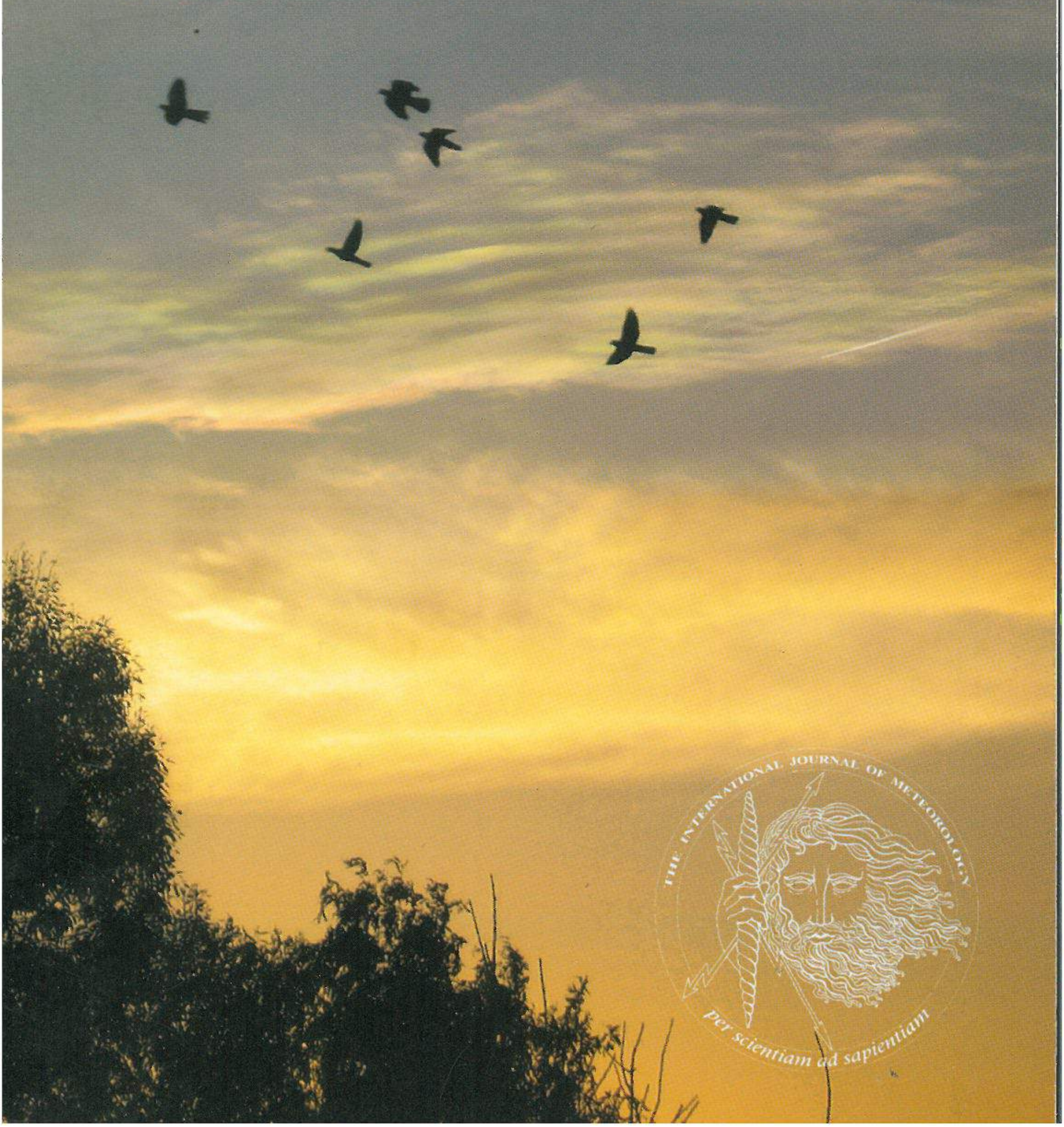
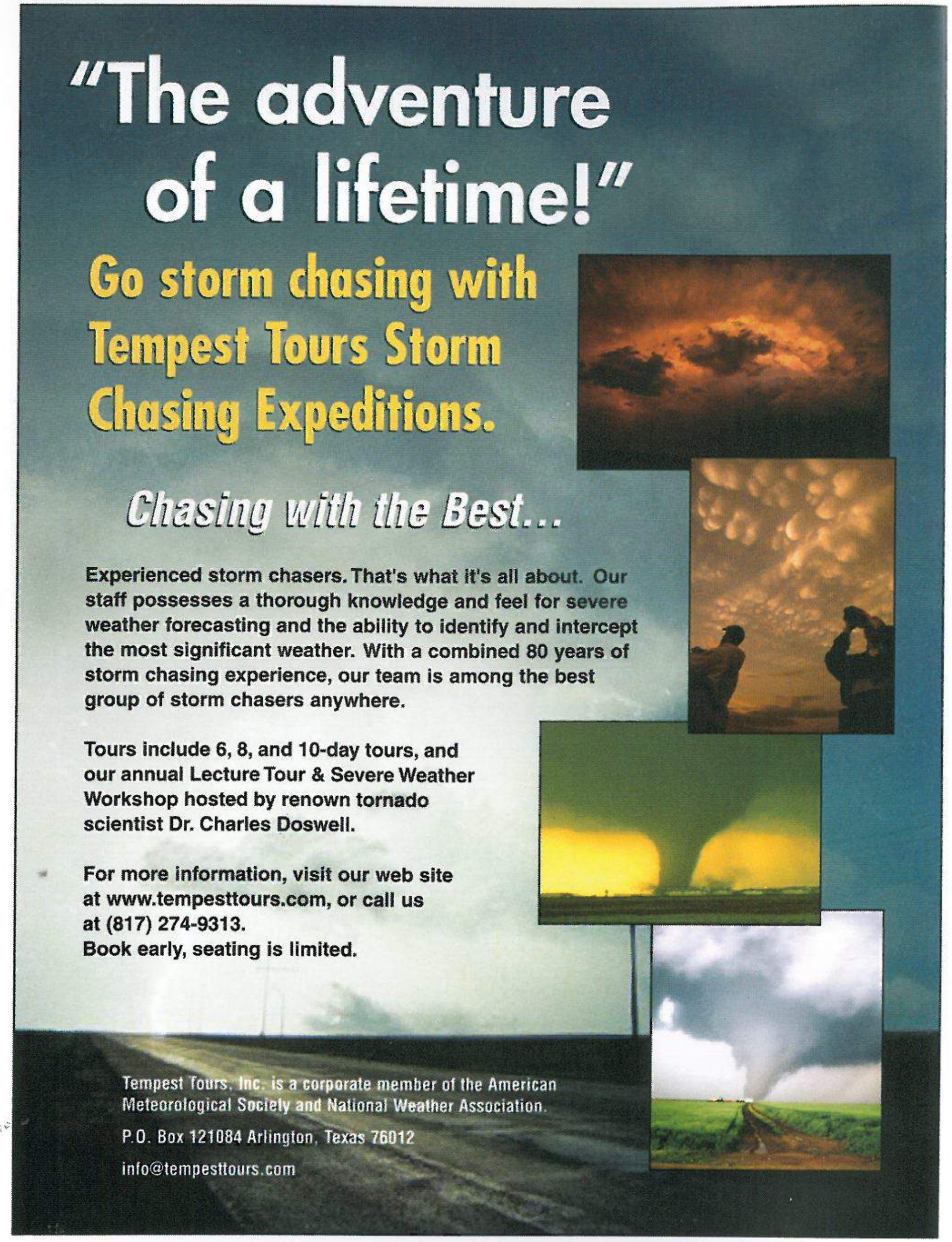
The International Journal *of* Meteorology

www.ijmet.org

Volume 33, number 327 April 2008





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THE **INTERNATIONAL JOURNAL** *OF* **METEOROLOGY**

Published in association with The Tornado and Storm Research Organisation (TORRO)
a privately supported research body, serving the international public interest

Editor-in-chief: Samantha J. A. Hall, International Editorial Office, PO Box 972,
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Please note that for universal citation purposes the recommended abbreviation for The Journal of Meteorology (ISSN 0307-5966) was *J. Meteorology, U.K.* The recommended abbreviation for The International Journal of Meteorology (ISSN 1748-2992) is *Int. J. Meteorology, UK.*

Published by Artetech Publishing Company, UK

Printed by Top Print, 43-44 Winwick Street, Warrington, Cheshire, U.K.

ISSN 1748-2992

LARGE-SCALE CIRCULATION ANOMALY INDICES IN RELATION TO VERY HIGH TEMPERATURE IN EGYPT DURING SUMMER 1998 (A CASE STUDY)

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Abstract: Based on daily and monthly data of surface temperature, zonal wind and vertical velocity obtained from NCEP/NCAR reanalysis, the author will try to investigate and understand some causes of extreme warming during August 1998. The interconnection between large scale anomaly indices (such as Hadley cell, zonal index, subtropical high pressure, Indian monsoon, subtropical jet stream) and surface temperature over Egypt were studied.

Keywords: Surface temperature, Large scale indices, extreme warming, Zonal Wind, NCEP/NCAR reanalysis.

INTRODUCTION

In the summer of 1998 heat waves and air pollution episodes plagued many regions of the world, particularly in Egypt and other Mediterranean countries, and in southern Europe (Trenberth, 1999). Local and regional climates in mid-latitudes are influenced by both large-scale atmospheric circulation and surface features (e.g. Lolis *et al.*, 1999). As spatial distribution of surface characteristics is relatively stable, it would be expected that large-scale climate plays an important role in causing changes in local climate. Studies of local climate change are often linked to variations in the atmospheric circulation (e.g. Yarnal, 1984). In characterizing large-scale circulation, an index which describes features of the large-scale circulation can be useful in explaining changes in surface climate elements (e.g. Kozuchowski, 1993). One such indices is the Zonal Index (ZI), originally developed by Rossby (1941) which has been widely used in studying European climate (Kozuchowski *et al.*, 1992).

It is well known that the 1997 and 1998 years were dominated by El Nino and La Nina respectively. But the big question is: why the summer 1998 was the warmest season in the 20th century, although many years were dominated by El Nino? In this paper the author will try to investigate and understand the causes of summer warming especially in August 1998. The datasets and methodology are described and climatic extremes of summer 1998 are also a main focus. The author also llustrates the association between surface temperature patterns over Egypt and atmospheric circulation indices.

DATA AND METHODOLOGY

The observed data used in this study include: (a) surface temperature at the mean sea level pressure (SLP), 850, 500 and 200 hPa (b) SLP (c) zonal wind at 250 hPa and (d) vertical velocity at 500 hPa. This data is obtained from the daily and monthly mean reanalysis dataset of the National Centers for Environmental Prediction–National Center for Atmospheric Research (NCEP–NCAR) for August 1997 and August 1998 (Kalnay *et al.*, 1996). The NCEP–NCAR reanalysis fields use a state-of-the-art global data assimilation system on a 2.5 ° longitude by 2.5 ° latitude grid.

Based on the daily data obtained from NCEP/NCAR, the derivation of the different index time series as a measure of the extratropical circulation modes is as follows: Based on the daily data of the sea level pressure the ZI can be calculated. The ZI is defined as the difference in SLP between the latitude circles 35 ° and 55 ° averaged over the entire globe. Hasanean (2004) defined the subtropical high pressure centre index (SHCI) in summer season as the regional mean SLP averaged over the area 28 °W–45 °W and 30 °N–38 °N). Also, Hasanean (2005) defined the Indian monsoon index (INDMI) as the regional mean SLP averaged over the area 50 °-80 °E and 20 °-30 °N) in summer season. The Hadley cell index is defined by Wang (2002) as the 500 hPa vertical velocity anomaly difference between the regions of 2.5 °-7.5 °S, 40 °-20 °W and 25 °- 30 °N, 40 °- 20 °W. The quantitative index of the subtropical jet stream (SJ) is defined as the maximum zonal wind of 250 hPa daily averaged over the area 42.5 °-82.5 °E and 40 °-45 °N) in summer season; this provides a measure of the centre core's strength of the SJ.

The standardized anomalies *Zi* are computed for all indices simply by subtracting the sample mean of the batch ($\bar{x}$) from which the data are drawn (x), and dividing by the corresponding sample standard deviation *Sx*.

Data in the present study are smoothed by a nine-pentad triangularly weighted running mean. This running mean is described as:

$$y_n = \frac{1}{25}(x_{n-4} + 2x_{n-2} + 3x_{n-2} + 4x_{n-1} + 5x_n + 4x_{n+1} + 3x_{n+2} + 2x_{n+3} + x_{n+4}) \qquad (1)$$

where *Xn* is the original value of the *n*th data and *Yn* is the smoothed value. This running mean is superior to an un-weighted running mean, in that it smoothes more effectively and it does not result in phase inversion, which may occur in the case of an un-weighted running mean (Burroughs, 1978).

The analysis of the interactions between the atmospheric circulation index's intensity and sea surface temperatures over Egypt can be obtained from the correlation analysis. The coefficient of variation (CV) can be defined as the standard deviation (SD) divided by the arithmetic mean multiplied by 100.

CLIMATIC EXTREMES DURING SUMMER 1998

The earth's global temperature in 1998 was recorded as the highest since 1860, according to the Intergovernmental Panel on Climate Change (IPCC, 2001). The global mean surface temperature is estimated to be 0.58 °C above the recent long-term average based on the period 1961-1990. It was the 20th consecutive year with an above normal global surface temperature. The 10 warmest years have all occurred since 1983, with seven of them since 1990 (IPCC, 2001). The IPCC (2001) has also shown that higher maximum temperatures and more hot days are likely to increase in frequency during the 21st century.

From the surface to 7 km altitude, record temperatures in 1998 were observed 0.47 °C higher than the average during the last 20 years, making 1998 by far the warmest year. In the lower stratosphere, 1998 was colder than usual, though not quite as cold as in the 1995-1997 period. Because changes in climate extremes are expected with anthropogenic-induced climate change, it is important to keep in mind the difference between the detection of a change, and being able to attribute that change to some identifiable climate forcing factor. The detection of changes in extremes on the basis of climate statistics is much more likely than the detection of event-driven extremes. This also holds true in attempting to attribute a detected change to some forcing factor.

Globally, preliminary surface data indicates that August 1998 remains at record warm levels with respect to 1880-1997 long-term mean. Preliminary August land station temperatures were 1.2 °C above the mean, while sea surface temperature readings (including ship, buoy, and satellite measurements) were nearly 0.57 °C above the mean, with a combined index value of 0.72 °C above the average.

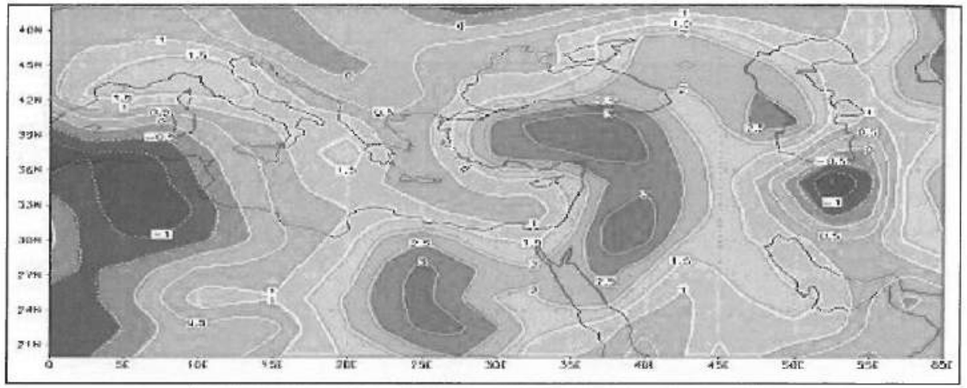


Figure 1. (a) Surface temperature (August 1998 - mean).

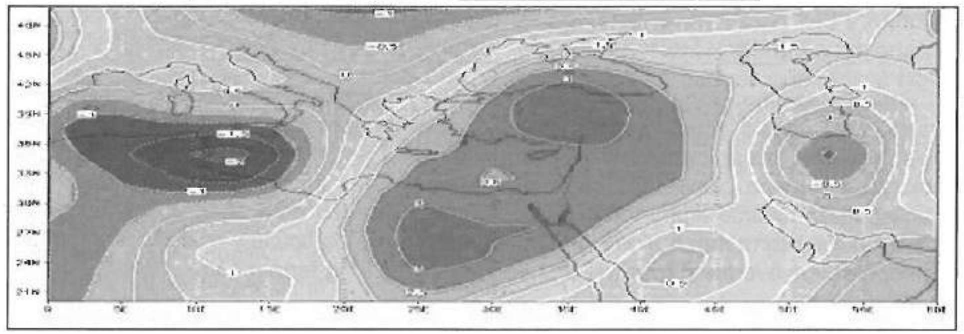


Figure 1. (b) Air temperature (August 1998 - mean) 850 hPa.

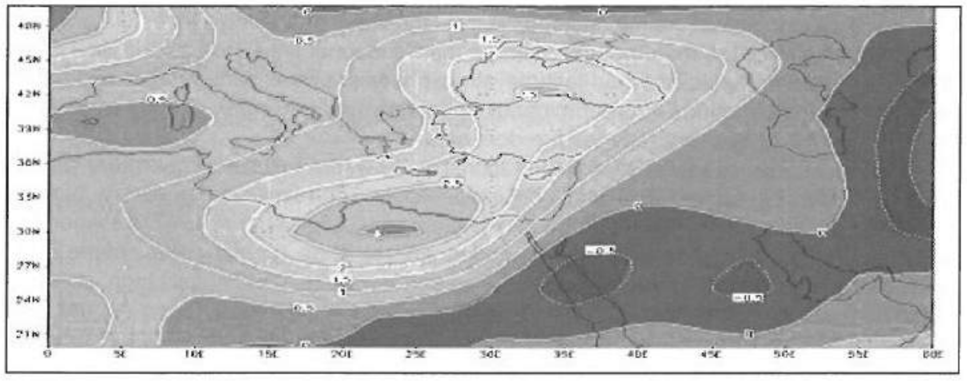


Figure 1. (c) Air temperature (August 1998 - mean) 500 hPa.

Figure 1 illustrates the differences between the temperature pattern of August 1998 and the average of 1960-2000 at the mean SLP, 850, 500 and 200 hPa. It is clear that August 1998 was warmer than the mean throughout all levels and from longitude 15 °E - 50 °E. The maximum difference (positive values) occurs at the surface and 850 hPa especially over Egypt and northeast and east of the Mediterranean. There are small negative values of temperature recorded over south-east Egypt, The Red sea, Saudi Arabia and over the Gulf area at 500 hPa level.

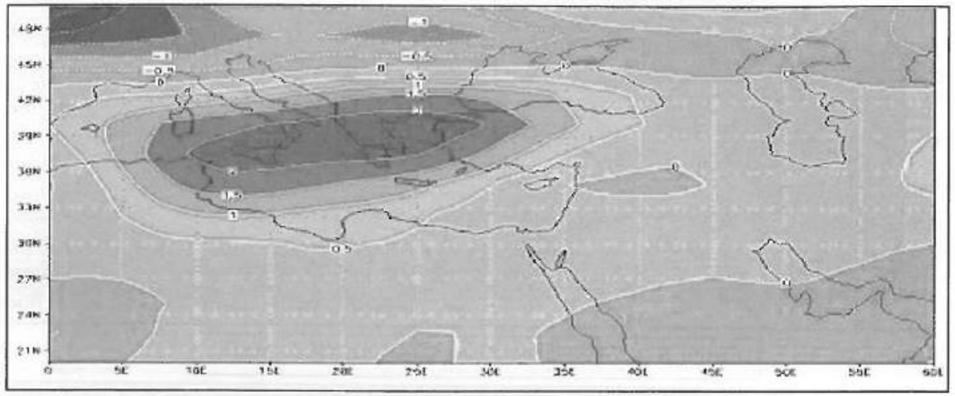


Figure 1. (d) Air temperature (August 1998 - mean) 200 hPa.

The lasting global surface warmth, likely related to the recent El Nino, has persisted, as central equatorial Pacific sea surface temperatures cool down to La Nina levels. However, ocean temperatures of the north-west South American coast remain quite warm. Near surface global land and ocean temperatures for the month of August 1998 established an all time high record. Temperatures averaged more than 0.7 °C above the 1880-1997 long-term mean. The high temperatures were particularly evident over the land as temperatures averaged over two degrees above the long-term mean.

TELECONNECTION BETWEEN SURFACE TEMPERATURE AND ATMOSPHERIC CIRCULATION PATTERNS

Sea level pressure teleconnection patterns

a) Zonal index (ZI) pattern:

The basic flow in the mid-latitudes is from the west; hence most investigators have examined the circulation features upstream on intra-seasonal time-scales (Kripalani *et al.*, 1997). On this time scale, the mid-latitude atmosphere shows a semi-regular alternation between high index periods of predominantly zonal flow and low index periods when large amplitude waves or blocking regimes are dominant.

Figure 2(a, b) represents the relationship between surface temperature pattern over Egypt and ZI in August 1997 and 1998 respectively. The results in Figure 2 (a, b) show an inverse relationship (r = -0.4 in August 1998 and r = -0.35 in August 1997) between two patterns with statistically high significant confidence level. Thus, for high values of the ZI the surface temperature is low and vice versa. Time series values of ZI exhibits high variability during August 1997 (coefficient of variation is 63 %) and low variability during August 1998 (coefficient of variation is 45 %). Consequently zonal mean waves during August 1998 are situated for the long period to give extreme heat waves over Egypt. In general, ZI in August 1998 tends to be zonal. So, the flow in August 1998 is mainly westerly with long wavelengths and low amplitudes.

At such times the polar low is intense and located far north. Surface lows and highs are elongated in an east-west direction and cyclones move rapidly in the zonal flow. A large sensitivity of the extratropical climate may be due to slight zonal flow shifts (Ting *et al.*, 1996). The extratropical regional climate "signal" associated with perturbed zonal mean circulation states is shown to exceed the signal associated with extreme phases of ENSO (Ting *et al.*, 1996).

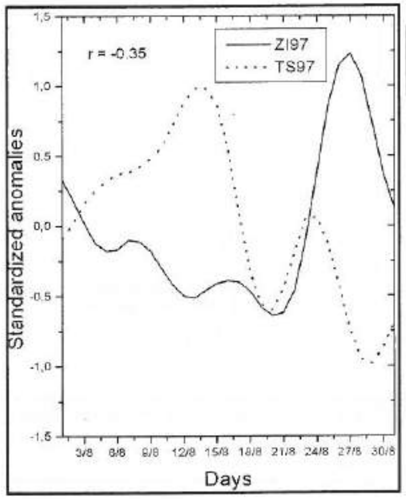


Figure 2. (a) ZI correlated with surface temperature over Egypt (August 1997).

b) Subtropical high pressure and Indian monsoon indices patterns:

Rodwell and Hoskins (2001) examined the dynamics of each of the summertime subtropical highs observed over the whole globe as a nonlinear model response to regionally assigned diabatic heating with realistic topography. They concluded that the combined effect of the topography and monsoonal heating to the east (i.e. the Mexican monsoon for the North Pacific high and the Indian monsoon for the Azores high) is of primary importance for the generation of the surface subtropical highs and subsidence aloft under the reinforcement by local cooling over the eastern oceans. They thus emphasized the upstream influence of monsoonal heating as the primary external forcing that can trigger the summertime formation of a subtropical high. Shaffrey *et al.* (2002) reached the same conclusion based on AGCM experiments. There is a clear "duality" between the monsoon condensational heating and the low-level subtropical circulation in the sense that either one would be very different without the other. Nevertheless, since the monsoons are essentially an amplification of summertime land–sea sensible heating contrasts, their heating have been taken as given, and the investigation has focused on how they affect the summer subtropical circulation.

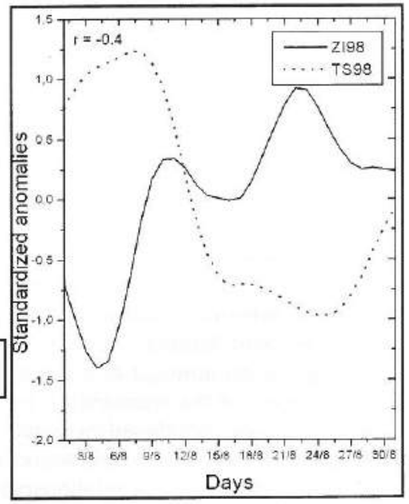
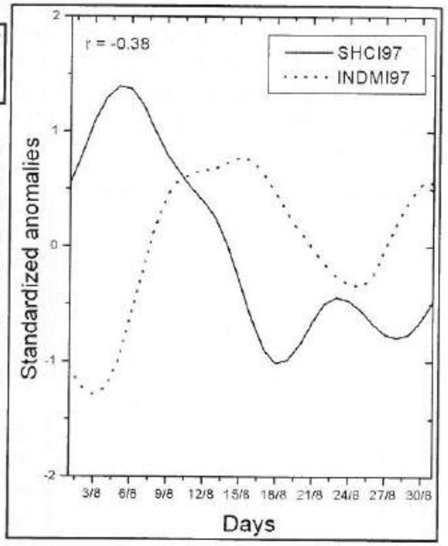


Figure 2. (b) ZI correlated with surface temperature over Egypt (August 1998).

Subtropical anticyclones and monsoons play a major role in the global circulation of the atmosphere and oceans (Rodwell and Hoskins 2001). A significant negative relationship between SHCI and INDMI are found in both periods (Figure 3 a, b). So, when the SHCI is strong the INDMI is weak and vice versa. The existence of the subtropical anticyclones has often been attributed to the Hadley circulation. Rodwell and Hoskins (1996) found that the Indian monsoon activity can induce a Rossby wave response, which produces an adiabatic descent amplified over the eastern Mediterranean.

Figure 3. (a) Subtropical high pressure centre index correlated with Indian monsoon low pressure centre index (August 1997).



In examining the changes of atmospheric circulation system in relation to the rapid warming during August 1998, the author first examines the changes in the centres of the Indian monsoon and North Atlantic subtropical high in order to determine the significance of these systems, and also exhibit the major changes in relation to the extreme warming. Figure 4(a, b) shows mean sea level pressure distribution pattern of the North Atlantic subtropical high pressure and Indian monsoon low pressure during August 1997 and August 1998 respectively.

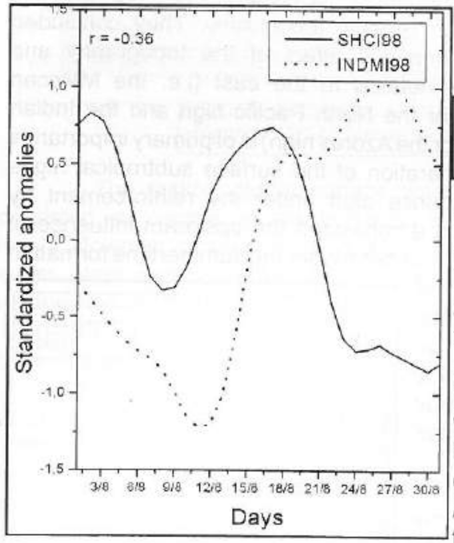
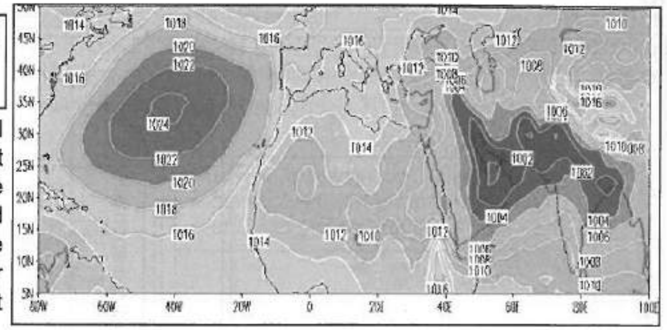


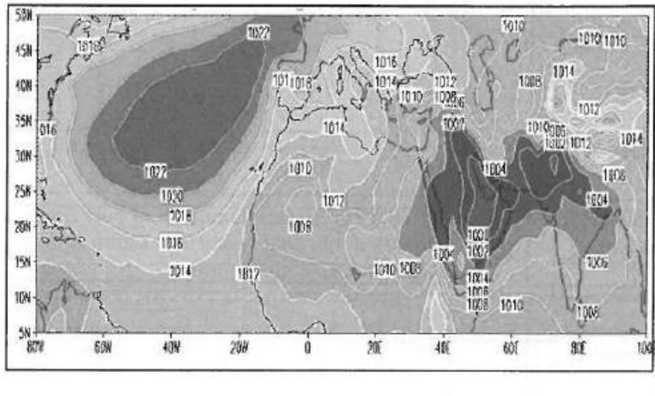
Figure 3. (b) Suptropical high pressure centre index correlated with Indian monsoon low pressure centre index (August 1998).

The distribution pattern shows a weakening and northward drift of the high centre in August 1998. While it exhibits a strong and southward drift in August 1997. On the other side, in August 1998 the Indian monsoon low pressure system shows up a generally lower, deepening central pressure (Figure 4b). Indian monsoon low pressure is weakened during August 1997 as presented in Figure 4a. The Indian monsoon low pressure exhibits an undergoing southward shift throughout August 1998 (Figure 4b). While it is illustrated that a northward shift is occurring through most of August 1997 (Figure 4a). Figures 4(a, b) suggests that a major change in atmospheric circulation systems occurred at roughly the same time in 1997, 1998. These results are in agreement with Tanaka *et al.* (2004). The relationship between surface temperature over Egypt and each atmospheric circulation system: SHCI and INDMI is presented in Figure 5. The duality of the relationship between SHCI and INDMI is also shown in Figure 5. A strong and high significant negative relationship (r = -0.55) between INDMI and surface temperature over Egypt are found during August 1998 (Figure 5d). Whereas a weak and insignificant positive relationship (r = 0.15) between them exists during August 1997 (Figure 5c). Consequently in the period of extreme change (i.e. warming) the trough of Indian monsoon is deepened significantly. On the contrary, the relationship between SHCI and surface temperature over Egypt is poor and insignificant during August 1998 and is excellent and significant during August 1997.

Figure 4. (a) Sea Level pressure - August 1997.



Consequently, when INDMI is deepening and dominant over Egypt the surface temperature is increased and vice versa. Therefore the surface temperature over Egypt was lower in August 1997.



Fu *et al.* (1999) found that, the warming period during the 1920s was due to weakening westerlies and the trade wind system. The Asian monsoon troughs deepened substantially in a situation generally favourable for the development of an active monsoon.

Figure 4. (b) Sea Level pressure - August 1998.

It is thought that the combination of these two features enhanced continental monsoons and implied lowered vertical wind shear over the oceans. This would tend to enhance the release of latent heat in the tropics, representing strengthened Hadley and Walker circulations. At least it may partly be responsible for greater aridity in subtropical land areas of both hemispheres during that period. The latter is also consistent with an expansion and/or strengthening of the subtropical high-pressure belt in the continents. The monsoon dynamics are coupled with the summer Hadley circulation dynamics through controls of the magnitude of the subtropical highs in the Northern Hemisphere (Cook, 2003).

Wind teleconnections

a) Hadley cell index pattern:

The Hadley circulation has long been defined as a zonally symmetric meridional circulation with an ascending motion over the Intertropical Convergence Zone (ITCZ) and a descending motion over the subtropical high pressure belt (e.g. Trenberth *et al.*, 2000). In the context of the general circulation, it is driven by the meridional differential heating in the global radiative process. The peak value occurs in early February and August. Perhaps this peak is not surprising as it is close to these times in the year when the annual cycle in surface temperature peaks (Trenberth, 1983).

Figure 6 (a, b) represents the relationship between surface temperature over Egypt and Hadley cell index. Inverse relationship between Hadley cell index and surface temperature are found in both months of El Nino and La Nina year (r = -0.36 in August 1998 and r = -0.25 in August 1997). But it is more evident in the La Nina Year, when it is statistically significant. In general, the Hadley circulation weakened in the 1998 La Nina year (Figure 6c). This result is in agreement with Tanaka *et al.* (2004).

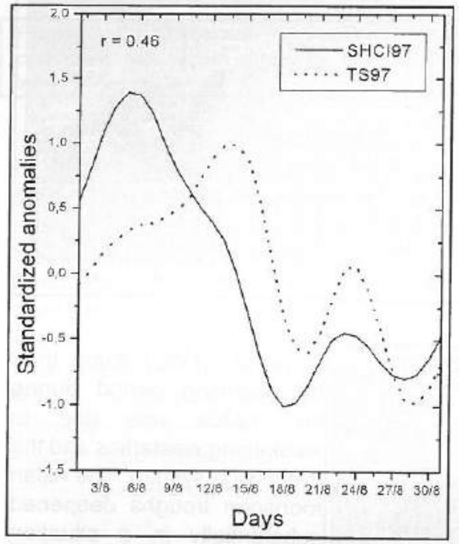


Figure 5. (a) Surface temperature over Egypt correlated with subtropical high pressure centre index (August 1998).

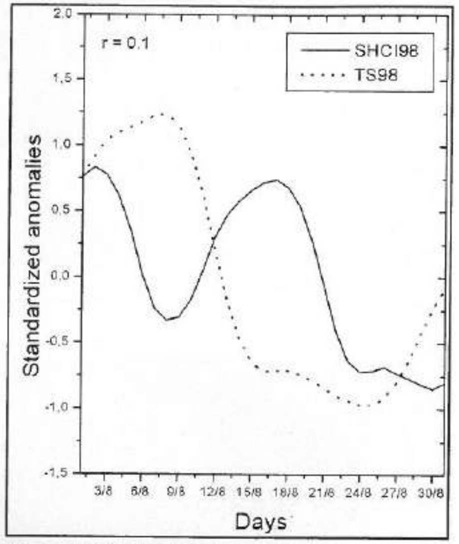


Figure 5. (b) Surface temperature over Egypt correlated with subtropical high pressure centre index (August 1998).

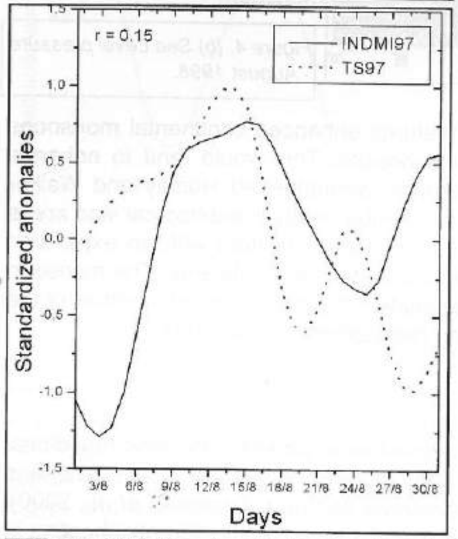


Figure 5. (c) Surface temperature over Egypt correlated with Indian monsoon low pressure centre index (August 1997).

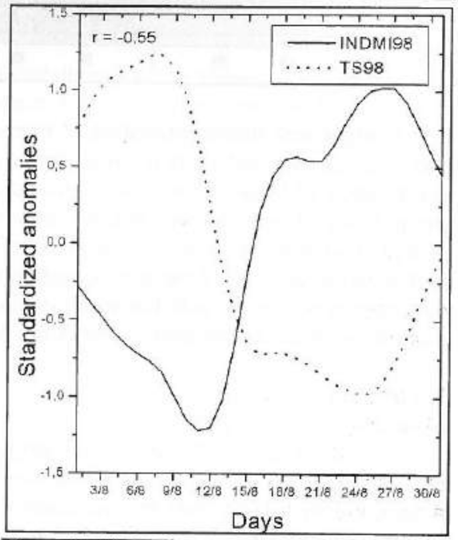


Figure 5. (d) Surface temperature over Egypt correlated with Indian monsoon low pressure centre index (August 1998).

Therefore the subsidence of the northern branch of the Hadley circulation is weakened and thus the subtropical high pressure also is weakened. The intensity of the Hadley circulation measured by the intensity and location of the subtropical high has increased in the last two decades. And the recent trend is argued in connection with recent global warming (Tanaka *et al.*, 2004).

The result of the study by Goswami *et al.* (1999) implies that the intensity of the Hadley circulation controls the intensity of the large scale monsoon. Intense Hadley cell circulation leads to intense SJ (Figure 7). Hadley cell index exhibits weakening during August 1998 and so the SJ is found to be weak and vice versa during August 1997.

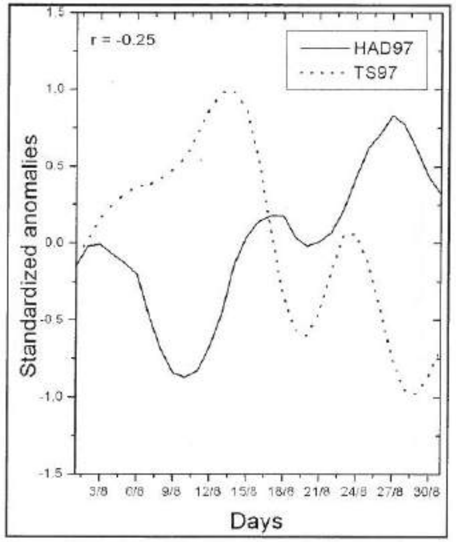


Figure 6. (a) Hadley cell index correlated with surface temperature over Ehypt (August 1997).

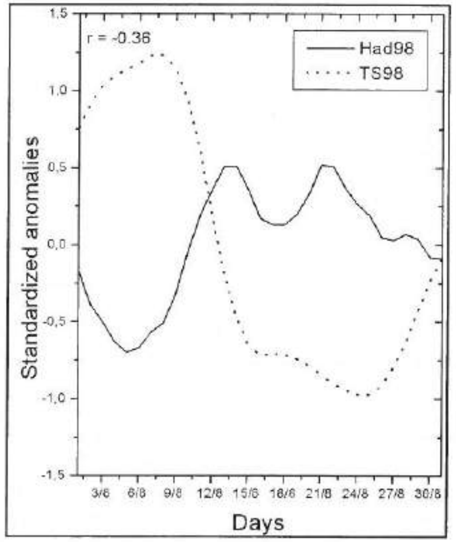


Figure 6. (b) Hadley cell index correlated with surface temperature over Ehypt (August 1998).

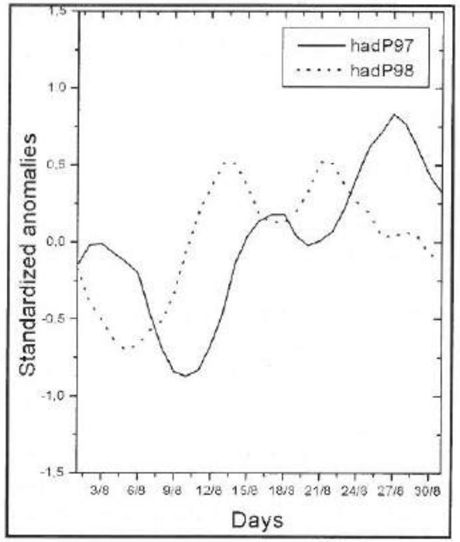


Figure 6. (c) Hadley cell index (August 1997) correlated with Hadley cell index (August 1998).

Significant positive correlations between un-weighted two time series of Hadley cell index and subtropical jet index is found during August 1998 (Figure 7b). Hou and Lindzen (1992) found that concentration in the thermal forcing within the Hadley cell can lead to a substantial increase in the strength of the Hadley circulation resulting in a much more intense subtropical jet.

b) Subtropical jet stream index pattern:

It is plausible that a connection may exist between the acceleration of the subtropical jet by the Hadley cell and the eddy-induced heat transport outside the Tropics (Hou, 1998). Black and Dole (1993) showed that modest zonal variations near the subtropical jet lead to relatively strong modulations in the amplitude of the stationary wave field in the mid-latitude troposphere.

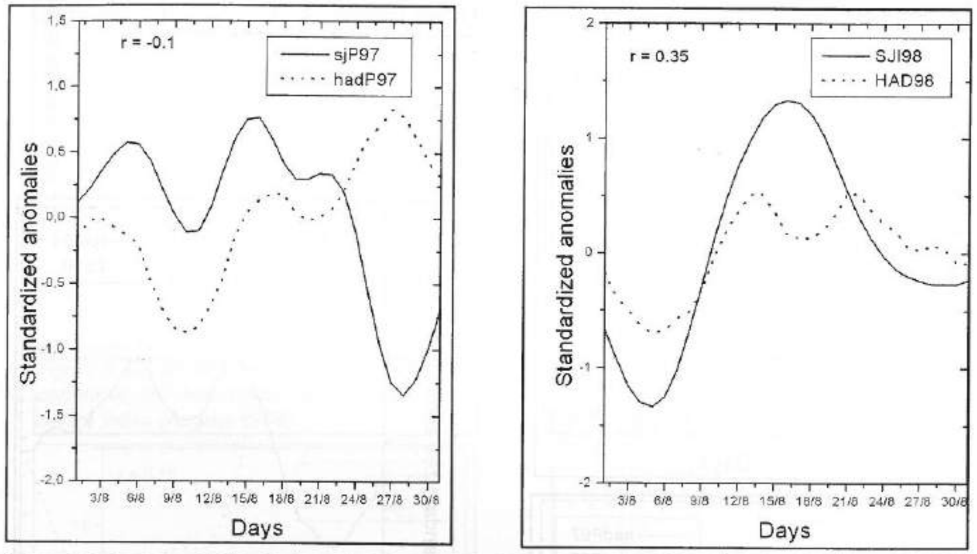


Figure 7. (a and b) SJ index correlated with Hadley cell index in the period of (a) August 1997, and (b) August 1998.

Relationship between surface temperature pattern over Egypt and subtropical jet stream index pattern (SJI) is shown in Figure 8 (a, b). An inverse relationship (r = -0.6) between the surface temperature pattern and SJI pattern during August 1998 is shown in Figure 8b. A positive relationship (r = 0.65) between SJI and surface temperature pattern during August 1997 is shown in Figure 8a. Both relationships are statistically highly significant. The inverse relationship between the SJI and surface temperature patterns may be related to the effect of the ZI on the SJI. The relationship between the SJI pattern and ZI pattern is positive in August 1998 (r = 0.45) and vice versa in August 1997 (r = -0.56) (Figure 9a, b). Lee and Feldstein (1996) noticed that the *Zi* is associated with latitudinal shifts of the westerly jet. The strength of SJ is shifted northward (southward) during August 1998 (August 1997) as shown in Figure 10(a, b). Also, the SJ is weakened and linked with the polar jet stream during August 1998 as seen in Figure 10b. Xoplaki *et al.* (2003) found that the high index, low index type lead to a weakened, intensified zonal flow to the Mediterranean respectively and a northward, southward shift of the SJ respectively. ZI type high and/or low is affected on zonal mean of the SJ as shown in Figure 9 (a, b). Significant positive, negative relationships between ZI and SJI during August 1998, August 1997 respectively is found (Figure 9a, b). Thus a high index in August 1998 leads to a northward drift of the SJI in agreement with Xoplaki *et al.* (2003). Ko and Vincent (1996) showed that the SJ across the south Pacific is much stronger, but weaker in the 1986-1987, 1988-1989 periods respectively during the ENSO cycle. Furthermore, the jet stream over southern Australia is the weakest during El Nino year.

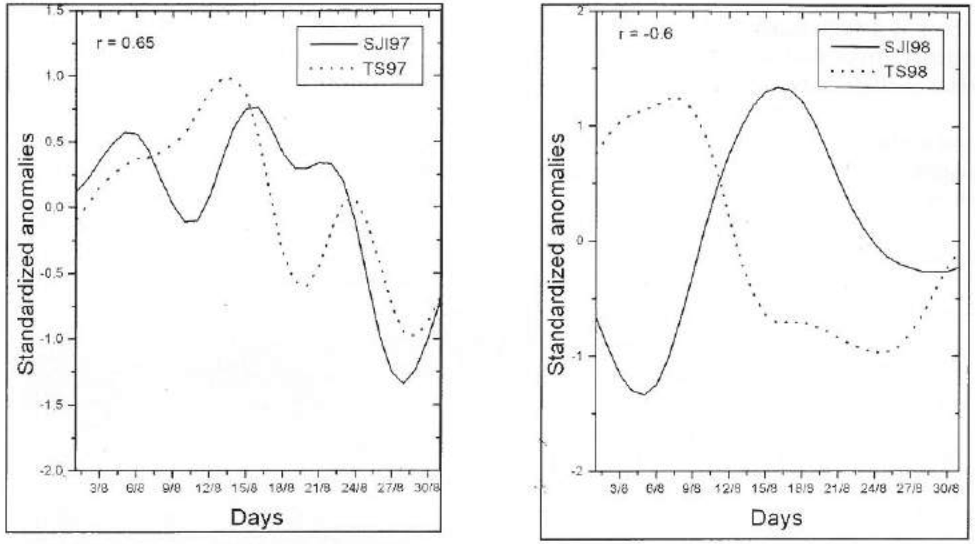


Figure 8. (a and b) SJI correlated with anomalies of surface temperature over Egypt in the period of (a) August 1997, and (b) August 1998.

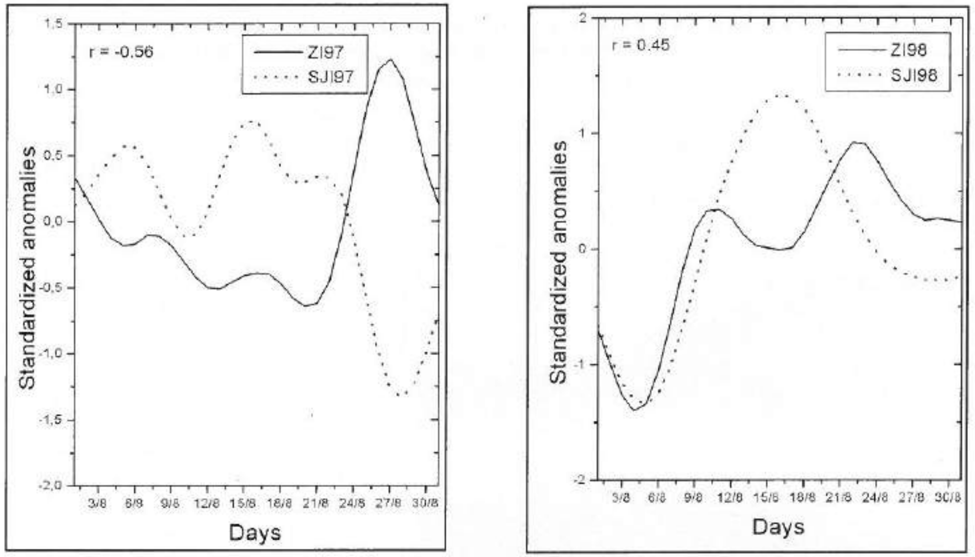


Figure 9. (a and b) Relationship between ZI and SJI in the period of (a) August 1997, and (b) August 1998.

CONCLUSION

In summarizing the results, a schematic picture is proposed for some of the principal mechanisms associated with the extreme warming during August 1998.

There is a statistically high significant confidence level between ZI and surface temperature across Egypt during both months of August 1997 and August 1998 respectively. Inverse relationships between ZI and surface temperature patterns over Egypt is found.

Concerning atmospheric circulation systems, the correlations with Indian monsoon and surface temperature over Egypt show different structures. August 1998 exhibits a strong negative correlation, whereas the weaker positive correlation is simultaneous in August 1997. Hence in the period of extreme warming (August 1998) the trough of the Indian monsoon is deepened significantly. The surface temperature is associated with SHCI. This relationship between surface temperature and SHCI suggests that the change of the sea level pressure of the SHCI induced the surface temperature change. During August 1997, the SHCI intensified and highly affected surface temperature over Egypt and in turn supported the area by cold air. During August 1998 the situation reversed. There is a clear duality between the INDMI and SHCI.

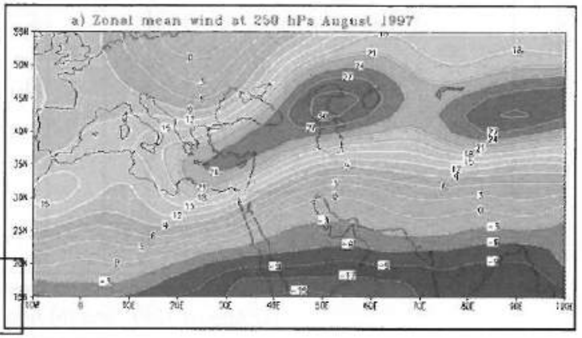


Figure 10. (a) Zonal mean wind at 250 hPa August 1997.

The mid-latitude temperature response to the subtropical Hadley circulation anomaly is dominated by enhanced power in low-frequency planetary waves (Hou, 1998). The increase in temperature in Egypt may be associated with the weakness in Hadley cell circulation. Significant negative relationships between Hadley cell index and surface temperature was found during August 1998. Hadley circulation affects North Atlantic subtropical high pressure and the recent trend is argued in connection with recent global warming. During extreme warming of surface temperature the intensity of Hadley cell circulation can intensify the SJ.

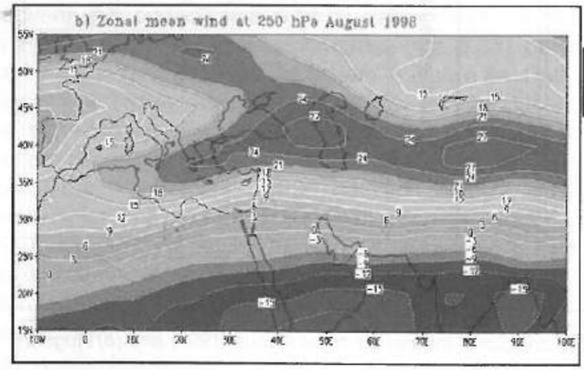


Figure 10. (b) Zonal mean wind at 250 hPa August 1998.

Extreme warming may be related to the change of location and strength of the SJ. High significant negative, positive correlations between subtropical jet stream index and surface temperature patterns over Egypt during August 1998, August 1997 was found. The anti-correlation between surface temperature and SJI may be related to the effect of the ZI on the SJ. The strength of SJ shifted to the north and weakened during August 1998, while it shifted to the south and intensified during August 1997.

ACKNOWLEDGEMENTS

The author wishes to thank NCEP/ NCAR for providing sea level pressure and vertical velocity data, Climate Prediction Center (NOAA, US) for providing the atmospheric data. The author is indebted to the ICTP (Italy), for making available the computer and other facilities in this work.

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BALL LIGHTNING – AN ELECTROMAGNETIC HALLUCINATION?

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Abstract: A common ad-hoc-hypothesis tries to explain ball lightning (BL) as an electromagnetic (EM) brain effect caused by ordinary lightning, i.e. as a lightning-induced hallucination. A critical assessment of this alleged effect has to link the physical properties of lightning and its EM field with the neurophysiology of EM-induced hallucinations, so-called magnetophosphens. Using the clinical field of EM brain stimulation – Transcranial Magnetic Stimulation (TMS) and repetitive TMS (rTMS) – with its experimental phosphene data, the authors conclude that EM fields of nearby lightning flashes, because of their spatial configuration and magnetic induction, are unlikely to produce magnetophosphenes. Phosphenes do not appear in lightning accident reports. Phenomenologically, EM phosphenes as elementary hallucinations do not correspond to BL.

Keywords: Ball Lightning, Electromagnetic Hallucination, Transcranial Magnetic Stimulation, repetitive Transcranial Magnetic Stimulation, Magnetophosphenes, Phosphenes.

BL AS AN AFTER-IMAGE OR HALLUCINATION

Rakov and Uman (2003) review 11 BL models with internal energy sources and five models with external sources. But there is also model number 17 – BL as sensory deception or hallucination. A brief history of this hypothesis group can be found in the monographies of Barry (1980) and Stenhoff (1999).

Barry (1980) includes optical illusions and perceptual effects. A near cloud-to-ground-flash may temporarily dazzle the observer and produce an after-image for several seconds. Stenhoff (1999) also presents the after-image hypothesis introducing "magnetic phosphenes" as an alternative hypothesis, quotes Becker (1963), Charman (1979) and discusses a 1977 case report. Kendl (2001), in a BL paper published by German GWUP (German Committee for Sceptical Enquiry), quotes Marg and Rudiak (1994) and calls "magnetic phosphenes" the most likely "null hypothesis" for the phenomenon. A similar position is taken by biocybernetics researcher Kammer (in Reinhardt, 2002).

The problem with this ad-hoc-hypothesis is its first-glance-validity without empirical basis. It tries to link an EM lightning phenomenon "in some way" with an EM brain phenomenon. This paper gives a critical assessment of the "BL EM hallucination hypothesis" written in collaboration with a second author who works in magnetic brain stimulation research (e.g. Klimesch, Sauseng and Gerloff, 2003) and a third author who is operator of a lightning detection network.

MAGNETIC EYE AND BRAIN STIMULATION

Marg (1991) and Barker (2001) have published historical overviews of magnetostimulation. In the 1790s, Galvani and Volta observed that nerves and muscles can be stimulated externally by electrical currents. LeRoy, a French chemist and physician, found out in 1753 that an iron wire (as bioelectrode) wound around the head of a blind patient, when connected to a Leyden jar, caused pain and the perception of a "descending flame".

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The sensation of light produced by stimuli other than light itself is called phosphene – from Greek *phos*, light, and *phainein*, to show.

In 1831, Faraday described electromagnetic induction as a current produced in a conductive object by a moving/time-varying magnetic field. Magnetic induction B (Vs/m^2) is measured in Tesla (T) with sub-units of 1 mT=0.001 T and 1 μT=0.000001 T. D'Arsonval (1896), a French physicist, was the first to place his head into a magnetic coil (110 Volt AC, 30 Amps, 42 Hz) where he experienced vertigo and flickering lights in his visual field. This direct magnetic effect on the nervous system was confirmed by Thompson (1910) who put his head between magnetic coils of 0.14 T and called the induced EM hallucinations *magnetophosphenes* (Marg, 1991; Barker, 2001). Magnusson and Stevens (1911, 1914; c.f. Marg, 1991) found out that the intensity of the visual impression depended on the intensity and rate of change of the magnetic field. The polarity of the magnet made no difference. The early studies did not distinguish between phosphenes caused by stimulation of the retina in the eye, and of the cortex. The International Programme on Chemical Safety (1987) reports 2-10 mT (0.002-0.01 T) as the minimum field strength for retinal magnetophosphenes with field variation frequencies greater than 10 Hz.

Not all phosphenes are caused by electromagnetic effects. "Seeing stars" after a blow on the eye is another phosphene. Deformation of the eyeball in darkness and pressure produces light sensations (Grüsser and Hagner, 1990). X-rays generate radiation phosphenes (Steidley, 1990). US astronauts in space flight saw spots or light flashes due to high energy cosmic radiation penetrating their retinal tissues (Pinsky, Osborne and Bailey, 1973). Migraine patients see phosphenes prior to or during attacks (Aurora *et al.*, 1999). Extremely-low frequency (ELF) EM fields can cause coloured and moving sensations (Reissenweber, David and Pfotenhauer, 1992).

A Sheffield working group achieved the first magnetic stimulation of the human motor cortex (Barker *et al.*, 1985). Placing a coil over the vertex of a normal subject, they demonstrated hand movements and recorded evoked muscle action potentials. The magnetic field pulse induces an electric field in the tissue, the resulting ionic current flow depolarizes nerve membranes and generates an action potential.

Cortical magnetic stimulation is called *Transcranial Magnetic Stimulation* (TMS; Walsh and Pascual-Leone, 2003) and is a rapidly growing international diagnostic and therapeutic field. Visual hallucinations are a by-product of this magnetic brain stimulation and have been empirically documented in a number of clinical studies (e.g. Antal *et al.*, 2003; Delbeke *et al.*, 2003; Fernandez *et al.*, 2002; Gerwig *et al.*, 2003; Kammer, 1999; Kammer *et al.*, 2001; Marg and Rudiak, 1994; Stewart *et al.*, 2001a, 2001b). Magnetic nerve stimulators typically consist of two distinct parts: a high current pulse generator for discharge currents of 5,000 Amps or more, and a stimulation coil for magnetic pulses with field strengths of 1 T or more with a pulse duration of some milliseconds. To maximize the effect, a capacitor discharges into the magnetic coil to achieve a rapidly rising magnetic field and a 1-20 mA/cm^2 induced current. Coil geometry and the anatomy of the region of induced current flow are other important constituents. Because of the complexity of the structure being stimulated, the actual value of the induced charge density per phase is difficult to calculate. Different brain areas, such as bone, fat, grey matter and white matter with their differing conductivities affect the induced current and its path (Jalinous, 2001). According to Madaus (1991), Magstim 200 (a common TMS stimulator) creates 1.5 T in the coil centre and 1 T in the cortex, in a distance of 2.5 cm. Figure 1 shows the functional principle: A coil produces a magnetic field which, as one or several needle impulses, induces an electric field in the tissue.

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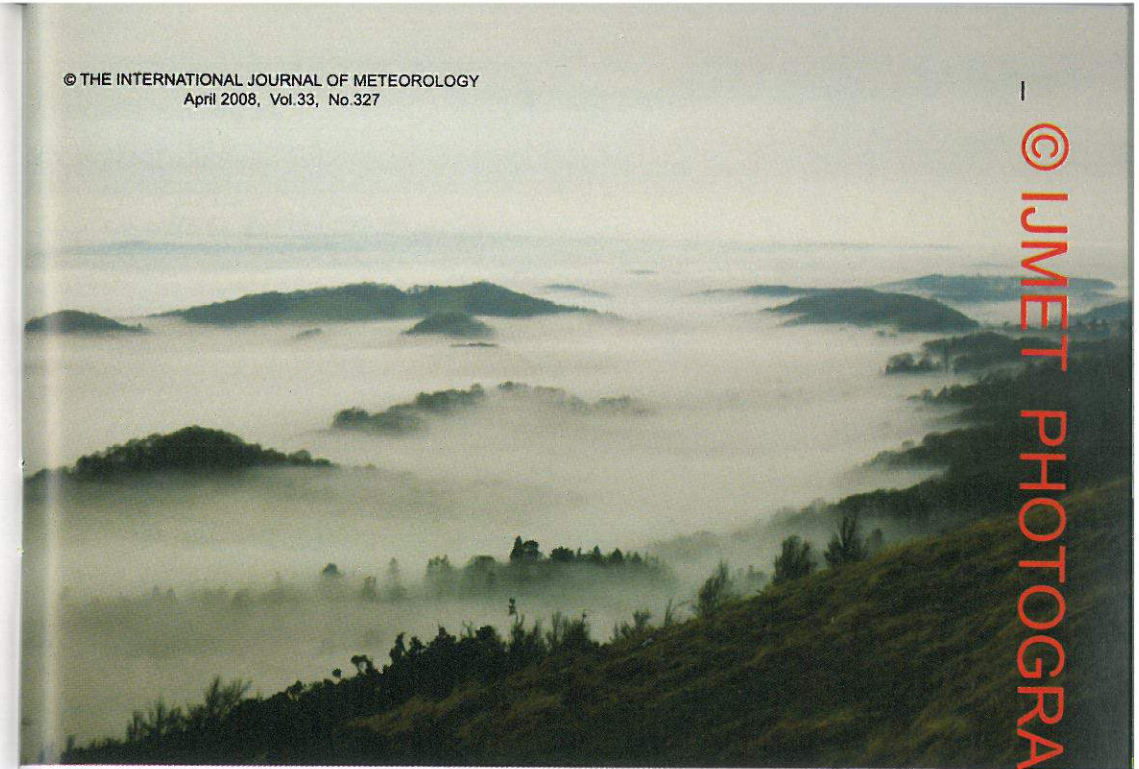

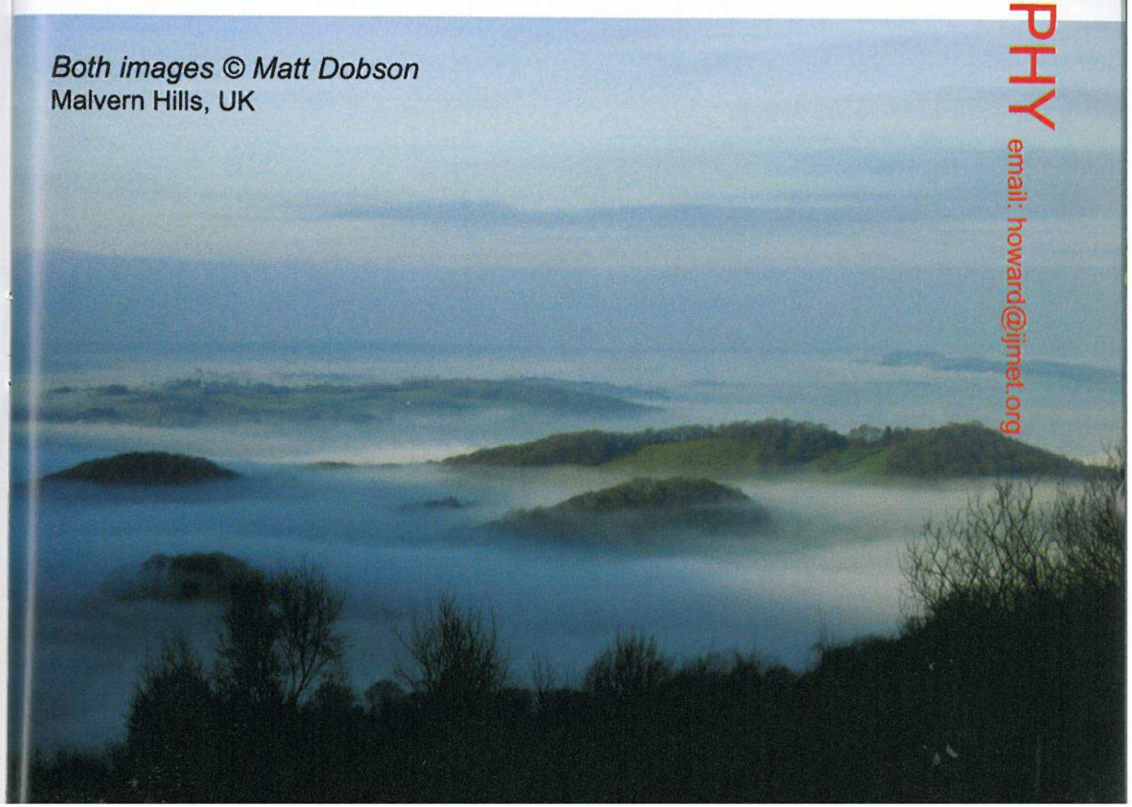

Both images © Matt Dobson
Malvern Hills, UK

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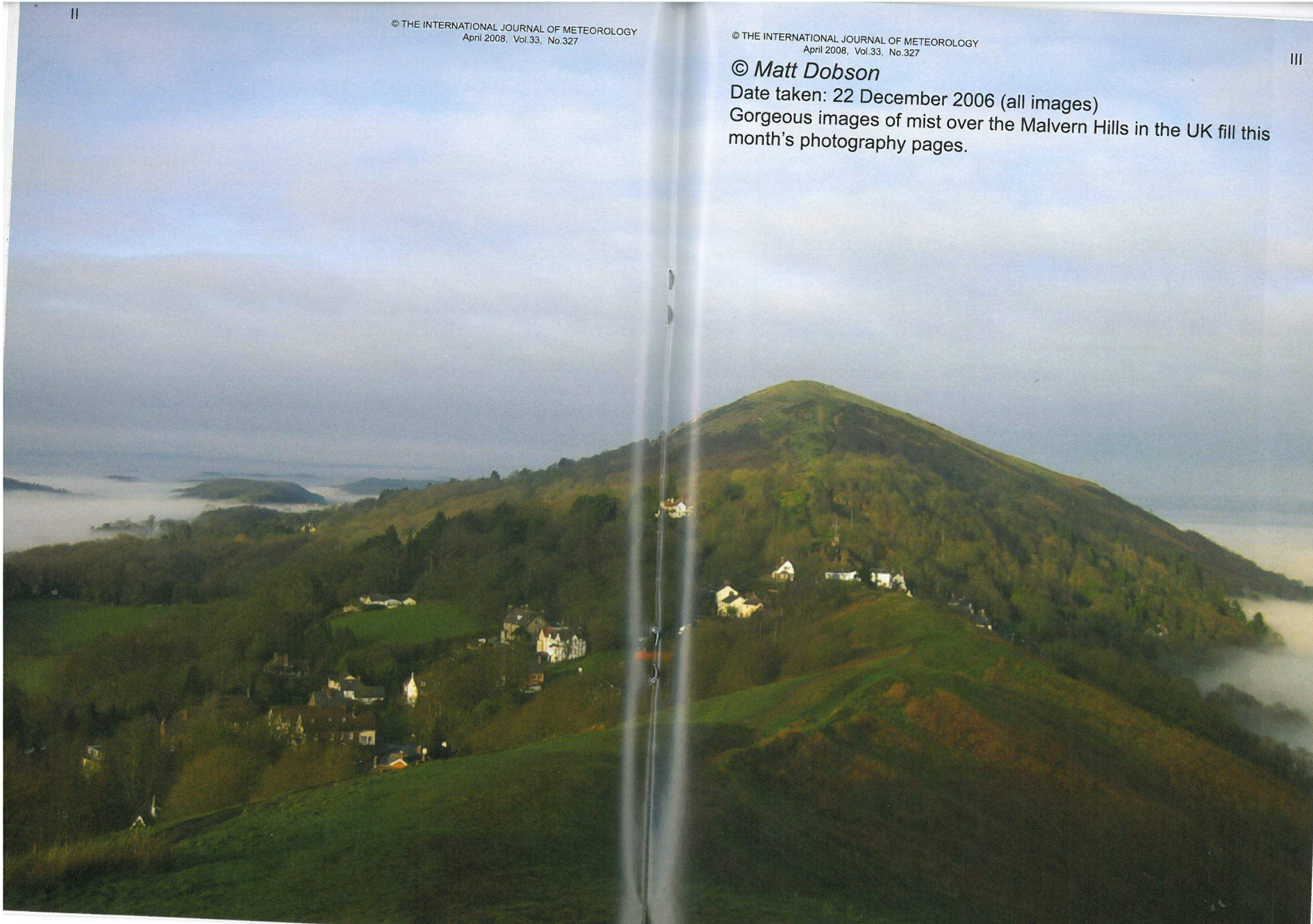

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Date taken: 22 December 2006 (all images)

Gorgeous images of mist over the Malvern Hills in the UK fill this month's photography pages.

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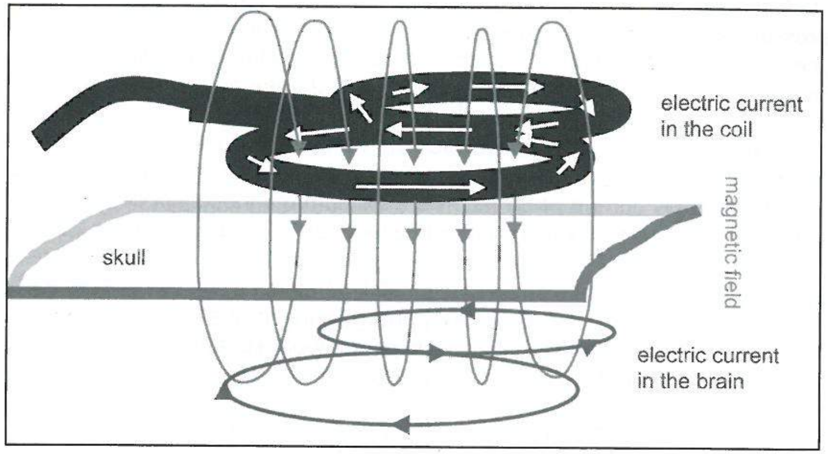
Figure 1. Functional principle of Transcranial Magnetic Stimulation (© Paul Sauseng).



Rapid rate stimulators recently produce bursts (tens of pulses per second) by means of a thyristor switch. The new technique is called *repetitive Transcranial Magnetic Stimulation* (rTMS). The output power level has to be adjusted so that no seizures are induced. Amassian et al. (2002) list documented neurophysiological effects of TMS and rTMS: Inhibitory effects on visual perception – suppression of visual area and higher level functions; excitatory effects – phosphenes induced in the occipital cortex and moderated by the frontal lobe.

LIGHTNING – AN EM BRAIN STIMULATOR? MECHANISM AND EFFECT SIZE

If external EM stimulation of the brain, especially at a rapid repetition rate, leads to neurophysiological effects including false visual perception, i.e. hallucinations, then it could be hypothesized that a conventional cloud-to-ground-flash near a person might duplicate this effect as a "natural EM stimulator" and act on the retina or cortex. The magnetic field is not as easily shielded as the electric field, therefore we should expect such an effect even within a building, behind a solid wall, when a nearby lightning flash strikes the ground. Likewise, the electric field does not easily enter the human body/brain, but the magnetic field does.

What is the EM environment of a lightning flash? Lightning is a transient phenomenon with high current amplitudes – the median value is in the range of 10 to 15 kA. The lightning channel is approximated as a straight and vertical conductor. If we assume a cloud-to-ground-flash of I=10 kA and a shielded (safe) person in r=10 m distance, the person's brain is exposed to 200 μT (Mikrotesla) for a short time. A strong discharge with 100 kA and 20 m distance results in 1000 μT (0.001 T). The formula for magnetic induction is $B = \mu_0 . H$, with the constant $\mu_0 = 4 \pi 10^{-7}$. $H (A/m) = I / 2 \pi r$. The Austrian ALDIS lightning statistics (2005) list a median of 13 kA and a maximum of 100 kA for negative flashes. For positive flashes, the median is 28 kA and single events may have maximum peak currents of 200 kA and more.

And the time window? The process of a cloud-to-ground-flash has an upper limit of one second which is only reached by multistroke events, this is when a first stroke is followed by a number of subsequent strokes. A typical negative cloud-to-ground flash is on average composed of three to five strokes.

Therefore, lightning-induced magnetic fields will appear mostly in the form of several peaks or impulses within one second, with intervals between the pulses of several milliseconds to 500 milliseconds.

Rakov and Uman (2003) report magnetic fields measured at a distance of 90 and 50 metres as part of the rocket triggering project at Camp Blanding. Return strokes produced a magnetic field intensity H of 30, 40, 15 and 20 A/m in a few µsec, which corresponds to magnetic induction ($B = \mu_o.H$) exposures of 37.7, 50.2, 18.8 and 25.1 µT at the respective distances.

Does a magnetic exposure of several hundred µT produce phosphenes? Vana (2003) reports an IRPA/WHO-threshold of 80 A/m equivalent to 100 µT for permanent exposition to a supply current of 50 Hz. The maximum magnetic flux density of household appliances in 3 cm distance was measured by German officials: Hair-dryer 2000 µT (0.002 T), electric razor 1500 µT (0.0015 T), drilling machine 800 µT, vacuum cleaner 800 µT, fluorescent lamp 400 µT, microwave oven 200 µT and 50 Hz AC. Other EM sources produced values under 50 µT (SSK, 1997). In comparison, the earth's magnetic field has about 40 µT (0.00004 T). The region of retinal magnetophosphenes lies between 10,000 µT (0.01 T) and 50,000 µT (0.05 T). The cortical magnetophosphene threshold for brain tissue is higher, around 1 T.

A direct cortical EM stimulation, as produced by TMS and rTMS, needs a local magnetic induction of at least 1 T, a 200 µsec magnetic impulse ("needle impulse") and an inhomogenous field, i.e. a local field maximum over a region of the brain (Stewart *et al.*, 2001a; Kammer *et al.*, 2001).

Although a natural lightning flash will have the required needle impulse shape and even repetitions by a series of strokes, induction will not reach 1 T, and will certainly not produce a local field maximum. As the above estimates show, average and close cloud-to-ground-flashes may produce EM effects reaching the magnetic exposition level of household appliances, but not the retinal and/or cortical magnetophosphene level.

With 1,000 to 1,500 lightning strike injuries in just the USA alone, per year, the existence of lightning-related phosphenes is not an inferior discussion, but should produce empirical records. Norman *et al.* (2001), in their review article on ophthalmic manifestations of lightning strikes, give a long list of physiological and neurological symptoms, but do not mention phosphenes in accident reports. Another source is an international review of neurological and psychiatric electrical and lightning injury sequelae (Duff and McCaffrey, 2001) where visual hallucinations are not listed as immediate accident symptoms.

PHENOMENOLOGICAL MISMATCH

Even if the magnetic stimulation level would reach 10,000 µT (0.01 T) in the retina or 1 T in the brain tissue – does the phenomenology of magnetophosphenes have explanatory power for BL observations? Or, in other words, are retinal/cortical magnetophosphenes visual phenomena which could be described by the untrained observer as BL?

Examples of excitatory TMS effects on visual perception are described as: flickering lights; flickering bars of lights; a small spot of white light; cloud-like; a strip of light; white, cuneiform shapes; coloured flashes or strips of light; bundles of lines; sawtooth figures; curved lines; bands and large dots; hyperbola-like (Amassian *et al.*, 2002; Kastner *et al.*, 1996; Kammer *et al.*, 2000; Meador *et al.*, 1997). In the dark, they were induced at lower TMS-intensities. While most are colourless, some subjects report colours, i.e. chromatophosphenes. Phosphenes can be stationary or moving. A single TMS spike will produce a short, stationary flash of light or shape. Stewart *et al.* (1999) report their rTMS experiment over V5, the extrastriate parietal brain area responsible for motion perception. Subjects who received a 0.5 to 1 s series of EM pulses saw a moving light dot, a moving cloud or moving lines during the stimulation period.

With TMS stimulation, phosphenes usually appear in the lower half of the peripheral visual field, opposite the stimulated side of the brain, contralateral to where the coil is positioned. The variety of phosphene shapes is compatible with some of the form constants of geometrical visual hallucinations classified by Klüver (1966): gratings, lattices, networks, filigrees, honeycombs, chequer-boards, cobwebs, tunnels, funnels, alleys, cones, vessels, spirals.

Central European BL observations (Keul and Stummer, 2002) typically include one round object seen for 3-5 s, sharply defined, not blinding, yellow-orange colour, horizontal or downward motion, one third of the cases inside buildings. 14 % report smells, 15 % sound, 12 % sparks, 22 % residue, 37 % an explosive terminal bang. With a median diameter of 25-30 cm and a median distance of 5-10 meters from the observer, the objects occupy optical angles of 1.5 to 3 °, which is not a "dot shape" but several times the size of the viewable full moon.

Comparing the two phenomenal groups, the authors see more differences than parallels. To assume that a nearby superbolt generates the required magnetic induction value, having a long series of subsequent strokes and accidentally an inhomogenous magnetic field stimulating the right cortical areas to generate a moving globe of light means a number of unnecessary entiae that will not survive Occam's Razor. The BL EM hallucination hypothesis does neither explain BL durations over one second, typical BL optical angles, nor does it explain sound, smells, sparks, residue or terminal explosions. Also, phosphenes will obviously not appear on photographs or videos.

Summing up the relevant points of the authors first empirical assessment of the BL EM hallucination hypothesis, its explanatory power for BL observations is not high, because:

a) the magnetic stimulation level of 0.01 T (retina) vs. 1 T (brain tissue) is not reached in cases of nearby average cloud-to-ground flashes;

b) only some of the lightning flashes will produce subsequent strokes, i.e. "needle impulses" necessary for repetitive phosphene generation;

c) magnetic stimulation by lightning can only explain simultaneous visual perceptions with a maximum duration of one second,

d) short-range lightning will not produce local field differences relevant for cortical magnetophosphene effects, but a rather homogenous field;

e) there is a phenomenological mismatch between the optical appearance of possible EM phosphene hallucinations and BL;

f) phosphenes are not commonly reported as medical lightning strike symptoms.

Therefore, we reach a negative conclusion for the EM BL hypothesis.

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April 2008, Vol.33, No.327

TORRO TORNADO DIVISION REPORT: SEPTEMBER - DECEMBER 2007

By PAUL R. BROWN and G. TERENCE MEADEN

Much of this period was quiet and anticyclonic with little whirlwind activity, the notable exception being on the 24th September, when an active cold front produced an outbreak of at least 14 known events that were tornadoes or suspected tornadoes; September also had two funnel clouds, plus a waterspout in the Irish Republic. For October, we know of just one tornado and one funnel cloud; for November, one waterspout and two funnel clouds; and for December, two tornadoes and one funnel cloud.

FC2007Sep21 *Scatsta, Shetland (c 60° 26' N 1° 16' W, HU 3972)*

Reported 'in the vicinity' of Scatsta in the 0920 GMT METAR.

Events of 24th September 2007

At 0000 GMT on the 24th September a low, 981 mb, was centred south of Iceland, and its intensifying cold front was moving east into Wales while a deepening wave was developing on it over the Irish Sea. During the early morning this front swept east across England accompanied by a line squall, and there were subsequently many reports of damage attributed (by the press) to tornadoes. Although there were certainly a number of (mostly weak) tornadoes, the evidence in many of the press reports is inconclusive, and some of the damage seems likely to have been caused by squalls or eddy whirlwinds. There is therefore some uncertainty over many of the classifications in the following list.

tn2007Sep23/I *Aberffraw, Anglesey (53° 11' N 4° 27' W, SH 3568)*

The first report of a tornado came from Anglesey just before midnight. According to the *North Wales Chronicle* (27th September) it occurred at 11.20 pm (2220 GMT), when "[Mr] Glyn Jones said that his son Bryn ... saw the landfall of the mini twister. Bushes and general debris were being blown around in an upward spiral, he explained." And Mr Tony Coates described it as "... a cloudburst followed by a huge swoosh and I felt a dramatic increase in pressure. It lasted a matter of two or three seconds, but it was quite unnerving."

q2007Sep24/I *Theescombe, near Amberley, Gloucestershire (51° 42' N 2° 12' W, SO 8501)*

The *Gloucester Citizen* of the 18th October reported that a "mini-tornado ... blew open windows, sucked out curtains and destroyed high-tension power cables." It appears to have happened at 5.30 am (0430 GMT), but there is insufficient detail here to confirm a tornado.

tn2007Sep24/II *Nuneaton, Warwickshire (52° 31' N 1° 27' W, SP 3691)*

Reported as a 'tornado' in the *Coventry Evening Telegraph* (24th September), but a site inspection by TORRO's Stuart Robinson found only uncertain evidence for this. There was, however, extensive damage to dozens of house roofs (and subsidiary damage to cars), indicative of severer winds here than in most other places, and we therefore retain the 'tornado' classification. Time (as given in the newspaper) was 6.15 am (0515 GMT). Force perhaps T2. Stuart Robinson reported that a "climbing frame actually came from the garden with the broken concrete panel - this travelled about 20 metres (the frame) which was at 90 degrees to the mean wind flow and suggests to me that this could have been tornadic after all."

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April 2008, Vol.33, No.327

q2007Sep24/II *Nottingham, Nottinghamshire (52° 58' N 1° 09' W, SK 5641)*

Reported in the *Nottingham Evening Post* (25th September) as a 'mini-tornado' but with insufficient evidence to rate it as more than a squall. Part of the roof of a bus depot was blown off. The previous day's edition of the same newspaper also mentioned other unverifiable tornado damage at Toton. Time was about 6.30 am (0530 GMT).

q2007Sep24/III *Towcester, Northamptonshire (52° 07' N 0° 59' W, SP 6948)*

The *Bucks Winslow Advertiser* (24th September) reported that a 'mini-tornado' was believed to have hit the area at 6.45 am (0545 GMT), but gives insufficient evidence to document it as more than a squall.

tn2007Sep24/III *Ollerton, Nottinghamshire (53° 12' N 1° 01' W, SK 6567)*

Reported in the *Mansfield Chad* (24th September). Trees, walls, fences, and roof tiles suffered damage at 6.50 am (0550 GMT). Ms Catherine Eyre said: "... all of a sudden, the bedroom window blew open and all I could see was a thick fog with the tornado coming through the garden. It completely destroyed the garage ..." And Mr William Doody described it as "like a train rushing through a station. I saw the tornado as it came through the garden destroying everything in its path..."

TN2007Sep24/IV *Long Eaton/Breaston, Derbyshire (52° 53' N 1° 15' W, SK 4933)*

The *Derby Evening Telegraph* (24th September) reported that a tornado damaged roofs and blew down trees in Long Eaton shortly before 7 am (0600 GMT). Mr Richard Holden described how the tornado twisted his chimney round and left it dangerously close to falling off: "It's turned the top of the chimney round through 45 degrees, and pulled up two trees." And the following day's edition of the paper quoted Mr George Mounsey of nearby Breaston, who saw the tornado pass as he looked out of an open window: "It was just like being on the bridge of a ship. The rain was spinning around in a circle and spraying into my face." Although the newspaper report regards these as two separate tornadoes, it seems likely that they were the same.

q2007Sep24/IV *Leighton Buzzard, Bedfordshire (51° 55' N 0° 39' W, SP 9225)*

Reported in the *Leighton Buzzard Observer* (24th September) as "Town hit by tornado", but the evidence is not really strong enough to rate it as more than a squall (the main damage was where a large section of scaffolding on a building site collapsed). Time given as 7 am (0600 GMT).

tn2007Sep24/V *Northampton, Northamptonshire (52° 14' N 0° 53' W, SP 7561)*

A report in the *Northampton Chronicle & Echo* (24th September) described how a 'mini-tornado' caused damage to many trees in the area shortly before 7 am (0600 GMT), and tiles were removed from roofs. Mr Steve Heaton, on the UKweatherworld forum, reported seeing the swirling wind coming down the road towards him. And in the 28th September edition of the *Chronicle & Echo* it was reported that the same tornado caused damage to trees at Sywell Country Park, where Mr Geoff Simons said: "The damage runs through the park as the tornado went, from east to west [*sic*]. It completely knocked down about four trees and damaged some other really big trees ..." (The actual direction of travel must have been west to east.)

tn2007Sep24/VI *Scunthorpe, Humberside (53° 35' N 0° 38' W, SE 8910)*

Reported in the *Scunthorpe Telegraph* (25th September) as a 'mini-tornado'.

The main damage was in Queensway and Bellingham Road, where Ms Bridget Johnson said: "The tornado hit about 7.20 am [0620 GMT]. It was dark and frightening and we could hear a whirring sound. It took the slates off the roofs and the tiles of four or five houses in a row and has blown down some of the trees nearby."

TN2007Sep24/VII *Farnborough, Hampshire (51° 16' N 0° 44' W, SU 8754)*

This was one of the few indisputable tornadoes for this day. First reported by *BBC Hampshire*, and later in the *Farnham Herald* (28th September), 25-30 homes were said to have been damaged, a caravan overturned, and a concrete bus shelter demolished, besides a number of trees uprooted or damaged. According to Mr Terry Parrott, who saw the tornado approaching, it occurred just before 0730 BST (0630 GMT). A site investigation was carried out by Sarah Horton of TORRO; among the witnesses she spoke to, Mr Jamie Hughes watched the roof of a block of garages lift off and rotate (clockwise) before being thrown against a house. Track length appears to have been just over half a mile (c 1 km), and width up to 50-60 m. Force T2/3.

tn2007Sep24/VIII *Wood Langham, near Market Rasen, Lincolnshire (53° 21' N 0° 16' W, TF 1485)*

Reported as a 'tornado' in the *Market Rasen Mail* (26th September). It damaged the home of Mr Owen Callaby and his family; and while much of the evidence presented would suggest no more than a squall, there were one or two features indicative of a tornado - it was said to have removed the *tops* of mature trees, and was described as "a spiral of debris stretching over 50 m" (though it is not quite clear what is meant by that). It also demolished a hen house and carried a rabbit hutch (including the rabbit) across the garden. Time was 7.30 am (0630 GMT).

tn2007Sep24/IX *Woking, Surrey (51° 19' N 0° 33' W, TQ 0058)*

The *Woking News and Mail* (27th September) reported this as "Twister rips through". More than a dozen trees were said to have been toppled across the town; and one witness, Ms Christianne Risman, said: "It was about 7.30 am [0630 GMT] ... I opened the curtain and then the tree fell down and it was spinning all around in circles." She added that the wind was so localised that children's toys in a neighbouring garden were untouched by it.

q2007Sep24/V *Hainault, London (51° 36' N 0° 06' E, TQ 4591)*

The *Ilford Recorder* (24th September) reported that a large tree was brought down by the wind. Mrs Sue Floyd said: "The wind was blowing normally, then all of a sudden there was a really sharp, short gust of wind. It sounded like a clap of thunder." Her neighbour, Mr Dave De La Haye said: "It was around about half past seven this morning [0630 GMT] ... I have heard descriptions of tornadoes, that they sound like a jet engine - that's exactly how I would describe it."

TN2007Sep24/X *Luton, Bedfordshire (51° 52' N 0° 24' W, TL 0921)*

Terence Meaden interviewed a witness, Ms Ruth Spaull, who saw the tornado funnel go through her garden at about 7.30 am (0630 GMT), taking a trampoline into the air and across the road. Her loft cover was sucked upwards into the attic space, and the noise was likened to that of a screaming jet aircraft. The house next door had some tiles removed, as did some houses in other roads, and several fences were blown down. Ms Spaull said its path was about 0.5 mile (800 m) long and that it crossed Limbury Road, Black Swan Lane, Riverside, Mallard Gardens, and Rumfold Avenue transversely.

The width of the condensation funnel as she saw it at ground level was about 4 metres. Suggested damage path width near her was 10 metres or more. Force T1. A report was published in the *Dunstable Gazette* (24th September).

tn2007Sep24/XI *Wansford and North Frodingham, Yorkshire (East Riding) (53° 59' N 0° 22' W, TA 0656)*

An account of this tornado was published in the *Driffield Times* (25th September). At Wansford it struck the farm of Mr Chris Akrill and Ms Sue Akrill at 7.35 am (0635 GMT), removing the roof of a barn, and sending garden items (including a bird table and lots of apples) flying through the air. Ms Akrill described the noise as like that of a 'jumbo jet', and the scene like that of a film [of a tornado]. The report goes on to say that about 10 minutes later a tornado (presumably the same one) was reported in nearby North Frodingham, where several buildings were damaged; and Ms Nancy Rookes described it as "a grey mass of water and wind". The grid reference given here is that of Wansford. An account was also published in the *Hull Daily Mail* (25th September), in which Mr Akrill noted that the grass had been flattened where the tornado passed over.

tn2007Sep24/XII *Eye (and Whittlesey?), Cambridgeshire (52° 36' N 0° 11' W, TF 2202)*

The *Peterborough Evening Telegraph* (24th September) reported that a driver watched the spinning wind of a 'tornado' lift a motor car that he was following a few inches off the ground, then spun it round into the path of an oncoming vehicle, leading to a major accident (but no injuries). Time was given as 7.40 am (0640 GMT). It also mentioned, without further details, reports of tornado damage near Whittlesey, but this is too vague to be documented separately.

TN2007Sep24/XIII *Wisbech, Cambridgeshire (52° 39' N 0° 10' E, TF 4609)*

Reported in the *Wisbech Standard* (25th September). The tornado passed through the ornamental gardens of Elgood's Brewery causing serious damage to several trees. Mr Nigel Elgood (who was also interviewed by Terence Meaden) said: "... It was very strong and just shredded its way through the trees. It had come along the river and changed course over the garden. There was lashing rain and strong wind for literally half a minute and it stopped..." Time given as 7.50 am (0650 GMT) by eye witness, who described the trail of damage as a long narrow swath.

TN2007Sep24/XIV *Little Stretton to Billesdon, Leicestershire (52° 35' N 1° 01'W, SK 6600 to 52° 36' N 0° 56' W, SK 7102)*

Stuart Robinson of TORRO was told of this tornado, which he was able to confirm after a visit to the site followed by aerial reconnaissance. Track length was 4.25 miles (7 km) from southwest to northeast over rural land, where the main damage was to trees; and it was notable that from the air the track could be discerned across a ploughed field. Force T1/2. (We do not have an exact time for this, but obviously it would have occurred on the same front as the others of this day.)

q2007Sep24/VI *Shipston-on-Stour, Warwickshire (52° 03' N 1° 37' W, SP 2540)*

Reported in the *Cotswold Journal* (26th September), where it was described as a 'mini-tornado'; but with nothing in the account to verify it we here document it as a squall (a marquee was blown down and a building suffered slight damage). Time given as 'early morning'.

q2007Sep24/VII *Redbridge, Greater London (51° 34' N 0° 03' E, TQ 4288)*

The *Epping Forest Guardian* (26th September) reported this as a 'tornado' but with no convincing evidence (two large trees were blown down). Exact time not given, but early in the morning.

FC2007Sep24 *Skegness, Lincolnshire (53° 08' N 0° 20' E, TF 5663)*

A photograph of a narrow funnel cloud over Skegness, by Mr Aidan Byrne, was shown on the television channel *Sky News* (TORRO has a copy). It appears to be about halfway to the ground, and the photograph is said to have been taken at 9 am (0800 GMT).

tn2007Oct09 *Near Boscombe Down, Wiltshire (c 51° 09' N 1° 44' W, SU 1839)*

This was seen by Mr Rich Cliff of the UKweatherworld forum at about 1800 (1700 GMT) as "a very large funnel cloud [which] went right down to the ground, but due to the light I was unable to see if it touched the ground. It was swirling very quickly with a distinct tube in the centre... It was a rope funnel of structure but quite wide at the top near the cloud base [1500 ft]." He watched it for about 30 seconds, after which it retreated into the cloud. Force T0. At 1800 GMT a shallow low, 1017 mb, was centred off The Wash, having moved southeast from Scotland during the day, while a small ridge of high pressure was building over Ireland. There was rain near the low, but only isolated showers elsewhere.

q2007Oct28/I *Forfar, Angus (56° 38' N 2° 53' W, NO 4550)*

Ms Joan Mitchell contacted us to say she was woken at 2.30 am (0230 GMT*) by an "Extremely loud, constant roaring and whooshing sound... [with] horizontal rain and wind lashing violently and constantly, trees were bent right over ... Event stopped suddenly, followed by extreme calm ... had been preceded by windy conditions (of normal range) and mild, warm air." Both this and the following report from the same area are suggestive of tornadoes, but in neither case does the evidence appear strong enough to document them as such.

At 0000 GMT a large complex low, main centre, 980 mb, was centred in the Iceland/Greenland area, and a cold front, with a band of moderate to heavy rain, was moving east across Scotland and Ireland. There was a minor wave on the front over the north coast of Ireland, which seems likely to have crossed the Angus area a few hours later (though it had disappeared on the 0600 analysis, by which time the front had cleared Scotland).

* This was the night the clocks changed, so there could be some confusion with the hour.

q2007Oct28/II *Dundee, Angus (56° 28' N 3° 01' W, NO 3632)*

Mr George Christie contacted the Editor, Samantha Hall, to say that during the night several of his strawberry tunnels had been ripped out of the ground, thrown 60 metres, and destroyed, while others either side were left intact; a large branch had also been torn from a tree. He could not give an exact time, but it was later than 1.00 am.

fc2007Oct28 *Gosberton, Lincolnshire (52° 52' N 0° 09' W, TF 2431)*

Report from Mr Mike Woods, but with too little detail to verify it. Time given as 1500 GMT. (There was a line of showers in the area at the time.)

q2007Nov08 *Cheltenham, Gloucestershire (51° 54' N 2° 04' W, SO 9422)*

The *Gloucestershire Echo* of the 9th November reported this as 'Whirlwind brings high street chaos'.

According to the paper, "A 40 ft tree ... was snapped near its roots and smashed to the ground ... A 30 ft pane of glass ... was hurled out of its frame and shattered on the pavement. The doors at the side entrance of M&S [Marks and Spencer] were blasted open ... [and a] flower stall ... was blown into the air and thrown 20 ft across the road." The time was given as 2.40 pm (1440 GMT). Despite the headline, the evidence does not seem strong enough to rate this as a tornado.

At 1200 GMT an intense low, main centre 971 mb, was moving east near the Shetland Isles, and its cold front was moving south over England and Wales. The front, which was in the Cheltenham area at the time of the incident, was accompanied by a narrow band of heavy rain, and was squally in places with gusts 40-50 knots.

FC2007Nov14 *Keld, North Yorkshire (54° 24' N 2° 09' W, NY 8901)*

Mr Tim Charlesworth contacted us about this funnel, which he photographed at 3 pm (1500 GMT). It was visible for about 15 minutes, and the pictures we have show a narrow funnel about a third of the way to the ground. At 1200 GMT a weak northerly airflow covered the British Isles, in which a small wave depression of 1019 mb was moving south through the Irish Sea. There was a spell of rain near the wave, and a few showers elsewhere, mainly in the east.

2FC2007Nov19 *Churston Ferrers, Tor Bay, Devon (50° 23' N 3° 32' W, SX 9055)*

The *Torquay Herald Express* (23rd November) published a photograph taken by Mr Mike Langman showing a funnel cloud about a third of the way to the sea over Tor Bay (precipitation shafts from a shower cloud are also visible). Twenty minutes earlier he had seen (but did not photograph) another funnel over Churston Woods. (The *Western Morning News* of the 21st November also published an account.) The time is not stated, but the context suggests early afternoon. At 1200 GMT a low, 993 mb, was centred off west Cornwall and drifting west; a shower trough lay over Devon and the western English Channel. There were showers, locally heavy and thundery, over many southern parts in the afternoon.

WS2007Nov21 *South of Rottingdean, East Sussex (c 50° 48' N 0° 02' W, TQ 3702)*

This waterspout was reported to us by Dr David Reby of the University of Sussex, who saw it just after 9 am (0900 GMT) several miles off the coast. "The very distinct funnel branched from a dark cloud formation over the Channel and appeared to reach the water surface (a brighter, wider funnel was clearly visible at its base)." It was visible for 10 minutes before dissipating. At 1200 GMT a complex area of low pressure covered the British Isles, with main centre, 995 mb, drifting north over northern England, and another centre, 997 mb, drifting east towards northwest France. Much of England had a dry morning, but radar showed a long narrow line of showers extending northeast from the central English Channel to the Sussex coast at the time of the spout.

fc2007Dec05 *Ebbw Vale, Gwent (51° 44' N 3° 10' W, SO 1805)*

Mr Paul Nash wrote to us that he saw a small funnel cloud during torrential rain and hail at 1235 GMT. It was only visible for 10-15 seconds before going out of sight. At 1200 GMT a broad westerly maritime Polar airmass covered the British Isles in association with multiple deep low centres, 960-964 mb, in the Iceland/Norwegian Sea area; a shower trough crossing western Britain was close to Ebbw Vale at this time. Showers, some of them heavy and thundery, occurred in many areas during the day.

TN2007Dec29 *Greatstone-on-Sea, Kent (50° 57' N 0° 58' E, TR 0822)*

The *Kent Messenger* (31st December) reported that a 'suspected tornado' caused localised damage to six homes in Dunes Lane during the night. Mrs Joanne Palmer said: "I was woken up by what sounded like a roaring clap of thunder. What had happened had been instantaneous. From the moment I got up from bed and looked out of the window the winds had died down."

Lorraine Evans of TORRO conducted a site investigation the following day, which revealed that the roof of a brick-built outhouse, consisting of large wooden beams and corrugated iron, was lifted off and parts of it carried up to 350 feet (c 100 m), causing a variety of subsidiary damage along the way, including knocking down a telegraph pole that it came in contact with. The time of occurrence was between 2.20 and 2.30 am (0220-0230 GMT). Known track length 140 m (towards northeast), width 40 m. Force T2.

At 0000 GMT a complex low, centres 982-987 mb, was moving east towards north Scotland; its main frontal system had cleared the country (except Shetland), but a secondary cold front was crossing England, and timing suggests that this feature was responsible for the tornado. There was a band of locally heavy rain on this front (and further bands of showers behind it).

tn2007Dec29 *Bottisham, Cambridgeshire (52° 13' N 0° 15' E, TL 5460)*

According to *BBC Cambridgeshire*, a tornado was responsible for felling several mature trees (at least one of which fell onto a building) in Tunbridge Lane, while other parts of the village were largely unaffected; and a similar report appeared in the *Cambridge Evening News* of the 31st December. Neither report makes it clear exactly when this happened: the BBC said 'early morning', but they sometimes say that when they mean the middle of the night; and the *Evening News* said 'early hours', adding that one of the residents spent some time clearing up 'after 4 am'; so it seems likely that it was on the same front that produced the *Greatstone* tornado above. Force perhaps T1. Tony Gilbert of TORRO noted that "Radar exhibited a classic broken S-bend which is [identified] with some types of tornado that cause damage within squalls."

Waterspout in the Irish Republic

WS2007Sep29 *Mizen Head, County Cork (c 51° 27' N 9° 50' W)*

A photograph of this waterspout was published by Mr Bob Schafer on the Stormtrack internet forum. The cone is only visible for a third of the way down from the cloudbase, but there is clearly disturbance of the sea surface beneath it. It appears to have been taken at about 1250 GMT. At 1200 GMT a weak easterly airflow covered much of the British Isles between a high, 1021 mb, near Shetland and a low, 988 mb, well to the southwest of Ireland. Most places were dry, but a few showers occurred near an old slow-moving occlusion over Ireland and southwest England.

Annual totals for 2007

Although much of 2007 was fairly quiet for whirlwind activity, a six-week cyclonic spell in June and July produced well over a hundred funnel cloud sightings. The known whirlwind totals for the year for the British Isles (including provisional totals for the Irish Republic) are currently: 54 tornadoes, two of which began as waterspouts; nine other waterspouts; and 162 reports of funnel clouds (some of which were of multiple sightings). These whirlwinds were spread over a total of 70 days during the year. There were also six reports of land devils and two of eddy whirlwinds over water.

ACKNOWLEDGEMENTS

TORRO is extremely grateful to all the members and other correspondents who have provided information on the whirlwinds of 2007, or who have carried out site investigations. Without their enthusiasm it would be impossible to produce these reports. Full details are stored in TORRO's Databank.

RECALL: THE INTERNATIONAL TORNADO INTENSITY SCALE

Dr. G. Terence Meaden devised The International Tornado Intensity Scale in 1972 to categorise wind speeds of tornadoes. The scale is directly related to the Beaufort Scale and is the only true tornado intensity scale with a sound scientific base from wind measurements.

Please refer to this guide to help you identify tornado strengths in Paul R. Brown and G. Terence Meaden's monthly tornado reports.

Tornado Intensity	Tornado Classification and Windspeed	Damage Descriptions (*guidance only*)
T0	Light Tornado 17 - 24 m s-1 (39 - 54 mi h-1)	Loose light litter raised from ground level in spirals. Tents, marquees, awnings seriously disturbed. Some exposed tiles, slates on roofs dislodged. Twigs snapped; trail visible through crops. Wheelie bins tipped and rolled. Garden furniture & pots disturbed.
T1	Mild Tornado 25 - 32 m s-1 (55 - 72 mi h-1)	Deck chairs, small plants, heavy litter becomes airborne. Minor damage to sheds. More serious dislodging of tiles, slates. Chimney pots dislodged. Wooden fences flattened. Slight damage to hedges and trees. Some windows already ajar blown open breaking latches.
T2	Moderate Tornado 33 - 41 m s-1 (73 - 92 mi h-1)	Heavy mobile homes displaced. Light caravans blown over. Garden sheds destroyed. Garage roofs torn away and doors imploded. Much damage to tiled roofs and chimneys. Ridge tiles missing. General damage to trees, some big branches twisted or snapped off, small trees uprooted. Bonnets blown open on cars. Weak or old brick walls toppled. Windows blown open or glazing sucked out of frames.
T3	Strong Tornado 42 - 51 m s-1 (93 - 114 mi h-1)	Mobile homes overturned / badly damaged. Light caravans destroyed. Garages and weak outbuildings destroyed. House roof timbers considerably exposed. Some of the bigger trees snapped or uprooted. Some heavier debris becomes airborne causing secondary damage breaking windows and impaling softer objects. Debris carried considerable distances. Garden walls blown over. Eyewitness reports of buildings physically shaking. Mud sprayed up the side of buildings

T4	Severe Tornado 52 - 61 m s-1 (115 - 136 mi h-1)	Motorcars levitated. Mobile homes airborne / destroyed. Sheds airborne for considerable distances. Entire roofs removed from some houses. Roof timbers of stronger brick or stone houses completely exposed. Gable ends torn away. Numerous trees uprooted or snapped. Traffic Signs folded or twisted. Some large trees uprooted and carried several yards. Debris carried up to 2km leaving an obvious trail.
T5	Intense Tornado 62 - 72 m s-1 (137 - 160 mi h-1)	Heavier motor vehicles (4x4, 4 Tonne Trucks) levitated. Wall plates, entire roofs and several rows of bricks on top floors removed. Items sucked out from inside house including partition walls and furniture. Older, weaker buildings collapse completely. Utility poles snapped.
T6	Moderately-Devastating Tornado 73 - 83 m s-1 (161 - 186 mi h-1)	Strongly built houses suffer major damage or are demolished completely. Bricks and blocks etc. become dangerous airborne debris. National grid pylons are damaged or twisted. Exceptional or unusual damage found, e.g. objects embedded in walls or small structures elevated and landed with no obvious damage.
T7	Strongly-Devastating Tornado 84 - 95 m s-1 (187 - 212 mi h-1)	Brick and Wooden-frame houses wholly demolished. Steel-framed warehouse-type constructions destroyed or seriously damaged. Locomotives thrown over. Noticeable de-barking of trees by flying debris.
T8	Severely-Devastating Tornado 96 - 107 m s-1 (213 - 240 mi h-1)	Motorcars carried great distances. Some steel framed factory units severely damaged or destroyed. Steel and other heavy debris strewn over a great distances. A high level of damage within the periphery of the damage path.
T9	Intensely-Devastating Tornado 108 - 120 m s-1 (241 - 269 mi h-1)	Many steel-framed buildings demolished Locomotives or trains hurled some distances. Complete debarking of any standing tree-trunks. Inhabitants survival reliant on shelter below ground level.
T10	Super Tornado 121 - 134 m s-1 (270 - 299 mi h-1)	Entire frame houses and similar buildings lifted bodily from foundations and carried some distances. Destruction of a severe nature, rendering a broad linear track largely devoid of vegetation, trees and man made structures.

NOTES

Tornadoes of strength T0, T1, T2, T3 are termed weak tornadoes.
Those reaching T4, T5, T6, T7 are strong tornadoes.
T8, T9, T10, T11 are violent tornadoes.
Because the Tornado Scale is open-ended, it can be extended beyond T10 using the formulae below where v = wind velocity, T = Tornado Intensity number, and B = Beaufort Force number.

$v = 2.365 (T+4)^{1.5}$ metres per second $v = 8.511 (T+4)^{1.5}$ kilometres per hour.

$v = 5.289 (T+4)^{1.5}$ miles per hour $v = 4.596 (T+4)^{1.5}$ knots.

Thus, $B = 2 (T + 4)$ and $T = (B/2 - 4)$.

See www.torro.org.uk for further details on the T scale.

TORRO THUNDERSTORM REPORT FOR THE UNITED KINGDOM: APRIL 2007

By BOB PRICHARD

* This month, we also include the report for May 2007 as the May edition of the IJMet is devoted entirely to the Greensburg (USA) tornado.

As it was one of the driest months ever recorded over much of the country, it is hardly surprising that there was very little thunder.

The only storm of any note broke over the Merthyr Tydfil area of south Wales on the afternoon of the 15th, and reportedly gave 31 mm of rain in two hours. It was amongst a scattering of thundery showers that drifted north over the Welsh hills as hot air over the country destabilised somewhat ahead of an advancing weak Atlantic cold front. Thunder also affected Jersey early next morning before pressure built strongly in cooler air.

The last few days of the month brought isolated reports of brief activity. On the 22nd, there was thunder in showers around Dublin in mid-afternoon and during the night of the 24th/25th it occurred in cold frontal rain around parts of the west coast of Ireland. This front crossed the British Isles during the 25th and became very weak; as an anticyclone built northeastwards across Scotland behind it on the 26th, the front stalled over southeast England then drifted back westwards across England and Wales early on the 27th. A few pulses of rain were associated with it and there was isolated thunder in the southeast on the 26th and the western Midlands early on the 27th – when there was also an isolated fierce flash of lightning a few miles northwest of Bournemouth Airport. It struck within the perimeter fence of the Defence Fuels Group installation at West Moors and sparked a small heathland fire, which was quickly extinguished by firefighters. As the month closed, a few thundery showers clipped southwesternmost regions in an easterly airflow on the 29th and 30th.

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April 2008, Vol.33, No.327

TORRO THUNDERSTORM REPORT FOR THE UNITED KINGDOM: MAY 2007

By BOB PRICHARD

There was only one notably thundery day this month - the 31st. It was, therefore, a rather unusual May in being very wet but with most of the rain not thundery in nature; for example, Beccles (Suffolk) recorded 171 mm of rain – and no thunder. There was a scattering of thundery activity through the month, but large areas of the country were thunder-free and there were just isolated reports of three days with thunder.

The month began with isolated thunder in the extreme southwest on the 1st, but most of the first week was fine. By the 7th, a blustery, showery westerly airflow covered the country and the next three or four days brought isolated reports of thunder. During the evening and night of the 11th/12th, thundery showers crossed southern counties under a cold pool on the southern flank of a depression that was moving into Scotland, and there were one or two more thundery showers later in the day. The 13th saw weak thundery activity transfer northeast during the middle of the day, near the wave tip of an inner frontal system, from the Channel Islands to Essex; it was a 'one-bang' effort for most, but a more intense storm affected east Kent as the cold front crossed here in mid-afternoon. The heaviest rain that day was near the track of the main depression in a swathe through southwest England, Wales, the Midlands and northern England – but it was not accompanied by thunder (perhaps surprisingly: cf the very similar weather pattern of 21 May 2006). There were isolated thundery showers in southwest England on the evening of the 13th and one or two in northern regions on the 14th. On the 15th, a small depression meandered over the English Midlands; some thundery activity developed around it, with a lively storm over Oxford in the late afternoon. A vigorous depression drifted northeast off northwest Scotland from the 18th to 20th, and isolated thunder accompanied showers around it in the west and north.

The Spring Bank Holiday weekend of the 26th to 28th was exceptionally wet and cold in the south as a deepening depression drifted east close to the south coast; there was no thunder in this rain, but a few showers in the northerly airflow in its wake turned thundery – especially around the Mersey late on the 28th. This area was affected again shortly after dawn on the 29th, and later in the day there were also a few thundery showers towards the southeast. One or two more thundery showers appeared on the 30th.

Just when it seemed this would be a strangely quiet May, given how wet it was, the 31st brought widespread heavy thundery showers; they drifted north across the West Country, the Midlands and parts of East Anglia, northern England and southern Scotland during the afternoon and evening. Some of the storms were quite intense and there were reports of heavy hail. It was the only day of the month on which damaging lightning was reported. Two people were hit: a man in Coventry and a boy at Stretford (Manchester), but both lived to tell the tale. In the former, paramedics reported that he had burns where the lightning had entered and left his body, his hair was singed, and one shoe had disintegrated. His clothes were described as completely blackened. In the latter, the 14-year-old was sitting on his bike and sheltering under a tree with two friends when he was hit by the bolt and knocked unconscious. He suffered second and third degree burns to 10 % of his body. One of his friends commented: 'there was an orange flash and a bang and then we saw him fall to the floor. It was so loud I couldn't hear for a bit afterwards'. A house was set on fire near Woodhall Spa (Lincolnshire). One of the worst storms of the day hit Kirkcaldy (Fife), and flash flooding was reported from the Edinburgh area.

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LETTERS TO THE EDITOR

Storms in Mablethorpe, Lincolnshire 16/17 July 2007

Roy Bedford, West Yorkshire, UK.

My annual camp at Mablethorpe was memorable, to say the least - six thunderstorms in two days, over 80 mm of rain and floods on the camp site.

The forecasts had predictedheavy rain in all areas, and I knew the dangers, but I was determined to have my holiday. After all, what's a little raain to a seasoned camper? June had been disastrous - record rainfall, thousands of homes and businesses flooded out, and some tragic loss of life. July was shaping up to be very similar, and my holiday booking was just three days before the Evesham/Tewkesbury floods.

The fireworks began early Monday morning, 16th July. Claps of thunder and heavy rain on the tent woke me at 3 am. A repeat performance at 9 am left small lakes across the field, but I remained high and dry on a grassy ridge. The main Camping Club field at Mablethorpe is an old medieval strip-farming system, with ridges and hollows running from top to bottom of the site. All good campers know to avoid the hollows and pitch on higher ground.

The rest of Monday was warm and pleasant with a moist southerly breeze, plenty of sunshine, and lumps of fluffy cumulus building through the afternoon.

It was about 8.30 that evening when I saw the next storm approaching from the south, inky black with spasmodic lightning and distant rumbles. Heavy rain began at about 9 pm and continued for two hours, accompanied by vivid lightning and almost continuous thunder. Torrential rain and hail battered the tent so loudly, I couldn't hear my radio head-set. Water soon filled the hollowss across the field. Some of it was still there the following morning. I heard that Hull had been badly hit that night by the same storm, and many streets were flooded again, so soon after the devastation of the June floods.

The forecast for Tuesday was even worse - more storms, and the possibility of the odd tornado. In fact a tornado had already been seen in Worcestershire.

After a fine, warm morning, the first of the storms struck at lunchtime with rare ferocity, followed shortly by a second cell, even more powerful. Bursts of hail and rain were accompanied by a violent wind, howling and screaming as it tore leaves from an adjacent oak tree and plastered them against the tent, along with grass and other debris picked up from the next field. I feared for the safety of the tent as the walls were driven in like balloons, and sat with my coat and shoes on, ready for the worst. After about 20 minutes the storm passed on to the north, only to be followed by another, almost identical, with similar gusting winds. I must be thankful that the wind strength was well short of a full-blown tornado. In my exposed position, I wouldn't have stood a chance.

The field became waterlogged again, and I heard more reports of serious flooding in Hull and Bridlington as the storms continued north. Total rainfall in Lincoln for this period was about 70 mm. My location must have received far more than this, because I know that Lincoln missed at least three of the most dynamic cells.

I plotted the track of Tuesday's storms - they all ran parallel to the coast, running about 1 km inland. Unfortunately the Mablethorpe site is also 1 km inland, which is why I was in the best possible position to observe them.

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I am told that storms often do follow the coast. Sea breezes interact with the gradient wind, holding the storms on that track. The long southerly track through Lincolnshire encourages the formation of cumulus. Running up against cooler sea breezes, the storms are invigorated, enhancing the formation of hail and heavy rain. This could also explain the high incidence of tornadoes in Lincolnshire, and how I caught such strong winds on Tuesday.

On reflection, Mablethorpe was not the safest place to be sitting in a tent! But I am glad I was there to experience it.

Thank you to Roy for this incredible account - it really highlights some of the dangers severe weather can bring and shows we all must adopt safety advice at all times during such conditions. Roy will shortly receive his free gift for this contribution.

We want to produce a special issue on last year's flooding, so if any of you experienced any severe weather from those storms in particular, we want to hear from you. All readers and contributors are encouraged to write letters and accounts like this on any severe weather topic and we really enjoy receiving them. Contact details can be found on the contents page or on our website.

Correction to short communication on Cherrapunji (India) rainfall

Dr N. Shobha and Dr O. N. Dhar, Pune, India

In the April 2006 issue of your esteemed journal, a short communication was published under the heading "Cherrapunji breaks the world record for one-day duration" (April, 2006, Volume 31, Number 308, pp 146-147). On re-checking the records of rainfall with the original records of this station with India Meteorological Department, Pune, we have found that the information given in our small note on page 146 is not correct.

Actually the one-day highest rainfall at Cherrapunji observatory was recorded on 16 June 1995 and its magnitude was 1563 mm. The rainfall recorded on 10 June 2003 at the observatory was 184 mm and not 1840 mm. By oversight the mistake in rainfall was published in "Mausam" journal of India Meteorological Department and the same mistake was also repeated in September's issue of *Weather*, UK.

Many thanks to Dr Shobha and Dr Dhar for highlighting this mistake. It has also come to the editorial department's attention that the units in R Lakshminarayanan's letter in last month's IJMet were also incorrect regarding Cherrapunji rainfall. The units should have been millimetres and not centimetres. We apologise for any confusion caused.

Send your stunning cover shots to howard@ijmet.org

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"An international magazine for everyone interested in weather and climate, and in their influence on the human and physical environment."

ISSN 1748-2992