Meteorology and the Community

By F E. DIXON, Irish Meteorological Service

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Introduction

I must first stress—what is often added only as a postscript to a paper—that any opinions expressed are the personal views of the author. They must not be accepted as representing the opinions of the Directorate of the Irish Meteorological Service, or of the Department of Industry and Commerce to which it is at present attached. To these bodies I am much indebted, both for the supply of much material and for permission to use it in the way I have done

Should scientists be subordinate to Civil Servants ? Should the scientific services be amalgamated under one Ministry of Applied Science ? Is there sufficient liaison between the meteorologists and other scientists, particularly agriculturists, or between the Meteorological Service and the universities ? These and similar questions are more often asked than answered, and it is striking that different countries supply very divergent answers. Here is a summary of the replies made in 1950 by 70 States to the question. "Who shall administer the national meteorological service ? "

One of the two largest groups, each numbering 18, answer "The Government," or "The State;" the Central Statistics Office is an Irish example of such treatment. The other group of 18 all have meteorology subordinate to Ministries of Transport and/or Communications. Seven place meteorology with agriculture ; another seven with the surface defence forces. Six tie it to Departments of Air or Aviation, and four to Education. Ireland is one of the three putting Industry and/or Commerce in charge Another three, with Departments of Interior, place it there, and yet another three class it in Public Works. The 70th State is the Argentine Republic, where meteorology is dealt with in an Institute of Technical Affairs.

Such a summary must be qualified : in this country meteorology and aviation are so closely linked that they are treated as one item in the Public Estimates, and it would be justifiable to reclassify Ireland in the aviation group Other countries also might be reallotted if we knew more of their internal workings. The main conclusion to be drawn is unaffected by such considerations. It is, that meteorology has many applications and different States attach different importance to different applications.

The explanation in the case of Ireland is that by international agreement each country is responsible for supplying detailed forecasts to aircraft flying over it, or across the oceans washing its shores So Ireland must be able to give the necessary information for trans-Atlantic flights. In the mid-1930's the United States and Britain were planning to open regular trans-Atlantic air services, and when the Irish Meteorological Service was formed in 1936 its first object was to equip and man a forecasting station at Shannon Airport. It was thus natural that the same administration should handle meteorology and aviation Now, 20 years later, most of the forecasters' time is still devoted to flight forecasts, but they are able to assist the general public through the press and radio, and supply special forecasts for particular sections of the community

In many countries Meteorological Services are much older than aeroplanes, and one can easily understand that the requirements of agriculture often had first claim, as they still have in a few areas. How the meteorologist is helping the farmer and how he could help more, are among my later topics.

Although the Irish Meteorological Service is a young organisation, it can claim to have behind it a long succession of Irish meteorologists A bibliography in course of preparation contains the names of nearly 200 men, some, such as Kirwan, Apjohn, Robinson, Beaufort, having made important contributions to the development of meteorology.

The Meteorological Office

The principal collector of Irish data, and until 1939 the supplier of all Irish weather forecasts, was the Meteorological Office of the United Kingdom. Its history illustrates the difficulties of finding the right Department or Ministry to supervise the work The Office came into existence as a result of Maury's propaganda He, a lieutenant in the U.S Navy but not on active service through injury, organised weather and wind observations by ships in all parts of the oceans, and by studying the results showed how sailing vessels could accelerate their journeys by making proper use of the more reliable wind systems. So valuable were the results that Maury called the first International Meteorological Conference to co-ordinate similar efforts by other maritime countries That was at Brussels in 1853 and the conference urged the setting up of national organisations. The British Government thereupon established the Meteorological Department as part of the Board of Trade, with Rear-Admiral Fitzroy (1805-65) in command His new title in 1854 was "Meteorological Statist," but he was still a seaman at heart and his efforts were directed to forecasting when storms could be expected At first he tried to make the sailors help themselves by supplying barometers to selected harbours, with instructions for interpreting their indications (i) Fitzroy also organised the telegraphic reporting to him from a network of 20 places, and early in 1861 began to supply warnings to ports whenever gales were foreseen. The success of the scheme was quickly proved. For example, in February of the following year the shareholders of the Great Western Docks at Plymouth were told that their revenue was seriously down compared with earlier years, owing to the large reduction in the number of ships requiring repair for storm damage.(ii) Daily newspaper forecasts were introduced in August 1861; they were less successful, but generally accepted as good enough to justify the small expenditure involved In 1863 the name of the Department was changed to "Meteorological Office" and in 1867 it was taken

(i) Fitzroy, R *Barometer and Weather Guide* London 1858.
(ii) Fitzroy, R. *The Weather Book* London 1863, p 171

out of the hands of the Board of Trade and placed under a committee headed by Sir Edward Sabine (1788–1883), a native of Dublin, who had carried out geophysical surveys throughout the British Empire. Most of the committee members were scientists and their first major change was to suppress the forecasts as not being based on sound scientific ideas. There was a public outcry, and the storm warning service was restarted, but not the daily forecasts, they did not reappear until 1879. By then Sabine had resigned in protest against an 1877 reorganisation by which the unpaid "Committee" became a paid "Council," nominated by the Royal Society, with the Hydrographer to the Navy as an ex-officio member

Another Dubliner, R H. Scott (1833–1916) who had succeeded Fitzroy in 1867, directed the Office throughout this difficult time and steadily developed the system of observing stations and the liaison with other countries He always took particular interest in the Irish work, carrying out annual inspections himself He established a Meteorological Observatory on Valentia Island, and later moved it to its present site on the adjacent mainland After his death in 1916 his executors presented his valuable library to the Observatory, where it is carefully preserved as his memorial

Scott's successor as Director was W N Shaw (later Sir Napier Shaw) Listen to this extract from his presidential address to Section A of the British Association at its last Dublin meeting in 1908

> "It is wasteful to collect observations which will never be used, it is equally wasteful to decline to collect observations which in the future may prove to be of vital importance It is wasteful to discuss observations that are made with inadequate appliances, it is equally wasteful to allow observations to accumulate in useless heaps because you are not sure that the instruments are good enough. It is wasteful to use antiquated methods of computation or discussion, it is equally wasteful to use all the time in making trial of new methods It is wasteful to make use of researches if they are inaccurate, it is equally wasteful to neglect the results of researches because you have not made up your mind whether they are accurate or not. It is wasteful to work with an inadequate system in such matters as synoptic meteorology, it is equally wasteful to lose heart because you cannot get all the facilities which you feel the occasion demands"

Shaw did much to improve the inadequate system of synoptic meteorology, and would have accomplished more had not the first World War put on his shoulders the task of reorganising to meet the demands of the fighting services Separate offices were established under the Admiralty, the Royal Engineers, and the Air Ministry, and their work was co-ordinated somehow This complex situation did not long survive the Armistice and in 1920 the offices were amalgamated and attached to the Air Ministry under a new committee, presided over by the Controller-general of Civil Aviation. Other committee members represented the War Office, Colonial Office, the Royal Society of Edinburgh, and later the Scottish Office. The

Committee did not function during the second World War, and when it was re-formed in 1947 there were additional members, from the universities and the Ministry of Fuel and Power.(i)

Although not politically independent, Scotland is to some extent a separate entity from England, and it has its own Advisory Council on Meteorology. This is probably in recognition of the important work done by the Scottish Meteorological Society (1855–1921, then absorbed by the Royal Meteorological Society). (ii) Ireland was never distinguished in this way, and even after the establishment of Irish independence the Irish observing stations and the Irish forecasts were still controlled by the British Meteorological Office.

In the middle 1930's it was realised that a change was necessary, and in 1936 an Irish Meteorological Service came into existence as part of the Department of Industry and Commerce, and under the directorship of A. H. Nagle. He resigned in 1948 to join the United States Weather Bureau, and was succeeded by the present Director, Dr. Mariano Doporto

The Irish Meteorological Service

Although Mr. Nagle took office in 1936 he had at first only secretarial staff to help him, and it was not until early in 1939 that any more professional or technical men were appointed. A major difficulty was training the officers who were to have the responsibility of issuing forecasts. There was no suitable university course in Ireland, and recruits had to be sent abroad to learn their meteorology. A comprehensive course was planned, starting in London at the Imperial College of Science and ending with periods of duty at the principal research and forecasting centres in Norway and elsewhere. One term in London was completed by seven "cadets"; then World War II commenced, and the scheme had to be abandoned Fortunately, there was in Ireland a small group of men loaned by the British Office to provide aviation forecasts at the embryonic Shannon Airport in Foynes. Some of these had experience in training forecasters and undertook the teaching. When the School of Cosmic Physics in the Dublin Institute of Advanced Studies was founded it was hoped that it would develop into a suitable establishment for training new meteorological officers. Instead, the Service has continued to do all its own training, under the control of some of the men recruited in 1939. Several years ago a Training Centre was planned, to be sited at Rosslare Harbour, in an area where an observing station was long overdue. Unforseen delays have been protracted and numerous, so that the observing station was not opened until December, 1956, and training has been accommodated successively at Cahirciveen, Shannon Airport and at Dublin Airport.

The men loaned by Britain left in 1941, and for the rest of the "emergency" the work, and the numerous staff, progressed satisfactorily. But when peace came and civil aviation began to expand rapidly

(i) Since this paper was read the Meteorological Committee has again been changed to comprise an independent chairman, two scientists, and two laymen, the Government Offices and Ministries being no longer represented

(ii) Veryard, R G History and Constitution of the Meteorological Office. *Weather*, Vol X pp 178-182, 1955 on both cross-Channel and trans-Atlantic routes, a serious shortage of forecasters became apparent. As a temporary expedient, experienced men were hired from wherever they could be found—mainly from the United States At one period the forecasting staff at Shannon included simultaneously American, German, Polish, Portuguese, British and Irishmen Eventually, in 1954, sufficient local men were trained and the temporary personnel repatriated. To supplement the direct intake from universities, selected men from the lower grades were assisted to obtain university degrees and thereby qualify for promotion

Now another emergency has arisen in the Service · the work continues to expand, but it is becoming increasingly difficult to find men with suitable qualifications, and more men are lost by resignation than can be recruited. The principal reason for the resignations is inevitably money Although the salary scales seem attractive, they are less than the sums offered by British industry for efficient scientists. Money is not the only cause. Some men never settle to the system of varying hours of duty, and in particular find night duty a hardship It is difficult to find a remedy, but the situation is embarrassing and it will clearly be several years before the Service can undertake any additional major tasks such as expanding the programme of meteorological assistance to agriculture.

Similar problems have arisen with the lower grades—the Meteorological Assistants. There also resignations have overtaken appointments, just when more men are needed to man new observing stations. The Irish Service has modified the system of manning stations from that prevailing before 1939. Then there was only one station in the 26 Counties area which had a full professional staff Observations at the other four reporting stations were made by local people employed only part-time. Five new stations set up since 1939 have all full-time staff, and the four older ones are being replaced by others similarly manned. One more new station is due to open soon and yet others are likely to be necessary.

The initial headquarters of the Irish Meteorological Services were over shops in St. Andrew Street, Dublin, in a building which had twice suffered bomb explosions, and with sagging floors barely able to support the weight of presses and filing cabinets. In 1941 the Director moved to the present premises at 44 Upper O'Connell Street, which also house the administrative sections, the Climatological Division, the Instruments and Supply Division, Instrument Workshops, and the Library. The last three occupy an extension at the rere with an entrance from Moore Lane. On the roof of the extension are facilities for observing and for instrument testing There is an air-raid shelter, which is now crammed with data and charts, and future storage of the rapidly accumulating new material is a serious problem. At a recent check it was found that maps, etc. in stock weighed 60 tons and filled 2,700 cubic feet. Some space can be saved by microfilming, but in legal enquiries and Court cases it is often essential that the original documents shall be available. The library expansion is a less serious problem, books and bound periodicals being added to the extent of only a few feet per year The nucleus of this library was presented by the British Meteorological Office and by the Royal

Meteorological Society. Other Meteorological Services were also generous and there is a steady influx of their publications in exchange for those issued in Ireland.

Some of the details of living and working conditions in that early period of the Shannon Airport in Foynes are best forgotten Conditions were rather better when the airport transferred across the Shannon to Rineanna. At Dublin Airport the first meteorological office was one room in what still retains the name of "the red-brick building"—the only surviving structure of the first aerodrome established there in World War I. When the new terminal building was designed most of the top two floors were allotted to meteorology, thanks to the foresight of the then Director Regrettably, some other sections of the airport community had not allowed for expansion when stating their requirements. Within a few years they were invading the meteorological rooms one by one, some of which were admittedly not much used—because the Meteorological Service could not find enough men. Now, even if we can obtain recruits, the work will suffer through over-crowding

The other out-station which has been developed considerably is the Valentia Observatory at Cahirciveen, so called to commemorate its original position on Valencia Island, but spelled with a *t* to avoid confusion with the Spanish Valencia. It was originally a dwelling house for the Superintendent, with only a few rooms allocated to science Now all the rooms are offices or workshops and other buildings have been added for special equipment, such as the radar set used to track balloons sent up twice a day to explore the the upper atmosphere.

Climatological Division

A simple definition of climate is "average weather." A truer one is "the weather that never happens." It is almost always wetter or drier, colder or warmer than the alleged normal, whether that is based on the arithmetic mean or mode or median, or a mixture of them. So Climatology is the study of frequencies, and provides many exercises in theories of extreme values and others of the statistician's delights. This branch of meteorology is relatively new up to ten years ago textbooks on climatology were mainly descriptive accounts of the averages and ranges of the elements in different regions. Then a new book appeared, *Methods in Climatology*, by Professor Pollak of Dublin and Professor Conrad of Princeton, and, more recently, another important work has appeared with a similar theme (i)

The Climatological Division of the Irish Meteorological Service was started by Professor Pollak and planned on modern lines, with a thoroughly trained staff assisted by the most suitable calculating machines. They collect and collate millions of figures every year. Each doubtful digit is investigated and observers are sometimes surprised by the detective ability shown by the climatologist in discovering the errors of reading instruments, or slips in copying When the errors have been eliminated, selections of the summarised data are

(i) Brooke, C E P and Carruthers, N *Handbook of Statistical Methods in Meteorology*, London 1953 published in a monthly weather report, printed on the premises, and which circulates throughout the world in exchange for similar emanations from other countries The principal data are presented by maps of isopleths as well as tables, and the rainfall maps are also issued separately on a larger scale

Whereas the weather reports on which day-to-day forecasts are based are sent in by professional meteorologists, those used by the climatologist include many from amateurs and from men and women who do the work as a minor part of their daily round Hospitals, Forestry Stations, Agricultural research centres, E S B. plants, maintain sets of meteorological instruments and read them at least once a day Of the 865 rain-gauges now in operation a large number are at Garda barracks

The E S B is a good example of the applications of climatological data Before building expensive dams or installing generators they must know how much water will be available, how much rain can be expected and what proportions will be lost by evaporation and percolation They must know how much water need be stored to provide for rainless periods, and what excess supply there may be in times of flood When a plant is working the engineers must keep a constant watch on the rainfall, and on the temperature when snows are melting, to assist in predicting the river-flow for a few days ahead Utilisation of wind-power will need further studies of climatological data—and more demands on the forecasters.

The climatologist can help in many types of planning in deciding the sunniest site for a hospital, the most frost-free area for a fruit-farm, a humid place for spinning mills, etc. When a new airfield is being considered the climatologist can advise which of the possible fields experience the least fog and low cloud, which combination of runway directions will best minimise the occasions of cross-wind landings, and which of the runways will need the maximum installation of landing aids Admittedly, the climate is not the only consideration, and inaccessibility may rule out the field which the climatologist thinks the most suitable Ignoring the expert's advice sometimes yields very good results when Dublin's water supply was being improved in the 1860's the engineers based their calculations of the water available on the rainfall measurements in Phoenix Park, Dublin rejecting the higher figures for the privately maintained gauge at Fassaroe, which later experience showed to have been more applicable.(1) The result is that, in spite of the continued increase of population, far beyond that envisaged a century ago, Dublin still has an excellent supply of water

The climatologist and meteorologist are sometimes subpoenaed to give evidence, testifying to such things as the severity of a storm, and whether it was more severe than one normally expects. Or he may be asked whether fog at a particular time and place was thick enough to explain why a motorist failed to see a pedestrian, or vice versa Officers of the Irish Meteorological Service have given evidence at several enquiries into air and sea accidents and a problem has arisen concerning their status as scientific expert witnesses The

(1) Neville, P. The Water Supply of the City of Dublin *Proc Inst C E.* Vol XXXVIII, 1874

accidents often occur many miles away from any meteorological station and the meteorologist stating his opinion of the probable weather is basing his views on a careful study of his maps, compiled from reports for a large area, before and after the time of the incident. From his training and experience he can estimate the rate of movement of belts of bad weather, he can interpolate some of the data, and can usually give a confident reply to the questions asked. But, however confident he may be, he is liable to find his evidence set aside in favour of the statement by an eye-witness, even when the eye-witness was one of the parties involved, and interested in proving the weather was to blame.

Forecasting Division—Value of Weather Forecasts

One estimate of the financial value of meteorology was made a century ago It was in the days of sailing ships, and the average time for a passage to Australia from Britain was 183 days. The studies by Maury, already mentioned (Page 82) enabled ships to do the voyage in only 135 days, a reduction of 26 per cent , and the number of voyages per ship in a given time was increased by 36 per cent. Such a saving was worth £2,000,000 a year to British shipping alone (i) The increased use of steam-power made Maury's work obsolete, but the modern meteorologist can help aviation as Maury helped shipping. Taking a typical winter month, the average time for a flight from London to New York by the most direct route was found to be 20 h. 20 m If the flights were planned to take full advantage of favourable winds the average time was reduced to 17 h. 48 m That is a saving of 12 per cent or an increase in the number of flights per aircraft of 14 per cent.(ii) These percentages look less impressive than those for sailing ships, but there is another factor to be considered the amount of fuel can be cut by nearly 12 per cent and that means a valuable increase in the number of passengers or weight of cargo which can be carried, with a consequent increase in operational profit, or reduction in loss.

If you ask an air pilot why he needs a meteorological service it is unlikely that he will mention the economic factors. He will probably consider as more important the warnings he receives of areas of dangerous icing, thunderstorms, fogbanks and other hazards. That flying is now as safe as most forms of surface transport is largely due to the efficiency of the meteorologist in predicting winds and temperatures, clouds and weather, visibility and turbulence. I do not know of any attempt to assess the financial value of this to the community, but we can say that the forecaster is an essential member of the team of scientists and technicians whose efforts have made Civil Aviation possible.

Ships as well as aircraft find meteorologists invaluable. There are still 6,800 shipping accidents reported each year, but many fewer than before broadcast storm warnings and other forecasts became possible. In a few respects the meteorologist is becoming less

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(i) Maury, M F. *The Physical Geography of the Sea and its Meteorology* London 1855 (and many later editions)

(ii) Sawyer, J S Theoretical aspects of pressure-pattern flying Met Reports. Vol 1 1949 (M P 4960) indispensable · as radar improves and is installed more widely, ships (and aeroplanes) can find their way through fog. However, a small ship caught by a gale on a lee shore is in deadly peril, and warning services will always be needed to enable ships to avoid dangerous situations.

There are many other warning services. The E.S.B. like to be warned of the likelihood of "day darkness"—the gloom which necessitates the switching on of tens of thousands of lights, putting a heavy additional load on the generators. And the E S B. require regular predictions of rain, and forecasts of thunderstorms or ice-storms, both of which may damage transmission lines. Similarly Dublin Corporation is advised when it may be necessary to call out the snow shovels, or the sand lorries for treating icy roads. We cannot count how many more car crashes or broken limbs there would be without the warning system, but if any serious accidents are prevented there is justification for the very small fraction of the forecaster's time which these services take up.

The extension of these services by supplying special weather forecasts to other public bodies, industrial concerns, farmers, etc. are obvious developments, and I need not give many more examples. I would like to discuss a few of the possibilities of helping the farmer, notably the potato blight warnings.

The Potato Blight Warnings

The modern "blight warnings" exemplify the results possible when there is real co-operation between biologists, agriculturists, and meteorologists. Thanks to them we know the life history of the fungus *Phytophthora infestans* (Mont) de Bary, and particularly we know that the fungicidal sprays are effective only at one phase of its development, when spores emerge and spread the infection Spraying carried out to a rigid programme (e.g so many weeks after planting and at regular intervals thereafter) may be ineffectual, wasteful of time and material If the spray is applied too long before the spores appear not only may rain wash it away, but there will be unprotected new foliage. And if the spraying is delayed until the blight is detected, it is too late ; spores will already have established mycelium in the foliage of many more plants than the few which have visible signs of blight.

Fortunately we now know what weather is necessary for the emergence of the spores, and we know that, if the fungicide is applied as soon as such weather occurs, it will have the maximum effect. The Dutch were the first to apply this knowledge by issuing blight warnings, as long ago as 1928 The weather criteria they used involved the careful study of four elements, but British workers discovered that as good results could be obtained by much simpler formulae with only two variables—temperature and humidity, and the system used in Ireland is an improvement of the British technique.(i) It is not yet perfect, and even if it were the meteorologist could not claim the entire credit for saving the potato crop. What he does claim is

(i) Bourke, P M A Forecasting from weather data of Potato Blight and other plant diseases and pests World Met Organisation Tech Note No 10 Geneva, 1955 that careful use of his advice will ensure that the yield of sound tubers is as large as fungicidal protection can achieve and that the expense of spraying will be kept to a minimum.

Mr. Bourke, the Assistant-Director of the Irish Meteorological Service, was responsible for instituting the improvements to pre-existing systems and for inaugurating the Irish warnings in 1952. He is Chairman of the working group of Weather and Plant Diseases of the Commission for Agricultural Meteorology of the World Meteorological Organisation, and has recently returned from nearly a year in Chile, to advise on the possibilities of blight warnings there.

The potato studies can be used, not only to give blight warnings, but also to predict the severity of blight attacks, and hence the yield of untreated crops There are many other natural products whose yields can be predicted from meteorological data Good examples are supplied by wheat The pale western cutworm (*Agrotis orthogonia*) can be serious in the United States. Its active period is Spring, but major attacks occur only if the preceding Summer was dry. So the extent of damage can be forecast six months ahead! Then comes Brown Rust (*Puccinia triticina*) which is controlled by Spring weather, and confident estimates of its damage can be made two months before harvesting.

Some agricultural forecasts are made possible by simple phenological studies. Phenologists are the people who carefully record the date of the first cuckoo or the last swallow, etc. and such dates can be a valuable index of the accumulated effects of weather. The application to forecasting arises from the similar behaviour of plants and of different infections. A typical example from France is that when *Gnomia veneta* appears on sycamore trees it is time to prepare to combat the much more serious vine mildew (*Plasmopara viticola*) which will make its appearance in a few days.(i)

It is regrettable that these examples are taken from other countries than Ireland Each country has its own climate and its own collection of diseases, and considerable further research is necessary before there can be much extension of the forecasting of plant diseases here.

The future of Agricultural Meteorology in Ireland

I hope that I have convinced you that already the meteorologist can help to improve the efficiency of agriculture in Ireland, and that he could do more The present Meteorological Service is understaffed and losing more men than it is recruiting. It cannot undertake the necessary research programme. The proposed Agricultural Institute might provide facilities, but so far meteorology has not even been mentioned as a possible subject for its curriculum. A similar oversight occurred when a symposium was convened in March 1956 to collect views on " How I would plan to increase agricultural output " No meteorologist was invited and (as far as can be deduced from press reports) no speaker mentioned the possible assistance of weather experts.

What is needed is an Agricultural Research Council with representatives from the farmers, the chemists, the biologists, the statisti-

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(i) Bourke, P M A *loc cit*

icans, and the meteorologists, competent to prove to the Minister of Finance which lines of research are most certain to be profitable investments, and which University or Institute should be asked to undertake the work. It would also control a central advisory service and maintain a library through which millions of meteorological and other relevant data could be made available

Such ideas are utopian and, if anything practical is eventually established, it will not be for some years Meanwhile much could be done to publicise the existing services I have mentioned the potato blight warnings At the Spring Show each year there are well designed educational exhibits emphasising *inter alia* the importance of spraying against blight But even last year there was no mention of the provision of forecasts of the best times to spray, and no reminders of the uselessness of spraying at the wrong time

Weather and Health

Since correlations are found between plant diseases and the weather, it is to be expected that human diseases may be studied in the same way They can, and one finds valuable possibilities, particularly for short-range forecastings

Many diseases show well marked seasonal incidence, with the peaks and troughs modified and displaced during years of abnormal weather. The only data which I quote, however, depict the normal seasonal fluctuations for five representative classes of complaint

Number of Notifications of selected diseases in respect of thirteen four-weekly periods averaged over three years (1954-56)

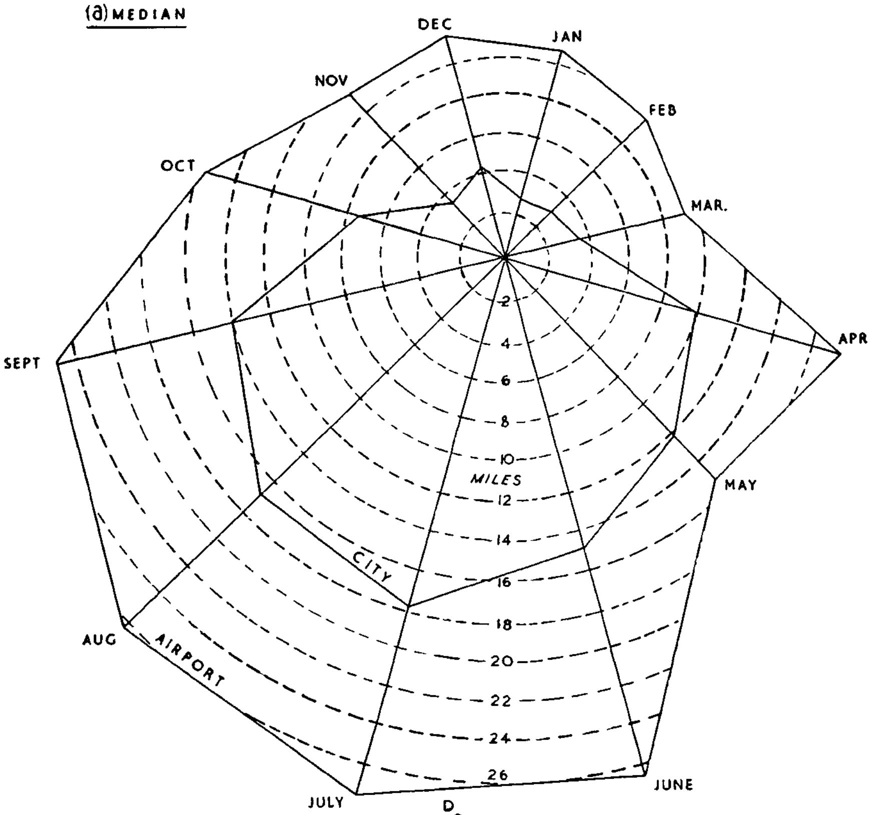
DISEASE	PERIOD												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Whooping Cough	462	382	293	243	274	275	281	249	219	167	191	254	249
Influenzal Pneumonia	8	17	54	27	20	4	6	4	3	3	3	7	5
Measles	352	641	992	1,105	1,259	1,178	1,150	580	280	221	358	419	320
Diarrhoea and Enteritis	56	62	64	57	69	80	83	101	177	162	111	90	61
Acute Anterior Poliomyelitis	12	10	5	6	3	4	13	32	42	41	43	30	15

The above data are for Ireland, supplied by the Central Statistics Office, Dublin

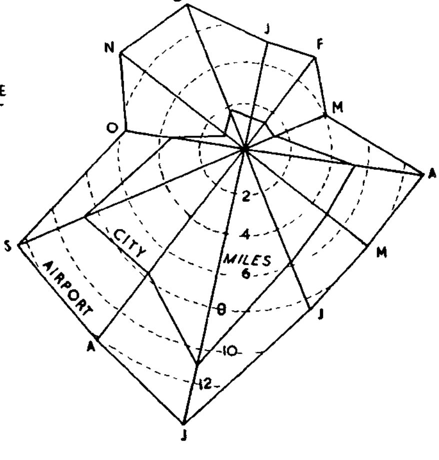
Inspection of the Table reveals that Whooping Cough is most prevalent at the beginning of the year after a rapid increase from its minimum in September Pneumonia is almost absent except in the period from February to May and the third interval has twice as many cases as any other Measles has its minimum at the same time as Whooping Cough, but does not reach its maximum until mid-May The Diarrhoea and Enteritis group are almost exactly opposite in phase to Whooping Cough, with mid-winter minimum and a sharp peak frequency in late August. Similarly Polio fluctuations are the mirror image for those for Measles—minimum in Spring and reaching a flat maximum in late Summer and early Autumn

ANNUAL VARIATION OF VISIBILITY AT 10h. G.M.T. DUBLIN 1951—1955

(a) MEDIAN



(b) LOWER QUARTILE



The regularity of the variations suggests correlating with temperature and in some cases, as Diarrhoea and Enteritis, it is noticeable that every hot spell in Summer is closely followed by an increase in the disease, so that mere inspection of the temperature records assists materially in forecasting outbreaks The correlation is usually more complex Polio seems to break out in a rainy period following a hot spell, and further analysis is desirable.

Both weather and disease show evidence of cycles with lengths of a few years, cycles which are subject to changes of phase and of little value for assisting predictions However, as in so many other fields of research, there are grounds for hope that further investigations may yet yield useful results

Another type of health forecasting, fortunately not yet necessary in Ireland, relates to the poisonous fogs which happen in large industrial centres such as London It takes a few days of continuous fog for the impurities to accumulate to dangerous proportions, and the meteorologist can usually forsee the continuance of the fog in time for warnings to be issued to the public—and to the owners of the chimneys belching forth the noxious fumes In Ireland fogs rarely last long and the concentration of Sulphur Dioxide in a fog has never reached a toxic level. But the health, and the prosperity, of the community would benefit if frequency and density of city fogs were reduced. And the reduction could be effected if there were fewer open hearths and more use of smokeless fuels, burned in properly designed stoves ; and if factory chimneys were all fitted with filters, or furnaces with smoke-consuming appliances. Then we would find that buildings would require less frequent refacing and repainting , clothes would need washing less often , curtains would rot less quickly And, incidentally, the saving of fuel would quickly pay for the cost of the new equipment needed As far as I know, the financial losses due to air pollution have never been computed for Irish cities, but the figures derived from surveys in other countries suggest that for Dublin the direct loss is over a million pounds a year, without taking into account the loss of working-time through extra sickness, and some other items.(i)

It will be many years before Irish householders can be persuaded to abandon the use of the open hearth, and meanwhile the meteorologist can help in several ways. He can advise on the necessary height of chimneys for the safe dispersal of poisonous emanations, and the best sites for unavoidable smoke-producing plants. And he can supply the evidence of pollution to help the campaign for purer air.

A diagram has been compiled to demonstrate how dirty is the air breathed by Dubliners. It depicts the " visibility " (the distance at which suitably large objects are clearly recognisable) from a roof top in O'Connell Street, Dublin, and at Dublin Airport only six miles away. The data presented, based on observations made at 10 a m. G.M T. each day, are the median and quartile values of the visibility, i e. the distance exceeded on half and threequarters of the days respectively.

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(1) Marsh, A. Smoke : The Problem of Coal and the Atmosphere. London 1947

At the Airport, even in the foggiest months, the median is 9 to 11 miles and the quartile 4 to 6 miles, compared with city distances of only 3 to 4 miles and 1 mile. There is less difference in summer, mainly due to there being fewer domestic fires lighted, but the city air is at all times appreciably less transparent Not all Dublin's pollution is locally produced, much of it coming from Great Britain, and in general our visibility is less with easterly than with westerly winds, because of the pollution originating in the English and Welsh industrial areas. The origin of the smoke was proved long ago by Hartley, who analysed air-borne dust and showed the presence of substances which must have come from South Wales.(i)

Accuracy of Weather Forecasts

The numerical assessment of the accuracy of a weather forecast is an extremely difficult problem, and has been the subject of extensive research in many countries (ii) The method at present used in the Irish Meteorological Service is a development of Vernon's concept of the skill score, (iii), using S=(R–E)/(N–E) where R is the number of correct forecasts, N the total number of occasions and E the expected number of accurate forecasts on some standard such as chance Thus if we set up the contingency table for a simple case where the forecast can only be right or wrong

Actual \ Forecast	Occurrence	Non-occurrence	Total
Occurrence	a	b	C
Non-occurrence	c	d	D
TOTAL	A	B	N

Then $S=(a+d-E)/(N-E)$ and E may be taken as $(AC+BD)/N$
Hence $S=2\,(ad-bc)/(BC+AD)$
In the special case of $b=c$ this value of S is found to be identical with $\sqrt{\frac{\chi^2}{N}}$ a measure of accuracy which has sometimes been used

Where the 2×2 table is inapplicable a 3×3 arrangement can sometimes be adapted For sunshine the form used is ·

Actual \ Forecast	Sunshine duration as percentage of possible			Total
	0—33%	34—67%	68—100%	
0—33%	a	b	c	D
34—67%	d	e	f	E
68—100%	g	h	k	F
TOTAL	A	B	C	N

(i) Hartley, W N Haze, Dry Fog, and Hail *Sc Proc R D S* Vol IX 1902, p 547-558

(ii) Bleeker, W Verification of Weather Forecasts De Bilt (Kon Ned. Met Inst No 125 B I 2 1946)

(iii) Vernon, E M A New Concept of Skill Score for Rating Quantitative Forecasts (*U.S M W Rev* Oct 1953)

The skill score S is then $(a+e+k-E)/(N-E)$ where $E=(AD+BE+CF)/N$

The limits of S are +1 for consistently accurate forecasting and zero when the forecasts are successful no more often than can result from chance. A negative value of S can occur, with the extreme value of —1 when the forecasts are all quite wrong.

An alternative index, which is based on deviations from expectations, is

$S_d=1-N\ (b+2c+d+f+2g+h)/A\ (E+2F)+B\ (D+F)+C\ (2D+E)$

This also has a maximum of +1, but the minimum of zero occurs both for all-wrong forecasts and for chance results.

In practice, the values found for S and S_d are usually between $+\frac{1}{3}$ and $+\frac{1}{2}$, and differ for the different weather elements, so that there is no clear-cut significance level, and the main usefulness of the skill assessment is in seeking evidence of improvement in the accuracy of the forecasting. Some results for recent years are :

Vales of Skill Score S

Year	Precipitation (Rain, etc)	Gales	Sunshine
1954	0 43	0 49	0 24
1955	0 48	0 59	0 24

The above figures are for the forecasts broadcast through Radio Eireann Some of the data have been analysed in greater detail For example, during 1955 the presence or absence of rain in Connaught was correctly foreseen on the previous day on 321 days (276 wet, 45 dry), an accuracy of 88 per cent , but the skill score is only +0·58. This is due to the fact that Ireland is a rainy country . if a forecaster had predicted rain every day he would have achieved 83 per cent. success, although his skill score would be 0 , if he had forecast that each to-morrow would have the same character as the current day his skill score would jump to 0·41 and the percentage of success to 85

The skill scores I have quoted have been for routine forecasts, prepared at fixed times each day. In a different category are such items as Gale Warnings, issued only when the need becomes apparent. Whenever a forecaster studies a newly completed map of the most recent data (which is at least 50 times a day) he asks himself such questions as " Do any current forecasts require alterations ? " " Are any special warnings necessary ? " " Can I now cancel any of the warnings in force ? " Hence there is a large preponderance of " *d* " entries in the contingency table, i e occasions when it is correctly foreseen that no warning is needed This modifies the procedure for assessing the S index, the expression for which becomes $2a/(2a+b+c)$ when d tends to infinity.

Gale warnings provide one of the few cases in which we can compare the accuracy of former experts with that of modern methods . with other forecasts there have been so many changes of procedure and the amount of data that no valid comparison can be made. For Gale Warnings some figures are ·

Gale Warnings for the Seas around Ireland

Year	Successful Warnings (a)		Gales forecast when none occurred (c)		Warnings issued after gales had begun (b_1)		Gales for which no warnings were sent (b_2)	Skill Score $S = \frac{2a}{2a+b_1+b_2+c}$
	No	%	No	%	No	%	No	
1905 ..	126	61	78	38	3	1	3	0 76
1955 .	135	69	35	18	17	14	0	0 84

Improvement is most obvious in the reduction of false alarms. On the other hand there is an *apparent* increase in the proportion of warnings issued late Most of the late warnings during 1955 were of gales which began at 5 or 6 a m and which had not been foreseen until after Radio Eireann had closed the night before It is suspected that analogous cases in 1905 were classed among the successful warnings.

Some special classes of forecasts are assessed by different methods. One important meteorological service to transocean flight is the provision of wind predictions several hours before any intended flight, to assist the air company to estimate fuel requirements, to revise time schedules, etc On the principal transatlantic route through Shannon Airport it is found that the average wind for the whole route to Newfoundland can have a westerly component of up to 65 knots at the 700 mb level (about 10,000 ft) although on other days it can be 30 knots from the East Higher up the winds are stronger, and at 500 mb (about 18,000 ft.) the range is from westerly 108 to easterly 72.(i)

The errors of these forecasts during a twelve-month period have been analysed by O'Carroll, who found that the errors have a compound normal distribution with interesting characteristics.(ii) From this paper the following table has been derived

	Error +37 to +23	+22 to +8	+7 to −7	−8 to −22	−23 to −37 knots	
700 mb	0 2	11 6	78·3	9 7	0 2	%
500 mb	0·7	17 2	68·4	13·3	0·4	%

On 94·6 per cent. of the occasions the forecast for the 700 mb level was accurate within 12 knots, and even these figures do not perfectly represent the accuracy of the forecasts, in that errors tabulated include errors of observation as well as errors of prediction.

(i) Gillman, C. J and Rohan, P K. An Analysis of Wind Components at the 700 and 500 mb. levels along the Great-Circle track between Shannon Airport and Gander Airport, Newfoundland. Irish Meteorological Service Technical Note 17, Dublin 1954

(ii) O'Carroll, F M An Investigation into the Accuracy of Wind Forecasts, prepared at Shannon Airport for the Great-Circle route Shannon-Gander. Irish Meteorological Service Technical Note No 20 Dublin 1955

International Meteorology

Most of the applications of meteorology that I have mentioned are domestic, but they are possible only through international co-operation Scientific friendships are more enduring than political pacts and have often continued active even when the scientists' rulers were at war. For example, it is recorded of Kirwan that, even when most of Europe was at war, his letters were allowed to pass freely(i)—letters concerned with collecting temperature measurements for his major climatological work, and the only meteorological work he published in book form (ii)

Every improvement in communications has assisted science. In Ireland the first effective telegraph was the semaphore system designed by R. L Edgeworth (1744–1817). In 1794 messages were exchanged between England and Scotland Ten years later, assisted by his brother-in-law (later also his son-in-law) Beaufort (1774–1857) he installed a chain of semaphore posts across Ireland and could send a message from Galway to Dublin in eight minutes (iii)

One of the first experimenters with the electric telegraph in Ireland was W Rowan Hamilton (1805–65). Although Astronomer-Royal for Ireland, he was not very interested in astronomy, but it was in connection with the astronomical use of telegraphed time signals that he experimented with wires at Dunsink in 1853 (iv)

The international exchange of meteorological messages by telegraph began in the 1850's, and international meetings were held to make financial arrangements and to devise simple codes for condensing the messages The meetings led to the formation of the International Meteorological Organisation in 1878, and in the next 60 years it extended its scope to include every branch of meteorological work, maritime, aviational, agricultural, climatological, etc. and produced almost complete uniformity of units, instruments and methods of observing. The codes are masterpieces of compression, a single line of 30 to 40 digits reporting in detail the pressure, temperature, humidity, wind, cloud types, amounts and heights, past and present weather, and sometimes additional items The system of reducing everything to numbers is not only compact, but has the further great advantage that numbers are the most widespread international language.

The I M O was controlled by a committee elected from representatives of the national meteorological services. Its activities ceased with the beginning of World War II, and after the war it was reconstituted as the World Meteorological Organisation—a specialised agency of the United Nations Organisation, and managed by a committee elected from the representatives of the subscribing *governments*. The personnel are mostly the same as before, but they attend the conferences as civil servants and no longer as scientists. One result seems to be an increase in expenditure and Ireland's contribution

(i) Donovan, M Proc. R. I. Ac. Vol. IV pp xxxi-lxviii

(ii) Kirwan, R An Estimate of the Temperature of Different Latitudes, London 1787 and Berlin 1788

(iii) Edgeworth, R L Essay on the Telegraph *Trans R I Ac* Vol IV 1795. Edgeworth, R L *Memoirs* (2 vols) London 1820

(iv) Graves, R P *Life of Sir William Rowan Hamilton* Dublin 1882. Vol III, p 468 is now £750 a year as compared with £40 to the I.M O in 1937. Whether or not some economies could be effected without reducing the amount of useful work done, a small country such as Ireland receives quite good value. As an example of the efficiency of the international co-operation in exchanging information, let us consider what is happening at the moment. At 6 p m G M T this evening observations were made simultaneously at several thousand stations and ships scattered all over the world These were collected at a few centres and rebroadcast from them by radio, telegraph and teleprinter. In Ireland we received the broadcasts for Europe, the Mediterranean, North Africa, the North Atlantic Ocean, plus Iceland and Greenland, the continent of North America, and the West Indies. By 8 p m. sufficient of the reports will have been decoded and inserted in the maps for the forecasters at Dublin and Shannon Airports to deduce what is happening along the flying routes and from which direction the next troughs of low pressure will approach By 11 p.m. there will be about 400 reports on the map and the forecaster will have drawn in the isobars and fronts, and will have made up his mind as to what can be expected to-morrow One of these charts is completed every six hours. Others covering a smaller area on a larger scale are done every three hours, and a third type, showing only Ireland, Wales and parts of England and Scotland, is compiled every hour. These charts are the forecaster's main tools whether he is concerned with to-morrow's weather for the daily newspapers or Radio Eireann, the gale warnings for shipping, the potato blight forecast for the farmer, the general flying forecast for the Irish Air Corps, or detailed predictions for every aircraft flight, whether for Aer Lingus' short routes or for the longer flights out of Shannon Airport

International Union of Geodesy and Geophysics

The World Meteorological Organisation administers the *technical* aspects of meteorology · its sub-commissions are styled technical commissions The international organisation for the *science* is a part of the International Union of Geodesy and Geophysics, founded after the first World War, and now affiliated to U.N.E S.C.O. through the International Council of Scientific Unions. Its functions are carried out through national committees and the Irish Committee includes men from the Ordnance Survey, Geological Survey, Fisheries Branch of the Department of Agriculture, the University Colleges, Royal Irish Academy and the Seismic Observatory at Rathfarnham as well as the Meteorological Service. These national committees presents reports of progress in their scientific activities to the triennial meetings of the central body, when a large number of original papers are also read. The cost to Ireland is £100 a year, of which only a fraction represents meteorology.

International Civil Aviation Organisation

Another international body interested in meteorology is I C.A O, the successor to I.C.A N. and primarily concerned with the safety of international flying. It promulgates standard procedures for all routines and emergencies, specifying uniform meteorological codes, time-tables for airport broadcasts, the radio frequencies used, etc Its meteorological work thus overlaps that of the W M O. but the two bodies are usually able to agree on their recommendations

The most widely publicised I C A O. service to meteorology is the maintenance of the so-called " weather ships " The name is significant, suggesting that the weather reports are more important than the navagational aids and rescue services provided by the ships There are now nine stations in the North Atlantic Ocean and a ship stays near the agreed position for about six weeks, not leaving until a relief ship is nearby

Many other ships send reports, but they are less valuable than those of the weather ships, since these others are naturally concentrated along the main sea routes, and they leave large empty spaces on the charts. The reports from a moving ship have to be corrected for the effects of the ship's progress from one observing hour to the next. Worse than that, the reports from the moving ships are sometimes wrong, even deliberately wrong ! A captain once confessed (even boasted) to me that he had several times knowingly sent weather reports with wrong positions. His explanation was that during the iceberg season he normally detoured well to the South of the direct route, in spite of his owners' instructions that he must keep to the shortest route, whatever the risk So he observed the weather and sent his message as a report of conditions up to 300 miles North of his true position. If there happen to be more honest ships reporting from the same area such deceits can be detected If there are no other reports to check against, the erroneous message may seriously mislead the forecasters.

An outstanding case of a dishonest observer comes from a tropical region where, for months at a time, the elements vary scarcely at all, except for the regular daily ups and downs of pressure and temperature An inspector paid a surprise visit to the station and found it deserted Enquiries disclosed that the observer had taken an unauthorised holiday, and had left at the Post Office a pile of telegrams to be dispatched at the scheduled hours !

Reverting to the Weather Ships, Ireland has not yet supplied any ships or crews, its contribution being purely financial, now £1,000 per year

Three Irish ships, owned by Irish Shipping Ltd are among the hundreds of moving ships which report regularly every six hours whenever they are at sea Observations made by the " Irish Cedar " while in Eastern waters, were filed by the Australian Bureau of Meteorology, and included notes of some unusual phenomena which supplied material for articles in the *Australian Meteorological Magazine* (1)

Conclusion

It is a regrettably common experience to be misrepresented when one's remarks appear in print My worst case was when a summary of one of my papers appeared with a headline "Meteorology is now an exact science." It never was, and never will be. Forecasting is a little more accurate than 20 years ago, and much more accurate than 50 years ago. New instruments and improved techniques will enable

(1) *Australian Meteorological Magazine* No 8 pp 48-50 and No 11, pp 83-88

us to continue a slow improvement. But there is a limit, and we are becoming conscious of it. The atmosphere is an unstable fluid. " Abnormal " events such as heat waves, cloud-bursts, gales, are incidentals in the continued motions of the air, redistributing the energy received from the sun. These events can be traced back, often to quite small beginnings, so small that we can only surmise their existence. Often we can assign no initial cause and postulate some such genesis as the random meeting of a few stray eddies to form a larger one, stochastic phenomena for which only average frequencies can be predicted, not the time or location of individual occurrences. By increasing the number of observing stations we only increase our chance of detecting a new development early in it's career, when it is becoming amenable to the laws of hydrodynamics and thermodynamics, so that its further growth can be calculated. In some cases the search for a cause is fruitless because a system seems self-maintaining, e.g. a Jet Stream (a narrow belt of strong winds about six miles up) can be explained as resulting from the juxtaposition of warm and cold masses of air. But once a Jet Stream is there its consequences include the warming of the air to one side and the cooling to the other. Our understanding of the problem is, however, increasing, and I hope that I have succeeded in assuring you that the Irish Meteorological Service is already playing a useful part in serving the community and that it is potentially an even greater asset.

APPENDIX

Numbers of Staff in the Irish Meteorological Service

The following Table gives the number of Staff on the payroll of the Irish Meteorological Service at the beginning of each calendar year. Progress was satisfactory until 1953, but not since, and during 1956 there were as many resignations as appointments.

	Grades			
Year	Officers	Assistants	Others	Total
1937 ..	1	0	3	4
1938 .	2*	9*	4	15
1939 .	3*	9*	3	15
1940 .	16*	17*	13	46
1941 ..	18*	29	18	65
1942	17	31	31	79
1943 ..	17	31	34	82
1944	20	31	49	100
1945 .	18	48	45	111
1946 .	22	56	48	126
1947	20*	59	43	122
1948	35*	65	42	142
1949	39*	72	50	161
1950	40*	90	49	179
1951	38*	95	57	190
1952 .	41*	107	56	204
1953	45*	125	53	223
1954	48*	126	47	221
1955	42	139	49	230
1956 .	44	136	50	230
1956 (2) .	44	137	46	227

Allocation

Year	Director's Office	Inst and Supply	Climatology	Shannon Airport	Dublin Airport	Valentia Obs	Out Stations	Training
1937	4							
1938	4			4*		7		
1939	5			4*		6		
1940	6		2	15*	2	5		16
1941	8		7	20*	3	10		17
1942	10		11	33	17	8		
1943	11		12	33	19	7		
1944	18		12	43	15	12		
1945	10	10	12	50	12	17		
1946	9	13	12	55*	15	15		7
1947	10	11	11	45*	16	17	8	4
1948	11	12	10	61*	24*	17	4	3
1949	10	14	17	61*	27*	18	4	10
1950	9	14	19	68*	28*	24	13	4
1951	10	14	22	65*	33*	23	15	8
1952	9	14	25	67*	34*	22	15	18
1953	10	14	24	68*	41*	30	16	20
1954	11	14	24	72*	40	30	16	14
1955	11	15	26	74	44	33	20	7
1956	11	14	25	72	40	36	30	2
1956 (2)	10	13	25	66	42	32	35	2

Notes to Table

All figures for January 1st except 1956 (2) which are for August 1st

Figures asterisked include staff on loan from other Meteorological Services

"Officers" include Director, Assistant Director, Senior Meteorological Officer, Meteorological Officer, or equivalent ranks in other services

"Assistants" include Senior Meteorological Assistant, Meteorological Assistant Station Assistant, or equivalent ranks in other services

"Others" include Clerical Officers, Writing Assistants, Typist, Messenger, etc , but not Cleaner or Domestic

DISCUSSION

Captain Brendan Flanagan Mr Chairman, Ladies and Gentlemen, I am indeed delighted to have this opportunity of seconding the vote of thanks to Mr. Dixon. His paper was most interesting—but more than that, it is an important paper, and I can only hope that the points he has raised will not pass unnoticed by those who may be in a position to influence official thinking in this country.

While the community at large gains from having a weather service, at present it is the small percentage of the community directly engaged in the Air Transport Industry who have most to gain or lose. As a representative of the aviation industry I am glad to have this opportunity of commenting upon a small part of the fund of meteorological information so ably presented by Mr. Dixon here to-night.

Very briefly an airline plans its operations under three guiding principles In order of importance these are—Safety, Comfort, and Economy

By his reference to radar and modern aviation aids, Mr Dixon, inadvertently, may have conveyed the impression that in the implementing of the safety principle, the trend is towards improved technology rather than improved meteorology This is not the case. In fact, with each improvement in an engineering facility, more accurate meteorological information is likely to be required. A typical example of this is the change over from piston engined aircraft to jet aircraft. Due to its greatly increased fuel consumption, modern jets cannot afford to carry the same fuel reserves as did the slower piston-engined aircraft, consequently more accurate wind velocity forecasts are a necessity There are, of course, many meteorological hazards which the aircraft may encounter in flight, e g Mr Dixon mentioned thunderstorms, icing, fog and low cloud

Now there is, I think, a popular misconception that the modern aeroplane can land in thick fog or with a cloud layer on the surface The facts of the matter are these Using the most modern techniques and equipment available, the pilot will not attempt to land in visibility of less than 400 yards or with a cloud base lower than 200 feet. Why ? Because the pilot must see and physically fly the aeroplane on to the runway Radar and suitable instrumentation help him to approach the runway so that he is in a suitable position to carry out, visually, a safe landing They cannot land for him or even help him to land When the meteorological limits are reached, the pilot either sees the runway and lands or he overshoots and proceeds to an alternate airport, where better weather prevails. The problem is best appreciated if it is realised that once the meteorological limits are reached, the pilot, casting aside instruments and relying solely on skill and experience, has about 25 seconds in hand before making contact with the runway. In these 25 seconds, he must assess accurately speed, height, wind drift, power setting, etc., and at the same time manually control the aeroplane The crying need of the air pilot, therefore, is more improved weather forecasting which will prevent him arriving at a destination where it is extremely difficult and often impossible for him to effect a safe landing.

In fairness to the Irish Meteorological Service, let me say that in our experience they are equal to any other service with whom we come in contact, and indeed, superior to many of them.

For the comfort of passengers it is essential that a turbulent free height is chosen. In making his choice of a comfortable altitude the pilot is of course guided by the route weather information available.

Finally, I spoke of economy It is in this field that the meteorologist has really proved his worth to the airline operator. In his paper, Mr. Dixon cites the London–New York route, giving examples of the saving to be achieved by availing of special meteorological information On this route the average saving, per flight is three hours. When it is realised that, exclusive of crews' salaries, it costs over £300 per hour to operate a long distance aircraft, the economic advantages may be more readily appreciated

One further example of the meteorologists' contribution to aircraft economics is worthy of mention Pan American Airways recently made a meteorological survey of their Tokyo to Honolulu route. By taking advantage of high altitude winds of strength up to 150 m.p.h., the airline has cut its flying time on the route by seven hours or about 35 per cent.

Relations between pilots and meteorologists are, as Mr Dixon might say, often turbulent. Consequently, the view I have given you is from the angle of the flight deck straight through the windscreen I might say, and not through rose-tinted spectacles.

Two other parts unconnected with aviation, and mentioned by Mr. Dixon in his paper, struck me rather forcibly

I had thought that "smog" was very much a London or Los Angeles problem The fact that it costs the citizens of Dublin in one million pounds per year is, in these lean times, worthy of note

The second point deals with agriculture

We are an agricultural country We have obviously an excellent weather service which could be of great assistance to the agricultural community. This is evident when we consider that the Government of Chile availed of the services of the Assistant Director of the Irish Meteorological Service for almost a year, advising on the potato blight To our amazement we now learn that the proposed Irish Agricultural Institute totally ignores the existence of the science of meteorology Thanks to Mr. Dixon, and with apologies to the *Readers' Digest*—"their slip is showing"

As a representative of the profession most frequently served by the Meteorological Service, I have great pleasure in seconding this vote of thanks to Mr Dixon.

Thank you

Mr Bourke (*Irish Meteorological Service*) also congratulated the speaker. As regards applied meteorology, he felt that its value in the case of a particular industry or undertaking was determined mainly by three factors—the accuracy of the meteorological advice, precise knowledge of the effect of meteorological factors on the industry and the economics of taking protective measures against unfavourable weather In some cases progress was retarded not so much by the limitations of meteorology as by the incompleteness of our knowledge of the second or third factors.

In a reference to potato blight epidemiology, Mr Bourke contrasted the fecund period in plant pathology represented by the second half of the 19th century with the comparative sterility of recent years. He felt that those engaged in agricultural research had allowed themselves to be intimidated by their concept of modern statistical methods so that the simple and effective experiments of earlier days had been supplanted entirely by large scale projects in which the wood was too often invisible for the procedural trees. The technique had been exalted at the expense of the idea There was a need to return to common sense in the planning of agricultural experiments.