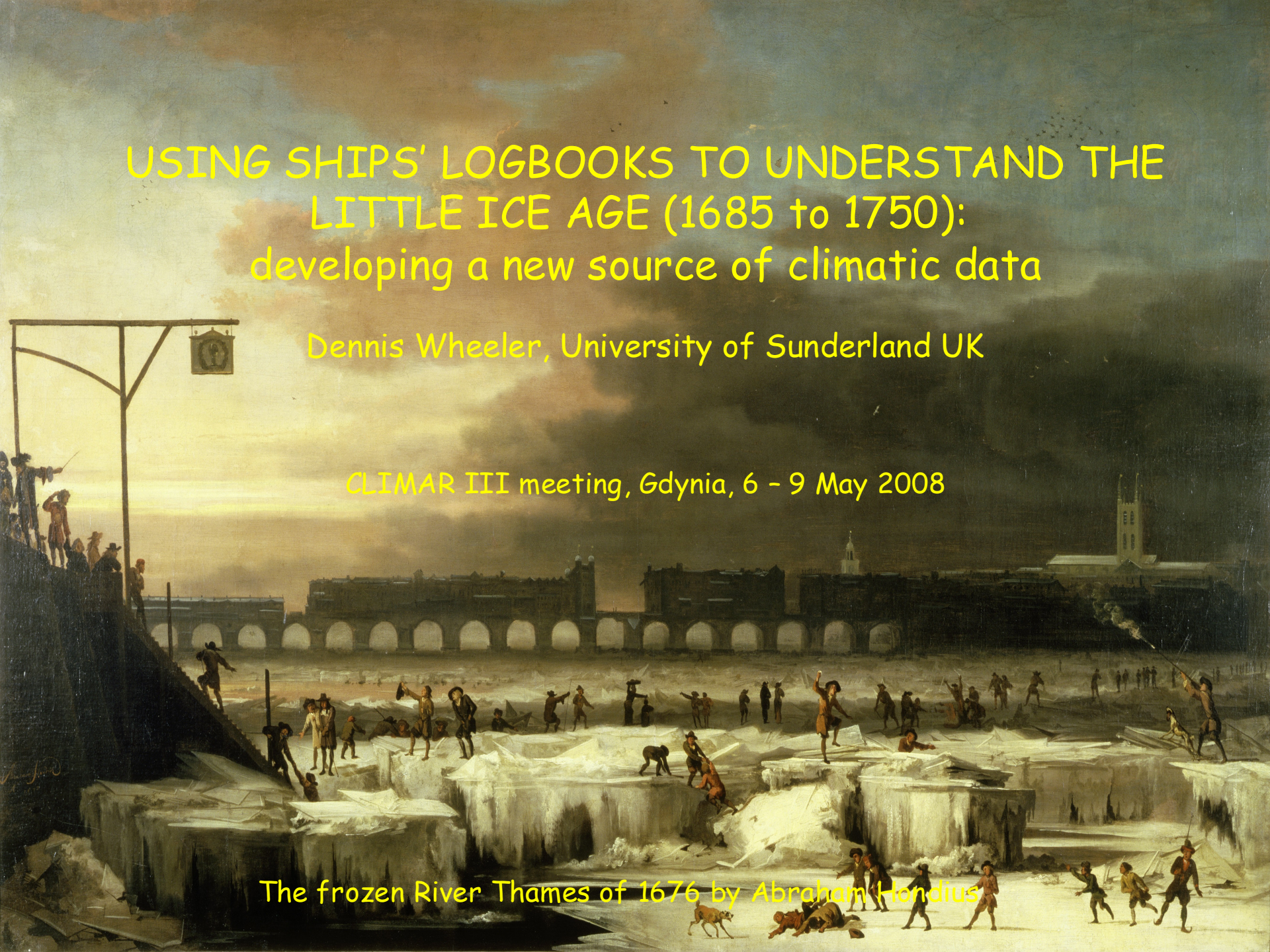
USING SHIPS' LOGBOOKS TO UNDERSTAND THE LITTLE ICE AGE (1685 to 1750): developing a new source of climatic data

Dennis Wheeler, University of Sunderland UK

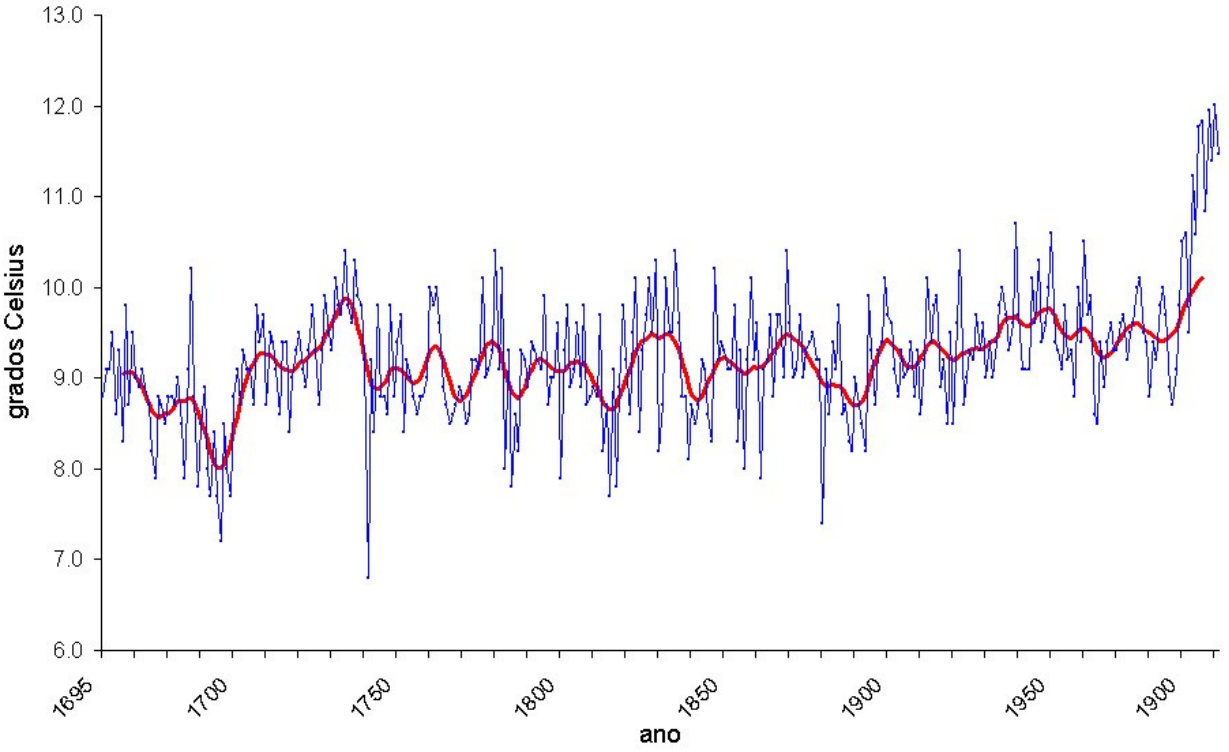
CLIMAR III meeting, Gdynia, 6 – 9 May 2008



The frozen River Thames of 1676 by Abraham Hondius

Sources of data for the Little Ice Age:

The Central England Temperature series (CET) prepared by Gordon Manley begins in 1659, continues to the present day and provides the world's longest instrumental temperature series

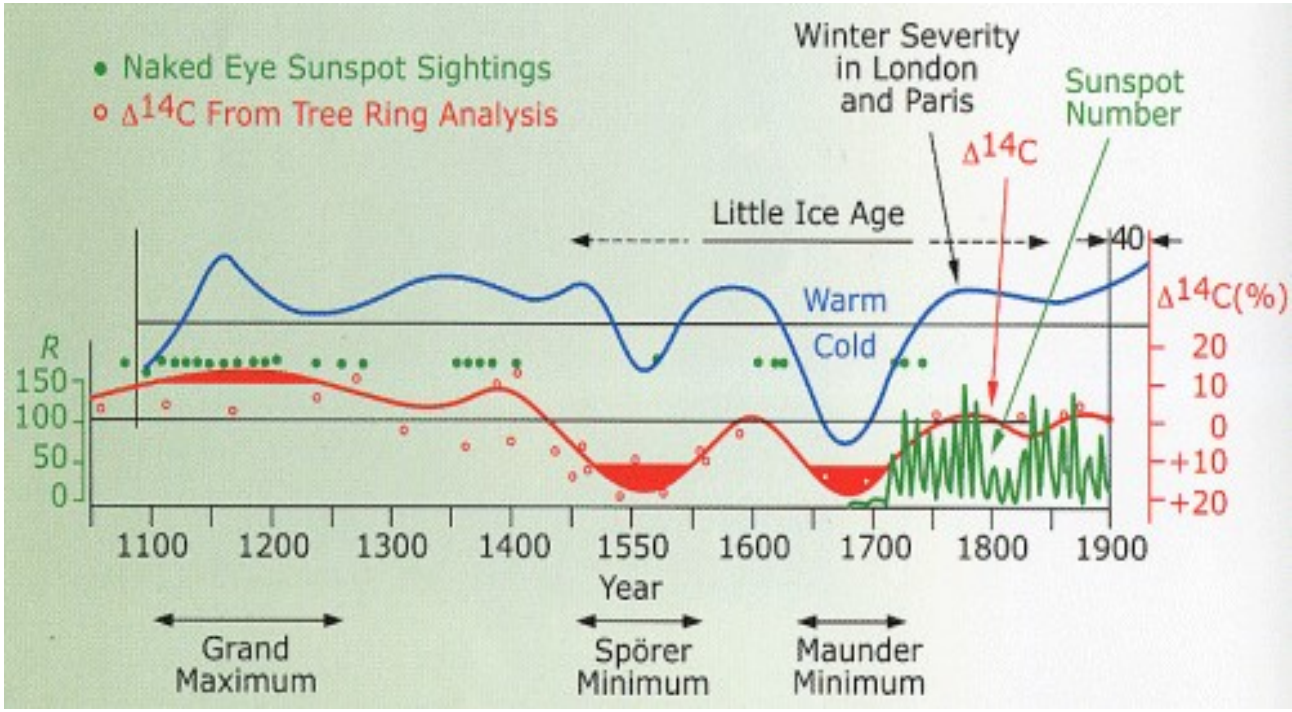


The CET with a 12-year Gaussian filter (1659-2000)

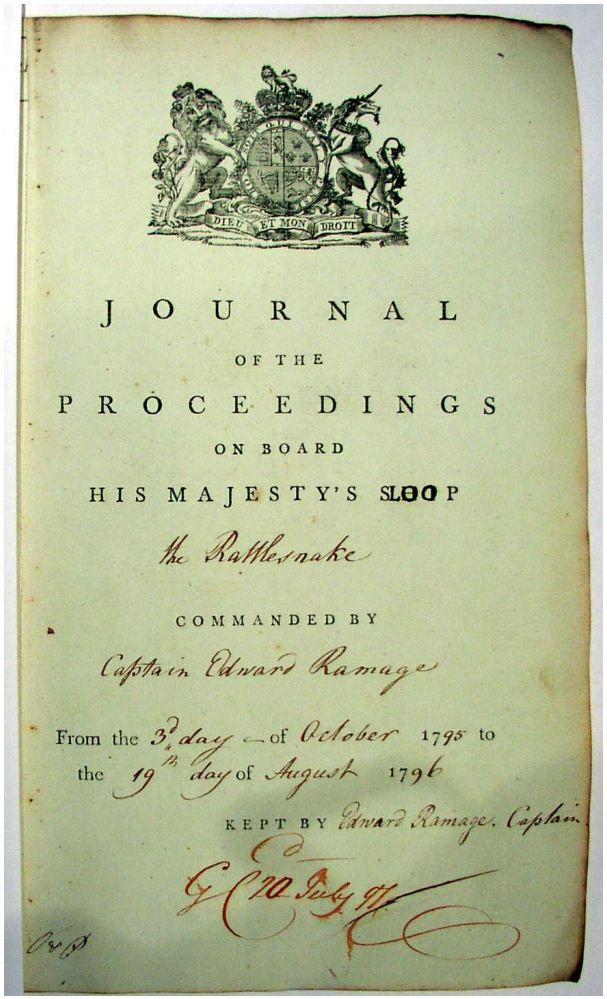
Sources of data for the Little Ice Age:

Cosmogenic isotopes - variations in ^{14}C in tree rings is the result of variations in the intensity of solar radiation received by the Earth's atmosphere.

Graph showing variations ^{14}C (red line), in the solar cycle (green line). The LIA coincides with periods of solar quiescence, particularly the Maunder Minimum.



To which sources can be added ship's logbooks, but what is a logbook?



JOURNAL

OF THE

PROCEEDINGS

ON BOARD

HIS MAJESTY'S SLOOP

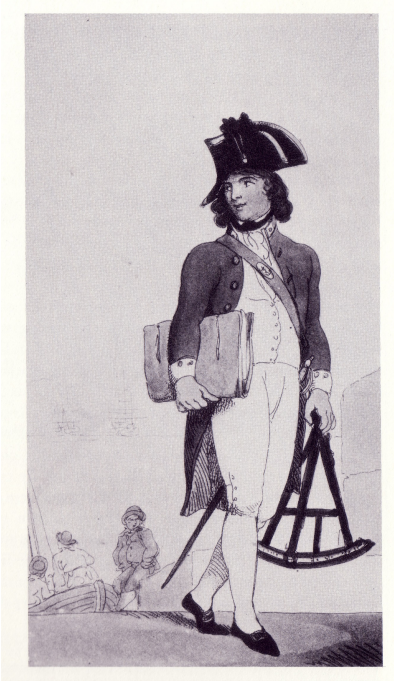
the Rattlesnake

COMMANDED BY

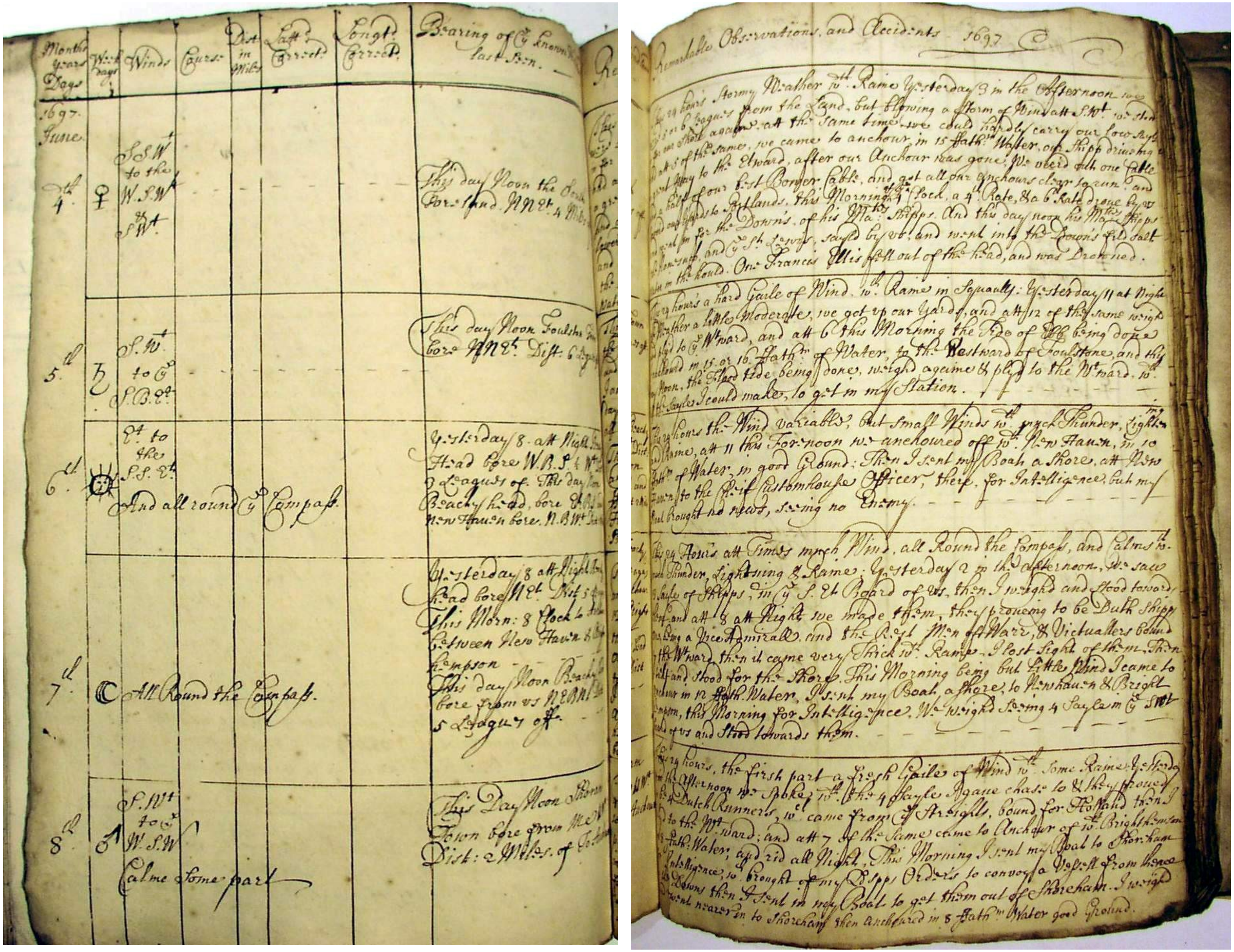
Captain Edward Ramage

From the *3d* day of *October* 1795 to
the *19th* day of *August* 1796

KEPT BY *Edward Ramage. Captain*



Pages from a typical Royal Navy logbook from the late C17 (HMS Experiment)



Logbook presentation became increasingly standardised in the late C17

the date

the day (astronomical symbol - Friday)

wind direction

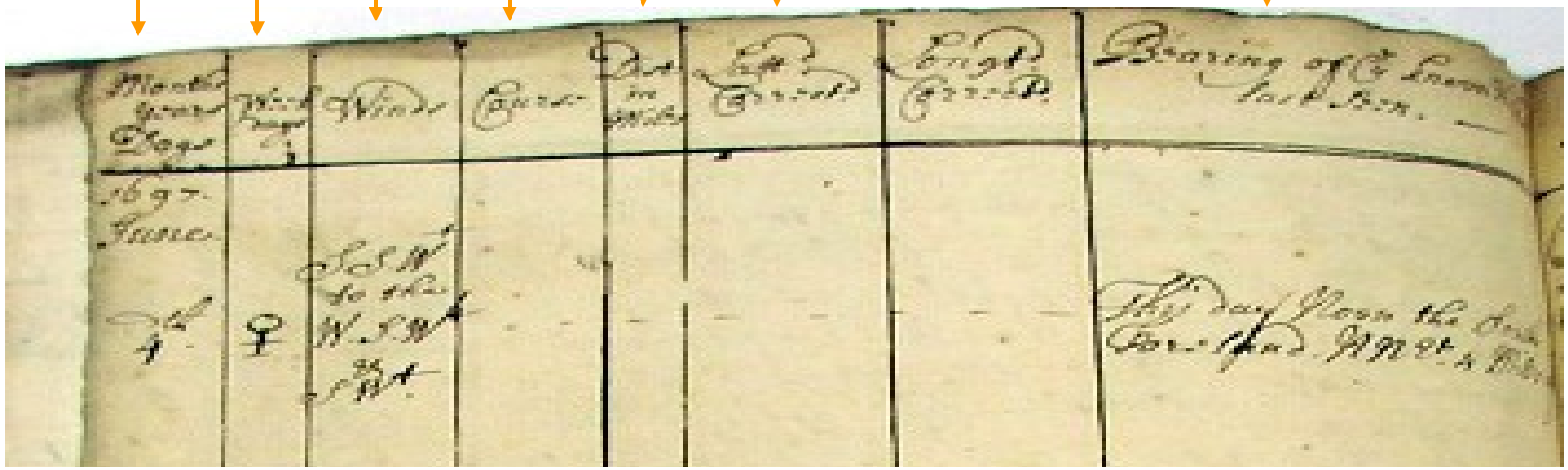
course

Distance sailed each day

latitude

longitude

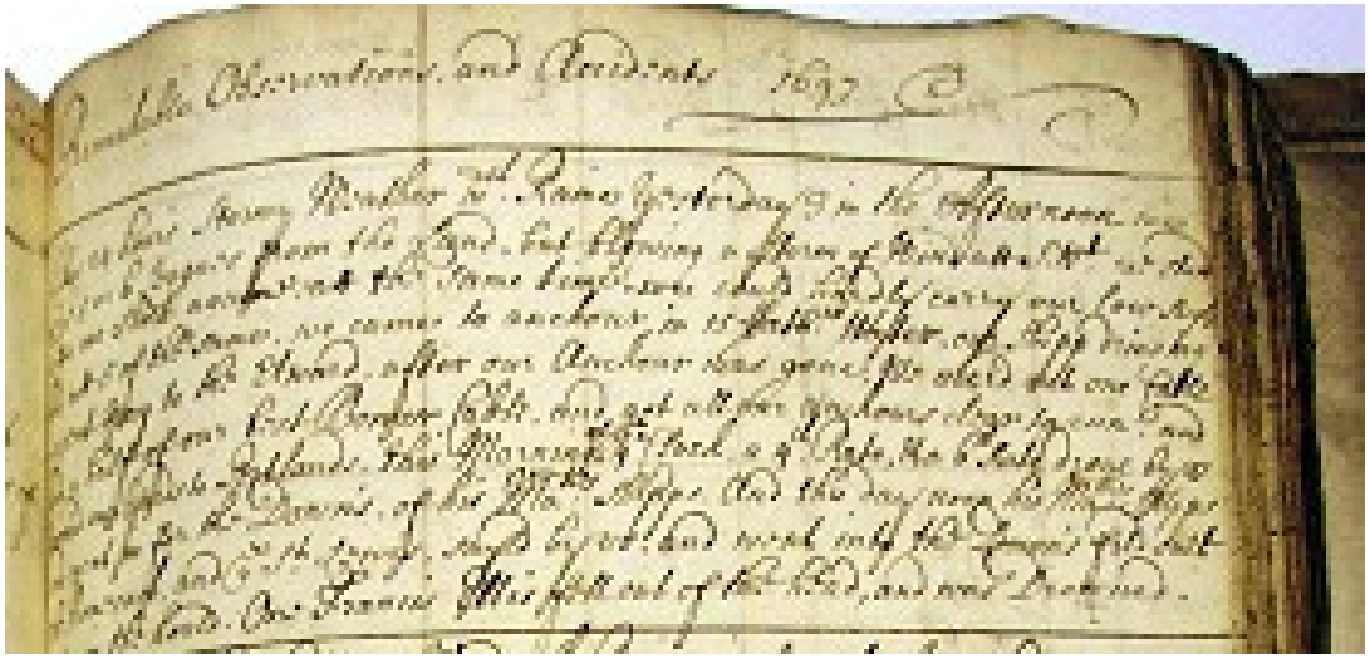
bearing to landmarks



Winds: SSW to the WSW, SW

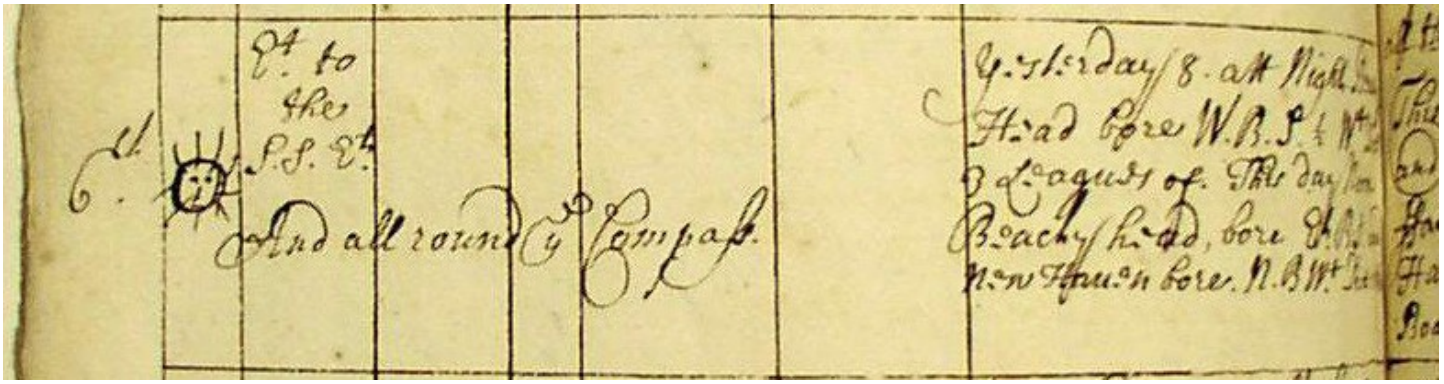
Location: South Foreland NNE 4 miles

The facing, right-hand, page contains a general description of the days activities on board, but always begins with a note on the wind force and weather

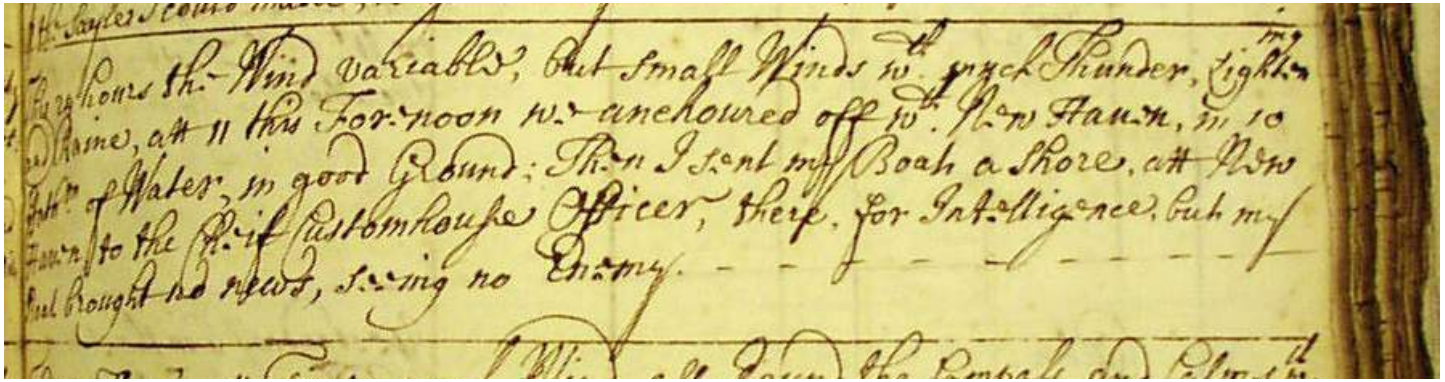


“These 24 hours stormy weather with rain”

Details from 6th June 1697 (OS) when off Newhaven and Beachy Head



Winds: Et to the S.S.Et And all round the Compass

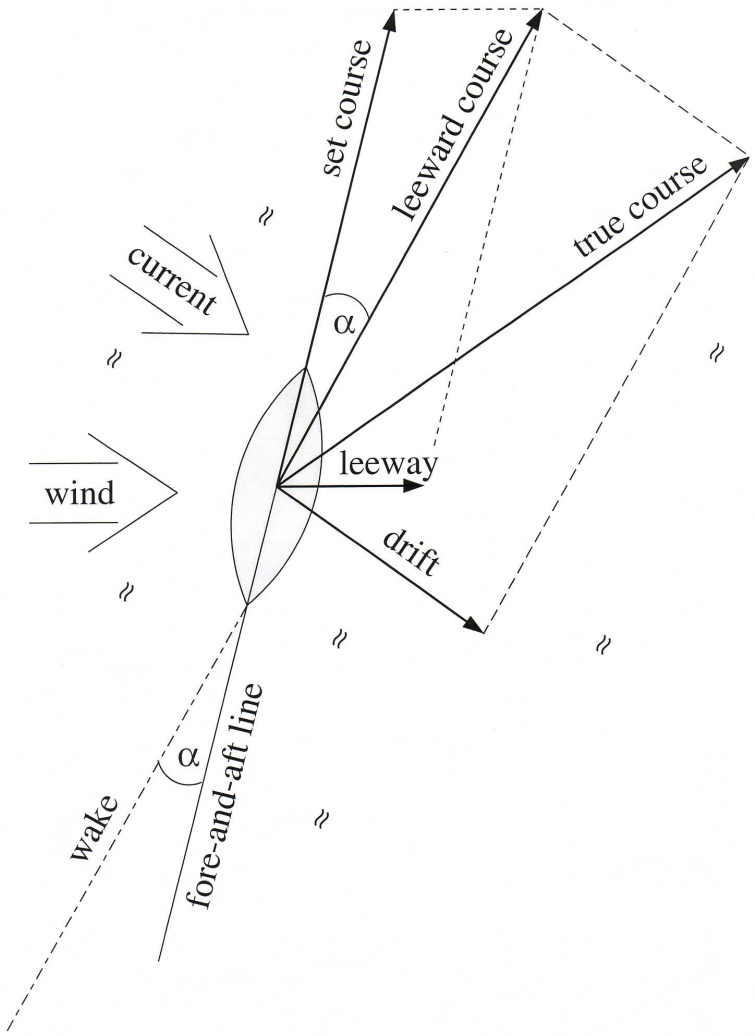


These 24 hours the Wind variable but small Winds wth much Thunder, lightning and raine

Charles Brooking: East Indiaman in a gale

Logbooks were not written as meteorological diaries – they were navigational aids, and they had to be reliable or the consequences could be catastrophic!

The wreck of the Association by an unknown artist



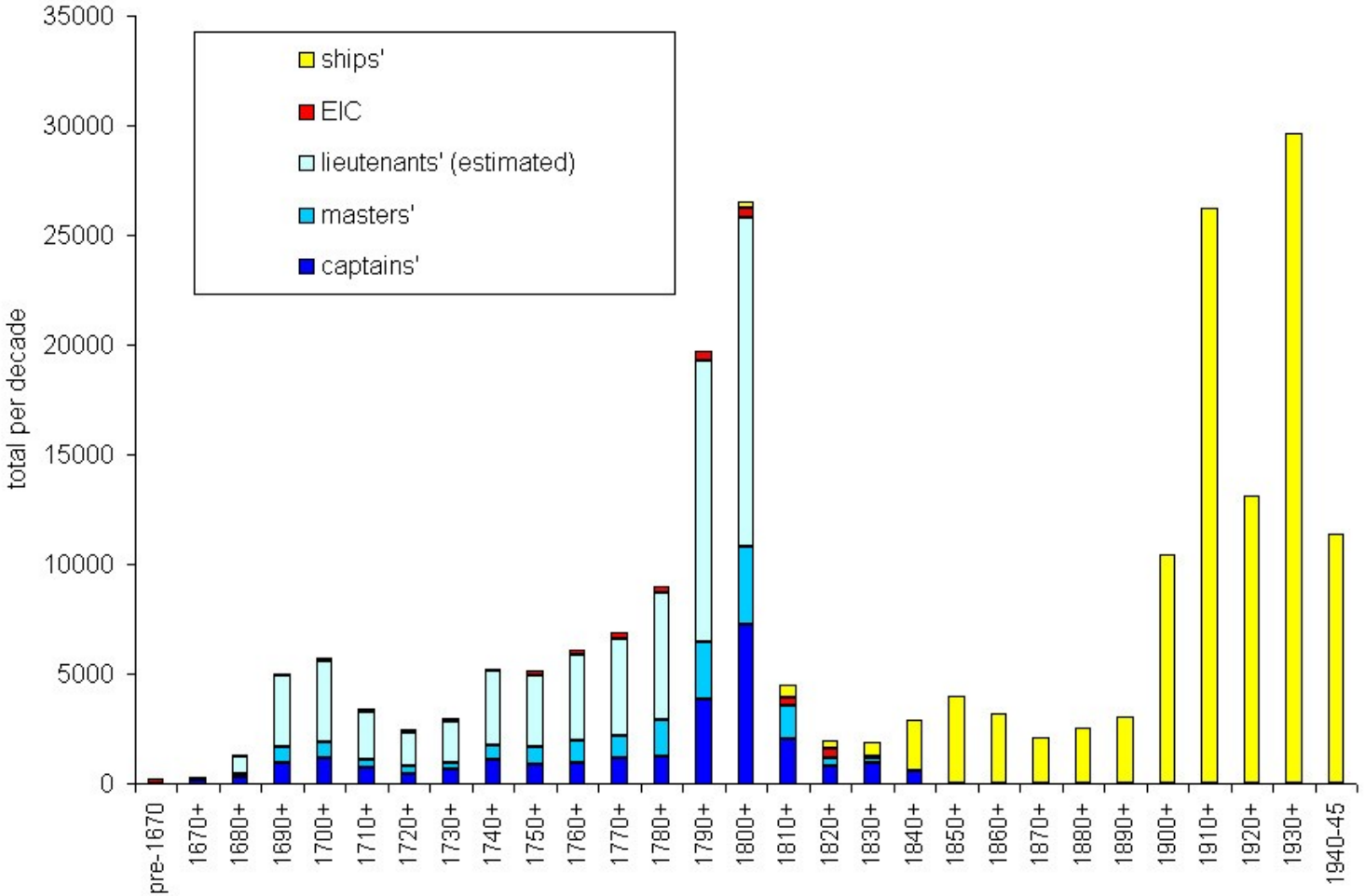
By paying attention to the forces at work on the ship's direction it was possible to estimate the her latitudinal and longitudinal displacement over the previous 24 hours.

As the years went by mariners began to accumulate an important knowledge of the winds and currents in different parts of the world.

Fortunately, these records have not been lost!

Logbooks in UK archives (1670 to 1945)

Including over 120,000 for the pre-instrumental period, with an average coverage of 6 months = c.22 million days of observations!



LOGBOOK DATA

From the mid-nineteenth ships began to report using instrumental data, but weather was observed long before that time and logbooks included a daily record of weather experienced at sea. The record consisted of:

Wind force (using pre-Beaufort Scale conventions)

Wind direction (32 point compass)

General description of the weather

including notes on cloud cover fog,

rain, snow, hail, thunder etc.

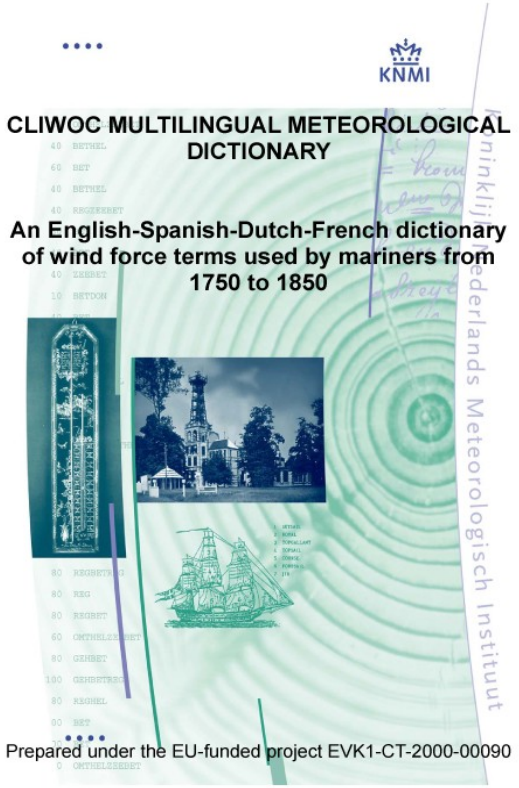
This system is similar to that used today by VOSs (Voluntary Observing Ships)

Ships' logbooks provide an important source that offer the advantages of:

3. The observations are fixed in space (lat/long) and time (dated)
4. The observations are homogenous in respect of time of observation (noon) and of recording (standard, pre-Beaufort vocabulary)
5. Observations are made AT SEA thereby filling a spatial gap and avoiding significant boundary layer effects
4. Data are not proxy, and record conditions at the time
11. The source is one of great abundance

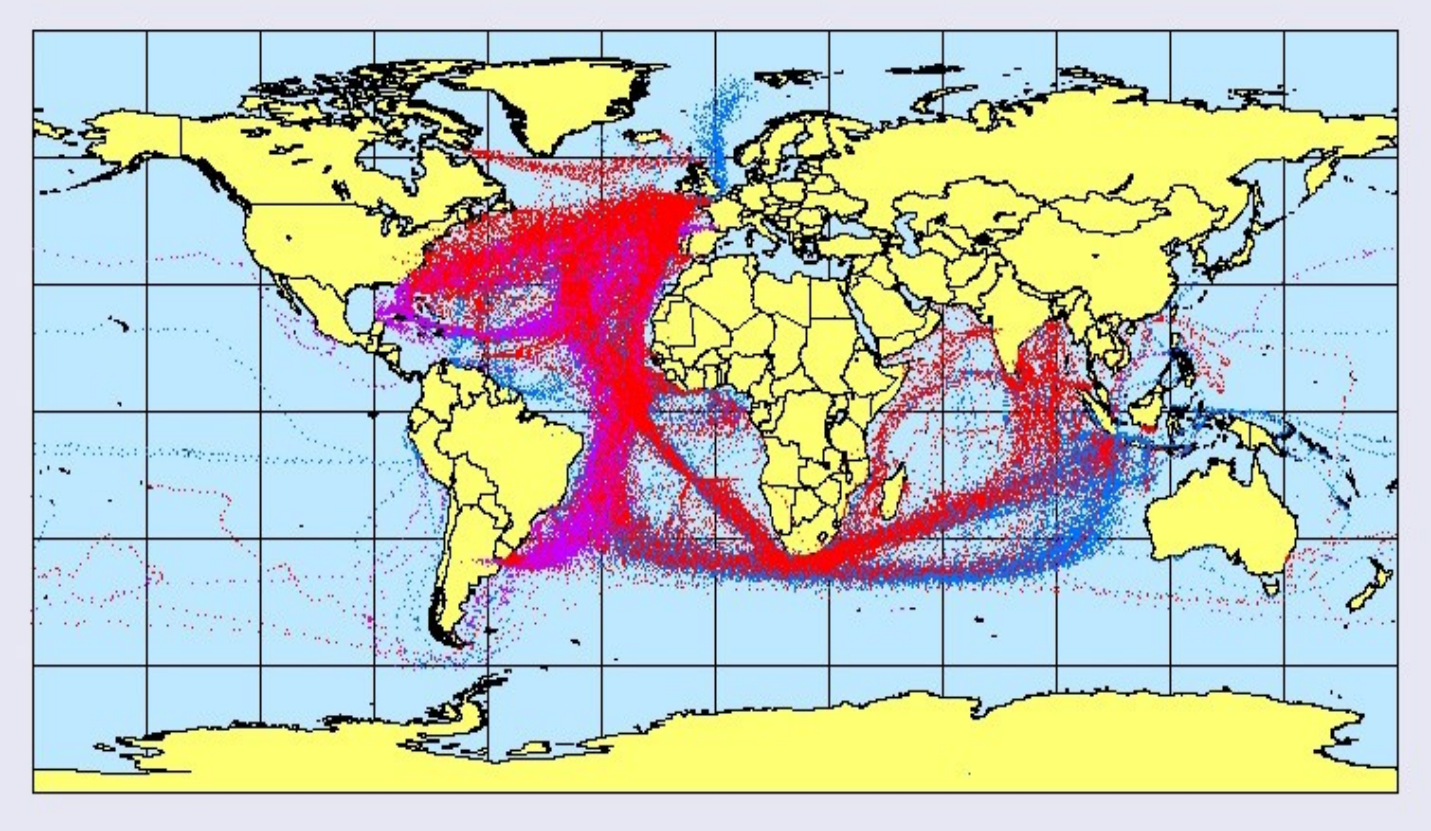
Studies by the EU-funded CLIWOC project (Climatological Database for the World's Oceans: 1750 to 1850) have concentrated on data verification, calibration and on the preparation of a database (285,00 entries thus far) – visit

www.ucm.es/info/cliwoc



And download the pdf version of the multi-lingual dictionary of wind force terms.

See also CLIWOC poster in CLIMAR III

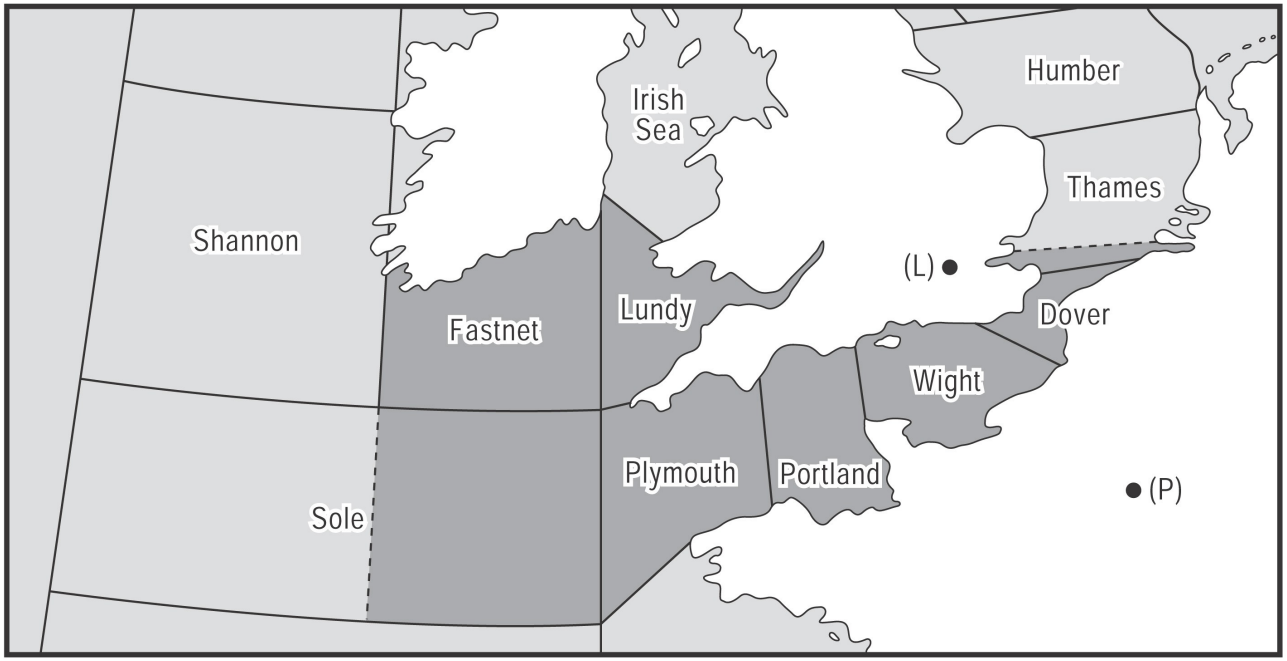


CLIWOC data coverage (1750-1850 only)

C17 LOGBOOK PROJECT

The oldest English logbooks from which a daily series can be assembled date from 1685, and a daily database has been compiled for this area from January 1685 to December 1700

The geographic range is limited to the seas close to the British Isles in those areas where naval activity was most intense and logbooks abundant.



The study area – by current day shipping forecast areas

The database

Time frequency: daily

Period: January 1685 to December 1700

Variables:

- wind force (original and Beaufort equivalent)
- wind direction (original and reduced to 4-point compass)
- gale days (from converted wind force terms > force 8)
- rain days (from days when rain or drizzle was noted)
- snow days (ditto but for snow)
- frost days (interpreted from general descriptions)

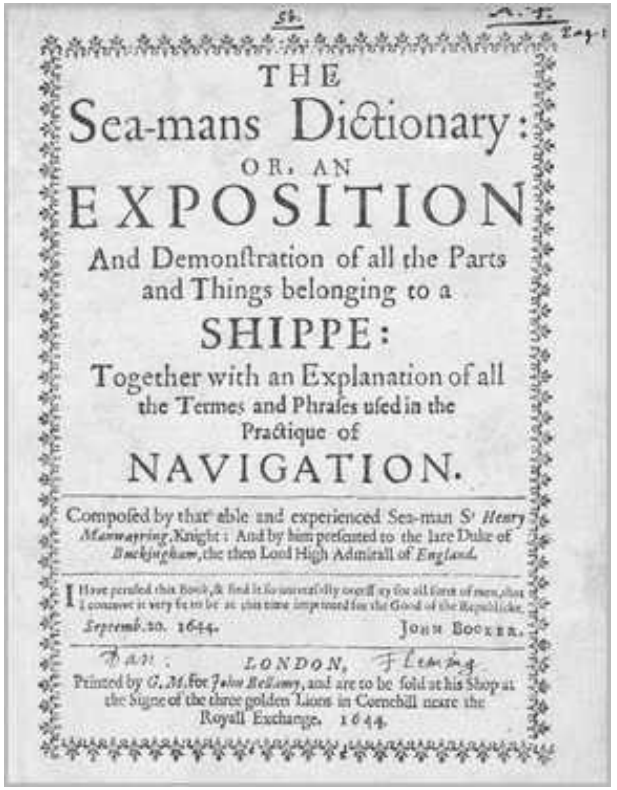
Metadata: logbook catalogue number, ship's name

Data treatment: wind force – consistency of vocabulary and usage.

70 different terms were encountered in a sample of 5000+, but 85% of entries comprise the 10 most commonly used:

Rank of usage	Term	frequency	Cum. Frequency (%)
1	*fresh gales*	1211	29.4
2	little wind	621	44.5
3	*moderate gales*	457	55.6
4	blowing a hard gale	342	63.8
5	small gale	210	68.9
6	blows hard	207	74.0
7	variable	134	77.2
8	fine gales	129	80.4
9	*calm*	99	82.6
10	*strong gales*	93	84.9

Using content analysis methods and contemporary documents, a dictionary was produced expressing archaic wind force terms in Beaufort Scale equivalent values (0 to 12).



THE
Sea-mans Dictionary:
OR, AN
EXPOSITION
And Demonstration of all the Parts and Things belonging to a
SHIPPE:
Together with an Explanation of all the Termes and Phrases used in the Practique of
NAVIGATION.

Composed by that able and experienced Sea-man Sr Henry Mainwaring, Knight: And by him presented to the late Duke of Buckingham, the then Lord High Admirall of England.

I Have perused this Book, & find it so universally copious for all sorts of men, that I conceive it very fit to be at this time imprinted for the Good of the Republicke.
Septemb. 20. 1644. JOHN BOOKER.

LONDON,
Printed by G. M. for John Bellamy, and are to be sold at his Shop at the signe of the three golden Lions in Cornehill neare the Royall Exchange. 1644.

Defoe's scale of wind

Term	grade	Term	grade
stark calm	0	a top sail gale	6
calm weather	1	blows fresh	7
little wind	2	a hard gale of wind	8
a fine breeze	3	a fret of wind	9
a small gale	4	a storm	10
a fresh gale	5	a tempest	11

Today we have 'gale warnings' and the term carries with it the threat of poor weather. On the Beaufort Scale we have

near gale (force 7), gale (force 8) and strong gale (force 9)

But to the C17 mariner all winds were gales:

fine gales, small gales, light gales, fresh gales

easy gales and gentle gales

but also

brave gales, indifferent gales,

soft gales and pleasant gales

A C17 gale was:

anything from this

to this

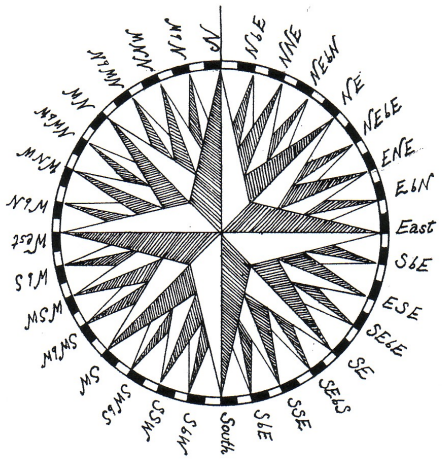
Dates were corrected:

2. From Julian to Gregorian calendar (+10 days & + 1 year from Jan to March)
3. Dates were corrected to take account of the nautical day (-1 day)

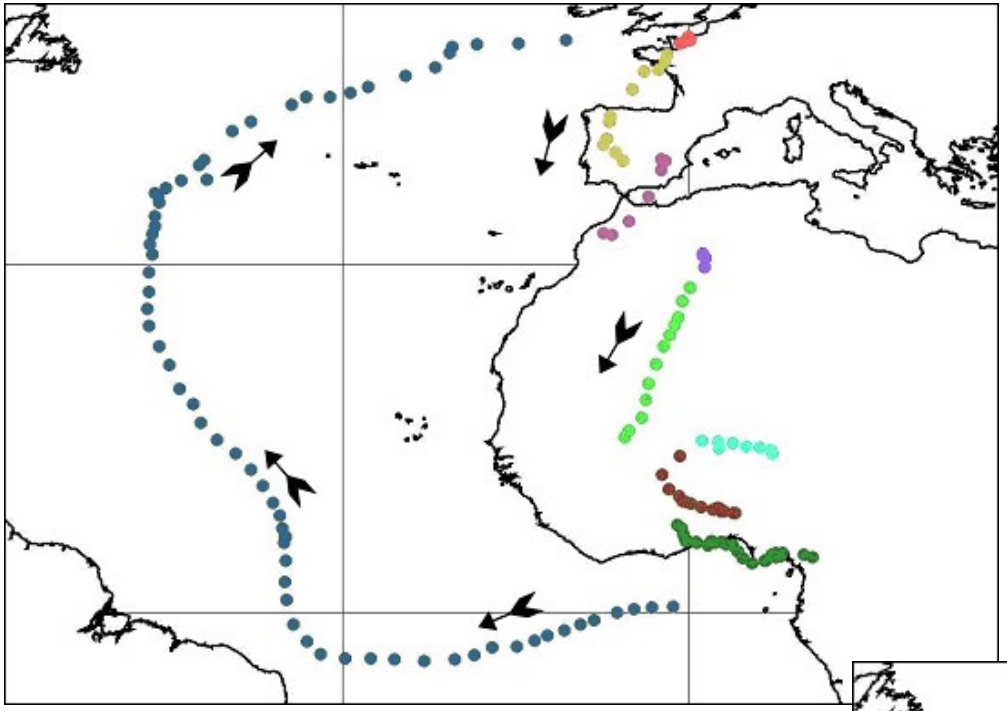
Wind directions, which were recorded as magnetic bearings on a 32-point compass, required no correction as the local variation at the time was then less than one compass point (11.25 degrees).

Observations were then categorised

into N, S, E and W groups.

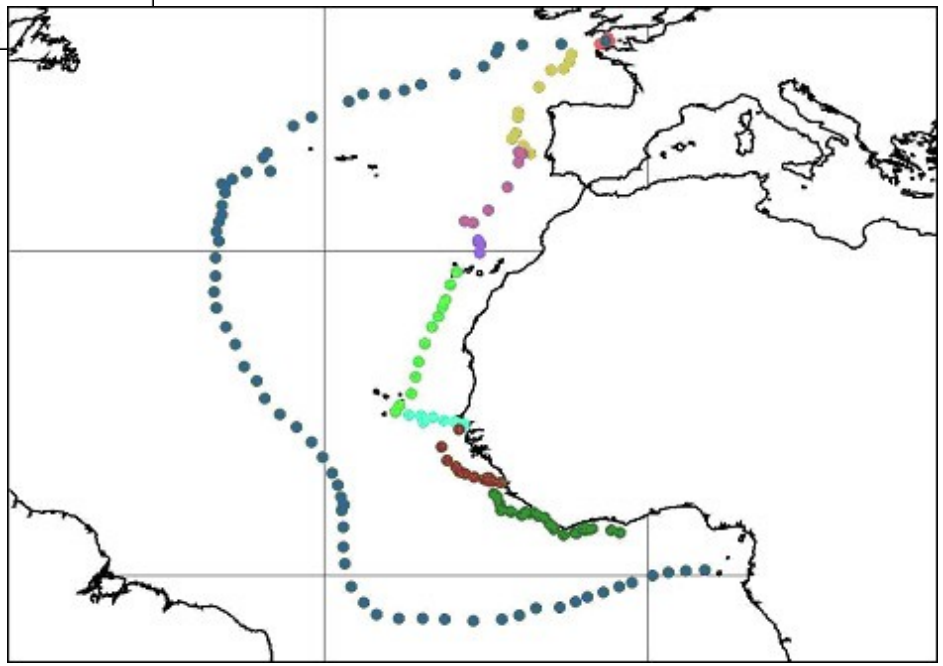


Correction for zero meridian: the case of HMS Surprise



Longitudinally uncorrected courses

Corrected course



Results (1): correlation of wind direction with the Central England Temperature series

CET anomalies	N	E	S	W
annual	-0.26*	-0.23*	0.38*	0.15
Spring (MAM)	-0.27	-0.25	0.44*	0.09
Summer (JJA)	0.02	0.19	0.08	-0.19
Autumn (SON)	-0.29*	-0.13	0.42*	0.04
Winter (DJF)	-0.40*	-0.48*	0.38*	0.49*

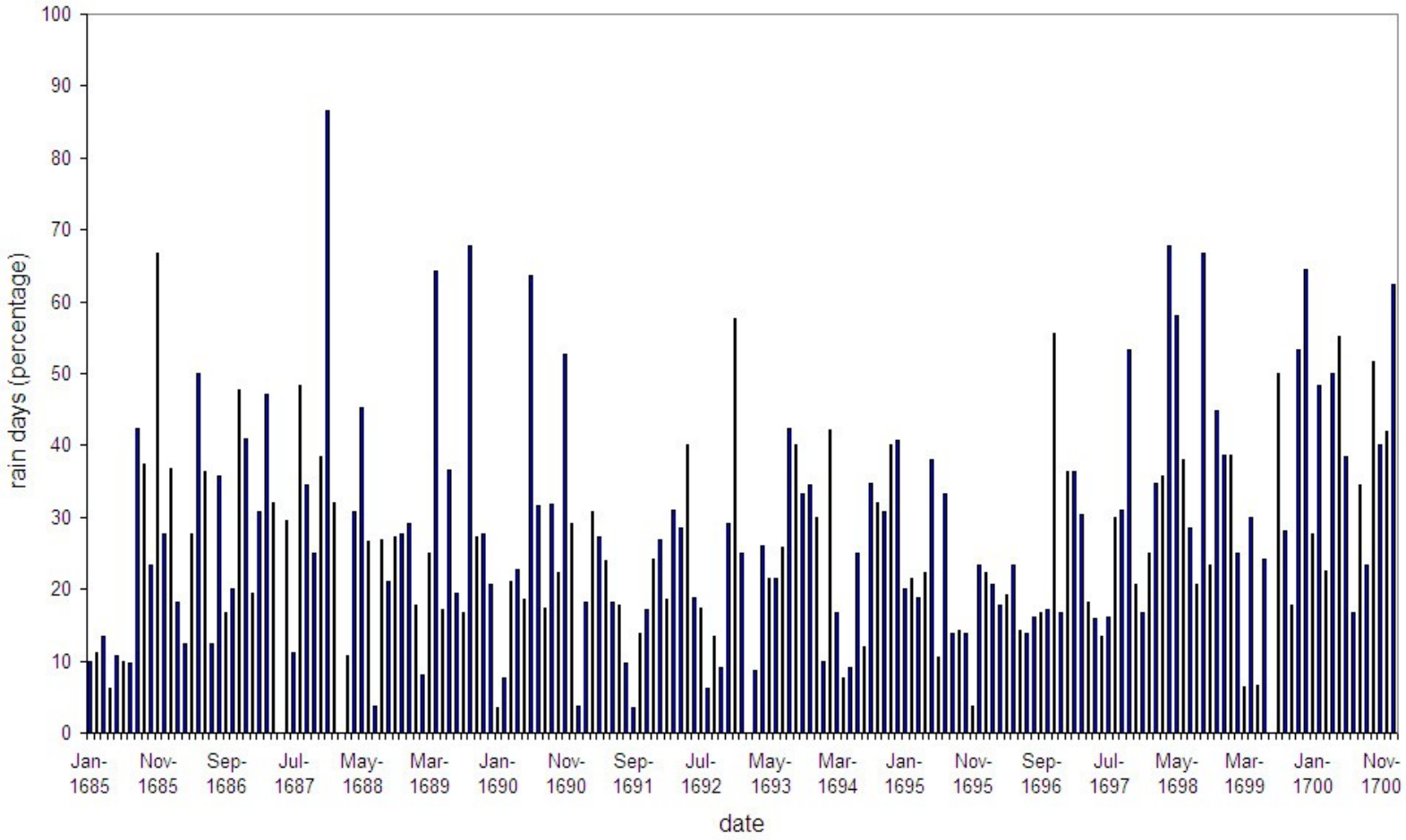
* Significant at the 0.05 level

Results (2): correlation of wind direction with Luterbacher's proxy-based NAO index

NAO index	N	E	S	W
annual	-0.22**	-0.40**	0.17*	0.36**
Spring (MAM)	-0.19	-0.33*	0.11	0.36*
Summer (JJA)	0.01	-0.09	-0.25	0.21
Autumn (SON)	0.02	0.36*	0.20	0.17
Winter (DJF)	-0.42**	-0.54**	0.41**	0.53**

** significant at the 0.05 level

Results (3): rain day record (monthly) 1685 - 1700



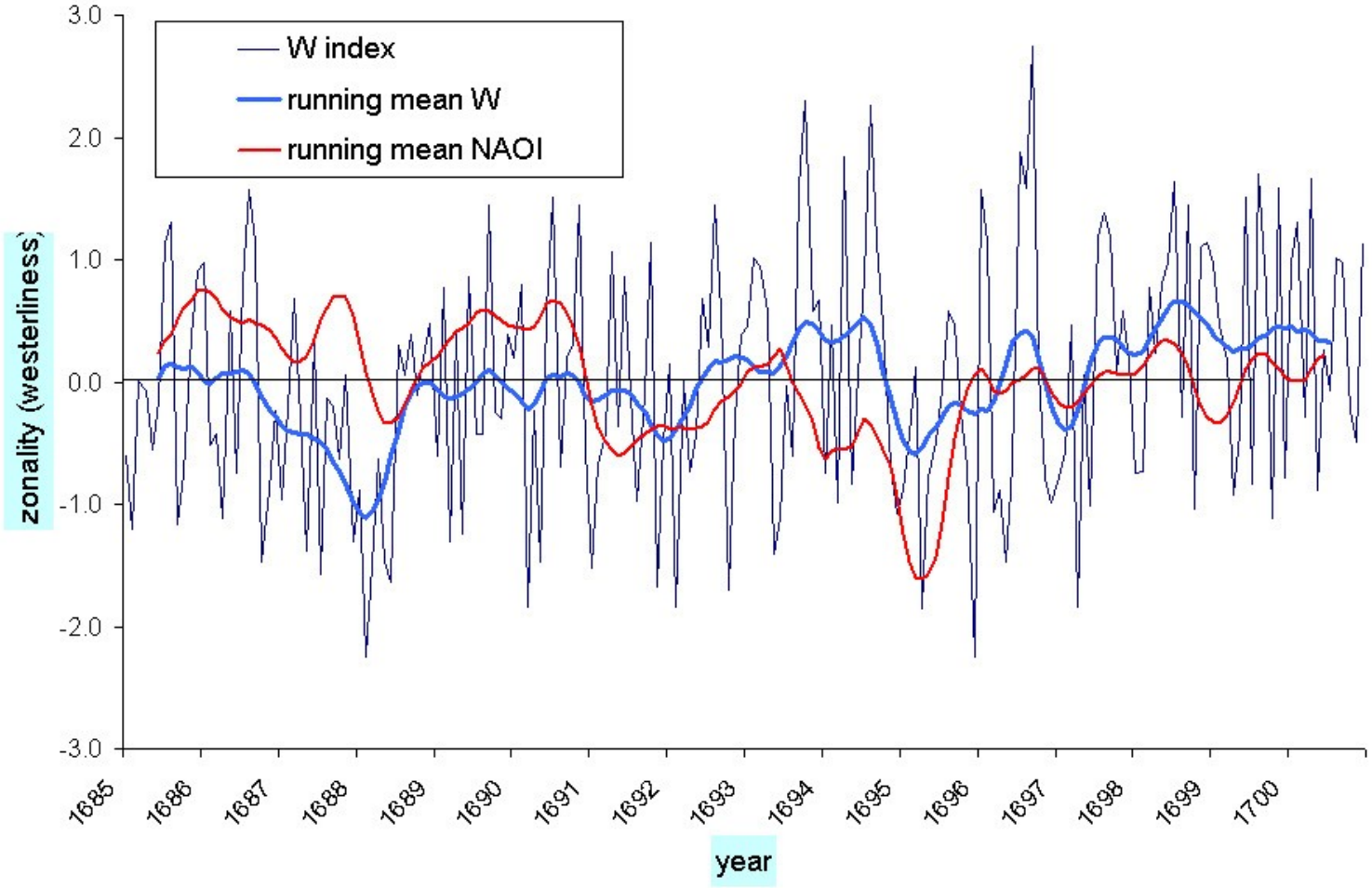
Results (4): distribution of winds by months

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	year
N	0.24	0.16	0.22	0.18	0.25	0.17	0.22	0.17	0.18	0.19	0.19	0.20	0.20
E	0.25	0.26	0.25	0.23	0.28	0.20	0.20	0.14	0.13	0.23	0.21	0.19	0.21
S	0.13	0.21	0.20	0.22	0.20	0.23	0.12	0.19	0.15	0.22	0.20	0.24	0.19
W	0.37	0.37	0.34	0.37	0.27	0.40	0.47	0.51	0.54	0.36	0.40	0.37	0.40

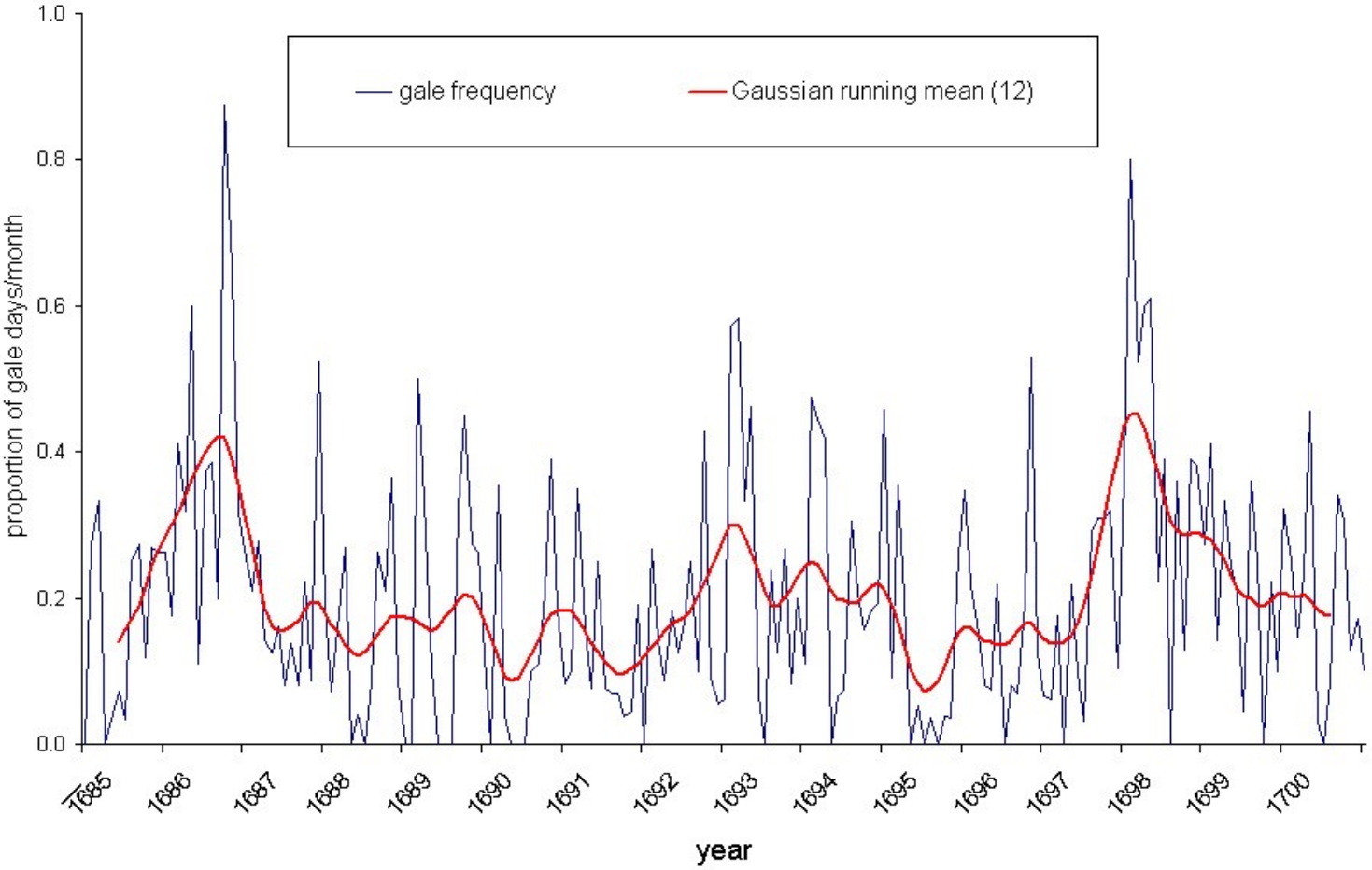
Results (5): comparison of wind directions with C20 patterns (differences: modern – C17)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
N	0.01	**0.10**	-0.09	**0.12**	0.02	0.08	0.02	0.02	-0.04	0.01	0.06	-0.06
E	-0.09	-0.05	**0.13**	0.03	-0.04	-0.04	-0.09	-0.02	0.09	-0.04	-0.03	-0.05
S	**0.11**	0.02	0.06	-0.06	0.00	-0.04	0.02	0.00	0.08	0.02	0.08	0.04
W	-0.02	-0.07	**-0.11**	-0.09	0.02	0.01	0.05	0.00	**-0.13**	0.01	-0.10	0.08

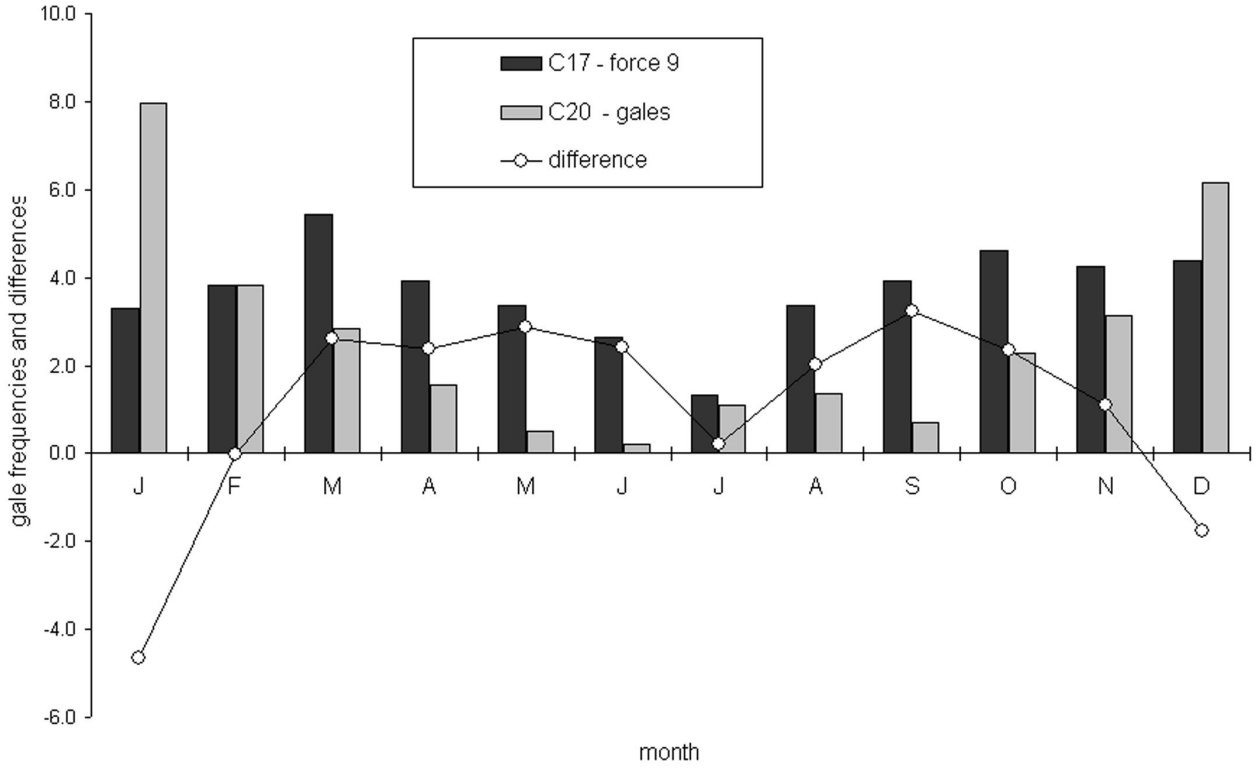
Results (6): time series of westerliness (with NAOI)



Results (7): time series of gales



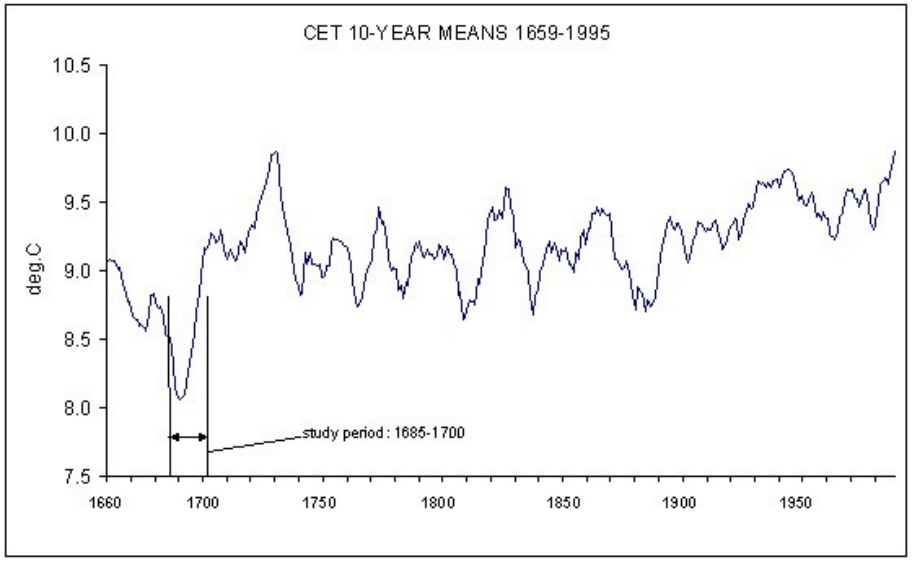
Results (8): was the Late Maunder Minimum more stormy?



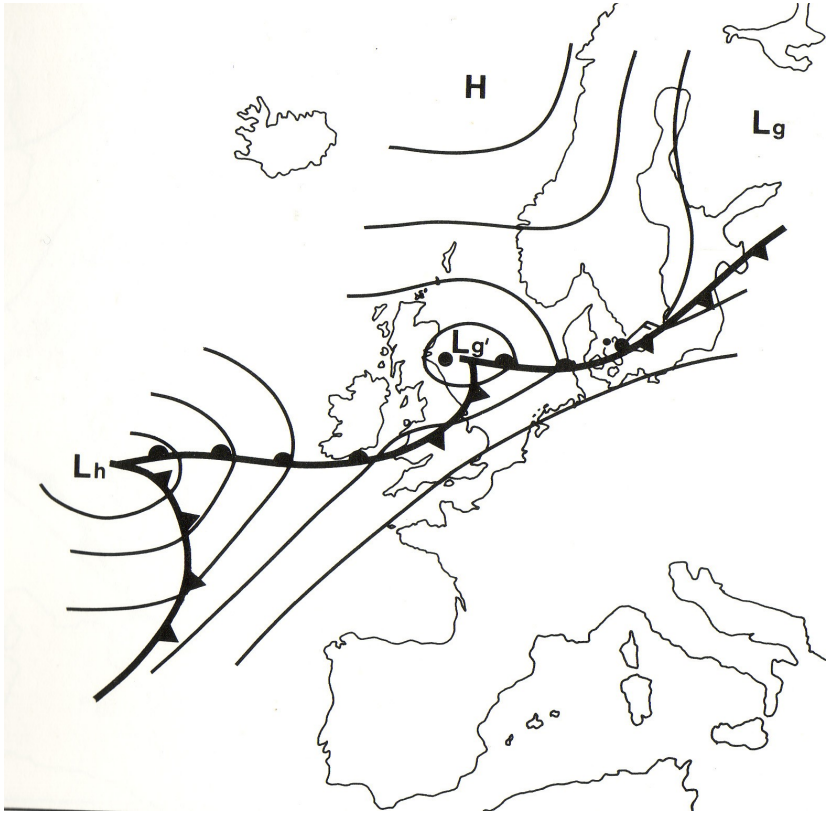
Possible causes of storminess:

Higher summer frequencies: mid-latitude cooling and steepening of the latitudinal temperature gradient and southward shift of the polar jet stream?

Reduced winter frequencies: more frequent Scandinavian (thermal) anticyclonic 'blocking'?



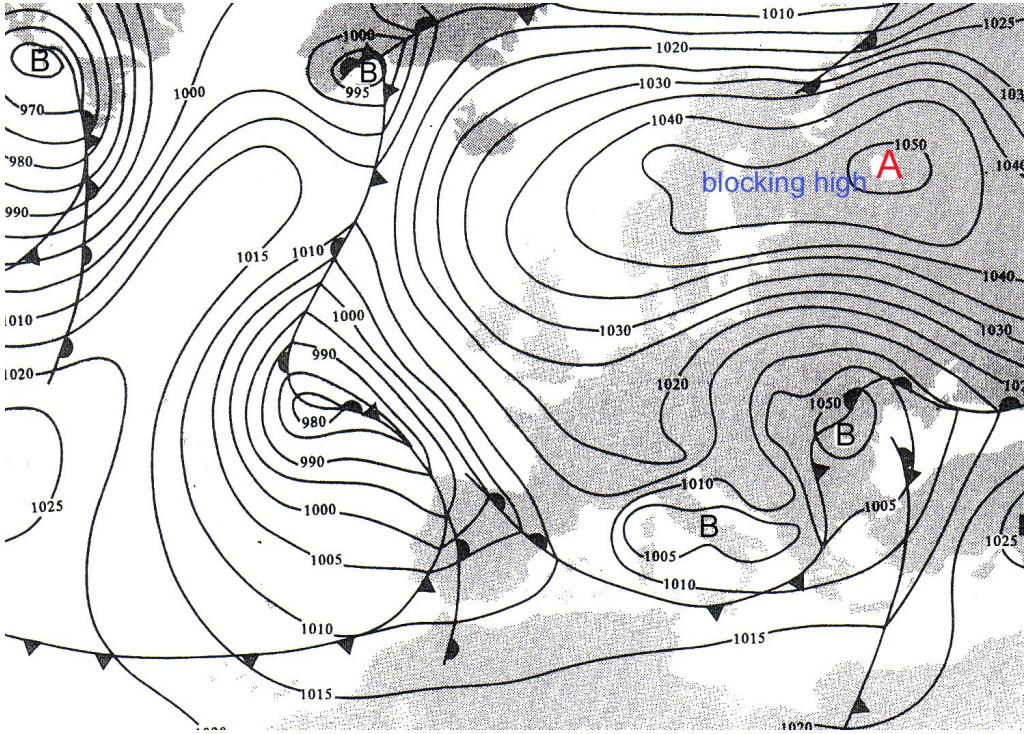
Lamb's studies of the Spanish Armada campaign of the summer of 1588 suggests southward displacement of the polar jet with consequent unusual storm activity across the British Isles: as in the summer of 2007?.



Reconstruction for 13 August 1588.

As example of a winter 'blocking high'.

12th January 1982 when temperatures in Sunderland fell to –12 degrees Celsius.



Results (8): data structure by Factor analysis (with orthogonal rotation)

Factor 1 – thermal

(24% of variance)

Factor 2 – zonal

(21% of variance)

Factor 3 – pressure

(14% of variance)

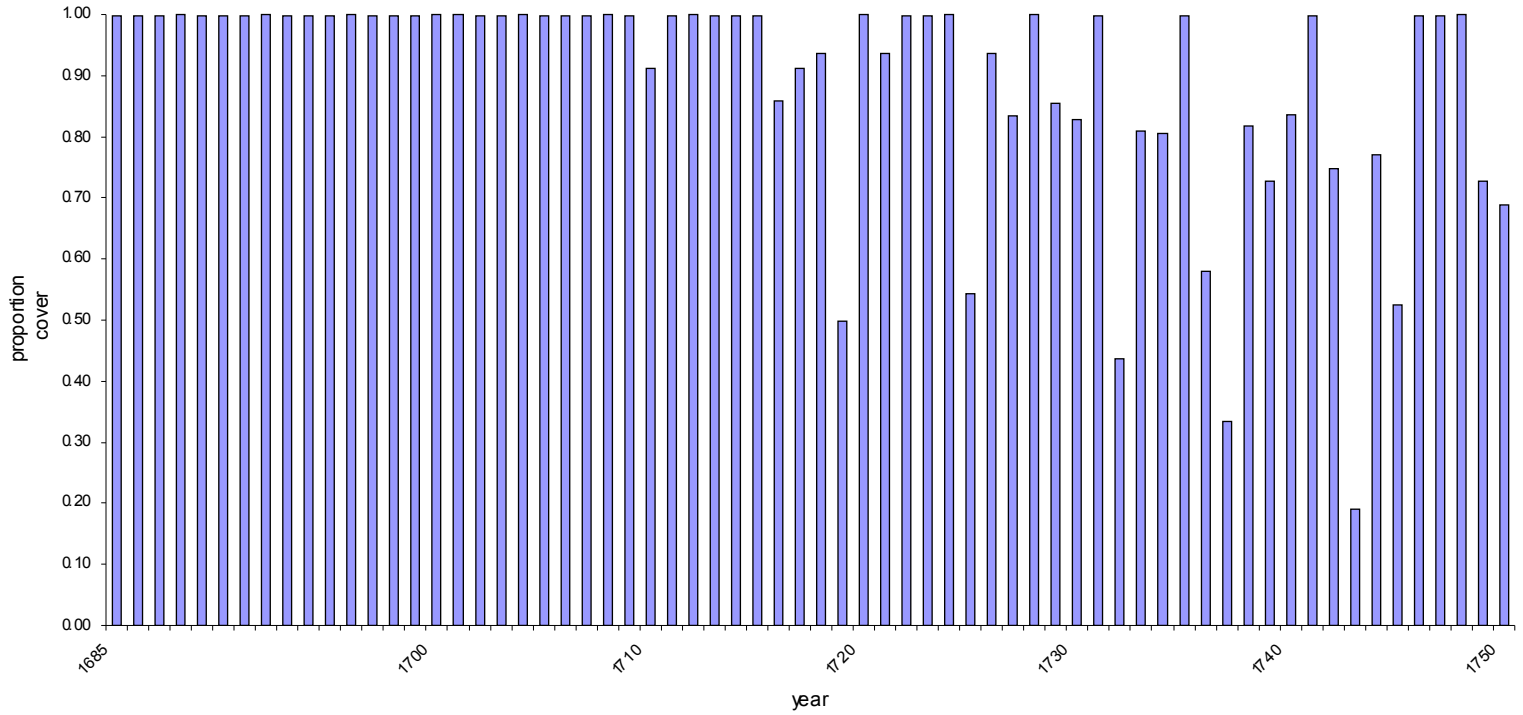
Factor 4 – cyclonic

(13% of variance)

	Component 1	Component 2	Component 3	Component 4
N	**-0.814**	-0.097	-0.066	-0.010
E	-0.060	**0.915**	-0.031	-0.202
S	**0.614**	0.110	-0.307	0.137
W	0.149	**0.838**	0.130	0.100
Gales force 9+	0.119	0.099	0.081	**0.823**
Rain days	0.009	0.161	-0.266	**0.720**
Snow days	-0.615	-0.109	-0.295	0.289
Frost days	**-0.713**	-0.093	-0.072	-0.393
CET anomaly	**0.634**	0.598	0.115	0.116
Paris air pressure	0.410	0.178	**0.783**	-0.199
NAO index	0.501	**0.716**	-0.171	-0.036
EU index	-0.337	-0.074	**0.870**	0.019

Future projects (1): completion of English Channel series:

Daily records 1685 to 1750 – proportion of days with abstracted raw data. Total numbers of days with data 15738



Future projects (2): logbooks and high latitude climates

From the high latitude: whaling logbooks, This example is from the Hull whaler the Eagle, whose voyage to the Davis Straits in 1820 took her as far a 78N!

Hull whalers painted by John Ward

SHIP EAGLE W. BREWIS Captn.

Date	Winds	Remarks &c on board at Greenland May 1820
Wednesday 24th May. 1820.	N. E b E.	P.M. Strong Breezes & hazy, We working to the Nd at 12..30 saw a Fish sent away 3 Boats at 2..30 up Boats no Fish to sa, made Sail & stood to the Nd amongst Streams & straggling Ice at 9 P.M. bored through a heavy Stream of Ice several Fish in Sight, at 10..30 got through, at 11..45 George Headon Mate struck a Fish, at 12 Wm. Wilson struck another but unfortunately both these were lost by the Harpoons drawing, at 12..15 John Richardson struck a Fish, at 5..50 got her hauled up she having died below at 6 am began to flinch at 7..50 finished flinching, set the Watch; latter part light Winds and frosty Wr. We plying amongst Floes 16 Sail in Sight
Latd. obsd. 78.59.	N.N.E	
Thursday 25th May	N.N.E / N.W. / Vble	P.M. Do. Wr. plying as above saw a straggling Fish at times, Boats on the Watch occasionally Middle part Do. Wr. saw several Fish but could get near for Bay Ice, at 5. AM. called all hands sent away 6 Boats, Ends light Winds and clear Wr. several Ships in Sight
Friday 26th May	Vble	Light Airs and Variable 6 Boats on the Watch at 5 P.M. took up 4 Boats without Success 2 Boats on the Watch latter and Middle part Do. Wr. saw several Fish two and 3 Boats on the Watch occasionally as required 45 Sail in Sight
Sun Obscure