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A study of a katabatic wind at Brüggen on 27 February 1975

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Summary

An investigation was carried out into the circumstances associated with a good example of a katabatic wind recorded at Brüggen. It is suggested that the apparent rapid decay of the katabatic wind after 2000 GMT was due to the anemometer head becoming submerged in a suddenly deepening pool of more stagnant colder air and that katabatic winds continued to flow at higher levels above the station. It is also suggested that buoyancy waves occurred associated with fluctuations in the height of the stable interface between the air in the top of the cold stable layer and the lower part of the warmer katabatic flow.

1. Introduction

Brüggen (station 10 401) is situated at 51°12′N, 06°08′E and 76 m above mean sea level (m.s.l.) on a small ridge (Fig. 1). Southwards, the ground first falls to about 40 m across the valley of the Rur then rises gently to 200 m at Aachen, a distance of 50 km, and then more steeply to over 610 m in the Eifel range of hills, a further distance of 20 km. Katabatic winds are not uncommon at Brüggen although in general wind speeds do not exceed 4 m s^{-1}. However, almost invariably these winds prevent fog formation, even when the air temperature falls below the normally forecast fog-point or, on occasions when fog is present, they may clear the fog.

2. Synoptic situation

At 1200 GMT on 27 February 1975 an anticyclone of 1037 mb was centred near Dresden with a ridge extending to the southern North Sea (Fig. 2). A very light pressure gradient associated with south-easterly winds existed over most of Germany and the Benelux countries. The air mass was dry with a relative humidity of 41% at Brüggen at 1200 GMT and as will be seen from the following table and Fig. 3, the air at 610 m over Uccle (near Brussels) and Essen at 1200 GMT was even drier.

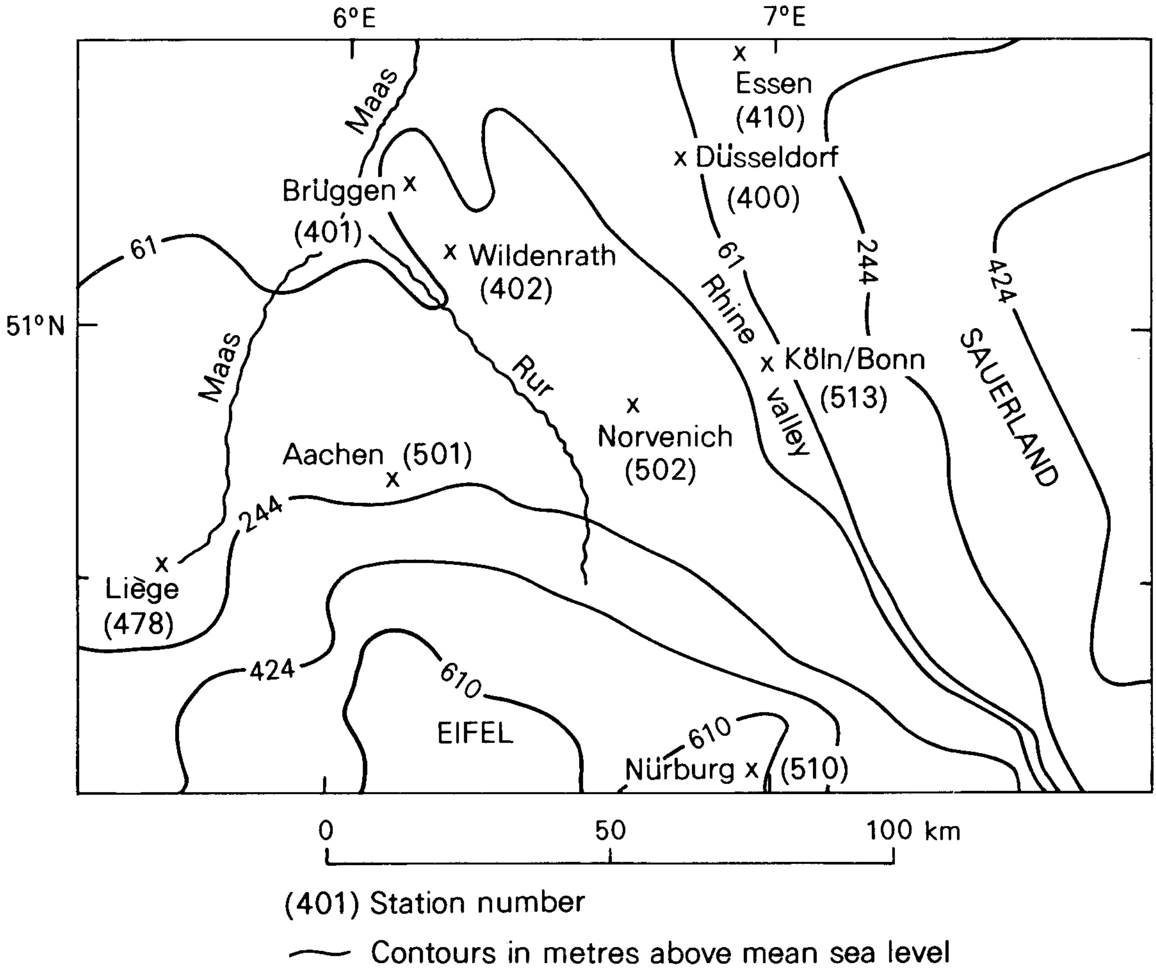

Figure 1. Location of Brüggen showing high ground and principal reporting stations in the area.

Temperature and humidity measurements

(a) *On the surface at Brüggen*

Time GMT	12	15	18	21	(Sunset 1713)
Air temperature (°C)	8·9	10·8	6·2	4·3	
Dew-point (°C)	−3·8	−4·1	−4·6	−4·3	
Relative humidity (per cent)	41	35	46	53	

(b) *By radiosonde at* 610 *m* (*approximately* 960 *mb*)

	Essen	Uccle
Time GMT	12	12
Air temperature (°C)	4·0	4·0
Dew-point (°C)	−18·0	−13·0
Relative humidity (per cent)	18	28

At 1800 GMT winds obtained by radiosonde from Essen and Uccle were 160–170°, 2–5 m s^{-1} at heights to 900 mb (about 1060 m).

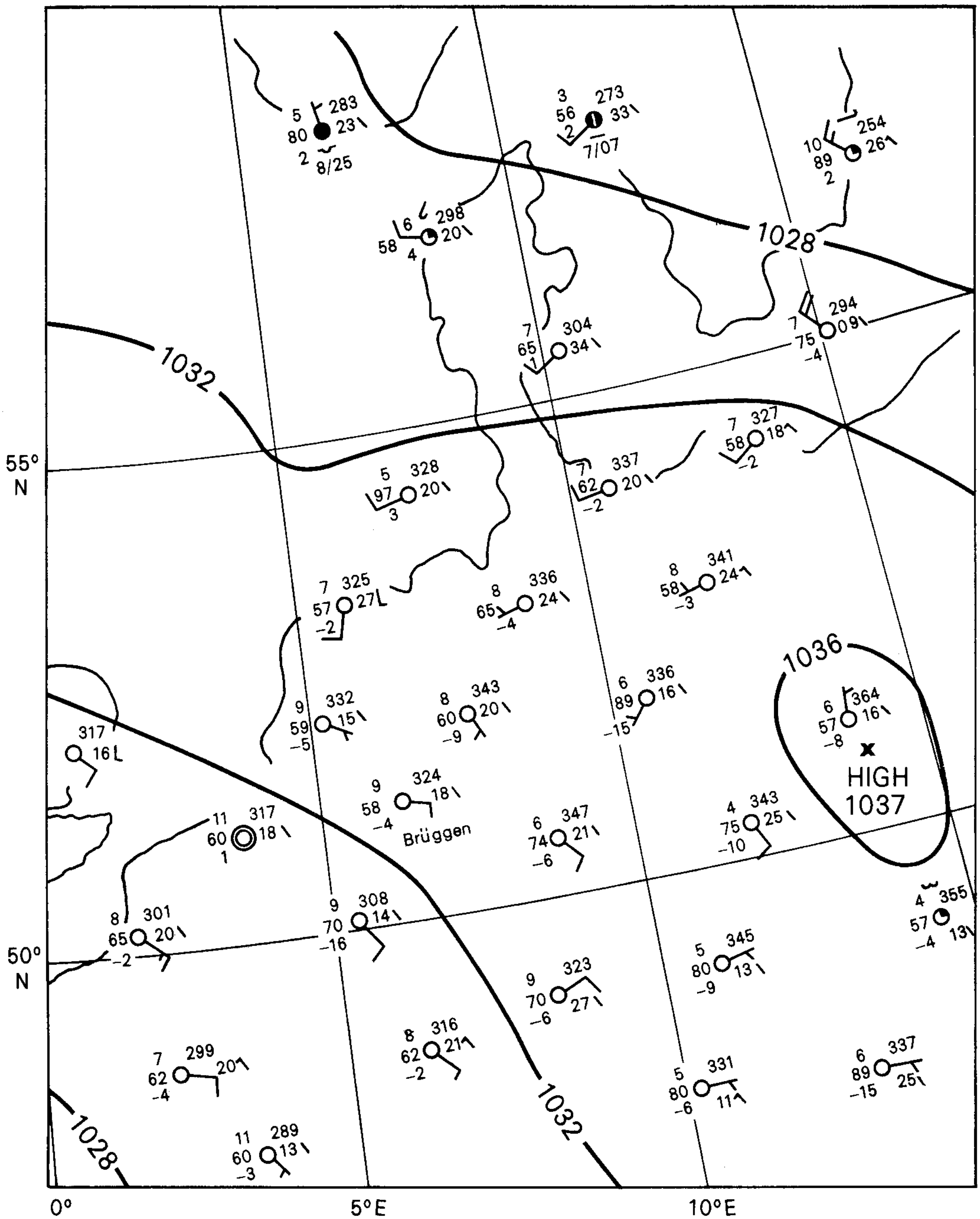

Figure 2. Synoptic situation on 27 February 1975 at 1200 GMT.

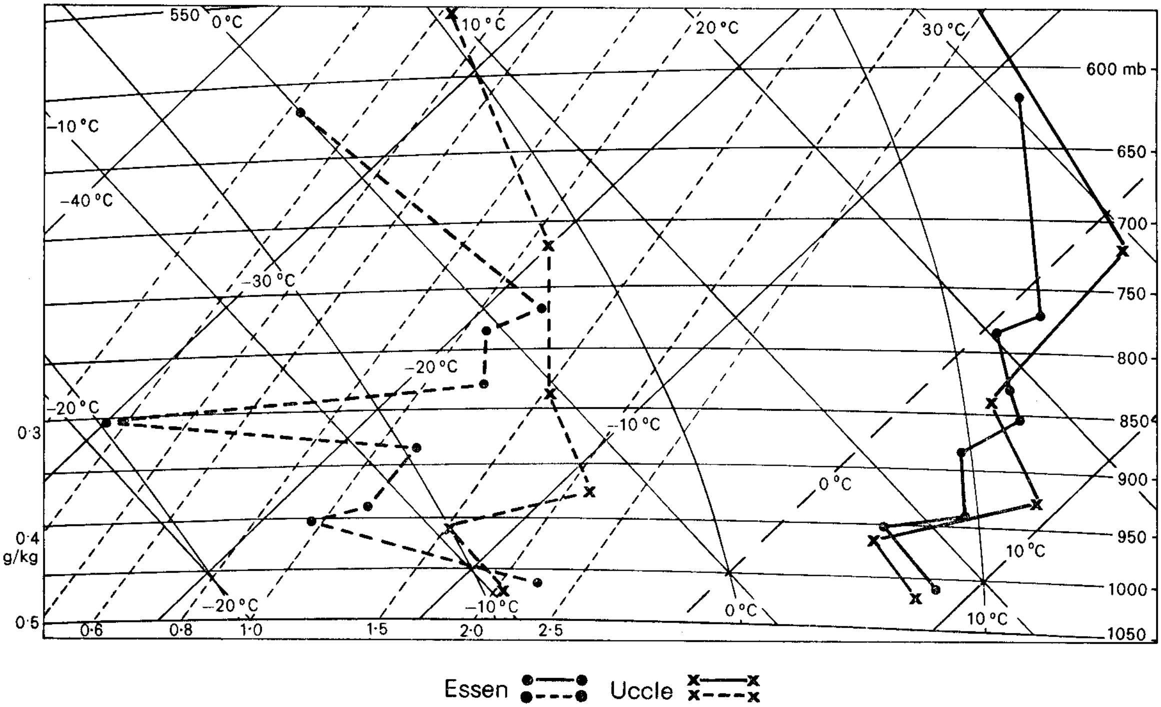

Figure 3. Radiosonde ascents for 1200 GMT on 27 February 1975.

3. Observations at Brüggen

(a) *Development of the katabatic wind*

Throughout the day and into the evening, skies were clear over north-west Germany and the Benelux countries. The mean surface wind at Brüggen during the afternoon was 110°, 10 kn (5 m s^{-1}), but from 1600 GMT the wind decreased in speed, became less turbulent and backed to become 100°, 5 kn by 1730 GMT (Fig. 4). Thereafter the wind started to veer and increased in both speed and gustiness, with a maximum veer to 180° being reached at about 1920 GMT when the mean speed had increased to 10 kn. By 1950 GMT the mean speed had reached 14 kn, with a gust to 20 kn, but from 1950 to 2010 GMT the wind rapidly backed and decreased to 060°, 5 kn and the traces narrowed. Tabulated values in Fig. 4 are mean wind directions and speeds (degrees true and knots) and a maximum gust (knots) in the hour indicated. Time marks on extensions of Fig. 4 indicate that the chart time is in accord within a minute of the times at which the marks were recorded.

For the rest of the night until 0400 GMT the surface wind speed varied between 2 and 7 kn, but four notable peaks occurred—at 2230, 0005, 0235 and 0335 GMT. The wind direction changed frequently. In particular there were periodic fluctuations between north-east and south-east with a period of about 15 minutes between 2015 and 2115 GMT and further periodic fluctuations of smaller amplitude and a slightly longer period between 2130 and 2230 GMT, all associated with wind speeds of about 5 kn (see Fig. 4). Other, less pronounced, periodic variations continued through the night associated with lower speeds. On three of the occasions of speed increases already noted, the wind direction reverted to southerly, associated with the strong katabatic.

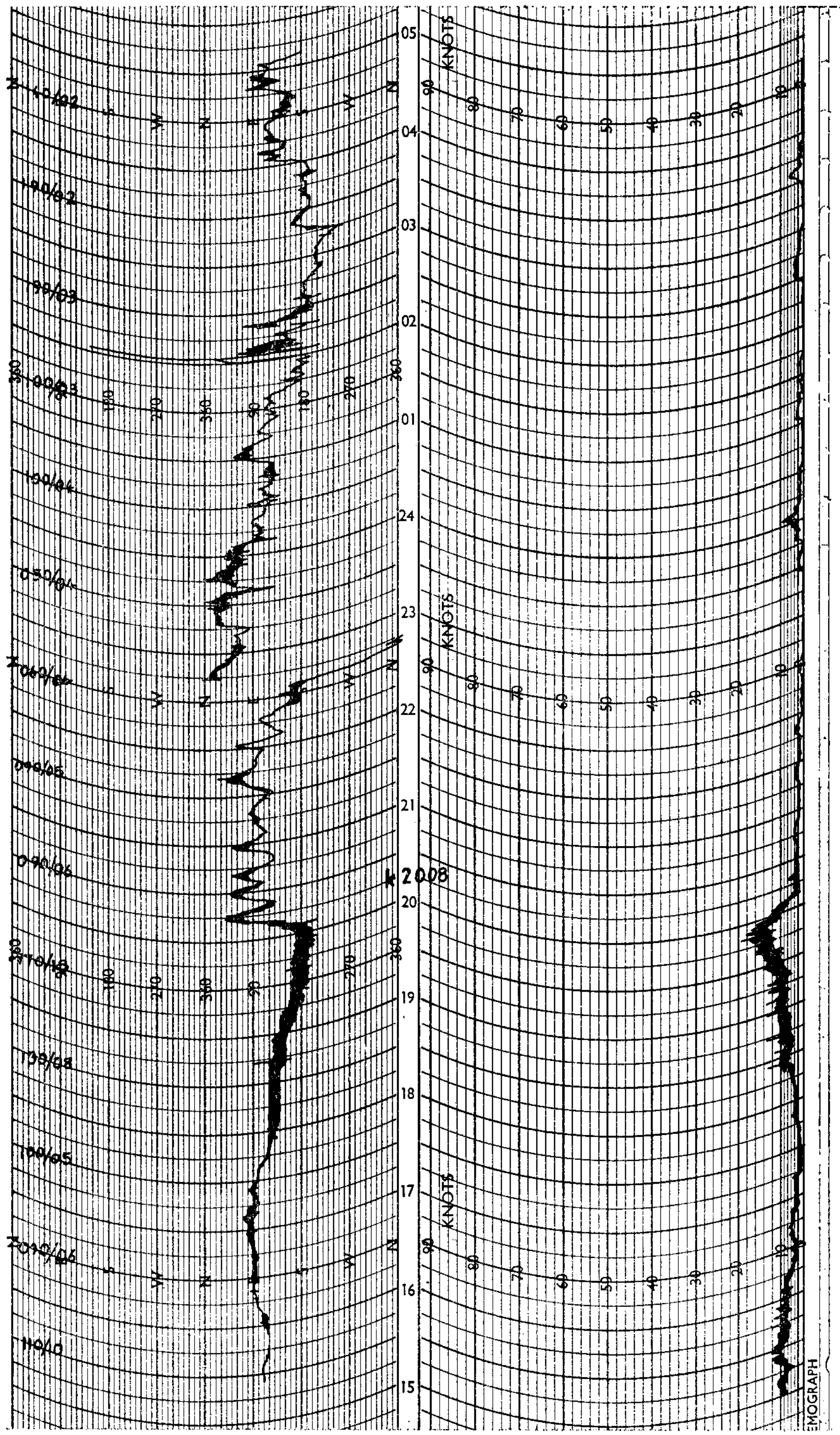

Figure 4. Anemogram from Brüggen, 27–28 February 1975.

(b) *Variation in surface temperature, humidity and pressure*

From a reading of 10·8 °C at 1500 GMT, the temperature fell rapidly to 5 °C at about 1800 GMT, but between 1800 and 2000 GMT, whilst the katabatic wind was being recorded, it exhibited two apparently periodic fluctuations between 5 °C and 6·5 °C with periods close to one hour (Fig. 5(a)). The sharp fall of temperature was resumed from about 2000 to 2200 GMT, but although there was a slow overall fall of temperature during the night, periodic fluctuations occurred with rises and falls of temperature of 1 to 2 °C, with a period of about one hour until 0300 GMT but with longer periods after this time. Similar changes but of opposite signs were recorded on the hygrogram (Fig. 5(b)).

By superimposing corresponding maxima and minima on the hygrogram and thermogram for different parts of the night it is evident from the detailed shapes of the traces that the two traces are in antiphase throughout the night. However, this superimposition also indicates that the relative apparent times of the two records changed from a difference of the order of 30 to 35 minutes at the start of the night—in reasonable agreement with the evidence from the time marks—to a difference of about 15 to 20 minutes late in the night. Apparently the relative timings of the two records changed by something of the order of 15 minutes during the course of the night. It is likely that this change was due not so much to clock rates of the recording drums, but to non-coincidence of the pen arcs with the curved time lines on the charts. If this is so it implies that the time of the autographic record is (at least sometimes) a function of the variable under record—as well as the clock rate. This incompatibility of timing between thermogram and hygrogram made it impracticable to relate time on these records with sufficient precision, relative to the phases of the anemogram pulsations, to be sure of the phase relationship between the oscillations of wind and of temperature and humidity.

The barogram trace (Fig. 6) shows that pressure mostly fell slowly and unsteadily throughout the 27th and 28th without any particularly unusual features. Nevertheless there was a temporary increase in the rate of fall followed by a check to little change at about 1930 barogram time, which, according to the time mark at 1150 on the 27th, corresponds to about 2000 clock time. However, again there is uncertainty in the timing. According to the time marks the barogram time is about 20 minutes slow on the 26th, 30 minutes slow on the 27th and 30 minutes fast on the 28th.

4. Observations in the surrounding area

(a) *The observed synoptic temperature field*

Synoptic observations of the temperature distributions at screen level, together with associated winds and dew-points within 200 km of Brüggen at 2100 GMT on 27 February and 0300 GMT on 28 February are shown in Figs 7(a) and 7(b) respectively. Areas of relatively high temperature in the foothills of the Eifel and Sauerland are apparent on both charts. In flowing down the slopes the dry air would be subject to adiabatic warming at a rate approaching the dry adiabatic lapse rate (i.e. about 5 °C/500 m). The extent of this warming would depend on the height change experienced by the air along its track. If this were the only factor the air temperature would increase northward on the charts as the air flow from the hilltops passed over lower and lower ground. The fact that the screen temperature decreased northward from the foothills at these times indicates that a more complex process was taking place, such that away from the foot of the steeper slopes radiative cooling was more than making up for lower station levels—as far as screen-level temperature was concerned.

(b) *Surface wind, temperature and pressure characteristics at other stations in the local area*

Copies of the anemograms, thermograms and barograms were obtained from a number of stations in the vicinity of Brüggen—i.e. Wildenrath (89 m above m.s.l.), Nörvenich (135 m above m.s.l), Düsseldorf

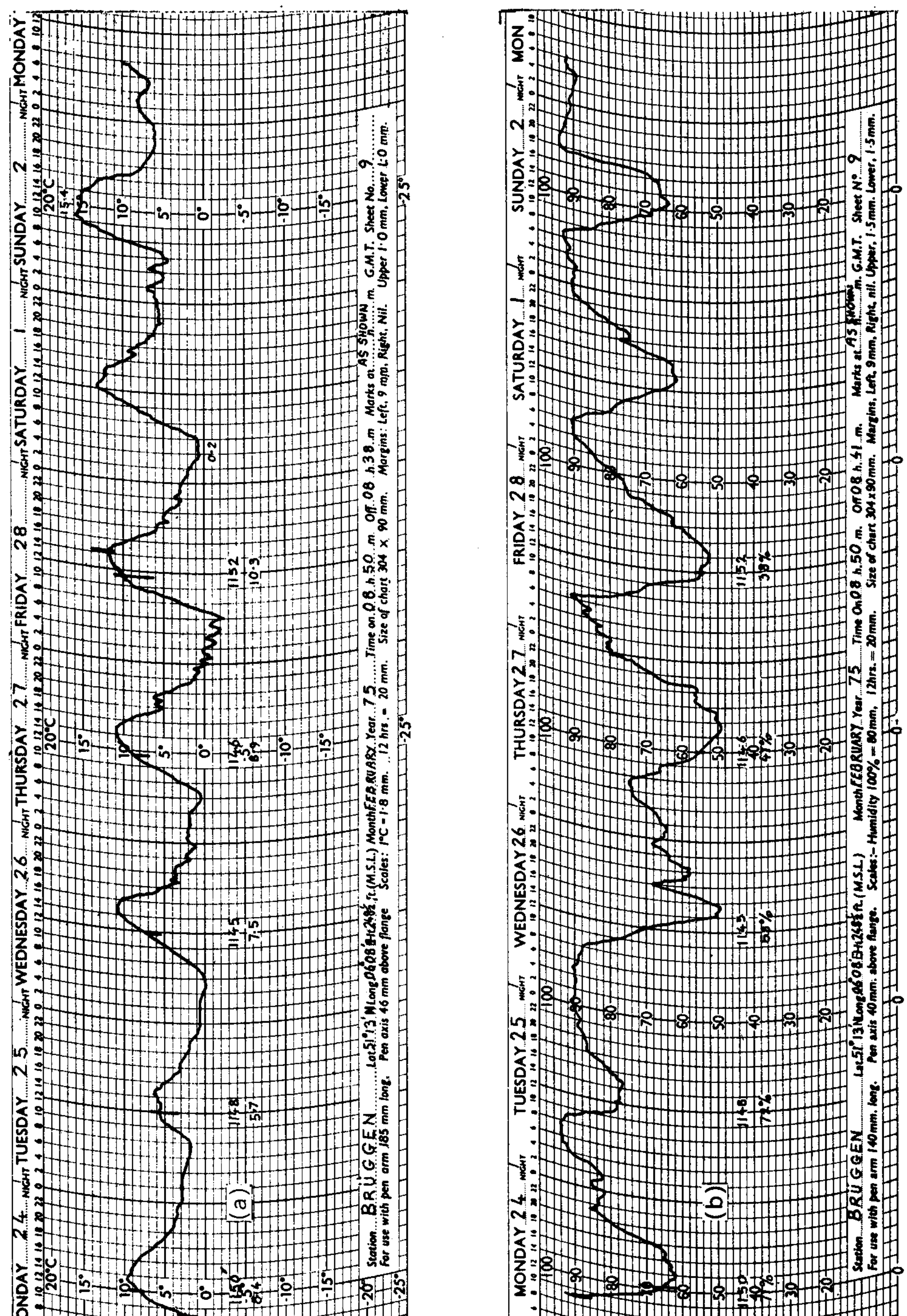

Figure 5. Thermogram (a) and Hygrogram (b) from Brüggen, 24 February–2 March 1975.

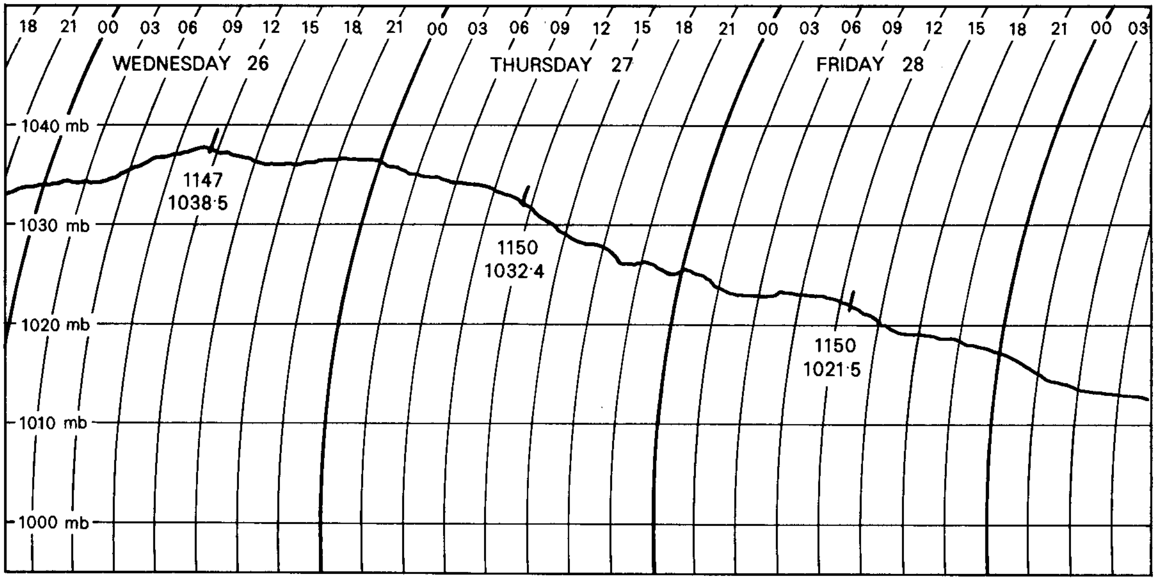

Figure 6. Copy of barograph trace from Brüggen, 26–28 February 1975.

(44 m above m.s.l.), Köln/Bonn (92 m above m.s.l.), Aachen (205 m above m.s.l.) and Essen (161 m above m.s.l.). In general, katabatic winds were in evidence at all these stations and the thermograms at most sites displayed features comparable with, but less well-marked than, those recorded at Brüggen.

At Wildenrath—less than 20 km to the south-south-east of Brüggen—the anemometer continued to record a southerly until 2055 GMT (i.e. one hour later than at Brüggen), then backed to easterly with direction oscillations from north-east to south-east of periods of about 12 to 20 minutes.

At Nörvenich—50 km to the south-east of Brüggen—the anemometer recorded a temporary backing from south-east to north-east at about 2020 GMT, but a southerly continued until after 2200 GMT before backing to an easterly and there is evidence of fluctuations of temperature at about 2020 GMT.

At Aachen—60 km to the south of Brüggen—the anemometer recorded a north-easterly wind from 1500 to after 1800 GMT, and thereafter the direction indicated wandered between north-east and south with signs of sticking until after 2000 GMT, but then resumed normally fluctuating recording at slightly west of south until after 0300 GMT.

The barograms showed small-scale features similar to those recorded at Brüggen.

5. Discussion

(a) *Conditions suitable for the katabatic wind to develop*

From the midday radiosonde ascents at Uccle and Essen, it would be expected that the temperature in the free air at 610 m above m.s.l. to the north of the Eifel range during the afternoon would have been 4 °C (Fig. 3). Over the high ground at about the same level above the sea, typified by Nürburg, 629 m above m.s.l. and some 120 km south-south-east of Brüggen, the 1500 GMT surface temperature was 7 °C, i.e. some 3 °C higher. By 1800 GMT the temperature at Nürburg had fallen to 3 °C. On the basis of the usual rates of temperatures change in clear weather it is suggested that it fell in the following manner:

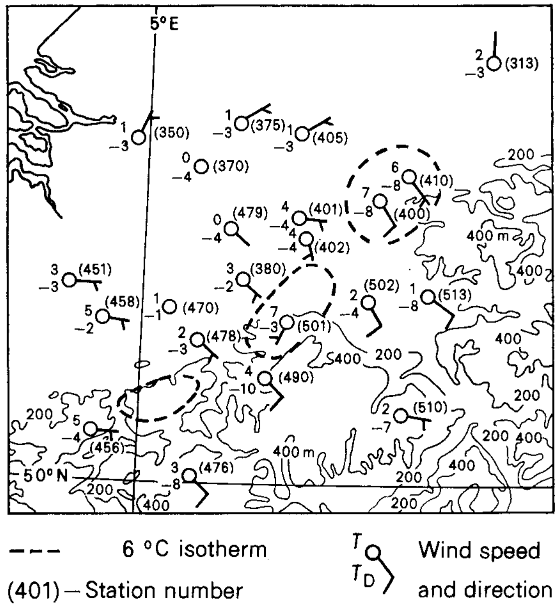

Figure 7(a). Surface chart for 2100 GMT on 27 February 1975.

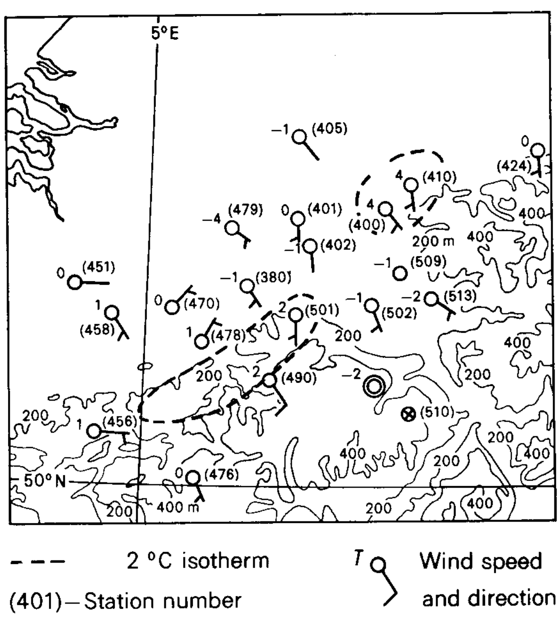

Figure 7(b). Surface chart for 0300 GMT on 28 February 1975.

Surface temperature at Nürburg

Time GMT	15	16	17	18	19
Air temperature (°C)	7·0	6·5E	5·5E	3·0	2·0E

E = Estimated

The decrease in speed and associated backing and reduced gustiness of the wind recorded between 1600 and 1730 GMT at Brüggen is likely to be due to the decrease in insolation (sunset 1713 GMT) and consequential reduction in the downward flux of eddy momentum from the wind in the free atmosphere.

Around 1730 GMT the surface temperature over the higher ground had fallen to equal the value of 4 °C, which existed at the same height above m.s.l. in the free air to the north. Thereafter, as the temperature over the slopes of the hills fell further, the surface air became denser than that at the same level relative to m.s.l. above the low ground and began to sink. With this process taking place all along the slopes of the Eifel range, from levels at about 610 m to the lower level around 180 m, a southerly katabatic wind was produced. This wind reinforced the light south-easterly flow that existed due to the pressure gradient so that the strength of the surface wind increased up to values recorded at Brüggen. It is probable that the katabatic wind occurred in the form of several streams down the hillsides, the one affecting Brüggen perhaps being steered northward along the Brüggen ridge.

At Brüggen after the peak katabatic wind at 1950 GMT the surface wind fell light with the periodic fluctuations in wind direction and temperature already noted.

(b) *Possible explanation for the observed surface wind and temperature variations at Brüggen*

As demonstrated by Fig. 4 the katabatic wind at Brüggen was turbulent, which would increase the depth of the atmosphere otherwise involved and modify both the temperature and the wind profiles in the vertical. The change of temperature with height in this dry turbulent current would tend to approach the dry adiabatic lapse rate and the associated rate of change of mean wind with height would be relatively small although some of the differences between turbulent elements could be quite high. The apparent rapid decay of the strong katabatic flow around 2000 GMT with subsequent wind changes and the nocturnal temperature changes are of particular interest. The following suggests tentative explanations of the observations.

The nocturnal radiative process gave rise not only to the katabatic wind but also to ground-based layers of more stagnant air, characterized by increase of temperature with height, which grew in depth above local ground levels as the night progressed. Initially these ground-based stable layers would form as isolated puddles over local depressions and low relatively level ground but as their tops grew upwards these puddles would progressively amalgamate into larger and larger pools effectively forming deepening sinks above which wind in the free air would continue to flow. At the interface zone between the top of the stagnant pools and the free atmosphere there would be a marked shear of wind. Where the wind above the stagnant stable layer had been augmented by katabatic effects, involving air parcels travelling downwards through substantial heights, the air in the katabatic current would have been subjected to adiabatic warming along its trajectory (as well as radiational cooling) and the rate of increase of temperature with height in the stable layer would probably be enhanced through the interface zone. This combination would give rise to travelling buoyancy waves which would effectively vary the local height of the interface as they passed by. If the wind shear with height became too strong to be supported by the thermal stability, turbulence would develop and redistribute the profiles to reduce the wind shear—effectively deepening the interface, extracting wind energy from the free atmosphere, and feeding into the sinks, so that the pools grew further in depth. In particular, katabatic winds would flow on top of and mix into the tops of pools growing above lower level ground, in the way rain-streams on uneven pavements flow to form puddles and—with the aid of indicators such as traces of oil—can be seen to stream for a time in the upper parts of the puddles they feed. There is also the possibility that hydraulic jumps could form at the foot of the steeper hills and propagate along the stable layer and interface as suggested by Clarke (1972) in his explanation of the morning glory of the Gulf of Carpentaria, following Ball (1956) in his theory of strong katabatic winds in the neighbourhood of Antarctic coasts. It is noteworthy that Ball, describing these winds, states: 'During the period of the lull strong winds may be both audible and visible higher up the slopes and sometimes a strong air stream, rendered visible by drift snow, is seen overriding the calmer air beneath'.

The Brunt–Väisälä period of the stable layer and interface would be of the order of a few minutes or even much less, but that of the turbulent katabatic layer would be much longer, of the order of half an hour at least, and probably substantially longer, depending on how little the lapse of potential temperature in the turbulent katabatic layer departed from zero. Thus buoyancy waves with periods in the range from a few minutes to an hour or so would tend to be trapped and travel long distances in the interface and stable layer, and be associated with periodic changes in the local height of the interface above the ground. These height changes would be in addition to the more general increase of height of the interface with time from sunset.

Within this general hypothesis—which involves the anemometer head at Brüggen becoming submerged in a more stagnant layer about 2000 GMT, whilst a wind probably still katabatically enhanced continued to blow in some rather higher layer—there are three possibilities to consider, which we call (A), (B) and (C). In (A) the stagnant stable layer grew over the local ground so that the local interface grew above the level of the thermograph and hygrograph screen soon after sunset—some hours before it grew above the anemometer head. In (B) the stagnant stable layer grew over lower ground gradually spreading to engulf the screen and anemometer head at nearly the same time—rising locally at Brüggen much more rapidly than in the first. In (C) the depth of the stagnant stable layer of (B) also increased almost discontinuously when a hydraulic jump passed over the area.

On (A) during the period 1700–2000 GMT at Brüggen—whilst the anemometer was recording the developing katabatic wind but the screen was in the stagnant stable layer below the level of the interface —passage of some of the buoyancy waves on the interface should appear as cyclic variations of temperature and coincident and antiphase oscillations of relative humidity. Indeed the two oscillations shown on these instruments during the period 1800 to 2000 GMT with periods close to one hour could be evidence of such waves. There are no clearly defined associated wave features on the anemogram. (Up to this time it is postulated that the anemometer head remained above the level of the interface.) Associated changes in surface pressure are likely to be too small to be reliably detected on an ordinary barogram and it cannot be claimed that particular small changes are associated with particular waves (no microbarograph records are available). However, on this first possibility the apparent decay of the katabatic wind recorded at about 2000 GMT would be mainly a record of the shear of wind across the interface—a vector change of the order 15 kn (7 m s^{-1}) over a very small height interval presumably of only a few metres. Considering the Richardson number

$$(Ri) = \frac{g}{\theta} \cdot \frac{\partial\theta/\partial z}{(\partial v/\partial z)^2} \quad \ldots \quad (1)$$

(where θ is the potential temperature,
g is the acceleration due to gravity,
v is the horizontal wind vector, and
z is the vertical co-ordinate)

the flow will be unstable, resulting in a redistribution and a reduction of the vertical shear of wind if (Ri) is less than, say, $\frac{1}{4}$. Putting $g = 10$ m s^{-2}, $\theta = 280$ K and expressing equation (1) in finite difference form this becomes

$$\frac{\Delta\theta\Delta z}{(\Delta v)^2} = 7. \qquad \text{.. .. ..} \qquad (2)$$

Thus if $\Delta v = 7$ m s^{-1} and $\Delta z = 2$ m then to avoid instability $\Delta\theta$ is required to be of the order of 175 K which is quite impossible and decisively disproves (A).

Alternatively, setting an order of magnitude of 5 K for $\Delta\theta$, then for $\Delta v = 7$ m s^{-1}, Δz needs to be 70 m to avoid instability. This accords more reasonably with (B) and especially (C), that the stagnant stable layer grew first over lower ground and the change of wind at Brüggen at about 2000 GMT was associated with much more rapid change of height of the interface above Brüggen than in (A)—so that the screen as well as the anemometer was not submerged in the stable layer until nearly 2000 GMT.

The temperature (and humidity) changes from 1600 to 2000 GMT are then interpreted as an ordinary diurnal fall (a rise for humidity) —checked by the developing katabatic air stream (which was itself warmed adiabatically during the descent and deeper than the more stable surface air)—with the diurnal fall resumed after the screen became submerged. The periodic changes recorded between 1800 and 2000 GMT are then interpreted as mesoscale advective features associated with the veering of the wind from south-east to south as the katabatic wind developed. The temperature and humidity variations between 1800 and 2000 GMT are thus considered to be due to different physical mechanisms to those recorded later in the night.

The check in the fall of pressure at about 1930 barogram time (probably about 2000 clock time) might be evidence in support of the hydraulic-jump concept.

After 2000 GMT, when the top of the stable layer was above the anemometer head at Brüggen, passage of buoyancy waves along the interface and within the stable layer showed up as vector variations in the wind recorded by the anemometer (especially as wind direction variations) as the height of the interface and its associated shears of wind oscillated relative to and above the anemometer head. The periods of these oscillations, as recorded on the anemograph, started at about 12 minutes over the first two cycles, increased to about 21 minutes over the next four cycles and there is evidence that quasi-periodic changes continued throughout the night—many of them with periods of about 15 minutes. The periods of the oscillations on the thermogram and hygrogram which also continued throughout the night were much longer, ranging from about 1 to $1\frac{1}{2}$ hours—the longer periods occurring in the latter part of the night. Since the screen is much closer to the ground than the anemometer head it is likely to be affected by only some of the oscillations of the height of the interface which affected the anemometer.

The vector wind changes recorded at the surface in the first few cycles after 2000 GMT are of the order of 3 m s^{-1}. It is a matter of speculation what shear this represents in the vertical. If the associated potential temperature change (which is likely to be larger than any associated temperature change at the screen level) is 2 K equation (2) implies that the lower limit for Δz is 30 m; if $\Delta\theta$ is 5 K then the lower limit for Δz is 13 m.

If this explanation is broadly correct it is to be expected that when oscillations of wind and temperature are due to the passage of the same wave they will be related in phase such that veered winds are associated with temperature maxima and with relative humidity minima. The evidence in this respect is inconclusive; there appears to be both support and contradiction, but as already stated it proved impracticable to relate the time on the thermogram and hygrogram with sufficient precision relative to the phases of the anemogram pulsations.

Evidence in support of the contention that a wind enhanced by katabatic effects continued to blow over Brüggen after it had ceased at anemometer level is provided by the anemograms already mentioned for Wildenrath, Nörvenich and Aachen which continued to record katabatic winds long after the katabatic wind had apparently ceased at Brüggen. Presumably it took longer for the interface to grow above anemometer heights at these stations. It is conceivable that the katabatic wind above Brüggen decreased considerably after 2000 GMT and that the buoyancy waves travelling over Brüggen were generated by the interaction of katabatic winds elsewhere nearer the hills and a pre-existing stable layer as suggested by Christie *et al.* (1978) for their microbarograph waves of elevation. However, whatever the source of the buoyancy waves and whether or not the wind in the free air above Brüggen continued to be enhanced by katabatic effects the Brüggen anemograph indicates that substantial wind shear in the vertical continued to exist above anemometer height throughout the night.

6. Conclusions

The outstanding example of a katabatic wind recorded at Brüggen on 27 February 1975 was stronger than usual and apparently decayed at about 2000 GMT. Subsequent fluctuations of wind, particularly in direction, were recorded through the night, mainly with periods of the order of 15 minutes. Fluctuations of temperature and relative humidity, in antiphase, in the screen were recorded from about 1800 GMT through the night with periods mainly of the order of one hour.

The recorded changes are consistent with (a) the development of a layer of katabatic wind, (b) the development of a more stagnant stable ground-based layer, whose interface with a windier layer grew upwards starting above lower ground to pass suddenly above both the thermometer screen (2 m above ground level) and above the anemometer head (10 m above ground level) at about 2000 GMT, (c) the passage of trapped buoyancy waves along this interface and within the stable layer, and (d) the existence of strong shear of wind with height above Brüggen long after 2000 GMT. This suggests that an organized low-level wind shear, perhaps hazardous to aircraft, could be encountered at the bottom as well as at the top of a katabatic air stream at night—even after the local anemometer had ceased to record the katabatic flow.

Acknowledgements

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A comparative study of classifications of monthly mean sea surface temperature anomalies in the North Atlantic Ocean

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Summary

On the basis of mean monthly sea surface temperature data received in 1977 from the Meteorological Office at Bracknell, a classification of anomalies has been made for the North Atlantic Ocean. This is compared with the classification made by Ratcliffe (1971). In a good number of cases there is general agreement between the results of the classifications, but in many cases there are important differences.

Introduction

Nowadays it is generally assumed that ocean surface temperature anomalies on a large scale form one of the most important factors which might cause long-term weather anomalies. For this reason—in the search for methods to improve long-term weather forecasts—there was at the Royal Netherlands Meteorological Institute a few years ago a need of a climatology of North Atlantic sea surface temperatures (SST). In a preliminary study monthly SST anomalies have been calculated for each 1° × 1° square of this ocean for the period from January 1949 to December 1972. This was done using a magnetic tape, received from the Meteorological Office at Bracknell, containing mean monthly SST data for this period as well as monthly normals derived from U.S. Naval Oceanographic Office (1967). These data have also been used by Ratcliffe (1971). The number of observations is very variable both in space and in time. There are too many gaps to give a representative picture of the whole ocean for a certain month. The best coverage was found for about the same area as that used by Ratcliffe for his classification of SST anomalies (Fig. 1).

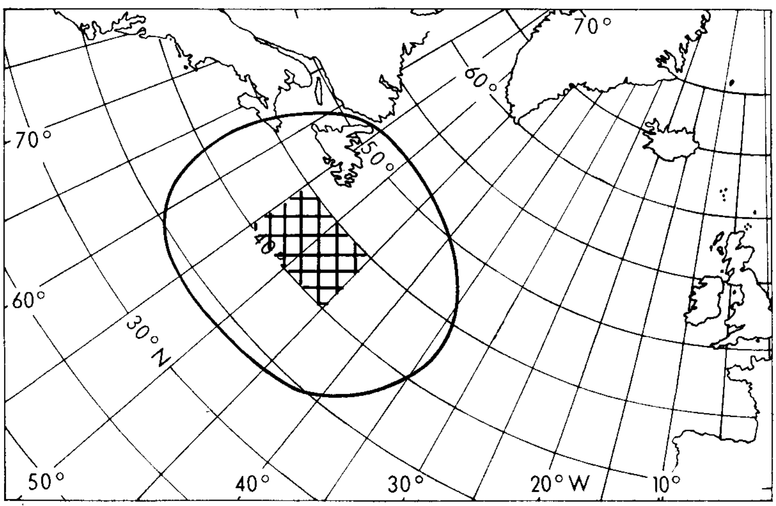


Figure 1. Area of ocean warmer or colder than usual for main classificaton types WP5 (warm case) and CP5 (cold case). Displacements east and west of the main anomaly centres by up to 10° are defined as WPE or WPW for the warm cases and CPE or CPW for the cold cases.

Because of the poor data coverage the original plan to make a classification for the whole North Atlantic Ocean was abandoned. Instead of this only the easy exercise of classifying the available material was performed, using the criteria and types described by Ratcliffe (1971).

The classification

In Tables I, II and III the present classification is compared with the Ratcliffe classification. The details of the classification are repeated here briefly.

The main classification concerns the sign of the anomaly of sea surface temperature in the area between 35°–50°N and 40°–60°W, particular importance being given to the sign of the anomaly from 40°–45°N and 45°–55°W (see cross-hatching in Fig. 1). If there is a well-defined warm or cold pool—anomaly exceeding 1 °C—covering much of this area the classification is WP5 for a warm pool centred near 50°W, WPE for a warm pool displaced up to 10° eastwards (i.e. centred between 40° and 50°W), WPW for a warm pool displaced up to 10° westwards (i.e. centred between 50° and 60°W) and there are three similar categories for cold pools, i.e. CP5, CPE and CPW. In the E and W cases particularly, the warm and cold pools may extend beyond the eastern or western boundaries respectively of the area as defined.

In addition to the six main types other classifications are possible. These are:

(a) *EZ or enhanced zonality.* In this class the ocean is colder than usual in the north-west Atlantic and warmer than usual in the southern and eastern part of the North Atlantic (Fig. 2).

(b) *DZ or decreased zonality.* In this class the ocean is warmer than usual in the north-west Atlantic and colder than usual in the southern and eastern part of the North Atlantic.

(c) *MWW or meridional warm west.* In this case the ocean is warmer than usual in the west (west of about 30°W) and colder than usual east of 30°W.

(d) *MCW or meridional cold west.* In this class the ocean is colder than usual in the west (west of about 30°W) and warmer than usual east of 30°W.

The comparison

It would take too much space to give the whole comparison for each individual month, so the following has been done. For both warm and cold pools there are three possibilities: WPW, WP5 and WPE for warm pools, and CPW, CP5 and CPE for cold pools. Combinations of these types can occur. In order to make an objective comparison between both classifications the classes have been extended in the following way:

WWW — WPW, WP5 and WPE.
WW . — WPW and WP5; no anomaly in the eastern part of the considered area.
W . . — WPW only.
W . C — WPW and CPE.
. . . — No anomaly, no type.
. W . — WP5 only.
etc.

This comparison can be found in Table I. In the 288 possible cases there was exact agreement 75 times (26·1 %); in 105 cases (36·5 %) there was a difference in one of the three positions; in 88 cases (30·5 %) there was a difference in two positions; while in 20 cases (6·9 %) all three positions were different.

Of the 89 months which were not classified in the sense of WP or CP in the original classification 59 could be classified with the help of the new data, while of the 62 months which could not be classified with the new data, 32 were classified in the original classification.

Table I. *Comparison of the present classification with the original classification by Ratcliffe over the period* 1949–72. *The numbers represent numbers of months*

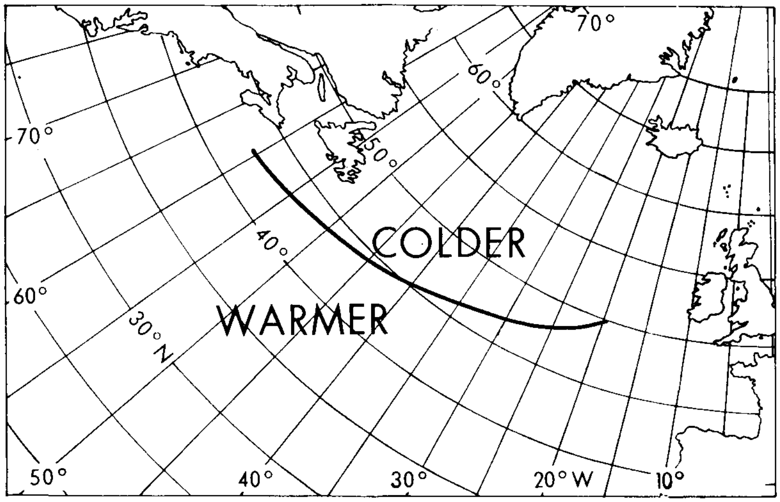
	Present classification																								
Ratcliffe	WWW	WW.	W..	W.W	.W.	.WW	..W	WWC	W.C	.WC	WC.	CCC	CC.	C..	C.C	.C.	.CC	..C	C.W	CWC	CW.	CWW	.CW	...	Total
WWW	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
WW.	5	—	2	5	—	—	—	—	2	—	—	—	—	—	—	—	—	1	—	—	—	—	—	3	18
W..	2	1	8	3	—	2	3	1	1	—	—	—	—	1	—	—	—	2	1	—	—	—	—	4	29
W.W	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
.W.	7	—	4	1	3	1	1	—	1	1	—	1	1	2	—	—	1	6	—	—	—	1	—	9	40
.WW	4	1	—	—	—	1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	14
..W	2	—	—	—	—	—	6	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	1	11
W.C	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	3
.WC	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1
WC.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1
CCC	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	2
CC.	—	—	—	—	—	—	—	—	—	—	—	2	2	4	—	—	1	1	—	—	—	—	—	—	10
C..	—	—	—	—	—	—	—	—	—	—	—	1	—	5	1	1	—	1	3	—	—	1	—	1	14
.C.	—	—	—	—	—	—	—	—	—	—	—	2	—	1	—	1	1	3	—	—	—	—	1	2	11
.CC	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	1	—	—	—	—	—	—	—	—	3
..C	—	—	—	—	—	—	—	—	—	—	—	8	—	—	1	—	2	16	—	—	—	—	—	4	31
C.W	1	—	—	—	—	—	1	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	4
CWC	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1
CW.	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	3
...	2	—	1	4	3	1	11	—	4	—	—	8	—	8	—	2	1	10	3	1	—	—	—	30	89
Total	24	2	15	14	6	5	28	1	9	1	—	25	3	23	3	5	8	41		1	—	2	1	62	288

Table II. *Comparison of both classifications with a reduced number of classes*

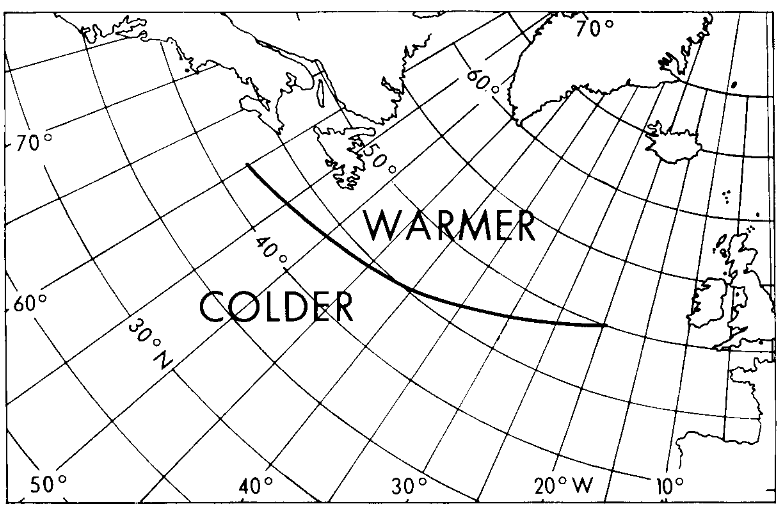
	Present classification				
Ratcliffe	WP	MC	CP	NC	Total
WP	68	10	15	22	115
MC	4	1	6	2	13
CP	—	5	58	8	71
NC	22	8	29	30	89
Total	94	24	108	62	288

Table III. *Comparison for the types DZ and EZ*

	Present classification			
Ratcliffe	EZ	DZ	NC	Total
EZ	26	1	12	39
DZ	1	17	34	52
NC	29	13	155	197
Total	56	31	201	288



(a) Enhanced zonality EZ.



(b) Decreased zonality DZ.

Figure 2. Area of ocean warmer or colder than usual for EZ and DZ classification.

'Not classified' means that there was no clear anomaly existing over a larger area (within 35°–50°N, 40°–60°W); it is not excluded that these cases can be classified as DZ or EZ.

For some months several classifications are possible. Of the 32 times that DZ occurred in the period 1949–72 it was accompanied in 16 cases by CP and in 3 cases by WP. Of the 56 times that EZ occurred in this period it was accompanied in 15 cases by CP and in 18 cases by WP. This confirms Ratcliffe's conclusion that DZ often occurs together with CP and less often with WP. However, his conclusions that EZ occurs more often together with WP than with CP is not confirmed.

Some researchers (Ratcliffe and Murray 1970, Oerlemans 1975) use a rougher classification by taking WWW, WW ., W . ., W.W, .W., . .W and .WW together to form one class WP (Warm Pool) and by taking CCC, CC., C.., C.C, .C., .CC and ..C together to form one class CP (Cold Pool). This has also been done in Table II. In class MC (Mixed Classification) those cases are taken together in which, for example, in the western part of the area considered there is a positive anomaly and in the eastern part a negative anomaly or the other way round. NC means Not Classified.

Of the 115 cases in which the Ratcliffe classification was WP there is agreement in only 68 cases. For CP the agreement is better, namely in 58 of the 71 cases. Finally, in Table III a comparison is given for the types EZ and DZ. Here, too, the agreement is not very good.

Persistence

The mean duration of the cold patterns was found to be 3·3 months and that of the warm patterns was 2·8 months. According to the Ratcliffe classification these numbers are respectively 1·7 and 2·9 months for the period 1949–72. So we also find a substantial difference here.

Conclusion

An attempt has been made to reproduce the Ratcliffe classification for the period 1949–72 using a tape with mean monthly SST data received from the Meteorological Office and using his criteria (objectively applied). Nevertheless, there are many differences in the results. This does indicate at least some ambiguity and one must be very careful in correlating certain atmospheric phenomena with certain categorized sea surface temperature anomaly patterns.

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551.574.41 (423)

Unusual road surface condensation

By B. A. Davey

(Meteorological Office, Royal Air Force Lyneham)

Summary

During the afternoon of 10 December 1980 the formation of a large quantity of moisture on road surfaces was witnessed at Lyneham. This note sets out to explain this phenomenon.

Introduction

By 1600 GMT on 10 December 1980 the duty observer at Lyneham had become concerned because the concrete and tarmac road surfaces in the vicinity of the observing office had become wet, although no precipitation had been observed. A thorough inspection of rain-gauges and all exposed metal and glass objects was made, but no evidence of precipitation could be found, nor could condensation be found elsewhere. The grass was also found to be dry.

By late evening so much moisture had formed that it began to collect in small pools, as though there had been a recent moderate shower.

Reports of what seemed to be the same phenomenon having occurred were received from towns and villages near Lyneham, namely: Wootton Bassett at 1500 GMT, Purton at 1900 GMT and Devizes at 1800 GMT (see Fig. 1). (The author had noticed moisture forming as early as 1415 GMT in the vicinity of Lyneham.)

Weather

On the day in question the south of England was under the influence of a cloudy south-westerly airstream (see Fig. 2). The wind between 1200 and 2200 GMT was a steady 210°, 7 m s^{-1}, with gusts to 13 m s^{-1}. Very small amounts of precipitation were recorded around the periphery of the area under discussion, but the Upavon rainfall radar confirmed that it was unlikely that any precipitation occurred in the vicinity of Lyneham. (The last recorded precipitation was on 5 December 1980.)

Although the airstream could be classified as tropical maritime it was not exceptionally moist, the humidity rising slowly throughout the day from a minimum of 76% at 0800 GMT to a maximum of 91% at 2100 GMT.

During the previous fortnight air temperatures at Lyneham had been well below average and ground frosts occurred on every night but one. The absolute minimum temperatures for this period occurred during the morning of 8 December when the air temperature fell to −5 °C and the concrete minimum (as measured by the standard alcohol-in-glass thermometer) fell to −7·5 °C. Subsequently the temperatures rose slowly as the mild south-westerly airstream became established.

Discussion

In addition to routine hourly observations of air temperatures at Lyneham an hourly record is also maintained of temperatures on and slightly below the surface of a 91 × 91 × 10 cm concrete slab. The concrete temperatures are measured by electrical resistance thermometers exposed both on, and 5 mm below, the surface of the concrete slab.

A study of graphs constructed from all the observations (see Fig. 3) reveals some interesting fluctuations in all the temperatures.

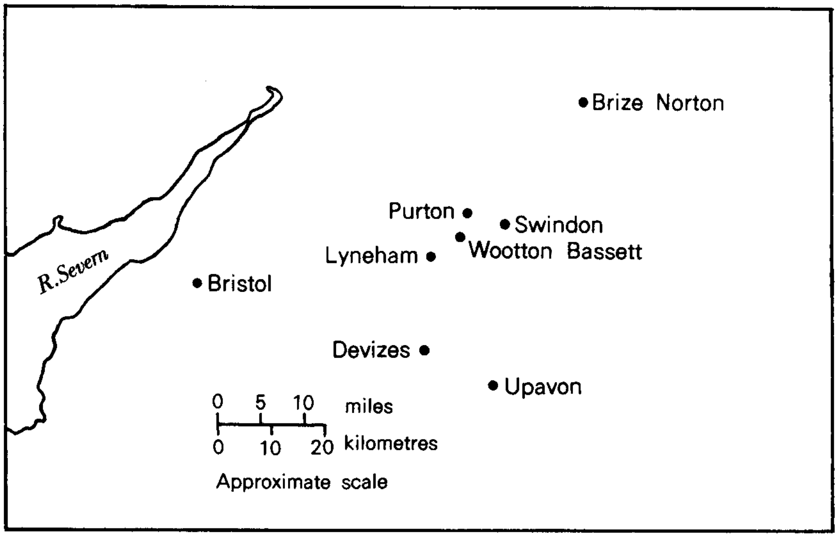

Figure 1. Showing Lyneham and surrounding area.

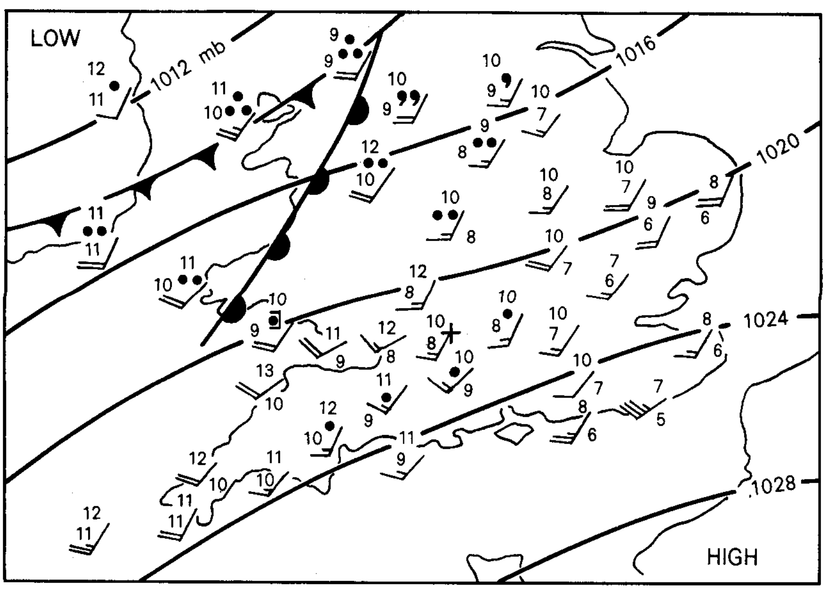

Figure 2. Synoptic situation at 1500 GMT on 10 December 1980. (Cross indicates Lyneham.)

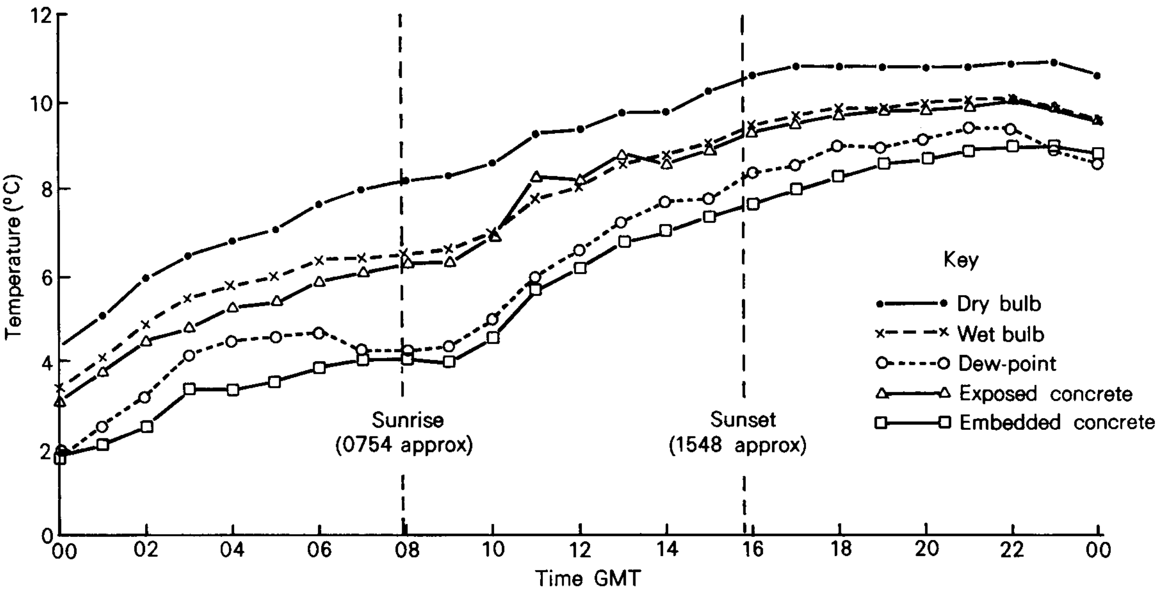

Figure 3. Hourly readings of the various temperatures at Lyneham on 10 December 1980.

As would be expected from the changing synoptic situation both the dry- and wet-bulb screen temperatures show a steady increase throughout the day, although a reduction in the rate of increase of the wet-bulb temperature between 0600 and 0900 GMT indicates the passage of a patch of relatively drier air. Moister air returned soon afterwards.

From 0600 GMT the graphs of temperatures recorded by the two concrete thermometers closely follow the shape of the wet-bulb temperature curve. The relatively large increase in temperature registered by the exposed concrete thermometer between 1000 and 1100 GMT can be attributed to low cloud cover temporarily dispersing and allowing a small amount of heating to reach the surface despite an almost total cover of medium-level cloud.

The subsequent fall of temperature on the concrete surface between 1300 and 1400 GMT coincides with the author first noticing a dampness on the road surface and is believed to have been the result of moisture forming on the electrical resistance thermometer and causing it to act as a wet-bulb thermometer, particularly as it was exposed to wind.

At the same time the temperature difference, ΔT_c, between the dew-point of the air and the temperature 5 mm below the concrete surface increased from a consistent 0·3–0·4 °C to 0·6–0·7 °C. This increase in ΔT_c seems to have come about solely through a reduction in the rate of increase of the temperature of the concrete slab. No explanation can be offered as to why this should have occurred but there is little doubt that the effect was not an isolated one. It is important to note that the true temperature of the skin of the concrete in contact with the air is given neither by the exposed thermometer lying on the surface (it responds partly at least to air temperature) nor by that embedded at 5 mm. With the flux of heat being downward in this case the true skin temperature would be a little above that at a depth of 5 mm, but it must have been below the dew-point temperature of the air during the period of condensation.

The apparent lack of condensation earlier in the day, between 0300 and 0600 GMT when ΔT_c exceeded 1 °C, is difficult to explain but the answer may be related to the humidity of the air. At this time the relative humidity, measured at screen level, did not exceed 85% (see Table I) and it is suggested that had any condensation occurred it would have quickly evaporated. After 1300 GMT the relative humidity increased to 85–88% and, although only slightly greater than the earlier measurements, it was sufficient to restrict any evaporation.

Table I. *Hourly humidities at Lyneham for* 10 *December* 1980

Time GMT	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Relative humidity (%)	83	84	83	84	85	84	81	77	76	76	78	80	83	84	87	85	86	86	88	88	90	91	90	87	88

Conclusion

It has long been appreciated that the advection of mild moist air over a cold surface results in condensation. What makes this event so noteworthy is the large amount of moisture deposited even though concrete and tarmac road surface temperatures could only have been very slightly below the dew-point temperature of the air.

In view of the large amount of condensation it is interesting to speculate whether or not this mechanism can contribute to increased streamflow in much the same way that fog drip does (Gardiner 1977, Gurnell 1976).

Some practical forecasting rules related to conditions leading to icy roads have suggested that condensation occurs when there is a 'sudden' change from cold to milder weather. The event described here occurred long after the onset of the milder weather.

Acknowledgements

I should like to thank Mr B. J. Booth, Senior Meteorological Officer, Lyneham for his help and encouragement in formulating this article, and Mr R. P. Gosnell, the observer on the afternoon and evening of 10 December 1980.

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Letter to the Editor

Origins of the Meteorological Office

The recent article by Mr R. P. W. Lewis on the beginnings of the Meteorological Office[1] contained much that was of interest, and it seems worth while to extend the story backwards for a few more years.

Although the origins of the Office undoubtedly followed directly from the 1853 Brussels conference convened by Lieutenant Maury, U.S.N., the conference itself arose out of a British initiative taken by Major-General Sir John Burgoyne, R.E., the Master-General of Fortifications. In 1851 Burgoyne had been responsible for the origination of a scheme for making meteorological observations at foreign and colonial stations of the Royal Engineers[2] and, with the intention of extending this network still further, he sought assistance from the American government.[3] The proposals were referred to Maury (then head of the US National Observatory in Washington), who welcomed the idea in principle but suggested that the scope be broadened to include other nations, proposing in turn that an international conference be called to consider the possibilities of co-operation between the leading maritime powers. Burgoyne demurred, thinking that an international conference would present too many difficulties and that the United Kingdom and the United States of America as 'the greatest maritime powers' should proceed alone since 'they would intercommunicate in the same language and, it is believed, have the same weights and measures'. In the face of Burgoyne's reaction, Maury now pursued the idea of an international conference on his own, his efforts eventually resulting in the 1853 meeting in Brussels referred to above. Ten nations attended, Britain being represented by Captain F. W. Beechey, R.N., head of the Marine Department of the Board of Trade, and Captain Henry James, R.E., the officer in direct charge of the scheme of meteorological observations organized at Burgoyne's direction.[4]

It is interesting to note that Lord Wrottesley, who figured prominently in the subsequent moves towards the actual founding of the Office,[5] was himself a close associate of Burgoyne, and that his third son, the Hon. George Wrottesley, an officer in the Royal Engineers, married Burgoyne's daughter in 1854 and became his A.D.C. a year later.[6] This close personal relationship was again in evidence when Burgoyne was recalled to Britain during the war in the Crimea, following an almighty row with the French. Wrottesley objected to the manner in which the recall was announced in Parliament as possibly casting a slur upon Burgoyne's reputation and he induced Lord Lansdowne, the Government leader in the Lords, to deliver a 'very eloquent eulogium'[7] on Burgoyne in the House.[8] Captain James eventually rose to become head of the Ordnance Survey, an interesting sideline being that James Glaisher,[9] then in his early twenties, had worked with him earlier on the survey of Ireland during 1829–30.[10]

To go back just one step further, Burgoyne's work for meteorology appears to have been prompted by William Reid, another Royal Engineers officer, who had served under Burgoyne during Wellington's Peninsular Campaign and also at New Orleans.[11] Reid became interested in the circulatory theory of storms when confronted with hurricane damage in the West Indies during the early 1830s and he worked on the problem of storms[12] in close collaboration with the American, W. C. Redfield.[13] The study of what we would now call synoptic meteorology was attempting to take its first systematic, if faltering, steps at this time, another pioneer in the field being Captain Francis Beaufort, R.N., the Hydrographer of the Navy, who attempted to set up a system of marine observations in the 1830s, but failed owing to lack of funds.[14]

Finally, the choice of FitzRoy as head of the new department probably followed from initiatives taken during his term as Tory M.P. for Durham in the 1840s. FitzRoy's persistence in seeking to promote legislation on the subject of safety at sea resulted in the setting up of a Parliamentary Select Committee to study the subject in 1843.[15] FitzRoy was both appointed to the Committee as a member and called as first witness.[16] The final report of the Committee included proposals for a number of important reforms, but it also generated considerable opposition from shipowning interests faced with the prospect of expense in raising safety standards on their ships.[17] Unfortunately, at this stage FitzRoy was appointed Governor of New Zealand and the proposals lapsed,[18] although many of them were later included in the Merchant Shipping Act of 1854.[19]

The evidence that was given to the Committee by FitzRoy was to take on a quite different significance several years later when, in 1861, he was to go well outside his original brief as head of the Meteorological Department and set up the world's first comprehensive storm warning and weather forecast[20] service for shipping, using the recently developed facility of the electric telegraph. The repercussions for FitzRoy himself were tragic, but the traditions of service to the community by the meteorologists had been well and truly laid.

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Notes and references

1. Lewis, R. P. W.; The founding of the Meteorological Office, 1854–55. *Meteorol Mag*, **110**, 1981, 221–227.
2. Details of the organization are contained in: James, Captain Henry, R.E., F.R.S.; Instructions for taking meteorological observations at the principal foreign stations of the Royal Engineers. London, John Weale, 1851.
3. The whole of the correspondence dealing with Burgoyne's original proposal and the reasons behind Maury's subsequent actions is contained in: *P.P.* (*Parliamentary Papers*), 1852–3, LX, 443.
4. Abstract of copy of Report of Conference held at Brussels respecting meteorological observations. *P.P.*, 1854, XLII, 443.
5. Op. cit., note 1.
6. Wrottesley, Hon. George; A history of the family of Wrottesley of Wrottesley Co. Stafford. Exeter, William Pollard, 1903, pp. 382–383.
7. Ibid., pp. 379–380.
8. *Hansard*, 3rd series, 136, 1737–1738.
9. James Glaisher, F.R.S., was the secretary and inspiration of the British (later Royal) Meteorological Society from the time of its formation in 1850 until 1873 (apart from the years 1867–68, when he was President). A brief account of his career is given in: Hunt, J. L.; James Glaisher, F.R.S. (1809–1903). *Weather*, **33**, 1978, 242–249.
10. Hollis, Henry Park; Dictionary of national biography, supplement 1901–11 (entry on James Glaisher). Oxford University Press (reprinted 1966).
11. There are many references to Reid in: Wrottesley, Hon. George; Life and correspondence of Field Marshal Sir John Burgoyne, Bart (2 vols). London, Richard Bentley, 1873.
12. His principal work on the subject was: Reid, Lt.-Col. W., C.B.; An attempt to develop the Law of Storms. London, John Weale, 1838.
13. Redfield was amongst the first to propose a circulatory theory of storms, publishing an article on the subject in the *American Journal of Science and Art*, **20**, 1831. There are apparently three folio volumes of the correspondence between Reid and Redfield held in the library at Yale University.
14. Beaufort does not appear to have left a record of these activities, but they are mentioned in a number of sources, for example: Prouty, Roger; The transformation of the Board of Trade 1830–1855. London, William Heinemann, 1957, p. 52.
15. Parliamentary Select Committee on Shipwrecks. The first report of the Committee was ordered by the House of Commons to be printed on 10 August 1843.
16. Minutes of the proceedings are given in: *P.P.*, 1843, IX. The record of FitzRoy's evidence notes his opinion *inter alia* that '... neglect of the use of the barometer has led to the loss of many ships: from a want of attention to the barometer they have either closed the land (if at sea), or have put to sea ... at improper times and in consequence of such want of precaution the ships have been lost, owing to bad weather coming on suddenly ... While alluding to the use of the barometer, I may remark, that if barometers were put ... at the principal stations round the coast ... they might be the means not only of preventing ships going to sea just before bad weather was coming on, but of preventing the great losses of life which take place every year on our coasts ...'

17. The story of the hesitating progress towards reform of the Merchant Shipping regulations during the second quarter of the nineteenth century is recorded in: Op. cit., note 14, pp. 34–51.
18. FitzRoy's stay in New Zealand was brief, turbulent and unhappy. In contrast to his fundamentalist views on religion, his attitude towards race relations was, in practice, very advanced for his day, although based on the belief that all men are of one blood, having originated in the biblical lands and spread across the world. In consequence, FitzRoy was not disposed automatically to support the settlers against the native Maoris. There is also little doubt that the aristocratic FitzRoy adopted an arrogant attitude in dealing with the relatively rough-hewn colonists.
19. Merchant Shipping Act, 1854, *P.P.*, 1854, IV.
20. FitzRoy issued his first storm warnings on 6 February 1861. The first organized system of forecasts and storm warnings was instituted by Christoph Buys Ballot in Holland during May 1860, but the organization was on a smaller scale than the slightly later British system.

Notes and news

25 years ago

The following extract is taken from the *Meteorological Magazine*, January 1957, **86**, 25.

Royal Society International Geophysical Year Expedition to Antarctica

Since early January 1956 the advance party of the British International Geophysical Year Expedition has been established at a site a mile and a half inland on the ice shelf in Coats Land on the eastern side of the Weddell Sea. The base is known as the Royal Society Base, Halley Bay. The revised co-ordinates are 75° 31′S, 26° 36′W. The main party of the International Geophysical Year Expedition and that of the Trans-Antarctic Expedition sailed from London on November 15, 1956 in the M.S. *Magga Dan* (2,000 tons). The Trans-Antarctic Expedition base is at Shackleton, 77° 57′S, 37° 16′W, about 250 miles south-westward of Halley Bay.

The Expedition's main party of 20 under the leadership of Col. R. A. Smart, R.A.M.C., includes 11 scientific members who will be responsible for the observational programme of the aurora, geomagnetism, glaciology, the ionosphere, meteorology, radio-astronomy and seismology until the end of 1958. The component for work in meteorology, geomagnetism, glaciology and seismology consists of the following members of the Meteorological Office, Messrs. J. MacDowall, A. Blackie, J. M. C. Burton, D. T. Tribble and D. G. Ward; all of whom, along with several other of their Office colleagues, volunteered for this enterprise more than a year ago. They will be joined, for 1957, by another colleague, Mr P. H. Jeffries, who has been with the Trans-Antarctic Expedition advance party at Shackleton throughout 1956. Having accomplished their indispensable mission during 1956 of establishing the base at Halley Bay, instituting preliminary scientific observations and carrying out other essential pioneer work, the advance party, which includes Mr D. W. S. Limbert of the Meteorological Office, will return to the United Kingdom early in 1957.

An immediate preoccupation of the new arrivals at Halley Bay will be to erect, on the ice shelf, the instrument and observation huts (including those for the geomagnetic instruments and for filling radiosonde balloons) and additional aerial arrays, and to install equipment with minimum delay so that everything shall be fully operational well before the beginning of the International Geophysical Year, July 1, 1957.

Our best wishes for complete success go to the whole party at Halley Bay, and to the several other similar parties in the far South, in their endeavours to achieve significant contributions to the general International Geophysical Year programme for Antarctica.

50 years ago

The following extract is taken from the *Meteorological Magazine*, January 1932, **66**, 287–288.

Fog, Friday, December 18th

The following may be of some interest. Morning, thick fog and hoar frost. Fair and sunny midday. Wind light—NE. Afternoon and evening, blinding fog, which made the eyes run with water, and smelling strongly of soot. My brother and I, after pedal-cycling through fog during the evening, returned home with complexions and clothes the colour of nigger minstrels. Traffic was chaotic. Next morning trees, vegetation, telegraph wires and clothes lines were an inch thick with dirty black frost. Cabbages, &c., were filthy and had to receive many ablutions.

The evening fog drifted from north-west and visibility was at times less than three feet.

F. CLAUDE BANKS

Market Gardens, Horndon-on-the-Hill, Essex. *December* 28*th*, 1931.

*** Although such unpleasant occasions of thick smoke-laden fog continued to occur until the 1950s—the case of 5–8 December 1952 was notorious—the passing of the Clean Air Act in 1956 has by now made them things of the past.

Reviews

Red sky at night shepherd's delight? Weather lore of the English countryside, by Paul J. Marriott. 155 mm × 245 mm, pp. viii + 376, *illus.* Sheba Books, Oxford, 1981. Price £9.90.

This is a book of collected weather lore with a difference. Mr Marriott, as a professional meteorologist, has not only collected nearly 1900 adages classified by reference to months of the year, movable feasts, birds, animals, reptiles and insects, wild flowers and plants, and a host of other topics, but has subjected nearly all of them to careful observation and testing and published his results. Each adage is given a star rating—one to six—and many have attached the results of a two-year trial in the form (number of times total) and percentage. The book is charmingly illustrated with Victorian and earlier sketches of birds, trees and flower motifs. A good bibliography is given and a list of the data sources used for some of the assessments and ratings. Adages are included for their oddity and quaintness as much as for any conceivable value; for example, 'A dead kingfisher hung up by the legs even inside a house is said to turn its beak to windward'—a foolish but interesting saying, as the author remarks. The more sensible and useful sayings are explained by reference to scientific meteorology where possible.

The text would have benefited from more careful checking and editing which might have removed many examples of spelling mistakes and clumsy and ungrammatical English. Occasionally the reader is baffled. Commenting on 'If rats are more restless than usual, rain is at hand', the author says, 'Although rats are experts of conditioning, the "more restless" habit is really old hat'; I do not know what this means.

The 'thunder planet' (page 215), a term which puzzles the author, presumably means Jupiter, the Roman god of storms and thunder corresponding to Thor and Zeus.

R. P. W. Lewis

Earth, space and time: an introduction to earth science, by John Gabriel Navarra. 185 mm × 235 mm, pp. viii + 438, *illus.* John Wiley & Sons, New York, Chichester, Brisbane, Toronto, 1980. Price £12.65.

This book is yet another in the rapidly increasing number on all aspects of earth science, including sections on geology and continental drift, oceanography, the biosphere, the atmosphere, and the evolution of the universe and solar system. The meteorologist naturally turns to the section on the atmosphere, composed of three chapters entitled respectively 'The atmospheric envelope', 'Circulation within the atmosphere', and 'Weather analysis and forecasting'; he will rapidly conclude that if the author's knowledge of the other topics dealt with in the book is as deficient as it is of meteorology it is a bad book indeed. Howlers abound, for example:

'. . . English farmers . . . have seen their growing season decline by two weeks since 1950. The shortened growing season in England has meant an overall loss in grain production of possibly 100,000 tons per year.' (page 263).

'Examination of the troposphere reveals that temperatures decrease at a rate of 3·5°F for every 1000 feet of height (6·4°C per kilometer). This phenomenon is known as the **normal adiabatic lapse rate.** It is the average normal decrease in the temperature of air with height in the troposphere.' (Page 271).

Mr Navarra is weak on Latin too: 'The solar radiation that reaches the Earth and is involved in heating its surface and atmosphere is often referred to as **insolation.** The term is an abbreviation for incoming solar radiation.' (Page 280).

In discussing the general circulation of the atmosphere (pages 304–305), he contrasts ideas of large-scale convection and heat transfer with those of conservation of momentum as though they were in some way mutually exclusive and not complementary.

On page 308 is a map of Africa and Arabia showing 'Sahel Areas' over Arabia and 'The Sudan' over Niger.

The codes and symbols shown on pages 330–331 are in many respects long out of date internationally, and probably so even in local US contexts; cloud-cover in tenths and winds in Beaufort force are two examples.

There are, however, no howlers in the account given of computer-modelling and numerical analysis and prediction in the chapter on 'Weather analysis and forecasting'. The reason is simple: these topics are not mentioned. After all, it is only a quarter-century since such methods were first used operationally.

The book is of course beautifully produced by Wiley, with excellent photographs and diagrams that are always clear even if incorrect.

R. P. W. Lewis

Dr J. Glasspoole, I.S.O.

Dr John Glasspoole, who died on 11 October 1981, was the last surviving member of the old British Rainfall Organization which had been founded by J. A. Symons, F.R.S., in the last century and was taken over by the Meteorological Office in 1919. (The *Meteorological Magazine* is of course the official continuation of *Symons's Monthly Meteorological Magazine*, the organ of the Organization.) Dr Glasspoole joined the British Rainfall Organization in 1916 when it was a small independent body under the control of Dr Hugh Robert Mill and Mr Carle Salter. For several years the Organization remained as a separate unit of the Office, but was then absorbed by the general British Climatology Division; Dr Glasspoole's responsibilities became correspondingly diversified though his chief concern continued to be the study of rainfall. During his career—he retired as a Principal Scientific Officer on 31 December 1957—he was regarded as the outstanding British expert on rainfall and meteorological hydrology. His interest in rainfall continued until the end of his life, and during the past year letters from him have appeared in the correspondence columns both of the *Meteorological Magazine* and of *Weather*.

Dr Glasspoole had been, in his younger days, a lawn tennis player of considerable ability; in later life he took up the game of bowls at which he also became an expert.

Obituary

We regret to record the death on 5 August 1981 of Mr D. S. Lillingstone, Assistant Scientific Officer, who was stationed at Coltishall. Mr Lillingstone joined the Office in 1964, and had spent almost all his career at Coltishall.

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NOTICES

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