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STUDIES OF SEVERE THUNDERSTORM CHARACTERISTICS IN CHHOTA NAGPUR REGION OF INDIA USING GCM OUTPUTS AND ITS ASSOCIATION WITH RADAR REFLECTIVITY

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Abstract: Analysis of shear and kinematics in the regions depicted by the T80 Global Circulation Model (GCM) output can be used for forecasting the occurrence of severe thunderstorms, particularly, for the region between Lat 21°N to 27°N and Lon 85°E to 93°E which is particularly prone to thunderstorm activity. In this paper, the analysis of T80 GCM has been used to investigate the characteristics of severe thunderstorms. The analysis of the kinematic and shear distinctly aid the prediction of thunderstorm development. Wind carrying enough moisture along with a dry air front from the opposite direction can initially be lifted above the Lifted Condensation Level (LCL). Arguably, this can be further aided by topographical features giving rise to Nor’westerners with reversed wind flow. The authors also investigated some situations where certain thunderstorms resulted in tornados. T80 GCM outputs show distinctive features in flow patterns at 1000 hPa, 700 hPa, 500 hPa and 200 hPa for the case of thunderstorm development. This study aims to aid forecasting methods for thunderstorms by studying flow patterns and squall line development in radar observations to enhance forecasts.

Keywords: T80 Global Circulation Model, Chhota Nagpur, India, Lifted Condensation Level, shear, geopotential height, gpm, mesoscale, squall lines, NWP, supercell, thunderstorm, tornado, radar.

INTRODUCTION

Severe tornado events from 1838 to the time of writing in February 2006 reveal that the region between Lat 21°N to 27°N and Lon 85°E to 93°E (Figure 1) is prone to thunderstorm activity. More importantly, during April-May, South West Bengal, Bangladesh and parts of Chhota Nagpur often experience devastating calamities (Bhattacharya, 1994). Convective systems break hot summer spells and often act as relief for areas with low lying water tables. However, supercell development with deep convection, high wind speeds, thunder and lightning cause extensive damage to the villages whose population are often poor without proper housing. In most cases the severe thunderstorms have winds from the south-southeast at the surface (925 hPa - 1000 hPa) originating from the Bay of Bengal achieving upward lift, travelling beyond the Lifted Condensation Level (LCL) from strong surface heating from the Chhota Nagpur Plateau region. The wind carrying enough moisture along with a dry air front is initially lifted above the LCL, which can then be aided by local topographical features creating Nor’westerners with reversed wind flow. Such convective systems can be traced using GCM outputs as well as radar reflectivity (Stolzenburg et al., 1998). This paper investigates some occurrences of severe thunderstorm events often occurring in tornadic situations.

Forecasting for such severe thunderstorm events is significantly important for many different sectors of the community such as power, commerce, agriculture and tourism. Accurate prediction can help prevent significant loss by taking pre-emptive measures. The authors’ work focuses on the genesis and occurrence of severe, organised convective systems from the GCM outputs in association with radar outputs for characterisation.
Many severe thunderstorm events have been investigated in the past in light of this objective for the present study. For this, special parameters from the GCM outputs for the detection of severe thunderstorms are analysed in order to use these tools when forecasting. The study of thunderstorms and Nor'Westers for the region of Chhota Nagpur and adjoining Bangladesh has given important results to improve forecasting.

ANALYSIS AND RESULTS

Meteorological characteristics the authors noticed in each thunderstorm were examined. These were:
- Characteristic shear regions at 700 hPa with a neutral stretch or low wind region (Figures 2 - 6) in the wind flow pattern. Characteristic streaming of North Westerly wind just south of the shear zone (i.e. observed $\frac{dv}{dz}$ from 850 hPa to 200 hPa) for all the cases.

The presence of a trough at 700 hPa over the region where thunderstorms are likely to occur (Figure 13 - 16); the $z$ (geo-potential height) values range from 3080 to 3120 gpm for the trough in the affected areas.
- A trough is also observed at higher levels at 500 hPa with 5790 gpm (Figure 17).

The air mass thunderstorm that forms away from frontal systems or other synoptic disturbances in northwestern India is common and is usually a non-severe phenomenon. These storms are formed where moist, unstable conditions exist in the atmosphere. Air mass thunderstorms are usually produced in areas of very little vertical wind shear and can indicate thunderstorms are likely to occur. When thunderstorms are severe they may produce brief high winds or hail which develop because of high instability. Some of these storms can be characterised as pulse severe storms and are short lived for one to two hours.

The AN (analysis) data files, from the model outputs that were used for the weather forecasts are available in the archive at the National Centre for Medium Range Weather Forecasting (NCMRWF), India and have been used to characterise the thunderstorm activity. The AN data files were used for hindcast (analysis of past model simulated data).
The analysis of the model outputs during these days show certain unique features to that help characterise thunderstorms.

In the present investigation, data for some thunderstorms which occurred during the model run period were noted from records and selected chronologically for analysis. In our present study the analysis of data from the dates 10 April 1995, 13 May 1996, 15 April 2000, 20 March 2005 and 22 March 2005 have been used for observing KE of the regions and corresponding shear measures which are not done routinely. From the analyses of the output (Figures 2-18), certain characteristics have been observed that could be immensely useful when predicting thunderstorms using NWP, especially predicting the occurrence in adjoining areas of Chhota Nagpur and West Bengal.

Shear zones, in particular, are of special relevance for thunder and lightning. These zones become prominent approximately 18 hours before thunder and lightning occurs. This is due to gradual dissipation of intense kinetic energy in the affected regions. The regions showing a minimum wind speed as a result of energy dissipation with vertical shear and its association with a circulation at upper levels generally referred to as mesocyclone supports the cause for development of charge separations and potential difference needed for lightning discharges. It has been observed that the shear zones found in the NWP and GCM output with characteristic values of KE J/kg experienced thunder and lightning. Moreover, the bimodal type (two adjacent branches of contours in the KE pattern) distribution of the kinetic energy regions as (Figure 8) led to a tornadic situation but were mostly associated with severe weather that gave rise to heavy rainfall, thunder and lightning for up to 36-48 hours.
A severe thunderstorm is defined by the authors as a storm with wind speeds > 80 km/hr associated with overcast dark sky, thunder and lightning followed by rain. The characteristics of shear regions and kinematics are initial indicators of thunderstorm like situations. Model outputs from the days when a tornado occurred have been investigated to enable the identification of special parameters which are characteristic of tornadic events. The authors investigated severe storms with a short duration ranging from 30 minutes to two hours with dark overcast cloud for about 10 - 15 minutes. These kinds of storms mostly occurred during the afternoon hours from 1500 to 1800 Local Time (LT) (i.e. 0930 to 1230 GMT).

DISCUSSION

Vertical wind shear gives rise to some characteristic dynamic processes within the storm that affects the evolution, strength, persistence and motion of the cell. These characteristics are generally:

- Shear dissipates the energy of a rotating updraft during the process while giving rise to a horizontal vorticity and also tilts the updraft vertically.
- The dynamical pressure equation states that a pressure gradient force pointed toward the centre of rotation must balance rotation about a vertical axis of the updraft. It would lower pressure in the middle levels of a storm where the rotation/updraft is strongest.
- This perturbation of vertical pressure eventually would give rise to a stronger updraught into the middle-levels, which in turn would cause even more rotation (due to vertical stretching) as the updraught speed increases with height. The deeper the convective system's wind shear, the more efficient this dynamic process is and ultimately this seems to be one of the main parameters which aid thunderstorm development.

The cyclonic circulation results in low pressure, causing an enhanced steady-state updraught of the air parcels to move vertically upwards due to the flow and lifting of the mixed dry warm air with that of cool moist air from the Bay of Bengal side; dynamic forces are more important than buoyancy forces in supporting updraught strength and rotation. Weaker instability and the dissipation of energy during the updraught/downraught of the storm results in storm tilt and a right movement compared to the mean wind as expected in most of the cases. For this reason the storms, for most of the time affect the adjoining areas of Bangladesh in a North-east direction and such indications are also seen in the coverage of shear regions.

It appears that a thunderstorm in the studied region is formed as a result of mixing moisture from the Bay of Bengal with rising warm air from the opposite direction. For this to occur it is necessary to have enough force that is capable of lifting the air warm and cold fronts (Andra Jr., 1993) that results due to merging of oppositely flowing wind over a favourable inclined terrain. As in the present case a sea breeze and a mountain have played a vital role. Some pockets in certain regions are reported to have a common occurrence of thunderstorms (Pawar et al., 2002). A much favoured region is the West Bengal - Chhota Nagpur region (Figure 1), where thunderstorms can occur for an extended period of time if a mesocyclone develops along with the other characteristic features of thunderstorm development. Some additional features sometimes occur particularly in the cases of severe thunderstorms. Wind patterns with almost a neutral region (a low wind field area) at 700 hPa (Figures 2 - 5) associated with a strong north-west wind which is exactly in an opposite direction to that of winds with moisture from Bay of Bengal at 1000 hPa for a sudden convective process signify a dominant shear region with the upward convection lifting well above the LCL. There seems a tendency to tilt to the right for severe types.
The first cause that gives rise to lightning and thunder can be attributed to the charge separations in the differential layers of the lifted moist and warm air streams - supported by observations (Williams et al., 1989). For this reason, the shear zones are of special relevance to thunder and lightning. The regions showing a minimum wind speed as a result of vertical shear and its association with circulation at upper levels (generally referred to as the mesocyclone) supports the cause for development of charge separations and that kind of potential difference. It has been observed that shear zones obtained in the NWP and GCM results experienced thunder and lightning activity when all other meteorological conditions stated in this paper are simultaneously satisfied. It may be noted that in earlier studies the thunderstorm events were essentially dealt in a different way (Mills et al., 1998) using NWP models did not investigate the intense KE regions at 700 hPa.

Characteristic squall line developments in the radar outputs occur rapidly making forecasting for these events difficult. However, their detection in global model forecasts supplemented with radar reflectivity may help forecasting within the region (Smedsmo et al., 2005). Nevertheless, this is region specific with a supportive terrain. The characterisation and pattern observed so far is applicable for the target zone. Those however have not come out as general cases that could be randomly applied for other regions.

It is also important to note that the wind shear results in dissipation of much of the intensified KE at 700 hPa during the process of upward draught movement of moist warm air parcels and simultaneous downward movement of the cool dry air. The supporting radar observations (Figures 19 - 20: inside front cover) for a matured stage squall line (Doviak and Zrnic, 1993) result in heavy rains with thunder and lightning.

The radar recordings confirm the occurrence of thunderstorm activity with a lead-time of few hours to support the GCM results. However, the GCM output gives enough indication that the thunderstorm is likely to occur almost 18 hours in advance. 12 hourly model simulations for analysis and forecast have been done and a notable trend of distinctive features for the severe thunderstorms can be seen 18 hours ahead. The similar KE distributions over the affected regions also show a distinctive shear zone for the same areas. For this type of development, the important information that can be retrieved from the squall lines on radar and range height indicators is the extent of rainfall with the spatial coverage (Bringi et al., 1990 and Caylor and Chandrasekar, 1996) within the region of mesocyclonic circulation.

When the prevailing situations in GCM outputs match severe thunderstorm characteristics, one must track the squall line’s development from the radar output (Weckwerth, 2005) to make a good forecast for thunderstorm-affected regions. Hence a constant improvement is achieved in forecasting severe weather caused by thunderstorms.

**CONCLUSIONS**

The T80 GCM outputs clearly show some distinctive features in flow patterns at 700 hPa, 500 hPa and also 200 hPa. Even though the analysis of the model is based on the data of 0000 hours; the occurrence of thunderstorms is very well reflected in the GCM output. The affected area slightly varies, as there is always a gradual motion towards the south-east. The prediction accuracy of the thunderstorm is dependent on the extent of data input in the model.

The characteristics of KE and shear regions (Figures 7 - 13) are initial indicators for thunderstorm situations.
The presence of a mesocyclone is a clear indicator that a thunderstorm is present as also reported in the recent studies. However, Showalter indices are not mandatory features for the investigated region. The mesocyclone condition, if observed, generally tends to denote a severe thunderstorm with a longer lifetime, thereby aiding the forecasting for severe weather situations.

Any thunderstorm for this region can be conveniently forecasted from the GCM outputs, in cases when they are detected in the flow pattern from the shear zones, some additional features need to be assessed such as the KE in J/kg and shear measures. Also, it is evident from climatological trends that forecasters ought to be vigilant during the April-May period for predicting thunderstorms in the investigated region. The results obtained from this work may be useful for the prediction of thunderstorms and their associated lightning, if simultaneously supplemented by radar squall line development.

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REFERENCES


MULTIPLE BALL LIGHTNING OBSERVATIONS AT NEURUPPIN, GERMANY

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Abstract: An unusual event, which included multiple Ball Lightning observations, is reported in detail. The observations can be correlated unambiguously with the first lightning of a brief winter thunderstorm. According to the lightning detection network BLIDS the lightning had an enormous peak current of 370 kA. Its strike point was several kilometres away from the observations. Based on the observres' reports which were collected immediately after the event, several Ball Lightning models or hypotheses can be excluded, especially the models based on the direct interaction of the lightning channel and matter, and also models explaining Ball Lightning as optical illusions.

Keywords: Ball Lightning, positive lightning, multiple observations, Ball Lightning hypotheses, lightning detection network, peak current, winter thunderstorm, Germany, Neuruppin.

INTRODUCTION

Despite research efforts dating back at least 170 years (Arago, 1838), ball lightning (BL) remains a most enigmatic natural phenomenon. Its rarity, the unpredictability of its occurrence in space and time, and its short duration and the limited range of visibility make its observation by anybody but a chance observer a practical impossibility.

The problems concerning the quality of the many anecdotal reports on BL observations have led a number of scientists, among them prominent lightning researchers like Berger (1973) to the assumption that basically all BL reports are based on misinterpretation of other phenomena. Other researchers are less sceptical concerning the existence of BL as an independent atmospheric phenomenon (Rakov, Uman 2002), but it is nevertheless obvious that any progress in understanding BL is hampered by the lack of high-quality observations.

This paper tries to improve this situation by reporting the essential facts of a BL event that took place in the town of Neuruppin, Brandenburg (Germany) on 15 January 1994. The event is unusually well documented because of fortuitous circumstances.

The staff of the local meteorological station witnessed parts of the event and the chief of staff started to collect witness reports immediately. Supporting information about the lightning activity in the thunderstorm is available from the lightning detection network of Siemens, BLIDS (Blitz Informations Dienst von Siemens). In total, about 11 different BL objects were reported, which is a very high number for a single event. The amount of information available allowed a clear correlation between a lightning stroke and the multiple BL observations, enabling the exclusion of a number of BL models or hypotheses.

GEOGRAPHICAL AND METEOROLOGICAL SITUATION

Neuruppin is a town of about 30,000 inhabitants situated in a flat countryside about 60 km Northwest of Berlin. The town borders the western shore of a long, slightly curving lake running north-south (Figure 1). The meteorological station lies at its southern outskirts on the border of the lake.
The event that took place then is best described in the words of the meteorologist on duty, Th. Hinz: "An exceptionally bright flash of light was seen originating from the north, followed by a very loud thunder about 10 seconds later." Later, the staff of the station observed three more discharges in the form of linear lightning. Because the office had no windows facing north, the source of the light could not be seen directly, but all objects in view were brightly illuminated. The weather diary of the station notes: "Thunderstorm (light) N E 16:06 – 16:28" (time in UTC).

Soon after the first discharge, telephone calls were coming in at the station, with people enquiring about the nature of the light and the noise, both of which were generally perceived as unusually strong. The chief of staff, Donald Bäcker, collected the data of the enquiring people and he also called in the local newspaper for more witness reports. At that time, he thought that the primary discharge itself had been some type of BL, because no linear discharge had been observed. To his surprise, the reports did not only contain accounts of the primary flash, but often about luminous spheres above the roofs or inside houses. He was first inclined to dismiss these reports as incredible, but as more and more reports of similar nature but from different people continued to come in, he became convinced that they were real. In total, 34 reports were collected, which included the identity of the observers and a brief transcript of their observations. After finishing the collection of reports, D. Bäcker published a summary in the local newspaper on the 31st March, and in the supplement of the internal report (DWD, 1994) of the German weather service.

About one year later, two of the authors, K. and S. Nätäri, visited all witnesses for interviews. With few exceptions, people were ready to give more information about their observations. In these reports, five classes of phenomena can be distinguished: the primary lightning flash (the light and the loud thunder); corona discharges; two large BL objects over the roofs and over the lake; several small BL objects inside or around houses; and a residual category which includes including widespread damage to telephone systems and the like.

The spatial distribution of the observer's location is centered at Neuruppin, distributed over several square kilometres. There are no reports from villages further east, but some observations have been made at the eastern shore of the lake. For a detailed description see the translation of the most important witness reports in the appendix (pages 199-200).

The lightning detection network BLIDS recorded only five lightning discharges on 15 January 1994 in a square of 50 by 50 km, centered at Neuruppin (Table 1). The first one was at 1606 UTC, a positive lightning with an enormous peak current of 370 kA. It was followed by four less intense discharges between 1609 and 1622, where the two last ones were nearly coincident. Thus, the numbers of discharges noted by the meteorologists and by BLIDS are in agreement. BLIDS located the first discharge about 5 km east of the centre of the lake bridge. The other discharges were recorded even further east. BLIDS data gives a distance of 7 km between the lightning hit point and the meteorological station, whereas the estimate from the time interval between thunder and lightning as noted above (about 10 seconds) is only about 3 km. The location accuracy of BLIDS is given as 1 km. Data from two cases where positive lightning destroyed trees (Heidler et al., 2000) give a difference between the BLIDS data and ground strikes of between 1 and 2 km. Considering the difficulty in judging time differences, one can consider that the data are compatible.

Obviously, all observations of BL objects appeared in coincidence with the first, positive lightning of a winter thunderstorm. No linear lightning channel was observed; all observers with a direct line of sight to the measured hit point describe it as a more or less point-like source. The lightning channel must have been much shorter than usual. Initially, before the BLIDS data were taken into account, this was a source of confusion between the large BL objects and the primary flash.
Another possibility is that a considerable part of the lightning was an intra-cloud discharge, which was screened from the view of the observers, such that only the short connection to ground was visible.

Table 1. BLIDS data, giving the lightning in the query window. The distance is to the town centre of Neuruppin.

<table>
<thead>
<tr>
<th>Centre position Window</th>
<th>12.80100°E 52.92900°N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square side length</td>
<td>12.49306°E 53.15379°N - 13.1056°E 52.70420°N</td>
</tr>
<tr>
<td>Time window</td>
<td>15 Jan 1994:00:00:000 - 15th Jan 1994:23:59:999 (UTC)</td>
</tr>
<tr>
<td>Number of cloud-ground strokes</td>
<td>5</td>
</tr>
<tr>
<td>Number of cloud-cloud strokes</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Time (UTC)</th>
<th>Longitude</th>
<th>Latitude</th>
<th>Type</th>
<th>Strength [A]</th>
<th>Distance [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.01.94</td>
<td>16:08:36:698</td>
<td>12890</td>
<td>52940</td>
<td>CG</td>
<td>370000</td>
<td>5600</td>
</tr>
<tr>
<td>15.01.94</td>
<td>16:09:32:481</td>
<td>12905</td>
<td>52944</td>
<td>CG</td>
<td>34000</td>
<td>6600</td>
</tr>
<tr>
<td>15.01.94</td>
<td>16:10:51:260</td>
<td>12929</td>
<td>52945</td>
<td>CG</td>
<td>97000</td>
<td>8500</td>
</tr>
<tr>
<td>15.01.94</td>
<td>16:22:11:961</td>
<td>13119</td>
<td>52950</td>
<td>CG</td>
<td>24000</td>
<td>21000</td>
</tr>
<tr>
<td>15.01.94</td>
<td>16:22:11:979</td>
<td>13114</td>
<td>52958</td>
<td>CG</td>
<td>-59000</td>
<td>16000</td>
</tr>
</tbody>
</table>

Positive lightning of considerable strength has been reported repeatedly for winter thunderstorms (Rakov and Uman, 2002; MacGorman and Rust, 1998). Wind shear, displacing the upper, positive end of a charge dipole from the lower, negative one, has been put forward as a likely mechanism for this type of lightning (Brook et al., 1982, Engholm et al., 1990). In the case of Neuruppin, wind shear may well have been present. The lightning detection system recorded a cluster of negative lightning flashes close to the town of Kyritz, about 30 km west of Neuruppin. It is likely that the lower, negative end of the charge dipole caused these negative flashes, whereas the positive charge, displaced in easterly direction by the wind shear, produced the predominantly positive flashes east of Neuruppin. In addition to these two bipolar clusters, the thunderstorm produced only two other flashes in a square region of 150 by 150 km centred at Neuruppin.

OBSERVER REPORTS

Several observers noted corona, one at a very large scale: observer 5 on the eastern shore of the lake, having a free field of view towards the hit point, observed huge bundles of blue flame extending to the sky. Observers on the western shore also reported corona discharges, but of a more common scale: e.g. blue light appearing on a metal sieve being used for sifting sand (observer 7) or blue sparks emanating from the microphone on a telephone handset. It appears that observer 5 saw negative leaders, indicating an electric field in excess of 1 MV/m. This is roughly the value obtained in high voltage engineering for the breakdown field of negatively charged conductors (Küchler, 1996). The corona discharges were present for a period of several seconds (observer 7 and 13).

Coincident with the primary discharge, several objects were observed which pass the definition of BL: luminous, floating, spherical or elliptical objects with a lifetime of several seconds (Rakov and Uman, 2002, Stenstold, 1999). The largest object is described as a bright, yellow ball of about the size of the appearance of a full moon, hovering motionless over the roofs. About four observations can be ascribed to this object.

A second large, red spherical object was seen passing over the lake bridge from south to north and vanishing in or slightly above the lake; for this object there are at least three independent observations.

At least nine smaller BL objects were seen outside and inside of houses. Details of the observations are given in the Table 2. In four cases, more than one observer saw the same object. Several of these objects occurred only briefly, for about a second. This is the case for two of the objects seen inside houses, where the BL objects were observed from appearance to extinction. Other BL objects existed for longer, so they could be observed with ease. Some of the objects showed the type of independent motion typically associated with BL.

<table>
<thead>
<tr>
<th>Observer Number</th>
<th>Primary flash observed</th>
<th>Type of observation</th>
<th>Distance to hit point (km)</th>
<th>Outside/inside house</th>
<th>Thunder mentioned</th>
<th>Size, motion</th>
<th>Number of observers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Large BL 2</td>
<td></td>
<td>5.7</td>
<td>outside</td>
<td>no</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Large BL 1</td>
<td></td>
<td>6.6</td>
<td>outside</td>
<td>yes</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3a</td>
<td>indirect Large BL</td>
<td></td>
<td>5.2</td>
<td>inside</td>
<td>no</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3b</td>
<td>Small BL</td>
<td></td>
<td>7.2</td>
<td>inside</td>
<td>yes</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Small BL</td>
<td></td>
<td>5.1</td>
<td>inside</td>
<td>0.2 m, yes</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Corona</td>
<td></td>
<td>4.7</td>
<td>outside</td>
<td>no</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Large BL 2</td>
<td></td>
<td>4.3</td>
<td>inside</td>
<td>yes</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>Corona</td>
<td></td>
<td>4.8</td>
<td>outside</td>
<td>no</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>possible</td>
<td></td>
<td>3.8</td>
<td>inside</td>
<td>yes</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>indirect Large BL</td>
<td></td>
<td>5.8</td>
<td>outside</td>
<td>yes</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>Large BL 1</td>
<td></td>
<td>5.8</td>
<td>outside</td>
<td>yes</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>Small BL</td>
<td></td>
<td>6.8</td>
<td>outside</td>
<td>yes</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>Unclear coronal?</td>
<td></td>
<td>3.8</td>
<td>outside</td>
<td>yes</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
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Table 2. Summary of witness reports.

Generally, the shape was described as spherical, but in one case, where the object could be observed longer, the shape was definitely described as round but flat, like a satellite dish. The witness saw this object through a window at a distance of less than a meter. Another object was described as "oval like an egg."
Obviously, there is a considerable spread in the characteristics of these BL objects, but the evidence nevertheless points to a common origin, being linked to the exceptionally strong positive lightning stroke.

THE NEURUPPIN CASE AND ITS CONSEQUENCES FOR BL MODELS

Given the current state of knowledge about BL, it is reasonable to assume that there is only one type of BL. If this assumption is made, several conclusions regarding BL theories can be drawn from these observations, enabling the elimination of certain hypotheses.

Sceptics of BL observations often claim that they are after-images on the retina due to exposure of the intense flash of light from the linear lighting. None of the witnesses observing the smaller BL objects had been able to see the primary flash directly; thus this explanation can be excluded. Since the strike point of the primary lightning was several kilometres away from most of the observers, optical illusions like phosphenes due to the exposure of the brain to strong and varying magnetic fields can be excluded as well. No evidence for a strong magnetic field was reported. Furthermore, theories claiming that BL objects are due to illusions created by external factors like light flashes or magnetic fields will find it impossible to explain the consistent observation of the same BL object by several people. One has to conclude that the observations are based on real, physical phenomena.

The large distance between the observations and the primary flash eliminates all theories requiring the direct interaction of the lightning channel with the material forming the BL. This relates to theories, which are based on combustion of materials like carbon or silicon, e.g. Fischer (1981) and Abrahamson and Dinnis (2000). At a distance of several kilometres, the primary flash cannot have acted only via the electric field or by electromagnetic radiation. Whereas, there is clear evidence for a strong electric field, there is none for strong electromagnetic radiation. Therefore the strength and maybe the duration of the electric field must have played a central role in the copious production of BL.

Several of the smaller BL objects were reported to have moved through curtains or, in one case, through windows. In one case the curtain is reported to have had brown spots at the position where the BL penetrated; the other curtains and windows were undamaged. All BL models based primarily on physical matter will find it impossible to explain such behaviour. The only models which appear to be compatible with all facts are those based on electromagnetic radiation stored in a conducting shell (e.g. Dawson, 1969; Jinnison, Endean, 1997, and Zheng, 1990).

CONCLUDING REMARKS

In summary, the Neuruppin case stands out of other BL observations because it is very well documented. Initially, information was collected immediately by a meteorologist. Witnesses were inquired for more details of their observations less than one year later. The sequence of events makes it very unlikely that several people conspired to make a hoax by producing fake observation reports. The observations can be well correlated with data from the lightning detection network BLIDS, enabling a satisfactory reconstruction of the events by linking the first lightning of the thunderstorm to the observed BL objects.

All evidence points to the fact that the many BL objects were created several kilometres away from one single, very strong positive flash, in a region where the electrical field was at very substantial levels. Based on this evidence, BL models calling for a direct interaction of the lightning channel and the material forming the BL object can be excluded. Also, BL models based on optical or other illusions associated with the light or the magnetic field of the primary flash can be excluded with certainty.
This photo was taken right before sunset at Anza-Borrego Desert State Park, California, USA. The lenticularis-style shape of the clouds had dominated the skyline since noon. With the sunset, colours became more and more spectacular and changed from one minute to the next, depending on the reflection.

© Dr. Sascha, O. Becker
(See the others in this stunning collection at www.cloudappreciationsociety.org).
Since the primary flash was not the direct source of energy for the formation of BL objects, one is forced to conclude that other and weaker sources like the energy stored in the electrostatic field must have been involved.

In order to substantiate the conclusions drawn above, it would be very important to increase the number of BL observations where a direct causal relationship between a lightning stroke and the BL objects can be established. Lightning detection systems, combined in the EUCLID (European Cooperation for Lightning Detection) network, are now covering most of Europe. These lightning detectors work primarily with time-of-flight information and pinpoint the time of lightning flashes with sub-second accuracy. In order to correlate specific lightning flashes with BL observations, therefore the time of observation is very important. If more BL observations could be correlated with specific lightning parameters like polarity, current amplitude and strike distance, one can expect that more light could be shed on the creation conditions and maybe also on the nature of BL objects.

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ACKNOWLEDGEMENTS

We are indebted to Stefan Thern from BLIDS (Siemens) for supplying us with the data of the lightning detection network.

APPENDIX: OBSERVERS’ REPORTS

Observer 5: On this day, I was working in the kitchen. Dark clouds were approaching, which I kept watching. Suddenly, there was an unusual flash. It could be compared in appearance to a mal-adjusted electric welder, which produces similar blue sparks. Of course, here the dimensions were much larger: huge blue bundles were stretching towards the sky. Then I heard a loud bang...

Observer 7: The sand sieve was lying on a metal wheelbarrow, its frame extending over the edge of the wheelbarrow. Suddenly, the sieve was lit up in a blue light... The light vanished, and I wanted to continue working. Suddenly I heard a loud bang.
My wife went inside, but before I could make up my mind to follow her, the sleeve was lit up again in a blue light...

Observer 14: While talking to an acquaintance on the phone, located in the corridor, I looked through the closed window into the small inner courtyard. I was half a metre away from the window. Suddenly left of the chimney there appeared a silvery bright light. I couldn't understand where the light was coming from, and then the object approached me. I was afraid to be hit, but the closed window reassured me. The object travelled down from the roof in an ambiguous path. I noticed a type of trail behind it, but that may have been an optical illusion produced by the brightness and the speed of the phenomenon. It was swimming the window, so I could watch it. It was shaped like a satellite dish. The object was less than a meter away, two thirds of it under the window, the rest visible. It didn't have a rigid shape... Sometimes, it changed the shape slightly, as if unsure in which direction it should disappear.

The whole thing lasted for a while, so I could tell my acquaintance that there was a funny type of lightning. Then, to my relief, the dish vanished in a vertical direction. There was a very loud bang, which made me think of a thunderstorm. Heat or something similar I did not feel, but there was a cracking noise on the phone.

Observer 16: I was sitting in my favourite corner in the living room, my daughter playing around with the armchair. Suddenly, there was a bright light between me and the child. At first, I thought that the child had been playing with the camera, which was lying on the armchair, but she looked at me with a frightened expression. From the hallway, also my husband looked at the light with a stunned expression. Its duration was only one to two seconds. It was directly over the floor, oval not large, and about 1 m long. In the middle it was blue and around it was very bright. It didn't move... Nothing was damaged. Outside it started to rumble and then there was a loud bang.

Observer 17: With a friend we were driving on the car on the "Seadamm"-bridge towards the city centre. Something very bright approached us. Everything around was so brightly lit that we couldn't see anything through the windows. Probably the object crossed directly over the roof of the car, there was no other traffic. We could only see that to the right it either disappeared into the lake or it simply dissolved... Suddenly there was a loud bang...

Observer 20: At that time, we - my son, a friend and I - were in the workshop. A wood milling tool was standing there, about 80 to 100 cm away from the outer wall. Suddenly something as bright as a magnesium torch was lit up in this space, the workshop was bathed in a bluish light. The luminous object was about one meter above the floor and it had a diameter of 50 to 60 cm. My friend was facing in the opposite direction, so he could only see the light, but my son was running towards me and hugged me. The duration of the whole thing was very short, hardly more than a second. Soon afterwards there was a loud, scary bang which pressed against our wall... Nothing was destroyed...

Observer 23: At that time, I was sitting on the couch doing some handicraft. I was able to look out of the window in north-easterly direction. Suddenly there was a luminous ball on the balcony, directly in front of the window. First thought I thought it was an errant balloon, but it was standing much too quietly between the metal rail and the antenna (Comment added: a VHF TV Yagi antenna). With its 40 cm diameter it was standing for a very long while on the balcony. I don't know if it was more than one minute, I didn't look at the watch. The colour I could see, but it was difficult to describe. It was not a proper red, nor yellow, may orange comes closest. It wasn't blinding; therefore I was not afraid. I could hear thunder from outside...

Observer 25: I was sitting in the corner of the room, reading a newspaper. Suddenly something swished past me, coming through the closed window. The curtains were closed, but the over-curtains were drawn open. The object had the size of a small glass lampshade and looked like a yellowish light bulb. From the window it moved to the opposite side of the room along the cabinets. Left of me it turned back and moved directly at me, but luckily didn't touch me. I passed it at a close distance and returned through the window... its movement was very swift. It hissed and the object was brighter than then when with sunshine..., I could not hear thunder. The curtain was undamaged, as well as the TV set.
However, in response to a thermal depression (or Heat Low) forming to the south-west of London in the early afternoon (Figure 1), the associated first cold front stalled in an east-west orientation (see also Figure 2, the 5 km radar imagery from Warden Hill in Dorset: inside rear cover) during mid to late afternoon.

![Map of Mesoscale sketch analysis of the synoptic situation at 1500 GMT on 10 September 2005. C = position of Chieveley. Isobars drawn at 1 mb intervals. Based on chart information supplied by the Met Office via BADC and Paul Brown of TOGRO.](image)

Showers and thunderstorms became slow moving during this period and gave some intense downpours, particularly in the Bristol-Cardiff areas, around Westbury and Frome on the north-west edge of Salisbury plain, at Chieveley on the Berkshire Downlands (Pike, 2006) and close to the heat low over Surrey and north Kent during the evening.

This "inner" cold front separated slightly cooler, "drier" air (with dewpoint temperatures of 14-15 °C) which was moving up from the south coast of England, from the very humid ("muggy") air, with dew points of 17-18 °C, over East Anglia and the Thames Valley (see mesoscale analysis in Figure 1). The second cold front is evident over the English Channel in the visible satellite image for 1530 GMT (Figure 3), marked by a significant change to clearer skies. However, this latter front was by then weakening with only patchy light rain.

**INTENSE SHOWERS AND THUNDERSTORMS, GLAMORGAN TO KENT, IN THE AFTERNOON OF 10 SEPTEMBER 2005**

Figure 3 highlights the eruption of intense cumulonimbus cells overland along the first cold front; on the continent near the France-Belgium border, and also with a conspicuous storm over West Berkshire, England.

This storm at Chieveley has previously been noted by Pike (2006). The EA rain gauge at Chieveley STW recorded 84.8 mm for the day, all in the two hour storm from 1445 GMT with 73.6 mm falling between 1500 and 1600 GMT. 300 metres away in the village, amateur meteorologist and professional biologist Dr Bill Little measured 87.1 mm for the day, all attributable to the 120 minute period of the storm (Gustard, A. and Little, W., Pers. Comm.). At North Heath farm, 1 km west of Chieveley, 70.6 mm was recorded. The local press described flash flooding on the A4069 at Hermitage and, especially, on the A34 which was closed for over six hours following flooding one metre deep on the M4 underpass. The Highways Agency referred to storm damage to the electronic drainage sensors as a contributory factor (Newbury Weekly News), although run-off from embankment sides blocking drains with silt and flints must be suspected in view of the rainfall intensity.

The storm evidently drifted very slowly north-westwards across sparsely populated downland before decaying (consistent with the "steering level" winds), with rainfall totals above 40 mm recorded at least 5 km north-west of Chieveley (45.2 mm at Little). In contrast rainfall gradients to the south and east were much smaller than only 6.4 mm fell at Speen (6 km south) and 2.2 mm at Yattendon Court (7 km east), with no rainfall at all recorded in parts of Newbury.

![Mesoscale-8 false colour high resolution visible image, 1530 GMT on 10 September 2005. Copyright EUMETSAT (2005).](image)

Following an earlier thundery shower passing to the east between 1421 and 1430, at Woodlands St Mary, near Hungerford, much distant lightning and rumbling thunder was observed to the north-east between 1500 and 1603 GMT (with a close discharge at 1546) accompanied by steady but light to moderate rain; towards the end of the period a fresh northerly breeze sprang up for a time. Between 1610 and 1700 the development of a cumulonimbus in the more immediate vicinity gave 9 mm of rain (including a torrential downpour from 1635 to 1643 as a new 'daughter' cell formed).
Further west, the Bristol area was also affected by intense shower activity during the afternoon, though without thunder. TORRO's Bryan Williams at Fishponds reported that increasing medium level cloud and rapidly growing embedded cumulus caused the sky to quickly become very dark between 1415 and 1430 GMT. A heavy downpour began suddenly at 1445 and persisted until 1600 when rain ceased equally abruptly after depositing 32 mm in the 75 minute period. Some houses in the Clifton area were reported to have been hit by flooding.

To the south-east, another TORRO observer Andy Brown's thunderstorm report describes the onset of a torrential local rainfall over Westbury (Wiltshire), on the north-west edge of Salisbury Plain (see also Convective, February 2006). This cumulonimbus turned thundery as it drifted very slowly south-westwards (on the right flank of the heat low) and he recorded 40 mm of rain by 1800 GMT, most of which, he noted, would have fallen between 1825 and 1700 GMT. About two miles south-west a Met Office gauge at Dilton Court recorded a daily fall of 57.3 mm, while another official reading in the village of Upton Scudamore gave 54.0 mm.

During the evening, thunderstorm activity became focussed just south of London, initially Surrey and north-west Kent, and later a little further east. Flooding closed the A42 main road near Dartford (Kent), 41.8 mm of rain fell at Wisley (Surrey), including 37.2 mm between 1800 and 1900 GMT, while nearby East Horsley recorded 37.7 mm in 65 minutes from 1800 GMT (Col. Bulletin, September 2005). At Claygate (Surrey) two periods of thunder were observed, to the north-east and north, during the afternoon. Further thunder occurred to the south and west between 1745 and 1825 GMT. The fourth period of thunder began at 1845, initially from the east, but then with a heavy overhead thunderstorm from 1900 to 2015. Of the 39.9 mm which fell during this 75 minute period, 25 mm was recorded in 10 minutes from 1925 GMT (Prichard, 2005).

Figure 4. Classification of heavy rainfalls of up to 2 hours duration by E. G. Blitham, British Rainfall 1935.

ACKNOWLEDGEMENTS
Special thanks are due to Sue Daillar and Prof. Paul Hardaker for the supply of the radar sequence; to Prof. Robert Moore for the satellite imagery; to Andy Brown, Paul Brown, Bob Prichard and Bryan Williams for their accounts of the day's events; and to Belinda Robinson at BADC (Met O Land stations dataset) and Dr Alan Gustard and Dr Bill Little for correspondence and some additional rainfall readings.

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TORRO THUNDERSTORM REPORT FOR THE UNITED KINGDOM: AUGUST 2006

BY BOB PRICHARD

After a fairly quiet start to the month, there was a fair amount of thundery activity from the 13th, with several violent storms. Most of the outbreaks came in showery weather, leading to a rather patchy distribution parts of southern and northeast England, as well as quite large areas of Wales, Scotland and Ireland, had no thunder, but it was heard on five days at a fair number of reporting stations in England and there was a small area around Norwich with totals of eight to ten ‘days with thunder heard’. How quickly has nature righted the balance in Norwich, after - a perhaps unprecedented - thunder-free first half of the year!

At the beginning of the month, a cool, blustery northwesterly airflow affected northern and eastern Britain. On the 1st, showers turned thundery as they reached coastal areas of east and northeast England in the afternoon. North and east Norfolk was again affected on the 2nd, when flash flooding occurred at Sheringham, where it is reported that 75 mm of rain fell in three hours; it was the day of the town’s carnival (or was supposed to have been!). After a brief hot spell - the only one of the month - an otherwise weak cold front drifting southeast triggered one or two thunderstorms in the extreme southeast on the 7th, notably at Eastbourne where flooding followed about 40 mm of rain in under an hour.

A deep depression drifted east-south-east close to northern Scotland during the 9th and into the North Sea on the 10th, when another blustery showery northerly airflow developed; isolated thunder may have occurred in one or two coastal locations from Northumberland to Norfolk in the evening. By the 12th, the depression had filled somewhat and was centred over the Netherlands. Strong northerly winds brought a bleak day to eastern England; on the forward edge of this cool, wet weather, thundery showers affected parts of Kent in the afternoon, and there was a report of 31 mm of rain in one hour at Faversham. Isolated thunder also occurred within the rain area near Lowestoft towards midnight. The afternoon and early evening of the 13th saw several sharp thunderstorms giving torrential rain to parts of southeast England; they developed on the boundary between cloudy, cool air to the west and bright skies to the east as the frontal trough which had soaked central eastern England on the 12th drifted westwards. A line of continually regenerating cumulonimbus cells extended from near St Albans through Heathrow and west Surrey/east Berkshire into Hampshire from early afternoon until well into the evening. 118 mm fell at Virginia Water, and around 100 mm at Bagshot and Ash; not surprisingly, there was serious flooding, albeit along rather a narrow track - many places only a few kilometres to the west and east had very little rain. There were, though, other thunderstorms that afternoon in the southeast, with a few incidents of lightning damage. The roof of a house was set on fire at Reigate, and the entire attic and contents destroyed; a girl felt a minor electric shock whilst using a computer. At Eastbourne, lightning struck a 12 year-old girl while she was walking a dog; her heart and breathing stopped briefly and she was resuscitated by a community support officer and a member of the public before being taken to an intensive care unit. In the early evening, as storms moved through London on their way from west Essex to mid Surrey, two houses were struck at Tooting. It must be of concern that this day’s storms were not forecast.

Thundery activity was quite widespread from the 16th to the 23rd. Initially, a depression that was near Iceland on the 14th moved south and lay to the south of Ireland on the 16th.

The pressure pattern over our islands on this day was that of a cyclone, and in response to some warm sunny spells, a few thunder showers developed over England during the afternoon and into the evening. Meanwhile, the occlusion from the depression had already given heavy rain to Cornwall overnight, before weakening in situ. As the depression began to drift northeast, this rather diffuse front edged into southern England during the night of the 16th/17th, and scattered thunderstorms drifted north to the east of London; lightning caused damage to a church tower and a house in Cromer. There was also some thunder in Cornwall at the end of the night. During the 17th, increasingly widespread and active thunderstorms moved northwards in bands over England and Wales; sharp thundery showers also affected parts of Scotland. The most notable outbreak was over the Midlands and southern counties of northern England during the afternoon, with tornadoes at Baston (Lincolnshire) and near Warwick. Conical hail, fifteen mm in diameter was reported from Pershore. 22 mm of rain fell in one hour at Chepstow, whilst there was 15 mm in fifteen minutes at Penzance in the late afternoon, with large hail and flooding nearby, as well as a funnel cloud. Central southern and southeast England were not affected by these storms; elsewhere, there were many reports of lightning damage. Amongst the most notable, a man was struck (via the tarmac) and suffered minor injuries as he stepped out of a van at Tutbury (Staffordshire). Six people were evacuated after a block of flats was hit at Cardift, and emergency gas and electricity repairs were needed after a block of houses was hit at Ross-on-Wye. Six thousand properties lost their electricity in Lincolnshire, four thousand in Leicestershire and 2500 in Derbyshire. A tree was shatterd at Bawsey (Norfolk), blocking a road. Houses were badly damaged at Leigh (Greater Manchester) and Huddersfield, and eight television sets were blown up when a residential home was struck in Rochdale. Near Glasgow, lightning struck a semi-detached house, hole in the roof and starting a fire which gutted the roof space and upper floors; the adjoining house was also damaged.

During the 18th, the slowly filling depression moved into England; a developing area of rain moved slowly northwards across the country and was thundery in places - especially over eastern and southeastern Britain early in the day. 38 mm of rain fell in twenty minutes at Poole and lightning knocked out power at Corfe Mullen: at Taunton, electrical equipment in a child's bedroom was set on fire and destroyed. Several people were evacuated when an electrical sub-station was set alight and exploded at Weston-super-Mare. Several houses were struck in south Wales. Lightning disrupted all rail services at York station for two hours; the entire signalling system was affected with twelve modules knocked out, probably from multiple strikes. The station building was hit at the west end (near platform eleven), causing it to "shake like an in-morning"; lightning struck a house at South Shields, setting the roof on fire, and there was a similar event later at Solihull, as thundery showers developed widely behind the rain area (but again missed the southeast, although some places here had caught the overnight storms). At Kiddleminster, a woman and her baby were thrown across a bedroom after the house was struck. Cattle were killed near Cheltenham and Market Harborough. Flooding was reported from Cheltenham, Northampton and Doncaster. 33 mm fell in thirty minutes at Bromsgrove, whilst a localised severe thunderstorm at Torquay gave 37 mm in an hour in the early afternoon.

With the depression sitting right over the country, further thundery showers developed over England during the afternoon of the 19th: the southeast once again missed out. At Mapperton (Somerset) in the late afternoon, a local historian was one of two independent "first hand" observers of a ball lightning incident. He was going up the garden steps in a sudden heavy shower and, following a simultaneous lightning flash and crack of thunder, he observed "ten feet in front of us a dense oval of blue flame which burst from something not much bigger than a rugby ball". It rolled over a bonfire site and disappeared through a fence into the adjoining garden.
From this next door property a woman described "a big red and orange flame, pointed at the front, flashed across the window and went into the hedge", in a third property, behind the hedge, power was cut off. A hailstorm at Calthorpe (Norfolk) during an evening thunderstorm caused severe damage to crops and fruit; many grapes were bruised and leaves were shredded in a field of maize. There were further thundery showers around Norwich and Redcar on the afternoon of the 20th in a west to northwesterly airflow around the retreating depression; on the 21st, thunder accompanied a frontal system that moved across the country from the Atlantic, affecting parts of Yorkshire around dawn and areas of London, East Anglia and Kent through the middle of the day. Near Leeds, lightning struck a house and blew a five foot hole in the roof; all electrical wiring was destroyed and all sockets blown off the wall. Another house was struck and badly damaged at Sprowston (Norfolk).

A temporary ridge of high pressure brought tranquility on the 22nd, but thunderstorms reappeared on the 23rd as a complex frontal system drifted across the country; they were quite widespread during the afternoon and evening over Wales, western and northern counties of England, with isolated thunder also over southern Ireland and eastern Scotland. Flooding was reported near Hull, whilst from Bromsgrove there is a report of 48 mm of rain in an evening thunderstorm, during which lightning set a house on fire. Near Worcester, a girl had a lucky escape when lightning struck and severely damaged her bedroom just after she had left it because she was frightened by the storm. Severe fire damage was caused to the roof of a school at Droitwich, whilst at Aylburton (Gloucestershire) a two hundred foot high Wellingtonia tree took a direct strike and exploded with such force that other trees in the vicinity (part of a 19th century wild garden) were brought down. Limbs from the tree were thrown up to one hundred metres in all directions, leaving behind a fifty foot stump. A house was fired at Derby, nearly 500 properties lost power in Lincolnshire and at Flamborough Head a lightning strike - observed by a Watch Officer - was reported to have caused a landslip of about 100 tons of rock (buttress) on the south side of the headland. During the evening, another thundery area moved northeast across the Channel Islands to the Isle of Wight and continued across parts of southeast England during the early hours of the 24th; it was associated with a developing wave on a cold front and rain was rather more of a feature than thunder. Behind the fronts, an isolated thundery shower was reported from near Hull in the afternoon. A fairly vigorous showery westerly airflow brought more widespread thundery showers from the 27th to the 29th; on the 27th, they affected Northern Ireland in the late afternoon and parts of north Wales and northern England during the evening, on the 28th it was the turn of southeastern England in the afternoon, with a repeat performance from Northern Ireland eastwards later, and on the 29th they were fairly widespread across central and eastern England during the afternoon and early evening - a house was struck and slightly damaged at Grimsby.

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TORRO TORNADO DIVISION REPORT:
OCTOBER AND NOVEMBER 2006

OCTOBER AND NOVEMBER 2006 were both very mild months, making the autumn as a whole the warmest on record in the Central England series. The weather during these two months was often unsettled and wet, but the first two weeks of November were mainly anticyclonic. The first few days of October and the second half of November were quite active for whirlwinds but the intervening period was quiet. There were four known tornadoes over land in October, seven reports of funnel clouds, and a strong waterspout that made landfall at Brighton. For November we have records of five tornadoes and three funnel clouds (a number of doubtful reports have been discounted).

WS(+TN)2006Oct01 Brighton, East Sussex (50° 50' N 0° 07' W, TQ 3106)

Several people saw this waterspout as it moved east just off the coast at Brighton in the early morning. In a report on the BBC, Mr Peter Machin (who took a good photograph of it) said he watched the 'tornado' for 10-15 minutes: "I looked out and saw a black cloud with the funnel underneath. It was moving towards Peacehaven and seemed to be getting bigger and bigger as it got closer." There was also a report in The (Brighton) Argus of the 2nd October. And in a national newspaper, Ms Jean Hopkins said: "The sky turned black and a howling wind started to pick up. It must have stretched about 1,000 ft into the sky and it was about 150 ft wide at its base. It seemed to be throwing up water and other debris as it moved along the seafront..." The time was about 6:45-7:00 am (0545-0600 GMT). The classification reflects the fact that it was seen and photographed hitting the cliffs, but is said to have disintegrated as it did so.

At 0600 GMT the British Isles were within the circulation of a low, 990 mb, centred close to southwest Ireland and moving slowly northeast. Its occluded front was just clearing the east coast of England, but other shower troughs moved east across England and Wales during the day. Showers occurred fairly widely, and were accompanied by thunder in southern and eastern areas of England.

FC2006Oct01 Ronaldsway, Isle of Man (54° 05' N 4° 36' W)

The 1450 GMT METAR from Ronaldsway Airport reported a recent funnel cloud (within the past half-hour).

FC2006Oct01/II Newmains, Wishaw, Lanarkshire (55° 47' N 3° 52' W, NS 8256)

Ms Amanda Nelson photographed this funnel shortly before 6 pm (1700 GMT). The picture shows it about a third of the way to the ground (information from Mr Alex Stephens).

FC2006Oct01/II Great Livermere, Suffolk (52° 18' N 0° 45' E, TL 8871)

TORRO member Andy Scott observed "a ragged funnel cloud... where the flanking line joined the main updraught [of a thundercloud] - it had a smooth, rounded tip and lasted approximately three minutes." Time was about 1815 BST (1715 GMT). The storm gave hail up to 8 mm diameter.

TN+FC2006Oct01A, Starson, Norfolk (52° 24' N 1° 17' E, TM 2384)

TORRO's Dr Charles Briscoe inspected the damage caused by this tornado at Cranes Watering Farm (Starston) at 1845 (1745 GMT).
Because of the open nature of the ground, damage was limited to the farm buildings. The asbestos roof of a barn was removed and blown into the farmhouse, breaking the windows and dislodging roof tiles. The occupants (who escaped injury) described "the enormous bang and roar as the tornado went over," which lasted less than a minute. Another barn had its roof lifted and put down again. A photograph (name of photographer not stated) shows the funnel at least two-thirds of the way to the ground, and Dr Briscoe was told of a second funnel that appeared but did not reach the ground. The track through the farm was about 200 m long, from southwest to northeast, and about 40 m wide. Force T2.

Dr Briscoe also received a photograph of a very broad wedge-shaped funnel, apparently reaching the ground in the distance, taken about two hours later than 1815 GMT, and 20 miles (30 km) northeast of the Stanstar tornado, which is here regarded as a separate event; but because this later one occurred over uninhabited marshland (possibly going out to sea), there were no reports of damage.

The 1450 GMT METAR from Manston Airfield contained a report of a funnel cloud. About a week later the Herne Bay Gazette (12 October) published an undated photograph taken by Mr Andrew Fisher of a narrow, well-formed funnel cloud, about a quarter of the way to the sea, over Herne Bay. It was said to be visible for 20 minutes, and was also seen from Tankerton and Thanet, this is assumed to be the same as the Manston sighting. At 1200 GMT a westerly airstream covered the British Isles between a complex low, 99 mb, over Scandinavia and a high, 1030 mb, west of Portugal. A shower trough was moving slowly east to reach the east coast by 1800 GMT. Scattered showers affected mainly northern parts of England, but there were also a few in the Kent area in the afternoon.

Mr Matthew Porter contacted Terence Meaden about a very thin funnel, which he said was touching the ground, but he did not detect any rotation. Time was given as 1740 BST (1840 GMT). At 1200 GMT a low, 986 mb, was moving slowly east near the north coast of Scotland, and a back-bent occlusion was over the Hebrides and western Ireland. There were showers in many parts of Britain during the day, some of them heavy.

Mr Roger Longshaw and others witnessed this tornado, which passed from southwest to northeast close to the golf course near Thame about 2 pm (1300 GMT). A short video film was taken, showing a thin weak funnel descending from a low stratus base. It seems unlikely that it would have caused significant damage. (Information from the Oxford Mail via Richard Pearson of TORRO.) At 1200 GMT a cold front was moving very slowly east over Scotland and England, associated with a deep depression, 967 mb, south of Iceland. There were showers and outbreaks of rain, heavy and thundery in places, on and ahead of the front. The tornado appears to have occurred just ahead of it.

The 1420 GMT METAR from Ronaldsway Airport reported a recent funnel cloud (within the past half-hour). At 1200 GMT the British Isles were within the circulation of a complex low with centres 978-981 mb in mid-Atlantic, and a secondary centre, 986 mb, in Liverpool Bay.

Various occcluding fronts were circulating round the country. There were showers, mainly over land, but a few also in the Irish Sea.

3 AFC2006Oct23 Longton, Lancashire (53° 43' N 2° 47' W, SD 4725)

Three, possibly four, funnels were seen by Mr Daniel Robinson (reported on UKweatherworld forum) between 1715 and 1830 BST (1615-1730 GMT). At 1800 GMT a cyclonic col covered most of Britain between a low, 975 mb, in the Bay of Biscay and a minor low, 987 mb, just west of Scotland. There were no reports of showers or Cb in the area at the time.

If a006Nov11 Chester, Cheshire (53° 11' W 2° 53' W, SJ 4068)

At 1212 GMT the aluminium roof of a supermarket was blown off, injuring one person and damaging several motor cars (from the Daily Post of the 13th November). This was one of several reports of localised wind damage received for this day, but none of them was definite enough to be documented as a tornado. At 1200 GMT a brisk westerly airstream covered the British Isles between a low, 974 mb, to the east of Iceland and a high, 1033 mb, southwest of Ireland. There were heavy showers (some with thunder) over Scotland and the far north of England, but further south showers were mostly light.

In 2006Nov17 Exeter, Devon (50° 43' N 3° 31' W, SX 9292)

The (Exeter) Express and Echo (18th November) reported that a 'mini-tornado' damaged trees and property in the Burnthouse Lane and Riverside Valley Park areas of Exeter at about 3 am (0300 GMT), and quoted Ms Jenny McCarthy; "I can only describe the very severe and sudden violent wind accompanied by a rumbling, not unlike the sound of an express train. In the morning, there was a lot of debris and my neighbour's greenhouse was missing panes of glass." We also received a separate report (via the UKweatherworld on-line forum) of wind damage to trees at the crematorium during the night.

At 0000 GMT most of Britain was covered by a southwesterly airstream associated with a low, 970 mb, northwest of Scotland, and secondaries west and southwest of Ireland. A cold front was near the west coast of Ireland, and a shower trough was approaching Cornwall; this trough, accompanied by heavy showers and thunderstorms, would have been in the Exeter area at the time of the report.

This was reported in the Isle of Wight County Press of Friday the 24th November as a 'mini-tornado', and was said to have occurred "about 3 pm [1500 GMT] on Friday", which we assume to be the previous Friday (17th). It 'picked up a metal builder's shed and garden furniture, damaged fences, blew down trees, and ripped out and snappied off substantial shrubs... The shed was deposited 15 m away..." Force T1-2. The cold front mentioned in the Exeter entry crossed the Isle of Wight about mid-afternoon, accompanied by heavy rain and a 90-degree veer of wind; the tornado was evidently on this front.

Details of this tornado were published quite widely in the local and national press.

According to Mr Paul Collins in The News (Portsmouth) of the 27th November: "The wind seemed to ease off a bit and then I heard a high-pitched whistling... It started swirling round in circles down the bottom of my field and my truck was pushed about 25 ft as I sat inside. I looked into the field and my three ponies were 10 to 12 ft in the air and just flopped to the ground [physically unharmed but agitated]..."
I watched a whole roof and all sorts of things swirling around about in the tornado, which was twice the height of the trees. It picked up everything and just threw it. Then I heard a tremendous bang and it was a horsebox going over.

TORRO's Tony Gilbert carried out a full site investigation on the 27th, which established that a tornado of force T2-3 occurred at 1040 GMT. Track was towards the northeast, approximately 800 m in length, and up to 75 m wide. Damage noted: stationary lorry overturned, widespread roof damage, brick garage shifted off foundation by two inches, garden walls taken, and several trees uprooted. There was thunder just before, and hail just after.

At 1200 GMT the British Isles were within the circulation of a low, 970 mb, centred off northwest Scotland. A cold front lay from Shetland through the north Sea to the Bay of Biscay, with a wave centred over the east Midlands. The tornado occurred in association with this wave as it crossed Hampshire earlier in the morning.

FC2006Nov25 Witcham, Cambridgeshire (52° 23' N 0° 09' E, TL 4679)
Mr Darren Blunt contacted TORRO about this funnel cloud, which he saw to his right while travelling west on the A142 road between Ely and Chatteris at 1130 GMT. "It was cone-shaped and swirling with clouds of light grey which stood out from the dark grey background. Approx 100-150 ft from the ground, maybe 100 ft in diameter at the top of the cone."

FC2006Nov25 Abbertillery, Gwent (51° 44' N 3° 08' W, SO 2104)
Ms Rhian Sweet saw what appeared to be a whirlwind at about 8.30 pm (2030 GMT, i.e. after dark). In her correspondence with TORRO she said the clouds were "dark grey... like an arch shape... over the mountain between Abbertillery and Pontypool. There was a funnel coming from one of the points on the cloud but it was not in contact with the ground." She also noted hail, heavy rain, and a very strong wind (but no thunder or lightning). At 1800 GMT a strengthening southerly airflow covered the British Isles ahead of a deep depression, 955 mb, centred well to the west of Ireland. Rain was spreading in to the far west, but ahead of it most places were dry; rainfall radar, however, shows an isolated large shower over the South Wales valleys at the time of the report.

Note: Witness gave the date as "Sunday night", which we take to mean the evening of Sunday the 26th, but colloquially this could mean the night of Saturday/Sunday, making the date the 25th - there were showers over South Wales on that evening as well.

TN2006Nov28/1 Bow Street, NE of Aberystwyth, Ceredigion (52° 26' N 4° 01' W, SN 0284)
Nicky Lambert-Ford of TORRO first alerted us to this tornado, which, according to a local resident, Mr Elwyn Owen, occurred at 1.18 am (0118 GMT); and John Mason was promptly on the scene next day to inspect the damage. His conclusion was that there had been a severe T4 tornado with a track length of two km - from the A487 road south of Bow Street to the estate opposite Rhyspery School to the north; some lightweight debris later turned up as far as 20 km from its source, indicating perhaps a much longer track. The direction of travel was towards north-northeast, and maximum width was 100 m. There was a good deal of damage to trees and buildings, and a large Portakabin (a sort of metal hut) was lifted up and destroyed, parts of it being wrapped round the swings in a children's playground. Among the witnesses John Mason spoke to was an ambulance driver whose vehicle was struck by the tornado: "I can only describe it as driving into a black tidal-wave. You literally could not see a thing ahead and I had to stop"; this lasted about 15 seconds, after which he was able to continue his journey.

At 0000 GMT the British Isles were within the returning maritime Polar airmass of a deep low, 963 mb, centred south of Iceland, and a secondary cold front was approaching the Welsh coast from the west. A band of very heavy showers affected Wales and southwest England just ahead of this front.

FC2006Nov28 Eggerton Hill*, Winterbourne Abbas, Dorset (c 5° 42’ N 2° 32’ W, SY 6190)
This was seen by Mr Colin Morgan from the hills northwest of Winterbourne Abbas. He described "an unusual low cloud base forming to the north. Although no touchdown was observed, it definitely seemed to be the early stages of a tornado." He said that it lasted about 30 minutes around 2.30 pm (1430 GMT). There were showers in the area at the time.

* The closest matching name we can find on the OS map is Eggerton Hill.

tn2006Nov28/11 Near Littlehampton, West Sussex (c 5° 48’ N 0° 32’ W, TQ 0202)
Little is known about this event. A correspondent (full name withheld) reported a 'tornado' on the South Downs at 1835 GMT, seen from Littlehampton. There were showers in the area at the time.

If you know of any events not listed in these reports, or have any further details for any of the listed reports, please get in touch - sam@jmot.org or send reports direct to TORRO reports@torro.org.uk. Thank you. Please also feel free to write to us with your account of events, photos and documentation.

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SIX DEGREES. OUR FUTURE ON A HOTTER PLANET By Mark Lynas (2007)

This is an alarming book - and intended to be. Three years ago, the author, a journalist campaigner and broadcast commentator wrote "High Tide News from a Warming World" which he visited a number of different parts of the world where climate change is already having an adverse effect, and there was plenty to make politicians ponder in that volume.

Now, after a year spent almost exclusively in the Ratcliffe Science Library in Oxford, going through historical evidence and more modern articles, the author has written an account of how the world might look - and react - if the temperature were to rise in accordance with the IPCC predictions of a global temperature increase between 1 °C and 6 °C before the end of the century.

Even at the lowest end of that range, the effects are startling enough, while as the upper level is reached, the author believes that civilisation as we know it will be impossible, all makes very sobering reading.

To begin with norther hemisphere civilisation, and, depending on the time-scale of the increase, fauna and flora, will move northwards and upwards. Even by the time 3 °C is reached, most of the world's ice caps will have disappeared, with serious effects on those parts of the world that rely on snow melt etc for steady river-flows.

Once 3 °C is exceeded, many parts of the world will become too hot to support the ever increasing population, especially as production of food etc will inevitably drop. Then water wars are likely, and as large numbers of people migrate in an increasingly desperate search for food and shelter, world order will breakdown; the USA might invade Canada, for instance.

These predictions are by no means far-fetched, based as they are on solid paleontological evidence (as evidenced in his extensive notes of sources). Although the author is fearful that in some respects the "tipping point" may already have been passed (e.g. for Arctic ice-cover), the book is not all doom and gloom. For in a long seventh and final chapter, entitled "Choosing Our Future" he explains what can still be done - provided there is the political will across the world.

MELTING ICE - RISING SEAS. The front line of global warming UGI Briefing #146.

Understanding Global Issues, publishes 10 issues a year on topical subjects as varied as Christianity in the New Millennium; The Drugs Challenge; and The Democratic Republic of Congo. As the introduction reminds the reader, this is the third issue of UGI devoted to climate change, the two earlier ones having been in 1997 and 2002. In addition, the edition earlier this year (number 141) was devoted to Natural Disasters.

In the short space allocated (all issues are of exactly the same length and format), the topic is covered quite well: there are chapters on The Melting of the North Pole Ice; Positive Feedback Mechanisms; Rising Seas, Disappearing Land, as well as a final section entitled Fingers in the Dyke: mitigating measures. It is well written and gives a sound, if necessary superficial survey of this increasingly important topic. Particularly valuable are the Additional Notes and Bibliography, which also contains a short list of useful websites.

I think that all readers of this Journal would learn something from this volume, and at the price, can readily be afforded by all. Recommended.

Spectacular Land Devil in the Lake District (Wednesday 4 April 2007)
LD2007/4/04 (13.10 GMT) Castle Crag, Cumbria - Map Reference NY 252 158 - 30 feet (9 m) high, 20 feet (6 m) in diameter.

I have seen dust storms in car parks and trees torn by winter storms, but never have I seen such a spectacular event as the Land Devil which struck in the Lake District, UK, on the slopes of Castle Crag, Borrowdale.

High pressure across Scotland and the North Atlantic had brought fine, settled weather to most of the British Isles, and it was a calm, pleasant day as I descended from the craggy slate summit (elevation 950 feet) towards the village of Rosthwaite.

The open woodland on the south-facing slope was warming up nicely in the afternoon sunshine. Dried bracken litter cloaked the ground, where celandines and coltsfoot pushed up their flowers in a profusion of yellow blooms. The temperature was around 61 °F (16 °C), and there wasn’t a breath of wind.

A sudden whooshing sound heralded the start of a disturbance. Oak leaves and bracken fronds lifted from the floor and bunched into the branches of a 30-foot (9 m) oak tree, accompanied by a whistling sound similar to that of a whirling skipping rope. As the gust intensified, more leaves were lifted and propelled through the tree, with a commotion like a flock of starlings suddenly taking flight. Debris crashed through the branches and spiralled into the air.

The wind shifted to the next tree and continued the performance, close to where I stood. So localized was the eddy, I could feel no movement of air, although I could have reached our and caught passing leaves.

It must have lasted about 30 seconds, although it seemed much longer. Then as quickly as it began, the disturbance ended. Clouds of leaves and bracken, deprived of their driving force, floated gently back to earth, showering me with dust and grit.

Robins began to sing again from the treetops, completely unperturbed. I continued my journey into the village, where the shop was doing roaring trade in ice creams and drinks. Tourists relaxed in the sunshine, unaware of the treat they had just missed.

Roy Bedford, Wakefield.

Thank you Roy for such a great letter and account of your amazing experience of this Land Devil. Please keep sending in your letters and photographs. Addresses and contact details can be found on the contents page or on our website: www.iijmet.org.
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