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Retirement of Mr M. J. Blackwell

Mr Michael Blackwell, Deputy Director (Communications and Computing), retired from the Meteorological Office on 28 June 1985 after a career of almost thirty-five years in the Office during which time he was active in a wide range of tasks both in Research and in the more operational activities of the Services side of the Office.

Mr Blackwell was educated at University College School, Hampstead and St Albans School before joining the RAFVR as a Sergeant Compass Adjuster in 1943. In 1945, however, he moved to the Meteorological Branch of the RAFVR and was trained as a 'dependant forecaster'. By 1947 he had become a Flying Officer forecasting at RAF Finningley and, although he was offered the chance to join the Meteorological Office as an Assistant Experimental Officer, he decided instead to take his chances at St John's College, Cambridge. Graduating with an Honours Degree in Physics in 1950, he accepted the offer of a post as a Scientific Officer in the Meteorological Office in August 1950.

After the usual training at Alexandra House, and a short spell of forecasting at ATCC Gloucester, he was posted into research in 1951 at Kew Observatory under Dr G. D. Robinson. There he quickly settled down to work on solar and terrestrial radiation, and papers on the automatic integration of solar radiation and 'Five years of continuous recording of daylight illumination at Kew Observatory' showed his keen interest in all aspects of the observational side of meteorology.

In April 1955 he married and, on promotion to Senior Scientific Officer, was posted to become Superintendent of Eskdalemuir Observatory. His responsibilities there included observations of geomagnetism, atmospheric electricity, ozone, atmospheric chemistry and pollution, evaporation, and snow gauging, and during the following three years he significantly improved the standard of the instrumentation at Eskdalemuir, bringing it fully up to date.

The year of International Geophysical Co-operation in 1959 — in effect an extension of the immediately preceding International Geophysical Year — led to Mr Blackwell's secondment from November 1958 to June 1960 to the Falkland Islands Dependencies Service as Chief Scientist, Halley Bay, at the British Antarctic Survey Base Z, Coats Land. He was in charge of a wide range of geological, oceanographic and meteorological measurements and his work during 1959, and the resulting papers, were later recognized by the award of the Polar Medal. He returned from the snow and ice in 1960 to a short period of forecasting on the upper-air bench at Bomber Command, High Wycombe, but, following promotion to Principal Scientific Officer in November 1960, he soon moved to take over the post of Senior Meteorological Officer of the Meteorological Research Unit attached to the School of Agriculture, Cambridge University.

There followed a most productive period during which Mr Blackwell forged a new, close relationship with the Plant Breeding Institute and the Cambridge University Schools of Agriculture and Botany. He wrote a number of papers on the measurement of natural evaporation, the turbulent transfer of water vapour near the ground and the surface energy balance, and became well known as an expert in the field of micrometeorology and its applications to agriculture. In 1964 he also became responsible for the work at the Meteorological Research Unit, Cardington including the use of constant density balloons (tetroons) as Lagrangian tracers.

In early 1967 Mr Blackwell attended the three-month General Management Course at the Administrative Staff College, Henley where he enjoyed the syndicate work and the 'despecialization of the specialist'. This was followed by a move to Bracknell where he took over as Head of the Surface Instrument Development Section in the Operational Instrumentation Branch. The work involved the introduction of synoptic and marine automatic weather stations and the development of new instrumentation to measure winds, temperature, humidity and rain. He also became the UK representative at international meetings of WMO Working Groups of the Commission for Instruments and Methods of Observation.

In 1970 he was promoted to Senior Principal Scientific Officer and took over as the Assistant Director (Operational Instrumentation). With the rapid evolution of technology these were exciting times, and Mr Blackwell was a pioneer in encouraging the early stages of two important COST projects (COST — Co-operation in Science and Technology — is an organization working under the aegis of the Commission of the European Communities). The COST-43 project buoy program (which is now successfully operating both fixed and drifting buoys in the North Atlantic and the North Sea) had its origins in his work in the early 1970s, and the COST-72 project on meteorological instrumentation dealt with balloons, radiosondes and automatic weather stations in the 1970s before taking on its new role in the 1980s of encouraging the development of a European weather radar network. During this period Mr Blackwell was also actively encouraging co-operation on many international committees, and his long experience and broad viewpoint were sought widely. He also found time to be Chairman of the Staff General Purposes Committee, and a member of the Institution of Professional Civil Servants Higher Grades Committee as well as acting on the Royal Meteorological Society's *Weather* Board as the News Editor.

In April 1976 came well-deserved promotion to Deputy Chief Scientific Officer as Deputy Director (Communications and Computing). It must have come as quite a surprise to enter this completely new field at this level, but within a year he was firmly in the saddle applying an even temper, sound judgement and common sense to the rapidly evolving 'high technology' world of super-computers and information technology. The period 1976–85 has seen a revolution in these areas. The computer complex known as COSMOS has been enhanced by the introduction of the Cyber 205 and the IBM 3081D, which has allowed new, advanced numerical weather prediction models to be run. The telecommunications centre (AUTOCOM) has changed from teleprinter operation and 50-baud line to high-speed message switching using the Ferranti Main Enhancement, and now the Phase IV Tandem system; and a forward-looking strategy and implementation plan for the future requirements of the Office for outstation communications and automation has been developed. New forms of digital facsimile and graphical display systems have also come into operation. All this has required careful technical planning and close liaison between diverse groups of users, operators and manufacturers. Mr Blackwell has directed these developments with quiet authority and confidence.

Mr Blackwell's first wife died in 1978, and he remarried late in 1981. I shall miss his wise and helpful counsel and I am sure that all his colleagues will want to join me in wishing Michael and his wife, Joy, a long and happy retirement in their new home in Henley.

D. N. Axford

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Field investigations of radiation fog formation at outstations

By J. Findlater

(Meteorological Office, Bracknell)

Summary

Special instrumentation placed at selected outstations for evaluation of its potential usefulness to local forecasters has been utilized to provide detailed information on the development of radiation fog. Relationships between the height of the fog top and the base of the capping inversion have been derived.

It is demonstrated that the cessation of turbulence, which is often coincident with the formation of radiation fog *in situ*, can be detected by a low-speed anemometer mounted at a height of 2 m.

Data from a mini-radiosonde system have indicated that the surface temperature at the time the sky becomes obscured by fog is preserved at the base of the capping inversion as it rises aloft. A possible technique for estimating the height of the top of the developing fog is suggested.

1. Introduction

During the winters of 1981/82, 1982/83 and 1983/84 some investigations into the formation and persistence of radiation fog were carried out at Bedford. The investigations had two main aims. Firstly, using the results from earlier field studies at Cardington by the Meteorological Office Cloud Physics Branch, to examine the usefulness to local forecasters of:

(i) a low-speed anemometer mounted at a height of 2 m capable of measuring speeds down to 0.2 m s^{-1};

(ii) a commercially-available monostatic acoustic sounder;

(iii) a mini-radiosonde system for local soundings of the boundary layer.

Secondly, to acquire data for further studies of the structure and development of radiation fog directed towards improving local forecasting. It is the latter aspect to which this report refers. Some data are also included from Lossiemouth where the mini-sonde was sited in summer 1983 to gather data in sea fogs. Examples from that station where radiation fog formed in the slab of moist air advected inland are presented.

2. Historical

Taylor (1917) noted that conditions favourable for the formation of radiation fog were moist air at the surface, mainly clear skies, and generally light winds. Deposition of dew took place when the surface cooled below the dew-point of the air in the lowest metre or so. Stewart (1955) drew attention to the fact that the air at screen level may itself be saturated for a few hours before fog formation and that the direct cooling of the lowest 1 km of air by radiation and by turbulent diffusion were comparable. Monteith (1957) pointed out that dew deposition decreased abruptly when the wind speed at 2 m fell to less than 0.5 m s^{-1} and Kraus (1958) found that radiation fog began to form when the wind at 1 m fell to less than 0.5 m s^{-1} and the initial shallow fog was often detached from the surface by a few tens of centimetres.

Detailed studies by Roach *et al.* (1976), Brown and Roach (1976) and Roach (1976), using data from balloon-borne probes at Cardington, indicated that significant fog development occurred when low-level winds (at about 2 m) decreased from a mean speed of 1–2 m s^{-1} to 0.5 m s^{-1} or less. As the fog thickened the soil heat flux overcame radiative cooling and the surface temperature rose slightly. Simultaneously, the inversion base rose aloft from the surface as the sky became obscured, with a slightly superadiabatic lapse rate developing in the fog layer. It was concluded by these authors that radiational cooling favours fog formation whilst turbulence inhibits fog formation by mixing warmer air downwards. Turbulence also allows moist air to be brought down to the surface where its moisture is condensed out as dew, but when turbulence is suppressed, as in very light winds with a strong stable lapse rate, continued cooling leads to formation of fog droplets in the lower layers. Other important factors which emerged from the Cardington studies were the roles of soil heat flux and the removal of water by gravitational settling, perhaps aided by some scavenging of fog droplets by vegetation.

Further studies of the Cardington data by Caughey *et al.* (1978) related the fog-top height deduced from temperature profiles to the echo layer from an acoustic sounder and the fog-top height indicated by a balloon-borne droplet spectrometer to the base of the capping inversion.

The Cardington data from 26 cases of radiation fog were also used by Findlater (1981) to indicate the relative constancy of the temperature at the base of the inversion during the nocturnal formation and persistence phases of radiation fog, and to demonstrate an average height difference of about 50 m between the base of the inversion and the fog top, i.e. the inversion base lay below the fog top.

A schematic representation of the development of radiation fog *in situ* is shown in Fig. 1 and emphasizes the importance of very light winds at a height of 1–2 m above the ground. However, most radiation fogs are complicated to a greater or lesser degree by advective effects.

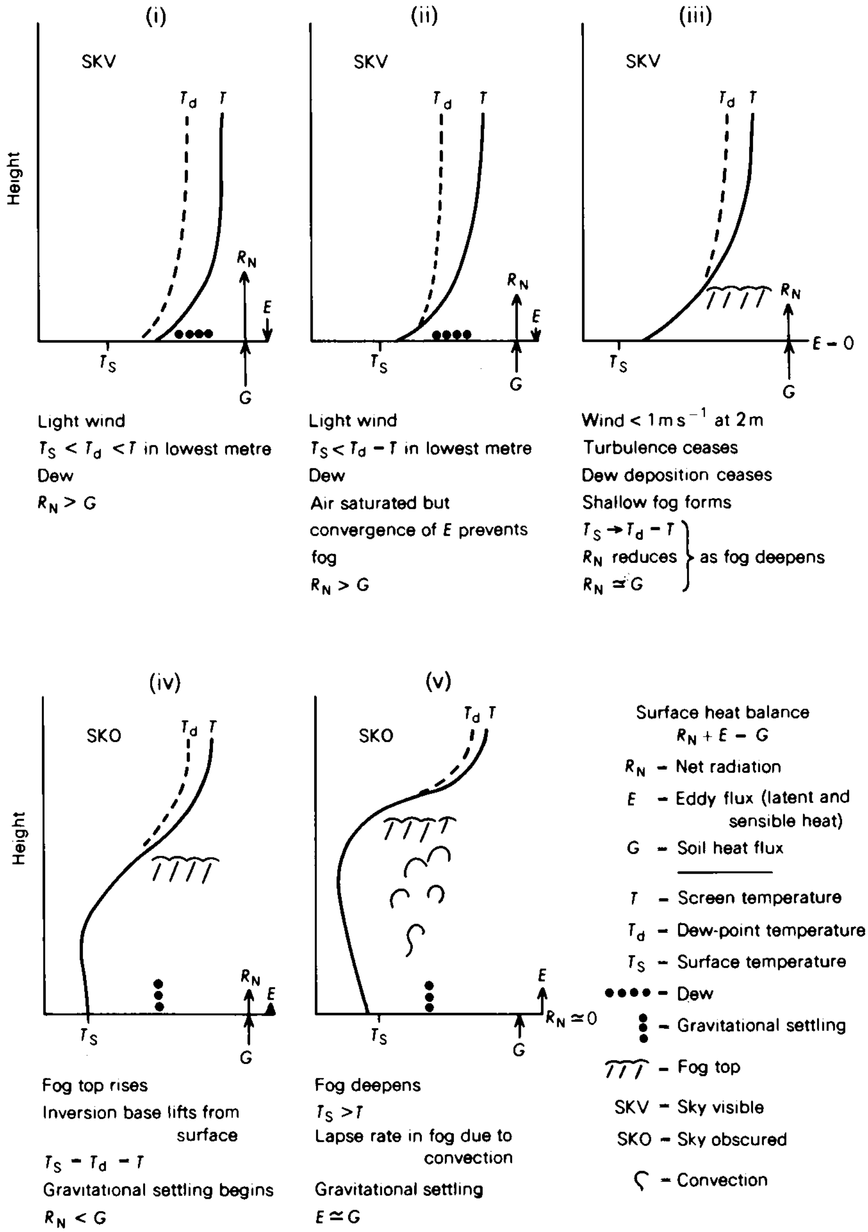

Figure 1. Schematic diagram of the development of radiation fog *in situ*.

Fig. 2 shows one example of a radiation fog at Cardington based on data from instrumented captive balloons. Features of interest are:

(i) The lifting of the inversion base from the surface at about the time that the fog becomes deep enough for the sky to become obscured.

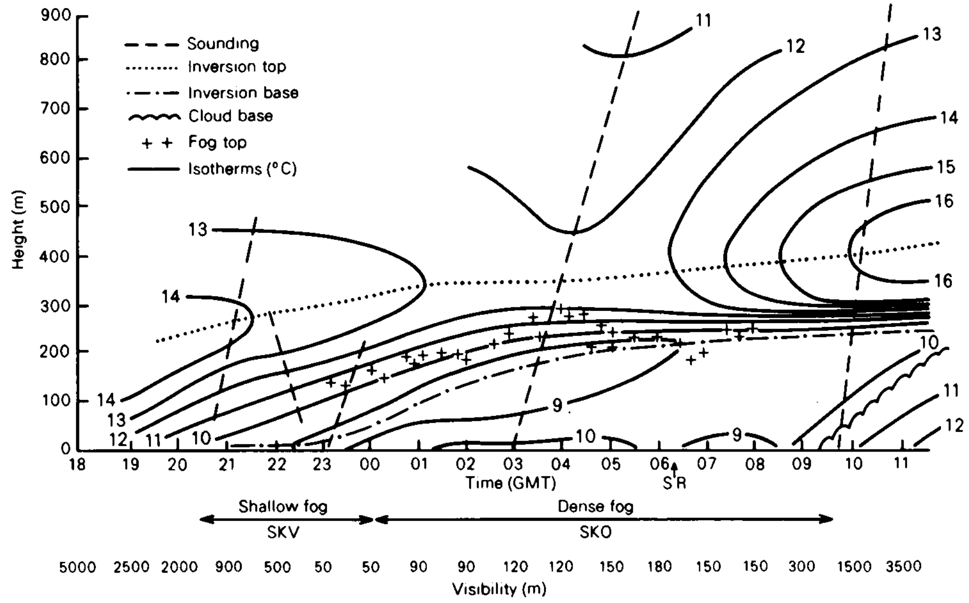

Figure 2. Time cross-section of the development of a radiation fog at Cardington, 17–18 October 1977. SR — sunrise, SKV — sky visible, SKO — sky obscured.

(ii) The rise of surface temperature when the sky becomes obscured and the establishment of a lapse rate up to the inversion base.

(iii) The relative constancy of the temperature of the inversion base as it rises from the surface to a height of about 230 m.

(iv) Small-scale fluctuations of fog-top height, indicated by a droplet spectrometer and a point visibility meter supplemented by data from an acoustic sounder. The balloon soundings of temperature did not have the time resolution to reveal any concomitant small-scale fluctuations in the level of the inversion base.

Data from the droplet spectrometer and point visibility meter have been used to indicate, as in Fig. 3, that the fog top often lies about 50 m (± 20 m) above the base of the inversion.

3. The experimental equipment

Synoptic reporting stations are equipped with standard anemometers mounted at a height of 10 m above the ground and these have stopping speeds of about 3 or 4 knots (1.5–2.0 m s^{-1}). These instruments are not suitable for monitoring the important changes in very light wind speeds at 1 or 2 m to which the earlier studies had drawn attention. The Working Group on the Acquisition and Operational Use of Boundary Layer Measurements recognized this deficiency and recommended that a Porton low-speed anemometer be placed at an airfield for use in local fog studies. The Royal Aircraft Establishment at Bedford was chosen as the site because of a fog-flying program at that station.

Also, a Sensitron monostatic acoustic sounder acquired for evaluation as a local forecasting aid was later installed at Bedford. A report on the operation of this instrument and the potential usefulness of the data to forecasters has been prepared by Findlater and Cole (1983).

Early in 1983 a Kaymont mini-sonde system was sited temporarily at Bedford. The sondes were

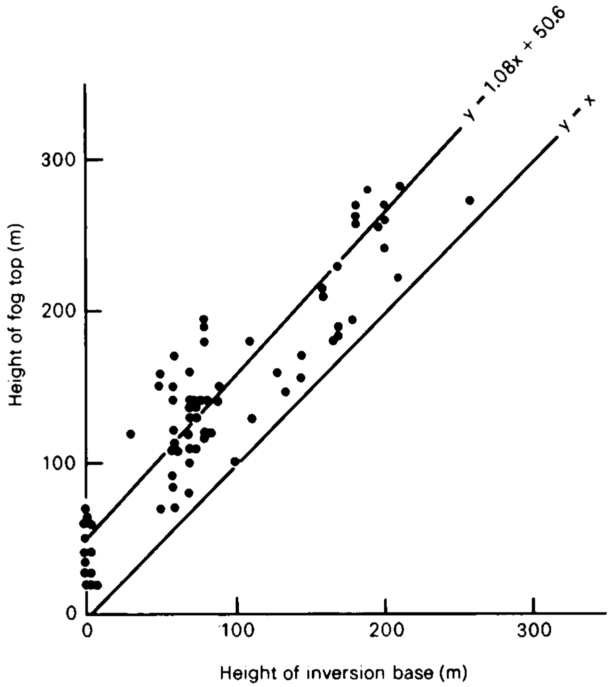

Figure 3. Relation between height of inversion base and height of radiation fog top, based on data from Cardington.

released from the meteorological office whilst the 2 m anemometer was 110 m to the north-east, near the acoustic sounder, on an open grass area. The standard 10 m anemometer is 450 m east-north-east of the meteorological office. In the summer of 1983 the mini-sonde system was transferred to Lossiemouth for studies of sea fog.

Reports on the actual usefulness of the acoustic sounder and the mini-sonde system to local forecasters have been prepared for consideration by the Working Group and what follows are a few examples of how the data have been used for subsequent studies.

4. Case studies at Bedford

(a) *18–19 January 1982*

Fog formed in patches at 1925 GMT with visibility ranging from 800 to 1500 m. At the time of patchy fog formation the 2 m wind dropped to 1.5 m s^{-1} for a few minutes with lulls to 1.2 m s^{-1} and was non-turbulent during this short period. Thereafter the speed and the turbulence increased. The profiles of wind speed and direction at 2 m and 10 m, and of visibility and temperature, are shown in Fig. 4. All values are reduced to 5-minute mean values from the original records.

From 2120 to 2125 GMT wind speeds at both levels fell until 2145 GMT. At this time the 10 m speed increased slightly whilst the speed at 2 m continued to fall to a minimum value of 0.5 m s^{-1} at 2200 GMT with a marked reduction in turbulence characteristics of both speed and direction — coincident with the fog thickening and becoming more widespread. Indeed, at the time of fog formation a decreasing speed at 2 m appeared to be related to an increase at 10 m, and vice versa, (as in Fig. 4) from 2145 to 2230 GMT. However, no firm conclusions can be drawn owing to the horizontal separation of the two anemometers.

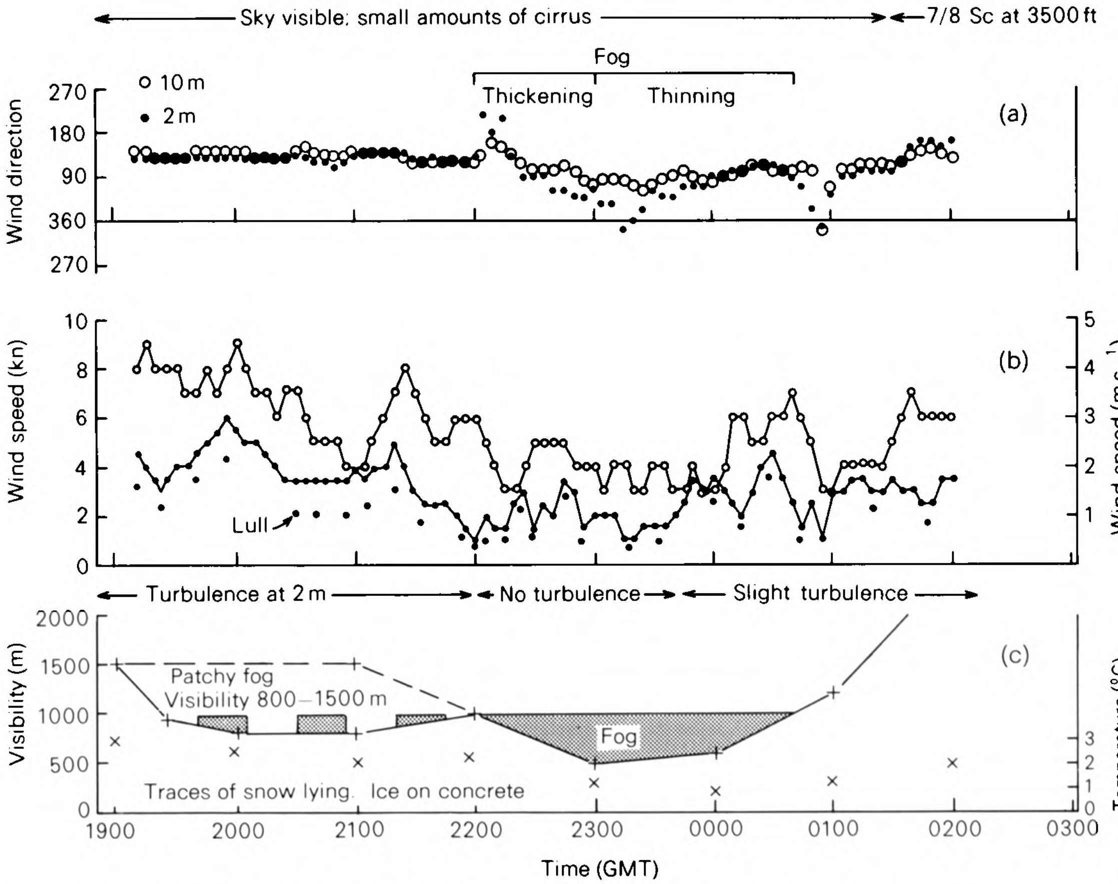

Figure 4. Wind direction (a) and speed (b) at 2 m and 10 m, and visibility and temperature (c) at Bedford, 18–19 January 1982 (x indicates temperature).

The wind speed at 10 m fell from 2200 GMT to reach its minimum at 2210–2215 GMT, i.e. 10–15 minutes after the minimum at 2 m, with a temporary change of direction similar to that at 2 m. The 2 m wind direction swung from the general south-easterly to a south-westerly of short duration (10 minutes) and the air could then have moved towards the 10 m anemometer, 380 m distant, at about 0.75 m s^{-1} to reach the 10 m instrument 8 or 9 minutes later. The reasonable correspondence of the actual time of arrival of this fickle wind suggests that this change was indeed advective.

Whether the extensive fog which formed at eye-level at 2200 GMT deepened significantly is not known. The acoustic sounder, which does not record information below about 45 m, showed a stable layer up to between 200 and 300 m, but because the sky remained visible throughout the period, the inversion was almost certainly ground-based and the fog shallow.

The record of the 2 m anemometer shown in Fig. 5 indicates the striking change in the character of turbulence at 2200 GMT when fog formed. Wind speed continued to vary after fog formation but the difference between gusts and lulls over short periods (say 5 minutes) was markedly reduced. No such detailed change of turbulence can be detected in the record of the 10 m anemometer (Fig. 6).

It may be concluded that, in this case, the sensitive anemometer at 2 m provided more information relevant to the local development of fog than the standard anemometer at 10 m. The former showed clearly the suppression of low-level turbulence at the time of fog formation and thickening, with speeds

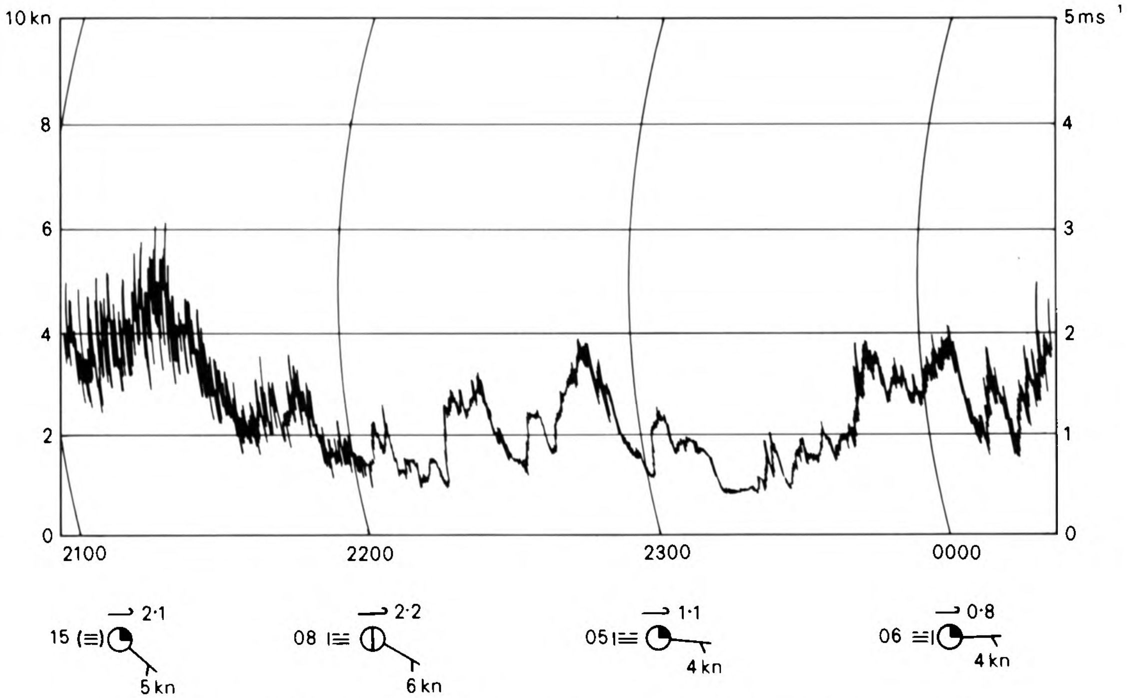

Figure 5. Record of 2 m wind speed and hourly observations at Bedford, 18–19 January 1982.

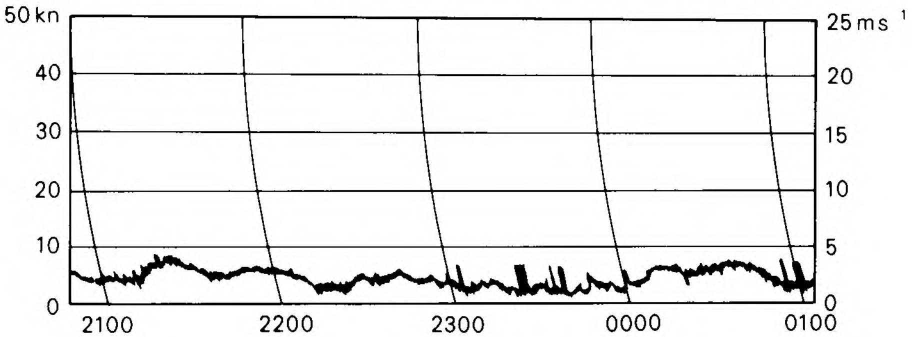

Figure 6. Record of 10 m wind speed at Bedford, 18–19 January 1982.

lulling to 1 m s^{-1} at the time of patchy fog formation and to 0.5 m s^{-1} or less during the thickening phase. Advective effects are considered to have been absent.

(b) *8–9 November 1983*

Another example of the change in turbulence characteristics at the time of significant fog development is shown in Fig. 7 by the open-scale record of the 2 m sensitive anemometer. The gust–lull difference steadily decreased after 2300 GMT to become small from 2320 GMT when visibility fell from 2500 to 600 m and then to 200 m by 0000 GMT. Subsequently the difference became smaller and the visibility fell to 100 m in dense fog at 0015 GMT. Again, these changes cannot be detected in the coarse-scale record of the 10 m anemometer shown in Fig. 8. Though the fog was dense the sky remained visible and

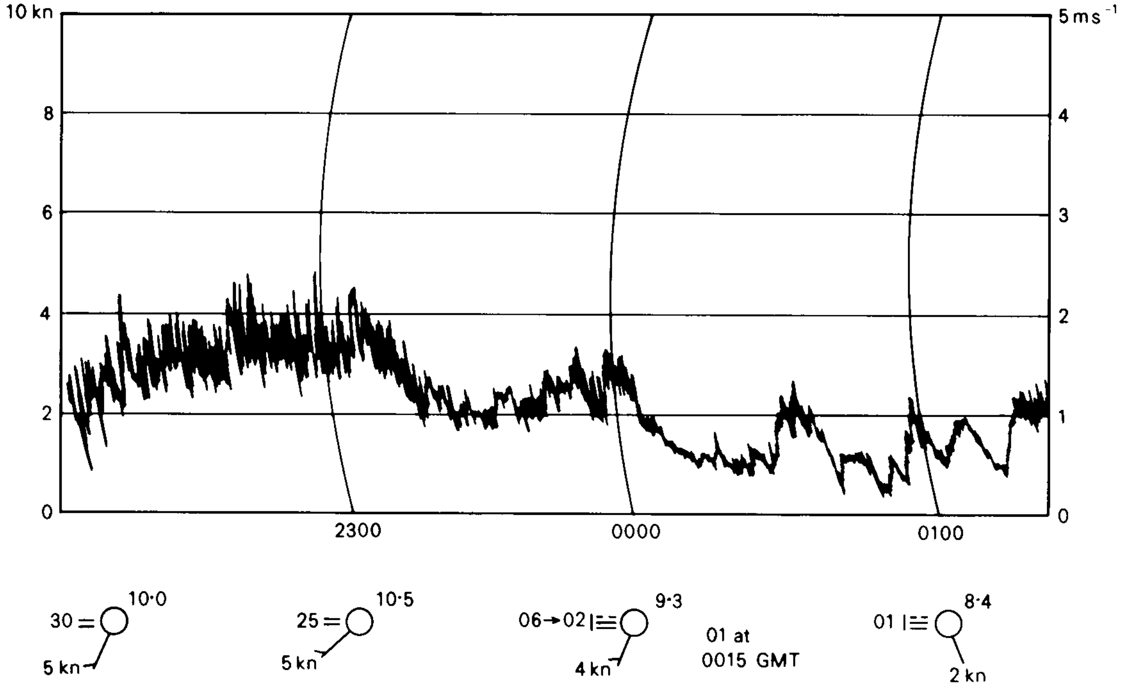

Figure 7. Record of 2 m wind speed and hourly observations at Bedford, 8–9 November 1983.

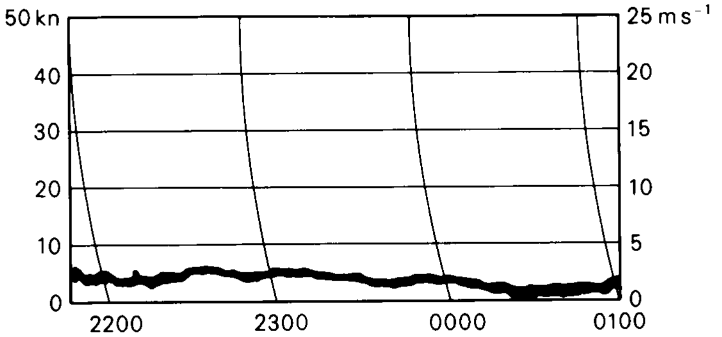

Figure 8. Record of 10 m wind speed at Bedford, 8–9 November 1983.

it may be deduced that the inversion remained based on the surface. In this case, as in the former, the acoustic sounder could not be used to determine the fog top since the inversion base was below 45 m.

Several other cases examined show the same 2 m low-speed anemograph trace characteristics whilst others do not. Those which do not are associated with the higher wind speeds at both 2 and 10 m levels where the fogs, whilst developing, had a marked advective component and *in situ* developments could not be detected. Other cases were upslope fogs from the south-east.

(c) *9–10 November 1983*

This example was the only case where significant amounts of data were available simultaneously from the mini-sonde, the low-speed anemometer at 2 m, the acoustic sounder and from aircraft operating in the fog.

A sequence of mini-sondes was flown from the afternoon of the 9th, before fog formation, until late morning on the 10th when the fog had deepened to about 140 m. A time cross-section of this period is shown in Fig. 9. During the afternoon and evening, under clear skies, the screen temperature fell steadily and visibility was reduced to below 1000 m at 1830 GMT. With sky visible and outgoing long-wave radiation the screen temperature continued to fall and the fog became dense. Fog tops of 10 and 15 m were measured by the duty observer who climbed the control tower staircase at 2110 and 2230 GMT whilst the horizontal visibility was about 100 m. The screen temperature reached its minimum value of 7.3 °C at 0100 GMT when the sky had become obscured and, owing to reduced outgoing long-wave radiation and the soil heat flux, it subsequently rose to over 8 °C by 0400 GMT as a lapse rate became established in the deepening fog. Visibilities of 50 m or less occurred during this phase. The inversion base rose steadily (but see later) from the surface to reach 100 m by 0900 GMT. Aircraft reports of fog top near this time confirmed the top of the fog to be about 25 m above the inversion base. The three measurements of inversion base temperature of 7.3 °C at the surface, 7.8 °C at 45 m, and 7.2 °C at 100 m over a period of 8–9 hours confirm the earlier finding from the Cardington data of the conservative nature of this parameter. This fog was in association with 2 m winds of 2–3 m s^{-1} from the east-north-

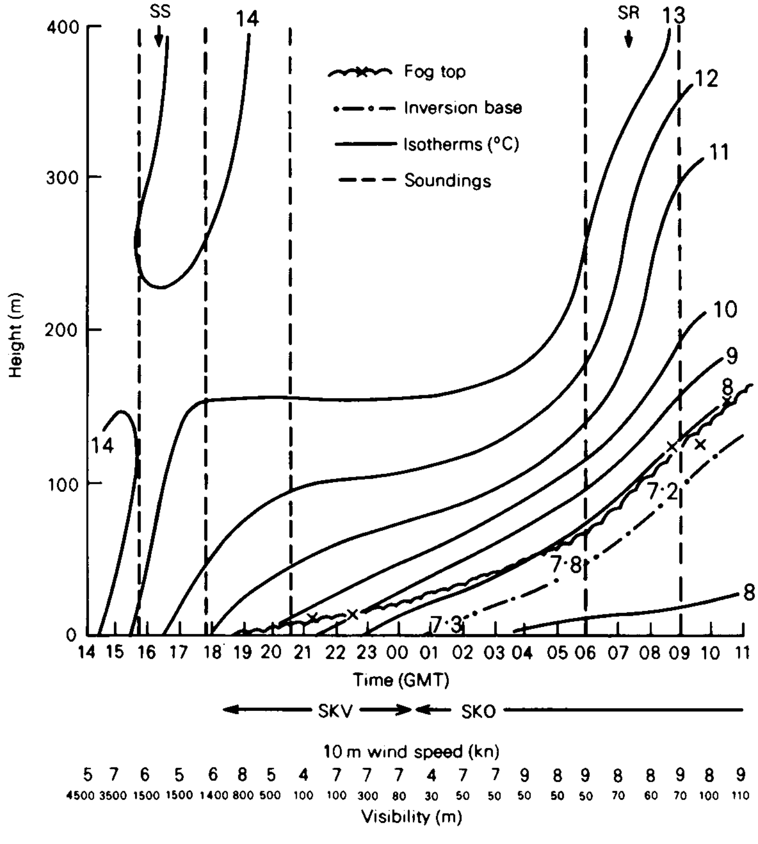

Figure 9. Time cross-section of fog development at Bedford, 9–10 November 1983. SS — sunset, SR — sunrise, SKV — sky visible, SKO — sky obscured.

east and the advective contribution masked any changes in turbulence at 2 m similar to those of the earlier analyses.

The time cross-section shown in Fig. 9 may be used to reconstruct soundings at 2-hour intervals as in Fig. 10(d) (Figs 10(a), (b) and (c) will be discussed later) and from this several points of interest emerge. These apply only to the formation and deepening phase of fog formation, and are as follows:

(i) The marked fall of screen temperature between 1900 and 0100 GMT whilst the fog thickened but the sky remained visible.

(ii) The rise of screen temperature from 0100 to 0500 GMT after the sky became obscured in the deepening fog.

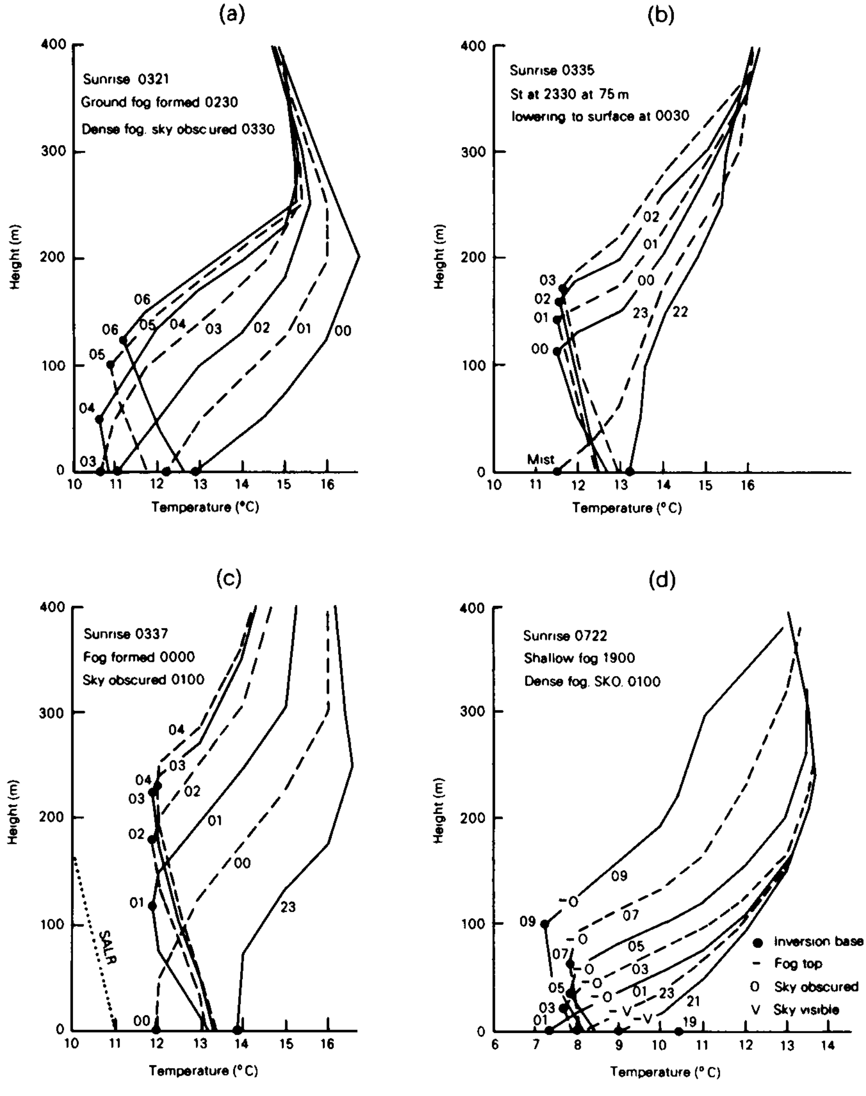

Figure 10. Reconstructed soundings in radiation fog at (a) Lossiemouth, 20 June 1983, (b) Lossiemouth, 7–8 July 1983, (c) Lossiemouth, 10–11 July 1983 and (d) Bedford, 9–10 November 1983. Figures 23, 00, 01, etc. indicate times of the soundings. All times are GMT. SALR — saturated adiabatic lapse rate.

(iii) The warming of the bottom of the fog layer between 0100 and 0500 GMT.

(iv) The cooling of the fog top until shortly after the sky became obscured, when the fog-top temperature remained sensibly constant as it rose aloft.

(v) The relative constancy of the inversion-base temperature (within 1 °C) after the sky became obscured.

(vi) The steady cooling of the air up to about 100 m above the fog top until 0500 GMT. Changes in the upper temperature profile after 0500 GMT, e.g. a cooling of 3 °C at 200 m between 0500 and 0900 GMT, may reflect advective rather than developmental changes.

The acoustic sounder record from Bedford for the period 0600 to 1100 GMT on 10 November 1983 is reproduced in Fig. 11(a), where the dark vertical lines extending downwards from the top of the record after 0730 GMT are due to background noise from road traffic and aircraft. The quasi-horizontal dark echo is that generated by the scattering of sound from temperature inhomogeneities on a scale of about half the wavelength of the transmitted sound, and indicates the lower part of the inversion layer. Below the inversion layer, which is mainly from 100 to 200 m, are the convective plume echoes in the fog layer. The transition from convective plumes to the dark layer echo marks the base of the inversion at about 100 m in this case. For a fuller explanation of the interpretation of acoustic records in fog situations the reader should refer to Caughey *et al.* (1978). Earlier work at Cardington indicated that the fog top often lay about 50 m (± 20 m) above the base of the inversion.

The dark vertical line at 0850 GMT indicates the noise made by an aircraft taking off in fog, when the visibility was 70 m. The aircraft reported the fog top at a height of 120 m. Later flights measured fog tops at 125 m at 0930 GMT and 150 m at 1035 GMT as the fog deepened. These fog tops are shown in Fig. 11(a) and are approximately 50 m above the indicated inversion base.

A sounding made by the mini-sonde at Bedford at 0611 GMT is included in Fig. 11(b) for comparison of the inversion layer with the echo layer. In this case the dark echo layer corresponds well with the

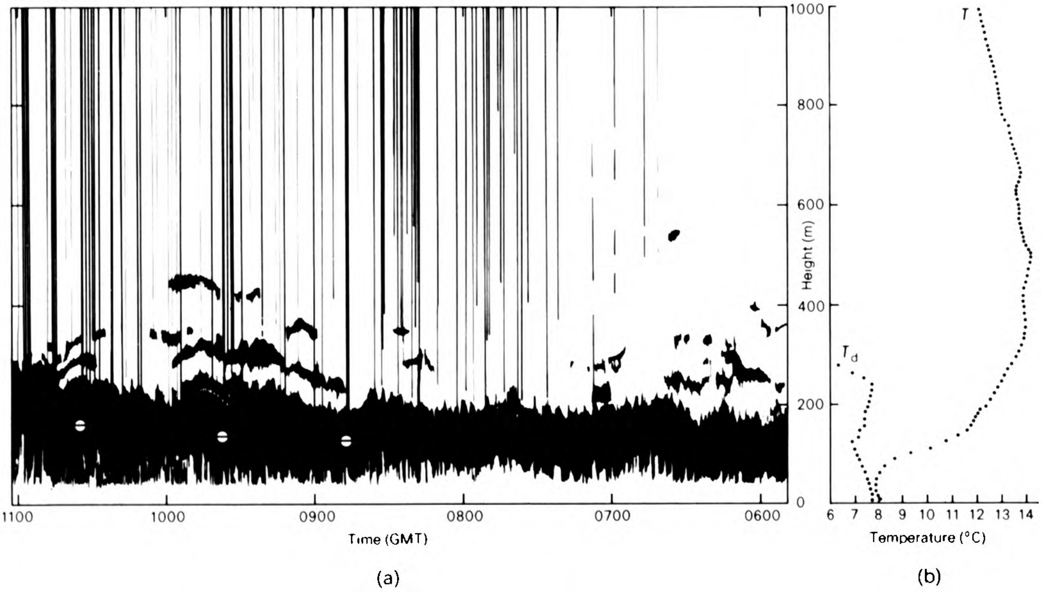

Figure 11. Acoustic sounder record from Bedford (a), 10 November 1983 and a sounding made by a mini-sonde released from Bedford (b) at 0611 GMT for comparison. Fog tops measured by aircraft are indicated by horizontal lines bisecting white circles.

steepest part of the inversion, though more such comparisons are needed to assist interpretation of more complex acoustic records.

A sounding was made at Cardington at 0849 GMT, through the fog shown in Fig. 11(a), using a tethered balloon. Data revealed a pronounced wind shear at the fog top, a typical characteristic of many radiation fogs. In the fog layer the wind was generally north-easterly, 4 m s^{-1}, but just above the fog top was south-easterly, about 9 m s^{-1}.

On some occasions the sounder gives a clear and unambiguous record of inversion layers capping fog, stratus or stratocumulus cloud. One example is given in Fig. 12 where the acoustic record, coupled with data from the standard cloud-base recorder, allowed the cloud height and thickness to be continuously monitored.

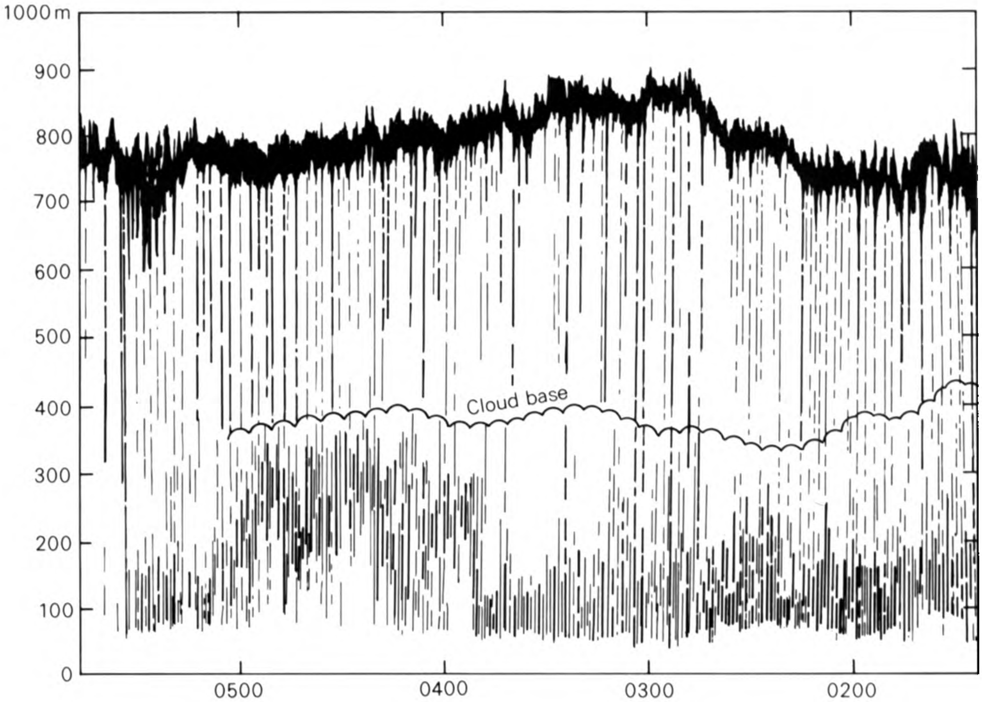

Figure 12. Acoustic sounder record from Bedford, 9 March 1983 monitoring the inversion capping a layer of stratiform cloud. Cloud bases measured by a cloud-base recorder have been entered to indicate the thickness of the cloud.

5. Case studies at Lossiemouth

During the summer of 1983 the mini-sonde system was deployed to Lossiemouth for the study of haar, the sea fog which affects eastern coasts of Scotland and England in the spring and early summer. These studies continued in 1984 when mini-sonde data were supplemented by detailed data gathered offshore by the Hercules aircraft of the Meteorological Research Flight. The results of these experiments will be reported in due course but it is noteworthy that three series of mini-sonde flights were made in conditions when radiation fog formed over the coastal plain after moist sea air had been advected inland during the previous afternoon. In these cases the radiation fogs formed over the airfield with calm or light south-west to west surface winds.

These examples have been analysed in a similar fashion to that of 9–10 November 1983 at Bedford (shown in Fig. 10(d)) and have been included as Figs 10(a), (b) and (c) for comparison with the Bedford example. The reconstructed soundings from Lossiemouth are at 1-hour intervals, rather than at 2-hour intervals, because of the rapidity of development at Lossiemouth.

The radiatively formed fogs at Lossiemouth show very similar characteristics to those listed for Bedford in Section 4(c) and will not be elaborated upon here. It is emphasized, however, that in each of the four examples shown in Fig. 10 the inversion base and fog top rise aloft without significant change of temperature. Rather than the fog top cooling during the night it appears to grow upwards into the cooling layer whilst preserving its temperature. This is evident from the skeletal profiles shown in Fig. 13.

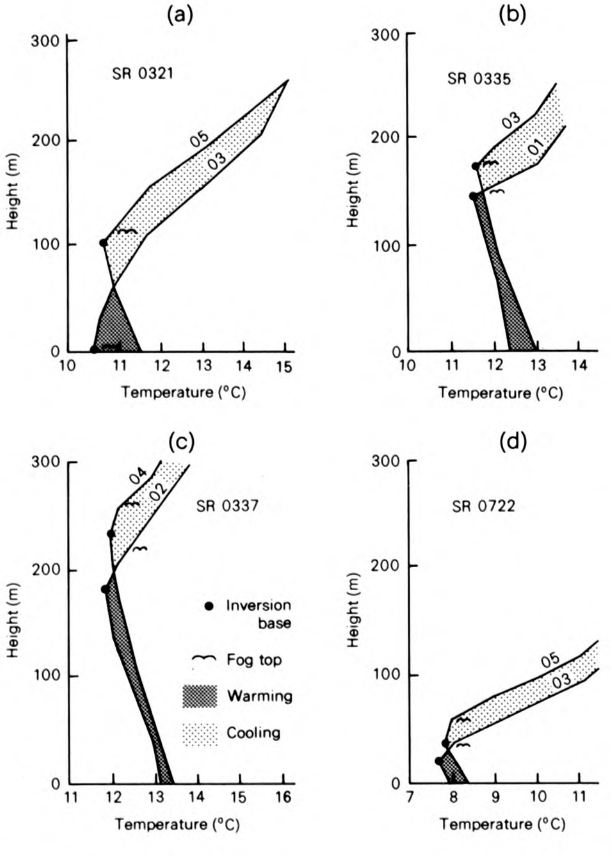

Figure 13. Skeletal profiles of the deepening of radiation fog, illustrating the warming of fog and the growth of its top into the cooling layer at (a) Lossiemouth, 20 June 1983, (b) Lossiemouth, 8 July 1983, (c) Lossiemouth, 11 July 1983 and (d) Bedford, 10 November 1983. SR — sunrise. All times are GMT.

6. Conclusions

The results of the trials to assess the suitability and usefulness of the acoustic sounder, mini-sonde and low-speed anemometer to local forecasters will be circulated elsewhere; here, only conclusions drawn from the studies of data in fog situations that may be of immediate interest to local forecasters will be noted. These are:

(a) Soundings at Cardington and Bedford show that the top of radiation fog is often 50 m (± 20 m) above the level of the inversion base. The inversion base is on the surface when the sky is visible in fog, but is aloft when the sky is obscured and surface temperature has begun to rise owing to the fog deepening. This confirms earlier studies by Roach *et al.* (1976).

(b) A low-speed anemometer at 2 m can detect the cessation of turbulence at low level which is often coincident with the initial formation of fog *in situ*, or the thickening of an existing shallow fog. The degree of turbulence may be more important than the actual light wind speed. Standard anemometers exposed at a height of 10 m do not detect the changes in the degree of turbulence at the time of fog formation, nor the very light winds associated with non-advective fog formation when the direction of drift may be important. Experiments are now being carried out with the low-speed anemometer mounted at a height of 0.5 m to determine whether the cessation of turbulence can be detected earlier closer to the surface prior to fog formation, and whether there may be some predictive value in such measurements.

(c) Data from the mini-radiosonde system have proved to be invaluable for local fog forecasting by revealing the depth of the moist layer and lapse rate before fog formation and the depth of fog thereafter.

(d) Soundings made by captive balloons at Cardington, and by mini-sondes at Bedford and Lossiemouth, indicate that if radiation fog actually forms at a temperature (T_{AF}) and its temperature subsequently falls to a minimum (T_{MF}) at the time the sky becomes obscured then the temperature of the base of the inversion remains sensibly constant at this value (T_{MF} ± 0.5 °C) as the inversion base rises aloft. After the inversion leaves the surface and the temperature rises to reach, say, T_{HH} at hour HH, then if a saturated adiabatic lapse rate can be assumed between T_{HH} and T_{MF} the height of the base of the inversion may be estimated (see Fig. 14). This relationship appears to apply only during the formation phase whilst fog is still deepening during the night and early morning, and advective effects are minimal. This finding is based on a relatively small number of cases and further studies are required to verify it.

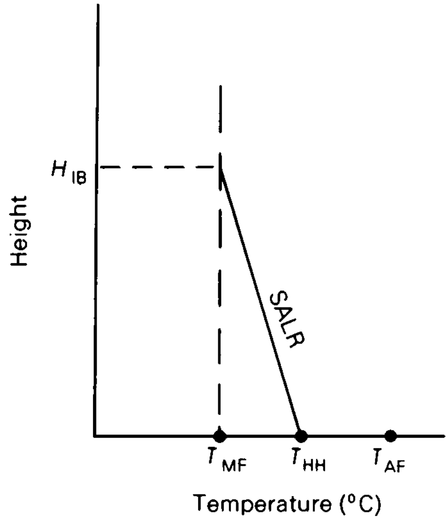

Figure 14. Schematic diagram to estimate height of inversion base, where T_{AF} — temperature at time of actual fog formation, T_{MF} — temperature at time sky became obscured, T_{HH} — temperature at hour HH after sky became obscured, H_{IB} — height of inversion base with fog top possibly 50 m (± 20 m) above. SALR — saturated adiabatic lapse rate.

(e) The acoustic sounder at Bedford has demonstrated its capability of continuously monitoring the height of inversions which cap not only fog layers but those associated with stratus, stratocumulus and haze layers. Fluctuations on long and short time-scales are clearly indicated. However, there are some occasions when the acoustic sounder yields records which are difficult to interpret, or are ambiguous. Further studies with local upper-air temperature soundings are desirable to formulate guidelines for interpretation of the acoustic record.

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Many helpful discussions have been held with Dr W. T. Roach and the author is grateful for the resulting amendments which have been introduced.

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Instrumentation at Eskdalemuir Observatory

By W. K. Young

(Eskdalemuir Observatory)

Summary

A brief description is given of some of the less commonplace instruments currently at Eskdalemuir Observatory and an indication is presented of the uses made of the instrumental data.

1. Introduction

Eskdalemuir Observatory (Fig. 1), established in 1908, is situated in the south-west of Scotland on the west side of the White Esk valley, which runs north–south. The site is approximately 280 metres (800 feet) above sea level. The region is mountainous by British standards with many peaks in excess of 300 metres. Over the last 20 years the local terrain has been progressively changed from open, exposed, moorland to coniferous forest. A reservoir has also been constructed in the adjacent Black Esk valley.

The site was originally established as a purpose-built geomagnetic observatory. During the 75 years since its opening the staff of Eskdalemuir have carried out a varied program of work which includes among its disciplines seismology, meteorology and atmospheric chemistry. A variety of non-standard instruments have been acquired to support the observational programs over the years. Many of the instruments to be found at Eskdalemuir are of a specialized nature and, in some cases, unique. This

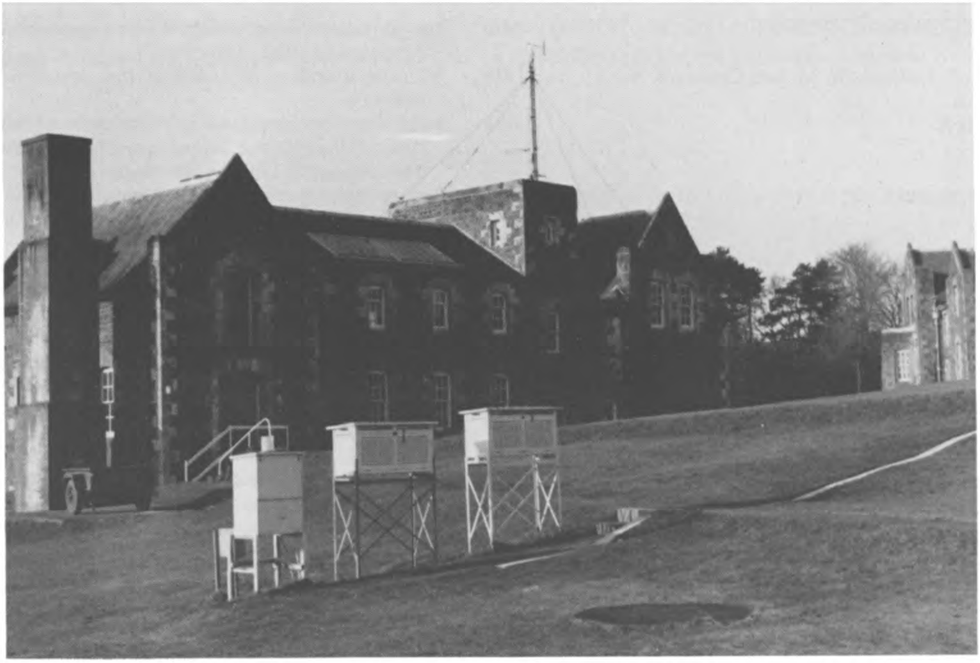

Figure 1. Eskdalemuir Observatory.

paper will concern itself, primarily, with those more unusual devices used for meteorological and environmental monitoring purposes, and the uses to which the data are put.

Not all of the programs have been continuous. Geomagnetism, basic meteorology and seismology have the longest record durations. However, in the case of meteorology, it should be noted that re-siting and changes in the instrumentation have resulted in discontinuities in the long-term records which may not be apparent to the casual user.

2. The current program

The Observatory, at present, contributes to a large variety of programs for both national and international institutions. The British Geological Survey (BGS), who currently have responsibility for the site, maintain both seismological and geomagnetic monitoring on a continuous basis. The meteorological staff are required to carry out an observing program on a 24-hour basis in support of the role of the station as (i) a Principal Land (Synoptic) Station, (ii) a Reference and Principal Climatological Station, (iii) a Principal Radiation Station and (iv) a Regional World Meteorological Organization (WMO) Background Pollution Monitoring Network (BAPMoN) Station. In addition the observers assist BGS in their work by contributing to the daily operation and analysis of both the seismological and geomagnetic records. The pollution monitoring activities are mainly of a supervisory nature and all sample analyses are carried out by those institutions for whom the sampling is done, or their appointed agencies.

Instrumentation which is now in working order consists of a mixture of that needed to support current programs and items of a historical interest which were used in earlier programs. For ease of presentation such instrumentation is grouped below according to the variables it measures rather than the observing programs it supports.

3. Pressure

Apart from the normal precision aneroid and open-scale barometric devices used for synoptic purposes, there are three other pressure measuring instruments working at Eskdalemuir. Two have historical interest and one is in use for a specialized purpose.

The Fortin barometer, introduced in 1928, is still in working condition, though now requiring refurbishment. Occasional checks are made of the readings given by this mercury barometer, though the considerable skill required in setting the mercury level in the bottom chamber leads to an operationally unacceptable variability in the results.

A Dines float barograph (Fig. 2) is also run routinely, mainly for historical reasons. This device consists of a simple mercury barometer with the lower end turned upwards to form an open-topped chamber. Into this is inserted a glass bell float with air trapped between the mercury and the top of the glass dome. Through a pulley system the small changes in level of the mercury caused by variations in the atmospheric pressure are magnified to give a readable trace. Virtually no temperature compensation is required owing to the careful choice of materials employed in the mechanical system. The instrument responds to small pressure fluctuations ($<$0.5 mb/5 min) more effectively than the open-scale recording device in operational use. However, it also suffers, as a consequence of this fast response characteristic, from some wind noise. The chart is changed daily rather than the more usual weekly, enabling the user to see details on a finer time-scale than with the other recorder.

The third pressure measuring instrument is an infra-sonic microbarograph (Fig. 3). This device is designed to detect short-period pressure transients of 1 to 250 microbars amplitude and with a period of

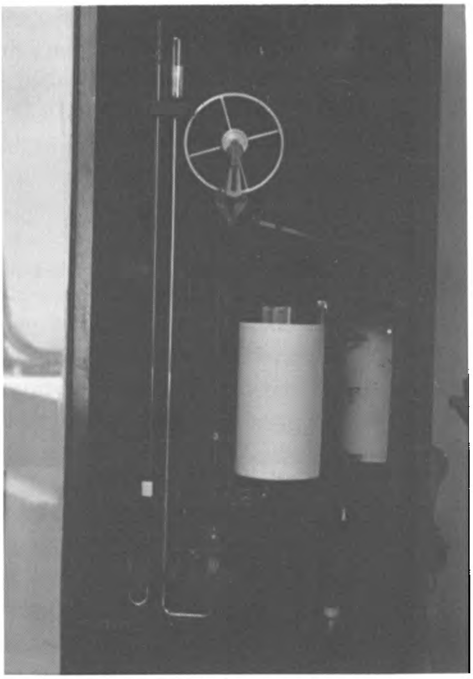

Figure 2. The Dines float barograph.

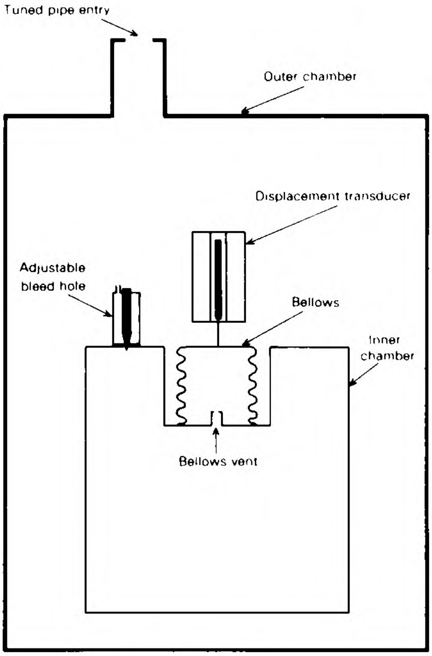

Figure 3. Simplified diagram of the infra-sonic microbarograph.

approximately 1 to 1000 seconds. The absolute value of atmospheric pressure is not measured. Inside an outer, rigid chamber is another smaller and equally rigid cylindrical chamber. At the top of the inner chamber is a small-bore bleed hole which allows the air in the inner chamber to adjust slowly to the familiar scale of pressure changes experienced by synoptic observers. In addition a metal bellows extends downwards from the top of this inner chamber, which is effectively sealed from the atmospheric pressure of the outer cylinder. Atmospheric pressure in the latter is maintained through a tuned pipe. Short-period variations in pressure within the pass-band of the sensor cause the bellows to move a distance proportional to the difference in pressure between the two chambers. This motion is converted to a d.c. voltage and the output from the microbarograph is modified, electronically, to a signal which can be recorded on magnetic tape alongside the output of the BGS seismometers. This enables the seismologist to distinguish between small, real seismological disturbances and those generated by the passage of atmospheric shock waves, and provides an interesting link between what might be viewed as unrelated sciences. A further use for the record, which is also available on sensitized paper, is in the investigation of public complaints about 'sonic bangs'. These acoustic waves produce a high-frequency trace which is very close to the upper limit of response of the sensor. They vary in duration, frequency and number of arrivals according to the distance from the event and the altitude at which it originates. One example of a signal can be seen in Fig. 4. This record shows a combination of the normal background 'microbaroms' — small 5-second tropospheric waves — and illustrates the much faster nature of a 'sonic bang' event.

In the case of a public complaint the authorities occasionally contact the Observatory to determine

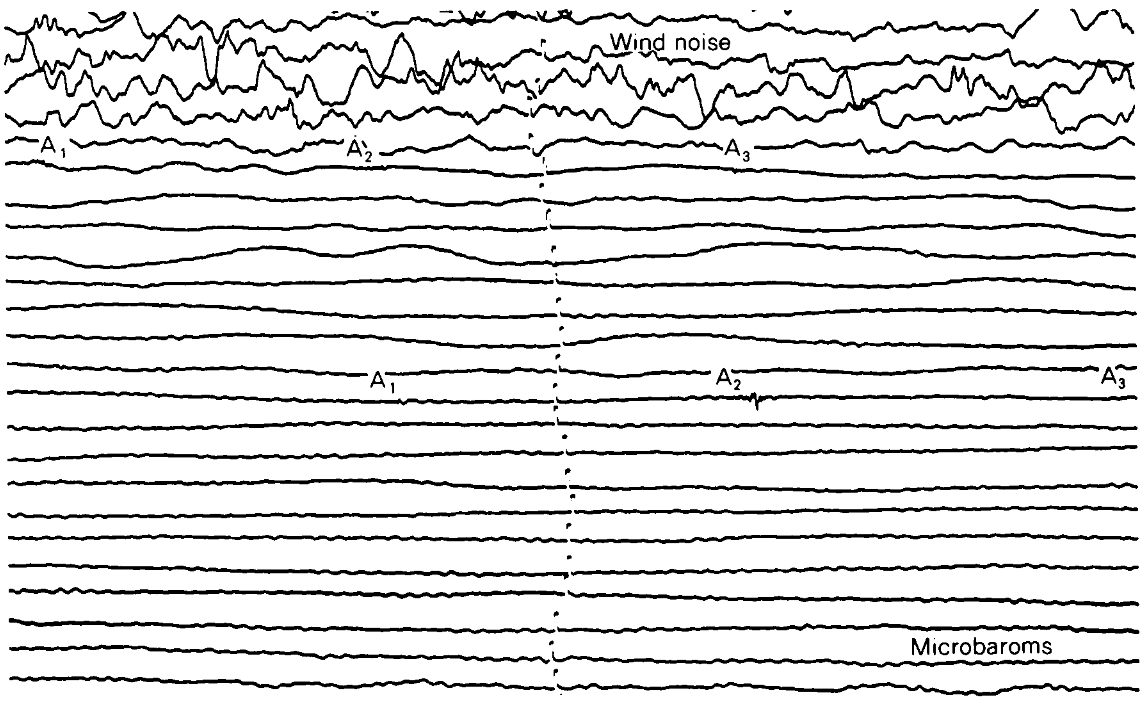

Figure 4. Part of the record produced by the infra-sonic microbarograph. Two 'sonic events' can be seen with triple arrivals A_1–A_3 for each event, which are due to the multi-path nature of the signal.

whether a record is available. If such an event is identifiable on the record, then the time of arrival of the wave can be given. Occasionally it is possible to estimate the distance of the source of the wave providing the event has also registered on some of the remote seismic sensors of the Observatory network. In the instance illustrated the event probably originated some 50–100 km away.

4. Wind

The operational wind sensor is a Mk 4 wind system which feeds data to a DALE (Digital Anemograph Logging Equipment) and has been in use since 1980. The mast is about 300 metres north-west of the main building on slightly sloping ground. Since the introduction of remote reading electrical anemographic equipment to Eskdalemuir in 1965 all wind records have come from this location.

Before the use of electrical sensors the wind system in use was installed on top of the tower in the main building. This consisted of a Dines pressure tube anemograph (PTA) which records direction through direct mechanical coupling from the vane and speed by a Pitot head system connected to a water manometer. The present Dines PTA was installed in 1933. It is principally maintained for historical reasons though it is fully operational and can be brought into service in times of electrical system failure. The effect of oversheltering on the PTA due to adjacent trees and buildings has been described in a letter by McIntosh (1955). This letter should be referred to if any climatological study of wind at Eskdalemuir is intended.

It is worth noting at this point that this is one of the records in which discontinuities are most apparent. There have been four different wind speed recording systems in the 75 years of observing and each has been sufficiently different in sensitivity to cause step changes in the long-term means. The gradual afforestation of the local area coupled with the intermittent lopping of nearby trees has produced a data set which must be treated with caution. It is suspected that the current wind speed measurements are being progressively affected by a plantation on an adjacent ridge. There is, at present, no system whereby a public enquiry to the Meteorological Office about any wind data set is automatically annotated as to deficiencies in, or reservations about, the exposure of the sensor.

5. Precipitation

There are six precipitation gauges currently in use at Eskdalemuir. The main instruments are a 5-inch standard rain-gauge, a 12-inch tilting-siphon recorder (TSR), a 750 mm^2 tipping-bucket rain-gauge (TBR) connected to a magnetic tape event recorder (MTER), and a 5-inch standard rain-gauge in the evaporation tank enclosure. All but the last gauge are in turf wall pits.

The 5-inch gauges give an accumulated total and are read at selected times of the day. The TSR gives a trace which can be used to determine the hourly rainfall, and the data stored on the MTER tape can be read for minute-by-minute rainfall values where rainfall of 0.2 mm gives one pulse or count.

Also installed, in addition to the main gauges, are an open-scale TSR and a Hellman–Fuess gravimetric snow gauge. The open-scale TSR is similar in construction to the normal 24-hour recorder but has a fast-running clock which drives a chart roll lasting 5 days. Minute-by-minute values can be determined more reliably from this record than from the normal TSR owing to its expanded time-scale. The Hellman–Fuess gauge (Fig. 5) is normally installed in a deep pit with a turf wall. This device catches all precipitation in an interchangeable copper bucket through a typical orifice. The lower half of the instrument consists of a dynamic balance with pen plus a chart drive (Fig. 6). The Hellman–Fuess gauge is maintained primarily for historical purposes and is in use every winter. It is the only gauge at the Observatory capable of giving a reasonable indication of rate of snowfall since most other devices used at Eskdalemuir and other meteorological stations are designed to record liquid precipitation only. The

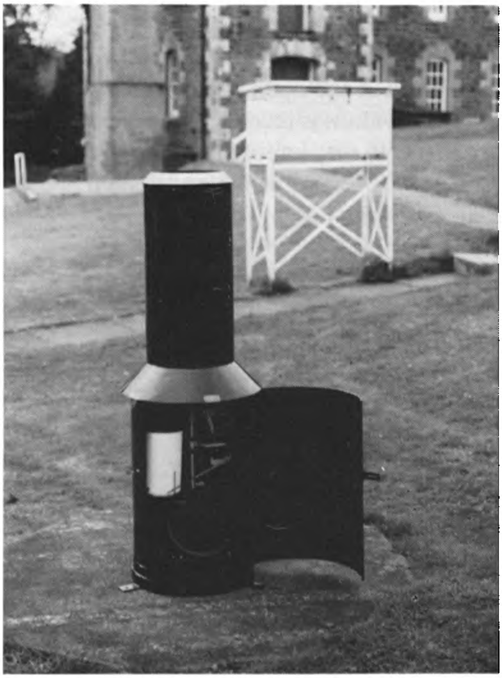

Figure 5. The Hellman-Fuess snow gauge.

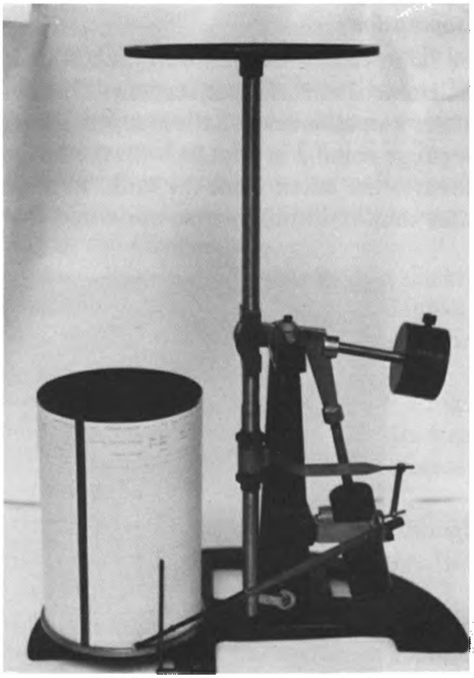

Figure 6. Dynamic balance with pen and chart drive of the Hellman-Fuess snow gauge.

record, however, is not routinely used by the Meteorological Office but this does not detract from its potential value to a researcher. There are three drawbacks to its use: firstly it is prone to wind noise in that gusting moves the bucket causing some blurring of the trace; secondly, the balance system works on knife edges which are delicate and removal of the bucket can cause displacement of the pivots; lastly, the chart gives a 24-hour record of precipitation expressed as millimetres of rainfall up to a maximum of 35 mm and not a snow depth, *per se*. Fig. 7 shows a typical record provided by the snow gauge.

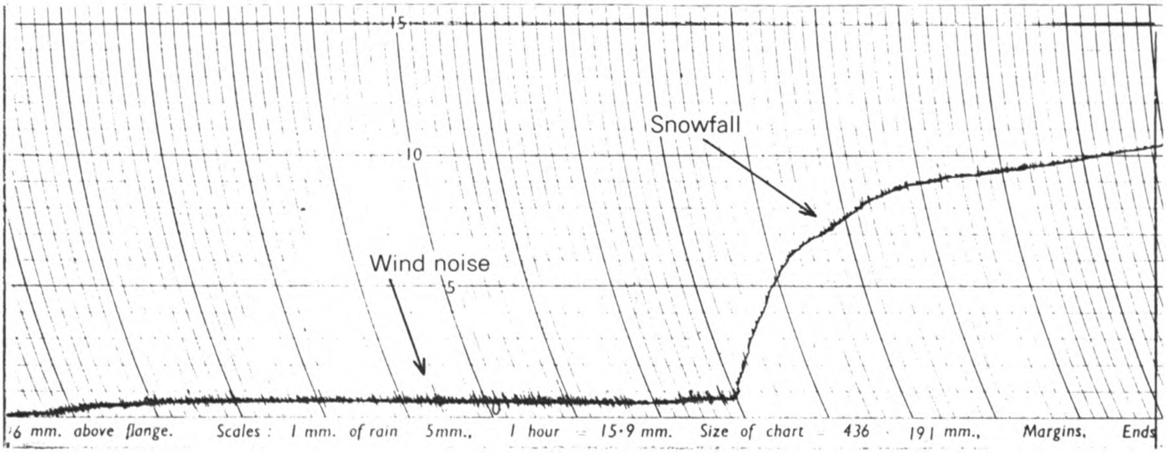

Figure 7. Part of a record produced by the snow gauge.

6. Evaporation

The large British evaporation tank is in use at selected stations throughout the United Kingdom. Eskdalemuir is one of these stations. This device is usually sited in the open and its 6 feet square area simulates a small lake of shallow depth. Water loss due to evaporation is recorded by a rigidly mounted hook gauge coming in contact with the surface of the water. Daily measurements of water loss/gain in millimetres are taken from the tank. In addition, the daily run of wind at 0.5 and 2 metres plus the 24-hour rainfall in millimetres are noted from the site of the tank (Fig. 8).

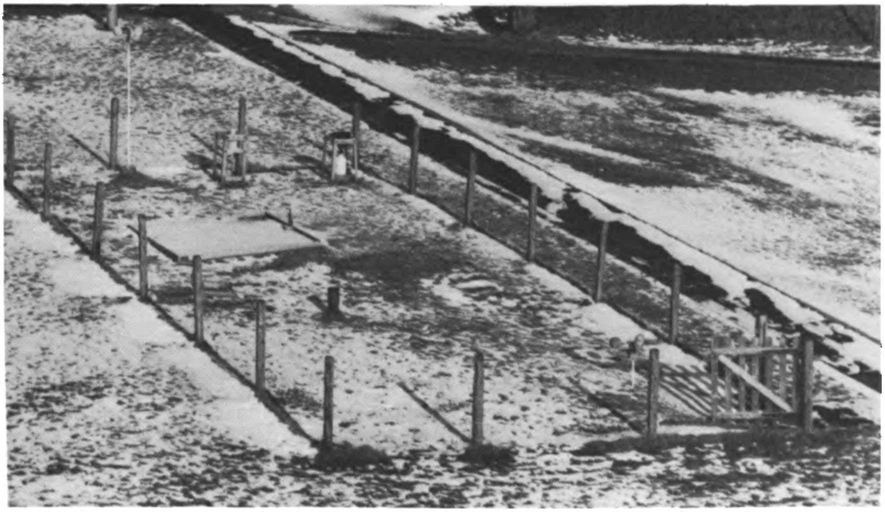

Figure 8. Site of the evaporation tank.

7. Temperature

No unusual instruments are now employed for measurement of temperature though this has not always been the case.

During its history the Observatory has seen several changes to the source of its temperature data. Originally these came from a large photothermograph screen. This was one of the earliest applications of photography in science and consisted of two mercury-in-glass thermometers in which the mercury columns obstructed light focused through their glass capillaries on to photographic paper on a rotating drum. The device was cumbersome and occupied a louvered screen as large as a garden hut. It was possible to read the temperature directly from the thermometers as well as from the recording.

In the 1950s and 1960s temperatures were reported from the thermometer screen situated about 18 metres closer to the main building. Following a short trial in the late 1960s the readings from an aspirated psychrometer, designed at Kew, were substituted for the screen readings in the climatological record. This continued until 1981 when the practice was abandoned in favour of using, once more, the readings from the screen, in order to make Eskdalemuir temperatures compatible with those from the remainder of the UK network.

Soil temperatures at 30 and 100 cm are measured. However, owing to the type of terrain and the generally high water table caused by the adjacent land draining across the measuring site, the soil temperatures at the recommended shallower depths are not recorded. A bare earth patch is not maintained for the same reasons.

8. Sunshine and radiation

Radiation records of one type or another have been kept at this Observatory since 1910. As a Principal Radiation Station, Eskdalemuir records global and diffuse radiation, sunshine hours and radiation balance. In addition to these basic requirements a normal incidence pyrheliometer is used to measure direct radiation. The outputs from the radiation sensors are connected to a Mk 3 MODLE (Meteorological Office Data Logging Equipment). A visible record of instrument output is also maintained on a Kent chart recorder which acts as a back-up in case of logger failure. All data are initially processed at Bracknell in the main computing facility prior to checking at the Observatory.

Both global and diffuse radiation are detected using Kipp's CM5 Moll–Gorczinski-type pyranometers. The Eppley normal incidence pyrheliometer is also a thermopile device fitted into a tube with the sensitive area at its base. The tube is directed so that the image of the solar disc is maintained on the sensing surface by means of a motor-driven equatorial mount.

The radiation balance meter, designed and built at Kew Observatory, consists of two horizontal sensing thermopiles mounted back to back and coated in a durable matt black coating. The surfaces are continually aspirated by a motor-driven fan. Because its surfaces are exposed to the elements it is unreliable in precipitation.

A Campbell–Stokes sunshine recorder has been in use at the Observatory since 1908. Although the siting has been improved in recent years the basic problem of obstructions due to local hills to the east and west cannot be eliminated.

All the data from Eskdalemuir are, after checking and quality-control procedures, stored in the radiation and sunshine archives of the Meteorological Office. From here they are made available to users on request. Applications include climatology, agrometeorology, solar energy feasibility studies, building and engineering design.

9. Atmospheric electricity

Atmospheric electricity measurements were made at Eskdalemuir from 1909 until the end of 1983. These were mainly concerned with the vertical potential gradient. During the late 1970s an attempt was made to introduce air–earth current measurement into the program. This was not successful as the level of precipitation and unreliable nature of the device chosen resulted in the record being too discontinuous to be of any value.

Potential gradient was, in the latter years, measured with a Sigrist PG meter. This device consisted of a remote, electrically isolated probe vertically mounted on a plastic post fixed in concrete flush with the surrounding grass and well away from buildings. At the top of the probe was mounted a radioactive source (americium 241) which prevented accumulation of charge. The sensor was connected to a high impedance amplifier and the output was directly expressed in volts per metre. Calibration was by comparison with a quartz fibre electrometer which had a 1-metre rod sensor of similar design to the probe. Output was fed directly to the MODLE used for radiation data and transferred to the main computer complex at Bracknell. Results of measurements were sent annually to Leningrad where they were sometimes published in a summary produced for WMO.

There are no known users of the data and for this reason the program has been discontinued.

Another related sensor which is still operating at the Observatory is the experimental lightning counter. This device, constructed for BGS to monitor geomagnetic disturbance due to ground strike lightning, consists of a narrow band, fixed gain, VLF receiver tuned to 11 kHz. Any signal at the antenna exceeding a predetermined amplitude threshold triggers a counter. An analogue trace of the activity is also provided. The counter is read daily and the charts are held for examination in cases of extreme activity. The energy envelope of individual flashes can be visually observed as a wave-form by attaching an oscilloscope to the outlet provided.

10. Pollution

The Observatory grounds are probably the most thoroughly monitored 2 hectares in Britain.

Sampling of radioactive materials is carried out for the Environmental and Medical Sciences Division, Harwell. Two bottles of rain-water are collected, one for measurement of tritium and the other for isotopes. Also a filter for radioactive dust is exchanged each week in a 'hi-volume' sampler. The results of these monitoring programs are published each year by Harwell (Cambray *et al.* 1983).

Several tasks are carried out for Warren Spring Laboratory, Stevenage. These are in support of measurements of:

(a) Smoke in air. This involves changing a filter daily and checking the volume of air sampled.

(b) Solid and gaseous sulphur in air. Both a filter and a special solution are changed daily.

(c) Lead and other heavy metals in air; another filter project, this only needs to be changed once a week.

(d) Acid rain. A bottle is changed on rainy days. These bottles, along with the sulphur samples, are sent weekly to Warren Spring Laboratory.

(e) Suspended particulates (dichotomous sampler). Two magazines of filters, to obtain daily samples of fine and coarse particles, are changed once a month.

Results of most of these activities are available in the publications of the United Kingdom Review Group on Acid Rain (1983), the United Nations Economic Commission for Europe European Monitoring and Evaluation Programme (EMEP) (1984a, 1984b) and Warren Spring Laboratory (1985).

Two further rain-water samples are analysed at the Laboratory of the Government Chemist in London. These samples are slightly different in nature. One is taken from a cabinet with a rain funnel on top. The funnel is continuously open and both dust and rain are collected. The second is taken from an automatic precipitation collector designed and built by the Meteorological Office. This device has an electronic sensor which, when it detects precipitation, opens a lid and allows a funnel to rise up out of the interior to be given a clear exposure. On cessation of precipitation and after a reasonable delay the procedure is reversed.

This latter rainfall sample is one of the three parts of the minimum contribution to WMO BAPMoN expected of a Regional Station. The second part of the BAPMoN program is the measurement of turbidity or atmospheric optical thickness. This is done by monitoring direct solar radiation at four different standard wavelengths using narrow-band filters in a solid-state sunphotometer. Observations are only permissible in clear sky conditions and local weather does not permit very frequent observations! The third part of the minimum contribution is 'hi-volume' sampling of suspended particulate matter. It is intended that suitable equipment will be installed soon.

11. Conclusion

The normal suite of meteorological instruments employed at most Meteorological Office observing stations is, equally, to be found at Eskdalemuir. However, the station has a much greater range of instrumentation and activities.

Whilst use is already made of most of the measurements, it is hoped that this article will bring to the attention of those at present unaware of the facilities offered, the wide scope of the data suite produced by the Observatory.

Acknowledgements

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Interesting cloud features seen by NOAA-6 3.7 micrometre images

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Summary

The appearance of clouds over the British Isles and North Sea at three wavelengths — visible (0.8 micrometres (μm)) and infra-red (3.7 and 11 μm) — is described for 3 July 1984. The daytime 3.7 μm AVHRR (Advanced Very High Resolution Radiometer) images show far more detail over clouds than the other two channels which are normally used for forecasting purposes. A cloud scattering radiative model is used to show the sensitivity of 3.7 μm radiances to water drop size and water/ice phase, and the nearest coincident synoptic chart is given for comparison with the satellite images.

For a trial period from July 1984 NOAA (National Oceanic and Atmospheric Administration, USA) have been disseminating 3.7 μm images over the automatic picture transmissions (APT) from NOAA-6. These daytime 3.7 μm images have shown new features in clouds not seen in the more conventional visible and 11 μm infra-red channels. An example is shown in Fig. 1 where NOAA-6 AVHRR visible 0.8 μm (channel 2), 11 μm (channel 4) and 3.7 μm (channel 3) images over the United Kingdom are shown. The appearance of the 3.7 μm image during the day is complex because it is a mixture of emitted

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terrestrial and reflected solar radiation. Dark shades represent high radiance and light shades low radiance. One interesting area of clouds marked 'A' is over north-east and central southern England. At visible wavelengths this cloud is not particularly bright, having a lower reflectance than the cloud further out over the North Sea. The 11 μm image shows the cloud-top temperature to be uniform over a large area at about 270 K (derived from the calibrated image) for the clouds over the United Kingdom and the North Sea. The 3.7 μm image, however, shows a significant difference between the cloud over the United Kingdom and north-east coast (marked 'A') and the cloud further out over the North Sea, the former having a much darker appearance corresponding to higher radiance. The cloud area marked 'B' also shows much more structure in the 3.7 μm image than in the other conventional channels where the area appears uniform in reflectance and cloud-top brightness temperature ($\approx$260 K) even after the images were enhanced to show up small changes in radiance.

The large variations in 3.7 μm radiance seen over cloud during the daytime are due to different cloud reflectances at 3.7 μm. This is a different but related effect to that reported by Eyre *et al.* (1984) who make use of the difference between the cloud or fog emissivities at 3.7 μm and 11 μm to detect the presence of fog and low cloud at night. For optically thick clouds the two are related according to the simple expression:

$$r + \epsilon = 1$$

where r is the cloud reflectivity, and ϵ is the cloud emissivity.

To simplify interpretation of the daytime 3.7 μm image the emitted radiation component was subtracted from it by using the 11 μm radiance. Assuming the same surface/cloud emissivity and atmospheric absorption at both wavelengths, a 3.7 μm emitted radiance can be inferred from the 11 μm emitted radiance by applying the Planck function. This emitted 3.7 μm radiance is then subtracted from the observed 3.7 μm radiance leaving the reflected solar radiance at 3.7 μm shown in Fig. 2. Light shades denote high reflected radiance, dark shades low radiance. The cloud layer marked 'A' has a reflectance significantly greater than the cloud over the North Sea. The large variations in reflectance shown in Fig. 2 are certainly real but the assumptions given above are not always valid owing to small differences in emittance at the two wavelengths giving differences in brightness temperature of up to 2.5 K (Eyre *et al.* 1984). Therefore small variations of reflectance in Fig. 2 should be treated with caution.

Cloud reflectances at 3.7 μm have been modelled using a cloud scattering model. This model is based on the matrix operator method of solving the equation of radiative transfer in a scattering medium (e.g. Plass *et al.* 1973, Grant and Hunt 1968). It is azimuth-independent but can be used in the solar infra-red region with the restriction that the sun must be positioned at the zenith. For this case the sun is in fact fairly low (58 degrees from the zenith) so the actual values computed in the model will be different from those observed. However, the relative changes in reflectance as a function of drop size should not be greatly affected by the sun angle. The phase functions for each of the droplet sizes for refractive indices corresponding to both water and ice were calculated using a Mie scattering program. The results were then used as input to the cloud model and first used to calculate the reflection and transmission matrices for a thin initial layer (optical depth $\tau_0 = 2^{-15}$) in which single scattering only is assumed. The matrices for that layer were then combined with those for an identical layer to find the matrices for the layer thickness $2\tau_0$. Continuing with this 'doubling' procedure the reflection matrices were formed for clouds with optical depths $\tau = 0.122, 0.244 \ldots 62.5, 125$ and from them the cloud reflectivities for the satellite zenith angle were selected. The results from the model, shown in Fig. 3, show that the cloud reflectance varies strongly as a function of cloud drop size and thermodynamic phase. These results are in broad agreement with those computed by Arking and Childs (1983) with a solar zenith angle of 60 degrees. Therefore we can infer that the bright clouds in the 3.7 μm image should be made up of mainly small drops whereas the dark clouds (represented by dark shades in Fig. 1(c)) will be made up of larger drops or ice

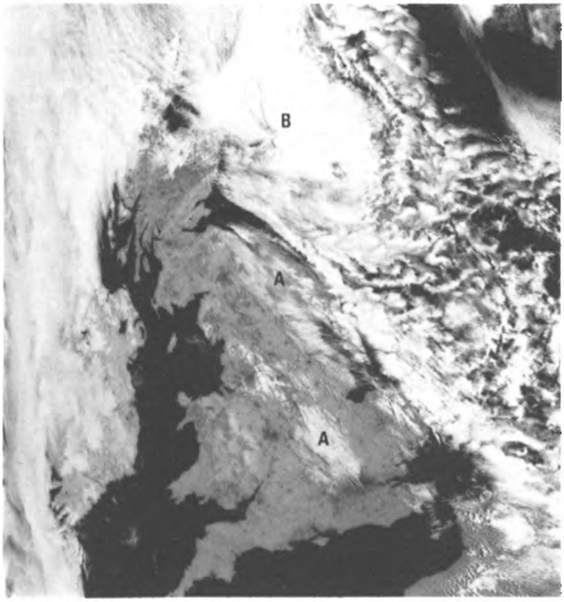

Figure 1(a)

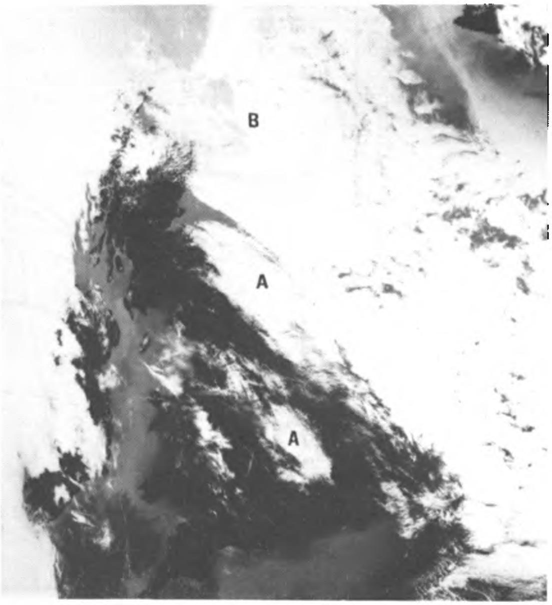

Figure 1(b)

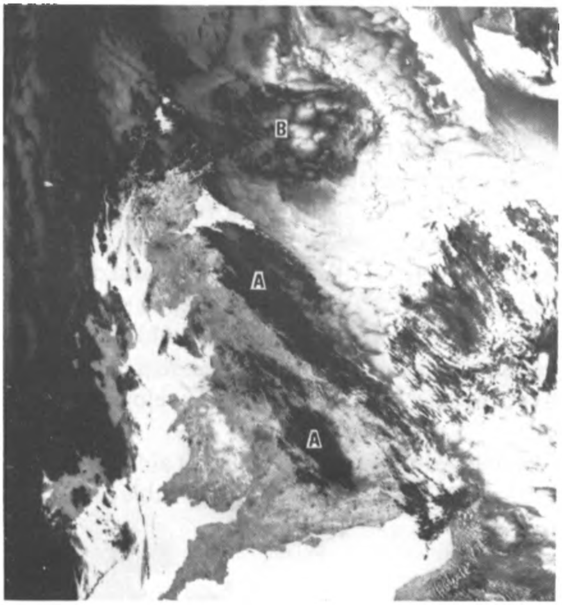

Figure 1(c)

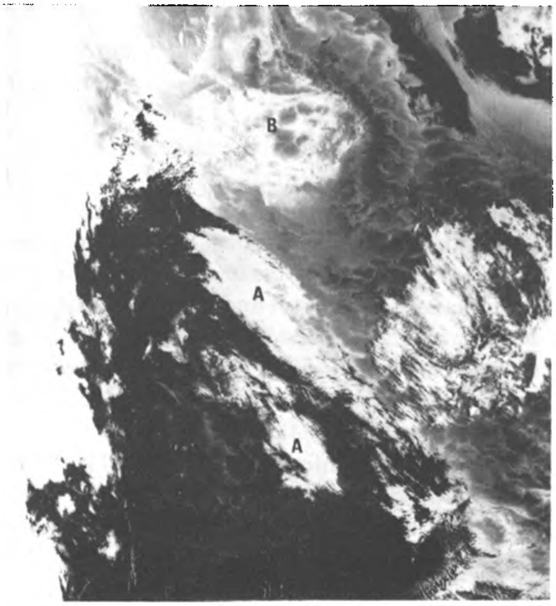

Figure 2

Figure 1. NOAA-6 AVHRR images recorded at 0738 GMT on 3 July 1984 over the United Kingdom and North Sea. The visible image (a) is channel 2 (0.8 μm), the infra-red image (b) is channel 4 (11 μm) and the 3.7 μm image (c) is channel 3. The areas of cloud marked 'A' and 'B' are referred to in the text.

Figure 2. An image constructed from the 3.7 μm and 11 μm images in Fig. 1 of reflected solar radiance at 3.7 μm. Bright areas correspond to high reflectances.

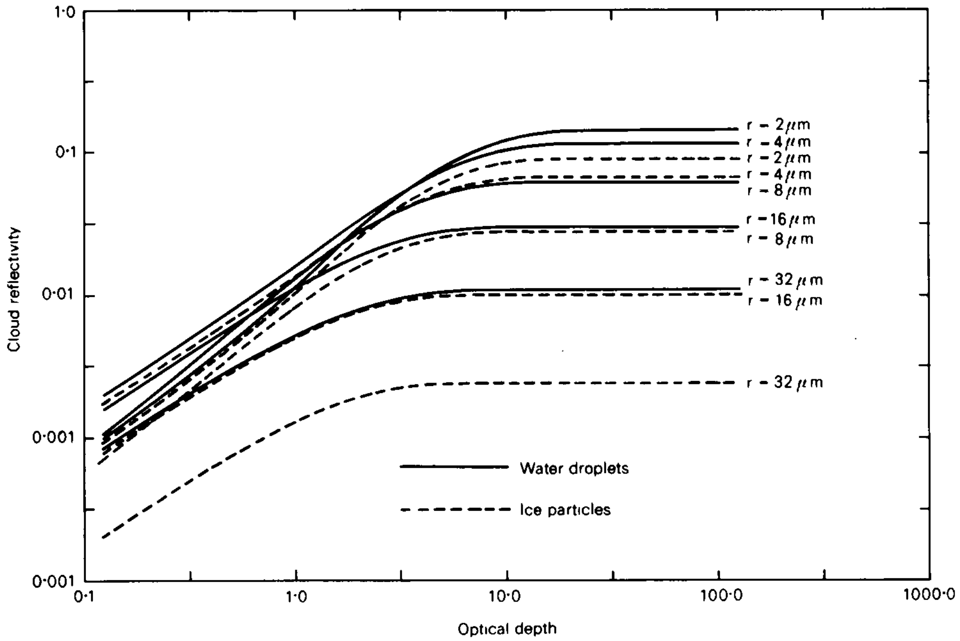

Figure 3. Results from a cloud scattering model where solar zenith angle = 0°, zenith angle of observer = 31.43° and wavelength = 3.7 μm.

particles. The latter are unlikely to be present here given the general appearance of the cloud and the cloud-top temperature.

The surface synoptic chart for 0900 GMT (1 h 22 min after the satellite image was recorded) is reproduced in Fig. 4. Stratocumulus cloud at 3000 ft with lower cumulus is reported along the north-east coast and further south corresponding to the bright cloud in Fig. 2 extending from London to the Midlands. Over the North Sea low stratus cloud with base at 200 ft is reported. This suggests that for this case the North Sea stratus has a different drop size distribution from the stratocumulus and developing cumulus over north-east and central southern England. The cloud area marked 'B' shows up dark areas of low radiance embedded in cloud of a higher radiance as seen in Fig. 2. These could be related to convective activity within the cloud, the dark areas being due to a different drop size distribution in the cloud being convected upwards. These dark areas have also been seen at the tops of developing cumulus cloud by Scorer (1984).

The additional information provided by these 3.7 μm images could be an important aid to forecasters and cloud physicists particularly when the high-resolution AVHRR data become available on a routine basis in real time.

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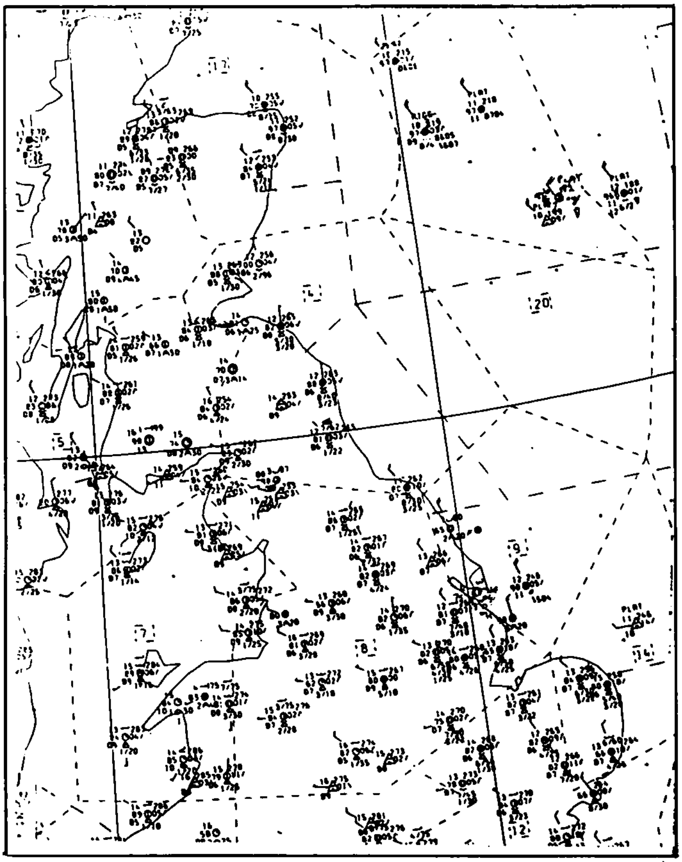

Figure 4. The synoptic chart over part of the United Kingdom and North Sea for 0900 GMT on 3 July 1984.

Awards

L. G. Groves Memorial Prizes and Awards

The presentations of the L. G. Groves Memorial Prizes and Awards for 1983 were made on 21 November 1984 at the Main Building, Ministry of Defence, Whitehall. Air Vice-Marshal L. A. Jones, CB, AFC, FBIM (ACAS(OPS)) presided, and Miss Margaret Groves made the presentations. Miss Groves is the daughter of Leslie Groves, a younger brother of Major Keith Groves in memory of whose son the Prizes and Awards are given each year.

Air Vice-Marshal Jones began the proceedings and conveyed the apologies of Sir Peter Harding, VCAS, for being unable to preside himself owing to other urgent commitments. Air Vice-Marshal Jones gave a brief history of the awards, and offered his congratulations to the winners. Mr Robin Wight, who presented the prizes in 1983, then spoke of how his own contacts in the RAF had told him how valuable a stimulus had been provided by the L. G. Groves Memorial.

The citations were read by Air Commodore T. H. Stonor (Inspector of Flight Safety, RAF), and Miss Groves presented the winners with their prizes and certificates, adding her own personal congratulations.

The 1983 Aircraft Safety Prize was awarded to Sergeant J. Cook, then of the Survival Equipment Section, RAF Gütersloh, Germany (now having left the Service) in recognition of his initiative and inventiveness in designing and producing a modification to the SS10 life-raft. The boarding handles in their present position, i.e. each side of the bow of the life-raft, have been proved to be nearly out of reach of the average aircrew member. This modification removes these handles and replaces them with two strips of running grab handles along both sides of the buoyancy chamber. The modification can be embodied by using current materials and is well within the capacity of all survival equipment sections. It is relatively cheap and simple and greatly improves the survival prospects of all who use the equipment. It has now been accepted for all in-service life-rafts.

The 1983 Meteorology Prize was awarded to Mr C. G. Collier, then of the Radar Research Laboratory at Malvern, Worcs (now Assistant Director (Operational Instrumentation) Meteorological Office), for his work in radar meteorology. Whilst at the Meteorological Office Malvern, between 1976 and 1984, he had been responsible for developing and implementing techniques for the measurement by radar of surface precipitation and for the processing, communication and display of information from a network of radars. This development was based on results from an experimental precipitation radar project, and work at the Royal Signals and Radar Establishment on radar data processing. Mr Collier has extended both of these areas of work to an important degree by bringing them to a state of operational viability. The radar network pictures, which are being made available to a growing number of meteorological officers within minutes of data time, provide the kind of mesoscale detail required by forecasters in generating products for aviation and for other customers needing highly specific forecasts in the 0- to 3-hour time-scale. For instance, while rain itself is not normally a hazard to low-flying aircraft, the associated poor visibility and low clouds are. Although the radar pictures cannot present specific data on these variables, when used in conjunction with conventional observations the extent of hazardous conditions may be inferred. As part of the radar development program Mr Collier has been involved, in collaboration with the water industry, in the North West Weather Radar Project, which demonstrated the operational viability of an unmanned radar system to provide quantitative rainfall data for use in river management and flood prevention schemes. This project has provided the technical basis for a network of radars including one which covers the London area. Mr Collier's ideas are also being taken up within a European context. He has made an outstanding contribution to the scientific and technical development to operational status of a new meteorological observing system.

The Meteorological Observer's Award for 1983 was awarded to Mr A. N. Bentley of the Marine Projects Section, Meteorological Office, for his contribution to the production, installation and maintenance of observing systems capable of providing meteorological data from data-sparse marine areas to guide forecasting for civil and military purposes; noting in particular that his enthusiastic leadership, technical skills and courage in a hostile environment have led to significant progress in the introduction of instrumented buoys and automatic weather stations.

The 1983 Second Memorial Award was awarded jointly to Squadron Leader A. G. Pearce (OC Flying) and Flight Lieutenant M. R. Wistow (SFSO), both of RAF St Athan flight test crew, for their achievement in recommending that the Black and Decker F11 lightweight vacuum cleaner be approved

Sergeant J. Cook, winner of the Aircraft Safety Prize, receives his prize from Miss Margaret Groves.

Mr C. G. Collier, winner of the Meteorology Prize, receives his prize from Miss Margaret Groves.

Mr A. N. Bentley, winner of the Meteorological Observer's Award, is congratulated by Miss Margaret Groves.

Squadron Leader A. G. Pearce (centre) and Flight Lieutenant M. R. Wistow, joint winners of the Second Memorial Award, are congratulated by Miss Margaret Groves.

L. G. Groves Memorial Prize and Award winners with Miss Margaret Groves and Air Vice-Marshal L. A. Jones, left to right: Squadron Leader A. G. Pearce, Flight Lieutenant M. R. Wistow, Sergeant J. Cook, Miss Groves, Air Vice-Marshal Jones, Mr C. G. Collier and Mr A. N. Bentley.

for flight test crews at maintenance units to collect the debris dislodged in aircraft during the trials. The device was tested by the officers in a Jet Provost and a Phantom and the results were most impressive and the debris was easily collected. Later, extension of its use to Flying Training School units is also envisaged. This has proved to be a simple but effective method of removing potentially dangerous cockpit debris such as swarf, dust and metal particles.

Review

Principles of remote sensing, by P. J. Curran. 187 × 245 mm, pp. xi + 282, *illus*. Longman, London, New York, 1985. Price £11.95 (paperback only).

Recently there has been an increasing number of courses available in environmental remote sensing and, as the author states in the preface, this book aims to provide students of these courses with a broad background in the subject. In most respects this book succeeds in this aim, providing a useful introduction to the subject with a wealth of references at the back to allow readers to delve further into their particular areas of interest. The author has written the book in a style that is easy to read and many interesting illustrations (a few in colour) are included. There are very few equations in the text so this book would not be very useful to those readers who want to understand in detail the precise physical mechanisms involved.

The book is essentially divided into three main parts. The first deals with the interaction of electromagnetic radiation with the surface and atmosphere. There is a good section here on defining quantities and units used and another on the interaction of radiation with vegetation and soil. However, the section on atmospheric effects was covered in one page. A more detailed description of atmospheric absorption and scattering effects would have been useful here, as most satellite remote sensing measurements have to remove these before extracting the parameter of interest. Similarly there is no discussion of the effects of clouds on electromagnetic radiation which should have been included here. The second part deals with the different measurement techniques currently employed for environmental remote sensing. There is a detailed description of aerial photography techniques and the different types of film used, with many illustrations given. Aerial sensors are also discussed with an interesting section on airborne radar. Finally, a good description of satellites used for remote sensing is given by using a logical classification scheme for the different types. There is some confusion over the ERS-1 satellite as there are in fact two (one Japanese and one European). It would have been helpful if the author had stated this at the first mention of ERS-1 in the text. The final part describes various types of image-processing equipment currently available and the many different processing algorithms which can be applied to the data. Analogue image processing is mentioned here but with the advent of low-cost digital image-processing systems most of the text correctly concentrates on discrete (digital) image processing. Topics such as calibration, geometric correction and image enhancement are all covered.

At the back of the book there are some useful appendices containing a list of addresses from which remote sensing data can be obtained, a list of remote sensing journals, a list of acronyms, etc. I am sure that *Principles of remote sensing* will be invaluable to any student on a remote sensing course and worthwhile reading for anybody who would like to find out more about remote sensing without going into too much detail. As the author states at the end of his introduction, the ultimate aim of remote sensing is to obtain, on a routine basis, reliable information to help us manage our fragile planet. This book describes how this goal is now in sight.

R. W. Saunders

Obituary

We regret to record the death on 18 February 1985 of Captain J. H. Jones, Port Meteorological Officer, Bristol Channel Area.

John Holland Jones (Jack to all his friends and colleagues) was born in May 1920 and was due to take retirement only a few months after his untimely demise at the age of 65. He had been appointed Port Meteorological Officer at Cardiff in July 1976 and he elected to continue in the position beyond the optional retirement age of 60.

Jack Jones began his seagoing career as an apprentice indentured to the British Tanker Company in 1937 aboard the *British Engineer* and on obtaining his Second Mate's Certificate in 1941 he was promoted to Third Officer; he then remained with the BP Tanker Company, as it became known, throughout his seagoing career up to 1975 when he retired from the sea as Master of the *British Confidence*. He was promoted to command in 1956 when he became Master of the *British Diligence*.

During his years as Master he sent us a total of 12 meteorological logbooks of which 4 were assessed as Excellent. He received Excellent Awards in 1961, 1970 and 1971.

Highlights of Captain Jones's career included the award of the Coronation Medal and the honour of being selected to lay the Remembrance Sunday wreath at the Cenotaph in Whitehall in November 1973, on behalf of the Merchant Navy and Fishing Fleets.

He was a Warden of the Swansea and South Wales Company of Mariners and a well known and respected member of the local community in his home town of Swansea as well as amongst his many professional contacts in the Cardiff area. He was always the most cheerful and courteous person to talk to, whether it was by telephone with Bracknell or across the table at a conference.

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CONTENTS

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