Additional Wind and Stability Observations at Sómastaðagerði in Reyðarfjörður

Contents

1. Introduction

In a letter, dated 27 December 1999, STAR (Staðarvalsnefnd iðnaðarsvæða á Reyðarfirði) has asked Veðurstofa Íslands to provide, as far as possible, further meteorological information of importance in connection with the operation of the proposed aluminium plant at Hraun in Reyðarfjörður. The new information was requested, if possible, by the middle of January 2000 and was to be based on already existing observations.

The present report contains results of meteorological observations carried out at Sómastaðagerði during the period May to October 1999. They are presented in a similar way as was done for the period May 1998-April 1999 in a recent Report of Veðurstofa Íslands: Wind and Stability Observations at Sómastaðagerði in Reyðarfjörður, VÍ-G99018-TA04.

In particular Veðurstofa Íslands has been asked to address the representativity of the observations made at Sómastaðagerði during the 12 month period May 1998-April 1999 that were used as basis for model calculations of pollution dispersion from the aluminium smelter by The Norwegian Institute for Air Research, NILU. Of importance in this connection are the new stability data now available for the period May-October 1999. For further addressing this question, the wind observations at Kollaleira during the years 1983-1997 and the simultaneous wind observations at Sómastaðagerði and Kollaleira during the one year period May 1998-April 1999 have been used in an attempt to estimate the wind conditions at Sómastaðagerði for each of the 15 years 1983-1997. Results of wind observations at Kollaleira have earlier been presented by Veðurstofa Íslands in the Report: Vindmælingar að Kollaleiru 1983-1998, VÍ-G99009-TA02.

2. Observation Sites and Instrumentation

Since late April 1998 a 38 m high observation mast has been located at Sómastaðagerði on a low gravel platform (65° 02.0’ N, 14° 06.7’ W), elevation of the platform 32 m above mean sea level. The instruments used at Sómastaðagerði have been the same from the beginning of the observations. Platinum resistance thermometers Logan 100PRT have been used for air temperature observations at 3.0, 10.5 and 36.5 m above the platform. For protection from radiation and precipitation 6-plate Gill radiation shields have been used. For observations of wind direction and wind velocity a Wind Monitor-MA 05106, Marine Model, from R.M. Young has been used at 10.3 m height. Two Gill UVW anemometers are also installed at 10.8 m and 36.6 m and a Vaisala temperature and relative humidity sensor HMP-35D at 3.0 m, but these data are not used in this report. A Measurement and Control Module CR10X from Campbell Scientific, Inc. has been used for collecting the observation data. The observation mast is shown in Fig.1 and the instruments at the 10 m level in Fig. 2.

A recalibration of the temperature sensors in July 1999 indicated that the measurements at 3.0 m height were underestimating temperature by 0.1° C. Due to the small size of this correction and the uncertainty of the period when the temperature should be corrected, the data are used without corrections in this report.

Fig. 1. The anemometer mast at Sómastaðagerði.
Photo: Flosi Hrafn Sigurðsson, 1999.

Fig. 2. Anemometers and thermometer at 10.3 - 10.8 m above the ground at Sómastaðagerði.
Fhoto: Flosi Hrafn Sigurðsson, 1999.

Fig. 3. The anemometer at Kollaleira.
Photo: Elvar Ástráðsson, 1997.

Fig. 4. Mjóifjörður filled with fog in the morning of 29 July 1999.
Photo: Flosi Hrafn Sigurðsson, 1999.

At the weather station Kollaleira (65° 02’ N, 14° 14’ W) a Woelfle Lambrecht 1482 Mechanical Wind Recorder was installed in late 1982 at 2.0 m above the ground some 120 m NE of the station (the older weather station). Wind direction and wind way are recorded and the records have been used to determine hourly values of wind direction and wind velocity for the years 1983-1999. The wind recorder at Kollaleira is shown in Fig. 3.

A map of Reyðarfjörður and adjacent areas is shown in Fig. 5. Several current observation and proposed observation stations mentioned in this report are indicated on the map.

3. Wind Observations at Sómastaðagerði, May-October 1999

The frequency (in %) of wind directions at 10.3 m above the ground at Sómastaðagerði is presented for each of the months May-October 1999 in Table 2 and as wind roses in Annexes 1-6. For comparison the corresponding frequency in the months May-October 1998 are also shown in Table 2 . For the high summer, June-August 1999, the mean frequency and mean wind velocity for each wind direction is shown in Annex 7, and in Annex 8 this is shown for the night hours 00-06 GMT and in Annex 9 for the day hours 12-18 GMT.

The average wind velocity for each wind direction during the months May-October 1999 is presented in the histograms on the lower part of the Annexes 1-6. The average wind velocity for each of the months May-October 1999 is also presented in Table 1 as well as corresponding values for the months May-October 1998.

Table 1. Average wind velocity at Sómastaðagerði,
May-October, 1999 and 1998, m/s.

May		June		July		August		September		October	
1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998
3.7	3.6	4.0	3.6	3.8	4.4	2.6	3.7	3.7	3.9	4.3	6.3

In particular we point out the low mean wind velocity during August 1999. The monthly mean was only 2.6 m/s. Examples of especially calm days are 2 August and 20 August with mean wind velocities of only 1.15 m/s and 1.22 m/s, respectively. On 2 August easterly winds were most common through the day, two thirds of the time the wind was blowing from between northeast and southeast. During several short intervals the wind was, however, blowing from between south and west. The wind speed was between 0 and 3 m/s. On 20 August the winds were mainly westerly during the night and evening, but easterly during the day. Most of the time the wind speed was below 2 m/s, but between 12 and 15 GMT the easterly winds reached between 3 and 4 m/s.

On 2 August 1999 the edge of a high pressure area was located over Eastern Iceland. At the mast in Sómastaðagerði the stability class was neutral but somewhat higher up there was a marked temperature inversion as shown in Fig. 11.

Table 2. Frequency of wind directions at Sómastaðagerði,
May - October 1999 and 1998, %

		May		June		July		August		September		October	
	Dir.	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998
N	360	0.8	1.5	0.8	1.1	0.8	0.9	1.6	1.1	1.5	2.8	2.6	1.1
	10	0.8	1.1	1.3	1.3	0.7	0.8	1.3	1.0	1.3	1.2	1.5	0.7
	20	0.9	1.0	1.0	1.4	0.8	0.7	1.1	0.9	1.2	0.9	1.3	0.4
	30	1.2	1.0	1.3	1.3	1.1	0.9	1.7	1.3	1.6	1.6	1.6	1.0
	40	1.7	1.6	1.6	2.5	1.4	1.3	2.3	1.7	1.8	2.4	2.3	1.1
	50	2.9	3.0	2.4	3.9	2.1	2.6	4.1	3.1	4.0	3.9	3.5	2.2
	60	6.0	6.5	4.9	5.6	4.0	5.9	7.1	9.3	5.7	5.2	5.0	2.5
	70	9.2	9.9	8.9	8.2	8.6	9.0	9.9	19.0	8.3	6.6	6.4	2.1
	80	10.3	10.3	13.4	13.2	12.0	11.9	13.1	12.7	8.7	5.6	4.1	2.3
E	90	8.7	8.8	10.4	8.8	9.6	8.1	9.6	6.9	7.2	4.2	4.0	1.7
	100	6.5	4.8	5.7	4.2	6.4	3.9	6.0	2.8	5.2	3.5	2.1	1.5
	110	4.1	2.3	3.8	3.0	3.1	1.8	3.2	1.7	3.4	3.7	1.8	1.7
	120	2.3	2.0	3.7	2.9	2.8	1.3	2.9	1.0	3.4	4.1	1.0	1.6
	130	1.6	2.0	1.0	2.0	1.5	0.6	1.7	0.7	1.2	1.7	0.9	1.2
	140	0.9	1.0	0.6	1.2	1.0	0.6	1.1	0.3	1.0	0.4	0.4	0.5
	150	0.7	1.0	0.7	0.5	0.6	0.4	0.6	0.3	0.9	0.3	0.4	0.5
	160	0.9	0.6	0.6	0.1	0.5	0.2	0.5	0.4	0.8	0.3	0.3	0.5
	170	0.5	0.7	0.8	0.2	0.4	0.3	0.4	0.2	0.6	0.3	0.3	0.3
S	180	0.6	0.7	0.6	0.3	0.3	0.3	0.4	0.3	1.1	0.3	0.5	0.6
	190	0.7	0.9	0.4	0.1	0.4	0.2	0.4	0.3	1.1	0.4	0.4	0.7
	200	0.7	1.5	0.9	0.3	0.3	0.4	0.6	0.4	1.1	0.7	0.7	0.6
	210	0.6	1.2	0.9	0.6	0.5	0.3	0.6	0.4	0.7	0.7	0.9	0.5
	220	1.4	1.9	1.1	1.3	0.7	0.5	0.9	0.8	1.2	0.9	1.1	0.4
	230	2.4	2.1	1.9	2.0	1.4	1.4	1.7	1.0	1.8	1.7	1.5	1.6
	240	3.0	3.2	3.4	2.6	2.3	3.8	3.0	2.8	2.6	4.1	3.5	2.8
	250	4.1	3.8	4.7	3.9	4.2	5.4	3.4	3.4	4.1	7.5	5.6	5.1
	260	5.1	4.7	4.5	7.1	6.0	6.2	2.7	3.5	5.0	7.0	8.5	8.8
W	270	4.9	3.8	4.4	5.2	5.7	5.7	2.8	4.5	6.0	5.3	8.5	11.3
	280	3.6	3.9	3.9	4.6	5.7	6.5	3.0	4.8	3.3	4.1	8.5	15.3
	290	3.2	2.6	3.1	2.4	4.9	6.6	3.1	3.8	2.8	3.1	6.4	14.2
	300	1.7	1.8	2.2	1.2	3.5	2.5	1.8	1.6	2.8	3.0	3.9	5.7
	310	1.9	1.7	1.4	1.3	1.8	1.8	1.3	1.3	2.0	3.1	2.4	3.2
	320	1.1	1.1	1.2	0.8	1.3	1.4	1.0	1.0	1.2	3.2	1.9	1.8
	330	1.4	1.5	0.9	1.0	0.7	0.9	0.9	0.6	1.3	1.9	1.9	1.3
	340	1.7	1.5	0.6	1.0	0.6	1.0	0.9	0.7	1.1	1.4	2.0	0.9
	350	1.0	1.3	0.7	1.0	0.8	0.8	1.0	0.8	1.5	2.0	1.6	1.3
Calm		0.8	1.8	0.4	2.0	1.6	3.2	2.2	3.7	1.6	0.9	0.9	0.9

4. Temperature and Stability Observations at Sómastaðagerði, May-October 1999

Mean monthly air temperature at 3.0 m, 10.5 m and 36.5 m above the ground is presented in Table 3 for the months May-October 1999 and 1998. For comparison the mean temperature at 2.0 m above the ground at Kollaleira is also presented.

Table 3. Mean monthly air temperature at 3.0 m, 10.5 m and 36.5 m heights, Sómastaðagerði, May- October 1999 and 1998, °C.

	May		June		July		August		September		October	
	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998
$\mathbf{T_{3.0}}$	5.12	5.74	8.44	6.11	10.17	8.26	9.86	8.95	7.83	6.68	5.13	2.64
$\mathbf{T_{10.5}}$	5.29	5.71	8.54	6.00	10.21	8.23	10.00	9.07	8.06	6.93	5.52	2.93
$\mathbf{T_{36.5}}$	5.18	5.61	8.45	5.79	10.10	8.16	9.98	9.04	8.02	6.96	5.62	2.93
$\mathbf{Kollaleira_{2.0}}$	5.7	6.5	9.3	6.8	10.9	8.6	10.5	9.8	8.1	6.7	5.0	2.4

The summer months June-September were unusually warm in 1999.

The temperature difference between 36.5 m and 3.0 m on the one hand and 36.5 m and 10.5 m on the other hand are presented for the months May-October 1999 in Annexes 10-15. The data for the first day of the month start where 1 is marked on the x-axis of the diagrams, the data for the second day where 2 is marked etc.

The mean diurnal variation of the temperature difference between the observation levels is shown in Annexes 16-18 for each of the months May-October 1999.

On the whole the stability situation during May-October 1999 seems similar to what was earlier found for May-October 1998.

5. Estimated Distribution of Wind Directions for Sómastaðagerði, 1983-1997

Simultaneous wind observations at Kollaleira and Sómastaðagerði during the 12 month period May 1998-April 1999 have together with wind observations at Kollaleira for each of the years 1983-1997 been used to simulate the distribution of wind directions at Sómastaðagerði for each of these years as well as for the periods April-September and October-March of each year. The results may be considered an educated guess or estimate. Based on this we have estimated the average distribution of wind directions at Sómastaðagerði for the 15 years 1983-1997, presented in Fig. 6 together with the values for the period May 1998-April 1999. In the same way, data for the months October-March are presented in Fig. 7 and for the months April-September in Fig. 8.

For the new observation period May-October 1999 the distribution of wind directions at Sómastaðagerði is presented in Fig. 9 and compared with the distribution during the same months 1998.

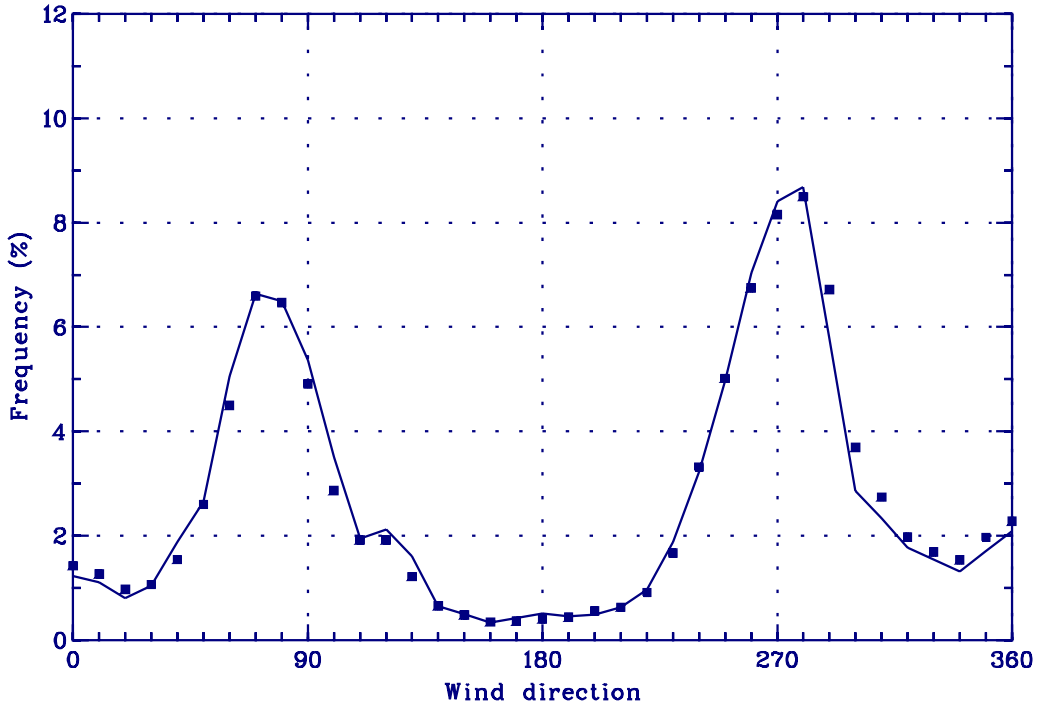


Fig. 6. Simulated average whole year distribution of wind directions at Sómastaðagerði for the 15 years 1983-1997 (curve), compared to the observed distribution at Sómastaðagerði for the single year May 1998 - April 1999 (squares).

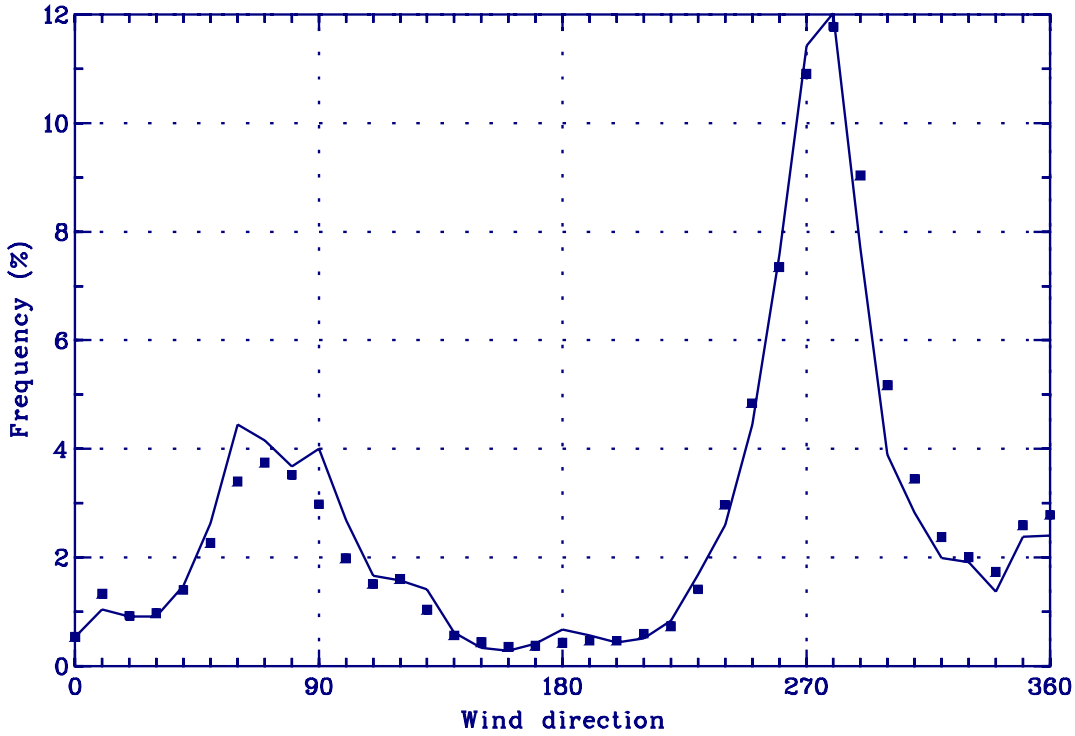


Fig. 7. Simulated average distribution of wind directions at Sómastaðagerði for the autumn and winter months (October - March) of the 15 years 1983-1997 (curve), compared to observed distribution at Sómastaðagerði for October 1998 - March 1999 (squares).

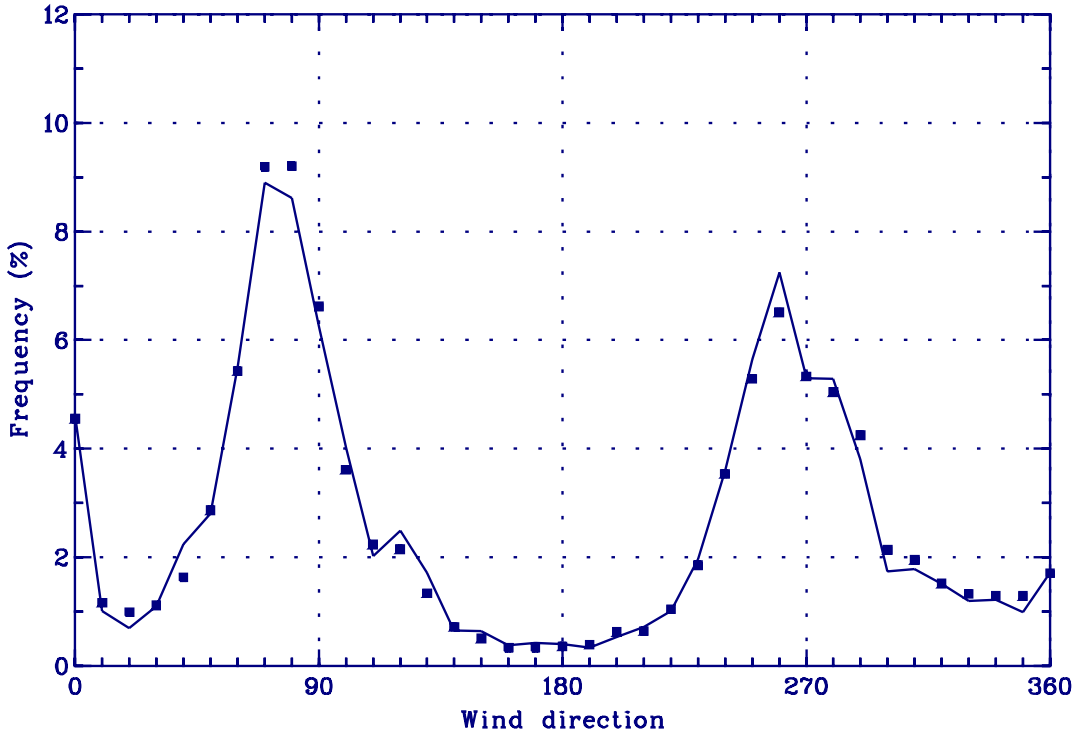


Fig. 8. Simulated average distribution of wind directions at Sómastaðagerði for the spring and summer months (April - September) of the 15 years 1983-1997 (curve), compared to the observed distribution at Sómastaðagerði for May 1998 - September 1998, and April 1999 (squares).

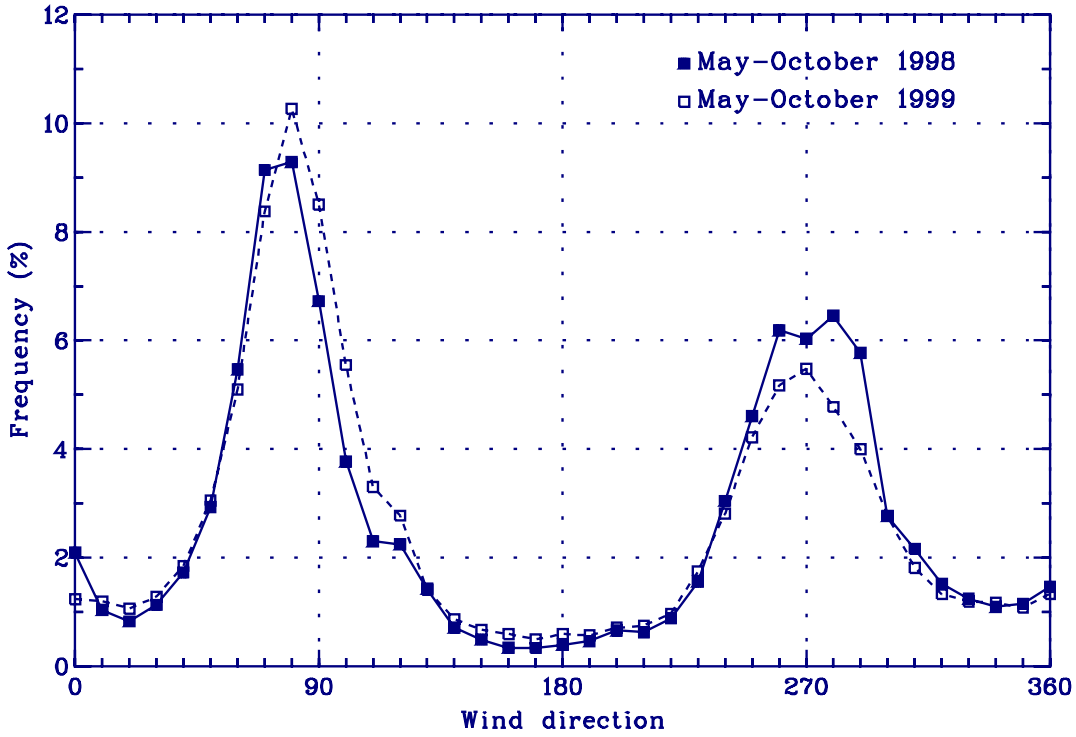


Fig. 9. Observed distribution of wind directions at Sómastaðagerði for May - October 1998 and 1999.

To emphasize the year to year variation of wind directions Fig. 10 presents the variability for Kollaleira in the years 1983-1997 and compares it to the 12-month period May 1998-April 1999.

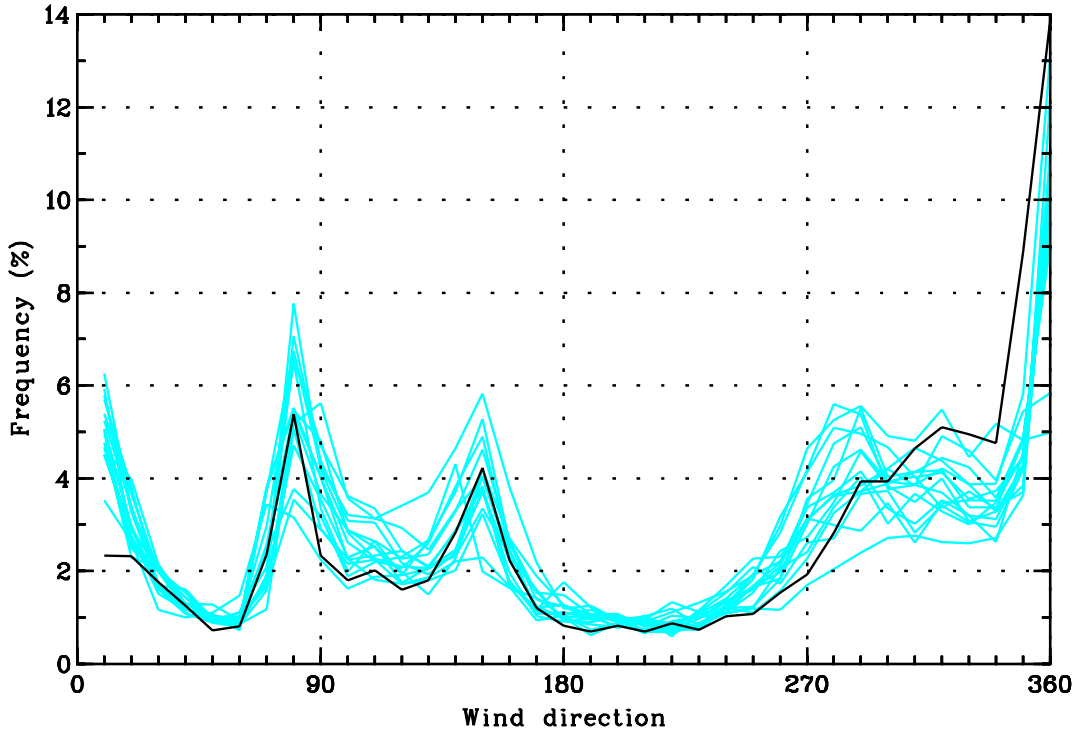


Fig. 10. Distribution of wind directions at Kollaleira for the 15 whole years 1983-1997 (gray), compared to the single year May 1998 - April 1999 (black).

To further emphasize the variability of wind directions between individual years we present wind roses for Kollaleira for the years 1983 and 1985 in Annex 20.

6. Conclusions and Remarks

It is our conclusion that the wind data for the period May 1998-April 1999, used as basis for NILU's dispersal calculations for the proposed aluminium smelter in Reyðarfjörður, are representative and probably near average for the 15 year period 1983-1997. However, the wind distribution varies considerably from year to year. In unfavourable years some addition is therefore called for to the model calculations of pollutant concentrations based on a near-average year. The concentrations in unfavourable years must also to be within the air quality guidelines.

During summer there is also the possible recirculation of partially polluted air inside Reyðarfjörður to be taken into account. The wind is then usually easterly (blowing inland) during days but westerly (blowing towards the sea) during nights. This is the typical sea and land breeze situation with reversed winds at a higher level. During the day the air rises at the end of the Reyðarfjörður valley, then turns eastwards, and to complete the circulation it descends again over the sea. In Annex 19 we present a wind rose for Seley, an island outside Reyðarfjörður (see map in Fig. 5). The main axis of the wind rose is along the coast and easterly winds are uncommon. To maintain the easterly winds observed during summer days at Sómastaðagerði and

other observation places in inner Reyðarfjörður, it is therefore resonable to conclude that the air sinks over the outer part of Reyðarfjörður. As a consequence, recirculation of somewhat polluted air inside Reyðarfjörður is indicated. This air will again pass over the plant and take up additional pollution. The same will also happen to air blowing eastwards over the plant shortly before morning and coming back over the plant when the wind direction turns early in the morning.

When comparing with the air quality guidelines for SO_2, it is necessary in addition to NILU´s model calculations also to take into account SO_2 pollution from Búðareyri, probably mainly from the fish oil and fish meal plant. Pollution from such plants is occasionally known to be a considerable nuisance for periods of days in the fiords of Eastern Iceland during calm weather and temperature inversions. In this connection we present Fig. 4 with Mjóifjörður nearly filled with dense fog in the morning of 29 July 1999. At Dalatangi dense fog was reported at 03, 06 and 09 GMT on 29 and 30 July. On both days dense fog was also reported at Kollaleira in Reyðarfjörður at 09 GMT, the first observation hour of the day. In Fig. 11 we present temperature observations from three automatic stations during the period 28 July - 6 August 1999.

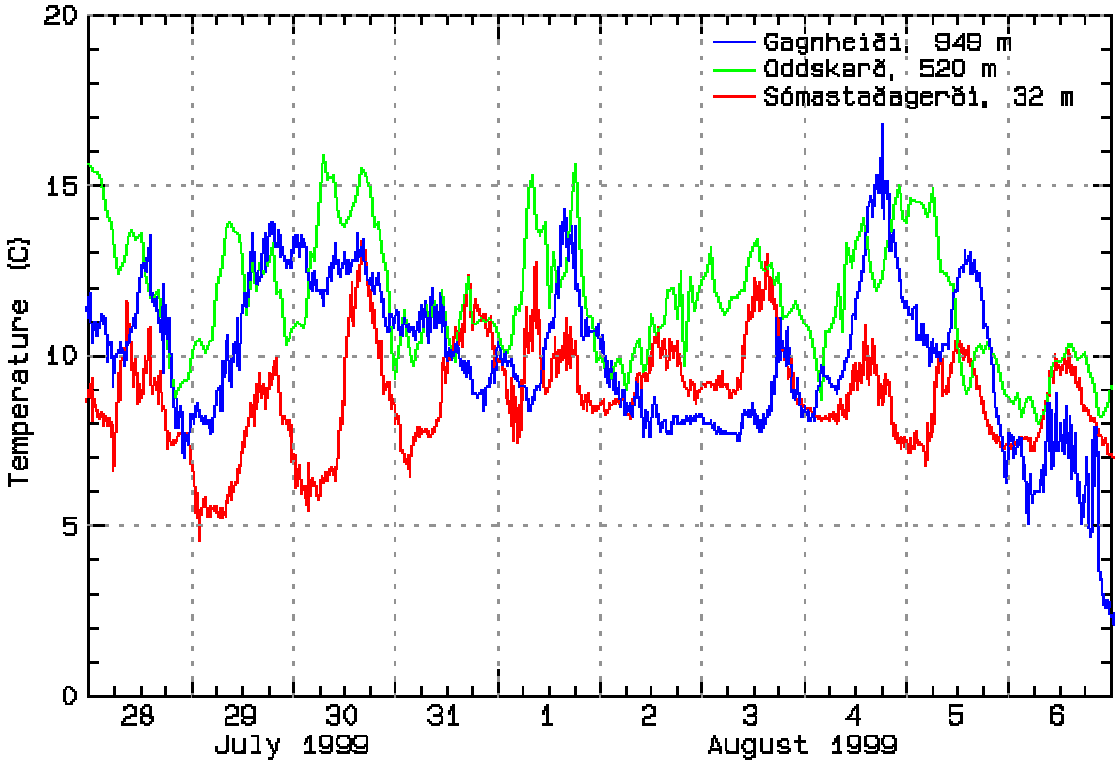


Fig. 11. Temperature observations at Sómastaðagerði, Oddskarð and Gagnheiði during the inversion period 28 July-6 August 1999.

The stations are Sómastaðagerði, height 32 m a.m.s.l., Oddskarð, height 520 m a.m.s.l. and Gagnheiði, height 949 m a.m.s.l. A strong temperature inversion, i.e increase of temperature with height, is shown between Sómastaðagerði and Oddskarð, and for part of the time the inversion reaches as high as the station Gagnheiði. The strong increase of temperature with height was verified by using also measurements made by the automatic stations Eskifjörður (2 m a.m.s.l.), Hallormsstaðaháls (580 m

a.m.s.l.) and Fjarðarheiði (600 m a.m.s.l.). A high pressure area was near or above Iceland for most of the period.

NILU has stated that the accuracy of long-term average concentrations calculated with models of the type used by them for the smelter in Reyðarfjörður varies between 5 and 20 %, depending on the complexity of the source term, impact area and the duration of the calculation period. They have also stated that the critical side of the dispersion modelling depends much more on the representativity of the input data, such as emission and meteorological data, than on the equations used in the model. The complexity of the topography in Reyðarfjörður, the great variability of weather in Iceland, and the possibility of recirculation of air inside Reyðarfjörður during summer, call in our opinion for somewhat greater uncertainty. This should be kept in mind when comparing model calculations with air quality guidelines.

However, Veðurstofa Íslands has earlier stated, after having studied NILU's model calculations of average pollution concentrations together with other information from NILU, as well as the available meteorological data, that we believe an aluminium smelter with an annual production of 120.000 tonns of aluminium should be acceptable. By using a wet scrubber in addition to a dry scrubber we even believe that a later extension to 240.000 tonns per year should probably be acceptable.

Earlier we have also pointed out that a smelter with an annual production of 480.000 tonns of aluminium is a very large smelter, twice the size of the largest aluminium smelter in Norway. In our opinion this is too large a smelter to be located in the long and narrow Reyðarfjörður, surrounded by high mountains and with difficult dispersion conditions. This opinion is based on NILU's model calculations, the uncertainty mentioned above, and on our studies of the meteorological conditions in the Reyðarfjörður area. It should be kept in mind that the Government Regulation No. 48/1994 not only includes the air quality guidelines in Annex 3, used by NILU for comparison with model calculations, but also includes para. 25.1, stating that air pollution shall be kept at a minimum and the valuable clean and unpolluted air maintained.

7. The Need for Further Observations and Permanent Monitoring

If an aluminium plant is built in Reyðarfjörður, monitoring of weather and pollution will be necessary. The present observation mast at Sómastaðagerði could then be moved to a suitable place between the plant and Búðareyri where observations of wind and vertical temperature gradient should permanently be carried out. In addition sampling of precipitation and air for chemical analysis should be carried out at the plant, and on the eastern side of Búðareyri and on Hólmaháls. The results of this monitoring would be of great importance for evaluating possible later enlargement of the aluminium plant.

For clarification of the air circulation inside the fiord 2-3 automatic stations observing wind and temperature could be very valuable. They should be operated for 2-3 years. As suitable places we would especially like to mention Vattarnes at the mouth of Reyðarfjörður and a promontory in the hillside WNW of Sómastaðir and east of Ljósá at approx. 180 m height a.m.s.l.

8. References

1. Flosi Hrafn Sigurðsson, Hreinn Hjartarson, Torfi Karl Antonsson and Þórður Arason: Wind and Stability Observations at Sómastaðagerði in Reyðarfjörður, May 1998-April 1999. Veðurstofa Íslands, Report VÍ-G99018-TA04, Reykjavík, October 1999, 55 p.

2. Flosi Hrafn Sigurðsson, Hreinn Hjartarson, Torfi Karl Antonsson and Þórður Arason: Wind Observations at Eyri and Leirur in Reyðarfjörður. Veðurstofa Íslands, Report VÍ-G99015-TA03, Reykjavík, August 1999, 32 p.

3. Flosi Hrafn Sigurðsson, Hreinn Hjartarson, and Torfi Karl Antonsson: Vindmælingar að Kollaleiru (Wind Observations at Kollaleira). Veðurstofa Íslands, Greinargerð VÍ-G99009-TA02, Reykjavík, June 1999. 41 p. (In Icelandic).

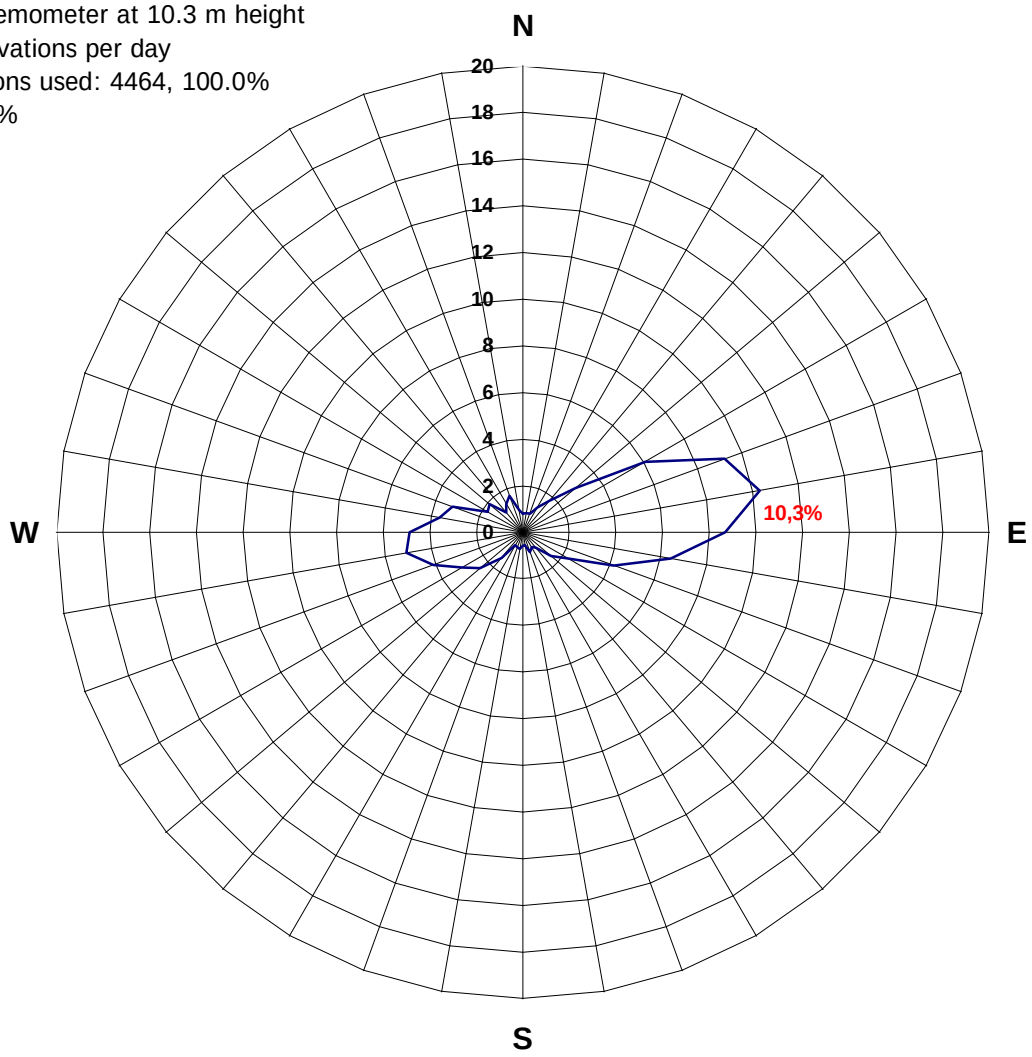
4. Flosi Hrafn Sigurðsson and Hreinn Hjartarson: Veðurathuganir á Reyðarfjarðarsvæðinu (Weather Observations in the Reyðarfjörður Area). Veðurstofa Íslands, Reykjavík 1986. 116 p. (In Icelandic).

5. Cristina Guerreiro: Update of model calculations for a planned aluminium smelter at Hraun, Iceland. NILU, OR 40/99, September 1999. 54 p.

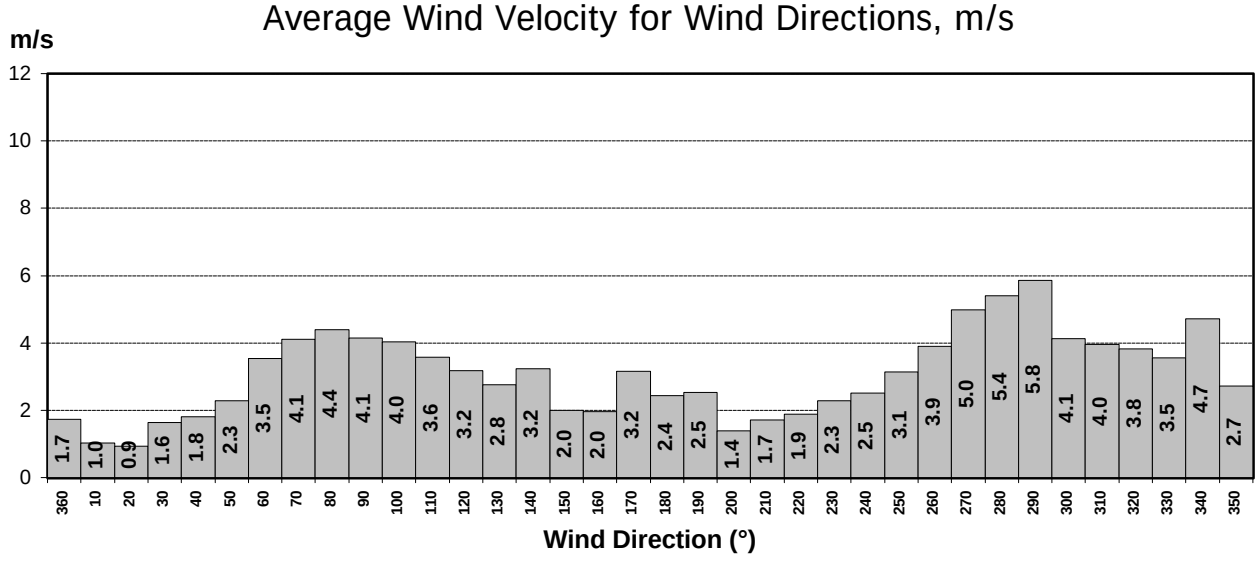
6. Svein Knudsen: NOTE, Answers to the comments on the EIA for an aluminium smelter on Iceland. NILU, O-2057, November 1999. 12 p.

Frequency of Wind Directions, %
May 1999

Young Anemometer at 10.3 m height
144 observations per day
Observations used: 4464, 100.0%
Calm: 0,8%

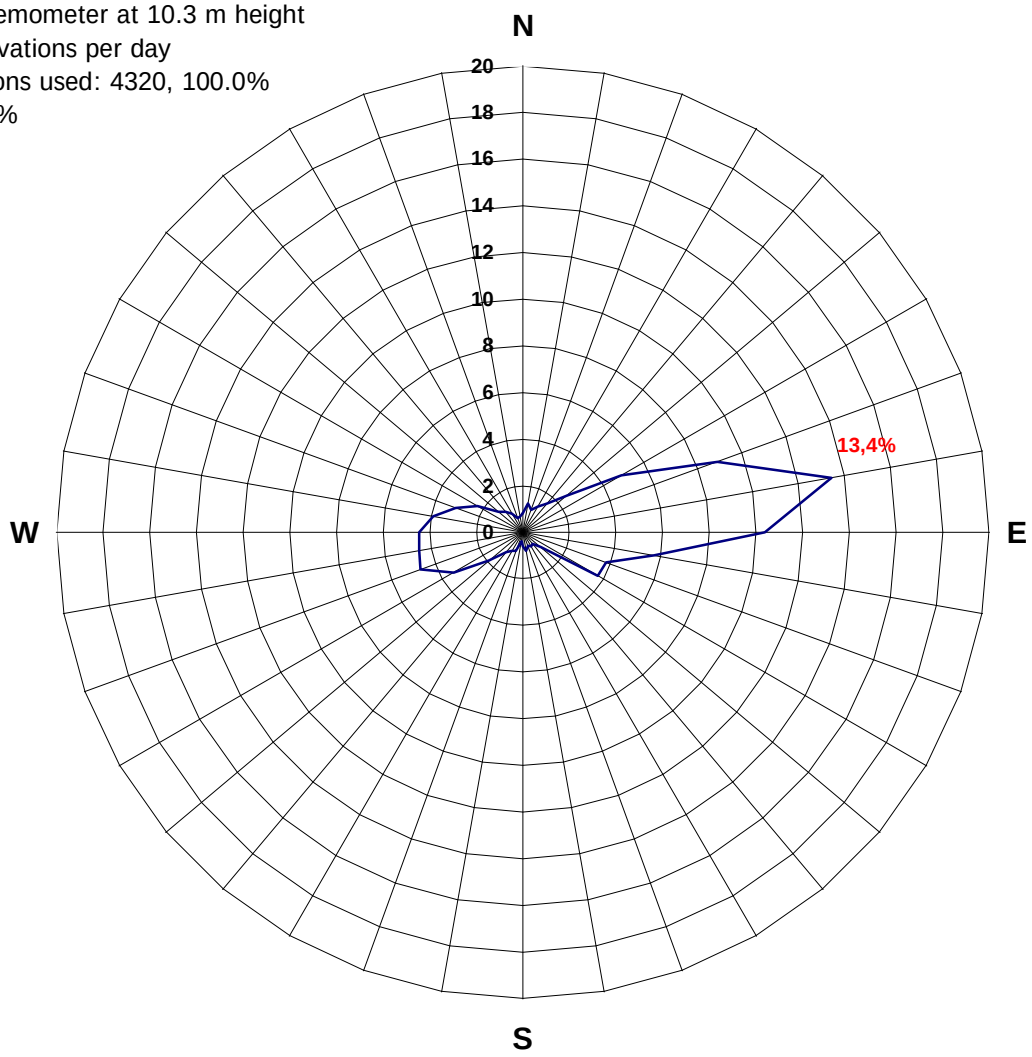


Average Wind Velocity for Wind Directions, m/s

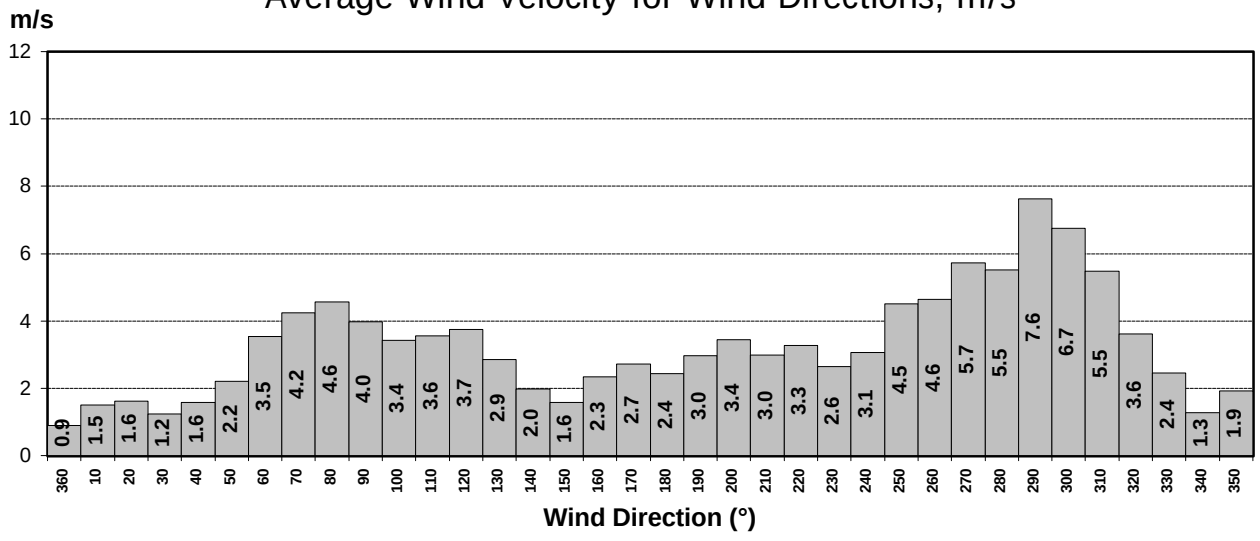


Frequency of Wind Directions, %
June 1999

Young Anemometer at 10.3 m height
144 observations per day
Observations used: 4320, 100.0%
Calm: 0,4%

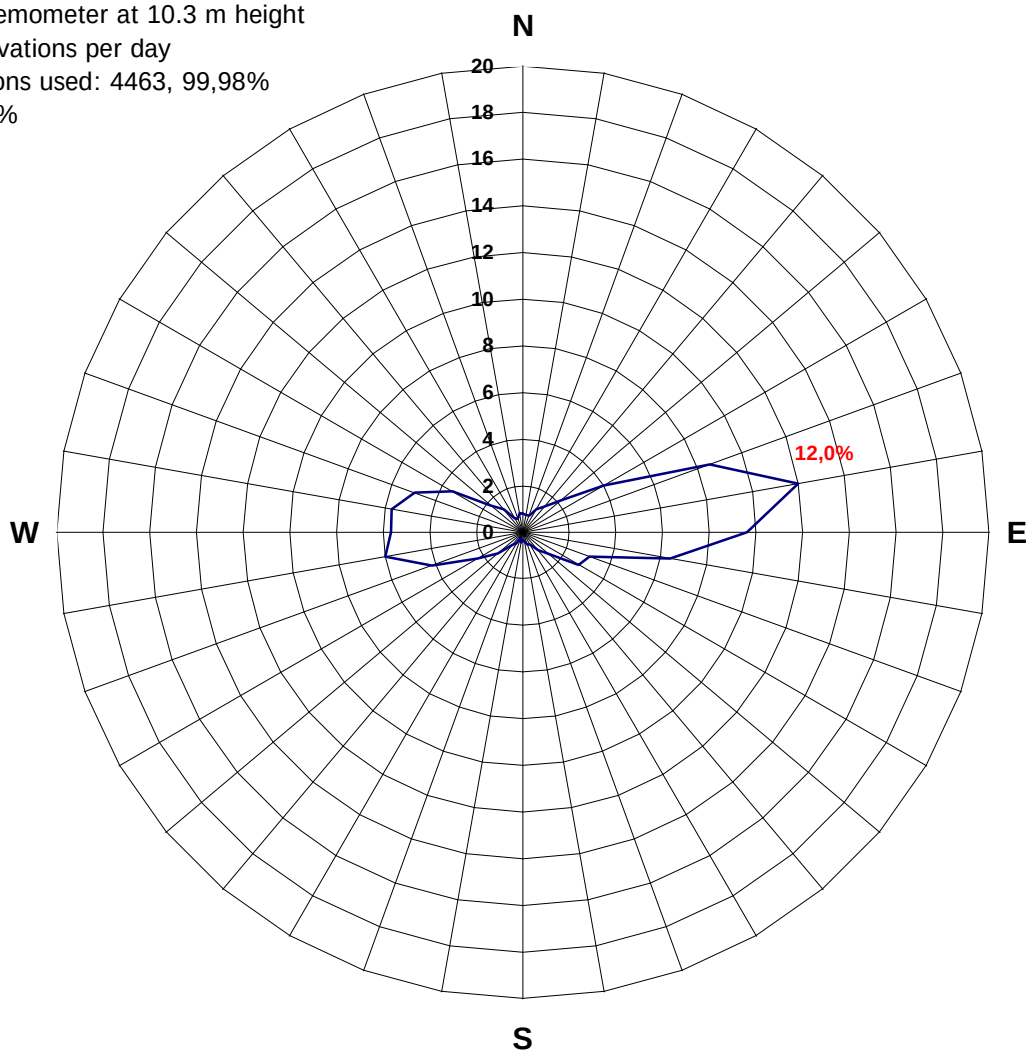


Average Wind Velocity for Wind Directions, m/s

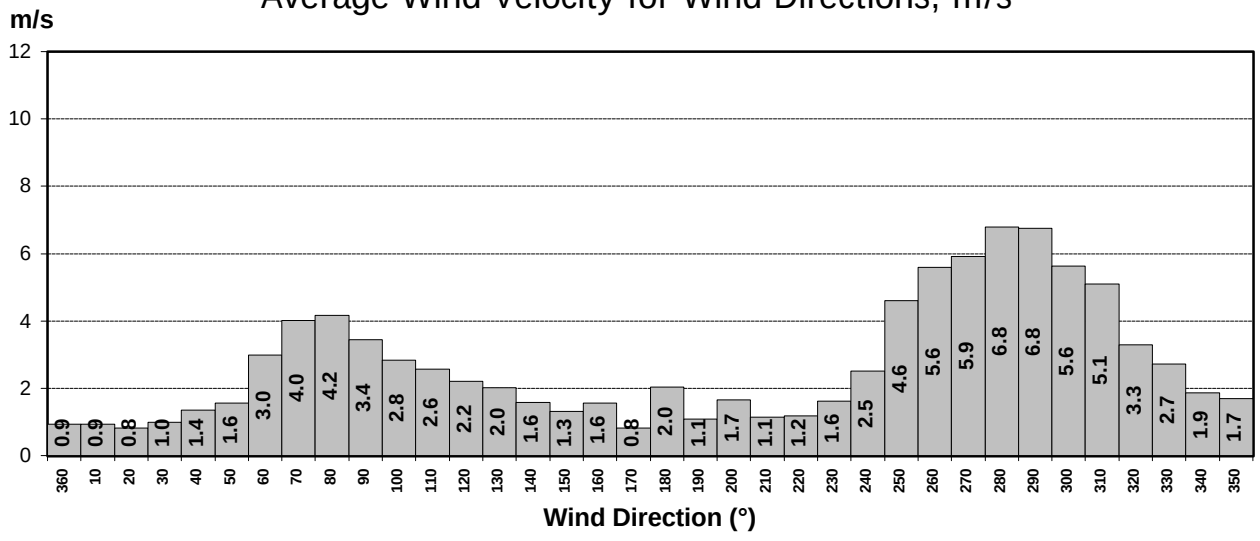


Frequency of Wind Directions, %
July 1999

Young Anemometer at 10.3 m height
144 observations per day
Observations used: 4463, 99,98%
Calm: 1,6%

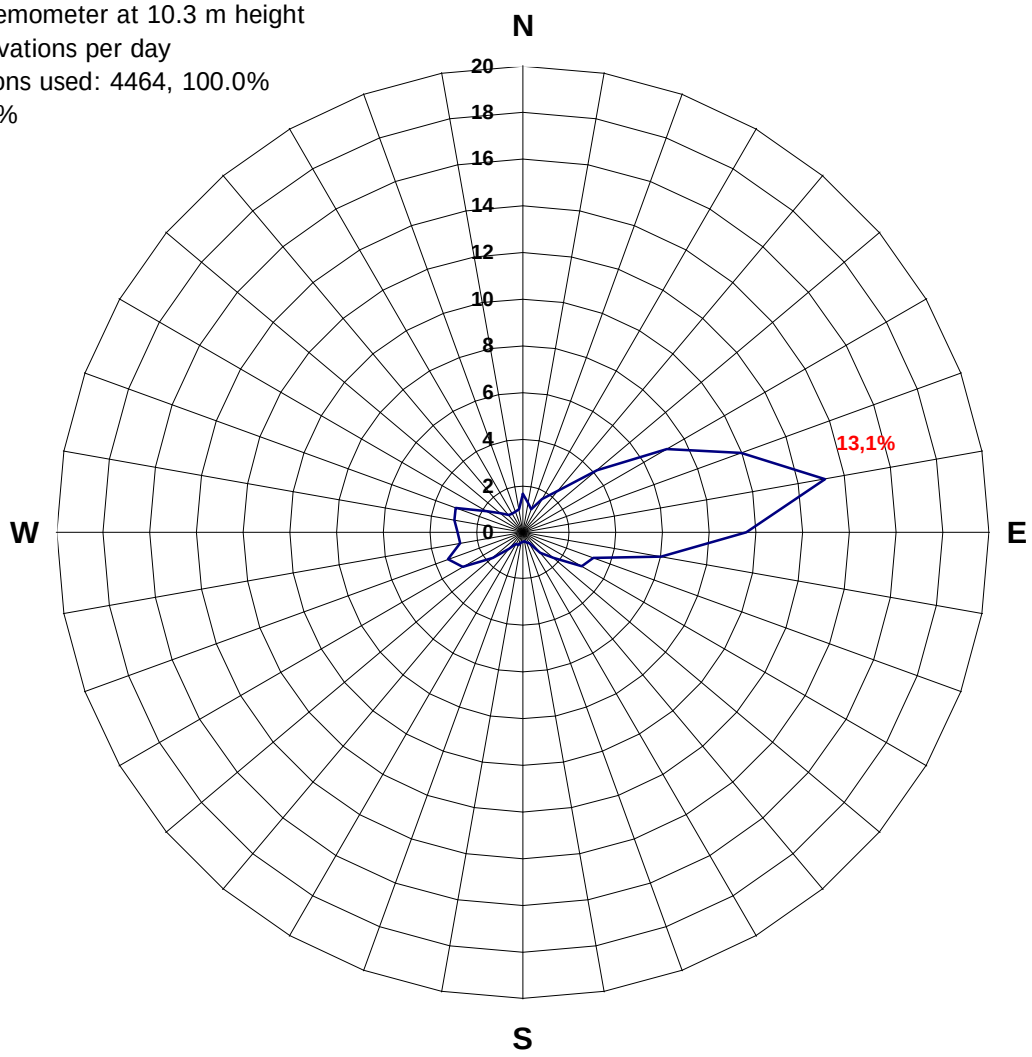


Average Wind Velocity for Wind Directions, m/s

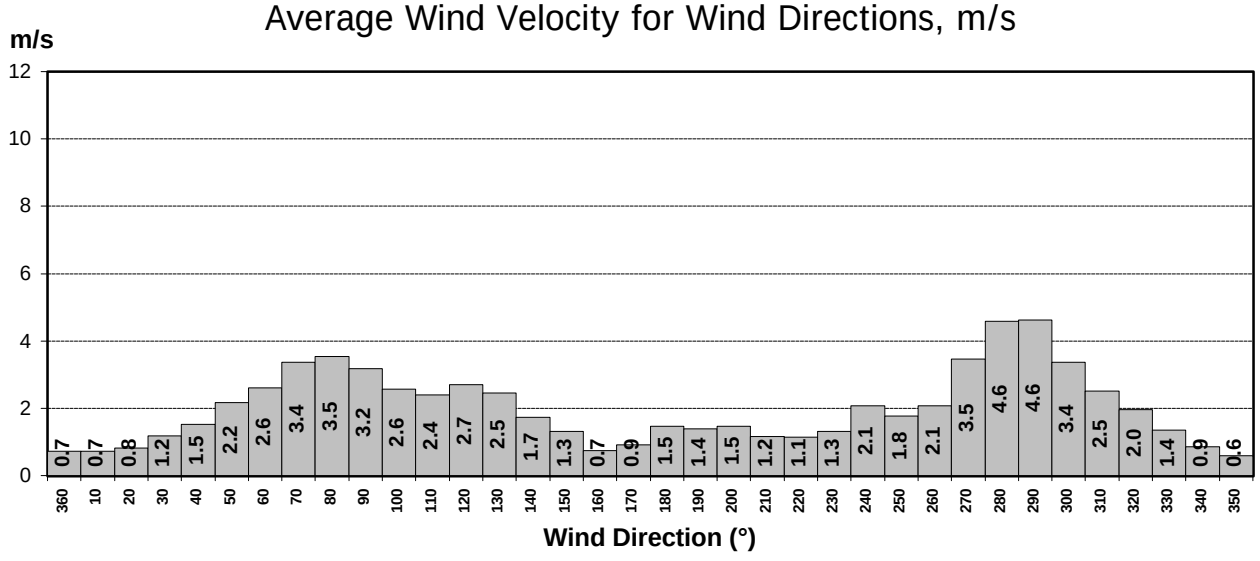


Frequency of Wind Directions, %
August 1999

Young Anemometer at 10.3 m height
144 observations per day
Observations used: 4464, 100.0%
Calm: 2,2%

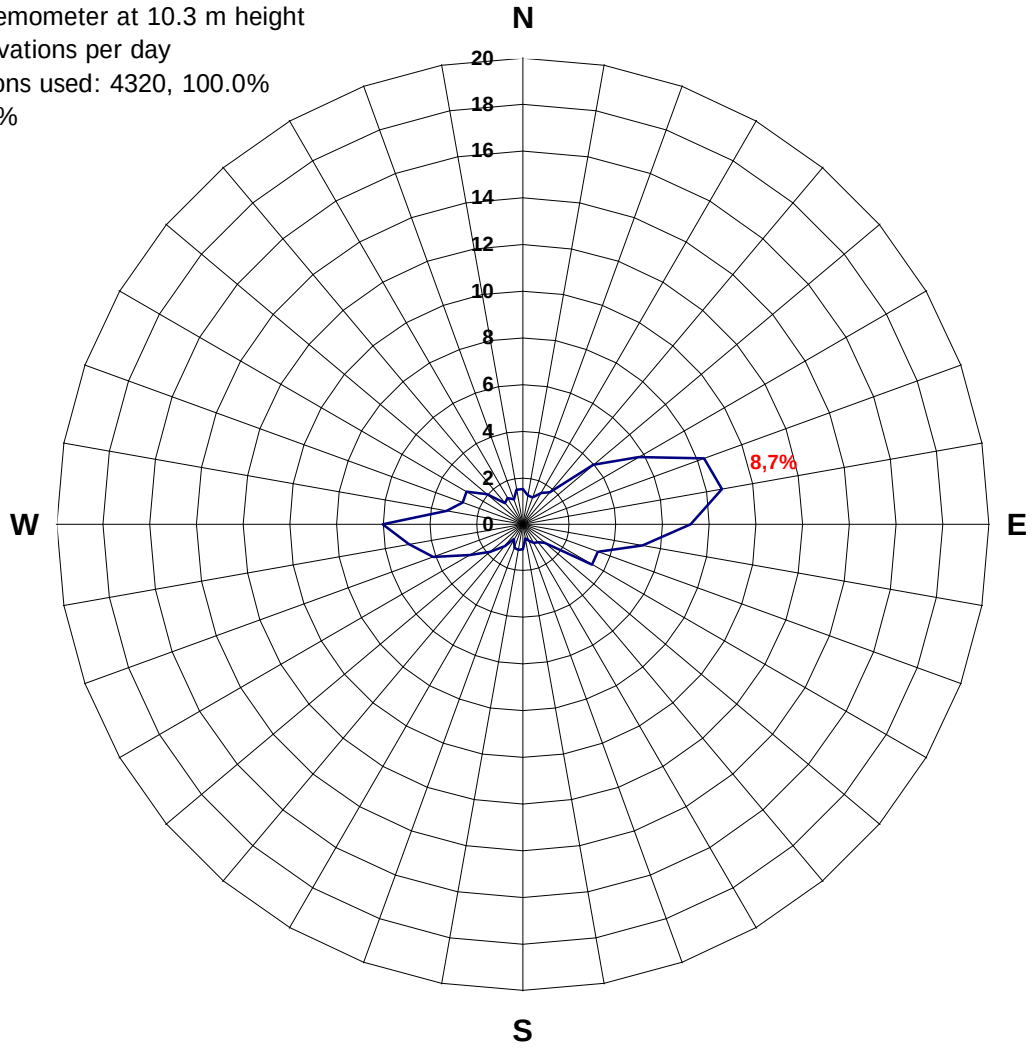


Average Wind Velocity for Wind Directions, m/s

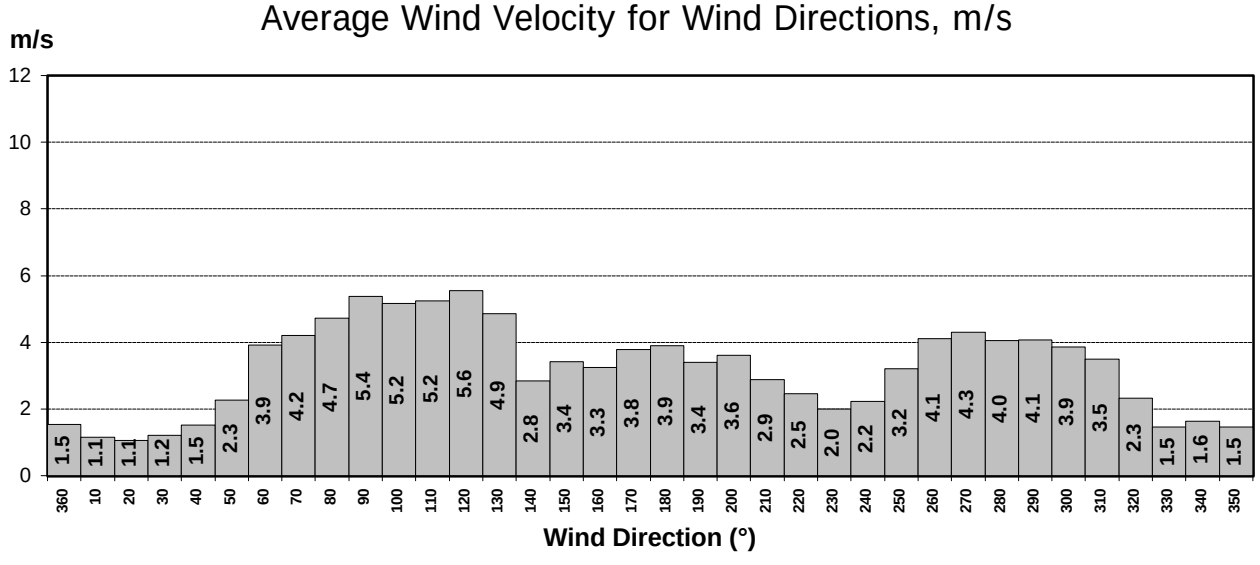


Frequency of Wind Directions, %
September 1999

Young Anemometer at 10.3 m height
144 observations per day
Observations used: 4320, 100.0%
Calm: 1,6%

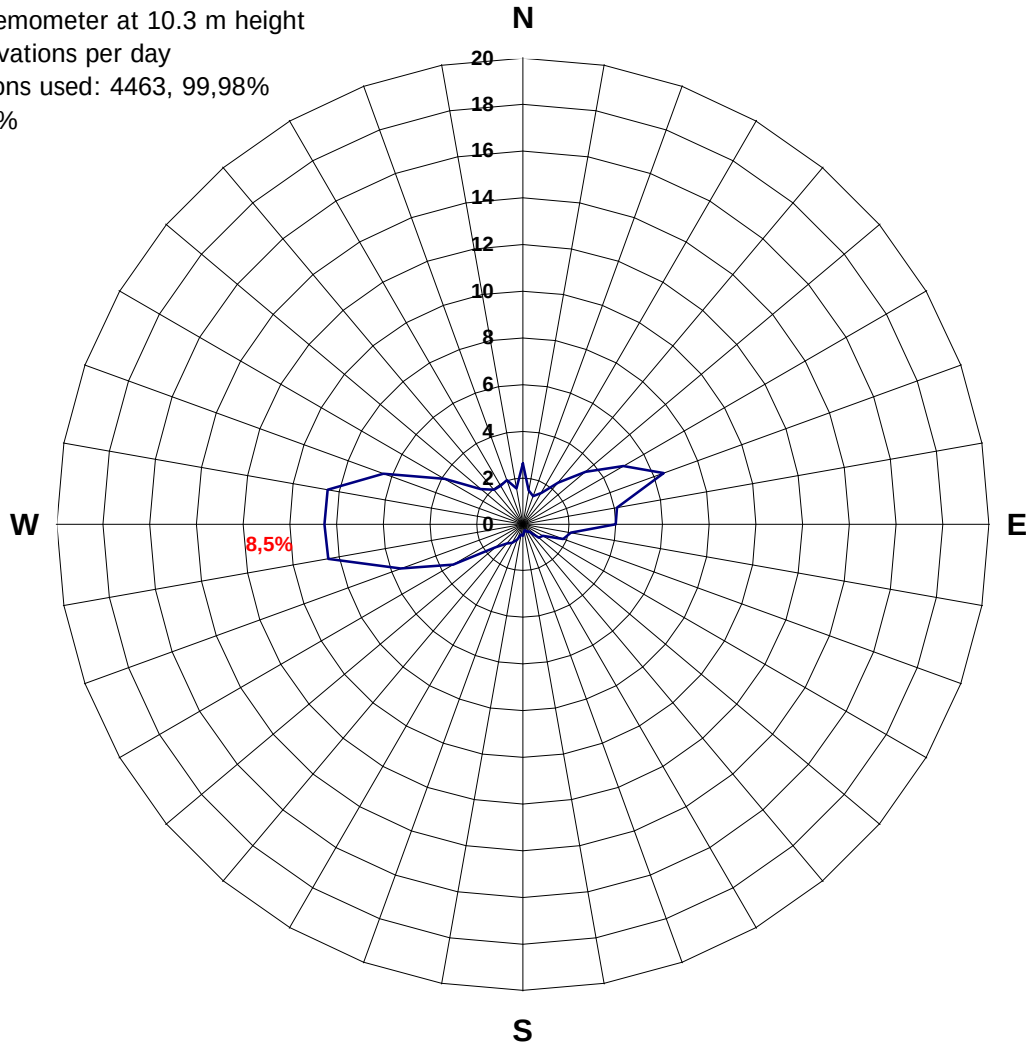


Average Wind Velocity for Wind Directions, m/s

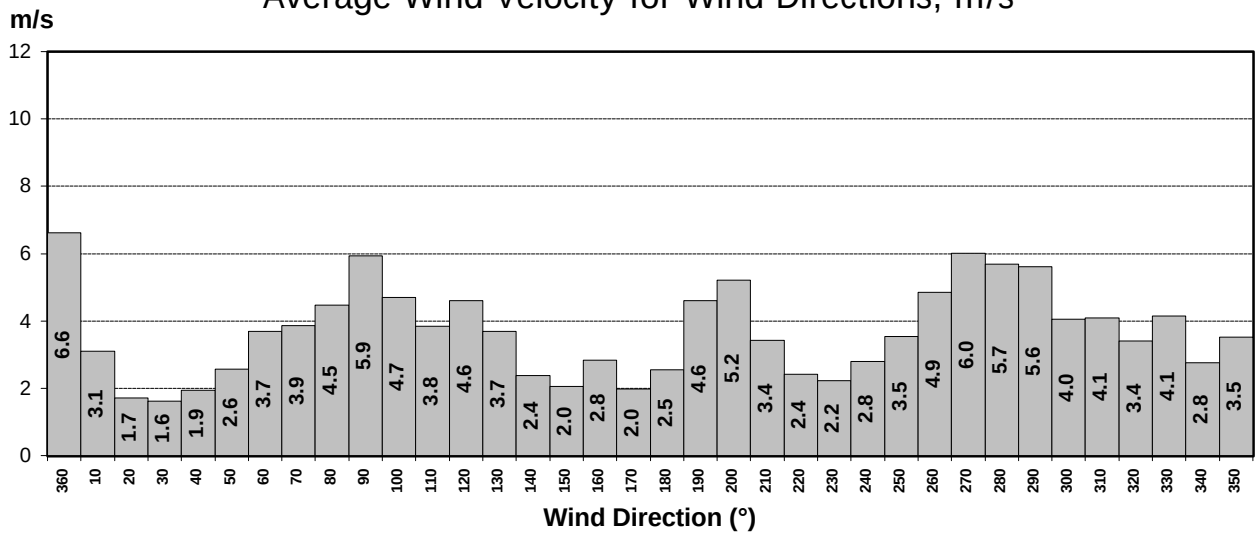


Frequency of Wind Directions, %
October 1999

Young Anemometer at 10.3 m height
144 observations per day
Observations used: 4463, 99,98%
Calm: 0,9%

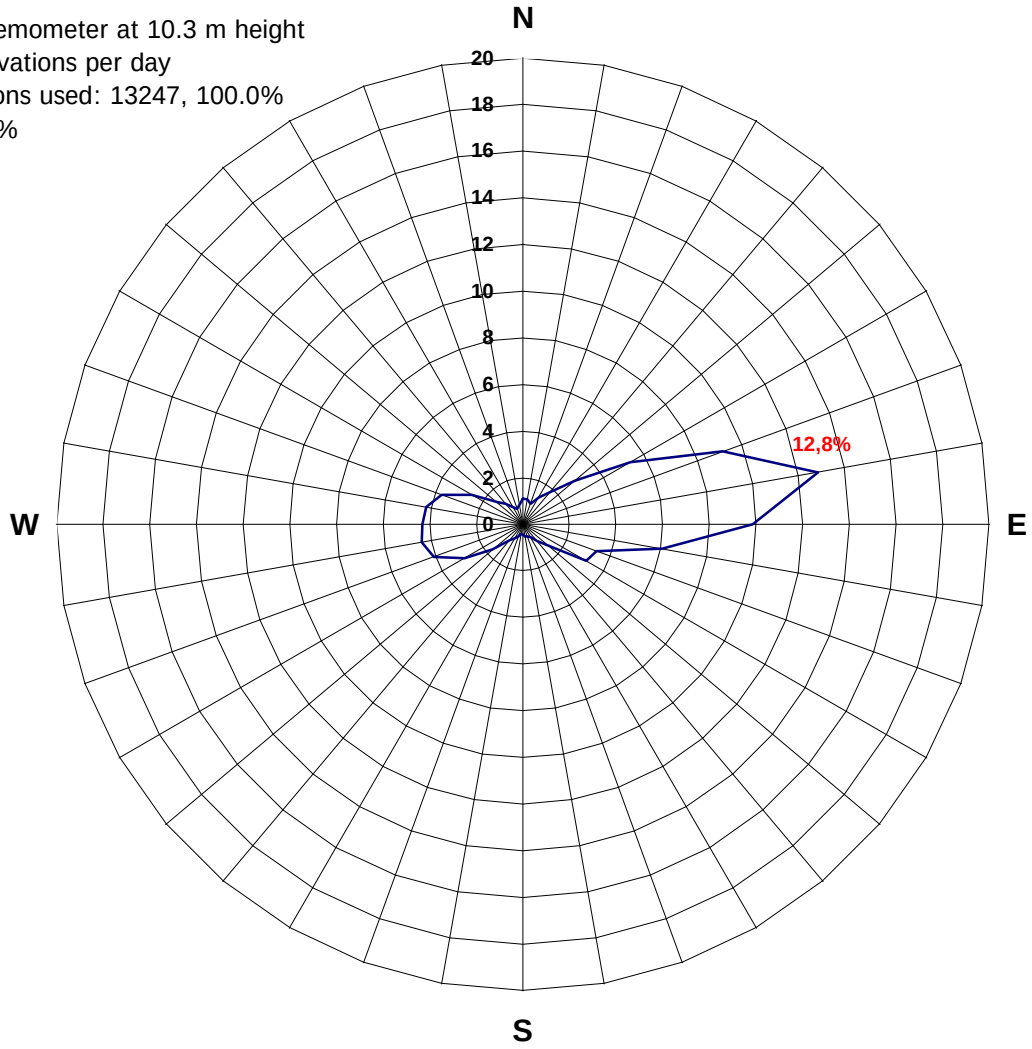


Average Wind Velocity for Wind Directions, m/s

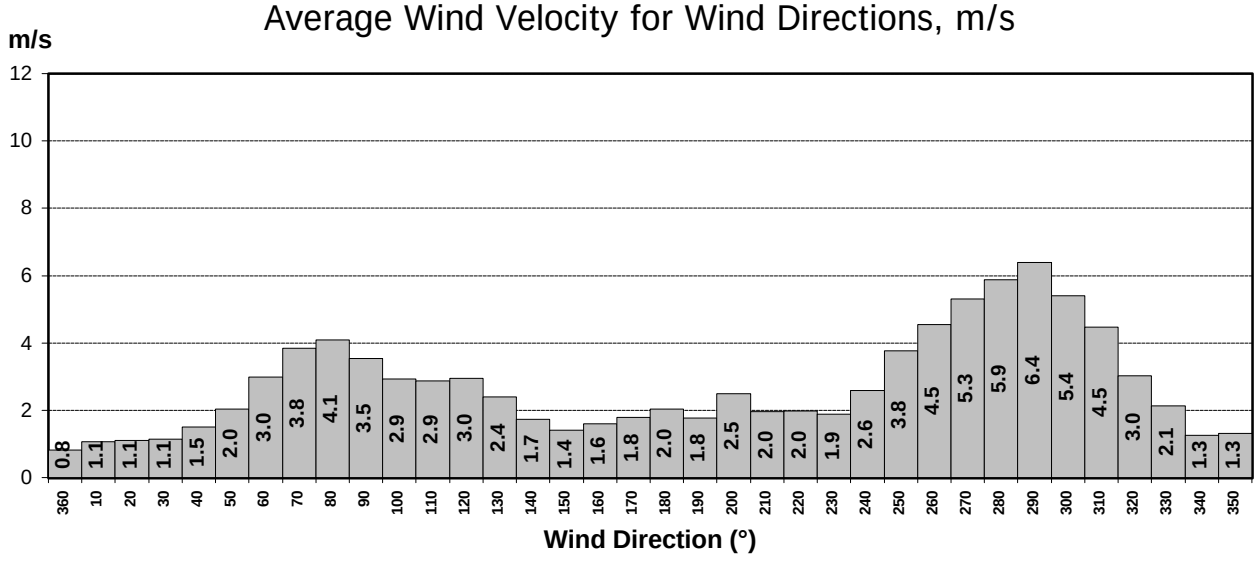


Frequency of Wind Directions, %
High Summer, June - August 1999

Young Anemometer at 10.3 m height
144 observations per day
Observations used: 13247, 100.0%
Calm: 1.4%

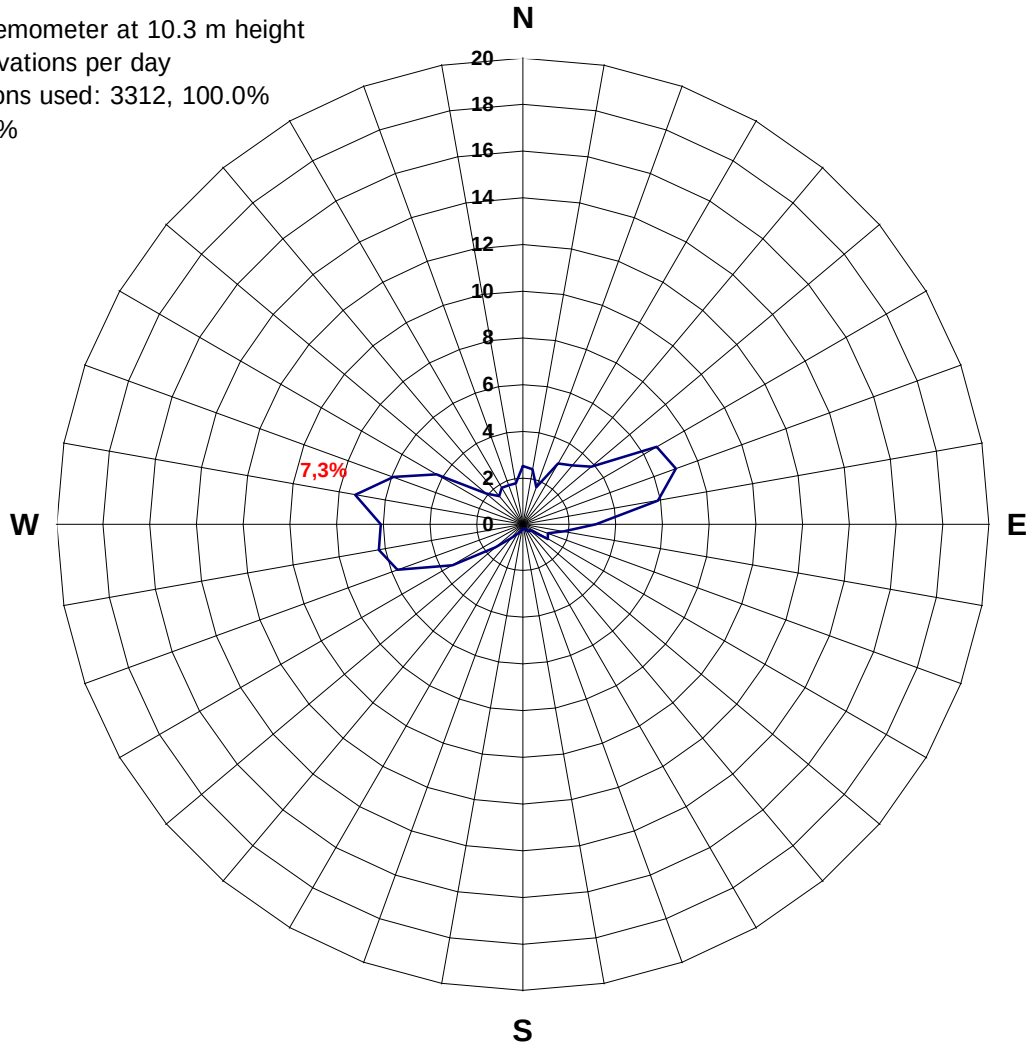


Average Wind Velocity for Wind Directions, m/s

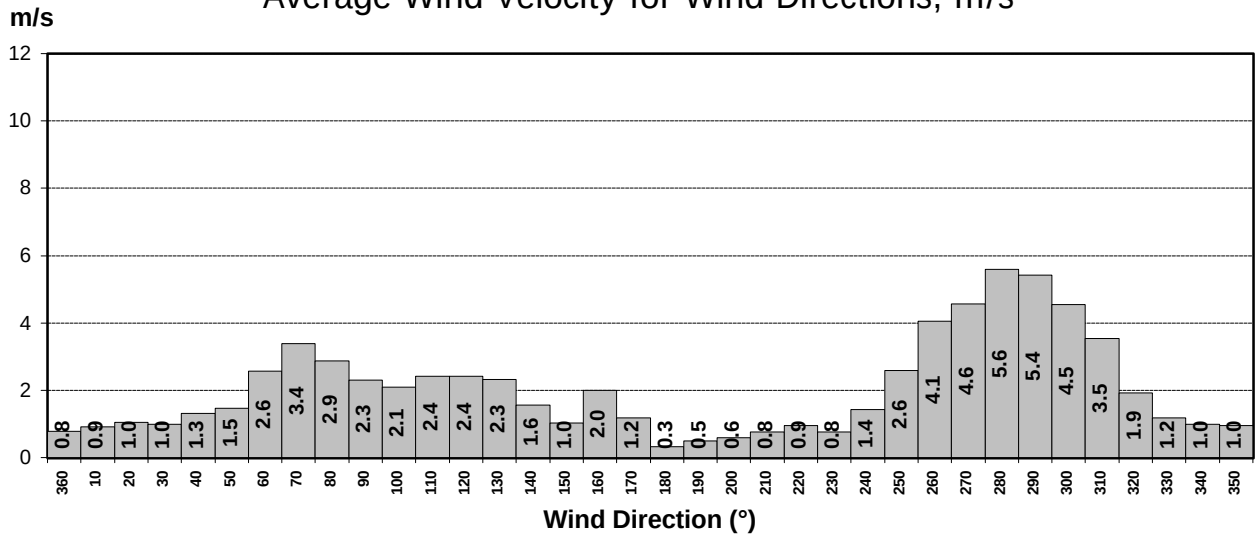


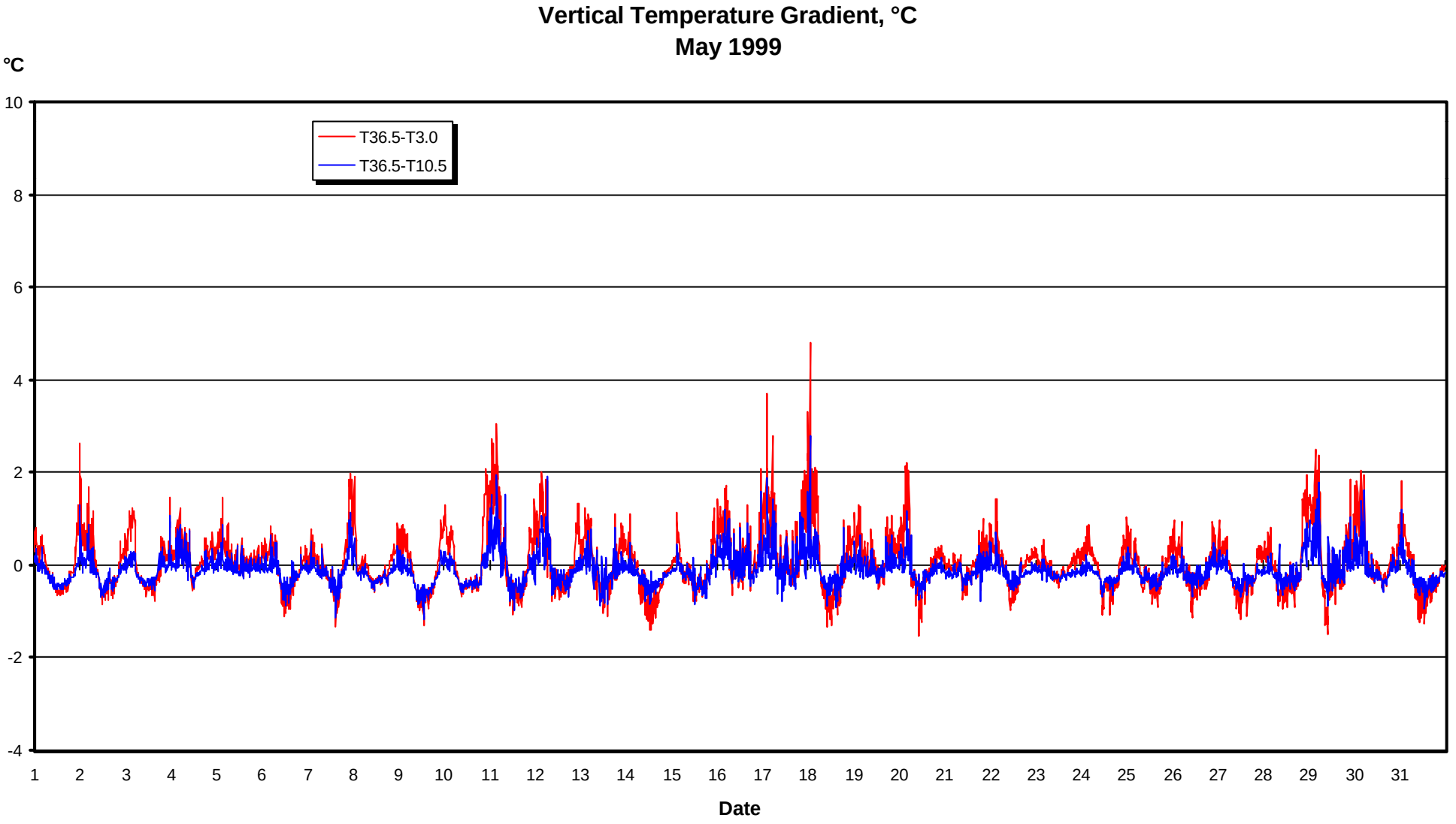
Frequency of Wind Directions, %
High Summer, June - August 1999, Night Hours 00-06 GMT

Young Anemometer at 10.3 m height
144 observations per day
Observations used: 3312, 100.0%
Calm: 3.5%

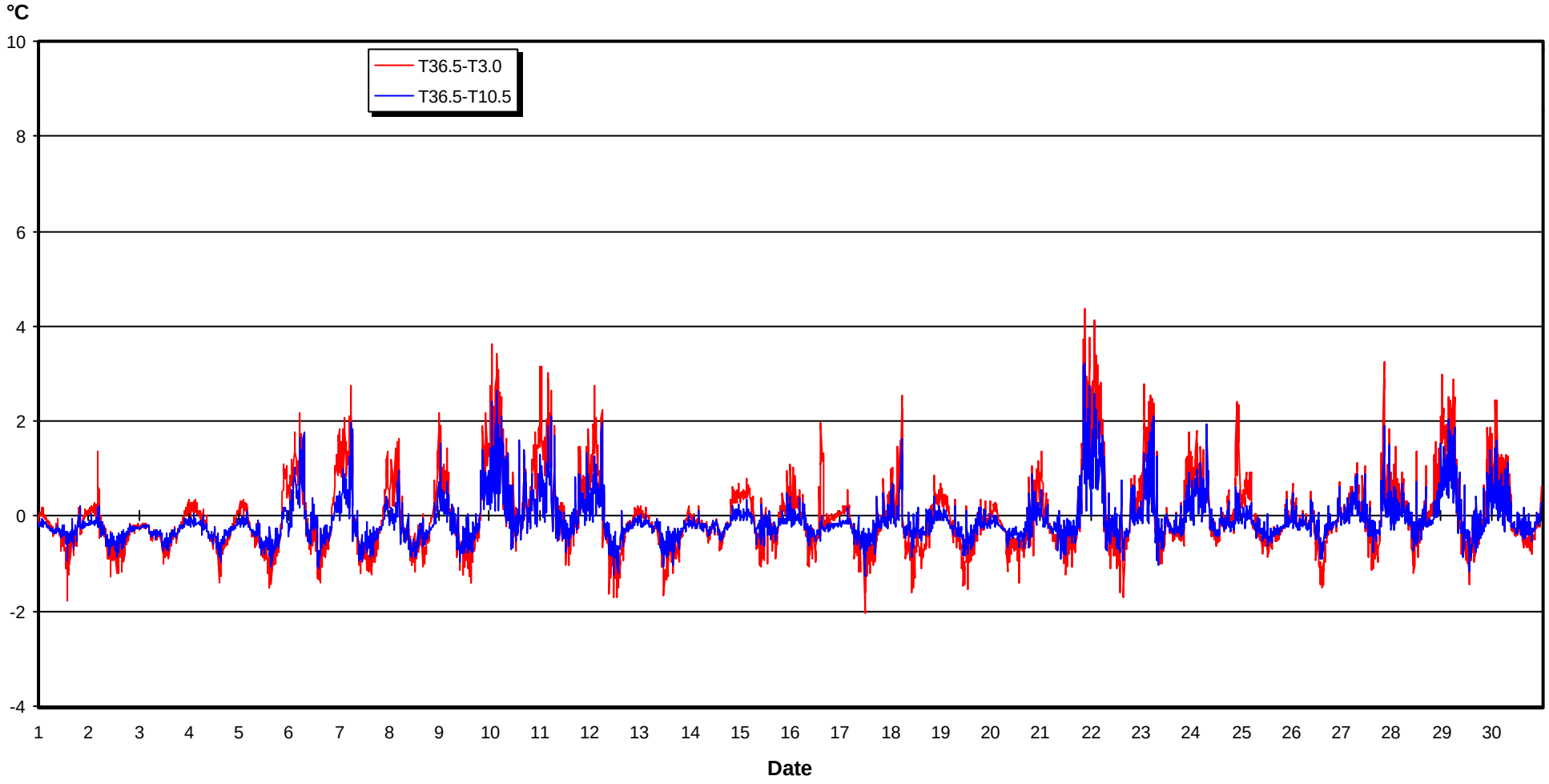


Average Wind Velocity for Wind Directions, m/s

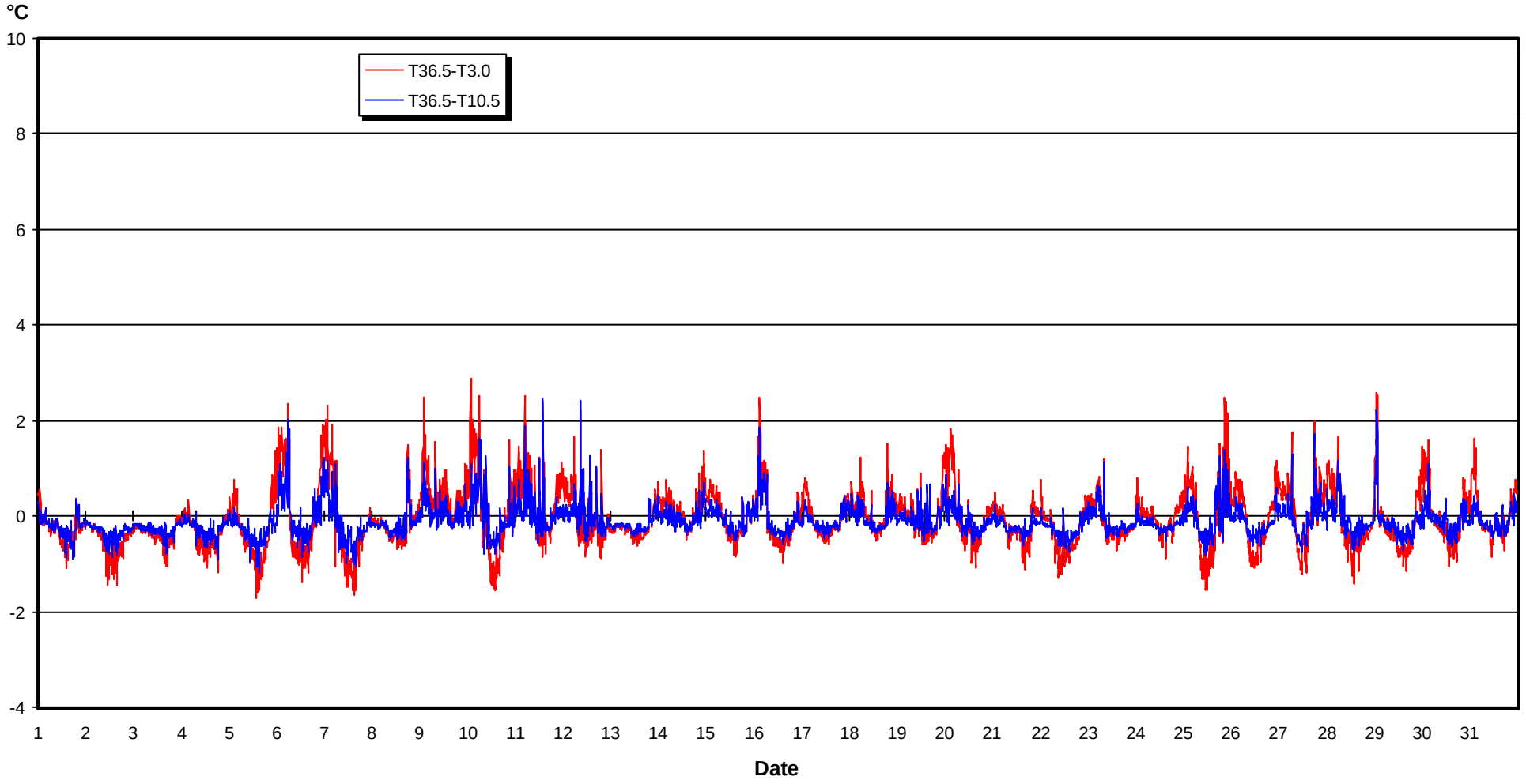


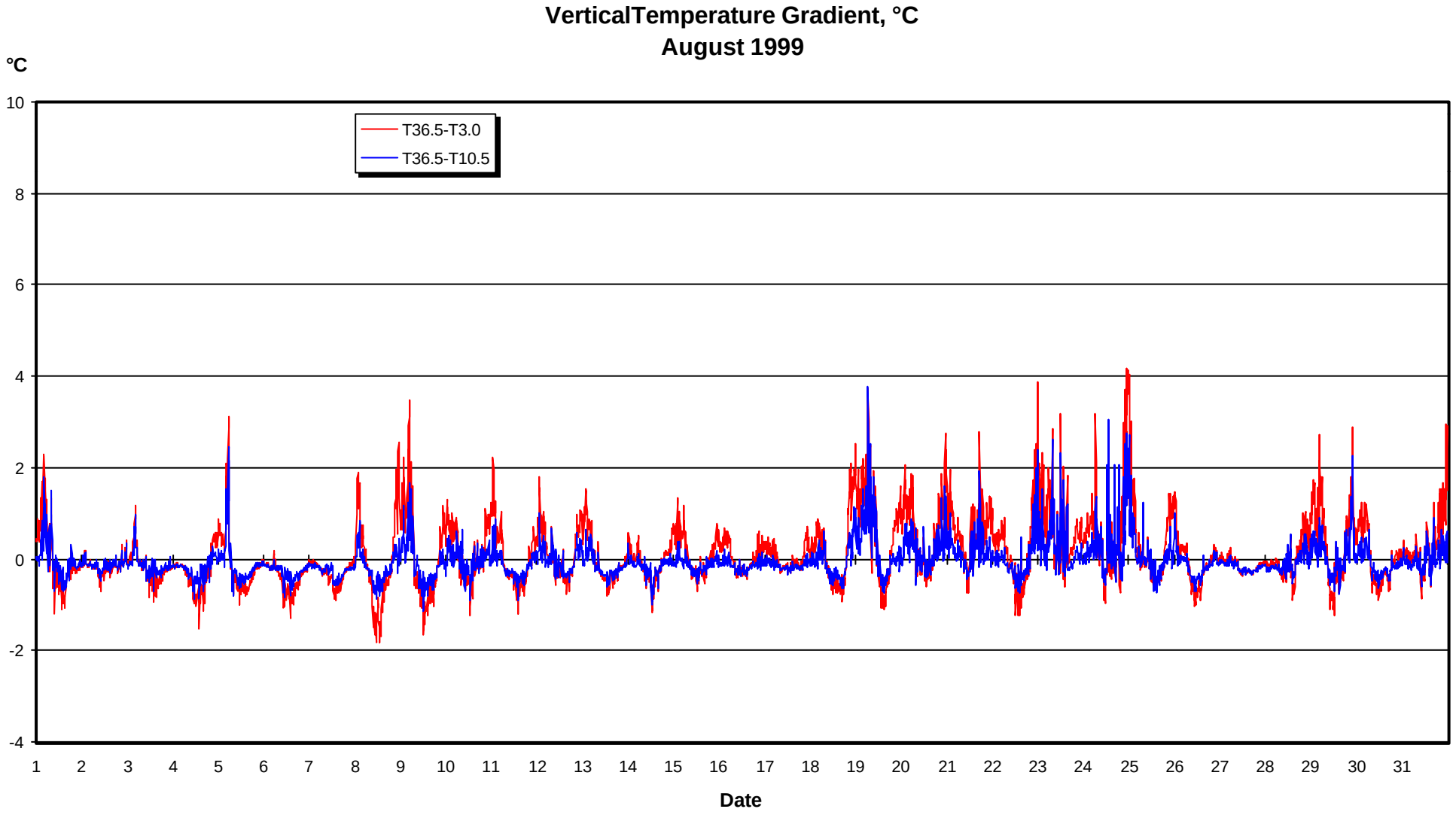

Vertical Temperature Gradient, °C
May 1999
°C
10
8
6
4
2
0
-2
-4
T36.5-T3.0
T36.5-T10.5
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
Date

Vertical Temperature Gradient, °C
June 1999

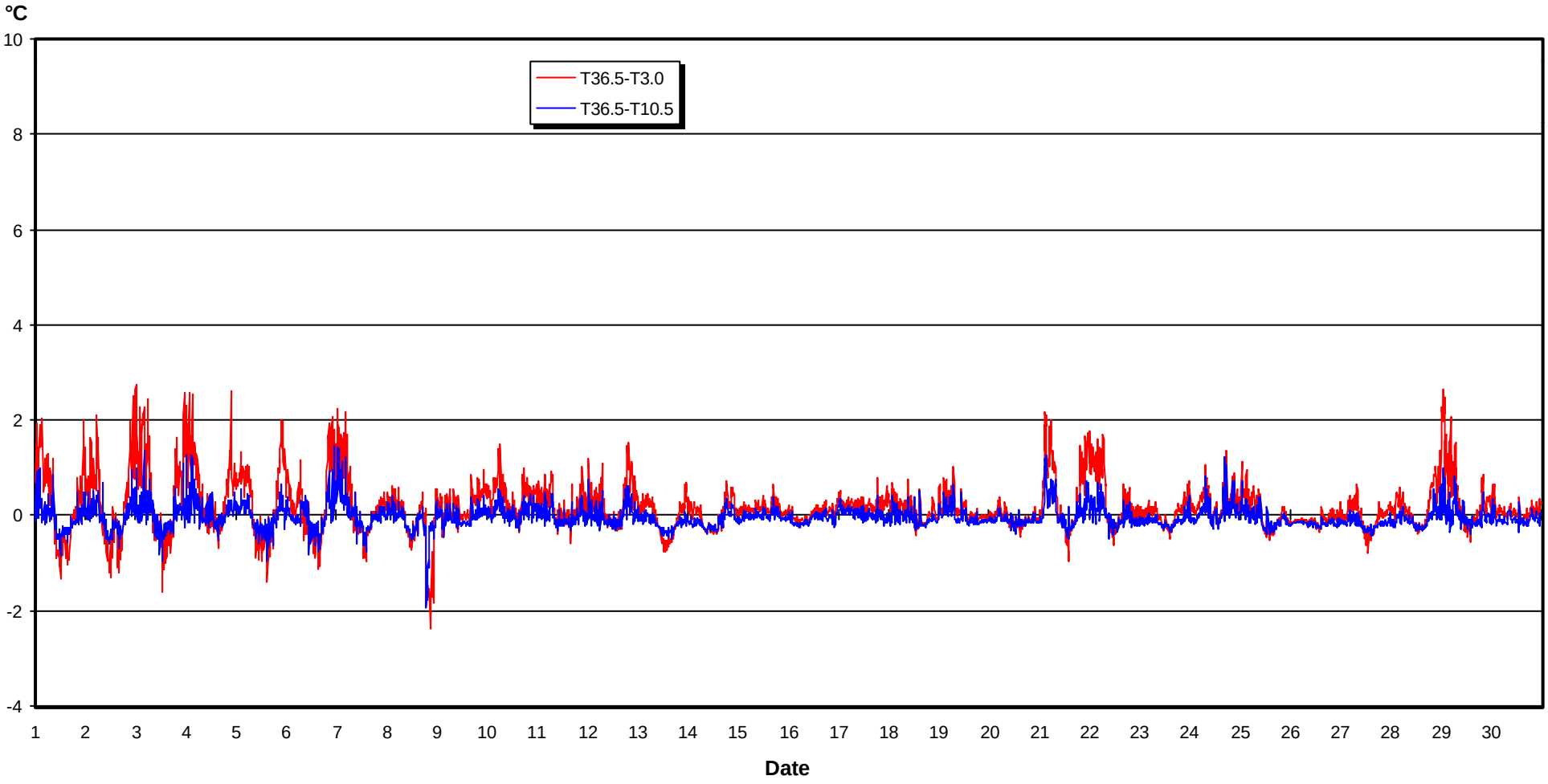


Vertical Temperature Gradient, °C
July 1999

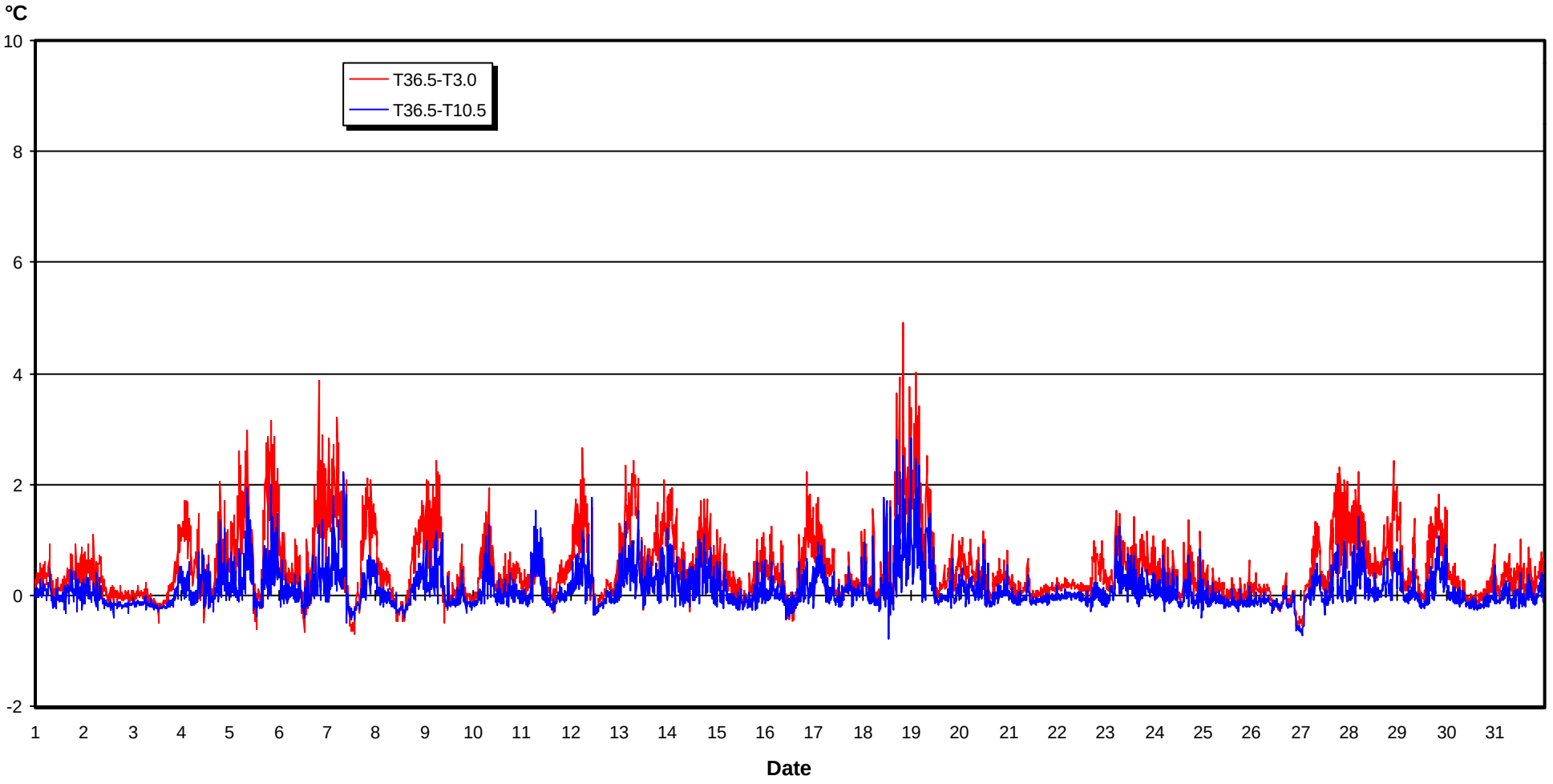



VerticalTemperature Gradient, °C
August 1999
°C
T36.5-T3.0
T36.5-T10.5
10
8
6
4
2
0
-2
-4
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
Date

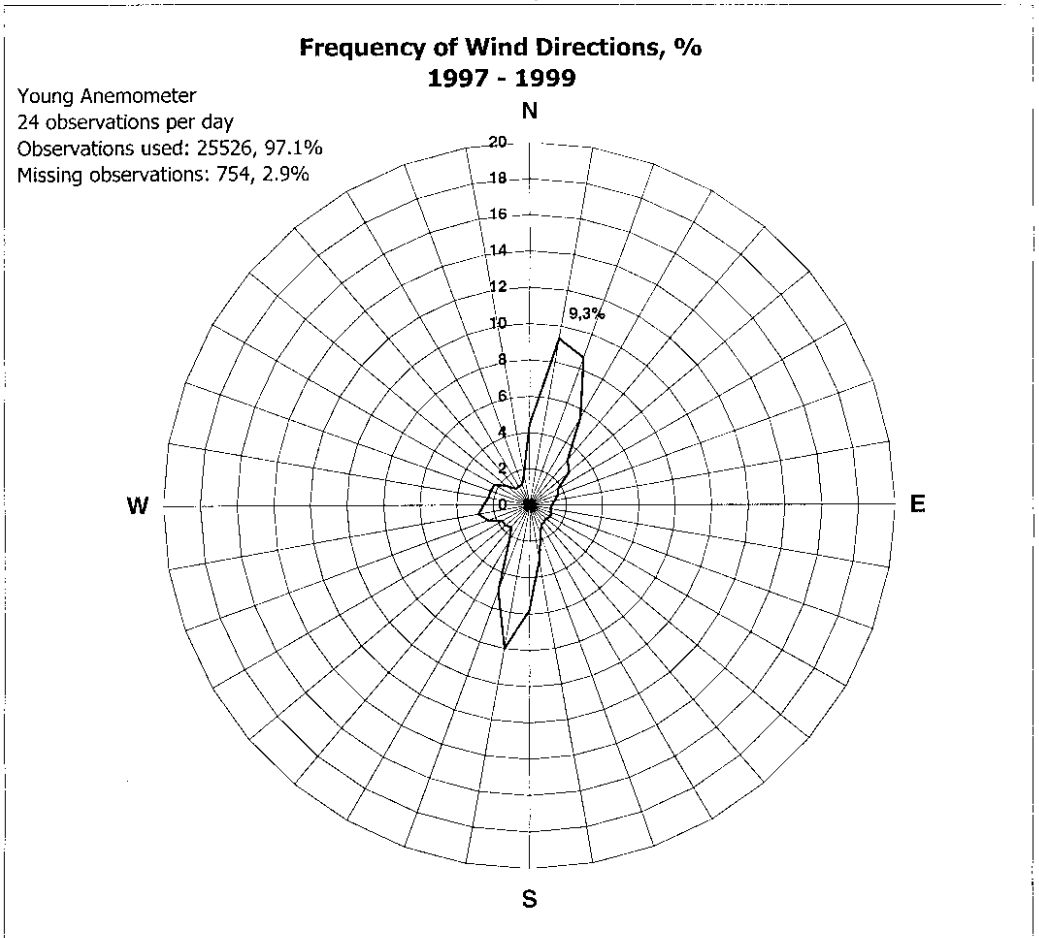
Vertical Temperature Gradient, °C
September 1999

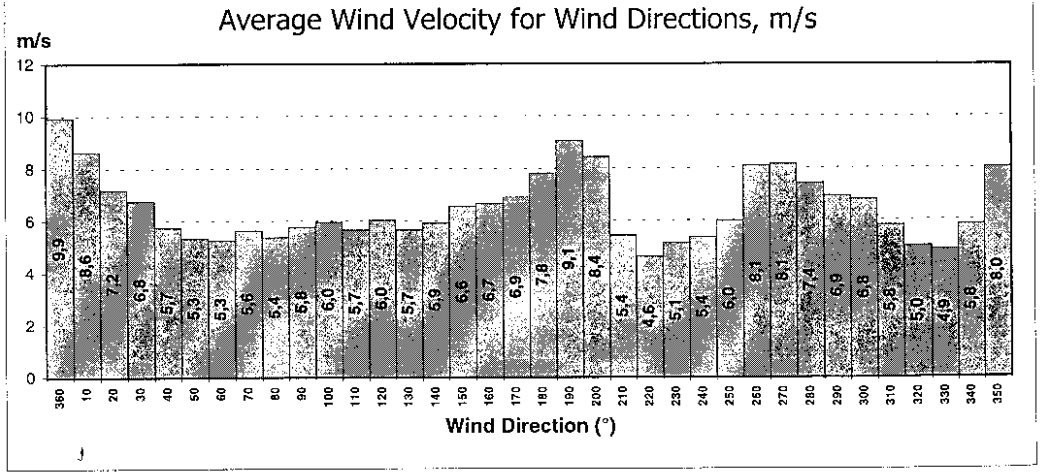


Vertical Temperature Gradient, °C
October 1999



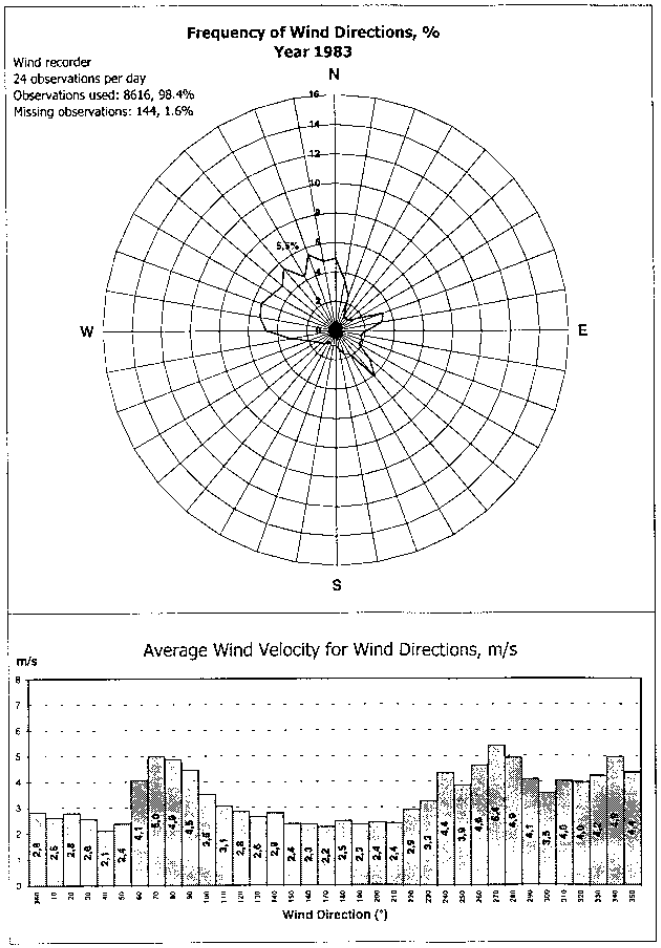
Seley



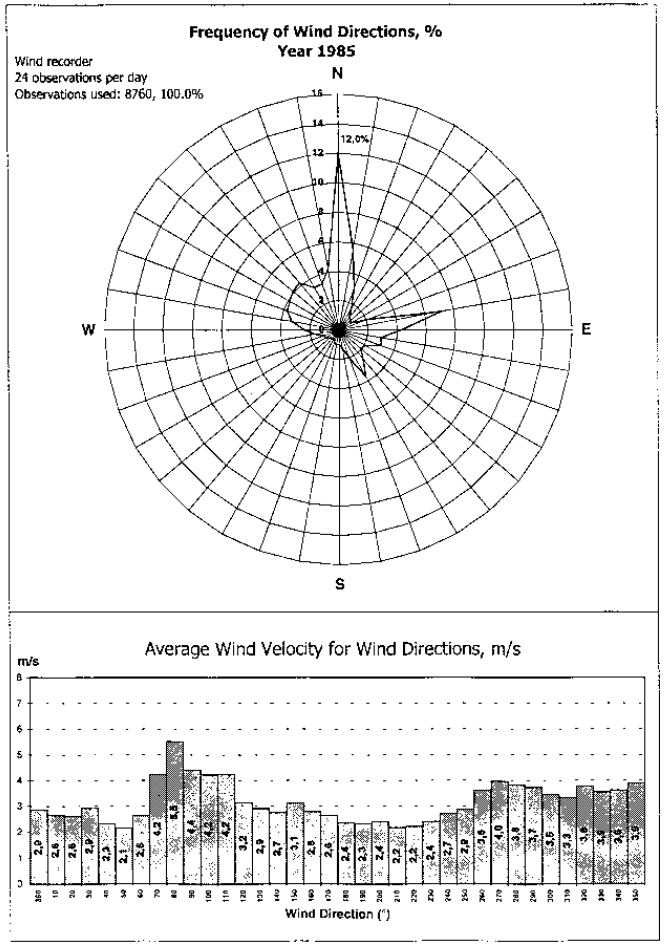


Annex 19

Kollaleira



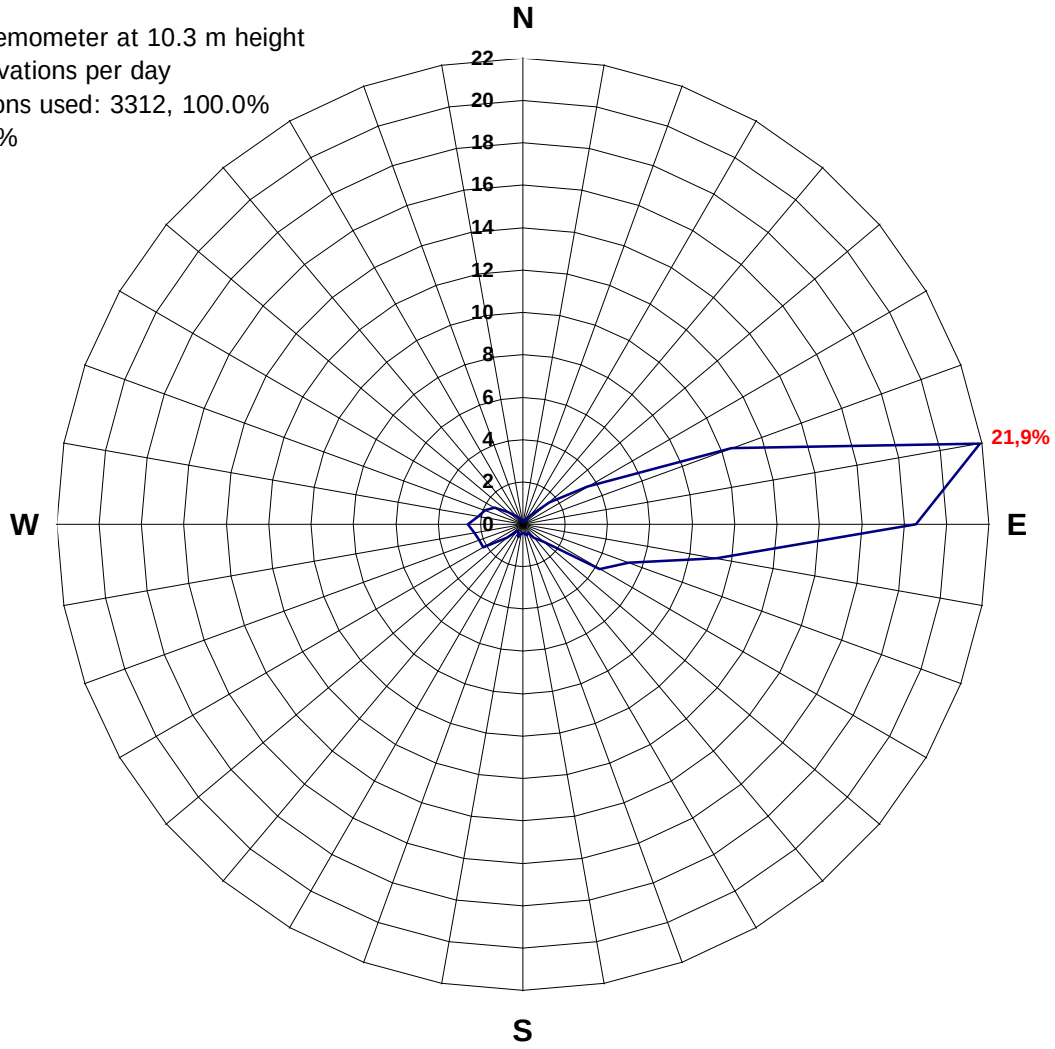
Kollaleira



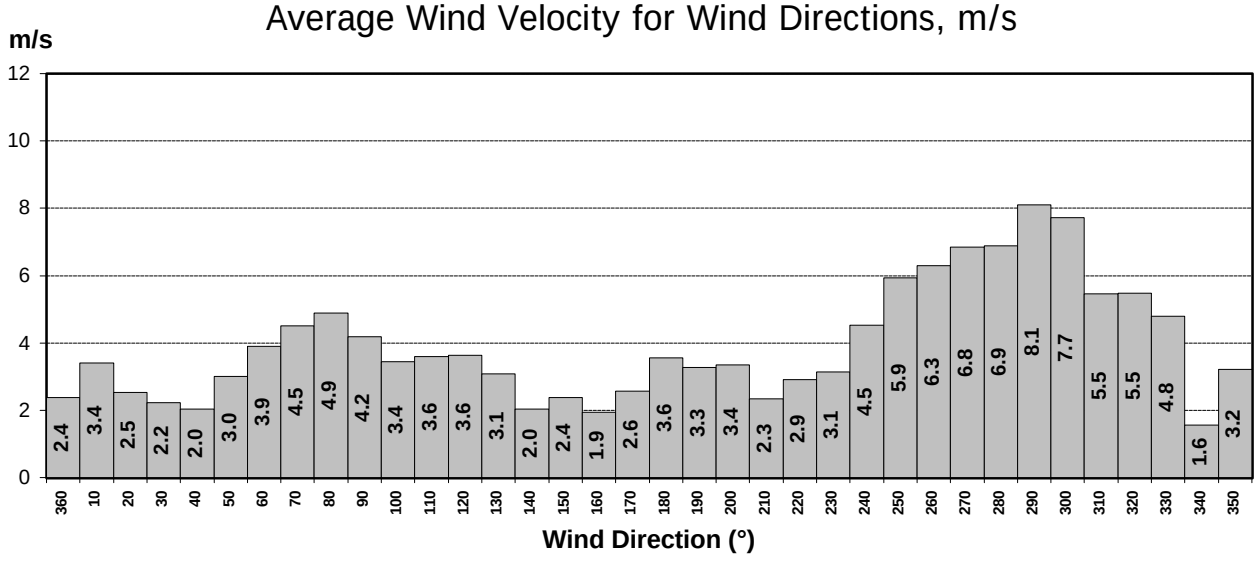
Annex 20

Frequency of Wind Directions, %
High Summer, June - August 1999, Day Hours 12 - 18 GMT

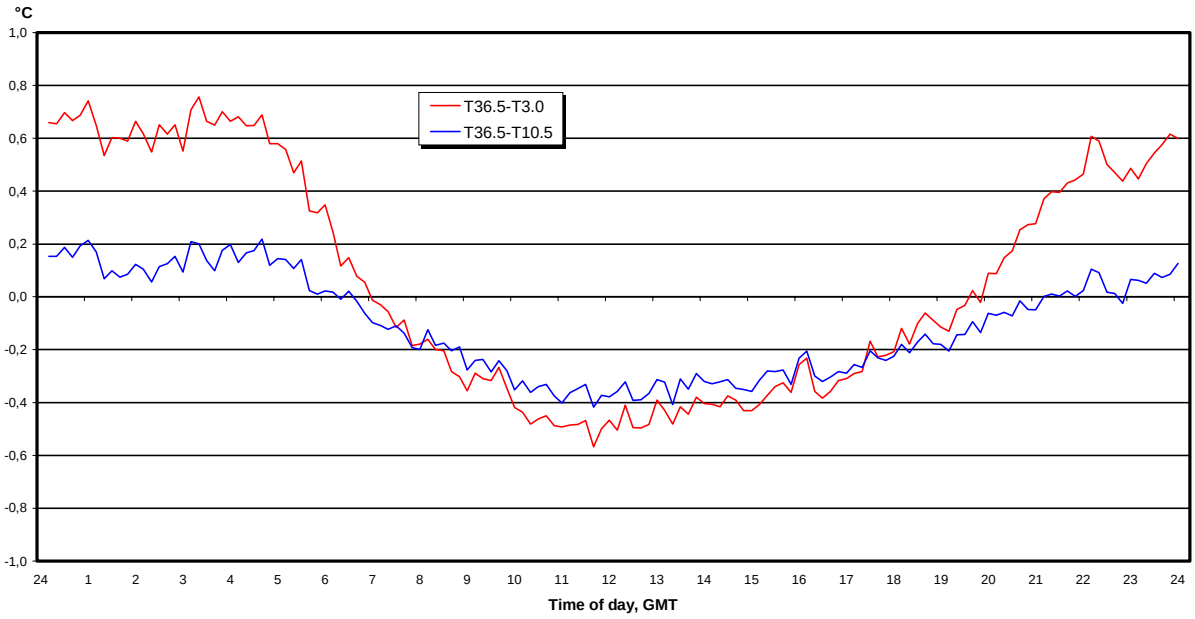
Young Anemometer at 10.3 m height
144 observations per day
Observations used: 3312, 100.0%
Calm: 0.1%



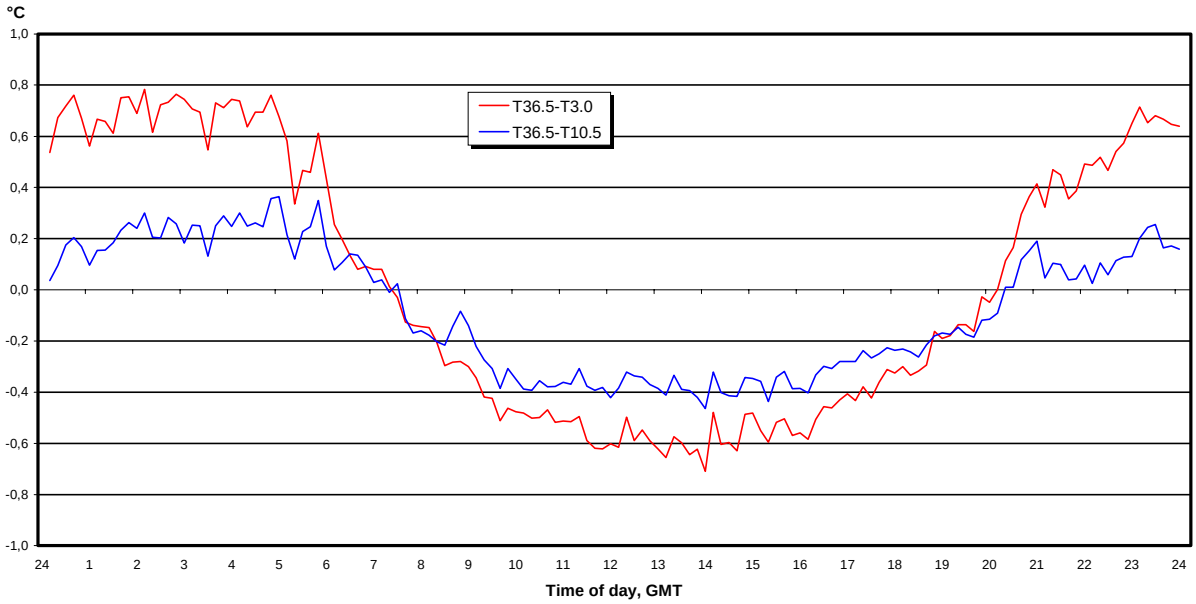
Average Wind Velocity for Wind Directions, m/s



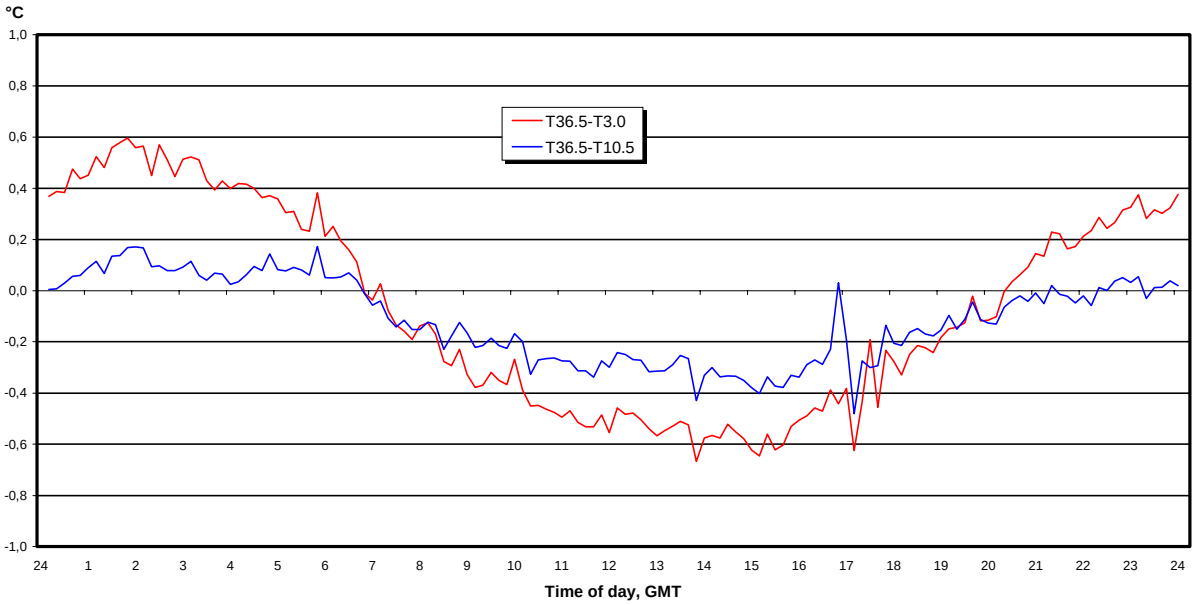
Sómastaðagerði
Average Vertical Temperature Gradient, °C
May 1999



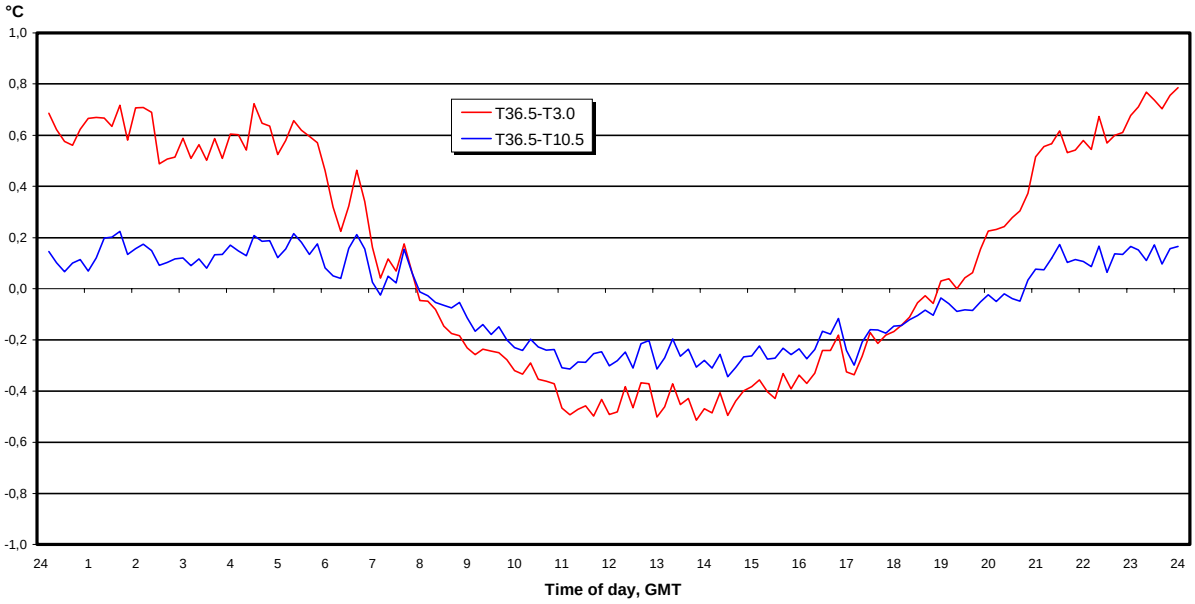
Sómastaðagerði
Average Vertical Temperature Gradient, °C
June 1999



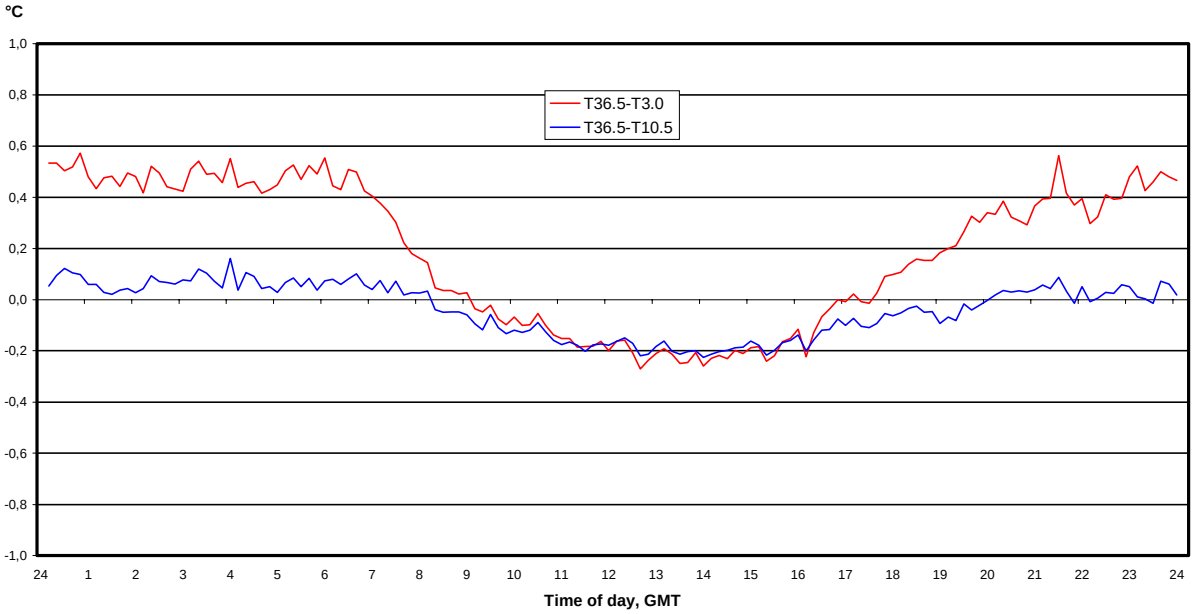
Sómastaðagerði
Average Vertical Temperature Gradient, °C
July 1999



Sómastaðagerði
Average Vertical Temperature Gradient, °C
August 1999



Sómastaðagerði
Average Vertical Temperature Gradient, °C
September 1999



Sómastaðagerði
Average Vertical Temperature Gradient, °C
October 1999