DNMI DET NORSKE METEOROLOGISKE INSTITUTT

klima

BIBLIOGRAPHY OF RADIOSONDES

SOFUS LINGE LYSTAD

REPORT NO. 02/95 KLIMA

DNMI-RAPPORT

ISSN 0805-9918

REPORT NO.
02/95 KLIMA

DATO
20.11.1995

THE NORWEGIAN METEOROLOGICAL INSTITUTE
P.O. BOX 43 Blindern 0313 OSLO

Telephone: +47 22 96 30 00
Telefax : +47 22 96 30 50

TITLE

BIBLIOGRAPHY OF RADIOSONDES

AUTHOR

Sofus Linge Lystad

PROJECT CONTRACTOR

Telenor as

Norwegian Meteorological Institute

SUMMARY

Use of meteorological data for climatological purposes necessitate knowledge not only about the instrumentation used, but also about instrumental and observational practices and their changes through time. This report consists of short bibliographic notes on radiosondes during the last fifteen years. A short survey is given of common errors in radiosonde measurements.
Regional and national observational practices with WMO TEMP and PILOT codes are discussed.

SIGNATURE

Sofus L. Lystad
Senior Scientist

Bjørn Aune
Head of Climatology Division

Contents

Appendix

Preface.

This short bibliographic report on radiosondes, radiosonde performance, compatibility and comparison is written for the benefit of the "radiosonde group" originating from the COST 235 community and co-operating institutions.The actively participarting institutions in this group are CRC (Communications Research Centre, Canada) and NMI (Norwegian Meteorological Institute), RAL (Rutherford Appleton Laboratory U.K.), TR (Telenor Research, Norway). Through co-operative work with the programme of radiowave propagation of ITU (International Telecomunications Union), is also BT (British Telecom UK) involved. Since none of these,exept for NMI, belong directly to the meteorological community, the main part of the material presented here originates from meteorological sources, mainly from WMO or WMO related bodies. The main purpose is to give an idea of the knowledge and amount of information about radiosondes coming from this part of the scientific comunity.

Besides the instrumentation of the various rawinsondes or radiosondes is the mandatory management of the data itself of great importance for the general information conveyed over the global telecommunication system (GTS).

The basic information is encoded in the mandatory codes TEMP and PILOT designed by the World Meteorological Organization (WMO). Understanding of the selection of information through these codes is crucial for the utilization of the data. In that respect a more or less complete exposition of the mentioned codes are given in section 7.

Since the work of the radiosonde group is concerned with the use of the NCAR data of radiosondes for the period from 1980 and onwards, the bibliographic survey is more or less taken from the same period. Hence a focus is set on radiosonde types which have been used on a routine basis in this period and their compatibility.

This short review of papers is divided in seven parts :

1. Catalogues of radiosondes and equipment in use
2. Main types of radiosondes in use
3. Review of historical changes in equipment and observational practices
4. Intercomparisons of radiosondes
5. Validations of observational results
6. A short discussion of some radiosonde measurement errors.
7. TEMP and PILOT coding practises.

Once more it has to be said that this is not a complete list, but information focused mainly on the period 1980 to 1993.

Introduction.

In the meteorological services the instruments in use and the observation practices inevitably will change from time to time. From country to country there will also be differences in instruments and observation practices. Use of "historical" meteorological data on a global scale will therefore demand a knowledge of the history of the data.The instruments of the different radiosondes are no exception and the use of the NCAR world-wide set of radiosonde observations would also require knowledge of the history of the instruments and the treatment of the observations.

Fortunately the radiosonde observations has a major significance for meteorological operations and research. This is clearly recognised by CIMO, the Commission for Instruments and Methods of Observations, of the World Meteorological Organization (WMO), and expressed by the CIMO president Jaan Kruus in WMO/TD no. 587 as:

"Radiosonde observations remain of major significance for meteorological operations and research. Within the global network of upper-air stations, a variety of equipment is in use. There are good reasons for this, since competition between manufacturers is necessary to keep the cost of consumables under restraint. In other cases countries with large networks must be able to manufacture their own equipment in order to minimize expenditure on imported consumables.

Ideally, all the equipment in use would provide measurements of the same quality, but this is not yet the case. In order to improve this situation, it is necessary to identify the equipment types and also specific stations where data not conform to the desired standard. To this end, CIMO-X tasked a Rapporteur to study recent reports of "Radiosonde Compatibility Monitoring" to identify those radiosonde types and stations where significant improvements need to be made."

In the following is compiled papers concerning radiosondes published by WMO and other bodies that can be of interest for the work with the NCAR radiosonde data, that is papers concerning instrumentation and data mainly in the period 1980 to 1990. The main source of information on a world-wide basis will naturally be WMO and WMO bodies, but also several operational meteorological centres with a general interest in upper-air observations. CIMO has in their list of publications several items that can be of interest. The publications are listed according to CIMO "report number", and if possible, the WMO technical document number is also listed.

By WMO, WMO No.8 (Guide to Meteorological Instruments and Methods of Observation), a radiosonde generally comprises three main parts:

a) The sensitive meteorological elements which responds to the changes in the properties to be measured;
b) Some device for measurement at a distance, enabling the indications of the elements to be converted into an electrical form suitable for controlling;
c) The radio transmitter.

The parts a) and b) can be combined by using electrically sensitive elements.

The various types of radiosonde in general use at present differ mainly in the method by which the measuring elements control the electrical signals. They may be classified as follows:

1) Variable radio-frequency;
2) Variable audio-frequency;
3) Chronometric and pulse-counting;
4) Code sending.

A wide range of transmitter designs are in use; mainly solid-state circuitry is used up to 400 MHz and valve (cavity) oscillators at 1680 MHz. A few transmitters are crystal-controlled, generally to ensure the reception of data from launch.

Frequencies	status	ITU regions
27.5 - 28 MHz	Primary	All
153 - 154 MHz	Secondary	Region 1 only
400.15 - 406 MHz	Primary	All
1668.4 - 1700 MHz	Primary	All
35.2 - 36 GHz	Primary	All

Table 1 Frequencies for meteorological aids (WMO No. 8)

In addition to the radiosonde itself we also have the ground-station equipment which can be a manual system, a semi-automatic system or a fully automatic equipment. Radars or radio-theodolites are used for tracking the radiosondes. A fully automatic system undertakes the whole process from signal reception to producing a message in WMO format.

2700 - 2900MHz
5600 - 5650MHz
9300 - 9500MHz

Table 2 Frequencies for meteorological radars (WMO No. 8)

An upper-air observation is a meteorological observation made in the free atmosphere either directly or indirectly. For direct measurements pilot-balloon, radiosonde, radiowind, combined radiosonde and radiowind, or rawinsonde are used. Of all the upper-air observations which use telemetry signals to collect data, the radiosonde is the basic observation system. Radiosondes in use today measure the basic parameters of temperature, pressure and relative humidity or dew point (PTU) These measurements are carried out by sensors mounted in an instrument package which also contains a radio-frequency transmitter. The transmitter communicates the data to the ground receiving equipment which converts the signals into a strip chart recording or directly into a computer for further analysis. Regardless of the method employed, data are converted into a form which is easily recognisable and standardised. These forms are called coded messages and their formats have been standardised in accordance with the WMO Technical Regulations.

Probably the most widely used type of upper-air observation made throughout the world today is the rawinsonde observation (which is an abbreviation for radio-sounding wind observation). The rawinsonde observation keeps track of the radiosonde position and uses that information to calculate the winds. It uses the radiosonde as the active target. The methods for collecting the positional data may vary from country to country, but as an example all Norwegian stations use the NAVAID signals. Two types of NAVAID-based systems are LORAN-C and OMEGA. All Norwegian land based stations use the OMEGA system whereas the weather ship M or "Polarfront" uses LORAN-C and further for communication satellites as IMARSAT or METEOSAT .

The observations are reported at "mandatory levels" determined by the pressure values as (1000,925,850,700....,100 hPa), at "significant levels" determined by given magnitudes of the height gradient of the temperature and at "pilot-levels" a notion borrowed from the pilot balloon observation. Generally speaking this gives "fixed" levels for describing changes in the wind and the recorded heights are for instance multiples of 300 m (see section 7). Combining all these levels we may have well over 100 levels in one ascent depending of the structure of the atmosphere.

The obtained information is then coded according to the format given in the "Manual of codes" of WMO (WMO No. 306) and distributed on GTS (global telecommunication system).

Soundings are by WMO regulation made at the hours 00 and 12 UTC, and also at some stations at hours 06 and 18. UTC. World-wide this can differ by about one hour depending on country, look for national practices in WMO/TD 541.

Running quality check of data have been done at the UK-meteorological centre at Bracknell and now at the European Centre for Medium-Range Weather Forecasts in Reading (ECMWF).

The general meteorological data bases for upper-air information is thus based on the information conveyed in the meteorological codes TEMP and PILOT. As the various TEMP and PILOT codes are the main source of general upper-air meteorological information, an exhaustive exposition of the codes in general and regional and national practices is given in the section 7 based on WMO-NO 306, vols.I and II.

For the atmospheric refractivity computation only the PTU-values is needed and we will thus not bother with the special computation of upper-air winds and wind direction and as such, in the following, only refer to the observational units as radiosondes.

1. Catalogues of radiosondes and equipment in use.

WMO Catalogue of Radiosondes in Use .

The seventh session of the Commission for Instruments and Methods of Observations (CIMO) realised that, through the efforts of its various working groups on upper-air data, powerful tools had been developed for the routine adjustment of radiosonde data to improve upper-air data compatibility. In order to apply these tools, it had charged its Working Group on Upper-air Data Compatibility with making the necessary information available to Members of WMO so that the meteorological analysis centres could apply such adjustments effectively (Resolution 6, CIMO-VII)

The necessary information falls into three categories, namely

1. annual reports on radiosonde data compatibility based on the methods reported initially in WMO Technical Note No. 163 (WMO-No. 512);
2. the provision of up-to-date information on the use of radiosondes by Members so that the resulting meteorological data could be adjusted based on known characteristics of the sondes;
3. the provision of more general information on the compatibility of upper-air data from various sources.

The reports (1) have been prepared by the UK Meteorological Office (see section 5). The Secretariat of WMO has circulated a summary of each and made the full report available on request. The provision of information (2) is, of course, the subject of the various WMO catalogues of radiosondes in use.

rep. no.	WMO/ TD	title	ref./ author
5		WMO Catalogue of Radiosondes in Use by Members 1981	
11		WMO Catalogue of Radiosondes in Use by Members 1982	
27	176	WMO Catalogue of Radiosondes and Upper-Air Wind Systems in Use by Members 1986	
36	344	Directory of Upper-Air Stations April 1989 app. of WMO/TD 344	UK met. office
56	587	WMO Catalogue of Radiosondes and Upper-Air Wind Systems in Use by Members 1993	

An example taken from WMO/TD 587 is given in appendix 3 part A.

In addition to the catalogues in the list above, WMO issues approximately pr month their "OPERATIONAL NEWSLETTER" compiling all the information on changes to the operation of the World Weather Watch (WWW) and the Marine Meteorological Services (MMS).
A special table is included in "OPERATIONAL NEWSLETTER" in Annex I- Global Observing System to assist Members in reporting changes in the present status of implementation of observing programmes of SYNOP, TEMP and PILOT reporting stations.

An example (pages 1 and 2) taken from OPERATIONAL NEWSLETTER Volume 1994 - No. 8 (August 1994) is given in appendix 3 part B.

In addition the "Order Form" for the OPERATIONAL NEWSLETTER is attached in the same appendix as part C.

2. Main types of radiosondes in use

From the publications given in section 1 it is possible to extract some information of the main types of radiosondes in use. However, due to different ways of presenting the information in the various publications (sometimes the name of the radiosonde itself, sometimes the manufacturer etc.) it can be discrepancies in the numbers of the different radiosondes (an example is the various licensed types of the VIZ-radiosonde e.g. VALCOM, SANGANO, JINYANG etc.). We have, however, based the names and descriptions mainly on those given in WMO/TD 541 (see section 3) and partly on those given in WMO Catalogue of Radiosondes and Upper-Air Wind Systems in Use by Members 1993 (WMO/TD 587). That will cover radiosondes in use for most of the decade from 1980 to 1990. Table 2.1 presents the main types of radiosondes. The main type given as VIZ will then cover a lot of versions both of the radiosonde itself, but also of ground based equipment. According to WMO/TD 541 the VIZ Manufactory Company reports 138 different types or series of the VIZ radiosonde from 1950 to 1992.

Sonde	Manufacturer/orgin	First in use	Country
A-22	Malahit system	1957/60's/62	former USSR
AIR	Air Intellisonde AIR INC		USA
ASTOR	Phillips	1945/53/64	Australia
AUTOVOX	VIZ-licence	1960's	Italy
ELIN	ELIN		Austria
G78	Graw radiosondes	1987	Germany
GM60	Graw radiosondes	1960	Germany
IM-MK3	Indian Met.Serv.	1967/	India
JINYANG	VIZ-licence		Korea
MARS/MET	Meteorit 1/2 sys.	1983/84	former USSR
MEISEI	Meisei/OKI	1976/1985	Japan
MES	Mesural		France
MRZ	AVK system	1986	former USSR
MRZ-T	AVK prototype		former USSR
MSS	Space Data Corp.	1988	USA
ML-SRS	Meteolabor	1991	Switzerland
RKZ-5	Meteorit	1972	former USSR
RS15/ 18 /21 /80	Vaisala	1965/76/78/81	Finland
SANGANO	Canada VIZ-type		Canada
SDC	Space Data Corp.	1988	USA
SHANG GZZ	Shanghai Radio	early 1960's	China
UK RS3	U.K. Met.off.	1977	United Kingdom
VALCOM	Valcom (VIZ-type)		Canada
VINOHRADY	ZPA MARS 4WF Berlin		former GDR
VIZ	VIZ Manuf.comp.	1954/75/86/88	USA
VIZB	VIZ Manuf.comp.	1980/91	USA

Table 2.1 Main types of radiosondes in use in the decade 1980-1990.

To get an idea how the distribution of the main types of radiosondes have changed throughout the decade we give the following three tables based on the second and the last two catalogues in section 1.The first catalogue in section 1 do not contain information about the total number of national radiosonde stations, only the number of radiosonde types used in each country.

Manufacturer or Country of origin	Radiosonde name	Number of stat. in use	Fraction of total (%)
Vaisala, Finland	RS18/RS21/RS80	112	14
USA Canada	VIZ SANGAMO (VIZ)	178 33	23 4
Australia	RS3/ASTOR(Phillips)	37	5
Former USSR	Meteorit METxx/RKZ	22	3
UK	MK3	15	2
India	IM-MK3	19	2
Japan	MEISEI R80	20	3
France,Germany, Korea,Austria Switzerland	(MES /Graw/ Jinyang/ELIN/ Meteolabor)	41	5
Other flown	Vinohrady	2	
Unknown		300	39
Totals		779	100

Table 2.2 Use of radiosonde types in early 1982 (compiled from CIMO rep.no 11)

Manufacturer or Country of origin	Radiosonde name	Number of stat. in use	Fraction of total (%)
Vaisala, Finland	RS18/RS21/RS80	251	26
USA Canada USA	VIZ SANGAMO (VIZ) SDC/MSS	175 34 28	18 4 3
UK/Australia	RS3/ASTOR(Phillips)	20	2
Former USSR	MARS (Meteorit) METxx/RKZ	198	21
China	SHANG	90	9
India	IM-MK3	36	4
Japan	MEISEI R80	22	2
France,Germany Austria,Switzerland	(MES /Graw/Sprenger/ ELIN/Meteolabor)	38	4
Other flown	MICRO/Vinohrady	5	
Unknown		66	7
Totals		963	100

Table 2.3 Estimated use of radiosonde types in early 1989 (from WMO/TD 344)

Manufacturer or Country of origin	Radiosonde name	Number of stat. in use	Fraction of total (%)
Vaisala, Finland	RS80	331	35
USA Canada USA USA	VIZ,(VIZA,VIZB) VALCOM (VIZ) SDC/MSS AIR	159 21 26 2	17 2 3
Former USSR	MRZ (AVK) MARS (Meteorit) A-22/Met	109 75 8	12 8 1
China	SHANG	89	9
India	IM-MK3	35	4
Japan	MEISEI(R80/R91)	26	3
France, Korea Austria,Switzerland	(MES / JINYANG / ELIN /Meteolabor)	13	1
Mixture flown	Various of above	16	2
Unknown		29	3
Totals		939	100

Table 2.4 Estimated use of radiosonde types in early 1993 (from WMO/TD 587)

The great number of "unknown" radiosonde types in the catalogue from 1982 is mainly caused by lack of information from the former USSR with 158 radiosonde stations without specific information about the radiosonde types used. It can, however, be supposed that most of them were of the type Meteorit RKZ-x (i.e. various types of the RKZ model) since the more modern MARS-type first was introduced in 1983. Some stations may also have had the equipment of A-22 radiosondes with the Malahit system.

Referring to WMO Catalogue of Radiosondes and Upper-Air Wind Systems in Use by Members 1993 WMO/TD 587, we find that 16 main types of radiosondes are in use world-wide, although only about 7 of these are in operational use at a significant number of stations in 1993, see table 2.4.

The distribution over the globe in early 1993 is estimated in WMO/TD 587 and it is seen that it has a significant bias towards the northern hemisphere, 739 (82%) of the stations reside here.

Latitude band	no. of stations	% of total
60°N to 90°N	97	11
30°N to 60°N	453	50
0°N to 30°N	189	21
0°S to 30°S	105	11
30°S to 60°S	42	5
60°S to 90°S	14	2

Table 2.5 World-wide distribution of upper-air stations on land in early 1993 (WMO/TD 587)

A keynote paper presented at TECIMO-III by J. Nash discussing observation techniques ;

rep. no.	WMO/TD	title	ref./author
in 23	51	Methods of Observation. Assesment of the efficacy of modern radiosonde measurements. WMO (TECIMO-III) Ottawa, Canada	J.Nash 8-12/7 1985

takes a special interest in radiosondes and upper-air measurements. The two following tables are presented from this paper giving the desired characteristics of the equipment used, both for "synoptic" and local use:

Variable		Height range	Precision	Reproduc.	Reported resolution	Range	Sampling rate
Temp.		surf. to 30 hPa	≤ 0.6°C	≤ 1.0°C	0.1°C	-100. to 50.°C	10 m to 700hPa
		above 30 hPa	≤ 1.0°C	≤ 2.0°C			decreasing to pr 100m at 700 hPa
Humidity	>80%	surf. to 700 hPa	≤ 6%	≤ 6%	for Td	0 to 100 %	half that for T.
		above 700 hPa	≤ 10%	≤ 10%	0.1°C		no values req.
	< 80%	all levels	≤ 10%	≤ 10%			for T <-40°C
Geopot.		100 hPa		< 30 gpm	1 m to	0 to 40 gKm	at derived
		300 hPa		< 20 gpm	500 hPa		standard levels
		500 hPa		< 15 gpm	10 m above		
Signific. level height			≤ 4 hPa	≤ 10 hPa	1 hPa but 0.1 hPa at > 100 hPa	1060-5 hPa (0 to 40 km)	for P or H, one quarter that of temperature

Table 2.6 Data requirements : Soundings for synoptic use

Variable		Height range	Precision	Reproduc.	Reported	Range	Sampling rate
			(2 st. dev)	(2 st. dev)	resolution		
Temp.		surf. to 500 hPa	≤ 0.4°C	≤ 1.0°C	0.1°C	-45. to 35.°C	pr. 10 m or better
Humidity	>80%	surf. to 700 hPa	≤ 6%	≤ 6%	for Td	10 to 100 %	as for temperature
		700 to 500 hPa	≤ 10%	≤ 10%	0.1°C		
	< 80%	all levels	≤ 10%	≤ 10%			
Signific. level height			≤ 2 hPa	≤ 2 hPa	1 hPa	1060-500 hPa	for P or H, one quarter that of temperature

Table 2.7 Data requirements : Soundings for local use

The WMO "Guide on the global observing system" (WMO No. 488) gives the following values for the measured parameters

parameter	range	accuracy
air-pressure	1060 to 3 hPa	±0.5 to ±1.0 hPa
air-temperature	+60. to -90. °C	±0.5°C
relative humidity	0. to 100. %	±5.%

sonde	sensor	sensor type	range	resolution	reprocibility (rms)	time constant	reference
AIR	pres.	aneroid capsule					
IS-4A	temp.	rod thermistor **			±0,2°C	3 sec	WMO/TD 451
	hum.	carbon hygristor **			±5%	2 sec	WMO/TD 451
IND.MET	pres.	aneroid mechanical	5 to 1040 hPa				WMO/TD 312
MK3	temp.	rod thermistor	-90 to 50°C				WMO/TD 312
	hum.	Litium hygristor	10 to 90 %				WMO/TD 312
MARS	pres.	*					
	temp.	rod thermistor			±0,5°C	7 sec	WMO/TD 451
	hum	goldbeaters skin			±10%	10-12 sec	WMO/TD 451
Meisei	pres.	Baroswitch aneroid					
RS2-80	temp.	rod thermistor					
	hum.	resistive carbon					
MRZ	pres.	*					
MRZ-3A	temp.	rod thermistor			±0,5°C	5 sec	WMO/TD 451
	hum.	goldbeaters skin			±10%	10-12 sec	WMO/TD 451
Phillips	pres.	aneroid mechanical	5 to 1060 hPa		1.0 hPa		WMO/TD 312
	temp.	rod thermistor	-90 to 50°C		±0,5°C		WMO/TD 312
	hum.	carbon hygristor	20 to 100 %		±5%		WMO/TD 312
SHANG	pres.	aneroid capscule					WMO/TD 451
SMA GZZ	temp.	bi-metal			±0,5°C	7 sec	WMO/TD 451
	hum.	goldbeaters skin			±2%	5-12 sec	WMO/TD 451
Vaisala	pres.	aneroid capacitive	3 to 1060 hPa	0.1 hPa	0.5 hPa		WMO/TD 312
RS-80	temp.	ceramic capacitive	-90 to 60°C	0.1°C	±0,2°C	2.5 sec	WMO/TD 312
	hum.	Thin film capacitive	10 to 100 %	1%	±2%	1 sec	WMO/TD 312
VIZ	pres.	aneroid mechanical	5 to 1060 hPa		2.0 hPa		Richner 1982
1392-510	temp.	rod thermistor	-70 to 40°C		±0,2°C	3 sec	Richner 1982
	hum.	Thin film carbon	10 to 100 %		±5%	2 sec	Richner 1982
U.K. MET	pres.	aneroid	5 to 1050 hPa	0.1 hPa	1.0 hPa		WMO/TD 174
RS3	temp.	tungsten wire	-80 to 40°C	0.03°C	±0,2°C	<1 sec	WMO/TD 174
	hum.	goldbeaters skin	5 to 100 %	1%	±10%	6 sec	WMO/TD 174

* no pressure sensor, height determined by radar/radio theodilite. See appendix 5
** same as VIZ sensors (WMO/TD 451)
blank entries, no obtained information

Table 2.8 Characteristics of some common radiosondes.

Since the very first radiosonde was launched at Pavlovsk (former USSR) by Moltchanov the 30'th of January 1930, the different sensors in the radiosondes have been (and still are) subject to a perpetual, ongoing process of improvements. It is therefore more or less impossible to fix a given date or a limited period of time where a given type of sonde get "new, improved" sensors within a world-wide network. Some countries update their equipment rapidly, other countries keep older versions in operation for quite a long time.

However, in table 2.8 some information is given about the various sensors, based on data from the various WMO intercomparisons and SONDEX. The information is in principle valid according to the reference and thereby the given year. For the "link sondes" there are no problems, the Vaisala RS80-15N participating in all four phases (Vaisala news 131/1993), and the VIZ sonde 1392-510 participating in the three first phases (WMO/TD 451).

In tables 2.9 and 2.10 are shown, not only for general information, but also as an example of the ongoing improvements of the sensors, the "lag" coefficients depending of sensor types used in the various Vaisala radiosondes. Tables have been taken from WMO/TD 303. For the temperature sensor at given pressure levels are the lags given in seconds:

radiosonde type	years used	sensor type	pressure level 1000	300	100	30
RS11	1938-59	bimetal strip	10.5	16.4	26.5	46.6
RS12	1960-75	bimetal strip	5.1	8.0	12.9	22.6
RS18	1976-80	bimetal ring	3.5	5.5	8.8	15.5
RS80	1981-	capacitive bead	2.3	3.6	5.8	10.2

Table 2.9 Thermometer lag coefficient in seconds. (Huovila,Tuominen WMO/TD 303)

For the various humidity sensors is given dependent of temperature and also (for the rolled hair sensor) of humidity itself, the lag in seconds:

radiosonde type	years used	sensor type	RH%	temperature °C 20	0	-20	-40	-50
RS11	1938-55	normal hair		30	55	400		
RS12/RS18	1956-80	rolled hair	100	3	6	40		
			60	6	11	53		
			20	10	33	145		
RS80	1981-	capacitive thin film		1	5	30	140	250

Table 2.10 Hygrometer lag coefficient in seconds. (Huovila,Tuominen WMO/TD 303)

In addition it can be mentioned that the Vaisala RS21 sonde was equipped with a bimetallic ring (as RS18) as temperature sensor and a capacitive thin film element (humicap) as humidity sensor. This sensor is housed in a duct in the RS21, but is used unshielded in the RS80 sonde, see Richner 1982.

The above mentioned lags are also in accordance with information about the UK MK3 sonde with increments from about 8 sec. to 30 minutes at -40 C° for the goldbeaters skin sensor (personal communication by J. Elms, UK Met office).

For data according to different principles of instrumentation see part 6.

3. Review of historical changes in equipment and observational practices.

General review of historical changes.

To assist climate researchers in interpreting data from the global radiosonde network, the Commission for Instruments and Methods of Observation decided at its tenth session in Brussels, 11-22 September 1989 (CIMO-X, Resolution 11), to "appoint a Rapporteur on Historical Changes in Radiosonde Instruments and Practices with the following terms of reference:

a) To conduct an enquiry amongst Members on national historical changes in radiosonde temperature and humidity instruments, methods of observation and data reduction, and reporting practices;

b) To collect bibliographic references on such changes;

c) To prepare a report on the results of the enquiry..... "

A very valuable paper describing the historical records concerning radiosondes of Member countries emerged from this work:

rep. no.	WMO/ TD	title	ref./ author
50	541	Historical Changes in Radiosonde Instruments and Practices	D.J.Gaffen 1993

The report gives a summary of radiosonde types and a summary of historical changes by nation from 1930's to the early 1990's, an example is given in appendix 4.

In addition is given a detailed survey of algorithms in use for conversion of the measured temperature and relative humidity data to dewpoint and dewpoint depression for transmission.

As seen from appendix 4, references dealing with specific national radiosonde networks are given in the appropriate national summaries. In addition is given several general bibliographies dealing with

1. dewpoint depression computation.
2. radiosonde performance and comparisons.
3. use of radiosonde data for climatic research.
4. other relevant references.

The complete answers to the questionaire are included as four microfiches in the rapporteurs report.

4. Intercomparisons of radiosondes

WMO International Radiosonde Comparisons :

Arising from Resolution 10 (CIMO-IV) and from Resolution 33 (EC-XVIII) the Working Group on Radiosonde and Radiowind Measurements of CIMO-IV organised a series of comparisons of reference sondes in 1968 and 1969. The Working Group on Radiosonde Instruments and Measurements of CIMO-V later organised a single comparison in 1972, supplemented by laboratory work and check flights in 1973. The whole CIMO comparison programme was as follows:

comparison	location	time	participants
First	Stuttgart	27/5 -30/5 1968	Finland / FRG
Second	Tateno	14/12 -20/12 1968	Japan / USSR
Third	Leningrad	19/8 -23/8 1969	USSR / Finland
Fourth	Bracknell	11/9 -30/9 1972	Finland / Japan
Fifth	Bracknell	14/5 -27/5 1973	Finland / UK

The equipment used was more or less specialised versions of operational radiosondes, and they are as such not included in table 4.5 of this section. The Finish RS16 and RS22-12 sondes are derived directly from the models RS13 and RS15 that were in routine operation. The complete report of the whole set of comparisons including the instrumentation used, is given in

WMO. No.	Techn. note	title	ref./ author
394	140	Upper-air sounding studies	A.H.Hooper
		vol. 1: Studies on radiosonde performance	1975
		parts II and III	pp 63-109

Shorter discussions about the same comparisons are given in

WMO. No.	title	ref./ author
284	Upper-air instruments and observations	1969
	Proceedings of the WMO Technical Conference,	
	Paris , 8-12 September 1969	
	Comparaison des sondes de reference	A.Valentin
		pp 299-237
	The USSR-Japan reference radiosonde comparison	V.L.Shlyakhov N.Arizumi
		pp 249-265

To further compare and standardise radiosonde observations WMO initiated their latest series of international radiosonde intercomparisons in four phases within the time span 1980 to 1993. The comparisons where to be done in four different environments and to be carried out in different climates and in different parts of the year. The first phase was staged in Beaufort Park UK. from 18 June to 27 July 1984, the second phase in Wallops Islands, Virginia, USA, from 4

February to 15 March 1985. The third phase was carried out in Dzhambul, USSR, from 7 to 26 August 1989. A fourth phase took place in Japan in Tsukuba from 15 February to 13 March in 1993.

Reports from the three first mentioned intercomparisons are:

rep. no.	WMO/ TD	title	ref./ author
28	174	WMO International Radiosonde Comparison Phase 1, (Beaufort Park UK 1984)	A.H.Hooper 1986
29	312	WMO International Radiosonde Intercomparison Phase 2, (Wallops Island USA 1985)	F.Schmidlin 1988
30	195	WMO International Radiosonde Comparison (UK,1984 / USA,1985)	J.Nash/F.Schmidlin 1987
40	451	WMO International Radiosonde Comparison Phase 3, (Dzhambul USSR 1989)	A.Ivanov et.al. 1991

The various types of radiosondes used in the intercomparisons are given below together with instruments and sensors used in the different phases. The Vaisala radiosonde RS80-15N is the link radiosonde of the comparisons and is the only radiosonde that has participated in all four phases.

Country	Inst.	Pres. Sens	Temp. Sens	RH Sens.
Finland	Vaisala RS 80	Aneorid Capacitive	Ceramic chip Capacitive	Thin-film Capacitive
UK	RS3	Aneorid	Tungsten Wire	goldbeater's skin
FRG	Graw G 78 C	Aneroid Capacitive	Bead Thermistor	Thin-film Carbon
USA	VIZ 1392-510	Aneroid Mechanical	Rod Thermistor	Thin-film Carbon
USA	Beukers Lab. inc 1524-511	Aneroid Mechanical	Rod Thermistor	Thin-film Carbon

Table 4.1 Phase 1: Participants, radiosondes and sensors. WMO/TD 174

Country	Inst.	Pres. Sens	Temp. Sens	RH Sens.
Australia	Philips RS4 MK3	Aneroid mechanical	Rod Thermistor (lead Carbonate)	Carbon hygristor
Finland	Vaisala RS 80	Aneorid Capacitive	Ceramic chip Capacitive	Thin-film Capacitive
India	Ind. Met. Dept MK3	Aneroid Mechanical	Rod Thermistor (Titan. Diox.)	Lithium hygristor
USA	VIZ 1392-510	Aneroid Mechanical	Rod Thermistor (lead Carbonate)	Carbon hygristor
UK	Graw M60	Dbl. Aneroid Mechanical	Bi-metal	Hair

Table 4.2 Phase 2: Participants, radiosondes and sensors. WMO/TD 312

Country	Inst.	Pres. Sens	Temp. Sens	RH Sens.
USSR	Mars-2 (MRS)	no	Thermistor	goldbeater's skin
USSR	MRZ-3A	no	Thermistor	goldbeater's skin
China	SMA-TC-1	no	Thermistor	Hygristor
China	SMA-GZZ	Aneroid capscule	Bi-metal	goldbeater's skin
Finland	Vaisala RS 80	Aneorid Capacitive	Ceramic chip Capacitive	Thin-film Capacitive
USA	VIZ 1392-510	Aneroid Mechanical	Rod Thermistor (lead Carbonate)	Carbon hygristor
UK	AIR IS-4A-1680HS	Aneroid capsule	Rod Thermistor	Carbon hygristor

Table 4.3 Phase 3: Participants, radiosondes and sensors. WMO/TD 451

Country	Inst.	Pres. Sens	Temp. Sens	RH Sens.
Japan	Meisei RS2-80	Baroswitch Aneorid	Rod Thermistor	Resistive carbon
Japan	Meisei RS2-91	Aneorid Capacitive	Rod Thermistor	Thin-film Capacitive
Finland	Vaisala RS 80-15N	Aneorid Capacitive	Ceramic chip Capacitive	Thin-film Capacitive
USA	VIZ Microsonde 2	Aneorid Capacitive	Rod Thermistors *	Resistive carbon
USA	AIR IS-4A-1680HS	Aneorid Capacitive	Rod Thermistors *	Carbon element
USA NASA	AIR IS-4A-403L	Aneorid Capacitive	Rod Thermistors *	Resistive carbon

Table 4.4 Phase 4: Participants, radiosondes and sensors. (WMO report is not yet issued, data is taken from Vaisala News 131/1993).

* 3 thermistors

Shorter contributions relating to the WMO radiosonde intercomparisons are among others

rep. no	WMO/TD	title	ref./author
in 22	50	Evaluation of temperature, pressure and geopotential measurements obtained during Phase 1 of the WMO Intenational Radiosonde Comparison WMO (TECIMO-III) Ottawa, Canada	M. Kitchen J. Nash J.F.Ponting 8-12/7 1985

rep. no	WMO/TD	title	ref./author
in 22	50	Comparison of relative humidity measurements from Phase 1 of the WMO Intenational Radiosonde Comparison WMO (TECIMO-III) Ottawa, Canada	J. Nash M. Kitchen J.F.Ponting 8-12/7 1985

Nash, J. Kitchen M. Ponting J.F.	Initial consideration of radiosonde and windfinding system performance obtained at phase 1 of the WMO International Radiosonde Comparison. Meteorological Office Bracknell 1985	OSM No. 32

rep. no	WMO/TD	title	ref./author
in 22	50	Report of Phase 2 of the WMO Radiosonde Comparison WMO (TECIMO-III) Ottawa, Canada	F. Schmidlin F.G.Finger 8-12/7 1985

rep. no	WMO/TD	title	ref./author
in 57	588	An examination of new technique for temperature and humidity measurements correction evaluation using Dzhambul radiosonde intercomparison data WMO (TECO-94) Geneva, Switzerland	A.M.Balagurov M.B.Fridzon A.P.Kats 28/2-2/3 1994

Various radiosonde comparisons

Other reports issued by WMO/CIMO or other bodies that can be of relevance in comparing radiosondes are listed below. For reports prior to about 1980 see WMO/TD 541.

A statistical analysis of data from a large series of the VIZ sonde is given in

Author	title/journal
Hoehne. W.E.	Precision of National Weather Service upper air measurements
	NOAA Tech. Memo. NWS T&ED-16 1980 pp 23

A short survey of the performance of the VIZ sondes from the early eighties is given in:

Author	title/journal
Richner, H.	Reproducibility of VIZ Radiosonde Data and Some Sources of Error
Phillips, P.D.	Jour.Appl. Meteor. vol 20 no 8 1981 pp 954-962

A comparison of Vaisala RS18, USA VIZ-1292 and Swiss Meteolabor radiosondes took place in two phases; a field experiment at Payerne in October 1978, ASOND-78, and a series of laboratory tests of the sensors carried out by Swiss Meteorological Institute in Locarno-Monti during 1978/79. The results are given in :

Author	title/journal
Phillips, P.D et al.	ASOND-78 : An intercomparison of Vaisala, VIZ and Swiss radiosondes
	Pure and Appl. Geoph., 119 (1980/81) pp 259-277

A comparison of Russian and Japanese radiosonde data is discussed in

Author	title/journal
Parker, D.E.	An intercomparison of Russian and Japanese upper-air data.
	Meteor. O13 Branch Memo No. 97 U.K. Met. Off. 1982

The field phase of the Alpine Experiment (ALPEX), the last major programme performed within the framework of GARP with the ASOND project gave rise to another international radiosonde intercomparison, called SONDEX. Data from a ten-day period (20/04 81 to 29/04 81) comprising 154 ascents were analysed. The sondes were AIRSONDE (AIR), ASA from meteolabor, GR 78 (Graw RSG78), SP76 (Sprenger E076 Q 400), SWISS (Meteolabor), THOMM (Thommen J-R 3.2), Vaisala RS18, RS21C, RS21N and RS80-15N, and VIZ 1392 accu-lok. The results are given in:

Author	title/journal
Richner H. and Phillips P.D.	The Radiosonde Intercomparison SONDEX Spring 1981,Payerne Pure and Appl. Geoph., 120 (1982) pp 852-1198

A resumé of the above report is given as:

Author	title/journal
Phillips, P.D et al.	SONDEX - The ALPEX radiosonde intercomparison 5th Symp. on Meteorol. Observ. and Instrumentation Toronto April 11-15 1983 pp 141-147 Amer. Met. Soc.

From The Netherlands a comparison of Vaisala RS21-12C, Vaisala RS80-15N and BEUKERS Microsonde (system W-8000) in 1984 is described in the following report:

rep.no.	WMO/TD	title	ref./author
in 15		A Comparative Investigation of three Comercial Radiosonde Systems WMO (TECEMO) Noordwijkerhout Netherlands	K.H.Annema et al. 24-28/9 1984

Comparisons of the UK RS3, Vaisala RS80, the Graw M60 and the Kaymont Airsonde AS-TH was done in several twin flights at Crawley radiosonde station UK in the period July 1981 to September 1983 and they are described in the following report:

rep.no.	WMO/TD	title	ref./author
in 15		Multiple-flight radiosonde intercomparison WMO (TECEMO) Noordwijkerhout Netherlands	J.Nash 24-28/9 1984

In February 1987, the Australian Bureau of Meteorology began a radiosonde comparison program pursuant to a contract to supply radiosonde systems for their upper air network. Phase two of the trials was conducted at the U.K Meteorological Office's facillity at Crawley. Participating radiosondes were the AIR IS-4A-403 Intellisonde, the U.K. RS3 sonde and the Vaisala RS80 sonde. For a reference, mainly describing the performance of the AIR IS-4A-403 Intellisonde, see:

rep.no.	WMO/TD	title	ref./author
in 35	303	An account of the development, testing and introduction of a new digital radiosonde WMO (TECIMO-IV) Brussels, Belgium	R.A.Munio 4-8/9 1989

Phase 3 in the trials, carried out at NASA's Wallops Flight Facility and is descibed in the later mentioned reference of Schmidlin et al, WMO/TD 303

The Russian radiosonde systems Meteorit-2, OKA-3 with the MARS-2 radiosonde,and the Finnish MicroCORA with the RS80-15N were compared at Minsk from 27 October through 1 November and the results are given in:

Author	title/journal
Karhunen, P. et al	Comparison of data from the Soviet atmospheric radiosonde system (Meteorit-2, Mars-2, OKA-3) and the Finnish Micro-CORA.system
	Meteor. Gideor., 11 1987 pp 111-115

A radiosonde evaluation test was conducted at the Pacific Missile Test Center, Pt Mugu, California in December 1988. The radiosondes used in the test was the AIR IS-4A sonde, the Vaisala RS80 sonde, the Space Data Corp. MSS 1680 MHz sonde and the standard VIZ sonde. References to this and some results is given in the above mentioned paper of R. A. Munio, WMO/TD 303, in table 4.5, refered as MUNIO 89a.

The ground systems MicroCORA og DigiCORA for the Vaisala radiosonde system with the RS80-15N radiosonde are compared and discussed in:

rep.no.	WMO/TD	title	ref./author
in 33	222	A Comparative Investigation of the Vaisala MicroCORA and DigiCORA Ground Systems. WMO (TECO-1988) Leipzig GDR	W.A.A.Monna K.H.Annema 16-20/5 1988

The Chinese GZZ59 and the Vaisala RS18 radiosondes are compared and discussed in :

Author	title/journal
Wong, N.Y.,	Comparison between the results obtained with the Vaisala RS18 and the Chinese GZZ59 radiosondes under operational conditions in Guangzhou.
	Royal observatory Technical Note (Local) No. 42, 1988, Hong Kong

Discussion of the Indian radiosonde MK4 in relation to Vaisala RS80 and the standard VIZ radiosonde together with the use of high precision radar (data form the second phase of the WMO intercomparisons) is given in

Author	title/journal
Sehadri N.	Comparative study of Indian radiosonde and radar geopotential heights.
	Mausam vol 39 no 3 1988 pp 317-334

Australian Phillips RS4 and Vaisala RS80 radiosondes are compared and discussed in :

Author	title/journal
Uddstrom, M.J.	A comparison of Phillips RS4 and Vaisala RS80 radiosonde data
	J. Atmos. Oceanic Tech. 6 (1) 1989

Results of comparative products of Soviet RKZ-2 and Finnish RS80-15N radiosondes from R/V Passat in November-December 1985 on its 47th expeditionary voyage from Kalipeda and Helsinki to Odessa are analyzed in the following paper. The main observations and accordingly the deployment of radiosondes were made in the region bounded by 30° and 50° N and 5° and 45° W.

Author	title/journal
Zaitseva, N.A. et al	Instruments, observations and processing results of comparisons of Soviet and Finnish radiosondes
	Meteor. Gideor., 1 1989 pp 105-110

A field experiment carried out at NASA's Wallops Flight Facility, located at Wallops Island, Virginia between 11-22 April 1988 intended to evaluate the performance of several upper-air systems used in the USA. AIR deployed two 1680 MHz radiosondes, one was an analog radiosonde called Airsonde, and the other a digital radiosonde called Intellisonde. Vaisala participated with the RS-80 radiosonde. VIZ had a VIZA and a VIZB sonde. VIZB is intended to replace VIZA in due time. A radiosonde manufactured by Space Data Corporation was of the MSS type. Results of the comparison is given in:

rep.no.	WMO/TD	title	ref./author
in 35	303	Results of a comparison of radiosondes used by United States agencies. WMO (TECIMO-IV) Brussels Belgium	F.J.Schmidlin et al. 4-8/9 1989

General problems of observation, collecting and archiving upper-air data are discussed in:

Author	title/journal
Schwartz, B. E. Doswell, C. A.	North American Rawinsonde Observations : Problems, Concerns, and a Call to Action.
	Bull. Am. Met. Soc. 72 1991 pp.1885-1896

Two series of field tests conducted at NASA's Wallops Island Flight Facillity during March 1987 and April 1988 (Schmidlin, WMO /TD 303 1989) is discussed in the following paper. During these tests, several sondes were attached to the same 300-g baloon, which was tracked by a precision C-band radar and each associated ground system. An evaluation was made of temperature, pressure and relative humidity, and of wind sensing capabillity between two Vaisala systems (Marvin and DigiCORA) and three AIR systems (optical, analog and digital). Intercomparison data between these systems are presented.

Author	title/journal
Olsen, R.O. Okrasinski, R.J. Schmidlin, F.J.	Intercomparison of upper air data derived from various radiosonde systems
	Proc. 7-symp. on Meteorological Observations and Instrumentation New Orleans January 14-18 1991 Am. Met. Soc.

In 1988, the VIZ "A" sonde was phased out in favor of a redesigned sonde known as VIZ "B" sonde at 83 continental locations within United States. Only United States-operated cooperative sites in Mexico and the Caribbean continued to use the VIZ "A" sonde. Also in 1988, approximately 15 U.S. sites switced to a sonde manufactured by the Space Data Corporation (SDC). Direct intercomparison testing between the VIZ "B" and the SDC sonde has not been performed, but the individual performance characteristics of all three sondes are described in

Author	title/journal
Ahnert, P.A.	Precision and comparability of the National Weather Service upper air measurements.
	Proc. 7-symp. on Meteorological Observations and Innstrumentation New Orleans January 14-18 1991 Am. Met. Soc.

A practical experience, but not a specific intercomparison experiment, from testing and operating automated upper-air sounding systems such as UK RS3, pcCORA (Vaisala RS80), the AIR Intellisonde and the KISS-system of NCAR using Vaisala RS80 sondes, is reviewed in

rep.no.	WMO/TD	title	ref./author
in 49	462	Practical expirience from the operation of automated upper-air sounding systems in the U.K. WMO (TECO-92) Vienna, Austria	J.B.Elms J.Nash 11-15/5 1992

The PREFRS 92 radiosonde test was hosted by the UK Meteorological Office at Crawley for the three weeks from 16 February until 6 March 1992. Radiosondes participating in the test were the UK RS3 radiosonde, the Vaisala RS80 radiosonde, the Meteolabor SRS-400 from Switzerland and two sondes from USA, the AIR Intellisonde and a modified VIZ-Microsonde. A summary of the results is given in :

rep.no.	WMO/TD	title	ref./author
in 57	588	Comparison of potential reference radiosonde observations - results from PREFRS-92	J.Nash 1994 pp 115-120
		WMO(TECO-94) Geneva, Switzerland	28/2-2/3 1994

Several sonde comparisons with alternate equipment has been done in the later years. The Joint Acoustic Propagation Experiment (JAPE-91) was conducted at White Sands Missile Range, New Mexico during July 11-28 and August 19-29 of 1991. Two Doppler sodars, manufactured by REMTECH Inc, a 924 MHz wind profiler, and a Radio Acoustic Sounding System (RASS) were deployed by the U.S. Army Research Laboratory to collect boundary layer wind and temperature. Upper-air wind, temperature and humidity data were collected by periodically released rawinsondes of the AIR type (Intellisonde) tracked by an automatic radio theodolite and a Vaisala RS80 sonde tracked by a Vaisala DigiCORA ground station. The results are given in:

rep.no.	WMO/TD	title	ref./author
in 57	588	Intercomparison of remote and ballonborne sensors	R.O.Olsen et al pp 115-120
		WMO(TECO-94) Geneva, Switzerland	28/2-2/3 1994

Other papers by WMO/CIMO that can be of interest are:

rep. no.	WMO/ TD	title	ref./ author
in 35	303	Proposals for the design of future WMO radiosonde comparisons.	J.Nash 1989 pp 47-52
in 49	462	Development and application of a reference temperature radiosonde.	F.J.Schmidlin 1992 pp 129-133
in 49	462	Link radiosondes for future WMO radiosonde comparisons.	J.Nash 1992 pp 134-138
in 57	588	Effects of changes in radiosonde instruments and practices on climatological upper-air temperature records.	D.J.Gaffen 1994 pp 127-130
in 57	588	Radio sounding in Austria, a historical review of instruments and data.	H.Dobesch 1994 E.Rudel K.Zimmerman pp 431-435
in 57	588	Development of a reference radiosonde	W.F.Dabert 1994 pp 137-142

In the following cross-reference table is shown various intercomparisons between the major radiosonde types.

d	sonde	RS18	RS21	RS80	AIR. analo	AIR digit.	Beuke micro	VIZA 1292	VIZA 1392	VIZB	SP.D MMS	Kaym	RS 3	Mars-2-2	MRZ-3A	SMA-GZZ	SMA-TC-1	Meisei RS-80	Meisei RS-91	Graw G78C	Graw M60	Philli. RS4	Ind. MK 3	Mete. SWISS
I	RS18		e	e	e			f	e							k				e				e
	RS21	e		eh	e		h		e											e				e
	RS80	e	eh		en	cdnpqr	h		abcden pqr	n	nq	i	aipr	c	c	c	c	d	d	ae	bi	bl	b	e
A	AIR analo.	e	e	en		n			en	n	n									e				e
	AIR digit.			cdnpqr	n				cnqr	n	nq		pr	c	c	c	c	d	d					
	Beukers mi.		h	h					a				a							a				
	VIZ 1292	f																						
	VIZ 1392	e	e	abcden pqr	en	cnqr	a			n	nq		ar	c	c	c	c			ae	b			e
	VIZB			n	n	n			n		n													
	Space D. MMS			nq	n	nq			nq	n														
	Kaymont			i									i								i			
	RS 3			aipr		pr			ar			i								a	i			
SR	Mars-2-2			c		c			c						c	c	c							
	MRZ-3A			c		c								c		c	c							
I	SMA-GZZ	k		c		c			c					c	c		c							
	SMA-TC-1			c		c			c					c	c	c								
P	Meisei RS2-80			d															d					
	Meisei RS2-91			d														d						
G	Graw G78c	e	e	ae	e				ae				a											e
	Graw M60			bi					b			i	i									b	b	
st	Phillips RS4			bl					b												b		b	
lia	MK3			b					b												b	b		
itz	meteo swiss	e	e	e	e				e											e				

ble 4.5 Cross-reference for radiosonde intercomparisons, for full reference see text in section 3.

WMO International Radiosonde Comparison phase 1
WMO International Radiosonde Comparison phase 2
WMO International Radiosonde Comparison phase 3
WMO International Radiosonde Comparison phase 4
SONDEX

f: ASOND-78
g: Parker 1982
h: Annema 1984
i: Nash 1984
j: Karhunen 1987

k: Wong 1988
l: Uddstrom 1989
m: Zaitseva 1989
n: Schmidlin 1989
p: Munio 1989

q: Munio 1989a
r: Nash 1994

5. Validations of observational results.

5.1 WMO/CIMO papers concerning radiosondes and geopotential measurements.

WMO/CIMO's concern for required performance of aerological instruments from the viewpoint of the purpose to which their results are put and of the limitations set by the atmosphere itself is put forward in

WMO. No.	Techn. note	title	ref./ author
119	45	Performance requirements of aerological	J.S.Sawyer
		instruments.	1962

WMO. No.	Techn. note	title	ref./ author
267	112	Performance requirements of aerological	C.L. Hawson
		instruments.	1970

Two reports, issued as WMO Technical Notes and often cited are:

WMO. No.	Techn. note	title	ref./ author
394	140	Upper-air sounding studies	1975
		vol. 1: Studies on radiosonde performance	A.H.Hooper
		vol. 2: Manual computation of radiowinds	R.Vockeroth

WMO. No.	Techn. note	title	ref./ author
512	163	The compatibility of upper-air data	1978
		part 1: Research on compatibility of data from radiosondes, rocketsondes and satellites	F.G.Finger R.M.Mcinturff
		part 2: The compatibility and performance of radiosonde measurements of geopotential height in the lower stratosphere for 1975-76	E.Spackman

These reports were more or less basis for the CIMO Working Group on upper-air compatibility who outlined necessary forthcoming work, gave a list of radiosondes in use and involved the UK Meteorological Office in further studies of the radiosonde compatibility in the following Working Group report:

meeting report no.	WMO/TD	title
81-2		Report of the first session of the CIMO Working Group on upper-air compatibility Geneva, 26-30 January 1981

Since some of the standard outcome from the radiosondes are computed values, the need for standardising the computing algorithms was also recognised. A first report was presented whitin CIMO:

rep.no	WMO/TD	title	ref./author
21	175	Algorithms for automatic aerological soundings	A.H.Hooper 1986

The WMO intercomparisons have the drawback that they comprise only a limited number of types of radiosondes and in addition they can by nature only be done in a limited number of climates. Ideas of using meteorological forecasting models to validate the compatibility and performance of radiosonde measurements in the lower stratosphere have therefore been put forward.

Computation of geopotential heights and then let the results being subject to a hydrostatic equilibrium condition for the atmosphere, give a convenient tool for a consistency check of the reported PTU-values.

rep. no.	WMO/ TD	title	ref./ author
36	344	Compatibility of Radiosonde Geopotential Measurements	M.Kitchen 1988
56	587	Compatibility of Radiosonde Geopotential Measurements 1990,1991 and 1992	T.Oakley 1993

A discussion of possible errors in geopotential height arising from successive integration of the hydrostatic equation is given in

Author	title/journal
Passi R.M. Lally V.E.	Variance of the Hydrostatically Integrated Height.
	Jour. Appl. Met. vol. 27 no 11 1988 pp 1294-1298

5.2 UK Meteorological Office, Bracknell, reports.

As mentioned above (section 1) the UK. meteorological office in Bracknell was in the early eighties given the role as a monitoring centre for upper air data by a recommendation of CIMO. Several reports were issued on the subject of compatibility of radiosonde measurements in the atmosphere.

Author	title	ref
Moores, W.H.	Compatibility of radiosonde measurements in the upper troposphere for the period 1/11/80-31/10/81 Meteorological Office Bracknell 1982	OSM No. 19
Nash, J.	Compatibility of radiosonde measurements in the upper troposphere for the period 1/11/81-31/10/82 Meteorological Office Bracknell 1984	OSM No. 24
Nash, J.	Compatibility of radiosonde measurements in the upper troposphere and lower stratosphere for the period 1/11/82-31/10/84 Meteorological Office Bracknell 1985	OSM No. 31
Nash, J. Kitchen M. Ponting J.F.	Initial consideration of radiosonde and windfinding system performance obtained at phase 1 of the WMO International Radiosonde Comparison. Meteorological Office Bracknell 1985	OSM No. 32
Forrester G.F.	A summary of the quality of radiosonde geopotential measurements (1975-1984) Meteorological Office Bracknell 1986	OSM No. 33
Kitchen, M.	Compatibility of Radiosonde Geopotential Measurements 1988 Meteorological Office Bracknell 1989	OSM No. 38

5.3 ECMWF papers.

As recommended by the ninth session of CBS (Commission for Basic Systems), Geneva 1988, lead centres have been appointed for each main type of observation and the presently nominated centres are:

RSMC Bracknell for marine surface observations
RSMC ECMWF for radiosonde and pilot observations
WMC Washington for aircraft and satellite observations

As a lead centre for radiosonde and pilot observations ECMWF issues global data monitoring reports. The ECMWF global data monitoring report is a monthly publication intended to give an overview of the availability and quality of observations from the Global Observing System within the World Weather Watch of the World Meteorological Organisation.

The information presented on data quality is based on differences between observations and the values of the corresponding ECMWF first-guess fields (6-hour forecast) interpolated to the observation points.

ECMWF produces the monthly report as part of its routine monitoring activity in order to facilitate the exchange of monitoring information. Copies of the report are sent to major GDPS centres participating in data monitoring activities as initiated and recommended by the ninth session of the Commission for Basic Systems (CBS) in Geneva 1988, and to the WMO Secretariat and the International TOGA office in Geneva.

It must be mentioned that the monthly reports are marked with :"*This paper has not been published and has only a very limited circulation. Permission to quote from it should be obtained from the ECMWF.*"

rep. no.	ECMWF reports	title	ref./ author
		ECMWF Global Data Monitoring Report monthly edition	

A joint effort by ECMWF and WMO was the ECMWF/WMO workshop on radiosonde quality and monitoring.

rep. no.	ECMWF reports	title	ref./ author
		ECMWF/WMO workshop on radiosonde quality and monitoring. ECMWF 14-16 December 1987	

5.4 Papers about the temperature and humidity sensors of radiosondes.

The different sensors in the radiosondes, as already mentioned, have been subject to a perpetual ongoing process of improvements. Data from various stages of this process can be found in the reports and papers mentioned below. In addition are given various results from sensor comparisons, mostly from operational sondes, but also from more specialised and evolutionary equipment. In this respect can be mentioned that in the last WMO radiosonde intercomparison in Tsukuba in Japan were two of the three sondes from USA of experimental design (AIR and VIZ) and one of the two participating sondes from Vaisala was a special version of the RS80 sonde with a new humidity sensor. Reports are given by ascending years.

Author	title/journal
Williams S.L. Acheson D.T.	Thermal time constants of U.S. radiosondes used in GATE.
	NOAA Tech. Memo EDS CEDDA-7, 1976 pp 68

Author	title/journal
McInturff, R.M.	Day-night differences in radiosonde observations of the stratosphere and troposphere
	NOAA Tech. Memo NWS NMC 63, 1979 pp 47

Author	title/journal
Schmidlin, F.J.	Repeatability and measurement uncertainity of the U.S. meteorological rocketsonde
	Jour. Geophys. Res. vol 86 1981 pp 9599-9603

Author	title/journal
Schmidlin, F.J. et al.	Preliminary estimates of radiosonde thermistor errors
	NASA Tech. Pap. TP 2687 1982 pp 15

Author	title/journal
Pratt, R.W.	Review of radiosonde humidity and temerature errors
	Jour. Atmosph. and Ocean tech. vol 2, 1985 pp 404-407

rep. no.	WMO/TD	title	ref./author
in 22	50	Comparisons of relative humidity measurements from Phase I of the WMO International Radiosonde Comparison WMO (TECIMO-III) Ottawa, Canada	J.Nash M.Kitchen J.F.Ponting 8-12/7 1985

rep. no.	WMO/TD	title	ref./author
in 22	50	Radiosonde sensor performance in rain and clouds. WMO (TECIMO-III) Ottawa, Canada	V. Antikainen V.Hyvönen 8-12/7 1985

Author	title/journal
Raj Y.E.A. et al	Discontinuities in temperature and contour heights resulting from change of instruments at Indian radiosonde stations.
	Mausam. vol 38, no 3 1987 pp 407-410

rep. no.	WMO/TD	title	ref./author
in 33	222	Development and application of corrections to the US radiosonde rod thermistor temperature measurements WMO (TECO-1988) Leipzig, GDR	Schmidlin, F.J. J.K.Luers 16-20/5 1988

Author	title/journal
Wade C.G. Wolfe D.E.	Preformance of the VIZ carbon hygristor in a dry environment.
	12th Conf. Forecasting and Analysis. Monterey October 1989 pp 58-62 Am. Met. Soc.

Author	title/journal
Fridzon, M.B.	Estimation of temperature and humidity measurement errors at radiosondes on the USSR aerological network
	Met. & Gidrol. No. 5 1989 pp 114-118

rep. no.	WMO/TD	title	ref./author
in 35	303	Effect of Radiosonde Lag Errors on Upper-Air Climatological Data WMO (TECIMO-IV) Brussels, Belgium	S.Huovila A.Tuominen 4-8/9 1989

Author	title/journal
Luers, J.K.	Estimating the Temperature Error of the Radiosonde Rod Thermistor under Different Environements
	Jour. Atmosph. and Oceanic Tech. vol 7 1990 pp 882-895

Author	title/journal
Huovila, S.. Tuominen, A.	On the Influence of Radiosonde Lag Error on Upper-Air Climatological Data in Finland 1951-1988
	Finnish Meteorological Institute Met Pub. N. 14 1990 pp 29

Author	title/journal
Schmidlin, F.J.	Derivation and application of temperature correction for the United States radiosonde
	Proc. 7-symp. on Meteorological Observations and Innstrumentation New Orleans January 14-18 1991 Am. Met. Soc.

Author	title/journal
Elliot, W.P. Gaffen, D.J.	On the utility of radiosonde humidity archives for climate studies.
	Bull. Amer.Meteor. Soc 72 1991 pp 1507-1520

rep. no.	WMO/TD	title	ref./author
in 49	462	Solar and infrared temperature correction studies with a special Vaisala RS-80 radiosonde WMO (TECO-92) Vienna, Austria	Antikainen, V. Turtiainen, H. 11-15/5 1992

rep. no.	WMO/TD	title	ref./author
in 49	462	Determination of the radiation error in the laboratory WMO (TECO-92) Vienna, Austria	A.Dumbs 11-15/5 1992

Author	title/journal
Garand L.	On differences in radiosonde humidity-reporting practices and their implications for numerical weather predictions and remote sensing.
	Bull. Am. Met. Soc. 73(9) 1992 pp. 1417-1423

rep. no.	WMO/TD	title	ref./author
in 57	588	Effects of changes in radiosonde instruments and practices on climatological upper-air temperature records WMO (TECO-94) Geneva, Switzerland	D.J.Gaffen 28/2-2/3 1994

6. A short discussion of some radiosonde measurement errors.

First, being a little philosophical, what is really the concept of error or radiosonde error? Intuitively this is a a wrong measurement or it is a system producing wrong data, data not consistent with the "reality". This may perhaps be a result of the "state of art" at that time or place and not necessarily be the case of "one wrong instrument" among others behaving well. As time goes by, we get improved instruments with better approximation to the "reality" and no one sees a harm in that. This is not errors from the "instrumental point of view", but for a climatologist it may be the cause of serious problems, i.e. inhomogenities in climatological data series.

We have then to face at least two problems, the wrong or part-time malfunctioning instrument within one spesific type of radiosondedesign, or the case that two or more radiosonde designs do not give the same measuring results under the same atmospheric conditions and the case of a changing data series, not as the result of a changing atmospheric impact, but as the natural result of a natural improving development in time of the sensor and measurement technology.

It is not possible to give an exhaustive exposition of radiosonde errors on a limited number of pages. As a consequence of the manufacturers awareness of the of the various problems and their different attempts to solve them, a multitude of different designs of radiosondes and sensors have appeared.

A radiosonde system as such consists of the ascending device as well as the ground based system that receives the signals and conveys them into the mandatory WMO codes. Here we face another problem, since the reporting practices from different countries using different radiosondes have not been the same. Differences in the measurements practices results in different and often diverging results (WMO/NO 306 vol II).

In brief, according to WMO/NO 394 three types of error occur in radiosondes themselves:

1. Systematic errors characteristic of the type of sonde in use.
   i.e. the departure from truth of the data mean of a population of sondes made to a common design.

2. Sonde error (so-called), peculiar to a particular instrument, persisting throughout the sounding, usually varying smoothly as the sonde ascends through the atmosphere, but varying from one sounding instrument to another.
   i.e. the scatter of the averaged data of individual sondes about their population mean

3. Random errors in individual observations, which occur during a sounding as a scatter about the smoothly changing sonde error.
   i.e. the scatter of individual values from a single sonde about their own average.

In addition we may include for the climatological use of radiosonde data the following possible causes for "errors":

4. Change in reporting procedure with no change in instrument.
5. Change in instrument type from the same manufacturer.
6. Change in instrument manufacturers.

This three last items should not be forgotten in the present work of the "radiosonde group".

The general radiosonde system should also cope with accurate measurements under extreeme conditions (see tables 2.6 and 2.7) and not necessarily only low pressure and temperature. As an example ; obtaining reliable temperature and humidity profiles through the clouds are major challenges for the radiosonde sensor design. The main problem is actually water and its transition from one phase to another. Survey of some general problems are taken from WMO/TD 50 and given in table 6.1

Phenomenon	resulting problem	
	temperature	humidity
rain	sensor reading too high or too low after impact of water droplets depending on temperature of the rain	recovery from direct wetting, need for protection includes problems of disturbing the air, especially thermally
condensation	sensor reading too high due to released latent heat of water.	recovery without accuracy degradation (sensor itself), temperature induced errors in the sample volume (duct, if used)
evaporation, sublimation	sensor reading too low due to loss of latent heat	temperature induced errors in the sample volume (duct, if used)
icing	sensor reading too high due to released latent heat, decreasing sensitivity because of increasing mass and insolation	measurement of relative humidity with respect to water shifts to measuring saturated relative humidity with respect to ice when the active area is ice covered can be recognised by temperature profile
high humidity response		recovery after thick layers of high humidity

Table 6.1 Some problems in radiosonde sensor performance in rain and clouds.

Temperature elements.

Temperature elements should have a reasonable rapid response to changes of temperature and be as free as possible from radiation errors. Four main types of temperature elements are in use: bimetal strip, ceramic semi-conductor (thermistor), wire ressistor and a capacitive device.

Table 6.2 shows "typical values" of the time constant depending on pressure level for the instrumental principles

Thermometer element	Lag coefficient in seconds at		
	1000 hPa	100 hPa	10 hPa
Thermistor rod, 1,27 mm diameter, coated	4.5	10.6	30
Bimetallic strip 42 mm long, 22 mm wide 0.2 mm thick	5.	13.5	35
Ceramic resistor, 2 mm diameter, 30 mm long	5.	17.	
Nickel wire, 0.1 mm diameter	0.02	0.06	
Tungsten wire, 0.0135 mm diameter			≈0.1
Capacitive Bead as for RS80	2.3	5.8	

Table 6.2 Typical time constants for thermometer elements. (WMO no 8, WMO/TD 303)

The effect of lag error on old radiosonde data is very evident. The lag of the temperature sensor can be recognised in statistics of the height of the ground inversion and in the smoothing of sharp edged inversions. The influence of the thermometer lag may also be found as systematic errors in old geopotential data in atmospheric layers with rather large lapse rates (WMO/TD 303).

The radiation induced error is probable the largest error component in radiosonde temperature measurements. The error occurs when a temperature sensor is cooled below or heated above the ambient air temperature by radiative heat exchange. The error has two independent components; solar and infrared radiation error. The magnitude of the solar component depends mainly on solar elevation angle, ascent rate of the sonde and the albedo may also have some influence. The infrared component is determined by the thermal radiation balance between the sensor and the atmosphere. Its magnitude have greater variation than that of the solar component, depending in a complicated way on factors such as surface temperature, cloud cover, moisture content of the ambient air and on the temperature profile of the atmosphere.

Defiencies in the USA radiosonde temperature measurement accuracy has for example been quoted as -2.9°C to 1.8°C at 10 hPa (ref. in WMO/TD 462). The WMO International Radiosonde Intercomparisons have shown that mean temperature differences between the different instruments range from +/-1.0°C at 100 hPa to approximately +/- 2-0°C to +/-4.0°C at 10 hPa (ref. in WMO/TD 462), see also figure 6.1 from WMO/TD 222.

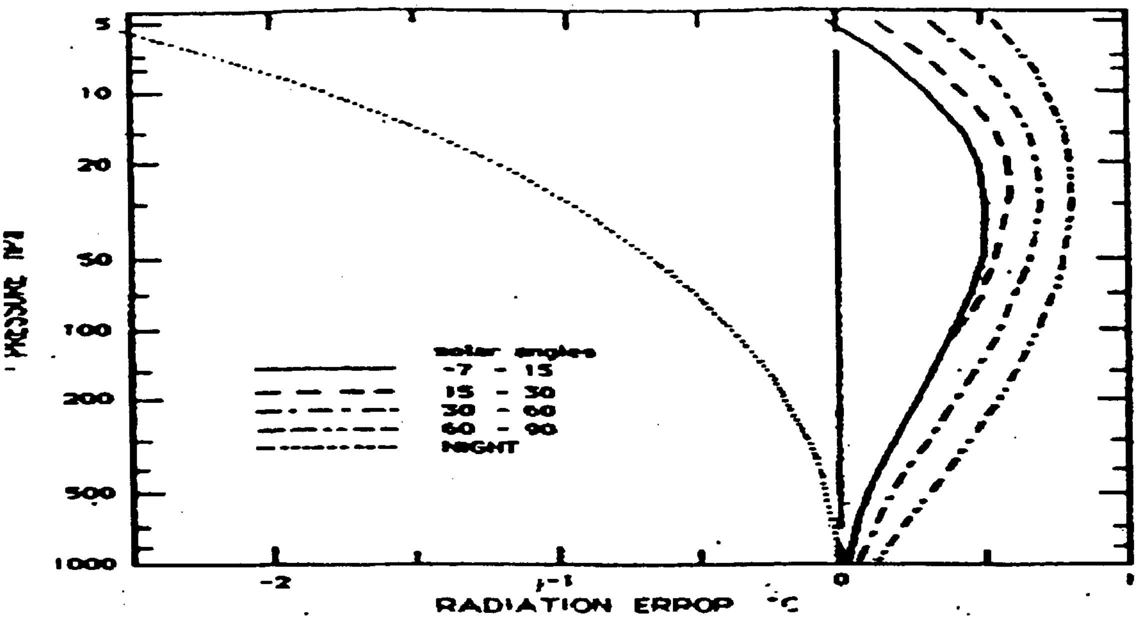

Figure 6.1 Radiation error (temperature corrections) derived for the standard US radiosonde instrument
Figure from F.J.Schmidlin and J.K.Luers (WMO/TD 222)

Several attempts to remedy the problem has been put forward, as the design of the temperature sensor itself (i.e. the geometry of the sensor as well as the material and the coating of the sensor and how it is arranged within the total "sonde package"), and in the software that deals with the sensor signals. As a consequence of different design and other solutions to the problem it is impossible to give "real" definite values of the magnitude of the radiation error on different sonde measurements of temperature.

At NASA's Wallops Flight Facility (WMO/TD 303) was used a specially configured radiosonde to develop a method to correct radiosonde temperature measurements. The measurement method is based on the use of three temperature sensors, identical except for their coatings. The different spectral responses of the sensor coatings enable computation of the radiation errors from the sounding data. The special Vaisala sonde RS80/3T is designed after the same principles (WMO/TD 462) and results from a small number of flights with this radiosonde can give some idea of the magnitude and distribution of the radiation errors for the RS80 sonde. In table 6.3 is shown values depending on solar elevation and pressure level.

solar	P (hPa)						
elevat.	200	100	50	30	20	15	10
5°					-1.3	-1.5	-1.6
10°	-0.4	-0.7	-1.0	-1.3	-1.6	-1.7	-1.8
15°	-0.5	-0.8	-1.1		-1.5	-1.7	-1.9
20°	-0.5	-0.8	-1.2	-1.5	-1.8	-1.9	-1.9
25°	-0.5	-0.7	-1.0	-1.2	-1.4	-1.6	

Table 6.3 Measured radiation error for given pressure and solar elevation (WMO/TD 462)

It is evident that the error will increase both with height and solar elevation, and that is also supported by the values in the table 6.3. The obtained error values then gives rise to correction functions to the temperature measurements from the standard radiosonde. The residual error is of the order given in table 2.8 in section 2. As the improvements of the sensors may also improvements in the different correction functions give rise to problems, i.e. inhomogenities in a temperature series. Differences between the Vaisala radiosonde systems used in the WMO Radiosonde Comparisons and the systems in use at operational stations may not be negligible. In particular, there are still several different radiation temperature correction functions being used with Vaisala radiosondes. V84 used at 1984 and 1985 WMO comparisons and V86 used at 1989 and 1993 WMO comparisons.

Correction type	Description
V82	Vaisala RS80 radiation correction 1982
V84	Vaisala RS80 radiation correction 1984
V86	Vaisala RS80 radiation correction 1986
V93	Vaisala RS80 radiation correction 1993
NIR	Vaisala RS80 radiation correction 1982 but No Infra-Red correction

Table 6.4 Radiation correction type for Vaisala sondes

In WMO/TD 587, "WMO Catalogue of Radiosondes and Upper-air Systems in use by Members (1993)" is also included in the text the information if or if not radiation correction is applied and if possible the type of correction. See also section 7 where WMO express the necessity of and give the possibility to inform about the radiation correction used in the specific radiosonde ascent through the TEMP code.

Humidity elements.

The accuracy of the humidity sensors or measurements is known to depend on the value and sign of the gradients of temperature, the atmospheric humidity content and pressure. Other factors are the direct influence of cloud's water and the impact of solar radiation.

Table 6.5 shows "typical values" of the time constant for several instrumental principles

Humidity element / material	Temperature °C					
	20.	10.	0.	-10.	-20.	-30.
Hair	30.	40.	55.	175.	400.	800.
Hair, rolled flat	10.	10.	12.	15.	20.	30.
Goldbeater's skin	6.	10.	20.	50.	100.	200.
Carbon hygristor	0.3	0.6	1.2	3.	7.	15.
Capacitive thin-film sensor	0.3	0.7	1.5	4.	9.	20.

Table 6.5 Typical time constants (seconds) for humidity elements. (WMO no 8)

The error lag of the hygrometers increases considerably with decreasing temperature, and the influence of the hygrometer lag on humidity data thus greatly depends on altitude and also on seasonal temperature differences. The systematic difference in relative humidity at the 300 hPa level between old data measured with normal hair hygrometers and new data measured with for instance the Vaisala Humicap is 10-13 % in the summertime and 24-31% in the wintertime in Finland (WMO/TD 303).

The main problem of the different humidity sensors apart from the time constants is the ability to "recover" from the passage through rain and clouds with occasional wetting of the sensor. The thin film capacitance sensor (Vaisala) tended to read lower and is of slightly lower reprosibility than the carbon hygristors (VIZ). On the average the sensors used in the first two phases of the last WMO comparisons (WMO/TD 195) read about 5% low relative to saturation in low level clouds. The relative performance of the carbon hygristors and the thin film capacitance sensor does not change to any large degree between the different levels sensed in the atmosphere. However, if the measurements in the ascents that were "dry", are separated from those in ascents were the radiosondes were wetted by passage through low level clouds, significant differences were found (WMO/TD 195). In the range of relative humidity from 20% to 70% the thin film capacitors were found to read higher than the carbon hygristors by about 17% on average, while in dry ascents the measurements were effectively identical.

The Lithium chloride hygristor (Indian Mk3) degrades rapidly at levels above 600 hPa. While relative humidity values at higher values than 40% were biased low relative to truth by about 7% at temperatures between 0°C and 20°C this bias increased to as much as 17% in the temperature range between -20°C to -40°C. Goldbeater's skin, used for instance in the UK RS3 radiosonde, has a time constant much slower than the carbon hygristor and the thin film capacitor (ref. table 6.2) e.g. at low levels the transition in and out of dry layers corresponds to time constants of response of between 10 and 15 seconds. At upper levels the time constants associated with the transition into and out of the thin moist layer around 360 hPa were about 3 to 5 minutes whereas the estimated time constants of response of the carbon hygristor sensor was about 20 seconds at the same level. The Russian radiosondes Mars-2 (MRS) and AVK-1-MRZ-3A (MRZ) and the Chinese SMA-GZZ uses also goldbeater's skin in the humidity sensors. At lower temperatures, from -10°C to -40°C, recognisable errors (WMO/TD 451) were caused by the large thermal lag. The time constants of response for both systems were estimated to be in the range 1 to 4 minutes.

The hair sensor used in the Graw M60 radiosonde, has a time constant of similar magnitude to those of the goldbeater's skin sensor.

The management of the signals from the sensors is of great importance for the radiosonde, and particular for the more modern types. Some systems has a more or less continuos surveillance of the environment, others only a part time function. As an example we take the procedures of RS80 (Vaisala) and the Russian MRS and MRZ sondes. The MRS system only samples relative humidity for 25 seconds every 100 seconds so that if signal reception is poor and a few samples is corrupted, interpolation must be performed between samples of many minutes apart. For this reason, very large errors (differences between sonde types) may occur (WMO/TD 451).

As an example of "unwanted effects" of "change in reporting procedure with no change in instrument" we refer to Elliot & Gaffen in WMO/TD 462. Current practice in several countries is to report the dew point as "missing" if the temperature is below -40°C. The U.S.A. will, in the near future change this practice and the dew points will be reported at much lower temperatures. When this happens there will be an apparent drop in water vapour, particularly at high latitude locations in winter. To estimate this effect, the authors examined some Canadian data records. Canada uses the same hygristor as the U.S. standard VIZ sonde, but does not use the -40°C cut-off. By comparing mean monthly specific humidities they estimated what the apparent drying could be, at 500 hPa there could be an apparent drop in specific humidity of 30 to 40% during the colder months at about 70°N. At lower latitudes the effect will be less but could still be as high as 10% along the southern Canada/U.S. border. This effect will also increase with decreasing values of the air pressure.

The intent of automation of systems is to standardise procedures, improve data consistency, and cut personnel costs and for radiosonde systems this is no exception. According to Schwartz and Doswell III (se page 23) the automated procedures have been accompanied by a decrease in the quality control of data. As an example they describe the North American rawinsonde system. During 1986, the NWS (National Weather Service) automated the data-reduction function at all their sounding sites by introducing the original minicomputer-based ART (Automated Radio Theodolite). The negative impact of this totally automated system upon the operational data stream is summarised in

Author	title/journal
Schwartz, B.E.	Rawinsonde data: Operational and archival concerns.
	12th Conf. Weather Forecasting and Analysis Monterey 1989 Am. Met. Soc.

During the summer of 1990, the NWS completed most of the new micro-ART system implementation. Although no doubt an improvement from the old system, the new system still depends on the observer to perform the quality check procedures. As a result, some of the problems still to be seen in the operational data may be related to the observers not following the new procedures implemented within the new ART system.

Even if all radiosonde stations launched the same type of radiosonde with identical sensors, there is a possibility of inhomogeneities in the reported data due to differences in the manner in which the measured data are converted to meteorological reports. The "dewpoint algorithm" is an example of this. The meteorological TEMP-code has as mandatory parameter the dewpoint depression, and measured temperature and relative humidity must be converted to obtain the dewpoint temperature. WMO/TD 541 reports 26 methods to do this conversion and seventeen of these are different computational algorithms that are or were in use in 14 nations. Many of the algorithms are based on the venerable Magnus equation, but constants vary slightly from algorithm to algorithm. Others are based on different formulation of the saturation vapour pressure dependence on temperature. The above mentioned -40°C cut-off in temperature also plays a role here.

WMO/TD 541 concludes with: "The differences in dewpoint depression methods are a source of inhomogeneity in archived upper-air data. The same temperature and relative humidity observations at two stations using different algorithms could result in different dewpoint depressions being computed, but the difference is generally only a single tenth or whole degree, depending on the dewpoint depression. The problem is most noticeable at the extremes of the meteorological temperature range. The overall effect of the different methods is small compared with other sources of error in radiosonde humidity data, with the exception that the use of different cut-off values introduces a large source of inhomogeneity in cold, dry environments."

As a concluding example as the possible effect of "change in instrument type from the same manufacturer" we show a figure from Elliot & Gaffen in WMO/TD 462. The figure which gives monthly dew point anomalies at 500 hPa at Jeddah, Saudi Arabia, shows clearly the effect when the station in 1977 changed from the use of Vaisala's RS18 radiosonde with a hair hygrometer to their RS21 with a new thin-film capasitor.

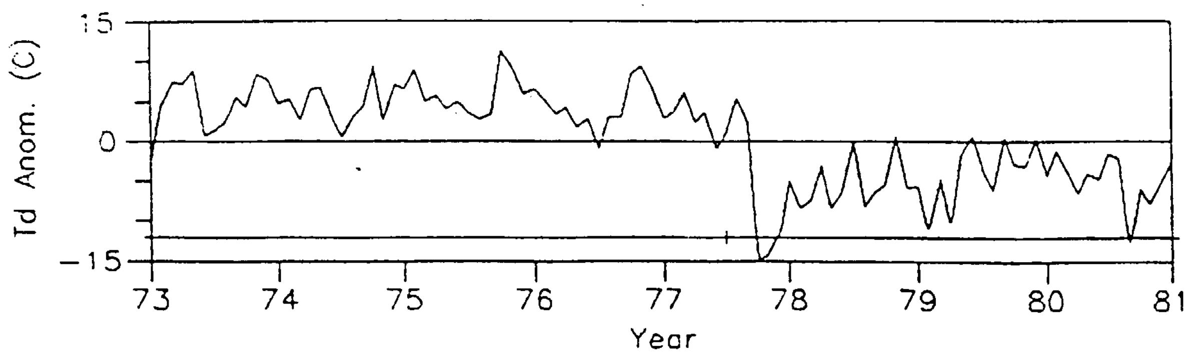

Figure 6.2 Montly dew point anomalies at 500 hPa at Jeddah, Saudi Arabia. (WMO/TD 462)

7 The WMO codes TEMP and PILOT

The WMO code forms TEMP and PILOT are the basic means to convey meteorological observations from the tropospheric and stratospheric part of the atmosphere, or as it is called the "upper-air" observations. As such observations are mainly done by the rawinsondes or radiosondes and end up in the mentioned code forms, it is important to have an idea of the construction of these codes and the regional and national practices of the codes to understand the real content of the information conveyed.

Since the code reports are distributed by GTS, the global meteorological telecommunication system, this information is the main part of the information contained in the "world wide" meteorological data bases, as for instance the NCAR data base.

The code forms and the meteorological information contained in the reports designed by WMO concerning radiosondes are explained in this section.

Since regionally and nationally practices exists of the code forms, this is also reported here according to WMO No 306 vol. II, Manual on Codes, Regional Codes and National Coding Practices, the 1987 edition with the latest supplement of 1993 (Supplement no 6).

Apart from the various choices of "fixed levels" for radiosondes without direct pressure measurements, the different encoding practices of the humidity observations create some problems in comparisons of results.

The whole section is organised as follows:

(a) The complete layout and construction of the codes TEMP and PILOT together with a selection of the general regulations.
(b) Regional codes and national coding practices as reported to WMO. For the different regions, see (d)
(c) Legend for symbolic letters used in the coding with appropriate meaning and reference to the relevant coding tables of WMO, see (e).
(d) The regions of WMO with the station number system.
(e) Selected code tables with respect to equipment used for rawindsondes and radiosondes. For the complete set of coding tables see WMO NO 306 vol. I & II.

The codeform "TEMP"

TEMP (FM 35-IX Ext.) is the name of the code for an upper-level pressure, temperature, humidity and wind report from a fixed land station. TEMP SHIP (FM 36-IX Ext.) is the name of the code for an upper-level pressure, temperature, humidity and wind report from a sea station. TEMP DROP (FM 37-IX Ext.) is the name of the code for upper-level pressure, temperature, humidity and wind report from a sonde released by a carrier balloon or aircraft equipped by with dropsondes. TEMP MOBIL (FM 38-IX Ext.) is the name of the code for upper-level pressure, temperature, humidity and wind report from a mobile land station.

A TEMP report is identified by M_jM_j = TT, a TEMP SHIP report is identified by M_jM_j = UU, a TEMP DROP report is identified by M_jM_j = XX, and a TEMP MOBIL report is identified by M_jM_j = II

The code form consists of four parts as follows:

Part	Identifier letters	Isobaric surfaces
A	AA	Up to and including the 100-hPa surface
B	BB	Up to and including the 100-hPa surface
C	CC	Above the 100-hPa surface
D	DD	Above the 100-hPa surface

Each part can be transmitted separately.

The code form is divided into a number of sections as follows

Section number	Indicator figures or symbolic figure groups	Contents
1	-	Identification and position data
2	-	Data for standard isobaric surfaces
3	88	Data for tropopause level(s)
4	66 or 77	Data for maximum wind level(s) with and data for vertical wind shear
5	-	Data for significant levels, with respect to temperature and/or relative humidity
6	21212	Data for significant levels, with respect to wind
7	31313	Data on sea-surface temperature and sounding system
8	41414	Cloud data
9	51515 .... to 59595	Code groups to be developed regionally
10	61616 .... to 69696	Code groups to be developed nationally

Complete code form

Part A					
Section 1	$M_iM_iM_jM_j$	D....D**	$YYGGI_d$		
		IIiii*			
		or			
		$99L_aL_aL_a$	$Q_cL_oL_oL_oL_o$	$MMMU_{La}U_{Lo}$***	$h_0h_0h_0h_0i_m$****
Section 2	$99P_0P_0P_0$	$T_0T_0T_{a0}D_0D_0$	$d_0d_0f_0f_0f_0$		
	$P_1P_1h_1h_1h_1$	$T_1T_1T_{a1}D_1D_1$	$d_1d_1f_1f_1f_1$		
	....	....	....		
	$P_nP_nh_nh_nh_n$	$T_nT_nT_{an}D_nD_n$	$d_nd_nf_nf_nf_n$		
Section 3	$88P_tP_tP_t$	$T_tT_tT_{at}D_tD_t$	$d_td_tf_tf_tf_t$		
	or				
	88999				
Section 4	$77P_mP_mP_m$	$d_md_mf_mf_mf_m$	$(4v_bv_bv_av_a)$		
	or				
	$66P_mP_mP_m$				
	or				
	77999				

Part B					
Section 1	$M_iM_iM_jM_j$	D....D**	$YYGGa_4$		
		IIiii*			
		or			
		$99L_aL_aL_a$	$Q_cL_oL_oL_oL_o$	$MMMU_{La}U_{Lo}$***	$h_0h_0h_0i_m$****
Section 5	$n_0n_0P_0P_0P_0$	$T_0T_0T_{a0}D_0D_0$			
	$n_1n_1P_1P_1P_1$	$T_1T_1T_{a1}D_1D_1$			
		....			
	$n_nn_nP_nP_nP_n$	$T_nT_nT_{an}D_nD_n$			
Section 6	21212	$n_0n_0P_0P_0P_0$	$d_0d_0f_0f_0f_0$		
		$n_1n_1P_1P_1P_1$	$d_1d_1f_1f_1f_1$		
		....	....		
		$n_nn_nP_nP_nP_n$	$d_nd_nf_nf_nf_n$		
Section 7	(31313	$s_rr_ar_as_as_a$	8GGgg	$9s_nT_wT_wT_w$)	
Section 8	41414	$N_hC_LhC_MC_H$			
Section 9	51515				
	52525				
	.....				
	59595				
Section 10	61616				
	62626				
	......				
	69696				

Part C

Section 1	$M_iM_iM_jM_j$	D....D** IIiii* or $99L_aL_aL_a$	$YYGGI_d$ $Q_cL_0L_0L_0L_0$	 $MMMU_{La}U_{Lo}$***	 $h_0h_0h_0i_m$****
Section 2	$P_1P_1h_1h_1h_1$ .... $P_nP_nh_nh_nh_n$	$T_1T_1T_{a1}D_1D_1$ .... $T_nT_nT_{an}D_nD_n$	$d_1d_1f_1f_1f_1$ .... $d_nd_nf_nf_nf_n$		
Section 3	$88P_tP_tP_t$ or 88999	$T_tT_tT_{at}D_tD_t$	$d_td_tf_tf_tf_t$		
Section 4	$77P_mP_mP_m$ or $66P_mP_mP_m$ or 77999	$d_md_mf_mf_mf_m$	$(4v_bv_bv_av_a)$		

Part D

Section 1	$M_iM_iM_jM_j$	D....D** IIiii* or $99L_aL_aL_a$	YYGG/ $Q_cL_0L_0L_0L_0$	 $MMMU_{La}U_{Lo}$***	 $h_0h_0h_0i_m$****
Section 5	$n_1n_1P_1P_1P_1$ .... $n_nn_nP_nP_nP_n$	$T_1T_1T_{a1}D_1D_1$ .... $T_nT_nT_{an}D_nD_n$			
Section 6	21212	$n_1n_1P_1P_1P_1$ .... $n_nn_nP_nP_nP_n$	$d_1d_1f_1f_1f_1$ .... $d_nd_nf_nf_nf_n$		
Section 9	51515 52525 59595				
Section 10	61616 62626 69696				

* Used in FM 35-IX Ext. (TEMP TT)
** Used in FM 36-IX Ext. and FM 38-IX Ext. (TEMP SHIP, TEMP MOBIL)
*** Used in FM 36-IX Ext.FM 37-IX Ext. and FM 35-IX Ext. (TEMP SHIP, TEMP DROP, TEMP MOBIL)
**** Used in FM 38-IX Ext. (TEMP MOBIL)

Selected rewiev of the Regulations:

Parts A and C

Section 2 : Standard isobaric surfaces

In Section 2, the data groups for the surface level and the standard isobaric surfaces of 1000, 925, 850, 700, 500, 400, 300, 250, 200, 150 and 100 hPa in Part A, and of 70, 50, 30, 20 and 10 hPa in Part C shall appear in ascending order with respect to altitude.

When the geopotential of a standard isobaric surface is lower than the altitude of the reporting station, the air temperature-humidity group for that surface shall be included. Solidi (/////) shall be reported for these groups. The wind groups for these levels shall be included as specified by the value reported for symbol I_d.

When wind data are available for all levels, the wind group shall be included for each level as indicated in the symbolic code form. If wind data are not available for all levels, the procedures given below shall be followed:

(a) When wind data are missing for one or more standard isobaric surfaces but are available for other standard isobaric surfaces below and above the level of missing wind data, the wind group(s), i.e. $d_nd_nf_nf_nf_n$ shall be coded by means of solidi (/////);

(b) When wind data are missing for a standard isobaric surfaces and are also missing for all succeeding standard isobaric surfaces up to the termination of the ascent, the wind group shall be omitted for all these levels and the symbol I_d reported accordingly.

Whenever it is desired to extrapolate a sounding for computation of the geopotential at a standard isobaric surface, the following rules shall apply:

(a) Extrapolation is permissible if; and only if, the pressure difference between the minimum pressure of the sounding and the isobaric surface for which the extrapolated value is being computed does not exceed one-quarter of the pressure at which the extrapolated value is desired, provided the extrapolation does not extend through a pressure interval exceeding 25 hPa.

(b) For the purpose of geopotential calculation, and for this purpose only, the sounding will be extrapolated, using two points only of the sounding curve on a T-log p diagram, namely that at the minimum pressure reached by the sounding and that at the pressure given by the sum of this minimum pressure and the pressure difference, mentioned in (a) above.

Section 3 : Tropopause level(s)

When more than one tropopause is observed, each shall be reported by repeating Section 3.

Parts B and D

Section 5 : Significant levels with respect to temperature and/or relative humidity

If, in the determination of significant levels with respect to specified criteria for changes in air temperature and/or relative humidity, the criteria for either variable are satisfied at a particular point in altitude, data for both variables (as available) shall be reported for that level.

Dew-point data shall be derived using the function (or a near equivalent) for the relationship between saturation vapour pressure over water and air temperature (specified in WMO NO. 49 Technical Regulations). Dew-point data shall not be reported when the air temperature is outside the range stated by WMO for the application of the function, a lesser range may be used as a national practice.

The highest level for which a dew point is reported shall be one of the levels selected in accordance with Regulations 35.3.1.2 and 35.3.1.3, see below.

The reported significant levels *alone* shall make it possible to reconstruct the air temperature and humidity profiles within the limits of the criteria specified.

Regulation 35.3.1.2
The following shall be included as "mandatory significant levels":

(a) Surface level and the highest level of the sounding, or aircraft reference level and termination level for descent soundings;
(b) A level between 110 and 100 hPa;
(c) Bases and tops of inversions and isothermal layers which are at least 20 hPa thick, provided that the base of the layer occurs below the 300-hPa level or the first tropopause, whichever is the higher;
(d) Bases and tops of inversion layers which are characterized by a change in temperature of at least 2.5°C or a change in relative humidity of at least 20 per cent, provided that the base of the layer occurs below the 300 hPa level or the first tropopause, whichever is the higher.

NOTE: The inversion layers of (c) and (d) may be comprised of several thinner inversion layers separated by thin layers of temperature lapse. To allow for this situation, the tops of the inversion layers of (c) and (d) shall each be at a level such that no further inversion layers, whether thick or thin, shall occur for at least 20 hPa above that level.

Regulation 35.3.1.3
The following shall be included as "additional levels". They shall be selected in the order given, thereby giving priority to representing the temperature profile. As far as possible, these additional levels shall be the actual levels at which prominent changes in the lapse rate of the air temperature occur:

(a) Levels which are necessary to ensure that the temperature obtained by linear interpolation (on a T-log P or essentially similar diagram) between adjacent significant levels shall not depart from the observed temperature by more than 1°C below the first significant level reported above the 300 hPa level or the first tropopause, whichever level the lower, or by more then 2°C thereafter;

(b) Levels which are necessary to ensure that the relative humidity obtained by linear interpolation between adjacent significant levels shall not depart by more than 15 per cent from the observed values; (The criterion of 15 per cent refers to an amount of relative humidity and NOT to the percentage of the observed value, e.g. if an observed value is 50 per cent, the interpolated value shall lie between 35 per cent and 65 per cent.)

(c) Levels which are necessary to limit the interpolation error on diagrams other than T-log P. These levels shall be such that the pressure at one significant level shall exceed 0.6 for levels up to the first tropopause and shall be determined by use of the method for selecting additional levels but with application of tighter criteria.

When a significant level (with respect to air temperature and/or relative humidity) and a standard isobaric surface coincide, data for that level shall be reported in Part A and B (or C and D, as appropriate).

In Part B, the successive significant levels shall be numbered 00 (station level), the first level 11, the second level 22,.... etc. ....99, 11,22, ... etc. In Part D the first level above the 100 hPa shall be numbered 11, the second level 22,.... etc. ....99, 11,22, ... etc. The code figure 00 for n_0n_0 in Part B shall never be used to indicate any level other than station level.

In Parts B and D, a layer for which data are missing shall be indicated by reporting the boundary levels of the layer and a level of solidi (/////) to indicate the layer of missing data, provided that the layer is at least 20 hPa thick. The boundary levels are the levels closest to the bottom and the top of the layer which the observed data are available. The boundary levels are not required to meet "significant level" criteria. The boundary levels and the missing data level groups will be identified by appropriate nn numbers. For example :

$33P_3P_3P_3$	$T_3T_3T_{a3}D_3D_3$
44///	/////
$55P_5P_5P_5$	$T_5T_5T_{a5}D_5D_5$

where the levels 33 and 55 are the boundary levels and 44 indicates the layer for which data are missing.

Section 7 : Sounding system indication, radiosonde, system status, launch time sea-surface temperature groups.

In TEMP SHIP reports, Section 7 when included shall report the solar or infrared radiation correction, sounding system identification, radiosonde type, system status, actual time of launch and sea-surface temperature. In TEMP and TEMP MOBIL reports, Section 7 when included shall report only the solar or infrared radiation correction, sounding system identification, radiosonde type, system status and actual time of launch.

The codeform "PILOT"

PILOT (FM 32-IX Ext.) is the name of the code for an upper-wind report from a fixed land station. PILOT SHIP (FM 33-IX Ext.) is the name of the code for an upper-wind report from a sea station. TEMP MOBIL (FM 34-IX Ext.) is the name of the code for upper-wind report from a mobile land station.

A PILOT report is identified by M_jM_j = PP, a PILOT SHIP report is identified by M_jM_j = QQ, and a TEMP MOBIL report is identified by M_jM_j = EE

The code form consists of four parts as follows:

Part	Identifier letters	Isobaric surfaces
A	AA	Up to and including the 100-hPa surface
B	BB	Up to and including the 100-hPa surface
C	CC	Above the 100-hPa surface
D	DD	Above the 100-hPa surface

Each part can be transmitted separately.

The code form is divided into a number of sections as follows

Section number	Indicator figures or symbolic figure groups	Contents
1	-	Identification and position data
2	44 or 55	Data for standard isobaric surfaces
3	6,7,66 or 77	Data for maximum wind level(s) with altitudes given in pressure units or tens of geopotential metres and data for vertical wind shear
4	8, 9 (or 1) or 21212	Data for fixed regional levels and/or significant levels, with altitudes given either in geopotential units or in pressure units.
5	51515 .... to 59595	Code groups to be developed regionally
6	61616 .... to 69696	Code groups to be developed nationally

Complete code form

Part A

Section 1	$M_iM_iM_jM_j$	D....D** IIiii* or $99L_aL_aL_a$	$YYGGa_4$ $Q_cL_0L_0L_0L_0$	 $MMMU_{La}U_{Lo}$**	 $h_0h_0h_0h_0i_m$***
Section 2	$44nP_1P_1$ or $55nP_1P_1$	ddfff	ddfff	.....	etc.
Section 3	$77P_mP_mP_m$ or $66P_mP_mP_m$	$d_md_mf_mf_mf_m$	$(4v_bv_bv_av_a)$		
	or $7H_mH_mH_mH_m$ or $6H_mH_mH_mH_m$ or 77999	$d_md_mf_mf_mf_m$	$(4v_bv_bv_av_a)$		

Part B

Section 1	$M_iM_iM_jM_j$	D....D** IIiii* or $99L_aL_aL_a$	$YYGGa_4$ $Q_cL_0L_0L_0L_0$	 $MMMU_{La}U_{Lo}$**	 $h_0h_0h_0i_m$***
Section 4	9 or 8	$t_nu_1u_2u_3$	ddfff	ddfff	ddfff
	....				
	9 or 8	$t_nu_1u_2u_3$	ddfff	ddfff	ddfff
	or 21212	$n_0n_0P_0P_0P_0$ $n_1n_1P_1P_1P_1$ .... $n_nn_nP_nP_nP_n$	$d_0d_0f_0f_0f_0$ $d_1d_1f_1f_1f_1$ .... $d_nd_nf_nf_nf_n$		
Section 5	51515 52525 59595				
Section 6	61616 62626 69696				

Part C

Section 1	$M_iM_iM_jM_j$	D....D**	$YYGGa_4$		
		IIiii*			
		or			
		$99L_aL_aL_a$	$Q_cL_0L_0L_0L_0$	$MMMU_{La}U_{Lo}$**	$h_0h_0h_0i_m$***
Section 2	$44nP_1P_1$				
	or	ddfff	ddfff	....	etc.
	$55nP_1P_1$				
Section 3	$77P_mP_mP_m$				
	or	$d_md_mf_mf_mf_m$	$(4v_bv_bv_av_a)$		
	$66P_mP_mP_m$				
	or				
	$7H_mH_mH_mH_m$				
	or	$d_md_mf_mf_mf_m$	$(4v_bv_bv_av_a)$		
	$6H_mH_mH_mH_m$				
	or				
	77999				

Part D

Section 1	$M_iM_iM_jM_j$	D....D**	$YYGGa_4$		
		IIiii*			
		or			
		$99L_aL_aL_a$	$Q_cL_0L_0L_0L_0$	$MMMU_{La}U_{Lo}$**	$h_0h_0h_0i_m$***
Section 4	9 (or 1)				
	or	$t_nu_1u_2u_3$	ddfff	ddfff	ddfff
	8				
	....				
	9 (or 1)				
	or	$t_nu_1u_2u_3$	ddfff	ddfff	ddfff
	8				
	or				
	21212	$n_1n_1P_1P_1P_1$	$d_1d_1f_1f_1f_1$		
		....	....		
		$n_nn_nP_nP_nP_n$	$d_nd_nf_nf_nf_n$		
Section 5	51515				
	52525				
	.....				
	59595				
Section 6	61616				
	62626				
	......				
	69696				

* Used in FM 32-IX Ext. (PILOT PP)

** Used in FM 33-IX Ext. and FM 34-IX Ext. (PILOT SHIP, PILOT MOBIL)

*** Used in FM 34-IX Ext. (PILOT MOBIL)

Selected rewiev of the Regulations:

Parts A and C

Section 2 : Standard isobaric surfaces

In Section 2, the data groups for the surface level and the standard isobaric surfaces of 1000, 925, 850, 700, 500, 400, 300, 250, 200, 150 and 100 hPa in Part A, and of 70, 50, 30, 20 and 10 hPa in Part C shall appear in ascending order with respect to altitude.

When pressure measurements are not available, wind data shall be reported using geopotential approximations to the standard isobaric surfaces.

All standard isobaric surfaces within the sounding shall be represented in Section 2 of the report by either a data group or a group of solidi (/////).

Section 3 : Maximum wind level(s) and vertical wind shear

A maximum wind level is defined as a level at which the wind speed is greater than that observed immediately above and below that level.
Regulation 32.2.3.1 : For coding purposes, a maximum wind level:

(a) Shall be determined by consideration of the first of significant levels for wind speed, as obtained by means of the relevant recommended of equivalent national method and *not* by consideration of the original wind-speed curve (see below for significant levels).
(b) Shall be located above the 500 hPa isobaric surface and shall correspond to a speed of more than 30 metres per second.

Whenever more than one maximum wind level exists, these levels shall be reported as follows:

(a) The level of greatest maximum wind speed shall be transmitted first;
(b) The other levels shall be classified in descending order of speed, and be transmitted only if their speed exceeds those of the two adjacent minimals by at least 10 metres per second
(c) The levels of maximum wind with the same speed shall be encoded successively, beginning with the lowest one.
(d) Furthermore, the highest level attained by the sounding shall be transmitted, provided:
    (i) It satisfies the criteria set forth in Regulation 32.2.3.1 above;
    (ii) It constitutes the level of the greatest speed of the whole sounding.

When a maximum wind occurred within the sounding and its level was determined by means of pressure, the indicator figures 77 shall be used in the first group of Section 3, i.e. $77P_mP_mP_m$.

When a maximum wind occurred within the sounding and its altitude was expressed in tens of standard geopotential metres, the indicator figure 7 shall be used in the first group of Section 3, i.e. $7H_mH_mH_mH_m$.

When the greatest wind speed observed throughout the sounding occurred at the top of the sounding and the level of the greatest wind was determined by means of pressure, the indicator figures 66 shall be used in the first group of Section 3 i.e. $66P_mP_mP_m$.

When the greatest wind speed observed throughout the sounding occurred at the top of the sounding and the altitude of the greatest wind was expressed in tens of standard geopotential metres, the indicator figure 6 shall be used in the first group of Section 3 i.e. $6H_mH_mH_mH_m$.

The group $4v_bv_bv_av_a$ shall be included only if data for vertical wind shear are computed and are required to be reported.

Parts B and D

Significant levels

The reported significant data *alone* shall make it possible to reconstruct the wind profile with sufficient accuracy for practical use. Care shall be taken that:

(a) The direction and speed curves (in function of the log of pressure or altitude) can be reproduced with their prominent characteristics;

(b) These curves can be reproduced by an accuracy of at least 10° for direction and 5 metres pr second for speed;

(c) The number of significant levels is kept strictly to a necessary minimum.

NOTE: To satisfy these criteria, the following method of successive approximations is recommended, but other methods of attaining equivalent results may suit some national practices better and may be used:

(1) The surface level and the highest level attained by the sounding constitute the first and the last significant levels. The derivation from the linearly interpolated values between these two levels is then considered. In no direction deviates by more than 10. and no speed by more than five metres per second, no other significant level needed be reported. Whenever one parameter deviates by more than the limit specified in paragraph (b) above, the level of greatest deviation becomes a supplementary significant level for *both* parameters.

(2) The additional significant levels so introduced divide the sounding into two layers. In each separate layer, the deviations from the linearly interpolated values between the base and the top are then considered. The process used in paragraph (1) above is repeated and yields other significant levels. These additional levels in turn modify the layer distribution, and the method is applied again until any level is approximated to the above mentioned specified values.
For the purpose of computational work, it should be noted that the values derived from a PILOT report present two different resolutions:
    (a) Winds at significant levels are reported to the resolution of 5. in direction and one metre per second in speed.
    (b) Any interpolated wind at a level between two significant levels is *implicitly* reported to the resolution of ±10° in direction and ±5 metres per second in speed.

Fixed levels

The fixed levels reported in Section 4 shall be determined by regional decision.

In Section 4, the data groups for the fixed and significant levels within the sounding shall appear in ascending order with respect to altitude.

When the altitudes of regional fixed levels and/or significant levels are given in units of 300 metres, the indicator figure 9 shall be used in Section 4 up to and including the height of 29700 metres. Above that level, the indicator figure 1 shall be used to specify that 30000 metres be added to the heights indicated by $t_nu_1u_2u_3$.

When the altitudes of regional fixed levels and/or significant levels are given in units of 500 metres, the indicator figure 8 shall be used in Section 4.

To indicate that the first wind group refers to station level, u_1 shall be coded / (solidus), and appropriate values shall be reported for t_n, u_2 and u_3.

The altitudes of fixed regional and significant levels shall be reported *either* in geopotential units *or* in pressure units. Only one of the units shall be used in a coded report.

Region I (Africa) : Regionally code practices

Codes FM 32-IX PILOT and FM 33-IX PILOT SHIP

Part A. Section 2.
When upper wind is measured without simultaneous pressure measurement, the following altitudes shall be used as approximations to the standard isobaric surfaces:

Standard isobaric surface (hPa)	Altitude (m)
850	1500
700	3000
500	5700
400	7500
300	9600
250	10800
200	12300
150	14100
100	16500

Part B. Section 4.
In addition to wind data at significant levels, altitudes of which shall be reported in geopotential units, data shall be included as available, for the following altitudes: 600, 900, 2100, 3900, 4500 and 5100 m.

Part C. Section 2.
The following altitudes shall be used as approximations to the standard isobaric surfaces:

Standard isobaric surface (hPa)	Altitude (m)
70	18600
50	20700
30	23400
20	25800
10	29700

Part D. Section 4.
In addition to wind at significant levels, altitudes of which shall be reported in geopotential units, data for the following fixed levels shall be reported: 21000, 24000, 27000,30000,33000 m, and all successive levels at 3000 m intervals, provided that they do not coincide with one of the significant levels.

Codes FM 35-IX TEMP and FM 36-IX TEMP SHIP

Part B. Section 9.
Section 9 shall be used in the Region in the following form:

51515 ; $77h_7h_7h_7$; $T_7T_7T_{a7}D_7D_7$; $d_7d_7f_7f_7f_7$
; $60h_6h_6h_6$; $T_6T_6T_{a6}D_6D_6$; $d_6d_6f_6f_6f_6$

Region I (Africa) : nationally code practices

ALGERIA

PILOT code.
This service follows the procedures established by Region VI for PILOT reports.
Section 2
When the upper-wind observation is carried out by a method not permitting direct pressure measurements, the altitudes are given as

Standard isobaric surface (hPa) hPa	Altitude (m) metres
850	1500
700	3000
500	5400 or 5500
400	7200
300	9000
200	12000
150	13500
100	16000
70	18500
50	20500
30	23500
20	26500
10	31000

Section 4
(1) Sounding carried out by a procedure enabling wind and pressure measurements; to be obtained simultaneously: Apart from the significant levels, the wind data at the 900, 800, 600 and the 250 hPa level should be transmitted in Part B.
(2) Sounding carried out by a method not permitting direct pressure measurements:
  (a) Altitudes expressed in units of 500 metres;
  (b) Below 14000 metres, the wind data at 500, 1000, 2000, 2500, 4000 and 10000 metres should be included in this section of Part B;
  (c) The significant levels may be included from above 14000 metres to the end of the sounding in Parts B and D, except for those appearing in Part C.

NOTE : For the coding of dd, the direction from which the wind blows is always rounded to the nearest ten degrees.

TEMP code
This service follows the procedures established by Region VI for TEMP reports.

Part B, Section 6
Apart from the significant levels, this section should include the wind data at 1000 metres above the surface as well as the data at the 800 and 600 hPa levels.
NOTE : For the coding of dd, the direction from which the wind blows is always rounded to the nearest ten degrees.

CONGO, COTE D'IVORE, MALI, NIGER, RWANDA, SENEGAL

PILOT code.
Part B, Section 6
This section is used to report surface wind direction and speed in the following form:
61616 ddfff

EGYPT

PILOT code.
Part B, Section 4
wind data are reported for the following altitudes, as available; 300, 600, 900, 2100, 3900, 4500, 5100, 6600 and 10800 metres.

Part C, Section 2
In addition to wind data at the standard isobaric surface, the wind data at the isobaric surfaces 9, 8, 7, 6, 5, 4, 3 and 2 hPa are reported. The following altitudes are used as the corresponding altitudes to these isobaric surfaces;

altitude (m)	Isobaric surface (hPa)
31000	9
32000	8
33000	7
34600	6
36000	5
37500	4
39000	4
41000	2

TEMP code
In addition to the data at the standard isobaric surfaces, the data at the isobaric surfaces 9, 8, 7, 6, 5, 4, 3 and 2 hPa are reported.

MADEIRA

PILOT code
Part B, Section 6
This section is used to report wind data at 300 metres in the following form:
61616 101// ddfff

TEMP code
Part B, Section 10
This section is used to report wind data at 300 and 600 metres in the following form:
61616 $11PPP_{300}$ $ddfff_{300}$
$22PPP_{600}$ $ddfff_{600}$

MOROCCO

PILOT code
ddfff : Wind direction is reported to the nearest 5° only when the wind speed is greater than 60 knots.

TEMP code
ddfff : Wind direction is reported to the nearest 5° only when the wind speed is greater than 60 knots.

Region II (Asia) : Regionally code practices

Codes FM 32-IX PILOT and FM 33-IX PILOT SHIP

Part A. Section 2.
When upper wind is measured without simultaneous pressure measurement, the following altitudes shall be used as approximations to the standard isobaric surfaces:

Standard isobaric surface (hPa)	Altitude (m)
850	1500
700	3100
500	5800
400	7600
300	9500
250	10600
200	12300
150	14100
100	16600

Part A. Section 3.
The inclusion of group $4v_bv_bv_av_a$ shall be left to national decision. However, Members are recommended to include this group in PILOT reports as often as possible.

Part B. Section 4.
In addition to wind data at significant levels above sea level, altitudes of which shall be reported in geopotential units, data are included (as available), at least for the following altitudes: 300, 600, 900, 2100, 3600, 4500 and 6000 m.

Part C. Section 2.
When the standard isobaric surfaces cannot be located by means of pressure-measuring equipment, the following altitudes shall be used as approximations to the standard pressure levels:

Standard isobaric surface (hPa)	Altitude (m)
70	18500
50	20500
30	23000
20	26500
10	31000

Codes FM 35-IX Ext.TEMP and FM 36-IX Ext.TEMP SHIP

Part A. Section 2.
Data for the standard 925 hPa isobaric surface shall be included in Part A, Section 2, of reports, in accordance with Regulation 35.2.2.1.

Part A. Section 4.
The inclusion of group $4v_bv_bv_av_a$ shall be left to national decision. However, Members are recommended to include this group in PILOT reports as often as possible

Region II (Asia) : Nationally code practices

DEMOCRATIC YEMEN

TEMP code
Time of observation : One ascent is made at 1200 UTC
Part B, Section 6
Apart from the significant levels, this section includes the wind data at 900, 800 and 600 hPa levels.

HONG KONG

PILOT code
Part B, Section 4
The symbolic figure group 21212 is used. Wind data included refer to significant levels as well as for the following fixed levels: 900, 800 and 600 hPa.

TEMP code
Part B, Section 9
The following code form is used

```
51515 11P1P1P1 d1d1f1f1f1
      22800    ddfff
      33600    ddfff
```

$P_1P_1P_1$ refers to pressure (hPa) at 1000 m above the surface and $d_1d_1f_1f_1f_1$ is its wind. Wind for 800 hPa is described by groups 22800 ddfff and for 600 hPa by groups 33600 ddfff.

INDIA

PILOT code
Reporting of upper winds by rawinsonde stations:
(a) Rawinsonde stations, except those indicated in (b) below, issue Part B of PILOT reports only, without significant levels, in addition to complete TEMP report.
(b) Rawinsonde stations, observing upper winds with Selenia radar, do not report wind data in TEMP reports, but issue a complete PILOT report.

JAPAN

PILOT code
Part B, Section 6
This section is used under the following symbolic form for reporting wind data for 900, 800 and 600 hPa
61616 11900 ddfff
22800 ddfff
33600 ddfff

TEMP code
Section 10
Same remarks as for the PILOT code.

KUWAIT

PILOT code
Parts B and D, Section 4
Indicator figures 8 or 9 are always used.

LAO PEOPLE'S DEMOCRATIC REPUBLIC

PILOT code
Parts A and C, Section 2
Indicator figures 55 are always used.

Parts B and D, Section 4
The altitudes of regional fixed levels and significant levels are given in units of 300 m.

REPUBLIC OF YEMEN

PILOT code
Parts B and D, Section 4
Apart from the significant levels, the wind data at the 900, 800 and 600 hPa level are reported.

SAUDI ARABIA

TEMP code
Parts B and D, Section 10
The following code form is used
61616 $11P_1P_1P_1$ $d_1d_1f_1f_1f_1$
22800 ddfff
33600 ddfff

$P_1P_1P_1$ refers to pressure (hPa) at 1000 m above the surface and $d_1d_1f_1f_1f_1$ is its wind. Wind for 800 hPa is described by groups 22800 ddfff and for 600 hPa by groups 33600 ddfff.

USSR (former)

PILOT and TEMP codes

The actual time of observation is given for GG in Moscow time and not in UTC.

Region III (South America) : Regionally code practices

Codes FM 32-IX PILOT and FM 33-IX PILOT SHIP

Part A. Section 2.
Altitudes constituting the best approximations to the standard isobaric surfaces shall be determined nationally.

Part B. Section 4.
In addition to wind data at significant levels, altitudes of which shall be reported in geopotential units, data shall be included as available, for the following altitudes: surface, 300, 600, 900, 2100, 2400, 4200, 6000 and 8100 m.

Part C. Section 2.
The following altitudes shall be used as approximations to the standard pressure levels:

Standard isobaric surface (hPa)	Altitude (m)
70	18300
50	20700
30	23700
20	26400
10	30900

Part D. Section 4.
In addition to wind at significant levels, altitudes of which shall be reported in geopotential units, data for levels every 3000 m, beginning at 33000 m, shall be reported as available, provided they do not coincide with one of the significant levels.

The altitudes 33000 m and above shall be encoded using units of 500 m.

Region III (South America) : Nationally code practices

ARGENTINA

PILOT code
Part A, Section 2
The following altitudes are used as approximations to the standard isobaric surfaces:

Standard isobaric surface (hPa)	altitude used in the PILOT reports (m)	
	North of 40°S	South of 40°S
850	1500	1500
700	3000	3000
500	5700	5400
400	7500	7200
300	9600	9000
250	10500	10200
200	12300	12000
150	14100	13500
100	16200	15900

Region IV (North and Central America) : Regionally code practices

Codes FM 32-IX PILOT and FM 33-IX PILOT SHIP

Part A. Section 2.
Altitudes constituting the best approximations to the standard isobaric surfaces shall be determined nationally.

Part B. Section 4.
In addition to wind data at significant levels, altitudes of which shall be reported in geopotential units, data at the following levels shall be included: 300, 600, 900, 1200, 1800, 2100, 2400, 2700, 3600, 4200, 4800, 6000 and 7500, 9000 and 15000 m.

Part C. Section 2.
Regulation as given for Part A, Section 2 shall apply.

Part D. Section 4.
In addition to wind at significant levels, altitudes of which shall be reported in geopotential units, data at the following fixed levels shall be included: 18000, 21000, 24000, 27000, 30000, 33000 m. and all successive levels at 3000 m provided they do not coincide with one of the included significant levels.

The altitudes 33000 m and above shall be encoded using units of 500 m.

Codes FM 35-IX Ext.TEMP and FM 36-IX Ext.TEMP SHIP

Part B. Section 9.
When required, additional information for levels up to and including the 100 hPa level shall be reported in this section by including supplementary groups $101A_{df}A_{df}$. A regional code table is established for this purpose an is given in WMO-no 306 as Code table 421.

Part D. Section 9.
When available, information for 7, 5, 3, 2 and 1 hPa shall be included in Section 9.

When required, additional information shall be reported by including the supplementary groups $101A_{df}A_{df}$.

Region IV (North and Central America) : Nationally code practices

CANADA

PILOT code
Section 3
Only one maximum wind (the greatest maximum) is reported. $H_mH_mH_mH_m$ is reported in increments of 30 feet, i.e. the altitude in feet of the level of maximum wind is obtained from a coded report by multiplying the value reported for $H_mH_mH_mH_m$ by 30.

Section 4
Altitudes of fixed regional levels and significant levels are reported in units of 300 metres.

UNITED STATED OF AMERICA

TEMP code
Parts A,B,C and D
When the relative humidity at any level is less than 20 per cent, the dew-point depression is encoded as code figure 80, i.e. D_nD_n equals 30°C. For temperature below -40°C, dewpoint depression is reported as missing.

Region V (South-West Pacific) : Regionally code practices

Codes FM 32-IX PILOT and FM 33-IX PILOT SHIP

Part A. Section 2.
When no pressure measurements are available, wind data shall be reported for altitudes which constitute the best approximations to the standard isobaric surfaces, and which shall be determined nationally.

Part A and C Section 3.
The levels reported, in addition to the level of the greatest maximum wind speed (or the highest level attained by the sounding, if the wind speed there is the greatest), shall be the levels of other speed maxima in the sounding, provided their speeds exceed the intervening minimum speeds by more than 10 m/s.

Part B. Section 4.
In addition to wind data at significant levels, altitudes of which shall be given in geopotential units, data, whenever available, shall be reported for the following levels: 900, 2100, 2400, and 4200 m.

Region V (South-West Pacific) : Nationally code practices

AUSTRALIA

PILOT code
Parts A and C. Section 2.
Altitudes constituting the best approximation to the standard isobaric surfaces are determined as follows:

Groups of stations	Location
A	North of 25°S plus Kalgoorlie (94637)
B	25°S-33°S
C	33°S-40°S
D	40°S-45°S
E	Macquarie Island (94998)

Standard isobaric surface (hPa)	Altitude used in the PILOT reports (m) Groups of stations,			
	A	B	C	D
850	1500	1500	1500	1500
700	3100	3100	3100	3000
500	5800	5800	5700	5600
400	7600	7400	7300	7200
300	9600	9400	9300	9200
250	10900	10700	10500	10400
200	12400	12100	12000	11800
150	14200	13900	13800	13600
100	16500	16400	16300	16200
70	18600	18600	18600	18500
50	20700	20700	20700	20600
30	23900	24000	24000	23900
20	26600	26600	26600	26600
10	31200	31300	31300	31300

For the Macquarie Islands is given in WMO No 306 Vol. II a table for pressure heights (1000 hPa to 1 hPa) in metres for each month.

TEMP code
Parts B and D Section 5
The criteria for determining significant levels in respect to relative humidity shall be obtained by linear interpolation between adjacent significant levels, such that the dew point shall not deviate more than 2°C from the observed value.

NOTE for upper wind : The majority of upper wind observations at Australian controlled stations are carried out by wind finding radar equipment. They are therefore not included in TEMP reports in the code form FM 35-IX Ext.

NOTE on hours of observation : During summer time, Australian standard times for upper temperature, humidity and pressure synoptic observations are 1100 and 2300 UTC in all Australian States and island stations operated by Australia, but not at Australian Antarctic stations.

FRENCH POLYNESIA

PILOT code

Parts A and C, Section 2

Altitudes constituting the best approximation to the standard isobaric surfaces are determined as follows:

Standard isobaric surface (hPa)	Altitude in the PILOT reports (m)	Standard isobaric surface (hPa)	Altitude in the PILOT reports (m)
850	1500	150	14100
700	3000	100	16500
500	5700	70	18600
400	7500	50	20700
300	9600	30	24000
250	10800	20	26700
200	12300	10	31200

Part B, Section 4

In addition to wind data at significant levels and at fixed levels for Region V, data whenever available are reported for the following levels: surface, 300,600 and 8400 metres.

INDONESIA

PILOT code

Parts A and C, Section 2

Altitudes constituting the best approximation to the standard isobaric surfaces are the averages of the heights of such surfaces determined from radiosonde data.

MALAYSIA

PILOT code

Parts A and C, Section 2

Altitudes constituting the best approximation to the standard isobaric surfaces are determined as follows:

Standard isobaric surface (hPa)	Altitude in the PILOT reports (m)	Standard isobaric surface (hPa)	Altitude in the PILOT reports (m)
850	1500	150	14200
700	3100	100	16500
500	5800	70	18600
400	7600	50	20600
300	9700	30	23800
250	10800	20	26400
200	12400	10	30000

Part B, Section 4
In addition to wind data at significant levels, altitudes of which are given in geopotential units, data whenever available are reported for the following levels: surface, 300, 900,2100, 3600, 4200 and 10800 metres.

NEW CALEDONIA AND LOYALTY ISLANDS

PILOT code
Parts A and C, Section 2
Altitudes constituting the best approximation to the standard isobaric surfaces are determined as follows:

Standard isobaric surface (hPa)	Altitude in the PILOT reports (m)	Standard isobaric surface (hPa)	Altitude in the PILOT reports (m)
850	1500	150	14100
700	3000	100	16500
500	5700	70	18900
400	7500	50	20700
300	9600	30	24000
250	10800	20	26700
200	12300	10	31200

TEMP code
D_nD_n When the relative humidity is less than 10 per cent for levels where the temperature is higher than -40°C, a relative humidity constant of 8 percent is used in the calculation of the dew point temperature.

NEW ZEALAND

NOTE on missing data: A stratum of missing data is encoded as follows: The levels bounding the missing stratum will be encoded as significant levels. Between these the mean wind for the stratum will be encoded with the height indicator as / (solidus). Fixed levels falling within this stratum are not encoded.

PAPUA NEW GUINEA

PILOT code

Part B, Section 4

(a) Data whenever available are reported for the 600 and 3600 metre levels in addition to those levels specified for regional use.

(b) Data reported for the regional pressure levels refer to the next computation above that pressure level when the computation is not made at the pressure level.

(c) Criteria for determining significant levels:

(i) Wind speed differs by 10 m/s or more from the wind speed at the nearest lower level reported;

(ii) Wind direction differs by 45. or more from the nearest lower level reported when the wind speed at the level under consideration is 10 m/s or more;

(iii) the highest level attained up to an including the 100 hPa level.

Part D

Part D is not used in PILOT reports.

NOTE on hours of observation: Standard times for upper wind synoptic observations are 0500, 1100, 1700 and 2300 UTC.

PHILIPPINES

PILOT code

Parts A and C, Section 2

Altitudes constituting the best approximation to the standard isobaric surfaces are determined as follows:

Standard isobaric surface (hPa)	Altitude in the PILOT reports (m)	Standard isobaric surface (hPa)	Altitude in the PILOT reports (m)
850	1500	150	14100
700	3100	100	16500
500	5800	70	18600
400	7500	50	20500
300	9600	30	23800
250	10800	20	26500
200	12300	10	31000

TEMP code

Parts B and D, Section 6

Transmission of this section is optional

SINGAPORE

PILOT code
Parts A and C, Section 2
Altitudes constituting the best approximation to the standard isobaric surfaces are determined as follows:

Standard isobaric surface (hPa)	Altitude in the PILOT reports (m)	Standard isobaric surface (hPa)	Altitude in the PILOT reports (m)
850	1500	150	14200
700	3100	100	16500
500	5800	70	18600
400	7600	50	20600
300	9700	30	23800
250	10800	20	26400
200	12400	10	30000

Part B, Section 4
In addition to wind data at significant levels, altitudes of which are given in geopotential units, data whenever available are reported for the following levels: surface, 300, 600, 900, 2100 and 4200.

Region VI (Europe) : Regionally code practices

Codes FM 32-IX PILOT and FM 33-IX PILOT SHIP

Part A. Section 2.
When upper-wind observation is carried out without simultaneous pressure measurement, the following altitudes shall be used as approximations to the standard isobaric surfaces:

Standard isobaric surface (hPa)	Altitude (m)	alternatively (m)
850	1500	1500
700	3000	3000
500	5500	5400
400	7000	7200
300	9000	9000
250	10500	10500
200	12000	12000
150	13500	13500
100	16000	15900

Part A. Section 3.
The inclusion or omission of the group $4v_bv_bv_av_a$ shall be left to national decision. Members are encouraged to include this group as often as possible

Part B. Section 4.
(i) When upper-wind observation is carried out without simultaneous pressure measurement and altitudes are indicated in geopotential units (use of symbolism $8/9t_nu_1u_2u_3$ ddfff), wind data shall be included in this section for the significant levels as well as for the following fixed regional levels:
either 1000, 2000, 4000 m (when group $8t_nu_1u_2u_3$ is used)
or 900, 2100, 4200 m (when group $9t_nu_1u_2u_3$ is used)

(ii) When upper-wind observation is carried out without simultaneous pressure measurement and altitudes are indicated in pressure units (in whole hectopascals) (use of the symbolic form 21212 $n_nn_nP_nP_nP_n$ $d_nd_nf_nf_nf_n$), wind data shall be included in this section for the significant levels as well as for the following fixed regional levels: 900, 800 and 600 hPa (considered as approximations to the levels 1000, 2000,4000 m, respectively).

The different levels in Section 4 shall be inserted so that they succeed each other in ascending order of altitude.

Part C. Section 2.
When the standard isobaric surfaces cannot be located by means of pressure-measuring equipment, the following altitudes shall be used as approximations to the standard pressure levels:

Standard isobaric surface (hPa)	Altitude (m)	alternatively (m)
70	18500	18300
50	20500	20700
30	23500	23700
20	26500	26400
10	31000	30900

Part C. Section 3.
The inclusion or omission of the group $4v_bv_bv_av_a$ shall be left to national decision. Members are encouraged to include this group as often as possible

Part D. Section 4
This section shall contain wind data for significant levels up to the top of the ascent.

Codes FM 35-IX Ext.TEMP and FM 36-IX Ext.TEMP SHIP

Part A. Section 4.
The inclusion or omission of the group $4v_bv_bv_av_a$ shall be left to national decision. Members are encouraged to include this group as often as possible

Part B. Section 9.
This section shall be used in the following form:

51515 $11P_1P_1P_1$ $d_1d_1f_1f_1f_1$
22800 ddfff
33600 ddfff

the subsection beginning with the symbolic figure group 51515 shall be included to transmit the following wind data :

(i) Wind for 900 or 1000 m above the surface, described by groups $11P_1P_1P_1$ $d_1d_1f_1f_1f_1$ in which $P_1P_1P_1$ is the pressure (in hectopascals) at 900 or 1000 m above the surface. These winds are included to calculate wind vector differences:
(ii) Wind for 800 hPa, described by groups 22800 ddfff
(iii) Wind for 600 hPa, described by groups 33600 ddfff

Part C. Section 4.
The inclusion or omission of the group $4v_bv_bv_av_a$ shall be left to national decision. Members are encouraged to include this group as often as possible

Region VI (Europe) : Nationally code practices

AUSTRIA

PILOT code

Parts A and C, Section 3

When the last maximum wind level occurs 1 km before the top of the sounding, the group $4v_bv_bv_av_a$ is coded as $4v_bv_b//$

Part B, Section 6

This section is used to report wind data at 500 and 800 metres above mean sea level, in the following form:

61616 $ddfff_{500}$ $ddfff_{800}$

TEMP code

Parts A and C, Section 4

When the last maximum wind level occurs 1 km before the top of the sounding, the group $4v_bv_bv_av_a$ is coded as $4v_bv_b//$

Part B, Section 10

This section is used to report wind data at 500 and 800 metres above mean sea level, in the following form:

61616 $11PPP_{500}$ $ddfff_{500}$
$22PPP_{800}$ $ddfff_{800}$

CZECH REPUBLIC

TEMP code

Part B, section 9

This section is used to report wind data at 1000 metres above the surface and at the 800 and 600 hPa levels:

51515 $11PPP_{1000}$ $ddfff_{1000}$
$22PPP_{800}$ $ddfff_{800}$
$33PPP_{600}$ $ddfff_{600}$

FRANCE

PILOT code

ddfff and $d_md_mf_mf_mf_m$: The direction from which wind is blowing is always indicated in tens of degrees by means of Code table 0877.

Part B, Section 4
Data are sent for three additional levels: surface, 500 and 2500 metres, these two last levels being considered as approximations to the surfaces 950 and 750 hPa.

Parts B and D, Section 6
This section is used in the following form

$$61616\ n_0A_0A_0A_0A_0\ \ d_0d_0F_0F_0F_0F_0\ \ldots\ldots$$
$$n_1\ldots\ldots\ d_1d_1\ldots\ldots$$
$$n_nA_nA_nA_nA_n\ \ d_nd_nF_nF_nF_nF_n$$

where n_n is sequential number of significant levels.
NOTE: The code figure n=0 is used only to identify the surface level; significant successive levels are numbered in ascending order with code figures n=1,2,3..9,1,2,3...

$A_nA_nA_nA_n$	Altitude of significant level, in decametres.
d_nd_n	True direction, in tens of degrees, from which wind is blowing at specified levels, starting with station level (Code table 0877).
$F_nF_nF_n$	Wind speed, in knots, at specified levels starting with station level.

TEMP code
Parts B and D, Section 6
When the wind speed is less than 2.5 m/s, the wind direction is not considered for the determination of the significant levels of wind.

ddfff
$d_nd_nf_nf_nf_n$
$d_md_mf_mf_mf_m$
$d_td_tf_tf_tf_t$

The direction from which wind is blowing is always indicated in tens of degrees by means of Code table 0877.

GERMANY

PILOT code
Parts A and C, Section 2
Altitudes constituting the best approximation to the standard isobaric surfaces are determined as follows:

Standard isobaric surface (hPa)	Altitude in the PILOT reports (m)	Standard isobaric surface (hPa)	Altitude in the PILOT reports (m)
850	1500	150	13500
700	3000	100	15900
500	5400	70	18300
400	7200	50	20700
300	9000	30	23700
250	10500	20	26400
200	12000	10	30900

Part B, Section 2
Wind data are reported for the following altitudes, as available: 900, 2100 and 4200 metres (above mean sea level) and for the three first 300-m steps (above mean sea level), where the first step has to be 150 metres above station level. Up to two additional steps shall be reported when at these heights significant wind changes (direction and/or speed) have been observed.

Parts A and C, Section 3
The group $4v_bv_bv_av_a$ shall be reported for each wind maximum.

<u>TEMP code</u>
Parts A and C, Section 4
The group $4v_bv_bv_av_a$ shall be reported for each maximum wind.

HUNGARY, REPUBLIC OF

<u>TEMP code</u>
Parts B, Section 10
This section is used in the following symbolic form:

61616 92hhh TTTDD ddfff

and contains the geopotential height hhh, temperature TTT, dew point depression DD, wind direction dd and wind speed fff at the 925 hPa level. This section is included in the reports for 0000 UTC and 1200 UTC.

ITALY

<u>TEMP code</u>
Parts B, Section 9
This section is used to indicate wind data at 900 metres above the station.

NORWAY

<u>TEMP code</u>
Parts B, Section 10
This section is used in the form:

61616 ddfff ddfff ddfff

where the code figures ddfff refers to the thermal winds in the layers:

700 hPa - 900 metres
500 hPa - 900 metres
300 hPa - 500 hPa

PORTUGAL (including AZORES)

PILOT code
Parts A and C, Section 2
Altitudes constituting the best approximation to the standard isobaric surfaces are determined as follows:

Standard isobaric surface (hPa)	Altitude in the PILOT reports (m)	Standard isobaric surface (hPa)	Altitude in the PILOT reports (m)
850	1500	150	13500
700	3000	100	15900
500	5400	70	18300
400	7200	50	20700
300	9000	30	23700
250	10500	20	26400
200	12000	10	30900

Part B, Section 4
Wind data are reported for the following altitudes, as available: 600. 900,1200, 2100, and 4200 metres.

Part B, Section 6
This section is used to report wind data at 300 metres, in the following form:

61616 101// ddfff

TEMP code
Part B, Section 10
This section is used to report wind data at 300 and 600 metres above mean sea level, in the following form:

61616 $11PPP_{300}$ $ddfff_{300}$
$22PPP_{600}$ $ddfff_{600}$

ROMANIA

PILOT code
Part B, Section 4
Wind are reported for the following altitudes, as available: 900, 1200, 1800, 2100, 2400, 2700, 4200, 6000, 8100 and 9000 metres.

RUSSIAN FEDERATION

PILOT code

In Parts B and D, a section beginning with the symbolic figure group 51515 is added:

Part B 51515 $/V_bV_bV_aV_a$
Part D 51515 $/V_bV_bV_aV_a$ $H_eH_ed_ed_ef_e$

$/V_bV_bV_aV_a$: Group indicating vertical wind shear in layers 1 km below and 1 km above maximum wind level. The specifications of this group are as follows:

V_bV_b : Absolute magnitude of the vector difference, in whole metres per second, between maximum wind speed observed 1 km below this maximum wind level.

V_aV_a : Absolute magnitude of the vector difference, in whole metres per second, between maximum wind speed observed 1 km below this maximum wind level.

When the absolute value of vector difference is under 10 m/s the first figure of V_bV_b or V_aV_a is coded as 0.

NOTE :This group may be included not more than twice in Part B, the first group relating to the level of the highest maximum wind speed, the second group relating to the level of the second highest maximum wind speed.

$H_eH_ed_ed_ef_e$: This group is included in Part D from 1 April until 30 September if, at heights above 16 km and up to the ascent, or in a layer with a vertical extent exceeding 5 km, a change of the wind from westerly directions (230°-320°) to easterly directions (040°-140°) is observed. The specifications of the group are as follows:

H_eH_e : Height, in kilometres, of the lower boundary of the layer, where a steady wind of an easterly direction is observed.

d_ed_e : Direction of the wind, in tens of degrees, at the lower boundary of the layer in which steady easterly winds are observed. Units of degrees of wind direction are rounded off to the nearest ten in the usual manner.

f_e : Wind speed, in metres per second, at the lower boundary of the layer in which steady easterly winds are observed. Wind speed 10 m/s and greater is reported by 0.

NOTE: If a number of layers with reversed wind direction are observed, the transmitted data refer only to the lowest layer.

TEMP code

Part B, Section 9

This section is used in the following symbolic form: 51515 $/V_bV_bV_aV_a$

The specifications and the use of the group are the same as those indicated for Part B of PILOT.

Part D, Section 9
This section is used in the following symbolic form:

51515 $/V_bV_bV_aV_a$ $H_eH_ed_ed_ef_e$

The specifications and the use of the groups are the same as those indicated for Part D of PILOT, except that the lower boundary of the layer, where a steady east winds are observed, is given in pressure units of 1 hPa.

SWITZERLAND

PILOT code
Part B, Section 4
Wind data are reported for the following altitudes, as available: 1000, 2000, 4000, 5000, 6000 and 14000 metres.

UNITED KINGDOM

PILOT code
Parts A and C, Section 2
Altitudes constituting the best approximation to the standard isobaric surfaces are determined as follows:

Standard isobaric surface (hPa)	Altitude in the PILOT reports (m)	Standard isobaric surface (hPa)	Altitude in the PILOT reports (m)
850	1500	150	13500
700	3000	100	15900
500	5400	70	18300
400	7200	50	20700
300	9000	30	23700
250	10500	20	26400
200	12000	10	30900

Parts A and C, Section 3
The group $4v_bv_bv_av_a$ shall be reported for each maximum wind.

TEMP code
Parts A and C, Section 4
The group $4v_bv_bv_av_a$ shall be reported for each maximum wind.

Part B, Section 9
Groups $11P_1P_1$ and $d_1d_1f_1f_1f_1$ are used to report the pressure and wind at 900 metres above the surface.

REGION ANTARCTIC : regionally code practices

Code FM 32-IX PILOT

Parts A and C, Section 2
When the standard isobaric surfaces cannot be located by means of pressure equipment, the following altitudes shall be used as approximation to the standard isobaric surfaces:

Standard isobaric surface (hPa)	Altitude in the PILOT reports (m)	
	either	or
850	1500	1200
700	3000	2700
500	5000	5100
400	6500	6600
300	8500	8400
250	-	-
200	11000	10800
150	12500	12600
100	15000	14700
70	18500	18300
50	20500	20700
30	23500	23700
20	26500	26400
10	31000	30900

Part B, Section 4
In addition to wind data at significant levels, altitudes of which are given in geopotential units, data at the following fixed levels shall be reported:
When indicator figure 9 is used (height in metres) :
300, 600, 900, 1500, 1800, 2100, 2400, 3000, 3600, 4200, 4800, 6000, 7500, 9000, 12000 and the highest reportable level reached if below the 100 hPa surface.
When indicator figure 8 is used (height in metres) :
500, 1000, 2000, 2500, 3500, 4000, 4500, 5500, 6000, 7000, 7500, 9000, 12000 and the highest reportable level reached if below the 100 hPa surface.

If a significant level occurs within 150 metres of one of the fixed levels when indicator figure 9 is used, the data for the significant level shall be reported in the fixed level group in place of the data observed at the fixed level.

Requirements for international exchange.
Parts A, B, C and D shall be included in international exchanges and in exchanges within the Antarctic.
NOTE: If the data in Parts A and/or C are completely duplicated in a TEMP report, Parts A and/or C may be omitted.

Codes FM 35-IX Ext. TEMP, FM 36-IX Ext. TEMP SHIP and FM 35-IX Ext. TEMP DROP

Requirements for international exchange.
Parts A, B, C and D shall be included in international exchanges and in exchanges within the Antarctic.

REGION ANTARCTIC : nationally code practices

AUSTRALIA, stations operated by

NOTE on hours of observation : During summer time, Australian standard times for upper temperature, humidity and pressure synoptic observations are 1100 and 2300 UTC in all Australian States and island stations operated by Australia, but not at Australian Antarctic stations.

PILOT code
Parts A and C, Section 2
When the standard isobaric surfaces cannot be located by means of pressure-measuring equipment, long-term monthly means of the heights of such surfaces determined from radiosonde data are used as the best approximation to the standard surfaces.

In WMO NO 306 vol. II are given tables for pressure heights (1000 hPa to 1 hPa) in metres for each month for the stations 89571 Davis, 94986 Mawson and 89611 Casey.

Legend for symbolic letters

Symbolic letter(s)	meaning
$A_{df}A_{df}$	Form of additional data reported (Region IV) (Code table 421).
a_4	Type of measuring equipment used, (Code table 0265) see below.
C_H	Clouds of the genera Cirrus, Cirrocumulus and Cirrostratus (Code table 0509).
C_L	Clouds of the genera Stratocumulus, Stratus, Cumulus and Cumulonimbus (Code table 0513).
C_M	Clouds of the genera Altocumulus, Altostratus and Nimbostratus (Code table 0515).
D....D -	Ship's call sign consisting of three or more alphanumeric characters. Call sign consisting of three or more alphanumeric characters for mobile land station making upper-air observations or issuing a radiological report on a routine basis and/or in case of accident.
D_0D_0 D_nD_n	Dew-point depression at standard isobaric surfaces or at significant levels, starting with station level.
D_tD_t	Dew-point depression at the tropopause level.
dd	True direction (rounded off to the nearest 5°), in tens of degrees, from which wind is blowing.
d_md_m	True direction (rounded off to the nearest 5°), in tens of degrees, from which maximum wind is blowing.
d_0d_0 d_nd_n	True direction (rounded off to the nearest 5°), in tens of degrees, from which wind is blowing at specified levels starting with surface level.
d_td_t	True direction (rounded off to the nearest 5°), in tens of degrees, from which wind is blowing at the tropopause levels.
fff	Wind speed in metres per second or knots. See note 1 under dd.
$f_mf_mf_m$	Maximum wind speed, in metres per second or knots. See note 1 under dd and note under YY.
$f_tf_tf_t$	Wind speed in metres per second or knots, at the tropopause level.

Symbolic letter(s)	meaning
$f_0f_0f_0$ $f_nf_nf_n$	Wind speed, in metres pr second or knots, at specified levels starting with station level.
GG	Actual time of observation, to the nearest whole hour UTC. In the case of upper-air observations, the actual time of observation is the time at which the balloon or rocket is actually released, or the time at which the aircraft actually takes off from the surface.
GGgg	Time of observation, in hours and minutes UTC. Actual time of launching the radiosonde.
$H_mH_mH_mH_m$	Altitude of level of maximum wind, in tens of standard geopotential metres.
$h_0h_0h_0h_0$	Elevation of mobile land station making an upper-air observation, in either metres or feet as indicated by i_m.
$h_1h_1h_1$ $h_nh_nh_n$	Geopotential of the standard isobaric surfaces P_1P_1,P_2P_2,.. P_nP_n , in standard geopotential metres and tens of standard geopotential metres. (1) Geopotentials of surfaces below sea-level shall be reported by adding 500 to the absolute value of the geopotential (2) The geopotential shall be reported in whole standard geopotential metres up to, but not including, 500 hPa and higher, omitting if necessary the thousands or tens of thousands digits.
h	Height above surface of the base of the lowest cloud seen (Code table 1600). (1) The term "height above surface" shall be considered as being the height above the official aerodrome elevation or above station level at a non-aerodrome station, or above the surface of the water in report from ships.
I_d	Indicator used to specify the hundreds of hectopascals figure.
i_m	Indicator for units of elevation, and confidence factor for accuracy of elevation (Code table 1845) see below.
II	Block number.
iii	Station number. The station numbers have been allocated as in table 1 below.
$L_aL_aL_a$	Latitude, in degrees and minutes.
$L_0L_0L_0L_0$	Longitude, in tenths of a degree.
MMM	Number of Marsden square in which the station is situated at the time of observation (Code table 2590).

Symbolic letter(s)	meaning
M_iM_i	Identification letters of the report (Code table 2582).
M_jM_j	Identification letters of the part of the report or the version of the code form (Code table 2582).
n	Number of consecutive isobaric surfaces for which wind data are reported, starting with the surface specified by P_1P_1.
n_0n_0 n_nn_n	Number of level, starting with station level. (1) Station level shall be coded $n_0n_0 = 0$.
N_h	Amount of all the C_L cloud present or, if no C_L cloud is present, the amount of all the C_M cloud present. (Code table 2700).
P_1P_1	Pressure at the lowest standard isobaric surface, with respect to altitude, for which wind data are reported. See note (1) for $P_0P_0P_0$.
P_1P_1 P_nP_n	Pressure of standard isobaric surfaces (1000 hPa = 00, 925 hPa = 92).
$P_0P_0P_0$ $P_nP_nP_n$	Pressure at specified levels. (1) The pressure of surfaces up to and including the 100-hPa surface shall be reported in whole hectopascals. Above the 100-hPa surface pressure shall be reported in tenths of a hectopascal.
$P_mP_mP_m$	Pressure at the maximum wind level. See (1) for $P_nP_nP_n$.
$P_tP_tP_t$	Pressure at the tropopause level. See (1) for $P_nP_nP_n$.
Q_c	Quadrant of the globe (Code table 3333).
r_ar_a	Radiosonde/sounding system used (Code table 3685) see below.
s_n	Sign of the data, and relative humidity indicator (Code table 3845).
s_r	Solar and infrared radiation correction. (Code table 3849) see below.
s_as_a	Tracking technique/status of system used (Code table 3872) see below.
T_{a0} T_{an}	Approximate tenths value and sign (plus or minus) of the air temperature at specified levels starting with station level. (Code table 3931).
T_{at}	Approximate tenths value and sign (plus or minus) of the air temperature at the tropopause level. (Code table 3931).

Symbolic letter(s)	meaning
T_0T_0 T_nT_n	Air temperature not rounded off, in degrees Celsius, at specified levels starting with station level.
T_tT_t	Air temperature, in whole degrees Celsius, at the tropopause level.
$T_wT_wT_w$	Sea-surface temperature, in tenths of a degree Celsius, its sign being given by s_n.
t_n	Tens digit of the altitude, expressed in units of 300 metres or 500 metres which applies to the following data groups.
U_{La}	Unit digit in the reported latitude.
U_{Lo}	Unit digit in the reported longitude.
u_1	Unit digit of the altitude, expressed in units of 300 metres or 500 metres, for the first data group following.
u_2	Unit digit of the altitude, expressed in units of 300 metres or 500 metres, for the second data group following.
u_3	Unit digit of the altitude, expressed in units of 300 metres or 500 metres, for the third data group following.
v_av_a	Absolute value of the vector difference between the maximum wind and the wind blowing at 1 km above the level of maximum wind, in units indicated by YY.
v_bv_b	Absolute value of the vector difference between the maximum wind and the wind blowing at 1 km below the level of maximum wind, in units indicated by YY.
YY	Day of the month (UTC), with 01 indicating the first day, 02 the second day, etc. In FM 32-IX, FM 33-IX, FM 34-IX, FM 35-IX, FM 36-IX, FM 37-IX, FM 38-IX, YY shall be used to indicate the unit of wind speed in addition to indicating the day of the month. When the speeds are given in knots, 50 shall be added to YY. When the speed is given in metres per second, YY shall not be modified.

Station number. The station numbers have been allocated as follows:

Region I	Africa	60000-69999
Region II	Asia	20000-20099 20200-21999 23000-25999 28000-32999 35000-36999 38000-39999 40350-48599 48800-49999 50000-59999
Region III	South America	80000-88999
Region IV	North and Central America	70000-79999
Region V	South-West Pacific	48600-48799 90000-98999
Region VI	Europe	00000-19999 20100-20199 22000-22999 26000-27999 33000-34999 37000-37999 40000-40349
Stations in the Antarctic		60000-69999

Table 1 WMO station number system.

WMO code table 0265, a_4 Type of measuring equipment used.

code figure	meaning
0	Pressure instrument associated with wind measuring equipment
1	Optical theodolite
2	Radiotheodolite
3	Radar
4	Pressure instrument associated with wind measuring equipment but pressure element failed during ascent
5	VLF-Omega
6	Loran-C
7	Wind profiler
8	Satellite navigation
9	reserved

WMO code table 3685 $r_a r_a$, Radiosonde/sounding system used.

Code figure	
00-01	Reserved
02	No radiosonde/passive target (e.g. balloon plus reflector, etc.)
03	No radiosonde/active target (e.g. balloon plus transponder)
04	No radiosonde/passive temperature-humidity profiler
05	No radiosonde/active temperature-humidity profiler
06	No radiosonde/radio-acoustic sounder
07-08	No radiosonde/....(reserved)
09	No radiosonde/sounding system not specified or unknown
10	VIZ type A pressure-commutated (USA)
11	VIZ type B time-commutated (USA)
12	RS SDC (Space Data Corporation - USA)
13	Astor (no longer made - Australia)
14	VIZ Mark I microsonde (USA)
15	EEC Company type 23 (USA)
16	Elin (Austria)
17	GRAW G. (Germany)
18	Reserved for allocation of radiosondes
19	GRAW M60 (Germany)
20	Indian Met Service MK3 (India)
21	VIZ/Jin Yang Mark I microsonde (South Korea)
22	Meisei RS2-80 (Japan)
23	Mesural FMO 1950A (France)
24	Mesural FMO 1945A (France)
25	Mesural MH73A (France)
26	Meteolabor Basora (Switzerland)
27	AVK-MRZ (Russian Federation)
28	Meteorit Marz2-1 (Russian Federation)
29	Meteorit Marz2-2 (Russian Federation)
30	Oki RS2-80 (Japan)
31	VIZ/Valcom type A pressure-commutated (Canada)
32	Shanghai Radio (China)
33	UK Met Office MK3 (UK)
34	Vinohrady (Czechoslovakia)
35	Vaisala RS18 (Finland)
36	Vaisala RS21 (Finland)
37	Vaisala RS80 (Finland)
38	VIZ LOCATE Loran-C (USA)
39	Sprenger E076 (Germany)
40	Sprenger E084 (Germany)
41	Sprenger E085 (Germany)
42	Sprenger E086 (Germany)
43	AIR IS - 4A - 1680 (USA)

WMO code table 3685 (cont.) $r_a r_a$, Radiosonde/sounding system used.

Code figure	
44	AIR IS - 4A - 1680 X (USA)
45	RS MSS (USA)
46	AIR IS - 4A - 403 (USA)
47	Meisei RS2-91 (Japan)
48	VALCOM (Canada)
49	VIZ Mark II (USA)
50	GRAW DFM-90 (Germany)
51-59	Reserved for allocation of radiosondes
60	Vaisala RS80/MicroCora (Finland)
61	Vaisala RS80/DigiCora or Marwin (Finland)
62	Vaisala RS80/PCCora (Finland)
63	Vaisala RS80/Star (Finland)
64	Orbital Sciences Corporation, Space Data Division, transponder
	radiosonde, type 909-11-XX, where XX corresponds to the model
	of the instrument (USA)
65	VIZ transponder radiosonde, model number 1499-520 (USA)
66-89	Reserved for allocation of automated sounding systems
90	Radiosonde not specified or unknown
91	Pressure-only radiosonde
92	Pressure-only radiosonde plus transponder
93	Pressure-only radiosonde plus radar reflector
94	No-pressure-only radiosonde plus transponder
95	No-pressure-only radiosonde plus radar reflector
96	Descending radiosonde
97-99	Reserved for allocation of sounding systems with incomplete sondes

Notes

(1) References to countries in brackets indicate the manufacturing location rather than the country using the instrument.

(2) Some of the radiosondes listed are no longer in use but are retained for archives purposes.

WMO code table 3849 s_r, Solar and infrared correction.

code figure	meaning
0	No correction
1	CIMO solar corrected and CIMO infrared corrected
2	CIMO solar corrected and infrared corrected
3	CIMO solar corrected only
4	Solar and infrared corrected automatically by radiosonde system
5	Solar corrected automatically by radiosonde system
6	Solar and infrared corrected as specified by country
7	Solar corrected as specified by country

WMO code table 3872, $s_a s_a$ Tracking technique/status of system used.

code figure	meaning
00	No wind finding
01	Automatic with auxiliary optical direction finding
02	Automatic with auxiliary radio direction finding
03	Automatic with auxiliary ranging
04	Not used
05	Automatic with multiple VLF-Omega frequencies
06	Automatic cross chain Loran-C
07	Automatic with auxiliary wind profiler
08	Automatic satellite navigation
09-18	Reserved
19	Tracking technique not specified
20-29	Reserved ASAP : Ship systems
30-39	Reserved ASAP : Sounding systems
40-49	Reserved ASAP : Launch facilities
50-59	Reserved ASAP : Data acquisition systems
60-69	Reserved ASAP : Communications
70	Reserved ASAP : All systems in normal operation
71-98	Reserved
99	Status of system and its components not specified

Appendix 1.

WMO No.	TN	TD	CIMO rep.	Publication	page(s)
8				Guide to Meteorological Instruments and Methods of Observation	4,5,36,39
49				Technical regulations	5,49
119	45			Performance requirements of aerological instruments	27
267	112			Performance requirements of aerological instruments	27
284				Upper-air instruments and observations	16
306				Manual on Codes vol. 1&2	6,34,42,65,68,82
394	140			Upper-air sounding studies	16,27,34
488				Guide on the Global Observing System	12
512	163			The compatibility of upper-air data	7,27
			81-2	Report of first session of the CIMO working group on upper air data compatibility	28
			5	WMO Catalogue of Radiosondes in Use by Members 1981	7
			11	WMO Catalogue of Radiosondes in Use by Members 1982	7,10
			15	WMO/CIMO TECEMO 1984	21
		175	21	Algorithms for automatic aerological soundings	28
		50	22	WMO/CIMO TECIMO-III 1985	19,31,32,35
		51	23	WMO/CIMO TECIMO-III 1985 keynotes	12
		176	27	WMO Catalogue of Radiosondes and Upper-AIR Wind Systems in Use by Members 1986	7
		174	28	WMO International Radiosonde Comparison, Phase I 1984	13,17
		312	29	WMO International Radiosonde Intercomparison, Phase II 1985	13,17
		195	30	WMO International Radiosonde Comparison, UK, 1984 / USA, 1985	17,39
		222	33	WMO/CIMO TECO-1988	22,32,36,37
		303	35	WMO/CIMO TECIMO-IV 1989	14,21,22,23,25,32, 36,37,39
		344	36	Compatibility of radiosonde geopotential measurements	7,10,28
		451	40	WMO International Radiosonde Intercomparison, Phase III 1989	13,14,17,18,40
		462	49	WMO/CIMO TECO-92 1992	24,25,33,36,37,40, 41
		541	50	Historical Changes in Radiosonde Instruments and Practices	6,9,15,41
		587	56	Report by the Rapporteur on Radiosonde Compatibility Monitoring	4,7,9,11,28,38
		588	57	WMO/CIMO TECO-94 1994	19,24,25,33

WMO/CIMO papers mentioned in this report with reference to page(s).

Appendix 2.

Abbreviations used:

ALPEX	Alpine Experiment (within GARP)
ART	Automated Radio Theodolite
ASAP	Automated Shipboard Aerological Programme
ASOND	Alpine Sonde experiment (within ALPEX)
CBS	Commission for Basic Systems
CIMO	Commission for Instruments and Methods of Observation
CRC	Communications Research Centre, Canada
EC	Executive Council of WMO
ECMWF	European Centre for Medium Range Weather Forecasts
GTS	Global Telecommunication System
GARP	Global Atmospheric Research Programme
GATE	GARP Atlantic Tropical Experiment
GDPS	Global Data-processing System
GTS	Global Telecommunication System
ITU	International Telecommunications Union
JAPE	Joint Acoustic Propagation Experiment
MMS	Marine Meteorological Service
NASA	National Aeronautics and Space Administration
NCAR	National Centre for Atmospheric Research
NMI	Norwegian Meteorological Institute
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
PILOT	Code FX 32 (WMO No 306)
PREFERS	Potential Reference Radiosonde
PTU	Pressure, Temperature, Humidity
RAL	Rutherford Appleton Laboratory, UK.
RSMC	Regional Specialized Meteorological Centre
SONDEX	Sonde experiment (within ALPEX)
SYNOP	Code FX 12 (WMO No 306)
TCEMO	WMO Technical Conference on Instruments and methods of observation
TCIMO	WMO Technical Conference on Instruments and methods of observation
TECO	WMO Technical Conference on Instruments and methods of observation
TEMP	Code FX 35 (WMO No 306)
TOGA	Tropical Ocean and Global Atmosphere Programme
TR	Telenor Research, Norway
UTC	Universal Time Clock
WMC	World Meteorological Centre
WMO	World Meteorological Organization
WMO/TD	WMO/Technical Document
WMO/TN	WMO/Technical Note
WWW	World Weather Watch

Appendix 3

Appendix 3a

WMO catalogue of Radiosondes and Upper-Air Wind Systems in Use by Members

As an example of such catalogues we show a copy of a page from CIMO report 56 or WMO/TD 587, "WMO catalogue of Radiosondes and Upper-Air Wind Systems in Use by Members (1993)" prepared by T. Oakly.

More or less similar catalogues are previous issued by infrequent intervals.

Appendix 3b

OPERATIONAL NEWSLETTER

All information on changes to the operation of the World Weather Watch (WWW) and Marine Meteorological Services (MMS) is being assembled and distributed by the Secretariat of WMO on a monthly basis.

The information consists for instance of new stations, deleted stations and changes to existing stations. As an example we show copies of two pages from volume 1994 - No. 8 (August 1994) showing all three cases, new, deleted and changes of surface-based stations.

Appendix 3c

OPERATIONAL NEWSLETTER

Since this publication is valuable in monitoring the operational status of the global station network, we add a copy of the "order form" of the publication.

Appendix 3a

TABLE 2
UPPER-AIR STATIONS AND RADIOSONDE TYPES 1993

STATION NUMBER	LAT (+=S)	LONG (-=W)	STAT. HGHT	STATION NAME	COUNTRY	SONDE	ALT SONDE	TEMP PROG.	PILOT PROG.	DATE UPD.
01001	70.93	-8.67	9	JAN MAYEN	NORWAY	VRS80N		0012		02/93
01028	74.52	19.02	18	BJORNOYA	NORWAY	VRS80N		0012		02/93
01152	67.26	14.37	20	BODO	NORWAY	VRS80N		0012		02/93
01241	63.70	9.60	10	ORLAND	NORWAY	VRS80N		0012		02/93
01384	60.20	11.10	201	OSLO/GARDERMOEN	NORWAY	VRS80N		0012		02/93
01415	58.88	5.63	14	STAVANGER/SOLA	NORWAY	VRS80N		0012		02/93
02185	65.55	22.13	34	LULEA/KALLAX	SWEDEN	VRS80		0012	0618	01/93
02225	63.18	14.50	366	OSTERSUND/FROSON	SWEDEN	VRS80		IRREG	IRREG	01/93
02365	62.53	17.45	6	SUNDSVALL-HARNOSAND	SWEDEN	VRS80N		0012	0618	01/93
02465	59.35	17.95	22	STOCKHOLM/BROMMA	SWEDEN	VRS80N		0012	0618	01/93
02527	57.67	12.30	155	GOTEBURG/LANDVETTER	SWEDEN	VRS80N		0012	0618	01/93
02544	58.52	14.53	102	KARLSBORG	SWEDEN	VRS80		IRREG	IRREG	01/93
02591	57.65	18.35	47	VISBY AEROLOGISKA	SWEDEN	VRS80		0012	0618	01/93
02836	67.37	26.65	179	SONDANKYLA	FINLAND	VRS80N		0012		12/92
02935	62.40	25.68	145	JYVASKYLA	FINLAND	VRS80N		0012		12/92
02963	60.82	23.50	103	JOKIOINEN	FINLAND	VRS80N		0012		12/92
03005	60.13	-1.18	84	LERWICK	UNITED KINGDOM	VRS80		0012	0618	09/93
03026	58.22	-6.32	13	STORNOWAY	UNITED KINGDOM	VRS80		0012	0618	09/93
03170	56.43	-2.87	5	SHANWELL (Closed)	UNITED KINGDOM	VRS80		0012	0618	03/92
03213	54.32	-3.40	9	ESKMEALS	UNITED KINGDOM	VRS80L		IRREG	IRREG	09/93
03240	55.41	-1.60	75	BOULMER	UNITED KINGDOM	VRS80L		00061218		09/93
03322	53.55	-2.92	56	AUGHTON	UNITED KINGDOM	VRS80L		00061218		09/93
03496	52.68	1.68	14	HEMSBY	UNITED KINGDOM	VRS80	VRS80L	0012	0618	09/93
03502	52.13	-4.57	134	ABERPORTH	UNITED KINGDOM	VRS80		IRREG	IRREG	09/93
03693	51.55	0.83	3	SHOEBURYNESS	UNITED KINGDOM	VRS80		IRREG	IRREG	09/93
03743	51.20	-1.80	133	LARKHILL	UNITED KINGDOM	VRS80		IRREG	IRREG	09/93
03763	51.38	-0.78	74	BEAUFORT PARK	UNITED KINGDOM	VRS80		IRREG	IRREG	10/92
03774	51.08	-0.22	144	CRAWLEY (Closed)	UNITED KINGDOM	VRS80		0012	0618	09/92
03808	50.22	-5.32	88	CAMBORNE	UNITED KINGDOM	VRS80		0012	0618	09/93
03882	50.90	0.33	54	HERSTMONCEUX	UNITED KINGDOM	VRS80L		00061218		09/93
03920	54.48	-6.10	38	LONG KESH	UNITED KINGDOM	VRS80L		00061218		09/93
03953	51.93	-10.25	14	VALENTIA	EIRE	VRS80N		0012	18	01/93
04018	63.97	-22.60	38	KEFLAVIK	ICELAND	VRS80N		0012		12/92
04202	76.52	-68.83	59	THULE AIRFORCE BASE	GREENLAND	MSS		0012		12/92
04220	68.70	-52.75	40	EGEDESMINDE	GREENLAND	VRS80N		0012		12/92
04270	61.18	-45.43	4	NARSSARSSUAQ	GREENLAND	VRS80N		0012		12/92
04320	76.77	-18.77	11	DANMARKSHAVN	GREENLAND	VRS80N		0012		12/92
04339	70.48	-21.97	65	SCORESBYSUND	GREENLAND	VRS80N		0012		12/92
04360	65.60	-37.63	50	ANGMAGSSALIK	GREENLAND	VRS80N		0012		12/92
06011	62.02	-6.77	55	THORSHAVN	DENMARK (FAROE ISL)	VRS80N		0012		12/92
06030	57.10	9.87	3	ALBORG	DENMARK	VIZ		06		12/92
06181	55.77	12.52	40	KOBENHAVN	DENMARK	VRS80N		0012	0618	12/92
06260	52.10	5.18	4	DE BILT	NETHERLANDS	VRS80N		00061218		12/92
06447	50.80	4.35	104	UCCLE	BELGIUM	VRS80N		0012		12/92
06476	50.03	5.40	557	ST-HUBERT	BELGIUM	VRS80N		0012		12/92
06496	50.47	6.18	570	ELSENBORN	BELGIUM			IRREG	IRREG	12/92
06610	46.82	6.95	491	PAYERNE	SWITZERLAND	ML-SRS		0012	0618	12/92
07110	48.45	-4.42	103	BREST	FRANCE	VRS80L		0012		12/92
07145	48.77	2.02	168	TRAPPES	FRANCE	VRS80L		0012		12/92
07180	48.68	6.22	217	NANCY/ESSEY	FRANCE	VRS80L		0012		12/92
07481	45.73	5.08	240	LYON/SATOLAS	FRANCE	VRS80L		0012		12/92
07510	44.83	-0.70	61	BORDEAUX/MERIGNAC	FRANCE	VRS80L		0012		12/92
07645	43.87	4.40	62	NIMES/COURBESSAC	FRANCE	VRS80L		0012		12/92
07761	41.92	8.80	9	AJACCIO	FRANCE	VRS80L		0012		12/92
08001	43.37	-8.42	67	LA CORUNA	SPAIN	VRS80N		0012		12/92
08023	43.47	-3.82	65	SANTANDER	SPAIN	VRS80N		0012		12/92
08160	41.67	-1.02	258	ZARAGOZA A/P	SPAIN	VRS80N		0012		12/92
08221	40.47	-3.58	633	MADRID	SPAIN	VRS80N		0012		12/92
08301	39.55	2.61	6	PALMA DE MALLORCA	SPAIN	VRS80N		0012		12/92
08430	38.00	-1.17	62	MURCIA	SPAIN	VRS80N		0012		12/92
08495	36.15	-5.33	4	GIBRALTAR	GIBRALTAR	VRS80N		0012	0618	09/93
08508	38.73	-27.07	54	LAJES	PORTUGAL (ACORES)	VRS80N		0012		12/92
08522	32.63	-16.90	56	FUNCHAL	PORTUGAL (MADEIRA)	VRS80N		0012		12/92
08579	38.77	-9.13	104	LISBOA/GAGO COUTINHO	PORTUGAL	VRS80N		0012		12/92
08594	16.73	-22.95	55	SAL	CAPE VERDE ISLS	VIZ		0012		12/92
10035	54.53	9.55	48	SCHLESWIG	GERMANY	VRS80		0012	0618	01/93
10046	54.38	10.15	31	KIEL-KRONSHAGEN	GERMANY			IRREG	IRREG	01/93
10184	54.10	13.38	6	GREIFSWALD	GERMANY	VRS80N		00061218		01/93
10200	53.35	7.22	5	EMDEN-KONIGSPOLDER	GERMANY	VRS80		0012	0618	01/93
10238	52.82	9.93	69	BERGEN	GERMANY			IRREG	IRREG	01/93
10304	52.72	7.32	26	MEPPEN	GERMANY			IRREG	IRREG	01/93
10338	52.47	9.70	55	HANNOVER	GERMANY	VRS80		0012	0618	01/93
10384	52.47	13.40	46	BERLIN-TEMPELHOF	GERMANY			IRREG	IRREG	01/93
10393	52.22	14.12	115	LINDENBERG	GERMANY	VRS80		00061218		01/93
10410	51.40	6.97	153	ESSEN	GERMANY	VRS80		0012	0618	01/93
10437	51.13	9.28	223	FRITZLAR-KASSELERW	GERMANY			IRREG	IRREG	01/93
10486	51.12	13.68	232	WAHNSDORF	GERMANY	VRS80		0012	0618	01/93
10548	50.55	10.37	453	MEININGEN	GERMANY	VRS80		000612	18	01/93
10618	49.70	7.33	377	IDAR-OBERSTEIN	GERMANY	VRS80		0012	0618	01/93
10739	48.83	9.20	315	STUTTGART	GERMANY	VRS80		0012	0618	01/93
10771	49.43	11.90	415	GARMERSDORF	GERMANY	VRS80		0012	0618	01/93

Annex I

GLOBAL OBSERVING SYSTEM

C. INFORMATION ON OPERATIONAL STATUS OF ELEMENTS OF THE SURFACE-BASED SUB-SYSTEM

1. PUBLICATION NO. 9, VOLUME A - STATIONS

1.1 New stations

Index No.	Name	Latitude	Longitude	Elevation HP	Elevation H/HA	Pressure Level	Surface observations 00	03	06	09	12	15	18	21	Obs. H / Obs. S	Upper-air 00	06	12	18	Re-marks
Region I — Egypt																				
62335	Rafh	31°12'N	34°12'E	-	-		.	.	X	X	X	X	X	.	H06-18	.	.	.	.	
62336	El Arish	31°05'N	33°49'E	-	-		.	.	X	X	X	X	X	.	H06-18	.	.	.	.	
62387	Minya	28°05'N	30°44'E	40	37		X	X	X	X	X	X	X	X	H00-24	.	.	.	.	
62389	Malwy	30°45'N	27°42'E	44	-		.	.	X	X	X	X	X	.	H06-18	.	.	.	.	
62463	Hurguada	27°09'N	33°43'E	14	16		X	X	X	X	X	X	X	X	H00-24	P	.	P	.	
Region II — Former U.S.S.R. (effective 1 August 1994)* (this is a repetition of the information inserted in Volume 1994-No. 3)																				
29570	Krasnojarsk Opytnoe Pole	56°02'N	92°45'E	276	-		X	X	X	X	X	X	X	X		.	.	.	.	
29572	Emel'Janovo	56°11'N	92°37'E	296	-		.	.	.	.	.	.	.	.		RW	.	RW	.	
29862	Hakasskaja	53°46'N	91°19'E	256	-		X	X	X	X	X	X	X	X		RW	.	RW	.	
31736	Habarovsk	48°32'N	135°14'E	72	-		.	.	.	.	.	.	.	.		RW	.	RW	.	
31977	Sad-Gorod	43°16'N	132°03'E	82	-		X	X	X	X	X	X	X	X		RW	.	RW	.	
32215	Severo-Kurilsk	50°41'N	156°08'E	23	-		X	X	X	X	X	X	X	X		RW	.	RW	.	
Region IV — U.S.A.																				
72215	Peachtree City, GA	33°22'N	84°34'W	244	262		.	.	.	.	.	.	.	.		RW	.	RW	.	
(replaces 72311 for upper-air observation effective 29 August 1994)																				
72230	Shelby County Airport, AL	33°10'N	86°46'W	-	178		.	.	.	.	.	.	.	.		RW	.	RW	.	
(replaces 72229 for upper-air observation effective 22 August 1994)																				
72249	Ft. Worth, TX	32°50'N	97°18'W	-	196		.	.	.	.	.	.	.	.		RW	.	RW	.	
(replaces 72260 for upper-air observation effective 11 July 1994)																				
72305	Newport, NC	34°47'N	76°53'W	11	11		.	.	.	.	.	.	.	.		RW	.	RW	.	
(replaces 72304 for upper-air observation effective 18 July 1994)																				
72558	Valley, NE	41°19'N	96°22'W	350	350		.	.	.	.	.	.	.	.		RW	.	RW	.	
(replaces 72553)																				
72565	Denver Int. Airport, CO	39°52'N	104°40'W	1656	1656		X	.	X	.	X	.	X	.	H00-24	.	.	.	.	
(replaces 72469 for surface observation date will be announced)																				
72632	White Lake, MI	42°42'N	83°28'W	329	321		.	.	.	.	.	.	.	.		RW		RW		
(replaces 72637 for upper-air observation effective 13 September 1994)																				

* According to request made by the Russian Federal Service for Hydrometeorology and Environmental Monitoring (ROSHYDROMET)

C. Information on the operational status of elements of the surface-based sub-system *(continued)*

1. Publication No. 9. Volume A - Stations / 1.1 New stations *(continued)*

Index No.	Name	Latitude	Longitude	Elevation HP	Elevation H/HA	Pressure Level	Surface observations 00	03	06	09	12	15	18	21	Obs. H Obs. S	Upper-air 00	06	12	18	Re-marks
							Region VI — Former U.S.S.R. (effective 1 August 1994)* (this is a repetition of the information inserted in Volume 1994-No. 3)													
27199	Kirov	58°36'N	49°38'E	158	-		X	X	X	X	X	X	X	X		RW	.	RW	.	
27459	Niznij Novgorod	56°16'N	44°00'E	157	-		X	X	X	X	X	X	X	X		RW	.	RW	.	
27730	Rjazan'	54°38'N	39°42'E	158	-		X	X	X	X	X	X	X	X		RW	.	RW	.	
27944	Tambov	52°44'N	41°28'E	161	-		X	X	X	X	X	X	X	X		RW	.	RW	.	
34106	Kursk	51°44'N	36°16'E	209	-		X	X	X	X	X	X	X	X		.	.	.	.	
34123	Voronez	51°42'N	39°13'E	149	-		X	X	X	X	X	X	X	X		.	.	.	.	

1.2 Deleted stations

Region	Index No.	Name
Region I — Egypt	62408	Edfou
	62460	Sharm El Sheikh
Region II — Former U.S.S.R. (effective 1 August 1994)*	29574	Krasnojarsk (Emel'Yanovo)
(this is a repetition of the information inserted in Volume 1994-No. 3)	29865	Abakan
Region V — New Zealand	93853	Lauder Edr

1.3 Changes to existing stations

Index No.	Name	Surface observations 00	03	06	09	12	15	18	21	Obs. H Obs. S	Upper-air 00	06	12	18	Re-marks
		Region I — Egypt													
62300	Salloum	X	X	X	X	X	X	X	X	H00-24	R	W	R	W	
62305	Sallum Plateau	X	X	X	X	X	X	X	X	H00-24	R	W	R	W	
62306	Mersa Matruh	X	X	X	X	X	X	X	X	H00-24	R	W	R	W	
62332	Port Said/El Gamil	X	X	X	X	X	X	X	X	H00-24	.	.		.	
62357	Wadi El Natroon	.	.	X	X	X	X	X	.	H06-18	.	.		.	
62360	Shebin El Kom	X	X	X	X	X	X	X	X	H00-24	.	.	.	.	
62375	Giza	.	.	X	X	X	X	X	.	H06-18	.	.		.	
62378	Helwan	.	.	.	.	.	.	.	.	H00-24	R	W	R	W	
62414	Asswan	X	X	X	X	X	X	X	X	H00-24	R	W	R	W	
62419	Abu Simbel	.	.	X	X	X	X	.	.	H06-15	.	.	.	.	

* According to request made by the Russian Federal Service for Hydrometeorology and Environmental Monitoring (ROSHYDROMET)

Appendix 3c

Order Form

TO NEW READERS:

IF YOU WOULD LIKE TO RECEIVE FUTURE ISSUES OF THE
"OPERATIONAL *NEWSLETTER*"
FREE OF CHARGE, PLEASE FILL IN DETAILS CLEARLY BELOW

✂ --

"OPERATIONAL *NEWSLETTER*"

Kindly mail me future copies of the
"OPERATIONAL NEWSLETTER" (W/OIS) in

- ☐ English
- ☐ French
- ☐ Russian
- ☐ Spanish

Name:..

Address: ....

....

....

....

....

✂ --

Send the coupon to ☞

WORLD METEOROLOGICAL ORGANIZATION
SECRETARIAT
WWW/OPI
41, avenue Giuseppe-Motta
PO Box 2300
CH - 1211 GENEVA
Switzerland

Telephone:	National (022) 730 81 11
	International +41 22 730 81 11
Telegrammes:	METEOMOND GENÈVE
Telex:	41 41 99 OMM CH
Facsimile:	41 22 734 23 26

Appendix 4

Historical Changes in Radiosonde Instruments and Practices.

The very valuable report of D.J. Gaffen : "Historical Changes in Radiosonde Instruments and Practices." issued as CIMO report no 50 or WMO/TD 541 gives an excellent survey over the changes in sondes used by Members and the various observation practices.

As an example we show information from her report concerning Canadian radiosondes.

Appendix 4

CANADA

I. CURRENT INSTRUMENTS AND PRACTICES (As of 6 December 1990)

VIZ radiosondes (produced in Canada by Valcom) tracked by GMD radiotheodolite at most stations. At these stations, humidity data are not reported for temperatures below -65°C and relative humidities less than 9%. No temperature corrections are applied.
Väisälä RS80 and DigiCORA ground systems at some stations. At these stations, no humidity cutoffs are used, and temperature corrections are applied.

II. PAST CHANGES IN INSTRUMENTS AND PRACTICES

1945-55: Two groups of stations: (1) Canadian Meteorological Service stations using Canadian-designed Chronometric radiosondes. Windfinding, if any, was accomplished optically. (2) Joint Arctic Weather Stations (JAWS), operated jointly with United States. Radiosondes supplied by the U.S. Weather Bureau were used with Metox or SCR-685 radiotheodolite.
1955-56: Introduced 403 MHz radiosondes and Metox and SCR-658 radiotheodolites to replace Chronometric radiosondes. In any year, radiosondes were from the same manufacturer (VIZ Manufacturing Company) as those used by U.S. Weather Bureau.
1960: Began gradual (2 year) introduction of exposed, white-coated rod thermistor with no radiation correction applied. Data conversion identical to U.S. Weather Bureau.
1962: Began installation of GMD radiotheodolites at 20 (of 34) sites.
1963: Introduced VIZ (107 MHz) radiosondes at Ocean station "P" to replace Chronometric radiosonde.
1964-66: Completed conversion of all stations to GMD radiotheodolites.
1966-68: Introduced carbon element to replace lithium chloride humidity sensors.
1973: Introduced new humidity duct to improve readings at high solar elevation angle.
1974: Converted Ocean station "P" from 107 MHz to 403 MHz, which resulted in improved data.
1977: Introduced monolobe (solid state) antenna to replace mechanical Conscan Spinner in GMD radiotheodolites. No evidence of change in wind accuracy.
1978: Introduced ADRES minicomputer system. Wind data were calculated automatically, but an operator extracted the raw meteorological data.
1978: Changed humidity algorithm to allow computations for all temperatures above -65°C. Previously, humidity data were terminated at -40°C.
1980: Converted 18 of 33 stations to use transpondersondes. These were flown when the elevation angle in flight was expected to be less than 12°; produced a considerable improvement in wind data.
1980: Introduced a new carbon hygristor. The supplied algorithms resulted in relative humidity readings 2 to 5% too low in the range 90 to 100%.
1980-82: Radiosondes were supplied by VIZ.
1983: Introduced a new humidity algorithm with ADRES to correct the values in the 90 to 100% range.
1985: Converted Prince George (71896) to Väisälä RS80 radiosondes and DigiCORA. Winds were computed using Omega, but a software problem produced erroneous winds. A temperature correction is applied to the data (as compared with the GMD/ADRES stations, which do not apply a temperature correction).

1986: Introduced pre-baselined radiosondes. Previously all sondes had undergone a manual baseline lock for temperatures and humidity. Discovered that the manual baseline technique was prone to producing an incorrect humidity lock at low relative humidity, which resulted in data below 60% being biased too high. It is estimated that at 20% relative humidity the relative humidity error could be as great as 10%.
1987: Closed station at Shelbourne, Nova Scotia. Opened one at Yarmouth (71603) using VIZ Mk I radiosondes and Beukers W8000 Navaid system; windfinding was accomplished using Loran-C.
1988: Converted station at Coral Harbour (71915) from GMD radiotheodolite to Väisälä DigiCORA. Same comments as for Prince George apply here. (See 1985 entry.)
1989: Converted station at Fort Nelson (71915) from GMD to Väisälä DigiCORA. Solved the Omega wind problem for all three DigiCORA stations. The RS80 radiosondes were no longer baselined for temperature and humidity; the values were accepted as accurate. Pressure was still baselined and corrected.

III. PLANNED CHANGES IN INSTRUMENTS AND PRACTICES

Yarmouth will be converted to the VIZ Zeemet system with the VIZ Mk II radionsonde in early 1991. Winds will be calculated using cross-chain Loran-C. Saskatoon (Saskatchewan) will become operational in mid-1991 using the VIZ Zeemet system. Starting in 1992, a gradual conversion of all stations to Navaid technology is planned.

IV. STATION HISTORIES

Station histories are available in (1) Station Inspection Report and (2) Station Information System (a computerized system) from the Atmospheric Environment Service, Attention: CCAA. In addition, station histories including station names, locations, and periods of record are available in the Climatological Station Catalogue (1989, six volumes). See microfiche Appendix 4 for additional information.

Appendix 5

The equation of the pressure calculation used in MARS and AVK sondes.

The Meteorit and AVK systems compute pressure distribution along height from their radar height measurements and the radiosonde (MRS or MRZ) obtained temperature and humidity. The formula used is (WMO/TD 451)

$$P = \gamma e_a + (P_0 - \gamma e_a)\, e^{-F}$$

$$F = g_\phi\, \Delta\Phi / RT$$

where

P_0 : observed station pressure
P : pressure at the upper boundary of the layer considered
e_a : vapour partial pressure in the layer considered
T : temperature of the layer
R : gas constant
g_ϕ : acceleration of gravity at the latitude ϕ
$\Delta\Phi$: geopotential height of the layer considered
γ : = 0.378, ratio of the difference between air density and vapour one to the air density

Appendix 6

Humidity measurement reporting practices.

Since the variations of the humidity are of great importance for the "radiosonde group" in the calculation of the radio refractive index, it is also of interest to know the national practices of reporting and also archiving data for the atmospheric humidity. In spite of the regulations given by WMO it exists several practices on national scale. Limitations in reporting relative humidity caused by low temperature may have consequences for stations of very high latitudes were winter temperatures at the surface may be of approximately the same value as the "cut-off temperature".

From WMO/TD 541 (Gaffen) and WMO no 306 is compiled a very rough set of information given below. For a full use of such information, a study of station history with changes in instrumentation and observing practices should be done.

Australia	Before 1982, humidity not measured below -40°C 1982 VIZ carbon hygristor, humidity measured to -60°C or 100 hPa For constant low humidity (below approximately 30%), all dewpoint depressions reported as 30°C (coded as 80) From 1987 measured to -60°C or 20 hPa whichever occurs first.
Bahamas	Humidity measuring practices as United States of America.
Belgium	Dewpoint depression not transmitted for temperatures below -40°C.
Belize	For relative humidity below 20%, dewpoint depression is reported as 80 in the code and 30°C in the archived data.
Canada	VIZ (Valcom) sondes: from 1978 no humidity data are reported for temperatures below-65°C and relative humidities less than 9%. Previously cut-off was at -40°C. Vaisala sondes : no humidity cut-offs are used.
Cape Verde	VIZ sondes : humidity not reported for temperatures less than -40°C.
Chile	Introduced Vaisala sondes 1985 to 1988, before introduction of these humidity cut-off employed as in the United States.
China	Humidity is not reported for temperatures below -60°C.
Costa Rica	For relative humidity below 20%, dewpoint depression is reported as 80 in the code and 30°C in the archived data. When temperature is below -40°C relative humidity is reported as missing.
Cuba	Before 1989 was relative humidity reported as missing for temperatures below -40°C. No cut-offs are today's practice.

Czechoslovakia	Introduced in 1980 practice of replacing relative humidity under 10% with the value 10%.
Finland	1981 Introduced MicroCORA system which allows temperature and humidity reports at all levels. Previously humidity was measured only up to 300 hPa.
India	For temperatures less than -40°C or relative humidity less than 15%, no humidity data are reported.
Ireland	Introduced Vaisala sondes in 1977, before that was for temperatures below -40°C the humidity values from the Kew sondes were discarded. Humidity values less than 5% were taken as 5%, and above 100% as 100%.
Malaysia	Humidity measured to -60°C in dewpoint or 200 hPa whichever occurs first.
New Caledonia and Loyalty Islands	When the relative humidity is less than 10 per cent for levels where the temperature is higher than -40°C, a relative humidity constant of 8 percent is used in the calculation of the dew point temperature.
Pakistan	Humidity is generally not reported above 250 hPa
Poland, Republic of	For temperatures less than -40°C, no humidity data are reported.
Republic of Korea	Before 1987 was for temperatures lower than -40°C or relative humidity below 10%, humidity reported as missing. Today's practice is to report all humidity data.
Saudi Arabia	before 1978 dewpoint was not reported for temperatures below -40°C. Today no cut-offs are used.
Seychelles	Relative humidity is reported as missing for temperatures below -40°C.
Switzerland	Relative humidity less than 10% is reported as 10%.
Thailand	Humidity data are not reported for relative humidity below 10% or temperatures below 40°C.
Tunisia	Began in 1978 reporting humidity data for the entire sounding. Previously, no humidity data were reported for pressures less than 300 hPa.
USSR (former)	At stations were MARS/Meteorit data are manually processed, humidity data are not transmitted for temperatures below -40°C and dewpoint depression is determined using graphical scale. At stations with automatic data processing, dewpoint depression is calculated.
United States	For relative humidity below 20% the dewpoint depression is coded as 80 Which gives 30 in the archived data. For temperature below -40°C dewpoint depression is reported as missing.