

Handwritten text in purple ink, partially legible: "Licht", "de", "van de", "hand", "streijl"

20 OMTHELZEEBET

40 BETHEL

Historical maritime wind scales until 1947

60 BET

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40 REGZEEBET

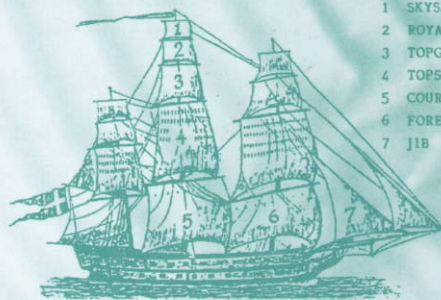
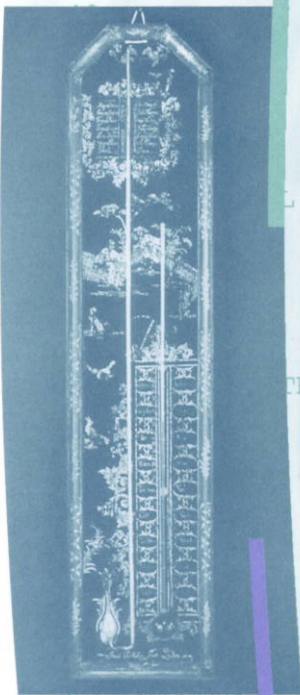
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Hendrik Wallbrink and Frits Koek

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- 1 SKYSAIL
- 2 ROYAL
- 3 TOPGALLANT
- 4 TOPSAIL
- 5 COURSE
- 6 FORESAIL
- 7 JIB

40 BETREG

80 REGBETRAG

80 REG

80 REGBET

60 OMTHELZEEBET

80 GEHBET

100 GEHBETREG

80 REGHEL

10 BET

De Bilt, 2009

0 BET

1 OMTHELZEEBET

KNMI-Memorandum

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The KNMI-program HISKLIM aims at making historical land and sea climate data from Dutch sources physically accessible, with the highest possible time resolution and quality. The program started in 2000 and will run 5 to 10 years.

- HISKLIM-1 Het KNMI-programma HISKLIM (HISTorisch KLIMaat) / T. Brandsma, F.B. Koek, H. Wallbrink en G.P. Können. (also KNMI-publication 191)
- HISKLIM-2 Gang van zaken 1940-48 rond de 20.000 zoekgeraakte scheepsjournalen / H. Wallbrink en F.B. Koek. (also KNMI-publication 192)
- HISKLIM-3 Historische maritieme windschalen tot 1947 / H. Wallbrink en F.B. Koek. (Memorandum)
- HISKLIM-4 Onbekende weersymbolen in oude Extract-Journalen (1826-1865). / H. Wallbrink en F.B. Koek. (Memorandum)
- HISKLIM-5 CLIWOC, Multilingual Meteorological Dictionary; an English-Spanish-Dutch-French dictionary of wind force terms used by mariners from 1750-1850 (also KNMI-publication 205)
- HISKLIM-6 DIGISTAD (DIGitaliseren STADswaterkantoor). H.W. Riepma. (Memorandum)
- HISKLIM-7 Parallel air temperature measurements at the KNMI-terrain in De Bilt (the Netherlands) May 2003–April 2005, Interim report. / T. Brandsma. (also KNMI-publication 207)
- HISKLIM-8 Hisklim COADS, Final report. / H. Wallbrink and F. Koek. (also KNMI-publication 210)
- HISKLIM-9 DIGISTAD, Disclosure of the hourly meteorological observations of the Amsterdam City Water Office 1784-1963, Final report. / H. Wallbrink and T. Brandsma. (also KNMI-publication 220)
- HISKLIM-10 Report on meteorological observations at Willemstad, Curaçao, during the period 1910-1946. / P.V.J. Girigori (Memorandum)
- HISKLIM-11 The US Maury collection metadata 1796-1861. / H. Wallbrink, F. Koek and T. Brandsma (also KNMI-publication 225)



HISTORICAL MARITIME WIND SCALES UNTIL 1947

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CONTENTS

0.	PREFACE	3
1.	INTRODUCTION.....	4
2.	THE FIRST MARITIME WIND OBSERVATIONS.....	5
3.	THE 17TH AND 18TH CENTURY	6
3.1.	WIND ESTIMATIONS DURING THE EARLY 17TH CENTURY	6
3.2.	THE ASSESSMENT OF WIND STRENGTH IN THE 17TH AND 18TH CENTURY THROUGH SAIL SETTINGS.....	7
3.3.	DETERMINATION OF THE WIND DIRECTION IN THE 17TH AND 18TH CENTURY	8
3.4.	SAIL SETTINGS OF 17TH AND 18TH CENTURY SHIPS VERSUS THE INTERNATIONAL BEAUFORT SCALE WIND FORCE.....	9
4.	DE BEAUFORT WIND FORCE SCALE	10
4.1.	HISTORY AND DEVELOPMENT.....	10
4.2.	THE INTERNATIONAL BEAUFORT SCALE OF WIND FORCE, 1874	11
5.	MARITIME WIND OBSERVATIONS IN THE NETHERLANDS: 1850-1898.....	12
6.	MARITIME WIND OBSERVATIONS IN THE NETHERLANDS: 1898 – PRESENT.....	14
7.	ACCURACY OF THE WIND DIRECTION AND THE ESTIMATED WIND FORCE.....	16
8.	EQUIVALENT WIND SPEEDS FOR THE ESTIMATED WIND FORCE.....	18
9.	LIST OF USED ABBREVIATIONS.....	19
10.	LIST OF FIGURES	19
11.	LIST OF TABLES	19
12.	REFERENCES	20

0. PREFACE

In 2001 the Dutch version of this memorandum was published and from the start it was a demanded product in English speaking countries. This publication is a translated and updated version of this previously released KNMI memorandum HISKLIM 3 (Wallbrink and Koek, 2001). We are much obliged to the University of Michigan (Ann Arbor, MI, USA) who helped us on the way with the translation of the original Dutch memorandum.

1. INTRODUCTION

The strongly increasing interest for historical climate data (HISKLIM, CLIWOC, RECLAIM, ACRES) over the past few years led to several projects with the purpose of taking maritime wind data, originally from old ship logs, digitize them and make them available through e.g. a database. In order to be able to interpret the data correctly, additional information about the carried sails of full rigged ships is essential. The so-called metadata is also of great importance for the knowledge of the quality of the observations in existing international climate databases (e.g. ICOADS).

This publication will go in depth into the origins and developments of wind scales that have been used to make subjective wind force estimates. From the 17th century onward a chronological overview is given of the terminology that the crew used among each other in order to exchange information regarding the wind direction and wind force of the ocean.

2. THE FIRST MARITIME WIND OBSERVATIONS

Ever since ships sailed the seas, the winds have been named in many ways. It was very important to the crew to be able to know the wind climate for specific times of the year in certain areas. At the beginning of this era, Plinius (Plinius, AD 77) for example, already described the best method to sail back and forth between the Gulf of Aden and India. The initial trip was sailed in 40 days downwind with the help of the ‘Hippalus’ or ‘Hypalus’, also known as the southwest wind (later the southwest monsoon). The way back was usually started at the beginning of the Egyptian month Tybis (December). One then sailed with the help of the ‘Vulturnus’, an east-southeasterly wind.

The wind directions were represented with Latin abbreviations until the 17th century. The Latin abbreviations sometimes cause confusion with the abbreviations that we use today. See Table 1 (Lamb and Johnson, 1966).

Abbreviation	Name	Wind direction
S.	Septentrionalis	Northerly
Or.	Orientalis	Easterly
M. or Mer.	Meridionalis	Southerly
Occ.	Occidentalis	Westerly
S. Or.		Northeasterly
M. Or. or Mer. Or.		Southeasterly
M. Occ. or Mer. Occ.		Southwesterly
S. Occ.		Northwesterly

Table 1: Latin abbreviations used to describe the wind direction, in use until around 1600

Around 1600 the first information about the wind began to appear in ship logs. Towards the end of the 17th and in the 18th century the Dutch VOC ships often logged information regarding the wind direction and the wind force in the ship logs. Instruments used in order to measure the wind speed did not exist yet which is the reason why wind observations from that time need careful analysis.

3. THE 17TH AND 18TH CENTURY

3.1. *Wind estimations during the early 17th century*

During the 17th century it was common to use different names for the wind force depending on how the wind was experienced. One would estimate the wind force by use of the surroundings, for example through the behaviour of a well known, trusted ship in a rough sea or the whistling of the wind through the rigging or the appearance of the sea surface. More important however was the amount of sail the ship could carry under various wind conditions.

One of the first publications in which the wind force was mentioned was an English publication titled: 'An Accidence, or the Pathway to Experience Necessary for all Young Seamen', from 1626 by Captain John Smith (Smith, 1925). One spoke here of: 'a calme, a breze, a fresh gaile, a pleasant gayle, a stiffe force gayle, it ouerblows, a gust, a storme, a spoute, a loume gaile, an eddy wind, a flake of wind, a Turnado, a mounthsoune, a Herycano'. Unfortunately no accompanying description is given by Captain John Smith.

In the 17th century the Dutch and also Danish crews (Frydendahl et al., 1992) developed a special terminology to describe the wind. Table 2 gives some 17th century Dutch terminologies that are related to wind direction and wind force (source: VOC logbooks).

Dutch expression	Description
Hapje, Zogje, Zugje	A dying breath. A little bite, huff, or puff of wind
Fariabel lugie	A slant wind. Very weak, variable wind
Labberkoelte, flauwe koelte, lichte koelte	A sluggish wind. A listless wind. A limp wind. Wind weak, sails without wind
Bramzeilskoelte	A topgallant wind. A reasonable wind. Topgallant sails should be reefed for more than a reasonable wind because the ship became top heavy
Dichte of Stijve koelte	Fresh or stiff breeze to strong breeze
Bakstage of Bakstags wind. 'anders gezeylt'	A quartering wind, 45° abaft the abeam. To quarter i.e. sailing with wind on vessel's quarter
Marszeilskoelte	A topsails wind. Strong wind
De wind is wiew (waauw)	The wind is angry (good)
Haak of Kaak; Haakwinden	Hook or jaw winds. Pulling wind or storm. Up and coming hard, bending, winds
Huiken en guiten	Cloak and rogue like winds. The wind blows (hard wind)
Onderzeilskoelte	Course sails wind. Sailing under courses only. From strong withstanding hard wind to storm.
Bijlegger	A strong wind dead ahead. The vessel was hove-to
Lenzen voor top en takel	Sailing under bare poles i.e. with no sail set or only a storm staysail
Zeilen waaien uit de lijken	Sails blow out of the leeches. Leeches or bolt ropes: ropes sewn around the edge of a sail
Uitschot	Slip-up. Wind veering in addition to a sudden increase in wind force
Droge buien; zengen	White squalls. Sudden wind gusts often at clear skies

Table 2: 17th Century Dutch expressions in order to describe wind force



- A. Royals
- B. Topgallant sails
- C. Topsails
- D. Courses

Figure a: Sail settings of a late 18th century sailing ship

3.2. *The assessment of wind strength in the 17th and 18th century through sail settings*
Towards the end of the 17th century the wind force on a Dutch sailing ship was based upon the highest open sails that a full rigged ship could carry. The highest sails were the first to be reefed or furled with increasing wind speeds. The ships from that time, for example a flute ship, galleon or frigate, were square rigged with three masts, equipped with (from top to bottom) royal sails, topgallant sails, topsails, and course sails. The extremely popular flute ship however was not always equipped with royals during the 17th century.

In the beginning of the 17th century sailing ships were built with a very high poop deck. These raised quarter-decks (or poop-decks), designed to be higher than the enemy in a battle at sea, sometimes caught more wind than the sails. From the end of the 17th century onward, when guns were placed onboard of merchant ships, the ships were built with lower quarter-decks. Because of this development, the wind force estimations from sail settings in the beginning of the 17th century can differ from the wind force estimations made in the beginning of the 18th century.

During the 18th century sailing ships increased in size and the masts became higher however the sail settings hardly changed. Sometimes staysails were added between the masts and the bowsprit was extended with a jib boom. This enabled the ships to sail close-hauled and faster. From the end of the 18th century onward, 'royal sails' or 'royals' were fixed above the topgallant sails on large sailing ships (Figure a).

When the wind breezed up it was possible to reef the sails three to four times. With a single reef in a topgallant or topsail the wind would be named as a 'fresh breeze' to 'strong breeze' (Table 2). Four reefs or close-reefed would be named a 'topsail gale'. In the 17th century most of the time there was no distinction between a sluggish wind, a limp wind and a light wind. The scales for wind force at sea appear in literature only in the beginning of the 18th century. Some examples are shown in Table 3. For comparison the international Beaufort scale from 1874 has been added. Note that the Beaufort numbers cannot be compared directly with the old wind scales.

Holland, 18th century (descriptive terms used in VOC ship logs)	England, Approx. 1700 (Daniel Defoe)	Beaufort, 1874	
		Number	Standard name
Stilte, Stil, Stilleties	Stark calm	0	Calm
Flauwe koelte, Slappe koelte, Fariabel lugie	Calm weather	1	Light air
Labberkoelte/coeltie/lugie, Slappe bramzeilscoeltie	Little wind	2	Light breeze
Topzeilskoelte, Bramzeilskoelte		3	Gentle breeze
Marszeils koelte	A fine breeze	4	Moderate breeze
Gereefde marszeilskoelte, Stijve marszeils koelte	A small gale	5	Fresh breeze
Dubbel gereefde marszeilskoelte	A fresh gale	6	Strong breeze
Digt gereefde marszeilskoelte	A topsail gale	7	Moderate gale
Onderzeilskoelte	Blows fresh	8	Fresh gale
Gereefde onderzeilskoelte	A hard gale of wind	9	Strong gale
Storm	A fret of wind	10	Whole gale
	A storm	11	Storm
	A tempest	12	Hurricane

Table 3: 18th Century wind force scales compared to the International Beaufort scale.

Note: the Beaufort numbers cannot be compared directly with the old scales

3.3. Determination of the wind direction in the 17th and 18th century

The square rigged sailing ships in the 17th and 18th century were difficult to sail close-hauled i.e. as close to the wind as possible. Often they sailed 'free' or 'downwind' which means one would sail with the wind blowing from astern. If it were necessary to sail close-hauled, then one would sail 'clean full', 'full and by' or 'by the wind'. These expressions give an indication of the direction of the apparent wind (Table 4). This wind direction would usually be noted in double compass points (1 point = 11.25 degrees; 32 points = 360 degrees; see Table 16) and was determined by the direction of the dogvane, placed on the weather-side of the quarterdeck or the pennants worn at each masthead. Up until around 1850 the apparent wind direction of the vanes was not adjusted for the speed and direction of the ship in order to get the true wind direction (KNMI, 1866). This is a factor that needs to be strongly considered during the analysis of wind observations.

The directions during this time were noted at Dutch ships as 'regtwijzend' i.e. relative to the geographical north, and 'miswijzend' i.e. relative to the magnetic north. The old ship logs would usually mention how the directions were measured. It wasn't until after 1850 that all directions were 'regtwijzend' and the true wind direction (relative to the geographical north) was noted in the logbook.

Course (Dutch)	Sailing course	Apparent Wind Direction
Op de wind	On the wind	The wind dead ahead
In de wind	Close hauled, In the wind.	Wind before the beam as far as possible. Sails hardly full, shivering
Bij de wind,	Close hauled, By the wind	Wind before the beam. All sails full, lying as near as the wind as possible. Angle between the keel of the ship and wind direction is 60°
Met stuurboord halzen toe,	Boat was on a starboard tack	With the wind on the starboard side
Met bakboord halzen toe	Boat was on a port tack	With the wind on the port side
Vol en bij (bij matige winden)	Close hauled, Full and by (with moderate winds)	Wind before the beam. All sails full. Angle between the keel of the ship and wind direction is 6 points or 67.5° (1 point = 11.25°)
Ruimschoots (bij zwakke winden)	Close hauled, Clean full (with weak winds).	Wind before the beam. Keeping the sail full, bellying off the wind. Angle between the keel of the ship and wind direction between 6 and 8 points (80°)
Halve wind	Reaching. Wind abeam	With the wind on the beam, 8 points (90°)
Van de wind, Ruime wind	Sailing large. Sailing with large sheets and tacks	Wind abaft the beam but not straight from behind
Voor de wind, Met open halzen zeilen	Running (free), downwind, squared away	Wind abaft the beam. The wind comes in straight from behind

Table 4: Ships courses and the apparent wind direction for full rigged ships

3.4. Sail settings of 17th and 18th century ships versus the International Beaufort scale wind force

Although the old wind force descriptions cannot be converted directly into Beaufort numbers, one can make a reasonable estimate of the wind force from the description of the open sails of the ship. The crew used more or less uniform sail settings for square rigged sailing ships (Table 5). Regardless if one sailed with only one large topsail (17th century) or with topsails and topgallant sails (18th century) one would start reefing the sails with wind force 4 to 5. With a lower wind force one would have all possible sails set. If the topgallant sails were close-reefed and the topsails double-reefed then there was a lot of wind, force 6 to 9. By the time that there were storms, wind force 10, one would sail with hardly any sails set usually only with storm staysails (De Booij, 1888).

Sail settings for full rigged ships	Beaufort Number	Wind force description
All sails set; Full and by	1 – 4	Weak to moderate winds
Single-reefed sails; Topgallant sails one reef; Topsails one reef	5 – 6	Strong winds
Double and treble-reefed sails	6 – 9	Hard to stormy winds
Close-reefed; Courses one reef	10	Storm
Scud under bare poles	11 – 12	Hurricane

Table 5: Rule of thumb for 17th and 18th century sail settings versus the International Beaufort scale of wind force, 1874

4. DE BEAUFORT WIND FORCE SCALE

4.1. History and development

Towards the end of the 18th century the Englishman Alexander Dalrymple, the first Hydrographer of the English 'East India Company' and also of the Royal Navy, introduced a wind force scale with 13 scale parts (0-12) for maritime use in succession to a windmill scale designed by the English engineer John Smeaton. Dalrymple included this scale in his 'Treatise on Navigation', which was examined by the English commander Sir Francis Beaufort (Cook, 1989). Around the same time, but independent from Dalrymple, Rous designed a quantitative maritime wind force scale. This scale was based on a large amount of experiments relating to wind pressure mostly completed by English coastal stations (UK Met Office, 2007). The English Colonel James Capper published this scale in 1801 in his 'Observations on the winds and monsoons' (Table 6).

In his private log (January 13, 1806) kept on board of the English frigate HMS Woolwich (Table 6), Beaufort wrote the Dalrymple scale in a slightly amended form: with 14 scale parts (0-13). He changed the scale again in 1807 when he decided to combine the scale numbers 1 and 2 and push all the following numbers up (Garbett, 1926). That same year he decided to include a description of the sail settings of a man-of-war (a square rigged frigate with three masts and equipped with 44 cannons) sailing under different wind conditions. The scale was not used by anyone but Beaufort himself. In 1832 an article appeared in the 'Nautical Magazine' titled 'The Log Board' with the recommendation to universally use the Beaufort scale. On December 28, 1838 the scale was officially introduced in the English Navy through a memorandum to 'All Captains and Commanding Officers of Her Majesty's Ships and Vessels' (Wood, 1838), (Table 7). There were no alterations made to this scale since 1807. The scale was first recommended for general use on merchant ships in the 'Barometer Manual' of 1862 (Garbett, 1926). The scale was recommended in The Netherlands in the 'Universal Extract-Journal' in 1854.

Rous/Capper, 1801			Beaufort/Dalrymple, 1806	
Statute miles/hour	Force/square feet (Avoirdupois pounds)	Description	Nr.	Description
1	0.005	Almost calm	0	Calm
2 – 3	0.020 – 0.044	Just perceptible	1	Faint air just not calm
4 – 5	0.079 – 0.123	Gentle breeze	2	Light airs
10 – 15	0.492 – 1.107	Fresh breeze	3	Light breeze
20 – 25	1.968 – 3.075	Fresh gale	4	Gentle breeze
30 – 35	4.429 – 6.027	Strong gale	5	Moderate breeze
40 – 45	7.873 – 9.963	Hard gale	6	Fresh breeze
50	12.3000	Storm	7	Gentle steady gale
60	17.715	Violent hurricanes, Tempests, etc.	8	Moderate gale
80	31.490		9	Brisk gale
100	49.200		10	Fresh gale
			11	Hard gale
			12	Hard gale with heavy gusts
			13	Storm

Table 6: The first quantitative scales of wind force (Rous/Capper, 1801) and the first Beaufort scale (1806) based on Dalrymple

Historical Maritime Wind Scales until 1947

Nr.	Beaufort	Deep Sea Criterion, 1838	
0	Calm	Calm	
1	Light air	Just sufficient to give steerage way	
2	Light breeze	With which a well-conditioned man-of-war, under all sail, and clean full, would go in smooth water from:	1 - 2 knots speed
3	Gentle breeze		3 - 4 knots speed
4	Moderate breeze		5 - 6 knots speed
5	Fresh breeze	In which the same ship could just carry close hauled	Royals and courses
6	Stiff breeze		Single reefs and topgallant sails
7	Moderate gale		Double reefs, jib and courses
8	Fresh gale		Treble reefs and courses
9	Strong gale		Close reefs and courses
10	Whole gale	With which she could only bear close reefed main topsail and reefed foresail	
11	Storm	With which she would be reduced to storm staysails	
12	Hurricane	To which she could show no canvas	

Table 7: The first Beaufort scale used by the British Navy. Memorandum Wood, 1838

4.2. The International Beaufort scale of wind force, 1874

Following the introduction of the Beaufort scale in 1838 in England many other attempts were made to express the wind force in numbers. Curtis gave more than 20 different wind force scales for the period 1845-1894, varying in length from 5 to 20 scale numbers (Curtis, 1897).

Halfway the 19th century the rigging of the sailing ships began to change drastically from that full rigged ship in 1838. Topgallant and topsails were split into upper and lower topgallant and top sails. For this reason an adjusted Beaufort scale was adopted in 1874 at the Maritime Meteorological Conference in London based on a full rigged sailing ship from that period with double topgallant and top sails. The new scale only differed by the description of the double topgallant and topsails at scale numbers 6-10 (Table 8). The Dutch version of the 13-part scale (Table 12) is from 1898. Prior to 1898, during the period 1854-1898, a 12-part scale (Table 9, 2nd column) was used in The Netherlands.

Nr.	Beaufort	Deep Sea Criterion, 1874	
0	Calm		
1	Light air	Just sufficient to give steerage way (full rigged ship in 1874)	
2	Light breeze	That in which a well-conditioned man-of-war, with all sail set, and clean full, would go in smooth water from:	1 - 2 knots speed
3	Gentle breeze		3 - 4 knots speed
4	Moderate breeze		5 - 6 knots speed
5	Fresh breeze	That to which she could just carry in chase, full and by	Royals and courses
6	Strong breeze		Topgallant sails
7	Moderate gale		Topsails, jib and courses
8	Fresh gale		Reefed upper topsails and courses
9	Strong gale		Lower topsails and courses
10	Whole gale	That with which she could scarcely bear lower main topsail and reefed foresail	
11	Storm	That which would reduce her to storm staysails	
12	Hurricane	That which no canvas could withstand	

Table 8: The International Beaufort scale for ships equipped with a 'double topsail yard' rig; London, 1874

5. MARITIME WIND OBSERVATIONS IN THE NETHERLANDS: 1850-1898

Shortly after the ‘First Maritime Meteorological Conference’ in Brussels, September 1853, the first meteorological ship logbooks, in Dutch: ‘Extract-Journaal’, were made available to the Dutch merchant and navy ships by the KNMI. The wind direction and wind force was reported 3 times a day, at 8 o’clock in the evening, at 4 o’clock in the morning and at noon (= 12 o’clock). The most prevailing wind direction and force over the past 8 hours was to be recorded in the logbook. The time was reported in ship time, meaning local time. Because one assumed that most Dutch ships used the ‘regtwijzend’ compass, (compass pointing to true north), it was asked to log the true wind direction, averaged over one third part of the day in whole points relative to the geographical (true) north.

At the conference in Brussels, the three sections of the day were defined as follows (KNMI, 1853):

The first section: 12.00 hours (noon) to 20.00 hours (in the evening)

The middle section: 20.00 hours (in the evening) to 04.00 hours (in the morning)

The last section: 04.00 hours (in the morning) to 12.00 hours (noon)

The wind force on Dutch ships was determined by a ‘table of sail settings for the ship’ on the first page of the logbook and was expressed in a 12-part (0-11) Beaufort scale (KNMI, 1866) (Table 9).

During the period 1936-1941 almost all of the historical Dutch meteorological ‘Extract-Journals’ from the period 1854-1938 were punched at the KNMI. During the punching Table 9 was exclusively used to convert estimated wind force into Beaufort scale numbers. These are the numbers that eventually were submitted to the ICOADS database.

Bft. nr.	The wind force as mentioned in the Dutch ‘Extract Journals’ (1850-1898), sailing <i>full and by</i>	Wind force terms (in Dutch) used in the Netherlands for Beaufort scale numbers (1850-1898)	KNMI description of Beaufort scale numbers (1850-1898)
0	Calm	Stilte, in slecht water, geen vertier	Stilte
1	Ship just has steerage way	Flauwe koelte	Flauwe-stuur
2	Ship’s speed 1 – 2 knots	Labberkoelte	Flauwe koelte
3	Ship’s speed 3 – 4 knots	Bramzeilskoelte	Ligte koelte
4	Ship’s speed 5 – 6 knots	Stijve bramzeilskoelte	Matige koelte
5	With royals	Marszeilskoelte	Frissche koelte
6	Topgallant sails and single-reefed topsails	Stijve marszeilskoelte	Sterke koelte
7	Double-reefed topsails	Gereefde marszeilskoelte	Matige wind
8	Treble-reefed topsails	Dubbel gereefde marszeilskoelte	Frissche wind
9	Close-reefed topsails and courses	Digt gereefde marszeilskoelte	Sterke wind
10	Close-reefed main topsail and reefed fore sail	Stijve digt gereefde marszeilskoelte	Veel wind
11	Storm staysails only	Storm	Storm
12		Orkaan	Orkaan

Table 9: The Beaufort scale of wind force used in the Netherlands during the period 1850-1898

The ships were asked to determine the true wind direction and the true wind force using the ship speed and the apparent wind direction and apparent wind force. On board of Dutch Navy ships this was achieved with the help of a table (Table 10) (L'Honoré Naber, 1901). In this table DD is the true wind direction and FF the true wind force.

Apparent wind force	True wind direction and	Speed of the ship																				
		4 knots						7.5 knots						12 knots								
		Apparent wind direction in points with respect to the bow						Apparent wind direction in points with respect to the bow						Apparent wind direction in points with respect to the bow								
		2	4	6	8	10	12	14	2	4	6	8	10	12	14	2	4	6	8	10	12	14
Bft		True wind direction and force						True wind direction and force						True wind direction and force								
1	DD	3	7	9	11	12	13	13	9	10	11	12	13	14	15							
	FF	1	1	1	1	2	2	2	1	1	1	2	2	3	3							
2	DD	3	6	8	10	11	13	15	5	8	10	11	13	14	15	10	10	11	12	13	14	15
	FF	1	1	2	2	2	3	3	1	1	2	2	3	3	4	1	2	2	3	3	4	4
3	DD	3	5	7	9	11	13	14	4	7	9	10	12	13	15	6	8	10	11	13	14	15
	FF	2	3	3	3	3	4	4	2	2	3	3	4	4	5	1	2	3	4	4	5	5
5	DD		5	7	9	11	13	14	3	5	8	10	11	13	14	4	7	9	10	12	13	15
	FF		4	5	5	5	5	6	3	4	4	5	5	6	6	3	4	4	5	6	6	7
6	DD			7	9	11	12	14		5	7	9	11	13	14	3	6	8	10	12	13	14
	FF			6	6	7	7	7		6	6	6	7	7	7	4	5	6	7	7	8	8
8	DD									5	6	9	11	13	14	3	5	7	9	10	13	14
	FF									7	7	8	8	8	9	6	6	7	8	8	9	9

Table 10: Recalculation from apparent wind direction and apparent wind force to true wind direction (DD) and true wind force (FF)

Example 1:

Ship's speed	12 knots
Apparent wind direction	6 points
Apparent wind force	6 Beaufort
True wind direction (DD)	8 points
True wind force (FF)	6

Example 2:

Ship's speed	7.5 knots
Apparent wind direction	12 points
Apparent wind force	6 Beaufort
True wind direction (DD)	13 points
True wind force (FF)	7

In some Dutch 'Extract-Journals' the ships were classified according to the ship speed by descriptive terms. Terms varying from a 'slow ship' to an 'extremely fast ship' were used. For a good interpretation the average ship speed in knots versus the log classification is given in Table 11 (1 knot = 1 nautical mile/hour = 1852m per hour).

Speed of the ship according to the log (end of the 19th century)	Average speed (in knots) of a sailing ship	Average speed (in knots) of a steamship
Slow	2.5	5
Fast	5	12
Very Fast	9	17
Extremely Fast	12	24

Table 11: Average speed in knots of a late 19th century sailing ship or steam ship

6. MARITIME WIND OBSERVATIONS IN THE NETHERLANDS: 1898 – PRESENT

A new 13-part Beaufort scale (0-12) with adjusted terminology appeared in the KNMI meteorological ship logbook of 1898. Only 12 Beaufort numbers (0-11, see Table 9) were used in the ship logs prior to 1898. The sail settings were described on the basis of double rigged topgallant and topsails. At the same time KNMI changed the Dutch wind force description (Gallé, 1915). The new wind force description now also was valid for climatological land stations and for telegraphic ship's weather reports (IMC, 1913).

Later, the Beaufort scale was expanded with the scale of Petersen (Petersen, 1927), which was based on the appearance of the sea surface. Another expansion was a scale for use on lighthouses and coastal semaphore stations where the wind force was estimated with respect to the behaviour of fishing vessels (Table 12). After the 1947 International Meteorological Conference (IMC) in Washington, the wind speed in the meteorological logbooks was now reported in knots. Nevertheless the old KNMI description for the Beaufort scale of wind force was still used. The IMC is presently known as the World Meteorological Organization – WMO.

Around 1880 about half of the entire world fleet consisted of steamships (Figure b, Moyses-Bartlett, 1946). In the Netherlands, during the period of 1890-1900, only 4% of all the meteorological logbooks received at the KNMI were from sailing ships (KNMI Yearbooks). Because the Beaufort scale was based on the behaviour of sailing ships, sailors onboard steamships were forced to estimate the wind force through the use of different criteria in the surroundings. In 1927 the German sailing captains P. Petersen and M. Prager designed a wind force scale based on the appearance of the sea surface for different wind speeds. This scale was based on simultaneous observations of the appearance of the sea surface and Beaufort wind force. The observations, done by Prager, spanned a period of 721 days during the years 1903-1905 (Prager, 1905). Following a request to several countries to test the Petersen scale in practice (International Meteorological Conference Warsaw, 1935) KNMI asked the Dutch captains several questions in order to validate the scale (KNMI, 1937). The scale was adopted by the IMC in 1947 during the International Meteorological Conference in Washington.

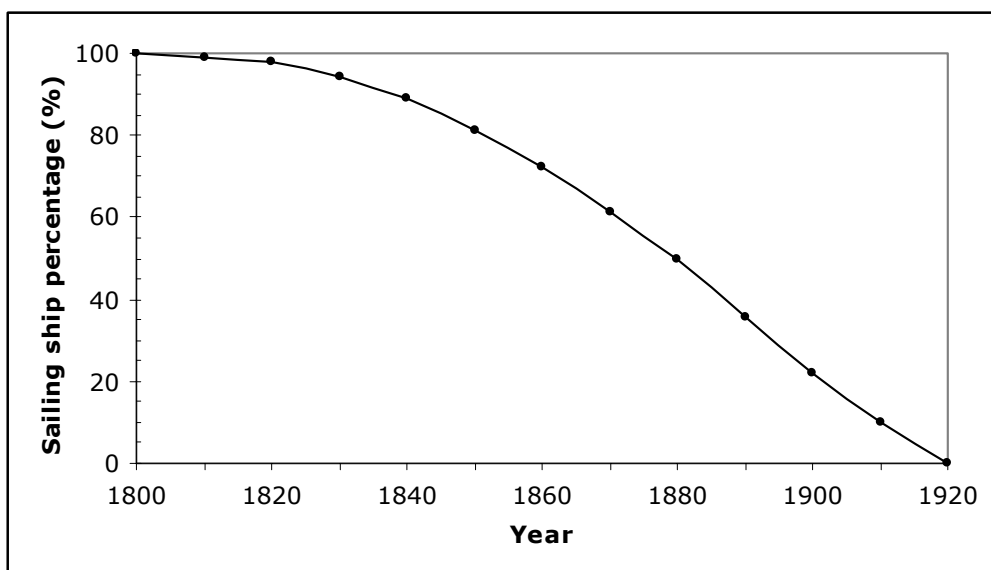


Figure b: Percentage sailing ships of the total number of ships (world wide)

Historical Maritime Wind Scales until 1947

Bft nr.	Steamships since 1898	Sailing ships since 1874	Fishing vessels since 1935	Petersen scale since 1947
0	Calm	No speed	Sea like a mirror	Sea like a mirror
1	Light air	Just sufficient to give steerage way	Sufficient to give good steerage way to fishing vessels with the 'wind free'	Ripples with the appearance of scales; no foam crests
2	Light breeze	Speed 1 to 2 knots	Fishing vessels with topsails and light canvas, full and by, make up to 2 knots	Small wavelets; crests of glassy appearance, not breaking
3	Gentle breeze	Speed 3 to 4 knots	Fishing vessels begin to heel over slightly under topsails and light canvas make up to 3 knots 'full and by'	Large wavelets; crests begin to break; scattered white caps
4	Moderate breeze	Speed 5 to 6 knots	Good working breeze. Fishing vessels heel over considerably on a wind under all sail	Small waves becoming longer; numerous white caps
5	Fresh breeze	Sailing with royals	Fishing vessel shorten sail	Moderate waves, taking longer form; many white caps; some spray
6	Strong breeze	Sailing with topgallant sails	Fishing vessel double reef gaff main sails	Larger waves forming; white caps everywhere; more spray
7	Near gale	Sailing with upper and lower topsails	Fishing vessel remain in harbour and those at sea hove to	Sea heaps up; white foam from breaking waves begins to blow in streaks
8	Gale	Sailing with reefed upper topsails	Fishing vessel take shelter if possible	Moderately high waves of greater length; edges of crests begin to break into spindrift; foam is blown into well-marked streaks
9	Strong gale	Sailing with lower topsails and reefed fore sail		High waves; seas begin to roll; dense streaks of foam; spray may reduce visibility
10	Storm	Sailing with main course and storm staysail		Very high waves with overhanging crests; sea takes white appearance as foam is blown in very dense streaks; reduced visibility
11	Violent storm	Sailing with storm staysails only		Exceptionally high waves; sea covered with white foam patches; visibility still more reduced
12	Hurricane	No canvas		Air filled with foam; sea completely white with driving spray; visibility still more reduced

Table 12: The maritime Beaufort scale of wind force 1898-present

7. ACCURACY OF THE WIND DIRECTION AND THE ESTIMATED WIND FORCE

The wind direction was logged as the compass direction where the wind came from. Before 1850 directions were either very imprecise, in double compass points (NE, NW etc.) or, especially during the VOC period, logged extremely accurately in half quarter or eight points (Table 15). For the conversion from points to degrees and the subdivision of the point, one would use Table 14 and Table 15. After 1850 it was common to use English abbreviations for the Dutch names of the double compass points (Table 13) (Bleeker, 1954).

Noord	N
Noordoost	NE
Oost	E
Zuidoost	SE
Zuid	S
Zuidwest	SW
West	W
Noordwest	NW

Table 13: Dutch names and English abbreviations for double compass points

During the 19th century estimation of the wind force was partly (for the scale numbers 0-4) based on an English Ship-of-the-line sailing close hauled, and partly (scale numbers 5-9) defined by the amount of sail that the same type of ship sailing close hauled and chasing another ship, could carry. For the highest scale numbers the storm sails that could be carried were used for the approximation of the wind force. Most captains had enough experience to estimate the wind force using the Beaufort scale, even if the ship wasn't square rigged or if the ship didn't sail close hauled (Bossen and Van der Zee, 1922). It was soon clear that indeed the wind force estimations expressed in Beaufort scale numbers would always give the same result regardless of the size of the ship, and even disregarding the change from a sailing ship to a steamship (Verploegh, 1957).

Around 1850 it was not unusual to log the wind force more accurately than that which the scale supplied, and to log them in half Beaufort scale numbers. A wind force of $3\frac{1}{2}$ or $4\frac{1}{2}$ Beaufort was fairly common during that time.

In May 1914 a comparison was made between more than 10 different steamships that steamed in the southern part of the Arabic Sea. One assumed that a difference in position of 10 to 30 nautical miles would present no noticeable difference in the wind. It was then discovered that the average error in wind force was 0.3 ± 0.3 Beaufort and an average error in wind direction of 0.4 ± 0.5 points (Gallé, 1915). This reinforced the decision to use whole Beaufort scale numbers and whole compass points.

In 1957 it was showed that on average 75% of observers estimate within a margin of one Beaufort scale number. For wind forces below 5 Beaufort it was showed that on average only 1% of the observers estimate the wind force wrong by at least one Beaufort scale number. Above 5 Beaufort this increased to 4-10% of the observers (Verploegh, 1957).

Historical Maritime Wind Scales until 1947

Points	Compass direction	Degrees	Points	Compass direction	Degrees
1	N by E	11° 15'	17	S by W	191° 15'
2	NNE	22° 30'	18	SSW	202° 30'
3	NE by N	33° 45'	19	SW by S	213° 45'
4	NE	45° 00'	20	SW	225° 00'
5	NE by E	56° 15'	21	SW by W	236° 15'
6	ENE	67° 30'	22	WSW	247° 30'
7	E by N	78° 45'	23	W by S	258° 45'
8	E	90° 00'	24	W	270° 00'
9	E by S	101° 15'	25	W by N	281° 15'
10	ESE	112° 30'	26	WNW	292° 30'
11	SE by E	123° 45'	27	NW by W	303° 45'
12	SE	135° 00'	28	NW	315° 00'
13	SE by S	146° 15'	29	NW by N	326° 15'
14	SSE	157° 30'	30	NNW	337° 30'
15	S by E	168° 45'	31	N by W	348° 45'
16	S	180° 00'	32	N	360° 00'

Table 14: Conversion of compass points to degrees

Points	Degrees ° Minutes ' Seconds "	Points	Degrees ° Minutes ' Seconds "	Points	Degrees ° Minutes ' Seconds "	Points	Degrees ° Minutes ' Seconds "
0	00° 00' 00"	2	22° 30' 00"	4	45° 00' 00"	6	67° 30' 00"
1/8	01° 24' 22"	2 1/8	23° 54' 22"	4 1/8	46° 24' 22"	6 1/8	68° 54' 22"
1/4	02° 48' 45"	2 1/4	25° 18' 45"	4 1/4	47° 48' 45"	6 1/4	70° 18' 45"
1/3	03° 45' 00"	2 1/3	26° 15' 00"	4 1/3	48° 45' 00"	6 1/3	71° 15' 00"
3/8	04° 13' 07"	2 3/8	26° 43' 07"	4 3/8	49° 13' 07"	6 3/8	71° 43' 07"
1/2	05° 37' 30"	2 1/2	28° 07' 30"	4 1/2	50° 37' 30"	6 1/2	73° 07' 30"
5/8	07° 01' 52"	2 5/8	29° 31' 52"	4 5/8	52° 01' 52"	6 5/8	74° 31' 52"
2/3	07° 30' 00"	2 2/3	30° 00' 00"	4 2/3	52° 30' 00"	6 2/3	75° 00' 00"
3/4	08° 26' 15"	2 3/4	30° 56' 15"	4 3/4	53° 26' 15"	6 3/4	75° 56' 15"
7/8	09° 50' 37"	2 7/8	32° 20' 37"	4 7/8	54° 50' 37"	6 7/8	77° 20' 37"
1	11° 15' 00"	3	33° 45' 00"	5	56° 15' 00"	7	78° 45' 00"
1 1/8	12° 39' 22"	3 1/8	35° 09' 22"	5 1/8	57° 39' 22"	7 1/8	80° 09' 22"
1 1/4	14° 03' 45"	3 1/4	36° 33' 45"	5 1/4	59° 03' 45"	7 1/4	81° 33' 45"
1 1/3	15° 00' 00"	3 1/3	37° 30' 00"	5 1/3	60° 00' 00"	7 1/3	82° 30' 00"
1 3/8	15° 28' 07"	3 3/8	37° 58' 07"	5 3/8	60° 28' 07"	7 3/8	82° 58' 07"
1 1/2	16° 52' 30"	3 1/2	39° 22' 30"	5 1/2	61° 52' 30"	7 1/2	84° 22' 30"
1 5/8	18° 16' 52"	3 5/8	40° 46' 52"	5 5/8	63° 16' 52"	7 5/8	85° 46' 52"
1 2/3	18° 45' 00"	3 2/3	41° 15' 00"	5 2/3	63° 45' 00"	7 2/3	86° 15' 00"
1 3/4	19° 41' 15"	3 3/4	42° 11' 15"	5 3/4	64° 41' 15"	7 3/4	87° 11' 15"
1 7/8	21° 05' 37"	3 7/8	43° 35' 37"	5 7/8	66° 05' 37"	7 7/8	88° 35' 37"
2	22° 30' 00"	4	45° 00' 00"	6	67° 30' 00"	8	90° 00' 00"

Table 15: Subdivision of points to degrees (0° – 90°)

The subdivision is as follows: 00 = Calm, no wind;

Examples: 1/4S = 16 1/4 points = 182° 48' 45"; 1/8SSE = 14 1/8 points = 158° 54' 22"

8. EQUIVALENT WIND SPEEDS FOR THE ESTIMATED WIND FORCE

With the invention of the Robinson anemometer in 1846 it seemed possible to measure the wind speed on board ships instead of estimating the wind force. One hoped that the measured wind speed would be more accurate than the estimated wind force in terms of the Beaufort scale numbers. In 1898 for the first time a table appeared in the KNMI meteorological ship log that showed the wind speed in meters per second for the different values of the Beaufort scale (Gallé, 1915). These equivalent wind speeds, determined by the Englishman R.H. Scott, were internationally adopted in Vienna, 1874 (Table 16). See Report of the Permanent Committee of the First International Meteorological Congress at Vienna for the year 1874.

Scott's numbers for the wind speeds appeared to be much too high. The designer of the anemometer, Robinson, assumed that a linear relationship existed between the wind speed (v) and the rotation speed of the anemometer (u): $v = 3u$. Later it appeared that the 'constant' was not 3 but something between 2.2 and 2.5 (Gallé, 1915). Looking back, the numbers for wind speeds were approximately 20-40% too high.

In 1900 KNMI adopted the German 'Seewarte' wind speed scale designed by Köppen (Köppen, 1898). This equivalent scale was replaced again in 1908 with English equivalents coming from the Meteorological Office in London (IMC, 1913). Used were the maritime equivalents displayed in Table XVII, p. 40 from the report M.O. No. 180, 1906.

Much research has been done regarding the values and the accuracy of wind measurements by anemometers on board sailing ships, all with very little success. The researchers finally gave up when they realized that a representative wind speed could not be measured anywhere on a full rigged sailing ship (Ramage, 1982).

Beaufort, 1874	R.H. Scott, 1874 (m/s)	Köppen, 1898 (m/s)	London, 1906 (m/s)
0	0 – 1.5	0	0 – 1.3
1	3.5	1.7	2.2
2	6	3.1	3.6
3	8	4.8	4.9
4	10	6.7	6.7
5	12.5	8.8	8.7
6	15	10.7	11.0
7	18	12.9	13.4
8	21	15.4	16.1
9	25	18.0	19.7
10	29	21.0	23.7
11	33.5	24.4	> 25
12	40	–	> 25

Table 16: Equivalent wind speeds for the Beaufort wind force, as used from 1874. The London-table was used until 1946

9. LIST OF USED ABBREVIATIONS

ACRE	A tmospheric C irculation R econstruction over the E arth
CLIWOC	CL imatological database for the W orld O Ceans 1750 - 1850
HISKLIM	H ISTorisch KL IMaat
ICOADS	I nternational C omprehensive O cean- A tmosphere D ata S et
IMC	I nternational M eteorological C ommittee
KNMI	K oninklijk N ederlands M eteorologisch I nstituut
RECLAIM	RE covery of L ogbooks A nd I nternational M arine data
VOC	V erenigde O ostindische C ompagnie
WMO	W orld M eteorological O rganization

10. LIST OF FIGURES

Figure a:	Sail settings of a late 18th century sailing ship.....	7
Figure b:	Percentage sailing ships of the total number of ships (world wide).....	14

11. LIST OF TABLES

Table 1:	Latin abbreviations used to describe the wind direction, in use until around 1600.....	5
Table 2:	17th Century Dutch expressions in order to describe wind force.....	6
Table 3:	18th Century wind force scales compared to the International Beaufort scale.....	8
Table 4:	Ships courses and the apparent wind direction for full rigged ships.....	9
Table 5:	Rule of thumb for 17th and 18th century sail settings versus the International Beaufort scale of wind force, 1874.....	9
Table 6:	The first quantative scales of wind force (Rous/Capper, 1801) and the first Beaufort scale (1806) based on Dalrymple.....	10
Table 7:	The first Beaufort scale used by the British Navy. Memorandum Wood, 1838.....	11
Table 8:	The International Beaufort scale for ships equipped with a 'double topsail yard' rig; London, 1874.....	11
Table 9:	The Beaufort scale of wind force used in the Netherlands during the period 1850-1898.....	12
Table 10:	Recalculation from apparent wind direction and apparent wind force to true wind direction (DD) and true wind force (FF).....	13
Table 11:	Average speed in knots of a late 19th century sailing ship or steam ship.....	13
Table 12:	The maritime Beaufort scale of wind force 1898-present.....	15
Table 13:	Dutch names and English abbreviations for double compass points.....	16
Table 14:	Conversion of compass points to degrees.....	17
Table 15:	Subdivision of points to degrees (0° – 90°).....	17
Table 16:	Equivalent wind speeds for the Beaufort wind force, as used from 1874. The London-table was used until 1946.....	18

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