The Meteorological Magazine

April 1991

Variability of global surface temperature
Noctilucent clouds during 1989

HMSO

Met.O.998 Vol. 120 No. 1425

First published 1991

HMSO

HMSO publications are available from:

HMSO Publications Centre
(Mail and telephone only)
PO Box 276, London, SW8 5DT
Telephone orders 071-873 9090
General enquiries 071-873 0011
(queuing system in operation for botl

HMSO Bookshops
49 High Holborn, London, WC1V 6
258 Broad Street, Birmingham, B1 21
Southey House, 33 Wine Street, Brisi
9–21 Princess Street, Manchester, M(
80 Chichester Street, Belfast, BT1 4J'
71 Lothian Road, Edinburgh, EH3 9

HMSO's Accredited Agents
(see Yellow Pages)

and through good booksellers

The
Meteorological
Magazine
April 1991
Vol. 120 No. 1425

551.524.32(4/9)

The normal distribution and the interannual variability of the global surface temperature record

A.H. Gordon
Flinders Institute for Atmospheric and Marine Sciences, Flinders University of South Australia, Bedford Park, South Australia

Summary

If the hypothesis is put that the frequency distributions of the year-to-year changes in the hemispheric surface-temperature anomalies, constituting the available climatic record, fit the normal density function curve, then the distributions may be assumed to have been randomly drawn from a normally distributed population. If there are significant differences between the observed and expected distributions, such differences could suggest fingerprints of some outside forcing. Chi-square tests between the frequencies of the actual values and the expected frequencies computed from the normal density function for the Meteorological Office series and for the Climatic Research Unit series of hemispheric surface-temperature anomalies indicate that there is no significant difference between them in the northern hemisphere. In the southern hemisphere the Meteorological Office series shows no significant difference whereas the Climatic Research Unit series indicates a significant difference at the 1% level. The latter significance arises partly from the two values at each of the two tails of the distribution, the arithmetical sums of which almost cancel one another. When these values are removed there remains a difference at the 5% level caused by insufficient negative values in the −0.05 °C to −0.25 °C class intervals.

1. Introduction

Karoly (1990) has stated that there are two parts to the detection of climate change: (a) the identification of a pattern of climate change or fingerprint which is specific to an enhanced greenhouse-effect and could not be due to any other climatic process, and (b) the observation of a significant trend or change in amplitude of such a fingerprint. The *Scientific assessment of climate change* (IPCC 1990) states that the global temperature has increased by 0.3 °C to 0.6 °C during the last century, and that this warming is consistent with climate model predictions, but also of the same magnitude as natural climate variability.

One suggested avenue of search and closer identification of the predicted global warming is to investigate to what extent and in what respects frequency distributions of the interannual variability of the hemispheric temperature series for the period covered by past climatic records differ from those to be expected from the normal distribution. It is recognized that the frequency distributions of many kinds of observational and experimental data closely approximate the normal curve. Among these are time series of surface temperature anomalies from some reference mean value. An example might be a series of mean temperatures for a

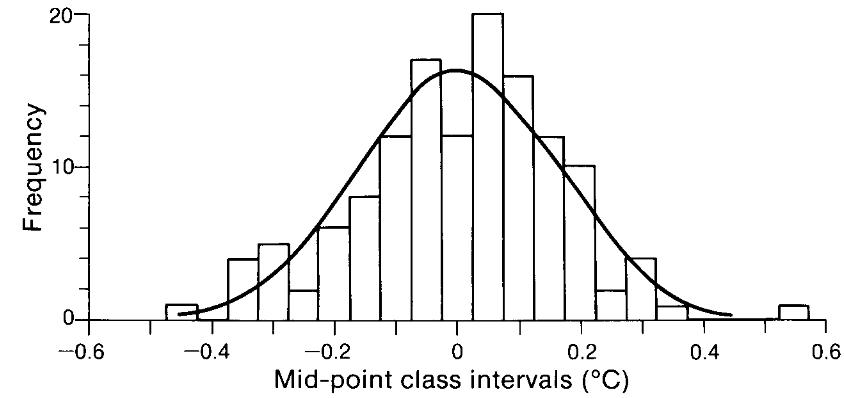

Figure 1. Histogram of the frequency distribution of the year-to-year changes of mean surface temperatures for the northern hemisphere for the Meteorological Office data set, superimposed by the normal curves corresponding to the expected values for the hypothetical normal distribution of the series. The expected frequencies are computed to two decimal places for a normal distribution of mean zero and a standard deviation 0.164 °C.

given day of the year for a given station covering a period of 100 years, compared with the mean value for that day for the whole period. There is no obvious artificial constraint at either end of the extremes of the distribution of anomalies. It might be reasonable to suppose therefore that, barring some imposed forcing or trend, such anomalies would be likely to be normally distributed within acceptable levels of significance. In such a case the cumulative sum of the anomalies would tend to approach zero.

Two sets of combined land- and marine-surface temperature anomalies for the two hemispheres have been tabulated in the form of anomalies from a 30-year reference mean. The first set, assembled by the Meteorological Office, henceforth called the MO set, covers the period 1856–1989. The second set, assembled by the Climate Research Unit of the University of East Anglia, henceforth called the CRU set, covers the period 1861–1989 (Jones 1988). If each value of a given series is subtracted from the value for the preceding year the individual series may be converted into ones expressing the changes in temperature from one year to the next, that is, the interannual variability. We will assume that the various series of interannual changes possess a normal distribution of mean zero and standard deviation computed from the real data. In effect, the true means for the two data sets and the two hemispheres are displaced from zero by from 0.003 °C to 0.006 °C, giving rise to positive trends which account for the observed global warming. These displaced mean values are approximately one half of the smallest magnitude to which the accuracy of the series is calculated (0.01 °C). We want to find out in more detail the reasons why the long-term means of the changes in temperature from one month to the next are displaced from zero. The difference between the two means and zero are not statistically significant.

2. Discussion

Figs 1 and 2 show histograms of the actual frequency distributions of the interannual variability of the surface temperature anomalies for the two hemispheres for the MO data set. The value 0.05 °C has been chosen as a reasonable class-interval, allowing mid-points at multiple integrals of 0.05 °C. The histograms have been superimposed by the normal curves corresponding to the expected values for the hypothetical normal distributions of the series, computed from the normal density function tables. The sum of the expected values is very close to the total frequency of 133 cases. In the northern hemisphere there are a few class intervals at the extremes of the distribution for which these expected frequencies are less than unity. These have been excluded in calculating chi-square test sums. The tests conducted over the remaining range of values are shown in Table I. The differences are not significant at the 10% level for either the MO or CRU data sets. Tests for symmetry show that both sets of data are symmetrical, that is, chi-square sums testing for asymmetry do not reach the 10% level of significance.

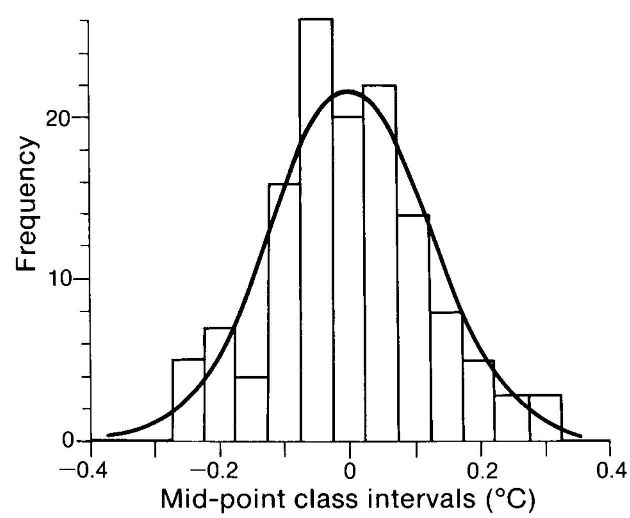

Figure 2. As Fig. 1 but for the southern hemisphere. The standard deviation is 0.121 °C.

The class intervals were divided into four categories:
(a) positive values contributing to warming,
(b) lack of positive values contributing to cooling,
(c) negative values contributing to cooling, and
(d) lack of negative values contributing to warming,
where the description contributing to warming or cooling means whether the actual frequencies are greater or less than the expected frequencies on the two halves of the x-axis of the normal distribution. Chi-square tests do not show significance at the 10% level for any of the four categories. Table II shows the actual amount of warming or cooling contributed by each of the four categories for the two data sets. The values are obtained by multiplying the differences between the actual and expected frequencies in each class interval by the value at the centre-point of that class interval. The warming is divided fairly evenly between the positive and negative class intervals in the MO series, but is contributed entirely by the negative values in the CRU series. The total warming is almost the same for both data sets.

The chi-square test for the whole MO series is not significantly different from a normal distribution at the 10% level. Neither is the distribution of values within any of the four categories significant at that level. However, the CRU series gives significance at the 1% level for the whole series. This is mainly due to the contributions made by the outer two extreme class-intervals on both the positive and negative sides of the y-axis, i.e. $|0.20|$ °C and $|0.25|$ °C. The arithmetical sum of these class intervals almost cancels out. Nevertheless, categories (a) and (c) both reach the 1% level, suggesting that these two categories are not normally distributed. Category (d) is significant to the 5% level. The contributions made by category (d) are caused by a lack of negative values in the band widths covering the class intervals from −0.05 °C to −0.25 °C with maximum warming centred at about −0.17 °C or about 1.23 standard deviations. A chi-square test for asymmetry shows that both data sets are symmetric. The sums do not reach the 10% level. Table II shows the individual contributions made by each set within each category.

3. Results

It will be useful to classify results of the analyses according to whether they are common to both data sets or differ between the two sets, bearing in mind the fact that some sampling errors may arise in using the mid-points of the class intervals to compute the contributions to warming and cooling.

Table I. Values of chi-square test sums applied to the differences between observed and theoretical normal distribution values for the different class-intervals. In the northern hemisphere values have been excluded where the expected frequency is less than unity; in the southern hemisphere there are no class intervals where this occurs. Figures in brackets are significance levels (n.s. denotes not significant). $K-3$ degrees of freedom where K is the number of class intervals (Bendat and Piersol 1986).

	Data set	
	Climate Research Unit	Meteorological Office
Northern hemisphere	13.65 (n.s.)	13.38 (n.s.)
Southern hemisphere	31.69 (1%)	13.68 (n.s.)

Table II. Contributions to warming and cooling (°C) made by the total number of above- and below-expected frequencies for the four categories (a)–(d) described in the text.

Data set	Category				Total
	(a)	(b)	(c)	(d)	
Northern hemisphere					
Meteorological Office	1.88	−1.58	−1.77	2.17	0.70
Climate Research Unit	1.18	−1.24	−1.23	1.88	0.59
Southern hemisphere					
Meteorological Office	0.78	−0.73	−1.24	1.39	0.20
Climate Research Unit	1.45	−0.83	−1.46	2.05	1.21

Results common to both sets include:

1. A warming in each hemisphere.
2. In the northern hemisphere the values at the extremes of the distribution where the expected frequencies are less than unity contribute to slight cooling.
3. The northern hemisphere temperature changes are normally distributed to an acceptable level of significance according to chi-square tests.
4. Both hemispheres are symmetrical to an acceptable level of significance.
5. The greatest contribution to warming is made by a lack of negative values centred at about −0.17 °C.
6. The total warming for the northern hemisphere is in good agreement.
7. If one includes all the observations in both hemispheres the negative values contribute a greater share of the warming than the positive values.
8. If we call the contributions (a) and (c) real values and the contributions (b) and (d) ghost values we find that the real values contribute to cooling while the ghost values contribute to warming when the average of these values is found for the two hemispheres.

Results which show differences between the two data sets are:

1. In the southern hemisphere the chi-square test for the CRU set shows high levels of significance that the distribution of year-to-year changes is not normally distributed.
2. The average trend for the CRU set for the two hemispheres is nearly 1.5 times greater than for the MO set.
3. The warming shown in Table II for the southern hemisphere is six times greater for the CRU than for the MO set.
4. In the northern hemisphere the individual contributions to each of the four categories are numerically greater for the MO set.
5. In the southern hemisphere the individual contributions to each of the four categories are greater for the CRU set.
6. The mean warming for the two hemispheres as given in Table II for the CRU set is just double that given by the MO set.

4. Conclusions

The search for some fingerprint to detect an enhanced greenhouse-effect global warming requires a kind of Sherlock Holmes approach. The chief finding in the analysis presented is that although there is no statistical evidence of a forced warming, on the basis of comparisons with assumed normal distributions of the year-to-year changes, at least in the MO data set, if such a warming does exist it could be accounted for by a lack of negative values of the interannual variability, particularly centred about the −0.17 °C class interval bandwidth. This could result from an imposed interannual forcing, the amplitude of which is in phase with the cooling bandwidth of about −0.17 °C. Alternatively, the atmosphere is unable to lose heat efficiently by long-wave radiation within this bandwidth. Both mechanisms could be due to the enhanced greenhouse-effect.

The second main conclusion arises from a comparison of the two data sets. It seems that the MO series is more stable and subject to less erratic behaviour than the CRU series in so far as the southern hemisphere series is concerned. Comparison of the southern hemisphere results would indicate that those given by the MO set are more reasonable than those obtained from the CRU set. In particular the CRU series might give a false impression that the southern hemisphere was warming faster than the northern hemisphere, or even that the warming was in some way being forced by the southern hemisphere. The MO series gives rise to a much more cautious approach to global warming.

Acknowledgements

I would like to express my thanks for the helpful advice of Jonathan Tawn of the Department of Statistics and Probability of the University of Sheffield and also to the Editor of the *Meteorological Magazine* for comments and suggestions.

References

Bendat, J.S. and Piersol, A.G., 1986: Random data. New York, Wiley.

IPCC, 1990: Scientific assessment of climate change. Geneva, WMO/UNEP, Intergovernmental Panel on Climate Change.

Jones, P.D., 1988: The influence of ENSO on global temperatures. *Clim Mon*, **17**, 80–89.

Karoly, D., 1990: Greenhouse climate change fingerprint detection. Canberra, IGBP Workshop No. 13, Mathematical and statistical modelling of climate change processes.

551.593.653(4):551.605.1

Noctilucent clouds over western Europe during 1989

D.M. Gavine
29 Coillesdene Crescent, Edinburgh EH15 2JJ

Summary

Noctilucent cloud reports by voluntary and professional observers in the British Isles, Denmark, The Netherlands and Belgium suggest that a high incidence of the phenomenon is maintained.

Table I summarizes the noctilucent cloud (NLC) reported to the Aurora Section of the British Astronomical Association (BAA) during 1989. The times (UT) are of the reported sightings, not necessarily the duration of a display. 'Negative' nights (Table II) are based on the judgement of two or more experienced observers north of 54° N with clear or nearly clear sky conditions over the period of the night when NLC is likely to occur. There were 39 positive and 7 suspected NLC sightings. For brevity, the Finnish–Estonian NLC observations are not now mentioned here. Full details of these are published annually in the periodical *Ursa Minor* of the URSA Astronomical Association (Laivanvarustajankatu 3, SF-00140 Helsinki 14). Contributions were received from 41 individual observers and 8 meteorological stations in the United Kingdom, 11 stations of the Royal Netherlands Meteorological Institute, four observers in Denmark, one in Belgium and one in Eire. Superb photographs by Mr Olesen and Mr Andersen of Denmark have again enhanced BAA exhibitions and conferences.

As before, the intention of the Aurora Section is to provide a data bank for professional workers. Details of individual nights are available from the author, but all NLC data up to 1987 are held in the Balfour Stewart Archive at the University of Aberdeen.

Our thanks to all observers, amateur and professional, and to Mr Ron Livesey, Director of the BAA Aurora Section, Mr Tom McEwan, Director of the Junior Astronomical Society Aurora Section, Mr V. Mäkelä (Finland), Dr B. Zwart (The Netherlands), Mr J.Ø. Olesen (Denmark), Dr M. Gadsden (University of Aberdeen) and Mr M. Zalcik (USA–Canada NLC Network).

Table I. Displays of noctilucent clouds over western Europe during 1989

Date — night of	Times UT	Notes
5/6 May	2240	Faint NLC suspected at Fortrose.
7/8	2108–2125	Very faint bands, possible billows, visible up to 42° in binoculars at Morpeth.
9/10	2235–2320	Very faint bands below 10° at Fortrose.
14/15	2050	Orange tinted bands suspected at Gilze Rijen, The Netherlands.
20/21	2110–2300	Suspect faint bands very low, Fortrose.
21/22	2130–2215	Veil, faint bands and patches at Morpeth.
26/27	2150–2215	Bands up to 30°, Fortrose. Faint NLC at Appingedam, The Netherlands. Suspected aurora at Clwyd, 2330.
30/31	2230	Ronaldsway reports possible small NLC 'wisp'.
4/5 June	2303	Very faint veil and a few bands E and W at Milngavie by Glasgow.
5/6	2233–2247	Faint bands suspected at Genk, Belgium.
9/10	2215–2300	Possible faint bands in haze, Morpeth.
10/11 June	2215–0200	Moderate to faint bands and patches observed from Moray Firth to N. Wales. Billows developed from 0030.
13/14	0008–0100	Thin bands at 11°, St Andrews.
14/15	2230–0115	Faint bands and billows observed from Moray Firth to N. Wales.
15/16	0030–0215	Bands and patches seen at Witham, Essex; photographed in I. of Man.
16/17	2345	Fairly bright bands and billows photographed by Dr Soper in I. of Man. No NLC in Scotland.
17/18	0015–0035	Positive NLC sightings at Dundee and I. of Man, no details.
18/19	2230–0113	Faint bands observed in NW Highlands, Moray Firth and Teesside; detected by Mr Bone at Cambridge 2230–2300.
20/21	2330–0215	Moderate to faint bands and veil, max. altitude 20° at Kilbirnie by Ayr; faint bands at Dundee.

Date — night of	Times UT	Notes
21/22 June	2255–0200	Faint bands and patches at Dundee and Co. Clare. At Kilbirnie Mr McEwan observed NLC becoming bright and extensive with radiating band structure up to 45° from 0045.
22/23	2240–0215	Faint bands and billows observed from Edinburgh to Newport Pagnell, and at Vildbjerg, Denmark.
23/24	2230–2345	Faint veil, bands and billows in trop. cloud gaps in Co. Clare; moderately bright bands up to 20° at Rønne, Bornholm.
25/26	2200	Bands in haze at Rønne.
26/27	2300–2355	Faint bands to 10° at Kilbirnie, faint NLC in Co. Clare.
27/28	2253–0255	Bright display, all forms, observed from W. of Scotland to RAF Benson near Oxford and Witham, Essex. Complex structures developed from 0015.
29/30	2300–2310	Suspect faint band at Alness.
30/1 July	2300–0200	Bright bands, billows and whirls up to 20° at Copenhagen; faint bands at Cambridge 0200.
1/2	2300–0215	Bright blue bands and whirls, some patches of billows, observed throughout Scotland and at Teesside.
2/3	2230–0215	Rather faint veil, bands and billows seen from Moray Firth to Northampton, faint forms in zenith at Alness. Bright and extensive display at Vildbjerg 2230–0155, all forms, into S. sky at alt. 148° at 0155, photographed by Mr Andersen. Reported by 6 stations in The Netherlands.
3/4	2200–0215	Moderately bright bands and extensive veil, patches of billows, observed in central Scotland, I. of Man and as far S. as Northampton. Bright bands and billows photographed at Vildbjerg. Reported by 5 stations in The Netherlands.
4/5	2300–0030	Faint bands and patches from central Scotland to I. of Man.
6/7 July	2230–0105	Bright bands seen from Moray to Edinburgh.
7/8	2130–0015	Bright NLC visible in haze and trop. cloud at Kilbirnie, bands at Rønne and Kølvrå, Denmark.
9/10	2248–0048	Faint bands at Orkney.
10/11	2220–2245	'Bands and whirls' photographed at South Shields, probably cirrus.
12/13	0045–0215	Faint bands and billows at Morpeth.
13/14	2020–0150	Moderately bright bands and billows up to zenith at Sumburgh and Kirkwall. Bright NLC at Rhoon, Deventer and Valkenburg.
14/15	2220–0300	Fairly bright, all forms, observed from Moray to Essex, up to 80° at Morpeth at 0230. Billows and whirls developed later.
15/16	2130–0247	Bright, all forms, observed from Shetland to I. of Man, also Esbjerg and Bornholm.
16/17	0045–0247	Moderately bright bands and billows seen from Moray to Ayrshire, and Genk, Belgium.
17/18	0052–0215	Horizontal bands at Kilbirnie, no NLC before 0045.
19/20	0105–0300	NLC in haze at Kinloss; bright billows observed throughout The Netherlands.
20/21	2305–2345	Moderately bright bands at 10°, billows and whirls developing later, at Alrø, Denmark.
25/26	2040–0230	Faint bands observed at Aberdeen, Ayrshire, I. of Man, Vildbjerg and Funen.
31/1 Aug.	0108–0330	Faint bands appearing late, bright billows and whirls developing after 0200. Observed from S. Scotland to Swansea.
2/3	0050–0300	Bright NLC in patches at Wick, Orkney and Kinloss.

Table II. Negative nights (British Isles) north of latitude 54° N

May 25/26, 27/28, 29/30, 31/June 1; June 6/7, 19/20, 28/29; July 5/6, 18/19, 30/31; Aug. 6/7.

Correspondence

551.578.45(430.1):551.578.46:551.515

Contribution to the discussion on 'A heavy mesoscale snowfall event in northern Germany'

Among the interesting points in this discussion (*Meteorol Mag*, **119**, 271) are the techniques of snowfall measurement, radar observation of snowfall and the amounts of precipitation over land and sea.

1. Snowfall measurements

Difficulties associated with radar measurements of snow are well known. Perhaps the shortcomings of conventional measurements of snowfall, i.e. collecting the snow in vessels or measuring the depth of snow cover, are not so familiar. With high winds, as in this event, the snow is drifting and piles up at certain areas while other areas may be nearly free from snow. Open areas on the coast may get a very thin snow cover, not at all representative of the precipitation. Since snow cover measurements are point ones their representativeness must be questioned. Measurements with ordinary vessels suffer of course from drifting snow, but there are no means of knowing how much of the drifting snow is caught by the vessel, besides which a gauge suffers from wind losses. As an example I refer to Fig. 9 in the paper by Andersson and Nilsson (1990). During 9–13 January 1987 the station at the southern tip of Gotland recorded an accumulated precipitation of 183 mm (water equivalent). At the routine check by the Division of Climatology this amount was questioned. According to the observer snow had piled up at the observation point — the accumulation was then corrected to 57 mm! As a consequence, charts of snow depth after snowfall combined with high wind speeds may not be representative of the precipitation distribution. At least the radar does not suffer from these wind effects! Another consequence is that 'water-equivalent to snow depth ratios' do not say much about the density of snow cover in these weather events.

2. Radar observations

The radar observations from Hamburg and the 'continued snow shower generation' over the Lübeck Bight are seemingly contradictory to the satellite pictures (Figs 2 and 5 in Pike (1990)), and show that the cloud band extends much further north-east, well beyond Bornholm Island. Probably the detection range of the Hamburg radar in this case was something between 100 and 150 km (the distance from Hamburg to the south-west Lübeck Bight is about 70 km). The precipitation was probably shallow, and overshoots the radar beam beyond these ranges. An observer looking at the radar screen then gets the impression that cells form where they are actually advected into the area. An image from the Norrköping weather radar from the same event (see Fig. 1) shows another precipitation band that, according to satellite images, extended into the Gulf of Finland, but is visible only out to a range of about 120 km. This radar, the Ericsson prototype weather radar, probably had somewhat better sensitivity than the Hamburg radar (I assume the Hamburg radar was the EEC C-band with 8 ft antenna (described by Attmanspacher (1984)). This range effect is also illustrated in Fig. 2 showing the precipitation distribution according to the weather radar for a similar weather situation. Also in this case the precipitation band extended into the Gulf of Finland.

3. Snowfall over land and sea

Some mesoscale simulations with the HIRLAM forecasting system (horizontal grid spacing 22 km with 16 vertical levels) recently performed by Nils Gustafsson (who kindly put them at our disposal), show amazing similarities with the satellite pictures (Fig. 2 in Pike's paper). As an example Fig. 3 shows the computed precipitation accumulation from 0600 to 1800 UTC on 12 January 1987, from initial data at 0000 UTC (note that this was the day after Pike's picture but the weather situation was persistent, for instance Lübeck had 7 mm precipitation in the form of snow from 0600 UTC on 12 January to 0600 UTC on 13 January). Even the V-shape of the clouds just north of the German coast is reproduced on the computed precipitation distribution! The maximum precipitation is found north of Rügen, that is over the sea as in Figs 1 and 2.

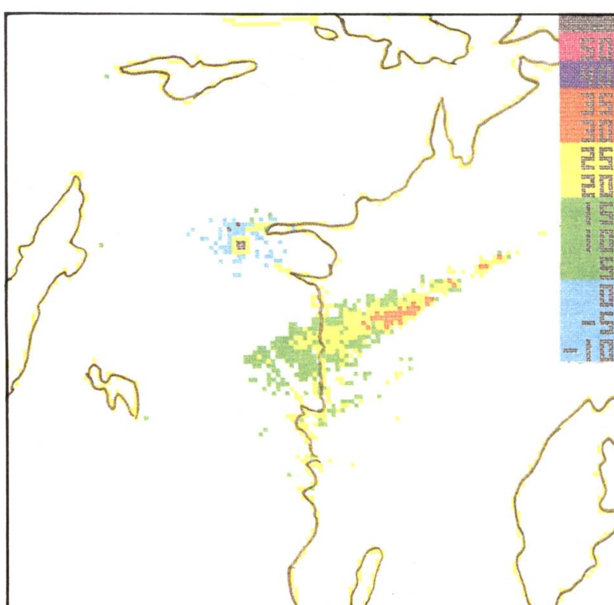

Figure 1. Map of reflectivity at 500 m height from the Norrköping radar, range 240 km, at 1000 UTC on 12 January 1987. The scale on the right gives reflectivity in dBz. The band of precipitation actually extended towards the east-north-east into the Gulf of Finland. Owing to range effects the radar can only detect precipitation out to about 120 km. The radar is at the centre of the picture surrounded by weak (blue) ground echoes.

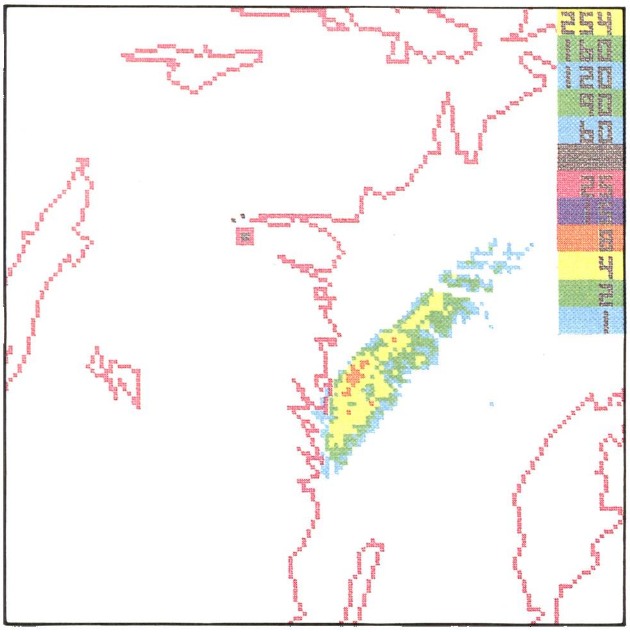

Figure 2. Radar map of accumulated precipitation from 0615–1200 UTC on 28 January 1987 from the Norrköping radar, range 240 km. The scale on the right gives precipitation in millimetres. The precipitation rate–reflectivity relation used is $Z = 200 \times R^{1.6}$, where Z is the reflectivity ($mm^6\,m^{-3}$) and R the precipitation rate ($mm\,h^{-1}$). Note that most of the precipitation lies at about the same distance from the radar. Though the amounts given at these ranges from a shallow precipitation system are uncertain, the maximum no doubt occurs over the sea.

References

Andersson, T. and Nilsson, S., 1990: Topographically induced convective snowbands over the Baltic Sea and their precipitation distribution. *Weather and Forecasting*, **5**, 299–312.

Attmannspacher, W., 1984: Radar network in Germany. *In* Seminar on radar meteorology, Erice, 4–14 October 1982. Geneva, WMO, No. 626.

Lumb, F.E. and Pike, W.S., 1990: Correspondence. *Meteorol Mag*, **119**, 271.

Pike, W.S., 1990: A heavy mesoscale snowfall event in northern Germany. *Meteorol Mag*, **119**, 187–195.

T. Andersson

Swedish Meteorological and Hydrological Institute
S-60176 Norrköping
Sweden

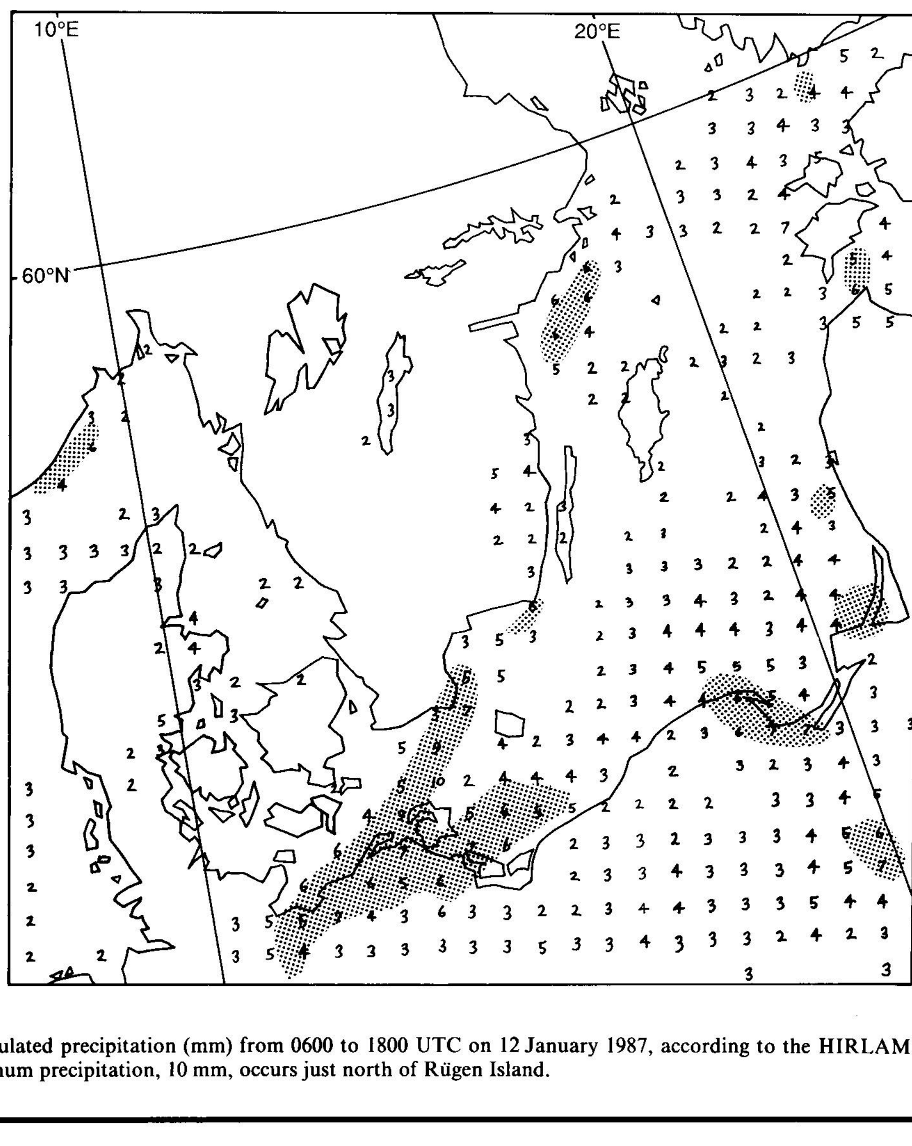

Figure 3. Accumulated precipitation (mm) from 0600 to 1800 UTC on 12 January 1987, according to the HIRLAM. Areas >5 mm are stippled. The maximum precipitation, 10 mm, occurs just north of Rügen Island.

Reply by W.S. Pike

I will try to confront the majority of points raised and answer them as best as I am able.

1. Snowfall measurements

All available observations indicate that the heavy snowfall near Hamburg occurred with relatively light surface winds of only 5–15 kn. Hence, it appears that the fresh snow reports of 40–60 cm over the 24-hour period ending 0600 UTC on 12 January 1987 were very good estimates of the representative level depth. Presumably Andersson accepts them because he does not refer at all to this remarkable 'inland' maximum!

Throughout history confusion has arisen through the use of unstandardized methods and unsynchronized times of measurement. In the United Kingdom, to obtain average and representative figures for both snow depth and water equivalent, a mean of at least three snow samples is required (Meteorological Office (1982), chapter 9).

In 1942/43 Bergeron wisely instructed his observers in south-east Sweden 'to measure the snow depth, if possible, in forest glades, or in similar places, where it had not drifted' (Bergeron 1949). Had this been achieved at Hoburg (the south-west tip of Gotland, see Fig. 1) a more representative water equivalent for the long and non-standard period (9–13 January 1987) might have been made in the first place.

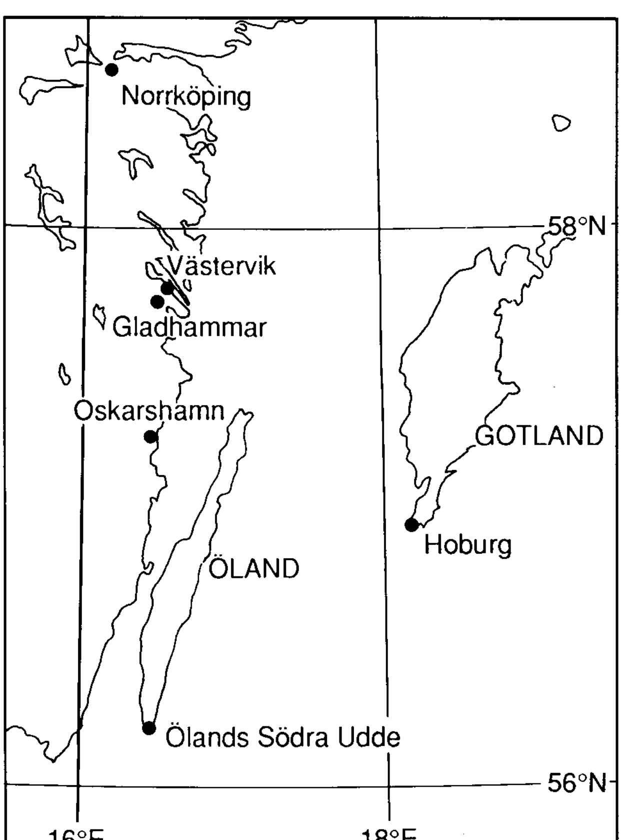

Figure 1. Locations of places mentioned in text.

Perhaps water equivalents have traditionally been more important in lowland United Kingdom than in Sweden where rivers are generally more youthful and fast-flowing. Water equivalents give engineers a useful idea of how much water would be additionally released, in a catchment area, by a sudden thaw. Such a problem has resulted in serious flooding of the Thames and Severn Rivers in England (e.g. in March 1947 when 14 000 hectares of the East Anglian Fens disappeared under water).

2. Radar observations

It is true that the cloud band extends beyond Bornholm, but Fig. 3 of Pike (1990) shows that the convection intensified in the Mecklenburg Bight. Is this not consistent with the Hamburg radar observations?

The radar interpreters at both Hamburg Airport and Maritime Weather Offices described a 50 km wide band of precipitation stretching from beyond radar range in the north-east, then passing away to the south-west. This broad quasi-stationary band was aligned over the Lübeck Bight, near the coast, and new shower cells were observed to be continually developing within the band over the water.

This seems acceptable for several reasons: (1) sea-surface temperatures were slightly higher in the Mecklenburg/Lübeck Bights, i.e. 3–3.5 °C, compared with 2.5 °C or less further north-east in the Baltic Sea, (2) land-breeze components from over northern Germany were adding strength to the convergence line convection near the Bight coast, and (3) two convergence lines themselves converge in the vicinity of Warnemünde (as illustrated in Pike (1990) Figs 1 and 7).

Bennetts *et al.* (1986) have shown that, in conditions of uni-directional wind shear, convective clouds are usually relatively short-lived (½–¾ hour). Ascents from Greifswald (not shown) indicate that east to north-east winds were increasing with height and time during Sunday evening (11 January) when the shower cells were seen to be continually developing over the Mecklenberg Bight. With cells taking perhaps 20–30 minutes to form and produce snow showers and tops to 12 000 ft it seems quite reasonable to assume that the Hamburg radar observations were genuine.

Figs 1 and 2 of Pike (1990) also show two convergence lines and the associated convective snow bands merging into a V-shape (at SGK) just off the Swedish coast near Gladhammar (G), which is precisely where radar observations of 'precipitation maxima' have occurred on several occasions (including 12 and 28 January 1987). We should remember, however, that these observations relate to snow in the clouds, which has yet to precipitate at quite a shallow angle in strong winds.

Fig. 6 of Andersson and Nilsson (1990) confirms that aligned precipitation cells sometimes meet in a V-shape; in the case of 3 January 1985 the merger took place some 100 km out to sea from the Norrköping radar. Such precipitation cells perhaps take 20 minutes to develop over a short 'fetch' of Baltic Sea, aided here by the strength and involvement of a north to north-north-easterly land-breeze component from over the Stockholm peninsula. Other dependent factors would include instability, friction and cyclonic curvature of the isobars. No two cases are exactly alike.

F.E. Lumb (personal correspondence) now points out that Figs 2 and 4 of Pike (1990) show, at least over 11–12 January 1987, 'the topography (as modified by ice) favoured an east-north-east to west-south-west convergence zone extending from the Gulf of Finland to the vicinity of Västervik. It was able to maintain itself as a well-marked band all the way because the wind direction throughout the unstable layer (not just at 950 mb) was between east and north-east'.

3. Snowfall over land and sea

It is unfortunate that Fig. 3 in Andersson's letter does not cover the same period as the heavy snowfall near Hamburg (i.e. 24 hours up to 0600 UTC on 12 January 1987). Does the interesting 'HIRLAM' computer program take land-breeze convergence into account?

Referring to Fig. 5 of Pike (1990), this was based on some 140 observations from 'climatological and rain-gauge stations' of the Deutscher Wetterdienst, and 45 similar stations from the East German (as it then was) equivalent. At that time both German meteorological services seemed more willing to send the author this snowfall data than they were to exchange it between themselves! This situation has now changed and Herr Kresling has been joined by Dr Tiesel (from East Germany) in Hamburg, where they are currently (January and February 1991) working together investigating any further mesoscale snowfall events which might affect the southern Baltic area. Perhaps they will find that another snowfall maximum occurs over the sea to the north of Rügen Island? If not, verification is the responsibility of Andersson with respect to the case of 12 January 1987.

Concerning the snowfall over south-east Sweden, every situation is going to vary slightly from a similar one. The case of 3 January 1985 was quite similar to that of 28 January 1987 in that the snowfall was not prolonged and occurred with cyclonically curved isobars after passage of a depression. However, the depressions had very different tracks, the former passing southwards and the latter south-eastwards into the southern Baltic — these events lasting no more than 24–48 hours.

The situation over 9–13 January 1987 was very difficult again in that a prolonged east to north-easterly airflow was involved. F.E. Lumb (personal correspondence) makes the comment ... as regards Fig. 9 of Andersson and Nilsson (1990), 'the very rapid decrease in snowfall north of 58° N on the coast of Sweden is interesting. It can be explained by Fig. 1 of Pike (1990) which shows that, taking the ice areas into account, the open sea track of the surface wind (the key factor in initiating convection) shortened rapidly north of 58° N'.

The theoretical nocturnal maximum of coastal snowfall associated with convergence cloud bands due to slackening of the land to sea-surface thermal contrast by day is illustrated by the water equivalent and snowfall observations from Västervik over 10–14 January 1987 (Table I). Confirmation comes from the precipitation observer at Oskarshamn who reported dry spells between 0800 and 1600 UTC on the 11th, and 0900 and 1600 UTC on the 12th. A nocturnal maximum is, presumably, less of a feature further north, where there is little or no solar heating at this time of year.

Table I. Snowfall observations at Västervik, 10–14 January 1987

Date	Precipitation		Snow depth at 06 UTC	
	18–06 UTC	06–18 UTC	Fresh (past 24 hrs)	Total
	(mm)		(cm)	
10	0.2	nil	nil	43
11	0.6	8.7	2	45
12	11.5	3.2	23	68
13	6.5	4.1	10	78
14	2.6	1.9	12	90

4. Conclusion

The northerly land-breeze component from over the Stockholm peninsula, when added to the low-level north-easterly synoptic-scale airflow, is probably the single most significant factor in: (1) maintaining the convergence line and associated convective snow band over the sea, and (2) generating heavier shower cells within this snow band towards the Swedish coast (as shown in Figs 1 and 2 of Andersson (1990)). Careful study of the cloud-street alignment on satellite photographs is likely to help confirm this (e.g. Fig. 2 of Pike (1990) clearly points to such an effect of land-breeze involvement on 11 January 1987).

References

Andersson, T. and Nilsson, S., 1990: Topographically induced convective snowbands over the Baltic Sea and their precipitation distribution. *Weather and Forecasting*, **5**, 299–312.

Bennetts, D.A., McCallum, E. and Grant, J.R., 1986: Cumulonimbus clouds: an introductory review. *Meteorol Mag*, **115**, 242–256.

Bergeron, T., 1949: The problem of artificial control of rainfall on the globe. 2. The coastal orographic maxima of precipitation in autumn and winter. *Tellus*, **1**, 15–32.

Meteorological Office, 1982: Observer's handbook. London, HMSO.

Pike, W.S., 1990: A heavy mesoscale snowfall event in northern Germany. *Meteorol Mag*, **119**, 187–195.

W.S. Pike

19 Inholmes Common
Woodlands St. Mary
Newbury
Berkshire RG16 7SX

Notes and news

The warmest year ever globally

Global mean-surface-temperatures based on land and marine measurements during 1990 were the highest since comparable records began in the middle of the 19th century. The 1990 global mean-surface-temperature was 0.39 °C above the average level during the period 1951–80. This value exceeds that of the previous warmest year, 1988, by at least 0.05 °C. Six of the seven of the previous warmest years of the near 140-year-long record have all occurred since 1980. In descending order the years are 1990, 1988, 1983, 1987, 1944, 1989 and 1981. The 1990 value follows the warmest decade (1980–89) ever recorded when temperatures were 0.20 °C above the 1951–80 average.

The warmth of 1990 was particularly evident over Europe and western Siberia, the Far East and most of the United States and southern Canada. Some regions, nevertheless, remained cooler than the 1951–80 reference period, notably north-eastern Canada, Greenland and the central Arctic. The southern hemisphere was relatively less warm than the northern. For the globe, March 1990 was, relative to average, easily the warmest month of this or any other year.

There was also exceptional warmth in the 1.5–10 km layer of the lower atmosphere, where 1990 was the warmest year in records that begin in 1958. These data also reveal the 1980s as the warmest decade. Recent satellite-based observations have confirmed the reliability of the surface data and especially the upper-air data, but satellite results are not yet available for the whole of 1990.

Although it is still too early to confirm whether the recent exceptional warmth is related to the greenhouse effect, international scientific opinion strongly supports the reality of an enhanced greenhouse effect, and it is likely that it has played some role in contributing to the recent warmth.

Reviews

Weather radar networking, edited by C.G. Collier and M. Chapuis. 165 mm × 235 mm, pp. xvi+580, *illus.* Dordrecht, Boston, London, Kluwer Academic Publishers, 1990. Price Dfl.240.00, US $139.00, £89.00. ISBN 0 79230 672 4.

This book is an unedited version of the proceedings of a seminar, held in Brussels in September 1989, which marked the 'half-way stage' of the COST-73 project. The COST (European Co-operation in Science and Technology)-73 project 'associates 16 countries in western Europe with the aim of setting up a weather radar network providing real-time measurements of rain, snow and hail'.

From the outset, I found myself asking the question: why have these conference proceedings been made into a high quality text costing £89 rather than the usual relatively cheaply produced volume? Perhaps the key is found on page 444 when, after surveying the present use of weather radar data in a number of European countries, Newsome summarizes 'There is a danger, however, that the momentum of the international co-operative work that has been successfully carried out so far under COST-73 will be lost, unless it continues to be energetically pursued under the aegis of an international organisation'. I suspect this publication is an attempt to present the state of the art of weather radar networking to the appropriate organizations.

The 580 pages of the book take the reader through over 60 separate papers divided into six sessions which survey (exhaustively) the state of radar networking in nearly 20 different countries, current and new techniques in weather radar networking and the combining with other forms of data through to meteorological, hydrological and other applications of weather radar. The text is 'camera ready', reduced in size from the original. There are a variety of typefaces, some texts are closely spaced or painfully small to read. Unexplained jargon, acronyms and spelling mistakes abound, particularly in the first half of the book. There is also much repetition, for example the difficulty of measuring rainfall from radar using the radar rainfall 'Z R relationship' is discussed by countless authors. Sadly, there has been no editing, even of papers by contributors whose first language is not English.

These criticisms apart, within the maze of material, there are a number of very interesting papers, although some have been published in similar form elsewhere. Certainly for the country or organization just embarking on setting up a weather radar network, there is a wealth of material covering the meteorology, and current computer hardware and software technology, together with a very extensive list of references. However, the would-be user will find much of it hard going. A far more attractive and slimmer text could have been produced by thorough editing, particularly of the first section where a small number of tables and brief summaries could easily have replaced the bulk of pages 1–190.

G.A. Monk

Earth's rotation from eons to days, edited by P. Brosche and J. Sündermann. 168 mm × 247 mm, pp. xv+255, *illus.* Berlin, Heidelberg, New York, London, Paris, Tokyo, Hong Kong, Springer-Verlag, 1990. Price DM 128.00. ISBN 3 540 52409 6.

Fluctuations in both the magnitude and direction of the rotation vector of the 'solid' Earth (mantle, crust and cryosphere) occur over time-scales ranging from days to billions of years. They are caused by dynamical processes occurring within the solid Earth; by interactions of the solid Earth with the underlying liquid metallic core and the overlying hydrosphere and atmosphere; and by the gravitational action of the Moon, Sun and other astronomical bodies. The accurate determination of these fluctuations and their reconciliation with models of the composition, structure, dynamics and evolution of all regions of the Earth present challenging problems in astronomy and many branches of the Earth sciences, including meteorology and oceanography.

The book under review reports the proceedings of a workshop that took place in Bielefeld in 1988, bringing together leading workers from several countries. The reports include summaries of recent work on: the radio-astronomical technique of very long baseline interferometry for making any accurate determinations of the orientation of the solid Earth in space and special and general relativistic corrections needed when making such determinations; Earth rotation changes in historical and geological times as revealed by observations of lunar occultations and eclipses and by various geological records; the dynamics of the Earth–Moon–Sun system; and long-term changes in the structure of the Earth associated with the gradual lengthening of the day over geological time. Of particular interest to meteorologists and oceanographers are the chapters on variations of the angular momentum budget for tides of the present oceans, the pole tide and the damping of the Earth's free nutation, the seasonal angular momentum of the thermohaline ocean circulation, and atmospheric effects on the Earth's rotation.

The book, which is aimed at research workers, contains much useful information, including many references, but it lacks a subject index. Most of the chapters are well-written, but some contain obscurities which seem to have escaped the scrutiny of the editors.

R. Hide

Weather Watch, by R.F. File. 158 mm × 240 mm, pp. xii+299, *illus.* London, Fourth Estate Ltd, 1990. Price £14.99. ISBN 1 872180 12 4.

The Guardian has always had good 'back page' coverage of weather details from around the British Isles and further afield. In the last few years an innovative column known as 'Weather Watch' has appeared as a very readable supplement to the daily maps, text and data. Dick File's name must very quickly have registered in the readers' minds as being identified with the provision of snappy and most often topical accounts designed to inform and educate. He has continued with this unique task and the measure of its success is presumably expressed in the appearance of this volume published by a *Guardian*-owned company.

The book is thus in essence a natural development of the kind of short column presentation and aims to be the 'complete guide to our weather, the perfect companion for both the professional and armchair weather watcher'. The 299 pages of text are wide ranging as is indicated by the chapter headings of Evidence of past climates, Understanding weather, World weather, British weather, Local weather, Signs in the sky, Observing the weather, Forecasting, Holiday weather, Weather for business, and Climate change. The book also contains a Glossary of some five dozen common terms, and six appendices ranging from temperature and pressure conversion tables to British and world climate data. Finally, 26 black and white plates are bound in the centre of the book in addition to a good range of figures scattered through the text.

The great strength of this book lies in Dick File's readable style in combination with his varied experience at the 'sharp end' of operational meteorology. Nowhere is the text 'dry' and his good humour is used to effect throughout the text — the feel of his genuine personal interest in weather and its links with other aspects of nature appear at regular intervals and make the book that bit more engaging.

So much for the style, how about the content? With any wide-ranging popular text there are almost inevitably going to be some errors. Overall this book treats its topics well and in an up-to-date fashion — even including the official record maximum temperature for the United Kingdom measured at Cheltenham last summer. Each topic is allotted about three to four hundred words in snappy sections which generally are linked in a logical succession in each chapter. The only bones I think should be picked relate to:

1. The perpetuation of the archaic notion that the Asian monsoon is a very large-scale sea-breeze feature — it would be much more interesting to engage the reader in a modern discussion of the sub-planetary nature of the phenomenon.
2. The inaccurate passage relating to storm surges sloshing into the Thames Estuary after being 'deflected' from the Dutch Coast — this is a topic which needs more accurate explanation, and
3. the idea that westerly jets occur because the Earth is rotating in that direction — this doesn't help much in explaining seasonal easterly jets in the tropical area for example.

It is a shame that the selection of black and white plates are not referred to in the text and that some of them could have been better quality — particularly the satellite images. The cloud pictures could, for example, have illuminated the discussion on static stability which is always a thorny topic — especially for the armchair reader.

These comments are meant to illustrate that, although there are a few things I feel could be improved, the vast majority of the text achieves its stated aims — and for

Correction

Meteorological Magazine, April 1991, p. 73, Review of *Global Air Pollution.*

The specific reference to Professor Scorer's book was accidentally transposed to the second paragraph, but should have been included at the end of the first paragraph, as an alternative book to the one under review. Apologies are offered for any implied misrepresentation.

the price of £14.99 is an excellent buy not only for professionals and armchair readers but also for school-teachers and upper-school students.

The author's humour and operational experience can no better be summarized than to quote his adaptation of Harold Wilson's famous adage — 'A week is a long time in meteorology'!

R. Reynolds

Global air pollution: Problems for the 1990s, by H.A. Bridgman. 155 mm × 235 mm, pp. xiv+261, *illus.* London, Belhaven Press, 1990. Price £12.95 (paperback), £30.00 (hardback). ISBN 1 85293 009 3 (paperback), 1 85293 094 2 (hardback).

Gone are the days when any informed person would suppose the atmosphere could take anything and everything we are prepared to throw into it, without the potential for adverse, and perhaps disastrous, consequences. Of course many many specialist and popular books have been written in the last decade or so discussing one or other of the important environmental issues related to air pollution. Howard Bridgman has attempted to bring many of these major issues together in one book. Topics include acid rain, the ozone hole, tropospheric oxidants and aerosols, climate warming, major radioactive releases, nuclear winter and urban air quality. The contents are fairly up-to-date (with a few exceptions) and are broadly based on the contents of a third-year course Dr Bridgman gives at the University of Newcastle in Australia. Although the approach is non-mathematical it goes into the issues seriously and to sufficient depth to be a potentially useful text. The nearest contenders on my own bookshelf are a 1988 WMO Conference Proceedings (No. 710) called *'The Changing Atmosphere'* (which incidentally is not referenced in Bridgman's book).

However, I regret having to report that Dr Bridgman's book, and Professor Scorer's excellent book *Meteorology of air pollution: implications for the environment and its future* which has recently appeared, deserve, and should quickly receive, more effort by both publisher and author. Glancing quickly through the book, I began to share the disappointment the author must have felt on seeing his first copy. In addition to some spelling mistakes and the irritating mix of English and American spellings, there are problems that are more serious. At least three tables have a most usual 'error': the final line is repeated and repeated up to 40 times! Why wasn't this picked up and removed? Furthermore the print is very small and rather feint. I can imagine anyone with weak eyesight finding it very tiresome to read. Some figures have background maps which are so feint that boundaries are almost invisible. It all gives a very poor impression.

The author could also be well advised to consult other experts in the various areas he covers for their comments. I will restrict my contenders for change to just four:

(a) Acid rain studies in Europe: this is an inadequate section, consisting largely of results from the rather dubious monthly data collected in the European Atmospheric Chemistry Network Programme. He should consult some recent European Monitoring and Evaluation Programme and EUROTRAC Reports (for example) which have thrown a lot more light on the subject.

(b) The section on dry deposition also lacks authority. He should consult the numerous papers by Hicks, Garland and Fowler. Nicholson's excellent review in *Atmos Environ,* **22**, p. 2653 (1988) should also be drawn from.

(c) Dr Bridgman quotes values of Cs-137 deposition in the United Kingdom resulting from the Chernobyl accident. Unfortunately most of his numbers in the text are a thousand too small!

(d) I found many of the definitions he gives in his Glossary unsatisfactory. To take the first entry as an example, he defines 'advection' simply as the horizontal movement of air.

To summarize then, Dr Bridgman has contributed a potentially very useful book. The first edition is marred by very low publishing standards and by inadequate scientific consultation. I would strongly urge him to put these right as quickly as he can and move into a second edition. The effort could be very worthwhile.

F.B. Smith

Television weathercasting: A history, by R. Henson. 155 mm × 234 mm, pp. xii+193, *illus.* Jefferson, North Carolina, McFarland, 1990. Price £26.25. ISBN 0 89950 492 2.

The first thing I did on receipt of the book was to flick through to see what had been said about the BBC presentations. No BBC. How can a book be written without considering the best and most sophisticated presentation in the world! Maybe ITN is considered, after all it is new and different! No ITN. What about the rest of Europe — nothing. I know that Americans are often accused of being insular but surely one cannot write a history of TV weathercasting without considering where it all started way back in 1936. After all, we see American broadcasts all the time at the BBC. The book itself looks as if it was printed in 1936, no colour and certainly not worth the cover price of £26.25.

Having said all that the book is unique. I do not know of another on a similar subject — the author himself saying that he was appalled to find that shelves were full of books on newscasts and sportscasts but not weathercasts, despite the fact that weather affects more people than the latest summit or football match.

The book deals in detail with all aspects of American TV weather forecasts with chapters covering the range from 'Technical Matters' to 'From Silly to Serious'. The author starts by saying that 'over the decades the weatherman has become a trusted yet sometimes scorned symbol' — I agree. He goes on 'despite the attention heaped on newscasters it is weather that consistently ranks top in the ratings' (as it does here with more people actually switching on for the 9.28 p.m. weather than watch the preceding news or the following light entertainment programme). He further makes the salient point that in the flashy world of TV, dry facts alone are not enough to attract audiences, weathercasters have to present their information with liveliness and friendliness. Some have gone to absurd lengths such as giving the forecast submerged in a tank of water or dressed as Carmen Miranda, whereas others stay on duty for 24 hours giving warnings and updates on either tornadoes or hurricanes.

The first chapter deals with the history of TV and radio forecasts and the way styles have changed. How flippant weathercasts waned during the Vietnam war and did not reappear to the same extent. It also mentions the concern of the American Meteorological Society whose seal of approval has done a lot to maintain professionalism.

It was also nice to read in chapter 2 that the American audience is as intolerant as ours, and does not take kindly to any alteration, or worse, elimination, of the regular reports. Equally nice was the fact that Bob Ryan of WRE (Washington), one of the biggest stations, has a working schedule and environment very similar to ours at the BBC (he also works in a cupboard with a camera and VDUs for company, although he does have an assistant).

Thankfully we have not resorted to the same antics here as described in chapter 3. Rather the reverse as, instead of using puppets, there is a puppet of Ian McCaskill used in Spitting Image. We do not use animals either, although we do have a fish! It is satisfying to read that the moans of the presenters are the same the world over; Rebecca Rehers of Salt Lake City says in this chapter 'I get 3½ mins. There's not a lot you can do. Plus, we cover five states' — we have to cover the whole of Europe in 1½ minutes! I read also that one certain way of improving the ratings is to deliver the forecast standing on one's head!

Chapter 4 notes that in the USA it was years before the National Weather Service employees were allowed to appear and even now it is a rare event, subject to many restrictions. Here in Britain we pioneered TV forecasts with few problems from unions, Parliament or the business community. No such restrictions appear to exist in the USA on the radio side as the chapter goes on to describe the NOAA 24-hour weather radio which, apart from a continuous flow of information, even provides a tone alert to radios that are switched off when a severe weather warning is issued.

The chapter on technical matters makes fascinating reading, at least it does for me, and again it is nice to read that throughout the decades the BBC has often been in the forefront as far as innovation is concerned, except for the introduction of radar where we lagged some 25 years behind (even now many USA stations are heavily into Doppler radar).

One the major criticisms of the book is that it is highly repetitive and could well have been fitted into half its 193 pages. By the time one gets to chapter 6 the repetitions become tedious, especially as they start virtually right from page 1.

There is one final item of interest, and that is the section on the Weather Channel; the channel, only available via cable, has become profitable in only 3 years. The book states that the Weather Channel 'talent' has a vast workload and spends about 75 minutes a day before the cameras with a team of 40 meteorologists and 10 graphic artists working behind the scenes. I feel that the productivity at the BBC is greater as we often spend 20 minutes on camera with no-one behind the scenes!

A final quote 'On 21 September 1938 a powerful hurricane approaching the Carolines veered north. Weather Bureau officials in Washington gave the all clear for the entire east coast. Morning forecasts in New England called for rain and breeziness; by evening gusts at Blue Hill, Mass. reached 186 mph' — sounds familiar!

In the States mass-produced weather is called McWeather — so what, we have McCaskill and MacFish (the older ones amongst you will remember the firm across the road from the Met. Office in Bracknell).

Of little or no interest to the British reader is the vast appendix listing biographies, awards and a large bibliography. This, with the index, takes up the last 60 pages.

M.J. Fish

Books received

The listing of books under this heading does not preclude a review in the Meteorological Magazine at a later date.

The mathematical theory of non-uniform gases, by S. Chapman and T.G. Cowling (Cambridge University Press, 1991, £19.50, US$32.50) presents a detailed account of viscosity, thermal conduction and diffusion based on the solution of the Maxwell–Boltzman equations. Also, the theory of Chapman and Enskog is extended in this paperback edition which is part of a series. ISBN 0 521 40844 X.

Sunsets, twilights, and evening skies, by A. and M. Meinel (Cambridge University Press, 1991, £13.95, US$19.95) contains many illustrations and explanations of the varied phenomena associated with the subject. It is a paperback version of an earlier edition. ISBN 0 521 40647 1

Radar photographs — 9 January 1991 from 1400 to 1515 UTC

Fig. 1 shows an example of a radar 'bright-band' which is exceptional in the way it conforms to the textbook structure of the phenomenon. Bright-bands are associated with melting snowflakes beneath the 0 °C wet-bulb level. At the wavelengths used by weather radars, ice has a reflectivity about one fifth that of water. Large, dry snowflakes are even less reflective than a solid ice particle of the same size would be because of the pockets of air between the crystals. Once a snowflake acquires a coating of water due to melting, it reflects like a giant raindrop. Such hydrometeors dominate the radar return because the radar reflectivity varies as the sixth power of the drop diameter. The consequence is that a radar scanning in a vertical plane sees a band of anomalously intense precipitation at a height near the 0 °C isotherm. On the black and white analogue displays used originally, this appeared as a brighter region, hence the name 'bright-band'. A radar scanning with its beam at constant elevation will see the bright band enhancement at a range which depends on the beam elevation as well as the height of the band. In steady cold rain this might be expected to produce an annulus of apparently heavier rain centred on the radar; in practice this is almost never observed for five reasons:

(1) The annulus can only be seen if there is precipitation at the appropriate range.

(2) The rainfall intensity is often so variable and patchy that the ring is disguised.

(3) With the quantized display system used by the UK radar network, the same colour is used for rates of 1–4 mm h^{-1}, 4–8 mm h^{-1}, 8–16 mm h^{-1}, etc. It follows that a brightening by a factor of ×3.5 will not be seen if the base rainfall rate is 1 mm h^{-1}. The brightening is often less than ×4 but in extreme cases it seems to reach ×16 (usually at ranges in excess of 100 km).

(4) Case studies suggest that the effect becomes more pronounced as rainfall rates approach 4 mm h^{-1} — but widespread rain of this intensity is uncommon over the British Isles unless the atmosphere is strongly baroclinic. The variation in height of the melting level through a well marked front will cause the annulus to be distorted.

(5) When the radar data is composited, part of the area occupied by the annulus may not be used, that replacing it will not, in general, be at the correct range from its radar to show bright-band effects.

Fig. 1 shows the development of an almost perfect bright band annulus about the Dyfed radar in south-west Wales during the afternoon of the 9 January 1991 as a warm front approached from the south-west (Fig. 2). The data is displayed in a slightly different way from the usual radar network one: the lower limit is 1/32 mm h^{-1} instead of 3/32; and an additional level has been inserted so that there is a colour change from yellow to red at 2 mm h^{-1}. Observe how an annulus of high intensity develops around the radar with outliers to east and west, also due to bright-band.

Because ground clutter is an inevitable consequence of a very low elevation beam, UK radars use a higher elevation beam (1.5° at Dyfed), called 'beam 1', for data

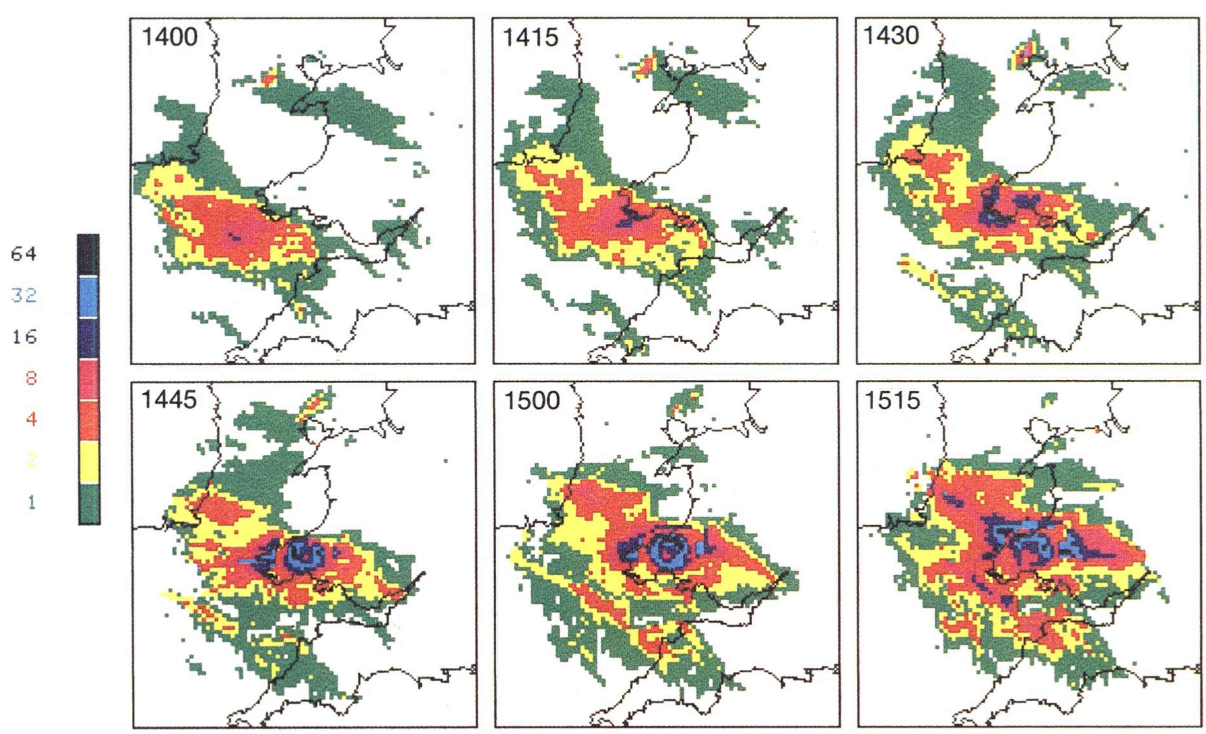

Figure 1. Evolution of a 'bright-band' annulus about the Dyfed radar from 1400 to 1515 UTC on 9 January 1991. Radar rainfall rates are indicated by the adjacent key, the number giving the rate (mm h^{-1}) at the top of the band.

gathering close to the radar (within about 35 km at Dyfed). The lowest elevation beam, 'beam 0', is used for greater ranges. Fig. 3 shows how this arrangement can lead to a double bright-band effect, as in this example. If the melting level is lower than L_1 the effect will only show on beam 1; if above L_2, only on beam 0: in this event the bright-band was at 440 m above the radar. The curve I shows schematically the cross-section of the intensity map assuming a uniform rainfall rate and making no allowances for the different reflectivities of rain and dry snow. Note that for a bright-band of uniform depth, the intensity will be higher nearer the radar where it occupies a greater fraction of the beam depth.

The overestimation of the rainfall rate caused by the bright band is clearly apparent from Fig. 4, the hyetogram from Brawdy, 48 km west of the radar. For the period of Fig. 1 (1400–1515 UTC) the ground truth is an almost constant 4 mm h^{-1} (red/magenta) as compared with cyan (16–32 mm h^{-1}) and possibly black (32–64 mm h^{-1}) pixels in the radar picture. The maximum rainfall rate at Brawdy was 10 mm h^{-1} at 1536 UTC on the line of strong echoes running north-west to south-east near the south-west boundary of the system, on the surface warm front in Fig. 2.

R.M. Blackall

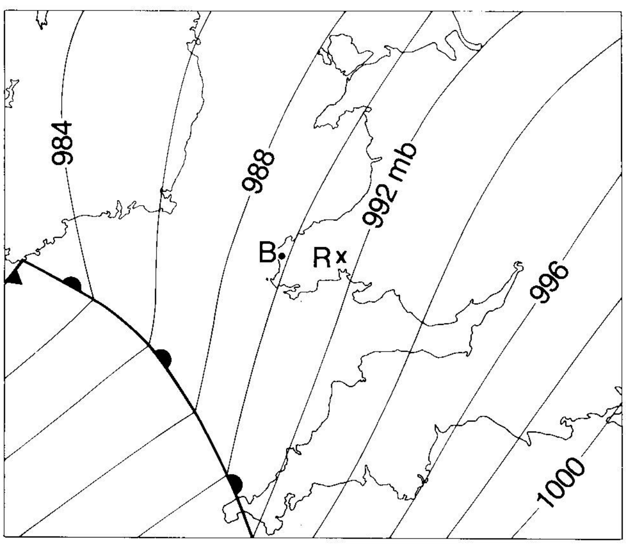

Figure 2. Surface synoptic chart for 1500 UTC on 9 January 1991. Isobars are at 2 mb intervals. R marks the location of the Dyfed radar and B the location of Brawdy.

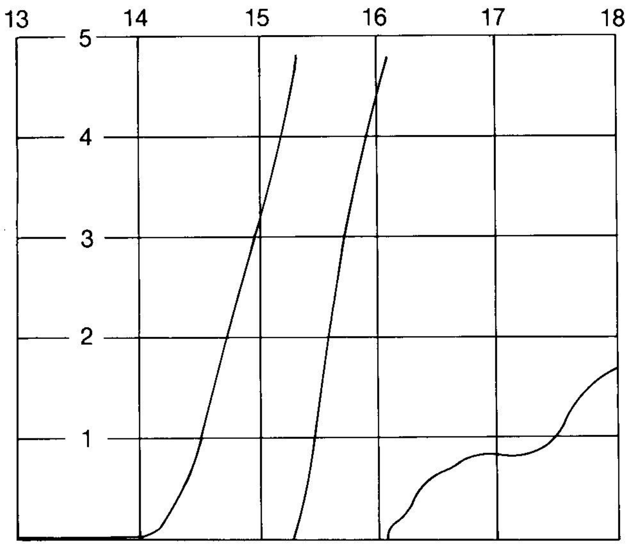

Figure 4. Hyetogram from RAF Brawdy from 1300 to 1800 UTC on 9 January 1991. The rainfall rate is 4 mm h^{-1} for the period shown in Fig. 1. The peak intensity is about 10 mm h^{-1} at 1536 at the passage of the warm front shown in Fig. 2.

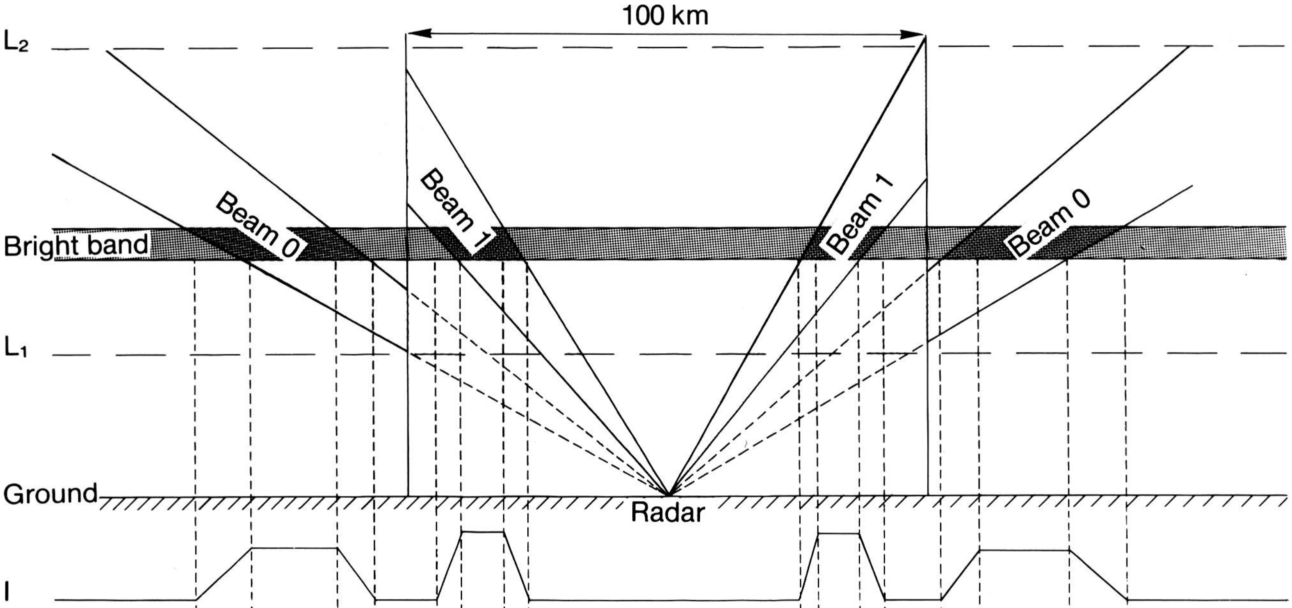

Figure 3. Diagram showing the position of the two beams used for gathering data. Beam 1 is used for gathering data close to the radar, whilst beam 0 is used for greater ranges. The higher-elevation beam is used by the radar close in to avoid ground clutter, leading to a double annulus if the bright band lies between levels L_1 and L_2 (vertical scale greatly exaggerated). The curve 'I' shows the level of enhancement of the radar return above the true value.

GUIDE TO AUTHORS

Content

Articles on all aspects of meteorology are welcomed, particularly those which describe results of research in applied meteorology or the development of practical forecasting techniques.

Preparation and submission of articles

Articles, which must be in English, should be typed, double-spaced with wide margins, on one side only of A4-size paper. Tables, references and figure captions should be typed separately. Spelling should conform to the preferred spelling in the *Concise Oxford Dictionary* (latest edition). Articles prepared on floppy disk (Compucorp or IBM-compatible) can be labour-saving, but only a print-out should be submitted in the first instance.

References should be made using the Harvard system (author/date) and full details should be given at the end of the text. If a document is unpublished, details must be given of the library where it may be seen. Documents which are not available to enquirers must not be referred to, except by 'personal communication'.

Tables should be numbered consecutively using roman numerals and provided with headings.

Mathematical notation should be written with extreme care. Particular care should be taken to differentiate between Greek letters and Roman letters for which they could be mistaken. Double subscripts and superscripts should be avoided, as they are difficult to typeset and read. Notation should be kept as simple as possible. Guidance is given in BS 1991: Part 1: 1976, and *Quantities, Units and Symbols* published by the Royal Society. SI units, or units approved by the World Meteorological Organization, should be used.

Articles for publication and all other communications for the Editor should be addressed to: The Chief Executive, Meteorological Office, London Road, Bracknell, Berkshire RG12 2SZ and marked 'For Meteorological Magazine'.

Illustrations

Diagrams must be drawn clearly, preferably in ink, and should not contain any unnecessary or irrelevant details. Explanatory text should not appear on the diagram itself but in the caption. Captions should be typed on a separate sheet of paper and should, as far as possible, explain the meanings of the diagrams without the reader having to refer to the text. The sequential numbering should correspond with the sequential referrals in the text.

Sharp monochrome photographs on glossy paper are preferred; colour prints are acceptable but the use of colour is at the Editor's discretion.

Copyright

Authors should identify the holder of the copyright for their work when they first submit contributions.

Free copies

Three free copies of the magazine (one for a book review) are provided for authors of articles published in it. Separate offprints for each article are not provided.

Contributions: It is requested that all communications to the Editor and books for review be addressed to the Chief Executive, Meteorological Office, London Road, Bracknell, Berkshire RG12 2SZ, and marked 'For *Meteorological Magazine*'. Contributors are asked to comply with the guidelines given in the *Guide to authors* which appears on the inside back cover. The responsibility for facts and opinions expressed in the signed articles and letters published in *Meteorological Magazine* rests with their respective authors.

Subscriptions: Annual subscription £33.00 including postage; individual copies £3.00 including postage. Applications for postal subscriptions should be made to HMSO, PO Box 276, London SW8 5DT; subscription enquiries 071–873 8499.

Back numbers: Full-size reprints of Vols 1–75 (1866–1940) are available from Johnson Reprint Co. Ltd, 24–28 Oval Road, London NW1 7DX. Complete volumes of *Meteorological Magazine* commencing with volume 54 are available on microfilm from University Microfilms International, 18 Bedford Row, London WC1R 4EJ. Information on microfiche issues is available from Kraus Microfiche, Rte 100, Milwood, NY 10546, USA.

April 1991

Vol. 120
No. 1425

Contents

Page

The normal distribution and the interannual variability of the global surface temperature record. A.H. Gordon 61

Noctilucent clouds over western Europe during 1989. D.M. Gavine 65

Correspondence
Contribution to the discussion on 'A heavy mesoscale snowfall event in northern Germany' (by W.S. Pike, **119**, 187–195 and 271). T. Andersson 67
Reply by W.S. Pike 69

Notes and news
The warmest year ever globally 71

Reviews
Weather radar networking. C.G. Collier and M. Chapuis (editors). *G.A. Monk* 71
Earth's rotation from eons to days. P. Brosche and J. Sündermann (editors). *R. Hide* 71
Weather watch. R.F. File. *R. Reynolds* 72
Global air pollution: Problems for the 1990s. H.A. Bridgman. *F.B. Smith* 73
Television weathercasting: A history. R. Henson. *M.J. Fish* 73

Books received 74

Radar photographs — 9 January 1991 from 1400 to 1515 UTC.
R.M. Blackall 75

ISBN 0-11-728855-1

9 780117 288553

ISSN 0026–1149

Printed in the United Kingdom for HMSO
Dd 0291241 4/91 C13 503 12521