

DNMI

DET NORSKE METEOROLOGISKE INSTITUTT

klima

HANØYTANGEN , ANNUAL SYNTHESIS/ANALYSIS 1994

Knut A. Iden

RAPPORT NR. 16/95 KLIMA



DNMI-RAPPORT

DET NORSKE METEOROLOGISKE INSTITUTT
P.O.BOX 43, BLINDERN 0313 OSLO

TEL. : (22) 96 30 00

ISSN 0808-9918

REPORT NO.

16/95 KLIMA

DATE

MAY 8 1995

TITLE

HANØYTANGEN , ANNUAL SYNTHESIS/ANALYSIS 1994

PREPARED BY

Knut A. Iden

ORDERED BY

KVÆRNER CONCRETE CONSTRUCTION
CONTRACT NO: KCC/PAC004/001

SUMMARY

The measurements earlier given in monthly reports are summerised. A more comprehensive analysis with regard to 10/100 year values is performed. When analysing the simultaneous wind values from the three height levels, it is seen that the wind is accelerated in the lower levels in situations with strong wind and wind direction in the interval 160° - 230°, the interval where the maximum wind speed most probably will occur. This gives reason for a height reduction when estimating 10/100 year values for an "undisturbed" point 10 m above the fjord.

SIGNATURE

.....*Knut A. Iden*.....

Knut A. Iden
PROJ. RESPONSIBLE

.....*Bjørn Aune*.....

Bjørn Aune
HEAD OF DIVISION

HANØYTANGEN

ANNUAL SYNTHESIS/ANALYSIS 1994

BY

Knut A. Iden, DNMI

LIST OF CONTENTS

Summary

1. Introduction.....	1
2. The data collecting system.....	2
2.1 Measuring site.....	2
2.2 Instrumentation	3
2.3 Calibration factors.....	3
2.4 Preventive maintenance.....	4
3. Results (Tables and Diagrams).....	5
3.1 Climatological summary.....	5
3.2 3-D Histograms.....	6
3.3 Occurrence tables of wind speed for the 10 m level of the mast.....	9
3.4 Monthly wind roses for the 10 m level of the mast.....	16
3.5 Discussion of results.....	18
4. Computation of 10/100 year estimates of wind speed	19
4.1 10/100 year estimates of the wind speed based on the 10 m level of the mast....	19
4.2 10/100 year estimates of the wind speed 10 m above mean sea level.....	23
5. References.....	25
Appendix 1.....	26
Appendix 2.....	27

Summary

The summary will be brief comments on:

- . the aim of the measuring project
- . the measurements performed
- . the validity of the results.

10/100 year estimates of the wind speed

1. Introduction

At the building site at Hanøy tangen, probable environmental loads were estimated (43/92 Klima) without any measurements at the site. The estimates were based on the data series from the lighthouse station Hellisøy (1.1.1957-31.12.1991) and a shorter series at Storebuneset near the Askøy bridge (23.10.1987-30.04.1990). All locations are given in Figure 1 below.

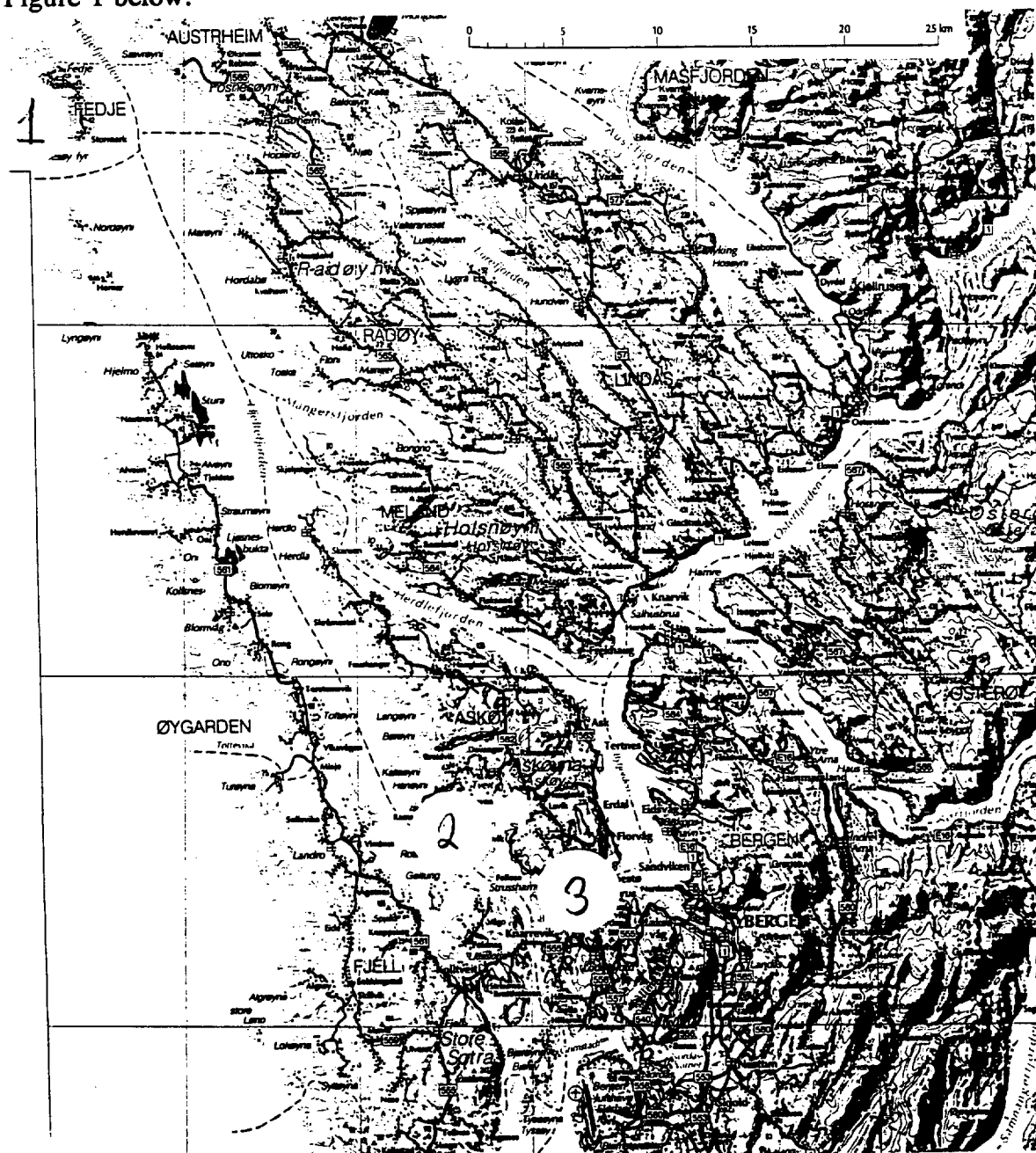


Figure 1 Map giving the location of Hellisøy Fyr (1), Hanøy tangen (2) and Storebuneset (3).

The meteorological measurements at the building site was started in November 1993 motivated both by the need of such data when performing weather sensitive operations and for the assessment of the estimates of the environmental loads. This assessment is based on the parallel series between Hellisøy and Hanøytangen. Unfortunately the wind measurements at Hellisøy were lost until 3.2.1994 due to instrument failure. The parallel series used is 3.2-31.12.1994.

2. The data collecting system

2.1 Measuring site

Hanøytangen is located at Askøy approximately 15 km NW of Bergen. The measuring site is located SW of the "shipyard" in an area not influenced directly by the building activity. Figure 2 shows the building site with the mast where the instruments are located. Unfortunately, waste from the building activity are burned in the area near the mast. False heating turned out to be a problem for the measurement of the air temperature and the air humidity. Spikes and other un-physical values have been removed from the data record. However, there may still be values present in the data series influenced to some degree by the false heating.

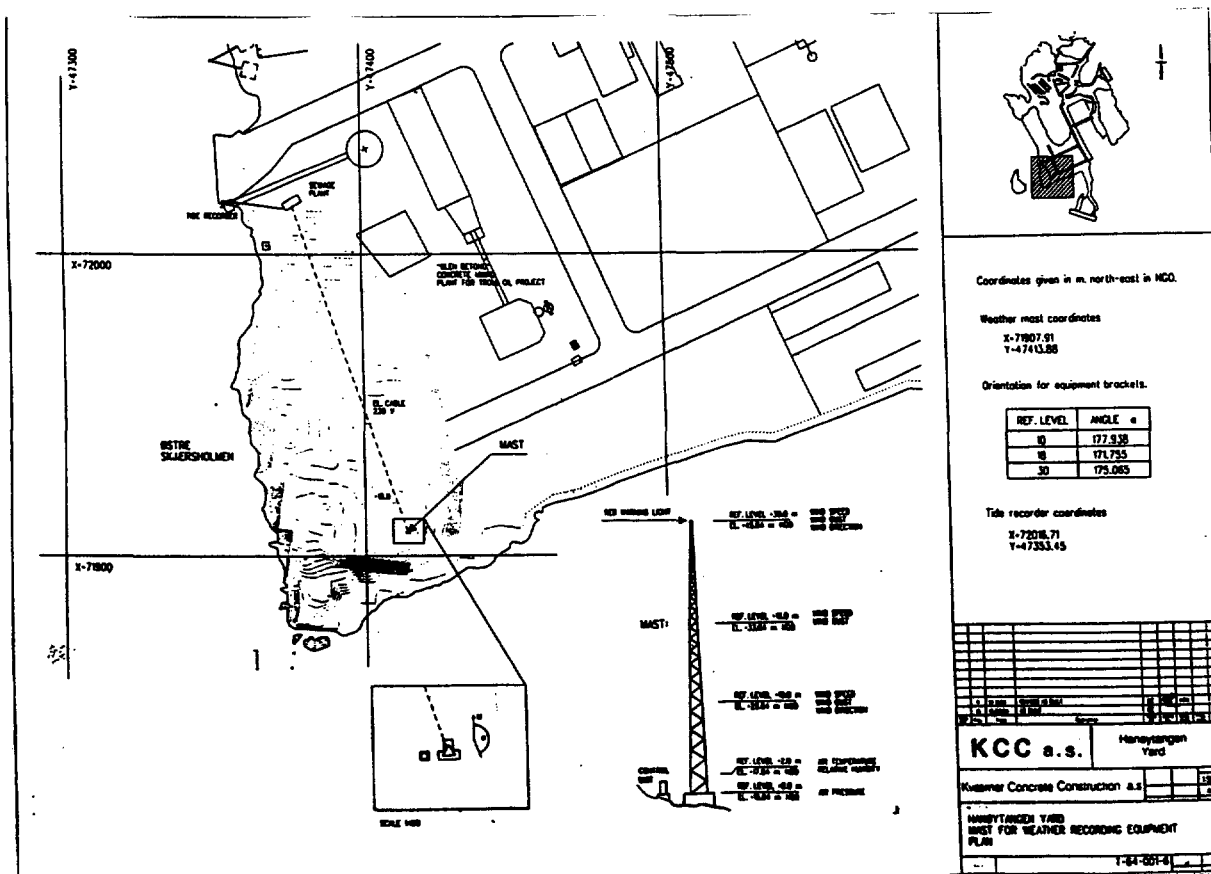


Figure 2 The measuring site at Hanøytangen.

2.2 Instrumentation

As can be seen on Figure 2 the instruments are set up in a mast of 30 m height. The foot of the mast is 15.64 m a.m.s.l.. The parameters measured in the different levels are :

30 m (+15.64)	: wind speed, gust wind speed, wind direction
18 m (+15.64)	: wind speed, gust wind speed
10 m (+15.64)	: wind speed, gust wind speed, wind direction
2 m (+15.64)	: air temperature, air humidity
0 m (+15.64)	: air pressure

The instruments were delivered by A/S Aanderaa Instruments in Bergen. All installation were also done by A/S Aanderaa. The sensors used are the following :

The wind speed/gust sensors	: Model no. 2740 (Aanderaa)
The wind direction sensors	: Model no. 2750 (Aanderaa)
The air temperature sensor	: Model no. 3145 ser.no.1456 (Aanderaa)
Radiation screen	: Model no. 2992 (Aanderaa)
The air humidity sensor	: Model no. 2820 ser.no.0019 (Aanderaa)
The air pressure sensor	: Model no. 2810 ser.no.0804 (Aanderaa)

2.3 Calibration factors

The instruments were calibrated by Aanderaa Instruments prior to the installation 23.11.1993. The calibration factors for the different instruments were given in a fax dated 28.1.1994 and are given in table 1.

Table 1 Calibration factors applied in the period Nov. 1993 - Dec. 1994 at Hanøytangen.

CALIBRATION FACTORS DETERMINED 23.11.1993							
Coeff. in the formula $A+B*N+C*N^2+D*N^3$							
CHANNELL	PARAMETER	UNIT	A	B	C	D	
1	REF		0	1.000E+00	0	0	0
2	Wind speed 30 m	m/s	4.000E-01	7.460E-02	0	0	0
3	Wind gust 30 m	m/s	4.000E-01	7.460E-02	0	0	0
4	Wind direction 30 m	deg.	1.500E+00	3.490E-01	0	0	0
5	Wind speed 18 m	m/s	4.000E-01	7.460E-02	0	0	0
6	Wind gust 18 m	m/s	4.000E-01	7.460E-02	0	0	0
7	Wind speed 10 m	m/s	4.000E-01	7.460E-02	0	0	0
8	Wind gust 10 m	m/s	4.000E-01	7.460E-02	0	0	0
9	Wind direction 10 m	deg.	1.500E+00	3.490E-01	0	0	0
10	Air temperature	deg.C	-4.382E+01	8.103E-02	9.164E-06	0	0
11	Rel. Humidity	%	-2.027E+00	1.013E-01	0	0	0
12	Air pressure	hPa	9.161E+02	1.691E-01	0	0	0

2.4 Preventive maintenance

The instruments have not been recalibrated during the period 23.11.93-31.12.94. Visual inspections have been performed to check reasonable performance of the wind measurement equipment. For such a long measuring period, the temperature-, humidity- and pressure sensors should have been compared to reference instruments to expose any drifting in the instruments at Hanøytangen.

3. Results (Tables and Diagrams)

3.1 Climatological summary

Table 2

Observation Period :													Location:	
From : 01/12/93													Level: 2 m a.g.	
To : 31/12/94													HANØYTANGEN DEC 1993 - DEC 1994	
CLIMATOLOGICAL SUMMARY														
	DEC 93	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Air Temperature														
Mean Day min.	-0.2	0.2	-2.1	0.8	3.7	6.1	8.4	12.6	12.1	9.2	5.5	5.4	3	
Abs min.	-4.6	-4	-6.3	-5.1	0.3	1.1	4	8.7	8.1	3.2	0.2	1.5	-1.6	
Mean Day max.	4.3	3.8	3.3	5.3	8.4	13.2	12.3	19.4	17.7	14.7	9.8	8.7	6.6	
Abs max.	10.1	6.7	6.4	10.5	14.9	22.7	18.4	26.4	29	22.1	14.8	14.7	11.2	
Mean	2.2	2.1	0.1	3	5.9	9.5	10.2	15.8	14.6	11.8	7.5	7.2	2.5	
Datcoverage in %	100	77	100	100	99	100	76	99	100	100	99	99	99	
Relative Humidity														
Mean Day min.	58	61	44	59	57	44	64	56	57	52	60	66	67	
Abs min.	40	44	27	29	30	19	40	25	32	23	35	31	48	
Mean Day max.	81	81	73	84	84	80	86	85	84	82	84	85	86	
Abs max.	90	89	90	89	91	89	93	91	89	91	90	91	91	
Mean	71	70	60	73	72	63	78	72	73	69	74	78	79	
Datcoverage in %	100	77	100	100	100	100	77	99	100	100	100	99	99	
Air pressure														
Mean Day min.	989.7	991.6	1016.7	993.4	1004.4	1013.7	1008.3	1017.7	1010.1	1006.6	1007.4	1007.6	997	
Abs min.	968.1	966.2	989.7	969.4	970.9	1004.7	991.9	1010.8	996.9	985.6	983	979.2	971.2	
Mean Day max.	1000.1	1003.5	1023.6	1004.7	1011.8	1018	1015.8	1020.9	1015.1	1012.1	1014.2	1016	1008.5	
Abs max.	1019.7	1019.6	1045.2	1024.3	1028.8	1027.8	1028.1	1026.4	1023.5	1023.7	1030.9	1031.4	1030.4	
Mean	995	998	1020	999.1	1008.2	1016	1012.2	1019.3	1012.5	1010.3	1011	1011.8	1003.4	
Datcoverage in %	100	77	100	100	100	100	77	99	100	100	99	99	99	
Coefficient Transfert														
from level 10 to 18	1.048	1.051	1.046	1.024	1.022	1.049	1.035	1.04	1.048	1.044	1.037	1.022	-	
from level 10 to 30	1.105	1.117	1.088	1.055	1.053	1.119	1.067	1.077	1.117	1.115	1.12	1.097	1.092	
from level 18 to 30	1.051	1.059	1.036	1.029	1.032	1.063	1.03	1.032	1.063	1.065	1.068	1.078	-	
Data coverage in %	99-100	77	100	100	93-100	100	77	100	100	100	98-100	100	100	
Remarks:														
The summary is based on air temperature, humidity, pressure and wind speed measured each 10 minute.														

3.2 3-D Histograms

Air temperature

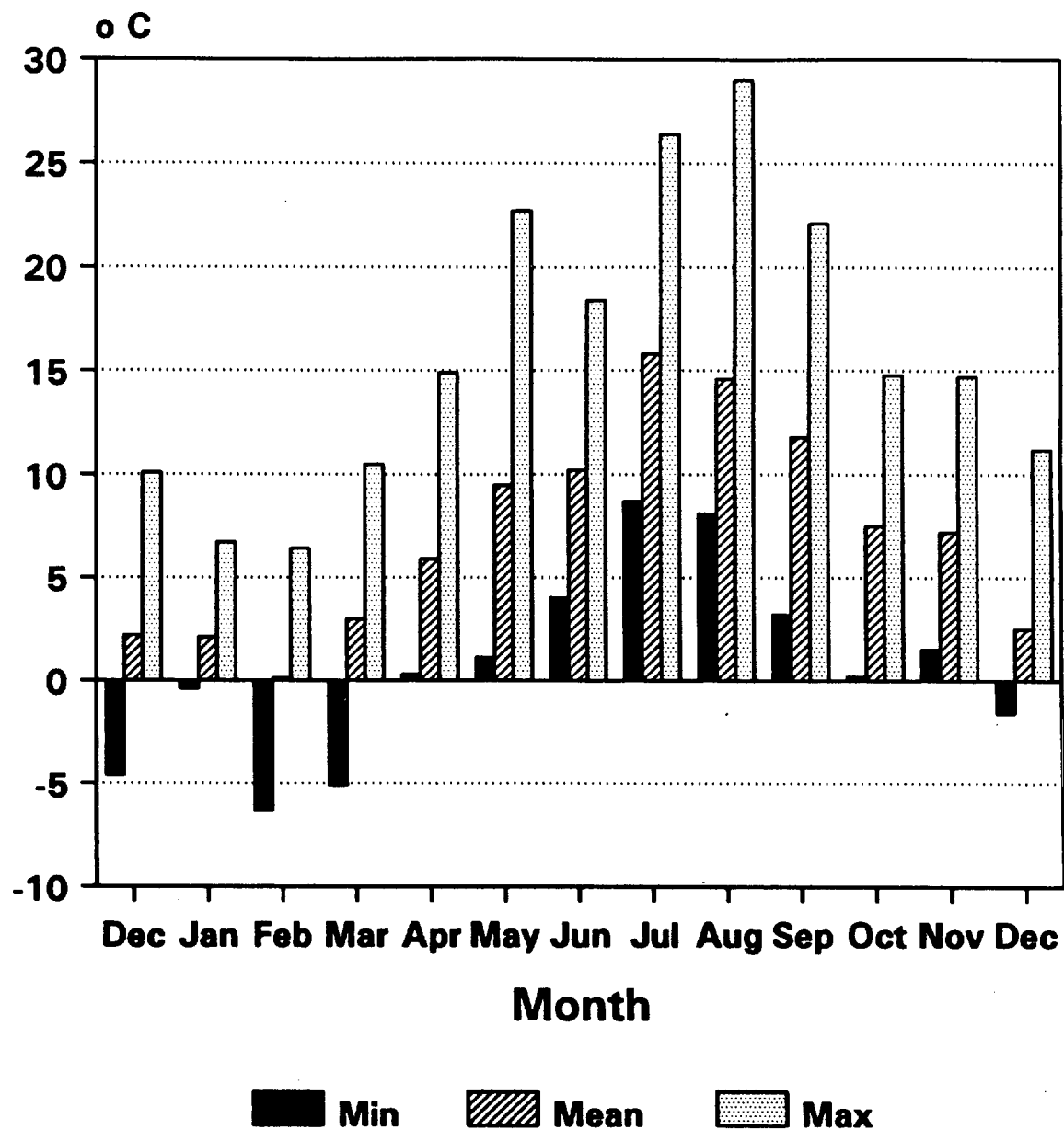


Figure 3 Air temperature at Hanøytangen 1.12.93 -31.12.94

Air humidity

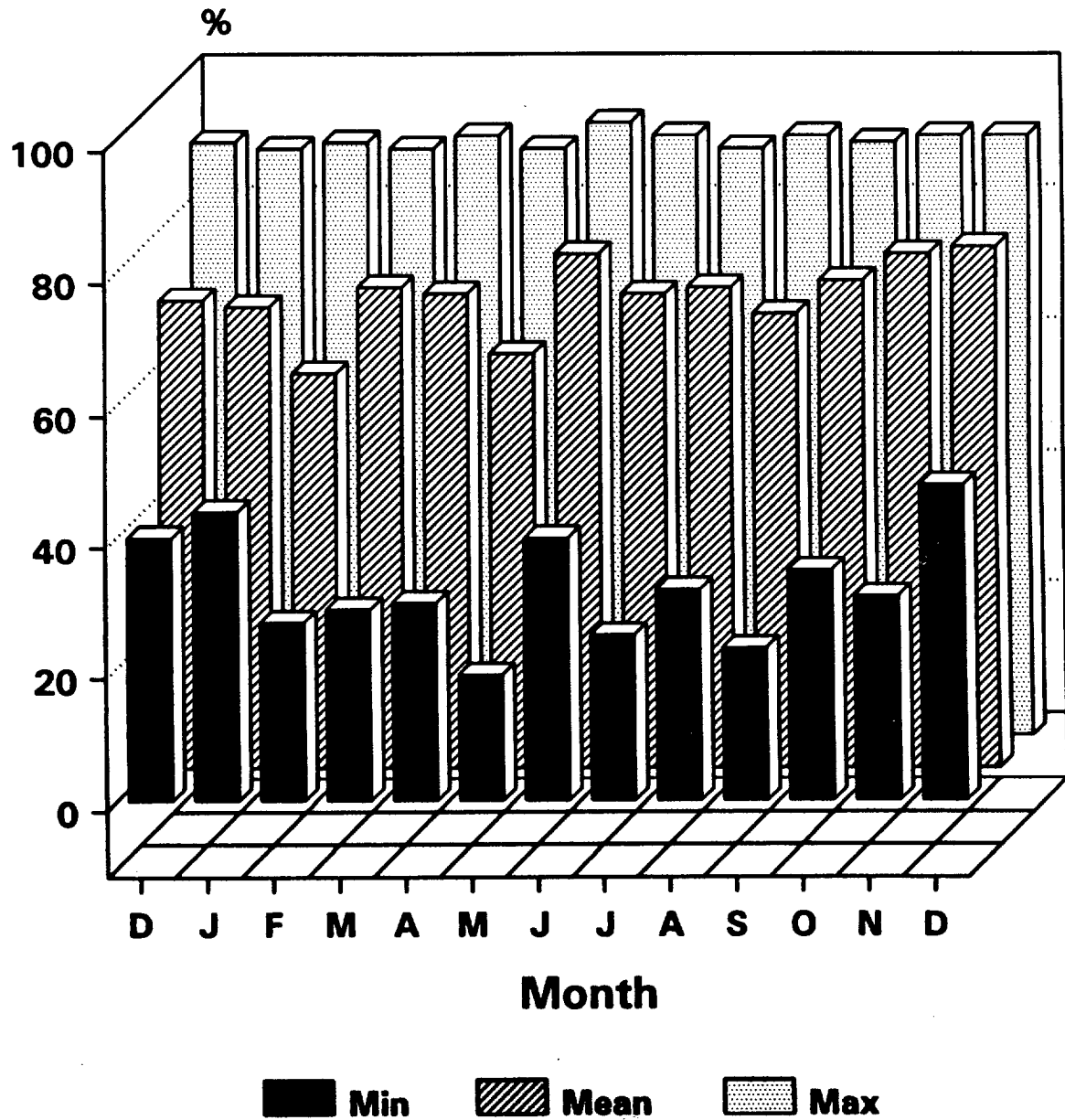


Figure 4 Air humidity at Hanøytangen 1.12.93-31.12.94.

Air pressure

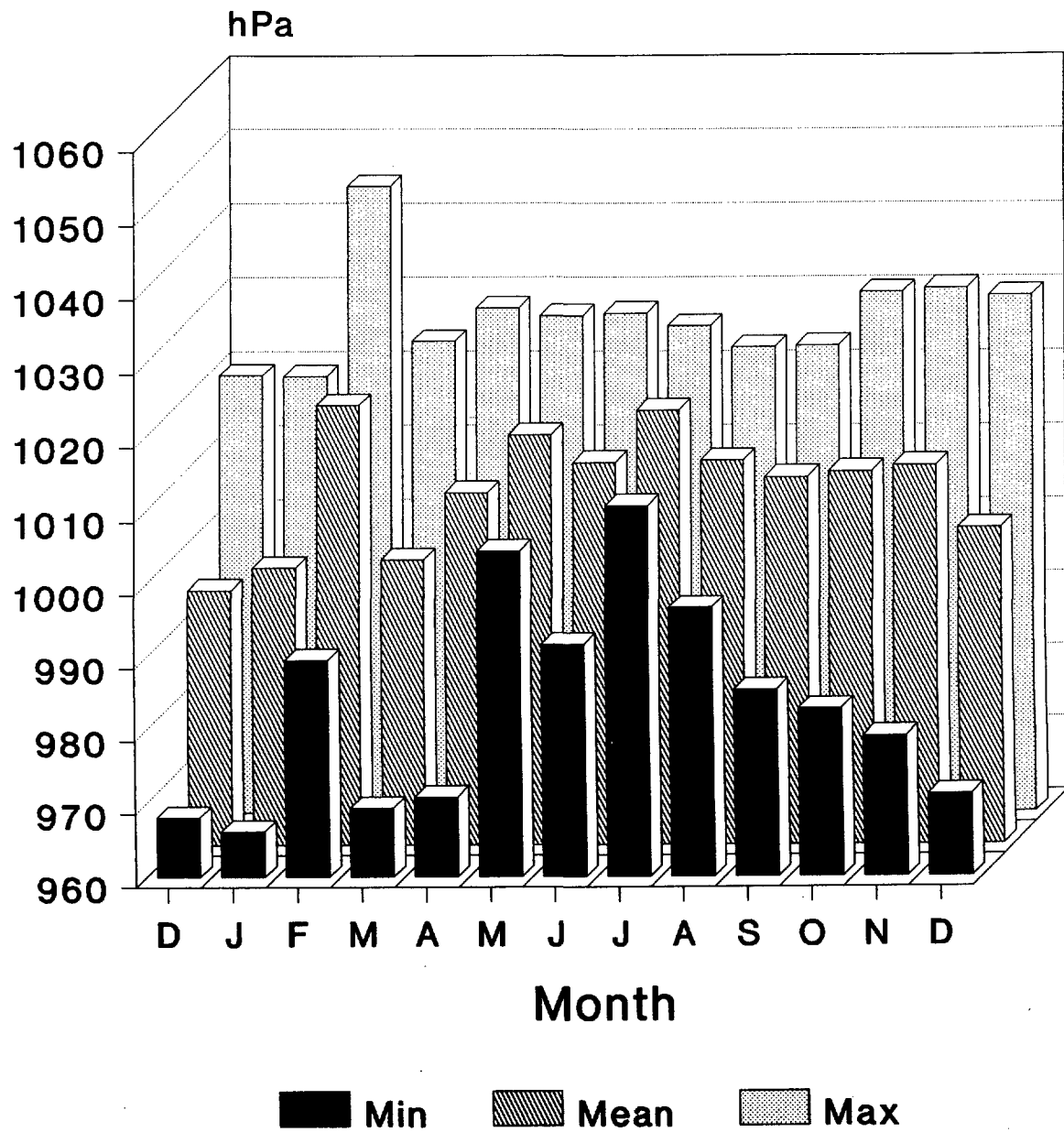


Figure 5 Air pressure at Hanøytangen 1.12.93-31.12.94.

3.3 Occurrence tables of wind speed for the 10 m level of the mast

On the next pages diagrams are given for the number of occurrences of "windows" of different lengths. The content of the tables are based on the hourly maxima (F_x) of the 10 minute mean of the wind speed measured in the 10 m level. The monthly tables forming the basis for the diagrams are given in Appendix 2 (December 1993 included).

First a period fulfilling the criterion $F_x < \text{Limit}$ is sought. The length of this period is divided by the length of the actual window and may result in multiples of the actual window or zero if the length of the period is less than the length of the actual window. This procedure is repeated through the month and the number of the different windows are accumulated. The number of possible windows is besides the weather conditions, also dependent on the data coverage. In January and June the data coverage is 77 %. This must be kept in mind when the low number of windows these months are considered. The data coverage of the different months is presented in figure 6.

HANØYTANGEN

Datacoverage Wind Speed 10 m a. ground

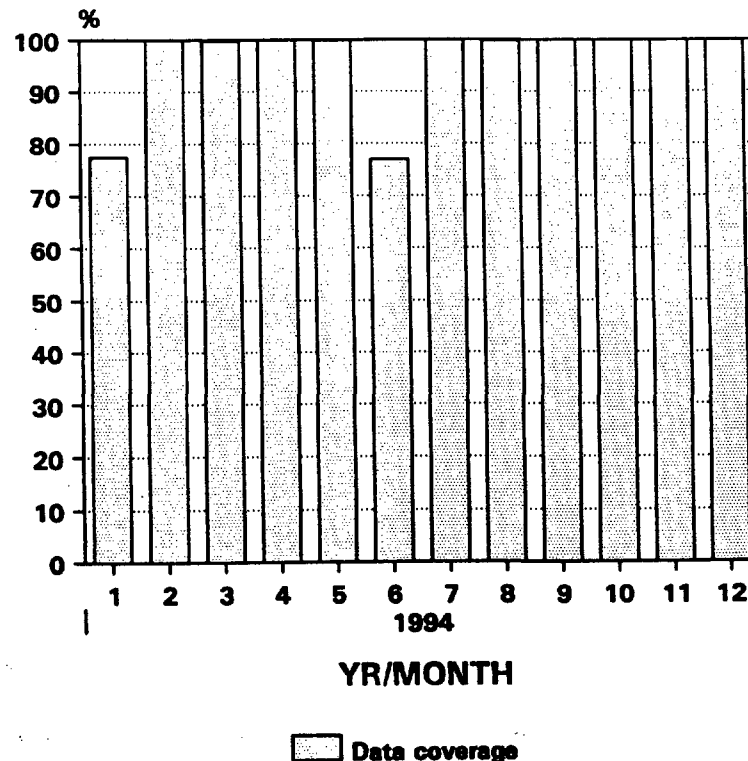


Figure 6 Data coverage for wind speed measurements in the 10 m level.

HANØYTANGEN

Occurrence of Windows
Wind Speed 10 m < limits

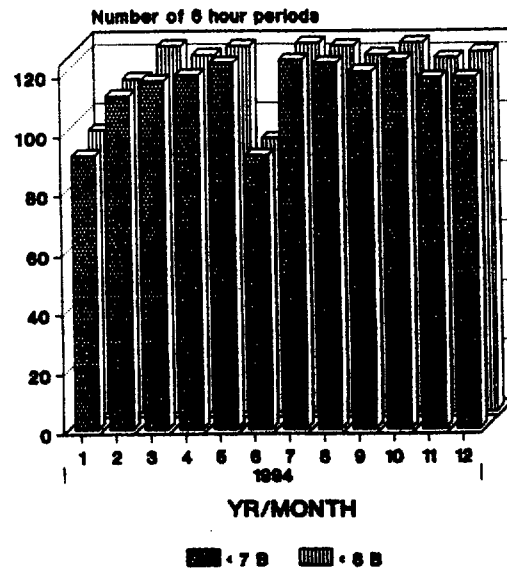
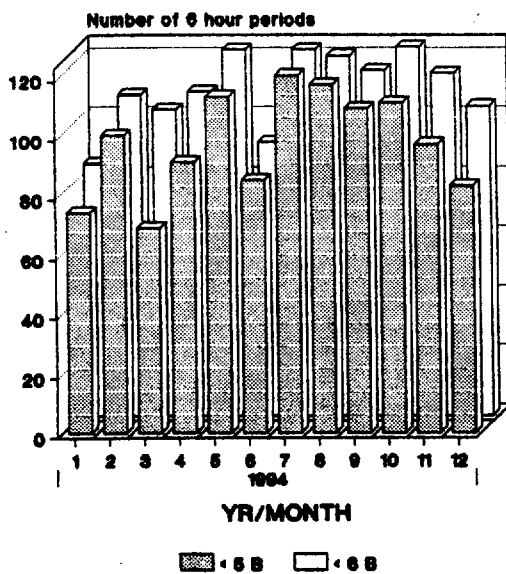
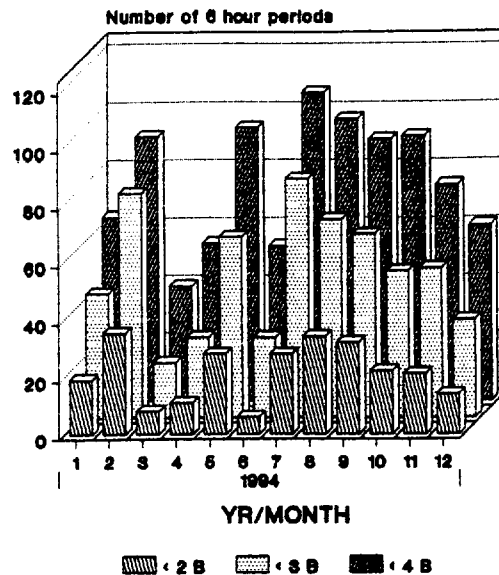


Figure 7

HANØYTANGEN

Occurrence of Windows
Wind Speed 10 m < limits

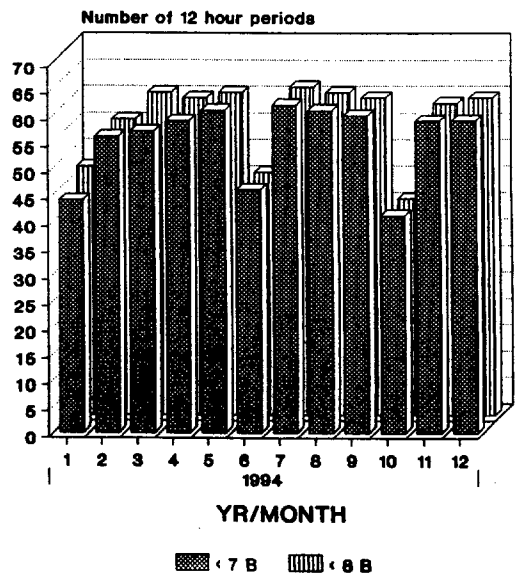
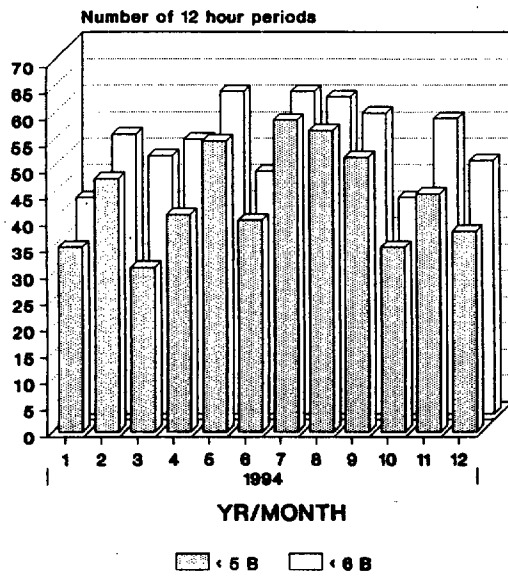
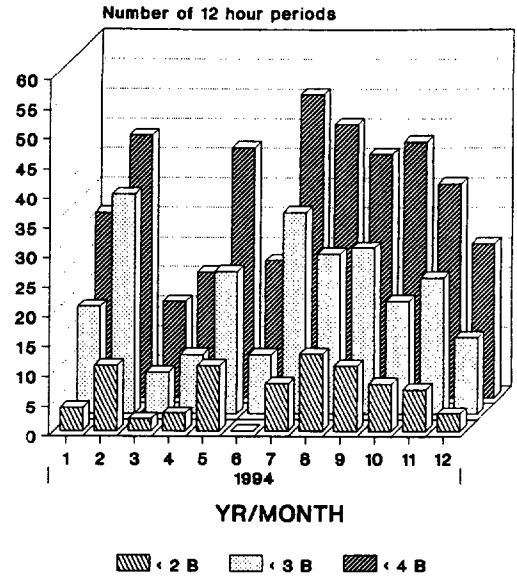


Figure 8

HANØYTANGEN

Occurrence of Windows
Wind Speed 10 m < limits

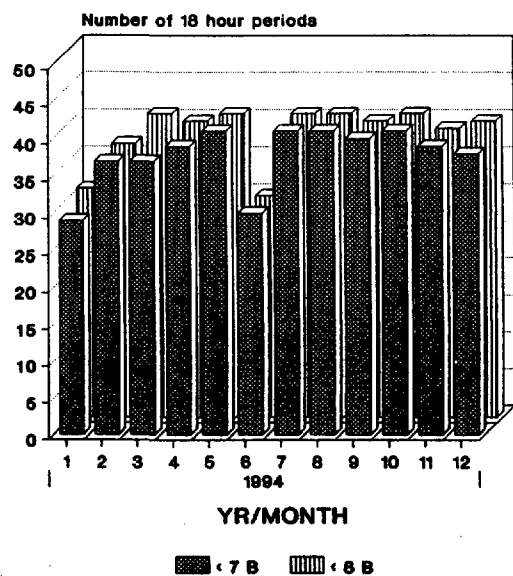
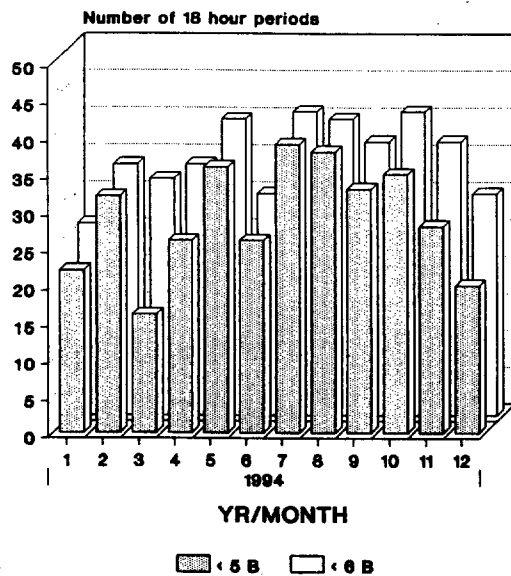
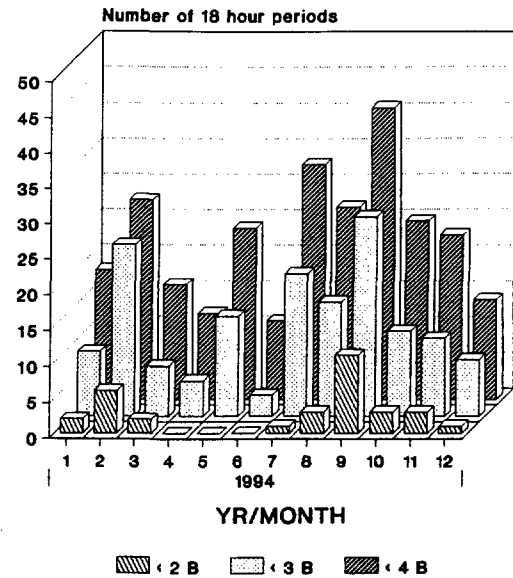


Figure 9

HANØYTANGEN

Occurrence of Windows
Wind Speed 10 m < limits

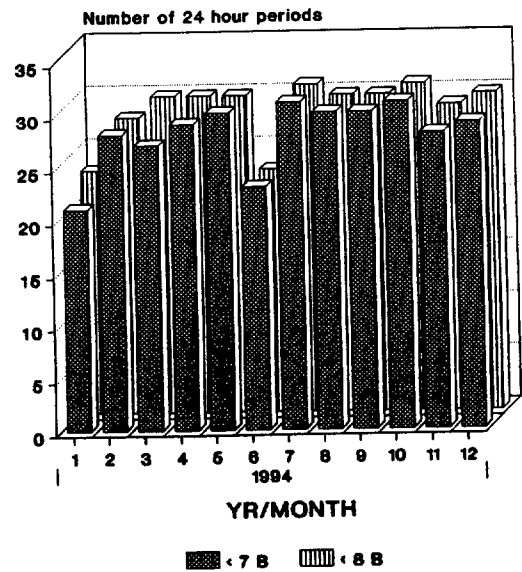
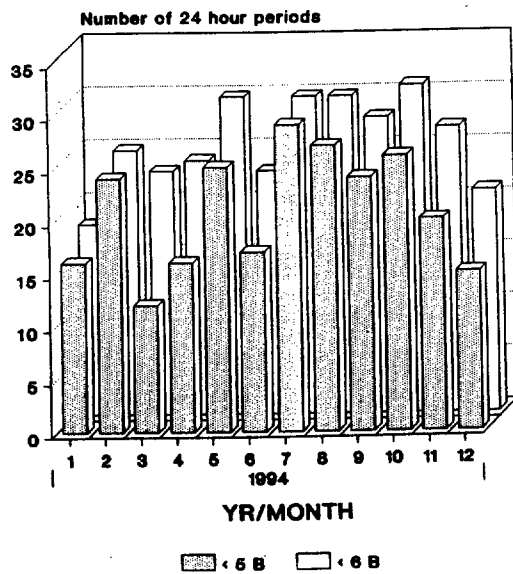
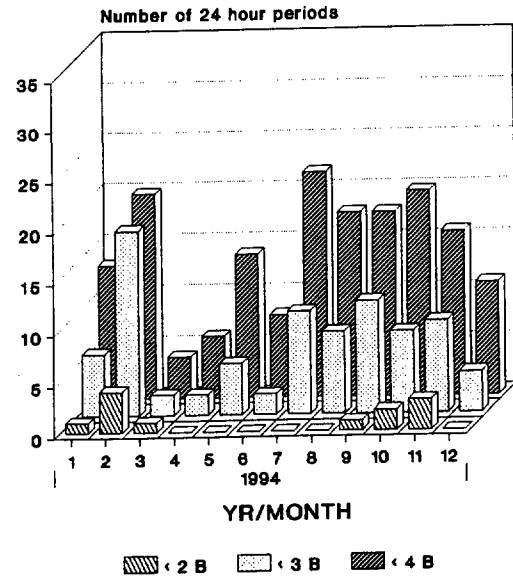


Figure 10

HANØYTANGEN

Occurrence of Windows
Wind Speed 10 m < limits

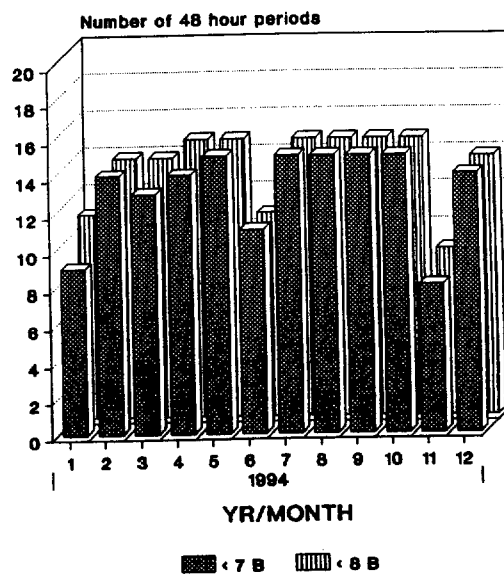
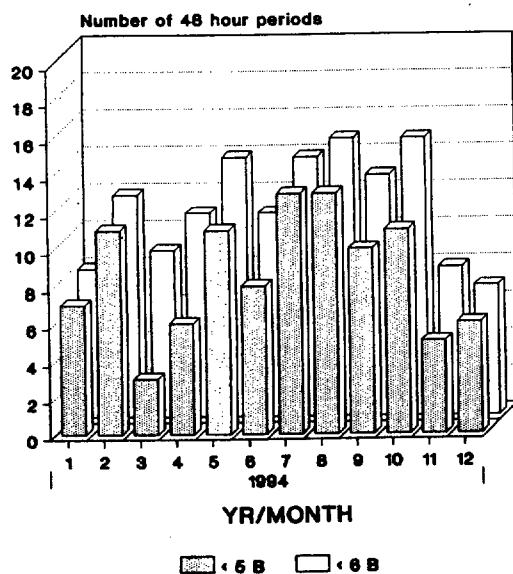
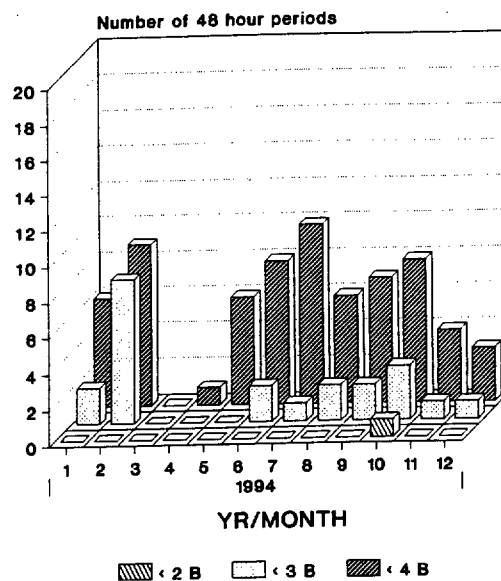


Figure 11

HANØYTANGEN

Occurrence of Windows
Wind Speed 10 m < limits

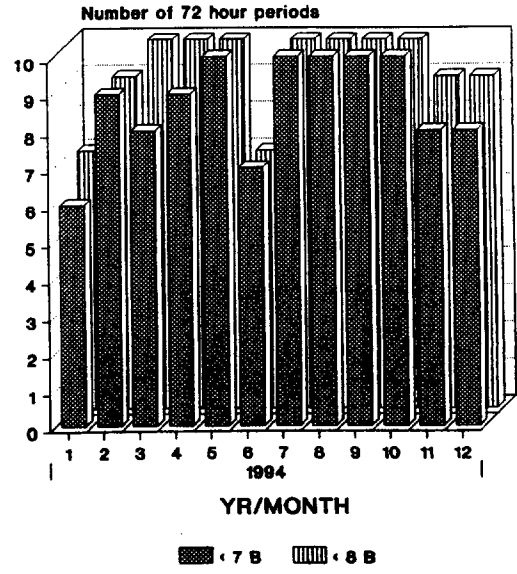
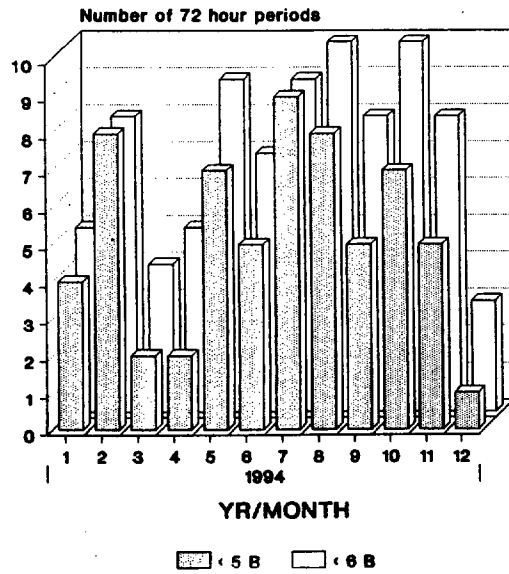
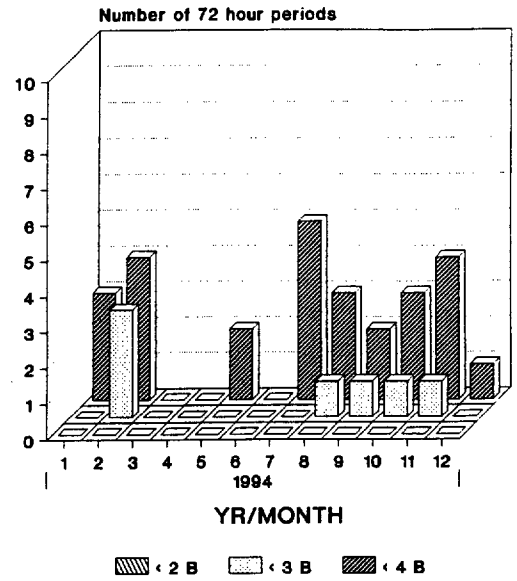


Figure 12

3.4 Monthly wind roses for the 10 m level of the mast

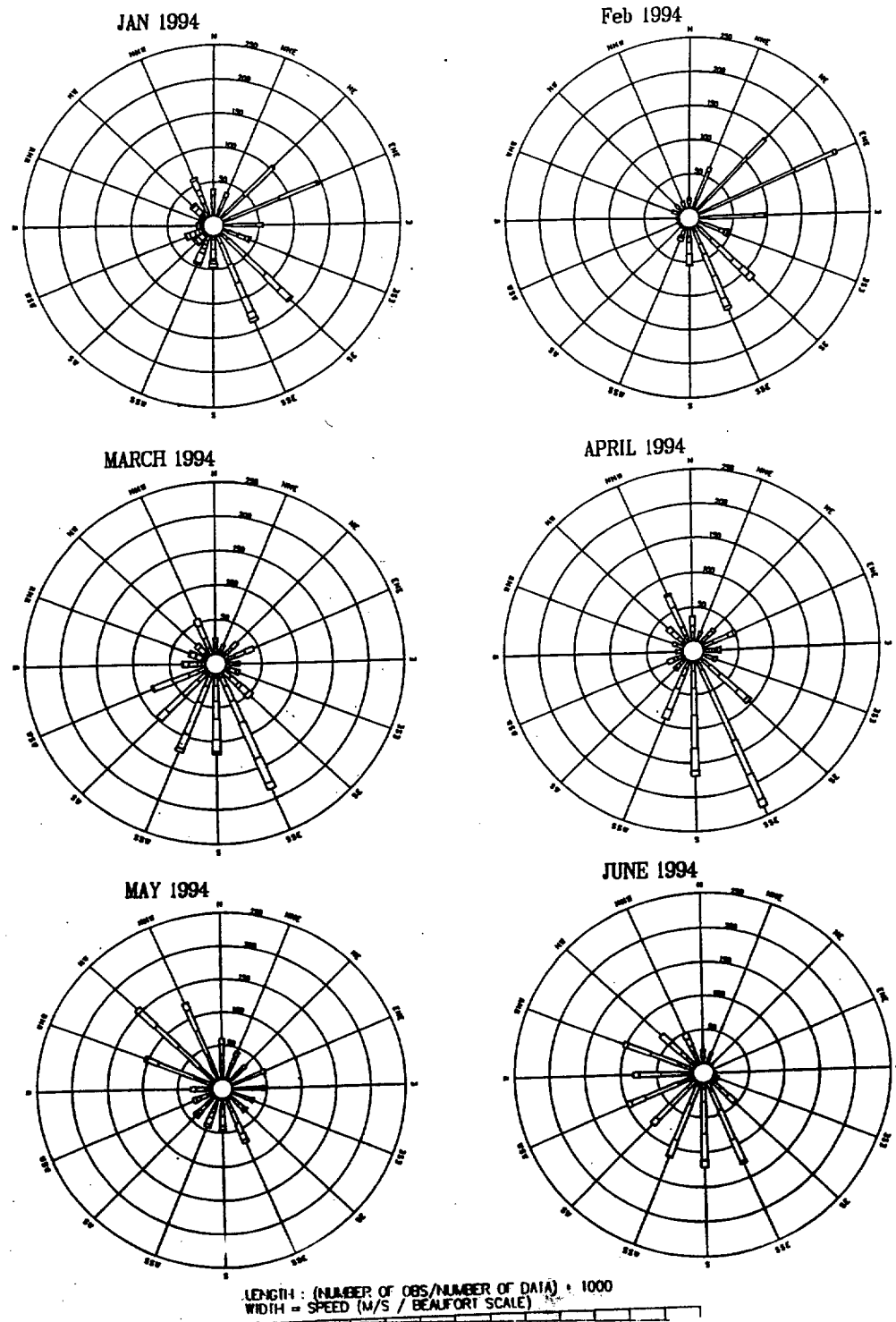


Figure 13 a Frequency of wind speed for the different directions (10 m level).

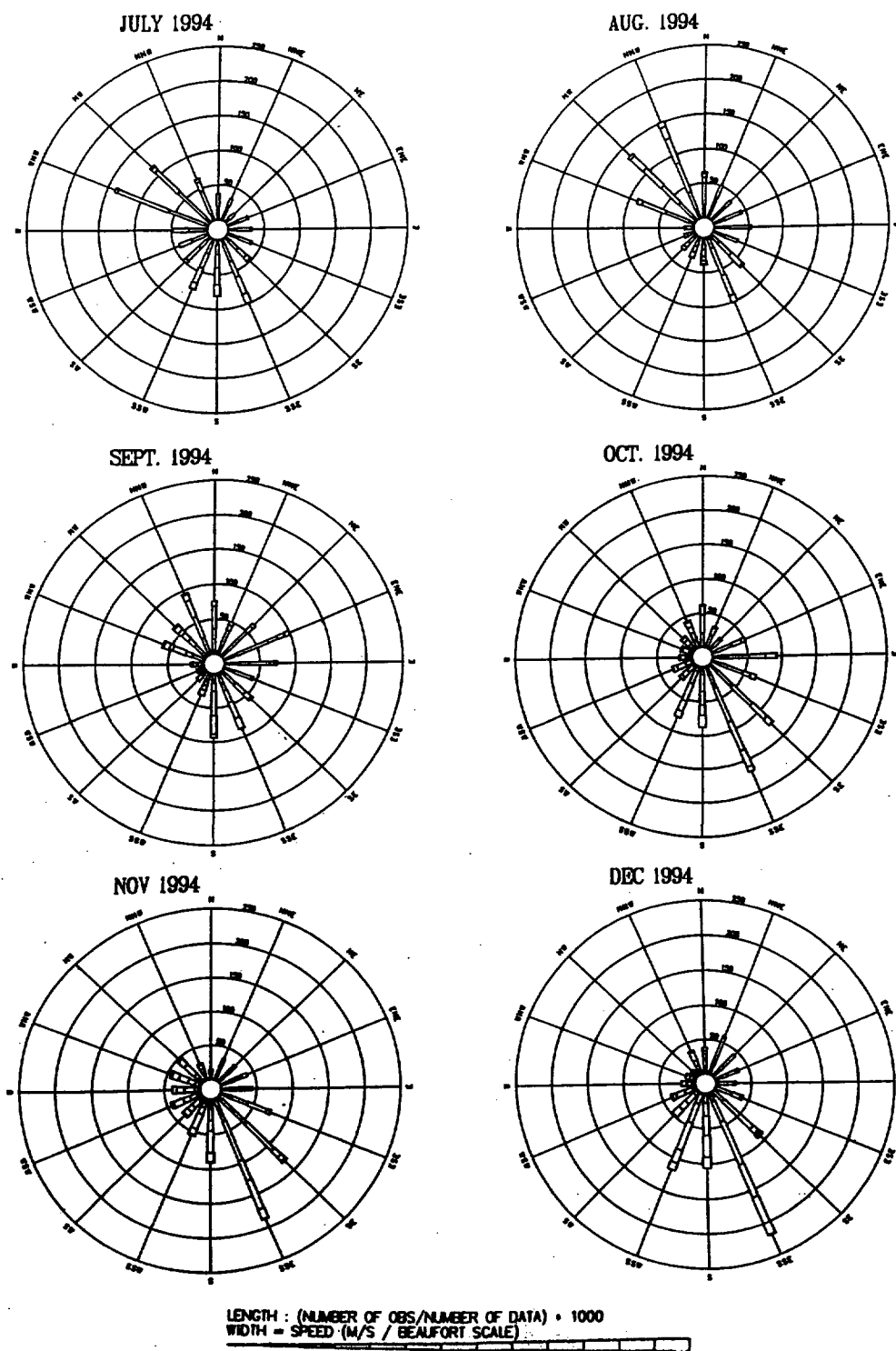


Figure 13 b Frequency of wind speed for the different directions (10 level).

3.5 Discussion of results

Flesland Flyplass is the nearest observing station with a long record of air temperature. In table 3 a summary of the observations in 1994 and for the complete series covering the period November 1955 - December 1994 is given. Compared to the normal values, the monthly means of 1994 for February, June and October show marked negative deviations. The months of March and May are slightly below the normals while all the others have monthly means above the normals.

The observed minimum values are for all months with exceptions for May and June far from the monthly minimum for the complete data series. Regarding the maximum values, the ones for August and November are close to the long time for these months. The monthly absolute maximum temperatures observed at Hanøytangen (Table 2) in 1994 are corresponding very well with the measurements at Flesland Flyplass. As could be expected, the minimum temperatures are generally higher at Hanøytangen, located closer to open water.

Bergen - Florida is the nearest observing station with precipitation measurements. A summary of the measurements are also given in table 3. Compared to the monthly normal value, February 1994 was exceptionally dry with a sum of only 9 mm. The period July - November was also well below the normal while June 1994 got 305 mm which is a new record for June at this station. The precipitation will on an average be lower at Hanøytangen, however, the relations to "normals" at Hanøytangen will probably show the same.

Table 3

Observation Period :												
From : 01/01/94												
To : 31/12/94												
Coverage : 100 %												
FLESLAND FLYPLASS 1994												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Air Temperature												
Min	6.1	-9.8	-7.4	-0.1	-1	2.3	7.1	6.2	1.1	-2.1	-0.8	-3.5
Mean	1.3	-1.4	2.2	5.4	8.9	9.8	15.7	15.1	10.8	6.3	6.1	3.8
Max	8	5.4	10.5	14.2	21.7	19.5	26.7	28.8	20.8	14.3	14.3	10.6
Normal	0.8	0.7	2.3	4.8	9.3	12.1	13.3	13.3	10.6	8	3.9	1.8
Deviation	0.5	-2.1	-0.1	0.6	-0.4	-2.3	1.6	0.8	0.2	-1.3	2.1	2
Flesland 1955.11-1994.12												
Air Temperature												
Abs. Min	-19.4	-13.3	-11.3	-7.7	-2.5	0.7	3	2.8	-1	-6	-13.1	-15.6
Abs. Max	13.8	11.6	16.2	21.6	25	29	29.5	29.5	25	20.4	15.3	14
BERGEN - FLORIDA 1994												
Precipitation												
Sum	206	9	336	233	102	305	116	127	180	77	195	427
Normal	190	152	170	114	106	132	148	190	283	271	239	235
% of Normal	151	10	196	222	96	231	78	67	64	48	75	182
Bergen - Florida 1983 - 1994												
Min. sum	79	5	52	17	35	25	56	117	63	113	62	195
Max. sum	478	334	432	295	198	303	206	352	478	586	474	433

4. Computation of 10/100 year estimates of wind speed

4.1 10/100 year estimates of the wind speed based on the 10 m level of the mast

In report No. 23/90 KLIMA the method used by Harstveit to link the short series at Storebuneset to the longer series at Hellisøy fyr with the purpose of estimating 100 year values for the location with the shorter series, is described in detail. In the report No 43/92 KLIMA the transfer coefficients between Hellisøy and Storebuneset were used to make estimates for wind speed with 10 and 100 year return periods.

For the assessment of the estimates the same intervals for the wind directions at Hellisøy have been used as discriminant function for the data in the parallel series Hellisøy-Hanøytangen. As mentioned in the introduction, the wind instruments were out of function until 3.2.1994. The assessment is therefore based on the period 3.2-31.12.94 with some small gaps due to missing data at Hanøytangen (June).

In table 4 the situations with the highest wind speed with direction in the interval 030°-129.9° and corresponding values at Hanøytangen are presented. To be picked out there must exist data on both locations.

Table 4 Situations picked out to determine the transfer coefficients between Hellisøy and Hanøytangen for wind speed when wind direction is in the sector 030°-129.9° at Hellisøy.

SECTOR 030-129.9 AT HELLISØY												
DATE	FFhe	DDhe	FXhe	FGhe	FF10ha	DD10ha	FX10ha	FG10ha	FF18ha	FX18ha	FG18ha	
1994/02/09/06	14.2	124	18.1	21.1	11.3	142	11.3	15.6	11.4	11.4	15.6	
1994/03/02/13	14	129	14.3	16.2	5.9	125	6.6	9.1	6	6.7	9.4	
1994/03/13/06	13.8	124	14.4	16.9	10.3	128	11	14.7	10.2	11	15	
1994/07/25/07	10	102	10.1	12	5.3	86	5.3	6.4	4.7	4.7	5.8	
1994/04/09/07	10.4	93	10.9	14	8.3	83	8.3	12.3	8.2	8.2	11.4	
1994/05/04/15	10.1	124	10.3	12.4	8.2	86	8.6	10.3	8.5	8.5	10.3	
1994/02/07/09	9.6	125	9.6	11.7	3.5	78	4.2	6.1	3.6	4.1	5.5	
1994/06/18/06	9.7	127	9.8	11.5	6.7	130	6.9	8.8	6.5	6.7	8.5	
1994/08/26/06	9.6	125	9.7	11	7	141	7.3	9.1	6.9	7.2	9.1	
1994/09/30/11	8.7	44	8.7	11.9	7.8	62	7.9	12.3	8.5	9.1	12.9	
1994/10/31/08	11.5	103	12	15.1	8.7	80	9.9	13.2	8.1	9.4	13.5	
1994/10/25/21	9.5	125	9.9	10.8	6.9	129	8.2	11.4	6.7	8.1	11.4	
1994/10/19/01	9.3	129	9.3	10.3	4	147	4	5.5	3.6	3.8	5.5	
1994/10/23/20	9.3	111	10.7	12.6	6.9	114	8.6	13.5	6.6	8.5	13.2	
1994/12/08/14	19.4	122	19.4	24	15.5	179	17	23.7	15.5	17	23.4	
1994/12/29/01	11.6	129	12.5	14.8	5.9	132	6	8.2	5.3	5.5	7.9	
1994/11/12/23	10.4	129	11	12.1	2	117	3.5	4.9	2	3.6	5.2	
1994/12/28/19	9.7	125	10.2	11.6	6	105	6.9	9.1	5.9	6.7	8.5	
1994/11/11/11	9.5	110	10.9	12.5	6.1	86	6.7	8.8	5.7	6.3	9.1	
SUMMER	210.3	2200	221.8	262.5	136.3	2130	148.2	203	133.9	146.5	201.2	
FF10HA/FFhe	0.648122											
FG10HA/FFhe	0.963288											

In table 4 the heading of the columns have the following meaning :

- FFhe : 10 min mean wind speed at the observing hour (Hellisøy).
- DDhe : 10 min mean wind direction at the obs. hour (Hellisøy).
- FXhe : Max 10 min mean wind speed since last obs. hour (Hellisøy).
- FGhe : Max 3 sec mean wind speed (gust) since last obs. hour (hellisøy).
- FF10ha : 10 min mean wind speed (10 m level) at the obs. hour (Hanøytangen).
- DD10ha : 10 min mean wind direction (10 m level) at the obs. hour (Hanøytangen).
- FX10ha : Max 10 min mean wind speed (10 m level) since last obs. hour (Hanøytangen).
- FG10ha : Max 3 sec mean wind speed (gust, 10 m) since last obs. hour (Hanøytangen)
- FF18ha : 10 min mean wind speed (18 m level) ...
- FX18ha : Max 10 min mean wind speed (18 m level) ...
- FG18ha : Max 3 sec mean wind speed (18 m level) ...

Table 4 contains simultaneous values for Hellisøy and Hanøytangen. To compute the transfer coefficients, the columns in the tables involved in the computations are sorted individually. The result is given in table 5 where the 10 highest values are the basis for the computations. The same procedure is applied for the other wind direction intervals.

Table 5

SECTOR 030-129.9 AT HELLISØY												
DATE	FFhe	DDhe	FXhe	FGhe	FF10ha	DD10ha	FX10ha	FG10ha	FF18ha	FX18ha	FG18ha	
1994/02/09/06	19.4	124	18.1	21.1	15.5	142	11.3	23.7	11.4	11.4	15.6	
1994/03/02/13	14.2	129	14.3	16.2	11.3	125	6.6	15.6	6	6.7	9.4	
1994/03/13/06	14	124	14.4	16.9	10.3	128	11	14.7	10.2	11	15	
1994/07/25/07	13.8	102	10.1	12	8.7	86	5.3	13.5	4.7	4.7	5.8	
1994/04/09/07	11.6	93	10.9	14	8.3	83	8.3	13.2	8.2	8.2	11.4	
1994/05/04/15	11.5	124	10.3	12.4	8.2	86	8.6	12.3	8.5	8.5	10.3	
1994/02/07/09	10.4	125	9.6	11.7	7.8	78	4.2	12.3	3.6	4.1	5.5	
1994/06/18/06	10.4	127	9.8	11.5	7	130	6.9	11.4	6.5	6.7	8.5	
1994/08/26/06	10.1	125	9.7	11	6.9	141	7.3	10.3	6.9	7.2	9.1	
1994/09/30/11	10	44	8.7	11.9	6.9	62	7.9	9.1	8.5	9.1	12.9	
1994/10/31/08	9.7	103	12	15.1	6.7	80	9.9	9.1	8.1	9.4	13.5	
1994/10/25/21	9.7	125	9.9	10.8	6.1	129	8.2	9.1	6.7	8.1	11.4	
1994/10/19/01	9.6	129	9.3	10.3	6	147	4	8.8	3.6	3.8	5.5	
1994/10/23/20	9.6	111	10.7	12.6	5.9	114	8.6	8.8	6.6	8.5	13.2	
1994/12/08/14	9.5	122	19.4	24	5.9	179	17	8.2	15.5	17	23.4	
1994/12/29/01	9.5	129	12.5	14.8	5.3	132	6	6.4	5.3	5.5	7.9	
1994/11/12/23	9.3	129	11	12.1	4	117	3.5	6.1	2	3.6	5.2	
1994/12/28/19	9.3	125	10.2	11.6	3.5	105	6.9	5.5	5.9	6.7	8.5	
1994/11/11/11	8.7	110	10.9	12.5	2	86	6.7	4.9	5.7	6.3	9.1	
SUMMER	125.4	1117	115.9	138.7	90.9	1061	77.4	136.1	74.5	77.6	103.5	
FF10HA/FFhe	0.72488											
FG10HA/FFhe	1.085327											

The quotients are based on the 10 highest values when the respective columns are individually sorted

The resulting transfer coefficients are given in table 6. When compared to those determined by the parallel series between Hellisøy-Storebuneset, we find that the coefficients based on the measurements at Hanøytangen are higher for some of the wind direction intervals and lower for other. For the wind direction interval where the extreme wind most probably will occur, the transfer coefficients based on measurements at Hanøytangen is lower both for the 10 min mean and the 3 sec gust leading to lower estimates for 10/100 year extreme values than the preliminary values given in the report 43/92 Klima.

Table 6 Estimates of transfer coefficients based on data from Hellisøy (He) and Hanøytangen (Ha) for the period 3.2-31.12.1994.

V(Han.,10 min)/V(He.,10 min)						
V(Han.,3 sec.)/V(He.,10 min)						
030-129°	130-159°	160-199°	200-229°	230-299°	300-339°	340-029°
0.73	0.75	0.78	0.78	0.78	0.80	0.69
1.11	1.08	1.07	1.08	1.17	1.11	0.96

The estimates for the wind speed at Hellisøy given below and these new transfer coefficients are applied to compute the wind speed estimates for Hanøytangen.

Table 7 Estimates of extreme values for the 10 min mean of the wind speed (V_{10}) with return periods 10 and 100 years valid for Hellisøy Fyr.

DIRECTION	SUMMER		WINTER	
	May - August		September - April	
	$V_{10,10}$	$V_{10,100}$	$V_{10,10}$	$V_{10,100}$
030-060°	12.3	14.7	19.2	21.7
070-100°	13.0	15.5	16.6	18.8
110-120°	18.1	21.6	24.4	27.6
130-150°	20.6	24.6	28.3	32.0
160-190°	23.8	28.4	30.5	34.4
200-220°	23.8	28.4	30.5	34.4
230-290°	21.6	25.8	27.6	31.2
300-330°	21.1	25.2	28.6	32.3
340-020°	21.6	25.8	28.3	32.3

Table 8 Estimates of values for the 10 min mean wind speed (V_{10}) with return periods 10 and 100 years valid for Hanøytangen. The estimates are based on computations made for Hellisøy Fyr and the parallel series between Hellisøy Fyr and Hanøytangen for the period 3.2-31.12.1994.

	SUMMER		WINTER	
	May - August		September - April	
DIRECTION	$V_{10,10}$	$V_{10,100}$	$V_{10,10}$	$V_{10,100}$
030-060°	9.0	10.7	14.0	15.8
070-100°	9.5	11.3	12.1	13.7
110-120°	13.2	15.8	17.8	20.1
130-150°	15.5	18.5	20.7	23.4
160-190°	18.6	22.2	23.8	26.8
200-220°	18.6	22.2	23.8	26.8
230-290°	16.8	19.9	21.5	24.3
300-330°	16.9	20.2	22.9	25.8
340-020°	14.9	17.8	19.5	22.3

Table 9 Estimates of values for the 3 sec. gust wind speed (V_g) with return periods 10 and 100 years valid for Hanøytangen. The estimates are based on computations made for Hellisøy Fyr and the parallel series between Hellisøy Fyr and Hanøytangen for the period 3.2-31.12.1994.

	SUMMER		WINTER	
	May - August		September - April	
DIRECTION	$V_{g,10}$	$V_{g,100}$	$V_{g,10}$	$V_{g,100}$
030-060°	13.7	16.3	21.3	24.1
070-100°	14.4	17.2	18.4	20.9
110-120°	20.1	24.0	27.1	30.6
130-150°	22.2	26.6	30.6	34.6
160-190°	25.5	30.4	32.6	36.8
200-220°	25.7	30.7	32.9	37.2
230-290°	25.3	30.2	32.3	36.5
300-330°	23.4	28.0	31.7	35.9
340-020°	20.7	24.8	27.2	31.0

4.2 10/100 year estimates of the wind speed 10 m above mean sea level.

The estimates for the 10 m level here and in the previous monthly reports is the 10 m level of the mast which is ca. 25 m above mean sea level. In this annual synthesis report, the question of reduction may be studied by the measurements in the three different height levels. This has not been done in the monthly reports where only the transfer tables between the levels have been presented. However, from these tables it can be seen that accelerations in the 10 and 18 m levels are present in the measurements leading to values below 1 for the coefficients between the 30 m level and the other.

The transfer tables are giving a monthly summary. It is clear that during a month, all wind speed and directions may occur leading to a rather inhomogeneous data set for the determination of the transfer coefficients between the levels. To determine more accurate transfer coefficients applicable for strong wind with directional resolution, the data set is sorted in the same direction intervals as those used in 43/92 Klima. Cases with wind speed below certain limits are left out.

The transfer tables for the direction intervals 160°-199.9° and 200°-229.9° are evenly distributed around 1.000 for wind speed above 15 m/s and 12 m/s respectively, documenting accelerations of the measurements in the 10 m and 18 m levels for the wind directions which is critical for the dimensioning.

The mean wind profile in the lower level of the atmosphere depends very much on the turbulence of the air. It is therefore not possible to define a profile that is equally valid for all weather conditions. However, the most used profile of the mean wind speed can be represented by a power law of the type :

$$\frac{u_z}{u_{10}} = \left(\frac{z}{10}\right)^n$$

where u_z = the mean wind speed at height z in meter
 u_{10} = the mean wind speed at anemometer height 10 m a. ground
 n = factor most commonly varying between 0.11-0.13

Accelerations in the lower layer will destroy this wind profile. The topography will be the main reason for the accelerations. Over open sea it is assumed that the wind profile is undisturbed.

Assuming the measurements in the 30 m level (45 m above mean sea level) is undisturbed for the direction interval 160° - 229.9° , an implication will be that our measurements in the 10 m and 18 m levels in strong wind conditions represents the undisturbed 30 m level. This will also be valid for the 10/100 year estimates as well as they are based on

the situations with strongest wind.

Another implication of this result is reason to reduce the estimates from the 30 m level of the mast (45 m) to estimates valid for 10 m above mean sea level over assuming an undisturbed wind profile over the fjord. If $n=0.11$ is used the reduction factor will be of the order 1.20. This means that the estimates for the most critical directions can be divided by 1.20 when applied for the 10 min mean wind speed 10 m above the mean sea level where the condition of an undisturbed wind profile may be assumed.

5. References

- Harstveit,K.,1990 : Askøy Bro. Sluttrapport for vindmålinger på Storebuneset 23.10.87-30.4.90. DNMI rapport nr. 23/90 KLIMA.
- Iden,K. and Reistad,M.,1992 : Climatological Statistics for Hanøytangen at Askøy near Bergen. DNMI report no.43/92 KLIMA.
- Iden,K.,1994 : Hanøytangen, November 1993, report no.14/94 KLIMA
- Iden,K.,1994 : Hanøytangen, December 1993, report no.15/94 KLIMA
- Iden,K.,1994 : Hanøytangen, January 1994, report no.16/94 KLIMA
- Iden,K.,1994 : Hanøytangen, February 1994, report no. 17/94 KLIMA
- Iden,K.,1994 : Hanøytangen, March 1994, report no. 18/94 KLIMA
- Iden,K.,1994 : Hanøytangen, April 1994, report no. 22/94 KLIMA
- Iden,K.,1994 : Hanøytangen, May 1994, report no. 26/94 KLIMA
- Iden,K.,1994 : Hanøytangen, June 1994, report no. 29/94 KLIMA
- Iden,K.,1994 : Hanøytangen, July 1994, report no. 31/94 KLIMA
- Iden,K.,1994 : Hanøytangen, August 1994, report no. 36/94 KLIMA
- Iden,K.,1994 : Hanøytangen, September 1994, report no. 39/94 KLIMA
- Iden,K.,1994 : Hanøytangen, October 1994, report no.45/94 KLIMA
- Iden,K.,1995 : Hanøytangen, November 1994, report no.9/95 KLIMA

Appendix 1

BEAUFORT SCALE OF WIND

BEAUFORT NUMBER	DESCRIPTIVE TERM	MEAN VELOCITY IN KNOTS	MEAN VELOCITY IN m/s
0	Calm	< 1	0 - 0.2
1	Light air	1 - 3	0.3 - 1.5
2	Light breeze	4 - 6	1.6 - 3.3
3	Gentle breeze	7 - 10	3.4 - 5.4
4	Moder. breeze	11 - 16	5.5 - 7.9
5	Fresh breeze	17 - 21	8.0 - 10.7
6	Strong breeze	22 - 27	10.8 - 13.8
7	Near gale	28 - 33	13.9 - 17.1
8	Gale	34 - 40	17.2 - 20.7
9	Strong gale	41 - 47	20.8 - 24.4
10	Storm	48 - 55	24.5 - 28.4
11	Violent storm	56 - 63	28.5 - 32.6
12	Hurricane	64 and over	32.7 and over

Appendix 2

MONTHLY OCCURRENCE TABLES

Observation Period :									Location :
From :01/01/94			JANUARY 1994						Level : 10 m a.g.
To : 31/01/94									Coordinates:
Coverage : 77.4%			HANØYTANGEN						X = 71908
Number of data: 3454									Y = 47414
OCCURRENCE TABLE									
NUMBER OF WINDOWS FROM 6 TO 72 HOURS									
Wind Speed <= Beaufort		1	2	3	4	5	6	7	8
Duration									
6 H		0	19	43	64	74	85	92	95
12 H		0	4	18	31	35	41	44	47
18 H		0	2	9	18	22	26	29	31
24 H		0	1	6	13	16	18	21	23
48 H		0	0	2	6	7	8	9	11
72 H		0	0	0	3	4	5	6	7
Remarks : Based on maximum 10mn wind speed within the interval period, in any direction, at 10 metres level									

Observation Period :									Location :
From :01/02/94			FEBRUARY 1994						Level : 10 m a.g.
To : 28/02/94									Coordinates:
Coverage : 100.0%			HANØYTANGEN						X = 71908
Number of data: 4032									Y = 47414
OCCURRENCE TABLE									
NUMBER OF WINDOWS FROM 6 TO 72 HOURS									
Wind Speed <= Beaufort		1	2	3	4	5	6	7	8
Duration									
6 H		0	35	78	92	100	108	112	112
12 H		0	11	37	44	48	53	56	56
18 H		0	6	24	28	32	34	37	37
24 H		0	4	18	20	24	25	28	28
48 H		0	0	8	9	11	12	14	14
72 H		0	0	3	4	8	8	9	9
Remarks : Based on maximum 10mn wind speed within the interval period, in any direction, at 10 metres level									

PAC 004 WEATHER ANALYSIS IN HANØYTANGEN
 Annual Synthesis/Analysis 1994

Observation Period :									Location :
From :01/03/94			MARCH	1994					Level : 10 m a.gr.
To :31/03/94									Coordinates:
Coverage : 99.8%			HANØYTANGEN						X = 71908
Number of data: 4457									Y = 47414
OCCURRENCE TABLE									
NUMBER OF WINDOWS FROM 6 TO 72 HOURS									
Wind Speed <= Beaufort		1	2	3	4	5	6	7	8
Duration									
6 H		0	8	19	40	69	103	117	123
12 H		0	2	7	16	31	49	57	61
18 H		0	1	4	9	16	32	37	41
24 H		0	1	2	4	12	23	27	30
48 H		0	0	0	0	3	9	13	14
72 H		0	0	0	0	2	4	8	10
Remarks : Based on maximum 10mm wind speed within the interval period, in any direction, at 10 metres level									

Observation Period :									Location :
From :01/04/94			APRIL	1994					Level : 10 m a.gr.
To :30/04/94									Coordinates:
Coverage : 100.0%			HANØYTANGEN						X = 71908
Number of data: 4320									Y = 47414
OCCURRENCE TABLE									
NUMBER OF WINDOWS FROM 6 TO 72 HOURS									
Wind Speed <= Beaufort		1	2	3	4	5	6	7	8
Duration									
6 H		0	11	28	55	91	109	119	120
12 H		0	3	10	21	41	52	59	60
18 H		0	0	5	12	26	34	39	40
24 H		0	0	2	6	16	24	29	30
48 H		0	0	0	1	6	11	14	15
72 H		0	0	0	0	2	5	9	10
Remarks : Based on maximum 10mm wind speed within the interval period, in any direction, at 10 metres level									

PAC 004 WEATHER ANALYSIS IN HANØYTANGEN
Annual Synthesis/Analysis 1994

Observation Period :									Location :
From :01/05/94		MAY	1994						Level : 10 m a.g.
To :31/05/94									Coordinates:
Coverage : 99.9 %		HANØYTANGEN							X = 71908
Number of data: 4458									Y = 47414
OCCURRENCE TABLE									
NUMBER OF WINDOWS FROM 6 TO 72 HOURS									
Wind Speed <= Beaufort	1	2	3	4	5	6	7	8	
Duration									
6 H	2	28	63	95	113	123	123	123	
12 H	0	11	24	42	55	61	61	61	
18 H	0	0	14	24	36	40	41	41	
24 H	0	0	5	14	25	30	30	30	
48 H	0	0	0	6	11	14	15	15	
72 H	0	0	0	2	7	9	10	10	
Remarks : Based on maximum 10mm wind speed within the interval period, in any direction, at 10 metres level									

Observation Period :									Location :
From :01/06/94		JUNE	1994						Level : 10 m a.g.
To :30/06/94									Coordinates:
Coverage : 76.9%		HANØYTANGEN							X = 71908
Number of data: 3322									Y = 47414
OCCURRENCE TABLE									
NUMBER OF WINDOWS FROM 6 TO 72 HOURS									
Wind Speed <= Beaufort	1	2	3	4	5	6	7	8	
Duration									
6 H	0	6	28	54	85	92	92	92	
12 H	0	0	10	23	40	46	46	46	
18 H	0	0	3	11	26	30	30	30	
24 H	0	0	2	8	17	23	23	23	
48 H	0	0	0	2	8	11	11	11	
72 H	0	0	0	0	5	7	7	7	
Remarks : Based on maximum 10mm wind speed within the interval period, in any direction, at 10 metres level									

PAC 004 WEATHER ANALYSIS IN HANØYTANGEN
Annual Synthesis/Analysis 1994

Observation Period :									Location :
From :01/07/94									Level : 10 m a.gr.
To :31/07/94									Coordinates:
Coverage : 100.0%									X = 71908
Number of data: 4464									Y = 47414
OCCURRENCE TABLE									
NUMBER OF WINDOWS FROM 6 TO 72 HOURS									
Wind Speed <= Beaufort	1	2	3	4	5	6	7	8	
Duration									
6 H	0	28	83	107	120	123	124	124	
12 H	0	8	34	51	59	61	62	62	
18 H	0	1	20	33	39	41	41	41	
24 H	0	0	10	22	29	30	31	31	
48 H	0	0	1	10	13	14	15	15	
72 H	0	0	0	5	9	9	10	10	
Remarks : Based on maximum 10mn wind speed within the interval period, in any direction, at 10 metres level									

Observation Period :									Location :
From :01/08/94									Level : 10 m a.gr.
To :31/08/94									Coordinates:
Coverage : 99.8 %									X = 71908
Number of data: 4455									Y = 47414
OCCURRENCE TABLE									
NUMBER OF WINDOWS FROM 6 TO 72 HOURS									
Wind Speed <= Beaufort	1	2	3	4	5	6	7	8	
Duration									
6 H	2	34	69	98	117	121	123	123	
12 H	0	13	27	46	57	60	61	61	
18 H	0	1	15	27	38	40	41	41	
24 H	0	0	8	18	27	30	30	30	
48 H	0	0	2	6	13	15	15	15	
72 H	0	0	1	3	8	10	10	10	
Remarks : Based on maximum 10mn wind speed within the interval period, in any direction, at 10 metres level									

PAC 004 WEATHER ANALYSIS IN HANØYTANGEN
Annual Synthesis/Analysis 1994

Observation Period :										Location :
From :01/09/94										Level : 10 m a.gr.
To : 30/09/94										Coordinates:
Coverage : 100.0 %										X = 71908
Number of data: 4320										Y = 47414
OCCURRENCE TABLE										
NUMBER OF WINDOWS FROM 6 TO 72 HOURS										
Wind Speed <= Beaufort	1	2	3	4	5	6	7	8		
Duration										
6 H	0	32	64	91	109	116	120	120		
12 H	0	11	28	41	52	57	60	60		
18 H	0	3	16	27	33	37	40	40		
24 H	0	1	11	18	24	28	30	30		
48 H	0	0	2	7	10	13	15	15		
72 H	0	0	1	2	5	8	10	10		
Remarks : Based on maximum 10mm wind speed within the interval period, in any direction, at 10 metres level										

Observation Period :										Location :
From :01/10/94										Level : 10 m a.gr.
To : 31/10/94										Coordinates:
Coverage : 100.0 %										X = 71908
Number of data: 4464										Y = 47414
OCCURRENCE TABLE										
NUMBER OF WINDOWS FROM 6 TO 72 HOURS										
Wind Speed <= Beaufort	1	2	3	4	5	6	7	8		
Duration										
6 H	0	22	51	92	111	124	124	124		
12 H	0	8	19	43	54	62	62	62		
18 H	0	3	12	25	35	41	41	41		
24 H	0	2	8	20	26	31	31	31		
48 H	0	1	3	8	11	15	15	15		
72 H	0	0	1	3	7	10	10	10		
Remarks : Based on maximum 10mm wind speed within the interval period, in any direction, at 10 metres level										

PAC 004 WEATHER ANALYSIS IN HANØYTANGEN
Annual Synthesis/Analysis 1994

Observation Period :										Location :
From :01/11/94										Level : 10 m a.gr.
To :30/11/94										Coordinates:
Coverage : 100.0 %										X = 71908
Number of data: 4318										Y = 47414
OCCURRENCE TABLE										
NUMBER OF WINDOWS FROM 6 TO 72 HOURS										
Wind Speed <= Beaufort	1	2	3	4	5	6	7	8		
Duration										
6 H	1	21	52	75	97	115	118	119		
12 H	0	7	23	36	45	56	59	59		
18 H	0	3	11	23	28	37	39	39		
24 H	0	3	9	16	20	27	28	29		
48 H	0	1	3	6	9	13	14	14		
72 H	0	0	1	4	5	8	8	9		
Remarks : Based on maximum 10mm wind speed within the interval period, in any direction, at 10 metres level										

Observation Period :										Location :
From :01/12/94										Level : 10 m a.gr.
To :31/12/94										Coordinates:
Coverage : 98.6 %										X = 71908
Number of data: 4403										Y = 47414
OCCURRENCE TABLE										
NUMBER OF WINDOWS FROM 6 TO 72 HOURS										
Wind Speed <= Beaufort	1	2	3	4	5	6	7	8		
Duration										
6 H	0	14	34	61	83	104	121	119		
12 H	0	3	13	26	38	48	60	59		
18 H	0	1	8	14	20	30	40	39		
24 H	0	0	4	11	15	21	30	29		
48 H	0	0	1	3	6	7	14	14		
72 H	0	0	0	1	1	3	9	9		
Remarks : Based on maximum 10mm wind speed within the interval period, in any direction, at 10 metres level										

PAC 004 WEATHER ANALYSIS IN HANØYTANGEN
Annual Synthesis/Analysis 1994

The occurrence table for December 1993 is given in the report for this month. To make the access to these data more easy the table is added here.

Observation Period :										Location :
From :01/12/93			DECEMBER 1993							Level : 10 m a.g.
To : 31/12/93										Coordinates:
Coverage : 100.0%			HANØYTANGEN							X = 71908
Number of data: 4464										Y = 47414
OCCURRENCE TABLE										
NUMBER OF WINDOWS FROM 6 TO 72 HOURS										
Wind Speed <= Beaufort		1	2	3	4	5	6	7	8	
Duration										
6 H		0	15	39	58	90	106	119	124	
12 H		0	4	15	27	41	51	58	62	
18 H		0	3	10	16	24	32	39	41	
24 H		0	1	5	12	18	23	28	31	
48 H		0	0	1	3	7	10	13	15	
72 H		0	0	0	2	4	6	9	10	
Remarks : Based on maximum 10mm wind speed within the interval period, in any direction, at 10 metres level										

PAC 004 WEATHER ANALYSIS IN HANØYTANGEN
Annual Synthesis/Analysis 1994