The JOURNAL of METEOROLOGY

TWO PHOTOGRAPHS OF THE TORRO EXHIBITION

Volume 13, number 131 **September 1988**

JOURNAL OF METEOROLOGY

"An international journal for everyone interested in climate and weather, and in their influence on man."

Editor: Dr. G. T. Meaden — Vol. 13, no. 131, September 1988

ESCAPER AND ENVIRONMENT

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INTRODUCTION

The influence and control of the environment on human behaviour has long been a topic invoking much discussion (e.g. Huntington, 1924, 1945, Semple, 1911). While it is generally accepted that environmental conditions such as weather and climate can influence a person's or group's actions, the degree of that influence is the subject of debate. Do elements of weather and climate control the human response to an event or do these factors play a more passive role in human lives? One group's response, in particular, to a variety of environmental conditions may provide new insight into the relationship between environment and human activity. This group of people whose actions, mood and, indeed, very lives have been influenced to varying degrees by a foreign environment are those people termed 'escaping prisoners of war'.

Escaping has been characterized as "the greatest sport in the world" (A. J. Evans in Reid, 1952, p.9); where "freedom, life and loved ones are the prize of victory, and death the possible though by no means inevitable price of failure (Reid, 1952, p.9)". Yet because the stakes involved with this "sport" are so high, a successful escape generally requires extensive planning and accounting for every possible detail. Neglect of even the smallest consideration can lead to failure. One consideration that must be constantly reviewed and analyzed in reference to an escape attempt is the environment, and in particular the weather. Each element of the weather, such as rain, fog, snow, sleet, wind, or extreme cold may expose the escaper to increased risks or, conversely, may aid the escaper in successfully fleeing from the prison and subsequently avoiding recapture. The observation, interpretation and use (or misuse) of the weather events by prisoners provides an informative study on the interactions and degree of influence between the environment and humans under stress situations. In this study we examine the writings of prisoners captured during World War II and analyze their various escape attempts with specific emphasis on their interaction with the environment and, in particular, weather phenomena.

An escaping prisoner of war from the very beginning has many disadvantages with which to contend. One of the major functions of a prison camp is, of course, to make escape extremely difficult if not impossible. For example, Colditz Castle, the German prison fortress reserved for all Allied officers who had escaped from other camps, was regarded as "escape proof" by the German High Command. At all times, the prison garrison outnumbered the prisoners. There were shear drops of a hundred feet from the barred barrack windows. Sentries patrolled the barbed wire fences while search towers exposed all parts of the fortress under the night.

If a prisoner actually escaped from a prison camp, he had to contend with still more difficulties. He was generally in an unfamiliar area, cut off from his own army, unable to speak the language and at the mercy of a variety of weather elements. While many of the problems could be addressed ahead of the actual escape, i.e., smuggled maps, language practice and so on, the difficulties associated with the weather were more difficult to assess. Added to the complexity of the problem was the knowledge that individual weather elements could help or hinder an escape attempt depending on a variety of factors.

RAIN

Rain is a phenomenon which may exert a variety of different influences on an escape. These influences can generally fall into one of three categories: 1) the physical properties of the rain itself, 2) the environmental conditions associated with rain and 3) the perception of the guards, the prisoners and inhabitants of the area to rain and its physical influences on escaping.

The physical properties of the rain itself generally were unfavourable for an escape attempt. Rain was physically degrading on the handmade escape clothing and materials fashioned by the prisoners. For example, in the December 23, 1941 escape of 25 German U-boat officers from a Phoenix, Arizona prison camp during a rare winter thunderstorm, the officers had planned to sail down an irrigation canal to a river and then to Mexico via a makeshift boat. As Lieutenant Wolfgang Clarus recalled, the weather following the escape "was a real downpour. So we snuggled up in a patch of bushes on the outskirts of Phoenix, pulled the boat canvas over us and went to sleep. It fitted beautifully. However, the tar ran somewhat and we all got dirty. But more important, the damn thing shrank. Mistake number one: we should have washed the material before stitching it. Seveal days later we had to shorten all the struts" (Moore, 1978, p.158).

The degrading effect of rain on escape clothing was, however, anticipated by some prisoners. The escape of Airey Neave and Lieutenant Tony Luteyn from Colditz is a case in point. The escape involved constructing German uniforms and equipment and literally walking out of the camp. Imitations of German greatcoats were constructed with minor alterations from Dutch army coats while leather parts, such as belt and revolver holsters, were made from linoleum and leggings from cardboard. Yet while the prisoners were proud of their work, they realized that the clothing "was not good enough for a permanent disguise – the cardboard leggings, for instance, would not have looked very well after heavy rain! – and we decided they should be discarded and hidden in the woods outside the Castle" (Reid, 1952, p.122). Wearing a second set of clothing underneath the uniforms was the solution to the potential problem.

Deterioration of escape clothing due to rain occurred during the escape of Captains P. R. Reid and Rupert Barry and 2nd lieutenant Peter Allen from Oflag VII C. On the fifth day after their escape from the camp, "a cold drizzle began to fall. We became restless and argued about going on. With odd-looking capes and blankets over our shoulders, we trudged . . ." (Reid, 1952, p.47). While the escapers' clothes had passed close examination during the dry conditions of the previous days, they had not been constructed to withstand these types of conditions. It should have been of little surprise to the escapers that "a few men stared at us . . . and later a motor-lorry caught us (and) a youth leaned out and had a good stare at us" (Reid, 1952, p.48).

A demoralizing effect caused by the rain on the escapers also played a role in their final recapture. Reid reported during his escape with Barry and Allen from Oflag VII C that the rain had "continued till nightfall and then ceased, leaving us cold, wet and dispirited" (Reid, 1952, p.48). Forced by the weather therefore to travel through a village at night, the trio were re-captured shortly before midnight by a German patrol.

Despite these aspects of rain on escape attempts, most prisoners surprisingly regarded rain as favourable escape weather. This is because of the potential usefulness of certain environmental conditions associated with rain. One of the primary problems with escaping is avoiding detection by the guards. Rain is directly associated with cloud cover and darkness. These factors apparently weighed more heavily in the prisoners' mind than the potential debilitating effects of rain. For instance, a prisoner noted "It rained all day in torrents, the heaviest rainfall we had ever had, but this would mean a dark night and it would not upset our plans" (Reid, 1952, p.89). During the escape of Lieutenants Flanti Steinmetz and E. H. Larive, they noted the sky "was heavily overcast . . . a few minutes later it even started to rain. Good, the harder the better; it would make the night pitch black and the guards less observant" (Reid, 1984, p.79). Wing Commander Harry Day and four companions imprisoned in Sachsenhausen Concentration Camp north of Berlin dug a hundred foot long tunnel then "waited for a suitable time, and in September there was a moonless night with the added cover of a drizzle or rain" (Brickhill, 1950, p.201).

Perception also is an important factor to be considered when escaping during a rain event. In general, there is less traffic and commerce during rain events than during drier weather. This may explain part of the success of the German U-boat officers in escaping from the Arizona prison camp. Rain is an abnormal, and generally avoided, phenomenon to people in the desert areas of the south west United States, at least more so than other parts of the country. As the prisoners emerged from their tunnel and proceeded to assemble the handmade canvas boat, they found the surrounding area generally peaceful and uninhabitated. They were able to separate and travel away from the camp without detection and thereby avoid re-capture for many days following the escape. In fact, many prisoners were never detected by either the local inhabitants or the official search parties but rather turned themselves back into custody due to lack of food and comfort (Moore, 1978).

Such success appears to be the exception to the rule, however. Rain events were generally regarded by prisoners as hindrances to travel following an escape. Most escapers noted an increased suspicion of people walkng in the rain by the local inhabitants. Such travel is not regarded as a normal activity and, hence, the local

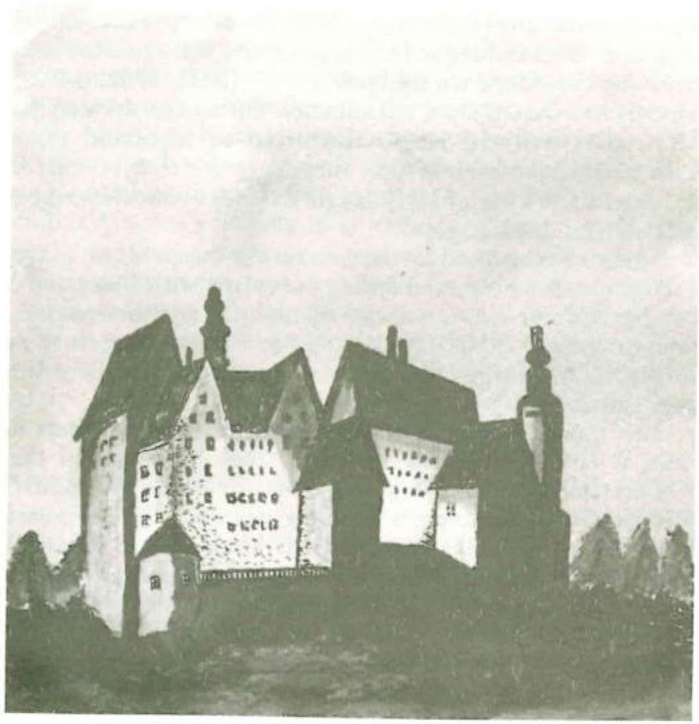

Fig.1: Reproduction of a watercolor painting of Colditz Castle, Germany.

inhabitants took notice of people walking during such weather. As already discussed, Reid, Barry and Allen received several strange looks and stares from the local population of the area through which they were forced to travel during the rain shower. Although Lieutenant Mairesse Lebrun managed to vault the Colditz prison wall dressed in rather unusual clothing: shorts, a yellow cardigan, an open-necked shirt and gym shoes (Reid, 1952, p.98), he found that the three nights and two days of continuous rain following the escape, together with his rather odd clothing, forced him to travel at night to avoid the detection, and subsequent suspicion, by the inhabitants of the area (Reid, 1984).

The local population were not the only ones to regard activity during rain as unusual and suspicious. Prison guards also noted excessive energy and activity of prisoners during rain as unusual. This was recognized by British air-force officer Peter Howard in the famous "wooden horse" from Stalag III (Williams, 1949). The escape involved digging a tunnel underneath a large vaulting horse carried out into the prison grounds each day. As Williams describes,

> "All through the summer their working had been controlled by the weather. Once the trap was lifted and the workers were in the tunnel, it took them all of fifteen minutes to get back to the shaft, close the trap and get ready to be carried in. They could not afford to be caught out by a shower of rain. If it started to rain, the vaulters could not continue without arousing the suspicion of the guards. Nor could they run for the shelter of the canteen leaving the vaulting horse to stand out in the rain. The obvious thing was to carry the horse in with them and they could not do this with the trap open and two men in the tunnel. So they studied the weather carefully and if it looked at all like rain, they had to vault without digging. Nearly every time they took the horse out it was only after long discussions on the weather. (Williams, 1949, p.100).

Because the tunnel took three and a half months of digging, the physical and mental toil forced the men to reconsider their original plans. Howard stated the decision of the escapers in the final stages of the escape, "We'll just have to vault in the rain, that's all. The goons think we're mad already. We'll just have to risk it and hope they don't get suspicious" (Williams, 1949, p.107).

In summary, rain is a climatic variable that could often be favorably exploited during the actual escape but generally proved an impediment during subsequent travel from the prison camp. Although, as discussed later, escape is generally regarded as a summer phenomenon, snow is another climatic variable that contributes to the success and failure of many escape attempts.

SNOW

Most escapers tended to regard snow as a major hindrance to an escape. There are many physical constraints imposed by snow cover:

1) In general, the footprints made in the snow by an escaper allow for relatively easy tracking and recapture of the prisoner. This was part of the reasoning used by a German officer during a transfer of prisoners. He noted "that it was no use trying to escape because: (a) it was mid-winter with snow everywhere . . . and (b) (the prisoner's) boots would be removed on the train" (Reid, 1953, p.147). Despite these obstacles, not only did several escape from the train but seven men actually crossed the Carpathian Mountains and reached Hungary.

2) It is extremely difficult for an escaper to make rapid progress by foot across the countryside in deep snow. As many of the prisoners from Stalag Luft III reported in their Great Escape of 1944, the "snow and slush (covering the fields) had forced them back on to the roads and into the hands of the patrols" (Brickhill, 1950, p.174).

3) As with rain, travel during snow events is not regarded as a normal activity and, hence, the local inhabitants would have a greater suspicion of people walking during such weather.

4) Snow increases the potential for frostbite. One of the recaptured prisoners from Stalag Luft II "limped a little behind the others. It was Al Hake, and Ogilvy managed to whisper a few words to him. Hake said he had frostbitten feet" (Brickhill, 1950, p.185).

A more extreme case of the dangers associated with winter travel is an escape made during the winter of 1940-41. A prisoner buried himself under the snow covering the prison football field. His plan was to remain to be left behind after the field was deserted. He remained completely buried under the snow for five hours until a prearranged bugle call from the compound gave him the signal that it was dark. He proceeded to dig out of his snow grave and slowly climbed up and over the now unguarded fence around the football field. The exercise was, however, excruciatingly painful: one of his legs was frostbitten and he was unable to walk properly. He was soon recaptured (Crawley, 1985).

Conditioning provided some measure of control over this type of difficulty. An American prisoner, First Lieutenant Dave Bowling, had slept in the snow several nights under one of the barracks to ready himself for his escape attempt. In addition, others had sacrificed their rations for him so that he was in good physical shape. During a late December evening in 1944, Bowling crawled out from under the barracks and began moving towards the fence. He crawled through the nearly two feet deep snow under the cover of a white bedsheet. Whenever the tower lights moved toward him, he sprawled face down in the snow with his arms outstretched so that the sheet completely covered him. From the watch tower, he appeared as nothing more alarming than a small lump of snow. Once the light moved past him, he crawled with the sheet over his head toward the fence. He proceeded to cut an opening through the wire fence (making sure to time his activity such that even with the lights, the guards would see nothing but the featureless white expanse of snow). Although Bowling was recaptured before reaching Allied forces, the escape itself demonstrates the potential for exploitation of the environment. As Simmons (1960, p.159) stated, "It sounded simple but would have been impossible without the snow".

Bowling was not the only prisoner to attempt this method of escape. In February 1941, four other officers crawled under the gate leading out of a German prison camp, covered in sheets. They, however, were caught before they could get beyond the fence (Crawley, 1985).

Snow therefore could be considered as an aid to escaping if the escaper was physically prepared to handle its effects and astute enough to recognize its advantages. Major Patrick Reid, an accomplished escaper, noted, specifically with regard to snow, that "I think it was a Chinese philosopher who once said that everything in nature can be turned to man's advantage if only man can find the way" (Reid, 1952, p.131). His idea involved the construction of a snow tunnel as means of escape.

Snow tunnels have two important advantages. They are relatively quick to construct and they do not have the dispersal problems associated with earthen tunnels. The main problems associated with snow tunnels are that they need fairly deep snow conditions over an extensive area in order to be profitably constructed and, as Reid noted, snow can melt quickly. Reid's snow tunnel in Colditz was four yards in length and a foot and nine inches tall along a roof in Colditz Castle where the snow had piled up three feet. Although he worried about melting. Reid found that the tunnel did not melt with his body heat but instead formed a compact interior ice wall (Reid, 1952, p.132). The one "cave in" he experienced was speedily remedied with the use of cardboard. Reid's tunnel was, however, quickly discovered and, indeed, we have found no record of a successful escape which took place through snow tunnels.

WIND

A phenomenon associated with snow coupled to strong winds (i.e., blizzard conditions) can also enhance the escaper's chances of a successful escape. Visibility

may be reduced to as little as a few yards during blizzard conditions. Wind and snow can therefore aid the escaper by decreasing visibility and thus hide the imperfections in the escape, particularly with clothing. When Airey Neave and Tony Luteyn escaped in German uniforms from Colditz Castle, they were pleased to notice that "the ice blustery wind caused (the snow) to swirl crazily around the courtyard, decreasing visibility to a few yards and giving them ideal cover" (Reid, 1952, p.83). Undoubtedly their chances with this type of escape would have been slimmer on a clear summer evening or even on a calm winter day because of the increased visibility and, therefore, more detailed inspection available to the guards.

Wind is an often overlooked climatic variable in escape planning. It has had, in general, a distinctly positive effect on escapes. Movement of air has the attribute of reducing to some extent the sound of voices and physical noises. Thus many prisoners felt that a strong wind was beneficial to the escape process. For example, the organizer of the "Great Escape" of seventy-six men from Stalag Luft III stated that one of the four factors that he considered vital to an escape attempt was "a wind to cover up noises" (Brickhill, 1950, p.136). The absence of a noise-covering wind was cause for anxiety by Major Reid and his companions on the night of their first escape until they realized that "the river . . . rushing talkatively down the mountains, made up for the silence reigning elsewhere" (Reid, 1952, p.17).

Wind, when coupled with cold temperatures, permits another interesting exploitation by escaping prisoners. The following example illustrates such a case in the use of wind chill. Prisoners in Oflag XXI B had decided to break out on a night that had "heavy clouds . . . massing in an angry sky. Gusts of wind went humming through the wire, blowing into camp, and causing the guards to turn their backs to its source . . . the potato patch (that contained) the exit of their tunnel" (Williams, 1952, p.155). An attempt on this type of night probably had a better chance of success than during a still, calm night simply due to the unwillingness of the guards to survey the potential escape location as carefully as they normally would. Fifteen prisoners escaped during that night from Oflag XXI B. Crawley (1985) suggests that the cold wind in some cases not only caused the guards to stay towards the back of their watch towers but also created the conditions for the side windows of the towers to freeze over with ice and so hinder the guards in their survey of the wire fence. This offered enticing opportunities for even daylight "wire job" escapes. Crawley (1985) reports on three such attempted escapes.

DARKNESS

As mentioned previously, darkness is also an important variable to consider in planning an escape. Jacky Rae, a New Zealand Spitfire pilot, felt it was so important that he made it the keystone of his 'reverse psychology' escape attempt (Brickhill, 1952). He reasoned that most attempts associated with cutting the wires surrounding the camp had failed because, on a dark night, the guards always concentrated their attention on the darker areas of the camp. He decided therefore to make his attempt in an area that was constantly swept by searchlights. The unorthodoxy of his attempt almost permitted a truly classic escape: he was only two strands away from cutting completely through the fence and freedom before he was spotted.

In general, however, darkness was welcomed by the prisoners to cover their escape activities. Captain Kenneth Lockwood, of the Colditz alumni, has referred to darkness as the proverbial 'escaper's friend' (personal communication, 1987). Group Captain Massey, senior British Officer at Stalag Luft III, for example, persuaded the camp kommandant during January 1944 to let the prisoners walk about between the barracks until ten o'clock because "it was the off-season for escape" (Brickhill, 1950, p.124). This meant removal of the sand from their tunnel "had never been so easy" because due to the cover of darkness, there was no need for their otherwise elaborate dispersal procedures. The concept of "escape season" will be discussed in detail later in this study.

OTHER CLIMATIC VARIABLES

If darkness was the escaper's friend, then a major enemy for the prisoners was the light of the moon. The leader of the "Great Escape" of 1944, R.A.F. squadron leader Roger Bushell, stated that one factor he considered vital to an escape attempt was "no moon" (Brickhill, 1950, p.136). During the construction of the tunnel, a moonlit night could be very dangerous for the "penguins", those men who carefully dispersed on the parade grounds the dirt from the tunnel. Bushell was reluctantly forced to close down the tunnelling operation during those bright moonlit conditions. As Paul Brickhill reported, "Roger, impatient and irritable, gave the pack-up order and there was no tunnel work for a week. Every day he went along to Chaz Hall (the escape committee's meteorologist) and asked what the weather would be that night and every day Hall gave the same answer, 'Bloody moon, no cloud'. (Brickhill, 1950, p.126)". As additional proof of the importance that Bushell placed on lighting conditions, the actual escape of seventy-six men from Stalag Luft III occurred not coincidentally on March 24, 1944, the one of three "most moonless nights" of the months of March and April and, consequently, one of the darkest nights (Brickhill, 1950, p.136).

Another "obscuring" environmental condition welcomed by escaping prisoners was fog. Although in general the occurrence of fog was relatively rare in the records of escaping POWs, the few references made do suggest that it was considered a positive attribute to an escape. For example, an "attempt to climb out of Colditz prison yard and over the roofs . . . was born one rare foggy winter's day when the high roofs of the castle were completely blocked out of sight" (Reid, 1953, p.185). There were dangers, however, as the prisoners noted that "to climb sixty feet on roofs that were floodlit was a very dangerous business, particularly when there was no fog" (Reid, 1953, p.184).

Fog could on occasion even save the lives of the prisoners and guards. For example, during a discovered escape attempt at Colditz, "It was very foggy and it was raining too that evening . . . There was nothing the guard could do about (shooting the escaping prisoners) . . . he daren't fire blindly into the fog" (Reid, 1953, p.106). While it is likely that not all guards would react in that fashion, the fact that some did is evidence of a strong potential effect of fog on an escape.

Temperature, in general and extreme cold in particular could dramatically influence all parts of an escape attempt. In the "pre-escape" portion of the attempt, perception plays a role in how actions under cold conditions are interpreted. In Stalag Luft III, for example, the cold influenced the actions of the "stooges", prisoners who were assigned to watch the prison guards and protect the various escape operations such as forgery, clothing manufacture and the actual tunnelling. Paul Brickhill (1950, p.117) relates that by early December in 1944, "it was too cold to be outside, so some of the stooges looking after the factories (i.e. escape operations) stood out like sore thumbs as they loitered around the same spots in the snow day after day, and it didn't take long for (a guard's) watery eyes to fasten on the stooges at each end of barracks 110". The solution finally used by the prisoners was to leave the escape operations unguarded so that the guards would think that work had stopped.

The bitter cold could also lead to physical ailments that interfered with escape operations. In the famous "French Tunnel" constructed in Colditz, although the workers were lying on freezing granite, they were "not even allowed to catch a cold. We were under the chapel floor and a German in the church would think it funny if he suddenly heard a cough coming from under his feet" (Reid, 1953, p.74).

In the actual escape attempt, the physical endurance of the few escapers who tried escapes during the cold season was tested to the limit. In the escape of Airey Neave and Tony Luteyn mentioned earlier, once they had passed the guards in their makeshift uniforms, they had to scale a twelve-foot high stone wall. First, Neave managed to scale the wall with the assistance of Luteyn. Although Neave then managed to sit astride the wall in order to help Luteyn, "freezing weather was taking its toll on their agility and strength" (Baybutt, 1982, p.81). The following brief excerpt elaborates on this problem:

> Time and again, the Dutchman (Luteyn) tried without success to maintain his hold of the stones which were covered in ice and snow. Neave, his fingers numbed of feeling, tried gripping Luteyn's wrist, but balanced precariously on top of the wall, he was unable to support himself. Finally in a desperate effort, Luteyn managed to climb high enough for Neave to hook his hands under the Dutchman's armpits . . . They were too exhausted from their efforts to talk. They just sat there, astride the wall, their breath puffing . . . in the sub-zero night air" (Baybutt, 1982, p.82).

Probably the greatest influence of cold weather on escaping was associated with travel after the initial escape. The potential for severe discomfort (e.g., frostbite) and even death due to exposure to extreme cold emphasized the importance of pre-escape planning regarding adequate clothing and travel routes. Finding adequate shelter was often a major problem for the escapers because (1) the landscape in general was foreign to them, and, (2) the suspicions of the local people often prevented them from obtaining shelter in motels or taverns. In the winter of 1944, chief petty officers Wally Hammond and Tubby Lister escaped from Colditz Castle to find "the weather could scarcely have been worse. Sleet had been driving into the carriage windows as they drew into the station; the temperature was now below freezing and a high wind was blowing snowy gusts into the booking hall. It was no night to spend in the countryside . . . to find a sheltered hiding place where they would not freeze to death was, virtually, impossible . . ." (Reid, 1953, p.165).

Numerous otherwise successful escapes were ended as escapers were captured or forced to give themselves up due to the cold. Crawley (1985) writes of several escapes tried at a camp near Barth during a cold blizzard in March of 1942. The most ingenious escape involved the impersonation of a Continental chimney sweep. Although the man did manage to pass inspection by the guards, once outside the camp, "the weather again proved too severe, and after a night spent looking for somewhere to rest in 20° of frost, the prisoner was caught" (Crawley, 1985, p.115).

Yet humans can sometimes overcome this adverse condition in ways that may seem both comical and yet ingenious. Evans (1946) writes of an escaper who swam a canal in winter and who "only avoided freezing to death by getting into a pigsty and cuddling an old sow. 'She stank a bit, but she was wonderful'" (Evans, 1946, p.22).

Many prisoners both used and were influenced by various elements of the weather. We have shown that rain, snow, fog, wind, darkness and extreme cold could have both positive and negative influences on an escape attempt. An interesting variable that addresses a longer time scale is that of climate. Could climate, and more importantly the prisoners' and guards' *perception* of climate, be exploited and therefore lead to successful escapes?

'ESCAPE SEASON'

The climatic term "escape season" reoccurs often in the literature regarding escapes, and, in particular, with regard to the extensive literature on the Colditz prison camp. Prisoners (and guards) used this term to define the time of the year when escapes were considered to be the most feasible. Generally this was regarded as the warmer half of the year. Some comments from various World War II prisoners reflect this preception of an "escape season":

"April 9 . . . the opening of the 'escaping season' (Reid, 1984, p.46).

"With spring in the air the escaping season would soon be accelerated into top gear (Reid, 1984, p.166).

". . . thinking of summer, the escape season (Brickhill, 1950, p.29)".

"Normally by September the escape season was considered to be over (Reid, 1984, p.166).

"Winter, relatively speaking, is the escapers' 'close season', though the second world war was to see many time hallowed rules of this nature broken (Reid, 1952, p.104)".

While these comments suggest that many of the prisoners believed there was a distinct "escape season", the question remains as to whether there was an actual relationship between the season of the year and the number of attempted escapes from prison camps. A dataset that is available to aid in the answer of that question is the comprehensive listing (including dates) of all escape attempts from the Colditz camp during World War II (Reid, 1984). The monthly distribution of these escape attempts is summarized in Table 1. In all, there were 181 attempted escapes from Colditz during the war. Over 68% of these escapes (123) occurred during the six-month period from April through September. This certainly suports the argument that there was a definite time of the year in which escapes were most prevalent. Specifically, the months with the most escape attempts were May and July while those with the fewest attempts (at Colditz) were February and March.

Table 1: Total Attempted Escapes from Oflag IVc by Month (1941-1945)

	Jan	*Feb*	*Mar*	*Apr*	*May*	*June*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Total	10	3	6	14	27	16	24	21	20	7	21	11
%[1]	5.5	1.7	3.3	7.7	9.4	14.9	13.3	11.6	11.0	3.9	11.6	6.1

[1](Percent of the total number of attempted escapes)
Total attempted escapes: 181

Total Successful Escapes from Oflag IVc by Month (1941-1945)

	Jan	*Feb*	*Mar*	*Apr*	*May*	*June*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Total	1	0	0	0	4	1	4	3	4	6	2	5
%[e]	3.3	0	0	0	13.3	3.3	13.3	10.0	13.3	20.0	6.7	16.7

[e](Percent of the total number of successful escapes)
Total successful escapes: 30

(source: Reid, 1984)

Perhaps more important than the seasonal distribution of total escape attempts is the monthly proportion of *successful* escapes. While the summer warm season appears to have been the "escape season", data from Table 1 suggest that it was not the "best time in which to accomplish a successful escape. A histogram of monthly totals for attempted and successful escapes is shown in Figure 1. The peak time of successful escapes was somewhat later in the year than was the case with total escape attempts (80% of all successful escapes took place netweem July and December). While there were only seven total escape attempts during the month of October, six of these escapes were successful. December was also a rather successful escaping month with five "home runs" (a term used by the prisoners to describe a successful escape). Conversely, there was only one successful escape

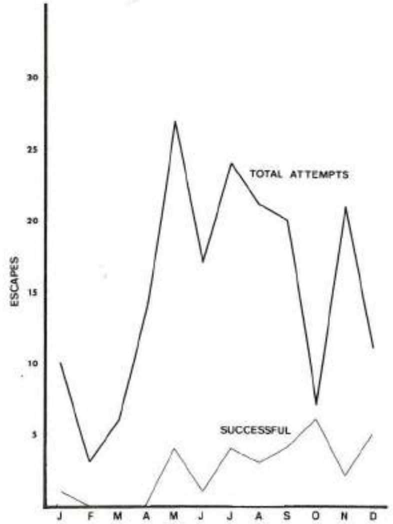

Fig 2: Graph of the seasonal distribution of number of people associated with attempted escapes and successful escapes (shaded) from Colditz Castle (1941-1945). Data source: Reid (1984).

during the period from January through April. This is not surprising considering the relatively small number of total escape attempts during these months. We find it somewhat surprising that there were not more attempts during March and April because one would expect that after a long winter, "cabin fever" might tend to lead to more total (although probably not successful) escape attempts.

The difference in the seasonal distribution of total and successful escape attempts poses an interesting question. If this difference is "real" and not just an artifact of the relatively small number of successful escapes, what possible explanation might be advanced to account for the difference in timing? First it is not at all surprising that the total number of escape attempts was greatest during the warmer months. One would expect prisoners to attempt to escape more often during the warm season simply because of the relative ease with which they could survive outside of the camp after making their escape. This same expectation, however, may also help to account for the large failure rate of these attempts. The camp commandant and the guards would be expected to realize that warm weather would promote escapes and consequently were more alert to escape-related activity. Indeed, Paul Brickhill, in charge of protecting the British forgers from German eyes, observed that because "the summer lingered on, and the weather stayed good for escaping, that was probably why (the German security officer) kept (his guards) up to the mark (Brickhill, 1950, p.111)".

This alertness might have diminished as the year progressed into the colder months of fall and early winter. The perception of the commandant and the guards was that this was a "closed season" for escapes. As the prisoners in Stalag Luft III noted during January: "It had never been so easy to get rid of the sand (from the tunnel), because as it was the off-season for escape, Massey (the British commanding officer) had persuaded Von Lindeiner (the camp commandant) to let the prisoners walk about between the block till ten o'clock. Covered by darkness, there was no need to use the trouser bags (Brickhill, 1950, p.124)". The guards may not have been as watchful for potential escapes to the extent to which they were during the warmer season. Therefore, the prisoners may have been able to escape *successfully* during periods with weather that was perceived by the guards as being essentially unfit for escaping.

CONCLUSIONS

The statistics do indicate preferred times of the year for successful escapes. It appears, however, that this tendency was not acknowledged as an influencing factor in actual escape planning. As Kenneth Lockwood suggests, escaping "was a matter of opportunity" (personal communication, 1987). We have endeavoured in this study to demonstrate that a variety of environmental conditions played important roles in creating that escape opportunity whether through the physical stresses of the environment or the perception of the given condition by the guards and prisoners.

Whereas this study has suggested that both climate and weather do have an influence on people, particularly those people under stress, it is important to realize that in these cases, the environmental conditions are not the sole controlling factors. Lack of food, the accuracy of forged materials, the knowledge of language and other non-environmental conditions are also important escape-

forcing mechanisms. Particularly, none of these prison escapes, successful or otherwise, would have been possible without the ingenuitiy of the prisoners themselves. As Major Reid indicated, it is the ingenuity of the people involved coupled with the physical constraints and perceptions of the weather that provides an incentive to escape. It is that ingenuity which allows people to use and yet be influenced by the environment on the way to achieving their desired goals.

Acknowledgements: We deeply appreciate the comments and suggestions of Patrick Reid and Kenneth Lockwood on the topics raised in this research.

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THE DEVELOPMENT OF A P.C.-COMPATIBLE AUTOMATIC WEATHER STATION

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Abstract: The general approach used in developing an automatic P.C.-compatible weather station which utilizes an intelligent and versatile RS232 interface is described. The reliability, advantages and the drawbacks of the developed system are discussed.

INSTRUMENTATION

The Kuwait Institute for Scientific Research (KISR) automatic meteorological station [1] is located at the Institute campus at 29° 20 latitude, 47° 57 longitude. It is currently equipped with 12 weather-monitoring instruments which simultaneously and round-the-hour monitor the following 12 weather parameters:

1 – direct normal solar radiation (Eppley normal incidence pyrheliometer, model NIP).

2 & 3 – diffused and global radiation from 0.285 10^{-6}m to 2.8 10^{-6}m (Eppley pyranometers, model 8-48).

4 – global ultraviolet solar radiation from 0.290 10^{-6}m to 0.385 10^{-6}m (Eppley U.V.-radiometer, model TUVR).

5 – infra-red radiation from 4.10^{-6}m to 50.10^{-6}m (Eppley pyrgeometer, model PIR).
6 – ambient temperature (two-terminal integrated circuit temperature transducer, Analogue Devices, model AD 590).
7 – relative humidity (Hygrometric Inc., model 8501A).
8 – wind-speed cup anemometer (Climet, model 011-3).
9 – wind direction (wind direction vane, Climet, model 013-30).
10 – sunshine hours (EKO instruments, sunshine duration meter, model MS-091) and sunshine meter converter (EKO instruments, model S1 – 03910).
11 – atmospheric dust (digital dust indicator, model P-5, MDA Scientific, Inc.).
12 – barometric pressure (aneroid barometer, with Lambrecht KG, model 811).

DATA ACQUISTION SYSTEM (DAS)

The DAS (Fig. 1), designed to automate the measurement procedure, was developed jointly by KISR and Georgia Institute of Technology. The system is equipped with 112 current input channels, 8 low-level input voltage (0-10 mV) channels and 8 high-level input voltage (0-10 V) channels. The low-level voltage channels are multiplexed and fed to an instrumentation amplifier where the signal level is matched to the input requirement of the 12- bit A/D converter (0-10 V range). The current input channels are fed to a current amplifier after multiplexing. The amplifier output signals are then coupled to the A/D converter.

The operation of the DAS is controlled by an Intel single board computer (ISBC 80/30) based on an 8085 Intel processor. The board contains a 16 K-byte RAM and utilizes two 2K-byte EPROMS which can be programmed to scan selected channels at the desired rate. The minimum scanning time per channel which can be achieved by the DAS ranges between 1-2 msecs.

After each scan, data acquired by the DAS are immediately transferred to an IBM P.C. via an RS232 standard interface.

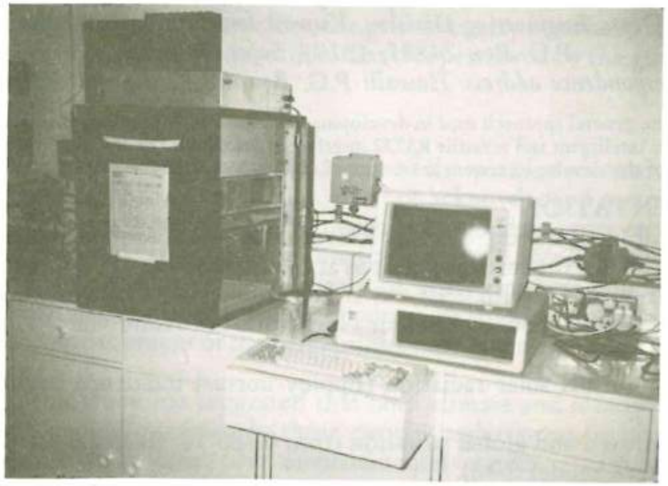

Fig.1: A view of the Data Acquisition System, DAS, interfaced with an IBM P.C.

WEATHER DATA COLLECTION AND MANIPULATION

The DAS is programmed to read the weather instruments' output every 26 seconds. Over a 30-minute period the DAS reads each of the 17 channels 60 times (4 minutes deadtime period). Following each scan, data are dumped instantaneously into the buffer of an IBM P.C. which is programmed to store the transferred hexadecimal data into a string. The programme retrieves the string, breaks it into bytes and calculates the decimal equivalent of each byte. The input of each channel is calculated by combining every two consecutive bytes. During a 4-minute deadtime period after an array matrix of 17 channels x 60 readings is completed, data are processed and recorded on a floppy diskette by the P.C.

When the collection of the array matrix elements is completed an average output reading for each sensor is calculated except for the following three sensors: wind direction vane, digital dust indicator and sunshine hours duration meter. Because it is erroneous to calculate average wind direction by directly averaging instantaneous readings, an algorithm based on vector addition was developed for this purpose and incorporated into the P.C. programme.

An electronic integrator-dump circuit was designed and built to be incorporated with the digital dust indicator so that atmospheric dust levels could be measured on an automatic basis by coupling the instrument to the DAS. The output of the dust indicator is integrated over a 26-second period and dumped instantaneously into the DAS upon receiving a pulse every 26 seconds from the DAS ISBC 80/30 computer board. An average reading for the 60 integrated readings is calculated by the P.C. during the 4-minute deadtime interval.

The dust indicator readings are used primarily to indicate the relative dust levels in the atmosphere. Because dust-particle weights and average sizes vary daily in Kuwait, it was extremely difficult to calibrate the instrument for all possible local dust conditions.

The visibility readings which appear in Table 1 (column 9) are calculated from a model based on correlating visibility to infra-red sky radiation, ambient temperature and absolute humidity [2,3,4].

An algorithm based on comparing the ramped output readings of the sunshinemeter converter (EKO SI – 03910) was included in the programme to determine the integrated sunshine duration. A counter was set to count the number of times the output is incremented (the output is incremented when sunshine radiation exceeds a threshold value). Then the resultant number of counts is divided by the total number of readings (60 readings) and multiplied by 30 minutes to give the period of sun-duration in minutes.

A new half-hourly session of data collection is started when a reset pulse from the P.C. clock is received by the DAS (ISBC 80/30) computer board.

Daily, the recorded data transferred from the floppy diskette to KISR's mainframe (IBM 4341) via an AST-PCOX card (IBM 3278/3279) to be processed, analyzed and stored in a meteorological data base. A monthly bulletin which tabulates the collected hourly-daily climatological data (Table 1) is produced every month [5]. Also, a summary of weather-parameter monthly means is included in the bulletins.

WEATHER PARAMETERS FOR THE DAY :060187

TIME	TEMP	HUMIDITY			WIND		BAROM. PRES.	VIS.	ATM. IR	SOLAR RADIATION				AIR-MASS
	C	DP C	RH %	AH G/M3	DIR. DEG.	SP. M/S	MBAR	KM	WH/M2	GR WH/M2	DR WH/M2	DN WH/M2	UV WH/M2	
0- 1	30.9	20.6	54.4	17.1	255.	6.1	1001.	7.6	407.	0.	0.	0.	0.	0.0
1- 2	30.5	20.5	55.6	17.1	278.	5.8	1001.	7.3	406.	0.	0.	0.	0.	0.0
2- 3	29.9	20.0	55.3	16.5	262.	5.7	1001.	7.8	401.	0.	0.	0.	0.	0.0
3- 4	30.5	19.8	53.2	16.3	298.	6.7	1002.	12.1	388.	0.	0.	0.	0.	0.0
4- 5	29.9	19.6	54.1	16.1	283.	4.2	1002.	11.6	384.	0.	0.	0.	0.	0.0
5- 6	29.9	19.4	53.5	15.9	273.	4.9	1002.	12.2	382.	53.	37.	3.	2.	0.0
6- 7	30.3	18.8	50.5	15.4	278.	4.7	1002.	9.8	391.	263.	129.	219.	10.	0.0
7- 8	31.0	19.7	51.0	16.2	245.	3.1	1003.	9.3	398.	486.	181.	504.	21.	2.0
8- 9	32.5	20.9	50.6	17.3	244.	1.9	1003.	9.0	410.	695.	211.	636.	32.	1.5
9-10	34.0	22.7	51.9	19.3	259.	2.2	1003.	10.6	416.	863.	244.	722.	41.	1.2
10-11	35.0	24.1	53.1	20.8	319.	5.1	1003.	9.9	429.	982.	335.	753.	48.	1.1
11-12	35.2	24.4	53.8	21.3	323.	6.7	1002.	8.1	438.	1028.	449.	705.	49.	1.0
12-13	36.2	25.1	53.1	22.1	164.	5.3	1002.	9.8	439.	989.	480.	635.	47.	1.0
13-14	36.6	25.0	51.6	21.9	326.	5.6	1001.	9.5	440.	914.	383.	631.	43.	1.1
14-15	36.8	25.3	52.2	22.4	326.	5.6	1001.	12.7	432.	773.	296.	569.	35.	1.2
15-16	36.5	25.1	52.4	22.2	167.	5.1	1000.	12.5	430.	572.	245.	425.	25.	1.5
16-17	37.1	25.2	51.0	22.2	4.	5.2	1000.	13.2	431.	356.	191.	281.	15.	2.0
17-18	35.6	24.8	53.9	21.8	336.	4.9	1000.	11.3	428.	151.	111.	97.	6.	0.0
18-19	34.5	24.5	56.4	21.5	8.	4.5	1000.	7.6	436.	22.	21.	5.	3.	0.0
19-20	33.9	23.5	54.6	20.2	171.	4.7	1000.	6.5	436.	0.	0.	0.	0.	0.0
20-21	32.5	23.5	59.2	20.3	333.	3.2	1000.	8.2	420.	0.	0.	0.	0.	0.0
21-22	31.9	23.0	59.4	19.7	291.	2.0	1000.	7.5	418.	0.	0.	0.	0.	0.0
22-23	30.6	21.9	59.8	18.6	245.	2.3	1000.	5.5	421.	0.	0.	0.	0.	0.0
23-24	29.7	20.6	58.6	17.2	234.	2.6	1000.	5.8	410.	0.	0.	0.	0.	0.0
AVE.	33.0	22.4	54.1	19.1		4.5	1001.	9.4	416.3	TOTAL RAD.IN WH/M2:				
MAX.	37.1	25.4	61.3	22.5		6.8	1003.	15.8	445.2	GR=8147.1 DR=3312.9				
MIN.	29.4	18.8	50.1	15.3		1.6	1000.	4.1	377.9	DN=6185.5 UV= 377.1				
STD.	2.6	2.3	3.0	2.5		1.5	1.	2.7	19.0	SUNSHINE HRS =11 : 30				

Table 1. A sample of collected hourly-daily weather data extracted from climatological data for June 1987.

SYSTEM PERFORMANCE AND RELIABILITY

Although the data acquisition system and weather monitoring instrumentation are operated on a daily basis in what is usually a very harsh climate, excellent reliability was achieved. The problem most frequently encountered in the early stages of development of the system was the unreliability of the electrical utilities in Kuwait. This was easily alleviated by connecting the mains supply to a utilities support system incorporating battery storage. By also installing a duplicate system it was possible to achieve almost 100% reliability.

To ensure that recorded data were reliable, periodic calibration of both data acquisition system and weather monitoring instrumentation was carried out. Calibration of the data acquisition system was straightforward and was accomplished by connecting a voltage calibration source (Electronic Development Corp., Model E100) to each input channel in the DAS and checking the output of the analogue to digital converter. Calibration of the weather monitoring instrumentation was carried out using the procedures recommended by the manufacturers.

CONCLUSION

Even in harsh climates typical of Kuwait, the routine collection of meteorological data can be reliably achieved on an automatic basis using a data acquisition system. The system described here has many advantages for such applications. It is reliable and in the event of malfunction, it is modular in design, thus ensuring short down time and easy maintenance. The system is also flexible (it can handle instruments with current, low voltage or high voltage outputs) and can easily be interfaced to a personal computer via its RS232 interface. For applications where high-speed multiplexing of channels is required, the system is unsuitable because of the switching speed limitations imposed by the read relays in its multiplexer system. This limitation could be removed however by replacing the relay-based system with a multiplexing system based on solid-state switching.

Acknowledgement: We wish to thank the Energy Department for providing us with a sample of the weather data.

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FURTHER DAMAGE ON THE SPURN PENINSULA 4 MARCH 1988

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Abstract: Further damage by heavy swell on 4th March 1988 resulted in the road to Spurn Head being completely destroyed over a distance of 300-350 metres in the vulnerable 'narrow' section – a demonstration of the enormous power of an onshore swell but on this occasion NOT the result of a sea-surge.

Five years ago I discussed the effects of the North Sea surge in the Humber area on 31 January – 1 February 1983 (Spink 1983). This was the last occasion when the Spurn peninsula was seriously affected by north-easterly wave action. On Friday 4 March a large slow-moving Polar low (centre about 980mb) lay over Norway. A very heavy swell from the north-north-east affected the East Yorkshire coast, and the vulnerable Spurn area caught the full brunt. In my note of 1983 I mentioned the vulnerability of the 'narrow' section which had been breached on previous occasions both recently and historically, notably in 1953 and 1978, though in both instances the road, apart from being flooded with mud, was not damaged to any irreparable extent.

However, on 4 March 1988 the swell was such that a length of the concrete road was undermined and collapsed for 300-350 metres, thus cutting off normal traffic to the headland where lighthouse and lifeboat personnel are housed, not to mention the large modern coastguard tower. A visit on 10 March revealed the full extent of the damage which was confined to the narrow neck area. Approximately 150 metres of concrete road had been undermined and had collapsed. The vital water pipe from Kilnsea to the headland had been destroyed and a narrow hosepipe substituted as a temporary measure.

The 'neck' is an attenuated length of about one kilometre running at the lowest point of the peninsula, no wider than 120 metres from beach to beach. This vulnerable sector is 'protected' by enormous blocks of granite and cement on the North Sea side, but there are earthen banks before and after this sector where the widths are greater and strengthened by indigenous vegetation such as buckthorn. The earthen banks offer little protection and have been much eroded since my 1983 visit.

It was interesting to observe that the area 'protected' by the deposits of concrete and granite blocks (each weighing several tonnes) suffered the worst because the blocks have many gaps between them. Thus the force of the swell would be greatly accentuated by being forced through the gaps to the road. This is illustrated by the fact that not only has the concrete road collapsed after being undermined but many of the huge blocks have subsequently been lifted and deposited on the collapsed road surfaces.

Thomas Sheppard (1912) reproduced in his book a number of historical maps of the Humber area from Elizabethan days onwards, and shows *inter alia* a navigation map of the mouth of the Humber dated 1820. It shows clearly two breaks in the narrow part of the Spurn Isthmus; thus we have a warning of history repeating itself. Now that the military importance of Spurn as a place for sea-defences, as in the 1914 and 1939 wars, which necessitated both a rail and road link has lapsed, it would appear that at present the fate of the all-important link road is in the balance and that Spurn may yet find itself an island again after the next full-blooded sea surge which could come at any time. The necessary finance to rebuild and protect a permanent road at present seems uncertain.

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DEATHS IN BRITAIN FROM THE WEATHER IN 1987

This month-by-month list contains all known deaths directly attributed to weather hazards, i.e. thunderstorms, blizzards, floods, gales, etc. Indirect deaths, such as road accidents due to fog, ice, etc, are also tabulated for each month, but only important groupings are specifically mentioned; maritime casualties are also included. For details of how deaths are tabulated see *J. Meteorology*, Vol.1, no 5, pp. 168-169.

January: The first, and only, direct weather related death this month was reported on the 13th when a man was found dead in a snow drift near Ceres, Fife, Scotland. At least 91 indirect weather deaths were reported during the month, 80 of them during a cold spell around the middle of the month, the other eleven deaths were in road accidents attributed to adverse weather conditions, including three in a car which hit snow plough at Nidmar about 40km west of Aberdeen, on the 18th, there were no maritime deaths reported during the month.

February: There were no direct, or maritime deaths reported in February.

March: Nine direct weather related deaths were reported this month, all in the gales and strong winds which hit many areas of the country on the 27th, three died when tree fell on to van at Lower Kingswood, Bansted, Surrey, two deaths occurred when walls were blown down by winds, one in Hendon, London, the other in Newport, South Wales, two others died when trees were uprooted, one died when tree fell on them at Shipdham, near Dereham, Norfolk, the other tree fatality was on the A595 road at Bigrigg, Cumbria, when a car was hit. Of the other two deaths reported, one occurred on the A5 near Shrewsbury when one lorry was blown into the path of another lorry and the other death reported, which occurred on the 30th, was the result of injuries received on the 27th when a pedestrian was blown over in Nuffield Road, Oxford. There were three indirect deaths reported during month, two on the 27th as a result of the gales and rain, one died in a landslip on a building site at Edington, near Westbury, Wiltshire, the other reported death was when a man picked up a "live" power cable brought down by the winds at Lewknor, Oxfordshire. The two maritime deaths of the month also occurred on the 27th, one was a man swept off trawler by heavy seas 45km east of Falmouth. Cornwall, the other fatality was off Alexandra Dock, Hull, when barge *Besthorpe* sank in storm.

April, May, June and July: No direct, indirect, or maritime deaths reported.

August: One direct death reported this month, a man struck by lightning at cricket match at Isleworth, West London, there were no indirect or maritime deaths reported during the month.

September: There were no direct deaths during September, three indirect deaths were noted, all on the 6th in road accidents during rain storms in the Midlands, another 12 people were injured. The two maritime deaths reported in the month occurred on the 11th when the f.v. *Sandy Lady* sank in heavy seas some 6.5km off the Lancashire coast.

October: This month will be long remembered for the great gale of the 16th, which claimed nine of the 14 direct deaths reported during the month; two died at Highcliffe, Dorset, when a falling tree hit a fire engine; three died in separate incidents as chimneys collapsed through roofs of buildings, one in Windsor, Berks, one at Hove, Sussex and the other at Hastings, Sussex; also at Hastings a man was killed by a beach hut being blown across the beach. One person died when a tree hit a house in Chatham, Kent; also in Kent part of a house collapsed at Biddenden, killing one person, the ninth death in the great gale was in Lincoln's Inn Field, London, when a falling wall killed a vagrant.

The other five deaths during the month all occurred in floods in Wales in the rains which followed the great gale; on the 18th one person died when swept away by floods near Aber, Bangor and four died on the 19th when a train plunged off a flood damaged bridge near Llandovery, in the west of the country.

At least 13 indirect deaths were reported during the month, four of which occurred on the 10th, all were pedestrians involved in separate road accidents during heavy rain, the other nine deaths were in association with the great gale of the 16th, either on the day or in subsequent days, four died on the 16th, three in road accidents attributed to the gale, the others occurred between the 18th and 31st and involved people clearing fallen trees, power lines etc.

The two maritime deaths reported were again associated with the great gale of the 16th when the bulk carrier *Sumneo* sank outside Dover harbour.

November: One direct death reported this month, on the 11th heavy seas washed a boy from his bicycle on the promenade at Peacehaven, Sussex. The two indirect deaths reported occurred on the 29th when a car hit a stationary lorry on the A31 at Alresford, near Winchester, in fog. There were no maritime casualties this month.

December: The final direct death of the year was on the 31st when heavy seas washed a boy into the sea at Porthleven, Cornwall. There were no indirect or maritime deaths reported during the month.

The total number of direct deaths in 1987 is therefore 27; indirect deaths totalled at least 112; maritime deaths amounted to 6. The number of known direct weather-related deaths in the last seven years are as follows: 1981, 28; 1982, 44; 1983, 21; 1984, 32; 1985, 10; 1986, 39; 1987, 27. For previous years totals see *J. Meteorology* Vol.9, no.90, p.178(1984).

May I take this opportunity to thank all the people who have sent me newscuttings via Dr. Meaden for World Weather Disasters, and especially D. A. Holmes, who has sent many valuable cuttings from Indonesia, and also Mrs. P. Brook, from Erith, Kent and Mr. W. G. Collins from Hitchin, Herts, who sent many useful cuttings on the great gale of October 16th, and lastly, the proprietors of *Lloyd's List* for permission to use extensively from their newspaper. Additional correspondents are always welcome, and may write to me direct at 94, St. Andrews Road, Bordesley Green, Birmingham, B9 4LN.

ALBERT J. THOMAS

UNUSUAL GUST OF WIND IN LANCASHIRE 7th FEBRUARY 1988

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Abstract: A gust that was unusual for not only the maximum velocity recorded but also its sudden occurrence is considered. Meteorological changes recorded on autographic instruments and damage caused are described and interpreted, and the possible origins of the event are discussed.

At 2100 GMT on Sunday, 7th February 1988 a gust of 106mph (47.5m/s) was recorded at Hazelrigg weather station, which is the field station of the Department of Environmental Science at the University of Lancaster. The site is 94m above sea level and has a high frequency of gales due to its exposed position, 10km east of the tidal mudflats of Morecambe Bay, with views of the Cumbrian Mountains and occasionally the Isle of Man and Snowdonia. The slope to the coast is steady but undulating, while to the east the land falls steeply to 50m at the River Conder before rising to 413m at Clougha Pike 5km away, eventually reaching 561m at Wards Stone, the highest peak in the Bowland Fells, 5km further east.

AUTOGRAPHIC DATA

Although such a strong gust may occur in very stormy weather at exposed sites like Hazelrigg, the present event is unusual because the winds are otherwise quite moderate. From 2000 to 2200Z, the second highest gust was 42mph, while the

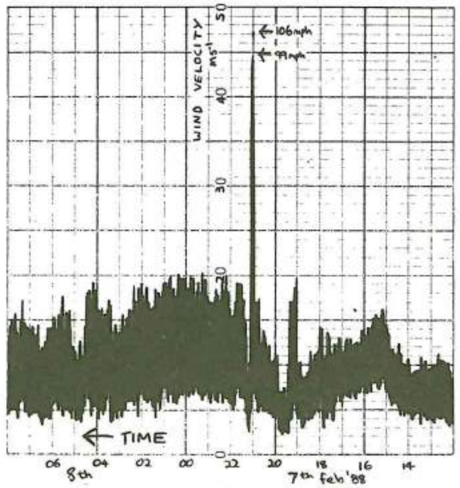

Fig.1: Anemograph trace showing gust of 106mph at 2100 GMT on 7th February 1988.

second highest gust of the day (and the following day) was 46mph, about 2¼ hours after the 106mph gust. The suddenness of the 106mph gust is quite clear from Figure 1, which also shows a lull in which the velocity fell to 5mph just after the gust. The wind direction also varied sharply. From 1200Z the wind backed, reaching S by 1600Z, but just before 1800Z it suddenly veered from S to WNW and backed to SSW in the space of a few minutes. The wind then started veering with a particularly sharp jump to W at 1900Z, before backing to SSW again at 2100Z, the time of the gust. Although insignificant in comparison with direction jumps earlier in the day, the veer at 2100Z to W was very noticeable because there was very little variability within the overall wind veer.

Other recording instruments showed sudden changes around 2100Z. The temperature fell from 4.0°C to 1.5°C and then recovered to 3.0°C in the space of about 5 minutes. The humidity fell from 86% at 2000Z to 67% at around 2100Z, before rising to 91% quite quickly. As the surface temperature drop paralleled the air temperature drop, no hail (or very little) fell, otherwise the surface temperature would have dropped to near freezing and would then remain fairly constant until the hail melted. So there was no hail, but a rainfall of 2.7mm registered by the tipping bucket gauge at 2100Z was also recorded by the Jardi gauge.

The barograph showed that pressure was constant at 1006mbar from 0400 until 1030Z, when it started falling quickly; despite the passage of an occluded front, pressure continued falling to 988mbar at 2100Z, after which it started rising slowly.

DAMAGE

With such a high wind velocity, one would expect considerable damage, but no damage of any kind was seen in the instrument enclosure or sustained by the field station building, adding mystery to this already unusual event. A careful search for boundary damage was made along fences and hedgerows, but again none could be found. Attention was then moved to other structures in the field. Small wooden sheds were found to be undamaged, and so too were disused aerials. However, near the western (lower) end of the field a wooden feeding trough for sheep, weighing over 75kg, had been moved 5.1m from its original position, and fresh, localised gouging of nearby grass showed that the trough had been rolled.

Following this, the area under investigation was extended to include a small mature mixed wood which bordered on the lower end of the field. The whole wood was littered with twigs and small branches of Scots Pine (the only conifers); in addition, a large pine branch was also found which was 4.3m long, 16cm in diameter, and was estimated at about 100kg in weight. The other end of the branch was also broken, and the remaining section was found a further 5.0m away, this being 1.7m long. The main branch displayed clear signs of shearing where it had become detached from the parent tree, the nearest end of the branch lying 6.5m away from the tree. However, the branch was found near the base of a neighbouring tree which displayed severed and broken branches at a similar height to which the sheared branch was removed from the parent tree. This suggests that the branch was moved almost horizontally into the neighbouring tree causing this additional damage, which infers very high wind speeds. Smaller, but still significant, coniferous branches were also found amongst the general damage of broken twigs. The most significant damage to deciduous trees was a 4.0m long branch which had been detached along with smaller branches fanning out from their parent tree.

INTERPRETATION

Given the meteorological conditions and damage recorded let us now consider the possible origin of this violent gust. It seems that we are not dealing with an isolated cumulonimbus in the showery airstream following the occluded front, which cleared the area at about 1900Z; pressure continued dropping until 2100Z, after which it rose slowly, suggesting that a trough followed the front – which would help to explain the wind veer and decrease in temperature. The trough's existence was confirmed on the Bracknell facsimile transmission of the 1200Z synoptic chart.

It is tempting to suggest that a tornado was responsible for the gust – this would certainly explain its suddenness and also the shearing of the large branch in the wood. A velocity of 106mph corresponds to a T3 tornado on the TORRO scale. However, the tornadic evidence is not conclusive on three counts:

a) Movement of objects was mostly confined from 240° to 280°, whereas a tornado would have strewn objects in much more widely differing directions.

b) The wind-direction record would have shown a very significant disturbance, rather than a slight veer.

c) There was no rapid decrease and increase in pressure at the trough as would be expected if a tornado was responsible, despite the close proximity of the field-station building, where the barograph is kept, to the instrument enclosure.

Nevertheless, it is an interesting thought that some sudden and violent squalls could be of a rotational nature, such as a weak tornado or an eddy whirlwind as suggested by G. T. Meaden in a private communication. Sudden and violent squalls like this example deserve careful investigation and interpretation as some may well contain vortices.

CONCLUSION

From the available meteorological data and identified damage, it is concluded that the gust of 106mph at 2100 GMT on 7th February 1988 was the result of a very sudden, short-lived and violent squall that was non-tornadic, associated with a trough behind an earlier occluded front. This gust represents the highest wind speed ever recorded at the University since records began in 1966, and it is unlikely that such a strong gust will be recorded again for a considerable length of time at this site, even though it is exposed. In fact, in the high winds that affected much of north-western Britain only two days later, the highest gust recorded at Hazelrigg was a relatively tame 74mph at 1745Z.

Acknowledgements: Thanks are offered to Mr. Martin Beadle (Meteorological obsever) of the Department of Environmental Science at the University of Lancaster for access to the data, and special thanks to Dr. Robin McIlveen (Meteorologist) of the same department who made many valuable comments.

WORLD WEATHER DISASTERS: DECEMBER 1987

1-31: Rain, high winds and low temperatures in Victoria state, Australia, 30,000 sheep died of exposure; between 0900 hours on the 1st and 0700 hours on the 2nd 46mm of rain fell on Melbourne in heaviest December rainfall in 10 years. The high winds and seas around Port Phillip Bay sank or swamped about a dozen boats. *Daily Telegraph. Lloyds List.*

1-9: Rain, high winds and floods in southern Thailand and north-east Malaysia:
Thailand: Hit from 1st to 9th by heavy rains and floods which covered 74 districts of eight provinces, leaving 24 dead and affecting nearly 200,000 others and causing widespread losses to rice crops; six of dead were in a fishing vessel which capsized in winds off Surat Thari province.
Malaysia: Heavy rains and floods drove 1200 people from homes between the 1st and the 6th and on the 17th huge waves destroyed over 100 houses in coastal villages in the states of Terengganu and Kelantan, in north-east of country. *L.L.*

4-6: Torrential rains, floods and landslides in central Peru left 22 dead and about 50 missing, in the village of San Juan de Ubiriki two schools and 30 houses buried in landslide which hit at 0420 hours, three other villages also hit by mudslide. *L.L.*

5: A China Airlines Boeing 747 on a flight from Los Angeles to Taipei flew into clear air turbulence while four hours flying time from Taipei, injuring nine of the 376 passengers aboard aircraft. *L.L.*

6: Mu *Jan Yung No 2* sank in heavy seas about 74km north of Okinoshima, Honshu, Japan, leaving 11 crew missing. *L.L.*

7: Rain flooded houses and roads along the Algarve coast, Portugal, no casualties reported. *International Herald Tribune.*

7: Incessant rains touched off landslides in Tasikmalaya regency, west Java, Indonesia, leaving one dead, 80 homes buried in village of Cikuya, 19 of which were totally destroyed, many cattle swept away by landslides. *Jakarta Post.*

7-8: Torrential rains and floods in Lebanon, in the Jisr al Basha district of Beirut, floods caused walls of military dormitory to collapse leaving five dead and three injured, the rains also brought down power lines and cut roads to north of Beirut. *L.L.*

8: Heavy smog in Athens, Greece, led to restrictions on traffic. *I.H.T.*

8-17: Heavy rains in south Cianjur regency, West Java, Indonesia, destroyed at least 47 houses with 383 others threatened; paddy fields and fish ponds also damaged, no casualties. *J.P.*

8(reported): Storm in central Vietnam on November 18/19 (see entry dated 11-20 in November return) left 86 dead, provinces of Nghia Binh and Phu Knanh worst affected. *L.L.*

9: A DC-9 aircraft belonging to Toa Domestic Airlines on a domestic flight from Oita to Haneda airport, Tokyo, Japan, encountered clear air turbulence which injured nine of those aboard. *L.L.*

12-13: Monsoon floods swept through five subdistricts in the Pidie regency in Aceh, Sumatra, Indonesia, leaving three dead with 15 houses destroyed. *J.P.*

12-13: Monsoon rains and floods in north Sumatra, Indonesia, hundreds of homes inundated, landslides reported, but no casualties reported. *J.P.*

13-16: Powerful snowstorm from New Mexico to mid-west of U.S.A., insured losses put at $125 million in nine states, drifts up to 1.5 metres deep reported in New Mexico on the 13th; on the 14th a tornado hit West Memphis, Arkansas, leaving six dead and over 100 injured, tornadoes also reported from three other states; the snowstorm hit the mid-west states on the 15th-16th with winds gusting to 121 km/h and snowfalls up to 300mm, rail, road and air transport severely disrupted, at least 21 direct and indirect deaths reported in storm. *L.L., I.H.T.*

14-17: Typhoon "Phyllis" hit the central Philippines on the 16th and 17th, with winds gusting to 140 km/h on Samar Island, no major damage reported, as "Phyllis" approached the Philippines; however, fringe winds and heavy seas sank a vessel off Samar Island, leaving 10 dead and 13 missing. *L.L.*

14-15: Torrential rains caused flash floods in the Solok region of west Sumatra, Indonesia, leaving 41 dead, in the 24-hour period 138mm of rain fell, 140 homes, a mosque and a school destroyed in five villages hit by floods. *J.P.*

14-28: Torrential rains, floods and landslides in south Sulawesi, Indonesia, left at least 117 dead in what was described as worst disaster in south Sulawesi, at least 494 homes, eight school buildings and 24 bridges destroyed, thousands of hectares of paddy fields and plantations seriously damaged. *J.P.*

15: Winds, fog and low temperatures left 16 students dead on Mt. Lawu, Java, Indonesia. *J.P.*

15-17: Strong winds, snow, ice and freezing temperatures in central and southern California caused insured property damage of $10 million, snow reported around San Diego. *L.L.*

20: Vessel, the *Binter,* sank in heavy seas off central Kalimantan, Indonesia, near to Bawean island, leaving 78 missing. *J.P., L.L.*

21-23: Heavy rains in Cairo and the Nile delta, Egypt left 24 dead in traffic accidents, 20 when bus left road in heavy rain at Kom Hamada and fell into an irrigation canal; the rains, described as worst in five years, caused numerous power and telephone interruptions. The harbours of Alexandria and Suez closed down. *L.L.*

22(reported): It was reported that the floods affecting seven provinces of Indonesia in the last four months have been more destructive than those affecting the country previously. *J.P.*

23-30: Heavy snow and cold in many areas of U.S.A.:

23rd-24th: Snow and cold in California, San Diego, reported first snow in 20 years.

24th: Snow fell from southern Rockies to the Great Lakes, winds gusted to 160km/h in canyons in north-west Utah.

25th: Up to 250mm of rain in Tennessee and Arkansas, caused widespread floods; in towns of Millington, Tennessee and West Memphis and Marion in Arkansas, at least 600 homes flooded; meanwhile Tucson, Arizona, had first white Christmas in 13 years.

26th to 28th: Western and central areas of U.S. hit by heavy snow storms, up to 762mm of snow on western plains, shut Denver, Colorado airport and closed many highways in Colorado, Wyoming and Oklahoma, in Los Angeles the temperature fell to 35°F (1.5°C) in the downtown area of the city on the 26th, equalling a 106 year record; floods in Tennessee, Arkansas area receding on the 27th, although floods still up to 1.2 metres deep in areas; at least 26 traffic deaths reported in storm related accidents.

29th: Storm moved into New England, extending from Michigan to West Virginia, Virginia, Maryland and Delaware; up to 305mm of snow reported, transport disrupted.

29th-30th: Temperatures below − 18°C reported in northern New England and upstate New York. *L.L., I.H.T., Birmingham Evening Mail.*

26: Bus ran into funeral procession in dense fog near Luxor, Egypt, leaving 13 dead and seven others injured. *Sunday Telegraph.*

26-28: Torrential rains, floods and landslides in Minas Gerais state, eastern central Brazil, left at least 11 dead and 1500 homeless in four towns in state. *L.L.*

29: All northern Italian airports except Genoa closed because of fog, flights delayed, cancelled or diverted. *I.H.T.*

29-31: Strong winds, rains and floods in England and Wales, on the 29th floods in south Wales and on the 31st heavy seas washed boy from beach at Porthleven, Cornwall. *D.T.*

30: Smog in Athens, Greece, led to restrictions on traffic. *I.H.T.*

30(reported): Unseasonable warm weather, has been disrupting ski resorts in the Swiss, French an Austrian Alps. *D.T.*

31-1 Jan 88: Up to 508mm of rain fell on Oahu island, Hawaii, U.S.A., causing widespread flash flooding, which left 72 people homeless and damage put at $29 million; 1000 homes damaged in and around city of Honolulu, worst of damage occurred in south eastern section of Oahu, eight homes destroyed, 315 badly damaged and 748 received minor damage. *L.L.*

ALBERT J. THOMAS

THE MYSTERY OF THE CROP-CIRCLES: A B.B.C. FILM

This summer a film unit team from B.B.C. Television, Pebble Mill, spent six days on location in Wiltshire and Hampshire compiling a film for the weekly magazine *Country File* on the subject of geometrically shaped damage patterns in crops. The project began in June, following the second TORRO Conference at Oxford, with an approach to Dr. Meaden for information concerning what was potentially a visually-dramatic and interesting phenomenon well-suited for presentation as a spectacle for television viewers.

The scientific aspects of the problem, including especially the well-attested atmospheric vortex origin of the circles, were plainly stated in the initial discussion and in the interviews filmed at Corhampton in Hampshire on 23rd June and they were strongly restated later as well. In addition, in interviews filmed in July, eye-witness Melvyn Bell described the vortex which he had seen so clearly one summer's evening five years earlier while it was flattening a perfect spiral-circle in a Wiltshire wheatfield, and Roy Lucas recounted his observations of three spinning vortices which he witnessed near Yatesbury on 16th June of this year.

However, the objective of the programme being to "inform and entertain" (it could never be a scientific documentary because of the nature of the magazine series) the programme makers searched for variety by interviewing people holding weird or unconventional views. The result is that amusing sequences are to be included of interviews with believers in UFO's and the paranormal who choose to reject any natural origin for the circles from within our atmosphere and some of whom fantasize that the circles are "created by an unknown force, possibly manipulated by an unknown intelligence" or are "caused by high-energy fields within the earth" possibly "linked to ancient world-wide energy paths (ley lines)". Although crop-specialists are more usefully questioned as well, much of the film is likely to overemphasize wholly unscientific and irrelevant topics.

We are told that the final mix for the 24-minute film (out of 4½ hours of filmed material) is to be the work of a non-scientific editor not involved in the filming, and that no conclusions will be drawn by either producer (also a non-scientist) or editor. "The viewer will be left to draw his own conclusions".

The programme is to be broadcast on BBC 1 national television, and should go out at 12.30 p.m. on a Sunday at the end of September or in October (this suggests 25th September or 2nd October as the most likely dates from which the choice will be made, but probably the former).

During the summer an I.T.V. production team from T.V.S. Southampton was also compiling a programme using the fly-on-the-wall method. Brief items have appeared on T.V.S. and H.T.V. (Bristol) newsreels. An autumn showing for this film is a possibility.

THE SECOND TORRO CONFERENCE ON TORNADOES AND STORMS: PHOTOGRAPHS

Once again a highly successful conference was held at the Oxford Polytechnic. Speakers included two guests from abroad, Professor John Snow (Purdue University) and Professor Jean Dessens (Université de Clermont Ferrand, Puy de Dôme), shown here (centre left to right) with Derek Elsom and Terence Meaden.

The front-cover illustrations show some of the displays set up by Dr. Elsom and colleagues in the associated TORRO exhibition. David Brooks (top photo) of Anglia Television did a fine job as chairman.

LITERATURE REVIEWS AND LISTINGS

Book Reviews

WIND AS A GEOLOGICAL PROCESS. By R. Greeley and J. D. Iversen. Cambridge University Press 1987, 333pp., £15.00.

At first glance the title doesn't appear to be of direct interest to the amateur or professional meteorologist but to return this book to the shelf without exploring between its covers would be to miss an enjoyable and enlightening experience. To those of us who have been taught, or now teach, physical geography the name Bagnold is synonymous with aeolian geomorphology. In recognising the importance of his work, the authors set out to "build upon the solid foundation laid by Bagnold" although one might well question the terminology used here in reference to shifting sands!! The most interesting feature of this book is the extrapolation of terrestrial processes to Mars, Venus and Titan using available remote sensing data. These bodies have different gravitational acceleration and atmospheric density to Earth. To appreciate the importance of our understanding of aeolian processes it is necessary only to look at the extensive areas of the Earth where desertification is a real and life-threatening problem.

Chapter 1 provides the reader with an introduction to the significance of aeolian processes in relation to human activity and signposts the obvious value of remote sensing techniques. Chapter 2 is of particular interest to the meteorologist in that it examines the nature of boundary layer airflow. The treatment is standard and is competently done. The following three chapters deal in detail with the physics of particle motion, aeolian abrasion and corrosion, and sand deposits and bedforms, drawing on the authors' obvious and considerable experience of laboratory and field experimentation. Chapter 6, which examines the interaction of wind action and topography, starts with a somewhat weak and, I suspect, outdated discussion of larger scale motion. The use of windstreaks from remotely sensed images as diagnostic of boundary layer airflow is good reading and is well supported by laboratory and field data. Terrestrial relationships are then extrapolated to Mars, Venus and Titan. The final chapter deals with windblown dust on Earth and Mars. To help the reader there is an extensive glossary of 200 or more terms, and for the student there are more than 400 references to support further reading.

The book is scholarly, the diagrams and photographs are clear and helpful, and most of all it is interesting. Highly recommended and well worth considering for class adoption in this paperback form.

S. J. HARRISON

IN THE WAKE OF THE HURRICANE. By Bob Ogley. National Edition. Froglets Publications, Brasted Chart, Westerham, Kent, TN16 1LY, 1988, 132pp, £7.50.

Despite the torrent of meteorological literature with which reviewers are nowadays assailed, it is still rare to find a publication whose illustrations are far more important than its text. *In the Wake of the Hurricane* is such a rarity, for its 16 or so pages of text are more than outweighed by around 130 well-produced photographs, of which 12 are in full colour. This is precisely the mix needed to give the reader an immediate and lasting impression of the devastation wrought by the storm of 16 October 1987 in the Channel Islands and on the mainland of south-east England. There are, in addition, some photographs and commentary relating to earlier notorious storms over Britain. The text, such as it is, has an easily-assimilated, journalistic style. Within little more than a month of its appearance a first edition of the book sold 25,000 copies: it is to be hoped that this new, 'national edition' (which examines the storm damage over a much wider area than did its predecessor) enjoys even greater popularity, especially as some of the proceeds from its sale will go towards The National Trust Trees and Garden Storm Disaster Appeal. For those like myself, living in areas which mercifully escaped the full fury of the storm, this book will always prove far better than countless pages of scientific erudition and debate in conveying what actually happened on that dreadful night. (80,000 copies were reported sold by the end of July!)

L. TUFNELL

Journal Review

CHINESE JOURNAL OF ATMOSPHERIC SCIENCES. (English translation of Scientific Atmospherica Sinica) Allerton Press, New York. Annual Subscription $295 (4 issues).

This journal is one of the premier outlets for atmospheric research carried out in China and although it was started a decade ago, it was only with the 1987 issues that its publication in English allows the international meteorological community to have access to some of the excellent research work being carried out in China. The journal publishes high quality, state-of-the-art papers on atmospheric research with an emphasis on dynamic meteorology, atmospheric physics and chemistry but including papers on climatic changes, acid rain and atmosphere-ocean interaction.

In the first translated issue many of the papers are of a type and standard similar to those in the *Quarterly Journal of the Royal Meteorological Society.* Perhaps the most accessible paper to climatologists is a study of the relationship between the acidity of precipitation and synoptic conditions in Shanghai.

In the last thirty years or so modern atmospheric sciences have been developing fast in China. Unfortunately, due to the language barrier, up to now research results have been obscured from an international readership. Visiting meteorologists from the west have testified to the range and diversity of the research in progress and gradually links have been established between individuals and institutions. With the continual improvement in relations between China and the west it is becoming possible to judge the value and contribution that Chinese scientists are making.

This is a journal to which the major international meteorological libraries will want to subscribe, and for a specialized readership it will be welcomed as a valuable addition to the literature.

ALLEN PERRY

LETTERS TO THE EDITOR

SUNSPOTS, CYCLES AND WEATHERBELTS

A lifetime spent out of doors with a more than ordinary interest in weather and its development has led to a number of thoughts which need putting to paper, if only to clarify their connections. Some people study weather for its own sake, they enjoy mulling over their records, exulting in their extremes without too much concern for their reasons. Some of us would like to use records and observations to forecast weather trends. This has led to all kinds of mathematical concepts of cycles and inter-relationships, a few of which have stabilised but many frustratingly submerge almost as soon as they are noted. Weather, like lightning, seldom strikes the same place twice. The mobility of global weather is such that detailed forecasting for more than a few days seems likely to remain impossible, but long-term overall trends certainly seem possible.

I think it rather a pity that mathematics have come to play so big a part in meteorology, as it encourages introspection and detailed analysis (aggravated enormously by computer addiction) at the expense of the overall view.

On this basis it may be profitable to look at the cause of weather and work upwards rather than study weather records and look for reasons. The cause of weather, as we all know but seldom consider, is the sun. Its output varies from month to month, year to year, decade to decade, even century to century. One erratic cycle of 10-11 years seems well authenticated, with a superimposed 22 year cycle fairly well established. They appear to be related to sunspot activity with maximum insolation received at 8-9 sunspots monthly. With either fewer or greater numbers the total energy received is reduced.

With maximum insolation the width of the equatorial thunderstorm belt ("intertropical convergence zone" – Oh, the jargon!) will increase and so will total rainfall there, spreading over the margins of the adjacent desert areas to the north and south of it. Conversely, as at present (written March 1988), a time of a low solar power, the belt is at its narrowest and deserts extend back towards the equator, bringing Eritrea and the Sudan into the news. That the people's erstwhile nomadic lifestyle following the rains annually has been politically discouraged or prevented, is glossed over. The weather is a much more newsworthy scapegoat. Readers will be able to relate other tropical weather quirks (El Nino, Indian monsoon, etc) to this movement of the belt.

At latitudes 20° – 40° North and South, with maximum insolation there will be more dried-out air sinking from the equatorial thunderstorm belt to extend the desert belts ("sub-tropical high pressure zones") towards the poles, the airflow even reaching our shores more often. Conversely with minimum insolation.

Coming to the changes one might expect in our own latitudes 50° – 60°N, at times of maximum insolation we will find the northern fringe of the warm dry air closer to and even overlapping Britain more often (though often moistened to varying depths by a long sea track). At the same time polar air is reduced in quantity and intensity and invades us less often. I can recall the depressions of the warm thirties which used to travel to the North Cape or well into the continent. For the past few years, even a decade or two, most finish up in the North Sea, and northerly invasions are frequent, even in summer.

There are other consequences of a slowing of circulation with reduced insolation. The atmosphere will be less well mixed. Large parcels of air, especially over continents, will stagnate and become very warm or cold according to season. Sooner or later a situation will arise when these extreme parcels drift into unaccustomed situations, giving record temperatures. Extreme weather is likely on their fringes too when they clash with contrasting airflows. With less circulation there is likely to be less cloud, intensifying winter continental anticyclones, making them larger and more resistant to invasion by moister airmasses.

Other consequences will occur during the waxing and waning of the sun's periodicities. When the energy input begins to increase from low levels, as at present, the increasing amounts of warmer air from the subtropical highs will have to overcome the accumulated cold of the previous year or two and is likely to result in increased local rainfall and windiness. Conversely as it winds down, contrasts in opposing airmasses become less, there will be less mixing and quieter weather.

All this seems rather obvious but the difficulty in trying to prove the concept is – what weather statistics does one use and from what localities? By selecting statistics one can prove anything from the "greenhouse effect" to the coming ice age; people do it quite convincingly. The earth's lack of surface uniformity and the resulting distortions provide the greatest problem. Theoretically if the concept is true then all statistics should relate, but some better than others.

Perhaps for a start we should check on the width of the subtropical thunderstorm belt by looking at rainfall figures on its fringes. They should show a marked periodicity. A study of depression tracks and their length in the north Atlantic over the past 50 years should be revealing. Perhaps, too, the temperature range in areas covered by continental anticyclones will show periodicity. But one has to think globally rather than parochially. Does anyone want a Ph.D.?

Perhaps I have just invented yet another theory to cover the current crop of "media induced weather mysteries" which incidentally covers "ozone holes". Another year or two should tell us whether this is sun or aerosol-related – I expect the former.

Station House, Achnashellach,
Strathcarron, Ross-Shire, Scotland. PETER H. HAINSWORTH

HIGH RAINFALL INTENSITIES

The short paper by D. J. Stainer in Vol.12, no.123, prompted me to write with reference to an extreme rainfall event which I observed in 1980 at Chelmsford, Essex.

The date was 15th August. During the night of 14th/15th, there was a spectacular thunderstorm and 12.4mm was recorded. The 15th began dull with intermittent moderate rain (0.2mm), but sunny intervals developed by late morning and it turned very warm (maximum 24°C). It was humid too and large cumulus congestus developed during the afternoon. At 7.00 p.m., I noticed a huge, dark congestus cloud to the W.S.W. Although moving slowly, the cloud was moving towards home and when it didn't rain within the hour I was surprised. However, I can only assume that it was this cloud which gave the torrential shower at 9.25 p.m.

There was no thunder or lightning and it was dead calm; the noise of the rain was unbelievable (there was no hail). After just five minutes, the rain ceased and I carefully measured the amount in the gauge – it came to a staggering 13.1mm. The gauge was in a slightly sheltered position but in the calm situation this is unimportant, and – yes – I did empty the gauge that morning!

If my calculations are correct, the shower produced a rainfall intensity of more than 155mm/hr. Other personal observations have not even come close to this figure in more than ten years of recording – the next highest I have been able to measure was on 10th August 1986 in North Hampshire when there was an intensity of about 80mm/hr (the Greenham/Ecchinswell storm. I would be interested to know whether similar rainfall intensities have been recorded elsewhere in Britain in recent years.

The Long House, Parsonage Green, Cockfield,
Bury St. Edmunds, Suffolk. EDWARD MILLS

THE TORRO THUNDERSTORM DIVISION

Readers of this Journal will have noticed that recent TORRO Thunderstorm Reports have been compiled by Mr. Adrian James of Tilehurst, Reading. It will also not have pass unnoticed that reports written by myself were becoming increasingly delayed due to pressure of work, meteorological and otherwise. Thankfully, Adrian, a colleague and weather associate of mine for a number of years, kindly agreed to join me with the running of the TORRO Thunderstorm Division and has since made an impressive start by clearing a considerable back-log of summaries in a very competent manner.

Would present contributors to the thunderstorm division please note that storm reports are still to be sent to me at the Corsham Office as in the past, and may I take this opportunity to remind *all* readers that reports and press cuttings of thunderstorms are required from all parts of the British Isles. Details of reporting procedures, etc, will be forwarded upon request.

77 Dicketts Road, Corsham,
Wiltshire, SN3 9JS. KEITH O. MORTIMORE

TORRO THUNDERSTORM REPORT: September 1987

By ADRIAN C. JAMES
Thunderstorm Division, Tornado and Storm Research Organisation,
16 Dudley Close, Tilehurst, Reading, Berkshire.

On several occasions during September areas of thundery showers moved east-north-east up the Channel or across southern England; as a result, days with thunder were most numerous to the south of London, particularly along the line of the North Downs, where thunder was heard on five days in some localities. Over much of the rest of Britain the distribution of thunder was quite sparse, although convection induced by the sea in vigorous polar airstreams casued a number of thundery outbreaks in the north and west of Scotland. On the Isle of Skye, Armadale reported four days with thunder in the course of the month.

Northern Ireland had thundery showers on the morning of 1st in the wake of a cold front which moved south-east into England and Wales during the day; subsequently, thunderstorms broke out over south-east England in the mid-evening, and were rather intense for a time in parts of Surrey and Berkshire. On 5th, as a distinct upper trough succeeded a cold front across the country, thunderstorms developed fairly widely, notably over east and south-east England in the afternoon. Some of the storms were heavy with hail in places, but they passed quickly away on the blustery west wind. The next two days were showery in the north; thunder was heard over Orkney early on 6th, and in a few localities in northern England on the afternoon of 7th. Thunder remained largely confined to northern Britain during the middle of the month. Squally showers turned

Thunder-days in September 1987 were as follows: (Averages refer to the period 1951-1980).

September 1987	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		Total	Ave.
England	X				X		X			X	X			X				X	X		X	X	X	X	X							13	12.3
Wales																							X	X								2	5.9
Scotland					X	X				X		X	X	X			X					X	X	X								10	6.5
Ireland	X																					X	X	X								4	5.3
Total	X				X	X	X			X	X	X	X	X			X	X	X		X	X	X	X	X							17	14.6
Netherlands	X			X	X	X	X	X	X	X	X			X			X	X	X	X	X	X	X	X	X	X	X					21	11
Belgium	X	X		X																		X	X	X	X								–

thundery over the west of Scotland on the afternoon of 10th, and thunder was also reported from Carlisle in the early evening. Dover alone recorded thunder on 11th, in the mid-evening ahead of a cold front approaching from the west, but over the following three days the Hebridean Islands of Scotland were swept by thundery showers as a deep low transferred along the polar front to the north-east of Iceland. A little well-scattered thunder also occurred in central northern and eastern England on the morning of 14th. There was thunder on Skye in the late evening of 17th, and a single discharge at Manston (Kent) in the early hours of the next morning.

Meanwhile, much of France had been experiencing unusually high temperatures for the season, and on 19th this hot weather began to advance northward into southern England. At the same time, relatively cool Atlantic air was converging from the south-west. Near the triple-point of the consequent depression, thunderstorms commenced at medium level over south Devon in the late morning, moving east-north-east across southern and south-east England through the afternoon and early evening. An observer at Linwood (Hampshire) described the onset of the storm as sudden and violent, and hail was noted at Ashley Heath (Dorset) when the storm was overhead. There were power failures in several districts and a house was struck and set on fire by lightning at Poole. These particular storms continued their eastward progress across Europe to reach southern Russia by 21st, when some thunder preceded a cold front over east Sussex in the early evening.

As a deep depression ran north-east to the west of Scotland, unstable air of polar origin covered the British Isles for several days from 22nd, when there was thunder in Northern Ireland and highlands and islands of Scotland during the afternoon, and over the Isles of Scilly and west Cornwall around midnight. The 23rd began with showers in south-west England and south Wales which spread to the Midlands and central southern England through the morning, and to the eastern side of England in the afternoon. The showers were often accompanied by thunder, and at Rogate, near Petersfield (Hampshire), a man was obliged to extricate himself from his parked car when a flash of lightning caused a 30,000 volt power cable to fall across its roof. The vehicle ignited and was entirely destroyed. The north and west of Britain were also affected by scattered thunderstorms which continued after midnight in western Ireland, while lightning was seen in the early hours of 24th over many parts of south-east England from an outbreak of thunderstorms in the eastern English Channel. With an upper trough extending south over Britain, heavy showers, giving hail and thunder in places, continued in western regions through the day, especially in parts adjacent to the sea; over land, day-time insolation resulted in scattered thunderstorms in the south and east of England during the afternoon. The last reported thunder of the month occurred late in the afternoon of 25th, at Boulmer on the coast of Northumberland.

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TORRO THUNDERSTORM REPORT: October 1987

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Pressure was anomalously low to the north-west of Scotland in October, and on many occasions very strong unstable flows of Maritime Polar air delivered heavy showers to the south and west of Britain. Further, the frontal zone dividing warm air over the continent from cool Atlantic air was often to be found in the vicinity of central and southern England. This combination of circumstances resulted in an excessive number of thunder-days in southern coastal regions of England and Wales, but especially so along the coasts of Kent and Sussex, where a total of eight days with thunder was registered in several places. Over Britain as a whole, the number of thunder-days in October was the highest since 1976; even so, it was only on 5th that thunderstorms were widespread inland, while large tracts of the country away from coasts exposed to the onshore south-westerly winds heard no thunder at all.

A depression was slow-moving over the Bay of Biscay for several days early in October, generating areas of heavy rain which advanced northward into the south and west of Britain. Thunder was heard in the distance towards Dartmoor from Broadwoodwidger (Devon) on the afternoon of 2nd, and from west Cornwall and Scilly Isles on the afternoon of the following day. Further storms affected a few places in south and south-west England late on 3rd, and thunder continued into the early hours of 4th in some coastal regions of Sussex and Hampshire. The heavy rain

Thunder-days in October 1987 were as follows: (Averages refer to the period 1951-1980).

October 1987	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total	Ave.
England		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X				X	X	X	X							X	20	10.2
Wales				X	X			X	X		X	X	X	X		X	X	X	X	X	X											14	5.4
Scotland					X	X					X	X	X	X		X		X		X												9	5.9
Ireland					X							X	X	X	X	X	X	X		X	X											10	5.6
Total		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							X	24	12.5
Netherlands					X	X	X	X	X	X		X	X	X	X	X	X				X	X							X			15	11
Belgium						X		X					X	X										X				X				6	–

associated with the storms moved north across England and Wales during the day, giving thunder at Barmouth (Gwynedd) in the afternoon; after dusk, as the old low to the south-west began to transfer north-east ahead of an approaching cold front, thunderstorms returned to south-west England, and these were carried north into south Wales and the south-east of Ireland overnight. Meanwhile, a separate area of thunderstorms had developed at the western edge of a frontal boundary on the near continent, and this traversed south-east England in the early hours of 5th, later drifting north over the eastern part of East Anglia. A fire was started when lightning struck the old peoples' home in Sandwich (Kent), and garden sheds were set ablaze in consequence of an oak tree being hit by lightning at Southend (Essex). Thunderstorms extended through the west of Britain into Scotland during the afternoon, whilst a house and hospital suffered lightning damage at Weston-super-Mare and severe flooding occurred to the east of Clevedon (Avon). The additional uplift provided by the Pennines to the already unstable air initiated a major outbreak of storms over the north of England in the evening. There were numerous reports of lightning damage from West and South Yorkshire, with electricity supplies being interrupted in many districts, while hail up to 15mm in diameter covered the ground at Castleford (West Yorkshire), which received 30mm rain within one hour.

Rumbles of thunder far out to sea were heard from Dover early on 6th; later in the day, parts of London and the south-east together with a few localities elsewhere reported thunder as showers followed a cold front across the country. Some very heavy rain fell over England on 7th as well-scattered thunderstorms broke out around a waving frontal zone which produced the downpour. The 8th was a day of squally west wind, with showers turning thundery in the south and west of England and Wales, and also at Bingley in West Yorkshire. Over the next two days a complex frontal zone became oriented north-east to south-west across England and Wales. Thunder occurred mostly east of a line from Swanage to the Wash on the afternoon and evening of 9th, although storms were also reported from Broadwoodwidger and Barmouth. Thunder was noted at Honington (Suffolk) as the cold front finally cleared East Anglia late on 10th; in its wake, showers and thunderstorms, sometimes accompanied by hail, were experienced overnight in Kent and along southern and western coasts. Further thunder was heard on the evening of 11th in parts of western Britain as an occlusion swept in from the Atlantic. The 12th and 13th were showery with minor troughs embedded in a turbulent westerly current of air. On both dates, heavy showers with hail and thunder in places disturbed the hours of darkness around southern and western coasts, while a few storms broke out inland during the day. Thunder was reported from Kent and Sussex in the small hours of 13th as an area of heavy rain moved north-east across these counties, and at Donaghadee (Co. Down) lightning was seen *darting from anvils into a clear sky* in the early evening. For much of the following night, lightning was observed over the eastern English Channel from adjacent coastal regions, and Lancaster had several thunderstorms with hail on the morning of 14th when fire alarms in the town were activated by lightning. Thunder then became largely confined to the western coastal fringes of Britain, and 15th was generally thunder-free after a scattering of overnight storms in Ireland.

The very deep depression which swirled across the country early on 16th gave rise to a violent gale in south-east England, where the night sky flickered with electrical discharges due to power lines clashing together in the gusts. The air was thick with flying particles of salt, and in a report of the gale in *The Lunar Section Circular* of November 1987, Mr. P. W. Foley noted an occurrence of St. Elmo's Fire near Maidstone (Kent) when the wind was at its strongest. The first thunderstorms associated with this depression affected the coasts of Cornwall and south-west Wales in the early hours, and thunder was reported from Newport (Isle of Wight) at the height of the gale. During the morning the Bristol area was visited by an intense storm, in the course of which two oaks at Lower Failand were struck by lightning, and a number of unlucky pheasants which had been roosting in the trees were killed. Lightning damaged houses at Ardsbeg and Magheraroarty on the coastal fringe of Donegal in a spectacular storm that covered the surrounding country with a blanket of hail. Thunderstorms were scattered across Britain through the afternoon and became quite widespread for a time in south-east England. Violent storms deluged part of North Wales in the evening, with 69.5mm rain being measured at Trawsfynydd in the 24 hours to 09 GMT on 17th, and an observer at Blaenau Ffestiniog reported a fall of 100mm. Isolated storms continued during the night, but most had passed away by dawn. Later on 17th a deepening depression moved northward off the western Irish coast, and extensive power failures in that region were caused when lightning struck electricity supply lines. As a cold front advanced eastward, thunderstorms developed over the Southern Uplands of Scotland early on 18th, and over Northern Ireland later in the day. Thunder was recorded at Carmarthen (Dyfed) during the evening of 18th and in the early hours of 19th while a waving frontal trough remained almost stationary overhead.

Thundery activity was less remarkable during the rest of October. The 20th and 21st were very wet days over much of the country as low pressure transferred from Biscay to the north of Scotland. Isolated storms occurred late on 20th in South Wales, Dumfries and parts of Ireland, and a few places near the coast had thunder the following day. More thunder was heard at times around the coast of south-east England on 22nd and 23rd, and over the Channel Islands early on 24th. A spell of quieter weather succeeded until a low off the coast of Brittany introduced some thunder to Cornwall and Jersey on the morning of 31st.

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WORLD WEATHER REVIEW: March 1988

United States. *Temperature:* warm except in parts of S.; +4degC in N. Montana and N. of N. Dakota; –1degC in N. Florida. *Rainfall:* mostly dry (including Hawaii); wet only in a band from N.W. Washington through Colorado to E. Texas and along Gulf of Mexico, and N. Dakota to N. Michigan. Over 200% locally in Louisiana, S.W. Mississippi, N. Florida, N. Dakota, N.W. Michigan; more widely in Oklahoma. Under 50% very widespread; under 25% from Califonia to W. and S. Utah, S.W. Colorado and S. W. Texas; W. Kansas to W. Iowa; parts of S. Dakota; Honolulu.

Canada and Arctic. *Temperature:* warm in nearly all of Canada and Alaska; W. Greenland; +5degC from S.W. Saskatchewan to interior Alaska; +8degC in W. Alberta. Cold in W. Coastal Alaska, S.W. Quebec; Iceland and E. Greenland to Franz Josef Land; -4degC in Spitzbergen and E. Greenland; -7degC in Franz Josef Land. *Rainfall:* wet near Pacific coast; S. Saskatchewan to Quebec and Newfoundland; most of Baffin Island; Franz Josef Land and N.W. Alaska. Over 200% from S. Saskatchewan to Newfoundland; in and near N. Baffin Island; locally near Pacific coast and in N.W. Alaska. Dry in most of Alaska; W. Canada away from coast; Maritime Provinces; most of Greenland and Iceland to Spitzbergen. Under 50% widely in all these areas (except possibly Spitzbergen).

South and Central America. *Temperature:* generally warm in South America 15-40°S.; Guatemala to Honduras; +3degC in N. Argentina, extreme S. Brazil. Cold in Bolivia and most of Mexico (mainly -1degC). *Rainfall:* wet in Bolivia, N. Paraguay, Mato Grosso (Brazil), S. Uruguay, C. Mexico, Honduras; much of N.E. Argentina. Over 200% locally in all these areas; over near Buenos Aires and in C. Mexico. Dry in N. and C. Chile, N.W. Argentina, S. Paraguay, N. Uruguay, extreme S. and much of E. Brazil, Bahamas; most of Mexico to El Salvador. Under 50% in all these areas, especially N. Chile, S. Paraguay to N. Uruguay; Mexico.

Europe. *Temperature:* warm from European Russia to N.E. Sweden, Bulgaria and E. Romania; much of British Isles; Brittany, S. Spain; +2degC nearly everywhere in European Russia; +7degC in N. Urals. Cold elsewhere; -1degC locally from S.W. France to S. Poland; E. Sweden and parts of Norway. *Rainfall:* an extremely wet month, with an unusually large area exceeding 200%: N.E. France, Low Countries, Germany, Switzerland, E. Hungary, N. and E. Romania, E. Bulgaria, W. Austria; much of W. European Russia; parts of British Isles, Czechoslovakia, E. Poland, Jugoslavia, Finland, E. Sweden and probably Denmark. Over 300% widespread in W. Germany. Dry in Norway, N., S.E. and extreme E. European Russia, Spain, Portugal, S. coastal France, N. Italy, N. Greece. Under 50% at least locally in all these areas, except perhaps N. Italy; under 25% in most of Spain and nearly all of Portugal. Provisional sunspot number 76 (January: 60; February: 40).

Africa. *Temperature:* mostly warm N. of Sahara (except parts of N. Algeria and W. Tunisia) and in and near South Africa; +1degC widely in both areas. *Rainfall:* mainly dry N. of Sahara, except S. Morocco, interior N.W. Algeria, Nile Delta and locally in S. Tunisia (all locally over 200%); under 50% widespread. West in most of South Africa and neighbouring areas; over 200% widely in W. Cape Province and locally elsewhere. Dry near Orange estuary, N.E. Natal and S. coast of Cape Province (all locally under 50%).

Asiatic U.S.S.R. *Temperature:* mainly warm; +7degC in N. Urals. Cold in upper Lena basin, N. Taimyr Peninsula, near L. Balkhash and in N.E.; -5degC near Bering Sea. *Rainfall:* wet from Yenisey Gulf to Tartary Strait; W. Kazakhstan (over 200% widely in both areas); E. Kamchatka. Dry elsewhere; under 50% in most of Ob basin; L. Baikal to upper Amur basin; in N.E..

Asia (excluding U.S.S.R.). *Temperature:* warm in N. Turkey, S. Arabia, C. and S. India, S.W. and extreme N.E. China, E. Burma to Sarawak and Philippines (except N. Vietnam); much of Japan; +2degC in S.E. India, much of Philippines and locally in Thailand. Cold from S. Turkey and Cyprus to N. Arabia; N. Pakistan to Bangladesh; most of China; S. Korea, N. Vietnam; -2degC in S. Turkey, N. Vietnam; -3degC widespread in C. China. *Rainfall:* wet from Turkey and Cyprus to N.E. Arabia; N. Pakistan, N. India, C., E. coastal and extreme N.E. China, C. Laos, Sarawak; most of Japan and Malaya. Over 200% locally in all these areas, except perhaps Laos and Sarawak; widely in S. Turkey, N. Pakistan, C. China. Dry in N.W. and S. Arabia, S. Pakistan, S. and N. China, Mongolia, Korea, Thailand, Philippines; most of India, Bangladesh and Laos. Under 50% locally in S. Bangladesh, widely in the other areas.

Australia. *Temperature:* warm except in S.E. Queensland and N.E. New South Wales; +2degC in N. and extreme W. *Rainfall:* wet from Arnhem Land to Spencer Gulf and near Eighty Mile Beach; over 200% widely in C. area. Dry elsewhere; under 50% in S.W. and N.E.

M.W.R.

WEATHER SUMMARY: May 1988

May was yet another warm month with mean temperatures around one degree Celsius above the average in southern counties of Great Britain, a little less in the north. Highest maximum values were reached around mid-month, rising to 28.5°C at Colwyn Bay (Clwyd) on 15th, 25.3° at Littlehampton (West Sussex) on 14th and

23° to 24°C in parts of western Scotland on 14th and 15th. Although the temperature rose to only 5.1° at Lerwick on 2nd the coldest weather of the month closely followed the warmest with marked falls in maxima to 6.8° at Fylingdales (North Yorkshire) and 8.6° at Newcastle on 17th and 7.8°C at High Bradfield (South Yorkshire) on 18th. The highest minimum temperature was 13.5° at Lathom (Lancashire) on 15th, while on 8th the temperature fell to only 13.2°C at Brighton. There were a number of quite chilly nights during the month and screen temperatures dropped to below freezing in favoured localities at times. Lowest values included -2.4° at Bastreet (Cornwall) and -2.0° at Rannoch School, Dall (Tayside) on 21st, -2.3° at St. Harmon (Powys) on 6th and -1.8°C at Eskdalemuir on 20th. On the grass -8.5° was recorded at Straide (Co. Mayo) and -6.9° at East Hoathly (East Sussex) on 20th. In Scotland there was a grass minimum of -6.9°C at Glenlee on 18th. Generally it was a dry month with less than 75 percent of the normal in a number of places but the showery nature of the rainfall in May resulted in some quite high percentages in places. Heavy thunderstorms to the north-west of London produced some locally high 24-hour totals on 7th and 8th, Uxbridge recording 63.5mm on 7th. Elsewhere 32.3mm fell at Bastreet (Cornwall) and 22.6mm at St. Mawgan on 28th, 29.1mm fell at Invergordon (Cromarty Firth) on 1st and 23.5mm at Dover on 30th. East Anglian sunshine totals were generally a little below the normal but over much of the U.K. it was a sunny month, particularly in east and north-east Scotland.

A depression to the south-west of Britain tracked slowly north-east across the country during the early days of the month giving all parts a very showery spell with thunderstorms in a number of places. Rising pressure brought a change to more settled conditions on 5th with a good deal of sunshine, especially on 5th and 6th, but showers and thunderstorms spread to southern counties on 7th and storms were locally very severe in the east on 8th. The following few days were rather unsettled with some rain in places. Most parts were warm and sunny between 13th and 15th, under the influence of an anticyclone to the north-west of Scotland but a cold front spread much colder air southwards across the U.K. on 16th and a northerly airstream continued to feed polar air down across the country on 17th and 18th. There was some rain in places and the 19th was especially cool and showery with thunderstorms in a number of places. An anticyclone that settled over the country on 20th gave a couple of dry, sunny days followed by clear and cold nights but late on 22nd frontal systems spread rain into south-west England and heralded a spell of unsettled weather that continued until the end of the month. Bands of rain repeatedly crossed the country, and rain was particularly heavy in the south-west on 28th, but it was not all bad and there were also some quite pleasant days with good spells of sunshine.

K. O. M.

TEMPERATURE AND RAINFALL: MAY 1988

	Mean				*Grass*					
	Max	*Min*	*Max*	*Min*	*Min*	*Rain*	*%*	*Wettest*	*RD*	*Th*
AUSTRIA: Innsbruck	21.8	9.4	28.7(26)		93.5			15.7(31)	12	4
BELGIUM: Uccle	18.9	10.2	25.3(25)	3.9(21)		116.0	187	25.3(26)	19	-
„ Rochefort	19.0	6.7	25.6(25)	-1.6(21)		106.0	151	27.9(9)	17	-

„ Houwaart	21.8	7.6	28.0(25)	-0.9(21)	-2.1(21)	107.4	165	37.8(27)	18	8
DENMARK: Fanø	17.6	9.0	25.6(27)	2.3(22)		39.4	90	8.6(28)	12	2
„ Frederikssund	18.8	7.8	27.2(28)	3.8(11)	-1.2(11)	23.1	50	16.2(21)	7	2
GERMANY: Berlin	21.1	10.2	28.1(27)	3.4(22)	1.4(22)	9.6	19	3.7(31)	9	5
„ Hamburg	19.6	8.6	28.4(27)	1.6(19)	-3.2(19)	46.9	85	26.9(19)	13	5
„ Frankfurt	21.3	10.2	28.3(26)	2.7(22)	0.3(21)	27.2	49	9.2(27)	12	5
„ Munchen	19.5	8.2	24.8(26)	2.4(23)	-1.5(22)	37.5	78	19.4(29)	15	7
GREECE: Thess'loniki	24.6	14.1	29.0(19)	7.0(3)		25.8		9.1(26)	10	4
ITALY: Casalecchio	22.4	14.0	26.0(31)	10.0(v)	8.0(1)	137.8	241	46.0(21)	13	5
MALTA: Luqa	25.2	16.6	29.2(10)	10.8(2)	5.8(2)	0.1		0.1(31)	0	0
NETH'NDS: Ten Post	19.2	9.0	28.0(26)	0.4(21)	-3.3(21)	18.0	33	2.9(5)	10	2
„ Schettens	18.2	8.5	26.5(26)	1.5(22)	-1.8(19)	32.9	72	7.8(28)	10	3
„ De Bilt	19.2	9.0	26.5(26)	0.5(21)	-3.9(21)	47.0	87	10.0(27)	14	6
„ Lemmer	18.6	8.9	26.4(26)	3.3(6)	0.8(22)	30.5	60	6.2(4)	11	6
NORWAY: Donski	17.7	5.6	27.0(28)	0.8(19)		45.4		17.1(31)	10	1
SWEDEN: Valla	18.5	5.1	25.9(29)	-1.0(10)		16.7		6.8(31)	12	1
SWITZ'LAND: Basel	20.8	10.2	27.2(25)	2.9(22)		58.3	77	10.3(8)	20	12
EIRE: Galway	15.6	7.8	23.3(16)	3.6(19)		87.2	114	27.0(11)	15	1
„ Straide	15.2	6.3	22.0(16)	-1.0(20)	-8.5(20)	69.8	98	12.1(11)	18	3
SHET'AND: Whalsay	10.6	5.9	14.0(21)	1.5(20)	-6.7(1)	47.5	125	15.5(8)	12	0
„ Fair Isle	9.3	6.2	12.0(14)	3.2(19)	1.1(20)	32.3	82	8.8(1)	13	0
SCOT'AND: Braemar	13.6	3.9	19.8(15)	-1.7(20)	-2.7(20)	36.4	53	8.6(29)	12	0
„ Inverdruie	16.6	3.4	23.0(15)	-3.2(20)	-6.9(20)	34.3	48	7.1(2)	11	1
„ Rannoch	14.5	3.3	22.8(16)	-2.0(21)	-2.4(19)	40.4		12.8(1)	11	0
„ Edinburgh										
WALES: Pembroke	17.1	7.8	24.4(15)	3.1(20)	-1.6(20)	65.1	89	12.3(24)	16	0
„ Velindre	16.3	6.2	21.6(14)	0.3(6)	-4.0(6)	95.9	137	12.5(25)	16	0
„ Carmarthen	15.7	7.6	24.9(15)	1.9(6)	-2.1(21)	88.8		18.9(28)	15	1
„ Gower	15.7	8.4	21.2(16)	4.4(20)	-0.3(20)	91.7	120	31.0(28)	11	2
GUERNSEY: Airport	15.0	9.3	18.8(7)	5.7(20)		32.6		12.0(28)	8	0
ENGLAND:										
Denbury, *Devon*	16.8	7.9	24.0(14)	1.9(21)	-0.7(21)	77.1	117	22.4(28)	11	0
Gurney Slade, *Somerset*	16.3	5.6	22.2(17)	-0.1(20)	-0.4(20)	100.2	109	21.2(30)	13	0
Yatton, *Avon*	17.7	7.7	23.0(17)	1.3(20)	0.0(20)	60.2	84	17.5(25)	12	1
Bradford-o-Avon, *Wilts*	17.5	7.5	22.8(13)	2.8(6)		39.6		7.2(30)	9	0
Corsham, *Wiltshire*	17.3	7.2	23.1(14)	2.6(20)	-0.3(20)	38.6	56	8.7(29)	10	0
Mortimer, *Berks*	17.5	7.3	23.4(14)	2.1(20)	-2.2(20)	34.4	65	13.3(16)	13	4
Reading Univ., *Berks*	17.1	7.9	22.6(14)	1.7(20)	-3.1(20)	34.0	59	7.5(8)	15	2
Sandhurst, *Berkshire*	18.0	7.3	23.9(14)	-0.1(20)	-1.1(20)	54.7	113	24.3(8)	13	2
Romsey, *Hampshire*	18.5	7.6	24.4(8)	0.0(20)	-2.0(20)	25.0	36	9.4(28)	10	2
Horsham, *Sussex*	17.9	8.6	23.8(14)	1.6(20)	-1.0(20)	41.0	76	7.7(28)	16	2
Brighton, *Sussex*	17.4	9.4	23.8(14)	3.0(20)		38.8	64	8.1(28)	13	1
Hastings, *Sussex*	17.1	9.7	22.6(15)	4.9(20)	2.9(20)	77.5	150	25.3(25)	10	2
Dover, *Kent*	16.2	8.7	21.5(13)	2.0(20)		65.2	137	23.5(30)	16	1
East Malling, *Kent*	16.9	8.5	21.6(13)	1.5(20)	-3.3(20)	56.3	120	22.4(7)	16	1
Epsom Downs, *Surrey*	17.4	7.4	24.1(14)	-0.6(20)	-1.2(20)	48.1	75	12.4(30)	16	3
Reigate, *Surrey*	17.9	7.8	24.1(14)	0.6(20)		37.4	69	7.7(29)	17	2
Guildford, *Surrey*	17.8	8.4	23.9(14)	3.2(20)	1.4(20)	45.5	75	15.2(4)	13	3
Sidcup, *London*	17.9	8.5	23.3(15)	1.5(20)	-0.6(20)	41.6	78	10.7(30)	15	1
Hayes, *London*	17.6	8.4	23.5(14)	1.6(20)	-0.2(20)	59.8	88	23.6(7)	16	3
Hampstead, *London*	16.9	8.4	21.9(14)	3.8(20)	-3.0(20)	87.2	162	36.1(8)	15	1
Royston, *Hertfordshire*	17.3	8.0	23.2(14)	3.5(20)	-1.0(20)	57.2	113	11.5(30)	15	1
Loughton, *Essex*	17.6	8.1	22.2(24)	2.1(20)	-1.9(20)	41.7	70	8.8(7)	14	2
Buxton, *Norfolk*	16.1	8.0	21.2(13)	1.7(20)	-0.2(20)	26.3	57	5.3(30)	11	2
Ely, *Cambridgeshire*	17.3	6.6	23.5(15)	1.6(20)		51.6		11.6(29)	14	3
Luton, *Bedfordshire*	17.2	7.3	23.2(14)	-0.2(20)	-3.3(20)	49.8	96	9.4(7)	12	2
Buckingham, *Buck'shire*	16.8	6.3	20.6(14)	0.7(20)	-3.3(20)	57.5	108	12.3(29)	15	2
Oxford University	17.1	7.8	22.8(14)	3.0(20)	-1.6(20)	32.0	63	8.4(29)	12	–

	Mean				*Grass*					
	Max	*Min*	*Max*	*Min*	*Min*	*Rain*	*%*	*Wettest*	*RD*	*Th*
Churchdown, *Glo'shire*	17.8	7.2	22.8(14)	1.1(6)		41.8	83	9.2(29)	12	0
Stourbridge, *W.Midla'ds*	17.0	7.8	22.1(15)	2.5(20)	-2.0(21)	52.2	80	9.6(30)	13	2
Birmingham Univ'sity	16.8	7.1	21.2(15)	1.3(20)		65.9		10.2(1)	13	3
Wolverhampton	16.4	6.7	22.2(15)	2.5(21)	-1.0(21)	54.6		8.5(29)	13	3
Kettering, *Northants*	16.4	6.9	20.5(15)	1.1(20)		43.7	69	9.1(7)	16	0
Louth, *Lincolnshire*	15.4	7.2	19.8(28)	3.2(19)		46.7		7.1(23)	16	0
Nottingham *Nott'shire*	17.1	7.4	20.8(16)	3.7(20)	0.4(20)	39.0	81	7.0(3)	17	3
Middleton, *Derbyshire*	13.3	6.4	18.2(16)	3.1(18)		70.8	97	15.9(1)	16	0
Stretton, *Staffs*	–	–	23.0(15)	3.5(21)	-1.1(20)	48.9	93	13.0(1)	–	3
Keele University, *Staffs*	15.3	7.0	21.3(14)	3.4(21)	-1.8(20)	68.8	108	11.9(31)	17	4
Liverpool, *Merseyside*	17.3	7.9	24.5(15)	2.9(21)		51.8		13.0(3)	12	3
Lathom, *Merseyside*	16.3	7.7	23.1(14)	3.5(21)		44.7		12.6(30)	13	2
High Bradfield, *S.Yorks*	12.0	5.9	17.8(16)	3.0(18)		58.4		13.3(3)	16	–
Cottingham, *Humb'side*	16.5	6.9	20.9(16)	2.7(21)		33.4		6.2(26)	16	4
Carlton-in-Cleveland	14.7	6.8	19.3(6)	2.4(18)	-1.6(18)	54.0		6.2(8)	17	5
Durham University	14.8	5.9	19.5(15)	1.6(20)	-1.6(21)	58.0	107	7.7(11)	19	–
Sunderland, *Tyne/Wear*	12.6	7.7	17.8(27)	4.5(18)		49.9	119	10.0(26)	14	0
Carlisle, *Cumbria*	15.5	6.7	22.1(16)	1.4(20)		70.0	119	16.7(2)	12	–
CANADA: Halifax	21.2	-0.2	21.2(5)	-0.2(9)		69.0		17.2(3)	18	2
„ Pincourt	20.7	9.2	27.7(29)	1.0(15)		40.4		10.1(16)	11	2
U.S.: Bergenfield, *NJ*	21.9	10.8	31.7(31)	4.4(9)		102.4		32.8(18)	14	7
JAMAICA: Kingston	32.8	25.6	34.6(24)	23.0(3)		42.6	43	25.2(2)	5	0
AUS'LIA: Mt.Wave'ey	17.9	10.8	26.5(1)	5.5(31)		83.6		20.3(18)	19	0

CUMBRIA RAINFALL:

Appleby, 49.5mm (90%); The Nook, Thirlmere, 93.9mm (68%); Coniston, 99.0mm (74%); Hawkshead, 106.3mm (102%).

THE JOURNAL OF METEOROLOGY
LE JOURNAL DE MÉTÉOROLOGIE

Published in association with
The Tornado and Storm Research Organisation
a privately-supported research body, serving the national public interest

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Subscriptions for 1988, Volume 13, *including surface post,* U.K. £32.00; rest of world £35.00; *including airmail* £40.00. For personal subscriptions from individuals deduct £15.00 from each of these rates. Subscriptions for students and senior citizens £12.50 only upon request.

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Published by The Artetech Publishing Co., 54 Frome Road, Bradford-on-Avon, Wiltshire, BA15 1LD.

Printed by The Dowland Press Ltd., Frome, Somerset.

ISSN 0307-5966

JOURNAL OF METEOROLOGY Vol. 13, no. 131, September, 1988

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FRONT COVER:

The exhibition at the second TORRO conference, Oxford Polytechnic, 4 June 1988, with David Brooks the conference chairman.

EDITORIAL OFFICE:

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