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The Meteorological Office main marine data bank

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Summary

This paper describes the development of the Meteorological Office archive of marine data. There is some discussion of the limitations of the data and a brief outline is given of the services, based upon analysis of the data in the archive, available to industry.

1. Introduction

Marine data have been collected from the birth of the Meteorological Office in the mid 1850s and indeed the Office owes its existence to concern about the effects of adverse weather on maritime operations and loss of life at sea. In this paper some idea is given of the scope of the Meteorological Office archive of marine data, the difficulties in preparing and using it, and an indication of the services available to industry as a result of its development.

The main source of data has always been observations made by deck officers during the course of their normal duties aboard merchant ships. Data are also received from light-vessels and ocean weather ships, and in more recent times from buoys, oil and gas platforms, and soon from satellites. Fig. 1 summarizes the main sources of data.

Most of the maritime nations collect and archive marine data from ships of their national merchant fleets regardless of the position of the vessel at the time the observation was made. Since the position at any time is known only by the operator, meteorologists studying particular oceanic areas used to find it difficult to discover just how many ships were in the area at any given time and, hence, how representative their own national archive might be.

In the early 1960s the National Meteorological Services of a number of countries, under the auspices of the World Meteorological Organization (WMO), nominated nine countries each of which was to be responsible for the collection and archiving of marine data from a nominated area. Fig. 2 shows the

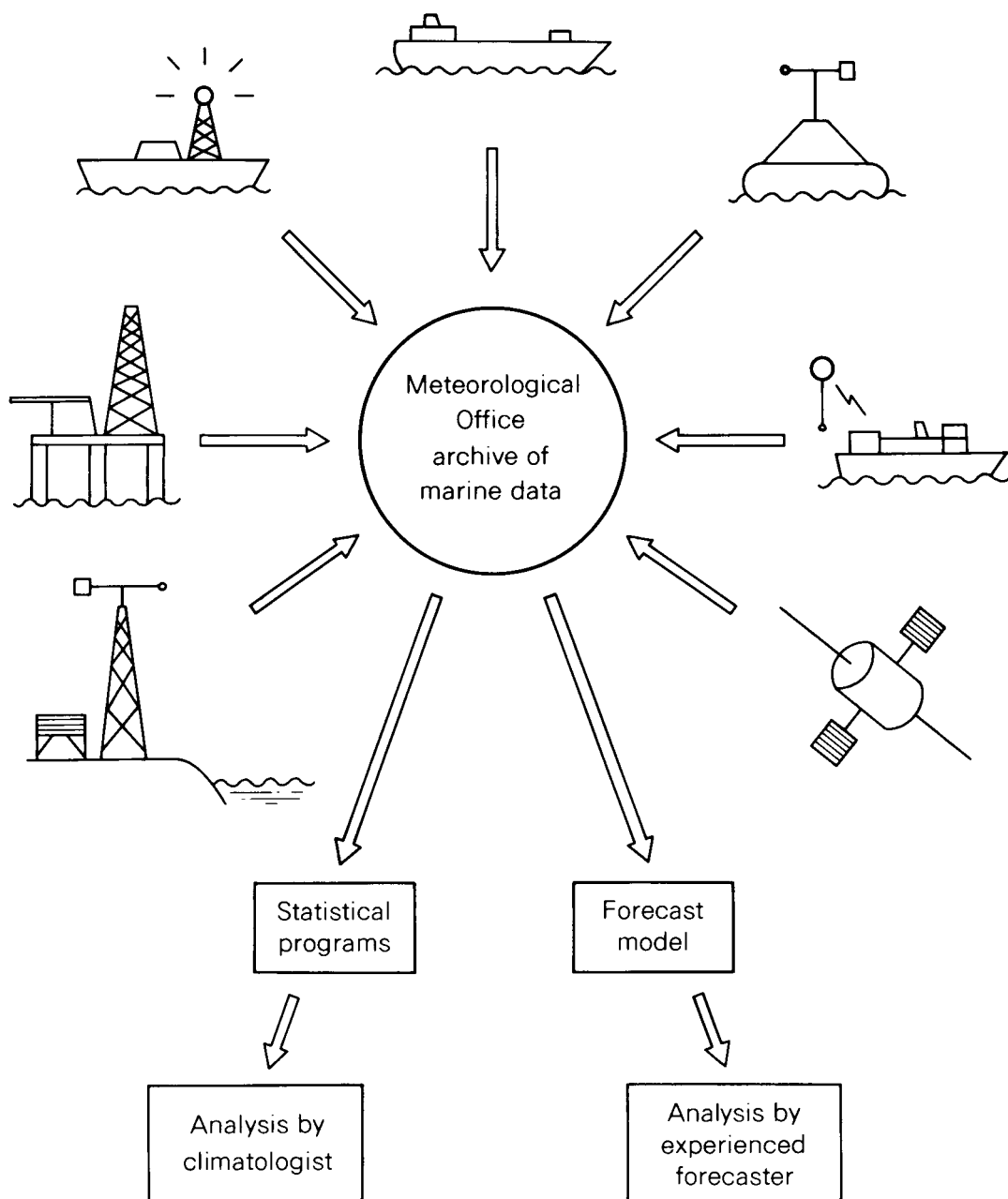


Figure 1. Schematic representation of the Meteorological Office marine data processing system.

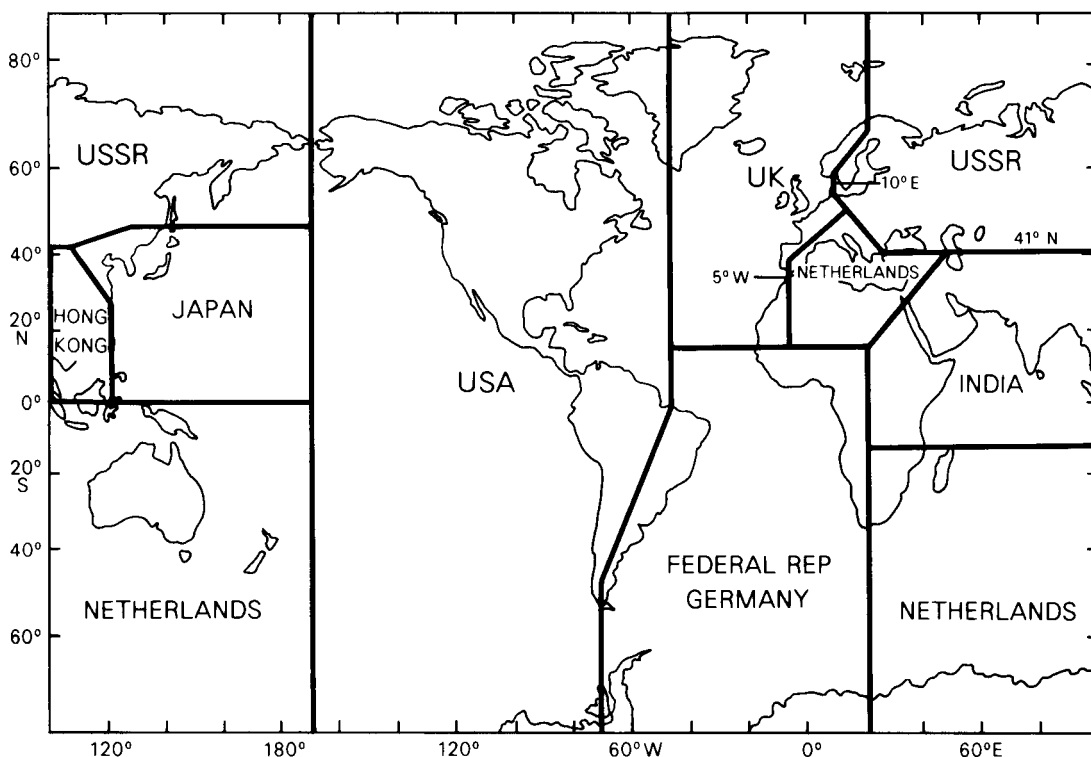


Figure 2. Areas of responsibility of eight nations acting as data centres under the provisions of WMO resolution 35.

area of responsibility of each of the eight countries remaining in the scheme. All countries send data from their ships to the collecting centre for the area in which the ship happens to be at the time the observation was made. This exercise in international co-operation is working well, aided by modern computer techniques for sorting and exchanging data. Thus, under the provisions of WMO Resolution 35, the Meteorological Office has a complete archive of marine data for the North Atlantic from 1960 to date.

2. The development of the Meteorological Office main marine data bank

Meteorological data from British ships had been keyed on punched cards before the Second World War, and the process was continued during and after the War. A major effort was made in the late 1940s to accelerate keying of historic data so that much of the contents of logbooks held in document archives was transferred to cards. Sorting and analysis of data were still relatively laborious, relying on the electro-mechanical Hollerith machine. During the 1960s some marine data were stored on magnetic tape, and computer analysis became possible, but little serious effort had been directed towards the historic data.

In 1972 the Meteorological Office purchased an IBM 360/195 computer and also set up a Systems Development Branch to produce software systems for the new machine. One of the projects allocated to the new branch was to sort and archive the historic marine data, to develop a system to deal with the data collected under the provision of WMO Resolution 35, and to merge these data with those from

other sources. At about the same time an international project to extract and archive Historic Sea Surface Temperatures (HSST) and some other marine meteorological parameters was started. The United States Climatological Data Center (Asheville) was the leading organization, largely because of its ordered data base which was considerably in advance of that held by any other centre. The timing of the project was unfortunate as it diverted effort from the main marine data bank to produce a data base (HSST) that was scientifically valuable but not of great interest to commercial operators.

At first sight it may seem a simple process to create a data bank from data already on punched cards. The reality was very different; the cards had been produced with little quality control and without regard to coding changes and so it was necessary to produce programs to cope with each different code form and hybrids which worked on mixed codes. Hybrids were necessary because mariners often did not change codes on the agreed date and sometimes the change-over was spread over a year or two.

Many other problems were found and solved: for example some ships timed observations by GMT, others by local time, and some even by ship's watches. The whole process was complicated by the amount of data, estimated at about 40 million individual observations. This total included a global collection of data purchased from the United States Climatological Center in the late 1960s and known as TDF 11 after the tape shelf number used for storage in Asheville. Historic German data acquired in 1945 were also added. One difficulty in merging data from a number of different sources is avoidance of duplication, so software had to be developed to identify and remove duplicate observations.

The data bank has been designed for direct access. This means, in principle, that data for a given location and time can be extracted directly, by use of comprehensive indexes, thus avoiding a sequential search. In this respect it is more advanced than some other archives which use sequential storage on magnetic tape with a separate record of what is contained on each tape. At present, however, the Meteorological Office archive is also in advance of technology, because direct access devices of the mass storage type, which have sufficient capacity to accommodate the entire meteorological data archive (Shearman 1980), are not yet available. Thus the data are still stored on magnetic tapes, limiting the speed of access. Transfer of the data bank to an appropriate mass storage system, when available, should be relatively easy without reformatting.

The final stage of development of the data bank has depended upon further international co-operation. Exchange agreements have been made with the United States, Netherlands and the Federal Republic of Germany so that all available data for their respective areas of responsibility can be added to the data bank. Arrangements have also been made to purchase the Hong Kong collection. Fig. 3 shows the current status of the main marine data bank.

3. Quality control of data

Data cannot be used with confidence unless information is available regarding their quality. Clearly it was impossible to rely upon a manual scrutiny of the vast amount of marine data to be processed, and so a computer-based quality-control system was developed. The computer programs were designed to be used on historical data and also to process future British and foreign data. Historic data originating before 1960 were quality controlled entirely automatically, while data after 1960 were also subjected to some manual verification. The historic data received only 'second-stage' quality control whereas contemporary data are subjected to a two-stage computer check. There is an initial brief scrutiny of the manuscript logbook when it is received to identify obvious coding errors followed by the first stage of computer checking which consists mainly of fairly crude range checks and is designed to screen keying and other gross errors. The second stage checks the internal consistency of each observation and also carries out some more detailed range checking using background fields of air and sea temperature. After each stage the suspect data are either rejected or manually amended. During second-stage

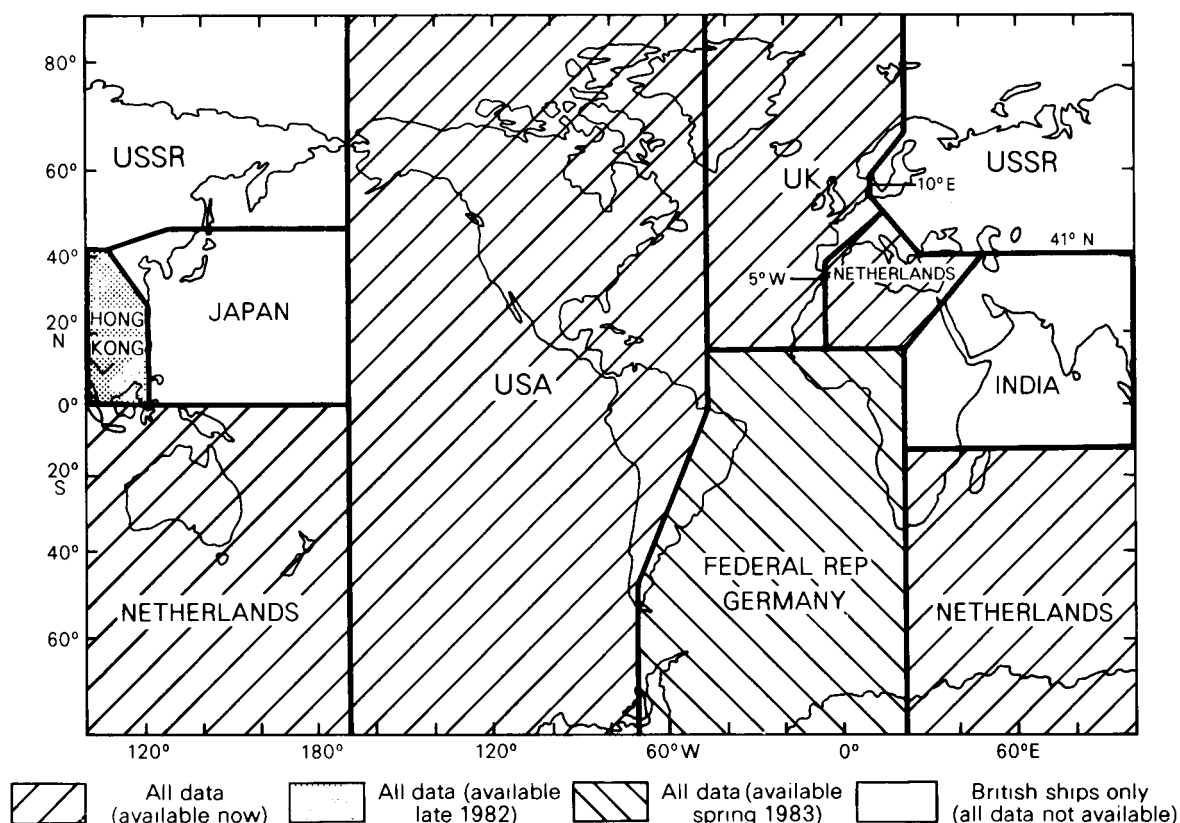


Figure 3. Status of the Meteorological Office global archive of marine data.

quality control the reason for any change that has been made is stored, together with the original data, in a separate, but cross referenced, quality control data set. This technique ensures that original data are never lost and may be restored if necessary.

Data from other countries are processed in the same way, except for the initial logbook scrutiny which cannot be made. Areal quality control, based on comparisons with surrounding observations and widely practised with land data, is not attempted because the observing network is in a state of flux as ships move between ports. Thus the selection of known reliable 'neighbouring' observations is almost impossible, though it would be possible to use analysis techniques from the numerical modelling schemes to perform some areal checking. However, such methods are based upon pressure fields so that the related wind checking is relatively coarse and aimed at achieving a comparatively smooth field. Similar checks are available for temperatures. It is unlikely that such methods would be any more effective than those based on range checking with background fields. If they were made more rigorous, the data could be too heavily smoothed; legitimate climatic extremes could then be lost. The quality-control routines are used on data from merchant ships, light-vessels and ocean weather ships because all these constituent data sets of the main marine data bank are designed to the same format specification. The only exception is the data from oil and gas platforms; these data are stored in the same format, but lack the detailed present-weather code essential for the quality control.

4. Accuracy of data

The data from merchant ships are based largely on visual estimates, although there is a strong preference for instrumental data in some quarters on the grounds that these must be better than mere estimates. There are a number of sources of instrumental data at present, mainly ocean and other weather ships, light-vessels, oil platforms and buoys. The physical parameters most considered are probably those relating to wind and waves. The Meteorological Office marine climatology group has made a comparison of visual and instrumental data, examining closely instrumental data as part of that study (Graham 1981). Such data are only as good as the exposure and observing practice associated with them. On weather ships the anemometer is mounted on a yard-arm 20 metres above the sea and is subject to a series of impulses as the ship rolls and pitches. The reported winds are spot values taken from a dial gauge, supposedly averaged, by eye, over 15 seconds. The effective height of the anemometer is unknown because it depends upon the state of the sea and the ship's motion.

Winds are measured on light-vessels by using hand-held anemometers and the exposure is entirely dependent on the location and stance of the observer. Although winds are nominally one-minute averages, it is much more likely that they are closer to 15 second spot winds. The least satisfactory collection of wind data comes from oil and gas platforms because exposure is always a compromise, and often poor, because of the nature of these large and complex structures. The anemometer height is often 50 metres to 100 metres above sea level and it is rarely clear whether attempts have been made to reduce winds to sea level using a simple formula or, indeed, what period has been used for wind averaging.

Such data are usually adequate for synoptic forecasting purposes, despite their shortcomings, because the mainstay of the synoptic analysis is the pressure field; wind observations give additional information to the forecaster and are considered in the context of the general synoptic situation. This is analogous to the position over land where winds are greatly affected by frictional and other effects to produce turbulence. Wind measurements to be used for climatological purposes need to be consistent and should 'stand alone'. Visual observations of wind speed are made primarily from state of sea and, hence, are effectively at sea level. They are equivalent to winds averaged over a period of about one hour, because the response time of the sea is equal to or greater than an hour. Therefore, they form an internally self-consistent body of data. The Meteorological Office study does not reveal any evidence that measured data currently available are any better than visual data. Data from the DB 1 buoy are an exception to this finding. However, the record is so short that it is not acceptable for most climatological purposes.

Visual estimates of wave heights and wave periods are not as reliable as reports of wind speeds; the subjective apportionment into wind wave and swell wave is often dubious and, for climatological purposes, it is preferable to combine the components to give a resultant wave height unless there is a very good reason to isolate one particular component. There is a large body of visual wave data and a reasonable wave climatology can be obtained despite the wide scatter of values and the existence of erroneous estimates. However, estimation of extreme waves is probably best done from the wind field because, on average, three times as many ships report winds as waves, and the effect of erroneous or outlying wave heights upon an extreme value analysis can be disproportionate. In passing it should be noted that the separation of waves into wind and swell components, and sometimes even the reporting of more than one wave train, is of value synoptically. This is another example of the forecaster being able to use data of a lower quality than is acceptable for climatological purposes.

The visual estimate of wave heights remains the only way of obtaining a satisfactory wave climatology because there are very few instrumental records of a suitable length within the continental shelf area. There are records from wave recorders on light-vessels, notably that at Seven Stones, but

such recorders are not considered reliable for the entire period between vessel refits. Thus the Seven Stones record reduces from 20 years on site to about 10 years of reliable record.

5. The importance of wind averaging times

Several references have been made to the time period used for wind averaging and the concern of the climatologist about the length of period used. Fig. 4 shows six hours of wind speed record from an anemomograph on an oil platform. Winds may be extracted from this record as averages over various periods from ten minutes to several hours. The Meteorological Office traditionally uses a wind averaged over the ten-minute period preceding each hour as the synoptic wind for that hour, and an average wind over the entire hour for climatological purposes. An examination of the trace shown in Fig. 4 reveals a considerable variability in ten-minute mean winds, some being larger, some smaller, than the corresponding hourly mean wind. If a sufficiently large number of observations is used the mean ten-minute wind and mean hourly wind will be almost identical, but the standard deviation of ten-minute winds will be much higher. This means that a frequency distribution of ten-minute winds will be different in shape from that of hourly winds, and that extreme winds estimated from the two distributions will differ. In fact the extreme derived from the distribution of ten-minute winds is 7 to 8% higher than that from the hourly winds. The variability in the one-minute wind is even higher than for the ten-minute wind, and it is also likely that a mean over a long period of one-minute winds read from a dial will be higher than the corresponding mean hourly wind. The dial will indicate large fluctuations in wind, and the human observer will probably tend to bias his estimated mean value for one minute towards the higher gust. Even without this effect the extreme wind derived from the one-minute distribution is approximately 19% higher than that derived from hourly mean winds.

Thus it can be seen that the wind averaging time must be known, and should be the same throughout the body of data used for any analysis. This is clearly not so for some instrumental data especially when different instrumental data sources are combined. On the other hand, visually observed winds by officers on board ship have been shown to be climatologically self-consistent within the acceptable tolerances, despite their apparent subjectivity in the eyes of the non-mariner.

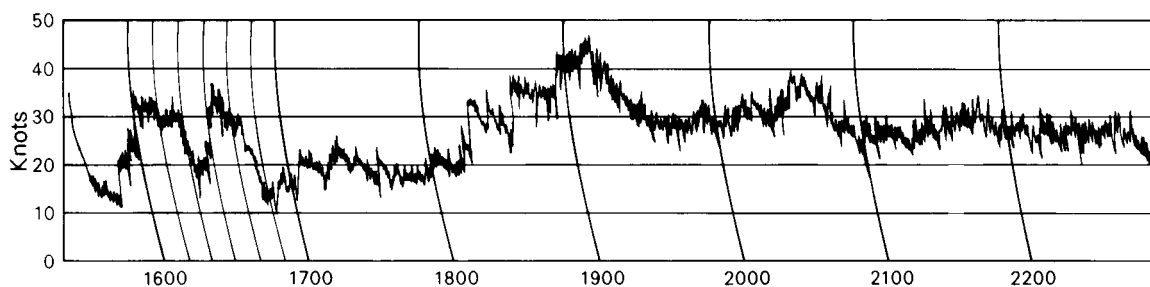


Figure 4. A copy of a six hour period of an anemograph trace from an anemometer mounted on an oil platform.

6. Length of record

With the exception of those from the ocean weather ships and light-vessels, most instrumental records of wind and wave are short, consisting of less than five years of data. Some wave records are less than one year in length. Even if the difficulty of applying an extreme-value analysis technique to a small number of values could be overcome there must always be doubt regarding how representative the short period of data will be when compared with the long term climate.

Figs. 5 and 6 show the year-to-year variations in the percentage frequency of occurrence of several categories of wind speed and wave height. The data used were visual observations from merchant ships for an area off the east coast of Scotland. The year-to-year variations are quite marked and it is easy to see that both frequency distribution and extremes derived from a year or two of data will probably not be representative of long term conditions.

7. Analyses available from the Meteorological Office Marine Climatological Bureau

Analyses can be produced for most of the traditional meteorological parameters for locations anywhere in the world. A short list is given in Table I. The Marine Climatology Bureau of the

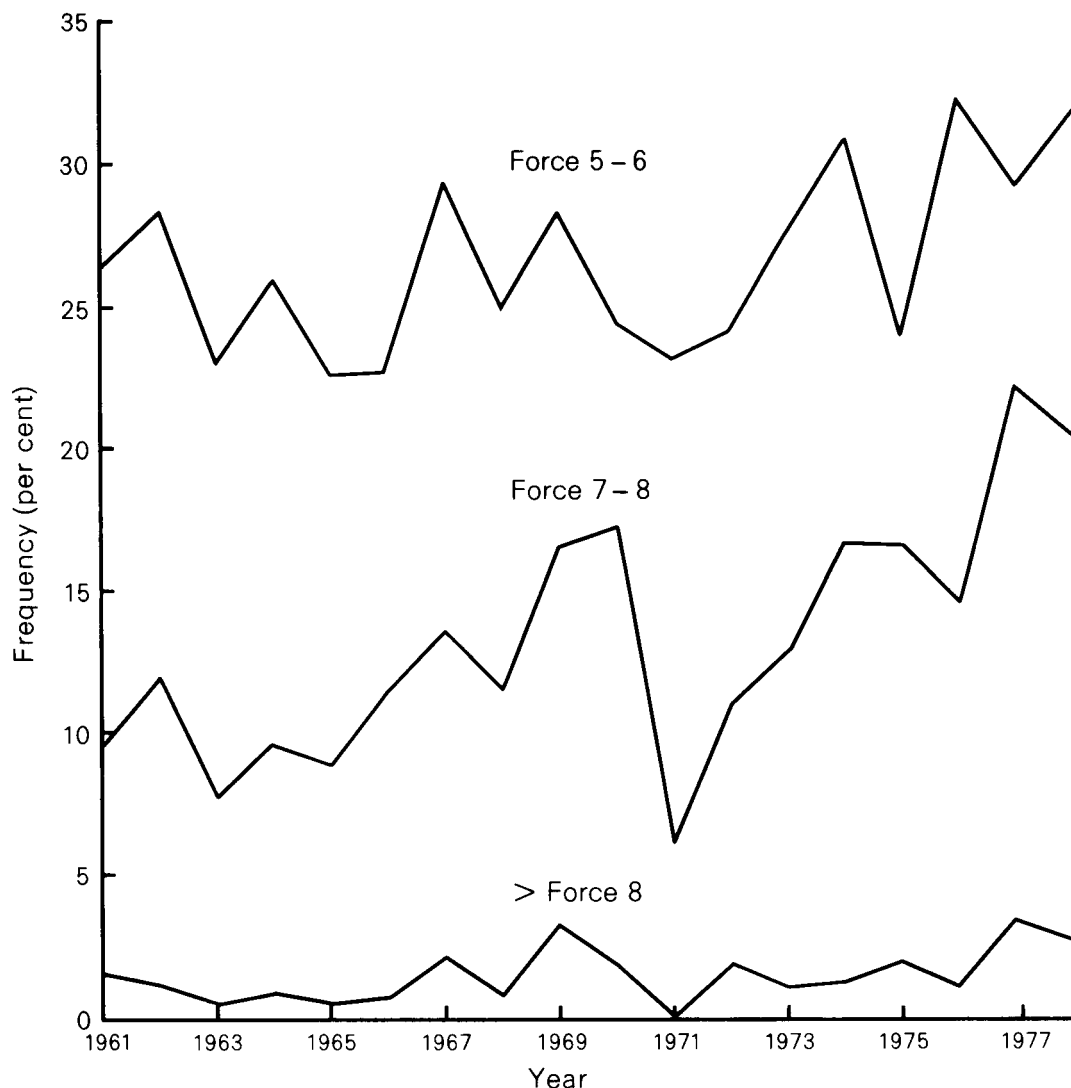


Figure 5. Percentage frequency of occurrence of winds in each year calculated from visual observations from an area 57°N to 59°N, 2°E to 2°W.

Table I. *A selection of parameters available from the climatological archive*

Wind: speed and direction
 Weather: past and present
 Cloud: type and amount
 Temperature: air, dew-point, wet-bulb and sea
 Wind waves: height and period
 Swell waves: height, direction and period
 Visibility
 Air pressure
 Sunshine/radiation

Meteorological Office has concentrated upon development of a number of standard sub-programs that produce commonly required analyses from the data stored in the main marine data bank. These computer programs can be assembled to provide information in the form of computer printout for the customer, or as the starting point of an investigation which will end with a comprehensive report.

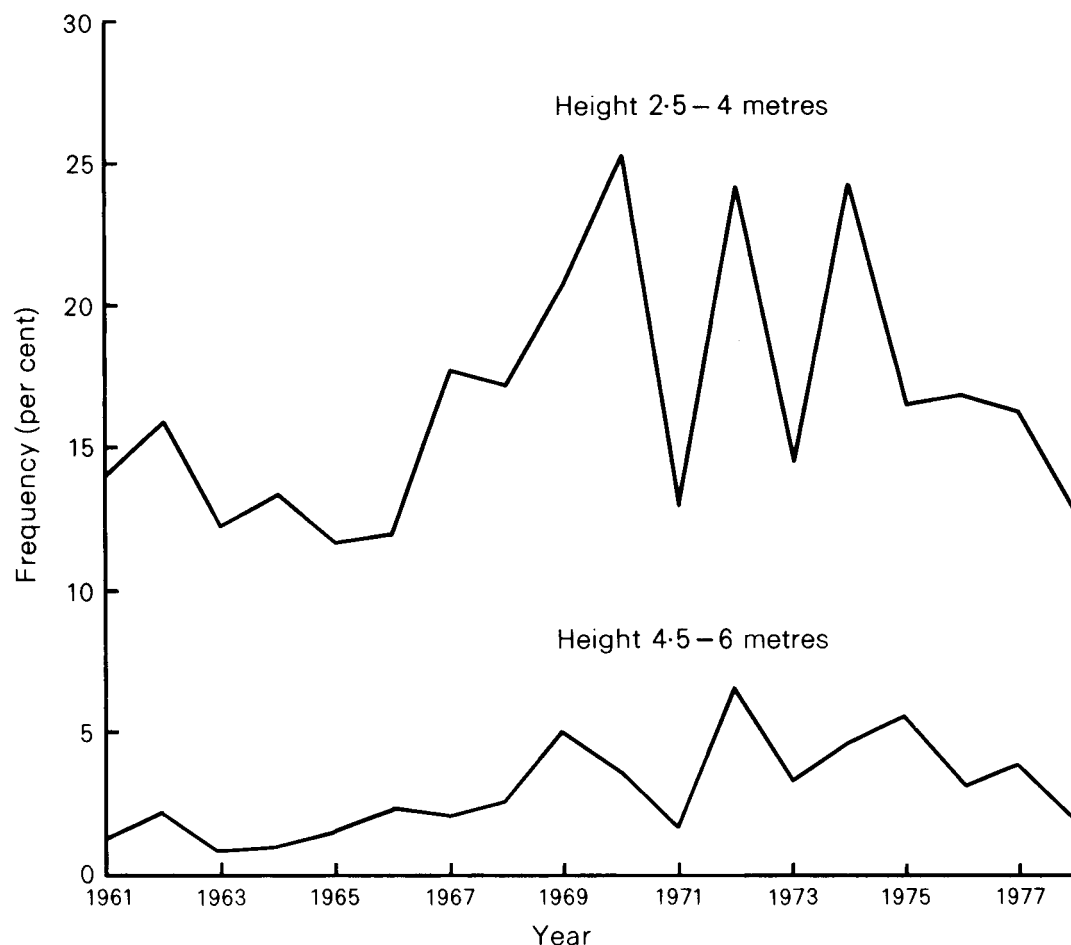


Figure 6. Percentage frequency of occurrence of wave heights in each year calculated from visual observations from an area 57°N to 59°N, 2°E to 2°W.

Some examples of typical sub-program analyses are shown in Table II. Use is made of computer graphics so that graphs of percentage exceedences, Weibull extreme-value plots, wind roses and histograms can be produced quickly on microfilm or on paper. In addition to standard analysis programs already available, specialized software can be developed to deal with customers' individual requirements.

Table II. *Analyses produced from the climatological archive*

Wind frequency according to month, direction, and speed
Waves according to month or season, direction of movement, period and height
Air temperature according to month
Dew-point temperature according to month
Sea surface temperature according to month
Visibility according to month

Although most investigations involve some computer analysis of data, few enquiries can be answered automatically. Considerable effort is made to discuss the customers' problems and requirements in order to find the best way of presenting environmental data to meet those needs. In general, every effort is made to give an answer to even the most difficult of problems, whilst stating firmly any reservations which have to be made because of the inadequacies of the data or uncertainties referred to above.

As well as knowledge of marine climatology, the members of the Bureau have individual experience and expertise in such fields as weather forecasting, meteorological statistics, computer programming and systems analysis and research. They also have access to staff engaged upon research in many relevant branches of meteorology and will seek advice from other experts as necessary.

8. Conclusion

The Meteorological Office has expended a significant amount of its resources upon the development of a global archive of marine data. Much of the data consists of visual estimates which, despite their limitations, form a consistent body of information that can be used by an experienced analyst with more confidence than could reasonably be shown for the short instrumental records available. This situation is unlikely to change significantly until a number of well-exposed robust instruments are deployed and left on site for ten years or more. Although the data bank, or parts of it, can be purchased by meteorological consultants, and small amounts have been in the past, it is the current position that the computer archive maintained by the Meteorological Office is unique within the United Kingdom. The only comparable data banks are held by a few of the corresponding national authorities in certain other countries. The marine enquiry bureau is therefore confident in its ability to answer marine climatological enquiries from the most trivial to the most complex. Problems can be tackled that are considered intractable by many other organizations.

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Concentrations of Aitken nuclei in the boundary layer round the British Isles

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Summary

Aitken nucleus (AN) measurements made round the coastline of the British Isles within the boundary layer are presented and discussed. The aerosol concentration in maritime air masses, which are modified as they pass over land, is shown to depend mainly upon the land track upwind of a particular location, with local effects due to anthropogenic nuclei sources.

1. Introduction

Many experiments have been conducted with the aim of exploring variations in the horizontal and the vertical in the Aitken nucleus (AN) concentration. In particular, many data gathered from aircraft flights round the British Isles have already been published by Day (1955, 1957) and by Durbin and Murgatroyd (1964) and some success was achieved in relating high particle concentration to likely industrial sources upwind. Also, it was recognized that the land areas represented the major source of aerosol in the AN size range (Day 1957) but no quantitative explanation of the measured horizontal variability in boundary layer concentrations was attempted.

It has been suggested that the majority of AN particles formed over land consist mainly of ammonium sulphate and are formed *in situ* by a gas to particle conversion process which probably involves a photochemical reaction (see e.g. Haaf and Jaenicke 1980), the necessary compounds for the conversion from gas to particulates probably arising from natural vegetation. Observations of a diurnal cycle of the AN concentrations, which support this hypothesis, have been made in the USA by, e.g., Mamane and Pueschel (1980) and in the east of England by Kitchen *et al.* (1982). In complete contrast to these conclusions, Ayers and Bigg (1982) have made extensive aircraft measurements of aerosol concentrations downwind of Australian cities and concluded that the continental AN originated mainly from anthropogenic, rather than natural sources.

Interest in aerosol measurements has been revived recently partly because of the possible effects of aerosol concentration and composition upon the radiation budget of the atmosphere and hence e.g. the heat budget of the boundary layer (see e.g. Moores 1982). The modification of air masses by passage over the British Isles may be of importance in causing spatial variations in these effects. The work described here provides a simple explanation of the major horizontal variations in AN concentration observed in three case studies.

2. Experimental details

AN concentration measurements were obtained using a standard 1957-type Pollak counter on board the C-130 aircraft of the Meteorological Research Flight (Kitchen 1982). In the Pollak counter the Aitken nuclei are converted into fog droplets by means of an adiabatic expansion in a cloud chamber. The extinction of a parallel light beam passing through the fog is measured and is related to the nucleus concentration. The measurements were made within the boundary layer between 150 and

1000 m above sea level around the British Isles. The effects of sampling at different temperatures and pressures will have introduced errors in AN concentration as described by Pollak and Metnieks (1960, 1961). Likely uncertainties in concentrations measured using a Pollak counter have been quoted as 5% by Metnieks and Pollak (1959) but a thorough investigation by Podzimek *et al.* (1981) has suggested that errors at the extreme ends of the instrument range may be larger than this. Order of magnitude variations were observed during the present experiments, however, and instrumental errors have been ignored as they are not significant in relation to the following discussion.

The data consist of measurements made at intervals of 1.5 to 2 minutes which at aircraft speeds is equivalent to a horizontal distance of 9 to 12 km between samples. The sample volume of the Pollak counter is about 260 cm³ which is obtained in a time of about 8 s (equivalent to 800 m). Each measurement was therefore considered as being a point sample. The three flights described took place on 10 July 1979, 22 and 26 January 1982 and are referred to as Days 1, 2, 3 respectively hereafter.

The measurements during Day 1 (Fig. 1(a)) were made entirely over the sea at a height of approximately 1000 m above sea level north from the North Wales coast out over the Irish Sea and to the north of Ireland to 57°N 8°W, followed by the reciprocal course back towards the North Wales coast. On Days 2 and 3, almost identical flight tracks were flown round the coastline of England, Wales and Ireland (Figs. 1(b) and 1(c)). Most of the observations on these latter two days were made at 150 m above sea level, but transits across land areas were at heights of 600–800 m.

The synoptic conditions, in particular the wind field, on the three days are obviously of importance in the interpretation of the aerosol data. The observed surface winds are shown in Figs. 1(a), 1(b) and 1(c) along with an analysis of the surface pressure field obtained using an objective scheme of Purser and McQuigg (1982). Conditions on Day 1 were anticyclonic in the region of interest with an inversion capping the boundary layer which, from the midday Aldergrove radiosonde ascent, was near 1500 m. In contrast, on Days 2 and 3, the situation was cyclonic with a broad westerly flow across most of the British Isles. On these days, there was no marked inversion as the air mass was unstable with widespread deep convection, particularly over the more northern parts of the flight tracks. Care was taken to avoid sampling within precipitation.

3. Results and discussion

The measured AN concentrations are presented in Figs 2(a), 2(b) and 2(c) as a function of time. The data from periods when the aircraft was considered to be above the boundary layer (i.e. during the transit to the Welsh coast on Day 1 and the transits over central Scotland on Days 2 and 3) have been omitted. The most obvious feature of the AN concentration measurements is that during some parts of the flights, the concentrations were very low ($< 1000 \text{ cm}^{-3}$) with small variability, whereas during the remainder of the time when concentrations were generally at a higher level there occurred a number of sharp peaks which were poorly resolved by the measurements, i.e. their extent in the across-wind direction was probably less than about 10 km. The lowest concentrations were observed in air which appeared not to have passed over land in the British Isles and therefore represented background concentrations in the North Atlantic air with a long ocean track. Minimum concentrations were about 100 cm^{-3} on Days 2 and 3 and about 800 cm^{-3} on Day 1 and are typical of the North Atlantic background (see e.g. Moore 1952). On Days 1 and 2 the air arriving on the western coasts of Britain had passed around the northern flank of an Azores anticyclone, whereas on Day 3 the air mass was Arctic in type. The air mass origin does not therefore explain the difference in the minima.

In order to investigate possible reasons for the increased AN concentrations in air which passed over land, three correlation coefficients have been calculated, which are based on three alternative

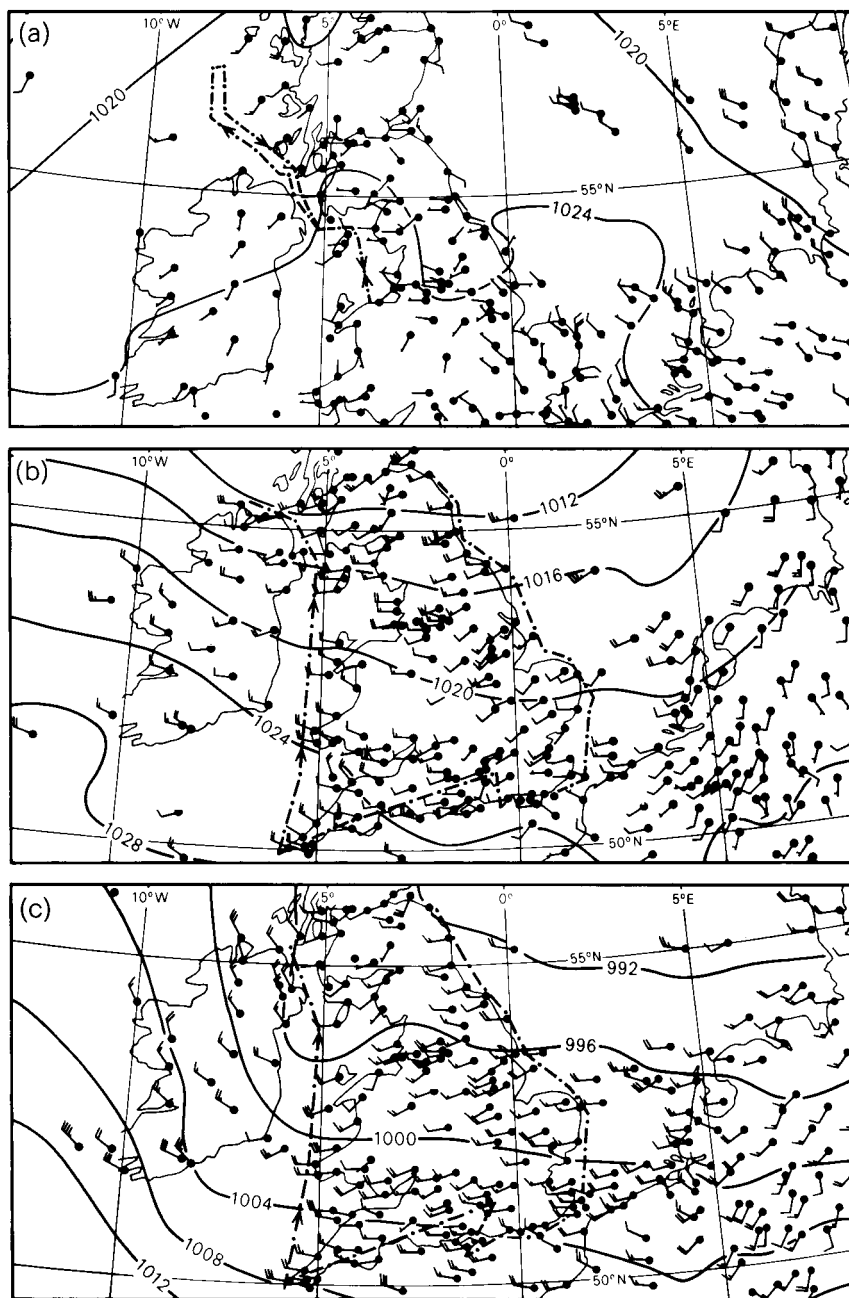


Figure 1. (a) Map of the British Isles showing surface winds and pressure analysis for 12 GMT on Day 1 (10 July 1979). The part of the aircraft track for which data are plotted in Fig. 2(a) is marked by a dash-dot line.

(b) Similar to 1(a) but for 12 GMT on Day 2 (22 January 1982).

(c) Similar to 1(a) but for 12 GMT on Day 3 (26 January 1982).

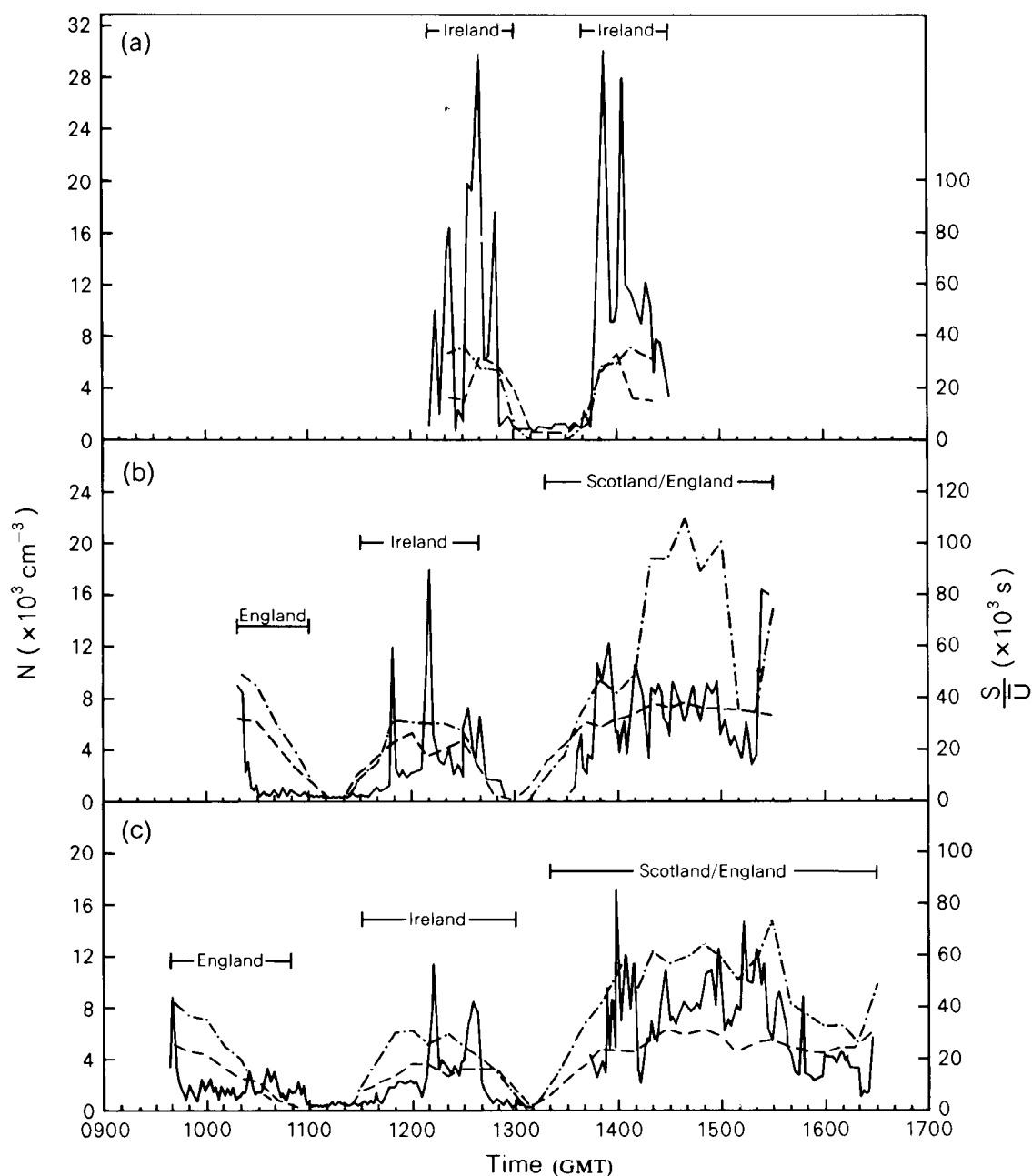


Figure 2. (a) Measurements of AN concentrations (solid line), estimated values of S/U (dash-dot line) and calculated values of N at 10-minute intervals from integration of equation (1), all plotted against time (GMT). Those periods when the aircraft track was downwind of land are marked by horizontal bars.

(b) Similar to 2(a) but for Day 2.

(c) Similar to 2(a) but for Day 3.

hypotheses. The starting point for two of the three hypotheses is the simple budget equation of Lopez *et al.* (1976)

$$dN/dt = \phi/h - KN^2 \quad \dots \dots \dots (1)$$

where N is the AN concentration at time t
 ϕ is the nucleus flux (production rate)
 h is the mixing layer depth
 K is a coagulation constant.

Application of this equation assumes that the aerosol composition and size distribution remains uniform to the extent that a single value of K can be used and also that precipitation scavenging was not significant. Both assumptions are necessary because of the lack of experimental data. This equation was previously successfully used to explain diurnal cycles of AN concentration in an experiment conducted at Cardington, Beds (Kitchen *et al.* 1982). In that experiment, a value of K of about $2.4 \times 10^{-9} \text{ cm}^3 \text{ s}^{-1}$ was obtained which was in agreement with that inferred from observations by Mamane and Pueschel (1980) (ϕ/h was estimated to be about $0.13 \text{ cm}^{-3} \text{ s}^{-1}$).

The three alternatives which are considered are as follows:

(a) Production over the land areas on the three days was uniform in space and time, but zero over the sea and this production was not offset by coagulation. Ignoring the coagulation term in equation (1), and integrating following an air parcel, we have $N \propto \phi S/h\bar{U}$, where S is the length of the land track upwind of a point and $1/\bar{U}$ is the mean reciprocal wind speed along that track.

(b) The lifetime of AN in the boundary layer is short compared to S/\bar{U} , i.e. coagulation dominates equation (1). As in (a) the production over land was uniform in space and time, but zero over the sea. Concentrations would quickly reach a plateau over the land and rapidly decay once the air passed over the sea again. In this case, over the sea, the AN concentration is given by

$$1/N - 1/N_0 \propto KS'/\bar{U} \quad \dots \dots \dots (2)$$

where N_0 is the AN concentration over land and S' is the distance downwind of the land.

(c) The last possibility considered is that the AN concentration depended solely upon whether a point lay in the lee of land in the British Isles. The concentration N therefore is not described by equation (1), but by a step function which takes a value of 1 downwind of land and 0 elsewhere.

These three hypotheses have been tested using the observations in the following way. Back trajectories from points on the aircraft track at approximately 50 km intervals were estimated. The task of calculating such a large number of trajectories objectively from analysed wind fields was considered unjustified for this application and they were estimated by drawing streamlines by eye. The surface wind directions were used over the land and the geostrophic wind over the sea. Whilst the surface wind was probably most appropriate for the observations made at 150 m above sea level on Days 2 and 3 it might have been better to use the geostrophic wind over both land and sea on Day 1. For the sake of treating all the data uniformly, however, the same method was adopted for Day 1 as for Days 2 and 3. These trajectories were used to calculate three correlation coefficients between N and S/\bar{U} , $1/N$ and S'/\bar{U} , and N and the step function defined in (c) above. These coefficients are therefore a measure of the success of each of the hypotheses (a), (b) and (c) above in describing the concentration observations. Table I contains the different correlations for each day. In all cases the best correlation was between N and S/\bar{U} with a maximum value of the coefficient of 0.79 on Day 3. There was some evidence of a relationship between N and S'/\bar{U} on Day 1, but little support for either of hypotheses (b) and (c) on Days 2 and 3. The values of S/\bar{U} used in this analysis have also been plotted in Figs 2(a), 2(b) and 2(c).

Table 1. Correlations between measured Aitken nucleus concentrations and calculated parameters based upon estimated trajectories.

k_{NS} is the correlation coefficient between N and S/\bar{U} .

k_{NH} is the correlation coefficient between N and a step function which takes the value 1 downwind of land areas and 0 elsewhere.

$k_{NS'}$ is the correlation coefficient between $1/N$ and S'/\bar{U} .

Day	k_{NS}	k_{NH}	$k_{NS'}$
1	0.76	0.59	0.68
2	0.66	0.35	0.35
3	0.79	0.34	0.48

The strength of the relationship between upwind land track and AN concentration justifies the extension of the analysis to see whether the inclusion of both production and coagulation terms is capable of describing the measurements quantitatively. As mentioned above, some values of ϕ/h and K have previously been derived by Kitchen *et al.* (1982). These were inserted into equation (1) and the equation integrated to give values of N at points on the aircraft track. These calculated values are plotted on Figs 2(a), 2(b) and 2(c) for comparison with the observations. An additional assumption implied here is that a single value of ϕ/h applied to all the cases. This assumption is necessitated because of the uncertainty in specifying h on Days 2 and 3, in the absence of any inversion. Also that ϕ/h and K are approximately the same in the present cases as those inferred from the Cardington measurements. In view of the crude theory and gross assumptions, the agreement between N observed and calculated is surprisingly good, with a large part of the horizontal variability accounted for. This result may be fortuitous as the estimated error in ϕ/h alone was of the order of 50% (Kitchen *et al.* 1982).

The above theory, however, does not account for the local sharp increases in AN concentration because it assumes that the source of AN is uniform over the land area. Most of the peaks in AN concentration were measured downwind of major industrial areas or conurbations, e.g. on all three days a marked increase in concentration was observed downwind of Belfast. The implication therefore is that a sizeable fraction of the AN were anthropogenic in origin. In order to estimate a lower bound to this fraction, the area of the peaks was calculated (by taking a 20-minute mean as a baseline) and compared to the total area of the measured AN time series (Figs 2(a), 2(b) and 2(c)). The fraction calculated in this way was highest on Day 1, at about 30%, whilst on Days 2 and 3 it was about 10%. This difference may have been due to the more stable conditions on Day 1 resulting in higher peak concentrations.

Fixing an upper bound to the anthropogenic fraction is more difficult, but has been attempted by reference to the work of Ayers and Bigg (1982). From measurements downwind of Australian cities, Ayers and Bigg found a direct proportionality between population and anthropogenic AN production. The present observations were not sufficiently detailed to enable fluxes from cities in the UK to be calculated following the method of Ayers and Bigg (1982). It is possible, however, to estimate the average surface flux of AN if it is assumed that the anthropogenic production per person is the same in the British Isles as in Australia. From Fig. 1 in Ayers and Bigg (1982), the AN production is estimated to be 8×10^{13} per second per person. Therefore over the Irish Republic with a population density of 45 km^{-2} , ϕ calculated in this way is about $3.6 \times 10^5 \text{ cm}^{-2}\text{s}^{-1}$. Over the UK with an average population density of 230 km^{-2} , ϕ is about $1.8 \times 10^6 \text{ cm}^{-2}\text{s}^{-1}$. Taking a somewhat arbitrary value of $h = 1500 \text{ m}$ (as on Day 1), then ϕ/h exceeds the value inferred from the observations of Kitchen *et al.* (1982) by over an order of magnitude. This difference is sufficiently large to suggest that any

relationship between AN production and population is probably not the same in the British Isles as in Australia, but does not rule out the possibility that all the AN observed in the present cases were anthropogenic in origin. This is not considered likely in view of the evidence of a dominant natural source, at least in rural areas (see Introduction).

4. Conclusions

Whether the majority of AN observed in the boundary layer over land are of anthropogenic or natural origin remains in some doubt. However, production of AN clearly occurs over the land areas of the British Isles and it seems likely that with a westerly airflow, there is a strong longitudinal gradient of AN concentration. On western coasts receiving air direct from the Atlantic, concentrations are likely to be $< 1000 \text{ cm}^{-3}$ and on most of the east coast at least an order of magnitude higher. If spatial variations also occur in boundary layer concentrations of larger particles in the aerosol spectrum (in the range 0.1 to 10 μm radius) then there may be corresponding variations in cloud microphysical structure, attenuation of incoming solar radiation and visibility. Systematic horizontal variations in aerosol may therefore be of importance in a number of areas of meteorological interest and the interaction between aerosol and solar radiation in particular is being actively studied at present.

Acknowledgements

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Further composite rainfall records for the United Kingdom

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Summary

Details concerning further composite rainfall series are presented for England and Wales. Together with previously produced series the new series will provide a basis for many studies including water resources.

Introduction

By far the best source of composite rainfall records for the United Kingdom is that put together by Tabony (1980). This gives composite series of monthly observations back to before 1860 for 39 sites in the United Kingdom and Eire. The 39 sites are listed, together with seven others constructed by the author, in Wright and Jones (1982). Tabony's (1980) data set also includes a number of records for continental Europe particularly for France, Italy, Sweden, the Netherlands and the Federal Republic of Germany. Further details of this data set and some analyses of it may be found in Tabony (1981). The method of construction of a composite record is described by Craddock and Wales-Smith (1977), Craddock (1977) and Jones (1981).

The composite series have been produced for a diversity of regions and, in the author's opinion, for most sites within the UK it should be possible to produce a composite rainfall record extending back to at least 1870 within 40 km of the chosen site. The apparent lack of long-period records on site compilations such as RAINMASTER produced by the Meteorological Office should not prove a hindrance. Consultation of the annual volumes of the excellent publication *British Rainfall* from 1865 will enable records for earlier years to be found.

The new rainfall series

As a result of recent work the author has produced homogeneous composite records for a further 15 sites. This note contains details about each site, duration of individual site records, corrective factors, etc. It is impracticable to publish all the monthly rainfall totals, but, copies can be obtained from the author in an appropriate computer media form e.g. computer listing or magnetic tape. Copies of the series will also be lodged with the Meteorological Office.

The author's work has concentrated on specific river catchments, so the new series are centred on three main regions—Devon (River Exe), south-eastern parts of Wales and neighbouring parts of England (River Wye) and northern England (Rivers Eden and Tees). Site locations and length of records for the 15 new sites are given in Table I. The Carlisle site is also given by Tabony (1980), but the record has now been extended back to 1757 making Carlisle the third longest homogeneous rainfall series in the UK.

In Appendix A the individual site records used, years of observations, heights etc. are listed for all 15 composite sites. In Appendix B the stations used to produce the composite records are given, together with the corrective factors used to adjust the older rain-gauge sites to the key site. These appendices contain the basic information for each site. For each composite record the time and effort required can be judged from the record for Cirencester (Jones, 1980). The author has also produced homogeneous

Table I. *New homogeneous rainfall records for sites commencing before 1860*

Gauge No.	Gauge name (Key site)	First year of monthly records	National Grid reference	Height metres
1	Carlisle	1757	NY390544	35
2	Darlington	1843	NZ285134	30
3	Barnard Castle	1856	NZ056164	171
4	Banbury	1850	SP458418	91
5	Bedford	1846	TL081463	29
6	Taunton	1859	ST229238	22
7	Tiverton	1854	ST035103	79
8	Cullompton-Bradninch	1837	SS994034	69
9	Ross-on-Wye	1859	SO606235	50
10	Leominster	1831	SO501587	72
11	Kington	1841	SO339576	155
12	Penrith	1851	NY497259	191
13	Appleby	1857	NY684198	146
14	Patterdale	1860	NY391163	146
15	Newton Rigg	1846	NY493310	171

Table II. *Homogeneous rainfall records for sites commencing after 1860*

Gauge No.	Gauge name (Key site)	First year of monthly records	National Grid reference	Height metres
1	Winsford	1897	SS906348	189
2	Bulland Lodge	1864	ST054273	229
3	Honeymead	1871	SS797392	378
4	Clayhanger	1865	ST022230	165
5	Exford (Lower Thorne)	1875	SS843383	290
6	Huntsham*	1874	SS990180	241
7	Dulverton	1911	SS912280	134
8	Crediton	1865	SS832006	91
9	Monmouth	1867	SO507126	16
10	Hereford*	1861	SO482433	82
11	Sarnesfield	1870	SO368509	122
12	Hay-on-Wye	1884	SO181393	84
13	Talgarth	1899	SO136354	183
14	Brecon	1867	SO037276	168
15	Evancoyd*	1885	SO261630	227
16	Llanddewi-Ystradenay	1885	SO107685	234
17	Builth Wells	1896	SO038530	229
18	Llysdinam	1882	SO009584	197
19	Llanbadarn	1895	SO097777	297
20	Llwyn Madoc	1881	SN903524	223
21	Tremothic Farm	1873	SO359317	198
22	Broadfield House	1875	NY440443	155
23	Haresceugh	1887	NY610428	244
24	Blencarn	1876	NY637312	170
25	Kirkby Stephen	1865	NY771077	191
26	Askham Hall	1865	NY515239	186
27	Wasdale Pike	1869	NY537084	564
28	Mosedale Cottage	1867	NY496095	440
29	Kidmoor	1869	NY479193	335
30	Nunwick Hall (Penrith SW)	1872	NY568352	99

* Sites where earlier rainfall records are available but which do not form a continuous link with the present series.

rainfall records for a further 30 sites with starting dates between 1861 and 1911. The names, length of record and location of these sites are given in Table II.

Some details concerning the rainfall series

Where possible, in forming a composite rainfall series, it is best to use as few as possible different gauge records, preferring those nearest the key site. For all the sites this criterion was adhered to. It can be seen from the Appendices that for most sites more gauge records were collected than necessary. The extra gauge records were used to verify the 'catch at the site records' used in the composite record.

Some of the key sites are relatively close together and it proved necessary on three occasions to use part of the same source record for two composite series. Cullompton and Tiverton both use the Halberton record for the year 1957 while the series for Barnard Castle and Darlington both use years from Catterick (Tunstall), although in this case the years used in each series are not the same. Kington and Leominster both use the years 1856 and 1857 of the Orleton record.

At Kington the source record from Lynhales (Robinson) has two corrective factors caused by a change of site. In this case the site change was documented in the 10-year rainfall books at the Agriculture and Hydrometeorology Branch of the Meteorological Office. Where a site change or gauge change was suspected, but not documented, the particular record was rejected and replaced by an alternative. This proved possible in most cases because of the abundance of gauge records. The major exception to this was the Castle Road record for Bedford. It appears from comparisons with other gauges that this site was at Castle Road only since 1904. The record shows a distinct inhomogeneity before 1902.

By far the longest series produced is the extension of Tabony's (1980) record for Carlisle back to 1757. Apart from the records used from Dumfries and Applegarth Manse (Dumfriesshire) all the records for producing the Carlisle series are from within 10 miles of Carlisle. Unfortunately, only annual values are available for some years in the 1780s for the Dumfries record. The main bases of the extended record are the two records from Carlisle, those kept by Dr J. Carlyle between 1757–1783 in Abbey Street and by Mr Pitt at Shaddongate between 1801–24. The latter observer also took daily air temperature readings for the same period and these are also available.

Conclusions

The new composite series presented here together with previous published series, particularly those given by Tabony (1980), facilitate studies of the long term spatial variability of rainfall and its spectral behaviour (e.g. Tabony 1977, 1981), as well as riverflow reconstruction (e.g. Wright and Jones, 1982).

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Appendix A. Individual site records collected at each key site.

Gauge No.	Gauge name	Years of observations (Missing years in parentheses)	Observer(s)*	Height metres
1	<i>Carlisle</i>			
	Carlisle (Tabony)	1845 →	Carlisle Council	35
	Athenaeum	1841–1848	N. Fisher	?
	Harraby	1840–1846	J. Atkinson	?
	Carlisle (Elliot)	1835–1842	Dr Elliot	?
	Wigton	1822–1826	J. Pemberton	?
	Wigton, Aikbank	1792–1809	Revd J. Golding	?
	Carlisle, Shaddongate	1801–1824	Mr Pitt	12
	Carlisle, Abbey Street	1757–1783	Dr J. Carlyle	25
	Dumfries	1775–1789	Dr Copeland	?
	Whinfell Hall	1829–1833	W. Robinson	?
	Applegarth Manse	1827–1850	Revd W. Dunbar	55
	Scaleby House	1863–1940	R. A. Allison	34
2	<i>Darlington</i>			
	South Park	1923 →	Mr J. Morrison	30
	Public Park	1898–1922 (1907/9/12)	Mr J. Morrison	46
	Hummersknott	1898–1930 (1919)	Mr J. Short	61
	Elcott Hurworth	1890–1903	Revd W. E. Short	37
	Hurworth Grange	1890–1915	Mrs Backhouse	49
	Cleveland Parade	1874–1917	S. Hare (W. W. Willmott)	49
	South-east Gardens	1859–1897 (1873/4)	J. Richardson	43
	Catterick (Tunstall)	1866–1888	H. G. Marshall	107
	Richmond	1843–1872	J. Miller	168
3	<i>Barnard Castle</i>			
	Bowes Museum	1922 →	Curator	171
	County School	1888–1950	E. Wells (Bursar)	168
	East Layton	1875–1913	Miss Maynard (Miss Proud)	175
	Whorlton	1879–1894 (1880)	Miss Dodgson	129
	Greta Bridge	1869–1974	T. Dodgson	131
	Catterick (Tunstall)	1866–1888	H. G. Marshall	107
	Winston	1856–1867	T. Dodgson	140

Appendix A. *continued*

Gauge No.	Gauge name	Years of observations (Missing years in parentheses)	Observer(s)*	Height metres
4	<i>Banbury</i>			
	Grimsbury	1886 →	Superintendent	91
	West Adderbury	1892–1967	Lt.-Gen. Sir E. Graset	103
	High Street	1852–1887	T. Beesley	105
	Wroxton	1876–1885	A. R. Tawney	149
	Cotefield Bodicote	1876–1891	T. E. Cobb	117
	Parson's Street	1850–1872	J. E. Jarvis	104
	Bodicote	1894–1924	J. F. Starkey	118
	Bloxham Grove	1890–1914	Revd G. Warriner	118
5	<i>Bedford</i>			
	Observatory	1831–1843 (incomplete)	Admiral Smyth/Mr Glanville	?
	Bedford	1851–1865	Dr H. Barker	32
	Western Street	1869–1893	D. Roble	34
	Castle Road	1878–1960 (1903)	Newbury family	30
	Tempsford Hall	1873–1892	Col. W. Stuart	24
	Clapham Park	1875–1888	J. Howard	67
	The Park (Mowsbery)	1906–1973	Borough Engineer	36
	Bedford (Meteorological Office)	1957 →	Meteorological Office staff	85
	Cardington (Meteorological Office)	1953 →	Meteorological Office staff	29
	St. Peter's Street	1888–1908	W. Godfrey	35
	Amphill Road	1902–1908	T. Pearce	27
	Cardington Village	1846–1890	J. McLaren	27
	Cardington Village (Post)	1848–1869	J. McLaren	27
	The Grove	1888–1899	W. B. Graham	33
6	<i>Taunton</i>			
	Vivary Park	1910 →	Taunton Borough Council	22
	Milverton Old Halls	1877–1944	Bere family	76
	Cothelstone House	1875–1921	C. E. J. Esdaile	131
	Blagdon Hill Reservoir	1894–1921	H. J. Coles	179
	Claremont	1891–1901	E. Ball	24
	Norton Fitzwarren	1888–1894	H. Ruddle	43
	Bishop's Lydeard House	1872–1889	C. Smith	56
	Fulland's School	1865–1884	N. Reed	?
	Castle	1855–1874 (incomplete 1858–9)	G. Gillett	15
7	<i>Tiverton</i>			
	Willand, Losinga	1972 →	Mrs M. Godfrey	79
	Willand	1958–1971	I. M. Godfrey	75
	Halberton	1940–1962	Miss M. G. Izat	91
	Halberton	1906–1929 (1917–20)	Capt. G. Izat	73
	Blundell's School	1929–1941	E. G. Pierce	82
	Hartnolls	1913–1930	Maj.-Gen. Bowles	69
	St. Aubryn's Park	1921–1940	Mr Fox-Strangeways	120
	Ivy Place, St. Peter's Street	1880–1909	H. S. Gill	82
	Cove	1862–1894	W. N. Row	140
	Hayne	1854–1864	W. H. Gamber	122

Appendix A. *continued*

Gauge No.	Gauge name	Years of observations (Missing years in parentheses)	Observer(s)*	Height metres
8	<i>Cullompton-Bradninch</i>			
	Bradninch, Westfield	1959 →	C. W. Beer	69
	Halberton	1940-1962	Miss M. G. Izat	91
	Bradninch	1905-1956	Miss H. R. Hepburn	91
	Cullompton	1881-1952	T. Turner (Foster, Trezise)	62
	Bradninch Vicarage	1877-1887	Revd W. A. Strong	96
	Strathculme	1864-1882	C. R. Collins	48
	Clyst Hydon	1847-1880	Revd J. Huyshe	61
	Bradninch	1842-1873	C. Matthews	71
	Broadhambury	1837-1873	Revd W. Heberden	122
9	<i>Ross-on-Wye</i>			
	Alton Court	1966 →	Welsh Water Authority	50
	Ross, Perrystone Court	1890-1973	Mr T. Greenaway	158
	Ross, Graig	1859-1943	H. Southall	65
10	<i>Leominster</i>			
	Leominster	1966 →	Welsh Water Authority	72
	Kimbolton, Grantsfield	1913-1968	Miss D. W. Hutchinson	129
	Farm	1883-1912	E. H. Southall	79
	West Lodge	1858-1882	E. H. Southall	76
	Orleton	1831-1896	T. H. Davis	59
	Pembridge, Weobley	1888-1929	T. L. Hall	88
11	<i>Kington</i>			
	Lyonshall	1942 →	R. H. Green	155
	Lynhales	1927-1944	Mrs R. F. Hibbert	189
	Sunset	1919-1936	H. Langston	151
	Pembridge, Weobley	1888-1929	T. L. Hall	88
	Lynhales	1867-1917	S. Robinson	173
	Orleton	1831-1896	T. H. Davis	59
	Titely	1841-1855	R. B. Boddington	180
12	<i>Penrith</i>			
	Tirrill	1969 →	R. F. Porter	191
	Castle Park	1938-1974	Borough Engineer	149
	Benson House	1913-1956	A. B. Sinclair	152
	Fell Lane, Fir Bank	1866-1930	H. Lester	175
	Nordana	1887-1908	G. V. Smith	198
	Brougham Hall	1851-1885	Mr A. Lodge	149
	Penrith	1835-1854 (1840-50)	Mr Bird	?
13	<i>Appleby</i>			
	Castle Bank	1890 →	Lady Holmes	146
	Bongate	1941 →	J. F. Whitehead	151
	Appleby	1857-94	Dr Armstrong	135
14	<i>Patterdale</i>			
	Patterdale Hall	1835 → (1957-60)	Mr A. Milne/Miss C. Marshall	146
	Greenside Mine	1872-1961	Basinghall Mining Syndicate Ltd	335
	Grisdale Ruthwaite Lodge	1889-1935	Mr A. Milne/Miss C. Marshall	534

Appendix A continued

Gauge No.	Gauge name	Years of observations (Missing years in parentheses)	Observer(s)*	Height metres
15	<i>Newton Rigg</i> Newton Rigg	1883 → (1950, 1894–99)	Cumbria College of Agriculture and Forestry	171
	Hutton John	1916–1968	F. Huddleston	210
	Blencowe	1871–1896	T. Fawcett	183
	Greystoke Castle	1887–1925	A. Tremayne-Butler	198
	Greystoke Castle	1846–1874	T. G. Benn	213

* Where there has been more than one observer, only the observer who took the readings over the longest period is given.

Appendix B. Individual site records used to form composite series together with corrective factors

Gauge No.	Gauge name	Years used	Factor
1	<i>Carlisle</i>		
	Carlisle (Tabony)	1845 →	1.0
	Harraby	1840–1844	0.864
	Carlisle (Elliot)	1835–1839	0.946
	Applegarth Manse	1834	0.842
	Whinfell Hall	1829–1833	0.582
	Applegarth Manse	1827–1828	0.842
	Wigton	1825–1826	0.969
	Carlisle, Shaddongate	1801–1824	1.019
	Wigton, Aikbank	1792–1800	0.869
	Dumfries	1784–1791	0.703
	Carlisle, Abbey Street	1757–1783	1.112
2	<i>Darlington</i>		
	South Park	1923 →	1.0
	Hummersknott	1920–1922	1.0094
	Public Park	1919	1.0
	Hummersknott	1918	1.0094
	Cleveland Parade	1877–1917	0.9993
	Catterick (Tunstall)	1873–1876	1.0083
	Richmond	1843–1872	0.8789
3	<i>Barnard Castle</i>		
	Bowes Museum	1922 →	1.0
	County School	1895–1921	1.0204
	Whorlton	1881–1894	1.0918
	East Layton	1875–1880	1.0833
	Greta Bridge	1869–1874	1.0906
	Catterick (Tunstall)	1868	1.2295
	Winston	1856–1867	1.2585

Appendix B. *continued*

Gauge No.	Gauge name	Years used	Factor
4	<i>Banbury</i>		
	Grimsbury	1968 →	1.105
	West Adderbury	1925–1967	1.0
	Bodicote	1894–1924	0.964
	Bloxham Grove	1890–1893	1.009
	Cotefield Bodicote	1886–1889	0.993
	High Street	1873–1885	0.997
	Parson's Street	1850–1872	1.0
5	<i>Bedford</i>		
	Cardington (Meteorological Office)	1969 →	1.0
	Cardington (Meteorological Office)	1968	1.17
	Cardington (Meteorological Office)	1954–1967	1.0
	Castle Road	1904–1953	0.948
	St. Peter's Street	1900–1903	0.973
	The Grove	1891–1899	0.962
	Cardington Village	1846–1890	0.936
6	<i>Taunton</i>		
	Vivary Park	1910 →	1.0
	Blagdon Hill Reservoir	1894–1909	0.8485
	Norton Fitzwarren	1888–1893	0.9346
	Bishop's Lydeard	1884–1887	0.9792
	Fulland's School	1865–1883	1.1533
	Castle	1859–1864	1.1116
7	<i>Tiverton</i>		
	Willand, Losinga	1972 →	1.0
	Willand	1958–1971	0.965
	Halberton	1942–1957	1.0161
	Blundell's School	1929–1941	0.9383
	Halberton	1921–1928	0.8665
	Hartnolls	1917–1920	0.8906
	Halberton	1906–1916	0.9744
	Ivy Place	1892–1905	0.9189
	Cove	1862–1891	0.8768
	Hayne	1854–1861	0.8768
8	<i>Cullompton-Bradninch</i>		
	Bradninch, Westfield	1859 →	1.0
	Halberton	1957–1958	1.035
	Bradninch	1953–1956	1.026
	Cullompton	1881–1952	0.9771
	Clyst Hydon	1847–1880	1.1051
	Broadhambury	1837–1846	1.0455
9	<i>Ross-on-Wye</i>		
	Alton Court	1974 →	1.0
	Ross, Perrystone Court	1936–1973	0.9625
	Ross, Graig	1859–1935	0.982
10	<i>Leominster</i>		
	Leominster	1969 →	1.0
	Kimbolton, Grantsfield	1913–1968	1.0338
	Farm	1896–1912	1.0513
	Farm	1883–1895	0.9459
	West Lodge	1858–1882	1.1226
	Orleton	1831–1857	0.9964

Appendix B. continued

Gauge No.	Gauge name	Years used	Factor
11	<i>Kington</i>		
	Lyonshall	1945 →	1.0
	Lynhales	1927–1944	1.069
	Sunset	1919–1926	1.0765
	Pembridge, Weobley	1918	1.211
	Lynhales	1874–1917	1.0237
	Lynhales	1867–1873	1.1566
	Orleton	1856–1866	1.1616
	Titley	1848–1855	1.199
	Titley	1841–1847	1.0241
12	<i>Penrith</i>		
	Tirrill	1975 →	1.0
	Castle Park	1954–1974	1.233
	Benson House	1931–1953	1.2208
	Fell Lane, Fir Bank	1874–1930	1.3212
	Brougham Hall	1851–1873	1.2562
13	<i>Appleby</i>		
	Castle Bank	1890 →	1.0
	Appleby	1857–1889	1.0
14	<i>Patterdale</i>		
	Patterdale Hall	1961 →	1.0
	Greenside Mine	1957–1960	0.9453
	Patterdale Hall	1860–1956	1.0
15	<i>Newton Rigg</i>		
	Newton Rigg	1951 →	1.0
	Hutton John	1950	0.7285
	Newton Rigg	1926–1949	1.0226
	Greystoke Castle	1887–1925	0.8517
	Blencowe	1874–1886	0.9218
	Greystoke Castle	1846–1873	0.9265

Notes and news

Retirement of Dr Gwyn James

Dr D. G. James. Chief Meteorological Officer, Meteorological Research Flight, Farnborough, retired from the Meteorological Office on 17 September 1982 after a career of 32 years.

Gwyn James was educated at Barry County School and University College, Cardiff. After two years working at the Telecommunications Research Establishment (Malvern) and in industry, he returned to Cardiff to complete the honours course in mathematics and in 1950 obtained a Ph.D. for research into flow over two-dimensional aerofoils. He joined the Meteorological Office later that year as a Scientific Officer and after a period of forecasting training was posted to the Meteorological Research Flight at Farnborough. There he did pioneer work on the measurement of the fine scale structure of convection.

In 1954 Dr James moved to the Forecasting Research Division at Dunstable where he developed statistical techniques for forecasting dissipation of stratocumulus and formation of cirrus, and in November of that year was promoted to Senior Scientific Officer. In December 1956 a posting to the Central Forecasting Office began a period of upper-air forecasting duties which were to take him, during 1958, to Christmas Island and in 1959 to London (Heathrow) Airport.

In 1960 Dr James returned to research, joining the High Atmosphere Branch at Kew Observatory. There he became responsible for developing data interpretation techniques for the Meteorological Office's first satellite experiment. He was promoted to Principal Scientific Officer in 1961 and, shortly after, spent a year with the Satellite Group of the US Weather Bureau. During that period in Washington he studied the application of satellite cloud pictures to forecasting and took part in ground-based experiments which were to lead to development of the first instrument for measuring atmospheric temperature profiles from space. Dr James was to return to the USA in 1964 and 1969 to participate in critical tests of this satellite instrument and the experience led to his involvement, as a consultant to the European Space Research Organization, in a study of a possible European polar-orbiting meteorological satellite.

But that is jumping ahead. In 1963 Dr James rejoined the High Atmosphere Branch, by then at Bracknell, and developed balloon-borne sensors to measure atmospheric radiation and stratospheric humidity. After a brief spell in the Forecasting Research Branch, he was transferred in 1966 to the newly formed Cloud Physics Branch. He headed the cloud dynamics group and took a major part in the planning, execution and data analysis for Project Scillonian, an important series of field-studies of warm fronts involving deployment of radars on the Isles of Scilly and our meteorological research aircraft.

Dr James was promoted to Senior Principal Scientific Officer in July 1971 and took up the post of Chief Meteorological Officer, Meteorological Research Flight. His first major task was planning and preparation for conversion of a Hercules C-130 into the Flight's main research aircraft. It had been agreed that the aircraft would take part, in the summer of 1974, in an international experiment, known as GATE, to study organized convection over the tropical Atlantic. Delays to delivery of the aircraft resulted in only six months being available for installation and testing of the meteorological instrumentation. Through his enthusiasm and organizing ability the task was completed in time for the C-130 to play a major role in GATE. In following years, he collaborated with research branches and outside organizations to extend the scope of on-board instrumentation, particularly for cloud physics and atmospheric chemistry. A measure of his achievement is that the C-130 is now one of the best meteorological research aircraft in the world, much in demand for international collaborative experiments (such as JASIN and KONTUR) and providing observational data for many research projects in the Meteorological Office. Until quite recently Dr James flew regularly in the C-130.

Dr James's enthusiasm linked with a balanced judgement have gained him the respect and co-operation of all who have come into contact with him. These qualities and his wide experience have been particularly valuable in management of the Meteorological Research Flight. He is a keen golfer and, as befits a Welshman, a talented singer with wide interests in music. He has thoughts of moving from Virginia Water to be nearer the hills of Wales. We wish Gwyn and his wife Vida a long and happy retirement. *Hir oes a llawenydd iddynt!*

D. E. Miller

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NOTICES

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