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TECHNICAL ASSISTANCE PROGRAMME

REPORT ON METEOROLOGICAL REQUIREMENTS OF ICELAND

Prepared for the Government of Iceland

by Dr. Anders Angstrom

Appointed by the
United Nations Technical Assistance Administration
in collaboration with the
World Meteorological Organization

FOREWORD

In accordance with a request from the Government of Iceland dated 30 June 1955, addressed to the World Meteorological Organization pursuant to the Basic Agreement dated 9 August 1956, concluded between the Government and the United Nations concerning technical assistance, the Technical Assistance Administration appointed Dr. Anders K. Angström, to advise on Climatology and Agricultural Meteorology.

The duration of Dr. Angström's assignment was from 30 July to 9 September 1956. His final report to the Government follows.

TABLE OF CONTENTS

ANNEXES

INTRODUCTION

1. My original terms of reference were given in a letter of 27 July 1956 from the Secretary-General of the World Meteorological Organization (WMO), Mr. D.A. Davies, who after some introductory remarks gave the following instructions:

2. "I must rely therefore upon you, in the first instance, to establish the problems and to suggest broad policy lines along which solutions might best be found. Your report should cover the over-all meteorological requirements which would respond to technical assistance but you must, at all times of course, take into account the wishes of the Icelandic Government and in particular Mrs. Gudmundsson. In the second place, your report should cover these problems to which you are able to devote your time in the short period available to you in Iceland."

3. Later Mr. Dyer, Chief of the WMO Technical Assistance Unit, visited Iceland for mutual discussions with Mrs. Gudmundsson and myself during the time 8-9 August. A more detailed plan for my expert work was then agreed upon. The formal directive from the Secretary-General of WMO is attached at Annex VI. The report here given is substantially in accordance with this plan.

4. The report is partly based upon experiences gained during visits at Vedurstofan, Reykjavik, at the Forecasting Services at Reykjavik and Keflavik, at the aerological station at Keflavik and at a number of minor climatological stations mentioned in Annex V to which visits were arranged by Mrs. Gudmundsson on various occasions.

5. The facts mentioned in the report are mainly taken from information obtained from Mrs. Gudmundsson, Mrs. Adda Bara Sigfusdottir, chief of the climatological section, Mr. Flosi Sigurdsson, chief of the instrument section, Mr. Hlynur Sigtryggsson, chief of the forecasting service at Keflavik and Mr. Jonas Jakobsson, at the forecasting service, Reykjavik, and Mr. Eysteinn Tryggvason, chief of the geophysical section.

6. A visit was made on 15 August to the Minister of Foreign Affairs of Iceland, Mr. Emil Jonsson, who, on that occasion, and at a subsequent lunch, gave valuable information concerning some views held by the Icelandic Government as regards the meteorological work and also some information concerning the need of the water power industry for exact information about snow and precipitation conditions.

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7. It was necessary to contact the representatives of the practical fields of work, in which the Meteorological Service must be considered of special value. Mrs. Gudmundsson therefore agreed to convene a meeting of such representatives to discuss questions of mutual interest. The meeting was held at Vedurstofan on 31 August 1956 under the chairmanship of the Director of the National Research Council, Mr. Thorbjörn Sigurgeirsson.

8. Among the persons present may be especially named those who took a prominent part in the discussion, namely: The Chairman, Jakob Gislason, Director of the State Electricity Board, Ingolfur Davidsson, Botanist of the University Research Institute, Gunnar Arnason, Secretary of the Agricultural Association, David Olafsson, Director, Directory of Fisheries, Unnsteinn Stefansson, Oceanographer of the University Research Institute, Hermann Einarsson, Ichthyologist of the University Research Institute, Gudmundur Marteinsson, Engineer of the Reykjavik Forestry Association, Helgi Sigurdsson, Director of the Reykjavik District Heating System, Sigurjon Rist, Hydrologist of the State Electricity Board.

9. Mrs. Gudmundsson opened the meeting. The present author gave an introductory speech on the subject of "Applied Meteorology". In the discussion, several points of view were brought forward which tended to illuminate and suggest means of intensifying the collaboration between the meteorologists on the one hand and the representatives of the practical fields on the other.

ORGANIZATION OF THE METEOROLOGICAL SERVICE OF ICELAND

10. The Central Meteorological Service of Iceland, Vedurstofan, comprises a number of different sections, which, on the whole, have the same tasks and objects as similar divisions belonging to the meteorological institutes within WMO in general. Thus there is an administrative section dealing chiefly with questions of organization, finance, salaries and appointments, a synoptic section under which comes the forecasting for general as well as for specific aeronautical purposes, a climatological and an instrumental section, of which the first-named deals chiefly with processing and publication of climatological data, the latter with comparisons and calibrations of meteorological instruments, inspection of stations, etc. The field of activity and objects of the instrumental and the climatological sections will, in accordance with my terms of reference, be especially considered in the present report. The list of staff and the instructions governing the work of these sections within the Icelandic Service are included as Annexes I and II. I will come back later to questions closely connected with these Annexes.

11. The smaller a meteorological service is, the more the conditions within one section will affect also the conditions within the other ones. It is only to a limited degree possible to maintain separation between the fields of work within one section and those of other sections and it is not desirable to try to do so. Lack of personnel, or the special qualifications of individual members of the staff, makes it often desirable that a meteorologist is used also outside the section to which he originally belongs.

12. An undesirable consequence of this is, however, that personnel deficiencies within one section of the institute affect also to some degree the other ones. This is true as regards deficiencies in the amount and qualifications of the staff.

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But the statement is valid also concerning certain factors of organization and equipment, which fall especially under the present consideration, namely:

(1) the meteorological network, its density and outfit, and

(2) the meteorological instruments, their construction, calibration and control.

Both these factors are basic ones, affecting most of the meteorological work within different fields. I will treat these basic factors separately before going into special questions as regards the use of meteorological observations for solving certain problems within practical fields of industry, fishery, forestry and agriculture, all of which to some extent must govern our ideas as regards the costs which could reasonably be spent upon a meteorological service in general.

1. DENSITY OF METEOROLOGICAL STATIONS

13. The general impression is that the net has a rather satisfactory density within the parts of Iceland where stations chiefly are situated. Thus, within the coastal region the density of the net corresponds to one station within every square of 40 km side. On the other hand a wide region of about 40,000 square km surface, representing the inner part of the country and forming about 40 per cent of the surface of the whole island, has no meteorological stations at all. The corresponding deficiency as regards our knowledge of weather and climate of the interior of Iceland is closely related to a deficiency also of our knowledge of the influence of height above sea level on weather and climate at Iceland. All the meteorological stations are situated at heights below 450 m and practically below about 200 m, only three stations being at altitudes between 200 and 450 metres, in spite of the fact that great parts of the country are above 450 metres and considerable parts above 800, e.g. Vatnajökull, Hofsjökull and Langjökull rising to 1,200 metres or more.

14. For the study of climatological correlations with factors within agriculture and forestry, such as crop and vegetable diseases, the vacuum itself does not seem serious, as the region where stations are lacking falls outside the regions where vegetables are grown or grazing occurs. But for every forecasting work, either for agricultural or other purposes, the deficiency means reduced possibilities of making accurate forecasts. The weather to be expected at a certain place is closely related to what goes on in the three dimensional space within rather wide regions and the vacuum in the meteorological station net implies a heavy handicap for the forecaster. He may wish to forecast fogs and clouds for the air traffic or frost and rain for the farmer.

15. It must be emphasized that what is said here applied not only to the so-called "synoptic" stations which are often unduly distinguished from the "climatological" ones, which do not send daily telegrams to a weather service. Mainly for financial reasons the synoptic stations must be comparatively few, and it is often questionable to what extent they represent a wider synoptic area. It is only through comparison with the reports of the climatological stations within the surroundings - which generally are sent in to the service only once a month - that the represenativeness of a synoptic station can be tested and a clear idea can be obtained about the extension of the region which it actually represents. In this way a well-planned climatological net is a necessary complement to the snynoptic net.

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For certain purposes a net of stations not sending daily telegrams is sufficient. The forecasting service cannot do effective work without the experience gained from the wider net including climatological stations. These points must be clearly kept in mind when the sufficiency of a net of meteorological stations is considered. The maps in Annex III give a clear idea about the geographical distribution of the Icelandic net. They show the situation of the synoptic stations (open circles) as well as the stations sending only monthly reports (squares). The stations proposed to be established are marked with filled circles.

2. FREQUENCY AND KIND OF OBSERVATIONS

16. Even very frequent observations at the existing stations cannot compensate for the gap mentioned under 1. Provided that stations are not totally lacking within a region, an increase in the frequency of the observations may, however, to some extent make up for the deficiencies arising from the sparseness of the net. Of the sixty-nine Icelandic stations, ten synoptic ones make seven or eight observations a day, fifty-one make from three to six observations a day, only two stations making two observations a day. It ought to be pointed out in this connexion that a kind of station frequently established in most countries, namely that making only measurements of precipitation, does exist only in very limited degree in Iceland. One of the reasons for this seems to be that the places where able observers can be found are rather scarce and that, where they actually exist, as much use as possible must be made of them. It follows, however, that the net giving precipitation is unusually sparse and that it is scarcely possible to form, on the basis of its reports, a clear idea of the distribution of precipitation over Iceland, not even for the regions where stations are found, viz. for the coastal land. I will come back to the consequences later.

17. A classification of the Icelandic meteorological stations into the categories defined by the Technical Regulations of WMO may be illuminating.

18. Of the sixty-nine Icelandic stations eighteen can, if one leaves aside minor limitations in the programme, be classified as being of the first, while nineteen are of the second order. The rest may be regarded as being of the third order, having less comprehensive observations than those of the second order.

19. This means that the more qualified stations of the first order are rather well represented in the Icelandic net. Sweden with its area almost five times as large as Iceland has only slightly more than seventy-six stations which may be classified as being of the first order and ninety-six of the second one. On the other hand, its temperature measuring stations are about 400 against Iceland's sixty-one, and its stations measuring rainfall are nearly 1,000 against Iceland's about seventy. I have referred to these conditions in Sweden not in order to press the comparison but because they clearly bring out the deficiencies of the Icelandic net. The urgent need as far as Iceland is concerned seems to be concentrated on an increase of the more simple meteorological stations, those measuring only temperature or rainfall or both. The reports of these stations are especially important for the purposes of agriculture and forestry and also for the hydro-electric planning, matters to which I will return later.

20. Some words may finally be said concerning the aerological observations. Iceland has only one aerological station, namely at Keflavik, jointly operated by

an Icelandic and an American staff. I am not going to report on the activity of this station in detail, chiefly because I regard it as mainly falling outside my terms of reference, but also because it is evident that it fulfils to a reasonable extent the demands of ICAO on such a station. Together with eight other Icelandic synoptic stations, the aerological station at Keflavik, at which ordinary synoptic observations are also carried out, is maintained through joint support from a number of countries under the administration of ICAO. Four aerological ascents a day giving temperature, humidity, air pressure and direction and speed of wind, are made regularly at Keflavik. With regard to the needs of synoptic forecasting, an unofficial request was made at the Regional Meeting of the Regional Association VI, Second Session, that an aerological station be established, preferably in the eastern or north eastern part of the country. It must be pointed out in this connexion that the aerological stations are not simply a matter of concern for the needs of the air traffic. It is only by way of an aerological network that we are able to draw synoptic maps showing the distribution of air pressure, temperature, humidity and air movement within different layers of the atmosphere, and it is only through a careful consideration of these charts together with the surface map, that modern weather forecasting can achieve effective results. The ordinary synoptic, the aerological and the so-called climatological stations must thus all be regarded as one inseparable whole, all with the purpose of satisfying industry, agriculture, fishing, forestry, hydro-electric activity and aeronautics in their needs of reliable weather forecasting. It must therefore be pointed out that a second aerological station at Iceland would be of high value not only for the air traffic but also for the forecasting in general which, as regards the Icelandic region, is hampered to some degree through the sparseness of the aerological network over these parts of the North Atlantic. The costs of an aerological station are, however, so large that it seems out of the question that the Icelandic Government at present would be able to accept them.

3. SPECIAL STATIONS

21. According to a recommendation by the CCl (CCl I - Annex I) special stations should be established and maintained to meet the requirements of, inter alia:

(a) Radiation climatology

(b) Mountain climatology

(c) Health resort and sport climatology

(d) Micro-climatology

(e) Agricultural climatology, phenology, forestry

(f) Hydrology

22. In most of the Nordic countries these demands are fulfilled only to a rather limited extent. Radiation climatology has been subject to investigations, but yet rather incomplete ones, in Sweden and Finland; mountain climatology in Norway and to a very limited extent in Sweden; health resort and sport climatology can scareely be said to have been the object of research in any of the Nordic countries, if one looks away from more sporadic attempts, and the same can be said

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as regards micro-climatology. Agricultural climatology, phenology and forestry have been subject to several attempts to correlate weather and climate with agricultural results, mostly on the basis of measurements and reports from ordinary meteorological stations (rainfall and temperature). The attacks on these problems have in many cases given promising and highly interesting results.

23. Close co-operation between hydrology on the one hand and climatology and weather forecasting on the other has been established in Sweden, where a meteorological bureau and a hydrological one are combined in one institute - Sveriges meteorologiska och hydrologiska institut. Also in Norway and Finland there is undoubtedly co-operation, but under less regulated forms.

24. I have started with this very general survey on the conditions within the other Nordic countries because they must be kept in mind from the beginning when the deficiencies at Iceland are considered.

25. One must emphasize that, in order that the studies which ought to be served by the establishment of the stations under (a) to (f) above shall be fruitful, the first and fundamental condition is that a comparatively dense net of stations be organized measuring (1) temperature, (2) rain and snow fall, (3) cloudiness and humidity. It is too expensive to establish complete nets of stations falling under (a) to (f), at least in sparsely populated countries; and the evident task of such special stations must therefore be given observations and records of special elements like radiation, temperature of ground and of plants, snow depth, etc., which can be correlated with other more ordinary meteorological observations like those made at our stations of first, second and third order. On the basis of such correlations we may, after some time, be able to draw climatological charts concerning elements which are not necessarily observed within the ordinary net. Again we must here emphasize the necessity of building up the net of temperature and rain measuring stations. In the first place, new stations ought to be established at localities where plants are grown, grazing occurs, forest is planted, and/or where the population is comparatively dense. The evident relation between water power, precipitation, and snow cover ought to be investigated and stations ought to be placed according to corresponding needs.

26. After these general remarks on the importance of the development of the ordinary net, I wish to consider separately some of the items under (a) to (f).

(a) Radiation climatology

The only station at Iceland recording total radiation on a horizontal surface from sun and sky is at Keflavik, where records, with several and sometimes long interruptions, have been taken since 1951. The measuring device is an Eppley pyranometer - the instrument is often wrongly called a pyrheliometer - in combination with a recorder of type Honeywell-Brown.

The Eppley pyranometer has been subjected to a number of rather detailed studies by, among others, the Weather Bureau in Washington (several reports in Monthly Weather Review) and by the Swedish Meteorological Institute. Several different factors influence the readings and it is generally not possible to indicate a constant which can be applied under all conditions. To some extent the "constant" is dependent on temperature and on the sun's height above the horizon. Further the constant is liable to be subjected to deterioration on account of various conditions, as for instance, leakage of air into the evacuated globe. All these conditions of the Eppley pyranometer should be controlled by rather frequent observations with a standard pyrheliometer, like the Smithsonian or the Ångström pyrheliometer.

The total radiation income from sun and sky at different parts of the surface of the earth is an important climatological factor on which temperature and humidity conditions are largely dependent. In the programme for the World Meteorological Atlas, drawn up by the World Meteorological Organization, there enters now, as an important item, the drawing of maps showing isolines for the energy income from the sun at different regions of the world. It seems important for the value of such maps, that considerable attention be given to the accuracy and representativeness of the observations.

The equipment and maintenance of stations for radiation measurements must entail considerable costs if they are not combined with other works like those of an aerological station. In order to get a more general idea about the conditions over wider regions, it is therefore necessary to correlate the radiation observation with other meteorological factors more easily observed. One such factor is cloudiness; another one, not quite as easily but generally more accurately recorded, is "hours of sunshine". Thus if records of total radiation are correlated with records of sunshine at the same place we may, from formulas which have been developed, give an accurate picture of the total radiation at stations within the same region.

The stations in Iceland recording sunshine are at present only three. A net of at least six and preferably ten such stations would highly increase the value of the radiation measurements at Keflavik, where some improvement of the instrumental outfit seems necessary.

(b) Mountain climatology

Iceland would, if more densely populated, and with easier transport conditions give excellent opportunities for investigating the relation between altitude and meteorological factors at high latitudes. Studies of the run-off and evaporation from the Vatna Jökull by Ahlmann and his collaborators, and other researches by Hjulström and also by Thorarinsson have given sporadic results, applied to periods of comparatively short duration. Among other results they show the relation between climatological factors and run-off, an important relation especially for all considerations concerning the resources available for hydro-electric power. If one tries to develop an ideal programme for a meteorological net of stations, one can therefore scarcely avoid emphasizing the importance of having at least one mountain station at a high level, preferably at about 1,000 m. or more. In Iceland the transport conditions and possibility of getting observers for such a station are however such that one must regret that its establishment at present falls outside what can be hoped for as regards an immediate programme. What at present ought to be possible seems to be the maintenance, during some part of the year, of a station at between 600 and 700 metres, which to some small degree may also contribute to the filling out of the meteorological gap over the interior of Iceland.

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(c) Health resort and sport climatology

In Iceland the improvement of a general climatological net may, to a reasonable degree, fill these demands.

(d) and (e) Micro-climatology, agricultural climatology, phenology and forestry

These are all closely related to one another. I have pointed out above the desirability that meteorological stations within the ordinary climatological net should to a great extent be situated at places where their observations are applicable to the practical needs of agriculture. Temperature, precipitation, humidity and sun radiation (closely related to sunshine and cloudiness) are here the most important meteorological elements. As regards temperature and humidity and also sun radiation one often hears the remark from biologists that the meteorological measurements do not give what is actually asked for by the biologist, namely the temperature and humidity around the plant itself, and the radiation to the plant or tree which the biologist is studying. To some extent this whole discussion, illuminating as it is, is founded upon a misinterpretation concerning what is the task of the meteorologist and what is the task of the specialist on biology or forestry. It is not the task of the meteorologist to measure the temperature at, or radiation to, different parts of a tomato plant or a tree, because he has generally no education which tells him what parts of the leaf or the plant are important to know something about. It is clearly the task of the biological expert to furnish such observations. If they are intended to form a basis for studies regarding plant diseases and plant distribution in relation to meteorological factors, or for forecasts over wide areas, they ought to be put in the hands of the meteorologist who, in the first place, should try to find the correlation - or the relation - between these observations and those made within the ordinary network. First, if the result of such a study is unsatisfactory, the problem may be taken up whether or not new observations ought to be added to those of the meteorological network: e.g. measurements at other heights above the surface of the ground etc. The meteorologist can seldom take upon himself the task of observing and reporting the conditions under the special conditions studied by an expert in fields other than meteorology; he must have a general regulation on how his observations shall be made in order that he may not lose the comparability between the regions under his control.

For those who find the above reasoning too abstract I will give two concrete examples taken from my work within the Swedish Meteorological Service. I was requested to find the temperature conditions determining the period of the year when farming generally took place at Sweden (cultivation of soil, sowing, etc.). It was found that this period very nearly coincided with the interval when the mean temperature of the day, computed from measurements in the screens, had been above + 3°C. The correlation for the twenty stations investigated, situated at various parts of the country (from latitude 55°N to 66°N), was very high between the two periods in question. One could hardly ask whether, for instance, the minimum temperature of the night would not give a higher correlation and consequently be a better indicator. The correlation was found to be just about the same or slightly less. It had

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evidently been of very little practical value to try to relate the farming period to the temperature of the surface of the ground or of some special plant, because these temperatures are extremely variable within small distances, and it had scarcely been possible to find representative values for them.

Another case is offered by the frost forecasts for agricultural purposes. It was found that the probability of damage by frost is a rather simple function of the temperature below 0°C, as measured in the regular screens, and that it takes on considerable values first when the temperature goes below -3°, which naturally means that in many fields of crop the temperature is still some degrees lower. But what matters from a practical point of view is not so much the evident fact that what determines the damage in individual cases is the temperature of certain parts of the plants in question. It is for the biologist to investigate that. For the meteorologist who is forecasting, or who gives his opinion as regards regions liable to be free from or damaged by frost, it is in most cases sufficient to know how the damage is in general correlated to the ordinary observations at his regular meteorological net. If he could have stations at every field with different kinds of crop, and covering also all kinds of various topography, forecasts may, perhaps with greater success, be based upon results of such measurements. But as this, in actual practice, is impossible from economic and other reasons, the natural policy, when one wishes to promote the practical interests of industry, forestry, agriculture and water power seems, in the first hand, to build up the regular meteorological net and complement it through stations, the reports of which are as representative as possible for surrounding areas.

What has here been said applies also to an element, which has great actuality, namely the evaporation. Rather expensive means can be found to measure the evaporation from a part of the earth's surface covered by vegetation, the evaporating surface being kept wet by artificial means, if necessary, and the water level being kept constant. What one thus obtains is what Thornthwaite has defined as "potential evaporation". From the basic value of the potential evaporation one can, through methods applied by Thornthwaite and accepted in many places, compute the evaporation from the ground, if one knows its content of water. Highly interesting as these measurements are, their introduction in the Icelandic meteorological net, meets with some very heavy obstacles. The instrument itself, with its recording device, is rather expensive, the cost being about 50,000 Icelandic crowns. In addition to this, the instrument must be managed and kept in good service by one or preferably two observers, whose joint annual salaries (as they probably can do some other job also) need perhaps not be above the cost of the instrument. Here comes, however, an important limitation. The instrument gives the potential evaporation at a certain place under the the conditions existing there as regards temperature, cloudiness, rain, wind, and sunshine. In countries where wide homogeneous areas exist, covered with practically the same kind of vegetation and with the same kind of soil, as for instance over great parts of New Jersey, the measurements with the Thornthwaite instrument can be made in such a way that they are representative for large regions. But in a country like Iceland this is scarcely possible, if we do not install a rather large number of instruments, which from evident reasons must be impossible at present.

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Attempts are now made at the United States Weather Bureau by the Chief of the Climatological Division, Dr. Thom, to correlate the real evaporation from the ground, which is of very great interest, with simple measurements of evaporation from pans and of temperature and humidity at the regular meteorological stations. I am not aware of how far this investigation has now proceeded, but I have been informed some time ago that the results then seemed rather promising. It may be possible, if our expectations are correct, to introduce at comparatively small cost evaporation pans at a considerable part of the forty-two Icelandic stations now measuring both temperature and humidity.

(f) Hydrology

Through hydrological measurements we may get a clearer idea of the water balance over wider regions. Such an understanding is to some extent of value in connexion with agricultural problems.

Irrigation may, at some times of the year, be possible and prove profitable if springs and melting glaciers can be used. But the most evident benefit concerns the hydrology and the water power administration. Run-off - the source of water power - is the difference between precipitation and evaporation and, especially in the Spring when great quantities of water are stored in the form of ice and snow, a clear conception of precipitation and evaporation gives possibilities for forecasting run-off which have proved extremely valuable for the water power industry in Sweden and Norway. A condition for this is naturally that there exists a comparatively dense net of stations and that the snow stored at higher altitudes where the stations are scarce is correlated in a reasonable way with the measurements at lower levels. The development of such relationships has been an important task of the combined meteorological and hydrological services. In Iceland such studies are still hampered by the lack of stations measuring temperature, precipitation and snow cover, especially in the interior of the country. An important first attempt to gain some information concerning the relation between precipitation and run-off is made through the installation of nine stations in the surroundings of Hvalvatn, where the precipitation is measured by totalizators. Their position is marked by crosses in the map (Annex IV). The stations were established in 1947 - 1955. The results are, however, still awaiting closer examination and treatment.

4. FURTHER PURPOSES FOR WHICH OBSERVATIONS WITHIN A CLIMATOLOGICAL NET ARE OF VALUE

27. In the earlier part of the report I have mentioned briefly some fundamental reasons which make regular observations within a meteorological net desirable. The importance for forecasting is evident and need not be further considered. The need for the water power industry is probably not so urgent as in Sweden or Norway but a closer co-operation between meteorology and hydrology in Iceland, and a development of the meteorological net to meet corresponding needs, will probably prove profitable.

28. In many respects one is capable of finding remedies for the deficiencies of nature. Most conspicuous are perhaps our ways of making up for the differences

between actual temperature and what we find comfortable. Heating and air conditioning has caused revolutions in that respect. The energy necessary for heating a house, for instance, is dependent chiefly on air temperature, wind velocity and to some extent on radiation. If we know these factors in their normal variation during the year, and the isolating material from which the house is built, we may give with accuracy the energy necessary for heating to a desired temperature.

29. In Sweden the costs of heating are included in a special allowance to civil servants, if the climate can be regarded as hard, and the regulations are given on the basis of the temperature maps prepared by the Meteorological Bureau. Not all cases are as clear as that in showing the value of meteorological observations. It is well known, however, that "the climate largely determines the type of vegetation that grows naturally in any part of the world and the kinds of agricultural production that are possible. The three most important factors in climate from the standpoint of plant response are temperature, water supply, and light." 1/

30. Research now going on in several parts of the world has in many cases given rather clear ideas of what climatic conditions are necessary for the growth of certain plants. Advantage has been taken of that for transferring plants from one region of the world to another with highly profitable results. Cotton, coffee, and a number of different kinds of palms have thus been transferred to regions where their production is now vital and is, at the same time a source of prosperity in the countries concerned. Further new species of plants are developed and, knowing the climatic conditions of a region of a country, it is in a number of cases possible to tell if a certain kind of pine or fir tree, or a certain species of potato plant, can be cultivated with profit or not.

31. I will take one simple example of what meteorological and practical experts can do jointly because it applies to so many cases in the climates of high latitudes. We have found, let us assume, that a killing frost for potato plants generally occurs when the temperature goes down to -6°C or lower, at a representative meteorological station in the vicinity. If the critical period for the plant is indicated by the specialist, the meteorologist can tell that, at the corresponding time of the year, the producer of potatoes must count on one killing frost in let us say seven years as an average. From a practical point of view it then has to be considered if the profit from the good crop in six years makes up for the spoilt or damaged crop in one year. If not, potatoes ought evidently not to be cultivated in that place. Considerations like this have proved of great benefit to, among others, the cultivators of oranges and they ought to be applied to many activities within various fields. A sound statistical treatment of meteorological observations is, however, necessary for these applications.

32. A new field has recently been opened through research concerning the relation between plant diseases and climatological factors. I will take one example which applies especially to Iceland and also has the advantage of having been subjected

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1/ From "Climate and man". 77th Congress - House Document No. 27, Washington. Yearbook of Agriculture 1941.

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to a special and rather comprehensive report by WMO, namely "The forecasting from weather data of potato blight and other plant diseases and pests".2/ In the following short comments I limit myself to the question of potato blight.

33. Research in various countries has given the result that certain specified meteorological conditions generally occur before the outbreak of a potato blight. Thus the temperatures ought to be above 10°C but not above about 22° and the humidity ought to be higher than about 70 to 90 per cent. The period during which this ought to occur, in order to promote a potato blight, is found somewhat different in different countries. For the Netherlands Everdingen suggested a period of fourteen days whereas in most countries where such investigations have been made the criterion applies to twelve to forty-eight hours, with some differences as regard the limit value for relative humidity. In England warnings are now issued for potato blight in order that the farmers may cover the haulm of the growing plants by a fungicide which will kill the spores or prevent their germination. "The increase in potato crop yield which results from a successful extension of the life of the green foliage can be considerable."

34. These warnings are now issued in many countries, where forecasts have also been extended to other plant diseases, such as those of tobacco, tomatoes, wheat corn and pine.

35. The method of investigating the relations between damage and diseases on plants, and meteorological factors, is yet in its first stage of development. The attacks on the matter have generally had a considerable lack of precision, being rather vague in their definitions, and are as a rule not made in such a way that it is possible to compare, without going into the basic material, the advantages of one method over another. They show a deficiency very common in meteorological analysis of the kind here mentioned, disclosing the absence of modern statistical methods, through which the occurrence of a special phenomenon, for instance the potato blight, could be expressed as a probability function, reaching a comparatively high value within certain meteorologically defined limits and falling down to low values on both sides of it. For the development of forecasting for industry, forestry and agriculture, it seems very important that modern statistical methods are now applied.

5. INSTRUMENTS AND METHODS OF OBSERVATION, CALIBRATION AND CONTROL

36. The general instrument equipment within the Icelandic meteorological net is very similar to that used in other countries: it has, on the whole, an internationally accepted character. Thus air pressure is read from barometers of the Casella or Fuess type, temperature and humidity from thermometers of a type generally used. The thermometer screen is of a type experimented with in Norway and found to have the advantage of not being too easily filled with snow. Its dimensions are about 40 x 55 x 90 cm. The bulbs of the thermometers are two metres above the surface of the ground, to allow for a varying height of snow-cover.

2/ World Meteorological Organization, Technical Note No. 10.

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37. The deficiencies are not apparent at the best stations which, in general, fill reasonable requirements, but appear at a rather high number of inferior stations. The inferiority of these stations generally has one or two causes. Firstly, for economic reasons, not all stations have the free standing more expensive screens but screens mounted on the outside of the walls of houses. Through the heating of the walls by the sun considerable errors are here introduced. Of the sixty-one stations making temperature observations not less than fourteen thus have not free standing screens. Secondly, there are too few inspections of the stations and a corresponding insufficient control to ensure that the instruments are in good shape and give correct values. The number of stations inspected in the various years is seen from the following table:

Number of inspected stations

1951	1952	1953	1954	1955	1956
7	11	5	9	16	21

38. A regulation by WMO advises that stations of the kind here considered ought to be inspected once every second or third year. Consequently in three to four years sixty-nine stations ought to be inspected. The actual inspections are not half as frequent. A considerable improvement has occurred, however, in the last year, 1956.

39. Also as regards the inspections, the deficiency is caused by lack of means to keep a sufficient staff for inspections. They are generally carried out by the instrumental section with some help from all the other divisions and the director herself.

40. One serious drawback evidently is that the institute has neither a good laboratory nor an instrument shop where instruments can be controlled, standardized, repaired or kept in store under satisfactory conditions. Many of the recording instruments and all mercury barometers must now be sent abroad for repair which includes costs and, especially, loss of time, the observations being often interrupted for long periods. Furthermore, the meteorological work often requires experiments to be carried out for the purpose of improving methods in use. Recording instruments like thermographs and hygrographs ought to be carefully calibrated, not for single values but within the whole scale, the response of such instruments being often subjected to changes with time.

41. Rain gauges may probably be constructed and repaired in the instrument shop. A trained mechanician as head of the shop ought to be helpful also for experiments and for the inspection of stations. It must be considered - a matter, however, which falls outside the present report - whether his time would not allow him to do work also for other State institutes with similar purposes; for instance the hydrological service. This is a matter to be considered in connexion with his principal duties and the extent to which they will take up his time. It seems important, in all events, that his terms of reference should be flexible.

6. PROCESSING AND PUBLICATION OF OBSERVATIONS

42. This work is covered by the programme for the activity of the climatological section, a programme which is given in Annex II. The monthly weather publication issued by the Institute is included in the same Annex, as also the annual summary.

43. Some special points must be emphasized in this connexion. The plan is, on the whole, in conformity with the proposed regulations of CCl (CCl-I, 1953) with a number of limitations, however, as regards details. I will not go into these details more deeply, especially as I think they are of minor importance for the aim of the present report. For small meteorological services with limited staff and limited means at their disposal, it is necessary to introduce simplifications in order to save time and people. This applies for instance to such regulations as those of paragraphs 5 and 6, page 82-86, Technical Regulations Part VI (CCl-I, 1953). What ought to be especially stressed as regards the processing of the climatological data in the Icelandic Meteorological Service is that for all synoptic stations the observations since 1949 are introduced on punched cards and that computations by machine are made from them. In this respect the Icelandic Service is quite modern and ahead of what prevails in many other much larger services.

44. I wish especially to emphasize here again the desirability of computations of frequencies. They are an almost necessary condition for applicability of climatological data to practical questions such as water power resources and agricultural problems. Through the introduction of the punched card system the Icelandic Service has highly facilitated the introduction of such computations in the future.

45. The computations and especially the publications are, however, very much behind in time. The monthly weather report the "Vedrattan" is thus more than four years behind time, whereas similar publications from other weather services generally are issued during the month following the one to which the data applies. The reasons for this are twofold, namely lack of staff for computations and retardation in printing. The printing is now made in a printing office of the Government, which evidently is overloaded by work for different purposes. An improvement would be to make the printing through photostatic machines or similar arrangements within the Institute itself, which would to some extent further increase the work of the already too few staff. This drawback, however, would probably be fully compensated by the decrease of the work of proofreading.

46. The time lag of the computations stresses the point of increasing the staff to some extent. There is small use for climatological observations unless their processing takes place comparatively quickly after the observations are made. If too long a time elapses, deficiencies in the instruments and ways of making observations are not discovered in due time, but a collection of inferior material, sometimes of no use at all, is obtained often introducing a confusion of some sort which means still more unnecessary work. When a comparatively expensive net of meteorological observations is kept going - and I believe such an enterprise, according to many and long experiences, to be economically and practically sound - it is rather bad economy not to take care that the best possible use is made of this net. It is a loose expenditure of time, staff and costs not to do so. Sufficient personnel for certain basic computations and for inspections of stations must be available.

47. I am not implying through this that the routine processing, in computing means and averages etc., necessarily should be increased, or that the climatological regulations resulting from a century of meteorological conferences necessarily should be followed in detail. On the contrary, I think reductions in the official demands are necessary in the present case.

48. What I regard as essential, however, is that the staff should be large enough to give the qualified members opportunity to give thought and work to something outside the regular routine programme of processing and observing. If climatology is to be able to give something of real practical value to industry, agriculture, water power, etc., it cannot always adhere simply to old rules of processing, but it must try to develop new rules and new methods in view of the special demands of modern practical life. Many of these demands may be filled through an intelligent application of frequency computation and statistical relations with considerations of probabilities. Works along these lines are now beginning to appear in literature, especially from the United States. Especially for the water power industry, these modern methods of attacking climatological problems seem to be of high value.

7. PRACTICAL CLIMATOLOGICAL PROBLEMS

49. It is not possible here to give more than a brief suggestion of what kind of attacks on practical climatological problems one would consider to deserve priority. I will simply refer in general form to a few cases:

1. Detailed temperature maps over Iceland ought to be drawn, showing temperature, through isotherms, at various localities. The map of the interior cannot be founded simply on observations, but must be obtained from an extrapolation from existing reports from low level stations. From these reports an attempt ought to be made to express monthly mean temperatures (t) through a function $t = F(h, \varphi) + \Delta$, where h is the height above sea level, φ is the latitude and Δ is a comparatively small term giving the deviation of the actual observations from F. The function F may probably with good approximation be assumed to be a linear function of h and φ, viz:

$$F = a - b \cdot h - c\varphi$$

For further details I refer to my paper "On the air temperature in Sweden 1901-30", Meddelanden fran Statens Meteorologisk-Hydrografiska Anstalt.

The results of such a computation will promote correlation studies between agricultural conditions and temperature conditions in Iceland and may serve forestry, grazing, and several industrial activities as already has been the case in Sweden.

2. A study of the relation between precipitation, evaporation and run-off is of special interest for the water power industry. In countries like, for instance, Sweden and Norway, one may for a period of the length of one year assume the run-off to be simply equal to the difference between

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precipitations and evaporation. For periods not covering a whole number of years, account must be taken of the storage in the ground, the relation taking the form:

$$R = P - E - G$$

where: R = run-off, P = precipitation, E = evaporation, and G storage in the ground, all referred to the time interval in question, for instance a year. It must here be kept in mind, however, that the run-off R which generally, for instance in Sweden, refers simply to the run-off through rivers, floods and small streams, which is visible and measurable, must in Iceland be regarded as composed of two parts, one R_a corresponding to the run-off just named, the other one R_b, the invisible sources and springs which take place below the surface of the ground and which have no visible outlet in the ocean.

As the Icelandic Minister of Foreign Affairs, Mr. Emil Jónsson, emphasized to me in a discussion with regard especially to the aims of the present report, the quantity G plays a highly important part in the Icelandic run-off, much of the water coming from underground springs. Water is stored at great depths, and the run-off may thus be determined by precipitation conditions at times far back. I will not enter here upon the best ways in my opinion of attacking this important technical problem; I wish here only to refer to an investigation by Dr. B. Rodhe at Stockholm, who has attacked the problem of ice formation in the Baltic with methods which I think would apply to the run-off problem in Iceland if only the temperature factor in the research of Rodhe is replaced by a precipitation factor in the present case.

3. Damages by frost ought to be correlated with observed minimum temperatures and a probability function determined, which indicates the probability of frost damage, let us say on potato plants, at different temperature intervals.

4. Similar research ought to be made concerning the relation between potato blight and meteorological factors, like temperature, humidity, rain, and sunshine.

5. Measurements of the total radiation at Keflavik ought to be related to records of hours of sunshine; and records of sunshine at a number of stations ought to be used for giving information concerning the radiation and illumination climate of Iceland.

50. All investigation under (2) - (4) needs close collaboration between the meteorologists on the one hand and, on the other, the technical or agricultural experts in the field to which climatology is applied.

51. The great advantage of scientific research in fields of human activity is contained not simply in the practical results immediately produced, even if they may be considerable. Scientific research and its results have a faculty for attracting interest and stimulating activity in a way that routine observations or

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processing according to accepted rules seldom have. The latter are necessary, no doubt, also for enabling us to do the former, but it is scarcely possible that they alone would be able to keep up the spirit of curiosity, of interest for penetrating the laws of nature, which are necessary to give to qualified technical and scientific staff of a meteorological institute the feeling of satisfaction which alone in the long run, can stimulate efficient work.

* * * * * *

52. In the first part of this report I have given a general survey on the Icelandic Meteorological Service, on the work it is doing and not doing and on the deficiencies which adhere to it. In many cases I have suggested improvements, in others I have felt forced to admit the impossibility of finding remedies, partly because of economic reasons. On the basis of these earlier considerations, and with due regard to economic means, reasonable practical demands, and possibilites of getting what is desired, for instance as regards qualified personnel, I will now try to summarize my earlier considerations and formulate a proposal about what seems to me ought to be done immediately in order to increase the efficiency of the meteorological service.

53. It seems possible now that considerable improvements can be made with the aid of TAA. But it is also evident that aid from TAA is impossible or of little use if it does not go hand in hand with certain improvements which no one other than the Icelandic Government itself can produce. It therefore seems important to correlate the activities to be expected from the Government with those of TAA and see how they together may give something which can be regarded as a satisfactory improvement.

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8. AMELIORATIONS AND EXTENSIONS WHICH OUGHT TO BE PROPOSED TO THE ICELANDIC GOVERNMENT

54. 1. There is an immediate need for the extension of the office space about 170 square metres being a minimum requirement. Possibilities seem now to exist to get this space within a new building planned by the School of Navigation. The part which ought to be reserved for the meteorological service is to be used for workshop, laboratory and for housing meteorological original reports and diagrams. It is expected that a large part of the necessary outfit of the laboratory and the workshop may be obtained through the aid of TAA. Still a certain additional allowance ought to be included in the budget for raw material, for the workshop and for furnishing new rooms. A sum of 20,000 Icelandic crowns all at once seems to be a reasonable request for that purpose, provided the aid from TAA is obtained. Repair and construction of instruments, especially rain gauges, anemometers and thermometer huts, should be done in the shop. Further, it should be considered whether or not the workshop could to some extent be self supporting by doing work also for other institutes against payment.

It must be strongly emphasized, however, that the measure taken for providing more space must be regarded as only a provisory one. Already in 1926 the Parliament had realized the need for a special building for the meteorological service and a decision to this end was taken (Law 15, June 15, 1926). Not only the main part of "Vedurstofan" but also the forecasting service at Reykjavik works now under difficult conditions on account of the lack of room and space. At the airport of Reykjavik the general forecasting office, as well as the one for the air traffic, are combined in a small rather old-fashioned building, where the space is too limited to allow undisturbed work.

The possibility must be considered of combining the whole meteorological service, general forecasting, administration, climatology etc. in the same building. Great advantage would be gained by having administration, library, laboratory and workshop in the same place.

2. Increase in the number of stations

At least six new synoptic (and at the same climatological) stations are desirable. Proposed places for these stations can be seen in the map in Annex III. In addition to this, one high level station in the interior of Iceland at least 600 m. high should, if possible, be established. It scarcely seems possible that it can be in function during the whole year, the possibilities of maintaining it for as long a time as possible must be investigated. Its location ought to be selected with regard to the water power interests.

It seems possible that the costs for erecting the new stations may totally or to a large part be taken from the budget already presented by the institute. An additional annual allowance of about 10,000 Icelandic crowns seems, however, desirable for erecting and operating stations.

3. Increase in staff

(a) The workshop should be in the hands of a trained mechanician, able to do fine mechanics, to repair and construct and also to help in inspecting and controlling meteorological stations. He also should be capable of helping with standardizations, calibrations and other experiments in the laboratory. According to Icelandic salary scales, a man qualified for such a job could demand a salary of about 5,000 Icelandic crowns a month. His existence is an absolute necessity if the workshop and the laboratory are to be effective.

(b) Of the present staff, the Director and four other members have full academic degrees, but still about ten have had corresponding meteorological education after their "abituruent" examination.

It seems to me highly desirable to increase somewhat the qualified staff in accordance with views which I have expressed above. One more reason, besides that of giving opportunities for scientific work, is that it seems desirable that qualified meteorologists should be able to step into vacancies left by the above-named qualified chiefs of section. This procedure is so much more desirable since I am going to propose that fellowships or scholarships of the kind now given by the United Nations be applied for later, so that these officials, responsible for the development within their section, may have a wider contact with international work within their fields.

I thus propose that means for engaging another qualified meteorologist with a university degree should be put at the institute's disposal. The new member ought to be qualified to organize and partly direct work within the climatological, instrumental, and geophysical sections and some weight ought to be laid upon his qualifications to make practical contacts and use them.

(c) Finally, to facilitate the increasing work of processing climatological observations, and to speed up this work to some extent, one assistant ought to be added to the climatological section. I think two would be highly desirable; one of them would then help to keep the library, now under the care of the geophysical section, in good condition. Especially if the aid now requested from TAA is granted, some additional assistant work will be involved in keeping inventory lists of instruments and a register of inspections.

9. AID TO BE REQUESTED FROM TAA

55. 1. For adequate outfit of workshop and laboratory with machines for repair and construction and instruments and apparatus for experiment at low temperatures and for control and calibration especially of thermometers, hygrometers and barometers. Important also for instruction and education purposes.

Sum at present difficult to fix, but it seems probable that an allowance of about $12,000 would give good opportunities, while about $8,000 would represent a minimum for an adequate outfit.

2. For supplementation of the radiation instruments, now rather deficient at Keflavik. Standard pyrheliometer with auxiliary instruments at approximate cost of about $700.

Also desirable but not necessary is a reserve instrument of type Eppley or Moll-Gorczynski, cost of the latter being not above $150 at present.

3. Outfit of five stations, in addition to now existing three, with Campbell-Stokes sunshine recorders. Records of these instruments may, in combination with measurements of total radiation income at Keflavik, constitute a basis for computing radiation distribution and light climate of Iceland as a whole. Important from the point of view agriculture and health.

A condition for the aid requested under (1) to (3) should be that the Icelandic Government agrees to the contributions proposed under sections (1) and (3) (a) of paragraph 54.

10. FURTHER EXPERT AID TO ICELAND

56. The Icelandic service, to some extent isolated as it is through the situation of the country, is in great need of further expert aid. This evidently can be achieved in two ways. Either some representatives of the staff can go to the experts, or the experts should go to the institute. The first alternative would be preferable were it not for the difficulties of doing without qualified staff members. Especially during the time of the International Geophysical Year, the whole staff is needed for fulfilling the home programme. The second alternative is therefore the only one to be considered at present.

(a) An expert on instruments and methods of observation is needed for about three months to instruct in the use of meteorological instruments and their calibration and standardization. He ought to help in mounting and installing instruments like the radiation outfit and sunshine recorders. He ought to help in planning and installing the outfit of the laboratory and the workshop.

(b) A climatological expert for about three months. He ought to be familiar with modern statistical methods, probability and frequency computations. He ought to have had practical contacts especially with water power needs, but preferably also with forestry and agriculture. It is important that he satisfies rather high requirements on his mathematical standards. He ought to aid in planning special practical meteorological research.

Remark:
57. A condition to ensure that the experts may be of greatest possible benefit to the institute is that the requirement in paragraphs 54 and 55 are fulfilled. If all of these requirements are not satisfied, a corresponding limitation of the work and time of the experts may prove necessary.

58. The visit of the named specialists should not exclude the possibilities of obtaining scholarships for Icelandic meteorologists at a later stage.

11. SCHOLARSHIPS

59. As soon as the staffing position permits, scholarships should be sought for professional training under the Expanded Programme of the United Nations Technical Assistance.

12. FINAL REMARKS

60. Finally I wish to add a few general remarks. In the general part of the report I have at different places compared the Icelandic meteorological net with that of other Nordic countries. I have also in some respects compared the size of the staff of different countries, showing that the size of the net as well as of the staff is relatively small in Iceland compared with the size of the country. It is evident that a comparison made in this way does not give full

credit to the endeavours of Iceland in the meteorological field. Due regard ought to be taken also of the population, which is only about 160,000 against 7 millions in Sweden and 3-1/2 millions in Norway. It is true that one cannot expect an effective meteorological service to continue to function below certain fundamental costs. A weather service for instance takes certain costs to run, in great part independent of the size of the population which has to support it. On the other hand, meteorology of different countries as in our time so interwoven into international enterprises that it seems not reasonable that a small population shall be loaded too heavily with the task of keeping up an all-covering meteorological service. ICAO has already furnished considerable aid for keeping up the synoptic stations and a weather service for the air traffic at Keflavik. But even with due regard to this aid, the remaining part of the net and the service represent an annual cost which is considerably higher on the individual in Iceland than in the other Nordic countries.

61. This makes it justified that additional international means are used for giving some further aid to Iceland in the form of technical equipment and expert help.

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ANNEX I.

COMPARISON OF STAFF BETWEEN METEOROLOGICAL SERVICES

IN NORWAY AND ICELAND

	Norway* 30.6.1954	Iceland 1956
Climatological Section		
Meteorologist	3	1
Assistant meteorologist	2	
Chief Clerk	1	
Clerk	4	
Meteorological Assistant	8	2
Supernumerary staff**		1
	18	4
Precipitation Section		
Meteorologist	3	
Assistant meteorologist	1	
Meteorological Assistant	2	
Supernumerary staff	1	
	7	0
Instrument Section		
Meteorogolist	3	1
Assistant meteorologist	2	
Clerk	2	
Distribution clerk	1	
Meteorological Assistant	1	
Chief of workshop	1	
Instrument maker	2	
Carpenter	1	
Supernumerary staff	1	
Mechanic		1/2
	14	1-1/2
Stations		
Reporting weather stations:		
Normal	121	37
Others	53	2
Not reporting	35	24
	209	63
Precipitation Stations	433	6
Preparing of monthly summaries	176	61
Pentades for agriculture	37	0

* Extracted from Annual Report of Norwegian Meteorological Institute.
** To reduce the delay in the preparation of monthly summaries.

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ANNEX II.

WORK CARRIED OUT IN THE CLIMATOLOGICAL SECTION

Checking of all logbooks and monthly summaries received (including checking of temperature readings, calculation of dew-point, pressure and coding).

Guidance of the observers concerning observations and completing of forms.

Inspection of meteorological stations. All observations (up to 8 observations daily) from reporting stations are recorded on punched cards by the Climatological Section.

Work for the publication Vedrattan:

1. In the case of the reporting stations, the punched cards are used for the calculation of monthly tables to the extent that this is possible, taking into account the present layout of the monthly tables. The calculation work is mostly carried out by the IBM calculation centre.

2. The monthly summaries for non-reporting stations are still calculated by means of ordinary calculating machines in the Climatological Section itself.

3. A detailed review of the past weather based on the charts prepared by the Forecasting Section, daily precipitation measurements for all stations and the daily mean temperature for a few stations; tables of wind forces of more than 7 Beaufort and frequency of fog are also calculated for each month.

4. Proof reading.

Calculations of CLIMAT for Reykjavik and Akureyri, and checking of CLIMAT and TEMP CLIMAT for Keflavik.

Aeronautical summaries are prepared for Keflavik airport in conformity with the WMO regulations by means of punched cards and are put on stencils. The Section replies each year to a great number of enquiries from different countries about weather and climatic conditions in Iceland.

Calculations of normal values.

At present an effort is being made to reduce the delay in the preparation of the publication Vedrattan, but nothing is being done to prepare new calculations of normals.

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Aerological observations from Keflavik are not regularly prepared for publication.

Information on damage and accidents caused by bad weather is collected by the staff of the Section. Furthermore the staff prepares statements about weather conditions for use in law courts.

FIELD OF ACTIVITY OF INSTRUMENT SECTION

Buying and making of instruments.
Repairing and maintenance of instruments.
Determination of corrections.
Despatch of instruments.
Stock of instruments.

Repairing and making of various types of equipment and furniture.
Instrument card index.
Tables of corrections.

Historical survey of the activity of the weather stations in co-operation with the Climatological Section.

Inspection of meteorological stations.

Establishment of new stations.
Maintenance of the precipitation measurements in uninhabited mountain areas.

Methods of observation.
Preparing of handbooks and instructions for carrying out meteorological observations in co-operation with the Climatological Section and others which may be given this task.

Experiments with instruments.

Correspondence of the Section.

Other tasks which naturally belong to the Section or have been referred to it by the Director.

The staff of the Instrument Section consists of one meteorologist and one mechanic, who also acts as the driver for the Institute. Until further notice, the meteorologist is also supervising the archives of the Institute. He is also working on attempts to forecast the weather for 2 - 3 days. Slightly more than half of the working hours of the mechanic is taken up by his duties as driver for the Institute.

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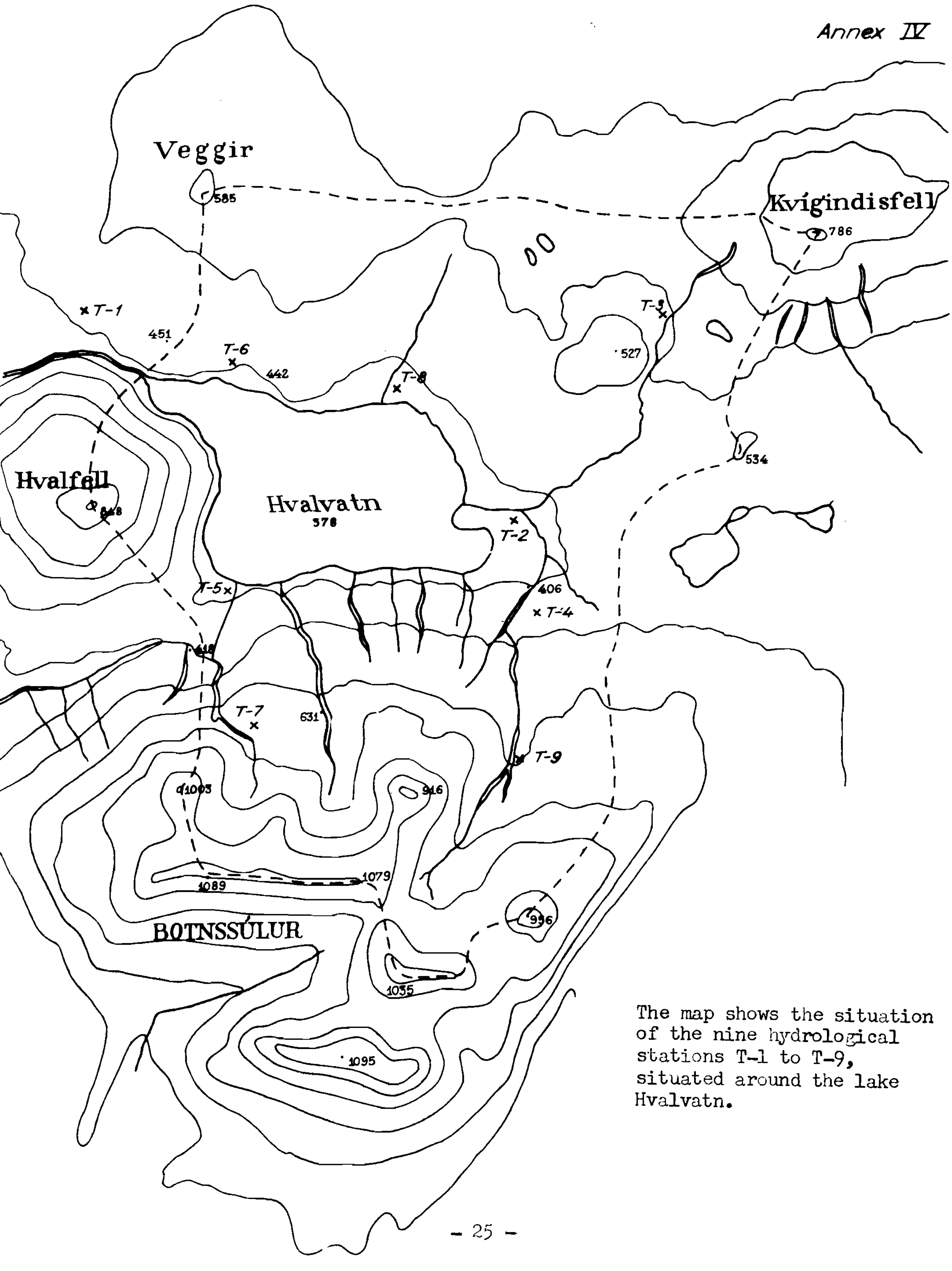

The map shows the situation of the nine hydrological stations T-1 to T-9, situated around the lake Hvalvatn.

ANNEX V.

TOURS OF VISIT AND INSPECTION

Tour I - Sunday, August 5th.

Participants: Dr. Ångström
Director Mrs. T. Gudmundsson
Chief Meteorologists Eysteinn Tryggvason and
Flosi Sigurdsson

Route: Reykjavik - Thingvellir - over Kaldidalur to Húsafell - Reykholt - Sidumuli - Whale-station at Hvalfjördur - Reykjavik.

The route went over the National Park at Thingvellir, where a synoptic station was inspected. From here the route followed a rough way over wild and uninhabited land. On the one side of the road the view was over the glaciers Thórisjökull, Langjökull and Eiriksjökull, on the other side over the glacier of Ok. The highest point on this route is 727 metres above the sea. From Húsafell the route went over Reykholt, a place where Snorri Sturluson the famous Icelandic bard and author, who lived in the 12th - 13th century has lived and owned house and land.

At Sidúmuli the synoptic meteorological station was inspected.

From here the route followed the coast to Hvalfjördur and further to Reykjavik.

Tour II - Thursday, August 9th.

Participants: Dr. Ångström
Mr. Dyer
Director Mrs. T. Gudmundsson

Route: Reykjavik - Hveragerdi - Thingvellir - Reykir i Mosfellssveit - Reykjavik.

At Hveragerdi there are a great number of hot springs. A visit was made to the greenhouses which are heated through water from the springs. Bananas, figs and various kinds of melons and cucumbers are here cultivated. Arrival at Thingvellir after having passed the hydro-electric plants which furnish Reykjavik and South Western Iceland with electrical power.

At Thingvellir a visit was made to the most known historical places. Here the Icelandic Parliament was instituted as early as 930 A.D. On the way to Reykjavik a visit was made to the hot water plant at Reykir at Mosfellssveit. From the hot sources at Reykir hot water is pumped through tubes to Reykjavik. About 60 per cent of all houses at Reykjavik are heated in this way.

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Tour III - Thursday, August 9th.

Participants: Dr. Ångström
Mr. Dyer
Director Mrs. T. Gudmundsson

Route: Reykjavik - Keflavik - Reykjavik.

Inspection of the weather forecasting service and of the aerological station at Keflavik.

Tour IV - Saturday, August 18th.

Participants: Dr. Ångström
Director Mrs. T. Gudmundsson
State Archivarian Bardi Gudmundsson

Route: Reykjavik - Múlakot - Tumastadir - Sámsstadir - Reykjavik

Visit to the famous garden with trees and flowers - birches, pines, firs, fragarias etc., at Múlakot. From there to the forestry experimental plant Tumastadir, where different kinds of especially firs and pines are grown. The experimental farming plant Sámsstadir was also visited and the climatological station there inspected. Experiments are here made in connexion with general farming and cultivation especially of oats and barley. On the way back to Reykjavik there was opportunity to see the result of the attempts at Rangárvellir to grow grass over large fields earlier covered only by sand.

On August 20th Dr. Ångström inspected the forecasting centre and the synoptic station at the airport of Reykjavik. He also has inspected two climatological stations, Vidistadir and at Ellidaár near Reykjavik.

Tour V - August 29th to 30th.

Participants: Dr. Ångström
Eysteinn Tryggvason

Route: Reykjavik - Akureyri - Mývatn - Akureyri - Reykjavik

We left Reykjavik at about 0900 hours on August 29th and came to Akureyri one hour later.

We left Akureyri at 1110 hours for Vaglaskógur (forest), Godafoss (waterfall) and Mývatn (beautiful and famous lake). At Reynihlid we visited the climatological station. We saw the fumaroles at Námuskard and the hydro-electric plant at Laxá and visited Eysteinn Tryggvason's parents at Laugaból.

At a farm "Geiteyjarströnd" near Mývatn we saw a wind-driven generator and asked for the experience of that:

In the autumn 1937 a 6-volt "Wincharger" wind-generator was set up together with accumulators. The aim was to convert the wind power to light in the house. This worked quite well, except that the accumulators were destroyed after about two years' use, and then had to be replaced by new ones. With new accumulators the use of the light would be limited to about two weeks in calm weather. In the winter 1955-56 the dynamo went out of function and was not repaired because a new electric supply had been introduced.

Similar experience had been gained at Midvik near Akureyri, where a 12-volt "Wincharger" was set up in 1942. It still worked but the accumulators were destroyed after about two years' use. As the accumulators are very expensive, the electric power is also expensive.

We were the guests of "Flugfélag Islands" (Iceland Airways) for the trips Reykjavik to Akureyri and back.

ANNEX VI.

DIRECTIVE TO DR. A. ÅNGSTRÖM RELATIVE TO WMO/TAA MISSION TO ICELAND

(Reference WMO Secr. 11898/56/AT/ICE/EXP/A 20 August 1956)

"To survey and report upon notable deficiencies which may exist in the climatological and instrument sections of the Meteorological Service in Iceland and to make recommendations for any practical steps towards their effective elimination.

To make recommendations or observations upon such other matters as may be requested by the authorities in Iceland.

In your report particular reference should be made to the following points:-

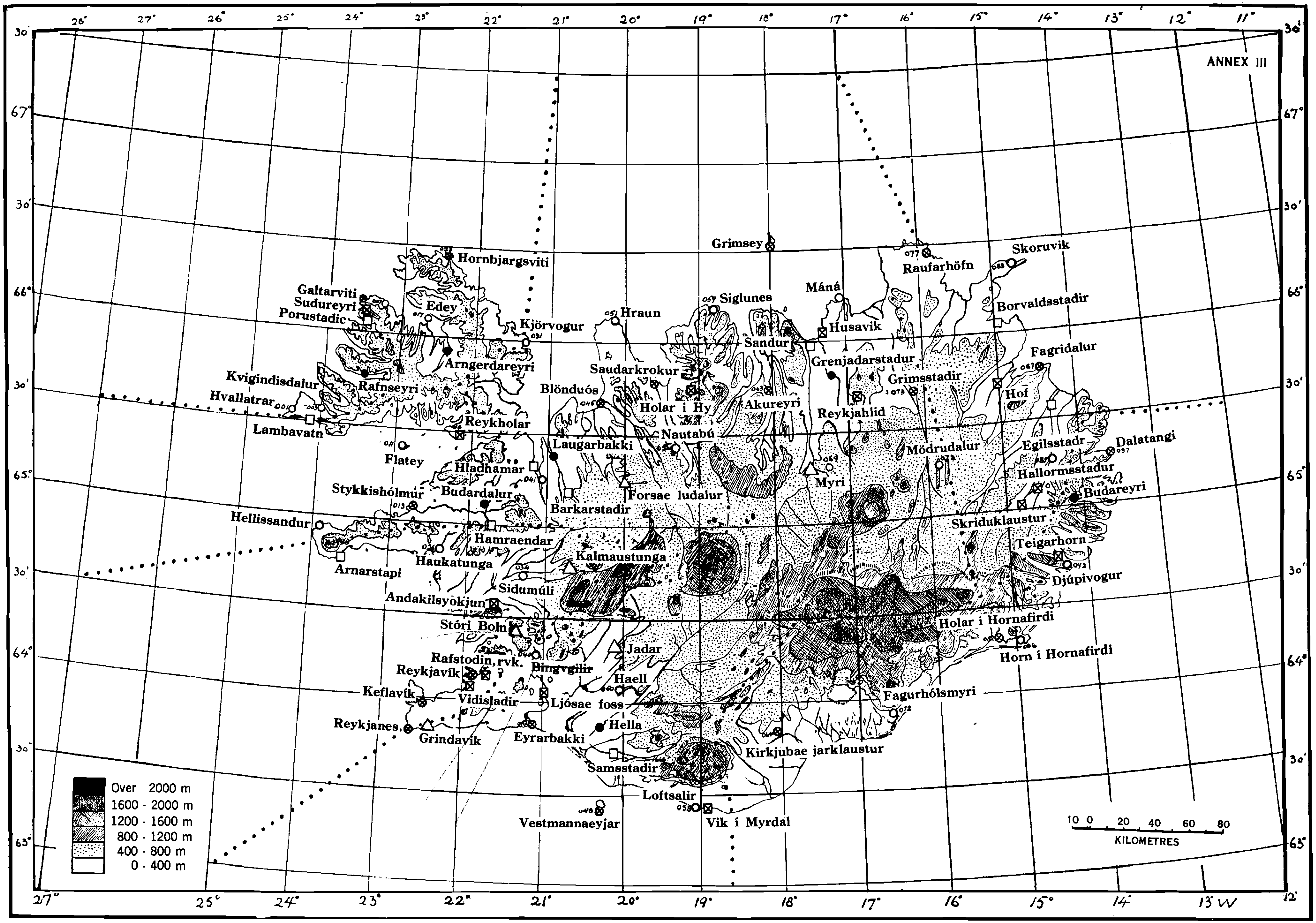
(a) Climatological and statistical requirements including:

- (i) observational network
- (ii) station equipment
- (iii) processing of data
- (iv) publication of data
- (v) particular requirements to meet special needs e.g. hydrology, agriculture, fisheries, wind power etc.

(b) Instrumental requirements including:

- (i) equipment for the climatological network
- (ii) repair, calibration and maintenance of instrumental equipment.

(c) Training needs for professional and technical staff."


ANNEX III
Grimsey
Raufarhöfn
Skoruvik
Hornbjargsviti
Galtarviti
Sudureyri
Porustadic
Edey
Kjörvogur
Hraun
Siglunes
Máná
Husavik
Borvaldsstadir
Sandur
Grenjadarstadur
Fagridalur
Arngerdareyri
Saudarkrokur
Grimsstadir
Kvigindisdalur
Rafnseyri
Hvallatrar
Blönduós
Holar i Hy
Akureyri
Reykjahlid
Hof
Lambavatn
Reykholar
Nautabú
Laugarbakki
Mödrudalur
Egilsstadr
Dalatangi
Flatey
Hladhamar
Myri
Hallormsstadur
Stykkishólmur
Budardalur
Forsae ludalur
Budareyri
Barkarstadir
Hellissandur
Skriduklaustur
Hamraendar
Kalmaustunga
Teigarhorn
Haukatunga
Arnarstapi
Djúpivogur
Sidumúli
Andakilsyokjun
Stóri Boln
Holar i Hornafirdi
Jadar
Horn i Hornafirdi
Rafstodin, rvk.
Reykjavík
Bingvgilir
Haell
Keflavík
Vidisladir
Ljósae foss
Fagurhólsmyri
Reykjanes
Grindavik
Hella
Eyrarbakki
Kirkjubae jarklaustur
Samsstadir
Loftsalir
Vestmannaeyjar
Vik i Myrdal
10 0 20 40 60 80
KILOMETRES
Over 2000 m
1600 - 2000 m
1200 - 1600 m
800 - 1200 m
400 - 800 m
0 - 400 m