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TELECONNECTION BETWEEN GLOBAL CLIMATIC EVENTS, ATMOSPHERIC CIRCULATION CHANGE AND STREAM FLOW OVER THE RIVER NILE

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Abstract: An overview is presented of the principal features of the El Nino Southern Oscillation (ENSO), Tropical Atlantic sea surface temperature and North Atlantic Oscillation (NAO), which are teleconnections in terms of stream flow over the River Nile. Atmospheric circulation changes associated with wet and dry in the flood season (from July to October) are described using the NCEP/NCAR Reanalysis data from July to October, especially in El Nino and La Nina years. The natural stream flow over the River Nile depends mainly on Sahelian rainfall. Inverse relationships are found between 3-months seasonal cycle stream flow and ENSO over the River Nile. Tropical Atlantic sea surface temperature have similar response to ENSO influence on stream flow over the Nile, which indicates inverse relationships with stream flow. The influence of North Atlantic Oscillation (NAO) is much weaker on stream flow over the River Nile. Unlike other seasons, the spring season of stream flow indicates positive relationships with ENSO and Tropical Atlantic sea surface temperatures. The duration of the rainfall amount depends upon both location of the inter-tropical convergence zone (ITCZ) and the meridional sea surface temperature (SST) gradient in the tropical Atlantic. Tropical Easterly jet stream was weakened in El Nino year and enhanced in La Nina year accompanying with the dry and wet condition respectively. During La Nina year, easterly wind is strong not only over North Africa but also over tropical Atlantic Ocean. The oscillation and strength of Asiatic monsoon low pressure and subtropical high pressure play an important role in rainfall over the Nile River.

INTRODUCTION

The Nile flood, predominantly from the Ethiopian Highlands of the Blue Nile, accounts for over 75% of the annual flow. The Nile flood occurs in the four months July to October. Regional precipitation has increased over most land areas, with the exception of tropical North Africa and parts of Southern Africa, Amazonian and western South America (Mark, et al. 2001). Natural factors, which include changes in precipitation regimes particularly over the headwaters of the Blue and/or White Niles, changes in evaporation, and changes in vegetation in the catchments, affect runoff. Such changes however, may also be anthropogenic in origin with precipitation being affected by, for example, human-induced (Nicholson, 1988). Additional anthropogenic factors affecting the total natural stream flow include the extraction of water for domestic, agricultural, industrial, or power generation purposes. On the global scale, decadal to century-scale variability and change in the climatic system are determined by nature e.g. solar cycle, and anthropogenic factors e.g. greenhouse gases and aerosols (IPCC 1990, and 1996).

Although ENSO has been shown to be one of the primary dominants of inter-annual variability of rainfall in the low-latitude, its influence on Africa remains controversial. Links between ENSO and large-scale precipitation patterns have been examined since the earliest studies of this phenomenon. Indeed, the pioneering studies by Walker (1923, 1924, 1928), which first documented ENSO on a global scale, were motivated by attempts to understand and predict variations in Indian monsoon rainfall and then were expanded to studies of precipitation around the globe. The possible relationships might exist between a climatic event, termed El-Nino Southern Oscillation (ENSO) phenomenon, and other climatic anomalies worldwide (Ropelewski and Halpert, 1987). Ropelewski and Halpert (1987) indicated that oscillations in the state of the ocean-atmosphere system in the Pacific region (ENSO) are related to inter-annual fluctuation of rainfall and river flow in several regions of the world. Ogallo (1985) illustrated the negative relationships between rainfall over many parts of Eastern Africa and ENSO event. However, the relationship between ENSO and rainfall over that portion of the Ethiopian Plateau, which contribute to River Nile inflows has not been thoroughly investigated. Eltahir (1996) and Wang and Eltahir (1998) found significant relationship between stream flow over the Nile and El Nino and Southern Oscillation.

The North Atlantic Oscillation (NAO) is most pronounced in winter but detectable as a characteristic pattern in all months. The winter NAO pattern contributes the largest fraction of the Northern Hemisphere temperature variability of any mid-latitude or tropical mode of fluctuation. NAO fluctuations are found in the patterns of precipitation in between Mediterranean Eurasia/Africa and the eastern United States as well as storminess over the ocean and adjacent land areas.

Many researchers investigated relationship between Sahelian rainfall and Atlantic Ocean sea surface temperature. Lough (1986) and Ropelewski and Halpert (1987) found that inter-annual variations in Sahelian rainfall have been linked to Atlantic Ocean sea surface temperature anomaly pattern. Sahelian Region extended from 12.5^{o}N to 20^{o}N and from the Atlantic to the Red sea (Folland et al. 1991). The deficient precipitation in the Sahel tends to be associated with anomalous cold SST in the south Atlantic (Hastenrath, 1990). Tropical Atlantic SSTs and the latitudinal position of the inter-tropical convergence zone (ITCZ) are connected with Sahelian rainfall variability (Tourre and Lamb 1997, Ward, 1998). Sea surface temperature anomalies in the tropical Atlantic can lead to shifts in climatic patterns over Africa. Also, it has a significant impact on the position and intensity of the ITCZ, which in turn influence the rainfall over the Sahel in Africa (WCRP, 1997).

The aim of this research is to study the association between global climatic events (ENSO, Atlantic ENSO, and NAO), atmospheric circulation changes and stream flow over Nile River). Data and methodology are presented and an attempt is made to examine the relationships between mean natural stream flow for three irrigation stations on the River Nile and global climatic events. While relationship between type of atmospheric circulation and the prevalence of rainfall during El Nino and La Nina year is shown.

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BRITISH WEATHER SUMMARY: JANUARY 2003

This was a lively month of contrasts. In the mean, temperatures were not far from a degree above normal, rainfall generally above normal in the north and east and below in the south and west - and sunshine mostly well above normal, registering over 100 hours in some southern coastal regions, including a reported British January record of 121.6 hours at Weymouth.

The very wet weather that affected many areas in the closing days of 2002 continued for a couple of days into 2003 over central and southern regions, as vigorous depressions raced eastwards across the south; there was a good deal of flooding. Colder, drier weather in the north pushed south across the whole country by the 4th, and the floods slowly subsided under often sunny skies. There were snow showers, especially - at first - in the north. As high pressure settled over Scotland on the 6th and 7th, some valleys here experienced persistent severe frost; at Aviemore on the 7th, the temperature only rose from -18C to -9C. Areas of snow moved southwest across some eastern and southeastern counties on the 7th and 8th, and over ten centimetres accumulated in parts of south Essex.

The anticyclone slipped southwards in the second week of the month, and much milder air spread from the northwest to all areas by the 13th. It became generally cloudier and windier with some rain, although it was the 18th before the southeast had much rain. A deep area of low pressure crossed the country from the west between the 20th and 22nd; heavy rain affected various areas, but there were also clearer zones with some overnight frost and fog - and sunshine. A strong rise of pressure around the 23rd (nearly 60 millibars in 48 hours in the south) led to the sunshine and overnight frost becoming briefly, more widespread - then it became exceptionally mild on west to northwesterly winds. 18.3C was recorded at Aboyne (Aberdeenshire) on the 26th, equalling the British record for January, and 17C in parts of southeast England on the 27th. Strong northwest to northerly winds then brought much colder, very wintry weather, with a notable blizzard from the Wash to northwest London on the 30th.

BRITISH WEATHER EXTREMES: JANUARY 2003

Hottest:	18.3°C	Aboyne, Aberdeenshire	26th	Warmest:	7°C	Penzance, Cornwall
Coldest:	-18.3°C	Aviemore, Highland	7th	Coolest:	2.4°C	Darvel, Strathclyde
Most Rain:	50.7mm	Sconser, Highland	24th	Wettest:	286mm	Sconser, Highland
Most Sun:	8 hrs	Wokingham, Berks.	31st	Driest:	39.5mm	Neston, Cheshire
Windiest:	73mph	Llsfaen, Clwyd. Down	16th	Dullest:	33.3hrs	Edinburgh, Mid Lothian
Sunniest:	121.6 hrs	Weymouth, Dorset				

Extremes data supplied from 60 private UK weather stations
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DATA AND METHODOLOGY

There are two primary sources of the main Nile River channels, the Blue Nile and the White Nile. Combining with these sources to augment the Nile's flows are three other major tributaries: Bahr El Ghazal, River Sobat and River Atbara. The annual yield of the Blue Nile at Khartoum is around 54-milliard m^3 per year. The total amount of water provided by the White Nile at Malakal is on the average 29-milliard m^3 per year, distribution is relatively uniform throughout the year. The average amount of water arriving to Aswan is estimated to be of 84-milliard m^3 per year.

Monthly mean stream flow observations at three hydrological stations situated in the Nile were used: Aswan (20.9° N, 32.9° E) from 1950 to 1996, Khartoum (24.0° N 32.9° E) and Malakal (9.5° N, 31.6° E) from 1950 to 1996. The stream flow data set for the Nile has been supplied by the Ministry of Water Resources of Egypt. Monthly data of North Atlantic Oscillation index, and global sea surface temperature (SST) anomalies (Nino3, Tropical Atlantic Ocean) during the period from 1950 to 1996 were obtained from National Center for Atmospheric Research (NCAR). The strength of the NAO phases are measured through an index, defined as the difference between the normalised pressure anomaly, at Gibraltar, and that at Reykjavik (Iceland). This index has been computed by Jones et al. (1997). The Nino3 index which covers the area between 5°N-5°S latitude and 150°W-90°W longitude is often used an index of SST anomalies associated with ENSO cycle (WMO, 1996). Therefore Nino3 is used here to investigate the relationship between ENSO and stream flow over Nile River. Tropical Atlantic sea surface temperatures, which lies between 10°S, to 10°N latitude and from 0 to 360 degree longitude may affect stream flow over the River Nile.

The NCEP/NCAR Reanalysis data of mean geopotential height, vector wind at 1000 hPa, zonal wind at 150 hPa, and surface outgoing longwave radiation from July to October were obtained from Climate Diagnostics Center (NOAA, Boulder, Co.). A large part of the results presented here are based on classical correlation analysis, which considers the "similarity" between the variability of two variables (Mood et al., 1974). In this case the variables are the 12 month life cycle of ENSO, Tropical Atlantic SSTs, NAO and stream flow over Nile River. Running mean for 3-months of stream flow over Nile River are computed.

STREAM FLOW AND GLOBAL CLIMATIC EVENTS

Although correlation coefficient is simple by definition, it can indicate a physical relationship between two or more variables. Thus, the so-called correlation matrices are the base for a "factor analysis" which has wider meaning than the "principal component analysis". Both of which have been applied frequently during the last few decades, Maheras (1985), Ehrendorfer (1987), Pandzic (1988), and Pandzic and Trinic (1998). Their application is also significant in data assimilation techniques e.g. for data control or their "objective analysis" (Daley, 1991). Even in testing deterministic models, correlation coefficients can play a significant role (Carrol, 1995). Taking all this into consideration, the use of correlation indices in the study of meteorological and hydrological phenomena makes sense, especially if a field to field relationship is considered, as in this study.

STREAM FLOW AND ENSO

The influence of ENSO on Africa precipitation has been well documented in a number of studies over the past two decades, see for example Nicholson and Entekhabi (1986), Ropelewski and Halpert (1987, 1989), Lamb and Peppler (1991), Mason and Lindesay (1993) and Diaz et al. (2001). Both El Nino and La Nina events are a normal part of the behaviour of SSTs in the tropical Pacific where the main variations occur through atmosphere-ocean interactions on inter-annual time-scales (Philander, 1990). However, the basin-scale phenomenon is linked to global atmospheric circulation and associated weather anomalies.

The temporal and spatial structure of the ENSO teleconnections is now illustrated using time series of three hydraulic stations over Nile River. Figure 1 highlights the seasonal changes for three stations that have strong but opposite correlation with ENSO SSTs. In the top panel of Figure 1, 3-month running seasonal correlations with ENSO index are shown for the Aswan station. The Figure shows maximum negative correlation, indicating greater stream flow than normal during El Nino (warm phase) in late summer (July - October), but an opposite and weak effect during the late spring (March - June). The correlations are plotted together with the total seasonal stream flow to show the seasonal character of stream flow for each station. For the Khartoum station, Figure 1b, ENSO has the same effect compared with Aswan station. Malakal station, Figure 1c, is another area, where ENSO indicates positive correlation with stream flow during the spring and early summer (May - August), and negative correlation during seasons from September to April.

It is noticed that the years when the southern oscillation (SO) is negative (El Nino phenomenon) there is rainfall shortage in the Sahel and vice-versa (Nicholson and Kim, 1997). Changes in atmospheric circulation accompanying El Nino induce changes in cloud cover and evaporation which, in turn, increase the net heat flux entering remote Ocean (Klein et al. 1998). Also, in the tropical North Atlantic, a weakening of the trade winds during El Nino reduces surface evaporation and increases sea surface temperatures (SSTs).

TROPICAL ATLANTIC SEA SURFACE TEMPERATURE AND STREAM FLOW

A phenomenon similar to but weaker than the Pacific El Nino also occurs in the Atlantic (Latif and Grotzner, 2000). During a warm phase, trade winds in the equatorial western Atlantic are weak and SST is high in the equatorial eastern Atlantic. The converse occurs during a cold phase. This phenomenon is called the Atlantic zonal equatorial mode (or the Atlantic El Nino). Although sea surface temperature anomalies in the Tropical Atlantic are weaker than those associated with ENSO, they can lead to shifts in climatic patterns over Africa and Americas that can have major and sometimes disastrous environmental and socio-economic impacts (WCRP, 1997 and Marshall et al. 2001).

Egg-sized hailstones injure 100 in China

Hailstones the size of eggs crashed into an eastern Chinese province, destroying 18,000 homes and injuring more than 100 people, according to state press and local officials. The hailstorm hit Zhejiang province and lasted for 10 minutes, said an official from the social disaster rescue relief section of the Bureau of Civil Affairs in Wenling city. “Forty-two villages from two townships were stricken,” he said. “The hailstones were the size of eggs, some up to 45mm (1.8 inches) big. “Our estimates are that 60,000 villagers were affected, among which 30,000 people were seriously affected.” 10 people were seriously hurt in the storm and that “numerous people were slightly hurt.” The China Daily put the injury toll at 105. *Source: Beijing (AFP) 14.03.03*

Climatologists warn of increase in flooding

Europe’s largest ever earth sciences conference was told that the frequency of devastating flooding like that experienced throughout central Europe last summer will increase and we are less prepared than ever to cope with it. Speakers at the conference in the Czech Republic warned that not only is the world getting warmer, it’s also getting wetter. Studies of climate change suggest that a wetter world may be not only a consequence of global warming, but a trigger for more dramatic temperature rises. Last year, 15 people died and 220,000 were evacuated from the Czech Republic alone. Richard Betts from Hadley Centre for Climate Prediction and Research warned colleagues they have been underestimating the risk of future flooding. Current studies of how climate change will affect average rainfall only take into account the ability of air to hold more water as it gets warmer - which increases evaporation and creates more rainfall. This factor alone would increase river flows worldwide by about 1% by 2100, making rivers more likely to burst their banks. But he said this picture ignores the effects of greenhouse gases on plants. In response to high levels of carbon dioxide, plants shrink their stomata the holes in the surface of their leaves through which gases pass in and out. This drastically reduces water loss from the plants, leaving more water in the soil. *Source: The Irish Examiner 29.04.03*

Extreme access in Antarctica

A 31m high aluminium stairway tower has been erected on the Antarctic Plateau at an altitude of 3243m as part of international meteorological research (photograph back cover). The principal function of the tower is to provide a continuous colour-calibration feedback for satellites involved in climate studies and weather forecasting. The tower was supplied by Upright Special Engineering based in Ireland. The United States National Science Foundation funded the purchase of the tower and equipment. *Further information www.upright.com.*

Tornado and Storm Research Organisation new merchandise launched

The new TORRO merchandise was previewed to members at the Spring meeting to much acclaim. The new 2003/2004 range of T-shirts, sweatshirts polo shirts and mugs are proving very popular. A price list and order form can be obtained at: http://www.torro.org.uk/merchandise.htm

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The heavy snow caused hazardous conditions across many parts of Scotland with the county of Tayside being the worst affected.

Ball Lightning Summary 2002 published: VAN DOORN, P (2003) TORRO Ball Lightning Division Report for 2002. *J. Meteorology, UK* vol.28 no.278 pp135-137

TORRO was formed in 1974 and undertakes research on tornadoes and other whirlwinds (such as waterspouts and land devils), thunderstorms, hailstorms, lightning impacts, ball lighting, heavy snowfalls & blizzards, wind storms and coastal storm impacts as well as weather-health relationships. TORRO also issues severe thunderstorm and tornado advisories for the British Isles. Further details of TORRO's activities can be found on the Internet at: http://www.torro.org.uk. Additional copies of the TORRO Annual Review 2002 (and copies of previous years) are available at £2.00 including postage (cheque made payable to TORRO) from Professor Derek M Elsom, TORRO, Geography Department, Oxford Brookes University, Headington, Oxford, OX3 0BP. Telephone 01865-483761. Fax 01865-483937. E-mail: torro@brookes.ac.uk

NEWS

Fifty Arctic lakes show effects of climate warming

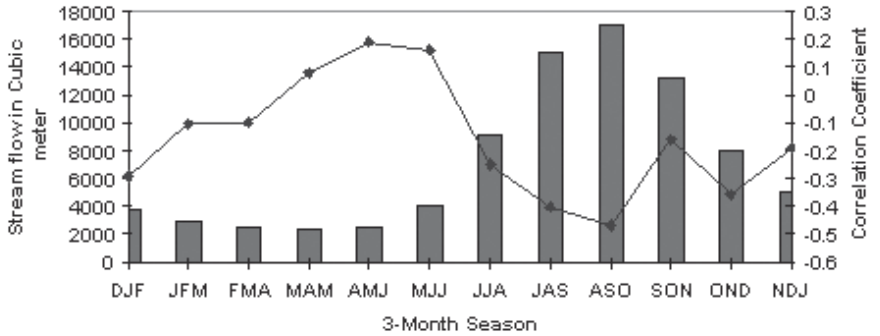
Dramatic clues to North American climate change have been discovered by a team of Queen's University scientists in the bottom of 50 Arctic lakes. Using innovative techniques that enable them to collect historic evidence from fossilised algae in lake bottom sediment, the researchers have found signs of marked environmental changes in a variety of lakes of different depths and composition, within a 750-km region bordering the northern tree line. The changes are a signal of things to come in the rest of North America, say the Queen's paleolimnologists. "We're seeing a significant, regional change in the ecology of these lakes over the past two centuries that is consistent with warmer conditions," says Dr. John Smol, Canada Research Chair in Environmental Change and co-head of the university's Paleoecological Environmental Assessment and Research Laboratory (PEARL). Dr. Smol conducted the study with Dr. Kathleen Rühland and student Alisha Priesnitz of Queen's Biology Department. The Queen's study will be published in the international journal Arctic, Antarctic, and Alpine Research. *Source:Terradaily 14.04.03*

Global Warming Could Trigger Cascade of Climatic Changes

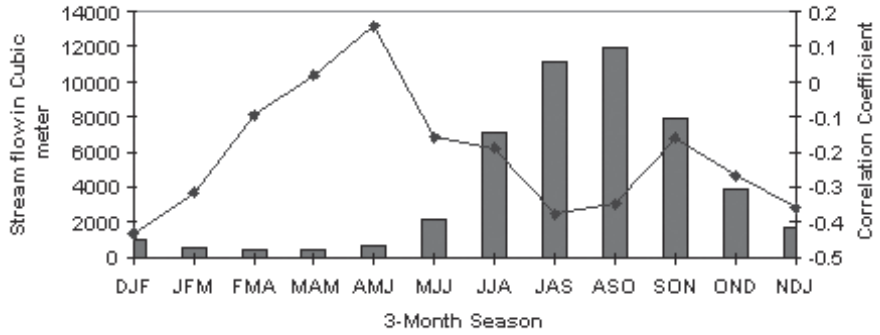
Global warming and the partial melting of polar ice sheets can dramatically affect not only sea levels but also Earth's climate, in ways that may be complex, rapid and difficult to adjust to. Sea level and climatic changes in Earth's distant past, near the end of the last Ice Age about 14,600 years ago, offer significant clues to some phenomena that Earth may experience in the near future, possibly in coming decades or centuries. The research was done by scientists at the University of Victoria, Oregon State University, and the University of Toronto. It revealed changes in global temperature, sea level and ocean currents that can occur with surprising rapidity. "With the advent of global warming, we're trying to identify the climatic surprises that may be in store for us, the events that we really aren't expecting," said Peter Clark, a professor of geosciences at OSU and a co-author of the study. "The more we look at this, the more it appears there have been large and abrupt changes in climate and sea level that are interconnected. If these changes were to happen in the future, they could cause huge societal disruptions."

Source: Terrawire 17.03.03

(a) Aswan Station



(b) Khartoum Station



(c) Malakal Station

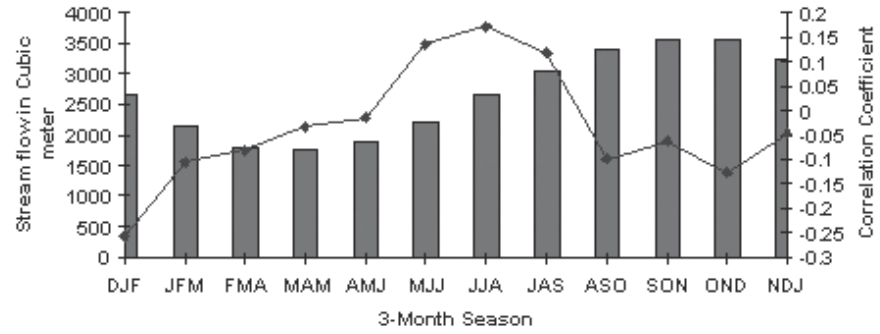


Figure 1. Temporal evolution of correlation between the indicated seasonal stream flow with the corresponding seasonal ENSO. Bars denote seasonal mean stream flow (left hand scale).

Figure 2 illustrates the temporal behaviour of the Tropical Atlantic SSTs-stream flow correlation in the three stations (Aswan, Khartoum and Malakal) over the River Nile. In the case of Aswan station, Figure 2a, negative correlations peak appear from July to February months, but an opposite and strong effect is evident during the spring months (April-May). The influence of Tropical Atlantic SSTs on Khartoum station, Figure 2b, has the same effect on Aswan station. In the Malakal station, Figure 2c, peak (negative) correlations occur in the winter months (from about November to February) but an opposite correlation during summer season (from about May to August) is found.

Many researchers found strong relationship between Sahelian rainfall and Atlantic Ocean sea surface temperature such as Lough (1986), Ropelewski and Halpert (1987) and Hastenrath (1990). Tropical Atlantic SSTs are connected to out-of-phase rainfall anomalies in the Sahel region (Ward, 1998). Sahelian rainfall variability is closely linked to the meridional sea surface temperature SST gradient in the tropical Atlantic, and the latitudinal position of the inter-tropical convergence zone (ITCZ) (Tourre and Lamb, 1997). The Atlantic Ocean SST fluctuations correspond to those of the northern and southern hemisphere oceans as a whole. The northern Indian Ocean tends to warm up roughly in phase with the Southern Hemisphere. There is a general correspondence with the rainfall fluctuations in the Sahel with wet (dry) periods in Sahel associated with negative (positive) anomalies in differential (SH-NH) ocean SST.

NORTH ATLANTIC OSCILLATION (NAO) AND STREAM FLOW

The North Atlantic Oscillation (NAO) is the alternation of atmospheric mass between the subtropical and sub-polar regions of North Atlantic Ocean. NAO is characterised by variations on monthly and seasonally time-scale in the regional sea level pressure gradient, the mid-latitude westerlies, sea surface temperatures and the climate of adjacent land area. Figure 3 presents the results of the correlation analysis between NAO and stream flow for Aswan, Khartoum and Malakal stations. The main feature of Figure 3 is that the effect of NAO on stream flow over the River Nile was weak with an exception at two months in Khartoum station, March with negative sign correlation and August with positive sign correlation. In general, during the flood season (from about June to October) positive correlation was indicated at all stations approximately. Also, the NAO has different influence than the ENSO and Tropical Atlantic SSTs on stream flow over the Nile. The link between stream flow over Nile River and North Atlantic Oscillation (NAO) is weak. These results are consistent with that of the previous studies of Mark et al., (2001), WCRP, (1997), and Ward (1998). The NAO is not an important modulator of global precipitation, but it does explain 8% of annual (more in winter) variability not spatially averaged northern mid-latitude precipitation.

NAO also generates a component of climate variability over the northern rim of the continent. The known change in the north-south inter-hemispheric gradient of sea surface temperature (SST) has accompanied climate fluctuation not just in the Sahel, but also through much of the tropics (Ward, 1998).

HEAVY SNOWFALLS DIVISION SUMMARY FOR THE UNITED KINGDOM 2002

By RICHARD WILD

TORRO (Director of Blizzards and Heavy Snowfalls Division)

The year 2002 had virtually no heavy snowfalls, in fact only a total of three heavy snowfall days occurred during the entire year with no heavy snow occurring across Wales and/or the southern parts of the United Kingdom.

25th January

Rain across Ireland (due to a warm front) spread eastwards across the United Kingdom turning to snow in many parts of Scotland and Northern England by the afternoon. Some of the snow was heavy and continuous, with some places across Scotland seeing falls between 10-15cm. This amount of snow caused severe disruption to several major routes. The worst affected area was Inverness, where high winds compounded the problem, with several drivers stuck in snowdrifts.

23rd February

Troughs and an occluded front (associated with a polar low) caused the worst heavy snowfall of 2002 to many parts of Scotland, Northern Ireland and Northern England. There were widespread wintry showers across these areas, which at times merged to give a longer spell of snow in places, especially across Northern Scotland. During the day, these sleet and snow showers pushed southwards across other parts of the United Kingdom, but the snowfalls were not as significant as in Scotland and Northern England. The heavy snow was also associated with high winds. The snow and the wind brought chaos across the roads across northern districts of the United Kingdom as blizzards caused treacherous conditions with many accidents. Snow drifts up to 6m in height, blocked many routes, especially across the higher routes of Scotland. Hundreds of homes also lost power supplies, while emergency services advised people to stay at home. The heavy snow caused a driver to be killed and his passenger to be injured when their car slid off the A19 in Peterlee, County Durham and hit a lamppost. In Scotland, police rescued 16 people, including a child, when they were trapped in their cars after snowplough crews were unable to reach them on the A9 Wick-to-Inverness road. By 0400 GMT, 12cm of snow lay at Eskdalemuir, Dumfries and Galloway, while at Wishaw, Strathclyde the snow depth at 0900 GMT was 7cm. Between 1000-1100 GMT, 5cm of snow fell at Aviemore, Inverness-shire with 19cm of snow lying there by the end of the evening. Other snow lying measurements that day included 17cm at Kyle, Sutherland, 8cm at Stornoway, Western Isles and 10cm at Saughall, Ayrshire. Middleton, Derbyshire had 14cm of snow lying by the end of the day (the largest snowfall there since February 1994). Snowdrifts of 1m will still visible at Middleton, Derbyshire by the end of February.

10th March

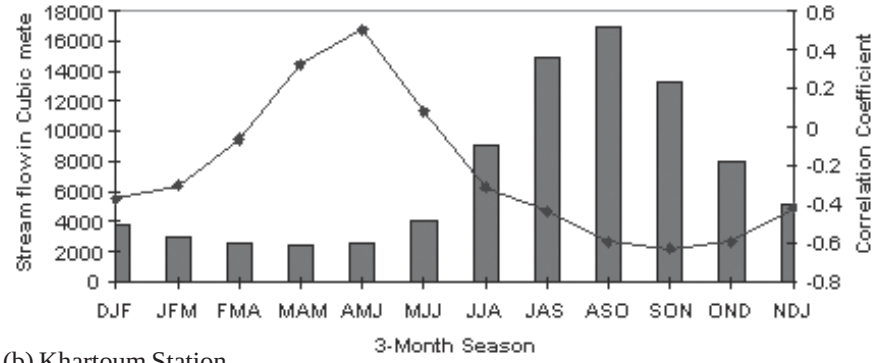
The final heavy snowfall day of 2002 saw heavy snow fall across the hills of Northern England and Scotland, due to a warm front which pushed in from Ireland during the early morning. An avalanche on Beinn Dearg, near Ullapool, Highland killed two men. 11cm of snow fell at Ardtalnaig, Perthshire but soon melted, while Carnbo, Kinross-shire recorded a snowfall of 13cm by the end of the morning.

Fig. 3 Timing of the path of the depression associated with the Jeanette windstorm.

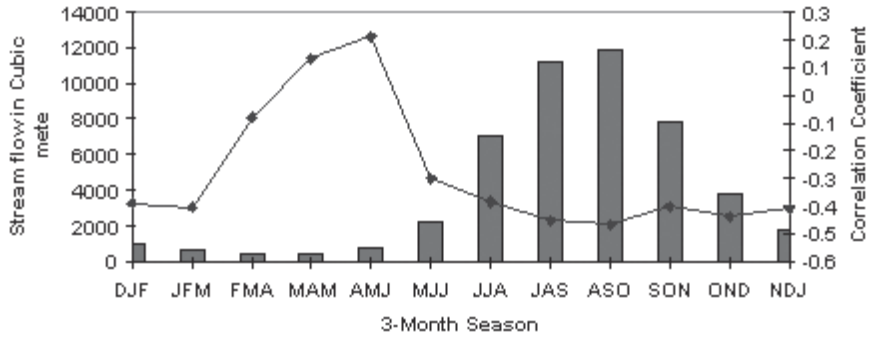
By evening, the low was over southern Sweden, leaving the UK in moderating WNW winds to the north of a high (1035) over Biscay (Fig. 3). At the very exposed Needles lighthouse on the Isle of Wight, a gust of 102 mph was recorded around 0500 GMT. 96 mph was recorded at the (also very exposed) station at Mumbles Head (south-west Wales). Many stations over England and Wales experienced their strongest gust speeds since the 29th / 30th October 2000 windstorm and some stations in East Anglia experienced their highest gusts since the Burns day storm of 25th January 1990. 7 people were killed as a direct result of the storm in the UK and at least a further 23 across northern Europe. Most deaths were the result of falling trees. Property damage in the UK was worst in Wales, the Midlands and East Anglia. 300,000 homes were left without power, and electricity companies were criticised, as many homes remained without power even a week later! A replica inflatable army tank and a 25ft inflatable Ronald McDonald both broke free from their moorings and were being eagerly sought by their owners!

The storm also caused considerable disruption to transport. In Scotland, a ferry carrying 80 passengers was stranded for 80 hours after it failed to land at Lerwick in the Shetland Isles and at Heathrow Airport, over 60 flights were cancelled. Insured loses across northern Europe were estimated at £500M with the most severe losses in Germany and the Netherlands and further substantial losses in the UK (£50M), France, Austria, Poland Czechoslovakia. Economic losses were estimated at £1Billion.

(a) Aswan Station



(b) Khartoum Station



(c) Malakal Station

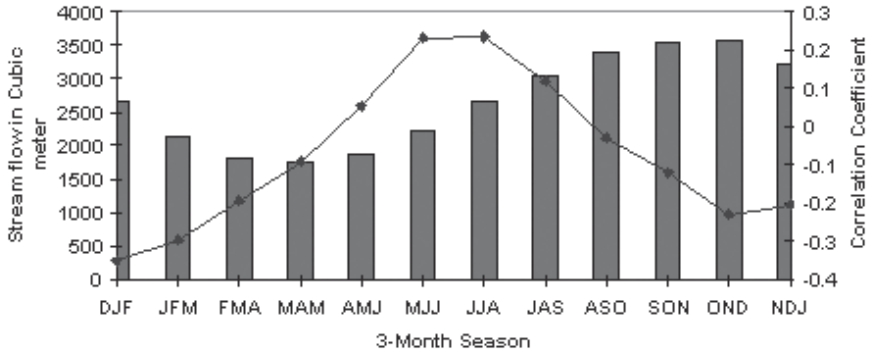
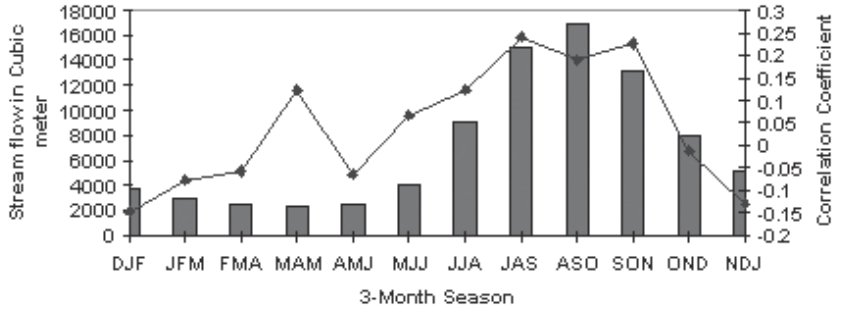
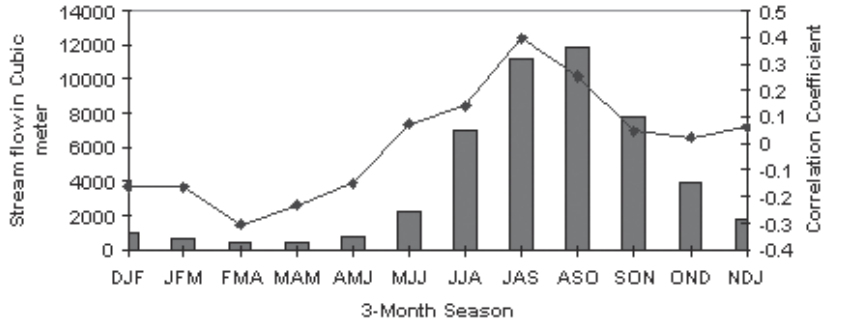


Figure 2. Temporal evolution of correlation between the indicated seasonal stream flow with the corresponding seasonal Tropical Atlantic sea surface temperature. Bars denote seasonal mean stream flow, (left hand scale).

(a) Aswan Station



(b) Khartoum Station



(c) Malakal Station

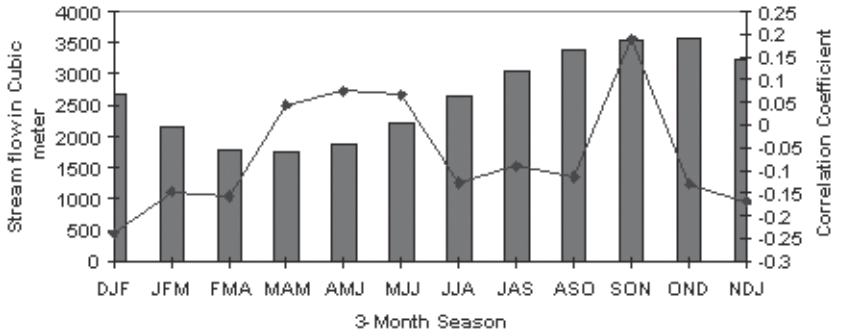


Figure 3. Temporal evolution of correlation between the indicated seasonal stream flow with the corresponding seasonal North Atlantic Oscillation, NAO. Bars denote seasonal mean stream flow (left hand scale).

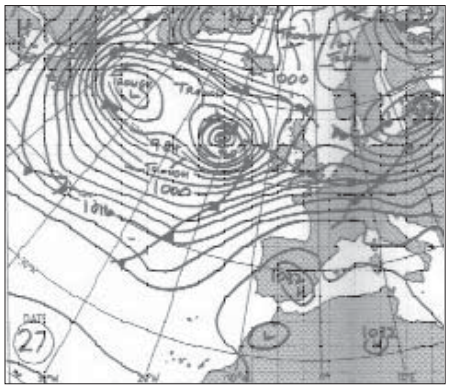


Fig. 1a Noon Sunday January 27th 2002

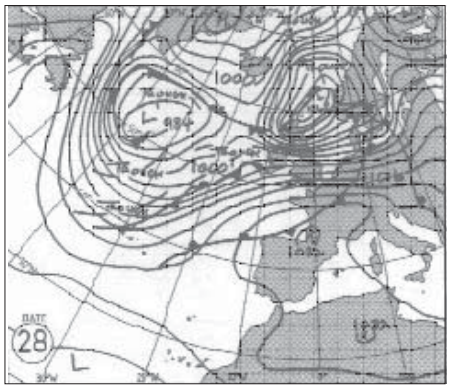


Fig. 1b. Noon Monday January 28th 2002

Maximum wind gusts at high level stations were impressive: Cairngorm summit (1090m) reported 141mph around noon, Aonach Mor (1130m) 130mph and the summit of Ben Nevis 120mph. Lower down, Glen Ogle (564m) recorded 123mph - the highest gust since the station opened in 1996. Gusts from low level stations were rather less severe. Barra reported 85mph, the (joint) highest gust for any day in a series going back to July 1997. Edinburgh Gogarbank reported 82mph, the highest gust since the site opened 3 years previously. Across northern Britain, 7 people were killed by the storm, several as a result of lorries being blown over. Railtrack suspended all of its train services in Scotland, 35,000 homes suffered power cuts in Northern Ireland, and a further 40,000 homes were left without power across Scotland (mainly the Western Isles, Argyll and Tayside)

October 27th Windstorm - "Jeanette"

Late October windstorms have been a recurrent feature of recent years, and there is some evidence to suggest that the period 25-31st October represents a stormy "singularity". During the 26th a small low originating in the West Atlantic moved rapidly ENE towards Ireland (Fig 2a and 2b). It crossed Ireland and northern England during the morning of the 27th exiting in northeastern England and giving very strong winds and damaging gusts on its southern flank.

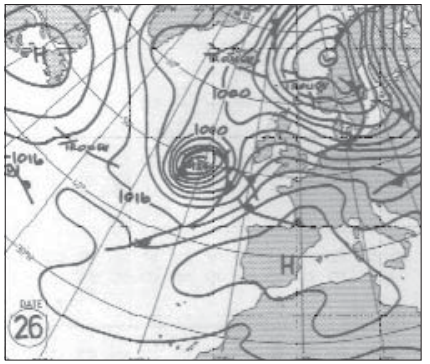


Fig. 2a Noon Sunday October 26th 2002

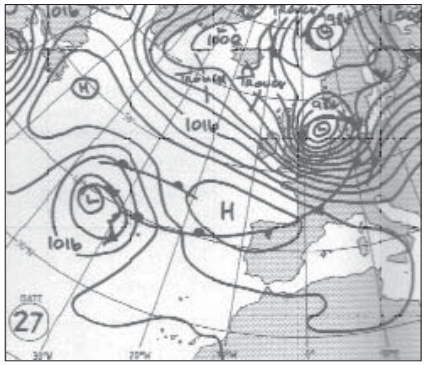


Fig. 2b Noon Monday October 27th 2002

On the following day a funnel cloud was observed during a storm chase across the southern provinces of Ireland. A paper on this event has been submitted to the Journal for future publication. No other reports of this event were received. Thus it would have been a 'lost' event had not the chase been carried out. Late in the morning of the following day, 25 October, in the east of Ireland, a small tornado (T0) did minor damage in Co. Wicklow. Again, a site investigation was carried out. But the major event of the year occurred later that day when during the afternoon a tornado occurred in Co. Longford that did considerable structural and tree damage. This was a T4 event and was the most intense of the year. It was triggered in a surface trough behind a cold front with very strong upper winds. Again, a full site investigation was carried out very soon afterwards. This survey identified and mapped a track of 2.4km. During these three days a complex low crossed Ireland and brought stormy weather within 24 hours after the tornadoes had occurred. This meant that considerable care was necessary to distinguish between damage due to the storm event and the tornadoes.

For 25 October an experimental severe thunderstorm watch had been issued by TORRO that covered southern and central Eire. Both Co. Longford and Co. Wicklow are located within the region that was subject to the watch. Although the main threat identified was severe thunderstorms, the tornado threat was identified as a possibility. The success of this experimental watch is a promising development that will, hopefully, be developed further in the year ahead.

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WINDSTORM DIVISION SUMMARY FOR THE BRITISH ISLES 2002

By STEPHEN K ROBERTS

Director TORRO Windstorms Division

OVERVIEW

2002 saw just 2 major wind storm events affect the UK. The first, occurred on 28th January, and swept across central and southern Scotland, Northern Ireland and north eastern England. The second event occurred on the 27th October when an intense depression sped east northeastward across the British Isles.

January 28th Windstorm

January is the windiest month of the year on average for the UK, and noted for the severity of its windstorms. (44% of all major windstorms to occur in recent decades have occurred during January). On the 28th, a deep but filling low (964mb) moved northeast just to the north of Scotland before passing over the Northern Isles (Fig.1a and 1b). Westerly gales or severe gales blasted northern Britain during the morning, as the low passed through. There followed a dramatic rise in pressure of 20mb in just a few hours during the afternoon.

Nevertheless these observations do not explain the cause of the variations in the global transfer of the planetary circulation system. But they prove that it is important to search for climatic fluctuations as forming an integral part of the planetary scale systems. NAO has more effect on Western African than Sahelian region (Tourre and Lamb, 1997). A major transition of NAO between decadal periods of extreme states (low to high) in the early 1970's coincided with shifts in rainfall patterns in Western Africa (WCRP, 1997).

ATMOSPHERIC CIRCULATION CHANGES

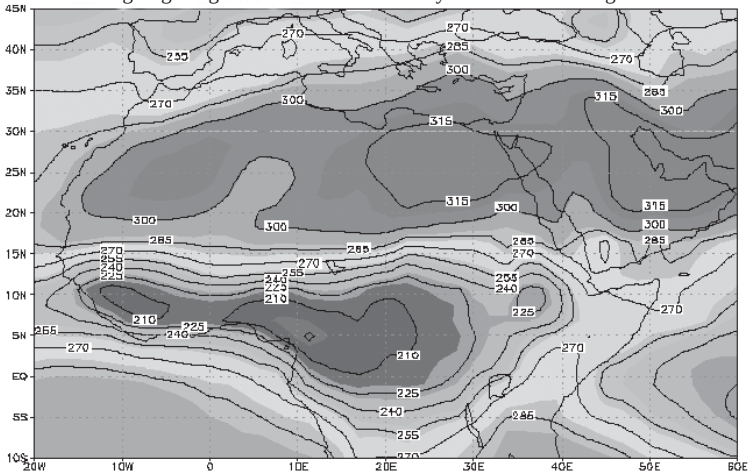
Changes or fluctuations in atmospheric and oceanic circulation are important elements of climate. Such circulation changes are the main cause of variations in climate elements on a regional scale, sometimes mediated by parallel changes in the land surface, (IPCC 1990, 1996). ENSO and NAO are such examples. Changes in atmospheric circulation patterns are considered as an indicator of possible climate change. Obviously, a close relationship exists between type of atmospheric circulation and the prevalence of rainfall. There is observational evidence that the frequency of certain European circulation patterns has changed during the last 30 years (Zwart, 1992; 1993). General Circulation Models indicate changes in the Northern Hemisphere Storm tracks, Hall et al. (1994). Circulation change and its effect on variability of stream flow, especially during El Nino and La Nina years are described. The year 1987 is well recognised as one of the peak periods of the well known Sahelian drought as well as the remarkable low Nile River floods. Also, the year 1975, La Nina year, which indicates wet in Sahel region and high Nile River floods. It is suggested that the change in Hadley and Walker circulation types plays an important role in Africa rainfall, but this requires further examination.

INTER-TROPICAL CONVERGENCE ZONE (ITCZ)

Tropical African precipitation is largely controlled by the north-south oscillation of the Inter-Tropical Convergence Zone (ITCZ). The ITCZ moves with the seasons, following the sun. The north-south movement of the ITCZ is the most important feature of the tropical climate system since it largely controls the spatial and seasonal distribution of the rainfall (Farmer and Wigley, 1985). When the ITCZ climbs up to 20^{o}N, whether the excess is global for the continent (if the progress is slow) or the situation is almost normal (if the progress is moderate, i.e. five months on the way there, and three months on return). It could happen that the ITCZ does not exceed the southern regions of the continent. In such condition there is excess in the south and deficit in the north. The opposite occurs when the ITCZ advances rapidly northwards and stays for a long time in that position. The surface outgoing longwave radiation apart from being used as a component of the radiation balance, has proved to be useful for studies of the large-scale circulation over the tropics, e.g., Heddinghaus and Krueger (1981), Nitta and Yamada (1989), and Abdel Wahab and Hasanean (1999). This is because the tropics are largely modulated by cloudiness.

Figures 4a, and 4b illustrate the regional distribution of mean surface outgoing longwave radiation from July to October for the 1987 El Nino year and 1975 La Nina year respectively. From these Figures we see that the ITCZ for 1975 La Nina year was at 15°N latitude, while in 1987 El Nino year was at 10°N latitude. As shown in Figures 4 the values of surface outgoing longwave radiation for 1987 El Nino year are greater than the corresponding ones for 1975 La Nina year, especially at the ITCZ. A southward displacement of the ITCZ on the tropical Atlantic is resulting from the enhancement of north-easterly trade winds (Janicot, 1997 and Janicot et al. 2001) also see Figures 6a, and 6b.

(a) Mean surface outgoing longwave radiation from July to October during 1987 El Nino year



(b) Mean surface outgoing longwave radiation from July to October during 1975 La Nina year

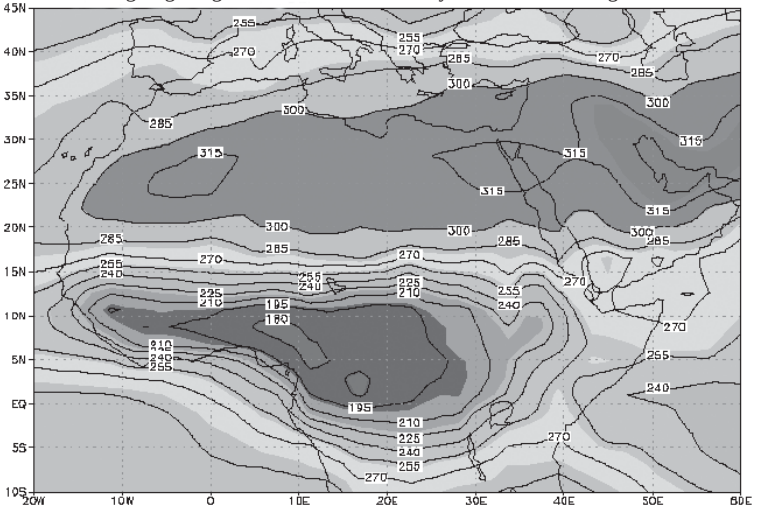


Figure 4. (a) and (b) Mean Surface outgoing long-wave radiation from July to October during 1987 El Nino year and 1975 La Nina year

THE SUMMER SEASON

This was clearly marked because there was a break of three months between the early year events and July. The two months of July and August had eleven of the year's events - three tornadoes and eight funnel clouds. There was what, for Ireland, seemed to be a remarkable outburst of activity on 9th July when five funnel cloud events were recorded in Counties Kerry, Galway, Mayo, Tyrone and Donegal. Four of these were photographed and the remaining case was sketched by a scientist who made the report. The first to be reported (to Met Eireann) was recorded by a group of media studies students with a camcorder visiting a wind farm site, while the final one eventually came to light much later during the month of October, after a feature on this research in a national newspaper (different from the newspaper article mentioned earlier). Between these, the other reports emerged during ongoing investigations across the country. Only then did the same date begin to show up in all five cases. Their timing indicates that they were probably associated with the gradual progression northwards of an active trough influencing the western half of Ireland, since the Kerry FC was at 1230pm., Moy in Co.Tyrone at 1510hrs, Balla in Co Mayo at 1600hrs and finally the most northerly, close to Letterkenny in Co. Donegal, at 1900hrs. At least one further (as yet unconfirmed) case suggests there may well have been others not reported.

The tornadoes occurred during August, but they were relatively weak events. Over the last few years August has been a relatively active month as far as tornadoes and funnel clouds in Ireland are concerned. The three summer tornadoes were not intense ones (two were T0 and one was T1), but with the three funnel clouds these had one less usual feature, namely that they occurred in the south and east of the country in areas where recorded events have been less frequent than elsewhere. Remarkably, the 24-hour period centring on 17-18 August recorded whirlwind activity for the fourth year running (out of the four years during which intensive studies have been carried out). This time one tornado and two funnel clouds occurred in County Cork behind a cold front in a very slack wind field on a pleasant, warm afternoon. All three were photographed. The other two tornadoes occurred in County Wicklow and were observed by mountain walkers on different occasions, demonstrating that such areas are not truly 'empty' of these events, as the Irish database was beginning to suggest. These were distant sightings and required site investigations to confirm their locations at Rathdangan (4th August) and Ballysmutton (20th August).

EVENTS LATE IN THE YEAR

Other than a waterspout observed during a period of about 15 minutes approximately three miles south of the Fastnet Rock in late September, the final period of activity was in late October. Then there were events on three successive days. Firstly, on 23 October, there was a tornado in Dunfanaghy, Co. Donegal that may have commenced offshore between Horn Head and Tory Island. A full site investigation (on land) has shown that its track is traceable from close to the headland, through the village of Dunfanaghy, to the nearby inland hills. Enquiries have been made to the island about the early past of the track, but so far these have drawn a blank, even though a local report is circulating on land that it was observed from the island.

Interestingly, this occurred some considerable distance away from main belt of thunderstorms that were crossing the southern counties of Ireland. These produced lightning damage, but no whirlwind phenomena were reported. An active portion of a cold front produced the thunderstorms, but the tornado was close to a triple point much further to the north.

The second tornado did not occur until March. A classic col structure between two anticyclones, one to the north and the other to the south of Ireland, contained a trough which produced the tornado. There was also a particularly strong upper level jet at the time, evident in the Hillsborough upper air sounding. The tornado occurred near Garvahy in County Tyrone. This was a smaller event in terms of its intensity (T1). Since it occurred in the mid-afternoon and included a hotel, shop, parked cars and a number of homes in its damage path, it was well witnessed. Had it been of similar intensity to the Carrigallen tornado, the consequences could have been very serious. A thorough site investigation was completed and showed that the damage path was considerably longer (7km) than what was extensively reported in the regional media.

Another early year event was a waterspout off the County Cork coast. This was traced several months afterwards as a result of a feature on this research and an appeal for information in a local newspaper. However, a number of months had passed between the time when the event occurred and the subsequent report. As a result, no specific date could be identified, only the time of year.

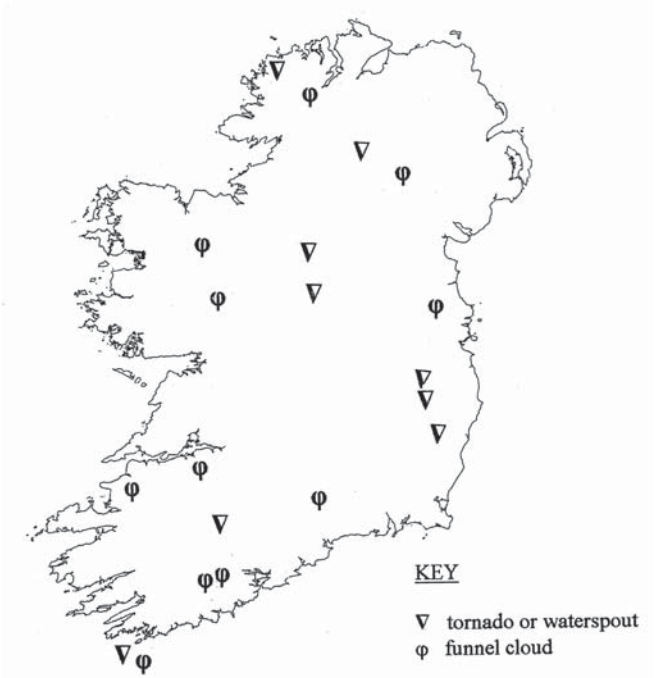
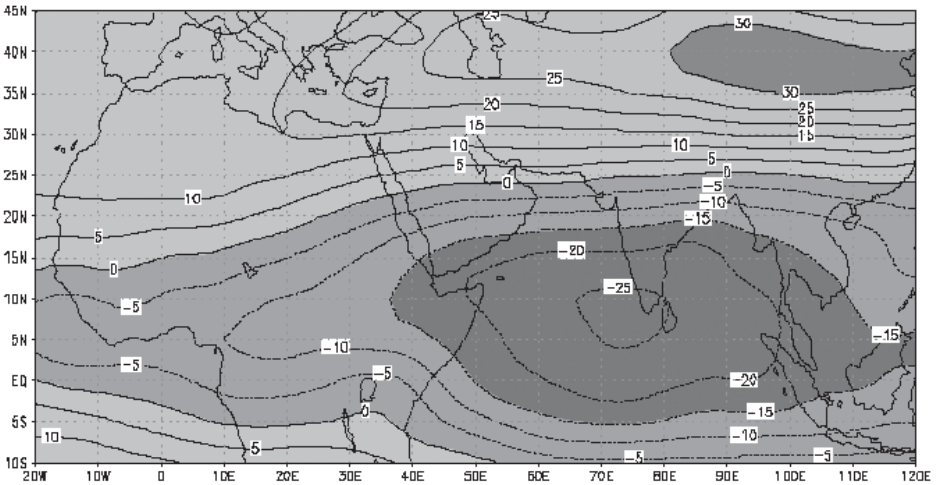


Fig 1. The distribution of tornadoes, waterspouts and funnel clouds across Ireland for 2002

According to Hastenrath (1990), displacement of the ITCZ is a dominant factor for Sahel drought, on both the inter-annual and decadal time scales. Tourre and Lamb (1997) have found Sahelian rainfall variability is closely linked to the latitudinal position of the ITCZ. Also, they found that the latitude of the ITCZ depends upon both local condition and remote forcing.

(a) Mean zonal wind component at 150 hPa from July to October during 1987 El Nino year



(b) Mean zonal wind component at 150 hPa from July to October during 1975 La Nina year

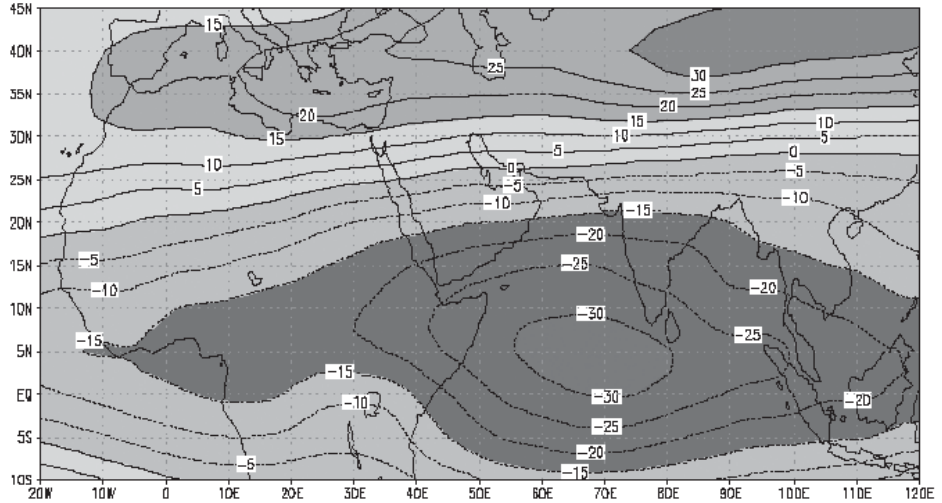


Figure 5(a) and (b) Mean zonal wind component at 150 hPa from July to October during 1987 El Nino year and 1975 La Nina year

EASTERLY WIND

Several observations have shown variations of circulation between wet and dry years. Figures 5a and 5b present the mean zonal wind at 150 hPa during 1987 El Nino Year and 1975 La Nina year respectively. From these Figures one can see that the Tropical Easterly Jet (TEJ) was weaker than normal over Africa during 1987 El Nino year but in 1975 La Nina year it is stronger and concentrate over Arabian sea and extended more and more over Africa in agreement with many researchers such as Kidson (1977), Newell and Kidson (1979; 1984), Kanamitsu and Krishnamurti (1978), and recently Nicholson and Grist (2001). Nicholson and Grist (2001) state that, since one of the strongest contrasts between the 'wet Sahel' and 'dry Sahel modes is the strength of the TEJ, the TEJ probably also plays a pivotal role in rainfall variability. The speed of the TEJ also decreased.

Figures 6a and 6b illustrate the mean vector wind at 1000 hPa during 1987 El Nino Year and 1975 La Nina year respectively. In the case of EL Nino year, decrease of easterly wind occurs not only over Africa but also over the Atlantic Ocean and vice-versa in the case of La Nina year. Also, the equatorial westerlies are shallower and weaker than normal.

INDIAN MONSOON AND SUBTROPICAL HIGH PRESSURE SYSTEM

In Figures 7a and 7b, taken at the height of 1000 hPa for mean months from July to October in 1987 El Nino year and 1975 La Nina year respectively, the Asiatic monsoon was weaker than normal and shifted southeastward. Also, the subtropical high pressure oscillated more eastward over North Africa in 1975 La Nina year than in 1987 El Nino year.

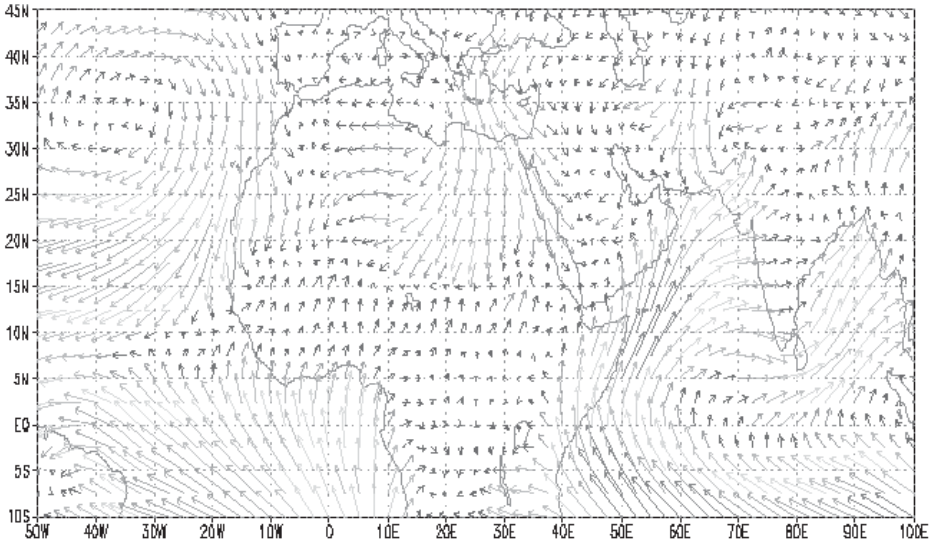


Figure 6a. Mean vector wind component at 1000 hPa from July to October during 1987 El Nino year

Aug 9. Maidens Green, Berkshire
Aug 10. Tollesbury, Essex
Aug 19. Raunds, Northamptonshire
Aug 23. Trealaw, Rhondda Valley
Aug 24. Bottesford, Leicestershire
*Sep 7. Dungannon, Co. Tyrone
Oct 15. Torquay, Devon
Oct 15. Tiptrce, Essex
Oct 15. Kirby Cross, Essex
Oct 15. Holland on Sea, Essex
Oct 15. Shottisham, Suffolk
*Oct 15. Mundon, Essex
Oct 22. Mossley, Greater Manchester
Oct 22. Weston-super-Mare, Avon
Oct 25. Portchester, Hampshire

REFERENCE

GILBERT, A. (2003): Note on the theory of tornadoes of the 'landspout' variety. *J. Meteorology*, 28:11-14 (January 2003).

TORNADOES IN IRELAND SUMMARY 2002

By JOHN TYRRELL
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Compared with the tornado and other whirlwind activity reported for the year 2001, this year was slightly more active. Extensive checking of reports and site investigations have resulted in confirmed totals of eight tornadoes, one waterspout and eleven funnel clouds. This gives a total of 20 events, which is slightly up on the previous year's total of 17. These were more widely spread around Ireland this year, compared with some previous years that had reasonably relatively marked geographical concentrations (e.g. 2000). The events were shared among twelve counties (Figure 1). It was particularly interesting to note that areas with particularly low frequencies recorded in the past such as the south and southeast, especially away from the coast, produced a number of these. This demonstrated how different the distribution may be from one year to another.

THE EARLY MONTHS OF THE YEAR

Another difference was the early start to the year. This began with a severe tornado (T4) on 26 January in a remote corner of County Leitrim, at Carrigallen. This was also a little unusual in that it occurred in the early hours of the morning (approximately 5am). Since this was well before dawn, there were no eyewitnesses. However, it was unmistakably heard as it cut a swathe of damage across the landscape. A full site investigation of this event was carried out and has been reported (Tyrrell, 2003).

There were several multiple waterspout sightings, the most spectacular being of six in succession near Tenby in south-west Wales on 9 September. Witness Dave Roberts was only 400 yards from the first of the "very spectacular pure white columns" when it formed.

FUNNEL CLOUDS

There were 50 definite funnels and 17 probables, ranging in date from 17 April (Reading University) to 14 November (Portsmouth). May, as usual, was a fairly active month, with eight reports, but unusually there was only one in June. The peak months were July (15) and August (28). The total of eight in October was high for that month. Spectacular photographs of a funnel near Shepton Mallet, Somerset, on 2 August, appeared in many newspapers.

LAND DEVILS

The land devil season is always relatively restricted and this year was no exception. The earliest and latest dates were 19 June (Havenstreet, Isle of Wight) and 24 August (Odiham, Hampshire and Calthorpe, Norfolk) On 20 June a land devil lifted chairs, ladies' hats and a yellow gazebo at Royal Ascot, watched by the Queen!

REMARKABLE SHOWERS

Maggots were reported to have fallen with rain at Porthtowan, Cornwall, on 27 January (COL, January 2002, page 5), but no evidence is given that they did not arrive by more normal means.

UK TORNADOES OF 2002 (*indicates probable tornadoes)

Jan 26. Alsager, Cheshire
Jan 26. Fradley, Staffordshire
*Feb 26. Church Enstone, Oxfordshire
Mar 10. Harbert, Western Isles
Mar 21. Galvaghay, Co. Tyrone.
*Apr 26. Hazlemere, Buckinghamshire
Apr 28. Ryhall/Stamford, Lincolnshire
May 2. Thurrock, Essex
May 2. Caldicott, Gwent
May 26. Haywards Heath, West Sussex
May 26. South Lincolnshire
Jun 14. Horsforth, Leeds, West Yorkshire
Jun 14. Middlesbrough, Cleveland
Jul 2. Pickering, North Yorkshire
*Jul 20. Brightlingsea, Essex
Jul 28. Ixworth, Suffolk
Jul 30. Northallerton, North Yorkshire
*Jul 30 Leatherhead, Surrey
Aug 3. Warndon, Hereford and Worcester
Aug 4. near Worcester, Hereford and Worcester
Aug 5. Orsett, Essex
Aug 9. West Bexington, Dorset

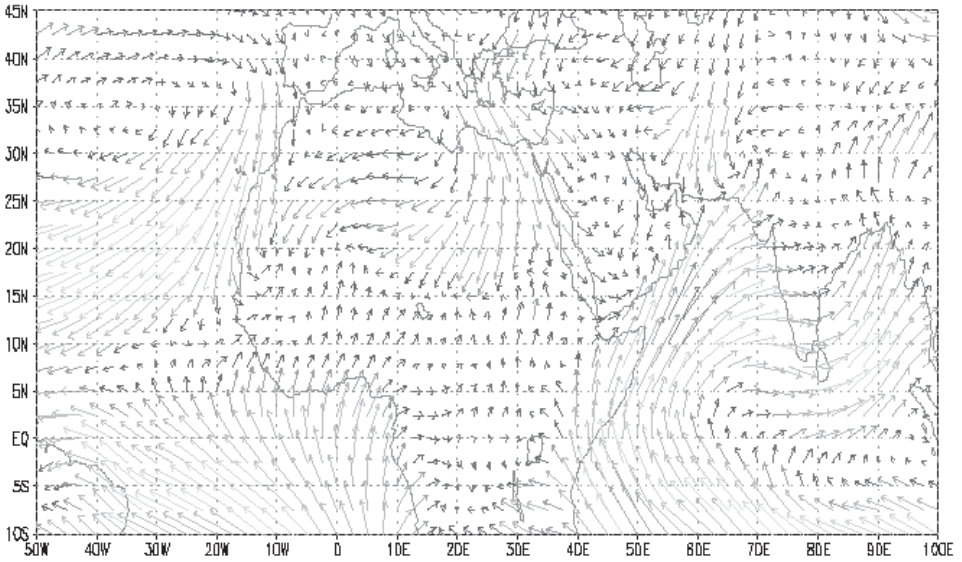

Figure 6b. Mean vector wind component at 1000 hPa from July to October during 1975 La Nina year

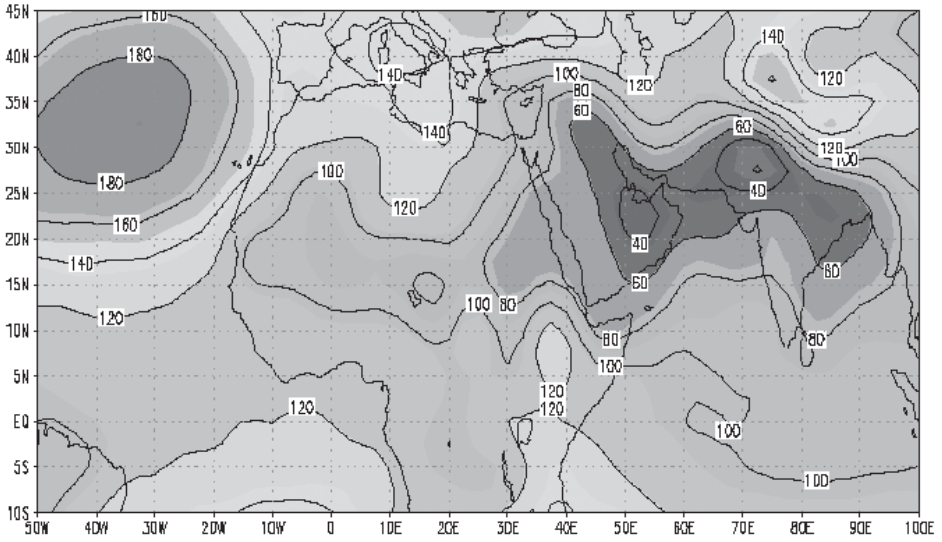

Figure 7a. Geopotential height composite mean July - October during 1987 El Nino year.

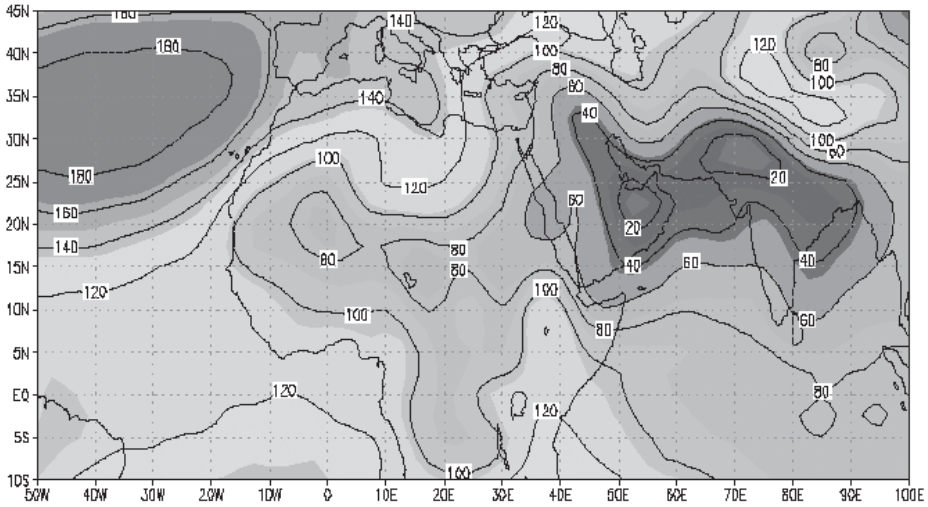

Figure 7b. Geopotential height composite mean July - October during 1975 La Nina year.

In tropical Africa, rainfall is governed by the annual migration of the subtropical high pressure cells on both sides of the equator and the changes in their strength, as well as the north-south swings of the ITCZ. The major climatic impact of ENSO is mostly restricted to the tropics and the Asian summer monsoon region (Li and Yanai, 1996). The intensification of the subtropical highs over the oceans during the cold phase would promote subsidence over the oceans, with compensating ascent over the land.

CONCLUSION

The correlation coefficient results reveal that during ENSO event (warm phase) the stream flow is decreased and vice-verse with La Nina (cold phase). Positive correlation between steam flow and ENSO is found during spring season. Tropical Atlantic Sea surface temperatures is like the ENSO relationship with stream flow over the River Nile. The impact of North Atlantic Oscillation on stream flow over the Nile is very weak. Rainfall-SSTs feedback may play a role in the African situation. Meteorological system such as SSTs over Pacific and Atlantic Oceans seems to play an important role together with Inter-tropical convergence zone (ITCZ) and consequent rainfall or stream flow over the Nile River.

The transition from a wet to a dry climate in the Sahel can be associated with similar decadal trends in the atmospheric circulation in the tropical Atlantic sector and corresponds to a southward shift of northernmost location of the "Inter-Tropical Convergence Zone" in summer. The variation of the inter-hemispheric sea surface temperature (SST) gradient has a significant impact on the position and intensity of the ITCZ, which in turn influences the rainfall over the Sahel in Africa and consequently the stream flow over the River Nile.

TORNADOES IN THE UNITED KINGDOM 2002

By MICHAEL W. ROWE

Director TORRO Tornado Division

INTRODUCTION

The number of major whirlwinds reported in the United Kingdom during 2002 was slightly higher than in 2001. Provisional numbers (with those for 2001 in brackets) are: tornadoes 37 (27); waterspouts 14 (12); funnel clouds 67 (52). There were also nine land devils, the same number as in 2001, three eddy whirlwinds and one whirlwind of uncertain type, making a total of 129 cases (two cases count as both tornadoes and waterspouts).

TORNADOES

There were 31 definite and six probable tornadoes in 2002. It is most encouraging to see such a small number of unconfirmed tornadoes. The first tornadoes of the year were on 26 January at Alsager, Cheshire (investigated by Mike Scott and Matt Capper) and Fradley, Staffordshire (investigated by Karl Robbins). TORRO is very grateful to the increasing number of active site investigators. The last known tornado was at Portchester, Hampshire, on 25 October, and was investigated by Tony Gilbert.

Tornado activity was well spread through the year, and only November and December are without a known tornado. The peak months were August and October, each with nine. Among the more notable cases one of the earliest was at Harbert, Isle of Lewis, on 10 March. This began as a waterspout; the date is very early for waterspouts in any part of Britain, and tornadoes appear to be very rare in the Hebrides. The most widely publicised tornado of 2002 was probably the one near Bridport, Dorset, on 9 August. A photograph of the dark, wide, trailing funnel appeared in most national and many local newspapers, and on the inside front cover of the Journal of Meteorology for January 2003 (plate 1d). TORRO Executive Tony Gilbert has written an account of the tornadoes and funnel clouds of 9 August and the synoptic conditions which produced them (Gilbert, 2003). The most interesting day for tornadoes was probably 15 October, when there were six tornadoes and two funnel clouds. The Torquay tornado of this date was one of the most widely reported cases of the year. A report in the Torquay newspaper the Herald Express of 16 October gives a map showing a path from Paignton north to Bishopsteignton, 13km in a straight line. The evidence for this relatively long path is not known, and in fact the path is suspiciously curved in the Torquay area.

WATERSPOUTS

Waterspouts, like tornadoes, occurred in most months of the year, the earliest being on 20 January in the Forth estuary and the latest on 25 November off Guernsey. Only February, June and December had no known waterspouts. A report from the Isle of Man on 11 December is better classed as an eddy whirlwind. The case at Harbert in the Hebrides on 10 March, unusual for both date and location, has already been mentioned. Another unusual location was a reservoir at Farmoor, Oxfordshire, onto which a spout descended on 28 April.

November 16th

This was the first of consecutive thundery weekends along the coast of Dorset and Hampshire as onshore winds carried vigorous convective activity off the English Channel, around low pressure just to the south-west and west respectively. In Swanage (Dorset) it was reported that a snowplough had to clear hailstones from the Studland Road.

November 23rd

In the morning there were reports of large hail, about small marble size, in Southampton, and at Thornford (Dorset).

November 24th

The New Forest area was hit by a lively thunderstorm around daybreak (Fig 1), the culmination of a particularly thundery November in the area (six thunder days were observed by TORRO's Mike Rowe at Lymington). The hailfall affected Christchurch, Hinton Admiral and Brockenhurst, covering roads in up to 13cm of ice. The hailstones ranged from pea to marble size.

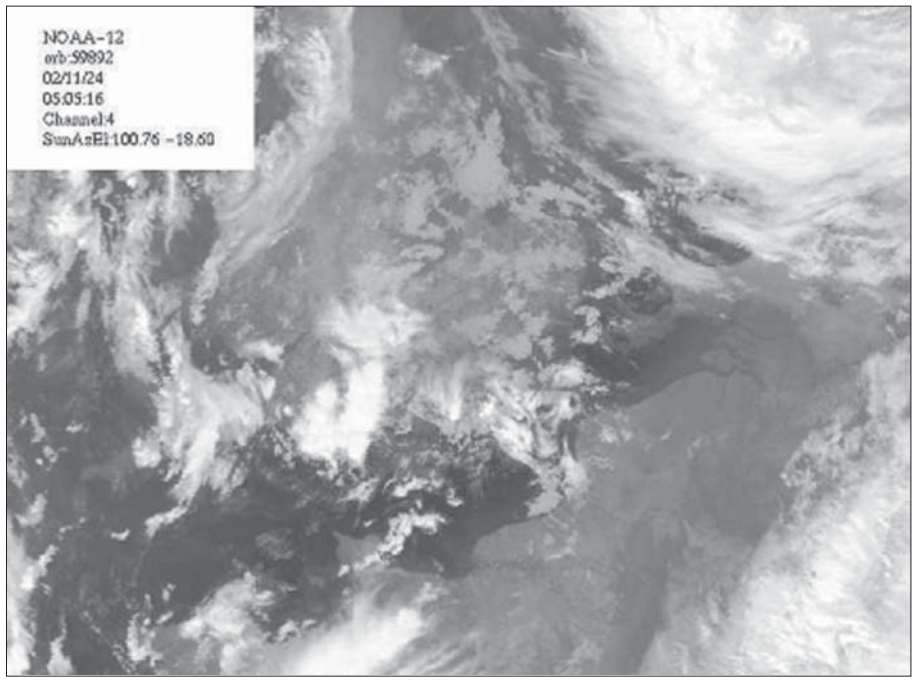

Fig 1. Infrared satellite image, 24th November 2002, large thunderstorm anvils spreading off the warm English Channel into Central Southern England, where an intense hailstorm affected the New Forest area. (Courtesy of University of Strasbourg).

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When a warm surface temperature anomaly occurs to the north of the equator, the ITCZ is shifted north of its normal position and atmospheric convection activity accordingly follows the ITCZ northward, causing unusually high rainfall in Sahel region. The opposite happens when the SST condition is reversed.

Weakened trade winds, the southward displacement of the ITCZ and enhanced equatorial convection are features common to both the Atlantic and the Pacific regions during an El Nino (warm SST anomaly). The strength and oscillation of the Asia monsoon and sub-tropical high pressure affect rainfall over the River Nile during El Nino and La Nina years.

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At Stony Stratford the hail was small marble size (13 to 18mm across), large enough to hurt on impact. At Two Mile Ash the hail, up to 14mm across, partly covered the ground, knocking petals off garden rose bushes. Meanwhile, the second severe hailstorm within 10 days struck the small county of Rutland. At the village of Wymondham hail, described as golf ball size, broke windows. Western parts of the Nottingham area were also affected by severe hail in the evening storms. In Cinderhill, Bullwell and Hucknall, hailstones at least 20mm across (described as "golf balls" in Bulwell) holed conservatory and carport roofs.

July 30th

A violent wind-driven hailstorm affected a swath of North Yorkshire between 1500 and 1530 GMT. A few miles south of Northallerton hailstones were described as golf ball size and stripped much greenery off trees and dented caravan roofing. At nearby Carlton Miniot the severe hail squall flattened many field crops. At the village of Skipton-on-Swale the hail was piled up to 20cm deep. All fruit on apple and pear trees was covered in brown bruise marks. Large tree branches were also broken off.

August 3rd - 4th

A slack area of low pressure covered southern England. Thundery showers became increasingly widespread across central and southern England on 3rd with hail in parts of the West Midlands. "Extremely large" hail accompanied a squally thundery shower in the Stoke-on-Trent area in the late afternoon. At Halesowen there was a brief burst of near golf ball sized hail in the early evening. At Market Overton (Rutland) a bowls match was abandoned after a thunderstorm on 4th, during which hail completely covered the green!

August 15th

A cold front pushed slowly and erratically into hot air across eastern England. An area of severe thunderstorms affected East Anglia (where several places had reached 29C) for several hours in the evening with reports of marble sized hail at Felthorpe, and hail pea sized or larger at Dereham and Melton Constable (Norfolk).

September 8th

A filling depression was drifting very slowly southwards from Scotland into England while an associated 500mb trough covered the British Isles. During a thunderstorm at St Andrews, Fife, hailstones up to 10mm across were observed by TORRO's Richard Wylde.

October 25th

A strong west-south-westerly "returning polar maritime" airstream brought quite widespread squally, thundery showers and hail. At St Cleer and Redgate, near Liskeard (Cornwall), schoolchildren at a school function had to run for cover just after lunch when hailstones of 50 pence piece size (30mm x 10mm) fell. The hailstones were clear, but shaped like broken glass with sharp, jagged edges. Thumbnail size was witnessed by TORRO's Tony Gilbert at Portchester (Hants) in mid afternoon, and, about two hours later large hail fell in parts of London. TORRO observer Penny Coleman noted 10mm diameter hail at Manor Park, East London, while there were reports of hail about 30mm across ("the size of tomatoes") at nearby East Ham and in Camden (North London). Further north, heavy hailstorms covered the ground in parts of Nottingham and Carlisle.

June 2nd

As a cold front engaged a very warm southerly airflow, a large area of thunderstorms broke out across northern England during the evening. The first reports of hail were around Chester, followed by observations of marble sized chunks of ice at Loveclough and Haslingden (Lancs). TORRO member Matt Hugo observed hailstones of up to 32mm across in north Rossendale (Lancs).

June 10th

Pressure was low west of Scotland with the British Isles in a rather cool, unstable west to south-westerly airstream. Typically in such summer situations, "downwind" East Anglia experienced both the highest temperatures (19C at Marham and Coningsby) and the most vigorous shower activity. Marble sized hail fell at Marham (Norfolk) and large hail fell in the Higham and Brooms Barn areas of Suffolk, shredding sugar beet leaves at the latter location.

July 3rd

Hail damaged plants at Brampton (Cumbria) during a showery day in an unstable north-westerly airstream.

July 20th

A very slack surface area of low pressure drifted east-south-east across England and Wales. The 500mb chart showed a marked upper trough covering the British Isles; however daytime heating lifted surface temperatures to average July values (e.g. 21C in the Midlands and East Anglia).Thunderstorms occurred quite widely across the East Midlands, Yorkshire and East Anglia, accompanied by several fierce hailstorms. At the village of Whissendine, Rutland, hail up to 23mm diameter covered much of the grass areas between 1130 and 1200 GMT. The hailstones were described as like marbles or "slightly squashed redcurrants" and hurt on impact. Large runner beans and winter greens had all their leaves holed "as if eaten". At Santon Downham, Norfolk, hail up to 25mm across fell in the late afternoon accompanied by a strong squall; hail of small marble size was also reported just to the west on the south Lincolnshire border.

To the north-west of Chelmsford, Essex, marble sized hail destroyed up to 80% of oilseed rape, peas and wheat crops in the most intense hailstorm to hit this area since the great storm of 26th May 1985 (see Elsom and Webb 1993).

July 28th-30th

The year's hottest spell was also associated with the most outstanding outbreak of thunderstorms in 2002 (for background see the Annual Thunderstorm summary)

July 28th

The two week thundery spell began with a severe thunderstorm outbreak across west Suffolk. Large hail fell on a SSW-NNE swath from Chedburgh (hail 10mm across) to Hundon ("hail almost golf ball size") and on to Stansfield, where car paintwork was chipped by the hail.

July 29th

During one of the early thunderstorms that late afternoon, observer Nick Verge observed scattered disc shaped hail 15 to 20mm across at Maidensgrove, south Oxfordshire.TORRO observers Ray Peverall and Simon Culling both witnessed large hail in the great Milton Keynes thunderstorm which raged for much of the evening.

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TORRO ANNUAL REVIEW 2002

THUNDERSTORM SUMMARY FOR THE BRITISH ISLES 2002

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OVERVIEW

Thunder day totals in 2002 (Table 1) were below average in many areas, but above normal in much of East Anglia and parts of south-east England, near some coasts in the north-west of the British Isles, and along the English Channel coast adjacent to the Isle of Wight. Coulsdon (Surrey) experienced thunder on 24 days. However, at Velindre (Powys) the annual total (5 days) was the lowest since 1991 (4 days) and the second lowest since the 1970s. At Carlton-in-Cleveland (North Yorkshire) a total of 7 thunder days was the equal fewest (with 1989) in annual records back to 1983.

Features of the year reflected in the distribution of storm days included:

1. The very disturbed, "westerly" spell in late January and February when thundery showers especially affected north-westernmost areas in vigorous polar maritime airstreams. Stornoway had four storm days in February, Broadford (Skye) had six thunder days by 9th March and at Straide, north-west Ireland, seven of the 12 annual thunder days had occurred by 7th March.

2. The absence of June thunder across a large area of south-west England, central south England, Wales and the Midlands. Apart from in the East Midlands there was also a significant deficit of thunder in these areas in July.

TABLE 1 – THUNDER DAYS IN 2002 (NB all averages refer to 1961-1995 unless otherwise note
* estimate based on TORRO's map of 1961-1985 annual frequencies

STATION	COUNTY	2002 total	Average 1961-1995	Diff +/-
Bury St Edmunds	Suffolk	23	16 (Honington)	+7
Loughton	Essex	22	20 (25 years)	+2
Calthorpe	Norfolk	19	15 (Coltishall)	+4
Epsom Downs	Surrey	17	17	0
Wokingham	Berkshire	17	17 (Beaufort Park 1962-85)	0
Heathrow	London	15	14	+1
Lymington	Hants	14	11 (Southampton 1969-85)	+3
Waddington	Lincs	14	14	0
Keyworth	Notts	12	16	-4
Straide, Co Mayo	Ireland	12	10	+2
Kidwelly (Llangyndeym)	Carmarthen	12	8*	+4
Fishponds	Bristol	11	10 (1950-1999)	+1
Hastings	E Sussex	11	13 (1971-1995)	-2
Ringway	G Manchester	11	14	-3
Bournemouth (Kings Pk)	Dorset	10	8	+2
Oxford	Oxon	10	12 (24 years)	-2
Gloucester (Longlevens)	Glos	10	10 (20 years Innsworth)	0
Halesowen	W Midlands	10	15 (Elmdon)	-5
Cosby	Leics	10	13	-3
Fleet (Holbeach)	Lincs	10	17 (1988-1999)	-7
Newtownards	Co Down, Ireland	9	5	+4
Ebbw Vale	Monmouth/Gwent	8	10*	-2
Woodlands St Mary	Berks	8	13 (11 years and *)	-5
Barnstaple	Devon	8	9 (Chivenor 17 years)	-1
Allerton Bywater	West Yorkshire	8	9*	-1
Eskdalemuir	Dumfries	8	10	-2
Stornoway	W Isles	8	4	+4
Stony Stratford	N Bucks	8	14 (12 years)	-6
Guernsey Airport	Channel Isles	7	12	-5
Carlton-in-Cleveland	North Yorkshire	7	13 (1983-1999)	-6
St Mawgan	Cornwall	7	8	-1
Aldergrove	N Ireland	7	6	+1
Lyneham	Wiltshire	6	11 (1971-1995)	-5
Leeming	N Yorkshire	6	9	-3
Johnstone, Elderslie	Renfrew	6	7 (Abbotsinch)	-1
Velindre	Powys	5	10 (1972-2000)	-5
Swansea	West Glamorgan	4	10*	-6
Dyce	Aberdeenshire	4	4	0
Leuchars	Fife	4	5	-1
Valley	Anglesey	2	6	-4

March 9th.

Hail 10-11mm diameter fell at Coulsdon (Surrey), the third time in 5 weeks hail reaching this size had fallen at the station.

April 18th

Predominantly dry, anticyclonic weather in the first in the first three and a half weeks of April was interrupted as a cold front crossed England and Wales overnight 17th/18th, followed by a slack, unstable westerly airflow underneath a trough evident at 500mb. Thundery showers were widespread across central and southern England. Hailstones up to 10mm across were observed around Pinner (West London), Windlesham (Kent), Lewknor (Oxon) and Derby. At Pinner hail covered the ground thickly, as it did also at Storrington (West Sussex). At Ware, Hertfordshire, hail, described as of large pea to small marble size, stripped small leaves from trees and new growth off shrubs.

April 26th, 28th

Thunder broke out suddenly as a fast-moving "double" cold front crossed the south Midlands and south-east England in the early afternoon of the 26th. At Maidensgrove and Assendon, near Henley in Oxfordshire, intense hail 5 to 10mm across stripped many leaves and damaged delphiniums. During the evening of the 26th the unstable polar air in the wake of the front brought thunder and hail to north-west England, with observers at Wigan (Greater Manchester) and Chorley (Lancs) reporting hail around 10mm diameter; at the former location the ground was completely covered. North-west England also experienced some fierce hail during thundery showers on the evening of the 28th in a strong westerly airflow of polar origin just south of a deep depression over northern Scotland. At Worsley, Manchester, hail carpeted the ground, and blossom, catkins and leaves were brought down off trees; an unconfirmed report from Oldham referred to "golf ball hail". There were reports of marble sized hail in Stoke-on-Trent, while at Cosby, near Leicester, pea sized hail covered the ground.

May 1st-2nd.

A slow-moving upper trough extended south over the British Isles and western Europe and, as the old surface depression near north-east Scotland filled and drifted away north-east, north-north-westerly winds fell light. On 1st pea sized hail briefly covered the ground at Earl Shilton (Leics). On 2nd several heavy hailstorms were reported. At Poxwell (Dorset) the ground was covered 10cm deep, and a white cover was also reported at Shaftesbury. At Longfield (Kent) foliage on plants and trees was damaged.

The most remarkable storm on the 2nd occurred at Wishaw, North Lanarkshire. Some hailstones of 40 to 45mm diameter were observed. Although generally of the soft variety (which splattered on impact), a few individual stones bounced several feet.

May 26th-27th

An area of low pressure swung north across southern England on the 26th and later became slow moving across western Scotland as it filled on the 27th. Thunder was moderately widespread across the south and Midlands on 26th. Pea sized hail knocked new buds off runner beans at Early near Reading (Berks). Hailstones were observed at 10mm across at Cinderford (Glos), and 9 to 12mm at Wymeswold (Leics) where they were described as painful on impact. At Cropwell Bishop (Notts) hail covered the ground.

On the 27th there was an accumulation of "quite large" hail in central Belfast.

Thunder and hail were quite widespread in squally showers across southern England. Hail of 5 to 10mm diameter was observed in several locations such as Swindon (Wilts), Sutton Scotney (Hants/Berks border), Peckham and Telegraph Hill in South London, and Coulsdon (Surrey) where the hail lay up to 3cm deep. There was an unconfirmed report of marble sized hail from the Hounslow area of West London. Hail up to 10mm across also fell at Llansadwrn (Anglesey).

February 26th-27th

As on the 5th an airstream originating over Greenland arrived on a very long sea track, but this time on strong westerly winds south of a belt of low pressure extending from south-east Greenland across Scotland to south Sweden.

A particularly dramatic cumulonimbus system crossed north-west England in the late afternoon of the 26th. Pea sized hail covered the ground at Heswall (Merseyside). Quite frequent and vivid lightning, fierce squalls, hail up to 15mm across (marble size) and a finale of heavy snow were observed at Standish, near Wigan (Greater Manchester) and at Rawtenstall, Rossendale (Lancs). Other western locations to report large hail on the 26th were Lisburn, Antrim (Northern Ireland) and (in the morning) Raglan (Monmouthshire) where hail 12mm diameter fell. On the 27th there were reports of hail around 10mm across from Llandaff in Cardiff and the Bideford area of Devon where fields were covered. Coulsdon (Surrey) experienced a second violent hailstorm of the month in the afternoon. The hail, up to 13mm across, lay on the ground for over 18 hours. Hail averaging 11mm diameter fell at Benfleet (Essex).

TABLE 1. THE NUMBER OF DAYS WITH DAMAGING HAIL IN THE BRITISH ISLES, 1981-2002

1981	6	1992	10
1982	17	1993	18
1983	19	1994	17
1984	12	1995	8
1985	20	1996	6
1986	17	1997	17
1987	14	1998	18
1988	11	1999	25
1989	13	2000	28
1990	11	2001	22
1991	9	2002	20
		1981-2001 average	15

Table 2. Severe hailstorms in the year, 2002 (intensity of H2-3 or more)

May 2nd	Wishaw (N Lanarkshire)	H2/3
July 20th	Chelmsford (Essex)	H2/3
July 28th	Chedburgh - Stansfield (Suffolk)	H3
July 29th/1	Wymondham (Rutland)	H4
July 29th/2	Cinderhill-Bulwell-Hucknall (Nottingham)	H3
July 30th	Carlton Miniott-Skipton-on-Swale (North Yorkshire)	H3-4
October 25th	St Cleer/Redgate, Liskeard (Cornwall)	H2-3

3. The notable thundery period from 28th July to 10th August, coinciding this year with the classic "height of the European summer monsoon". The latter has been associated with the peak annual incidence of cyclonic weather types over the British Isles (Kelly, Jones and Briffa 1997, ref H Lamb's classification). The activity in this spell in 2002 predominantly, but not exclusively, affected eastern areas.
4. A very cyclonic, "southerly" November was associated with a high incidence of late autumn thunder near the coasts of central southern England, e.g. 6 thunder days occurred at Lymington, Hampshire.

WIDESPREAD THUNDERSTORM OUTBREAKS IN 2002

The identification of days of days of widespread thundery activity has again been based on the geographical "spread" of stations used in Bob Prichard's 1946-1985 survey (J. Meteorology 12, pp 83-86), the automation of various synoptic stations being compensated for by the use of more reports from voluntary observers. Thunder could be described as widespread on 11 days in 2002 (May 3rd, 17th and 26th; June 2nd; July 20th, 29th and 30th; August 3rd, 7th and 18th; and October 25th), below the 1946-1995 average of 15 days. Only 17th May (in the south-west) and 29th-30th July (central and east Britain) were occasions of large storm systems with very extensive overhead electrical activity. On the other days noted above activity was essentially "showery", though slow moving cumulonimbus systems gave some lengthy "action" at a local level.

REPORTED INCIDENCE OF OVERHEAD STORMS AND LIGHTNING DAMAGE IN 2002

(overhead thunder is defined as electrical activity reported by an observer to be at a distance of 5km or less, or "close")

Overhead thunder was reported on 15 days at Ware, Hertfordshire, and on 12 days at Loughton, Essex. Significant lightning incidents (e.g people directly or indirectly struck, houses and other buildings struck, trees struck and damaged, strikes causing an electricity supply cut over a large area) reported to TORRO in 2002 are summarised in Table 2. The total reports were noticeably fewer than in 2001 and only just over half the total for 1999, the most thundery recent year in respect of the number of widespread severe events. 2002 would have been a very "quiet" year had it not been for the two-week thundery spell from 28th July to 10th August during which nearly half (78) of the known lightning incidents for the year were logged. Sadly, these included the first lightning fatality since 1999 following an incident in a Leicester park on 3rd August.

Counties reporting the highest number of incidents in 2002 were: Buckinghamshire with 17 incidents (all on 29th July!); Norfolk and Suffolk with 11 each, Devon (6 on 17th May) and London with 10 each, and Essex with 9. The five Eastern counties of Essex, Cambridgeshire, Suffolk, Norfolk and Lincolnshire had a total of 45 incidents reported. Of the 166 reported lightning incidents in 2002, 61 were in July of which 55 occurred on the 29th-30th July, the most outstanding thunderstorm episode during the year.

TABLE 2a. REPORTED LIGHTNING INCIDENTS

Region	2002	2001	2000	1999
Southern England	42	83	49	80
Midlands , E Anglia, Lincs	89	99	41	174
Northern England	20	15	35	34
Wales	1	14	5	18
Scotland	8	10	8	2
Ireland	5	5	22	8
Channel Isles	1	0	1	0
TOTAL	**166**	**226**	**161**	**316**

Table 2b. REPORTED LIGHTNING INCIDENTS BY MONTH, 2002

January	2	
February	7	
March	2	
April	7	
May	18	
June	18	
July	61	(29 incidents on 29th, 26 incidents on 30th)
August	31	(9 days with incidents)
September	1	
October	4	
November	14	
December	1	

SEVERE THUNDERSTORMS IN 2002

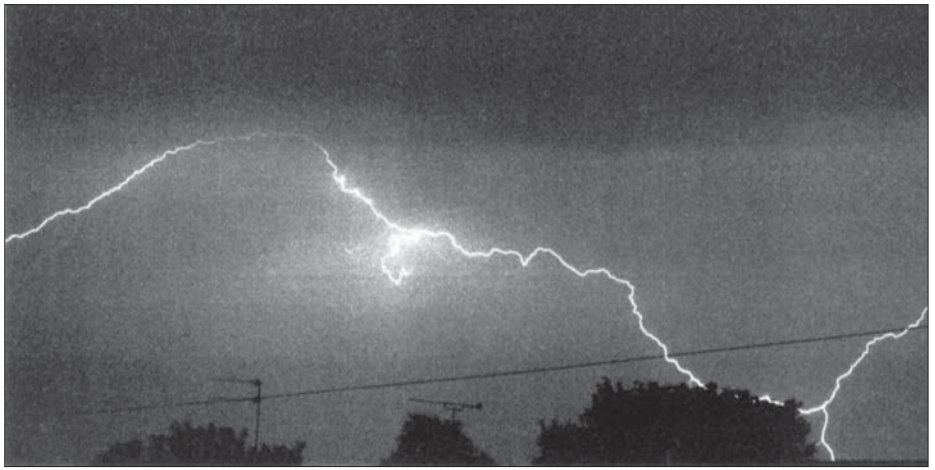
May 17th

At 0000 GMT a southeasterly airstream covered most of the British Isles (28.5C was recorded in Jersey on the 16th), while a trailing cold front was virtually stationary across western Ireland but further south, was pushing slowly eastwards across Biscay and Iberia. As the front undercut hot air over western France a large area of severe thunderstorms developed, and drifted northwest across southwest England and South Wales over the following 12 hours. Individual observers in Devon and South Wales experienced around six hours of activity, with lightning damage at several places in the former county, and severe flash flooding in West Glamorgan and Carmarthenshire.

June 2nd/3rd

The year's second brief incursion of very warm southerlies and an ensuing cold front brought some heavy thunderstorms to Northern England on the evening of 2nd, with widespread disruption to electricity supplies and TV reception in the north-east. A wave on the front brought another lively outbreak of storms to Norfolk in the early hours of the 3rd.

She remained in intensive care on life-support for three days and needed ten days recovering in hospital. Another of the surfers said "everything went black. I felt an intense pain in my head like being hit with a sledgehammer, and an almighty bee sting". The lightning apparently first struck a tree on the cliff, splitting it in two, and the electrical discharge then passed into the sea. The 21-year-old surfer who suffered the worst was ankle deep in the water when lightning struck while the other three affected by the electrical discharge were in deeper water.



Lightning over Ware, Hertfordshire, on the late evening of 7th August 2002 (courtesy of Michael Skinner)

Acknowledgements: The authors wish to thank TORRO members and others for forwarding reports, including press clippings. Their willingness to investigate incidents, sometimes conducting interviews, is much appreciated.

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HAILSTORM DIVISION SUMMARY FOR THE BRITISH ISLES 2002

By JONATHAN WEBB

Director TORRO Thunderstorm and Hailstorm Division

Potentially damaging hail (TORRO intensity H1 or greater) was reported on 20 days in 2002 (Table 1).

February 5th

There was a large, deep, complex area of low pressure to the west and north of the British Isles. A strong south-westerly airstream behind a waving cold front blew returning maritime polar air, originating around Greenland but with a very long "fetch", across Ireland, England and Wales.

July 29th

Wigston, Leicester (Leicestershire). 1830. Lightning struck a house which had the patio and front door open. "Suddenly this red ball...with sparks coming from it, came in and went through the house". A charger for an electric wheelchair came on as did a battery-operated electrical game, and a bouncy ball with a flashing spark inside lit up. The red ball disappeared in a couple of seconds leaving a slight burning smell. An 11-year old girl was left with a faint red mark on her head. She "felt as if someone had pinched her really hard on the forehead (she felt a slight burn) and then on the leg ... like someone had set my leg on fire". She had two metal clips in her hair.

July 31st

Hungerford (Berkshire). At 0712 GMT there was huge discharge, "a blinding blue glare and with it a tremendous bang", witnessed first-hand by TORRO observer John Weevers. He felt the discharge in his chest. Doors and windows in the house were blown open and items fell from shelves. The sky dish/receiver, digi-box and television in the house were destroyed. Nearby houses also experienced damage to electrical equipment.

August 3rd (1)

Leicester (Leicestershire). A 23-year-old man was struck an killed by lightning as he and two male friends (23- and 30-years-of-age) sheltered from torrential rain (with thunder "a long way off") under a tree in Aylestone Recreation ground where they were participating in football training. The two friends were injured. One described how "my leg was totally shot....completely white, the kneecap was blue" and the other suffered an injury to his groin. Both were treated in Leicester Royal Infirmary.

August 3rd (2)

Canterbury (Kent). A man holding an umbrella was struck by lightning when helping to set up a fun day and fete at Parkside Primary School. He was not knocked off his feet but his right arm went "completely numb" and he had "no feeling there for two days". He was left with a burn mark on his wrist.

August 7th

Woolwich (London). At 1848 GMT, lightning struck a house in Lamport Close, shattering a window and starting a roof fire. A 27-year-old mother was "knocked sideways" and her nine-year-old son suffered cuts to his head from flying window glass. A television, video and games' console were damaged.

August 18th

Boston (Lincolnshire). When lightning struck a house, the owner (gender unknown), who was holding kitchen taps at the time, was knocked unconscious and a stereo system was burned out.

November 23rd

Hawkes Point-Porth Kidney Sands, Carbis Bay, near St.Ives (Cornwall). At about 1600 GMT, a group of surfers were struck by lightning and four were knocked down. Two of these were knocked unconscious and seriously hurt and were airlifted by helicopter to Treliske Hospital, Truro. One of these, a 21-year-old woman suffered cardiac arrest and required heart and lung resuscitation at the scene from an off-duty doctor and a motorcycle paramedic (who used a defribrillator).

July 20th

Widespread thunder affected the East of England as a shallow depression drifted east across England and Wales. There was lightning damage to buildings in the Midlands, flash flooding in the Nottingham and Hull areas, several severe hailstorms (see 2002 hailstorm summary) and tornado damage at Brightlingsea, Essex.

July 28th-31st

Hot air shifted northwards into the British Isles on the 27th as pressure built over Eastern Europe. Temperatures reached 30C in the London area on the 28th when a small, but severe outbreak of thunderstorms (see hailstorm summary) affected East Anglia. Meanwhile a cold front, which had been encroaching from the northwest, slowed and became trailing across the England/Scotland border and the Irish Sea by 0000 on 29th. During the next 48 hours it eventually returned north into Scotland and pivoted forward again into southwest Britain, as an area of low pressure developed over central and eastern England. Further details of the rather complex background to the various areas of storms during this period are discussed in the monthly thunderstorm report (Prichard 2003).

The main series of severe thunderstorm outbreaks began over the east and southeast Midlands late on the afternoon of the 29th (Fig 1) following peak temperatures of over 32°C in West London. Three TORRO observers (Ray Peverall, Simon Culling and Chris Scoggins) witnessed the ferocious storm that affected the Milton Keynes area in the evening; at its height there were 12 to 20 lightning discharges per minute. Fifteen houses in the district were struck and set alight in separate lightning incidents. At least two of these houses, in New Bradwell and in Great Linford suffered extensive destruction of their roof space. In one road in Wolverton, not only was a house struck and fired, but all 45 properties were left with flooded gardens. There was extensive disruption to traffic lights and electric lifts in the town.

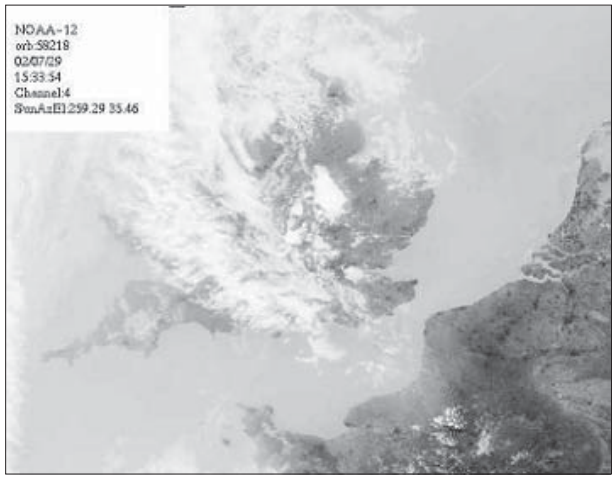

Fig.1. Infra-red satellite image for 1533 GMT, 29th July 2002. The first large cumulonimbus system erupts over the East Midlands and the severest thunderstorm outbreak of 2002 is underway (courtesy of University of Strasbourg).

Later that evening and into the early hours of 30th storms also left a trail of lightning damage across the north-east Midlands and Lincolnshire with 10,000 homes in Leicestershire losing power. Several buildings were damaged by lightning in the Humber area, where lightning intensities reached a peak rate of 12 to 15 discharges per minute. Further severe storms occurred later on 30th; from Kent and London northwards across East Anglia (where activity continued for over 12 hours around the Wash), and also in the east and north Midlands, northern England and south and east Scotland. 114mm of rain fell at Penistone (South Yorkshire), 109mm at Heckmonwicke (West Yorkshire) and 103mm at Charnwood Forest (Leicestershire). At Harrogate (North Yorks), TORRO's Roger Bickerton recorded 90mm of which 36mm fell in an hour. There was severe flash flooding in numerous localities, including parts of Northamptonshire, Leicestershire, south-west Essex, west Norfolk (83mm at RAF Marham), Lincolnshire (73mm at RAF Waddington), north Derbyshire (Glossop), Yorkshire, southern Scotland (where there were many landslip incidents) and central Scotland (especially central and eastern areas of Glasgow).

Lightning caused widespread and prolonged power failures in Suffolk, Cambridgeshire and (for the second successive night) Lincolnshire, while at least five buildings were struck in West Suffolk. In Scotland, 50,000 homes in the Edinburgh area lost power in the storms. During the period between 1200 GMT on 28th and 1200 GMT on 31st July thunder was heard during 16 standard hours at Bury St Edmunds (Suffolk) and during 12 hours at Nettleham (Lincoln).

August 7th

A cold front pushed very slowly southeast into a residue of very warm, stagnant air across England and Wales. Numerous slow-moving thunderstorms were associated with lengthy periods of electrical activity and flash flooding. 71.5 mm fell at Hampstead, London (60mm in one hour) and numerous London underground stations were forced to close by flooding. During storms on the Northamptonshire/Buckinghamshire border, 63mm fell in two hours at Silverstone and 60mm in one hour at Olney. Ball lightning incidents were reported at Hertford and at Addlestone (Surrey).

September 7th-9th

During a short unsettled spell in an otherwise anticyclonic month, torrential thundery downpours caused severe local flooding around Inverness on the 7th, while flash flooding affected Swanage (Dorset) early on the 9th when 88mm of rain fell before 0900 GMT.

Further details of each month's storms and their synoptic background are published in The Journal of Meteorology, UK. New thunderstorm observers are always welcome. Further details and either monthly or individual storm report forms are available from the author.

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LIGHTNING STRIKES TO PEOPLE IN THE BRITISH ISLES 2002

By DEREK ELSOM * and JONATHAN WEBB**

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INTRODUCTION

Reports were received of people being struck directly or indirectly by lightning in the British Isles on nine days during 2002. A total of 18 people (11 male, 6 female, 1 gender unknown) were struck in 11 separate incidents. A 23-year-old man died whilst sheltering under a tree with two friends in Leicester on 3rd August. His death was the first to have occurred from lightning in the British Isles since two women were killed in Hyde Park, London, on 22nd September 1999 (Elsom, 2001). A lightning incident involving four surfers near St Ives, Cornwall, on 23rd November received widespread national media attention. A 21-year-old female surfer required resuscitation and spent 10 days in hospital recovering. Six of the lightning incidents during 2002 involved people indoors receiving electrical shocks when lightning struck the building they were in and, in two cases, when they were using a land-line telephone. One indoor incident in Leicester on 29th July may have involved ball lightning. Overall, there were far fewer known lightning incidents affecting people compared with the previous two years. Generally, there were fewer days during the year with overhead thunder being reported and fewer widespread thunderstorm events. The EA Technology Location System recorded around 207,000 ground strikes in 2002 for the UK compared with 403,000 in 2001 and 310,000 in 2000 (Don Eaton, *pers comm*).

INDIVIDUAL INCIDENTS

May 17th

South Molton (Devon). A lady using the telephone at about 1000 GMT reported how a "blinding flash of lightning pulled the phone out of her hands". The telephone "landed across the room"... and her hand became "claw shaped with a spasm".

June 2nd

New Ross (County Wexford, Ireland). Lightning struck three men, including a father and his son, who were taking part in the district angling club's three-day event. They were thrown on to rocks. They were all briefly hospitalised.

June 10th (1)

Risby, Bury St Edmunds (Suffolk). At 1555 GMT, lightning struck Cherry Trees School in the Chase. The areas affected were the main hall, kitchen and office buildings. A heater in an upstairs office caught fire, setting fire to floorboards, curtains and a wall. Computers and modems were wrecked. Fire systems were burnt out. One female teacher was struck by lightning as she led children out, but she was not seriously hurt.

June 10th (2)

Ixworth (Suffolk). Lightning struck a building leaving a hole in the roof and damaging electrical cables. A councillor inside received an electrical shock via the telephone he was using and he was thrown across the room.