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A computer program to process vaisala
RS 21-12 C radiosonde data.

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A COMPUTER PROGRAM TO PROCESS VAISALA RS 21-12 C RADIOSONDE DATA

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ABSTRACT

A Vaisala RS 21-12 C radiosonde is used for boundary layer research at the Royal Netherlands Meteorological Institute. Pressure, temperature and wind data are stored on paper tape. A Self Reading Theodolite is used to determine the wind profile. A set of computer programs for the processing of the raw data is described. The main functions of the subprograms are:

- Conversion of the raw data to meteorological parameters. A set of algorithms, given by Vaisala is used for that purpose.
- Interpolation of the parameters to successive two-millibar levels, and calculation of some derived parameters.
- Matching of the wind data to the radiosonde data.
- Quality check of the data.

CONTENTS

1. INTRODUCTION

The Royal Netherlands Meteorological Institute (KNMI) carries out theoretical and experimental boundary layer research. During experiments a Vaisala RS 21-12 C radiosonde (403 MHz) is used to measure the temperature, humidity and pressure in and above the boundary layer. Most of the ground equipment used for these radiosoundings is also manufactured by Vaisala: Ground Check Chamber GC 20, UHF Receiver UR 12 and PTU Digitizer COD 11. This radiosonde system measures the parameters mentioned above automatically every eight seconds. After some processing, the data is stored on paper tape by a Facit 4070 Punch.

Elevation and azimuth of the sonde are also measured, to determine the wind profile. For this purpose a Self Reading Theodolite is used (Warren Knight, Philadelphia U.S.A., model 87 AG). At more or less regular time intervals a push-button is used to activate a Theodolite Data Recording System (Part number 801560-0, Northern Precision Laboratories Inc., Fairfield N.J., U.S.A.). This recording system produces a printout of elevation, azimuth and time.

For the processing of these raw data a set of computer programs has been written in BEA (Burroughs Extended Algol) for the Burroughs B6800 computer at KNMI. This set consists of several subprograms. The main functions are:

a. Conversion of the raw radiosonde data to meteorological parameters

The data on paper tape consist of five-digit octal numbers, representing frequencies as transmitted by the radiosonde. A set of algorithms, given by Vaisala, is used to convert these numbers to decimal meteorological parameters.

b. Interpolation of parameters

The radiosonde measures pressure, temperature and humidity every eight seconds, but not simultaneously. Since the time intervals are known, the measured values of temperature and humidity can be interpolated to values that belong to the nearest measured pressure level. Then potential temperature, dew point, specific humidity and height are calculated. Finally the interpolated and calculated values, and the raw data are printed.

c. <u>Quality check of data</u>

While reading the paper tape, only punching errors are removed. During the data-processing several checks are made to detect erroneous values and malfunctions of the equipment. The operator can chose whether suspect values are rejected, or printed with some indication. It is also possible to run the program without automatic fault detection. All these quality checks are part of the processing mentioned sub b.

d. <u>Calculation of wind, temperature and humidity profiles</u>

The theodolite data (if available) are used to calculate the wind speed and wind direction profiles. The radiosonde data are used to calculate the altitude of the wind levels. The number of wind levels is determined during the flight by the theodolite operator, by pressing the button more or less frequently. These wind levels do in no way correspond to the radiosonde data levels (every eight seconds). Now the complete wind, temperature and humidity profiles are determined. Through interpolation these parameters are calculated for successive two-millibar levels, and a complete printout of the data is made. When no wind data are available, the program functions in the same way, omitting the wind profile.

e. <u>Plotting of wind, temperature and dew point profiles</u>

Temperature and dew point profiles and, if available, the wind profile are plotted on an aerological diagram.

2. GENERAL INFORMATION

2.1 Layout of the paper tape

The radiosonde measures temperature T, relative humidity RH, pressure P, and two reference frequencies K_1 and K_2. In addition a second pressure signal P_p is transmitted, which must be used above the 100 mbar level. The measurement of this group of parameters is repeated at time intervals of about eight seconds. A clock signal is generated by the COD 11 digitizer (a part of the receiving equipment) for every group of parameters. The output of each measuring cycle is stored on paper tape, so the time interval between the punching cycles is also about eight seconds. For each cycle, the time is measured when the punching starts, so corrections must be made afterwards to determine the exact moment at which a certain parameter actually was measured by the radiosonde. Since the radiosonde measures (and transmits) the various parameters within a group consecutively in time, every parameter within a group has an individual time correction.

The data is punched in 8-channel ASCII code. The values are given in five-digit octal numbers. The time is in seconds; direct interpretation of the other values is impossible. An example of a punching cycle is given in figure 1. A complete tape consists of 12 ground check cycles, followed by the flight measurements. There is no tape feed between any of the cycles. The 12 ground check cycles consist of calibration values, as described hereafter.

2.2 Calibration of the radiosonde and ground level measurements

Every radiosonde is calibrated by the operator shortly before launch. The Ground Check Chamber GC 20 and a well-calibrated barometer are used for that purpose. To carry out the calibration, the radiosonde sensors are exposed to known values of temperature, pressure and humidity in the GC 20. The values, measured by the radiosonde, are punched in the same way as during the flight. The procedure consists of three phases:

a. Exposure to known temperature and pressure

   Four cycles are punched, of which T, P, K_1 and K_2 are used. The operator writes down the temperature and pressure in the GC 20.

b. Exposure to a known humidity; low value, usually RH = 2%
Four cycles are punched, of which RH, K_1 and K_2 are used. The operator writes down the humidity in the GC 20.

c. Exposure to a known humidity; high value, usually RH = 75%
Four cycles are punched, of which RH, K_1 and K_2 are used. The operator writes down the humidity in the GC 20.

This completes the calibration.

The sensors for T, P_p and P of the radiosonde have also been calibrated in the factory. Three groups of three numbers will be used in the calculations. These numbers are specific for every radiosonde.

The ground level values of the parameters, measured by the sonde, and some synoptical observations are written down at the start of the flight. These are used for calculations, or just for the final printout of the sounding.

All these ground check values are noted down on a standard form (in Dutch) and must be fed into the computer by hand. In this way a file is created which can be recognized by the project code (5 positions) and the radiosonde number (7 positions). The file is called GRCHK (short for groundcheck). Its layout is shown in figure 2; an example is given in figure 3.

2.3 Theodolite data input

An example of the printout of the Theodolite Data Recording System is given in figure 4. Here C denotes clock, A azimuth and E elevation; the time of the start is always 0 s. Time is given in hours, minutes and seconds, while azimuth and elevation are in degrees.

A theodolite data file is created (manually), called THEO/project code/sonde number. An example corresponding to the printout in figure 4, is given in figure 5. On every line we see elevation, azimuth and time. Only the first line is different; here we see a code number (always 1), followed by wind direction (degrees) and wind speed (knots) of a ground measurement, followed by the station height (m). This first line must be added to the theodolite data, when file THEO is created.

2.4 Project code file

A project code (5 positions) is used to simplify the identification of data files. During processing, a project number (1 to 9) refers to the project code. The project codes are listed in a file called PROJECT. The project number is the corresponding line number in this file. An example of this file is given in figure 6. So project number 2 corresponds to project code PUK 81.

3. DESCRIPTION OF THE PROGRAMS

A flow chart of the set of programs is given in figure 7. The programs SONDE, WIND, TEMP and PLOTROOS are described hereafter.

3.1 Program SONDE

3.1.1 Input

- Radiosonde data and Groundcheck data from paper tape (input code number 6) or diskfile SONDE (input code number 10). One of these code numbers must be used in the start procedure. When the data input comes from paper tape, the data are stored on diskfile SONDE automatically. Therefore paper tape input is necessary only for the first run, and should not be used more often than necessary.
- Calibration data and groundlevel measurements from diskfile GRCHK.
- Project code from diskfile PROJECT. The appropriate project number must be used in the start procedure.

3.1.2 Output

- Printout of radiosonde data after interpolation to pressure levels and calculation of derived parameters.
- Printout of raw data, i.e. paper tape data converted to meteorological parameters without any interpolation.
- Printout of calibration data and resulting corrections.
- Diskfile OUTSONDE. This file contains the radiosonde data after interpolation to pressure levels and calculation of derived parameters, including the groundlevel measurements. This file will be removed automatically when program TEMP is executed.

An example of the printout is given in figure 8.

3.1.3 Special features

Automatic quality check of the data, and automatic deletion or labeling of erroneous values is possible. Moreover parts of the output can be suppressed. A choice must be made out of the options given in figure 9; the corresponding quality check code number must be used in the start procedure. The code number for 2 mbar values is only to be used in the start procedure for program WIND.

The quality check is in no way foolproof. Not all types of suspect values are rejected. On the other hand correct values are sometimes rejected when the preceding value was found to be suspect. A careful inspection of the output, if necessary followed by corrections in the data files, is important if reliable radiosonde data are to be obtained.

3.1.4 Links to other programs and files

- The start procedure for SONDE also starts TEMP when the quality check code number ≠ 0.
- Diskfile OUTSONDE provides for data input to WIND and TEMP.

3.1.5 Identification of files

Most of the files are identified by extra numbers and codes:

- GRCHK:
  GRCHK/project code/radiosonde number.
- SONDE:
  SONDE/project code/radiosonde number.
- PROJECT:
  no extra identification.
- OUTSONDE:
  OUTSONDE/project code/radiosonde number.
  project code : 5 positions, characters and numbers.
  radiosonde number: 7 positions, numbers only.

3.1.6 Start procedures

The program SONDE can be started by two startjobs:

1. START JOB/SONDE (A, B, C, D,)
2. START JOB/PROFILE (A, B, C)

where:

A = project number

B = radiosonde number

C = quality check code number

D = input code number; 6 for paper tape, 10 for diskfile

A listing of these startjobs is given in Figures 10 and 11.

When paper tape input for the radiosonde data is used, only JOB/SONDE can be used.

3.1.7 Computations

Conversion of paper tape data to meteorological values

The octal numbers are first converted to decimal values and stored in diskfile SONDE. This yields the time in seconds, but additional conversion is necessary for the other parameters. The decimal samples (S) are converted to the corresponding frequencies (f) in MHz, using:

$$f = (S + 231424) * 10^{-4} \tag{1}$$

So T_s, RH_s, P_{ps}, K_1, K_2 and P_s, measured by the sonde, are now represented by frequencies. No further conversion is necessary for K_1 and K_2. In order to calculate the meteorological values from these frequencies, the following procedure is used for T, P_p and P:

Compute y:

$$y = \frac{f_2^{-2} - f_E^{-2}}{f_2^{-2} - f_1^{-2}} \tag{2}$$

where f_1 and f_2 are the frequencies corresponding to K_1 and K_2; f_E is the frequency corresponding to T, P_p, or P.

Compute v:

$$v = \frac{1}{2.375 - y} \tag{3}$$

Compute the meteorological value M:

$$M = (c_0 + c_1 v + c_2 v^2) * 0.1 \tag{4}$$

Here the c_i are the factory calibration values for T, P_p and P, stored on lines 8, 9 and 10 in diskfile GRCHK. In this way meteorological values for T_s, P_{ps} and P_s are found. The units are °C, mbar and mbar. Finally a correction as a result of the preflight calibration is necessary for T_s and P_s.

During the calibration procedure the sonde is placed in the Ground Check Chamber, and T_{sc} and P_{sc} are measured. Four cycles are punched, and the mean values are used to compute T_{sc} and P_{sc}, following the procedure already described. If any value differs more than the standard deviation from the mean value, this value is rejected. In case that more than one value differ more than the standard deviation from the mean value, no values are rejected. The reference values T_r and P_r are measured by the operator. In this way the corrections ΔT and ΔP are found:

$$\Delta T = T_r - T_{sc} \tag{5}$$

$$\Delta P = P_r - P_{sc} \tag{6}$$

Subsequently every T_s and P_s value measured by the sonde must be corrected to find its final value:

$$T = T_s + \Delta T \tag{7}$$

$$P = P_s + \Delta P \tag{8}$$

There is no calibration procedure for P_p, so that $P_p = P_{ps}$.

To convert the frequency representing RH to a meteorological value (percent), a different procedure is followed, in which the calibration is directly incorporated. Using (2) we compute y. Then we compute z:

$$z = \frac{y - z_2}{z_1 - z_2} * (x_1 - x_2) + x_2 \tag{9}$$

To calculate x_1, x_2, z_1 and z_2 we need the preflight calibration values, found for a low and a high humidity (2% and 75%). These two calibrations consist of four measurements each, and again one can be rejected by calculation of the standard deviation. The formulas to calculate x_i and z_i ($i = 1,2$) are:

$$x_i = \frac{- 9.1366 + \sqrt{83.4775 + 133.734 * (123.431 - A_i)}}{133.734} \tag{10}$$

where A_1 = 2%.
A_2 = 75%.

$$z_i = \frac{f_2^{-2} - f_{Ei}^{-2}}{f_2^{-2} - f_1^{-2}} \qquad (11)$$

where f_{E1} = radiosonde frequency corresponding to 2% RH.

f_{E2} = radiosonde frequency corresponding to 75% RH.

f_{Ei} is calculated using (1).

Finally the value found for z (9) is converted to a relative humidity value (percent):

$$RH = 123.431 - 18.2712 * z - 133.734 * z^2 \qquad (12)$$

This completes the conversion of paper tape data to meteorological values. Formulas (1) to (12) have been provided by Vaisala.

Interpolation to pressure levels; calculation of derived parameters

For each group of measurements the time is measured only once; the clock is read when the measurements are punched. However, the data are sampled before the punching, so a time difference is introduced. Moreover the parameters are not measured simultaneously, so a time correction is necessary for each parameter within a group. If $t_{g,i}$ is the time given for group i, we calculate for every group i a time interval τ_i (usually about 8 s):

$$\tau_i = t_{g,i} - t_{g,i-1} \qquad (13)$$

Then we calculate the individual measuring time $t_{X,i}$ for each parameter X within group i.

Individual measuring time:

$$t_{T,i} = t_{g,i} - 1.25 * \tau_i$$

$$t_{RH,i} = t_{g,i} - 1.10 * \tau_i$$

$$t_{Pp,i} = t_{g,i} - 0.90 * \tau_i$$

$$t_{P,i} = t_{g,i} - 0,40 * \tau_i$$

No correction is necessary for K_1 and K_2, since these parameters are nearly constant. Since the clock starts when the sonde is launched, but the start of a measuring cycle is arbitrary, it is possible that some values are measured just before the start. Therefore groups with $t_{g,i} \leq 10$ are rejected.

Since the parameters within a group are not measured simultaneously, the parameters are not measured at the same height. By linear interpolation the individual measurements are now converted to the values that belong to the pressure level of the relevant group. The calculated individual measuring times are used for that purpose.
If index p,i denotes the value of a parameter at the pressure level of group i, we have

$$RH_{p,i} = RH_i + \frac{t_{p,i} - t_{RH,i}}{t_{RH,i+1} - t_{RH,i}} * (RH_{i+1} - RH_i) \qquad (14)$$

$$T_{p,i} = T_i + \frac{t_{p,i} - t_{T,i}}{t_{T,i+1} - t_{T,i}} * (T_{i+1} - T_i) \qquad (15)$$

From now on we shall use the parameters at pressure levels without any indication.

We can now calculate the potential temperature θ (°C), the dew point TD (°C) and the specific humidity SH (g/kg):

$$\theta = (T + 273.15) * (1000 / P)^{0.286} - 273.15 \qquad (16)$$

$$TD = 241.83 * \{ (\frac{\log (RH * 0.01)}{7.63} + \frac{T}{T + 241.83})^{-1} - 1 \}^{-1} \qquad (17)$$

$$SH = 1000 * \{ \frac{100 * P}{0.622 * RH * 6.107 * 10^{7.63*T/(241.83+T)}} - \frac{0.378}{0.622} \}^{-1} \qquad (18)$$

Finally we calculate the height of every (pressure) level. For that we must first find the mean virtual temperature $\overline{T}_{v,i,i+1}$ (K) of the layer between level i and i+1 through (19) and (20):

$$\overline{T}_{v,i,i+1} = 0.5 * (T_{v,i} + T_{v,i+1}) \qquad (19)$$

$$T_{v,i} = (T_i + 273,15) * (1 + 0.00061 * SH_i) \qquad (20)$$

Then we calculate the height z_n of level n (in geopotential meters) as addition of all underlying layers:

$$z_n = h + \sum_{i=0}^{n-1} \frac{1}{9.8} * 287 * \bar{T}_{v,i,i+1} * \ln \frac{P_i}{P_{i+1}} \qquad (n \geq 1) \qquad (21)$$

where h is the height of the station in meters, and P_o (i = 0) the pressure at the radiosonde station, measured with a station barometer (not corrected to sea level). For n = 0, we take z_o = h.

3.2 Program WIND

3.2.1 Input

- Radiosonde data from diskfile OUTSONDE.
- Groundlevel measurements from diskfile GRCHK.
- Theodolite data from diskfile THEO.
- Project code from diskfile PROJECT.

3.2.2 Output

- Printout of radiosonde data, including parameters derived by SONDE and wind data, after interpolation to pressure levels in 2 mbar steps.
- Diskfile OUTPROFILE. This file is identical to the printout; it will be removed automatically when program TEMP is executed.

An example of the printout is given in figure 12.

3.2.3 Special features

See description of program SONDE.

If no file THEO is available, wind data are given as 9999.

3.2.4 Links to other programs and files

- Diskfile OUTPROFILE provides for data input to TEMP and PLOTROOS.

3.2.5 Identification of files

- OUTSONDE:

  OUTSONDE/project code/radiosonde number.

3.2.6 Start procedures

The program WIND can be started by a startjob:

START JOB/PROFILE (A, B, C)

where:

A = project code number

B = radiosonde number

C = quality check code number

A listing of this startjob is given in figure 11.

This procedure starts program SONDE first. The programs TEMP and PLOTROOS are started by this startjob when program WIND is ready.

3.2.7 Computations

First linear interpolation is used to convert the radiosonde measurements and derived parameters (program SONDE) from arbitrary pressure levels (as measured by the sonde) to successive pressure levels in 2 mbar intervals. Then the theodolite measurements must be matched to these 2 mbar steps.

The radiosonde and theodolite measurements have the same time scale. So for every theodolite measurement the corresponding height can be found from the sonde data. Now the position of the sonde in a rectangular coordinate system is computed, relative to the start position: using elevation and height of the sonde, the distance along the earth surface is computed, and transformed into rectangular coordinates using the azimuth of the sonde. For low angles of elevation a correction must be applied for refraction in the atmosphere. To that end a fictitious earth radius is used. The correction depends on the height of the sonde. The main formulas are:

$$d = R_f * \phi \tag{22}$$

where d = distance along earth surface (m)

R_f = fictitious earth radius (m)

ϕ = angle corresponding to d, seen from earth centre (rad)

$$\phi = \arccos\left(\frac{R_f}{R_f + z} * \cos \varepsilon\right) - \varepsilon \tag{23}$$

where z = height of sonde (m)

ε = elevation of sonde (rad)

$$R_f = R * (1 + 0.22 * \exp(-z / 48000)) \qquad (24)$$

where R = earth radius = 6371229 m.

To compute wind speed and direction at height z (corresponding to a 2 mbar level), the position of the sonde at heights z + 25 and z - 25 (m) is computed by interpolation. Along the two horizontal axes of the coordinate system two wind speeds are determined from the displacement in a known time interval. In this way a mean wind speed and wind direction at height z for a height interval of 50 m are found.

3.3 Program TEMP

This program is a modified version of the operational program TEMPS, in use at KNMI to process synoptical radiosonde data. The improvement of the vertical resolution is one of the modifications.

3.3.1 Input

- Radiosonde data, including wind, from diskfile OUTPROFILE.
- Radiosonde data, excluding wind, from diskfile OUTSONDE.
- Groundlevel measurements from diskfile GRCHK.
- Project code from diskfile PROJECT.

OUTPROFILE can only be used used if WIND has been run, otherwise the output will not contain wind data.

3.3.2 Output

- Plotfile MONW/TEMP.

  This file contains temperature and dewpoint temperature as a function of height, and wind data - if available - in 50 mbar level intervals. A plot can be made on a standard (KNMI) θ_s, p^κ diagram. An example is shown in figure 13.

3.3.3 Special features

- TEMP removes diskfile OUTSONDE after use.
- To plot the temperature and dewpoint temperature profiles, all available data are used.

3.3.4 Identification of files

- MONW/TEMP:
  (PLT) MONW/TEMP/radiosonde number.

3.3.5 Start procedures

The program TEMP can be started by the startjobs SONDE and PROFILE, as described before.

3.4 Program PLOTROOS

3.4.1 Input

- Wind data from diskfile OUTPROFILE.
- Groundlevel measurements from diskfile GRCHK.
- Project code from diskfile PROJECT.

3.4.2 Output

- Plotfile MONW/WIND:
  This file contains wind data as a function of height. An example of plotted wind data is shown in figure 14. Height marks are given at 500 m intervals.

3.4.3 Identification of files

- Plotfile MONW/WIND:
  MONW/WIND/radiosonde number.

3.4.4 Start procedure

The program PLOTROOS can be started by the startjob PROFILE.

4. ACKNOWLEDGEMENTS

The formulas to compute a wind profile from the theodolite data, taking into account the curvature of the earth surface and the refraction in the atmosphere were provided by H.R.A. Wessels and Dr. A.G.M. Driedonks. The program PLOTROOS was written by A. Snijders. Discussions with J.G. van der Vliet contributed to the final form of this set of programs.

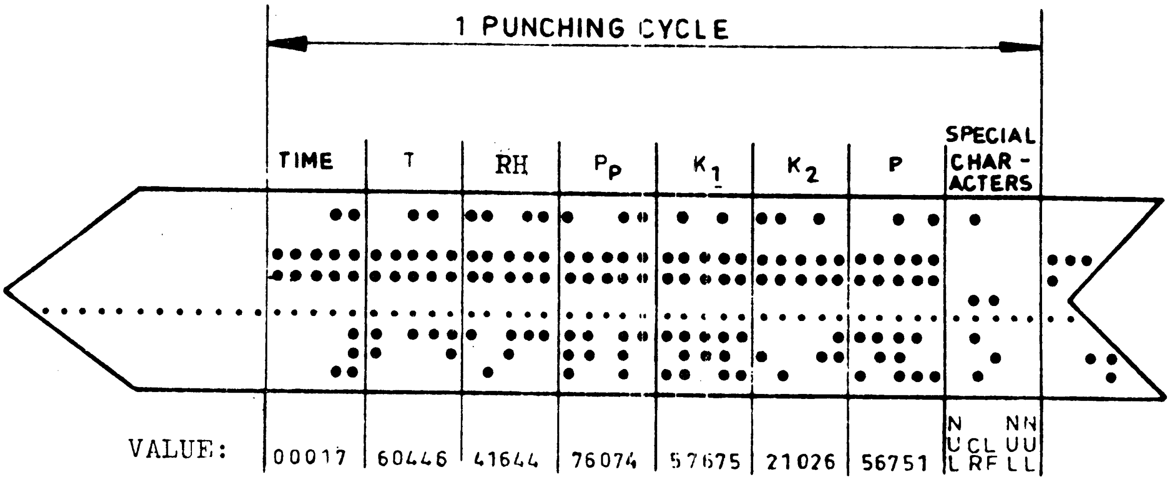


Fig. 1. layout of the paper tape

GRCHK/project code/radiosonde number

100 date (DDMMYY)

200 time of start (HHMM in UTC)

300 radiosonde number (xxxxxx.x)

400 ground check temperature (°C)

500 ground check pressure (mbar)

600 ground check humidity low (% RH)

700 ground check humidity high (% RH)

800 factory calibration for T (c_0, c_1, c_2)

900 factory calibrations for P_p (c_0, c_1, c_2)

1000 factory calibration for P (c_0, c_1, c_2)

1100 station name

1200 station height (m)

1300 ground level temperature (°C)

1400 ground level pressure (mbar)

1500 ground level humidity (% RH)

1600 ground level dewpoint temperature (°C)

1700 clouds in code form $N_h C_l h C_m C_h$

1800 indication of cloudiness (N/8, text)

(1300–1800: station observations at the start of the flight)

1900 remarks

2000 remarks

Fig. 2. layout of file GRCHK

GRCHK/CAB 81/6158013

100	270581
200	0831
300	615801.3
400	23.1
500	1006.1
600	002
700	075
800	--2525,4313,-742
900	--885,1458,1910
1000	-10608,22857,8741
1100	CABAUW
1200	0
1300	15.3
1400	1006.1
1500	72
1600	10.2
1700	12532
1800	4/8, CU AC CI
1900	TEST FLIGHT
2000	

Fig. 3. example of file GRCHK

```
C 0 0.0 0.4 5
A 0 1 1 0.3 0
E 0 0 4 6.0 7

C 0 0.0 0.2 5
A 0 1 0 9.6 9
E 0 0 4 6.7 3

C 0 0.0 0.1 5
A 0 1 1 4.8 9
E 0 0 4 5.3 3

C 0 0.0 0.0 6
A 0 1 2 3.8 7
E 0 0 3 5.3 5
```

Fig. 4. output of Theodolite Data Recording System

```
THEO/PUK81/6455381
100     1,245,12,4
200     35.35,123.87,00.06
300     45.33,114.89,00.15
400     46.73,109.69,00.25
500     46.07,110.30,00.45
```

Fig. 5. example of file THEO

```
PROJECT
100     CAB81
200     PUK81
300     TEST1
400     CAB82
```

Fig. 6. example of file PROJECT

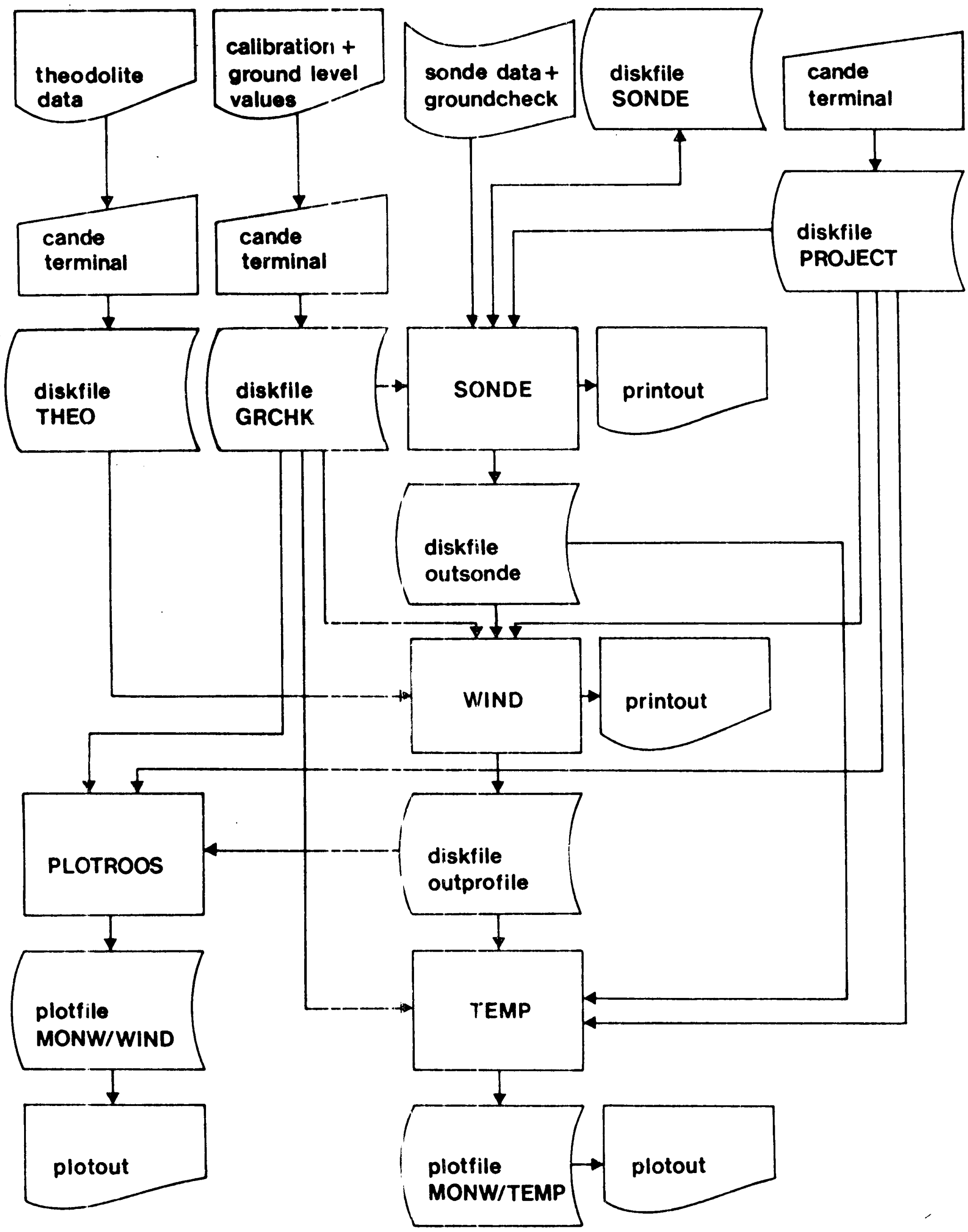


Fig. 7. flow chart of the set of programs

R A D I O S O U N D I N G

DATE : 1- 6-1983 15.18 GMT

RADIOSONDENR. : 481138.3
NAME OF STATION : ZWEEFVV
HEIGHT OF STATION : 4 M
CLOUDS : 32631 5/8, CU, AC, CI

PRESS MBAR	HEIGHT GPM	TIME SEC	TEMP C	P-TEMP C	DEW-P C	RH %	SH G/KG	
1010.5	0							
1010.0	4	0.0	22.0	21.2	14.2	61	10.0	GROUNDLEVEL
1003.0	64	12.8	20.2	19.9	12.1	60	8.8	
998.3	105	20.8	19.7	19.8	11.5	59	8.5	
993.8	144	28.8	19.7	20.2	11.2	58	8.4	
989.9	177	36.8	20.4	21.2	11.3	56	8.5	
985.2	219	44.8	20.3	21.5	11.1	56	8.4	
979.9	266	53.4	20.0	21.7	11.0	56	8.4	
975.5	305	61.8	20.1	22.2	10.8	55	8.3	
973.0	327	69.8	20.2	22.5	10.5	54	8.2	
969.6	356	78.4	20.0	22.6	10.4	54	8.1	
967.4	377	86.8	19.8	22.6	10.4	55	8.2	
964.1	406	94.8	19.5	22.6	10.3	55	8.1	
960.9	434	103.4	19.3	22.6	10.2	56	8.1	
957.4	466	111.8	19.0	22.6	10.2	57	8.1	
954.1	495	119.8	18.7	22.7	10.0	57	8.0	
949.5	537	128.4	18.4	22.8	9.9	57	8.0	
947.4	556	136.8	18.2	22.7	9.8	58	8.0	
944.9	578	145.4	17.9	22.7	9.8	59	8.0	
942.4	601	153.8	17.6	22.6	9.7	60	8.0	
938.4	637	162.4	17.4	22.8	9.5	60	7.9	
936.3	657	171.4	17.3	22.9	9.3	59	7.8	
934.2	676	179.8	17.1	22.8	9.3	60	7.8	
930.8	707	188.4	16.8	22.8	9.2	61	7.8	
926.6	746	196.8	16.4	22.8	9.1	62	7.8	
923.2	777	205.4	16.2	22.9	9.2	63	7.9	
918.8	817	214.4	15.8	22.9	9.1	64	7.8	
915.5	848	222.8	15.5	22.9	9.0	65	7.8	
913.0	871	231.4	15.2	22.8	8.9	66	7.8	
909.1	908	239.8	15.0	22.9	8.7	66	7.7	
906.4	933	249.0	14.7	22.9	8.5	66	7.7	
904.3	953	257.8	14.5	22.9	8.4	67	7.6	
901.0	984	266.4	14.2	22.9	8.4	68	7.6	
897.0	1021	275.4	14.1	23.1	8.4	69	7.7	
895.8	1032	283.8	13.8	22.9	8.4	70	7.7	
892.4	1064	292.4	13.4	22.9	8.7	73	7.8	
888.8	1098	301.4	13.2	23.0	8.3	73	7.7	
886.4	1122	309.8	12.9	22.9	8.3	73	7.7	
882.3	1160	318.4	12.6	23.0	8.2	75	7.7	
878.6	1195	327.4	12.2	23.0	7.8	74	7.5	
873.9	1240	335.8	11.9	23.1	7.6	75	7.5	
869.3	1285	344.4	11.4	23.1	7.6	77	7.5	

Fig. 8. example of printout of program SONDE

R A D I O S O U N D I N G

DATE : 1- 6-1983 15.15 GMT

RAW DATA

RADIOSONDENR.	:481138.3
NAME OF STATION	:ZWEEFVV
HEIGHT OF STATION	: 4 M
GROUND LEVEL -TEMPERATURE	: 22 C
-HUMIDITY	: 61 %
-PRESSURE	: 1010 MBAR
CLOUDS	:32631 5/8, CU, AC, CI

TIME SEC	TEMP C	HUM %	P<100 MB	REF1 MHZ	REF2 MHZ	P>100 MB
0	21.76	58.36	215.17	25.590	24.013	1009.51
8	21.58	57.84	214.99	25.591	24.013	1006.33
16	20.83	58.48	214.87	25.590	24.013	1003.03
24	20.04	60.03	215.48	25.591	24.013	998.26
32	19.60	58.87	215.00	25.592	24.014	993.81
40	19.73	57.75	214.61	25.592	24.014	989.94
48	20.52	55.14	215.45	25.591	24.014	985.22
57	20.25	55.76	215.25	25.591	24.015	979.87
65	19.94	56.49	214.64	25.592	24.015	975.46
73	20.17	54.10	215.55	25.592	24.015	972.96
82	20.15	53.70	215.12	25.592	24.014	969.64
90	20.00	54.01	215.11	25.592	24.015	967.35
98	19.80	54.94	214.72	25.592	24.015	964.10
107	19.47	55.22	215.49	25.593	24.016	960.88
115	19.26	55.74	215.06	25.593	24.015	957.39
123	18.93	57.03	214.90	25.593	24.016	954.11
132	18.68	56.55	214.43	25.593	24.016	949.49
140	18.36	57.83	215.33	25.593	24.016	947.39
149	18.19	58.11	215.16	25.593	24.016	944.91
157	17.90	59.46	214.94	25.593	24.016	942.39
166	17.60	59.62	214.59	25.594	24.016	938.43
175	17.41	59.70	214.25	25.594	24.016	936.26
183	17.33	58.82	215.18	25.594	24.017	934.16
192	17.02	60.61	214.91	25.594	24.017	930.82
200	16.71	60.95	214.34	25.594	24.017	926.58
209	16.35	62.28	214.15	25.594	24.017	923.16
218	16.13	63.64	214.30	25.595	24.017	918.84
226	15.77	64.29	214.71	25.594	24.017	915.46
235	15.43	65.85	214.19	25.594	24.017	913.04
243	15.14	66.45	215.00	25.595	24.017	909.07
253	14.95	66.22	214.49	25.595	24.017	906.40
261	14.69	66.37	214.67	25.594	24.016	904.25
270	14.46	67.01	214.12	25.595	24.017	900.97
279	14.19	68.30	215.02	25.595	24.017	896.99
287	14.05	68.61	214.83	25.594	24.017	895.79
296	13.72	70.61	214.50	25.595	24.017	892.39
305	13.31	74.17	214.17	25.595	24.017	888.83
313	13.13	71.81	214.92	25.595	24.017	886.36
322	12.87	74.16	214.60	25.595	24.017	882.34
331	12.58	74.81	214.39	25.594	24.018	878.62
339	12.17	74.32	214.75	25.595	24.017	873.92
348	11.89	74.99	214.42	25.595	24.017	869.27

Fig. 8. example of printout of program SONDE; raw data

```
GROUNDCHECKVALUES:
TEMPERATURE        30.2 C
PRESSURE         1009.8 MBAR
HUMIDITY LOW          2 %
HUMIDITY HIGH        75 %

TEMP.  CORRECTION =    0.5832
PRESS. CORRECTION =    0.0743

RADIOSONDENR. :    481138.3
CALIBRATION VALUES :
 T:     -2350      3853      -437
PP:     -1930      4805      -812
 P:     -9331     20412      9810


GROUNDCHECK LISTING:

      TEMP.                   REF.1 REF.2 PRESS
00344 61070 34650 76067 57521 20703 56402
00352 61103 34654 76060 57524 20704 56412
00360 61076 34656 76050 57524 20705 56412
00366 61103 34643 76055 57526 20705 56377

            RHLOW       REF.1 REF.2
00656 61075 41401 76005 57533 20716 56410
00664 61071 41377 76064 57533 20716 56415
00672 61102 41403 76070 57535 20716 56421
00677 61072 41374 76061 57525 20720 56415

            RHHIGH      REF.1 REF.2
00021 61040 30603 30645 76026 20701 56374
00027 61037 30612 30657 57676 20675 56402
00035 61037 55735 30655 76034 20675 56374
00042 61042 32770 30653 76034 20725 56376
```

Fig. 8. example of printout of program SONDE; calibration data

	quality check code number							
	0	1	2	5	6	7	8	9
quality check	*	*		*	*	*	*	*
automatic deletion		*			*		*	
indication	*	*		*	*	*	*	*
print out	*	*	*					*
file OUTSONDE	*	*	*	*	*	*	*	
2 mbar values	*	*	*			*	*	*

Fig. 9. quality check code number

JOB/SONDE (11/23/83)

```
?BEGIN JOB SONDE(INTEGER PROJ,INTEGER RSNR,INTEGER SIGN,INTEGER CLS)
 USERCODE=MONW/PW;
 CHARGE=AFMALG;
 CLASS=CLS;
 MAXPROCTIME=1100-(CLS*CLS*CLS);
 MAXIOTIME=1100-(CLS*CLS*CLS);
 MAXLINES=2800-(CLS*CLS*CLS);
 REAL DT;
 TASK TSK;
 IF SIGN EQL 1 OR SIGN EQL 6 OR SIGN EQL 8 THEN
 DISPLAY(STRING(RSNR,*) & " WITH AUTOMATIC DELETE")
 ELSE DISPLAY(STRING(RSNR,*) & " WITHOUT AUTOMATIC DELETE");%
 DT:=RSNR*1000+PROJ*10+SIGN;
 RUN SONDE(CLS DIV 10)[TSK];VALUE=DT;
 DT:=RSNR*100+PROJ;
 IF SIGN NEQ 0 AND TSK IS COMPLETEDOK THEN
 RUN TEMP;VALUE=DT;
 END JOB;
```

Fig. 10. job/sonde

JOB/PROFILE (11/23/83)

```
?BEGIN JOB PROFILE(INTEGER PROJ,INTEGER RSNR,INTEGER SGN);
 USERCODE=MONW/PW;
 CLASS=10;
 CHARGE=AFMALG;
 STRING STR;
 REAL DT;
 DT:=RSNR*1000+PROJ*10+SGN;
 RUN SONDE(1);VALUE=DT;
 RUN WIND;VALUE=DT;
 DISPLAY("OPSTARTVALUE. " & STRING(DT,*));
 RUN PLOTROOS;VALUE=DT;
 STR:="MONW/WIND/"&STRING(RSNR,7);
 RUN(OPER)INSERTPLOTQ ON OPER(STR);
 DT:=RSNR*100+PROJ;
 RUN TEMP;VALUE=DT;
 END JOB
```

Fig. 11. job/profile

R A D I O S O U N D I N G

CALCULATED 2 MBAR LEVELS

DATE : 1- 6-1983 15.18 GMT

RADIOSONDENR. : 481138.3
NAME OF STATION : 7WEEFVV
HEIGHT OF STATION : 4 M
CLOUDS : 32631 5/8, CU, AC, CI

PRESS MBAR	HEIGHT GPM	TIME SEC	TEMP C	P-TEMP C	DEW-P C	RH %	SH G/KG	DD DEGR	FF M/SEC
1010.0	4.0	0.0	22.0	21.2	14.2	61	10.0	270.0	4.1
1008.0	21.2	3.7	21.5	20.8	13.6	61	9.6	9999.0	9999.0
1006.0	38.4	7.3	20.9	20.4	13.0	60	9.3	247.9	5.7
1004.0	55.7	11.0	20.4	20.1	12.4	60	8.9	247.9	5.7
1002.0	72.9	14.5	20.1	19.9	11.9	59	8.7	247.9	5.7
1000.0	90.1	17.9	19.8	19.8	11.7	59	8.6	247.9	5.7
998.0	107.4	21.3	19.7	19.8	11.5	59	8.5	246.3	6.0
996.0	124.7	24.9	19.7	20.0	11.4	59	8.4	244.9	6.3
994.0	142.0	28.5	19.7	20.2	11.3	58	8.4	243.1	6.5
992.0	159.4	32.5	20.0	20.7	11.3	57	8.4	234.2	6.1
990.0	176.8	36.7	20.4	21.2	11.3	56	8.5	223.7	5.9
988.0	194.3	40.1	20.4	21.4	11.2	56	8.4	218.0	6.4
986.0	211.9	43.5	20.3	21.5	11.2	56	8.4	221.4	7.0
984.0	229.3	46.8	20.2	21.6	11.1	56	8.4	211.0	9.3
982.0	246.7	50.0	20.1	21.6	11.1	56	8.4	204.7	9.2
980.0	264.5	53.2	20.0	21.7	11.0	56	8.4	199.4	9.2
978.0	282.1	57.0	20.1	21.9	10.9	56	8.3	202.7	7.6
976.0	299.8	60.8	20.1	22.2	10.8	55	8.3	201.4	7.7
974.0	317.5	66.5	20.1	22.4	10.6	54	8.2	198.1	8.1
972.0	335.2	72.3	20.1	22.5	10.5	54	8.1	196.5	8.3
970.0	353.0	77.5	20.0	22.6	10.4	54	8.1	197.1	8.2
968.0	370.8	84.4	19.9	22.6	10.4	54	8.2	198.5	7.8
966.0	388.6	90.1	19.7	22.6	10.4	55	8.1	198.9	7.9
964.0	406.5	95.1	19.5	22.6	10.3	55	8.1	198.9	8.2
962.0	424.4	100.4	19.4	22.6	10.2	55	8.1	198.3	8.7
960.0	442.3	105.5	19.2	22.6	10.2	56	8.1	197.5	8.9
958.0	460.2	110.3	19.0	22.6	10.2	56	8.1	196.2	9.0
956.0	478.2	115.2	18.9	22.6	10.1	57	8.1	195.4	8.9
954.0	496.2	120.0	18.7	22.7	9.9	57	8.0	195.1	9.1
952.0	514.2	123.7	18.6	22.7	9.9	57	8.0	195.6	9.3
950.0	532.3	127.4	18.4	22.8	9.9	57	8.0	193.0	7.7
948.0	550.3	134.4	18.3	22.8	9.8	58	8.0	188.7	7.3
946.0	568.5	141.6	18.1	22.7	9.8	59	8.0	187.6	6.8
944.0	586.6	148.4	17.8	22.7	9.8	59	8.0	190.1	7.3
942.0	604.7	154.6	17.6	22.6	9.7	60	8.0	194.4	7.4
940.0	622.9	159.0	17.5	22.7	9.6	60	7.9	195.1	8.2
938.0	641.1	164.2	17.4	22.8	9.5	60	7.9	193.3	7.9
936.0	659.4	172.5	17.3	22.9	9.3	59	7.8	193.1	7.7
934.0	677.7	180.2	17.0	22.8	9.3	60	7.8	192.9	7.6
932.0	696.0	185.4	16.9	22.8	9.2	61	7.8	192.5	7.9
930.0	714.3	190.0	16.7	22.8	9.2	61	7.8	192.8	8.5
928.0	732.6	194.0	16.5	22.8	9.1	62	7.8	194.2	9.1
926.0	751.0	198.3	16.4	22.8	9.1	62	7.8	194.4	9.1
924.0	769.4	203.3	16.2	22.8	9.2	63	7.8	194.3	9.1

Fig. 12. example of printout of program WIND

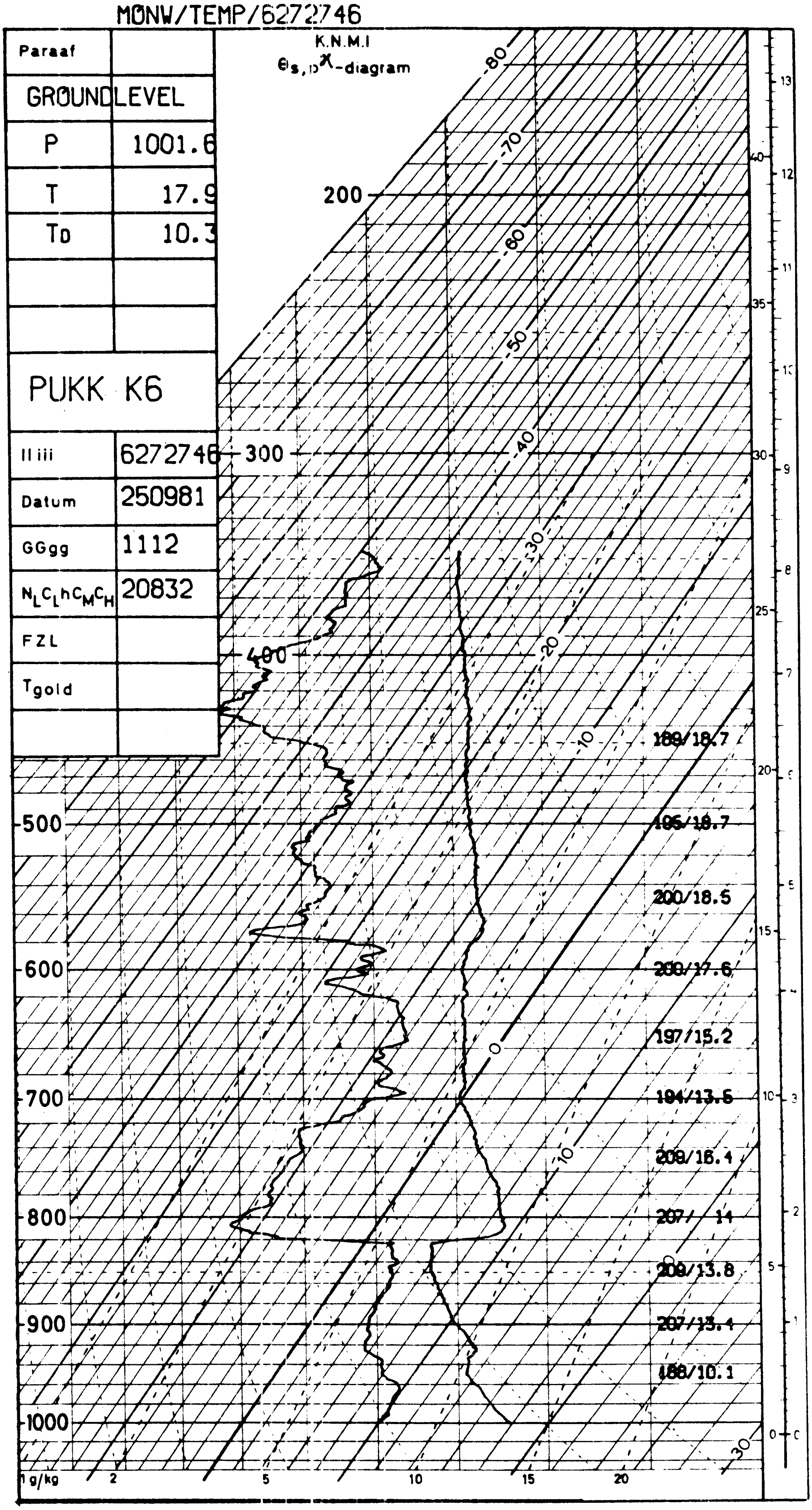
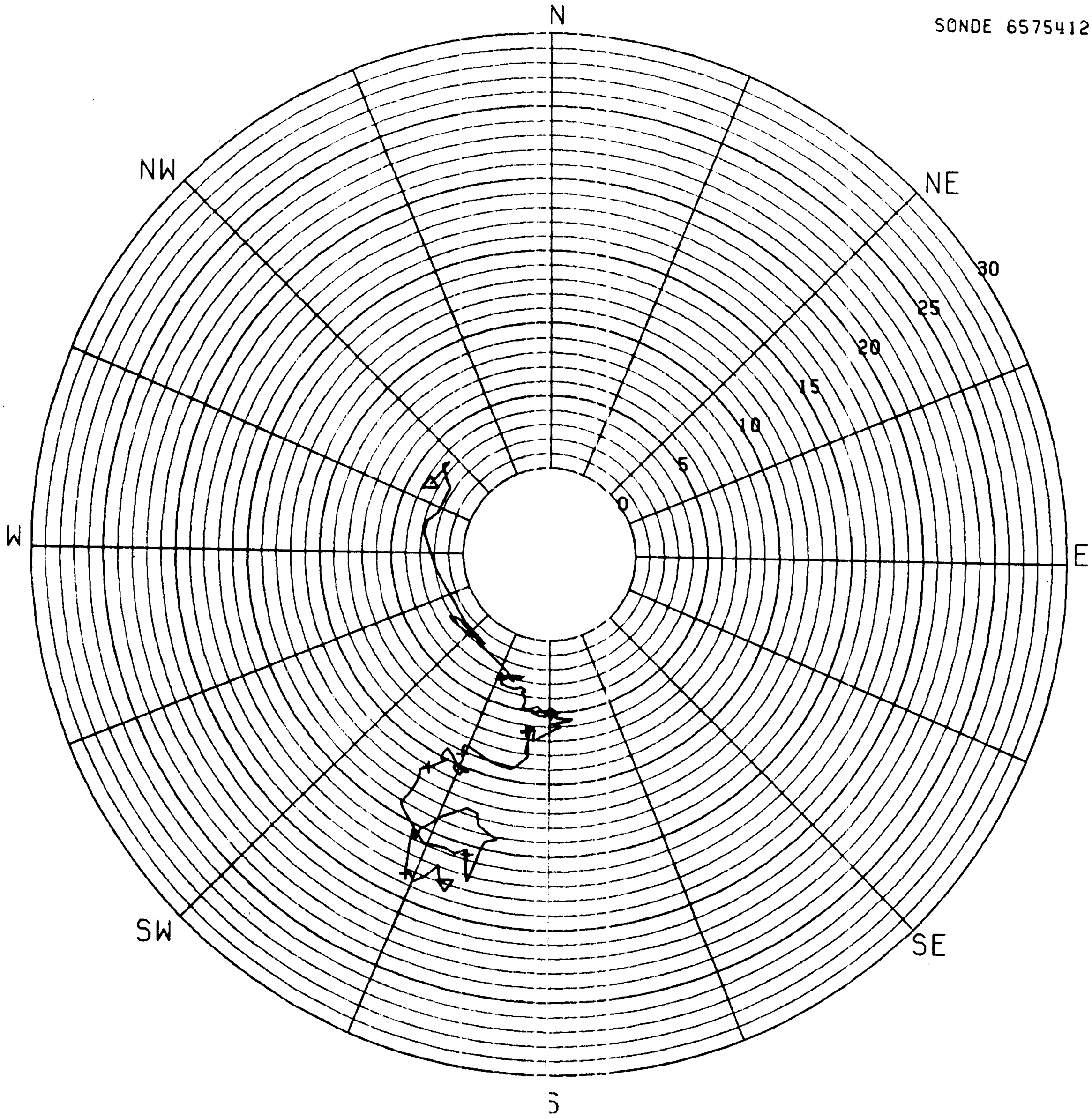


Fig. 13. example of plotout of program TEMP

UPPERWIND: COAST
ZWEEFVV
20.05.83
12.01 GMT
SONDE 6575412



VALUES AT 500 M INTERVALS:

	HEIGHT (M)	DIRECTION (DEGREES)	SPEED (M/SEC)
△	4	300	3.6
+	495	201	3.3
+	995	179	5.1
+	1500	187	6.4
+	1991	203	9.2
+	2506	209	11.1
+	3007	195	15.7
+	3490	204	18.4
▽	3704	197	18.0

GROUNDLEVEL

PPP	:	1009.6
TTT	:	13.5
TD	:	9.9
CLOUDS:		78701
	:	7/8, CU, SC, CI

\+ = EACH 500M INTERVAL
△ = START
▽ = END

Fig. 14. example of plotout of program PLOTROOS