DEPARTMENT OF INDUSTRY AND COMMERCE
METEOROLOGICAL SERVICE

TECHNICAL NOTE No. 23

# THE USE OF SYNOPTIC WEATHER MAPS IN POTATO BLIGHT EPIDEMIOLOGY

BY

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## SUMMARY

The synoptic weather situations which lead to weather favourable and unfavourable to potato blight are discussed. The principles are then applied to the 1956 potato growing season in Ireland, U.K. and Northwest Europe, and the conclusions derived from weather maps alone are shown to be in agreement with the observed appearance and spread of the disease. The value of meteorological charts as a supplement to the different systems in use for potato blight forecasting is further illustrated by a general review of the 1952-5 seasons, and by examples which refer to Prince Edward Island, Virginia, U.S.A., and South Chile. The method provides a link between studies in blight epidemiology and advanced research work in synoptic meteorology.

## Chapter 1

## INTRODUCTION

1. In the course of papers presented by the writer at two recent international symposia on potato blight forecasting -

- Phytophthoraprognose - Konferenz held in Braunschweig, Germany on December 10th-11th, 1956 under the aegis of the Biologische Bundesanstalt fur Land - und Forstwirtschaft

- Meeting of the British Mycological Society held in London on January 5th, 1957 to discuss "The Epidemiology of Potato Blight" (Reported in "Nature", Vol. 179, No. 4554, 9th February, 1957, pp. 294-5),

a series of slides was shown to illustrate the major meteorological situations which favoured the spread of potato blight in Britain, Ireland and North-western Europe during the months June to August, 1956. In response to several requests, these diagrams are reproduced in the present note in order to permit of considered comparison with observations of the weather-disease relationship in the area covered.

2. The criteria used for defining and identifying weather favourable to potato blight differ from country to country, and often with individual workers on the problem. A number of these criteria are reviewed in a recent WMO publication (Reference 5) and others are described elsewhere (10(a), 11, 19, 22).

It is proposed, in a later note, to publish a critical review of the different approaches to defining "blight weather". For the present purpose, we proceed on the assumption that, irrespective of its relative merit, each of the systems in use contains, at least for the area in which it is applied, some kernel of the truth.

We may, for our purpose, divide weather situations into three categories:-

(a) those giving conditions markedly favourable to the spread of potato blight i.e. prolonged moist and humid weather

(b) those giving conditions quite unfavourable to the disease i.e. prolonged dry and sunny weather

(c) those giving intermediate conditions.

Any reasonable criteria should give positive indications for (a) and negative for (b). It is in the case of intermediate conditions, which may be of importance for a slow but significant spread of the disease, that the different systems normally give inconsistent results.

Irrespective then of the criteria in use in any area, synoptic weather analysis may be used to investigate the major situations favourable and unfavourable to the progress of the disease in each growing season. This is illustrated in Maps 6 to 11 which show the meteorological systems which produced the main periods of "blight weather" in NW Europe during the months June-August 1956. In this "blight year" there were no lengthy periods of markedly unfavourable weather over the entire area in question. This did not apply in other years (e.g. 1955). Indeed in many seasons the date and duration of completely unfavourable spells of weather have a marked influence on the progress of blight. There has been a tendency in some quarters to concentrate entirely on the analysis of the highly favourable periods, a procedure which, in some years and areas, leads to an incomplete picture of the development of the disease.

3. In the Blight Warning Service which is operated by the Meteorological Service in Ireland, full use is made of synoptic charts. (4). The Irish criteria for indentifying "blight weather spells", which are described in full in the listed publications, are not relevant to the present discussion. Warnings are not based directly on the reports of "blight weather" at individual stations. These reports are passed to the Central Office, where the corresponding causal agency in the general meteorological situation is identified from the weather maps, and the limits of geographical distribution and probable duration of the blight-weather spell are deduced. In other words, the synthesis of the individual reports into a coherent picture is carried out with the help of synoptic weather maps. The issue of warnings is based on the sequence of spells which have occurred to date and on the expectation of recurrence of the kind of situation which gives weather favourable for blight.

4. Although weather maps are not used in potato blight forecasting in England and Wales, the procedure employed there has developed empirically in what is basically the same direction. (13, 14). The individual "warning periods" are charted and mapped at a central office, and greater weight is given to a widespread "flush" of warnings, which is, of course, the reflection of a major favourable meteorological factor in the general weather situation.

Nevertheless in Britain, and even more so on the Continent, there has been some reluctance to accept a suggestion that synoptic weather charts could usefully be employed as a supplement to whatever blight forecasting criteria are employed. One of the most frequent objections is that, whilst the methods might be applicable in Ireland to relatively fresh and simple weather systems coming directly from the Atlantic, the more complex pressure patterns and terrain differences over the land areas of Europe did not readily lend themselves to such an approach.

5. In an effort to show that these difficulties were not insurmountable, the major "blight-weather" situations affecting Ireland in 1956 were extrapolated, using weather charts only, into England and Wales. The resulting analysis for Britain was essentially the same as that shown in maps 6 to 11, except that the system affecting Eastern England on June 8-12 (Map 6) was omitted since it did not influence any part of Ireland. The extrapolation, prepared without any prior knowledge of favourable periods or disease progress during the season outside of Ireland, was discussed at an informal meeting at Harpenden, England, in August 1956, and the deductions based thereon, including mean dates for blight appearance in different parts of England and Wales, showed a remarkable measure of agreement with the observed facts.

6. With this encouragement, the analysis was afterwards extended to cover Northwest Europe, and Maps 6 to 11 in the same form as herein reproduced, were presented at the Braunschweig and London Meetings in December 1956-January 1957. Standard surveys of plant diseases of the kind carried out in England and Wales are not in operation in most countries. However the deductions shown on the charts checked well with those of individual German workers and, in particular, with the observations of Dr. M. Unruh (Bonn) in the Rheinland.

The present publication is intended primarily to permit a more leisurely and widespread comparison of the charts with observations in different areas. The writer will be grateful for any comments sent to him at the Irish Meteorological Service, 44 Upper O'Connell Street, Dublin.

7. The plant pathologist who is not working in close cooperation with a meteorologist has a natural difficulty in dealing with modern weather map analysis. The introductory remarks on the principles of Air Mass Analysis which were included in the spoken lectures are not reproduced here. However the recently issued fourth edition (1956) of the "Weather Map" (M.O. 595), produced by the British Meteorological Office and published by H.M.S.O. at 10s. 6d., provides in concise and excellent form (particularly

in Chapter 6) all that it is necessary to know in order to interpret meteorological charts. A more elementary account is given in Chapter 1 of "Weather and the Land", Bulletin No.165 of the (British) Ministry of Agriculture Fisheries and Food, published in 1955 by H.M.S.O. at 3s. 0d. A broad knowledge of this kind is assumed in the following chapters.

## Chapter 2

## SYNOPTIC WEATHER SITUATIONS AND BLIGHT

1. Experience in Ireland over a number of years shows the following synoptic situations to be those which normally give the most important periods of weather favourable for the development of potato blight in that area

(a) Open warm sectors of Maritime Tropical Air, particularly where a sequence of waves is involved

(b) Stagnant or slow-moving depressions giving lengthy periods of wet overcast weather

(c) Active quasi-stationary fronts giving similar weather

Other synoptic situations may give rise to favourable situations of lesser duration or affecting limited areas. The penetration inland of wet sea fog is often associated with the presence of Maritime Tropical Air. A siuation of significance for the western seaboard but of less importance elsewhere is that of a westerly weather sequence, with a quick succession of frontal troughs uninterrupted by direct cold air outbreaks, so that cloudy and humid weather is virtually continuous on the coast and rainy spells are frequent. A situation rare in Ireland but possibly more important elsewhere is that in which an area is caught in a pincer movement between two fronts, more or less parallel, approaching from opposite directions. This situation might be regarded as a particular but important case of (c) above.

2. The most important weather situations giving weather which hinders blight development are -

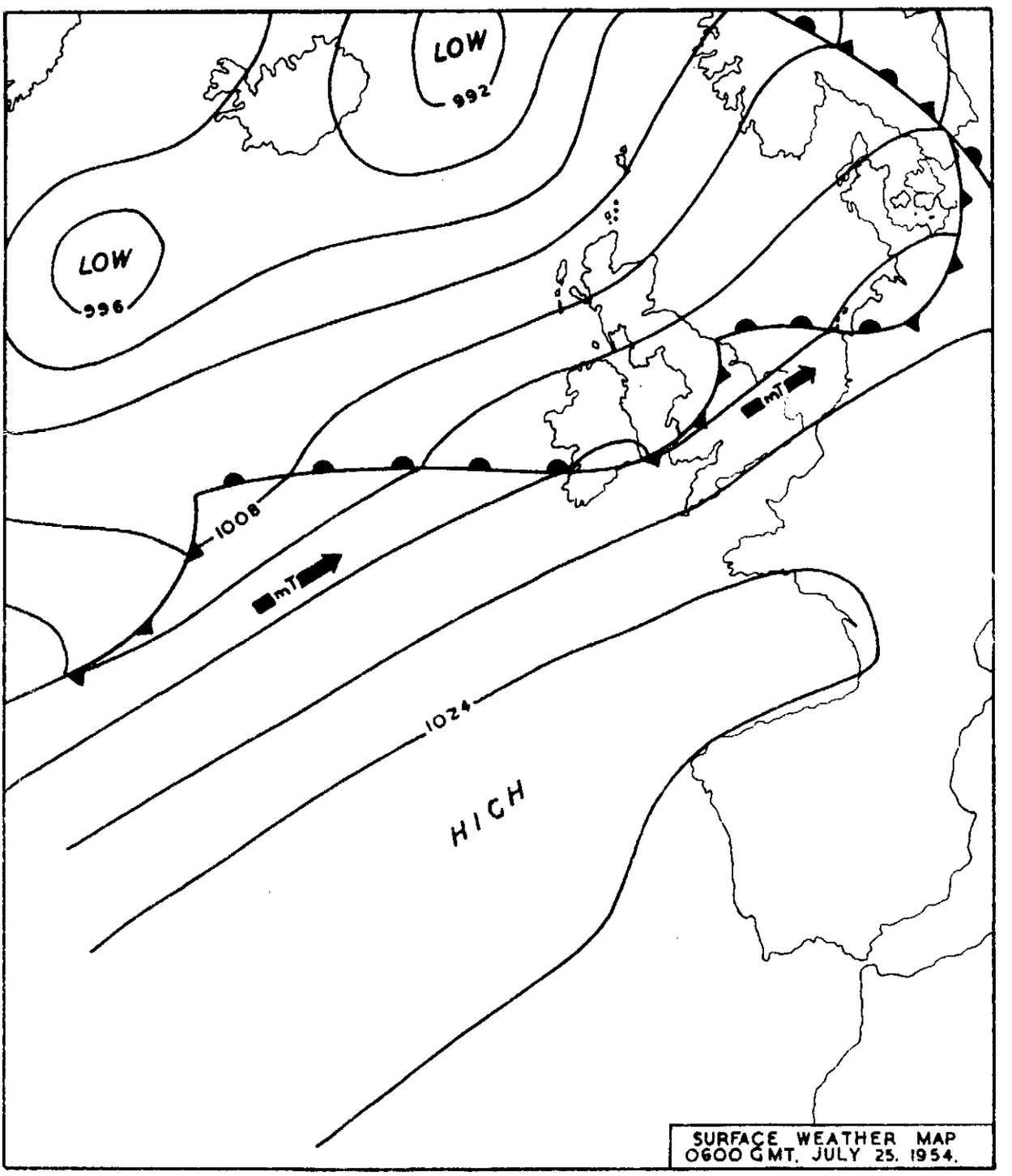
(d) Anticyclonic or ridge conditions, accompanied by dry sunny weather

(e) A direct break-through of a Northerly current of cold air from the Arctic regions following a depression. This shuts off the westerly sequence and, though it normally gives wet and showery weather, the occurrence also of bright periods creates conditions different from the muggy overcast weather most favourable to the spread of blight infection.

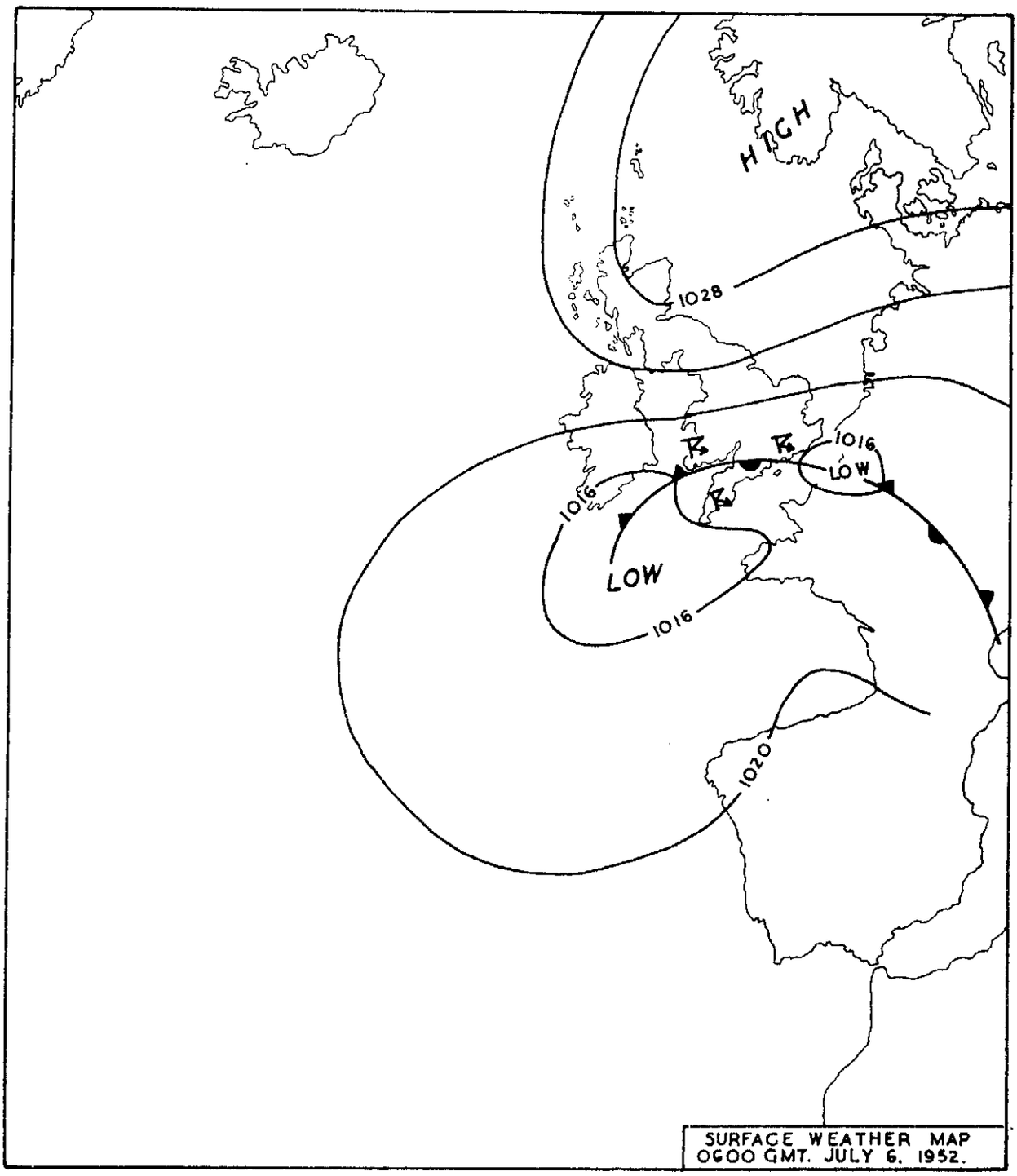
In the following paragraphs, the five synoptic situations of major importance to blight epidemiology are considered in greater detail, with the help of examples taken from the growing seasons 1952-5.

### 3. MAP 1 : WAVES OF MARITIME TROPICAL AIR

Maritime tropical air as it reaches Northwest Europe in Summer normally gives ideal conditions for the development of blight:- high humidities, overcast skies with rain or drizzle, and temperature of the order of 12 - 16°C.




Map I. Waves of maritime tropical air.




Map 2. Slow-moving or stagnant complex ("puddle") low.

A single wave, unless slow moving and with a very open warm sector, usually gives rise only to a limited period of "blight weather"; a sequence of waves can, however, lead to very lengthy spells.

The illustration Map 1 (Surface Weather Map for 0600 GMT, 25th July, 1954) shows a series of three waves of Maritime Tropical Air extending across Germany, the Low Countries, England, Wales and Ireland to the Atlantic. The corresponding "blight-weather" (period July 22nd-26th, 1954) was important over a wide area. The third spraying warning in Ireland in the 1954 season was issued in connection with this system on July 23rd. In addition to Ireland, virtually the whole of England and Wales was affected (14, 19, 8) and, as a result of this and earlier favourable weather "the range of outbreak dates was from July 25th to August 7 over a wide area" (14). In Scotland, 'Beaumont periods' at this time (July 22nd - July 26th) were noted at Dunblane, Strathallan, Renfrew, West Freugh, Prestwick and Auchincruive. "Epidemic development of blight indeed followed within a reasonable time after this widespread forecast in all parts of west Scotland. It first appeared in Auchincruive on 4 August, some 11 days after the Beaumont period" (7b). The period was also noted by van der Zaag (23) working in Noord-Brabant in Holland; there, "on August 1 the disease had spread throughout the province". Uhlig's data for Germany (22) show that the period showed up at Bonn, Giessen, Hannover, Würzburg and other German stations.

So extensive a penetration of active mT waves across the land mass of Britain into continental Europe, although a recurrent feature of the "bad summer" of 1954, is not frequent in normal years. In most years, however, one or two waves, skirting the South Coast of Ireland, pass up the Channel into the North Sea and give weather favourable to blight in limited coastal areas of South Ireland and South England, North France, Belgium, Holland and North Germany. If such a disturbance takes a slightly more Northerly track up the Bristol Channel (see Map 10), it will affect a much wider area in Britain, with corresponding lesser effect on continental Europe.

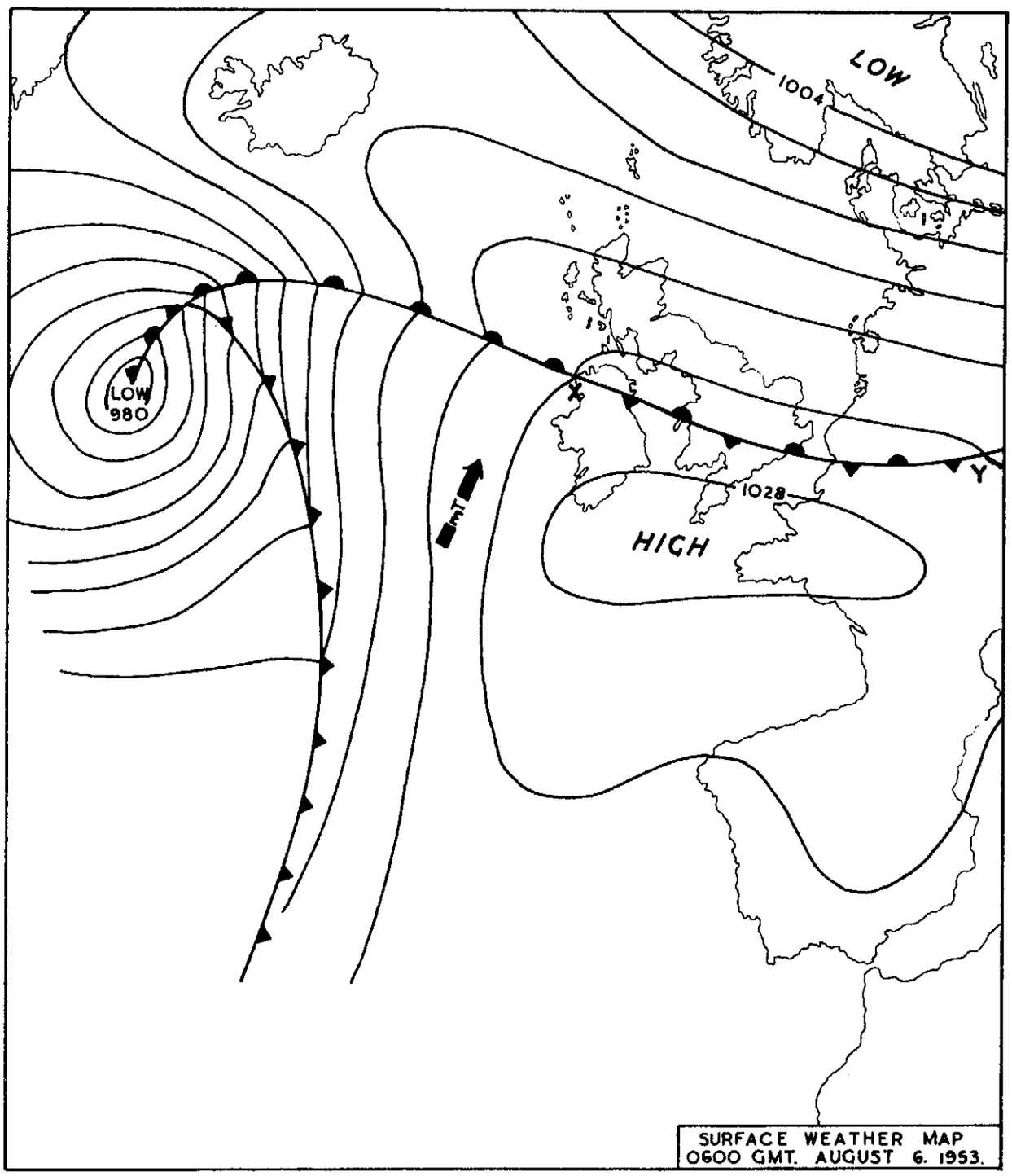
It is much more usual, however, for these waves to follow a SW to NE track, with the apex of the waves to the West of Ireland (For typical examples, see Charts 10 and 11 of (4b) and Charts 47, 50 and 54 of (4c)). The main impact of "blight-weather" in such situations is on the windward shores (SW England, South and West Ireland, West Scotland) and the regularly heavier impact of blight in these areas is a reflection of the frequency of the weather-type. Indeed in a season dominated by this kind of situation (e.g. the Summer of 1952 in Great Britain and Ireland), the disease is of significance only in western coastal areas and unimportant in the Midlands and East (4b, 13).

## 4. MAP 2 : SLOW MOVING OR STAGNANT COMPLEX ("PUDDLE") LOW

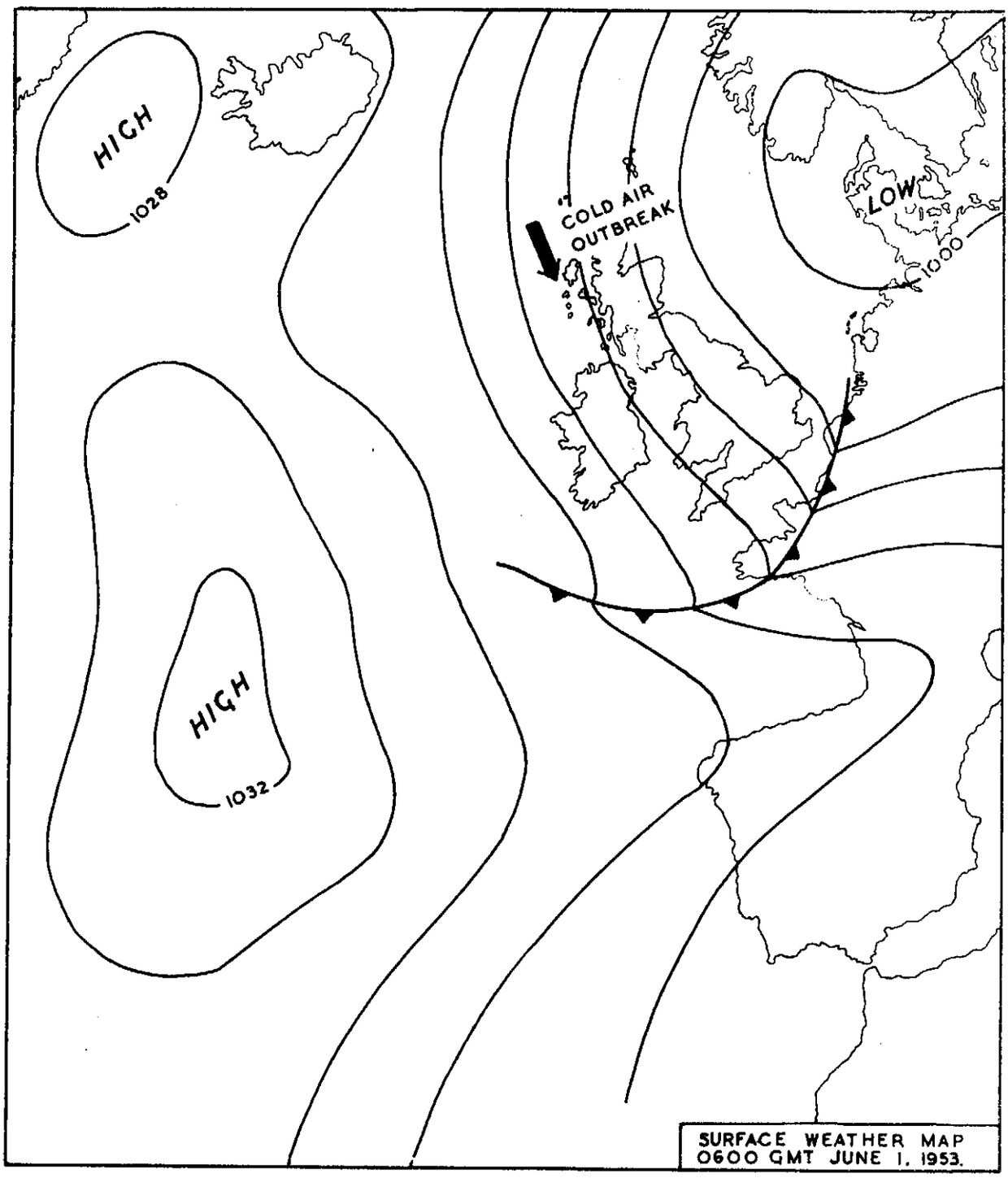
Whilst the effect of mT waves is normally heaviest on the westerly areas, particularly Ireland, which receive the first impact, the importance of the stagnant "puddle" depression is usually greatest further east. It is, primarily, a "continental" rather than a "maritime" phenomenon.

The presence of mT air is not essential to make a "puddle low" effective for blight stimulation. The temperature level in this situation in Summer in NW Europe is almost always close to the optimum for the disease and the persistent rainfall arising from convergence maintains a high level of humidity. Frequently ill-defined quasi-stationary fronts are associated with the stagnant depression. The air is usually unstable, in contrast to mT waves which are markedly stable, and, particularly in the later stages of the puddle low, widespread outbreaks of thunderstorms are not uncommon.

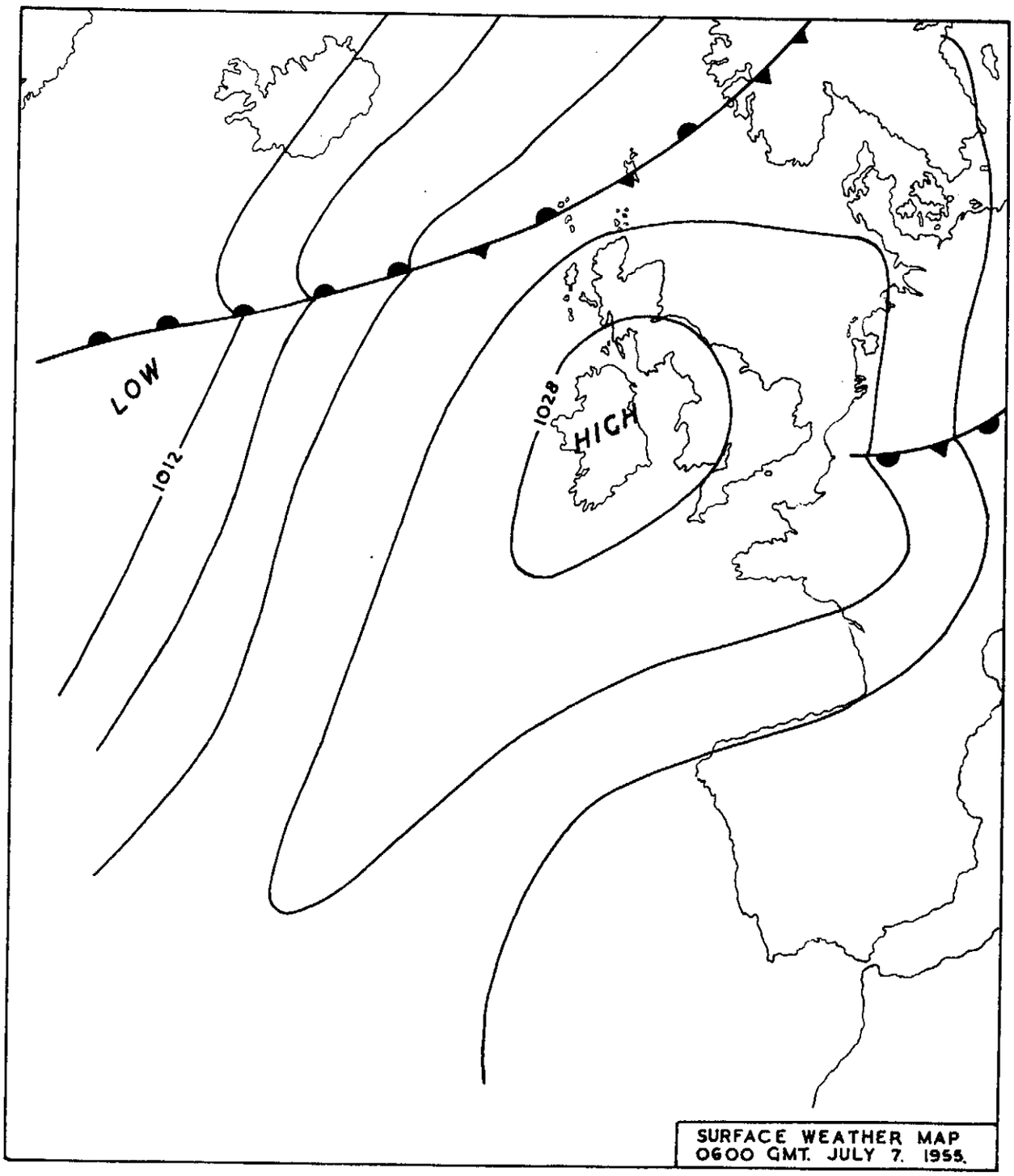
The illustration (Map 2) shows the surface weather map for 0600 GMT, 6th July, 1952. A meandering thundery low moved North from the Bay of Biscay on July 6th, merged with an Atlantic system on the 7th and continued slowly Northwards across Ireland on the 8th. It gave rise to lengthy periods of "blight weather" in South and East Ireland, Southwest England, Wales, North England and Scotland (4b, especially Chart 12; 13 and 7a).




Map 3. Active quasistationary front (section XY)




Map 4. Cold air outbreak and 'blocking' situation.




Map 5. Anticyclonic or ridge situation.

An example of far greater extent and duration occurred in 1956 (Map 9) and will be discussed in the next chapter.

## 5. MAP 3 : ACTIVE QUASI-STATIONARY FRONT

This is normally of much lesser over-all importance than either of the two previous situations, mainly because it affects only a limited area on either side of the front. Usually, too, it can be treated as an off-shoot of one or other of the two main favourable situations, since one of the airmasses separated by the front is often Maritime Tropical and since the quasi-stationary front may, in the more active cases, be associated with a stagnant trough or depression.

Thus in the example (Map 3 : Surface Weather Map for 0600 GMT, 6th August 1953), the quasi-stationary front XY is linked with a Maritime Tropical warm sector to the West and the corresponding "blight weather" at a number of British stations (14, 19) could be regarded as an extension of the considerable periods in Ireland due to the broad current of mT air (4c).

This particular situation (August 4th-9th, 1953) is discussed in some detail in reference 4c, pages 9, 11-12. It is interesting to note that the sharp rise in blight intensity in Ireland in mid-August which was due to this situation is also shown in the blight progress curve for the Bristol area published by Large ((14), page 43, figure 4).

## 6. MAP 4 : COLD AIR OUTBREAK AND 'BLOCKING' SITUATION (UNFAVOURABLE)

Any lengthy period of weather quite unfavourable to blight is important not only in following the progress of the disease but also in the timing of spray warnings. A complete check to the spread of the disease, often lasting 4 - 7 days or longer, occurs when a depression is followed by a direct northerly break-through of cold polar air.

The illustration (Map 4: Surface Weather Map for 0600 GMT, June 1st, 1953) shows a typical example which led to unfavourable weather over the U.K. and Ireland up to June 9-10. A corresponding feature worthy of note is the building-up of an anticyclonic barrier stretching from North to South in the Eastern Atlantic. This 'blocking action' (21) shuts off westerly weather sequences from NW Europe and prevents the direct influx of mT air for some time. In the case illustrated the next Atlantic depression to affect Ireland arrived on June 14th-15th.

'Blocking action' may be caused not only by high pressure areas but also, for example, by a cold stationary depression to the west of Ireland which diverts warm and active lows to the South of the country. The sheltering effect in this case will, however, normally be limited and the diverted lows may give appreciable 'blight weather' in continental areas.

The duration and extent of the weather unfavourable to blight caused by a situation of the type shown in Map 4 varies considerably with the pressure configuration and with the limits of the Southwards sweep of cold air, which is often blocked at the Pyrenees or Alps. In the case under consideration, the first break occurred in South France on June 6th, 1953. By June 10th, a slow-moving depresssion had moved NE and was centred over South Germany. By June 11th-13th, the system had degenerated into a stagnant puddle low affecting the North Sea coasts and Eastern England (14, 19, 22, 23).

## 7. MAP 5: ANTICYCLONIC OR RIDGE SITUATION (UNFAVOURABLE)

The hot, dry and sunny weather associated with anticyclonic conditions in Summer is obviously markedly unfavourable to blight.

In the situation shown in Map 5 (Surface weather map for 0600 GMT, 7th July 1955) inland weather conditions were hostile to the disease throughout the U.K. and Ireland, as indeed they were in similar situations throughout most of the Summer of 1955.

However, even in this situation, favourable conditions for blight can occur on the periphery of the high-pressure system, in coastal areas close to the trailing end of frontal systems and with on-shore winds, particularly if wet sea fog is present.

## Chapter 3

## THE 1956 POTATO SEASON (MONTHS JUNE TO AUGUST)

1. The six major synoptic weather situations giving "blight-weather" in NW Europe in the months June, July and August, 1956 are illustrated in Maps 6 to 11 inclusive. To save space the marginal months of May and September have not been considered; these, of course, would be required for a fuller analysis. How these maps came to be drawn has already been described in Chapter 1.

Each surface weather map is for a fixed time more or less centrally situated in the corresponding period of "blight weather." Isobars are drawn for 4 mb. intervals. Fronts are shown in the conventional way. Where relevant, the track of a depression or wave centre is indicated by a broken line with arrow heads.

Since few plant pathologists have direct and continuing access to a weather analysis centre, the weather charts consulted for the present purpose have been deliberately restricted to those published for general use by the British and West German Meteorological Offices - the "Daily Weather Report" and "Taglicher Wetterbericht" respectively. Many refinements could be introduced by using the far wider range of detailed charts, including hourly maps, available in a modern meteorological office. However the purpose of the present paper is to illustrate that even an approximate and relatively crude approach leads to conclusions of value in blight epidemiology.

Corresponding to each weather map of the 1956 series is a chart showing the approximate limits of "blight weather" arising from the situation. The entire area affected is hatched on these charts; cross-hatching shows the region considered to have been most seriously affected. The outer limits have been assessed from the area of prolonged precipitation, the activity of the system and the direction of wind relative to coastlines. An indication is given where discontinuous "spots" are expected to have occurred in favourable districts outside the main area. No allowance for topography has been made over Continental Europe. The only data regarding 'blight-weather' and disease impact available when the charts were drawn was in respect of Ireland (for the entire season) and for England (up to early August).

The periods shown on the "blight-weather" charts cover the entire term of activity of the system and do not necessarily apply to every part of the area shown. Further details are given in the remarks on each situation which follow.

2. MAP 6: PERIOD JUNE 8th-12th, 1956

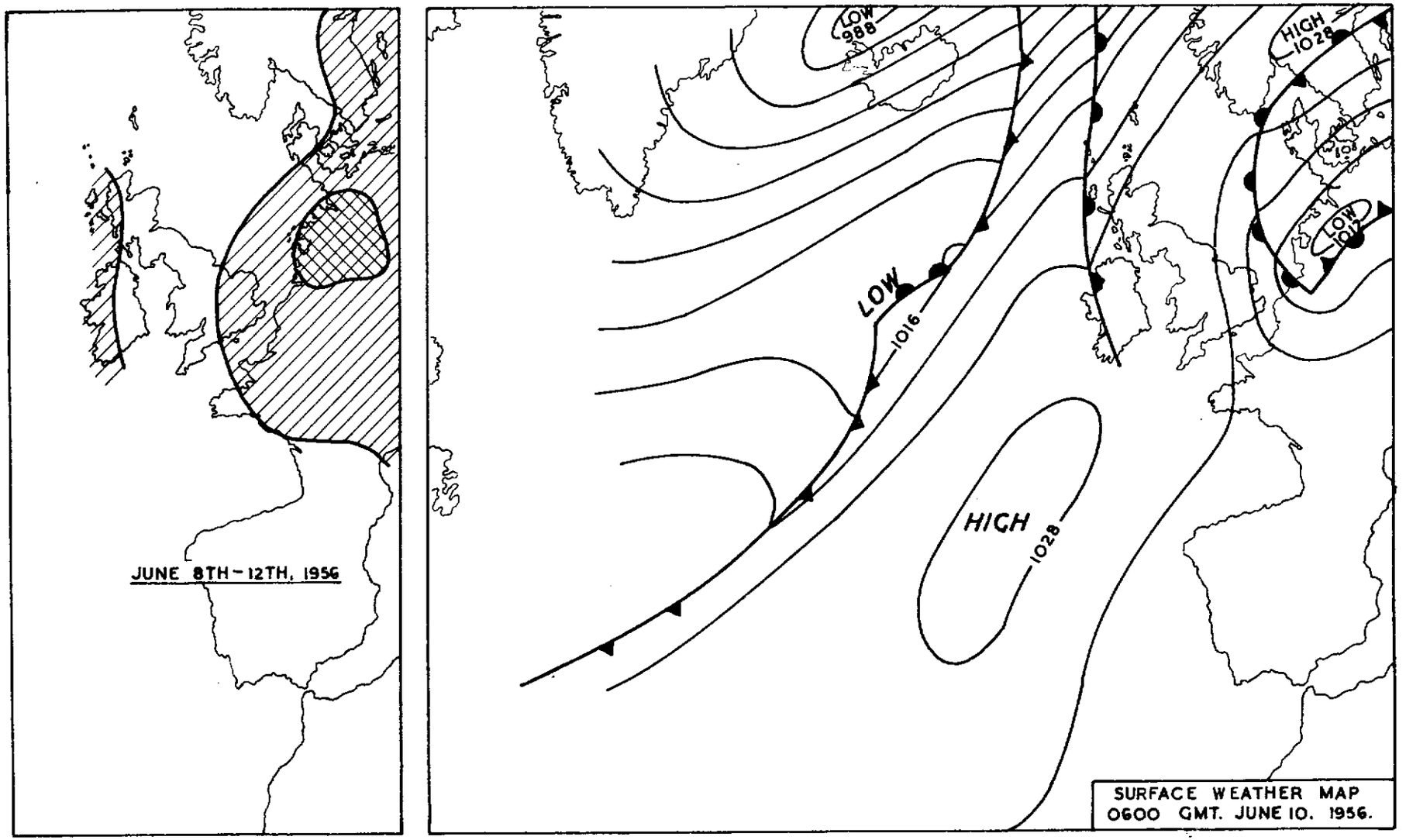
Two distinct systems appear on this map. The Irish and Scottish west coasts experienced fairly substantial periods of "blight-weather" under the influence of a quasi-stationary front with Maritime Tropical air behind. Completely separated from this pressure system was a complex low over NW Europe which had originated as a wave on a quasi-stationary front in Germany, and which gave persistent rain over a wide area. The zone of blight weather extended to SE England, but a substantial part of the U.K and Ireland was affected neither by the European nor the Atlantic system.

3. MAP 7: PERIOD JUNE 16th-21st, 1956

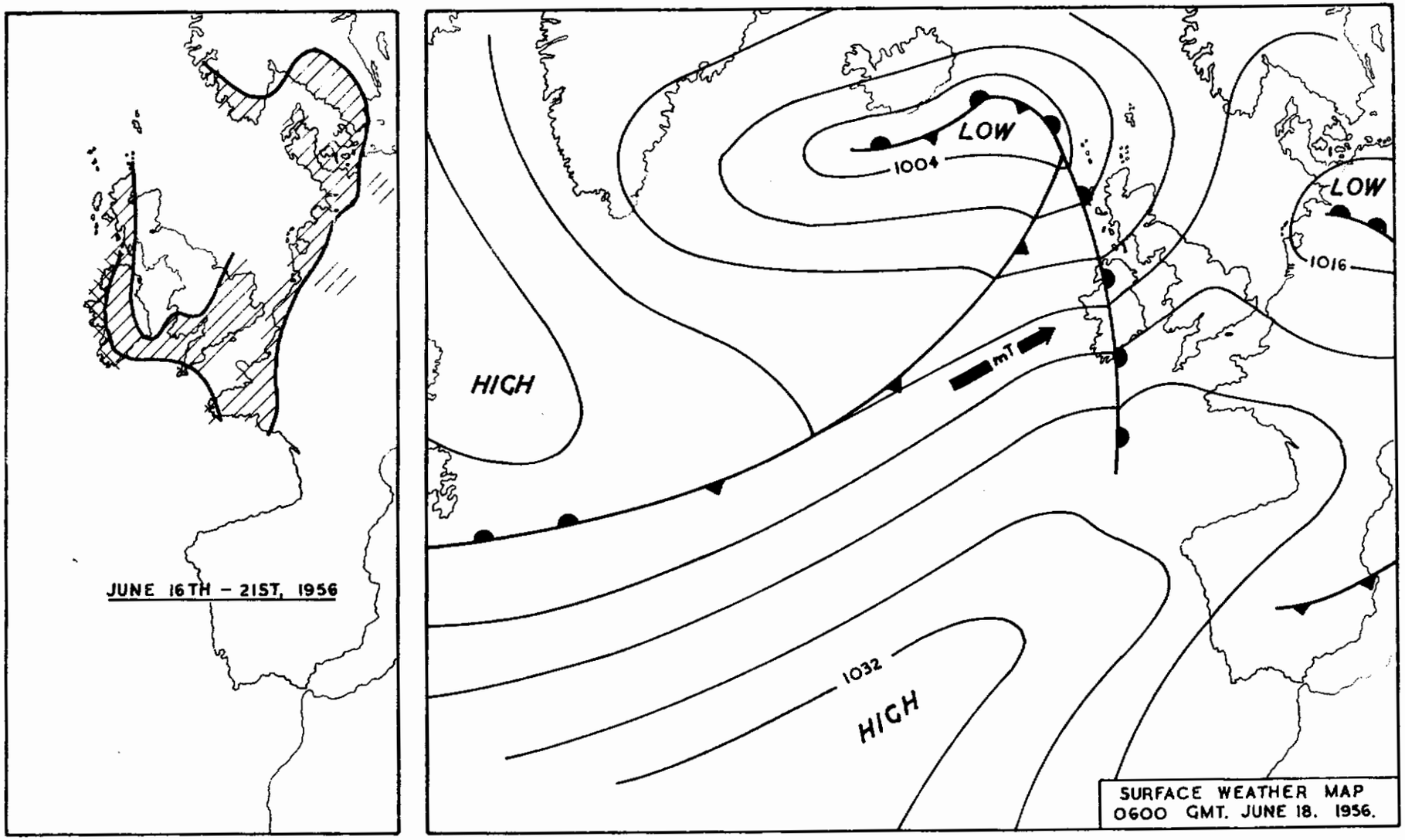
This case involved a series of depressions with warm sectors of Maritime Tropical air. The first, partially visible to the right of the map, moved on 16th-17th along the South coast of England, affecting surrounding coasts and East England, and filled up in North Germany. The second wave (see Map 7) followed a much more Northerly track and affected mainly Ireland and West Scotland; the same areas were influenced by the slow-moving Warm Front of a third depression on June 20th-21st.

4. MAP 8: PERIOD JULY 4th-12th, 1956

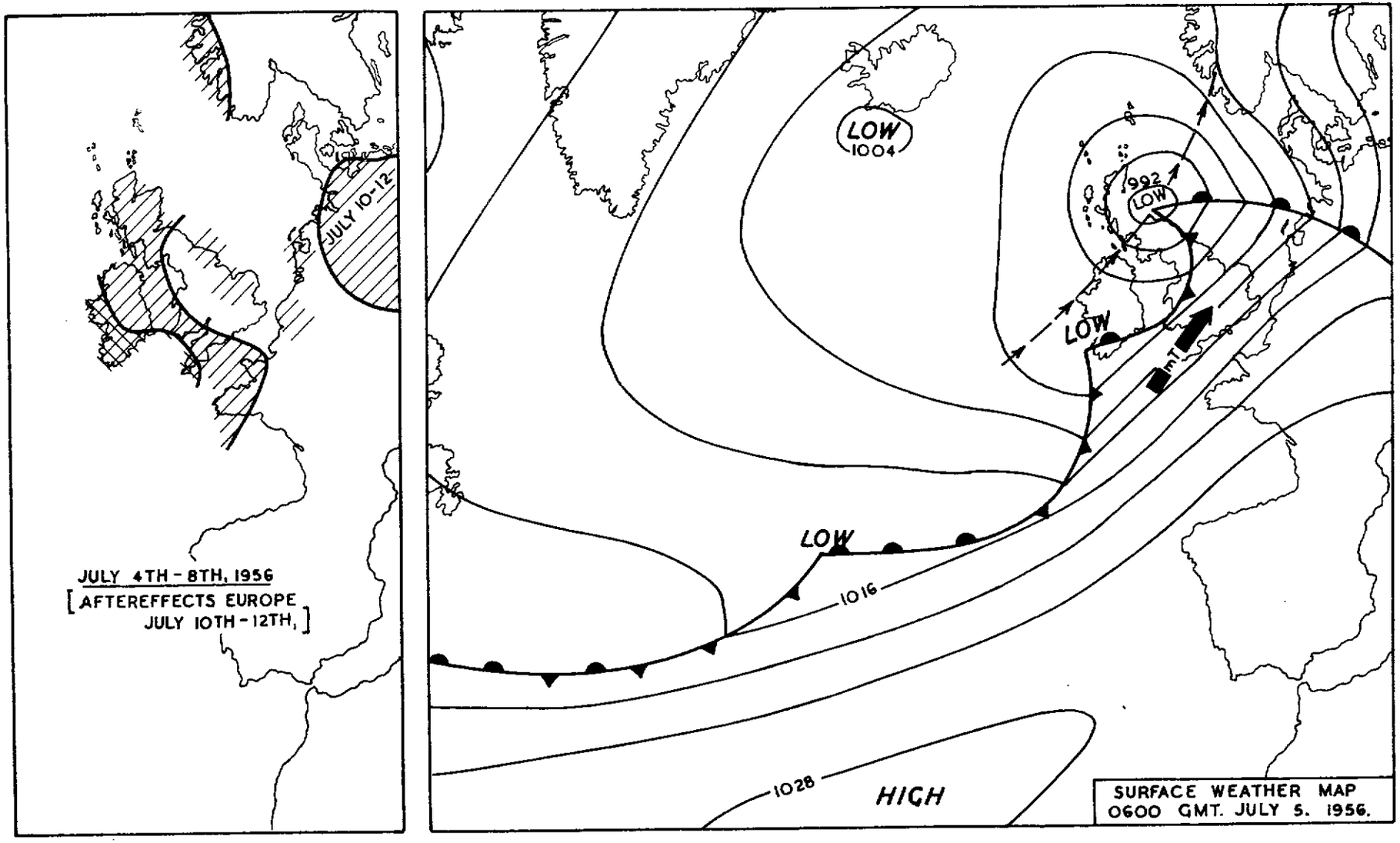
This represents a classical case of a series of five waves of Maritime


JUNE 8TH - 12TH, 1956
LOW
988
HIGH
1028
LOW
1016
HIGH
1028
LOW
1012
SURFACE WEATHER MAP
0600 GMT. JUNE 10. 1956.

Map 6.


JUNE 16TH – 21ST, 1956
LOW
1004
LOW
1016
HIGH
mT
1032
HIGH
SURFACE WEATHER MAP
0600 GMT. JUNE 18. 1956.

Map 7.


JULY 10-12
JULY 4TH - 8TH, 1956
[AFTEREFFECTS EUROPE
JULY 10TH - 12TH,]
LOW
1004
992
LOW
LOW
LOW
1016
1028
HIGH
SURFACE WEATHER MAP
0600 GMT. JULY 5. 1956.

Map 8.

Tropical Air. The first wave moved rapidly NE from the South of Ireland. The next three waves are shown on Map 8. In view of the rather southerly track, appreciable areas of the U.K. and Ireland were affected but, as usual with disturbances moving in a Northeasterly direction, the heaviest impact was on the West and South coasts of Ireland and on SW England. June 6th represents a lull in most areas and the period ended on July 8th in Ireland/England. The lull on the Continent, which, outside of Norway, had not been seriously affected by the earlier waves, lasted from July 6th to 9th, but on July 10th, the final cold front of the system developed a new wave in the Rheinland which gave favourable weather in Germany on July 10th-12th.

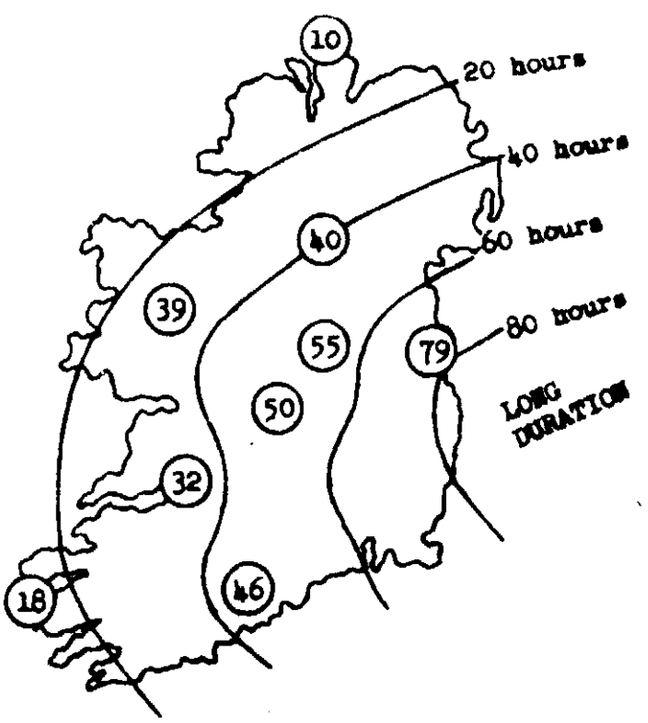
5. MAP 9: PERIOD JULY 13th-18th, 1956

Immediately following an excellent example of a train of MT waves came the best example in recent years of a blight-stimulating 'puddle low.' It was particularly remarkable for the extent of the area which came under its influence.

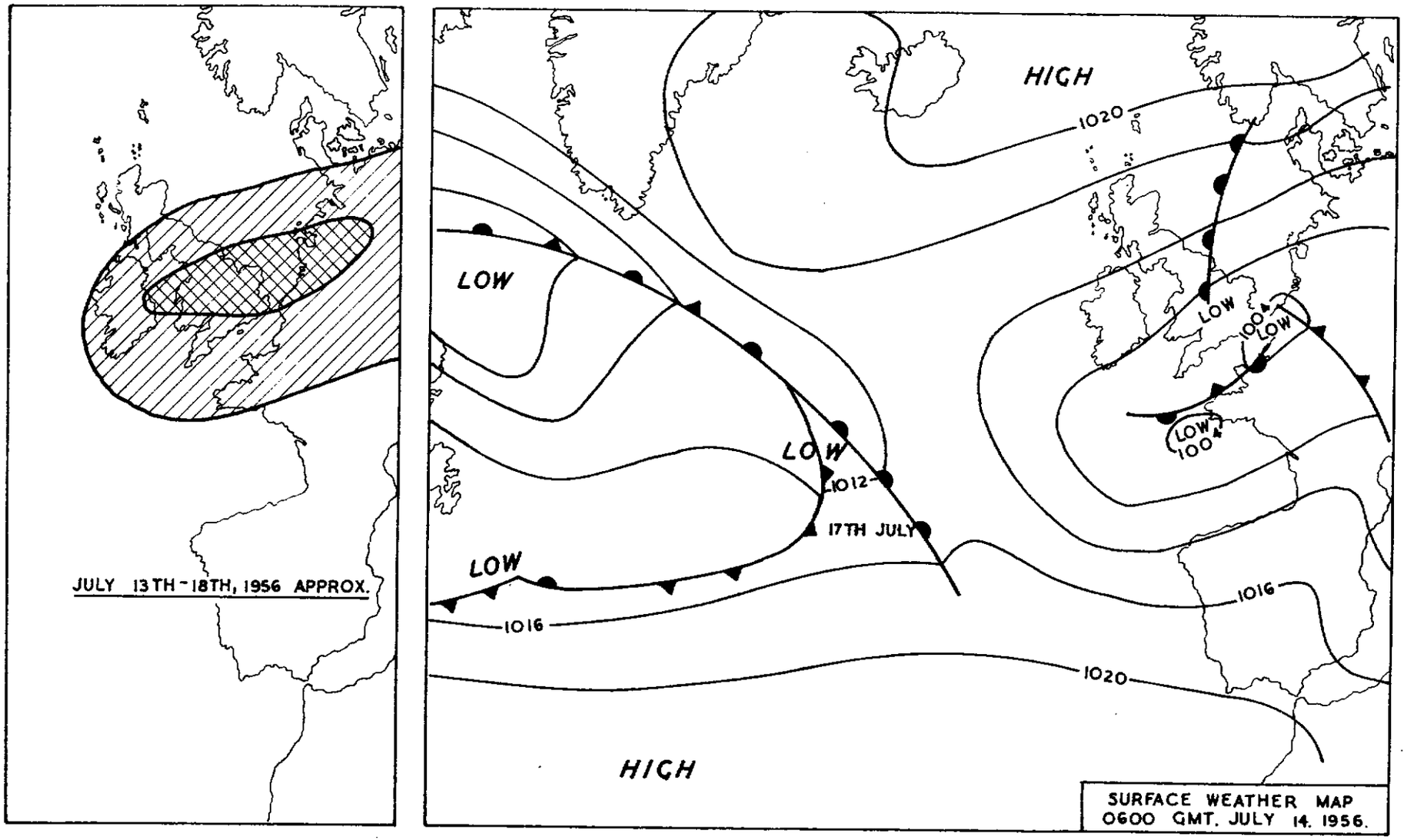
On July 13th, the old Cold Front of the preceding system regressed as a Warm Front from the Continent, affecting the English East and South coasts as well as neighbouring continental areas. By July 15th-16th, the active belt associated with the complex low pressure area extended across Ireland, England, North France, Low Countries and Germany as far as Poland. On July 17th a new Atlantic low joined the system which by then was filling up in Europe.

Over most of the area affected, this was not only the most important spell in the 1956 season, but also one of best-marked periods of any recent year. In England it led to the most complete and decisive flush of warnings that had occurred in any year since full records are available (1950).

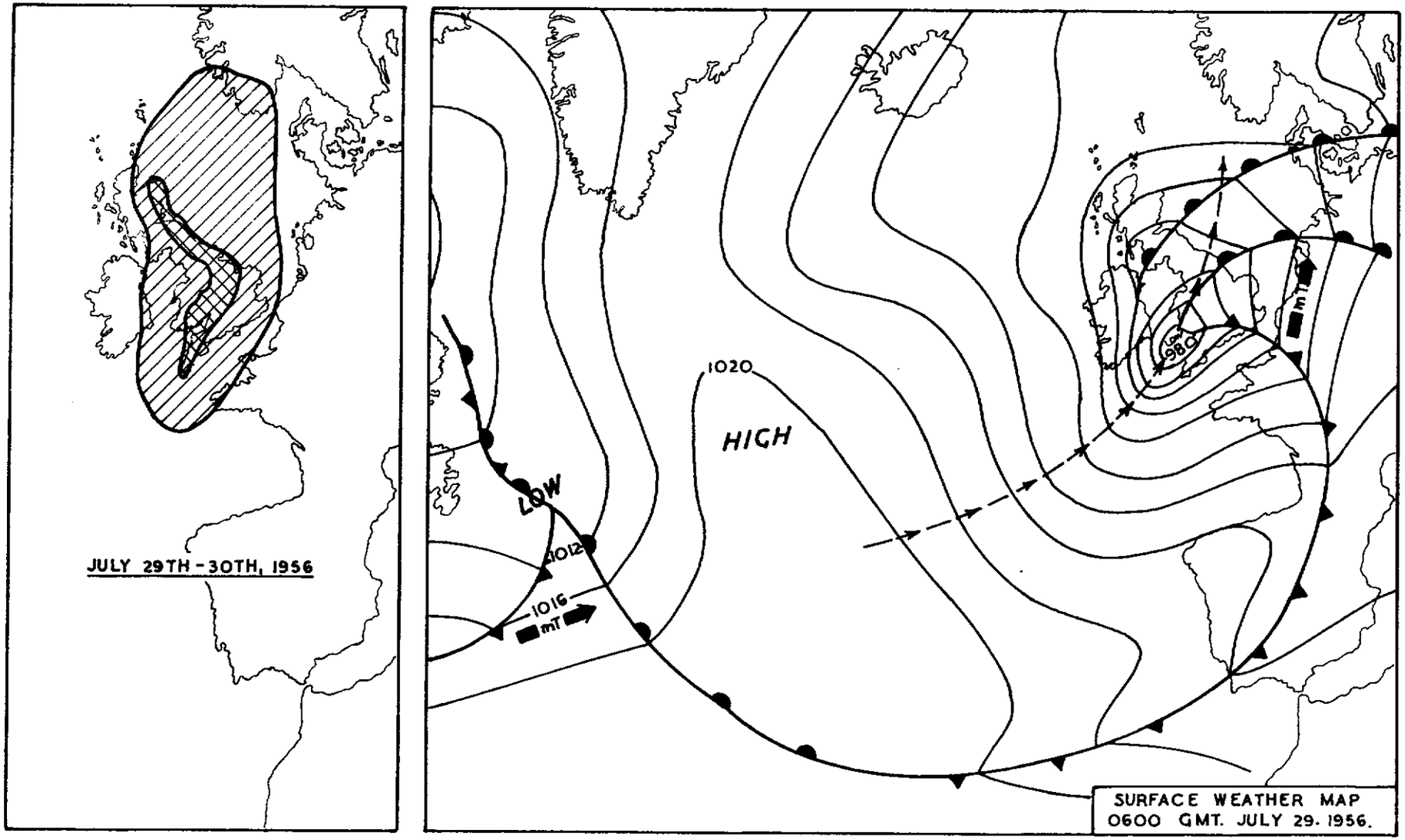
Continental 'puddle lows' rarely extend their influence beyond the Eastern half of England. The present case was exceptional in that it spread westwards to take in the whole of Ireland. The illustration shows an advantage of the concept of "effective duration" (4), since the lines of equal duration give a configuration in remarkable agreement with that derived from synoptic weather maps in Map 9.



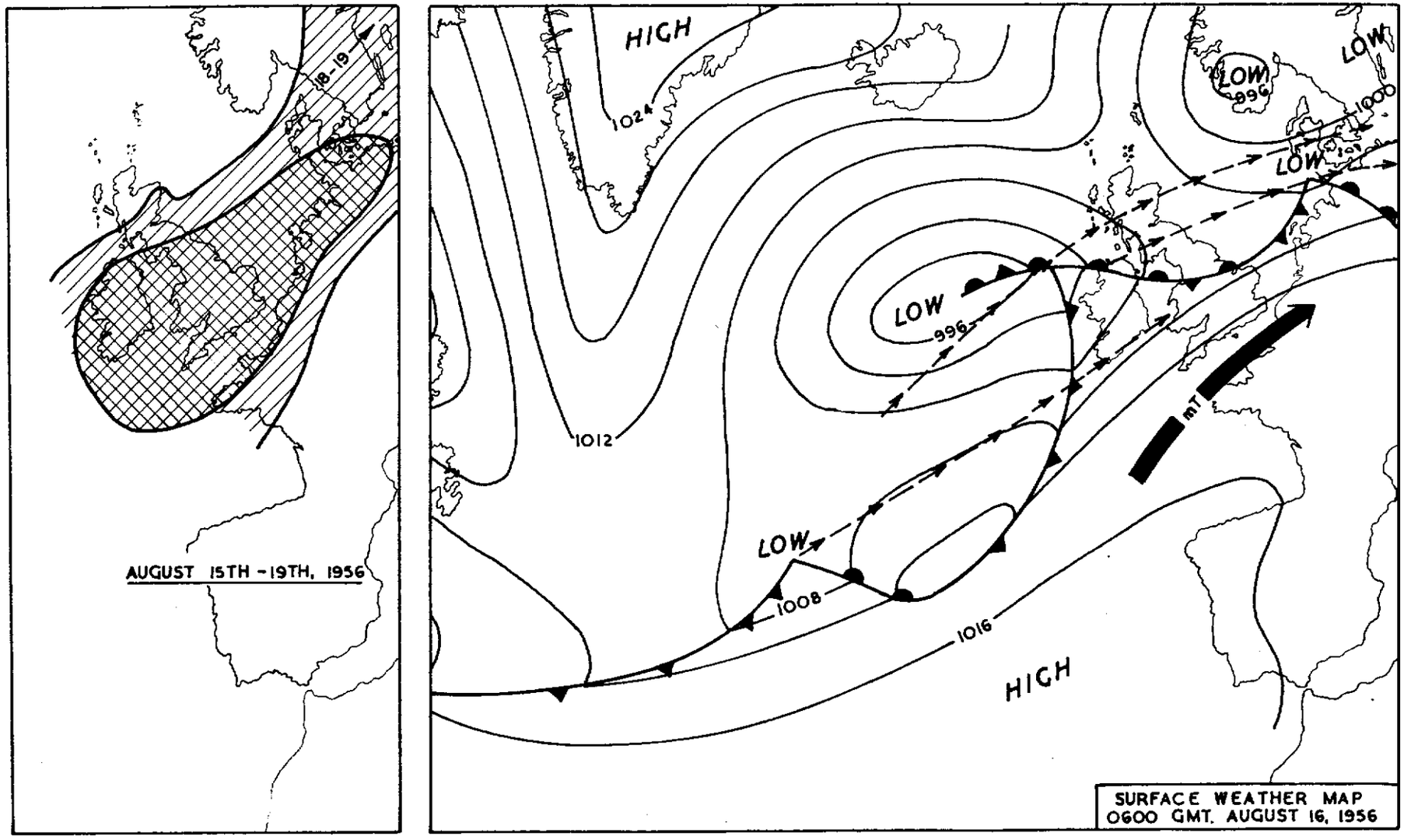

EFFECTIVE DURATION OF BLIGHT WEATHER IN IRELAND: JULY 15th-18th 1956


JULY 13TH - 18TH, 1956 APPROX.
HIGH
1020
LOW
LOW
1012
17TH JULY
LOW
1016
1016
1020
HIGH
LOW
100
LOW
LOW
100
SURFACE WEATHER MAP
0600 GMT. JULY 14. 1956.

Map 9.


JULY 29TH - 30TH, 1956
1020
HIGH
LOW
1012
1016
mT
mT
980
SURFACE WEATHER MAP
0600 GMT. JULY 29. 1956.

Map 10.


18-19
AUGUST 15TH - 19TH, 1956
HIGH
1024
1012
LOW
996
LOW
996
1000
LOW
LOW
1008
1016
HIGH
mT
SURFACE WEATHER MAP
0600 GMT. AUGUST 16, 1956

Map 11.

6. MAP 10 : PERIOD JULY 29th-30th, 1956

On July 29th a depression of exceptional intensity for the time of year moved up the Bristol Channel and crossed England in a Northeasterly direction. The accompanying blight-weather was virtually confined to Britain.

This unusual storm and its synoptic background are discussed in some detail by Houghton (9). It caused severe damage and some deaths. Flooding and landslides occurred in some areas. Farmers and fruit growers suffered heavily as corn was flattened and fruit trees were stripped.

A rather surprising effect of the storm, in view of the heavy rainfall, is discussed by Spence in his paper on "Soil Blowing in the Fens in 1956" (20). In fact, it is remarkable that the two instances in 1956 of severe soil erosion by winds in the Fens quoted by Spence (July 5 and July 29-30) occurred in connection with blight-weather systems. The possible relevance of this factor to the exposure of tubers in the ground to blight infection merits consideration.

7. MAP 11 : PERIOD AUGUST 15th-19th, 1956

This shows a series of three active waves of Maritime Tropical air, which were deflected across Britain towards the Baltic. The situation is broadly similar to that so common in 1954 and illustrated in Map 1. The corresponding blight weather was widespread and prolonged.

8. The six situations described in the preceding paragraphs were the most important from the angle of blight epidemiology in NW Europe in June-August 1956. As regards the situations of lesser importance, whether they show up or not in local blight-weather detection systems depends largely on the criteria in use. Nevertheless for completeness sake the full catalogue of the weather in these months, reviewed from the point of view of blight spread, is given in the following paragraph. Broadly, the criterion applied has been that of the "Irish rules". Since these are drawn up on the basis of a minimum requirement, "lulls" (unfavourable weather) mentioned in the catalogue should also be reflected by other criteria. However periods of weather completely unfavourable to blight over a large area were few and short in 1956.

The catalogue is reproduced herewith in its original form as deduced from weather maps. Later checks against independent observations in Germany did not suggest the need of major amendments but showed, as might be expected, minor disagreements. For instance, the 'pincer' situation of June 24-25 gave more than 'slight' favourable weather in the Rheinland.

9. REVIEW OF BLIGHT-WEATHER PERIODS, JUNE-AUGUST 1956

Britain, Ireland and Western Europe

(W.F. = Warm Front, C.F. = Cold Front,
Q.S.F. = Quasi-stationary Front)

June 1 - 4 Slight favourable periods in two successive rapidly moving waves of warm Maritime Polar air. Confined to West coast of Ireland and Scotland; extreme SW England; possibly Dutch coast (4th).

June 5 - 7 Unfavourable except possibly Central Germany (Q.S.F.).

June 8 - 12 IMPORTANT SPELL See paragraph 2 and Map 6.

June 13 - 15 Unfavourable except for spots in South Germany (QSF with wave)

June 16 - 21 IMPORTANT SPELL See paragraph 3 and Map 7.

June 22 - 23 Mainly unfavourable: isolated spots.

June 24 - 25 Slight favourable weather in Germany-Netherlands, squeezed

between East moving W.F. from Poland and C.F. advancing down the North Sea.

June 26 - 27 Mainly unfavourable: isolated spots.

June 28-July 3 Slight favourable weather in scattered areas. Wave moved rapidly N.Scotland to Baltic July 28-29, with QSF from Brussels to Belfast on 29th. Moved slowly North Eastwards 30th. C.F. moved eastwards July 1st 2nd and stagnated for a while, with slight waves, on 2nd-3rd on the French-German border.

July 4 - 12 IMPORTANT SPELL See paragraph 4 and Map 8.

July 13 - 18 VERY IMPORTANT SPELL See paragraph 5 and Map 9.

July 19 - 28 Unimportant periods in some places, as follows:-

19th-21st: North France; South and SE England; Low Countries.

22nd : West Ireland

23rd-24th: West Ireland; English-Scottish border; Dutch and N.German coast.

25th-27th: Ireland; Scotland; Finland

28th : England; Ireland; Netherlands; Rheinland (Thundery low and trough, moving NNE).

July 29 - 30 IMPORTANT SPELL See paragraph 6 and Map 10.

July 31 Tail end of previous case affected Denmark and coastal Germany and Holland.

August 1 - 3 MODERATE SPELL mT depression but moving rather rapidly gave widespread but fairly short periods:-

1st Aug : Ireland; Britain; N.France.

2nd Aug : Scotland; E.England; Netherlands; W.Germany

3rd Aug : E.England and E.Scotland; Netherlands; Rheinland; Poland.

August 4 - 7 Lull in most places. Possible 'spots' in Netherlands and Rheinland (4th-5th), North Germany (7th) and South France (7th).

August 8 - 10 Lull in most places. 'Spots' in Ireland, West Scotland and possibly England.

August 11 Fairly widespread short periods in Ireland, Britain, N.France, Netherlands, W.Germany and (11th-12) Scandinavia, Poland.

August 12 Lull.

August 13 - 14 Quick moving low gave 'spots' in Ireland and Britain - possibly in North Sea area.

August 15 - 19 IMPORTANT SPELL See paragraph 7 and Map 11.

August 20 - 21 Nil, apart from residual effects from previous case in South Scandinavia and Finland.

August 22 - 23 Wave depression affecting France and later South Germany. Some 'spots' Irish and Scottish West coast on 23rd due occlusion from Atlantic.

August 24 - 25 Wave affecting Poland 24th and Finland-E.Scandinavia 25th. Occlusion gave slight 'spots'(with thunder) Netherlands and W. Germany 24th. New wave moved rapidly up English Channel giving short periods France, S.England, Netherlands and W.Germany.

August 26 Nil except Finland.

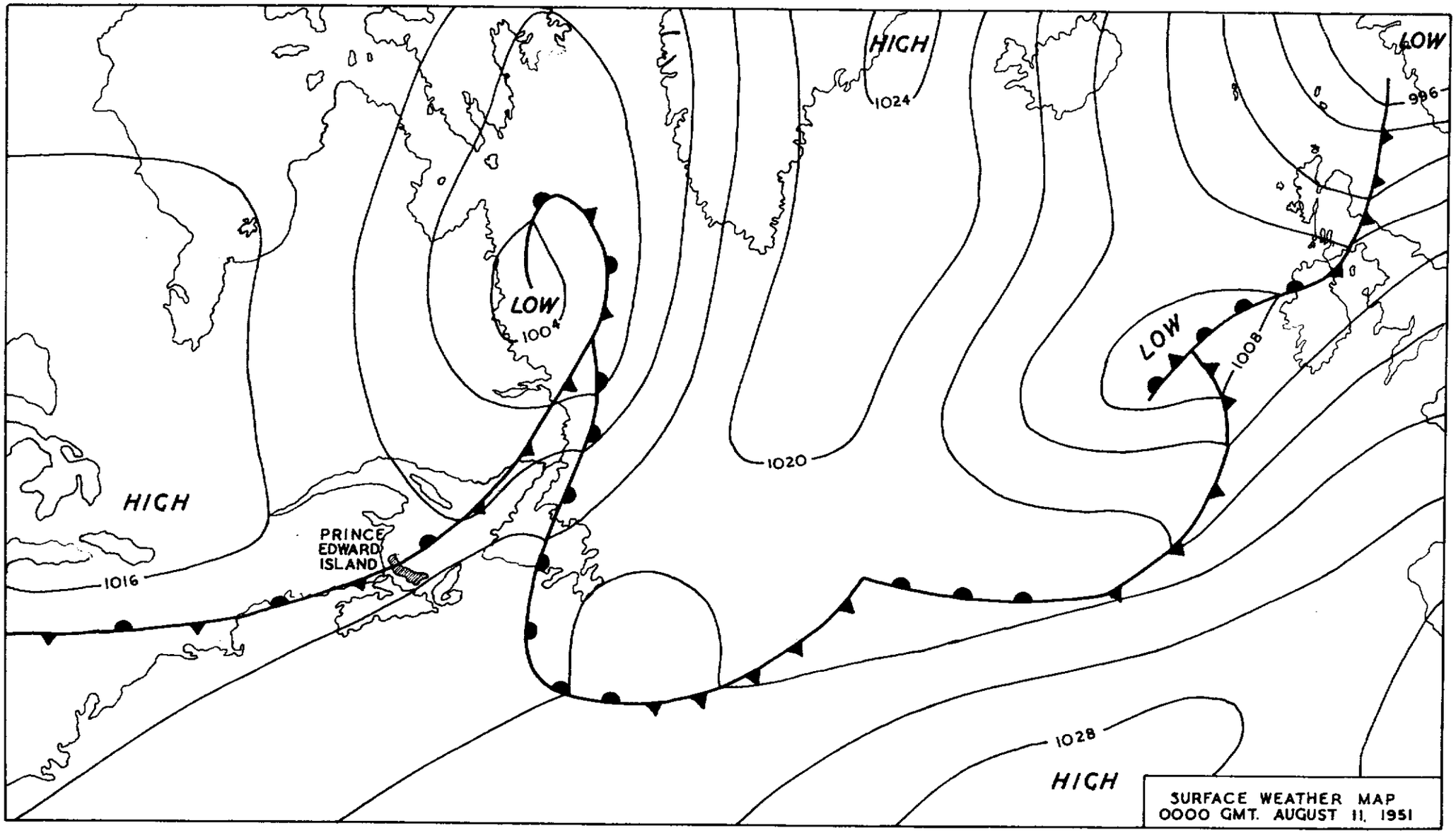
August 27 - 28 Shallow low to S. of Ireland moved NE, giving spots in S.England,

France and en route to Scandinavia.

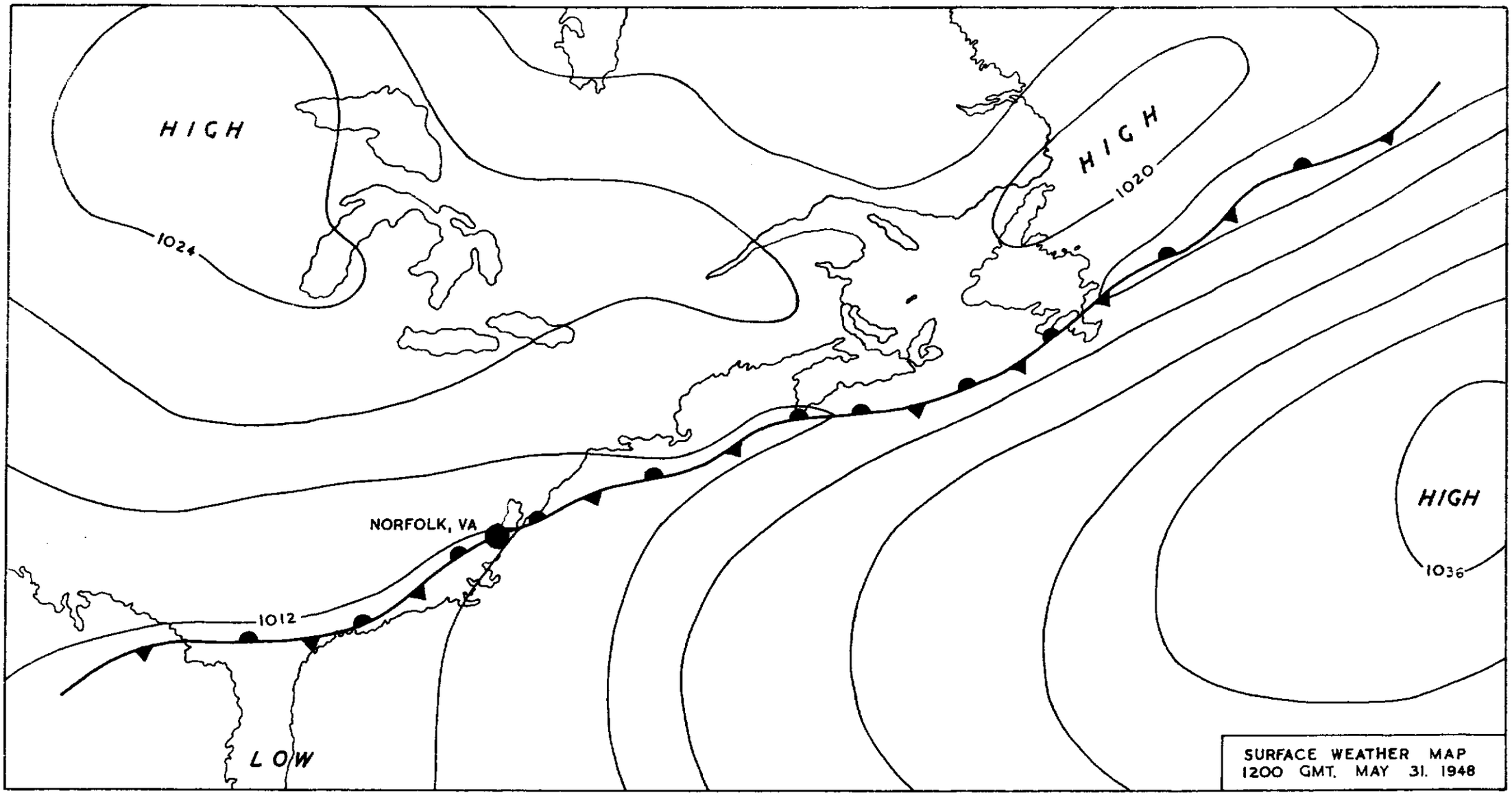
August 29 Low over Baltic. Coastal 'spots' E.England and SW.Sweden.

August 30 Continental low gave short favourable periods in Poland and E.Germany.

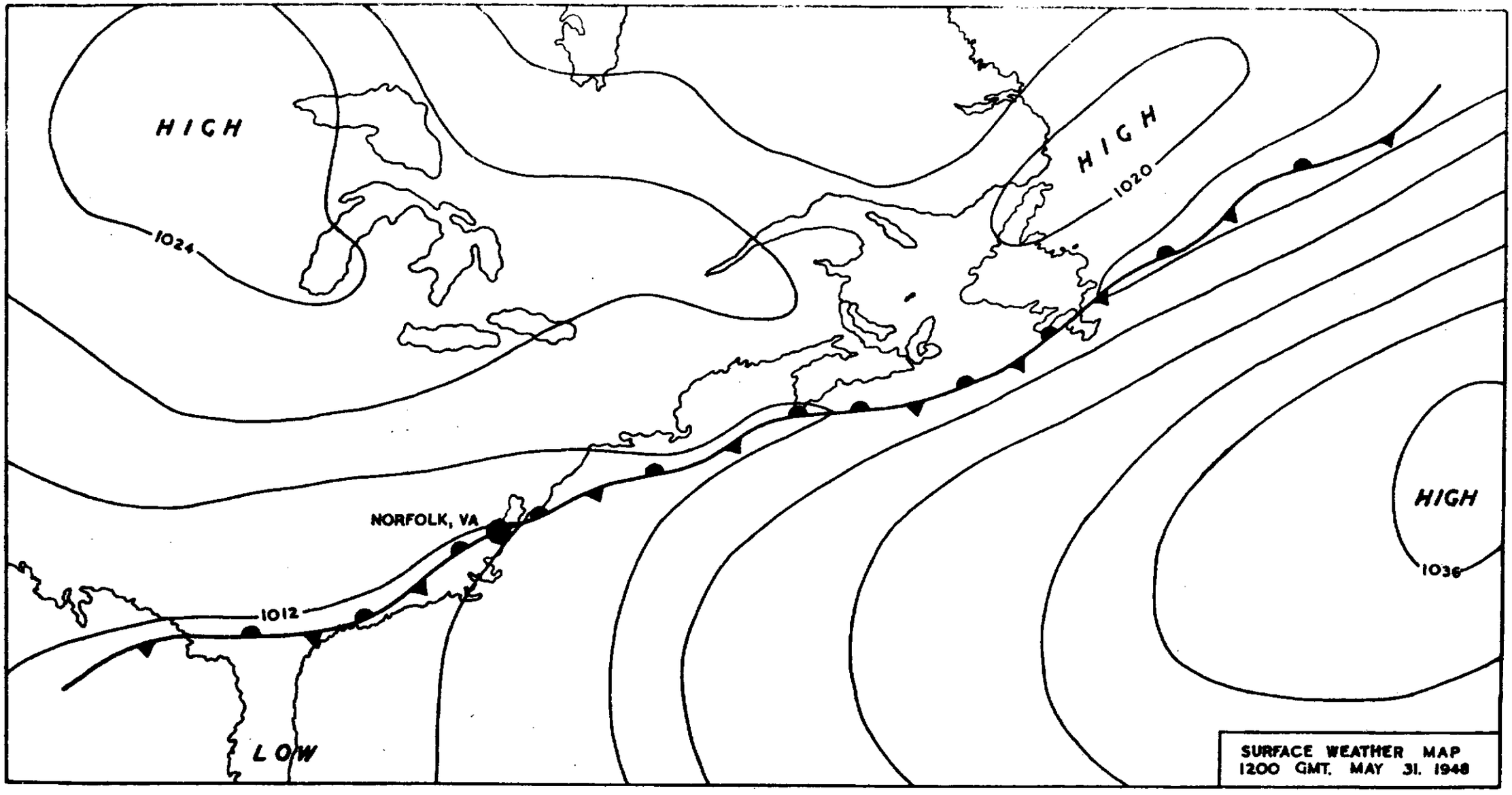
August 31 Unfavourable outside N.Spain.


HIGH
1024
LOW
996
LOW
1004
LOW
1008
1020
HIGH
PRINCE
EDWARD
ISLAND
1016
1028
HIGH
SURFACE WEATHER MAP
0000 GMT. AUGUST 11, 1951

MAP 12.


HIGH
1024
HIGH
1020
HIGH
1036
NORFOLK, VA
1012
LOW
SURFACE WEATHER MAP
1200 GMT. MAY 31. 1948

MAP 13.


HIGH
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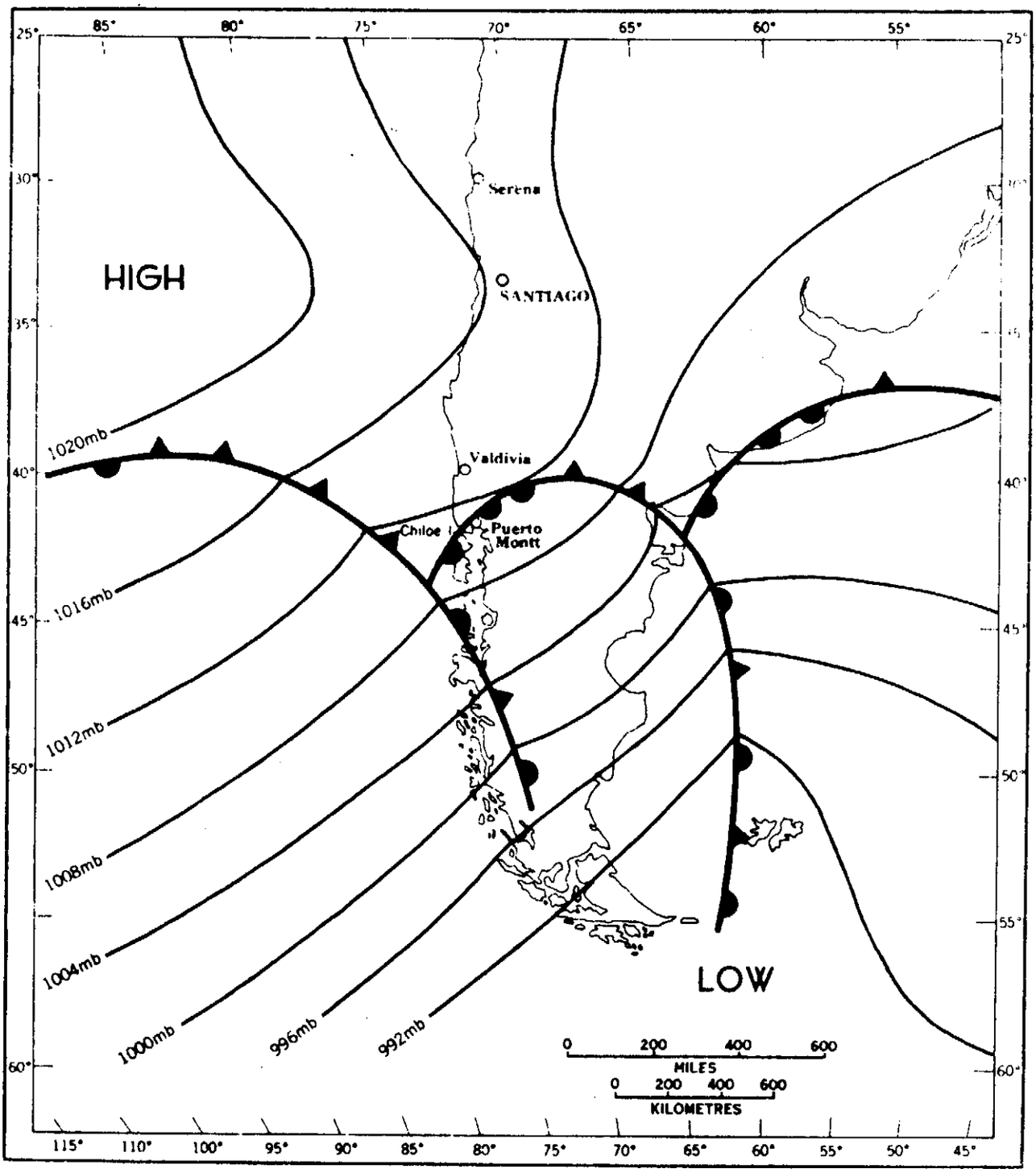
1036
NORFOLK, VA
1012
LOW
SURFACE WEATHER MAP
1200 GMT. MAY 31. 1948

MAP 13.




MAP 14. SURFACE WEATHER MAP FOR 2300 GMT. FEBRUARY 23, 1956

different areas as there was between the appearance of the disease. The feature of the 1956 blight-weather situation in Britain was that the major spells struck twice in the West, twice in the East, and twice more or less universally, and the result, taking due account of the timing of the periods, should be a fairly high measure of homogeneity in the onset and progress of the disease during the season. These deductions, fairly made and recorded in advance of knowledge of the disease survey, were fully confirmed. It has not proved possible to confirm or refute a further deduction, clearly indicated in Maps 6 to 11, that, in this year of heavy blight in most areas, Eastern Scotland should have escaped very much more lightly.

5. It may well be argued that 1956, with clear-cut weather situations and uniform blight progress, was an exceptionally easy season for general deductions. After all, the spell shown on Map 9, most important for the impact of the disease, was such that it might have been detected even with a blunt instrument.

To test this objection, and with all the reservations appropriate to 'hindcasting' it may be of interest to glance over the main synoptic features of earlier years and compare the corresponding deductions with the facts of blight occurrence on main crops in England and Wales so excellently summarised in Large's diagrams (13, 14). Once again only the main months June to August are considered and for the most part, only the effect on England is discussed.

1952

June 13 - 15 — A thundery low moved NE from the Bay of Biscay up the English Channel to Germany/Denmark.

This system and associated quasi-stationary fronts affected, inter alia, Eastern England and the English Midlands (13, 19). The micro-climate in potato crops in Germany during this period is illustrated by Johannes (11, Figures 5 and 6).

June 21 - 22 — A depression centre (mT air) passed Eastwards across Northern England to Denmark. All Ireland was affected but the impact of the system in England was spasmodic. For Germany, see Johannes (11, Figure 5).

June 28 - July 2 — Broad wave of mT, with QSF over Northern Ireland and England at one time. Not very significant in England.

July 6 - 8 — Meandering thundery low which moved N from Bay of Biscay across Ireland. See Map 2 and Paragraph 4 of Chapter 2.

Rest of July — Little except coastal spells mainly in the West, due to mT air or quasistationary fronts.

August 5 - 10 — The main spell of the season. A wave depression on 5th degenerated rapidly into a puddle low which affected at one time or another a large area including Ireland, England, Germany, North Sea Coasts and France.

Rest of August — Similar to "Rest of July" except that a thundery trough reached from London to Hamburg on August 15th-17th.

SUMMARY OF 1952 SEASON

No appreciable blight weather in the Eastern half of England occurred between June 15 and Aug. 5. Attacks were therefore late and light in this area (and also in the corresponding part of Ireland). Appreciable blight attack was confined to the West coast in both islands. This is typical for a year such as 1952, characterised by a general mild Westerly airflow, with systems affecting mainly the Western littoral and no important early stagnant lows to develop the disease in the East.

1953

June 1 - 9 Unfavourable

June 11 - 13 European stagnant low affecting Eastern England. For discussion of these two cases see paragraph 6 of Chapter 2 and Map 4.

June 14 - 17 On June 14 - 15 an Atlantic depression crossed the North of Ireland to merge with and reinforce the 'puddle low' of June 11-13, which moved Northwards into Scotland on June 16-17th. The corresponding time shift in Beaumont Periods from South to North can be seen in Large's Figure 3 (14), comparing East, South East, and East Midlands with West Midlands and North.

This puddle low affected at one time or another most of Western Europe between 45° and 60°N and between 10°E and 5°W, but its influence did not extend in any appreciable degree to Ireland, where only 'spots' of blight weather were occurring, mainly coastal. In fact blight came comparatively late to Ireland in 1953 and was particularly late inland. In contrast, because of the present and following spell, blight struck the English East coast as early as the SW, which normally leads comfortably.

June 21 - July 2 Maritime Tropical Air reached Ireland on June 21st-22nd from the SW (Bourke (4c), Charts 14 and 49). Although important in Ireland, this system, of itself, would only have affected Western and Southern England, mainly in coastal areas. However on June 23rd, a QSF over Europe, stretching SE from Holland, led to the development of a stagnant trough and later to a weak 'puddle low' which influenced Europe from June 24th-28th (22, 23) and affected the English East Coast in on-shore drift and even, at times, the Irish East Coast. The effect of the puddle low continued, with interruptions in places, until July 2nd.

Rest of July and August

In contrast to June, weather systems for the remainder of the season were mainly Westerly, with the gradient of impact progressively lighter from West to East of Great Britain and Ireland. No further 'puddle lows' affected Eastern England, and only two Westerly systems were sufficiently strong to extend their influence appreciably to that area - those of July 11 - 13 (mT from the NW (14, 19), also affecting Germany (22)) and of August 4th-9th, which has already been discussed in paragraph 5 of Chapter 2.

Accordingly, although 1953 was a "blight year" in most parts of England due to widespread favourable weather in the second half of June, the progress of the disease was more rapid in the West than in the East in July and August.

SUMMARY FOR 1953

In contrast to 1952, the Eastern half of England, under the influence of 'puddle lows', got appreciable 'blight-weather' from June 11th-July 2nd, which gave the disease an early start there. Later the airflow was mainly Westerly, but the disease had been sufficiently established to make the year a blight one in England generally.

1954

This was the year of the "bad summer". Its synoptic features have been described so extensively elsewhere (25, 26, 3, 24) that it is unnecessary to discuss it in detail here.

In one respect, this 'blight' year resembled the 'non-blight' year of 1952 i.e. the air flow was predominantly Westerly. But whereas in 1952

the effect was mainly confined to Western coastal areas, in 1954 the Westerlies were much stronger, depression tracks were more Southerly, and the active waves passed with undiminished vigour right across England and into the Continent. The situation shown in Map 1 and discussed in paragraph 3 of Chapter 2 may be taken as representative of the season.

The result was a uniform West to East zoning of blight outbreaks, with however, a comparatively short range of time between the earliest appearance of the disease (West) and the latest (East). In other words, because of the unusual penetrativeness of the Westerly air current, the gradient of blight outbreaks across the country was much less distributed in time than is normal in this kind of situation. Similarly, the progress of blight after its appearance followed a like course in all areas but with rather less steep a slope in the East than in the West.

The 'blight year' 1954 in England differs synoptically from the 'blight years' 1953 and 1956, in that the general impact of the disease in the latter years arose from the combined effects of two quite separate types of weather - mT waves attacking from the West and stagnant lows attacking from the East - whereas in 1954 the latter were few and relatively unimportant whereas the former were unusually vigorous and penetrating. The differing effect on outbreak dates is clearly visible by comparing Large's (14) Figure 4 (1953), which shows two separate "early attack" centres, one in the Fen area and the other in the Southwest, with his Figure 5 (1954) showing a much more uniform zoning from West to East.

Although isolated examples of mT waves penetrating through Britain to Europe occur in every year, it is most unusual for them to dominate an entire season as they did in 1954. For 'blight years' in East England, 1953 and 1956 are synoptically far more representative years.

## 1955

The 1955 season commenced as if it also might prove to be a 'blight-year'. There were several minor systems in the first half of June e.g. a thundery trough from the SW on 3rd-4th which affected France, S W. England and S. Ireland; a small wandering low which gave spots of blight weather in France, S. and E. England on 7th-9th and affected the Netherlands and Germany on 10th; a pair of mT waves from the West, with associated quasistationary fronts in the period June 11th-16th. The most important period of the month followed, when a QSF moved up from the South on the 19th with a shallow low stagnating briefly in the North Sea and affecting the Rheinland and Denmark on June 21st-22nd. mT waves followed on 22nd and 23rd.

Later pressure began to build up, and the anticyclonic situation shown on Map 5 and discussed in paragraph 7 of Chapter 2 was typical of most of July and the early part of August; in the remarkably dry and sunny weather of this "good" summer the inland potato crops in England suffered much more from drought than from the negligible impact of blight (1, 2, 3, 14). The flow of maritime air was pushed towards the NW; the impact of 'blight-weather' in Ireland was virtually confined to drizzly sea-fog along the extreme West coast; presumably the Western islands of Scotland and the Norwegian coasts experienced the same effect from the displaced mT air.

No widespread favourable weather recurred in England until, in the period August 8-15th, a stagnant low meandered vaguely around the North Germany-North Sea area, affecting Eastern England and much of NW Europe. Two waves of mT air followed in the period August 15-18. During August 28-30 a thundery stagnant low over Northern Germany affected a wide area including the British East Coast. The spells, though they led to a fairly rapid progress of the disease in the Fens and other Eastern areas (14), came too late to alter the characteristics of 1955 as a notable 'non-blight' year in England.

6. The discussion in the preceding paragraphs illustrates what is considered to be the main merit of the synoptic approach to blight

epidemiology i.e. by facilitating the synthesis from the reports of 'blight-weather' at individual stations it leads to a clear and readily-understood general picture, and enables the wood to be distinguished from the trees.

Further, as shown several times in the detailed discussion, it provides a means of bringing together the observations made in different areas by different methods. Indeed, by tending to neutralise the disadvantages involved in the rigid numerical limits necessarily imposed by the various 'models' used to identify 'blight-weather', it provides hope of bringing a very desirable measure of unity into investigations at present proceeding on different lines.

The other great advantage of the synoptic approach is that it leads directly to a means of forecasting favourable and unfavourable periods. This particularly applies to the 'series of waves' situation where the probability of further waves can often be foreseen by the meteorologist. The upper-air pattern gives guidance to the probable path of the depressions; in the 1954 season, for instances, the Southerly track was associated with a corresponding concentration of the mean thermal gradient (25, 26). One of the main difficulties in ordinary forecasting, that of exact timing of the successive waves, is not important from the point of view of blight epidemiology; it is sufficient to be able to say that further waves of mT air will arrive within a period of a few days. The ridges between successive waves normally provide suitable weather for spraying operations.

The 'puddle low' does not lend itself so readily to advance forecasting but even here there is assistance to be gained from modern meteorological methods. Thus Pothecary and Bushby (18)discuss, using electronic computations, the unexpected subsequent stagnation to the East of Britain of a mT depression which moved across Ireland and Northern England on August 17-19th, 1954, and later gave rise to an extensive puddle low which affected a large part of Europe up to August 25th, 1954.

The synoptic approach enables us, in fact, to hitch the wagon of blight forecasting to the (comparative!) star of modern meteorological research. An immediate possibility is to develop a kind of plant disease climatology by comparing the "blight-fomenting" situations with the synoptic catalogues summarised, amongst others, by Lamb (12) and Levick (16) for Britain and by Baur and Flohn for continental Europe (See references in (12)). It may well prove that the frequency of occurrence of stagnant lows in the North Sea area in June and July is closely related to the frequency of occurrence of blight years in, for example, the Wash area (15).

Naturally the fullest application of modern meteorological technique will only be achieved where the mycologist can confer with trained meteorologists. The need for such collaboration in the synoptic approach represents, I feel, another of its advantages. Where potato blight forecasting is left almost entirely to the meteorologist, the loss of help from the plant pathologist is sorely felt. On the other hand, the botanist working on his own too often is reduced to using little more than thrice or even once-a-day climatological station observations and perforce neglects the advances made by meteorology in the last fifty years. Air mass analysis, upper air data, and the concepts of 'blocking' (21) and 'steering' all have their potential applications in environmental studies of plant-disease, in adition to the detailed studies being made by the plant pathologists (8). Full progress will only be made when both parties are brought into the closest association.

It must be added that the synoptic approach, for all its advantages, involves a reduction rather than an increase in effort. Although it is recommended that individual station reports should still be used, the number required for epidemiology in association with weather map analysis could be appreciably reduced. From the meteorologist's point of view, the synoptic procedure uses techniques in everyday use for general weather forecasting and thus minimises the extra work required for plant disease investigations. Finally, it provides a possible means of considering simultaneously a whole group of plant diseases with similar general requirements for humidity, moisture and temperature.

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