical information on upper-air (radiosonde) stations around the globe. The metadata set, which is being made available through the National Climatic Data Center, is a compilation of information from both published and unpublished sources. The database is organized by station identification number, and gives a series of events for each station in chronological order. The events relate mainly to changes in station location, instrumentation, and observing practices. The metadata set is contained in a relational database structure, which uses supplemental tables to expand on the basic historical information in a main table. Because this is an initial version of the database, a number of caveats are presented. Improved versions are quite likely to be developed in the future.

1. INTRODUCTION

Studies of multi-decadal variations and trends in tropospheric and stratospheric temperature, humidity, winds, and pressure fields rely, perforce, on radiosonde data assembled from the global upper-air observing network. The network has been in operation since the late 1930s, when radiosondes were first used to probe the atmosphere. Radiosonde data also provide a standard for the development and implementation of retrievals of atmospheric temperature and humidity using satellites, and they serve as calibration data for other upper-air sensing systems.

The utility of the radiosonde data is compromised, however, by spatial and temporal inhomogeneities that can confound data users (Elliott and Gaffen, 1991; Gaffen, 1994; Parker and Cox, 1995; Soden and Lanzante, in press). Because the network has been operated by numerous national weather services (both civilian and military), different instruments and observing practices have been used at different stations. And because the network has been operated chiefly for operational weather forecasting, neither the long-term continuity of the climatological record nor the compilation or maintenance of upper-air station history information has been a primary goal.

Because of the increasing interest in using upper-air data records for climate research, an effort has been made to compile radiosonde station history information in a digitized form for use by interested researchers. This brief report summarizes the status of that effort and the resulting metadata set. Because the metadata set will quite likely be improved in the future, the limitations of the current version are outlined.

2. GOALS

The ultimate (but probably unachievable) goal for this project is to present complete information on the attributes of each station in the global upper-air network and the associated data. The first phase of work toward that goal was a foundation-building one. For this phase, a more realistic goal was to develop an initial version of a metadata set including as much information as could be obtained from diverse existing sources, and to present it in a standard format, for easy automatic access and easy updating when additional information is obtained.

A priority was placed on information that would affect interpretation of climatological data records, particularly of temperature and humidity. Thus information on changes in instruments and observing practices was of much higher priority than information on station names, for example. A further goal was to provide attribution for all information in the metadata set so that an interested user could consult original source material.

3. METADATA DEFINITION

The definition of metadata as "data about data" is not particularly useful for specific metadata applications. For the purposes of this report and the metadata set of upper-air station histories, metadata can, perhaps, best be defined by listing the types of information that have been included in the current metadata set. In general, the information types can be categorized as follows:

- Identification of the upper-air station (identification numbers, station names)
- Station location (latitude, longitude, and elevation)
- Entities responsible for operating the station (e.g., country, meteorological service, civilian or military authority)
- Instruments used for making upper-air radiosoundings
- Observing practices (e.g., time and frequency of observation)
- Methods used to convert raw data to atmospheric sounding data for recording and transmission
- Data reporting practices (e.g., special data cutoffs, corrections applied to the data)
- Recognized data problems and possible remedies

These categories encompass most of the types of information included. In general, the information is either static or dynamic: either it is applicable to a particular moment or it relates to a change in a given attribute at a particular moment. This distinction is made because the historical metadata available is in either the static or dynamic form. In either case, this information is called an "event." Table 1 provides a complete listing of the types of events included in the metadata set. A more thorough explanation of these events is deferred to the discussion of the format of the metadata set in Section 5.

4. UPPER-AIR METADATA SOURCES USED

The main sources of information for the station history metadata set are (1) a listing of station names, identification numbers, and locations provided by National Climatic Data Center (NCDC, R. Tanner, personal communication, 1995) and (2) a report on an international survey on historical changes in radiosonde instruments and practices (Gaffen, 1993). Both of these sources attempt to be comprehensive in both time and space, although neither is exhaustive. In addition, recent radiosonde network metadata was taken from World Meteorological Organization (WMO) catalogues of radiosondes in use (Oakley, 1993; WMO Operational Newsletters beginning 1992). Older versions of these catalogues (WMO, 1965, 1982; Spackman, 1977; Kitchen, 1986), digitized by the U.K. Meteorological Office (D. Parker and M. O'Donnell, Hadley Centre, Bracknell, personal communication, 1995), were also used.

The main sources were supplemented by several literature references and material acquired through personal contact with national experts. These sources provided station-by-station information on instrument changes for the following specific countries: Japan (Miyagawa, 1990), India (Raj et al., 1987), Austria (Dobesch et al., 1992), France (M. Leroy and G. Oualid, Meteo-France, Paris, personal communication, 1995), South Africa (Weather Bureau, 1979, 1990), the United States (and to a lesser extent other North American countries) (Schwartz and Govett, 1992), the former Soviet Union (A. Sterin and N. Zaitseva, Central Aerological Organization, Moscow, personal communication, 1993), and China (P. Zhai, State Meteorological Administration, Beijing, personal communication, 1994). The last three of these supplied digitized datasets, but in very different formats. Miscellaneous memoranda from the U.S. National Weather Service (NWS) Office of System Operations and National Technical Information Messages broadcast as part of the NWS Family of Services were sources of information for the U.S. network changes in the late 1980s and early 1990s.

One included element of nonmeteorological, but potentially relevant, history is the date of independence for the country in which a station is located. These dates were extracted from the World Factbook 1993 (CIA, 1993) on the conjecture that when colonies achieved independence, changes in meteorological observations may have been made. Because upper-air observations require relatively expensive expendable equipment, a newly independent state could conceivably elect to purchase equipment from a new source, which could influence the data. The main motivation for including these metadata was an acknowledgment that meteorological metadata were lacking for many former colonies in Africa, South America, and the Atlantic, Pacific, and Indian Oceans.

The reference section of this report, Section 10, gives full bibliographic information for each of the publications cited either in this report or in the metadata set, or in both.

5. FORMAT OF THE METADATA SET

5.1. Relational Database Structure

The metadata set is a relational database constructed using commercially available Microsoft Access (version 2.0) software. The conceptual framework of relational database management, in which multiple tables with related information of different types are linked, is very useful for radiosonde metadata presentation. In this case, the main table contains historical metadata events and is organized according to WMO station identification number and time: station information appears in numerical order by identification number, and for each station the historical information is presented chronologically. The main station history table has 23,465 records for 2445 stations. Each record contains one metadata event and consists of the fields listed in Table 2. Supplemental information is included in other tables of the relational database.

As an example of how records in different tables can be related, consider a historical metadata record that indicates that a particular radiosonde model was in use at a particular station on a particular date. A related table will give the pressure, temperature, and humidity sensors associated with that radiosonde model. Another table will give a description of the operating principle of the temperature sensor. Yet another table will give comparable information about the humidity sensor. This structure is meant to reduce redundancy and facilitate the production of reports that incorporate information of different types from the related tables.

To ensure homogeneity of the metadata set and to facilitate searches, an attempt has been made to limit the possible entries both for event type and for event explanation information. The possible event types are those listed in Table 1. Although the "miscellaneous" type does exist, it was used most often for information on national independence dates; therefore the vast majority of events in the metadata set are stated explicitly.

Since each event is presented in a separate record, there is some repetition in the metadata set. For example, if an instrument change is reported, other metadata (station identification and location information) remain the same as in the previous record.

Table 3 is a small subset of records from the main station history table. Because each record contains 28 fields (11 of which are quality flag fields), the records are spread across two pages, and two fields (the comment and record number fields) are not shown in Table 3. (Note that by eliminating the comment field in Table 3, the station national independence date information, associated with the "Miscellaneous" event types, is not shown.) Otherwise, the fields are organized according to the structure shown in Table 2, and, when appropriate, the quality flag fields follow the fields to which they relate.

The metadata in Table 3 illustrate of the sort of information, and some of the problems, one may find. The records for Sverdlovsk, Russia (WMO identification number 28440) give historical information covering the period 1936-1992. Most of the events relate to radiosonde models, but there are some inconsistencies between the information based on the USSR station history and the U.K. Meteorological Office's catalogues. For example the USSR station history indicates that after June 1989 the station used the MRZ radiosonde, whereas the U.K. Meteorological Office catalogue for 1989 indicates that the MARS radiosonde was used at the station.

A similar problem can be seen in the records for Pretoria, South Africa (WMO number 68263) in 1986. Note that the "Date Uncertain" field contains "yes" for records based on the U.K. Meteorological Office catalogues. The Pretoria records also show the use of the "Alternates" field. In February 1959 the Väisälä RS12 and RS13 radiosonde were both in use, as indicated by the notation "I1" and "I2" in the "Alternates" field.

The records in Table 3 for Dulan, China (WMO number 52836) show no inconsistencies in a 37 year record. The apparent discrepancy between the 1989 use of the GZZ-2 radiosonde and the December 1992 use of the Shanghai Radio radiosonde is clarified by noting that these are two different names for the same Chinese radiosonde.

Records for Bethel, Alaska, USA (WMO number 70219) give 55 years of station history, including the most recent event of the entire metadata set, the November 1995 introduction of Väisälä radiosondes to the network operated by NOAA NWS. The Kaitaia, New Zealand (WMO number 93012) records include events relating to changes in temperature ducts and relative humidity sensor. Generally, these are not explicitly noted. For example the March 1989 change to the Väisälä RS80 radiosonde probably involved a change in sensor types, but that information is not given in the main Station History table but in a supplemental table.

5.2. Supplemental Tables

The explanatory information for event types and for other fields in the main station history table is contained in supplemental tables. Table 1 indicates the supplemental table relevant to each event type. Not all event types have explanatory material in supplemental tables.

The current version of the relational database includes the following tables. It is quite likely that future versions will incorporate additional tables. The current versions of most of the supplemental tables are included in this report as Tables 4 to 18. One table not included in this report gives options for the information that can be placed in the "before" and "after" information fields of the main station history table (Table

2). This table is a composite of the entries in Tables 4 to 18. In a modified form, Table 1 is also included as a supplemental table.

5.2.1. Radiosonde types (Table 4)

This table, as it appears in the digital metadata set, gives information on more than 150 radiosonde types, their country of origin, and their sensors. Types are given in terms of the manufacturer, model, and operating frequency. Temperature, pressure and humidity sensor types are listed when known. Additional details, including operating range and error characteristics for some sensors, may be found in Gaffen (1993). Table 4 gives only a small subset of the entries in the full table. (See also Section 6.2.5.)

5.2.2. Humidity sensor types (Table 5)

Types and operating principles for various humidity sensors are given, along with a reference to the source of the information.

5.2.3. Temperature sensor types (Table 6)

As in Section 5.2.2, but for temperature sensors.

5.2.4. Pressure sensor types (Table 7)

As in Section 5.2.2, but for pressure sensors.

5.2.5. Duct types (Table 8)

This short table gives a explanatory information about ducts.

5.2.6. Balloon types (Table 9)

This "table" lists the types of balloons used to carry the radiosondes.

5.2.7. Humidity algorithms (Table 10)

This table gives explanatory information for the abbreviated "before" and "after" information entries that involve humidity algorithms in the main table.

5.2.8. Radiation corrections (Table 11)

Some explanatory information is given for the abbreviated radiation correction entries used in the main table. In some cases, little was known about the radiation corrections. When available, references are given.

5.2.9. Data correction types (Table 12)

This table explains abbreviations used in the main table for entries dealing with data corrections.

5.2.10. Data cutoff types (Table 13)

This table explains abbreviations used in the main table regarding data cutoffs.

5.2.11. Reporting practices (Table 14)

This table explains abbreviations used in the main table involving reporting practices.

5.2.12. Ground equipment types (Table 15)

This table includes the ground equipment types used in the main table and attempts to provide some explanation. Obtaining information about ground equipment was not considered a priority for this initial metadata set. (See also Section 6.2.6.)

5.2.13. Computing systems (Table 16)

The table explains abbreviations used in the main table to describe the methods by which calculations were made to process radiosonde data.

5.2.14. Country digraphs (Table 17)

This supplemental table gives country names for the two-letter country codes, or digraphs, used in the country code field of the main table. The digraphs are a standardized geopolitical data element promulgated in the Federal Information Processing Standards (FIPS) 10-3 by the National Bureau of Standards, U.S. Department of Commerce, and maintained by the Office of the Geographer, U.S. Department of State. The table allows the user to associate a digraph with the "conventional short form" of the country name, as given in The World Factbook 1993 (CIA, 1993). Table 17 is the complete FIPS list, but not all the digraphs were used in the Station History table.

5.2.15. WMO regions (Table 18)

This table is provided to allow the user to determine in which of the seven WMO regions a particular station is located. The table gives ranges of station identification numbers and the associated WMO region.

6. METADATA QUALITY

Unfortunately, the quality of this upper-air station history metadata set cannot be controlled or assured. It should be recognized that the metadata set contains very little new information; it is simply a compilation, in a consistent format, of information more or less readily available from numerous other sources. As such, the quality of the metadata is not guaranteed and is variable, depending on its source. In addition, the metadata set is a work in progress. This report provides basic documentation of an initial "product" that has been subjected to only a very basic quality control process.

6.1. Basic Quality Control and Quality Flags

Once all the metadata were assembled, it became obvious that some of them could not be accurate. A quality flag is included for many of the fields of each metadata record to give the user some idea of the credibility of the record. Table 2 indicates which fields have associated quality flags.

In general, this field is left blank. If the metadata are of dubious quality, a question mark (?) appears, but the information was retained in this version of the metadata set in case the quality judgment is in error. In some cases, obvious errors in the metadata were corrected, and a "c" appears as a quality flag. Most of the corrections involved inconsistencies in station location information. In the 23,465 metadata records (each containing 11 quality control fields) a total of 3,207 fields are flagged with a "?", and 2,687 were changed and are flagged with a "c". The majority of the fields that were changed were country code fields, which needed to be standardized. Additional quality control information is in the "Uncertain Date" field, which contains the value "Yes" for 38% of all the records, including for all the those derived from the WMO catalogues. (See Section 6.2.7.)

6.2. Known Metadata Problems and Shortcomings

Several caveats regarding the current metadata set are in order:

6.2.1. Provisional nature of the metadata set

The author is aware of the problematic nature of presenting a provisional metadata set. However, even a provisional product has utility for current research. Such a product is of some value to the work of the Comprehensive Aerological Research Data Set (CARDS) project at NCDC and to the efforts of the WMO Commission for Climatology's Rapporteur on Upper-Air Station Histories. In addition, users of a provisional metadata set could assist in identification of errors and suggest improvements. For these reasons, the current metadata set is being made available, and this report provides documentation for it. However the user should be cautious in light of the known shortcomings with the metadata set discussed in Sections 6.2.2-6.2.7, and the likelihood of other, as yet unidentified, problems.

6.2.2. Country identification and station names

Because this metadata set is for meteorological research purposes, not the documentation of political history, there has been no attempt to provide accurate historical information on changes in country names. The country given in each record is generally the current country. Apologies are extended in advance for any incorrectly located stations and for failure to note changes in national boundaries and country names. No political statements should be inferred from such inaccuracies.

The station names in some of the original metadata sources were truncated. No effort has been made to correct them. In addition, multiple station names have been used for some stations, and no effort has been made to impose uniformity.

6.2.3. Station opening and closing dates

There may be some confusion about metadata records indicating "station opened" and "station closed" as events. These records are based on information on station location provided by R. Tanner at NCDC. The dataset from NCDC had station locations presumed valid between two dates, and these dates were used in the current metadata set as the station opening and closing dates at the appropriate location. In many cases, the entry giving the closing date is followed by another entry with a new opening date at a nearby location. In some cases, there are other station history records preceding the record with the first "station opened" event. This is generally the result of the fact that the NCDC dataset may not have included station location information for the early years of station operation.

6.2.4. Incomplete station history information

The historical information for many stations is not complete, and it would be a mistake to assume otherwise. In particular, interpolation of historical information could result in errors. For example, if the metadata set indicates that one type of radiosonde was used at a given station in 1969, and a second type was used in 1980, it is possible that yet a third, unknown type was used during the 1970's.

6.2.5. Plethora of radiosonde types used

Because there is no standard nomenclature for radiosondes, the number of radiosonde types named in the metadata set is enormous, more than 150. The attributes of many of the sonde types are not given, and it is quite likely that some identical sonde types are listed separately under different names.

6.2.6. Dearth of information about ground systems and windfinding methods

As mentioned in Section 2, the focus of this effort was to document changes that may affect climatological upper-air temperature and humidity records. Little effort was expended to determine historical changes in ground systems used at radiosonde stations or in methods of determining winds aloft. Some information is included in the metadata set, but it is far from comprehensive.

6.2.7. Application of information pertaining to countries to individual stations

Many of the sources consulted in preparing the metadata set gave historical information relevant to all (or most) of the upper-air stations in a given country but did not include specific information for each station. Such information was applied to all stations thought to be in the country in question. Potential problems include (1) the possibility that not all stations in a given country were operated in the same manner and (2) the association of historical events with stations that may not have been in operation at the time in question. The WMO catalogues of radiosondes that were provided by the U.K. Meteorological Office (WMO, 1965, 1982; Spackman, 1977; Kitchen, 1986) and some of the historical information derived from Gaffen (1993) are of particular concern.

6.3. Planned Enhanced Quality Control

As part of planned quality checks of this metadata set, it will be used as the basis for an ongoing upper-air station history effort under the auspices of the WMO Commission for Climatology. Roger Tanner of NOAA/NCDC is serving as Rapporteur for Upper-Air Station Histories and intends to base his inquiries to the involved nations on these metadata and request corrections and updated information. His work should result in a metadata set of higher quality than this one.

In addition, this metadata set will be used in conjunction with upper-air data as part of climate research efforts at NOAA's Air Resources Laboratory. We hope to use objective statistical techniques to identify radiosonde data discontinuities and compare the timing of the discontinuities with metadata events. Discrepancies between the two could result in identification of errors in the metadata, which could be noted in future versions of the metadata set.

6.4. How You Can Help

It is hoped that users of this metadata set will also assist in identifying errors. Such information should be forwarded to both of the following individuals:

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7. SUMMARY OF METADATA SET OF UPPER-AIR STATION HISTORIES

The metadata set is a relational database with one main table and 15 associated supplemental tables. The main table has 23,465 metadata records for 2445 stations. Figure 1 gives a broad summary, by WMO region, of the global distribution of the stations and metadata. The density of the metadata can be grossly estimated as the ratio of the number of metadata entries per station in each region. However, it should be noted that within WMO regions, the distribution of metadata among countries, and among stations within countries can be very uneven.

Figure 2 illustrates the temporal distribution of the metadata by showing the number of records in the main station history table per decade, excluding those records associated with national independence dates. In general, the amount of metadata increases with time. It is quite likely that more information for the decade of the 1990's will be collected.

As shown in Figure 3, 40.7% of the metadata events are associated with instruments. Another 27.7% are related to station locations, and 21.5% to data corrections, cutoffs and other observing practices. The main sources of metadata are shown in Figure 4. The majority (42.6%) of the metadata events are based on information in the catalogues of radiosondes in use compiled by the U.K. Meteorological Office.

8. METADATA SET AVAILABILITY

The metadata set is available electronically from NOAA's National Climatic Data Center. To obtain upper-air metadata via the World Wide Web, access NCDC's homepage at *http://www.ncdc.noaa.gov*.

The Microsoft Access version of the metadata set is available via file transfer protocol (ftp). For a direct ftp connection:

a) Enter: *open ftp.ncdc.noaa.gov*

b) Log in as: *ftp* or *anonymous*

c) Use your electronic mail address as the password

d) For a list of available commands, enter: *help*

e) To change to the correct subdirectory, enter: *cd /pub/data/stnhistory*. A text file in this subdirectory should indicate the station history files.

The Microsoft Access file containing the metadata set requires about 11.4 megabytes of storage.

9. ACKNOWLEDGMENTS

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10. REFERENCES

The following are full literature citations for the abbreviated references in the main table and the supplemental tables. The references marked with an asterisk are cited in the current report.

*Antikainen, V., 1973: Solar radiation error of Väisälä radiosonde RS 18. Väisälä News, 57, 3-10.

*Billions, N.S., 1965: Equations for computer processing U.S. Weather Bureau radiosonde temperature and relative humidity data. Rep. No. RR-TN-66-3, U.S. Army Missile Command, Redstone Arsenal, AL, 35809, 6 pp.

*CIA (Central Intelligence Agency), 1993: The World Factbook 1993. 489 pp. plus maps. [Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161, Tel. (703) 487-4650.]

*Dobesch, H., E. Rudel, and K. Zimmermann, 1992: Radiosounding in Austria: A historical review of instruments and data. Papers presented at the WMO Technical Conference on Instruments and Methods of Observation (TECO-92), Vienna, Austria, 11-15 May 1992, WMO/TD - No. 462, Instruments and Observing Methods Report No. 49, pp. 431-435. World Meteorological Organization, Geneva, Switzerland.

*Elliott, W.P., and D.J. Gaffen, 1991: On the utility of radiosonde humidity archives for climate studies. Bull. Amer. Meteor. Soc., 72, 1507-1520.

*Gaffen, D.J., 1993: Historical changes in radiosonde instruments and practices. WMO/TD-No. 541, Instruments and Observing Methods Report No. 50. World Meteorological Organization, Geneva, Switzerland, 123 pp.

*Gaffen, D.J., 1994: Temporal inhomogeneities in radiosonde temperature records. J. Geophys. Res., 99, 3667-3676.

*Hawson, C.L., 1956: Meteorological Office practice for the application of radiation and lag corrections to temperatures measured by radio-sonde MK IIB. Meteor. Mag., 85, 75-78.

*Hayashi, H., Y. Sekiguchi, and A. Yada, 1956: On solar radiation error and its correction of Japanese radiosonde. JMA Geophys. Mag., 27, 361-375.

Horhammer, J., 1971: New Väisälä radiosondes. Väisälä News, 56, 3-7.

Huovila, S., and A. Tuominen, 1990: On the influence of radiosonde lag errors on upper-air climatological data in Finland 1951-1988. Meteorological Publications No.14, Finnish Meteorological Institute, Helsinki, 29 pp. [Available from Government Printing Centre, P.O.B. 516, 00101 Helsinki, Finland.]

*Kitchen, M., 1986, Radiosonde type catalogue. Loose minutes held by U.K. Meteorological Office, Bracknell, Berkshire, D MET O 1/6/1/15, unpublished.

*Kitchen, M., 1988: Compatibility of radiosonde measurements. Observational Services Memorandum (OSM) No. 38. U.K. Meteorological Office, Bracknell, Berkshire, unpublished.

Lindqvist, A., 1963: Väisälä radiosonde type RS12: Introduction to theory, principles and operation. Väisälä News, 19, 3-11.

Lindqvist, A., 1966: New Väisälä radiosonde type RS13 with a transistorized transmitter: Introduction to theory, principles and operation. Väisälä News, 30, 3-11.

*Miyagawa, K., 1990: A quantitative analysis of day-night temperature differences observed by Japanese rawinsondes. Tenki, 2, 38-48. [NASA Tech. Translation NASA-TT-21268, available from SCITRAN, P.O. Box 5456, Santa Barbara, CA 93150, tel. (805) 969-2413.]

*Oakley, T., 1993: Report by the rapporteur on radiosonde compatibility: Part A, WMO catalogue of radiosondes and upper-air wind systems in use by members (1993). WMO/TD-No. 587, Instruments and Observing Methods Report No. 56, World Meteorological Organization, Geneva, Switzerland, 89 pp.

*Parker, D.E., and D.I. Cox, 1995: Towards a consistent global climatological rawinsonde data-base. Int. J. Climatol., 15, 473-496.

Pettifer, R.E.W, 1992: The history of upper-air measurements, Väisälä News, 127/1992, 6-11. [Available from Väisälä Oy, PL 26, SF-00421, Helsinki, Finland.]

*Raj, Y.E.A., V. Mathew, and J.C. Natu, 1987: Discontinuities in temperature and contour heights resulting from change of instruments at Indian radiosonde stations. Mausam, 38, 407-410.

*Schwartz, B.E., and M. Govett, 1992: A hydrostatically consistent North American radiosonde data base at the Forecast Systems Laboratory, 1946-present. NOAA Technical Memorandum ERL FSL-4, NOAA/ERL/FSL, 325 Broadway, Boulder, CO 80303, 81 pp.

*Scrase, F.J., 1954: Radiation and lag errors of the meteorological office radiosonde and the diurnal variation of upper air temperature. Quart. J. Roy. Meteor. Soc., 80, 565-578.

*Scrase, F.J., 1956: Application of radiation and lag corrections to temperatures measured with Meteorological Office radiosonde. Meteor. Mag., 1005(85), 65-78.

*Soden, B.J. and J.R. Lanzante: Satellite and radiosonde climatologies of upper tropospheric water vapor. J. Climate, in press.

*Spackman, E.A., 1977: Compatibility and performance of radiosonde measurements of geopotential height in the lower stratosphere. MET O 20 Technical Note No. II/106, U.K. Meteorological Office, Bracknell, Berkshire, unpublished.

Suzuki, S., and M. Asahi, 1978: Influence of solar radiation on the temperature measurement before and after the change of the length of suspension used for the Japanese radiosonde observation. J. Meteor. Soc. Japan, 56, 61-64.

*Trifonov, G.P., 1980: Fifty years of USSR radiosonde studies on the atmosphere. Meteor. Gidrol., 6, 112-117.

Uddstrom, M.J., 1984: Solar radiation corrections for New Zealand and Australian radiosondes. New Zealand Meteorological Service Scientific Report No. 6, New Zealand Meteorological Service, PO Box 722, Wellington, 43 pp.

*U.S. Weather Bureau, 1964: History and catalogue of upper air data for the period 1946-1960. Key to Meteorological Records Documentation No. 5.21, U.S. Weather Bureau, Washington, DC, 352 pp.

Väisälä, 1967: Radiation error table Type: RSRN12 for Väisälä radiosonde types RS 12, 13 15, calculated 12.3.1967, (Table 9). Väisälä Oy, PL26, SF-00421, Helsinki, Finland. [Complete reference information not available.]

*Väisälä, V., 1965: The radiant and convective radiation error components of the shielded temperature sensor of radiosonde RS12. Väisälä News, 25, 8-11.

*Väisälä Met Systems, 1989: SOND standard sounding program. Ref. No. R0516-1, Date: 1989-01-04, Väisälä Oy, PL26, SF-00421, Helsinki, Finland, 14 pp.

*Väisälä Met Systems, 1990: RS 80 radiosondes. Ref. No. R0422-2, Date: 1990-03-06, Väisälä Oy, PL26, SF-00421, Helsinki, Finland, 16 pp.

*Weather Bureau, 1979: Climate of South Africa: Part 13, Upper-air statistics. WB 39, U.D.C/U.D.K. 551-587(68), Research Division, Weather Bureau, Department of Transport, Pretoria, South Africa, 99 pp.

*Weather Bureau, 1990: Climate of South Africa: Part 14, Upper-air statistics 1968-1987. WB 41, U.D.C/U.D.K. 551-587(68), Weather Bureau, Department of Environment Affairs, Pretoria, South Africa, 136 pp.

*WMO (World Meteorological Organization), 1965: Short-period averages for 1951-1960 and provisional average values for climat temp and climat temp ship stations. WMO/OMM - No.170.TP.84, Geneva, Switzerland.

WMO, 1981: Upper-Air Data Compatibility: WMO catalog of radiosondes in use by members. Instruments and Observing Methods Report No. 5, Geneva, Switzerland, 3 pp. plus 5 tables.

WMO, 1982: WMO catalogue of radiosondes in use by members. Instruments and Observing Methods Report No. 11, Upper-Air Data Compatibility, Geneva, Switzerland, 3 pp. plus 5 tables.

*WMO, 1983: Guide to meteorological instruments and methods of observation, Fifth Edition. WMO-No. 8, Geneva, Switzerland.

*WMO, 1986: WMO catalogue of radiosondes and upper-air wind systems in use by members. Instruments and Observing Methods Report No. 27, WMO/TD-No. 176, Geneva, Switzerland, 27 pp., unnumbered.

*WMO: Operational Newsletter, Geneva, Switzerland. [A regular publication of the World Weather Watch and Marine Meteorological Services, available from WMO, Case Postale 2300, CH-1211 Geneva, Switzerland.]

ACRONYMS

ADRES	Unknown. Refers to mini-computer system used in Canada.
ART	Automatic Radio-Theodolite
CARDS	Comprehensive Aerological Research Data Set
CIA	Central Intelligence Agency
CORA	Correlation Radio Wind System
FIPS	Federal Information Processing Standards
GMD	Ground Meteorological Direction-finding (system)
LORAN	long-range navigation
NCDC	National Climatic Data Center
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
UTC	Universal Coordinated Time
WBRT	Weather Bureau Radiotheodolite
WMO	World Meteorological Organization

Table 1. Event types included in the upper-air metadata set.

Event Type	Explanation	Static or Dynamic	Related Supplemental Table Number
USING SONDE MODEL	Radiosonde models	Static	4
CHANGE SONDE MODEL	Radiosonde models	Dynamic	4
USING RH SENSOR	Relative humidity sensors	Static	5
CHANGE RH SENSOR	Relative humidity sensors	Dynamic	5
USING T SENSOR	Temperature sensors	Static	6
CHANGE T SENSOR	Temperature sensors	Dynamic	6
USING P SENSOR	Pressure sensors	Static	7
CHANGE P SENSOR	Pressure sensors	Dynamic	7
CHANGE T DUCT	Duct types	Static	8
CHANGE RH DUCT	Duct types	Dynamic	8
USING BALLOON TYPE	Balloon types	Static	9
CHANGE BALLOON TYPE	Balloon types	Dynamic	9
USING RH ALGORITHM	Relative humidity algorithms	Static	10
CHANGE RH ALGORITHM	Relative humidity algorithms	Dynamic	10
USING RADIAT. CORR.	Radiation corrections	Static	11
CHANGE RADIAT. CORR	Radiation corrections	Dynamic	11
USING CORRECTION	Data corrections	Static	12
CHANGE CORRECTION	Data corrections	Dynamic	12
USING DATA CUTOFF	Data cutoffs	Static	13
CHANGE DATA CUTOFF	Data cutoffs	Dynamic	13
USING REPORT. PRAC.	Reporting practices	Static	14
CHANGE REPOR. PRAC.	Reporting practices	Dynamic	14
USING GROUND EQUIP.	Ground equipment	Static	15
CHANGE GROUND EQUIP	Ground equipment	Dynamic	15
USING COMPUTER	Computing systems	Static	16
CHANGE COMPUTER	Computing systems	Dynamic	16
USING FREQUENCY	Radio frequency of operation	Static	none
CHANGE FREQUENCY	Radio frequency of operation	Dynamic	none

Table 1 (continued).

Event Type	Explanation	Static or Dynamic	Related Supplemental Table Number
USING WIND EQUIP.	Equipment for determining winds	Static	none
CHANGE WIND EQUIP.	Equipment for determining winds	Dynamic	none
USING CORD LENGTH	Length of suspension cord between balloon and instruments	Static	none
CHANGE CORD LENGTH	Length of suspension cord between balloon and instruments	Dynamic	none
USING GRAVITY VALUE	Value of gravitational constant	Static	none
CHANGE GRAVITY VAL.	Value of gravitational constant	Dynamic	none
USING CALIBRATION	Method of calibrating sensors	Static	none
CHANGE CALIBRATION	Method of calibrating sensors	Dynamic	none
USING BASELINE	Baseline check of sensors before launch	Static	none
CHANGE BASELINE	Baseline check of sensors before launch	Dynamic	none
USING OBS. TIME	Observation time	Static	none
CHANGE OBS. TIME	Observation time	Dynamic	none
OPERATED BY	Entity responsible for station	Static	none
CHANGE OPERATOR	Entity responsible for station	Dynamic	none
STATION OPENED	Station opened	Static	none
STATION MOVED	Station moved	Dynamic	none
STATION CLOSED	Station closed	Static	none
OBS. SUSPENDED	Suspension of observations	Static	none
OBS. PROG. REDUCED	Reduction of observation program	Dynamic	none
OBS. RESUMED	Resumption of observation program	Static	none
OBS. PROG. EXPANDED	Expansion of observation program	Dynamic	none
CHANGE ID NUMBER	Change station identification number	Dynamic	none
CHANGE STATION NAME	Change station name	Dynamic	none
START OF PROBLEM	Start of a problem	Static	none
END OF PROBLEM	End of a problem	Static	none
MISCELLANEOUS	Miscellaneous metadata, including national independence dates	Static or Dynamic	none

Table 2. The format of each metadata record in the main tabled and whether each field has an associated field for a quality control flag.

Field	Quality Flag?	Details
Identification number	yes	WMO station number.
Station name	yes	Often a city name. For U.S. stations, state abbreviation is also given.
Country code	yes	Two-letter FIPS code identifying the country.
Latitude	yes	In decimal form, with positive values for northern hemisphere, negative for southern.
Longitude	yes	In decimal form. Positive values from 0 to 360, increasing westward.
Elevation	yes	In meters above sea level.
Month of event	yes	Month in which the event took place, expressed in Arabic numbers from 01 to 12. If the month is not known, a value of 00 is included in this field.
Year of event	yes	Year in which the event took place.
Uncertain date	no	If the original metadata source was uncertain or unclear about the date of the event, or if the date was judged to be dubious, this field contains "Yes".
Event type	yes	See Table 1 for possibilities.
Alternates	no	In case the event type "USING SONDE MODEL" or "USING RADIAT. CORR." appears more than once for a particular station on a particular date, this field contains "I1", "I2", or "I3" for alternate instruments or "R1", "R2", or "R3" for alternate radiation correction methods. Radiation correction method alternate "R1" should be paired with instrument alternate "I1" , etc.
Before information	yes	For static events, the pertinent information for the date in question. For dynamic events, the relevant information for the period preceding the change date.
Link	no	Either the word "to" (for dynamic events) or blank (for static events).
After information	yes	For static events, nothing appears in this field. For dynamic events, the relevant information for the period following the change date.
Reference	no	An abbreviated citation of the source of metadata. See the reference section of this report for full citations.
Comment	no	Any non-standard information or explanatory text.
Record number	no	A number whose value is unique for each record. Because the metadata have been sorted since initial entry, the record numbers are not in strict numerical order.

Table 3. A sample of records from the main Station History table for five stations. Each record spans two pages. The fields shown are those listed in Table 2, except the "Comment" and "Record Number" fields are not shown.

WMO I	QF-	Station Name	QF-	Cou	QF-	Latitu	QF-	Longitu	QF-	Eleva	QF-	Mon	QF-	Year	QF-	Dat
28440		SVERDLOVSK		RS		56.7		298.9		287		00		1936		No
28440		SVERDLOVSK		RS		56.7		298.9		287		00		1960		Yes
28440		SVERDLOVSK		RS		56.7		298.9		287		00		1961		No
28440		SVERDLOVSK		RS		56.7		298.9		287		00		1964		No
28440		SVERDLOVSK		RS		56.7		298.9		287		08		1967		No
28440		SVERDLOVSK		RS		56.7		298.9		287		00		1976		Yes
28440		SVERDLOVSK		RS		56.7		298.9		287		00		1986		Yes
28440		SVERDLOVSK		RS		56.7		298.9		287		03		1986		No
28440		SVERDLOVSK		RS		56.7		298.9		287		06		1988		No
28440		SVERDLOVSK		RS		56.7		298.9		287		00		1989		Yes
28440		SVERDLOVSK		RS		56.7		298.9		287		08		1991		No
28440		SVERDLOVSK		RS		56.8		299.4		287		12		1992		No
28440		SVERDLOVSK		RS		56.8		299.4		287		12		1992		No
52836		DULAN		CH		36.3		261.9		3400		00		221		No
52836		DULAN		CH	c	36.3		261.9		3400		12		1955		No
52836		DULAN		CH		36.3		261.9		3400		12		1955		No
52836		DULAN		CH		36.3		261.9		3400		04		1956		No
52836		DULAN		CH		36.3		261.9		3180		05		1956		No
52836		DULAN		CH		36.3		261.9		3180		12		1956		No
52836		DULAN		CH	c	36.3		261.9		3180		00		1957		No
52836		DULAN		CH		36.3		262		3190		01		1957		No
52836		DULAN		CH	c	36.3		262		3190		00		1959		Yes
52836		DULAN		CH	c	36.3		262		3190		00		1959		No
52836		DULAN		CH	c	36.3		262		3190		00		1965		No
52836		DULAN		CH		36.3		262		3190		12		1973		No
52836		DULAN		CH		36.3		261.9		3190		01		1974		No
52836		DULAN		CH		36.3		261.9		3190		00		1976		Yes
52836		DULAN		CH		36.3		261.9		3190		00		1986		Yes
52836		DULAN		CH		36.3		261.9		3190		00		1986		Yes
52836		DULAN		CH		36.3		261.9		3190		00		1989		Yes
52836		DULAN		CH	c	36.3		261.9		3190		11		1990		No
52836		DULAN		CH	c	36.3		261.9		3190		11		1990		No
52836		DULAN		CH		36.3		262		3192	?	12		1992		No
52836		DULAN		CH		36.3		262		3192	?	12		1992		No
68263		PRETORIA/IRENE		SF		-26		331.8		1525		04		1910		No
68263	?	PRETORIA		SF		-26		331.8			?	02		1959		No
68263	?	PRETORIA		SF		-26		331.8			?	02		1959		No
68263		PRETORIA/IRENE		SF		-26		331.8		1525		00		1960		Yes
68263		PRETORIA (IRENE)		SF	c	-26		331.8		1525		00		1970		Yes
68263	?	PRETORIA		SF		-26		331.8			?	09		1972		No
68263	?	PRETORIA		SF		-26		331.8			?	03		1974		No
68263		PRETORIA/IRENE		SF		-26		331.8		1525		07		1974		No
68263	?	PRETORIA/IRENE		SF		-26		331.8			?	09		1985		No
68263		PRETORIA/IRENE		SF		-26		331.8		1525		00		1986		Yes
68263		PRETORIA/IRENE		SF		-26		331.8		1525		04		1987		No
68263		PRETORIA/IRENE		SF		-26		331.8		1525		04		1987		No
68263		PRETORIA/IRENE		SF		-26		331.8		1525		00		1989		Yes
68263		PRETORIA (IRENE)		SF	c	-26		331.8		1525	c	12		1990		No
68263		PRETORIA (IRENE)		SF		-26		331.8		1523	?	01		1993		No

Table 3 (continued).

Event Type	Alt	QF-	Before Information	QF	Link	After Information	QF-	Reference
STATION OPENED								NOAA NCDC
USING SONDE MODEL	I1		RZ 049					UK Met. O. (pers. comm.)
CHANGE SONDE MODEL			RS 049		to	A22 SERIES		USSR station history
CHANGE SONDE MODEL			A22 SERIES		to	RKZ 1		USSR station history
CHANGE SONDE MODEL			RKZ 1		to	RKZ 2		USSR station history
USING SONDE MODEL	I1		A22 SERIES					UK Met. O. (pers. comm.)
USING SONDE MODEL	I1		MARS					UK Met. O. (pers. comm.)
CHANGE SONDE MODEL			RKZ 2		to	MARS		USSR station history
CHANGE SONDE MODEL			MARS		to	MRZ		USSR station history
USING SONDE MODEL	I1		MARS					UK Met. O. (pers. comm.)
MISCELLANEOUS								CIA (1993)
USING SONDE MODEL	I1		MRZ					Oakley (1993)
USING RADIAT. CORR.	R1		MISC. RADIATION COR.					Oakley (1993)
MISCELLANEOUS								CIA (1993)
USING SONDE MODEL			RZ 049					PanMao Zhai (pers. comm.)
STATION OPENED								NOAA NCDC
STATION CLOSED								NOAA NCDC
STATION OPENED								NOAA NCDC
STATION CLOSED								NOAA NCDC
CHANGE CORRECTION			NO CORRECTION		to	VIRTUAL TEMP. CORR.		Gaffen (1993)
STATION OPENED								NOAA NCDC
CHANGE SONDE MODEL			VAISALA RS12		to	RZ 049		Gaffen (1993)
CHANGE RADIAT. CORR			NO RAD. CORRECTION		to	MISC. RADIATION COR		Gaffen (1993)
CHANGE SONDE MODEL			RZ 049		to	GZZ-2		PanMao Zhai (pers. comm.)
STATION CLOSED								NOAA NCDC
STATION OPENED								NOAA NCDC
USING SONDE MODEL	I1		GZZ-2					UK Met. O. (pers. comm.)
USING SONDE MODEL	I1		GZZ-2					UK Met. O. (pers. comm.)
USING RADIAT. CORR.	R1		MISC. RADIATION COR.					UK Met. O. (pers. comm.)
USING SONDE MODEL	I1		GZZ-2					UK Met. O. (pers. comm.)
USING DATA CUTOFF			NO DATA ABOVE 10 MB					Gaffen (1993)
USING DATA CUTOFF			RH MISSING FOR T<-60					Gaffen (1993)
USING SONDE MODEL	I1		SHANGHAI RADIO					Oakley (1993)
USING RADIAT. CORR.	R1		MISC. RADIATION COR.					Oakley (1993)
MISCELLANEOUS								CIA (1993)
USING SONDE MODEL	I1		VAISALA RS13					Weather Bureau (1979)
USING SONDE MODEL	I2		VAISALA RS12					Weather Bureau (1979)
USING SONDE MODEL	I1		VAISALA (Generic)					UK Met. O. (pers. comm.)
CHANGE SONDE MODEL			VAISALA (Generic)		to	WEATHERMEASURE		Gaffen (1993)
CHANGE SONDE MODEL			VAISALA RS13		to	VIZ (GENERIC)		Weather Bureau (1979)
CHANGE SONDE MODEL			VIZ (GENERIC)		to	VAISALA RS21		Weather Bureau (1979)
STATION OPENED								NOAA NCDC
CHANGE SONDE MODEL			VAISALA RS21		to	VAISALA RS80		Weather Bureau (1990)
USING SONDE MODEL	I1		VAISALA RS21					UK Met. O. (pers. comm.)
STATION CLOSED								NOAA NCDC
STATION OPENED								NOAA NCDC
USING SONDE MODEL	I1		VAISALA RS80					UK Met. O. (pers. comm.)
USING SONDE MODEL			VAISALA RS80					Gaffen (1993)
USING SONDE MODEL	I1		VAISALA RS80					Oakley (1993)

Table 3 (continued).

WMO I	QF-	Station Name	QF-	Cou	QF-	Latitu	QF-	Longitu	QF-	Eleva	QF-	Mon	QF-	Year	QF-	Dat
70219		BETHEL AK		US		60.8		161.7		8		00		1776		No
70219		BETHEL AK		US		60.8		161.7		8		10		1940		No
70219		BETHEL AK		US		60.8		161.7		8		10		1954		No
70219		BETHEL AK		US		60.8		161.7		4		11		1954		No
70219		BETHEL AK		US		60.8		161.7		4		07		1955		No
70219		BETHEL AK		US		60.8		161.7		11		11		1956		No
70219		BETHEL AK		US		60.8		161.7		4		11		1956		No
70219		BETHEL AK		US		60.8		161.7		11		12		1956		No
70219		BETHEL AK		US		60.8		161.8		4		01		1957		No
70219		BETHEL AK		US		60.8		161.8		39		11		1958		No
70219		BETHEL AK		US		60.8		161.8		4		11		1958		No
70219		BETHEL AK		US		60.8		161.8		39		09		1960		No
70219		BETHEL AK		US		60.8		161.8		39		04		1965		No
70219		BETHEL AK		US		60.8		161.8		39		03		1972		No
70219		BETHEL AK		US		60.8		161.8		39		11		1981		No
70219		BETHEL AK		US		60.8		161.8		36		11		1981		No
70219		BETHEL AK		US		60.8		161.8		36		09		1986		No
70219		BETHEL AK		US		60.8		161.8		36		10		1988		No
70219		BETHEL AK		US		60.8		161.8		36		00		1989		Yes
70219		BETHEL AK		US		60.8		161.8		36		07		1989		No
70219		BETHEL AK		US		60.8		161.8		36		03		1990		No
70219		BETHEL AIRPORT AK		US		60.8		161.8		46	?	12		1992		No
70219		BETHEL AK		US		60.8		161.8		36		07		1995		No
70219		BETHEL AK		US		60.8		161.8		36		11		1995		No
93012		KAITAIA		NZ		-35		186.3		80	c	09		1907		No
93012		KAITAIA		NZ		-35		186.3		80	c	00		1960		Yes
93012		KAITAIA		NZ		-35		186.3		80	c	10		1960		Yes
93012		KAITAIA		NZ		-35		186.3		80	c	00		1981		Yes
93012		KAITAIA		NZ		-35		186.3		80	c	00		1982		Yes
93012		KAITAIA		NZ		-35		186.3		80	c	00		1982		Yes
93012		KAITAIA		NZ		-35		186.3		87		08		1985		No
93012		KAITAIA		NZ		-35		186.3		87		00		1986		Yes
93012		KAITAIA		NZ		-35		186.3		87		00		1989		Yes
93012		KAITAIA		NZ		-35		186.7		87	c	03		1989		No
93012		KAITAIA		NZ		-35		186.7		86.0	?	01		1993		No
93012		KAITAIA		NZ		-35		186.7		86.0	?	01		1993		No

Table 3 (continued).

Event Type	Alt	QF-	Before Information	QF	Link	After Information	QF-	Reference
MISCELLANEOUS								CIA (1993)
STATION OPENED								NOAA NCDC
STATION CLOSED								NOAA NCDC
STATION OPENED								NOAA NCDC
CHANGE GROUND EQUIP			72.2 MHz		to	SCR 658 & METOX		Schwartz & Govett (1992)
STATION OPENED								NOAA NCDC
STATION CLOSED								NOAA NCDC
STATION CLOSED								NOAA NCDC
STATION OPENED								NOAA NCDC
STATION OPENED								NOAA NCDC
STATION CLOSED								NOAA NCDC
CHANGE GROUND EQUIP			SCR 658 & METOX		to	WBRT-57		Schwartz & Govett (1992)
CHANGE RH SENSOR			LiCl HYGRISTOR		to	CARBON HYGRISTOR		Schwartz & Govett (1992)
CHANGE RH DUCT			DUCT		to	RE-DESIGNED DUCT		Schwartz & Govett (1992)
STATION CLOSED								NOAA NCDC
STATION OPENED								NOAA NCDC
CHANGE COMPUTER			MINI-COMPUTER		to	MINI-ART 2 SYSTEM		Schwartz & Govett (1992)
USING SONDE MODEL			VIZ B					Schwartz & Govett (1992)
USING SONDE MODEL	I1		SPACE DATA					UK Met. O. (pers. comm.)
CHANGE SONDE MODEL			VIZ (Generic)		to	SPACE DATA		NOAA NWS
CHANGE COMPUTER			MINI-ART 2 SYSTEM	?	to	MICRO-ART SYSTEM		NOAA NWS
USING SONDE MODEL	I1		SPACE DATA					Oakley (1993)
CHANGE SONDE MODEL			SPACE DATA		to	VIZ B		NOAA NWS
CHANGE SONDE MODEL			VIZ B		to	VAISALA RS80-56		NOAA NWS
MISCELLANEOUS								CIA (1993)
USING SONDE MODEL	I1		DIAMOND HINMAN					UK Met. O. (pers. comm.)
CHANGE T DUCT			NO DUCT		to	DUCT		Gaffen (1993)
CHANGE RH SENSOR			LiCl HYGRISTOR		to	CARBON HYGRISTOR		Gaffen (1993)
USING SONDE MODEL	I1		VIZ 1395					UK Met. O. (pers. comm.)
USING RADIAT. CORR.	R1		NO RAD. CORRECTION					UK Met. O. (pers. comm.)
STATION OPENED								NOAA NCDC
USING SONDE MODEL	I1		VIZ 1395					UK Met. O. (pers. comm.)
USING SONDE MODEL	I1		VIZ (Generic)					UK Met. O. (pers. comm.)
CHANGE SONDE MODEL			UNKNOWN SONDE		to	VAISALA RS80		Gaffen (1993)
USING SONDE MODEL	I1		VAISALA RS80					Oakley (1993)
USING RADIAT. CORR.	R1		VAISALA RS80 1986					Oakley (1993)

Table 4. Radiosonde types, their country of origin, and their sensors. This is a small subset of the full table in the digital metadata set and is meant only as a sample of the type of information included.

Type	Country	Temperature Sensor	Humidity Sensor	Pressure Sensor
A22-III (403 MHz)	USSR	Spiral bimetal plate	Goldbeater's skin	Two bronze aneroid boxes with thermal compensation
Graw M60 (27 and 403 MHz)	Germany	Bimetal cylinder	Artificial hair	Aneroid capsule
GZZ-7	China	Rod thermistor	Carbon hygristor	Nickel span C aneroid
India Mark 3 (401 and 1680 MHz)	India	Rod thermistor with titanium dioxide coating	Lithium chloride hygristor	Baroswitch
Kew Mark IIB	United Kingdom	Cylindrical bimetallic strip	Unvarnished goldbeater's skin	Aneroid capsule
MARS (1782 MHz) (Also known as MARZ)	USSR	Rod thermistor (covered with anti-radiation hydrophobic varnish since 1967)	Goldbeater's skin	None
Meisei RSII-80	Japan	White glass-coated thermistor	Carbon hygristor	Nickel-span aneroid capsule
Mesural FMO 1944C (400 MHz)	France	White-coated rod thermistor (VIZ military model)	Goldbeater's skin diaphragm	Aneroid capsule (pre-calibrated)
Philips Mark II	Australia	White ceramic rod resistor	Lithium chloride	Single aneroid capsule
SRS-400 (Meteolabor)	Switzerland	Thermocouple	VIZ Accu-Lok Hygristor (13286-065)	Water hypsometer
Väisälä RS80	Finland	THERMOCAP - ceramic capacitive bead	HUMICAP - capacitive thin film element	BAROCAP - capacitive aneroid sensor
VIZ 1395 (403 MHz)	USA	Rod thermistor with white coating	Carbon hygristor	Baroswitch

Table 5. Humidity sensor types and operating principles.

Humidity Sensor	Operating Principle	Reference
HUMAN HAIR	The length of human hair increases with increasing relative humidity.	WMO (1983)
ROLLED HUMAN HAIR	The length of human hair increases with relative humidity. Hairs that have been flattened with rollers have improved response.	WMO (1983)
GOLDBEATERS SKIN	A membrane from the intestine of an ox (used also to separate gold leaf) changes length in response to humidity changes.	WMO (1983)
LiCl HYGRISTOR	The resistance of a strip coated with an electrolytic film of lithium chloride increases with increasing relative humidity.	WMO (1983)
CARBON HYGRISTOR	Finely divided carbon particles are suspended in a hygroscopic film whose length changes with humidity, and the resistance increases with humidity.	WMO (1983)
RE-DESIGNED RH DUCT	Humidity sensor is housed in a newly designed duct.	None
HUMICAP - BEAD	A thin-film sensor whose capacitance varies with relative humidity. A polymer serves as a dielectric material on this sensor, used on Väisälä radiosondes.	Väisälä Met Systems (1990)

Table 6. Temperature sensor types.

Temperature Sensor	Operating Principle	Reference
THERMISTOR	The electrical resistance of a ceramic element changes with temperature.	WMO (1983)
ROD THERMISTOR	The electrical resistance of a cylindrical ceramic element changes with temperature.	WMO (1983)
BEAD THERMISTOR	The electrical resistance of a spherical ceramic element changes with temperature.	WMO (1983)
BIMETAL	Two metals of different expansivity (usually invar and steel or invar and brass) are riveted or welded together so that the element bends when heated.	WMO (1983)
BIMETAL COIL	A bimetal in the shape of a coil.	WMO (1983)
BIMETAL STRIP	A bimetal in the shape of a strip.	WMO (1983)
CERAMIC FLAKE	Uncertain.	
THERMOCAP - BEAD	The capacitance of a dielectric ceramic bead changes with temperature. Used on Väisälä radiosondes.	Väisälä Met Systems (1990)
WIRE RESISTOR	The resistance of a metal wire changes with temperature.	WMO (1983)
BOURDON TUBE	Uncertain. (Bourdon tubes are generally associated with pressure measurements.)	
CAPACITIVE TYPE	Uncertain. Probably, sensor capacitance varies with temperature.	
ELECTROLYTIC TYPE	Uncertain.	

Table 7. Pressure sensor types.

Pressure Sensor	Operating Principle	Reference
ANEROID	Capsule made of metal with elastic properties deflects with changes in atmospheric pressure.	WMO (1983)
BOURDON TUBE	A tube of elliptical cross section changes in cross section and length as a function of atmospheric pressure.	WMO (1983)
BELLOWS TYPE	Flexible bellows respond to changes in atmospheric pressure.	WMO (1983)
BAROCAP	Small aneroid capsule responds to changes in pressure measured by capacitive transducer plates inside. Used on Väisälä radiosondes.	Väisälä Met Systems (1990)
HYPSOMETER	An electrical thermometer measures the boiling point of a liquid, which is a function of atmospheric pressure.	WMO (1983)

Table 8. Duct types.

Abbreviated Entry in Main Table	Explanation
NO DUCT	Sensor is not in a duct.
DUCT	Sensor is in a duct.
REDESIGNED DUCT	Sensor is not changed, but the duct design is changed.

Table 9. List of balloon types.

VARNISHED PAPER
GOLDBEATERS SKIN
SILK
RUBBER
MULTIPLE BALLOON
WITH PARACHUTE
LATEX
PLASTIC

Table 10. Humidity algorithms.

Abbreviated Entry in Main Table	Explanation
MANUALLY COMPUTED	Humidity computations are made by hand.
SLIDE RULE	A specially designed slide rule is used.
GRAPH	A specially designed graph is used.
NOMOGRAM	A specially designed graph and ruler are used.
EVALUATOR	A specially designed mechanical device, often circular, operated much like a slide rule, is used.
PSYCHROMETRIC TABLE	Numerical tables are used.
AUTOMATIC COMPUTING	Computations are done by machine (computer).
CORRECTED ALGORITHM	An earlier algorithm has been corrected.
BILLIONS ALGORITHM	Algorithm developed by Billions (1965)
MISC. ALGORITHM	Miscellaneous algorithm.

Table 11. Radiation corrections.

Abbreviated Entry in Main Table	Explanation	Reference
NO RAD. CORRECTION	No radiation corrections are applied.	
MISC. RADIATION COR.	A radiation correction is applied.	
SCRASE CORRECTIONS	Corrections developed for the U.K. Meteorological Office MKIIB radiosonde.	Scrase (1954, 1956); Hawson (1956)
VAISALA CORRECTIONS	Corrections developed by Väisälä are applied.	
VAISALA RS18	Corrections developed by Väisälä for the RS18 radiosonde are applied.	Antikainen (1973); Väisälä (1965)
VAISALA RS21	Corrections developed by Väisälä for the RS21 radiosonde are applied.	
VAISALA RS80 1982	Corrections developed by Väisälä in 1982 for the RS80 radiosonde are applied.	
VAISALA RS80 1986	Corrections developed by Väisälä in 1986 for the RS80 radiosonde are applied.	Väisälä Met Systems (1989)
VAISALA 1986 NO I.R	Solar radiation corrections developed by Väisälä in 1986 for the RS80 radiosonde are applied but without the infrared component.	
VAISALA RS80 1993	Corrections developed by Väisälä in 1993 for the RS80 radiosonde are applied.	
COR. AT 30 & 50 MB	Corrections are made at 30 and 50 mb.	
COR. BET. 400 & 10 MB	Corrections are made for levels between 400 and 10 mb.	Gaffen (1993; see page 86 on United States); Hayashi et al. (1956)
COR. AT 200 & 100 MB	Corrections are made at 200 and 100 mb.	Gaffen (1993; see page 44 on Hong Kong)
UKMO KEW MK3 COR.	Corrections for the U.K. Meteorological Office MK3 radiosonde.	
GRAW M60 CORRECTIONS	Corrections for the Graw M60 radiosonde.	
GRAW 1978 COR.	Uncertain. Probably corrections developed in 1978 for the Graw radiosonde.	
DESIGNED FOR UCCLE	Uncertain. Probably specific corrections designed for application at the Uccle, Belgium, station.	

Table 12. Data correction types.

Abbreviated Entry in Main Table	Explanation
NO CORRECTION	No corrections are applied.
TEMP. LAG CORRECTION	Corrections are applied to adjust for the lag in the temperature sensor.
RH LAG CORRECTION	Corrections are applied to adjust for the lag in the relative humidity sensor.
PRES. LAG CORRECTION	Corrections are applied to adjust for the lag in the pressure sensor.
MISC. CORRECTION	A miscellaneous correction is applied.
VIRTUAL TEMP. CORR.	Uncertain. Probably, this involves the (correct) use of virtual temperature, rather than (incorrect) use of temperature, in the calculation of geopotential height.

Table 13. Data cutoff types.

Abbreviated Entry in Main Table	Explanation
NO CUTOFFS	Data reported for the entire sounding.
NO DATA ABOVE 10 MB	Soundings terminated at 10 mb.
NO RH ABOVE 200 MB	Humidity data terminated at 200 mb.
NO RH ABOVE 300 MB	Humidity data terminated at 300 mb.
RH MISSING FOR T<-40	Humidity data not reported for temperature below -40°C.
T<-65 OR RH<9% NO RH	Humidity data not reported for temperature below -65°C or relative humidity below 9%.
T<-40 OR RH<15 NO RH	Humidity data not reported for temperature below -40°C or relative humidity below 15%.
P<300 OR T<-40 NO RH	Humidity data not reported for pressure lower than 300 mb or temperature below -40°C.
P<200 OR T<-60 NO RH	Humidity data not reported for pressure lower than 200 mb or temperature below -60°C.
P<200 OR T<-65 NO RH	Humidity data not reported for pressure lower than 200 mb or temperature below -65°C.
P<100 OR T<-60 NO RH	Humidity data not reported for pressure lower than 100 mb or temperature below -60°C.
RH MISSING FOR T<-60	Humidity data not reported for temperature below -60°C.
DEW PT=30 FOR RH<30%	Dew point depression reported at 30° when relative humidity is below 30%.
DEW PT=30 FOR RH<20%	Dew point depression reported at 30° when relative humidity is below 20%.
SET RH=10% FOR RH<10%	Relative humidity is set at 10% for all values measured as less than 10%.
MISC. CUTOFF	Miscellaneous cutoff.

Table 14. Reporting practices.

Abbreviated Entry in Main Table	Explanation
WINDS IN M/SEC	Winds are reported in units of meters per second.
WINDS IN KNOTS	Winds are reported in units of knots (nautical miles per hour).
HUMIDITY AS RH	Humidity data are given in terms of relative humidity.
HUMIDITY AS DEW PT.	Humidity data are given in terms of dew point temperature.
HUMIDITY AS DPD	Humidity data are given in terms of dew point depression.

Table 15. Ground equipment types.

Ground System	Explanation
72.2 MHz	A short-wave receiver operating a 72.2 MHz. Audiomodulated signals are recorded on a chart roll. See U.S. Weather Bureau (1964) for details.
SCR 584	Signal Corps Radio-direction-finder. Manually operated electronic tracking device.
SCR 658 & METOX	Signal Corps Radio-direction-finder. Manually operated electronic tracking device. See U.S. Weather Bureau (1964) for details. The of meaning notation "SCR 658 & METOX" is unclear.
GMD	Ground Meteorological Direction-finding. Electronic theodolite and radio receiver developed by U.S. military. See U.S. Weather Bureau (1964) for details.
GMD-1	First operational version of the GMD system. See U.S. Weather Bureau (1964) for details.
GMD-1A	Version of the GMD-1 system.
GMD-1B	Version of the GMD-1 system.
GMD-4	Version of the GMD system, presumably with a transponder system, allowing the measurement of slant range (as was included in the GMD-2 design). See U.S. Weather Bureau (1964) for details.
WBRT-57	U.S. Weather Bureau radiotheodolite, based on the GMD technology.
WBRT-60	U.S. Weather Bureau radiotheodolite.
LORAN	System using long-range navigation.
OPTICAL THEODOLITE	Visual tracking of balloon using optical theodolite.
RADIOTHEODOLITE	Radio tracking of balloon using radiotheodolite.
ADRES	Canadian computerized ground station. See Gaffen (1993).

Table 16. Computing systems.

Abbreviated Entry in Main Table	Explanation
MANUAL METHODS	Human operators compute meteorological quantities using graphs of radio signals as a function of flight time.
CALCULATOR	Electronic calculators are used in computations of meteorological quantities.
SEMI-AUTOMATIC'METH.	Some, but not all, of the calculations are made automatically, with the aid of a programmable desktop calculator.
AUTOMATIC METHODS	All the data reduction is done automatically, by computer.
TRANSISTORIZED EQUIP.	Computers based on transistor technology are used.
TIME SHARE COMPUTER	Computations are done with the aid of a large computer, not dedicated to the task of radiosonde data processing.
MINI-COMPUTER	Computations are done using a personal computer.
CORA	Computations are made by the Väisälä Correlation Radio Wind System (CORA) dedicated ground system, which also tracks the radiosonde using the OMEGA navigational network.
MICROCORA	Computations are made by the Väisälä MicroCORA dedicated ground system.
DIGICORA	Computations are made by the Väisälä DigiCORA dedicated ground system, which also tracks the radiosonde using the Navaid navigational networks.
ART SYSTEM	Computations are made by the U.S. National Weather Service Automatic Radio-Theodolite ground system, which employs a desktop computer.
MINI-ART 1 SYSTEM	Updated version of the ART system.
MINI-ART 2 SYSTEM	Further updated version of the ART system.
MICRO-ART SYSTEM	An updated system based on MINI-ART.

Table 17. Country digraphs and associated country names.

Digraph	Country	Digraph	Country
AF	Afghanistan	IO	British Indian Ocean Territory
AL	Albania	VI	British Virgin Islands
AG	Algeria	BX	Brunei
AQ	American Samoa	BU	Bulgaria
AN	Andorra	UV	Burkina
AO	Angola	BM	Burma
AV	Anguilla	BY	Burundi
AY	Antarctica	CB	Cambodia
AC	Antigua and Barbuda	CM	Cameroon
XQ	Arctic Ocean	CA	Canada
AR	Argentina	CV	Cape Verde
AM	Armenia	CJ	Cayman Islands
AA	Aruba	CT	Central African Republic
AT	Ashmore and Cartier Islands	CD	Chad
ZH	Atlantic Ocean	CI	Chile
AS	Australia	CH	China
AU	Austria	KT	Christmas Island
AJ	Azerbaijan	IP	Clipperton Island
BF	The Bahamas	CK	Cocos (Keeling) Islands
BA	Bahrain	CO	Colombia
FQ	Baker Island	CN	Comoros
BG	Bangladesh	CF	Congo
BB	Barbados	CW	Cook Islands
BS	Bassas da India	CR	Coral Sea Islands
BO	Belarus	CS	CostaRica
BE	Belgium	IV	Cote d'Ivoire
BH	Belize	HR	Croatia
BN	Benin	CU	Cuba
BD	Bermuda	CY	Cyprus
BT	Bhutan	EZ	Czech Republic
BL	Bolivia	DA	Denmark
BK	Bosnia and Herzegovina	DJ	Djibouti
BC	Botswana	DO	Dominica
BV	Bouvet Island	DR	Dominican Republic
BR	Brazil	EC	Ecuador

Table 17 (continued).

Digraph	Country	Digraph	Country
EG	Egypt	VT	Holy See (Vatican City)
ES	El Salvador	HO	Honduras
EK	Equatorial Guinea	HK	Hong Kong
ER	Eritrea	HQ	Howland Island
EN	Estonia	HU	Hungary
ET	Ethiopia	IC	Iceland
EU	Europa Island	IN	India
FA	Falkland Islands (Islas Malvinas)	XO	Indian Ocean
FO	Faroe Islands	ID	Indonesia
FJ	Fiji	IR	Iran
FI	Finland	IZ	Iraq
FR	France	EI	Ireland
FG	French Guiana	IS	Israel
FP	French Polynesia	IT	Italy
FS	French Southern and Antarctic Lands	JM	Jamaica
GB	Gabon	JN	Jan Mayen
GA	The Gambia	JA	Japan
GZ	Gaza Strip	DQ	Jarvis Island
GG	Georgia	JE	Jersey
GM	Germany	JQ	Johnston Atoll
GH	Ghana	JO	Jordan
GI	Gibraltar	JU	Juan de Nova Island
GO	Glorioso Islands	KZ	Kazakhstan
GR	Greece	KE	Kenya
GL	Greenland	KQ	Kingman Reef
GJ	Grenada	KR	Kiribati
GP	Guadeloupe	KN	North Korea
GQ	Guam	KS	South Korea
GT	Guatemala	KU	Kuwait
GK	Guernsey	KG	Kyrgyzstan
GV	Guinea	LA	Laos
PU	Guinea-Bissau	LG	Latvia
GY	Guyana	LE	Lebanon
HA	Haiti	LT	Lesotho
HM	Heard Island and McDonald Islands	LI	Liberia

Table 17 (continued).

Digraph	Country	Digraph	Country
LY	Libya	NU	Nicaragua
LS	Liechtenstein	NG	Niger
LH	Lithuania	NI	Nigeria
LU	Luxembourg	NE	Niue
MC	Macau	NF	Norfolk Island
MK	Macedonia	CQ	Northern Mariana Islands
MA	Madagascar	NO	Norway
MI	Malawi	MU	Oman
MY	Malaysia	NQ	Pacific Islands (Palau)
MV	Maldives	ZN	Pacific Ocean
ML	Mali	PK	Pakistan
MT	Malta	LQ	Palmyra Atoll
IM	Isle of Man	PM	Panama
RM	Marshall Islands	PP	Papua New Guinea
MB	Martinique	PF	Paracel Islands
MR	Mauritania	PA	Paraguay
MP	Mauritius	PE	Peru
MF	Mayotte	RP	Philippines
MX	Mexico	PC	Pitcairn Islands
FM	Federated States of Micronesia	PL	Poland
MQ	Midway Islands	PO	Portugal
MD	Moldova	QR	Puerto Rico
MN	Monaco	QA	Qatar
MG	Mongolia	RE	Reunion
MH	Montserrat	RO	Romania
MO	Morocco	RS	Russia
MZ	Mozambique	RW	Rwanda
WA	Namibia	SH	Saint Helena
NR	Nauru	SC	Saint Kitts and Nevis
BQ	Navassa Island	ST	Saint Lucia
NP	Nepal	SB	Saint Pierre and Miquelon
NL	Netherlands	VC	Saint Vincent and the Grenadines
NA	Netherlands Antilles	SM	San Marino
NC	New Caledonia	TP	Sao Tome and Principe
NZ	New Zealand	SA	Saudi Arabia

Table 17 (continued).

Digraph	Country	Digraph	Country
SG	Senegal	UP	Ukraine
SR	Serbia and Montenegro	TC	United Arab Emirates
SE	Seychelles	UK	United Kingdom
SL	Sierra Leone	US	United States
SN	Singapore	UY	Uruguay
LO	Slovakia	UZ	Uzbekistan
SI	Slovenia	NH	Vanuatu
BP	Solomon Islands	VE	Venezuela
SO	Somalia	VM	Vietnam
SF	South Africa	VQ	Virgin Islands
SX	South Georgia and the South Sandwich Islands	WQ	Wake Island
SP	Spain	WF	Wallis and Futuna
PG	Spratly Islands	WG	West Bank
CE	Sri Lanka	WI	Western Sahara
SU	Sudan	WS	Western Samoa
NS	Suriname	XX	World
SV	Svalbard	YM	Yemen
WZ	Swaziland	CG	Zaire
SW	Sweden	ZA	Zambia
SZ	Switzerland	ZI	Zimbabwe
SY	Syria	TW	Taiwan
TI	Tajikistan		
TZ	Tanzania		
TH	Thailand		
TO	Togo		
TL	Tokelau		
TN	Tonga		
TD	Trinidad and Tobago		
TE	Tromelin Island		
TS	Tunisia		
TU	Turkey		
TX	Turkmenistan		
TK	Turks and Caicos Islands		
TU	Tuvalu		
UG	Uganda		

Table 18. WMO regions.

Station Number Range			
Start	End	Region Number	Region Name
00001	19999	VI	Europe
20000	20099	II	Asia
20100	20199	VI	Europe
20200	21999	II	Asia
22000	22999	VI	Europe
23000	25999	II	Asia
26000	27999	VI	Europe
28000	32999	II	Asia
33000	34999	VI	Europe
35000	36999	II	Asia
37000	37999	VI	Europe
38000	39999	II	Asia
40000	40349	VI	Europe
40350	48599	II	Asia
48600	48799	V	Southwest Pacific
48800	49999	II	Asia
50000	59999	II	Asia
60000	69999	I	Africa
70000	79999	IV	North and Central America
80000	88999	III	South America
89000	89999	VII	Antarctica
90000	98999	V	Southwest Pacific

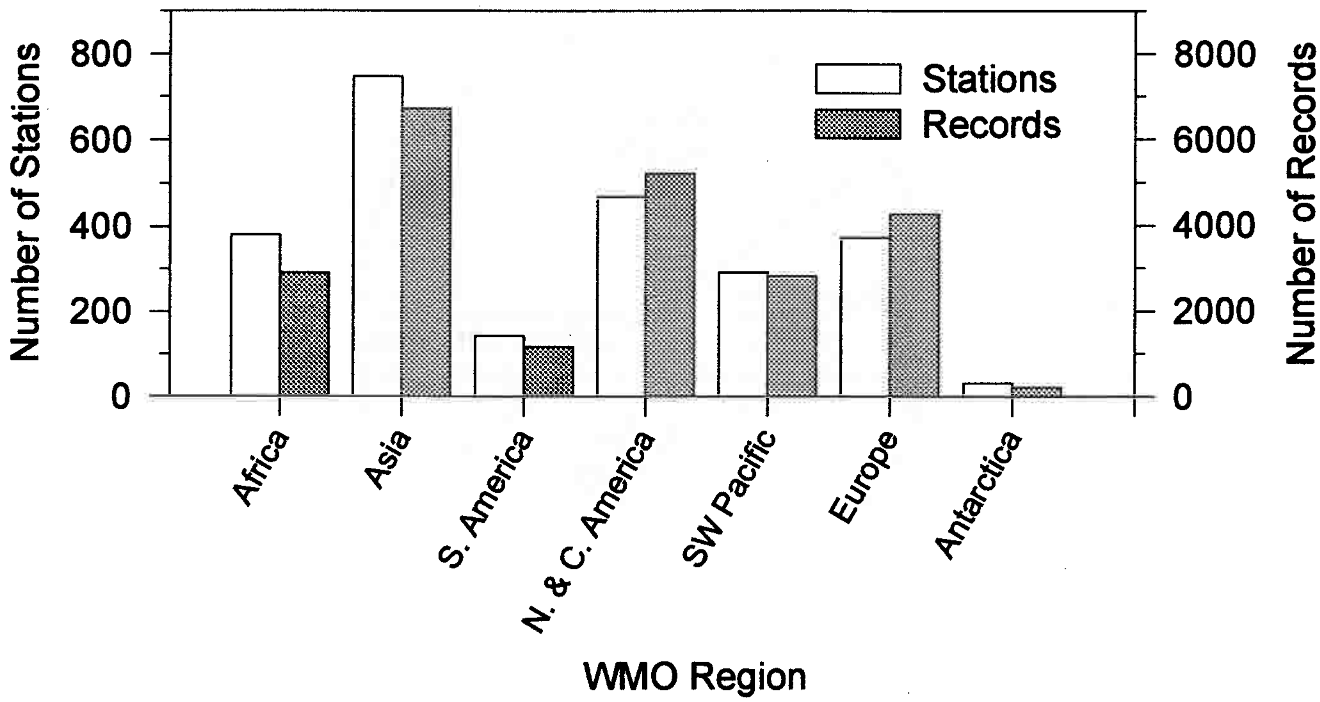

Figure 1. Summary of the contents of the metadata set of upper-air station histories, by WMO region.

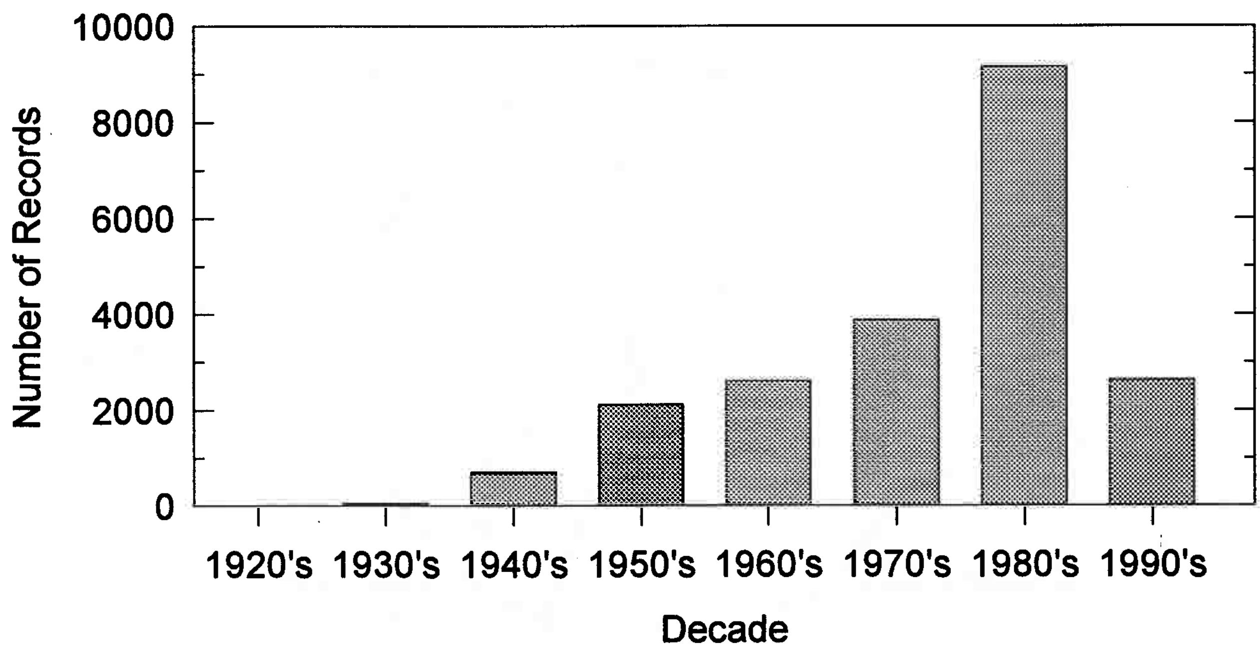

Figure 2. Number of station history records per decade. This chart excludes those records pertaining to national independence dates.

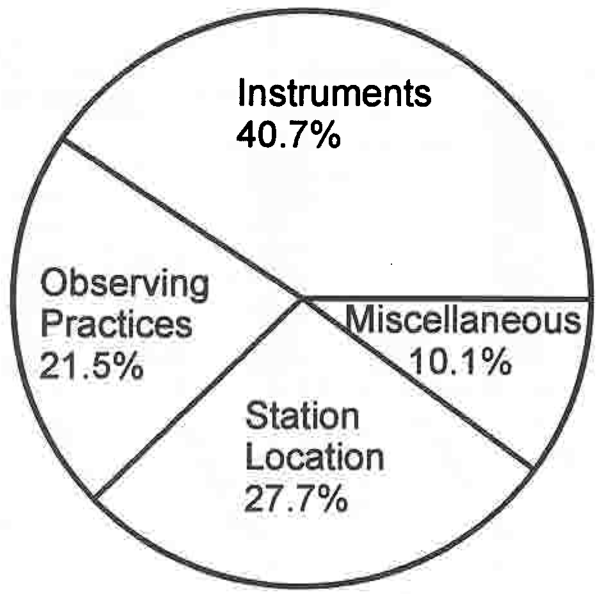

Figure 3. Summary of the contents of the metadata set of upper-air station histories, by metadata type.

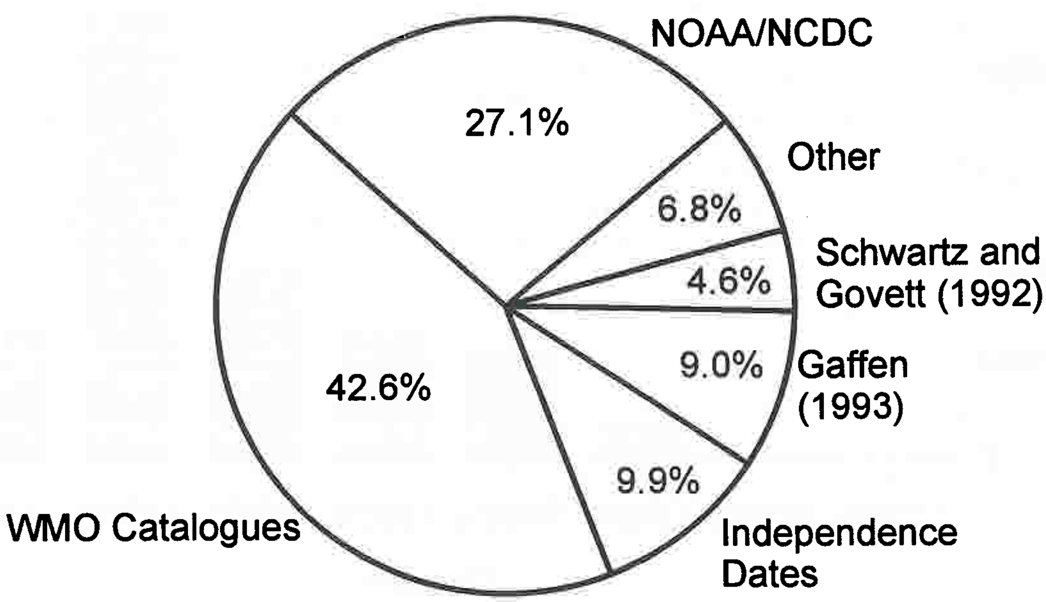

Figure 4. Summary of the contents of the metadata set of upper-air station histories, by metadata source.

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