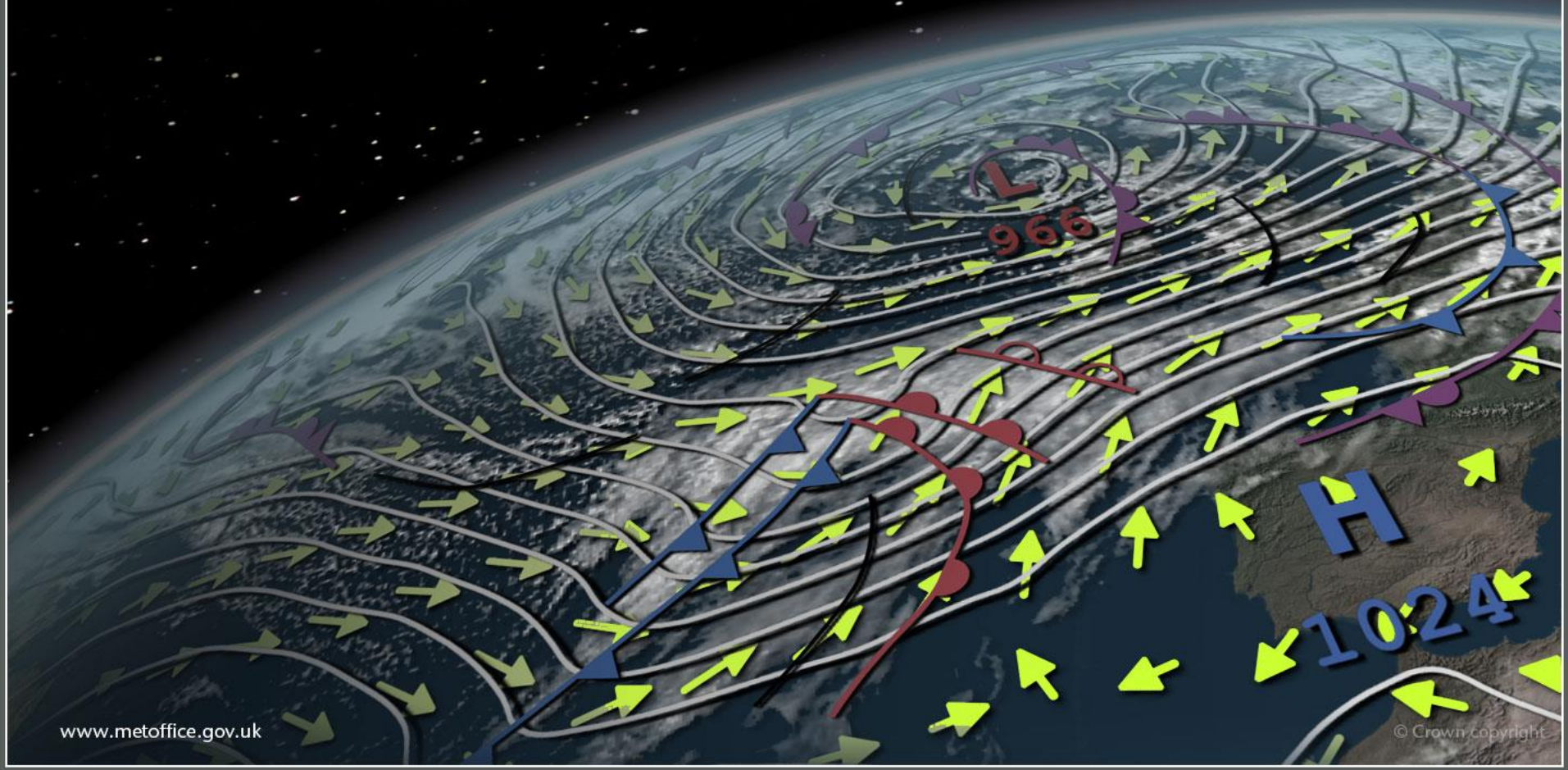
A Personal History of Meteorological Visualization

Chris Little, IT Fellow, Met Office

Wednesday 30 Sept 2015, ECWMF, Reading



www.metoffice.gov.uk

Talk Outline

Computer Graphics & Met Office

Timelines:

- Cartography
- Graphing
- Meteorology

Meteorology and Technology

Where are we now?

Future possibilities?

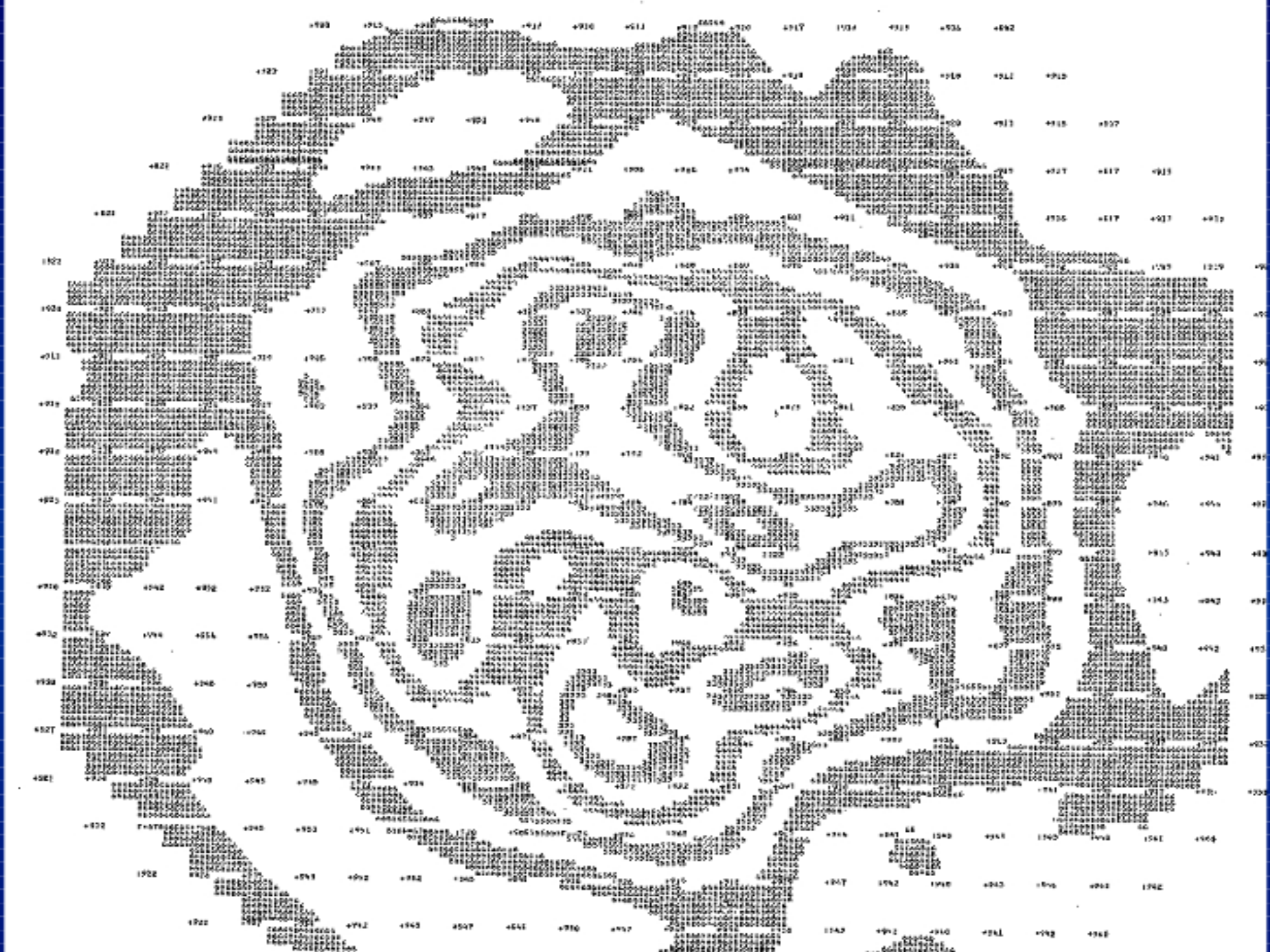
Computer Graphics & Met Office

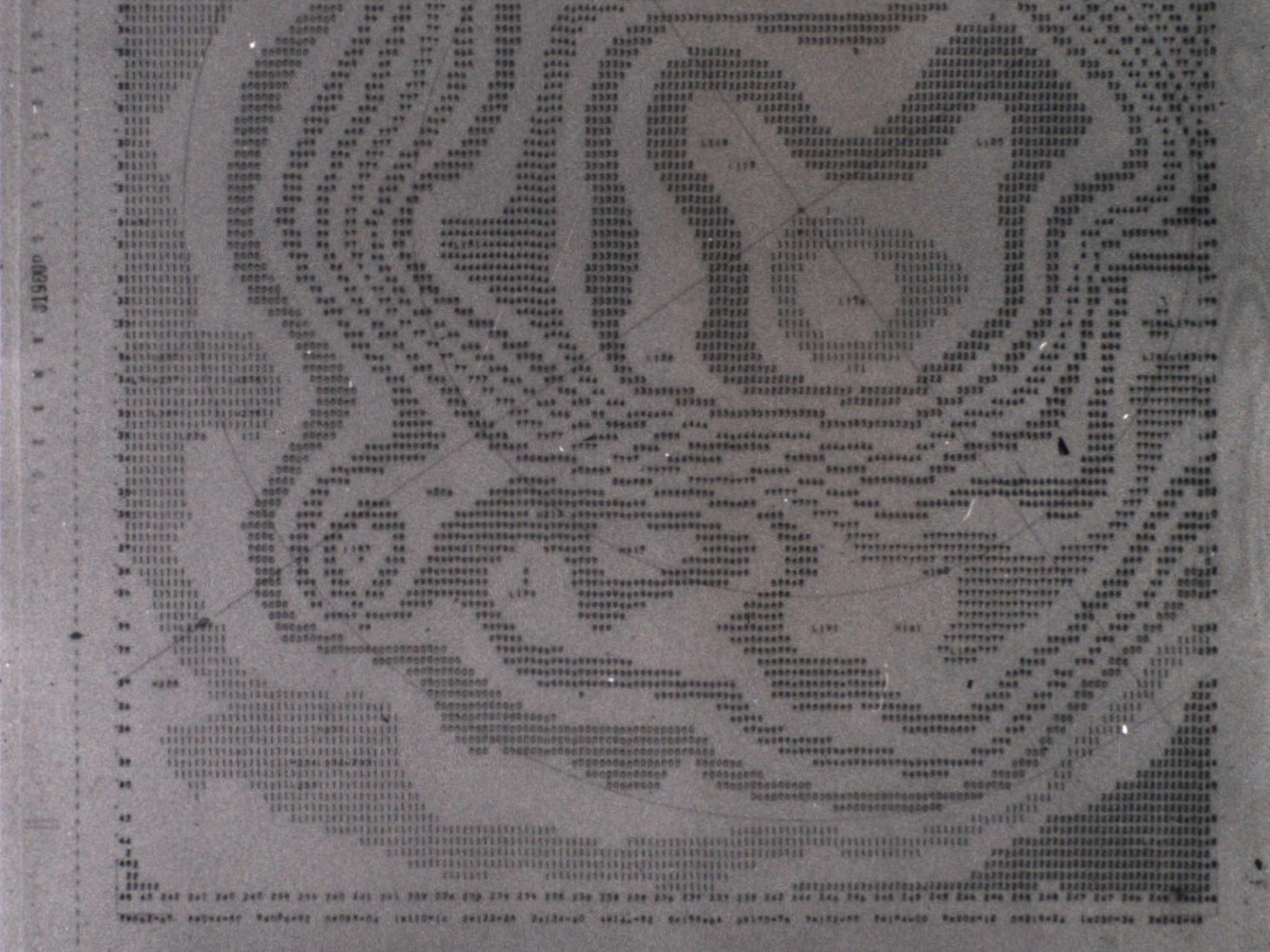
Computer Graphics Timeline

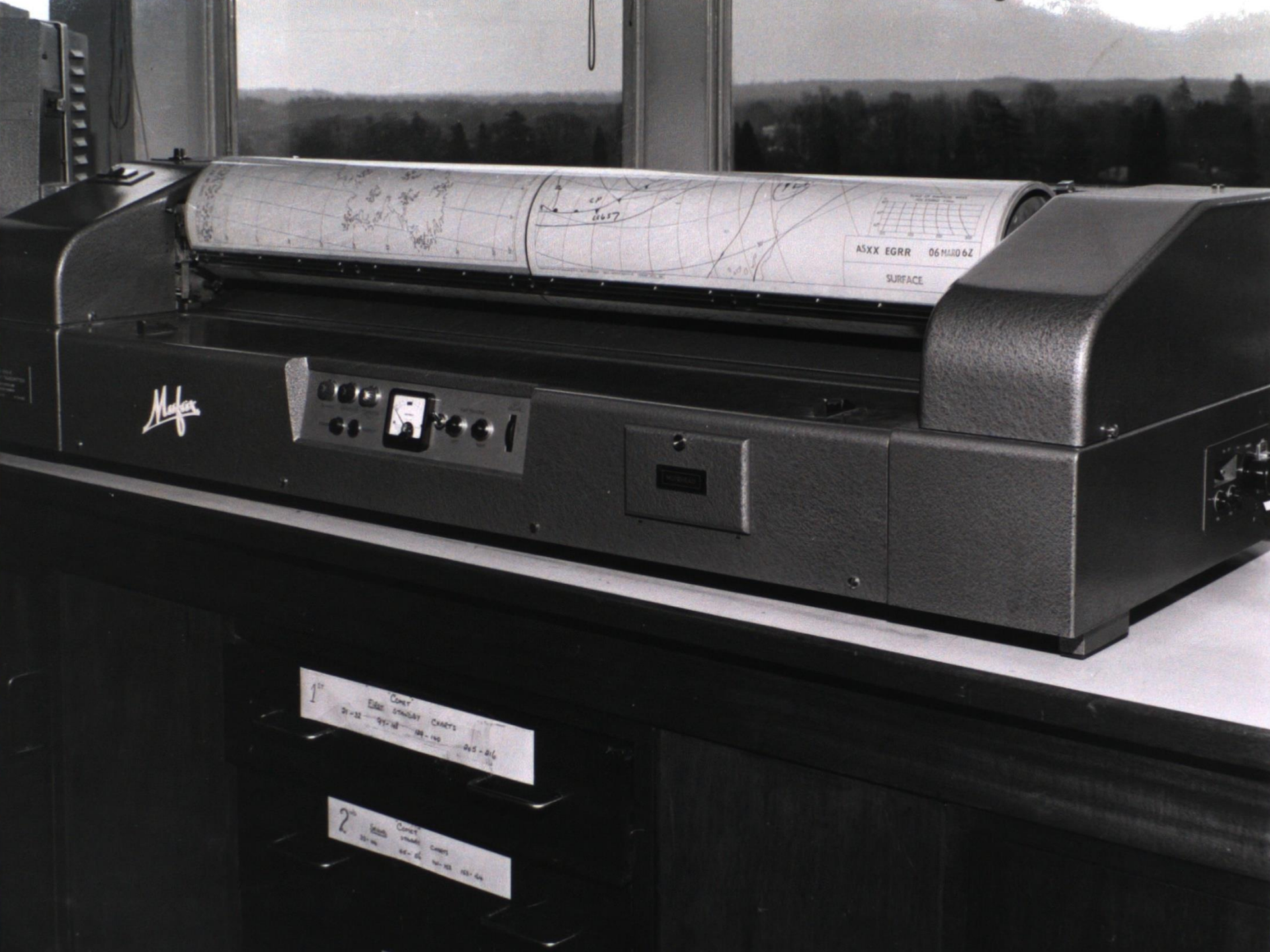
1946 ENIAC
1949 Whirlwind, Williams Tube, Core
1951 Graphics display on Whirlwind
1954 Fortran
1955 Light pen on SAGE
1959 IBM/GM develop CAD system
1960 “Computer Graphics” coined
1964 IBM 2250, RAND Grafacom input tablet
1965 Bresenham Algorithm, Tektronix storage tube
1968 E&S head mounted display
1969 Bell Unix, Xerox GUI
1971 RAMTEK, GINO library
1972 C, Intel 8008 chip, Atari/Pong
1973 1st SIGGRAPH
1975 Cray-1, Microsoft
1976 CG standardisation starts
1977 SIGGRAPH Core & GKS develop
1979 IBM 3279 terminal
1980 PHIGS develops
1982 SGI, Sun, Adobe, Autodesk founded

1982 USA Today Newspaper colour Wx map
1985 ISO GKS published
1986 TIFF defined, X-Windows
1987 GIF defined, ISO CGM published
1988 GKS-3D and PHIGS published
1989 PHIGS+, Motif1.0, RenderMan
1990 MS Windows 3.0
1991 WWW, JPEG/MPEG
1992 OpenGL released by SGI
1993 Mosaic browser
1994 Netscape browser
1995 Sun Java
1997 Macromedia Flash 1.0
1998 XML, Google, MPEG-4

Algorithms & software developments skipped






ASXX EGRR 06 MAR 06Z
SURFACE
Muirhead


Muirhead

Mainstream computing >1971

1968 Government permission to buy new computer

1969-08-20 IBM 360/195 Announced

1969-09-04 UKMO issues ITT (IBM360/85, ICL1908A and CDC7600)

1971 IBM 360/195 initial delivery

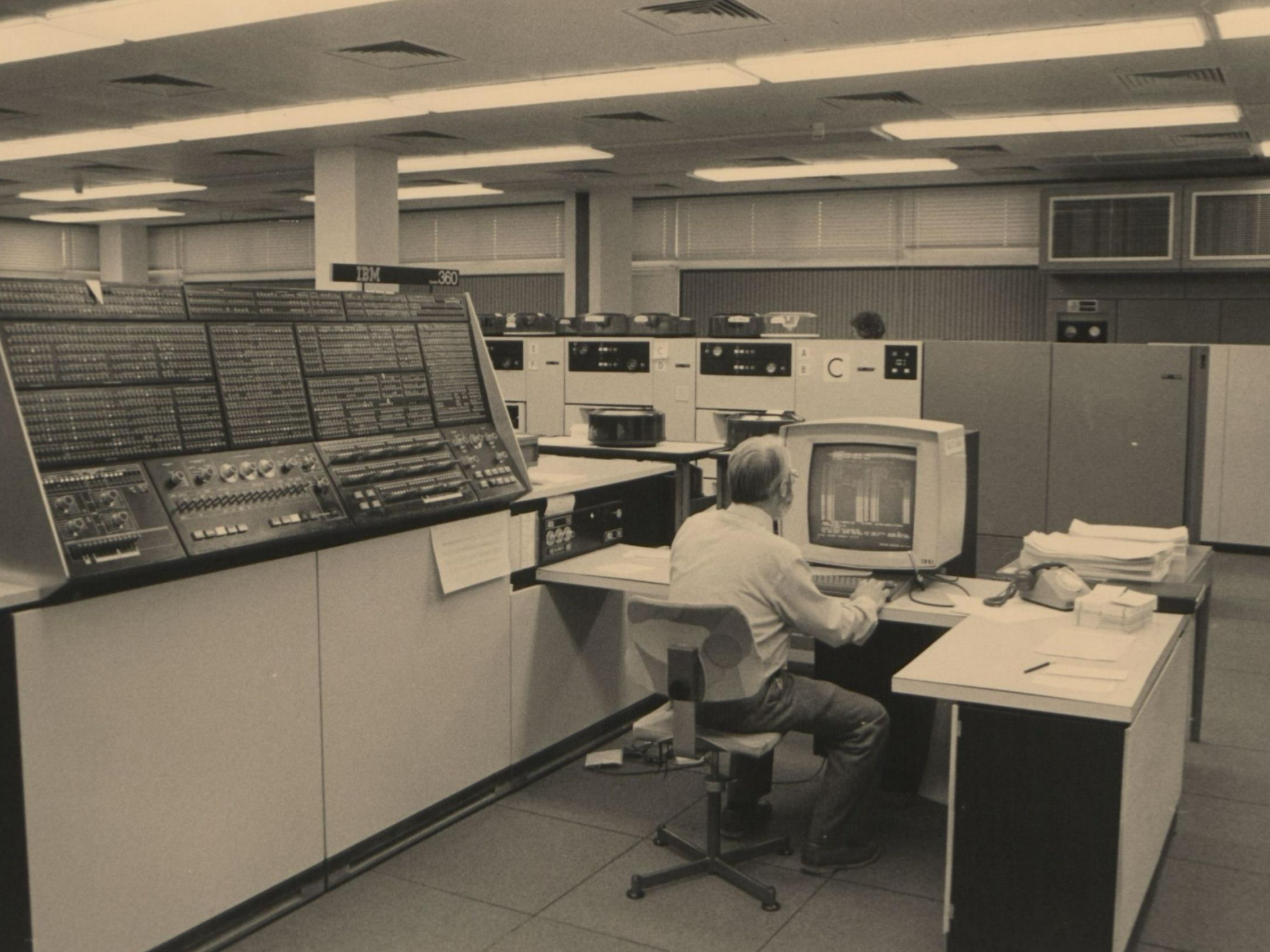
1972-10 Final configuration, upgraded devices within original budget:

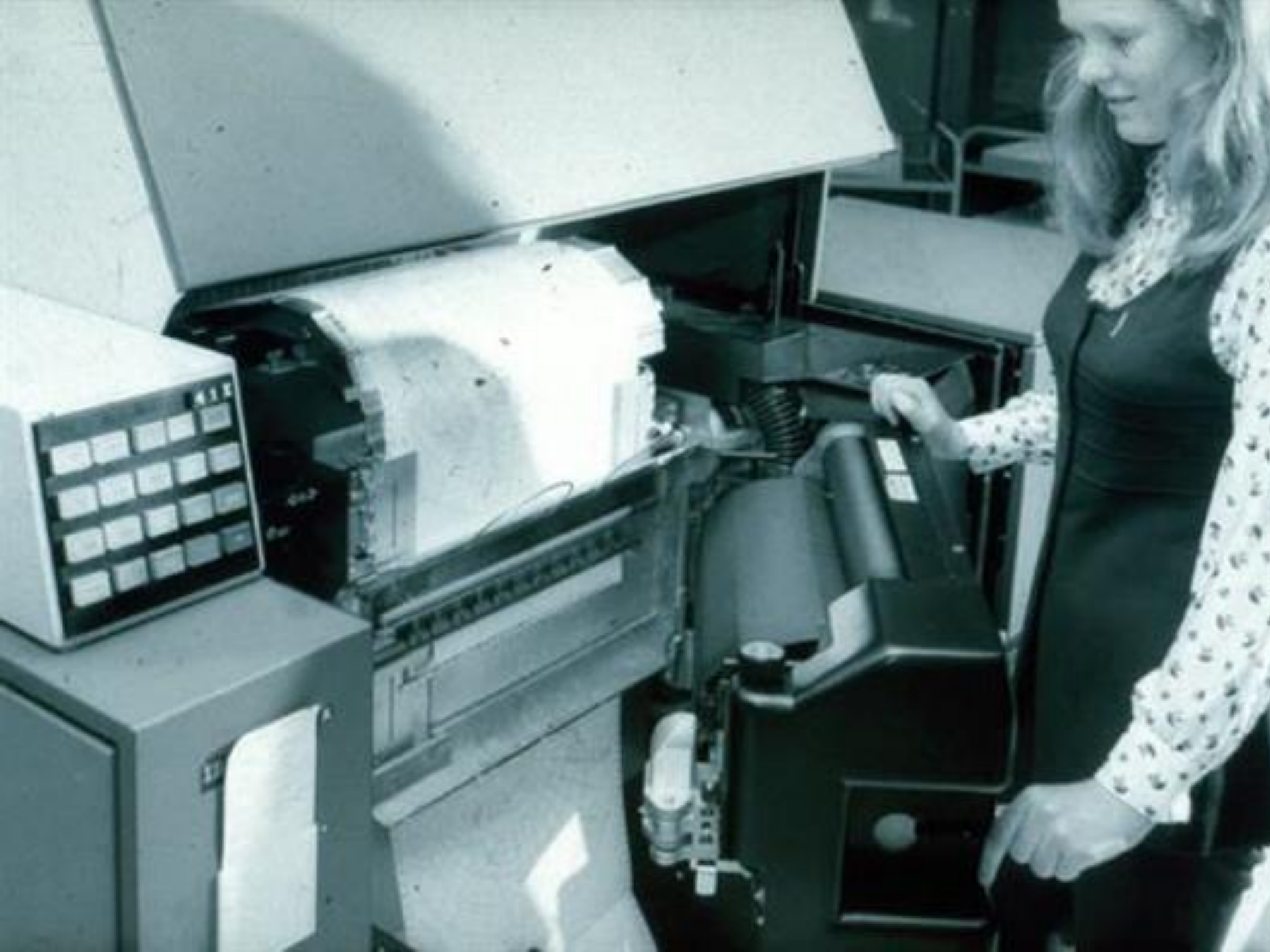
1xIBM2301 Fixed head disk, 6xIBM3330 disk drives, IBM3333 exchangeable disk units, 6xIBM3420 9 trk 800/1600dpi tape drives magnetic tape units, 2xIBM2250 CRT displays, operating consoles.

2x Calcomp microfilm 835 recorders, resolution 2200x3400 (already in use in BoM and DWD) Seem to have upgraded to 1670 (16000x16000)

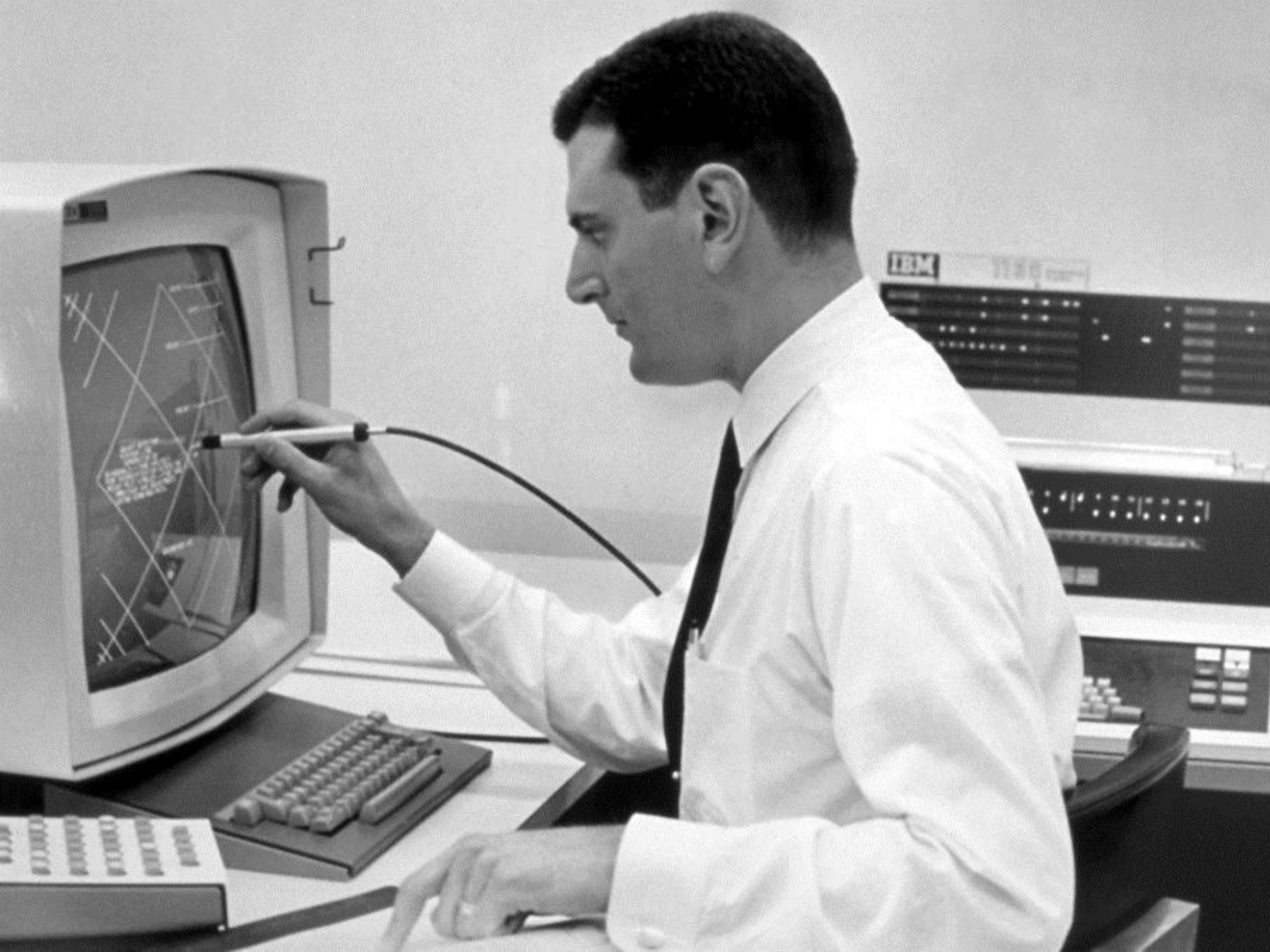
160col printer requested, IBM only 144col, substituted & interfaced MDS9160

UKMO agrees to ship KDF9 tape drive to Montpellier and back to interface to IBM controllers. UKMO kept 2xKDF9 400dpi drives until tapes transferred.

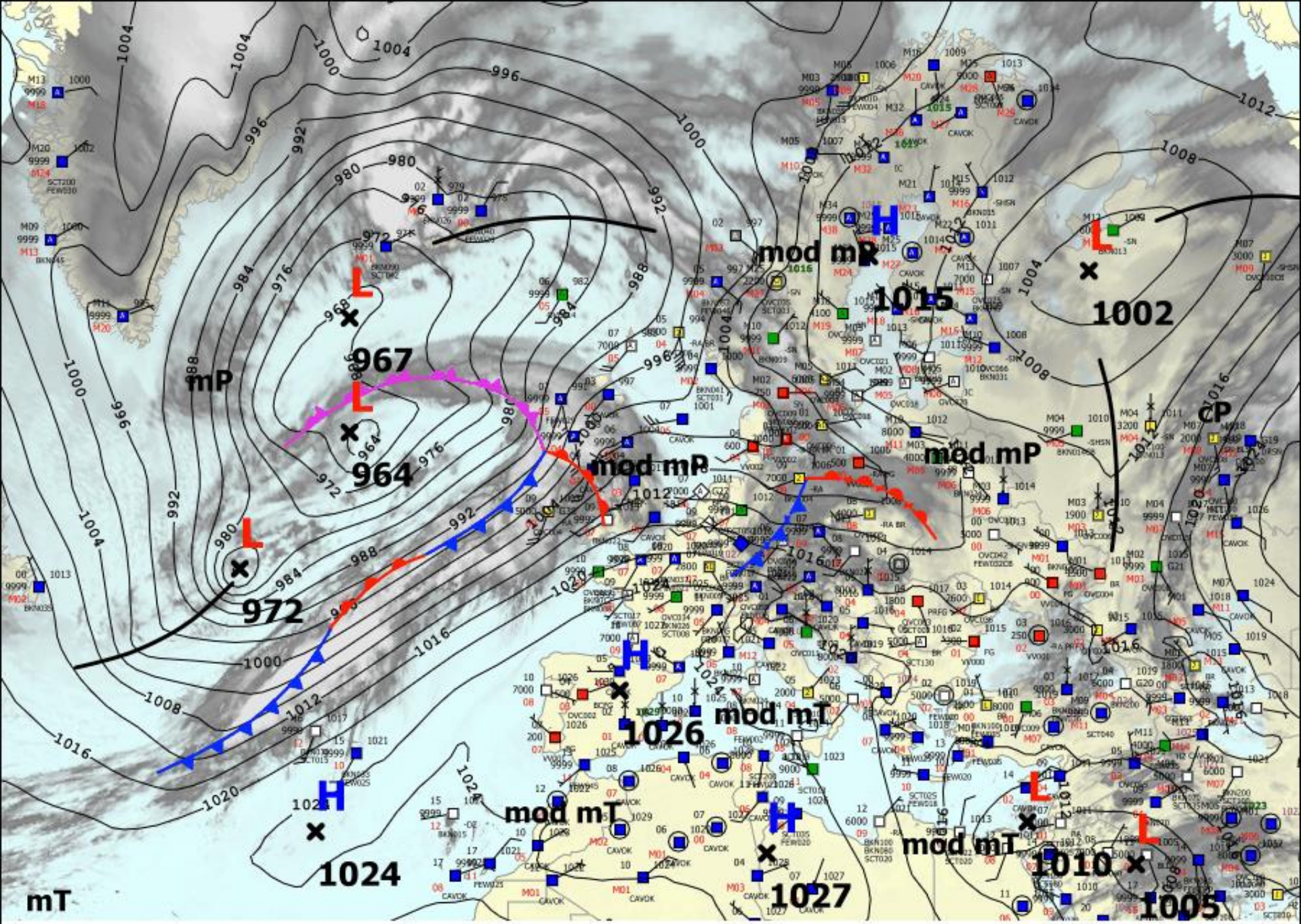

IBM 360

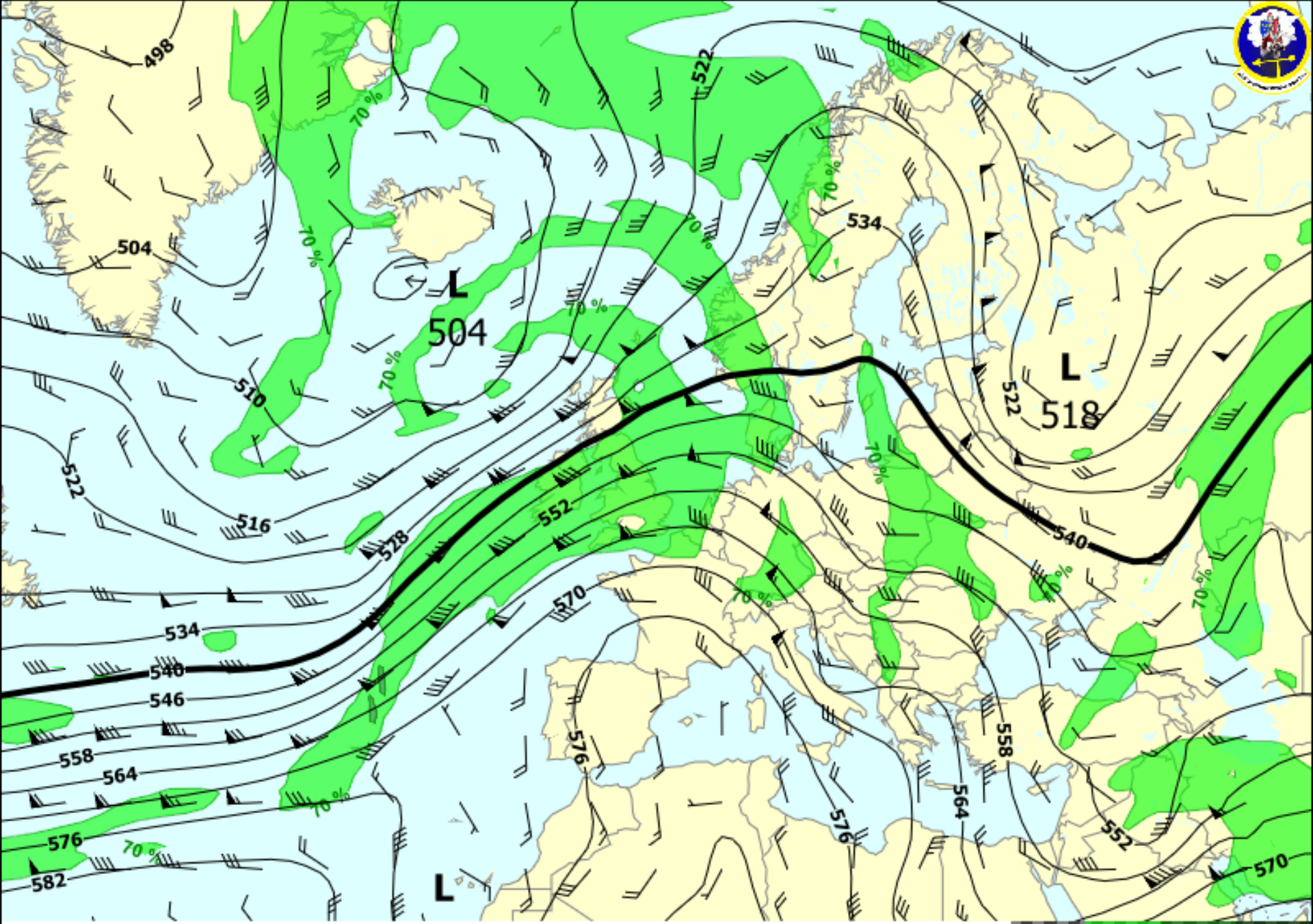



CALCOMP
ERASE
TYPE 611


IBM


KWTV

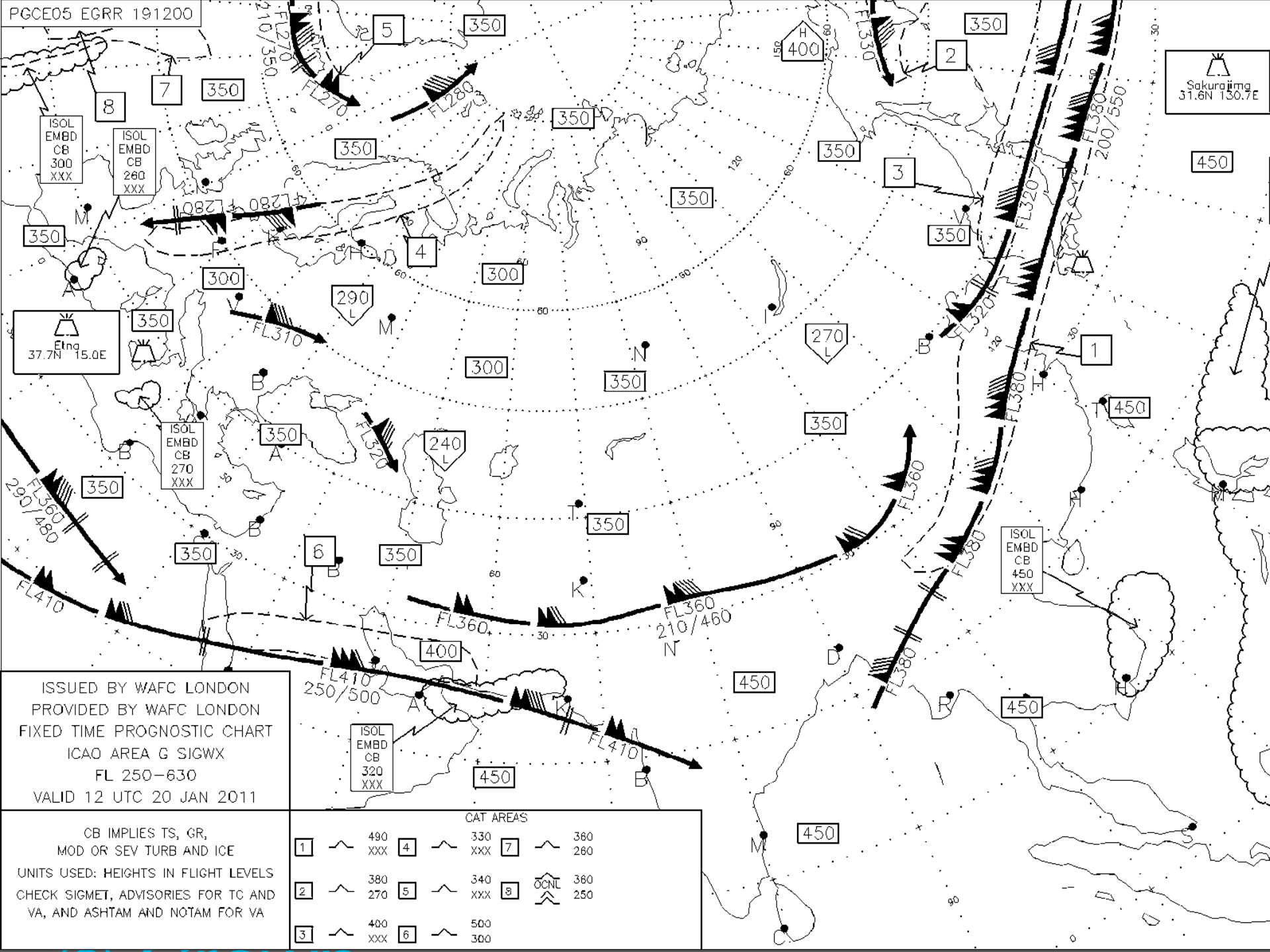

SURFACE ANALYSIS
VT: 15 JAN 007 POSTED AT: 15/00387
L - LOW PRESSURE
H - HIGH PRESSURE
-COLD FRONT
-STATIONARY FRONT
967
964
972
1026
1024
1027
1015
1002
1010
1005
mP
mT
mod mP
mod mT
CP



500MB GPH | RH | WINDS VT: SAT 15 JAN 12Z (T+12)
UKMO GLOBAL MODEL 15/00Z

0 70 90 100

GPH EVERY 60 METRES


PGCE05 EGRR 191200
ISSUED BY WAFC LONDON
PROVIDED BY WAFC LONDON
FIXED TIME PROGNOSTIC CHART
ICAO AREA G SIGWX
FL 250–630
VALID 12 UTC 20 JAN 2011
CB IMPLIES TS, GR,
MOD OR SEV TURB AND ICE
UNITS USED: HEIGHTS IN FLIGHT LEVELS
CHECK SIGMET, ADVISORIES FOR TC AND
VA, AND ASHTAM AND NOTAM FOR VA
CAT AREAS
1 490 XXX
2 380 270
3 400 XXX
4 330 XXX
5 340 XXX
6 500 300
7 360 260
8 OCNL 360 250
ISOL EMBD CB 300 XXX
ISOL EMBD CB 260 XXX
ISOL EMBD CB 270 XXX
ISOL EMBD CB 320 XXX
ISOL EMBD CB 450 XXX
Etna 37.7N 15.0E
Sakurajima 31.6N 130.7E
FL270/350
FL280/360
FL280
FL310
FL320
FL330
FL360
FL380
FL410
FL360 290/480
FL380 200/550
FL360 210/460
FL410 250/500
290 L
240 L
270 L
H 400
350
300
400
450

Timeline: Cartography

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Map of the World

Babylonian

About 700-500 BC

Probably from Sippar, southern Iraq

British Museum

500BCE

Map derived from Hecatæus's *Periodos Ges*

‘*Journey Round the World’*.

Divided into two books, "Europe" and "Asia

Follows Homeric idea that the world is ‘round’ surrounded by ocean

Met Office

T-O Map

8th Century Spanish copy

Represents the physical world described by the 7th-century Isidore of Seville

Etymologiae
Chapter 14, *de terra et partibus*

Met Office

Aristotle’s 3/5 climatic zones

12th-century manuscript of Macrobius's *Commentarii in Somnium Scipionis*

ca. 1150.

Copenhagen, Det Kongelige Bibliotek

Al-Masudi

947CE

The Meadows of Gold and Mines of Gems

(مروج الذهب ومعادن الجواهر ,*Muruj adh-dhahab wa ma'adin al-jawhar*)

Quantitative maps

Ptolemy's Gazeteer

Following Marinus of Tyre, c 150CE

Latitude was measured from the equator in Africa but expressed in terms of hours rather than in degrees of arc:

The equator was set at 12 hours of midsummer daylight, while the Arctic was thought to have 24. Ptolemy specifies 10, then later 7, climatic zones corresponding to length of day.

His Prime Meridian ran through the Fortunate Isles, the westernmost land recorded, in the Canary Islands or Cape Verde.

The maps spanned 180 degrees of longitude from the Fortunate Isles in the Atlantic to China.

Locations based on travellers reports

Land based Itineraries

E.g. Itinerarium Burdigalense ("Bordeaux Itinerary") is the oldest known Christian itinerarium.

Written by the "Pilgrim of Bordeaux, it recounts the writer's journey to the Holy Land in the years 333 and 334 CE

(By land through northern Italy, Danube valley, Constantinople, Asia Minor and Syria to Jerusalem. Back via Macedonia, Otranto, Rome, and Milan.

Distinguishes each boundary of one Roman province to the next, and distinguished carefully between each change of horses (mutatio) and a stopover place (mansio), and the differences between the simplest cluster of habitations (vicus) and the fortress (castellum) or city (civitas).

Persians also had itineraries

Met Office

Roman Illustrated Itinerary

300-400 CE

Copy from 1200 CE

“Peutinger's Tabula”

Periplous

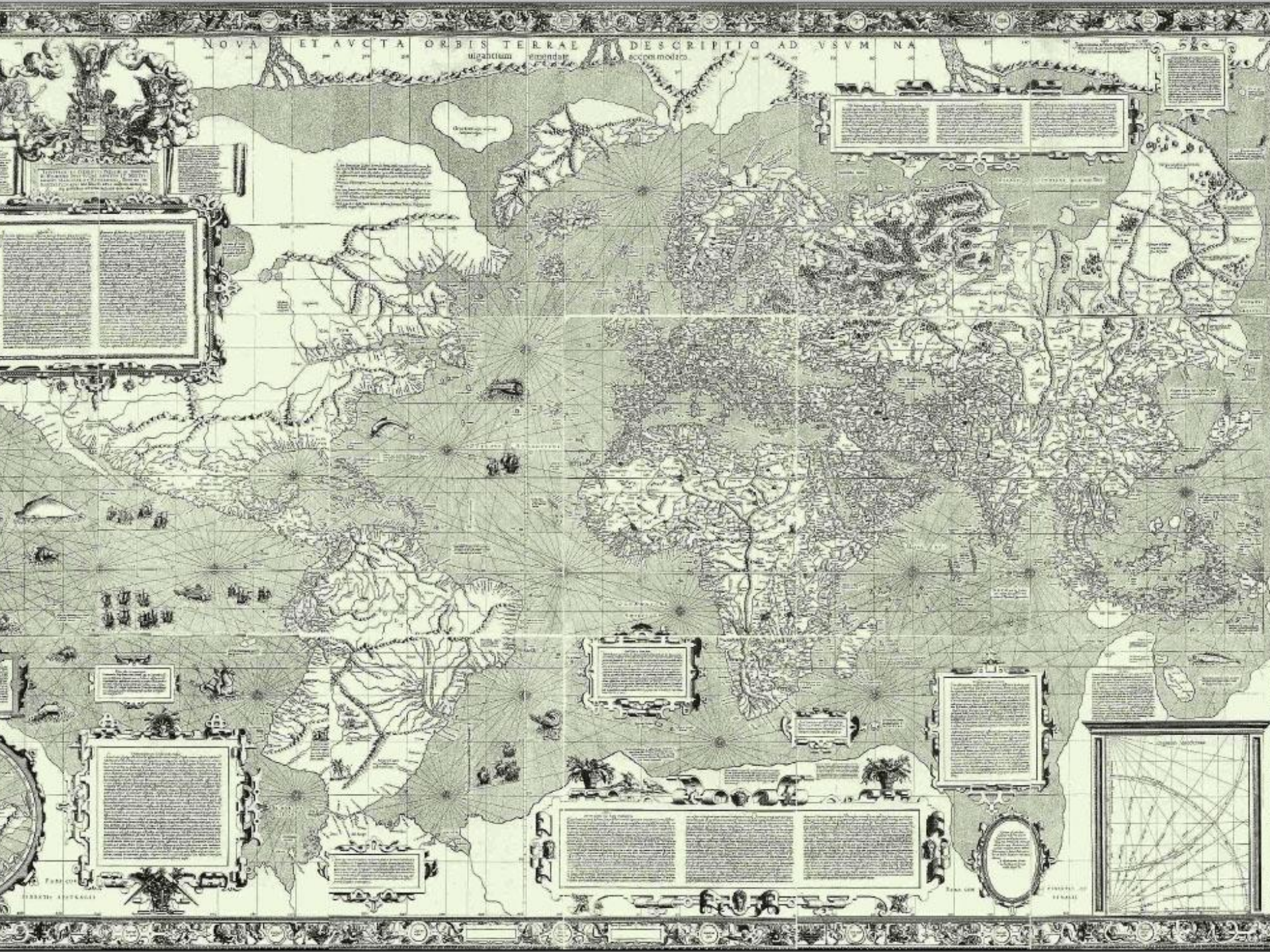
Route list along a coast

Hanno's Periplous (600BCE) survives in a single Byzantine manuscript Codex Heidelbergensis 398.

Erythraean Periplous 100 CE, Red Sea to Ganges

Massaliote Periplus, (possibly 600 BCE) coasts of Atlantic Europe,

Portolan: Periplus plus pictures

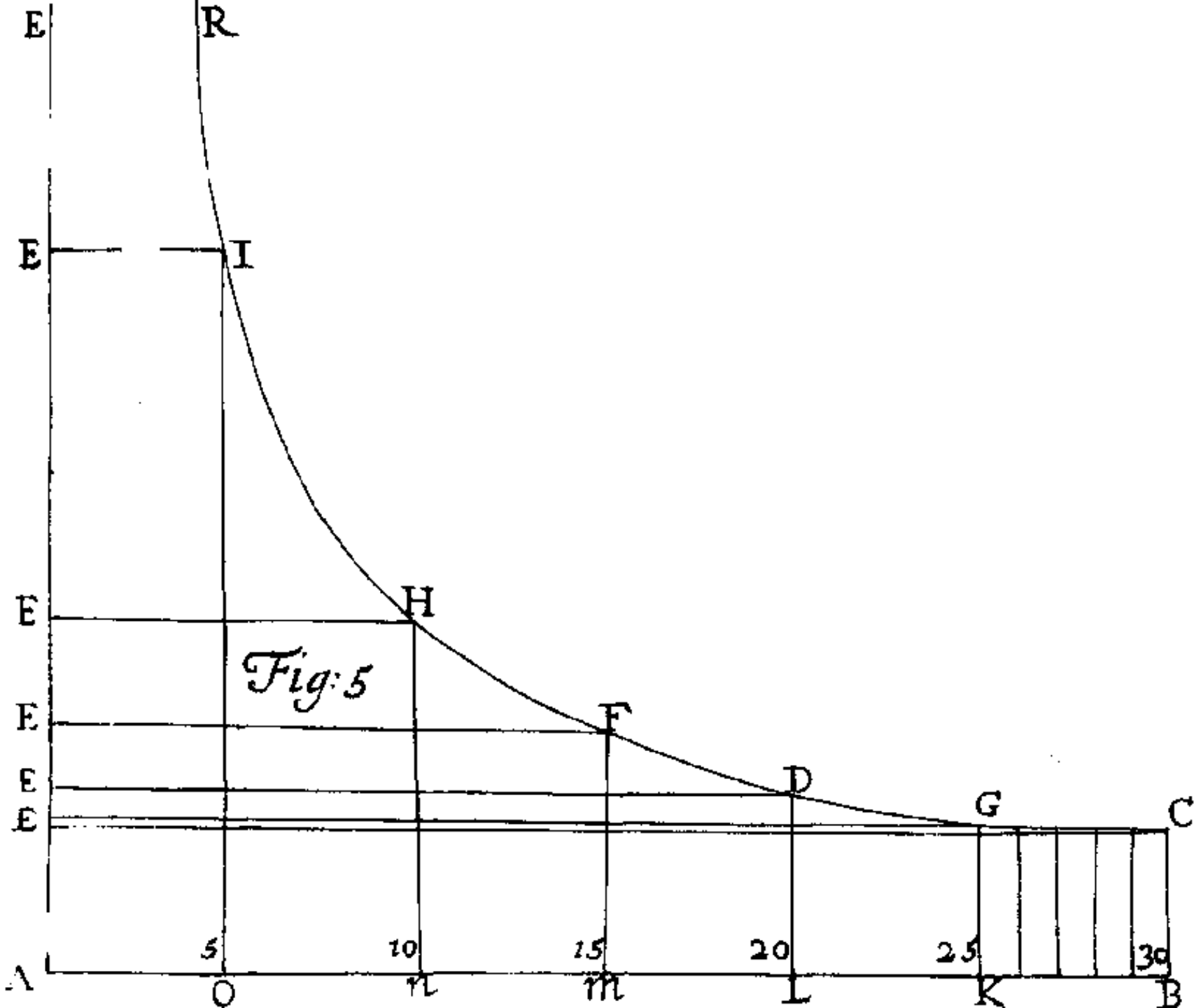

NOVA ET AVCTA ORBIS TERRAE DESCRIPTIO AD VSVM NA
uigabtium
emendat
accommodata

ORBIS TERRÆ COMPENDIOSA DESCRIPTIO EX PERITISSIMORVM

TIVS ORBIS GEOGRAPHORVM TABVLIS ET NOVISSIMIS OBSERVATIONIBVS DESCRIPTA


LABORADOR
OR
NOVA BRITANNIA
NORTH AME
CANADA
NEW FRANCE
NEW ENGLAND
VIRGINIA
CAROLINA
RI CA
GOLFE
MEXICO
BAHAMA ISLES
CUBA
HONDURAS
CARIBBE ISLANDS
VENEZUELA
SOUTH
THE
WESTERN
OCEAN
West Variation
AZORES
WESTERN ISLES
CAPE DE VIRDE ISLES
GUALATA
ARGUIN
AFRI
GUINEA
FOR SPAIN
BAY OF BISCAY
Tropick of Cancer
The Line of no Variation
East Variation

Halley's Trade Wind Map 1656


E
R
E
I
E
H
Fig: 5
E
F
E
D
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C
5
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25
30
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n
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L
K
B

Carte des lignes Isothermes par M.r A. de Humboldt

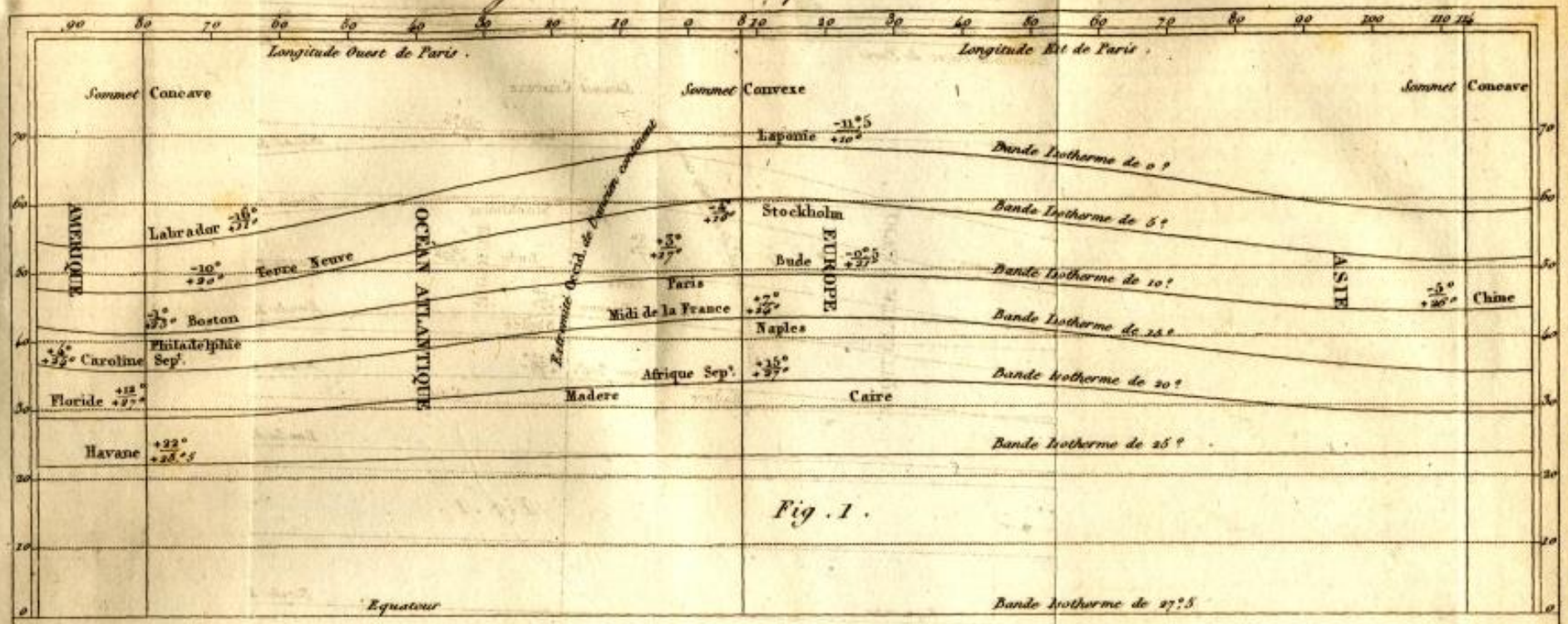
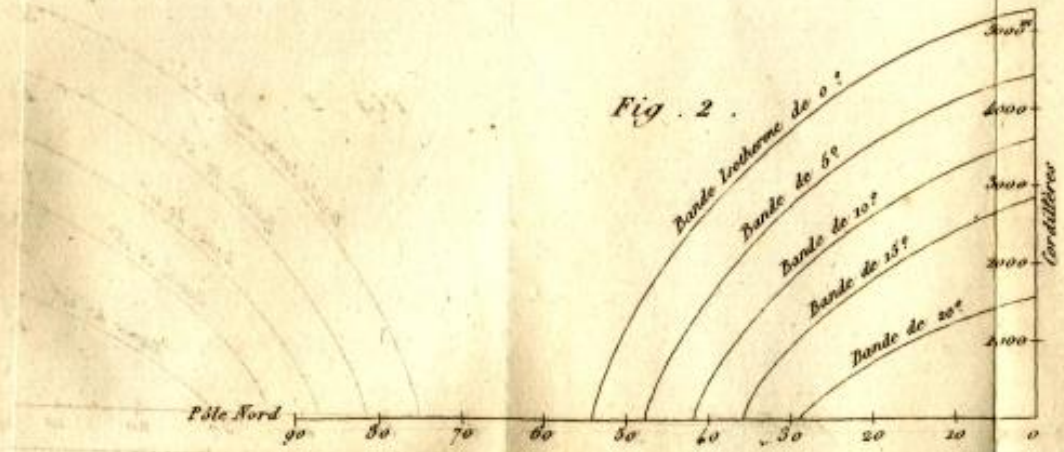
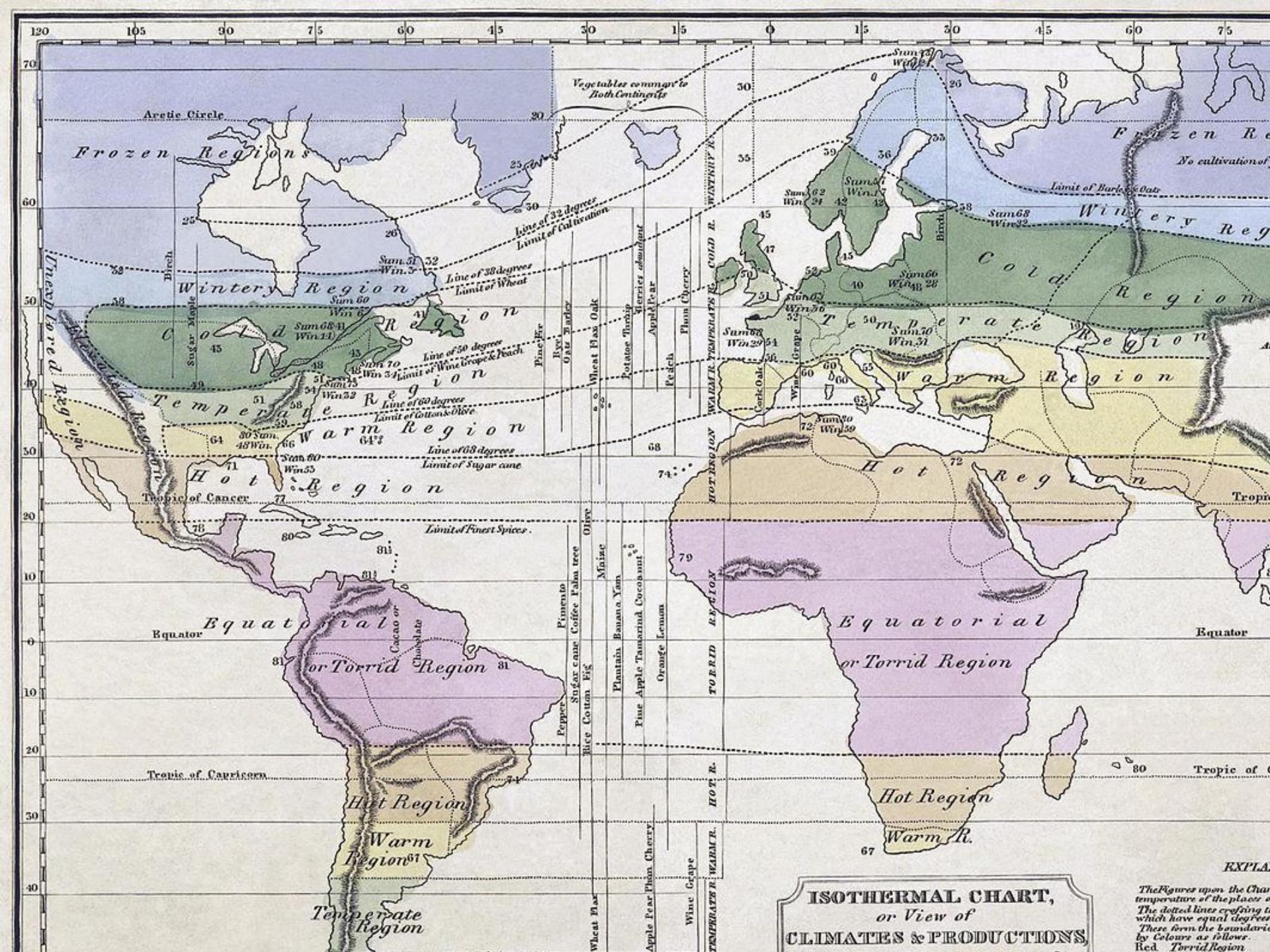


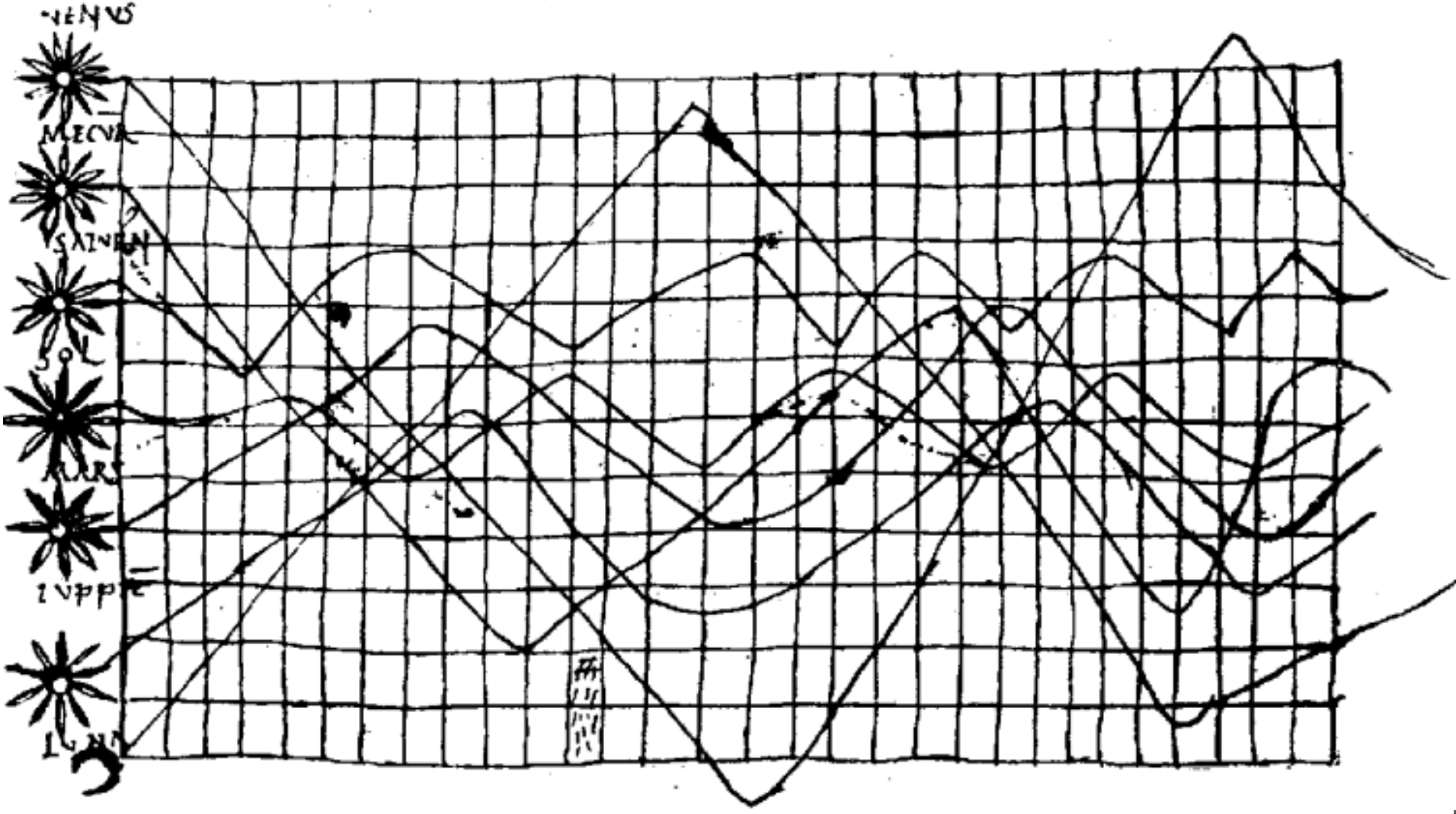
Fig. 1.



Gravé par Adam.

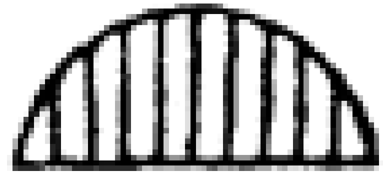

ISOTHERMAL CHART,
or View of
CLIMATES & PRODUCTIONS
Arctic Circle
Frozen Regions
Vegetables common to Both Continents
Line of 32 degrees Limit of Cultivation
Line of 38 degrees Limit of Wheat
Line of 50 degrees Limit of Wine Grape & Peach
Line of 60 degrees Limit of Cotton & Olive
Line of 68 degrees Limit of Sugar cane
Limit of Finest Spices.
Limit of Barley & Oats
No cultivation of
Wintery Region
Cold Region
Temperate Region
Warm Region
Hot Region
Tropic of Cancer
Tropic of Capricorn
Equator
Equatorial or Torrid Region
Hot Region
Warm Region
Temperate Region
Cold Region
Wintery Region
Hot Region
Warm R.
Tropic of
Equator
Birch
Sugar Maple
Pine Fir
Rye
Oats Barley
Wheat Flax Oak
Potatoe Turkip
Apple Pear
Peach
Plum Cherry
Cork Oak
Wine Grape
Olive
Maize
Pimento
Pepper
Sugar cane Coffee Fabia tree
Rice Cotton Fig
Plantain Banana Yam
Pine Apple Tamarind Cocoanut
Orange Lemon
Cacao or Chocolate
Apple Pear Plum Cherry
Wine Grape
Wheat Flax
COLD R.
WINTRY R.
WEARER TEMPERATE R.
TEMPERATE R.
HOT TORRID REGION
TORRID R.
HOT R.
WARM R.
EXPLA
The Figures upon the Chart
temperature of the places
The dotted lines crossing
which have equal degrees
These form the boundaries
by Colours as follows.
Red Torrid Region

Timeline: Graphing

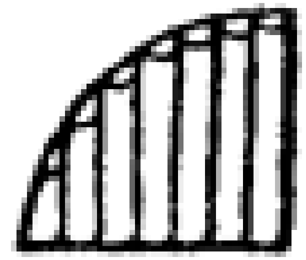

VENVS
MERCVR
SATVRN
IVPPIT

difformis uniformiter variatio reddit uniformiter difformiter difformem. ¶ Latitudo uniformiter difformiter difformis est illa que inter excessus graduum eque distantium servat eandem proportionem aliam tamen a proportione equalitatis. Nam si inter excessus graduum inter se eque distantium servaretur proportio equalitatis tunc esset latitudo uniformiter difformis ut patet ex diffinitionibus membrorum secunde divisionis. Rursus si nulla proporcio servatur tunc nulla posset attendi uniformitas in latitudine tali et sic non esset uniformiter difformiter difformis. ¶ Latitudo difformiter difformiter difformis est illa que inter excessus graduum eque distantium non servat eandem proportionem sicut in secunda parte patebit. Notandum tamen est quod sicut in supradictis diffinitionibus ubi loquitur de excessu graduum inter se eque distantium debet accipi distantia secundum partes latitudinis extensive et non intensive ita ut loquantur de eis diffinitiones de distantia secundum situali non autem graduali

scip. et fiat ad in

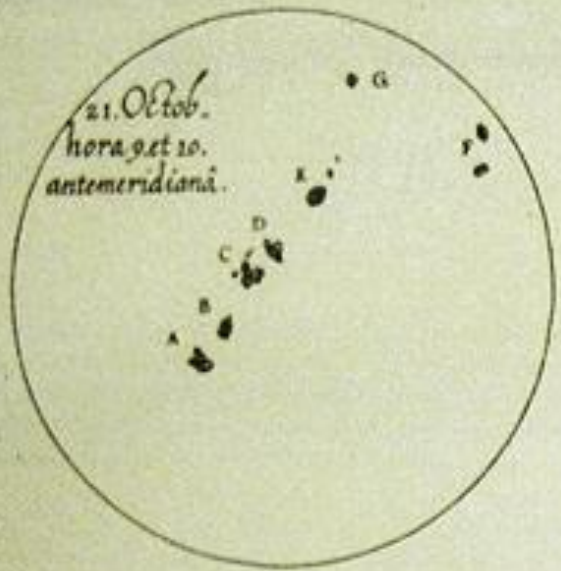


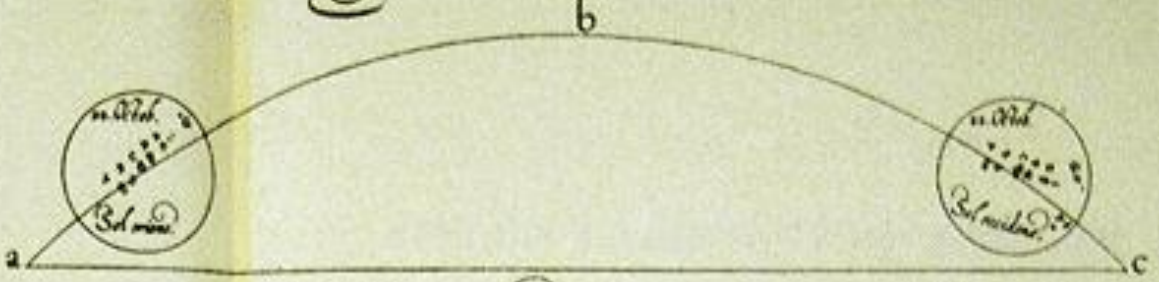
difformiter difformis



dif. dif. difformis

MACVLAE IN SOLE APPARENTES, OBSERVATAE anno 1611. ad latitudinem grad. 48. min. 40.





a c, horizon. a b c, arcus solis diurnus. Soloriens ex parte a, maculas exhibet quas vides, occidens verò c, easdem ratione primj motus, nonnihil inuertit. Et hanc matutinam vespertinamq; mutationem, omnes maculæ quotidie subeunt. Quod semel exhibuisse et monuisse, sufficiat.

Macula I fuit valde conspicua, propter notabilem præ reliquis magnitudinem.

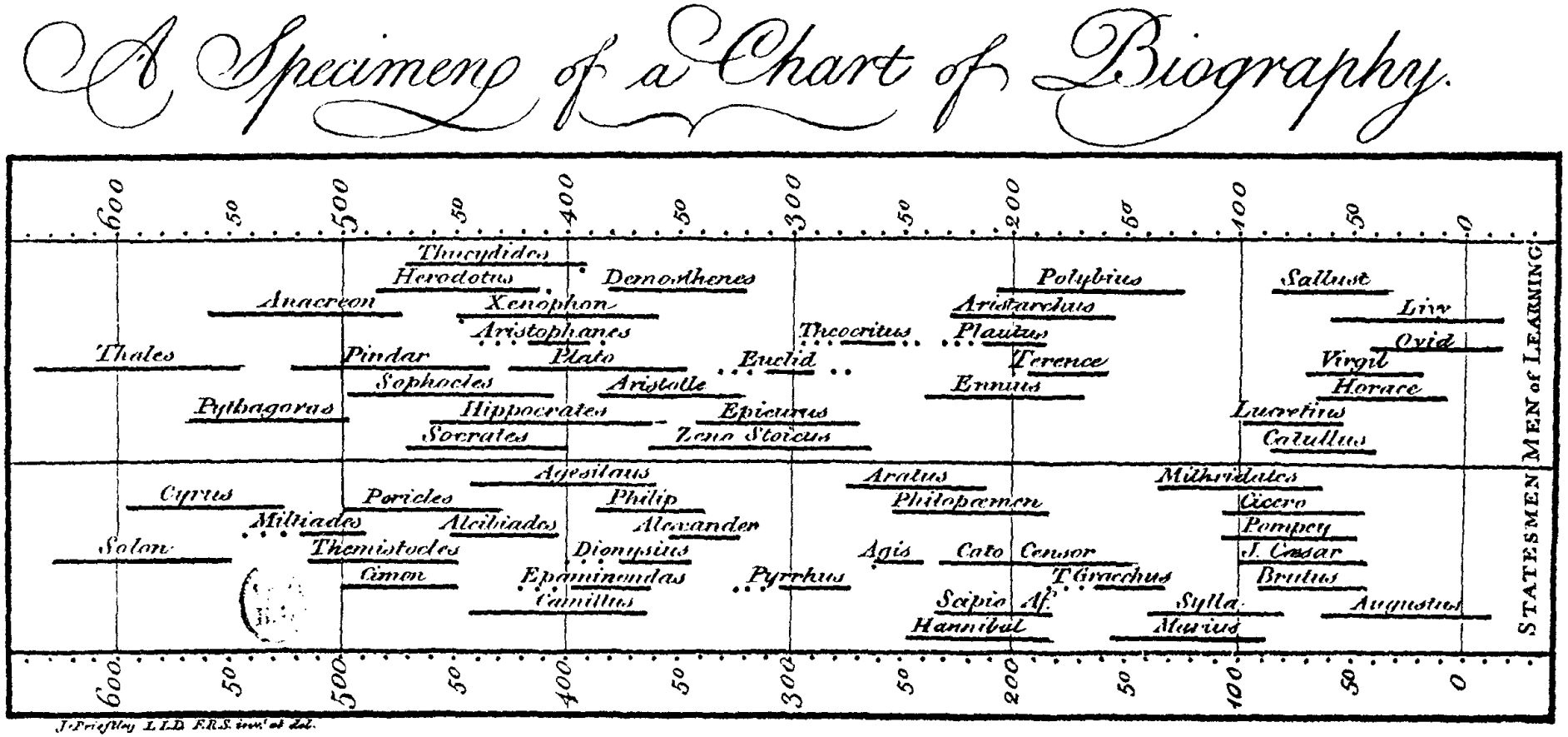
Figura quæ habet annexum signum X, est Oculteri.

Macula M, est hactenus visarum maxima, nulliq; primæ magnitudinis sideri fixo cedit.


MANCHE
GOLFE DE GASCOGNE
GOLFE DE GENES
MER MEDITERRANEE


Met Office

Joseph Priestley's Timeline 1765



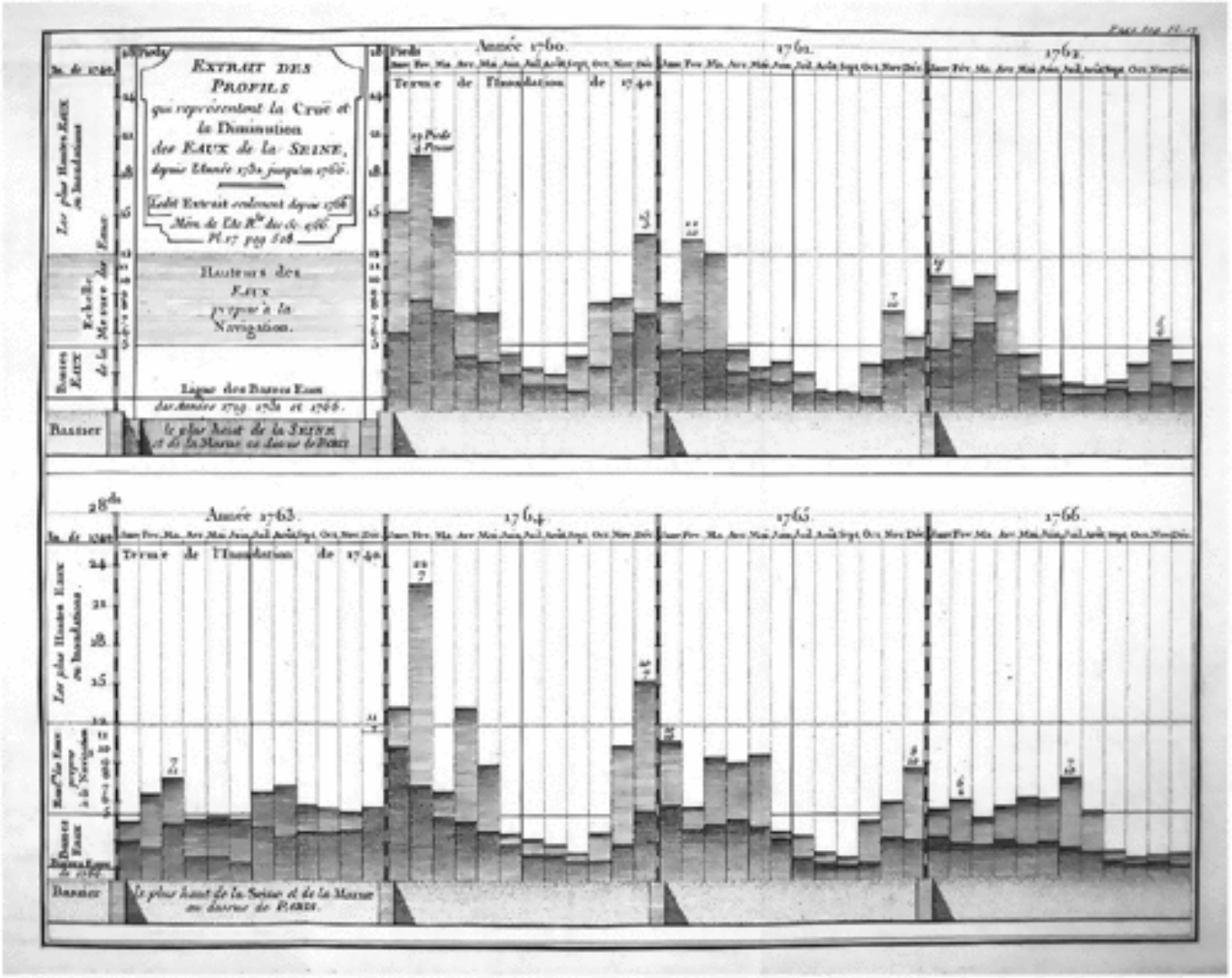
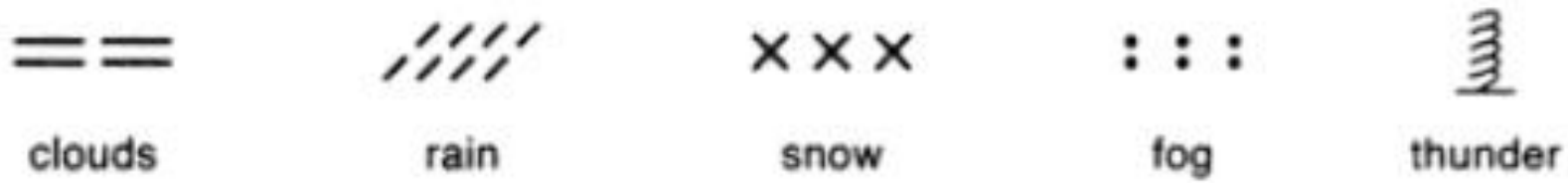


Figure 1. A time-line bar graph, "Extrait des Profils qui représentent la Cruë et la Diminution des Eaux de la Seine," by Philippe Buache, published in 1770, showing month-by-month high and low levels of the Seine, 1760-1766.

J. H. Lambert, 1771



Meteorological Society of the Palatinate, 1781–1792

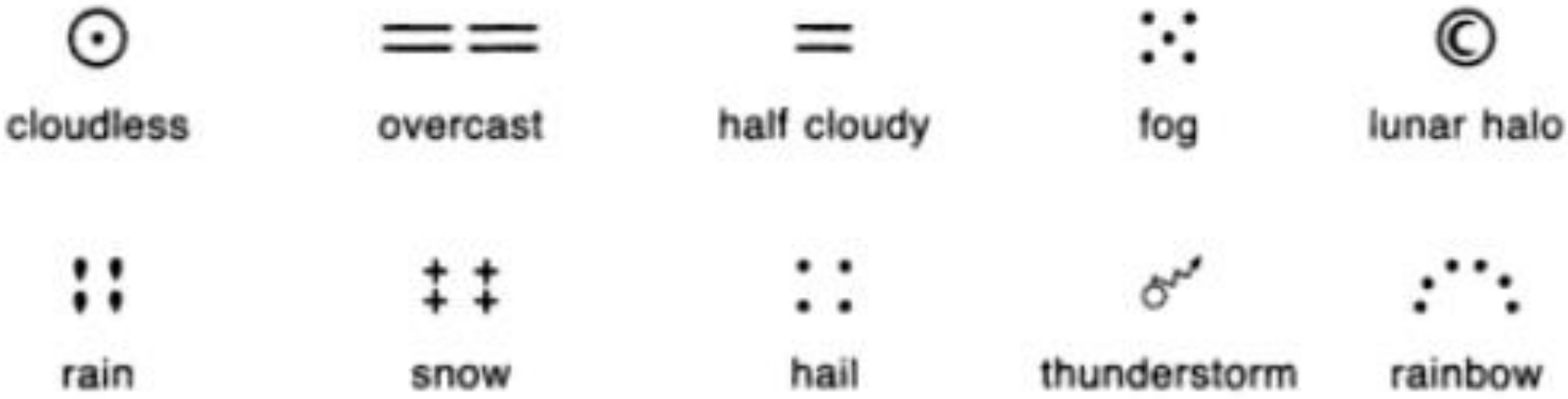
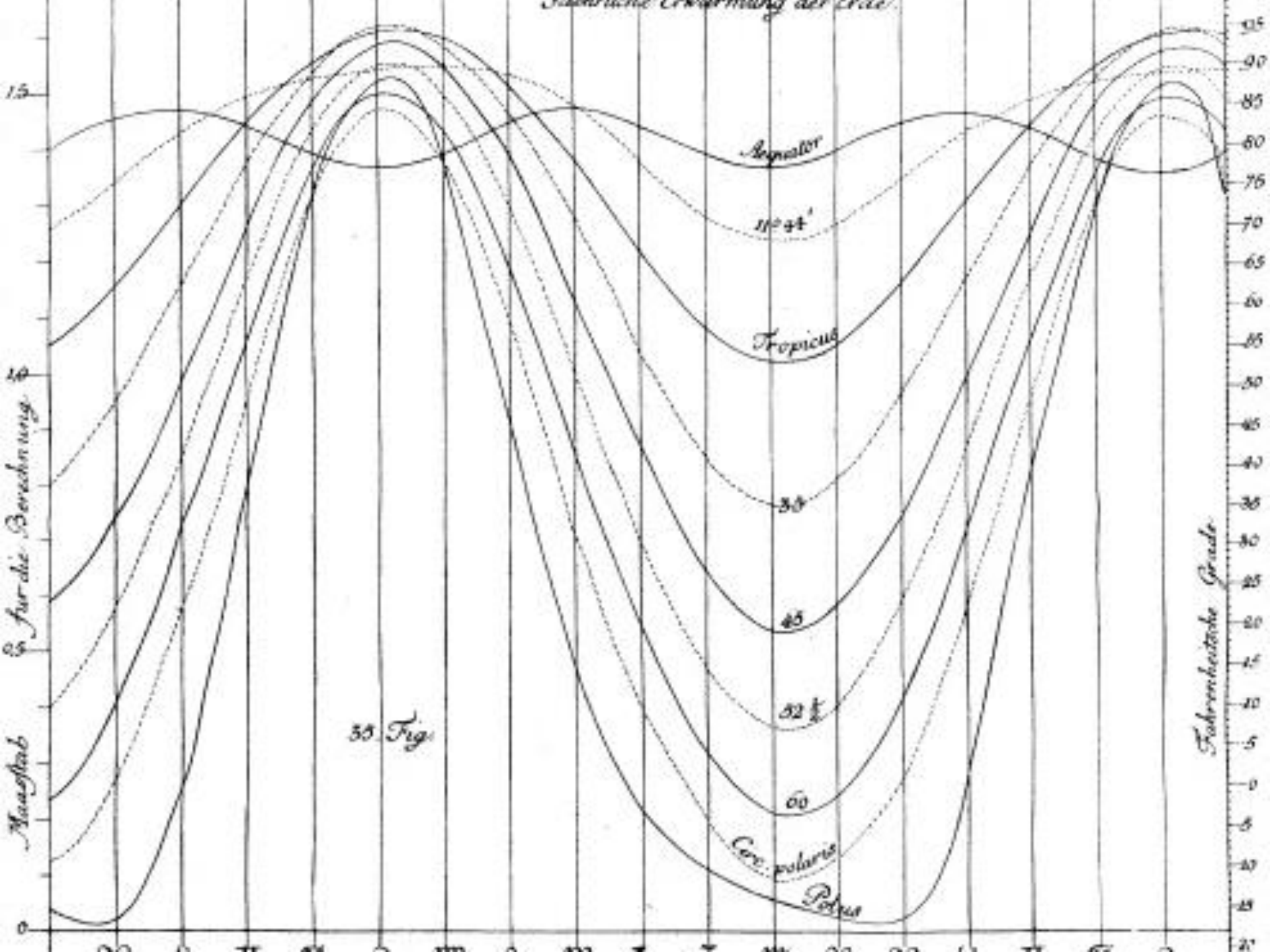


Fig. 12.4. Weather glyphs devised by Lambert in 1771 (upper row) and the Meteorological Society of the Palatinate between 1781 and 1792 (lower rows). Compiled from C. Fitzhugh Talman, "Meteorological Symbols," *Monthly Weather Review* 44 (1916): 265.


Jährliche Erwärmung der Erde
Aequator
11° 44'
Tropicus
30
45
52 ½
60
Circ. polaris
Polus
Maasstab zur die Berechnung
Fahrenheitsche Grade
15
10
0
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20

55 Fig.

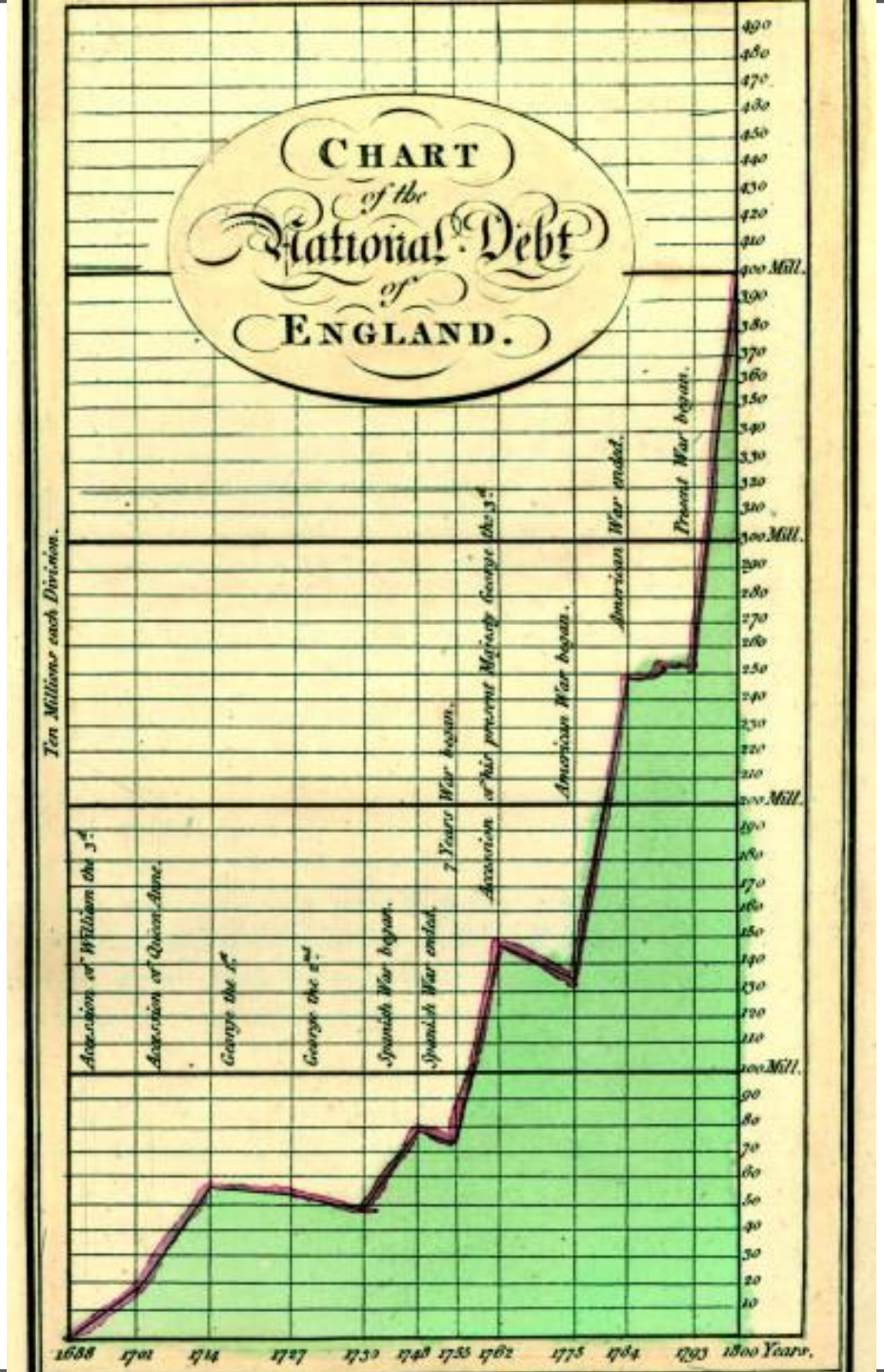
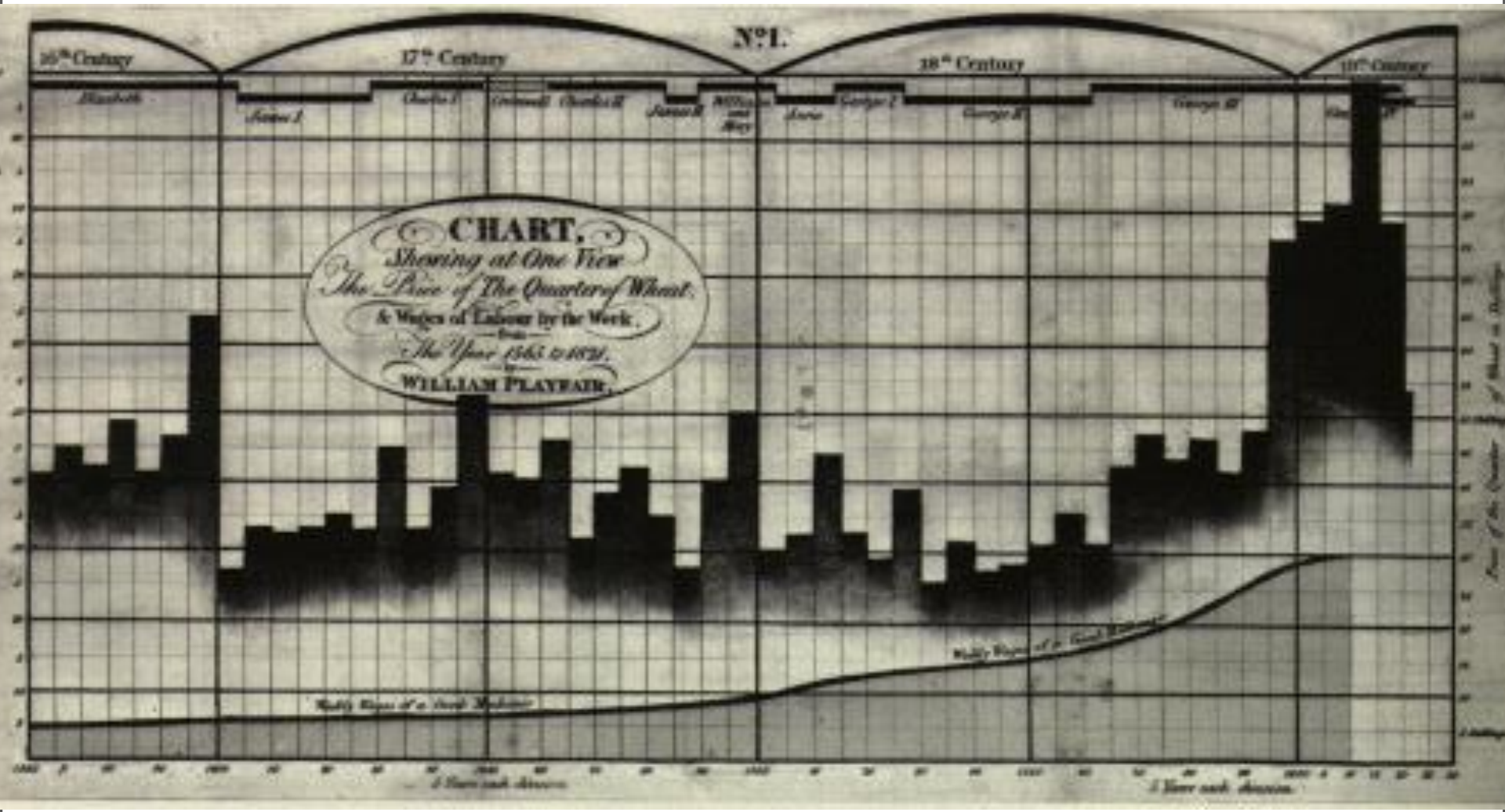
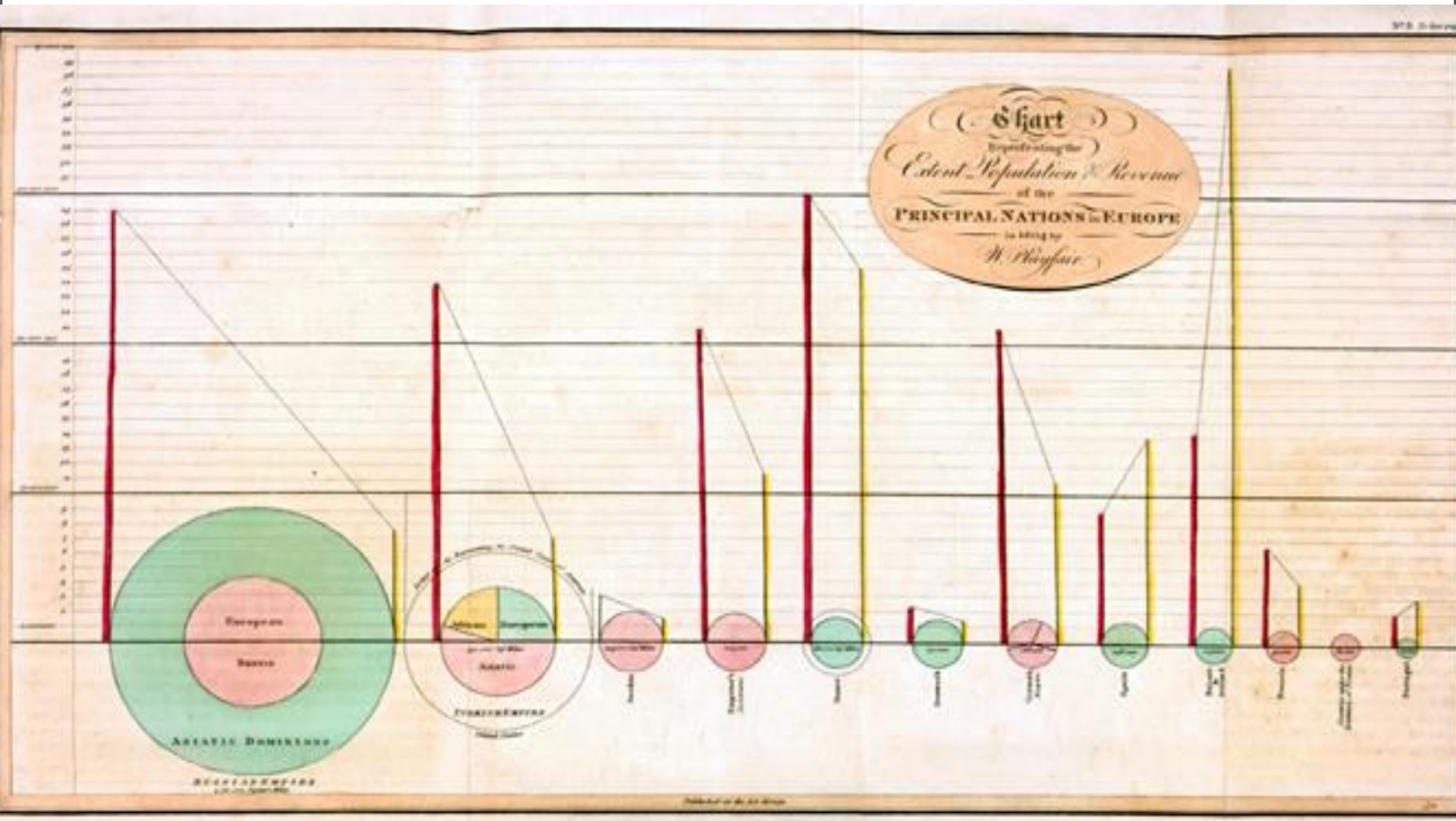


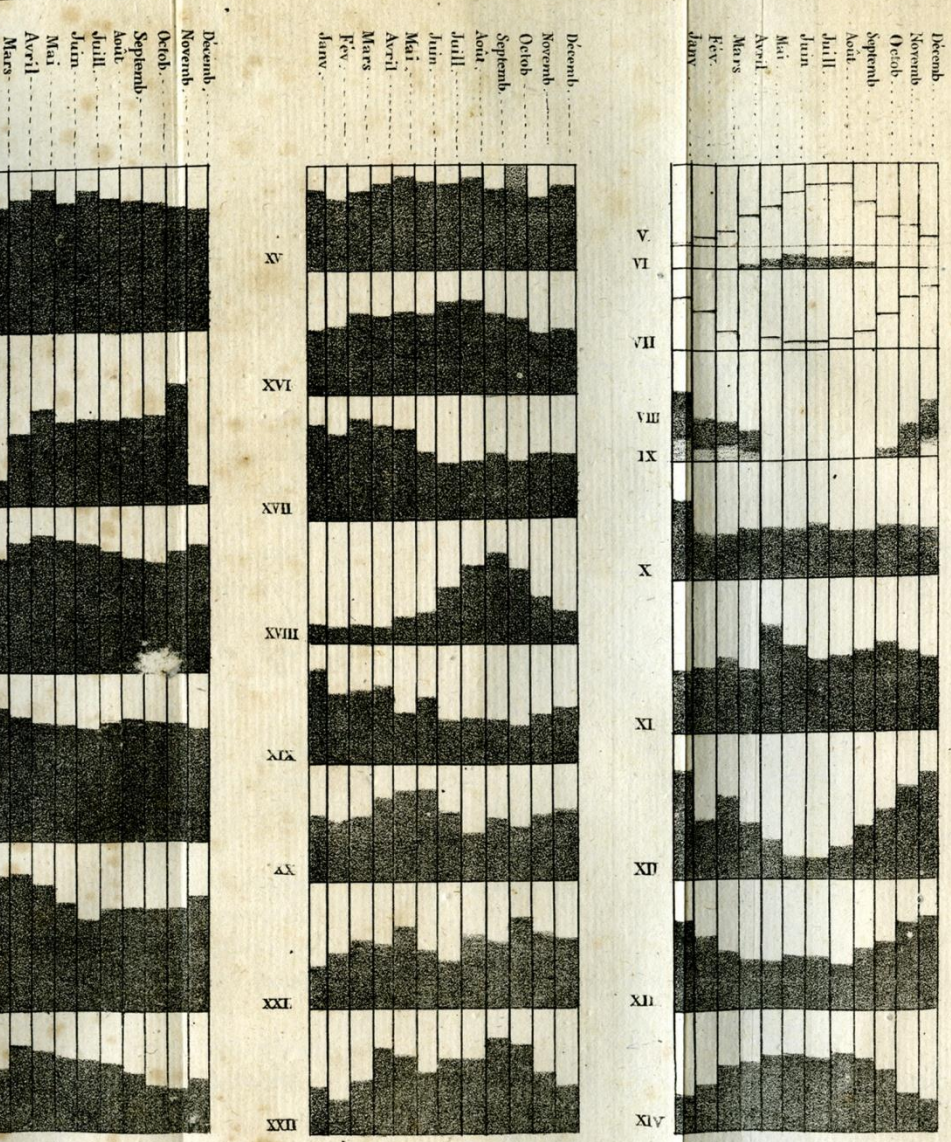
CHART
of the
National Debt
of
ENGLAND.
Ten Millions each Division.
Accession of William the 3d.
Accession of Queen Anne.
George the 1st.
George the 2nd.
Spanish War began.
Spanish War ended.
7 Years War began.
Accession of his present Majesty George the 3d.
American War began.
American War ended.
Present War began.
490
480
470
460
450
440
430
420
410
400 Mill.
390
380
370
360
350
340
330
320
310
300 Mill.
290
280
270
260
250
240
230
220
210
200 Mill.
190
180
170
160
150
140
130
120
110
100 Mill.
90
80
70
60
50
40
30
20
10
1688
1701
1714
1727
1739
1748
1755
1762
1775
1784
1793
1800 Years.

William Playfair's Bar Charts 1786



William Playfair's Pie charts 1801




Décemb.
Novemb.
Octob.
Septemb.
Août.
Juill.
Juin.
Mai
Avril
Mars
Févr.
Janv.
XV
XVI
XVII
XVIII
XIX
XX
XXI
XXII
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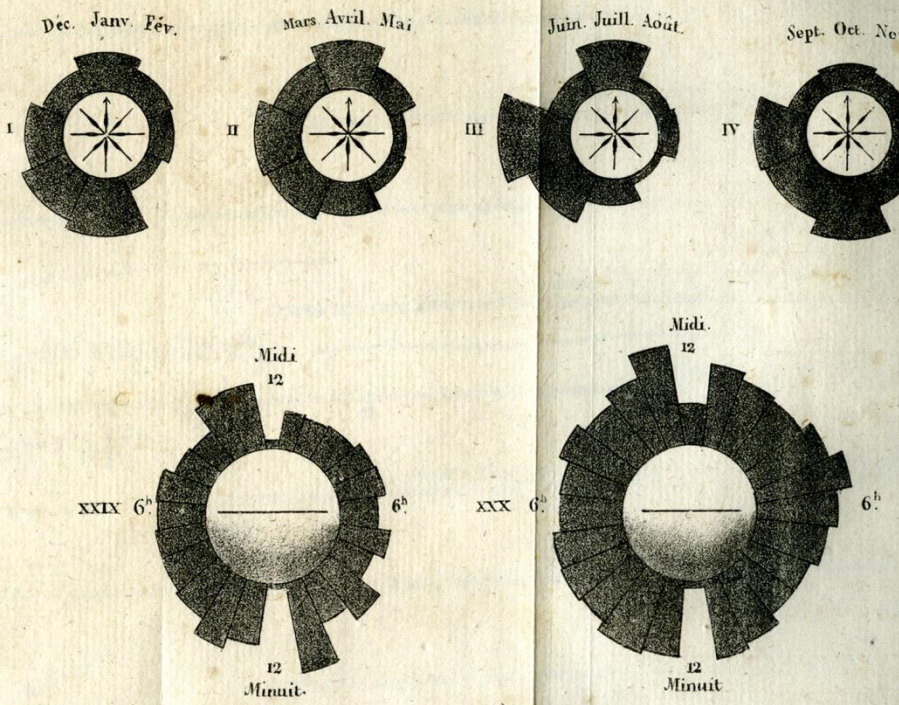
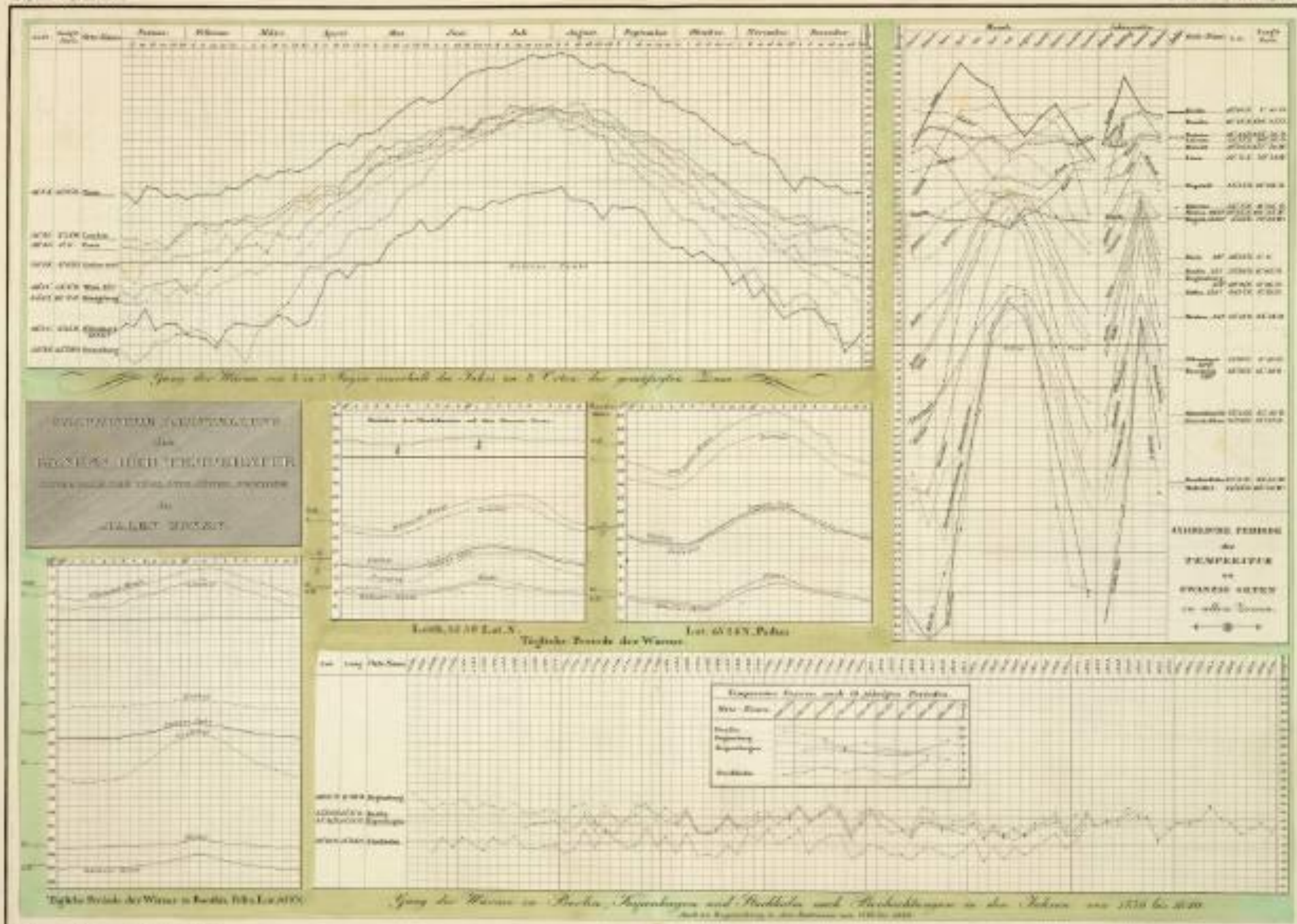
VI
VII
VIII
IX
X
XI
XII
XIII
XIV


Déc. Janv. Fév.
Mars Avril. Mai
Juin. Juill. Août.
Sept. Oct. No
I
II
III
IV
Midi
12
XXIX 6.h
6.h
12
Minuit.
Midi.
12
XXX 6.h
6.h
12
Minuit


Januar
Februar
März
April
Mai
Juni
Juli
August
September
October
November
December
Tägliche Periode der Wärme

1850.

Met Office

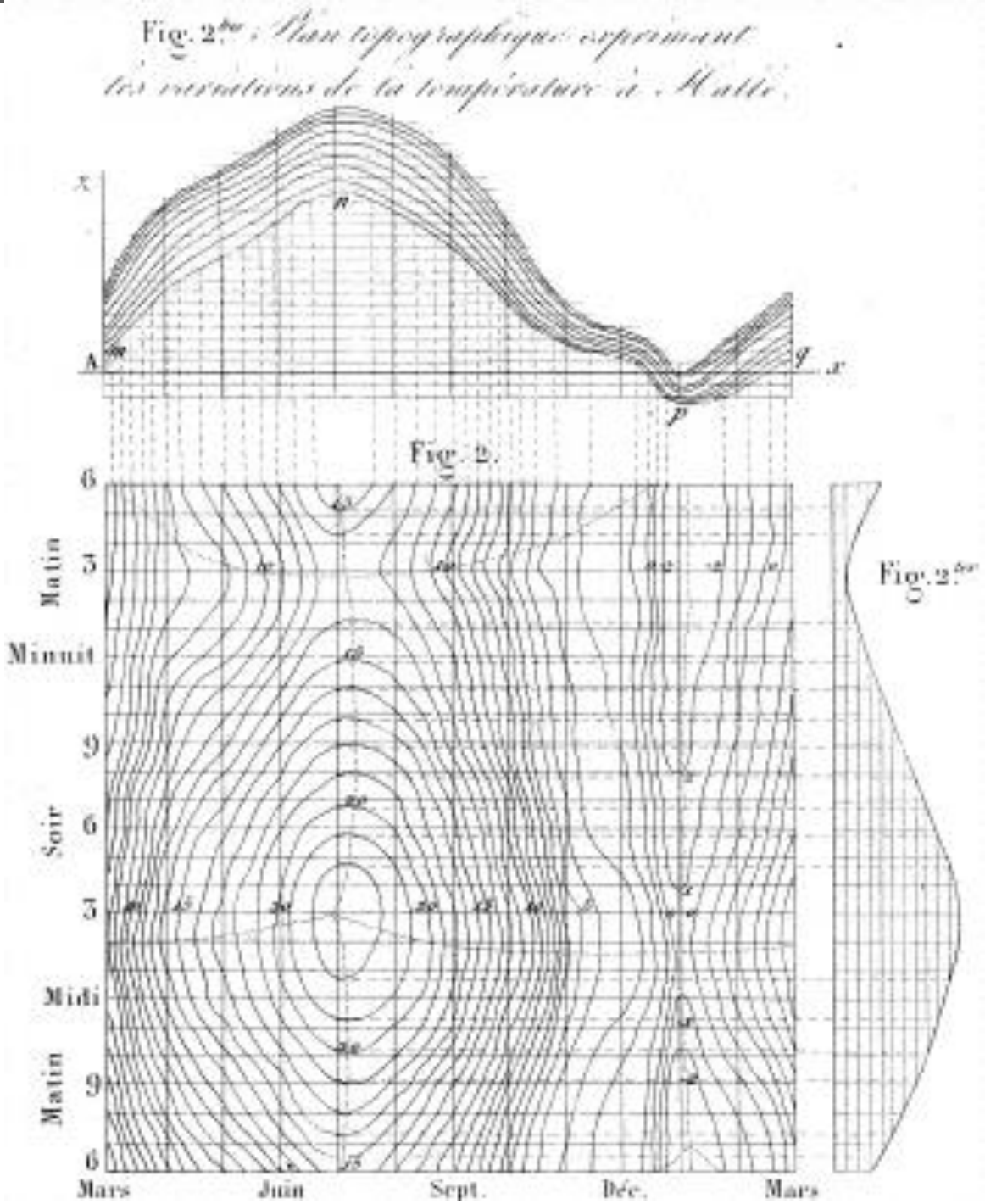
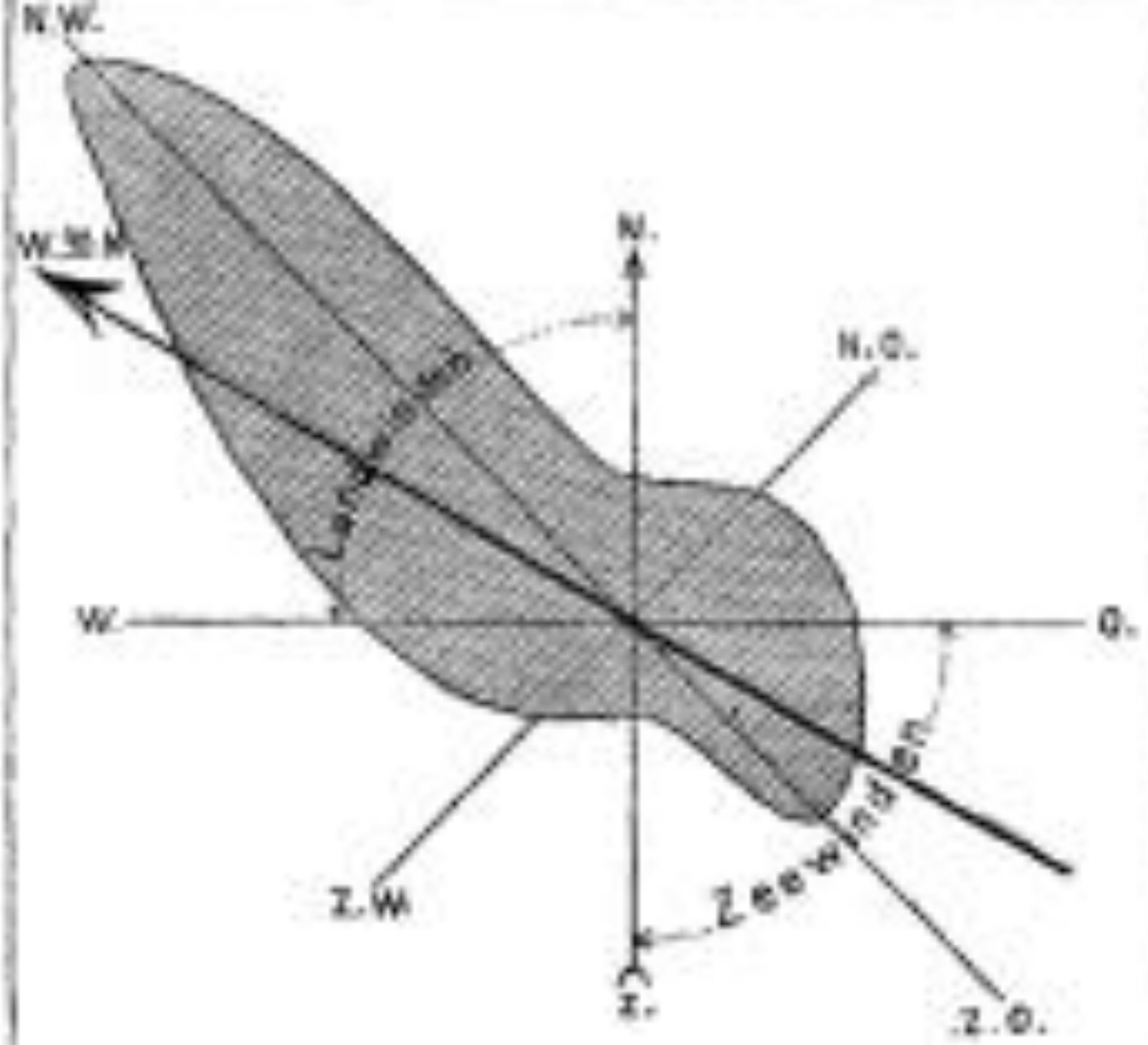


Fig. 2ter : Plan typographique exprimant
les variations de la température à Kiel.
x
A
y
x
Fig. 2.
6
Matin
3
Minuit
9
Soir
6
3
Midi
Matin
9
6
Mars
Juin
Sept.
Déc.
Mars
Fig. 2ter


N.W.
W. tot N.
N.
N.O.
W.
O.
Z.W.
Z.
Z.O.
Zeewind

Abaque hexagonal donnant **sans calcul** et **sans relèvements** la déviation du compas, pour le bateau « **Le Triomphe** ».

Formules :

$$\delta = A + B \sin \zeta' + C \cos \zeta' + D \sin 2\zeta' + E \cos 2\zeta'$$

$$B = \text{arc sin}\left(\mathfrak{B}\left(1+\tfrac{1}{2}\sin D\right)\right) ; \quad C = \text{arc sin}\left(\mathfrak{C}\left(1-\tfrac{1}{2}\sin D\right)\right) ; \quad \mathfrak{B} = \tfrac{1}{2}\left(\text{cotg}\,\theta + \frac{P}{H}\right) ; \quad \mathfrak{C} = \tfrac{1}{2}\left(\text{ftg}\,\theta + \frac{Q}{H}\right)$$

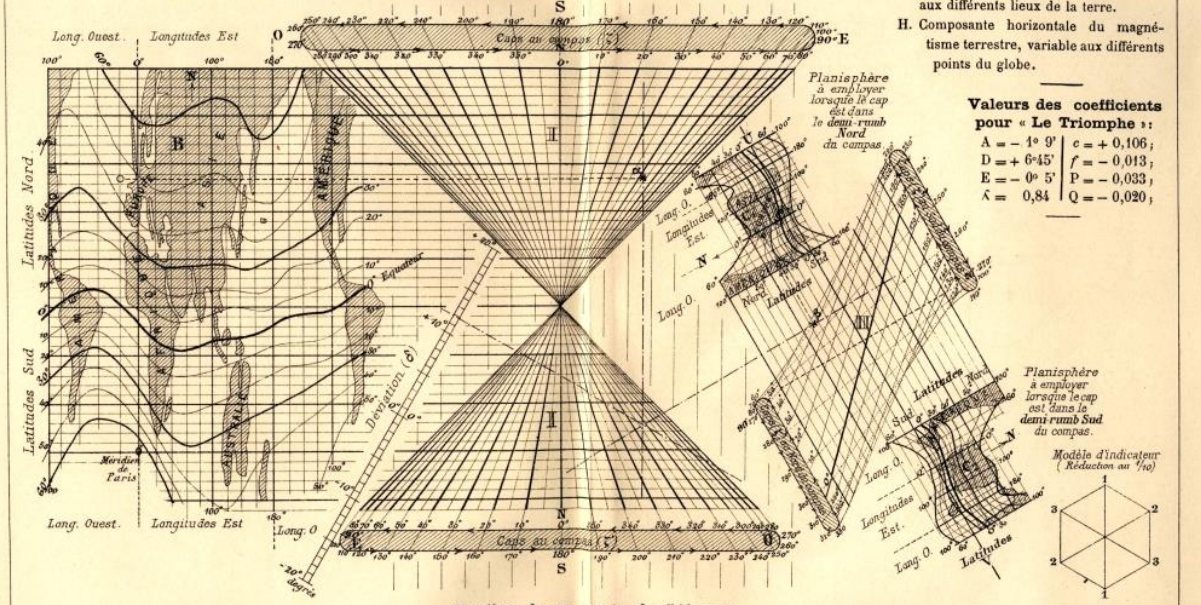
Légende :

θ Angle d'inclinaison magnétique variable aux différents lieux de la terre.

H. Composante horizontale du magnétisme terrestre, variable aux différents points du globe.

Valeurs des coefficients pour « Le Triomphe » :

A = − 1° 9′	c = + 0,106 ;
D = + 6°45′	f = − 0,013 ;
E = − 0° 5′	P = − 0,033 ;
k = 0,84	Q = − 0,020 ;



Manière de se servir de l'Abaque :

Pour consulter cet abaque, on se sert d'un **indicateur** hexagonal transparent, orienté comme le montre le modèle ci-dessus.

1° Prendre, sur la planisphère anamorphosée B, le point situé à la rencontre du **méridien du lieu** avec la courbe ayant pour cote la **latitude**.

Projeter ce point horizontalement sur la génératrice du cône I répondant au cap ζ′ du compas. — Marquer d'une petite croix (∝), au crayon, le point ainsi obtenu.

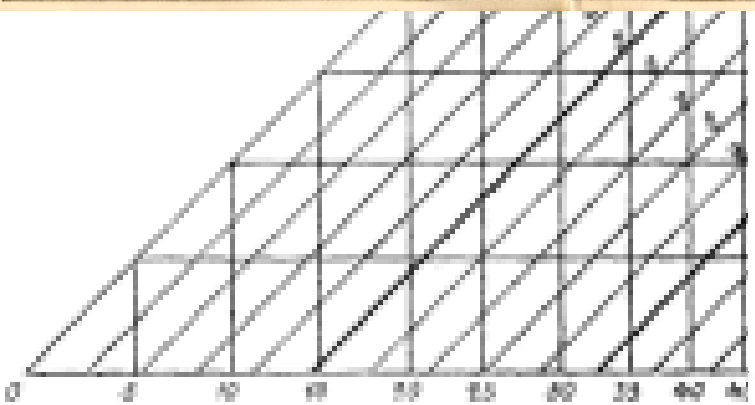
2° Prendre de même — sur la planisphère supérieure C_1, si le cap est dans le demi-rumb nord du compas — sur la planisphère C_2, si le cap est dans le demi-rumb sud — le point de rencontre du méridien et de la courbe ayant respectivement pour cotes la **longitude** et la **latitude** du lieu.

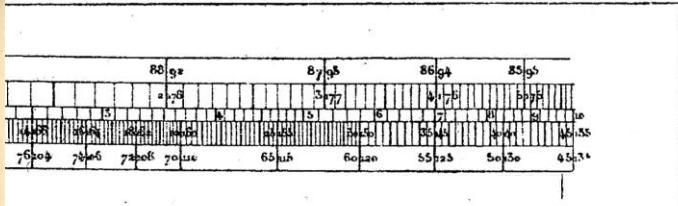
N.-B. — Pour ne pas salir le dessin, il est bon de le recouvrir d'une feuille de toile calque, placée le côté rugueux en dessus, sur laquelle on marque les deux petites croix (∝) et (β). — On efface ces dernières d'un coup de gomme, une fois le résultat obtenu.

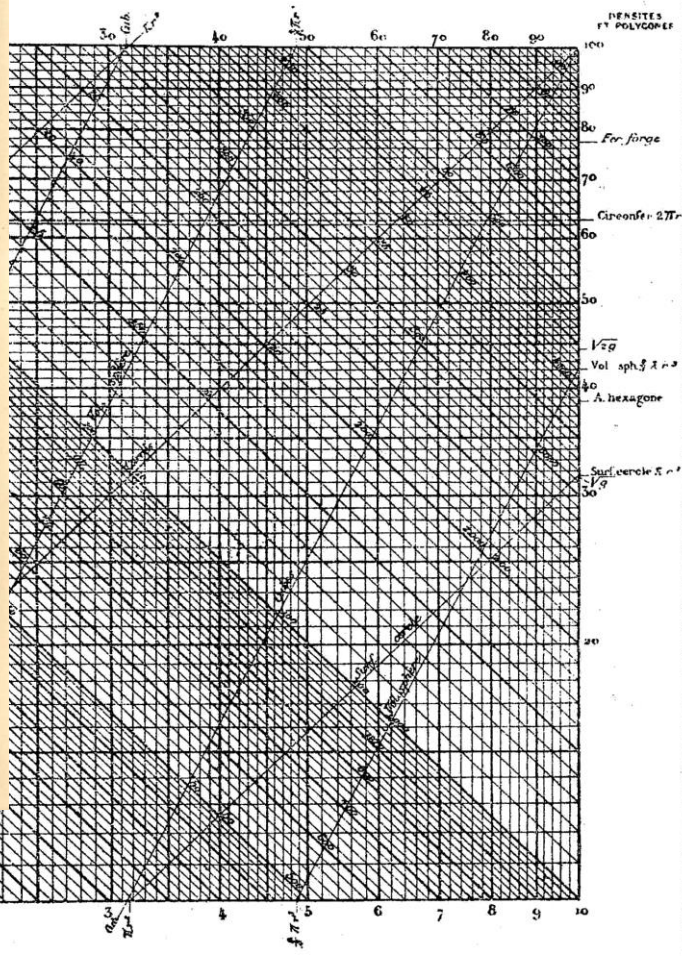
3° Projeter ce point parallèlement à la direction UV (\ ) sur la génératrice de l'hyperboloïde II répondant au cap ζ′. — Marquer également d'une petite croix (β) le point obtenu.

3° Placer le diamètre vertical (|) de l'indicateur sur la croix (∝) ; amener ensuite, par un glissement vertical, le diamètre 2-2 ( ) sur la croix (β). — On lit à ce moment sur le diamètre 3-3 (\ ) à la rencontre de l'échelle δ qui lui est perpendiculaire, la valeur de la **déviation totale** δ .

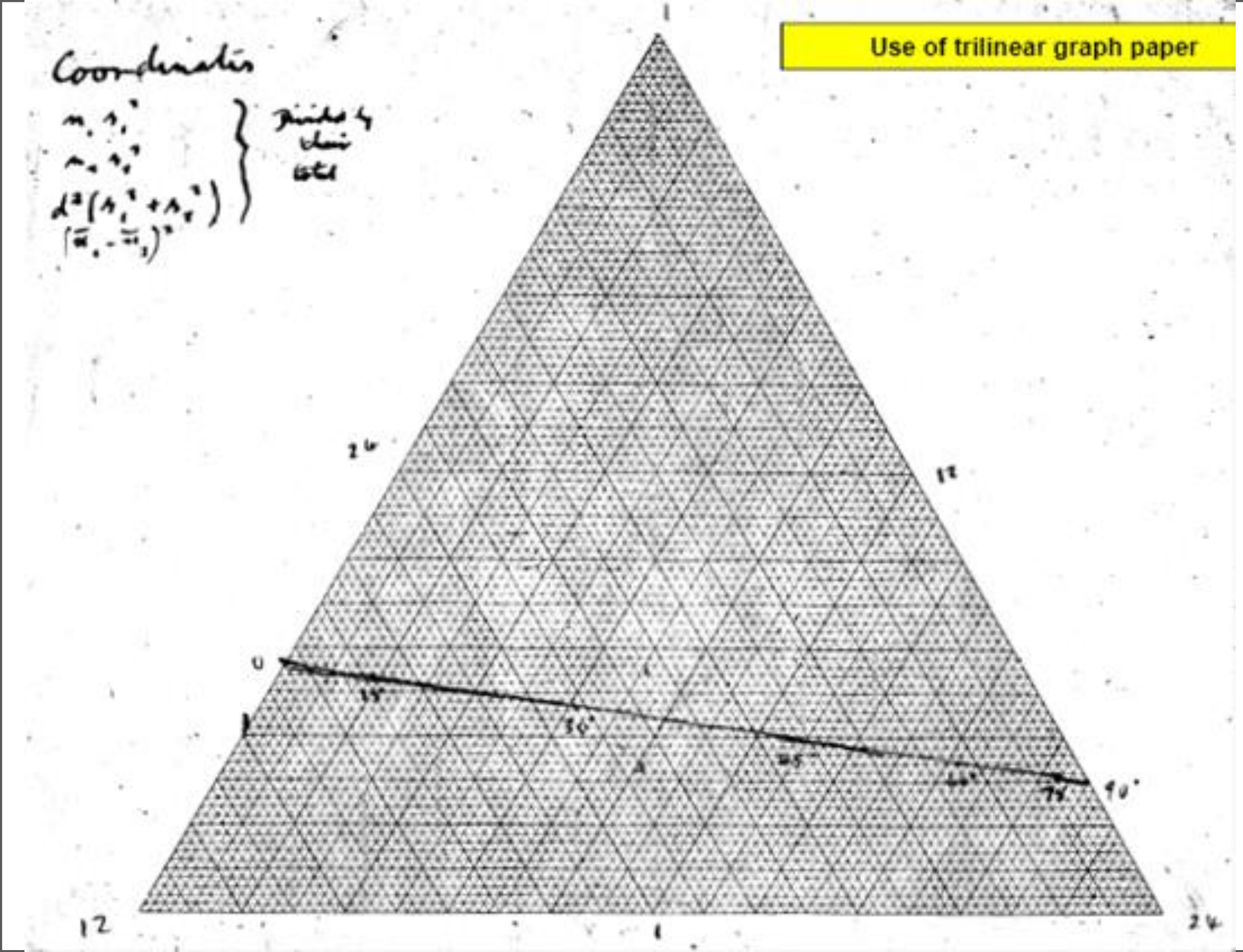
Sur la planche, à titre d'exemple, on a figuré les croix (∝) et (β), et, en traits tiretés (— . — . —), les positions des diamètres de l'indicateur, pour un point situé dans l'Atlantique, par 20° de long. O. et 42° de latitude N., et pour un cap ζ′ = 41°,5. — On lit, pour la déviation totale : δ = 11°,8.







Use of trilinear graph paper



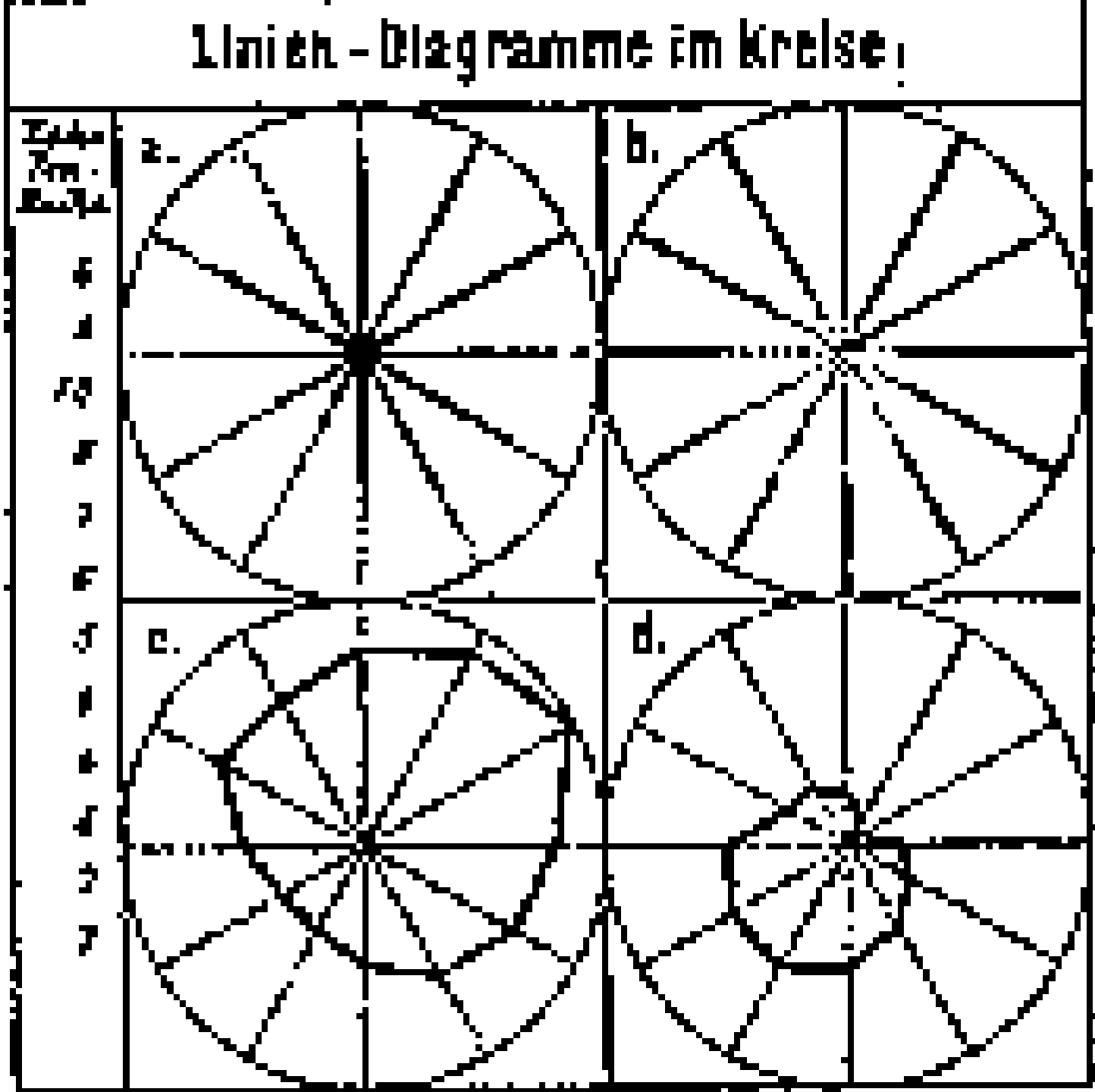
Met Office

Georg von Mayr

Polar diagrams

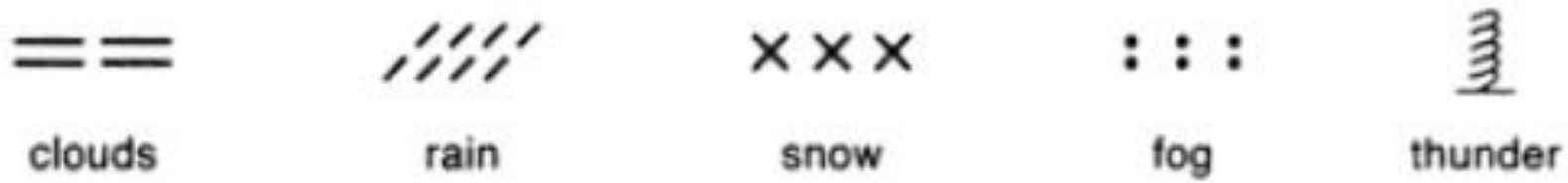
Star plots

1877



Timeline: Meteorology

J. H. Lambert, 1771



Meteorological Society of the Palatinate, 1781–1792

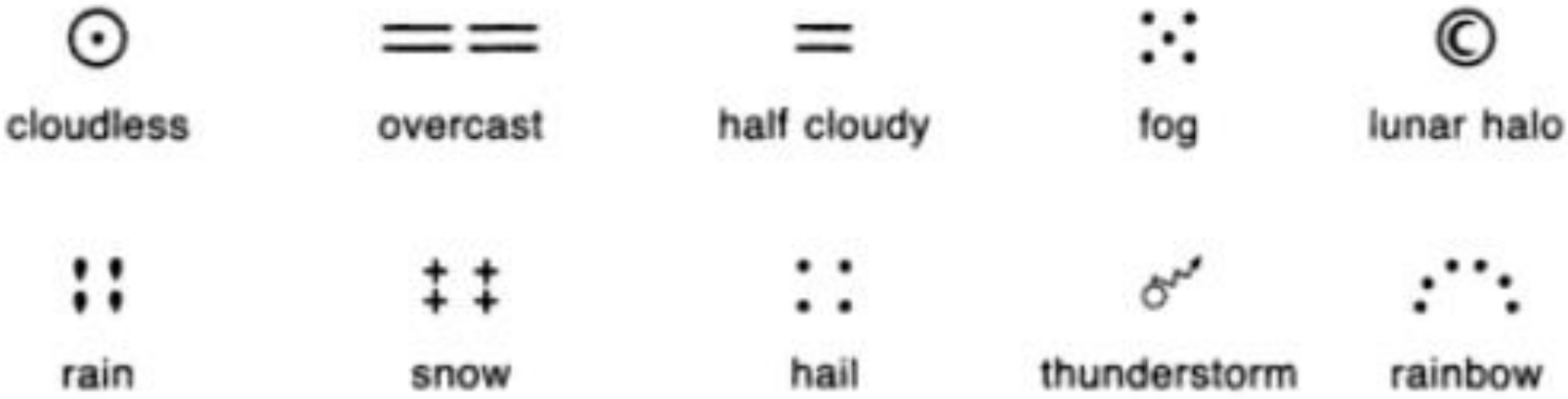
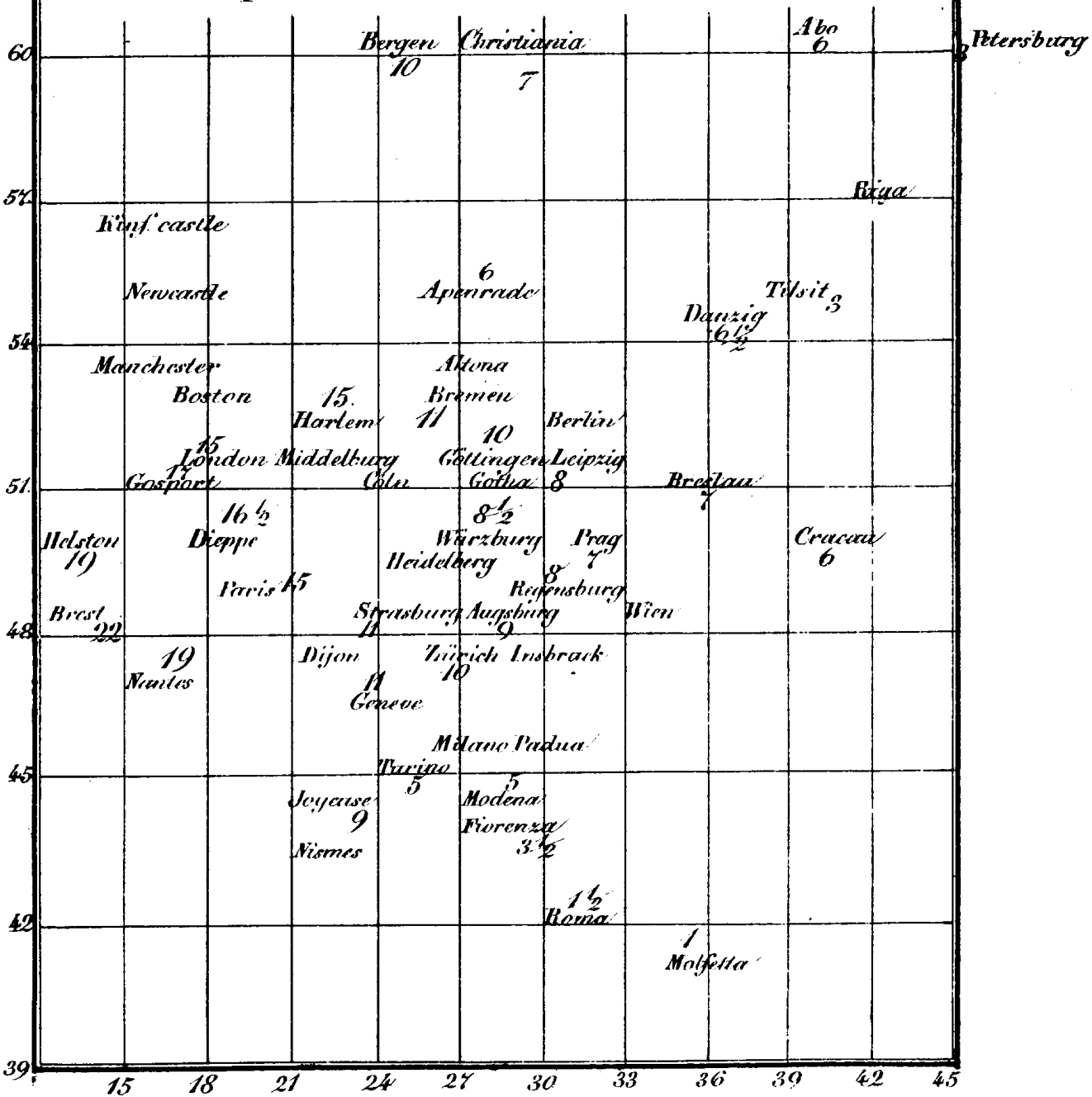


Fig. 12.4. Weather glyphs devised by Lambert in 1771 (upper row) and the Meteorological Society of the Palatinate between 1781 and 1792 (lower rows). Compiled from C. Fitzhugh Talman, "Meteorological Symbols," *Monthly Weather Review* 44 (1916): 265.

Tabula geographica, altitudines mercurii die 24 Decembr. hora 6. vespertina observatas exhibens.



Beaufort's Weather Code

1820-1825 version

b. Blue sky

c. Clear, transparent atmosphere

ci. Cirrus clouds

cl. Cloudy

cu. Cumulus clouds

d. Mist (damp air)

Dk Dark weather but atmosphere clear

f. Foggy

f: Dense Fog

g. Gloomy weather

h. Haze

m. Mist in valley

p. Passing cloud

1831 Beaufort Wind Force Scale, used by Commander Fitzroy

0	Calm	
1	Light Air	Or just sufficient to give steerage way
2	Light Breeze	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
3	Gentle Breeze	3 to 4 knots
4	Moderate Breeze	5 to 6 knots
5	Fresh Breeze	Or that to which a well-conditioned man-of-war could just carry in chase, full and by. Royals, etc
6	Strong Breeze	Single-reefed topsails and top-gallant sail
7	Moderate Gale	Double reefed topsails, jib, etc
8	Fresh Gale	Treble-reefed topsails etc
9	Strong Gale	Close-reefed topsails 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 which would reduce her to storm staysails
12	Hurricane	Or that which no canvas could withstand

Beaufort Wind Speed Scale: Sea

Speed	km/hr	knots	Term	Sea
0	Calm	Calm	Calm	Sea like mirror
1	2-5	1-3	Light Air	Ripples with appearance of scales: no foam crest
2	6-11	4-6	Light Breeze	Small wavelets; crests of glassy appearance, not breaking
3	12-18	7-10	Gentle Breeze	Large wavelets; crests begin to break; scattered whitecaps.
4	19-30	11-16	Moderate Breeze	Small waves, becoming longer; numerous whitecaps.
5	31-39	17-21	Fresh Breeze	Moderate waves, taking longer form; many whitecaps; some spray
6	40-50	22-27	Strong Breeze	Larger waves forming; whitecaps everywhere; more spray.
7	51-61	28-33	Near Gale	Sea heaps up; white foam from breaking waves begins to be blown in streaks.
8	62-74	34-40	Gale	Moderately high waves of greater length; edges of crests begin to break into spindrift; foam is blown in well-marked streaks.
9	75-87	41-47	Strong Gale	High waves; sea begins to roll; dense streaks of foam; spray may reduce visibility.
10	88-102	48-55	Storm	Very high waves with overhanging crests; sea takes white appearance as foam is blown in very dense streaks; rolling is heavy and visibility is reduced
11	103-117	56-63	Violent Storm	Exceptionally high waves; sea covered with white foam patches; visibility further reduced.

Beaufort Wind Speed Scale: Land

Code	km/hr	knots	Term	Land
0	Calm	Calm	Calm	Smoke rises vertically.
1	2-5	1-3	Light Air	Smoke drifts slowly downwind.
2	6-11	4-6	Light Breeze	Leaves rustle.
3	12-18	7-10	Gentle Breeze	Leaves are in motion.
4	19-30	11-16	Moderate Breeze	Small branches on trees move.
5	31-39	17-21	Fresh Breeze	Small trees sway.
6	40-50	22-27	Strong Breeze	Large branches sway.
7	51-61	28-33	Near Gale	Whole trees in motion.
8	62-74	34-40	Gale	Twigs and small branches break off trees.
9	75-87	41-47	Strong Gale	Large branches break off; slight structural damage.
10	88-102	48-55	Storm	Trees broken; minor structural damage.
11	103-117	56-63	Violent Storm	Widespread damage.
12	108-132	64-71	Hurricane	Violent movement of trees and much destruction.
13	133-148	72-80		
14	149-165	81-89		
15	166-183	90-99		
16	184-200	100-108		
17	201+	109+		

Beaufort's Code evolution

Code	1806-1807	1807-1810	1810-1812	1820-1825	1826-1832
b.	Blue sky	Blue sky	Blue sky	Blue sky	Blue sky, clear or turbid atmosphere
c.	Clear i.e., definite, sharp horizon Clear, transparent atmosphere		Definite sharp horizon, distant objects clearly visible Individual passing clouds		Bright objects visible from afar
ci.				Cirrus clouds	
cl.	Cloudy	Cloudy	Cloudy	Cloudy	
cu.				Cumulus clouds	
d.	Dry, warm air			Mist (damp air)	Drizzle, fine rain
da.		Damp air	Damp air		
dk	Dark, close air	Dark, gloomy weather		Dark weather	Dark weather but atmosphere clear
dp.	Damp air				
dr.	Drizzle	Drizzle	Drizzle		
f.	Fine weather	Fine weather	Fine weather	Foggy	Fog
f:				Dense Fog	
fg.	Foggy	Fog	Fog		
g.	Dark, gloomy weather			Dark, gloomy weather	Gloomy weather Dark, gloomy weather
ge.		Gloomy weather			
gr.	Greasy sky	Greasy sky	Greasy sky		
h.	Haze	Hazy weather	Haze	Haze	Hail
hr.	Heavy rain	Heavy rain	Heavy rain		
hsh.	Heavy showers	Heavy showers	Heavy showers		
hsq.	Heavy squalls	Heavy squalls	Heavy squalls		
l.	Lightning	Lightning	Lightning		Lightning
m.		Mist		Mist in valley	Mist or hazy atmosphere
o.					Overcast. Entire sky covered by thick clouds.

Synoptic Charts need common Time

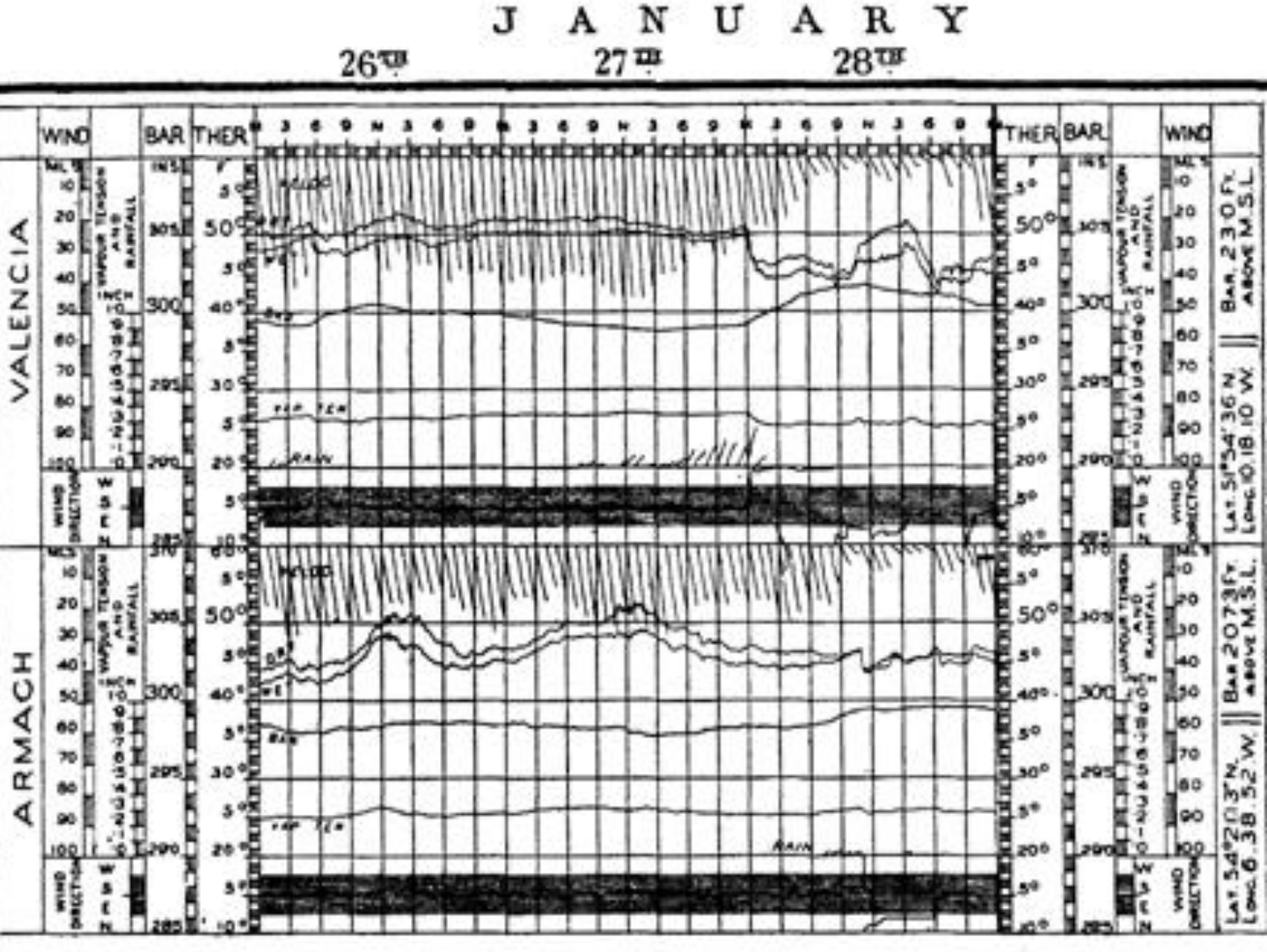
Railroad and telegraph companies pushed for a simplified standardized time keeping. Consequently, civil time zones were initially instituted in the:

UK 1847

New Zealand 1868

USA and Canada 1883

Worldwide scheme 1884

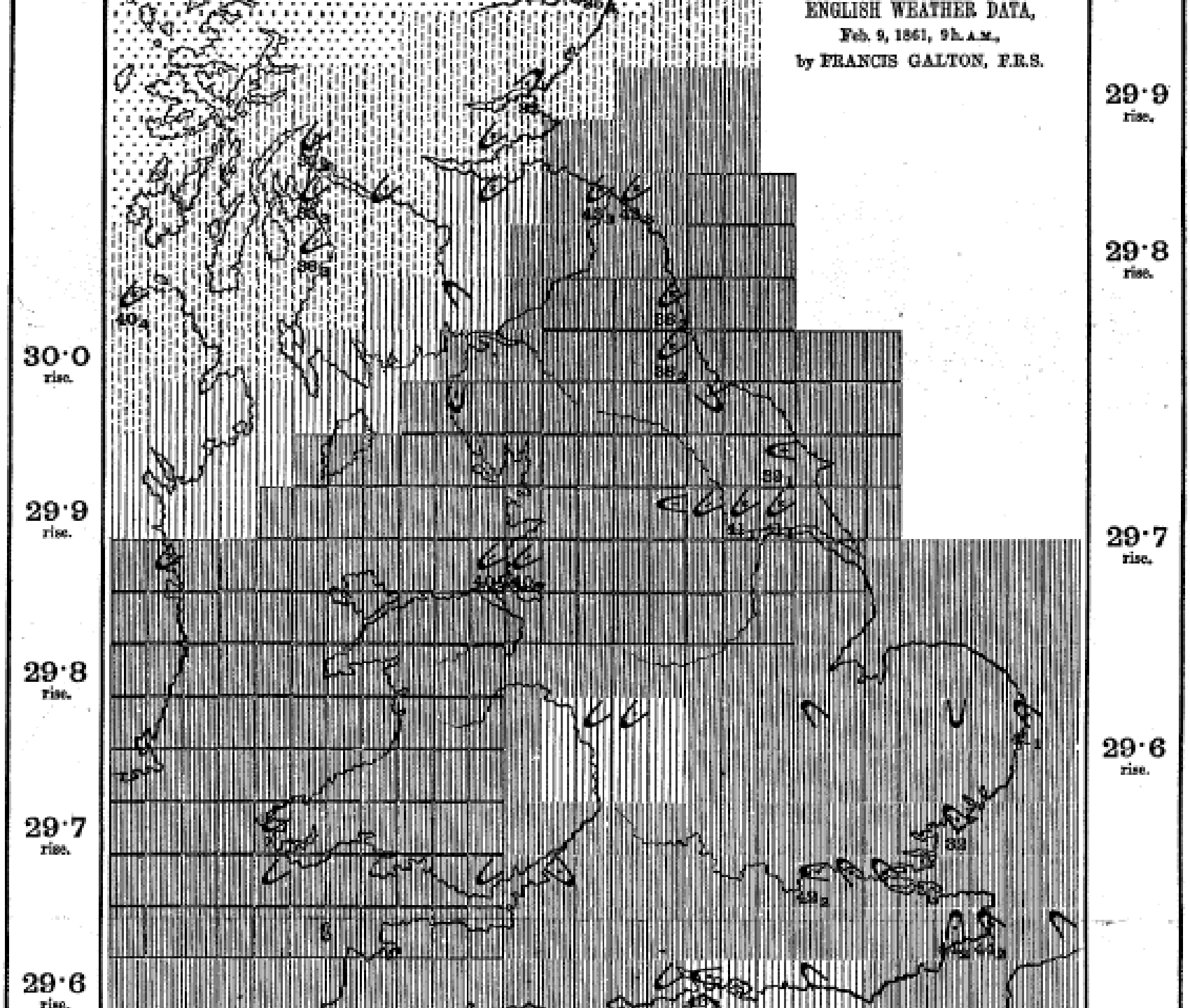

JANUARY
26th
27th
28th
VALENCIA
ARMAGH
WIND
BAR
THER
RAIN
Bar. 23·0 Ft. above M.S.L.
Lat. 51°54'36 N. Long. 0.18.10 W.
Bar. 207 Ft. above M.S.L.
Lat. 54°20'3 N. Long. 6.38.52 W.

SYNCHRONOUS WEATHER CHART OF ENGLAND.

16th January 1861, 9 A.M.

From Reports received by the Meteorological Society of London, by the Board of Trade, and by the Trinity House.

By FRANCIS GALTON, F.R.S.,
and Honorary Secretary to the Royal Geographical Society of London


ENGLISH WEATHER DATA,
Feb. 9, 1861, 9h. A.M.,
by FRANCIS GALTON, F.R.S.
30·0
rise.
29·9
rise.
29·8
rise.
29·7
rise.
29·6
rise.
29·9
rise.
29·8
rise.
29·7
rise.
29·6
rise.


WEATHER MAP
OF THE
BRITISH ISLES
for
MONDAY, AUG. 8.
9 a.m.
IRISH SEA
ST GEORGE'S CHANNEL
BRISTOL CHANNEL
ENGLISH CHANNEL
EXPLANATION OF THE SYMBOLS

Sept^r. 3^rd

WEATHER REPORT.

1860

At ~~8~~ 9 A.M.

	B.	E.	M.	D.	F.	C.	I.
Aberdeen							
Greenock	30·07	55	52	WSW	2	1	b
Berwick							
Copenhagen							
Portrush							
Galway							
Hull	30·06	54	52	W	2	6	o
Liverpool							
Queenstown							
Helder							
Yarmouth	30·06	63	59	NW	2	5	c
London	30·13	50	54	W	2	2	b
~~Kew~~ Dunkirk	30·15	59	52	WSW	0	1	b
Dover							
Portsmouth	29·96	59	58	SW	3	3	bc
Plymouth	30·06	60	—	NNW	2	0	oc
~~Penzance~~ Cherbourg	30·11	61	55	WNW	0	1	b
Havre	———	57	—	—	–	2	bc
Jersey	30·15	59	56	NNW	2	2	bc
Brest	30·07	52	—	NW	0	9	oc
Bayonne							
Lisbon							

EXPLANATION.

B.—Barometer corrected and reduced to 32° at sea-level (mean). E.—Exposed (but shaded) thermometer. M.—Moistened bulb (for evaporation and dew point). D.—Direction of wind (true). F.—Force (0 to 12). C.—Cloud (1 to 9) proportion. I.—Initial letters: b.—blue sky; c.—clouds (detached); f.—fog; h.—hail; l.—lightning; m.—misty (hazy); o.—overcast (dull); r.—rain; s.—snow; t.—thunder.

NOTE.—A letter repeated augments—thus, r r much rain.

October 1st

WEATHER REPORT.

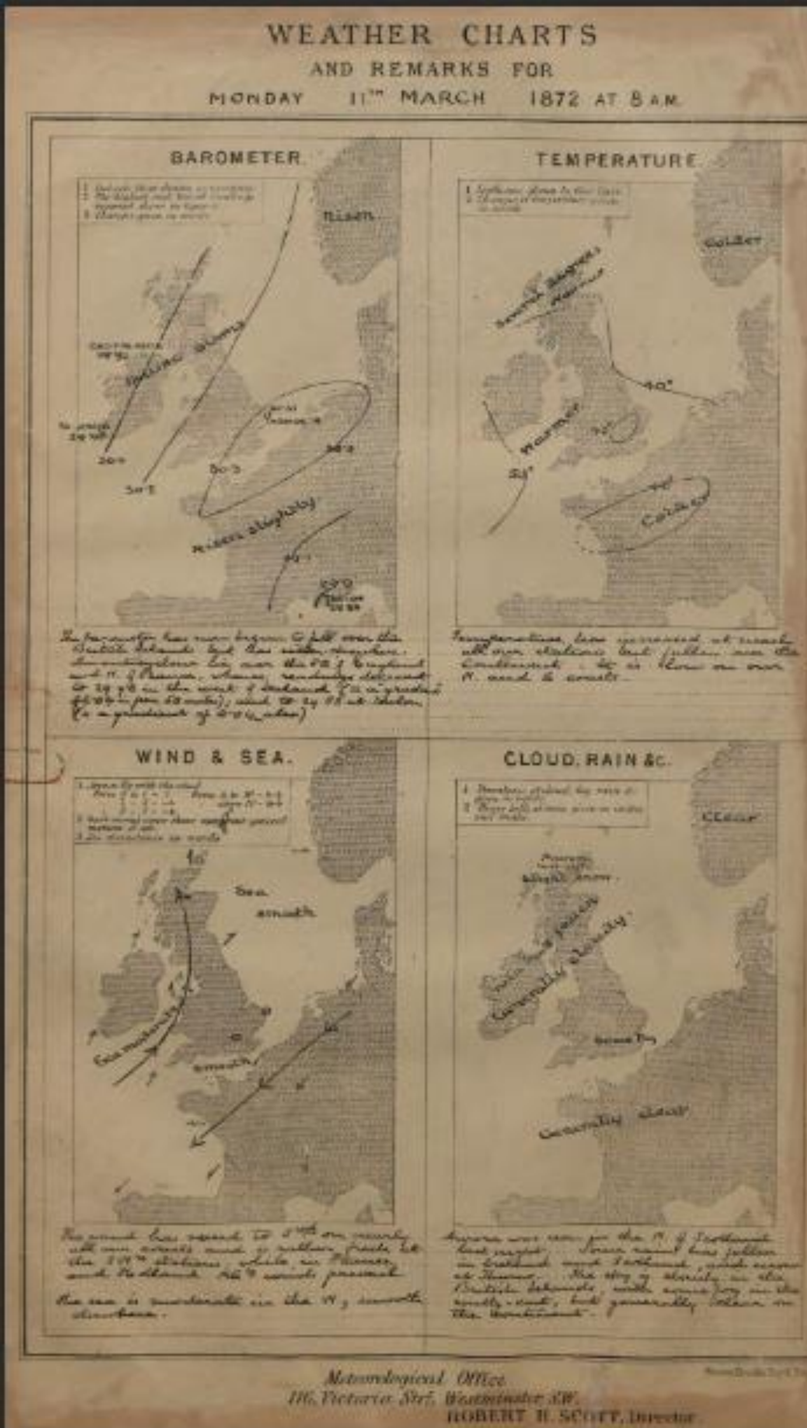
At 8 to 9 A.M.

	B.	E.	M.	D.	F.	C.	I.
Aberdeen	30·24	49	48	SW	1	9	m
Greenock	30·33	47	46	NW	1	9	m
Berwick	30·30	52	51	WSW	—	—	—
Copenhagen	30·31	51	—	ENE	4	–	bc
Portrush	30·30	40	47	S	2	2	b
Galway	30·33	51	50	W	2	5	c
Hull	30·20	52	51	NNW	2	7	o
Liverpool	30·32	53	51	NNW	2	8	c
Queenstown	30·34	49	48	NE	2	5	b
Helder	30·24	—	—	S	0	–	bc
Yarmouth	30·28	54	53	NW	1	6	o
London	30·28	50	47	NW	1	9	m m
Kew	30·28	49	48	W	0	9	m
Dover	30·26	57	53	NNW	2	2	c m
Portsmouth	———	51	50	N	3	6	o
Plymouth	30·24	57	56	NW	1	1	b m
Penzance	30·38	51	50	NNW	1	5	b
Jersey	30·33	53	52	NE	1	0	m
Brest	30·27	40	—	N	0	9	o
Bayonne	30·24	54	—	SSW	0	9	o r
Lisbon	30·26	62	—	N	2	4	bc

EXPLANATION.

B.—Barometer corrected and reduced to 32° at sea-level (mean). E.—Exposed (but shaded) thermometer. M.—Moistened bulb (for evaporation and dew point). D.—Direction of wind (true). F.—Force (0 to 12). C.—Cloud (1 to 9) proportion. I.—Initial letters: b.—blue sky; c.—clouds (detached); f.—fog; h.—hail; l.—lightning; m.—misty (hazy); o.—overcast (dull); r.—rain; s.—snow; t.—thunder.

NOTE.—A letter repeated augments—thus, r r much rain.



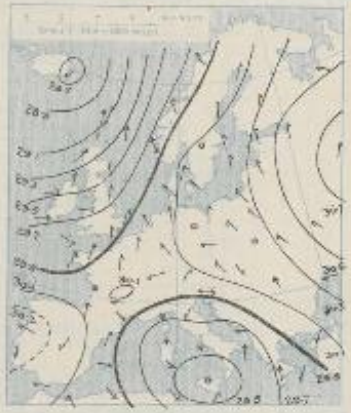
WEATHER CHARTS
AND REMARKS FOR
MONDAY 11TH MARCH 1872 AT 8 A.M.
BAROMETER
TEMPERATURE
WIND & SEA.
CLOUD, RAIN &c.
Meteorological Office
116, Victoria Str., Westminster S.W.
ROBERT H. SCOTT, Director

WEATHER CHARTS
FOR Wednesday, 1st August, 1900.
I. BAROMETER, WIND AND SEA. This Morning.
II. TEMPERATURE AND WEATHER. This Morning.
LOW
HIGH
Barometer fallen
Generally Low
COOLER AT NEARLY ALL STATIONS
WARMER
III. BAROMETER and WIND - Yesterday morning.
IV. Means of DAILY MAXIMUM TEMPERATURES For the two monthly period July-August (1871-95.)
V. Means of DAILY TEMPERATURE at 8 a.m. for the Two monthly period July-August (1871-95)

SUPPLEMENTARY CHARTS OF BAROMETER AND WIND

FOR 8 A.M. AND 6 P.M. YESTERDAY

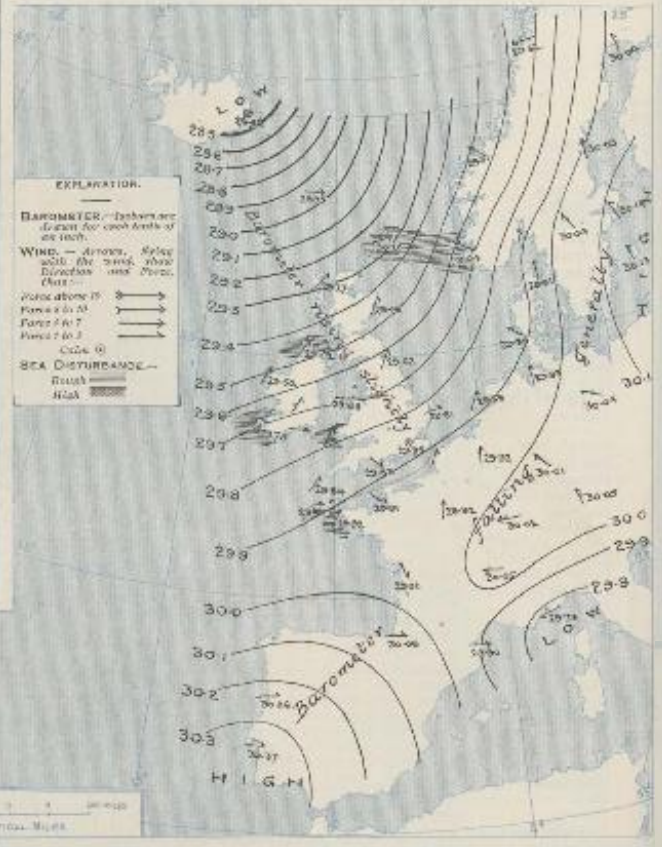
8 A.M. YESTERDAY.



6 P.M. YESTERDAY

Sunday, WEATHER

1. BAROMETER, WIND AND SEA AT 8 A.M. TO-DAY.



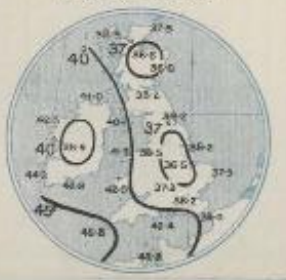
NOTES ON THE GENERAL SITUATION AT 8 A.M.

Barometrical pressure is now highest, 30·3 in. and upwards, in the south of Portugal, but is also high, 30·1 in. and upwards, over the upper part of the Baltic. The lowest readings, 28·6 in. and less, are found in a depression lying off eastern Ireland, and over the extreme northern parts of our area the barometric gradient for Scotland and Southwesterly winds is rather steep.

The wind is light to moderate from the Southeastward in these Islands, but draws into South in Denmark and Sweden and into Southeast or East in the west of Norway, with a gale at Skudesness. In the southwestern parts of France it is Westerly Northwest. Temperature has changed very irregularly. Over these Islands as a whole the Barometer is still rather low, the morning readings being below 30" at all but a few stations in the west and southwest, and slightly below the freezing point in the east and southeast of England. In several parts of Germany and Central France the Barometer is below 20°. The weather varies greatly in different localities. Fog prevails in the east and southeast of England as well as in the north and east of France, showers are reported at several of our western stations, and snow is falling at Paris. The sea is slight or smooth generally but is rather rough in our extreme northern and northeastern coasts generally, and rough off the southwest of Norway.

AVERAGES OF TEMPERATURE AT 8 A.M. FOR THE MONTH OF FEBRUARY.

(Derived chiefly from Observations extending over the 35 years—1871-1905.)



NOTES REFERRING TO INFORMATION GIVEN

(a) At the British and Irish Stations the readings of the barometer are not corrected for the difference in The approximate correction is:—For stations North of Malin Head and North Shields + ·03 Malin Head and North Shields + ·02 in., but for Scilly and Jersey + ·01 in.

(b) The Sunshine for London given in this table is recorded on the Tower of the Wesleyan Training is recorded at Littlestone-on-Sea.

(c) The information relating to Weather is indicated by the following letters—b. blue sky; bc. sky e. wet air, without rain falling; f. fog; g. gloomy; h. hail; l. lightning; m. misty (hazy); o. t. thunder; u. ugly, threatening; v. visibility, unusual transparency; w. dew; x. hoar frost; z.

* AN ASTERISK is inserted in all places for which information is not usually received.

WIRELESS TELEGRAMS

Received during the 24 hours ended at 9.30 a.m. to-day.

Hour of Observation.	Name of Ship.	Position of Ship		Reading of Barometer.	Wind.		Weather.	Air Temp.	Sea Disturbance.
		Lat.	Long.		Direc.	Force.			
		°	°	ins.				°	
1. a.m.	—	47.32	6.15	29.98	NNW	3	6	51	3
8. a.m.		48.36	5.49	29.88	WSW	2	6	49	2

TERMS OF SUBSCRIPTION for the Daily Weather Report forwarded by Book Post, £1 per a

Single Copies (price 1d.) may be obtained after 3 p.m. on the day of issue at the Meteorologica Railway Stations:—Victoria, Charing Cross, King's Cross, St. Pancras, Euston.

FORECASTS OF WEATHER for one day in advance are drawn up at 11 a.m., and between 7 Telegram, on paying at any Post office in the United Kingdom Sixpence in addition Information as to the Terms on which Forecasts can be sent daily, for a long or short period, m

METEOROLOGICAL OFFICE, 63, VICTORIA STREET, S.W.

EXPLANATION.

BAROMETER.—Isobars are drawn for each tenth of an inch.

WIND.—Arrows, flying with the wind, show Direction and Force, thus:—

Force above 10 → Force 8 to 10 → Calm ⊙

Force 4 to 7 → Force 1 to 3 →

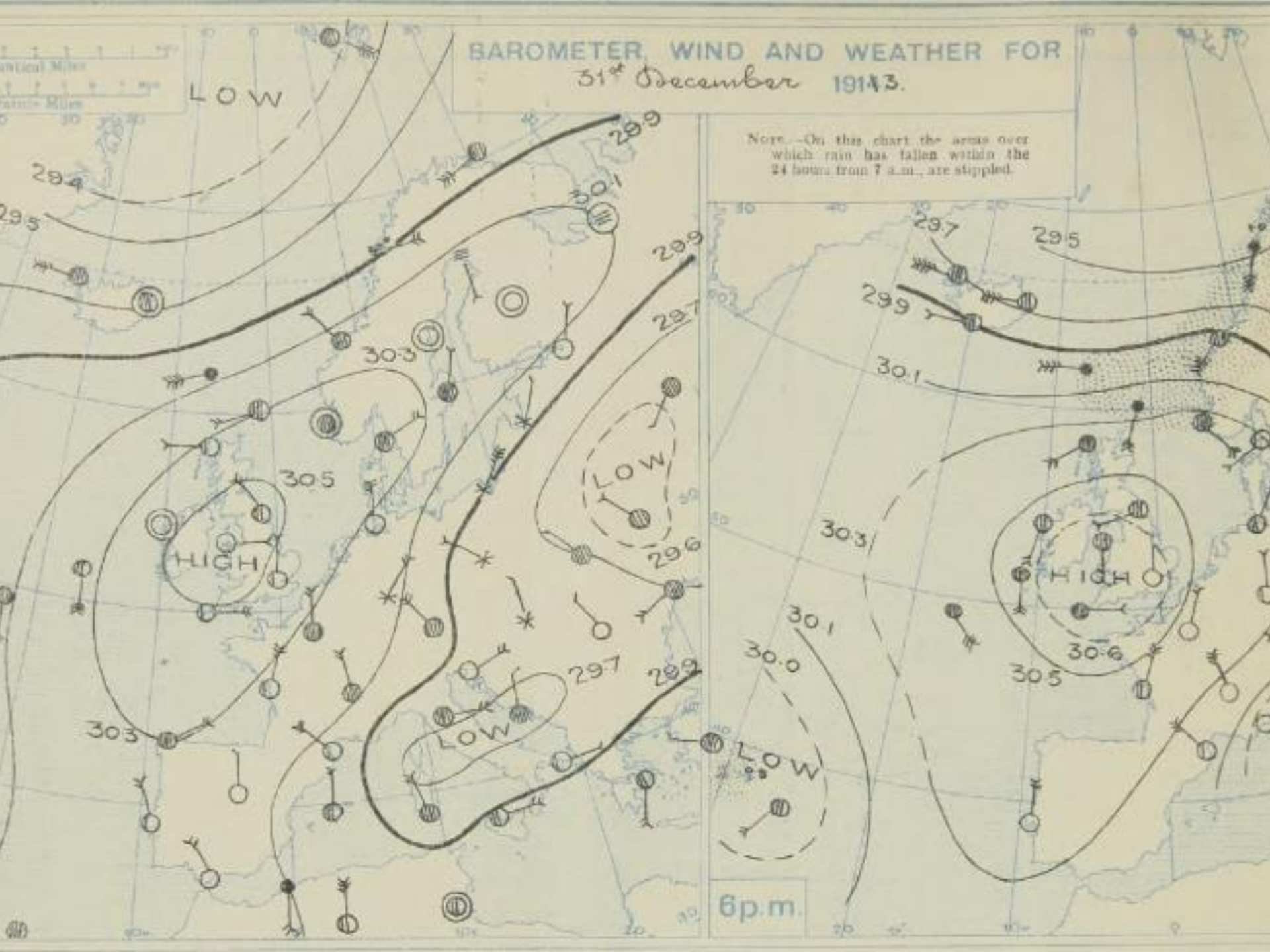
TEMPERATURE.—Given in degrees Fahrenheit. Isotherms by dotted lines.

WEATHER.—Shown by the following Letters and Symbols:—b, clear sky; c, cloudy; o, overcast; ≡, fog; •, rain falling; ▲, hail; ✱, snow; T, thunder; K, thunderstorm.

SEA DISTURBANCE.

Rough ~ High ≈

⁂ Wireless Message.


BAROMETER, WIND AND WEATHER FOR
31st December 1943.
Note.—On this chart the areas over which rain has fallen within the 24 hours from 7 a.m., are stippled.
LOW
29·4
29·5
29·9
30·1
29·9
29·7
30·3
30·5
HIGH
LOW
29·6
29·7
29·2
30·3
LOW
29·7
29·5
29·9
30·1
30·3
HIGH
30·6
30·5
30·1
30·0
LOW
6p.m.

SCALE OF SURFACE VISIBILITY.

0	Very bad	Objects not visible beyond	200	metres	(320 yards).
1	Bad	" " "	500	"	(545 yards).
2	Very poor	" " "	1,000	"	(0·6 mile).
3	Poor	" " "	2,000	"	(1·2 miles).
4	Indifferent (Ordinary)	" " "	4,000	"	(2·5 ").
5	Fair (Ordinary)	" " "	7,000	"	(4·3 ").
6	Good, above ordinary	" " "	12,000	"	(7·5 ").
7	Very good, unusual	" " "	20,000	"	(12·4 ").
8	Exceptionally good	" " "	30,000	"	(18·6 ").
10	Objects visible beyond 30,000 metres (18·6 miles).				

BEAUFORT NOTATION.

b blue sky (not more than a quarter covered).
bc sky partly cloudy (one half covered).
c generally cloudy (three quarters covered).
d drizzle, or fine rain.
e wet air without rain falling.
f fog. g gloom.
h hail. l lightning.
m mist.
o overcast sky.
p passing showers.
q squalls.
r rain.

BEAUFORT NOTATION.

rs sleet, *i.e.*, rain and snow together.
s snow.
t thunder.
u ugly, threatening sky.
v unusual visibility.
w dew.
x hoar frost.
y dry air; humidity less than 60 per cent.
z dust haze; the turbid atmosphere of dry weather.

Suffixes 0, 1 and 2 attached to Beaufort letters signify intensity, 0=slight, 2=heavy. Underlining is used to express continuity.

WEATHER SYMBOLS.

Clear sky	○	Sky ¼ clouded	◔
Sky ¼ clouded	◔	Sky ½ clouded	◑
Overcast sky	●	Rain falling	●
Snow	✳	Hail	▲
Fog	≡	Mist	≡
Thunder	ϒ	Thunderstorm	ϒ
Lightning	↯	Gale	↙
Aurora	⌓	Solar halo	⊕
Rime	⚜	Lunar halo	◯
Glazed frost	⌒	Solar corona	◎
Glazed roads	⌒	Lunar corona	◎
Snow lying	▨		

SEA DISTURBANCE.—
Rough ~~~ High ~~~

METEOROLOGICAL OFFICE. LONDON.

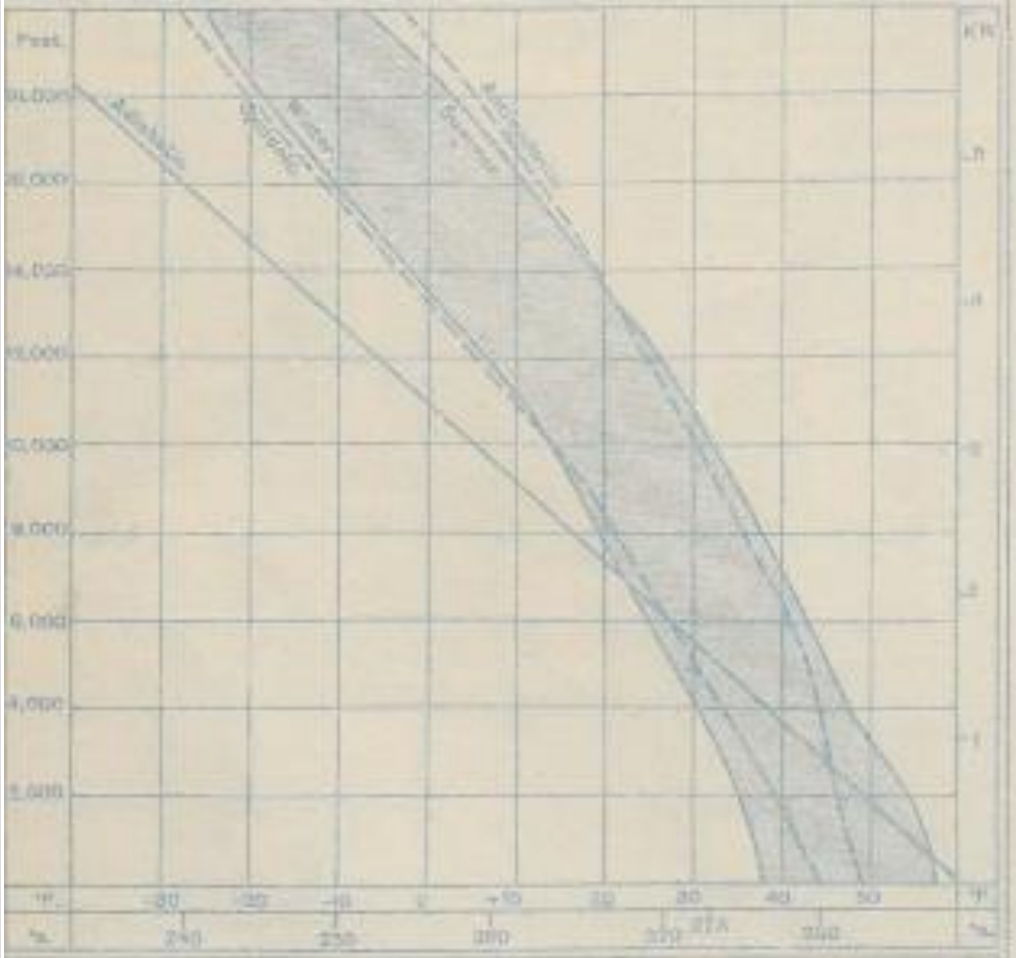
DAILY WEATHER REPORT UPPER AIR SUPPLEMENT. No. 20,949 C.

Compiled from Observations at the Office Observatories, and Meteorological Stations of the Air Ministry.

DIRECTION AND MEAN VELOCITY IN MILES PER HOUR, OF SURFACE AND UPPER WINDS: CLOUD FORMS AND AMOUNT.

AFTERNOON OF 31ST MARCH.

UPPER AIR TEMPERATURES.



NOTES

Upper Air Forecasts for 24 Hours Commencing 15h. on April 1st, 1919

Scotland and NE. England.
Wind from NE. reaching 25-30 mph. at about 2000 feet. A NEly. current will probably be maintained up to at least 10,000 feet.

South-East England.
Winds up to 15 mph. at 2000 feet, ultimately becoming N. or NE. and increasing somewhat.

Ireland and Western England.
Winds from N. or NNE. 15-20 mph. at 2000 feet. A Nly. current will probably be maintained up to at least 10,000 feet.

THE BEAUFORT SCALE OF WIND FORCE.

Beaufort Number.	Admiral Beaufort's General Description of Wind.	Specification for use on Land, based on observations made at Land Stations.	Limits of Mean Velocities Statute Miles per Hour
0	Calm	Calm; smoke rises vertically	Less than 1
1	Light air ..	Direction of wind shown by smoke drift	1–3
2	Slight breeze ..	Wind felt on face; leaves rustle	4–7
3	Gentle breeze ..	Leaves and small twigs in constant motion; wind extends light flag	8–12
4	Moderate wind	Raises dust and loose paper; small branches are moved ..	13–18
5	Fresh wind ..	Small trees in leaf begin to sway; crested wavelets on inland waters	19–24
6	Strong wind ..	Large branches in motion; whistling heard in telegraph wires	25–31
7	High wind ..	Whole trees in motion; inconvenience felt when walking against wind	32–38
8	Gale	Breaks twigs off trees; generally impedes progress	39–46
9	Strong gale ..	Slight structural damage occurs (chimney pots and slates removed)	47–54
10	Whole gale ..	Seldom experienced inland; trees uprooted	55–63
11	.. .. ..	Very rarely experienced; accompanied by widespread damage	64–75
12	Hurricane ..	.. ..	Above 75

BEAUFORT NOTATION.

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y dry air; humidity less than 60 per cent
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WEATHER SYMBOLS

Suffixes 0, 1 and 2 attached to Beaufort letters signify intensity, 0 = slight, 2 = heavy. Underlining is used to express continuity.

Meteorology & Technology

Technology/Meteorology Timeline - 1

Met Office

Pigment	<6000 BCE	
Clay & Stylus	2500 BCE	
Papyrus	1000 BCE	
Parchment & Ink	170 BCE	
Paper	c.105 CE	
Woodblock printing	200 CE	
Movable ceramic type	1040	
Engraving	1430	
Metal type Press	1453	
Etching	1515	
Mezzotint	1642	c.1600 Good global maps
Magic Lantern	1646	
3 Colour printing	1710	
Aquatint	1772	
Printed graph paper	1794	
Lithography	1796	c.1800 Scientific diagrams & graphs

Technology/Meteorology Timeline - 2

Met Office

Carbon paper	1801
Chromolithograph	1837
Daguerrotype	1839
Rotary press	1843
Electric/chemical Fax	1846

1816 Brandes charts for 1783.
1826 Brandes paper & chart at Leipzig
1828 Dove attempts weather maps

1840 Charts by Espy, Reid & Readfield
1843 Loomis publishes 1836 US storm

1847 GMT (railway time)

Technology/Meteorology Timeline - 3

Met Office

Electric/chemical Fax 1846

1849-07 Glaisher's manual Daily Weather Maps
1850-1900 National statistical offices Europe.
1850 Washington DC telegraphic weather maps
1851 First printed Daily Weather Map, London, Wheatstone's electric telegraph &. Lithography

1855 French telegraphic weather maps

1857 3rd International Statistical Congress: Exhibition, discussion of standard diagrams.

1860 UK Daily Weather Report to newspapers, 6 dys/wk, from 3 commercial telegraph stations.
1861-01 Electric Telegraph Co. Wind & Weather Map at its offices: 23 disks, with 2 hands indicating reported weather
1861-09 Publication of Weather Map of the British Isles by the Daily Weather Map Co Ltd.

Technology/Meteorology Timeline - 4

Hectograph (Gelatin)	1869	1869 Issue of the first lithographed Daily Weather Report by the Meteorologica1 Office. 1871 Publication by the Shipping and Mercantile Gazette of Daily Wind Charts of the British Isles. 1872-03 UKMO printed daily weather maps 1872-08 Leipzig Conference, 26 questions and agreement of standardised symbols etc
Offset printing	1875	1875 Times publishes 6pm Weather Map
OHP	1880	
Hot metal typesetting	1884	
Punched card	1884	
Cathode Ray Tube	1885	1885 "Principles of forecasting by means of weather charts", Ralph Abercromby
Mimeograph (Stencil)	1886	
Cinematography	1895	
		1901 International Statistical Congress recommends sparing use of hieroglyphs and symbols

Technology/Meteorology Timeline - 5

Photostat/Rectigraph	1907
Screen printing	1910
Trans-atlantic fax	1924
Spirit duplicator	1923
Television	1926
Bar printer	1934
Xerography	1938
Phototypesetting	1949
Inkjet printing	1951
Drum printer	1952
Videotape	1956
Dye-sublimation	1957
Pen plotters	1958
Drum plotter	1959
Line (chain) printer	1959
Film recorder	1959
Mouse & Sketchpad	1962
CCITT Fax machines	1966
Dot matrix printing	1968
Laser printing	1969

1922 Wireless weather manual, MO255, mentions plotting
1936 First TV Weather chart
1936 "Instructions for the preparation of weather maps with tables of the specification and symbols", Form 2459
1949 TV Weather maps with captions and voice-over
1954-01 First live TV forecast
1954 Maj Bedient USAF & Dahlqvist SHMI, develop zebra charts
1966 UK contract microfilm plotter, online or paper tape. Isopleth chart <3 min Flat bed plotter too

Where are we now?

History of inventing/tailoring technologies

☒ Operating Systems

☒ Programming Languages

☒ Telecoms Protocols

☒ Telecom computers (message switching)

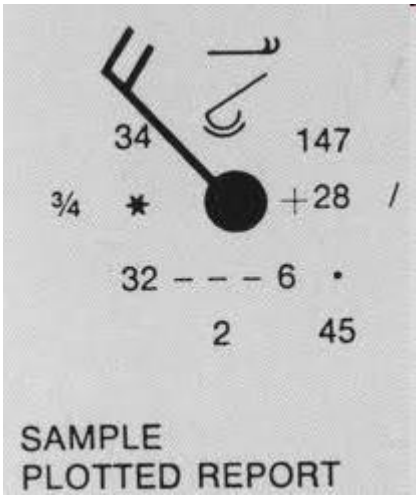
? Data Formats

☑ Semantics

☑ Visualisations

WMO Present Weather Symbols

Met Office



ww	0	1	2	3	4	5	6	7	8	9
00										
10										
20										
30										
40										
50										
60										
70										
80										
90										

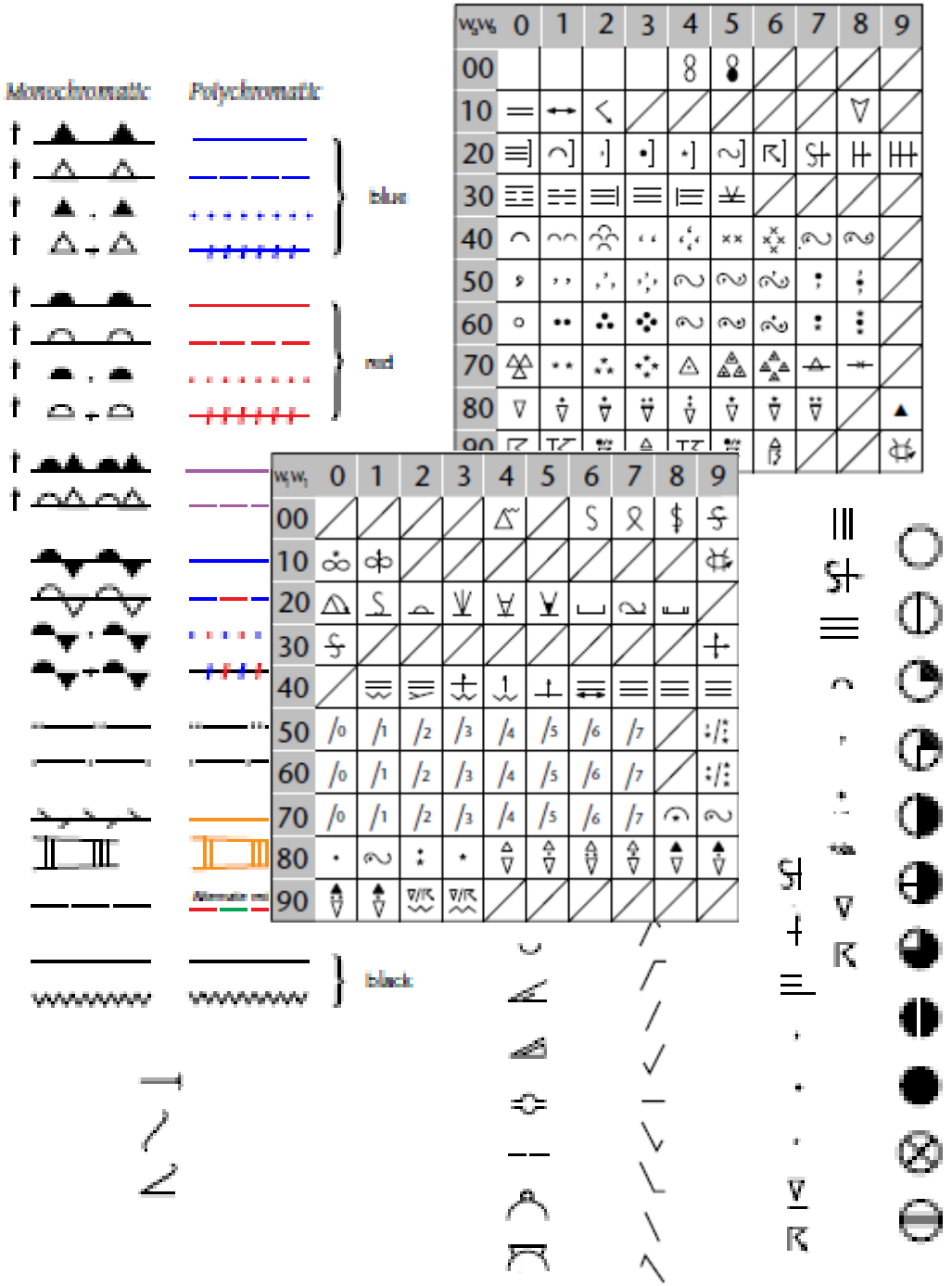
	1	2	3	4	5	6	7	8	9
C_L									
C_M									
C_H									

But also

- Present Weather from Automatic station
- Additional Weather
- State of Ground, frozen or not frozen,
- Etc

- Aviation SigWx symbols too

- Over 400 in total, plus >100 wind arrows



WMO Weather Symbols

Not changed in 50 years

Some symbols added, but probably hardly used

Nearly all computing devices can display them

Still no consensus on imagery, radar, colour scales, etc

Perhaps not appropriate

UBLIC

OGCMetOceanDWG / WorldWeatherSymbols

A complete set of WMO weather symbols in SVG with full metadata. — Read more

Clone in Windows | ZIP | HTTP | SSH | Git Read-Only | git@github.com:OGCMetOceanDWG/WorldWeatherSymbol | Read+Write access

branch: master | Files | Commits | Branches 1 | Tags

WorldWeatherSymbols /

37 commits

Merge pull request #11 from tomkralidis/master ...

iedwards authored 13 days ago — latest commit ca6805f31c

CH_CloudHigh	13 days ago	pretty print .svg files (#8) [tomkralidis]
CL_CloudLow	13 days ago	pretty print .svg files (#8) [tomkralidis]
CM_CloudMedium	13 days ago	pretty print .svg files (#8) [tomkralidis]
C_CloudGenus	13 days ago	pretty print .svg files (#8) [tomkralidis]
Ds_ShipDirection	13 days ago	pretty print .svg files (#8) [tomkralidis]
E_StateOfGround	13 days ago	pretty print .svg files (#8) [tomkralidis]
Eprime_StateOfGround	13 days ago	pretty print .svg files (#8) [tomkralidis]
Ft_Fronts	13 days ago	pretty print .svg files (#8) [tomkralidis]
ICAO_SigWx	13 days ago	pretty print .svg files (#8) [tomkralidis]
N_TotalCloudCover	13 days ago	pretty print .svg files (#8) [tomkralidis]

Future possibilities

Future possibilities?

- 5 years: No specialized meteorological visualization software, all done in generic geospatial software with meteorological style sheets?
- 10 years: No specialized geospatial software, all done in generic ‘browser’?
- Real 3D displays when?
- Virtual Reality/Augmented Reality/Head-Up Displays make 3D easier?

Consequential suggestions:

1. Codify and expose meteorological styles
2. Expose meteorological symbols and their semantics
   - Try t o put into Unicode
3. Move away from existing rigid symbols with artificial 10x10 structure imposed by telegraphic codes
4. ‘Abstract’ symbols powerful. C.f. SigWx chart

Met Office

Questions & Answers

A Bibliography

Imago Mundi: The International Journal for the History of Cartography

Mr. Selden's Map of China, Timothy Brook (New York: Bloomsbury, 2013)

Harrell, J.A.& V.M. Brown, "The world's oldest surviving geological map - 1150 BC Turin papyrus from Egypt", *Journal of Geology* 100 (1992), pp3-18.

http://www.cartographic-images.net/Cartographic_Images/Cartographic_Images.html

https://en.wikipedia.org/wiki/ , with caution!

Milestones in the history of thematic cartography, statistical graphics, and data visualization, Michael Friendly, (2009-08-24)
http://www.math.yorku.ca/SCS/Gallery/milestone/milestone.pdf

http://www.infovis.info/info.php

The

Air Apparent: How Meteorologists Learned to Map, Predict, and Dramatize Weather, Mark Monmonier, University of Chicago Press, 15 Nov 2000

Met Office

Chaldean Influence

600

Hanno, Circumnavigation of Africa

500

Scylax of Caryanda in India

Travels of Herodotus

The idea of **SPHERICAL EARTH** AND **THE ZONES**
Pythagoreans, c.450 — Aristotle (384–322)
Eudemus, tropics at 24° (384–322)

400

Pytheas : measures the latitude of Massilia, reaches British Isles, records Thule

Alexander the Great

300

Hypocrates – seven **climates** (Eudoxus ?)

HIPPARCHVS cc 150
- 360° system of lat + long. -es
- Delerm of longitude
- Conic projection
- Astrolabe

200

Péi Hsiu, 224–273 { map of Chinese Empire (lost) / principles of cartography

100

B. C. A. D.

Agrippa, Map of the Empire
Strabo, Geographia – main source-book completed 19 A.D.

Pomponius Mela, Cosmography

Pynax of Dionysius, Periegetes

MARINVS of Tyre, System of geography – plain chart cc. 120

PTOLEMY (c. 90–168)
- Geography with 8000 place names
- Atlas of 28 maps
- Geocentric system of planets
- Projections

200

Severus tablet of Rome

Solinus, Memorabilia

300

PEVTINGER TABLES

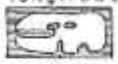
DEVELOPMENT of Lat.+Long. SYSTEM

IONIAN GEOGRAPHERS

Anaximander 611–546 credited with first map

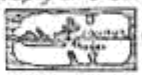
DISK-SHAPED EARTH

Hecataeus, Geography

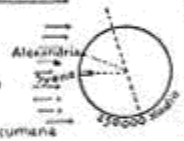


Democritus 450–360

Dicaearchus 326–296
- Measurement of mountains
- Geography of Greece



ERATOSTHENES 270–196 measurement of Earth



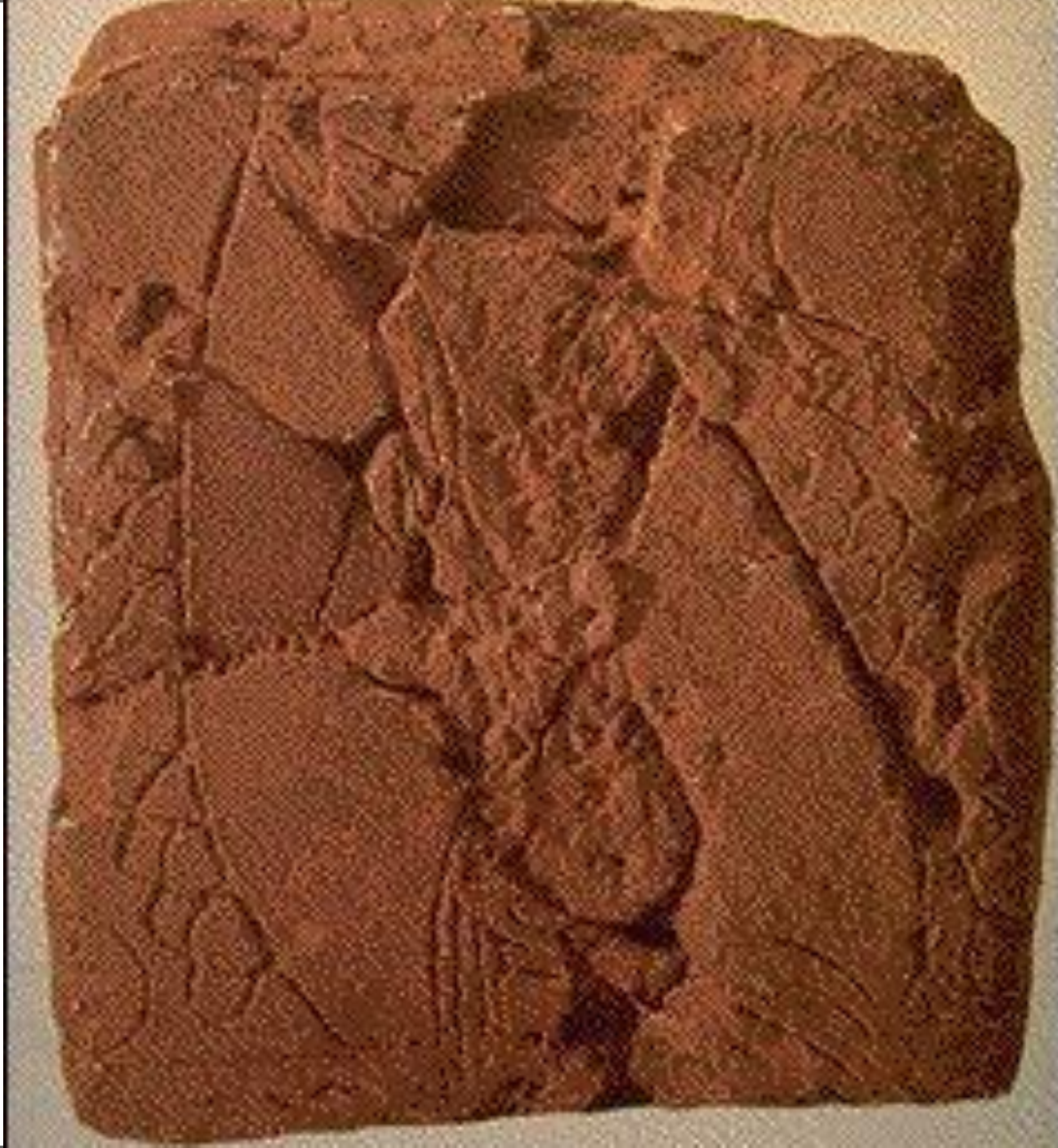
Crates, Globe

Posidonius, measurement of Earth 130–50

Met Office

Clay Tablet map from Ga-Sur

~2500 BCE



Met Office

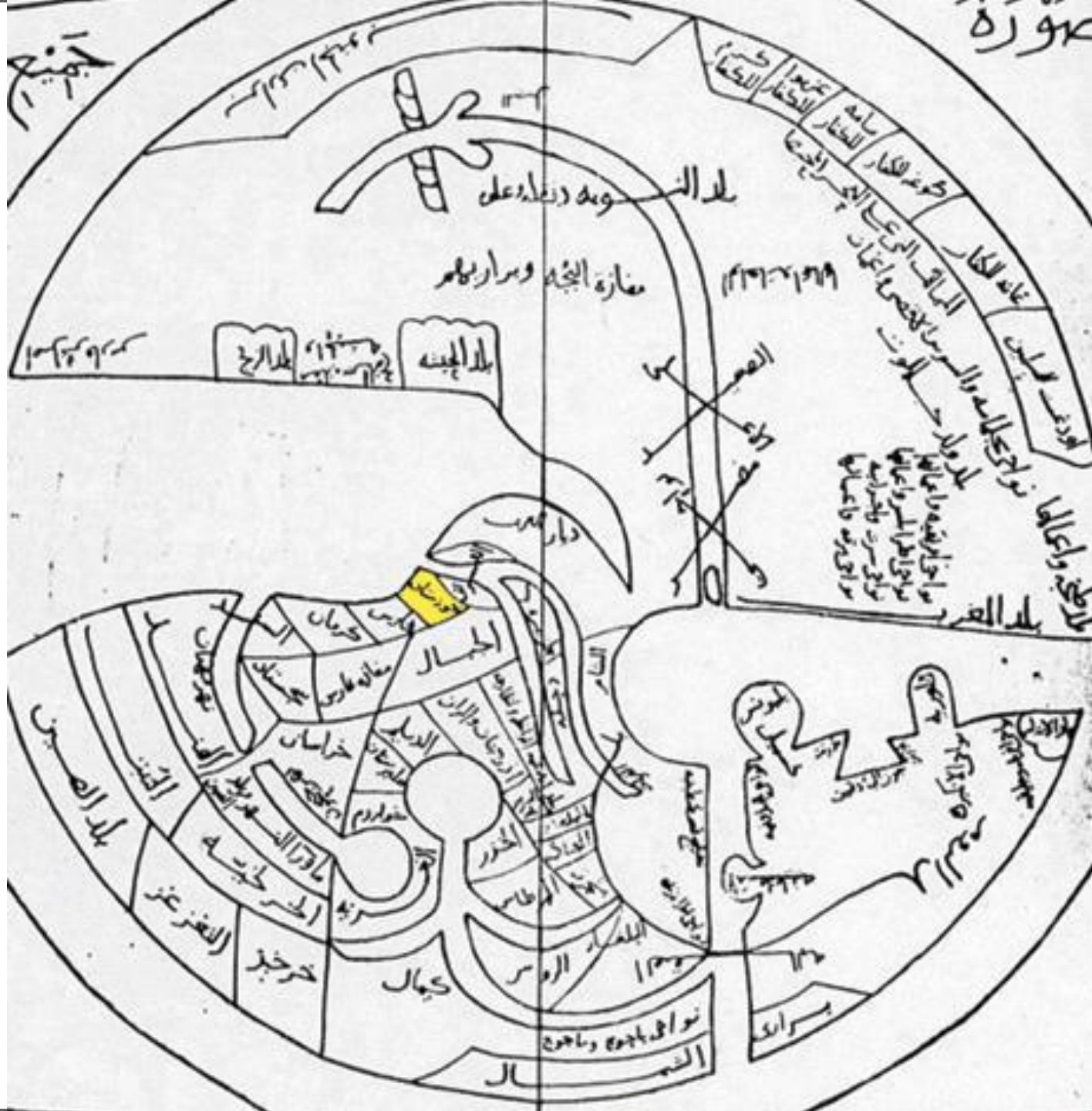
Muḥammad Abū'l-Qāsim Ibn Ḥawqal

(محمد أبو القاسم بن حوقل)

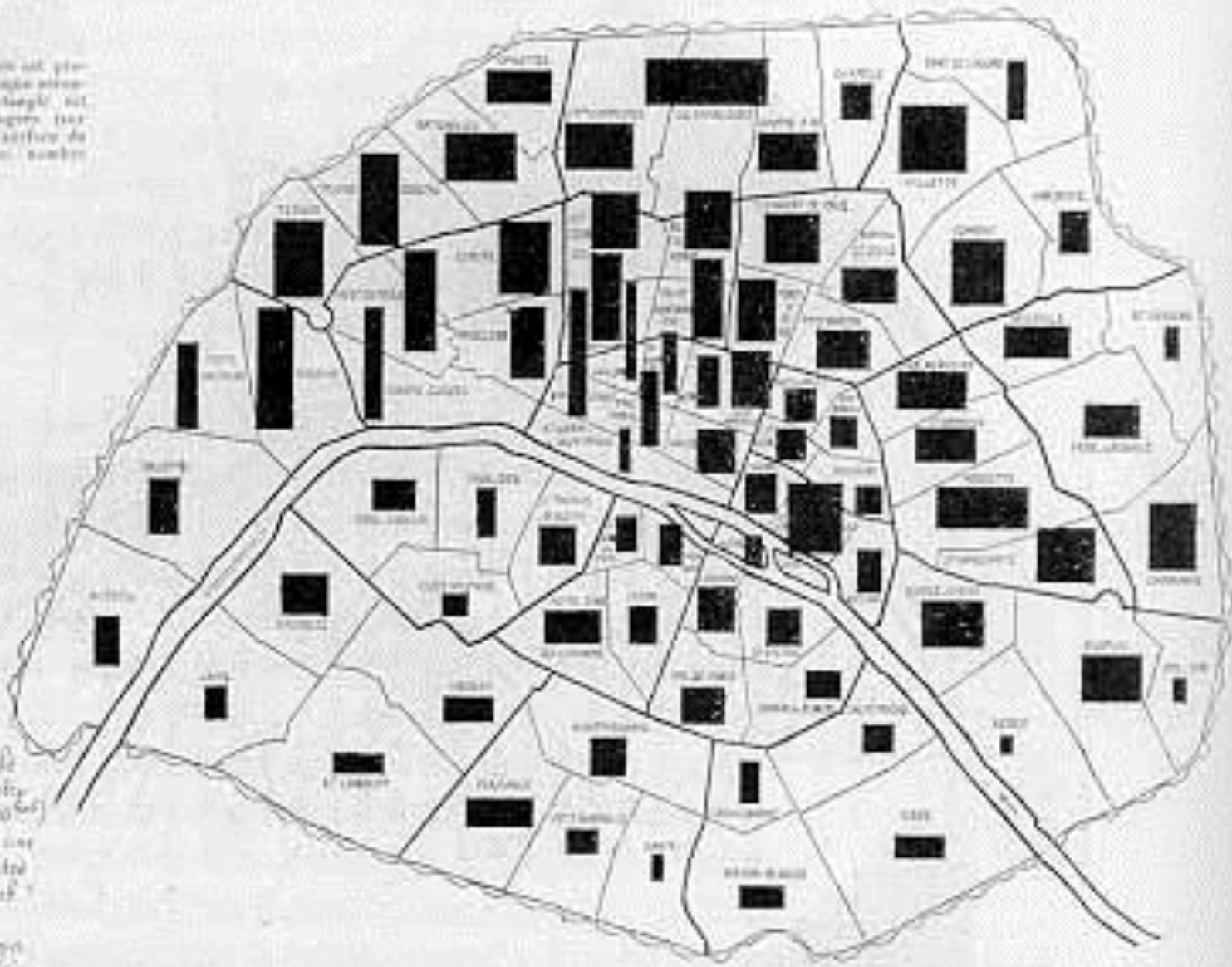
977CE

Ṣūrat al-'Arḍ

("صورة الارض " "
"The face of the Earth")



Les étrangers à Paris en 1891

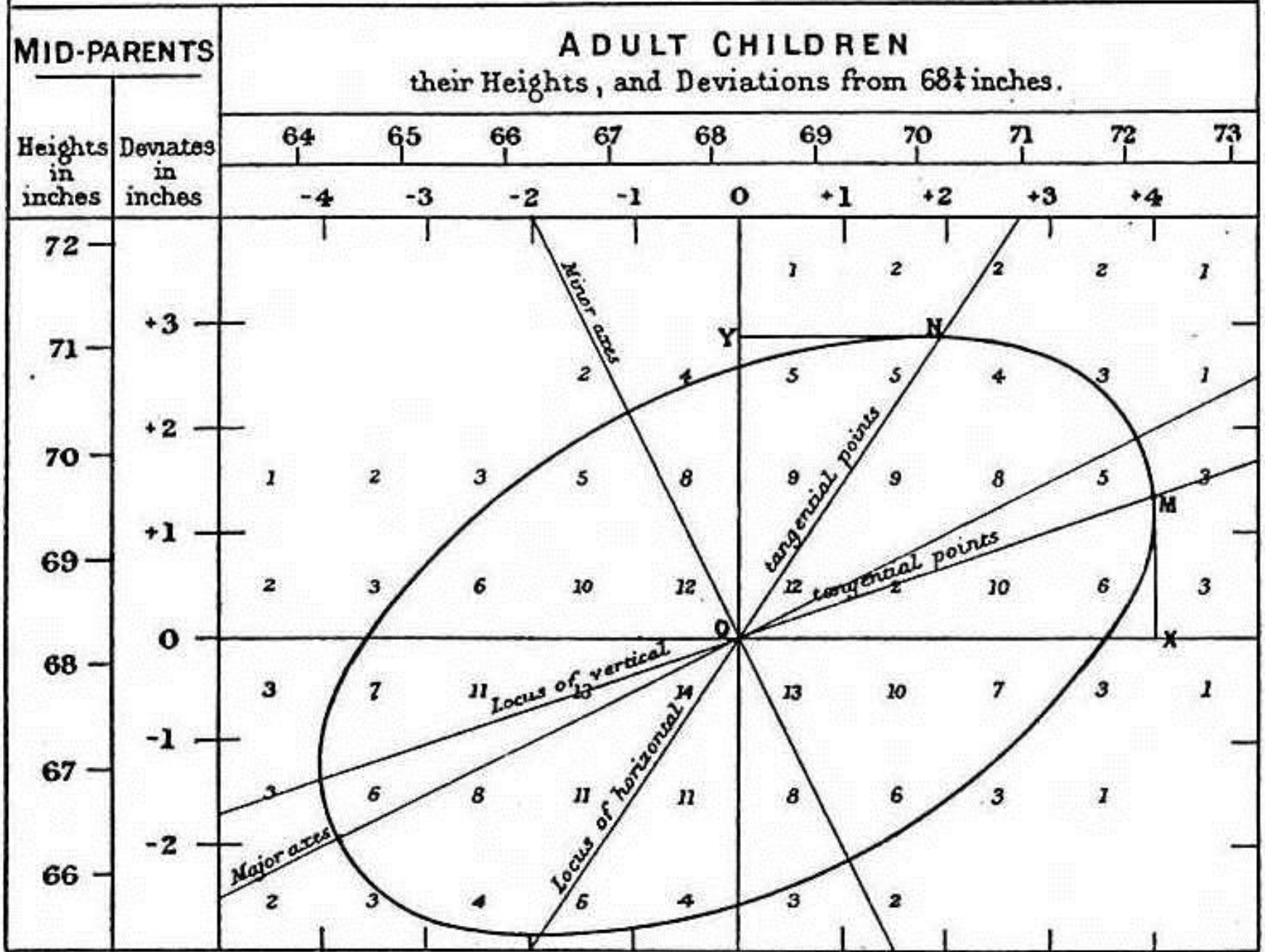


Nombre absolu et fréquence des Étrangers à Paris (1891)

Instruction. — La base de chaque rectangle est proportionnelle à la population absolue de chaque arrondissement. La hauteur de chaque rectangle est proportionnelle à la fréquence des étrangers (sur 1000 habit. combien d'étrangers). Donc la surface de chaque rectangle est proportionnelle au nombre absolu des étrangers $\left(\frac{n}{p} \times p = n\right)$.

DIAGRAM BASED ON TABLE I.

(all female heights are multiplied by 1·08)



Beaufort's Code evolution

Code	1806-1807	1807-1810	1810-1812	1820-1825	1826-1832
b.	Blue sky	Blue sky	Blue sky	Blue sky	Blue sky, clear or turbid atmosphere
c.	Clear i.e., definite, sharp horizon Clear, transparent atmosphere		Definite sharp horizon, distant objects clearly visible Individual passing clouds		Bright objects visible from afar
ci.				Cirrus clouds	
cl.	Cloudy	Cloudy	Cloudy	Cloudy	
cu.				Cumulus clouds	
d.	Dry, warm air			Mist (damp air)	Drizzle, fine rain
da.		Damp air	Damp air		
dk	Dark, close air	Dark, gloomy weather		Dark weather	Dark weather but atmosphere clear
dp.	Damp air				
dr.	Drizzle	Drizzle	Drizzle		
f.	Fine weather	Fine weather	Fine weather	Foggy	Fog
f:				Dense Fog	
fg.	Foggy	Fog	Fog		
g.	Dark, gloomy weather			Dark, gloomy weather	Gloomy weather Dark, gloomy weather
ge.		Gloomy weather			
gr.	Greasy sky	Greasy sky	Greasy sky		
h.	Haze	Hazy weather	Haze	Haze	Hail
hr.	Heavy rain	Heavy rain	Heavy rain		
hsh.	Heavy showers	Heavy showers	Heavy showers		
hsq.	Heavy squalls	Heavy squalls	Heavy squalls		
l.	Lightning	Lightning	Lightning		Lightning
m.		Mist		Mist in valley	Mist or hazy atmosphere
o.					Overcast. Entire sky covered by thick clouds.

Met Office

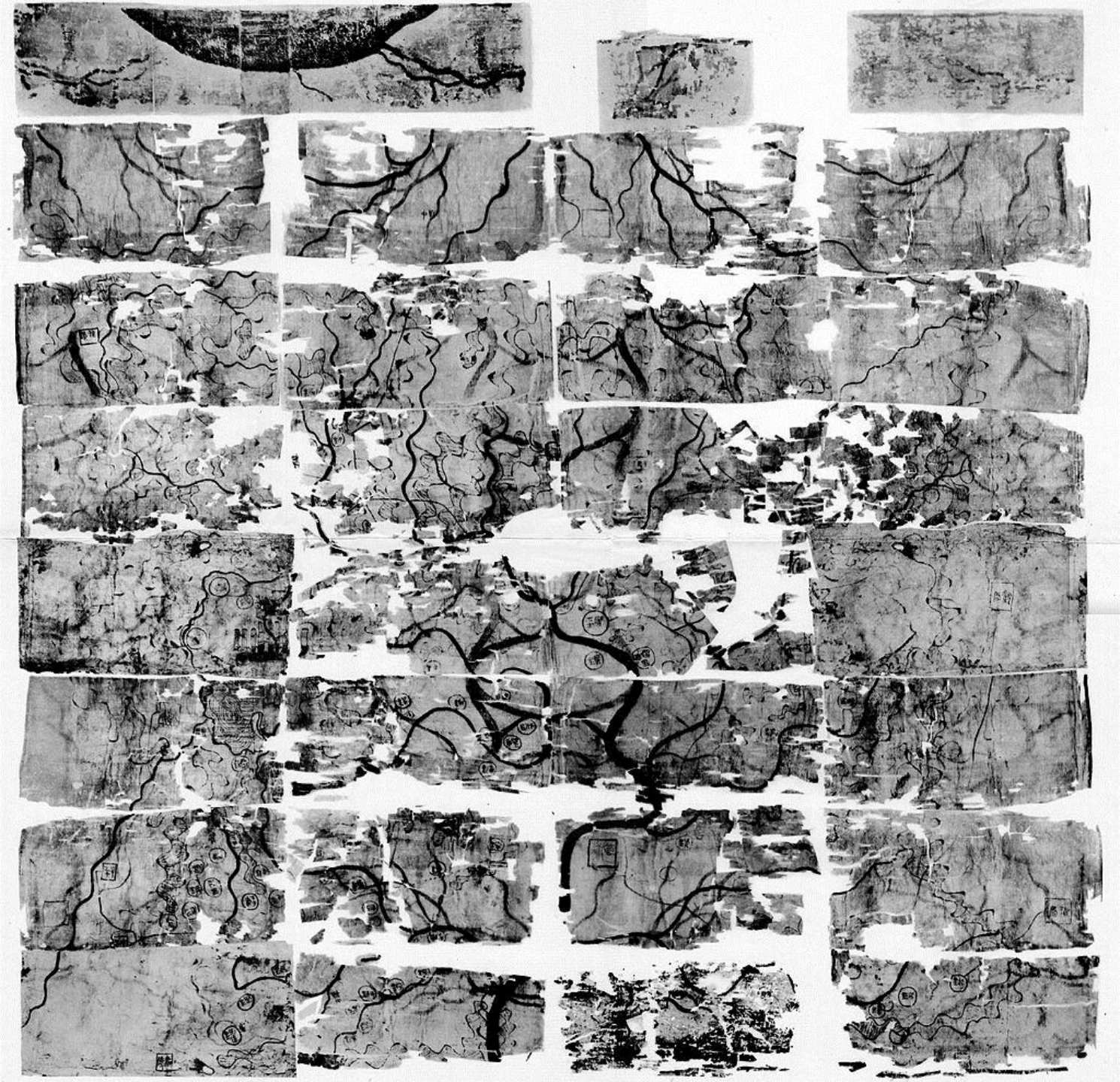
Chinese Silk map from Mawangdui tumulus

~168 BCE

3 maps: Topography of Changsha;

Military map of southern Changsha;

Prefecture map.



Met Office

Selden Map of China

東西洋航海圖

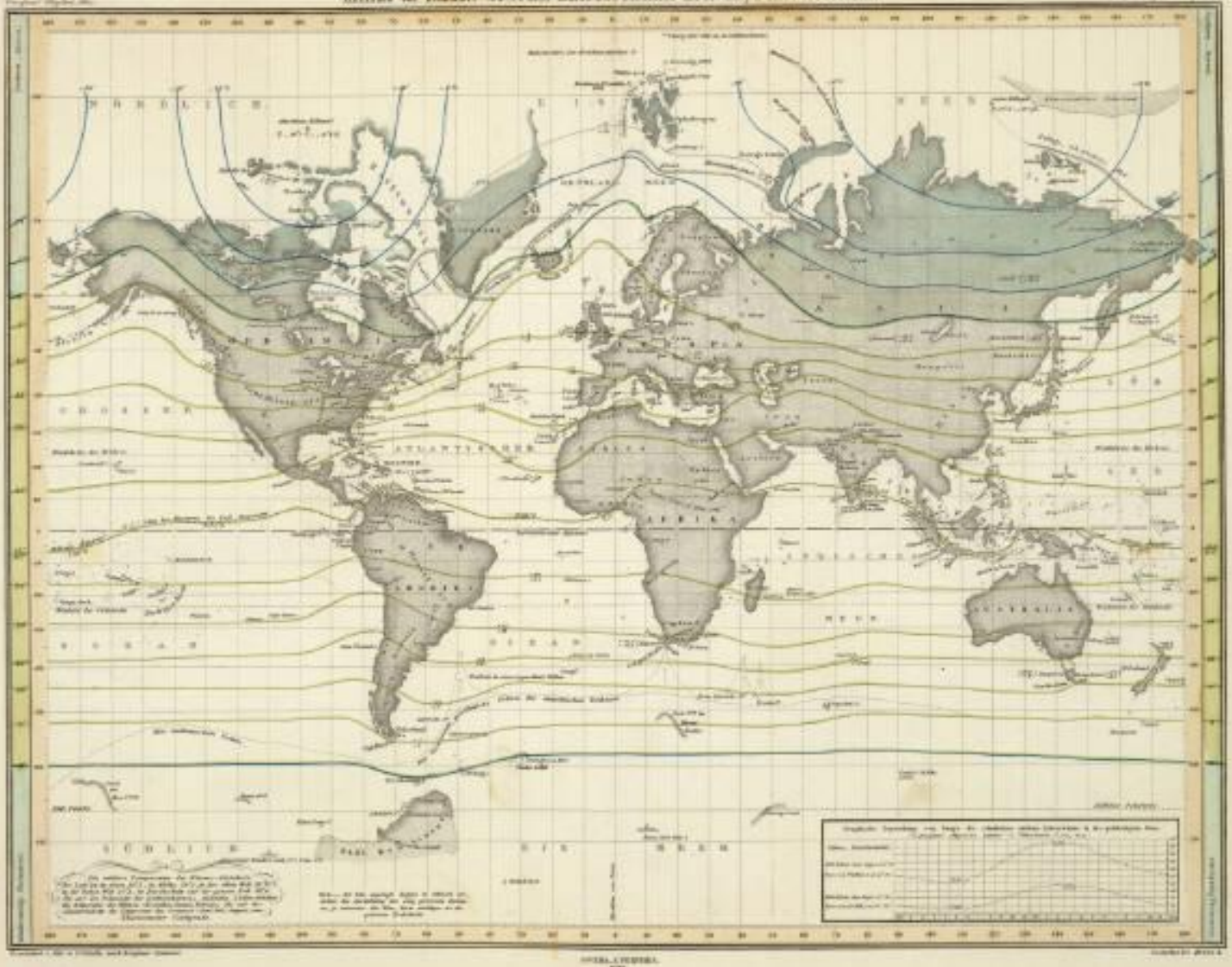
(Dōng xīyáng hánghǎi tú)

~1606-1624

Met Office

Da Ming Hun Yi Tu map

~1390CE


SYSTEM DER ISOTHERM-KURVEN,
NÖRDLICH
ATLANTISCHER
OCEAN
EUROPA
ASIEN
AFRIKA
AMERIKA
INDISCHER
OCEAN
AUSTRALIEN
SÜDLICH