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THE CLIMATIC CONDITIONS OF ICELAND

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Before discussing the climatic conditions of Iceland, which is the main object of this paper, I would like to mention briefly some factors, which to a great extent influence weather and climate in our country.

Iceland is situated in the middle of the North Atlantic near the boarderlines between warm and cold ocean and air currents. The Gulf stream passes just to the south on its course north-eastwards and one of its branches, the Irminger current, encircles the south, west and north coasts. On the other hand, a branch of the cold East-Greenland current, known as the East-Iceland current, flows in a south and southeasterly direction along the east coast. Especially off the NW- and SE-coasts a front is found between these two different currents. The strenght of the currents is among other things controlled by climatic factors, and we will later on see an exellant example of the consequences of a decrease in temperature, as illustrated by the increased extension of sea ice. It is obvious, that the oceanographic conditions must influence weather and climate considerably, as all air masses arrive in Iceland after having passed over sea.

Similar to ocean currents warm and cold air masses often meet near Iceland. The front between polar and tropical air masses is called polar front. It can almost invariably be found on weather maps somewhere on the North Atlantic. Most cyclones start as disturbances on this front, then often intensify and move mainly from west to east or from southwest to northeast. The cyclones often pass very near Iceland and irregular and large pressure variations are therefore common. Lowest pressure

ever measured in Iceland is, when reduced to M.S.L., 92o mb. Highest pressure ever measured is 1o54 mb.

A map showing annual mean pressure over the North Atlantic (fig. 1) confirms that cyclones must be frequent near Iceland, as a low pressure centre is in mean found a short distance SW of the country. In climatology this "mean" low has got the name "the Icelandic low"

The travelling cyclones bring with them precipitation and bad weather conditions, and rapid changes in weather may occur in their path. Particularly in winter it may change in the course of a few hours for instance from southerly strong winds with rain or drizzle and temperature 5-1o°C, to northerly gale force winds, snowfall and temperatures 5-1o°C below freezing. The temperature contrasts between tropical and polar air masses are greatest in winter, and consequently the lows are more intensive in that season than in summer.

From the mean pressure map in fig. 1 it may further be seen, that Greenland, over which a pronounced high often is situated, may influence the weather in Iceland considerably, mainly by strengthening the north-easterly air flow.

Finally the fact, that Iceland is a mountainous country must be mentioned. In regions, where there are onshore winds the increasing height of the terrain inland may increase cloudiness and precipitation, while on the leeward side with offshore winds the clouds tend to dissolve, with resulting clear weather. This means, that one part of the country may have good weather, even if it is unfavourable in the other parts.

The climate of Iceland is maritime with cool summers and mild winters. Annual mean temperatures (1931-6o) range from 2°C to 5.7°C in the lowlands. At Reykjavík it is 5.o°C. Compared with a mean annual value for the latitude 65°N as a whole (-5.5°C) it will be found that annual temperatures in Iceland are up to 1o°C higher.

The annual range of temperature, i.e. the difference between the average temperature during the warmest and the coldest months, is very small. At the coasts it is generally of the order 9-12°C, but inland 12-15°C. July is the warmest month of the year in most parts of the country, except at the north and east coasts, where August is a little warmer. February is generally the coldest month, though with the exception of Southwest-Iceland, where January is

coldest. The difference between these two months is however always very small.

At Reykjavík the average temperature in July is 11.2°C compared with for instance 17.6°C in London, 14.4°C in Trondheim and 16.8°C in Gander. The average temperature in January is -o.4°C. Corresponding figures are for London 4.2°C, Trondheim -3.4°C and Gander -6.1°C.

In fig. 2 is shown the mean temperature of January in Iceland. Only in few places does the temperature of this month exceed 0°C, mainly at Reykjanes and some parts of the South coast. The highest single value is 1.4°C at Vestmannaeyjar. At the west and partly also the north coast the temperature is 0° to -1°C, but already in the fjords it decreases to -2°C. There is a general decrease of temperature in this month when going inland, partly because of an increase in the height, and partly because temperature decreases in winter with increasing distance from the shore. This decrease amounts to some 2.0°C/1oo km. In the highland except for highest mountains and glaciers the January temperature is of the order -4° to -8°C.

In fig. 3, which shows the mean temperature of July we can at first take a look at the regions, where it exceeds 10°C, the temperature, which in Köppens classification of climates is intended to mark the boundary between temperate rainy climates and snow climates. These are found in all lowland areas from Snæfellsnes, south- and eastward to Southeast - Iceland. In the Reykjavík area and in the inland of Borgarfjörður and Southwest - Iceland the temperature even exceeds 11°C. Other regions over 10°C are lowlands in inner parts of fjords in West-, North- and East-Iceland. At the coasts of Vestfirðir, North- and East-Iceland the July temperature is 8-1o°C, and in the highland generally 6-9°C. Excluding the effect of difference in height, the temperature in summer is, contrary to winter, found to increase inland, but this is not the case in all parts of the country.

Monthly temperatures are quite variable from year to year. This is especially the case in winter. At Reykjavík the highest average value in January in this century is 3.6°C (1964) and the lowest -7.3°C (1918). In July the highest value is 13.3°C (1917) and the lowest 9.5°C (197o).

Monthly mean values of temperature do not show all characteristics of this element. As an example it may be mentioned that in summertime there is a distinct difference in temperature on fair

days between North- and East-Iceland on the one hand and South- and West-Iceland on the other. In the first mentioned region fair weather is associated with southerly and warm air, and Föhn-effect may besides add to the temperature, which then often rises to 2o-25°C in the afternoon. In the southern and western parts on the contrary fair weather occurs in northerly and cool air and the maximum temperature will generally be lower.

A great part of the precipitation in Iceland falls in south-easterly wind directions. Consequently, as can be seen from fig. 4 the region of maximum precipitation is found in the south-east part of the country with maximum annual values of more than 4ooo mm on the glaciers Vatnajökull and Mýrdalsjökull, and values mainly above 16oo mm in lower areas. In SW- and W-Iceland the amount in lowland is of the order 1ooo-16oo mm at the coasts but 7oo-1ooo mm farther inland. The north and northeast parts of the country are the regions of minimum precipitation, with values 4oo-6oo mm in lower areas, and absolute minimum less than 4oo mm in an extensive area north of the huge glacier Vatnajökull, which creates a "rain shadow" for the rain-bearing southeasterly winds.

The precipitation is to a great extent dependent on local conditions and varies greatly within the same region. A good example of this can be mentioned from the Reykjavík area. At Reykjavík airport the annual precipitation is about 8oo mm, in the eastern part of the town at Elliðaár it is 9oo mm, on a small hill less than 1o km east of the town it is 1o4o mm and in the mountains farther east estimated values reach 3ooo mm per year.

Autumn and early winter are the seasons of greatest precipitation, with maximum in October. May and June are the driest months. As an average for the country October's share of the annual precipitation is 12% and May's 5%.

Number of days with measureable precipitation is high in Iceland. As an example the number is 212 per year at Reykjavík and 139 at Akureyri.

Monthly values of precipitation vary very much from year to year and months with no precipitation at all have occured.

In North-Iceland much of the winter precipitation falls as snow and a complete snow cover may persist for weeks or even months, whereas in South-Iceland winter thaws are frequent and snow cover is variable. Because of snowfall and great wind velocities, measurements of precipitation are not very reliable in

winter, the measured values being too low.

Distribution of annual mean pressure over the North Atlantic as was shown in fig. 1 indicates, that E and NE wind directions could be expected to be frequent in Iceland. Fig. 5 showing the frequency of the different wind directions at several weather stations, confirms this partly at least at the coastal stations in S- and NW-Iceland. Apart from them it is seen, that the wind roses are of rather irregular shape, and it is difficult to find a description valid for the country as a whole. In general however W and NW winds can be said to be rare. Local conditions, landscape and direction of fjords or valleys control the frequencies, as can be seen f.inst. at Síðumúli, Þóroddsstaðir, Akureyri and Egilsstaðir. In summer sea breeze changes the frequencies considerably at the coasts.

As can be expected in a country, where low pressure areas pass frequently wind velocities are in general high, especially at the coasts, and particularly in winter, when the cyclones are most intensive. Gale force winds are common, especially at the south coast. At Vestmannaeyjar, where the wind conditions are exceptional, the mean wind reaches 1oo knots at times, and days with wind force 9 or more amount to 58 per year. In Reykjavík the corresponding number is 12 per year. In the last few years wind gusts have been measured at 2-3 weather stations. During this short period gusts of 1o7-1o9 knots have been measured.

From historical accounts of weather it can be learned, that climatic conditions have been subject to considerable changes since the settlement of Iceland. The first centuries after the settlement (9th - 12th centuries) it is estimated, that temperature conditions were at least as favourable as in the warm part of the present century (192o-1964). At that time glaciers were small and barley was cultivated. About year 12oo the climate deteriorated, temperature decreased, and since then the climatic conditions were more or less unfavourable until about 192o, when a marked amelioration was experienced. Appreciable temperature variations took nevertheless place during these cold centuries. A minimum of temperature was about 13oo, but some increase followed in the last part of the 14th century. The 15th century is considered to have been rather mild, although records from that century are sparse. After 15oo the climate deteriorated

again and the 17th, 18th and 19th centuries were very cold.

In 1845 systematic meteorological observations started in Iceland. Then a weather station was set up at Stykkishólmur in W-Iceland, and has been in almost continuous operation ever since. An examination of temperature observations from this particular station will give a fairly good picture of the conditions for the country as a whole, as temperature variations are almost in phase in the different parts of the country. In winter temperature variations are more extreme than in summer. It is possible to divide the whole period since 1846 into several distinct shorter periods according to the mean temperature of that season (December - March) as follows (Sigfúsdóttir 197o):

Period	Mean temperature in winter (Stykkishólmur)
1846-1852	-o.7°C
1853-1892	-2.3°C
1893-192o	-1.7°C
1921-1965	-o.1°C
1966-1971	-2.o°C

It is worth mentioning, that the last two winters were again similar to the mild winters before 1965 with temperatures somewhat above 0°C.

The table shows, that low temperatures were prevailing in the period 1853-192o, while a relatively warm period followed in 1921-1965 (1921-1964 in N-Iceland). A dramatic change took place around 1965. The annual temperature then dropped down to a level comparable with the cold period before 192o, and the following years, 1966-1971, were all much below normal values. This decrease in temperature was most pronounced in NE- and E-Iceland, what can at least partly be explained by the presence of sea ice, which is one of several serious consequences of climatic deterioration in Iceland

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The sea ice, which occasionally visits the coasts of Iceland in winter, particularly in late winter, is a part of the main ice flow in the East-Greenland current. The extension of the ice flow is variable from year to year, but generally it is less in mild periods than in cold ones. It also varies with the time of the year. Fig. 6 shows the limits of sea ice in October when it is near minimum, and in March-May, which are the months of greatest

extension. It can be seen, that under normal conditions the main ice edge does not reach the coast of Iceland, while in severe ice years the ice may extend along the NW-, N- and E-coasts, and in extreme cases is even carried westward along the south coast.

Fig. 7 shows sea ice near Iceland in the 2oth century, and clearly indicates the great difference between mild and cold periods, which I mentioned before. Sea ice was not a problem at all at the Icelandic coasts during the mild period of 192o-1964. It was therefore an unpleasant and unexpected experience when in 1965 the pack ice reached the N-coast in an amount comparable with that of ice years in earlier cold periods. After 1965 several ice years have occured, the most severe being 1968, when especially during the months of April and May, pack ice filled fjords and harbours on the N- and E-coasts and obstructed navigation. Some ice drifted to the south along the east coast and was at its maximum observed off Ingólfshöfði on the south coast. Fig. 8 shows a chart from an ice reconnaissance flight on 29th May 1968. One must go back to the year 1888 to find a similar extension of the sea ice.

Considerable ice was observed also in 1969 and some in 197o, but since then the ice has not reached the coasts. For the first time since 1964 the mean temperature was above normal in 1972, and then the question arises, if this short but serious cold period is over, or if one in Iceland must be prepared to meet new years with sea ice, winterkilling of grasses and other difficulties, which always can be expected in a country, which is so sensitive to climatic changes.

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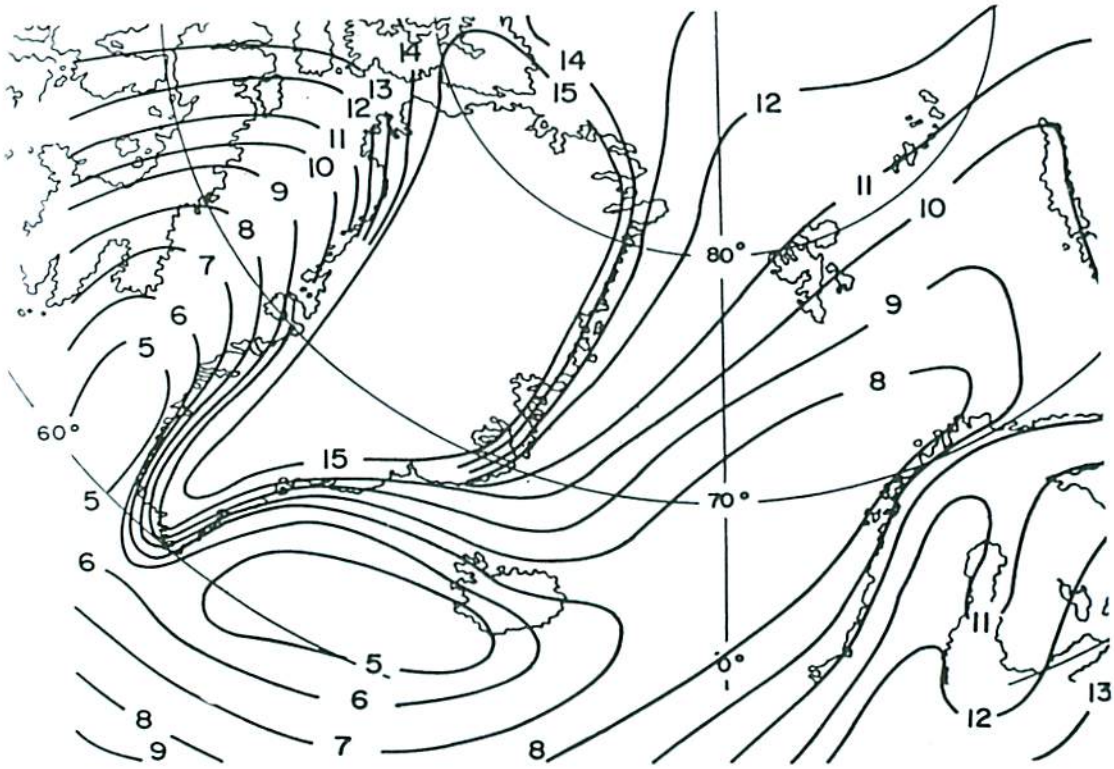

Fig. 1. Annual mean pressure near Iceland (from Vowinckel and Orvig 197o, after Prik 1959).

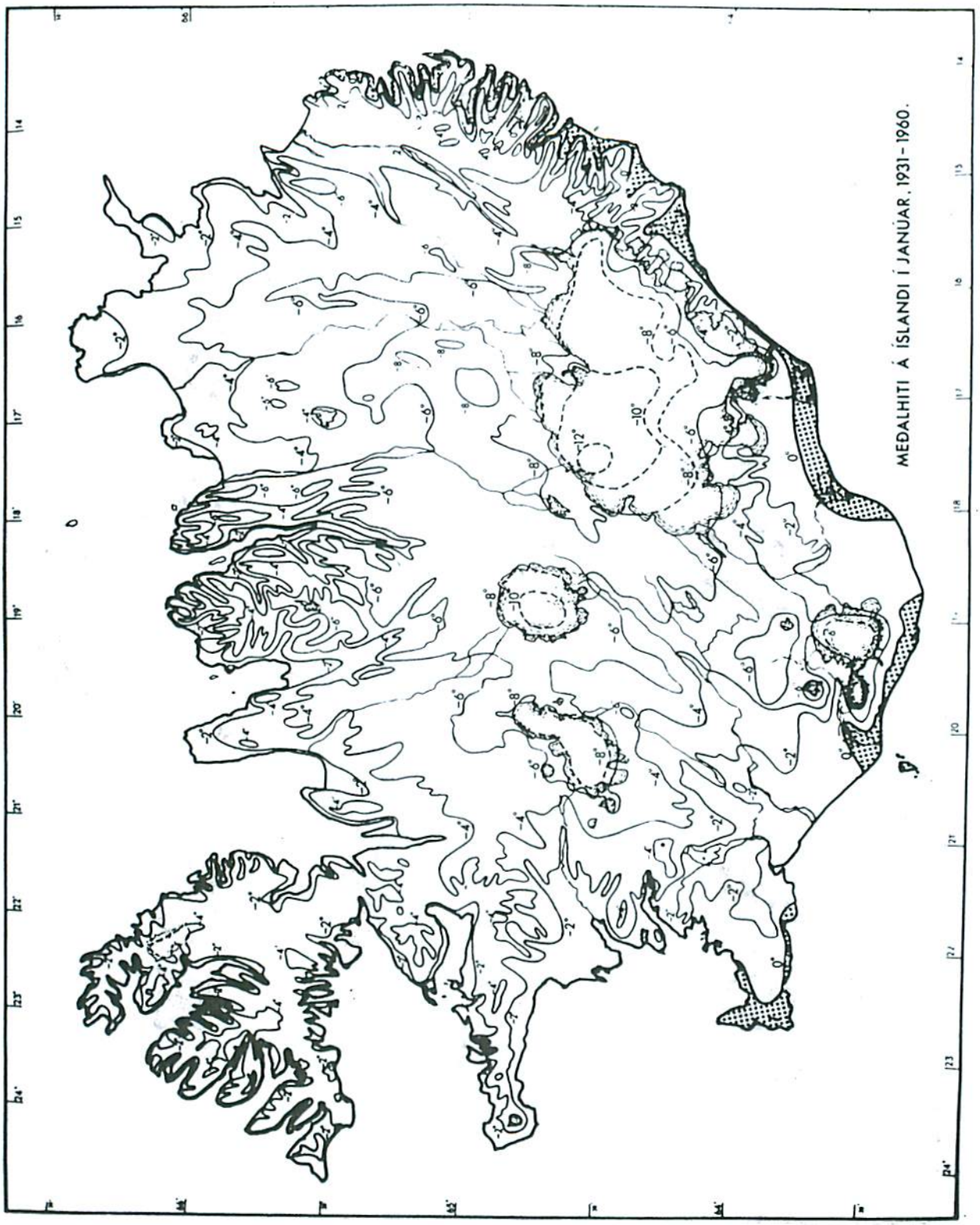

Fig. 2. Mean temperature of January in Iceland.

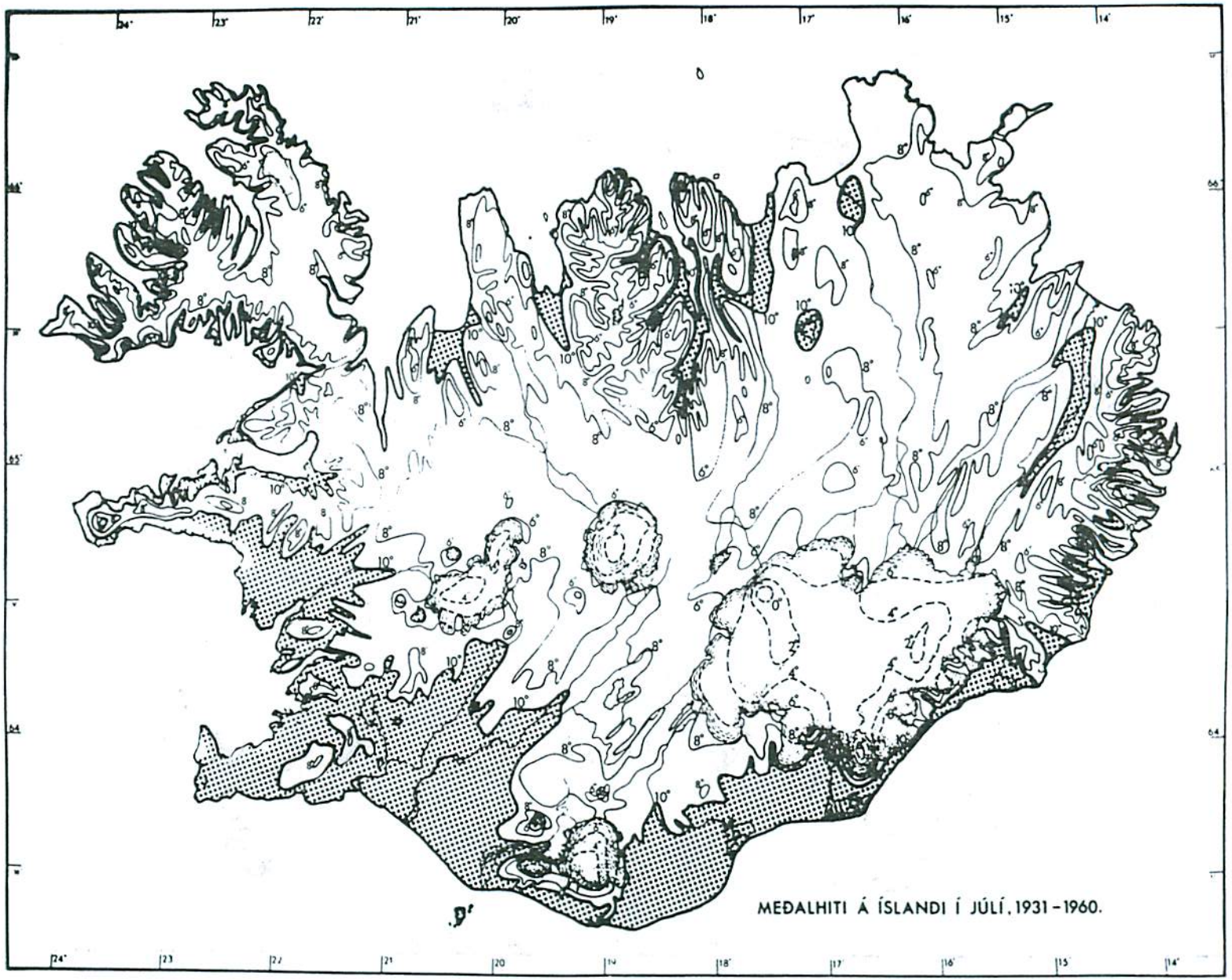

Fig. 3. Mean temperature of July in Iceland.

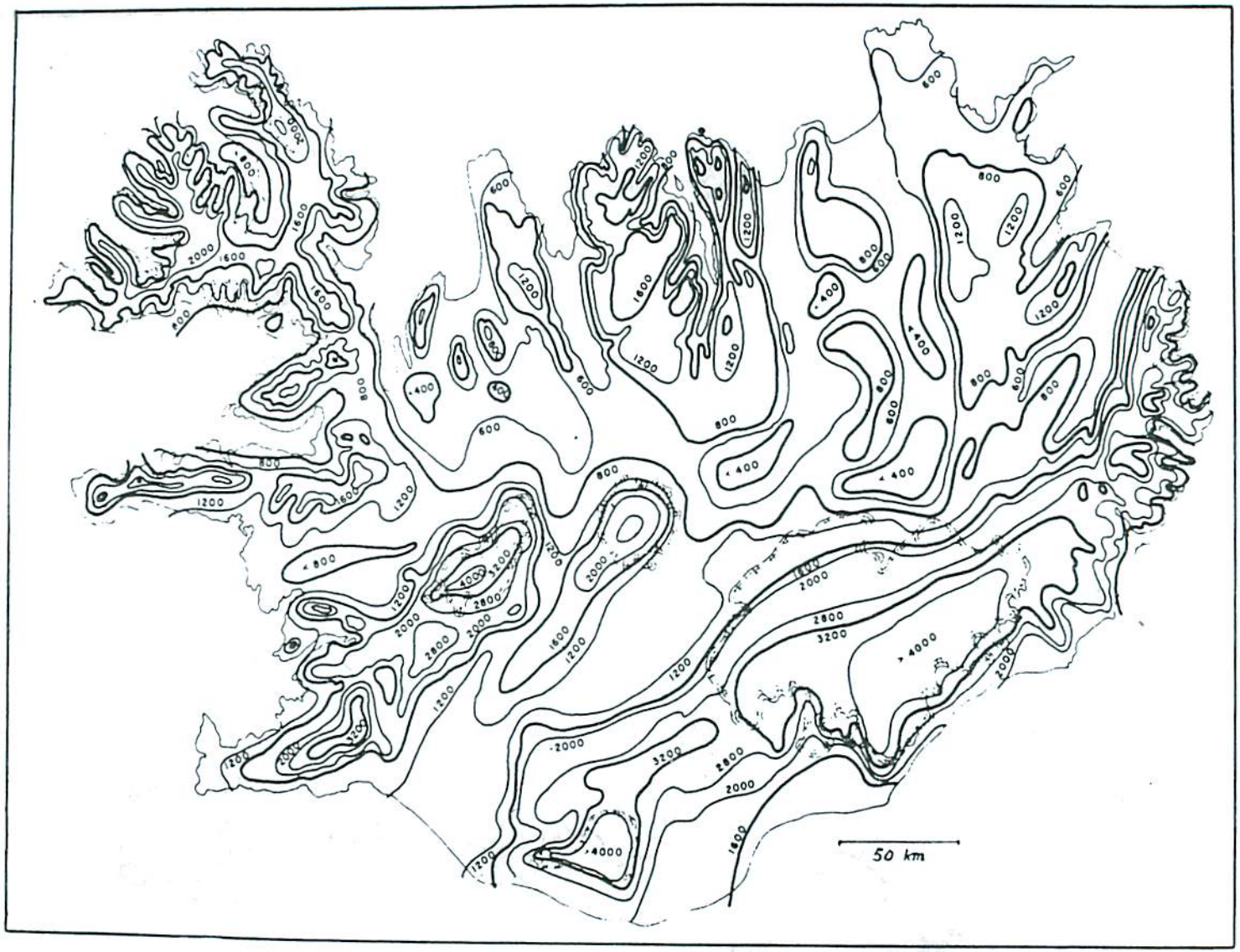

Fig. 4. Annual precipitation in Iceland (after Sigfúsdóttir, printed in Einarsson 1971).

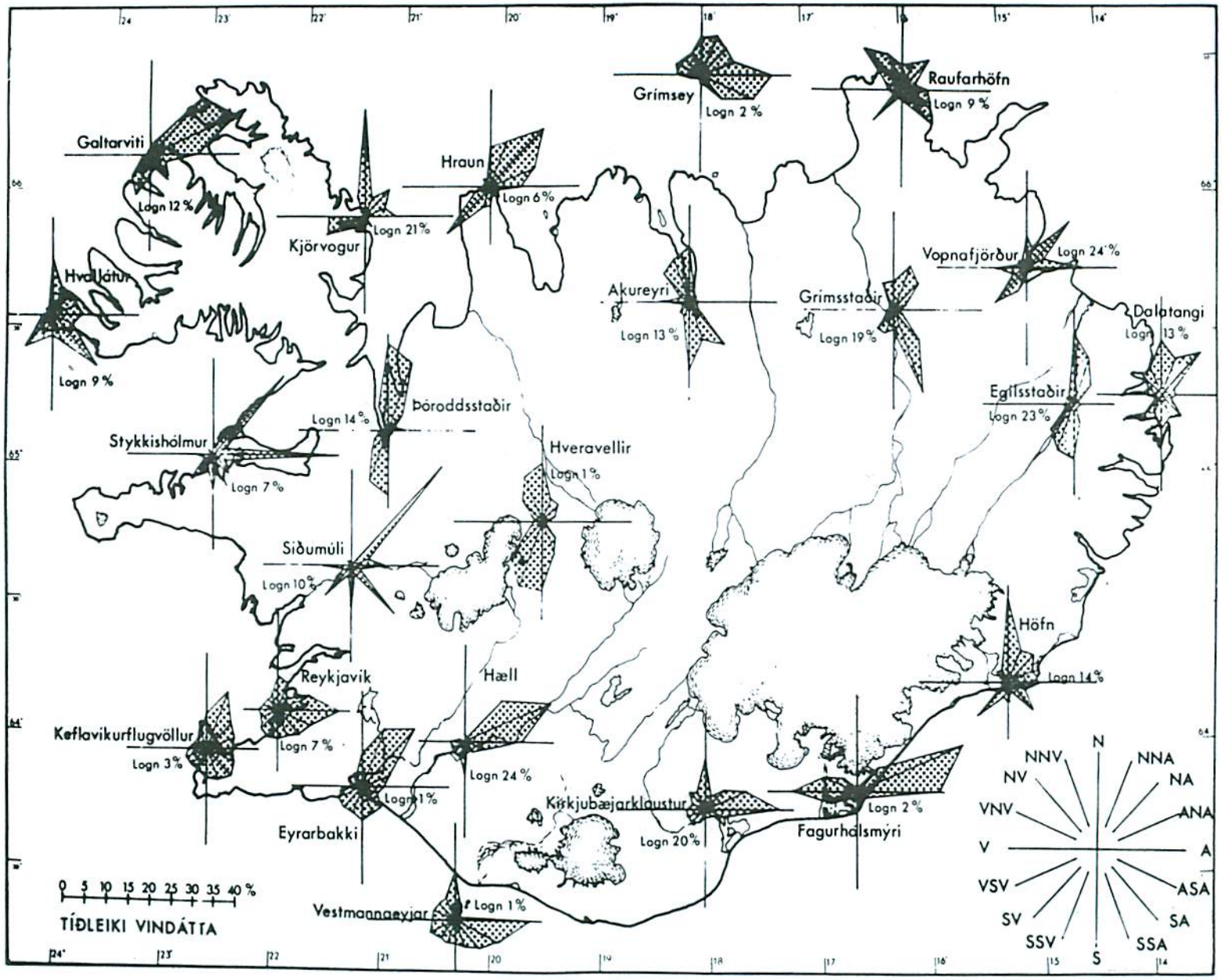

Fig. 5. Annual frequency of different wind directions at several Icelandic weather stations.

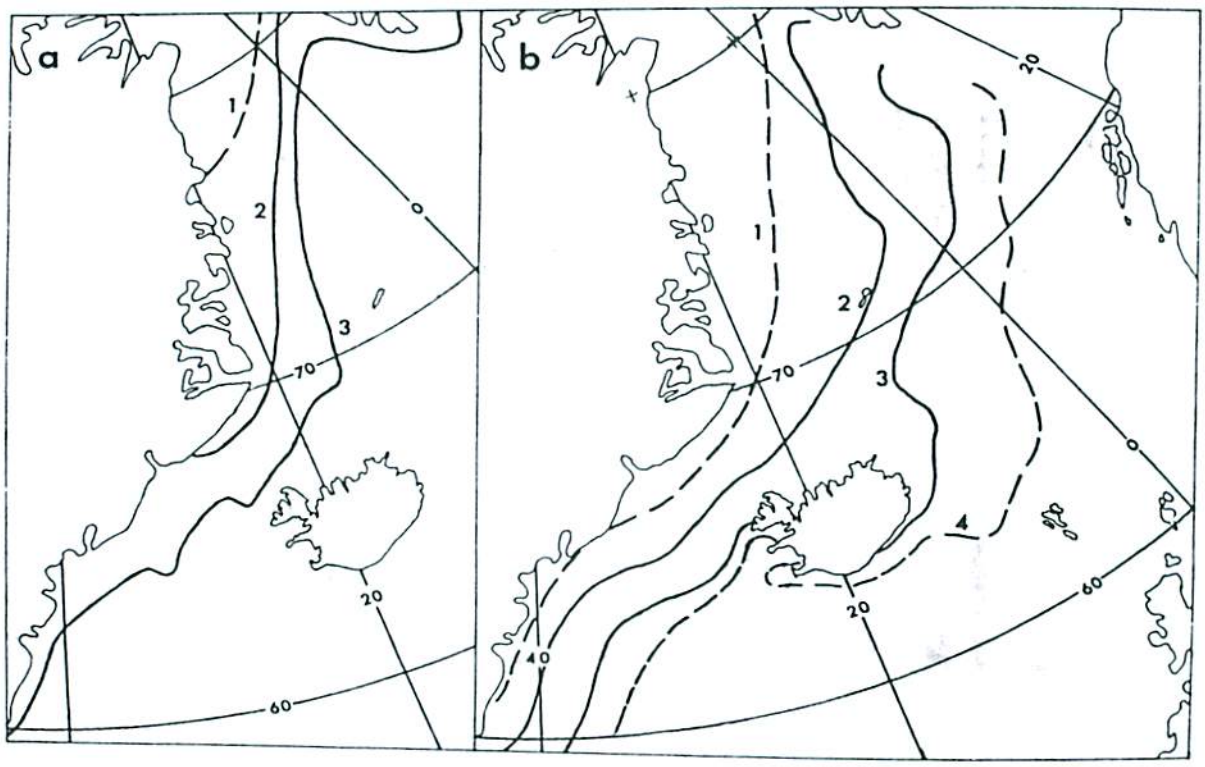

Fig. 6. (á) Recent limits of sea ice in early October, 1 minimum, 2 normal, 3 maximum. (b) Limits of sea ice in March - May, 1 recent minimum, 2 recent normal, 3 recent maximum, 4 estimated maximum in historical times. (Eyþórsson og Sigtryggsson 1971).

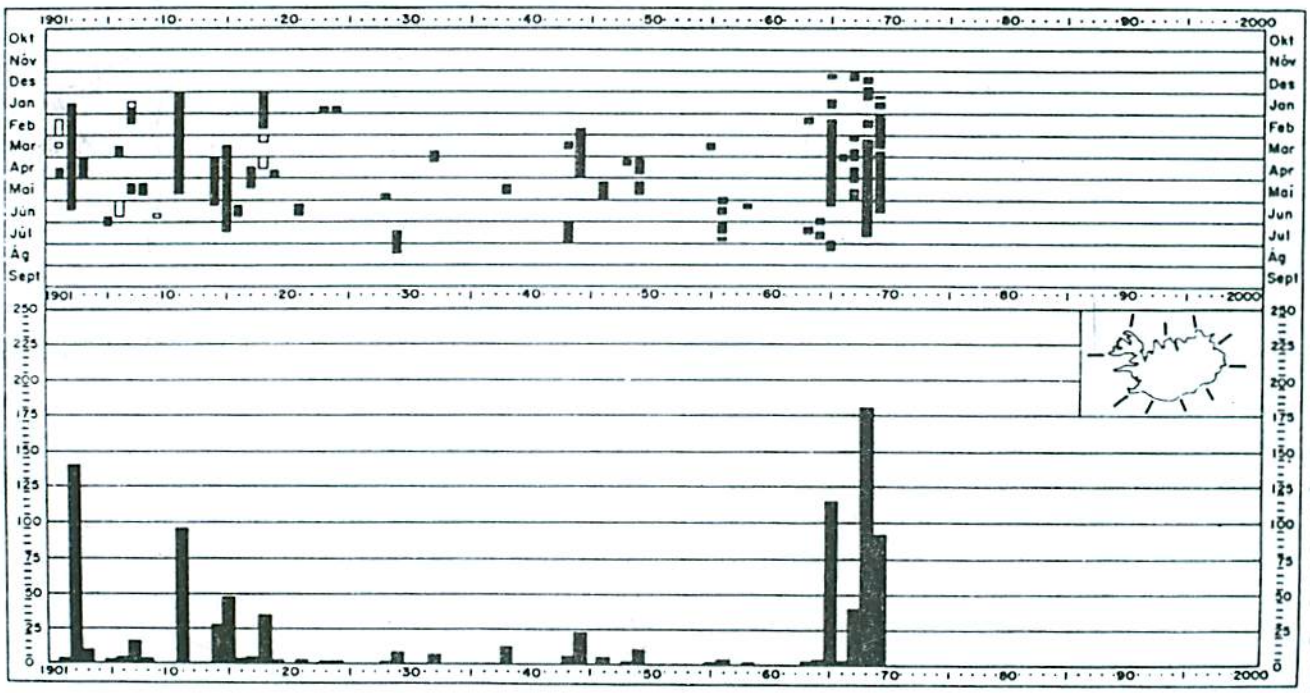

Fig. 7. Sea ice near Iceland in the 2oth century. The upper part shows the period when ice was observed. The lower part shows an "ice index" i.e. the product of number of weeks with ice per year, and the number of coastal areas near which it was observed. Insert map shows the limits of the areas. Redrawn and extended from Koch (1945). (Eyþórsson and Sigtryggsson 1971).

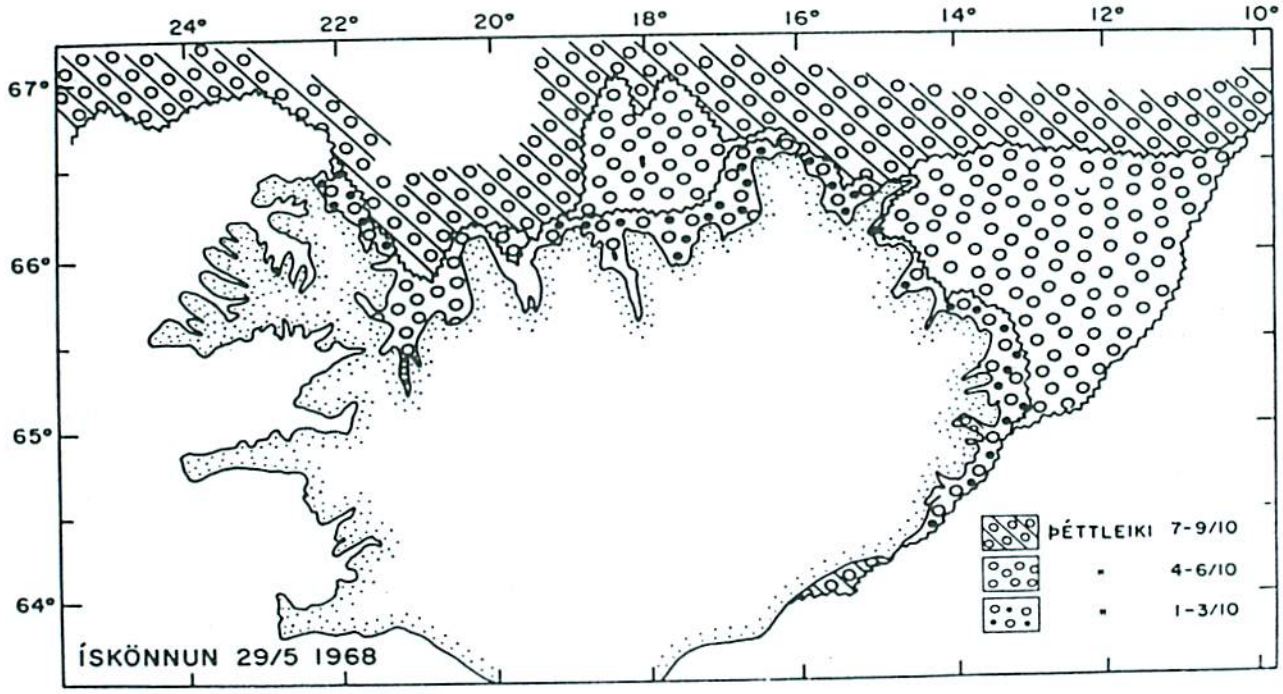

Fig. 8. Ice reconnaissance flight, May 29, 1968. (Sigurðsson 1969).