

# **Weather Observations and a Tentative Meteorological Analysis of the Period May to July 1588**

**K.S. Douglas and H. H. Lamb**

**1979**



**Climatic Research Unit  
School of Environmental Sciences  
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Compiled by K.S.Douglas  
and analysed by H.H.Lamb



**Supplement to Climatic Research Unit Research Publication No. 6**

**WEATHER OBSERVATIONS AND  
A TENTATIVE METEOROLOGICAL ANALYSIS  
OF THE PERIOD MAY TO JULY 1588**

**By K.S. Douglas  
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## WEATHER OBSERVATIONS AND A TENTATIVE METEOROLOGICAL ANALYSIS OF THE PERIOD MAY TO JULY 1588

This Supplement to Climatic Research Unit Research Publication No. 6 (CRU RP 6), entitled **A Meteorological Study of July to October 1588: The Spanish Armada Storms**, is published in order to make available the material relating to the earlier part of the same summer between 11th May and 22nd July 1588.

Tabulations in this publication give:

- (i) Weather reported by the Spanish ships.
- (ii) Weather reports from English sources.
- (iii) Weather reported by the Danish astronomer, TYCHO BRAHE, on the island of Hven ( $55^{\circ}55'N$   $12^{\circ}45'E$ ) in the Sound (Øresund).
- (iv) Notes on the meteorological analysis here presented in the synoptic weather maps for the period.
- (v) The apparent sequence of wind circulation patterns:  
British Isles daily weather type classification for May to October 1588.

It was not possible to apply the tests which indicated the degree of reliability that may reasonably be claimed for the analysed weather maps for late July to October 1588 published in CRU RP 6. This was because, with the observation points more widely spread out in May to mid July, from the ships near the Portuguese and Spanish coasts to the island between Denmark and Sweden, all the observations available had to be used to establish a reasonable analysis over the area, and none could well be held back to be used later to test a preliminary analysis.

The maps presented in this Supplement therefore are untested, but they were produced by the same analyst (H.H. LAMB) as those for July to October 1588 which had been drawn earlier and tested. Any estimate of their trustworthiness stands on this procedure and on their internal consistency and satisfactoriness in explaining the observations.

It has been decided that there is sufficient interest in the material collected together in this Supplement that it should be published rather than remain unknown and inaccessible to others to use in whatever ways may be appropriate. Some such subsequent uses may perhaps bring forth further observations that will provide some test of the map analysis that is so far lacking.

The apparent sequence of British Isles daily weather types or circulation patterns over the British Isles region over the period from 12 May to 10 October 1588 is given in Table 5.

For convenience, the definitions of the types recorded in this Table are printed on pp. 3–4. Hybrid types are recorded on many days when the definitions of more than one type are simultaneously fulfilled. Unclassifiable days, shown by a hyphen, mean that incompatible types such as Anticyclonic and Cyclonic occurred over different parts of the British Isles or at different stages during a day during which quick changes were going on. For a fuller account see LAMB (1972). A complete daily classification from 1861 onwards is printed therein and has been continued from 1972 to date. The years 1781 to 1786 have also been similarly classified.

The frequencies of the various types of pattern over the British Isles region during this period and the corresponding probable frequencies for the complete year 1588 are as follows:

	W	NW	N	E	S	AC	C	U
Percentage 12 May to 10 October 1588	12	5	11	6	16	25	19	6
Corresponding whole year percentage: adjusted for seasonal variations, supposedly occurring as in 1861 to 1973	13	5	10	7	21	23	17	6



## APPENDIX

### DEFINITIONS OF THE BRITISH ISLES WEATHER TYPES

The following types are recognized in the classification here presented:

#### A. Anticyclonic type

Anticyclones centred over, near, or extending over the British Isles; therewith also cols situated over the country, between two anticyclones.

The weather associated with this type is: *Mainly dry with light winds (though thunder often occurring in cols in summer); usually warm in summer and cold or very cold in winter. Mist and fog are frequent in autumn.*

#### C. Cyclonic type

Depressions stagnating over, or frequently passing across, the British Isles. The further criterion is used that a depression should be centred, or its central isobar on a 4— to 5—mb spacing should extend, over the mainland of Britain or Ireland at some time during the day. Small cyclonic features may be overlooked if they constitute merely details within a col when most parts of the British Isles are under anticyclonic influence. Further, to reduce the fortuitous element in the positions on any one day of the cyclone centres of a single cyclone sequence, individual days between the passing of separate centres over Britain are also counted as cyclonic if the isobars retain cyclonic curvature or if the main (surface) low-pressure axis remains over the country.

The weather associated with this type is: *Mainly wet or disturbed weather, with very variable wind directions and strengths; usually mild in autumn and early winter, cool or cold in spring, summer and (sometimes) in late winter. Both gales and thunderstorms occur.*

#### W. Westerly type

High pressure to the south (also sometimes south-west and south-east) and low pressure to the north of the British Isles. Sequences of depressions and ridges travelling eastwards across the Atlantic. (This general type has been described by some authors as South-Westerly because the surface winds blow from about SW for more of the time than from other directions. The steering of pressure systems is generally from about W or WSW. This can be taken as the most mobile, or 'progressive', of all the types.)

The weather associated with this type is: *Generally unsettled or changeable weather, usually with most rain in northern and western districts of the British Isles. Winds shifting rapidly between S and NW, occasionally SE or even E for a short time. Cool in summer, mild in winter with frequent gales.*

#### NW. North-Westerly type

Azores anticyclone displaced north-east towards the British Isles or north over the Atlantic west of our coasts, or with extensions in these directions. Depressions (often forming near Iceland) travel south-east or east-south-east into the North Sea and reach their greatest intensity over Scandinavia or the Baltic.

The weather associated with this type is: *Unsettled or changeable weather, particularly in northern and eastern districts of the British Isles, sometimes with fresh or gale-force winds from between W and N. The warm sectors may contain unstable air, especially in late winter and spring. This type is cooler than the W type and milder than the N type.*

#### N. Northerly type

High pressure to the west and north-west of the British Isles, particularly over Greenland, and sometimes extending as a continuous belt south over the Atlantic Ocean towards the Azores. Low pressure usual over the Baltic, Scandinavia and the North Sea. Depressions move southwards or south-eastwards from the Norwegian Sea (sometimes having formed in the Iceland – Jan Mayen region, sometimes having come through from farther north, sometimes having entered the Iceland – Jan Mayen region by way of a col near southern Greenland).

The weather associated with this type is: *Cold, disturbed weather at all seasons, especially in eastern and northern districts. Snow and sleet are common in winter; also associated with late-spring and early-autumn snow on high ground in the north, and with late-spring frosts in all districts. The onset of N-type weather is often accompanied by high winds.*

#### E. Easterly type

Anticyclones over, or extending over, Scandinavia and towards Iceland. Depressions circulating over the western North Atlantic and in the Azores-Spain-Biscay region.

The weather associated with this type is: *Cold in autumn, winter and spring; sometimes intensely cold in southern districts and suitably exposed localities elsewhere, with occasional snow in the south and snow or sleet showers in eastern and north-eastern districts; fine in the west and north-west. Warm in summer, sometimes thundery. Very dry weather in western districts, relatively dry in many other districts except in the east and south.*

#### S. Southerly type

High pressure covering central and northern Europe. Atlantic depressions blocked west of the British Isles or travelling north or north-eastwards off our western coasts. (Seems less persistent than the other types, occurring mainly as occasional variations within spells that are predominantly either of W or E type; very rare in summer.)

The weather associated with this type is: *Warm and thundery in spring and summer, mild in autumn. In winter it is mild or cold according as the airmass carried over the British Isles is oceanic or continental in origin.*

TABLE 1 WEATHER REPORTED BY THE SPANISH SHIPS

Notes on the Weather May-July 1588

DATE (New Style Calendar)	POSITION	REPORT	INTERPRETATION
11th May Wednesday	At Lisbon	<i>Duke to the King, 14th May</i> The Armada took advantage of a light easterly wind which blew for a few hours on the 11th inst., to drop down the river to Belem and Santa Catalina, where the ships now only await a fair wind to sail. God send it soon!	
21st May Saturday	At Lisbon	<i>Duke to the King</i> ... deploring the bad weather that still detains the Armada at Lisbon.	
28th May Saturday	At Lisbon	<i>Duke to the King</i> The weather is not good and a NNW wind is blowing but I have sent some ships down the river and some more went down today with a great deal of trouble. They are at anchor at the bar. If a land wind blows tomorrow morning I will go down with the rest of the fleet.	
29th May Sunday	At Lisbon	<i>Duke of Medina Sidonia to the Duke of Parma</i> "God sent us a fair wind to sail on 29th although the breeze was very light. With the aid of the galleys I was able to leave port that night without any damage."	Between 29th May and 9th June, a period of 12 days, the weather off Portugal seems to have been continuously fair with winds light N, NW or NE.
1st June Wednesday	At Cape Roca (just north of Lisbon).	<i>Duke to the King</i> "On the 30th I sent a letter to your Majesty giving an account of the ships getting under way that day and the following morning with the wind in the NW we sailed with it out to sea all day and all night and yesterday (Tuesday 31st) until midday. Since then it has been so light and contrary we stood 18 leagues out to sea with our sails struck as we were finding ourselves drifting to leeward of Cape Espichel."	

DATE	POSITION	REPORT	INTERPRETATION
10th June Friday	Off Portugal 40°N	<p>"At 1 o'clock on 31st a sea breeze came up at WNW and we tacked away from the land sailing all day and night with the same wind."</p> <p>"Today we sighted land SW off Cape Roca. The weather is calm and with such light winds that the ships are unable to make steerage way. I am waiting for the tide and with that I will head for the Berlengas which if they can be doubled tomorrow I would find myself in a much better position."</p> <p><i>Duke to the Duke of Palma</i></p> <p>"...since the 31st May the weather has been so contrary that we could only put the Armada out to sea and endeavour to keep up to windward sufficiently to avoid drifting round Cape St Vincent. We have done our best by tacking and keeping out to sea until the weather improved which it began to do yesterday (Thursday 9th). It now looks as if it would serve us well..."</p> <p><i>Duke to the King (also on the 10th)</i></p> <p>"...since the 1st of this month I have told you that I have sailed on although with little help from the weather, making headway with great difficulty, putting out to sea and trying to hold on to deep water. We kept falling away a lot and have even been very close to Cape St Vincent. There was little we could do except keep tacking and wait for better weather. Since yesterday it has begun to blow from WSW and with that I hope in God to begin to sail this Armada in the right direction. Today we are 90 leagues from land according to the pilots and at 40°N [i.e. only the equivalent of about 90 miles north of Lisbon and some 270 miles out into the Atlantic, after being at sea for 12 days]."</p> <p><i>Duke to the King</i></p> <p>"...all well".</p>	<p>On 9th June at 40°N they began to get a wind from SW and from then till 13th there seems to have been enough wind for progress to be made, though the direction of the wind is not always given.</p>
13th June Monday	Off Cape Finisterre		

DATE	POSITION	REPORT	INTERPRETATION
18th June Saturday	Off Cape Priorio	<p><i>Duke to the King</i></p> <p>"... I wrote to your Majesty on the 14th to the effect that we had doubled Cape Finisterre in good weather. I am staying close to land along Galicia till we get to the harbour of Mugia where we will rejoin the galleys. I had ordered them to wait there and collect fresh supplies of meat, fish, vegetables and salt pork in accordance with orders I sent to the Marquis de Cerrvalo by patache on the 10th ... [about the 14th] the wind came round to the North which is an off-shore wind here and unfavourable for us. I held off out at sea where I have delayed progress another three days. The pilots' opinion is that we should enter Corunna or Ferrol. The galleys from Mugia sailed out to join us yesterday 17th and the <i>wind being still very light Northerly</i> I decided to send them on to Corunna to help to collect fresh supplies. They took some boats in tow behind them. I took the Armada closer in to wait for them six leagues out at sea."</p> <p>"Up to now they have not arrived back and the weather is picking up from the SW so I shall wait for them all day in this position. As the weather is now in my favour I shall not delay any longer no matter how desperate we are for fresh food."</p> <p>"Up to now the Armada has been well and healthy, we have not lost a warship nor had any unrigged." (They had however lost the David Chico with a broken main mast but she was a merchant ship.)</p>	<p>By 14th the wind had fallen light Northerly again.</p> <p>The Azores High seems to have re-established itself somewhat farther north than in the preceding days.</p>
21st June Tuesday	In Corunna	<p><i>Duke to the King</i></p> <p>19th Sunday "... forced to enter Corunna because of lack of water and food" (40 ships accompanied the Duke, the rest would have come in but it was too late that evening).</p>	<p>During the night of 19/20th June the weather became thick and heavy with strong wind (unfortunately direction not given but seems to have been generally westerly or southwesterly).</p> <p>This looks like Atlantic low pressure systems influencing the area this time with their centres much closer to the ships in 40 to 45°N.</p>

DATE	POSITION	REPORT	INTERPRETATION
<p>24th June Friday</p>	<p>At Corunna</p>	<p>"During that night and the next day the weather became so heavy that it is believed that the ships have run out to sea. The local people say that so violent a sea and wind accompanied by such sea-mist and rain has never been seen. It is fortunate that the whole Armada was not caught outside, particularly the galleys as they surely would have been lost. The whole Armada would have been scattered with the mists and squalls and could not have followed me and it would have been many days before we could have been united again."</p> <p>"...with this weather which this afternoon has begun to moderate I expect the ships will now make for this port ..."</p> <p>"It pains me greatly that on 20th June (virtually mid-summer) we should have suffered such rough weather as to cause the Armada to be split up ... it will be some days before we can leave this port as some of the ships have been unrigged and, as has appeared on their arrival, all need water."</p> <p><i>Duke to the King</i></p> <p>"...on Wednesday (22nd) in the afternoon the Capitana galleass and the Girona came into this port and somewhat later the same day the Grangrin with the galleons San Marcos and San Felipe and another 10 ships. Don Alonso de Leyva put into Vivero with a further 10 ships, which leaves 27 or 28 ships and two galleasses still missing."</p> <p>"...The pilots say that they had never seen such storms at this time of year as that of Sunday and Monday, and that of yesterday morning (Thursday 23rd)."</p> <p>"We can take it that news has reached England that the Armada has been dispersed by the weather..."</p>	<p>From 21st till 24th "weather almost unabated". Showers at the back of the first depression seem to have been followed by another similar low pressure system on 23rd—24th.</p> <p>The centres seem to have been very far south for the time of year and suggest the blocking influence of Arctic high pressure farther north and outbreaks of Arctic air to latitudes near 40°N in mid Atlantic. (cf. map of the situation over western Europe on 25—26th May 1588).</p>

DATE	POSITION	REPORT	INTERPRETATION
27th June Monday	At Corunna and in the Bay of Biscay	<p>"The weather today is so overcast and close with so many showers and thunderstorms that we are badly held up."</p> <p>"Since the 21st June the weather has continued almost unabated, as bad as anything in December, such that neither the men of the Armada nor of this coast have seen the like. I have taken all the care possible and have sent pataches along the coast and out to sea to try to get news of the missing ships, but so far I have heard nothing."</p> <p><i>The Report of Ensign Esquivel (a voyage in a Patache to the Scillys to look for the missing ships and return to Corunna).</i></p> <p>"We sailed from Corunna on 27th June with the wind in the West. With it we sailed Northwards until the middle of the night when the wind changed to WNW where it stayed until 29th (Wednesday)."</p> <p><i>A Report from the vice-flagship of the hulks (the San Salvador), the leader of the ships which sailed on to rendezvous at the Scillys instead of putting into Corunna.</i></p> <p>"... while we pursued our voyage to Scilly the wind went round to WSW. By the time we were off the Lizard in thick weather the wind changed to NW. We then made a long tack WSW out to sea to approach the Scillys from the West and continued on long tacks all Thursday (30th June) and Friday (1st July) in order to stay off the Scillys. Late on Friday a very furious wind sprang up from NNE. The sea was terribly rough and running high from NE."</p>	<p>On 30th June thick weather from WSW off the Scillys changing after a time to NW suggests the passing of a cyclone centre. "Winds from every quarter of the compass" seem to indicate that the centre passed over them.</p>



DATE	POSITION	REPORT	INTERPRETATION
2nd July Saturday	Off the Scillys	<p><i>Ensign Esquivel</i>            "During the night we had a violent gale with winds from every quarter of the compass. At daybreak the wind settled in the North . . . so strong and seas so heavy that the patache shipped a quantity of water with every wave. We ran thus in a southerly direction with the wind astern blowing a gale."</p> <p><i>The Almirante of Hulks</i>            "The sea was terribly rough and running high from the NE. . . on Saturday night we ran towards Corunna with the wind astern as we could do no more."</p> <p><i>Ensign Esquivel</i>            "We ran south under a foresail only."</p> <p><i>The Almirante of Hulks</i>            "The gale continued to blow furiously until Sunday when it began to back to the North and we tried to make for Cape Ortegal by Monday or Tuesday."</p> <p><i>Voyage of the Galleon San Juan Bautista with 2 Zabras looking for the English Fleet — Pablo de Aramburu.</i>            "We set sail with both Zabras on 7th July in the morning with the wind SE up to the point of Sardinero when the wind came round Westerly. We sailed north until next morning a distance of 22 leagues."</p> <p>"We sailed with the wind NE our course NW<math>\frac{1}{4}</math>N — 30 leagues."</p> <p>"The wind was SSW and WSW, our course NW<math>\frac{1}{4}</math>N — 32 leagues."</p>	During the following three days the wind seems to have stayed at near gale force NE then backing to N.
3rd July Sunday	In Biscay		
7th July Thursday	From Corunna		
8th July Friday	In Biscay		
9th July Saturday	In Biscay		

DATE	POSITION	REPORT	INTERPRETATION
10th July Sunday	Off Biscay	"Sailed on main foresail only, wind WNW course N — distance 12 leagues."	
11th July Monday	Off Brittany	"We sailed a short distance out to sea on the same course (N) with the wind SW in towards land we made use of the oars."	
12th July Tuesday	In the mouth of the Channel	"At nightfall we sighted Cape Longnose (Land's End). The wind blew up low cloud and we were unable to do anything."	12th—14th July. Low pressure system from SW with centre crossing close to the ships off Lands End.
13th July Wednesday	Bristol Channel	"We went into the Bristol Channel on different tacks with a very strong wind from the SE."	
14th July Thursday	In the Bristol Channel	"We prayed to our Lady and the wind began to abate. We sailed back to Cape Longnose with a favourable wind for Spain" (i.e. a wind from about N).	
15th July Friday	Off the Seven Stones Reef	"At nightfall we were off the Seven Sisters with a westerly wind. We were in great difficulty."	By 15th the wind is westerly again off the Scillys but at Corunna it was from the North, a brief taste of the usual northerly associated with the Azores High.
15th July Friday	At Corunna	<i>The Duke's letter to the King</i> "At present a North wind is blowing which is contrary for us. We are ready to sail and await only the weather."	
16th July Saturday	Off Lands End	<i>Aramburu</i> "We sailed in a gale."	
17th July Sunday	Off Lands End	"It moderated somewhat and we sailed on till nightfall by which time we were four leagues off St Michael's Mount. We would have landed but the wind came round SSE and we were forced to steer WSW and take in sail. It was so overcast and stormy that we lost sight of both zabras."	17th—18th with winds starting at SSE overcast and stormy veering to westerly with a clearance indicating passage of another low pressure system following that of 12th—14th probably centred not far to the north.

DATE	POSITION	REPORT	INTERPRETATION
18th July Monday	Off the Scilllys	<p>"We passed close to the north of the Scilllys. At midday the wind came round to the West and it cleared up. We could not see our company and we turned to sail southwards but could not double the Scilllys so we had to go north "</p>	
19th July Tuesday	Off the Scilllys	<p>"The wind came round SE and we were able to get away."</p>	
20th July Wednesday	In Biscay	<p>"We set sail for Spain not being able to make repairs with the heavy weather."</p>	
	At Corunna	<p><i>Council of all the leading Captains</i>          "Since yesterday it has been raining with the wind light in the SW. At 10 o'clock on the morning of the 20th the rain had stopped and the wind came round to the West and then WNW strong.</p>	<p>19th-20th — Another low pressure system approaches from the Atlantic, this time centred further to the South giving rain at Corunna and bringing winds round to SW.</p>

TABLE 2 WEATHER REPORTS FROM ENGLISH SOURCES

DATE (New Style Calendar)	LOCATION	SOURCE	REPORT	COMMENT
1st June	Dover	Lord Henry Seymour to Burghley	The Lord Admiral and I parted our companies on the Narrow Seas the 31st May taking his course to Plymouth having a very good wind for the purpose.	Wind fresh easterly.
2nd June	Plymouth	The Lord Admiral to Burghley	... I thought good to let your Lordship understand how that upon Tuesday last 31st May the wind serving exceedingly well I parted with my Lord Henry Seymour appointing him to stay on the Narrow Seas. . . so passing the same morning athwart of Dover and with a pleasant gale all the way along came and arrived this day 2nd June about 8 o'clock in the morning at this port of Plymouth.	Confirms Henry Seymour's easterly wind on 31st May and that it continued at least until 2nd June.
7th June	Plymouth	The Lord Admiral to Burghley	... we have done watering and are only watching here for a wind [to depart towards Spain]. God send us a wind to put us out . . .	The Lord Admiral's first complaint of an unfavourable wind for leaving Plymouth - generally fresh southwesterly.
16th June	Plymouth	Drake to Burghley	... when we went into the Channel we were met with southerly and southwesterly gales. For seven days we battled with the storm till with unabated violence it veered to westward and on 16th we entered Plymouth.	9th-16th June continuously strong W and SW winds.
23rd June	Plymouth	The Lord Admiral to Walsyngham	... we can do no good as this wind is; for it holdeth here at west and south-west and bloweth up so as that no ship here but her Majesty's great ships dare ride out in the Sound. . . we are not able to get the weather of this harbour. . . we should be driven to the leewards either to Portland or to the Isle of Wight. I know not what weather you have there with you, but here is such weather as never was seen at this time of year.	Wind firmly and continuously in West and South-West. Suggests high pressure to the south and east but no indication of movement of low pressure systems to the north and west.

DATE (New Style Calendar)	LOCATION	SOURCE	REPORT	COMMENT
24th June	Plymouth	The Lord Admiral to Walsyngham	<p>(In the same letter Howard presumes the Armada to have left Lisbon and circled west then north to take advantage of the westerly winds with which they could make for Ireland or Scotland as well as England.)</p> <p>Sir we have endured here these days Wednesday (22nd), Thursday (23rd) and Friday (24th) an extreme and continual storm. . . we have ridden it out in the Sound because we had no room in the Catwater for the lesser ships that were there . . . we do continually tarry and lie aboard in all the storm where we may compare that we have danced as lustily as the gallantest dancers in the Court.</p> <p>. . . the South-West wind that shall bring them [the Spaniards] to Scotland or Ireland, shall put us to leeward. . . yet shall we not be able to go to them as long as the wind be westerly.</p>	Obviously associated with the storms affecting the Spanish ships on the Asturian coast this week but frustratingly lacking in details of wind direction and timing of rainfall.
25th June	Plymouth	The Lord Admiral to Walsyngham		Wind still westerly.
30th June	The Downs near Dover	William Wynter to Walsyngham	<p>(Writing about the Armada's prospects of leaving Lisbon, the Groyne etc) . . . It is a bad season of the year for any ships that are in Lisbon and to the southwards of it upon the coast of Spain, to come to the northwards by reason of the North and North-Westerly wind that bloweth commonly from the middle of May until the latter end of August upon that coast.</p>	General expectation of the Azores anticyclone, not in fact fulfilled in 1588.
1st July	Plymouth	The Lord Admiral to the Council	. . . Our victuals are not yet come but we hope shortly to hear of them if this wind continue 40 hours.	In other words they have had some relief from the westerly wind which should allow the supply ships to make their way down the Channel to them from Dover.

DATE (New Style Calendar)	LOCATION	SOURCE	REPORT	COMMENT
2nd July	Straits of Dover	Lord Henry Seymour to Walsyngham	<p>...I put out on Wednesday to the sea in hopes to have met with our victuallers, but on Friday we were put in again with a southerly wind.</p> <p>...suddenly the wind arose at North and by East enforcing us to weigh for Blackness where we anchored with marvellous foul weather some thirty hours. These actions befell yesterday 1st July so as now the wind it come three points more being North-North-East.</p>	<p>...This was the approach of the deep depression which chased the Spanish ships back from the Scillys.</p> <p>Confirms the northerly gales experienced by the Spanish ships at the Scillys and in Biscay.</p>
5th July	Before Dunkirk	Lord Henry Seymour to Walsyngham	...as yet the wind being so contrary hath retained all the shipping in Dunkirk.	i.e. West and North-West.
14th July	Plymouth	Thomas Fenner	...They [the Spanish ships sighted off the Lizard 1st July] cannot be but returned [to Spain], in that they had sundry times large winds to enter the Sleeve (the Channel) again.	Intervals of SW winds in July between 1st and 20th.
17th July	Off Ushant	Thomas Fenner	...at three o'clock in the afternoon the wind being northerly it was concluded to go for Spain, Ushant bearing of us ENE next land some 15 leagues off.	
19th July	Off Ushant	Thomas Fenner	...being shot some ten leagues of South and by West of Ushant the wind came up at South-West blowing much wind.	
16th July	Off the entrance to the Channel	The Lord Admiral to Walsyngham	On Sunday (10th)... having the wind at North-East I bore to Scilly, but the wind continued not 16 hours there but turned SouthSouthWest that we were fain to lay it off and on in the Sleeve and could get no further.	A late report of the depression of 12th-13th July approaching from SW.

DATE (New Style Calendar)	LOCATION	SOURCE	REPORT	COMMENT
22nd July	The Downs off Dover	Lord Henry Seymour to Walsyngham	Such summer season saw I never the like; for what for storms and variable unsettled winds ... having of late sundry times put over with Southerly winds so far as Calais and suddenly enforced still with great westerly gales to return to our English coasts.	The depressions of 12th—20th July.
28th July	The Downs off Dover	Lord Henry Seymour to Walsyngham	The storm arose presently most outrageous and such as my being aboard the seas this winter I never saw greater.	The depression which caught the Armada off Ushant 26th—28th July.



**TABLE 3**  
**WEATHER REPORTED BY**  
**THE DANISH ASTRONOMER TYCHO BRAHE**  
**ON THE ISLAND OF HVEN (55°55'N 12°45'E)**  
**IN THE SOUND**

DATE (New Style Calendar)	REPORT
11th May 1588	Beautifully clear the whole day, at night foggy.
12th May 1588	Foggy, clear; light, increasing NW wind.
13th May 1588	Clear, fresh NW.
14th May 1588	Cloudy and clear at once (variable sky, partly clouded); light, increasing E wind.
15th May 1588	Clear most of the day through, at night cloudy, light W.
16th May 1588	Variable sky, sometimes light rain; moderately fresh W.
17th May 1588	Variable sky, light NE.
18th May 1588	Clear. Afternoon and night cloudy. Calm the first part of the day, then light to increasing NW.
19th May 1588	Cloudy, increasing W wind.
20th May 1588	Beautifully clear, still; towards evening light then increasing S wind, cloudy; at night rain.
21st May 1588	Cloudy, hard, increasing E wind.
22nd May 1588	Overcast, SE storm; towards evening E, rain in the night.
23rd May 1588	Variable sky, light rain at times, S.
24th May 1588	Variable sky, in the afternoon a halo around the sun; towards evening light rain, at night cloudy, S.
25th May 1588	Clear. Afternoon cloudy, light SW.
26th May 1588	Cloudy. In the night rain. S.
27th May 1588	Clear, light N.
28th May 1588	Clear, light N.
29th May 1588	Clear, light N.
30th May 1588	Cloudy, moderate E.
31st May 1588	Clear, light to moderate E.
1st June 1588	Clear, light to moderate E.
2nd June 1588	Clear, light to moderate E.
3rd June 1588	Fairly clear, light N.
4th June 1588	Fairly clear, light N.
5th June 1588	First part of the morning somewhat humid, later cloudy. Moderate SE.
6th June 1588	Cloudy. Afternoon rain, SW storm.
7th June 1588	First part of the morning some light rain, later variable sky, stormy SW wind.
8th June 1588	Variable sky, stormy W wind a point towards the S.
9th June 1588	First part of the morning it rained a bit, later clear, stormy NW. In the night cloudy, light W a point towards the N.
10th June 1588	Fairly clear, NW.
11th June 1588	Clear. Afternoon cloudy, rising N wind.

**DATE**  
**(New Style Calendar)**

**REPORT**

12th June 1588	Cloudy, moderate from WNW.
13th June 1588	Fairly clear, NE; in the night cloudy, S.
14th June 1588	Cloudy, sometimes clearing, light N.
15th June 1588	Cloudy, rising SE wind, towards midday rain.
16th June 1588	Variable sky, sometimes rain; at night cloudy with rain, light to increasing SW.
17th June 1588	Cloudy, sometimes rain, rising W wind.
18th June 1588	Mostly clear, light to moderate N.
19th June 1588	Clear most of the day and night through, calm.
20th June 1588	Clear for the most part, SE.
21st June 1588	Clear for the most part, SE.
22nd June 1588	Mostly clear, SE.
23rd June 1588	Mostly clear, SE.
24th June 1588	Fairly clear, light NE.
25th June 1588	Variable sky, light E, towards evening there came a sudden storm from ESE.
26th June 1588	Cloudy, NE.
27th June 1588	Cloudy, afternoon rain which lasted all through the night, NE wind.
28th June 1588	Rain all day till towards evening, light SE.
29th June 1588	Cloudy, light, increasing SE.
30th June 1588	Misty, clear sky, light SE.
1st July 1588	Misty, clear sky, light SE.
2nd July 1588	Cloudy and foggy (misty or hazy?), light to moderate N wind.
3rd July 1588	Thick weather or very hazy sunshine, light NE wind.
4th July 1588	Thick weather or very hazy sunshine, light NE.
5th July 1588	Thick weather or very hazy sunshine, light NE later W wind.
6th July 1588	Foggy at first; after the fog cleared cloudy, moderate to rising W wind.
7th July 1588	Cloudy, WNW storm.
8th July 1588	Sudden heavy rain in the morning, then lighter rain with a rising S wind; sudden rains in the afternoon, light to moderate W wind.
9th July 1588	Sometimes rain, light SW; otherwise variable sky; towards 10 o'clock thunder and sudden heavy rain. In the afternoon there were more sudden rain showers, light SW.
10th July 1588	Variable sky, moderate to rising SSW wind. At night clear and still.
11th July 1588	Mostly clear, light to moderate S.
12th July 1588	Variable sky, light to moderate N; at night rain.
13th July 1588	Cloudy, sometimes sudden rain, NE later E wind.
14th July 1588	Rain the first part of the day, later cloudy but dry, SE.
15th July 1588	Light rain the first part of the morning, later cloudy, W.
16th July 1588	Cloudy all day, at night clear, light SW wind.
17th July 1588	Variable sky, light NW.
18th July 1588	Cloudy, towards midday rain. Early in the afternoon rain again which lasted till evening, fairly fresh NW wind.
19th July 1588	Cloudy, rising W wind, rain most of the day from midday till evening, at night cloudy but dry.
20th July 1588	Variable sky. Afternoon and evening beautifully clear, still.
21st July 1588	Clear, light NW.

TABLE 4 NOTES ON THE METEOROLOGICAL ANALYSIS

DATE (New Style Calendar)	NOTES
12th–17th May 1588	Lows from the Iceland area or farther north moved SE to Denmark and the Baltic by 16–17th.
25th–26th May 1588	Remarkably extended meridional trough with Lows travelling northwards over Europe from Africa or the Mediterranean, a pattern for which there is some evidence as a special characteristic of the Little Ice Age climate.
31st May 1588	The situation on the 1st and 2nd June remained similar, but the winds dropped to calm near Lisbon, presumably as the col between the northern anticyclone and the high pressure centre in the Azores-Madeira region moved slowly south.
6th June 1588	The wind in Denmark had been SE'ly on the 5th. The winds seem to have been SW'ly at Plymouth and varying between E and N on the Portuguese coast.
9th June 1588	The wind in Denmark veered from SW with rain early in the day and became strong NW but later much lighter.
14th June 1588	Strong SW to W winds have been maintained for a long time in England and to some extent in Denmark, presumably by a depression sequence passing further north; but Denmark had an interlude of light winds on 12th–13th June with clear weather and wind veering around the compass. We may deduce that a small anticyclone centre was passing over Denmark on the 13th, presumably the division between one depression family and the next. Perhaps in some kind of remote association with this, the belt of SW'lies has just shifted north of Cape Finisterre (Spain) and put the Spanish ships into a light N'ly breeze.
18th June 1588	Denmark had rain and W'ly wind on the 17th. After the N'ly wind on this date a period of clearer weather followed with light W wind on the 19th. Plymouth had continued SW and W winds, mostly strong and accompanied by foul weather. The SW wind was just picking up again at Corunna (Spain) and by the 19–20th became a severe storm.
20th June 1588	The transference south, to near Spain, of the main cyclonic centre implies the existence of an outbreak of cold N'ly winds proceeding to low latitudes somewhere about longitudes 20–25°W. Plymouth continued to have foul, strong SW'ly weather most of the time, but Denmark had four days of anticyclonic influence with light SE breeze. The situation continued similar to this map in Spain, England and Denmark until the 23rd; the variations of storm intensity in NW Spain led up to another severe storm climax on the 23rd after somewhat lighter conditions on the 22nd.
24th June 1588	The high pressure cell affecting Denmark has moved farther NW. Plymouth is experiencing a climax of storms blowing into the Sound, i.e. from S or SSW and related to that which affected NW Spain on the 23rd. By the 24th the weather in NW Spain has turned very thundery, and by the 27th the wind there had veered W. The Low shown on this map off Spain and Portugal seems therefore now to have acquired the character of a cold pool which travels only slowly northeastwards, unlike the previous waves which had developed on the cold front.
27th June 1588	Denmark seems to have been involved since the evening of the 25th with a new frontal system coming from the E and SE. The cold Low and the fronts which had been affecting Corunna (NW Spain) have passed away to the NE. By the 28th the winds in the Bay of Biscay had become WNW and near Scilly NW'ly.

**DATE**  
**(New Style Calendar)**

**NOTES**

- 29th June 1588      The most disturbed skies are now reported from Denmark, where the weather becomes increasingly humid, presumably as warm air comes up from the SE. The wind continues from NW or N off SW England on the 30th, and then on 1st July increases to gale from NNE, evidently as a new Low approaches; in the Channel as far west as Devon the wind was then strong S'ly.
- 1st July 1588      As the wind became lighter in Denmark over the previous two days, the old Low probably moved farther away, i.e. back towards the S and SW across England. It seems necessary to hypothesize that a new frontal Low was travelling E farther S; this is likely because the known supply of cold air to such low latitudes would produce a sharp front. The approach of this southern Low seems to have led to a coalescence of the two depressions off SW England and carried the combined centre eastwards on the following day.
- 2nd July 1588      The old British Isles Low has now been absorbed into the new Low travelling NE from Spain. Additionally, it is clear that there is a vigorous new Arctic outbreak of N'ly winds associated with a northern anticyclone which has already spread its influence south to the latitude of Biscay and somewhat east to affect Denmark.
- 3rd July 1588      The strong winds over Biscay are beginning to back more N'ly.
- 5th July 1588      The wind has just changed from NE to W in Denmark. On the 6th the W'ly wind there became stronger and on the 7th became a stormy WNW wind, presumably under the influence of a new system approaching from the NW. A calmer interval occurred in NW Spain, but by the 7th the wind at Corunna was SE'ly again and a new disturbance was approaching.
- 7th July 1588      The renewed storm in Denmark has not affected Spain, and is not known to have affected England, so probably came with a jetstream from the NW or WNW.
- 8th July 1588      The warm sector over Denmark now has come from the SW and can only be the one which passed the Spanish ships at Corunna the day before. It has therefore been a fast travelling system. The wind veered SW in Denmark by afternoon on the 8th, but the weather and sky continued variable. There was thunder there on the morning of the 9th and the wind continued SW until the 12th, when it veered N.
- 10th July 1588      The last wave on the cold front over Europe seems not to be developing, and in Denmark the following night was clear and still, the weather on the 11th there still fine with a light S wind. The whole complex low pressure system over northern Europe seems by then to have been filling and moving east. By the 12th the wind in Denmark became N'ly. The NE wind in the Channel on the 10th was replaced the next day by wind from the SSW under the first influence of a new cyclonic system approaching from the SW.
- 13th July 1588      The slowly advancing, occluding Low has at last reached Denmark, taking three days on its way from northern France. By the 14th the light wind in Denmark had become SE, presumably as the front passed. By the 14th the winds in SW England had become strong N'ly. As has happened repeatedly in 1588, we see a N'ly outbreak developing over the eastern Atlantic and proceeding to the lower middle latitudes. It must be these outbreaks that keep generating further cyclonic activity in such an unusual low latitude for summer.
- 15th July 1588      The small ripple on the front over France may have been responsible for the overcast day with light SW wind in Denmark on the 16th.

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**DATE**  
**(New Style Calendar)**

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**NOTES**

17th July 1588

The new depression advanced quickly from the SW to the mouth of the Channel. The brisk N<sup>ly</sup> wind behind it did not last many hours before becoming W<sup>ly</sup>. This was a change which saved some of the English ships from their quick, but mistaken decision to go for Spain to seek out the Armada there. Such a move might have led to disaster and one can imagine that the return of the wind to the W<sup>ly</sup> quarter could have been regarded as a miracle in England's favour, though the people concerned probably never knew of their mistake about the location of the Armada at that time. The ridge of high pressure over the North Sea may be intensifying ahead of the new Low, since the wind in Denmark continued from NW and strengthened by the 18th.

19th July 1588

The Low over Sweden has travelled from near Cornwall on the 17th and seems now to be moving more slowly, although the High over NE France is developing somewhat and moving quickly NE so that Denmark was in its central region the next day. Rain continued at Corunna (NW Spain) for 24 hours, evidently close to the front throughout that time.

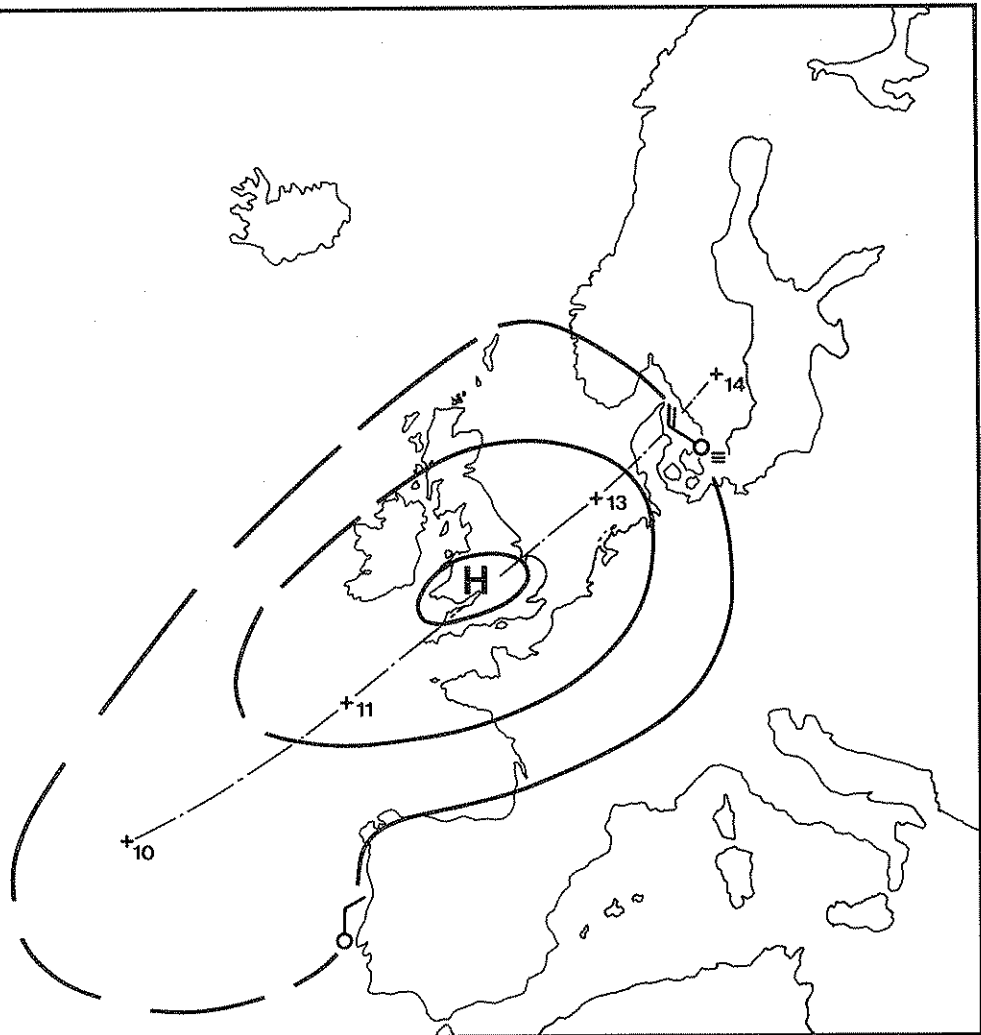
20th July 1588

The complex Low near the mouth of the Channel is being maintained in that area by a succession of frontal wave depressions apparently coming from the lower subtropical latitudes and deepening as they run into the central cyclonic area, which therefore moved only slowly to the southern North Sea by 22–23rd July. During that time the Swedish Low apparently backed a little and renewed a NW<sup>ly</sup> breeze in Denmark.

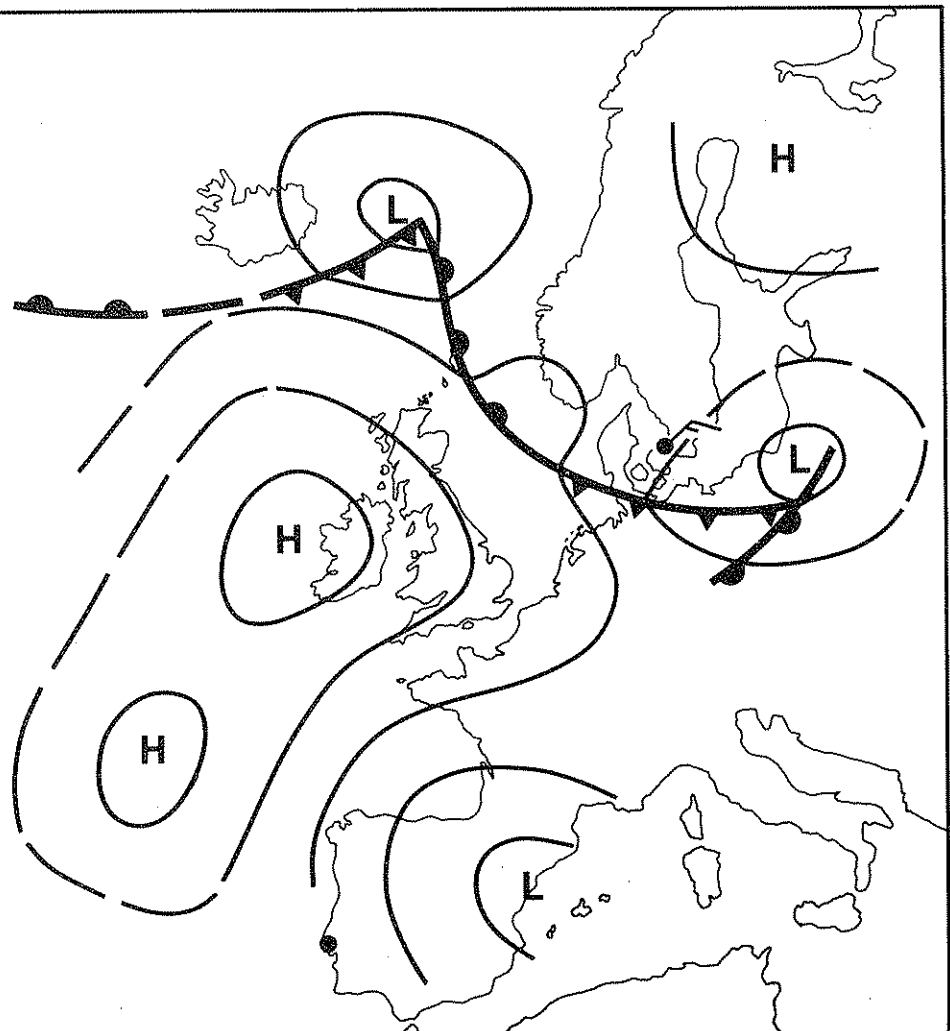
**TABLE 5** APPARENT SEQUENCE OF WIND CIRCULATION PATTERNS:

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12 May 1588



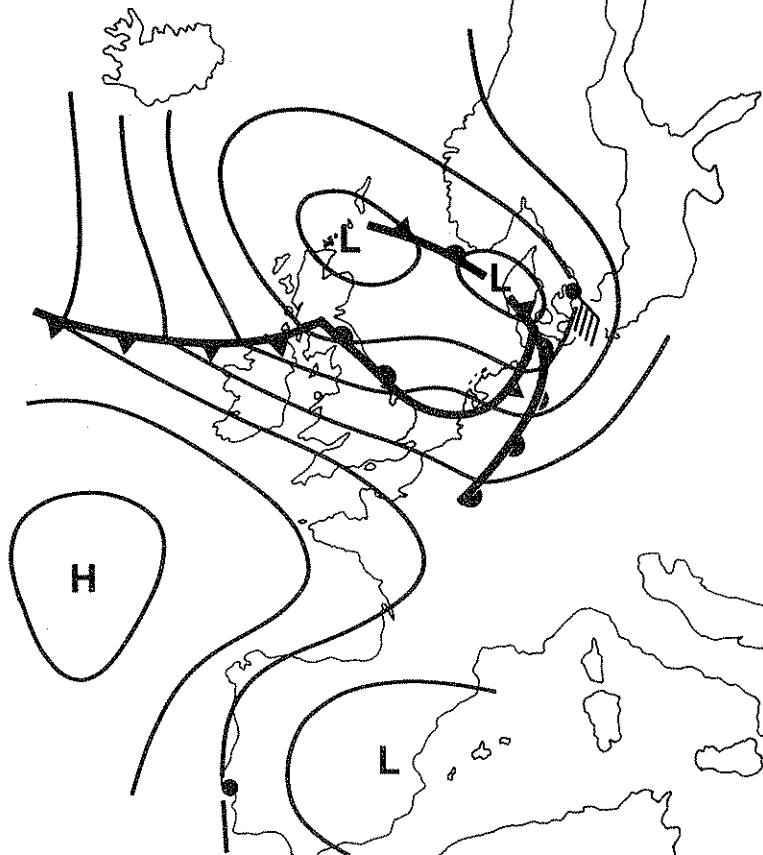
17 May 1588





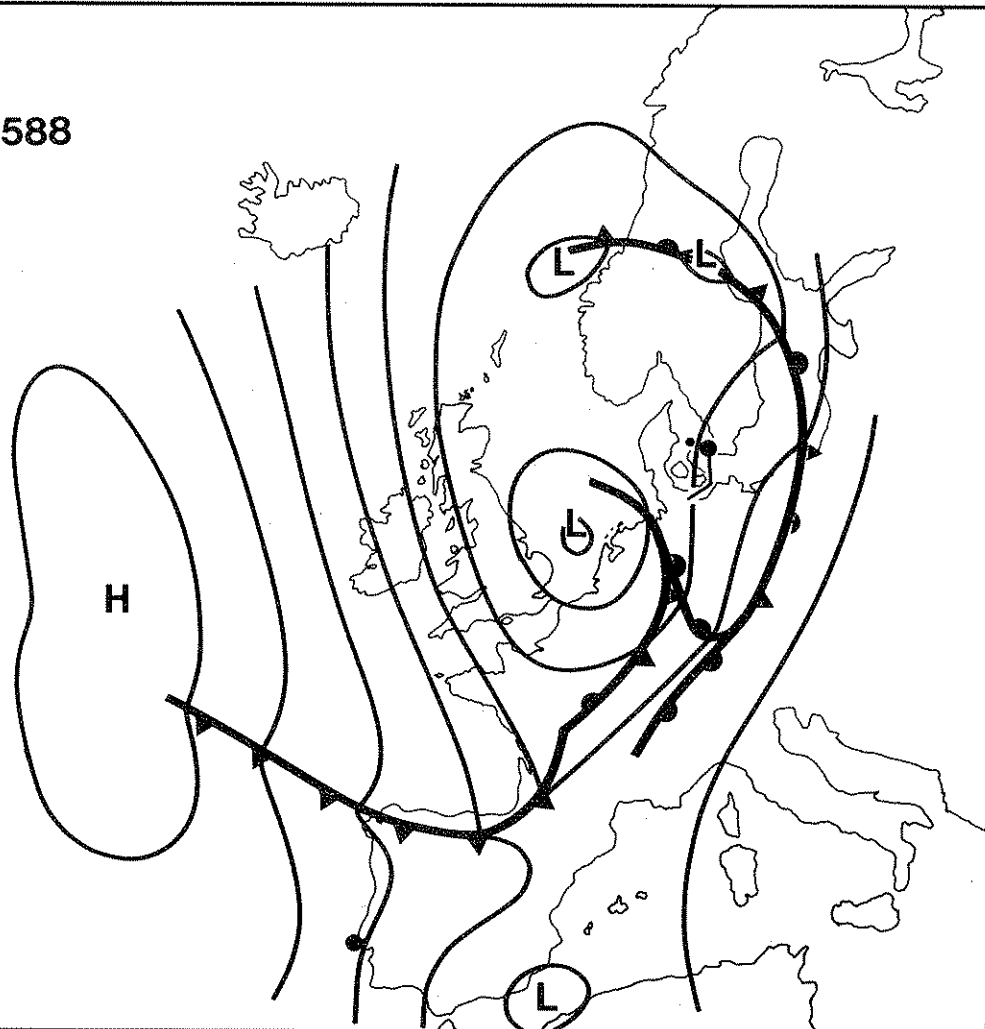
**22 May 1588**

**H**



**Night of  
23-24 May 1588**

**H**



Night of  
25-26 May 1588

H

H

L

L

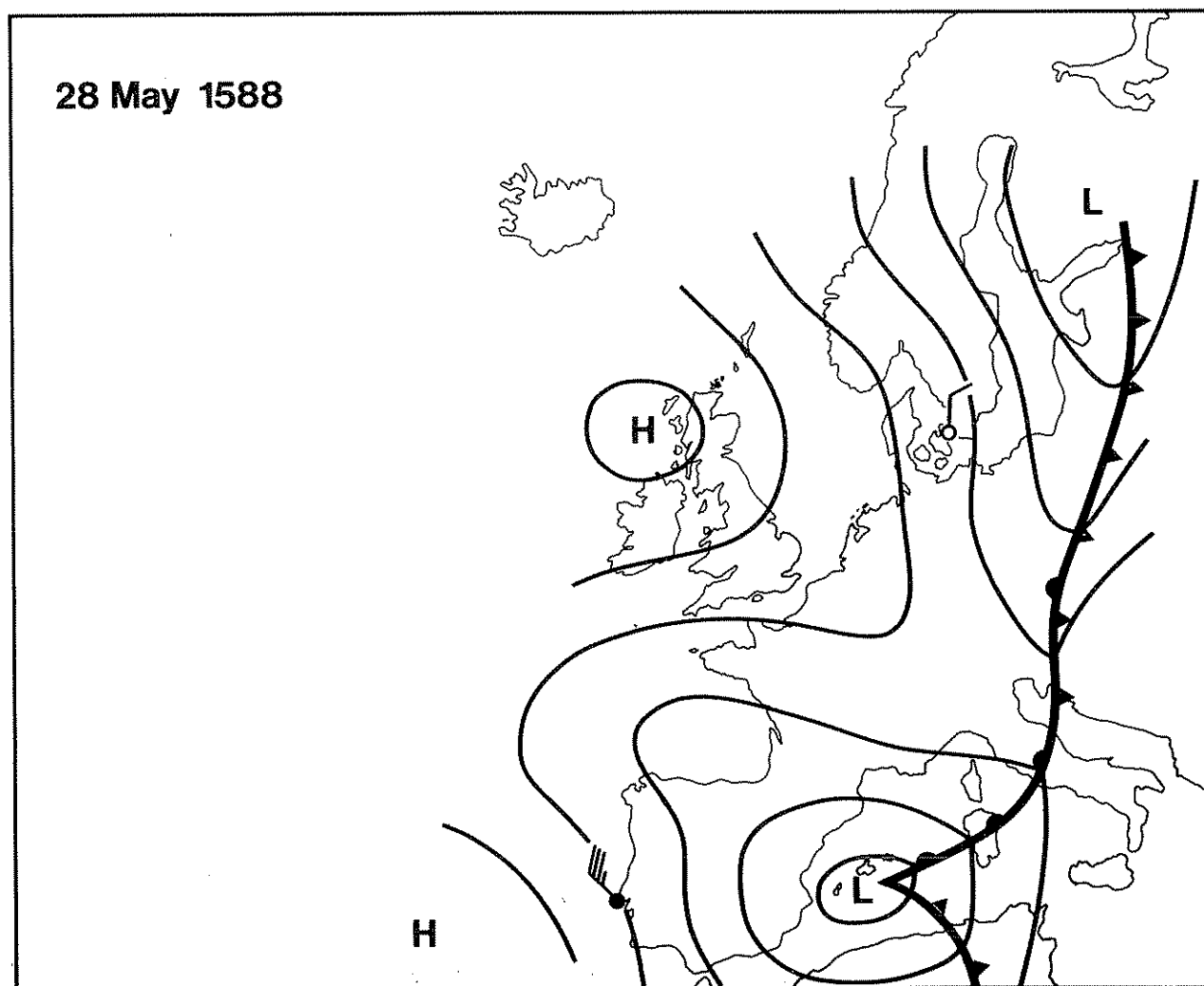
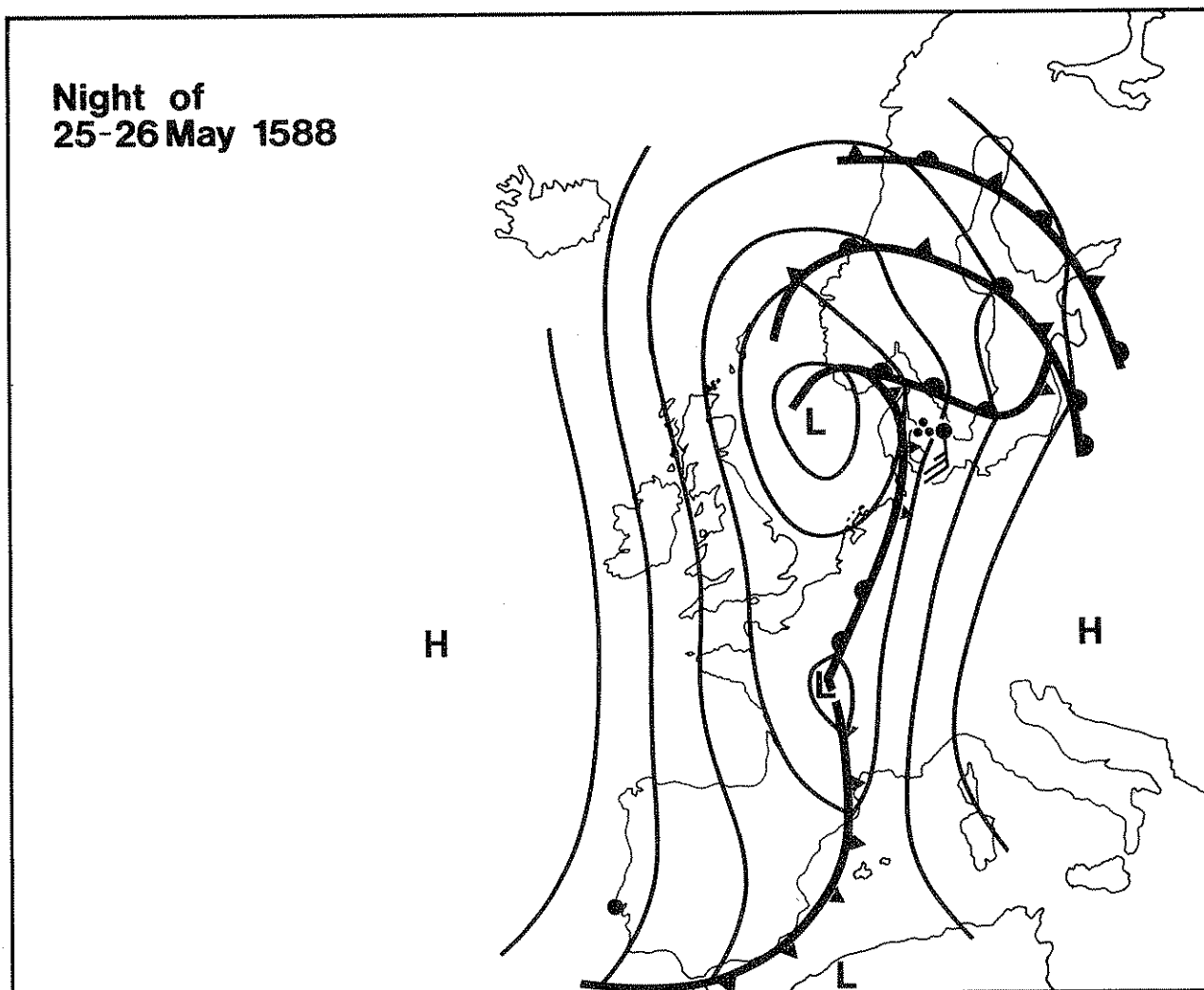
28 May 1588

H

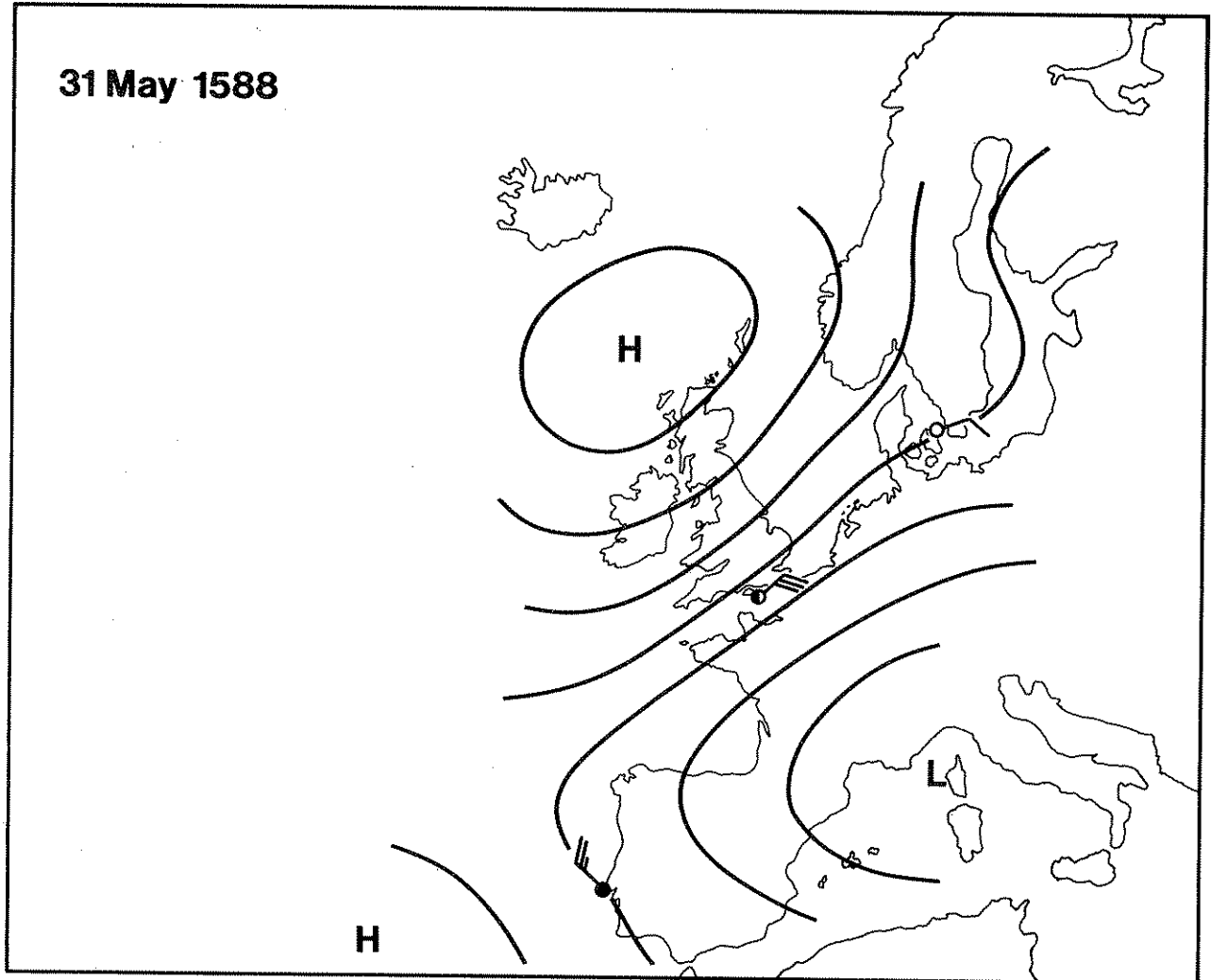
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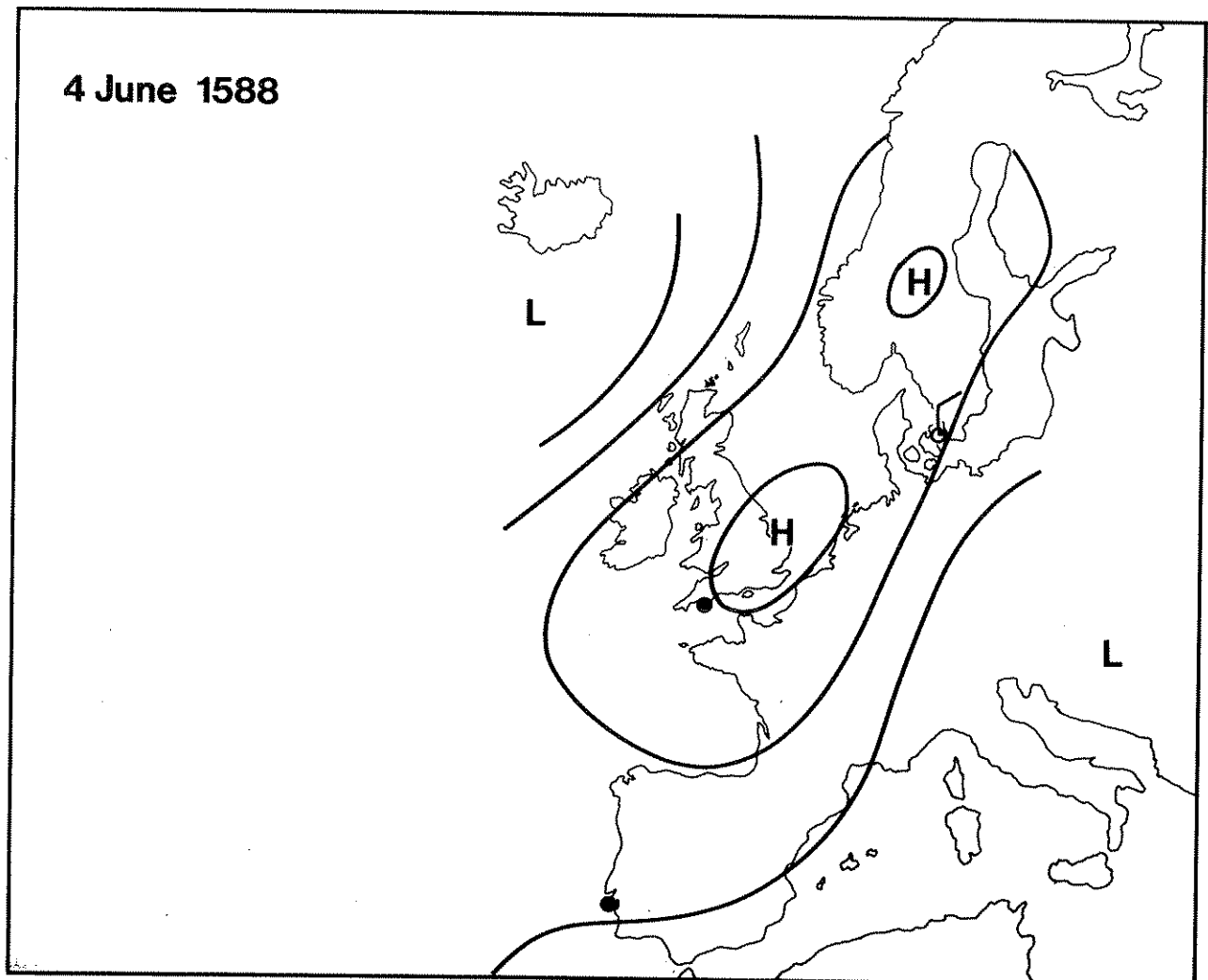
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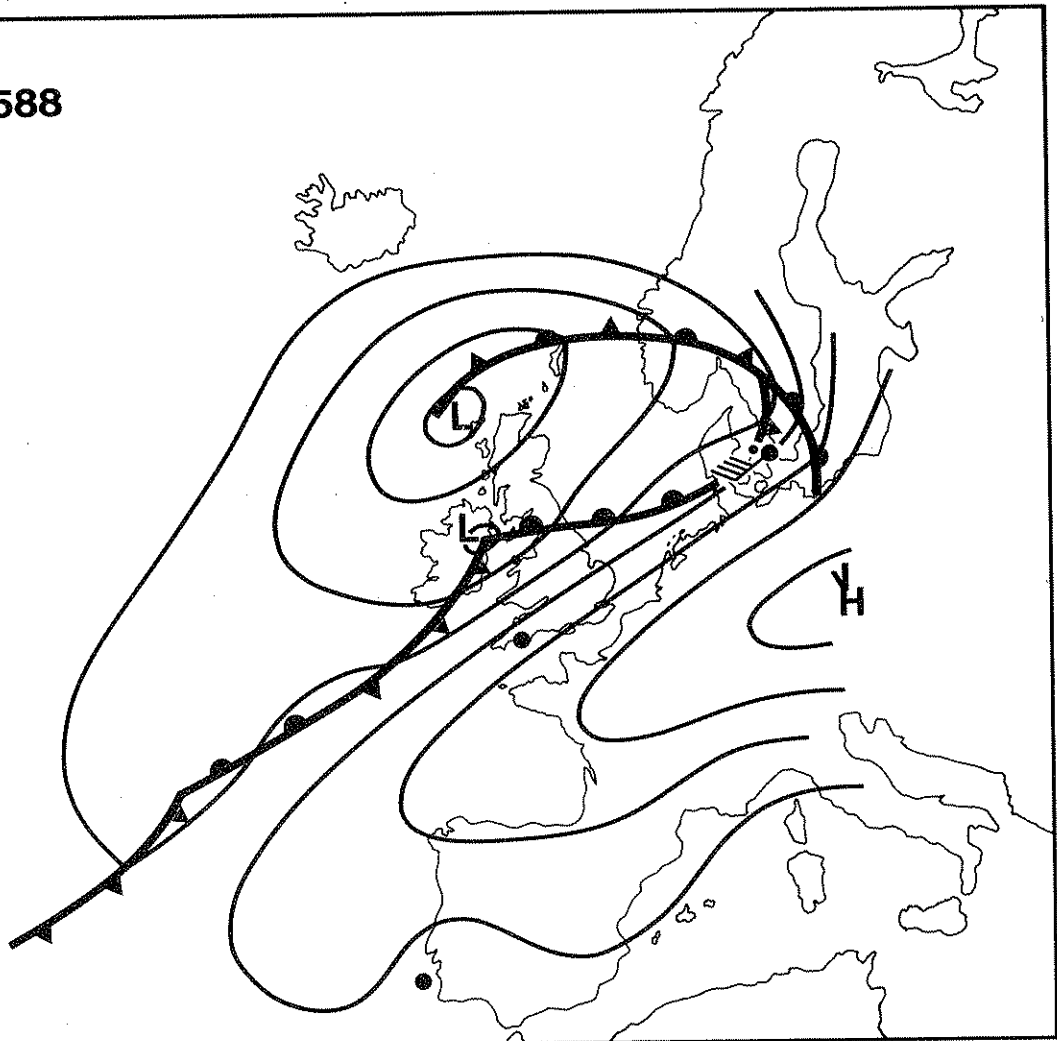
31 May 1588



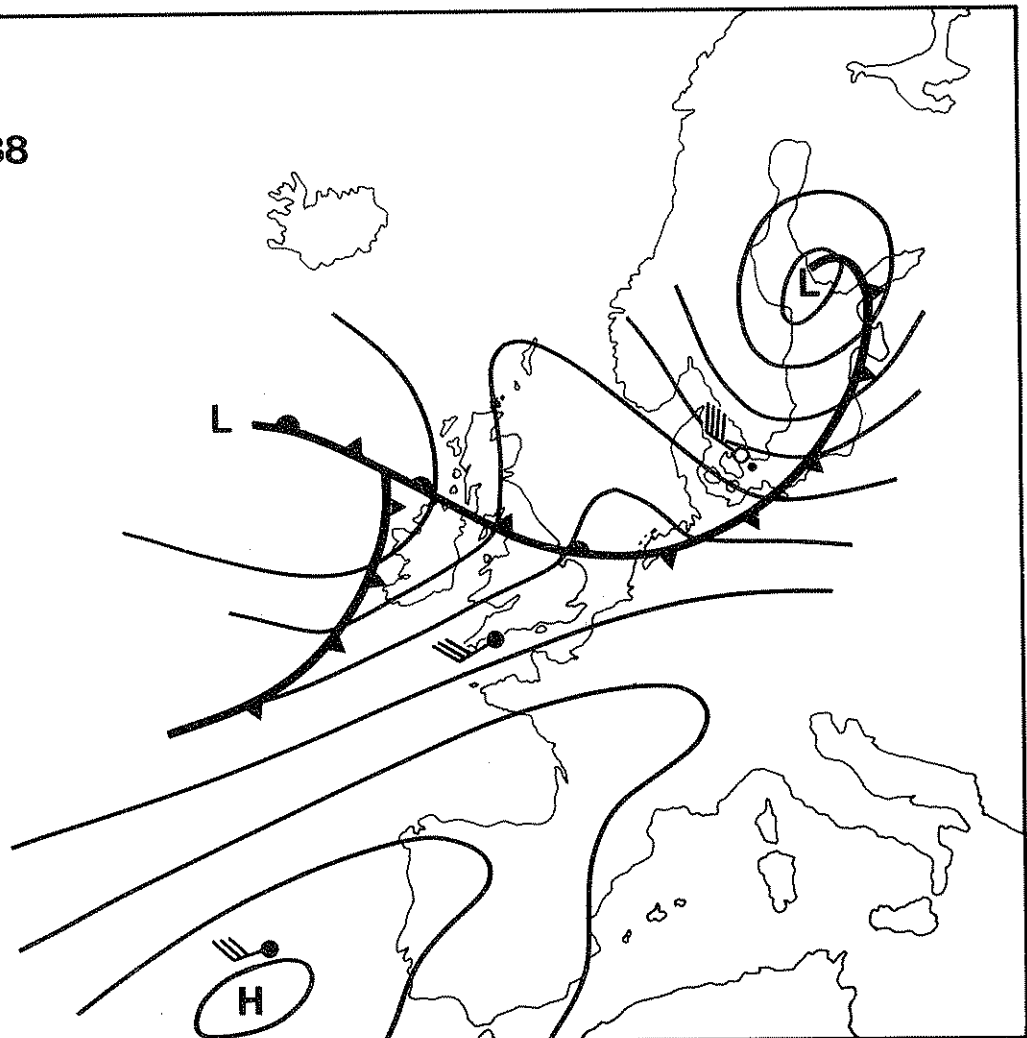
4 June 1588



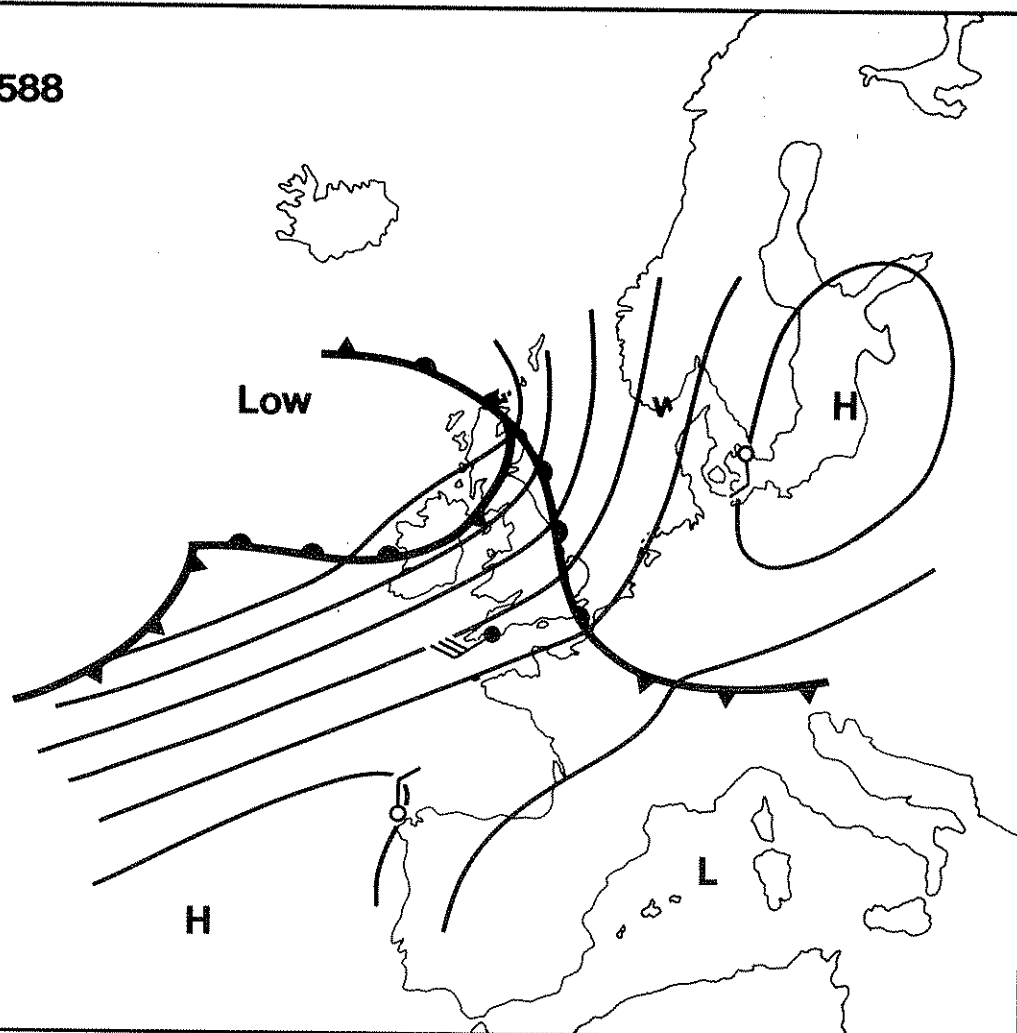
6 June 1588



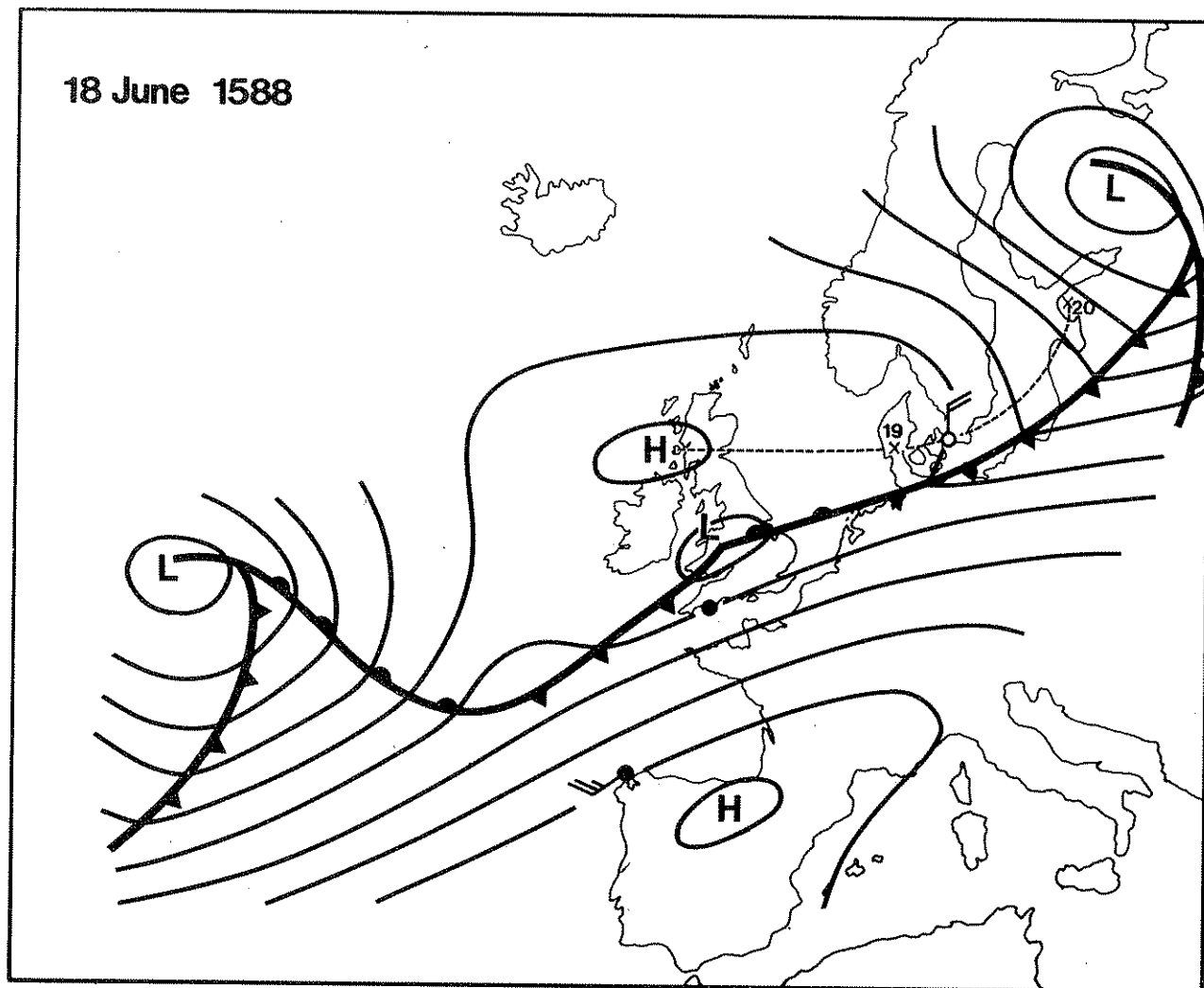
9 June 1588



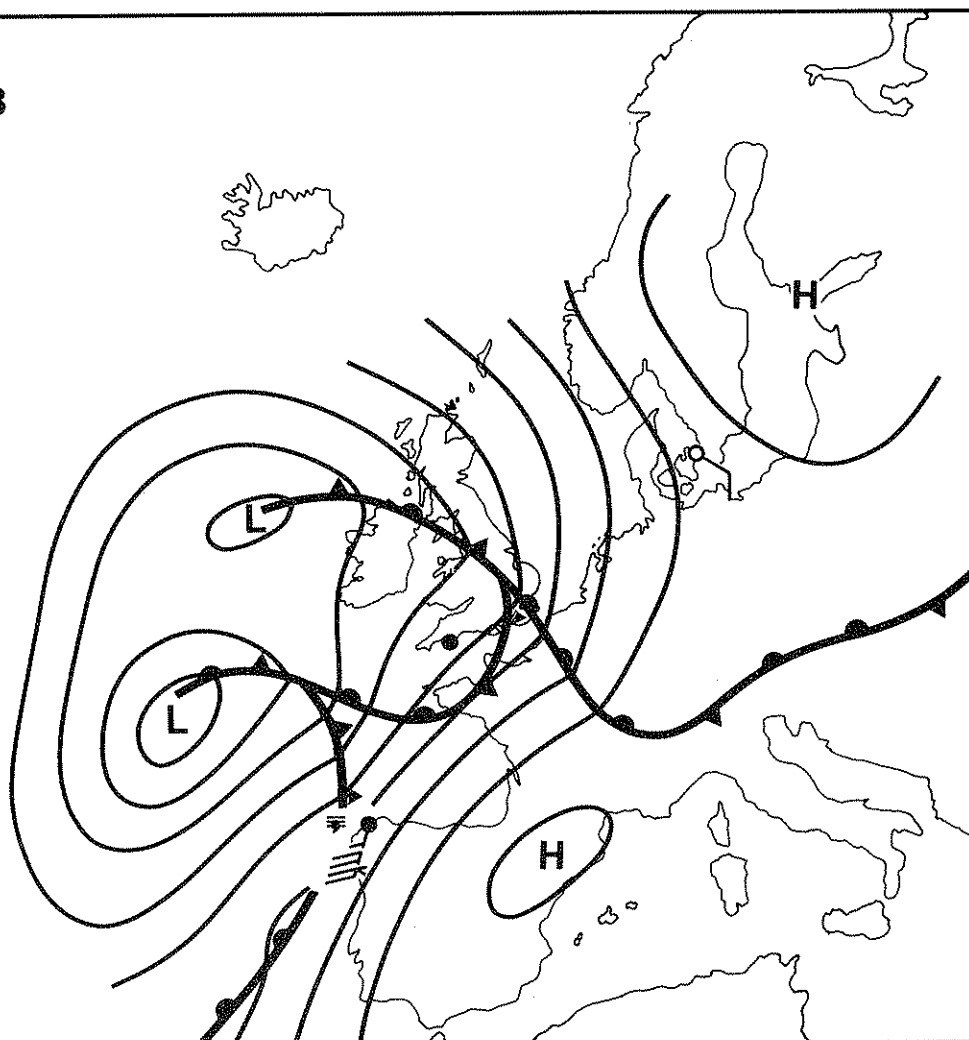
14 June 1588



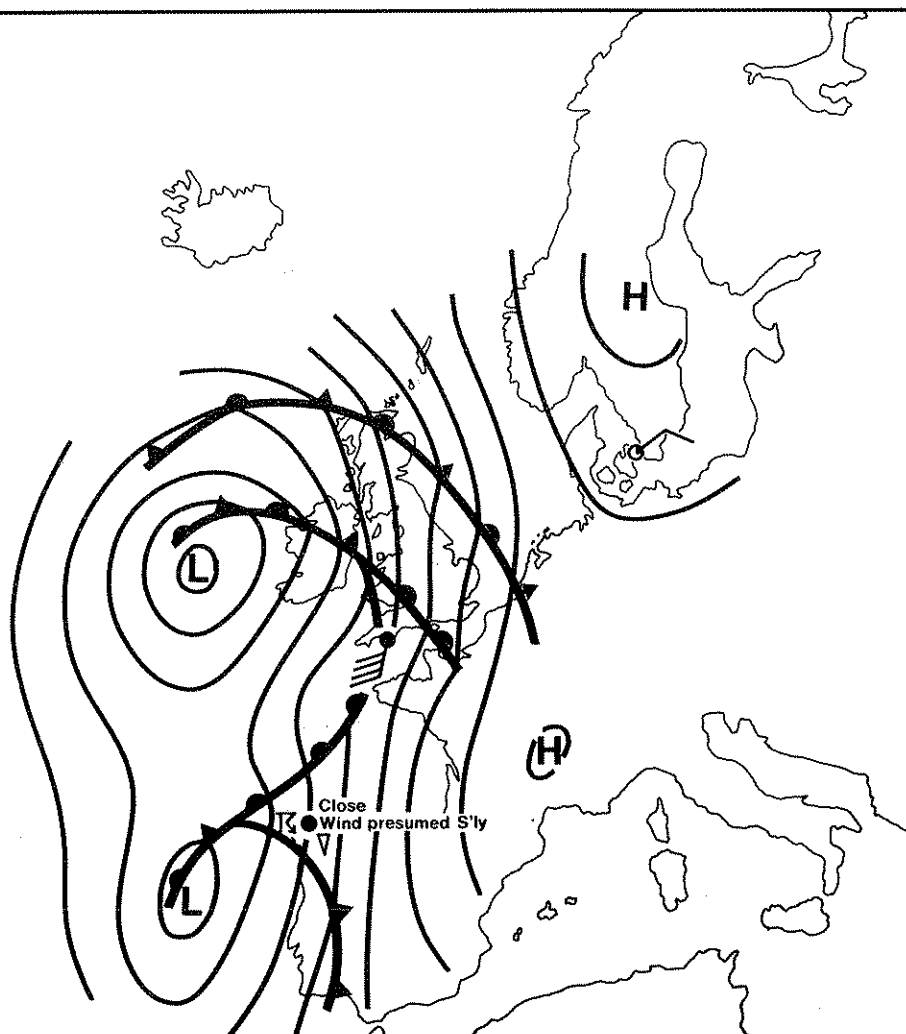
18 June 1588



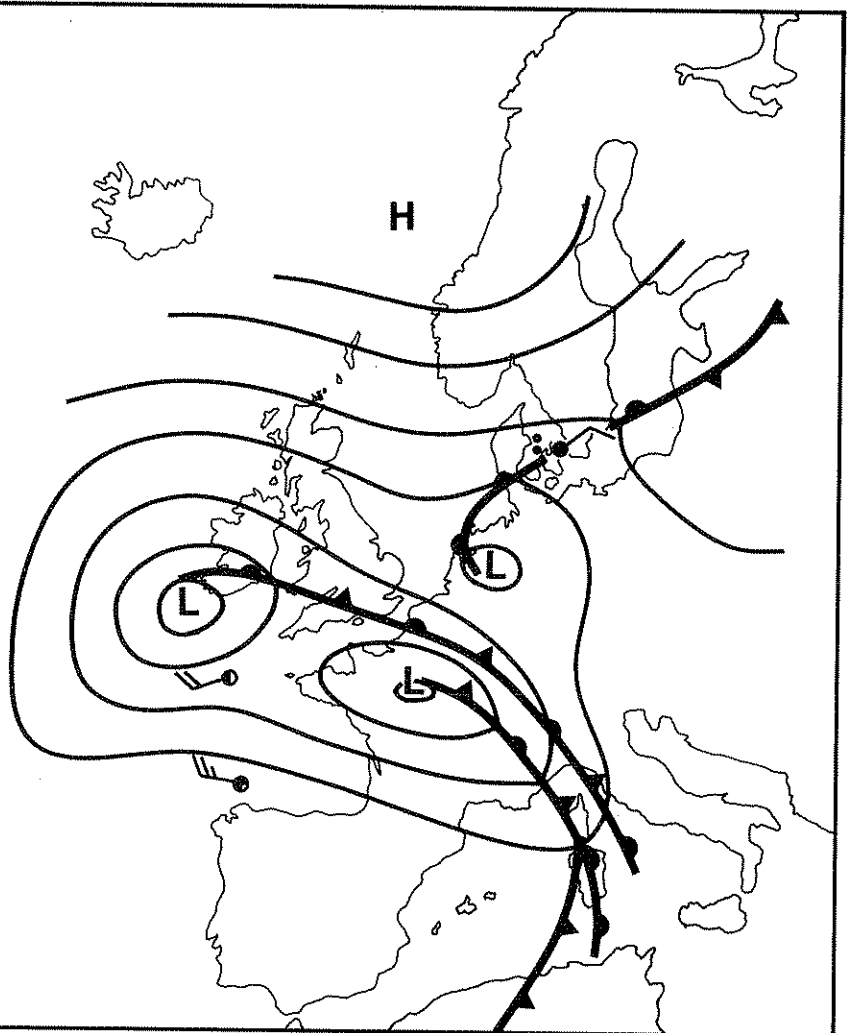
20 June 1588



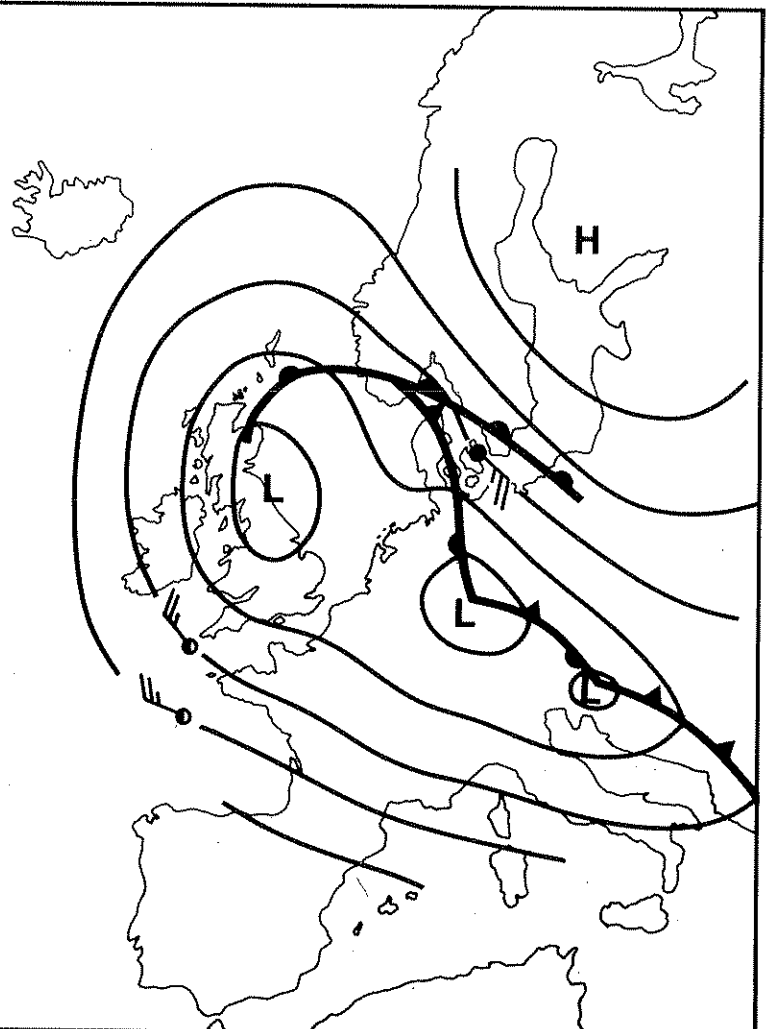
24 June 1588



27 June 1588

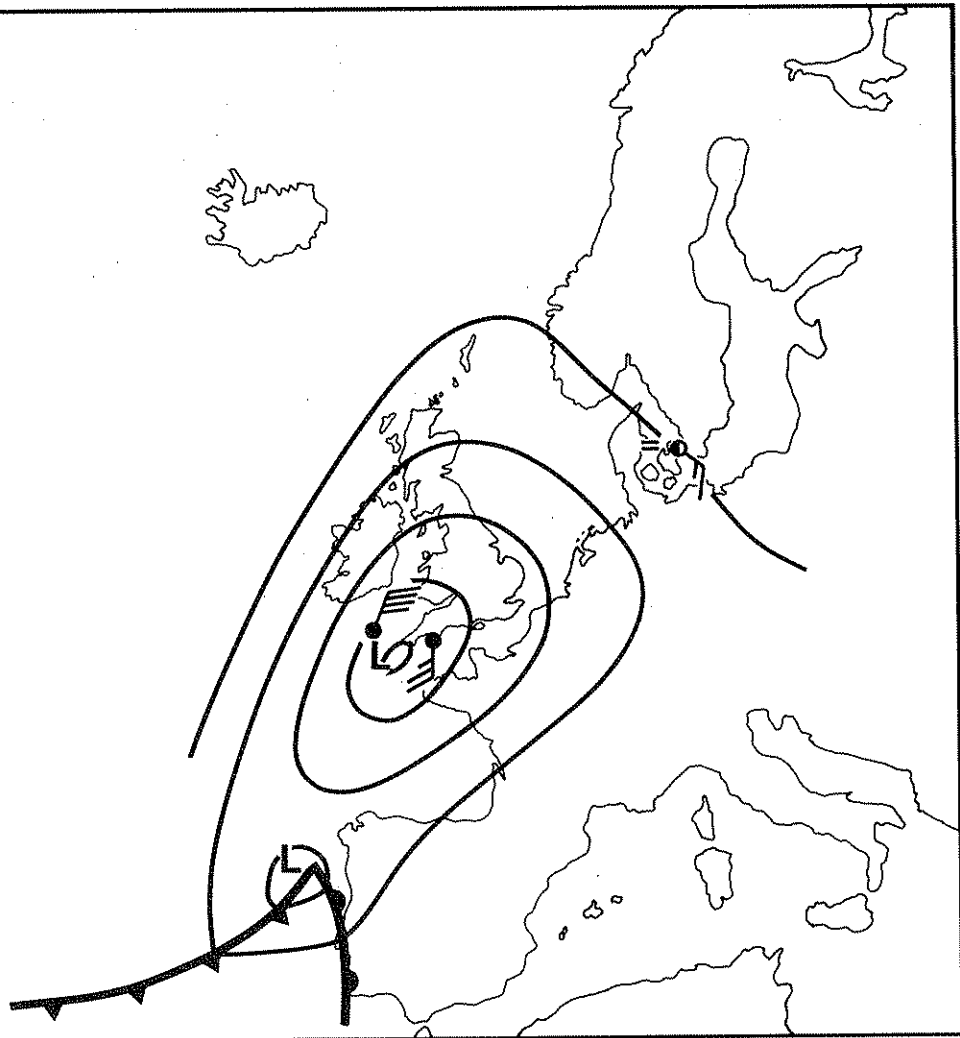


29 June 1588

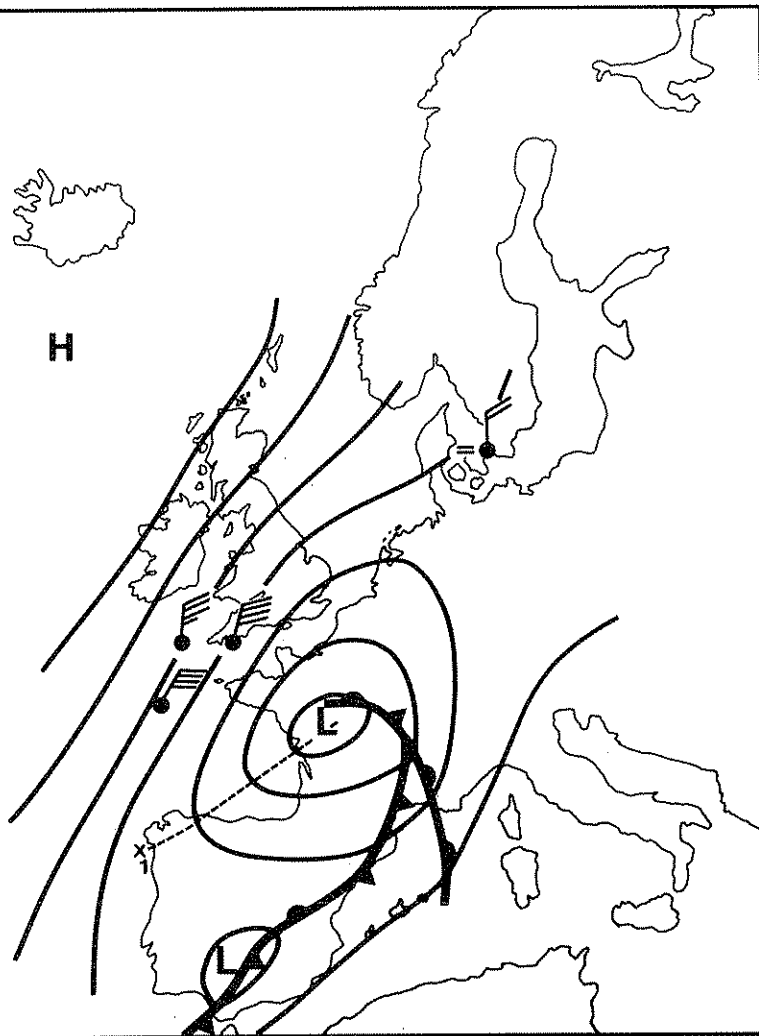




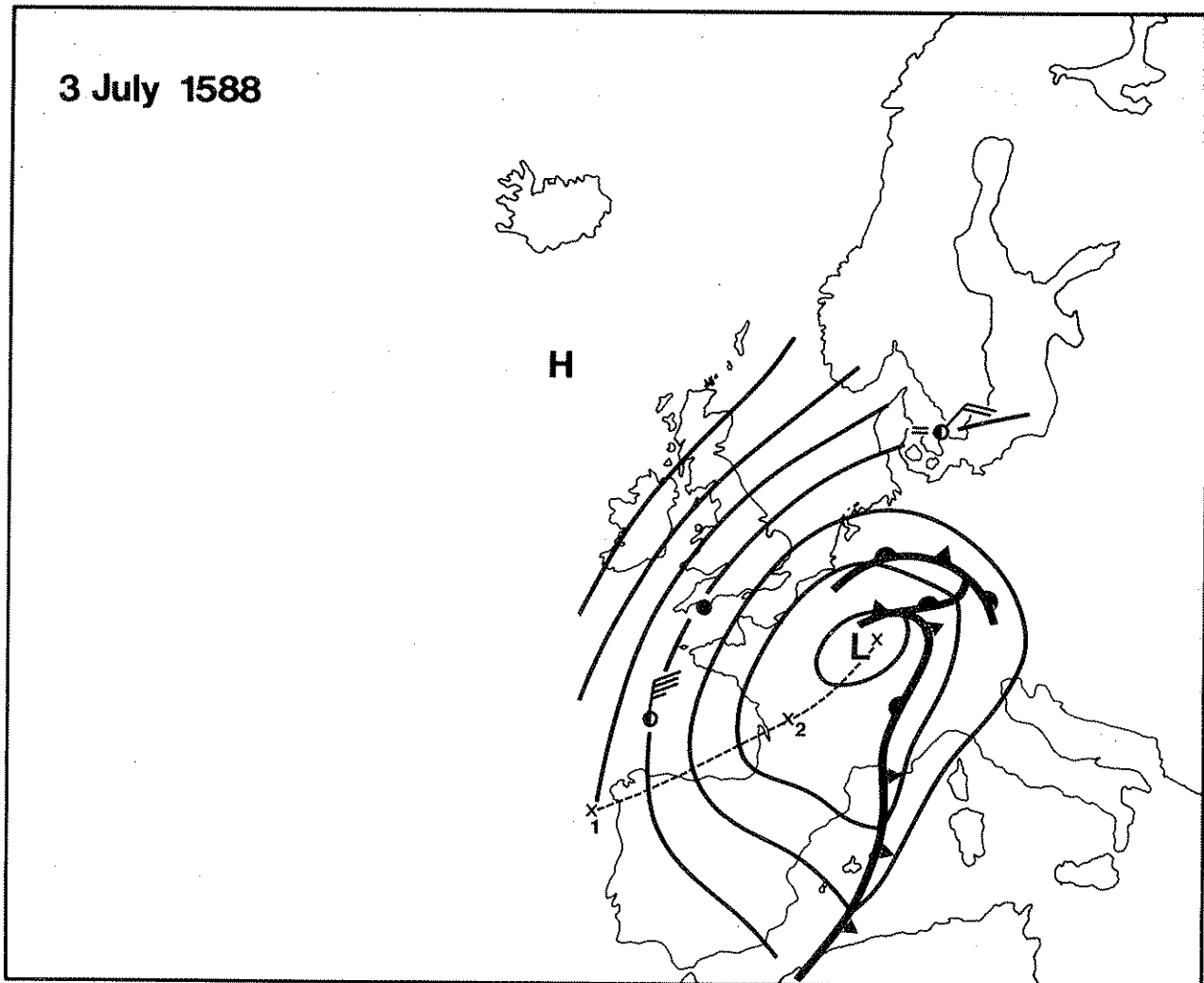
1 July 1588



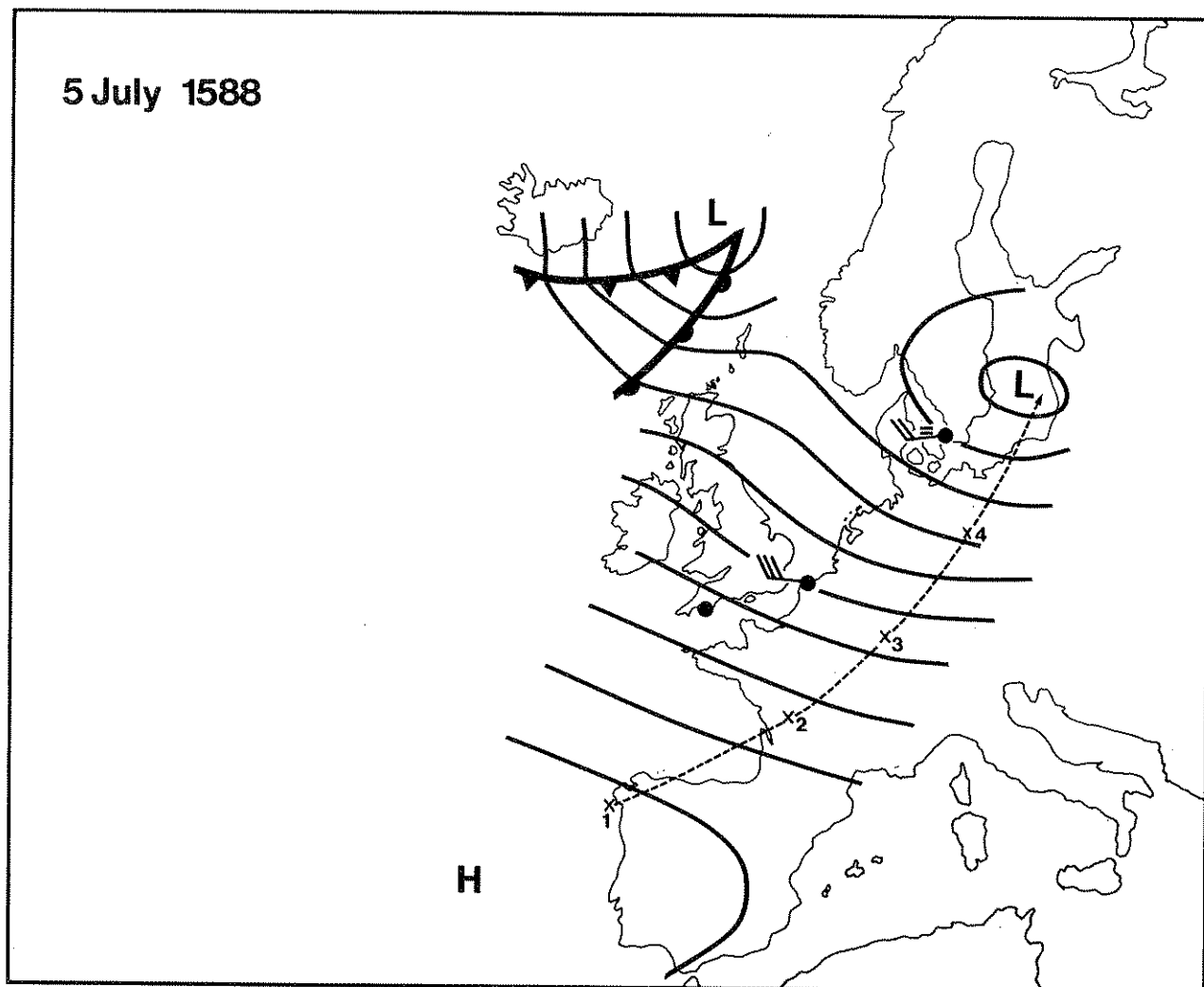
2 July 1588



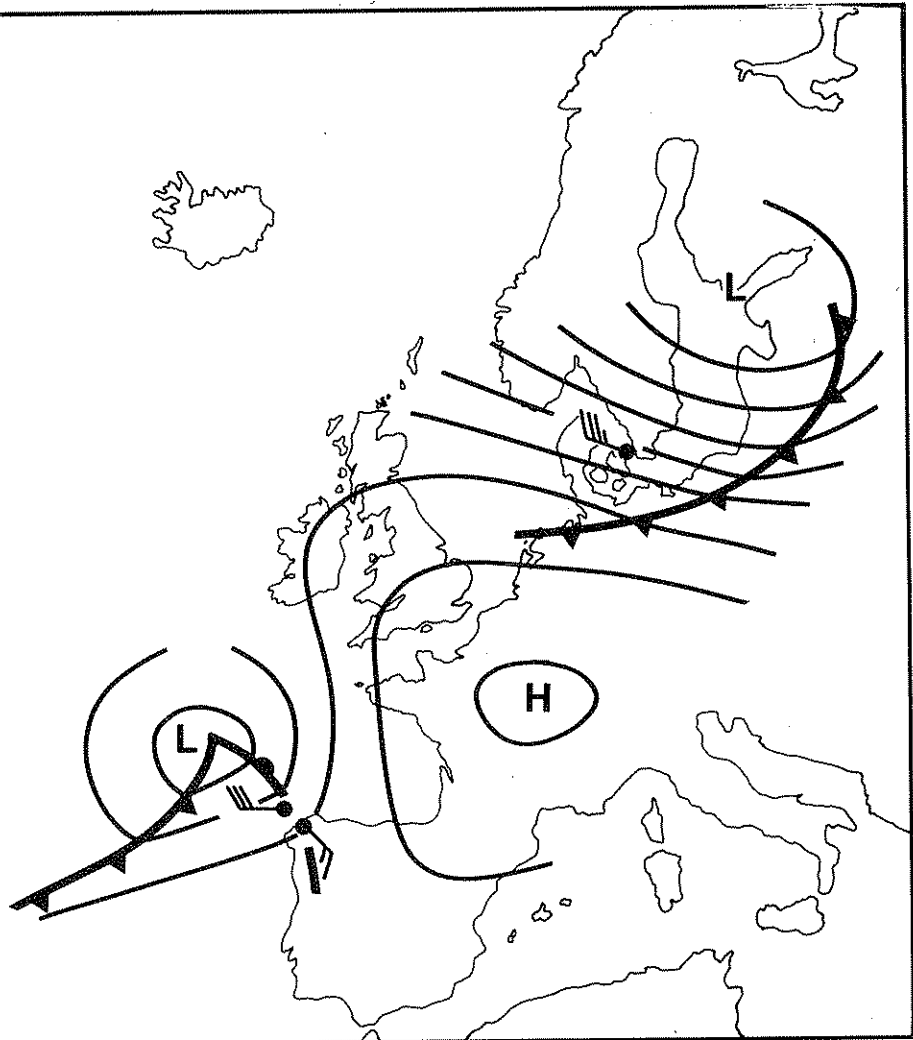
3 July 1588



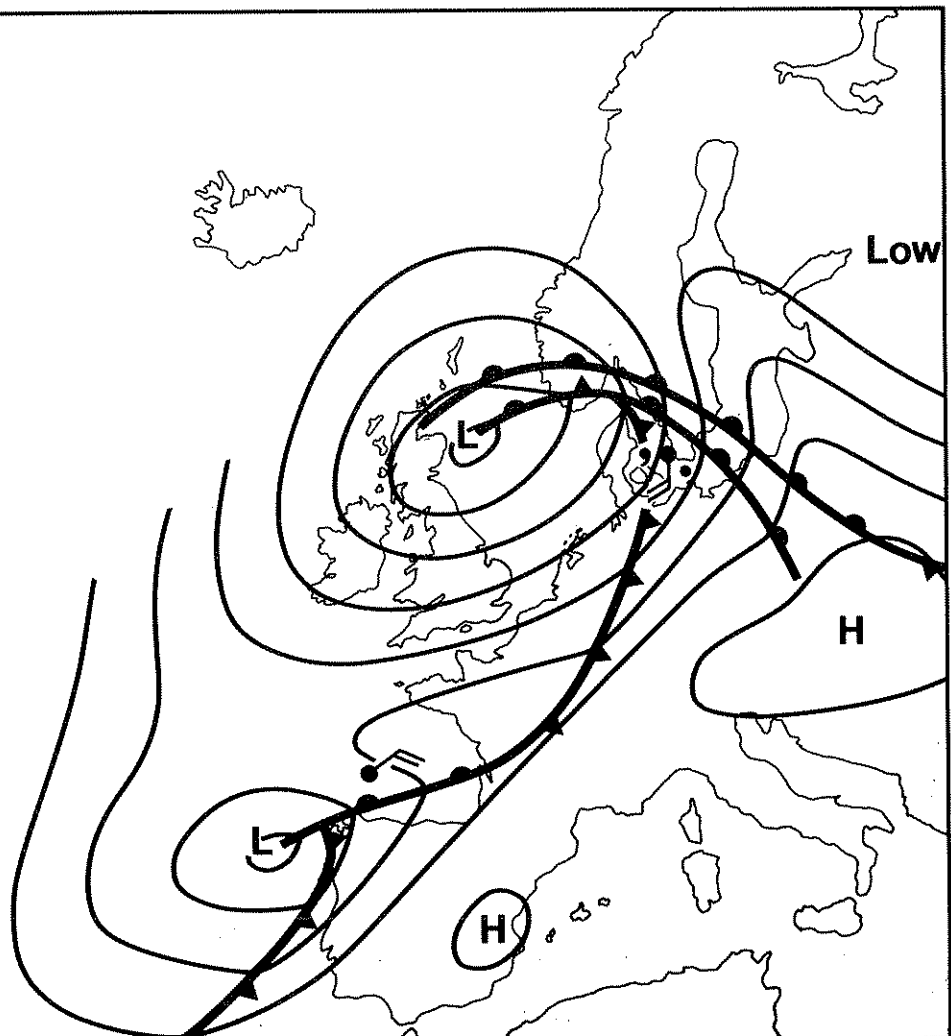
5 July 1588



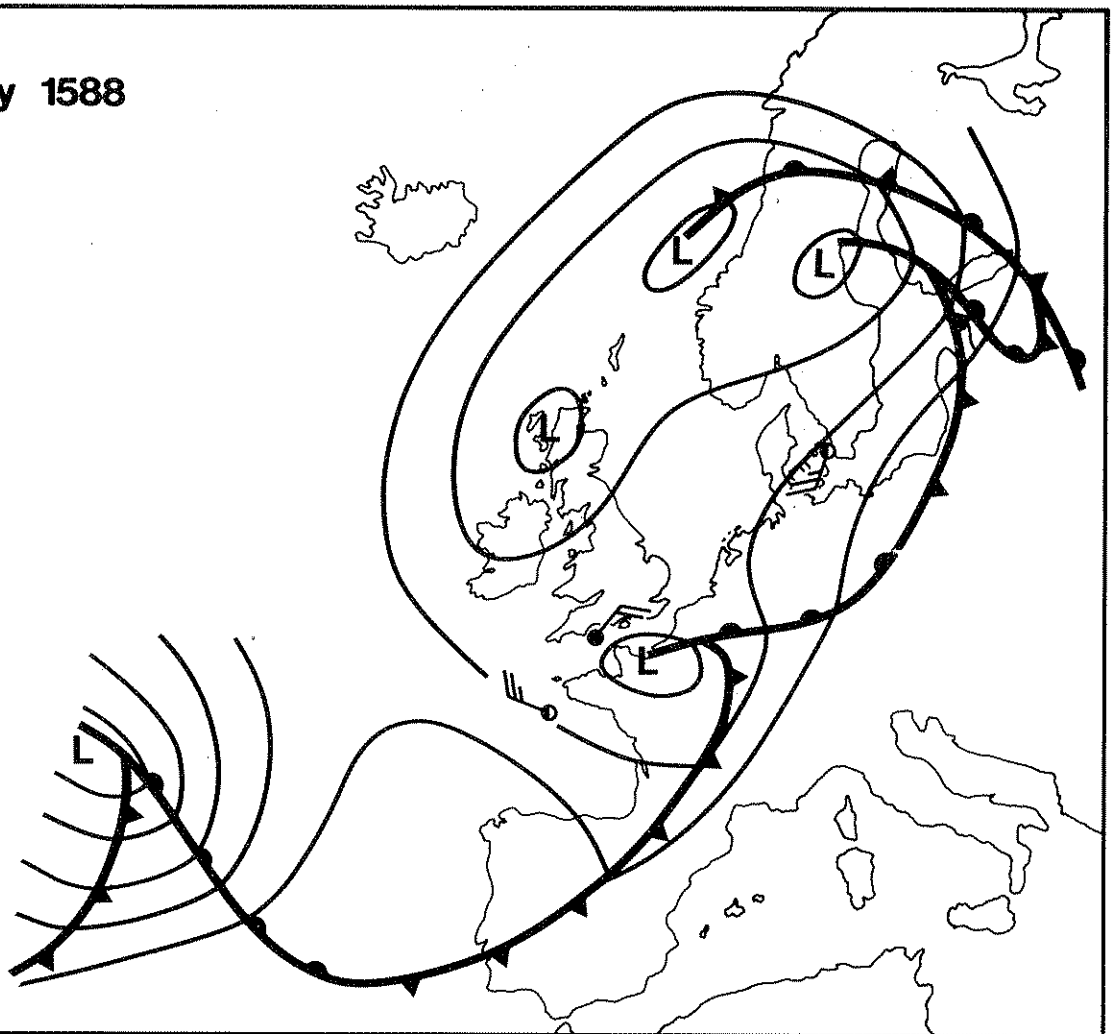
7 July 1588



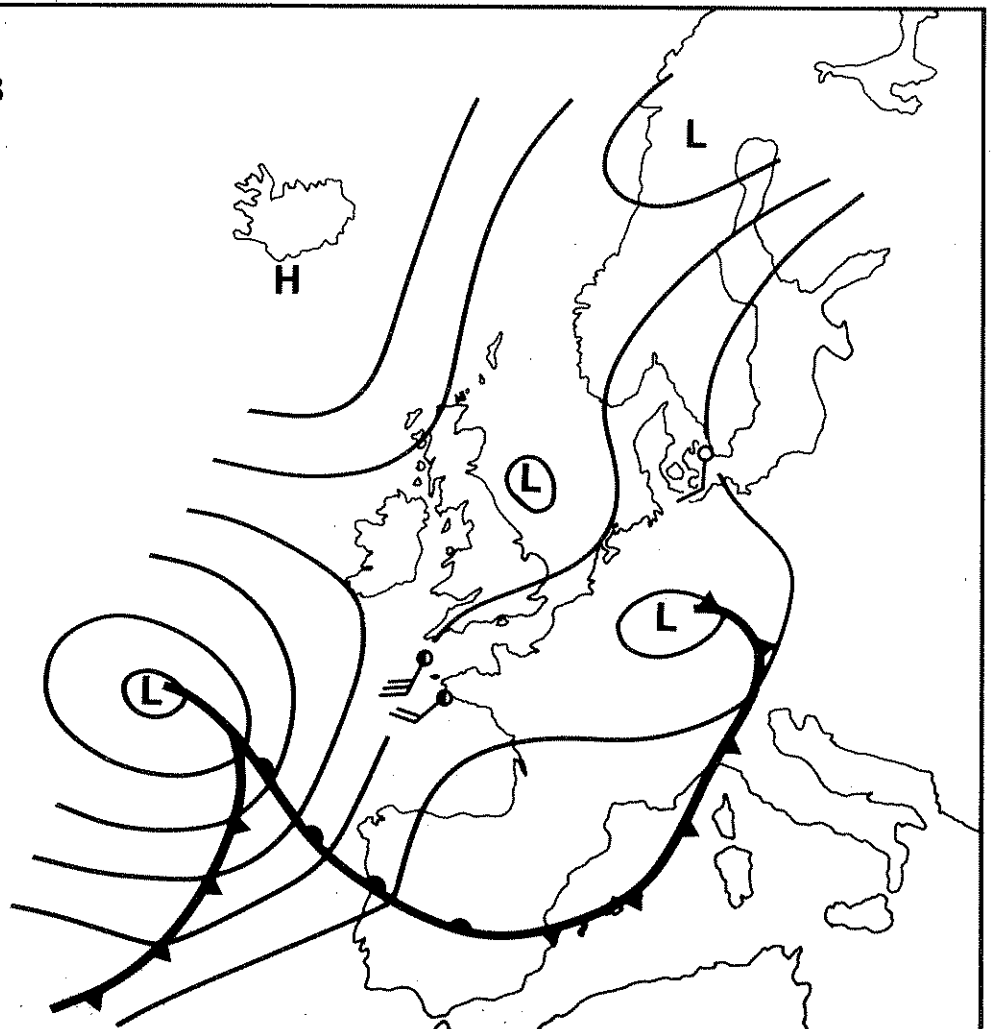
8 July 1588



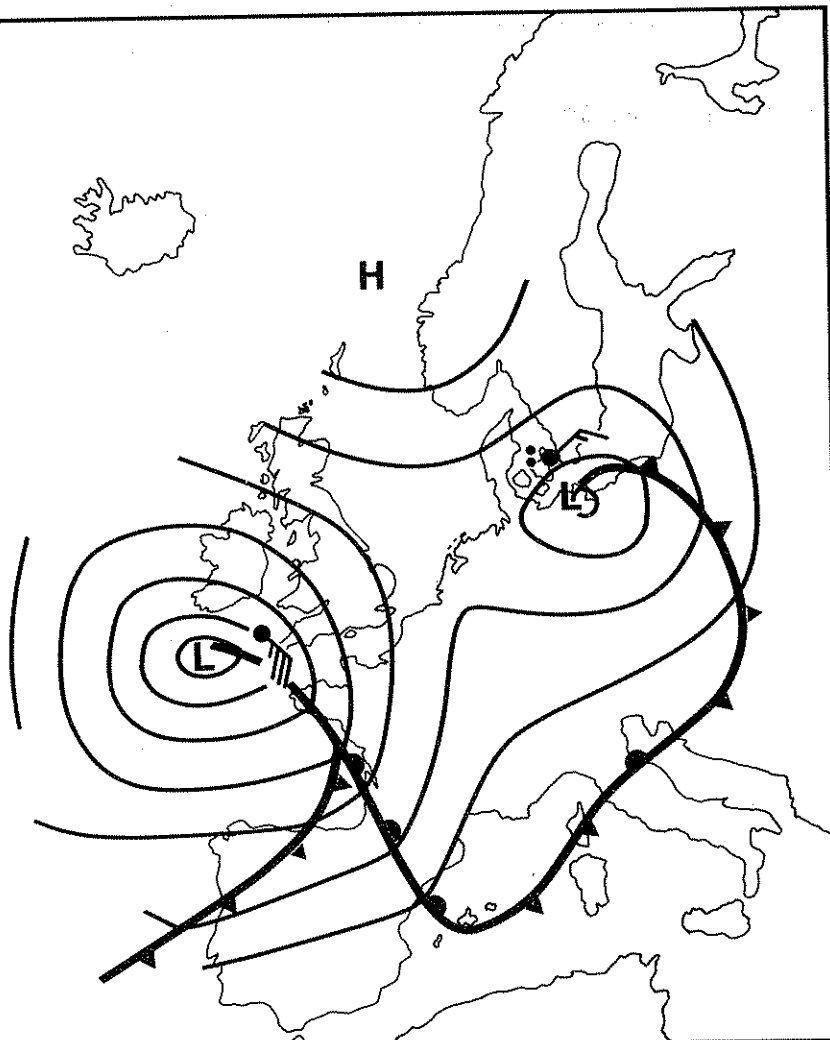
10 July 1588



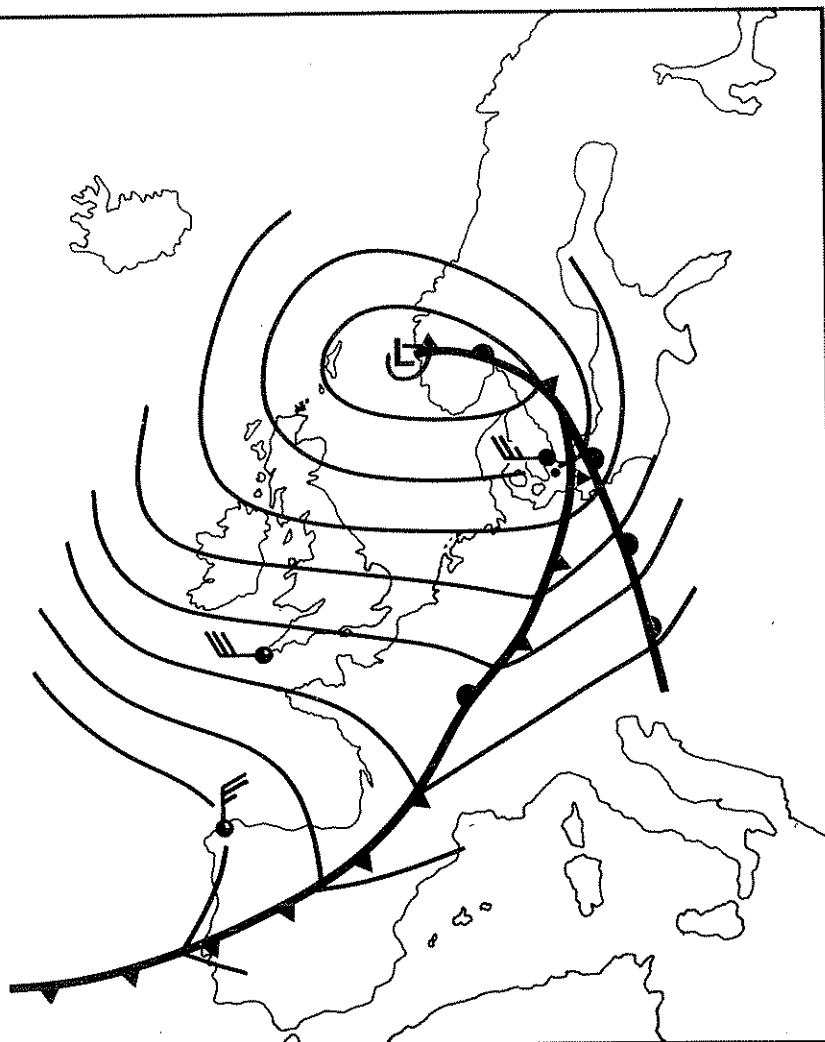
11 July 1588



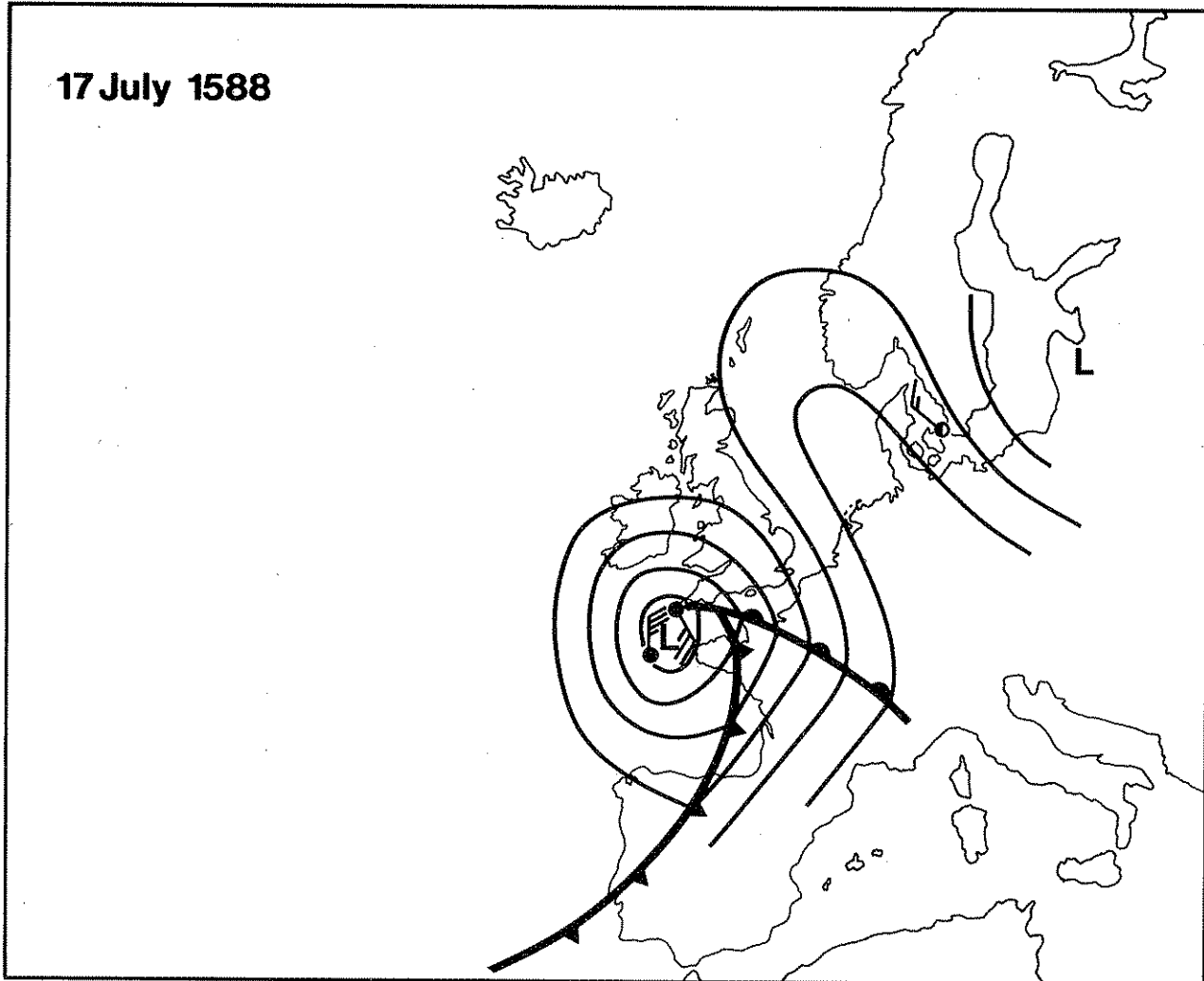
13 July 1588



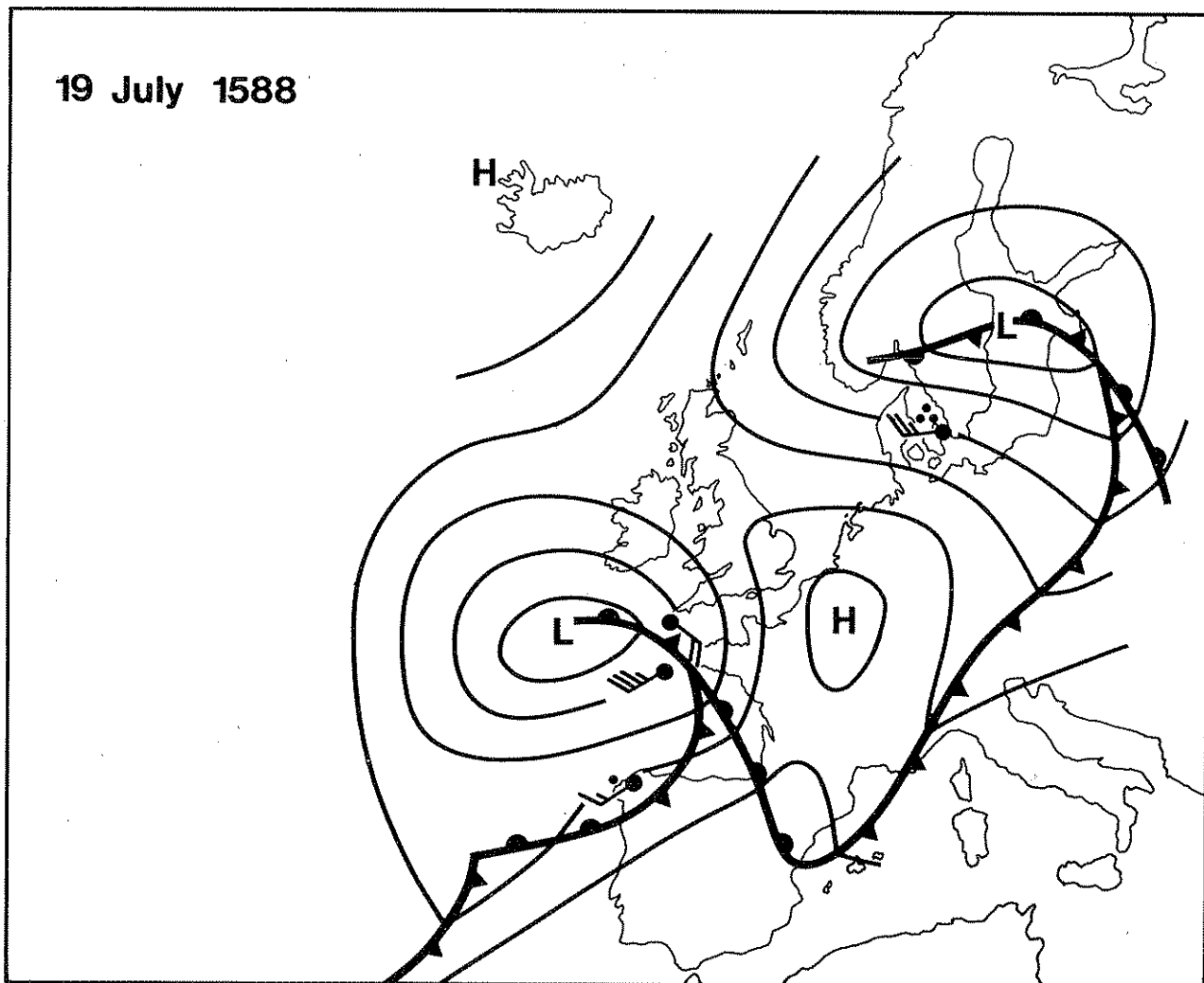
15 July 1588



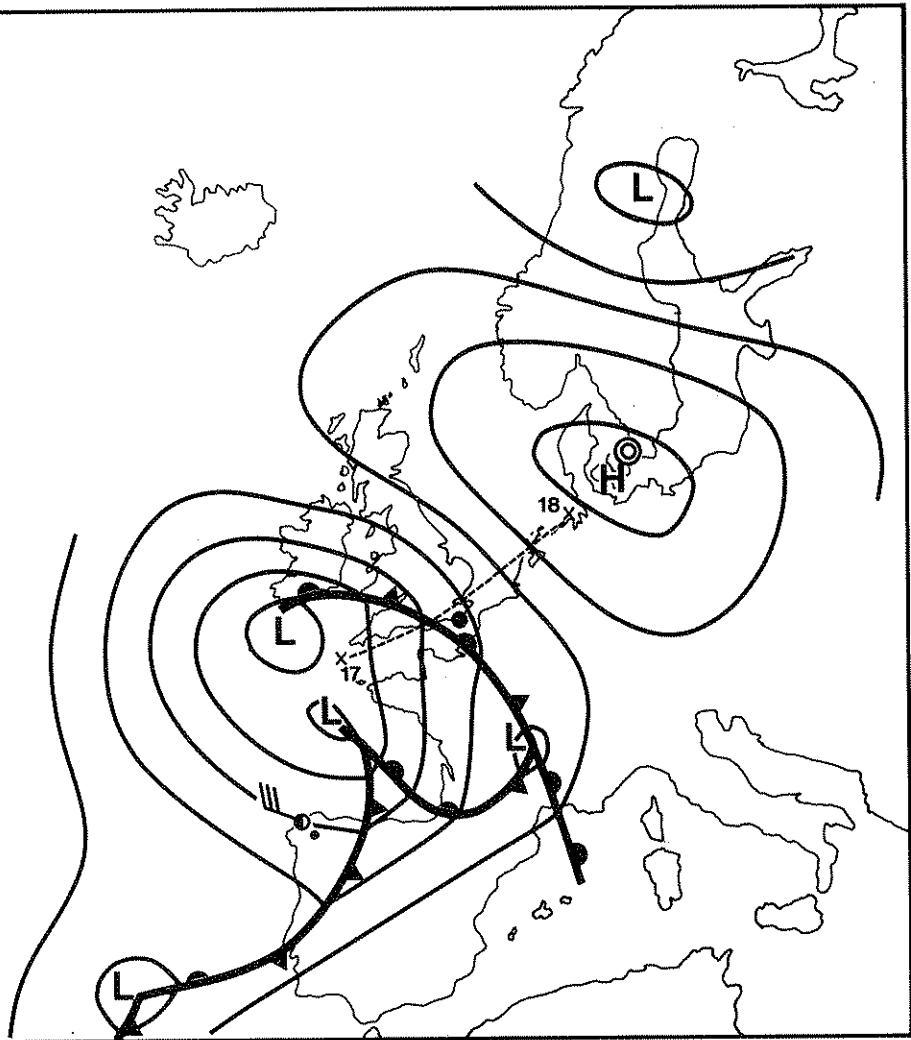
17 July 1588



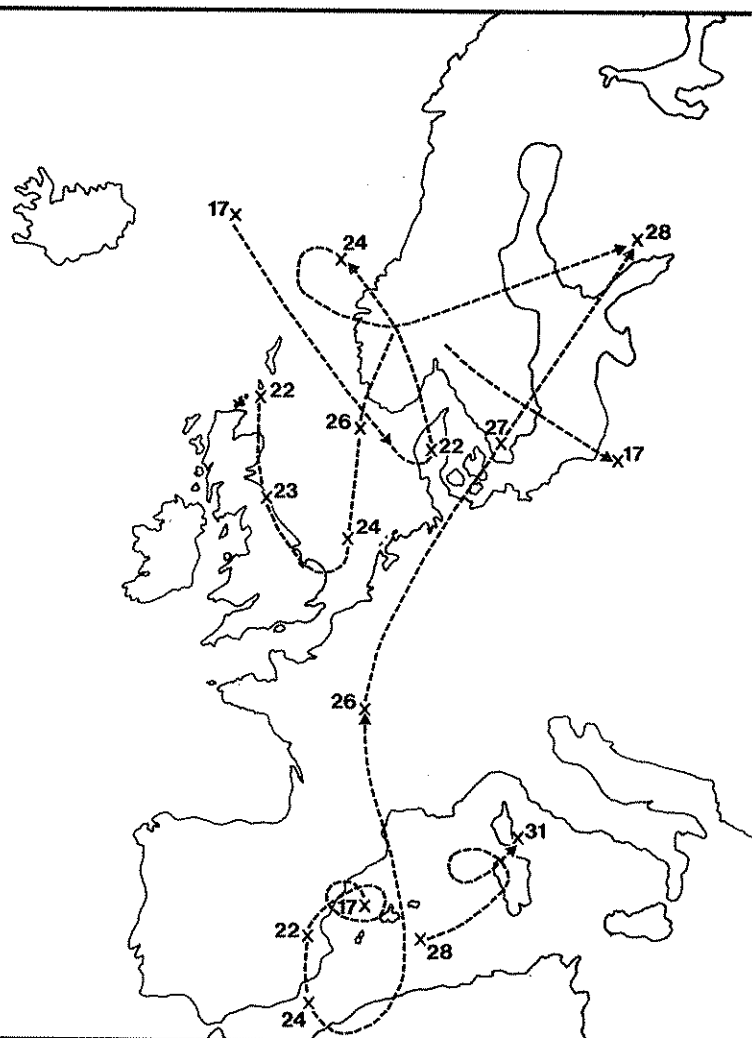
19 July 1588



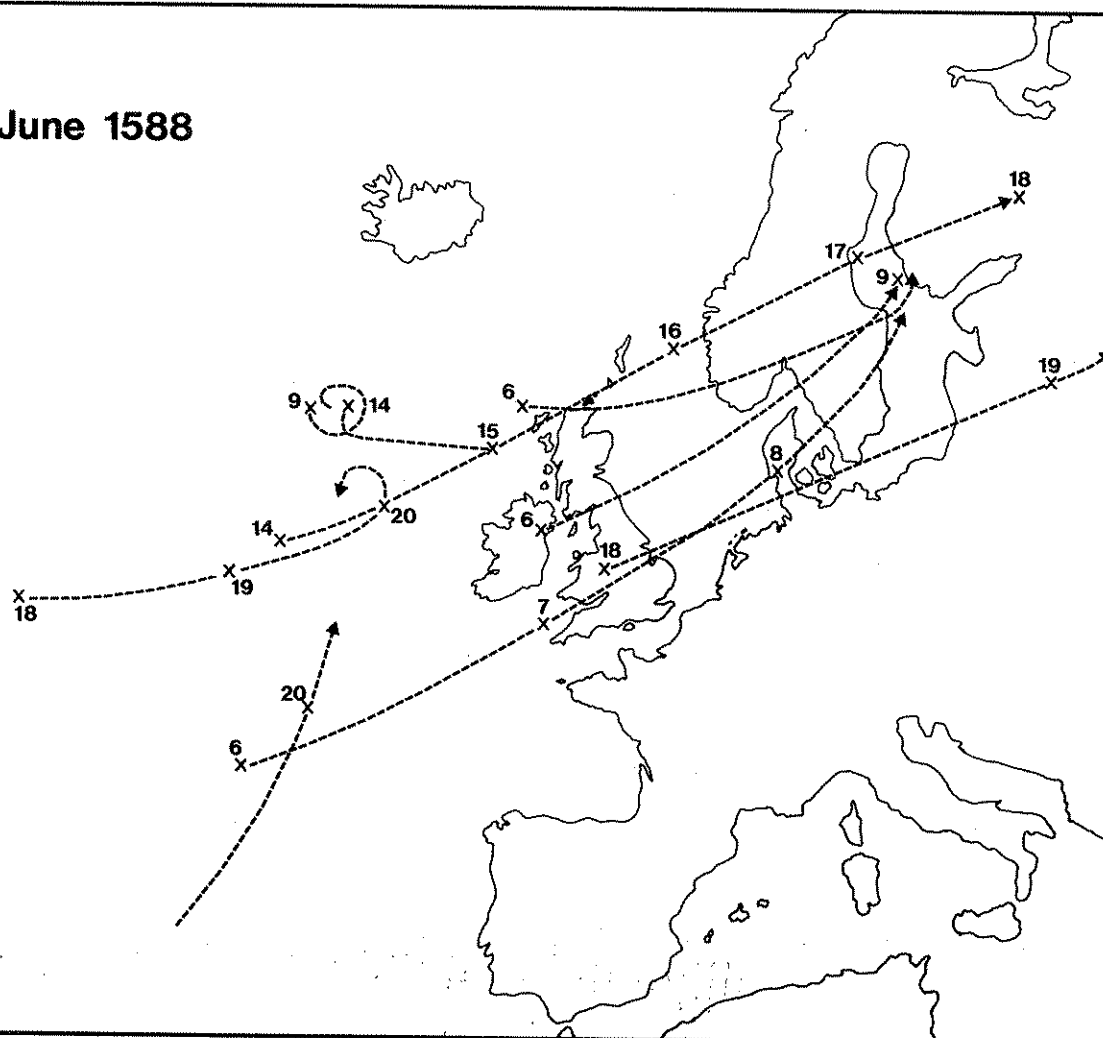
Afternoon of  
20 July 1588



**Lows**  
**17-31 May 1588**

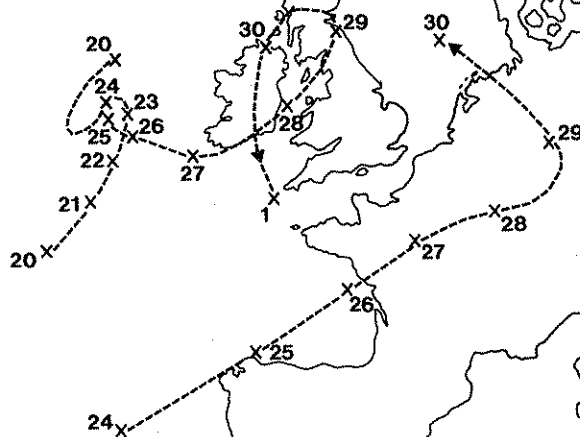


**Lows**  
**6-20 June 1588**

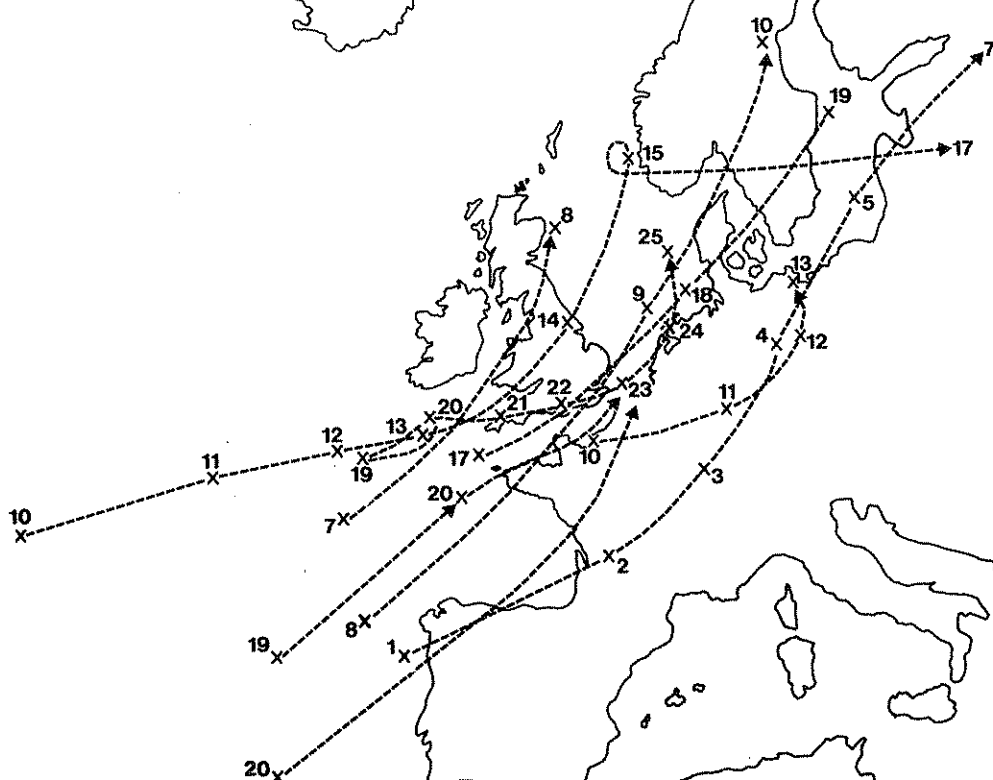




**Lows**  
**20 June -**  
**1 July 1588**



**Lows**  
**1-25 July 1588**



## Authors

K. S. Douglas

Hubert Lamb



**Climatic Research Unit  
School of Environmental Sciences  
University of East Anglia**