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Stefan Trzeciak

**An Analysis of Frequency and Directions of Stormy Winds  
on the Szczecin-Świnoujście Fairway**

*Based on data from the period 1961–1990 a frequency profile was made for the occurrence and directions of stormy winds on the Szczecin-Świnoujście fairway. The analysis performed showed a differentiation of the wind frequency both along the fairway and over the year – their number in the cold half-year is almost twice as high as in the summer half-year. The directions are similar in various periods of the year.*

**Analiza częstości i kierunków wiatrów sztormowych  
na torze wodnym Szczecin-Świnoujście**

*W oparciu o dane z lat 1961–1990 przeprowadzono charakterystykę częstości występowania oraz kierunków wiatrów sztormowych na torze wodnym Szczecin-Świnoujście. Analiza wykazała zróżnicowanie częstości występowania tych wiatrów wzdłuż toru, gdyż zwiększa się ona ze zbliżaniem się do morza oraz zróżnicowanie w okresie roku – ich liczba w półroczu chłodnym jest prawie dwukrotnie większa niż w półroczu ciepłym. Częstość kierunków z jakich te wiatry wieją jest w okresie całego roku zbliżona.*

The Szczecin-Świnoujście fairway leads from the sea along the river Świna, the Mielński and Piastowski Channels, the Szczecin Lagoon, the Roztoka Odrzańska (the Odra Brook), the Szeroki Nurt (the Wide Midstream), the Domiąża and the Odra to the port of Szczecin. It is about 37 miles long, and its width and depth vary throughout. Its geographical location subjects it to the clash of continental climate, dry and severe, and the oceanic climate, mild and damp with the latter slightly prevailing due to the proximity of the Baltic (Prawdź 1979). The influx of one or the other kind of air brings about considerable variability of the weather situation and consequently of the navigational conditions, with a lot of foggy days (Trzeciak 1992) and strong stormy winds making manoeuvring difficult. The last-mentioned factor is the subject of the present work, which sets out to answer the question about the frequency of stormy winds, their higher or smaller probability and the distribution of their directions on the fairway over a year. The analysis was performed on the basis of thirty-year observation material concerning the number of days with stormy wind (of 10 m/s speed at least which corresponds to 6 or more degrees on the Beaufort scale) from the years 1961–1990 at meteorological stations at Szczecin-Dąbie and Świnoujście and the smaller station at Trzebież. The data were collected from Meteorological Yearbooks published by the Institute of Meteorology and Water Economy and the Maritime Meteorological Announcements of the IMGW (Institute of Meteorology and Water Economics) at Gdynia branch and also directly from the IMGW at Warsaw. The stations mentioned are the only ones situated close to the fairway discussed. The Świnoujście station is located on a dune on the Western side of the Świna, at Szczecin Dąbie – in open space of the airport close to the Dąbskie Lake, and the small station at Trzebież in the Harbour Master's area. According to the recommendations of the WMO, World Meteorological Organization – wind observations are performed every hour, just like other meteorological features, at the smaller stations, on the other hand, three times in every 24 hours at 6.00, 12.00 and 18.00 hrs GMT. In order to store the comparability of the data from meteorological stations and posts, the latter are obliged to note all important meteorological phenomena, including winds of speed  $>10$  m/s, apart from the three above-mentioned times binding for them.

### **Analysis of results**

#### **Szczecin-Dąbie**

In the years 1961–1990 1046 days with stormy wind were registered at Szczecin Dąbie, which gives an annual average of 34.9 days. 9.5% of the total annual number of days are stormy days.



As can be concluded from the data in Table 1. the frequency of stormy wind occurrence is varied in the annual scale. There are more of them in winter, fewer in summer. The months with the most frequent occurrence of storms are January – 4.4 days, March – 4.1 days, November and December – 4.1 days each. February comes next, but with a considerably larger loss – 3.3 days. The fewest winds of this kind come in June, July and August – only 1.5 days a month.

In the cold season of the year, i.e. from October to March, the number of stormy days is clearly higher than in the warm season, from April to September. The former has 22.6 stormy days on the average, i.e. almost 65%, whereas the latter has 12.3 days, i.e. below 35%.

In relation to the total monthly number of days the share of days with stormy winds ranges from 8.4% in October to 13.7% in November. In the summer season the share is much smaller oscillating between a mere 5.0% in June and 10.5% in April. It should be noted that the value of warm-season April exceeds the value of cold-season October.

The differences between the cold and the warm season of the year are also stressed by the monthly share of stormy days in the upper annual number of days where this phenomenon occurs. In the former period it ranges from 12.3% in January and 12.0% in March to 7.4% in October; in the latter from 8.5% in April to 4.3% in June. As can be seen, in most cases it is twice as large, and in some almost three times as large in the winter months as in the summer months.

The number of stormy days in particular years and half-years in the thirty-year period analysed is also extremely variable. The highest number of these years noted in one year was 65 and it exceeds three times the smallest that was registered – 17 (a difference of 48). In the cold half-year the highest noted number was 44 and the smallest one 23 (a difference of 21), in the warm season it was 22 and 9 days (a difference of 13).

Most frequently (Table 2) the winds were noted from the directions of the Western quadrant – SW, W and NW. In total, a little less than 47% falls on these directions in the cold season, almost 53% in the summer season and 50% in the year of the total number of stormy winds. Direction N is not much different in comparison with them (especially in the warm season) – from which there blew respectively almost 15%, over 17% and less than 16% of those winds. They were noted twice or even three times less frequently from the E and SE directions – on the average, the frequency of their occurrence did not exceed 10%, and in one case not even 5%. What is remarkable is a very similar direction distribution in the cold and the warm half of the year.

Table 1

Characteristic of stormy-winds number of days at Szczecin-Dąbie (1961–1990)

Month	Average	Share in the period's day's number (%)	Share in the annual number of days with stormy wind (%)	Max	Min
January	4.3	13.9	12.3	13	0
February	3.3	11.8	9.4	9	0
March	4.2	13.5	12.0	11	1
April	3.0	10.0	8.5	8	0
May	2.2	7.1	6.3	10	0
June	1.5	5.0	4.3	8	0
July	1.6	5.2	4.6	5	0
August	1.7	5.5	4.9	6	0
September	2.3	7.7	6.6	7	0
October	2.6	8.4	7.4	7	0
November	4.1	13.7	11.7	15	0
December	4.1	13.2	11.7	10	0
Cold half-year XIII	22.6	12.3	64.8	44	23
Warm half-year IV–IX	12.3	6.6	35.2	22	9
Year	34.9	9.5	100.0	65	17

Table 2

Frequency (%) of stormy winds' directions at Szczecin Dąbie (1961–1990)

Directions	Cold half-year X–III	Warm half-year IV–IX	Year
N	14.6	17.4	15.6
NE	11.3	8.8	10.1
E	8.3	6.8	7.8
SE	7.4	3.5	5.2
S	11.1	10.8	11.0
SW	15.3	16.6	16.0
W	15.4	17.2	16.4
NW	16.6	18.9	17.9



### Trzebież

In the thirty-year-period analogical to Szczecin Dąbie, 866 days with stormy winds were recorded at Trzebież, which means fewer. Accordingly, the annual average is lower, which makes up 28.9 days. Stormy days constitute 7.9% of the total number of days in a year.

According to Table 3 the months with the highest average number of days with storms are January – 3.3 days and March and December – 3.1 days each. February comes a little further – 2.9 days and November – 2.7 days. These months are a little ahead of October and one of the summer-season months – April, both 2.6 days each. The least frequent stormy winds are recorded in July – only 1.2 days per month on the average, and in August – 1.4 days. They occur very seldom in September, too; 1.8 day on the average, and in May and June, 2.1 days each. They occur much more frequently in the earlier mentioned April – 2.6 days.

In the cold season of the year stormy winds occur much more frequently than in the warm one. In the former, 17.7 stormy days are registered on the average, which constitutes a little above 61%, and in the latter only 11.2 days, that is a little less than 39% of their total annual number.

The share of stormy days in the number of days in a month is also higher in the period; it ranges from 8.5% in October to 10.6% in January and at the same time it is very even in particular months. In the warm period it ranges from 3.9% in July up to as much as 8.7% in April, which month clearly differs by its high value from the other months of the period.

It is similar concerning the share of days with stormy winds in the total annual number of days. In the winter months it ranges from 9.0% in October and November to 11.4% in January, and in the summer months from 4.1% in July to 9.0% in April.

The number of stormy days in those years is also characterised by a high degree of changeability. The largest number of stormy days recorded in one year was 47, the smallest 26, with a difference of 21. In the cold half-year the values are 39 and 14 (25 the difference), and in the warm half-year 25 and 12 (difference 13).

The distribution of directions of stormy winds at Trzebież is similar to that of Szczecin Dąbie. Westerly and northerly directions prevail – SW, W, NW and N (Table 4). Each of them makes up over 15% of their total number, that is over 60% of those winds all in all. The winds were also least frequently recorded from south-easterly directions – E, SE and S. Also, as in Szczecin Dąbie, their percentage distribution in the cold and warm seasons of the year is very similar – in most directions the differences do not exceed 1% and only in one case (SE), reaching less than 3%.

Table 3

Number profile of days with stormy winds at Trzebież (1961–1990)

Month	Average	Percentage share in the period's number of day's	Percentage share in the yearly number of days with stormy winds	Max	Min
January	3.3	10.6	11.4	9	0
February	2.9	10.4	10.0	10	0
March	3.1	10.0	10.7	10	0
April	2.6	8.7	9.0	6	0
May	2.1	6.7	7.3	8	0
June	2.1	7.0	7.3	6	0
July	1.2	3.9	4.1	7	0
August	1.4	4.5	4.8	5	0
September	1.8	6.0	6.2	7	0
October	2.6	8.5	9.0	11	0
November	2.7	9.0	9.0	6	0
December	3.1	10.0	10.7	9	0
Cold half-year XIII	17.7	9.6	61.2	39	14
Warm half-year IV–IX	11.2	6.1	38.8	25	12
Year	28.9	7.9	100.0	47	26

Table 4

Frequency (%) of stormy winds' directions at Trzebież (1961–1990)

Directions	Cold half-year X–III	Warm half-year IV–IX	Year
N	15.6	15.0	15.3
NE	12.3	11.4	12.1
E	8.1	7.4	7.9
SE	5.5	8.2	6.6
S	9.2	10.2	9.8
SW	15.1	14.4	14.3
W	16.1	18.2	17.4
NW	18.1	15.2	16.6



### Świnoujście

In the period 1961–1990 1242 stormy days were recorded all in all at Świnoujście. On the average 41.4 days fall on each year. Stormy days make up 11.3% of the total yearly number of days.

It results from analysis of Table 3 that stormy winds were recorded most frequently in March – 4.9 days in a month on the average, next in November – 4.8 days, and in January 4.5 days. These three months of the year's cold season tower quite clearly above the other months of the winter period. These winds were recorded least frequently in July – only 1.9 days in the month on the average and 2.0 days in June. These two months also stand out quite clearly from the other warm-season months.

On the average, 25.2 days fall on the cold season, that is a little more than 61%, and 16.0 days on the warm season – a little less than 39%.

The share of stormy days' number in the number of days in the month ranges from 15.0% in November and 15.8% in March to 11.6% in October in the cold season, and from 6.1% in July to 12.7% in April in the warm season, April being the month standing out in this respect both at Szczecin Dąbie and Trzebież.

The share of particular months of the winter season in the yearly number of stormy days is very even and ranges from 11.8% in March and 11.6% in November to 8.7% in October; in the summer period from 4.6% in July and 4.8% in June to 7.5% in April.

The number of stormy days also varies considerably from year to year; the largest recorded in one year is 63, the smallest 22, which gives a difference of 41. In the winter half-year 41 is the largest number and 27 the smallest, with a difference of 14, in the summer half-year 29 and 16 respectively, with a difference of 13.

The prevalence of stormy winds from western quadrant directions at this station – SW, W and NW over the other directions is very clear (Table 6). More than 15% of their total falls on each of them, and in the case of NW even about 19%. This is more than at Szczecin Dąbie and Trzebież.

Next in turn is direction N with wind frequency over 12%. These winds were recorded least frequently from southerly and easterly directions – E, SE and S – in the range of 7–9%. In both parts of the year, the cold and the warm, the distribution of directions is very similar, just as in the case of the observation points discussed above.

Table 5

Number profile of days with stormy winds at Świnoujście (1961–1990)

Month	Average	Percentage share in the period's number of day's	Percentage share in the yearly number of days with stormy wind	Max	Min
January	4.5	12.2	10.9	14	0
February	3.6	12.9	8.9	15	0
March	4.9	15.8	11.8	10	0
April	3.8	12.7	7.5	12	0
May	3.0	9.7	7.2	14	0
June	2.0	6.7	4.8	9	0
July	1.9	6.1	4.6	10	0
August	2.5	8.1	6.0	8	0
September	2.8	9.3	6.8	10	0
October	3.6	11.6	8.7	12	0
November	4.8	16.0	11.6	15	0
December	4.0	12.9	9.7	17	0
Cold half-year XIII	25.4	13.9	61.3	41	27
Warm half-year IV–IX	16.0	8.7	38.7	29	16
Year	41.4	11.3	100.0	63	22

Table 6

Frequency (%) of stormy winds' directions at Świnoujście (1961–1990)

Directions	Cold half-year X–III	Warm half-year IV–IX	Year
N	12.9	12.0	12.4
NE	9.8	10.0	10.1
E	7.4	9.7	8.6
SE	8.2	7.7	7.9
S	8.7	8.8	8.7
SW	15.7	15.6	15.7
W	17.4	17.3	17.4
NW	19.8	18.7	19.1



### Discussion of results

Analysing the data contained in Tables 1 – 6 it can be noticed that there are both differences and similarities between Szczecin Dąbie, Trzebież and Świnoujście. The differences concern the total number of stormy days recorded at these observation points; the similarities, on the other hand, concern their distribution over the year and the directions from which they blew.

The stormy winds discussed were registered most frequently at Świnoujście, next at Szczecin Dąbie and least frequently at Trzebież. Due to short distances between these places the cause of relatively large differences in the number of storms is certainly not bound with the number of baric lows passing over the places, as these configurations generally take up spaces of hundreds of kilometres (Wiśniewski i Grzelak – 1980) and thus cover all three points. It seems, however, that the cause may be their different distance from the sea and in the meteorological gardens being located in them. The station at Świnoujście, where most of the stormy winds were registered, is situated in the open space on the sea shore (a dune) and not being sheltered from the north and the west is directly exposed to strong winds blowing most often from these very directions. The station at Szczecin Dąbie and the small station at Trzebież, on the other hand, are located considerably further in the land and the friction of the moving air against the hard, uneven and afforested ground diminishes its speed considerably. The cause of the difference between Trzebież, where fewer winds were recorded, and Szczecin Dąbie may be the unfavourable location of the anemometer at Trzebież on the premises of the Harbour Master, close to buildings and surrounding tall trees, which are likely to affect the measurement results.

On the other hand, all of these points, that is Szczecin Dąbie, Trzebież and Świnoujście are very similar, as already mentioned, with respect to the distribution of stormy days over the year and their directions. In all of them their number in the cold part of the year considerably exceeds their number in the warm part; at the same time, the similar percentage proportions between these parts of the year are preserved. And so, out of the total annual number of stormy days in the cold season about 65% falls on Szczecin Dąbie and about 61% on Trzebież and Świnoujście each. January is the stormiest month in all these places (Szczecin Dąbie – 4.3 days, Trzebież – 3.3 days and Świnoujście – 4.9 days). Apart from January, the months most frequently repeating themselves are March, November and December, next February and, now with a much smaller number of stormy days, October. The fewest stormy winds in all these places are registered in July and June, and then, much more frequently, in August.

One more characteristic feature of all three points draws our attention, their concordance. Both at Szczecin Dąbie as at Trzebież and Świnoujście a very high number of storms are recorded in April, a month considered as on the warm part



of the year. At Szczecin Dąbie and Świnoujście it is clearly higher than in October, a month of the cold part, and at Trzebież they are equal. Its April value is high enough to surpass even the other winter months in a few cases. The cause of such high number of storms in April may be due to the arrival of spring, somewhat delayed in these areas, which in turn is due to the proximity of the chilled Baltic. It follows from numerous works on the climate of Poland (*inter alia* Bac and Rojek – 1979, Koźmiński – 1983 and Prawdzic – 1979) that this delay, as compared with the rest of the country, reaches 2 to 3 weeks. Also, the considerably lower number of storms in October as compared with other months of the winter half-year can be accounted for by the prolonged autumn and longer period of good weather (again, Bac, Koźmiński and Prawdzic).

The predominating directions of stormy winds in all three points of observations are SW, W, NW and N. This is an effect of western air circulation, prevalent in moderate geographical latitudes and the influx of baric lows from those directions. Eastern circulation, on the other hand, occurs seldom and has a high-pressure characteristic bringing good weather, cloudless or with few clouds. In a situation like this, strong winds occur only when there is a low-pressure embayment nearby, or if a local low-pressure centre arises causing the formation of a large pressure gradient in turn. Such winds occur mainly on the outskirts of highs, often accompanied by sunny weather.

### Conclusions

1. There is some diversity in the occurrence of stormy winds on the Szczecin – Świnoujście fairway.
2. The most frequent stormy winds are recorded at Świnoujście, over 41 days a year, next at Szczecin Dąbie, almost 35 days a year, and finally at Trzebież, less than 29 days.
3. Wind frequency in the cold period (Oct.–March) is almost twice as large as in the warm half-year (April–Sept.).
4. Months with the highest frequency of stormy winds are January and March, which are ahead of December and February.
5. The least frequent stormy winds are noted in June and July.
6. Independently of the season of the year stormy winds blowing from the directions of the western quadrant – SW, W and NW prevail in a decisive way.



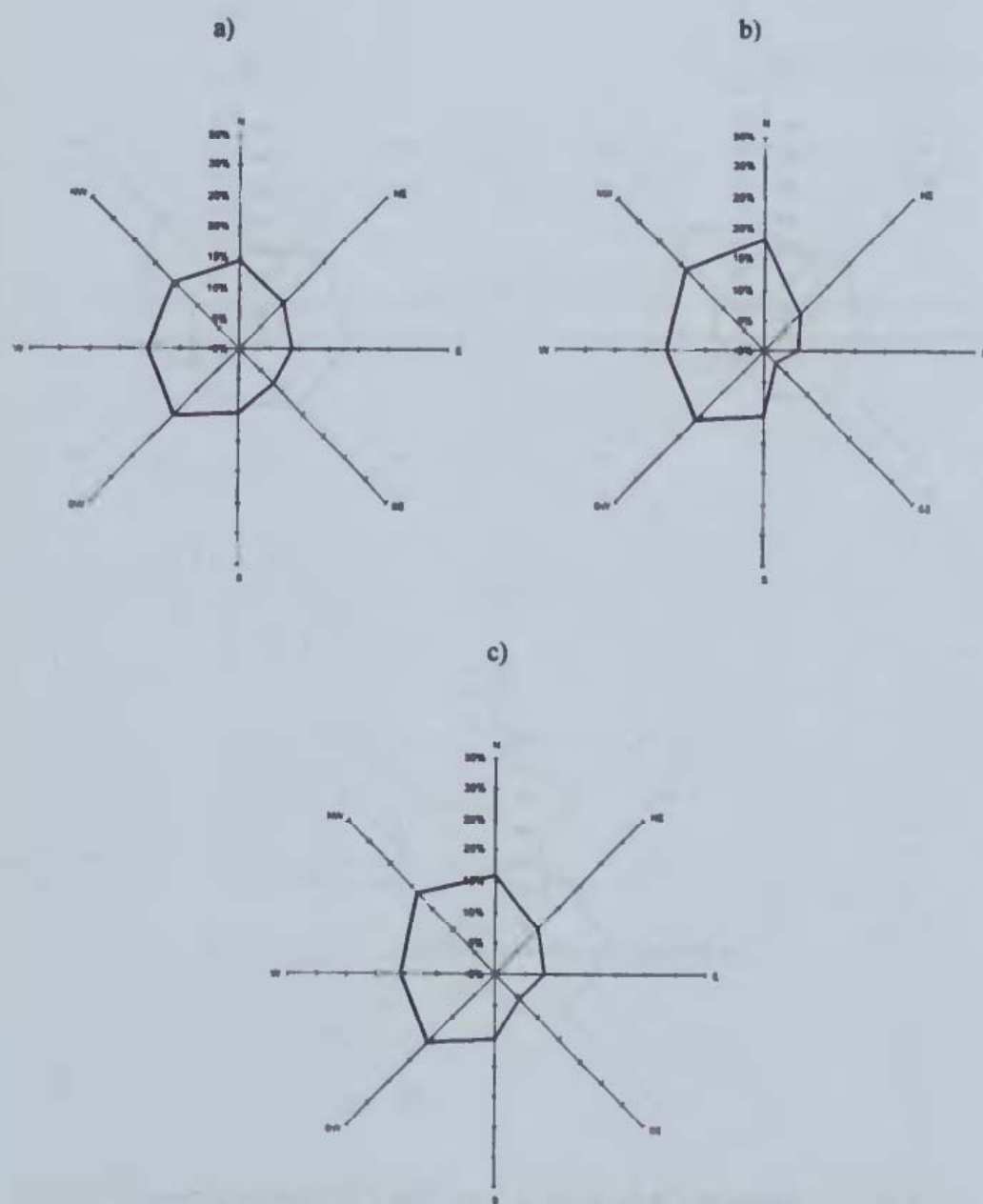


Fig. 1. Frequency percentage of directions of stormy wind at Szczecin Dąbie (1961-1990):

- a) cold half-year X - III
- b) warm half-year IV - IX
- c) the year

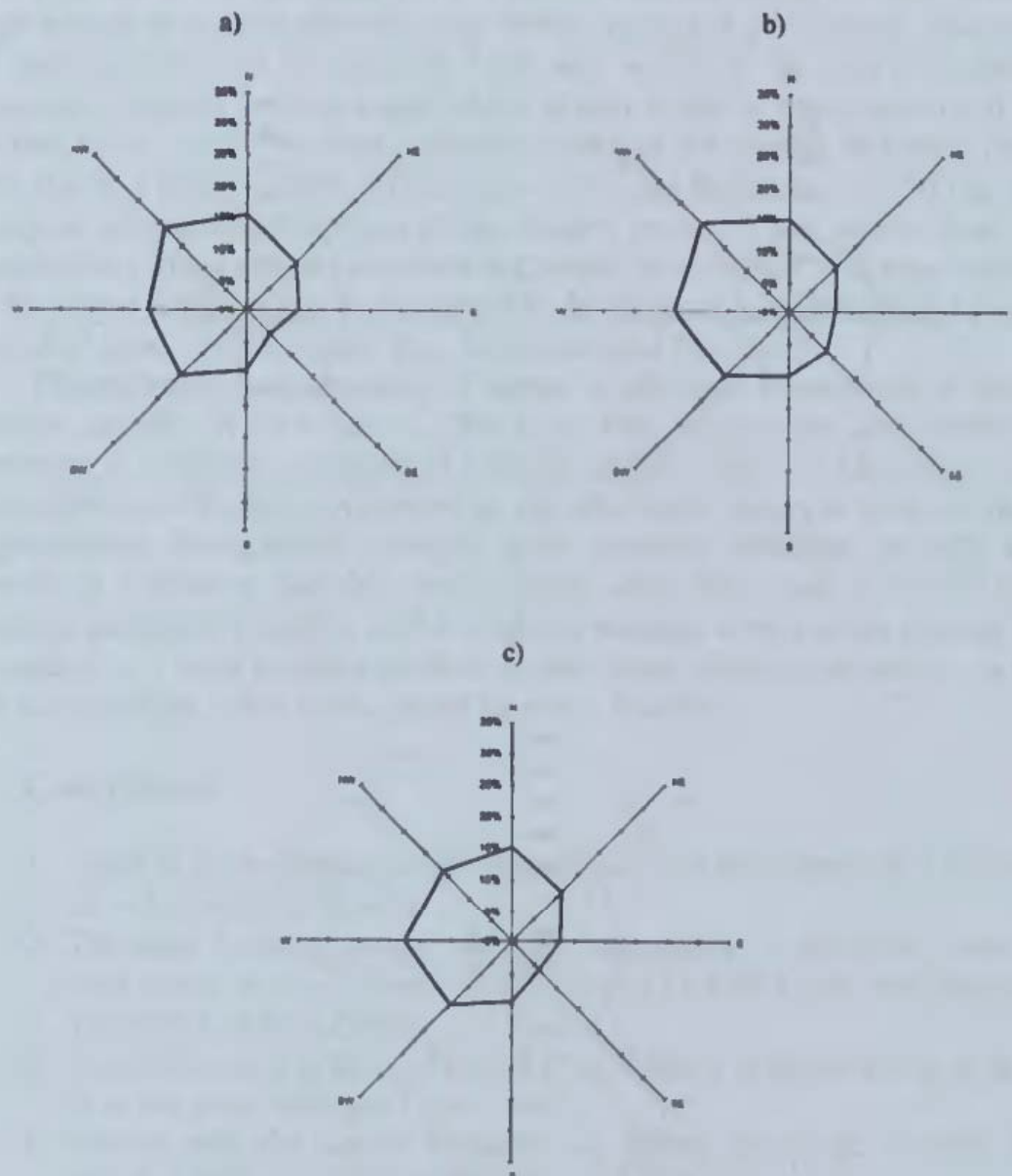


Fig. 2. Frequency percentage of directions of stormy wind at Trzebież (1961-1990):

- a) cold half-year X - III
- b) warm half-year IV - IX
- c) the year



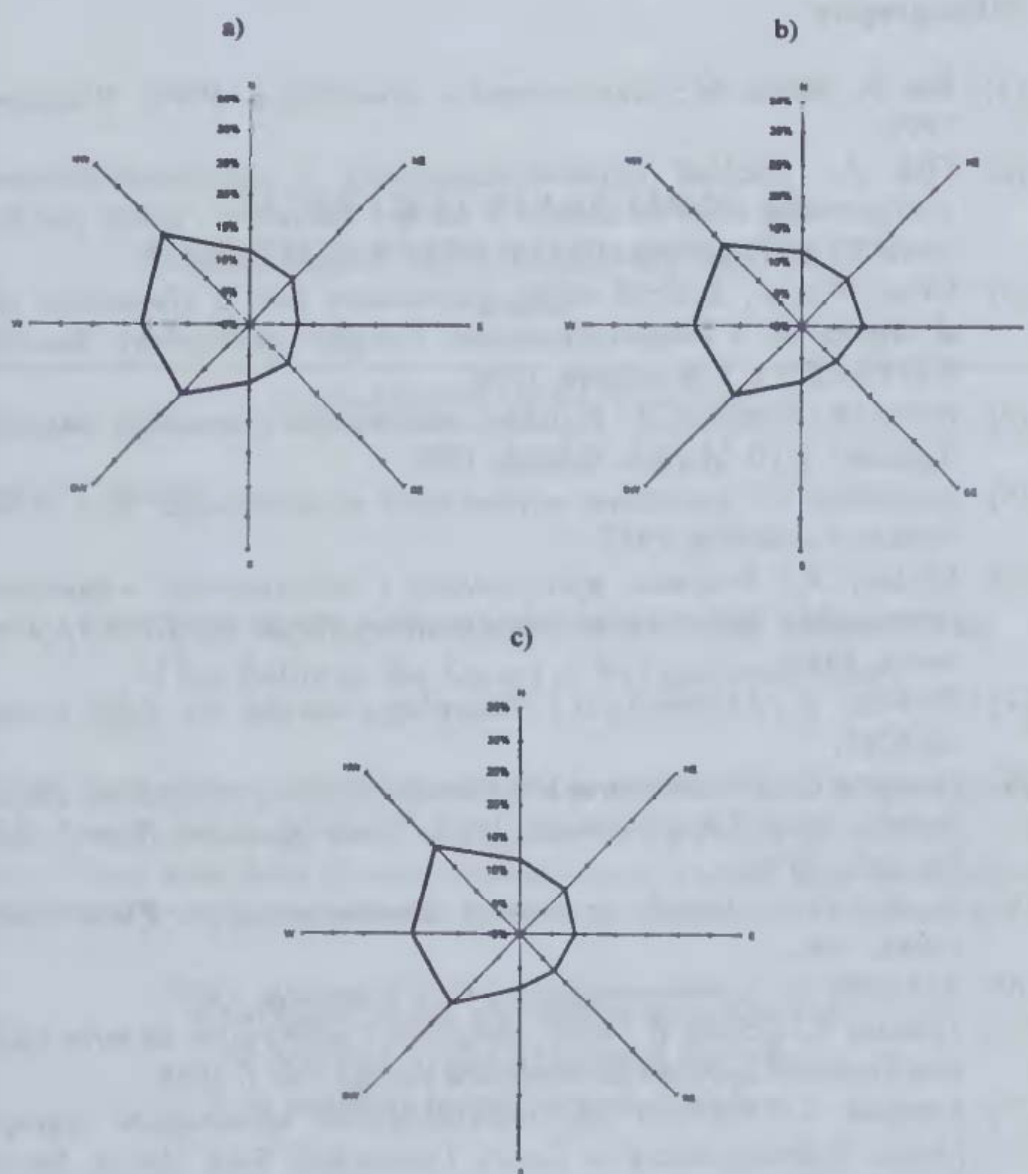


Fig. 3. Frequency percentage of directions of stormy wind at Świnoujście (1961-1990):

- a) cold half-year X - III
- b) warm half-year IV - IX
- c) the year

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