DANISH METEOROLOGICAL INSTITUTE

TECHNICAL REPORT

92-3

Danish Weather Observations 1675-1715

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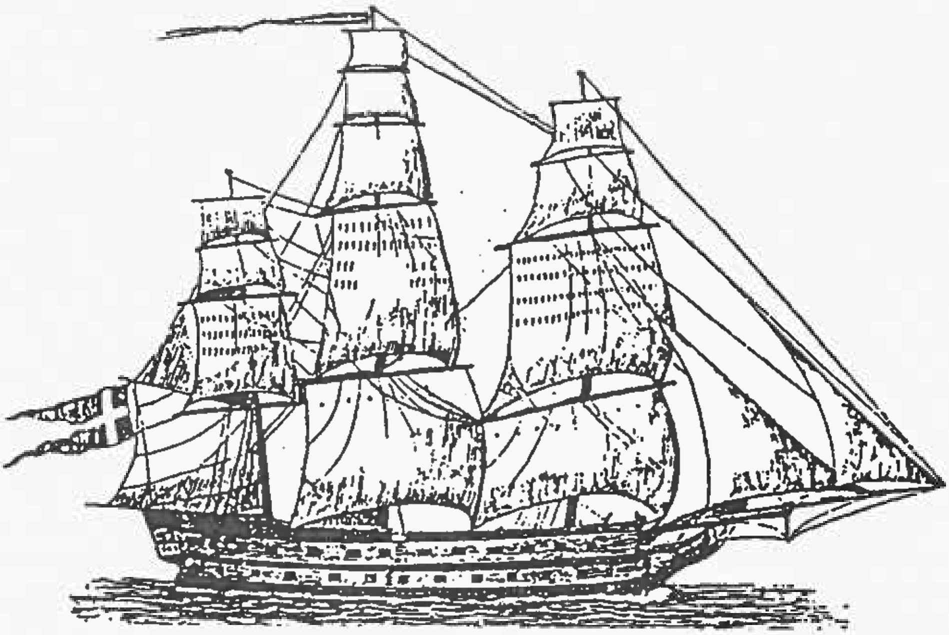

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Abstract

This report describes a digitized set of weather observations from the period 1675–1715. These data origin from Danish logbooks from the longer period 1675–1875, which have been transcribed to a standard meteorological form on code schemes. The subset of data treated has been sorted into 7 standard regions of the Danish waters. In each region the data have subsequently been averaged on a daily basis. The purpose of this averaging is to greatly reduce the temporal inhomogeneity of data, which is due to the continuing improvement of observation methods and skill of the observers in this very first period of systematic weather records from Danish ships. The data are thus intended to be suitable for application in reconstruction of daily weather maps. However, because of remaining temporal inhomogeneity, climate statistics or timeseries analysis on this 40 years period should be performed only with great caution.

Contents

1 Introduction

Before the foundation of the Danish Meteorological Institute in 1872 one of the best sources of meteorological data were logbooks from ships and lights. The astronomer Tycho Brahe was the first to perform systematic weather observations, especially on wind force and direction. He was probably encouraged by the Danish King Frederik II, who was worrying about the contemporary knowledge about weather phenomena: Under his kingdom, in a war against Sweden, an unexpected storm near Gotland the night after July 28, 1566 destroyed 1/3 of the Danish Navy with 6000 men. Tycho Brahe did 15 years of observations in the period 1582 to 1597 from his observatory "Uranienborg" on the island Ven in the Danish sound Øresund. Thereafter there was a period of less systematic weather observations in the harbour of Copenhagen which are not preserved. In 1670 the Danish King Christian V ordered entering of logbooks several times a day on the naval ships. The enterings of the logbooks should among other things consist of wind and weather observations. A great many of these logbooks have survived until today.

The naval ships mainly navigated Danish Waters, Norway – Iceland – the Faroe Islands, West India, the European waters and the Mediterranean. During several hundred years there were stationary guard ships at the roadstead at Copenhagen, at Helsingør (Elsinore) and at Nyborg, see figures 1 and 2. These guard ships constituted as it were three meteorological stations with generally six daily observations. Many of these logbooks are still available in the Danish National Archive.

The oldest lighthouse and lightship books date from 1779, initiated by an official instruction. For some light ships and light houses (for instance Skagen (the Skaw) and Anholt) nearly all logbooks from 1779–1875 still remain with generally three observations a day. One when the light was turned on, one at midnight, and one when the light was turned off.

In the end of the 1970'ies there was a possibility to employ staff members to extract the meteorological observations from the logbooks. These necessary transcriptions were carried out for more than ten years, and ended in the summer 1991. The efforts were concentrated on the above mentioned three positions and the nearby waters. The material present has been extracted in such a way that nearly all the registrations for the whole year except winters from 1675 to 1873 are available. Most of them from the roadstead, "Rheden", of Copenhagen. It has been possible to extract many registrations from winters of the first half of the eighteenth century for the two sea forts "Trekroner" and "Prøvestenen" at Copenhagen. Some of the logbooks have been transcribed more than once by different staff members at different times to get a picture of the reliability of the copies.

There now exist some 4000 months transcribed ship logbooks and app. 3000 months logbooks from lights. A total of 7000 months spread over the years 1675 to 1873.

THE ØRESUND REGION

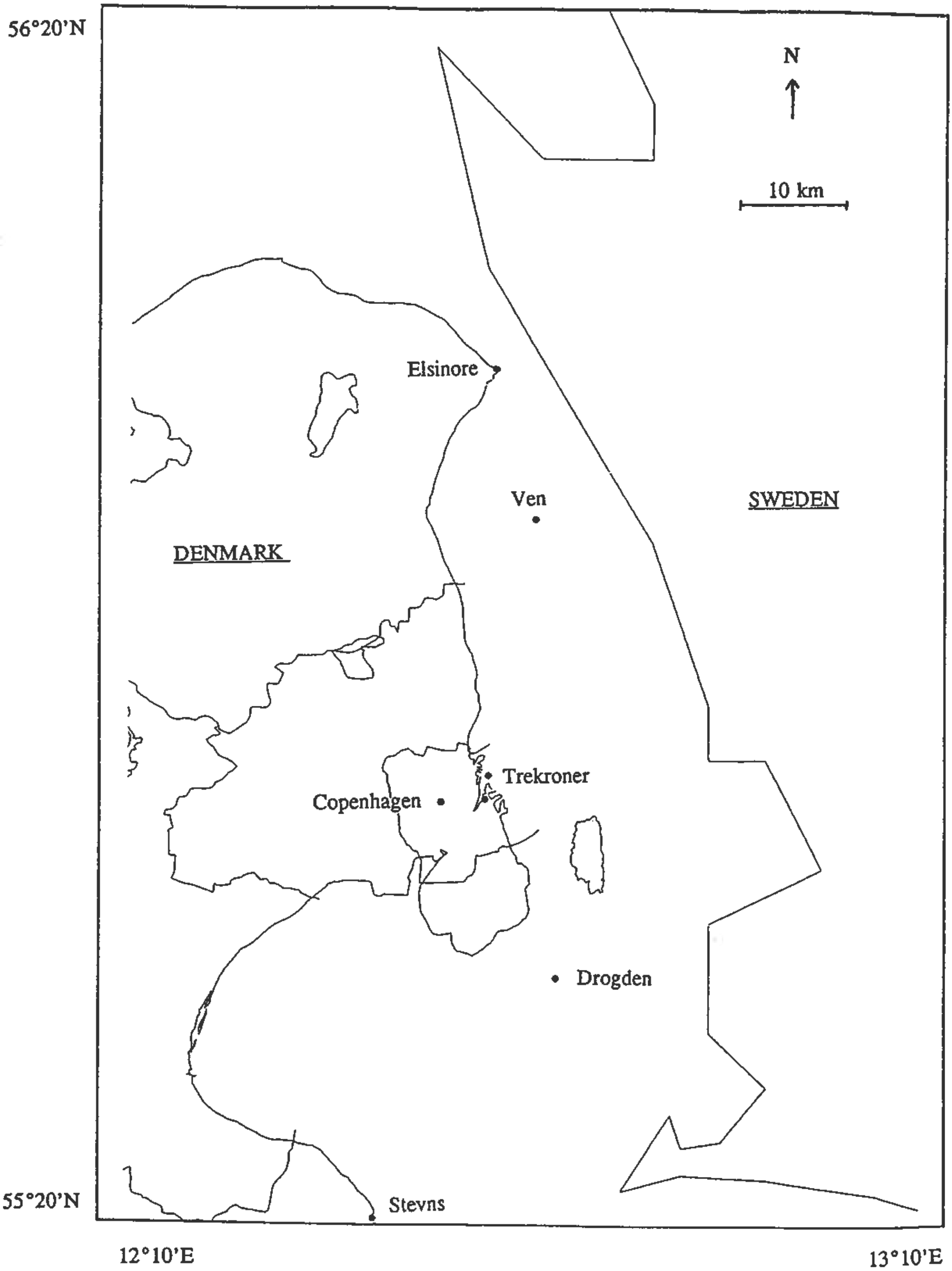

Figure 1: Map of the Øresund region with place names cited in the text.

The material includes about one million observations of the wind direction and wind force, the weather (snow, rain, fog, thunder etc.) and remarks on the cloud cover and occasionally on cold and warmth. The observations were for a long time done without any other instruments than the compass.

The transcriptions have been carried out according to equal directions and are available in a form that resembles modern meteorological weather telegrams and are converted to meteorological units of today; ready for digitization on computers. When all the data have been analyzed it will be possible to comment on especially the wind climate in Denmark for 300 more years than the present app. 120.

The present report describes a digitized subset of the ship logbook data from the period 1675–1715. In order to obtain temporal homogeneity during these years, the observations have been subdivided into 7 Danish maritime areas, and a daily average has been performed. The thus available at DMI contain in each record observation time, ships position, wind direction, wind speed and an indication if one or more of eight classes of weather phenomena occurs during the day.

2 Time

2.1 Change from Julian to Gregorian calendar

In Denmark the calendar was changed from Julian to Gregorian in year 1700 such that Monday, March 1. 1700 follows Sunday, February 18. 1700. In some southern European contries the Gregorian was introduced already in year 1582. Therefore the dates of the present dataset are all transformed to Gregorian time.

2.2 Observation hours

The logs were usually kept at 6 standard observation hours a day. However in many logbooks, especially in the first 20 years, only 1 to 3 of the daily records contain weather observations.

2.3 Averaging procedure

In the dataset, the mean hour of observation is specified. Observations in the middle of the night are often referred to the day before, therefore the mean hour is in average biased a little towards the end of the day.

3 Positions

3.1 Determination of position

The ship positions were originally given as a name of the site. For example "Drogden" is the name of the southern Øresund bottom threshold to the Baltic and is situated around 55°38′N, 12°40′E (Southeast of Copenhagen). The positions were transcribed to latitude / longitude coordinates with the aid of a map or a currently updated list of positions. The keepers of the logbooks often noted the positions only once in a while. Therefore the positions for construction of this dataset have been duplicated from the last recorded position in the logbook.

3.2 Averaging procedure

The logbook observations were each referred to one of the 7 regions shown in figure 2, the six of which approximate the official Danish maritime divisions with the names

Skagerak

Kattegat

The Sound

The Belts

Western Baltic

The Baltic at Bornholm,

and the seventh covers a couple of cruises into the area

Gotland – Øland.

The average position given in the dataset is the mean latitude and longitude of those individual observations, for which the wind speed vector is determined (see 5.3).

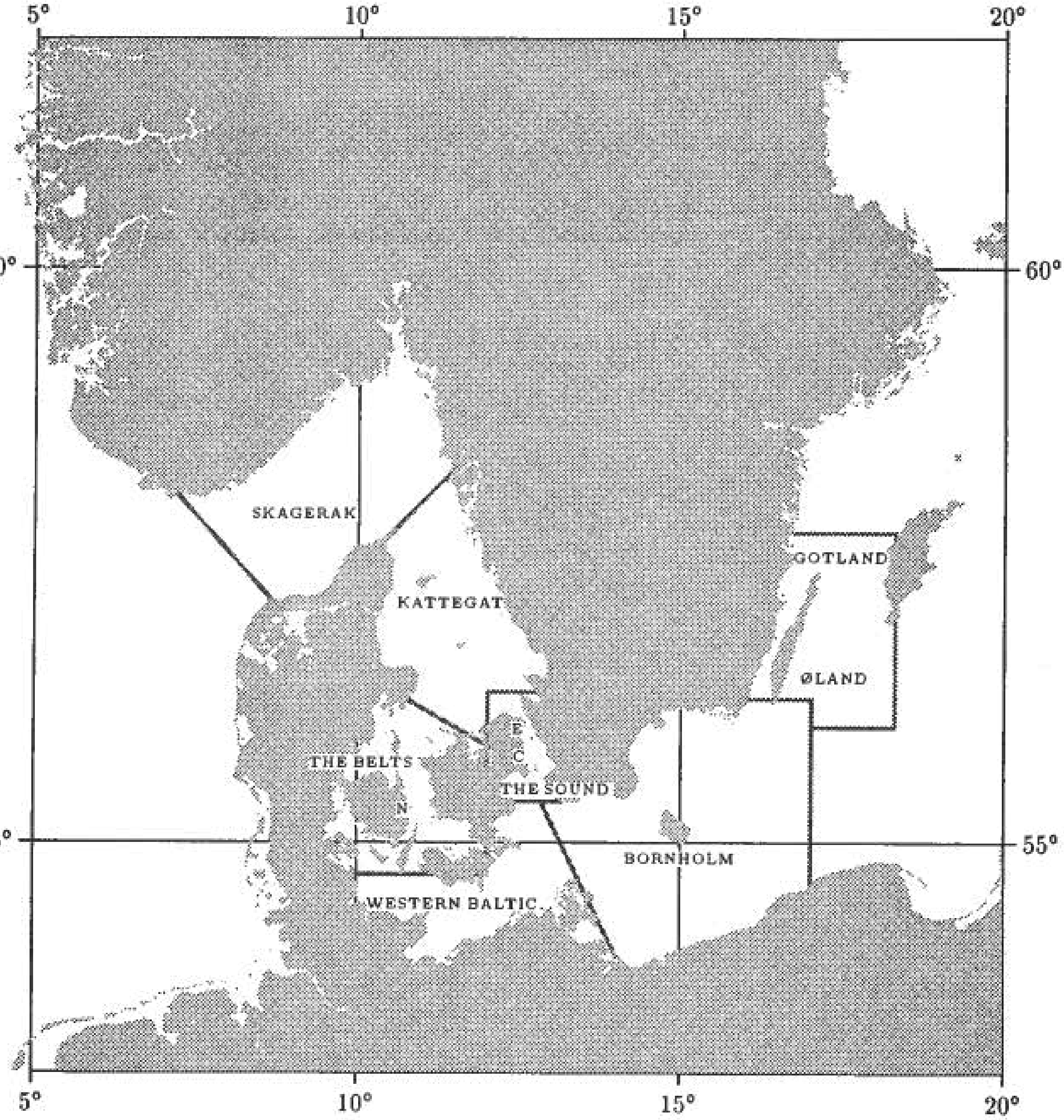

Figure 2: 7 maritime areas of the Danish waters. The positions of Nyborg, Elsinore and Copenhagen are labeled with 'N', 'E' and 'C'.

4 Wind direction

4.1 The compass

The wind direction was defined as the direction on the compass from which the wind blows.

The compass had since before Viking time 8, 16 or 32 divisions corresponding to intervals of 45°, $22.5^\circ$and 11.25°. It must be emphasized in statistical examinations of the records, that such a discretization in intervals of a given length D leads itself to an uncertainty with a standard deviation $D/\sqrt{12}$ (Kristensen and Kirkegaard 1987).

4.2 Correction for magnetic declination

The compas direction is influenced by the magnetic declination, which, in the Copenhagen area, was about 3°W in 1675, and decreased linearly with time to about 10°W in 1715 (Abrahamsen 1973).

Only after year 1692 or 1693 the compasses of the Danish navy had their north point directed towards the magnetic north (Frydendahl 1992). Before then the variation of the declination with position and time was not fully emphasized, and corrections for the declinations were done internally in the compasses.

For this dataset the logbook wind directions were corrected for the declination using the above mentioned linear decrease from 1675 to 1715.

4.3 Average wind direction

The daily mean wind direction in each region is determined as described in section 5.3.

5 Wind force

5.1 The ships

The ships themselves were used as "sounders" of the strength of the wind. The wind force was considered to be characterized by the highest sails a ship was able to carry at the given wind. Thus the recorded force is not a direct measure of the wind speed, but is more directly related to the power the wind excerts on the ship, which of course is determined mainly by the wind speed.

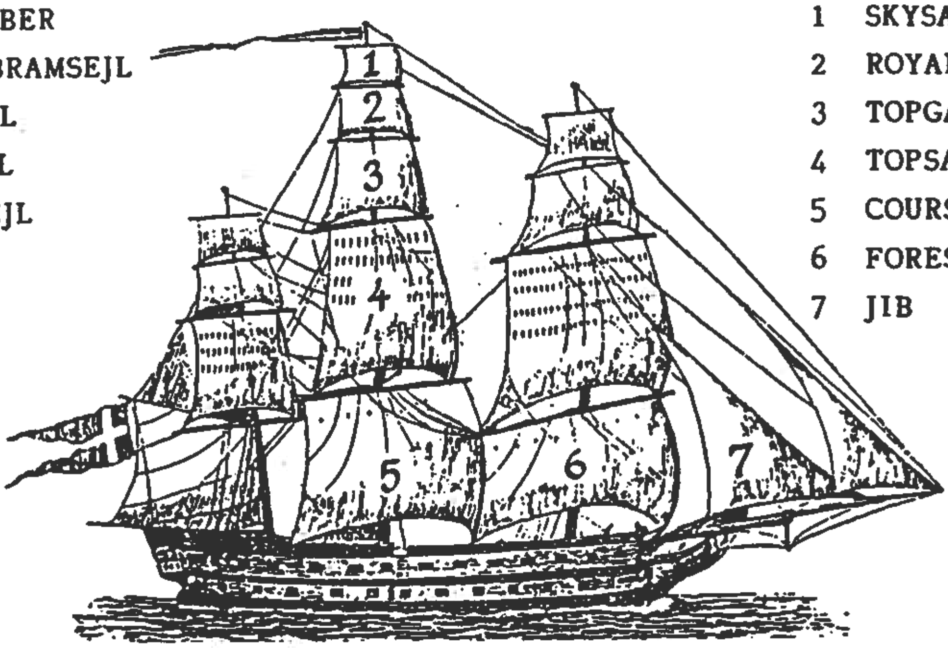

Figure 3: The sails on a typical ship in the beginning of the 19'th century.

Table 1: The original Beaufort sea scale. After Fitzroy (1839).

0	Calm	Or just sufficient to give steerage way	
1	Light Air	Or that in which a man-of-war with all sail set and clean full, would go in smooth water from	1 to 2 knots
2	Light Breeze		3 to 4 knots
3	Gentle Breeze		5 to 6 knots
4	Moderate Breeze		
5	Fresh Breeze	Or that to which a well-conditioned man-of-war could just carry in chase full and by	Royals & Courses
6	Strong Breeze		Single-reefed and top-gallant sails
7	Moderate Gale		Double-reefed top-sails, jib & C.
8	Fresh Gale		Treble-reefed top-sails & C.
9	Strong Gale		Close-reefed top-sails and Courses
10	Whole Gale	Or that with which she could scarcely bear close-reefed main-topsail and reefed fore-sail	
11	Storm	Or that with which she could scarcely bear close-reefed main-topsail and reefed fore-sail	
12	Hurricane	Or that which no canvass could withstand	

On figure 3 is shown the sails carried on a typical ship in the beginning of the 19'th century. The sails labeled 3, 4, 5, 6, and the three masts have been part of the fundamental ship construction since 1600.

Frydendahl (1992) in his detailed examination of the ship constructions, shows that the way they carry their sails is surprisingly homogeneous since app. year 1600.

5.2 The wind scale

On the basis of standard nomenclature of the wind force the Danish Admiral M. Bille in 1840 published an authoritative wind scale, formulated in terms of the sail carriage. This scale containing items labeled 0 – 12 was shown by Frydendahl (1992) to be equivalent to the Beaufort sea-scale. Shown in table 1 is the original Beaufort sea scale, which has given name to the modern Beaufort scale defined in terms of purely physical behaviors of the sea surface under the action of winds.

Based on preliminary studies of the Danish maritime wind scales it was decided that the wind forces should be transcribed by use of a wind scale, shown in table 2, which is simply a slight modification of the scale of Admiral Bille. It was shown by Frydendahl (1992) that the modern Beaufort scale is more equivalent to the scale of Bille used on Danish ships in the 19'th century than to the original Beaufort scale shown in table 1. The original Beaufort numbers 6–9 are 1 value higher than the corresponding Danish sea scale. This is due in part to the traditional interpretation of the Sea scale in Denmark, and in part to the difference in the backgrounds of Bille and Beaufort. While the sail carriages in the scale of Bille refer to the most safe sailing conditions for the Danish ships, the Beaufort scale refers to the limitations in extreme circumstances.

5.3 Average wind speed and average wind direction

Individual wind force observations were transformed to a representative wind speed at a height of 15–25 meters above sea level using the WMO (CMM–IV) conversion table shown in table 3. An observation of both wind speed and direction defines a wind vector, i.e an oriented linepiece with two Cartesian coordinates (zero wind speed defines a vector with coordinates equal to zero). For days in which there was at least one observed wind vector in a region, the average wind direction and speed is defined from the mean vector coordinates. In case of a day with no wind speed observations, but at least one well-defined direction, a vector of length one was tentatively assigned to each direction. In such cases the mean direction is also defined as the direction of the mean vector, but if the length of the mean vector is less than 0.5 the mean direction is considered ill–defined.

Table 2: The wind scale used for transcription of data. Frydendahl (1992) has shown that the modern Beaufort scale is more equivalent to the scale of Bille used on Danish ships in the 19'th century than to the original Beaufort scale shown in table 1.

	Danish name	English translation	Characteristic old Danish expressions
0	Stille	Calm	Stilagtig
1	Liden Laring: Blaff	Light winds	Laber laring, liden kuling, liden ånding, liden sejls kuling, liden luft, liden labring, laber kuling, omløbende luft, liden dral, løje(r), slap kuling, laber og stille, læsejls kuling
2	Laber Bramsejls Kuling	Weak *topgallant* wind	Liden BK, slap BK, topsejls kuling, flov kuling, låring
3	Bramsejls Kuling	*Topgallant* wind	Frisk BK, stiv BK, ordinær kuling, jævn kuling, mådelig kuling
4	Mærsejls Kuling	Weak *topsail* wind	Laber MK, liden MK, frisk MK, stiv MK, hård MK, frisk kuling
5	Rebet Mærsejls Kuling	Single–reefed *Topsail* wind	Frisk rebet mærssejls kuling, stiv rebet MK, hård rebet MK, temmelig stiv kuling, stiv kuling
6	Torebet Mærssejls Kuling	Double–reefed *Topsail* wind	Stiv torebet MK
7	Trerebet Mærssejls Kuling	Treble–reefed *Topsail* wind	Stiv trerebet MK, hård kuling
8	Klosrebet Mærssejls Kuling	Close–reefed *Topsail* wind	
9	Undersejls Kuling	*Course* wind	En halv storm
10	Stiv Undersejls Kuling	Strong *course* wind	Storm
11	Flyvende Storm	Strong storm	Stærk storm, orkanagtig storm
12	Orkan	Hurricane	

Table 3: The CMM–IV equivalent wind speeds and intervals (from WMO 1970. See also Issemer and Hasse 1991).

Beaufort number	Mean equivalent wind speed m/s	knots	Interval of equivalent wind speeds m/s	knots
0	0.8	1.6	0–1.3	0–2
1	2.0	3.9	1.4–2.7	3–5
2	3.6	7.0	2.8–4.5	6–8
3	5.6	10.9	4.6–6.6	9–12
4	7.9	15.2	6.7–8.9	13–16
5	10.2	19.8	9.0–11.3	17–21
6	12.6	24.5	11.4–13.8	22–26
7	15.1	29.4	13.9–16.4	27–31
8	17.8	34.6	16.5–19.2	32–37
9	20.8	40.4	19.3–22.4	38–43
10	24.2	47.0	22.5–26.0	44–50
11	28.0	54.4	26.1–30.0	51–57
12		62.6	≥30.1	≥58

In the dataset the daily averaged wind speed is given in both knots, m/s and Beaufort (c.f. table 3 on page 12).

The wind scale in use for transcription has not been modified at all during the over 10 years period of transcription.

6 Cloud cover and various other weather elements

6.1 Cloud cover

In general the transcription of the logbooks were done using a scale of 0 – 8 defined in table 4. However, the cloud cover is for the period in consideration (1675–1715) most often noted as either of two: clear sky or overcast. In averaging the observations in a specific area over a day, as we have done, only resulting values of cloud cover 0 or 8 are significant. The cloud cover, and the other weather elements, are recorded with substantial intermittency in the ships logs. Therefore no climate statistics can be estimated, such as mean values or exceedance probabilities.

Table 4: The cloud cover classification

N	Modern cloud cover	Danish logbook expressions
0	sky clear	Klar luft - klart vejr, godt vejr
1	1/8 or less of the sky covered	
2	2/8 of the sky covered	Liden klaring - temmelig klar luft, nogenlunde klar luft, opklarende luft, klaret noget af, afklaret luft, klar luft med nogen små skyer, nogle drivskyer, stribet luft, klar og blandet luft, klar og skyet luft
3	3/8 of the sky covered	
4	4/8 of the sky covered	Blandet luft - foranderlig luft, variabel luft, skyet luft, klar skyet luft, grå skyer, tempereret luft, separeret luft, grå blandet luft, tyk blandet luft, klar blandet luft, drive skyer, optrukken luft, fordelt luft, klar og tyk luft, fordelt til mørk luft, klar og grå luft, klar grå skyet luft, grå skyet klar luft, grå og klar skyet
5	5/8 of the sky covered	Tykke drive skyer - regnagtig luft, klar mørk skyet, klar og optrukken tordenluft
6	6/8 of the sky covered	Omtrukken
7	7/8 of the sky covered, but not 8/8	
8	overcast	Grå luft - overtrukken luft, tykning, mørkt vejr, tyk luft, tordenluft, stiv luft, tynd grå luft, grå og mørk skyet, grå mørk skyet, tyk skyet luft, grå skyet
9	sky obscurred	

codes 1–4 also known as scattered clouds

codes 5–7 also known as broken clouds

6.2 Other weather elements

On the transcription of weather notes the character codes shown in table 5 was used. Under impression of the content of the logbooks we have chosen the 8 subdivisions fog . . . frost:

6.2.1 Fog : Codes A, B, C, c, D.

6.2.2 Rain : Codes E, F, G, g, W.

6.2.3 Snow : Codes H, I, J, K, L, M.

6.2.4 Hail : Codes N, O, P, Q.

6.2.5 Thunder : Codes R, S, T.

6.2.6 Sun : Codes Ø, d, f.

6.2.7 Aurora Borealis : Code Å.

6.2.8 Frost : Codes a, y, æ, V, Y, Z.

Table 5: Modern weather codes used for transcription.

A	Mist
B	Ground fog
C or c	Fog
D	Rime fog
E	Drizzle
F	Rain
G or g	Rain showers
W	Freezing rain
H	Sleet
I	Sleet showers
J	Snow
K	Snow showers
L	Snow grains
M	Snow pellets
N	Ice pellets
O	Hail showers
P	Hailstones
Q	Ice Prisms
R	Lightning
S	Thunderstorms in the surrounding area
T	Thunderstorms at the station
U	Dew
V	Rime
X	Glaze
Y	Drifting snow
Z	Blowing snow
Æ	Drifting or blowing dust or sand
Ø	Sunshine
Å	Aurura Borealis
a	Frost
b	Flamed air
d	Nice weather
e	Mild air
f	Beautiful weather
h	Unsteady weather
k	Cold air
l	Growing weather
m	Moist weather
n	Warm air
r	Hot air
p	Squally weather, not necessarily rain
q	Gusty air
t	Rough weather
u	Haze
v	Thaw
y	Drift ice
æ	Fast ice

7 General remarks on the data quality

7.1 Wind direction

In general we consider the wind direction to be the best data element of the present dataset. A comparison of the results by different transcribers on the same logbooks has shown that they agree fairly well. To estimate the quality of the logbooks themselves we performed a comparison in the Øresund area of different ships observing wind force and direction the same day. The root-mean-square of deviations between different

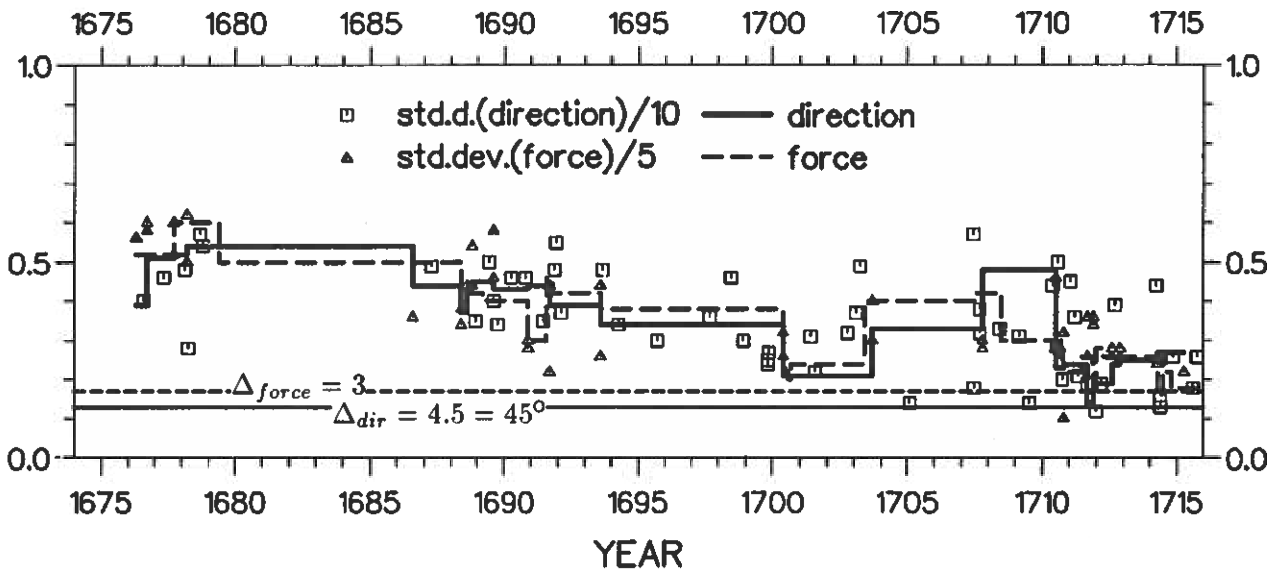

Figure 4: Root-mean-square of difference between simultaneous observations of wind direction and force. The values are divided by a "worst" case, roughly estimated as the root-mean-square of an equal distribution over all direction and force scale values. One marker is drawn for each individual ship at its mean observation date. The lines are drawn through the average of all comparisons, each step covers 100 individual days; for example 4 simultaneous ships in the same 25 days will result in a line step. Also drawn are the standard deviations $\frac{\Delta}{\sqrt{12}}$ due to the ideal discretization steps Δ.

ships decreases, as shown in figure 4, with years until year 1710 where it approaches a minimum. Figures 5 and 6 illustrate the general trend, that the agreement between observations improves significantly during the period.

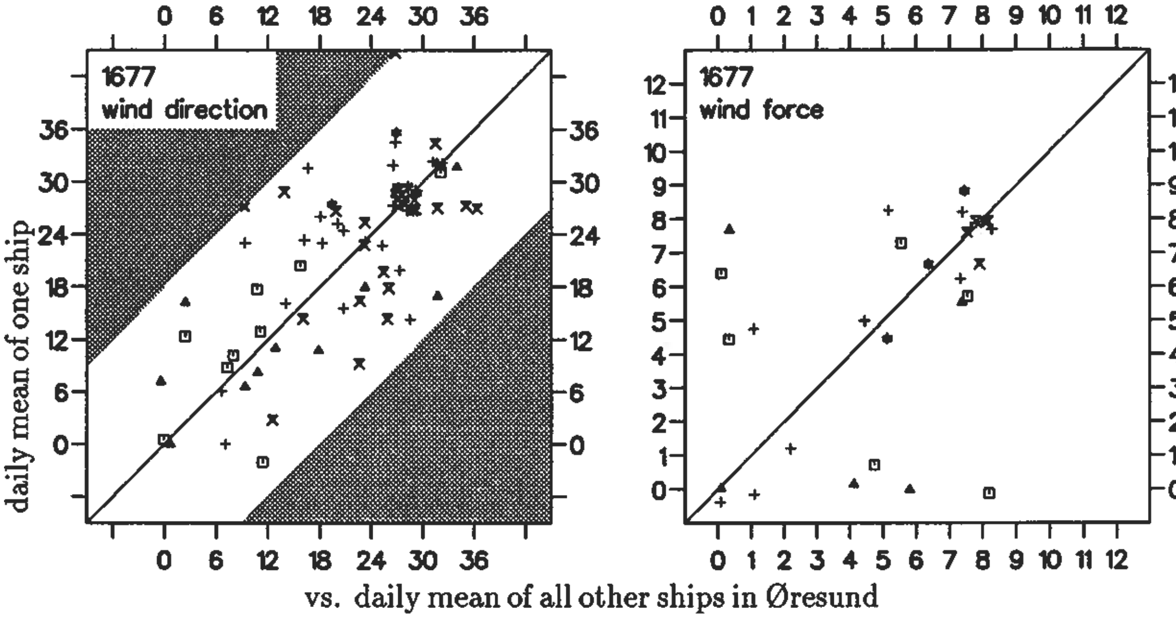

Figure 5: Øresund 1677. Comparisons of ships observations on the same day. Only observations during daytime (7 am – 5 pm) are included to minimize the effect of local seabreases. Wind directions are excluded when the wind force is lower than 2. Individual ships are distinguished by different markers. Compare figure 6.

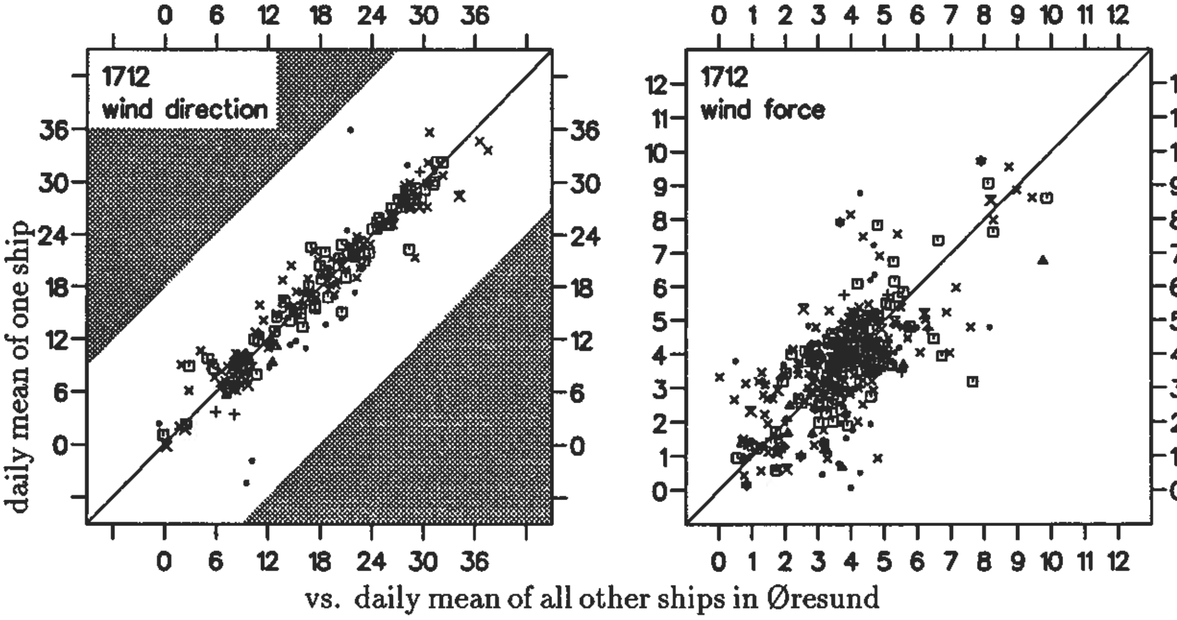

Figure 6: Øresund 1712. As in figure 5.

7.2 Wind force

The wind force has one major disadvantage: In its reduction from a subjective expression to a scale value there is some natural ambiguity, which is not completely random but strongly determined by the definition of the scale, as in table 2. This has as a consequence that the density distribution of observed wind forces will not fully resemble the distribution over a continuous, physically defined scale (for example m/s or knots). In fact, the modern Beaufort sea scale was designed on the basis of the older scales

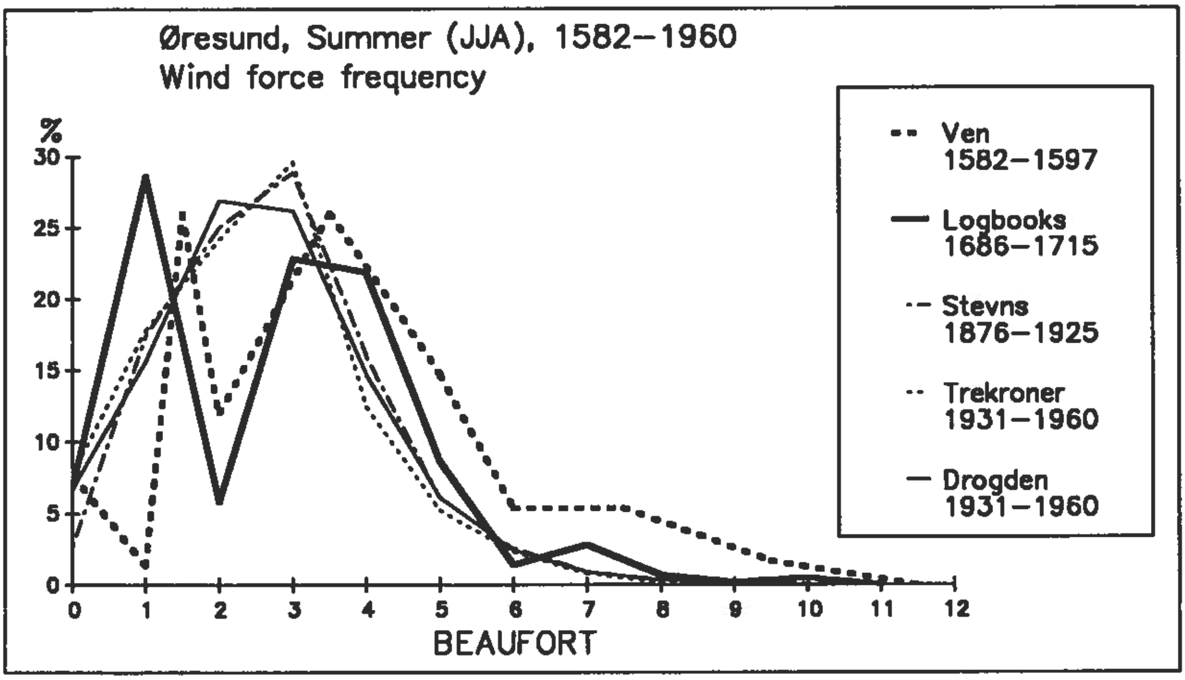

Figure 7: Density distribution of wind force observed in the Øresund area: 1. Tycho Brahe observations 1582–1597 transcribed by la Cour (1876) using a scale similar to Beaufort; 2. Øresund part of the present dataset 1686–1715 transcribed to the wind scale of table 2; 3. Stevns 1876–1925 (DMI 1933) using the Beaufort scale (c.f. table 1); 4. Trekroner 1931–1960 (Frydendahl 1971) using the Beaufort scale; 5. Drogden 1931–1960 (Sparre 1981) using the Beaufort scale.

to provide a continuous transformation to physical wind speed units. Fundamental discussions of the modern Beaufort scale are found in Simpson (1906), WMO (1970), Kaufeld (1981), Issemer and Hasse (1991) and Kristensen and Frydendahl (1991). The distribution of the present dataset is compared to three modern observation series near Copenhagen (observed in Beaufort units) and a transformation performed by la Cour (1876) on the observations of Tycho Brahe from 1582–1597.

We consider the see–saw form of the distribution of the present dataset shown in figure 7 to be a simple consequence of the ambiguous deliminations between individual wind force categories. We know (Frydendahl 1992) that the *general* extent of the wind scale is similar to the Beaufort scale. Therefore simple, local, scale transformations are allowed, as long as no new, artificial, information is added. For example, the wind speed categories 1 and 2 in table 2 on page 11 may be connected in one.

7.3 Cloud cover

Although days with fully overcast (cloud cover 8) or clear sky (cloud cover 0) are reliable, the daily averages may be misleading, as the distribution of various cloud covers between 0 and 8 is unknown.

7.4 Other weather elements

The informational quality of the other weather codes are unknown at present. Because a specific event is not always noted in the logbook when it occurs, we cannot rely on statistical distributions of the data. There were usually too few data to perform individual comparisons like what we did for the wind speed and direction. But comparisons with other observations can be done in connection with reconstructions of synoptic weather maps.

7.5 Distribution of observations over the years

In order to provide a quick view over the number of weather data 1675 – 1715 we show the number of days with observations of the data elements described in sections 4 to 6 during all the years (figure 8), the average distribution over the months (figure 9) and frequency distribution of number of observations per day (figure 10). It should specifically be noticed that there are no preserved observations in the periods October 1680 to November 1683, the whole years 1685, 1702 and 1704, only seven days in 1705, and with very few exceptions over the years there are no observations in the months January – March.

8 Conclusion

The present daily mean weather data from the period 1675–1715 are very useful for comparison with contemporary observations from other regions within a synoptic distance from Denmark. This may be done in form of weather maps. With such comparisons it may be a useful tool for analysis of the interaction of climate and antropological changes.

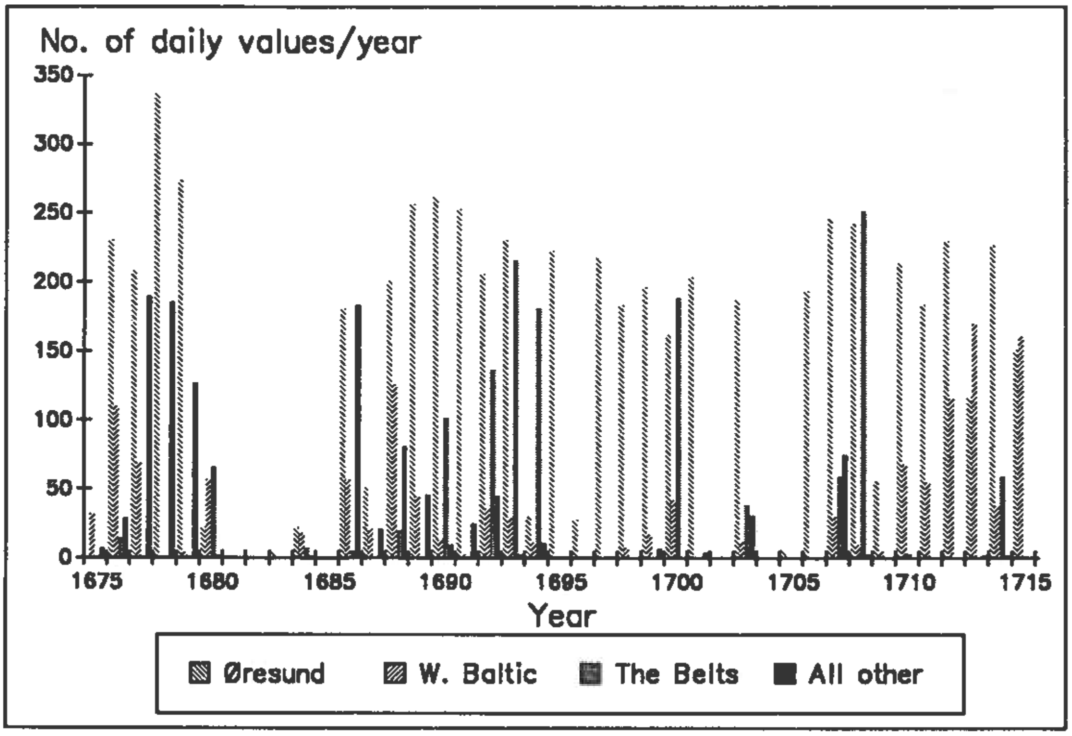

Figure 8: The distribution of number of daily values each year.

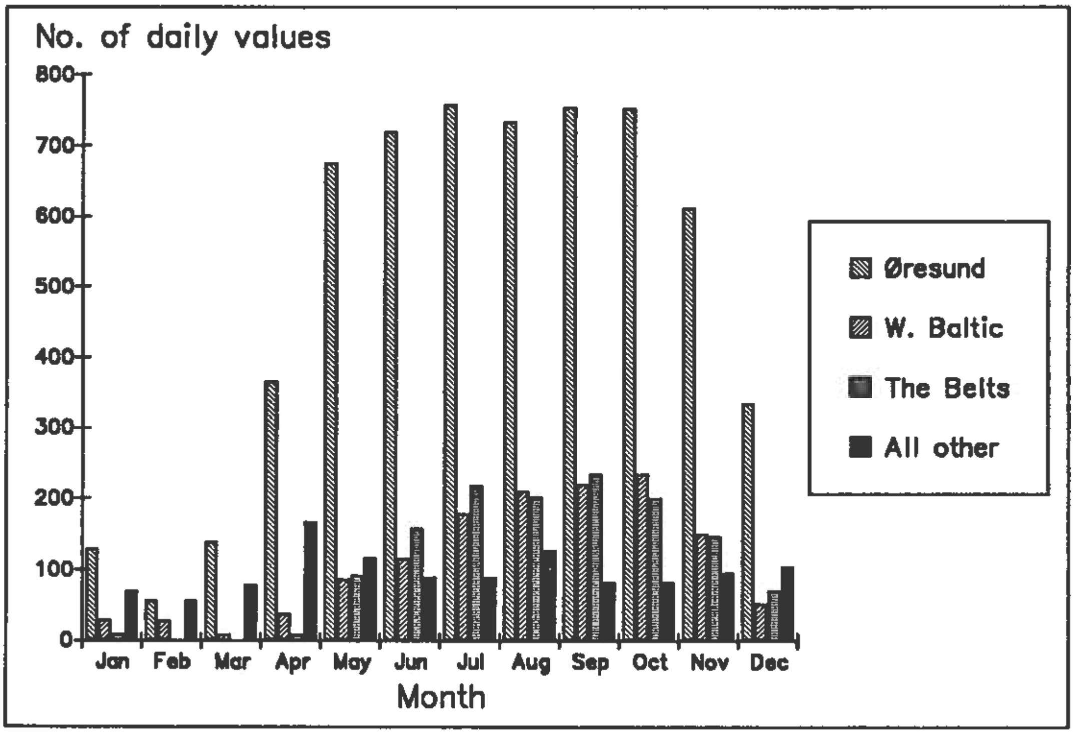

Figure 9: The distribution over the months of number of daily values averaged over the period 1675 – 1715.

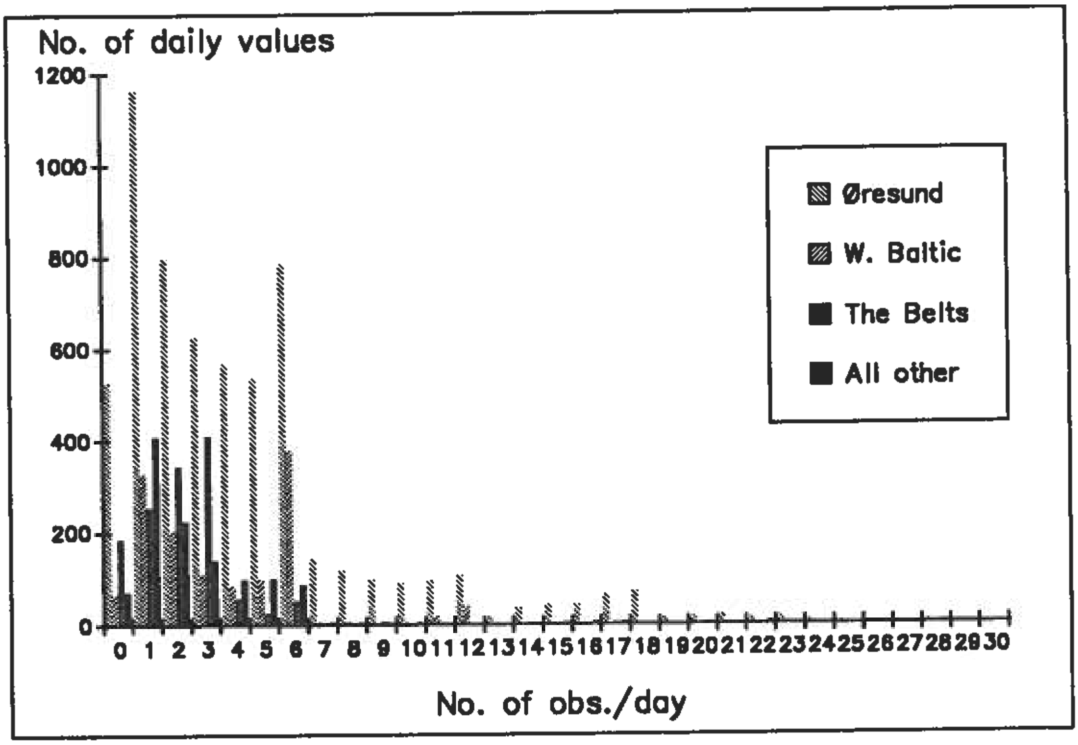

Figure 10: Frequency distribution of the number of observations per day.

On the contrary, examinations of the climate statistics based on the present material should be performed only with great care. One should keep in mind the strong temporal inhomogeneity of the data, which for example appears in the decreasing trend during the period 1675–1715 of the deviations between observations from different ships on the same day.

However, as we have found in figure 4, such discrepancies between different logbooks become small after 1710, and attain a level which practically cannot be lower. Therefore, on the longer, 300 years, timescale from 1675 till today, the temporal imhomogeneities of wind observations from the danish logbooks are lilely to be small.

Digitization and analysis of the full period 1675–1875 of Danish logbooks from ships and lights still await.

9 Acknowledgements

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A Appendix: Overview over data format

This collection contains 7 files of daily averaged weather data from the Danish logbooks 1675 to 1715. In total, approximately 7400 different days are represented, most of them in long, continuous periods during the seasons late spring to early winter.

The 7 files corresponds to 7 different geographic regions in the Danish area according to the table:

(for overlapping regions the highest occurrence in the table is chosen, i.e. the position 12.75°E, 55.75°N is in the Øresund, not in the Kattegat)

file name	**region** ('lat' is 'latitude*100'; 'lon' is 'longitude*100')	**description** (in Danish/English)
(No file)	(lon<900 and lat<6251–0.625*lon) or lat>0.54*lon+5540	(Excludes positions outside the system: Skagerak–the Baltic Sea)
skage.dat	lat>0.577*lon+5164 and lon<1200	Skagerak
oresu.dat	1200<lon<1315, 5535<lat<5631	Øresund/the Sound
katte.dat	lon<1305 and lat>5980–0.33*lon	Kattegat
belth.dat	lat>5472 and lon<1200	Bælthavet/the Belts
vestl.dat	lat<7013–1.15*lon	Vestlige Østersø/western Baltic
oster.dat	lon<1700 and lat<5625	Østersøen o. Bornholm/the Baltic at Bornholm
gotla.dat	lon<1830 and lat<5770	Gotland–Øland/–region of the Baltic Sea

For printing each line in a file 'g', the following code was used:

```
fprintf(g," %4d %2d %2d %2d %5d %5d %5.1f %4.1f %4.1f %2d %4.1f\
 %1d %1d %1d %1d %1d %1d %1d %1d %2d\n\r",
year,month,day,hour,latitude,longitude,DD,FFSI,FF,Bft,N,
fog,rain,snow,hail,thunder,sun,aurora_borealis,frost,no);
```

- The year,month,day has been changed to Gregorian date from the Julian calendar, which was used in Denmark before March 1, 1700.

- The 'hour', 'latitude' and 'longitude' are daily mean observation times and positions, and are defined for all printed lines; units: 1/100°N or E.

- 'DD', 'FFSI', 'FF' and 'Bft' are wind direction(*degrees*), speed(*m/s*), speed(*knots*) and mean Beaufort value derived from the vector mean wind;
  when speed and direction are unknown, DD=999.9, FFSI=99.9, FF=99.9 and Bft=99
  when the force only is unknown, FFSI=99.9, FF=99.9, Bft=99 and DD is an average direction
  when FFSI=FF=0.0, the direction is undefined: DD=999.9
  For the approximate conversion from logbook *wind-categories* to *knots* the WMO (CMM-IV) scale has been used (see Issemeer and Hasse 1991);
  The geomagnetic declination at Copenhagen (N. Abrahamsen 1973) has been subtracted from the wind direction.

- 'N' is the average cloud cover. Very often, the cloud cover is noted as only one of either '0': clear sky or '8': cloudy; thus the daily average is somewhat unprecise.
  when unknown, N=99.9;

- 'fog' ... 'frost' are 8 types of weather observations, each of which is
  =1 if there were at least one observation during the day,
  =0 else;

- 'no' is the number of wind vector observations during the day.