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Description of the Cabauw turbulence dataset 1977-1979

C. Hofman

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1. Introduction

At selected days between 3-Aug-1977 and 9-Feb-1979 various observation projects have been carried out at the Cabauw tower with propeller bivanes and fast thermocouples. These turbulence measurements were done at 6 different levels(200,160,120,80,40 and 20 m). In some special cases a smaller number of levels was used. The data are available on tape or on diskette (see Appendix A, B, C and D).

For various projects it was necessary to launch special prepared radio sondes, which send their information for a period of about 20 minutes. The reached height of the sondes was at least 1000 m, on the average about 3000 m. The ascent speed was approximately 150 $m*min^{-1}$. The nearest regular WMO radiosounding station is at De Bilt, ~ 25 km ENE of Cabauw. The dataset of the radio sounding measurements is as a separate file available on diskette and not further discribed in this report. A table of local soundings is given in Appendix E.

This report gives an overview of the collected turbulence data.

The next table shows a survey of the turbulence data set, which contains all turbulence measurements and a selection of height where standard slow response observations were made.

	WIND		TEMPERATURE		RADIATION			TURBULENCE				
	speed	dir	dry	wet	glob.	net.	albedo	u	v	w	Td	Tn
	FF	DD	T_d	T_w								
height m.												
213					X							
200	X	X	X	X				X	X	X	X	X
160	X	X	X	X				X	X	X	X	X
120	X	X	X	X				X	X	X	X	X
80	X	X	X	X				X	X	X	X	X
40	X	X	X	X				X	X	X	X	X
20	X	X	X	X				X	X	X	X	X
20 b	X	X	X	X				X	X	X	X	X
10 b	X	X	X	X								
5 b	X	X	X	X								
2 b	X	X	X	X								
.6 b			X	X								
20 c	X	X										
EB-site					X	X	X					

"EB-site"= energy-balance measuring field near the mast.
At the EB-site also Bowen ratio, soil heat flux and precipitation are observed.
The letters b and c after the height identify separate auxiliary masts, b at the SE side and c at the NW side.

For more instrumentation information and for references to existing publications on the mast, see ref. 6.

2. Tape processing procedure

The registration at Cabauw was done on the magnetic tape unit of a HP 2100 MX micro computer, while for further processing of the data the Burroughs B6800 mainframe computer at De Bilt was used. Several computer programs have been developed for that purpose. See ref.1 for a detailed description of these programs. We here give the outline of the procedures.

First, the unlabeled tapes of the HP 2100 MX computer are converted to tapes for the Burroughs. This is done by a program called TRIVDUMP. This program also transforms the turbulent temperature signals (t_d, t_n and ntc) to dry- and wet-bulb values. The converted and transformed data are stored on a tape called TRIVAAN‹YYDDDHHmm›. If necessary, corrections can be carried out by means of the program TRIVCOR. Then, a new tape with the same title as the input tape is created.

Next the other elements, which are still given in volts on the TRIVAAN‹YYDDDHHmm› tape, are converted to SI units, and existing gauged observations on the spatial orientation of the sensors is used to calculate leveling corrections. This all is done by the TRIVOM program. The program produces a new tape called TRIVOM‹YYDDDHHmm›.

These tapes are the basic tapes for further processing. When a correct TRIVOM‹YYDDDHHmm› tape is obtained, the previous tapes, both TRIVAAN and the original unlabeled HP tape, are cleared for recycling.

Using the TRIVOM‹YYDDDHHmm› tape as input, the TRIVBER program computes mean values, standard deviations, skewness, kurtosis, maximum- and minimum values for a given time interval. The next step is the transformation from the polar coordinates on the TRIVOM‹YYDDDHHmm› tape to Cartesian coordinates by the TRICAR program. This program produces a new tape called TRICAR‹YYDDDHHmm›.

This TRICAR‹YYDDDHHmm› tape is the input for the last program in the queue, called KORREL, which calculates fluxes, correlations and some secondary quantities (e.g. L, u_*, T_*), and prints them out. It also is possible to store the calculated data on disk (value=1 option). The file on disk is called KOR/‹starttime›/‹endtime›/‹interval›. Enough spare space is reserved on the diskfile for additional data.

The TRICAR‹YYDDDHHmm› tape is not stored, only the TRIVOM‹YYDDDHHmm› files are archived in a tape library. An outline of the processing procedure is given by figs. 1 and 2 on pages 7 and 8. For detailed file descriptions see Appendices A and B.

3. Description of the existing data set

a. The set of TRIVOM tapes contains 97 tapes (see Appendix C) with fast registration (5 or 10 Hz) which are described by A.G.M. Driedonks, P.A.T. Nieuwendijk and C.J. Goes (see ref. 1). In order to create more space on a tape, 2 values are stored in one Burroughs word.

b. The file TRIVAANMETINGEN/7779 contains 30-min. mean values. The file is made from the KOR/<starttime>/<endtime>/<interval> files, which have been created by the KORREL program.
If available, the following items have been added to the file:
- Wind and temperature of the main tower at 20, 40, 80, 120, 160 and 200 m;
- Temperature of the secondary tower, called b-tower, at 10, 5, 2 and .6 m;
- Horizontal and vertical gradients of wind and temperature, calculated by (CATG) SFCWINDANALYSE/ CARDDATA or otherwise (CATG) SFCTEMPANALYSE/ CARDDATA; $|du/dz, dv/dz|$, α and $d\theta/dz$ were derived from an empirical fit over the entire profile (see ref. 7).
- Boundary layer height, measured with an acoustic sounding system and/or a local radio sounding, or alternatively calculated with a model and then represented by a negative value (see ref. 4).
- Net- and global radiation, latent-, sensible-, and soil heat fluxes obtained from measurements made at the observation area surrounding the mast.

The turbulence quantities u', v', w', Td', Tn' and q' are computed in the surface wind coordinate system, where X is aligned with the wind direction at 20 m height and Z is perpendicular to the earth surface.

The turbulence quantities consist of the fluctuation part of the signal after removal of linear trend. The trends have been calculated over a 30 minute period.

The complete datafile TRIVAANMETINGEN/7779 is stored on a library maintenance tape called CHOFDUMP. A program called (HOFC)LISTOUT creates a hard copy of the data and the following additional quantities:

$$u_* = \sqrt[4]{(u'w')^2 + (v'w')^2}$$

$$L = \frac{-((u'w')^2 + (v'w')^2)^{3/4}}{.35 * 9.8 * w'Td' / (273 + Td_{(10)})}$$

$$ff_{(geo)} = \sqrt{U^2_{(geo)} + V^2_{(geo)}}$$

$$dd_{(geo)} = (\pi - \arctan(V_{(geo)} / U_{(geo)}) + \pi/2) * 360/2\pi$$

The geostrophic wind parameters are obtained by a procedure developed by Cats (see ref. 1).

c. The file on a diskette
This file is a copy of the file TRIVAANMETINGEN/7779 on a 1.2 Mb diskette which is formatted in PC DOS.

4. Availability of data

Requests for use of the data by third parties should be adressed to:
Royal Netherlands Meteorologial Institute,
a/o Head of the Physical Meteorological Research Department,
P.O.Box 201, 3730 AE De Bilt, The Netherlands,
telephone 31-30-766462, telex 47096 nl.

4. References:

1. G.J. Cats 1977: Berekening van de geowind,
   Royal Netherlands Meteorological Institute,
   Scientific Report W.R. 77-2

2. A.G.M. Driedonks, P.A.T. Nieuwendijk and C.J. Goes, 1980: A set of computer programs to process turbulence data measured at the 200 m mast at Cabauw.
   Royal Netherlands Meteorological Institute,
   Scientific Report W.R. 80-3.

3. A.G.M. Driedonks, 1982: Models and observations of the growth of the Atmospheric Boundary Layer.
   Boundary-Layer Meteorol. 23, 283-306.

4. A.G.M. Driedonks, H. van Dop and W. Kohsiek, 1978: Meteorological observations on the 213 m mast at Cabauw in the Netherlands.
   Proc. 4th Symp. on Meteor. Observ. and Instr., Denver., Amer. Meteor. Soc., Boston, 41-46.

5. A.G.M. Driedonks, 1981: Dynamics of the well-mixed atmospheric boundary layer.
   Royal Netherlands Meteorological Institute,
   Scientific Report W.R. 81-2.

6. W.A.A. Monna and J.G. van der Vliet, 1987: Facilities for research and weather observations on the 213 m tower at Cabauw and at remote locations.
   Royal Netherlands Meteorological Institute,
   Scientific Report W.R. 87-5.

7. F.T.M. Nieuwstadt, 1984: The turbulent structure of the stable nocturnal boundary layer.
   J. Atmos. Sci., 41, 2202-2216.

8. A.P. van Ulden, J.G. van der Vliet and J. Wieringa, 1976: Temperature and wind observations at heights from 2 m to 200 m at Cabauw in 1973.
   Royal Netherlands Meteorological Institute,
   Scientific Report W.R. 76-7.

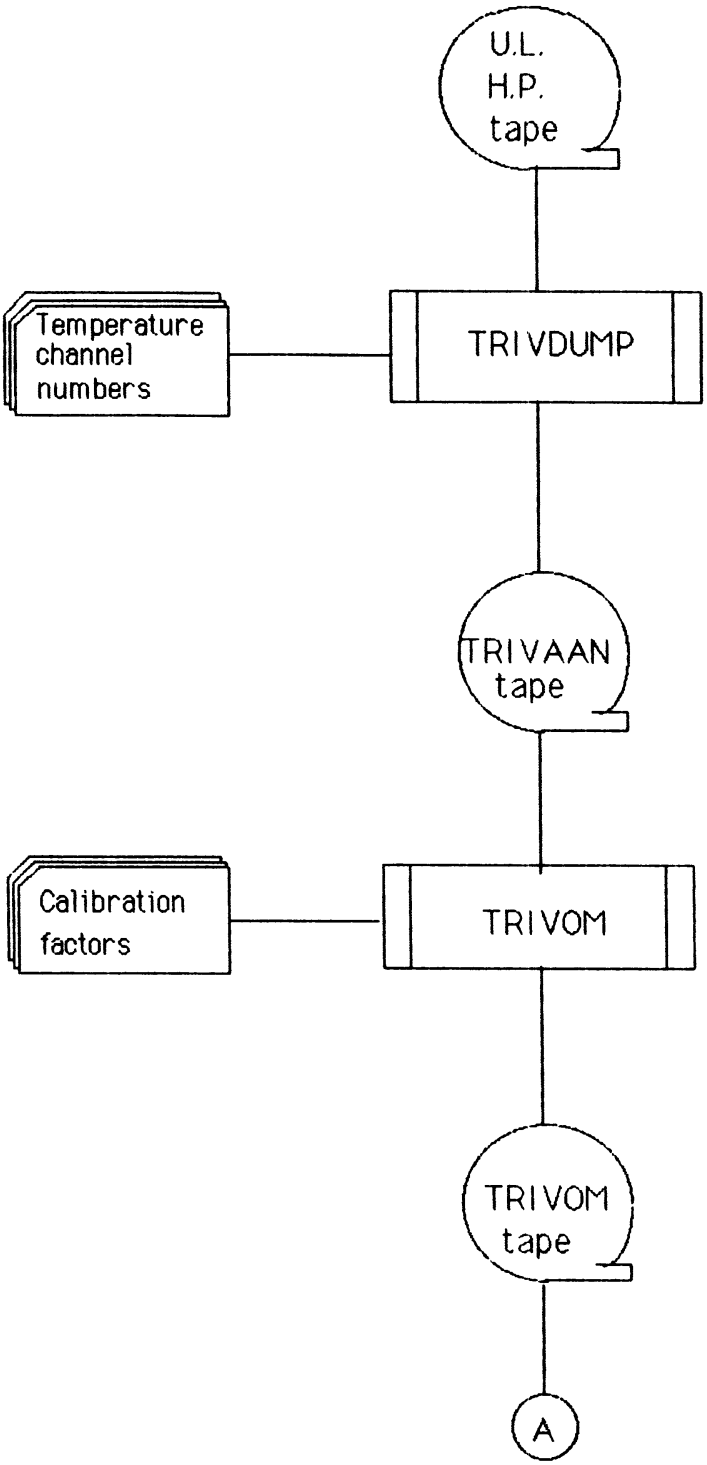
U.L.
H.P.
tape
Temperature
channel
numbers
TRIVDUMP
TRIVAAN
tape
Calibration
factors
TRIVOM
TRIVOM
tape
A

fig. 1

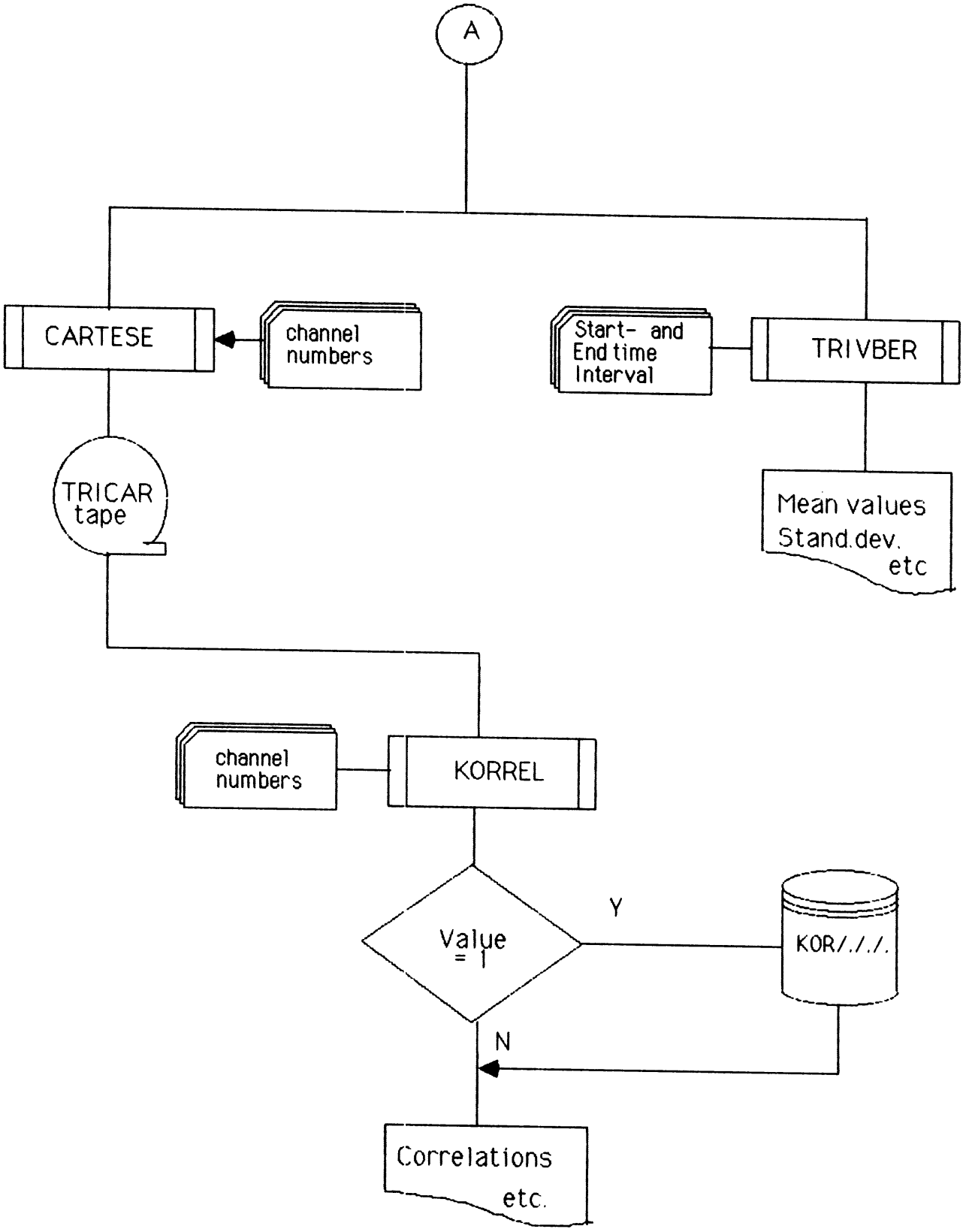
A
CARTESE
channel numbers
Start- and End time Interval
TRIVBER
TRICAR tape
Mean values
Stand.dev.
etc
channel numbers
KORREL
Value = 1
Y
KOR/././.
N
Correlations
etc.

fig. 2

APPENDIX

A. File descriptions

a. A TRIVOM file (for detailed description see ref. 2).

File title : TRIVOM‹YYDDDHHmm›
Blocksize : 2600
Maxrecsize : 26
Units : Words
Density : 6250 BPI

records 0,1,2 and 3 : tape indentification.
record 4 until end of file : data records.

‹YYDDDHHmm› means starting time of the tape where
JJ = Year - 1900
DDD = Daynumber in the year
hh = Starting hour
mm = Starting minute.

Description of a TRIVOM data record.

Word 0 to 19	: Data in SI units (2 data per word)
Word 20 to 24 1/2	: Not routinely used. (filled with 99999)
Word 24 second part	: (YEAR-1900)*1000+ daynumber
Word 25 first half	: Hour * 100000 + minutes * 1000 + seconds *10 + millisec. of the sample
Word 25 second half	: Sample number.

b. The TRIVAANMETINGEN/7779 file

File title : (HOFC)TRIVAANMETINGEN/7779
Maxrecsize : 210
Blocksize : 1050
Areasize : 100
Areas : 10
Units : words

c. The diskette file

Title : \TRIVAAN\METINGEN\BEST7779.DAT
Format : PC DOS
Capacity : 1.2 Mb
Units : ASCII
Values are separated by a space. ‹20_H›
Recors are separated by a carriage return followed by a linefeed.
‹$0D_H$ $0A_H$›
Missing values are represented by 99999.
The unused elements (28,165 until 209) contains a 0 (zero).

B. Content of a record from the tape- or diskette file

For meaning of the symbols see Appendix D.

EL. NR.				
0	YYDDDHHmm (startingtime)			
1	YYDDDHHmm (endingtime)			
2	Number of samples			
3	DD	20	mtr.	Tower
4	DD	40	,,	,,
5	DD	80	,,	,,
6	DD	120	,,	,,
7	DD	160	,,	,,
8	DD	200	,,	,,
9	FF	2	,,	,,
10	FF	5	,,	,,
11	FF	10	,,	,,
12	FF	20	,,	,,
13	FF	40	,,	,,
14	FF	80	,,	,,
15	FF	120	,,	,,
16	FF	160	,,	,,
17	FF	200	,,	,,
18	Td	.6	,,	,,
19	Td	2	,,	,,
20	Td	5	,,	,,
21	Td	10	,,	,,
22	Td	20	,,	,,
23	Td	40	,,	,,
24	Td	80	,,	,,
25	Td	120	,,	,,
26	Td	160	,,	,,
27	Td	200	,,	,,
28	Not used			
29	DD	20	mtr.	Turbulence
30	DD	40	,,	,,
31	DD	80	,,	,,
32	DD	120	,,	,,
33	DD	160	,,	,,
34	DD	200	,,	,,
35	FF	20	,,	,,
36	FF	40	,,	,,
37	FF	80	,,	,,
38	FF	120	,,	,,
39	FF	160	,,	,,
40	FF	200	,,	,,
41	Td	20	,,	,,
42	Td	40	,,	,,
43	Td	80	,,	,,
44	Td	120	,,	,,
45	Td	160	,,	,,
46	Td	200	,,	,,
47	Tn	20	,,	,,
48	Tn	120	,,	,,
49	q	20	,,	,,
50	q	120	,,	,,

51	U_{geo}	
52	V_{geo}	
53	du/dx	
54	du/dy	
55	dv/dx	
56	dv/dy	
57	dT/dx	
58	dT/dy	
59	u'^2	20 mtr.
60	u'v'	,,
61	u'w'	,,
62	u'Td'	,,
63	u'Tn'	,,
64	u'q'	,,
65	v'^2	,,
66	v'w'	,,
67	v'Td'	,,
68	v'Tn'	,,
69	v'q'	,,
70	w'^2	,,
71	w'Td'	,,
72	w'Tn'	,,
73	w'q'	,,
74	Td'^2	,,
75	Td'Tn'	,,
76	Td'q'	,,
77	Tn'^2	,,
78	Tn'q'	,,
79	q'^2	,,
80	u'^2	40 mtr.
81	u'v'	,,
82	u'w'	,,
83	u'Td'	,,
84	v'^2	,,
85	v'w'	,,
86	v'Td'	,,
87	w'^2	,,
88	w'Td'	,,
89	Td'^2	,,
90	u'^2	80 mtr.
91	u'v'	,,
92	u'w'	,,
93	u'Td'	,,
94	v'^2	,,
95	v'w'	,,
96	v'Td'	,,
97	w'^2	,,
98	u'Td'	,,
99	Td'^2	,,
100	u'^2	120 mtr.
101	u'v'	,,
102	u'w'	,,
103	u'Td'	,,
104	u'Tn'	,,
105	u'q'	,,
106	v'^2	,,

107 v'w' 120 mtr.
108 v'Td' ,,
109 v'Tn' ,,
110 v'q' ,,
111 w'^{2} ,,
112 w'Td' ,,
113 w'Tn' ,,
114 w'q' ,,
115 Td'^{2} ,,
116 Td'Tn' ,,
117 Td'q' ,,
118 Tn'^{2} ,,
119 Tn'q' ,,
120 q'^{2} ,,
121 u'^{2} 160 mtr.
122 u'v' ,,
123 u'w' ,,
124 u'Td' ,,
125 v'^{2} ,,
126 v'w' ,,
127 v'Td' ,,
128 w'^{2} ,,
129 u'Td' ,,
130 Td'^{2} ,,
131 u'^{2} 200 mtr.
132 u'v' ,,
133 u'w' ,,
134 u'Td' ,,
135 v'^{2} ,,
136 v'w' ,,
137 v'Td' ,,
138 w'^{2} ,,
139 w'Td' ,,
140 Td'^{2} ,,
141 Boundary layer height
142 |du/dz,dv/dz| 20 mtr.
143 α ,,
144 dθ/dz ,,
145 |du/dz,dv/dz| 40 mtr.
146 α ,,
147 dθ/dz ,,
148 |du/dz,dv/dz| 80 mtr.
149 α ,,
150 dθ/dz ,,
151 |du/dz,dv/dz| 120 mtr.
152 α ,,
153 dθ/dz ,,
154 |du/dz,dv/dz| 160 mtr.
155 α ,,
156 dθ/dz ,,
157 |du/dz,dv/dz| 200 mtr.
158 α ,,
159 dθ/dz ,,
160 Global radiation
161 Net radiation
162 Soil heat flux
163 Sensible heat flux
164 Latent heat flux
165 until 209 Not used

C. List of available turbulence measuring periods.

Starttime ‹YYDDDHHmm›	Endtime ‹YYDDDHHmm›	Sampling frequency (Hz)
772150350	772150630	10
772150640	772150930	10
772150940	772151230	10
772170300	772170550	10
772170555	772170850	10
772170855	772171150	10
772472200	772480400	5
772480430	772481000	5
772570350	772570530	5
772570615	772571030	5
772630200	772630800	5
772710615	772710940	5
780481450	780482050	5
780482110	780482230	5
780511420	780512020	5
780512040	780520240	5
780520250	780520850	5
780520900	780521500	5
781381630	781382200	5
781382210	781390400	5
781491110	781491540	5
781491630	781492200	5
781492210	781500400	5
781500410	781501000	5
781501020	781501600	5
781501610	781502200	5
781502210	781510400	5
781510410	781511000	5
781511010	781511600	5
781511650	781512200	5
781512210	781520400	5
781520430	781521000	5
781521010	781521600	5
781522210	781530400	5
781661300	781661600	5
781661610	781662200	5
782351600	782352200	5
782352217	782360400	5
782360410	782361000	5
782551300	782551600	5
782551615	782552215	5
782552245	782560430	5
782560440	782561000	5
782681615	782682215	5
782682320	782690430	5
782690445	782691100	5
782691115	782691515	5
782771530	782771730	5
782771810	782772330	5
782772345	782780545	5
782841240	782841720	5

Starttime <YYDDDHHmm>	Stoptime <YYDDDHHmm>	Freq. (Hz)
782841750	782842320	5
782842330	782850530	5
782850540	782851130	5
782851140	782851730	5
782851740	782852330	5
782852345	782860530	5
782860540	782860800	5
782860830	782861130	5
782861140	782861730	5
782861740	782862330	5
783401230	783401800	5
783401810	783402350	5
783410000	783410600	5
783410610	783411200	5
783411225	783411800	5
783411810	783412350	5
783420000	783420600	5
783420610	783421200	5
783531200	783531740	5
783540000	783540600	5
783540610	783541200	5
790391230	790391740	5
790391750	790392350	5
790400000	790400600	5
790400610	790401210	5

YY = Year - 1900 (e.g. 1978 = 78).
DDD = Daynumber (1 to 365).
HH = Hours (U.T.C.).
mm = minutes.

D. List of Symbols and Units

Symbol	Description	Units (SI)
DD	Winddirection	deg North
FF	Windspeed	$m\ s^{-1}$
Td	Dry bulb temperature	°C
Tn	Wet bulb temperature	°C
q	Specific humidity	$g\ kg^{-1}$
U_{geo}	Geostrophic wind (East-componont)	$m\ s^{-1}$
V_{geo}	Geostrophic wind (North-component)	$m\ s^{-1}$
du/dx	Horizontal Gradients in East(x)-North(y) system	s^{-1}
du/dy	,, ,, ,, ,, ,,	s^{-1}
dv/dx	,, ,, ,, ,, ,,	s^{-1}
dv/dy	,, ,, ,, ,, ,,	s^{-1}
dT/dx	,, ,, ,, ,, ,,	°K m^{-1}
dT/dy	,, ,, ,, ,, ,,	°K m^{-1}
u'	X-Component of velocity fluctuation	$m\ s^{-1}$
v'	Y-Component of ,, ,,	$m\ s^{-1}$
w'	Z-Component of ,, ,,	$m\ s^{-1}$
Td'	Dry bulb temperature ,,	°C
Tn'	Wet bulb ,, ,,	°C
q'	Specific humidity ,,	$g\ kg^{-1}$
u'^2		
u'v'		
u'w'		
u'Td'		
u'Tn'		
u'q'		
v^2		
v'w'		
v'Td'		
v'Tn'		
v'q'	Covariance matrix of u', v', w', Td', Tn' and q'	
w'^2		
w'Td'		
w'Tn'		
w'q'		
Td'^2		
Td'Tn'		
Td'q'		
Tn'^2		
Tn'q'		
q'^2		
	Boundary layer height	m
|du/dz,dv/dz|	Absolute value of the windshear vector	s^{-1}
α	Direction of the windshear vector	deg North
dθ/dz	Potential temperature gradient	°C m^{-1}
	Global radiation	$W\ m^{-2}$
	Net radiation	$W\ m^{-2}$
	Soil heat flux	$W\ m^{-2}$
	Sensible heat flux (Bowen method)	$W\ m^{-2}$
	Latent heat flux (,, ,,)	$W\ m^{-2}$

All values are multiplied by 10^5, so as to make them integers.

E. List of available local radio sounding measurements

Date <YYMMDD>	Launching time <HH.mm>
780117	12.59
780418	9.52
780418	12.34
780529	14.14
780530	3.49
780530	6.09
780530	7.50
780531	4.01
780531	5.56
780531	7.48
780531	8.50
780601	5.03
780601	6.30
780601	7.56
780601	9.46
780613	9.57
780613	12.49
780615	13.07
780726	10.03
780726	12.59
780802	10.01
780802	13.19
780824	4.36
780824	5.36
780824	7.54
780912	13.14
780925	14.45
780926	5.31
780926	6.55
780926	8.21
780926	9.16
781004	15.28
781010	13.10
781010	13.54
781011	14.48
781012	6.01
781012	6.47
781012	7.24
781012	8.13
781012	9.03
781012	9.41
781012	10.19
781012	10.57
781012	12.57
781012	13.53
781013	6.34
781013	7.15
781013	8.01
781013	8.42
781013	9.27

Date <YYMMDD>	Launching time <HH.mm>
781013	10.04
781013	10.36
781031	10.38
781031	13.19
781206	9.00
781206	13.49
781207	13.40
781207	14.25
781208	8.23
781219	14.11
781220	5.12
790202	14.34
790208	16.03

YY = Year - 1900 (e.g. 1978 = 78).
MM = Month (1..12).
DD = Day of the month (1..31).
HH = Hours (U.T.C.).
mm = minutes.

The data of a single sounding are devided in two parts; first a block with standard pressure levels and second a part with characteristic levels.