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Extreme wind analysis at Stadlandet

Knut Harstveit

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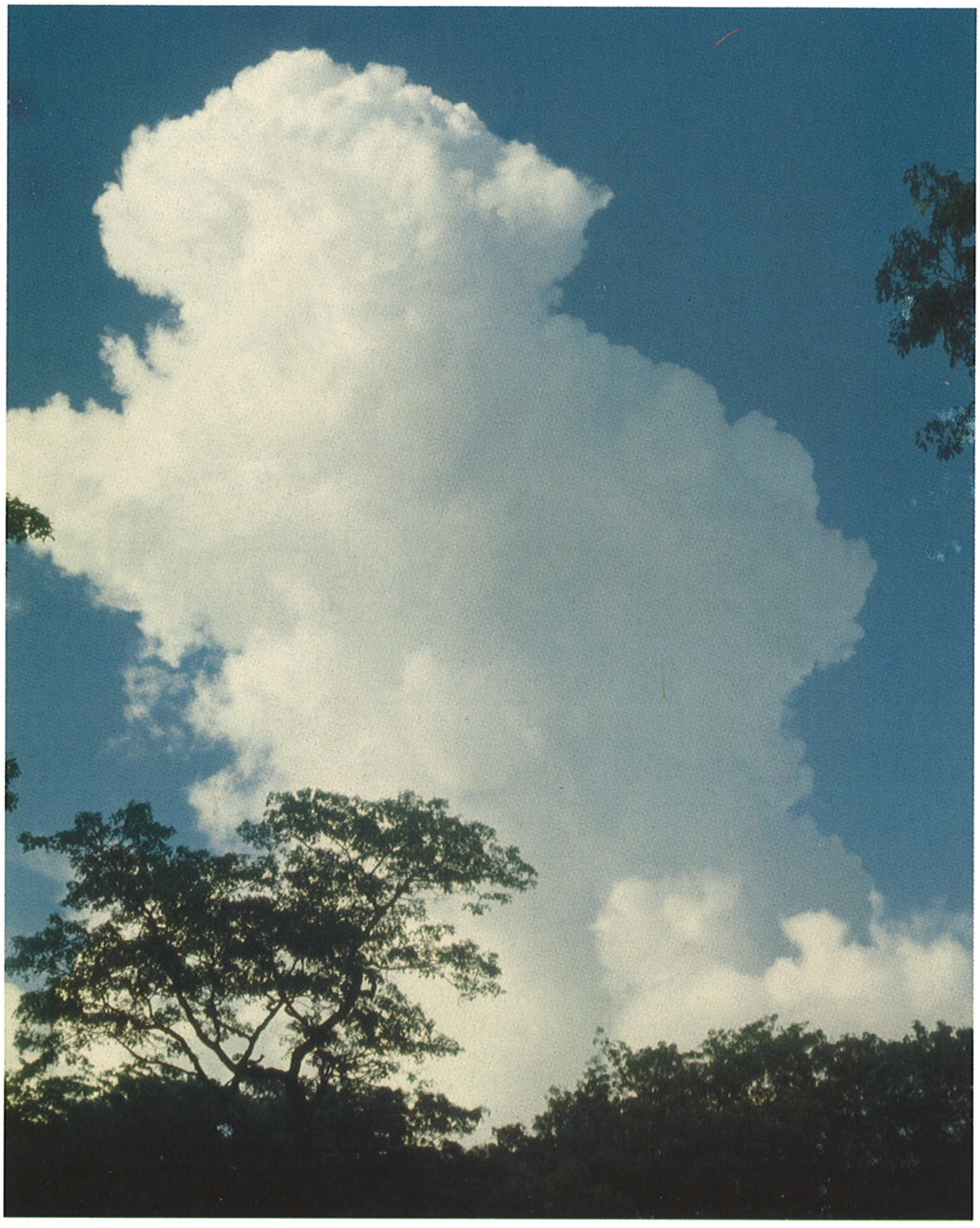

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EXTREME WIND ANALYSIS AT STADLANDET

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KJELLER VINDTEKNIKK

SUMMARY

This work is made for Kjeller Vindteknikk, using the data collected from August/September 1998 to the end of December / the beginning of January 1999.

50 year values of mean wind speed and wind gusts are given 50 m above ground at 11 sites at the Stadlandet peninsula, some 400 m above sea level.

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Extreme wind analysis at Stadlandet

Summary

Data from 25 years at Svinøy lighthouse are analysed by the Gumbel extreme value method. From this analysis the 50 year 10 min extreme wind speed is calculated to 41 m/s. The sector coefficients show a rather strong variation, from 0.52 at south-east and 1.00 at south-west, giving sectorial 50 year wind speeds from 21 to 41 m/s. From the shorter period 1993-98 sectorial coefficients from Svinøy to the very exposed station, Kråkenes are calculated, giving a 50 year value of 49 m/s. The strongest wind comes from south-west, while in the sector E to SE the 50 year value is only 23 m/s due to the shielding from land.

There are established coefficients from Kråkenes to the anemometer in the top of each of 11 project masts. From this comparison and the sectorial values of Kråkenes, the 50 - year values of wind speed of the project stations are established. The tables below show the extreme values of the 10 min mean wind speed, u, and the next table the corresponding values of the 2 sec. wind gusts. The all - direction 50 - year values of the wind gusts vary from 54 to 71 m/s, and are typically slightly higher than at Kråkenes.

	u110	u111	u112	u113	u114	u115	u116	u117	u118	u119	u120
N	29.2	25.7	26.8	26.5	31.0	32.9	30.7	24.7	30.6	26.4	32.2
NE	28.3	31.3	26.4	31.6	30.0	33.8	29.2	30.0	29.6	32.8	30.8
E	26.2	24.4	21.3	23.8	22.6	23.9	24.8	21.9	25.6	23.8	23.5
SE	40.3	36.0	34.0	40.5	39.7	35.1	39.2	35.9	44.4	34.2	23.1
S	33.2	48.4	33.8	39.1	35.4	36.1	38.7	41.2	38.8	30.1	40.3
SW	45.5	46.7	47.1	48.7	38.2	42.1	42.6	51.8	47.5	30.1	49.5
W	36.5	36.3	37.9	33.8	32.9	33.4	35.3	38.5	36.1	28.3	36.7
NW	30.2	25.0	26.5	27.4	29.1	30.3	27.0	22.0	27.6	22.1	30.2
All	46	50	47	49	41	42	44	52	49	35	50

	ug110	ug111	ug112	ug113	ug114	ug115	ug116	ug117	ug118	ug119	ug120	ugK
N	36.8	33.6	36.4	36.9	41.0	46.3	38.2	33.5	36.2	33.1	40.0	36.9
NE	36.2	37.2	39.1	40.5	43.7	45.4	40.8	38.1	37.0	39.4	46.2	38.5
E	32.2	29.4	27.5	30.2	32.5	33.4	31.2	27.6	32.4	29.7	33.3	28.0
SE	49.0	51.5	44.9	51.5	50.9	44.4	50.7	44.7	53.3	50.5	43.6	42.4
S	42.8	59.8	42.0	46.2	44.7	45.7	48.1	56.1	52.1	50.1	53.5	52.4
SW	59.4	63.7	58.7	59.6	54.5	57.9	57.0	70.8	64.0	49.9	60.7	59.2
W	43.7	53.5	46.9	43.5	44.9	44.5	46.5	54.8	49.1	46.3	48.8	49.8
NW	35.3	34.4	33.9	36.8	39.4	42.0	34.3	33.6	38.6	34.3	38.0	35.5
All	59	65	59	60	56	58	57	71	64	54	61	59

1. Introduction

There have been carried out wind measurements at Stadlandet in Selje community since August 1998. The aim is to describe the wind climate at the peninsula and to find out the possible wind energy production. The measurements are carried out 50 m above ground and some 400 m above sea level. The peninsula Stadlandet is sited at the North-western corner of Norway, known as one of the most windiness areas of Norway. Roughly spoken, the area is a mountain plain with no tall vegetation and steep escarpments at most sides.

Kjeller Vindteknikk have carried out the measurements for Statkraft SF. Site and topography, sensors and sensor masts are described in the report «Description of wind monitoring system at Stadt» (1).

The collected data clearly suggest that wind mills in this area have to deal with large wind loads. However, more exact knowledge of the return periods of extreme wind is essential to choose the optimal strength of the constructions.

This work is made for Kjeller Vindteknikk, using the data collected from August/September 1998 to the end of December / the beginning of January 1999. The report should not be distributed without permission from the employers.

2. Data procession and data quality

The received data from Kjeller Vindteknikk include 11 stations at the Stadlandet (1). The quality of the data was first inspected. The wind directions and wind speeds from the two measuring levels in each mast were cross - checked, and all speeds from all top levels were compared. The gust factors from each top level were verified. The gust factor is defined by the maximum wind gust from a 10 min period divided to the mean value of this period.

For mean winds above 15 m/s, all those controls were made. Some gust factors, gf < 1.00 due to errors, and such data were removed. Besides, gf>2.0 suggests questionable data except at high turbulent sites. Such data were inspected and obvious errors removed. Besides, all storm values used in the extreme value statistics were carefully controlled.

By use of the data quality control, some peak gust values (49 - 60 m/s) due to noise were found. All such values were easy identified, they occurred during periods of much lower wind speed at all other sensors, including the sensor showing the peak value. The easy identification was essential since the effect on the extreme statistics would have been rather striking. There were, however, not many such peaks, indicating that such noise should be of rather low confidence when using all-wind statistics.

The stations 110, 112, 113, 114, 115, 116, 118 and 120 have reasonable long periods of registration, while at the stations, 111, 117 and 119 the wind are measured in some shorter periods.

3. Reference stations

The record lengths from the test stations are far to short to produce any extreme values without comparing to any reference station of long records. There are two stations operated by the Norwegian Meteorological Institute, DNMI in the neighbourhood. Svinøy lighthouse is situated at a small islet some 18 km NNE of the Stad area, while Kråkenes lighthouse is situated at an outer peninsula 18 km SSW of the area. The stations so may be of equal validity when used as reference stations for the project area.

Figure 1.
Map of the Stad area and the position of reference stations Svinøy and Kråkenes.

At Kråkenes data have been stored electronically since 1993 with a sampling frequency 1/hour. Wind gusts, 10 min wind speed, and the corresponding maximum values every hour are stored, together with the wind direction. The data from this period are homogenous, and the only problem has been some periods with no signals due to defaults of the automatic weather station. Before 1993, however, the quality of the data are less good due to instrumental changes, and wind gusts have not been measured. Related to extreme value analysis, the most serious matter is due to the upper limit of the registration equipment, about 30 - 35 m/s. Kråkenes is a very windy station, and this upper limit is exceeded almost every year, and by the strongest storms, during several hours with no possibility of extrapolating the real value. So the station cannot be used alone as a long-time reference station.

Svinøy, on the other side, have been operated by Fuess 90z, which is a better anemometer, also measuring gust. However, this anemometer as well has too low upper limits; 40 - 45 m/s for wind gusts and 30 m/s for mean wind speed. But the station is somewhat less wind exposed for the strongest storms from south to south-west, and there have been possible to give reasonable extrapolations of data by inspecting the trace and comparing to neighbouring stations. The record length is far homogenous from 1974 to 1998. However, data from the station are stored electronically only from each 6 hours. Data stored are 10 mean wind speed, 3-5 s wind gust and wind direction, measured at 00, 06, 12, and 18 GMT. Also the maximum values last 6 hours of the wind gust and 10 min wind speed are stored. Continuous registrations exist, but at paper strips.

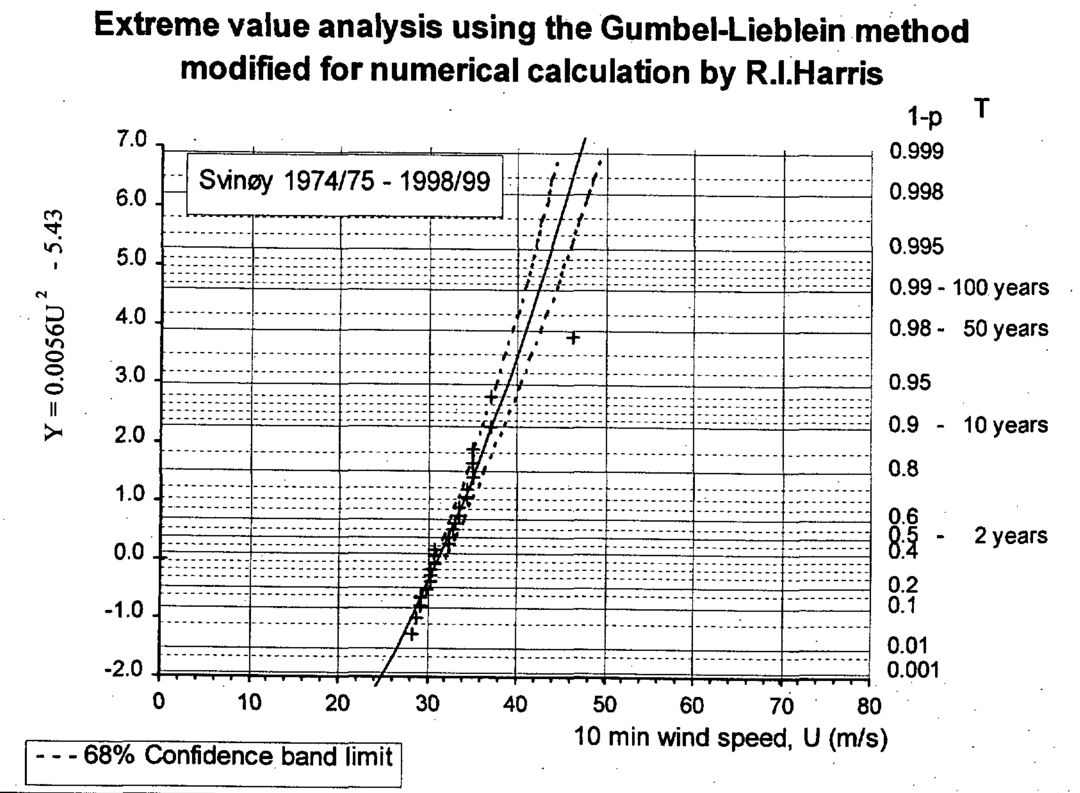
The maximum wind speed of each of the 8 wind directions is earlier read by students and exist as a part of an extreme value data basis.

4. Methods and results

A method of calculating extreme values from a long data series at Svinøy (1974/75 - 98/99) and comparing these data to Kråkenes using the shorter period 1993-98 was chosen. Data from Kråkenes were transferred to a project reference station and from this station further to the rest of the project masts, using some 5 months during autumn 1998.

4.1 Extreme value analysis of the Svinøy data

Data from 25 years at Svinøy lighthouse (1974/75 - 1998/99) are analysed by the Gumbel extreme wind method. The results is given in Figure 2. The analysis is made using U^2 as free variable. The parent data at Svinøy are Rayleigh - distributed (Weibul - distribution with the form parameter of 2), and then U^2 have a better convergence than U (2). As seen, the fit to the data is rather good, except from the data point of 46 m/s, representing the hurricane of 1.1.92. This storm value is objectively plotted as an outlier. An up to day analysis using an automatic method suggested by R. Harris (3) to determine the Gumbel parameters by the Lieblein technique is used. This method gives less weight to the highest and lowest yearly extremes.



p	0.5	0.2	0.1	0.05	0.04	0.02	0.01	
T	2	5	10	20	25	50	100	years
U	32.3	35.3	37.2	38.9	39.4	41.0	42.5	m/s
U_T/U_{50}	0.79	0.86	0.91	0.95	0.96	1.00	1.04	

Figure 2

Extreme value analysis of data from Svinøy lighthouse including transfer factors from the all-direction value to the specified directional extremes.

The 50 year 10 min extreme wind speed at Svinøy was calculated to 41.0 m/s by the Gumbel analysis. The sector coefficients were calculated by a procedure of choosing the highest episodes of each sector through the period, the results are 0.58 to 1.00, giving sectorial 50 year wind speeds from 21.3 to 41.0 m/s.

Table 1

Sectorial transfer coefficients and 50 - year extreme values of 10 minute wind speed at Svinøy

	N	NE	E	SE	S	SW	W	NW	All
Tr.coeff.	0.70	0.69	0.58	0.52	0.86	1.00	0.92	0.68	1.00
50 yr.w.	28.7	28.3	23.8	21.3	35.3	41.0	37.7	27.9	41.0

4.2 Transformation from Svinøy to Kråkenes

From the period 1993-98, sectorial coefficients from Kråkenes to Svinøy were calculated for 7 sectors; N, NE, E+SE, S, SW, W, and NW. The 5 highest wind episodes were individually sorted, giving 7 transfer coefficients. The results are given in Table 2. It is there seen that the wind at Kråkenes is stronger than at Svinøy, especially the wind from south-west. The 50 - year value at Kråkenes is calculated to 49.4 m/s, which is very high. The reason probably is a combined effect of the local speed-up at Kråkenes lighthouse and a little more regional effect usually referred to at the corner effect at Stad.

The 50 year extreme wind speed at Kråkenes then are given in the right column of Table 2.

Table 2
Sectorial and all-sector 50 year wind speeds at Svinøy and Kråkenes, and directional transfer coefficients from Svinøy to Kråkenes.

	U_{50Sv}	U_K/U_{Sv}	U_{50K}
N	28.6	1.03	29.5
NE	28.1	1.10	30.8
E + SE	23.6	0.99	23.4
S	35.2	1.14	40.1
SW	41.0	1.21	49.4
W	37.6	1.12	42.0
NW	27.7	1.06	29.4
All	41.0		49.4

4.3 Relations between Kråkenes and the project stations

To select the project reference station, a correlation analysis was performed, using the average value from all stations and each of the stations in turn. For the 10 min mean wind speed, the correlation coefficient varied through 0.94 to 0.97 for the stations of longest data series. The fluctuation of the wind direction was also calculated by adding the squared deviation between each station and the average value. The square root of this value varied in average from 27 to 40°. The station no 118 was chosen as the reference station due to the combination of a high correlation coefficient and a low direction deviation (0.96; 27°). The station also has continuos data series and is situated far out at the plateau, being an average in the further computations.

At Kråkenes the maximum wind gust, Ug and the maximum 10 min wind speed, U_{x10min} are stored each hour. The same data were chosen from station no 118. Then all periods showing missing data at one of the two stations were removed also from the other station. All time spots where the values of $U_{x10min} \geq 10$ m/s at one of the two stations were stored also at the other station, while other data were removed. The remaining data were divided in 8 wind directions (N, NE, E, SE, S, SW, W and NW) by use of Kråkenes as direction indicator. Ug and U_{x10min} from each station and each sector were then independently sorted. The independent sorting procedure is suitable because all noise due to uneven distributed wind fields then easily smoothes out.

The same procedure was used in comparing stn. 118 and each of the other project stations.

Transfer coefficients from Kråkenes to stn. 118 and further to the other stations were so calculated, using U_{x10min} from Kråkenes as the free variable. The coefficients were calculated using the n strongest wind-data, n=1,2,3,....... . The choice of the actual value of n to be used in the further work, is a compromise between the need for data, and the wish of using the strongest wind episodes.

The coefficients from the mean wind, U_{x10min} at Kråkenes to the project stations are shown, using the average of the 5 highest speeds to the corresponding wind (Table 3) and wind gusts (Table 4). Table 5 shows that there are rather small differences using 5 or 10 episodes, typical 0 to 5 %, being a weak tendency of slightly lower coefficients using n=10. Therefore, n=5 is used in the further analysis, since the long return periods are of primary interest.

Table 3

Transfer coefficients from the U_{x10min} data at Kråkenes to the project stations calculated by the procedure given in chapt.4, using n=5 number of data.

n=5	**u110**	**u111**	**u112**	**u113**	**u114**	**u115**	**u116**	**u117**	**u118**	**u119**	**u120**
N	0.99	0.87	0.91	0.90	1.05	1.11	1.04	0.84	1.04	0.90	1.09
NE	0.92	1.01	0.86	1.02	0.97	1.10	0.95	0.97	0.96	1.06	1.00
E	1.12	1.04	0.91	1.02	0.97	1.02	1.06	0.94	1.10	1.02	1.00
SE	1.73	1.54	1.46	1.73	1.70	1.50	1.68	1.54	1.90	1.47	0.99
S	0.83	1.21	0.84	0.98	0.88	0.90	0.97	1.03	0.97	0.75	1.01
SW	0.92	0.95	0.95	0.99	0.77	0.85	0.86	1.05	0.96	0.61	1.00
W	0.87	0.86	0.90	0.80	0.78	0.80	0.84	0.91	0.86	0.67	0.87
NW	1.03	0.85	0.90	0.93	0.99	1.03	0.92	0.75	0.94	0.75	1.03

Table 4

Transfer coefficients from the U_{x10min} data at Kråkenes to U_g at the project stations calculated by the procedure given in chapt.4, using n=5 number of data.

n=5	**ug110**	**ug111**	**ug112**	**ug113**	**ug114**	**ug115**	**ug116**	**ug117**	**ug118**	**ug119**	**ug120**	**ugK**
N	1.25	1.14	1.24	1.25	1.39	1.57	1.30	1.14	1.23	1.12	1.36	1.25
NE	1.17	1.21	1.27	1.31	1.42	1.47	1.32	1.24	1.20	1.28	1.50	1.25
E	1.38	1.26	1.18	1.29	1.39	1.43	1.34	1.18	1.38	1.27	1.42	1.20
SE	2.10	2.20	1.92	2.20	2.18	1.90	2.17	1.91	2.28	2.16	1.87	1.81
S	1.07	1.49	1.05	1.15	1.11	1.14	1.20	1.40	1.30	1.25	1.33	1.31
SW	1.20	1.29	1.19	1.21	1.10	1.17	1.15	1.43	1.29	1.01	1.23	1.20
W	1.04	1.27	1.11	1.03	1.07	1.06	1.11	1.30	1.17	1.10	1.16	1.18
NW	1.20	1.17	1.16	1.25	1.34	1.43	1.17	1.14	1.31	1.17	1.29	1.21

Table 5
The relation between the transfer coefficients from Kråkenes to the project stations calculated by the procedure given in chapt.4, using n=5 and n=10 number of data.

n10/n5	u110	u111	u112	u113	u114	u115	u116	u117	u118	u119	u120
N	1.01	0.97	0.99	1.00	0.99	1.01	1.00	0.98	0.99	0.97	1.00
NE	1.00	0.99	1.01	0.97	1.00	0.97	0.99	1.00	1.02	1.03	1.03
E	0.95	1.03	1.04	1.03	1.03	1.01	1.02	1.04	1.04	1.00	1.01
SE	0.93	0.95	0.95	0.96	0.95	0.96	0.96	0.95	0.95	1.02	0.95
S	1.02	0.98	1.00	1.01	0.99	1.00	1.00	0.98	1.00	0.97	1.00
SW	0.95	0.99	0.98	0.98	1.00	0.97	0.97	0.97	0.97	0.99	0.99
W	1.00	0.94	0.99	0.99	0.99	0.98	0.97	0.92	0.98	0.99	0.97
NW	1.00	0.97	1.01	1.01	1.02	0.97	1.01	0.98	1.00	0.92	0.98

n10/n5	ug110	ug111	ug112	ug113	ug114	ug115	ug116	ug117	ug118	ug119	ug120	ugK
N	1.00	0.99	0.99	0.99	0.99	0.99	0.99	0.99	1.01	1.04	0.99	1.00
NE	0.97	0.98	0.99	0.99	1.01	1.00	1.04	0.99	1.03	1.02	1.00	0.99
E	0.97	1.06	1.01	1.01	1.00	0.96	1.01	1.04	1.03	1.00	1.00	1.00
SE	0.99	0.95	0.94	0.95	0.94	0.96	0.96	0.93	0.95	0.98	0.95	0.95
S	1.02	0.98	1.04	1.04	0.99	1.00	1.00	0.98	1.02	1.00	1.02	0.99
SW	0.98	0.97	0.99	1.00	0.97	0.99	1.01	0.96	0.98	1.02	0.99	1.00
W	0.99	0.96	0.99	0.96	0.98	1.02	0.99	0.93	1.00	0.99	1.01	1.01
NW	1.02	1.00	1.04	1.00	0.99	0.99	1.02	0.97	1.00	0.95	0.99	1.01

The transfer coefficients now are used to give extreme values for the different measuring sites at Stadlandet. For calculating the all-sector values, it is presumed that each sector contribute to this value by a lower probability than 0.02, and thus that the sum of the sectorial contributions give 0.02. This means that the all sector value give some higher extremes if 2 or more sectors give extremes of approximately the same speed.

If other return periods; T should be of interest, the coefficients U_T/U_{50} from Figure 1 are recommended.

Table 6
Calculated extreme values of 10 min. wind speed with 50 year return period at the 11 project stations on the Stadlandet peninsula.

	u110	u111	u112	u113	u114	u115	u116	u117	u118	u119	u120
N	29.2	25.7	26.8	26.5	31.0	32.9	30.7	24.7	30.6	26.4	32.2
NE	28.3	31.3	26.4	31.6	30.0	33.8	29.2	30.0	29.6	32.8	30.8
E	26.2	24.4	21.3	23.8	22.6	23.9	24.8	21.9	25.6	23.8	23.5
SE	40.3	36.0	34.0	40.5	39.7	35.1	39.2	35.9	44.4	34.2	23.1
S	33.2	48.4	33.8	39.1	35.4	36.1	38.7	41.2	38.8	30.1	40.3
SW	45.5	46.7	47.1	48.7	38.2	42.1	42.6	51.8	47.5	30.1	49.5
W	36.5	36.3	37.9	33.8	32.9	33.4	35.3	38.5	36.1	28.3	36.7
NW	30.2	25.0	26.5	27.4	29.1	30.3	27.0	22.0	27.6	22.1	30.2
All	46	50	47	49	41	42	44	52	49	35	50

Table 7

Calculated extreme values of 2-3 sec wind speed with 50 year return period at the 11 project stations on the Stadlandet peninsula, and Kråkenes lighthouse.

	ugl10	ugl11	ugl12	ugl13	ugl14	ugl15	ugl16	ugl17	ugl18	ugl19	ugl20	ugK
N	36.8	33.6	36.4	36.9	41.0	46.3	38.2	33.5	36.2	33.1	40.0	36.9
NE	36.2	37.2	39.1	40.5	43.7	45.4	40.8	38.1	37.0	39.4	46.2	38.5
E	32.2	29.4	27.5	30.2	32.5	33.4	31.2	27.6	32.4	29.7	33.3	28.0
SE	49.0	51.5	44.9	51.5	50.9	44.4	50.7	44.7	53.3	50.5	43.6	42.4
S	42.8	59.8	42.0	46.2	44.7	45.7	48.1	56.1	52.1	50.1	53.5	52.4
SW	59.4	63.7	58.7	59.6	54.5	57.9	57.0	70.8	64.0	49.9	60.7	59.2
W	43.7	53.5	46.9	43.5	44.9	44.5	46.5	54.8	49.1	46.3	48.8	49.8
NW	35.3	34.4	33.9	36.8	39.4	42.0	34.3	33.6	38.6	34.3	38.0	35.5
All	59	65	59	60	56	58	57	71	64	54	61	59

The typical 50 year wind gust at the area is calculated to 60 - 70 m/s, 50 m above ground. The high value of 71 m/s at site 117, is probably due to a combination of a ridge and a saddle point exposed to south-west. On the opposite, when the strong south-westerly wind hit the cliff at site 119, it separates, increasing the turbulence, confusion the local wind direction, but lower the wind speeds. This is especially seen as the low value of the 50 year 10 min wind speed from SW, 30 m/s. The reason for the non-equal extremes in the area is due to the rough terrain. For sites at other places than at the measuring sites, it therefore should be reasonable to choice the highest spot value.

5. References

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Appendix

Table A.1

Independent sorted hourly maxima of the 10 min mean wind speed and the 2-3 sec. wind gusts, and the variation of the transfer coefficient according to number of episodes used. Stations: Kråkenes and stn. 118.

N

Ukx	Ukg	U118	Ug118	Ukg/Ukx	U118/Ukx	UG118/Ukx
20.6	25.6	21.37	25.5	1.24	1.04	1.24
20.2	25.5	21.10	24.5	1.25	1.04	1.22
20.0	25.1	20.82	24.5	1.25	1.04	1.22
19.9	24.9	20.72	24.5	1.25	1.04	1.23
19.8	24.6	20.22	24.5	1.25	1.04	1.23
19.7	24.2	20.01	24.5	1.25	1.03	1.23
19.3	23.9	19.93	24.5	1.25	1.03	1.23
19.2	23.8	19.62	24.5	1.25	1.03	1.24
18.9	23.7	19.27	23.5	1.25	1.03	1.24
18.7	23.3	19.10	23.5	1.25	1.03	1.24

NE

Ukx	Ukg	U118	Ug118	Ukg/Ukx	U118/Ukx	UG118/Ukx
21.8	28.5	20.65	27.5	1.31	0.95	1.26
21.4	27.0	20.29	25.5	1.28	0.95	1.23
21.0	25.8	19.98	24.5	1.27	0.95	1.21
20.6	24.5	19.70	24.5	1.25	0.95	1.20
19.5	24.5	19.41	23.5	1.25	0.96	1.20
18.2	23.0	18.34	23.5	1.25	0.97	1.21
18.1	21.8	18.02	23.5	1.25	0.97	1.23
17.7	21.7	17.71	23.5	1.24	0.97	1.24
17.7	21.7	17.50	22.5	1.24	0.98	1.24
17.5	21.1	17.36	21.5	1.24	0.98	1.24

E

Ukx	Ukg	U118	Ug118	Ukg/Ukx	U118/Ukx	UG118/Ukx
20.0	23.2	19.72	22.5	1.16	0.99	1.12
16.4	19.3	17.98	22.5	1.17	1.04	1.23
15.4	18.5	17.17	22.5	1.18	1.06	1.30
14.7	18.4	17.00	22.5	1.19	1.08	1.35
14.6	17.9	16.95	22.5	1.20	1.10	1.38
14.2	17.2	16.74	21.5	1.20	1.11	1.40
14.0	17.1	16.47	21.5	1.20	1.12	1.42
14.0	17.0	16.40	20.5	1.21	1.12	1.43
13.8	16.5	16.26	19.5	1.20	1.13	1.42
13.3	16.2	16.19	19.5	1.21	1.14	1.43

Table A.1 cont.

SE

Ukx	Ukg	U118	Ug118	Ukg/Ukx	U118/Ukx	UG118/Ukx
13.7	25.3	26.22	30.5	1.85	1.91	2.22
13.5	23.3	25.12	30.5	1.79	1.89	2.24
12.7	23.2	25.03	29.5	1.80	1.91	2.27
12.6	22.8	23.79	29.5	1.80	1.91	2.28
12.1	22.5	22.58	27.5	1.81	1.90	2.28
12.0	20.4	21.25	25.5	1.80	1.88	2.26
11.5	18.7	20.98	24.5	1.77	1.87	2.24
11.3	18.3	20.79	24.5	1.76	1.87	2.23
11.3	17.7	18.36	21.5	1.74	1.84	2.20
11.3	17.7	17.09	21.5	1.72	1.81	2.17

S

Ukx	Ukg	U118	Ug118	Ukg/Ukx	U118/Ukx	UG118/Ukx
33.8	45.3	31.90	42.5	1.34	0.94	1.26
32.4	43.8	31.73	42.5	1.35	0.96	1.28
31.9	40.7	31.04	41.5	1.32	0.97	1.29
31.7	40.2	30.83	41.5	1.31	0.97	1.29
30.5	39.7	29.73	40.5	1.31	0.97	1.30
30.4	38.8	29.44	40.5	1.30	0.97	1.30
30.2	38.3	29.20	40.5	1.30	0.97	1.31
29.8	38.1	29.04	40.5	1.30	0.97	1.32
29.7	37.9	28.99	40.5	1.29	0.97	1.32
29.6	37.5	28.97	40.5	1.29	0.97	1.33

SW

Ukx	Ukg	U118	Ug118	Ukg/Ukx	U118/Ukx	UG118/Ukx
38.6	45.8	35.72	47.5	1.19	0.93	1.23
36.1	45.5	34.57	47.5	1.22	0.94	1.27
34.7	40.1	34.31	47.5	1.20	0.96	1.30
33.5	40.0	32.66	44.5	1.20	0.96	1.31
33.5	39.9	32.33	41.5	1.20	0.96	1.29
33.3	39.6	32.21	40.5	1.20	0.96	1.28
32.9	39.5	29.66	39.5	1.20	0.95	1.27
31.8	38.7	27.84	39.5	1.20	0.94	1.27
31.7	38.0	26.91	39.5	1.20	0.94	1.27
30.7	37.9	26.39	39.5	1.20	0.93	1.27

Table A.1 cont.

W

Ukx	Ukg	U118	Ug118	Ukg/Ukx	U118/Ukx	UG118/Ukx
24.0	28.6	23.88	32.5	1.19	0.99	1.35
23.3	27.4	21.80	26.5	1.18	0.97	1.25
23.1	27.2	18.10	26.5	1.18	0.91	1.21
22.8	27.0	17.60	24.5	1.18	0.87	1.18
21.8	25.9	17.24	24.5	1.18	0.86	1.17
21.6	25.9	17.19	24.5	1.19	0.85	1.16
20.9	25.9	17.09	24.5	1.19	0.84	1.16
20.2	25.7	16.86	24.5	1.20	0.84	1.17
20.2	24.1	16.83	23.5	1.20	0.84	1.17
20.1	24.0	16.78	23.5	1.20	0.84	1.17

NW

Ukx	Ukg	U118	Ug118	Ukg/Ukx	U118/Ukx	UG118/Ukx
20.6	23.5	17.74	23.5	1.14	0.86	1.14
17.7	22.2	17.62	23.5	1.19	0.92	1.23
17.4	21.6	16.59	23.5	1.21	0.93	1.26
16.9	20.0	15.76	23.5	1.20	0.93	1.29
16.0	19.7	15.69	22.5	1.21	0.94	1.31
15.9	19.6	14.97	22.5	1.21	0.94	1.33
15.8	19.5	14.95	22.5	1.21	0.94	1.34
15.7	19.4	14.90	20.5	1.22	0.94	1.34
15.7	19.4	14.87	19.5	1.22	0.94	1.33
15.6	19.3	14.85	19.5	1.22	0.94	1.32